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ABSTRACTS

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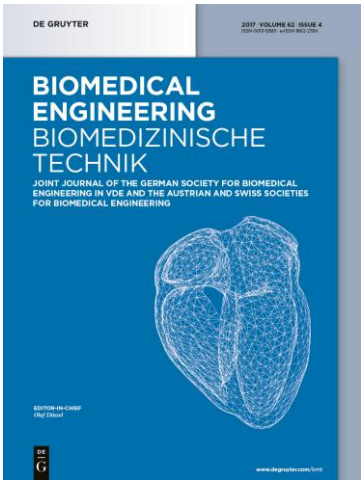
DGBMT VDE DGMP Deutsche Gesellschaft für Medizinische Physik e.V. ÖGMP Österreichische Gesellschaft für Medizinische Physik SGSMP SSRPM SSRFM



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Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Intercenter validation of a knowledge based model for automated planning of volumetric modulated arc therapy for prostate cancer. The experience of the German RapidPlan Consortium.	C Schubert (University Medical Center Hamburg-Eppendorf, Germany); C Weiss (Klinikum Darmstadt, Germany); O Waletzko (Klinikum Dortmund, Germany); D Voelzke (Strahlentherapie Bonn-Rhein-Sieg, Germany); S Toperim (University Medical Center Hamburg-Eppendorf, Germany); A Roeser (Helios Klinikum, Germany); S Puccini (Strahlentherapie Bonn-Rhein-Sieg, Germany); C Mehrens (Klinikum Dortmund, Germany); JD Kueter (University Medical Center Schleswig-Holstein, Campus Lübeck, Germany); K Hierholz (Klinikum Dortmund, Germany); K Gerull (University Medical Center Schleswig-Holstein, Campus Lübeck, Germany); A Fogliata (Humanitas Clinical and Research Center, Italy); A Block (Klinikum Dortmund, Germany); L Cozzi (Humanitas Clinical and Research Center, Italy)	Session 1	Radiation therapy I – IGRT and ART	V 1	10.09.2017	14:30
Evaluation of the consistency in a clinically implemented plan selection strategy for adaptive radiotherapy in cervix cancer	Martin Buschmann (Medical University of Vienna, Austria; Medical University of Vienna, Austria); Alina Sturdza (Medical University of Vienna, Austria); Katarina Majercakova (Medical University of Vienna, Austria; Medical University of Vienna, Austria); Stephanie Smet (Medical University of Vienna, Austria); Dina Najjari (Medical University of Vienna, Austria); Richard Pötter (Medical University of Vienna, Austria); Dietmar Georg (Medical University of Vienna, Austria; Medical University of Vienna, Austria); Yvette Seppenwoolde (Medical University of Vienna, Austria; Medical University of Vienna, Austria)	Session 1	Radiation therapy I – IGRT and ART	V 2	10.09.2017	14:30
Detection of changes in the patient anatomy using the integrated detector array of a tomotherapy system	Kai Schubert (Universitätsklinikum Heidelberg, Germany); Sebastian Klüter (Universitätsklinikum Heidelberg, Germany); Xenia Wester (Universitätsklinikum Heidelberg, Germany); Dieter Oetzel (Universitätsklinikum Heidelberg, Germany); Jürgen Debus (Universitätsklinikum Heidelberg, Germany)	Session 1	Radiation therapy I – IGRT and ART	V 3	10.09.2017	14:30
Photon fluence reconstruction for online dose verification	Damian Czarnecki (Technische Hochschule Mittelhessen, Germany; Carl von Ossietzky Universität Oldenburg, Germany); Thilo Seliger (Philipps-Universität Marburg, Germany); Rolf Kussaether (MedCom Gesellschaft fuer medizinische Bildverarbeitung mbH, Germany); Ulf Mäder (Technische Hochschule Mittelhessen, Germany); Björn Poppe (Carl von Ossietzky Universität Oldenburg, Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; Universitätsklinikum Gießen-Marburg, Germany; Frankfurt Institute for Advanced Studies (FIAS), Germany)	Session 1	Radiation therapy I – IGRT and ART	V 4	10.09.2017	14:30
A tissue-equivalent test environment for malfunctions of active medical implants and electronic devices due to radiation	Manuel Stich (Ostbayerische Technische Hochschule Amberg-Weiden, Germany; University Hospital Würzburg, Germany); Larissa Blümlein (Ostbayerische Technische Hochschule Amberg-Weiden, Germany; Hospital St. Marien Amberg, Germany); Felix Schmidl (Ostbayerische Technische Hochschule Amberg-Weiden, Germany); Anne Slawig (Ostbayerische Technische Hochschule Amberg-Weiden, Germany; University Hospital Würzburg, Germany); Richard Lösch (Hospital St. Marien Amberg, Germany); Matthias Hipp (Hospital St. Marien Amberg, Germany); Zehra Ese (MR:comp GmbH, Germany; University of Duisburg-Essen, Germany); Marcel Kressmann (MR:comp GmbH, Germany); Jakob Kreutner (MR:comp GmbH, Germany); Gregor Schaefers (MR:comp GmbH, Germany); Herbert Köstler (University Hospital Würzburg, Germany); Ralf Ringler (Ostbayerische Technische Hochschule Amberg-Weiden, Germany)	Session 1	Radiation therapy I – IGRT and ART	V 6	10.09.2017	14:30
Surface plasmon resonance measurements of receptor binding kinetics for physiologically-based pharmacokinetic modeling of molecular radiotherapy using PSMA-11	Gordon Winter (Universität Ulm, Germany); Anja Vogt (Universität Ulm, Germany); Nusrat J. Begum (Universität Ulm, Germany); Christoph Solbach (Universität Ulm, Germany); Ambros J. Beer (Universität Ulm, Germany); Gerhard Glatting (Universität Ulm, Germany); Peter Kletting (Universität Ulm, Germany)	Session 2	Cells, materials and biochemistry I	V 7	10.09.2017	14:30
A lab-on-a-chip for purification of miRNAs from archival (FFPE) tissue samples	Gregory Dame (Medizinische Hochschule Brandenburg, Germany); Ole Behrmann (Universität, Germany); Julian Heni (Universität, Germany); Frank Hufert (Medizinische Hochschule Brandenburg, Germany); Gerald Urban (Universität, Germany)	Session 2	Cells, materials and biochemistry I	V 8	10.09.2017	14:30
System for automated cell cultivation and analysis	Mike Stubenrauch (Technische Universität Ilmenau, Germany); Robert Fischer (Technische Universität Ilmenau, Germany); Martin Hoffmann (Technische Universität Ilmenau, Germany); Jens Müller (Technische Universität Ilmenau, Germany); Stefan Sinzinger (Technische Universität Ilmenau, Germany); Klaus Liefeith (Institut für Bioprozess- und Analysenmesstechnik e.V., Germany); Hartmut Witte (Technische Universität Ilmenau, Germany)	Session 2	Cells, materials and biochemistry I	V 9	10.09.2017	14:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Cell culture-based *in vitro* models for investigating the SPION passage through cellular barriers	Christine Gräfe (Universitätsklinikum Jena, Germany); Elena Müller (Universitätsklinikum Jena, Germany); Ioana Slabu (Physikalisch-Technische Bundesanstalt, Germany); Andreas Weidner (Technische Universität Ilmenau, Germany); Frank Wiekhorst (Physikalisch-Technische Bundesanstalt, Germany); Andreas Hochhaus (Universitätsklinikum Jena, Germany); Silvio Dutz (Technische Universität Ilmenau, Germany); Joachim H. Clement (Universitätsklinikum Jena, Germany)	Session 2	Cells, materials and biochemistry I	V 10	10.09.2017	14:30
Non-intrusive performance analysis of implantable electrodes	Max Eickenscheidt (Universität Freiburg, Germany); Jonas Eberhardt (Universität Freiburg, Germany); Thomas Stieglitz (Universität Freiburg, Germany)	Session 2	Cells, materials and biochemistry I	V 11	10.09.2017	14:30
Effective parameters describing mechanisms of magnetic separation using superparamagnetic beads	Uwe Steinhoff (Physikalisch-Technische Bundesanstalt, Germany); Norbert Löwa (Physikalisch-Technische Bundesanstalt, Germany); Frank Wiekhorst (Physikalisch-Technische Bundesanstalt, Germany)	Session 2	Cells, materials and biochemistry I	V 12	10.09.2017	14:30
Operation models of the temporal bone: generation and biomechanical properties - How well can haptic properties of the bones be simulated?	Ulrich Vorwerk (Univ. HNO Klinik Magdeburg, Germany)	Session 3	Middle ear: Modelling, diagnostics, therapy I – Modelling	FS 1	10.09.2017	14:30
Effect of middle ear transfer function on stapes quasi-static stiffness induced by a novel 3-axis force sensor	Christof Röösli (UniversitätsSpital Zürich, Switzerland); Ivo Dobrev (UniversitätsSpital Zürich, Switzerland); Jae Hoon Sim (UniversitätsSpital Zürich, Switzerland); Thomas Linder (Kantonsspital Luzern, Switzerland); Alex Huber (UniversitätsSpital Zürich, Switzerland)	Session 3	Middle ear: Modelling, diagnostics, therapy I – Modelling	FS 3	10.09.2017	14:30
Combined optoacoustic and acoustic tomography system for investigation of fingers	Wolfgang Bost (Fraunhofer IBMT, Germany); Milan Oeri (Fraunhofer IBMT, Germany); Steffen Weber (Fraunhofer IBMT, Germany); Steffen Tretbar (Fraunhofer IBMT, Germany); Marc Fournelle (Fraunhofer IBMT, Germany)	Session 4	Imaging and image processing I – Optics and endoscopy	V 14	10.09.2017	14:30
Computer assisted detection of polyps during colonoscopy – results from an initial technical study	Peter Klare (Klinikum Rechts der Isar, Germany); Christoph Sander (Klinikum Rechts der Isar, Germany); Martin Prinzen (Fraunhofer IIS , Germany); Christian Münzenmayer (Fraunhofer IIS , Germany); Sebastian Nowack (Fraunhofer IIS , Germany); Stefan von Delius (Klinikum Rechts der Isar, Germany); Thomas Wittenberg (Fraunhofer IIS , Germany)	Session 4	Imaging and image processing I – Optics and endoscopy	V 15	10.09.2017	14:30
3D-panoramic images for laparoscopy	Daniel Erpenbeck (Fraunhofer IIS , Germany); Tobias Bergen (Fraunhofer IIS , Germany); Niels Lemke (Schoelly Fiberoptics, Germany); Thomas Wittenberg (Fraunhofer IIS , Germany)	Session 4	Imaging and image processing I – Optics and endoscopy	V 16	10.09.2017	14:30
Impact of new ICRU-90 recommendations on clinical photon and electron reference dosimetry	Klemens Zink (Technische Hochschule Mittelhessen, Germany); Damian Czarnecki (Technische Hochschule Mittelhessen, Germany); Philip von Voigts-Rhetz (Technische Hochschule Mittelhessen, Germany)	Session 5	Dosimetry, radiation protection and radiation biology I	V 17	10.09.2017	16:15
Monte Carlo based investigation of the beam quality correction factor kQ depending on the chamber's level of detail	Tabea Pretzsch (University of Applied Sciences, Germany); Philip von Voigts-Rhetz (University of Applied Sciences, Germany); Damian Czarnecki (University of Applied Sciences, Germany); Klemens Zink (University of Applied Sciences, Germany; University Medical Center Giessen-Marburg, Germany)	Session 5	Dosimetry, radiation protection and radiation biology I	V 18	10.09.2017	16:15
Experimental investigation of the depth-dependent fluence perturbation of parallel-plate chambers in clinical electron beam	Philip von Voigts-Rhetz (Institut für Medizinische Physik und Strahlenschutz, Germany; Universitätsklinikum Gießen-Marburg, Germany); Hilke Vorwerk (Universitätsklinikum Gießen-Marburg, Germany); Klemens Zink (Institut für Medizinische Physik und Strahlenschutz, Germany; Universitätsklinikum Gießen-Marburg, Germany)	Session 5	Dosimetry, radiation protection and radiation biology I	V 19	10.09.2017	16:15
Small-field output factor corrections of gas-filled and solid photon detectors – Derivation from their lateral dose response functions by a convolution technique in comparison with direct measurement	Daniela Poppinga (Universität Oldenburg, Germany); Jutta Meyners (Universität Oldenburg, Germany; Imland Klinik, Germany); Björn Delfs (Universität Oldenburg, Germany); Dietrich Harder (Universität Göttingen, Germany); Björn Poppe (Universität Oldenburg, Germany); Hui Khee Looe (Universität Oldenburg, Germany)	Session 5	Dosimetry, radiation protection and radiation biology I	V 20	10.09.2017	16:15
Abdominal dose from radiology and radiotherapy imaging – CT and CBCT protocols	Yvonne Dzierma (Universitätsklinikum des Saarlandes, Germany); Franziska Ziegenhain (Universitätsklinikum des Saarlandes, Germany); Katharina Bell (Universitätsklinikum des Saarlandes, Germany); Philippe Jagoda (Universitätsklinikum des Saarlandes, Germany); Peter Minko (Universitätsklinikum des Saarlandes, Germany); Arno Buecker (Universitätsklinikum des Saarlandes, Germany); Christian Rübe (Universitätsklinikum des Saarlandes, Germany)	Session 5	Dosimetry, radiation protection and radiation biology I	V 22	10.09.2017	16:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Influence of age and gender on 5-min QT variability	Rico Schroeder (Ernst-Abbe-Hochschule Jena, Germany); Sarah Radon (Ernst-Abbe-Hochschule Jena, Germany); Claudia Fischer (Ernst-Abbe-Hochschule Jena, Germany); Mireia Valero (Universitat Politècnica de Catalunya (UPC), Spain); Montserrat Vallverdu (Universitat Politècnica de Catalunya (UPC), Spain); Annette Peters (Helmholtz Zentrum München, Germany); Siegfried Perz (Helmholtz Zentrum München, Germany); Andreas Voss (Ernst-Abbe-Hochschule Jena, Germany)	Session 6	Biosignal processing and monitoring I	V 26	10.09.2017	16:15
Moss-embroidered electrodes for an ECG monitoring shirt	Tim Bolle (Institut für Textiltechnik der RWTH Aachen University (ITA), Germany); Jaime Lopes (IncreaseTime SA, Portugal); Adelino Leite Moreira (University of Porto (UniC), Portugal); Vitor Vieira (Inova DE GmbH, Germany); Thomas Gries (Institut für Textiltechnik der RWTH Aachen University (ITA), Germany); Stefan Jockenhoevel (Institut für Textiltechnik der RWTH Aachen University (ITA), Germany); Akram Idrissi (Institut für Textiltechnik der RWTH Aachen University, Germany)	Session 6	Biosignal processing and monitoring I	V 27	10.09.2017	16:15
Breitbandige Energie-Absorbanz zur Mittelohrdiagnostik	Alexander Mewes (UKSH Kiel, HNO-Klinik, Germany); Matthias Hey (UKSH Kiel, HNO-Klinik, Germany)	Session 7	Middle ear: Modelling, diagnostics, therapy II – Diagnostics	FS 4	10.09.2017	16:15
Impedance measurements for a middle ear screening for newborns and infants.	Tobias Sankowsky-Rothe (Jade Hochschule, Germany); Andreas Becker (Universitätsklinik für Hals-Nasen-Ohren-Heilkunde, Germany); Karsten Plotz (Jade Hochschule, Germany; Universitätsklinik für Hals-Nasen-Ohren-Heilkunde, Germany); Andreas Radeloff (Universitätsklinik für Hals-Nasen-Ohren-Heilkunde, Germany); Rüdiger Schönfeld (Universitätsklinik für Hals-Nasen-Ohren-Heilkunde, Germany); Matthias Blau (Jade Hochschule, Germany)	Session 7	Middle ear: Modelling, diagnostics, therapy II – Diagnostics	FS 5	10.09.2017	16:15
Intra-operative monitoring during tympanoplasty	Hannes Seidler (Technische Universität Dresden, Germany); Marie-Luise Metasch (Technische Universität Dresden, Germany); Matthias Bornitz (Technische Universität Dresden, Germany); Marcus Neudert (Technische Universität Dresden, Germany); Nicoloz Lasurashvili (Technische Universität Dresden, Germany); Thomas Zahnert (Technische Universität Dresden, Germany)	Session 7	Middle ear: Modelling, diagnostics, therapy II – Diagnostics	FS 7	10.09.2017	16:15
Towards standardized surgical robotics interoperability for intraoperative assistance systems	Richard Bieck (Universität Leipzig, Germany); Gero Kraus (Universität Leipzig, Germany); Christoph Georgi (Universität Leipzig, Germany); Thomas Neumuth (Universität Leipzig, Germany)	Session 8	Image guided, robotic and miniaturised systems for intervention and therapy I	V 29	10.09.2017	16:15
Integration of a light weight robot control with an advanced medical image processing platform for optimizing accuracy in medical interventions	Scheherazade Kraß (Universität Bremen, Germany); Sebastian Tauscher (Leibniz-Universität Hannover, Germany); Lüder A. Kahrs (Leibniz-Universität Hannover, Germany); Junichi Tokuda (Brigham and Women's Hospital, United States); Ron Kikinis (Universität Bremen, Germany; Brigham and Women's Hospital, United States; Fraunhofer MeVis, Germany; Harvard Medical School, United States)	Session 8	Image guided, robotic and miniaturised systems for intervention and therapy I	V 30	10.09.2017	16:15
Development of a high precision MEMS tilt sensor for navigation systems in robot-assisted surgery	Benjamin Arnold (Technische Universität Chemnitz, Germany); Daniel Wohlrab (Technische Universität Chemnitz, Germany); Christoph Meinecke (Technische Universität Chemnitz, Germany); Jan Mehner (Technische Universität Chemnitz, Germany)	Session 8	Image guided, robotic and miniaturised systems for intervention and therapy I	V 31	10.09.2017	16:15
Prototype of an automated photobiomodulation treatment device for in vitro wound healing studies	Martín Canziani (Hochschule Furtwangen University, Germany; Universidad de Buenos Aires, Argentina); Jacquelyn Dawn Parente (Hochschule Furtwangen University, Germany); Paola Belloni (Hochschule Furtwangen University, Germany); Knut Möller (Hochschule Furtwangen University, Germany); Sabine Krüger-Ziolek (Hochschule Furtwangen University, Germany)	Session 8	Image guided, robotic and miniaturised systems for intervention and therapy I	V 32	10.09.2017	16:15
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Mixed fields of range-shifted and pristine bragg peaks are safe and improve sparing of collateral OARs in PBS proton therapy	Agnieszka Wilk-Kohlbrecher (Paul Scherrer Institute, Switzerland); Rosalind Perrin (Paul Scherrer Institute, Switzerland); Nanta Fachouri (Paul Scherrer Institute, Switzerland); Vasilis Rompokos (University College Hospital, United Kingdom); Francesca Albertini (Paul Scherrer Institute, Switzerland); David Oxley (Paul Scherrer Institute, Switzerland); Sairos Safai (Paul Scherrer Institute, Switzerland); Damien Charles Weber (Paul Scherrer Institute, Switzerland); Alessandra Bolsi (Paul Scherrer Institute, Switzerland); Tony Lomax (Paul Scherrer Institute, Switzerland)	Session 9	Radiation therapy II – Particle therapy I	V 35	11.09.2017	08:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Improving the lateral fall-off for proton pencil beam scanning	Carla Winterhalter (Paul Scherrer Institute, Switzerland); Sairos Safai (Paul Scherrer Institute, Switzerland); David Oxley (Paul Scherrer Institute, Switzerland); Damien Charles Weber (Paul Scherrer Institute, Switzerland); Tony Lomax (Paul Scherrer Institute, Switzerland)	Session 9	Radiation therapy II – Particle therapy I	V 36	11.09.2017	08:30
Investigation on beam width tolerances for proton and carbon ion pencil beam scanning	Benjamin Ackermann (Heidelberg Ion-Beam Therapy Centre (HIT), Germany); Stephan Brons (Heidelberg Ion-Beam Therapy Centre (HIT), Germany); Malte Ellerbrock (Heidelberg Ion-Beam Therapy Centre (HIT), Germany); Oliver Jäkel (Heidelberg Ion-Beam Therapy Centre (HIT), Germany; German Cancer Research Centre, Germany)	Session 9	Radiation therapy II – Particle therapy I	V 37	11.09.2017	08:30
Optimization of a compton camera prototype for particle beam range verification	Silvia Liprandi (Ludwig Maximilians Universitaet Muenchen, Germany); Saad Aldawood (Ludwig Maximilians Universitaet Muenchen, Germany; King Saud University, Saudi Arabia); Tim Binder (Ludwig Maximilians Universitaet Muenchen, Germany); Georgios Dedes (Ludwig Maximilians Universitaet Muenchen, Germany); Michael Mayerhofer (Ludwig Maximilians Universitaet Muenchen, Germany; Universitaet Hamburg, Germany); Akram Mohammadi (National Institute of Radiological Sciences, Japan); Fumihiko Nishikido (National Institute of Radiological Sciences, Japan); Sodai Takyu (National Institute of Radiological Sciences, Japan); Ingrid Valencia-Lozano (Ludwig Maximilians Universitaet Muenchen, Germany); Taiga Yamaya (National Institute of Radiological Sciences, Japan); Katia Parodi (Ludwig Maximilians Universitaet Muenchen, Germany); Peter G. Thirolf (Ludwig Maximilians Universitaet Muenchen, Germany)	Session 9	Radiation therapy II – Particle therapy I	V 38	11.09.2017	08:30
Comparison of prompt gamma emission for helium and proton beams: a Monte Carlo study	Riccardo Dal Bello (DKFZ, Germany; Max Planck Research School, Germany); Joao Seco (DKFZ, Germany; Heidelberg University, Germany)	Session 9	Radiation therapy II – Particle therapy I	V 39	11.09.2017	08:30
Sensor components of a miniaturized implant for haemodynamic controlling	Jens Weidenmüller (Fraunhofer IMS, Duisburg, Germany) Özgü Dogan (Fraunhofer IMS, Duisburg, Germany) Alexander Stanitzki (Fraunhofer IMS, Duisburg, Germany) Mario Baum (Fraunhofer ENAS, Chemnitz, Germany) Dirk Wünsch (Fraunhofer Institut für Elektrische Nanosystem, System Packing, Chemnitz, Deutschland) Maik Wiemer (Fraunhofer Institut für Elektrische Nanosystem, System Packing, Chemnitz, Deutschland) Michael Görtz (Fraunhofer IMS, Duisburg, Germany)	Session 10	Medical measuring techniques I	V 43	11.09.2017	08:30
Flow characterization in a multiplexing infusion system	Saif Abdul-Karim (Fachhochschule Lübeck, Germany; Universität zu Lübeck, Germany); Yanglei Tan (Fachhochschule Lübeck, Germany); Jörg Schroeter (Fachhochschule Lübeck, Germany); Bodo Nestler (Fachhochschule Lübeck, Germany)	Session 10	Medical measuring techniques I	V 44	11.09.2017	08:30
Concept of a small-size and low-cost respirator for one way usage	Henning Jürß (Universität Rostock, Germany); Martin Degner (Universität Rostock, Germany); Hartmut Ewald (Universität Rostock, Germany)	Session 10	Medical measuring techniques I	V 45	11.09.2017	08:30
Digitization-time for a paradigm shift in educating biomedical engineers	Clemens Bulitta (Ostbayerische Technische Hochschule Amberg-Weiden, Germany)	Session 11	Digitisation in basic and further education – What now?	V 48	11.09.2017	08:30
Are "digital natives" unfit for the "digital future"?	Michael Möller (Hochschule für Technik und Wirtschaft, Germany)	Session 11	Digitisation in basic and further education – What now?	V 49	11.09.2017	08:30
Laser Assisted Bioprinting (LAB) without sacrificial metal layer for contamination free assembly of cell cultures	Richard Lensing (Fraunhofer Institute for Laser Technology ILT, Germany); Nadine Nottrodt (Fraunhofer Institute for Laser Technology ILT, Germany); Martin Wehner (Fraunhofer Institute for Laser Technology ILT, Germany); Arnold Gillner (Fraunhofer Institute for Laser Technology ILT, Germany)	Session 12	Cells, materials and biochemistry II	V 51	11.09.2017	08:30
Chitosan hydrogel composite biomaterials for repairing the intervertebral disc tissue	Anayancy Osorio-Madrazo (University of Freiburg, Germany); Peter Fratzl (Max-Planck Institute of Colloids and Interfaces, Germany); Gerald Urban (University of Freiburg, Germany); Laurent David (University of Lyon 1, France)	Session 12	Cells, materials and biochemistry II	V 52	11.09.2017	08:30
Multicellular spheroids: a model for nanoparticle-cell interaction studies	Johanna Demut (Universitätsklinikum Jena, Germany); Christine Gräfe (Universitätsklinikum Jena, Germany); Andreas Hochhaus (Universitätsklinikum Jena, Germany); Joachim Clement (Universitätsklinikum Jena, Germany)	Session 12	Cells, materials and biochemistry II	V 53	11.09.2017	08:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Towards a biohybrid lung: long-term stability and gas exchange capacity of endothelial cells seeded on gas permeable PDMS membranes	Sarah Menzel (Institute of Applied Medical Engineering (AME), Germany); Christine Donay (ITA - Institut für Textiltechnik, Germany); Felix Hesselmann (Institute of Applied Medical Engineering (AME), Germany); Suzana Djeljadini (DWI - Leibniz Institute for Interactive Materials, Germany); Stefan Jockenhoevel (Institute of Applied Medical Engineering (AME), Germany; ITA - Institut für Textiltechnik, Germany; Maastricht University, Netherlands); Christian G Cornelissen (Institute of Applied Medical Engineering (AME), Germany; RWTH Aachen University Hospital, Germany)	Session 12	Cells, materials and biochemistry II	V 54	11.09.2017	08:30
Hörrehabilitation durch aktive Implantate im Incudostapedialgelenk	Till Moritz Eßinger (Technische Universität Dresden, Germany)	Session 13	Middle ear: Modelling, diagnostics, therapy III – Therapy	FS 9	11.09.2017	08:30
Comparison of clinically and experimentally determined output level of the MET T2 transducer	Hannes Maier (Medizinische Hochschule Hannover, Germany); Susan Busch (Medizinische Hochschule Hannover, Germany); Bernd Waldmann (Cochlear Ltd, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany); Martin Großöhmichen (Medizinische Hochschule Hannover, Germany)	Session 13	Middle ear: Modelling, diagnostics, therapy III – Therapy	FS 10	11.09.2017	08:30
Intraoperative, objective, frequency-specific auditory threshold determination via Vibrant Soundbridge - feasibility study	Oliver Dziemba (Universitätsmedizin Greifswald, Germany); Samuel Blanc (MED-EL Medical Electronics, Austria)	Session 13	Middle ear: Modelling, diagnostics, therapy III – Therapy	FS 11	11.09.2017	08:30
Pulse wave analyses: Which parts of the pulse wave are clinically relevant	Johannes Baulmann (Universitätsklinikum Würzburg, Germany)	Session 14	Blood pressure, vascular stiffness, pulse wave, central blood pressure – a interdisciplinary challenge for cardiovascular risk stratification	FS 12	11.09.2017	08:30
Validation of blood pressure measuring devices – clinical update. The German Hypertension League (Deutsche Hochdruckliga DHL®) Quality Seal Protocol for blood pressure-measuring devices: 15-year experience and results from 105 devices	Siegfried Eckert (Ruhr-Universität Bochum, Germany)	Session 14	Blood pressure, vascular stiffness, pulse wave, central blood pressure – a interdisciplinary challenge for cardiovascular risk stratification	FS 13	11.09.2017	08:30
Non invasive blood pressure monitoring based on photoplethymographic signals	Hans-Georg Ortlepp (CiS Forschungsinstitut für Mikrosensorik GmbH, Germany); Olaf Brodersen (CiS Forschungsinstitut für Mikrosensorik GmbH, Germany); Martin Schädel (CiS Forschungsinstitut für Mikrosensorik GmbH, Germany); Thomas Ortlepp (CiS Forschungsinstitut für Mikrosensorik GmbH, Germany)	Session 14	Blood pressure, vascular stiffness, pulse wave, central blood pressure – a interdisciplinary challenge for cardiovascular risk stratification	FS 14	11.09.2017	08:30
Bioprinting of vascularized bone tissue	Petra Kluger (Fraunhofer IGB c/o Reutlingen University, Germany)	Session 15	Additive manufacturing for biomedical applications	FS 16	11.09.2017	08:30
Alginate di-aldehyde gelatin crosslinked hydrogel (ADA-GEL) for biofabrication approach: Tailoring of tubular structures for blood vessel supply	Florian Ruther (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Aldo R. Boccaccini (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Thomas Distler (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Tobias Zehnder (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Rainer Detsch (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany)	Session 15	Additive manufacturing for biomedical applications	FS 17	11.09.2017	08:30
Two-step printability assessment for inks processed with extrusion-based bioprinting	Tomasz Jüngst (Universitätsklinikum Würzburg, Germany); Naomi Paxton (Universitätsklinikum Würzburg, Germany); Thomas Böck (Universitätsklinikum Würzburg, Germany); Willi Smolan (Universitätsklinikum Würzburg, Germany); Jürgen Groll (Universitätsklinikum Würzburg, Germany)	Session 15	Additive manufacturing for biomedical applications	FS 18	11.09.2017	08:30
3D-printed biomimetic in-vitro-tumor-angiogenesis-model	Jan Schöneberg (Universitätsklinikum RWTH Aachen, Germany); Benjamin Theek (Universitätsklinikum RWTH Aachen, Germany); Federica De Lorenzi (Universitätsklinikum RWTH Aachen, Germany); Andreas Blaeser (Universitätsklinikum RWTH Aachen, Germany); Fabian Kießling (Universitätsklinikum RWTH Aachen, Germany); Horst Fischer (Universitätsklinikum RWTH Aachen, Germany)	Session 15	Additive manufacturing for biomedical applications	FS 19	11.09.2017	08:30
Extrusion based 3D printing for biomedical applications: opportunities and limitations	Michael Gelinsky (TU Dresden, Germany)	Session 15	Additive manufacturing for biomedical applications	FS 20	11.09.2017	08:30
Comparison between conventional and suspended radiation protection in interventional radiology	Robin Etzel (Technische Hochschule Mittelhessen, Germany); Alexander M. König (Philipps-Universität Marburg, Germany); Boris Keil (Technische Hochschule Mittelhessen, Germany); Andreas H. Mahnken (Philipps-Universität Marburg, Germany); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Session 16	Dosimetry, radiation protection and radiation biology II	V 56	11.09.2017	10:30
Attenuation properties of materials used for X-ray protective aprons	Ludwig Büermann (Physikalisch-Technische Bundesanstalt, Germany)	Session 16	Dosimetry, radiation protection and radiation biology II	V 57	11.09.2017	10:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Automated dose control for selective retina therapy using optical coherence tomography - a prove of concept	Daniel Kaufmann (Berner Fachhochschule, Switzerland); Christian Burri (Berner Fachhochschule, Switzerland); Patrik Arnold (Berner Fachhochschule, Switzerland); Volker M. Koch (Berner Fachhochschule, Switzerland); Christoph Meier (Berner Fachhochschule, Switzerland); Boris Povazay (Berner Fachhochschule, Switzerland); Joern Justiz (Berner Fachhochschule, Switzerland)	Session 16	Dosimetry, radiation protection and radiation biology II	V 59	11.09.2017	10:30
Impedance based ultrasound probe tracking system for 3D peripheral vessel imaging	Jens Ziegle (Otto-von-Guericke University Magdeburg, Germany); Johannes Krug (Otto-von-Guericke University Magdeburg, Germany); Ghazanfar Ali (Otto-von-Guericke University Magdeburg, Germany); Julian Sprung (PIUR Imaging, Austria); Robert Bauer (PIUR Imaging, Austria); Frederik Bender (PIUR Imaging, Austria); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Session 17	Image guided, robotic and miniaturised systems for intervention and therapy II	V 60	11.09.2017	10:30
Auditory display for ultrasound scan completion	David Black (University of Bremen, Germany; Jacobs University, Germany; Fraunhofer MEVIS, Germany); Jennifer Nitsch (University of Bremen, Germany; Fraunhofer MEVIS, Germany); Horst Hahn (Jacobs University, Germany; Fraunhofer MEVIS, Germany); Ron Kikinis (University of Bremen, Germany; Fraunhofer MEVIS, Germany; Brigham and Women's Hospital and Harvard Medical School, United States)	Session 17	Image guided, robotic and miniaturised systems for intervention and therapy II	V 61	11.09.2017	10:30
Polymer gel-based isocenter test for a MR-linac-system	Stefan Dorsch (Deutsches Krebsforschungszentrum, Germany); Philipp Mann (Deutsches Krebsforschungszentrum, Germany); Clemens Lang (Deutsches Krebsforschungszentrum, Germany); Armin Runz (Deutsches Krebsforschungszentrum, Germany); Christian Karger (Deutsches Krebsforschungszentrum, Germany)	Session 17	Image guided, robotic and miniaturised systems for intervention and therapy II	V 62	11.09.2017	10:30
A compact source for microbeam radiation therapy and phase contrast imaging	Stefan Bartzsch (Klinikum rechts der Isar, Germany; The Institute of Cancer Research, United Kingdom); Uwe Oelfke (The Institute of Cancer Research, United Kingdom); Jan Wilkens (Klinikum rechts der Isar, Germany)	Session 17	Image guided, robotic and miniaturised systems for intervention and therapy II	V 63	11.09.2017	10:30
Concept of an implant with an integrated sensor actuator system for the monitoring and influencing of the mechanical implant bone interface	Holger Lausch (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Thomas Töppel (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Eric Hensel (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Michael Brand (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Katarina Gille (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Christian Rotsch (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany)	Session 18	Organ and patient support systems I	V 65	11.09.2017	10:30
Monitoring of the inner ear function during and after cochlear implant insertion using cochlear microphonics	Sabine Haumann (Dept. of Otolaryngology, Hannover Medical School, Germany; Cluster of Excellence "Hearing4all" (EXC 1077/1), Germany); Andreas Büchner (Dept. of Otolaryngology, Hannover Medical School, Germany; Cluster of Excellence "Hearing4all" (EXC 1077/1), Germany); Hannes Maier (Dept. of Otolaryngology, Hannover Medical School, Germany; Cluster of Excellence "Hearing4all" (EXC 1077/1), Germany); Thomas Lenarz (Dept. of Otolaryngology, Hannover Medical School, Germany; Cluster of Excellence "Hearing4all" (EXC 1077/1), Germany)	Session 18	Organ and patient support systems I	V 66	11.09.2017	10:30
A method for lower back motion assessment using wearable 6D inertial sensors	Marco Molnar (TU Berlin, Germany); Tilman Engel (Universität Potsdam, Germany); Hannes Kaplick (Universität Potsdam, Germany); Frank Mayer (Universität Potsdam, Germany); Thomas Seel (TU Berlin, Germany)	Session 18	Organ and patient support systems I	V 70	11.09.2017	10:30
Plasma electrolyte concentrations in patients with chronic kidney disease influence cardiac pacemaking in a computational model	Yannick Lutz (Karlsruher Institute of Technology (KIT), Germany); Alan Fabbri (University of Bologna, Italy); Stefano Severi (University of Bologna, Italy); Olaf Dössel (Karlsruher Institute of Technology (KIT), Germany); Axel Loewe (Karlsruher Institute of Technology (KIT), Germany)	Session 19	Modelling and simulation I	V 71	11.09.2017	10:30
Optimal ECG lead systems to maximimze left atrial information content	Axel Loewe (Karlsruhe Institute of Technology (KIT), Germany); Sebastian Debatin (Karlsruhe Institute of Technology (KIT), Germany); Gustavo Lenis (Karlsruhe Institute of Technology (KIT), Germany); Olaf Dössel (Karlsruhe Institute of Technology (KIT), Germany)	Session 19	Modelling and simulation I	V 73	11.09.2017	10:30
Developing and coupling a lumped element model of the closed loop human vascular system to a model of cardiac mechanics	Steffen Schuler (Karlsruhe Institute of Technology (KIT), Germany); Lukas Baron (Karlsruhe Institute of Technology (KIT), Germany); Axel Loewe (Karlsruhe Institute of Technology (KIT), Germany); Olaf Dössel (Karlsruhe Institute of Technology (KIT), Germany)	Session 19	Modelling and simulation I	V 74	11.09.2017	10:30
From clinics to the virtual beating heart: a general modeling workflow for patient-specific electromechanical heart simulations	Lukas Baron (Karlsruhe Institute of Technology (KIT), Germany); Axel Loewe (Karlsruhe Institute of Technology (KIT), Germany); Olaf Dössel (Karlsruhe Institute of Technology (KIT), Germany)	Session 19	Modelling and simulation I	V 75	11.09.2017	10:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Measurement of moisture at skin surface based on hyperspectral technology	Marianne Maktabi (Diaspective Vision GmbH, Germany); Claire Chalopin (Diaspective Vision GmbH, Germany); Philip Wahl (Diaspective Vision GmbH, Germany); Thomas Neumuth (Diaspective Vision GmbH, Germany)	Session 20	Hyperspectral imaging and optical techniques in medicine	FS 21	11.09.2017	10:30
Workflow for intraoperative hyperspectral imaging in neurosurgery	Richard Mühle (Technische Universität Dresden, Germany); Martin Oelschlägel (Technische Universität Dresden, Germany); Stephan B. Sobottka (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Matthias Kirsch (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Gabriele Schackert (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Ute Morgenstern (Technische Universität Dresden, Germany)	Session 20	Hyperspectral imaging and optical techniques in medicine	FS 22	11.09.2017	10:30
Monitoring hemodynamics and oxygenation in the renal cortex of rats by a combined near-infrared spectroscopy and invasive probe approach	Dirk Grosenick (Physikalisch-Technische Bundesanstalt (PTB), Germany); Thomas Gladytz (Physikalisch-Technische Bundesanstalt (PTB), Germany); Heidrun Wabnitz (Physikalisch-Technische Bundesanstalt (PTB), Germany); Rainer Macdonald (Physikalisch-Technische Bundesanstalt (PTB), Germany); Andreas Pohlmann (Max-Delbrück-Centrum für Molekulare Medizin, Germany); Thoralf Niendorf (Max-Delbrück-Centrum für Molekulare Medizin, Germany); Kathleen Cantow (Charité Universitätsmedizin, Germany); Bert Flemming (Charité Universitätsmedizin, Germany); Erdmann Seeliger (Charité Universitätsmedizin, Germany)	Session 20	Hyperspectral imaging and optical techniques in medicine	FS 25	11.09.2017	10:30
Requirements for a fully-digital surgical microscope regarding the state of the art of surgical microscopes and the surgeon's visual perception	Andreas Wachter (Karlsruher Institute of Technologie (KIT), Germany); Werner Nahm (Karlsruher Institute of Technologie (KIT), Germany)	Session 20	Hyperspectral imaging and optical techniques in medicine	FS 27	11.09.2017	10:30
Experiences and Practice with the interactive telemedical assistance system COMES®	Petra Friedrich (Hochschule Kempten , Germany); Bernhard Wolf (Steinbeis-Transferzentrum Medizinische Elektronik und Lab on Chip-Systeme , Germany)	Session 21	Ambient Medicine®	FS 28	11.09.2017	10:30
Telematic rehabilitation in neurology	Kai-Uwe Hinderer (medica Medizintechnik GmbH, Germany); Martin Knauer (Hochschule Kempten , Germany); Petra Friedrich (Hochschule Kempten , Germany); Bernhard Wolf (Steinbeis-Transferzentrum Medizinische Elektronik und Lab on Chip-Systeme , Germany)	Session 21	Ambient Medicine®	FS 30	11.09.2017	10:30
Auditory-induced cortical activation patterns measured by functional near infrared spectroscopy (fNIRS)	Günther Bauernfeind (Hannover Medical School, Germany; Exzellenzcluster "Hearing4all" (EXC 1077/1), Germany); Selina C. Wriessnegger (Graz University of Technology, Austria); Sabine Haumann (Hannover Medical School, Germany; Exzellenzcluster "Hearing4all" (EXC 1077/1), Germany); Thomas Lenarz (Hannover Medical School, Germany; Exzellenzcluster "Hearing4all" (EXC 1077/1), Germany)	Session 22	Imaging in Hearing	FS 35	11.09.2017	10:30
Development of long-term stable measurement phantoms for quantitative magnetic particle imaging	Lucas Wöckel (Technische Universität Ilmenau, Germany); Volker C. Behr (University of Würzburg, Germany); Cordula Grüttner (micromod Partikeltechnologie GmbH, Germany); Olaf Kosch (Physikalisch-Technische Bundesanstalt Berlin, Germany); Anne Mattern (Technische Universität Ilmenau, Germany); Patrick Vogel (University of Würzburg, Germany; University Hospital Würzburg, Germany); James Wells (Physikalisch-Technische Bundesanstalt Berlin, Germany); Frank Wiekhorst (Physikalisch-Technische Bundesanstalt Berlin, Germany); Silvio Dutz (Technische Universität Ilmenau, Germany)	Poster session 1	Imaging and image processing I	P 1	11.09.2017	15:15
Spin echo based cardiac diffusion imaging sequences at 7T: performance and feasibilty ex vivo	David Lohr (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Maxim Terekhov (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Andreas Max Weng (University Hospital Wuerzburg, Germany); Anja Schröder (University Hospital Wuerzburg, Germany; Wuerzburg branch of the Fraunhofer IGB, Germany); Heike Walles (University Hospital Wuerzburg, Germany; Wuerzburg branch of the Fraunhofer IGB, Germany); Laura Maria Schreiber (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany)	Poster session 1	Imaging and image processing I	P 2	11.09.2017	15:15
Dose splitting using a dual-source computed tomography	Babak Alikhani (Medizinische Hochschule Hannover, Germany); Hans-Jürgen Raatschen (Medizinische Hochschule Hannover, Germany); Thomas Werncke (Medizinische Hochschule Hannover, Germany)	Poster session 1	Imaging and image processing I	P 3	11.09.2017	15:15
Metabolite diffusion measured by MR spectroscopy without water suppression reveals microstructural information in human gray matter	André Döring (Depts. Radiology and Clinical Research, University Bern, Bern, Switzerland, Switzerland); Victor Adalid Lopez (Depts. Radiology and Clinical Research, University Bern, Bern, Switzerland, Switzerland); Roland Kreis (Depts. Radiology and Clinical Research, University Bern, Bern, Switzerland, Switzerland)	Poster session 1	Imaging and image processing I	P 4	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Ultrasound thyroid texture classification using a simple texture pattern characterization	Prabal Poudel (Otto-von-Guericke University Magdeburg, Germany); Alfredo Illanes (Otto-von-Guericke University Magdeburg, Germany); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Poster session 1	Imaging and image processing I	P 5	11.09.2017	15:15
Using a segmented multi-echo EPI sequence with simultaneous multislice acquisition for dynamic contrast-enhanced MRI	Finya Reichardt (Strahlenklinik, Medizinische Physik, Universitätsklinikum Essen, Germany); Klaus Eickel (Fraunhofer MEVIS Institute for Medical Image Computing, Germany); Anika Söhner (Strahlenklinik, Medizinische Physik, Universitätsklinikum Essen, Germany); David Andrew Porter (Fraunhofer MEVIS Institute for Medical Image Computing, Germany); Marc Maaß (Evangelisches Krankenhaus Wesel, Germany); Matthias Günther (Fraunhofer MEVIS Institute for Medical Image Computing, Germany); Lutz Lüdemann (Strahlenklinik, Medizinische Physik, Universitätsklinikum Essen, Germany)	Poster session 1	Imaging and image processing I	P 7	11.09.2017	15:15
Determination of the volume of microchannels in bone phantoms by magnetic resonance imaging (MRI) and micro computed tomography (µCT)	Christian Seiler (Tierärztliche Hochschule Hannover, Germany); Matthias Lüpke (Tierärztliche Hochschule Hannover, Germany); Frank Goblet (Tierärztliche Hochschule Hannover, Germany); Jan-Peter Bach (Tierärztliche Hochschule Hannover, Germany); Hermann Seifert (Tierärztliche Hochschule Hannover, Germany)	Poster session 1	Imaging and image processing I	P 10	11.09.2017	15:15
B0-mapping and shimming efficiency for *ex vivo* MR imaging of the heart at ultra-high field: validation of standard shimming protocols of magnetom terra 7T scanner	Michael Hock (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Maxim Terekhov (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); David Lohr (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Laura Maria Schreiber (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany)	Poster session 1	Imaging and image processing I	P 11	11.09.2017	15:15
Parameter optimization for simulation-based artefact correction in computed tomography	Steffen Melnik (Fraunhofer Institute for Production Systems and Design Technology, Germany); Eckart Uhlmann (Fraunhofer Institute for Production Systems and Design Technology, Germany)	Poster session 1	Imaging and image processing I	P 12	11.09.2017	15:15
Simulation model for resolution and contrast analysis of microscopic images based on optical coherence contrast method	Yilun Su (Karlsruhe Institute of Technology (KIT), Germany)	Poster session 2	Imaging and image processing II	P 13	11.09.2017	15:15
Algorithm development for simulation and experimental validation of ultrafast doppler imaging	Stephen Tai (Fraunhofer IBMT, Germany); Holger Hewener (Fraunhofer IBMT, Germany); Marc Fournelle (Fraunhofer IBMT, Germany)	Poster session 2	Imaging and image processing II	P 15	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Establishment of a small animal setup for multimodal imaging and irradiation	Christian Neubert (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Brandenburg University of Technology Cottbus - Senftenberg, Germany); Johannes Müller (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany); Rebecca Bütof (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Armin Lühr (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany); Cläre von Neubeck (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany); Michael Schürer (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Elke Beyreuther (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany); Falk Tillner (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf,	Poster session 2	Imaging and image processing II	P 18	11.09.2017	15:15
Extending cell simuation for fluorescence microscopy bacteria movies	Veit Wiesmann (Fraunhofer-Institut für Integrierte Schaltungen IIS, Germany); Matthias Bergler (Fraunhofer-Institut für Integrierte Schaltungen IIS, Germany); Christian Münzenmayer (Fraunhofer-Institut für Integrierte Schaltungen IIS, Germany); Thomas Wittenberg (Fraunhofer-Institut für Integrierte Schaltungen IIS, Germany)	Poster session 2	Imaging and image processing II	P 19	11.09.2017	15:15
Light path analysis in hyperspectral imaging setups for wound diagnostics using Monte-Carlo-simulation	Bert Henrik Herrmann (Hochschule Wismar, Germany); Christoph Hornberger (Hochschule Wismar, Germany)	Poster session 2	Imaging and image processing II	P 20	11.09.2017	15:15
MRI investigation of biodegradable implants with incorporated magnetic nanoparticles	Benedikt Mues (RWTH Aachen, Germany); Thomas Schmitz-Rode (RWTH Aachen, Germany); Ioana Slabu (RWTH Aachen, Germany)	Poster session 2	Imaging and image processing II	P 21	11.09.2017	15:15
Uptake heterogeneity quantification in lung cancer: impact on image features variability of 3D- and 4D-PET/CT protocols.	Montserrat Carles (Universitätsklinikum Freiburg, Germany); Thomas Bach (Universitätsklinikum Freiburg, Germany); Irene Torres-Espallardo (Hospital Universitario y Politecnico La Fe Valencia, Spain); Dimos Baltas (Universitätsklinikum Freiburg, Germany); Ursula Nestle (Universitätsklinikum Freiburg, Germany); Luis Marti-Bonmati (Hospital Universitario y Politecnico La Fe Valencia, Spain)	Poster session 2	Imaging and image processing II	P 22	11.09.2017	15:15
3D-ultrasound-angiography – a new technique for diagnosis of vascular liver diseases	Valentin Blank (Uniklinikum Leipzig AöR, Germany); Volker Keim (Uniklinikum Leipzig AöR, Germany); Johann Pelz (Uniklinikum Leipzig AöR, Germany); Thomas Karlas (Uniklinikum Leipzig AöR, Germany)	Poster session 3	Imaging and image processing III	P 24	11.09.2017	15:15
Magnetic manipulation in combination with preclinical magnetic particle imaging	Anna Bakenecker (Universität zu Lübeck, Germany); Thomas Friedrich (Universität zu Lübeck, Germany); Anselm von Gladiss (Universität zu Lübeck, Germany); Thorsten M. Buzug (Universität zu Lübeck, Germany)	Poster session 3	Imaging and image processing III	P 25	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Remote sensing of vital signs in neonatology – a multispectral, camera-based approach	Michael Paul (RWTH Aachen University, Germany); Christoph Weiss (RWTH Aachen University, Germany); Sabrina Caprice Behr (RWTH Aachen University Hospital, Germany); Boudewijn Venema (RWTH Aachen University, Germany); Konrad Heimann (RWTH Aachen University Hospital, Germany); Jens Mühlsteff (Philips Research, Netherlands); Thorsten Orlikowsky (RWTH Aachen University Hospital, Germany); Steffen Leonhardt (RWTH Aachen University, Germany)	Poster session 3	Imaging and image processing III	P 26	11.09.2017	15:15
Hyperspectral imaging – preoperative analysis of kidneys during normothermic extracorporeal machine perfusion	Wenke Markgraf (Technische Universität Dresden, Germany); Philipp Feistel (Technische Universität Dresden, Germany); Jannis Lilienthal (Technische Universität Dresden, Germany); Christine Thiele (Technische Universität Dresden, Germany); Hagen Malberg (Technische Universität Dresden, Germany)	Poster session 3	Imaging and image processing III	P 28	11.09.2017	15:15
Influence of orthogonal receive channels on the spatial resolution in magnetic particle imaging	Anselm von Gladiss (University of Luebeck, Germany); Matthias Graeser (University Medical Center Hamburg-Eppendorf, Germany); Thorsten M. Buzug (University of Luebeck, Germany)	Poster session 3	Imaging and image processing III	P 29	11.09.2017	15:15
Real-time functional magnetic resonance imaging neurofeedback as a neuroscientific tool	Michael Marxen (Technische Universität Dresden, Germany); Dirk K. Müller (Technische Universität Dresden, Germany); Philipp Riedel (Technische Universität Dresden, Germany); Michael N. Smolka (Technische Universität Dresden, Germany)	Poster session 3	Imaging and image processing III	P 30	11.09.2017	15:15
Image to phantom registration for CT dose calculation using the software tool GMCTdospp	Dennis Sauerwald (Technische Hochschule Mittelhessen, Germany); Ulf Mäder (Technische Hochschule Mittelhessen, Germany); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Poster session 3	Imaging and image processing III	P 31	11.09.2017	15:15
Temperature measurement during focused ultrasound treatment with diagnostic ultrasound	Tina Fuhrmann (Hochschule Merseburg, Germany); Klaus-V. Jenderka (Hochschule Merseburg, Germany)	Poster session 3	Imaging and image processing III	P 32	11.09.2017	15:15
An investigation of the modeling error of linearization for EIT reconstruction	Bo Gong (Hochschule Furtwangen, Germany); Benjamin Schullcke (Hochschule Furtwangen, Germany); Sabine Krüger-Ziolek (Hochschule Furtwangen, Germany); Knut Möller (Hochschule Furtwangen, Germany)	Poster session 3	Imaging and image processing III	P 34	11.09.2017	15:15
Force sensitive robotics for automated ultrasonic diagnostics and therapy	Sven Böttger (Universität zu Lübeck, Germany); Svenja Ipsen (Universität zu Lübeck, Germany); Mohammed Al-Badri (Universität zu Lübeck, Germany); Floris Ernst (Universität zu Lübeck, Germany); Achim Schweikard (Universität zu Lübeck, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 35	11.09.2017	15:15
Dual mode microwave ablation applicator with power efficient heating capabilities	Carolin Reimann (TU Darmstadt, Germany); Margarita Puentes (TU Darmstadt, Germany); Martin Schüßler (TU Darmstadt, Germany); Thomas J. Vogl (Johann Wolfgang Goethe Universität Frankfurt, Germany); Rolf Jakoby (TU Darmstadt, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 36	11.09.2017	15:15
Technical approaches to avoid air bubbles for improved patient safety during TURB	Jincy Mariam John (Otto-von-Guericke-Universität Magdeburg, Germany); Holger Fritzsche (Otto-von-Guericke-Universität Magdeburg, Germany); Axel Boese (Otto-von-Guericke-Universität Magdeburg, Germany); Michael Friebe (Otto-von-Guericke-Universität Magdeburg, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 37	11.09.2017	15:15
Flexible and low-cost instrument holding concept for interventional MRI	Juan Sebastián Sánchez López (Otto-von-Guericke University Magdeburg, Germany); Robert Odenbach (Otto-von-Guericke University Magdeburg, Germany); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 38	11.09.2017	15:15
Objective measurement of instrument-tissue interaction in laparoscopic surgery	Patrick Haas (Universitätsklinikum Tübingen, Germany); Wolfgang Kunert (Universitätsklinikum Tübingen, Germany); Jonas Johannink (Universitätsklinikum Tübingen, Germany); Andreas Kirschniak (Universitätsklinikum Tübingen, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 41	11.09.2017	15:15
Real time MRI/US fusion using inside-out tracking for interventional procedures and guidance	sathish balakrishnan (INKA - Intelligente Katheter, Germany); Alfredo Illanes (INKA - Intelligente Katheter, Germany); Prabal Poudel (INKA - Intelligente Katheter, Germany); Yesashwini Nagaraj (INKA - Intelligente Katheter, Germany); Bjoern Menze (INKA - Intelligente Katheter, Germany); Michael Friebe (INKA - Intelligente Katheter, Germany)	Poster session 4	Image guided, robotic and miniaturised systems for intervention and therapy I	P 42	11.09.2017	15:15
A miniaturized sensor for needle tip force measurements	Christian Hatzfeld (Technische Universität Darmstadt, Germany); Sonja Wismath (Technische Universität Darmstadt, Germany); Markus Hessinger (Technische Universität Darmstadt, Germany); Roland Werthschützky (Technische Universität Darmstadt, Germany); Alexander Schlaefer (Technische Universität Hamburg-Harburg, Germany); Mario Kupnik (Technische Universität Darmstadt, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 43	11.09.2017	15:15
Determination of needle orientation angles from artifact geometry in simulated magnetic resonance images	Heinrich Martin Overhoff (Westfälische Hochschule, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 45	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Examination of the correlation between external patient movement and the corresponding movement of implanted gold markers in the liver	Marc Ziegler (Universitätsklinikum Erlangen, Germany); Sebastian Lettmaier (Universitätsklinikum Erlangen, Germany); Rainer Fietkau (Universitätsklinikum Erlangen, Germany); Christoph Bert (Universitätsklinikum Erlangen, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 46	11.09.2017	15:15
Wizard-guided fibula transplant registration for navigation-assisted mandibular reconstruction in craniomaxillofacial tumor surgery	Sebastian Kallus (University of Heidelberg, Germany); Moritz Berger (University Hospital Heidelberg, Germany); Urs Eisenmann (University of Heidelberg, Germany); Igor Nova (University of Heidelberg, Germany); Kolja Freier (University Hospital Heidelberg, Germany); Hartmut Dickhaus (University of Heidelberg, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 47	11.09.2017	15:15
Minimal-invasive image guided treatment of spine metastasis in late cancer disease with thermoablation: now and then	Mathias Becker (Otto von Guericke Universität Magdeburg, Germany); Steffen Serowy (Otto von Guericke Universität Magdeburg, Germany); Jörg Franke (Klinikum Magdeburg, Germany); Magnus Hanses (Fraunhofer-Institut für Fabrikbetrieb und -automatisierung IFF, Germany); Simon Adler (Fraunhofer-Institut für Fabrikbetrieb und -automatisierung IFF, Germany); Martin Skalej (Otto von Guericke Universität Magdeburg, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 48	11.09.2017	15:15
Electrospray based delivery of therapeutic active substances in vitro and in vivo	Paulius Ruzgys (University Hospital Bern, Switzerland; University of Bern, Switzerland; Vytautas Magnus University, Lithuania); Stephan Boehringer (University of Applied Sciences and Arts Northwestern Switzerland, Switzerland); Saulius Šatkauskas (Vytautas Magnus University, Lithuania); Thomas Geiser (University Hospital Bern, Switzerland; University of Bern, Switzerland); Amiq Gazdhar (University Hospital Bern, Switzerland; University of Bern, Switzerland); David Hradetzky (University of Applied Sciences and Arts Northwestern Switzerland, Switzerland)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 49	11.09.2017	15:15
SMARTSCOPE - portable, easy to use and cheap smartphone endoscopic system	Axel Boese (Otto-von-Guericke Universität Magdeburg, Germany); Michael Friebe (Otto-von-Guericke Universität Magdeburg, Germany)	Poster session 5	Image guided, robotic and miniaturised systems for intervention and therapy II	P 50	11.09.2017	15:15
A factor graph-based change point detection with an application to sEMG-Onset and activity detection	Christian Hoffmann (Institut für Medizinische Elektrotechnik, Universität zu Lübeck, Germany); Eike Petersen (Institut für Medizinische Elektrotechnik, Universität zu Lübeck, Germany); Thomas Handzsuj (Institut für Medizinische Elektrotechnik, Universität zu Lübeck, Germany); Giacomo Bellani (Institut für Medizinische Elektrotechnik, Universität zu Lübeck, Germany); Philipp Rostalski (Institut für Medizinische Elektrotechnik, Universität zu Lübeck, Germany)	Poster session 6	Biosignal processing and monitoring I	P 51	11.09.2017	15:15
Experimental workflow for determining psychological stress from physiological biosignals	Alexander Pilling (OTH Regensburg, Germany); Franz Suess (OTH and University Regensburg, Germany); Simone Kubowitsch (OTH Regensburg, Germany; University Regensburg, Germany); Sebastian Dendorfer (OTH Regensburg, Germany; OTH and University Regensburg, Germany)	Poster session 6	Biosignal processing and monitoring I	P 53	11.09.2017	15:15
Monitoring of drilling induced noise during ear surgeries	Matthias Bornitz (TU Dresden, Germany); Mario Fleischer (TU Dresden, Germany); Thomas Zahnert (TU Dresden, Germany)	Poster session 6	Biosignal processing and monitoring I	P 54	11.09.2017	15:15
Performance evaluation of state-of-the-art neural recorder SoCs	Michael Haas (Universität Ulm, Germany); Mahdi Rajabzadeh (Universität Ulm, Germany); Maurits Ortmanns (Universität Ulm, Germany)	Poster session 6	Biosignal processing and monitoring I	P 57	11.09.2017	15:15
Statistical assessment of cardiac excitation by morphology-based clustering of local activation waves	Tobias Oesterlein (Karlsruhe Institute of Technology (KIT), Germany); Axel Loewe (Karlsruhe Institute of Technology (KIT), Germany); Gustavo Lenis (Karlsruhe Institute of Technology (KIT), Germany); Olaf Dössel (Karlsruhe Institute of Technology (KIT), Germany)	Poster session 6	Biosignal processing and monitoring I	P 59	11.09.2017	15:15
Automatic crackle detection in children with pneumonia	Julian Langer (Technische Hochschule Mittelhessen, Germany); Keywan Sohrabi (Technische Hochschule Mittelhessen, Germany); Wilfried Nikolaizik (Universitätsklinikum Gießen Marburg, Germany); Patrick Stein (Technische Hochschule Mittelhessen, Germany); Marcel Geis (Technische Hochschule Mittelhessen, Germany); Andreas Weissflog (Thora Tech GmbH, Germany); Volker Gross (Technische Hochschule Mittelhessen, Germany)	Poster session 7	Biosignal processing and monitoring II	P 62	11.09.2017	15:15
A feasibility study to record human knee sounds	Olaf Nalik (Technische Hochschule Mittelhessen, Germany); Volker Gross (Technische Hochschule Mittelhessen, Germany); Lukas Huber (Technische Hochschule Mittelhessen, Germany); Patrick Fischer (Technische Hochschule Mittelhessen, Germany); Tibor Jung (Technische Hochschule Mittelhessen, Germany); Andreas Weissflog (Thora Tech GmbH, Germany); Keywan Sohrabi (Technische Hochschule Mittelhessen, Germany)	Poster session 7	Biosignal processing and monitoring II	P 63	11.09.2017	15:15
Major arterial cardiovascular simulator (MACSim) for variational parameter studies in patient-specific vascular geometries	Stefan Bernhard (Hochschule Pforzheim, Germany); Stefan Krickl (Hochschule Pforzheim, Germany)	Poster session 7	Biosignal processing and monitoring II	P 64	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Respiratory influence on HRV parameters analyzed during controlled respiration, spontaneous respiration and apnoe	Michael Kircher (Karlsruher Institut für Technologie, Germany); Robert Menges (Karlsruher Institut für Technologie, Germany); Gustavo Lenis (Karlsruher Institut für Technologie, Germany); Olaf Doessel (Karlsruher Institut für Technologie, Germany)	Poster session 7	Biosignal processing and monitoring II	P 65	11.09.2017	15:15
Beat-to-beat features in peripheral vascular impedance plethysmography for respiratory rate estimation	Michael Klum (Technische Universität Berlin, Germany); Dennis Osterland (Technische Universität Berlin, Germany); Alexandru-Gabriel Pielmus (Technische Universität Berlin, Germany); Timo Tigges (Technische Universität Berlin, Germany); Reinhold Orglmeister (Technische Universität Berlin, Germany)	Poster session 7	Biosignal processing and monitoring II	P 66	11.09.2017	15:15
Design and implementation of a teaching system for visual stimulation and recording of single unit and mass signals	Qusay Idrees Sarhan (Technische Hochschule Mittelhessen, Germany; University of Duhok, Iraq); Roman Eppinger (Technische Hochschule Mittelhessen, Germany); Stefan Gräf (Technische Hochschule Mittelhessen, Germany); Martin Nguyen (Technische Hochschule Mittelhessen, Germany); Thomas Schanze (Technische Hochschule Mittelhessen, Germany)	Poster session 7	Biosignal processing and monitoring II	P 67	11.09.2017	15:15
Sensor placement in a smart compression shirt to measure spontaneous breathing	Bernhard Laufer (ITeM, Germany); Jörn Kretschmer (ITeM, Germany); Paul David Docherty (University of Canterbury, New Zealand); Knut Möller (ITeM, Germany); Fabian Höflinger (University of Freiburg, Germany); L. Reindl (University of Freiburg, Germany)	Poster session 7	Biosignal processing and monitoring II	P 68	11.09.2017	15:15
Consistent mathematical modelling of the perfusion index and the pulse wave velocity measured by combined fingertip photoplethysmography and the electrocardiogram	Thomas Reich (Technische Universität Berlin, Germany); Timo Tigges (Technische Universität Berlin, Germany); Aarne Feldheiser (Charité - Universitätsmedizin Berlin, Germany); Oliver Hunsicker (Charité - Universitätsmedizin Berlin, Germany); Reinhold Orglmeister (Technische Universität Berlin, Germany); Alexandru-Gabriel Pielmus (Technische Universität Berlin, Germany); Michael Klum (Technische Universität Berlin, Germany)	Poster session 7	Biosignal processing and monitoring II	P 69	11.09.2017	15:15
Saturation correction in pulsed fields of high dose-per-pulse	Malte Gotz (OncoRay, Germany); Leonhard Karsch (OncoRay, Germany); Jörg Pawelke (OncoRay, Germany; Helmholtz-Zentrum Dresden-Rossendorf, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 71	11.09.2017	15:15
Investigation of radiation exposure to the ocular lens of urologists due to interventions	Josefin Hartmann (Klinikum Nürnberg, Germany); Michaela Wacker (Klinikum Nürnberg, Germany); Martin Baumüller (Klinikum Nürnberg, Germany); Roland Becker (Klinikum Nürnberg, Germany); Sascha Pahernik (Klinikum Nürnberg, Germany); Michael Wucherer (Klinikum Nürnberg, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 72	11.09.2017	15:15
Investigation of the LET-Dependency from BeO using single photon detection for dosimetry in proton beams	Johannes Radtke (TU Dresden, Germany); Thomas Kormoll (TU Dresden, Germany); Leopold Grabs (TU Dresden, Germany); Benjamin Lutz (Helmholtz-Zentrum Dresden-Rossendorf, Germany); Armin Lühr (National Center for Radiation Research in Oncology, Germany); Wolfgang Ullrich (TU Dresden, Germany); Jan Sponner (TU Dresden, Germany); Jürgen Henniger (TU Dresden, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 74	11.09.2017	15:15
A novel primary method for the determination of dose to water for kilovoltage X-rays	Steffen Ketelhut (Physikalisch-Technische Bundesanstalt, Germany); Ludwig Büermann (Physikalisch-Technische Bundesanstalt, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 75	11.09.2017	15:15
Quantification of patient exposure reduction with dynamic collimation for large detector CTs	Mario Liebmann (Klinikum Links der Weser, Germany; Carl-von-Ossietzky Universität, Germany); Jens Mathis Sauer (Carl-von-Ossietzky Universität, Germany); Daniel Kärcher (Carl-von-Ossietzky Universität, Germany); Björn Poppe (Carl-von-Ossietzky Universität, Germany); Heiner von Boetticher (Carl-von-Ossietzky Universität, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 76	11.09.2017	15:15
Influence of a magnetic field on the response of the MR-compatible Exradin A19MR farmer-type ionization chamber	Bhargesh Kandarp Shukla (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Claudia Katharina Spindeldreier (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Oliver Schrenk (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Steffen Greilich (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Christian P Karger (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Asja Pfaffenberger (Deutsches Krebsforschungszentrum (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 77	11.09.2017	15:15

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In-phantom dosimetry near a 192Ir brachytherapy source	Andreas Schönfeld (Carl von Ossietzky Universität Oldenburg, Germany); Katrin Büsing (Carl von Ossietzky Universität Oldenburg, Germany); Dietrich Harder (Prof. em. Georg August Universität Göttingen, Germany); Ndimofor Chofor (Radioonkologische Berufsausuebungsgemeinschaft Strahlentherapie Leer, Germany); Björn Poppe (Carl von Ossietzky Universität Oldenburg, Germany)	Poster session 8	Dosimetry, radiation protection and radiation biology I	P 78	11.09.2017	15:15
Investigation of the active volume dimensions of solid-state detectors using the PTB 10 MeV proton microbeam	Daniela Poppinga (Universität Oldenburg, Germany); Björn Delfs (Universität Oldenburg, Germany); Jutta Meyners (Imland Klinik, Germany); Frank Langner (Physikalisch-Technische Bundesanstalt (PTB), Germany); Ulrich Giesen (Physikalisch-Technische Bundesanstalt (PTB), Germany); Dietrich Harder (Universität Göttingen, Germany); Björn Poppe (Universität Oldenburg, Germany); Hui Khee Looe (Universität Oldenburg, Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 81	11.09.2017	15:15
Monte-Carlo study on the mechanism of the field size dependent overresponse of a synthetic diamond detector: the effects of the structural component densities and of the photon spectrum	Hui Khee Looe (Carl von Ossietzky Universität, Germany); Daniela Poppinga (Carl von Ossietzky Universität, Germany); Björn Delfs (Carl von Ossietzky Universität, Germany); Dietrich Harder (Georg August Universität, Germany); Björn Poppe (Carl von Ossietzky Universität, Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 82	11.09.2017	15:15
Response of ionization chambers in the presence of magnetic fields	Mohamad Alissa (THM-Gießen, Germany; ,); Philip von Voigts-Rhetz (THM-Gießen, Germany; ,); Klemens Zink (THM-Gießen, Germany; ,)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 83	11.09.2017	15:15
Development of ultraviolet ray irradiation device for gafchromic XR-SP2 films	Toshizo Katsuda (Butsuryo College of Osaka, Japan); Rumi Gotanda (Ibaraki Prefectural University of Health Sciences, Japan); Tatsuhiro Gotanda (Kawasaki University of Medical Welfare, Japan); Takuya Akagawa (Butsuryo College of Osaka, Japan); Nobuyoshi Tanki (Butsuryo College of Osaka, Japan); Atsushi Noguchi (Butsuryo College of Osaka, Japan); Tadao Kuwano (Okayama University, Japan); Kouichi Yabunaka (The University of Tokyo, Japan)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 84	11.09.2017	15:15
Optimizing the precision of positioning a 3D-dose distribution measuring device for Brachytherapy applications	Kim-Leigh Gabay (PTB, Germany); Thorsten Schneider (PTB, Germany); Friederike Grote (PTB, Germany); Jürgen Roth (PTB, Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 85	11.09.2017	15:15
Accuracy and anisotropy of three-dimensional ionization chambers for plan verification in robotic radiosurgery	Britta Loutfi-Krauss (Universitätsklinikum Frankfurt, Germany); Janett Köhn (Universitätsklinikum Frankfurt, Germany); Malte Mielke (Universitätsklinikum Frankfurt, Germany); Christian Scherf (Universitätsklinikum Frankfurt, Germany); Jörg Licher (Universitätsklinikum Frankfurt, Germany); Ulla Ramm (Universitätsklinikum Frankfurt, Germany); Oliver Blanck (Universitätsklinikum Schleswig-Holstein, Germany; Saphir Radiochirurgie Zentrum, Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 86	11.09.2017	15:15
Capabilities of the metrological electron accelerator facility (MELAF) for research in radiation effects	Andreas Schüller (Physikalisch-Technische Bundesanstalt, Germany); Christoph Makowski (Physikalisch-Technische Bundesanstalt, Germany); Ralf-Peter Kapsch (Physikalisch-Technische Bundesanstalt, Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 87	11.09.2017	15:15
Assessment of microscopic ion beam field variation using fluorescent nuclear track detectors	Alexander Neuholz (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany); Steffen Greilich (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany)	Poster session 9	Dosimetry, radiation protection and radiation biology II	P 88	11.09.2017	15:15
Development of micro electromechanical biosensor for fast detection of respiratory syncytial virus infections in newborns	Pavel Livshits (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Andreas Jupe (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Stefan Kahnert (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Martin Figge (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Stefan Mross (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Michael Goertz (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Holger Vogt (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany); Andreas Goehlich (Fraunhofer Institut für Mikroelektronische Schaltungen und Systeme, Germany)	Poster session 10	Medical measuring techniques I	P 90	11.09.2017	15:15
Registration and evaluation of alternative non-invasive parameters for orthostatic hypotension in geriatric patients	Matthias Goernig (Städtisches Klinikum Dresden, Germany); Sarah Weise (TU Ilmenau, Germany); Maik Pflugrath (TU Berlin, Germany); Jens Haueisen (TU Ilmenau, Germany)	Poster session 10	Medical measuring techniques I	P 91	11.09.2017	15:15

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Investigation of the viscosity of human middle ear effusions by endoscopic optical coherence tomography	Martin Schindler (TU Dresden, Germany); Joseph Morgenstern (TU Dresden, Germany); Julia Walther (TU Dresden, Germany; TU Dresden, Germany); Lars Kirsten (TU Dresden, Germany); Marcus Neudert (TU Dresden, Germany); Thomas Zahnert (TU Dresden, Germany); Edmund Koch (TU Dresden, Germany)	Poster session 10	Medical measuring techniques I	P 93	11.09.2017	15:15
Design of a switched-capacitor array for high-power applications with dense coverage of medium frequency-range	Andre Behrends (Universität zu Lübeck, Germany); Thorsten M. Buzug (Universität zu Lübeck, Germany)	Poster session 10	Medical measuring techniques I	P 94	11.09.2017	15:15
MEMS-FTIR-based reference system for glucose and lactate determination in the NIR wavelength range	Christian Stark (Luebeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Felix Fiedler (Luebeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Benjamin Redmer (Luebeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Reza Behroozian (Luebeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Stefan Müller (Luebeck University of Applied Sciences (FHL), Germany)	Poster session 10	Medical measuring techniques I	P 95	11.09.2017	15:15
Impedance matching of small laser fabricated double-sided intrafascicular electrode arrays	Matthias Mueller (Albert-Ludwigs-Universität, Germany); Christian Boehler (Albert-Ludwigs-Universität, Germany); Maria Asplund (Albert-Ludwigs-Universität, Germany); Thomas Stieglitz (Albert-Ludwigs-Universität, Germany)	Poster session 10	Medical measuring techniques I	P 96	11.09.2017	15:15
Autonomous powered R wave detector	Daniel Laqua (Technische Universität Ilmenau, Germany); Therese Winkler (Technische Universität Ilmenau, Germany); Konstantin Rönsch (Technische Universität Ilmenau, Germany); Christina Junger (Technische Universität Ilmenau, Germany); Saskia Habermann (Technische Universität Ilmenau, Germany); Peter Husar (Technische Universität Ilmenau, Germany)	Poster session 10	Medical measuring techniques I	P 97	11.09.2017	15:15
Health and sensors: sweat sensing	Harald Mathis (Fraunhofer-Institut FIT, Germany)	Poster session 10	Medical measuring techniques I	P 99	11.09.2017	15:15
Local stress investigation of periprosthetic fractures by total hip replacement - a finite element analysis	Michael Bauer (Institut für Werkstoffkunde/ Leibniz Universität Hannover, Germany); Stephan Brand (Klinik für Unfallchirurgie / Medizinische Hochschule Hannover, Germany); Julian Schrader (Institut für Werkstoffkunde/ Leibniz Universität Hannover, Germany); Christian Krettek (Klinik für Unfallchirurgie / Medizinische Hochschule Hannover, Germany); Hans Jürgen Maier (Institut für Werkstoffkunde/ Leibniz Universität Hannover, Germany); Thomas Hassel (Institut für Werkstoffkunde/ Leibniz Universität Hannover, Germany)	Poster session 11	Modelling and simulation I	P 100	11.09.2017	15:15
Development and validation of a equipment-specific Geant4 model for Elekta Agility collimator	Juliana Cristina Martins (Ludwig-Maximilians-Universität München, Germany); Abdulaziz Alhazmi (Ludwig-Maximilians-Universität München, Germany); Sebastian Neppl (Ludwig-Maximilians-Universität München, Germany); Claus Belka (Ludwig-Maximilians-Universität München, Germany); Michael Reiner (Ludwig-Maximilians-Universität München, Germany); Katia Parodi (Ludwig-Maximilians-Universität München, Germany); Stella Veloza (Ludwig-Maximilians-Universität München, Germany; Universidad Nacional de Colombia, Colombia)	Poster session 11	Modelling and simulation I	P 102	11.09.2017	15:15
Towards PET monitoring at the Austrian ion beam therapy center MedAustron	Heide Rohling (TU Wien, Austria); Hermann Fuchs (Medizinische Universität, Austria); Albert Hirtl (TU Wien, Austria); Marta Mumot (EBG MedAustron GmbH, Austria); Christian Reschl (EBG MedAustron GmbH, Austria); Lembit Sihver (TU Wien, Austria; EBG MedAustron GmbH, Austria); Markus Stock (EBG MedAustron GmbH, Austria)	Poster session 11	Modelling and simulation I	P 105	11.09.2017	15:15
Simulation of electrical fields in cardiac resynchronization therapy and temperature spread in HF ablation	Martin Krämer (University of Applied Sciences, Germany); Matthias Heinke (University of Applied Sciences, Germany); Reinhard Echle (University of Applied Sciences, Germany); Johannes Hörth (University of Applied Sciences, Germany)	Poster session 11	Modelling and simulation I	P 107	11.09.2017	15:15
Monte-Carlo based CT simulation of virtual patients for image guided radiotherapy	Simon Kirchhof (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany; National Center for Radiation Research in Oncology (NCRO), Germany); Kristina Giske (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany; National Center for Radiation Research in Oncology (NCRO), Germany); Lucas Burigo (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany; National Center for Radiation Research in Oncology (NCRO), Germany)	Poster session 11	Modelling and simulation I	P 108	11.09.2017	15:15

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Evaluation of pharmacokinetic models of low-molecular-weight contrast agents for perfusion quantification with dynamic contrast-enhanced magnetic resonance imaging	Stefan Hindel (Universitätsklinikum Essen, Germany); Anika Söhner (Universitätsklinikum Essen, Germany); Marc Maaß (Universitätsklinikum Essen, Germany); Lutz Lüdemann (Universitätsklinikum Essen, Germany)	Poster session 12	Modelling and simulation II	P 109	11.09.2017	15:15
First experiences of a Monte Carlo based plan verification software at the UKGM	Frida Dietz (Technische Hochschule Mittelhessen, Germany); Sascha Bosold (Universitätsklinikum Gießen-Marburg, Germany); Marcus Grimm (MedCom GmbH, Germany); Matthias Söhn (ScientificRT GmbH, Germany); Rita Engenhart-Cabillic (Universitätsklinikum Gießen-Marburg, Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; Universitätsklinikum Gießen-Marburg, Germany)	Poster session 12	Modelling and simulation II	P 110	11.09.2017	15:15
Probabilistic based algorithm to simulate ion nuclear reactions in the ion therapy energy range	Maria Jose Gonzalez Torres (Institut für Kern- und Teilchenphysik, TU Dresden, Germany); Jürgen Henniger (Institut für Kern- und Teilchenphysik, TU Dresden, Germany)	Poster session 12	Modelling and simulation II	P 111	11.09.2017	15:15
MR Radiomics features of brain metastasis allow for primary tumor identification	Frederic Madesta (Universitätsklinikum Hamburg-Eppendorf, Germany); Helge Kniep (Universitätsklinikum Hamburg-Eppendorf, Germany); Tobias Gauer (Universitätsklinikum Hamburg-Eppendorf, Germany); Tanja Schneider (Universitätsklinikum Hamburg-Eppendorf, Germany); Susanne Siemonsen (Universitätsklinikum Hamburg-Eppendorf, Germany); René Werner (Universitätsklinikum Hamburg-Eppendorf, Germany)	Poster session 12	Modelling and simulation II	P 112	11.09.2017	15:15
Degradation of sponge structures made of magnesium alloys as bone replacement material	Ann-Kathrin Krüger (Institut für Kontinuumsmechanik, Germany); Stefan Julmi (Institut für Werkstoffkunde, Germany); Christian Klose (Institut für Werkstoffkunde, Germany); Silke Besdo (Institut für Kontinuumsmechanik, Germany); Hans Jürgen Maier (Institut für Werkstoffkunde, Germany); Peter Wriggers (Institut für Kontinuumsmechanik, Germany)	Poster session 12	Modelling and simulation II	P 113	11.09.2017	15:15
Differential equations and cellular automata for avascular tumor growth	Jörg Wassenberg (Westfälische Hochschule, Germany); Waldemar Zylka (Westfälische Hochschule, Germany)	Poster session 12	Modelling and simulation II	P 116	11.09.2017	15:15
Models and simulation of central retinal vein pulsation for education and training in ophthalmology	Ute Morgenstern (Technische Universität Dresden, Germany); Dhara Bhavsar (Technische Universität Dresden, Germany); Richard Stodtmeister (Technische Universität Dresden, Germany)	Poster session 12	Modelling and simulation II	P 117	11.09.2017	15:15
Manufacturing and thermal treatment of degradable magnesium bone cages	Christine Donay (Institut für Textiltechnik der RWTH Aachen University, Germany); Janine Doeringer (Institut für Textiltechnik der RWTH Aachen University, Germany); Thomas Gries (Institut für Textiltechnik der RWTH Aachen University, Germany); Stefan Jockenhoevel (Institut für Textiltechnik der RWTH Aachen University, Germany; Institute for Applied Medical Engineering, Germany); Alexander Löwen (Institut für Textiltechnik der RWTH Aachen University, Germany)	Poster session 13	Organ and patient support systems I	P 119	11.09.2017	15:15
Complex braids for medical applications	Lukas Löhmer (Institut für Textiltechnik der RWTH Aachen University, Germany); Kathrin Kurtenbach (Institut für Textiltechnik der RWTH Aachen University, Germany); Thomas Gries (Institut für Textiltechnik der RWTH Aachen University, Germany); Stefan Jockenhövel (Institut für Textiltechnik der RWTH Aachen University, Germany; Institute of Applied Medical Engineering, Germany)	Poster session 13	Organ and patient support systems I	P 120	11.09.2017	15:15
Generating informative standard values of maximum forces and anthropometric data of the shoulder in pupils of classes 5 to 12 by means of an accessory to the HFD 200 hand and finger dynamometer diagnostics and therapy system	Cornelius Weber (Diakonissenanstalt, Germany); Hansjörg Weber (Niederlassung als Allgeinmediziner/Arbeitsmedizin, Germany)	Poster session 13	Organ and patient support systems I	P 121	11.09.2017	15:15
Impact of insertion velocity on insertion forces in cochlear implantation surgery	Silke Hügl (Medizinische Hochschule Hannover, Germany); Katharina Rülander (Medizinische Hochschule Hannover, Germany; Fachhochschule Münster, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany; Medizinische Hochschule Hannover, Germany); Omid Majdani (Medizinische Hochschule Hannover, Germany); Thomas S. Rau (Medizinische Hochschule Hannover, Germany)	Poster session 13	Organ and patient support systems I	P 122	11.09.2017	15:15
Evaluation of design limits for implantable high channel count connectors	Julia Koch (IMTEK, Universität Freiburg, Germany); Martin Schuettler (CorTec GmbH, Germany); Thomas Stieglitz (IMTEK, Universität Freiburg, Germany)	Poster session 13	Organ and patient support systems I	P 123	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Perception thresholds of cutaneous electric stimulation around the upper arm	Stephan Lau (Technical University Ilmenau, Germany); Patrique Fiedler (Technical University Ilmenau, Germany); Alexander Hunold (Technical University Ilmenau, Germany); Elke Haase (Technical University Dresden, Germany); Daniel Gröllich (Technical University Dresden, Germany); Kathrin Pietsch (Technical University Dresden, Germany); Katrin Höhn (Technical University Dresden, Germany); Martin Schmauder (Technical University Dresden, Germany); Hartmut Rödel (Technical University Dresden, Germany); Jens Haueisen (Technical University Ilmenau, Germany)	Poster session 13	Organ and patient support systems I	P 125	11.09.2017	15:15
Lifetime testing for flexible smart implants	Lena Bleck (NMI Naturwissenschaftliches und Medizinisches Institut, Germany); Jennifer Erb (NMI Naturwissenschaftliches und Medizinisches Institut, Germany); Rene von Metzen (NMI Naturwissenschaftliches und Medizinisches Institut, Germany); Alfred Stett (NMI Naturwissenschaftliches und Medizinisches Institut, Germany)	Poster session 13	Organ and patient support systems I	P 126	11.09.2017	15:15
Development of a system test procedure (STP) for CT-guided HDR brachytherapy	Fabian Krause (Universitätsklinikum S-H, Campus Kiel, Germany); Franziska Risske (Universitätsklinikum S-H, Campus Kiel, Germany); Susann Bohn (Universitätsklinikum S-H, Campus Kiel, Germany); Frank-Andre Siebert (Universitätsklinikum S-H, Campus Kiel, Germany)	Poster session 14	Radiation therapy I	P 127	11.09.2017	15:15
Fragmentation experiments with helium ions	Felix Horst (Technische Hochschule Mittelhessen, Germany; GSI Helmholtzzentrum für Schwerionenforschung, Germany); Christoph Schuy (GSI Helmholtzzentrum für Schwerionenforschung, Germany); Uli Weber (GSI Helmholtzzentrum für Schwerionenforschung, Germany); Hans-Georg Zaunick (Justus-Liebig-Universität, Germany); Kai-Thomas Brinkmann (Justus-Liebig-Universität, Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; Universitätsklinikum Giessen-Marburg, Germany)	Poster session 14	Radiation therapy I	P 128	11.09.2017	15:15
Measurement of tissue stopping-power ratios for ion-range prediction	Tom Russ (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany); Armin Runz (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany); Steffen Greilich (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany); Christian Möhler (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Germany)	Poster session 14	Radiation therapy I	P 130	11.09.2017	15:15
Development and Monte Carlo simulations of a 3D range-modulator for proton therapy	Yuri Simeonov (Technische Hochschule Mittelhessen, Germany); Uli Weber (GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany); Petar Penchev (Technische Hochschule Mittelhessen, Germany); Toke Printz Ringbæk (Technische Hochschule Mittelhessen, Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; Universitätsklinikum Gießen und Marburg GmbH, Germany)	Poster session 14	Radiation therapy I	P 131	11.09.2017	15:15
Fractionated radiosurgery of uveal tumours by means of HybridArcTM and novalis powered by TrueBeamTMSTx	Markus Wösle (Städtisches Klinikum Dessau, Germany); Philipp Goldschmidt (Städtisches Klinikum Dessau, Germany); Ilja F. Ciernik (Städtisches Klinikum Dessau, Germany)	Poster session 14	Radiation therapy I	P 132	11.09.2017	15:15
Analysis of robustness of proton plans in the treatment planning system RayStation considering setup and range perturbations	Lisa Pschichholz (Klinikum Bielefeld, Germany); Christian Bäumer (Westdeutsches Protonentherapiezentrum Essen (WPE), Germany); Dirk Geismar (Westdeutsches Protonentherapiezentrum Essen (WPE), Germany); Beate Timmermann (Westdeutsches Protonentherapiezentrum Essen (WPE), Germany)	Poster session 14	Radiation therapy I	P 133	11.09.2017	15:15
Retrospective evaluation of patient positioning data and dose exposure considering translation and rotation deviation in linac based stereotactic radiosurgery	Oliver Fielitz (Universitätsklinikum Düsseldorf, Germany); Holger Gottschlag (Universitätsklinikum Düsseldorf, Germany); Ioannis Simiantonakis (Universitätsklinikum Düsseldorf, Germany)	Poster session 14	Radiation therapy I	P 134	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Influence of anatomical changes in robust optimized proton plans for bilateral head and neck cancer targets	Macarena Cubillos Mesias (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany); Michael Baumann (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany); Esther G.C. Troost (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; University Hospital Carl Gustav Carus, Germany; German Cancer Consortium (DKTK), Germany; Helmholtz-Zentrum Dresden-Rossendorf, Germany; National Center for Tumor Diseases, Germany); Fabian Lohaus (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; University Hospital Carl Gustav Carus, Germany; German Cancer Consortium (DKTK), Germany); Linda Agolli (University Hospital Carl Gustav Carus, Germany); Maximilian Rehm (University Hospital Carl Gustav Carus, Germany); Christian Richter (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; University Hospital Carl Gustav Carus, Germany; German Cancer Consortium (DKTK), Germany; Helmholtz-Zentrum Dresden-Rossendorf, Germany); Kristin Stützer (OncoRay – National Center for Radiation Research in Oncology, Medical Faculty and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden-Rossendorf, Germany)	Poster session 14	Radiation therapy I	P 136	11.09.2017	15:15
Enhanced evaluation criteria for independent dose calculation tested at the MC-based verification software ProSomaCore	Felix Roden (Vivantes Klinikum Neukölln, Germany); Andre Wallin (Vivantes Klinikum Neukölln, Germany); Lukas Henze (Vivantes Klinikum Neukölln, Germany); Andrea Schwahofer (Vivantes Klinikum Neukölln, Germany)	Poster session 14	Radiation therapy I	P 137	11.09.2017	15:15
Evaluation of the stability of healthy volunteers aligned for whole brain irradiation without a mask	Patrick Rauwald-Josephs (Universitätsklinikum Marburg, Germany); Martin Böttcher (Universitätsklinikum Marburg, Germany); Hilke Vorwerk (Universitätsklinikum Marburg, Germany); Klemens Zink (Universitätsklinikum Marburg, Germany); Rita Engenhart-Cabillic (Universitätsklinikum Marburg, Germany)	Poster session 15	Radiation therapy II	P 138	11.09.2017	15:15
Effective workflow for radiation therapy departments with many VMAT irradiations through the use of Mobius 3D and Fx for plan-related quality assurance and a simple and pragmatic machine-related quality assurance program	Thomas Hauschild (Sozialstiftung Bamberg - MVZ aB, Germany); Maximilian Graf (Elekta GmbH, Germany); Thomas Koch (Sozialstiftung Bamberg - MVZ aB, Germany)	Poster session 15	Radiation therapy II	P 140	11.09.2017	15:15
QALender – a web-based system for supporting quality assurance in radiation therapy	Alexander Stoll (Reutlingen University, Germany); Franz Klein (Reutlingen University, Germany); Oliver Burgert (Reutlingen University, Germany); Christian Thies (Reutlingen University, Germany); Jussi Moog (Universitätsklinikum Tübingen, Germany)	Poster session 15	Radiation therapy II	P 141	11.09.2017	15:15
Influence of TomoTherapy-specific planning parameters on technical treatment parameters and dose distribution	Simon Howitz (Universitätsklinikum Jena , Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; Universitätsklinikum Gießen-Marburg, Germany; Frankfurt Institute for Advanced Studies, Germany)	Poster session 15	Radiation therapy II	P 142	11.09.2017	15:15

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Dosimetric characterization of microbeams for radiation therapy at the Munich Compact Light Source	Theresa Urban (Technical University of Munich, Klinikum rechts der Isar, Germany; Technical University of Munich, Germany); Stefan Bartzsch (Technical University of Munich, Klinikum rechts der Isar, Germany); Karin Burger (Technical University of Munich, Klinikum rechts der Isar, Germany; Technical University of Munich, Germany; Technical University of Munich, Germany); Benedikt Günther (Technical University of Munich, Germany; Technical University of Munich, Germany; Max-Planck-Institute of Quantum Optics, Germany); Martin Dierolf (Technical University of Munich, Germany; Technical University of Munich, Germany); Bernhard Gleich (Technical University of Munich, Germany); Klaus Achterhold (Technical University of Munich, Germany; Technical University of Munich, Germany); Stephanie E. Combs (Technical University of Munich, Klinikum rechts der Isar, Germany; Helmholtz Zentrum München, Germany); Franz Pfeiffer (Technical University of Munich, Germany; Technical University of Munich, Germany); Jan J. Wilkens (Technical University of Munich, Klinikum rechts der Isar, Germany; Technical University of Munich, Germany)	Poster session 15	Radiation therapy II	P 143	11.09.2017	15:15
Evaluation of new gantry angle dependence correction factors for pre-treatment IMRT plan verification with MatriXX Multicube Lite®and myQA®	Miriam Eckl (Universitätsmedizin Mannheim, Germany); Arianna Giuliacci (IBA Dosimetry, Germany); Ondrej Sevela (IBA Dosimetry, Germany); Frederik Wenz (Universitätsmedizin Mannheim, Germany); Hansjörg Wertz (Universitätsmedizin Mannheim, Germany)	Poster session 15	Radiation therapy II	P 144	11.09.2017	15:15
PRONTOX – a prospective randomized clinical trial for the treatment of non-small cell lung cancer patients at the University Proton Therapy Dresden	Annika Jakobi (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Kristin Stützer (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany); Julia Thiele (Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Sebastian Makocki (Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Esther G.C. Troost (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; German Cancer Consortium (DKTK), partner site Dresden, and Germany and German Cancer Research Center (DKFZ), Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Christian Richter (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; German Cancer Consortium (DKTK), partner site Dresden, and Germany and German Cancer Research Center (DKFZ), Germany)	Poster session 15	Radiation therapy II	P 145	11.09.2017	15:15
Density calibration of X-Ray CT using flash proton radiography for ion beam radiotherapy	Nils Peters (GSI Helmholtzzentrum für Schwerionenforschung, Germany); Martin Schanz (GSI Helmholtzzentrum für Schwerionenforschung, Germany)	Poster session 15	Radiation therapy II	P 146	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Dose calculation based on Hounsfield Unit calibrated cone beam CT images	Klara Dinkel (LMU Munich, Germany; LMU Munich, Faculty of Physics, Germany); Jan Hofmaier (LMU Munich, Germany); Guillaume Landry (LMU Munich, Faculty of Physics, Germany); Christopher Kurz (LMU Munich, Germany; LMU Munich, Faculty of Physics, Germany); Michael Reiner (LMU Munich, Germany); Katia Parodi (LMU Munich, Faculty of Physics, Germany); Claus Belka (LMU Munich, Germany); Florian Kamp (LMU Munich, Germany)	Poster session 15	Radiation therapy II	P 147	11.09.2017	15:15
Lessons learned about small field dosimetry from the commissioning of a secondary Monte Carlo dose calculation engine for cyberknife	Sebastian Klüter (Universitätsklinikum Heidelberg, Germany); Daniela Schmitt (Universitätsklinikum Heidelberg, Germany); Kai Schubert (Universitätsklinikum Heidelberg, Germany); Laura Wolf (Universitätsklinikum Heidelberg, Germany); Matthias Söhn (ScientificRT GmbH, Germany); Markus Alber (Universitätsklinikum Heidelberg, Germany; ScientificRT GmbH, Germany)	Poster session 15	Radiation therapy II	P 148	11.09.2017	15:15
Investigation of dynamic treatment beam geometries in stereotactic radiosurgery for intracranial lesions involving couch motion and their quality control procedures	Isabelle Brück (Uniklinik RWTH Aachen, Germany); Ahmed Gawish (Uniklinik RWTH Aachen, Germany); Michael J. Eble (Uniklinik RWTH Aachen, Germany)	Poster session 16	Radiation therapy III	P 149	11.09.2017	15:15
Towards clinical quality assurance of deformable image registration for each individual patient: scientific visualization for exploring uncertainties	Kristina Giske (German Cancer Research Center (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Hendrik Teske (German Cancer Research Center (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Kathrin Bartelheimer (German Cancer Research Center (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Rolf Bendl (German Cancer Research Center (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany; Heilbronn University, Germany)	Poster session 16	Radiation therapy III	P 150	11.09.2017	15:15
Combined PET-MR guided focused ultrasound and radiation therapy to improve treatment of cancer	Lisa Landgraf (ICCAS, Germany); Doudou Xu (ICCAS, Germany); Xinrui Zhang (ICCAS, Germany); Ina Patties (ICCAS, Germany); Michael Unger (ICCAS, Germany); Johann Berger (ICCAS, Germany); Shaonan Hu (ICCAS, Germany); Lydia Koi (OncoRay - Center for Radiation Research in Oncology, Germany); Aswin Hoffmann (OncoRay - Center for Radiation Research in Oncology, Germany); Marc Fournelle (Fraunhofer-Institut für Biomedizinische Technik IBMT, Germany); Steffen Tretbar (Fraunhofer-Institut für Biomedizinische Technik IBMT, Germany); Thomas Neumuth (ICCAS, Germany); Andreas Melzer (ICCAS, Germany)	Poster session 16	Radiation therapy III	P 151	11.09.2017	15:15
Development and implementation of 3D-dosimetric end-to-end tests in adaptive radiation therapy of moving tumors	Philipp Mann (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Maximilian Witte (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Torsten Moser (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Clemens Lang (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Armin Runz (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Wibke Johnen (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany); Jürgen Biederer (University of Heidelberg, Germany; German Lung Research Center (DZL), Germany; Gross-Gerau County Hospital, Germany); Christian Karger (German Cancer Research Center, Germany; Heidelberg Institute for Radiation Oncology (HIRO), Germany)	Poster session 16	Radiation therapy III	P 152	11.09.2017	15:15

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COMPASS-NRW: A dosimetry initiative of the regional section west of the DGMP (RSW-DGMP) to verify dynamic irradiation techniques	Uwe Heinrichs (Uniklinik RWTH Aachen, Germany); Eric Beckers (Gamma-Knife Zentrum Krefeld, Germany); Andreas Block (Institut für Medizinische Strahlenphysik und Strahlenschutz, Klinikum Dortmund gGmbH, Germany); Isabelle Brück (Uniklinik RWTH Aachen, Germany); Stephan Garbe (Radiologische Universitätsklinik, Strahlentherapie, Germany); Laura Guenther (Klinik für Strahlentherapie und Radio-Onkologie, HELIOS Universitätsklinikum Wuppertal, Universität Witten/Herdecke, Germany); Sedef Ibisi (TU Dortmund, Germany); Katrin Jurianz (Gamma-Knife Zentrum Krefeld, Germany); Martin Kühne (Klinik für Strahlentherapie Köln-Merheim, Kliniken der Stadt Köln gGmbH, Köln, Universität Witten/Herdecke, Germany); Katharina Loot (TU Dortmund, Germany); Arnd Röser (Klinik für Strahlentherapie und Radio-Onkologie, HELIOS Universitätsklinikum Wuppertal, Universität Witten/Herdecke, Germany)	Poster session 16	Radiation therapy III	P 154	11.09.2017	15:15
Software commissioning of a Monte-Carlo model for the double-scattering treatment head at University Proton Therapy Dresden	Jan Eulitz (OncoRay – National Center for Radiation Research in Oncology, Germany); Armin Lühr (OncoRay – National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden; German Cancer Research Center (DKFZ), Germany); Wolfgang Enghardt (OncoRay – National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden; German Cancer Research Center (DKFZ), Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Benjamin Lutz (Helmholtz-Zentrum Dresden - Rossendorf, Germany)	Poster session 16	Radiation therapy III	P 155	11.09.2017	15:15
Predicting clinical relative biological effectiveness in proton therapy based on (pre-) clinical dose response	Armin Lühr (Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Germany; OncoRay - National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), Germany; German Cancer Research Center (DKFZ), Germany); Cläre von Neubeck (OncoRay - National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), Germany; German Cancer Research Center (DKFZ), Germany); Michael Baumann (Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Germany; OncoRay - National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), Germany; Technische Universität Dresden, Germany; National Center for Tumor Diseases, Germany; German Cancer Research Center (DKFZ), Germany); Mechthild Krause (Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Germany; OncoRay - National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), Germany; Technische Universität Dresden, Germany; National Center for Tumor Diseases, Germany; German Cancer Research Center (DKFZ), Germany); Wolfgang Enghardt (Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Germany; OncoRay - National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), Germany; Technische Universität Dresden, Germany; National Center for Tumor Diseases, Germany; German Cancer Research Center (DKFZ), Germany)	Poster session 16	Radiation therapy III	P 156	11.09.2017	15:15
T-REF chamber: a new ion chamber tested for iris quality assurance and output check	Wolfgang W. Baus (Uniklinik, Germany); Georg Altenstein (Uniklinik, Germany)	Poster session 16	Radiation therapy III	P 157	11.09.2017	15:15
Determination of MCVT-Dose in helical IMRT	Sebastian Wellner (Universität Düsseldorf, Germany); Fred Röhner (Radiologische Universitätsklinik, Germany); Thomas Müdder (Radiologische Universitätsklinik, Germany); Felix Schoroth (Radiologische Universitätsklinik, Germany); Timo Wilhelm-Buchstab (Radiologische Universitätsklinik, Germany); Christopher Schmeel (Radiologische Universitätsklinik, Germany); Christina Leitzen (Radiologische Universitätsklinik, Germany); Susanne Vornholt (Radiologische Universitätsklinik, Germany); Stephan Garbe (Radiologische Universitätsklinik, Germany)	Poster session 16	Radiation therapy III	P 158	11.09.2017	15:15
Dosimetric comparison of intensity modulated radiotherapy techniques in head and neck cancer	Marie-Luise Pfeiffer (Universitätsklinikum Schleswig-Holstein, Klinik für Strahlentherapie (Radioonkologie), Kiel, Germany); Jürgen Dunst (Universitätsklinikum Schleswig-Holstein, Klinik für Strahlentherapie (Radioonkologie), Kiel, Germany); Frank-André Siebert (Universitätsklinikum Schleswig-Holstein, Klinik für Strahlentherapie (Radioonkologie), Kiel, Germany)	Poster session 16	Radiation therapy III	P 159	11.09.2017	15:15

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Uptake dynamics of graphene quantum dots into primary human blood cells following in vitro exposure	Thomas Heinzel (HHU Düsseldorf, Germany); Stefan Fasbender (HHU Düsseldorf, Germany); Rainer Haas (Universität, Germany)	Poster session 17	Cells, materials and biochemistry I	P 160	11.09.2017	15:15
Self-cleaning materials using the photocatalytic effect of titanium dioxide	Theresa Fischer (Technische Universität München, Germany); Markus Ahrens (Technische Universität München, Germany); Serhiy Yatsenko (SKZ - German Plastic Center, Germany); Johannes Rudloff (SKZ - German Plastic Center, Germany); Marieluise Lang (SKZ - German Plastic Center, Germany); Peter Heidemeyer (SKZ - German Plastic Center, Germany); Martin Bastian (SKZ - German Plastic Center, Germany); Markus Eblenkamp (Technische Universität München, Germany)	Poster session 17	Cells, materials and biochemistry I	P 161	11.09.2017	15:15
Impedance spectroscopy as a new tool to monitor re-epithelialization in wounded reconstructed human epidermis	Lisa Engelhardt (Universitätsklinikum Würzburg, Germany); Jan Hansmann (Universitätsklinikum Würzburg, Germany); Heike Walles (Universitätsklinikum Würzburg, Germany; Fraunhofer IGB Würzburg, Germany); Florian Groeber-Becker (Fraunhofer IGB Würzburg, Germany)	Poster session 17	Cells, materials and biochemistry I	P 163	11.09.2017	15:15
Engineering of organoid blood vessel patterns with regulated hemodynamics by exosomal functional somatic noncoding RNA angio-morphogens [angiotropins]	Josef H. Wissler (ARCONS Institute for Applied Research & Didactics, Germany)	Poster session 17	Cells, materials and biochemistry I	P 164	11.09.2017	15:15
Differentiating PPIX from its precursors as a strategy for drug-light interval assessment in photodynamic therapy	Rainer Landes (Otto von Guericke University Magdeburg, Germany); Alfredo Illanes (Otto von Guericke University Magdeburg, Germany); Alexander van Oepen (Otto von Guericke University Magdeburg, Germany); Daniela Göppner (Otto von Guericke University Magdeburg, Germany); Harald Gollnick (Otto von Guericke University Magdeburg, Germany); Michael Friebe (Otto von Guericke University Magdeburg, Germany)	Poster session 17	Cells, materials and biochemistry I	P 165	11.09.2017	15:15
Automatic algorithm to generate customized microporous membranes by additive manufacturing	Franz X Bauer (Technische Universität München, Germany); Denise Zapf (Technische Universität München, Germany); Stefan Leonhardt (Technische Universität München, Germany); Katharina Düregger (Technische Universität München, Germany); Markus Eblenkamp (Technische Universität München, Germany)	Poster session 17	Cells, materials and biochemistry I	P 166	11.09.2017	15:15
Additive manufactured multimicrophasic (MMP) systems for biomedical applications: perspectives and concepts	Markus Eblenkamp (Technische Universität München, Germany); Stefan Fischer (Technische Universität München, Germany); Sebastian Pammer (Technische Universität München, Germany); Stefan Leonhardt (Technische Universität München, Germany)	Poster session 17	Cells, materials and biochemistry I	P 168	11.09.2017	15:15
Current developments of an in vitro wound healing experimental system for photobiomodulation therapy research	Jacquelyn Dawn Parente (Furtwangen University, Germany); Sabine Hensler (Furtwangen University, Germany); M. Canziani (Furtwangen University, Germany; University of Buenos Aires, Argentina); Ann-Kathrin Kiefer (Furtwangen University, Germany); Margareta M Mueller (Furtwangen University, Germany); Knut Möller (Furtwangen University, Germany)	Poster session 17	Cells, materials and biochemistry I	P 169	11.09.2017	15:15
Novel three-dimensional (3D) microtissues for the discovery of chemoradiation-sensitizing compounds	Natasa Anastasov (Helmholtz Zentrum Mücnhen, Germany); Sabine Richter (Helmholtz Zentrum Mücnhen, Germany); Michael Atkinson (Helmholtz Zentrum Mücnhen, Germany)	Poster session 18	Cells, materials and biochemistry II	P 172	11.09.2017	15:15
Aspects of functional electro-chemical biocompatibility in microsystems	Cornelius Schilling (Technische Universität Ilmenau, Germany); Mike Stubenrauch (Technische Universität Ilmenau, Germany); Sebastian Köhring (Technische Universität Ilmenau, Germany); Danja Voges (Technische Universität Ilmenau, Germany); Hartmut Witte (Technische Universität Ilmenau, Germany)	Poster session 18	Cells, materials and biochemistry II	P 173	11.09.2017	15:15
Development of cell-laden electrospun hybrid membranes for blood propulsion devices	Giuseppino Fortunato (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland); Lukas Weidenbacher (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland; ETH Zurich, Switzerland); Gökce Yazgan (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland); Anne Géraldine Guex (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland); Anne-sophie Mertgen (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland; ETH Zurich, Switzerland); Markus Rottmar (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland); Katharina Maniura (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland); René Rossi (Empa, Swiss Federal Laboratories for Materials Science and Technology , Switzerland)	Poster session 18	Cells, materials and biochemistry II	P 174	11.09.2017	15:15
The effect of patient-specific parameters on the required quantity of apheresis cycles and the CD34+ yield of autologous stem cell donors	Folker Wenzel (Hochschule Furtwangen, Germany); Olga Janz (Hochschule Furtwangen, Germany); Dijana Pohl (Hochschule Furtwangen, Germany); Svenja Degenhardt (Hochschule Furtwangen, Germany)	Poster session 18	Cells, materials and biochemistry II	P 176	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
High resolution photopolymerization technique for fabrication of hydrogel based scaffolds	Mark Vehse (Hochschule Stralsund, Germany); Svea Petersen (Hochschule Osnabrück, Germany); Hermann Seitz (Universität Rostock, Germany)	Poster session 18	Cells, materials and biochemistry II	P 177	11.09.2017	15:15
In vitro release of leuprorelin acetate from PLA-based implants	Katharina Prüßmann (Ernst-Moritz-Arndt-Universität Greifswald, Germany); Dana Moritz (Ernst-Moritz-Arndt-Universität Greifswald, Germany); Werner Weitschies (Ernst-Moritz-Arndt-Universität Greifswald, Germany); Anne Seidlitz (Ernst-Moritz-Arndt-Universität Greifswald, Germany)	Poster session 18	Cells, materials and biochemistry II	P 178	11.09.2017	15:15
Laser-induced cell injury in closed microphysiological systems: a novel method to study regeneration processes	Florian Schmieder (Fraunhofer IWS, Germany; University Hospital CGC Dresden, Germany); Deborah Förster (University Hospital CGC Dresden, Germany); Jan Sradnick (University Hospital CGC Dresden, Germany); Bernd Hohenstein (University Hospital CGC Dresden, Germany); Frank Sonntag (Fraunhofer IWS, Germany)	Poster session 19	Cells, materials and biochemistry III	P 182	11.09.2017	15:15
Development of a chemically defined adipocyte/endothelial cell culture system for the use as fatty tissue implant	Ann-Cathrin Volz (Reutlingen University, Germany; University of Hohenheim, Germany); Svenja Nellinger (Reutlingen University, Germany; University of Tuebingen, Germany); Petra Juliane Kluger (Reutlingen University, Germany; Fraunhofer Institute for Interfacial Engineering and Biotechnology, Germany)	Poster session 19	Cells, materials and biochemistry III	P 183	11.09.2017	15:15
Novel ceramic structural composites for personalized bone graft substitutes	Matthias Ahlhelm (Fraunhofer Gesellschaft, Germany); Eric Schwarzer (Fraunhofer Gesellschaft, Germany); Uwe Scheithauer (Fraunhofer Gesellschaft, Germany); Tassilo Moritz (Fraunhofer Gesellschaft, Germany); Alexander Michaelis (Fraunhofer Gesellschaft, Germany)	Poster session 19	Cells, materials and biochemistry III	P 184	11.09.2017	15:15
Concept development and prototyping of a flow cell for blood preparation with acoustophoresis	Felix Fiedler (Lübeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Alexandra Schlüter (Lübeck University of Applied Sciences (FHL), Germany); Christian Stark (Lübeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Benjamin Redmer (Lübeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Reza Behroozian (Lübeck University of Applied Sciences (FHL), Germany; University of Lübeck (UzL), Germany); Stefan Müller (Lübeck University of Applied Sciences (FHL), Germany)	Poster session 19	Cells, materials and biochemistry III	P 185	11.09.2017	15:15
Trace analysis of silver and implant components like titanium, aluminum and vanadium in biological samples	Marie Rinne (Leibniz Universität Hannover, Germany); Carla Vogt (Leibniz Universität Hannover, Germany)	Poster session 19	Cells, materials and biochemistry III	P 187	11.09.2017	15:15
Measurement of tumor marker having a biochemical function in DNA-replication and transcription	Karin Lenger (Institute for Scientific Homeopathy, Germany)	Poster session 19	Cells, materials and biochemistry III	P 190	11.09.2017	15:15
IT-based psychoacoustic auditory diagnostic methods: Expert knowledge vs. machine learning technology?	Birger Kollmeier (Universität Oldenburg, Germany)	Network session 1	IT based diagnostics of hearing	NW 1	11.09.2017	15:15
Intraoperative objective physiology based audiological methods	Hannes Maier (Medizinische Hochschule Hannover, Germany); Andreas Büchner (Medizinische Hochschule Hannover, Germany); Sabine Haumann (Medizinische Hochschule Hannover, Germany); Mohammad Ghoncheh (Medizinische Hochschule Hannover, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany)	Network session 1	IT based diagnostics of hearing	NW 2	11.09.2017	15:15
Common audiological functional parameters (CAFPAs): diagnostic concept	Mareike Buhl (Universität Oldenburg, Germany; Cluster of Excellence Hearing4all, Germany); Marc René Schädler (Universität Oldenburg, Germany; Cluster of Excellence Hearing4all, Germany); Anna Warzybok (Universität Oldenburg, Germany; Cluster of Excellence Hearing4all, Germany); Jörg Lücke (Cluster of Excellence Hearing4all, Germany; Universität Oldenburg, Germany); Birger Kollmeier (Universität Oldenburg, Germany; Cluster of Excellence Hearing4all, Germany)	Network session 1	IT based diagnostics of hearing	NW 3	11.09.2017	15:15
Audiological measurement methods and auditory models: What is the state-of-the-art?	Thomas Brand (Universität Oldenburg, Germany); Christopher Hauth (Universität Oldenburg, Germany)	Network session 1	IT based diagnostics of hearing	NW 4	11.09.2017	15:15
Forecast of hearing performance in cochlear implant candidates using a prediction model	Andreas Buechner (Medizinische Hochschule Hannover, Germany); Sabine Haumann (Medizinische Hochschule Hannover, Germany); Volker Hohmann (Carl von Ossietzky-Universität, Germany); Hannes Maier (Medizinische Hochschule Hannover, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany)	Network session 1	IT based diagnostics of hearing	NW 5	11.09.2017	15:15
Vorhersage des Versorgungserfolges mit Hörgeräten	Marc René Schädler (Carl von Ossietzky Universität, Germany); Anna Warzybok (Carl von Ossietzky Universität, Germany); Birger Kollmeier (Carl von Ossietzky Universität, Germany)	Network session 1	IT based diagnostics of hearing	NW 6	11.09.2017	15:15
Klinische Einführung: Forschungscampus M²OLIE	Steffen Diehl (Universitätsmedizin Mannheim, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 7	11.09.2017	15:15

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Multi-modal imaging	Frank G. Zöllner (Heidelberg University, Germany); Tanja Gaa (Heidelberg University, Germany); Wiebke Neumann (Heidelberg University, Germany); Gordian Kabelitz (Heidelberg University, Germany); Khanlian Chung (Heidelberg University, Germany); Barbara Trimborn (University of Applied Sciences Mannheim, Germany); Ivo Wolf (University of Applied Sciences Mannheim, Germany); Lothar R Schad (Heidelberg University, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 8	11.09.2017	15:15
Automation technologies in intervention rooms	Jan Stallkamp (Fraunhofer, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 9	11.09.2017	15:15
Mass spectrometry imaging-based molecular biopsy analysis in the Mannheim Molecular Intervention Environment (M²OLIE)	Carsten Hopf (Hochschule Mannheim, Germany); Denis A. Sammour (Hochschule Mannheim, Germany); Katrin Erich (Hochschule Mannheim, Germany); Jan-Hinrich Rabe (Hochschule Mannheim, Germany); Alexander Geisel (Hochschule Mannheim, Germany); Christian Marsching (Hochschule Mannheim, Germany); Alexander Marx (Universitätsmedizin Mannheim, Germany); Sandra Schulz (Hochschule Mannheim, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 10	11.09.2017	15:15
Radiopharmaceuticals for non-invasive diagnostic imaging and molecular radiotherapy	Shanna Litau (Medizinische Fakultät Mannheim der Universität Heidelberg, Germany; Medizinische Fakultät Mannheim der Universität Heidelberg, Germany); Carmen Wängler (Medizinische Fakultät Mannheim der Universität Heidelberg, Germany); Marc Pretze (Medizinische Fakultät Mannheim der Universität Heidelberg, Germany); Björn Wängler (Medizinische Fakultät Mannheim der Universität Heidelberg, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 11	11.09.2017	15:15
Robotic assisted applications inside the molecular interventional room.	Sven Clausen (Universitätsmedizin Mannheim, Germany); Andreas Rothfuss (Fraunhofer IPA, Germany); Frederik Wenz (Universitätsmedizin Mannheim, Germany); Jan Stallkamp (Fraunhofer IPA, Germany)	Network session 2	Mannheim Molecular Intervention Environment (M²OLIE) – a physical and technological approach to minimally invasive intervention for oligo-metastasised patients	NW 12	11.09.2017	15:15
Modular systems and lightweight construction concepts - new possibilities for the defect-specific treatment of hip joint diseases	Torsten Prietzel (HELIOS Klinik Blankenhain , Germany); Michael Schmidt (Universität Leipzig, Germany); Kopper Michael (Forschungs- und Transferzentrum e.V an der Westsächsischen Hochschule Zwickau, Germany); Thomas Töppel (Fraunhofer IWU, Germany); Sibylle Hanus (TITV Greiz - Das Institut für Spezialtextilien und flexible Materialien Textilforschungsinstitut Thüringen-Vogtland e.V., Germany); Ronny Grunert (Fraunhofer IWU, Germany; Universität Leipzig, Germany)	Network session 3	Therapy of diseases of the musculoskeletal system	NW 13	11.09.2017	15:15
Development of a measuring system for the investigation of the force and the damping situation during the making of conical clamping between THA-shaft and -head	Toni Wendler (Universitätsklinikum Leipzig – KOUP und Plastische Chirurgie, Germany); Dirk Jörg Zajonz (Universitätsklinikum Leipzig – KOUP und Plastische Chirurgie, Germany); Stefan Schleifenbaum (Universitätsklinikum Leipzig – KOUP und Plastische Chirurgie, Germany); Torsten Prietzel (HELIOS Klinik, Germany)	Network session 3	Therapy of diseases of the musculoskeletal system	NW 14	11.09.2017	15:15
Applied research in the field of medical engineering in interdisciplinary networks of physicans and engineers - challenges and results	Christian Rotsch (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Ronny Grunert (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Michael Werner (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany); Lars Mehlhorn (Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Germany)	Network session 3	Therapy of diseases of the musculoskeletal system	NW 15	11.09.2017	15:15
Non-invasive measurement of electroencephalographic and electromyographic signals for the development of a brain controlled muscle stimulation system	Marcus Löffler (University of Applied Sciences Zwickau, Germany); Nico Spahn (University of Applied Sciences Zwickau, Germany); Martin Heilemann (University of Applied Sciences Zwickau, Germany; University of Leipzig, Germany); Dominik Wetzel (University of Applied Sciences Zwickau, Germany); Eileen Stark (University of Applied Sciences Zwickau, Germany); Maria Löffler (University of Applied Sciences Zwickau, Germany); Ralf Hinderer (University of Applied Sciences Zwickau, Germany); Silke Kolbig (University of Applied Sciences Zwickau, Germany); Markus Seidel (University of Applied Sciences Zwickau, Germany); Dirk Winkler (University of Leipzig, Germany)	Network session 3	Therapy of diseases of the musculoskeletal system	NW 16	11.09.2017	15:15
Accuracy study of a 3D printed patient specific brain biopsy system for veterinary medicine	Marcel Müller (Fraunhofer IWU, Germany); Dirk Winkler (Universität Leipzig, Germany); Robert Möbius (ZESBO - Zentrum zur Erforschung der Stütz- und Bewegungsorgane, Germany); Thomas Flegel (Universität Leipzig, Germany); Sarah Hanemann (Universität Leipzig, Germany); Sebastian Scholz (Fraunhofer IWU, Germany); Ronny Grunert (ZESBO - Zentrum zur Erforschung der Stütz- und Bewegungsorgane, Germany; Fraunhofer IWU, Germany)	Network session 3	Therapy of diseases of the musculoskeletal system	NW 17	11.09.2017	15:15

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Proton minibeam therapy: reduction of side effects studied in a mouse ear model	Günther Dollinger (Universität der Bundeswehr München, Germany); Christoph Greubel (Universität der Bundeswehr München, Germany); Judith Reindl (Universität der Bundeswehr München, Germany); Stephanie Girst (Universität der Bundeswehr München, Germany); Benjamin Schwarz (Universität der Bundeswehr München, Germany); Christian Siebenwirth (Universität der Bundeswehr München, Germany); Dieter Walsh (Universität der Bundeswehr München, Germany); Katarina Ilicic (Universität der Bundeswehr München, Germany); Gabriele Multhoff (Universität der Bundeswehr München, Germany); Jan Wilkens (Universität der Bundeswehr München, Germany); Thomas E. Schmid (Universität der Bundeswehr München, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 76	11.09.2017	16:30
Proton minibeam sizes and their influence to reduced side effects in an in-vivo mouse ear model	Matthias Sammer (Universität der Bundeswehr München, Germany); Judith Reindl (Universität der Bundeswehr München, Germany); Esther Zahnbrecher (TU München, Germany); Christoph Greubel (Universität der Bundeswehr München, Germany); Stefanie Girst (Universität der Bundeswehr München, Germany); Benjamin Schwarz (Universität der Bundeswehr München, Germany); Christian Siebenwirth (Universität der Bundeswehr München, Germany); Dietrich W.M. Walsh (TU München, Germany; Universität der Bundeswehr München, Germany); Katarina Ilicic (TU München, Germany); Sophie Dobiasch (TU München, Germany); Jan J. Wilkens (TU München, Germany; Helmholtz Zentrum München, Germany); Thomas Schmid (TU München, Germany; Helmholtz Zentrum München, Germany); Günther Dollinger (Universität der Bundeswehr München, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 77	11.09.2017	16:30
Preparation of small animal irradiation experiements with laser-accelerated protons	Florian Kroll (Helmholtz-Zentrum Dresden - Rossendorf, Germany; Technische Universität Dresden, Germany); Elke Beyreuther (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Florian-Emanuel Brack (Helmholtz-Zentrum Dresden - Rossendorf, Germany; Technische Universität Dresden, Germany); Lennart Gaus (Helmholtz-Zentrum Dresden - Rossendorf, Germany; Technische Universität Dresden, Germany); Leonhard Karsch (OncoRay, Germany); Stephan Kraft (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Josefine Metzkes (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Jörg Pawelke (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay, Germany); Hans-Peter Schlenvoigt (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Michael Schürer (OncoRay, Germany); Karl Zeil (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Ulrich Schramm (Helmholtz-Zentrum Dresden - Rossendorf, Germany; Technische Universität Dresden, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 78	11.09.2017	16:30
Ion computed tomography: experimental results and clinical potential	Sebastian Meyer (Ludwig-Maximilians-Universität München, Germany); Lorena Magallanes (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Benedikt Kopp (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Thomas Tessonnier (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Maximilian Göppel (Ludwig-Maximilians-Universität München, Germany); Bernd Voss (GSI Helmholtz Centre for Heavy Ion Research, Germany); Florian Kamp (Ludwig-Maximilians-Universität München, Germany); Claus Belka (Ludwig-Maximilians-Universität München, Germany); David Joel Carlson (Yale University School of Medicine, United States); Chiara Gianoli (Ludwig-Maximilians-Universität München, Germany); Katia Parodi (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 79	11.09.2017	16:30
Analytical investigation on the role of ion radiography for Hounsfield Unit conversion into relative stopping power in ion beam therapy	Maximilian Göppel (Ludwig-Maximilians-Universität München, Germany); Sebastian Meyer (Ludwig-Maximilians-Universität München, Germany); Lorena Magallanes (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Benedikt Kopp (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Katia Parodi (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Chiara Gianoli (Ludwig-Maximilians-Universität München, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 80	11.09.2017	16:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Monte Carlo simulation and experimental validation of magnetic field effects on proton dose distributions	Sonja Schellhammer (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany); Armin Lühr (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany; German Cancer Consortium DKTK, Germany); Sebastian Gantz (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany); Brad Oborn (Wollongong Hospital, Australia; University of Wollongong, Australia); Omid Zarini (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Patrick Wohlfahrt (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany); Karl Zeil (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Michael Bussmann (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Aswin Hoffmann (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany; Department of Radiation Oncology, Germany)	Session 23	Radiation therapy III – Particle therapy II	V 81	11.09.2017	16:30
Dosimetric validation of T1/T2 only pseudo-CT for proton therapy	Giampaolo Pileggi (DKFZ, Germany; Magna Graecia University, Italy); Christoph Speier (Friedrich-Alexander University Erlangen-Nürnberg, Germany); Gregory Sharp (Massachusetts General Hospital, United States); Ciprian Catana (Athinoula A. Martinos Center for Biomedical Imaging, United States); Jennifer Pursley (Massachusetts General Hospital, United States); Joao Seco (DKFZ, Germany); Maria Francesca Spadea (Magna Graecia University, Italy)	Session 23	Radiation therapy III – Particle therapy II	V 82	11.09.2017	16:30
The relative stopping power accuracy of helium CT imaging evaluated using the Monte Carlo method.	Pierluigi Piersimoni (DKFZ, Germany); Vladimir Bashkirov (LOMA LINDA UNIVERSITY, United States); Bruce Faddegon (University of California San Francisco, United States); José Ramos Méndez (University of California San Francisco, United States); Reinhard Schulte (LOMA LINDA UNIVERSITY, United States); Joao Seco (DKFZ, Germany)	Session 24	Imaging and image processing II – X-Ray and multimodal imaging	V 83	11.09.2017	16:30
Detection of cherenkov light from compton scattered electrons for medical applications	Ayesha Ali (Universität Siegen, Germany); Hedia Bäcker (Universität Siegen, Germany); Reimund Bayerlein (Universität Siegen, Germany); Randy Brill (Universität, United States); Rainer Brück (Universität, Germany); Tuba Conka (Universität, United States); Ivor Fleck (Universität Siegen, Germany); Lars Furenlid (Universität, United States); Stefan Heidbrink (Universität Siegen, Germany); Waleed Khalid (Universität Siegen, Germany); Matthias Mielke (Universität, Germany); Rico Schmidtbauer (Universität Siegen, Germany); Albert Walenta (Universität Siegen, Germany); Ulrich Werthenbach (Universität Siegen, Germany); Jens Winter (Universität Siegen, Germany); Michael Ziolkowski (Universität Siegen, Germany)	Session 24	Imaging and image processing II – X-Ray and multimodal imaging	V 85	11.09.2017	16:30
Development of a tissue-equivalent phantom for multimodal imaging of the prostate	Marie Wegner (Technische Universität Hamburg, Germany; Universitätsklinikum Hamburg Eppendorf, Germany); Johanna Spallek (Technische Universität Hamburg, Germany); Michael Kaul (Universitätsklinikum Hamburg Eppendorf, Germany); Marco Mittag (Universität Hamburg, Germany); Elisabetta Gargioni (Universitätsklinikum Hamburg Eppendorf, Germany)	Session 24	Imaging and image processing II – X-Ray and multimodal imaging	V 86	11.09.2017	16:30
Performance evaluation of MADPET4: a high resolution preclinical PET insert for 7T MRI	Negar Omidvari (Klinikum rechts der Isar, Germany); Jorge Cabello (Klinikum rechts der Isar, Germany); Geoffrey Topping (Klinikum rechts der Isar, Germany); Florian R. Schneider (Klinikum rechts der Isar, Germany; Now with KETEK GmbH, Germany); Stephan Paul (Technische Universität München, Germany); Sibylle I. Ziegler (Klinikum rechts der Isar, Germany; Klinikum der Universität München, Germany)	Session 24	Imaging and image processing II – X-Ray and multimodal imaging	V 87	11.09.2017	16:30
Heat resistant electronic modules for traceable intelligent medical sterile containers	Lukas Böhler (Aesculap AG, Germany; AGH University of Science and Technology, Poland); Mateusz Daniol (Aesculap AG, Germany; AGH University of Science and Technology, Poland); Anton Keller (Aesculap AG, Germany); Ryszard Sroka (AGH University of Science and Technology, Poland)	Session 25	User friendliness, risk management and hospital technology	V 88	11.09.2017	16:30
Sterilisable energy source for intelligent medical containers	Mateusz Daniol (Aesculap AG, Germany; AGH University of Science and Technology, Poland); Lukas Böhler (Aesculap AG, Germany; AGH University of Science and Technology, Poland); Anton Keller (Aesculap AG, Germany); Ryszard Sroka (AGH University of Science and Technology, Poland)	Session 25	User friendliness, risk management and hospital technology	V 89	11.09.2017	16:30

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Model to assess the impact on patient hypothermia of different ventilation systems in the operating room	Clemens Bulitta (Ostbayerische Technische Hochschule Amberg-Weiden, Germany); Dominik Lobenhofer (Ostbayerische Technische Hochschule Amberg-Weiden, Germany); Sebastian Buhl (Ostbayerische Technische Hochschule Amberg-Weiden, Germany)	Session 25	User friendliness, risk management and hospital technology	V 92	11.09.2017	16:30
4K vs HD resolution in laparoscopic surgery	Jonas Johannink (Universitätsklinikum Tübingen, Germany); Melanie Moroff (Universitätsklinikum Tübingen, Germany); Johanna Miller (Universitätsklinikum Tübingen, Germany); Peter Wilhelm (Universitätsklinikum Tübingen, Germany); Andreas Kirschniak (Universitätsklinikum Tübingen, Germany)	Session 25	User friendliness, risk management and hospital technology	V 93	11.09.2017	16:30
Risk management in radiotherapy - patient identification and patient verification	Jörg Licher (Universitätsklinikum Frankfurt, Germany); Janett Köhn (Universitätsklinikum Frankfurt, Germany); Britta Loutfi-Krauß (Universitätsklinikum Frankfurt, Germany); Christian Scherf (Universitätsklinikum Frankfurt, Germany); Ulla Ramm (Universitätsklinikum Frankfurt, Germany)	Session 25	User friendliness, risk management and hospital technology	V 94	11.09.2017	16:30
Cortical thickness and porosity assessment on ex-vivo tibiae using axial ultrasound transmission	Johannes Schneider (Charité Universitätsmedizin Berlin, Germany); Donatien Ramiandriosa (Charité Universitätsmedizin Berlin, Germany; Sorbonne Universities, France); Gianluca Iori (Charité Universitätsmedizin Berlin, Germany); Melanie Gräsel (Universitätsklinikum Schleswig-Holstein, Germany); Reinhard Barkmann (Universitätsklinikum Schleswig-Holstein, Germany); Kay Raum (Charité Universitätsmedizin Berlin, Germany); Pascal Laugier (Sorbonne Universities, France); Jean-Gabriel Minonzio (Sorbonne Universities, France)	Session 26	Biosignal processing and monitoring II	V 96	11.09.2017	16:30
The influence of gestational age on the maternal–foetal causal cardiac coupling	Andreas Voss (Ernst-Abbe-Hochschule Jena, Germany); Steffen Schulz (Ernst-Abbe-Hochschule Jena, Germany); Ahsan Khandoker (Ernst-Abbe-Hochschule Jena, Germany)	Session 26	Biosignal processing and monitoring II	V 98	11.09.2017	16:30
Screening for sleep apnea in routine Holter ECGs – a prospective evaluation	Christoph Maier (Hochschule Heilbronn, Germany); Hartmut Dickhaus (Universitätsklinikum Heidelberg, Germany); Hugo Katus (Universitätsklinikum Heidelberg, Germany); Jörg Friedrich (Universitätsklinikum Heidelberg, Germany)	Session 26	Biosignal processing and monitoring II	V 100	11.09.2017	16:30
Bioelectronic medicine – promises and challenges	Thomas Stieglitz (University of Freiburg, Germany)	Session 27	Bioelectronics and electroceuticals	FS 37	11.09.2017	16:30
Nerve cuff electrodes for electrically interfacing with the peripheral nervous system	Martin Schuettler (CorTec GmbH, Germany); Colin Bierbrauer (CorTec GmbH, Germany); Ronny Pfeifer (CorTec GmbH, Germany); Miguel Ulloa (CorTec GmbH, Germany); Christian Henle (CorTec GmbH, Germany); Joern Rickert (CorTec GmbH, Germany)	Session 27	Bioelectronics and electroceuticals	FS 38	11.09.2017	16:30
Bioelectronic approach for diabetes therapy	René von Metzen (Universität Tübingen, Germany); Udo Kraushaar (Universität Tübingen, Germany); Alfred Stett (Universität Tübingen, Germany)	Session 27	Bioelectronics and electroceuticals	FS 39	11.09.2017	16:30
Baroloop – selective vagal stimulation to treat hypertension	Dennis Plachta (neuroloop, Germany)	Session 27	Bioelectronics and electroceuticals	FS 40	11.09.2017	16:30
Device-mediated-therapy – a neurosurgeon"s perspective on implant design and device location	Mortimer Gierthmühlen (Klinik für Neurochirurgie, Germany); Dennis Plachta (Klinik für Neurochirurgie, Germany); Thomas Stieglitz (Klinik für Neurochirurgie, Germany); Josef Zentner (Klinik für Neurochirurgie, Germany)	Session 27	Bioelectronics and electroceuticals	FS 41	11.09.2017	16:30
Exposure in CT: Measurements of CTDI and DLP, guidelines and diagnostic reference levels	Georg Stamm (Universitätsmedizin Göttingen, Germany); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Session 28	CT-optimisation I	FS 42	11.09.2017	16:30
Parameters that influence image quality and dose	Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Session 28	CT-optimisation I	FS 43	11.09.2017	16:30
Three-dimensional calculation against mutually changed isodoses in brachytherapy due to inhomogeneity-based dose calculations	Mathias Walke (Universitätsklinikum Magdeburg, Germany); Yuliya Durnyeva (Universitätsklinikum Magdeburg, Germany); Peter Hass (Universitätsklinikum Magdeburg, Germany); Jan Scheermann (Universitätsklinikum Magdeburg, Germany); Sebastian Senz (Universitätsklinikum Magdeburg, Germany); Caroline Gabriel (Universitätsklinikum Magdeburg, Germany); Günther Gademann (Universitätsklinikum Magdeburg, Germany)	Session 29	Comparison of TG-43 and advanced dose calculation algorithms	FS 44	11.09.2017	16:30
Impact of heterogeneity-corrected dose calculation using a grid-based Boltzmann solver on breast and cervix cancer brachytherapy	Julia Hofbauer (Krankenhaus Hietzing, Austria; Medical University of Vienna, Austria); Christian Kirisits (Medical University of Vienna, Austria; Medical University of Vienna, Austria); Alexandra Resch (Medical University of Vienna, Austria); Yingjie Xu (Chinese Academy of Medical Sciences, China); Alina Sturdza (Medical University of Vienna, Austria); Richard Pötter (Medical University of Vienna, Austria; Medical University of Vienna, Austria); Nicole Nesvacil (Medical University of Vienna, Austria; Medical University of Vienna, Austria)	Session 29	Comparison of TG-43 and advanced dose calculation algorithms	FS 46	11.09.2017	16:30

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Phantom study to compare dose calculation in Oncentra Brachy TG-43 and ACE for skin treatments with superficial mould (Freiburg-Flab)	Renate Walter (Klinikum Augsburg, Germany); Frank Hensley (Ruprechts-Karl-Universität Heidelberg, Germany); Jürgen Kopp (Klinikum Augsburg, Germany); Georg Stüben (Klinikum Augsburg, Germany); Nikolaos Balagiannis (Klinikum Augsburg, Germany)	Session 29	Comparison of TG-43 and advanced dose calculation algorithms	FS 47	11.09.2017	16:30
High-speed kV-CBCT lung cancer imaging within single breath-hold: dose exposure and image quality phantom study	Anna Arns (Universitaetsmedizin Mannheim, Germany); Jens Fleckenstein (Universitaetsmedizin Mannheim, Germany); Frank Schneider (Universitaetsmedizin Mannheim, Germany); Volker Steil (Universitaetsmedizin Mannheim, Germany); Frederik Wenz (Universitaetsmedizin Mannheim, Germany); Hansjoerg Wertz (Universitaetsmedizin Mannheim, Germany)	Session 30	Radiation therapy IV – Tracking	V 102	12.09.2017	08:30
Is the assumption correct that the human body is rigid during couch tracking?	Alexander Jöhl (ETH Zürich, Switzerland; UniversitätsSpital Zürich, Switzerland); Marta Bogowicz (UniversitätsSpital Zürich, Switzerland; Universität Zürich, Switzerland); Stefanie Ehrbar (UniversitätsSpital Zürich, Switzerland; Universität Zürich, Switzerland); Matthias Guckenberger (UniversitätsSpital Zürich, Switzerland; Universität Zürich, Switzerland); Stephan Klöck (UniversitätsSpital Zürich, Switzerland; Universität Zürich, Switzerland); Mirko Meboldt (ETH Zürich, Switzerland); Melanie Zeilinger (ETH Zürich, Switzerland); Marianne Schmid Daners (ETH Zürich, Switzerland); Stephanie Tanadini-Lang (UniversitätsSpital Zürich, Switzerland; Universität Zürich, Switzerland)	Session 30	Radiation therapy IV – Tracking	V 103	12.09.2017	08:30
Dynamic treatment-couch tracking for motion mitigation during prostate SBRT – a geometric and dosimetric validation study	Stefanie Ehrbar (UniversityHospital Zurich and University of Zurich, Switzerland); Simon Schmid (UniversityHospital Zurich and University of Zurich, Switzerland); Alexander Jöhl (UniversityHospital Zurich and University of Zurich, Switzerland; ETH Zurich, Switzerland); Stephan Klöck (UniversityHospital Zurich and University of Zurich, Switzerland); Matthias Guckenberger (UniversityHospital Zurich and University of Zurich, Switzerland); Oliver Riesterer (UniversityHospital Zurich and University of Zurich, Switzerland); Stephanie Tanadini-Lang (UniversityHospital Zurich and University of Zurich, Switzerland)	Session 30	Radiation therapy IV – Tracking	V 104	12.09.2017	08:30
Motion extraction from 4D-MRI for MR-guided particle therapy of pancreatic cancer	Kai Dolde (DKFZ, Germany); Florian Maier (DKFZ, Germany); Patrick Naumann (Universitätsklinik, Germany); Regula Gnirs (DKFZ, Germany); Asja Pfaffenberger (DKFZ, Germany); Nami Saito (DKFZ, Germany; Universitätsklinik, Germany)	Session 30	Radiation therapy IV – Tracking	V 105	12.09.2017	08:30
Monte Carlo framework for the evaluation of interplay effects between dose application and respiratory motion	Asmus von Münchow (LMU Munich, Germany; LMU Munich, Germany); Katrin Straub (LMU Munich, Germany); Jan Hofmaier (LMU Munich, Germany; LMU Munich, Germany); Philipp Freislederer (LMU Munich, Germany); Christian Heinz (LMU Munich, Germany); Michael Reiner (LMU Munich, Germany); Christian Thieke (LMU Munich, Germany); Matthias Söhn (LMU Munich, Germany); Markus Alber (Heidelberg University Hospital, Germany); Ralf Floca (German Cancer Research Center (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Germany); Claus Belka (LMU Munich, Germany); Katia Parodi (LMU Munich, Germany); Florian Kamp (LMU Munich, Germany)	Session 30	Radiation therapy IV – Tracking	V 106	12.09.2017	08:30
Magnetic-field measurement and simulation of a field-free line magnetic-particle scanner	Jan Stelzner (Universität zu Lübeck, Germany); Thorsten M. Buzug (Universität zu Lübeck, Germany)	Session 31	Imaging and image processing III – Nanoparticle imaging and MRI	V 107	12.09.2017	08:30
Transportable magnetorelaxometry device for quantification and characterization of magnetic nanoparticles	Patricia Radon (Physikalisch-Technische Bundesanstalt, Germany); Maik Liebl (Physikalisch-Technische Bundesanstalt, Germany); Dirk Gutkelch (Physikalisch-Technische Bundesanstalt, Germany); Frank Wiekhorst (Physikalisch-Technische Bundesanstalt, Germany)	Session 31	Imaging and image processing III – Nanoparticle imaging and MRI	V 108	12.09.2017	08:30
Magnetic resonance imaging versus histology: Do they really measure the same?	Cindy Elschner (Leibniz-Institut für Polymerforschung Dresden e.V., Germany); Paula Korn (Universitätsklinikum »Carl Gustav Carus«,); Maria Hauptstock (Universitätsklinikum »Carl Gustav Carus«,); Matthias C. Schulz (Universitätsklinikum »Carl Gustav Carus«,); Ursula Range (Universitätsklinikum »Carl Gustav Carus«, Germany); Ulrich Scheler (Leibniz-Institut für Polymerforschung Dresden e.V., Germany)	Session 31	Imaging and image processing III – Nanoparticle imaging and MRI	V 109	12.09.2017	08:30
Organs contours by equipotential lines and adjustment to edges in CT images	Janine Becker (Helmholtz Zentrum München, Germany); Oleg Tischenko (Helmholtz Zentrum München, Germany); Mattia Fedrigo (Helmholtz Zentrum München, Germany)	Session 31	Imaging and image processing III – Nanoparticle imaging and MRI	V 112	12.09.2017	08:30
Contactless measurement of the arterial oxygen saturation	Christian Schiffer (Hochschule Trier, Germany); Andreas Diewald (Hochschule Trier, Germany); René Thull (Hochschule Trier, Germany)	Session 32	Medical measuring techniques II	V 114	12.09.2017	08:30

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Handheld endoscopic device for in vivo morphological imaging of the human oral mucosa by optical coherence tomography	Julia Walther (TU Dresden, Germany; TU Dresden, Germany); Christian Schnabel (TU Dresden, Germany); Nadja Ebert (TU Dresden, Germany); Michael Baumann (TU Dresden, Germany); Edmund Koch (TU Dresden, Germany)	Session 32	Medical measuring techniques II	V 115	12.09.2017	08:30
Process improvement of locking intramedullary nails	Sebastian Waltehr (ICM-Institut Chemnitzer Maschinen- und Anlagenbau e.V., Germany); Andreas Grundmann (ICM-Institut Chemnitzer Maschinen- und Anlagenbau e.V., Germany); Jens Biedermann (Medizin & Service GmbH, Germany); Jens Wutzler (Klinikum Chemnitz gGmbH, Germany)	Session 32	Medical measuring techniques II	V 116	12.09.2017	08:30
Evoked potentials from transcutaneous spinal cord stimulation	Thordur Helgason (Reykjavik University / Landspitali Uni Krankenh, Iceland); Gudbjörg Ludvigsdottir (Landspitali - Uni Hospital, Iceland); Bragi Arnason (Reykjavik University / Landspitali Uni Krankenh, Iceland); Vilborg Gudmundsdottir (Landspitali - Uni Hospital, Iceland); Gigja Magnusdottir (Landspitali - Uni Hospital, Iceland); Jose Luis Vargas Luna (Medical University of Vienna, Austria); Matthias Krenn (Medical University of Vienna, Austria); Winfried Mayr (Medical University of Vienna, Austria)	Session 32	Medical measuring techniques II	V 117	12.09.2017	08:30
Realization and testing of a 3D electrode array for measuring electric potential differences in a volume conductor	René Machts (Technische Universität Ilmenau, Germany); Alexander Hunold (Technische Universität Ilmenau, Germany); Jens Haueisen (Technische Universität Ilmenau, Germany)	Session 32	Medical measuring techniques II	V 118	12.09.2017	08:30
Individualized design of fluidically actuated cochlear implants	Silke Hügl (Medizinische Hochschule Hannover, Germany); Lena Zentner (Ilmenau University of Technology, Germany); Stefan Griebel (Ilmenau University of Technology, Germany); Omid Majdani (Medizinische Hochschule Hannover, Germany; Medizinische Hochschule Hannover, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany; Medizinische Hochschule Hannover, Germany); Thomas S. Rau (Medizinische Hochschule Hannover, Germany)	Session 33	Modelling and simulation II	V 119	12.09.2017	08:30
Comparison between intraopereative and chronic deep brain stimulation	Dorian Vogel (Fachhochschule Nordwestschweiz, Switzerland); Fabiola Alonso (University, Sweden); Karin Wårdell (University, Sweden); Simone Hemm (Fachhochschule Nordwestschweiz, Switzerland)	Session 33	Modelling and simulation II	V 120	12.09.2017	08:30
Simulation of light propagation in human skin and skull for the development of sensor system to measure the cerebral oxygen saturation non-invasively	Marian Rabe (Universität Rostock, Germany); Ulrich Timm (Universität Rostock, Germany); Jens Kraitl (Universität Rostock, Germany); Hartmut Ewald (Universität Rostock, Germany)	Session 33	Modelling and simulation II	V 121	12.09.2017	08:30
The DAAD Pagel Project "Supporting Medical Physics Education in Bangladesh"	Hensley Frank (Ruprecht Karls Universität, Germany); Volker Steil (Universitätsklinikum, Germany); Hasin Anupama Azhari (Gono Bishwabidyalay (University), Bangladesh); Flavia Molina (Universitätsklinikum, Germany); Golam Abu Zakaria (Klinikum Oberberg, Germany)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 48	12.09.2017	08:30
Cooperation in medical physics between Heidelberg University in Germany and Gono University in Bangladesh	Golam Abu Zakaria (Gummersach Hospital, Germany; Gono Bishwabidyalay (University), Bangladesh); Hasin Anupama Azhari (Gono Bishwabidyalay (University), Bangladesh); Volker Steil (Heidelberg University, Germany); Frank Hensley (Heidelberg University, Germany); Renate Walter (Klinikum Augusburg, Germany)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 50	12.09.2017	08:30
Gesundheitswesen und medizinische Physik in Vietnam	Ulrich Wolf (Universitätsklinikum Leipzig, Germany)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 51	12.09.2017	08:30
Medizinische Physik in Katar	Kai Schubert (Universitätsklinikum Heidelberg, Germany)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 52	12.09.2017	08:30
MephidA e.V., enhancing cancer care in low-resource countries	Ndimofor Chofor (Strahlentherapie Leer, Germany); Zanzem Atem Tung (Zentrum für Strahlentherapie und Radioonkologie , Germany); Pierre Bopda (AGAPLESION DIAKONIEKLINIKUM ROTENBURG gemeinnützige GmbH, Germany); Yao Thierry Joël Kra (Medizinisches Versorgungszentrum Lörrach, Germany); Rebecca Bücker (FUS-Bottrop, Germany); ERNEST Okonkwo (Ortenau Klinikum Offenburg-Gengenbach, Germany)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 53	12.09.2017	08:30
Experiences with installation, maintenance and expansion of a radio oncology department in Ghana (The Sweden Ghana Medical Centre - SGMC)	Bernhard Schiestl (Univ. Klinik Innsbruck, Austria)	Session 34	Medical physics and biomedical enigneering in the developing countries – Education and profession	FS 54	12.09.2017	08:30
Presentation of case studies for CT-protocol optimization.	Bernhard Renger (Inst. f. Radiologie /TU-München, Germany)	Session 35	CT-optimisation II	FS 55	12.09.2017	08:30
Discussion of the case studies	Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Session 35	CT-optimisation II	FS 56	12.09.2017	08:30
Proposal for Solutions.	Georg Stamm (Univertätsmedizin Göttingen, Georg-August-Universität , Germany)	Session 35	CT-optimisation II	FS 57	12.09.2017	08:30

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Status, limitations, and perspectives of current applications of pre-treatment computed tomography in radiation oncology	Steffen Greilich (Heidelberg Institute of Radiation Oncology (HIRO), Germany; German Cancer Research Center (DKFZ), Germany); Christian Richter (OncoRay - National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 58	12.09.2017	08:30
Dual-energy CT for photon therapy – benefits and limitations	Christian Möhler (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), Germany); Patrick Wohlfahrt (OncoRay - National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Christian Richter (OncoRay - National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Department of Radiotherapy and Radiation Oncology, Germany; German Cancer Consortium (DKTK), Germany); Steffen Greilich (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 59	12.09.2017	08:30
Dual-energy CT for particle therapy – benefits and limitations	Patrick Wohlfahrt (OncoRay - National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Christian Möhler (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), Germany); Steffen Greilich (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), Germany); Christian Richter (OncoRay - National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Department of Radiotherapy and Radiation Oncology, Germany; German Cancer Consortium (DKTK), Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 60	12.09.2017	08:30
Radiomics-prediction of patient-specific outcome using pre-treatment CT imaging	Alex Zwanenburg (National Center for Tumor Diseases, partner site Dresden, Germany; OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf, Germany; German Cancer Research Center (DKFZ), Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 61	12.09.2017	08:30
CT-radiomics to assess biological and functional tumor properties	Daniela Thorwarth (Eberhard Karls Universität Tübingen, Germany); Jairo Socarras Fernandez (Eberhard Karls Universität Tübingen, Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 62	12.09.2017	08:30
Do we need improved (dual-energy) CT imaging?	Esther Troost (Universitätsklinikum Carl Gustav Carus, Germany)	Session 36	High-precision radiotherapy – Do we need better pre-treatment CT imaging?	FS 63	12.09.2017	08:30
Towards alanine/ESR as a secondary standard for dosimetry in magnetic fields	Raya Roshana Gallas (Physikalisch-Technische Bundesanstalt (PTB), Germany); Thomas Hackel (Physikalisch-Technische Bundesanstalt (PTB), Germany); Ariane Fillmer (Physikalisch-Technische Bundesanstalt (PTB), Germany); Ralf-Peter Kapsch (Physikalisch-Technische Bundesanstalt (PTB), Germany)	Session 37	Young investigator forum	V 124	12.09.2017	10:30
Calorimetric determination of the kQ factor – Towards high precision dosimetry of clinical carbon ion beams	Julia-Maria Osinga-Blättermann (Physikalisch-Technische Bundesanstalt (PTB), Germany; Deutsches Krebsforschungszentrum (DKFZ), Germany); Ulrike Ankerhold (Physikalisch-Technische Bundesanstalt (PTB), Germany); Stephan Brons (Heidelberger Ionenstrahl-Therapiezentrum (HIT), Germany); Steffen Greilich (Deutsches Krebsforschungszentrum (DKFZ), Germany; National Center for Radiation Research in Oncology (NCRO), Heidelberg Institute for Radiation Oncology (HIRO), Germany); Oliver Jäkel (Heidelberger Ionenstrahl-Therapiezentrum (HIT), Germany; Deutsches Krebsforschungszentrum (DKFZ), Germany); Achim Krauss (Physikalisch-Technische Bundesanstalt (PTB), Germany)	Session 37	Young investigator forum	V 125	12.09.2017	10:30
Determination of RBE-weighted dose-response curves for MRI-detected radiation-induced temporal lobe reactions in patients: comparison between proton and carbon ion irradiations	Clarissa Gillmann (University Hospital Erlangen, Germany); Tony Lomax (Paul Scherrer Institute , Switzerland); Damien Weber (Paul Scherrer Institute , Switzerland); Oliver Jäkel (German Cancer Research Center, Germany); Christian Karger (German Cancer Research Center, Germany)	Session 37	Young investigator forum	V 127	12.09.2017	10:30
A novel treatment approach after glioblastoma resection: microcontroller-based surgical implant with light-emitting diods for postoperative irradiation of glioblastoma cells	Nicolas Bader (Hochschule Ulm, Germany); Felix Capanni (Hochschule Ulm, Germany); Marc-Eric Halatsch (Universität Ulm, Germany); Richard E. Kast (IIAIGC Study Center, United States); Christian Peschmann (Universität Ulm, Germany)	Session 38	Organ and patient support systems II	V 129	12.09.2017	10:30

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Low energy electron beam sterilization for novel interactive implants and their components	Jessy Schönfelder (Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Germany); Javier Portillo (Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Germany); Gaby Gotzmann (Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Germany); Marleen Dietze (Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Germany); Frank-Holm Rögner (Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Germany)	Session 38	Organ and patient support systems II	V 132	12.09.2017	10:30
Development of a controlled-occluding membrane as a stent graft component for spinal cord ischaemia prophylaxis	Alexander Loewen (Institut für Textiltechnik der RWTH Aachen, Germany); Alexander Gombert (Klinik für Gefäßchirurgie der Uniklinik RWTH Aachen, Germany); Larissa Hussmann (DWI – Leibniz-Institut für Interaktive Materialien e.V., Germany); Drosos Kotelis (Klinik für Gefäßchirurgie der Uniklinik RWTH Aachen, Germany); Alexander Töpel (DWI – Leibniz-Institut für Interaktive Materialien e.V., Germany); Sabrina Thies (DWI – Leibniz-Institut für Interaktive Materialien e.V., Germany); Valentine Gesché (Institut für Textiltechnik der RWTH Aachen, Germany); Andrij Pich (DWI – Leibniz-Institut für Interaktive Materialien e.V., Germany); Michael Jacobs (Klinik für Gefäßchirurgie der Uniklinik RWTH Aachen, Germany); Thomas Gries (Institut für Textiltechnik der RWTH Aachen, Germany); Stefan Jockenhoevel (Institut für Textiltechnik der RWTH Aachen, Germany; Institut für Angewandte Medizintechnik, Helmholtz-Institut der RWTH Aachen, Germany)	Session 38	Organ and patient support systems II	V 133	12.09.2017	10:30
Modelling of NTCP for acute side effects in patients with prostate cancer or brain tumours receiving proton therapy	Almut Dutz (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany); Linda Agolli (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Esther G.C. Troost (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Mechthild Krause (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Michael Baumann (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Armin Lühr (OncoRay – National Center for	Session 39	Modelling and simulation III	V 134	12.09.2017	10:30
Can radiomics of the tumor metabolism predict local recurrences in head and neck squamous cell carcinoma?	Stephanie Tanadini-Lang (University of Zurich, Switzerland); Marta Bogowicz (University of Zurich, Switzerland); Luisa Sabrina Stark (University of Zurich, Switzerland); Gabriela Studer (University of Zurich, Switzerland); Jan Unkelbach (University of Zurich, Switzerland); Matthias Guckenberger (University of Zurich, Switzerland); Oliver Riesterer (University of Zurich, Switzerland)	Session 39	Modelling and simulation III	V 135	12.09.2017	10:30

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Novel approach for integrating motion variability into 4D-dose reconstruction for extracranial SBRT	Thilo Sothmann (Universitätsklinikum Hamburg-Eppendorf, Germany; Universitätsklinikum Hamburg-Eppendorf, Germany); Tobias Gauer (Universitätsklinikum Hamburg-Eppendorf, Germany); Matthias Wilms (Universität zu Lübeck, Germany); René Werner (Universitätsklinikum Hamburg-Eppendorf, Germany)	Session 39	Modelling and simulation III	V 136	12.09.2017	10:30
Process optimization in medical care by technical innovations and digitization	Michael Czaplik (Uniklinik RWTH Aachen, Germany)	Session 40	Trends in patient monitoring and emergency care	FS 64	12.09.2017	10:30
Experience with two measurement modalities to objectify pulse palpation during cardio-pulmonary resuscitation	Jens Mühlsteff (Philips Research Europe, Netherlands); Ralph Wijshoff (Philips Research Europe, Netherlands); Dawn Jorgenson (Philips , United States); Pierre Woerlee (Eindhoven University of Technology, Netherlands); Gerrit Jan Noordergraaf (Elisabeth-Tweesteden Hospital, Netherlands); Lance B. Becker (NSUH - Dept of Emergency Medicine, United States); Joshua W. Lampe (NSUH - Dept of Emergency Medicine, United States); Pia Hubner (Medical University, Austria); Fritz Sterz (Medical University, Austria); James K. Russell (Russell Biomedical Research Consulting, United States); Christian Meyer (UKE Eppendorf University Hospital Hamburg, Germany)	Session 40	Trends in patient monitoring and emergency care	FS 65	12.09.2017	10:30
Cardiac support in emergency situations	Katrin Lunze (Abiomed Europe GmbH, Germany); Christoph Nix (Abiomed Europe GmbH, Germany); Thorsten Sieß (Abiomed Europe GmbH, Germany)	Session 40	Trends in patient monitoring and emergency care	FS 67	12.09.2017	10:30
Integrating Clinical Demands into Developing and Testing of Novel Devices	Michael Buschermöhle (KIZMO GmbH, Germany); Markus Meis (KIZMO GmbH, Germany)	Session 41	Innovation management in medical engineering	FS 70	12.09.2017	10:30
Cooperative patent classification as a mean of validation for support vector machine learning: case study in biomedical emerging fields of technology	Nader Hamadeh (RWTH Aachen University, Germany); Mark Bukowski (RWTH Aachen University, Germany); Thomas Schmitz-Rode (RWTH Aachen University, Germany); Robert Farkas (RWTH Aachen University, Germany)	Session 41	Innovation management in medical engineering	FS 71	12.09.2017	10:30
Opportunities and threats in accelerating the innovation transfer in medical engineering	Volker Wiechmann (medways e.V., Germany)	Session 41	Innovation management in medical engineering	FS 72	12.09.2017	10:30
User interaction torque monitoring of a 7-DOF upper-limb exoskeleton with IMU-based motion input	Markus Hessinger (Technische Universität Darmstadt, Germany); Arthur Buchta (Technische Universität Darmstadt, Germany); Eike Christmann (Technische Universität Darmstadt, Germany); Roland Werthschützky (Technische Universität Darmstadt, Germany); Mario Kupnik (Technische Universität Darmstadt, Germany)	Session 42	Human-machine-interaction in medicine – New approaches and current challenges	FS 73	12.09.2017	10:30
Situation detection in a powered lower limb orthosis	Jürgen Hielscher (Technische Universität Darmstadt, Germany); Sascha Schlemmer (Technische Universität Darmstadt, Germany); Markus Hessinger (Technische Universität Darmstadt, Germany); Christian Hatzfeld (Technische Universität Darmstadt, Germany); Roland Werthschützky (Technische Universität Darmstadt, Germany); Mario Kupnik (Technische Universität Darmstadt, Germany)	Session 42	Human-machine-interaction in medicine – New approaches and current challenges	FS 74	12.09.2017	10:30
Haptic assistive systems for precise and gentle interventions	Christian Hatzfeld (TU Darmstadt, Germany); Johannes Bilz (TU Darmstadt, Germany); Carsten Neupert (TU Darmstadt, Germany); Nataliya Stefanova (TU Darmstadt, Germany); Roland Werthschützky (TU Darmstadt, Germany); Mario Kupnik (TU Darmstadt, Germany)	Session 42	Human-machine-interaction in medicine – New approaches and current challenges	FS 75	12.09.2017	10:30
Medical Apps - To be or not to be (a medical device)?	Michael Imhoff (Ruhr-Universität Bochum, Germany)	Session 43	Digital health data for individualised medicine and care	FS 77	12.09.2017	10:30
Digitale Prozessketten in der Medizintechnik	Michael Wehmöller (Fakultät Wirtschaftsingenieurwesen Ostbayerische Technische Hochschule (OTH) , Germany)	Session 43	Digital health data for individualised medicine and care	FS 78	12.09.2017	10:30
EPItect - usage of an in-ear sensor as well as patient data to detect and document epileptic seizure patterns	Salima Houta (Fraunhofer-Institut für Software- und Systemtechnik, Germany)	Session 43	Digital health data for individualised medicine and care	FS 79	12.09.2017	10:30
Using wearables for decentralized individual long-term patient monitoring - a generic gateway architecture for multimodal sensor integration	Thomas Walzer (Hochschule Reutlingen, Germany); Natividad Martinez Madrid (Hochschule Reutlingen, Germany); Nisar P. Malek (Universität Tübingen, Germany); Oliver Burgert (Hochschule Reutlingen, Germany); Christian Thies (Hochschule Reutlingen, Germany)	Session 43	Digital health data for individualised medicine and care	FS 80	12.09.2017	10:30
A system to improve the hand sanitation in clinical environments	Lars Bölecke (Technische Universität Ilmenau, Germany); Johannes Freckmann (Technische Universität Ilmenau, Germany); Daniel Laqua (Technische Universität Ilmenau, Germany); Peter Husar (Technische Universität Ilmenau, Germany)	Poster session 20	User friendliness, risk management and hospital technology	P 193	12.09.2017	15:00
Establishment of a quality control system in diagnostic imaging in Northern Iraq	Robin Etzel (Technische Hochschule Mittelhessen, Germany); Hariwan Abdulkareem Mohammed (University of Duhok, Iraq); Haval Younis Yacoob Aldosky (University of Duhok, Iraq); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Poster session 20	User friendliness, risk management and hospital technology	P 194	12.09.2017	15:00

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Risks related to infusion pumps - First steps towards building up a device-specific ontology	Robin Seidel (Bundesinstitut für Arzneimittel und Medizinprodukte, Germany); Katrin Tamm (Bundesinstitut für Arzneimittel und Medizinprodukte, Germany); Ekkehard Stößlein (Bundesinstitut für Arzneimittel und Medizinprodukte, Germany); Wolfgang Lauer (Bundesinstitut für Arzneimittel und Medizinprodukte, Germany)	Poster session 20	User friendliness, risk management and hospital technology	P 195	12.09.2017	15:00
Implementing risk management or safety management in a radiotherapy institution: challenges, ideas and examples for solutions	Daniel Hummel (MVZ des Universitätsklinikums Tübingen, Germany); Michael Bay (MVZ des Universitätsklinikums Tübingen, Germany)	Poster session 20	User friendliness, risk management and hospital technology	P 196	12.09.2017	15:00
The human operator: transfer function of the motor control behavior	Hans Gerisch (Institut für Informationstechnik/ Universität der Bundeswehr München, Germany); Werner Wolf (Institut für Informationstechnik/ Universität der Bundeswehr München, Germany); Gerhard Staude (Institut für Informationstechnik/ Universität der Bundeswehr München, Germany); Andreas Knopp (Institut für Informationstechnik/ Universität der Bundeswehr München, Germany)	Poster session 20	User friendliness, risk management and hospital technology	P 198	12.09.2017	15:00
Probabilistic fibertracking in deep brain stimulation	Mauritius Hoevels (Uniklinik Köln, Germany); Alexandra Hellerbach (Uniklinik Köln, Germany); Andreas Gierich (Uniklinik Köln, Germany); Klaus Luyken (Uniklinik Köln, Germany); Martin Klehr (Uniklinik Köln, Germany); Jochen Wirths (Uniklinik Köln, Germany); Veerle Visser-Vandewalle (Uniklinik Köln, Germany); Harald Treuer (Uniklinik Köln, Germany)	Poster session 21	Imaging and image processing IV	P 200	12.09.2017	15:00
Detection of image plane orientation during two-photon laser scanning microscopy in brain tissue of mice using the geometry of stimulation and recording electrodes	Lisa Grochowski (Trier University of Applied Sciences, Germany); Frank Kirchhoff (University of Saarland, Germany); Klaus Peter Koch (Trier University of Applied Sciences, Germany); Michael Schweigmann (Trier University of Applied Sciences, Germany; University of Saarland, Germany)	Poster session 21	Imaging and image processing IV	P 201	12.09.2017	15:00
A novel algorithm for efficient detection and segmentation of metals for artefact reduction in computed tomography	Alfredo Illanes (Otto von Guericke University, Germany); Shiras Abdurahman (Otto von Guericke University, Germany); Michael Friebe (Otto von Guericke University, Germany)	Poster session 21	Imaging and image processing IV	P 203	12.09.2017	15:00
Interventional limited angle CT concept	Muhammad Usama Iftikhar (Otto-von-Guericke University Magdeburg, Germany); Robert Odenbach (Otto-von-Guericke University Magdeburg, Germany); Shiras Abdurahman (Otto-von-Guericke University Magdeburg, Germany); Alexander van Oepen (Otto-von-Guericke University Magdeburg, Germany); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Poster session 21	Imaging and image processing IV	P 208	12.09.2017	15:00
Quantitative chemical shift spectroscopy (CSI) with respect to B0- and B1-inhomogeneities	Heiner Baier (Universität Halle, Germany); Svatko Zhanna (Universitätsklinikum Halle, Germany); Rolf Peter Spielmann (Universitätsklinikum Halle, Germany); Manfred Knörgen (Universitätsklinikum Halle, Germany)	Poster session 21	Imaging and image processing IV	P 209	12.09.2017	15:00
Virtual enhancement of marker X-ray visibility for cerebral stents and flow diverters	Samuel Manthey (Otto von Guericke University Magdeburg, Germany); Hoffmann Thomas (Otto-von-Guericke-Universität Magdeburg, Medizinische Fakultät/Universitätsklinikum A.ö.R. (FME/UKMD) , Germany); Giorgio Cattaneo (Acandis GmbH & Co KG, Germany); Oliver Beuing (Otto-von-Guericke-Universität Magdeburg, Medizinische Fakultät/Universitätsklinikum A.ö.R. (FME/UKMD) , Germany); Bernhard Preim (Otto von Guericke University Magdeburg, Germany); Sylvia Saalfeld (Otto von Guericke University Magdeburg, Germany)	Poster session 22	Imaging and image processing V	P 210	12.09.2017	15:00
Characterization of carious lesions in vitro based on hyperspectral imaging data	Florian Tetschke (Technische Universität Dresden, Germany; Technische Universität Dresden, Germany); Lars Kirsten (Technische Universität Dresden, Germany); Edmund Koch (Technische Universität Dresden, Germany); Gerald Steiner (Technische Universität Dresden, Germany); Christian Hannig (Technische Universität Dresden, Germany)	Poster session 22	Imaging and image processing V	P 212	12.09.2017	15:00
Summarised difference temperature method for evaluating sagittal-symmetrical ROI pairs in medical thermal IR images	Carsten Siewert (University of Veterinary Medicine Hannover, Germany); Astrid Bienert-Zeit (University of Veterinary Medicine Hannover, Germany); Birgit Krogbeumker (Veterinary Medical Practice, Germany); Bernhard Ohnesorge (University of Veterinary Medicine Hannover, Germany); Hermann Seifert (University of Veterinary Medicine Hannover, Germany)	Poster session 22	Imaging and image processing V	P 213	12.09.2017	15:00

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Evaluation of magnetic field interactions, heating and artifacts of a new magnetic, ophthalmic implant at a 3T MRI	Ann-Kathrin Bodenstein (Tierärztliche Hochschule Hannover, Germany); Matthias Lüpke (Tierärztliche Hochschule Hannover, Germany); Christian Seiler (Tierärztliche Hochschule Hannover, Germany); Frank Goblet (Tierärztliche Hochschule Hannover, Germany); Ulf Hinze (Laser Zentrum Hannover e.V., Germany); Boris Chichkov (Laser Zentrum Hannover e.V., Germany); Patrick Wefstaedt (Tierärztliche Hochschule Hannover, Germany); Ingo Nolte (Tierärztliche Hochschule Hannover, Germany); Hermann Seifert (Tierärztliche Hochschule Hannover, Germany)	Poster session 22	Imaging and image processing V	P 214	12.09.2017	15:00
A mobile EIT system for fast image based medical indication	Christian Gibas (Universität Siegen, Germany); Steffen Büchner (Universität Siegen, Germany); Rainer Brück (Universität Siegen, Germany)	Poster session 22	Imaging and image processing V	P 215	12.09.2017	15:00
Muscle oxygenation monitoring using OXY DR2	Redwan Abdo A. Mohammed (Hochschule Wismar, Germany); Christoph Hornberger (Hochschule Wismar, Germany)	Poster session 22	Imaging and image processing V	P 217	12.09.2017	15:00
Online recognition of cortical blood flow by time-resolved thermography in neurosurgery	Juliane Müller (Technische Universität Dresden, Germany); Julia Hollmach (HiperScan GmbH, Germany; Technische Universität Dresden, Germany); Elisa Böhl (Technische Universität Dresden, Germany); Nico Hoffmann (Technische Universität Dresden, Germany); Stephan Sobottka (Technische Universität Dresden, Germany); Matthias Kirsch (Technische Universität Dresden, Germany); Gabriele Schackert (Technische Universität Dresden, Germany); Gerald Steiner (Technische Universität Dresden, Germany); Edmund Koch (Technische Universität Dresden, Germany)	Poster session 22	Imaging and image processing V	P 218	12.09.2017	15:00
Neuroimaging center python pipelines: a web-based image processing framework	Dirk K. Müller (TU-Dresden, Germany); Lukas Reimer (TU-Dresden, Germany); Niklas Förster (TU-Dresden, Germany); Pascal Lehmann (TU-Dresden, Germany); Michael Marxen (TU-Dresden, Germany)	Poster session 22	Imaging and image processing V	P 219	12.09.2017	15:00
Hyperspectral imaging and clinical practice – approach to integrate a new diagnostic tool	Alke Martens (Universität Rostock, IEF, Germany); Nikolaj Troels Graf von Malotky (Universität Rostock, IEF, Germany); Marian Nagorsnick (Universität Rostock, IEF, Germany)	Poster session 22	Imaging and image processing V	P 220	12.09.2017	15:00
Comparison of different methods of size specific dose estimate (SSDE) determination in computed tomography	Helat A. Hussein (University of Duhok, Iraq); Ulf Mäder (Technische Hochschule Mittelhessen, Germany); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Poster session 23	Imaging and image processing VI	P 221	12.09.2017	15:00
A novel automatic gauge detection algorithm for the performance test of a CT scanner with Catphan 600 phantom	Zhi Qiao (Institut für Medizintechnik Intelligente Katheter (INKA), Otto-von-Guericke-Universität Magdeburg, Germany, Germany); Alfredo Illanes (Institut für Medizintechnik Intelligente Katheter (INKA), Otto-von-Guericke-Universität Magdeburg, Germany, Germany); Shiras Abdurahman (Institut für Medizintechnik Intelligente Katheter (INKA), Otto-von-Guericke-Universität Magdeburg, Germany, Germany); Michael Friebe (Institut für Medizintechnik Intelligente Katheter (INKA), Otto-von-Guericke-Universität Magdeburg, Germany, Germany)	Poster session 23	Imaging and image processing VI	P 222	12.09.2017	15:00
Implementation of a correction procedure to decrease the effect of PSF-related signal leakage in 23Na NMRS	Aaron Globisch (Universität zu Lübeck, Germany); Uwe H. Melchert (Universität zu Lübeck, Germany); Christian Erdmann (Universität zu Lübeck, Germany); Martin Koch (Universität zu Lübeck, Germany)	Poster session 23	Imaging and image processing VI	P 223	12.09.2017	15:00
Submillimetre shifts and their impacts on PET-CT resolution	Stefan Kegel (Deutsches Krebsforschungszentrum, Germany); Charles Majer (Deutsches Krebsforschungszentrum, Germany)	Poster session 23	Imaging and image processing VI	P 224	12.09.2017	15:00
Optimization of X-Ray dark-field microCT and application in a murine lung model	Rico Burkhardt (TUM, Klinikum rechts der Isar, Germany; Technical University Munich (TUM), Germany; Helmholtz Zentrum, Germany); Stephan Umkehrer (Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany); Max von Teuffenbach (Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany); Karin Burger (TUM, Klinikum rechts der Isar, Germany; Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany); Julia Herzen (Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany); Peter Noel (Technical University Munich (TUM), Germany; TUM, Klinikum rechts der Isar, Germany); Stephanie E. Combs (TUM, Klinikum rechts der Isar, Germany; Helmholtz Zentrum, Germany; Deutsches Konsortium für translationale Krebsforschung (DKTK), Germany); Franz Pfeiffer (Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany); Jan J. Wilkens (TUM, Klinikum rechts der Isar, Germany; Helmholtz Zentrum, Germany; Technical University Munich (TUM), Germany; Technical University Munich (TUM), Germany)	Poster session 23	Imaging and image processing VI	P 226	12.09.2017	15:00

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Characterization of cerebral tissue with thermography and white light microscopy during neurosurgery	Christian Schnabel (TU Dresden, Faculty of Medicine CGC, Germany); Elisa Böhl (TU Dresden, Faculty of Medicine CGC, Germany); Juliane Müller (TU Dresden, Faculty of Medicine CGC, Germany); Nico Hoffmann (TU Dresden, Germany); Gerald Steiner (TU Dresden, Faculty of Medicine CGC, Germany); Matthias Kirsch (TU Dresden, Faculty of Medicine CGC, Germany); Gabriele Schackert (TU Dresden, Faculty of Medicine CGC, Germany); Edmund Koch (TU Dresden, Faculty of Medicine CGC, Germany)	Poster session 23	Imaging and image processing VI	P 227	12.09.2017	15:00
A framework for intraoperative visualization of spatiotemporal alterations in cortical optical properties induced by direct electrical stimulation	Martin Oelschlägel (Technische Universität Dresden, Germany); Stephan B. Sobottka (Universitätsklinikum Carl Gustav Carus, Germany); Matthias Kirsch (Universitätsklinikum Carl Gustav Carus, Germany); Gabriele Schackert (Universitätsklinikum Carl Gustav Carus, Germany); Ute Morgenstern (Technische Universität Dresden, Germany)	Poster session 23	Imaging and image processing VI	P 228	12.09.2017	15:00
An active shape model for automatic segmentation of the knee bones	Alex Ringenbach (FHNW-HLS , Switzerland)	Poster session 23	Imaging and image processing VI	P 230	12.09.2017	15:00
Single plane compton imaging – A novel concept for radionuclide imaging	Toni Kögler (Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany); Boyana Deneva (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Katja Roemer (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Theresa Werner (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany); Wolfgang Enghardt (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Heidelberg, Germany); Guntram Pausch (Helmholtz-Zentrum Dresden - Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany)	Poster session 23	Imaging and image processing VI	P 231	12.09.2017	15:00
Ion radiography with proton, helium- and carbon ion beams	Benedikt Kopp (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Lorena Magallanes (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Sebastian Meyer (Ludwig-Maximilians-Universität München, Germany); Chiara Gianoli (Ludwig-Maximilians-Universität München, Germany); Thomas Tessonnier (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany); Maximilian Göppel (Ludwig-Maximilians-Universität München, Germany); Stephan Brons (Heidelberg Ion Therapy Centre, Germany); Bernd Voss (GSI Helmholtz Centre for Heavy Ion Research, Germany); Ralf Panse (Heidelberg Ion Therapy Centre, Germany); Katia Parodi (Ludwig-Maximilians-Universität München, Germany; Heidelberg University Hospital, Germany)	Poster session 23	Imaging and image processing VI	P 232	12.09.2017	15:00
Concept of a multilayer biopsy needle for magnetic resonance imaging interventions	Marwah ALmaatoq (Otto- von-Guericke University Magdeburg, Germany); Axel Boese (Otto- von-Guericke University Magdeburg, Germany); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 233	12.09.2017	15:00
Integration and evaluation of 6 DoF input devices for computer-assisted planning in maxillofacial surgery	Urs Eisenmann (Institut für Medizinische Biometrie und Informatik, Germany); Konstantin Gegier (Institut für Medizinische Biometrie und Informatik, Germany); Igor Nova (Institut für Medizinische Biometrie und Informatik, Germany); Sebastian Kallus (Institut für Medizinische Biometrie und Informatik, Germany); Moritz Berger (Universitätsklinikum Heidelberg, Germany); Hartmut Dickhaus (Institut für Medizinische Biometrie und Informatik, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 234	12.09.2017	15:00
Modular three-dimensional magnetic camera dedicated to magnetic manipulation instrumentation systems	Joris Pascal (Fachhochschule Nordwestschweiz FHNW, Switzerland); Dorian Vogel (Fachhochschule Nordwestschweiz FHNW, Switzerland); Sven Knecht (University Hospital Basel, Switzerland); Christophe Chautems (ETH Zürich, Switzerland)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 235	12.09.2017	15:00

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Microsystembased functionalization of sensor catheters	David Wagner (Institut für Mikro- und Sensorsysteme - Universität Magdeburg, Germany); Kai Pitschmann (Institut für Mikro- und Sensorsysteme - Universität Magdeburg, Germany); Ulrich Schumann (Institut für Informations-und Kommunikationstechnik - Universität Magdeburg, Germany); Sebastian Freidank (Institut für Mikro- und Sensorsysteme - Universität Magdeburg, Germany); Bertram Schmidt (Institut für Mikro- und Sensorsysteme - Universität Magdeburg, Germany); Markus Detert (Institut für Mikro- und Sensorsysteme - Universität Magdeburg, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 236	12.09.2017	15:00
Packaging of µLEDs to flexible polyimide substrates	Martin Deckert (Otto von Guericke University Magdeburg, Germany); Michael Thomas Lippert (Leibniz Institute for Neurobiology, Germany); Jakub Krzemiński (Warsaw University of Technology, Poland); Kentaroh Takagaki (Leibniz Institute for Neurobiology, Germany); Frank W. Ohl (Leibniz Institute for Neurobiology, Germany); Bertram Schmidt (Otto von Guericke University Magdeburg, Germany); Markus Detert (Otto von Guericke University Magdeburg, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 237	12.09.2017	15:00
The development of an expert system as a virtual physiotherapist in the domestic environment	Paula Krüger (TU Dresden, Germany); Andreas Heinke (TU Dresden, Germany); Zbigniew Śliwiński (Physiotherapy Centre , Poland); Hagen Malberg (TU Dresden, Germany); Grzegorz Śliwiński (TU Dresden, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 238	12.09.2017	15:00
Instrument calibration for a camera based surgical navigation system	Manuel Katanacho (Fraunhofer Institute for Production Systems and Design Technology IPK, Germany); Oliver Krumpek (Fraunhofer Institute for Production Systems and Design Technology IPK, Germany); Eckart Uhlmann (Fraunhofer Institute for Production Systems and Design Technology IPK, Germany; Fraunhofer Institute for Production Systems and Design Technology IPK, Germany); Steffen Melnik (Fraunhofer Institute for Production Systems and Design Technology IPK, Germany)	Poster session 24	Image guided, robotic and miniaturised systems for intervention and therapy III	P 240	12.09.2017	15:00
3D packaging for an implantable hemodynamic control system	Tim Schröder (Fraunhofer ENAS, Germany); Mario Baum (Fraunhofer ENAS, Germany); Dirk Wünsch (Fraunhofer ENAS, Germany); Maik Wiemer (Fraunhofer ENAS, Germany); Thomas Otto (Fraunhofer ENAS, Germany)	Poster session 25	Biosignal processing and monitoring III	P 241	12.09.2017	15:00
An auscultatory non invasive blood pressure equivalent without PEP?	Simon Hofmann (University of Applied Sciences Giessen, Germany); Keywan Sohrabi (University of Applied Sciences Giessen, Germany); Christian Igler (Facharztpraxis für Innere Medizin, Germany); Nils Gilg (University of Applied Sciences Giessen, Germany); Andreas Weissflog (Thora Tech GmbH, Germany); Volker Gross (University of Applied Sciences Giessen, Germany)	Poster session 25	Biosignal processing and monitoring III	P 243	12.09.2017	15:00
A chip-based biosensor for the detection of glycosylphosphatidylinositol-anchored proteins in serum as stress biomarkers	Günter Müller (Helmholtz Zentrum München, Germany); Andreas Herling (Sanofi Germany GmbH, Germany); Matthias Tschöp (Helmholtz Zentrum München, Germany)	Poster session 25	Biosignal processing and monitoring III	P 244	12.09.2017	15:00
Impaired autonomic regulation in ideopathic sudden sensorineural hearing loss patients - Does it depend on hypertension?	Claudia Fischer (Ernst-Abbe-Hochschule Jena, Germany); Julia Ritter (University Hospital Jena, Germany); Orlando Guntinas-Lichius (University Hospital Jena, Germany); Andreas Voss (Ernst-Abbe-Hochschule Jena, Germany)	Poster session 25	Biosignal processing and monitoring III	P 245	12.09.2017	15:00
Correlation of Mayer waves in arterial blood pressure and retinal vessel diameter	Steffen Rieger (Technische Universität Ilmenau, Germany); L. Lüken (Technische Universität Ilmenau, Germany); Daniel Baumgarten (University for Health Sciences, Medical Informatics and Technology (UMIT), Austria); Sascha Klee (Technische Universität Ilmenau, Germany); Silvio Dutz (Technische Universität Ilmenau, Germany)	Poster session 25	Biosignal processing and monitoring III	P 246	12.09.2017	15:00
Empirical mode decomposition and time varying modelling for carotid audio signal analysis	Alfredo Illanes (Otto von Guericke University, Germany); Iván Maldonado (Otto von Guericke University, Germany); Axel Boese (Otto von Guericke University, Germany); Michael Friebe (Otto von Guericke University, Germany)	Poster session 25	Biosignal processing and monitoring III	P 247	12.09.2017	15:00
Nonparametric modeling of quasi-periodic signals: application to esophageal pressure filtering	Jan Graßhoff (Universität zu Lübeck, Germany); Georg Männel (Universität zu Lübeck, Germany); Philipp Rostalski (Universität zu Lübeck, Germany)	Poster session 25	Biosignal processing and monitoring III	P 248	12.09.2017	15:00
Using functio-anatomical prior knowledge in linear EEG/MEG source reconstruction methods	Mirco Fuchs (HTWK Leipzig, University of Applied Sciences, Germany; Max Planck Institute for Human Cognitive and Brain Sciences, Germany); Burkhard Maess (Max Planck Institute for Human Cognitive and Brain Sciences, Germany); Thomas Knösche (Max Planck Institute for Human Cognitive and Brain Sciences, Germany)	Poster session 25	Biosignal processing and monitoring III	P 249	12.09.2017	15:00
A wearable chest-strap ECG for real-time data processing	Aulia Arif Iskandar (Universität Würzburg, Germany); Wolfram Voelker (Universitätsklinikum Würzburg, Germany); Reiner Kolla (Universität Würzburg, Germany); Klaus Schilling (Universität Würzburg, Germany)	Poster session 26	Biosignal processing and monitoring IV	P 253	12.09.2017	15:00
Long-term signal prediction in a level-crossing behaviour analysis for seizure prediction in epilepsy	Katja Mühlberg (Institut für Grundlagen der Elektrotechnik und Elektronik, Germany); Ronald Tetzlaff (Institut für Grundlagen der Elektrotechnik und Elektronik, Germany)	Poster session 26	Biosignal processing and monitoring IV	P 255	12.09.2017	15:00

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Spectral analysis of signal averaging electrocardiography in atrial and ventricular tachyarrhythmias	Jonas Tumampos (Hochschule Offenburg, Germany); Matthias Heinke (Hochschule Offenburg, Germany); Johannes Hörth (Hochschule Offenburg, Germany); Carsten Bienek (Schwarzer Cardiotek GmbH, Germany)	Poster session 26	Biosignal processing and monitoring IV	P 257	12.09.2017	15:00
PPG imaging: investigating skin inhomogeneity using hyperspectral imaging and principal component analysis	Nicolai Spicher (University of Applied Sciences and Arts Dortmund, Germany); Fatih Tanriverdi (University of Applied Sciences and Arts Dortmund, Germany); Jörg Thiem (University of Applied Sciences and Arts Dortmund, Germany); Markus Kukuk (University of Applied Sciences and Arts Dortmund, Germany)	Poster session 26	Biosignal processing and monitoring IV	P 258	12.09.2017	15:00
Detector response in the build-up region of small 6 MV photon fields	Barbara Herzog (Universitätklinikum Würzburg, Germany); Sonja Wegener (Universitätklinikum Würzburg, Germany); Otto A. Sauer (Universitätklinikum Würzburg, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 259	12.09.2017	15:00
Evaluation of the ArcCheck 3DVH-module	Heidi Spickermann (Universitätsklinikum Würzburg, Germany); Sonja Wegener (Universitätsklinikum Würzburg, Germany); Otto A. Sauer (Universitätsklinikum Würzburg, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 260	12.09.2017	15:00
Dosimetric calibration of an electronic portal imaging device (EPID)	Thilo Seliger (Philipps-University Marburg, Germany); Damian Czarnecki (University of Applied Sciences, Germany); Rolf Kussäther (MedCom Gesellschaft für medizinische Bildverarbeitung mbH, Germany); Ulf Mäder (University of Applied Sciences, Germany); Rita Engenhart-Cabillic (Philipps-University Marburg, Germany; University Hospital Gießen-Marburg, Germany); Klemens Zink (University of Applied Sciences, Germany; University Hospital Gießen-Marburg, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 261	12.09.2017	15:00
Small animal irradiation: verification of the dose distribution in a phantom using thermoluminescent dosimeters	Carole Simon (Universitätsklinikum Köln , Germany); Samet Bozkurt (Universitätsklinikum Köln , Germany); Wolfgang Baus (Universitätsklinikum Köln , Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 262	12.09.2017	15:00
Influence of CT reconstruction kernels on dose distribution in liver radioembolization using tissue density estimation	Nadine Traulsen (Fraunhofer Institute for Medical Image Computing MEVIS, Germany); Smita Thoduka (Städtisches Klinikum Dresden-Friedrichstadt, Germany); Nasreddin Abolmaali (Städtisches Klinikum Dresden-Friedrichstadt, Germany); Andrea Schenk (Fraunhofer Institute for Medical Image Computing MEVIS, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 263	12.09.2017	15:00
Comparison between differing fill factor definitions for two-dimensional detector arrays	Tenzin Sonam Stelljes (University Clinic for Medical Radiation Physics, Germany); Daniela Poppinga (University Clinic for Medical Radiation Physics, Germany); Jana Kretschmer (University Clinic for Medical Radiation Physics, Germany); Leonie Brodbek (University Clinic for Medical Radiation Physics, Germany); Hui Khee Looe (University Clinic for Medical Radiation Physics, Germany); Dieterich Harder (Prof. em., Medical Physics and Biophysics, Germany); Björn Poppe (University Clinic for Medical Radiation Physics, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 265	12.09.2017	15:00
Design of a precise scintillation dosimetry system for the measuring of microcollimators	Catharina Scharmberg (Universitätsklinikum Essen, Germany; Technische Universität Dortmund, Germany); Marion Eichmann (Technische Universität Dortmund, Germany); Christian Rütten (Universitätsklinikum Essen, Germany); Bernhard Spaan (Technische Universität Dortmund, Germany); Dirk Flühs (Universitätsklinikum Essen, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 266	12.09.2017	15:00
Investigation of PEN based plastic scintillator dosimetry for Iridium-192 afterloading source	Sarah Schulz (Technische Universität Dortmund, Germany); Catharina Scharmberg (Universitätsklinikum Essen, Germany; Technische Universität Dortmund, Germany); Marion Eichmann (Technische Universität Dortmund, Germany); Christian Rütten (Universitätsklinikum Essen, Germany); Bernhard Spaan (Technische Universität Dortmund, Germany); Dirk Flühs (Universitätsklinikum Essen, Germany)	Poster session 27	Dosimetry, radiation protection and radiation biology III	P 267	12.09.2017	15:00
Experimental determination of conversion coefficients for estimating the patients' skin dose in surgical neuroangiography	Felix Bärenfänger (TU Dortmund, Germany); Stefan Rohde (Klinikum Dortmund, Germany); Andreas Block (Klinikum Dortmund, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 268	12.09.2017	15:00
Position-dependent non-reference condition corrections for treatment plan verification using two-dimensional detector arrays	Jana Kretschmer (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Leonie Brodbek (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Tenzin S. Stelljes (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Hui Khee Looe (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Björn Poppe (University Clinic for Medical Radiation Physics, Pius Hospital, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 269	12.09.2017	15:00

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Isocenter verification of a standard linear accelerator using the OCTAVIUS detector array 1000SRS	Leonie Brodbek (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Jana Kretschmer (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Tenzin S. Stelljes (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Hui Khee Looe (University Clinic for Medical Radiation Physics, Pius Hospital, Germany); Britta Loutfi-Krauss (Goethe University Frankfurt, University Hospital Frankfurt am Main, Germany); Oliver Blanck (SAPHIR Radiosurgery Center, Germany; University Clinic Schleswig Holstein, Germany); Björn Poppe (University Clinic for Medical Radiation Physics, Pius Hospital, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 270	12.09.2017	15:00
Determination of the amount of backscatter radiation in interventional radiography for the personnel	Revink Ali Ramadhan Wais (University of Duhok, Iraq); Robin Etzel (Technische Hochschule Mittelhessen, Germany); Martin Fiebich (Technische Hochschule Mittelhessen, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 271	12.09.2017	15:00
Effects of ultra-short pulsed proton bunches on malignant T and B cells	Jens Ehlert (Heinrich-Heine-Universität Düsseldorf , Germany; Universitätsklinikum Düsseldorf, Germany); Sven Spickermann (Heinrich-Heine-Universität Düsseldorf , Germany); Ron-Patrick Cadeddu (Universitätsklinikum Düsseldorf, Germany); Oswald Willi (Heinrich-Heine-Universität Düsseldorf , Germany); Rainer Haas (Universitätsklinikum Düsseldorf, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 272	12.09.2017	15:00
Comparison of thermoluminescence reader TLDcube and harshaw 3500 for dosimetry in radiology and radiation therapy	Dan Sidney Nitschke (Beuth University of Applied Sciences, Germany); Ulrich Jahn (Charite University, Germany); Oliver Neumann (Charite University, Germany); Volker Budach (Charite University, Germany); Martin Martin Roll (Beuth University of Applied Sciences, Germany); Markus Buchgeister (Beuth University of Applied Sciences, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 273	12.09.2017	15:00
Validation of cosmic ray flux models using a spacecraft-mounted radiation monitor	Vanessa Wyrwoll (Universität Oldenburg, Germany); Sascha Lüdeke (Universität Oldenburg, Germany); Hugh Evans (ESA, Netherlands); Björn Poppe (Universität Oldenburg, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 274	12.09.2017	15:00
Reducing radiation exposure and optimising image quality in x-ray examinations for neonates	Sergej Mikhailov (TU Dortmund, Germany); Nora Schulz (TU Dortmund, Germany); Annette Schmitz-Stolbrink (Klinikum Dortmund, Germany); Andreas Block (Klinikum Dortmund, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 275	12.09.2017	15:00
Experimental verification of the currently used estimation for dose to the uterus in fluoroscopy examinations	Katharina Schröder (TU Dortmund, Germany); Kilian Seth (TU Dortmund, Germany); Katharina Loot (TU Dortmund, Germany); Andreas Block (Klinikum Dortmund, Germany)	Poster session 28	Dosimetry, radiation protection and radiation biology IV	P 276	12.09.2017	15:00
A novel optical hydrophone for the single-shot field measurements of high-power-pressure-pulse fields	Abtin Jamshidi Rad (HAW Hamburg, Germany); Friedrich Ueberle (HAW Hamburg, Germany)	Poster session 29	Medical measuring techniques II	P 277	12.09.2017	15:00
Requirements for modular measuring systems in individual treatment and care of dementia patients (PYRAMID)	Axel Steinbach (Studiengruppe INSIDER Klinik m.S. Rheumatologie und Immunologie der Charité Universitätsmedizin Berlin, Germany); Jacqueline Detert (Studiengruppe INSIDER, Klinik m.S. Rheumatologie und Immunologie der Charité Universitätsmedizin Berlin, Germany); Erik Jung (Medizinische Mikrosysteme, Fraunhofer Institut für Zuverlässigkeit und Mikrointegration, Germany); Vera Höhne-Zimmer (Studiengruppe INSIDER Klinik m.S. Rheumatologie und Immunologie der Charité Universitätsmedizin Berlin, Germany); Michael Richter (Medizinische Mikrosysteme, Fraunhofer Institut für Zuverlässigkeit und Mikrointegration, Germany); Sebastian Freidank (AG Medizinische Mikrosysteme am Lehrstuhl Mikrosystemtechnik Institut für Mikro- und Sensorsysteme, Otto-von-Guericke-Universität Magdeburg, Germany); Tobias Leipold (Clinpath Gmbh, Germany); Marc Nagel (pilotfish GmbH, Germany); Luca Salvatore (Johner-Institut GmbH, Germany); Markus Detert (AG Medizinische Mikrosysteme am Lehrstuhl Mikrosystemtechnik Institut für Mikro- und Sensorsysteme, Otto-von-Guericke-Universität Magdeburg, Germany)	Poster session 29	Medical measuring techniques II	P 278	12.09.2017	15:00
Surface electromyography - measurement setup for the electrical characterisation of electrodes under consideration of boundary layer phenomena	Andreas Heinke (Institut für Biomedizinische Technik, TU Dresden, Germany); Paula Krüger (Institut für Biomedizinische Technik, TU Dresden, Germany); Zbigniew Śliwiński (Faculty of Medicine and Health Sciences, Poland); Hagen Malberg (Institut für Biomedizinische Technik, TU Dresden, Germany); Grzegorz Śliwiński (Institut für Biomedizinische Technik, TU Dresden, Germany)	Poster session 29	Medical measuring techniques II	P 279	12.09.2017	15:00
PromBERA – praeoperative EBERA – objektiver Promontorialtest zur Integritätsprüfung des Hörnervs bei Cochleaimplantat-Kandidaten	Daniel Polterauer (Klinikum Großhadern, Germany); Giacomo Mandruzzato (MED-EL, Austria); Maike Neuling (Klinikum Großhadern, Germany); Marek Polak (MED-EL, Austria); Joachim Michael Müller (Klinikum Großhadern, Germany); John-Martin Hempel (Klinikum Großhadern, Germany)	Poster session 29	Medical measuring techniques II	P 280	12.09.2017	15:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Examination of the skin conductance level (SCL) as an index of the activity of the sympathetic nervous system in physical and psychological stress situations	Janina Horstick (Fachhochschule Münster, Germany); Simon Siebers (Fachhochschule Münster, Germany); Claus Backhaus (Fachhochschule Münster, Germany)	Poster session 29	Medical measuring techniques II	P 281	12.09.2017	15:00
Impact of nocturnal respiratory symptoms (cough and wheezing) on the respiratory rate in patients with COPD	Olaf Hildebrandt (Technische Hochschule Mittelhessen, Germany; Philipps Universität Marburg, Germany); Ulrich Koehler (Philipps Universität Marburg, Germany); Karl Kesper (Philipps Universität Marburg, Germany); Werner Cassel (Philipps Universität Marburg, Germany); Patrick Fischer (Technische Hochschule Mittelhessen, Germany); Nilab Taher (Technische Hochschule Mittelhessen, Germany; Philipps Universität Marburg, Germany); Keywan Sohrabi (Technische Hochschule Mittelhessen, Germany); Volker Groß (Technische Hochschule Mittelhessen, Germany)	Poster session 29	Medical measuring techniques II	P 282	12.09.2017	15:00
Realization of pressure controlled ventilation for an automated public access emergency ventilator	Martin Degner (Universität Rostock, Germany); Henning Jürß (Universität Rostock, Germany); Hannes Nierath (Universität Rostock, Germany); Jens Schwarz (Sensatronic GmbH, Germany); Patricia Fuchs (Universitätsmedizin Rostock, Germany); Juliane Obermeier (Universitätsmedizin Rostock, Germany); Jochen Schubert (Universitätsmedizin Rostock, Germany)	Poster session 29	Medical measuring techniques II	P 283	12.09.2017	15:00
IMU-based motion capture system for real-time body joint angle measurement	Markus Hessinger (Technische Universität Darmstadt, Germany); Arthur Buchta (Technische Universität Darmstadt, Germany); Roland Werthschützky (Technische Universität Darmstadt, Germany); Mario Kupnik (Technische Universität Darmstadt, Germany)	Poster session 29	Medical measuring techniques II	P 286	12.09.2017	15:00
Development of an in silico-model to investigate the dynamic loads of a transcatheter aortic valve	Markus Bongert (FH Dortmund, Germany); Kuno Kloos (FH Dortmund, Germany); Marius Geller (FH Dortmund, Germany); Markus Schlömicher (Uniklinik Bergmannsheil Bochum, Germany); Tim Ricken (TU Dortmund, Germany); Volkmar Nicolas (Uniklinik Bergmannsheil Bochum, Germany); Justus Strauch (Uniklinik Bergmannsheil Bochum, Germany)	Poster session 30	Modelling and simulation III	P 288	12.09.2017	15:00
Heart rhythm model and simulation of electrophysiological studies and high-frequency ablations	Marco Schalk (Hochschule Offenburg, Germany); Matthias Heinke (Hochschule Offenburg, Germany); Johannes Hörth (Hochschule Offenburg, Germany)	Poster session 30	Modelling and simulation III	P 289	12.09.2017	15:00
Diffusion simulation of low molecular MRI contrast agents in micronecrotic tumor tissue for DCE-MRI	Olga Schimpf (Universitätsklinikum Essen Strahlentherapie, Germany); Stefan Hindel (Universitätsklinikum Essen Strahlentherapie, Germany); Lutz Lüdemann (Universitätsklinikum Essen Strahlentherapie, Germany)	Poster session 30	Modelling and simulation III	P 290	12.09.2017	15:00
A bile flow model for in-vitro testing of biliary stents – A prognosis of incrustation processes	Deusch Carolin (Universität Rostock, Germany); Olaf Specht (Institut für Implantatmaterialien und Biomaterialien e.V., Germany); Heidi Fleischer (Center for Life Science Automation - celisca, Germany); Ingolf Beutner (Klinikum Südstadt Rostock, Germany); Mareike Warkentin (Universität Rostock, Germany)	Poster session 31	Modelling and simulation IV	P 295	12.09.2017	15:00
Optimisation and validation of an FEA model for the simulation of the electrical flow through fish heads	Matthias Lüpke (Tierärztliche Hochschule Hannover, Germany); Wanda Hörnig (Tierärztliche Hochschule Hannover, Germany); Dieter Steinhagen (Tierärztliche Hochschule Hannover, Germany); Hermann Seifert (Tierärztliche Hochschule Hannover, Germany)	Poster session 31	Modelling and simulation IV	P 296	12.09.2017	15:00
Influence of total tumour volume on BED values: Simulation study using a PBPK model for 177Lu-labelled PSMA ligands	Nusrat Jihan Begum (Universität Ulm, Germany); Anne Thieme (Klinikum rechts der Isar, Technische Universität München, Germany); Ambros Beer (Universität Ulm, Germany); Matthias Eiber (Klinikum rechts der Isar, Technische Universität, Germany); Gerhard Glatting (Universität Ulm, Germany); Peter Kletting (Universität Ulm, Germany)	Poster session 31	Modelling and simulation IV	P 297	12.09.2017	15:00
Development of an algorithm for selecting the optimal radiopharmaceutical to molecular radiotherapy	Attarwala Ali Asgar (Medical Faculty Mannheim, Heidelberg University,Universitätsmedizin Mannheim, Germany); Luis David Jimenez (Medical Faculty Mannheim, Heidelberg University,Universitätsmedizin Mannheim, Germany); Deni Hardiansyah (Department of Electrical Engineering, Universitas Padjadjaran, Bandung, Indonesia, Indonesia; College of Pharmacy, University of Kentucky, BioPharm Building, 789 S. Limestone, Lexington, USA, American Samoa); Peter Kletting (Universitätsklinikum Ulm, Germany); Gerhard Glatting (Universitätsklinikum Ulm, Germany; Medical Faculty Mannheim, Heidelberg University,Universitätsmedizin Mannheim, Germany)	Poster session 31	Modelling and simulation IV	P 298	12.09.2017	15:00
Dynamic 7 layer model to generate synthetic signals for non-invasive fetal photoplethysmography	Marcel Böttrich (TU Ilmenau, Germany); Peter Husar (TU Ilmenau, Germany)	Poster session 31	Modelling and simulation IV	P 299	12.09.2017	15:00
Comparison of different Monte-Carlo-simulation software for phantom study in fluoroscopy	Dunja Jannek (Technische Universität Ilmenau, Germany); Andreas Keller (Technische Universität Ilmenau, Germany)	Poster session 31	Modelling and simulation IV	P 302	12.09.2017	15:00

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3D-Modell der Tuba Eustachii aus Fusionierung histologischer Schnitte und des CBCTs – Grundlagen funktioneller Aspekte	Robert Schuon (Medizinische Hochschule Hannover, Germany); J. Schwarzensteiner (Medizinische Hochschule Hannover, Germany); T. Lenarz (Medizinische Hochschule Hannover, Germany); G. Paasche (Medizinische Hochschule Hannover, Germany); S. John (Medizinische Hochschule Hannover, Germany)	Poster session 31	Modelling and simulation IV	P 303	12.09.2017	15:00
Data-driven leaflet modeling for personalized aortic valve prostheses development	Jannis Hagenah (University of Lübeck, Germany; Graduate School for Computing in Medicine and Life Sciences, Germany); Tizian Evers (University of Lübeck, Germany); Michael Scharfschwerdt (University Hospital Schleswig-Holstein, Germany); Achim Schweikard (University of Lübeck, Germany)	Poster session 32	Organ and patient support systems II	P 304	12.09.2017	15:00
Long-term study of sound localization in cochlear implantees – Measured with a modified clinical diagnostic setup using virtual sound sources (ERKI-method)	Katharina Schmidt (JADE-UNIVERSITY OF APPLIED SCIENCES, Germany); Karsten Plotz (JADE-UNIVERSITY OF APPLIED SCIENCES, Germany)	Poster session 32	Organ and patient support systems II	P 305	12.09.2017	15:00
Online particle measurements during the simulated use of drug coated balloons	Ronja Dreger (Universitätsmedizin Rostock, Institut für Biomedizinische Technik, Germany); Christoph Brandt-Wunderlich (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Anja Kurzhals (Universitätsmedizin Rostock, Institut für Biomedizinische Technik, Germany); Sebastian Kaule (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Niels Grabow (Universitätsmedizin Rostock, Institut für Biomedizinische Technik, Germany); Klaus-Peter Schmitz (Universitätsmedizin Rostock, Institut für Biomedizinische Technik, Germany; Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Wolfram Schmidt (Universitätsmedizin Rostock, Institut für Biomedizinische Technik, Germany)	Poster session 32	Organ and patient support systems II	P 306	12.09.2017	15:00
Development of a measuring system to prevent extravasations	Leonard Pawelzik (FH Münster, Germany); Uvo Hölscher (FH Münster, Germany); Claus Backhaus (FH Münster, Germany)	Poster session 32	Organ and patient support systems II	P 307	12.09.2017	15:00
Adaption of ankle joint prostheses from CT data and determination of data on ankle joint strength	Heiner Martin (University medicine Rostock, Germany); Josephine Menz (University medicine Rostock, Germany); Niels Grabow (University medicine Rostock, Germany); Thomas Mittlmeier (University medicine Rostock, Germany)	Poster session 32	Organ and patient support systems II	P 308	12.09.2017	15:00
Gait biomechanics of patients with forefoot amputation using a customized carbon fiber prosthesis	Eugen Dötzel (Hochschule Ulm, Germany); Felix Capanni (Hochschule Ulm, Germany); Thomas Engleder (Hochschule Ulm, Germany); Jürgen M. Steinacker (Universitätsklinikum Ulm, Germany)	Poster session 32	Organ and patient support systems II	P 309	12.09.2017	15:00
Requirement specifications for the development of a minimal-invasive venous valve prosthesis based on electrospun cusp structures.	Maria Boeck (Universitätsmedizin Rostock, Germany); Jonas Keiler (Universitätsmedizin Rostock, Germany); Michael Stiehm (Universität Rostock, Germany); Wolfram Schmidt (Universitätsmedizin Rostock, Germany; Universität Rostock, Germany); Carsten Momma (Cortronik GmbH, Germany); Heinz Müller (Cortronik GmbH, Germany); Sabine Kischkel (Universitätsmedizin Rostock, Germany); Carsten Michael Bünger (Universitätsmedizin Rostock, Germany); Wolfgang Schareck (Universitätsmedizin Rostock, Germany); Andreas Wree (Universitätsmedizin Rostock, Germany); Klaus-Peter Schmitz (Universitätsmedizin Rostock, Germany; Universität Rostock, Germany); Niels Grabow (Universitätsmedizin Rostock, Germany)	Poster session 32	Organ and patient support systems II	P 310	12.09.2017	15:00
Cardiac support systems with embedded ultrasonic flow measurement	Bernward Reszel (em-tec GmbH, Germany); Stefan Schätzl (em-tec GmbH, Germany); Timo Lebold (em-tec GmbH, Germany); Elmar Huber (em-tec GmbH, Germany); Oliver Lange (em-tec GmbH, Germany)	Poster session 32	Organ and patient support systems II	P 311	12.09.2017	15:00
Conduct a study on the research and exemplary development of context-sensitive support systems for dementia patients with subsequent evaluation	Cedric Mester (FH Münster, Germany); Maximilian Kehmann (FH Münster, Germany); Elisabeth Ibenthal (FH Münster, Germany); Claus Backhaus (FH Münster, Germany)	Poster session 32	Organ and patient support systems II	P 312	12.09.2017	15:00
Development of short-pulsed, high-field electromagnets for laser-based proton therapy	Michael Schürer (OncoRay - Technische Universität Dresden , Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; National Center for Tumor Diseases (NCT), Germany); Thomas Herrmannsdörfer (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Leonhard Karsch (OncoRay - Technische Universität Dresden , Germany); Florian Kroll (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Umar Masood (OncoRay - Technische Universität Dresden , Germany); Manfred Sobiella (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Jörg Pawelke (OncoRay - Technische Universität Dresden , Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany)	Poster session 33	Radiation therapy IV	P 313	12.09.2017	15:00

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A daily on-line plan delivery-QA of every fluence modulated treatment using the log files analysis software LINACWATCH (Qualiformed): defined tolerance limits and first results	Petra Hüttenrauch (Universitätsmedizin Göttingen, Germany); Thomas Failing (Universitätsmedizin Göttingen, Germany); Katharina Wilczek (Universitätsmedizin Göttingen, Germany); Daniela Wagner (Universitätsmedizin Göttingen, Germany)	Poster session 33	Radiation therapy IV	P 314	12.09.2017	15:00
Dose tracking and adaptive replanning at the example of prostate carcinomas treatment using RayStation	Mona Splinter (Deutsches Krebsforschungszentrum, Germany); Peter Häring (Deutsches Krebsforschungszentrum, Germany); Clemens Lang (Deutsches Krebsforschungszentrum, Germany); Eva Meyerhoff (Universitätsklinikum Heidelberg, Germany); Oliver Jäkel (Deutsches Krebsforschungszentrum, Germany)	Poster session 33	Radiation therapy IV	P 315	12.09.2017	15:00
Investigation of dosimetric deviations in MammoSite treatment using Monte Carlo simulations	Moritz Budde (Marien Hospital Herne, Germany); Irenäus A. Adamietz (Marien Hospital Herne, Germany); Ludwig Schmolinga (Marien Hospital Herne, Germany); Amal Ahl-Alhosseini (Marien Hospital Herne, Germany); Horst Hermani (Marien Hospital Herne, Germany)	Poster session 33	Radiation therapy IV	P 316	12.09.2017	15:00
Optimization of the quality assurance of a low-energy radiosurgery treatment for age-related macular degeneration	Jessica Garczarczyk (TU Dortmund, Germany); Marion Eichmann (TU Dortmund, Germany); Dirk Flühs (Universitätsklinikum, Germany); Bernhard Spaan (TU Dortmund, Germany)	Poster session 33	Radiation therapy IV	P 318	12.09.2017	15:00
MLC dosimetric leaf gap (DLG) and transmission (T) revisited: taking into account spatial variations of DLG and T	Manfred Sassowsky (Inselspital - Universitätsspital Bern, Switzerland); Michael Fix (Inselspital - Universitätsspital Bern, Switzerland); Peter Manser (Inselspital - Universitätsspital Bern, Switzerland); Daniel Frauchiger (Inselspital - Universitätsspital Bern, Switzerland)	Poster session 33	Radiation therapy IV	P 320	12.09.2017	15:00
Minimally invasive tumor radiation with a miniaturized X-ray source and needle applicator	Alexander van Oepen (Otto-von-Guericke University Magdeburg, Germany); Ali Pashazadeh (Otto-von-Guericke University Magdeburg, Germany); Axel Boese (Otto-von-Guericke University Magdeburg, Germany); Michael Friebe (Otto-von-Guericke University Magdeburg, Germany)	Poster session 33	Radiation therapy IV	P 321	12.09.2017	15:00
reation and verification of a RapidPlan-model for computer based planning of dynamic IMRT for patients with rectal cancer	Marcelle K. TCHITNGA (Heine-Heinrich Universität Düsseldorf, Germany); Arnd Röser (Helios Klinikum Wuppertal, Germany, Germany); German RapidPlan Consortium German RapidPlan Consortium (German RapidPlan Consortium, Germany); Marc Piroth (Helios Klinikum Wuppertal, Germany, Germany)	Poster session 33	Radiation therapy IV	P 322	12.09.2017	15:00
Validation of an electron head model for the use of the internal accelerator MLC	Oliver Dohm (Klinik für Radioonkologie, Germany)	Poster session 33	Radiation therapy IV	P 323	12.09.2017	15:00
Clinical implementation of a multi layer ionization chamber detector for quality assurance in proton therapy	Daniela Kunath (Klinik für Strahlentherapie und Radioonkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus Dresden, Technische Universität Dresden, Germany); Julia Hytry (OncoRay – Nationales Zentrum für Strahlenforschung in der Onkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Sebastian Makocki (Klinik für Strahlentherapie und Radioonkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus Dresden, Technische Universität Dresden, Germany); Stefan Menkel (Klinik für Strahlentherapie und Radioonkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus Dresden, Technische Universität Dresden, Germany); Maria Tschiche (Klinik für Strahlentherapie und Radioonkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus Dresden, Technische Universität Dresden, Germany); Wolfgang Enghardt (Klinik für Strahlentherapie und Radioonkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus Dresden, Technische Universität Dresden, Germany; OncoRay – Nationales Zentrum für Strahlenforschung in der Onkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institut für Radioonkologie – OncoRay, Germany; Deutsches Konsortium für Translationale Krebsforschung (DKTK), Partnerstandort Dresden und Deutsches Krebsforschungszentrum (DKFZ), Germany)	Poster session 34	Radiation therapy V	P 324	12.09.2017	15:00
Patient positioning accuracy in clinical practice: Influence of positioning errors on the real dose distribution for prostate and head-and-neck treatment	Katharina Bell (Universitätsklinikum des Saarlandes, Germany); Melanie Morlo (Universitätsklinikum des Saarlandes, Germany); Norbert Licht (Universitätsklinikum des Saarlandes, Germany); Christian Rübe (Universitätsklinikum des Saarlandes, Germany); Yvonne Dzierma (Universitätsklinikum des Saarlandes, Germany)	Poster session 34	Radiation therapy V	P 325	12.09.2017	15:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Evaluation of deformable image registration in syngo.via RT image suite VB20	Alexandra Friedrich (Technische Hochschule Mittelhessen, Germany); Ebru Cinar (Technische Hochschule Mittelhessen, Germany); Klemens Zink (Universitätsklinikum Gießen und Marburg GmbH, Germany; Technische Hochschule Mittelhessen, Germany); Martin Böttcher (Universitätsklinikum Gießen und Marburg GmbH, Germany); Rita Engenhart-Cabillic (Universitätsklinikum Gießen und Marburg GmbH, Germany); Hilke Vorwerk (Universitätsklinikum Gießen und Marburg GmbH, Germany)	Poster session 34	Radiation therapy V	P 326	12.09.2017	15:00
Quality assurance of precise, respiratory-gated radiotherapy	Phillip Schick (Universitätsklinikum Düsseldorf, Germany); Holger Gottschlag (Universitätsklinikum Düsseldorf, Germany); Ioannis Simiantonakis (Universitätsklinikum Düsseldorf, Germany)	Poster session 34	Radiation therapy V	P 327	12.09.2017	15:00
Deep inspiration breath-hold (DIBH) versus free breathing (FB) in treatment of breast cancer: evaluation of 20 patients	Stephanie Pensold (Krankenhaus Dresden-Friedrichstadt, Germany); Heiko Tümmler (Krankenhaus Dresden-Friedrichstadt, Germany); Philipp Schilling (Krankenhaus Dresden-Friedrichstadt, Germany); Judith Hiecke (Krankenhaus Dresden-Friedrichstadt, Germany)	Poster session 34	Radiation therapy V	P 328	12.09.2017	15:00
Positioning of catheters in HIPO inverse planning with centroidal voronoi tessellation for HDR-brachytherapy of prostate cancer	Jürgen Hense (Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Germany; German Cancer Consortium (DKTK), Germany; Hochschule Offenburg, Germany); Ilias Sachpazidis (Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Germany; German Cancer Consortium (DKTK), Germany); Harald Hoppe (Hochschule Offenburg, Germany); Dimos Baltas (Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Germany; German Cancer Consortium (DKTK), Germany)	Poster session 34	Radiation therapy V	P 329	12.09.2017	15:00
Daily procedures of radiation protection in proton therapy	Stefan Menkel (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Julia Hytry (OncoRay – Nationales Zentrum für Strahlenforschung in der Onkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Daniela Kunath (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Sebastian Makocki (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Maria Tschiche (Universitätsklinikum Carl Gustav Carus Dresden, Germany); Wolfgang Enghardt (Universitätsklinikum Carl Gustav Carus Dresden, Germany; OncoRay – Nationales Zentrum für Strahlenforschung in der Onkologie, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Technische Universität Dresden; Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany)	Poster session 34	Radiation therapy V	P 330	12.09.2017	15:00
Changes in quality of treatment-plans due to less irradiation directions for VMAT-plans	Patrick Rauwald-Josephs (Universitätsklinikum Marburg, Germany); Gheorghe Iancu (Universitätsklinikum Marburg, Germany); Martin Böttcher (Universitätsklinikum Marburg, Germany); Hilke Vorwerk (Universitätsklinikum Marburg, Germany); Klemens Zink (Universitätsklinikum Marburg, Germany); Rita Engenhart-Cabillic (Universitätsklinikum Marburg, Germany)	Poster session 34	Radiation therapy V	P 331	12.09.2017	15:00
Evaluation of the accuracy of a surface monitoring system for radiotherapy	Patrick Rauwald-Josephs (Universitätsklinikum Marburg, Germany); Martin Böttcher (Universitätsklinikum Marburg, Germany); Hilke Vorwerk (Universitätsklinikum Marburg, Germany); Klemens Zink (Universitätsklinikum Marburg, Germany); Rita Engenhart-Cabillic (Universitätsklinikum Marburg, Germany)	Poster session 34	Radiation therapy V	P 332	12.09.2017	15:00
Heart dose evaluation in left sided breast cancer treatment planning	Florian Exner (Universitätsklinikum Würzburg, Germany); Anne Richter (Universitätsklinikum Würzburg, Germany); Stefan Weick (Universitätsklinikum Würzburg, Germany); Otto Sauer (Universitätsklinikum Würzburg, Germany)	Poster session 34	Radiation therapy V	P 333	12.09.2017	15:00
Cone beam CT: evaluation of long term stability in dose and image quality	Petra Härtl (Universitätsklinikum, Germany); Oliver Koelbl (Universitätsklinikum, Germany); Barbara Dobler (Universitätsklinikum, Germany)	Poster session 35	Radiation therapy VI	P 336	12.09.2017	15:00
Dosimetric effects of soft tissue and bone matching approaches in image-guided radiotherapy of prostate cancer	Malte Mielke (Universitätsklinikum, Germany); Janett Köhn (Universitätsklinikum, Germany); Stefanie Preuß (Universitätsklinikum, Germany); Nadine Blümer (Universitätsklinikum, Germany); Britta Loutfi-Krauß (Universitätsklinikum, Germany); Martin Rauschal (Universitätsklinikum, Germany); Christian Scherf (Universitätsklinikum, Germany); Jörg Licher (Universitätsklinikum, Germany); Ulla Ramm (Universitätsklinikum, Germany)	Poster session 35	Radiation therapy VI	P 337	12.09.2017	15:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Constancy tests for linacs according to DIN 6875-4 and DIN 6847-5 for intensity-modulated radiation therapy using the QUALIMAGIQ platform from QualiFormeD	Miriam Kattinger (Marienhospital Stuttgart, Germany); Maya Shariff (Marienhospital Stuttgart, Germany; Universität Tübingen, Germany); Christian Gromoll (Marienhospital Stuttgart, Germany; Universität Tübingen, Germany; Universität Stuttgart, Germany)	Poster session 35	Radiation therapy VI	P 339	12.09.2017	15:00
Construction of a 3D printed head and neck phantom for dose evaluations in radiation therapy	Melanie Grehn (UKSH Campus Lübeck, Germany); Christian Ziemann (UKSH Campus Lübeck, Germany); Maik Stille (Universität zu Lübeck, Germany); Dirk Rades (UKSH Campus Lübeck, Germany); Thorsten M. Buzug (Universität zu Lübeck, Germany)	Poster session 35	Radiation therapy VI	P 340	12.09.2017	15:00
A new technics to the whole body irradiation (TBI)	Christian Gromoll (Marienhospital Stuttgart, Germany; Universität Stuttgart, Germany); Tanja Jungert (Marienhospital Stuttgart, Germany)	Poster session 35	Radiation therapy VI	P 341	12.09.2017	15:00
Path length correction for MRI compatible varian ring applicators	Thomas Bezold (Universitätsmedizin der Johannes Gutenberg Universität Mainz, Germany); Heiko Karle (Universitätsmedizin der Johannes Gutenberg Universität Mainz, Germany)	Poster session 35	Radiation therapy VI	P 342	12.09.2017	15:00
A new method for position-sensitive spectrometry of laser-accelerated proton bunches using the Timepix detector	Matthias Würl (Ludwig-Maximilians-Universität München, Germany); Francesco Olivari (Ludwig-Maximilians-Universität München, Germany; Università degli studi di Pavia, Italy); Chiara Gianoli (Ludwig-Maximilians-Universität München, Germany); Franz Englbrecht (Ludwig-Maximilians-Universität München, Germany); Anatoly Rozenfeld (University of Wollongong, Australia); Katia Parodi (Ludwig-Maximilians-Universität München, Germany)	Poster session 35	Radiation therapy VI	P 343	12.09.2017	15:00
Nonlinear robust optimization methods for 4D treatment planning in carbon ion therapy	Moritz Wolf (GSI, Germany); Christian Graeff (GSI, Germany)	Poster session 35	Radiation therapy VI	P 344	12.09.2017	15:00
Quality assurance for a replaced IRIS collimator system on a cyberKnife M6	Christian Albrecht (Schwarzwald-Baar-Klinikum, Germany); Manfred Alraun (Schwarzwald-Baar-Klinikum, Germany)	Poster session 35	Radiation therapy VI	P 345	12.09.2017	15:00
Analysis and evaluation of the treatment planning system monaco (Elekta) for parasinal tumours	Victoria Siepen (Uniklinik RWTH Aachen , Germany; FH Aachen Campus Jülich, Germany); Gisela Hürtgen (Uniklinik RWTH Aachen , Germany; RWTH Aachen, Germany); Achim Stahl (RWTH Aachen, Germany); Karl Ziemons (FH Aachen Campus Jülich, Germany); Michael J. Eble (Uniklinik RWTH Aachen , Germany)	Poster session 36	Radiation therapy VII	P 346	12.09.2017	15:00
Dose to organs at risk in boost irradiation for breast cancer-brachyboost vs. teleboost.	Julia Remmele (Uniklinikum Leipzig, Germany); Ulrich Wolf (Uniklinikum Leipzig, Germany)	Poster session 36	Radiation therapy VII	P 347	12.09.2017	15:00
Evaluation of new 2D ripple filters in scanned proton therapy	Toke Printz Ringbæk (Technische Hochschule Mittelhessen, Germany; Philipps University, Germany); Uli Weber (GSI helmholtzzentrum für schwerionenforschung gmbh, Germany); Alina Santiago (Philipps University, Germany; University Medical Center (UKGM), Germany); Yuri Simeonov (Technische Hochschule Mittelhessen, Germany); Peter Fritz (St Marien-Krankenhaus, Germany); Andrea Wittig (Philipps University, Germany; University Medical Center (UKGM), Germany); Gheorghe Iancu (University Medical Center (UKGM), Germany); Leszek Grzanka (Polish Academy of Sciences, Poland; AGH University of Science and Technology, Poland); Niels Bassler (Stockholm University, Sweden); Rita Engenhart-Cabillic (Philipps University, Germany; University Medical Center (UKGM), Germany); Klemens Zink (Technische Hochschule Mittelhessen, Germany; University Medical Center (UKGM), Germany)	Poster session 36	Radiation therapy VII	P 348	12.09.2017	15:00
Improving dose calculation accuracy using a virtual table model for positioning systems	Judith Hiecke (Krankenhaus Dresden-Friedrichstadt, Germany); Philipp Schilling (Krankenhaus Dresden-Friedrichstadt, Germany); Heiko Tümmler (Krankenhaus Dresden-Friedrichstadt, Germany); Knut Merla (Krankenhaus Dresden-Friedrichstadt, Germany)	Poster session 36	Radiation therapy VII	P 349	12.09.2017	15:00
Design and dosimetry of individually shaped shielding for beta eye plaque	Henning Manke (Technische Universität Dortmund, Germany); Catharina Scharmberg (Universitätsklinikum Essen, Germany; Technische Universität Dortmund, Germany); Marion Eichmann (Technische Universität Dortmund, Germany); Christian Rütten (Universitätsklinikum Essen, Germany); Bernhard Spaan (Technische Universität Dortmund, Germany); Dirk Flühs (Universitätsklinikum Essen, Germany)	Poster session 36	Radiation therapy VII	P 350	12.09.2017	15:00
Comparison of Monte Carlo simulations, radiochromic film measurements and TPS dose distributions for peripheral doses in Ir-192 multicatheter breast cancer brachytherapy	Marcel Klingner (Universitätsklinikum Leipzig, Germany)	Poster session 36	Radiation therapy VII	P 352	12.09.2017	15:00
First clinical experiences with the new transmission detector Dolphin on TrueBeam accelerator	Sedef Ibisi (TU Dortmund, Germany); Marvin Kowalski (TU Dortmund, Germany); Katharina Loot (TU Dortmund, Germany); Oliver Waletzko (Klinikum Dortmund, Germany); Ralf Rohn (Klinikum Dortmund, Germany); Andreas Block (Klinikum Dortmund, Germany)	Poster session 36	Radiation therapy VII	P 355	12.09.2017	15:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Mechanical investigation of newly hybrid dental implants	Carmen Zietz (Universitätsmedizin Rostock, Germany; INNOPROOF GmbH, Germany); Danny Vogel (Universitätsmedizin Rostock, Germany); Aurica Mitrovic (ZM Präzisionsdentaltechnik GmbH, Germany); Rainer Bader (Universitätsmedizin Rostock, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 358	12.09.2017	15:00
Influence of cold atmospheric pressure plasma on biofilms of staphylococcus epidermidis on structured titanium – concerning antimicrobial potential and gentamicin susceptibility	Katharina Wegner (Universitätsmedizin Rostock, Germany; Universitätsmedizin Rostock, Germany; Universitätsmedizin Rostock, Germany); Kathrin Duske (Universitätsmedizin Rostock, Germany); Thomas Dauben (Universitätsmedizin Rostock, Germany; Universitätsmedizin Rostock, Germany); Sarah Zaatreh (Universitätsmedizin Rostock, Germany); Hermann Lang (Universitätsmedizin Rostock, Germany); Thomas von Woedtke (Leibniz-Institut für Plasmaforschung und Technologie e.V., Germany); Rainer Bader (Universitätsmedizin Rostock, Germany); J. Barbara Nebe (Universitätsmedizin Rostock, Germany); Bernd Kreikemeyer (Universitätsmedizin Rostock, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 359	12.09.2017	15:00
Micro plasma source for the selective treatment of cell cultures	Mike Stubenrauch (Technische Universität Ilmenau, Germany); Michael Fischer (Technische Universität Ilmenau, Germany); Ady Naber (Karlsruher Institut für Technologie, Germany); Cornelia Wiegand (Universitätsklinikum Jena, Germany); Uta-Christine Hipler (Universitätsklinikum Jena, Germany); Hartmut Witte (Technische Universität Ilmenau, Germany); Jens Müller (Technische Universität Ilmenau, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 361	12.09.2017	15:00
Multilayer diffusion-barrier model for experimental determination of coated-implant related drug eluting processes	Jan Krieger (Fachhochschule Lübeck, Germany); Stephan Klein (Fachhochschule Lübeck, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 362	12.09.2017	15:00
96-well plate ultrasonic applicator for high-throughput in-vitro hyperthermia experiments	Christian Degel (Fraunhofer IBMT, Germany); Franz-Josef Becker (Fraunhofer IBMT, Germany); Holger Hewener (Fraunhofer IBMT, Germany); Doudou Xu (Universität Leipzig, Germany); Andreas Melzer (Universität Leipzig, Germany); Marc Fournelle (Fraunhofer IBMT, Germany); Steffen Tretbar (Fraunhofer IBMT, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 363	12.09.2017	15:00
A new concept of interconnecting feedthrough-bearing substrates with conducting wires in active implantable medical devices.	Michael Langenmair (Uniklinik Freiburg, Germany; Albert-Ludwigs Universität Freiburg, Germany); Fabian Kimmig (Albert-Ludwigs Universität Freiburg, Germany; neuroloop GmbH, Germany); Tim Boretius (neuroloop GmbH, Germany); Dennis T. T. Plachta (Albert-Ludwigs Universität Freiburg, Germany; neuroloop GmbH, Germany); Thomas Stieglitz (Albert-Ludwigs Universität Freiburg, Germany)	Poster session 37	Cells, materials and biochemistry IV	P 364	12.09.2017	15:00
The influence of different FimH gene structures of several Escherichia coli pathotypes on the attachment behaviour to intestinal cell lines and proteins	Christin Bartlitz (BTU Cottbus-Senftenberg, Germany)	Poster session 38	Cells, materials and biochemistry V	P 365	12.09.2017	15:00
Additive manufacturing of ceramic and metal-ceramic-components for medical applications	Uwe Scheithauer (Fraunhofer IKTS, Germany); Eric Schwarzer (Fraunhofer IKTS, Germany); Tassilo Moritz (Fraunhofer IKTS, Germany)	Poster session 38	Cells, materials and biochemistry V	P 366	12.09.2017	15:00
Tailored biofuctionalized surfaces fabricated by direct laserinterference patterning	Florian Rößler (TU Dresden, Germany); Christoph Zwahr (TU Dresden, Germany); Denise Günther (TU Dresden, Germany); Andrés Fabián Lasagni (TU Dresden, Germany)	Poster session 38	Cells, materials and biochemistry V	P 367	12.09.2017	15:00
Effect of iron content on the spectral quality of MPI tracer material	Kerstin Lüdtke-Buzug (Universität zu Lübeck, Germany); Ankit Malhotra (Universität zu Lübeck, Germany)	Poster session 38	Cells, materials and biochemistry V	P 368	12.09.2017	15:00
Chemically modified microstructured PDMS surfaces influence adipose-derived stem cell behavior	Svenja Nellinger (Reutlingen University, Germany; University of Tübingen, Germany); Markus Schneider (Reutlingen University, Germany); Ralf Kemkemer (Reutlingen University, Germany; Max Planck Institute for Intelligent Systems, Germany); Petra J. Kluger (Reutlingen University, Germany; Fraunhofer Institute for Interfacial Engineering and Biotechnology, Germany)	Poster session 38	Cells, materials and biochemistry V	P 369	12.09.2017	15:00
"Medical Grade" polymeric additive manufacturing technologies	Stefan Leonhardt (Technische Universität München, Germany); Miriam Haerst (Technische Universität München, Germany); Stefan Fischer (Technische Universität München, Germany); Sebastian Pammer (Technische Universität München, Germany); Franz Bauer (Technische Universität München, Germany); Markus Eblenkamp (Technische Universität München, Germany)	Poster session 38	Cells, materials and biochemistry V	P 370	12.09.2017	15:00
Preparation and characterization of a standardized testing procedure for covalently-immobilized biological coatings using a laminar flow cell	Silke Keller (University of Stuttgart, Germany); Janine Raßloff (Reutlingen University, Germany); Christopher Probst (Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Germany); Monika Bach (Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Germany); Petra Kluger (Reutlingen University, Germany; Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Germany)	Poster session 38	Cells, materials and biochemistry V	P 374	12.09.2017	15:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Investigation of infectious diseases using a novel in vitro diagnostic microfluidic chip	Taleieh Rajabi (Institut für Mikrostrukturtechnik (IMT), Germany); Helena Melzer (Institut für Mikrostrukturtechnik (IMT), Germany); Ralf Ahrens (Institut für Mikrostrukturtechnik (IMT), Germany); Guido Böse (Zendia GmbH, Germany); Adreas E. Guber (Institut für Mikrostrukturtechnik (IMT), Germany)	Poster session 39	Cells, materials and biochemistry VI	P 378	12.09.2017	15:00
Controlled infiltration of cells into electrospun scaffolds fabricated for applications in small diameter vascular grafts	Sinduja Suresh (Leibniz Universität Hannover, Germany); Oleksandr Gryshkov (Leibniz Universität Hannover, Germany); Birgit Glasmacher (Leibniz Universität Hannover, Germany)	Poster session 39	Cells, materials and biochemistry VI	P 380	12.09.2017	15:00
Rapid prototyping of implantable high accuracy platinum thin film tracks via laser evaporation	Patrick Kiele (IMTEK/ Universität Freiburg, Germany); Paul Čvančara (IMTEK/ Universität Freiburg, Germany); Matthias Mueller (IMTEK/ Universität Freiburg, Germany); Thomas Stieglitz (IMTEK/ Universität Freiburg, Germany)	Poster session 39	Cells, materials and biochemistry VI	P 381	12.09.2017	15:00
Polarimeter compensation methods for drift and scattering effects by using information comprising signal frequency components	Christian Stark (Lübeck University of Applied Sciences, Germany); Felix Fiedler (Lübeck University of Applied Sciences, Germany; ,); Benjamin Redmer (Lübeck University of Applied Sciences, Germany); Reza Behroozian (Lübeck University of Applied Sciences, Germany); Stefan Müller (Lübeck University of Applied Sciences, Germany)	Poster session 39	Cells, materials and biochemistry VI	P 383	12.09.2017	15:00
Model-based therapy	Thomas Neumuth (Universität Leipzig, Germany)	Network session 4	Special session on model-based therapy	NW 18	12.09.2017	15:00
Therapy decision support system using Bayesian networks	Mario A. Cypko (Universität Leipzig, Germany)	Network session 4	Special session on model-based therapy	NW 19	12.09.2017	15:00
Framework for context-aware assistance in integrated operating rooms	Stefan Franke (Universität Leipzig, Germany); Max Rockstroh (Universität Leipzig, Germany); Thomas Neumuth (Universität Leipzig, Germany)	Network session 4	Special session on model-based therapy	NW 20	12.09.2017	15:00
Visualization for model-based therapy decision support	Steffen Oeltze-Jafra (University of Leipzig, Germany)	Network session 4	Special session on model-based therapy	NW 21	12.09.2017	15:00
Optimizing procedures: value added services based on OR integration	Max Rockstroh (Universität Leipzig, ICCAS, Germany); Stefan Franke (Universität Leipzig, ICCAS, Germany); Thomas Neumuth (Universität Leipzig, ICCAS, Germany)	Network session 4	Special session on model-based therapy	NW 22	12.09.2017	15:00
Smart hip prosthesis – an overview	Frank Deicke (Fraunhofer IPMS, Germany)	Network session 5	Theranostic implants	NW 23	12.09.2017	15:00
Overview on an implantable multi sensor system for cardiovascular monitoring	Michael Görtz (Fraunhofer IMS, Duisburg, Germany) Anton Grabmaier (Fraunhofer IMS, Duisburg, Germany) Maik Wiemer (Fraunhofer ENAS, Chemnitz, Germany) Joachim Storsberg (Fraunhofer IAP, Potsdam, Germany) Claus Duschl (Fraunhofer IZI, Potsdam, Germany) Gerd vom Bögel (Fraunhofer IMS, Duisburg, Germany)	Network session 5	Theranostic implants	NW 24	12.09.2017	15:00
Controlling of a hand prosthesis using epimysial signals and peripheral nerve stimulation	Klaus-Peter Hoffmann (Fraunhofer-Institut für Biomedizinische Technik, Germany)	Network session 5	Theranostic implants	NW 25	12.09.2017	15:00
Fall-management system for elderly by multisensory-analysis with integration in a social environment	Jose Manuel Garcia (FH Münster, Germany); Leonard Backschat (FH Münster, Germany); Claus Backhaus (FH Münster, Germany); Uvo Hölscher (FH Münster, Germany)	Session 44	Home health care and ambient assisted living	V 140	12.09.2017	16:00
Consolidation of virtual coaching technologies for tele-rehabilitation	Hannes Schlieter (TU Dresden, Germany); Massimo Caprino (Casa di Cura del Policlinico Spa, Italy); Kai Gand (TU Dresden, Germany)	Session 44	Home health care and ambient assisted living	V 142	12.09.2017	16:00
The potential of psychophysical and health related knowledge for building automation control	Jannik Fleßner (Jade University of Applied Sciences, Germany); Melina Frenken (Jade University of Applied Sciences, Germany)	Session 44	Home health care and ambient assisted living	V 143	12.09.2017	16:00
Determination of the capillary diameter from T2 and T2* measurements	Lukas Buschle (DKFZ, Germany; Universitätsklinikum, Germany); Felix Kurz (DKFZ, Germany; Universitätsklinikum, Germany); Heinz-Peter Schlemmer (DKFZ, Germany); Thomas Kampf (Universität, Germany); Christian Ziener (DKFZ, Germany; Universitätsklinikum, Germany)	Session 45	Imaging and image processing IV – MRI	V 144	12.09.2017	16:00
How vessel architectural imaging depends on the vessel architecture	Lukas Buschle (DKFZ, Germany; Universitätsklinikum, Germany); Ke Zhang (DKFZ, Germany); Volker Sturm (DKFZ, Germany; Universitätsklinikum, Germany); Heinz-Peter Schlemmer (DKFZ, Germany); Felix Kurz (DKFZ, Germany; Universitätsklinikum, Germany); Christian Ziener (DKFZ, Germany; Universitätsklinikum, Germany)	Session 45	Imaging and image processing IV – MRI	V 145	12.09.2017	16:00
A simulation study in large receiver coil arrays for highly accelerated cardiac MRI	Robin Etzel (Technische Hochschule Mittelhessen, Germany); Andreas H. Mahnken (Philipps-Universität Marburg, Germany); Boris Keil (Technische Hochschule Mittelhessen, Germany)	Session 45	Imaging and image processing IV – MRI	V 146	12.09.2017	16:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Hyperpolarization without a polarizer: first 13C-MRI in vivo	Andreas Benjamin Schmidt (Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Stephan Berner (German Cancer Constortium (DKTK), partner site Freiburg; and German Cancer Research Center (DKFZ) , Germany; Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Moritz Braig (Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Waldemar Schimpf (Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Christoph Müller (German Cancer Constortium (DKTK), partner site Freiburg; and German Cancer Research Center (DKFZ) , Germany; Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Jürgen Hennig (Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Dominik von Elverfeldt (Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany); Jan-Bernd Hövener (German Cancer Constortium (DKTK), partner site Freiburg; and German Cancer Research Center (DKFZ) , Germany; Universitätsklinikum Freiburg, Medizinische Fakultät, Universität Freiburg, Germany)	Session 45	Imaging and image processing IV – MRI	V 147	12.09.2017	16:00
Towards current density imaging with ultra-low-field Nnclear magnetic resonance	Peter Hömmen (Physikalisch-Technische Bundesanstalt, Germany); Jan-Hendrik Storm (Physikalisch-Technische Bundesanstalt, Germany); Rainer Körber (Physikalisch-Technische Bundesanstalt, Germany)	Session 45	Imaging and image processing IV – MRI	V 148	12.09.2017	16:00
Susceptibility induced B0 gradients effect on myocardium tissue DTI at high magnetic fields: analysis of shimming strategies	Maxim Terekhov (Universitätsklinikum Würzburg, Germany); David Lohr (Universitätsklinikum Würzburg, Germany); Michael Hock (Universitätsklinikum Würzburg, Germany); Laura Schreiber (Universitätsklinikum Würzburg, Germany)	Session 45	Imaging and image processing IV – MRI	V 149	12.09.2017	16:00
Designing a distributed sensor system for the spectral analysis of ambient air	Jens-Uwe Just (HarzOptics GmbH, Germany); Christian Reinboth (HarzOptics GmbH, Germany); Andreas Müller (Prototype Design Müller, Germany); Ulrich Fischer-Hirchert (HarzOptics GmbH, Germany)	Session 46	BMBF-Zwanzig20 joint project: Fast Actuator and Sensor Technologies (FAST) care	FS 84	12.09.2017	16:00
Optimization of dynamic properties of exo-prostheses using a distributed inertial measurement system	Filip Szufnarowski (Otto Bock HealthCare GmbH, Germany); Erik Albrecht-Laatsch (Otto Bock HealthCare GmbH, Germany)	Session 46	BMBF-Zwanzig20 joint project: Fast Actuator and Sensor Technologies (FAST) care	FS 86	12.09.2017	16:00
Presentation of a concept to support rehabilitation through realtime feedback/monitoring in the home environment	Sebastian Stoutz (Otto-von-Guericke-Universität Magdeburg, Germany); Lutz Schega (Otto-von-Guericke-Universität Magdeburg, Germany)	Session 46	BMBF-Zwanzig20 joint project: Fast Actuator and Sensor Technologies (FAST) care	FS 88	12.09.2017	16:00
Requirements of low latency sensor/actuator networks for e-health applications	Matthias Stege (Exelonix GmbH, Germany)	Session 46	BMBF-Zwanzig20 joint project: Fast Actuator and Sensor Technologies (FAST) care	FS 89	12.09.2017	16:00
Regional specific airway resistance determined by electrical impedance tomography and body plethysmography	Sabine Krüger-Ziolek (Hochschule Furtwangen, Germany); Benjamin Schullcke (Hochschule Furtwangen, Germany); Bo Gong (Hochschule Furtwangen, Germany); Bernhard Laufer (Hochschule Furtwangen, Germany); Knut Möller (Hochschule Furtwangen, Germany)	Session 47	Biosignal processing and monitoring III	V 150	12.09.2017	16:00
New method for an interpolation of physiocal sequences in continuous blood pressure data	Steffen Rieger (TU Ilmenau, Germany); Daniel Baumgarten (UMIT, Austria); Silvio Dutz (TU Ilmenau, Germany); Sascha Klee (TU Ilmenau, Germany)	Session 47	Biosignal processing and monitoring III	V 153	12.09.2017	16:00
Multivariate high resolution joint symbolic dynamics (mHRJSD) - A new tool to analyze couplings in physiological networks	Steffen Schulz (Ernst-Abbe-Hochschule Jena, Germany); Minia Ricoy Castro (Universitat Pompeu Fabra, Spain); Beatriz Giraldo (Universitat Politècnica de Catalunya (UPC), Spain); Jens Haueisen (TU Ilmenau, Germany); Andreas Voss (Ernst-Abbe-Hochschule Jena, Germany)	Session 47	Biosignal processing and monitoring III	V 154	12.09.2017	16:00
Development of a viscosity model for a silicone rubber 3D printing process	Jan Stieghorst (Hannover Medical School, Germany; Cluster of Excellence Hearing4all, Germany); Theodor Doll (Hannover Medical School, Germany; Cluster of Excellence Hearing4all, Germany)	Session 48	Individualised implants	FS 91	12.09.2017	16:00
Direct acoustic stimulation with the codacs™	Hannes Maier (Medizinische Hochschule Hannover, Germany); Susan Busch (Medizinische Hochschule Hannover, Germany); Eugen Kludt (Medizinische Hochschule Hannover, Germany); Martin Großöhmichen (Medizinische Hochschule Hannover, Germany); Thomas Lenarz (Medizinische Hochschule Hannover, Germany)	Session 48	Individualised implants	FS 92	12.09.2017	16:00
Adaptive anticoagulant polymer coatings for blood contacting medical products	Carsten Werner (Leibniz Institute of Polymer Research Dresden, Germany)	Session 49	BMBF-Zwanzig20 joint project: RESPONSE	FS 95	12.09.2017	16:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Innovation strategies for cardiovascular implants – magnesium dcaffold and TAVI	Hüseyin Ince (Universitätsmedizin Rostock, Germany); Sebastian Kaule (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Alper Öner (Universitätsmedizin Rostock, Germany); Michael Stiehm (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Stefan Siewert (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany); Niels Grabow (Universitätsmedizin Rostock, Germany); Klaus-Peter Schmitz (Institut für ImplantatTechnologie und Biomaterialien e.V., Germany; Universitätsmedizin Rostock, Germany)	Session 49	BMBF-Zwanzig20 joint project: RESPONSE	FS 96	12.09.2017	16:00
Stenting the Eustachian tube – a new treatment concept for chronic otitis media	Thomas Lenarz (Medizinische Hochschule Hannover, Germany); Gerrit Paasche (Medizinische Hochschule Hannover, Germany); Robert Schuon (Medizinische Hochschule Hannover, Germany); Tamara Wilfling (Medizinische Hochschule Hannover, Germany); Heinz Müller (Cortronic GmbH, Germany); Carsten Momma (Cortronic GmbH, Germany); Daniel Lootz (Cortronic GmbH, Germany); Niels Grabow (Universität Rostock, Germany); Kerstin Schümann (Universität Rostock, Germany); Wolfram Schmidt (Universität Rostock, Germany); Klaus-Peter Schmitz (Universität Rostock, Germany); Marcus Eisenhut (Bess pro GmbH, Germany); Tobias Stein (Bess pro GmbH, Germany); Stephan Koch (Bess pro GmbH, Germany); Nicolas Bohm (Bess pro GmbH, Germany)	Session 49	BMBF-Zwanzig20 joint project: RESPONSE	FS 98	12.09.2017	16:00
Electrospun fleeces in drug delivery	Ralf Wyrwa (INNOVENT e.V., Germany); Torsten Walter (INNOVENT e.V., Germany); Matthias Schnabelrauch (INNOVENT e.V., Germany)	Session 49	BMBF-Zwanzig20 joint project: RESPONSE	FS 99	12.09.2017	16:00
Status and perspectives of NanoBioMedicine in Germany and Europe	Klaus-Michael Weltring (Gesellschaft für Bioanalytik Münster e. V., Germany; Deutsch Plattform NanoBioMedizin, Germany)	Session 50	NanoBioMedicine	FS 101	12.09.2017	16:00
Cell transplantation in lumbar spine disc degeneration disease	Hans Joerg Meisel (BG Klinikum Bergmannstrost, Germany); Christian Hohaus (Städtisches Klinikum Dessau, Germany); Yvonne Minkus (BG Klinikum Bergmannstrost, Germany); Timothy Ganey (Atlanta Medical Center, USA)	Session 50	NanoBioMedicine	FS 102	12.09.2017	16:00
Challenges in the drug release testing of nanomedicines	Mukul Ashtikar (Fraunhofer Institute for Molecular Biology and Applied Ecology , Germany)	Session 50	NanoBioMedicine	FS 103	12.09.2017	16:00
On the road to biomimetic implants by additive manufacturing using functional organic materials	Günter Tovar (Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie IGVP, Universität Stuttgart , Germany); Kirsten Borchers (Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie IGVP, Universität Stuttgart , Germany); Lisa Sewald (Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie IGVP, Universität Stuttgart , Germany); Alexander Southan (Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie IGVP, Universität Stuttgart , Germany)	Session 50	NanoBioMedicine	FS 105	12.09.2017	16:00
Determination of focal spot size for linear accelerators – Comparison of experiment and simulation	Matthias Sure (Uniklinik Köln, Germany); Wolfgang W. Baus (Uniklinik Köln, Germany); Alexandra Hellerbach (Uniklinik Köln, Germany); Mauritius Hoevels (Uniklinik Köln, Germany); Harald Treuer (Uniklinik Köln, Germany)	Session 51	Radiation therapy V – Advanced quality assurance	V 157	13.09.2017	09:00
The photon-brachytherapy radiation quality-index QBT	Golam Abu Zakaria (Klinikum Oberberg, Germany); Ulrich Quast (Uniklinikum Essen, Germany); Theodor Kaulich (Universitätsklinik für Radioonkologie, Germany)	Session 51	Radiation therapy V – Advanced quality assurance	V 158	13.09.2017	09:00
Quality assurance for interstitial brachytherapy using a hybrid flexitron afterloader system	Karoline Kallis (University Hospital Erlangen, Germany); Vratislav Strnad (University Hospital Erlangen, Germany); Rainer Fietkau (University Hospital Erlangen, Germany); Christoph Bert (University Hospital Erlangen, Germany)	Session 51	Radiation therapy V – Advanced quality assurance	V 159	13.09.2017	09:00
Sensitivity analysis of QA procedures by failure injection in treatment plans	Helmut Schneider (Radio-Onkologie-Zentrum KSA-KSB, Switzerland); Denis Ovcari (Radio-Onkologie-Zentrum KSA-KSB, Switzerland)	Session 51	Radiation therapy V – Advanced quality assurance	V 160	13.09.2017	09:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Monte-Carlo simulation of proton treatments to support treatment planning and patient-specific quality assurance	Jan Eulitz (OncoRay – National Center for Radiation Research in Oncology, Germany); Benjamin Lutz (Helmholtz-Zentrum Dresden - Rossendorf, Germany); Hakan Oesten (OncoRay – National Center for Radiation Research in Oncology, Germany; Massachusetts General Hospital and Harvard Medical School, United States); Patrick Wohlfahrt (OncoRay – National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Wolfgang Enghardt (OncoRay – National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden; German Cancer Research Center (DKFZ), Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany); Armin Lühr (OncoRay – National Center for Radiation Research in Oncology, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden; German Cancer Research Center (DKFZ), Germany)	Session 51	Radiation therapy V – Advanced quality assurance	V 161	13.09.2017	09:00
Unification of patient dosimetry and quality control for CT and CBCT	Hugo de las Heras Gala (QUART GmbH, Germany; Helmholtz Zentrum München, Germany); Felix Schöfer (QUART GmbH, Germany); Roberto Sánchez-Casanueva (Instituto de Investigación Sanitaria del Hospital Clínico San Carlos (IdISSC), Spain); Katharina Mair (Strahlentheraptie Süd, Germany); Bernhard Renger (University Hospital Rechts der Isar, Germany); Helmut Schlattl (Helmholtz Zentrum München, Germany)	Session 52	Dosimetry, radiation protection and radiation biology III	V 162	13.09.2017	09:00
Evaluation of the performance of the integral quality monitor	Sonja Wegener (Universitätsklinikum Würzburg, Germany); Barbara Herzog (Universitätsklinikum Würzburg, Germany); Otto A. Sauer (Universitätsklinikum Würzburg, Germany)	Session 52	Dosimetry, radiation protection and radiation biology III	V 164	13.09.2017	09:00
Detection of proton range variations in a clinical scenario via prompt gamma-ray timing	Theresa Werner (Helmholtz-Zentrum Dresden-Rossendorf, Germany); Johannes Petzoldt (Ion Beam Applications SA, Belgium); Katja Roemer (Helmholtz-Zentrum Dresden-Rossendorf, Germany); Johannes Berthold (Technische Universität Dresden, Germany); Andreas Rinscheid (Martin Luther Universität, Germany); Toni Koegler (Helmholtz-Zentrum Dresden-Rossendorf, Germany); Arno Straessner (Technische Universität Dresden, Germany); Wolfgang Enghardt (Helmholtz-Zentrum Dresden-Rossendorf, Germany; OncoRay – National Center for Radiation Research in Oncology, Germany; German Cancer Consortium (DKTK), partner site Dresden, and German Cancer Research Center (DKFZ), Germany); Guntram Pausch (Helmholtz-Zentrum Dresden-Rossendorf, Germany)	Session 52	Dosimetry, radiation protection and radiation biology III	V 165	13.09.2017	09:00
Computer-controlled analysis of solid state nuclear track detectors	Bernd Köhler (Karlsruhe Institute of Technology, Germany); Klaus-Martin Reichert (Karlsruhe Institute of Technology, Germany); Ingo Fesenbeck (Karlsruhe Institute of Technology, Germany); Christian Naber (Karlsruhe Institute of Technology, Germany); Stephan Allgeier (Karlsruhe Institute of Technology, Germany)	Session 52	Dosimetry, radiation protection and radiation biology III	V 166	13.09.2017	09:00
Computational fluid dynamics simulations and phase contrast-MRI validation of airflow in human pharynx during obstructive sleep apnea	Pragathi Gurumurthy (Universität zu Lübeck, Germany); Christina Hagen (Universität zu Lübeck, Germany); Patricia Ulloa (Universität zu Lübeck, Germany); Martin A. Koch (Universität zu Lübeck, Germany); Thorsten M. Buzug (Universität zu Lübeck, Germany)	Session 53	Modelling and simulation IV	V 167	13.09.2017	09:00
Effects of periodic inspiratory pressure patterns during variable controlled ventilation on recruitment and respiratory system mechanics – A numerical investigation	Robert Huhle (Universitätsklinikum Carl Gustav Carus, Germany); Jacob Herrmann (University of Iowa, United States); Marcelo Gama de Abreu (Universitätsklinikum Carl Gustav Carus, Germany); David W. Kaczka (University of Iowa, United States)	Session 53	Modelling and simulation IV	V 169	13.09.2017	09:00
CFD-analysis of contrast agent transport in coronary arteries and its impact on quantification of myocardial blood flow with bolus-based perfusion MRI measurements	Johannes Martens (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Sabine Panzer (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany); Jeroen Petrus van den Wijngaard (Academic Medical Center, Netherlands); Maria Siebes (Academic Medical Center, Netherlands); Laura Maria Schreiber (University Hospital Wuerzburg, Comprehensive Heart Failure Center, Germany)	Session 53	Modelling and simulation IV	V 170	13.09.2017	09:00
Simulation and development of a patient-specific carbon fiber forefoot prosthesis using finite element method	Muneer Gaashan (Hochschule Ulm, Germany); Thomas Engleder (Hochschule Ulm, Germany); Felix Capanni (Hochschule Ulm, Germany)	Session 53	Modelling and simulation IV	V 172	13.09.2017	09:00
4D treatment planning for lung tumours in particle therapy	Christian Graeff (GSI, Germany)	Session 55	Irradiation of thoracic tumours in particle therapy – Motion and modulation	FS 111	13.09.2017	09:00

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Experimental validation of an in-silico model for ion-beam modulation in lung parenchyma	Steffen Greilich (Heidelberg Institute of Radiation Oncology (HIRO), Germany; German Cancer Research Center (DKFZ), Germany); Riccardo Dal Bello (Heidelberg Institute of Radiation Oncology (HIRO), Germany; German Cancer Research Center (DKFZ), Germany); Oliver Jäkel (Heidelberg Institute of Radiation Oncology (HIRO), Germany; Heidelberg Ion Beam Therapy Center HIT, Germany; German Cancer Research Center (DKFZ), Germany); Christian Möhler (Heidelberg Institute of Radiation Oncology (HIRO), Germany; German Cancer Research Center (DKFZ), Germany)	Session 55	Irradiation of thoracic tumours in particle therapy – Motion and modulation	FS 112	13.09.2017	09:00
Considering bragg curve degradation due to lung-equivalent materials in Monte Carlo codes by applying a density modulation	Kilian-Simon Baumann (University Medical Center Giessen-Marburg, Germany; University of Applied Sciences, Germany); Matthias Witt (Marburg Ion-Beam Therapy Center (MIT), Germany); Uli Weber (GSI Helmholtzzentrum für Schwerionenforschung, Germany); Rita Engenhart-Cabillic (University Medical Center Giessen-Marburg, Germany); Klemens Zink (University Medical Center Giessen-Marburg, Germany; University of Applied Sciences, Germany; Frankfurt Institute for Advanced Studies (FIAS), Germany)	Session 55	Irradiation of thoracic tumours in particle therapy – Motion and modulation	FS 113	13.09.2017	09:00
Methoden der Reichweitenmodulation für eine schnelle Bestrahlung thorakaler Tumore	Uli Weber (GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany); Yuri Simeonov (University of Applied Sciences THM, Germany); Toke Printz Ringbaek (University of Applied Sciences THM, Germany); Klemens Zink (University of Applied Sciences THM, Germany)	Session 55	Irradiation of thoracic tumours in particle therapy – Motion and modulation	FS 114	13.09.2017	09:00
Integration of piezoelectric transducers in well plates for broadband acoustic spectroscopy	Susan Walter (TU Dresden, Germany); Henning Heuer (TU Dresden, Germany; Faunhofer IKTS, Germany)	Session 56	Surface and volume functionalised BioCHIPs for adherent biomaterials	FS 117	13.09.2017	09:00
Integrierte Mikrosensorik für induktive-elektrische Breitband-Impedanzspektroskopie	Michael Iwanow (TU Dresden, Germany); Henning Heuer (TU Dresden, Germany)	Session 56	Surface and volume functionalised BioCHIPs for adherent biomaterials	FS 118	13.09.2017	09:00
Dose measurement in the steep dose gradients around brachytherapy sources	Frank W. Hensley (Ruprecht-Karls-Universität, Germany); Michael Andrassy (Eckert & Ziegler BEBIG GmbH, Germany); Ndimofor Chofor (Pius-Hospital Oldenburg und Carl-von-Ossietzky-Universität Oldenburg, Germany); Dietrich Harder (Georg-August-Universität, Germany); Günther Hartmann (Deutsches Krebsforschungszentrum (DKFZ), Germany); Theodor Kaulich (Universitätsklinik für Radioonkologie, Germany); Michael Kollefrath (Klinik für Strahlenheilkunde, Germany); Michael Niekamp (Elekta GmbH, Germany); Björn Poppe (Pius-Hospital Oldenburg und Carl-von-Ossietzky-Universität Oldenburg, Germany); Thorsten Schneider (Physikalisch-Technische Bundesanstalt, Germany); Andreas Schönfeld (Pius-Hospital Oldenburg und Carl-von-Ossietzky-Universität Oldenburg, Germany); Edmund Schüle (Physikalisch-Technische Werkstätten Dr. Pychlau GmbH, Germany); Hans-Joachim Selbach (Physikalisch-Technische Bundesanstalt, Germany); Frank-Andre Siebert (Christian-Albrechts-Universität, Germany); Ulrich Quast (Universität Duisburg-Essen, Germany); Renate Walter (Klinikum Augsburg, Germany); Golam Abu Zakaria (Klinikum Oberberg, Germany)	Session 57	Dosimetry, radiation protection and radiation biology IV	V 173	13.09.2017	12:45
MR-µ-imaging based 3-dimensional-polymer gel dosimetry in comparison to 2D-film and 1D-diamond dosimetry of mm-sized photon pencil beams	Andreas Berg (Medical University of Vienna; Center for Medical Physics and Biomedical Engineering, Austria); Gerd Heilemann (Medical University of Vienna, Austria; MedicalUniversity of Vienna, Austria); Dietmar Georg (Medical University of Vienna, Austria; MedicalUniversity of Vienna, Austria)	Session 57	Dosimetry, radiation protection and radiation biology IV	V 175	13.09.2017	12:45
The influence of magnetic fields on the lateral dose response function of various photon dosimetry detectors	Björn Delfs (Universität Oldenburg, Germany); Dietrich Harder (Georg August University, Germany); Björn Poppe (Universität Oldenburg, Germany); Hui Khee Looe (Universität Oldenburg, Germany)	Session 57	Dosimetry, radiation protection and radiation biology IV	V 176	13.09.2017	12:45
Three-dimensional gel dosimetry for stereotactic radiosurgery of multiple brain metastases with helical tomotherapy	Thomas Rothe (Universitätsklinikum Freiburg, Germany); Giannoulla Sourmeli (Universitätsklinikum Freiburg, Germany); Rainer Saum (Universitätsklinikum Freiburg, Germany); Ute Ludwig (Universitätsklinikum Freiburg, Germany); Michael Bock (Universitätsklinikum Freiburg, Germany); Evangelos Pappas (Technological Educational Institute, Greece); Dimos Baltas (Universitätsklinikum Freiburg, Germany)	Session 57	Dosimetry, radiation protection and radiation biology IV	V 177	13.09.2017	12:45
Monitoring of cardiorespiratory signals using thermal imaging	Carina Barbosa Pereira (RWTH Aachen university, Germany); Michael Czaplik (University Hospital RWTH Aachen, Germany); Boudewijn Venema (RWTH Aachen university, Germany); Vladimir Blazek (RWTH Aachen university, Germany); Steffen Leonhardt (RWTH Aachen university, Germany); Daniel Teichmann (RWTH Aachen university, Germany)	Session 58	Imaging and image processing V – Miscellaneous	V 179	13.09.2017	12:45

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Thermography for perfusion analysis of the thoracic region after bypass grafting	Jens Müller (TU Dresden, Germany); Christian Thiele (TU Dresden, Germany); Antje Rost (TU Dresden, Germany); Imre Kukel (TU Dresden, Germany); Tamer Ghazy (TU Dresden, Germany); Stefan Rasche (TU Dresden, Germany); Christian Schnabel (TU Dresden, Germany); Juliane Müller (TU Dresden, Germany); Ronald Tetzlaff (TU Dresden, Germany)	Session 58	Imaging and image processing V – Miscellaneous	V 180	13.09.2017	12:45
Three-dimensional measurement of the blood flow in the umbilical cord using automated quantification of color doppler signals	Andreas Grundmann (ICM-Institut Chemnitzer Maschinen- und Anlagenbau e.V., Germany); Sebastian Walther (ICM-Institut Chemnitzer Maschinen- und Anlagenbau e.V., Germany); Thomas Scholbach (Chameleon Software GmbH , Germany); Jakob Scholbach (Chameleon Software GmbH , Germany)	Session 58	Imaging and image processing V – Miscellaneous	V 182	13.09.2017	12:45
Effect on 1-3 piezocomposite layout on resonance behavior of high-frequency ultrasonic transducers	Paul A. Günther (Fraunhofer IKTS, Germany); Holger Neubert (Fraunhofer IKTS, Germany); Sylvia Gebhardt (Fraunhofer IKTS, Germany)	Session 58	Imaging and image processing V – Miscellaneous	V 183	13.09.2017	12:45
Proton radiography for integrating positioning and treatment planning of small animals at an experimental proton beam	Johannes Müller (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany); Christian Neubert (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Brandenburg University of Technology Cottbus-Senftenberg, Germany); Cläre von Neubeck (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; German Cancer Consortium (DKTK), partner site Dresden, Germany; German Cancer Research Center (DKFZ), Germany); Mechthild Krause (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany; German Cancer Consortium (DKTK), partner site Dresden, Germany; German Cancer Research Center (DKFZ), Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; National Center for Tumor Diseases (NCT), partner site Dresden, Germany); Wolfgang Enghardt (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Germany; German Cancer Consortium (DKTK), partner site Dresden, Germany; German Cancer Research Center (DKFZ), Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany); Rebecca Bütof (OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Germany; Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; National Center for Tumor Diseases (NCT), partner	Session 58	Imaging and image processing V – Miscellaneous	V 184	13.09.2017	12:45
Continuous sleep-apnea screening in an unattended home-setting	Simon Annaheim (Empa, Switzerland); Martin Camenzind (Empa, Switzerland); Otto Schoch (Kantonsspital St. Gallen, Switzerland); Martin Brutsche (Kantonsspital St. Gallen, Switzerland); Florent Baty (Kantonsspital St. Gallen, Switzerland); René Rossi (Empa, Switzerland)	Session 59	Biosignal processing and monitoring IV	V 185	13.09.2017	12:45
Detection of nightly snore events in OSA patients	Lisa Steinbrecher (Technische Hochschule Mittelhessen, Germany); Keywan Sohrabi (Technische Hochschule Mittelhessen, Germany); Nilab Taher (Technische Hochschule Mittelhessen, Germany); Schahab Moeri (Universitätsklinikum Gießen Marburg, Germany); Ulrich Koehler (Universitätsklinikum Gießen Marburg, Germany); Andreas Weissflog (Thora Tech GmbH, Germany); Volker Gross (Technische Hochschule Mittelhessen, Germany)	Session 59	Biosignal processing and monitoring IV	V 187	13.09.2017	12:45
Evaluation of patient compliance during BIPAP-ventilation	Florian Schudt (University of Applied Sciences, Germany); Keywan Sohrabi (University of Applied Sciences, Germany); Werner Seeger (University of Giessen and Marburg Lung Center (UGMLC), Germany); Andreas Weissflog (Thora Tech GmbH, Germany); Volker Gross (University of Applied Sciences, Germany)	Session 59	Biosignal processing and monitoring IV	V 188	13.09.2017	12:45

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Comparison of camera-based and contact based estimation of the respiratory rate	Fabian Schrumpf (Hochschule für Technik, Wirtschaft und Kultur Leipzig, Germany); Christoph Mönch (Hochschule für Technik, Wirtschaft und Kultur Leipzig, Germany); Bianca Reichard (Hochschule für Technik, Wirtschaft und Kultur Leipzig, Germany); Mirco Fuchs (Hochschule für Technik, Wirtschaft und Kultur Leipzig, Germany)	Session 59	Biosignal processing and monitoring IV	V 189	13.09.2017	12:45
Time-frequency representations of combined EEG and MEG recordings during NREM sleep	Tilmann Sander-Thömmes (Physikalisch-Technische Bundesanstalt, Germany); Martin Glos (Charité, Germany); Alois Schlögl (IST Austria, Austria); Christian Veauthier (Charité, Germany)	Session 59	Biosignal processing and monitoring IV	V 191	13.09.2017	12:45
NPH patients in Bern – gold standard in therapy and its shortcomings	Christian Fung (Inselspital Bern, Switzerland)	Session 60	Normal pressure hydrocephalus – Model based analysis of pathogenesis and therapy options	FS 120	13.09.2017	12:45
FEM modelling for bioimpedance controlled monitoring of normal pressure hydrocephalus	Carlos Castelar (RWTH Aachen University, Germany); Steffen Leonhardt (RWTH Aachen University, Germany)	Session 60	Normal pressure hydrocephalus – Model based analysis of pathogenesis and therapy options	FS 123	13.09.2017	12:45
MRI flow measurements and what they tell us about hydrocephalus	Olivier Balédent (Université de Picardie Jules Verne, France)	Session 60	Normal pressure hydrocephalus – Model based analysis of pathogenesis and therapy options	FS 124	13.09.2017	12:45
From first ideas to technical feasibility	Gernot Echner (DKFZ, Germany); Armin Runz (DKFZ, Germany); Wibke Johnen (DKFZ, Germany); Matthias Borutta (DKFZ, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 125	13.09.2017	12:45
From imaging to a realistic model	Wibke Johnen (Deutsches Krebsforschungszentrum, Germany); Gernot Echner (Deutsches Krebsforschungszentrum, Germany); Armin Runz (Deutsches Krebsforschungszentrum, Germany); Matthias Borutta (Deutsches Krebsforschungszentrum, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 126	13.09.2017	12:45
Gels in radiation oncology	Armin Runz (Deutsches Krebsforschungszentrum, Germany); Wibke Johnen (Deutsches Krebsforschungszentrum, Germany); Matthias Borutta (Deutsches Krebsforschungszentrum, Germany); Gernot Echner (Deutsches Krebsforschungszentrum, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 127	13.09.2017	12:45
An anthropomorphic multimodality (CT/MRI) head phantom prototype for end-to-end tests in radiotherapy	Raya Roshana Gallas (Current working address: Physikalisch-Technische Bundesanstalt (PTB), Germany); Nora Hünemohr (Current working address: Ministry of Science, Research and the Arts, Germany); Armin Runz (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), National Center for Radiation Research in Oncology, Germany); Nina Isabelle Niebuhr (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), National Center for Radiation Research in Oncology, Germany); Oliver Jäkel (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), National Center for Radiation Research in Oncology, Germany; Heidelberg Ion-Beam Therapy Center (HIT), Germany); Steffen Greilich (German Cancer Research Center (DKFZ), Germany; Heidelberg Institute of Radiation Oncology (HIRO), National Center for Radiation Research in Oncology, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 128	13.09.2017	12:45
A patient similar phantom in adaptive radiotherapy	Mona Splinter (Deutsches Krebsforschungszentrum Heidelberg, Germany); Peter Häring (Deutsches Krebsforschungszentrum Heidelberg, Germany); Clemens Lang (Deutsches Krebsforschungszentrum Heidelberg, Germany); Wibke Johnen (Deutsches Krebsforschungszentrum Heidelberg, Germany); Nina Niebuhr (Deutsches Krebsforschungszentrum Heidelberg, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 129	13.09.2017	12:45
Use of an elastic anthropomorphic phantom for the evaluation of a new patient positioning device	Peter Häring (DKFZ, Germany); Javiera Godoy (DKFZ, Germany); Clemens Lang (DKFZ, Germany); Wibke Johnen (DKFZ, Germany); Armin Runz (DKFZ, Germany); Mona Splinter (DKFZ, Germany); Gernot Echner (DKFZ, Germany)	Session 61	Anthropomorphic phantoms in radiooncology	FS 130	13.09.2017	12:45
Clinical requirements for a new sensor system inside the ear for diagnostic applications in sleep medicine	Thomas Penzel (Charite Universitätsmedizin Berlin, Germany; International Clinical Research Center, St. Anne's University Hospital Brno, Czech Republic); Martin Glos (Charite Universitätsmedizin Berlin, Germany); Christoph Schöbel (Charite Universitätsmedizin Berlin, Germany); Ondrej Ludka (International Clinical Research Center, St. Anne's University Hospital Brno, Czech Republic); Ingo Fietze (Charite Universitätsmedizin Berlin, Germany)	Session 62	New techniques in biosignal analysis for detecting sleep-related respiratory disorders	FS 131	13.09.2017	12:45
Cardiorespiratory coupling in sleep apnea	Niels Wessel (Humboldt-Universität zu Berlin, Germany); Jan F Kraemer (Humboldt-Universität zu Berlin, Germany); Harald Krause (Humboldt-Universität zu Berlin, Germany); Maik Riedl (Humboldt-Universität zu Berlin, Germany); Thomas Penzel (Humboldt-Universität zu Berlin, Germany; Charité Universitätsmedizin Berlin, Germany); Jürgen Kurths (Humboldt-Universität zu Berlin, Germany)	Session 62	New techniques in biosignal analysis for detecting sleep-related respiratory disorders	FS 132	13.09.2017	12:45

Title	Authors (affiliation and country)	Session ID	Session	Abstract ID	Session date	Session start time
Analysis of tracheal sound signals for detection of sleep related breathing disorders	Martin Glos (Charité-Universitätsmedizin Berlin, Germany); Katharina Jelavic (Charité-Universitätsmedizin Berlin, Germany); Alexandra Günther (Charité-Universitätsmedizin Berlin, Germany); Thomas Penzel (Charité-Universitätsmedizin Berlin, Germany)	Session 62	New techniques in biosignal analysis for detecting sleep-related respiratory disorders	FS 133	13.09.2017	12:45
Pulse wave analysis provides additional CV risk information to polysomnography in sleep apnoea patients	Dirk Sommermeyer (Hochschule Mannheim, Germany; Universität Göteborg, Sweden); Martin Glos (Charité-Universitätsmedizin, Germany); Thomas Penzel (Charité-Universitätsmedizin, Germany); Ingo Fietze (Charité-Universitätsmedizin, Germany); Ding Zou (Universität Göteborg, Sweden); Jan Hedner (Universität Göteborg, Sweden); Joachim Ficker (Klinikum Nürnberg, Germany); Winfried J. Randerath (Krankenhaus Bethanien, Germany); Bernd Sanner (AGAPLESION BETHESDA Krankenhaus bH, Germany); Ludger Grote (Universität Göteborg, Sweden)	Session 62	New techniques in biosignal analysis for detecting sleep-related respiratory disorders	FS 135	13.09.2017	12:45

V 1

Intercenter validation of a knowledge based model for automated planning of volumetric modulated arc therapy for prostate cancer: The experience of the German RapidPlan Consortium.

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Purpose: To evaluate the performance of a model-based optimisation process for volumetric modulated arc therapy in a multicentric cooperative group. The Varian RapidPlan (RP) knowledge based engine was tested for the planning of RapidArc treatments on prostate cancer patients. The study was conducted in the frame of the German RapidPlan Consortium (GRC).
Methods and materials: A set of 43 patients from one institute of the GRC was used to build and train a RP model, the PTV including the prostate region and the pelvic lymphnodes. The model was shared with all members of the GRC plus an external site from a different country. An in silico multicentric validation of the model was performed at planning level by comparing RP-based against reference plans optimized according to institutional procedures. A total of 60 patients from 7 institutes were used for this investigation.
Results: On average, the automated RP based plans resulted fully consistent with the manually optimised set with a modest tendency to improvement in the medium-to-high dose region. A site by site evaluation showed different patterns of performance of the model, with some organs at risk resulting better spared with the manual or with the automated approach. In all cases the RP data fulfilled the clinical acceptability requirements. Discrepancies in the performance were due either to different contouring protocols or to different emphasis put in the optimization of the manual cases.
Conclusions: The multicentric validation demonstrated that it was possible to satisfactorily optimize with the knowledge based model patients from all participating centres. Due to possibly significant differences in the contouring protocols, the automated plans, though clinically acceptable and fulfilling the optimization goals, might benefit from further fine tuning of the constraints. The study demonstrates the reliability of the concept of sharing models among different clinical institutes in a cooperative framework.

V 2

Evaluation of the consistency in a clinically implemented plan selection strategy for adaptive radiotherapy in cervix cancer

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Introduction: A plan-of-the-day (POTD) approach based on a library of multiple plans is a promising strategy for online adaptive radiotherapy (ART) in cervix cancer due to daily organ motion. The procedure includes the daily selection of the smallest PTV encompassing the target volume on CBCT images. However, image quality can be deteriorated by artifacts and soft tissue contrast on CBCT is limited. Additionally, inter- and intraobserver variations may exist. The purpose of this study was to evaluate the plan selection consistency of a POTD strategy in cervix patients.
Materials and methods: Nine cervix patients were treated with the POTD-ART approach. Radiation was delivered by VMAT with 45 Gy in 25 fractions followed by brachytherapy. A two stage POTD-ART approach, consisting of two treatment plans, was clinically implemented. One plan was created for an empty bladder and the other one for a full bladder anatomy. The plan library was completed by a motion robust backup plan that included all motion. A daily CBCT was acquired and the POTD was selected by a single observer. To investigate the reproducibility, the selection process was repeated by a group of three experts (oncologists and physicists) without knowledge of the delivered plan after end of treatment. The agreement between expert-group-selected plans and treated plans was determined.
Results: In total 222 adaptively delivered fractions were analyzed. The initial selection consistency between delivered and retrospective plan selection was 84%. However, in 34 fractions empty and full plans were giving sufficient target coverage and the decision was just based on priorities in organ sparing. By considering these fractions, the agreement on adequate treatment selection increased to 93%.
Discussion: This study evaluates the adaption consistency of a POTD-ART strategy for cervix cancer that is based on a library of three VMAT plans. The plan selection agreement is considered high.

V 3

Detection of changes in the patient anatomy using the integrated detector array of a tomotherapy system

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The assumption of a constant patient anatomy throughout the course of a radiation therapy treatment is fundamental for the process of treatment planning. If the anatomy is changing an adaption of the treatment plan might be necessary. Presently adaptive radiation therapy is still time consuming and is not applied to every patient by default.
For the later simulation of anatomical changes a cylindrical phantom, partially covered with 2cm flab material, three treatment plans (Head-and-Neck-like, central and superficial PTV) were generated. All treatment plans were delivered 5 times with varying flab thicknesses from 1cm to 3cm. The data of the CT-detector-array acquired during these treatments was analyzed with the delivery analysis software using the 2cm-flab situation as reference. The calculated parameters were the mean signal on the detector, a gamma analysis and a direct difference comparison of the detector sinograms. Additionally the MVCT scans acquired before each treatment were used to calculate the dosimetric effect of the changes in the anatomy.
The measured mean signal on the detector changed significantly with the thickness of the flab. The gamma analysis and the difference comparison clearly identified the changed anatomical situations, depending on the chosen parameters (distance to agreement, signal difference). The MVCT based calculated dosimetric changes for the Head-and-Neck-like and the central PTV were +/- 2% for the median dose, maximum dose and the dose covering 95% of the PTV. The superficial PTV showed a more extreme behavior because the anatomical changes were in the PTV itself, or in the immediate proximity.
In this phantom study the detector signals recorded during plan delivery were used to detect ‘anatomical’ changes. Furthermore the evaluated parameters correlated with the calculated dosimetric effects. For the transfer to real patient cases more scenarios, including patient positioning, need to be investigated.

V 4

Photon fluence reconstruction for online dose verification

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To verify the dose delivered during an external photon radiation treatment it is necessary to calculate the initial photon fluence applied by a linear accelerator in front of the patient. In this work a calculation algorithm was develop to reconstruct the photon fluence from EPID images acquired during the treatment.
A dose calibration of the EPID image was performed to determine the absorbed dose in the EPID. The EPID images were corrected for scatter from patient and EPID by an iterative deconvolution using Monte Carlo calculated point spread functions (PSF) to determine the dose deposition Di by initial unscattered photons inside the EPID. The initial photon fluence was calculated based on the patient geometry from CT data and the deconvoluted dose Di.
To verify the algorithm RW3 phantoms with a thickness between 3 cm and 15 cm were irradiated by 6 MV photon fields of different field sizes and the resulting EPID images were evaluated with our algorithm.
The deviation between the reconstructed relative photon fluence for the phantoms and the flood field image was below 2.3% for field sizes of 5x5 cm² and 10x10 cm². For larger treatment fields of 20x20 cm² the deviation was below 4%.
In the clinical experiments the algorithm accomplished acceptable accuracy. In further studies the algorithm has to be optimized, eg. reconstruction parameters have to be adapted to the investigated clinical linear accelerator. Moreover, dose calculations using the reconstructed fluence as a particle source will be compered to dose measurements.

V 6

A tissue-equivalent test environment for malfunctions of active medical implants and electronic devices due to radiation

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Introduction and Aim: The demographic change has caused an increase in age-related diseases that need a active implants, e.g. pacemakers, defibrillators for therapy. Furthermore, the number of patients with tumors treated in radiation therapy also increased. The implanted medical device (iMD) is often in close proximity to the target volume (PTV) and its functionality can be temporarily or permanently disturbed radiation.
Material and Methods: For the standardized investigation of malfunctions, a body phantom with tissue-like materials was developed for broad energy range (70keV-15MeV). In the phantom, organ structures such as heart, ribs, spine and lung were made of materials which are equivalent to tissue regarding the interaction with radiation. A CT data set of the phantom was used for treatment planning (Pinnacle, Philips Medical Systems). Thus, dose caused by scatter at the iMD can be simulated. In addition to iMDs, electronic components can be inserted into the phantom and tested for malfunctions. Flash memory modules and lithium batteries were treated with 6MV by 3Gy. The verification of the planned dose was done with a 0.125cc dose chamber (Semiflex, PTW).
Results and Conclusion: Various materials were tested and evaluated for their tissue-equivalency. The materials (soft tissue: 10±2HU, lung: -903±13HU, heart: 25±3HU, bone: 832±16HU at 130keV) were validated by a CT scan and a Monte-Carlo simulations using pyPENELOPE. About 40% of the tested flash memory modules and 50% of the batteries showed an irreversible, atypical functional behavior. Errors were different reading speed or increased discharge duration. A valid test environment was developed, to test iMD and electronic assemblies. In the further course of the project*, different electronic components, iMD's and treatment options are investigated.
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V 7

Surface plasmon resonance measurements of receptor binding kinetics for physiologically-based pharmacokinetic modeling of molecular radiotherapy using PSMA-11

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Diagnosis and therapy of prostate cancer increasingly concentrates on approaches with prostate-specific membrane antigen (PSMA)-specific peptides like PSMA-11 or PSMA-617. The pharmacokinetics of these substances are relevant for development and optimization of those peptides as well as for modelling the metabolic processes in planning of individualized molecular radiotherapy. Reliable and reproducible pharmacokinetic data of substances obtained by easy-to-handle methods would be advantageous for all aspects. To determine the association and dissociation rate constants of the PSMA-specific peptides PSMA-11 (ABX) and GaPSMA-11 (ABX), surface plasmon resonance (SPR) spectroscopy using a Biacore X100 was performed. This technique allows the real-time analysis of the interaction between ligand and receptor without necessity of labelling and the influence of confounding side effects as in cell-based assays. In comparison to previously published binding affinity values obtained using cell assays, for PSMA-11 a 100-fold lower dissociation constants were determined using SPR spectroscopy. In contrast to most cell binding studies performed at 4°C, SPR spectroscopy facilitates physiological conditions with temperatures of 25°C or 37°C. These data can be implemented to model the binding and internalization processes of PSMA-11 to optimize application dose and biodistribution.

The determination of the binding kinetics for PSMA-11 and GaPSMA-11 yielded (0.07±0.02) nM and (0.04±0.02) nM at 25°C, and (0.07±0.04) nM and (0.10±0.08) nM at 37°C. These values are significantly lower compared to most published data (about 12 nM). No significant difference between the equilibrium dissociation constants KD measured at 25°C and at 37°C has been observed.

Molecular interaction data can be determined by highly reproducible and non-influenced SPR measurements. These data are of great value for peptide development and optimization: Implemented into a physiologically-based pharmacokinetic (PBPK) model, the binding and internalization processes can be successfully described and used for individualized treatment planning of molecular radiotherapy.

V 8

A lab-on-a-chip for purification of miRNAs from archival (FFPE) tissue samples

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MicroRNAs (miRNAs) are a family of more than 1500 small (20 to 23 nucleotides in length) noncoding RNA molecules that regulate numerous essential cell functions [1]. By targeting messenger RNAs for cleavage or translational repression, they can influence cell development /- differentiation and play an important role in the development of human cancers [2].
Here we present the development of a single step electrophoretic lab-on-a-chip approach for the purification of miRNAs from deparaffinated formalin fixed paraffin embedded tissues (FFPE) within three minutes.
The chip system is based on unique microfluidic technology that allows for accurate handling of µl sized fluid volumes by controlling the wetted areas within microfluidic chambers [3]. The technology is used to pattern two microfluidic chambers that are separated by a hydrogel. The raw clinical sample is introduced into the first of the chambers. A constant voltage is then applied across the chambers by coplanar electrodes. Anionic nucleic acids subsequently migrate though the hydrogel and are collected in the second chamber.
FFPE tissue samples were first chemically deparaffinated and then introduced into the chip-based extraction system. Obtained yields and purity allowed for the direct detection of miRNA species by stem-loop RT-qPCR without pre-amplification. Compared to a commercial kit (RNATotal, Ambion), miRNA yields from FFPE tissues were found to be up to 10-fold higher.
Compared to current procedures in clinical laboratories, the proposed system is able to greatly lower the time required for miRNA extraction as well as simplify the procedure by requiring only very few manual handling steps.
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V 9

System for automated cell cultivation and analysis

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While automation is practiced in many industrial and research fields, cell cultivation is still mainly based on manual handling and processes. Especially for mechano-sensitive cells (and at the present state of knowledge we may suppose that any cell is mechano-sensitive), transportation and handling procedures might impair experimental results due to provocation of inertial forces. To resolve this problem, our group focuses on the development of a modular, automated cell cultivation tool for a variety of experiments. We apply a biocentered approach: cells located in micro cultivation chambers act as the mechanically fixed center of the system, subsystems to supply the optimum cultivation conditions are built close to it and analytical tools move around.
The supply infrastructure provides proper physical (e.g. temperature and forces on cells), chemical (e.g. pH and availability of nutrients and gases) as well as biological parameters (e.g. cell-cell- and cell-matrix-interactions). These parameters possess a direct impact on cell reactions like differentiation or synthesis of specific metabolites and thus enable the investigation of cellular stimulus-response-mechanisms.
At present, we focus on differentiation pathways of ovine mesenchymal stem cells. The cells are cultivated inside of fitted microstructures (BioMOEMS – BioMicroOptoElectroMechanicalSystems) equipped with scaffold structures manufactured by two-photon polymerization. Together with sensor and actuator systems, these cultivation chambers are fitted into cultivation modules on the scale of a standard ANSI/SLAS microplate. Such modules can be used as a standalone solution or interconnected with other modules to allow the generation of new branches in cell research. The cells are observed via distributed sensors inside the modules and optional by an integrated analytic tool (moving optical system). Cultivation processes are controlled via a touchscreen interface. For acceptance, the user, i. e. laboratory personnel, is involved in the development process with user surveys.

V 10

Cell culture-based in vitro models for investigating the SPION passage through cellular barriers

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Superparamagnetic iron oxide nanoparticles (SPIONs) are in the focus for various biomedical applications such as targeted drug delivery, hyperthermal anti-tumor therapy, and as contrast agents for magnetic imaging methods. For their successful implementation, a detailed knowledge concerning their interaction with cellular interfaces is a fundamental requirement. Previously, we have demonstrated that dependent on the particle type SPIONs can penetrate into three-dimensional cellular structures such as spheroids. In order to analyse the ability of SPIONs to passage distinct cellular layers, we generated both, a transwell-based mono-layered cell culture model representing the human blood-brain barrier and a multiple-layered co-culture system representing the human blood-placenta barrier. First we studied the SPION passage through both barrier types by quantifying nanoparticle amounts found in the basolateral compartment. This was done by means of highly sensitive measurements via magnetic particle spectroscopy and atomic absorption spectroscopy. Additionally, we analysed the SPION-induced effect on barrier integrity by performing transendothelial electrical resistance measurements, molecular permeability assays, fluorescence microscopy, and histological cross-sections.
We show that SPIONs can clearly pass mono-layered barriers and found indications that also the multiple-layered blood-placenta barrier model is penetrated by SPIONs. Dependent on the particle type this SPION passage is not accompanied by the disruption of barrier integrity for both barrier models. The time- and concentration dependent nature of particle passage point towards distinct transcellular routes of SPION transport through the barrier-forming cells. In conclusion, based on the two cell culture barrier models and the highly sensitive SPION detection methods we could establish a valuable tool for the detailed analysis of particle interaction and penetration through cellular barriers. Thus, our approach improves the understanding of tissue penetration and, in consequence, considerably advances the strategy for tailored SPION configurations to successfully realize intended biomedical applications.

V 11

Non-intrusive performance analysis of implantable electrodes

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Functional electrodes for interfacing neuronal tissue undergo strong alterations during their application. Glia scar encapsulation, electrode displacement or destructive forces due to electrical stimulation represent only a few examples. Electrochemical impedance spectroscopy as well as Electrical Cell-Substrate Impedance Sensing are common techniques to determine these kind of processes. However, both techniques rely on a defined sinusoidal stimulation signal which is applied to the electrode under test. A non-destructive and non-intrusive method alternative is the recording of the intrinsic noise of the electrode and the interfacing tissue.
Customized low-noise amplifiers are designed to record voltage and current fluctuations in a broad frequency range between mHz up to several MHz. Different neuronal electrodes as well as counter electrode are placed carefully in buffered saline solutions or are covered with cultured MDCK cells to simulate tissues with different specific resistivity. Noise spectra are compared to classical impedance spectrograms.
The electrical properties of the electrode/electrolyte interface is clearly reflected in the whole bandwidth of the spectral noise resistance and shows good agreement with the measured impedance. The voltage power spectral densities can be used as a measure of the tightness between electrode and attached cells, when analyzing the adhesion noise between 1-10kHz. Furthermore the cell-cell junctions are reflected in a frequencies between 0.1-1kHz.
The analysis of noise spectra is a promising alternative to established electrical impedance spectroscopy, even if phase information are not accessible. Since this method is based on intrinsic processes of the electrode/tissue interface it is not influencing the system like an electrical stimulation. In addition, even more information about i.e. ongoing corrosion processes can be evaluated simultaneously.

V 12

Effective parameters describing mechanisms of magnetic separation using superparamagnetic beads

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Presently, magnetic separation using superparamagnetic beads is the economically most important (several hundred million Euros per year) application of magnetic nanoparticles (MNPs) for in-vitro diagnostics in biomedicine. By assembling several MNPs into one entity, the resulting beads become a smart magnetic material with adjustable magnetism for magnetic separation. This forms the basis of diagnostic kits where cells, viruses, proteins or nucleic acids specically bind to the magnetic beads and are directly extracted from blood, serum or other liquids with high efficiency by application of magnetic fields and field gradients. The previous literature on the underlying physics of magnetic separation describes the forces on a magnetic bead in an external field depending on a linear susceptibility and the saturation magnetization of the bead. In this contribution, we extend the established model by a Langevin function relating the effective magnetic moment of a superparamagnetic bead to the external magnetic field and the temperature. Furthermore, we discuss possibilities to take the magnetic interaction between MNPs as well as the anisotropy of the MNPs into account. The difficulties in modelling these two influences can be overcome by an empirical formalism based on the incorporation of the measured magnetization curve into the force calculation. This enables us to describe the interplay between MNP properties, distribution of MNPs to beads, magnetic field strength and magnetic gradient, which are all influencing the force on the magnetic beads. The application of the framework is demonstrated on measurements of the mobility of Dynabeads® suspended in solution. In summary, we show how relevant effective parameters for the force on magnetic beads during a separation process can be derived from magnetization measurements.

FS 1

Operation models of the temporal bone - generation and biomechanical properties - How well can haptic properties of the bones be simulate.

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Due to a limited availability of human bone for training purposes in ear surgery, authentic models are needed for an effective training of ear, nose, and throat specialists. In this work, the processing properties of an artificial model of the os temporale (the Magdeburg temporal bone model) are investigated with respect to the drilling and milling behavior as well as the elastic modulus. The Magdeburg temporal bone model is an epoxy resin facsimile of a human os temporale which is manufactured by 3D printing based on human computed tomography data.
The results are compared with the results of a human os temporale. The forces acquired during drilling and milling as well as the determined elastic moduli show significant differences between both types of material – all values of the original bone are significantly higher. However, reproducing the trabecular structure of human bone results in a similar degree of force fluctuations. Due to this, an authentic feeling for the surgeon is roughly provided by the given Anatomic Facsimile Model (AFM).

FS 3

Effect of middle ear transfer function on stapes quasi-static stiffness induced by a novel 3-axis force sensor

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Intra-operative quantification of the ossicle mobility could provide valuable feedback for the status of the patient's conductive hearing. Current methods for evaluation of middle ear mobility are mostly limited to the surgeon's subjective impression through manual palpation. This study investigates how middle ear transfer function is affected by stapes quasi-static stiffness of the ossicular chain. The stiffness of the middle ear is induced by a) using a novel fiber-optic 3-axis force sensor, and b) by artificially reduction of stapes mobility due to drying of the middle ear.
Middle ear transfer function, defined as the ratio of the stapes footplate velocity versus the ear canal sound pressure, was measured with a single point LDV in two conditions. First, a controlled palpation force was applied in three directions (superior-inferior, posterior-anterior, lateral-medial) with a novel 3-axis PalpEar force sensor (Sensoptic, Switzerland), while the corresponding quasi-static displacement of the contact point was measured via a 3-axis micrometer stage. The palpation force was applied sequentially, step-wise in the range of 1 – 200 mN. Second, measurements were repeated with various stages of stapes fixation, simulated by drying of the temporal bone, and ossicle fixation simulated by gluing of the stapes footplate.
Even moderate levels of palpation force (<3gF, <30mN) have negative effect (10-20dB) on the low frequency (<2 kHz), but no significant effect at higher frequencies. Force-displacement measurements around the incudostapedial joint showed quasi-static stiffness in the range of 200-400 N/m. Simulated stapes fixation (drying time of 5 – 7 hrs.) increases (5-10dB) the high frequency (>3kHz) and decreases (3-5dB) the low frequency (<1kHz) response of the middle ear. Stapes immobilization severely reduces (20-30dB) the low and mid frequency response (<4kHz) but has lesser effect (<10dB) at higher frequencies.
Stiffening of the ossicular chain by pushing on the ossicular chain has similar effects as drying. An incomplete fixation of the ossicular chain can be difficult to detect intraoperatively. Drying of the temperal bone during experiments may alter ossicular motion.

V 14

Combined optoacoustic and acoustic tomography system for investigation of fingers

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Arthritic diseases, including rheumatoid arthritis, psoriatic arthritis and osteoarthritis, have a prevalence between 2 and 3% and lead to joint destruction and deformation resulting in a loss of function. Current diagnostic methods rely on B-scan and Doppler ultrasound, x-ray or MRI, which have the drawbacks of low sensitivity and high user-dependency, involvement of ionizing radiation and high costs, respectively. We developed a combined US/OA imaging system for investigation of fingers allowing taking advantage of the high sensitivity of OA for imaging of vasculature and inflammation-related neovascularization.
Our system consists of 4 arc-shapes transducer arrays based on high-bandwidth cMUTs, allowing imaging of all 3 finger joints (full tomographic view of DIP and PIP, top/bottom view of MCP). The pitch of the arrays is 150 µm and the center frequency is around 10 MHz. The total number of 768 elements is connected to a multichannel electronics platform. The system DiPhAS (Digital Phased Array System, Fraunhofer IBMT) has 128 channels for transmit and receive, each allowing the digitization with up to 80 MSamples/s, and has been equipped with a 1 to 8 multiplexer. Signals are generated with a pulsed OPO laser system with a PRF of 100 Hz and a pulse duration of 6 ns (NT232, EKSPLA).
The system´s performance has been evaluated using different phantom structures. The measurements were made on wires directly immersed in the water bath. In addition, tissue phantoms made of PVA, in which bone material was integrated to mimic a real finger were developed. An isotropic resolution of approximately 150 µm was achieved in both modes. The system has furthermore been tested for compliance with MDD 93/42/EEC so that a clinical study can be performed soon.

V 15

Computer assisted detection of polyps during colonoscopy – results from an initial technical study

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The detection of adenomas is one main task during screening colonoscopy, as precursors of carcinomas can be detected and removed. Nevertheless, even though such screening programs have shown positive results in the past years, it can be observed, that still a considerable amount of polyps in the colon are overseen during colonoscopy. Hence, technical developments for the computer assisted detection (CADe) of adenomas and polyps and thus a support of the endoscopist would be quite helpful.
In the past three years a real-time, low-delay software-system based on visual structure, texture, color, and motion features has been developed for the detection of polyps during colonoscopy, which provides visual clues (image augmentation of potential areas with polyps) to the physician. In a technical feasibility study this approach has been tested on patients during routine colonoscopy. The primary goal was the technical feasibility of the system; the secondary goal was the comparison of the polyps as seen by the physician compared to the polyps automatically detected by the system.
Colonoscopic examinations of 58 patients could be captured and analyzed. There were no technical complications based on the software. Of the 75 polyps detected by the physician, 55 (73,3%) polyps were correctly seen by the system. Polyps not detect by the software were quite smaller compared to the polyps seen be the system (3,6±1,6 mm vs. 7,0±7,4 mm, p = 0,052). No polyp smaller than the size of 7 mm have been overseen by the system.
Furthermore, some of the overseen polyps had the tendency of a flat appearance (Paris Nomenclature II) compared to those detected and presented by the system (73,7% vs. 45,8%, p = 0,054).
The use of a real-time, low-delay system for a computer-assisted detection of polyps during colonoscopy is possible. 73% of all polyps detected by the endoscopist during this study were also seen by the software. Thus, in the next steps, the automated detection of small and flat polyps shall be addressed.

V 16

3D-Panoramic images for laparoscopy

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Today minimal invasive interventions based on laparoscopy are an established method in the field of surgery. For the patient the trauma, the physical damage of the body as well as the convalescence can thus be reduced. Nevertheless, due to limited and reduced sight such minimal invasive interventions provide various challenges to the surgeons. These challenges include the navigation of the laparoscope inside for the patient's body, the limited orientation in the working space, the partial loss of the third dimension, as well as the reduced view from the so-called "key-hole" intervention. These restrictions can partially be solved by using image processing techniques.
This contribution addresses the compensation of the reduced view by proposing a 3D-panoramic map based on stereo-laparoscopic image sequences. The input data of our approach consist of stereoscopic laparoscopy image sequences acquired during routine laparoscopic surgical interventions. In a first step each dual-frame of the stereo-sequence is rectified in order to find adequate correspondences in both views. Secondly, from each stereo pair frame a depth map is computed using various techniques such as block-matching (BM), semi-global block-matching (SGBM), or the linewise-hybrid recursive matcher (LHRM). Using the thus acquired depth-maps of a moving stereo-laparoscope a 3D-panoramic image can be obtained. To this end, the depth maps from the various laparoscopic views are registered to each other using point-cloud registration approaches such as feature matching (e.g. Brute-Force and FLANN) of extracted 2D or 3D SURF or DOP features combined with a RANSAC outlier filtering. The iterative closest point (ICP) method is optionally applied for a fine alignment step. These fused point clouds are then augmented using the stitched and blended textures from the original laparoscopic image data, this yielding a 3D-panoramic image of the interventional site providing an increased view for the surgeons.
This approach has so far evaluated on various stereoscopic image sequences from plastic and animal knee phantoms
as well as real stereo laparoscopic data from minimal invasive procedures. Currently the complete procedure runs in a conventional PC with approximately 10 fps. Potentially this approach can be achieved in real-time using GPU programming.

V 17

Impact of new ICRU-90 recommendations on clinical photon and electron reference dosimetry

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In 2016 the ICRU published a new report dealing with key data for ionizing radiation dosimetry (ICRU-90) partly updating the data for stopping powers for electrons and positrons given in report ICRU 37. New recommendations have been made for the mean excitation energies I for air, graphite and liquid water as well as for the graphite density to use when evaluating the density effect. Goal of the present work to evaluate the impact of these new recommendations on clinical reference dosimetry for high energy photon and electron beams. For that purpose Monte Carlo simulations using the EGSnrc code were performed for several compact and parallel plate ion chambers (NE2571, NACP, ROOS) used for reference dosimetry. Two different PEGS files containing the cross sectional data for the different materials included in the ion chambers and also water were created according to the recommendations of ICRU-37 and ICRU-90.
The chambers were positioned in a water phantom at the reference depth according to the IAEA TRS-398 code of practice. The field size for all simulations was 10 x 10 cm^2 at the phantom surface. In case of photons six phase space files from clinical accelerators and twelve spectra taken from literature in the energy range 4 – 25 MV-X and additionally a Co-60 source were applied. As electron source thirteen electron spectra available in literature were used (E_0 = 4 – 21 MeV). The source-surface-distance in all simulations was 100 cm. The Monte Carlo simulations did comprehend the calculation of the stopping-power-ratios water-to-air as well as the calculation of the corresponding beam quality correction factor k_Q for the mentioned ion chambers. The results show, that the new ICRU recommendations result in changes of stopping-power-ratios up to 0.6%. The impact on k_Q data for the chosen ion chambers is in the range of 0.1 – 0.2% only.

V 18

Monte Carlo based investigation of the beam quality correction factor k_Q depending on the chamber's level of detail

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Dosimetry protocols, like the TRS-398 and the DIN 6800-2, recommend ionization chambers to measure the dose-to-water D_w. For these measurements ion chambers were calibrated under reference conditions in a ^{60}Co-beam. To obtain the dose-to-water in another beam quality Q, the correction factor k_Q is introduced. This correction factor can be calculated with Monte Carlo simulations, in which mostly simplified ion chamber models are utilised. The aim of this study is to investigate the influence of the level of detail of a simulated chamber model.
The correction factor for beam quality k_Q was calculated as the ratio of dose-to-water D_w and the dose-to-air D_{air} within the detector: $k_Q=(D_w/D_{air})_{Q,Co\text{-}60}$. All simulations were performed with the EGSnrc Monte Carlo code. The simulations were realized in a 30x30x30cm³ water phantom at the reference depth z=10cm. A ^{60}Co-spectrum was used as reference beam quality and for the beam quality Q the photon spectra (6, 10, 15 and 18MV) of a Varian Clinac were applied. The beam was collimated to 10x10cm² on the surface of the water phantom with a SSD of 100cm. To calculate D_w a water voxel was placed at the measurement depth. Two different thimble chambers (air cavity of 0,125cm³ and 0,016cm³) were modeled with the egs++ user code egs_chamber. These chamber models were built in detail provided by blueprints of the manufacturer. To investigate the impact of chamber details on the calculated dose, the chamber models were simplified in five steps: the vent holes were eliminated and then the stem geometry was simplified in severeal steps. For all chamber models the k_Q values were calculated.
Depending on the level of detail of the chambers, the calculated k_Q values deviate up to 0,5-0,7% for the 0,125cm³ chamber and up to 0,7-1,0% for the 0,016cm³ chamber, especially in case of higher photon energies.

V 19

Experimental investigation of the depth-dependent fluence perturbation of parallel-plate chambers in clinical electron beam

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The electron fluence inside a parallel-plate ionization chamber positioned in a water phantom and exposed to a clinical electron beam deviates from the unperturbed fluence in water in absence of the chamber. One reason for the fluence perturbation is the “inscattering effect” as described in ICRU 35. Aim of this work is a detailed experimental investigation of this effect.
The experiments were performed in a solid-water phantom (RW3) sized 30x30x30cm³. One of the RW3 plates of height h=0.5 cm had a hole with radius r=1 cm which acts as the air cavity in the phantom. The spatial resolved dose directly below the cavity was scored with GAFCHROMIC ETB3 films. The phantom was placed below an electron applicator of field size 10 x 10 cm2 and irradiated with 6 MeV electrons from an Elekta Synergy accelerator. For the measurements the air cavity was positioned at depths of 1.0, 1.5, 2.0 and 2.5 cm in the phantom. The films were scanned with an Epson 10000xl-scanner (resolution 600dpi, color depth 48bit); a dose response calibration curve for the red channel was applied.
At 1.0 cm depth the relative dose profile shows the well known dose increase at the air/RW3 boundary of about 4% relative to the dose at the center of the cavity and a decrease of about 8% outside the air cavity within the RW3-phantom. The amplitude of this “dose oscillation” decreases with increasing depth of the cavity within the phantom and disappears at about 2 cm, which is less than the half value thickness of the electron beam. The experimental results are in agreement with already published Monte Carlo results [Zink Med.Phys. 2014].
The experimental results are partly in contradiction to the ideas summarized in ICRU 35 but confirm recent Monte Carlo simulations from Zink et al.

V 20

Small-field output factor corrections of gas-filled and solid photon detectors – derivation from their lateral dose response functions by a convolution technique in comparison with direct measurement

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A novel semi-empirical approach has been applied to derive the field-size dependent output factor corrections of small photon-beam detectors. The known two-dimensional lateral dose response functions of three ionization chambers (PTW 31014, PTW 31022, IBA Razor Chamber) and three solid state detectors (PTW microDiamond, PTW Diode E, IBA Razor Diode) were convolved with the true dose profiles measured with radiochromic EBT3 film at quadratic field side lengths from 3 to 40 mm to calculate the detectors' field size dependent output factor corrections. The results were verified by comparison with directly measured output factor corrections, using the scintillation detector Exradin W1 (Standard Imaging, Middleton, USA) as reference and applying SSD's of 60 and 90 cm at the Siemens Artiste accelerator to vary the field size over a large range. The resulting field-size dependent output factor corrections reflect the detector-specific influences of the volume-averaging and density effects. For the air-filled ionization chambers, the output factor corrections are larger than 1 at all field sizes due to volume-averaging. For the silicon diodes, the output factor corrections are smaller than 1 due to the density effect of the detectors' components. For the microDiamond detector the output factor correction is below 1 for field sizes equal to or larger than 5 mm, due to the densities of its structural components, but increases at smaller field sizes due to the prevailing volume-averaging effect (sensitive diameter 2.2 mm). Where comparison is possible, our results closely agree with the published experimental data.

V 22

Abdominal dose from radiology and radiotherapy imaging – CT and CBCT protocols

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Introduction: We compare the abdominal imaging dose from different 3D CT imaging techniques in radiology (standard CT, low-dose CT, dual energy CT) and radiotherapy (planning CT, kV-cone beam CT (CBCT) with 220°, 360° and high quality).
Material and Methods: For all scan protocols, the imaging dose was measured using thermoluminescent dosimeters (TLD's) at 86 positions in an Alderson anthropomorphic phantom. TLD positions were assigned to different organs and the average TLD reading at locations corresponding to each organ was considered as the organ dose. Secondary cancer risk corresponding to the dose (using the linear model) was evaluated and compared. The statistical analysis was made using one-way ANOVA with repeated measurements, pair-wise corrections were made using the Bonferroni correction.
Results: The ANOVA analysis shows significant differences between the protocols. Both the overall and organ-specific dose comparisons yield lowest doses for the modern radiological techniques (both dual source and care kV protocols, with an average dose of 0.43±0.01 mGy and 0.54±0.01 mGy, respectively). Dose from a standard abdominal CT protocol and a planning CT scan are considerably higher (average± standard deviation 13.58±0.18 mGy and 18.78±0.27 mGy, respectively). The CBCT protocols, which show a dose fall-off towards the field edges, have reduced dose for the standard 220° or 360° rotations (3.79±0.21 mGy and 7.76±0.37 mGy, respectively), whereas the high quality CBCT protocol has the highest dose (20.30±0.96 mGy). Analogous results are found for the organ doses, which translate to the estimated secondary cancer risk. The modelled risk lies in the range between 0.4 cases per million patient years (Mio PY) for the radiological scans (care kV and dual energy) and 300 cases per Mio PY for the high quality CBCT.
Conclusion: The modern radiotherapy imaging techniques, while much lower in dose than the therapy, are considerably higher in dose than modern radiology techniques.

V 26

Influence of age and gender on 5-min QT variability

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Temporal variations in ventricular depolarization and repolarization are quantifiable by analysis of the beat-to-beat variability of QT intervals (QTV). Indices from QTV and heart rate variability (HRV) are proven to be suitable for classification of cardiac patients' risks stratification. Effects of age and gender on QTV indices are inconclusive or insufficiently explained. In this study, general age- and gender-related influences on short-term indices of QTV and HRV were investigated analyzing 5-min resting high-resolution ECG recordings of 1801 healthy subjects from the KORA S4 (Cooperative Research in German Region of Augsburg) survey. From ECG we extracted heart rate and QT time series. From these time series linear HRV indices (meanHR, SDNN, RMSSD, pNN50, and LFn) and QTV indices (QTVI_log, QTc, and QTintmean) were estimated. Effects of age and gender on indices of QTV and HRV were statistically analyzed (SPPS 21, Mann-Whitney U test) by comparison of four subject groups: YF and YM (young females and young males, 25-49 years), and EF and EM (elderly females and elderly males, 50-74 years). As expected, a gender-independent significant loss of HRV (at least $p<0.0012$, Bonferroni correction) with aging was confirmed by diminished values of SDNN, RMSSD and pNN50 in elderly subjects compared to young subjects. All QTV indices were considerably increased in elderly subjects indicating a general rise of QTV with increasing age most probably caused due to changes in the cardiovascular structure and function with aging. Gender influences on both HRV and QTV indices were less pronounced compared to age influences. QTc and meanHR were lower and LFn was higher in males than in females particularly in younger subjects ($p<10^{-10}$) but also in elderly subjects ($p<0.0012$). However, that could not be seen in the QTV-index QTVI_log.
In summary, we found a high significant age dependency of QT variability but no dependency on gender.

V 27

Moss-embroidered electrodes for an ECG monitoring shirt

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Cardiovascular disease (CVD) is the main cause of death in Europe. CVDs can be broken down in several pathologies, which can be identified through different arrhythmia profiles. Atrial Fibrillation (AF) is the most common arrhythmia and an important cause of morbidity, both in itself and due to the associated risk for stroke. This condition is responsible for more than 750,000 hospitalizations and 130,000 deaths each year. Undetected cardiac issues due to the lack of post-hospitalization monitoring demands relevant innovations in healthcare.
The Eurostars CAST - CArdiac measuring Shirt for Telemedicine - project will create a T-Shirt with moss-embroidered textile electrodes to measure the patient's ECG coupled with the appropriate post processing for cardiologists. The system allows for continuous real time monitoring of patients that positively impact risk assessment and hospitalization. In this way CAST will address the growing cardiac problem with a seamless solution to facilitate the interaction between patients and cardiologists.
In this study, a suitable electroconductive thread for the development of moss-embroiderd ECG electrodes was selected. According to the electrode requirements such as a washability of up to 40 wash cycles and a low electrical resistance of less than 3 Ω/100 mm to ensure a high ECG signal quality, six electroconductive threads were investigated with regard to their electrical resistance after 0, 5, 10, 20, 30 and 40 wash cycles (ISO 6330:2012) using four-terminal sensing. Three of the six threads with the lowest electrical resistance after up to 40 wash cycles were selected for the evaluation of the electrical resistance of moss-embroidered ECG electrodes using the same wash cycles. It was shown that the electrodes made of Shieldex® 117/17 2 ply HC+B from Statex Produktions- & Vertriebs GmbH, Bremen, Germany show promising results for being used as ECG sensors in the CAST T-Shirt.

FS 4

Breitbandige Energie-Absorbanz zur Mittelohrdiagnostik

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Acoustic impedance measurement using single-frequency clinical tympanometry may essentially depend on insertion depth of the probe in the ear canal for frequencies beyond 2 kHz. Measurement of energy reflectance in the ear canal provides another potential way for middle ear diagnostic. Here, results of energy reflectance are presented in terms of energy absorbance (= 1 - energy reflectance). Energy absorbance is defined as the ratio of absorbed to incident sound energy in the ear canal and is nearly independent of probe insertion-depth. Using the Interacoustics “Titan” tympanometer, energy absorbance is registered applying a click stimulus (0.226 to 8 kHz), providing additional data on mechano-acoustical characteristics of the eardrum and middle ear system in a wider frequency range compared to the clinical tympanometry. Obtaining of these wideband energy absorbance under variation of the air pressure in the ear canal can require the same measurement duration as the single-frequency tympanometry. This work aims to give an overview of energy absorbance patterns in normal-hearing adults. Bandpass absorbance tympanograms show a single-peak shape for the pressure dependence of the absorbance averaged over frequencies from 0.380 to 2 kHz respectively a M-shape for frequencies from 3 to 4.6 kHz. Frequency depending energy absorbance (at peak pressure) rises with increasing frequency up to about 1 kHz, shows a plateau between 1 and 3 kHz and falls steeply for frequencies above 3.5 kHz. Frequency and pressure dependent absorbance may be reduced to various parameters for differentiating multiple eardrum and middle ear disorders and normal findings in a clinically practicable manner. The impact of the pressure pump speed on these parameters and their test-retest reliability are shown. However, further research on pathological ears is needed to demonstrate the actual utility of these parameters for differential diagnosis.

FS 5

Impedance measurements for a middle ear screening for newborns and infants.

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Universal newborn hearing screening (UNHS) programs typically show fail rates of about five per cent. While only a small percentage of the newborns who failed the UNHS have a permanent hearing loss, middle ear problems are much more common.
The aim of a currently ongoing project is the development of a screening test of the middle ear status of newborns and infants. The test will be based on a measurement of the acoustic input impedance of the ear in the frequency band from 500Hz to 10kHz. Compared to wide band tympanometry, the new test will be faster and easier to administer, because it will be conducted at ambient static pressure in the vented ear canal. It will feature individualized models of the ear canal volume and of the ear canal wall compliance, thus focusing on the input impedance of the *middle ear*. In previous projects, such input impedances of the middle ear could successfully be predicted for adults, in the frequency range of up to about 3 kHz. In newborns and young infants, not only the volume of the ear canal is smaller compared to adults, a special challenge will be the modelling of the much more compliant ear canal walls.
Currently, a study is taking place in which measurements of the acoustic input impedance of the ear are performed on infants with normal and on infants with pathological middle ear status, aged from 1 to 5 months.
Experiences and first results will be presented and discussed.

FS 7

Intra-operative monitoring during tympanoplasty

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Hearing results after tympanoplasty with ossiculoplasty depend on several biological and biomechanical factors. One important factor is the “fine tuning” of the prosthesis by the surgeon. The placement and adaption of the prosthesis can influence the hearing outcome up to 15 dB in some frequencies. Until now the surgeon’s experience is the only parameter that influences the tuning process since no intraoperative equipment is available.
A new measurement set up, consisting of an electromagnetic stimulation system and a Laser Doppler Vibrometer (LDV) to measure stapes vibration, has been developed to measure middle ear transfer functions (METF) during surgery. The coil of the electromagnetic stimulation system is placed below the head of the patient. A sterilized magnet is placed at the umbo. This way, manipulation at the ossicular chain is possible with real time control of stapes vibration by LDV. The LDV system was mounted to the microscope and the surgeon receives the signal feedback by headphone.
Experimentally, the equivalent sound pressure level of the electromagnetic excitation was about 70 to 80 dB which is 10 to 20 dB less than the acoustic stimulation. In the intraoperative setup the generated stapes displacements were about 5 to 20 dB smaller compared with the temporal bone experiments. Applied as real-time feedback system, an improvement in the middle ear transfer function of 4.5 dB in total and 20 dB in partial ossicular reconstruction were achieved.
The new developed measurement system is easy to handle during surgery and it is suitable to improve the hearing results after tympanoplasty. More patients have to be included into the study to verify the effect of different reconstruction methods and different prosthesis design.

V 29

Towards standardized surgical robotics interoperability for intraoperative assistance systems

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The introduction of a standardized service-oriented communication architecture for the operating room (OR) in the project OR.Net opened up new possibilities for interoperability of medical devices. Using the open IEEE Standards 11073 a medical device and its functionality can be represented in a tree-like structure with corresponding channels and metrics (parameters). Metric information of medical device functions, e.g. O^2-saturation or heart rate measurement is provided in a publish/subscribe-approach using the open surgical communication protocol (OSCP). We defined a 11073-conform medical device description of our surgical robotics system *SCORPIO*. We used a KUKA LWR iiwa 820R with the robot operating system (ROS) framework and integrated it with a service interface that implements 11073-conform control functions based on the OSCLib. In this way, the motion and safety control mechanisms are separated from the asynchronous service functions. The service interface is used to automatically register the *SCORPIO* system to a session in the OR. Furthermore, it provides access to the device metrics. Initially, implemented metrics are used to e.g. set coordinate system boundraries, patient registration data or instrument positions for the ROS to automatically provide necessary navigation information. For the first use case of needle placement an intraoperative entry planning system sends registration information to the *SCORPIO* system and sets the planning instructions to be performed. Path planning and motion control is then handed to the ROS application. Safety mechanism are threefold: (a) A footswitch is directly connected to the robot controller unit to release and stop motion in case of problems. (b) The sent registration data is used to define safezone bounding boxes to be excluded by the path planning. (c) Force feedback can be used to stop robot motion by hand. Subsequent safety and assistance features are intended for other use cases in future work.

V 30

Integration of a light weight robot control with an advanced medical image processing platform for optimizing accuracy in medical interventions

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Due to organ movement and tissue pressure needle based interventional acuracy is an important and challenging issue in minimal invasive medical interventions. Using iterative robot control for path correction during the needle insertion is assumed to be a progress for performing more acurate interventions.
We implemented a generic module interface within the medical image processing platform MeVisLab for seamlessly plug-in and plug-out robotic devices into MeVisLab via OpenIGTLink and for controlling the device iteratively for a near-real-time path planning and path correction. This module allows for sending and receiving different kinds of data sets (e. g. transformation matrix, position and rotation, image, status, string). We used this generic module to connect a Kuka Light Weight Robot (LWR iiwa) with MeVisLab to allow for using advanced segmentation and registration features for iterative robot control. The respective status of the Kuka LWR iiwa (position, configuration) is simulated and visualized as 3-D model in MeVisLab. Medical data sets including target pose (position and path towards it) can be send and received via the OpenIGTLink network protocol as well.
This integration of an advanced image processing platform with a robotic device will allow fast prototypical implementation of iterative path controlling scenarios, like segmentation of the target in intraoperative images for iterative refinement of target position in a control loop. With the presented work, segmentation (e. g. of target lesions) and registration (e. g. for aligning pre- and intra-interventional images) algorithms of MeVisLab can be used and directly applied to path re-planning of the Kuka LWR.

V 31

Development of a high precision MEMS tilt sensor for navigation systems in robot-assisted surgery

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Complicated minimally invasive interventions, e.g. in the fields of brain and abdominal surgery as well as locally limited high-dose irradiation and the biopsy or resection of tumors, are increasingly supported by surgical robots. In 2013, about 85 % of radical laparoscopic prostatectomies have been carried out robot-assisted in the USA. Thereby major advantages are scaling down of surgeon's hand movement to high-accuracy motions of the surgical instruments, precise locking mechanisms and tremor cancellation. Consequently, healthy tissue, blood vessels or nerves can be prevented from unintentional injury. Due to miniaturization of microelectromechanical systems (MEMS) the placing of orientation detection sensors close to surgical instruments is possible. The integration of the developed high-precision capacitive MEMS tilt sensor for example into an endoscope or near its mounting can facilitate vibration measurements and their compensation to improve accurate instrument positioning. A special fabrication technology for silicon high aspect ratio microstructures was used to increase the aspect ratio of the vertical comb electrodes which magnifys the capacitance gradient. Additionally, the sensitivity of the capacitive sensor is strongly improved by an electrode movement. In this work, further reduction of the fabrication restricted trench size of 4.5 µm to sub-micron trenches below the technological limitations is achieved using the innovative approach of laser-micro-welding. High aspect ratios of initially 15 up to 100 for trench sizes down to 800 nm were fabricated. In addition the electrode gap is reduced using the inherent electrostatic force of the comb sense electrodes and fixed by briefly high current through overhanging touching metal layers. Long time reliability was ensured by laser-micro-welding on the metal layers. Electrical and mechanical tests of the sensor show an increased sensitivity from 7.2 fF/° up to 60 fF/° due to gap reduction. By means of electrical and vibration measurements at 1 g the working range was determined with several Hz up to 2 kHz.

V 32

Prototype of an automated photobiomodulation treatment device for in vitro wound healing studies

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Photobiomodulation (PBM) is a light-based therapy that influences chronic wound healing processes. Results from PBM studies often lack repeatability because of inaccurate reporting or incorrect controlling of light irradiation parameters and measurement techniques. The importance of this is emphasized by recent guideline publications outlining the necessary parameters to be reported to assure repeatability. The purpose of this work is to describe the design, construction and validation of a device for performing repeatable LED-PBM treatment in vitro with adjustable parameters. This work aims to provide a baseline design for devices used in LED-PBM experiments, in order to allow researchers quick access to equipment that can deliver reliable and repeatable PBM treatments. The device consists of LED driver electronics with a USB interface and a separate LED module installed on cell culture trays capable of functioning inside an incubator without disrupting its normal operation. The LED placement and selection depends on the application, a sample setup is described here that can guide new designs. Light intensity is modulated with a PWM signal in order to ensure a constant spectrum emission by keeping a constant LED operating point during its ON time. Light wavelength can be modified by altering the relative light intensity settings for different groups of LEDs with different emission characteristics. Spectral irradiance on the targets and spatial irradiance uniformity are measured for validation. The device can be programmed for multiple-week-long experiments with complex treatment schedules through GUI or configuration file which allows for automated operation. The device will be employed in a 21-day long treatment pilot study with an in vitro 3D organotypic tissue wound model. This prototype represents our initial step towards developing a multi-modal advanced wound healing device combining light, mechanical and electrical biostimulation for treating chronic wounds.

V 33

Full HD endovideo with 4K panorama overview in laparoscopic optical phantom

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Introduction: Recent 4K monitors can display four times as many pixels than the established full HD laparoscopic endo cameras provide. Consequently, the additional monitor space can be used to present a laparoscopic panorama, computed from the laparoscopic video data, in which the original live video is centrally embedded.
Materials: The digital output of a standard HD endo video system (Storz laparoscope, 10mm 0°, Image 1 HD H3-Z camera head, optical zoom 2x) was connnected via an HDMI to USB3 converter to a PC with high end graphics card (Nvidia Gforce GTX980). Custom software computes a depth map from the motion parallax of the telescope. The resulting point cloud is coloured, matched, rotated and scaled, such that the central live image can be embedded seamlessly. The combination of panoramic point cloud and central live image is then displayed on a 55” 4K TV (Samsung UE55HU8290L). Moreover, inertial sensor technology was employed to compensate for inadvertent camera tilt.
Results: The system was successfully tested in an inanimate optical phantom box, using telescope panning or withdrawal to create an overview from which a suitable panorama could be computed. Due to the computational effort, the panorama update is slightly delayed with respect to the endo video. However, this does not present a significant usability issue, since the panoramic point cloud can be clearly distinguished from the live image and rapid camera movement is usually avoided during surgery.
Discussion: Next development steps are the adaption to a 30° telescope, compensation of organ movement / deformation, and removal of instruments from the panorama.
Conclusion: A laparoscopic panorama is feasable and can significantly improve orientation.

V 35

Mixed fields of range-shifted and pristine bragg peaks are safe and improve sparing of collateral OARs in PBS proton therapy

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Purpose: Treating shallow tumors with Pencil Beam Scanned (PBS) proton therapy typically requires a range-shifting pre-absorber to deliver pencil beams at ranges <4 cm. Such absorbers however degrade the lateral profile of the beam by widening the penumbra. For this reason, Gantry-2 at PSI supports two pre-absorber modes, **field-specific** (a pre-absorber of 4.1 cm water-equivalent thickness being in/out for the full field delivery), or **Bragg-Peak (BP)-specific** (the afore-mentioned pre-absorber being inserted automatically during delivery **only** for BPs with range <4 cm). In this work we show the potential clinical advantage in a planning study, and report on clinical commissioning measurements of mixed fields.
Methods: Different clinical patient plans, originally planned and delivered with **field-specific** pre-absorption, have been re-planned retrospectively using the **BP-specific** approach, and the resulting dose metrics for PTVs and OARs compared to those of the clinically applied plan. In parallel we measured BP-specific-mode fields to investigate the dosimetric effect of mixing range-shifted and pristine BPs with different lateral penumbrae, both absolute depth-dose, and spatially-resolved relative dose using a wedge phantom and a CCD camera-scintillating screen device.
Results: The planning study demonstrated that field- and BP- specific pre-absorption provide comparable target coverage and homogeneity, while the BP-specific approach substantially reduces the planned fields' lateral penumbrae (by ~2 mm). OAR D2 doses could be reduced (by 1-11 GyRBE) when using BP-specific pre-absorption. Absolute dose measurements in water of the field- compared to BP- specific modes were within 2.3% at all depths. Field flatness measurements from CCD images under the wedge phantom were all within 2.0%.
Conclusion: We demonstrated that automatic insertion of the pre-absorber only for low range BPs improves plan quality. Clinical commissioning of this mode showed that the mode is safe for application to patients, and will become the default mode for treatment plans at our centre.

V 36

Improving the lateral fall-off for proton pencil beam scanning

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Pencil beam scanning (PBS) is widely considered to be the future of proton therapy. However, without collimation, the lateral fall-off for PBS for shallow targets is inferior to passive scattering. The lateral fall-off for uncollimated PBS is depependent on two main parameters – the width of the pencil beam and the ability of the optimisation to laterally enhance field-edge pencil beams (edge-enhancement) such that the fall-off approaches that of a single pencil beam. In turn, the size of the pencil beam depends on energy, the thickness of any material in the beam-path, e.g pre-absorbers, and the air-gap between these and the patient. Here we comprehensively investigate the potential of collimation to improve PBS lateral fall-off taking all these factors into account. For all investigations, mono-energetic, square PBS fields based on PSI Gantry2 commissioning data (ranges 4.15cm-30.70cm) have been simulated in a water phantom, using the TOPAS3.0.p1 Monte Carlo tool. Both fixed (4cm water equivalent) and variable (8x5mm water equivalent, individually insertable range-shifter plates) pre-absorbers have been simulated. Without pre-absorber, collimation alone improves 80-20% penumbras at the Bragg-peak only for ranges up to 10cm (10cm air-gap). Sharpest lateral fall-off is achieved with edge-enhanced collimation (the inclusion of laterally collimated pencil beams into the optimisation) which reduces penumbra from 5.4mm to 2.8mm compared to uncollimated PBS (range 4.15cm, 10cm air-gap). For air-gaps above 5cm, the use of a variable, rather than fixed, pre-absorber reduces the penumbra, for example for the 20cm air-gap from 8.8mm to 6.2mm and further to 5.0mm when combined with edge-enhanced collimation (3.99cm range). Best penumbras were reached with pre-absorption devices placed downstream, rather than upstream, of the collimator. In conclusion, using edge-enhanced collimation, and the best possible arrangement of components, the lateral fall-off for PBS could be substantially improved, leading to less dose to the surrounding healthy tissue.

V 37

Investigation on beam width tolerances for proton and carbon ion pencil beam scanning

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Beside beam spot position and range, the beam spot width is one of the central parameters for the correct application of ion beam therapy plans utilizing pencil beam scanning techniques. The aim of this work is to investigate the influence of variations of the nominal beam width on the dose distribution of cubic dose volumes, utilized in QA.
Physical absorbed dose is optimized for cubic dose volumes with a spread out bragg peak (SOBP) of 3x3x3 cm^3 using the treatment planning system syngo RT Planning (Siemens, Germany). The nominal dose in the SOBP is 0.5 Gy. The depth in water of the centre of the cubes is 5.0, 12.5 and 20.0 cm, respectively. Plans are recalculated with MATLAB (The MathWorks, United States) with nominal and varied beam width. Dose distributions are analyzed performing a 3D gamma index analysis with criterias of 1mm distance to agreement and 5% dose deviation, normalized to global maximum. The maximum tolerable beam width deviations are determined where all points still show a gamma index < 1.
The maximum tolerable beam width variations for proton and carbon ion plans in medium and large depth are between -12%/+17% and -17%/+25%. The plans in small depth show rather small tolerable deviations with -7%/+10% for protons and -8%/+16% for carbon ions. It is observed, that this is mainly affected by the strong variation of the particle numbers per scan spot in each energy slice, optimized to achieve lateral penumbras as small as possible. Following this observation, we created plans in small depth with the same field size consisting uniform scanned energy slices. Resulting tolerable beam width deviations for these plans are -13%/+13% for protons and -19%/+25% for carbon ions.

V 38

Optimization of a compton camera prototype for particle beam range verification

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At LMU Munich we are developing a Compton camera for medical imaging. The camera is designed to detect prompt-γ rays induced by nuclear reactions during irradiation of tissue in particle therapy. Our prototype consists of two components: the scatterer is a stack of 6 double-sided silicon strip detectors and enables the tracking of the Compton scattered electrons; the absorber consists of a monolithic $LaBr_3$(Ce) scintillator and registers the energies of the Compton scattered γ-rays. Prompt γ-ray imaging requires the detection of the interaction position and deposited energies in both parts of the Compton camera. The camera has been characterized offline in the laboratory and online at clinical proton beams. Different consolidations and upgrade options are currently being studied: an upgrade of the DSSSD signal processing turned out to be mandatory. ASIC- and non ASIC-based alternatives are presently being evaluated in view of the performance requirements expected for a realistic treatment scenario. Improved shielding (thermally as well as EMP-related) together with an active air-cooling system resulted in a reduction of the DSSSD leakage current by about a factor of 4, helping the lower-energy signals to be registered. $CeBr_3$, comparable in performance to $LaBr_3$(Ce), however not suffering from internal radioactivity background, is being evaluated as an alternative to the present absorber. The concept of a monolithic absorber is being compared to a segmented scintillator (4-layer depth-of-interaction detector) from LYSO. The final goal is to design a versatile detector system from the experience gained with the present prototype and based on a compact and combined signal processing of scatterer and absorber. Such a Compton camera system could be applied for prompt-γ particle beam range monitoring and, in a hybrid geometry with PET detectors, for registering triple photons coincidences from suitable positron emitters (“γ-PET” mode) to exploit the enhanced sensitivity provided in this scenario.

V 39

Comparison of prompt gamma emission for helium and proton beams: a Monte Carlo study

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Charged particle radiation therapy relies on the favourable dose distribution of light ions compared to conventional radiotherapy. Among other ion species, Helium-4 beams present advantageous characteristics: reduced lateral and distal spread compared to protons and reduced fragmentation compared to Carbon-12. The finite range of the primary particles potentially allows sparing healthy tissue, which however requires a superior capability in range control. Compared to other range verification techniques such as post-treatment MRI or PET; the Prompt Gamma Imaging (PGI) permits a real-time range monitoring due to the instantaneous (<<ns) emission of the secondary radiation. Time and energy resolved PGI coupled with knowledge of the discrete reactions cross-sections has been proposed for absolute range verification. We aim to optimize the technique for Helium-4 beams. A systematic study should be supported by reliable Monte Carlo simulations. In this work, we adopted the Geant4 simulation toolkit to investigate the performance of different nuclear interaction models. For hadron-therapy applications, the Geant4 collaboration recommends the QGSP_BIC_HP physics lists in which intermediate energy (< 10 GeV) inelastic nuclear interactions are handled by the Binary Cascade Model (BIC), which has been shown to overestimates the experimental PG yield up to 50% for protons. The optimization of the more complex Quantum Molecular Dynamics Model (QMD) provides better results. Since a dedicated optimization for Helium-4 beams is missing, we investigate the performance of customized physics for such beams based on three different inelastic nuclear interaction models: Binary Light Ion Reaction (BICLI), Liege Intranuclear Cascade Model (INCL) and QMD. Our study aims at resolving the intensity of the discrete Gamma lines for different projectile energies towards experimental comparison. The INCL and QMD models reproduce the theoretical expectations better than BICLI. The investigated models show 2 to 4 times higher PG yields for Helium-4 compared to proton beams with the same range.

V 43

Sensor components of a miniaturized implant for haemodynamic controlling

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Continuous monitoring of physiological parameters in cardiovascular areas allows early detection of critical conditions which may lead to clinical symptoms and hospitalization, if not treated in time. Thereby early diagnostics, optimization of therapy and reduction of therapy costs can be achieved.
In medical applications it is generally recommended to obtain high-precision pressure measurements. Especially controlling of haemodynamics in pulmonary artery requires a very accurate detection of physiological changes in pressure having the additional challenge of a very high miniaturization level. Therefore, the concept of the presented implantable multi sensor system utilizes, amongst others, capacitive pressure sensor elements which are monolithically integrated in a CMOS process and suitable for medical implants due to their design. Additionally, activity and inclination elements, a temperature sensor unit and different self-monitoring functions, e.g. monitoring of the supply voltage, are implemented. Thus, further information about the patient are obtained, so that inaccuracies or faulty pressure measurements can be corrected in consideration of these measurands.
The core element of the implant is a multi-functional Application Specific Integrated Circuit (ASIC, recently developed at Fraunhofer IMS) which is able to handle all measurements but also power management and communication with the extracorporeal electronics. The implantable device operates without any battery. Each component is simulated and designed in such a way, that very low power consumption allows telemetric operation distances up to 15 cm. The communication is according to the international standard for passive RFID item level identification for air interface communications at 13.56 MHz (ISO/IEC 18000-3). The antenna is located within a ceramic interposer, which connects all components with each other. First results show that the multi sensor system, without any encapsulation layer, fulfill requirements to obtain high accuracy pressure measurements with errors < 2 hPa.

V 44

Flow characterization in a multiplexing infusion system

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Multi infusion systems impose life-threatening risks to patients (e.g. dosing errors). Several studies have stressed that unknown or ambiguous factors in drug administration might cause or contribute to the occurrence of many adverse drug events. In a previous work, we characterized the flow behaviour of a multi infusion system as one of these factors. Here, we present the flow behaviour in a drug multiplexing infusion system in vitro. A drug multiplexing infusion system is aimed to reduce the dosing errors that present in classical multi infusion systems. The idea of drug multiplexing is to administer medications in one catheter (instead of multi channels) reaching the patient to minimize the number of connection tubes. The flowing medications are separated by a separation medium. This helps to decrease the total dead volume of the delivery and also to reduce the potential of patient infection (e.g. bacterial infection). Therefore, a dedicated set-up was built. Solutions were prepared to resemble real medications. The solutions were delivered in varying flow rates via a central catheter into a flow-through cuvette in the set-up. An algorithm was developed and implemented for the dosing flow profiles. On-time measurements were carried out for the determination of solutions' concentrations by UV-VIS spectrophotometery. The drug multiplexing infusion system has a much lower compliance effect than in the multi infusion system. Results showed that, in drug multiplexing infusion system, the medications have higher dosage accuracy than normal multi infusion systems. Furthermore, less dosing fluctuations were noticed in the multiplexing infusion system. The influences of dosing rates, separation quality, influence of dye precipitation and of absorbance on the recorded spectra were noticed. However, the accurate dosage of the multiplexing infusion system can be affected by residuals in the selective valve, set flow rate, air supply and by the properties of the dosed solutions.

V 45

Concept of a small-size and low-cost respirator for one way usage

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This paper describes the concept of an innovative low-cost respirator with potential use as disposable. It mainly consists of a respiration mask, including a ventilation blower and integrated sensors and electronics. All functionality will be realized by the mask system. With this feature, the respirator does not need external devices and the commonly used respiratory tubes. On the contrary to conventional emergency-respirators, which usually are large, heavy and expensive, this low-cost respirator will be characterized by a lightweight and space-saving construction. All parts of the respirator are located closely to the patient, so the limited space around the patient will be free for alternative usage. Therewith it will be a particularly suited respirator in case of disaster or pandemic event, when it is essential to transport many of stocked respirators quickly and with little effort to a worldwide point of usage.
The respirator benefits of a simple design and contains sensors to ensure a safe operation. The airway pressure will be monitored to protect the patient and to allow pressure-controlled ventilation. Conditions like airway occlusion or leakage will be identified and indicated automatically. Preliminary researches with a model-based algorithm indicates the capability to identify the static lung parameters resistance and compliance and, by implication, the calculation of gas flow and the applied tidal volume, too. Cost and functionality will be clearly reduced in comparison to conventional emergency-respirators, implying a simplified handling. Nevertheless the respirator will feature the capability to adjust the parameters end-inspiratory and exspiratory pressure, I:E and respiration rate. The control will be realized by an operating panel or by using external mobile devices, which will be capable to visualize data. With a mean power consumption of $P_{Mean}<20$ W, powered out of line voltage or a battery, the respirator ensures operation, even in case of patient transport or blackout.

V 48

Digitization-time for a paradigm shift in educating biomedical engineers

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Digitization and the internet of things fundamentally change business models, value chains and processes in many industries including healthcare. Technology frequently becomes a commodity and requires new approaches. However current educational concepts, curricula and academic programs in engineering specialties including medical engineering so far do not reflect the needs and demands for the engineer of the future sufficiently. Medical engineers in the future need to be more familiar with clinical application, economics, project and process management. The basic engineering sciences however will still be important but a more holistic view is mandadeted to master the future challenges. This requires to grow a systems engineering workforce with digital and economic competence. The questions and challenges arising from these trends are discussed. Furthermore an outlook and examples of potential educational concepts and content to address these imperatives will be provided including aspects of computer aided engineering, modelling and simulation on the one hand side and business as well es economic knowledge on the other hand. Proposals for implementation will be presented.

V 49

Are "digital natives" unfit for the "digital future"?

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“Digitalization” describes an overall change in society in general and in the world of work in particular (“Industry 4.0”). It is often described as a scenario of more or less autonomous technical systems that reduce the personnel to mere “users”, who just put into execution or monitor the tasks to be performed. In healthcare systems with a shortage of adequately trained care personnel something like this may well be desirable. However, the other side of this scenario is that the systems described have to be designed, implemented, put into operation and maintained by “experts”. Obviously, graduates of engineering programmes should be such experts. Unfortunately, the (exclusive) use of (very) modern media and the corresponding equipment like smartphones and tablet computers results in the effect that many students – whose generation is labelled “digital natives” – are very well-trained “users”, i.e. well-trained consumers, but not much more: They do not perceive computers, data structures and data types for what they are and thus possess less competence for a self-reliant handling of them as compared to even a few years ago. They are scarcely capable of gaining an understanding of (causal) relationships or process sequences from texts (e.g., lab manuals) but are used to illustrated step-by-step manuals or instructional videos. They are even less capable of describing such relationships or sequences in their own words. Even their interaction with “new media” is that of an (impatient) “user”; they are not able to retrieve useful results from search engines, let alone to assess their usefulness or their reliability. Thus, to empower the “digital natives” to be the “experts” in the forthcoming “digital future” is a huge challenge for the education systems of today.

V 51

Laser Assisted Bioprinting (LAB) without sacrificial metal layer for contamination free assembly of cell cultures

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The fabrication of complex tissue structures via cell-by-cell assembly enables a wide range of applications in tissue engineering and stem cell research. With Laser-Assisted Bioprinting (LAB) – using the Laser Induced Forward Transfer (LIFT) process – a high spatial resolution and a high transfer rate can be achieved. LIFT allows for transferring a wide variety of biological materials, like cells or proteins resulting in ideal conditions for the fabrication of complex tissue structures. In this study a new LIFT process omitting a sacrificial metal layer is investigated. This is desirable to allow for a contamination free cell transfer without uncontrolled nano-particles coming from the absorber material, within the cell culture medium. To omit the metallic layer without increasing the radiation-induced strain on the cells, the cell surrounding hydrogel matrix itself is used as an absorbing material. A laser wavelength close to the absorption peak of the symmetric and asymmetric stretch vibrations of water is under investigation for LIFT. Preliminary results using a 3.0 µm wavelength laser source and a tophat-like beam shape show that gelatine based hydrogel can be transferred at transfer rates of 1000 drops per second. The estimated laser penetration depth ≤ 2 µm should result in a sufficiently thin absorption layer compared to the full thickness of the hydrogel of about 50 µm therefor the underneath cells should stay unharmed. Further reduction of laser influence on the cell could be achieved by beam shaping the laser radiation. In future experiments the influence of NIR irradiation on cell transfer and survival rate as well as the use of donut or tophat beam shapes will be evaluated.

V 52

Chitosan hydrogel composite biomaterials for repairing the intervertebral disc tissue

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Polysaccharide hydrogel composites were prepared for applications in intervertebral disc tissue engineering. Fiber-reinforced hydrogel nanocomposites were obtained by sol-gel processing of fiber-filled chitosan suspensions. Bioinspired fiber-oriented anisotropic hydrogels were developed by uniaxial loading of isotropic hydrogels. The parameters for processing the hydrogel composites were investigated in view of the target application. The alignment of the nanofibers within the chitosan hydrogel matrix was examined by synchrotron X-ray diffraction and monitored in situ during loading. Mechanical properties of the hydrogels were studied as well as the rheological properties of the originating viscous suspensions. The chitosan-based suspensions found applications as injectable formulation in the repairing of the functionality of the nucleus pulposus part of the disc. The composite hydrogels constituted patch implants for the repairing of the annulus fibrosus part, which also served as contention patch against nucleus prolapse. The input of hydrogel implant on the biomechanical properties of the treated intervertebral discs was investigated ex-vivo on pig model discs.

V 53

Multicellular spheroids: a model for nanoparticle-cell interaction studies

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Nanomaterials are increasingly used for clinical and biomedical applications as for contrast agents in magnetic resonance imaging. Especially superparamagnetic iron oxide nanoparticles (SPIONs) are developed for this purpose. The penetration into tissue and the interaction with cells are of particular interest. We sought to establish *in vitro* models which mimic the real *in vivo* situation to predict the action of nanoparticles in a more complex manner. One approach is the formation of multicellular spheroids. They were prepared by the IncuCyte Kinetic 3D Spheroid Assay and the hanging-drop method. The multicellular spheroids were tested for their applicability for nanoparticle-cell interaction studies also with respect to different phenotypes of various cell types. The physical interaction of the particles was analysed via laser-scanning-microscopy. To investigate the penetration depth of the SPIONs into the multicellular spheroids two methods were utilized, in particular serial trypsination and histological staining upon sectioning of the spheroids. Interaction studies show a charge dependent patterning. Cationic particles interact strongly; neutral particles show moderate and anionic particles almost no interaction with the multicellular spheroids. Serial trypsination was applied to investigate the distribution of the nanoparticles within multicellular spheroids. In our hands the procedure was not suitable for accurate and reproducible preparation of cell layers. This issue was addressed by the application of embedding and sectioning of the multicellular spheroids. The results reveal similar charge dependent effects as observed via the interaction studies. Furthermore, the observed penetration depth differs between different cell types resulting from distinct phenotypes. In conclusion multicellular spheroids as a complex cell culture system are suitable to investigate the interaction and penetration of SPIONs with/into tissue. Together with other *in vitro* approaches like trans-well test systems they can build a bridge between *in vitro* and *in vivo* models.

V 54

Towards a biohybrid lung: long-term stability and gas exchange capacity of endothelial cells seeded on gas permeable PDMS membranes

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In the field of lung support, there is currently no long-term solution despite lung transplantation. To improve hemocompatibility of extracorporeal lung support devices, we propose a biohybrid approach with endothelial cells (ECs) seeded on gas permeable membranes to obtain a physiological surface and hence, long-term stability. To optimize gas exchange performance while maintaining an integral cell layer, we evaluated the long-term stability of the EC layer on Polydimethylsiloxane (PDMS) membranes as well as changes in gas exchange capacity over this extendended time period. Both aspects are crucial for the development of a biohybrid lung device for chronic support. ECs derived from human umbilical cord veins (HUVECs) were seeded on RGD-functionalized PDMS membranes. Dynamic long-term cultivation was performed in a model system for a biohybrid lung (µ-slide with chamber height of 100 µm, ibidi) under physiological wall shear stresses (0.4 Pa) and with endothelial culture medium (EGM-2, Lonza). Cell morphology was assessed by bright field microscopy and by immunohistochemistry (CD31, von Willebrand factor (vWF)). At multiple time points of this long-term cultivation, gas transfer performance was determined in this model system by oxygenation of blood with pure oxygen via the endothelialized membrane. Blood was obtained from slaughtered pigs and adjusted to venous blood gas values. Over the entire period of long-term dynamic cultivation, the EC layer withstood the applied loads and an integral monolayer has been maintained. The cell layer stained positive against the typical EC markers CD31 and vWF, verifying the EC phenotype. The model system for a biohybrid lung provided oxygenation of the pig blood and allowed for repeated gas transfer testing. In this study, we demonstrated the long-term stability of an EC layer on PDMS membranes over extended cultivation periods and after multiple expositions to blood, representing a significant step towards the development of a biohybrid lung.

FS 9

Hörrehabilitation durch aktive Implantate im Incudostapedialgelenk

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Zur Behandlung von Hörschäden steht heutzutage eine Vielfalt an Hörhilfen zur Verfügung, neben klassischen Hörgeräten auch teil- oder vollimplantierbare Systeme. Die unterschiedlichen Ansätze tragen den unterschiedlichen medizinischen Indikationen Rechnung. Wir stellen einen neuartigen Schallwandlerbaustein vor, der als Teil eines potentiellen Vollimplantats geeignet ist. Er besteht aus zwei Piezomembranen in einem monolithischen Gehäuse, welches im Incudostapedialgelenk in die Gehörknöchelchenkette eingebracht wird. Die dafür notwendige Operation ist minimalinvasiv und reversibel. Das integrierte Sensor-Aktor System ist zunächst sehr instabil gegenüber Rückkopplungen. Aufgrund des bauartbedingt sehr kurzen Rückkopplungspfades liegen die kritischen Frequenzen weit außerhalb des Nutzbereichs; das System ist daher mithilfe von digitaler Regelungstechnik relativ leicht beherrschbar. Unter Benutzung eines *Least Mean Square*-Algorithmus (LMS) erreicht der Wandler mehr als 30 dB Hörverstärkung im mittleren bis oberen audiologischen Frequenzbereich und ist damit als Hörhilfe für Hochtonschwerhörigkeit geeignet.

FS 10

Comparison of clinically and experimentally determined output level of the MET T2 transducer

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Objectives: Comparison of the output level predicted for an implantable middle ear hearing device (IMEHD) from cadaver studies according to ASTM F2504-05 to the output level from clinical data. Further the intracochlear pressure difference (ICPD) was evaluated for prediction of the output level of IMEHDs in cadaver studies.
Study design: (1) Retrospective review of 24 recipients of a MET® Middle Ear Implant System (Cochlear™). (2) Experiments in 10 human cadaveric temporal bones (TBs) compliant to the modified acceptance criteria (Rosowski et al., 2007) of ASTM F2504-05.
Methods: Either the eardrum was stimulated acoustically or the incus body was stimulated mechanically by a MET T2 transducer (Cochlear). SFP vibrations were measured by LDV (Polytec GmbH) and intracochlear pressures differences between scala tympani (ST) and scala vestibuli (SV) were measured using FOP-M260 pressure sensors (FISO, Canada). The equivalent sound pressure levels (eq SPLs) generated by the actuator were calculated (1) on SFP vibration and (2) on ICPD. From the clinical measurements bone conduction thresholds and "direct thresholds" (measured with the fitting software) were converted to actuator driving voltage and obtained eq. dB SPL were compared to experimentally obtained results.
Results: The mean MET output level measured in cadaveric TBs by ICPD was 100 to 120 eq dB SPLFF @1VRMS. The output levels calculated from SFP vibration as recommended by ASTM F2504-05 were similar. The output levels from cadaver TBs as determined by ICPD were close to clinical results within < 5 dB.
Conclusion: In incus stimulation output levels calculated from ICPD were similar to output levels determined by SFP vibration and to clinical data. Based on our results, clinical output levels of IMEHDs stimulating the ossicles can be predicted by cadaver studies either by SFP vibration or more reliably by ICPD.

FS 11

Intraoperative, objective, frequency-specific auditory threshold determination via Vibrant Soundbridge - feasibility study

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Active, implantable hearing systems can be indicated if conventional hearing aids do not achieve a sufficient result, but cochlear implants are still contraindicated [2].
Via the Vibrant Soundbridge (VSB) the sound signal is converted into mechanical vibrations by means of a floating-mass transducer (FMT), which cause vibration in a coupled middle-ear structure and lead to a hearing perception.
Creating the best possible connection of the FMT to a middle ear structure is the basic prerequisite for achieving the desired hearing result [3, 4].
To date, no standardized measurement methods are available concerning the quality of the coupling of the FMT that can be measured during the operative phase.
A suitable measurement method should allow for a frequency-specific determination of the coupling quality, taking into account the individual hearing ability of the patient receiving the hearing aid.
So far, the basic suitability of transient stimuli for the determination of the coupling has been demonstrated in initial studies, though some difficulties occurred in the use of the ASSR [1].
In this lecture we show our results from electrical reaction audiometry (click BERA, Chirp BERA, NB Chirp BERA, ASSR in a patient simulator and describe their utility for possible intraoperative determination of FMT coupling quality.
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FS 12

Pulse wave analyses: which parts of the pulse wave are clinically relevant

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A heart cycle can be peripherally recorded as a single pulse wave. The classical analysis of the pulse wave can be done by the extremes: the pressure points that are called systolic and diastolic pressure. The past century was impressively dominated by these 2 points in terms of cardiovascular diagnosis and therapy. However, other parts of the pulse wave can be mathematically calculated. For example, a single pulse wave, recorded by cuff measurement at the brachial artery can be used to calculate the aortic pulse wave velocity as a measure of arterial stiffness (or arterial calcification), additionally to calculate the central pressure, the pressure the heart “sees” and has to fight against and many variables more. The clinical significance of the various parts of the pulse wave ranges, according to today's knowledge, from completely non-usefulness via very valid prognosis of heart attack/stroke/death ending up with the potency to redefine the cardiovascular killer no. 1 in the world (arterial hypertension) – all just using specific parts of a single pulse wave. Which parts of the pulse wave do bear these clinical relevance is the topic of the presentation.

FS 13

Validation of blood pressure measuring devices – clinical update: the German Hypertension League (Deutsche Hochdruckliga DHL®) Quality Seal Protocol for blood pressure-measuring devices: 15-year experience and results from 105 devices

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Hypertension is a major risk factor for cardiovascular disease and respective guidelines help making a proper diagnosis and choosing adequate treatment.
Automated measurement can be affected by differences in the quality of the components, including the workmanship of pressure transducers, valves, cuffs, and other hardware components.
Methods: The validation procedure has to be performed by three well-trained and experienced investigators. For reference measurements, standard BP auscultation with a mercury sphygmomanometer (Riva-Rocci-Korotkoff) and a dual earpiece teaching stethoscope for simultaneous auscultation is used. Ninety-six test subjects are selected based on age, sex, and systolic and diastolic blood pressure level according to protocol specifications. Wrist devices have to be tested additionally in 20 subjects with overt diabetes mellitus (10 men and 10 women) aged >56 years.
Results: From 1999 to 2014 a total of 105 blood pressure devices for self-measurement were tested according to the Quality Seal Protocol. Of these, 47.6% met all five validation criteria, 53.7% of the upper-arm devices (39 of 71) and 32.4% (11 of 34) of the wrist devices. Finger devices were not offered for testing. Forty-four devices (41.9%) failed multiple test criteria of the validation procedure. A sub-analysis with 51 devices tested showed that a stricter definition of the passing point score with a limit of ≥55% would slightly increase the consistency with the conventional criteria in comparison to a point score criterion ≥50% which was introduced in 2007.
Conclusion: The results illustrate the importance of a rigorous testing of blood pressure measuring devices used for home blood pressure measurement in order to prevent patients from erroneous treatment decisions.

FS 14

Non invasive blood pressure monitoring based on photoplethymographic signals

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The measurement of pulse the transition time is mostly performed to get information about the stiffness of the arteries. As the puls wave velocity also depends on the current blood pressure, several new methods and devices use pulse transition times for blood pressure monitoring. Some measure differences of the pulse arrival time at different sites. Onother way uses the de-composition of the measured pressure pulse in a direct and a reflected component. This paper describes an approach to get these two components out of the photo-plethysmographic pulse shape.
Based on a special micro-optical technology for emitter-receiver modules (MORES) the CiS Forschungsinstitut fuer Mikrosensirk GmbH developed a photoplethysmographic (PPG) sensor solution for reflective measurement at the auditory channel. The sensor device of only 5.4x3.2x0.7mm size fits into an individually prepared or a universal ear mold. The silicon sensor chip contains a receiver diode (5.45 mm^2) placed on one side of the sensor and two up to four LEDs of different wavelengths. The PPG signal is taken at the inside area of the tragus.
The initial goal was an in-ear monitoring system for pulse rate and blood oxygen saturation. In the course of an optimization of sensor geometry and signal acquisition the signal-to-noise ratio has been improved to allow detailed shape analysis of the recorded pulses. Several analysis methods have been tried to separate a direct and a reflected component out of the PPG shape, however without reliable results. Comparing the PPG wave with a simultaneously taken cuff-based pressure wave both appear completely different. Based on a modified “Windkessel” approach a model for the transfer of the pressure wave into the PPG wave has been developed. It allows also a simple backward projection of the PPG into an image of the pressure wave, which further can be analysed for transition times.

FS 16

Bioprinting of vascularized bone tissue

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Bone tissue is one of the most frequently transplanted tissues. Since procedures like the transplantation of autologous bone bear risks, though, regenerative medicine and tissue engineering reach to face those problems by engineering bone substitutes by using suitable materials and living cells. For the fabrication of bone tissue equivalents, evolving manufacturing techniques like bioprinting can be used. We developed bioinks that can either support the osteogenic differentiation of human adipose-derived stem cells (hASCs) and formation of a bone matrix by further addition of hydroxyapatite, or the formation of vascular structures by or human microvascular endothelial cells (ECs). The bioinks were used to build up geometries like 3D grids, cylindrical structures and combination hydrogels of bone and vascularization hydrogels via a microextrusion-based printing system, which were afterwards cultured for up to four weeks under static or dynamic culture conditions in a bioreactor. Evaluation of the hydrogels by mechanical analysis and staining of bone specific proteins like collagen type I, alkaline phosphatase and osteopontin showed formation of a bone matrix. This was also observes after culture under control conditions without the addition of osteogenic supplements, indicating osteoinductive properties of the hydroxyapatite. Co-culture of ASCs and ECs in a suitable hydrogel environment resulted in improved formation of bone matrix and capillary structures compared to the respective monocultures. Additionally, the perfusion culture in a bioreactor allowed the build-up and successful culture of cell-laden hydrogel constructs with a volume of >1 cm^2. In conclusion, we were able to develop bioinks and a printing process which allow the successful build-up of bone tissue equivalents whose bioreactor culture enables the set-up of relevant geometries and sizes.

FS 17

Alginate di-aldehyde gelatin crosslinked hydrogel (ADA-GEL) for biofabrication approach – tailoring of tubular structures for blood vessel supply

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Naturally occurring biopolymers like alginate and gelatin are extensively studied for many biomedical applications. Alginate is widely used in cell encapsulation and biofabrication due to its rapid ionic gelation with divalent cations, but has a very poor cell-material interaction. Gelatin on the other hand is a biodegradable protein which contains cell binding peptide sequences (RGD sequence). The composition of gelatin is very similar to that of natural type I collagen and therefore highly applied in the field of biofabrication. To overcome the limited mechanical properties of pure gelatin hydrogels and the drawbacks of alginate hydrogels alone, gelatin is covalently crosslinked with alginate di-aldehyde (ADA), which is prepared by partial oxidation of alginate. Thus, ADA-GEL forms a cell friendly hydrogel with tunable degradability and stiffness, which can be used for biofabrication applications such as microencapsulation and three dimensional printing of cells. We could show that 3D environments formed by ADA-GEL can be applied in regenerative medicine and cancer research to mimic native extracellular tissue conditions.
To mimic a native tissue successfully, it also requires the neovascularization of these engineered constructs. The human vascular system is a complex network of blood vessels of various sizes and different types of cells. Blood vessels are generally hollow structures, which are composed of a complex assembly of several shell layers. To generate functional vascular systems, two components are therefore critical, the colonizing cells and the scaffold material. The present work focused on plotting vessel-like structures based on ADA-GEL using a bioplotter and a core/shell-needle. The goal was to confirm ADA–GEL hydrogel as a promising material for immobilization of cells and for use in bioplotting technology, for fabrication of vessel-like constructs and thus to highlight it as a promising bioink in the field of biofabrication.

FS 18

Two-step printability assessment for inks processed with extrusion-based bioprinting

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Biofabrication is a young and active field of research and in one of its facets it aims for the automated production of biologically functional, hierarchical constructs for applications like tissue replacement. One of the key bottlenecks of biofabrication are suitable materials as these so-called inks need to have properties that enable to process them with techniques as 3D Bioprinting. In some cases, even cell laden inks are required to mimic the hierarchy of the tissue that needs to be regenerated. These bioinks impose even more stringent requirements on the materials as they need to combine good printing properties with adequate cytocompatibility. Scientists have set themselves the task to overcome this bottleneck by designing novel inks. To support them, we developed a two-step assessment focusing on ink printability via pressure driven extrusion-based bioprinting. The first step of this printability assessment is a simple screening based on fiber formation and layer stacking properties of material that is manually dispensed from a syringe. The second step requires a rheometer to evaluate the ink´s shear thinning and post-printing recovery. Applying a power law model to fit the shear viscosity data helped gaining deeper understanding of the dispensing process by estimating the conditions, like shear-rate, extrusion velocity, shear stress and residence time, present in the nozzle. Further it enabled the calculation of the mean shear rate present in the nozzle during dispensing and this information was used to analyze the recovery tests that shall imitate the dispensing process. Combining the data gained from the fit with printer parameters like pressure range, needle diameter and printing velocity helped gaining deeper understanding for the dispensing process and can be used to effectively design new bioinks. This two-step assessment was demonstrated and validated using different materials including non-printable compositions and represents an easy to reproduce approach.

FS 19

3D-printed biomimetic in-vitro-tumor-angiogenesis-model

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Tumor-associated angiogenesis, the formation of new blood vessels, is an essential process for the development of tumors, and therefore a suitable target for anti-cancer therapies. Here we present a novel method to produce a three-dimensional *in vitro* angiogenesis model by using a 3D drop-on-demand bioprinting technique with the aim to provide a more sophisticated, animal-free, *in vitro* drug screening under the principles of the 3R for a more ethical use of animals in testing. To resemble the natural structure of the vasculature, a dissolvable core made of gelatin is printed into a custom made bioreactor. Next, the gelatin is coated with a fibrin gel, laden with smooth muscle cells (SMCs), mimicking the thin layer of *tunica media*. The printed channel is surrounded by a fibrin/collagen hydrogel blend containing fibroblasts (*tunica adventitia*). Finally, the gelatin core is washed out and endothelial cells are introduced into the channel, resembling the *tunica intima*. The constructs are cultivated under physiological flow conditions and cancer cells are induced in proximity to the channels. Our results confirm that the printed constructs are stable for several weeks with a 20-50 µm thick continuous endothelium surrounded by an up to 200 µm thick layer of SMCs. The studied materials show high cell compatibility and cell viabilities of more than 80 % directly after the printing process and more than 90 % after four days. The mechanical characteristics of our hydrogels were tested and in line with the characteristics of natural vascular channels. We conclude that the proposed model could be further used as a tunable *in vitro* test platform to study the tumor-associated angiogenic process with a particular focus on effects of chemotherapy drugs in the future.

FS 20

Extrusion based 3D printing for biomedical applications: opportunities and limitations

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Additive Manufacturing (AM) is a currently fast developing research field and first industrial applications can be found in several disciplines. For biomedical engineering, AM is of special interest as specific tools and small devices (e. g. bioreactors for cell cultivation) can be fabricated in a fast and efficient manner. Extrusion based 3D printing (also called 3D plotting or direct writing etc.) enables utilisation of sensitive materials like biopolymer hydrogels, proteins, drugs or even living cells as it is based on deposition of materials which are pasty at room or physiological temperature.
In the last couple of years a hughe variety of biomaterials, suitable for 3D plotting, were developed, especially for medical applications.
3D bioprinting describes printing of live cells, suspended in soft hydrogels. This technology allows positioning of more than one cell type with high spatial accuracy within a 3D construct and guarantees high seeding efficiency compared to conventional cell seeding of pre-fabricated scaffolds. Very recently, our group has expanded 3D bioprinting to non-mammalian cells. We could demonstrate initially successful bioprinting with live microalgae (“green bioprinting”) and could show now that also plant cells can be utilised for 3D bioprinting. This opens up totally new possibilities for biotechnological applications like cascade reactions which is currently under investigation.
The paper will describe and discuss opportunities and limitations of extrusion based 3D printing in biomedical engineering with respect to suitable biomaterials, novel printing technologies (like multi-channel and core/shell plotting), fabrication of patient-specific constructs and integration of biological components, especially living cells.

V 56

Comparison between conventional and suspended radiation protection in interventional radiology

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Radiation protection clothing is a standard equipment in interventional radiology. However, during long examinations, the weight of conventional aprons often causes discomfort, fatigue and musculoskeletal problems for interventional radiology practitioners. Recently, a new weightless-like radiation protection garment (Zero-Gravity, Biotronik) has been introduced to provide an alternative to directly worn radiation clothing. It is freely suspended on a swing arm and snaps onto the user via a belt mechanism. It consists of a main apron part (1 mm Pb equivalence) and a glass face shield (0.5 mm Pb equivalence). In this study, we examined this new concept regarding its efficiency in personal radiation protection and compared it to a conventional two-piece apron (+ thyroid collar) suit. Standard ancillary shields, which was a hanging lead acrylic and an under-table lead apron were used for further comparison.
All measurements were carried out using a clinical angiography system (Artis Zee, Siemens) with a standard fluoroscopy protocol, and an anthropomorphic upper body phantom. An ionization chamber (U-Mo, Berthold) was used to measure the radiation exposure on five different representative heights and at two different positions of an examiner during a typical angiography intervention. The five measuring heights (30 cm, 100 cm, 130 cm, 150 cm, and 165 cm) were selected to reflect different body parts of an examiner (lower leg, gonads, thorax/lung, thyroid, and eye lenses).
The Zero Gravity system and the conventional radiation protection showed a mean dose reduction of 98.1% and 90.1%, respectively. By adding the under-table lead apron and the shielding acrylic to the Zero Gravity system and the conventional protection apron, an average reduction of 99.0% and 98.2% was found. In addition, both systems showed a variety in radiation protection depending on the height, tube angle, and position of the examiner.

V 57

Attenuation properties of materials used for X-ray protective aprons

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X-ray protective aprons shall comply with the second edition of the EN 61331-3 standard published in 2014 which supersedes the first edition published in 1999. Materials used for protective aprons shall have a lead equivalent of not less than 0.25 mm or 0.35 mm depending on the type of the apron. Compared to the old standard there are two significant changes in the determination of the lead equivalent. Firstly, the attenuation ratio shall be measured under broad-beam conditions (i.e. scattered radiation included) instead of narrow-beam conditions. Secondly, the lead equivalent shall be measured for the specified range of radiation qualities, 50 kV, 70 kV, 90 kV, 110 kV and 150 kV (optionally), instead of just for one quality (e.g. 90 kV). The changes represent a challenge for some types of lead-reduced or lead-free composite materials nowadays used for the vast majority of commercially available aprons. These lead-substitute composite materials are characterized by a larger attenuation factor at a lesser weight compared to purely lead-based materials, but only for the range of about 70 – 100 kV and if measured under narrow-beam conditions. They lose this advantage for radiation qualities produced at lower and higher values of tube high voltage. Since 2014, the Physikalisch-Technische Bundesanstalt (PTB) has offered the service of lead equivalent determination mainly on behalf of the Notified Bodies who are involved in the conformity assessment required for CE marking of such products. The main results obtained from a three-year material testing period are summarized and interpreted physically. A general trend is that the area weights of the composite materials used to date have to be increased in order to meet the new requirements. Furthermore, whether the lead equivalent is the appropriate quality criterion for X-ray protective aprons is discussed.

V 59

Automated dose control for selective retina therapy using optical coherence tomography - a prove of concept

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While conventional laser photocoagulation is an established method to treat diseases affecting the retina, such as age related macular degeneration, it can cause severe adverse damages leading to regions of visual impairment. It has been found that lesions limited to the retinal pigment epithelium (RPE) layer only—and thus not affecting the photoreceptors—can be clinically equally successful as coagulation of the entire retinal structure. Selective retina therapy (SRT) only targets this highly absorptive layer by employing pulsed lasers, operating at the spectral absorption peak with pulse lengths shorter than the thermal relaxation time of the RPE. Precise control of pulse energy is crucial to initiate sufficient RPE damage for treatment but to prevent collateral cellular damage caused by excess energy deposition. Since absorption properties vary strongly inter- and intraocularly, it is impossible to set static energy-thresholds within which successful treatment can be guaranteed. Additionally, pure RPE lesions are ophthalmoscopically invisible during treatment. Thus real-time monitoring and automated dose-control of the SRT laser is indispensable for clinical success of SRT.
We developed a treatment monitoring method based on high-resolution optical coherence tomography (OCT) coaxially aligned with the treatment laser. The absorption of short-pulse laser energy by melanin causes micro vapor bubble formation in the RPE with subsequent rapid shift of the scattering layer and thus a destruction of the coherence leading to a signal loss in the OCT-signal displayed as vertical black streaks in time-resolved OCT-scans. In ex-vivo experiments with porcine eyes we could successfully correlate theses OCT signal losses with respective microscopically visible lesions in the RPE and therefore precisely predict treatment outcome. A subsequent study using live/death staining confirmed spatial selectivity within the RPE. This demonstrates the feasibility of using OCT as a monitoring device.

V 60

Impedance based ultrasound probe tracking system for 3D peripheral vessel imaging

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Volumetric imaging of peripheral vessel structures is a method to locate and characterize vascular diseases. In peripheral arterial disease for example, plaque is narrowing the vessel structure causing blood shortage in the lower limbs. Classification of the diseases progression helps to design a proper therapy. Several diagnostic imaging systems are used to acquire tomographic images of the vessel structures. In computed tomography angiography (CTA) and partly in magnetic resonance angiography (MRA), the vessel volume is enhanced by means of intravenous contrast agent (CA). However, CA can lead to allergic reactions and can also be nephrotoxic. Additionally, the radiation dose in CTA, long examination times in MRA and the procedure costs are main disadvantages. Ultrasound (US) imaging systems equipped with a tracking system enabling the reconstruction of 3D datasets could alternatively be used to overcome these drawbacks. Electromagnetic or optical tracking of the US probe is used to link the acquired 2D US images to a coordinate system. With the spatial information a 3D volume is reconstructed and further vessel structures can be segmented and analyzed. However, the electromagnetic tracking system is limited to the area of the magnetic field, whereas the optical tracking system requires a line of sight between camera and ultrasound probe. We propose as an alternative a low-cost impedance based linear tracking system. The system is based on an alternating current applied between two active electrodes placed on the skin's surface covered with US gel. A sensing electrode placed on the US probe measures the electrical potential between the two active electrodes. Position of the US probe along one dimension was derived from the measured potentials due to an almost linear potential drop. The accuracy without an additional calibration method was approximately 5mm, which proved good enough for subsequent 3D reconstruction of the individual 2D images.

V 61

Auditory display for ultrasound scan completion

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Clinicians manually acquire sequences of 2D ultrasound images to evaluate the local situs in real-time. 3D volumes reconstructed from these sequences give clinicans a spatial overview of the area. Although 3D renderings are beneficial, drawbacks prohibit efficient interaction during acquisition. Current 2D image acquisition methods provide only one audible beep after each 2D scan added to the 3D volume, leaving the clinician without feedback about scan quality. This produces highly inhomogenous intensities of the anatomical structure with imaging artifacts, resulting in overexposed images and reduced image quality. Low-quality volumes must be reacquired, causing clinician frustration and wasted operation time.

Auditory display maps information to parameters of sound synthesizers so a user can “hear” underlying data. This has been investigated to guide instruments or warn when clinicians approach risks, aiding clinicians to focus on the situs while still receiving information. We harness auditory display for acquiring complete, high-quality scans.

Our auditory display employs a granular synthesizer with 9 simultaneous sawtooth oscillators. An array with 100 cells represents an ultrasound volume, for which each cell represents one scan, with values ranging from 0 to 100 as the completeness of each individual scan. The synthesizer maps completeness of the current and 8 neighboring cells to pitch, pitch variation, noisiness, low-pass filter rolloff frequency, and stereo width of 9 grains. The synthesizer mimics a vacuum sucking up dust: incomplete areas are heard as scattered, noisier, higher pitch, whereas complete areas are stable, less noisy, and lower pitched. Pilot studies show the auditory display allows high-quality, efficient individual and overall scan completion completely without a monitor. Thus, using auditory display to augment US acquisition could ensure higher-quality scans and improve reconstruction while reducing the use of monitors during the procedure and helping clinicians keep their view on the situs.

V 62

Polymer gel-based isocenter test for a MR-linac-system

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As new methods in image guided radiation therapy (IGRT) are being continuously developed, dedicated quality assurance (QA)-procedures need to be adapted. Especially for MR-LINAC systems, it is important to implement new methods for quality assurance (QA) of both, the LINAC and the MR components. A very promising method is offered by a 3D polymer gel dosimeter (PGD), which is evaluatied by MR imaging.
As a first step, the influence of different magnetic field strengths on the beam alignment to the isocenter was investigated and compared against the standard film-based QA-procedure (EDR2, Kodak, USA). This was realized by performing a “star shot” with a circular field (diameter d=0.5 cm) from different gantry angles (270°, 315°, 0° and 45°) and varying field strengths of 0 T, 0.3 T and 1 T. Experiments were performed on a clinical 6 MV LINAC (Artiste, Siemens, Germany) in combination with a mobile electromagnet (AGEM 5520, Schwarzbeck, Germany). Measurements were evaluated using the commercially available MEPHISTO software (PTW Freiburg, Germany).
Film and PGD showed well-comparable sizes of the isocenter spheres (0 T: 0.2 mm/0.1 mm, 0.3 T: 0.3 mm/0.3 mm, and 1 T: 0.4 mm/0.3 mm for film and gel, respectively). As expected, slightly increasing deviations were found for both methods with increasing field strength. Furthermore, a visible shift of the isocenter sphere relative to the isocenter position was found (0 T: 0.5 mm/0.4 mm, 0.3 T: 0.9 mm/1 mm, and 1 T: 1.8mm/ 0.7mm for film and gel, respectively).
As a conclusion, PGD can be considered as a valuable QA-tool for integrated MR-LINAC systems. As compared to the established film-based QA-procedure, it provides 3D- rather than 2D-Information. Future applications will focus on integrated MR-LINAC systems, which is currently being installed in Heidelberg, allowing to to perform an online evaluation of the PGD.

V 63

A compact source for microbeam radiation therapy and phase contrast imaging

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Various emerging x-ray applications in medical physics demand for high beam intensities and small source sizes. Examples are microbeam radiation therapy (MRT), high dose rate radiation therapy (FLASH) and phase contrast imaging (PCI). In the last two decades MRT, an innovative approach in radiation therapy using spatially fractionated radiation fields on micrometre scales, demonstrated in preclinical studies superior tumour control at equal normal tissue toxicity when compared to conventional radiotherapy. MRT could be a promising alternative in treatment of certain tumour species, especially where the surrounding normal tissue is sensitive, as brain or lung. Phase contrast imaging is known to provide significantly better contrast when compared to x-ray absorption imaging. However, both technologies vastly rely on a few large synchrotron facilities such as the European Synchrotron (ESRF) which provide appropriate beam qualities. This has so far impeded widespread clinical use of these methods. Here we present a new concept of x-ray microbeam generation based on conventional x-ray technology, that we term line focus x-ray tube (LFXT). In LFXTs an electron beam is focused to an extremely thin focal spot on a rapidly rotating tungsten target. A change in the mechanisms of target heating allows very high electron beam currents without melting the target material. In terms of photon flux and coherence length, the performance of the line focus x-ray tube compares with inverse Compton scattering sources. Moreover, the LFXT is capable of producing dose rates of up to 150 Gy/s in 50 cm distance from the target with a mean photon energy of around 150 keV. In finite element and Monte Carlo simulations we show that peak entrance doses of more than 700 Gy can be produced in a single application, before the target overheats. We show how this x-ray source could provide MRT and PCI in a hospital environment.

V 65

Concept of an implant with an integrated sensor actuator system for the monitoring and influencing of the mechanical implant bone interface

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Endoprostheses are mechanical components which have been optimized regarding biomechanical criteria and material aspects. An important claim is the realization of a stable implant-bone-interface. For example, the interface can be strongly influenced by load- or inflammation-induced bone reconstruction processes. This may lead to an exchange operation if the implant gets loose. The later an implant loosening is detected the higher the risk of complications is. The loosening of an implant can be determined by imaging procedures (e.g. X-ray) or functional diagnostics. However, these regular procedures are usually not possible and an implant loosening is detected too late.
The proposed approach describes an actuator based on a ceramic multilayer which is materially integrated during the additive manufactring process of a hip implant. The system is hermetically encapsulated in the implant and can be controlled wireless via an extracorporeal unit.
The implant and thus also the system consisting of implant and bone can be excited to vibrate in a defined manner. Changings in the implant-bone-interface leads to changes in the dynamic properties of the implant-bone-composite (e.g. resulting natural frequencies). Experimental investigations demonstrate the possibility of wireless energy transfer into the hermetically encapsulated implant. By using a 3D laser scanning vibrometer, the theoretically calculated mode shapes could be confirmed.
In addition to the mechanical stimulation, the thermal activation of integrated shape memory alloy (SMA) actuators is also possible with the developed actuator principle. These SMA components can be used to generate an additional pressure force at the implant-bone-interface and are intended to refix the implant at a beginning loosening or to prevent the degradation of the bone substance.
With its modular design, the developed actuator system can also be integrated into other implant systems and represents a possibility for the monitoring of the implant-bone-interface as well as the conditon monitoring of complex components.

V 66

Monitoring of the inner ear function during and after cochlear implant insertion using cochlear microphonics

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To preserve residual hearing during cochlear implant (CI) surgery it is desirable to use intraoperative monitoring during the electrode insertion. A promising method is the recording of cochlear microphonics (CM). The aim of the monitoring is to identify critical steps as well as to modify the ongoing insertion procedure immediately if necessary.
During the insertion of hearing preservation electrodes, different modes of intraoperative CM recordings were performed. In one mode the potentials were recorded extracochlear using a cotton wick electrode at the promontory wall before, during and after insertion. In a second mode the potentials were recorded intracochlear during, or directly after, insertion and postoperative during the follow up appointments. Here the CI electrode was used for recordings. The stimulation was done acoustically using tone bursts. The extracochlear recordings were done up to now with 50 patients, the intracochlear recordings with 20 patients (MedEl and Advanced Bionics).
Extracochlear recorded CMs showed peaks of maximal 0.5 µV in the according spectra for most patients. Intracochlear peaks of up to 30 µV were detected. In the first data, the amplitude of long term CMs seem to be in line with the audiometrical pure tone thresholds.
The recording of CMs is very good possible with all methods. The amplitudes of intracochlear recorded CMs were detected to be much larger than the extracochlear recorded CMs.

V 70

A method for lower back motion assessment using wearable 6D inertial sensors

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Inertial sensor have become widely used for motion tracking of the upper and lower limbs. We propose a method that facilitates clinical assessment of lower back motions by means of a wireless inertial sensor network. The sensor units are attached to the right and left side of the lumbar region, the pelvis and the thighs, respectively.
Since magnetometers are known to be unreliable in indoor environments, we use only 3D accelerometer and 3D gyroscope readings. Sensor fusion is performed by a recently developed quaternion-based algorithm, while compensation of integration drift in the horizontal plane is achieved by estimating the gyroscope biases from initial rest phases. The result are three-dimensional joint angles between the thighs and the pelvis and between the pelvis and the lumbar region.
We validate the proposed method with respect to an optical motion tracking system that determines the orientation of each skin-mounted sensor by means of reflective markers. The subject performs flexion/extension, lateral flexion, and rotation of the trunk. For each motion, the full angle set between all segments is determined.
Comparing the inertial joint angles to the optical joint angles yields a root-mean square deviation of less than one degree for angles in the frontal and sagittal plane and about one degree for angles in the transverse plane (both values averaged over all trials). The average maximum deviation is found to be about one degree for angles in the frontal and sagittal plane and about two degrees for angles in the transverse plane.
These results indicate that 6D inertial sensors are a promising tool for lower back motion assessment. Future research will focus on soft-tissue motion artifacts and medical interpretation of the obtained joint angles.

V 71

Plasma electrolyte concentrations in patients with chronic kidney disease influence cardiac pacemaking in a computational model

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Chronic kidney disease (CKD) affects more than 30 million patients in the European Union. CKD causes alterations in the extracellular plasma electrolyte concentrations, which affect cardiac electrophysiology. A total of 25% of all deaths of CKD patients are due to sudden cardiac death (SCD). Until recently, ventricular fibrillation was assumed to be the main reason. In a 2015 study, Wong et al. observed bradycardia and asystole as the predominant mechanisms of SCD in patients with CKD. This shows that the influence of electrolyte changes on the underlying mechanisms of pacemaking in the sinoatrial node (SAN) needs to be better understood. In this work, we have updated the computational model of the human SAN given by Fabbri et al. and investigated the CKD-induced change of $[Ca^{2+}]_o$ (0.6-3mM), $[K^+]_o$ (3-9mM) and $[Na^+]_o$ (120-150mM) on pacemaking. $[Ca^{2+}]_o$ had the most dominant effects on SAN function. Low $[Ca^{2+}]_o$ caused severe bradycardia in the model (down to 17 bpm) for 0.6 mM. A critical concentration range of calcium in the subspace $[Ca^{2+}]_{sub}$ was identified as the possible underlying mechanism for pacemaking. For increasing $[Ca^{2+}]_o$, the heart rate (HR) increased, resulting in 142 bpm for the highest calcium concentration. The effect of $[K^+]_o$ variation was similar to the one for $[Ca^{2+}]_o$, but caused less pronounced change. The resultant changes due to variation of $[Na^+]_o$ were relatively small. In this work, several potential mechanisms for SCD in CKD patients could be identified. The low HR for low $[Ca^{2+}]_o$ is seen as a possible link to the observed bradycardia in CKD patients. The findings in this work could lead to a better surveillance of $[Ca^{2+}]_o$ in hemodialysis patients, and therefore to a decrease in the SCD rate.

V 73

Optimal ECG lead systems to maximimze left atrial information content

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Atrial arrhythmias such as atrial flutter and atrial fibrillation are a burden for patients and a major challenge for modern healthcare systems. Identification of patients at risk to develop atrial arrhythmias at an early stage carries the potential to reduce the incidence by implementing appropriate strategies to mitigate the risks. Diagnostic methods based on the ECG are ideal risk markers due to their noninvasiveness and omnipresence. The left atrium (LA) plays a major role in the intiation and perpetuation of atrial reentry arrhythmias. However, the LA is not well represented in the P-wave derived through standard ECG leads. Here, we optimize ECG lead positions to maximize LA information content. Towards this end, we used a cohort of eight personalized computational models providing the unique opportunity to separate LA and right atrial (RA) contributions to the P-wave, which is not feasible in vivo. The location of maximum P-wave signal energy was located on the center of the chest for all subjects with marked overlap between regions of maximum LA and RA P-wave amplitude. The regions of highest ratio between LA and RA signal energy differed between patients. However, a region with LA signal energy being higher than that of the RA and providing a sufficiently large absolute P-wave amplitude was identified at the center of the back consistently across five models of the cohort. Optimized linear combinations of standard 12-lead signals yielded comparably good results. Our newly proposed electrode positions on the back as well as selected linear combinations of standard 12-lead signals improve the LA information content considerably. By using these, more relevant diagnostic information regarding the anatomical and electrophysiological properties of the LA can be derived in future.

V 74

Developing and coupling a lumped element model of the closed loop human vascular system to a model of cardiac mechanics

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Modelling the interaction of the heart and the vascular system allows to study the pumping efficiency of the heart in a controlled environment under various cardiac and vascular conditions such as arrhythmias, dyssynchronies, regions of stiffened myocardium, valvular stenoses or decreased vascular compliances.
To pose realistic hemodynamic boundary conditions to a four-chambered elastomechanical heart model, we developed a lumped element model of the closed loop human vascular system. Systemic and pulmonary circulations were each represented by a three-element Windkessel model emptying into a venous compliance. Both circulations were coupled by connecting the venous compliances to the corresponding atrium via venous resistances. Cardiac valves were represented by ideal diodes and resistances. Strong coupling between the heart and the vascular system model was accomplished by estimating the cardiac pressures that lead to continuous flows across the model interfaces. Active regulatory mechanisms were not considered. Pressures, flows and volumes throughout the circulatory system were simulated until a steady state was reached and the effects of model parameters on these hemodynamic parameters were evaluated in a sensitivity analysis.
Increasing the systemic peripheral resistance by 50% caused an 8% decrease in stroke volume (SV) and a 33% increase in mean arterial pressure. Increased venous resistance descreased the E/A wave ratio of the atrioventricular flow and led to a reduced SV by impeding passive cardiac filling. Increasing the arterial compliance decreased mean cardiac pressures, while only slightly reducing the SV. Larger arterial resistances mainly caused higher peak systolic pressures.
Furthermore, we show that embedding the heart model into surrounding elastic tissue by forcing permanent contact at the pericardial surface leads to more realistic time courses of atrial volumes and atrial pressure-volume curves composed of an A and a V loop as found in measurements.
In conclusion, this work enables simulations of diseases that involve significant cardiovascular interaction.

V 75

From clinics to the virtual beating heart – a general modeling workflow for patient-specific electromechanical heart simulations

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Generating meshes of complex structures in the human body like the heart organ is a prerequisite for computational simulations of of organ function. The quality of the conclusions derived from these simulations greatly depends on the quality and accuracy of the mesh they are based on. Volumetric computation domain can be represented by an equally-spaced voxel grid, or – in case of more sophisticated partial differential equation discretization methods (finite elements, finite volumes) – first, second or even higher order tetrahedral meshes.
Here, we present a workflow that is capable of creating high quality meshes for such simulations. The workflow contains segmentation, surface mesh generation, volume mesh generation, and patient-specific parameter fitting to produce the desired results. While segmentation itself is a more or less unique mapping from a grayscale DICOM data set to a labeled, three-dimensional voxel mesh, different approaches exist for their transformation to a surface mesh. Our process involves a two-level approach for obtaining triangular or mixed rectangular surface meshes of desired quality and resolution. Both are crucial for the next step: obtaining a volumetric tetrahedral grid with the desired degrees of freedom. In the last step, a derivative-free parameter estimation approach is used to calibrate the dynamic behavior and tailor the model patient-specifically.
All software used in the workflow is published under open source licenses and freely available. Its capability is demonstrated by means of an elastomechanical simulation of a human heart and yields measurable validation quantities in physiological ranges. We want to stress that the presented approach is generic and can easily be used for the model generation of other organs like liver, lungs or the aortic arch as well. The resulting meshes can be used for various types of simulations (electrical excitation propagation, blood flow) and use cases (clinical diagnostics, therapy planning etc.).

FS 21

Measurement of moisture at skin surface based on hyperspectral technology

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Hyperspectral imaging (HSI) technology provides new opportunities to measure essential patient information. Perfusion parameters like oxygen saturation and tissue haemoglobin concentration can be recorded. They are crucial values to monitor patient state.
In this work we considered the moisture of surfaces e.g. patient hand. We measured the water volume at skin surface using a HSI camera. The camera system can measure a spectrum from 500 to 1000 nm (resolution: 5 nm). The camera unit was a CMOS camera (spatial resolution: 640 × 480 pixels per image). An illumination unit containing eight 120 W halogen lamps was used.
In the first study we examined the moisture content by pipetting 0.1 ml water on a skin area of the hand and the foot (size 2 x3 cm²). This volume corresponds to little moisture volume on the skin. We measured the absorbance spectrum before and after pipetting. The mean absorbance increased over the full range of 0.0135±0.0195. Especially in the range between 550 nm and 600 nm the gap between the spectra was the largest.
In the second study we measured the moisture volume of the forehead before and after sport activity of two probands. The sweating of the probands was not visible but palpaple. We calculated the mean absorbance of the forehead and saw also an increasing over the full range of 0.1837±0.054. In the near-infrared band, the absorption with sport activity increased lesser than the absorbtion without sport activity. Thus, a water index can be calculated.
We showed that little moisture volume on the skin surface are measurable based on calculation of the absorbance of normal skin surface. Furthermore, our results showed that sweating is measurable in the near- infrared area before it is external visible. The quantitative monitoring of gustatory sweating patients could be a clinical application.

FS 22

Workflow for intraoperative hyperspectral imaging in neurosurgery

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For successful resection of brain tumors a precise preoperative surgical planning based on MRI images is essential, just like the intraoperative information about tumor border and brain tissue functionality. To identify functional areas of increased metabolism, Intraoperative Optical Imaging (IOI) technology can be used to generate two-dimensional activity maps. IOI uses a special hardware and software setup that analyses selected wavelengths or broad band spectra (RGB) of the reflected light from the exposed cortex. After performing a specific stimulation protocol and processing complex image data, two-dimensional navigated activity maps are generated. In contrast, hyperspectral imaging (HSI) expands the procedure to the whole continuous light spectrum between 500 to 1000 nm in order to obtain further information on brain tissue types and characteristics. We developed an HSI system with an intraoperatively usable HSI hardware setup based on a standard surgical microscope, a halogen light source, and a pushbroom HSI camera system. This HSI system was attached to the surgical microscope using a standard beam splitter. Illumination was coupled into the optical path of the surgical microscope via a fiber-optic. Via beam splitter an RGB camera was applied to adjust focus and zoom. Passing 10 clinical tests, the prototype was iteratively improved. Currently, after opening the cortex and before the beginning of tumor dissection, hyperspectral image data acquisition is employed. HSI data cubes are acquired that contain the spatially resolved spectral distribution of each pixel. Subsequently, the spectral characteristics of the different tissue types of the cortical surface were evaluated and visualized. Comparing preoperative MRI, intraoperative IOI, and HSI images with intraoperative anatomical landmarks and electrophysiological testing results, intraoperative hyperspectral imaging seems to be a promising additional imaging option. Therefore further work will focus on light source characteristics and on data classification algorithms.

FS 25

Monitoring hemodynamics and oxygenation in the renal cortex of rats by a combined near-infrared spectroscopy and invasive probe approach

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Acute kidney injury (AKI) is a frequent syndrome in hospitalized patients with a high risk of mortality. To improve the understanding of the pathophysiology of this disease basic investigations of renal hemodynamics and oxygenation in animal models are of high importance. We developed a combined near-infrared spectroscopy (NIRS) and invasive probe approach to obtain a comprehensive characterization of the balance between oxygen supply and oxygen demand in the kidneys of rats. A linear fiber optic probe with source-detector distances of up to 8 mm was placed on top of the exposed rat kidney to measure spatially resolved diffuse reflectance at three near-infrared wavelengths (690 nm, 800 nm and 830 nm). Tissue optical properties, hemoglobin concentration and oxygen saturation of hemoglobin in the cortex of the kidney were derived by a Monte Carlo model of photon propagation. Measurements of local tissue oxygen tension and local laser-Doppler flux were obtained from an invasive fiber optic probe that was inserted into the cortex of the kidney. In a study on 13 rats we investigated temporal changes during several types of interventions. For short occlusions of the renal artery or vein the decrease or increase in the cortical hemoglobin concentration per tissue volume could be quantified. Furthermore, the temporal behavior of oxygen saturation of hemoglobin and tissue oxygen tension in the kidney was found to be different. In a second group of interventions the mixture of the inspired gas was changed to induce hyperoxic, hypoxic and hypercapnic conditions which resulted in increased, decreased, or unaltered oxygen saturation. As expected, changes in hemoglobin concentration were much smaller during these interventions compared to the occlusions. Our results demonstrate the benefit of combining NIRS and invasive methods to better understand the complex physiology of the kidney.

FS 27

Requirements for a fully-digital surgical microscope regarding the state of the art of surgical microscopes and the surgeon's visual perception

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Today surgical microscopes are the gold-standard in microsurgery applications. Even though the state-of-the-art optomechanical technology is robust and reliable technique, surgical visualization systems still have a number of limitations according to usability requirements and the need for integration into a future fully-digital visualization workflow. For example, it is nearly impossible that more than two independent observer views can be realized in surgical microscope. Furthermore, multi-observer positions are mostly not independed from each other. The surgical microscope cannot provides the same image quality to each observer as in a single-observer case. A state-of-the-art microscope allows only a 2D overlay of pre-recorded patient data over the current surgery scene. Therefore, a real time 3D image fusion is not achieved.
To overcome the above-mentioned limitations, a new approach will be developed. The objective of this work is the technical concept for a fully-digital microscope. Fully-digital means that the observers view is now calculated from a fully rendered 3D model, which will be reconstructed from the surgery scene by using a multi-camera setup. The proposed set of requirements shall provide a guideline for the development of the optical recording system, the mounting system, the illumination system, the algorithm for 3D reconstruction, and multi-observer visualization. These requirements are benchmarked to the specifications of commercially available surgery microscopes regarding optical performance of the microscope and surgeon perception regarding the visualization.
The proposal of requirements allows developing a fully-digital surgical microscope close the use case of father application of surgical imaging. This reveals the vast possibilities of digital processing in the field of surgical visualization.

FS 28

Experiences and practice with the interactive telemedical assistance system COMES®

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COMES® means Cognitive Medical System. It offers a great variety of application options in diagnosis and therapy. With this system, individual data patterns can be gathered from the patient's real-life environment, thus allowing for an immediate and realistic impression of all manners of intervention structures to be obtained.
In cooperation with CoKeTT (COMES Kempten Test and Training Centre) we enable the testing of practically oriented therapy management systems for conditions such as diabetes, obesity, cardiovascular diseases, psychosomatic disorders, as well as for patients who require rehabilitative care. Potential users may develop suitable test scenarios, enhance existing equipment and also perform on-site tests of new diagnostic and therapeutic systems.
In recent years, we have conducted a great number of studies using COMES®, in particular with patients suffering from hypertension or obesity, both with elderly and young people. The presentation will give an overview of these projects related to teletherapy, virtual coaching, motivation based on feedback and the results.

1. PUMA - prevention and motivation concept for obese patients

By using COMES®, patients are enabled to view their physiological data such as blood pressure, their weight as well as their trends over time everywhere, at all times. Thanks to the already existing option of sending individualised feedback from the system to the user - for example relating to diet and exercise -, he or she can rely on a telemedical companion and coach as a support during therapy or when changing habits and lifestyle.

2. Biophysical feedback therapies

Tone and Tonus is an exemplary project for a feedback therapy that employs COMES®. In this project, we have especially investigated the anti-hypertensive effect of certain iterative sound-patterns as a possible intervention option for patients suffering from arterial hypertension.
All results have shown that thus achieving a better compliance and an increasing sustainability.

FS 30

Telematic Rehabilitation in Neurology

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Demographic change leads to an increased importance of telemedical assistance systems and telematically based therapeutic concepts during medical aftercare, especially in the development of new training programs for neurological rehabilitation. The completeness of long-term rehabilitation e.g. after a stroke often depends on the commitment of the affected person. After an accompanied therapy phase in a rehabilitation center, the motivation, to preserve the gained activity level in the usual environment, decreases rapidly. Giving the patient the possibility to use the daily hours of media consumption simultaneously for rehabilitation with therapeutic feedback, is our approach.
1. The real-time biofeedback-animation of a training on a telemedical rehabilitation-exerciser is combined with a TV-program, in a split-screen application. With giving the therapist the possibility to individualize the goals of this biofeedback-application, the patient shall be motivated to train regularly while watching TV. With the COMES®-interface, users has additionally the possibility to access and interpret training results, online.
2. This project shows the expansion to an audiotrainer where the target group comprises patients with Parkinson's disease and the main feature is the combination of physical cycling exercise and auditory biofeedback in the form of music. By this the patient is helped to establish a more consistent training pace which improves the symptoms and furthermore, the long-term motivation can be increased dramatically. To provide music for all individual preferences algorithms for automatic beat-tracking and real-time audio time-stretching are introduced.
3. DorsiFlex aims to develop an overall concept for a feedback-controlled individualized treatment of the lower musculoskeletal system. By means of monitoring the muscular activity with an intelligent pedal, spasms or certain motion patterns can be detected. A motor driven unit applies a fully individualized and adaptable treatment. A therapist can interact with the patient and prescribe therapy sessions online.
That way individual long-term therapy objectives can be fulfilled better in the everyday life.

FS 35

Auditory-induced cortical activation patterns measured by functional near infrared spectroscopy (fNIRS)

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Functional near infrared spectroscopy (fNIRS) is an optical technique for the assessment of cerebral oxygenation (changes of oxygenated and deoxygenated hemoglobin concentration) which strongly correlates with cortical (neuronal) activity. Recently, fNIRS has also been conceived as a promising neuroimaging approach for the investigation of the auditory cortex (AC) in the area of central auditory diagnostics. Special attention is given to the promising benefits for the application in cochlear implant (CI) users. In the present study we report on measurement of activation patterns in adult subjects during spatial presentation of tone stimuli with different intensities.
The measurements were carried out on ten adult hearing subjects using an Imagent^{TM} fNIRS system (ISS Inc., USA, 38 channels arranged bilaterally over left and right AC & frontal, central and parietal cortical areas). Participants performed a passive listening task consisting of six different conditions (1 kHz sine wave, amplitude modulated by 4 and 10 Hz, 10 s duration). Stimuli were presented spatially (binaural 'Bin' & loudness matched monaural left 'MonL' and right 'MonR') with two different intensities ('HIGH-': 70dB and 'LOW-': 40dB sound pressure level, SPL), resulting in 6 different conditions.
We found pronounced activation patterns, especially for the 'HIGH-' conditions, in cortical areas which are related with auditory processing, and additionally in frontal cortical areas. We also found significant differences in cortical activation patterns comparing 'HIGH-' and 'LOW-' stimulus presentation. These findings are in line with several fMRI studies investigating response variation with different SPL.
According to our experience and the results of the present study fNIRS is a readily available and frequently applicable method for the measurement of auditory-induced cortical activation patterns. Future investigations include the measurement of brain activity patterns induced by pure tone sounds as well as speech stimuli in hearing impaired participants and patients with cochlear implants.

P 1

Development of long-term stable measurement phantoms for quantitative magnetic particle imaging

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Interlaboratory performance evaluation of both commercial and custom-made Magnetic Particle Imaging (MPI) scanners requires dedicated phantoms with defined magnetic nanoparticle (MNP) distributions. Pre-requisite for the development of such phantoms is the establishment of suitable MNP-matrix combinations, which determine the magnetic properties of the phantom. To enable round robin tests using exactly the same measurement phantom in different labs, the magnetic and mechanic properties of the phantoms must be constant over durations of several months. Development of long-term stable phantom materials is therefore needed. To this end, Elastosil (an organic silicone) was used as a matrix material for phantom preparation. Four commercially available aqueous suspensions of MNP were tested for their suitability as MPI tracer materials, and embedded into the Elastosil matrix in various concentrations. The transfer of MNP from aqueous suspensions into organic silicones is a challenging and critical part of the phantom preparation. The obtained MNP-matrix combinations were tested for their mechanical stability by means of shore hardness measurements (Shore A). Furthermore, the homogeneity of MNP distribution within the matrix was determined by optical investigation of the samples with a microscope. Magnetic Particle Spectroscopy (MPS) was applied to investigate the temporal stability of the MPI performance of the MNP/Elastosil combinations. MPS measurements were conducted at regular timepoints spanning a 6 month period; beginning at the material fabrication. Finally, from the most promising material combinations, cylindrically shaped measurement phantoms (D = 12 mm, H = 12 mm) were fabricated and imaged by MPI. In summary, we have developed suitable combinations of MNP and Elastosil for the manufacture of long-term stable MPI phantoms. The prepared phantoms show constant magnetic and mechanical properties for the duration of the study and can be imaged by MPI. Ongoing work is focused on more structured measurement phantoms.

P 2

Spin echo based cardiac diffusion imaging sequences at 7T: performance and feasibilty ex vivo

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The short transverse relaxation time T_2^* of the myocardium limits the echo time (TE) that can be used for cardiac diffusion weighted imaging. This restriction becomes even more prominent at higher field strengths of 7T and above. While measuring at 7T potentially increases signal to noise ratio, B_0 field inhomogeneity is also increased. Purpose of this work was to compare spin echo (SE) sequence performance in cardiac diffusion imaging in ex vivo pig hearts at 3T and 7T.
Measurements were performed on 3T and 7T whole-body MRI systems (Siemens MAGNETOM Prisma and Terra) using a 1Tx/32Rx head coil. For imaging pig hearts were placed in a 0.9% sodium chloride solution. MRI with spatial resolution of 1.3x1.3x1.3mm^3 was performed within 10 hours after cardiac arrest. Using a single shot SE sequence 30 diffusion directions as proposed by Skare and five b_0 images were acquired for analysis of SNR, ADC, fractional anisotropy (FA) and helix angle (HA). To estimate T_2^* relaxation time a segmented EPI measurement with varying echo distance and effective train length was used.
SNR values in the myocardium of the left ventricle determined via single shot SE were 23 and 12 at 3T and 7T, respectively. This shows the significant effect of the T_2^* time at 7T for the TE (55ms) used. Geometrical distortions at 7T become acceptable for TEs below 45ms. Using segmented EPI at 7T resulted in reduced geometrical distortions when either echo distance or echo train length was shortened. Furthermore, reducing the echo distance from 1ms to 0.4ms lead to an SNR-increase of a factor of three. Due to SNR limitations and geometric distortions, SE approaches for cardiac diffusion imaging at 7T are only feasible with a segmented readout.

P 3

Dose splitting using a dual-source computed tomography

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The use of dual-source CT scanners (DSCT) enables to acquire simultaneously three data sets with three different radiation dose levels: two data sets for each X-ray tube and one combined virtual data set. The purpose of the current investigation is to find out the best tube current ratio regarding to the image quality (IQ) and the radiation dose. Thereby, we compared the IQ of an examination using single source CT as a reference with that obtained by virtual dual-source CT data set reconstructed from two raw data sets provided by a DSCT. For this aim a phantom of the type CATPHAN 503 was scanned by a DSCT of the third generation (SOMATOM Force, Siemens Healthcare). The dual-source data was obtained using four different ratios for X-ray tube currents of tubes A and B, i.e. A/B: 80%/20%, 70%/30%, 60%/40%, 50%/50%. The date was collected in the single-source mode by use of 100% tube current for the X-ray tube A. The IQ was evaluated in terms of the dose-normalized contrast-to-noise ratio (DCNR). Three image sets were reconstructed by a filtered back projection kernel (FBP Br40) and two iterative algorithms of different strength, ADMIRE level 2 and 3. Furthermore, we used a slice thickness of 1 mm for images reconstructed by the FBP and ADMIRE2 and 5 mm for the ADMIRE3 to identify the slice thickness influence on DCNR. In order to investigate the impact of the X-ray tube voltage on the results, measurements were performed by X-ray tube voltages of 90 and 110 kVp for both tubes.

P 4

Metabolite diffusion measured by MR spectroscopy without water suppression reveals microstructural information in human gray matter

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Synopsis: Metabolite diffusion was measured in 13 healthy volunteers in occipital gray matter on a clinical 3T system using non-water-suppressed diffusion-weighting magnetic resonance spectroscopy sequence. The fit routine was adjusted with optimized prior-knowledge constraints to resolve apparent diffusion coefficients (ADCs) of as many metabolites as possible. The model quality was evaluated on basis of the resulting relative standard deviation for the cohort.
Methods: The new sequence design uses the water signal as reference allowing for compensation of motion-related signal distortions in post-processing. This improves the spectral resolution on one hand, but more importantly leads to more accurate fitting. The acquired data were analyzed by a newly implemented simultaneous 2D fitting approach in the fitting tool FiTAID to determine the apparent diffusion constants of brain metabolites with use of different prior-knowledge restrictions. Applying most stringent constraints reduces the number of free metabolite ADCs from 19 components to merely 7 contributors, whereas fitting accuracy is improved. Without applying any prior knowledge 17 components are identified, though with strongly reduced fitting accuracy. The reduced number of individual ADCs in the first, and the deteriorated accuracy in the second case prevent resolution of significant ADC differences for viable information on tissue microstructure. Thus, a third prior-knowledge set was developed, able to reveal (highly) significant differences in diffusion properties of 13 metabolite components. Paired t-tests were used to identify significant differences between metabolites.
Results: It is shown in human gray matter that the neurotransmitter glutamate is diffusing significantly faster than the neuronal marker N-acetylaspartate. Further, a significant difference in ADC is found between the intracellular sugars myo-inositol and scyllo-inositol compared to glucose, which may be attributed to the large fraction of extracellular glucose.
Conclusion: Non-water-suppressed MR spectroscopy combined with 2D modeling allows for optimized determination of metabolite diffusion information and, thus, on the tissue microstructure.

P 5

Ultrasound thyroid texture classification using a simple texture pattern characterization

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The thyroid is one of the largest endocrine glands in the human body and is involved in several significant body mechanisms such as the regulation of the temperature of the human body. Hence, it is very important to monitor the thyroid state over time. For that, volume computation of Ultrasound (US) images for tracking changes is of prior importance and segmentation of the thyroid is one of the main steps for this purpose. Several approaches such as edge detection, thresholding, active contours, support vector machines and neural networks approaches have been proposed to correctly classify the thyroid region in US images. However, most of these approaches are not automatic and require long time to correctly classify the thyroid region. In this work a simple texture pattern similarity characterization for thyroid echogenicity matching is proposed. First the user selects in one US slice a point inside the thyroid and a template is generated around the selected pixel. This template is then used to search thyroid echogenicity in the whole set of US slices through the proposed pattern similarity characterization. This similarity is based on two image comparison indicators, one consisting on the mean square error and the other consisting on the correlation between the histograms of both images. The final similarity characterization is computed as the division of both indicators. A high value of this similarity is related with high matching of the template with the image. For evaluation proposes a texture database has been generated extracting several sub-images from six thyroid 3D US datasets obtained using an US device equipped with an electromagnetic tracking (GE Logiq E9). Results show that the similarity characterization is suitable for differentiating thyroid echogenicity from the rest of the US image and can be used as a strong feature for segmenting thyroid using classification methods.

P 7

Using a segmented multi-echo EPI sequence with simultaneous multislice acquisition for dynamic contrast-enhanced MRI

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A new multi –echo imaging sequence for dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) has been developed. To achieve a temporal resolution of 1.3 s a simultaneous multislice (SMS) acquisition has been added to a multi-contrast, segmented echo –planar imaging (EPI) sequence. The purpose of this sequence is to separate the MR signal into T1 and T2* components. If successful, common models could be used to better separate intravascular from interstitial signal contributions, allowing more reliable calculation of perfusion and permeability.
The sequence has been developed for a preclinical perfusion study using fast imaging of multiple contrasts. The sequence was tested in sedated pigs whose right hip and hindleg were scanned to determine signal intensity of the aorta and large muscles. Total acquisition time was 11 min and 0.1 mMol/kg gadolinium-based contrast medium (CM) was injected after the fifth acquisition. To separate the signal into relaxation changes rates (ΔR –maps) of T1 und T2*, the dynamic data acquired with three echo times (TE1=9 ms, TE2=21.5 ms, TE3=34 ms) were fitted. Baseline T1 was calculated from an acquisition with five repetition times but otherwise identical sequence parameters. Baseline T2* was calculated from the averaged signal of the time steps before CM arrival. From the ΔR –maps, regions of interest of the different muscles and of the aorta were generated to extract tissue ΔR –maps and the arterial –input –function (AIF). The validity of the sequence was analysed. The CM concentration change and susceptibility effects can be assessed over time.
Separation of the MR signal into T1 und T2* components is feasible using the sequence presented here. The results are suitable for further pharmacokinetic modelling and analysis of perfusion and permeability. Thus, the MR sequence is suitable for perfusion imaging of larger body regions with a temporal resolution necessary for bolus detection.

P 10

Determination of the volume of microchannels in bone phantoms by magnetic resonance imaging (MRI) and micro computed tomography (µCT)

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For a successful integration of biodegradable bone implants a fast angiogenesis is indispensable. New formed vessels transport necessary nutrition, minerals, growth factors, etc. to the site of implantation for the purpose of forming new bone tissue. Initially these vessels exhibit a diameter of just a few micrometers and are therefore too small to be resolved clearly in standard MRI or µCT. The aim of this study was to quantify the volume of liquid in microchannels in bone phantoms.
To form the microchannels, melt-spun sugar fiber networks were produced using a commercial available cotton candy machine (ZWM 3478, Clatronic, Kempen). The fiber network was doused by a degassed mixture of hardener and resin (Epoxy resin L 385, R&G Faserverbundwerkstoffe, Waldenbruch). After the epoxy had cured, the sugar fibers were dissolved in a water bath for serveral days leaving fine microchannels in the epoxy constructs.
The epoxy phantoms were placed in aqueous solutions of contrast agents (MRI: Dotarem (gadoteric acid); µCT: Xenetix 300 (Iobitridol)) of different concentrations and scanned in MRI (Philips achieva 3.0T TX, Dual Microscopy coil 47 mm) and µCT (Scanco Medical XtremeCT, 60 kV, 300 ms, 82 µm). The scans were analysed using the image processing program ImageJ. The averaged signal intensity in MRI scans and the averaged X-ray absorption in µCT scans were evaluated by manually positioned “region of interests” (ROI) and plotted against the concentration of the contrast agent and the volume of the channels, respectively.

P 11

B_0-mapping and shimming efficiency for ex Vivo MR imaging of the heart at ultra-high field – validation of standard shimming protocols of magnetom terra 7T scanner

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Despite improved signal-to-noise ratio (SNR) the MR imaging of the human heart at ultra-high field (UHF) ($B_0 \geq 7T$) is challenging. The complex structure of the heart and surrounding tissue leads to strong susceptibility induced spatio-temporal B_0-field variations. These gradients lead to significant signal losses and image distortions and, thus, their correction (shimming) both spatially and temporally is an absolute prerequisite of UHF cardiac MRI. B_0-mapping for shimming is based on phase differences of gradient-echo (GRE) images acquired at 2 or more echo times [$TE_{min}..TE_{max}$]. Both TE dynamic range (TE_{max}-TE_{min}=ΔTE) and sufficient image SNR at $TE=TE_{max}$ are important for efficient B_0-mapping. Insufficient ΔTE leads to a low B_0 resolution, while too high $\Delta TE \approx T_2^*$ typically leads to phase-wrapping and deteriorates both mapping and shimming efficiency.
In this work we tested the efficiency of standard shimming protocols available on the first serial Siemens Magnetom™ Terra 7T Scanner (equipped with third order shims) in order to find an optimal strategy for B_0-mapping and dynamic B_0-shimming of the heart at 7T. The B_0-mapping measurements of an excised pig heart (preserved in 0.9% NaCl solution) were performed using a 32-channel head coil. The 3D GRE was used with different TE_{min}=1.0..4.7ms and ΔTE=2.1..6.1ms with different coverage of the measured slices by the shimming volume. The typical pixel resolution was $1mm^2$ in-plane and 1..3mm in-slice. The T_2^* and B_0 (from magnitude and phase images respectively) were calculated using MATLAB.
It was found that for ex-vivo myocardial tissue the scanner's shimming methodology can be efficient in a rather narrow range of TE-times used for B_0-mapping. Only 2 of 8 available shimming algorithms provide consistent B_0-maps without phase-wraps. The typical T_2^*-time is 7ms. The shimming quality improves essentially when using minimal possible echo time (TE_1=1.0ms) in comparison with standard "cardiac" shimming performed at $TE_{1/2}$=4.8/7.2ms. The B_0-maps become inconsistent for ΔTE>3ms.

P 12

Parameter optimization for simulation-based artefact correction in computed tomography

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In computed tomography artefacts reduce the quality of reconstructed volume data. In the past 30 years many different artefact correction methods have been developed. Since every method has its own advantages and disadvantages the choice of the optimal correction method largely depends on the application. Recently presented simulation-based artefact correction methods overcome this problem. Assuming a model of the specimen is known, this approach is able to correct artefacts regardless the complexity of the object or its material composition. During this approach for every original x-ray image two artificial projection images were simulated. One polychromatic image with artefacts and one ideal monochromatic image without artefacts. The ideal monochromatic images can be computed by simply performing a forward projection utilizing the lambert beer law. The linear attenuation coefficient can be obtained from databases. The polychromatic images with artefacts are computed from a weighted sum of monochromatic images that were added by scatter images simulated using a monte-carlo algorithm. Optionally, detector noise can be considered as well. The difference of the two artificial images is used to correct the original x-ray images. Subsequently, the original images can be used for 3D reconstruction. If the artefacts were simulated correctly, the reconstructed volume is free of artefacts. In this abstract we investigate the influence of the monochromatic energy that is chosen for the simulation of the ideal artificial images. The results show that for very low energies total absorption is likely, thus the correction term will be corrupted. For very high energies the contrast of high and low density materials may suffer. Based on the results an approach for parameter optimization is presented, that considers the linear absorption coefficient of the different materials during simulation.

P 13

Simulation model for resolution and contrast analysis of microscopic images based on optical coherence contrast method

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Optical methods of imaging biological tissues are non-contact and low-risk techniques, which are of great advantage over conventional medical imaging modalities such as X-ray computed tomography (CT) and ultrasound imaging. On the microscopic level, scattering property of biological tissues is associated with tissue inhomogeneity. By detecting the backscattered light signal, structures of different reflectance can be distinguished. Coherent-gating gets rid of unwanted light resulting in further improvements of signal-to-noise ratio (SNR) and image contrast. Recent years optical imaging methods based on coherent-gating, optical coherence tomography (OCT) in particular, have been applied to medical diagnosis for its ability to localize pathological changes in tissues. Even cellular-resolution images have been demonstrated, where enlarged nuclei of neoplastic cells are visualized. However, a realistic modeling of microscopic image resolution and contrast using such methods are rarely reported. In this work, simulation of “en face” images from low-coherence interferometry (LCI) and spectral domain OCT (SD-OCT) is performed by our self-developed Matlab tool-kit. The image resolution and contrast are then examined with different system configurations, i.e. objectives with different numerical apertures (NAs), low-coherent light source of various central wavelength, bandwidth and optical power. Unlike the standard applications in ophthalmology, the tissue model in our tool-kit is designed to be less transparent than the eye. Thus the microscopic image contrast of such methods on turbid tissues is studied. This tool-kit can be further used to evaluate the performance of LCI or OCT systems for “en face” imaging, as well as to improve system design.

P 15

Algorithm development for simulation and experimental validation of ultrafast doppler imaging

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Doppler ultrasound imaging is an established diagnostic imaging tool for flow analysis and quantification. It has all clinically relevant advantages of standard sonography since they use the same technology. Now, velocity of blood flow is estimated with Doppler ultrasonography, either spectral Doppler or Doppler Colour Flow Imaging. However, there is always a compromise between spatial and temporal resolutions for either mode.
Ultrafast Doppler imaging gives an alternative to this dilemma. It potentially can achieve a frame rate up to several kilohertz and gives thereby access to phenomena which are hidden by the limited temporal resolution of classical Doppler Imaging modalities. Furthermore, in contrast to classical modalities, it allows quantitative estimation of velocities in the whole FOV. The key technology for attainment of ultrafast frame rates is plane wave ultrasound. Although its image contrast is lower, it can be enhanced by compounding approaches. Several plane waves tilted at different angles are sent to the medium and then images are coherently summed, forming a compound image which has higher signal-to-noise ratio and almost constant resolution throughout the FOV.
With the high PRF capabilities of our multichannel electronics platform DiPhAS for ultrafast Doppler, algorithms were developed using MATLAB and Field II Simulation. First, signals from numerical flow phantoms were simulated and used as input for the ultrafast Doppler algorithms. The phantom was a straight vessel of diameter 10 mm with steady parabolic profile in which the maximum velocity was 0.1 m/s. The simulation results showed the vessel clearly and its parabolic velocity profile with its maximum at 0.1 m/s. Then, accuracy of our algorithms for retrieving quantitative flow information was investigated on experimental data. In the experiment, a 5 MHz Vermon transducer was used in ultrafast Doppler imaging a silicone tube of diameter 8 mm with a steady flow at 0.1 m/s.

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Establishment of a small animal setup for multimodal imaging and irradiation

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For preclinical cancer research, dedicated small animal imaging and irradiation devices are increasingly gaining importance to examine experimental tumors and normal tissue models. We designed a special small animal bed, which is intended to be used for multimodal imaging (e.g. MRI, CT, PET) and image-guided treatment with different radiation types (e.g. photons, protons). The multimodality small animal bed was constructed with CAD software and produced with a 3D printer using the fused deposition modeling procedure. The bed is made of thin acrylonitrile butadiene styrene (ABS), which is fully compatible with magnetic fields, barely influence radiation and is chemically resistant against most frequently used disinfectants. To facilitate proper positioning and alignment of the animal, the bed contains a tooth bar and ear pins for cranial fixation as well as a detachable distal foot holder for the hind leg. For inhalation anesthesia, a respective mask is integrated. To avoid hypothermia, the bed is supplied with a controllable stream of HEPA-filtered warm air. Furthermore, the respiration of the animal can be monitored during the experiment using a respiratory cushion. Suitability of the prototype was tested for photon and proton irradiation as well as CT imaging and proton radiography. In conclusion, the designed multimodality bed enables standardized positioning of small animals and provides integrated solutions for their anesthesia, warming and monitoring. Ist use for multimodal monitoring and image-guided irradiation of experimental tumors will simplify the workflow and image analyses for preclinical radiooncological investigations.

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Extending cell simuation for fluorescence microscopy bacteria movies

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Various fluorescence microscopy techniques are employed in life sciences for the visual observation and quantification of changes in cell morphology during cell experiments. To capture fast effects such as bacteria growth, often movies are captured. Manual data assessment from the single frames of these movie is a tedious and time consuming task and the complexity increases for the assessment of the complete movies. Hence, automated image processing methods can be applied, but but novel image analysis algorithms such as convolutional neural networks (CNNs) need massive amounts of labelled image data for training and evaluation.
One solution of this problem is to acquire a manual labelling of the fluorescence movies by croud sourcing. Nevertheless, this solution is time consuming and the labelling is not reliable due to interobserver variability. An alternative is to *simulate* the bacteria movies and the related labelling. One adavantage of such a simuation is that the labelling is reliable and a huge amount of data can be generated in a short time.
In the proposed approach the bacteria shapes are modelled as ellipses texturized with intensity values calculated by the sigmoid function. The positions of dividing bacteria are determined on a frame basis by a noval approach based on energy minimization ensuring a realistic movement of bacterias. Additionally, noise and imaging artifacts are incorporated into the image sequence simulation.
As the simulation provides and saves detailed label information about the location, size, area and movements of all bacteria, such simulated movies are applicable for training and evalution of image processing algorithms. Additionally, the relationship of bacteria on consecutive frames is known for every single cell and this enables an objective rating of algorithms examing bactiera division even on frame regions closely covered with bacteria.

P 20

Light path analysis in hyperspectral imaging setups for wound diagnostics using Monte-Carlo-simulation

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Tissue Near Infrared Spectroscopy (NIRS) is an established method to monitor oxygenation of human tissue. The method is based on the absorption characteristic of oxygenated and deoxygenated hemoglobin. Hyperspectral Imaging is a non-invasive contactless method to record spectrally resolved images thus allowing to monitor the spatially resolved oxygenation of tissue. Tissue oxygenation in wounds is a strong indicator of the wound status and thus monitoring of the oxygenation may help to estimate the risk of non-healing wounds in an early stage.
To understand the interaction of light with human tissue in the special Hyperspectral Imaging Setup, a Monte-Carlo-Simulation is implemented in LabView(TM) which allows the analysis of the light paths from the light source through the tissue to the camera. The whole light path information of the photon packages is stored after each simulation run allowing to cope with different problems like the analysis of the penetration depth of the different wavelengths for different tissue parameters. The Monte-Carlo-Simulation is presented and a comparison of simulation results with measurements performed with the TIVITA(TM) hyperspectral camera (Diaspective Vision GmbH/Germany) on tissue phantoms is presented. The camera gives a full spectrum from 500nm to 1000nm. This allows the interpretation of spectral image data recorded on real human wounds.
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P 21

MRI investigation of biodegradable implants with incorporated magnetic nanoparticles

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Biodegradable implants such as vascular grafts are new promising therapeutic biomedical substitutes to restore the functions of diseased organs. In order to monitor the location as well as the postoperative degradation degree using magnetic resonance imaging (MRI), magnetic nanoparticles (MNP) were incorporated in the material of the implants and used as contrast agents. The visualization of the degradation process is linked to the question of how the immobilized and clustered MNP in the implant change the MRI signal. For the assessment of these changes, the behaviour of MNP incorporated in polylactic-co-glycolic acid (PLGA) implants as well as of MNP dispersed in different phantoms were analysed with MRI. The phantoms consisted of either free dispersed or immobilized self-synthesized iron oxide MNP with different sizes and clusters to mimic the immobilization of MNP in the PLGA implants during the degradation process. The MNP clustering was achieved by adding either sodium chloride or phosphate buffer to the MNP solution, which destroyed the MNP lauric acid coating. Various degrees of MNP immobilization were realized by preparation of MNP phantoms with different agarose content up to 3 wt%. For the investigation of T_2- and T_2^*- relaxation times of the implants and phantoms a Philips Achieva 3.0 T MRI scanner was used. Relaxation time maps were calculated to illustrate the local susceptibility differences in each pixel in the cross section of the implants and phantoms. To conclude, the relaxation times of both phantoms and implants were clearly dependent on MNP size, clustering and the degree of immobilization. These results demonstrate the feasibility of quantitative imaging of the degradation degree of implants in vivo with MRI.

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Uptake heterogeneity quantication in lung cancer – impact on image features variability of 3D- and 4D-PET/CT protocols.

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In lung cancer, the evaluation of the lesion with FDG-PET/CT imaging presents additional challenges due to respiratory movement. Only a few studies had investigated the impact of the motion compensation implied by retrospectively gated (4D-) PET/CT on image features (IF). In addition, the differences in the protocols employed and the results reported have motivated further evaluation. The aim of our work was to evaluate the impact of different static (3D) and dynamic (4D) PET/CT protocols on IF variability. Thirty IF derived from 40% contours on PET image were involved. Thirty-one lung patients (36 lesions) were retrospectively analyzed. IF derived from 4D-PET images were compared with respect to three static (3D) PET images derived from different data processing: 3D-PET, 3D-R-PET and 3D-4-PET. 3D-PET corresponded to the static protocol employed in our clinical routine. 3D-R-PET was obtained after resampling the 3D-PET to the voxel size of 4D-PET. The modification of the reconstruction parameters of 3D-PET protocol to comprise the voxel size of 4D-PET resulted in 3D-4-PET. Normality was evaluated by Shapiro-Wilk test. Bland-Altman plot analysis and Wilcoxon-Rank Test was employed to compare data sets. For most of the patients, IF values across the time bins of 4D-PET followed a normal distribution. The different data processing in the 3 static protocols under study had an impact on IF response. For our patient cohort, the compensation of tumor motion implied by 4D-PET (4D vs 3D-4) had not significant impact on IF response. In conclusion, in the study of the compensation of motion implied by 4D-PET, 3D data processing could lead to a misinterpretation of the impact on IF response. IF derived from 4D-PET had the advantage that the average and standard deviation across the time bins are statistically representative values. Therefore, their use could be recommended for monitoring and prognosis in lung cancer patients.

P 24

3D-ultrasound-angiography – a new technique for diagnosis of vascular liver diseases

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Introduction: Transabdominal sonography is the imaging method of choice for the diagnosis of liver diseases. In addition to examination of the liver parenchyma, ultrasound is very helpful to characterize vascular structures in the liver. However, the visualization of complex vascular structures is limited in common 2D-sectional planes and/or short video sequences. The 3D-ultrasound-angiography, based on digital image reconstruction, can improve vascular diagnostics.
Objectives: Evaluation of advantages and limitations of novel 3D-ultrasound-angiography techniques.
Methods: For this case series, three patients with different vascular anomalies of the liver were examined with a conventional ultrasound transducer. The common 2D B-mode images, which were grabbed from the video port of a Toshiba Aplio 500 ultrasound system, were concatenated with spatial information using magnetic field information and stored in a virtual 3D-volume. The reconstruction of this 3D-volumes was realized by a 3D-ultrasound software application on a conventional PC workstation.
Results: Patient 1 (female, 66 years) suffered from Hepatitis C induced liver cirrhosis. A portal-venous shunt was detected and visualized in the 3D-reconstruction. Using the spatial information, the shunt course could be depicted with high precision.
In patient 2 (male, 32years), diagnosis of Budd-Chiari-syndrome (occlusion of liver veins) was established. Ultrasound revealed a diaphragmatic stenosis of the left liver vein. The complex altered venous anatomy including collaterals and shunts was displayed in a 3D-reconstruction, which also revealed compression of the inferior cava vein caused hepatomegaly.
The third patient (female, 56 years) suffered from liver cirrhosis induced portal hypertension. Distinct umbilical collaterals were visualized using 3D-ultrasound reconstruction.
Conclusion: Ultrasound-angiography based on 3D-image reconstruction provides valuable additional diagnostic information in patients with complex vascular anomalies of the liver

P 25

Magnetic manipulation in combination with preclinical magnetic particle imaging

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Magnetic manipulation is of high interest in terms of drug targeting and minimal invasive surgery. Drugs as chemotherapeutics are bound to magnetic beads which can be directed by external magnetic fields towards a targeted volume. This allows lower dosages and healthy tissue is less affected. It is also possible to direct micro surgical devices, video or drug filled capsules into tissue regions which are difficult to access or into highly sensitive organs.
It needs to be considered, how to image and monitor the manipulation process: For in-vitro experiments microscopy methods are possible, but in-vivo experiments need to be imaged with a tomographic and real time imaging technique – here, Magnetic Particle Imaging (MPI) is a promising method.
MPI is an imaging modality determining the spatial distribution of superparamagnetic nanoparticles. It is highly sensitive and enables real time imaging with a resolution in the submillimeter range. It is based on the nonlinear response of the particles to alternating magnetic fields. A gradient field, forming a field free point (FFP), encodes the signal spatially.
The magnetic fields of existing MPI scanners can also be used for magnetic manipulation. Since the magnetic force always points along the field gradient towards the highest field amplitudes, magnetic devices can be moved and rotated by moving the FFP, e.g. on circular path ways.
The possible forces applied by a commercially available preclinical MPI system are investigated and the size of the devices movable by the available field gradients is determined. Since the administered force does not only depend on the size of the device and the magnetic field gradient, but also on the magnetization, it is aimed at analyzing the degree of magnetic saturation of the used devices and particles.

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Remote sensing of vital signs in neonatology – a multispectral, camera-based approach

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Preterm babies (neonates) need special medical care. Thus, monitoring of their vital signs is essential. The monitoring techniques that are currently used in neonatology, such as electrocardiography (ECG) or photoplethysmography (PPG) for oxygen saturation, are contact-based and often rely on adhesives to attach the required sensors to the skin. Unfortunately, in its immature state, the neonatal skin can easily be injured when these are removed. This further weakens the already vulnerable neonates and increases the risk of germ invasion and infection. These considerations and the gain of patient comfort motivate non-contact monitoring techniques, especially for this group of patients.
We present the first measurements of a multispectral camera-based setup for remote sensing of vital signs and its application in neonatology. The setup consists of six synchronized cameras which record videos in different bands of the electromagnetic spectrum, namely visible light (VIS), near-infrared (NIR) and long-wavelength infrared (LWIR). Vital signs are extracted via photoplethysmography imaging (PPGI), which requires active illumination, and infrared thermography (IRT), which is a passive technique that measures heat radiation. For PPGI, light-emitting diodes (LEDs) provide light that is selectively attenuated by optical filters, which are attached to the cameras.
Based on our multispectral measurements, we show that heart-related biosignals can be extracted via the photoplethysmographic principle in the VIS and NIR bands while temperature changes are visible in the LWIR band. Furthermore, respiratory signals are extracted by detecting and analyzing the neonate’s movement. The study was approved by the Ethics Committee of the RWTH Aachen University Hospital, Aachen, Germany EK 327/16.

P 28

Hyperspectral imaging – preoperative analysis of kidneys during normothermic extracorporeal machine perfusion

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Compared to traditional static cold preservation of donor kidneys, normothermic machine perfusion provides the possible benefits of improving graft viability and allowing its assessment before transplantation. However, methods of monitoring the functional parameters of ex-vivo kidneys have yet to be developed. In this respect, hyperspectral imaging (HSI) offers great potential as a noninvasive diagnostic tool to analyze the organ graft prior to the transplantation.
The hyperspectral imaging technique was used to measure the kidney status. Simulating a typical transplant setting, landrace porcine kidneys were prepared. Afterwards organs underwent normothermic perfusion, consisting of flow- and temperature-controlled pulsatile perfusion of the kidneys arteria with whole-blood. The kidney was illuminated with visible/near-infrared light and hyperspectral images were obtained before, during and after the preservation period. Suitable calibration and validation models were realized to closely approximate tissue characteristics. Based on multivariate data analysis, the oxygen saturation and the water levels were calculated from HSI recordings.
Experiments were carried out to show the feasibility of a hyperspectral imaging system for analyzing the kidneys status. Appropriate wavelength regions between 500 and 1000 nm for the detection of physiological kidney parameters were identified. After the conditioning, a correlation between the kidney status and the spectral data was detected.
Hyperspectral imaging was shown to be a potent tool for assessing different tissue characteristics of kidney grafts during normothermic machine perfusion.

P 29

Influence of orthogonal receive channels on the spatial resolution in magnetic particle imaging

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In magnetic particle imaging, superparamagnetic nanoparticles are excited by an oscillating magnetic field. Due to the non-linear magnetisation behaviour of the particles, the receive signal is a distorted version of the excitation signal. Harmonics of the fundamental frequency can be detected. Introducing a magnetic gradient field in order to spatially encode the receive signal, the spatial distribution of particles inside a field of view can be reconstructed by using e.g. a system matrix.
Typically, the receive signal is detected by receive coils that are parallel to the send coils. In a multidimensional setup, the distinct send and receive coils are orthogonal to each other in order to excite and detect in orthogonal spatial directions. When having a multi-dimensional setup but exciting in only fewer directions than possible, the receive signal of the supernumerary spatial direction is usually discarded (e.g. when acquiring 1D line scans or 2D slices in a 3D setup).
In this work, it is determined if the receive signal of the supernumerary spatial direction may improve the reconstruction result in terms of spatial resolution and image quality. For this, two 1D hybrid system matrices are acquired in a 2D magnetic particle spectrometer. Then, a resolution phantom is emulated using one of the system matrices. The other system matrix is used for reconstructing the resolution phantom. It is evaluated if the image quality and spatial resolution improve when additionally using the second receive channel for reconstruction.

P 30

Real-time functional magnetic resonance imaging neurofeedback as a neuroscientific tool

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Biofeedback and neurofeedback using electroencephalography has already a long history in the realm of clinical therapies, for example to treat migraine, anxiety or hyperactivity. Functional magnetic resonance imaging (fMRI) has received increasing attention in this regard in recent years because it provides unprecedented spatial resolution to specifically alter activity even in deep brain regions. Because of this unique strength, fMRI neurofeedback can be of interest not only for clinicians but also for neuroscientists to study functional brain networks by disturbing brain activity in a hypothesis-driven manner. We will present an example of this, were we have used fMRI neurofeedback to alter activity in the amygdala, a core region for the processing of emotions in the inferior brain. Activity in the amygdala is known to increase in response to arousing or negative images, which also slow down a simple reaction time task when used as a distractor, in comparison to neutral images. We tested the hypothesis that lower amygdala activity before task onset would lower the distractor effect of negative images. We found that down regulation of the amygdala was indeed associated with the abolishment of the distractor effect and that the reduction of the distractor effect was correlated with the capacity of a subject to down regulate. However, we could not show a direct trial-by-trial influence of baseline amygdala activity on reaction times. In summary, we demonstrated how fMRI neurofeedback can be used to affect behaviour and study functional brain networks.

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Image to phantom registration for CT dose calculation using the software tool GMCTdospp

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For the estimation of organ and effective patient dose of CT scans software tools like GMCTdospp can be used. GMCTdospp calculates the dose values for ICRP human phantoms based on actual CT studies of a patient using a set of source parameters e.g. utilized CT, the kVp, mAs and scan region. For statistical evaluation of large numbers of patients this could be a time consuming task and the determination of the scanned region, is user dependent and error-prone.
The aim of this work was to automate the transfer of the scan region from the CT study to the phantom and to maximize the accuracy of the determination in order to accelerate the dose estimation. The approach is based on the registration of CT localizer data to the ICRP phantom. First, a projection of the 3D ICRP phantom data along the y-axis was performed to create an artificial “phantom localizer”. Then, the real CT localizer image was cropped to the actual scan region based on DICOM header information and both datasets were matched.
The registration algorithm estimated the start and the end slice of the scan region in the phantom for nine CT studies. The results were compared to the manual determination of an experienced user. The deviation of the user and the algorithm for the start slice was 5,67±3,16 and for the end slice 5,83±5,85, respectively.
The method was able to determine the CT scan region and to transfer it to GMCTdospp for dose calculation in good agreement to the reference user for the start slice. For the end slice the standard deviation is higher due to the rigid registration approach. It is a first step towards a framework that can be used for dose management in a clinical environment to automatically estimate the effective patient dose of CT studies.

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Temperature measurement during focused ultrasound treatment with diagnostic ultrasound

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Ultrasound therapies are promising and non-invasive applications. They are used e.g. for cancer therapies like viro- or immunotherapy, various surgical applications of the prostate or liver, and blood-brain-barrier opening. A crucial step towards patient safety and comparability of treatments is still missing: easy-to-handle and affordable tools to assure the quality and accuracy of therapy devices and ways to verify treatment planning algorithms. To overcome this deficiency accurate spatial and temporal temperature maps of the treated region could be used.
Possibilities for non-invasive therapy monitoring by measuring temperatures or temperature changes are either done with magnetic resonance or diagnostic ultrasound imaging. Temperature measurement with diagnostic ultrasound during focused ultrasound heating is based on the echo-time-shift method. Speed of sound of tissue, and therefore the backscattered ultrasound signals, change with temperature resulting in a shift of the backscattered signal. This shift is used for temperature calculation. We monitored temperature changes induced with a focused ultrasound transducer (1.1 MHz) in an agar-graphite phantom with a linear diagnostic ultrasound array (10 MHz). A sigmoid function fit was used during calculation. The emergence of uncertainties due to intrinsic principles of the method and due to calculation was examined.
Depending on the purpose of the measurement, a compromise has to be made between the following: calculation accuracy, tolerance towards small patient or organ movements, reproducing large temperature changes or cooling processes, speed of the algorithm, and spatial accuracy. Within the range from 20 °C to 44 °C, in a tissue mimicking phantom uncertainties as low as 12.4% are possible, being mainly due to medium and therefore tissue properties.
The method of monitoring temperature changes for laboratory and clinical quality assessment of therapy devices might be a comparatively accurate, fast, and affordable one.

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An investigation of the modeling error of linearization for EIT reconstruction

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Electrical Impedance Tomography is an imaging method which attempts to reveal the conductivity distribution of a domain based on the electrical boundary condition. For time difference EIT, the voltage difference at two time steps is employed for reconstruction. This is an ill-posed inverse problem, especially, it is non-linear. The currently available EIT devices are all based on linearized reconstruction algorithms. The linearized reconstruction employs a reconstruction matrix which is essentially a regularized pseudoinverse of the Jacobian matrix. This reconstruction matrix multiplying the voltage differences will provide a distribution of conductivity changes. However, the linearized reconstruction contains modeling error. In this paper, we study the modeling error caused by linearization based on the complete electrode model through simulations. Specifying a current injection pattern in simulation, at each time step a simulated voltage measurement can be calculated from Maxwell's equations. The voltage difference between two time steps can be obtained. On the other hand, according to the assumption of linearized reconstruction, the voltage difference is assumed to be the Jacobian matrix multiplying the conductivity distribution changes. The discrepancy between these two voltage differences will be studied. This information will further be used for reconstruction to alleviate the modeling error.

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Force sensitive robotics for automated ultrasonic diagnostics and therapy

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Ultrasound imaging, while being widely used due to its low risks and low costs, is highly user dependent and time-consuming to perform. Robotic automation has the potential to make the image acquisition process more reproducible and facilitate retrospective diagnosis. However, special safety precautions for robot-assisted ultrasound imaging are mandatory to prevent patient and staff injury. When using conventional industrial robots, entry into the robot's working space is prohibited for reasons of safety.
In this project, we use the KUKA LBR iiwa 7 featuring a high degree of freedom, a workspace diameter of 1.6 m and the necessary force sensitivity for human collaboration. Each of its seven revolute joints contains a torque sensor, which is constantly monitored by our application software. The goal for robotic ultrasound is to maintain a defined contact force (5 N) in all spatial directions, especially during movement. When the maximum contact force is exceeded, the robot stops its forward motion. Consequently, the robot arm is able to dynamically adapt to physiological motion like respiration. Additionally, an adapted hand guiding mode was implemented, allowing for manual position corrections and enabling the patient to push the robot arm away in case of hazard or discomfort. The high articulation of this robot allows free positioning of the probe on the patient's body and makes this system universally usable. For remote control, a 3D input device (3DConnexion SpaceNavigator) is used. Its control signals are transmitted to the robot in real-time with latencies < 1 ms. In a next step, the use of haptic input devices will be investigated to also provide tactile feedback to the operator.
This force-sensitive collaborative robot motion control prototype was implemented within a larger project. It is an important building block for the development of a universal automatic robotic 4D ultrasound platform for diagnostics and therapy.

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Dual mode microwave ablation applicator with power efficient heating capabilities

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A microwave applicator is proposed for thermal ablation treatment with an integrated microwave sensor at the tip of the device based on oval shaped spiral ring resonators. During the percutanous intervention, the additional information from the sensor leads to an accurate localization of the targeted tumor in order to position the applicator with high precision and reduced number of insertions and readjustments. Reagrding the thermal ablation performance, the proposed applicator works in an operation frequency range from 4 GHz – 6 GHz with the advantage in terms of power efficiency as its competitors mostly using frequencies around 915 MHz and 2.45 GHz.
In this work, investigations are done on the penetrations depth of microwaves from the surface of the applicator into the surrounded material and the effects on the corresponding ablation zone size are done. Generally, the permittivity of organic tissue is complexed valued and frequency dispersive. The real part is related to the polarization capability of the material and the imaginary part contains losses due to polarization and conduction indicated by collisions in bound and free charges, respectively. The losses of organic tissue increase with frequency, resulting in a more focused electric field strength excited by a thermal ablation applicator. Consequently, the temperature in the vicinity of the applicator is increased and according to Fouriers Law, describing the conduction of heat, the heat flow is larger compared to the exposure with lower frequencies.
Measurements of the size of the ablation zone performed with a functional demonstrator of the proposed applicator inserted into ex-vivo beef liver tissue show promising results. A lesion of approximated 3 cm^3 is achieved when the tissue under test was exposed for 4 minutes with an input power of 20 W.

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Technical approaches to avoid air bubbles for improved patient safety during TURB

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Bubble formation in the transurethral resection of the bladder (TURB) is common as during resection of human tissue volatile gases are trapped. These volatile gases are a mixture of hydrogen and to a lesser quantity of explosive hydrocarbons. The majority of these gases were produced from the pyrolysis of human tissues and electrolysis of intracellular water due to high temperature during cutting and coagulation of tissue. Hydrogen gas alone will not cause explosions even with low amounts of oxygen produced by diathermy. However, when hydrogen is mixed with oxygen from the atmosphere, it will become flammable and can be ignited by a spark generated by the electro-surgery process. A potentially explosive gas creation at the patient site and during the procedure can lead to severe injuries. Also, the air bubbles suspended in the bladder dome interfere and cause blurred vision during RF-resection of the tissue in the bladder using a resectoscope.
We developed a catheter with an integrated micro air filter that can be attached to a standard resectoscope through the inner shaft. The catheter tip is flexible and can reach the entire suprapubic area of the bladder with the goal to trap air-bubbles, of which some contain gases (hydrogen, explosive methane, and nitrous oxide). The micro air filter is made of hydrophobic PTFE that allows the gases to pass freely while blocking aqueous liquids. A continuous irrigation and simultaneous suction can also be incorporated with the entire system.
Due to the frequent removal of working elements for cleaning and removing biopsy samples air can enter the bladder in a normal procedure. This can now be avoided with the proposed simple device and with that the safety of patients and surgical staff ensured during a transurethral procedure.
Keywords: endourology, endoscopic procedures, intravesical explosion, resectoscope, transurethral resection

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Flexible and low-cost instrument holding concept for interventional MRI

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The use of magnetic resonance imaging (MRI) in interventions brings multiple advantages compared to other imaging modalities, e.g. the elimination of ionizing radiation and high quality soft tissue differentiation. Clinicians would like to use MR-imaging for different types of interventional procedures such as MRI-guided biopsies. Real time MR-imaging provides the visualization of the biopsy needle during its introduction into the interventional area as well as the needed imaging information to ensure that the target area has been reached.
One of the biggest challenges for performing MRI-guided interventions is the required MRI-compatibility for all devices that are used around and inside the magnetic tunnel. To comply with it, unconventional materials and designs for devices used in a closed bore MRI-magnet need to be considered. A vast number of different concepts for MRI-compatible holding devices have been proposed that are generally rather complex, quite expensive and limit the available space in the magnetic tunnel. Therefore MRI-guided biopsies are performed mostly freehand and with high effort by the clinician. While inside the MRI-tunnel, the clinician must lean next to the patient for a long and uncomfortable period of time. Even in short-bore magnets it is very difficult to reach the target area.
We developed and evaluated a flexible and MRI-compatible concept for an instrument holding device for multiple clinical applications in- and outside the MRI-magnet. The exclusive mechanical device supports and disburdens the clinician during interventional MRI-procedures by holding different types of instruments such as small trays, mirrors, grippers or remotely controllable biopsy needle guides. Due to its mechanical construction it does not create any type of artifacts and still offers the same flexibility like a human arm while being stiff enough to support instruments without any undesired movements.

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Objective measurement of instrument-tissue interaction in laparoscopic surgery

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Background: Occuring forces in laparoscopic surgery are still less researched. However better knowledge would lead to a development of new instruments. Furthermore surgical black box training would benefit from force feedback as well as information regarding precision of movement.
Methods: A cardan joint is used to guarantee full movement of the instrument. Strain gauges detect forces while potentiometers capture position. Finally, all data is processed by a microcontroller. A magnetic lock enables the fast switch of different instruments while measuring.
Results: A measurement setup for force detection at the tool tip as well as position detection of the instrument were developed. Each standard laparoscopic instrument can be verified and no additional modification of existing instruments is needed. The mean relative measurement deviation of a sample force of 1500mN is 10% during various instrument positions, velocity and acceleration. The absolute measurement deviation of position determination is 1mm.
Conclusion: The presented setup enables measurement of occuring forces and provides data about instrument position for an objective assessment of instrument-tissue interaction. Thus this new design allows a new method for evaluating laparoscopic instruments as well as providing new parameters for surgical training.

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Real time MRI/US fusion using inside-out tracking for interventional procedures and guidance

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Ultrasound is a portable, non-invasive imaging modality. Fusing free-hand ultrasound with high definition imaging modalities like Magnetic Resonance Imaging (MRI) during interventional procedures can provide crucial information for the surgeon and help to improve the overall speed and accuracy of the therapy. One of the major problems in MRI and ultrasound fusion is the patient data deformation due to the time lag between pre-operative MRI and intra-operative ultrasound acquisition. In order to overcome this problem, we have proposed and tested a new method, which performs the MRI and ultrasound fusion inside the MRI suite immediately after the MRI images are acquired. In order to achieve this goal, MRI images were acquired by placing fiducial markers on the patient and by attaching a conceptually new 3D tracking system to the ultrasound probe to provide the spatial information of ultrasound relative to the MRI image. Electromagnetic or optical outside-in tracking techniques are commonly used to track the ultrasound probe. Both methods cannot be used in this setup because the former is sensitive to the MRI magnetic field and the later suffers from line of sight issues. To overcome this we have used an optical inside-out tracking approach, which tracks the position of the ultrasound probe based on a optical marker which is placed on the same position as the MRI fiducial markers. Additionally we propose a new method for better tracking accuracy using “One Real to Multiple Virtual Markers”(OR2MVM), which generates multiple virtual markers from a single real marker on the patient. Once the MRI and ultrasound slices are rigidly aligned, we then use normalized mutual information based registration. With a thyroid dataset of 6 patients and one thyroid phantom we were able to achieve a maximum mean squared error of registration of 24.5 mm2.

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A miniaturized sensor for needle tip force measurements

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Needle insertion is a common medical task. Certain procedures such as brachytherapy, biopsies or punctures of pericardial effusions require the insertion of comparably thick needles (Ø 1 mm) into human tissue. A large risk of additional tissue damaging exists because of the needle size. Additionally, the needle compresses and displaces tissue adjacent to the cutting site, which hinders the comparison with pre-operative imaging and, therefore, exact needle placement.
Approaches such as haptic feedback in training scenarios or as an assistive mean during an intervention are investigated in order to minimize tissue damage and unwanted puncture of valuable structures. Integration of additional sensors (such as optical coherence tomography equipment integrated in the needle tip) is researched to improve position accuracy. A pre-requirement for these techniques are accurate force measurements of the interaction forces at the needle tip.
In this work we present a force sensor that can be integrated in a needle tip with a diameter of 1.2 mm and a minimum length of 7 mm. It is manufactured by the conjunction of two half-shells, which are equipped with a specially designed semi-conductor strain gauge (gain factor $k \approx 40$). The application of the strain gauges to the unconnected half-shells is alleviated because of the good accessibility of the planar application surface. The strain gauge compromises a full-bridge-circuit in an area of 0.5×0.5 mm² and thus an decreased sensitivity to temperature influences. Electrical connection is made by a flexible PCB that is connected to the strain gauge before mechanical bonding with cyanacrylate adhesive. The PCB is integrated in the needle for connection to DAQ equipment. The force sensor has a nominal range of 10 N and exhibits a sensitivity of 3.2 mV/V/N, thus, lowering the requirements on the sensor electronics. Torque measurement is possible by usage of a different strain gauge design.

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Determination of needle orientation angles from artifact geometry in simulated magnetic resonance images

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The success of minimally invasive procedures under MR-guidance can be increased by the knowledge of the current needle pose, i.e. spatial needle tip location and needle orientation. For determination of needle tip location several measurement instrument, k-space receive data, and image data based methods have been reported. In addition, the needle orientation can be measured with additional instruments in principle. To avoid such instrumentation for k-space receive and image data based approaches, an indirect determination of orientation parameters in spherical angle coordinates, seems to be possible based on the geometry of the needle's MR-image artifacts. MR-images were simulated for a copper needle of 0.95 mm diameter in a copper sulfate medium for all pairs of 36 discrete azimuth and 15 discrete polar angles with Jülich Extensible MRI Simulator-software (JEMRIS). After MR-image binarization, the cross sectional geometry of such simulated artifacts resembled a four-leave clover. It's outer contour was modeled by two ellipses having 5 parameters (major and minor semi-axes, horizontal and vertical centre point coordinates, orientation angle relative to image's horizontal coordinate axis) each. Such ellipses have approximately horizontal and vertical major half axes. The parameters of the "vertical ellipse" motivated a product of two trigonometric function angular constants as a mathematical model mapping spherical angle coordinates (input variables) to major semi axis and orientation angle (simulated output variables). The model's parameters were identified by minimizing the 90%-quantile error of simulated – model parameters over all 540 input angle pairs. The 90%-quantile errors of output variables are < 5% of the respective simulated parameters. The inverse mathematical model is assumed to be useful to estimate the needle orientation from measured needle artifacts solely. It then allows to determine the needle pose by exploitation of k-space receive or image data and avoids additional measurement instrumentation.

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Examination of the correlation between external patient movement and the corresponding movement of implanted gold markers in the liver

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The Vero-SBRT system (Brainlab, Feldkirchen, Germany) is able to perform dynamic tracking (DT) to treat patients with intra-fractionally moving tumours. This system determines the tumour position by gold markers implanted near the target volume. The location of these markers is automatically monitored by regular kV X-ray imaging. Additionally, external IR-markers are applied on the patient's surface which are used to build up a correlation model between the external and internal motion. This model is trained at the beginning of every treatment fraction over several breathing cycles during which kV images are taken at 3 fps. To verify the validity of the model during treatment, a kV image is taken every second and the distance between measured and predicted marker position is calculated. If the deviation regularly exceeds a threshold of 3mm the model must be rebuild. We examined the data of the Vero system for 5 liver tumour patients treated with DT and found that on average the model was rebuild 2.9 times per fraction. To determine the severity of the changes in the model over the entire treatment we recalculated the correlation models of every fraction after shifting the underlying IR-marker data to a common baseline. This shift is necessary to cope with possible changes in the positioning of the IR-markers on the patients surface which leads to different absolute positions within the corresponding coordinate system. After this recalculation all models were applied on the same IR data set and the changes in the predicted marker positions were examined. The results of this study show that the correlation between external and internal markers implanted in the liver changes significantly over the period of the treatment (deviations from 4 to 20mm in every spatial direction). It can be concluded that DT should be based on internal markers and questions the viability using of external surrogates, which rely on constant correlations.

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Wizard-guided fibula transplant registration for navigation-assisted mandibular reconstruction in craniomaxillofacial tumor surgery

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Using microvascular fibula transplants for mandible and condyle reconstruction is a common, yet challenging approach in craniomaxillofacial tumor surgery. In cooperation with clinicians we are developing an electromagnetic (EM) navigation system for mandibular reconstructions to simplify the surgical procedure and to improve the clinical outcome. An important step is the evaluation of clinically applicable methods for fibula flap registration, which is presented in this work.
3-D printouts of fibula segments (from CT data) are manufactured with artificial landmarks (ALs). An EM tracking system (NDI-Aurora-V2) is used for data acquisition. To realize a freehand registration procedure, a custom-made 6-DoF reference sensor is directly attached to the fibula printout. Sample points are captured on the intraoperatively accessible fibula surface with a tracking pointer. The whole scanning procedures are supported stepwise by a wizard-guided software. Surface registration (ALs excluded) is performed with an adapted ICP (Iterative-Closest-Point) algorithm which incorporates a priori knowledge (PCA, feature extraction) about the scanning procedure for proper initialization.
36 surface phantom scans with 220-2450 sample points were evaluated. Average duration of surface recordings took 54.3 [±11.6] seconds. Validation of registration quality was performed by calculating the target registration error (TRE) of ALs. There were only weak correlation between TRE and number of sample points. Our adapted ICP approach reduced the average TRE from 6.2mm to 1.55mm. This wizard-guided approach was highly recommended by the surgeons during first clinical trials.
Our approach reveals clinically acceptable values and paves the way for a precise EM-based real-time tracking of fibula segments. Nevertheless, clinical application of scanning fibula surfaces is hampered by smaller unevenness caused by sporadic muscle tissue and tendons. This might be prevented by optimizing the pointer design. An additional button for interactions to take full control of the registration workflow would be useful as well.

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Minimal-invasive image guided treatment of spine metastasis in late cancer disease with thermoablation – now and then

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The therapy and local control of bone metastasis in late stage cancer disease is challenging, especially spine metastasis can reduce quality of life by severe pain and neurological symptoms like paraplegia. In an interdisciplinary team we have established a minimal-invasive, image guided local therapy of spine metastasis using thermoablation. Procedures are performed in an angio suite in general anesthesia. Using a multipolar thermoablation system large tumor volumes can be treated successfully with a minimal-invasive access with only 1 to 3 bipolar electrodes. While therapy planning is based on MR scans acquired before, needle guidance during the placement of the electrodes is performed with the help of 3D CT data sets acquired by rotational runs of the angio system and additional fluoroscopy. For optimal control during the access and reduction of x-ray dose exposition a navigation system is used additionally. The achieved tumor necrosis by thermoablation is documented by post procedural MR scans and during follow up. We have treated so far 107 tumors in 90 patients and can report a high technical success rate and only one severe complication. Small metastasis can be cured and local control of larger metastasis for months is possible by an one time treatment, leading to immediate pain reduction and improvement of quality of life. For further improvement of the method our interdisciplinary team has a research focus on nearly all aspects of the procedure: image fusion of pre-procedural MRT and CT, acquired during treatment, simulation of heat distribution by individual patient data for optimal tumor control, detection and correction of patient movement for example by breathing during the procedure, use of a robot to achieve maximal accuracy and safety during needle placement. We will present our clinical results and can give a precise description of the technical requirements for an optimized, minimal-invasive treatment system.

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Electrospray based delivery of therapeutic active substances *in vitro* and *in vivo*

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One of the essential success factors for drug-based therapy, is the entering of therapeutic active substances into the cells. This holds for chemotherapeutics as well as for genes; first will lead to death of cells, while second is intended to modify the cell expression, enabling a gene therapeutic effect. In this work, we present electrospray as versatile tool to deliver liquid therapeutics for physical targeted chemo- and gene therapy.
Electrospray is based on Coulomb repulsion, generated through electrical fields. It enables a liquid to disperse into an aerosol. Additionally the electrical field will accelerate created droplets towards tissue to be treated. This configuration is realized in our electrospray instrument, consisting of a stainless steel capillary, providing the liquid therapeutics, and connected to high voltage. The outlet of the capillary is placed within a well-defined working distance from the targeted region, connected to ground, and acting as counter electrode. Both electrical connections are placed within a single housing at the tip of our instrument, assuring a setup as a bipolar single port instrument. The current rigid device is designed with an outer diameter of 10 mm, working distances adjustable (1 to 10 mm), providing an acceleration voltage up to 6 kV and enabling a volume flow more than 20 µl/min.
To demonstrate the versatility of our concept, two application scenarios were investigated:
First electrospray mediated transfection of plasmid, using eGFP reporter gene on alveolar epithelial cells (A549) in vitro and evaluating transfection efficiency (FACS). A set of optimized parameters like working distance (4 mm), applied voltage (3 kV), flow rate (20 µl/min), delivered volume (75 µl), and procedure (3 x 25 µl) was obtained, resulting in a transfection efficiency up to (58.6±2.6)% using eGFP diluted in sucrose solution (370 mOsm; 75 µl).
Second, the electrospray mediated delivery of chemotherapeutics for cancer treatment. The effect of two times within 7 days electrospray mediated delivery of Cisplatin and Methotrexate on the growth of a subcutaneous lewis lung carcinoma in a mouse model in vivo was observed. Applying identical parameters the tumor size growth was retarded to (43±16) mm3 for Cisplatin and (22±12) mm3 for Methotrexate, while control tumor obtained a volume of (514±104) mm3.
In conclusion, we successfully demonstrated the applicability and performance of our electrospray device, for gene therapy in vitro, and for cancer therapy in vivo, providing promising results, which indicate the versatility of electrospray instrument.

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SMARTSCOPE – portable, easy to use and cheap smartphone endoscopic system

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Endoscopy is widely used for medical diagnosis and therapy. There are many systems on the market that typically include the endoscope, camera module, video processor, storage module and light source. Standard for endoscopic imaging is HD image quality. High end systems even offer 4K resolution. The cost for a HD endoscopic system is approximately 80.000 Euro. The systems are mostly installed on heavy carts with a large footprint. Some mobile applications based on smartphones are already known (e.g. CLEARSCOPE, endoscope-i), which can be adapted to almost every smartphone. For magnification of the image on the screen a microscopic lens system is installed between the smartphone and endoscope. This leads to a rather long and cumbersome setup.
Nowadays smartphones with high resolution cameras (23 Mpx) and 4K displays are available. We developed a mobile endoscopic system based on a Sony Z5 premium smartphone in an easy to use and small setup (SMARTSCOPE) and compared the image quality to a standard medical endoscopic system.
The smartphone was equipped with a usual cover and a snap mount for endoscopic eyepieces. For illumination a Fenix LD02 led lamp (100 Lumen max.) was selected. An adapter for connection to the endoscopes light input was designed. The whole endoscopic system can be assembled in a few seconds.
Three special phantoms including colour fields and stripe patterns were designed. Images were acquired with the SMARTSCOPE and an Olympus EVIS EXERA III system for comparison of resolution and colour reproduction. Image analysis was performed in ImageJ. The SMARTSCOPE offers nearly the same resolution but the illumination is worse. SMARTSCOPE allows easy video acquisition and data sharing. The setup is beneficial for mobile applications, when fast imaging is acquired or for third world use.

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A factor graph-based change point detection with an application to sEMG-Onset and activity detection

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Change point detection (CPD) algorithms are relevant tools to achieve triggering of various functions, e.g., in medical support devices. In the context of mechanical ventilation, one such application exists in detecting muscle activity based on electromyographic (EMG) measurements of the diaphragm. Change point detection algorithms to be applied in this setting are required to reliably detect the onset of the EMG signal in real-time and are usually desired to operate on the raw signal, thus minimizing the required effort for prior signal processing. In turn, information about the periods of muscular activity facilitates a wide range of subsequent signal processing and estimation algorithms. A novel algorithm for EMG-onset and activity detection is proposed based on a probabilistic graphical model, formulated as a factor graph. Factor graphs form a class of probabilistic graphical models representing the factorization of probability density functions as bipartite graphs. They can be used to exploit the conditional independence structure of the underlying model to effciently solve inference problems by message passing on graphs. Hence, the factor graph framework is capable of recovering a wide range of classical results in signal processing, estimation and control in a unified framework. The present work advocates the use of this class of models in the field of change point detection and activity estimation. Based on a combined factor graph representation of both the Kalman filter and the expectation maximization algorithm, regularized signal estimation is achieved. In conjunction with a simple dynamic model, the sparsity of the estimated input results in a filtered state estimate denoting the estimated activity level. Thresholding on this signal yields the desired detection of the onset and activity of the EMG signal. Possible extensions are outlined for automated adaptation of the threshold levels. The presented example highlights the efficacy of the proposed method on clinical data.

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Experimental workflow for determining psychological stress from physiological biosignals

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Contemporary, stress is a major growing concern impacting both individuals and population. Stress investigation has a beneficial wide range for the society resulting in an interesting area with many social advantages, e.g. improving learning, personal operations, and increasing work productivity. Mental stress is reflected by dynamic activity transformation of the autonomic nervous system (ANS). The examination of heart rate variability (HRV) and skin conductance response (SCR) is a common tool for the evaluation of the ANS. The main focus of this scientific investigation is to determine ways of monitoring, measuring and detecting psychological stress from physiologically obtained biosignals. The aim of this project is to establish a workflow in order to determine mental stress based on physiological behavior. The experimental workflow includes 1) the monitoring and physiological interpretation of biosignals, 2) signal processing (obtainment and calculation of stress indicating parameters, HRV frequency analysis methods, e.g. fast Fourier transformation, power spectral density and continuous wavelet transformation), 3) grouping of physiological reaction type comportment by clustering with the single-linkage and ward concept, 4) quantitative scaling of stress intensity based on mental stress mapping and an own established SCR parameter. Besides HRV and SCR, which are most sensitive to mental changes, the respiration, blood volume pulse and temperature were also considered for stress detection. The experimental workflow will be represented by physiological data from a previous study and a pre-study validation for future investigations. Significant stress recognition is rather possible on subject-dependent fashion, whereas in the case of subject-independence a more difficult problem is provided, due to the between-subject differences that typically appear in biosignals. Systems for automatic stress detection in general are a challenge for the years to come.

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Monitoring of drilling induced noise during ear surgeries

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It has been argued, that during surgery at the head, drilling induced noise can exceed recommended daily exposure limits. Because of general anaesthesia of the patients, evaluation of bone conducted noise level is limited to indirect and objective measurements. Therefore, we have developed a system which allows real-time estimation of the equivalent sound pressure level during surgery.
The system is built up of a calibration device (piezoelectric shaker connected to a force sensor) and a piezoelectric uniaxial acceleration sensor. The acceleration sensor is attached to the skull and calibrated by an explicit broadband force signal at the mastoid (generated by the calibration device). The equivalent sound pressure level L in dB(SPL) can be obtained from the force by using the standard for bone conduction hearing tests (EN ISO 389-3:1998). The acceleration measured during drilling can thus be converted to an equivalent sound pressure level, which then is subsequently weighted in the frequency domain using A- & C-Filter and in the time domain with a time constant of 125 ms (fast) according to DIN EN 61672-1 leading to L_{AF} and L_{CPeak}, respectively.
In seven monitored cochlear implant (CI) operations, we found equivalent sound pressure values L_{AF} of up to 120 dB(SPL) in maximum and L_{CPeak} of up to 133.9 dB(SPL). In three out of seven surgeries, the recommended daily exposure limits were exceeded. Greatest values had been observed during mastoidectomy and preparation of the implant bed.
We conclude that for extensive drilling, such as during CI-operations, a potential risk for temporary hearing impairment is given. Especially in single side affected ears, the contralateral, healthy ear is in danger of hearing disorders through bone conducted noise. This is in accordance to clinical results where after mastoidectomy temporary threshold shifts for bone conduction have been observed.

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Performance evaluation of state-of-the-art neural recorder SoCs

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The State-of-the-Art (SoA) in integrated, neural interfaces made great process over the last few years, producing new and powerful instruments for the study of the central nervous system and the treatment of neurological disorders. Scaling of CMOS technology led to a higher level of integration, allowing power and area efficient System-on-Chip (SoC) designs with large number of recording channels, stimulation capability and even single-chip closed-loop operation.
Additionally, the ongoing research in low noise analog front-ends led to different architectures for neural amplifiers with variations in key performance parameters, like input noise, power and area consumption. Different noise reduction schemes are reported in literature to improve especially the low-frequency noise behavior of the recorder which is dominant in the recording of Local Field Potentials (LFP).
The most prominent approach is the chopping technique, were the signal is converted into a higher frequency band, amplified, filtered and shifted back to the original band. Thereby an efficient suppression of the amplifiers low-frequency 1/f-noise is possible. However, this method increases the power consumption of the system since all amplifiers must be operated at a higher frequency and requires additional area for the chopping circuitry.
A second approach is the precise adjustment of the recorder bandwidth to the expected signal, which reduces not only electronic in-band noise, but also neural background noise. Several systems offer the possibility of digital or analog tuning even in the implanted state. Besides the improved noise performance, this technique yields the advantage of a reduced blind time after a stimulation event.
Since most of the SoA systems have contradicting key parameters, a suitable trade-off must be found for each individual application. Therefore an overview of available SoCs is given, together with a comparison of their key features and their performance regarding noise, channel size and recording bandwidth.

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Statistical assessment of cardiac excitation by morphology-based clustering of local activation waves

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Cardiac excitation during atrial fibrillation (AFib) is changing dynamically, compromising the ability to identify underlying mechanisms by intracardiac catheter mapping. Statistical analysis of dominant excitation patterns may help to identify and subsequently eliminate the drivers of this tachycardia. As the morphology of local bipolar intracardiac electrograms (EGMs) depends on the orientation of the propagating excitation wave, its evaluation for a fixed multichannel catheter position can provide information about the stability of the depolarization pattern. Up to date, analysis of morphology is most often done by computing a similarity index or the recurrence rate of individual EGMs, reflecting how often similar excitations appear. We sougth to extend this approach to a classification based analysis technique. In each multichannel EGM, local activation waves (LAWs) were automatically detected by assessing instantaneous signal energy. A greedy algorithm was implemented to cluster LAWs based on their similiarity. New clusteres were formed when similarity fell below a predefined threshold. The concept was tested using simulated EGM data (quadratic patch of cardiac tissue, bidomain simulation, both planar and focal excitations, various catheter types). Results demonstrated that the algorithm correctly identified and classified the simulated excitation patterns. Subsequent quantitative analysis allowed to both discard singular classes of excitation and identify dominant excitations. The presented method forms the basis for statistical assessment of prevailing depolarization patterns, and for computation of additional features like conduction velocity, presence of focal sources, or dissociation when applied on multichannel data.

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Automatic crackle detection in children with pneumonia

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Crackles are adventitious, explosive and discontinuous sounds, generally appearing during the inspiratory or also expiratory phase of breathing. Fine crackles are assumed by the sudden reopening of abnormal closed airways, while coarse crackles are assumed by bubbling of air through secretions. The characteristics of crackles are dependent on which lung units in the pulmonary airways are affected – fine crackles with a two cycle duration (2CD) < 10 ms and a high pitch sound mostly occur by a closure of the small airways while low-pitched coarse crackles with longer duration (2CD > 10ms) are found in affected larger airways. Crackles mostly occure in patients with pneumonia, heart failure or asbestosis.
Based on previous work of different research groups we extracted and compared several features and algorithms for crackle detection. The algorithms use especially bandpower- and wavelet-based filters, signal energy and entropy and several more features.
By using Teager-energy and bandpower based filters, as the fastest and most sensitive and specific feature, we developed an own algorithm for detecting crackles in children with pneumonia. Our dataset consists a sample of different night-time LEOSound recordings from the University Hospital of Giessen and Marburg. The sample was rated by a medical expert to compare these results with the automatic detection by our algorithm. We found a high correlation between rater and algorithm.

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A feasibility study to record human knee sounds

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The knee is one of the most complex joint in human body. A misuse or a disease, such as osteoarthritis, can support the mechanical wear of a knee. Besides pain, patients often feel a roughness in the knee joint and hear noises like clicking and rubbing. The analysis of these sounds helps to understand the reasons for pathological sound production and the motion process. This information can utilize to monitor athletes (e.g. football, soccer, and skier) or knee-wearing tasks to develop preventive trainings.
By now there is only one medical device for long-term sound recording, called LEOSound (Heinen + Löwenstein), which is specialized to monitor lung sounds and acoustic symptoms as coughing or wheezing. In this feasibility study we used the LEOSound for knee-sound recording. Two microphones were applied sidewise at the knee joint to minimize artifacts evoked by muscle and cords. In different test-cases (American football practice) the sound recordings show characteristic pattern for clicking and rubbing in a healthy and diseased knees. Our results show that LEOSound can also be used to record knee sounds.

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Major arterial cardiovascular simulator (MACSim) for variational parameter studies in patient-specific vascular geometries

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Cardiovascular diseases are the leading cause of death worldwide. Early detection of abnormal vascular morphologies like stenosis or aneurysms are essential to prevent fatal events. The aim of this study is the development and validation of a patient-specific cardiovascular simulator, that integrates statistical information from measurments of the abnormal pressure-flow conditions to improve the basic understanding and methods in the early diagnosis.
For this purpose, the hardware fluid flow simulator of the systemic circulation MACSim was developed and tested in a series of variational parameter studies. The vascular morphology was generated from a set of MRI images, resulting in a patient-specific artificial one-to-one replica of the human circulatory system. Pulsatile flow conditions were produced by a medical ventricular assist device (VAD) diaphragm pump. The viscosity of the human blood was modelled by a 60/40 vol.-% water-glycerin mixture. Windkessel elements at the peripheral ends of the network allow to vary the pressure and flow conditions within the physiological range.
The considered variational scenario was built upon a nominal arterial stenosis in the left art. femoralis 20 cm upstream the knee. The nominal cross sectional area was reduced between 30 and 80 %, while the length of the stenosis was modified within a range of 5 and 20 mm. Pressure and flow was measured at distinct locations within the system using 20 fluid compatible pressure and four Doppler ultrasound sensors, respectively. The measurement led to a series of multivariate statistical data sets and meta-information about the experiments, which was stored to a MySQL database for futher analysis using extensive data mining and signal classification techniques. The measured pressure and flow waveforms are in good qualitative and quantitative agreement to in-silico simulations and literature in terms of waveshape and specific wave futures like the dicrotic notch, peripheral steeping and translesional pressure drop.

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Respiratory influence on HRV parameters analyzed during controlled respiration, spontaneous respiration and apnoe

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The heart rate variability (HRV) is a measure commonly used to assess sympathetic and parasympathetic autonomic function. It is well known, that respiration can have a strong influence on HRV. Especially, a phenomenon called respiratory sinus arrhythmia (RSA) modulates the RR intervals and is a major contributor to the HRV. The interpretation of common HRV parameters can be ambiguous due to different respiration rates and patterns. To adress this ambiguity, the coupling of RSA on HRV was quantified and HRV parameters were compared during different respiratory states.
A pilot study with five healthy subjects was performed. A three-lead ECG was acquired and the respiration was estimated by measuring the ventilation of the lungs using the PulmoVista 500 by Dräger. This device uses Electrical Impedance Tomography (EIT) to monitor impedance changes due to the changing amount of air within the lungs during respiration. The subjects were asked to breathe at controlled respiration rates of 8, 15 and 24 breaths per minute as well as spontaneously for 1 min each. Furthermore, to analyze HRV during apnoic phases without any respiration, the subjects were asked to hold their breath for 40s at end-inspiration and end-expiration. After preprocessing of the ECG and respiration signal, the coupling between measured respiration and RR intervals was quantified using the Granger causality. If significant coupling was present, the HRV was separated from its respiratory influence using an ARMAX model. The measured respiration hereby formed the exogeneous input to the filter. Common HRV parameters were calculated for the original and decoupled RR intervals. We showed, that coupling strength depends on respiratory rates, which might complicate HRV interpretation. Moreover, the coupling is decreased during spontaneous breathing in comparison to controlled respiration. Additionally, we found, that HRV parameters during apnoic phases differ from decoupled HRV parameters during spontaneous or controlled respiration.

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Beat-to-beat features in peripheral vascular impedance plethysmography for respiratory rate estimation

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With an increasing interest in health, wearable monitors are on the rise. Most devices however are wrist-worn and thus limited in both sensorial and computational complexity. Especially acquiring the respiratory rate comfortably from the limbs has proven difficult, whereby predominantly reflectance PPG-based concepts have been proposed. In some cases, however, even highly integrated, optical measurements are too bulky. Using textile electrodes, for example in socks or gloves, the vascular impedance plethysmography (IPG) can be used to acquire pulsatile signals with minimum obtrusion. We propose a lightweight respiratory rate estimation using time-domain beat-to-beat features from the IPG followed by a spectral feature fusion step. To identify a suitable feature combination, we measured the arm IPG and the respiration in 10 healthy subjects. We then extracted 39 signal frames using automated signal quality assessment. Following, 7 time-domain features have been calculated for each IPG beat: (1) systolic peak amplitude, (2) diastolic peak amplitude, (3) augmentation index, (4) pulse area, (5) pulse interval, (6) crest time, (7) delta-T feature. In order to find the optimal feature combination, an average frequency spectrum over all features for each frame and all 127 possible feature combinations was calculated. The peak in in the physiologically meaningful interval between 6 breaths per minute (bpm) and 36 bpm was used as the respiratory rate estimation. By considering the MSE with respect to the reference rate we were able to select the optimal feature combination [1, 5, 6, 7], which gave the best estimation with an MSE of 1.58 +/- 3.11 bpm over all 39 signal excerpts. An IPG-based respiratory rate estimation in a space-limited environment is therefore feasible. Using only beat-to-beat features in the time domain and the FFT in the fusion step, the proposed concept can be implemented using computationally limited hardware in a wearable device.

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Design and implementation of a teaching system for visual stimulation and recording of single unit and mass signals

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Biosignals can be measured, monitored and analyzed in order to provide information about physiological functions and health statuses. These signals are useful for different types of applications, e.g. evoked potentials (EP). Commercial biosignal data acquisition and logging systems are frequently very expensive, developed via closed-source software and hardware, limited in functionality, difficult to cure defects, difficult to add new features, or not documented in detail. In addition, their level of abstraction is very high or they do not support recent advances in software technologies such as storing the gathered data to the cloud in order to be accessed and used by other systems remotely. We developed a budget priced biosignal data acquisition, logging and visual stimulation system. The system was designed to teach students the in-vivo recording of neuronal signals, e.g. visually evoked potentials or spike activities. The proposed system supports biomedical engineering education by allowing students to measure brain signals data in a flexible and interactive way from anaesthetized flies. Recordings can be done by putting electrodes on the exoskeleton or by positioning fibre micro-electrodes in the vicinity of the optic lobe or central brain. The hardware part of the system consists of supporting mechanical parts, a microelectrode manipulator manufactured according to our plans (by Thomas Recording, Gießen, Germany), National Instruments USB-6211 multifunction I/O device, and a module based equipment (including filter-amplifiers) to record signals and to provide visual stimuli. Here we focus on the stimulation and recording software. The software was written by using the graphical programming language LabVIEW. The recorded data can be stored into MATLAB MAT-files, which assures an easy and open post-processing by the students. Our approach provides the students a bottom up insight into acquisition and processing of electrical neuronal single-unit and mass signals as required for neurosignal and/or neuroprosthetical applications in biomedical engineering.

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Sensor placement in a smart compression shirt to measure spontaneous breathing

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Literature provides various approaches to link upper body surface motion during respiration with the underlying respiratory mechanics. An optimal system would provide a sufficient accuracy, be wearable and able to use in all circumstances - from unconscious patients in bed (to monitor the spontaneous breathing) to competitive athletes during training (to measure the tidal volume during exercise). In conjunction with the development of a smart compression shirt, which is able to assess the tidal volume, this study was done to analyse the required number of sensors in the shirt. Based on optoelectronic plethysmography (OEP), the optimal number of sensors and their positions in the shirt were analysed, regarding their ability to provide a sufficient accuracy for the tidal volume. Therefore, multiple OEP markers were fixed on a compression shirt and the OEP was done within a body plethysmograph, which was used as a reference. The participants wearing the shirt were advised to undertake diverse respiratory manoeuvres. Different algorithms were evaluated to process the obtained data and finally via a spline interpolation in combination with a delauney triangulation the tidal volume was derived from the position of the markers. Subsequently, marker by marker was removed from the dataset and the resulting volume was calculated. The calculation of the tidal volume was still sufficient even when the number of markers was remarkably reduced. The reduction of the quantity of markers / sensors is a compromise, because additional markers improve the accuracy of the measurement while on the other hand they increase the complexity of the measurement system. Dependent on the desired precision for the tidal volume, the optimal number of sensors and their location on the compression shirt was determined. Furthermore, anatomical constraints and the symmetry of the human body can be used to improve the results.

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Consistent mathematical modelling of the perfusion index and the pulse wave velocity measured by combined fingertip photoplethysmography and the electrocardiogram

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The human body has the ability to control the blood pressure in the cardiovascular system by the vasomotor activity of arterial blood vessels. However, these days physicians are unable to reliably monitor these changes in vessel diameter continuously and non-invasivly, nonetheless they could win precious time to react by observing these changes of vessel tone in possibly life-threatenig situations like undetected hemorrage. Therefore, we developed a coherent mathematical model based on physiological and physical principles that links the pulse-wave-velocity (PWV) and the perfusion index (PI) to the unobservable vessel diameter. Conveniently, both PWV and PI can easily be captured by means of routinely employed electrocardiographic and photoplethysmographic patient monitoring systems.
To calculate values for the PWV and the PI the model treats the internal vessel radius and its change as caused by the arterial volume pulse as input parameters, which illustrates the vasomotor activity on the given piece of tube. Furthermore these input parameters are combined through a given law to implement a correlation between them. Consequently, the PI, which is based on the Beer-Lambert law, can experience a noticeable change through vasomotor activity and in the same way the PWV, based on the Moens-Korteweg equation, will also change in value. Both health parameters are subject to different information sources and can be investigated through signalprocessing on fingertip photoplethysmograms and the electrocardiogram. For a simulated change in vessel radius from 0.6 to 1.2 mm as it is related to the radial artery, we calculated pulse-wave-velocities from 565 to 550 cm/s and perfusion index from 9 to 18 %.
As a result it is shown, that the combined mathematical model is able to calculate values for PWV and PI, which are comparable to physiological values recorded on humans.

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Saturation correction in pulsed fields of high dose-per-pulse

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Current developments in accelerator technology and beam application have the potential to bring pulsed radiation sources with very high dose-per-pulse into clinical application. In particular, laser-based particle accelerators and pencil beam scanning using synchro-cyclotrons provide intensely pulsed beams. Current methods to determine the saturation correction factor (k_s) in ionization chambers are not intended for use at such high dose-per-pulse, possibly leading to an inaccurate dosimetry. We present a method based on the numerical approximation of the ionization, charge reaction and transport processes in an ionization chamber, which is able to overcome the limitations of current procedures used to calculate k_s. This numerical work is supported by experimental data of a plane-parallel advanced Markus ionization chamber irradiated with a pulsed electron beam of a dose-per-pulse up to 600 mGy. At a low collection voltage of 100 V a satisfactory description of the saturation correction dependency on dose-per-pulse can be achieved using existing models and tuning their parameter values. However, at the reference voltage of 300 V this is not possible and the newly presented method shows marked improvements. Chief among the additional effects considered in the presented numerical method is the shielding of the electric field by the liberated charges, which alters the dose-per-pulse dependency of k_s in a way that can not be replicated by existing approaches.

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Investigation of radiation exposure to the ocular lens of urologists due to interventions

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Based on new radiobiological data, the International Commission on Radiological Protection (ICRP) recommends a dose limit of 20 mSv per year to the lens of the eye. Therefore, the annual dose limit in Germany will be reduced to 20 mSv in 2018 from currently 150 mSv. Urologists are exposed to an elevated radiation exposure in the head region during surgical interventions, due to the x-ray tube assembly above the patient commonly used in urology. Technical and/or personal radiation protections for the head are not often used by the urologist. To determine the radiation exposure to the ocular lens, a number of measurements for a variety of dose intensive fluoroscopy interventions were carried out. The impact of the experience of the urologists on the radiation exposure of the patients and the urologists themselves was investigated likewise.
For a period of two months, partial body doses (forehead, apron collar, forearm) for the urologists, surgery staff and anesthetists were measured. All 119 interventions were performed using the Uroskop Omnia Max (Siemens Healthineers, Erlangen, Deutschland). The urological interventions were divided into three groups based on expected radiation exposure. Three different types of dosimeter were applied: calibrated electronic personal dosimeter EPD Mk2 (Thermo Fisher Scientific, Waltham, MA, USA), thermoluminescent dosimeter (TLD-100H, copper-doped lithium fluoride, Thermo Fisher Scientific, Waltham, MA, USA) and RaySafe i2 dosimeter (RaySafe, Billdal, Schweden). The radiation exposure to the patient was documented using the dose area product and the fluoroscopy time.
The study setup allows a differentiated and time-resolved measurement of the radiation exposure during urological interventions. The mean dose value to the lens of the eye per intervention was determined to be 20 ± 75 µGy. Therefore, 1000 interventions can be performed until the annual dose limit to the eye lens is reached. Radiation exposure of the surgery staff corresponded approximately to half the exposure of the physician performing the intervention.

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Investigation of the LET-Dependency from BeO using single photon detection for dosimetry in proton beams

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Optically stimulated luminescence (OSL) is gaining greater importance in the field of personal dosimetry in the last few years. Its principle is based on the release of small amounts of light induced by the prior absorption of ionizing radiation. One suitable luminophore for OSL is beryllium oxide (BeO). Because of its near tissue equivalent effective atomic number of 7, it is excellent for personal dosimetry. Furthermore, the luminescence signal has a wide dose linearity ranging from the µGy region up to few Gy. For this reason, this ceramic can be used for several different areas of application. A new generation of measurement systems based on the OSL of BeO, which has a very low OSL light intensity, was developed by the radiation physics group at TU Dresden. This property allows single photon detection which is superior in contrast to other detection methods. Therefore, a single photon sensor was used as a detector. The single photon mode of the detector in combination with the so called timestamp detection method allows accessing the greatest possible information of the OSL light. This work applies the new system to dosimetry of a proton beam. Because of the LET-dependencies of the luminescence light, this presents a challenge. Common problems of solid state dosimetry are local saturation effects, which were investigated for BeO. Opportunities for correction in terms of the LET-dependency of the luminophore are being discussed. For the empirical determination of the behavior of BeO in proton beams, measurements at the medical proton therapy facility at the University Proton Therapy Dresden (UPTD) were carried out. All collected data were analyzed for LET-dependency on the response signal. For the measurements, BeO ceramics were placed at different depth infront and inside the spread out Bragg peak (SOBP). The dose read from dosimeters was analyzed with respect to the applied dose and the LET. All measurements infront of the SOBP shows no deviation of the estimated dose. The dose determination in the SOBP yielded an underestimation by 15%. This is object of current investigation.

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A novel primary method for the determination of dose to water for kilovoltage X-rays

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Kilovoltage X-rays are primarily used for treating skin cancers. Other applications include the treatment of Kaposi's sarcoma, rectal cancer, palliative radiotherapy and keloid treatments. Dosimetry protocols for these qualities are traditionally based on detectors calibrated in terms of air kerma K_a. In recent years, a paradigm shift has led to dosimetry protocols based on detectors directly calibrated in terms of D_w. These are traced back to new primary standards at the national metrology institutes.
At PTB, the calibrations in terms of D_w are performed with two transfer chambers which were calibrated directly against the primary standard water calorimeter in 2010. The measurement of D_w for a range of kilovoltage X-ray qualities with the calorimeter occupies the X-ray calibration facility for several months. However, after seven years of use, a re-calibration of the transfer chambers seemed necessary. Therefore, a new, less time-consuming procedure for measuring D_w was developed and will be presented. It is based on ionization chambers calibrated in terms of K_a. The calibration factor N_{Dw} is calculated using the mean ratio of mass-energy absorption coefficients of water to air, a method known from dosimetry protocols such as TRS 277 or AAPM TG61. An additional quality-dependent correction factor k_{ch} is required to take into account the altered spectra in water, the angular response of the detector, and the different materials of the chamber brought into the water for calibration. The mass-energy absorption coefficients can be calculated precisely with the Monte Carlo code system EGSnrc using measured spectra from our X-ray tubes. Measurements for ionization chambers of the types PTW TM30013 and NPL 2561 (with protective covers) show that the additional correction k_{ch} for the TH series is smaller than 1 %. This is therefore a viable option as a primary method to determine D_w for these qualities.

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Quantification of patient exposure reduction with dynamic collimation for large detector CTs

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Good image quality at low radiation dose is an important task in modern computed tomography (CT). CT scanner development led to multi-detector-scanners with up to 320 detector rows for fast image acquisition needed for example in CT coronary angiography. When these large detector CTs are used in routine spiral image acquisition, they are subject to “overscanning”, which describes the half rotation at the begin and end of an spiral acquisition needed for image reconstruction of the first image slice. Therefore, overscanning results in unwanted dose deposition in adjacent body regions next to the scanning region. To reduce this exposure dynamic collimators were introduced which open and close the primary beam collimation at the begin and end of the spiral acquisition.
Aim of this study is to evaluate the influence of dynamic collimation with different pitch settings on patient exposure and image quality (image noise).
Radiochromic film with a scale was scanned in a defined position on two different CT scanners with and without dynamic collimation. The scan was performed with 64x0.625 mm total collimation and different pitch settings.
Additional an anthropomorphic phantom was scanned with different pitch values to demonstrate the independence of pitch and image quality in terms of image noise. Subsequently we put a ROI (region of interest) in defined image positions in the phantom scan and compared the image noise.
Without dynamic collimation an overscanning of 108.1 ± 6.3 mm was found. With dynamic collimation this effect was reduced to: 52.8 ± 2.2 mm. Image noise was found to be constant as expected.
The overscanning effect can cause an unnecessary increase in dose of 10% - 30% depending on the scanning lenght. This dose can reduce by dynamic collimators and a low pitch which does not influence image quality.

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Influence of a magnetic field on the response of the MR-compatible Exradin A19MR farmer-type ionization chamber

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Recently, dedicated MR-compatible ionization chambers have become commercially available for dosimetry in hybrid devices for MR-guided radiotherapy (MRgRT). The response of ionization chambers is known to depend on the chamber type, the magnetic field strength and the orientation between chamber axis, beam and magnetic field [Meijsing PMB 2009, Reynolds Med Phys 2013].
The aim of this study was to investigate the response of the MR-compatible Exradin A19MR Farmer-type ionization chamber in magnetic fields of different field strengths and field orientations.
The chamber response to a 6MV photon beam was measured in a water phantom positioned in an experimental electromagnet (magnetic field strengths 0 - 1.1T). The magnetic field was aligned perpendicular to the chamber and beam axis.
The experiment was reproduced using the EGSnrc [Kawrakow Med Phys 2000, NRC PIRS 2009] Monte-Carlo code egs_chamber [Wulff Med Phys 2008] including a macro for particle transport in a magnetic field [Kawrakow]. Moreover, the chamber response was calculated for a magnetic field parallel to the chamber axis as well as parallel to the beam.
For a magnetic field perpendicular to chamber and beam axis, the measured dose response increased up to 8.7% at 0.9T and decreased for higher magnetic field strengths. Reversing the magnetic field direction yielded a maximum increase in response of 6.6% at 0.9T. The measured response agreed with the Monte-Carlo simulations within a statistical uncertainty below 0.2%. For a magnetic field parallel to chamber, the calculated dose response varied within $\pm$0.5%, while it slightly increased by 0.7% at 1.1T for a magnetic field parallel to the beam.
The response of the Exradin A19MR chamber perpendicular to beam and magnetic field was well-predicted by the simulations, and in the other orientations, only small effects of the field were observed. The chamber appears suitable for measurements in hybrid MRgRT devices.

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In-phantom dosimetry near a ^{192}Ir brachytherapy source

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Quality assessment or individualized therapy requirements may necessitate the direct dose or dose rate measurement in a water phantom surrounding a small applicator containing a single ^{192}Ir photon source. We propose a cross-calibration method analogous to the small calibration field method known from teletherapy photon dosimetry, but with the axis of the reference ionization chamber in the midplane of the ^{192}Ir photon source and pointing towards the source center. The method contains the following steps: a) Accurate localization of the source in the applicator by means of the water-phantom maximum-search function. b) Measurement of the relative radial dose profile with a small solid detector, using its known $k_{Q,M}$ values, and assessment of the radial range in which the dose rate is proportional to r^{-2}. c) Correction of the ionization chamber signal by the volume averaging effect correction factor $k_V = 1 + \sigma^2/r^2$ where σ^2 is the variance of a rotation-symmetric Gaussian distribution describing the response of the ionization chamber. d) Choice of the ionization chamber's effective point of measurement, guided by the requirement that the k_V- and $k_{Q,M}$-corrected ionization chamber signals also vary in proportion to r^{-2}. e) Cross-calibration of the small solid detector by assessment of the ratio between the two r^{-2}-proportional dose profiles at a recommended source-center distance, e.g. 30 mm. f) The calibrated small solid detector can then be used to measure dose or dose rate values under conditions deviating from the cross-calibration conditions. We illustrate the performance of these cross-calibration steps and the subsequent application of the small solid detector. In earlier work by U. Quast and U. Bormann, Medizinische Physik 1980 (ed. U. Rosenow), ISBN 3-7785-0669-2, p.495-500, a similar method of detector cross-calibration has been recommended.

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Investigation of the active volume dimensions of solid-state detectors using the PTB 10 MeV proton microbeam

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This study aims at the experimental determination of the diameters and thicknesses of the active volumes of solid-state photon-beam detectors, such as the PTW microDiamond, the PTW silicon diode Diode E and the Iba Razor Diode. The detectors were scanned using the 10 MeV proton microbeam of the PTB (Physikalisch-Technische Bundesanstalt, Braunschweig). The proton beam was adjusted parallel to the symmetry axes of the examined detectors. The diameters D of the active volumes were determined from the signal profiles obtained by scanning the proton beam radially across the active volume. The thicknesses T of the active detector volumes were determined by measuring the detector signal as a function of the thickness of aluminium foils placed before the detectors as absorbers, so that the Bragg peak could be stepwise scanned along the detectors' axes. The measurements were compared to Monte Carlo simulations based on the detector blueprints using the Monte Carlo code FLUKA, and the thickness of the sensitive volume was varied. The thickness yielding the best agreement with measurements was considered as the thickness of the active volume. In a second method, the absolute signals in terms of charge collected were calculated for the case without any aluminium absorber using the known number of incident protons, the proton stopping power in the detectors' components and the quotient W/e, the energy expenditure of a proton per electron released in the detector material W, divided by the elementary charge e. The determined active volume diameters closely agree with the dimensions stated by the manufacturers, whereas the investigated active volume thicknesses are slightly larger.

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Monte-Carlo study on the mechanism of the field size dependent overresponse of a synthetic diamond detector – the effects of the structural component densities and of the photon spectrum

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Measured output factor corrections of the synthetic microDiamond detector (PTW 60019, Freiburg, Germany) for a 6 MV photon beam at quadratic field side lengths of 5 mm and above show an overresponse resulting in correction factors below one. At smaller field sizes (< 5 mm), the volume averaging effect prevails, causing the correction factor to increase above one. The detector overresponse cannot be attributed to the production of secondary electrons within the sensitive volume due to its thickness of merely 1-2 μm. Therefore, the role of the structural components of the detector in causing the detector overresponse was investigated by modelling the influence of the density of the casting material placed above and of the diamond base located below the sensitive volume. Simulations showed that at field widths less than ca. 10 mm, at which lateral secondary electron equilibrium does not exist, the reduction of the sideward transport of the secondary electrons due to the enhanced density of these structural components causes the secondary electron fluence at the field center to increase compared with the case of the sensitive layer embedded in water. This fluence enhancement in the beam center increases with photon energy, as expected for a phenomenon associated with the lateral transport of Compton electrons. Therefore the Monte-Carlo simulations considered the exact detector structure including its walls, but also the field size dependent photon spectrum, and yielded output factor corrections close to the experimental values. The study confirms that the density of the wall materials is able to cause the overresponse of small photon dosimetry detectors in the absence of lateral secondary electron equilibrium.

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Response of ionization chambers in the presence of magnetic fields

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The next generation of medical electron linear accelerators will integrate magnetic resonance tomography (MRI). So it will be possible to take direct images of the moving tumor during radiotherapy treatment. On the other hand, the strong magnetic field have an impact on the trajectories of the produced secondary electrons because of the Lorentz force which eff ects both the dose distribution in water and the dose response of used detectors. For an accurate patient dosimetry these effects have to be well known and must be taken into account. Monte Carlo methods describe correctly the radiation transport in different media even in presence of magnetic fields and are therefore the gold standard for the evaluation of the impact of magnetic fields on clinical dosimetry.
In the present study the relative response of three different ionization chambers (PTW-T30013, EXRADIN-1ASL, NE2571) as a function of an external magnetic field was investigated with Monte Carlo simulations using the code EGSnrc. The chambers were modelled in detail according to the information given by the manufacturer and placed in a water phantom (30 x 30 x 30 cm^2). The chambers were irradiated under reference conditions following the recommendations of present dosimetry protocols, like IAEA TRS-398, i.e. the field size at the phantom surface was 10 x 10 cm^2, the focus-surface-distance 100 cm and the depth of the chamber's reference point was 10 cm. As photon sources several spectra of clinical medical accelerators with nominal energies between 6 and 18 MV-X were applied. The magnetic field was applied in different directions relative to the beam axis (z-direction) and the chamber's symmetry axis and was varied between 0 and 3 Tesla.
The results clearly show, that the response of all chambers vary up to about 10% in dependency of the magnetic field strength and the field direction.

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Development of ultraviolet ray irradiation device for gafchromic XR-SP2 films

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Three dimensional X-ray absorbed dose distribution of computed tomography (CT) using two half cylindrical acrylic phantoms with Gafchromic XR-SP2, ultraviolet (UV) rays were irradiated by a irradiation device using UV-light emitted diode (UV-LED) as a Pre-UV irradiation to correct nonuniformity error of Gafchromic XR-SP2.
UV intensities of UV irradiation device of a relative intensity dial were measured the dial of begin from 0 to 255. In addition, sufficient UV pre-irradiation durations to Gafchromic XR-SP2 were evaluated. UV irradiation durations were 1, 2, 3, 5, 10, 15, and 20 minutes. There are two important points were used to decide sufficient UV irradiation duration. First the mode value was not indicated '0' and seconds both sleeves of the graph indicated less than 1/10 of maximum mode value. In addition, paired t-test of Standard Deviation (SD) were performed that the improvement of correction of nonuniformity error.
Relative UV-A intensities and indicated dial memory were approximately linearly changed. Indicated at dial 0, irradiation intensity was 2,530 $\mu W/cm^2$ and dial 250, irradiation intensity was 12,800 $\mu W/cm^2$. When UV-A was irradiated 10 minutes to Gafchromic XR-SP2, the maximal pixel value was 604, minimal pixel value was 0, and mean value ± SDは197.282 ± 75.612. In addition, 1/10 mode value was 75.6. It was sufficient for irradiation duration. Correction of nonuniformity of the XR-SP2, it was indicated that SD value of with or without pre UV irradiation were reduced from 74.373 to 68.592. Uniformity was improved statistical significant ($p = 0.048$).
The UV (385 nm) irradiation device was developed. The sufficient pre-irradiation duration for Gafchromic XR-SP2 was approximately 5 minutes. Therefore, these irradiation method to Gafchromic XR-SP2 and irradiation device were improved homogeneous of Gafchromic XR-SP2. It was applicable as a premise of the 3D measurement of the CT dose distribution.

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Optimizing the precision of positioning a 3D-dose distribution measuring device for Brachytherapy applications

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Modern model based dose calculation algorithms for brachytherapy treatment planning systems aim to predict dose distributions more accurately than the widely-used TG-43 protocol, which is only based on dose in water. They are mostly validated through Monte Carlo simulations as high radiation doses and steep dose gradients present a challenge for accurate measurements of the dose distribution around a brachytherapy source and applicator in a water-phantom.
PTB is developing a measuring device to determine the 3D-dose distribution around clinical applicators within a water-phantom. A robot (Stäubli TX-60L) will be used to move a small plastic scintillation detector around the stationary applicator. To allow a comparison with modern Monte Carlo codes we aim to determine the dose in a specific point with a precission of 3 %.
One of the challenges in this project is the high precision spatial positioning that is required. E.g. at a distance of 1 cm from an Ir-192 source, an uncertainty of 50 µm in the positioning of the detector leads to a relative uncertainty of 1 % in the measured dose.
To enable accurate measurements with such precision, a suitable positioning system has to be implemented. Several methods to accurately determine the relative position of the detector to the source or the applicator with the source will be investigated.

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Accuracy and anisotropy of three-dimensional ionization chambers for plan verification in robotic radiosurgery

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Introduction: Absolute dose measurement in phantoms is often required for patient plan verification for CyberKnife radiosurgery. For small treatment beams the use of ionization chambers (ICs) with small sensitive volumes is necessary and due to variable non-coplanar beam directions a low anisotropy is desired. We investigated the measurement accuracy and anisotropy of recently introduced 3D-ICs.
Materials and methods: We analyzed the Semiflex-3D and PinPoint-3D and compared them with the standard Semiflex and PinPoint (PTW, Germany). We also compared profile measurements in reference to a Diode P (PTW). Furthermore, we simulated an isocentric axial, radial and mixed direction test plan with the ICs in a dedicated solid-water slab-phantom (PTW) using the 15mm collimator to avoid significant volumetric effects. Finally, we examined the PinPoint and PinPoint-3D for clinical plan verification with small collimators (5-20mm).
Results: For profile measurements orthogonal to the longitudinal axis, no significant difference were found between standard and 3D-ICs. For measurements along the axis the 3D-ICs showed better agreement to the Diode. For the test plans, no significant differences were observed between the Semiflex ICs (axial: 0.2%; radial: 0.01%; mixed: 0.44%). The PinPoint-3D agreed considerably closer to the treatment plan dose than the standard PinPoint (axial: -0.65vs.-2.65%; radial: +0.39vs.-1.80%; mixed: +0.24vs.-2.02%). Yet, no clear differences were observed between the standard and 3D-PinPoint for treatment plan verification (maximum difference 1.3%). Also, we found some remaining higher deviations (>3%) between both ICs and the plan dose which we attributed to volume effects due to the small beams.
Conclusion: Considering anisotropy the PinPoint-3D seems to bring improvements compared to the standard PinPoint. For treatment plan verification both PinPoint ICs can be adequately used, however the use of smaller volume chambers (i.e., the 3D-ICs) seems to be advised when validating small fields. Further studies concerning the volume effects are advised.

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Capabilities of the metrological electron accelerator facility (MELAF) for research in radiation effects

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The Physikalisch-Technische Bundesanstalt (PTB), the National Metrology Institute of Germany, operates an electron accelerator facility for service and research in the field of dosimetry for external beam radiotherapy. The PTB offers access to its metrologically well characterized radiation fields also for external researchers with other research projects beyond dosimetry in order to exploit the potential of the existing infrastructure. The purpose of this work is to outline the capabilities and the properties of our facility in order to identify further possible applications and to foster new collaborations. Our facility is equipped with a research electron linear accelerator with adjustable energy up to 50 MeV as well as with two clinical accelerators for high-energy photon radiation of six different accelerating voltages between 4 MV and 25 MV and electron radiation with nine energies between 4 MeV and 22 MeV. In addition a reference field of Co-60 gamma radiation from a 130 TBq source, monoenergetic neutron fields up to 20 MeV and an ion mircobeam are available. Forthermore, the PTB provides on-site an S1 laboratory for cell culture and microbiological preparations with qualification for genetically modified cells. The clinical accelerators are equipped with multileaf collimators allowing for investigations in small fields. An electromagnet with magnetic flux density up to 1.4 T and sufficient space between the pole shoes to place a water phantom can be positioned in front of each accelerator for tests of dosimetry procedures for MR guided radiation therapy. The properties of the research electron accelerator, as for instance the spectral electron fluence and the beam current can be measured with small uncertainties. Therefore, radiation effects can be studied as a function of the fundamental quantities. PTB is willing to support investigators by its expertise in the field of dosimetry and all issues related to its Metrological Electron Accelerator Facility.

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Assessment of microscopic ion beam field variation using fluorescent nuclear track detectors

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Radiotherapy with protons or heavier ions can be beneficial for some tumors compared to photons or electrons. Often, information on the particle spectrum is necessary, which is missing in standard ionometric measurements. Fluence-based track detectors provide access to this information.
However, the high spatial resolution does not correspond in a simple way to the necessary scale to estimate fluence. To this end, we derived the minimal spatial resolution for fluence based-dosimetry, for which stochastic fluctuations caused by the spatial randomness of particle arrival are smaller than the effects sought after. The evaluated statistical tools allow assessing possible microstructures in the ion beam, i.e. deviations from homogeneous lateral fluence.
We used aluminum-based Fluorescent Nuclear Track Detectors (FNTDs, size 8 x 4 x 0.5 mm^3) that have a high single particle tracking efficiency for the clinical LET range to test the performance of the statistical tools. Multiple detectors were irradiated at the Heidelberg Ion Therapy Center (HIT) with protons, helium and carbon ions with various energies. For the detector readout we used the automated confocal microscope "Landauer FXR-700RG" and for data analysis including 3d track reconstruction the "FNTD-package" (http://fntd.dkfz.de).
The results suggest that for the detection of fluence deviations of 1 % (10 %) in a carbon ion beam of approximately one Gy the spatial resolution has to be above 410 µm (40 µm). In mixed particle fields (e.g. secondaries in the spread-out Bragg peak) the necessary scale would even increase.

P 90

Development of micro electromechanical biosensor for fast detection of respiratory syncytial virus infections in newborns

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Infectious diseases are one of the world's leading causes of morbidity and death. In the case of newborns, infections with the Respiratory Syncytial Virus (RSV) are of particular significance. The guarantor of a successful treatment is an early disease diagnosis enabling the accurate patient stratification and prognosis of disease outcome. Conventional diagnostics for the identification of unknown pathogens require large sample volumes and are rather laborious and time-consuming. Therefore, rapid and ultra-sensitive point-of-care diagnostics, which enable faster and more personalized patient treatment for much lower costs, are gaining higher attention. The most critical component of these point-of-care devices is a bio-sensor that detects, with a high degree of precision, specific molecules.

In this work, a novel flexural plate wave (FPW) bio-MEMS sensor for the detection of RSV infections in newborns has been successfully designed, fabricated and tested. The sensor targets the detection of chemokines and an RSV protein in swab-samples, thus providing clinicians with reliable information on type and severity of the infection, and consequently enabling the adequate decision on the patient's treatment. The operating principle of the sensor, using the piezoelectric effect, is based on the frequency shift of a resonating membrane due to attachment of an additional mass.

The sensor's performance has been experimentally verified. The sensor's surface was functionalized with a layer of capture molecules (the layer is immobilized via click-chemistry) that specifically bind the target molecule. Clear resonant frequency shifts have been observed after the functionalized sensor was brought into contact with aqueous solutions (tris-buffer) of the chemokine, whereas bringing the sensor into contact with a non-target molecule led to hardly any frequency shift. This proves the selectivity of the fabricated device. The detection procedure using the developed sensor takes ca. 15 minutes, whereas with currently employed conventional methods several hours.

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Registration and evaluation of alternative non-invasive parameters for orthostatic hypotension in geriatric patients

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Estimation of orthostatic hypotension by arm cuff blood pressure- and heart rate registration (Schellong test) is difficult to perform in cases of restricted mobility in geriatric patients. Therefore, alternative, non invasive parameters for the registration of orthostatic hypotension are requested in the elderly population.
In 60 patients of the Geriatrische Rehabilitationsklinik Dresden Löbtau (mean 82 years, 80% female) blood pressure, impedance- and electrocardiogram were recorded by VasoScreen 3000 (medis, Ilmenau, Germany) for 5 minutes in a lying and 5 minutes in a standing position. Additional arm cuff blood pressure reference measurements were performed 1x in a lying- and after 1, 2 and 3 minutes in a standing position. A subset of derived parameters was correlated to the blood pressure and heart rate course during the 10 min registration. 11 patients were excluded due to contraindications (absence of sinus rhythm, deficient data quality, inability for standing during investigation). Statistics were performed by Wilcoxon signed-rank test and U-tests (MATLAB 9.2.).
In 19 patients (39%) orthostatic hypotension could be demonstrated by the criteria of Schellong. Promising alternative parameters showed complete or partly significant correlation to the course of blood pressure- and heart rate regulation: pre-ejection period (time between electrocardiographic Q-beginning and B point of the impedance cardiogram), velocity index, acceleration index and cardiac index. Additional measurements of a larger population are needed for the validation of our results.

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Investigation of the viscosity of human middle ear effusions by endoscopic optical coherence tomography

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A middle ear effusion is the result of an infection, a dysfunction or constriction of the Eustachian tube and is often associated with an inflammation of the ear (otitis media). More than 75 % of children at the age of 3 years have already suffered from otitis media. With the standard diagnostic methods, e.g. otoscopy, audiometry or tympanometry, it is not possible to characterize the effusion. At the moment, the effusion can be classified as serous or mucous by the physician only after paracentesis. The aim of our study is to support the physician in the decision whether the incision of the tympanic membrane is necessary.
In this study, we investigate model fluids, which simulate the viscosity and scattering properties of middle ear effusions ex vivo by endoscopic optical coherence tomography (EOCT). EOCT is a multifunctional diagnostic tool (combined otoscopy, laser doppler vibrometry) based on low coherence interferometry and has a penetration depth of 1 - 2 mm in scattering tissue. Using M-scans, the time dependent fluctuation of the intensity can be measured, which is the result of diffusion of particles in the effusion. By determination of the intensity-autocorrelation for each depth, a mean diffusion coefficient is calculated. By Stokes-Einstein equation, viscosity and diffusion coefficient are connected. In addition, all samples have been analyzed using a rheometer, which measures directly the viscosity of the effusion.

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Design of a switched-capacitor array for high-power applications with dense coverage of medium frequency-range

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Magnetic Hyperthermia has been studied for a number of years because of its suggested importance in therapeutic applications like cancer treatment. In addition to the magnetic field-generator which heats the magnetic nanoparticles with an alternating magnetic field, the behaviour of the used magnetic nanoparticles is of significant importance. It is well-known that the behaviour of the particles related to magnetic hyperthermia is dependent on several parameters like the amplitude of the magnetic field, the viscosity of the surrounding medium and the particles intrinsic properties. As it is relatively easy to arbitrarily change the amplitude of a magnetic field lots of studies have been carried out which examine the heating behaviour of magnetic particles depending on the amplitude of the magnetic field. However a change of frequency is technically more demanding, especially considering the typical frequency range of magnetic hyperthermia which is around $100\,\mathrm{kHz}$ to $1\,\mathrm{MHz}$ with corresponding amplitudes of around $3\,\mathrm{mT}/\mu_0$ to $30\,\mathrm{mT}/\mu_0$. Due to the technical difficulties it was only possible to select discrete frequencies to measure the magnetic heating behaviour of magnetic nanoparticle samples. As typical broadband matching techniques, like ladder-networks or transformer-based approaches fail due to either huge mismatch or limited bandwidth, only capacitive impedance matching provides the necessary quality of the impedance matching and equally tolerates the required amount of power to produce magnetic fields of a certain strength. This contribution presents a method to design a switched-capacitor array to provide a dense matching in the forementioned frequency-range while withstanding the high amounts of power that drive the field-generator. Besides the presentation of an design algorithm, a closer look will be taken on an exemplary result of this algorithm to show the feasibility of this approach to provide a measurement-system with arbitrarily selectable frequencies in the range of $100\,\mathrm{kHz}$ to $1\,\mathrm{MHz}$.

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MEMS-FTIR-based reference system for glucose and lactate determination in the NIR wavelength range

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Introduction: Glucose and lactate represent an important indicator for human metabolism performance. The determination is important for sports and clinical medicine. Due to several disadvantages of commonly used encymatic-amperometric methods, an optical measurement is desirable. Main challenges for optical determination are spectral overlap of different blood components and low absorbance of physiological glucose and lactate levels.
Methods: We built a measurement setup using novel MEMS-based Fourier spectrometers to exploit absorbance of glucose, lactate and albumin in the NIR wavelength range of 1300-2500 nm. A multivariate regression model was created to investigate predictability. Therefore, we compared different wavelength ranges and their combinations to obtain best accuracy for mixtures of glucose, lactate and albumin. Additionally the influence of data preprocessing methods was investigated. We took continuous reference spectra for compensation purposes because drift effects of light source emission or temperature-depending sample absorbance have huge influence on prediction accuracy. Sample contamination by previous measurements as a possible source of error was reduced by improving cuvette flushing procedure and evaluation of various cuvette geometries.
Results: Best results were achieved for 2050-2400 nm where the strongest NIR absorbance was found. Our measurements show that the optical distinction between glucose, lactate and albumin is possible. Especially glucose shows a high correlation with diluted water which improves prediction without impurities, but makes the system sensitive to similar resulting drift effects of sample temperature. Therefore continuous reference measurements are essential to ensure reliable concentration prediction.
Conclusion: We showed that spectral detection of glucose, lactate and albumin with MEMS-based Fourier-spectrometers is possible. By systematic investigation of interferences we were able to improve stability. This new spectrometer generation enables new opportunities regarding cheap glucose and lactate determination by obtaining spectral resolved data from samples.

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Impedance matching of small laser fabricated double-sided intrafascicular electrode arrays

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During the recent years we introduced a novel laser fabrication process for thin parylene C based electrode arrays. Utilizing a LUMERA LASER Rapid10 picosecond (ps) laser system the thickness of these electrode arrays can be driven below 40 µm. By only using materials classified for chronic implantation by the United States Pharmacopoeia (USP class VI) biocompatibility of the arrays was directly taken into consideration. This allowed for their application as an intrafascicular devices in long-term in vivo implantations. Whereas the inexpensive, maskless and flexible design are a clear advantage over lithographically structured thin film electrodes, the disparity in electrochemical behaviour between front –and backside electrodes might have unfavourable consequences.
Due to different approaches in opening the electrodes on the front -and backside, the active area of the opening varies, even though the geometrical area is the same. Sample electrode arrays were investigated optically and electrochemically to gain insight in the actual surface texture. Scanning electron microscope (SEM) imagining in combination with a focused ion beam (FIB) gave further insight in the porosity of metal surfaces treated by ultrashort laser pulses. Next to adjusting the geometrical area of the rougher electrode surfaces to achieve impedance matching, coating the electrodes with PEDOT and nanorough platinum was investigated.
It could be observed that the impedances of geometrically identical electrodes at 1 kHz differ about 30 % between the front and the back. This disparity overlaps with the rippled surface following laser hatching. While coating the electrodes only minimally changes the proportion, a drop of about one order of magnitude in impedance occurs. This drives the disparity towards the standard deviation of untreated electrodes, thus offering a second approach for impedance matching.
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Autonomous powered R wave detector

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Energy harvesting has the potential to substitute batteries for powering devices. Some industrial solutions are already available, but they use continuous energy sources, like temperature gradients or vibrations. For wearables, it is not possible to predict the time for energy input, so a smarter technology is needed to handle the energy input. The aim of the project is to monitor the instantaneous heart rate without the use of batteries powered only by discontinuous and stochastic power chunks.
The developed power management system collects electrical energy until the storage capacitor is fully charged. When it reaches a certain threshold, an ECG measurement is started for the next 3.5 seconds. The measured signal gets analyzed in real time with R wave detection and the result gets transmitted to a computer or mobile device via Bluetooth low energy.
The result is an ultra-low power circuit with a discrete signal processing unit. An analog Pan Tompkins Detector is implemented with low power optimized OPAs. A microcontroller detects the R wave peaks and measures the intervals which are transmitted via a separately powered Bluetooth low energy interface to a mobile device or PC.
The system is a functional prototype of a self-powered R wave detector for short time heart rate monitoring. The analog Pan Tompkins Detector of the developed prototype is optimized to spend minor energy. At a minor energy consumption, the device can measure only the ECG at rest. For a comfortable use of the device (for example as a sport wearable) the analog Pan Tompkins Detector must be optimized against motion artefacts. The future goal is to implement textile energy harvesters to power the circuit. Patches that use the triboelectrical effect can be integrated into normal clothes and gather energy during normal motion. The wireless communication will be powered by energy harvesting, too.

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Health and sensors – sweat sensing

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We have to face a demographic change in many countries: People are getting older and older and suffer from a whole variety of age-related diseases. The rates of hospitalisation increase. Clinical and home surveillance has to include age-specific morbidity and mortality.
Now we have to answer the question, if it is possible to keep the aged people as long as possible at home to reduce costs but not the quality of services in medicine , care and general support.
Here interdisciplinary engineering and the digital transformation can help and represent excellent opportunities to solve the above mentioned problems. New ecosystems can be formed and new disruptive models are necessary. Sensors, electronics, software merge in combination with business models.
The presentation refers to digitally transformed processes and shows different applications on the field of body area networks and vital parameter measurement in the context of telemedical and clinical applications.
The sensing of biomarkers out of sweat becomes more and more important because sweat contains a huge variety of different molecules such as glucose, lactate or even cytokines.
These systems are of importance for the daily monitoring of patients as well as for the surveillance of risk patients in a intensive care unit.
We will present a demonstrator of such a small and effective sweat sensor and the combination with the vital parameter monitoring as described above.

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Local stress investigation of periprosthetic fractures by total hip replacement - a finite element analysis

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Introduction: Every year, 350000 knee and hip prostheses are implanted solely in Germany. Thus, hip replacement is one of the ten most common surgeries. Because of rising life expectancy and increased mobility of patients, an increase of femoral fractures near the implanted hip joint can be observed. A reason for these periprosthetic fractures is the alteration of the femur's physiological properties. Periprosthetic fractures require surgery with plate and screw systems. In most cases, a screw is mounted in the pre-damaged bone material. This can lead to further losses of bone substance. The new medical approach is to fix the periprosthetic fracture through an LISS-plate, which is screwed into the artificial hip joint.
Methods: By means of the FE-method, a model of a thighbone with a hip prosthesis was created. In this model, local stress on the head of the hip prosthesis was studied extensively by application of a static stress. In the next step, the prosthesis was drilled in two positions and was subsequently fixed through an LISS-plate (TiAl6Nb7). The results are compared to non-drilled prostheses. Additionally, the prosthesis material was varied. On the one hand a cemented variant of a cobalt-iron alloy (CoCrMo) was used. For comparison, a cementless system with the forged alloy TiAl6V4 was studied.
Results: It is shown that all deformations of the prosthesis are in the elastic range. When comparing the drilled and the non-drilled prosthesis, higher load peaks can be detected in the drilled specimen. The highest stresses occurred at the hip in the prosthesis's joint head and around the drill holes.
FE analysis only represents a simplified model. The bone was defined as complete cortical material, bone-remodeling processes were not considered. The prosthesis model has been simplified to consist of solid material with given properties. Coatings have been neglected. Next steps will be in-vitro tests.

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Development and validation of a equipment-specific Geant4 model for Elekta Agility collimator

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The goal of this study is to develop and validate an equipment-specific Geant4 model of an Elekta Agility collimator to be used in Monte-Carlo simulations of dose distribution.
The Diaphragms and Multi-Leaf Collimators (MLC) were initially modelled based on Agility data available in literature. As geometry might change for different machines, specific MLC features, as tongue and groove (T&G), gap between leaves and positioning, have been defined as mathematical functions. The user can tune such features in order to match experimental measurements performed in a specific machine.
The Elekta Precise IAEA phase space files for 6 MV photon beam were used as primary generators. For validation of the model, simulation of dosimetric characteristics were carried out in Geant4 v.10.01.p02. Different rectangular fields were delivered to a virtual water phantom. Percentage depth dose (PDD) curves and lateral profiles were then compared to corresponding measurements conducted in an Elekta Synergy linac coupled with Elekta Agility collimation system. Furthermore, intraleaf and interleaf leakage and T&G effect were also investigated.
Good agreement was obtained between measured and simulated data for PDD and lateral profiles. However, small discrepencies were observed in small fields which could be attributed to the use of an Elekta Precise phase space. Moreover, a maximum leakage value of 0.55 % was observed for both measured and simulated data. An underdosage of approximately 20 % was observed due to the T&G effect in measurements and simulations. The obtained results are compatible with literature data.
The developed model was proven able to reproduce the Elekta Agility collimator. Small discrepancies might be corrected for by developing a more adequate phase space. Validation for 15 MV photon beam and IMRT plans is also foreseen.

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Towards PET monitoring at the Austrian ion beam therapy center MedAustron

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At the MedAustron proton and carbon ion facility in Wiener Neustadt/Austria, patient treatment started in December 2016. Ion beam therapy allows tumor conformal dose distributions, however, it is sensitive to deviations from the treatment plan, e.g. due to anatomical changes. Therefore, special care in quality assurance is required. Up to now, PET is the only clinically proven method for performing a 3D in-vivo dose monitoring for proton and ion therapy. At MedAustron, a Philips Gemini TF BigBore PET/CT is available in the vicinity of the treatment rooms, exclusively dedicated to offline PET monitoring after the irradiation. First workflow tests with PMMA targets, which were irradiated with protons, transported to the PET/CT using a patient trolley, and scanned in the PET/CT, have been successful and results will be presented. The targets were irradiated with protons of 198 MeV and 169 MeV. The PET acquisition can be started within 5 minutes after the end of the irradiation. The experimental effort is being accompanied by the establishment of software required for the clinical implementation of the PET monitoring. For the prediction of the activity distribution, the simulation tool GATE is used. The simulations are performed on a small in-house cluster. GATE provides several useful features for this purpose, e.g. an already implemented washout model and the possibility to model the PET scanner. Simulation results are compared with the data obtained during the workflow tests. Further tests are being planned, and for the second half of 2017 a patient study is under preparation.

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Simulation of electrical fields in cardiac resynchronization therapy and temperature spread in HF ablation

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The electrical field (E-field) of the biventricular (BV) stimulation is important for the success of cardiac resynchronization therapy (CRT) in patients with cardiac insufficiency and widened QRS complex.
The aim of the study was to model different pacing and ablation electrodes and to integrate them into a heart model for the static and dynamic simulation of BV stimulation and HF ablation in atrial fibrillation (AF).
The modeling and simulation was carried out using the electromagnetic simulation software CST. Five multipolar left ventricular (LV) electrodes, four bipolar right atrial (RA) electrodes, two right ventricular (RV) electrodes and one HF ablation catheter were modelled. A selection were integrated into the heart rhythm model (Schalk, Offenburg) for the electrical field simulation. The simulation of an AV node ablation at CRT was performed with RA, RV and LV electrodes and integrated ablation catheter with an 8 mm gold tip.
The BV stimulation were performed simultaneously at amplitude of 3 V at the LV electrode and 1 V at the RV electrode with a pulse width of 0.5 ms each. The far-field potential at the RA electrode tip was 32.86 mV and 185.97 mV at a distance of 1 mm from the RA electrode tip. AV node ablation was simulated with an applied power of 5 W at 420 kHz at the distal ablation electrode. The temperature at the catheter tip was 103.87 °C after 5 s ablation time and 37.61 °C at a distance of 2 mm inside the myocardium. After 15 s, the temperature was 118.42 °C and 42.13 °C.
Virtual heart and electrode models as well as the simulations of electrical fields and temperature profiles allow the static and dynamic simulation of atrial synchronous BV stimulation and HF ablation at AF and could be used to optimize the CRT and AF ablation.

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Monte-Carlo based CT simulation of virtual patients for image guided radiotherapy

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In image guided radiotherapy, a new CT is necessary whenever the dose distribution in a changing anatomy needs to be re-planned or re-checked. However, acquiring new CT images along with each treatment is not always feasible. In order to prevent additional exposure to radiation or because there is no CT scanner available it might be omitted. For instance, ion therapy particle facilities are currently not equipped with in-room 3D imaging, but use 2D fluoroscopic projections. Here, positioning and dose calculation exclusively rely on image registration with the planning CT. Due to the resulting vector field, (motion) artefacts and the statistical noise distribution from the planning CT are deformed unphysically. In order to tackle these shortcomings, we propose a new approach based on virtual imaging of patients. First, a reduced representation of the patient body is obtained from feasible images, i.e. a diagnostic CT. This representation is used to construct a virtual patient geometry resembling the real patient. On a computer level this is a hierarchy of nested tessellated volumes, each consisting of one distinct material. Secondly, a dedicated Monte-Carlo (MC) simulation of a Cone Beam CT (CBCT) is performed. It features a gantry hosting a 140 keV photon point source and a flat solid-state detector. A facility to load the virtual patient geometry from a XML-like file format is provided. Combining patient model and MC simulation we are able to produce a fully virtual CBCT image of a patient. As an advantage, we can control the noise level, resolve motion artefacts and dismiss common artefacts occuring in planning CTs. The validation of our workflow for generation of virtual images of simple phantoms and patient-like geometries will be presented. Possible future applications combining virtual imaging and a biomechinal model of patient movement will be discussed.

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Evaluation of pharmacokinetic models of low-molecular-weight contrast agents for perfusion quantification with dynamic contrast-enhanced magnetic resonance imaging

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Purpose: To evaluate perfusion quantification with different pharmacokinetic models for the distribution of low-molecular-weight contrast agents (LMCA) in skeletal muscle tissue using dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI).
Material and Methods: Tissue perfusion F_p was measured in the lower limb volume supplied by the femoral artery of seven pigs. With a 3-dimensional gradient echo sequence images were acquired during administration of an LMCA (gadoterate meglumine) and a blood pool contrast agent (BPCA, gadofosveset trisodium). Continuous infusion of the vasodilator adenosine into the femoral artery resulted in up to four times higher flow. Eight LMCA models were tested: the two-compartment exchange model (2CXM), the tissue homogeneity model, the distributed parameter model, for each of these a version extended by an arteriolar compartment (E2CXM). We compared the results of the LMCA models with those of a parallel two-compartment blood pool model (2CBPM). Measurements performed with a Doppler flow probe at the femoral artery served as the gold standard of reference. The models were tested in a highly vascularized human sarcoma in the lower limb and the same MRI technique as described above.
Results: Correlation of the 2CBPM with the Doppler probe measurements was $r = 0.8$ ($P < 10^{-4}$); the E2CXM showed the highest fit quality of all LMCA models and the most significant correlation with the Doppler measurements, $r = 0.78$ ($P < 10^{-4}$). The best correspondence between the capillary perfusion measurements of the LMCA models and those of the 2CBPM was found with the E2CXM (slope of the regression line equal to 1, $r = 0.85$, $P < 10^{-28}$). The fitting results for the clinical patient data corresponded very well with the results obtained in the animal experiments.
Conclusion: Our experimental results demonstrate that double contrast agent DCE-MRI in combination with the E2CXM is feasible and applicable in clinical routine.

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First experiences of a Monte Carlo based plan verification software at the UKGM

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ProSoma® Core is a Monte Carlo based software package for verification of radiotherapy treatments. It was developed by MedCom (Darmstadt) with the aim of integrating it in the quality assurance procedure. It offers an independent assessment of the radiation plan as well as a robustness analysis. The dose calculations can be compared in an interactive mode or in dose reports displaying gamma histograms and dose volume histograms. The dose reports provide customizable acceptance criteria for each treatment region. When supplied with machine log-files from the accelerator after irradiation, ProSoma Core enables a re-calculation of the dose delivered to the patient.
A beam model for the Elekta Synergy® linear accelerators at the department of radiotherapy at the university clinic in Gießen (UKGM) has been implemented in ProSoma Core. The base data required for the beam model were depth dose curves and dose profiles for several field sizes and their corresponding output factors. The measurements were performed in a water phantom (MP3, PTW) irradiated with 6 MV photons with field sizes ranging from 1x1 cm^2 to 40 x 40 cm^2. Dose distributions from the planning system (Pinnacle 9.10, Philips) have been compared to calculations in ProSoma Core and to the measured dose. The evaluation in ProSoma Core of a few clinically relevant plans will also be presented.

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Probabilistic based algorithm to simulate ion nuclear reactions in the ion therapy energy range

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Computation of precise dose deposition is of major relevance in ion therapy. A fast and precise ion transport program is being developed in the radiation physics group (ASP) at the TU Dresden. In the energy range of ion therapy, the ions undergo elastic scattering, inelastic collisions or nuclear reactions. The current program simulates elastic scattering and inelastic collisions of ions in matter based on the Binary Collision Approximation and Bethe-Bloch theory. Nuclear reactions occur more rarely than the other interactions, but they need to be considered in the calculations due to their contribution to the total dose deposition.
This work focuses on the implementation of the nuclear reactions into the existing program by including their explicit simulation and transport of the reaction products. An efficient method for processing the nuclear reactions based strictly on probabilistic principles has been developed. In contrast with other existing MonteCarlo transport programs, the present algorithm samples the possible occurrence of a nuclear reaction before the transport of the projectile takes place. The results of the implementation will be addressed in this presentation.

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MR Radiomics features of brain metastasis allow for primary tumor identification

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Radiomics is a quantitative analysis approach for medical images allowing non-invasive tissue differentiation by image feature extraction. Radiomics is therefore regarded as one of the most promising tools for cancer diagnosis and treatment in radiology and radiotherapy. Over 40% of cancer patients develop brain metastasis, in 5% of the cases the primary tumor remains unknown (CUP). As targeted treatment options are based on the primary lesion type, radiological in vivo techniques for metastasis type identification are desirable to reduce invasive biopsy interventions and to allow for faster and efficient differential diagnosis. We hypothesize that Radiomics based image feature analysis could facilitate and accelerate the identification of brain metastasis types in clinical practice. T1 post contrast MR images of 78 untreated patients with SCLC (n=36 metastasis), NSCLC (n=100 metastasis), melanoma (n=41 metastasis) and breast cancer (n=27 metastasis) were included in our analysis. Tumor segmentation was conducted by two experienced MDs with a semi-automatic approach. All images were normalized through histogram matching and isotopically resampled while keeping the in-plane resolution constant. Classical first order statistics, volume and shape based features as well as second order texture features were extracted as imaging biomarkers. Random forest algorithms were used as machine learning approach, feature selection was implemented with Randomized Logistic Regression. Model validation was conducted using a specific approach for grouped data to account for intra-patient correlations of extracted features. Radiomics signatures of brain metastasis yield classification performances with AUC of 0.67 for breast cancer, 0.73 for melanoma, 0.61 for NCSLC and 0.74 for SCLC, respectively. Quantitative image feature analysis may therefore accelerate tumor identification and serve as supportive decision tool for treatment regimens in case of brain metastasis with unknown primary.

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Degradation of sponge structures made of magnesium alloys as bone replacement material

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Bone tissue can be destroyed or has to be removed in consequence of accidents or diseases. This creates a defect in the tissue. In case of a critical sized defect the body cannot fill the gap autonomously, which indicates the use of a transplant or an implant. For last of which, magnesium alloys turned out to be a promising material in regards to their highly biocompatibility, good mechanical properties and controllable degradation behaviour. Regarding the structure, open pored sponge like structures are being developed and investigated as bone tissue can grow into these structures. Combining both features, the bone can grow into this implant, bridge the gap and the implant degrades as the bone grows. In this study it is assumed that the magnesium degradation is governed by diffusion of magnesium ions from the surface. This diffusion-controlled process induces the formation of a degradation layer. The degradation layer shows a change in material composition compared to the base material. Subsequently, this results in a change in mechanical properties of the implant. To simulate the degradation a numerical model including the diffusion equation was developed. The simulation model is based on the assumption that the magnesium concentration decreases from the surface to the material core gradually and that the Young's modulus of the material depends on the magnesium concentration. Additionally, the magnesium concentration at the surface of the implant decreases related to the flux of magnesium ions and the mass transfer coefficient of the environment. By means of this simulation model, the formation of the degradation layer can be expressed. Furthermore, the change of effective Young’s modulus of the structure was calculable. The model was implemented in the commercial finite element code Abaqus/Standard.

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Differential equations and cellular automata for avascular tumor growth

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There are two widely used classes of mathematical models for the description of avascular tumor growth. In the first class the tumor cell density is regarded as a continuous quantity subject to differential equations of reaction-diffusion type. The second class makes use of cellular automata in which the tumor cells are treated as discrete entities. In our work we explore the connection between the two classes of models by developing two closely related models from the two classes. Both models implement the cell cycle which is responsible for cell proliferation. The spatial tumor growth is achieved by cell diffusion. For the simulation of the oxygen supply we make use of a separation of time scales. Since the oxygen dynamics takes place on a much shorter time scale than the tumor dynamics the oxygen distribution can be assumed to be in an equilibrium for the simulation of the tumor dynamics. On the other hand the tumor can be regarded as a static object for the calculation of the oxygen equilibrium distribution. The simulation is performed by subsequent application of cell proliferation and diffusion steps. Each step can be treated independently according to the continuous or the discrete model, respectively. The differential equations for the continuous model are solved numerically. The discretized differential equations are very similar to the updating rules of the cellular automaton. It turns out that both models lead to similar simulation results which indicates their equivalence. The speed of tumor growth is in good agreement with the prediction made by the solution of the Fisher-Kolmogorov equation.

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Models and simulation of central retinal vein pulsation for education and training in ophthalmology

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Ophthalmologists are interested in deep understanding of ocular haemodynamics, but not all of them are acquainted with venous pulsation from assessing fundus camera video data. Spontaneous retinal vein pulsation is visible in nearly 80 % of healthy individuals. It demonstrates rhythmic variation in width and/or colour saturation of retinal veins near to or on the optic disc. The pulsation amplitude depends on several influencing quantities and conditions in the ocular, cranial, and the whole cardiovascular circulation system of the patient. Absence of vein pulsation can not only be generated by glaucoma pathophysiology, but also induced by time-dependent pressure difference and flow related constellations between intraocular, venous, arterial, and intracranial regions. The mechanisms of individual autoregulation and measuring methodology control the spatiotemporal behavior of pulsation characteristics.
A mathematical with a corresponding physical model kit is developed for representing these complex volume, pressure, flow, and vessel characteristic interrelations described in scientific medical literature. Definitions of quantities, parameters, and relationships are tried to maintain self-consistent. The mathematical model is based on algorithms of Guidoboni, Morgan, and others. It consists of 5 physiological compartments with freely selectable properties for special patient characteristics and is implemented under Matlab/Simulink. The simple physical model with only ocular, vein, and cranial compartment demonstrates rising and minimising of vein pulsation under specific conditions for educational purposes and will be complemented by arterial, tissue, and body compartments as well as pressure and flow sensors for comparing the model behavior with patient data. Controlled via a software GUI, the model kit can be used for simulation of characteristic cases for education and training in ophthalmology with substantial theoretical background.
Combining the cross-linked and complex scientific knowledge about retinal vein pulsation phenomenon in a physically interpretable system with unambiguously defined parameters, some preconditioned contradictions from medical point of view can be checked.

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Manufacturing and thermal treatment of degradable magnesium bone cages

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Available therapy options for large segmental bone defects (length > 5 cm) are a high physiological as well as psychological burden for the affected patients, as they are connected with long time of immobility and repeated operations.
The application of titan mesh cages is besides external fixators the most common treatment approach. Bone fragments and bone substitute are filled into the cages that are implanted to allow local regeneration of the defect bone. To avoid stress shiedling the titan cages have to be explanted after successful healing. Stress shielding occurs when there is no more load applied to the bone and thereby no stimulus for continued remodeling, therefore the bone starts to degenerate. The explantation is related to an additional health burden for the patient and a significant reduction of quality of life. Within the project MagCage a fully resorbable magnesium cage for the management of large segmental bone defects is developed to overcome these limitations.
Different textile technologies are evaluated for cage production. Compared to other manufacturing processes like e.g. laser-cutting, textile fabrication provides the advantage of minimal material waste. As delicate wires can be used for cage production, gas formation during the resorption process can be reduced to a minimum.
Braided samples could be produced with characteristics meeting with the defined requirements. Influences of the parameters braiding angle, wire and cage diameter on the mechanical as well as structural properties of the meshes were investigated. A thermal treatment procedure was developed to avoid widening of the edges after cutting the cages to length.
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Complex braids for medical applications

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There is a wide range of braided products for medical use, such as braided stents or suture material. Products like this show low complexity and can be braided by using circular braiding machines. The disadvantage of circular braiding machines is the limited possibility to produce products with a higher grade of complexity, such as bifurcation-stents or suture with loops. 3D-Braiding machines, like the hexagonal braiding machine developed in cooperation between the Advanced Fibrous Material Laboratory (AFML) of University of British Columbia, Vancouver and the Institut für Textiltechnik (ITA) of RWTH Aachen University, have the potential to manufacture braids with almost unlimited complexity. This is because the trajectories of the bobbin carriers are not bound to a certain track and can be moved to any position on the plate. Due to the the almost unlimited movement capabilities of the bobbin carriers the determination of there trajectory, for producing the required braid, is not trivial. Therefore a lot of knowledge regarding to the machine movement is needed.
Our approach is to split complex braids into less complex basic structures, such as circle, triangle or other simple braiding profiles, for which the definition of the position and trajectories of the bobbin carriers is much easier. Therefore different basic structures were analysed and the machine parameters for production defined. Combining the trajectories of the bobbin carriers for the basic structures within the production process will lead to the required complex shaped braid, like e.g. a bifurcation-stent. Furthermore for the production of a hollow structure a core is needed to support the braid. Therefore an adaptive core was developed which can be integrated into the machine and can be used for different trials and individual braids.

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Generating informative standard values of maximum forces and anthropometric data of the shoulder in pupils of classes 5 to 12 by means of an accessory to the HFD 200 hand and finger dynamometer diagnostics and therapy system

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Purpose: With a view to improving the precision and quality of measurements of the shoulder joint force it was intended to introduce structural improvements of the previously used HFD 200 hand and finger dynamometer (basic unit) measuring system and generate standard values of the shoulder joint maximum forces. This involved a clear enhancement of the comfort of use for patients, test persons and operators. Maximum force values of the shoulder joint and anthropometric data of the upper arm, shoulder, thorax, body height, and others, were to be used to determine the physical development of sound pupils of classes 5 to 12. The treatment result of patients with shoulder diseases was to be evaluated after the therapy with the HFD 200 using standard data of maximum shoulder forces of grown-up 12th class pupils.
Methodology: An accessory unit was integrated as a second force measuring transformer in the structure of the HFD 200 measuring and therapy system (basic unit). This concept and a set of ergonomically optimized epicondyle and elbow cups made it possible to measure the force precisely at measuring points of the distal upper arm in the conditions of retroversion and abduction. Ergonomic handles were developed to allow the measurement of the maximum force of anteversion on the basic unit. The measurement was made steadily defined in neutral-zero position. The investigation included 48 pupils aged 10 to 19 years. The maximum forces of 6 patients with diseases of the left shoulder joint were evaluated. Eight force and 24 anthropologic parameters yielded more than 8,000 single measurements. Mean values and scatters of data were statistically analyzed (Wilcoxon's pair comparison test).
Results: The improvements described led to a considerably higher precision of the measurement and determination of the actual maximum shoulder joint forces not only in the condition of abduction but also of anteversion and retroversion. The forces measured with the basic unit were 10 to 30 percent smaller. The magnitude of the force of anteversion depends of the diameter and design of the handles. Optimum handle diameters were found for the different classes. Informative standard data of the maximum shoulder joint forces and currently known anthropometric standard values were calculated and phases and periods of growth described. After the therapy the forces of the patients had increased from 50.4 to 94.3 percent of the standard values for pupils of the 12th class and the shoulder joints were free of pain and freely movable.
Conclusions: The technical solution described provides a comprehensive standardized diagnosis and therapy of the shoulder joint muscles. The physiological processes of growth can be described by means of informative tables of standard data and diagrams of the maximum shoulder forces and body measures of sound persons. They provide the basis for identifying pathological standard deviations, setting up targets of therapy and evaluating the results of shoulder rehabilitation in the fields of occupational, rehabilitation and sports medicine and science.

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Impact of insertion velocity on insertion forces in cochlear implantation surgery

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The development of automated insertion tools for cochlear implantations provides the possibility to control the insertion velocity which is assumed to influence the insertion forces. Insertion forces are correlated to insertion trauma, a risk factor for the loss of residual hearing. Preservation of residual hearing is therefor one of the most important objectives in modern cochlear implantation surgery. An automated insertion test bench was used for standardised insertions of electrode carriers to investigate the correlation between insertion velocity and forces in an artificial cochlear model.
Straight dummy electrode carriers with four embedded bare copper wires of graded lengths in order to replicate the stiffness gradient of real implants were fabricated. The geometry of the dummy electrodes was chosen similar to those of the Contour Advance (Cochlear Ltd., Sydney, Australia). Six insertion velocities (0.2; 0.4; 0.9; 1.6; 2.0; 2.8 mm/s) were analysed using twelve dummy electrodes. Each one was inserted six times, each time with another velocity. Maximum insertion depth was 17 mm. The insertion setup comprised a force sensor (K3D35, ME-Meßsysteme GmbH, Hennigsdorf, Germany) with 0.5 N nominal force mounted underneath the cochlear model and an insertion tool to grasp the dummy electrode and providing linear movement.
Maximum insertion forces occurred at the end of insertion. The lowest insertion velocity (0.2 mm/s) showed the significantly lowest maximal insertion force (3.88 mN ± 0.81 mN). Higher insertion velocities increased the insertion forces until a plateau was reached at 2.0 mm/s (6.11 mN ± 1.47 mN). This study indicates that very slow insertion reduces the insertion force in a cochlear model and might be beneficial for hearing preservation. Since such low speeds are not feasible manually, automatic tools for intraoperative use are under development.
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Evaluation of design limits for implantable high channel count connectors

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Progress of active implantable medical device development brings along increasing channel counts and challenges the present hardware concepts. While designs of cables and electronic packages can be adapted, connectors currently limit novel applications of neural implants.
When designing the contact zone for implantable electrical connectors, a planar arrangement of contact partners offers many advantages: surfaces can be easily cleaned during surgery by wiping before mating and the volume consumption of the contact zone is much smaller compared to other concepts e.g. comprising pins and receptables. Furthermore, one can rely on established implant manufacturing technologies for electrode arrays.
To enable high integration densities within reasonable overall geometries, contact pads have to be miniaturized. Regarding contact theory, electrical contact quality is independent from the apparent contact area. However, put into practice, several geometrical factors affect contacting and limit the miniaturization process. Those have to be carefully investigated for the design at hand. This study evaluates the miniaturization limits for laser-structured multilayer compounds of silicone rubber and platinum foil as contact partners.
The contact surfaces and the surrounding silicone rubber substrate form a topography whose aspect ratio is expected to be crucial for electrical contact establishment: Scaling down the contact pad geometries will enlarge the role the protruding silicone seals play in the mating process. On the way to a better understanding of those specific contact mechanics, several questions arise: Is there a critical aspect ratio from which on there will be no contact establishment possible anymore? Can a higher contact pressure compensate the impairing aspect ratio to a certain amount? Alternatively, does the incompressive nature of silicone rubber set a fixed topographical limit? We treat those issues within a setup that allows simultaneous evaluation of multiple electrical channels and the applied contact force.

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Perception thresholds of cutaneous electric stimulation around the upper arm

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Wearable warning systems can alert a person of imminent dangers. Acoustic and optical methods can be compromised by interference from the environment. Our objective is to determine percepts of cutaneous electric stimulation and their detection amplitude thresholds around the upper arm, opening a new path of perception for warning systems.
With ethics approval, we applied bipolar monophasic square pulses of 200µs duration to eight pairs of electrodes at regular positions around the right upper arms of four participants (2f, 2m, age 33±6y) at rest. The gel electrodes (Ø16 mm) were spaced approx. 5-6 cm centre-to-centre. By gradually increasing the amplitude we determined the amplitudes at which the pulse was (1) just noticeable, (2) drawing attention to itself, and (3) generating intolerable perceptions. The participants described the perception and its location using a questionnaire. We further measured the skin thickness including the subcutaneous fat layer under each electrode using a skinfold calliper.
The lower perception thresholds were at 1.8±0.41mA (mean±std), the attention thresholds at 3.8±1.4mA, and the intolerance thresholds at 8.5±4.4mA. While the first two thresholds were homogeneous around the arm, the intolerance thresholds were higher (10.3±4.7mA) at lateral to posterior sections and lower (6.3±3.5mA) at medial to anterior sections. Participants reported a short touch perception in the area of the electrodes for the first two thresholds. The intolerance thresholds were marked with a sting perception and/or with a localized muscle contraction. Skin thicknesses were higher at anterior-lateral to posterior sections (8.7±4.4mm compared to 3.5±2.6mm at other sections), coinciding approximately with the profile of the intolerance thresholds.
A robust amplitude window for tolerable percepts that draw the attention of the person could be found in all participants in the lateral to posterior sections of the upper arm. Electric warning methods can increase safety and environmental awareness.

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Lifetime testing for flexible smart implants

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In the research on miniaturized smart implants, developing a non-hermetic foil based encapsulation for semiconductor chips is mandatory to achieve small, biostable devices. However, opposed to implants using a hermetic housing, failure mechanisms caused by ion and water diffusion in foil encapsulated chips are not fully investigated. Since the device lifetime is a critical challenge in thin-film implants, test substrates integrating both conductors and microchips are fabri-cated to identify the failure sites. They feature specific structures on both chip and substrate level to monitore the fail-ures related to corrosion, electromigration and delamination. Additionally transistors, capacitors and diodes of a dedi-cated process control chip are employed as test structures for the failure mechanisms inside the circuits of the chip. Since so far, no standard for the testing of smart implants has been defined, a novel measurement setup that mirrors the body as closely as possible is designed. The samples are placed in a basin filled with phosphate buffed saline (PBS). A closed-loop pump and heating system controls the liquid level and temperature for up to 60 °C. The test samples are secured in a bending aperture with a low, continuous agitation mimicking the body's own movement while the electric properties are measured. First results using test structures based on gold conductive tracks encapsulated into 14-µm-thick polyimide are meas-ured at 37 °C. No changes could be observed in the 4-wire resistance measurement of a meander structure as well as the impedance spectroscopy of an interdigital electrode within the first week. The addition of mechanical stress to the resistor increased the resistance by 1.5 % with less than 0.04 % deviation in 400 measurements. A deliberately inducted defect in the interdigital electrode led to a decrease in impedance of more than two orders of magnitude, showing that any defects can be clearly distinguished.

P 127

Development of a system test procedure (STP) for CT-guided HDR brachytherapy

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One of the important proceedings of brachytherapy during the last years was the clinical implementation of complex modern technical procedures. 3D imaging is used regularly for the precise reconstruction of the applicator position. Afterwards irradiation planning is performed on basis of these imaging methods before the data transfer to the afterloading device itself proceeds. Therefore checking the whole treatment chain becomes increasingly important. In accordance with the recommendation of the Strahlenschutzkommission we describe in this work a STP for the CT-guided radiotherapy with an HDR afterloading device. A treatment chain consisting a SOMATOM S64 CT from Siemens and the treatment planning system (TPS) BrachyVision v13.7 from VMS utilizing the associated calculation formalism TG43 and the Acuros algorithm as well as a GammaMedplus HDR Afterloader with a 40.700U Ir-192 source is used for this study. First, several reproducible measurement setups for common applicators used in brachytherapy are developed with PMMA fixations for a water phantom (40x40x40cm3). Those setups are scanned with the CT and then the imaging data is imported into the TPS. Then, with the TPS calculated reference dose values for significant points on the side of the applicator (6.5cm) are verified with a PinPoint 3D chamber 31016 of the PTW Freiburg. It is shown that the deviations for the STP between calculation and measurement are $\leq$ 5% when using a metal implanting needle or a vaginal cylinder. Furthermore it can be shown that the STP provides reproducible results while repositioning the applicators without carrying out a new CT-scan. Thus the STP presented in this study allows a practice-oriented realization for checking the whole treatment chain for HDR afterloading technique. The presented system seems feasible to perform periodic system tests as well as to control the introduction of new techniques with sufficient accuracy.

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Fragmentation experiments with helium ions

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Radiotherapy with helium ions is considered as a possible alternative to proton and carbon ion therapy. Due to nuclear fragmentation of the projectiles during penetration through material, which leads to the loss of primary ions and to the build-up of fragments with different ranges, the Bragg curve gets altered and exhibits a tail. This implies that treatment planning codes must have realistic nuclear reaction models implemented. There is a lack of measurement data in the therapeutic energy range, therefore an experiment was performed to measure the charge- and mass-changing cross section at energies from 90 to 220 MeV/u on thin graphite targets at the Heidelberg ion beam therapy center (HIT).
For measuring the charge- and mass-changing cross sections, a common attenuation method was applied at low intensities of about 500 ions/s: The helium ions remaining after traversing the targets (3 thicknesses from 5 to 10 mm plus a no-target measurement for each energy) were identified by a ΔE-E-telescope consisting of a thin plastic scintillator and a thick BaF_2 scintillator triggered by a start scintillator. For improving the particle identification capability, the BaF_2 pulse shape was analyzed by means of fast waveform sampling. The cross sections could then be calculated from the remaining He-4 ions and the generated He-3 fragments as a function of target thickness.
The results of this experiment will be presented and compared to the nuclear reaction models implemented in the GSI treatment planning code TRiP98. The measured data can furthermore be compared to the nuclear models implemented in various Monte Carlo codes and will therefore significantly improve the accuracy of dose calculation in helium ion radiotherapy.

P 130

Measurement of tissue stopping-power ratios for ion-range prediction

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The prediction of ion ranges based on computed tomography (CT) images for particle therapy planning necessarily involves an empirical component due to the mean excitation potential (I-value) in the Bethe formula, which has no counterpart in the keV photon domain. Therefore, CT and ion range measurements of real tissues are required for calibration and verification purposes.
Using a hybrid measurement setup, which was optimized for both dual-energy CT (DECT) scans and ion range measurements, we investigated the animal equivalents to the most abundant soft tissues in the human body. After cutting 5 cuboids each out of 3 different lean porcine muscle tissues and 3 different bovine and porcine adipose tissues, they were fitted into 17.8x15x17.8mm sample chambers. Additionally, we were able to prepare homogeneous samples of naturally heterogeneous tissues like lung or brain with a vacuum blending approach.
Photon attenuation images were acquired using a dual-source CT scanner (Somatom Definition Flash, Siemens Healthineers, Forchheim, Germany) with two tube voltage combinations – 80kV/Sn140kV and 100kV/Sn140kV – and the iterative SAFIRE stage 5 reconstruction kernel. The relative ion range measurements were performed with a PeakFinder (PTW, Freiburg, Germany) at the Heidelberg Ion-Beam Therapy Center using carbon ions with an energy of 200 MeV/u.
With our optimized setup, ion stopping-power ratios (SPR) could be measured with a relative uncertainty smaller than 0.2%. In combination with the DECT modality for electron density determination, the I-value of each tissue sample was assessed. When investigating tissue variability, significant deviations in measured SPRs were found in e.g. adipose tissues – ranging from 0.952 to 0.980 – while other samples (e.g. muscle tissues) showed low variability with coinciding SPRs.
Presented results can be considered in the calibration and verification of ion range prediction methods, e.g. novel algorithms based on DECT.

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Development and Monte Carlo simulations of a 3D range-modulator for proton therapy

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Pencil beam scanning is the state-of-the art in particle therapy and leads to dose distributions with high level of conformity and homogemeity. Hoewever, it hasn't yet established in the treatment of moving targets, due to the large number of different iso-energy layers and the associated long irradiation time. The combination of only one energy and a so-called 3D range-modulator results in a tremendous decrease in irradiation time, potentially allowing the patient to hold his breath during treatment.
A 3D range-modulator was developed for a spherical target of 5 cm diameter. The modulator was optimized using a 151.77 MeV 1H pristine Bragg-peak, corresponding to ~ 15 g/cm^2 depth. It consists of pyramid-shaped pins with 4 mm^2 base area and different heights. The modulator was triangulated and manufactured in rapid prototyping technique. When irradiated, it creates a quasi-static irradiation field, tightly shaped around the target. The resulting dose distribution and modulating effect were simulated using the FLUKA Monte Carlo package. Two additional user routines were implemented: one to handle the complex geometry contour of the modulator and a second one for intensity modulated scanning.
FLUKA simulations show a homogeneous dose distribution, highly conformed to both the distal and proximal edge. Together with extremely short irradiation times, the 3D range-modulator is considered to be a clinically applicable method for very fast treatment of lung tumors.

P 132

Fractionated radiosurgery of uveal tumours by means of HybridArc™ and novalis powered by TrueBeam™ STx

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Introduction: Eye tumours are tiny, irregularly formed, subjected to movements and close to radiation sensitive organs. Tumours not accessible to brachytherapy due to size or location, are traditionally treated with proton beam therapy. Highly conformal radiotherapy with photons achieves good tumour coverage and local control rates. The optimal beam geometry and positioning technique, however, has not been conclusively defined. Here we report our experience with the irradiation technique HybridArc™ and image-guidance by ExacTrac® 6.0.6.
Material and Methods: Since 2014, we treated 51 patients with choroideal tumours. We evaluated the first twelve cases with a tumour volume range (0.1 … 5.2) cm^3. Before radiotherapy planning, four tantalum markers (Altomed Ltd., Boldon, UK) were attached around each tumour on the sclera. All patients were treated after instruction to keep their eyes closed to avoid movements. The treatment planning was done by iPlan® RT 4.5.3. By ExacTrac® 6.0.6 and Robotics® 2.0 (all by Brainlab AG, Feldkirchen, Germany) positioning was verified or improved prior to each beam fraction. The daily dose of 5.6 MeV FFF photons was delivered with a frameless radiosurgery system on a linear accelerator Novalis (Brainlab AG) powered by TrueBeam™ STx (Varian Inc., Palo Alto, CA).
Results: For all planning target volumes in the range (0.5 … 11.8) cm^3, we obtained dose constraints according to ICRU Report 62. The best target volume coverage and minimal dose to neighbouring structures was achieved with three to six dynamic conformal arcs and five to seven static IMRT fields. Since 2014, two patients suffered from liver metastases, and one patient was treated with enucleation due to persisting keratitis.
Discussion and Conclusion: The complexity of treatment planning and image-guidance required for photon therapy by HybridArc™ is clinically robust and effective. Photons from linear accelerators are widely available. We consider fractionated radiosurgery with photons to be the primary technique for most ocular tumours.

P 133

Analysis of robustness of proton plans in the treatment planning system RayStation considering setup and range perturbations

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Introduction: In this thesis a robustness analysis of proton beam plans is performed in the treatment planning software RayStation. These plans had been either planned in the Uniform-Scanning (US) technique or in the Pencil-Beam-Scanning (PBS) technique in the treatment planning software XiO or RayStation. The aim was to get general statements and relationships of plan parameters to the robustness of a plan.
Material and methods: The coverage of the clinical target volume (CTV) of 52 cases was analysed. The 52 cases are split into four groups regarding the tumour location (head/pelvic) and the treatment technique (US/PBS). For patients who had a tumour in their head the brainstem and the cochlea were analysed as organs-at-risk (OAR) and for pelvic patients the rectum and the femoral head were analysed. For the analysis perturbed plans are calculated and regarded which include range errors of plus and minus 3.5% and setup errors of 1 mm and 3 mm in all three spatial directions. The combination of these parameters results in 50 different perturbed plans for every case.
Results: The results are portrayed in DVH bands and in graphical representations regarding selective DVH parameters. The results show that all plans are robust against the given uncertainties while PBS plans variate more than US plans. The constraints of the analysed OARs are fulfilled in the analysis; however, special attention has to be payed on the femoral head under a bilateral prostate radiation.

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Retrospective evaluation of patient positioning data and dose exposure considering translation and rotation deviation in linac based stereotactic radiosurgery

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Stereotactic radiosurgery (SRS) necessitate high requirements on patient positioning prior irradiation. Most common techniques for patient positioning are as well cone beam CT (CBCT) as stereoscopic x-ray imaging (ET) in combination with a robotic 6 degrees of freedom (6D) couch. A TrueBeam STx linac equipped with the HD120 MLC (Varian Medical Systems, Palo Alto, USA) and the patient positioning and monitoring system ExacTrac (Brainlab, Munich, Germany) was being used to examine the highest degree of precision for SRS. Data concerning the correction and verification of 81 patients with up to five intracranial lesions were evaluated to get a mean uncertainty in positioning regarding translation and rotation: (a) with a global deviation or (b) a deviation depending on couch angle. The calculated overall shift in lateral, longitudinal and vertical directions were ±0.25 mm, ±0.20 mm and ±0.25 mm in translation, respectively ±0.40°, ±0.20° and ±0.25° in rotation. For (b) a shift in lateral and longitudinal rotation could be observed depending on the couch angle. The results were used to calculate a worst-case dose distribution spread of the target volume. The DVH analysis showed PTV dose increase up to (6.6 ± 2.8)% at D_{80} and (9.7 ± 1.3)% at D_{98}. The positioning of the patient was within the acceptable alignment tolerances, although a couch angle depending shift in lateral and longitudinal rotation could be detected. ET in combination with 6D couch movement supplies the expected accuracy. Dose impact considering couch angles and consequential changes in PTV coverage will be examined. Furthermore a comparison with CBCT correction will be made regarding to the dose exposure.

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Influence of anatomical changes in robust optimized proton plans for bilateral head and neck cancer targets

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Robust optimization in proton therapy considers uncertainties in patient setup and particle range during the optimization process. However, anatomical changes that may occur during the treatment course are neglected. The aim of this study was to quantify the influence of anatomical changes on the dose distributions for head and neck cancer (HNC) patients scheduled for bilateral neck irradiation.

Datasets from eight bilateral HNC patients, consisting of a planning computed tomography (CT) and weekly control CTs, were used. Intensity-modulated proton therapy plans were calculated with minimax robust optimization, accounting 3 mm and 3.5% for setup and range uncertainty, respectively. The dose to the low- and high-risk clinical target volumes (CTV) consisted of 57 and 70 Gy(RBE), respectively, in 33 fractions. Organs at risk, e.g. spinal cord, brainstem, parotid glands, larynx, pharyngeal constrictor and esophageal inlet muscle, were considered for plan optimization and analysis. The cumulative dose during 33 fractions was checked weekly taking the anatomy of the control CTs into account, and compared with the nominal plan.

Nominal plans fulfilled the clinical specifications of $D_{98} \geq 95\%$ of the prescribed dose to the CTVs (range: 95.8-98.8% for low-risk CTV and 96.2-98.9% for high-risk CTV). During the treatment course, anatomical changes lead to reduced D_{98} values in five patients, with minimum of 87.3% in the low-risk CTV and 91.3% in the high-risk CTV. Maximum doses to spinal cord and brainstem remained below 45 Gy and 54 Gy, respectively. Mean doses to the contralateral parotid gland remained below 26 Gy, except in one patient (maximum mean dose = 27.2 Gy).

For some patients, robust optimization prior to treatment initiation is insufficient to account for anatomical changes occurring during the treatment course. The results for a total cohort of 17 patients, including robustness analysis and plan adaptation strategies will be presented.

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Enhanced evaluation criteria for independent dose calculation tested at the MC-based verification software ProSomaCore

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The Monte Carlo (MC) based verification software ProSomaCore (MedCom) is going to be validated as secondary dose calculation system. Therefore, specific DVH based evaluation criteria were defined and verified in order to replace the gamma criteria.
The therapy planning system (TPS) Eclipse was the reference system used with the superposition algorithm AAA. 40 patients from four different entities were chosen: Mamma, HNO, Lung and Prostate. Since the algorithms inherently show different behaviour in tissues, the gamma criteria is not reasonable anymore in the typical thresholds to compare plans. Thus, two analysis were performed: (1) DVH were separated into the three density regions: lung (- 1000 / - 171 HU), softtissue (- 170 / 149 HU) and bones (150 / 2000 HU). This was considered over the whole calculation volume up to the 10 % isodose line and on the other hand for the PTVs only. (2) For the most important OARs of each entity, DVH criteria were specified for the plan evaluation.
The results for the density separation show the biggest differences in bony structures. The AAA overestimates on average about 3% over all cases and all dose regions compared to the MC. The evaluation of all OARs together shows an exponential dose dependence towards higher deviations (~ 20 %) at lower doses and less deviations (~ 2 %) at higher dose levels.
In summary, with the analysis (1) the deviations in the resulting verification plans can be separated by those arisen from the different algorithms and patient specific. With analysis (2) it can be concluded that a global deviation of ± 5 % should not be applied to the whole dose distribution. Moreover, deviation levels should be defined depending on the dose level (low or high dose). In general, the concept of gamma evalution should be reconsidered. The determined results will be implemented by the software ProSomaCore.

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Evaluation of the stability of healthy volunteers aligned for whole brain irradiation without a mask

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Essential for irradiations of brain tumours is an exact alignment of the patient. Today, it's commonly realised with different mask-systems. However, some patients show acute symptoms like seroma or inflammations, which lead to changes of the patient's surface. These changes may require a change in the shape of the mask, too. Some optical monitoring systems for patients, like the Optical Surface Monitoring System (OSMS) by Varian (Palo Alto, USA), are able to monitor the patient during the entire treatment. An analysis with healthy volunteers has been performed to evaluate the stability of an alignment for brain tumour irradiation without a mask, only by monitoring the patient with OSMS. The volunteers were fixed with tape, which was placed on the forehead and stuck on both ends of the couch, on a head-supporting-device. After the alignment a reference surface was recorded by OSMS. With this reference, the rotational and translational movements of the volunteer during a maximum time of 15 minutes were recorded every 10 seconds. As a second part of this study, after the monitoring the volunteers were realigned three times to evaluate the consumed time for the system. Within the first 5 minutes the average movements were in translational directions below 3 mm and rotational below 2°. The mean alignment time was below 1 minute. The measurements confirm that within the time, which is necessary for a whole brain irradiation, the volunteers remain firm with this system. Additional the OSMS is capable to perform a beam hold, if the patient moves beyond the given thresholds. For further estimations it's essential to perform more studies with real patients, since they're in a psychologically challenging situation. Furthermore, the alignment didn't take an additional expenditure of time.

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Effective workflow for radiation therapy departments with many VMAT irradiations through the use of Mobius 3D and Fx for plan-related quality assurance and a simple and pragmatic machine-related quality assurance program

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In radiotherapy departments with many VMAT irradiations quality assurance is a timeconsuming factor. Both planning-related quality assurance and machine-related quality assurance often take more time than planning itself. The Mobius 3D and Mobius Fx programs were introduced with the intention of minimizing the time required for the planning-related quality assurance. Mobius 3D and Mobius Fx both make an independent computational check of the monitor units, but also of the 3D dose distribution (gamma analysis) and the DVHs. The calculation with Mobius Fx is based on a logfile which records all relevant machine parameters during irradiation. The use of Mobius 3D and Fx fulfil the requirements of the DIN 6875-3 and 6875-4. In addition, a machine-related quality assurance program suitable for VMAT must be established. For this purpose, suitable VMAT standard plans have been introduced, which are radiated in the sense of a constancy check at the Linac and measured with Delta4 from Scandidos. To proof the sensitivity of these standard plans, machine errors were introduced and machine parameters disadjusted: beam-energy, flatness of cross-sectional profiles, calibration of jaw and mlc positions. The values for maximum leaf speed, maximum dose rate and maximum gantry speed were llimited. Summary of results: The time saving through the use of Mobius 3D and Fx with regard to plan-related quality assurance is enormous. The calculation results of Mobius agree more than 99% with the calculations of the planning system, e.g. always better than 95% when comparing dose distribution with gamma criterion 3% / 3mm. The measurement of the standard plans lead to the conclusion that many machine parameters, which should be regularly checked according to DIN 6875-4, can be recorded very effectively with a single measurement. In the case of relevant deviations, this is immediately reflected in the measurement results of the standard plans.

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QALender – a web-based system for supporting quality assurance in radiation therapy

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In radiotherapy, devices have to be tested and checked regularly in order to ensure patient safety and to fulfill current regulations such as DIN 6847-5 and DIN 6875-4. In most institutions, radiation physicists are working with paper-based checklists or Excel sheets. This does not support sustainable and efficient documentation management, long time evaluation, reminders for periodic tests and checks, online validation of readings or aggregated measurements.
We developed a web based Document Management System (DMS) to support Quality Assurance (QA) in radiation therapy. It allows to design clearly arranged measurement protocols according to the needs of specific departments, devices and regulations, and to fill them in online with measurements taken. It facilitates a review process and persists the resulting protocols as pdf documents. The system features a calendar and automated reminders.
We used Python 2.7 and the Django 1.9 Web Development framework running on an Apache2 Web server on an Ubuntu 14.04.0 LTS virtualized machine for our implementation. The database model allows for flexible document template generation including user-defined calculation of derived values and flexible layout for all parameters.
The QA protocols used in the University Hospital Tübingen were used as first draft for the web based protocols. The process of measuring parameters and the overall quality assurance tasks were defined by radiation physicists and refined by interviews.
The system allows flexible document generation and has been used in parallel to the routine documentation in the University Hospital Tübingen. Up until now over ten templates were used and measurements were taken. QAlender was well received by the radiation physicists, and due to their feedback, the handling and front end was optimized. More features are going to be implemented. We will do a formal evaluation of the benefits of the system in the next project phase.

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Influence of TomoTherapy-specific planning parameters on technical treatment parameters and dose distribution

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TomoTherapy offers a helical delivery of intensity modulated photon beam. The binary MLC generates many small fields within each projection, which necessitates dosimetry in small photon fields, one of the main challenges in clinical dosimetry.
The influence of TomoTherapy-specific planning parameters such as pitch, modulation factor and the number of iterations on average subfield size and further treatment parameters as well as clinical dose distributions were investigated. The planning parameters were combined, thus this study contains 30 plans for two different clinical cases.
A subfield in helical TomoTherapy was defined as the area projected into the isocentric plane which is collimated by directly adjacent leaves in x – and by the jaws in y – direction within one projection. With an in-house matlab tool, the fluence and opening-time weighted average subfield sizes were extracted from the dicom plan.
The further treatment parameters investigated were the actually used modulation factor, the average leaf opening time, the percentage of leaf opening times smaller than 70ms, and the gantry period.
Homogenity index, coverage index, conformity index and some dose constraints for regions at risks were compared to determine the influence on the dose distribution.
The more iterations and the higher the nominal modulation factor, the smaller are the average subfield sizes. The average square field lengths are between 3.5cm and 1.8cm for the investigated range of planning parameters.
A high complexity of the plan, e.g. high nominal modulation factor, low pitch and/or large number of iterations, improves the clinical dose distribution.
The higher the number of iterations, the lower is the used modulation factor, especially for high nominal modulation factors. The average leaf opening time increases with the number of iterations and the nominal modulation factor. However, the percentage of leaves with a leaf opening time smaller than 70ms increases with the nominal modulation factor.

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Dosimetric characterization of microbeams for radiation therapy at the Munich Compact Light Source

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Microbeam radiation therapy (MRT) is a preclinical technique in radiation therapy which employs irradiation of the tumor with a spatially fractionated beam. In our experiment, a tungsten grid in the beam produces 50 µm wide high-dose channels (peaks) alternating with 300 µm wide low-dose areas (valleys). Potential advantages of MRT are a higher tolerance of healthy tissue and thus increased tumor control in comparison with homogeneous irradiation. This therapy method is currently investigated in an in-vivo-experiment with tumor-bearing mice at the Munich Compact Light source, a compact laser-undulator synchrotron source for quasi-monochromatic X-rays tuned to 25 keV. For these experiments, an exact dosimetry and characterization of the beam is necessary, which requires a high spatial resolution and a wide dynamic dose range of the dosimeter. This was achieved by irradiation of radiochromic films (Gafchromic EBT3) with different exposure times to account for the different dose rates in peak and valley, so that on one film the dose in the peaks and on another the dose in the valleys was in the detectable range. The films were evaluated using a microscope, and combination of the films yielded the overall dose distribution. A critical parameter of MRT and its efficiency is the peak-to-valley-dose-ratio (PVDR), which was calculated from the films to be 210 ± 10. For comparison, the complete irradiation setup was also modelled using the Monte Carlo simulation toolkit Geant4. The dose distribution in the film was simulated, varying different parameters like distances of the peaks or beam shape, and evaluating their influence on the dose distribution and the PVDR. The simulation and the measurements are in reasonable agreement, with the simulation yielding 25% lower valley doses than the measurements, resulting in a PVDR of 280 ± 20.

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Evaluation of new gantry angle dependence correction factors for pre-treatment IMRT plan verification with MatriXX Multicube Lite® and myQA®

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The MatriXX® detector has a known chamber response dependence of the gantry angle which can lead to considerable deviations in the gamma passing rates if the detector is not oriented perpendicular to the beam. Together with the Mul-ticube Lite® phantom the detector is positioned on the treatment couch and gantry angle dependent correction factors are needed to maintain the accuracy of measurements. This study investigates the influence of different gantry angle look-up tables (LUTs) for 6 MV photons and the overall performance with myQA®.
myQA® is a quality assurance software (IBA Dosimetry, Schwarzenbruck, Germany) which combines machine quality assurance and patient plan verification. To evaluate the IMRT quality assurance with myQA patients® treatment plans of 15 patients (VMAT, dMLC and SaS) were calculated into the geometry of the MatriXX Evolution™ (IBA) in com-bination with a water equivalent phantom (Multicube Lite™, IBA). The measurements were performed on a 6 MV El-ekta Synergy® machine (Elekta, Stockholm, Schweden) using a fixed setup on the couch and a gantry angle sensor at-tached to the gantry. Afterwards, correction factors were calculated as the ratio of measurements and dose prediction obtained with the TPS (MONACO® v.5.1, Elekta). Original and improved LUTs were applied to the measurements. For evaluation gamma index analyses with 3%/3mm and dose profile comparisons were performed.
With the application of both LUTs the gamma index improved by a mean of 11.2 %. Overall, the correction led to the passing of on average 67 % more of all plans compared to the uncorrected measurements. The gamma passing rate between both LUTs showed an average difference of 0.05 %. Hence, the improved algorithm of the new LUT confirmed the reliability of the original LUT and the myQA® software is a promising method to verify patient plans especially for VMAT cases.

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PRONTOX – a prospective randomized clinical trial for the treatment of non-small cell lung cancer patients at the University Proton Therapy Dresden

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Patients with advanced non-small cell lung cancer have a low overall survival despite intense radiochemotherapy. Radiotherapy is often limited by the toxicity in the surrounding healthy tissue of the lung, oesophagus, spinal cord and heart. The prospective randomized clincial trial PRONTOX (NCT02731001) aims on the analyses of toxicities in patients treated for advanced lung cancer with either photon therapy or proton therapy. Only patients with tumor motion <10 mm are included. Photon and proton treatment plans are created based on time-resolved computed tomography (4D CT) imaging. Both plans are independently evaluated by experienced physicians for their applicability. If both treatments are deemed acceptable in terms of dosimetric parameters, randomization is executed. The dosimetric analysis includes the evaluation of the individual tumour motion and the uncertainties in range (3.5%) and set-up (±3 mm) for the proton treatment. During the treatment, respiratory surrogate signals were recorded for evaluation of breathing variabilities. In addition, control 4D CT were acquired once a week during treatment.
End of March 2017, three patients (all stadium IIIB) were included, of which two had already finished their treatment getting double-scattered proton therapy. For the three patients, tumour motion was negligible and had only small effects on the dose distribution. The additional uncertainty analyses revealed the robustness of the generated proton therapy plans against the individual motion (maximum motion amplitude <2 mm) as well as range and set-up uncertainties. Based on the control 4D CT, changes in the patient anatomy and tumour motion were assessed. For the two patients who already completed treatment, the effect of anatomical changes and tumour motion changes on the fractional and accumulated dose distribution was small. No intervention e.g. a treatment plan adaptation was required in any case. Follow-up showed no recurrence and no side effects for these two patients so far.

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Density calibration of X-Ray CT using flash proton radiography for ion beam radiotherapy

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Precise localization of the target volume and surrounding organs at risk (OAR) as well as the accurate determination of the density distribution is the basis of an effective cancer treatment with ion beams. The standard procedure, using X-ray CTs, implicitly requires the conversion of photon absorption coefficients into ion stopping power. In practice this is performed by a semi-empirical look-up table. This may result in deviations of up to three percent, affecting the ion range calculation and thus impeding treatments close to OAR. In this presentation, we propose a new procedure for calibrating clinical X-Ray CT data using a density distribution obtained by flash proton radiography, therefore avoiding the uncertainties of CT-value conversion and allowing a more precise cancer treatment. Flash proton radiography has been in use for decades in high energy density physics and material science. Recently, the Biophysics Department at GSI Darmstadt, in collaboration with the Los Alamos National Laboratory, has shown its potential for medical applications as well, achieving a spatial resolution in soft tissue in the micrometer range. Encouraged by these results, we focus on the density resolution in proton radiographs of tissue equivalent materials (such as PMMA), with uncertainties below one percent. The acquired density distribution is then used to recalibrate CT data obtained from clinical scanners. The benefits and limits of the procedure introduced will be evaluated using the GSI treatment planning software TRiP98.

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Dose calculation based on Hounsfield Unit calibrated cone beam CT images

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In clinical routine Cone Beam Computed Tomography (CBCT) is used for daily patient positioning but cannot be used directly for daily dose calculations because of the limited image quality. The purpose of this work is to evaluate dose calculation on CBCTs calibrated with the Elekta Hounsfield Unit (HU) calibration algorithm ($CBCT_{HU}$) compared to a conventional planning CT (pCT) and to a scatter correction approach ($CBCT_{cor}$). The scatter correction uses the pCT as a prior to correct the CBCT projections for scatter, facilitating dose calculation on the $CBCT_{cor}$.
We used the Catphan Phantom (Phantom Library), the Gammex Phantom (Sun Nuclear), a PMMA cylinder with Gammex inserts and a 3D printed head phantom (RTsafe, originally used for gel dosimetry). Dose was calculated with the Collapsed Cone algorithm in the treatment planning system Oncentra (Elekta).
CT numbers in HU of the $CBCT_{HU}$ and of the $CBCT_{cor}$ were compared to the corresponding pCT values. For low density structures in the phantoms the mean HU value of $CBCT_{HU}$ and of $CBCT_{cor}$ were within 40HU of the pCT values. In the bony structure the mean HU value of the $CBCT_{HU}$ was 100HU above the pCT value whereas for $CBCT_{cor}$ the mean value was 20HU below the corresponding pCT value. The head phantom with a generic Glioblastoma treatment plan was used to evaluate dose distributions. The mean relative dose difference compared to the pCT for a representative PTV was less than 1% and 0.1% for $CBCT_{HU}$ and for $CBCT_{cor}$, respectively. The maximum relative difference was 3.4% and 2.3% for $CBCT_{HU}$ and for $CBCT_{cor}$ respectively.
A sufficient dose accuracy on $CBCT_{HU}$ was found in the preliminary phantom study. In a next step the study will be extended to real patient data, beginning with brain and head and neck cases.

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Lessons learned about small field dosimetry from the commissioning of a secondary Monte Carlo dose calculation engine for cyberknife

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Recently, ScientificRT GmbH have developed a Cyberknife plan interface for their fast Monte Carlo dose calculation tool SciMoCa. Here, we present results from the commissioning of this Monte Carlo engine for a Cyberknife M6 with different detectors for small field beam data acquisiton. A SRS diode type PTW 60018 (unshielded) and a microDiamond detector type PTW 60019 were used for the beam data measurements in a water tank for the Monte Carlo commissioning.
Since the actual field sizes for the Cyberknife fixed cones can differ from the nominal sizes by more than 1mm, precise measurements are necessary for the commissioning. While unshielded diodes are often used for Cyberknife beam data measurements, comparisons with the microDiamond detector showed remarkable differences in the out-of-field low dose regions as well as for the output factors. The Monte Carlo calculations confirmed that the SRS diode shows a distinct overresponse in the low dose regions, which gets higher with increasing measurement depth and seems to be specific for the spectral characteristics of the Cyberknife beam.
Using the microDiamond data, validation of the Monte Carlo beam model yielded good agreement with the measurements. Maximum deviations in the penumbral regions of the cross profiles amounted to 1/10 mm. The output factors agreed within ±0,3%.
The results show that the Monte Carlo dose calculation can be used to detect inconsistencies within a set of beam data measurements, and illuminate new aspects regarding detector selection for Cyberknife beam data measurements. Because of the high accuracy, the Monte Carlo dose engine in future could also be used as reference for the evaluation of additional dose calculation algorithms that are in clinical use for Cyberknife, such as the newly introduced Pencil Beam algorithm for the InCise2 MLC, and for the recalculation of patient treatment plans.

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Investigation of dynamic treatment beam geometries in stereotactic radiosurgery for intracranial lesions involving couch motion and their quality control procedures

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The purpose of this study is to determine appropriate beam arrangements for VMAT based stereotactic radiosurgery of intracranial lesions involving couch motion (noncoplanar (NC-) VMAT). Limited by the construction of today's c-arm linear accelerators only a dedicated combination of couch motion and gantry rotation settings is possible and has to be adapted to the patient's anatomy. The combination of these two motions requires the implementation of further quality control procedures such as mapping the geometric precision. Therefore this study also introduces and demonstrates quality control procedures for radiation delivery techniques, combining couch and gantry motion.
27 patients recently treated with coplanar (CO-) VMAT were selected randomly from our clinical database. The prescribed dose was 22 Gy (for PTVs smaller than 5 cm^3) and 20 Gy (for PTVs up to 15 cm^3) delivered in one fraction. CO-VMAT plans consisted of one full arc, whereas NC-VMAT plans combined partial arcs to different couch angles at a single isocentre. This study uses a commercial treatment planning system (Pinnacle³, V. 14, Philips, Amsterdam) and a 6 MV linear accelerator (Axesse with Agility multi-leaf collimator, Elekta, Stockholm). NC-VMAT and CO-VMAT plans are compared according to standard criteria for treatment plan quality and delivery efficiency as there are the dose-volume-histogram, homogeneity index, conformity index, gradient index and monitor units.
This study demonstrates that the integrated combination of beam angle optimization and couch rotation can significantly reduce mean dose in the neurocranium keeping the maximal dose in critical serial organs as brainstem and chiasm below a fixed threshold value. PTV coverage is almost identical for all approaches. Furthermore methodical approaches extending the image-based tracking of a fiducial attached to the treatment couch shall be subsequently developed.

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Towards clinical quality assurance of deformable image registration for each individual patient – scientific visualization for exploring uncertainties

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In radiation therapy, deformable image registration methods are increasingly utilized in clinical routine. Getting better at measuring relevant anatomical changes in images throughout the treatment course, this methods promise to propagate contours to deformed geometries and merge multimodality scans despite different acquisition positions. Yet, accuracy and precision of available deformable image registration algorithms, while considered useful in combination with manual corrections, has not reached a level required for adoption in time-efficient workflows in clinical use. Quality assurance for resulting vector fields is an urgent challenge. However, current evaluation methods applied in scientific community, based on expert-defined landmarks or contours, are too time consuming to be applicable for each individual image of each patient. Therefore, visualization tools are still used to rate the quality of the registration leaving users uncomfortable regarding the uncertainty estimation. We present and discuss approaches expanding visualization techniques to explore the realism of registration results combining 4D volume rendering techniques with interactively selectable analysis functionalities allowing to calculate and display associated geometric and dosimetric uncertainties. Animated 3D representation of patient data allows the human brain, trained to identify meaningless motion patterns, a much detailed assessment of the realism of anatomical changes compared with 2D fusions. Interactively positioned points of interest, following the vector field in the animation, guide the eyes in multiple synchronized views selected by the user (e.g. volumes with different transfer functions for CT or MR grey level windows or fusion with structure sets and dose distributions). In case competing registration results are present, their synchronized display facilitates a direct comparison. While descriptive quantitative quality measures for deformable image registration results are still subject to investigation, extended visualisation techniques might help to bridge the present gap in quality assessment of deformable image registration methods in clinical trials and off-label use.

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Combined PET-MRguided focused ultrasound and radiation therapy to improve treatment of cancer

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Based on the thermal and mechanical effects on tissue, focused ultrasound (FUS) obtained an increasing role in medical applications. Radiation therapy (RT) is used as a main modality for treatment of cancer patients in the clinic. The aim of SONORAY project is to tap the synergistic effect of these two tissue destroying energies for a combined approach in treatment of malignant tumors and metastases. Due to poor availability of data which shows the impact of acoustic waves on tumor cells and tissue, we investigated biological fundamentals and developed computer-aided model formation.

A novel cell sonicator was developed with 96 single transducers generating homogenous ultrasound at an operating frequency of 1 MHz (maximum energy: 0.05 W/cm^2). A 150 kV X-ray machine (DARPAC 150-MC) was employed for irradiation at doses of 0 – 20 Gy. The analysis was conducted by using three different cell lines for prostate cancer (PC-3, Vcap, LNcap), glioblastoma (LN405, U87, T98G) and head/ neck cancer cell lines (FaDu, UT-SCC 5, UT-SCC 8). Effects at the cellular level on metabolism (WST-1), proliferation (BrdU), membrane integrity (LDH release) and apoptosis (Annexin V) were detected after treatment.

Our preliminary RT results showed dose dependent loss in cellular NAD(P)H levels of 60% for LN405 and T98G cell lines at 20 Gy and only a slight decrease of 30% (20Gy) for U87 and FaDu cells. A release of LDH was only observed for T98G cells from 4% (0 Gy) to 17% (20 Gy). The highest impact of RT was detected during analysis of DNA synthesis (BrdU) which nearly stopps at dosages above 5 Gy.

In conclusion, a fitted treatment for each cell line will be necessary based on the different radiosensitivities. Future *in vitro* investigations of effects of ultrasound as well as of a combined therapy on these tumor cells need to be conducted.

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Development and implementation of 3D-dosimetric end-to-end tests in adaptive radiation therapy of moving tumors

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Clinical implementation of novel advanced treatment techniques in adaptive radiation therapy requires proper workflow verification. However, this subject is not satisfactorily solved yet as current experimental validation techniques do not reflect the complexity of real patient treatments. In this work, several methods for patient-specific end-to-end tests were developed and applied to clinical workflows especially including treatments of moving tumors. End-to-end-tests were performed with geometrically well-defined phantoms as well as with an anthropomorphic dynamic ex-vivo porcine lung phantom in combination with a 3-dimensional (3D) polymer gel dosimeter (PGD). Different experimental settings of increasing complexity were tested in terms of (i) accuracy, (ii) feasibility of clinical workflows testing, (iii) validation of clinical concepts for motion-compensated treatments, (iv) additional integration of real-time markerless fluoroscopic imaging, and (v) validation of 4D dose calculation algorithms. Phantom irradiations were performed under static and dynamic conditions with and without beam gating. PGD evaluation revealed good tumor coverage for all treatment concepts and beam gating significantly reduced normal tissue exposure. In all cases, good agreement with the calculated dose distribution was obtained. As a conclusion, the established experimental workflow provides a versatile and valuable tool for geometrical and dosimetrical validation of advanced motion-compensated treatment techniques in adaptive radiation therapy.

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COMPASS-NRW – a dosimetry initiative of the regional section west of the DGMP (RSW-DGMP) to verify dynamic irradiation techniques

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Dynamic irradiation techniques like IMRT and VMAT rank higher in today's radiation therapy of malign diseases. However, the advantages with regard to dose conformity and protection of organs at risk are closely linked to higher technical implementation requirements by the linear accelerator. This is taken into account by an increased and extended machine and patient based quality assurance (QA). Parallel to an intensive QA, the authorities' request demands to recalculate a treatment plan, planned with a commissioned treatment planning system (TPS), with a second independent system. Physicists of the RSW-DGMP formed a collaboration to survey strategies, limits and prospects of a patient based QA by performing verification measurements. Centerpiece of this project is the online monitoring system Dolphin® in combination with the 3D patient dose analyzing software COMPASS (iba-dosimetry, Germany). The project is organized into four steps: 1. Validation of the beam-modelling for COMPASS; verifying and tuning of the implemented machine models. 2. Plan verification via calculation; standardized patient plans, generated by the institutions specific TPS, will be recalculated with COMPASS. 3. Measuring the standardized patient plans with Dolphin®; calculating the measured dose distribution based on the patient CT-data and comparing it to the distributions computed with the TPS and COMPASS. Here the focus is on the impact of patient plan modulation caused by steep dose gradients near organs at risk. 4. Evaluation of these results based on QA-methods of each institution. A further aim of the project is to define standardized criteria for the evaluation of patient based QA. For this project we are equipped with Elekta (Agility™, MLCi2, Beam modulator) and Varian (Clinac®, Truebeam™) linear accelerators, the TPS Philips Pinnacle³, Elekta Monaco® and Varian Eclipse™ and the QA systems PTW Octavius® (2D and 4D), Sun Nuclear ArcCHECK® and Varian portal dosimetry.

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Software commissioning of a Monte-Carlo model for the double-scattering treatment head at University Proton Therapy Dresden

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Compared to treatment planning systems (TPS) in proton therapy, Monte-Carlo (MC) simulations have the potential to describe radiation fields in patients more precisely. However, this requires, besides an accurate MC model of the treatment head, a thorough benchmarking with respect to dose measurements. The purpose of this work was to set up and validate a MC simulation model of the clinical proton treatment fields at the University Proton Therapy Dresden (UPTD).
A detailed model of the treatment head geometry of the UPTD in double-scattering mode (based on design drawings and measurements) was implemented using the MC simulation environment TOPAS. The proton beam source was optimized to match measured reference depth-dose distributions for all clinically available treatment field options at UPTD. The commissioned software model was validated against an independent set of clinical depth-dose and lateral dose validation data measured in a water phantom. A setup for the direct simulation of monitor units (MU), relating dosimeter readings in the treatment head to absolute dose in a water phantom, was implemented and benchmarked by absolute dose measurements.
Validation data on depth-dose distributions were reproduced within range differences of 0.26 mm and a relative dose uncertainty of 1% for all treatment options (i.e., comparable to measurement uncertainties). Simulated lateral dose profiles differed from validation data in lateral width and penumbra less than 0.95 mm and 0.56 mm, respectively. Measured MU values were predicted within 2% accuracy for several reference and patient treatment fields.
The commissioned MC model reproduced the dose validation data (measured during the clinical validation of the UPTD) within clinical tolerances. Hence, it enables high-precision simulations of clinical treatment fields and has the potential to predict patient-specific MU values to save expansive experimental beam time.

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Predicting clinical relative biological effectiveness in proton therapy based on (pre-) clinical dose response

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Currently, modelling of the relative biological effectiveness (RBE) for proton therapy as function of physical parameters, such as linear energy transfer (LET), receives increasing attention. However, clinical application of RBE models is primarily hampered by large uncertainties in the biological input data, especially, when derived in vitro. This study demonstrates the feasibility of using (pre-) clinical fractionation response data to estimate RBE in proton therapy.
An analytical description of RBE – independent of ion type and LET – was derived. It depends on dose, photon radiation response, and beam quality parameter Q defined as Z2/E (Z, E: ion charge, kinetic energy). Validation was performed with a large set of in vitro literature RBE data for different ions and cell lines. Furthermore, pre-clinical RBE literature data of the rat spinal cord (myelopathy) for fractionated carbon irradiation were analysed as function of Q. From their dose response to fractionation, linear-quadratic α_p and β_p parameters for particles were obtained for each Q value.
The derived model predicts a linear increase of α_p and RBE with Q. For all analysed cell lines, in vitro α_p and RBE data increased linearly with Q independently of ion type (for $Q < 2.5$). Also, the pre-clinical α_p from fractionation response increased linearly with Q while β_p hardly changed – both in accordance with the derived analytical description. Knowing α_p and β_p as function of Q allowed for a direct calculation of the measured RBE values.
RBE in particle therapy seems to be largely independent of ion type when parametrized by the beam quality Q. Clinically accessible data on fractionation response appear sufficient to estimate the RBE for a given Q. Clinical experience with a variable RBE from carbon ion therapy may be directly translated to proton therapy using the beam quality Q instead of LET (to describe ionization density).

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T-REF chamber – a new ion chamber tested for iris quality assurance and output check

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Purpose: Robotic stereotactic radiotherapy with the CyberKnife (CK; Accuray, Sunnyvale, USA) is usually carried out either with fixed collimators or using a multisegment collimator called Iris. Since field size of the Iris is variable, the settings have to be checked on a regular basis which is usually done with film. Replacing film with an ion chamber using the dose-area product (DAP) as figure of merit (Djouguela 2006) has the potential of greatly facilitating these checks. In addition, especially the T-REF chamber may also be used for output measurements and possibly for online dosimetry.
Material: The measurements were carried out on a CK robotic linac (Vers. 9.6) with collimator settings from 5 to 60 mm diameter. As ion chamber, a newly available plan parallel chamber (type 34091; PTW, Freiburg, Germany) with a diameter of 81.6 and a water equivalent thickness of only 2.1 mm was used (Ceska 2016). Film measurements were carried out with Gafchromic EBT3.
Results: The reproducibility of the DAP measured with the T-REF chamber is very good, the standard deviation being 1.0 % (relative to the DAP) or less, corresponding to 0.33 mm in diameter for the worst case, less than 0.07 mm for all other cases. The respective values for the film measurements are 1.4 % and 0.27 mm.
Conclusions: DAP measurements with the T-REF chamber are well suited for quality assurance of the CK Iris collimator. Results are comparable to those acquired with standard film measurements. Though it is not an absolute measure of the field opening the measurement seems to be more robust. By the same token this is also a check for constancy of the outputfactor of the CK. Furthermore, a construction is in the making to enable the T-REF for online transit dosimetry, the results of which will be presented at the conference.

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Determination of MCVT-Dose in helical IMRT

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For the treatment of patients using helical IMRT (Tomotherapy, Accuray) a MVCT is going to be performed for precise positioning on regular bases. Depending on the requirements for more precision in individual patient positioning, the MVCT will be perform in different slice thicknesses. This kind of MVCT-imaging enables a more precise application of the dose delivery in helical IMRT. Moreover with this kind of IGRT anatomic changes could be immediately respected for by using adaptive planning. But the MVCT generate an extra exposure to the patient especially where no PTV is set. Therefore this exposure needs to be examined and documented. This will be required by legislation in the near future.
About a precise evaluation of the dose of the MVCT in helical IMRT is not much known. In this investigation a systematic determination of the MVCT in different anatomic region will be evaluated. For dose determination in helical IMRT an algorithm has been developed for all MVCTs (Accuray). How this algorithm is functioning is described at Shah et al. (2005). For the MVCT-exposure the MCVT-dose engine (DoseCalc, Accuray) will be evaluated at 25 patients in 5 typical anatomic regions. The validation of those calculations will proof using a tissue-equivalent phantom. The accumulated dose and die dose distribution of the MVCT in those anatomic regions measured. Therefore the influence of different acquisitions parameter, such as pitch, slice thickness und scan length will examined at the phantom. In order to validate the calculation results dosimetrically, ionization chamber measurement will be performed using the Cheese phantom (Standard imaging). Based on those dose measurements a database for all clinical situations using MVCT-based IGRT will initiated; this database hand out information about the organ related dose and additional exposure for all organs of patient involved in the MVCT-imaging process.
As well as the measured dose for each MVCT-scan related to an anatomic region and the parameters under investigation and the calculation and the patient and the tissue-equivalent phantom are in dimension of 10-40mGy. These results are in very good agreement with measurements done by Mege et al. (2010). These acquired results will be used for the required documentation of the additional exposure of the MVCT.
It is recommended that the dose generated by the MVCT-based IGRT should be less the 5% of the total dose. Our dosimetric measurements demonstrate that a responsible use of MVCT-imaging in all scenarios of helical IMRT (tomotherapy) could easily establish this threshold.

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Dosimetric comparison of intensity modulated radiotherapy techniques in head and neck cancer

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To evaluate and compare dosimetric parameters of intensity modulated radiotherapy (IMRT: step and shoot (S&S), and sliding window (SW)) and volumetric modulated arc therapy (VMAT) for head and neck cancer.
Dose-volume-histograms of patients with naso-, oro- or hypopharyngeal cancer planned using Eclipse treatment planning system (v11) for IMRT, S&S (n=53) or SW (n=33), or VMAT (n=11) were studied. For the radiation techniques various linear accelerators were used. All machines used 6MV photons. Irradiation of target volumes (CTV, GTV), organs at risk and normal tissue were compared. Parotid analysis was performed considering two subgroups according to tumor localization. Furthermore the homogeneity index was evaluated. Statistical significance was assumed when $p<0.05$ using the two-sample t-test.
For CTV, SW provided better results for mean Dose [%] in comparison with S&S (106,02 vs. 111,67 (p=0.007)) and VMAT (106,02 vs. 117,78 (p=0.001)). There were no significant differences among all three techniques for GTV coverage.
In terms of mean doses delivered to parotid glands, S&S lead to the most efficient reduction for tumors localized in the naso- and oropharynx region, whereas no significant differences were observed for tumors in the hypopharynx region. Maximal doses delivered to the spinal cord were similar for all three techniques.
For D0.1cm³ of the skin, SW was significantly better than S&S in terms of lower irradiation (98,45 vs. 104,71 (p=0.002)), whereas no significant differences were observed for skin D1cm³ among all techniques. For normal tissue, V20 Gy, SW was significantly inferior to the two other techniques (SW 27,33 vs. VMAT 21,26 (p=0,024), SW 27,33 vs. S&S 23,12 (p=0,004)). Homogeneity index values were altogether satisfactory, being best with SW for CTV.
All three techniques provided satisfactory results without significant differences except for the slight superiority of SW in terms of target volume coverage and for skin sparing, but sacrificing normal tissue efficiency.

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Uptake dynamics of graphene quantum dots into primary human blood cells following in vitro exposure

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Human leukocytes obtained from samples of leukapheresis products of three healthy donors stimulated by granulocyte colony stimulating factor (G-CSF) were exposed to graphene quantum dots. A time- and concentration dependent uptake was observed with a significantly greater uptake into monocytes and granulocytes in comparison to lymphocytes, suggesting a better incorporation ability of cells with phagocytotic properties. We estimate that one cell can incorporate up to 2 billion quantum dots without significant viability changes. The uptake rates also correlate with the cell membrane area. Looking at the different lymphoid subsets a greater uptake was found into CD19+ B-, CD56+ natural killer cells and CD34+ hematopoietic stem cells (HSC) in comparison to CD4+ T- and CD8+ T cells. Independent of the cell type studied, the observed uptake dynamics is consistent with a diffusion-driven process, which allows the determination of cell-specific membrane permeabilities for the graphene quantum dots.

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Self-cleaning materials using the photocatalytic effect of titanium dioxide

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Germs are present in all areas of everyday life and can lead to dangerous infections. Surfaces with antimicrobial properties are used to reduce the risk of infection in sanitary facilities and hospitals. Apart from the addition of biocides or antibiotic agents to synthetic materials, recent studies show that applying the semiconductor titanium dioxide (TiO_2) generates antibacterial surfaces. The photocatalytic active TiO_2 leads to the development of reactive oxygen species (ROS) that are able to kill germs. The aim of the present study is to use TiO_2 to generate antibacterial polymeric bulk materials. AEROXIDE® TiO_2 P25 and KRONOClean® 7000 were incorporated in different polymeric materials to find the best TiO_2/polymer combination concerning photocatalytic and antibacterial activity.
As matrix material TPS and TPU were compounded with different concentrations of TiO_2. Test samples were produced by injection molding. The photocatalytic effect of the test samples was investigated by using contact angle measurements (photo induced superhydrophilicity) and methylene blue trials, before and after irradiation with UV light. In addition specimens were treated with plasma to increase the photocatalytic effect. The antimicrobial effect was examined by detecting the reduction rate of E.coli on photocatalytic active TiO_2/polymer compounds in microbiological tests.
An incorporation of titanium dioxide in the matrix materials up to 20 wt% was possible. After electromagnetic irradiation (UV) and plasma treatment the samples showed different intensities of the photocatalytic effect depending on the concentration of titanium dioxide. Evidence of a biocide effect was determined.
The study indicates that using titanium dioxide as an additive is a promising approach for the development of polymeric materials with antimicrobial properties. Further modifications of titanium dioxide compounds, long-term stability trials, investigation on mechanical properties and benchmarking with biocide disinfectants will be part of future investigations.

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Impedance spectroscopy as a new tool to monitor re-epithelialization in wounded reconstructed human epidermis

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Here we present a new in vitro test method to determine the efficacy of wound healing therapies in a physiological human three-dimensional environment, which could help to reduce the amount of animal testings. For this, we developed procedures to introduce and non-destructively assess wounds in reconstructed human epidermis (RHE) that closely resembles the histological architecture of human epidermis. Following maturation, RHEs with a surface area of 1.1 cm² were injured locally with a dermal punch (3 biological replicates with 8 technical replicates) resulting in defined wound areas of 3.1 – 50.2 mm². Subsequently, epidermal wound healing (EWH) was monitored for 14 days using a highly sensitive and non-invasive method called impedance spectroscopy (ImpSpec). The epidermal barrier was estimated by calculating the transepithelial electrical resistance at 1,000 Hz ($TEER_{1000}$) as well as fitting an equivalent circuit modeling the measured impedance spectra and resulting in the tissue's resistive and capacitive properties. After wounding, ImpSpec analysis showed an instant drop in the $TEER_{1000}$ and in the fitted resistance R_{RHE} by 7.6 kΩcm² (-95.2%) and 20.8 kΩ (-98.5%) respectively. This initial loss in impedance and the efficacy of EWH strongly depends on the wound size (-93.1% $TEER_{1000}$ and -97.6% R_{RHE} for 3.1 mm² to -98.3% $TEER_{1000}$ and -99.9% R_{RHE} for 50.2 mm² wound size). With ImpSpec, the recovery of the epidermal barrier can be monitored on-line and correlated to microscopic imaging of wound closure. Within 14 days, the $TEER_{1000}$ and R_{RHE} recovered and increased significantly. Additionally, EWH was histologically analyzed, confirming re-growth of a basal layer via migrating and proliferating keratinocytes in early stages of EWH. Along with the increasing impedance during EWH, the gradual regeneration of spinous and granular layer in the interim phase and the formation and strengthening of a high-resistive stratum corneum in the late phase of EWH was observed.

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Engineering of organoid blood vessel patterns with regulated hemodynamics by exosomal functional somatic noncoding RNA angio-morphogens [angiotropins]

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Objective: Different vessel phenotypes result from vasculo-, angio-, arterio- and lymph-angiogenesis by complex interplay of various cells and factors [proteins, RNA, metal ions, metabolites, hormones, environment]. Beyond genetics, diversity, complexity and tolerance of vascular phenotyes are vice versa requisites for function and survival of networked tissue cells with interfaces upon intrinsic and extrinsic [environmental] needs. It may be manifested beneficial or maladaptive entangled with e.g. implant- or cancer-angiogenesis-tolerance reactions. This investigation aimed at whether angio-morphogen RNA sequences for organoid capillary patterns are from inherited germline [Mendelian] or non-Mendelian somatic origin which retranslation does not anymore fit to inherited genes.
Methods: Angiotropin-RNA [ARNA] and MIR126 genes of microRNA-126 [miR-126] structures were used.
Results: miR-126 are small Mendelian split products of MIR126 genes. ARNA are exosomal RNP angiomorphogens from stressed mononuclear cells [shear, exercise, hypoxia, etc.], sequenced after isolation from extracellular fluids where it is active in vitro and tissue to form organoid capillary patterns: By metal ions [Cu, Ca, Na, K], a Mendelian-coded angiotropin-related protein [S100-A12] folds to a stable complex with a somatic non-Mendelian functional $^{5'}$end-phosphorylated, edited, modified, redox- and metallo-regulated non-coding hairpin ARNA [75n] with $^{5'}$CUG$^{3'}$-hairpin loop and modified bases isoG / adenosine-N1-oxide from Fenton-type redox-OH*/NO*-radical modification of adenosine. It is shown that ARNA are formed by stressed mononuclear cells by rearrangement, recombination, mutation, editing, modification, redox- and metalloregulation of inherited MIR-126 gene segments.
Conclusions: The results suggest novel targets for vascular therapy. Some aspects of non-Mendelian ncRNA resemble somatic generation of immune diversity. In this special case, all is achieved on the DNA level under antigen attack, namely for coding new proteins. Here, a general principle is disclosed operated by cells on all nucleic acid, protein and carbohydrate levels to manage any diversity and complexity problems with limited sets of inherited DNA in response to environmental chance reactions.

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Differentiating PPIX from its precursors as a strategy for drug-light interval assessment in photodynamic therapy

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Photodynamic Therapy (PDT) is based on the generation of Reactive Oxygen Species (ROS) inside tumours that destroy cancer cells. The procedure involves three main components: injection of a photosensitizer (PS), presence of oxygen, and light to start the process. Certain variables involved make the process difficult to monitor and optimise. The PDT process starts with the transport of PS inside the tumour, either exogenously or by inducing the synthesis of the PS endogenously to increase selectivity. The drug used to induce the endogenous production is Aminolevulinic Acid (ALA), which is gradually converted to a PS inside the tumour cells. The PS mainly involved is Protoporphyrin IX (PPIX). The interval of time between inoculation and light delivery is known as “Drug-Light Interval” and is one of the main variables influencing outcome of PDT. Based on fluorescence, the sequence of the intensity values of the fluorescence provides information about this interval by assuming the biggest peak as the optimal irradiation time. Too early or too late means that a sufficient concentration of PPIX cannot be ensured in strategic locations inside the cell jeopardising the therapy efficiency. Fluorescence gives no additional information about the actual position and amount of porphyrins inside the tissue. The best starting time for light delivery would be high concentration of PPIX inside the mitochondria. A way to determine this is to monitor the concentration of two precursors of PPIX, Uroporphyrin III and Coproporphyrin III, which are formed outside the mitochondria. We present a novel detection method for differentiating PPIX from these precursors, by monitoring the porphyrins at the same pH and focused on the main emission peaks between 600 – 650 nm, after excitation at 405 nm. The two precursors were distinguishable from PPIX at various concentrations. With this method, localized changes in porphyrin concentration can be identified.

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Automatic algorithm to generate customized microporous membranes by additive manufacturing

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Membranes have a wide spectrum of applications in medical devices. They are crucial elements e. g. in technologies for dialysis, fractionation of blood and clean rooms. Furthermore, in in-vitro diagnostics and bioreactors customized membranes are required to realize compartments. Additive Manufacturing (AM) allows to generate microporous membranes. Therefore, multiple layers with pores are printed with an offset to one another to overcome the restricted resolution of AM methods. Compared to conventional technologies AM can generate customized membranes regarding both filter geometry and pore diameter.
In this study we developed an algorithm in Blender 2.78a for customized membranes. The user can specify the desired pore size, pore form (triangular, rectangular or circular), dimensions of the membrane and whether or not a fixation frame is needed. The minimum pore size, layer height, and need for support structures were stored as pre-settings according to the selected AM technology. Additionally, a method to derive technology-dependent compensation values to improve the accuracy and reproducibility of the pores size, was established. So far two different additive manufacturing technologies were evaluated: Digital Light Processing and Multi Jet Modelling.
To validate if the desired pore size complied to the actual pore size, the membranes were tested with glass beads in following ranges: 0-50, 40-70, 70-110 and 90-150µm. The amount and diameter of glass beads before and after a filtering process, conducted for 2 min in a shaker unit, were analysed by automatic image analysis (Image J). The results showed an efficiency comparable to commercially available wire mesh membranes. So far the reproducible pore size was reduced to a minimum of 40 µm. Further reduction was limited, since the variance of the printing accuracy exceeded the pore size. Combined with improved printing technologies we expect our introduced approach to overcome these limitations in pore size.

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Additive manufactured multimicrophasic (MMP) systems for biomedical applications – perspectives and concepts

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Additive manufacturing is one of the most trendsetting technologies. So far its main advantage is seen in the freedom of design which allows the single-step fabrication of complex parts with undercuts and lightweight construction. However, further progress in 3D printing technology regarding machines and materials such as improved printing resolution, multicomponent printing, and printability of challenging materials including high performance polymers (e.g. PEEK) and elastomers (e.g. TPE, silicone rubber) offers options for further innovations.
In this study we demonstrate the 3-D printing of multicomponent materials with oriented inner structures on a microscale level, which we name multimicrophasic (MMP) systems. An important feature of MMP systems for biomedical applications is the possibility of realizing defined anisotropic properties. Combination and controlled micro arrangement of various materials with deviating hardnesses (e.g. thermoplasts + elastomers) via 3-D printing creates parts with smooth hard-soft-transitions, as well as orientation dependent tensile and compression properties. Thus the MMP approach allows the fabrication of biomedical parts imitating the biomechanics of the human body.
A further promising perspective of MMP parts for biomedical applications is the possibility to realize a new quality of biodegradable systems. By combining materials in the printing process with different rates of degradation the disintegration of parts can be adjusted in a time and location dependent way. This approach also allows changes of part properties over time, like growing pores within scaffolds or a stepwise reduction of part stiffness for healing stage adapted implants.
In our presentation we will demonstrate various examples of MMP parts featuring the above mentioned properties. Furthermore, we will address future technological challenges to promote the MMP approach. We will show that additive manufacturing offers not only new options for geometric part design but also possibilities to realize so far impossible material properties.

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Current developments of an in vitro wound healing experimental system for photobiomodulation therapy research

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Wounds remaining unhealed after three months of standard care require advanced wound healing therapy. Photobiomodulation (PBM) applies light as treatment and can influence chronic wound healing processes. The dose-response of PBM-treated in vitro and animal tissues is observed as biphasic, where cellular activity is activated or inhibited at a threshold light dosage. Light is fundamental to the therapeutic processes, however ‘the medicine’ (light properties) and ‘the dose’ (irradiation parameters) delivered to the system are often unverified or not reported in the literature. More understanding of the relationship between PBM treatment and biological response is necessary to optimize PBM as a clinical therapy to modulate chronic wound healing. Our overall aim is to develop a multi-modal advanced wound healing device that applies a combination of mechanical pressure, electrical fields, and light as treatment for chronic wound healing therapy. This work represents the current developments of our PBM device, study system, and analysis techniques towards a pilot study. Our wound system is an in vitro 3D organotypic tissue consisting of keratinocytes on top of a collagen dermal equivalent embedded with fibroblasts, macrophages, and neutrophils. We developed an image acquisition and planimetry system to measure the wound surface area and used these systems to develop a reproducible wounding technique. Our developed PBM device can operate in an incubator and is flexible to be configured to apply a range of therapeutic ‘medicines’ at a prescribed ‘dose’ in specification. We will apply a specified and verified light treatment to wounded tissue samples over 21 days. The dose-response will be evaluated by the wound surface area reduction and rate of wound closure as compared to untreated wound controls. This pilot study will demonstrate the first treatment application of our developed PBM device.

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Novel three-dimensional (3D) microtissues for the discovery of chemoradiation-sensitizing compounds

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The rapid evolution of resistance to both conventional and small molecule therapies is a challenging problem in oncology. One approach to overcome resistance is to use combinatorial treatments that exploit the synergies between different therapy modalities. The combination of chemotherapy and radiation treatment is emerging as a potentially effective combinatorial regimen, although the optimal mix has not been identified so far.
3D tumor spheroids have been used as relevant biological models for oncology drug discovery for many years, as 3D cell culture systems can provide a better representation of tissue-level biology over classical 2D culture systems. However, aside from chemotherapeutic interventions, these 3D models are also highly valuable tools for emulating radiotherapy *in vitro*. We have adopted innovative 3D-microtissue 96-well plate technology for the screening of potential radio-sensitizing compounds on tumour cells. We followed the response to radiation and drug-treatment of radiation on breast cancer and glioblastoma cells stably transduced with a GFP-expressing lentiviral vector. High throughput quantification of tumour 3D-microtissue growth was assessed in real time using the high content imaging platform (PerkinElmer, USA).
We have validated the tumour 3D-microtissue model by comparing the treatment of microtissues with different chemotherapeutic compounds used in the clinic and additionally analyzed novel HDAC inhibitors and MEK inhibitors of the MAPK signalling pathway. Results for Docetaxel, Doxorubicine, 5-FU, Vinblastine, SAHA and MEK1 inhibitor treatment showed that the corresponding IC50 values were improved by a single 2Gy or 4Gy radiation dose on radioresistant tumour cells. This screen confirms that the assay using the 3D-microtissue model system is able to detect novel compounds that modulate tumour cell survival after irradiation.

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Aspects of functional electro-chemical biocompatibility in microsystems

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Cells, same as macroscopic organisms, require a function saving environment that ensures a continuous exchange of substances, energy and information. Signal transport as well as signal processing are totally based on ion or molecule fluxes. When contacting living cells with metallic electrodes, several side effects like polarization, transition impedance, chemically induced corrosion etc. appear.
Bases of a general understanding of functional electro-chemical biocompatibility aspects in the area of microsystems are introduced, derived from experiences in several research projects.
We focus on hybrid microsystems to accommodate biologic specimen inside technical structures even for long-term experiments. First knowledge and engineering experiences were the synthesis of extracellular matrices (‘ECM’) and the fluidic support for the ion-management of crystalloid P-Proteins (‘Forisome’).
In microstructures, the domination of surface-related interactions makes the substance and energy transfer on interfaces to be a crucial and dynamic part. Respecting these propositions, microsystems allow for micro-chemical stimulation of cells as well as signal derivation on cells using ionomeric intermediate layers. One major part was the utilization of active polymers such as ‘Nafion’™.
We tested this approach in several experiments. One setup is a planar flow-through chamber with non-polarisable electrodes in which the galvano-tactic behaviour of protozoa could be observed. A double-chamber setup utilizes a cation-permeable membrane of Nafion™ to separate two fluidic compartments. In these, a concentration gradient is established between isotonic NaCl-solution and distilled water. This gradient generates a reproducible potential in a physiologically relevant level.
One functional criterion of life, even in technical environments, is communication. To avoid the aforementioned disturbance of side effects, a non-electric control of ion flux can be implemented using UV-light.
To maintain an undisturbed signal transfer from and to the technical systems and their electron-electric parameters, we found a suitable biological analogy in the primary cell-cell contacts, the so called gap junctions.

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Development of cell-laden electrospun hybrid membranes for blood propulsion devices

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Coagulation on the surfaces of blood-contacting materials is a major problem for ventricular pulsatile assist devices causing fatal complications for patients. Therefore, improved hemocompatible materials with appropriate elastic properties are urgently needed. In nature, the endothelium of blood vessels intimately regulates a range of physiological vascular functions including the prevention of thrombosis. The aim of this project is to develop a non-thrombogenic hyperelastic membrane for pulsatile blood propulsion devices inspired by nature's design of the blood vessel structure. For this, we are exploring cytocompatible fibrous polymer networks incorporating smooth muscle cells embedded within the three dimensional structure, and endothelial cells on its surface to mimic the native blood-tissue interface. Furthermore, novel concepts to enable targeted and stable long-term adhesion of these two cell types to the polymer network are developed in the frame of this biomimetic approach.
As a first proof of concept, 3D networks made of polymeric fibers (e.g. PVDFhfp) incorporating muscle cells (C2C12 murine skeletal myoblasts) were created by a simultaneous process of polymer electrospinning and cell electrospraying, including a preliminary cell encapsulation step by microfluidics (Gelatine) for cell protection against toxic solvents. Live/dead staining as well as microscopic cell analysis reveal no negative effect on viability and the expression of the characteristic cell phenotype compared to control samples.
Furthermore, in contact with blood fiber diameter and fiber surface topography were found to greatly influence the early events leading to thrombus formation, i.e. platelet adhesion and formation of a fibrin network. In a next step, complex 3D structures with smooth muscle cells homogenously distributed in the polymer network and endothelial cells covering the top surface will be developed.
This work is part of the Zurich Heart project of "Hochschulmedizin Zurich".

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The effect of patient-specific parameters on the required quantity of apheresis cycles and the CD34+ yield of autologous stem cell donors

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Introduction: In order to conduct a stem cell apheresis prior to a respective therapy, stem cells have to be mobilized from the bone marrow into the peripheral blood. In this paper we elaborated patient-specific as well as diagnosis-independent parameters, which have an influence on a successful stem cell mobilization.
Methods: Retrospective data were obtained from 300 apheresis cycles of 175 patients in the years 2009 to 2011. Correlation of potentially predictive factors (sex, age, BMI and CD34+ initial value) and quantity of apheresis cycles and CD34+ outcome was statistically analyzed using SPSS20.
Results: Using a demand-normalized analysis, there is no statistically significant correlation between age, BMI or sex and number of apheresis cycles needed. The p values were found to be 0.44, 0.53 and 0.86, respectively. Regarding the initial CD34+ value the p value of 0.017 displays a statistical significance in correlation to the applied apheresis cycles. As an example, donors showing < 15 CD34+ cells/µl needed in the mean 3.6 apheresis cycles, donors showing > 100 CD34+ cells/µl needed in the mean 1.1 apheresis cycles.
Conclusion: The initial CD34+ value could be identified as significant predictive factor for successful apheresis. The consequence for practical applications is the use of a drug-modified mobilization in case of patients with a low CD34+ initial value.

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High resolution photopolymerization technique for fabrication of hydrogel based scaffolds

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To produce complex hydrogel based scaffolds for Tissue Engineering precise techniques as in particular UV curing are needed. In 2014 an useful technique was presented by the authors. It was shown that (Micro-) Stereolithography based on Diode Laser Curing (DLC) offers various possibilities. Poly(ethylene glycol) diacrylate (PEGDA) mixed with 2-Hydroxy-4′-(2-hydroxyethoxy)-2-methylpropiophenone as photoinitiator (PI) allows a production of a wide range of complex geometries (e.g. scaffolds) by using the high resolution photopolymerization technique DLC. PEGDA photopolymers also enable the integration of drugs into the liquid phase before performing the UV curing process. It can be shown that a model drug (acetylsalicylic acid (ASS), a platelet aggregation inhibitor) can be released in controlled time scale from photopolymerized scaffolds into a 0.9% NaCl solution at 37°C. It can be shown that the compressibility of the reference pieces is sustainable at nearly 20% in spite of the ASS incorporation. Based on the achieved results several new possibilities are conceivable for the fabrication of drug delivering scaffolds and also for new hybrid photopolymerization techniques. Technical concepts of a hybrid technique based on DLC and high accuracy drug deposition will be presented.

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In vitro release of leuprorelin acetate from PLA-based implants

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Leuprorelin acetate (LA), a luteinizing hormone-releasing hormone (LHRH) agonist, currently used e.g. for the treatment of prostate cancer, is usually administered as an implant or microcapsules/microspheres using biodegradable polymers (e.g. polylactic acid (PLA) and poly(lactic /glycolic acid) (PLGA)). While microparticles with LA have been studied extensively, there is still little information about the in vitro release of LA from subcutaneous implants. Therefore, in vitro release testing of PLA-containing implants with a drug load of 5 mg (Leuprone® HEXAL 3-Monatsdepot, HEXAL AG, Holzkirchen, Germany) was performed using a shake-flask method in 10 ml dissolution medium (phosphate buffered saline, pH 7.4, PBS) for 62 days at 37.0 °C and 100 rpm in a shaking incubator. Quantification was carried out via HPLC after method validation of selected parameters. For additional stability testing a solution of LA was incubated as described above for 14 days. Samples were withdrawn every 24 hours and analysed for their LA content. Although the stability test indicated that LA was stable for at least 14 days, a drop of LA concentration was observed during release testing. After an initial burst of approximately 4-9 % of total drug load in the first 24 hours, concentration of LA in the dissolution medium dropped below the limit of detection followed by a second peak after 30 to 45 days. The decrease in concentration of LA might be attributed to adsorption onto the increasing polymer surface during swelling and erosion. Furthermore the shift in pH towards acidic conditions due to oligomer formation and aqueous hydrolysis of these oligomers to lactic acid during degradation of PLA might have influenced the stability of LA, especially in the core of the implant.

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Laser-induced cell injury in closed microphysiological systems: a novel method to study regeneration processes

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Closed microphysiological systems are miniaturized, chip-sized platforms that can be used as cellularized organoid systems to study cellular processes like migration, regeneration or proliferation in-vitro. Due to the limited accessibility of the cells inside of closed microphysiological systems, the establishment of a well-defined mechanism to induce specific cell damage is difficult. Here we present a novel laser based method to induce well-defined leasions in closed cell layers. This could be a novel tool to study cellular mechanisms of different cell lines after injury. The present project aimed to establish well-defined lesion in cellular layers without removing the dead cells and their signals. Considering that we constructed a microphysiological system that was produced by layer laminate manufacturing at Fraunhofer IWS. According to the experimental needs the microphysiological sytem contains two fluidic circuits wich includes reservoirs, channels, and an integrated micropump. To establish the method, blood endothelial outgrowth cells (BEOC) were seeded into the microfluidic system previously coated with collagen (5µg/cm²) at a density of approximately $7{,}5x10^4$ cells/cm². After 3 hours of attachment, a pulsatile flow was applied to the channels. When the whole channel was covered with an BEOC monolayer, laser ablation took place between day 3 and 6 after seeding. To induce the selective cell injury we used an JenLas® D2.mini laser that was optically integrated into an inverted microscope. The irradiation took several seconds at a power of 3W with a wave length of 532 nm. The damage and the following regeneration processes were observed by fluorescence microscopy using LIVE/DEAD® Viability/Cytotoxicity Kit. Time Lapse recording was used to visualize the regeneration of the injured cell layers and to study the interacton between different cell types within the sytem.

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Development of a chemically defined adipocyte/endothelial cell culture system for the use as fatty tissue implant

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Many patients would benefit from an artificially engineered adipose tissue to treat congenital deformities or replace lost, damaged or burned soft tissue. What prevent adipose tissue equivalents from clinical implementation are the limited stability in vitro and the undefined conditions within the manufacturing process, which mostly by default include animal-derived sera and thus also the risk of contaminations. Therefore the development of a completely defined system for the generation and physiological long-term maintenance of artificial adipose tissue is in great demand.
In this approach human primary adipose-derived stem cells (hASCs) were expanded and characterized in a xeno- and serumfree environment. HASCs were differentiated to adipocytes (hACs) on a novel cellulose-based material (CBM) for 14 days and further maturated until day 42 in defined media (without sera). Human microvascular endothelial cells (hmvECs) were maintained on CBM in an endothel-specific defined medium for 28 days. Next to the evaluation of cell viability, hACs and hmECs identity was proofen by cell-specific marker expression and a proof of function.
Under defined conditions a differentiation rate comparable to the serum-containing cotrol was achieved on day 14. Despite showing reduced cell adhesion compared to polystyrene, CBM accelerates and intensifies adipogenic differentiation under defined conditions. After maturation on day 42, defined attempts exhibited about 80 % mature ACs compared to serum-containing positive controls at comparable cell adhesion. HmvECs maintained their marker expression and functionality in the defined medium for 28 days. CBM significantly enhanced hmvEC adhesion and monolayer formation and additionally facilitated the spontaneous formation of vessel-like structures.
The developed defined media enable functional long-term culture of hACs and hmvECs, while CBM further supports adipogenic differentiation and the formation of vessel-like structures. The defined system thereby represents a promising tool for the artificial set-up, vascularization and long-term maintenance of adipose tissue and its implamantation in regenerative medicine.

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Novel ceramic structural composites for personalized bone graft substitutes

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The objective of the presented work is to show the benefits of a hybrid shaping process for achieving customizable ceramic composite structures with the potential to be inserted as bone replacement materials. Lots of research is being conducted to achieve bone graft substitutes, which are as similar to a bone as possible. This relates to either sufficient mechanical strength, a complex outer shape, maximal acceptance by the organism or biodegradability. However, there is scarcely a line of technology providing all of the required features at once. A solution is being provided by the combination of a foam producing and an additive manufacturing method. The proposed hybrid shaping route allows to combine porous bone-mimicking features *via* so-called Freeze Foaming as inner section of an optionally complex-shaped 3d-printed shell structure made by Lithography-based Ceramic Manufacturing (LCM). So far, bioceramics like hydroxyapatite, zirconia and mixtures of thereof were used. Computer tomographic analyses illustrate a mainly partial form and material fit between dense and porous features. Resulting scaffold composites are potentially applicable as artificial segments of larger bone sections. Demonstrators of a complex femoral bone model show the capability to theoretically substituting whole bones. *In-vitro* analysis of the porous Freeze Foams prove biocompatibility on the FDA live staining of mouse fibroblasts and osteogenic differentiation on the detection of alkaline phosphatase and collagene-1. In a next step, experiments will be conducted *in vivo*. Further follow-up research will deal with the strength of the LCM/Freeze Foam interface as well as the overall mechanical strength to show the potential of such parts to be used as customizable bone graft substitutes.

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Concept development and prototyping of a flow cell for blood preparation with acoustophoresis

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Light scattering effects the concentration determination of dissolved blood components by absorption spectroscopy. To improve the optical analysis, we develop a setup to separate blood cells from blood plasma. For a good separation process, a precise transparent flow channel with a minimum width of 250 µm is needed. Acoustophoresis uses the different acoustic properties of blood cells, fluids and flow cell materials. A high acoustic impedance of the flow cell material is necessary to achieve a standing acoustic wave inside the flow channel. Considering the acoustic impedance, silicon and glass are the materials of choice. A silicon flow channel needs to be combined with a transparent layer to fulfil the optical requirements of the flow cell. Glass accomplishes all specifications like acoustic impedance and optical transparency. The channel structure needs to be divided into three sections. The first section after the inlet is the main channel with a width of 1000 µm. The main channel gets divided into three side channels for blood cells and blood plasma. The plasma channels with a width of 250 µm are connected to the main channel at an angle of 45°. The cell channel is located between the plasma channels and has a width of 500 µm. All sections have a height of 1000 µm. After developing a flow cell concept for the separation of blood cells and blood plasma, the flow cell was built out of quartz glass EN08 by selective laser induced etching. Advantages of this flow cell are the optical transparency as well as chemical and mechanical stability. After successful test in a setup for blood separation, the flow cell will be used in blood gas analysers.

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Trace analysis of silver and implant components like titanium, aluminum and vanadium in biological samples

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Initiated by the increasing antibiotic resistance the use of antimicrobial silver is focused for different implant materials. This study is concerned with permanent TiAl6V4 implants, in which silver is incorporated into surface layers. The behavior and the accumulation within different organs and tissue of alloying elements of implant materials are of specific interest to assess their possible influence on the body. To evaluate the accumulation of the implant components in rat organs TiAl6V4 discs were implanted subcutaneous for different residence times. To get information about background values in the different rat organs control studies with HDPE implants were performed under the same conditions.
The accumulation of silver was analyzed in selected organs like liver, kidney, spleen and implant surrounding tissue. The silver amounts in the organs were analyzed via ICP-MS using an external calibration. The silver amount and the alloying elements in the implant surrounding tissue were analyzed via ICP-MS and ICP-OES for a comparison.
Regarding the silver accumulation an initial increase in the silver amount within all analyzed organs (liver, spleen, kidney) after the first days was observed. The silver amount decreased with increasing implantation time, so that after 6 months background level was almost restored. After 4 weeks and 6 months implantation time increased amounts of titanium, aluminum and vanadium were determined in the tissue near the implanted discs. The silver amount was also increased at every implantation time, although the high standard deviation between the similar time groups impedes a valuation of a trend formation. From the present results it is difficult to decide between a long-term accumulation of silver within the tissue or a continuous release of silver ions which is the intended antibacterial effect of implementing silver in the surface of TiAl6V4 implants.

P 190

Measurement of tumor marker having a biochemical function in DNA-replication and transcription

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Nearly 30 years ago thymidine kinase was tested as a tumor marker being enhanced in growing tumors. This enzyme activity was detected to be six enzyme forms A, B, C, D, E in nuclei of Morris-Hepatoma 9121 by DEAE-Cellulose-Chromatography; Enzyme C is tumor specific. These enzyme-forms synthesize deoxyribo- and ribotriphosphates from their corresponding nucleosides, substrates for DNA –and RNA-polymerases. The enzyme activities of these nucleoside-nucleotide-phosphotransfeases are allosterically regulated by steroidhormones and specific DNA-sequences. The newly detected nucleoside-nucleotide-phosphotransferases form complexes with specific DNA-sequences and steroidhormones with K_D-values of the known steroidhormone-receptors. It is proved that after injection of ^{3}H-steroidhormones into normal and Morris-Hepatoma-9121 rats the enzymes had bound the radioactive steroidhormones; but the normal enzyme pattern had been changed: the tumor marker, enzyme C, was formed which was also found in blood plasma, cytoplasm and purified chromatin of Morris Hepatoma 9121 and even in blood-plasma of early-tumor-bearing rats. Blood plasma of patients with neuroblastoma and leukemia had also different enzyme patterns in comparison with that of healthy persons. It was shown that the nucleoside-nucleotide phosphotransferases react according to the same reaction mechanism as that of the steroidhormone receptors: in blood plasma steroidhormones bind to the nucleoside-nucleotide-phosphotransferases, being transported into cytoplasma, then into nuclei, to chromatin, to specific DNA-sequences where transcription of DNA starts leading to distinct proteinbiosyntheses. Among them is the tumor marker, enzyme C, being able to influence the velocity of cell growth and the transcription of "wrong" proteins, causing necrosis in the cell. It can be concluded that a disregulation of steroidhormones by the endocrinal glands cause the formation of tumor specific nucleoside-nucleotide-phosphotransferases. After cell death the tumor specific enzyme appears in the blood plasma and attacks the next healthy cells. Nucleoside-nucleotide phosphotransferases are tumor markers with an important biochemical function in normal and tumor growth.

NW 1

IT-based psychoacoustic auditory diagnostic methods – Expert knowledge vs. machine learning technology?

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Modern methods for the diagnosis of hearing disorders and for the indication and evaluation of technical hearing devices (hearing aids and cochlea implants) can achieve a higher precision, plausibility and predictability for the details of the hearing disorder and its optimum compensation by employing IT techniques, auditory models, and machine learning. This session reviews the current state-of-the-art on the basis of the research work carried out within the Cluster of Excellence Hearing4All and provides an outlook towards further developments.
As an introduction, the concept of the "auditory profile" is reviewed: Each patient is characterized by a battery of psychoacoustic tests that are compiled by expert knowledge. However, the relation among these tests, the significance of their outcomes for deciding about the diagnosis and appropriate rehabilitative measures, and the efficiency of performing each single test is unclear. To establish a more rational and efficient diagnostic procedure, such an individual characterization should be supported by IT-based procedures that incorporate auditory and statistical models. The contributions in the current session will investigate from different points of view if these new, machine-learning-based approaches for the individual audiological characterization will displace the expert-knowledge-based approaches.

NW 2

Intraoperative objective physiology based audiological methods

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Objective measures to determine physiological properties in normal hearing subjects and patients are currently a of the backbone of clinical audiology. In contrast to subjective methods requiring active participation of patients, objective-physiology-based methods are appropriate for the use in non-responsive subjects under general anesthesia in the OR. Specifically for the implantation of Bone Conduction Instruments (BCI), Passive and Active Middle Ear Implants (AMEI) and Cochlea Implants (CI) such methods enable optimized implantations and generate reference data for postoperative controls. Beside recording of electrically evoked potentials in cochlea implants during routine our experimental results in animals and humans of intra-and extracochlear recorded acoustically evoked potentials indicate great potential for intraoperative monitoring, online feedback and damage avoidance. In AMEIs Laser Doppler Vibrometry (LDV) has proven to be a useful tool, but is expensive and not available in many ORs. Here the recording of device evoked (acoustic) potentials and the measurement of reverse transfer function (RTF) provides an inexpensive easy alternative method to determine the functionality of the device and to assist in optimization of sound transfer to the ossicles and the cochlea. Intraoperatively recorded acoustic responses e. g. nasal and outer ear canal sound pressure in BCI implantation not only helps to determine the functionality of the device and sound transmission intraoperatively, but can be applied to monitor function and osseointegration postoperatively.
In summary our results indicate that new applications can extend the portfolio of established interoperative methods to optimize surgical outcome and will contribute to increased safety and performance.

NW 3

Common audiological functional parameters (CAFPAs) – diagnostic concept

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ENT doctors and audiologists in different clinics share the goal of performing audiological diagnostics and suggesting appropriate provision with hearing devices. This process is not as objective as possible, since different clinics are using different test batteries of audiological measurements. For the purpose of comparing the outcomes of different test batteries, the Common Audiological Functional Parameters (CAFPAs) are introduced as abstract parameters that summarize and integrate audiological knowledge from different measurement procedures. The CAFPAs are designed to represent the information in a uniform and abstract way, thereby covering the most relevant functional aspects of a patient's hearing loss. From the CAFPAs, the type of hearing impairment or provision indication could be concluded independently of the used measurements. This abstract layer between measurements and diagnostical outcomes is not only human-readable, but could also act as a representation of audiological knowledge that can be used for modelling audiological diagnostics with Machine Learning methods, e.g. Bayesian Analysis. Such an approach would allow for analyzing large amounts of data, while humans would probably not be able to exploit the information included in patient databases of different clinics. As a starting point, the relationships between audiological tests, CAFPAs and diagnostical outcomes were defined by a survey conducted among audiology and ENT experts from Hanover and Oldenburg. From these results, a framework will be established that connects these three layers. In a next step, real patient data will be used to train the network. The CAFPAs could be of practical use for ENT doctors and audiologists - as a basis of communication about a patient's hearing deficits between different experts or between expert and patient. Including the CAFPAs in a Bayesian Network, a supporting tool for the audiologist could be created that provides an objective analysis of all available measurement data.

NW 4

Audiological measurement methods and auditory models – What is the state-of-the-art?

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In general, auditory models use input measures like, for instance, the hearing threshold for quantitatively predicting output measures like, for instance, speech intelligibility. Such predictions are required for testing the consistency of auditory parameters, for differential diagnostics, and for predicting of the success of hearing instruments. Certain measures like speech reception thresholds (SRT) in quiet can be predicted very precisely based on the hearing threshold as measured by the pure tone audiogram. This indicates that audibility is the crucial factor for this measure and that other factors may be neglected. For other measures, like the reduction of the hearing dynamics, the width of auditory filters, and speech intelligibility in noise, no such clear quantitative relations have been found, which indicates complex interactions between these measures. Different studies, however, revealed that the individual difference between observed and predicted intelligibility in noise is constant for a large variety of hearing situations and can be attributed to an individual speech intelligibility component. This individual component can be assessed using one reference measurement for one condition (e.g., SRT in steady-state noise) and then be used for individualized predictions for other conditions (e.g. SRT in fluctuating noise). In this way auditory and cognitive components of speech recognition can be separated to a certain degree. A further successful example is the binaural masking level difference (BMLD) for sinusoidal tones in noise which can be used to individualize predictions of a binaural speech intelligibility model (BSIM) predicting the BMLD of speech in noise. This indicates that binaural processing can be separated from speech processing.

NW 5

Forecast of hearing performance in cochlear implant candidates using a prediction model

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Over the years, indication criteria for cochlear implants were extended from total deafness to severe or even moderate hearing impairment in selected cases. Thus, it is increasingly important to predict the hearing performance after cochlear implantation to better define the boundary between cochlear implants, acoustic implants and conventional hearing aids. To be able to forecast individual hearing performance, an outcome prediction model has been developed, which utilizes preoperative audiometric measures as well as demographic factors and in turn tries to predict individual speech understanding with a cochlear implant.
Performed audiometric tests were the Freiburg Monosyllables and the Oldenburg Sentence Test (Olsa). Additionally, the visually presented Text Reception Threshold (TRT) test was administered. General state of health, socio-economic status (SES) and subjective hearing were also obtained through questionnaires.
Based on our current results, it can be concluded that a prediction model allows meaningful forecasts of cochlear implant performance.

NW 6

Vorhersage des Versorgungserfolges mit Hörgeräten

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Die Vorhersage des Erfolges bei der Versorgung von Schwerhörenden mit Hörgeräten basiert in der Regel auf Gruppenstatistiken und Erfahrungswerten. Für den Einzelfall ist dies häufig unzureichend. Schwerhörende können trotz ähnlicher Audiogramme sehr unterschiedliche Spracherkennungsleistungen aufweisen, und ebenso, mit ähnlichen unversorgten Spracherkennungsleistungen sehr unterschiedliche Gewinne durch ein Hörgerät erzielen. Deshalb ist das zeitaufwendige Ausprobieren und individuelle Anpassen mehrerer Hörgeräte oft erforderlich, um mit Gewissheit zu sagen, dass sich eine Anschaffung lohnt. Für eine individuelle Vorhersage des Versorgungserfolges muss die Schwerhörigkeit über das Audiogramm hinaus charakterisiert, und ihre Interaktion mit der Signalverarbeitung des Hörgerätes korrekt beschrieben werden. Mit diesem Ziel wurde das Framework zur Simulation von auditorischen Diskriminationsexperimenten (FADE), mit welchem die Ergebnisse des Matrixsatztestes für Normalhörende gut vorhergesagt werden können, um einen überschwelligen Parameter in Form einer Pegelunsicherheit erweitert. FADE erlaubt eine nichtlineare Vorverarbeitung der Stimuli (z.B. durch Hörgeräte). Die Pegelunsicherheit bewirkt eine effektive Reduzierung der Pegelauflösung und führt im Modell zu einer verringerten Spracherkennungsleistung. Sie kann mit Tondetektionsexperimenten im Störgeräusch individuell bestimmt werden. Das Modell wurde mit empirischen Daten von 19 Probanden, die den Bereich von „normalhörend“ bis „ausgeprägter Hörverlust“ abdecken, evaluiert. Neben Audiogrammen und Tondetektionsschwellen wurden monaurale Sprachverständlichkeitsschwellen bei 50% Worterkennungsrate mit dem deutschen Matrixsatztest versorgt und unversorgt in Ruhe, im stationären und fluktuierenden Störgeräusch gemessen. Die Versorgung fand mit dem Master Hearing Aid (MHA), das Echtzeit-Hörgerätealgorithmen auf gängiger Computerhardware zu Verfügung stellt, statt und umfasste die folgenden etablierte Methoden: Lineare Verstärkung, kompressive Verstärkung und mehrkanalige Rauschunterdrückung mit kompressiver Verstärkung. Die Auswertung zeigt eine signifikante Reduktion des mittleren Vorhersagefehlers über alle Konditionen von 8,2dB bei Individualisierung mit dem Audiogramm über 5,8dB bei Individualisierung mit psychoakustisch gemessenen Tondetektionschwellen auf 4,6dB wenn zusätzlich die überschwellige Komponente berücksichtigt wird. Für akkurate Vorhersagen der individuellen (versorgten) Spracherkennungsleistung ist die Definition eines quantifizierbaren überschwelligen Schwerhörigkeitsparameters, wie die der Pegelunsicherheit, ein wichtiger Meilenstein.

NW 7

Klinische Einführung: Forschungscampus M²OLIE

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Mit zunehmendem biomedizinischen Verständnis von Krankheitsprozessen wächst der Bedarf nach neuen Verfahren, mit denen die Behandlung des Patienten lokal, d.h. auf den Krankheitsherd beschränkt, und auf die Heilung des einzelnen Defekts in der Zelle fokussiert erfolgen kann. Eine solche Behandlung kann nur auf der molekularen Ebene erfolgen. Sie schont den Patienten im Vergleich zum alternativen chirurgischen Eingriff erheblich und fasst die Ursache der Krankheit an ihren Wurzeln an. Die Molekulare Intervention ist nicht mehr ausschließlich die Aufgabe eines einzelnen Operateurs, sondern verbindet unterschiedliche Disziplinen zu einem durchgängigen personalisierten, diagnostisch-therapeutischen Prozess. Der Grundgedanke von M²OLIE („Mannheim Molecular Intervention Environment“) ist die Entwicklung des Molekularen Interventionsraum der Zukunft unter Mitwirkung von Mediziner, Naturwissenschaftler, Ingenieure und Informatiker. Sie arbeiten an einem Interventionsraum der Zukunft, in dem Bildgebung, Diagnostik und Behandlung von Patienten mit einer begrenzten Anzahl von Metastasen in einem geschlossenen Kreislauf erfolgen.
Im Fokus steht dabei der sog. oligometastasierte Patient. Dabei handelt es sich um Patienten mit einer begrenzten Anzahl von Metastasen, die lokal, mittels minimal-invasiven Methoden beherrscht werden können. Der Anteil dieser Patienten nimmt ständig zu und spielt zukünftig eine immer größere Rolle.
Das Vorhaben verbindet als wesentliches Merkmal die Prozesse in den biologischen oder chemischen Laboren räumlich, zeitlich und funktionell mit den Vorgängen im Therapieraum. Am Ende der Entwicklung von M^2OLIE stehen für unterschiedliche Anwendungen klinische Prozesse und die benötigten Hilfsmittel, z.B. technische Systeme, wie z.B. roboter-assistierte minimal-invasive Therapien, Biomarker, Therapeutika etc., für molekulare Interventionen zur Verfügung. Außerdem wird die Infrastruktur von M^2OLIE so gestaltet, dass die Diagnose und Therapie in einem räumlich und zeitlich zusammenhängenden Ablauf ausgeführt und so klinisch erprobt werden kann. Die Infrastruktur umfasst dann zusammenhängende Räumlichkeiten für die Durchführung der verschiedenen Teilprozesse in einem funktionell und räumlich praktischen Kontext über multiple Zeitpunkte, die über gemeinsame IT-Werkzeuge effizient koordiniert werden.

NW 8

Multi-modal imaging

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Imaging has emerged as a tool in modern medical diagnostics and therapy. Nowadays, the single modalities e.g. magnetic resonance imaging (MRI) or computed tomography (CT) are combined into multimodal imaging protocols to extract the most comprehensive information for diagnostics or therapy of the patient.
Within the M2OLIE („Mannheim Molecular Intervention Environment“) project, we develop and employ advanced multimodal imaging techniques for diagnosis and treatment of oligo metastatic patients. This not only involves imaging for diagnostic purposes, but also to use the obtained imaging information to guide robot-assisted interventions and to enhance imaging via cone beam computed tomomgraphy (CBCT) during theseprocedures. In this presentation we will outline our current approach and show initial results. This includes a multimodal / multi-nuclear MRI protocol combining 1H-MRI and 23Na-MRI, image registration strategies to form a high-dimensional multiparametric space of the obtained imaging data and approaches to enhance CBCT imaging using prior knowledge from CT/MRI to allow for fast and low dose x-ray imaging.

NW 9

Automation technologies in intervention rooms

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Automation technologies are no longer exclusively used in the field of production. The use of automation solutions clearly grows in various fields starting with home automation, automated cars or even in medicine. Today, the goals of automation in intervention rooms are to increase quality, enhance efficiency and rule complexity. Therefore new concepts exceed the embodiment of automation in medicine as mere robot applications These challenges can only be met by highly integrated processes performed by various, partially autonomous coacting components.
In a subproject of the „Forschungscampus M2OLIE – Mannheim Molecular Intervention Environment“ in Mannheim a new concept for intervention rooms is investigated and stepwise evaluated. The intervention room is seen as a stage in the theranostic process chain of oligo-metastasised patients. This talk introduces the organisational and technical aspects of automated intervention environments and gives an outlook to future trends.

NW 10

Mass spectrometry imaging-based molecular biopsy analysis in the Mannheim Molecular Intervention Environment (M²OLIE)

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Mass spectrometry imaging (MSI) is an increasingly fast *ex-vivo* molecular imaging technology that enables simultaneous label-free measurement of thousands of lipids, metabolites or proteins in tissue sections in a spatially resolved manner. Thin sections of tumor resectates or biopsies obtained in the operating room as well as sections of formalin-fixed paraffin embedded (FFPE) tissue in pathology biobanks are coated with organic matrix chemicals and subsequently scanned with a frequency-tripled Nd:YAG laser (355 nm) at 5-100 µm spatial resolution and at 10,000 to 1,000,000 mass resolution in a mass range of 200 to 20,000 Da. The resulting data cubes map ion intensities onto x-, y- and mass-to-charge-coordinates. As a result, ion intensity images can be computed for all recorded biomolecules, which are characterized by their molecular masses. The "Mannheim Molecular Intervention Environment" (M²OLIE) develops a database of mass spectral fingerprints that are characteristic of tumor subtypes. Such a database is expected to enable fast biopsy classification and, based on this, patient-individualized recommendation of the best suited theranostic, which is also developed and produced by M^{2}OLIE. Eventual clinical use of very complex mass spectrometry imaging workflows requires rigorous standardization of methods. Therefore, in addition to introducing the M^{2}OLIE intervention environment, this talk will present experimental set-ups and new statistical scores for standardization of future clinical mass spectrometry imaging of biopsies.

NW 11

Radiopharmaceuticals for non-invasive diagnostic imaging and molecular radiotherapy

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The use of radiopharmaceuticals for non-invasive diagnostic imaging using e.g. positron emission tomography (PET), as well as for molecular radiotherapy of cancer has continued to grow at a very rapid pace. PET, an established and highly sensitive non-invasive imaging modality in clinical diagnostics, is used to follow the distribution and accumulation of the administered radiopharmaceuticals and thereby to enable the *in vivo* visualization and quantification of complex metabolic processes in target tissues. Imaging results can be obtained even before morphological changes of e.g. affected tumor tissue appear enabling the early functional diagnosis and also therapy in early stages of disease. Therefore, the diagnostic potential of radiopharmaceuticals is directly linked to the individual therapeutic approach whereby the therapy success can be monitored both before during and after therapy in short time enabling the adjustment of the therapy plan for the benefit of the patient.
Given a sufficiently high accumulation of the diagnostic PET radiopharmaceuticals (e.g., ^{68}Ga- or ^{18}F-labelled radiotracers) in the target tissue of interest, it is often possible to use these radiotracers as radiopharmaceuticals with therapeutic radionuclides (e.g. when using β^--particle emitters ^{90}Y and ^{177}Lu instead of ^{68}Ga). The specific cytotoxic effect of these radionuclides on the cancer tissue depends on the physical properties of the radionuclides (half-live, decay mode, linear energy transfer) and is further enhanced by cross-firing bystander effects. Using this effect of therapeutic radionuclides, even malignant cells being not directly addressed by the radiopharmaceuticalcan be affected by the energy deposition resulting in cellular damage and inducing cell death.
The design of these diagnostic and therapeutic radiopharmaceuticals, however requires optimization between specific *in vivo* targeting of the tumor and clearance of radiotracers from non-target-tissues to allow the efficient diagnosis and destruction of tumor tissues while preserving the integrity of surrounding tissues to the highest possible extent.

NW 12

Robotic assisted applications inside the molecular interventional room

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Objective: Surface irradiation of cutaneous lesions and Intraoperative Radiotherapy (IORT) after surgical resection of a tumor using a mobile low-kV X-ray source are promising interventional methods currently used in cancer treatment. However, the shape and size of the surface area to be treated is strictly limited by the available systems and applicators. It is not possible to reposition the irradiation unit in a discrete manner without producing (unpredictable) dose overlaps and peaks. Many patients who could benefit from this kind of therapy are excluded due to these limitations. Hence, there is a need to develop systems, which eliminate the limitations in terms of the shape, size, and surface of the targeted treatment area while enabling irradiation with a controlled, predictable and reproducible dose distribution.
Methods: A system is proposed comprising a Zeiss INTRABEAM X-ray source with an applicator for surface irradiation mounted on a commercially available robotic arm controlled by an algorithm designed for planning the required continuous path of the radiation source.
Results: The system is shown to be capable of irradiating areas composed of any number of rectangles of sufficient size on a flat surface with a mean dose deviation of less than 4% from the target dose, and a homogeneity index of less than 7% inside the target area. The dose gradient outside the target field has a fixed width (the diameter of the beam cone in the targeted irradiation distance) while the dose outside this gradient field is less than 1% of the target dose.
Conclusion and Significance: The presented results demonstrate the potential of the proposed setup to eliminate the limitations of available systems and thus include patients formerly excluded from this type of treatment. In addition a method for robotic Kypho-IORT will be presented.

NW 13

Modular systems and lightweight construction concepts - new possibilities for the defect-specific treatment of hip joint diseases

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In tumor endoprosthetics, implants are applied to reconstruct the proximal femur. The main problems of these implants are often the high weight and the biomechanically not optimal attachment of soft tissue. The aim of this work is the development of a long-term stable biomechanically correct implant of a proximal femoral replacement.
Based on lightweight construction concepts from vehicle construction, a topology optimization was performed with an existing modular implant basic body. The additive manufacturing process laser beam melting was applied to produce the implant with the material TiAl6V4. The individual modules were coupled by a specially designed polygon interface. To disconnect the interface, a joining instrument was used which applies a force at two defined points and thus elastically deforms the internal contour of the interface. This allows the reversible joining of the modular components. In order to fix the muscles anatomically correctly, textile attachment points made of multifilament polyester were produced by embroidery.
A functional model of a modular implant was produced. On the basis of a topology optimization, the new implant has a mass reduction of 400 g compared to a proximal femoral set, which was assembled from the MML system. The greatest savings potential was found in the trochanter module (weight reduction by 55%). The load-bearing structures consisted of TiAl6V4, whereas the shell of the neck module was made of polyethylene.
The reversible coupling was implemented by a polygonal interface. The force closure took place by switching off the external force effect and thus the deformation of the round bore hole into an elliptical geometry, which resulted in a "jamming" of the spigot.
According to ISO 7206 the fatigue strength of the implant was determined. The test implantation at a body donor showed that the implant can be placed under realistic conditions.

NW 14

Development of a measuring system for the investigation of the force and the damping situation during the making of conical clamping between THA-shaft and -head

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Nearly all of today's hip implants have a modular hip stem system in which the artificial joint head is connected to the femoral stem of the prosthesis during the operation. The junction of the two components is realized by the frictional connection of a conical clamping, which is produced by means of a hammer stroke. Decisive for the connection strength of the clamping is the maximum force applied once in the direction of the axis of the cone, which depends both on the initiated pulse and the damping of the human body. In order to investigate the applied forces of different operators and the influence of the damping soft tissue situation, a measuring system was developed which can be used in situ.
Because of its small size and the high upper frequency limit, a piezoelectric force sensor is used. This sensor is applied between the cone and the stem of a special measuring prosthesis. The measurement prosthesis is symmetrical from the lateral side, so that it can be implanted both left and right. As a result, the sample size is doubled in the case of planned in-situ tests. The attenuation is calculated by the impulse response of an acceleration sensor, which is applied to the top of the cone. The processing of the measurement data is done by a PC-software developed for this purpose.
Both sensors were validated by means of various pendulum tests. The pendulum initiated a defined pulse whose properties were measured with the sensors and compared with the theoretically available values. The force sensor showed a deviation of less than 1% and the acceleration sensor of approx. 2%.
The laboratory tests are followed by extensive in-situ experiments with the aim of examining the variance of different operators and the damping properties.

NW 15

Applied research in the field of medical engineering in interdisciplinary networks of physicans and engineers - challenges and results

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The development of new medical products and technical systems is a major challenge for all partic-ipants. In addition to clinical-medical and technical questions, questions of examination, approval and remuneration must also be considered. However, these challenges can only be adressed by a pooling of all stakeholders along the value chain in the development of new components and systems. At the same time, the creation of appropriate communication interfaces between all partners is essential.
The starting point of the development should be the determination of needs of physicians or therapists point of view. Based on this, the analysis and the transfer of the identified challenges into the engineering environment are carried out by means of appropriate intermediate stages. In the subsequent concept and development stages up to prototyping, the collaboration of physicians and engineers should always take place.
One way of working together along the entire value chain is to establish common networks or plat-forms. For example partners along the entire value chain are working together in the networks “Kinetek” (focus: locomotor system) and “Kunstgelenk” (focus: artifical joints), which were founded by Fraunhofer Institute for Machine Tools and Forming Technology IWU and the University Hospital of Leipzig.
Establishing a process chain for new medical devices and systems first requires taking a look at potential development paths that have various underlying motives. For example these approaches can be divided into technology-driven and findings-driven implant design. Creating a joint development platform for topology-optimized implants for example is viewed as an innovative approach. It requires suitable software interfaces that facilitate efficient communication and transfer of results between engineers and medical professionals since the approaches of the two disciplines differ as much as do the languages of the two disciplines.

NW 16

Non-invasive measurement of electroencephalographic and electromyographic signals for the development of a brain controlled muscle stimulation system

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Brain-computer interfaces are an innovation and great progress has already been made in this field of biomedical engineering. The basic principle of these systems is the conversion of neuronal activity of the central nervous system into motor actions as an example of direct communication between man and machine. Our group is developing a non-invasive system for the stimulation of muscles by surface electrodes. The initialization and control of the stimulation is triggered by the neuronal activity of the subjects. During the planned training phase, the activity in a specific frequency range of the electroencephalogram (EEG) will be displayed on a screen. The subjects will be required to deliberately influence this and specifically stimulate their leg musculature with specially developed electronics. From these measurements, a suitable frequency band in the EEG signal was determined and the chronological course of the muscle activity was examined by electromyography (EMG). For this purpose, the activities of the brain and muscles of a subject were recorded and analyzed during the movement of the lower limbs. Measurements in which the subject just imagines the movement were also made. An electronic system displays the beginning of an action by acoustic and visual signals and sends a trigger signal to the measuring devices to synchronize the signals in time. The EEG analysis showed that the activity in the range of the μ-band changes during the requested muscle actions. Software was developed which acquires and process the data online and displays the results as a feedback to a subject. The temporal course of the activity of the measured muscles could be determined from the EMG data. In order to study the shape of stimulation signals which are required for a determined muscle activity, the measured characteristic shapes of the EMG signal are reproduced with MATLAB and a microcontroller-based circuit.

NW 17

Accuracy study of a 3D printed patient specific brain biopsy system for veterinary medicine

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The sampling of brain tissue in veterinary medicine usually underlies a freehand performance without exact localization. The aim of the project was the accuracy evaluation of a 3D-printed subject specific system for brain biopsy in dogs.
At the beginning of the procedure, three small bone screws were fixed (bilateral and occipital/frontal) to the dog skull. Subsequently, three MR-markers filled with contrast agent were adapted and MRI scans performed (layer-thickness 1.0 mm). Within the MR images the coordinates of the target and entry point are determined by the surgeon. For evaluation an additional pre-CT (layer-thickness 0.7 mm) was realized. After image recording the MR-markers were removed. Due to a self-made algorithm a patient individual template was constructed. The final biopsy device made of ABS M30 was produced by a 3D printer (FDM).
To perform the biopsy the device was connected with the already embedded bone screws. Through a guidance track the skull was minimally invasive accessed at the intended location. Controlled by a depth stop the biopsy needle could be exactly moved in a desired direction up to the target point.
A further post-CT (thickness 0.7 mm) with inserted needle was performed to determine the final position of the biopsy needle tip. For receiving information about the difference between preoperative planned and achieved tip position the pre-CT was matched with the post-CT. Therefor 10 dog cadavers (n=20 target points) were applied.
The results showed an accuracy of 0.58 mm ± 0.34 mm (ranging from 0.09 mm to 1.17 mm) between the preoperative planned and the achieved needle position.
A patient specific 3D-printed biopsy system based on MR images was developed which enables a high precise brain biopsy. Moreover, the system matches up to current costly diagnosis techniques of image-guided neurosurgery and robot systems. Prospectively, it shall be transferred to human medicine.

V 76

Proton minibeam therapy – reduction of side effects studied in a mouse ear model

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Proton minibeam radiotherapy offers new possibilities to enhance the advantages of proton therapy: Compared to normal proton therapy, the side effects in normal tissues are reduced since fewer normal cells are suffering from irradiation-induced damage between the proton minibeams. Tumor control is kept as in normal irradiation mode through a homogeneous irradiation of the tumor due to beam widening with increasing track length. We report on the principles of a proton minibeam radiotherapy approach that might be suitable for future proton therapy devices.

We compare side effects in healthy tissue between proton mini- and broadbeam irradiation in the ear of Balb/c mice. At the ion microprobe SNAKE, 20 MeV protons were administered to the right ear of 2-3 months old, female Balb/c mice, using a mean dose of 60 Gy in two irradiation modes, homogeneous and minibeams. The homogeneous broad beam was delivered to a field of 7.2 x 7.2 mm^2 in the central part of the ear. The 4 x 4 mini-beams of 0.180 x 0.180 mm^2 size as well as widened minibeams were set in a distance of 1.8 mm applied with the same mean dose but spatially fractionated.

Inflammatory response, i.e. ear swelling and skin reactions were monitored for 90 days following irradiation. No ear swelling or other skin reaction was detected after the minibeam irradiations, while significant ear swelling, erythema and desquamation (crust formation) developed in homogeneously irradiated ears 3-4 weeks after irradiation. Loss of hair follicles was only detected in the homogeneously irradiated fields after 4-5 weeks. Widened proton minibeams show some but also reduced reactions. The results support the hypothesis that proton minibeam radiotherapy can result in reduced side effects in normal tissues and thus could become an option in clinical proton and/or heavy ion therapy.

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Proton minibeam sizes and their influence to reduced side effects in an in-vivo mouse ear model

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Proton radiotherapy using minibeams of sub-millimeter dimensions reduces side effects of conventional proton therapy by spatial fractionation as shown in a first animal study (1). Tumor control is assumed to be maintained by homogeneous irradiation inside the tumor due to beam widening with depth. We report on the tissue sparing effect of partially widened proton minibeams as they occur on their way to the tumor within the healthy tissue. This comparative study uses six different minibeam sizes in the ear of Balb/c mice using 20 MeV protons applied at the ion microprobe SNAKE (Munich). The average dose of 60 Gy is distributed in 4x4 minibeams, using Gaussian beam with sizes of σ = 0.09, 0.2, 0.31, 0.45, 0.56 and 0.9 mm and beam-to-beam distance of 1.8 mm. Inflammatory response were measured by visible skin reactions and ear swelling and monitored for 90 days following irradiation. The biggest beam sizes lead to significant ear swelling (up to 3-fold), erythema and desquamation 3-4 weeks after irradiation. With decreasing beam sizes, the maximum skin reactions decreased until almost no ear swelling or other visible skin reactions could be found at any time after irradiation. These results demonstrate that proton minibeam radiotherapy has the best tissue sparing effect for the smallest beams. However, even quite large minibeams still show less acute side effects than a homogeneous dose distribution, as in conventional approaches, and suggest, that a proton minibeam radiotherapy reduces side effects to quite large depths and has the potential to become a new approach in clinical proton and/or heavy ion therapy.
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(1) Girst et al., IJROBP 2016; 95 (1), 234-241

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Preparation of small animal irradiation experiemnts with laser-accelerated protons

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Laser-driven ion acceleration has been considered a potential alternative for conventional accelerators that may provide for a more compact and cost-efficient particle therapy solution in the future. The beam properties of laser-accelerated beams strongly differ from quasi-continuous beams from synchrotrons or cyclotrons. Laser-driven ion bunches are typically picoseconds short, yet carry up to 10^{13} particles with a broad energy spectrum and high divergence.
A current driving question is whether the highly intense pulsed ion beams obtain an equivalent biological effectiveness compared to quasi-continuous beams in the case that a living organism is irradiated. Therefore, a controlled small animal irradiation (LN229 glioblastoma cells on nude mouse ear) will be performed at the Dresden laser acceleration source Draco using an intense proton beam.
The talk gives a general overview on laser-acceleration efforts in the context of translational medical research at HZDR and focuses on the experimental preparation and characterization of a proton beamline based on two pulsed high-field (20 T) solenoid magnets. The magnets match the pulsed nature of the particle source and provide for efficient beam capture, transport and field formation. Two challenging experimental tasks will be critically discussed: First, 25 MeV proton beam production at mean dose rates of the order of Gy/min with a high degree of reproducibility. And second, the generation of homogeneous lateral and depth dose distributions beam means of the beam transport system.

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Ion computed tomography – experimental results and clinical potential

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Exploitation of the full potential of ion-beam therapy is currently hindered by its sensitivity to range uncertainties, demanding the development of imaging techniques capable of accurate assessment of the relative stopping power (RSP). Ion computed tomography (iCT) was investigated using a prototype integration-mode range telescope combined with active ion-beam delivery. Experimental carbon- and helium-iCTs of a cylindrical phantom with various tissue-equivalent inserts were acquired at similar physical dose and post-processed with a dedicated method relying on linear signal decomposition. The obtained results were compared to Monte-Carlo (MC) simulations using the FLUKA code with customized user routines to accurately emulate the acquisition scenario. The benchmarked simulations motivated the investigation of carbon-iCT for a head and neck patient case by importing the treatment planning X-ray CT in the MC framework. Results were quantified with respect to analytically calculated ground truth images. An approach for coupling the FLUKA code to the mechanistic repair-misrepair-fixation (RMF) model was implemented to account for the relative biological effectiveness (RBE) of ions. For experimental carbon- and helium-iCTs, the proposed post-processing method improved the RSP accuracy by more than 1%, resulting in a mean RSP error of 1.1% and 2.3%, respectively. A normalized cross-correlation better than 0.95 was observed for the clinical carbon-iCT, demonstrating comparable image quality with respect to the state-of-the-art single-particle tracking approach when combined with the same range telescope. The implemented RMF model predicted a mean RBE of 1.26 for the carbon-iCT with a physical dose of 40mGy. This study quantitatively presents the experimental outcomes of a multi-ion iCT comparison and puts forward the clinical potential for range verification in ion-beam therapy, with a focus on the biological dose calculation. Future investigations aim at extending the multi-ion comparison with particular reference to the biological response for low-dose imaging and the use of iCTs for treatment planning.

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Analytical investigation on the role of ion radiography for Hounsfield Unit conversion into relative stopping power in ion beam therapy

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In ion beam therapy the empirical calibration from Hounsfield Unit (HU) to Relative Stopping Power (RSP) can lead to range inaccuracies up to several millimeters. The purpose of this work is to investigate the role of ion radiography in improving the HU to RSP conversion (HU-RSP calibration curve refinement) using analytically simulated scanned proton and carbon ion pencil beams and different detector configurations.
Proton and carbon ion radiographies of an anthropomorphic phantom were simulated using both list- and integration-mode detector configurations. Controlled inaccuracies $\Delta\delta_{true}$ were randomly applied to the clinical-like true calibration so that $RSP_{empirical}=\Delta\delta_{true}\cdot RSP_{true}$. The root-mean-square error (RMSE) between the (empirically calibrated) digitally reconstructed radiography (DRR) and the (truly calibrated) ion radiography was minimized as $argmin_{\Delta\delta}\{RMSE[\Sigma_L(RSP_{true}-RSP_{empirical}(\Delta\delta))]\}$, where L was the ion trajectory. The latter was estimated as straight for carbon ions whereas curved for protons due to multiple Coulomb scattering. Accuracy and robustness were investigated as a function of increasing: I) number of radiographies ($\leq$128) II) deviation $\Delta\delta$ ($\leq$30% RSP_{true}) III) noise variance σ^2 ($\leq 10^{-1}\ RSP_{true}^2$).
In case of carbon ions, the RMSE was negligible ($\approx 10^{-11}$) within all settings in I) and II) while in III) the RMSE followed a power law trend $a\cdot(\sigma^2)^b$ ($a\approx 90.1$, $b\approx 4.8\cdot 10^{-1}$) up to 29.8 for extremely high noise variance $\sigma^2=10^{-1}$. With protons, list-mode detector configuration performed better than integration-mode, showing a RMSE median (interquartile-range) equal to 1.5 (0.8), whereas 4.7 (1.3) for integration-mode.
The HU-RSP calibration curve refinement resulted sensitive to the ion radiography noise and, as highlighted by protons, to the ion trajectory estimation enabled by the detector configuration. An enhanced sensitivity to inter-fractional anatomical changes is expected, as suggested by a twelve orders of magnitude larger RMSE for the carbon ion radiographies of a breathing anthropomorphic phantom. Hence, deformable image registration is foreseen to be incorporated in the HU-RSP calibration curve refinement.

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Monte Carlo simulation and experimental validation of magnetic field effects on proton dose distributions

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Given the physical properties and the sensitivity to morphological variations of proton therapy, it could greatly benefit from integration with magnetic resonance (MR) imaging. Such integration raises several challenges, as both systems mutually interact with each other. The problem of magnetic field induced dose distortions has been predicted by Monte Carlo (MC) simulation in previous studies, but no experimental validation has been performed yet. We present and compare simulated and measured dose distributions in a realistic magnet setup.
2D dose distributions of proton pencils beams (80-180MeV) traversing the field of a 1T NdFeB permanent magnet while depositing energy in a PMMA slab phantom were simulated using the Geant4 toolkit and measured using EBT3 radiochromic films. The Geant4 model was validated against depth-dose measurements performed with a multi-layer ionisation chamber. The magnetic vector field was calculated using finite-element modelling and validated experimentally using a Hall probe. Deflected beam trajectories and depth-dose curves were extracted from the 2D dose distributions and compared. Demagnetization and radioactivation of the magnet material were simulated and monitored during measurement.
The range predicted by the MC model agreed with the Giraffe measurements within 0.5mm, and calculated and measured magnetic field data agreed within 2%. The lateral beam deflection was clearly visible on EBT3 films and ranged from 1mm to 10mm for 80MeV and 180MeV, respectively. Simulated and measured range and deflection agreed within 1mm for all studied energies. Demagnetization and radioactivation effects were negligible.
For the first time, MC simulations of magnetically deflected proton beams inside tissue-equivalent material have been experimentally validated with dose measurements. The results indicate that the magnetic field induced proton beam deflection is both measurable and accurately predictable. This demonstrates the feasibility of accurate dose calculation as well as measurement within the framework of MR-integrated proton therapy.

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Dosimetric validation of T1/T2 only pseudo-CT for proton therapy

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The aim of this work is to use pseudo-CT (pCT) data, obtained from T1 and T2 weighted MRI, for proton therapy planning.
Data of 15 patients, including T1 and T2 weighted MRI and CT scans, were used in this study. The pCT was generated according to the methodology described in Speier *et al,* by segmenting the $T1_w$ and $T2_w$ MRI volume into 6 tissue classes (grey and white matter, cerebrospinal fluid, bone, skin and air). For each patient, three 18 Gy beams (2 axial and 1 coronal,) were designed on the pCT volume, for a total of 45 analyzed beams. The plan was then copied and transferred onto the CT that represented the ground truth. Range shift (RS) between pCT and CT was computed at R_{80} over 10 slices. The acceptance threshold for RS was set to 3.5% of R_{80}, according to the clinical guidelines of our Institution.
The median value of RS was 0.6 mm with lowest and highest absolute values being 0.08 mm and 3.8 mm respectively. 40 out of 45 beams passed the acceptance test. Largest discrepancies occurred in correspondence of the surgical hole of the scalp containing a metal plate. This happened because the segmentation process did not include metal classification, thus mis-assigning the Hounsfield Unit to skin or air. In this circumstance, the planned range on the pCT was deeper than the actual one detected on the CT.
This study showed the feasibility of using pCT, derived from MRI, for proton therapy treatment. The major benefit of MRI acquisition lies in better soft tissue contrast for tumor and organs at risk delineation. Further improvements of the methodology are required for the correct conversion of metal voxels to electron density.

V 83

The relative stopping power accuracy of helium CT imaging evaluated using the Monte Carlo method

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The purpose of this work was to evaluate the accuracy of relative stopping power (RSP) of helium computerized tomography (HeCT) in comparison to proton computerized tomography (pCT). A prototype scanner that tracks individual particles and measures their water equivalent path length, originally developed for pCT, was recently installed on the beam line at the Heidelberg Ion-Beam Therapy (HIT) facility, Germany, and used for HeCT for the first time. To systematically explore the characteristics of HeCT compared to pCT, a Monte Carlo (MC) simulation study was performed with the TOPAS tool to compare, in particular, the accuracy of the reconstructed RSP values obtained with 200 MeV/u protons and helium ions CT scans. To estimate the highest accuracy theoretically achievable, an ideal setup was simulated, consisting of a flat beam source and a totally absorbing energy-range detector. For both HeCT and pCT, the reconstructed RSP values were compared to the theoretically calculated ones. The following phantoms were used: cylindrical water phantoms with inserts of different materials, sizes and positions, the high resolution (CTP528) and sensitometry (CTP404) modules of the Catphan phantom, and a voxelized 10-year-old female phantom. The reconstructed RSP accuracy with respect to the theoretical values was better than 0.8% for the simulated water phantoms with inserts in the ideal configuration for both pCT and HeCT. Similarly, the RSP accuracy for the CTP404 module was of ~1%. For the digitized phantom HeCT scan, all structures were well recognizable in the reconstructed image and no artifacts were visible. The three main tissue materials (soft tissue, brain, and cranium) were well identifiable in the reconstructed RSP-volume distribution, as with pCT. In conclusion, MC simulations demonstrated accurate image reconstruction using helium beams. These results will be useful to optimize the performance of the experimental scanner and to explore the differences between HeCT and pCT.

V 85

Detection of cherenkov light from compton scattered electrons for medical applications

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Modern nuclear medicine and radiation therapy require imaging systems for higher energy gamma rays up to several MeV, where common detectors show insufficient detection efficiency. Especially monitoring dose delivery in radionuclide or proton/ion therapy would benefit from the ability to image high-energetic gamma rays as well as biomedical studies for the investigation of the distribution of important elements inside the human body. So called Compton cameras use a low-Z-scattering material where the incident gamma creates a high energetic electron and an absorption-layer for the scattered gamma. Coincident detection of both electron and scattered gamma allows for a reconstruction of the gamma-ray track based on kinematic considerations. The greatest challenge in this attempt is the simultaneous detection of electron and gamma. In order to overcome this weakness, a new concept is proposed using the detection of Cherenkov light created by Compton-scattered electrons which carry a large part of the momentum information on the incident gamma. Coincident detection of the photons on an array of Silicon Photomultipliers (SiPM) enables a reconstruction of the characteristic Cherenkov cone. Knowing the refractive index of the scattering material and the size and shape of the ellipse on the detection layer the interaction vertex, electron energy and momentum direction can be reconstructed. To prove the principle of the concept, in our set-up Cherenkov light from high-energetic, collimated electrons in acrylic glass is detected with a 4x4 channel SiPM array. A read-out board containing a StiC chip and a fast FPGA is used to take data from all 16 channels simultaneously allowing for offline coincidence search with a timing resolution of about 100ps. The results of these measurements will be presented in this talk. A potential prototype will be able to extend existing detection concepts and to improve their efficiency in the desired energy region.

V 86

Development of a tissue-equivalent phantom for multimodal imaging of the prostate

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In radiation therapy of prostate cancer, a correct definition of the target volume is essential for achieving a precise dose delivery while sparing normal tissue. However, the daily different fillings of rectum and bladder have a considerable effect on the position of the prostate. In this work, a deformable phantom was developed to investigate the influence of different fillings on prostate localization by means of multimodal imaging.
The considered modalities were computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography (US). Using patient-specific CT-data, mesh-models of the pelvis and femur heads were created. Hollow bone shells were 3D printed, then filled with a mixture of petrolatum and dipotassium phosphate and finally covered in gypsum and clear lacquer. A mould of the bladder was also printed and a smaller bladder was casted using wax. The organ shell was then created by adding silicon in the mould and melting the wax model. The rectum and prostate shells were created out of latex, the casing of PMMA. Prostate and muscle filling consisted of agarose, EDTA, Cu++, glass beads, lipid particles, protein, and water according to literature. Fat was mimicked with oil. The properties of such surrogates were investigated by measuring Hounsfield units (CT), relaxation times T1 and T2 (MRI), and attenuation coefficients (US).
The preliminary results show a good agreement with literature data: prostate: 33 ± 10 HU; fat: 118 ± 23 HU; inner bone: 148 ± 35 HU; bone shell: max 1275 HU.
Inner bone: T1:104 ± 94 ms; T2: 36 ± 21 ms. Attenuation coefficient of fat: 1606 m/s.
It can therefore be concluded that the surrogates show the characteristics of real tissue in terms of contrast, shape, and intensity and that the phantom can be used to investigate the effect of different organ fillings with multimodal imaging.

V 87

Performance evaluation of MADPET4: a high resolution preclinical PET insert for 7T MRI

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MADPET4 is a high resolution small animal PET insert under development, to be combined with a 7T Agilent-Bruker MRI scanner. The system aims for a spatial resolution below 1 mm at the center and below 2.5 mm at 80% of its 88 mm transaxial field of view (FOV). The unique geometrical design of the system allows for high count rate capability with depth of interaction correction. The complete system is composed of 2640 individually read out LYSO crystals with end face size of 1.5x1.5 mm^2, arranged in a dual layer configuration with lengths of 6 mm and 14 mm in inner and outer layers. They are coupled to 1.2x1.2 mm^2 non-magnetic, high gain KETEK SiPMs, eliminating the need for high frequency preamplifier components inside the MRI scanner. All crystals are transaxially facing the center of the FOV. A 3D-printed low-density plastic structure is used for holding the crystals. The system consists of 8 axial rings covering 19.7 mm in the axial direction. PETsys SiPM readout system is used for data acquisition and bias voltage regulation of the SiPMs. Each channel has an independent TDC for timing measurement and charge measurement is done using the time-over-threshold (ToT) method. An OSEM image reconstruction algorithm is implemented on GPU, using a Monte Carlo system matrix (SM). Cylindrical symmetries are used in the reconstruction to reduce the simulation time and SM file size. Preliminary tests with the PETsys readout system and inner modules of MADPET4 have shown coincidence time resolution of 580 ps and energy resolution of 24%, after nonlinearity correction. First tomographic images were successfully acquired using NEMA-NU4 and Derenzo resolution phantoms. Promising results have been obtained regarding MR compatibility of the system with FSE, FLASH, and EPI sequences. The system is currently being calibrated for complete performance evaluation tests.

V 88

Heat resistant electronic modules for traceable intelligent medical sterile containers

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In industry and logistics the possibility of tracking items is a well-established standard. However, in the medical sector, especially in hospitals, this is still in its infancy. One reason is the need of a full infrastructure of reader hardware in the clinics. Furthermore, the used technology needs to withstand multiple sterilisation cycles to be used for surgical tools. Beside tracking medical equipment also additional data can help to increase efficiency and safety.
This research is about the development of an electronic sensor system for sterilisable medical containers containing a power supply, sensors for both sterilisation and transport and a low power communication module. In contrast to common tacking methods this module can be connected to a regular smartphone or act like a common IoT device. This has the advantage that no specific hardware for the tracking is needed. However, to withstand the steam sterilisation temperature of up to 135 °C a heat resistant insulation needs to be found.
First tests were made with an epoxy resin to insulate the electronics and a high temperature battery. By using the sensor of a Bluetooth module the temperature inside the insulation could be measured during multiple steam sterilisations. Following, a partly insulated thermoelectric generator shall be used to get energy by the achieved temperature difference.
The results of the tests show that the used epoxy resin limits the temperature to 81 °C. However, the resin was damaged after 21 sterilisation cycles due to its high mass and entrapped air. Therefore, the insulation needs to be minimized and the electronic components need to be able withstanding higher temperatures. Additionally, insulations with not yet considered materials will be tested. Also the possibility of insulating just heat-sensitive parts like the power elements will be investigated.

V 89

Sterilisable energy source for intelligent medical containers

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Surgical container management plays a crucial role in hospital logistics. Moreover, it is very important to know the sterile status of the container due to infection threat during the handling, storage and transportation procedure. Nowadays most of the facilities use containers with sterile indicators and tracking system based on documentation and labelling. One of the main problems in container surveillance is the need of a power source able to withstand multiple sterilizations in high temperature (135ºC). Available solutions such as primary or secondary batteries have either short life-time, or cannot withstand temperature of steam sterilization. Our aim was to design an energy source module based on partially insulated thermoelectric generators (TEG). The whole module consists a specially aligned TEGs with insulation on one side to provide sufficient temperature gradient. As an insulation, several different materials as aerogel or silicon will be tested. First efficiency tests of energy source were performed on set of two 16x16 mm thermally parallel TEGs connected electrically in series. Devices were placed on heating plate as a heat sink, with temperatures varying from 25ºC up to 55ºC. Resulting gradient of 7,4ºC from hot to cold TEG side allowed to generate 0,83V DC voltage. The results of this test showed that relatively small TEG modules with low temperature gradient could generate the voltage which can be used for powering low-power electronics. However, during the sterilization procedure, temperatures and temperature gradients will be higher. This will generate voltage sufficient to power Bluetooth module and to use sterile container as traceable IoT device. Using bigger TEG plates should result in generating higher voltages and power. Combining such voltage source with high temperature energy storage systems, should result in long-life sterilisable power system. Due to promising results we plan to perform more specific tests in clinical setup in near future.

V 92

Model to assess the impact on patient hypothermia of different ventilation systems in the operating room

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Patient hypothermia during surgery is known to increase postoperative complications as well as being a risk factor for surgical site infections. Currently approximately half of all surgical site infections in Germany are caused by patient hypothermia during surgery. Both the DIN standard 1946-2: 2008-12 and DIN EN ISO 7730: 2005 refer to this problem as thermal comfort. In this study a model was developed to assess the impact of three different ventilation systems (temperature controlled airflow - TAF, unidirectional low turbulence displacement flow - TAV and turbulent mixing ventilation - TML) on body temperature of patients by means of a reference "phantom". For this purpose, a cubic container was built, which is open at the top. The container measures 40 cm * 40 cm * 40 cm and is filled to 39 cm with 37.5 ° C warm water. The temperature changes and cooling kinetics were recorded using digital graduated thermometers mounted on the test body at three different levels and at three different position on an OR table in respective operating rooms. Thermal comfort was assessed according to DIN EN ISO 7730: 2005.
It could be shown that all three different ventilation systems provide sufficient thermal comfort and are well suited to the needs of staff working in these rooms. With regard to patient cooling, no significant difference could be found in the different ventilation systems. The cooling kinetics of the reference body did not show significant differences for any of the assessed ventilation systems (TAF, TAV, TML). Furthermore, the cooling kinetics of the used phantom without a ventilation in operation did also not show significant differences. Thus we conclude that the cooling effect of ventilations systems in operating rooms may be overestimated.

V 93

4K vs HD resolution in laparoscopic surgery

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Introduction: Due to the dependency on a camera monitor system for laparoscopic surgery, advances in camera or monitor technique could have an impact on performance. Does 4K Resolution of the camera monitor System lead to better results in laparoscopic surgical tasks?
Materials and Methods: In a prospective study with 40 participants who were randomized in two groups. The Participants were medical students. Both groups were given the same video introduction whereafter they performed three different laparoscopic tasks. Two tasks were based on laparoscopic instrument handling, one on visual detail identification. One group started with an HD system and the other with an 4K system. After the other round of the tasks they switched to the other system. Besides the tests we conducted a survey among the participants.
Results: The 4K system scored a significant better rating in the subjective evaluation. There were no performance differences between the two systems regarding the two handling Tasks. In the test for visual performance the participants scored significantly better on the 4K System.
Conclusion: The Experiments show a superiority of the 4K system regarding the recognition of details. This wasn’t translated into a better performance of laparoscopic handling tasks.

V 94

Risk management in radiotherapy – patientidentification and patientverification

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According to the Radiotherapy-Risk-Profile of the World Health Organization (WHO) the incorrect identification of the patient is a risk with a high potential impact in nearly all stages of the radiotherapy process. In Germany about 340.000 patients received a radiotherapy treatment in about 8.500.000 sessions in 2014. Statistically nearly 300 Patients received a wrong treatment due to the incorrect identification of the patient. In the annual Report of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) only 2 cases are reported, but the estimated number of unreported or undetected cases might be reasonably higher. The probability of treating the wrong patient can be reduced by using the right strategy and methods during the process of radiotherapy. In this presentation, we depict, examine and rate several strategy and techniques. Simple approaches like active questioning according to the recommendations of the "Aktionsbündnis Patientensicherheit" and comparing patient photos as well as IT-based patient bar code identifier and integrating different biometric datasets for patient identification are compared. Rating creteria are reliability, complexity, convenience and compliance with the regulations of data privacy protection.

V 96

Cortical thickness and porosity assessment on ex-vivo tibiae using axial ultrasound transmission

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Osteoporosis is an underdiagnosed and undertreated metabolic bone disease. Currently, clinical fracture risk prediction is mainly based on a single parameter, i.e. bone mineral density (BMD). However, fracture resistance of bone is determined by a complex combination of micro-architectural, material and geometrical properties. Ultrasonic axial transmission (AT) measures the dispersion curves of guided waves (GWs) that propagate along the cortical layer of long bones, such as tibia and radius. Dispersion characteristics of GWs are determined by cortical thickness (C.Th) and mesoscopic stiffness, this latter material property depending strongly on cortical porosity. The goal of this study was to validate the cortical biomarkers at the tibia measured using AT. 20 tibiae from human cadavers were measured ex-vivo using a custom-made AT device (Azalée, Paris, France). Singular-value decomposition combined with 2D spatio-temporal Fourier transform was applied to extract the guided wave dispersion curves. C.Th and an index of cortical porosity (C.PI) were estimated after solving an inverse problem by fitting a 2D free transverse isotropic plate waveguide model to the experimental curves. Independent site-matched reference C.Th values were obtained from 39 µm voxel size high-resolution x-ray tomography (µCT). Reference C.PI was estimated from cross-sectional 100-MHz scanning acoustic microscopy (SAM) images. C.Th and C.PI were successfully obtained for 16 tibiae. The inverse problem could not be solved for 4 specimens due to poor ultrasonic response. Significant correlations ($p < 0.001$) were found between AT and the reference method (C.Th: $R2 = 0.84$, RMSE = 0.4 mm; C.PI: $R2 = 0.60$ RMSE = 3.8 %). For C.Th and C.PI biases of -0.12 mm and 3.41 % were observed, respectively. The cortical bone at the tibia was successfully characterized using AT ex-vivo. Further effort is now required to assess whether measurement of these bone strength related parameters enhance the prediction of atraumatic bone fractures.

V 98

The influence of gestational age on the maternal-foetal causal cardiac coupling

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Fetal development during pregnancy has been widely evaluated. Fetal heart rate variability (FHRV) is used as a reliable indicator of prenatal development. However, previous studies reported FHRV changes depending on the physiological and psychological states of the mother. However, the underlying mechanisms that generate FHRV patterns reflecting maternal–fetal cardiac couplings and their directionality are still poorly understood.
Therefore, the aim of this study was to quantify the direction of short-term maternal–fetal cardiac coupling in early, mid and late gestation fetuses by using the normalized short-time partial directed coherence (NSTPDC) analysis approach. We analyzed fetal electrocardiograms (fECGs) of 66 healthy fetuses; 22 from early gestation (16–25 weeks, GA1), 22 from mid gestation (26–30 weeks, GA2) and 22 from late gestation (32–41 weeks, GA3).
NSTPDC results demonstrated a causal influence of fetal on maternal heart rate in the early gestation, while it significantly decreased from early to mid-gestation age along with a significant increase of maternal to fetal coupling strength. The causal influence of maternal on fetal heart rate was the strongest in the mid gestation age and remained dominant in the late gestation. It seems to be that the maternal heart rate became a stronger driver for the fetal heart rate responses as time passes. This development begins in the second trimester and is especially pronounced in GA2.
In conclusion, we could demonstrate that the maternal–fetal cardiac coupling (strength and direction) between fetal and maternal heart rate changes with gestational age. In the mid gestation age the maternal to fetal coupling is dominated by the mother and retained strong afterwards.
This study provides detailed information about cardiac regulatory mechanisms in developing autonomic nervous system function in fetuses.

V 100

Screening for sleep apnea in routine Holter ECGs – a prospective evaluation

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Untreated sleep apnea is a risk factor for cardiovascular problems, and an economic burden for health care systems. This contribution presents an intermediate evaluation of the ongoing Carrera study („CARdiac REspitarory RAdar“). It targets accelerated identification of sleep apnea patients by prospective analysis of routine Holter-ECGs including typical complications like arrhythmias, co-medication, or comorbidity.
In 91 cardiologic in-patients (age: 64.3±12.1 years; BMI: 27.7±4.6kg/m2, 14 female) routinely scheduled for a Holter-ECG (Mortara H12+), we additionally registered a nocturnal polygraphy (PG, Heinen+Löwenstein Miniscreen 8). The apnea-/hypopnea index (AHI) and respiratory event index (REI) as obtained from the PG served as reference for an ECG-based severity index. This was quantified from modulations of ECG-amplitude and respiratory myogram interference based on correlation analysis. Agreement between PG- and ECG-based estimates was assessed using Bland-Altman diagrams with color-coded degree of ectopy. Moreover, accuracy of screening for REI≥15/h and AHI≥15/h was assessed.
The mean AHI was 16.0±14.7/h (median: 11.7/h), the average REI was 20.9±16.9/h (median: 16.3/h). We found a prevalence of 56% for REI ≥ 15/h, and a prevalence of 41% for AHI ≥ 15/h. 6 cases (7%) exhibited atrial fibrillation. The Bland-Altman diagrams indicated more consistent agreement of the ECG-based estimate with the REI. The agreement improved with better PG signal quality (i.e. lower sensor artifact time) and was better for lower REI/AHI values. In 75% of the cases the deviation was less than ±10 events/h. Reasons for deviations were identified. Arrhythmias did not derogate the estimate.
Screening for REI≥15/h yielded a specificity of 90% at 77% sensitivity. An alternative ternary screening strategy for AHI≥15/h identified 16% borderline cases with 82% sensitivity and 91% specificity for the remaining 84%.
We conclude that sleep-related breathing disorders have high prevalence in clinical cardiologic patient samples, and that screening of routine Holter-ECGs for sleep apnea is possible and reasonable.

FS 37

Bioelectronic medicine – promises and challenges

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Electrical active implants that overwrite signals of natural sensors and organs in the body might offer alternative treatment options to conventional pharmaceutical solutions. “Electroceuticals”, “electronic pills” and “bioelectonic medicine” are terms that describe approaches of neural interfaces and implants in that field of research. Widespread diseases in ageing societies like diabetes, rheumatic arthritis, asthma but also hypertension, autoimmune deficiencies like Crohn’s disease are on the research agenda of biomedical engineering groups and small and large size start-up companies. Promises have been made and have to be kept withing the next years.
An overview of the basic ideas and approaches of the field of bioelectronics medicice will be given including the different physical modalities that have been proposed to interface with the nervous system: electrical signals, optogenetic modifications, nanoparticles and ultrasound are the most prominient ones. The pathophysiological of the most often targeted diseases will be discussed with respect to the envisioned methodologies how the bioelectronics approach will target and influence the origin or symptoms of the specific disease. Target specifications of required implants will be derived and mirrored commercially available and approved implantable medical devices in clinical practice. Progress of research will be critically reviewed with respect to fundamental knowledge of the interaction mechanism. Technology readiness levels will be assessed of interfaces and implants from both, academic research groups commercial companies at an international level. New approaches do not only need novel medical devices but also further education of the medical personnel since not only pharmacological expertise is needed but also profound knowledge in electrophysiology and biomedical engineering. This overview will be concluded with a discussion of the challenges and the promised time lines as well as aspects of reimbursement of novel therapies in the health system.
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FS 38

Nerve cuff electrodes for electrically interfacing with the peripheral nervous system

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Bioelectronic medicine focusses on treating conditions such as rheumatic arthritis, diabetes, hypertension, infertility and others by electrically modulating disordered circuitry of the peripheral nervous system. For doing so, the targeted nerves need to be connected to an electrical interface. Cuff electrodes provide such an interface. They consist of an electrically insulating cylinder installed around the nerve having one or multiple electrical contacts facing towards the neural tissue. Passing an electrical current through the contacts will either artificially excite fibers of the nerve, inhibit natural signal traffic to travel along the nerve or modulate the natural neural signals. We developed a flexible method for making multi-contact nerve cuffs for nerve diameters ranging from 0.1 mm to 10.0 mm diameter applying laser-micromachining of medical grade silicone rubber and high-purity platinum-iridium foil. Depending on the nerve diameter and the location of implantation (deep cavities or rather superficial locations) the cuff closure mechanism has to be adapted. The closure mechanism is responsible for 1.) a reliable fixation of the cuff to the nerve, preventing it from slipping off, and 2.) ensuring electrical insulation between the inside (nerve) and the outside (surrounding tissue) area of the cuff, which is desired for electrical stimulation, and absolutely crucial for electrical recording of nerve signals. Four closure mechanisms have been developed: a) Buckle and belt closure for very small nerves, so called 'sling cuffs', b) Self-closing split-cylinder with dual-sealing lips, called 'tunnel cuffs' c) Self-closing split-cylinder cuffs without extra seals and d) self-wrapping spiral cuff electrodes.
The cuffs have been used extensively in animal studies, providing stable electrical stimulation and recording properties, as well as in human studies for fascicle-selective nerve stimulation.

FS 39

Bioelectronic approach for diabetes therapy

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State of the art blood glucose monitoring bases on electrochemical measurements of blood droplets or via implanted sensors. The determination of the blood glucose level is a crucial parameter for type 2 diabetes mellitus (T2DM) patients. Electrochemical sensors are prone to sensor drift due to immune reactions which are hard to predict. In the body the physiological glucose sensor is located in the pancreas, i.e. in the beta cells encapsulated in the islets of Langerhans. The glucose metabolisation within these cells results in characteristic electrophysiological patterns. Phases of activity and phases of rest alternate, the duty cycle of this sum signal depends on the metabolism. As the ratio of activity to non-activity encodes the information rather than the amplitude of the signal, this method is stable and drift-free. Thus, recording the electrical activity of islets of Langerhans can be used to determine the blood glucose level. Furthermore this electrical activity directly links to the amount of insulin secreted by the very same beta cells.
Long term malnutrition results in increased activity of the beta cells. This overactivity can lead to cell damage due to the production of reactive oxygen species (ROS), one mechanism of T2DM. Alternatively, electrical stimulation of beta cells also causes secretion of insulin. This artificially induced insulin release does not induce damaging metabolism-dependent ROS production. Combining the two approaches of using beta cells in situ as glucose sensors and electrical stimulation is a novel concept to treat T2DM. In a project funded by the ministry of economics and finance Baden-Württemberg (AZ 7-4332.62-NMI/49), institutes of the innBW consortium aim on developing implant prototypes, investigate the biological basics and design the hard- and software to evaluate this therapy.

FS 40

Baroloop – selective vagal stimulation to treat hypertension

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In recent years, hypertension has become a major threat to both, patience life expectancy and healthcare systems. While many patients can be treated pharmaceutically, a larger percentage shows no response to this treatment. The human body is capable to adjust the BP to the actual demands by means of several, independent pathways. Using selective vagal stimulation, with our patented multichannel cuff electrode, we were able to modulate the inherent blood pressure signals of rats, sheep and pigs. This neuromodulatory procedure triggers the baroreflex, a body's own negative feedback loop, which decreases the blood pressure. The selectivity of our approach is a result of the geometry of our electrodes as well as the stimulation paradigm. Our Baroloop implant, which currently undergoes chronic test runs, will become a smart implant, capable to use the heart rate as a loop back control and safety feature. Our cuff electrode is manufactured in thin film technology to support superior structural solution and mass production capability, alike.

FS 41

Device-mediated-therapy – a neurosurgeon's perspective on implant design and device location

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In the recent years, non-medical treatment of common diseases like epilepsy, parkinson's and hypertension has moved in focus of research, with many different deviced being developed. Beside meeting the technical criteria for governmental approval, practical aspects for implantation should be kept in mind in order to assure the easiest and safest surgical procedure. Implantable devices should be packed in at least two sterile bags to avoid accidental contamination if one bag is damaged during opening. In the operation room, the medical assisting staff must be able to unpack the devices comfortably with minimal risk of improper, contaminating opening of the packaging. During development of an implantable device, different areas of implantation should be provided in case a patient's condition does not allow the device being placed at the standard location. If a cable needs to be positioned subcutaneously, a bidirection tunneling device should be provided in order to assure clean and safe implantation with minimal cutaneous incisions. In thin patients, a bulky device with sharp edges can cause severe impaired wound healing with possibly catastrophic consequences like infection and sepsis. In contrast, a deep subcutaneous implantation in an obese patient can compromise telemetric communication. In the clinical routine it is desirable that an implant and its MRI compatibility is easy to identify via x-ray and that sufficient information on the implant is available via Internet.

FS 42

Exposure in CT – measurements of CTDI and DLP, guidelines and diagnostic reference levels

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CTDI and DLP are the fundamental dose values for computed tomography examinations. They are the basis for advanced dose calculations including size specific dose estimates (SSDE) for establishing diagnostic reference levels and can be used to optimize the scan protocols.
The basic concepts will be presented together with the assessment and optimization of the corresponding patient exposure. Local and international guidelines (AAPM) will be discussed in order to give practical hints for the use in daily routine.

FS 43

Parameters that influence image quality and dose

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With basics from lecture 1 the different scan parameters will be compared regarding their influence on patient dose and resulting image quality. In addition to tube voltage and tube current as protocol and user depended parameters also collimation/slice thickness and pitch as well as the different methods of tube current modulation and iterative reconstruction will be discussed.
After both lectures, the audience should have the necessary basic information to continue with the presentation of examples in session 2.

FS 44

Three-dimensional calculation against mutually changed isodoses in brachytherapy due to inhomogeneity-based dose calculations

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Question: With the introduction of inhomogeneous algorithms in brachytherapy, comparison plans with respect to the different algorithms can be safely generated. Often, however, the plans of both algorithms (TG-43 / ACE), especially in the abdominal region or in body regions with large surrounding scattering regions, differ very little in their respective DVH representation. Nevertheless, local shifts in specific isodoses are often caused by local small inhomogeneities and / or altered scattering regions. A three-dimensional absolute calculation of local differences with a vectorial representation allows a rapid evaluation and estimation of these differences, in plans that are almost identical in their DVH representation.
Methodology: By means of a proprietary C ++ tool programmed in the house, all the concrete structures of a brachytherapy plan can be easily extracted. Since isodoses can be deposited as an ROI structure, it is now possible to evaluate the isodose-based structures of plans computed with different algorithms. After the initial application of a Hull function to the extracted point clouds of an isodose starch, absolute concrete isodose distances can be calculated and displayed three-dimensionally by successive analysis of the deflection beams emanating from the inner center of gravity of an ROI structure in all directions. In order to solve the distance calculation of triangulated planes, vector-stretched equation systems are solved.
Result: The mathematical method allows the calculation of concrete absolute distances of two opposing isodose surfaces. It is possible with the proposed method to find and detect small local changes very quickly, despite the hardly visible differences in DVH.
Conclusion: For the scrolling and the elaborate search for possible differences of two plans, which are hardly different in DVH values, now a tool is available, in order to automatically search for isodose differences. This also provides an absolutely determining tool for analyzing the three-dimensional effects of changing isodoses.

FS 46

Impact of heterogeneity-corrected dose calculation using a grid-based Boltzmann solver on breast and cervix cancer brachytherapy

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Purpose: To analyse the impact of heterogeneity-corrected dose calculation on dosimetric quality parameters in gynecological and breast brachytherapy using Acuros, a grid-based Boltzmann equation solver (GBBS), and to evaluate the shielding effects of different cervix brachytherapy applicators.
Material and methods: Calculations with TG-43 and Acuros were based on computed tomography (CT) retrospectively, for 10 cases of accelerated partial breast irradiation and 9 cervix cancer cases treated with tandem-ring applicators. Phantom CT-scans of different applicators (plastic and titanium) were acquired. For breast the $V_{20Gy\alpha\beta3}$ to lung, the $D_{0.1cm^3}$, D_{1cm^3}, D_{2cm^3} to rib, the $D_{0.1cm^3}$, D_{1cm^3}, D_{10cm^3} to skin, and D_{max} for all structures were reported. For cervix cases, the $D_{0.1cm^3}$, D_{2cm^3} to bladder, rectum and sigmoid, and the D_{50}, D_{90}, D_{98}, V_{100} for the CTV_{HR} were reported. For the phantom study, surrogates for target and organ at risk were created for a similar dose volume histogram (DVH) analysis.
Results: Calculations with TG-43 overestimated dose for all dosimetric indices investigated. For breast, a decrease of ~8% was found for D_{10cm^3} to the skin and 5% for D_{2cm^3} to rib, resulting in a difference of –1.5 Gy EQD2 (equivalent dose to 2 Gy fractionation) for overall treatment. Smaller effects were found for cervix cases with the plastic applicator, with up to –2% (–0.2 Gy EQD2) per fraction for organs at risk and –0.5% (–0.3 Gy EQD2) per fraction for CTV_{HR}. The shielding effect of the titanium applicator resulted in a decrease of 2% for D_{2cm^3} to the organ at risk versus 0.7% for plastic.
Conclusions: Lower doses were reported when calculating with Acuros compared to TG-43. Differences in dose parameters were found larger in breast cases. A lower impact on clinical dose parameters was found in cervix cases. Applicator material causes systematic shielding effects that can be taken into account.

FS 47

Phantom study to compare dose calculation in Oncentra Brachy TG-43 and ACE for skin treatments with superficial mould (Freiburg-Flab)

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Since few years dose calculation algorithms are available, which are taking inhomogeneity of density into account. These new algorithms follow the recommendation of TG-186. Since 2008 in Augsburg patients with non-melanoma skin-cancer are treated with 3-D planned HDR-Brachytherapy by means of Ir-192 source and Freiburg-Flab. We are investigating the difference of dose calculated according TG-43 and TG-186 to points on the skin surface retrospectively in clinical cases with Oncentra Brachy (Elekta). For a better understanding of the results when running a dose comparison study for clinical cases with bended catheters a phantom study under clear geometric conditions is performed and will be presented here. A Flab 9cmx11cm was positioned on 7cm RW3, scanned and a 3D-planning performed in TG-43 and TG-186. To compare the data to published papers, which are comparing TG-43 to Monte Carlo calculation and to examine recommendation to cover the Flab with scatter material, RW3 from 0cm-5cm was positioned onto the Flab giving different scatter-conditions. The dose is calculated in TG-43 and in TG-186, by use of the f-factor, the dwell times in the TG-186 are adjusted to be the same as in TG-43. The dose is compared for points in -/+ 0.5cm and for several other distances, too. In the planning process the body is contoured but neither the target volume nor the Flab. In the clinical workflow one cannot contour the Flab precisely. We investigate the influence on dose calculation when the flab material is neglected, partial contoured by applying automated contouring and a rough contouring taking the air gaps as water equivalent. Oncentra Brachy gives two options in calculation accuracy the influence is investigated as well.

V 102

High-speed kV-CBCT lung cancer imaging within single breath-hold: dose exposure and image quality phantom study

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Lung tumors treated with hypo-fractionated deep-inspiration breath-hold benefit strongly from fast imaging and treatment. While treatment can be accelerated with flattening-filter-free techniques, conventional kV-CBCT for patient positioning takes about 2-4min in repeated breath-hold. Acceleration of linac gantry rotation from 3°/s to 18°/s would allow image acquisition within single breath-hold.
A comparison study between faster CBCT (18°/s) and conventional, clinical CBCT (3°/s) was performed to evaluate dose exposure and image quality. An inhomogeneous thorax phantom with four different tumor-mimicking inlays was used to simulate a lung cancer patient. The imaging preset setup was 200° rotation, 100kV and 0.1mAs/frame in conventional and faster CBCT. Dose exposure was determined at representative positions. Image quality was analysed regarding signal-to-noise ratio (SNR) in tumor and lung tissue, contrast-to-noise ratio (CNR), and geometry of tumor-mimicking shapes.
The dose exposure in different positions (tumor, both lungs, central and peripheral positions) was reduced by a factor of 3.8-4.8 (73.3-79.2%) to sub-mGy range; the lowest dose-reductions occured at the start- and stop-position of the gantry rotation due to gantry braking characteristics. In the high-density tumor-mimicking inlay and the low-density lung, the SNR was reduced by 10% respective 40% with faster gantry rotation. The CNR between tumor- and lung-material was reduced up to 70% due to undersampling. However, the image quality for tumor localization was still sufficient. The geometric shapes of the tumor-mimicking inlays were measured and comparison with the sizes provided by the manufacturer showed a mean difference of (-0.5±0.7)mm for conventional, and (-0.8±0.8)mm for faster CBCT, with maximum difference 2mm.
In conclusion, this study showed promising results for high-speed kV-CBCT lung tumor imaging with faster gantry rotation. Imaging times of ~10s in combination with fast treatment delivery could lead to future combined imaging and treatment within only several breath-holds and thus potentially increase treatment accuracy and patient comfort.

V 103

Is the assumption correct that the human body is rigid during couch tracking?

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Introduction: Couch tracking is one approach to mitigate intrafractional tumor motion in radiotherapy. The couch countersteers the tumor motion, however this might affect the patient's motion relative to the couch. This relative motion introduces uncertainty about the actual tumor position, and may degrade the couch tracking performance. So far, the magnitude of the relative motion is unknown.
Method and Materials: 85 volunteers were placed on a robotic couch that could move based on the volunteers' respiration. The couch switched three times between static and tracking conditions. An optical sensor recorded (10 Hz) a three-dimensional point cloud representing the surfaces of the volunteer and the couch. Markers placed on the volunteers (body markers) and the couch (couch markers) were tracked in these point clouds. The couch marker trajectories were combined to a rigid body trajectory, relative to which the body markers should ideally not move. The body marker motion consisted of relative motion and respiratory motion components. The respiratory component was subtracted from the body marker motion by correlating it to the measured respiration. Body markers with correlation coefficients below 0.9 were removed from further analysis. Finally, the difference of the body markers' relative motion between static and tracking was analyzed.
Results: Under tracking conditions, the markers showed significantly larger relative motion for all three dimensions ($p<0.0001$). The 95% confidence intervals were [0.29,0.39] mm, [0.31,0.44] mm and [0.32,0.4] mm for left-right, superior-inferior, and anterior-posterior relative motion, respectively. The largest differences were 2.1 mm (left-right), 2.3 mm (superior-inferior), and 2.3 mm (anterior-posterior) over all markers of all volunteers.
Conclusion: During couch tracking, the relative motion of the patient to the treatment couch was small for the majority of volunteers. However, a few volunteers exhibited substantial relative motion, therefore, patients should be checked on their relative motion before couch tracking treatment.

V 104

Dynamic treatment-couch tracking for motion mitigation during prostate SBRT – a geometric and dosimetric validation study

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Purpose: Prostate SBRT treatments demand high accuracy in dose application. Intra-fractional prostate motion might lead to target miss or increased dose to surrounding organs. The potential of dynamic treatment-couch tracking to mitigate the effect of the prostatic motion during prostate SBRT was evaluated geometrically and dosimetrically.
Methods: For ten prostate cancer patients, SBRT treatment plans with integrated boosts (prostate+5 mm: 5x7 Gy, index lesion+3 mm: 5x8 Gy) were prepared. For the geometrical evaluation, the plans were applied to a small lead ball placed at the beam isocenter. The ball was moved according to five prostate motion curves without motion compensation or with real-time compensation using the treatment couch while MV images were taken. These show the field edges in respect to the lead ball. The over- and underexposed areas were evaluated by comparison with static reference images. For the dosimetric evaluation, the plans were applied to a Delta4 phantom. The phantom was moved with and without couch tracking. The measurements were compared to a static reference measurement. The dose to 95% (D_{95}) of the prostate and index lesion and the gamma agreement ($\gamma_{1\%/1mm}$) of rectum and urethra were evaluated.
Results: The median (quartiles) over- and underexposed area was reduced significantly from 2.02 cm^2 (1.55 cm^2, 2.51 cm^2) without motion compensation to 0.45 cm^2 (0.40 cm^2, 0.54 cm^2) with couch tracking. The prostate D_{95} and index lesion D_{95} were significantly improved with tracking showing values closer to the static references. The rectum $\gamma_{1\%/1mm}$ was improved significantly from 64.2% (47.3%, 88.9%) without compensation to 100.0% (100.0%, 100.0%) with tracking and for the urethra $\gamma_{1\%/1mm}$ from 77.5% (59.6%, 92.9%) to 100.0% (100.0%, 100.0%).
Conclusion: Couch tracking significantly improved the accuracy of prostate SBRT in the presence of motion and was proven to be a feasible motion mitigation method applicable at conventional linear accelerators.

V 105

Motion extraction from 4D-MRI for MR-guided particle therapy of pancreatic cancer

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For the treatment of abdominal tumors, information about anatomical motion is essential. In particular, this is the case for particle therapy, where, due to the well-defined particle range and the inverse dose profile, motion-based uncertainties might lead to misdosages to the target and deliver unwanted dose to normal tissue. Time-resolved volumetric magnetic resonance imaging (4D-MRI) shows high potential to provide the necessary motion information without applying any additional dose to patients. The purpose of this study was to extract the motion of the pancreas from 4D-MRI data as a step towards MR-guided particle therapy of pancreatic cancer. For this purpose, 4D-MR images (spoiled 3D-encoded gradient echo, radial VIBE) were taken of several volunteers and sequence parameters were optimized to obtain high contrast between pancreas and its surrounding tissue. 4D-MRI data were reconstructed with an in-house developed self-gated motion-compensated algorithm. This algorithm provides 3D images of 20 breathing phases by including artifact-robust motion estimation into image reconstruction. For each volunteer, the pancreas was manually segmented on one of the available 20 breathing phases of the respective 4D-MR data set. The vector fields between the different breathing phases were calculated using first rigid and then B-Spline image registration algorithms. The pancreas segmentation was then transformed based on the calculated vector fields into each breathing phase. The trajectory of the center-of-mass of the pancreas was extracted from these data as well as Dice coefficients which describe the overlap of segmentations in different breathing phases. We identify the main motion of the pancreas in cranio-caudal direction and observe absolute motion amplitudes of 12-16 mm. The small Dice coefficients (mean 0.57, range 0.28-0.89) and the patient-specific motion patterns show that motion needs to be assessed carefully. 4D-MRI can be utilized to provide this crucial information.

V 106

Monte Carlo framework for the evaluation of interplay effects between dose application and respiratory motion

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We developed a 4D dose recalculation workflow to simulate the dose delivered to a moving target volume. The aim is to evaluate interplay effects between actual dose delivery and the motion of the tumor. The workflow combines Monte Carlo dose calculation with the linac log files and a dose accumulation based on 4D-CT images. Log data from the linac are retrieved with the Delivery Parameter Log File converter for Integrity (Elekta) and converted into small treatment plan fragments, each covering for example 0.1s. Every plan fragment is forward calculated on every 4D-CT phase using MCverify/Hyperion V2.4 (research version of Monaco 3.2, Elekta). This allows the simulation of arbitrary respiratory curves with a resolution of 0.1s by assigning every fragment to a distinct 4D-CT phase (e.g. changes in breathing frequency, different respiration patterns as well as simulation of gated treatments). As a final step AVID (a software framework for medical data processing developed at Deutsches Krebsforschungszentrum (DKFZ)) is used to accumulate dose fragments for each 4D-CT phase and to combine them to a total dose based on deformable image registration (plastimatch).
The developed workflow was validated with the Dynamic Thorax Phantom (CIRS) and applied to a lung tumor patient case (tumor volume 9cm^3, crano-caudal movement of 1.6cm in the 4D-CT).
Due to the large fields used in 3D-Conformal- and Dynamic Conformal Arc-plans, the dose distribution in the GTV was robust against changes in the simulated breathing. Advanced techniques showed relative changes in $D_{98\%}$ of 3.8% for IMRT and 2.4% for VMAT respectively (periodic breathing, treatment start in exhale compared to treatment start in inhale). Differences for $D_{2\%}$ were less prominent in the evaluated example case.
The developed workflow is able to show potential interplay effects between dose application and tumor motion for different treatment techniques and breathing scenarios.

V 107

Magnetic-field measurement and simulation of a field-free line magnetic-particle scanner

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In 2005, B. Gleich and J. Weizenecker initially presented the promising new tracer based medical imaging modality Magnetic Particle Imaging (MPI). It uses the nonlinear magnetization behavior of particles consisting of an iron oxide core coated with dextrane (super paramagnetic iron oxide nanoparticles, SPIONs). MPI has the potential to perform real-time imaging in the sub millimeter-range without the use of harmful radiation. To acquire a particle signal from the tracer, an alternating homogenous magnetic field (drive field) is applied. Due to the nonlinearity of the particle magnetization, the magnetic field is distorted and higher harmonics are generated that indicate a particle concentration within the field of view (FOV). To gain the spatial distribution, another magnetic field that exhibits a high gradient is applied simultaneously. This second field is called selection field.
Basically, there are two different types of selection fields. The first approach uses a constant magnetic gradient field containing a field-free point (FFP). Only SPIONs within the close vicinity of the field-free point contribute to the particle signal because all other particles within the FOV are magnetically saturated. As the FFP is moved by the drive field through the FOV a spatial distribution can be obtained. The second approach uses a rotatable field-free line (FFL) that is additionally translated by the drive field to obtain one dimensional projections for various angles. The advantage of the FFL approach is a higher signal quality at equal size and gradient strength while a drawback is a higher power consumption and a more complex coil topology to generate, rotate and translate the FFL.
In this work, the currently world's largest FFL MPI Scanner is investigated. Single components of the generated magnetic field are measured precisely to accomplish an accurate simulation of a translating and rotating field-free line.

V 108

Transportable magnetorelaxometry device for quantification and characterization of magnetic nanoparticles

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Due to their biocompatibility and superparamagnetic properties, magnetic nanoparticles (MNPs) are utilized in a variety of biomedical applications such as drug delivery, hyperthermia and imaging. The efficiency of these applications depends on the MNP characteristics (e.g. magnetic moment distribution, colloidal stability, hydrodynamic size distribution, binding on biological targets) and needs to be investigated prior in-vivo administration.
Magnetorelaxometry (MRX) measures the decaying magnetic response of the MNP sample after switching-off a polarizing magnetic field. It is utilized for the specific quantification and characterization of MNPs in biological systems, with detection limits of a few nanogram iron content. Magnetically shielded rooms are typically required for MRX measurements, since the MNP signals are several orders below urban magnetic fields. The shielding allows superconducting quantum interference devices (SQUIDs) to be used for signal detection, offering sensitivities down to 10^{-15} T $Hz^{-1/2}$, with bandwidths of several MHz. Here, we present a portable MRX device based on SQUIDs with integrated superconductive shielding for MRX measurements in a laboratory environment.
A superconducting niobium cylinder shields 6 SQUIDs distributed circumferentially around a horizontal warm bore (d =27mm, l =700mm), inside a liquid helium dewar vessel. A magnetization coil inside the warm bore provides magnetic fields up to 4 mT. The sensor-sample distance is below 20 mm. Within this device, the MNP sample (V = 150 µl) is magnetized for t_{mag} = 1 s and after a delay time of 300 µs needed for SQUID recovery, the MRX signal is simultaneously recorded by the 6 SQUIDs for t_{meas} = 1 s with a sample rate of 100 kHz. The signal-to-noise ratio is improved by averaging of ten individual MRX curves.
The transportable MRX device allows to access MNP characteristics in biological tissue in laboratory environment. The device might be extended to a MNP imaging system for small animal models.

V 109

Magnetic resonance imaging versus histology – Do they really measure the same?

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The vast majority of preclinical studies which monitor and evaluate the *in vivo* response of new materials apply histological techniques. However, using these methods the laboratory animals always have to be sacrificed at each time point. Subsequently, it is not possible to monitor the healing process of one animal repeatedly and a large number of animals is required for a particular study. The increased biological variability also impedes the comparability. Hence, there is a great need to develop and evaluate high-resolution *in vivo* imaging technologies which allows repeated measurements of individual animals. Imaging with high resolution is of great importance because the interface between implanted material and host system is the region of interest.
The authors demonstrate a detailed method comparison between histology and magnetic resonance imaging. Exemplarily, the bony ingrowth of tissue engineered bone substitutes for treatment of a cleft-like maxillary bone defect has been evaluated. First, the detectable anatomical structures of the artificial defect are presented. Both imaging methods enabled a detailed impression of the maxilla and the skull. Additionally to the qualitative description of the defect healing, quantitative parameters were measured by means of both methods. Agreement analysis has been performed using a graphical concordance analysis, which includes X-Y-scatter plots and Bland-Altman diagrams. A fast and clear depiction of statistically relevant measurement deviations was achieved by implementing the 95 % confidence intervall of the calculated bias. A slightly but significant bias in the case of the bone volume and a clearly significant deviation for the remaining defect widths between both methods were found. Moreover, a considerable effect of the analyzed section position to the quantitative result has been identified. The bias of the data sets was less originated due to the imaging modalities, but mainly on the evaluation of different slice positions.

V 112

Organs contours by equipotential lines and adjustment to edges in CT images

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The modelling of organs plays a vital role for the simulation of radiation transport for radiation protection and therapy. A new approach is to describe organ contours by a set of source points generating a field in analogy to electrical point charges. For an individual organ a model was created from already segmented data of human anatomy and a distribution of source points was found. The resulting equipotential lines provide appropriate fits for the contours of compact organs like heart, stomach and bladder. Now, the equipotential line shall be adapted to the edges in a CT image. The single source points placed in a CT slice are able to move within a given area thus their local contribution to the resulting equipotential line moves, too. Each source point shall be tested for its position in regard to the edges of the image that the resulting equipotential line provides a sensible fit for the organ contour. The principle of electrical fields offers an aspect that serves as criterion for optimising the place of a source point. The field lines are perpendicular to the equipotential lines and lead in radial direction from the source point. Edge detection is performed on the CT image by means of gradient methods. The scalarproduct of both wheighted by factor provides a measure to tell how good the equipotential line of the contour fits the edges of the image. If that term is maximised for a single source point, the place is considered to be better. That way an organ outline is registered to the detectable edges of the CT image.

V 114

Contactless measurement of the arterial oxygen saturation

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The arterial pulse rate and the arterial oxygen saturation (SaO_2) are an important part of monitoring a patient's vital signs. To estimate a patient's SaO_2 value conventional probes need to be attached to the subject's skin, in most cases around a finger or, in the case of premature infants, around a foot. This method is not always suitable, as there are reasons like damaged skin tissue or frequent loosening of the sensor, which prohibit attaching a probe directly.
With the methods presented here a camera based system can be used, that allows contactless measurements of the beforementioned vital signs. The system consists of a camera attached to a time multiplexed LED-array alternating red (660nm), near-infrared (810mn) and no active illumination synchronously during the exposure for each recorded image. The camera sensor's 10-bit ADC capability is barely sufficient for detecting arterial pulse related changes of brightness on an observed area of skin. Hence the ADC's sensitivity is extended by integrating brightness values over two areas of interest (64x64 pixels). Those areas of interest record an area of the subject's skin and a lifeless reference area, that is used to cancel the effects of an unstable lighting due to changes of the LEDs' luminosity. This theoretically allows the camera to detect changes of 2^{-22} in the luminosity value of the camera. By carefully choosing the sampling rate the camera's limitations fulfilling the sampling theorem for background noise sources can be minimized. After transforming the pre-processed signals into frequency domain, the subject's arterial pulse rate can be determined. The frequency-domain-signal contains information about the absorbance of light by pulsating arterial vessels corresponding to each used wavelength of light. This information can then be used to calculate the arterial oxygen saturation by approximating the Beer-Lambert law.

V 115

Handheld endoscopic device for in vivo morphological imaging of the human oral mucosa by optical coherence tomography

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Oropharyngeal carcinoma is currently the 10th most common cancer worldwide. Up to 400,000 incident cases of oral cancer are detected every year. In this regard, squamous cell carcinoma accounts for about 90 percent of these oral tumors. The difficulty of the in vivo classification of the lesions in dysplasia or else invasive carcinoma represents a constant therapeutic dilemma. Although the therapy options have improved in the last two decades, the overall 5-year survival rate of patients remained more or less unchanged. Therefore, the early diagnosis of oropharyngeal cancer and its precursor lesions remains the best way to ensure the survival of the patients and their quality of life. In this respect, optical coherence tomography (OCT) seems to be a promising imaging modality for the noninvasive detection of oral malignancy and the reliable screening of high-risk patients. This new method allows the contactless highly resolved imaging of biological tissue, by depth-resolved cross-sectional images and volume scans similar to ultrasound imaging. In this research, a new handheld endoscopic scanning unit is designed, which is accessible to almost every part of the human oral cavity. The development is based on a forward imaging endoscopic device, which allows the telecentric imaging with a working distance of 10 mm and a sufficiently large field of view of 5 mm. In combination with a customized high resolution OCT system of our workgroup, in vivo imaging of the non-ceratinized oral mucosa at different zones of the cheek, the lateral tongue as well the anterior palatal arch is performed. In an upcoming study, the endoscopic OCT scanner will be used first with volunteers for the systematic determination of the epithelial thickness in different regions of the human oral mucosa and second in a clinical study for the qualitative morphological and functional imaging of epithelial tissue alterations.

V 116

Process improvement of locking intramedullary nails

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Complex fractures of long bones require the insertion of an intramedullary nail into the medullary canal of the fragments. The distal and proximal endings of the intramedullary nail usually provides two cross-holes for interlocking with screws and therefore strengthening the fragments during the healing process. To locate these cross-holes, diagnostic radiology is applied using a C-arm system causing an exposure to X-ray radiation for the surgeon and patient. Aborted and repeated drilling might not be excluded.
The aim of the improvement is the reliable and exact localization of the intramedullary nail and its locking holes. We developed a method of navigation including the following components: two opponent sighting camera marker modules, a software tool including algorithms and a mechanical target device for detecting the nail holes within a minimum of X-ray shots. The camera-marker-modul consists of an IR camera, 4 LED-markers and a radio transmission unit. The camera marker module determines the position of the drilling machines depending on the nail holes. The position data is transferred in real-time, thus the surgeon can view the relative position on the computer display.
This newly developed method of locking intramedullary nails is a reliable and low-radation system. The system has the following benefits: avoidance and diminution of exposure to radiation respectively for the surgeon and patient, reduction of individual influences of the surgical result, reduction of sugery duration and avoidance of repeated operations, decreasing strain of the surgeon during technical operation, improvement referring to postural deformities and fatigue, enhancement of locking intramedullary nails by applying new operational and functional sequences, avoidance and reduction of X-ray diagnostic substances and simple, ergonomically designed and self-explanatory handling of the operation technique.

V 117

Evoked potentials from transcutaneous spinal cord stimulation

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Transcutaneous spinal cord stimulation (tSCS) has been shown to abbreviate spasticity in lower limbs in people with incomplete spinal cord injury (SCI) people. Therefore tSCS is a therapy of choice for SCI in our clinic. It is also known that SCI modulates the organisation of the brain in the way that it decreases the areas allocated for the control of the not connected extremity part. Therefore we hypothesize that the tSCS treatment can influence the plasticity of the brain as well. In this work the footprint of the tSCS in the EEG is sought in order to verify that the stimulating signals are transmitted to the brain.
In this first approach one healthy subject for control and one Cerebral palsy (CP) patient participated. Cortical somatosensory evoked potentials (SEP) where recorded during tibial nerve stimulation and during tSCS. The recording of SEP during tibial nerve is well documented so it serves as a proof of method. Then SEP was also recorded during voluntary ankle dorsiflexion and analyzed for event-related (de-)synchronization (ERD/ERS).
SEP is clearly to be seen in the sensorimotor cortex during tSCS. It is though different in form from the SEP during tibial nerve stimulation. As expected the ERD/ERS were focused over the Cz electrode as documented in the literature. After movement by the CP subject the synchronisation was limited and therefore different to a healthy subject. But no significant changes where found after treatment.
As the tSCS modifies the SEP the hypothesis that the treatment could influence the brains plasticity is supported. The difference in SEP between tSCS and tibial nerve stimulation suggests that different fibres in the spinal cord are stimulated. ERD/ERS patterns are changed in CP compared to a healthy subject.

V 118

Realization and testing of a 3D electrode array for measuring electric potential differences in a volume conductor

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Measurements of electric potential differences in a physical phantom volume conductor allow the assessment of electroencephalography source reconstruction procedures and for the assessment of electrical stimulation profiles during transcranial electric stimulation (TES) including device validation. In the present study, we describe the realization and testing of an electrode array to detect electric potential differences in a head shaped volume conductor.
The electrode array design follows the parietal curvature of a human inner skull. The polymer array comprises 23 rods plugged into a common base and was produced with additive manufacturing. Each rod holds three silver/silver chloride pellet electrodes, one placed at the tip and two along the shaft spaced 10 mm. The electrodes sample approximately a volume of an ellipsoidal cylinder with half axis of 30 mm and 25 mm and a height of 50 mm. The electrode array was first tested in a volume conductor homogeneously filled with a 0.17 % sodium-chloride solution. Two 50x50 mm stimulating rubber electrodes applying a direct current of 2 mA were placed at opposite sides of the volume conductor with a distance of 1200 mm to each other. A biosignal amplifier (eego-sports, ANT) recorded the electric potential differences at the electrodes in the array. In addition, simulations of the electric potential distribution in the same setup modelled by the finite element method were carried out in Comsol.
Using the electrode array, it was possible to record the electric potential distribution in the volume conductor. Distortions of the electric potential distribution were detected by comparing simulations neglecting and modelling the polymer rods. The strongest distortions were found in between the single rods and on their tops.
With the present study, we provide a proof of principle for the validation of simulations for electric potential distributions as used in TES in a homogeneous volume conductor.

V 119

Individualized design of fluidically actuated cochlear implants

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Fluidically actuated cochlear implants have the advantage to allow an individualized curvature behaviour of the implant at a predefined fluidic pressure. This enables one to cover the anatomical variation of the perimodiolar cochlea paths between the individuals. Within this study individualised designs based on the anatomical variation of the perimodiolar paths in the scala tympani were analysed.
For this study, three-dimensional datasets of the cochlea derived from µCT and Microgrinding were segmented in 22,5° steps around the modiolus of the spiral shaped cochlea, starting at the round window and ending at 675°. 23 Cochlea (11 right, 12 left) were analyzed in this way and the corresponding perimodiolor paths were extracted. The paths derived from right sided datasets were mirrored providing the requirements for statistical analysis, all paths were then projected into a plane and fitted with a spline function to mathematically describe the course of the curvature. This fitting was followed by an individual analytical synthesis (Wolfram Mathematica 10.4) to calculate the function for the specific geometrical design of an fluidically actuated implant for each perimodiolar path.
The radius of the inner hollow of the implant used for pressurization, the silicone material properties of this implant and the fitted perimodiolar paths had to be predefined as parameters to calculate the course of the outer implant radius for a fixed fluidic pressure (here 6 bar). The mean implant length, calculated for a complete insertion of 675°, is 16.4mm (range: 13.3-18.5mm). The basal and apical radius of the implant were calculated to be 0.32mm (0.30-0.33mm), respectively 0.22mm (0.21-0.23mm). Subsequently finite-element simulations were carried out to verify the calculated designs.
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V 120

Comparison between intraopereative and chronic deep brain stimulation

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The success of deep brain stimulation (DBS) therapy relies primarily on the localization of the implanted electrode, thus, the utmost accuracy in the targeting process is needed. Intraoperative microelectrode recording (MER) and stimulation tests are a common procedure to determine the optimal implant site but differences have been reported between the intraoperatively and postoperatively identified optimal stimulation positions. Differences in dimensions and operating modes exist between the intraoperative and the permanent DBS electrode, suggesting different stimulation fields, even when ideal placement is achieved. The aim of this investigation was to compare the electric field (EF) distribution around the intraoperative and the chronic electrode, assuming ideal placement. 3D models of the intraoperative exploration electrode and the chronically implanted DBS lead 3389 (Medtronic Inc., USA) were developed using COMSOL 5.2 (COMSOL AB, Sweden). The influence of the grounded guide tube of the exploration electrode, parallel MER trajectories and unused (floating) contacts of the chronic electrode were investigated. During the study, differences in the electrical connection between the patient and the ground of the respective pulse generator and their influence have also been explored. Simulations have been considered for current-controlled stimulation with grounded guide tubes and voltage-controlled with domain boundaries grounded for the intraoperative and chronic electrode respectively. Maximum radial extension of the EF isocontour at 0.2V/mm was used as the equivalence metric. Models were created using homogeneous grey matter tissue (σ=0.123 S/m). Simulations have shown the clear influence of the parallel trajectories and floating contacts, which tend to expand the isocontour away from the target. Exploration of guide tube and connection influence revealed electric field around the guide tubes. Differences in the EF shape between the exploration and the chronic DBS electrode have been observed which might be partially responsible for the differences reported between intraoperative and chronically identified optimal stimulation positions.

V 121

Simulation of light propagation in human skin and skull for the development of sensor system to measure the cerebral oxygen saturation non-invasively

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In the medical field, there is a high demand for non-invasive methods for monitoring of the status of patients. Heart rate and arterial oxygen saturation are such parameters, which can be measured with non-invasive optical methods, e.g. the photo-plethysmography. Red and near infrared (NIR) light is be able to penetrate human tissues and is applicable for in-vivo tissue spectroscopy. Some applications use the strong difference between the spectral absorption coefficient between oxygenated and deoxygenated blood. The simulation of the light, which is interacting with biological tissues is a useful method for sensor development and optimization.
In this paper a sensor concept for determining the cerebral oxygen saturation level and the simulation results of the light propagation are presented. As simulation tools the ray tracing software ASAP (Breault Research Organization) is used. ASAP software based on the radiative transfer theory of photons by using Monte Carlo method and it is possible to simulate the light propagation in biological tissues. A simplified model for the human head with different skin layers, the skull bone and the brain is realized. The simulated sensor system consists of a multi package LED with four wavelengths and up to four detectors. At first, for simulation of light travelling in the human brain an ideal source and detectors can be used. Later, the ASAP models can be adapted to realistic models of the LED's and detectors, which are used in the real prototype system. The detectors are placed in different distances to the source. The detected light of the detectors travelled on different paths through the tissues, depending from wavelengths e.g. energy of the photons. The selected sensor configuration can be evaluated and the simulation shows the middle penetration depth of photons, the signal intensity to the detectors and other important information for a later sensor development.

FS 48

The DAAD Pagel Project "Supporting Medical Physics Education in Bangladesh"

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The DAAD Pagel Project „Supporting Medical Physics Education in Bangladesh" is based on a number of previous projects by Working group AK16 of DGMP "Medizinische Physik in den Entwicklungsländern" and by the Heidelberg University Faculty of Physics in co-operation with the German Cancer Research Center (DKFZ). In the former projects the first master program teaching Medical Physicists in Bangladesh was initiated at Gono Bishwabidyalay (University) in Savar, Dhaka, and 11 students of the course were invited to Germany to work on the practical assignments of their Master's thesis. In 1998 The Bangladesh Medical Physics Association (since 2009 Society), founded in 1998 by these students has since then has organized national and international meetings and workshops, and has lobbied the Bangladesh Ministry of Health, achieving recognition of the profession of Medical Physics as important member of all fields of Radiation Medicine. In the years 2014-2017 the Pagel Project between the University of Heidelberg Medical Center in Mannheim and Gono University has continued these activities by inviting Gono students to parts of the Mannheim Medical Physics Masters course. Two PhD students were invited to Germany to fulfill the practical assignments of their thesis and 6 graduated medical physicists to achieve practical experience in 3 month visits at hospitals in Germany. Based on the experience of the ongoing project, the future cooperation between University of Heidelberg Medical Center in Mannheim and Gono University will focus on improving the teaching of mathematical and technical skills, by supporting co-operations between Gono and other universities, hospitals and government institutions in Bangladesh and in the South Asian area.

FS 50

Cooperation in medical physics between Heidelberg University in Germany and Gono University in Bangladesh

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In 1994, the Physics Department of Bangladesh University of Engineering and Technology (BUET), Dhaka started a health physics course on the post graduate level. From 1996 to 2000 in cooperation with the task group "Medical physics in the developing countries K16" of the German Society of Medical Physics (DGMP) five seminars and workshops were conducted in BUET gaining public awareness and motivating physicists to become medical physicists (MP). In 2000, a department of Medical Physics and Biomedical Engineering (MPBME) was founded in Gono University containing master course (120 credits) and since 2005 a bachelor (192 credits) course in MPBME. The syllabus of these courses is based on the documents of the DGMP, AAPM and IAEA.
In the years 2003-2006, nineteen students and teachers were educated and trained in German Cancer Research Center and Heidelberg University Hospital under the student-teacher-exchange program between the Gono University and the Heidelberg University financed by DAAD scholarship. This collaboration was extended in 2014 including Mannheim Medical Center for another 4 years from 2014-2017, educating 40 MP for research, teaching and clinical practice in Germany and in Bangladesh. With the help of minimal resources and young teachers approximately 30 MSc and 73 BSc degrees were reached and promising research work was initiated. Gono University expanded its cooperation with many hospitals and universities in Bangladesh and abroad especially in Germany, India and China.
For Bangladesh a need of 160 radiotherapy centers and 700 MP is estimated. Presently there are only 17 centers and 30 MP. The training program and the accreditation program for MP could be started with the help of the IOMP and the IAEA. Today 220 students studying in the MPBME department and in the near future Gono University will contribute significantly to cover the manpower requirements in Bangladesh.

FS 51

Gesundheitswesen und medizinische Physik in Vietnam

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Vietnam, gelegen in Südostasien, ist etwa so groß wie Deutschland, hat ca. 92 Mio. Einwohner und gehört mit einem Bruttoinlandsprodukt pro Kopf von 2088 US$ (2015, zum Vgl. BRD: 40.952 US$) zu den so genannten „Middle Income Countries“. Das vietnamesische Gesundheitswesen, eines der besseren der Region, hat neben dem eher unterfinanzierten staatlichen auch einen kleinen privaten Sektor, welcher der in den Städten wachsenden Mittelschicht Zugang zu moderner Medizin bietet. Im Rahmen der Anstrengungen zur Verbesserung der medizinischen Versorgung der Bevölkerung sind seit kurzem auch die meist besser ausgestatteten Militärkrankenhäuser verpflichtet, ihre Leistungen für die Zivilbevölkerung verfügbar zu machen. Insgesamt fehlt es an stationären Kapazitäten, moderner Medizintechnik und qualifiziertem Personal. So sind die Krankenhausbetten meist mit bis zu 4 Patienten gleichzeitig belegt. Strahlentherapeutische Einrichtungen gibt es z.B. 18 im Land mit insgesamt 36 Bestrahlungsgeräten für die Teletherapie, die Hälfte davon Beschleuniger, und 8 Brachytherapieeinheiten. Ausgebildete Strahlentherapeuten, Medizinphysiker und MTRA sind allerdings Mangelware

Da viele Vietnamesen ihre Ausbildung in der ehemaligen DDR erhalten haben, existieren auch heute noch enge Beziehungen der Alumni zu den Hochschulen in den Neuen Bundesländern. So gibt es seit über 15 Jahren vielgestaltige Kooperationen zwischen medizinischen Einrichtungen aus Leipzig und Ho Chi Minh City. Im Rahmen dieser Zusammenarbeit entstand in Ho Chi Minh City am Cho Ray Krankenhaus ein modernes nuklearmedizinisches Zentrum mit PET-CT, Radiochemie und Zyklotron sowie eine Strahlentherapie mit Beschleuniger, wobei Ärzte, Radiochemiker und Medizinphysiker einen Teil ihrer Ausbildung an der Leipziger Universitätsmedizin absolvierten. Seitdem sind Medizinphysiker und Strahlentherapeuten aus Leipzig und Rostock bei der Ausbildung von Medizinphysikern und Ärzten sowie als Berater für Krankenhäuser in Ho Chi Minh City und Da Nang engagiert. Größtes Problem ist dabei die finanzielle Absicherung dieser Aktivitäten, v.a. der Aufenthalte vietnamesischer Kollegen an den deutschen Einrichtungen.

FS 52

Medizinische Physik in Katar

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Seit 2004 werden in Doha (Katar) Patienten mit hochenergetischen Photonen- und Elektronenstrahlen behandelt. Die Abteilung des Al-Amal-Hospitals (Hamad Medical Corporation) wurde in Zusammenarbeit mit dem Universitätsklinikum Heidelberg geplant und in Betrieb genommen. Im Rahmen dieser Kooperation fuhren 2004 zwei Ärzte und ein Medizinphysikexperte aus Heidelberg nach Doha um die bereits installierte Anlage in Betrieb zu nehmen.
Der Aufbau der Linearbeschleuniger und aller zugehörigen Medizingeräte wie beispielsweise 3D Planungssystem, Blockschneidegerät, CT-Scanner, Simulator, Immobilisationssysteme, wurde initial von einem Team aus überwiegend englischen Physikern und MTRAs betreut. Für die Bestrahlungen waren 2 Linearbeschleuniger, sowie ein Brachytherapiegerät vorhanden. Die Kalibrierung der beiden Beschleuniger war identisch, wodurch ein wochenweise wechselnder Patientenbetrieb möglich war. Die Brachytherapie wurde zwar initial eingemessen, allerdings verzögerte sich derPatientenbetrieb um zwei Jahren, da es nicht möglich war weitere Quellen nach Katar einzuführen.
Nachdem alle notwendigen Lizenzen ausgestellt waren, bzw. englische, amerikanische und deutsche Lizenzen anerkannt wurden, und alle Geräte kommissioniert waren konnten die ersten Patienten bestrahlt werden. Mittlerweile wurde das gesamte Equipment in der Klinik ausgetauscht und durch ein Cyberknife ergänzt.

FS 53

MephidA e.V., enhancing cancer care in low-resource countries

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Low-income and middle-income countries have only 5% resources but account for up to 80% global cancer burden, with patients mostly presenting at their late stages. Radiotherapy, which has been identified to benefit up to 50% of cancer patients with either a curative or palliative end-point, remains inaccessible to over 90% of patients in low-income settings. This uneven distribution of treatment access results from lack of infrastructural and financial resources, trained medical and technical professionals and/or programs, geopolitical and economic instabilities, and of approaches to assure sustainability once the service is available. In order to tackle this issue from the base, cultural and behavioural barriers must be broken to enable practicable cancer preventive measures through lifestyle as well as encouraging early diagnosis and participation in screening and immunisation programs. Medical physicists in diaspora for Africa (MephidA e.V.) is a non-profit NGO aimed at turning the brain-drain to brain-gain by benefiting from the diversity of the professions of its members, comprising of experts in medical physics, radiation oncology, information technology, journalism, etc. Our activities encompass (i) organisation and distribution of donations of medical equipment in adherence with WHO recommendations, (ii) consultation in establishing radiotherapy departments by promoting up-to-standard treatment delivery techniques and the use of innovative electric power solutions such as solar energy, (iii) use of information communication techniques to facilitate tele-diagnosis and education, (iv) reconnecting and assisting professionals returning to deliver cancer care in Africa, (v) collaborating with partners and stakeholders to catalyse cancer care via basic training in forums, as well as developing and establishment of accredited teaching courses to train professionals at high educational institutions. As co-organisers of the Global Health Catalyst Summit in Harvard, we identify the event as a unique platform to network and gain more partners in the quest towards closing disparities in cancer access world-wide.

FS 54

Experiences with installation, maintenance and expansion of a radio oncology department in Ghana (The Sweden Ghana Medical Centre - SGMC)

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Ghana is a country with approx. 28 million inhabitants, currently there are three radiotherapy facilitates for EBRT and one Co60 afterloader available. This corresponds to one therapy device per 10 million inhabitants. Located in the capital Accra is the Sweden Ghana Medical Centre (1 Elekta Synergy), and the Korle Bu Teaching Hospital (1 COBALT 60 - Equinox 100, 1 BEBIG Brachy Co-60 HDR and a not yet commissioned Varian Unique), about 300 km to the north lies the Komfo Anokye Teaching Hospital (1 Co60 – Cirus). The installation of the ELEKTA Synergy at SGMC took place after a construction phase of four years, beginning 2008. In spite the useless measuring equipment and planning system, as well as untrained staff and flooding which made a new wiring necessary Lars Weber (2011-2012) succeeded the commissioning of the Linac. In March 2012, the first patient was irradiated. From 2011-2015 six physicists were concerned with the installation, the maintenance and expansion of the radiotherapy operation as well as the education and advanced training of the local physicists. Till today a radiotherapy department settled at nearly European level with MR, CT, Linac and chemotherapy-outpatient department, despite modest infrastructure can be maintained. Especially the energy supply from the public net functions only sporadically. The communication via internet and mobile phones is sufficient, fixed line network telephony is a matter of luck and the postal system is almost inexistent. For example, the acquisition of SF6 from ordering to delivery lasted up six months. Inscrutable finance and customs, as well as wretched transport routes contribute to enormous delivery times. The maintenance of the radiotherapy department is therefore an everyday fight for all involved persons. During my stay, four students could execute the necessary measurements for their master's thesis as well as a row of scientific presentations and publications.

FS 55

Presentation of case studies for CT-protocol optimization

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4 cases with optimization potential as well as software tools for necessary data analysis are presented. The approach to data analysis is demonstrated in a step-by-step way. This includes the extraction of important exposure parameters such as kV, mAs or collimated slice width.

FS 56

Discussion of the case studies

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The other 3 case studies are analyzed individually. The exposure parameters are determined by means of software tools from the image data and the respective problems are worked out. A comparison is made with the “Leitlinien der Bundesärztekammer” and the dose reference values.

FS 57

Proposal for Solutions

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Optimization proposals are presented for all 4 case studies. The effect of optimization on dose and image quality are presented. There is the possibility for interactive discussion and the introduction of other optimization suggestions from the auditorium.

FS 58

Status, limitations, and perspectives of current applications of pre-treatment computed tomography in radiation oncology

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Computed tomography (CT) images from fan-beam medical grade scanners are the current gold standard for treatment planning in radiation oncology: they provide geometrically correct, reliable, and quantitative measures of photon attenuation in the patient. However, this information is not fully identical with the physical quantities needed for dose calculation and optimization and additional uncertainty is introduced by inferring them from the kV images. Also, the low soft tissue contrast in CT impacts delineation accuracy. While additional imaging modalities are advocated as complementary – sometimes alternative – techniques to CT imaging, uncertainties in image registration can even deteriorate the quality of treatment planning.
Dual-energy CT – i.e. using scans from two X-ray spectra or detection in two separate energy ranges – retains the virtues of computed tomography while it opens at the same time the possibility to overcome the restrictions mentioned. It can improve the accuracy of dose calculation and delineation and enables to abandon the use of a general translation rule ("Hounsfield look-up table") for the photon attenuation (CT numbers) - replacing it by a patient-specific determination of radiological tissue quantities. DECT-derived quantities might additionally provide opportunities in advanced image analysis methods such as radiomics, i.e. the machine-learning-based approach for the prediction of patient outcome and treatment personalization. CT-based radiomics analyses might even be able to uncover information that can so far only be derived from additional multi-modal imaging.
Currently, many applications based on innovations in pre-treatment CT imaging and image analysis are investigated that could have the potential to change clinical practice in future. This presentation is intended to set the stage for the focus session which tries to look into the question, which of these applications can find its way into routine clinical application.

FS 59

Dual-energy CT for photon therapy – benefits and limitations

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In current treatment planning for both photon and particle therapy, a heuristic Hounsfield look-up table (HLUT) is used for the conversion of CT numbers to electron density or particle stopping-power ratios, respectively. However, this conversion is ambiguous and cannot account for patient-specific tissue variability or non-tissue materials (e.g., implants, contrast agent). This can lead to substantial difference in dose distributions. In contrast, dual-energy computed tomography (DECT) allows for direct patient- and tissue-specific determination of radiological quantities. Therefore, DECT is currently being investigated by many groups as an alternative imaging modality.
While the benefit of DECT is rather pertinent in particle therapy, where an accurate range prediction is crucial, we suggest that it might also improve conventional photon treatment planning, especially in the presence of non-tissue materials such as implants. In this context, DECT-based material characterization can help to identify implants of unkown composition. Moreover, their electron density can automatically be correctly assigned, as the DECT algorithm does not require tissue equivalency. This might provide more accurate dose distributions in cases, where the beam traverses a non-tissue material that would deviate considerably from the HLUT.
Furthermore, the acquisition of a DECT scan of patients with administered contrast agent enables the calculation of an image, where the influence of the contrast agent can effectively be removed. This would render the additional native CT scan obsolete, reducing overall CT dose to the patient. Finally, DECT also allows for a certain tuning of contrast by an overlay of the two images, which might be exploited for diagnostic or delineation purposes.

FS 60

Dual-energy CT for particle therapy – benefits and limitations

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Due to the physical advantages of particles in energy deposition compared to photons, a high-conformal tumor coverage can be reached while sparing healthy tissue more effectively. However, particle treatment planning is currently associated with large uncertainties related to a CT-based stopping-power and eventually particle range prediction. To fully exploit the physical benefit of particles, this substantial part of the overall range uncertainty of approximately 3.5 % of total range should be reduced.
Dual-energy CT (DECT) imaging is a promising technique to increase the accuracy of CT-based range predictions as already shown by many research groups. The effective benefit of DECT for particle treatment planning of cancer patients is currently proven using a comprehensive validation scheme to quantify the potential reduction of range uncertainties in daily clinical practise. In the framework of a joint project between DKFZ and OncoRay, extensive investigations on different levels (inhomogenous phantoms, biological tissue, clinical patient scans) have been performed. Here, a considerably improved accuracy of DECT compared to the current state-of-the-art, single-energy CT (SECT), could be shown in an anthropomorphic ground-truth phantom and biological tissues. Moreover, relative comparisons of predicted particle ranges in more than 100 proton treatment fields of patients reveal median range deviations of 1.5 – 2.0 % of total range between DECT and SECT. Based on these results, the clinical use of DECT-based range prediction would clearly improve the accuracy and robustness of particle treatment planning and is thus highly recommended to be the new standard imaging modality for treatment planning in particle therapy.

FS 61

Radiomics-prediction of patient-specific outcome using pre-treatment CT imaging

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Radiomics is the high-throughput analysis of medical images for treatment personalisation. It is hypothesised that medical images contain information related to both cancer treatment success and toxicity probabilities, allowing for the stratification of cancer patients using radiomics signatures prior to treatment. Models including radiomics features based on pre-treatment imaging are commonly reported to outperform models based on clinical parameters alone. Features extracted from medical images are the linchpin around which radiomics revolves. Generalisable radiomics models consist of a small signature set of highly reproducible image features and are trained on a large heterogeneous multi-centre patient dataset. Developments in radiomics are expected to follow two non-exclusive paths. The first path is the development of radiomics models using large multi-centre data sets of hundreds or thousands of patients. These data sets are heterogeneous, with varying imaging protocols, varying treatment and varying volume delineations. The size and heterogeneity of the available data will allow selection of a small set of reproducible features. However, such a feature set may not capture all the complexities and produce a sub-optimal model for treatment individualisation. The second path therefore focusses on increasing the size of the set of relevant, non-redundant and robust features. Standardisation of methodology and protocols, combined with an increase in quality and specificity of pre-treatment imaging enlarges the set of relevant features. Dual energy CT (DECT) is interesting in this respect. DECT is highly quantitative, offers noise reduction compared to conventional single-energy CT, and also allows for voxelwise determination of tissue-specific aspects such as electron density, effective atomic number, and tissue composition. Evaluations of DECT-based radiomics are ongoing, and first results will be presented at the meeting. In conclusion, high quality, standardised imaging and the willingness to share and collaborate are crucial for translation of radiomics from a promising technique into clinical application.

FS 62

CT-radiomics to assess biological and functional tumor properties

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Recently, the use of Computed Tomography (CT) image data for *Radiomics* has been proposed, which is the high-throughput extraction of a large amount of quantitative, mathematical features from imaging data to predict radiotherapy (RT) outcome. The aim of this study was to investigate the correlation of a prognostic CT-radiomics signature with hypoxia PET information, which has been shown earlier to be prognostic for therapy outcome in head and neck cancer (HNC).
For this study, planning CT data including contoured tumor volumes were available for n=149 HNC patients. The validation data set consisted of additional n=23 HNC patients where a planning CT and a hypoxia PET scan acquired with [^{18}F]-FMISO was available. For radiomics analysis, a total of 1141 radiomics features including intensity, shape, texture and wavelet features were calculated for each CT. In a first step, a prognosis model was trained using the data of the initial 149 HNC patients to derive a prognostic CT-radiomics signature. Then, the accuracy of this CT-radiomics signature was validated and compared to the prognosis score of FMISO PET (tumor to background > 1.4) in the validation cohort.
For the training cohort, a CT-radiomics signature was developed using Neural Networks which consisted of five radiomics features. The area under the curve (AUC) of this model was 0.79 ± 0.14. Applying this signature to the validation cohort yielded a residual AUC of 0.68, whereas patient stratification according to FMISO PET led to AUC_{FMISO}=0.67.
The results of this study show the great potential of CT-radiomics in terms of prognosis modeling and patient stratification. However, this study demonstrates that identification of patients with radiation resistant tumors using CT-radiomics performs comparable to FMISO PET imaging. Hence, CT-radiomics may have a role in the selection of hypoxic patients and thus in the planning of biologically adapted, personalized RT approaches.

FS 63

Do we need improved (dual-energy) CT imaging?

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In the era of image-guided high-precision radiotherapy, all clinically used imaging modalities need to benefit the individual patient's treatment outcome in order to be reimbursed. From a radiation oncologist's point of view dual-energy CT (DECT) ought to (1) improve target volume delineation, (2) decrease proton range uncertainty and (3) guide patient stratification using advanced image analysis methods, i.e., Radiomics.
(1) With the acquisition of DECT scans more information on the tissue composition and its contrast can be gathered. This may potentially air delineation of the primary tumor and surrounding organs at risk. Possibly, even the inter-observer variability may be reduced. In order to assess whether this is a measurable effect, we are currently conducting a delineation study. However, can this potential benefit also be transferred into clinical routine?
(2) Using DECT, the prediction of electron density (for photon therapy) and stopping-power ratio (for proton therapy) can be improved. Consequently, DECT would increase overall accuracy due to a patient-specific calculation without neglecting the intra- and inter-patient tissue diversity and variability. In particle therapy, CT-related range uncertainties may be reduced and the full potential of the beam modality subsequently exploited. Do we, however, dare to directly apply this in our clinics?
(3) Apart from improved treatment planning and delivery, DECT may also further characterize the primary target volume and possibly metastatically affected lymph nodes to predict outcome and enable patient stratification. This approach has been shown beneficial on non-contrast enhanced CT scans in non-small cell lung and head and neck cancer patients. Thus far, there are no data on the value of DECT. Thus, we need to ask: Are our current imaging protocols good enough to be quantitative? Do we need standardized imaging protocols in our own institution and different institutions? What does it take to make clinical decisions based on Radiomics?

V 124

Towards alanine/ESR as a secondary standard for dosimetry in magnetic fields

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An emerging field in radiotherapy (RT) is the combination of photon irradiations with magnetic resonance (MR) imaging in hybrid systems, enabling the adaptation of treatment plans in case of inter- or intrafractional changes. Dose measurements for quality assurance in this MR-guided RT have to be taken in the presence of a static magnetic field. Ionization chambers (ICs) are widely used in dosimetry, e.g. due to the convenient way that they are handled. However, in magnetic fields they are strongly affected by the electron return effect (ERE) [Raaijmakers2005]; deviations in the measured dose of up to 11% were found [Meijsing2009]. Hence, their application in MR-guided RT in accordance with dosimetry protocols like DIN 6800-2 involves correction factors compensating for the deviations due to the magnetic field. The determination of these correction factors with small uncertainties requires a well-defined secondary standard. We investigate the suitability of the alanine/ESR dosimetry system as such a secondary standard.
The concentration of free radicals arising in alanine pellets (ø 4.9 mm, shape of sweetener tablets) upon irradiation is proportional to the applied dose and can be read out via ESR spectrometry [Anton2005]. We exposed irradiated alanine pellets to static magnetic fields up to 3 T, as well as to strong gradient fields and HF-pulses as applied during MR imaging. Additionally, we examined the influence of the ERE due to air gaps surrounding alanine pellets during irradiations in a static magnetic field (1 T).
The alanine/ESR dosimetry system showed no interference in all these cases. This, together with the water equivalence and the small uncertainties, makes alanine/ESR a promising candidate for a secondary standard for dosimetry in magnetic fields, with which the required correction factors for the reliable use of ICs in magnetic fields could be determined. Further studies include irradiations of alanine pellets in MR-linacs.

V 125

Calorimetric determination of the kQ factor – towards high precision dosimetry of clinical carbon ion beams

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While radiotherapy with carbon ions is a very promising technique for cancer treatment, clinical dosimetry of carbon ions using ionization chambers has not yet reached the same level of accuracy as dosimetry of high-energy photons. The three times larger standard uncertainty originates from the limited knowledge of the so-called k_Q factor. This factor enters the calculation of dose and corrects for the response of the ionization chamber to the actual beam quality Q (here: ^{12}C) compared with the reference beam quality Q_0 (here: ^{60}Co). In order to substantially increase the dosimetric accuracy, high precision water calorimetry using the transportable water calorimeter of the Physikalisch-Technische Bundesanstalt has been performed in the entrance channel of a scanned 6 cm x 6 cm radiation field of 429 MeV/u carbon ions at the Heidelberg Ion-Beam Therapy Center. By absolute determination of absorbed dose to water, we were able to calibrate ionization chambers directly in the carbon ion beam and with that to experimentally determine k_Q. As a proof-of-principle study, two Farmer-type ionization chambers have been calibrated in a first experiment. Detailed characterization of the irradiation parameters and the radiation field allowed to achieve a standard measurement uncertainty of 0.8% for the experimental k_Q values for both chambers. This value corresponds to about a threefold reduction of the uncertainty compared to calculated values, which are currently used in clinical dosimetry. Thus, our result shows the potential of high precision water calorimetry to significantly reduce the overall uncertainty related to ionization-based dosimetry of clinical carbon ion beams. In order to extend the data basis of experimental k_Q values, a wide range of ionization chambers commonly used for reference dosimetry of carbon ion beams will be calibrated in the near future.

V 127

Determination of RBE-weighted dose-response curves for MRI-detected radiation-induced temporal lobe reactions in patients – comparison between proton and carbon ion irradiations

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Purpose: To derive the dose-response curve for temporal lobe reactions (TLR) after proton therapy and to compare the results to previously published dose-response curves for carbon ions to analyze, which version of the local effect model (LEM I or IV) provides more reliable estimates of photon-equivalent doses.
Methods and Materials: 62 patients treated with protons for chordomas or chondrosarcomas of the skull base at the Paul Scherrer Institute (PSI, Villigen, Switzerland) between 1998 and 2005 were analyzed for temporal lobe reactions (TLR) using contrast enhanced T1-weighted magnetic resonance imaging. Within the mean follow-up time of 38 months, TLR were observed in six patients (3 unilateral/3 bilateral). Dose-response curves for the individual temporal lobes were derived based on the relative biological effectiveness (RBE)-weighted maximum dose, excluding the 1 cm^3-volume with the highest dose, as independent dosimetric variable. The resulting dose-response curve was compared to previously published dose-response curves, which were obtained in a comparable patient collective with exactly the same method using LEM I or IV, respectively.
Results: The dose-response curves for proton and LEM I-based carbon ions were found to be almost identical while the curve of LEM IV was shifted towards higher doses. The resulting tolerance doses for protons, LEM I- or LEM IV-based carbon ions were $68.2^{-5.6}_{+2.7}$, $68.6^{-3.9}_{+3.0}$ and $78.3^{-5.0}_{+3.8}$ Gy (RBE) at the 5% effect level (TD_5) and $86.2^{-3.9}_{+14.8}$, $87.0^{-2.5}_{+3.2}$ and $99.8^{-3.0}_{+3.7}$ Gy (RBE) at the 50% level (TD_{50}), respectively.
Conclusions: The RBE-weighted dose prescription for protons leads to the same RBE-weighted dose-response curve for TLR as the one for LEM I-based carbon ions. Although this result still includes some uncertainty, the established dose-response curve for protons allows a much more solid assessment of the published RBE-weighted dose response curves for carbon ions than the available response data for photons.

V 129

A novel treatment approach after glioblastoma resection: microcontroller-based surgical implant with light-emitting diods for postoperative irradiation of glioblastoma cells

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Glioblastoma is the most common and most aggressive primary brain tumor in adults. The world health organisation (WHO) classified this quickly growing, malignant tumor as grade IV, i.e., the highest grade. The annual incidence of glioblastoma is 3 per 100,000 inhabitants. In 2016, there have been an estimated 12,120 new cases. Even with intensive treatment of glioblastoma consisting of so-called maximum safe resection followed by radiotherapy and chemotherapy, the disease routinely remains incurable and displays tumor recurrence and/or progression. Even after maximum available multimodal treatment, the median survival of patients with glioblastoma is only 14.6 months. Therefore, new therapeutic options are urgently needed. One such option is photodynamic therapy (PDT) which employs a photosensitizer that is taken up and selectively metabolized by tumor cells, then activated by light of specific wavelength to become cytotoxic. In experimental clinical settings, different PDT methodologies have already shown promising results. For the treatment of glioblastoma, intraoperative PDT, which uses high light intensities within a short period of time after tumor resection, has been explored. A novel approach has been developed at Ulm University of Applied Sciences in cooperation with Ulm University Hospital (Department of Neurosurgery). An implant for repetitive PDT (rPDT) is placed into the tumor resection cavity for long-time use. As a result, lower light intensities can be applied for longer time intervals to further reduce the residual tumor cells and minimize the adverse prognostic factor of tumor recurrence and/or progression. In vitro tests did not show any kind of resistance of glioblastoma cells towards the phototoxic effects exerted by the PDT even after repetitive treatments. In addition, an alternating treatment consisting of PDT and radiation with UV-light enhances the cytotoxic effects in vitro. A first implant prototype using LEDs for PDT and UV-light has been tested successfully in vitro and will be further evaluated in a preclinical in vivo model.

V 132

Low energy electron beam sterilization for novel interactive implants and their components

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Within the field of organ and patient support systems, research on novel interactive implants with integrated electronics composed of sensible materials and biological active substrates increased tremendous during the last years. Prior to implantation, these products and devices have to be sterilized. Tradtionional sterilization techniques like ethylene oxide or steam have their drawbacks when utilized for sensitive organic or metallic materials in sensors, microchips etc. Also, the use of gamma irradiation for such products is problematic due to long exposure time under radical atmosphere, which leads to an increased degradation and therefore can result in a loss of functionality.
Using low energy electron irradiation, it is possible to sterilize medical surfaces within some seconds because of very high dose rates. Thus, degradation processes which are occurring during the duration of gamma sterilization can be minimized using ultrafast electron beam sterilization. In addition, it is possible to define the penetration depth of the electrons in order to prevent electronic parts from damage. Besides sterilization of polymers and electronic components, it is possible to use low energy electron beam irradiation for sterilization of diverse biological materials like peptides, collagen matrices, transplantation tissues or hydrogels. Furthermore, specific material modifications can be addressed within these applications.
The process of irradiation sterilization is accepted all over the world and complies with international standards (ISO 11137). The aim of the development work at Fraunhofer FEP is to adapt the low energy electron beam process for new applications and products, but also to develop in-line-capable systems for sterilization applications in production processes and on-site batch systems. An overview of numerous sensitive components for interactive medical implants and products showing the potentials and limitations of low energy electron beam sterilization will be presented.

V 133

Development of a controlled-occluding membrane as a stent graft component for spinal cord ischaemia prophylaxis

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Thoracic and thoracoabdominal aortic aneurysms (TAAA) are complex and life-threatening diseases. The open aneurysm repair is a surgical intervention potentially associated with high morbidity and mortality. The process-associated risks and complications have been reduced by the implementation of the endovascular approach. However, the risk of spinal cord ischaemia leading to paraplegia is an unsolved problem of TAAA repair. For the complex and unpredictable supply of blood to the spinal cord by intercostal and lumbar collateral arteries, there is as yet no adequate solution in the area of endovascular stent grafts.
The aim of the scientific investigations is the development of a textile hydrogel composite membrane which occludes as a functional unit of a stent graft in a controlled time interval, which is necessary for the formation of collateral spinal cord supply. Thus the balancing act between safe endovascular aneurysm repair and the previously unresolved problem of protection against spinal ischemia can be ensured.
The occluding membrane consists of a textile hydrogel composite membrane. The mechanical properties, as well as the pore size and the pore size distribution are determined by the targeted design of the warp knitted textile structure. The hydrogel system is developed according to the required occlusion period. Finally, the textile mesh structure will be sheathed with the hydrogel and incorporated into the stent graft. Triggered by components of human blood, the hydrogel swells under controlled conditions and ultimately seals the membrane.
In this presentation the development of the textile hydrogel compostite membrane as a functional unit of a stent graft will be described. This part is devided into the development of the hydrogel system and the textile structure as well as the sheathing process. Subsequently, the most important results (occlusion period, permeability, mechanical properties, etc.) are described and discussed.

V 134

Modelling of NTCP for acute side effects in patients with prostate cancer or brain tumours receiving proton therapy

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The purpose of this study was to identify patients who likely benefit most from proton therapy (PT), based on the potential reduction of normal tissue complication probability (NTCP) compared to photon therapy. The NTCP models required for this comparison were developed using clinical data on acute side effects of prostate cancer and brain tumour patients having received PT.
In this study, 113 patients with primary brain tumours and 30 patients with adenocarcinoma of the prostate who had received PT were included. For the brain tumour patients, the radiation-induced acute side effects alopecia, erythema, pain and fatigue were considered. For prostate cancer patients, several gastrointestinal and genitourinary side effects were investigated. The occurrence of these side effects was correlated with different dose-volume parameters of associated organs at risk (OARs), such as skin and brain or rectum and bladder. The respective NTCPs were modelled by logistic regression. For every patient a volumetric modulated arc therapy (VMAT) photon treatment plan was retrospectively created. Differences in dosimetric parameters and NTCP between PT and VMAT plans were evaluated.
Significant correlations were found between acute side effects and dose to OARs. For example, occurrence of alopecia grade 2 and erythema grade ≥2 depended on dose-volume parameters in the high dose region of the skin ($p<0.001$). Proton plans showed significantly reduced low to intermediate dose volumes in all investigated OARs compared to VMAT plans ($p<0.001$). In the more relevant high dose volumes smaller differences between proton and photon treatment were found.
We found significant correlations between the occurrence of acute side effects and dose-volume parameters of associated OARs for patients with primary brain tumours or prostate cancer receiving PT. After inclusion of late side effects and validation in an external dataset, these NTCP models may be used to identify patients likely to benefit most from PT.

V 135

Can radiomics of the tumor metabolism predict local recurrences in head and neck squamous cell carcinoma?

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Radiomics studies have shown a link between heterogeneity of CT density and patient outcome. However, an interpretation of those results in terms of underlying biology is missing. This study aims to investigate whether radiomics of functional imaging (18F-FDG PET) correlates with local tumor control in head and neck squamous cell carcinoma (HNSCC).
We have retrospectively studied data from 121 HNSCC patients treated with definitive radiochemotherapy. Tumors were autosegmented based on the pretreatment FDG-PET scans using a gradient-based method and 569 radiomic features were extracted: shape (n=18), intensity (n=19), texture (n=44) and wavelet (n=488). Principal component analysis (PCA) combined with univariable Cox modelling was used to preselect relevant and uncorrelated radiomic features. Multivariable Cox regression with backward selection of variables was used to define a radiomic signature. The performance of the final model was quantified using concordance index (CI). Patients were stratified into low- and high-risk of recurrence groups based on a threshold from receiver operating characteristic curve for local recurrence at 18 months. The results were validated in a separate cohort of patients (n=57).
According to PCA, 95% of the variance of the calculated radiomic features was explained by 5 principal components. This resulted in preselection of 5 independent radiomic features. The final local tumor control model was based on 2 features: spherical disproportion and $GLSZM_{SZLGE}$. Tumors with a higher risk of recurrence were characterized by higher pretreatment spherical disproportion and lower $GLSZM_{SZLGE}$. The model showed a good performance in training (CI=0.72) and validation (CI=0.73) cohorts. The PET radiomics-based stratification into low- and high-risk of recurrence groups was significant in both cohorts.
The pretreatment PET radiomic local tumor control model showed a good discriminatory power. Round tumors (smaller spherical disproportion) with a bigger rim of low FDG uptake (higher $GLSZM_{SZLGE}$) had a better prognosis.

V 136

Novel approach for integrating motion variability into 4D-dose reconstruction for extracranial SBRT

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Radiotherapy of extracranial metastatic disease is commonly treated by SBRT using high dose radiation in a few fractions. Especially SBRT of lung and liver metastases is still considered challenging due to e.g. respiration-induced target volume deformation and tumor motion amplitudes up to several centimeters. Therefore, understanding motion-induced differences between planned and actual delivered dose and its potential interrelation with clinical outcome is crucial.
So-called 4D dose calculation approaches that combine patient-specific motion data and information about dose delivery are often proposed to retrospectively compute the delivered dose. However, current approaches are commonly based on motion information about one or few respiratory cycles as directly extracted from acquired 4D-CT/4D-CBCT planning images.
In our novel approach, we propose correspondence model-based 4D VMAT dose simulation for analysis of local metastasis recurrence after extracranial SBRT. Correspondence modeling allows for representation of intra-fractional patient motion variability by breathing signal-steered interpolation and extrapolation of deformable image registration motion fields. Here, we correlate the patients' internal motion information and external breathing signals acquired during 4D-CT imaging to predict the internal patient motion while treatment with only external breathing signal measurements being available. Ten lung and liver tumor patients with in total 15 metastases and known clinical endpoints were considered for 4D dose simulation analyses. The simulated dose distributions explicitly account for patient specific breathing variability and were compared to the original planned dose distributions by evaluating deviations of D_{95} per fraction and in total.
Overall, patients with local metastasis recurrence show highest negative deviations per fraction (every fraction exhibits an underdosage) and/or with regard to total dose compared to patients without recurrence. Our correspondence model-based dose simulation approach is able to predict possible errors during patient treatment planning and dose delivery, thus, it could be applied as a quality assurance tool after planning and each treatment fraction.

FS 64

Process optimization in medical care by technical innovations and digitization

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During the last decades, digitization have made life easier for everone. However, this process is not completed yet but ongoing. Actually, the process of digitization, interoperability and Internet of things have just started. Besides “normal life” and “industry 4.0”, even in medical care technical innovations and disruptive developments will have a major effect on future patient care and treatment. Systems using data mining and artificial intelligence aim to partly substitute physicians, telemedical applications provide “tele-present” specialists, numerous apps and wearable aim to improve the health of us customers. Indeed, technical innovations can optimize processes in medical care including the Emergency Medical Service (EMS), the acute care, the intensive care and the further patient treatment.
Exemplary projects addressing the issues “telemedicine”, “interoperability” and “innovative human-machine-interaction” will be presented that might have a major effect on future medical care. The tele-emergency physician will neither substitute the physician on-scene nor the paramedic on-scene, but will be an additional, meaningful module in EMS to improve quality. Manufacturer-independent data exchange protocols – based on the IEEE 11073 standard family dealing with medical device communication – will provide the precondition to realize an entire device-to-device communication in operating rooms, intensive care units and further hospital divisions. By means of augmented reality, a smart glasses can be applied in various medical fields. Adaptive to the actual context, helpful information, checklists, algorithms and messages can be displayed unobstrusively ensuring a high-quality, guideline-oriented medical treatment, e.g. in the management of mass casuality incidents.

FS 65

Experience with two measurement modalities to objectify pulse palpation during cardio-pulmonary resuscitation

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Cardio-pulmonary Resusitation (CPR) is the emergency treatment for patients suffering from a cardiac arrest with the goal of achieving return of spontaneous circulation (ROSC). The most basic approach for the assessment of ROSC is manual palpation, where a rescuer tries to feel the passing of a cardiac pulse by placing one or two fingers on the carotid or femoral artery. Palpation can only be applied during pauses in compressions and has been found to be unreliable, subjective and in particular time-consuming (often 25s or more even for trained people). It has a reported sensitivity of 90% and specificity of 55%. Nevertheless, palpation is a very important technique for the assessment of the need for CPR in an emergency situation and is recommended for Advanced Life Support (ALS) rescuers. Objectified detection of pulse presence is an obvious need in CPR for which a simple, low-cost and reliable sensor is currently missing. Such a sensor can assist rescuers to rapidly recognize a cardiac arrest situation requiring CPR and can help them determine when CPR should be stopped. Various approaches to objectify pulse presence in CPR applications have been investigated. This work presents our experience with two techniques to detect the presence of a spontaneous cardiac pulse: 1.) photoplethysmography (PPG) and 2.) accelerometry (ACC) at the carotid. The PPG approach has been tested in animal studies during automated and manual CPR. The animal studies showed that a spontaneous pulse could be recognized in the PPG signal in few-second pauses. Furthermore, spectral analysis allowed to recognize the spontaneous pulse rate during ongoing compressions and distinguish the spontaneous pulse rate from the compression rate. The ACC approach was initially evaluated in studies with healthy volunteers. Subsequently, ACC data were obtained in head-up tilt table tests and intensive care patients. Promising results with sufficient performance could already be observed for a limited set of clinical ACC data acquired during CPR.

FS 67

Cardiac support in emergency situations

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In contrast to a broken leg, the heart cannot be immobilised for functional regeneration in case of a heart failure. Instead, the blood has to be continously pumped through the body. Heart failures typically occur due to an oxygen deficiency caused by an obstruction of coronary vessels, an infection or mechanical/electrical dysfunction mainly resulting in a failure of the heart muscle of the left ventricle which is responsible for pumping the blood into the peripheral system. Hence, currently available therapy devices focus on the support of the left heart, e.g. the so-called LVAD (left ventricular assist devices), IABP (intra-aortic ballon pump) or the Impella® (an intravascular rotary blood pump).
The idea of the application of an Impella® pump is to have a small indwelling size and a short implantation time with the goal to recover the heart function. Therefore, all Impella® pump types are small in diameter (4-7.3 mm), generate blood flow by an impeller (2.5 – 5 L/min), and can be introduced via an artery into the left heart so that the cannula of the pump bridges the aortic valve. Right heart support devices are also available. For monitoring, a sensor measures the blood pressure in the aorta.
Today, the Impella® pumps are mainly used during cardiac interventions such as high-risk PCI (percutaneous coronary intervention) according to guidelines, and in the case of cardiomyopathy and myocardial infarction. A study on the pump efficiency during cardiogenic shock treatment is in progress. In addition, current animal trials focus on CPR support. More than 50.000 patients have already been treated in the U.S. and, for the future, the treatment of more cardiac failure scenarios is in focus. In addition, new pump generations are planned for pediatric and long-term support.

FS 70

Integrating clinical demands into developing and testing of novel devices

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New developments in medical technology should be driven by clinical demands as well as by technical possibilities. In order to allow for an efficient development process of new medical devices, a close contact between developers and intended users is necessary. By systematically and continuously involving clinical staff and medical practitioners in the development process, the potential for innovation can be increased. Even more importantly, innovation failures are prevented and new devices are better adapted to market demands if a thorough user centered design process is fol-lowed.
Individual manufacturers may not have a constant need for clinical user centered design (CUCD) but could rather ben-efit from on-demand services. In order to make CUCD available for a broad range of manufacturers and innovators, the industry in clinic platform KIZMO (Clinical Innovation Center for Medical Technology Oldenburg) was founded. It establishes the necessary bridge between manufacturers and clinics. By involving clinical staff and medical practition-ers as users, new and further developments of medical technology are efficiently supported and improved. KIZMO's first concepts and experiences from the fields of ENT, neurosurgery and phoniatrics demonstrate the possibilities of flexible and specialized industry in clinic platforms. Amongst others, KIZMO offers services like requirements analyses, prototyping and design, evaluation studies, user interface design, clinically relevant display of complex information, sound design for medical devices, technology scouting and innovation workshops.
In the CUCD process, KIZMO experts not only take into account safety aspects of human machine interaction for medical technology but also consider the joy of use. If the handling of medical devices is intuitive and if it conveys a positive impression, it has a higher chance of being successful on the market. This aspect often is at odds with technical advancements, but in order to consider all success factors of clinical devices, it should not be neglected.

FS 71

Cooperative patent classification as a mean of validation for support vector machine learning: case study in biomedical emerging fields of technology

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Studies on emerging fields widely use patent information to assess their evolution, often by classifying patents' text into emerging fields via supervised learning. The external validation of such supervised learning is cumbersome, nevertheless indispensable; therefore, classifiers need extensive expert ratings to validate their results. The *Cooperative Patent Classification* (*CPC*) system was recently introduced relying on examiners' decisions to categorize patents; however, it was rarely used to evaluate patent classifiers outcomes. Thus, we investigate the potential of CPC expert decisions for validating our Support Vector Machine (SVM) classifier, hypothesizing that the highly occurred CPCs in our training dataset represent narrow concepts, which SVM must identify.
Building on Schlötelburg's study on six emerging fields in Biomedical Engineering, we first trained SVM on patent's titles and abstracts. Second, from the training dataset CPC distributions, we identified the highest four and distinct occurred CPCs per emerging field. Third, we extracted a test dataset from PATSTAT and labeled it based on the high CPC occurrences. Fourth, we classified the test dataset using SVM and then compared its labeling with the CPC labeling.
The validation results showed a good overall predictive performance, which confirmed our hypothesis with an overall F1-score of 85%. For implants, diagnostics, surgery and telemedicine, results showed high F1-scores 91%, 92%, 91%, 87% respectively. For imaging and special therapy, results showed lower F1-scores 67% and 81% respectively.
The analysis of the results serves as an optimization and validation method for many text supervised learning models. Moreover, F1-scores studied at different classifier cutoffs can help identify a critical F1-score that suits the best performance expected from the classifier. The limitation of CPC as a system relies on human decisions that can be erroneous; furthermore, CPC concepts can belong to multiple emerging fields. This limitation creates ambiguity and inconsistency if not taken into consideration.

FS 72

Opportunities and threats in accelerating the innovation transfer in medical engineering

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"Opportunities and threats in accelerating the innovation transfer in medical engineering."

- When and how do we get to new ideas, - new products?
- Do we trust chance or an organized innovation process?
- In which context do ideas for further development arise?
- ¬ And above all: how to inhibit or promote regulatory requirements, standards, laws and regulations ideas and product developments?

Medical technology is described as one of the most innovative industries with immense growth opportunities. Why is it so and why is the journey from the idea to the world marketable product so complex? Because, Germany is a highly developed industrial country with an excellent research landscape.
With increasing complexity and competitive pressure, innovation is a necessary process for corporations, small and medium-sized businesses and start-ups.

FS 73

User interaction torque monitoring of a 7-DOF upper-limb exoskeleton with IMU-based motion input

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Assistive robots, such as upper-limb exoskeletons, require sophisticated online trajectory planning to ensure user safety during operation. In order to recognize the user intention, system integrated sensors are necessary to measure the interaction with the robotic device. In this work, the concept of a remotely controlled exoskeleton using an inertia measurement unit (IMU) motion capturing system is introduced, where the interaction between the human arm and the exoskeleton is measured with structurally integrated torque sensors. The motion capture system consists of four IMUs, placed on the torso, upper- and lower arm, and the hand of the operator, who performs the arm motion for the exoskeleton worn by the user. The upper-limb exoskeleton consist of a seven actuated joints, where each joint axis is collinear to their respective joint axis of the human arm. First, the joint angles of the motion capture system and exoskeleton are calibrated. The coordinate system alignment of the IMUs is based on a gravity-vector and omega calibration. For the exoskeleton, mechanical stops at the maximal joint angles define the zero positions. Once both systems are synchronized, the operator is able to remotely control the joint angles of the exoskeleton. The motion capture system detects movements of the arm with 100 Hz sample rate and a RMSE smaller than two degrees for static positioning and five degrees for dynamic movements to determine joint angles of the human arm during activities of daily living. The user interaction torque is derived from the measured torque and the dynamic properties of the exoskeleton. The overall goal of this work is to assist joint motion and monitor joint torques of a patient during continuous passive motion therapy, where a therapist teaches online movements with the IMU motion capture system.

FS 74

Situation detection in a powered lower limb orthosis

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Intoduction: Movement-assistive devices are designed to to recover lost abilities after injury or illness, compensate weakness or enhance human strength, sensitivity or accuracy. A situation detection subsystem can help to achieve a safe, reliable and intuitive human machine collaboration. We present the situation detection strategies to control a powered lower limb orthosis. The orthosis recognizes the current movement situation by evaluating the user's posture, motion and muscle activity and adapts to an adequate level of power support.
Methods: Our powered lower limb orthosis is designed to support the elderly in demanding movements, such as standing up from a seated position or stair climbing by providing an external torque to the knee. Integrated sensors measure ground reaction forces, angles in knee and ankle and muscle activities.
We persue two approaches to detect the seven most relevant situations in human everyday life: A fuzzy-logic based algorithm evaluates the sensor signals and calculates the probability of each situation based on a predefined set of rules. The situation with the highest probability is chosen to set the level of support.
The second strategy is a machine learning approach based on an artificial neural network. By training the network with offline sensor data the system extracts features and builds a user-adapted situation detection system.
Both approaches are evaluated on data sets derived from young healthy subjects performing a range of tasks in a predefined order.
Results: With both approaches, the seven most relevant situations for human mobility can be distinguished. Although all transitions between subsequent situations can be recognized without error, the moment of decision-making is crucial. A delayed support reduces comfort and reliability of the device. Both algorithms can be adjusted, considering the tradeoff between high dynamics and low error.
Conclusion: The fuzzy-logik based approach results in a simple and concise program code, that can be executed in real-time on simple processors. The manual implementation and adaption of the fuzzy rules is complex and time-consuming.
The machine learning approach requires more processing power but adapts automatically to the user by learning his movement patterns.

FS 75

Haptic assistive systems for precise and gentle interventions

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Minimally invasive interventions are state-of-the-art for surgical procedures. Recently, several robotic systems made entrance in clinical practise in order to improve ergonomic aspects of minimally invasive surgery procedures. However, haptic feedback is only employed in research systems. In this presentation, haptic assistance and feedback system structures and the respective challenges in the technical design as well as basic regulatory issues are discussed.

Based on two medical systems for minimally invasive surgery and cardiological interventions, ergonomic improvements, testbed task performance and future options for assistive functions are presented. Teleoperation approaches allow to design user interfaces and surgical robot independently, leading to improved ergonomic features for the user and improved movement precision of the robot compared to conventional, directly coupled mechanisms. Inclusion of haptic feedback reduces interaction forces, such minimizing tissue trauma and accelerating physical recovery. On the other hand, closed-loop control necessary for haptic feedback introduces new safety hazards. A promising approach strictly adapting to the human haptic perception capabilities is discussed as possible solution for this problem.

Furthermore, the existence of robotic as well as sensing features allows for more sophisticated task support. This includes semi-autonomous execution of common and repetitive tasks in surgical settings or advanced warning schemes based on intracorporal sensor data. Although technically promising, these options have to be evaluated in the context of clinical practise.

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Medical apps - To be or not to be (a medical device)?

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Medical Apps can be differentiated from Health Apps, as the former have a medical intended use. By this token they are medical devices – and the discussion would be over. From the user's perspective the definition may be broader: A medical app is an app that can influence healthcare professionals' decision making.
In many instances when using a medical app the healthcare professional does not realize that he/she is liable to any damage resulting from use of a medical app that is not approved as a medical device. Similarly, the healthcare organizations may be liable when using mobile device and apps in their networks. Especially when information presented by such applications influences critical medical decisions, malfunction of the respective network, mobile device or app can result in patient harm.
While for a medical device quality assurance and risk management are in the responsibility of the medical app's manufacturer, for other apps that are not regulated as medical devices this responsibility is with the operator/user when such apps are used in patient care.
Manufacturers must and users/operators should consider the guidance put forward by the FDA and/or the upcoming European Medical Device Regulations (MDR). Both, FDA and MDR, classify medical software (embedded or stand-alone) according to the harm a medical decision (mis)guided by such software may inflict on the individual patient. Under this ruling medical apps may even end up in the highest risk class comparable to active implantable devices.
This review presentation will present clinical examples and discuss challenges and potential solutions for the safe use of medical apps that may be medical devices.

FS 78

Digitale Prozessketten in der Medizintechnik

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Die Digitalisierung in der Medizintechnik hat bereits mit der Vernetzung von bildgebenden diagnostischen Systemen im Krankenhaus begonnen und kontinuierlich fließen Daten und Informationen in Produkte, Dienstleitungen, Services, Prozesse, Strukturen und Verwaltungssysteme ein.
Als Treiber der Digitalisierung lassen sich wissenschaftliche, technologische und organisatorische Innovationen identifizieren. Zunehmend erzeugen Sensoren, Softwareentwicklungen und Datenbanken technologische Mehrwerte und Wettbewerbsvorteile. Organisatorisch treiben Qualitätsziele, Organisation der Prozesse und erweiterte Geschäftsmodelle die digitale Transformation an. Im Zentrum der Digitalisierung stehen Informationen und Daten von Patienten, Versorgungsprozessen, Dienstleistungen und Medizinprodukten. Der Nutzen entsteht größtenteils bei der Verwaltung, Kontrolle und Management dieser Daten und kann zu einer Verbesserung der Versorgung führen.
In zum Teil polarisierenden Diskussionen wird die Digitalisierung zumeist als komplex oder auch unbeherrschbar wahrgenommen. Die Kritik betrifft insbesondere die Merkmale Komplexität, Vernetzung, Datenaufkommen, Datenschutz, Datensicherheit und Datenintegrität.
Erst wenn es gelingt, die Daten und Informationen des Patienten, der Versorgungskette und der Medizinprodukte sowie die kritischen Merkmale der Digitalisierung transparent aufzubereiten, kann der Mehrwert gehoben werden und die dazu erforderlichen Maßnahmen in der Qualitätssicherung zum Wohle des Patienten umgesetzt werden.
Der Verein Deutscher Ingenieure (VDI) beschäftigt sich seit Jahren mit Aspekten der Digitalen Transformation. Der Fachbeirat Medizintechnik des VDI befasst sich innerhalb der Gesellschaft Technologies of Life Sciences mit den Aufgaben der Ingenieure in den Unternehmen der Medizintechnik. Ergebnis sind praktische Empfehlungen wie beispielsweise zur Umsetzung der Qualitätssicherung von Software in der Medizintechnik.
Aktuell werden im Richtlinienausschuss VDI 5705 „Digitale Prozessketten in der industriellen Medizintechnik“ Anwendungen und Trends bei der Nutzung digitaler Daten von der Diagnose bis zum individualisierten Medizinprodukt zusammengeführt. Zielsetzung der Richtlinie sind Empfehlungen zur Beherrschung der Schnittstellen unter besonderer Berücksichtigung der Verantwortung, Qualitätssicherung und der Datensicherheit. Diese Richtlinie wird als Leitfaden für Medizinproduktehersteller Beispiele aus der industriellen Praxis aufzeigen, greift die kritischen Merkmale der Digitalisierung auf und bietet praktische Lösungen nach dem Stand der Technik an.

FS 79

EPItect – usage of an in-ear sensor as well as patient data to detect and document epileptic seizure patterns

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Epilepsies are among the most common neurological diseases worldwide. Characteristic symptoms are recurring epileptic seizures, which can be very stressful for the affected persons, relatives and carers due to the unpredictability of the time at which seizures occur, as well as the impairment of consciousness and the loss of control over different body functions. The early detection of seizures can possibly help to take of appropriate safety measures for the person concerned. In addition to such early detection, an accurate recording of the seizures also helps in the individual planning of the therapy. In the project EPItect, a BMBF-funded project, a multimodal sensor, which can detect seizures using biosignal patterns, is developed. The sensor is placed in the external auditory canal. The data are made available to selected persons via mobile devices. In this way, the personal environment can also be included if necessary. The networking infrastructure is based on the technical communication standard Electronic Case Record and enables the communication between patients, relatives and physicians considering privacy and data security. The physician can use the signals of the in-ear sensor and the recorded data such as context information to the seizure to optimize the therapy. In addition the anonymization and cross-patient aggregation of the data also enables clinical research, for example regarding the drug that reduces the seizures most effectively or different context parameters which trigger epileptic seizures. The consortium of the project EPItect coordinated by University Hospital Bonn consists of five institutions and two associated partners in Germany: Department of Epileptology at the University Hospital Bonn, Fraunhofer Institute for Software and Systems Technology ISST, Department of Neuropediatrics of the University of Kiel (UKSH), the North German Epilepsy Center in Schwentinental-Raisdorf, Cosinuss GmbH Munich, the University for Healthcare Professions in Bochum, and the Epilepsy Bundes-Elternverband e.V. in Wuppertal.

FS 80

Using wearables for decentralized individual long-term patient monitoring – a generic gateway architecture for multimodal sensor integration

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Individual monitoring of vital parameters is an important diagnostic tool in modern patient care. Currently, medically valid measurements are taken as short term recordings for several hours or days with specific devices unsuitable for everyday life. Long term monitoring is considered to improve understanding of diseases by a wide database as well as individual care by all over monitoring. However, this requires convenient and patient specific integration of sensors into a medically valid, robust and user-friendly wearable solution enabling remote maintenance. Existing consumer solutions e.g. fitness apps, do not provide the necessary flexibility for sensor integration and central data complementation.
We developed a gateway architecture which allows for generic integration of arbitrary sensors into a patient specifically configurable Personal Area Network (PAN). It is based on the Bluetooth Low Energy (BLE) standard, which allows for long battery lifetimes and is supported by common mobile devices such as smartphones. The architecture is based on an exchangeable driver bridge where the BLE generic attribute (GATT) profiles provide the necessary flexibility for arbitrary sensor integration. Thus, the PAN configuration consists of the patient specific GATT profiles, and measurement settings such as sample intervals and aggregation methods. Data is stored in a database with a generic data model for raw sensor data. Runtime information is presented via a graphical user interface generated automatically from the configuration of the data model. The data extractor component prepares raw sensor data for transmission to medical evaluation. The smartphone serves as wide area network (WAN) gateway to the medical data evaluation center providing secure data encryption and enabling medical interface standards such as Fast Healthcare Interoperability Resources (FHIR).
The architecture was successfully implemented as a prototype for personalized monitoring of UV-exposure by considering individual factors such as minimal erythema dose. The platform is currently extended for other sensors.

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A system to improve the hand sanitation in clinical environments

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Regarding the high numbers of nosocomial infections in todays clinical routine, our team proposes a system to automatically detect the need to sanitize hands and remember the healthcare professionals to use a dispencer. Our solution consists of a Bluetooth beacon for fencing the contaminated areas. Ultra-low-power electronics and optimized algorithms are used to conserve energy. A wristband registers entering or leaving a certain area around the patient bed and reminds to sanitize after leaving by visual and tactile stimulation. We use a simple RSSI based measurement for coarse distance estimation between wristband and our beacon (ca. 10 cm – 200 cm). When the medical staff sanitizes its hands, the wristband next to the dispenser receives a message via Bluetooth. At the same time gyroscopic data is collected to record the sanitation process. The dispenser module is based on the same Bluetooth beacon used for fencing contaminated areas. The beacon as well as the wristband will be completly encased in silicone to ease the sanitation of the whole system. For the purpose of powering the system the qi wireless charging standard is employed. As outcome, non-personal data will be collected on the wristbands memory during the work shift. This data will contain the information wether the personal has sanitized hands after leaving the contaminated area. Furthermore the data collected by the gyroscope sensor will allow to make a statement whether the personal has sanitized hands the proper way. The collected data could be used to compare the sanitizing habits of various wards and to create statistics for quality management. As the central hub of the system the wristband serves a dual purpose. It is collecting sanitation information during work shift and it bridges the gap between a central server infrastructure and the beacons. With the help of the data and the reminder function of our system we plan to improve sanitizing habits in hospitals.

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Establishment of a quality control system in diagnostic imaging in Northern Iraq

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Quality assurance is an important aspect in diagnostic imaging. In Germany, a system for quality assurance in diagnostic imaging is well established with standards for acceptance testing and for constancy testing for the whole variety in X-ray imaging. In quality assurance, a check must be performed, if an appropriate image quality is achievable at a given dose. In Kurdistan in Northern Iraq a quality assurance system should be set up.
The hospitals in Kurdistan are equipped with mostly new equipment. However, there is no quality program. Using the German standards, especially the DIN 6868-150 for acceptance testing and DIN 6868-4 for constancy testing should be established. A master student of the University of Duhok was trained in Germany and once back, he tested the equipment in Kurdistan. In addition, the measurement equipment (dosimeter, test phantom and accessories), which was donated by a German company, was brought to Duhok. Moreover, a training course for the technologists including theoretical and practical parts were given.
The quality assurance program was well accepted and in the tests of the equipment a few minor errors of the machine were found which have been unnoticed during clinical routine. The technologists need further regular training on the constancy test. In addition, a training to fix minor errors would be beneficial.
To setup a quality assurance system in the hospitals of Kurdistan, Northern Iraq is a difficult task. The benefits in doing the quality tests are obvious for all. However, when the quality assurance in not required by law, it is difficult to pay for the personnel to do these tests. Still, the benefits in the easier location of problems will achieve, that the test will be performed occasionally.

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Risks related to infusion pumps - first steps towards building up a device-specific ontology

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Despite their huge benefit for the controlled administration of drugs, infusion pumps are also being seen as one of the most top health technology hazards as just recently again been emphasized by the ECRI Institute's Health Hazards Report 2017. In the years from 2012 to 2016 the Federal Institute for Drugs and Medical Devices (BfArM), which is the competent authority in charge for scientific risk assessment of most of the critical incidents that occur with medical devices in Germany, has received more than 1300 critical incident reports related to infusion pumps.
By examining 479 selected incident reports, 60 risk-related patterns grouped in eight top categories were determined in agreement with the in-house vigilance device experts. The five major categories for failure modes identified were functional, electrical, mechanical and software-related failures as well as incorrect labelling. For each of the risk patterns a list of phrases describing the risk as well as a list of specific risk-related keywords was compiled. The latter will later be used as a basis for the ontology to be developed.
To guarantee the completeness of each list of pattern-specific keywords, all 479 reports were independently classified using all categories identified beforehand. Converting all incident descriptions to a single corpus then allowed calculating a similarity-measure between each report and a corpus of each keyword list to automatically classify the report. As expected a high sensitivity of more than 0.9 was achieved in every category therefore the keywords for each pattern have been identified correctly. The clear drawback of this simplistic approach is the very poor precision with an IQR between 0.02 and 0.19, which is caused by misclassification due to the list of keywords not being specific enough. In this respect the initial approach serves as a baseline for comparison with a full ontology to be used for automatic classification which is to be developed next.
This research is part of the OntoPMS project: a collaborative effort by medical device manufacturers and BfArM together with ontology and search specialists funded by the Federal Ministry of Education and Research (BMBF) within the program KMU-Innovativ/IKT (01IS15056G).

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Implementing risk management or safety management in a radiotherapy institution – challenges, ideas and examples for solutions

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When implementing risk management in a radiotherapy institution one will meet some challenges. Inconsistent national standards, small data base and missing experience in that field require looking over the plate rim and learning from other disciplines like nuclear power, reliability or aerospace engineering even though their methods have to be adapted for radiotherapy. First the frame for the risk management system has to be set for each institution in its individual context. Then all known and conceivable hazards have to be identified for all interested parties included in this frame (e.g. patients as well as staff, referrers, shareholders or cost payers). Even risks resulting from missed opportunities should be considered. Using existing data from internal and external CIRS, publications, experts brainstorming and top-down hazard analyzing methods are useful tools for that issue. Combinations of factors, situations and sequences (scenarios) should also been taken into account. For all identified hazards severities and probabilities must be determined. Using half-quantitative methods with clearly defined classification scores instead of qualitative methods leads to higher objectivity and better comparability. As solid data is rare likelihoods often have to be estimated reasonably. After identifying all hazards and analyzing all risks appropriate risk treatment actions have to be taken to reduce risks under a certain level. While some regulations require that risks to patient or personal safety must always be reduced as far as reasonably achievable each institution can define acceptable risk levels for other hazards. Risk treatment actions can produce new risks which also must been managed. Reevaluation of all risks after the risk treatment actions is essential. If remaining risks are above the defined acceptance level additional actions will have to been taken. This might be a multi-step process. Even the failure of risk treatment actions has to be considered.

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The Human operator: transfer function of the motor control behavior

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Many daily routine activities of the human are supported by machines which must be controlled by the user, like a car for moving, a milling-machine for mechanical part construction, a microsurgery-tool for minimal invasive operation, etc.. In all cases, the human has to control the technical device, and the question arises "Which tasks should be conducted by the human operator, and which tasks should be delegated to the device because of its superior performance?", which refers to the Human Factors field. To determine the capacity of the human operator in general terms, the concept of control theory is to determine the transfer function of the human operator. Doing this by a tracking task in a driving simulator results in a low pass behavior of the human with a cutoff frequency of 0.8 Hz. Thus, all control tasks of a process requiring a dynamic performance beyond this cutoff frequency should be dedicated to the automation because the human operator will be overstrained by them.

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Probabilistic fibertracking in deep brain stimulation

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Purpose: Deep Brain Stimulation (DBS) is a well established treatment option for movement disorders such as Parkinson disease, and increasingly applied in psychiatric disorders. Additional information provided by the calculation and visualization of fiber tracks in the brain is of increasing importance. Therefore we have implemented a standardized procedure to perform probabilistic fiber tracking. This information is helpful in both the precise definition of target regions and the prevention of adverse side effects. A typical side effect is the stimulation of the internal capsule in the treatment of Parkinson's disease which could result in motor or speech disturbance.
Methods: We present a procedure for the implementation of probabilistic fiber tracking for the planning process of DBS. It is based on the software library of the Oxford Centre for Functional MRI of the Brain, FSL v5.0.
In addition to the diffusion imaging with 40 gradient directions, the input data comprise additional B0 images for distortion correction, and are supplemented by the structural imaging in a conventional manner. We present a highly structured and automated workflow, which has been realized by an extensive set of Unix scripts and runs with minimal user interaction. The results of this process, the individual fiber tracks, are finally converted back into the DICOM format.
Results: The final DICOM export allows us to provide arbitrary fiber tracks for a variety of stereotactic planning systems, including Cranial3 and SurePlan from Medtronic (Dublin, Ireland) and iPS from Inomed (Emmendingen, Germany). The integration of these results might be used pre-operatively in the actual planning process, as well as post-operatively to explore the regions stimulated by active electrodes, which is particularly useful in the treatment of psychiatric indications.

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Detection of image plane orientation during two-photon laser scanning microscopy in brain tissue of mice using the geometry of stimulation and recording electrodes

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Two-photon laser scanning microscopy (2-PLSM) has become an important and widely used methodology to study network activities in the healthy and pathological brain in vivo. Repeated imaging sessions allow to follow single cell responses in long-term processes, e.g. during development, in disease or rehabilitation progression. So far, special head holders and biological landmarks at the brain surface, such as the pattern of the vasculature, have been used for precise re-positioning the experimental animal in repetitive imaging sessions. Here, a mathematical approach (implemented in MATLAB®) is presented that facilitates detection of brain tissue orientation. This method promises to be more flexible and robust against landmark changes. The advantage of a rectangular observation window of cortical surface microelectrodes for electrical stimulation or recording during 2-PLSM in brain tissue of mice was taken. Three corners of the electrodes observation window were used as marker points for calculating a local coordinate system acting as stationary brain tissue reference system. Calculating the rotation angles between the local coordinate system and the global coordinate system of the microscope leads to an exact definition of tissue orientation and reliable detection of cellular structures. On computational and practical level the new method was verified. The results showed the capability of the method to identify the orientation of the coordinate system related to the brain tissue. In addition, the required rotation precision for repeated detection of cellular structures is calculated and will be presented with general requirements in marker design. Finally, current limitations in practical use and possible improvements to optimize the proposed approach will be discussed.

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A novel algorithm for efficient detection and segmentation of metals for artefact reduction in computed tomography

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Artefacts due to high-density metals are a major hindrance to image quality and diagnostic accuracy in computed tomography (CT). Since it is common to have metal implants in the aging population, efficient and accurate metal artefact reduction algorithms are necessary. The state of the art algorithm for metal artefact reduction is projection completion. Here, metals pixels are segmented in projection images and replaced with interpolated values from non-metal pixels. One of the crucial components of metal artefact reduction algorithm is to segment the metals in the projection images. Currently, metals are segmented in prior reconstructed volumes and projected metal pixels are identified by forward projection. However, this workflow is computationally expensive and may not be applicable for fast reconstruction routines. This work presents a new algorithm for detecting metals from the projection itself without reconstruction and forward projection. It takes into account three main features for enhancing and differentiating metals from the background for an easier threshold-based segmentation, by assuming that metals have higher amplitudes, gradients, and curvatures. Therefore two indicators are proposed for extracting these features and are computed for each row of projection image. The first indicator is computed using a smooth differentiation filter for slope estimation and the second indicator takes into account the amplitude and curvature of each signal row. For that, a 2nd-degree polynomial is used to fit the signal inside a sliding window around the central sample. A final indicator is then computed as a simple product between the estimated amplitude, derivative and curvature resulting in a high enhancement of the metals. The last step consist on a thresholding over the resulting indicator using a Gabor filter for increasing detection accuracy. Our preliminary results show that metals are segmented accurately for multi-slice CT, and c-arm CT data sets and metal artefacts are significantly reduced.

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Interventional limited angle CT concept

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Radiography use ionizing radiation to generate images of the body, which has enough energy to cause damage to the patients DNA and increases a patient's risk of developing cancer. For image guidance in a surgery room conventional C-arm are frequently used. While these systems are movable but are very bulky, have a rather large detector - tube distance, and rarely provide tomographic images. For tool guidance purposes (e.g. needle injections, biopsy tools) a small attachable concept of a dedicated interventional X-ray system with very small detector - tube distance that is also able to provide depth information would be very beneficial. Our development intention was to design and implement a prototype intra-operative imaging system with the miniaturized low power and low dose X-ray tubes (MOXTEK 60 kV Magpro) and a flat panel detector (Teledyne Xineos-2222) capable of acquiring limited angle and limited field of view images (TOMOSYNTHESIS). A prototype was developed able to obtain planar imaging data at different x-ray tube / detector angles. The motion of the tube, attached to a mechanical arm was carried out by using a DC motor, while the detector was stationary. The DC motor was converted into a closed loop system with the help of magnetic encoder feedback into a micro-controller board achieving step angle and continues motion. All of this automation was controlled by LabView. The tomosynthesis prototype acquired data at a limited angle rotation (100°), acquiring 30 images in about 15 seconds. The obtained and with a custom developed SART (Simultaneous Algebraic Reconstruction Technique) reconstructed imaged showed the expected artefacts, but are satisfactory for the image guidance purpose while providing a very small setup, and very low dose imaging for a fraction of the cost of a conventional X-ray guidance system.

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Quantitative chemical shift spectroscopy (CSI) with respect to B_0- and B_1-inhomogeneities

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Introduction: CSI is a method to visualize the metabolism of larger brain volumes, which is important for many diseases like Alzheimer, dementia, extensive tumor areas etc.
Despite the fact, that a greater B_0-field causes a linear growing of the resolution, there exist a lot of disturbance variables, which diminish the accuracy of quantitative measurements of a 3T-device in relation to 1,5T.
Due to inhomogeneities in B_0- and B_1-fieldstrength, susceptibility artifacts and information loss as a result of the digitalization procedure, it is a much challenged task gaining precise quantitative values of metabolic concentrations in CSI. In this work we present measurements and numerical evaluations of the influence of these disturbances for 3T-MRI.
Materials and methods: The CSI-measurements were performed on the 3T-MRI Skyra (Siemens) on site.
A self-made head phantom containing brain metabolites (NAA, Cr, Cho, mI, Glm) was used for simulations (VeSpa) of basic data sets. The calculation of spectra from simulated and measured datasets was made by LC-Model. Graphic results were plotted by self-made Matlab-procedures.
Results: The influence of interfered factors could be quantified. Some routines are given for correction of B_0- and B_1-inhomgeneities. As a main topic the influence of the PSF (point spread function) due to digitalization of the CSI-measurements was reduced by a correction matrix.

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Virtual enhancement of marker X-ray visibility for cerebral stents and flow diverters

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Stents and flow diverters are common devices for endovascular X-ray-guided treatment of neurovascular diseases like aneurysms or artherosclerosis, but they are barely visible in many situations. To improve visibility during interventions, they are equipped with radio-opaque markers. However, since the marker size is limited, stents may still be nearly invisible during deployment. We virtually enhanced these markers with an overlay using locations supplied by a detection algorithm. For marker location, we used a feature detector according to their appearance in fluoroscopy and radiographic images. To increase perceptibility in regions with dense bone, we first subtracted a reference frame from the current frame, which also reduces the number of false positives. Remaining false positives were eliminated through post-processing. After detection, marker locations were visually enhanced with an overlay. For validation, five data sets were acquired with a skull phantom phantom different stents under fluoroscopy in the angio lab. Subsequently, a physician compared the enhanced and the unaltered images qualitatively. This investigation shows that even small markers of stents and flow diverters are detectable with common feature detectors. An overlay was created in all cases. In regions where bone masked the markers in fluoroscopy, the subtraction of a reference frame allowed their detection. The improved images support physicians to discern devices. In addition, our method was tested on clinical data with promising results. The proposed approach successfully demonstrates that the visibility of stent and flow diverter markers can be increased with image-based techniques and also that the markers of current devices are of sufficient size and opacity to be detected by low level feature detectors. In future, the image-based detection of X-Ray markers may assist in precise stent deployment in difficult interventions and create new possibilities for the design of X-Ray markers.

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Characterization of carious lesions in vitro based on hyperspectral imaging data

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Caries is one of the most prevalent diseases with irreversible degradation of dental hard tissue. The clinical diagnosis is based on visual and tactile examination. This is supplemented by bite wing radiographs for non-visible lesions, such as approximal caries. However, radiographic examination suffers from poor sensitivity for early stages of demineralization, continuous monitoring of lesion progression is limited due to the exposure of X-rays. As an alternative imaging modality, Hyperspectral Imaging (HSI) enables the non-invasive and simultaneous recording of spatial and spectral information without ionizing radiation. The aim of the present in vitro study was to determine characteristics of healthy and altered dental tissue, based on HSI data.
For in vitro measurements, extracted, human molar and premolar teeth with caries stages ranging from the radiographic category C0 (no visible demineralization) to C4 (lesion with involvement of the inner dentin) were used. HSI data were recorded by a CMOS based line-scanning camera (Diaspective Vision GmbH, Pepelow, Germany) in a spectral range of 500-1000 nm in combination with a broadband quartz tungsten illumination unit (OSRAM Licht AG, München, Germany).
As expected, penetration depth of light was higher in the near-infrared (NIR) range compared to the visible (VIS) range. Sound enamel showed a higher absorbance in the VIS range compared to early stages of demineralization (C1, C2). In contrast, a higher absorbance for carious lesions was found in the NIR range.
The present results suggest that early stages of caries can be characterized by means of HSI. Further work will focus on the classification of carious tissue based on multivariate approaches, as well as the validation of the classification in a model of posterior teeth.

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Summarised difference temperature method for evaluating sagittal-symmetrical ROI pairs in medical thermal IR images

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The diagnostic fields of application of infrared imaging are, above all, early detection of breast cancer, recognition of vascular malformations and blood circulatory disorders close to the body surface.
Detecting of pathological processes in the nasal passages or paranasal sinuses like inflammation and neoplasia could become a relevant application in equine veterinary medicine.
Two patient groups (I: inflammation, n = 11) and (II: neoplasia, progressive ethmoid haematoma, n = 8) and a control group (n = 30) were examined with infrared thermography cameras IR Flexcam® R2 (GORATEC-Technology, Erding) or VarioCAM® HR inspect (InfraTec, Dresden). Measured detector inhomogenity: $\sigma \approx 0.05$ resp. 0.07 °C.
Diagnostic procedures such as endoscopy, x-ray or CT were used to validate the diagnosis. Seven sagittal-symmetrical reference regions (Region of interest, ROI) pairs were defined above anatomical relevant structures (nasal passages and paranasal sinuses).
With the aid of the software IRBIS®3plus (InfraTec) the mean values of the temperatures inside of these ROIs were computed and in a second step the summarised temperature difference between the two ROIs of a reference region pair was calculated:

$$\sum_{i=1}^{7} \left| \Delta \bar{\vartheta} ROI_i \right| := \Delta \vartheta_{\Sigma} \quad (1)$$

Nonparametrical tests: Wilcoxon/Mann-Whitney-U-test
Temperature differences were observed with the summarised temperature difference score between the control animals (median value 4.8, range (min-value 2.3, max-value 9.6).
Patient group I with (inflammation) had a higher summarised temperature difference with the median value of $\Delta\vartheta_{\Sigma\_\text{Patient group I}} - \Delta\vartheta_{\Sigma\_\text{Control}} = 2.2$ ºC with $p = 0.027$.
Infrared thermography for detection of inflammatory conditions in the equine nasal passages is suitable for detection of inflammations. The thermal-transfer-coefficient between tissue-air is 50 to 100-times smaller than in a fluid-tissue boundary. Consequently, no significant results were observed in tumor patient group II.
This study supports a specificity of 0.83 with a sensitivity of 0.72 and is above the previously achieved sensitivity 0.52 of Holzer et al. (2010).

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Evaluation of magnetic field interactions, heating and artifacts of a new magnetic, ophthalmic implant at a 3T MRI

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The purpose of this study is to evaluate static magnetic field interactions, heating and artifacts for a newly developed magnetic, ophthalmic implant. This Implant exhibits a little ferromagnetic steel plate in a thin silicone layer. 12 different sizes of this steel plate with dimensions between 8 mm x 8 mm to 1 mm x 1 mm were tested to evaluate the relationship between the size of the metal and the magnetic forces, the potential heating and imaging artifacts. The magnetic forces were examined in the static magnetic field of a 3.0 T MRI (Philips, Achieva): The magnetic translation force F_Z is measured quantitatively by determining the deflection angle β using the international established deflection angle test of the American Society of Testing Materials guidelines (ASTM: F 2052). The translation force was found to be 9 times greater than the weight force of a single plate. The rotation force F_{rot} or torque was qualitatively evaluated by using a 5-point grading scale (0: no torque; +4: very strong torque). According to this test it was noted that each plate was exposed to a high rotation force (+4). For the investigation of the potential heating high-energetic pulse sequences were used in line with ASTM (F 2182-11a). The temperature was determined by using a digital thermometer as well as an infrared camera before and after the acquisition time. For this experiment each plate was put in a test tube with 1 ml purified water. In doing so only a negligible increase in temperature of nearly 0,25 °C was detected. For the examination of the artifacts the plates were put into an aqueous solution of Gadolinum and were aligned in different orientations due the direction of B_0.

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A mobile EIT system for fast image based medical indication

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Image based processes like MRT or CT are getting more an more important for todays medical challenges. In clinical practice however, those technologies have disadvantages like the time consuming preparation, their high monetary footprint and their invasive nature. Electrical impedance tomography (EIT) is an alternative medical imaging technique which is not only much cheaper but also noninvasive. Current EIT systems are not suitable for mobile application which is a major obstacle for exploring the techniques‘ capabilities. This paper proposes a portable EIT system for a quick, precise image based indication. The system consists of a 10x10cm multilayer printed circuit board which features wireless data transmission as well as a battery-only power supply. Our system is capable of using 32 electrode channels in order to achieve a relatively high image resolution compared to the small size needed for the system itself. A phantom was used to evaluate the products quality in a first practice test. The impedance distribution in the phantom has been processed with a simple reconstruction algorithm, leading to a clear image of the phantom. Our research aim of a mobile system providing fast, uncomplicated imaging for the first detection of a finding, such as an abnormal change in human tissue. After this first analysis, it may be decided whether further imaging is necessary. An elastic electrode tape has already been developed for this purpose and can be adapted to the circumference of the object to be measured.With access to this fast imaging system, waiting times for MRT and CT based imaging procedures are greatly reduced.Thus, patients can be treated more quickly which leads to declining costs for healthcare. Like classical imaging techniques, a mobile EIT system offers a broad field of application as well as fields of use currently not explored, e.g. gesture recognition.

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Muscle oxygenation monitoring using OXY DR2

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Measuring the oxygenation status of human tissue is desirable in many systems in clinical and emergency medicine as well as in sports science to quantify and measure the muscle status in every day training activities. Several NIRS instruments have been developed based on different methods. Among these sensors the OXY-DR2 system, manufactured by OXY4 GmbH/Germany, represents a new tool for the performance diagnostics in sport science. It employs continuous wave NIRS by emitting light from 7 different LEDs with wave-lengths between 500 (visible) and 910 nm (near-infrared) and detection of the reemitted light at different distances from the light sources.
The purpose of this study is to evaluate different signal extraction algorithms on time resolved intensity data of the reemitted light of the OXY-DR2 system and to develop artefact reduction algorithms. Algorithms used are the Modified Beer-Lambert method (MBL) to measure concentration changes in oxyhemoglobin (O2Hb) and deoxyhemoglobin (HHb) and Spatially Resolved Spectroscopy (SRS) to measure the socalled Tissue Oxygenation Index (TOI).
In this paper we present the results of a first experimental study to evaluate the change of the calculated parameters during different sport activities. More specifically, we have recorded the intensity of the reflected light from different tissue locations during different scenarios (normal perfusion, venous and arterial occlusion, measurments in rest conditions and under load). The calculated parameters are consistent with the expected behaviour and show good agreement with the results of a second NIR sensor which was used in parallel. The next step is to develop artifact recognition methods to distinguish motion artefact from effects caused by muscle contraction to improve the sensor performance during sport activities like running, cycling etc.
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Online recognition of cortical blood flow by time-resolved thermography in neurosurgery

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Intraoperative thermography in neurosurgery is a new approach for online measurement of thermal radiation emitted by the exposed cerebral cortex. It is a highly sensitive, contactless and label-free imaging method to detect small surface temperature variations of brain tissue. The use of uncooled microbolometers as thermal detectors allows a temperature resolution up to 30 mK and a spatial resolution of 125 µm per pixel at 30 cm object distance at a maximum acquisition rate of 60 Hz. Thermography can be used to correlate changes in brain surface temperature distribution to changes in regional cerebral blood flow (rCBF) within superficial elements. This work shows an online framework for cortical perfusion imaging that enables the intraoperative evaluation of rCBF by detecting and investigating an intravenously applied cold bolus. Previous studies revealed a low decrease of the temperature of blood vessels after injection followed by an increase to baseline. Thermodilution affects the temperature profile caused by a cold bolus, depending on the temperature gradient to blood circulation and mixing pattern. This method provides information about the intensity, duration and arrival time of the cold bolus shortly after data acquisition. To recognize small temperature gradients originating from observed processes besides technical artefacts, noise and interferences from external sources, it is necessary to include appropriate preprocessing algorithms in the analysis workflow. A flow phantom is used for validation and determination of performance parameter. The developed framework provides a tool for online perfusion monitoring to increase safety during vascular surgery and should support the surgeon in detecting perfusion disorders e.g. to examine the success of aneurysm surgery.

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Neuroimaging center python pipelines – a web-based image processing framework

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The NICePype (Neuroimaging Center Python Pipelines) image processing framework offers intuitive and efficient access to optimized pipelines through a web interface. The software has been developed at the Neuroimaging Center, Technische Universität Dresden, and is tailored towards applied scientists who employ neuroimaging. The core of the processing framework uses Nipype, an open source neuroimaging data processing framework in Python. Therefore, we benefit from a big developer community and existing interfaces to various software packages (e.g., FSL, FreeSurfer, SPM ...). All pipelines run parallelized even in a heterogeneous computational environment. The unified framework simplifies reproducibility of research results. The framework comprises: a) automatic sorting of neuroimaging data and setting of permissions, b) a pipeline class that allows automatic combination of pipeline steps taking requirements and dependencies into account, c) a web-interface allowing users to configure the processing pipelines and input data with optional manual adjustments, d) a database server as a system hub, that contains only metadata necessary for pipeline configuration but no personal or imaging data, e) NICePype workers that can run decentralized on different computers and start and monitor the jobs (CPU, memory and hard disk requirements are supervised and restricted, if necessary). f) Docker container for software components, which run on big clusters and desktop computers alike, g) quality assurance features including hash value checks to guarantee pipeline reproducibility and integrated web tools for assessing motion correction, coregistration and normalization. The details of the pipelines are available to the user in form of a short description for choosing the pipeline, a detailed description as needed for the method section of a publication, and a script containing the executed commands enabling the user to exactly reproduce the pipeline. The web-interface and the underlying processing framework will be demonstrated at the exhibit.

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Hyperspectral imaging and clinical practice – approach to integrate a new diagnostic tool

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Hyperspectral Imaging is a new method, which, on a meta level, could change wound diagnostics from a pure human centred optical approach to a digitally supported optical method. In everyday clinical practice, this has an effect on wound diagnostic processes, on wound treatment, and, on the long run, also on the complete (research and education based) view on the field of wound care. To support the development of hyperspectral imaging towards a fully-fledged method in everyday clinical practice, two steps can be taken. First step, which is described in this article, is the analysis of state of the art wound diagnostic and wound treatment in clinical environments. The second step, which is also sketched in the article, is the development of digitally available expert knowledge. This expert knowledge can be used in different ways: it can be used to structure a new field, with the goal to establish standards for education as well as for new diagnostic reasoning and documentation. The expert knowledge can additionally be used as add-on in the new hyperspectral imaging approach, as an extension to the digital imaging and documentation software for supporting the diagnostic process. Additionally to the pure documentation of facts and rules, as standard in medical expert (or diagnosis support) systems, the expert knowledge model also supports the reasoning over time and thus the investigation of the process of wound healing. The structure of the expert knowledge model and insights from working with medical and technical experts in this field are described in this paper. The paper resulted from the work done in the project HyperwoundCAM, which is founded by the TBI, with co-operating partners Diaspective Vision, University of Applied Sciences Wismar, and University of Rostock.

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Comparison of different methods of size specific dose estimate (SSDE) determination in computed tomography

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The purpose of this study was the comparison of two methods used to calculate the Size Specific Dose Estimate (SSDE) from CT images. The ratio of the SSDE for the two methods for different scan regions was evaluated. The first method used the patient size to find the effective diameter (Deff) and the SSDE while the second method used the patient attenuation water-equivalent diameter (Dw). In this study, the SSDE was calculated using both methods for a retrospective analysis of 10 abdominal, 15 thoracic, and 6 head CT examinations of human adults. The CT scans were segmented automatically to find the body contours. Subsequently, the segmentation results were used to calculate the effective diameter and the effective water equivalent diameter to find the CTDI to SSDE conversion factors for every slice according to the AAPM reports 204 and 220. The total SSDE for a scan is calculated as the average value of all slices. The results of this study show that the ratio Deff/Dw is about 0.98 ±0.06 for abdominal scans, 0.92±0.05 for thorax scans and 1.23 ±0.35 for head scans.
From these results, we can conclude that the ratios of Deff and Dw are reasonably constant for chest and abdomen examinations and could be used to determine Dw from Deff. However, due to larger variations of the amount of bone in head CT, in these examinations the difference between Deff and Dw can be more than 50%. Therefore, we recommend to use the water equivalent diameter Dw in reporting the SSDE.

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A novel automatic gauge detection algorithm for the performance test of a CT scanner with Catphan 600 phantom

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The performance test of a CT scanner is an important task for quality assurance. Modular Transfer Function (MTF) is used to characterize the spatial resolution which is an important factor of CT image quality. To measure the MTF specific performance phantoms are used. With the same spatial frequency, the imaging system is better if its corresponding MTF value is higher. The MTF is usually manually calculated and is a challenging process, since it is difficult to detect the important structures like gauges automatically from the reconstructed phantom images. We propose a computationally efficient semi-automatization of the MTF calculation by implementing an image detection algorithm prior to the MTF computation. The main purpose is to detect each gauge, ready for MTF calculation. The algorithm has been implemented for the Catphan 600 phantom for image performance test. Other algorithms like scatter correction and noise–suppressing reconstruction, neglect the image detection. Our algorithm involves coarse and fine detection steps of the response images of the high-resolution gauge system in phantoms to detect each gauge in the image. In a first step a binary transformation is performed on the original image and then the gauge circle is detected and cropped. The second step consists of a coarse and fine detection with rotation of the middle part based on the corresponding properties in the case that the segmented gauge is optimal. Based on this algorithm, the relevant gauges in the response images are able to be perpendicularly and completely segmented. The experimental results proved that based on this new algorithm, for an angle range of rotation, the corresponding gauge in this range is automatically detected as well as perpendicularly and completely selected. And it also showed robustness against gauge distortion, while at the same time the computational amount is relatively low.

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Implementation of a correction procedure to decrease the effect of PSF-related signal leakage in 23Na NMRS

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Because of the increasing availability of higher magnetic field strengths in nuclear resonance spectroscopy (NMRS) sodium, (23Na) NMRS has become more common. But even though 23Na is, besides hydronium, the most abundant cation in the human body, 23Na measurements still suffer from a low SNR. Thus, e.g. larger voxel volumes are used to compensate for the low sensitivity. Because of this it often cannot be avoided that voxels contain a mixture of white matter, grey matter, and CSF. In addition, the spectra of homogeneous voxels are also effected by point spread function (PSF)-related signal leakage to neighbouring voxels. In this study, a correction procedure was implemented to decrease the effect of signal leakage in 23Na NMRS using prior knowledge from 1H MRI and determine the approximate amount of brain matter and CSF in each voxel. Phantoms and healthy volunteers were placed in a clinical 3 T MRI system to obtain the spatial distribution of 23Na and a T1 data set. The PSF-related leakage was quantified experimentally in phantoms by placing probes, containing high quantities of 23Na, in one voxel leaving their neighbouring voxels empty. The implemented correction procedure was tested on spectra obtained from phantoms and in vivo in a 200x200 mm^2 field-of-view with 6.25x6.25x25 mm^3 voxel volume at an acquisition time of 20 min. At the expense of slight intensity loss, processing the signals leads to a decrease of PSF-related signal leakage. Furthermore, false signals from outside of the probe at the in vivo experiment were reduced using a high-resolution binary mask obtained from segmenting 1H MRI data. In conclusion, the amplitudes of different homogenous voxels containing the same substance showed less differences with than without the correction.

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Submillimetre shifts and their impacts on PET-CT resolution

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In this study, we investigated the results of lateral shifts way below the resolution limit of a PET-CT and if such shifts are detectable at all.
With an in-house specifically designed and constructed sliding table, which was capable of transmitting rotations into lateral shifts, we were able to generate submillimetre changes in the phantom positioning. By using this table, a Derenzo phantom was shifted 12 times laterally with a step width of 0.5mm each. This resulted in a maximum lateral shift of 6mm. The Derenzo phantom itself consisted of six segments with different borehole diameters, i.e. hot rods, which ranged from 12.45, 11.1, 9.5, 7.9, 6.4 to 4.8mm. In order to compare the measurements for all positions, for each measurement, using 18F-solution and a Biograph mCT (Siemens, Erlangen, Germany), 2*10^8 counts were acquired. However, to ensure the highest reconstruction quality, all reconstructions were made in the highest possible resolution, i.e. 512 times 512 pixel, using "UltraHD-ToF". We determined the impact of present partial volume effects and estimated the influence onto the resolution limit of the reconstructed images. Thus, for each measurement an intensity profile of the hot rods was used to examine the obtained image resolution limit. For further comparison, we also determined the resolution limit by estimating the point spread function of the reconstructed images. This was done by a deconvolution process facilitating a previously generated analytical model of the hot rods inside the Derenzo phantom. This method had the inevitable advantage to allow for an automated resolution assessment regardless of any user specific influences, i.e. slightly shifted or tilted lines of the intensity profiles of the hot rods.

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Optimization of X-Ray dark-field microCT and application in a murine lung model

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The first in-vivo phase-contrast microCT setup is now being used several years in the investigation of lung diseases in the murine model. It has been shown that the dark-field contrast provides additional information for different kinds of abnormalities in the lung. Since for in-vivo tomographies the imaging time is limited by anaesthesia, the imaging process has to be as efficient as possible. An according optimization spans all parts of the imaging process. We investigate the influence of several image acquisition protocols, not only balancing the amount of projections, the amount of phase steps, and the exposure time, but also showing that the reference scan can be acquired separately from the sample scan. We further studied the performance of gratings manufactured on a thinner substrate. Additionally, we compared different image processing techniques regarding their influence on the signal to noise ratio (SNR) and on their ability to handle artifacts. Starting from the most basic approach, we arrive at more advanced methods that eventually give the opportunity to apply reconstruction techniques more sophisticated than filtered backprojection (FBP) – namely Statistical Iterative Reconstruction (SIR). The latter is able to deal with undersampled tomographies and to increase the SNR considerably. Combining the optimization of hardware and software allows for the shortest possible imaging time while still maintaining a decent image quality of the transmission and dark-field reconstructions. Concretely, the current acquisition time of 40 to 60 minutes shall be reduced to below 30 minutes. Hence we seek to establish a standardized image acquisition protocol for the X-ray phase-contrast microCT.

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Characterization of cerebral tissue with thermography and white light microscopy during neurosurgery

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Neurosurgical interventions are a very specific medical field and require special demands and attention of surgeons and medical stuff due to the high importance of brain function and neurological processes. Because of the high concentration of functional tissue within the cortex, as much as possible healthy tissue should be preserved during surgical treatment like tumor resection or other procedures requiring tissue removal. Therefore, a broad spectra of diagnostic tools like CT or MRT is applied to the patient prior to the surgical intervention. However, suitable and easy to use intraoperative imaging tools with a high spatial resolution are still missing or cannot be used repeatedly. A promising approach could be intraoperative thermography in combination with white light microscopy. Thermography detects small differences in tissue heat transfer, which can be used to distinguish pathological tissue like tumors from the surrounding healthy tissue due to the differences in heat propagation as consequence of the different tissue vascularization. We used a commercial thermographic camera with a thermal resolution of 30 mK mounted on a surgical microscope to acquire image sequences of small temperature variations of the brain surface with an acquisition rate of 60 Hz. The custom-made data acquisition software allows the overlapping of thermal and white light images for a better online visualization of heat distribution to the surgeon. Furthermore, the setup can be tracked by neuronavigation, which will allow the correlation of thermal and white light imaging to preoperative volumetric data like MRT. This approach could be a new tool for intraoperative diagnostics and tissue characterization and improve patient’s outcome after neurosurgical interventions in the future.

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A framework for intraoperative visualization of spatiotemporal alterations in cortical optical properties induced by direct electrical stimulation

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Direct Electrical Stimulation (DES, DCS) of the exposed cortical surface is one of the most important tools for intraoperative localization of specific brain functions during neurosurgical interventions. It is used e.g. for mapping of cortical language organization or motor functions during surgical procedures like brain tumor resection. Although the method is widely applied, the underlying neuronal and metabolic mechanisms, triggered by electrical stimulation, are still poorly understood. Further investigating the method itself and the neuronal and metabolic effects induced by direct electrical stimulation, we created a framework, which intraoperatively allows the spatiotemporal characterization and evaluation of the stimulation result. The framework is based on the Intraoperative Optical Imaging (IOI) technique which is able to visualize alterations within the optical properties of the cortical surface, spatially and temporally highly resolved. For the acquisition of IOI image data a CCD camera is attached via beam splitter to the surgical microscope. Different light wavelength filter can be mounted within the optical path of the camera to focus on different physiological signal sources (e. g. blood volume or oxygenation variations). Image data acquisition is performed with the help of a developed C++ software that allows a wide variety of data acquisition settings, as well as acoustical and visual support for different stimulation protocols. The recorded image data can be analysed within a MATLAB software that computes two-dimensional maps, representing intensity and localization of the optical alterations overlaid on a whitelight image of the exposed cortical surface. Different computation algorithms for cortical map generation are implemented as well as tools to analyse and model the temporal characteristics of specific image regions. The framework was already succesfully tested under intraoperative conditions during neurosurgical procedures. Further work focusses on optimization of image evaluation comparing with preoperative acquired MRI data.

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An active shape model for automatic segmentation of the knee bones

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The production of patient-specific cutting blocks for optimal positioning of knee implants requires the segmentation of the knee bones in the joint area, which is in manual operation time consuming. On the approach of an active shape model (ASM) we have realized the fully automatic segmentation of the knee bones and cartilage in MRI data and implemented, so that the functionality can be integrated into the user code with a few lines. In order to form the model, we have manually segmented the training data, femur and tibia, covered them by a dense point distribution model (PDM), registered with Minimum Description Length (MDL) and computed in a first step a statistical shape model (SSM). In a second step we have captured the texture data from the training data, then normalized and computed to a classifier at each vertex of the model for the model image registration. And for a high efficiency the model works on different resolution scales. Our active shape has already been successfully tested on further MRI data and shows a high accuracy.

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Single plane compton imaging – a novel concept for radionuclide imaging

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Radionuclide imaging with Anger cameras is still the primary technology used in nuclear medicine. Since its invention in 1957, the general composition of these devices have basically not changed. The emitted gamma rays are collimated either by a pinhole or by a multichannel collimator, further converted to optical photons by a scintillator, which are then detected using multiple photomultiplier tubes (PMT). The interaction point of the detected gamma ray could be calculated from the light sharing distributed to individual PMTs.
To overcome the main drawbacks of the Anger camera (limited detection efficiency, decreasing spatial resolution of high energetic gamma rays, fixed dependency of the spatial resolution and detection efficiency from the used collimator…) a novel concept denoted as “Single Plane Compton Imaging” (SPCI) is presented. The SPCI is based on the idea of the “Directional Gamma Radiation Detector”.
First studies of an SPCI setup will be presented based on particle transport simulations performed with GEANT 4. Futhermore, preliminary experimental results acquired with a GAGG scintillator array and read out by digital silicon photomultiplier will be part of the discussion.

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Ion radiography with proton, helium- and carbon ion beams

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In ion beam therapy, empirically calibrated X-ray computed tomography (CT) is used for treatment planning. Recently, novel imaging techniques using ion beams have been investigated and ion radiography (iRad) and tomography (iCT) have shown the potential to resolve the WET (water equivalent thickness) and rWEPL (relative water equivalent path length) of phantoms with a reduced error compared to CT, respectively. However, mostly proton imaging has been investigated due to the greater availability of proton beams. This work establishes an experimental multi-ions quantitative comparison of iRads with proton, helium and carbon ion beams. To this end, four different phantoms of experimentally known rWEPL were irradiated at the Heidelberg Ion Therapy Centre with actively scanned proton, helium and carbon ion beams under comparable acquisition and dose settings. The investigated phantoms exhibit different geometrical features reflecting clinical-like scenarios in terms of rWEPL values and gradients. An integration-mode detector with 61 parallel-plate ionization chambers interleaved with 3mm thick absorber plates was used to acquire the iRads. Two post-processing methods were adopted: 1) Bragg-peak decomposition, based on Bragg curve modelling, to resolve signal ambiguities related to tissue inhomogeneities and 2) Channel-deconvolution, based on modelling of the ion scattering, to enhance the spatial resolution. For assessment of the image quality of the resulting iRads, the WET accuracy was quantified as normalized root mean square error (NRMSE) with respect to the analytically calculated ground truth. Relying on Bragg-peak decomposition, the carbon iRads showed the lowest mean NRMSE, equal to 7.98%, compared to 8.22% for helium iRads and 12.53% for proton iRads. After applying the Channel-deconvolution method, the overall mean NRMSE of iRads with protons, helium and carbon ions improved by up to 1.5%. These experiments showed the advantages of helium and carbon ions for ion radiography compared to protons when working with a integration mode detector.

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Concept of a multilayer biopsy needle for magnetic resonance imaging interventions

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Coaxial needles are one of the most used instruments in image guided minimal invasive therapy. For procedures under guidance of magnetic resonance imaging (MRI), the coaxial needle has to be compatible with the imaging system and safe for the patient, which means no or very little magnetic attraction / heating / electric charging, as well as acceptable artefacts in the images. Most coaxial needles used in high-field MR interventional procedures produce large susceptibility artefacts due to the material selection (stainless steel, NITINOL). Thus, a precise placement in the target structure can be difficult. To overcome this issue, needles made from ceramics or carbon fiber were presented by other groups but are prohibitive due to the very high costs and their limitated applications. We present a coaxial needle concept based on cost saving MR compatible plastics that provides a thin wall structure with increased stability for use in MR interventions. For the needle core a PEEK round profile was selected (PEEK Filament Victrex, 1.75mm diameter). PEEK offers hardness and form stability that is important to produce a sharp needle tip. For the hollow outer needle, three layers of tubes (Polyimide Vention medical tubes, 1.842, 1.918, 2.019mm) were arranged coaxial into each other in a cascade according to the expected bending strain. Each layer has a wall thickness of 0.0318mm. The layers were joined using glue (Loctide 4902). The outer diameter of the final hollow needle is 2.39mm, inner diameter is 1.76mm. Minimal wall thickness is 0.0318mm on distal end and maximal 0.127mm on proximal end. The final prototype was tested in mechanical performance. Bending stiffness and puncture force were evaluated in a phantom setup and compared to standard needles. The multilayer coaxial needle shows comparable mechanical performance to common needles, but is fully MR compatible.

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Integration and evaluation of 6 DoF input devices for computer-assisted planning in maxillofacial surgery

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Virtual planning of maxillofacial interventions comprises the measurement of parameters necessary for quantifying the intraoperative correction of bone segments' positions (e.g. upper or lower jaw). Beside functional issues like chewing and swallowing, aesthetic aspects are particularly relevant. Therefore, the surgeon has to fine-tune functional planning parameters to find out an optimal solution for the specific patient. Virtual planning systems support this task by offering tools for interactive adjustment. As sophisticated manipulation comprises all 6 degrees of freedom (6 DoF), an ordinary mouse device with 2 DoF could be unsatisfactory for this purpose.
In this work we present a generic interaction software module for utilizing 6 DoF input devices in MITK (Medical Imaging Interaction Toolkit) and evaluate two different 6 DoF interactors:
- Space Navigator (3DConnexion, Boston, USA)
- Custom-build electromagnetic tracked freehand interactor prototype

The input devices may be used for interacting with any 3D scene in MITK including rotation, zooming, panning and camera movement.
For evaluation purposes a typical planning scenario, representing the precise positioning of bone segments for manidbular reconstruction, was build up. Six test persons used both input devices and the traditional computer mouse to perform this planning task. Overall, the Space Navigator was best suited for the observed planning scenario.
Quantitative results show that all test persons were able to find a rough approximation rapidly using the 6 DoF interactors (on average in 15 s). On the other hand fine-tuning the segment's orientation was rather time consuming (>100 s) because the visual angle and the zoom settings had to be modified several times. Therefore, we plan to refine the interaction model to be customized for specific planning tasks e.g. by restricting the movement to certain degrees of freedom depending on the visual angle or by utilizing the interactor's buttons to confirm specific planning steps.

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Modular three-dimensional magnetic camera dedicated to magnetic manipulation instrumentation systems

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We present a three-dimensional magnetic camera based on monolithic three-dimensional Hall sensors integrated in CMOS technology. The device is aimed at supporting the development, installation, calibration, and maintenance of magnetic manipulation instrumentation systems. It also paves the way to new research and development activities in the field of magnetic navigation. Preliminary experimental results obtained in the electrophysiology lab at the University Hospital Basel illustrate the capability of our device to map the magnetic field generated by the Stereotaxis Niobe® navigation system. Our modular magnetic camera concept enables precise placement of magnetic sensors at different points within the volume of interest. This flexibility facilitates adaptation of the measurement to e.g. increase the spatial resolution locally by augmenting the amount of magnetic sensors placed in a given volume. The presented magnetic camera renders possible new research activities related to automatic localization of interventional instruments, such as catheters within magnetic navigation systems. The automatic magnetic localization of a catheter requires integration of a miniaturized magnetic sensor within the tip of the catheter and precise mapping of the control magnetic field with a magnetic camera, in order to not only better control but also locate the interventional instrument. In addition, we plan to use this modular magnetic camera to investigate possible cross sensitivity between clinical control and localization devices provided by different manufacturers, e.g. between the control system Stereotaxis Niobe® and the localization system Biosense Webster Carto®. The Carto® system uses small pick-up coils integrated within the catheter and an AC magnetic field generated underneath the patient that is superimposed to the control magnetic field of the Stereotaxis Niobe®. Even though permanent magnets should in theory not distort the AC magnetic field, our magnetic camera allows us to quantify any possible distortion that could stem from system non-idealities and potentially lower the localization accuracy.

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Microsystembased functionalization of sensor catheters

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The hot bar method is used to join a flexible interposer with copper wires inside the catheter wall. These copper wires with a diameter of 150 µm were integrated during the extrusion process of a polyethylene catheter with a diameter of 3 mm and a wall thickness of 1 mm. The wires will be used as signal and power lines. Because the copper wires located inside the catheter wall, the polyethylene material above the copper wires has to be removed for joining the interposer copper lines. The material ablation was done by a femtosecond laser. The advantage is a very good anisotropic profile and a precise material removal. A combined flexible flat cable (FFC) structure at a flexible printed circuit (FPC) with the sensors was used to connect the copper wires inside of the catheter wall. The solder material is deposited and melted on the copper lines of the interposer. The copper wires inside of the catheter wall and the copper lines of the interposer are positioned to each other with the help of a tacky solder flux. Detailed knowledge about the heat sensitive handling with the polyethylene catheter has to obtained before start the joining procedures. For the setup of the final joining procedure, there were used different types of test vehicles. Therefore the hot bar is placed at the back of the polyimide layer. The investigated parameters of the hot bar are stamp temperature, stamp force and time. After the setup analysis of the sensor test vehicle, the optimal joining parameters are discovered and the flexible interposer and the copper wires inside of the catheter wall could be joined. Finally, nondestructive (ultrasound, x-ray) and destructive methods (tweezer pull test, microsection) are investigated to evaluate the joining quality and quantity of the sensor catheter.

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Packaging of µLEDs to flexible polyimide substrates

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Recent developments in the field of optogenetics have created a demand for advanced engineering tools to stimulate neuronal activity using light. The generation of distinct, microscale stimulation patterns requires the integration of multiple light sources into flexible substrates used to manufacture neuronal interfaces. A common polymer substrate base material used for this purpose is polyimide. The thinness and flexibility of the material presents a challenge to mounting rigid LED light sources. Here we developed a packaging technology to mount and passivate 50 µm thick SMD µLEDs (190 x 190 µm², C470UT190-0314-31, Cree) to optically near-transparent thin-film polyimide foils fabricated from PI-2611 (HD-MicroSystems). The BPDA/PPD polyimide PI-2611 is characterized by low moisture uptake as well as similar thermal expansion as metallic thin-films. The electrical connectorization of the µLEDs is achieved by aerosol jet (AJ) deposition of UT DOTS Ag25TE silver ink. Mounting is achieved by epoxy resin (E8074, Resin Designs, LLC). The resin is underfilled using a pin transfer technology. Backside passivation is then achieved by a 2 µm parylene C thin-film (Spacialty Coating Systems, SCS).

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The development of an expert system as a virtual physiotherapist in the domestic environment

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Physiotherapy is more successful if the conventional therapy is intensified at home by self-reliant exercises. At home the therapeutic expertise is not available to the patient. Therefore, an expert system is proposed that provides a virtual therapist. This system should guide, correct and motivate the patient. Expert systems consist of three main components: the knowledge base, the inference component and the dialog component. The proposed technical realisation of this framework includes an artificial intelligence, sensors for movement detection and a visual interface for the patient. This work focuses the development of this artificial intelligence. The first step is to collect the necessary medical knowledge. In addition to the literature studies, targeted interviews with leading specialists are also conducted. The medical knowledge is translated into rules and features. Multivariate static methods are used for the selection of features which are sufficient to classify the correct execution of exercises. The next step is the development of suitable measuring principles for the movement detection. EMG sensors, acceleration sensors and 3D cameras were investigated. The results indicate that 3D-optical systems like Microsoft Kinect meet the requirements. The knowledge base is the input for the inference component. The task of this component is to simulate the decision-making process of the physiotherapist in the evaluation of a therapeutic exercise. Therefore, the method machine learning is used. The dialog component communicates with the user. The main goal of this component is to maintain the patient's cooperation and increase his motivation. Therefore, the patient’s behavior was analyzed by using the SORCK model. As a result, a gaming and gratification component is incorporated. The proposed concepts are the framework for the virtual physiotherapist which combine established technical solutions with new classification algorithm. The results of the parameter identification for the movement detection are presented.

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Instrument calibration for a camera based surgical navigation system

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In a current research project we develop a surgical navigation system where a camera mounted on a navigation instrument is used as measurement device. The navigation instrument, e.g. pointer, is located relative to the patient by computing the transformation of the camera to the patient. When the camera is mounted to an arbitrary instrument the required transformation of the camera to the instrument's tool center point (TCP) is unknown and needs to be calibrated. In this abstract we present a flexible mounting system and a calibration procedure for TCP computation. The mounting system is produced by selective laser sintering from polyamide PA12. It consist of a L-shaped base module that guides a jaw plate. A thread screw is used to press the jaw plate against the L-shaped base module and clamps it to the instrument. The camera is connected to the base module with integrated magnets so that it can be covered with sterile foil without damaging it. The calibration transformation, i.e. the transformation from the camera to the instrument's TCP, is computed by a camera based procedure. A calibration body with checkerboard pattern and ArUco markers in the white checkerboard squares (ChArUco) is used for this purpose. Rotationally symmetric pivot points with varying radii are manufactured and mounted on the calibration body to define positions that can be touched by the instruments tool tip during calibration. The transformation from the camera to one pivot point is determined by estimating the camera location relative to the checkerboard pattern in 30 different orientations (pivoting). Accuracy measurement are done with three reference instruments with known TCP. The results show a precition of the calibration transformation below 0.5 mm. The clamp mount was tested on different instruments with diameters from 2 mm to 20 mm and could be clamped without displacement.

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3D packaging for an implantable hemodynamic control system

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In this presentation, the 3D packaging for an implantable hemodynamic control system is proposed. The system consists of a pressure sensor, an ASIC for data and energy management, an accelerometer for measuring the position of the patient and an interposer as a base. The interconnects of a MEMS accelerometer, the integration of all components on the interposer and the encapsulation were elaborated within the Fraunhofer Lighthouse Project “Theranostic Implants” by Fraunhofer ENAS. The ASIC and the pressure sensor were developed by Fraunhofer IMS.
The base of the system, the interposer, features an LTCC technology with 75 µm line/space and 13 layers. It also contains a coil for inductive energy supply and data transmission. The ASIC and the MEMS accelerometer are mounted on the interposer either by flip-chip bonding with gold studbumps or by glueing and wire bonding. The bonds are stabilized with an underfiller and the wire bonds are protected by a glob top with a high thixotropy. The MEMS accelerometer is fabricated using deep reactive ion etching. After fabricating the MEMS core, it is wafer-level packaged with through-silicon vias. These through-silicon-vias are produced by etching square shaped holes in the silicon cap wafer. The buildup is investigated regarding bond quality and voids with micro computer tomography (Micro-CT) equipment and scanning acoustic microscopy (SAM). An Al_2O_3/Parylene system is used as a biocompatible and hermetic encapsulation. The system is highly miniaturized (length: 15 mm, diamter: 3 mm) due to the packaging technologies used and proved to be functional in first tests at Fraunhofer IMS.

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An auscultatory non invasive blood pressure equivalent without PEP?

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Puls transit time (PTT) is a non invasive method for estimating blood pressure. PTT is defined as the period of time, which the pulswave needs from systolic ejection to a certain point in the arterial system. Conventionally PTT is determined between the R-spike of the ECG and the arrival from the pulswave in the forefinger. Applying this method the pre-ejection period (PEP) is included in the PTT. PEP essentially depends on the sympatic activation of ventricle and negatively correlates with the heart period. Via an invasive animal experiment (canine) Zhang et al. 2011 proved, that 1/(PTT-PEP) is a better predictor for the diastolic blood pressure than 1/PTT. For the determination of the ejection time, phonocardiography and impedance cardiography have been applied.
Through temporary segmentation from the first heart sound into its internal acoustic components, events within the S1 can be defined and assigned to heart dynamics. Therefore the end of isovolumetric contraction of the left ventricel and the beginning ejection into the aorta ascendens can be indicated. Through the continous wavelet transformation and segmentation of pseudo spectrogram, we could isolate the acoustic components and fit them with bivariat models. By modeling and its proof of goodness of fit, it is possible to avoid misinterpretation and suppress potential outliers. The isohypse determined by bivariat modelling, enables us to detect the events of the heart dynamics.
First synchronised recordings of ultra sound doppler spectrums of the aorta ascendens and an intercostal parasternal auscultation show a high coincidence in time between the acoustic model and the starting point of the doppler spectrum.
By reducing the acoustic PEP from the PTT, the demonstrated method is an improvemend compared to the conventinal long term monitoring of the blood pressure equivalent via PTT.

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A chip-based biosensor for the detection of glycosylphosphatidylinositol-anchored proteins in serum as stress biomarkers

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The function of the post-translational modification of eucaryotic proteins with the glycolipidic structure glycosylphosphatidylinositol (GPI) remained enigmatic so far. Here a novel strategy is presented for the elucidation of the role of GPI-anchored proteins (GPI-AP), equipped with the complete GPI anchor and associated with phospholipids and cholesterol in extracellular complexes (GAPEC) which are assumed to be released in response to (metabolic) stress, such as prevalent during type 2 diabetes (T2D). The putative correlation of GAPEC in serum with (pre-)diabetic states has not been studied so far.
A chip- and microfluidic channel-based biosensor relying on surface acoustic waves (SAW) was used, which detects capturing of the GAPEC by the chip gold surface via the GPI-binding molecule, α-toxin, and monitors phospholipids of the GAPEC via binding of annexin-V. Time-resolved phase shifts and amplitude reductions of the SAW (signatures) reflected alterations in mass loading of the GAPEC to the chip surface and in their viscoelasticity, respectively, as validated with exosomes from primary rat adipocytes, which represent a subspecies of GAPEC. Pairwise comparison of SAW signatures produced by the GAPEC in pooled or individual serum samples in the presence of PIG enabled differentiation according to either genotype (between insulin-sensitive lean Wistar and ZF or insulin-resistant obese Wistar and ZDF or insulin-resistant obese ZF and diabetic obese ZDF rats) or body weight (between ZF lean and insulin-resistant obese or insulin-resistant ZDF lean and obese rats or Wistar lean and obese rats). Loss of the differentiating SAW signatures in course of elimination of GPI-AP, phospholipids or cholesterol and exposure toward physical stress, which was used for the delineation of critical threshold values for the differentiation, is compatible with serum GAPEC constituted by weak interactions between their components within a non-vesicular configuration. Thus, GPI-AP in serum GAPEC may be correlated to early stages of T2D, in particular, and regarded as phenomenological biomarker for the prediction of stress-related disorders, in general.

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Impaired autonomic regulation in ideopathic sudden sensorineural hearing loss patients - Does it depend on hypertension?

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The causes of idiopathic sudden sensorineural hearing loss (ISSHL) still remain uncertain, as does the specific site of inner ear disease. There is a high variability of severity of hearing loss, its spontaneous improvement, and response to medical treatment. Probably, this high variability expresses that ISSHL is a collective term for a multicausal disease. It is known that ISSHL influences the autonomic regulation (AReg).
The aim of this study was on the one side to validate the presence of an impaired AReg in ISSHL patients, differing from the AReg in normal-hearing controls (CON) and on the other side to investigate the influence of hypertension on the impaired AReg in ISSHL.
Firstly we investigated 19 CON (10 male, 9 female, age: 38.6 ± 8.3 years) and 14 ISSHL (8 male, 6 female, age: 48.6 ± 16.1 years) without hypertension. Secondly we investigated an age matched group of 27 ISSHL subdivided into two groups - hypertension (8 male, 4 female, age: 59.7 ± 7.3 years) and no hypertension (7 male, 8 female, age: 52.3 ± 14.1 years). Time and frequency domain analysis, segmented Poincaré plot analysis (SPPA) and joint symbolic dynamics (JSD) analysis were performed on 30 minutes beat-to-beat (BBI), systolic (SBP), and diastolic (DBP) blood pressure time series.
The results indicate significant differences in BBI ($p=0.0008$), SBP ($p=0.004$) and DBP ($p=0.001$) as well as JSD ($p=0.0007$) between CON and ISSHL. These indices were not affected by hypertension. However, a few and different parameters from DBP, SPSS and JSD revealed significant differences between the hypertension and no hypertension groups.
In conclusion, ISSHL patients clearly show an impaired AReg in different domains. The indices which characterize this impairment are independent from the co-morbidity hypertension. Hypertension leads also to an impairment of AReg that is, however, characterized by other indices.

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Correlation of Mayer waves in arterial blood pressure and retinal vessel diameter

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Static and dynamic retinal vessel analysis are promising tools for the early risk evaluation of cardiovascular diseases. Mayer waves are temporal biological variations visible in retinal vessel diameter and lead to uncertainties in this analysis. A correlation to blood pressure is described in literature. We investigated the temporal correlation of retinal vessel diameters and arterial blood pressure in the range of the low frequency waves in a multimodal measurement study to understand the temporal relation.
In accordance with the Declaration of Helsinki we performed measurements on 15 young and healthy subjects. Six repeated measurements with a duration of six minutes each were performed within a time period of 90 minutes. Retinal vessels were recorded by Dynamic Vessel Analyzer and the arterial blood pressure was recorded by means of a continuous blood pressure measurement device simultaneously. From the retinal vessel diameters, the equivalent values of arterial and venous vessel diameters CRAE and CRVE were calculated, the Mayer waves around 0.05Hz as well as 0.1Hz were extracted by filtering and the temporal dependencies were determined by cross correlation. Cross correlation yielded clear dependencies in most of the 90 datasets. The following time shifts are determined for the strongest correlations: For 0.05 Hz the minima of arteries are median -3.83 s / IQR 3.38 and the minima of veins are median -6.03 s / IQR 3.94. Around 0.1Hz the minima of arteries are median -4.01 s / IQR 1.90 and the maxima of veins are median -0.16 s / IQR 0.86. Distribution of the time shifts around 0.1Hz is much narrower than around 0.05Hz. Most of the outliers are shifted by one period. Randomly shifted outliers have lower correlation coefficients. Most outliers are concentrated on a few subjects. Outliers for arterial and venous correlation are not necessarily related.

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Empirical mode decomposition and time varying modelling for carotid audio signal analysis

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Auscultation is the acoustic diagnosis of the internal sounds of the body, using a stethoscope. It is performed for examination of the sounds of the circulatory and respiratory systems. Experienced clinicians can hear the flow of blood e.g. in the carotid arteries. We assume that this sound will change over the human life time due to changes inside the vessels. If it is possible to hear the blood flow, it should also be possible to automatically measure changes in the sound of the blood flow. The main problem is that it is necessary to detect dynamical changes at a really long term in a signal that is highly short-term nonstationary. In this work a time-varying (TV) Empirical Mode Decomposition (EMD) analysis was performed to find a trace in the carotid audio signal that is invariable in long-term spaced recordings. EMD has been proposed in the literature as an adaptive time-frequency signal analysis method for dealing with processes involving nonlinear and nonstationary characteristics. Here EMD is used to identify dynamical changes of the carotid blood flow that could be characteristic of each subject through the decomposition of the carotid audio signal in different modes. For that a stethoscope with a microphone were combined with a smartphone for the acquisition of carotid audio signals from five volunteer subjects at different dates in an interval of two months. The recorded signals were first filtered using a wavelet based band-pass filter. The signals were then decomposed using EMD and for some selected modes TV AR models were computed. Finally the TV spectrum and poles were calculated for analysis. Preliminary results show that the TV poles of some modes of the audio signal can be different from subject to subject, and the idea is to further investigate these patterns for patient specific very long-term monitoring.

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Nonparametric modeling of quasi-periodic signals – application to esophageal pressure filtering

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The pressure measured in the esophagus is an important quantity used for the assessment of patient-ventilator interaction during mechanical ventilation. Unfortunately, the esophageal pressure signal is subject to cardiogenic pressure oscillations, which may complicate diagnosis. This work addresses the separation of the respiratory and the cardiac signal component. The two signals can be discriminated by their fundamental frequency, however, conventional lowpass filtering is inappropriate due to band-overlap between the harmonics. Here we consider a nonparametric modeling approach via Gaussian processes. The quasi-periodicity of both signals in the mixture is described by their second order statistics, thus enabling the reconstruction of each source. The chosen kernel covers a wide range of respiratory and cardiogenic waveforms. Information about periodicity is incorporated from reference signals: the respiratory frequency is given by ventilatory data, the cardiac frequency by the electrocardiogram. The remaining hyperparameters of the covariance function are learned through maximization of the marginal model likelihood using gradient descent. We demonstrate the effectiveness of the method on esophageal pressure recordings of patients under assisted spontaneous ventilation. Compared to previous approaches for cardiogenic artifact removal, which merely incorporate the cardiac frequency, the proposed technique takes advantage of the additional information given by the periodicity of the respiratory signal. It provides a generic framework for the separation and denoising of respiratory-cardiac signal mixtures and thus may also be applied to related problems.

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Using functio-anatomical prior knowledge in linear EEG/MEG source reconstruction methods

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Reconstructing brain activity from electro-/magnetoencephalographic (EEG/MEG) data requires the solution of the bioelectromagnetic inverse problem. This problem, however, cannot be solved based on EEG/MEG data alone. Additional assumptions are needed to obtain a unique solution. A common class of methods is based on distributed source models, where a large number of sources (i.e., dipoles) with fixed orientations and locations cover the region of interest (e.g., the cortex). The task is to estimate a spatial distribution of the source strengths. As this is usually a strongly underdetermined problem (many more source strength than measurement channels), often spatial smoothness is used as an additional constraint. This is equivalent to the prior assumption of a particular source covariance structure.
Recent publications have suggested to alter this spatial correlation structure such that it reflects available knowledge on the functio-anatomical organization of the brain. In particular, it is possible to derive borders between different brain areas from various types of brain images. This allows assuming that sources located within the same area exhibit similar activity and sources in different areas are mutually uncorrelated. Here, we present Monte-Carlo simulations, which provide a systematic evaluation how such functio-anatomical prior knowledge influences the estimate of different linear inverse procedures. The study aimed at answering questions like “What happens if the course of boundaries is uncertain?”, “What if our knowledge on functional areas is limited to certain cortical regions?” and “Can prior knowledge improve source localization?”. We found that it is crucial that the incorporated boundaries and the underlying activity are consistent. Omitting boundaries or using additional boundaries expresses a believe on the source correlation structure that is not supported by data. Moreover, we demonstrate our method to localize auditory N100 activity from experimental EEG/MEG data. The results clearly suggest that spatially informed linear inverse methods provide very plausible reconstruction results.

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A wearable chest-strap ECG for real-time data processing

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Nowadays, the number of wearable users in health tracking are increasing. Observing our heart rate values on different activities level can show us the intensity of our body's workload. An advanced fitness tracker can measure heart rate from the wrist, ear, or chest. However, consider if these wearable devices can also be used for real-time heart condition analysis, then it will give us real-time feedback on our activity load. There are two common method to measure the heart rate by using an ECG or an optical sensor. A new wearable chest-strap ECG prototype with an ARM-Cortex M4 microcontroller, is proposed in this paper to do a real-time data acquisition and processing of the ECG signal then display it on a smartphone application. The prototype uses an analog-to-digital converter and a direct-access-memory onboard to acquire the data from a single lead ECG analog-front-end and then process using digital filters. It also has a 4 GB memory card, rechargeable Li-Po battery, and a Bluetooth LE 4.0 to communicate with an Android 4.3 smartphone. The test results were taken from a 33-year-old male subject with normal heart condition while doing daily activities, such as walking, sitting, standing, etc. We compare our results against the state-of-the-art wearable device Fitbit Alta HR, that uses an optical sensor. The acquired signal from our device calculates the heart rate every 3 seconds and display it directly on the smartphone, while the Alta HR calculates every 5 seconds and store it in the device for future synchronizing with the smartphone. Therefore, a wearable ECG device is able to do continuous real-time ECG data analysis to calculate the heart rate with clinical standard measurement.
Keywords-ECG; wearable device; real-time data processing; heart rate; fitness tracker.

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Long-term signal prediction in a level-crossing behaviour analysis for seizure prediction in epilepsy

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The automatic prediction of epileptic seizures by an implanted warning system would significantly improve the quality of life of a large number of affected persons. Research on this topic has been done since several decades but a reliable and to a large number of patients applicable prediction method has not been found up to now. The aim of this work is to present a generalized seizure prediction algorithm based on the analysis of Electroencephalography (EEG) signals.
Cellular Nonlinear Networks (CNN) were introduced by Chua and Yang in 1988 and later extended to an inherently parallel processing framework called the CNN Universal Machine (CNN-UM). The high computing power of analog realizations characterized by a low power consumption make CNN-UM an important platform for the development of an implantable seizure warning device.
In previous work the signal prediction error – as the difference between the original EEG signal and the corresponding CNN result – was investigated as a possible seizure warning feature. The sensitivity and specifity has been clearly improved by applying in a post-processing step a level-crossing behavior analysis where the mean level-crossing time and the mean level-crossing rate of the signal prediction error were investigated. But this post-processing method still not led to sufficient satisfying results for different patients. Investigations have demonstrated that the signal prediction error shows for several patients clear fluctuations correlating with EEG changes due to the day-night cycle and sleep cycles. It seems promising to process the signal prediction error further by applying a long-term signal prediction method in order to take these rhythms into account.
In this paper a generalized signal prediction error analysis extended by the long-term signal prediction will be presented. Afterwards the level-crossing behavior of signal prediction error changes are analysed as possible seizure precursors. Obtained results are assessed by receiver operator characteristic (ROC) and surrogate analysis. The results are compared to those obtained by the application of previous CNN – level-crossing behaviour analysis combined - methods.

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Spectral analysis of signal averaging electrocardiography in atrial and ventricular tachyarrhythmias

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Background: Targeting complex fractionated atrial electrograms detected by automated algorithms during ablation of persistent atrial fibrillation has produced conflicting outcomes in previous electrophysiological studies. The aim of the investigation was to evaluate atrial and ventricular high frequency fractionated electrical signals with signal averaging technique.
Methods: Signal averaging electrocardiography (ECG) allows high resolution ECG technique to eliminate interference noise signals in the recorded ECG. The algorithm uses automatic ECG trigger function for signal averaged transthoracic, transesophageal and intracardiac ECG signals with novel LabVIEW software (National Instruments, Austin, Texas, USA). For spectral analysis we used fast fourier transformation in combination with spectro-temporal mapping and wavelet transformation for evaluation of detailed information about the frequency and intensity of high frequency atrial and ventricular signals.
Results: Spectral-temporal mapping and wavelet transformation of the signal averaged ECG allowed the evaluation of high frequency fractionated atrial signals in patients with atrial fibrillation and high frequency ventricular signals in patients with ventricular tachycardia. The analysis in the time domain evaluated fractionated atrial signals at the end of the signal averaged P-wave and fractionated ventricular signals at the end of the QRS complex. The analysis in the frequency domain evaluated high frequency fractionated atrial signals during the P-wave and high frequency fractionated ventricular signals during QRS complex. The combination of analysis in the time and frequency domain allowed the evaluation of fractionated signals during atrial and ventricular conduction.
Conclusions: Spectral analysis of signal averaging electrocardiography with novel LabVIEW software can utilized to evaluate atrial and ventricular conduction delays in patients with atrial fibrillation and ventricular tachycardia. Complex fractionated atrial electrograms may be useful parameters to evaluate electrical cardiac arrhythmogenic signals in atrial fibrillation ablation.

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PPG imaging: investigating skin inhomogeneity using hyperspectral imaging and principal component analysis

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Photoplethysmography imaging (PPGi) allows for estimating the cardiac activity with a camera due to subtle skin color variations with a frequency associated to blood volume pulsations. To enhance signal-to-noise ratio, it is common practice to average all pixel values in a region-of-interest (ROI) over time, resulting in a single waveform. As recently demonstrated using RGB cameras, considering, e.g., two pixel subsets within the ROI reveals mutually greatly dissimilar waveforms attributed to skin inhomogeneity. In this work, we utilized hyperspectral imaging (HSI) with 16 bands for increased wavelength resolution and principal component analysis (PCA) for a more rigorous analysis of waveform distribution.
A camera (VRmagic D3, CMOS CMV2000, [470,620nm] wavelength range, 25 Hz) was used to record the forehead of three volunteers (male, [27,30y]) from a distance of 10cm for 20s duration. A ring of ultraviolet and white LEDs (Falcon FLDR-i100B-UV24-W) was mounted around the lens providing frontal illumination. For each video (ROI: 60x250pixels≈0.96x4cm) and camera band, we performed PCA by regarding pixel indices as variables and pixel waveforms as observations. In the space spanned by the first two principal component scores, we identified three disjoint classes, each containing 5% of all pixels. We computed an averaged waveform for each class and a reference using all pixels.
Our results showed a cardiac component in the reference waveform of HSI bands covering [530,580nm]. Additionally, one class exhibited a waveform similar to the reference (mean absolute percentage error: 9.35±2.25% (mean±std)), despite containing only 5% of all pixels. On the other hand, the other two classes contained mutually greatly dissimilar waveforms with inverted sign and did not show a distinct cardiac component. The spatial distribution of pixels within classes did not reveal any larger clusters of connected pixels.
In conclusion, PPGi applications could potentially be improved by rigorous analysis and selection of pixel waveforms.

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Detector response in the build-up region of small 6 MV photon fields

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Up to a depth of some centimetres, called build-up region, the dose increases due to indirect ionisation, mainly caused by compton-electrons. Additionally, low-energy photons and electrons, generated in the treatment head and in air, contribute to the dose near the surface. In this non-equilibrium situation, various effects influence detector response, such as volume effect, energy-dependence, detector shape, shielding and materials. In this work we investigated response differences of several detector types (microDiamond, shielded and unshielded diodes, parallel-plate and cylindrical ionization chambers) and possible explanations. Depth dose curves for various field sizes (0.6x06cm^2 - 10x10cm^2) were measured at SSD of 100cm at a Primus accelerator (Siemens, Germany) with a beam quality of 6MV and normalized to the value at 10cm depth. Detector response was compared to EBT3 Gafchromic films (Ashland, USA), which can be assumed to behave nearly water-equivalent. Geometric volume correction factors were calculated from dose maps on the film. From the surface to a depth of 9mm all detectors showed lower response than the film. For example for a 1x1cm^2 field the signal ratio of the detectors to the film was at maximum between 0.9 and 0.97 with the exception of the Roos chamber, for which it was 0.7. Volume averaging could account for the deviations of the largest detectors, but contributed a maximum of 1% to the semiconductor signals. Placing a lead foil below the collimator to filter electron contamination reduced the microdiamond response by 4% in the build-up region. The signal of the unshielded diode was reduced by 5%, twice as much as for the shielded one. In conclusion, we found out that all commercial detectors underestimate the dose near the surface. Electron contamination and volume averaging could explain the observed response differences only partly. The study of further influence parameters is in progress.

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Evaluation of the ArcCheck 3DVH-module

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Before patients are treated with volumetric arc or intensity modulated radiation therapy (VMAT, IMRT) treatment plans have to be verified to ensure that planned and delivered dose distributions concur. Since the prescription is based on dose volume histograms (DVH), it seems reasonable to base decisions on these data. There are commercial systems that reconstruct DVH using different approaches, e.g. the ArcCHECK 3DVH-module (Sun Nuclear) with its planned-dose-perturbation algorithm. We evaluated its performance with regular and artificial treatment plans using Pinnacle (Philips) and a Synergy linac with an Agility MLC (Elekta). The dose at the isocenter was measured with two ionization chambers having different volumes and a MicroDiamond and compared to the reconstructed 3DVH-dose in this region. For 2D comparison, EBT3 film pieces were irradiated in a custom-built inset. The influences of different field sizes were studied. For small fields, the reconstructed dose was higher than the measurement by up to 5% (6 MV) and 3.7% (10 MV) for a 2x2 cm² field. For a standard prostate and a head-and-neck VMAT-plans gamma passing rates (GPR) (3DVH-film) were above 91% (6 MV) and 96% (10 MV). A small and spherical target volume was irradiated with different plan types. The GPR (3DVH-film) for plans with 9 and 15 individual beams and a full conformal arc were better than for half rotation plans. Both influences (field size and plan type) were reduced by including the dose measured in the isocenter in the reconstruction. For half rotation GPR (3DVH-film) (3%/3 mm global, threshold=10%) increased from 42% to 88%. We conclude that the 3DVH module is useable for a standard VMAT plans. In general we recommend measuring the isocentric dose and including it in the 3DVH reconstruction. In further research sensitivity and specificity towards induced errors will be determined.

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Dosimetric calibration of an electronic portal imaging device (EPID)

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The use of complex treatment techniques and small-sized photon beams have increased the need for a highly accurate dose delivery and a patient individual dose verification. Due to the high spatial resolution and the broad availability, the interest in using Electronic Portal Imaging Devices (EPID) for dosimetric information has grown. In this work, we determined the parameters for the dosimetric calibration of an EPID and were able to convert portal images to the equivalent water dose deposited in the detector plane at the depth of 1.2cm.
Measurements were performed on an Elekta Synergy linac with a photon energy of 6 MV and an iViewGT^{TM} α-Si flat panel detector mounted on the linac gantry. The detector was operated in the IMRT-Dosimetric-Weighting mode with a modified calibration. By placing a solid water phantom in the irradiation field, an approximately uniform beam can be achieved during calibration. The dependency of the EPID signal to dose, dose rate, field size and phantom thickness was determined with a Semiflex ionization chamber (PTW, V = 0.3 mm^3). The off-axis dose response and ghosting effects were investigated with an ionization chamber array (PTW-729). EPID images of radiation fields with various sizes and phantoms were calibrated and compared to ion chamber array measurements and treatment planning (Pinnacle 9.10) calculations.
In this clinical experiment the dose profiles obtained by the calibrated EPID images showed good agreement with the array measurements and the TPS calculations. Deviations of less than 3% were observed, mainly attributable to the discrepancies to an entirely uniform beam during the gain calibration of the EPID. In further studies this effect will be evaluated and measurements with IMRT fields will be performed to validate the developed calibration.

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Small animal irradiation: verification of the dose distribution in a phantom using thermoluminescent dosimeters

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Purpose: In absence of a dedicated small animal irradiation device we irradiated mice with a stereotactically equipped conventional linac. To test the suitability of the conventional treatment planning system (TPS) we investigated the dose distribution in a self-designed phantom using Thermoluminescent dosimeters (TLD).
Methods: We used *TLD100 rods* with a *Harshaw TLD Reader 5500 (ThermoFisher)* and a *TLD oven (PTW)* for annealing and regeneration. The experiments are performed in a phantom made of polymethylmethacrylate (PMMA), which is 80 mm long with 35 mm diameter and contains three round cylindrical bores with a diameter of 10, resp. 8 mm with balsa wood as lung and PVC as bone equivalent material. In all, 14 TLDs at various positions in the phantom ('lung', 'spine', 'body') are finally used to compare the dose distribution of calculated plans in the TPS Eclipse (Vers. 13.6) with the measured dose. At least 10-fold irradiation is performed at the linear accelerator *TrueBeam STx* with the energy of 6 MV photons and a dose of about 1 Gy. For positioning we used conebeam-CT (as was done for the mice).
Results: The percentage deviation of the determined dose of all points in the mouse phantom at maximum 15 %, in 'lung', in the other positions 3.4 %.
Conclusions: In conclusion, the TLD results so far agreed with an acceptable margin of less than ten percent on average. However, since for 'lung' the deviations suggest further investigations. Therefore, further tests of different lung materials and additional algorithms applied in TPS will follow as well as further calibration steps for TLD will be carried out for reliable and comparable results.

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Influence of CT reconstruction kernels on dose distribution in liver radioembolization using tissue density estimation

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For successful liver radioembolization, the planning of absorbed dose inside normal liver and tumor tissue is crucial. Patient-individual, local 3D dose distribution can be calculated from SPECT/CT or PET/CT images. Thereby, the local tissue density, determined by conversion of CT Hounsfield units, is one important factor to be considered. To analyze the influence of different reconstruction kernel on dose distribution using CT-based tissue density estimation, we calculated dose distributions using the local deposition method and investigated the resulting effects.
CT data of six patients, who underwent diagnostic CT and pre-therapeutic 99mTc-MAA SPECT/CT imaging for radioembolization planning, were retrospectively analyzed. The SPECT/CT data sets for each patient were acquired on a SymbiaT (Siemens Healthcare) and were reconstructed by three different kernels (B08s, B30s, and B60s). For comparison purposes, diagnostic CTs, that were acquired on a LightSpeed VCT (GE Medical Systems) and reconstructed with a standard body kernel similar to B30s, were analyzed.
In an exemplary case, the determined mean liver density was 1.033 g/ml in the diagnostic CT and 1.010 g/ml in B08s, B30s, and B60s data. Mean tumor density was 1.057, 1.030, 1.031, 1.031 g/ml in diagnostic CT, and B08s, B30s, B60s CT. The mean of local relative dose difference $\Delta_{Bx/diagn} = |D_{Bx}-D_{diagn}|/D_{diagn}$ and standard deviation for CTs with B08s, B30s, and B60s kernel was 0.76 ± 4.41 %, 0.85 ± 4.96 %, and 0.91 ± 5.15 % for liver dose and 0.08 ± 0.99 %, 0.09 ± 1.12 %, and 0.12 ± 1.33 % for tumor dose. In all six cases, global mean liver dose differences were smaller than 2 Gy, and mean tumor dose differences were smaller than 3 Gy. These results show that CTs from SPECT/CT scanners can be used as diagnostic CTs for local density estimation in radioembolization dosimetry, independently from the investigated reconstruction kernels.

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Comparison between differing fill factor definitions for two-dimensional detector arrays

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The fill factor characterizes the error detection capability of a 2D detector array regarding beam collimation errors. It is calculated by the quotient of the sensitive area and the geometric cell area associated with a single detector on the array's surface. While Gago-Arias *et al.* (2012) estimated the sensitive detector width of a single detector as the FWHM of its fluence response function $K_M(x)$, we proposed to quantify the sensitive detector width $w(\Delta, d)$ by identifying, across the detector, the range of the lateral coordinate x where a MLC misalignment of Δmm causes a signal change which exceeds a signal threshold d relative to a homogeneously irradiated detector (Stelljes *et al.* 2017). This raised the interest for a numerical comparison between the two differing fill factor definitions.
In this work the fluence response functions of three commercially available detector arrays were measured using the 0.5 mm photon slit beam introduced by Poppinga *et al.* (2015). The measured fluence response functions of three detector arrays from PTW-Freiburg were used to calculate the sensitive detector widths and the fill factors. For the OCTAVIUS729 and OCTAVIUS1500 arrays, supplied with air-filled ionization chambers, the FWHM fill factors were obtained as 0.53 and 0.71 while the collimator monitoring fill factors were 0.59 and 0.84 respectively. For the inner area of the OCTAVIUS1000SRS array, supplied with liquid ionization chambers, the FWHM fill factor was 1.4, and the collimator monitoring fill factor was 1.0. We conclude that the FWHM fill factor characterizes air-filled ionization chamber arrays quite well, but does not yield a plausible fill factor value for the investigated liquid ionization chamber array.

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Design of a precise scintillation dosimetry system for the measuring of microcollimators

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Ocular brachytherapy is a commonly used modality in treatment of eye cancer. In recent years, nearly exclusively eye plaques with a homogenius layer of ruthenium-106 and plaques containing multiple iodine-125-seeds are applied. The
gamma radiation emitted by iodine is advantageous for the treatment of tumours with a thickness of more than 6-7 mm. Unfortunately, its higher range compared to rutheniums beta radiation leads to irradiation of a greater part of healthy tissue. The patented concept of microcollimators makes it possible to generate steep dose gradients and limit the radiated area to the actual tumour. The underlying principle is an alternating alignment of absorbing and transparent lamellae. This layered structure shapes the radiation field of a single seed in the manner of an x-ray collimator. Due to the small size of the utilized structures, a highly precise measuring method is needed. Scintillation dosimetry has shown to be well applicable for eye plaques in general, but the positioning of the detector has to be more accurate for microcollimators. This contribution focuses on the design of a new device for extremely precise scintillation dosimetry, which should later be used to optimize microcollimators and enable their use in clinical therapy.

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Investigation of PEN based plastic scintillator dosimetry for Iridium-192 afterloading source

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For any tumour treatment it is essential to have the knowledge of the dose distribution. This can be achieved by either numerical simulations or by dosimetric measurements. Depending on the measuring situation it can be advantageous to use a water equivalent detector, such as plastic scintillators. These scintillators can be manufactured in different and even very small sizes in order to gain a high spatial resolution. This applies especially to dosimetry and quality assurance of Iridium-192 afterloading sources. The recently evaluated material polyethylene naphthalate (PEN) can be connected without big effort to the fibre optics and the detector system.
Our research group of the co-operation of the TU Dortmund University and the University Hospital Essen investigates the dosimetric characteristics of this material. We focus especially on the energy dependence of PEN by performing numeric simulations. For an existing dosimetric system at an Iridium-192 afterloading source, the luminous efficiency of the detector, the absorption in the light guiding system, the detection probability of the light sensor and the elimination of the Cherenkov light in the light guide are investigated. First results of this research will be presented.

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Experimental determination of conversion coefficients for estimating the patients' skin dose in surgical neuroangiography

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Modern interventional procedures like mechanical thrombectomy lead to an increase of fluoroscopic time and number of radiographs so that deterministic skin effects are observed more often in interventional radiology like surgical neuroangiography. This research aims at determination of the patients' skin exposure as a consequence of a mechanical thrombectomy and at investigation of possibilities for dose reduction. As a measure for the skin exposure the peak skin dose (*PSD*) is used. The *PSD* is defined as the highest surface personal dose equivalent $H_p(0.07)$ at any portion of a patient's skin. For the determination of $H_p(0.07)$ by means of the examination data, we recommend the use of conversion coefficients which include contributions from back scatter and attenuation. These conversion coefficients were measured for peak tube voltages between 50 kV and 110 kV, for additional copper filtration up to 0.9 mm and different projections (p. a. and lateral). For these measurements, an Alderson head phantom, a semiconductor detector (silicon) with the DIADOS diagnostic dosimeter (Fa. PTW) and an artis zee biplane workplace (Fa. Siemens) are used. The evaluation of 50 patients, who have undergone a mechanical thrombectomy, exhibits a $PSD > 2$ Gy for about 20 % which is in the range of the thresholds of the SSK for deterministic skin injuries. Further 30 % receive a *PSD* of 1-2 Gy which gives at least cause for concern. Consequently, in surgical neuroangiography a systematic consideration of the *PSD* seems to be reasonable. Besides, a clear correlation between *PSD* and air kerma is shown. For the *DAP* this correlation is not possible due to large variations of field sizes. As a result, we are able to provide a table of conversion coefficients which enable the determination of *PSD* from the displayed parameters.

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Position-dependent non-reference condition corrections for treatment plan verification using two-dimensional detector arrays

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Two-dimensional detector arrays have become a standard tool for plan verification in radiotherapy. For this purpose, cross-calibration is carried out for selected chambers within the array, typically the central chamber. Several studies have shown that the response of the detectors in an array is dependent on the beam quality at each measurement point. To account for this influence a non-reference condition correction factor k_{NR} has to be applied for every detector within the array. This study investigates the variation of E_F within the irradiation area and its impact on k_{NR}. The k_{NR} distribution is calculated for various IMRT and VMAT plans by using the mean photon energy and its correlations with k_{NR} for different detector types (Chofor *et al.* 2014*)*. Each plan is projected on a planar area. To calculate k_{NR} at each detector position the corresponding fractions of out-of-field, in-field and penumbra dose are determined by weighting the local k_{NR} while using the detector specific relationship between k_{NR} and E_F. The k_{NR} variation among all detector positions in each plan is studied by setting different threshold values of the total photon fluence, above which the k_{NR} values are considered. We have shown that the variations of k_{NR} strongly depend on the detector type. The air-filled ionization chambers show a linear k_{NR} dependence on E_F with a low slope, which leads to small deviations in the final k_{NR} distribution. Diode detectors show an exponential dependence of k_{NR} on E_F. As a result, the range of the plan specific final k_{NR} distribution exceeds five percent when considering a fluence threshold of 20 % with respect to the maximum. The study shows that an additional plan and detector specific correction factor for detector array measurements should be considered.

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Isocenter verification of a standard linear accelerator using the OCTAVIUS detector array 1000SRS

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Stereotactic radiosurgery and radiotherapy require quality assurance of the isocentric accuracy. The gold standard of this verification is the Winston Lutz test. A study by Loutfi-Krauss *et al.* (2017, this issue) who tested different high-resolution detector arrays for QA of the CyberKnife showed that the liquid-filled OCTAVIUS detector array 1000SRS (PTW-Freiburg) is able to detect position deviations of 0.11 mm, offering a similar accuracy and sensitivity as the Winston Lutz test. This study investigates the ability of the array to verify the isocenter of a standard linear accelerator (Elekta Synergy) for stereotactic applications. At first, a small field (1x1 cm^2) is irradiated via an open arc and a star shot pattern. The 1000SRS detector array is used in combination with the OCTAVIUS 4D Phantom (PTW-Freiburg). Afterwards the open arc and the star shot pattern are measured for different position errors of the whole phantom setup. Using a translation stage (M-511.DG, PI, Karlsruhe) the phantom is shifted in longitudinal and lateral direction in 0.5 mm steps. In vertical direction the shift is accomplished manually by moving the treatment couch in 1 mm steps. Compared to an isocentric reference measurement the measurements are evaluated by the determination of a translation vector using the auto alignment function of VeriSoft (PTW-Freiburg). Comparing the translations detected by VeriSoft with the translation stage shifts a maximum deviation of 0.24 mm in longitudinal and 0.28 mm in lateral and vertical direction was determined. When considering the positioning accuracy of the Agility-MLC (Elekta, Crawley, England) of 0.2 mm (Harmeyer *et al.*, 2016), these results are in good agreement with the actual translation. The study underlines the fact that the 1000SRS array is able to detect variations in beam delivery with an adequate accuracy and sensitivity offering the possibility to verify the isocenter of a standard linear accelerator.

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Determination of the amount of backscatter radiation in interventional radiography for the personnel

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In interventional radiography, the personnel protects itself from the radiation using lead aprons. Frequently aprons are used, which shield only the front part of the body. It is known, that the scattered radiation scatters at the wall, floor and ceiling and thereby radiation will also come to the back side of the personnel. However, this amount is not well known and was determined in a clinical setup.
To produce about the same amount and distribution as in clinical exams an Alderson-Rando phantom was placed on an exam table and a p.a. projection of the abdomen was used. A dosimeter was placed in a lead cylinder, which was only open to one side, to measure only the radiation coming from this direction. The dose coming from the top (ceiling), bottom (floor) and from behind (wall) was measured in five heights. The values were compared with the total amount coming from all directions without shielding.
The dose rates measured in 1m distance coming from the ceiling were on average 0,64% of the total amount of dose, coming from the floor it was 4,6% and from the wall it was 0,77%. The doses were highest in higher positions, e.g. at the level of the eyes the doses were about 3 times as high as at the level of the shinbone.
Persons wearing aprons, which only shields the front part will receive significant doses to the back. Wearing an apron with a lead equivalent of 0,5mm approximately 2% of the radiation will pass. Comparing with the measurement results, the radiation levels coming from the floor, ceiling, and the walls are similar, so that the front and back will approximately get the same radiation levels.
An apron shielding the whole body should be worn by the personnel working in controlled areas.

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Effects of ultra-short pulsed proton bunches on malignant T and B cells

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Laser-driven ion acceleration is a promising field for radiotherapy. The dose rate is many magnitudes higher than of conventional accelerated ions. In this study ultra-short pulsed proton bunches irradiated thin layers (thickness about 10µm) of Ramos and Jurkat cells (malignant B and T cells). The protons were energy-separated by a magnetic double yoke. An adjustable slit was placed in front of the double yoke. By increasing its size the dosage was increased while the energy-resolution decreased. During the experiment the dosage was increased by the number of TNSA-events. For that purpose, the target consisting of a 5µm thick titanium foil was coiled and motorized unrolled. Additionally, the gap between the magnets was variable to adjust the proton energy. We irradiated the cells with proton energies from 1.8 to 4.2 MeV. To get a high cell density the suspension cells were centrifuged (>2e8 cells per milliliter ◊simultaneous irradiation of >300000 cells). For the flow cytometry examination the cells were permeabilized according to the FIX & PERM® protocol afterwards. To detect DNA double strand breaks and oxidative and nitrosative stress we used fluorochrome labeled antibodies against gH2A.X and nitrotyrosine. The irradiated cells (about 10000 events in the “cell gate”) showed up to 4-fold higher intensities in the gH2A.X-channel, while no irradiation effect was noted for nitrotyrosine. For dosimetry we used image plates and CR-39 (allyl diglycol carbonate) plates. The greyscale of the image plates depended on the dosage and they were either placed next to the irradiated cells to measure the shots on the cells or directly placed at the cell port instead of the cells. The CR-39 plates were also used instead of cells or directly placed in the cell port replacing the coverslip. The CR-39 plates placed behind the cells are expected to display the number of protons which hit the cells most precisely because the Bragg peak of the arriving protons is slightly behind the cell layer.

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Comparison of thermoluminescence reader TLDcube and harshaw 3500 for dosimetry in radiology and radiation therapy

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Thermoluminescence dosimetry (TLD) is a technique to determine radiation doses. A new portable TLD-reader TLDCube distributed by RadPro international GmbH (Wermelskirchen, Germany) has been introduced, which uses a ceramic heater (nitrogen gas shielding and coolilng) and a standard UV-VIS photomultiplier tube. This manual reader is compared to the well known manual Harshaw TLD3500 reader by ThermoFisher (Erlangen, Germany) for TLD100 LiF(Mg,Ti) and TLD100H LiF(Mg,Cu,P) for diagnostic kV (mammography, conventional radiology) and for radiation therapy MV radiation qualities. Fixed sets of preselected 50 TLD100H and 50 TLD100 were irradiated first to determine the individual calibration factors in identical manner for both readers with the same heating profile for TLD100H: 10s 135°C, ramp to 240°C with 8°C/s for 33.3s total. Annealing was performed at 240°C for 10 minutes in a PTW TLDO-oven with rapid cooling after removal between metal plates. For TLD100 the standard pre-readout anneal in the TLDO-oven and heating profile up to 300°C with 15°C/s for 20s in the reader was used. Subsets of 5 TLD100H for each dose measurement were subsequently irradiated in steps from 0.8mGy to 5.0mGy for 20kV to 121kV. For TLD100 a reduced set of kVs and doses was used. For measurements at radiation therapy qualities 25 of each TLD-type were used due to a smaller phantom available.
Subset doses were calculated in standard manner from an internal reference-TLD subset dose. The averaged relative deviations of the measuremented to the known doses was for the TLDCube for mammography 7.0% vs. 5.1% for the 3500 and 8.6% vs. 3.9% for conventional radiology for TLD100H. First results for TLD100 are 1.8% vs. 2.2% and 1.2% vs. 3.6%, respectively. Results for radiation therapy doses will be reported when completed.
The existing results indicate an acceptable performance of the portable TLDCube in comparison to the stationary 3500 TLD-reader.

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Validation of cosmic ray flux models using a spacecraft-mounted radiation monitor

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Radiation protection is of special importance in modern space travel. The impact of particle types ranging from protons to heavy ions and energies up to some GeV have to be considered for the successful realization of space mission. Besides possible threads to astronauts also the influence on and damages of electronic devices play an important role. The interplanetary radiation field generally consists of a low energetic (up to several hundred MeV) solar and a high energetic (relevant up to several 100 GeV) galactic component (GCR). The latter one acting as a constant radiation background modelled in its intensity by the solar activity.
To characterize the radiation environment many spacecrafts are equipped with radiation detectors. With her complex trajectory through the solar system, the ESA mission Rosetta offers an unique possibility to monitor the radiation flux in space over a period of nearly one complete solar cycle. To accomplish this, Rosetta was equipped with a radiation detector SREM (Standard Radiation Environment Monitor).
In this work SREM response functions for energies from 5 MeV to 100 GeV for hydrogen up to neon were calculated using the Monte Carlo environment Geant4 (version 10.01)/GRAS (version 03.04). We will show that by an application of these response functions to a theoretical GCR background based on the ISO 15390 model, time resolved count rate curves for the channels of the SREM detector can be reconstructed for the whole mission. Short time deviations from this curve can be related to sudden solar activities, such as flares. As to be expected the most prominent components to be considered in the calculations are H- and He- ions, offering even the possibility to verify the relative abundance of these ions in space. The influence of the spacecraft on the count rate will be described and discussed.

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Reducing radiation exposure and optimising image quality in x-ray examinations for neonates

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Due to the high water content of the tissue and the still evolving cells, neonates are known to be very radiosensitive. Nevertheless, x-ray examinations can prove to be vital, especially of the thoracic and abdominal region. These two radiographs are commonly combined into one survey radiograph, resulting in suboptimal collimation. This work investigates the radiation dose for two individual radiographic exposures of the thoracic and abdominal region. The dose measurements were conducted with a solid-state detector, the image quality was determined using a phantom which was specifically crafted to mimic the neonatal abdominal region. Due to the adapted collimation, the radiation exposure is significantly reduced when using two separate radiographic exposures. Compared to the survey radiograph, the two individual radiographs exhibit an average increase in contrast of 23%. This is attributed to the decrease in scattered radiation due to the smaller radiation field size, as well as the closer proximity of the investigated region to the central axis.

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Experimental verification of the currently used estimation for dose to the uterus in fluoroscopy examinations

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Any x-ray examination of a pregnant patient raises fears of a radiation-induced damage to the unborn child, notably birth deformities, genetic defects and pediatric cancer. The DGMP/DRG Report No. 7 (2002) contains a data table for rough examination of the expected dose to the uterus. As the technical features have rapidly evolved since 2002, we investigated whether the data for x-ray fluoroscopy is still up to date. For this purpose we performed dose measurements with continuous and pulsed fluoroscopy on three different generations of fluoroscopy systems. Our analysis indicates that the data table – published in accordance with fluoroscopy systems at the time - includes a safety buffer of 40% to create a conservative uterus dose estimation. The experimental results show a high potential for dose sparing when pulsed fluoroscopy is used; many current systems do not even offer continuous fluoroscopy. For pulsed fluoroscopy, the safety buffer increases from 40% to 59-92%. A review of the DGMP data table seems highly advisable, especially as it serves the reassurance of the pregnant patient.

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A novel optical hydrophone for the single-shot field measurements of high-power-pressure-pulse fields

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The measurement of ultrasonic fields are often performed using polyvinylidene fluoride (PVDF) membrane hydrophones. Even in the IEC Standard 61846, which defines the measurement of pressure pulse fields, specifies the hydrophones as PVDF comparable probes. The hydrophobic properties of the membrane limits the ability to measure negative pressure amplitudes and abets the occurrence of cavitation. Furthermore high pressure gradients leads to sensor damages, which is aggravated by cavitation collapse.
During recent years optical hydrophones are investigated. Refractive type optical hydrophones are based on the change of refractive index at a glass-water interface when the shockwave passes the sensitive area. Advantages of optical hydrophones are the high adhesion of the glass-sensor to water and the robustness of the probe which withstands pressure amplitudes of several 100 MPa. Disadvantages are the low sensitivity and the complicated handling of the probe. A major disadvantage of the optical and the PVDF hydrophones is the fact that they provide a single spot sensitive area, with the result that field measurements needs a repositioning of the probe. This is of special importance if the sound field is highly unstable, such as electro-hydraulic shockwave sources. In these case a complete scan of at least the focal region in a single measurement is of great demand.
In this work we introduce a novel optical hydrophone for the measurement of shockwave fields. Comparison measurements with a fiber optic hydrophone and a PVDF hydrophone measurements are presented. First evaluations show good agreement with calibrated measurements, regarding the amplitude, rise time and energy of the shockwave signal.

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Requirements for modular measuring systems in individual treatment and care of dementia patients (PYRAMID)

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Treatment of dementia may regard two points: causes or symptoms of dementia. Considering dementia from the side of symptoms, leading symptom is usually memory disorder. In International Classification of Diseases (ICD) dementia is associated with disorders of many higher cortical functions, including memory, thinking, orientation and speech. This results in severe limitations in daily life of dementia patients. In the collaborative project PYRAMID, a comprehensive requirement analysis of the development of a sensorfusion system for support of patients with early dementia and dementia was presented. A questionnaire was developed and implemented for survey. The questionnaire included demographic data, selected types of sensors and support systems, aspects of ethical and data protection requirements and questions about type of data.
First results of this survey showed that sensors for measuring values such as pulse rate, blood pressure and movement have received high approval values. These sensors often provide metric values and are therefore more suitable for measurement, survey and evaluation than ordinal or nominal variables that frequently are not precise enough for differentiated assessment. It should be noted, however, that individual values alone have low significance. For use with dementia, patient's metric values should be combined and fused with other parameters. Further research will study recording of which other parameters is meaningful and how they can be linked with metric values. Language e.g. serves the purpose of information, the creation of contacts, it has a communicative as well as a cognitive and social function. Focus is on the needs of the person concerned. Which key figures and parameters must be considered in functionality and usability? Ultimately, in addition to these aspects, medical, technical and hygienic reliability and safety of the system must be met at all times. The survey will generate important input to the functional specification of this project.

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Surface electromyography - measurement setup for the electrical characterisation of electrodes under consideration of boundary layer phenomena

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The electromyogram (EMG) on the skin surface is usually derived from Ag/AgCl electrodes. Advances in processing of conductive polymers and textiles make it possible to build novel forms of electrodes. If these electrodes are used for clinical diagnostics, the extent to which the impedance of these electrodes differs from the conventional ones has to be investigated. Impedance measurements with metal probes neglect boundary layer phenomena on the tissue. Measurements at human subjects are prone to many influencing factors and the stochastic nature of EMG signals results in large dispersion of the data set. This paper proposes a measurement setup which can replicate the boundary layer between the tissue and the electrode. In addition, the characteristics of the source signals as well as the electrical tissue properties can be adjusted reproducibly. The measurement setup consists of a sine wave generator, a network of copper plates and a layer of gelatine with a specially tuned ion concentration to mimic the electrical properties of human skin. In the network non-isolated copper plates (1 cm² active area) are resistively and capacitively coupled to each other according to the two-dimensional bidomain model. The anisotropy of the muscle tissue is taken into account by a larger coupling impedance in the transverse direction than in the longitudinal direction. To ensure that skin-like boundary layers are formed the circuit board is coated with the layer of gelatin. The molecular composition is comparable to the fat-free human skin. The electrical properties are determined by the water, lipid and ion concentration. Frequencies up to 500 Hz are relevant for the EMG. In this range, fat shows a negligible change in impedance. It could be shown empirically that by adjusting the concentration of collagen and sodium chloride, the gelatin layer can be adapted to the electrical parameters of different skin types.

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PromBERA – praeoperative EBERA – objektiver Promontorialtest zur Integritätsprüfung des Hörnervs bei Cochleaimplantat-Kandidaten

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Introduction: Promontory Stimulation is a well-established tool to stimulate preoperatively the cochlea by a temporary transtympanic needle placed on the middle ear. It was shown that eABR (Electrical Auditory Brainstem Response) recorded with Promontory Stimulation is an useful objective measure in CI candidates in testing and evaluating the presence and excitability of the auditory nerve and auditory pathway before cochlea implantation. This test is especially critical for a group of patient where it is hardly difficult or not even possible to judge the CI candidacy based on other pre-operative audiological tests. It was also demonstrated that a correct placement of the electrode tip on the RW niche, instead of the promontory, plays an important role on the efficacy of the electrical stimulation delivery. In this study we are going to show the feasibility of this measurement using the MED-EL clinical system.
Results: These preliminary data show the validity of PromStim test. The eABR were then later recorded by intra-op eABR elicited by CI electrode array, showing a good similarity with PromStim eABR and confirming the presence of responses.
Conclusion: PromStim eABR with MED-EL clinical system results easy to be used and feasible on CI candidates especially in whom the presence and excitability of the auditory nerve is in doubt.

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Examination of the skin conductance level (SCL) as an index of the activity of the sympathetic nervous system in physical and psychological stress situations

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To examine potential correlations between changes of blood pressure and arousal situations or pathological influences, the idea is to combine continuous blood pressure monitoring with an electrodermal activity measurement (EDA). The EDA is an evidence of the activity of the autonomic nervous system (ANS) which can be used as a stress indicator. Moreover, this measuring technique relates to psychological phenomena and comprises strong inter- and intra-individual differences. This work covers standardised measurements to examine the inter-individuality of the EDA-Data under physical and psychological stress situations by measuring the baseline values and arousal reactions. The 15 subjects (10♂; 5♀) received physical (Cold pressor test) and cognitive (Stroop test) stimuli with constant repetitions which have been proven to be an effective stress indicator. Additionally, the EDA baseline of every subject was measured in a quiet setting. For the analysis the means of the SCL were determined. The logarithmic representation displays a high inter-individual variability, characterised by a high SCL fluctuation range of the absolute values and SCL amplitudes. The relative comparison between stress situations and baseline within the subjects could not be related to a reference value because of the unverifiable correlation. Additionally, the three cognitive stress stimuli show a constant effect ($p=.320$; $\alpha=.05$) and reliability ($r=.997$) whereas the physical stress stimuli confirm a significant difference with a high reliability ($p=.004$; $\alpha=.05$; $r=.975$). A high variability was detectable between the subjects under equal conditions which made it complicated to standardise values for internal stress. This could be due to individual properties and the subjective strain of a person. Therefore the intra-individual comparison of the SCL is more meaningful than the inter-individual comparison. Nevertheless, the EDA should be combined with other parameters of the ANS for a more precise evaluation of stress situations in the context of changes in blood pressure.

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Impact of nocturnal respiratory symptoms (cough and wheezing) on the respiratory rate in patients with COPD

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Night-time respiratory symptoms have a considerable impact on sleep and life quality in patients with COPD. Lack of awareness of night-time symptoms can lead to worsened COPD control. In a previous study, we found severe nocturnal wheezing in 30% of patients with COPD. So far it is unexplored, if nocturnal wheezing, as a sign for obstructed lower airways, leads to oxygen desaturation and therefore to a variability in respiration rate. Automated long-term monitoring of respiratory symptoms with LEOSound combined with polygraphic measurement enables assessment of nocturnal wheezing and cough and an impact on O2-saturation, respiration and heart rate.
In an observational study we investigated the impact of of cough and wheezing on oxygenation, respiration and heart rate in patients with stable COPD (GOLD II-IV). 15 patients were included. The longterm lungsound measurement (LEOSound) was synchronized with the cardiorespiratory polygraphie (EMBLETTA GOLD) to correlate the respiratory sound-events (cough and wheezing) with O2-saturation, respiration rate, flow and ECG from the PG.
It is assumed that respiratory symptoms like wheezing and cough lead to an increased respiratory rate and heart rate acceleration as a result of hypoxia. Based on our data we can show that night-time respiratory symptoms are a sign for an insufficiently adjusted antiobstructive therapy and leads to worse health status.

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Realization of pressure controlled ventilation for an automated public access emergency ventilator

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A prompt support with cardiac reanimation and sufficient air ventilation is urgently required in resuscitation situations. Compared to the automated electrical therapy of the cardiac system that uses AEDs (automated external defibrillator) also automated systems for emergency ventilation by layperson would be beneficial to overcome the problems and to reduce the failures that often appear in manual respiration in emergency situations. For this application automated pressure controlled ventilation (PCV) is realized that utilizes adapted pneumatic components, sensors, electronics and algorithms assuring the patients safety requirements and fulfil respiration norms.
A fast reacting directed pressure controlled blower unit is developed for the air support. It enables a high flexibility of the ventilation profile regarding pressure minima and maxima and the ventilation time regime. The ventilators technical design principally avoids harmful pressures and thus ensures patients safety also in a case of malfunction. In addition special pneumatic valves are integrated that enable spontaneous breathing at each time. Based on online measurement of flow and pressure dysfunctions such as airway occlusion and leakage are detected by the system within only one respiration cycle. The analysing algorithms tolerate individual differences of the patients. Proximity sensors fixed at the respiratory mask are used to identify critical changes of the patients head position. The realized system can provide automated ventilation. The detection of malfunction and inefficient patient ventilation can be used to signalize the supporting person the need for help. In laboratory tests also oxygen and self-developed carbon dioxide sensors were implemented to enable a characterization of the patient's condition, these sensors can optionally be implemented in a future automated public access ventilator. The realized ventilator system was developed and tested at pneumatic dummies. Further, more than 50 healthy volunteers were successfully ventilated by the system under different conditions.

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IMU-based motion capture system for real-time body joint angle measurement

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A precise estimation of joint angles of the human body is an important requirement for assistive robotic systems. Real-time motion capture allows human-robot interactions with the upper limb during sophisticated positioning tasks. The measured joint angle trajectories provide a control variable for robots that are used in the area of rehabilitation, assistance or telemanipulation. Common camera based motion capture systems for movement analysis are expensive and require a stationary installation. Several commercial products use inertia measurement units (IMUs) for mobile motion capture of the human joint angles. However, costs of several thousand euros prevent the application in a broader field of medical robotics. In this work we present a low-cost motion capture systems for joint angle estimation of the human body. The modular system is based on MEMS IMUs (type BNO055, Robert Bosch GmbH, Germany) with an intelligent 9-axis absolute orientation sensor, which includes system on chip sensor fusion and filtering. Therefore, an additional Kalman or complementary filter is not required. For motion capture of the upper limb of a human user, four IMUs are fixed to the torso, upper arm, lower arm and hand with elastic bands. An additional microcontroller reads quaternions of the IMU sensors with 100 Hz sample rate via I2C to compute the rotation matrix of each sensor element. After all IMUs are calibrated, the relative position of each element is computed with an analytic procedure, using gravity-vector and omega calibration. The overall calibration process is done in less than ten seconds by moving the arm back and forth for a few times. The RMSE of the measured joint angles is smaller than two degrees for static positioning and five degrees for dynamic movements during activities of daily living. We successfully use the developed system to control an upper limb exoskeleton for robot-assisted rehabilitation.

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Development of an in silico-model to investigate the dynamic loads of a transcatheter aortic valve

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Aortic stenosis, with a prevalence of 2–5% in the over 65 year old patients and 5-10% in patients over 80 is the third most common cardiovascular disease. According to the German *Herzbericht*, in 2015, more than 15,500 catheter –supported aortic valve implantations reach a new high. This can be attributed to the expansion of the indication profile to patients with medium to low risk. As a result of relatively long use evaluation of the dynamic loading, such that on the seam between the valve ring and leaflet is increasingly important.
Using reverse engineering a 3-D model of transcatherter valve was modelled. To improve reproducibility a simplified model of the aorta was generated. The in silico model combined both models using the bi-directional fluid structure interaction method. In terms for physiological inlet limits, a hyperelastic constitutive formulation for bovine pericardial valve leaflet was used. The seam between the leaflet and valve frame was realized by a contact junction condition. Both solvers from ANSYS® (Fluent®, Mechanical®) were used for the computation.
There are significant differences valve leaflet distortion and the forces generated in the leaflet-frame interface that depended on the structure of the leaflet and its fastening. In addition, the more realistic, asymmetric valve leaflet led to a disparate distribution of forces. Within every cardiac cycle there is at least one load change during the opening process, which is the main reason for weakening of or damage to the leaflet. Flutter in the leaflet or single rupture of the leaflet results in increased frequency of load changes within a single cardiac cycle and subsequently greater damage.
The results were validated by comparison with other work using FE-simulation and tensile studies. Tensile testing showed the maximum load to significantly higher. For a more precise prediction of functional life further simulations, computations and experiments are required.
All in all, it can be concluded that simulations offer a useful insight into the dynamic load experienced by transcatheter aortic valves and the factors that influence functional life.

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Heart rhythm model and simulation of electrophysiological studies and high-frequency ablations

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Background: Target of the study was to create an accurate anatomic CAD heart rhythm model, and to show its usefulness for cardiac electrophysiological studies and high-frequency ablations. The method is more careful for the patients' health and has the potential to replace clinical studies due to its high efficiency regarding time and costs
Methods: All natural heart components of the new HRM were based on MRI records, which guaranteed electronic functionality. The software CST was used for the construction, while CST's material library assured genuine tissue properties. It should be applicable to simulate different heart rhythm diseases as well as various diffusions of electromagnetic fields, caused by electrophysiological conduction, inside the heart tissue.
Results: It was achievable to simulate sinus rhythm and fourteen different heart rhythm disturbance with different atrial and ventricular conduction delays. The simulated biological excitation of healthy and sick HRM were plotted by simulated electrodes of four polar right atrial catheter, six polar His bundle catheter, ten polar coronary sinus catheter, four polar ablation catheter and eight polar transesophageal left cardiac catheter. Accordingly, six variables were rebuilt and inserted into the anatomic HRM in order to establish heart catheters for ECG monitoring and HF ablation. The HF ablation catheters made it possible to simulate various types of heart rhythm disturbance ablations with different HF ablation catheters and also showed a functional visualisation of tissue heating. The use of tetrahedral meshing HRM made it attainable to store the results faster accompanied by a higher degree of space saving. The smart meshing function reduced unnecessary high resolutions for coarse structures.
Conclusions: The new HRM for EPS simulation may be additional useful for simulation of heart rhythm disturbance, cardiac pacing, HF ablation and for locating and identification of complex fractioned signals within the atrium during atrial fibrillation HF ablation.

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Diffusion simulation of low molecular MRI contrast agents in micronecrotic tumor tissue for DCE-MRI

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Pharmacokinetic compartment models are used to estimate physiological tissue parameters in the evaluation of dynamic contrast-enhanced magnetic resonance imaging. The typically used low-molecular-weight contrast agents (LMCA) extravasate from the capillaries and distribute in the interstitial space by diffusion. The fractional interstitial volume is increased in micronecrotic and necrotictumor tissue. Tumor vessels can only supply oxygen to the tissue over a limited radius, leading to necrotic tissue outside the radius. Therefore, the interstitial volume may vary within a tumor. Compartment models assume homogeneous tracer distribution within each compartment, neglecting diffusion effects. The present study investigates three compartment models in terms of how accurately they estimate the interstitial volume in inhomogeneous micronecrotic tumor tissue.
To model extravasation and diffusion of LMCA in the interstitial space of a heterogeneous tissue, iterative simulation was performed using macroscopic tissue discretization. The assessment of increased interstitial volume by the compartment models was determined by fitting the models to the simulated concentration-time curves. The extended Tofts model, a parallel 3-compartment model, and a sequential 3-compartment model were investigated.
For mean vessel distances of 100 and 150 µm, interstitial volume is overestimated by 6.9% and 10.0% using the extended Tofts model and by 8.6% and 15.5% using the parallel 3-compartment model. Conversely, the sequential 3-compartment model overestimates interstitial volume by 0.2% (100 µm) and underestimates it by 18.8% (150 µm). Overall, our results suggest that the interstitial volumes predicted by the sequential model deviate least from the interstitial volumes predefined in the simulation compared with the Tofts model and parallel model.

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A bile flow model for in-vitro testing of biliary stents – a prognosis of incrustation processes

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The endoscopic insertion of plastic biliary endoprostheses is an effective and well−established treatment for biliary strictures. Plastic stents are easy to insert and to remove. In comparison to the competitive self-expandable metallic stent plastic stents are also cost-saving. The major limitation of this technique is the short patency period, which can vary between only weeks to a few months.
There have been several efforts to prolong the patency period of biliary plastic stents. Some attemps have shown promising results during the in-vitro testing but so far none of the results could be confirmed by following in-vivo studies. The discrepancy between the tests results of in-vitro and in-vivo studies might be due to inadequate in-vivo models.
To tests newly developed biliary stents under conditions close to physiological ones a bile-flow model has been developed, which not only considered the physiological temperature, position and pressure of the bile duct but also the discontinuous volume flow of bile. Above all, the set-up provides the opportunity to measure the volume flow through the stent. This innovation leads to the possibility to observe how the volume flow decreases over time by occurring incrustration and to determine the time of stent occlusion.
The model is designed to pump bile (porcine or human) from a heated reservoir to higher situated reservoir. The fluid flowes through several connected stents by the force of gravity. A constant hydrostatic head ensures a pressure close to the physical one. For each stent the volume flow is measured separatly and contactless by a drop counter. The flow rate can be regulated by a steplessly adjustable tube clamp.
Aim of the bile flow model is to be more authentic and therefore to enable reliable prognosis concerning patency periods of new stents. In-vitro findings made with this model claim to be easier transferred in later in-vivo testing results.

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Optimisation and validation of an FEA model for the simulation of the electrical flow through fish heads

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The aim of the study was to validate and improve a computer model to simulate electrical current through a fish head using the finite element analysis (FEA). The specific conductivities for the tissues and organs used in the model were taken from the literature. Since these are data for human tissue, there are presumably significant deviations to the actual conductivities of the fish. Two fresh fish heads from a slaughter were used to validate the model. Under X-ray control a tip of a cannula was placed centrally in the brain of the fish head. The cannula was isolated except for the tip (2 mm). The second electrode (surface electrode) was a screw (radius 1.5 mm), which was placed at different locations on the surface of the head. The applied AC voltage had a value of 11.45 V. The currents between the electrodes were measured. The FEA model was extended by the additional electrodes. The original ambient material (water) was replaced by air. The current between the brain electrode and the respective surface electrode was determined by integrating the current density over the brain surface. The comparison between the experimental and the calculated current densities showed large deviations when the surface electrodes had skin contact. Therefore, the conductivity of the skin was varied. In order to determine the optimum conductivity, the measured and calculated currents were set in relation to the current intensity, which was determined between the eye electrode and the brain electrode, since no currents flowed through the skin. The optimum conductivity of the fish skin was assumed if the ratios of the experimental sites corresponded to the theoretical current ratios as well as possible. When the optimized conductivity was used, all the calculated and experimental current ratios were in good agreement.

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Influence of total tumour volume on BED values – simulation study using a PBPK model for ^{177}Lu-labelled PSMA ligands

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Advanced prostate carcinoma can be treated using prostate specific membrane antigen (PSMA) labelled with ^{177}Lu. The amount of injected peptide influences the biologically effective doses (BEDs). The influence of the unknown total tumour volume on the BED values of the tumour lesion and the relevant organs was not yet investigated. Therefore, the aim of this study was to investigate the influence of tumour volume on the BED values of the accumulating organs, i.e. two tumour lesions, the rest tumour, the salivary glands and the kidneys.
Eight patients with metastasized prostate cancer received an average activity of (7.2±0.34) GBq ^{177}Lu-labeled PSMA-specific peptides of (87.7±4.1) nmol. A physiologically-based pharmacokinetic (PBPK) model was used to simulate the biokinetics and resulting BEDs of each patient for an assumed total tumour volume between (0.1-10) l, the BED values of the rest tumour, 2 tumour lesions and organs at risk were calculated.
The average BED values of these patients for lesions, kidneys and salivary glands were (22.7±13.1) Gy, (5.7±2.2) $Gy_{2.5}$ and (13.9±5.2) $Gy_{7.5}$, respectively. Relative to tumour volumes of 0.1 l, for tumour volumes of 0.3, 1, 3 and 10 l, the lesion BED values decrease to (95±3)%, (83±10)%, (63±17)% and (36±18)%, respectively. For kidneys the decrease is (95±4)%, (83±11)%, (62±18)% and (36±17)%, and for salivary glands it is (95±3)%, (83±11)%, (62±17)% and (35±17)%.
BED values of the tumour and other relevant organs depend on the tumour volume in all patients differently. Therefore, for individualized optimization it is important to find an accurate calculation method for the total tumour volume to determine correctly the optimal amount of peptide and activity for each patient.

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Development of an algorithm for selecting the optimal radiopharmaceutical to molecular radiotherapy

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Peptide Receptor Radionuclide Therapy (PRRT) is increasingly used for treating neuroendocrine tumors (NETs). Kidneys and red marrow are usually the limiting organ at risk for PRRT. Kletting et al. recently developed an approach for obtaining an improved therapeutic result based on the estimation of the optimal combination of amount and activity for PRRT. In this work we aim at developing an approach to predict the optimum biodistribution based on the optimal combination of the type of radionuclide and peptide affinity. Therefore, a PBPK model for ^{111}In-DOTATATE developed in Matlab Simulink (R2017a) by Kletting et al. was adopted. Individual physiological parameters were taken from an average of 5 patients with NET. The parameters representing radionuclide half-life (decay constant) and peptide affinity (dissociation constant K_D) were varied with a fixed dissociation rate k_{off} value of $0.04s^{-1}$. A starting minimum half-life of 1h was used and incremented by powers of two upto 128h and adding 64.1h (^{90}Y), 161.5h (^{177}Lu) and 194.3h (^{131}I). The K_D starting from 0.1 nmol/l was incremented by powers of two upto 102.4 nmol/l. The peptide amount was fixed to 4 nmol with an infusion duration of 60 min. The therapeutic index (TI) was calculated as the ratio of the time integrated activity coefficients (TIACs) in the tumor to the TIACs in the organs at risk (OAR), i.e. kidney, red marrow, liver and spleen.
For kidney, liver and spleen, the optimal TI was obtained for a combination of a radionuclide with a short half-life (1-4 h) and a peptide with a large K_D value (102.4 nmol/l). However, for red marrow the optimal TI value was obtained for a combination of a long half-life (194.3 h) and a low K_D value (0.1 nmol/l). Hence, the physician has to take into account the trade-off between different OARs before making an individualized decision.

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Dynamic 7 layer model to generate synthetic signals for non-invasive fetal photoplethysmography

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Non-invasive fetal photoplethysmography is a method to capture the fetal pulse using optical absorption characteristics of pulsing arteries. A light source and photodetector are placed on the abdomen of the pregnant woman. The acquired signal carries information of the fetal heart rate and may be potentially used to compute the fetal oxygen saturation non-invasively.
The properties of the mixed fetal and maternal signal measured with this setup are widely unknown. Amplitude, kind of signal coupling and further information about the light source and photodetector need to be investigated. The starting point for further research is the dynamic 7 layer tissue model, described in this work.
The model consists of 7 slices representing several maternal and fetal tissues and arteries. In contrast to former presented tissue models, the diameter of the fetal and maternal arteries are time dependent. Light propagation is modeled using the helmholz equation interface of COMSOL Multiphysics. Reflections on tissue boundaries are taken into account by applying Robin-type boundary condition. The time varying model allows to set parameters like sampling rate, diameter of the fetal and maternal arteries and the position and number of light sources and photodetectors.
With the results of the simulation it is possible to analyse deterministic synthetically generated signals in time and frequency domain. These synthetic datasets will be used as a ground truth, since clinically measured signals are not available and difficult to analyse due to their highly stochastic character. The signals allow us to benchmark and optimize algorithms developed to extract the fetal and maternal pulse curve from the acquired signal mixture. Further, the simulations are a usefull tool to analyse source-detector configurations and to confirm the feasibility of non-invasive fetal photoplethysmographie and pulseoximetry.

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Comparison of different Monte-Carlo-simulation software for phantom study in fluoroscopy

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One interesting development in radiology is the use of Monte-Carlo-based simulations in comparison to real measurements. Especially in education of engineers the knowledge of advantages and disadvantages of different simulation software could be very useful for future work. So, we want to develop an experimental design for master students in Biomedical Engineering for area dosimetry and the verification with Monte-Carlo-based simulations.
Practical measurements took place in one of our X-Ray-laboratories. There is an X-Ray-tube for fluoroscopy with image intensifier. Different ionisation chambers were used for area dosimetry while fluoroscopy of a 10-cm thick water phantom with 100kV and 10x10 cm²-field. Values were taken from different positions in radiation field, especially for scattering besides and diagonally behind the phantom. Additionally, the dose values were taken in different heights, for example for estimation of eye lens dose.
In a second step the real measurements were simulated with different Monte-Carlo-based systems. There are a lot of systems on the market. We started with FLUKA from CERN. In comparison to these results we used EGSnrc from National Research Council Canada as a second system. Simulations with Penelope from Nuclear Energy Agency are still in progress.
The spectral distribution of X-Ray-tube was modelled by information from manufacturer. In all simulations, we varied the number of photons between 500.000 and 5.000.000.
Results of FLUKA and EGSnrc are quite similar. Differences to the measured dose values were observed. An actual master thesis investigates the causes for the differences and the usability of Monte-Carlo-simulation in education of master students.

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3D-Modell der Tuba Eustachii aus Fusionierung histologischer Schnitte und des CBCTs – Grundlagen funktioneller Aspekte

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Einleitung: Bis heute ist der exakte biomechanische Ventilmechanismus der Tuba Eustachii (TE) nicht hinreichend aufgedeckt. Dysfunktionen der TE stellen bis heute eine medizinisch relevante Pathogenese dar. Interventionelle Ansätze direkt an der TE werden seit langem immer wieder versucht, sind bislang aber nicht in der gewünschten Zuverlässigkeit wirksam. Eine 3D-Modellerstellung bietet u.a. die Möglichkeit, das Verständnis für regelhafte Tubenfunktion bzw. Dysfunktion zu vertiefen und ggf. neue physikalische Therapieverfahren zu simulieren.
Methoden: Das 3D-Modell wurde erstellt aus der Fusion eines CBCT eines markierten und eingebetteten Gewebeblocks einer Tuba Eustachii eines Schwarzkopfschafes sowie der anschließen angefertigten digitalisierter und segmentierter histologischer Schnitte.
Ergebnisse: Der 3D-DICOM-Datensatz des Gewebeblockes des CBCTs und die digitalisierten histologischen Schnitte konnte anhand Markern zu einem konsistentem 3D-Volumen fusioniert werden. Eine quantitative Auswertung und Relation ist nach Segmentierung der Kompartimente (Knochen, Knorpel, Muskel, Mucosa, Submukosa) möglich.
Schlußfolgerungen: Mit Etablierung dieser Methode ist einerseits eine hochaufgelöste und quantitativ exakte anatomische Topographie verfügbar. Zudem kann diese 3D-Modellbildung Grundlage für weitere funktionelle Studien sein, welche ein tieferes Verständnis der vermutlich hydraulischen Ventilfunktion geben und für die Entwicklung individualisierter Stentsysteme maßgeblich sein.

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Data-driven leaflet modeling for personalized aortic valve prostheses development

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While the aortic valve geometry is highly patient-specific, state-of-the-art prostheses are not capable of reproducing the individual geometry. Valve prostheses are only tested on their dynamical performance while the leaflet geometry is barely taken into account. One challenge is the mapping from the curved 3D shape extracted from imaging modalities to the planar 2D leaflet shape.
To address this problem, we set up a database to evaluate valve leaflet shape models. First, we acquired 3D ultrasound images of an ex-vivo porcine valve under physiologically realistic pressure. We extracted geometric key parameters describing the individual geometry from these volumetric images. In a second step, we cut out the valves leaflets, spread them on an illuminated plate and took a photograph of them. From these images, we extracted the leaflet shape using edge detection. We did this for 10 porcine aortic valves.
For all valves in the database, we modeled the leaflet shape using a state-of-the-art leaflet model based on the geometric key features and compared the result to the reference. Additionally, the database allows the derivation of a data-driven leaflet model. We estimated this model utilizing nonlinear Support Vector Regression (SVR) and evaluated it using a leave-one-out-method.
To the best of our knowledge, we created the first possibility to evaluate aortic valve leaflet shape models. The mean contour distance between the modeled leaflet shape and the reference was 2.92 mm for the state-of-the-art model and 1.46 mm for the data-driven model. These results indicate that state-of-the-art aortic valve prostheses are far from optimal with regard to the reproduction of a realistic leaflet shape and valve geometry. Utilizing machine learning, more realistic leaflet shapes can be estimated. This presents an important step towards personalized aortic valve prostheses.

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Long-term study of sound localization in cochlear implantees: measured with a modified clinical diagnostic setup using virtual sound sources (ERKI-method)

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Directional hearing is a fundamental characteristic of binaural hearing, because the perception of acoustic space is based on processing sounds with two ears. A person with normal hearing can pinpoint and discriminate different sound sources very accurately. But, how do Cochlear Implantees (CI) perform in localization tests? In clinical audiology, there is no standardized measuring method to evaluate the binaural localization ability in the free-field. So far it was impossible to determine the advantage of the CI implantation regarding localization ability.
The aim of our project was to upgrade a common diagnostic setup for audiology in Germany. Our ERKI-setup consists of the “Mainzer Kindertisch” with five loudspeakers in a semicircular position (angular resolution = 45° between speakers). To archive a higher angular resolution in the horizontal plane the setup was modified. In our study we generated virtual sound sources by loud speaker level differences (LSLD) between two adjacent loudspeakers obtaining 37 discriminable reference angles (five real and 32 virtual sound sources) in 5°-steps in a total frontal range of ±90°. The responses were recorded by a control dial and a LED-light strip to give visual feedback. We used different stimuli with a length of 300ms. This developed ERKI-method is an automated diagnostic tool for measuring sound localization in the free-field.
We measured localization patterns in three different groups: SSD, bimodal and bilateral CI implantees. The results revealed that it is possible to measure the directional hearing by using a mixture of real and virtual sound sources. Our modified setup can help to track the development of directional hearing in CI implatees. However, the improvement of localization ability over a period of several months is different for each patient. The localization patterns show a broad variety of different localization accuracy.

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Online particle measurements during the simulated use of drug coated balloons

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The evaluation of particulate matter of vascular implants, especially of drug coated balloons (DCB), is required by international standards (ISO, ASTM) as well as FDA guidance documents. Particles released during acute application of such devices may bear the risk to occlude small vessels causing micro embolization. The aim of this study was to investigate the number of particles during a simulated use procedure of DCB via online particle measurements.
Test samples were commercial PTCA-catheters (3.0x22 mm, n = 10) coated by homogenous pipetting 100 µl of a coating suspension (Paclitaxel-substitute fluorescein diacetate and ionic liquid cetylpyridinium salicylate 50/50 % (w/w) on the folded balloon surface. The simulated use procedure was conducted within a specifically developed flow loop, containing a guiding catheter, a tortuous path according to ASTM F 2394-07(2013) and an online particle counter (CHEMTRAC LaserTrac PC3400). Additionally, particle solutions were collected for further measurements (after 5 and 120 minutes) with an offline particle counter (Hach Lange HIAC ROYCO 9703).
Validation of both particle counting systems with particle count standards (Thermo Fischer CountCal) showed very equivalent results. Measured particle release from DCB was highest during the online measurements (56700 ± 28300, particles ≥ 10 µm) and reduced by 43 % after 5 min or 59 % after 120 min, respectively. Time dependent decrease was even higher when separately considering particles ≥ 25 µm and ≥ 50 µm (76 % after 5 min and 85 % after 120 min).
It is assumed that the massive particle reduction was caused by the dissolution of the water-soluble ionic liquid. The measurements show that online particle measurement is necessary to obtain information about the acute generated particulate matter, although it remains unclear, if water soluble particles have a negative effect on the human body regarding vessel occlusion or embolization.

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Development of a measuring system to prevent extravasations

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During intensive care highly effective medications are delivered into the venous system. Thereby the infusion fluid may be not administered correctly into the vein. If the vein catheter is located outside the vessel and the infusion fluid is delivered into the tissue, the growing fluid accumulation is named extravasation. Extravasations occur as a result of lack punctures or catheter dislocations due to patient movements.
Extravasations can be found in up to 6% of all infusion therapies. Owing to special vein properties and uncontrolled movements, preterm infants suffer from extravasations in up to 78% of all treatments. As a result of extravasations nervous dysfunctions, necrosis or sepsis can arise. Thereby extravasations of chemotherapeutics and liquids for parenteral nutrition are most critical.
Technical detection of the beginning extravasation is currently not available. Therefore, the research project reaches to develop a tool capable of detecting the beginning extravasation and protecting the patient.
In this context, a measuring system in dependence on the impulse-oscillometry is developed and tested. To identify the beginning extravasation, a pressure pulse is applied to the infusion line liquid column and the resulting pressure and flow trends are recorded at the vein catheter. Using the impulse response, the mechanical properties of the vein and the tissue are calculated respectively to differentiate the correct and the extravasational position of the vein catheter. The developed measuring system was tested in software simulations (LTspice) and authentic pig tissue.
Both, simulations and tests in real tissue, showed differences in the impulse response for correct and extravasational placement of the vein catheter. These differences increase with rising infusion fluid flow and can be measured instantly after applying the catheter. Thereby the beginning of extravasations can be detected and their development inhibited.

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Adaption of ankle joint prostheses from CT data and determination of data on ankle joint strength

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The ankle joint endoprosthesis has reached a standard of development, which allows calling it a routine treatment option of ankle joint arthrosis. However, there are still shortcomings with ensuring a long-lasting fixation of the prosthesis as well as with adaption to the individually different dimensions of the tibia. Therefore, investigations for the adaption of the ankle prostheses were carried out with a higher number of 500 patients. CT data were used which are usually obtained for medical report and surgery planning.
A method is presented that allows the adaption of ankle joint prostheses from CT data. The transversal sections were manually digitized and classified using geometrical parameters. The classification allows the dimensioning of the tibia component of ankle joint prostheses and a simplified estimation of the fixation of the prosthesis according to the linear beam theory.
Results of the dimensions of the tibia plateau and the derived magnitudes like principal area moment of inertia and the direction of the principal axes of inertia are presented for the patients and conclusions on the optimal design for a tibia component are derived.

P 309

Gait biomechanics of patients with forefoot amputation using a customized carbon fiber prosthesis

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Forefoot amputation are mainly caused by diabetes and cardiovascular diseases, while only a minority is linked to traumatic events. In 2013, the German federal bureau of statistics registered 46 cases of trauma caused amputation affecting the foot or ankle. Therefore, prosthesis manufacturers are less interested in the development of an adequate device supporting physiological gait. Existing prosthesis and orthosis do mainly cover cosmetic aspects, but do not take the foot's biomechanics into proper account. This reduces the patient's quality of life and does, in most cases, not allow sportive activities at all. Due to the lack of economical interest, the level of scientific knowledge in gait biomechanics of forefoot amputees is moderate.
The Ulm University of Applied Sciences developed in cooperation with Häussler (medical supply store) a novel highly dynamic patient customized forefoot prosthesis made of carbon fiber composite. The device restores the lost forefoot lever arm and enhances sportive activities such as walking, running and biking. Initially, the status and desired activity of five patients with forefoot amputation (Lisfranc and Chopart) treated with silicone prosthesis (standard treatment) was identified by an anamneses protocol. After patients were supported with a customized forefoot prosthesis, biomechanical gait parameters (kinetic and kinematic) were collected using 3D motion capturing (SIMI Reality Motion System) in combination with an instrumented treadmill (zebris medical). Initial tests with the novel device showed significantly improved specific gait parameters. Overall, all patients were walking at a higher velocity. The shift of the center of pressure (CoP) was reduced towards the body's core. The data on angle balance in the knee and ankle as well as plantar pressure distribution indicate an enhancement in direction of standard values.

P 310

Requirement specifications for the development of a minimal-invasive venous valve prosthesis based on electrospun cusp structures.

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Introduction: Chronic venous insufficiency defines the manifestation of venous diseases resulting from persistent venous hypertension as consequence of muscle pump failure and valvular incompetence leading to various pathologies. Goal of this study is to identify requirement specifications for the development of a minimal-invasive venous valve prothesis to compensate insufficient valves for venous pressure reduction as a permanent device-based alternative to conservative treatments.
Methods: In cooperation with clinical experts and by analyzing existing literature, physiological and technical requirements are specified. For characterization of native venous structures, post-mortem macro-/microscopic analysis of donor material was performed using different microscopical techniques (e.g. immunohistochemistry; REM/TEM; xray micro computed tomography) and sonographical detection of inner vein diameter in standing (Valsalva maneuver) and supine position. Uniaxial tensile testing and hydrostatic compliance testing by laser scanning are used for mechanical characterization.
Results: The Vena femoralis communis below the inguinal ligament was identified as relevant/potential (anatomical) site for implant application. For restoring insufficient valve funtion in this deep vein segment, clinical experts confirm an expected reduction of venous disease symptoms due to pressure reduction. Post-mortem mapping showed unsymmetrical valve deviation in corresponding veins (left/right) and that the segment has up to two valves (mostly biscupid). The mean inner diameter post mortem is 11.6±2.3mm. Sonography shows a diameter increase by 20% performing Valsalva maneuver while standing compared to supine position. Uniaxial tensile testing revealed anisotropic mechanical behavior of venous wall. For cusps higher breaking strain and tensile strength were measured (36%, 3.9MPa) compared to the wall (longitudinally: 19%, 0.7MPa; circumferencially: 15%, 1.9MPa).
Conclusion: The elaborated specifications will be used for structural design and dimensioning of a venous valve prosthesis, and to identify potential electrospinnable materials meeting the mechanical properties of venous tissue structures.
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Cardiac support systems with embedded ultrasonic flow measurement

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Medical devices for liquid based therapeutic applications typically require adequate flow control and management to fulfil risk and safety related requirements. Cardiac support systems with an impeller pump often calculate liquid flow indirectly, based on the hydraulic load resulting in a force on the impeller which can be measured electrically. Yet, such an indirect flow measurement does not satisfy all needs regarding patient safety and pump management and additionally requires a running pump. Therefore, independent non-invasive flow measurement, such as the ultrasonic based transit-time flow measurement technique is highly advantageous since it doesn't affect the flow path of the hemodynamically optimized systems.
This flow measurement technology was already successfully integrated about 15 years ago at em-tec in the centrifugal "RotaFlow" (Maquet, Getinge Group) pump which also presents a high challenge with respect to the complex flow pro-file due to strong flow disturbances and pulsatile flow. The technology ever since proved a high level of reliability and therefore is considered state-of-the-art.
Based on the previous experience, the design of the pump of the cardiac support system is analysed in detail to identify the optimal flow sensor position for a reliable flow measurement, especially taking into account material, electrical, hemodynamic and ultrasound aspects.
Additionally, general regulatory conditions for medical device development and relevant technical standards for circulatory support devices have to be considered in the early design phase to ensure compliance with approval re-quirements.
Technical signal processing solutions face on challenges with respect to specific hydrodynamic and electrical distortions in ultrasonic signals, which is a well-known limitation in many available cardiac assist device systems. Therefore, a special signal correlation analysis of the entire signal with a high sample rate is used to measure flow even under these compromised conditions. In-vivo trials have demonstrated long-term reliability of the flow measurement in implanted systems.

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Conduct a study on the research and exemplary development of context-sensitive support systems for dementia patients with subsequent evaluation

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Situation: Although the field of assistance system research has made great progress in the last few years, there is almost no medical technology solution for intelligent support of dementia patients available. The aim of the study was to develop and evaluate an infotainment system (video/audio) for dementia patients.
Method: On the basis of patient observations and family surveys, requirements for user-centered product development for dementia patients were collected. Based on the findings of the requirements analysis, an exemplary infotainment system was realized. In the next step, the developed system was implemented in the living environment of dementia patients and evaluated for ergonomics and improved quality of life (clinical benefit). The evaluation was carried out in a combination of usability studies and physiological measurements. It was investigated whether the infotainment system has a positive effect on the well-being of dementia patients.
Results: By analyzing the requirements and system implementing in the living environment of the patients, important insights and experiences for the development of assistance systems and further research activities are gained. A further gain in knowledge results from the analysis of the transferability of the methods is used for requirement analysis and for usability engineering for the target group of dementia patients.
Discussion / Conclusion: There is still a high need for research to analyze the user requirements for dementia patients, the design and development of appropriate assistance systems, and the evaluation of these systems taking into account the user group.

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Development of short-pulsed, high-field electromagnets for laser-based proton therapy

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The new particle acceleration by high intensity laser promises more compact and economic accelerators for cancer treatment. However, the resulting particle beam is pulsed with an ultra-short pulse-duration (~ ps) and has a large divergence and broad energy spectrum. Within the German joint research project “onCOOPtics” the clinical applicability of laser-driven proton beams is investigated including the development of a laser accelerator and suitable beam transport.
The designed magnets are intended for a compact beam transport system (gantry) which efficiently transports proton pulses (≤ 220 MeV) from generation to treatment site. For this purpose the initially divergent proton beam is captured by a cylindrical electromagnet (solenoid), deflected by 45° dipole magnets and focussed by quadrupole magnets, while the energy window is selected by adjustable lead apertures. The implementation as short-pulsed (~ 1 ms) electromagnets allows to generate very high magnetic field strengths (up to 20 T) for short times, which enables the compact construction of both individual magnets and the whole gantry system. The pulse frequency of the magnets can be synchronized with that of the laser accelerator. The high field strengths demand high peak currents (up to 20 kA) and the resultant heating is dissipated by a cooling integrated into the magnets.
The in-house developed pulsed magnets will enable a proton gantry 2-3 times smaller than those used in current clinical installations. Pulsed solenoids have been completely engineered and tested, and are routinely applied at laser particle accelerators. Two prototypes of a pulsed dipole and a first pulsed quadrupole were designed and manufactured, and their experimental characterization at the University Proton Therapy Dresden is in progress.
Pulsed electromagnets are crucial components of a compact gantry and after their extensive individual testing they will be combined step-by-step and used at the laser proton accelerator.
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P 314

A daily on-line plan delivery-QA of every fluence modulated treatment using the log files analysis software LINACWATCH (Qualiformed): defined tolerance limits and first results

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In Goettingen, the verification of fluence modulated plans is based on one pre-treatment measurement using the Matrix by IBA. During the following fractions, no further control takes place.
With LINACWATCH, the Log files analysis happens immediately after each fraction, giving the user more information about the daily performance of the LINAC.
The software is able to evaluate i.e. jaw-, carriage- and leaf positions as well as gantry and collimator rotation angles of every arc/field. These data are used to generate an integrated fluence map which can be compared to the planned fluence from the TPS, resulting in a gamma value.
The defined maximal tolerance limits for the jaws are ±2mm, ±1mm for the carriages and 0.5° for gantry and collimator rotation. These limits are set according to the initial acceptance procedures. The leaf tolerance is ±3mm and the gamma passing range, for comparison of the planned and integrated fluence with a 2mm/2% criterion, is 96%. The latter limits are set according to current experience with the program.
Up to now, we analyzed 300 VMAT-arcs, equally divided into the entities cerebrum, breast with lymph nodes and rectum.
98 out of 100 cerebrum arcs passed the specified limits. The gamma value was 99.4% on average. 87 out of 100 breasts with lymph nodes treatment arcs passed the given criteria. The reasons for the failed evaluations were leaf position errors, which amount to more than 3mm. Despite that, the gamma value was 99.3% on average. 98 rectum arcs passed with a 99.4% gamma value on average. Two arcs failed also due to leave position errors.
It seems that the constraint of 3mm for the MLC positions is often not enough for complex and highly modulated plans. Nevertheless, the remaining results showed that the defined tolerance limits can be maintained by the LINAC.

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Dose tracking and adaptive replanning at the example of prostate carcinomas treatment using RayStation

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In age of the image-guided radiation therapy (IGRT) it is essential to get an exact positioning of the patient and in order that an ideally exact location of planning target volume (PTV) and organs at risk (OAR). This is the only way to reach a conformal dose application of the PTV at the best care of OAR. Interfractional differences in bladder- and rectum-volume leads to dose deviations at PTV and OAR. The treatment planning system Ray Station (RaySearch) allows the operator to do dose tracking of all the fractions and -if wanted- adaptive replanning on fraction CT based on deformed dose. Three patients with prostate carcinomas, treated at German Cancer Research Center, were chosen for this analysis. Each of them got a photon treatment plan (6MV) using Ray Station with the prescription 76,5 Gy median on PTV in 34 fractions. Before each fraction a daily control-CT via in-room-CT was done. Based on the daily control-CT the PTV and all OAR were recontoured for every fraction. After elastic registration with planning CT, it was possible to do dose tracking and compare the accumulated dose distribution to the planned dose distribution using dose-volume-histograms and gamma-analyses. The dose deviations of the applied dose D_{50} for the PTV was 0,43 ± 0,14 Gy, the D_2 1,29 ± 0,3 Gy and the D_{98} 10,33 ±7,5 Gy less than prescribed. The accumulated median dose difference was -6,47 ± 3,94 Gy for the bladder, however it was 0,58 ± 0,4 Gy for the rectum. The passing rate for gamma-analyses with tolerance level 3 mm/ 3 % was 97,8 ± 0,65 %. After considering dose tracking some adaptive replannings were done. These effected lower dose differences of the applied median dose compared to the planned median dose of the PTV and OAR.

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Investigation of dosimetric deviations in MammoSite treatment using Monte Carlo simulations

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The surgical removal of breast cancer is often followed by postoperative irradiation with a radioactive source (brachytherapy). When performing the MammoSite treatment, a spherical silicone balloon is inserted and filled with contrast agent. In a period of about five days in several sessions, a 192-iridium source with a high activity travels through the catheter into the balloon (afterloading) to irradiate the remaining tumour cells in the cavity. Prior to each irradiation, treatment plans based on CT images are calculated. In most radiation clinics the resulting dose distributions are still based on algorithms which ignore density inhomogeneities.
In this study the occurring dose deviations as a result of the contrast medium, air pockets and the correction of the surrounding medium are investigated using monte carlo simulations. In publications that have already been published the causes were investigated separately although they actually influence each other. For example in case of air inclusions localized near the surface, dose corrections by reduced backscattering are neglected. Therefore a revision of those simulations is necessary. The dose deviations correlate with both the size of the balloon and the air inclusion as well as with the balloon-skin distance. To cover a large patient spectrum, 60 various monte carlo simulations are generated and evaluated.
Because of ignoring the density inhomogeneities, the real dose differs from the calculated dose. The deviation behind the air pockets is up to 15%. It increases with greater air pockets and is independent of the balloon-skin distance. The same dependency is shown with deviations of up to 10% when comparing the skin doses. The deviations are smaller because the influence of the wrong surrounding medium and the resulting increased backscattering has a greater impact. Due to linear dependencies, the deviations can be presented as functions of the balloon- and the air pocket radius.

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Optimization of the quality assurance of a low-energy radiosurgery treatment for age-related macular degeneration

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Age-related macular degeneration (AMD) causes damage to the macula, which is needed for sharp central vision. The common clinical treatment is a therapy with periodic chemical injections. However the number of injections can be reduced through an additional radiation therapy. There is a special device from Oraya Therapeutics Inc., which uses three robotically positioned 100 kVp collimated photon beams to deliver an absorbed dose of up to 24 Gy to the macula. The aim of this contribution is to improve the quality assurance of this device based on an existing prototype of a solid state eye phantom made from polystyrene and built at the radiotherapy centre at the University Hospital Essen. Monte-Carlo simulations were used to study the influence of parameters like the phantom size and material. These investigations are resulting in a new-built phantom with additional opportunities for dose measurement verifications.
Next to a soft x-ray ionization chamber and a radiochromic film, the new phantom holds the possibility to use a self-made scintillation detector. In the end this study will be completed by measurements with the new-built phantom.

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MLC dosimetric leaf gap (DLG) and transmission (T) revisited – taking into account spatial variations of DLG and T

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Intensity modulated radiotherapy techniques require careful modelling of multi leaf collimator (MLC) parameters in the treatment planning system (TPS), e.g. dosimetric leaf gap (DLG) and transmission (T) for the Varian Eclipse TPS. Eclipse requires single representative values of DLG and T as input, neglecting their spatial variations. While the measurement methods for DLG and T are generally well established, post-hoc corrections to DLG and T are sometimes necessary to fit measured data of clinical plans to TPS calculations.
We report about our experience of re-measuring DLG and T of a 120 leaf MLC using four different detector and phantom systems (ion chamber array in water, Semiflex and Roos chambers in solid water, Farmer chamber in polymethyl methacrylate). Spatial variations of DLG and T were determined and taken into account for the input values to the TPS by averaging the locally determined values of DLG and T. Some measurements were carried out using two different numbers of control points (CP) in the MLC steering files. We also investigated the potential impact of an extensive maintenance intervention (complete dismantling and re-assembly of the MLC) on DLG and T.
Validation of DLG and T was carried out by measuring chair fields in a water tank, measurements of patient verification plans using a cylindrical phantom with two two-dimensional detector arrays, and by recalculation of patient plans using a 3D independent dose calculation system. Post-hoc corrections of DLG and T to fit measurements to TPS calculations were not necessary. We found the number of CPs in the MLC steering files to have an important impact on measured DLG, while the influence of the maintenance intervention was negligible. Comparison with the commissioning values indicates that an update of the MLC controller software might have had an influence on the dosimetric properties of the MLC.

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Minimally invasive tumor radiation with a miniaturized X-ray source and needle applicator

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Radiotherapy is applied to tumors and surrounding tissue to destroy affected cells within a designated area. Usually the therapeutic ionizing radiation is delivered by external beam radiation (EBRT) or brachytherapy. External beam radiation damages healthy tissue, while brachytherapy is sometimes difficult to apply to deeper seated tumors. Low-energy, low-weight miniaturized X-ray tubes could be used in a portable setup to deliver therapeutic radiation minimally invasive to deeper seated tumors using a suited applicator. The applicator is designed as a conical lead shield with 2mm wall thickness to minimize radiation exposure of the sources environment and fits to the shape of the radiation exit window of the source. A collimation whole with 5mm diameter at the tip of the lead cone is used to attach a hollow, cylindrical stainless steel needle with 5mm outer and 4mm inner diameter, filled with air. The needle is inserted into the patient's body and navigated to the tumor via image guidance and placed according to the treatment plan. The maximum volume of the treated tumor is approximately 250mm³ with mentioned needle dimensions. The needle diameter can be changed to adjust the treatment volume. The dose rate can also be adjusted through the acceleration voltage and beam current setting of the source (40-60kV and 50-200µA). Dose rates measured at 10cm distance in air from the source head range from 104-450mGy per minute. This translates to radiation doses of up to 13.5Gy in 30 minutes to the tumor surface. Tumors too close to critical radiation sensitive structures or greater than 8mm diameter should not be considered. Since the energy of the X-Ray radiation source is relatively low the shielding effort in the treatment room is almost negligible. Such a system could be a low-budget option for an ambulatory setup for radiotherapy and could potentially be applied intraoperatively.

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Knowledge based planning – creation and verification of a RapidPlan-model for computer based planning of dynamic IMRT for patients with rectal cancer

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The aim of this master thesis is to create, verify and validate a RapidPlan model for computer based planning of dynamic IMRT for patients with rectal cancer in an adjuvant or neoadjuvant treatment setting.
In general the RapidPlan software creates a model for specific indications using clinical acceptable plans. These models are then used during the optimization phase for intensity-modulated treatment in that way, that for the contoured structures an estimation range of the DVH is calculated and converted into optimization goals (objectives). During the optimization process the software tries to pull the current DVHs in the direction of these objectives.
For the creation of the Rectal Cancer-Model, 30 training plans were selected from the patient library of the HELIOS Universitätsklinikum Wuppertal (HUKW). After the outlier analysis of the model, it was decided to remove 2 plans from the set of 30. The presence of the two rejected plans was influencing the regression analysis of the model too strongly.
Validation experiments were carried out using the obtained model. The quality of the clinical plans was then compared with those achieved using RapidPlan DVH optimization.
With regard to the dose homogeneity in the PTV, the clinical plans outperform in average the RapidPlan optimized ones. A similar conclusion follows from the evaluation of the dose drop at the edge of the target structure (dose gradient).
However, with the RapidPlan optimization an overall better protection of the OARs is achieved. Furthermore comparing the conformity of the dose distribution by means of the Paddick Index ($CN_{Paddick}$), it can be noted that the RapidPlan optimization generates significantly more tumor-conform dose distributions (0.94 to 0.90). This high conformity potential is rather associated with a higher dose modulation.
Finally, the potential and limitation of RapidPlan optimization procedure are reported.

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Validation of an electron head model for the use of the internal accelerator MLC

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It has been shown, that the combined use of electron and photon radiation treatments can be favourable for certain therapies. For easier application of electron irradiations the use of multi-leaf collimators (MLC) has been propagated. This can be realized nowadays by the use of add-on MLCs. On the other side the use of the internal MLC of the accelerator would be much more comfortable. In a previous publication we have shown, that the combined use of IMRT and electron fields formed by the internal MLC is possible. For extended planning studies it would be useful if the normal planning system could be used for modulated electron fields formed by the internal MLC as well.
To realize this we created an electron head model for our planning system HYPERION, enabling it to calculate electron fields formed by the MLCi of our Elekta Linacs. For commissioning these electron beams measurements were made at an Elekta SL15 Accelerator. Electron beams of 5x5 cm² and 40x40cm² without applicator were measured using a MicroDiamond detector (PTW Freiburg, Germany). For every field the depth dose curve on the central axis, inplane and crossplane profiles at 28, 50 and 100 mm depth were measured.
The measured depth dose curves and profiles were then compared to the calculated curves of the planning system. The depth dose curves could be reproduced better than 2% for most points with a maximum deviation of 5%, while the relative profiles could be reproduced better than 1%.
With this electron head model we can now calculate dose distributions of electron beams formed by the linac MLC in our standard planning system. This enables us to do extensive planning studies on the advantages or disadvantages of the use of the internal linac MLC with electrons, including modulated electron beams.

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Clinical implementation of a multi layer ionization chamber detector for quality assurance in proton therapy

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Due to the widespread range of parameters in proton therapy an extensive quality assurance (QA) is required to guarantee a high precision radiotherapy. One part of the regular machine QA comprises the measurement of depth dose curves for a set of different proton parameters. To optimize the QA procedure a multi layer ionization chamber detector (Zebra, IBA Dosimetry, Schwarzenbruck, Germany) is introduced at the University Proton Therapy Dresden (UPTD). The Zebra consists of 180 stacked plane parallel ionization chambers with a diameter of the collecting electrode of 2.5 cm. The spatial resolution is 2 mm. Using a Zebra depth dose curves of extended proton fields can be measured in double scattering as well as pencil beam scanning mode. A measurement takes only a few seconds in contrast to several minutes when scanning the curve stepwise with a single plane parallel chamber in a water phantom. Together with a faster setup of the Zebra time for that part of machine QA can be reduced from several hours to less than one hour.
The implementation and calibration of a Zebra at the UPTD will be presented. Furthermore, results of the machine QA for double scattering as well as pencil beam scanning will be shown in comparison to measurements using a water phantom.

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Patient positioning accuracy in clinical practice: influence of positioning errors on the real dose distribution for prostate and head-and-neck treatment

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Introduction: In order to consider potential positioning errors there are different receipes for safety-margins for CTV-to-PTV expansion. The aim of this study is to simulate the effect of positioning inaccurancy with clinically realistic patient treatment plans.
Material and methods: For a collective of 40 prostate and head-and-neck(H&N) patients each the isocenter was shifted back appropriately to the applied table shifts after positioning verification and the treatment plans were recalculated. For every single fraction all the treatment plans with the appropriate isocenter-shifts were summed to a new plan considering two scenarios: On the one hand, the summation of only shifted plans as an extreme (in the following labelled as shifted plan) to simulate that no positioning verifications had been performed. On the other hand, the more realistic case, for all fractions with verification imaging the original treatment plan was assumed and only the fractions in which no controls had been carried out the shifted plan calculated before was added. For the two scenarios different measures of quality, the dose distribution and NTCP were analysed and compared with the original treatment plan.
Results: For both entities, DVH and dose distributions show a marked deterioration of the target-coverage caused by the positioning inaccuracy. Sparing of OAR and NTCP analysis show controverse findings for both collectives, for H&N OAR are mostly spared less with the positioning unaccuracy, whereas for the prostate case the rectum is spared slightly better. Measures of quality like homogeinity, conformity and dose-gradient for both locations differ just minimally regarding the different scenarios.
Conclusion: PTV-coverage suffers markedly by the positioning inaccuracies, the shifted plans are in large parts clinically not acceptable. Surprisingly sparing of the rectum is not negatively affected by potential positioning errors for this prostate collective, however, for H&N the shifted plans show worse sparing of OAR.

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Evaluation of deformable image registration in *syngo*.via RT image suite VB20

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Anatomical changes may occur during the course of radiation therapy. Moreover, these changes influence the dose delivery and treatment outcomes. The magnitude of the anatomical changes can be evaluated by medical imaging (e.g. daily CBCT). In cases where rigid alignment cannot correct changes, it might be necessary to take a new CT-scan (re-CT) and adapt the radiotherapy treatment. With the aid of deformable image registration it is possible to support this workflow.
Deformable image registration calculates a deformable vector field between two image date sets enables for contour and dose propagation across the registered datasets.
The goal of this work is to evaluate the deformable image registration of the new software solution *syngo*.via RT Image Suite VB20 (Siemens Healthineers).
For this pupose five patients with a thoracic irridiation have been selected which received a re-CT during the course of therapy. Contour propagation is used to determine the deformable image registration accuracy. Since errors in contour propagation result automatically in dose propagation errors, this study is the first step in evaluating this software solution.
For the purpose of this evaluation, a clinical expert contoured eight structures: lungs (left and right), heart, ramus interventricularis anterior (RIVA), spinal cord, trachea, esophagus and the gross tumor volume (GTV).
Based on these organs, several accuracy criteria are calculated: Deformed Volume Ratio (DVR), Anatomical Volume Ratio (AVR), Dice Similarity Coefficient (DSC) and Centroid Distance (CD). These criteria allow for the evaluation of the agreement of the location and displacement of the contours and hence the performance algorithm for deformable image registration.
The data analysis and interpretation will be presented on the congress.

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Quality assurance of precise, respiratory-gated radiotherapy

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Radiotherapy is an important part of treatment for bronchial carcinoma patients. The main problem is that has to be taken into account the tumor movement (up to 2.5 cm cranial-caudal). Respiration-triggered irradiation enables protection of healthy tissue, but increases irradiation time and needs additional QA. Our aim was to minimize the QA in terms of: 1. RW3 phantom measurements of the absolute dose with and without gating, 2. Measurement of dose-blurring for different gating windows, 3. Triggered acquisition of kV/MV images in defined intervals of the respiratory cycle (gating window; GW).
The Brilliance CT Big Bore Oncology (Philips, Amsterdam, Netherlands) with the Respiratory Gating for Scanners (RGSC) module (Varian Medical Systems (VMS), Palo Alto, USA) is being used for the localization of moving lesions. The breathing irradiation performs on a moving phantom using a VMS TrueBeam STx. The sinusoidal movement (amplitude = 1.5 cm) with different frequencies is realized by a lifting table. A compact 0.3 cm^3 ionization chamber (PTW, Freiburg) was used for dose measurement. The same irradiation setup (10×10 cm^2 field, 6 MV photons, 100 MU) is used with and without respiratory gating. A radiochromic film (EBT3, Ashland, Covington, USA) is placed on the lifting table with water-equivalent material and irradiated (2 Gy, 2×2 cm^2) with gating/movement and without movement/gating. EBT3 is also providing spatial information about the blurring of the field resulting from the simulated breathing movement. The dose is evaluated considering multichannel analysis. Linac imagers are used for the localization of a marker on the lifting table giving information on the GW.
Comparison of the absolute doses with and without gating showed small deviations and was independent of the GW length. The deviation was less than 1‰ of the value without gating. Film evaluation showed that y-profile for D_{20} of the irradiation during the half GW was 3.53 mm longer than with no movement, while the length of the D_{80} was 2.82 mm shorter. Evaluation of the MV images (series of four images) showed that the maximal deviation of the marker position was smaller than 0.08 mm in the direction of movement and 0.03 mm in the perpendicular direction. For the kV images (series of five images) the maximal deviation was smaller than 0.07 mm in y and 0.03 mm in x.
The results show that the investigated system can be used for high precision gated irradiations. Furthermore kV/MV imaging ensures the detection of possible deviations accurately. Physiological breathing and VMAT techniques need further investigations.

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Deep inspiration breath-hold (DIBH) versus free breathing (FB) in treatment of breast cancer – evaluation of 20 patients

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In 2015 we installed an optical surface scanner (Catalyst, C-RAD) at our linear accelerators (2100CD, Varian). The system supports the initial positioning of the patient and allows monitoring respiration. Since 09/2015 we are using the scanner in combination with goggles as patient-feedback to irradiated patients with breast cancer in the DIBH technique.
We evaluated the benefit of DIBH at 20 patients using 2 planning-CT studies per patient (free breathing (FB) and DIBH). 19 patients were irradiated with a left mamma carcinoma, 6 of them received additional radiation of internal mammary lymph nodes. One patient received the DIBH technique with right-sided breast cancer to further reduce lung exposure.
Due to the increased lung volume (Mean +1024.4 cm³) the lung volume exposed with more than 25Gy (V_{25Gy}) was reduced from 27.4% to 18.6% (ΔV_{25Gy}= 8.8%) and the mean dose from 14.3Gy to 10.4Gy (ΔD_{mean}=3.9Gy) over all patients. Especially patients with lymph nodes benefit from DIBH (ΔV_{25Gy}= 11.1%; ΔD_{mean}= 4.7Gy).
The heart exposure decreased for all patients: both the mean dose and the exposed heart volume with more than 20Gy or 40Gy could be reduced (ΔD_{mean}= 2.9Gy; ΔV_{20Gy}= 5.5%; ΔV_{40Gy}= 3.1%). For all patients the maximum dose to the heart could be reduced drastically (ΔD_{max}=10.5Gy). Considering the location of the radiation sensitive arteries in this area, this point is very important for long term heart mortality. But our study also showed women who did not benefit from DIBH regarding the heart exposure, due to sufficient distance between heart and breast already in FB.
Because all patients received a better lung protection we use DIBH for all patients younger 60 years with left side breast cancer and/or internal lymph nodes irradiation. The system itself is convenient in use and works reliable with small additional time effort (<3min).

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Positioning of catheters in HIPO inverse planning with centroidal voronoi tessellation for HDR-brachytherapy of prostate cancer

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Purpose: The HIPO algorithm used in ultrasound-based prostate cancer treatment planning with Oncentra Prostate (Elekta-Nucletron) calculates the appropriate positioning of catheters. HIPO utilizes time-consuming variations of positions to determine an optimized plan. A more efficient approach is required to accelerate plan generation and improve quality.
Methods: In this study we use Centroidal Voronoi Tessellation (CVT) to position catheters. We introduce the restricted CVT (RCVT) to flatten 3D anatomies into 2D areas with the exception of areas where catheter positioning is infeasible for clinical/anatomical reasons. RCVT generates catheter positions that are matched to a given grid (template) with least-squares fitting. HIPO can use either internally generated positions or RCVT results for initialization. Both of these methods are compared for ten clinical cases covering a broad range of prostate volumes under variation of execution parameters. The clinically used number of catheters has been considered. Runtime and plan quality are evaluated based on dose-volume indices for both prostate as the planning target volume (PTV) and organs at risk (OARs).
Results: Combining HIPO with RCVT increased plan quality and reduced runtime. The objective function, an intrinsic parameter, improved in seven of ten cases. Paired, non-parametric statistical tests showed no downgrade of dosimetric indices in planning target volume and OARs whereby the PTV D_{98} significantly improved (p=0,0059). The dosimetric constraints were met after fewer iterations, reducing the average runtime by 50%. Despite inaccuracies imposed by the template resolution, in five of the ten cases the positions calculated by RCVT required no further adjustment, here HIPO only optimized dwell times. This indicates the strength of the RCVT in catheter positioning.
Conclusion: Combining HIPO with RCVT generates plans of enhanced quality for clinical use in shorter time. RCVT reduces iterations of HIPO. This approach opens perspective for better treatment planning also outside the prostate.

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Daily procedures of radiation protection in proton therapy

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There are only a few particle therapy facilities running in long-term routine in Europe. Thus here knowledge and experience with respect to procedures in radiation protection in particle therapy may be not spread widely. We want to share our experience in some important aspects of routine radiation protection in a proton facility.
Contrary to photon radiation therapy particle therapy faces the issue of lightly activated waste management. Especially when utilizing passive scattering field formation waste of activated brass and PMMA is produced regularly. Other materials such as plastics from patient immobilization and water in the accelerator cooling circuit are activated in each particle therapy. We present activation data and how these materials are handled in Dresden.
Moreover we show that the dose the staff is exposed with during work is below the detection threshold of our albedo dosimeters.
Additionally a case is presented which might be of general interest for particle therapy facilities: we show estimates of the uterine dose of a pregnant patient whose head was irradiated with passive scattering.

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Changes in quality of treatment-plans due to less irradiation directions for VMAT-plans

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Calypso by Varian (Palo Alto, USA) provides a direct localization and online tracking of extracranial tumours during treatment by implantation of electromagnetic transponders into the tumour. For recording of correct values by the system, the usage of the kVue couch by Qfix (Avondale, USA) is necessary. Because of obstructed movable rails, some irradiation directions are not usable for treatment without radiating through these rails. Within this study an evaluation of the differences in plan-quality of such plans was made in relation to plans without limitations. For each of 24 patients, showing different types of tumours, five plans were calculated with the treatment-planning-system Eclipse by Varian. Two plans were optimized by the "Photon Optimizer" (Version 13.6.23, Varian) with clinically used optimization-constraints. The structure-set for the first plan contained a model of the Varian IGRT couch and was optimized without limitations in relation to irradiation directions. For the second plan, the optimization was made on base of a structure-set using a model of the kVue Qfix couch and with the forenamed limitations. Furthermore, the dose of three additional plans was calculated, based on the kVue plans but with misalignments of either one rail or the patient. For comparison of the plan-quality, Conformity Number (CN), Healthy Tissues Conformity Index (HTCI), Coverage Index (CI) and Homogeneity Index (HI) where calculated for the 95%-isodose. For the directly optimized plans the Volume of the 80%- and 60%-isodose were analysed in addition. Looking at CN, HTCI, CI and HI the quality of the plans with limitations is clinically acceptable, but slightly below the quality of the plans without limitations. Also clinical acceptable are the plans with misalignments. The mean volumes of the 80%- and 60%-isodose of the plans with limitations are a little bit larger than the volumes of the plans without limitations.

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Evaluation of the accuracy of a surface monitoring system for radiotherapy

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The Optical Surface Monitoring System (OSMS) from Varian (Palo Alto, USA) is able to record a three-dimensional representation of a patient's surface. Hence, after the initial alignment of the patient, its movements can be monitored during the entire treatment. The given accuracy of this system is below 1 mm for translational and below 1° for rotational movements. This accuracy would allow treatments of head tumours without a mask-system, e.g. whole Brain irradiation. In order to evaluate the technical feasibility of such a system, an analysis of the OSMS detected values, translational and rotational, was performed using an Alderson-head-phantom. The phantom was fixed with tape on a head-supporting-device. The tape was placed on the "forehead" of the phantom and stuck to both sides of the couch. After the initial alignment of the phantom, a reference surface of the phantom and its position was recorded by OSMS. For this reference the values of pitch, roll and rotation of the couch were zero. Then, rotational movements have been performed in steps of 0.1° to a total range of 3° separately for each rotational degree of freedom. After every step, the new values shown by OSMS have been recorded. Additionally, combined rotational movements and combined rotational and translational movements have been performed and recorded to evaluate the stability of the values detected by OSMS for larger displacements. The measurements confirm that OSMS is capable to detect submillimetre translational and rotational movements below 0.5°. This leads to the technical possibility to treat the whole brain of a patient without a mask-system for immobilization. Essential for the system is an option to hold the beam, if OSMS detects a movement of the patient beyond the given thresholds. Before patients can be treated with this technique, additional studies with volunteers need to be done.

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Heart dose evaluation in left sided breast cancer treatment planning

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The heart represents an organ with a high risk of damage from radiotherapy treatment of left sided breast cancer. Multiple dose parameters describing the risk to the heart can be found in the literature (e.g. maximum or mean dose, dose in the coronary arteries or the cardiac apex). A simple method to compare the dose to the heart for new plans to the dose of formerly accepted and applied plans is presented in this work. To this end, the mean and maximum dose values of the heart of 49 patients, treated with tangential beam directions, were retrospectively analyzed. These values where normalised to their corresponding prescription dose and normalized mean ($D_{mean,norm}$) and maximum ($D_{max,norm}$) values for every treatment plan were created. Assuming that high values in mean and maximum dose indicate a higher risk for damage to the heart, threshold values were defined for both. The upper quartile was chosen as our threshold to identify the highest values. These were approximately ~90% for $D_{max,norm}$ and ~5% for $D_{mean,norm}$ covering 75% of all data. A script in our treatment planning system Pinnacle³ was implemented, allowing for $D_{mean,norm}$ and $D_{max,norm}$ evaluation of a current plan and feedback to the planner whether our goals ($D_{mean,norm}$ <5% and $D_{max,norm}$ <90%) are met with the current state of the plan. Only 4 patients out of 35 that were analysed using this script during planning did break both thresholds. This may be caused due to an anatomically proximate position of the heart in relation to the target volume or the dose coverage of the target volume that was of higher priority than the protection of the heart. In conclusion, by establishing achievable heart dose limits, the quality of our plans could be improved.

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Cone beam CT – evaluation of long term stability in dose and image quality

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The purpose of the study was the evaluation of the long term stability in image quality and dose of On-Board Cone Beam CT systems.
Three Elekta linear accelerators (linac) of type Synergy with On-Board CBCT (XVI) are available at Regensburg University Medical Center. The phantom Catphan is used for examination of uniformity, low contrast, high resolutionand geometrical parameters. Dose is measured with a CT chamber in the center of a cylindrical phantom. For evaluation of the stability of the indicated parameters, two XVI studies with two different clinical presets were investigated on each linac over a time range of 2 years (linac 1 and linac 2) and 4 years (linac 3) depending on the installation date of the linacs. One preset (head and neck) used 100 kV and a clockwise gantry rotation of 255° -100°, the other (prostate) 120 kV and a full rotation counter-clockwise. The results of image quality are evaluated according to the acceptance test procedure defined by Elekta.
In comparison all three linacs show a similar behavior. Average values ± standard deviation for image uniformity are 6.8%±4.3% / 6.7%±1.8% / 6.2%±2.3% and for low contrast9.4±14.3 / 5.9±3.6 / 6.2±33.7 respectively. Maximum deviation in distance, measured over all directions, linear accelerators and time was 1.3 mm. The minimum detectable gap size ranged from 0.167cm to 0.125cm. Differences in dose in case of preset head and neck amounted to -1.8%±6.0% / 1.9%±6.4% / 0.1%±1.5% for linac 1/2/3 respectively i.e within the tolerance of 10% for all three linacs. Differences in dose for preset prostate 11,9%±6,7% / 0,5%±4,4% / -0,4%±1,1% for linac 1/2/3 maximum deviation are 18,7% over all linacs
In summary, results for dose and image quality i.e. within tolerances over time for all three Cone-Beam-CT.

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Dosimetric effects of soft tissue and bone matching approaches in image-guided radiotherapy of prostate cancer

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Introduction: Setup of image-guided radiotherapy (IGRT) in prostate cancer can be based on bone alignment or soft tissue information. Due to the fact that during treatment the prostate gland may be located at different positions relative to the bony anatomy, it is often not possible to exactly reproduce the patient setup of the planning CT. The aim of this study is to work out the dosimetric effects of dislocations of the target volume and the pelvic bone separately from each other. Whereas the former has a direct impact on the dose coverage in terms of a geometrical displacement of the tumour, the tissue density variations resulting from incorrect bone alignment in comparison to the treatment plan may result in appreciable dose deviations.
Methods and materials: The study is based on a representative planning CT of a prostate cancer treatment. The originally optimised and applied VMAT plan serves as a reference for the tested variations. Scales of the applied shifts in all spacial directions are extracted from a set of kV-Cone Beam CT (kV-CBCT) scans. Movements of the prostate are reproduced in terms of appropriately shifted PTV and GTV ROIs. Misalignments of the bony anatomy are simulated as corresponding shifts of the beam isocenter, implying a dose recalculation with use of an -in all other respects- original beam configuration. Dose coverage of the prostate is then compared for a variety of realistic spatial deviations.
Results: Current intermediate results point towards a higher impact of the spatial location of the prostate on the target dose coverage compared to the positioning of the bony anatomy. Nonetheless, the effect of the latter is still of significance. Analysis is ongoing. Final conclusions will be presented.

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Constancy tests for linacs according to DIN 6875-4 and DIN 6847-5 for intensity-modulated radiation therapy using the QUALIMAGIQ platform from QualiFormeD

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Introduction: The quality assurance of electron linear accelerators for medical use is essentially regulated by norm DIN 6847-5. For special techniques specific additional norms (eg. DIN 6875-4) apply to IMRT. The parameters to be evaluated can be roughly divided into a dosimetric and a geometric part. While a stable normative basis exists for testing the dosimetry parameters (DIN 6800-2), the comprehensive examination of the geometric parameters is extremely complex. The scope of testing is also very much dependent on the accelerator's specific equipment of. This work investigated the suitability of the Qualimagiq QA software. In particular, all necessary tests for the MLC, parameters for dynamic techniques and geometric parameters have been included in the tests.
Material and methods: The Qualimagiq QA software consists of many different modules. For each module, different phantoms are irradiated under precisely defined conditions. The results are generated by means of the EPID after the test; both kV and MV images are generated. The images are entered as DICOM images into the QA software for evaluation. The results are compared with predefined tolerances and the test is evaluated accordingly. This solution enables all of the MLC tests as proposed in the norm DIN 6875-4, testing of dynamic techniques and, in particular, verification of the coincidence between kV and MV isocenter and their correspondence to the mechanical isocenter. The tests can be separated in time into the image acquisition and data evaluation.
Results: The controls for the MLC as required in DIN6875-4, quality assurance of additional parameters for the control of dynamic techniques and mechanical tests can be carried out very well and efficiently with the solution presented. All data of the constancy tests are accessible via the software and can therefore be edited. In particular, the creation of trend curves inside the software solution is an appropriate instrument for preventive calibration or repair. The integrated test for checking the various isocentres is very well suited for assessment of this parameter, which is extremely important for IGRT. All tests can be carried out in an acceptable length of time. All phantoms and test procedures are described very well and the test procedures are highly standardized. Thus, a high error tolerance is ensured against different examiners. The automated analysis of the image data by the software ensures objective data analysis.
Summary: With the QUALIMAGIQ software, the majority of tests according to DIN 6875-4 and DIN 6847-5 can be carried out and evaluated. The results are managed in the software and can be further processed. In addition to the evaluation of individual tests, the capability to perform trend analysis should be emphasized. Tolerances can be defined for the various constancy tests, so that the evaluation is carried out automatically. However, evaluation of the tolerances is a very complex process and requires advanced user experience. Use of the QUALIMAGIQ software for QA ensures a consistent quality of the parameters to be tested. Significant time savings can be made compared to conventional methods. The procedure is very well suited for routine checks.

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Construction of a 3D printed head and neck phantom for dose evaluations in radiation therapy

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Various phantoms exist for the evaluation of imaging modalities and dose measurements in radiation therapy. The purchasing of commercial phantoms is usually associated with high costs and can rarely be adapted to individual tasks. However, due to the fast development of rapid prototyping, manufacturing phantoms at low cost and according to own requirements is possible nowadays. This results in the advantage of combining the characteristics of different phantoms flexibly into one.
A head and neck phantom was constructed as a prototype. In this part, many different aspects, such as stereotactic radiosurgery or parotid gland protection and the suitability of such a constructed phantom can be tested well. The phantom is arranged in several layers in order to place radiochromic films between these layers. In addition, this type of construction allows a quick and cost-effective adaptation of individual layers to various measurement requirements. The phantom surface as well as the bone shells were created with a 3D printer and filled with tissue-equivalent materials. Conventional plaster was used as a bone equivalent material and polyuretane casting resin as a tissue equivalent material. The simulation of air-filled, anatomical structures was carried out with the help of silicone rubber.
The completed prototype shows anatomical deviations. Due to the printing material, some areas, such as some vertebral bodies, could not be sufficiently filled with the bone equivalent material. Various layers show defects in the tissue equivalent areas, which probably arose in the curing process. The anatomical weaknesses can be avoided in any further productions.
Due to the layered design, the phantom offers a useful flexibility and a wide range of possible applications. In addition, the phantom can be used in different imaging modalities and is very suitable for dose measurements.

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A new technics to the whole body irradiation (TBI)

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Introduction: In the course of the introduction of the whole body radiotherapy (TBI) in our clinic an analysis of the existing technics was carried out first. Besides, appeared that the technics are unchanged for many years as much as possible and set aside the modern opportunities of the radiationtherapy as much as possible. The most frequent technic are the radiotherapy in the large distance in a chair with next balance radiotherapy of the over dosage and protection of the lungs as well as the radiotherapy on a translation couch with lung protection near to patient.
Material and methods: After the analysis of the different technics a radiotherapy on a fixed couch was to favored in belly and back treatment position. The couch is on the ground. For reasons of the ability for reproduction of the field connections the couch should not be moved. The couch contains an admission for a x-ray cassette to the documentation of the lung blocks and a PMMA spoiler near to patient to the controlled increase of the skin dose. The blocks are near to focus in the shadow tray and are used with every fraction. These are transmission blocks them the lung dose on the demanded dose value lower. To be able to plan this technics the clinical used radiotherapy planning system (Oncentra master plan) should be used. In preexperiments the suitability of the TPS was examined to the calculation by dose distributions in the bigger distance. Besides, a good agreement could be ascertained between measured and calculated dose distributions up to distances of about 2.5 m. The measurements were verified with the water phantom and EBT3 films. The PMMA spoiler is considered by a factor. The patient receives before the planning a whole body-CT. in belly and back situation. The position of isocenter is determined in the CT and should already improve in the CT the geometrical ability for reproduction between both patient's positions. Afterwards two plans are calculated in belly and back situation and are added in the TPS to a whole dose distribution. The fields are so arranged that a field by maximum field size covers the head and the body trunk. This field with gantry angle 0 ° also contains the transmission blocks. This allows with the setting of the patient a very exact positioning of the patient and a control of the position of the blocks. The extremities will be applied by 1-2 connection fields irradiates without movement of patient or couch. The dose divergences in the area of the field connections are correspondent with the suitable guidelines and lie in the area 5-7%.
Result: Now the described technics is for more than two years in use. The clinical results correspond to the expectations. Up to now no complicationshave appeared by lung toxicitys or problems in the connection area of the fields. To the documentation and quality assurance an x-ray imae of the thoracal region is made with the first radiotherapy and is measured in each case in the central axes with diodes the entry dose. Moreover, in the introduction phase still the dose was measured in the field connection areas and the escape dose for well-selected points. The dose measurements correlate in the area of the allowed tolerance with the TPS.
Summary: The presented technics permits a quick and safe realisation of the whole body irradiation. By the application of the planned transmission blocks the lung dose is predictable very accurately and the blocks are to be positioned very exactly. Now for further developments of the radiotherapy technology for the reduction of possible toxicitiys an other optimisation of the dose distribution would be possible in the lung.

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Path length correction for MRI compatible varian ring applicators

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As it is advised for brachytherapy applicators, we analysed our new MRI compatible ring applicators for cervix cancer patients. For each ring (26 mm x 45°, 30 mm x 45°, 26 mm x 60°, 30 mm x 60° and 30 mm x 60° Vienna) we exposed three gafchromic XRQA2 films. First with the x-ray marker wire inside the ring applicator to visualise the tip of the catheter using a simulator. After this we irradiated the film with the actual Iridium source using a plan with a 1 cm step size and 2 cm offset.
The analysis of the films was done with ImageJ by overlaying the scanned films with an image of the applicator reconstructed in Eclipse Brachytherapy Planning. With an Image manipulation program the tip of the applicator was aligned with the tip of the marker wire. The body structure was aligned with the outer contour visible on the film. For each planned and irradiated source position the angular offset was measured and the nominal path length difference calculated. The smallest mean offset was found in the 26x45 the biggest in the 30x60 ring, 3.4±0.5 mm and 4.2±0.4 mm. The minimum and maximum path length deviations across all measurements were 1.9 mm and 5.1mm respectively.
As a result, to minimize the error in treatment plans, we have to apply an additional offset of 4 mm to the ring applicator after optimization of the patient plan. For a test we irradiated one film for each ring with an additional offset of 4 mm and analysed the film according to the described procedure. The maximum deviation for the corrected applications was 0.8±0.8 mm which is within tolerance of an acceptable application.

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A new method for position-sensitive spectrometry of laser-accelerated proton bunches using the Timepix detector

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Due to continuous advances in the development of high-intensity lasers, laser-driven ion acceleration might become a compact alternative to produce ion beams with energies suitable for biomedical applications. Major differences compared to conventional accelerators are the enormous particle flux (> 10^7 protons/cm^2/ns) and a broad (up to 100% spread) energy spectrum, which needs to be characterized accurately and efficiently. We present a new method for the determination of an unknown polyenergetic proton spectrum using the hybrid pixel detector Timepix. It is based on the measurement of the energy deposition of all protons in the sensor chip along the entire Bragg curve. Unlike common face-on irradiation, the sensor chip is irradiated edge-on, i.e. the sensor surface is parallel to the beam direction. A 150µm thin slit is positioned centred prior to the sensor chip. The energy-calibrated detector is used in time-over-threshold mode. In order to characterize the detector response, we irradiated the Timepix detector in edge-on mode at our Tandem accelerator with 20MeV protons and degraded their energy using 3D-printed plastic absorbers of various thicknesses. Beam current was set low so that individual proton tracks could be identified. Based on the measured tracks and supported by FLUKA Monte Carlo simulations, we built up a system response matrix for reconstruction of unknown proton spectra. The performance of this approach was evaluated by running the reconstruction algorithm on various data sets, consisting of a known number of either monoenergetic or polyenergetic proton tracks. We found good agreement between reconstructed and true spectra, with discrepancies typically below 10%. Hence, this approach can be applied to unknown proton spectra, like for laser-accelerated protons. Measurements with proton energies up to 80MeV are planned for extending this method to energies expected in upcoming experiments at the Centre for Advanced Laser Applications (CALA).

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Nonlinear robust optimization methods for 4D treatment planning in carbon ion therapy

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We introduced robust optimization into non-linear biological optimization of GSI's TRiP4D to avoid internal IMPT dose inhomogeneities. Here we present a conformal robust 4D optimization delivering a homogeneous dose to each motion phase, which requires synchronized beam delivery.
The implemented worst case scenario method currently considers 9 different scenarios in the optimization process (nominal scenario, 2 water-equivalent path length (WEPL) changes and patient positioning errors in 6 directions). In every iteration step LEM-based RBE-weighted doses are calculated for all scenarios from the current set of beam fluences respecting fragment spectra and LET. During the conformal 4D optimization approach a treatment plan is calculated for each motion phase. All beam weights are scaled by the number of phases. Within this optimization strategy robust IMPT is compared to conventional IMPT with 5 mm isotropic margins. The resulting plans are then used for a straight forward 4D dose calculation. Robustness is tested by condsidering 4D dose distributions for different uncertainty scenarios.
Using robust IMPT in a patient case with a lung tumor in close proximity to heart, a motion amplitude > 2 cm and a target dose of 9.4 GyE, heart maximal point dose could be reduced from 10.5±0.6 GyE to 8.6±0.8 GyE averaged over all uncertainty scenarios by slightly decreasing V95 from 87.6±10.6 % to 85.8±4.8 %. The steeper falloff and smaller spread in the robust DVHs could enable space for a potentially higher target dose.
An initial patient simulation shows the feasibility and the importance for robust 4D optimization methods for moving targets in carbon ion therapy. A further extension of the algorithm for a extended 4D robust optimization where the impact of all CT phases is considered in every iteration step will follow.

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Quality assurance for a replaced IRIS collimator system on a cyberKnife M6

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The Cyberknife M6 (Accuray Inc., USA) is a high precision robotic stereotactic radiosurgery device. It delivers high dose to a specified target with a geometric precision below 1mm. To achieve the necessary accuracy the whole system has to perform with small margins in all subsystems. One subsystem is the IRIS-Collimator, a computer controlled adjustable beam collimator that delivers 12 different beam sizes from 5 to 60 mm diameter. The manufacturer specifies a reproducibility of the field size below 0.2 mm. The determination of the initial performance of a specific collimator system is part of the system commissioning measurements. In case of hardware defects the collimation system has to be replaced. Since a replaced collimation system doesn't necessarily deliver nominal beam sizes with deviations below the specified 0.2 mm regarding to the old system, even if reproducibility of collimation is below 0.2 mm, it is necessary to check the performance of a replaced collimation system and - in case of detected deviations - measure new commissioning data.
Extensive quality assurance is necessary to approve correspondence of planned dose distributions with delivered dose.
We developed methods using a small ionization chamber and a solid state detector in a water equivalent phantom as well as a liquid ion chamber array for stereotactic dose distributions to check delivered dose accuracy. Therefore a defined set of orthogonal and oblique beams using all available field sizes is planned and delivered to the phantom. Measurements of absolute dose and relative dose distributions are performed.
The proposed method allows to check a replaced collimation system in a few hours to support the decision if a whole recommissioning of the collimation system is necessary. The accuracy of a recommissioned system can be controlled using the same methods.

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Analysis and evaluation of the treatment planning system monaco (Elekta) for parasinal tumours

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Treatment planning of parasinal tumours is challenging because of high density differences due to air cavities in this region. These differences can lead to uncertainties in the dose calculation algorithms in treatment planning systems (TPS). This work compares the results of an analytical dose calculation (Pinnacle, Philips, Amsterdam) to a Monte-Carlo based approach (Monaco, Elekta, Stockholm). Although calculations using Monte–Carlo (MC) methods are more time consuming, they convince with better performance according to local tissue inhomogenities.
Treatment plans based on the Volume Modulated Arc Therapy (VMAT) are created for patients with parasinal tumours.
For both TPS – Pinnacle and Monaco – the same CT dataset and delineated anatomical structure are used for the treatment planning. Treatment plan optimization in Pinnacle is performed using a clinical procedure, whereas for Monaco a treatment planning procedure is developed.
The aim of this master thesis is the comparison of parasinal tumours treatment planning using Pinnacle and Monaco TPS and the elaboration of the quality of Monaco because of its MC algorithm which is said to be the most suitable in this field of irradiation. Therefore a Monaco treatment planning procedure is developed and the obtained results are evaluated in consideration of prescribed paramteres.
For example the prescribed dose and other dose limits for organs are checked for compliance. Furthermore the dose volume histogram (DVH) is assessed verifying that the $D_{98\%}$ and $D_{2\%}$ criteria are met and for additional examination of the quality of the dose calculation algorithm the heterogeneity index and the conformity index are examined.
Furthermore the results are evaluated by comparing the MC algorithm with the analytical approach.
Therefore the analytical dose calculated in Pinnacle, the MC recalculated dose of the Pinnacle treatment plan in Monaco and the dose of the optimized treatment plan generated in Monaco are compared with one another.

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Dose to organs at risk in boost irradiation for breast cancer- brachyboost vs. teleboost

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Radiotherapy is a well established method for minimising local recurrences in terms of breast cancer. Due to the high survival rates, longterm risks become a major concern. New techniques try to minimize the dose to the heart to avoid cardiotoxic effects. This study examines the differences in dose to organs at risk (OAR) in terms of boost irradiation with 3D conformal radiotherapy (3DCRT) and brachytherapy with Ir-192. Fifty one patients were included in the study (20 = rightsided, 31 = leftsided). All patients received a planning CT for whole breast irradiation as well as for brachytherapy. The target volume and OAR (heart, ipsi- and contralateral lung, contralateral breast, liver, oesophagus and thyroid gland) were delineated. The heart was segmented into 10 substructures. To compare the brachytherapy plans with a standard technique, 3DCRT teletherapy plans (6 MV photons) were recalculated for each patient. For left- and rightsided patients the relative mean doses to all heart substructures were lower for brachytherapy than for teletherapy. Relative mean doses were between 1.7 and 8.5 % of the prescribed dose for brachytherapy vs. 3.0 and 10.7 % for teletherapy in case of leftsided breast cancer. For the rightsided patients the relative dose varied between 0.9 and 4.3 % for brachytherapy vs. 1.8 and 6.6 % for teletherapy. The ipsilateral lung received on average 5.2 % of the prescribed dose for brachytherapy vs. 10.3 % for teletherapy. Mean relative dose to the contralateral breast was 0.3 % for brachytherapy and 1.2 % for teletherapy. Only for thyroid and liver the relative doses were higher for brachytherapy than for teletherapy. The liver dose ranged between 0.5 and 2.7 % for brachytherapy vs. 0.6 and 1.5 % for teletherapy. This dosesparing potential of brachytherapy should be considered when introducing new techniques for accelerated partial breast irradiation.

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Evaluation of new 2D ripple filters in scanned proton therapy

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We have shown previously that ripple filters (RiFis) of an improved 6 mm thick design with two-dimensional pins can be used in scanned carbon ion therapy for widening the Bragg peak (BP) to reduce the accelerator energy shifts needed to homogeneously cover the target volume and thus reduce the irradiation time. This design could potentially be used in proton therapy too, widening the BP to an extent, which would be beneficial in treatment planning. RiFis are normally not used with protons due to larger scattering and straggling effects.
Measured proton Bragg curves confirm the functionality of the new RiFi design. Base data for treatment planning in the form of depth-dose distributions and lateral profiles were generated with the Monte Carlo code SHIELD-HIT12A with and without the RiFi and imported in the treatment planning systems TRiP98 and proton Eclipse. Proton plans on simulated spherical targets in water were done in TRiP98 for a systematic analysis of the RiFi performance and for comparisons with carbon ion plans for the same respective energy step sizes. For a dosimetric evaluation of the RiFis on clinical cases, proton plans for 12 NSCLC lung tumours fixated under high-frequency jet-ventilation were calculated in Eclipse.
Slightly worse dose conformity and homogeneity were found with RiFis compared to without the RiFi but satisfactory dosimetric results within the planning objective could be obtained for all cases. A general increase in conformity and homogeneity was found as a function of target size and isocenter depth. This effect is found to be more pronounced for protons than for carbon ions. For small superficial targets requiring low beam energies, the RiFi might result in an unacceptable large lateral beam broadening, which could be lowered by opting for a combined RiFi and range shifter setup.
Experimental data and planning studies illustrate that 2D RiFis could be used in proton therapy to lower the irradiation time.

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Improving dose calculation accuracy using a virtual table model for positioning systems

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Since 2015 our clinic is using an indexed positioning system (OmniBoard, Macromedics) mounted on the linear accelerators table (Varian CD 2100).
The table top is made of carbon fiber (thickness 2.5cm) but at certain areas consolidated with plastic material. The Hounsfield values range from -900 to +500HU. An additional thorax board can be used in combination with the table top and is made of the same materials. This study investigates how the additional material in the beam influences dose distribution especially for VMAT plans and how this effect can be considered in a practical way during treatment planning (TPS Eclipse V13.0).
A planning study with head and neck VMAT plans showed a significant influence to the dose distribution when neglecting the positioning system, in particular the mean Dose to the PTVs was reduced by about 3%. Using the standard TPS table model this effect could be reduced but deviations still remained.
In order to improve the internal table model a RW3 phantom placed on the couch top was irradiated from different gantry angles and dose was measured in the isocenter (10x10cm², ionization chamber). The attenuation of the couch top was calculated for different angels and couch positions with a mean of 6.4% for 6MV and 4.2% for 15MV photons. Thereafter the dose distribution was calculated in the TPS with different settings for the table model changing the HU for couch surface and interior to minimize deviations between measurement and calculation. Suitable Hounsfield values were empirical found for the couch surface (-400HU) and interior (-840HU) for both energies.
The new table model was tested for VMAT patient plans against a calculation with contoured positioning system as part of body structure. A good agreement for PTV and organs at risk could be achieved (mean differences < 1%) also for positions with more dense material in the couch top. Major deviations were limited to low dose areas below 50% of the prescribed dose.
Using a virtual table model seems to be a convenient compromise between accurate calculation and time consuming contouring of positioning systems.

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Design and dosimetry of individually shaped shielding for beta eye plaque

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Ruthenium-106 plaques have been an established method within brachytherapy to treat eye tumours for over 50 years. As every patient's tumour has a special geometry, especially the tumour base shape, healthy tissue will always be irradiated with beta rays. This may lead to loss of vision or other health risks, if functional structures receive a dose beyond their limit. The idea of an individual metal shielding to protect the healthy tissue next to the tumour such as the optic nerve or blood vessels is under processing research. The geometry of the shielding is adapted to the individual tumour. This way the healthy tissue can be spared significantly better than with the conventional radiation therapy.
Our research group of the co-operation of the TU Dortmund University and the University Hospital Essen investigates two approaches of protection: plastic with metal powder, and pure metal.
This project focuses on geometries of silver protections and their effect on the radioactive dose in the healthy tissue, both with Monte Carlo calculation and measurements. This numerical simulation will be performed with Geant4. Several geometries of the shielding rim are included in order to optimize the shape. The material is manufactured in liquid state and moulded into the desired shape. The dose distribution of the eye plaque modified with the shielding is then determined by means of a scintillation detector system based on the recently evaluated material polyethylene naphthalate (PEN).

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Comparison of Monte Carlo simulations, radiochromic film measurements and TPS dose distributions for peripheral doses in Ir-192 multicatheter breast cancer brachytherapy

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Clinical brachytherapy treatment planning is conventionally based on the TG-43 formalism computing the dose from the superposition of a single source dose distribution in a water sphere. Thus, neither composition and density of heterogeneities nor finite dimensions of patient geometries are considered. For multicatheter brachytherapy of breast cancer the question arises whether there is an effect of the proximity of lung and ribs on the correctness of the calculated peripheral dose distribution.
A polymethyl methacrylate phantom of the left upper body was designed and built for measurement with radiochromic films in the heart and equally implemented in EGSnrc for Monte Carlo simulation. Dose parameters for the heart, lung and ribs are evaluated in order to quantify the differences to dose distributions calculated by TG-43 formalism.
Maximum dose differences between TPS dose and Monte Carlo simulations of up to 27% in the lung, 5% in the ribs and 1,6% in the heart were found. The differences in mean doses of these three organs at risk were beneath 1%. Regarding the heart mean and maximum dose of the Monte Carlo simulation were validated by radiochromic film measurements.
Although the underestimation of the mean dose in the heart of TG-43 formalism could lead to an underestimation of major coronary events of up to 0,6% it was shown that uncertainties in catheter and source localization have a higher impact on the main uncertainty of dosimetry in brachytherapy.

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First clinical experiences with the new transmission detector Dolphin on TrueBeam accelerator

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The transmission detector Dolphin (IBA Dosimetry) in combination with the quality assurance platform COMPASS (IBA Dosimetry) offers the prohability of real 3D treatment plan verification. Before implementation into clinical routine a validation of beam model and some dosimetric measurements have to be done. For Elekta accelators the increase of surface dose due to the influence of the transmission detector is well known. As far as we know there are no data for the surface dose of the Varian TrueBeam available. Whereas for the region beyond the dose maximum in the depth dose curve there are no differences, the build-up regions show deviations up to 20% for large field sizes. This deviation shows a wide field size dependency, for smaller field sizes than 10cm x 10cm it vanishes. In comparison to Elekta accelerator the skin dose is twice as much at the TrueBeam. The transmission factor for the TrueBeam is slightly higher than for the Elekta accelerator.
Until now we use COMPASS only for pre-treatment verification because of the approval for online verification from Varian is not available. For the first clinical experience various treatment plans (Eclipse) of different entities and treatment techniques were measured with Dolphin and verified by COMPASS. In the software COMPASS are various tools for plan verification: Beside of the common evaluation with Gamma analysis like with the 2D array technique there is also the option for 3D dose reconstruction inside the patient anatomy by analysing the DVHs and 3D Gamma evaluation.
For the average dose difference we observed wide variations for minor structures. Our future outlook is to compare the average dose differences for the various entities.

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Mechanical investigation of newly hybrid dental implants

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Titanium and titanium alloys are common used materials for dental implants, however they have biological limitations for oral use. Ceramics meet the demands of biocompatibility, but their susceptibility to implant fracture is increased. Therefore, a combination of both materials could be an advantage for dental implants. Therefore, a new hybrid implant combining titanium and ceramic components by glass solder fixation was introduced. The aim of the present study was to investigate the static and dynamic mechanical properties of such hybrid implants.

Two different types of hybrid implants were tested, which consisted of a metallic inlay made of titanium grade 4 or grade 5 (primec GmbH) fixed in a thin modified Cercon ceramic (yttrium stabilized zirconium dioxide) shell with a diameter of 4.3 mm (DeguDent GmbH) via glass solder and a titanium abutment fixed with an abutment screw. For each group $n = 4$ were tested according to DIN EN ISO 14801. The static tests were performed displacement-controlled until implant failure with 0.2 mm/s and the dynamic tests with sinusoidal load levels of 20 to 200 N and 24 to 240 N until failure or $5x10^6$ run out cycles.

The Cercon ceramic implant with the Ti grade 5 abutment showed higher fracture loads (298 N ± 42 N) in the static tests compared to the implants with the Ti grade 4 (262 N ± 22 N). During dynamic testing two specimens of both groups reached $5x10^6$ cycles at the load level of 200 N. At the higher load level one specimen with the Ti grade 5 reached the required cycles, none with the Ti grade 4.

The tested hybrid implants showed favourable static and dynamic failure loads comparable to other titanium or ceramic dental implants. Further research has to be performed to determine the *in vivo* performance of hybrid implants.

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Influence of cold atmospheric pressure plasma on biofilms of *staphylococcus epidermidis* on structured titanium – concerning antimicrobial potential and gentamicin susceptibility

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Adherence to biomaterials and formation of biofilms are important factorsin the pathogenicity of microorganisms, which may result in persistent infections despite aggressive antibiotic therapy. Within biofilms, bacteria are protected from hostdefense mechanisms and administered antibiotics. Cold atmospheric pressure plasma, an ionized electrically discharged gas-flow, might be an alternative for treating biofilms associated with implant-related infections. Our previous research showed the antimicrobial potential of atmospheric pressure plasma in altering the morphology and reducing viability of bacterial biofilms. The objective of the current experimental study was the examination of the influence of plasma on *S. epidermidis* biofilms concerning antimicrobial potential as well as gentamicin susceptibility.
Biofilms of *S. epidermidis* ATCC 35984 were grown on sterile, rough titanium alloy samples (Ti6Al4V, ø11 mm, Rz=20 µm, DOT GmbH) for 24 h in Tryptone-Soy-Broth (TSB, 37 °C, 5 % CO_2). Furthermore an antibiotic sensitivity test of *S. epidermidis* cultures was carried out. Plasma treatment of the biofilms was performed by using an atmospheric pressure plasma source working with argon and 1 % 0_2 admixture (kINPen08, INP, Germany) for 1 and 3 min. Biofilm-bound bacteria were quantified by measurement of viable bacterial counts after plasma-treatment and further cultivation for 24 h in TSB with gentamicin-sulfate.
The antibiotic sensitivity test of control bacteria indicated a resistance against gentamicin. Treatment of bacterial biofilms with plasma by kINPen08 reached a significant reduction of vital bacteria up to two log-units within the biofilm in comparison to the untreated control. After further cultivation of plasma-treated biofilms for 24 h in gentamicin-supplemented TSB, total reduction of vital bacteria to 0 CFU/ml was achieved in contrast to the untreated control with $1.17*10^4 \pm 1.63*10^3$CFU/ml. Our results demonstrate the potential of atmospheric pressure plasma combining major purposes dealing with infected implants: to remove and degrade the bacterial biofilm and simultaneously increase the gentamicin-susceptibility.

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Micro plasma source for the selective treatment of cell cultures

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A miniaturized ceramic atmospheric plasma source for use in life sciences has been developed. It is manufactured using LTCC-technology (Low Temperature Cofired Ceramics). Plasma generation is based on buried electrodes, which provoke a Dielectric Barrier Discharge (DBD). The technology employed allows small feature sizes (electrode width 150 µm, barrier thickness 40 µm) as well as precision in µm range, resulting in very low power consumption of the system (approx. 1 W). Thus, the maximum temperature at the point of use is kept below 40 °C.
The flexibility of the manufacturing process (layer lamination, screen printing, patterning etc.) offers additional features like robust fluidic structures (channels, chambers, gas distribution) as well as the direct implementation of electronic components.
The plasma produced by the system can be tuned depending on the assembly structure of the system and the pattern of electric excitation. The different parts of the plasma characteristics (ozone generation, reactive radicals, ultraviolet radiation) and their effects can be separated. To prove biocompatibility and experimental compatibility with cell cultures (low temperature at the point of use), a method for temperature measurements on the bottom of a multi-well plate is presented. The impact of plasma on cell cultures was evaluated. Keratinocytes and fibroblast cell lines were applied to test the cell tolerability of the treatment with the micro-plasma source while test with bacteria (S. aureus, MRSA und P. aeruginosa) and yeast (C. albicans und M. pachydermatis) investigated its antimicrobial potential.

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Multilayer diffusion-barrier model for experimental determination of coated-implant related drug eluting processes.

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A problem of modern orthopaedic surgery are implant-associated infections. These infections are difficult to treat with conventional methods due to biofilm formations on the implant surface which protects the bacteria colonies against systemically applied pharmaceuticals. Depending on the degree of the disease, removal of the infected implant could be necessary.
A reliable approach to avoid colonisation of the implant surface is a preventative coating of the implant with an antibiotic-releasing covering.
Even infection-uncritical applications could benefit from drug eluting coatings, for example if the implant elutes growth stimulants which supports the healing process after the implantation.
There are no standardized in-vitro measurements for the development of drug eluting implants or drug coatings in general. The mostly used test methods (paddle apparatus and flow-through-cell) are originally developed to determine the dissolve speed of tablets and show poor in-vivo/in-vitro correlation (IVIVC) when applied to coated implants.
We are working on an experimental setup to fills this gap and provide a better testing method for drug eluting implants, to enable faster and cheaper development cycles with reduced need for animal studies.
The experimental setup contains a modified flow-through-cell with fluorescein-sodium as a model drug and an artificial membrane as a replacement for the implant-surrounding tissue. The membrane separates the flow channel (acceptor channel) from the drug solution (donator channel). The concentration is measured spectroscopically inside of the acceptor channel with an UV/Vis spectrometer.
We have shown, that pHEMA (poly(2-hydroxyethyl methacrylate)) based hydrogels are suitable and reproducible substitutes for biological membranes, related to research of diffusive mass transport through membrane layers up to 8 mm thickness.
The diffusion resistance through the hydrogel is tuneable by changing the percentage of crosslinker (EGDMA), photoinitiator (TPO) and dilution. A further possibility to imitate different biological membranes is realized by stacking membranes and create multilayer hydrogels.
By using this options to manipulate the diffusion barrier, we plan to provide a drug eluting measurement method which is comparable to drug eluting processes in the human body.

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96-well plate ultrasonic applicator for high-throughput in-vitro hyperthermia experiments

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While diagnostic ultrasound has been established as standard tool within the medical community for decades, therapeutic ultrasound is only emerging in the last years. While HIFU is based on the delivery of high energy densities allowing coagulation in applications such as tumor therapy, ultrasound hyperthermia produces a soft temperature increase leading to an improved metabolic activity of cells, resulting for instance in a better drug uptake. However, existing setups for hyperthermia experiments on cells do not comply with pharmaceutical standards where parallelization is required in view of producing results with a high level of statistical significance.

In view of overcoming the mentioned limitations of existing systems, we developed a cell applicator allowing to investigate the effect of ultrasound on cells, in particular in the context of hyperthermia. The device is based on a 8 x 12 matrix of single element ultrasound transducers and has been set up in 4 versions with centre frequencies of 0.5, 1, 1.5 and 2 MHz. All transducers allow acoustic dry coupling to the bottom of the well plates. The applicator is driven by a modified version of Fraunhofer IBMT´s multichannel ultrasound platform DiPhAS. A special software interface, that allows adjusting the transmit parameters of individual wells or groups of wells, has furthermore been developed.

The sound field of the applicator has been measured in order to verify that there is no overlap between the beams of individual transducers. Furthermore, the standard deviation of the transducer efficiency has been assessed to 9 %. In another set of experiments, the cross coupling between individual transducers was investigated (damping of 35-40 dB to neighbouring element). Finally, the acoustic intensities for all transmit settings were assessed (max 0,05 W/cm²). Hyperthermia experiments were initially conducted with water filled wells and the ability to acoustically induce a temperature increase was demonstrated.

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A new concept of interconnecting feedthrough-bearing substrates with conducting wires in active implantable medical devices

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The development and application of new active implantable medical devices (i.e. neuromodulators for the treatment of hypertension) require an ever-increasing amount of stimulation and recording sites. In many cases the therapeutic electrical signals generated by the implant penetrate a hermetic enclosure of the involved electronics via feedthrough structures. Typically, a multi-fibre-core cable connects these feedthroughs with the machine-tissue interface. In state-of-the-art applications (with a low amount of channels), i.e. pacemakers or cochlear implants, cables are connected directly to the metal pins or ribbons of the hermetic feedthroughs. This well established and reliable interconnecting technique, however, comes to its limitation when an active implant requires a high amount of channels. For an envisioned packaging concept new ways to connect thin metal wires to the feedthrough-bearing ceramic substrate are developed and characterized. The investigated method uses glass-based screenprinting paste with a gold-filler as a bondpad for metal wires. Sputtered metal connects the fired paste and the location of the feedthroughs on the ceramic substrate. Laser-welding is the method of choice for a long term stable mechanical and electrical connection between the wires and the paste. In this new approach, the paste is applied in laser structured trenches on the ceramic substrate. This allows for rapid prototyping of geometries, since no screen printing mask is needed to apply the paste before firing. Furthermore, the trenches are designed in a way, that the metal wire can be pressed in a cavity, which constrains the movement of the wire in all directions during the laser-welding of the wires. This can enhance the repeatability and speed of the welding process significantly. Since the interconnects between the wire and the paste are located beneath the ceramic surface, high resistance to shear forces is to be expected, which is beneficial for the long term stability of this packaging concept.

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The influence of different FimH gene structures of several *Escherichia coli* pathotypes on the attachment behaviour to intestinal cell lines and proteins

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FimH is an adhesin located on the surface of type-1 fimbriae and is known to have high mannose-binding properties. For example, it can bind to the zymogen granule membrane glycoprotein 2 (GP2), which is an autoantigen of pancreatic antibodies in inflammatory bowel diseases such as Crohn's disease and ulcerative colitis. This glycoprotein is expressed in the pancreas and on the apical surface of intestinal cells. However, the influence of different FimH structures on the binding behaviour to intestinal cell lines and proteins has not yet been determined.
This attachment behaviour can be determined using adhesion assays that measure the amount of bacteria. For these experiments the new VideoScan-technology developed by the former HS Lausitz was used. Intestinal human and animal cell lines were incubated with bacterial suspension. Bound bacteria stained with a fluorescent dye were counted using VideoScan and were evaluated as bacteria per image. Non-pathogenic *Escherichia coli*, enteropathogenic *E. coli* (EPEC), and enterotoxigenic *E. coli* (ETEC) of human, porcine, and bovine excrement were used. The FimH sequences of the bacterial strains containing the adhesin were tested.
Preliminary results have shown that approximately 93 % of tested *E. coli* strains contain the fimbrial adhesin. Furthermore, 30 different FimH variants have been identified. These FimH gene structures seem to be specific for the bacteria pathotypes. Such mutations in gene structures are the cause of different adhesion behaviour, which can cause different immune responses.

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Additive manufacturing of ceramic and metal-ceramic-components for medical applications

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Additive manufacturing (AM) techniques allow the preparation of tailor-made structures for different applications. The Fraunhofer IKTS uses the lithography-based ceramic manufacturing (LCM) technology and develop new suspensions (alumina, zirconia, Hap, ATZ, ZTA, Si_3N_4, glass) for AM of tailor-made implants which combine dense and lattice ceramic structures. The combination of LCM and freeze foaming allows the combination of tailor-made dense outer geometries with a high porosity inside.
Another approach – thermoplastic 3D printing (T3DP) – offers new prospects for fabrication of multi-material components. High-filled ceramic and metal feedstocks based on thermoplastic binder systems were used for AM of dense ceramic components and metal-ceramic-composites.
For all sintered samples a density of about 99 % and higher was obtained. Our results will be demonstrated on different demonstrators for medical applications like knee implants, spinal implants and bipolar components for minimally invasive surgery.

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Tailored biofuctionalized surfaces fabricated by direct laserinterference patterning

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Surface engineering of biomedical materials is considered as an essential technology to adapt the cell and bacteria adhesion on implant surfaces in the human body and medical products. Specific topographic features can have both, cell adhesion-promoting and bacteria-repellent properties. Depending on the application, one or both of them at the same time are required. Typical materials used for implants and medical products are titanium and several polymers. Common methods to change the surface properties of these materials are either cost-intensive (i.e. coatings) or not efficient due to multi-step process (i.e. grain blasting and etching). In order to meet the technical requirements to succeed in a specific market, it is necessary to develop and establish new manufacturing processes to produce functional surfaces with high processing speeds and low costs.
A well suitable technology to fulfill these requirements is direct laser interference patterning (DLIP). Using the interference of two or more coherent laser beams, periodic grooves, grids or dimples, with pitches in the micrometer and submicrometer range, can be produced with high processing speeds up to 0.36 m²/min on metallic surfaces and even 0.9 m²/min on polymers.
In this work we show the implementation of interference surface structures on different materials and their antibacterial and cell adhesion promoting properties. Groove and grit-like structures in the range of 0.5 up to 20 µm were obtained on titanium and polyimide (PI) by nanosecond pulses at UV and VIS wavelength. Cell and bacteria adhesion tests under various conditions were performed. As result, structures smaller or much larger than the bacteria size reduce the number of cells per unit of area. Cell tests showed adhesion promoting effects of DLIP structures with spatial periods larger than 1 µm.

P 368

Effect of iron content on the spectral quality of MPI tracer material

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In Magnetic Particle Imaging (MPI) superparamagnetic iron-oxide nanoparticles (SPIONs) with biocompatible coatings play a crucial role for the diagnostic quality of the resulting images. Due to the nonlinear magnetization behaviour of SPIONs in aqueous suspensions or isotonic solvents this material is used as tracer for MPI. The tracer is excited with a sinusoidal magnetic field leading to a nonlinear remagnetization that can be detected with receive coils. The pattern of harmonic frequencies in the Fourier spectrum of the measured particle remagnetization is a characteristic fingerprint of the particular tracer material.
However, the effect of iron concentration within the imaging mechanism of MPI is not yet fully understood. This is critical for the combined use of SPIONs for imaging and hyperthermia. Since the iron concentration is typically low when the tracer is administered for imaging porposes, it will be comparably high for hyperthermia, where particles must accumulate at the target pathology. For high concentrations, however, particle-particle interactions may occure that are not modelled with the Langevin theory of superparamagnetism.
Therefore, different MPI tracer materials are investigated via their spectral fingerprints using Magnetic Particle Spectroscopy (MPS) in dilution and up-concentration series. All colloidale suspensions of coated nanoparticles are of core sizes of 5 to 25 nm dispered in an aqueous carrier
The iron content was calculated by photometric measurements of the phenantroline iron complex. The magnetization was measured by a highly sensitive MPS made at the Institut of Medical Enineering. For comparison of different particles systems the spectral MPS results have been normalized to the iron content. For all measurements the same conditions (e.g. temperature, sample volume) are used. All measurements were compared with Resovist, the gold standard in MPI. It has been found that the iron content alone does not rule the behaviour in the imaging process in MPI.

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Chemically modified microstructured PDMS surfaces influence adipose-derived stem cell behavior

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The control of stem cell behavoir by surface topography is a promising tool regarding diverse medical applications including implatable medical devices and scaffolds for tissue engineering. The effects of surface geometry on adipose-derived stem cell (ASC) behavoir are highlighted by many studies. It is well known that cells interact at a high level with their surrounding extracellular matrix (ECM) *in vivo* and growth substrates or scaffolds *in vitro*. The surrounding material can provide cues that guide cell behavoir. In the context of cell based therapies it is essential to understand how material surfaces influence stem cell behavior. In the present study the influence of microstructured polydimethylsiloxane (PDMS) surfaces with different chemical and physical modifications on ASC behavior was examined. ASCs were isolated from tissue samples from donors undergoning plastic surgery by enzymatic digestion. PDMS molds with different microstructures were produced using photolithography. Contact angle meassurment of PDMS molds revealed a higher hydrophilicity after O_2 plasma treatment. Chemical modification with ECM proteins collagen type I and fibronectin was successful proven by immunohistochemical staining. ASCs were cultured on these surfaces for 21 days. It was found that ASCs adhere onto different microstructures with chemical and physical modifications of PDMS. Focal adhesion distribution was proven by immunofluorescenc staining of F-actin and vinculin. After 21 day culture period ASCs exhibit a structure specific orientation depending on microtopographic geometry and chemical modification. Further it can be observed that ASCs exhibit longer pseudopodia on microstructured surfaces compared to the planar control. Oil red O and alizarin red staining revealed no adipogenic or osteogenic differentiation of ASCs on microstructured PDMS. To further investigate the influence of microstructure of surrounding material on ASCs different geometries and chemical and physical modifications should be examined to their effect on ASC behavoir.

P 370

"Medical Grade" polymeric additive manufacturing technologies

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Additive manufacturing (AM, also known as 3D printing) has been successfully introduced in the field of medical engineering over the last few years. In particular, patient individual implants, prothetics, orthoplastics or surgery models have been driving forces in establishing AM technologies. To raise AM in the field of medical engineering to the next level, new materials as well as innovative and for medical applications optimized 3D printers have to be developed. Especially the development of biocompatible printable high-perfomance (e.g. Polyetheretherketone, PEEK) and flexible (e.g. TPE, Silicone rubber) materials, as well as appropriate printing technologies that at the same time fulfill the strict purity requirements for the production of medical products, are of special interest. In addition two component 3D printers that can process rigid and flexible materials in one step will enable the manufacturing of biomechanically optimized medical products.
At the Institute of Medical and Polymer Engineering at the Technical University of Munich, different 3D printing technologies (based on Fused Filament Fabrication), optimized for medical applications, have been developed and will be presented. These include a PEEK printer, a printer for flexible thermoplastic elastomers (down to hardness shore A 50), a printer for silicone rubber, as well as a two-component 3D printer. PEEK samples for tensil tests were produced by both, 3D printing and injection molding, to compare the mechanical properties. The influence of printing parameters on the appearance of internal defects of the printed parts was studied by microtomography. Promising approaches to print flexible (e.g. flexible small caliber tube systems) as well as hybrids out of rigid and flexible materials were evaluated, resulting into options to realize medical products with biomimetic properties in future.

P 374

Preparation and characterization of a standardized testing procedure for covalently-immobilized biological coatings using a laminar flow cell

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In recent years, the development and application of bioactive surface coatings (e. g. as implant coatings) has grown rapidly in the field of medical engineering, tissue engineering, and regenerative medicine. Bioactive coatings in general attempt to mimic the multifactorial aspects of extracellular matrix (ECM). In a natural tissue the ECM resembles the three-dimensional microenvironment of the cells. It is composed of a highly complex mixture of biomolecules and is essential for cellular processes like cell adhesion and migration, biomechanical stimuli, or signal transduction. However, single ECM components (e. g. collagen) fail to achieve the molecular complexity and organization of the ECM in vivo. Therefore, the use of complex cell-derived ECMs as coating materials gained attention since it is a promising attempt to preserve, at least to a large extent, the complexity of native matrices. However, these biological matrices still lack specific addressable functional groups, which are often required for the covalent immobilization of biological matrices onto the surface of implant materials. To overcome this limitation, we developed an azide-functional ECM which can be addressed in a highly specific biorthogonal click reaction (Huisgen cycloaddition). Therefore, we incorporated azide groups into the glycan structures of the ECM by Metabolic Glyco Engineering and we could show that this »*click*ECM« can be covalently linked to alkyne-functional surfaces.
In order to evaluate and compare the coating stability of this covalent *click*ECM coating compared to regular physisorbed coatings in a standardized procedure, we developed a special flow cell. This CAD-manufactured polycarbonate cell allowed us to overflow three coated implant materials at the same time with a defined flow rate and flow medium for a certain amount of time. Laser Scanning Microscopy and Multiphoton Microscopy were performed afterwards to image the biological coatings in order to evaluate the respective coating condition.

P 378

Investigation of infectious diseases using a novel in vitro diagnostic microfluidic chip

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Malaria is an infectious disease in which parasites enter the human body through the bite of the Anopheles mosquito. When the pathogens are released into the bloodstream, at first nonspecific disease symptoms occur. To start the essential medical treatment, a fast and sensitive diagnosis is necessary. The gold standard method of malaria diagnostics is the microscopic examination of blood smears. However, this requires laboratory equipment and medical specialists, which is usually not present in the affected malaria centers. For this purpose, a novel microfluidic chip system has been developed. It is based on the optical detection of the specific coupling of the pathogens to the bottom of a microfluidic channel. While the laminar flow in a microfluidic channel causes the pathogens to remain in the center of the channel, we developed herringbone structures on the top surface of the channel to generate turbulences, which deflect the pathogens downwards resulting in an increase of the coupling. Mathematical simulations show that in the areas with herringbone structures, elevated velocities and turbulent flow could be observed. To verify these results, we developed channel systems with different herringbone structures, where the flow behavior was examined microscopically by using polymer beads. The experiments demonstrated clearly the formation of desired turbulences. For the final microfluidic system a reliable passive filling system is necessary. For that purpose we have combined the fluidic capillary forces inside narrow channels with the additional suction force of a nonwoven material. The experiments have shown that the flow behavior inside the system can be controlled by means of additional ventilation holes.

P 380

Controlled infiltration of cells into electrospun scaffolds fabricated for applications in small diameter vascular grafts

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Owing to the paradoxical nature of electrospinning, it is difficult to produce a nanofibrous structure with large pores, the ideal environment for cell infiltration. The literature shows many attempts to achieve this with varied results. This project proposes a novel twist (alginate cell printing) to sacrificial electrospinning to increase cell infiltration. The aim is to fabricate a multilayered hybrid polymeric scaffold by electrospinning, characterise it, seed it with appropriate cells using a cell printer, and measure the cell infiltration of the resultant structure.
PCL-gelatin fiber mats with different concentration ratios were electrospun. Fiber diameter and pore size before and after gelatin leaching were measured and the mats were tested for tensile strength and wettability. 3T3 fibroblasts are printed on an optimised fiber mat with alginate in defined patterns as opposed to direct manual cell seeding (lacking in homogeneity). Multiple layers are stacked, incubated and allowed to attach to each other. Cell infiltration depth is then studied by z-axis fluorescence microscopy.
PCL-gelatin produces a wide range of nano-and microfibres (3.5±2.5µm) as compared to monodisperse fibres in PCL scaffolds (1.8±0.3µm). It is even possible to fabricate PCL-gelatin mats of thicknesses as low as 10µm, a clear advantage. Fiber diameters are reduced greatly after 8hrs of gelatin leaching in acidic water (2.3±1.5µm) indicating an increase in pore size. Contact angle measurements indicate a drastic increase in hydrophilicity on addition of gelatin.
The addition of alginate cell printing onto PCL-gelatin scaffolds is important to protect the cells from shear and mechanical stresses during printing and stacking. As both gelatin and alginate dissolve away during cell culture, the cells will be able to infiltrate the multilayered structure to a larger extent and with more ease than before.

P 381

Rapid prototyping of implantable high accuracy platinum thin film tracks via laser evaporation

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Implantable printed circuit boards are often fabricated using a screen printing process (e.g. Pt/Au paste) in combination with alumina substrates. Due to inaccurate edges a minimal track distance of 0.125 mm occurs. Additionally, the need of screen printing masks limits the flexibility in design changes. As an alternative the sputter deposition of a platinum thin-film metallization followed by laser structuring was examined. Platinum was used because of its inert properties, which allows assembling (e.g. soldering) without chemical or mechanical postprocessing. We evaluated laser parameters to structure the sputtered metallization with different thicknesses (100 nm, 200 nm and 300 nm). The resulting metallization was characterized with respect to the quality of the edges and the adhesive strength to the substrate using a pull testing setup with a cartridge applying forces up to 100 N (Dage Series 4000 Bondtester). Therefore, copper wires were soldered onto 2x2 mm² Pt-pads. The edges of the metallization were sharply defined with a lateral deviation smaller than 2 µm whereby the minimal track distance was limited by the laser focus spot (≈60 µm). The 200 nm thick platinum layer featured the lowest median adhesive strength with a value of 5.83 MPa, followed by the 100 nm layer with 9.59 MPa and the 300 nm layer with 13.07 MPa. In all cases cohesive failure occurred. Taking into account the recommended threshold of reliable pad adhesion (=17 MPa) for screen printed metallizations, these values are comparatively small. Regarding the quality of the edges and the flexibility of the design the present process is encouraging. To handle the adhesive strength it is highly recommended to introduce an adhesion promoter (e.g. titanium), which develops a mixed oxide at the Pt-Al_2O_3 interface. Implementing this layer leads to a plurality of parameter combinations whereby an optimization with a Design of Experiment is proposed.

P 383

Polarimeter compensation methods for drift and scattering effects by using information comprising signal frequency components

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Introduction: Glucose measurements play an important role in clinical medicine. Drawbacks of commonly used encymatic-amperometric reactions for determination could be overcome by polarimetry. This method is very sensitive to temperature-dependent drift and scattering effects occurring during measurements in tissue, blood or moving interstitial fluid. For accurate glucose determination there is a demand for a real-time compensation method of sample absorbance, drift and scattering effects with no additional hardware effort.
Methods: We built a polarimeter including two crossed Glan-Thompson polarizers, a flow-through cuvette and a Faraday rotator. A frequency analysis of the detector signal was performed to extract intensities at information-comprising frequency components and individual drift and scattering influences were investigated. We generated various flow profiles for glucose solutions by a syringe pump to determine their influence on the polarimeter signal. Ambient temperature was varied to investigate the influence on each intensity. Correlations between flow profiles, temperature fluctuations and signal intensities were calculated to evaluate possible compensation methods.
Results: Measurements show that sample scattering, drift and absorption effects could limit glucose prediction accuracy and that they have a unique influence on each frequency components. This unique influence enables sample absorption and light source drift compensation as well as the detection of scattering effects to prevent failure in measurements. A compensation of scattering effects is partially possible, but suffers from complex depolarization procedures. Moreover, strong scattering results in a detector saturation which leads to frequency shares and impedes every compensation approach.
Conclusion: By extracting information comprising polarimeter signal frequency shares we created a real-time compensation method for sample absorbance, and drift effects of light source or detector with no additional hardware effort. For non-saturated detectors this enables reliable glucose measurement and detection of occurring scattering to prevent failure measurements.

NW 18

Model-based Therapy

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Information systems are an essential part of modern hospital infrastructure. They are used in all diagnostic and therapeutic processes. Additionally, they focus on the support of patient management and hospital logistics. Information systems, yet, gain importance to support patient-specific therapy selection, therapeutic application and therapy management.
The basic idea of this paradigm are computer models of the patient and the therapeutic process. They will in future extend the direct interaction between the physician and the patient. Their goal is to increase the therapeutic efficacy and the treatment speed as well as to reduce the invasiveness of the therapy for the patient. The various models are the core components of the decision support and realize the clinical activities with different degrees of automation.
The models extend the capabilities of clinical users and provide a variety of usage options. An example is the implementation of simulations and predictions based on the patient-specific models. Bot are required for the therapy success and the decision support provided thereby. This strategy also requires an integration of information from heterogeneous data sources. So they need to be synchronized from different partial models. As a result, the systems will enable the combination of multimodal information sources, sensors and databases and the application of situation-aware and context-adaptive therapy support systems.

NW 19

Therapy Decision Support System using Bayesian Networks

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Complex cancer cases require patient individual treatment decisions. Therefore, a multidisciplinary team of clinical experts analyses and discusses a large amount of patient data regarding guidelines, studies, and experiences. Disregarding of information may result in suboptimal treatment. Computer systems can support clinical decision making with transparent and reproducible recommendations in order to increase quality of patient care and safety. The selection, development, validation and integration of a supporting system is crucial for its acceptance.

At ICCAS Leipzig, we developed a concept for a Bayesian network-based therapy decision support system. Bayesian network are probabilistic graphical models that allow a representation and analyses of comprehensive decisions with uncertainty. The concept includes actors (developers, domain experts and users) and technical components (decision networks, engines, repositories, and user interface designs) and interaction in between. For the development, we worked closely together with clinical experts of the University Hospital Leipzig. As a first disease, we selected laryngeal cancer.

From the concept, a subset of technical components was developed including a treatment decision network for laryngeal cancer as well as methods and tools for expert modeling and network interaction. The network consists of more than 900 variables with more than 1100 dependencies and was modeled in period of three years. A subnetwork, representing the tumor, lymph node, metastasis classification, was validated using clinical data and experts. Modeling tools were developed to enable expert modeling without background knowledge about Bayesian networks. A network interaction tool was developed for visual decision verification. Tools were evaluated using the subnetwork.

The close collaboration between engineers and clinicians ensured the development of a desired system and tools. Future work should extend the available tools to enable collaborative modeling beyond institutional boarders. Furthermore, additional visualization tools will be required to support decisions dependent on the users, environments and available interaction devices.

NW 20

Framework for context-aware assistance in integrated operating rooms

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Surgical workflow management may compensate the increase in complexity of the processes in modern operating rooms. Our project aims to design a framework for context-aware assistance and to implement a cooperative surgical working environment. The intelligent environment shall unburden the OR team from device configuration, information seeking, and documentation. The prototypical setup includes medical devices, infrastructure components and novel top-level services. The implemented framework for technical context-awareness is based on a combination of various methods for three major aspects: the formal modeling of procedures, the intraoperative tracking and processing, and the rule-based system adaptation.
For the modelling of the situational context, several perspectives, including surgical tasks, patient state, treatment progress, and technical resource usage were considered based on Adaptive Trace Models and Hidden Markov Models. These contextual information are provided to the OR network based on IEEE 11073-SDC and can be evaluated by devices and systems to adapt to the surgical situation.
Following that concept, a set of applications was implemented in a realistic demonstrator setup designed for Functional Endoscopic Sinus Surgery (FESS). This included reactive behaviour, such as an automated switching of the primary display, as well as long-term analysis, for instance for documentation. The documentation is supported by an automated selection of captures of the endoscope and a recognition of five different “Operationen- und Prozedurenschlüssel”. The context-aware assistance functionalities were evaluated with twenty-four simulated FESS porcedures in the demonstrator setup.
The robustness of the situational context recognition as well as the applied rules are crucial for a successful realization of context-aware assistance. The functionalities high differ in their demands to the underlying workflow technology. Whereas reactive behavior solely relies on an accurate perception of specific situations on a fine-granular perspective, long-term analysis requires generalized interpretations of sub-processes. Hence, frameworks for context-aware assistance need to support both perspectvies.

NW 21

Visualization for Model-Based Therapy Decision Support

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The most critical problem in therapy decision making is the predictive and personalized weighting of therapeutic options under consideration of the patient's individual anatomy and physiology. Approaches of model-based therapy decision support addressing this problem require a visualization of the underlying model in order to understand its logic and to gain trust into its predictions. An important model type with specific demands on visualization is probabilistic models.
A probabilistic model represents weighted causalities between patient information aggregated from the hospital information system and knowledge derived from medical textbooks, clinical studies, and therapeutic guidelines. This type of models is often implemented as Bayesian network and predicts the most appropriate patient-specific therapeutic option(s) by means of Bayesian inferencing. At ICCAS Leipzig, we developed a model of laryngeal cancer treatment in close collaboration with the head and neck department of the University Hospital Leipzig. The part of this model related to tumor staging has been recently integrated in prototypical software for the visual verification of cancer staging results in preparation of clinical expert meetings discussing cancer cases (tumor board).
The prototype allows for a fast identification of factors influencing the tumor staging and for the comparison of a manually derived clinical staging and a computed one. This comparison is crucial in preparation of the tumor board in order to detect inconsistencies in the clinical staging early and avoid lengthy clarification attempts during the tumor board. The prototype has been evaluated with five experienced physicians, each studying 20 complex cases of laryngeal cancer. First results show that physicians are able to master the prototype after about 10 training cases. Interviews indicated that working with the prototype leads to an improved understanding and memorization of the underling cancer staging process.

NW 22

Optimizing procedures: value added services based on OR integration

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The German flagship project OR.NET focussed on medical device interoperability based on open standards. The communication uses a refined service-oriented architecture, a so called Service-Oriented Medical Device Architecture (SOMDA). The integration technology is currently in the process of standardization as IEEE 11073-SDC. The scope of the project also included realtime communication based on Powerlink, and integration into the clinical IT using DICOM and HL7. The approach ensures syntactic and semantic interoperability in openly integrated operating rooms. However, device interoperability is as an enabling technology. Clinicians and hospital operators will profit from the implementation of novel services that provide added values. The services range from data integration, for instance by visualization of relevant parameters in the field of view of the surgeon, via manual parameterization in remote control, to (semi-)automatic assistance functionalities.
At the Innovation Center Computer Assisted Surgery in Leipzig, a realistic demonstrator for openly integrated operating room technology was implemented based on the IEEE 11073-SDC in cooperation with manufacturers and academic institutes. The applications include vital data overlays in the endoscopic video, a centralized control console, and a video routing, among others. In a qualitative evaluation study with clinicians and hospital operators, various additional services were presented and discussed with the stakeholders.
Because of the eased access to data that are revelant for intraoperative decision making and the simplified interaction with the medical devices, a more streamlined clinical workflow can be expected. This may also result in an improved patient safety as well as a reduced intervention time. Beyond the intraoperative potentials of openly integrated operating rooms, manufacturers and vendors may profit from a simplified integration of novel technologies into existing installations. Finally, hospital operators may benefit from a comprehensive data integration and more flexibility in compiling OR setups.

NW 23

Smart hip prosthesis – an overview

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Artificial hip joints are mostly implanted in patients suffering from arthrosis, a widespread disease in modern society. It is generally caused by wear to the joint cartilage, and subsequent damage to the surrounding bone structure, muscles, joint capsules and ligaments. The main symptoms are joint pain and restricted mobility. Older people are at greater risk of developing arthrosis which means that, given the current demographic trends, there are an increased number of people requiring artificial hip replacements.
The hip prosthesis being developed by Fraunhofer researchers as part of the Fraunhofer Lighthouse Project Theranostic Implants is equipped with electronic sensors and actuators that enable the physician to monitor the fit of the artificial hip joint and the bone ingrowth without further surgical intervention, and to readjust the position of the implant if necessary. Conventional prosthetic hip joints have a tendency to work loose because they are unable to adapt to changes in the bone structure. This usually means that they have to be replaced after ten to fifteen years. But hip revision surgery is a complicated medical procedure and carries with it a high risk to the patient's health.
The presentation is about the status of the development focusing on specific components, modules and solutions addressing a new type of hip prosthesis integrating sophistictated sensor and actuator functionalities as well as an first idea of how to potentially use it in practice.

NW 24

Overview on an implantable multi sensor system for cardiovascular monitoring

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Continuous monitoring of physiological parameters in cardiovascular areas allows early detection of critical conditions which may lead to clinical symptoms and hospitalization, if not treated in time. Thereby early diagnostics, optimization of therapy and reduction of therapy costs can be achieved. Therefore, the focus on research lies on the development of highly miniaturized smart and implantable sensors with an appropriate encapsulation for long-term applications.
The concept of the presented multi sensor implant utilizes, amongst others, capacitive pressure sensor elements (monolithically integrated in a CMOS process), activity and inclination detection elements and a temperature sensor unit. Thus, additional information about the patient are obtained. Those results are used for side effect compensation which enables a more accurate pressure measurement. Sensor chips, passive components and an antenna coil for telemetric energy and data transmission are integrated in only one Low Temperature Cofired Ceramic (LTCC) circuit board. An inductive near-field coupling at a frequency of 13.56 MHz is used.
Most implantable and medically approved systems are encapsulated by biostable metals such as titanium. Since these popular materials limit further miniaturization of implantable sensor systems, this research work also deals with new encapsulation techniques which provide biocompatibility, long-term functionality and show suitable pressure transmission properties. These requirements can be achieved by a three-dimensional passivation of the micromechanical pressure sensor membranes by a stack of very thin layers applied by Atomic Layer Deposition (ALD). These layers show hermetic sealing and high conformity, even on complex topographies. Additionally, a stack of currently developed and medical approved polymers are applied. Thus, the implant obtains a proper shaping which is necessary to prevent for potentially dangerous blood clots caused by the implant itself.

NW 25

Controlling of a hand prosthesis using epimysial signals and peripheral nerve stimulation

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Smart implants combine diagnosis and therapy in a single miniaturized system. They are closed loop systems with different sensors and actuators including wireless signal and energy transmission. Under coordination of the Fraunhofer-Institute of Biomedical Engineering (IBMT) the Fraunhofer Lighthouse Project »Theranostic implants« concentrates the technological possibilities of 12 Fraunhofer Institutes to a marketable technology platform. Exemplary three prototypes with high relevance to the market are built up and tested. Almost the whole area of the theranostic implants is covered: (a) skeletal: smart hip prosthesis, (b) cardiovascular: hemodynamic controlling, and (c) neuromuscular: myoelectric control of hand prosthesis with sensory feedback. Demands of these three prototypes show the driving force for the technology development.
The neuromuscular demonstrator is a complete implantable system for functional assistance. To control the hand prostheses intuitive, eight implantable flexible microelectrodes are used for the invasive acquisition of muscle activities. The signals are pre-processed in an application-specific integrated circuit (ASIC). Four-channel electrical neural stimulation gives the patens a sensory feedback. The ASIC generates the stimulation signal depending on the measured grip force. Telemetry module is used for wireless real-time signal transmission and inductive energy transmission including adaptive energy management. Optical and RF communication was characterized. The detection of the desired hand movement was possible after signal processing including pattern recognition as well as signal classification. Three different possibilities for encapsulation are realised and tested: (a) titanium (b) ceramics and (c) multilayer polymer. The whole development and manufacturing process was accompanied by regulatory affairs including quality and risk management.

V 140

Fall-management system for elderly by multisensory-analysis with integration in a social environment

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Older people are prone to fall due to their reduced mobility, effects of medication and decreased brawn. Despite of the fact that not all falls lead to injuries, its percentage is high enough to be considered as a major public-health concern. This gains even more pertinence by taking into account that, based on the fear of falling, avoidance of movement reduces social interactions. Several approaches were made to detect falls focused on analysing body movements and identifying changes in acceleration. Unfortunately, these systems are compromised when the fall-speed is not high enough or the impact to the ground is smoothed in some manner. The developed system intends to solve these issues by monitoring not only the body movements but also the body position, obtaining a method to detect fast and slow falls. Position is calculated using high resolution barometric pressure sensors to compute the height difference between the chest and the feet. Motion sensors capture also the movements on these points, enabling to distinguish falls in contrast to daily life activities with similar body positions. Additionally, our system involves relatives and neighbours offering a new way of emergency response. Whenever a fall occurs, the system begins to communicate with the user in order to check how severe the injury is. Depending on the user reply, the system decides to call emergency medical assistance or to use a neighbour and family network to provide help for minor injuries. Therefore, we are capable of offering a fast aid attention, reducing unnecessary calls to emergency services and providing a self-determined life for older people with ongoing participation in their social environment. The presented contribution shows the developed system in detail and gives an overview about our first evaluation results.

V 142

Consolidation of virtual coaching technologies for tele-rehabilitation

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One out of six people in the European Union has a disability, usually caused by an acute episode or a chronic disease. Providing a suitable rehabilitation is the main issue for people as they age as it helps people to live independently and enhance their Quality of Life. However, as the rehabilitation period usually lasts some months, the continuity of care often is interrupted in the transition from the hospital to the home. Virtual Coaches can help these patients to proceed with a personalized rehabilitation that complies with age-related conditions. These are a key technology for empowering patients through the enhancement of the adherence to the care plan and the risk prevention.
The project *Virtual Coaching Activities for Rehabilitation in Elderly* addresses two major shortcomings of the status quo: a participatory design driven by the users' needs and the personalization of the care pathways enabled by technology. In fact, rehabilitation is an ideal setting for "users" (physicians and patients) interacting together for a longer period into the clinic. This allows to use the knowledge behind the clinical profiles and the clinical pathways that will drive the behaviour of the virtual coach at home.
The aim is to adapt existing AAL-services from former EU projects, such as eWall or Miracolus Life, to develop a holistic ICT-concept (information and communication technology) for an adaptive virtual coaching. Therefore, the ICT-concept will integrate a semantic layer (*universAAL*) including a reasoning engine that merges all patient-related and context information together. The research project consolidates the state-of-the-art on virtual coaching technologies and outlines a holistic concept for integrating these technologies. The findings shall be used to deploy these advanced services for virtual coaching on a telehealth platform (*FIWARE*-based).

V 143

The potential of psychophysical and health related knowledge for building automation control

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This work draws a comparison between psychophysical knowledge and normative values for building automation control concerning the regulation of indoor air parameters. Thereby, the considered environmental parameters, which are controllable and observable via building automation systems, are the air temperature, the relative humidity, the air movement, and the air change rate. Standards for building environment assessment and control give energy efficiency issues a top priority and possibly leave positive effects on the human's well-being out. Psychological experiments revealed recent knowledge about the effect of the environmental parameters towards the human's perception of the indoor air quality. Beside the air change rate, the temperature, the humidity, and the air movement have a major effect on the perceived air quality. However, these effects are unattended by the standards addressing the indoor air quality. The purpose of the comparison is the identification of differences in order to design a more adaptive and human-centered control method. Moreover, environmental factors with effects towards the human's well-being, like pollutant concentrations, are considered as well. Furthermore, knowledge gaps are identified and possible further investigations are presented. A general approach to enhance the control strategy of building automation systems, based on the comparison results and researched health related effects of environmental parameters, is discussed. Individual parameters like the origin or the metabolism, which are not observable via unobtrusive and retrofit sensors, may influence the human's comfort, but are too complex to include in the regulation process. In addition, the discussed strategy is focussed on the design of an initial building automation controller, which is nevertheless able to be adapted based on the user's preferences. In conclusion, the involvement of psychophysical and health related knowledge about environmental parameters is able to improve the control strategies of building automation systems and potentially reduces health risks and symptom appearances.

V 144

Determination of the capillary diameter from T2 and T2* measurements

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The mean capillary diameter is an important quantity to assess angiogenesis-induced changes in tumorous tissue, yet its value is usually two orders of magnitude smaller than the typical resolution in a MR-experiment. However, a detailed analysis of the T_2- and T_2^*-relaxation times allows estimating the mean capillary diameter: due to the susceptibility difference between blood filled capillaries and the surrounding tissue, local magnetic field inhomogeneities produce a small T_2^* and a long T_2-relaxation time for large capillaries. With decreasing capillary size, T_2^* increases, since the movement of spin-bearing particles compensate the field inhomogeneities. However, the T_2-time decreases, since a rephasing of the local magnetization is prevented by diffusion effects.
In this work, we analyze the dephasing process around randomly distributed capillaries. Yablonskiy and Haacke analyzed this geometrical model in detail for negligible diffusion (MRM 32:749, 1994). They could connect the signal around randomly distributed capillaries with the local magnetization around a single capillary. Ziener et al. could analytically solve the Bloch-Torrey equation to reveal the local magnetization around a single capillary for arbitrary diffusion effects (Ziener et al., PRE 85:051908, 2012). We generalize the results of Ziener et al. for spin echo experiments, apply the mechanism developed by Yablonskiy and Haacke and reveal analytic expression for T_2 and T_2^* in dependence on the regional blood volume fraction, the magnetic field strength, the capillary diameter and the diffusion coefficient. The results are numerically validated against random walk simulations and show a better agreement than previously developed approximations, especially for small radii (summarized in Dickson et al., JMR 212:17, 2011). Finally, a theoretical model of spin dephasing around randomly distributed capillaries is developed. The results show a good agreement compared to random walk simulations even for small capillary radii and thus, allow the estimation of capillary radii from T_2 and T_2^*-measurements.

V 145

How vessel architectural imaging depends on the vessel architecture

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Vessel architectural imaging (VAI) is a promising method in magnetic resonance imaging to gain information about the microstructure of the examined tissue. VAI simultaneously measures the spin-echo and gradient-echo signal during the injection of a bolus. The direction and shape of the gradient-echo spin-echo vortex curve are connected to microscopic tissue parameters.
So far, the vortex curve has only been qualitatively described (Kiselev et al., MRM 53:553, 2005), empirically analyzed (Stadlbauer et al., JCBFM 37:632, 2017, Emblem et al., Nat Med 19:1178, 2013) or numerically modelled (Kjolby et al., MRM 56:187, 2006).
In this work, we provide an analytical model of the vortex curve in dependence on the vessel radius, the regional blood volume fraction, the diffusion effect and the magnetic field strength.
The bolus injection leads to magnetic field inhomogeneities around the vessels. For large vessel radii, the gradient echo decays fast, whereas the spin-echo signal can be rephased. For intermediate vessel radii, diffusion effects lead to a decreased dephasing of the local magnetization. Thus, the gradient-echo signal decay slows down. However, the local magnetization can not be rephased with the spin-echo pulse due to the movement of spin-bearing particles around the vessels. For small vessels, the magnetic field inhomogeneities are compensated by strong diffusion effects around the vessels. For both, gradient- and spin-echo signal decay slowly.
Thus, for arterial vessels, the gradient-echo peaks before the spin-echo, since the vessel radii decrease during the passage of the bolus and the vortex curve possesses a clockwise direction. For venous vessels, the vortex curve possesses an anti-clockwise direction. Theoretical results are compared with measurements of patients with glioblastoma multiforme (3 Tesla) and mouse models (9.4 Tesla).
Summarized, the presented model quantitatively describes the vortex curve in vessel architecture and thus, allows an improved analysis of vessel architecture imaging measurements.

V 146

A simulation study in large receiver coil arrays for highly accelerated cardiac MRI

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In cardiac magnetic resonance imaging (CMR), both spatial and temporal resolved images of the cardiac cycle must be acquired in a reasonable time frame in order to comply with the patient's ability to be successfully scanned. Therefore, in CMR, parallel acquisition has impacted clinical applications such that nearly every cardiac examination is performed with an array comprising multiple surface coil elements. Receiver coil array simulation within realistic constrains are helpful for decision-making in coil design for magnetic resonance imaging, especially when the array comprises many surface coil elements. In this study, three different coil array arrangements utilizing 64 loop elements were systematically evaluated regarding their encoding capabilities for accelerated simultaneous multi-slice cardiac acquisitions. All array simulations were carried out within the constraints of realistic coil former geometries: *Array A*) 64-channel coil, loop diameter: 90 mm, overlapped design, symmetrically distributed. *Array B*) 64-channel, diameter: 70 mm, gapped array, symmetrically distributed. *Array C*) 64-channel, overlapped design but using a target specific loop size variation (diameters: 50-130 mm), where smaller elements are centered over heart and larger elements around the target region.
We used the fast volume integral equation solver MARIE to simulate acceleration capabilities of the different array arrangements. The simulation included a conductive dielectric load (σ = 0.71 S/m, ε_r = 63.8) using a meshed torso model. Excitation was emulated using a sinusoidal unit current at the Larmor frequency of 123 MHz. The complex reception profile of the coil was taken as the B1 component of the simulated field in the transverse plane. Besides, we calculated each array's mutual noise resistance matrix.
The novel array layout *C* consisting of small loop element near target region, but large once beyond the heart, showed the best encoding capabilities for simultaneous multi-slice cardiac acquisitions. Therefore, it seems to be well-suited for highly accelerated CMR.

V 147

Hyperpolarization without a polarizer: first 13C-MRI *in vivo*

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MRI is a powerful imaging tool but suffers from a low sensitivity, that severely limits its use for detecting metabolism *in vivo*. Hyperpolarization (HP) has demonstrated the enhancement of MRI signal by several orders of magnitude, enabling the detection of metabolism with a sensitivity that was hitherto inaccessible. However, typically, the production of HP tracers is slow and expensive, requiring a dedicated device ("polarizer").
Recently, we introduced a new, simple, low-cost (≈ 1000 €) method that does not require a polarizer, but enables the production of HP tracers within the MR itself (Schmidt *et al.*, Nat. Comm. 2017): by Synthesis Amid the Magnet Bore, A Dramatically Enhanced Nuclear Alignment (SAMBADENA) was achieved.
Here, we present the first *in vivo* application of SAMBADENA: No more than 8 s were required to produce one injection dose of a hyperpolarized angiography tracer within the MRI, next to an animal. Approximately 5 s later, the tracer was injected into the tail vein of an adult mouse (30 g, 14 weeks old), and 10 s later, ^{13}C-MRI was acquired, visualizing the vena cava, aorta and femoral arteries of the rodent.
The tracer used was 80 mM 1-^{13}C-2,3,3-$^{2}H_3$-hydroxyethyl-propionate (HEP), dissolved in ~ 700 µl H_2O, polarized to ~ 6 %, a ~10^5 fold enhancement at 7T, using 100% enriched *para*-hydrogen, *l*-PH-INEPT+ sequence and 4.4mM Rh-catalyst concentration. Static and dynamic (2 fps) ^{13}C-MRI were acquired using a single-shot one-slice RARE sequence in ~200 ms, with a 8.4 cm FOV and resolutions varying from 0.6 to 2.6 mm. All animals were measured under the approval of the local ethics committee.
While both HP and MRI leave room for optimization, this first SAMBADENA *in-vivo* ^{13}C-angiography demonstrates the potential of the method as a fast, simple, low-cost alternative for HP to unlock the hidden powers of MRI.

V 148

Towards current density imaging with ultra-low-field Nnclear magnetic resonance

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Magnetic resonance imaging (MRI) can be utilized for direct detection of small volume currents within the human brain possibly enabeling current density imaging (CDI) of externally applied currents and direct neuronal current imaging (NCI). The information gained with CDI, in combination with anatomical images obtained with the same device, can be utilized for dc conductivity mapping providing crucial a priori information for the electromagnetic inverse problem.
In CDI, the current density J generates a magnetic field B_J resulting in a measurable phase change in nuclear spin precession. In conventional high-field MRI, the B_0 field is fixed in spatial direction and magnitude limiting the detection of small currents. In comparison, ultra-low-field (ULF) MRI in the µ-Tesla range exhibits a much higher B_j-to-B_0 ratio and gives the possibility of current imaging in all spatial directions by appropriate pulse sequences. Simulations have shown that the most crucial step towards successful ULF CDI implementation is the achievement of sufficient signal-to-noise ratio.
We present an ultra-low noise single-channel SQUID system comprising a 45 mm diameter pick-up coil inductively coupled to a current sensor SQUID. We improved a custom made low-noise liquid helium dewar that houses the sensor to ensure negligible thermal noise. Operated inside the Berlin Magnetically Shielded Room BMSR2 we find an outstanding sensitivity only limited by thermal noise generated by the µ-metal walls. Utilizing a first order gradiometer we achieve a noise level of approximately 180 $aT/Hz^{1/2}$ at the pursued Larmor frequency of 1.6 kHz. We integrated the sensor system into an optimized ULF MRI setup that was designed to retain the low-noise performance while ensuring sufficient sample magnetization and field homogeneity. With this improved setup we are able to perform 3d head images and approach CDI in phantom experiments. In addition we present our efforts to implement CDI in vivo.

V 149

Susceptibility induced B_0 gradients effect on myocardium tissue DTI at high magnetic fields: analysis of shimming strategies

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The diffusion tensor imaging (DTI) plays an important role in cardiac MRI providing information on both structural and functional properties of myocardial tissue. To cover enough diffusion directions within a single breath-hold an EPI-readout is usually employed. This makes cardiac DTI extra sensitive to the B_0-inhomogeniety which are intrinsically strong within the heart due to heterogeneous structure and motion. Therefore, the adequate shimming strategy is crucial for getting DTI-images appropriate for reconstruction the tissue structure. Fresh ex-vivo pig hearts were used for measurements with spin-echo based (single-shot and segmented EPI-readout) and in-house developed stimulated echo based DTI sequences. Measurements were done on 3T and 7T Siemens Magnetom™ scanners (“Prisma” and “Terra”, respectively). The total TE-time and inter-echo distance (in segmented EPI) have been varied in order to study the effect on distortions in DTI at different B_0-gradients. For the 3..5mm measured slices the effect of shimming slab thickness and position was analyzed. The B_0-gradients maps were acquired using 3D-GRE phase images. The standard scanner-side DTI reconstruction was used to get essential diffusion parameters (ADC, fractional anisotropy (FA), first DT-eigenvector (E1) components). The analyzed parameters were: 1) bias and heterogeneity of ADC and FA distributions 2) integrity of the E_1-components described by cross-correlation of histograms and its relation with the local B_0-gradients. As expected, the heterogeneity of B_0-field and respective shortening of T_2* leads to increasing heterogeneity and bias of ADC and FA. The homogeneity of both improves for shimming volume matching measured slice. The integrity of the E_1 components distribution drops down essentially for the shimming volume displacement relative to measured. This means, that shimming covering the volume essentially larger than specific slice should be preferable for the high B_0-gradients in-vivo, if standard scanner algorithms are used. Alternatively, the dynamic shimming with the navigation to the measured slice should be applied.

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FS 84

Designing a distributed sensor system for the spectral analysis of ambient air

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Ambient air can contain a number of organic chemicals known as volatile organic compounds (VOCs). These VOCs can not only affect human health, but can also be seen as indicators for various health problems, if they are detected in human respiratory air. As part of the BMBF-funded project “fast care” (2016 – 2019), HarzOptics GmbH is developing a distributed sensor system for the spectral analysis of ambient air (SAMBA – Spectral analysis of AMBient Air) to be integrated into a larger, real-time health monitoring system for patients with chronic conditions. SAMBAaims to deliver highly accurate information on a) the quality of the ambient air itself and b) the long-term presence of small quantities of VOCs in ambient air. While general air quality data gathered will primarily be used for controlling home automation systems (air quality improvement), data gathered on VOC concentration will hopefully be usable as indicators for hitherto undiscovered health problems, provided that the monitored rooms are occupied by a single person for prolonged periods of time (e.g. overnight measurements in single bedrooms without outside air circulation). This presentation will present the first technical draft for SAMBA, outline the intended development project within the larger “fast care” context and present some of the difficulties connected with spectral detection of VOCs in ambient air.

FS 86

Optimization of dynamic properties of exo-prostheses using a distributed inertial measurement system

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Modern exo-prostheses enable the amputees to (re)gain an increasing number of abilities ranging from an autonomous gait at different velocities, through bicycle riding and jumping, up to alternating stair-climbing. At the same time, the complexity related to fitting and configuring these devices correctly increases due to a broad choice of components with different properties and a large number of control parameters in the prostheses. The state-of-art approach for provisioning an amputee is based on a subjective choice of components by a certified prosthetist orthotist (CPO), followed by an objective statical alignment process and again subjective tuning of prosthesis' parameters based on a visual assessment of gait dynamics by a therapist. The subjectivity in the latter phase of the provisioning process has been addressed in clinical research by the employment of motion capture systems based on infra-red (IR) cameras and reflective markers. Although such systems offer a high-level of accuracy in the estimation of gait kinematics, they are not-widely used due to their space requirements, high price and relatively long set-up times.
We propose a portable, compact and affordable measurement system based on a network of distributed wireless inertial sensors. The system can be set-up quickly and intuitively by a non-technician and used even in space-constrained facilities while achieving a level of accuracy in the estimation of gait kinematics comparable to visual motion capture systems. The measurement system is complemented with an expert system which is capable of online estimation of gait parameters, their visualization and the derivation of objective suggestions for tuning the configuration of the prosthesis by a CPO/therapist either directly or remotely. Furthermore, through the connection to a cloud-based storage the measured data can easily be compared with reference measurements for properly provisioned subjects, used for statistical evaluation and as a proof of a high-quality provisioning for reimbursement institutions.

FS 88

Presentation of a concept to support rehabilitation through realtime feedback/monitoring in the home environment

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To assure an appropriate medical and therapeutical care particularly in economically underdeveloped and rural areas, we implement an interdisciplinary and integrated approach to home care. In the project fast care (fast care – Echtzeitfähige medizinische Assistenzsysteme, BMBF; https://de.fast-zwanzig20.de/gesundheit/fast-care/), we develop, implement and evaluate a patient-related concept, covering the areas diagnosis, monitoring and therapy/exercise in rehabilitation. To acquire data as discreet as possible, mobile inertial sensors as well as a stationary camera and a depth sensor are integrated in the user's everday life. We aim to provide a real time feedback giving instantaneous gait corrections and additionally an exercise-related feedback allowing progress monitoring to support the user comprehensively. This concept is completed by an interface that allows a doctor or therapist to access measured data as well as to communicate with the user. Based on the collected data, an individual feedback can be given or adjustements to the treatment plan can be made. All interfaces in the depicted health care chain will be optimized to accomplish ultra low latency for the provided applications. The user benefits from a professional treatment by a specialist without having to overcome the long way to the doctor's office. This would help to preserve and improve the user's quality of life, in particular among people with limited mobility. After implementation, the application is evaluated with regard to effectiveness and user acceptance.

FS 89

Requirements of Low Latency Sensor/Actuator Networks for E-Health Applications

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fast care entwickelt ein echtzeitfähiges Sensordatenanalyse-Framework für intelligente Assistenzsysteme im Bereich Ambient Assisted Living, eHealth, mHealth, Tele-Reha und Tele-Care. Ziel ist die Bereitstellung eines medizinisch validen, integrierten Echtzeit-Situationsbildes auf Basis einer verteilten, ad-hoc vernetzten, alltagstauglichen und energieeffizienten Sensorinfrastruktur mit einer Latenzzeit von weniger als 10 ms. Das integrierte Situationsbild, das physiologische, kognitive, kinematische Informationen des Patienten umfasst, wird durch die intelligente Fusion der Sensordaten generiert. Es kann als Basis sowohl für die schnelle Erkennung von Risiken und Gefahrensituationen als auch für alltagstaugliche medizinische Assistenzsysteme dienen, die autonom in Echtzeit intervenieren und aktives telemedizinisches Feedback erstmals ermöglichen.
Für das echtzeitfähige Sensornetzwerk wurden verschiedene existierende Funkstandards evaluiert und hinsichtlich verschiedener Parameter qualifiziert. Ausgehend von den Use-Cases wird eine Systemarchitektur vorgestellt, welche für die Realisierung eines echtzeitfähigen Sensordatenanalyse-Frameworks für intelligente E-Health Assistenzsysteme ermöglicht.

V 150

Regional specific airway resistance determined by electrical impedance tomography and body plethysmography

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Electrical Impedance Tomography (EIT) is an imaging modality which can be employed to assess regional lung ventilation distribution in patients with obstructive lung diseases, such as chronic obstructive pulmonary disease or cystic fibrosis. Relative impedance changes within the lung corresponding to lung function parameters, such as the ratio of the maximal volume of air exhaled within the first second of a forced expiration and forced vital capacity (FEV_1/FVC) or the ratio of maximum expiratory flows at 25% and 75% of vital capacity (MEF_{25}/MEF_{75}), have been used to evaluate airway obstruction and ventilation inhomogeneity in these patient groups. Patients with obstructive lung diseases usually show a more inhomogeneous ventilation distribution compared to lung-healthy subjects.
A new method calculating regional specific airway resistances (reg_sRaw) within the lung utilizing EIT and body plethysmography derived data, which might be useful to identify obstructed lung areas, should be introduced. Body plethysmography is a well-established method for pulmonary function testing providing global lung parameters. A system combining EIT and body plethysmography is applied to determine regional impedance changes within the lung and pressure changes within the box of the body plethysmograph during normal tidal breathing. EIT images with a resolution of 32 × 32 pixels representing the distribution of relative impedance changes within the lung are obtained. Measured relative impedance changes correlating with air volume changes are derived to get an EIT flow signal for each pixel. The EIT flow is plotted against changes in box pressure during a tidal breath resulting in a ‘breathing loop’ for each pixel. The reg_sRaw for each pixel is defined as the reciprocal slope of a ‘breathing loop’ and can be used to generate functional EIT images indicating regional airway obstruction.
This method might be useful to identify regional airway obstruction in spontaneously breathing patients with obstructive lung diseases.

V 153

New method for an interpolation of physiocal sequences in continuous blood pressure data

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Continuous blood pressure measurement using Finometer Pro (Finapres B.V.) is an established method in research. In standard setup, recordings are interrupted by Physiological Calibration (Physiocal) sequences of 2–4s every minute. In frequency and correlation analysis, these sequences lead to prominent artefacts which should be reduced by interpolating these Physiocal sequences.
In this work, we present a novel interpolation method that detects the Physiocal sequences by their flat signal shape and removes them until the next diastolic peaks. An artefact free signal part with roughly the same length is taken from the signal shortly after this sequence and fitted to the Physiocal sequence by resampling and linear compensation of the gradient.
For evaluation, 24 artefact free blood pressure datasets of 8 volunteers with a length of 400s each were recorded with Physiocal switched off manually. Artificial measurement gaps with durations of 2–4s were randomly generated every 50–60s. Measurement gaps were filled up by the new interpolation method. In comparison, the gaps were filled up by (a)zeros, (b)the mean value of the remaining data and by (c)linear interpolation. Results are compared to original signal in full frequency range and in frequency ranges of typical cardiac changes between 0.02-0.07Hz and 0.07-0.15Hz by calculating the mean differences and the correlation coefficients.
Mean difference of the new algorithm is 0.86mmHg compared to 7.9mmHg(method a), 1.2mmHg(b) and 1.6 mmHg(c) in full frequency range. Correlation coefficient is 0.96 compared to 0.53(a), 0.96(b) and 0.92(c). In the frequency range of 0.02-0.07Hz, mean difference is 0.66mmHg compared to 13.0mmHg(a), 1.2mmHg(b) and 2.7mmHg(c). The new interpolation method leads to a signal more similar to the original compared to standard interpolation methods. The benefit of the new interpolation method is more prominent in lower frequency ranges whereas higher frequency components in heart rate like extrasystoles cannot be reproduced.

V 154

Multivariate high resolution joint symbolic dynamics (mHRJSD): a new tool to analyze couplings in physiological networks

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During the last years methods for analyzing complex physiological regulatory networks have been developed. These methods allow to analyze couplings in dynamic systems. Recent advances in nonlinear dynamics and information theory facilitate a multivariate study of information transfer between time series.
In this study, we introduce a new tool to analyze multivariate couplings – the multivariate high resolution joint symbolic dynamics method (mHRJSD) based on a redundancy reduction strategy and the analysis of dynamic processes by means of symbols. MHRJSD is characterized by three symbols, a threshold for time series transformation, and 8 coupling pattern families. Therefore, three time series were transformed into a multivariate symbol vector, where symbol sequences with increasing values were coded as "2", decreasing values were coded as '0' and unchanging (no variability) values were coded as '1'. Afterwards the symbol vector was subdivided into short words of length three (27 different word types). Afterwards, all single word types were grouped into 8 pattern families (E0, E1, E2, LU1, LD1, LA1, P, V) representing different aspects of autonomic modulation, and were sorted into an 8x8x8 pattern family density matrix resulting in 512 coupling patterns.
MHRJSD was validated by test signals of 30 min length where typical autonomic regulation patterns were simulated. Therefore, specific signals (ranging from simple ones to highly complex ones, e.g. E0/E0/E1, and E1-P-LU1/E1-V-LA1/E0-LD1-LU1) were simulated including all possible types of word of the 8 patterns (E0, E1, E2, LU1, LD1, LA1, P, V). The obtained mHRJSD results were checked, whether the family patterns were correctly detected and classified.
The simulation results showed that mHRJSD is able to detect all possible combinations of pattern family within artificial time series. The mHRJSD approach extending univariate and bivariate symbolic methods seems to be a promising method of analyzing coupling in physiological networks.

FS 91

Development of a viscosity model for a silicone rubber 3D printing process

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Medical rapid prototyping of individualized implants has become a major field in additive manufacturing. Several rapid prototyping techniques were developed to fabricate e.g. individualized bones and orthopaedic implants. Although these techniques can be used for a wide range of experimental applications, no printing technique is available for silicone-rubber-based neural implants e.g. cochlear implant electrodes or electrocortical grid. To close this gap, we presented a silicone rubber 3D printing process.
Since the standard “medical grade” silicone rubber are thermal-curing liquids, an infrared high-speed-curing system was used which heats up the printed silicone rubber instantly and thereby cures the initially viscous silicone rubber material before it spreads out during the curing process. To optimize the fabrication accuracy and resolution of this system, a time-temperature profile for the curing process should be evaluated, where the spreading of the silicone rubber material is minimal. Therefore, further knowledge about the curing mechanisms and the rheological behavior of the silicone rubber is mandatory. As the spreading dynamics of polymeric liquids depends mainly on the viscosity of the polymeric liquid, a rheology model was developed which correlates the infrared heat-related temperature-time profile with the curing-related viscosity rise and the temperature related viscosity fall.
Two commonly used silicone rubbers (Silpuran 2430 and 2440, Wacker Chemie AG) were characterized with a vulcameter at different isothermal temperatures (35°C - 70°C). Their isothermal viscosity curves were correlated to their temperature-time profiles via an empirical viscosity expression by using a two-stage Arrhenius equation. To cope with a realistic nonisothermal curing process, a time-temperature integral for the degree of cure was introduced into the isothermal model and tested at different heat rates (5 K/min - 60 K/min).
Good correlations were observed, giving the ability to optimize the curing conditions of the curing process to the rheological behavior of the used silicone rubber.

FS 92

Direct acoustic stimulation with the codacs™

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Currently available conventional hearing aids often do not provide sufficient benefit to patients with severe-to-profound mixed hearing losses (MHL). The new implantable hearing system Codacs™ was designed to close the treatment gap between active middle ear implants and cochlear implants in cases of severe-to-profound mixed hearing loss. The so called Direct Acoustic Cochlea Implant (DACI) uses a piston prosthesis in a stapedotomy that directly provides acoustic input to the perilymph. Comparison of outcomes with Cochlea Implant (CI) recipients demonstrate that for patients with sufficient cochlear reserve speech intelligibility in noise is significantly better with the Codacs™ than with a CI (Kludt et al., 2016). On the other hand, results with conventional hearing aids show less benefit than what can be obtained under optimal conditions (PBmax, Hoppe et al., 2016). Here our results indicate that the benefit is significantly better in Codacs™ patients than with conventional hearing aids. Reports that the Maximum Power Output (MPO) of the Codacs™ covers the residual dynamic range even in severe hearing loss patients (Zwartenkot et al., 2014) and own experimental and clinical results support these findings. Furthermore long term analysis up to 5 years gives no indication for an accelerated presbyacusis by direct stimulation.
Our results indicate that for patients with sufficient cochlear reserve, speech intelligibility in noise is significantly better with the Codacs™ than with a CI. On the other side Codacs™ results are close to what can be obtained under optimal conditions (PBmax) and there are no indications for negative long term effects.

FS 95

Adaptive anticoagulant polymer coatings for blood contacting medical products

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We report about feedback-controlled anticoagulant hydrogels obtained by crosslinking of the anticoagulant heparin with star-shaped poly(ethylene glycol) using peptide linkers, which are selectively cleaved by different activated blood coagulation factors acting as proteolytic enzymes. The hydrogel system delivers heparin in amounts triggered by the environmental levels of enzymes of the coagulation cascade, which in turn become inactivated due to released heparin. The approach was explored for cleavable peptide units differing either in their thrombin turnover rates or in their responsiveness to factors activated earlier in the course of blood coagulation, were used for the formation of the biohybrid materials. Release triggered by the early coagulation factors Xa (FXa) or FXIIa/kallikrein was shown to enhance the efficiency of the released anticoagulant. Furthermore, FXa-cleavable gels enabled a faster release of heparin, which was attributed to the lower affinity of the factor for heparin. Combining early and fast responses, FXa-cleavable gels were shown to provide anticoagulant protection of biomaterial surfaces at low levels of released heparin in human whole-blood incubation experiments. These features provide sustainable, autoregulated anticoagulation, addressing a key challenge of many medical therapies. To combine anticoagulant and antiseptic characteristics, we furthermore incorporated silver nanoparticles in anticoagulant poly(ethylene glycol) (PEG)-heparin hydrogel coatings deposited on thermoplastic polyurethane materials commonly used for vascular catheters. For prolonged antimicrobial activity, the silver-containing starPEG-heparin hydrogel layers were shielded with silver-free hydrogel layers of otherwise similar composition. The resulting multi-layered gel coatings showed long term antiseptic efficacy against Escherichia coli and Staphylococcus epidermidis strains in vitro, and similarly performed well when incubated with freshly drawn human whole blood with respect to hemolysis, platelet activation and plasmatic coagulation. The introduced hydrogel multilayer system thus offers a promising combination of hemocompatibility and long-term antiseptic capacity to meet an important clinical need.

FS 96

Innovation Strategies for Cardiovascular Implants – magnesium scaffold and TAVI

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Drug-eluting stents (DES) reduce restenosis rates compared with bare-metal stents and are the present default device for percutaneous coronary intervention. However, concerns have been raised about the use of DES, such as the risks of delayed arterial healing, late and very late stent thrombosis, hypersensitivity reactions to polymers, and accelerated in-stent formation of neoatherosclerosis.
Bioresorbable scaffolds (BRS) were designed to overcome these limitations. So far, two drug-eluting polymeric BRS have received CE-mark approval. BRS designs should ensure sufficient but temporary scaffolding with performance similar to metallic DES with respect to recoil, healing, and restenosis rates, followed by safe degradation and absorption, enabling restoration of vasomotion and prevention of late unfavourable effects of metallic stents. In contrast, a magnesium-based metallic BRS was developed as an alternative to polymeric scaffolds. Its safety and performance in symptomatic patients with de-novo coronary artery lesions was assesed in the BIOSOLVE-II study. This novel metallic BRS could be an alternative to polymeric BRS for treatment of obstructive coronary disease.
Another predominant research focus in cardiovascular intervention is the development of novel devices for transcatheter-aortic valve implantation (TAVI). Technical breakthrough was achieved with the introduction of fully retrievable and repositionable prostheses. Current activities are aimed at optimizing perioperative results by facilitating valve implantation and consequently reducing risk of sub-optimal hemodynamic valve performance. Moreover, timely preoperative analysis of native aortic valve anatomy, including correct sizing as well as depiction of the calcification amount and distribution, play a major complementary role in enhancing procedures and ensuring satisfactory device performance. In addition, other technical aspects, such as the reduction of catheter size for improved implantation through radial access, annular sealing to reduce leakage, and new artificial leaflet materials as a replacement for xenogene pericardium, have to be managed to overcome current limitations, and to create a new generation of device.

FS 98

Stenting the Eustachian tube – a new treatment concept for chronic otitis media

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Chronic otitis media is a frequent problem that affects approximately 2 million people in Germany. The main underlying pathophysiology is the impaired function of the Eustachian tube which equalizes the pressure between the middle ear and the environment. Several concepts have been tried to overcome chronic tube dysfunction with a very low success rate. The stent concept overcomes the major reason for Eustachian tube dysfunction which is located in the cartilage part. Stents will keep the tube open while the nasal orifice can be actively opened and closed during swallowing.
Method: Cardiovascular stents have been designed to be placed into the Eustachian tube stenting the cartilage part lateral to the nasal orifice. Design parameters have been determined using models of the human and black sheep cadaver. The stents were positioned into the Eustachian tube and the position validated by endoscopy, CT-scan and histology.
Chronic sheep experiments have been performed for 3 months and the position of the stents were checked by a CT-scan and endoscopy. The tissue reaction was examined by histology.
Results: Stents can be reliably positioned in the cartilage part of the Eustachian tube with no signs of migration. The stents keep the Eustachian tube open, middle ears appeared ventilated. Only a mild tissue reaction can be observed in bare metal stents, drug eluting stents and absorbable stents.
Conclusion: Stents for the Eustachian tube seem to be a feasible treatment option for patients with a chronic Eustachian tube dysfunction. The optimized stent design will be tested in chronic animal experiments and thereafter first prototypes for human use will be further tested for their biocompatibility and mechanical properties.

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Electrospun fleeces in drug delivery

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Electrospun nano- and microfibers can be prepared from a large number of polymeric biomaterials. It was already possible to encapsulate antibiotics and various other drugs. As well as proteins and growth factors can be successfully incorporated into electrospun fibers. Due to special features like large surface to volume ratio electrospun fleeces have an outstanding potential in drug delivery developing sophisticated delivery systems for drugs, large bioactive agents or cells. Depending on the type of the carrier polymer and according to the properties of the incorporated substance the drug release can be adjusted in a wide range. Also the use of various electrospinning techniques enables further fine tuning of the drug release properties.
Our studies describe the fabrication of metronidazole-loaded fibers. The hydrophobic drug was dissolved together with the carrier polymer in an organic solvent or alternatively in a suitable polymer melt by extrusion before electrospinning. Based on the organic solutions and melts single fiber fleeces were generated. In a co-electrospinning approach core-shell electrospun fibers were prepared using coaxial nozzles. These coaxial fibers with encapsulated metronidazole in the core led to a sustained and controlled release circumventing e. g. a high burst release due to the diffusion barrier of the shell. It was also possible to produce multi-drug delivery systems whereby metronidazole was combined with ampicillin as second antibiotic. First, both antibiotics were combined in a single fiber fleece of one polymer. Using a dual electrospinning nozzle system, fleeces were prepared containing different fibers with one antibiotic in one polymer fiber. Additionally fleece layers were created which are stacked on top of each other.
The metronidazole release from the generated delivery systems was investigated showing significant differences depending on the used carrier polymer and especially the applied technique emphasizing electrospun drug-loaded fleeces for development of well adapted application-specific drug delivery systems.

FS 101

Status and perspectives of NanoBioMedicine in Germany and Europe

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Nanotechnology is one of the Key Enabling Technologies (KET) for the development of new and especially personalised products for diagnosis and therapy of many diseases. In this very interdisciplinary field, called NanoBioMedicine, not only close collaboration of chemists, physicists, biologists and engineers is necessary but also an intense dialogue between industry and regulators to bring safe and efficacious nanobiomedicines to patients. The interaction of such diverse stakeholders requires an intense communication, which is enabled and managed by the German platform for NanoBioMedizin.
The aim of the platform founded by 90 representatives from research organisations, industry and government agencies in 2015 is to bring results of nanobiomedical research faster and more efficiently to the patient. The means to achieve this are described by the members in a position paper and action plan. Both papers detail the R&D topics and structural requirements for a dynamic development of NanoBioMedicine in Germany and put them into perspective with the strategic research and innovation agenda of the European Technology Platform Nanomedicine. The presentation will highlight the trends described in these papers.

FS 102

Cell transplantation in lumbar spine disc degeneration disease

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Introduction: Low back pain is an extremely common symptom, affecting nearly three-quarters of the population sometime in their life. Given that disc herniation is thought to be an extension of progressive disc degeneration that attends the normal aging process, seeking an effective therapy that staves off disc degeneration has been considered a logical attempt to reduce back pain. The most apparent cellular and biochemical changes attributable to degeneration include a decrease in cell density in the disc that is accompanied by a reduction in synthesis of cartilage-specific extracellular matrix components. With this in mind, one therapeutic strategy would be to replace, regenerate, or augment the intervertebral disc cell population, with a goal of correcting matrix insufficiencies and restoring normal segment biomechanics. Biological restoration through the use of autologous disc chondrocyte transplantation offers a potential to achieve functional integration of disc metabolism and mechanics.
Methods: We designed an animal study using the dog as our model to investigate this hypothesis by transplantation of autologous disc-derived chondrocytes into degenerated intervertebral discs. As a result we demonstrated that disc cells remained viable after transplantation; transplanted disc cells produced an extracellular matrix that contained components similar to normal intervertebral disc tissue; a statistically significant correlation between transplanting cells and retention of disc height could displayed.
Results: Following these results the Euro Disc Randomized Trial was initiated to embrace a representative patient group with persistent symptoms that had not responded to conservative treatment where an indication for surgical treatment was given. In the interim analyses we evaluated that patients who received autologous disc cell transplantation had greater pain reduction at 2 years compared with patients who did not receive cells following their discectomy surgery and discs in patients that received cells demonstrated a significant difference as a group in the fluid content of their treated disc when compared to control.
Discussion: Autologous disc-derived cell transplantation is technically feasible and biologically relevant to repairing disc damage and retarding disc degeneration. Adipose tissue provides an alternative source of regenerative cells with little donor site morbidity. These regenerative cells are able to differentiate into a nucleus pulposus-like phenotype when exposed to environmental factors similar to disc, and offer the inherent advantage of availability without the need for transporting, culturing, and expanding the cells. In an effort to develop a clinical option for cell placement and assess the response of the cells to the post-surgical milieu, adipose-derived cells were collected, concentrated, and transplanted under fluoroscopic guidance directly into a surgically damaged disc using our dog model. This study provides evidence that cells harvested from adipose tissue might offer a reliable source of regenerative potential capable of bio-restitution.
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FS 103

Challenges in the drug release testing of Nanomedicines

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Despite the tremendous advances in drug delivery, the limitations of the analytical technologies involved in the characterization of nanomedicines are impeding further progress of an emerging market. Discriminating the drug release profile between different formulations is one of the most important quality criteria in development and quality control of pharmaceuticals and biopharmaceuticals. Unfortunately, there are only few methods available to sensitively measure this important parameter for nano-sized carriers. The wide range of materials and formulations used in drug therapy also requires different approaches for various types of formulations. Currently, there are several methods available for the release testing of orally administered nanocrystal formulations. In many of these, sampling procedures entail a risk of disrupting the carrier structure resulting in a more rapid drug release. Other technologies relying on dialysis are of limited sensitivity and do not discriminate well between different formulations or batch qualities. In this context, the barrier properties of the dialysis membrane are rate limiting to the drug released from carrier system. With the development of the dispersion releaser technology, a novel dialysis-based technique will come into market. In future, it may be used to support formulation development with a more reliable methodology to improve nanotechnology based products.

FS 105

On the road to biomimetic implants by additive manufacturing using functional organic materials

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Biomimetic implants would mimick natural structures by their design as well as by their chemical composition. Shape forming of objects by additive manufacturing is possible for a variety of metallic and ceramic materials as well as for a number of soft matter systems. Our goal is to widen the path to use functional organic materials in order to create biomimetic structures and surfaces for the design of functional implants. Therefore, complex polymer based systems are being developed that are well suited to be shaped by additive manufacturing. The materials have to match the technical needs of the process and at the same time the needs of biocompatibility and biofunction. They should form artificial structures that mimick natural body parts. We present an approach towards creating artificial articular cartilage and artificial vascular structures.

V 157

Determination of focal spot size for linear accelerators: comparison of experiment and simulation

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Purpose: The focal spot size of photon beams is an important parameter of linear accelerators with main impact on beam penumbra and in small fields also on the output factor. Several methods have been proposed to determine the spot size but use in clinical routine is often challenging. In this work, we compare two methods with simple experimental setup, the iterative maximum-likelihood-estimation-maximization-(MLEM)-algorithm (Papaconstadopoulos,2016) for beam profiles and direct imaging using a beam-spot-camera.
Methods: For both methods dose distributions were measured using radiochromic film (Gafchromic-EBT3) scanned with an EPSON 10000XL and evaluated using software written in MATLAB. The MLEM algorithm will update the source distribution after each iteration step. Reasonable stopping criteria were found through Monte-Carlo simulated data. The beam-spot camera consists of closely packed layers of lead (thickness 0.34mm) and polycarbonate (Lexan;0.26mm) with a length of 20cm. The full width-at-half-maximum (FWHM) of the dose profile was measured for various distances between the x-ray target and the film. An extrapolation of the FWHM-values was used to determine the spot size.
The experimental measurements were performed on a Varian TrueBeam and an Accuray CyberKnife. The measurements were done by different collimator-settings and source-detector-distances. Both methods were validated through Monte-Carlo-Simulations using EGSnrc-code.
Results: The accuracy of the reconstruction methods towards the simulated data lies within 0.4mm/0.2mm (MLEM/Camera). The measured source size using a 20mm collimator in crossplane results in 2.22(±0.15)mm / 2.61(±0.39)mm for the CyberKnife and in 1.19(±0.17)mm / 1.36(±0.65)mm for the TrueBeam. Results for inplane measurements were 2.24(±0.30)mm / 3.25(±0.08)mm (CyberKnife) and 1.43(±0.18)mm / 1.29(±0.09)mm (TrueBeam).
Conclusion: Both methods can be used to measure focal spot sizes of photon beams with high accuracy. Our simulations indicate that accuracy of both methods can further be improved by applying correction factors. The MLEM method needs less beam-on-time but is very sensitive to stopping criteria.

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The photon-brachytherapy radiation quality-index Q^{BT}

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Radiation sources for photon-brachytherapy are calibrated in terms of the air-kerma rate or air-kerma-strength, while the dose is prescribed in terms of the absorbed dose to water. Thus, the clinical medical physicists have to convert the data. But, many brachytherapy treatment planning systems use the AAPM-TG-43-formalism, assuming that only one source is used and that the body is infinite homogeneous water without heterogeneities. This can cause dose deviations. Prior to clinical application of a new brachytherapy treatment method, dose distributions have to be measured. The response $R(\bar{E}_F)=(D_{Det}/D_w)x(M-M_0)/D_{Det}$ of dosimetry-detectors can be described as product of two independent components, both being strongly energy dependent. For probe-type dosimetry, the mean photon energy $\bar{E}_F$ has to be known at the measuring position. Not every user has the possibility of MC-simulation to determine $\bar{E}_F$. The external beam radiation quality index $Q^{TT}=TPR_{20/10}$ is not valid for brachytherapy. But, the photon-brachytherapy radiation quality-index $Q^{BT}=(D_{prim}(2cm))/(D_{prim}(1cm))$ allows to determine $\bar{E}_F$. Q^{BT} can be derived easily from published primary- and scatter-separated dose-data. As $Q^{BT}(E_F) = (1/4)\ e^{-\mu\ x\ 1cm}$ and $\mu(E)$ is tabulated, the mean effective energy of the primary radiation can be determined for all commercially available brachytherapy photon sources at the AAPM TG-43 reference position (r=1 cm; θ=90°) and can be converted for the total radiation at the measuring position by using published data. The primary spectrum and thus Q^{BT} depend on the design of the source-type and its active length. This photon-brachytherapy radiation quality-index Q^{BT} characterize the penetration power and the potential of scatter-production. Some national metrological institutes, e.g. PTB, have developed $D_{w,1}$-primary standards. There is still the need to develop and use suitable $D_{w,1}$-secondary- und -transfer-standards for traceability. Also brachytherapy dosimetry-detectors should be calibrated under brachytherapy conditions, e.g. with a ^{60}Co-brachytherapy source. The terminology of photon-brachytherapy dosimetry has recently been actualized: DIN 6803-1:2016-10.

V 159

Quality assurance for interstitial brachytherapy using a hybrid flexitron afterloader system

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Interstitial multi-catheter brachytherapy is one treatment option for breast cancer after breast conserving surgery. In order to ensure the success of the therapy, detection of errors prior to treatment is important. This study explored whether an electromagnetic tracking (EMT) system integrated into a prototype afterloading system can be used for error detection.
Between 10/2016 and 03/2017 the implant geometry of 10 patients treated with HDR brachytherapy was acquired at each treatment fraction. The catheter traces were tracked using a prototype afterloading system (Flexitron, Elekta, The Netherlands) equipped with a 5 degrees of freedom EMT sensor and an Aurora EMT system (Northern Digital Inc., Canada). Prior to estimating the patient implant deviations, the reliability of the evaluation routine was assessed using a phantom study. Each catheter trace from the EMT measurement was registered onto the reconstructed catheters from the planning CT images and to well-defined points in the calibration phantom independent of any imaging distortion. Based on a fitting function, the dwell positions (DP) are reconstructed from the EMT measurement and compared to the DP defined in treatment planning.
In the phantom study, the tracked catheters were registered to the CT catheters with a precision of 0.52 mm and to the calibration catheters with a precision of 0.49 mm. The reconstructed DP showed a RMSE of 0.39 mm to the CT data. The user variability of manual catheter reconstruction in the planning CT, and the accuracy of the EMT were the limiting factors to acquire a precise evaluation. The detailed analysis of patient data is ongoing but first estimations showed a registration error of 0.75 mm and a DP RMSE of 0.49 mm, when comparing the treatment DP and the measurement at the CT table just after the planning CT image was acquired. Nonetheless, the proposed methodology made it possible to detect manually introduced shifts and swaps.

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Sensitivity analysis of QA procedures by failure injection in treatment plans

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Even though most of QA methods for patient treatment and machine QA are standardized, the real sensitivity for failure detection is rarely analyzed. In this study we investigate the sensitivity of QA methods and equipment to artificial failures. Within this abstract, only a short summary of the results can be given. Failure injection was done by modifying RT-DICOM plans and direct machine parameter modification to test "morning check" and the VMAT treatment plan checks. Changes to the beam limiters (MLC&Jaws) and the meterset modifies the field and the delivered dose. On dynamic plans, modification is done with temporal modulation as well. QA BeamChecker+ is used for detection of simple static field symmetry modifications. All measurements are done on Truebeam LINACs (Varian). Treatment plans for VMAT were created in Eclipse and modified with an in-house software. A Delta4 Phantom is used for measurement of dynamic plans and the ScandiDos Delta4 software for analysing the results.
Measurements were performed by introducing errors in a stepwise manner to adjust the nominal value. Asymmetric shrinking and moving of the beam field in the static case corresponds to measured symmetry and flatness. In the VMAT plan, when an offset is applied to all control points in one MLC group, the plan would not pass at our standard gamma criterion 2%/2mm (+0.6mm offset gives pass-rate (PR) of 94%, +1mm PR 85%). Smaller effects are investigated with temporal modulation of single MLC leafs. Opening one leaf by +10mm for 10% to 90% of beam time reduces the PR from 95% to 85%. Failure injection through arbitrary beam aperture and dose rate modifications allows a deeper understanding of the QA methods used. It is possible to identify gaps in the QA and discover the limits of accuracy. In future an automatic approach could increase precision and reduce workload.

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Monte-Carlo simulation of proton treatments to support treatment planning and patient-specific quality assurance

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Monte-Carlo (MC) methods represent very useful tools to complement, support and validate analytical treatment planning systems (TPS), as well as to save experimental beam time. The purpose of this work was to provide an experimentally validated MC-based treatment planning workflow at University Proton Therapy Dresden (UPTD).
A software framework, using the MC tool TOPAS, was developed and experimentally validated, which simulates proton treatment plans at the UPTD. Clinical treatment plans (brain, prostate) and computed tomography (CT) datasets were imported in DICOM format. Implementation of CT-number to material conversion and of patient-specific hardware (apertures and compensators) was experimentally verified. MC-based dose distributions were compared to the TPS XIO. Simulated dose, linear-energy-transfer (LET), and relative-biological-effectiveness (RBE, using measured *in vitro* RBE) data and the XiO plan were imported into the TPS RayStation for plan evaluation.
Comparison of absolute MC and planned TPS dose inside the high-dose volume (> 95% dose prescription) resulted in high gamma pass rates ≥ 98% (1 mm, 2 % dose). Outside, dose differences reached values up to 8 Gy (>10% prescribed dose) for volumes up to 4 cm^3. These were particularly found at the field edges and regions with high-density gradients (e.g. bone and air cavities). LET and variable RBE hot spots were obtained at (distal) field edges while RBE values below 1.1 were predicted at the field center. Clinical dose values (dose times RBE) differed by up to 10 Gy (>15% prescribed dose) comparing the assumptions of either a constant (1.1) or a variable RBE.
Experimentally validated MC-based treatment planning and delivery at UPTD has been mapped into a clinical TPS. Relevant clinical dose differences between TPS and MC were obtained. Therefore, MC simulations should be used to support treatment planning and patient-specific quality assurance in proton therapy.

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Unification of patient dosimetry and quality control for CT and CBCT

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The recent EFOMP-IAEA-ESTRO guidelines for quality control of CBCT devices demonstrate the unification of the image quality control in all kinds of CBCT. Indeed also multi-detector CT (MDCT) can be checked using the same tests for high and low-contrast resolution, uniformity, CT numbers, artefacts and geometrical stability. We have studied the applicability of estimations of incident air kerma to unify also the dosimetry in both modalities, not only for quality control but also for patient dose estimations.
Empty scans of the most common protocols were performed in CBCT systems of a linac, a C-arm and a dental scanner, as well as in a MDCT. Incident air kerma (without backscatter) was measured at the flat panel in the CBCT systems and at the isocentre in the MDCT using a solid-state probe. The average $K_{a,i}$ at the skin of a hypothetical patient head $K_{a,i}$(skin) was subsequently calculated using the formula derived for each modality. A kerma-area product meter and thermoluminiscence dosimeters (TLD) were used for comparison.
The corresponding Ka,i(skin) were 3.33±0.19 mGy (dental scanner); 15.2 ± 0.8 mGy (C-arm, high dose protocol); 3.23±0.16 mGy (linac, head protocol) and 13.9 ± 0.7 mGy (MDCT, head protocol). The TLD measurements for the MDCT provide readings between 10.3 ± 1.1 mGy and 13.8 ± 1.4 mGy. The KAP meter attenuates the beam intensity by 8 % (125 KVp) up to 13 % (80 KVp).
The $K_{a,i}$(skin) is as easy to estimate as other quantities for quality control and, as opposed to the other quantities, represents actual patient exposure. Therefore it can be useful for both quality control and patient dose estimations.

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Evaluation of the performance of the integral quality monitor

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Pre-treatment verification of IMRT and VMAT plans is mandatory to ensure the correct application of these complex techniques. However, it is desirable to facilitate the often time consuming QA process without compromising quality. The Integral Quality Monitor IQM (iRT Systems, Germany) is a detector mounted on the gantry head, which suggests such improvements mainly by very limited user-interaction, less chance of setup errors and the possibility to measure fields up to 40x40cm². The detector is a large ionization chamber with varying distance between the electrodes in MLC direction for a position-dependent signal. For each field segment a value similar to a dose-area product is measured and compared to a calculated reference.
We evaluated the detector for its suitability for clinical use for a period of over two years of beta-testing on a Synergy with Agility MLC (Elekta, Sweden). Long term reproducibility was tested by measuring plans repeatedly over a period of half a year resulting in <1% standard deviation. The detector has only a small effect on the beam and absorption can be accounted for by an energy-dependent factor. Measured signals of over 200 IMRT fields of different treatment regions were on average 0.2% below and 0.4% above the calculated value with a 1.3% and 1.4% standard deviation for standard-sized and long IMRT fields respectively. The largest deviations were observed in Mamma IMRT fields. Measurements of artificial and three clinical plans showed that a 2% warning and 3% action tolerance allowed to detect a variety of induced errors.
We concluded that the IQM detector is an adequate IMRT QA tool for a range of treatment plans. Its strengths are especially the easy handling and verification of large fields otherwise cumbersome to verify with many other QA phantoms. The evaluation of the performance of VMAT is in progress.

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Detection of proton range variations in a clinical scenario via prompt gamma-ray timing

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Proton therapy has been established as an important technology used in cancer treatment. Due to the interaction behavior of charged particles with matter, patients treated with protons benefit from the precise deposition of the dose in the tumor volume. Currently, proton beams cannot be tracked in the patient's body during the irradiation. To overcome this obstacle, different methods are under discussion, which aim at the verification of the proton range in real time during the treatment.
One approach is the Prompt Gamma-ray Timing (PGT) method, which aims to reconstruct the range information of the primary protons out of measured time-resolved emission profiles (PGT-spectra) of promptly emitted gamma rays, which are produced along the particle track in the tissue. After verifying this novel technique in first proof of principle experiments, we intend to translate PGT into clinical practice. The requirements comprise for example low beam currents and short irradiation times, which challenges detectors, electronics and data acquisition. Therefore the hardware is extensively tested and characterized in a clinical scenario with realistic treatment plans and beam parameters.
The general applicability of the developed PGT detection system will be shown by presenting first results of uncollimated measurements carried out in the treatment room of the Universitäts Protonen Therapie Dresden. In the experiment the data acquisition system stored the energy and timestamp event per event in listmode for further analysis. Thereby, it was possible to assign the recorded PGT-spectra with the single beam spots of the correlated treatment plan. Despite of the limited statistics, it was possible to detect range shifts in a PMMA target, induced by cylindrical air cavities with thicknesses of up to 5 mm by analyzing the statistical moments of the prompt gamma distribution.

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Computer-controlled analysis of solid state nuclear track detectors

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The Karlsruhe Institute of Technology (KIT) uses a passive measurement method with polycarbonate detectors (thickness: 300 µm, area: 250 mm²) to determine Radon-222 air concentration. The alpha radiation emitted from Radon-222 generates initially invisible nuclear tracks (n-tracks) in the detector material. In a postprocessing etching step, visible etching craters (e-craters) form around the n-tracks.
For automatic analysis of the detectors, KIT develops a system for a Computer-controlled Analysis of Radon Detectors (CARD). The hardware setup comprises a computer-controlled x-y-stage (travel range: 150 x 150 mm²), a tray for 40 detectors, an LED light panel, a microscope with a camera (resolution: 1628 x 1226 pixels, 1.6 µm/pixel) and a computer for control and image processing. First, a high-resolution mosaic image (100 million pixels) is generated automatically for each detector from 93 overlapping single images.
To determine the number of n-tracks we use specially adapted image processing methods: For a reliable segmentation and separation of the e-craters a high-pass filtered image and an image generated by the second derivative are jointly analyzed. After merging the results a distance and a watershed transformation is applied to improve the separation of remaining contiguous e-craters. However, especially in the case of highly exposed detectors, the separation of the individual e-craters is not always reliable. Therefore, each individual e-crater is examined for multiple n-tracks applying an erosion filter, binary image generation and subsequent blob analysis. The empiric fact that n-track size accounts for about 7% of the surrounding e-crater area is included as prior knowledge in the binary image generation. As a final step all detected n-tracks are added up.
Based on numerous CARD-tests using calibration samples, the automatically detected n-track sum is a reliable measurement value for the Radon-222 air concentration.

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Computational fluid dynamics simulations and phase contrast-MRI validation of airflow in human pharynx during obstructive sleep apnea

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Obstructive sleep apnea (OSA) is a frequent sleep disorder caused by the repetitive partial or complete obstruction of the upper airway despite the ongoing breathing effort. Numerical simulation is emerging as an important tool for the understanding of airflow conditions causing OSA. To ensure the reliability of numerical simulations, validation of the results is required. This study presents the comparison of pharyngeal flow patterns at different flow rates simulated using computational fluid dynamics (CFD) and measured using phase-contrast magnetic resonance imaging (PC-MRI).
A computational model based on the stationary incompressible Navier-Stokes equation solved with finite element method was used. An anatomically accurate human pharynx model was used for the simulations. It was obtained from the 3D segmentation of computed tomography (CT) image data of a patient with OSA. The boundary conditions consisted of flow rates of 250 ml/s or 500 ml/s at the inlet and zero pressure at the outlet.
PC-MRI was used to measure the flow patterns in a 3D-printed pharynx model based on the segmented CT data in a 3T MR system using an RF-spoiled gradient-echo sequence. A mixture of 55.27% glycerol in water was used as a test fluid at 25°C. An MR-compatible flow pump was used to achieve a flow rate of 88 ml/s or 177 ml/s, respectively, to replicate the inlet boundary conditions of the simulations.
Comparable flow patterns obtained from CFD simulations and PC-MRI show that the stationary incompressible Navier-Stokes based model is a good predictor of the measured flow patterns. Below the minimum cross-sectional area of the oropharynx, the flow patterns show a flow separation and a region of recirculation associated with the largest negative wall static pressure. The validation proves the reliability of CFD and further supports the use of CFD as a potential tool for the understanding of OSA.

V 169

Effects of periodic inspiratory pressure patterns during variable controlled ventilation on recruitment and respiratory system mechanics – a numerical investigation

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Periodic variation of tidal volumes (V_T) during random variable controlled ventilation improves gas exchange, but not respiratory system elastance in experimental models of the Acute Respiratory Distress Syndrome (ARDS). The positive effects seemed to increase with increasing V_T-period (P_{VT}) in the tidal volume pattern. However an indefinite increase of P_{VT} would result in conventional non-variable ventilation. This suggests that deterministic resonance with a distinct P_{VT} maximizing these positive effects may exist. Here we investigated the effects of P_{VT} on respiratory system mechanics in a numerical model of lung recruitment/derecruitment.
A parallel branching numerical computer model consisting of 150,077 terminal acini was used, assuming a nonlinear global pressure-volume relationship V=1.45-1.56e-0.073P with acinar recruitment/derecruitment modeled as stochastic processes. All simulations were performed assuming pressure controlled ventilation with positive end-expiratory pressure (PEEP) of 5cmH_2O and mean delta airway pressure ΔP_{aw}=10cmH_2O and respiratory rate of 30min^{-1}. Variability in ΔP_{aw} was based on a Gaussian distribution which was then reorganized to yield periods of $P_{\Delta Paw}$=0,2,4,…30,32 cycles, all with identical probability distributions. 100 cycles were simulated for each period, starting with a completely recruited lung. Model parameters were analysed after omitting the first 20 cycles of the simulation.
Global model resistance R decreased and compliance C increased with increasing ΔP_{aw} period. Differences in R and C were significant compared with random ΔP_{aw} pattern for $P_{\Delta Paw} \geq 22$ of about 8% and 6%, respectively, reaching values similar to conventional non-variable ventilation with $P_{\Delta Paw} \geq 26$ cycles. The decrease in recruited acini at end-expiration with ΔP_{aw} period was accompanied by a decrease in compliance, mean recruited acini volume, and total lung volume.
The results of these simulations are consistent with experimental models of ARDS, and confirm the potential of deterministic resonance to improve mechanics and stabilize recruited lungs.
Submission of Abstracts for Oral or Poster Presentation

V 170

CFD-analysis of contrast agent transport in coronary arteries and its impact on quantification of myocardial blood flow with bolus-based perfusion MRI measurements

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Scientific aims of the project are analysis and correction of systematic errors in dynamic contrast-enhanced magnetic resonance perfusion imaging. In this non-invasive method, the passage of intravenously injected contrast agent (CA) through tissue is monitored to quantify myocardial blood flow (MBF). This requires knowledge of CA wash-in through upstream epicardial vessels, the arterial input function (AIF). For technical reasons this cannot be quantified in the supplying vessels and is thus measured in the left ventricle (LV), which introduces risks of systematic errors in MBF quantification due to CA dispersion in coronary vessels. Purpose of the study is the investigation of the influence of ever smaller epicardial vessels on bolus dispersion.
With dedicated software, 3D vascular models are extracted from porcine coronary imaging cryomicrotome data (resolution: 160 µm) and meshed with computational grids of predominantly hexahedral type. Following CFD-simulations are performed in two steps. First Navier-Stokes-equations for non-Newtonian blood flow are solved for one cardiac cycle. Subsequently resulting physical fields describing blood flow are used to compute the advection-diffusion-equation for CA transport over several cardiac cycles. At the model inlet the measured AIF_{LV} is applied as boundary condition and resulting dispersed AIF_{disp} at model outlets are used to assess errors in MBF quantification using an appropriate blood-tissue exchange model. CA dispersion is assessed by means of the variance σ^2 (i.e. temporal broadening) of the injected bolus along its passage through the cardiovascular geometry.
According to the central volume theorem dispersion values in the analyzed vascular model comprising vessel generations 3-7 (starting at LAD's first diagonal branch) range between σ^2=(0,03-1,81) s^2 (mean: (0,56±0,49) s^2) at the model outlets. However, complex influences of vessel curvature, tapering and bifurcations plus CA diffusion still require profound analysis. Correspondingly computed MBF values show systematic MBF underestimation ranging between 4-16 %, when CA bolus dispersion is neglected.

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Simulation and development of a patient-specific carbon fiber forefoot prosthesis using finite element method

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The current approach, taken by orthopedic technicians in building a custom-made forefoot prosthesis made of carbon fiber composite, is mainly based on trial and error. In order to improve the efficiency of the production of such devices, the University of Applied Sciences Ulm developed a novel finite element based procedure. The design of prosthesis is divided into several steps. The initial step is the identification of patient's anatomical parameters (e.g. foot length and width) and the desired sportive activity by an anamnesis protocol. Then, the modelling of a patient-specific CAD shell model of the prosthesis, suitable for two types of forefoot amputation levels (Lisfranc and Chopart), which is used for performing simulations, is carried out. In order to cover a large range of different anatomical parameters the shell model is parametrized. Subsequently the material properties, the number of carbon layers and the fiber orientation are defined by using Ansys Composite PrePost. The boundary conditions (such as loadings, contacts and supports) set for the simulation, are based on patient-specific data and worst case scenarios for the respective activity. These activities vary from walking, running and biking to different ball sports. The physiological flexibility values in the ankle and metatarsal joint, as well as material fracture limits in fiber and matrix were determined as validation parameters for a successful simulation of the forefoot prosthesis. In case of passing defined criteria, the carbon layout plan is used by the orthopedic technician to build up the device. Next steps consider the development of a database, including various layout plans for different patient parameters, loading conditions and flexibility levels.

FS 111

4D treatment planning for lung tumours in particle therapy

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Lung tumours continue to pose a major health problem associated with high mortality, even though early stage tumours can nowadays often be treated successfully by photon SBRT. Particle therapy with its physical and biological advantages could potentially improve treatment of locally advanced tumours by escalating dose while preserving low toxicity. Currently, several lung cancer studies have been registered, mostly using passive scattered proton irradiation.

Scanned particle therapy could offer even better dose conformity but is also associated with significant challenges, including interplay and motion-induced range changes. Routine clinical treatment therefore remains the exception in few centres.

A major component of treatment planning for lung tumours are methods for 4D-dose calculation to both assess interplay and the effectiveness of motion mitigation techniques. In addition even in the presence of motion mitigation, motion blurs dose outside of the target, so that adequate dose to normal tissue should not be judged from static dose distributions. Together with recorded beam records and a motion surrogate, the same dose engine can also be used for 4D-dose reconstruction.

Several strategies for motion compensation exist, ranging from amplitude reduction to ITV techniques to advanced conformal irradiation. Using advanced 4D-planning, also multiple lesions in complex planning situations can be targeted, with an especially large dosimetric advantage over photon irradiation. In this context, robust planning for simultaneous optimization is compared to single field optimization.

A clinical realization of scanned particle irradiation of lung cancer is shown in the example of NIRS, Japan. The solution achieved there also highlights the importance of specific technical capabilities for solving the motion problem.

FS 112

Experimental Validation of an in-silico Model for Ion-Beam Modulation in Lung Parenchyma

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Current treatment planning for radiotherapy with protons and heavier ions cannot account for the degradation of the sharp distal fall-off of the Bragg peak caused by microscopic density heterogeneities in the lung. This applies especially to analytical treatment planning systems (TPSs), since no generally accepted model for lung parenchyma exists. However, also Monte-Carlo based planning is affected since it relies on the same computed tomography (CT) images, which cannot resolve sub-voxel heterogeneities.
We therefore developed a model of the microscopic geometry of lung parenchyma based on lung specific features (alveoli dimension, lung density) and breathing state parameters (air filling state, water equivalent thickness traversed, WET). The model was implemented using the FLUKA Monte-Carlo multi-particle transport code. To benchmark its accuracy, we compared the predictions to the modulation found in a series of transmission experiments with lung-like phantoms and clinical proton and carbon beams at the Heidelberg Ion-Beam Therapy center (HIT). The model was found not to depend on the beam energy and particle type and to match the experimental data with a slight underestimation (-2.5 %) of the degradation parameters, yet guaranteeing the correct reproduction of all the relevant characteristics in the degraded dose distribution.

FS 113

Considering bragg curve degradation due to lung-equivalent materials in Monte Carlo codes by applying a density modulation

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Sub-millimetre-sized heterogeneities like lung tissue cause Bragg peak degradation. If not considered in treatment planning this can significantly influence the dose distribution in lung cancer patients.
We are capable of considering Bragg Peak degradation in Monte Carlos codes and hence MC-based treatment-planning systems by applying a density modulation within the voxels associated with the lung.
In a first MC-simulation a voxelised geometry consisting of sub-millimetre-sized voxels filled with either lung tissue or air was used to demonstrate Bragg peak degradation due to lung-equivalent materials. A new material characteristic ‘modulation power’ was introduced to quantify the magnitude of the degradation.
Using the modulation power, a density distribution was derived applicable to 2 mm thick voxels. This is the resolution of typically used treatment-planning CTs for lung cancer. The previously used voxelised geometry was replaced by 2 mm thick voxels. Hence, the transition from realistic lung-equivalent materials to clinically relevant data was performed.
Each voxel was filled with lung tissue and the lung tissue’s density in each voxel was individually randomised for each simulated particle in order to reproduce the Bragg peak degradation.
Using the voxelised geometry representing lung tissue we were able to demonstrate Bragg peak degradation due to lung-equivalent materials. A greater modulation power correlated with a greater degradation.
By modulating the density of the lung tissue in each of the 2 mm thick voxels we were able to almost perfectly reproduce the Bragg peak degradation from the previously used voxelised geometry representing lung tissue.
In conclusion, we are capable of describing and reproducing Bragg peak degradation due to lung-equivalent materials in Monte Carlos codes by applying a density distribution. We can hence consider and analyse the effects of this degradation in treatment planning.

FS 114

Methoden der Reichweitenmodulation für eine schnelle Bestrahlung thorakaler Tumore

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In ion beam therapy, a particularly conformal dose distribution can be achieved when the ion beam is controlled via the raster-scanning method. Especially, for treatment of thoracic cancer a fast raster-scan irradiation is very desirable, because this allows several repetitions (rescanning) of the irradiation and minimizes artefacts by interplay-effects. In order to speed-up the raster-scanning with carbon beams, a ripple filter is normally used. It modulates the beam and enlarges the Bragg-peak. This enables a step size for the iso-energy layers of typically 3 mm (instead of 1 mm) and accelerates the scanning treatment by a factor of three. A new design for ripple filters was now developed that allows steps of 6 mm and reduces the treatment time by further 50%. The new design can be realized by 3D-printing. Treatment planning studies show that in the vast majority of cases the dose conformity and homogeneity for 6 mm energy steps is comparable to that for 3 mm steps.
Building on the experiences for the 3D-printing of the new ripple filters with 6 mm high pins, a new 3D modulator was designed that allows a tumour conformal irradiation of small and medium sized target volumes by scanning with only one fixed energy. The 3D modulator consists of many thin pins with a well-defined shape and different lengths of typically 3-50 mm. The shape of the 3D modulator is specific for the corresponding tumour volume. Due to the fact that only one energy slice is needed, the modulator leads to a tremendous decrease in irradiation time, allowing the patient to hold his breath during treatment. The dose conformity is comparable to that from a standard raster-scanning irradiation with many energy steps. This could be shown with a high-resolution dose verification of typ. 40.000 dose points.

FS 117

Integration of piezoelectric transducers in well plates for broadband acoustic spectroscopy

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The purpose of this research is the integration of acoustic sensors in well plates with PolCarr® carriers for in vitro diagnostics of cells. In this study piezoelectric transducers are used to excite and receive short ultrasonic waves with broad frequency spectra, that interact with the adherent cell culture. The frequency spectrum of the received time signal is analysed to evaluate the condition of the cells. One of the major advantages in comparison to optical techniqes is, that the well plate need not to be removed from the incubator to perform continuous monitoring.
Based on preliminary test with different test liquids and yeast cells, several concepts have been developed and evaluated for the integration of such sensors. Two demonstrator systems are presented based on the most promising concepts.
The first approach is to integrate a set of sending and receiving transducers into the wall of the well, that are directly opposite to each other. These transducers can be used for a transmission technique or a combined transmission and echo technique to analyse the transmitted waves as well as the backscattered. Conventional piezoelectric transducers can be used and therefore the resonance frequencies can vary in the range of 10 MHz to 50 MHz, depending on type and thickness of the transducer material.
The second approach is to deposit a piezoelectric aluminium nitride thin film on the backside of the PolCarr® carrier. In this case it is not possible to distinguish the echos from the substrates surface and the echos from the cell culture or the culture medium, therefore the resonance behaviour of the whole system is analysed. The resonance frequencies are in the range of 100 MHz for the thickness vibration mode, but there is an additional influence caused by the mechanical clamping of the thin film on the substrate.

FS 118

Integrierte Mikrosensorik für induktive-elektrische Breitband-Impedanzspektroskopie

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The talk is focused to inductive-electrical impedance spectroscopy to provide information for monitoring of cell stages or characteristics during the breeding phase. The research is based on the PolCarr® carrier that allows a adherent fixation of cells.
The inductive-electrical impedance spectroscopy allows in comparison to capacitive-electrical impedance spectroscopy a contactless measurement also through a glass tube wall. Due to this, the cells can be left in their breeding environment. Other sources of interference can be kept as low as possible.
First the theory of magnetic properties will discussed. The influence of the cell by which properties during the breeding phase are observed and their interaction in the nutrient solution is described. For this purpose, conductivity solutions with KCl were chosen. Based on this, yeast was observed in a sugar solution. A comparison of the measurement results of the electro-inductive impedance spectroscopy illustrates the differences. In the following presentation, first results on the electro-inductive impedance spectroscopy will be presented, with particular reference to the first measurements at the demonstrator. The further development and integration is shown, which is the basis for an monitoring with microtiter plates.

V 173

Dose measurement in the steep dose gradients around brachytherapy sources

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Dose measurements at a few cm distance from brachytherapy sources are difficult due to the complexity of positioning the source and detector with the required precision of around 0.1 mm, and due to the uncertainties in detector response caused by energy-dependence, unclear effective point of measurement and volume averaging of detector signal across the extended sensitive volume. Verification of new calculation algorithms in brachytherapy incorporating tissue inhomogeneities, the calibration and relative dosimetry of kV-irradiators used at short source-tissue-distances in intraoperative radiotherapy and also clinical situations when applying these techniques require verification by measurement for which the present codes of practice for dosimetry in radiotherapy are not applicable. A formalism under preparation by the DIN 6803-3 working group describes the determination of absorbed dose to water D_w from measurement by multiplication of calibration and correction factors defined in analogy to the well-known codes of practice: $D_w = M \cdot N_{D,w} \cdot k_{Q,M} \cdot k_V \cdot \prod_i k_i$, where $k_{Q,M}$ is the factor correcting for the radiation quality at the point of measurement and k_V corrects for the volume averaging effect. Values of $k_{Q,M}$ are given in the work by Chofor et al. (Z.Med.Phys. **26** (2015) 238). Otherwise, small solid detectors can be cross-calibrated to a small ionization chamber at a point in water at around 3-5 cm distance from the source with the chamber's effective point of measurement and k_V determined as proposed by Schönfeld et al. (to be published). DIN 6803-3 will describe these approaches to dose measurement in the source vicinity with acceptable uncertainty, preferentially for detectors with small volume averaging.

V 175

MR-µ-imaging based 3-dimensional-polymer gel dosimetry in comparison to 2D-film and 1D-diamond dosimetry of mm-sized photon pencil beams

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In small-field dosimetry of mm-sized beams the performance characteristics: spatial resolution and dose discrimination with reference to detector-noise represent the most important criteria for detectors. 3D-Magnetic-Resonance-based Polymer-gel-Dosimetry (MRPD) avoids the distortion of the radiation field due to water/tissue equivalence of the whole detector and allows for the 3-dimensional measurement of the dose distribution within one single multi-slice imaging experiment. We investigated the performance characteristics of several dosimeters known for their high spatial resolution capabilities for the following challenging setting: a 6MV photon-field below (depth=12mm) 4 differently sized lead collimators (thickness=1cm) with diameters of d4=1,92mm down to d1=0,46mm. We compared the results on lateral dose-profiles of different 3D-MR-µ-imaging based measurement protocols: a short, medium and long lasting protocol at different nominal spatial resolution (pixel-size:156-468µm) to two different film (EBT3) scanning protocols (pixel-size: 35-169µm) and a µ-diamond detector (PTW60019) with profiles at high- and low-resolution direction.
Results: a short 3D-multi-slice parameter multi-echo MR-measurement protocol lasting about 20 min is capable of detecting all of the very small radiation-fields down to d1=460µm at relative modulation strength of about 5% of the incident dose. The dose noise is dependent on the MR-protocol used and might be reduced with long lasting (h) protocols down to below 1,5%. 3.) We consider here film dosimetry at pixel-size of 169µm as the best reference standard with regard to spatial resolution in 2dimensions. The high-resolution film scanning protocol at 720dpi suffers from noise and is hardly able to differentiate the low-level dose-modulations below d1=500µm collimation. 4.) The diamond detector stands out for excellent signal-to-noise-ratio and reports the same FWHM-diameter values as film and gel for the high-resolution scanning protocol within errors. However it does not confirm the non-single-Gaussian-like profiles with slight dose-enhancement at the edges for the 1,92mm and 1,54mm collimations, which film and gel appear to indicate.

V 176

The influence of magnetic fields on the lateral dose response function of various photon dosimetry detectors

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With the introduction of MR-Linac systems for image guided radiotherapy, new challenges in clinical dosimetry emerge due to the Lorentz force which modifies the trajectories of the secondary electrons compared to the case without magnetic field. The aim of this study is to determine the 1D lateral dose response functions, $K(x\text{-}\xi)$, of clinically established photon dosimetry detectors under the influence of magnetic fields. Function $K(x\text{-}\xi)$ is the convolution kernel transforming the true dose profile $D(\xi)$ into the disturbed signal profile $M(x)$ measured with a detector. For the air-filled PTW Semiflex 3D 31021 ionization chamber, the PTW microDiamond 60019, the PTW Si diode 60017 and the scintillation detector Exradin W1, kernels $K(x\text{-}\xi)$ were determined by Monte-Carlo simulation using 0.25 mm wide ^{60}Co and 6 MV slit beams. The detectors were modelled following manufacturers' specifications and placed at 5 cm water depth. Magnetic fields of 0, 0.5, 1 and 1.5 T, oriented perpendicular to the beam axis, were applied. Distortions of $K(x\text{-}\xi)$ were found to depend on the magnetic field, the density of the detector's structural components, and the orientation of the detector relative to the magnetic field. Kernel $K(x\text{-}\xi)$ of the air-filled ionization chamber with its low-density air cavity shows the strongest asymmetrical deformation by action of the magnetic field. The semiconductor detectors with materials of larger density than water also show asymmetrical, but smaller distortions of their $K(x\text{-}\xi)$ functions. Kernel $K(x\text{-}\xi)$ of the nearly water equivalent W1 was found to be almost independent from the magnetic field. Functions $K(x\text{-}\xi)$ of various detectors in magnetic fields can be used to derive correction factors, and the absence of magnetic field influences on kernel $K(x\text{-}\xi)$ of a water-equivalent detector calls for practical applications.

V 177

Three-dimensional gel dosimetry for stereotactic radiosurgery of multiple brain metastases with helical tomotherapy

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Dosimetric evaluation of helical tomotherapy is challenging due to the 3D nature of the treatment plan. In this work, two 3D printed dosimetric phantoms (RTsafe, Athens, Greece) were used for 3D dosimetry. Both phantoms represent with sub-mm accuracy the real patient anatomy in terms of bone structures and soft tissue. One was filled with polymer gel (for 3D relative dosimetry) and the other one with water, having an ion chamber insert (for absolute dosimetry). Treatment planning for multiple brain metastases was performed on a commercial system (Accuray Planning Station, Sunnyvale, CA,USA). A stereotactic radiosurgery treatment plan for the simultaneous irradiation of the lesions was calculated on the CT images of the phantom. Both phantoms were irradiated with identical treatment plans. In the gel filled phantom the 3D dose distribution was assessed with MRI by measuring the dose-dependent transverse relaxation rate R2. Therefore, 4 multi-slice T2-weighted fast spin echo (HASTE) data sets were acquired (TE = 36, 435, 834 and 1230 ms; TR = 2520 ms, spatial resolution = 1.45x1.45x2mm³, total measurement time 4min 10s), and R2 maps (R2 = 1/T2) were extracted from a mono-exponential fit. R2-maps were converted to relative dose-maps for qualitative and quantitative dosimetric evaluation, and co-registered to the CT data. The comparison between calculated and measured dose distribution showed an excellent spatial agreement, and a gamma analysis revealed a very good agreement between relative dose distributions. The absolute dose measurements with the PinPoint 3D ion chamber (PTW, Freiburg, Germany) deviated by less than 1% from the TPS dose calculation and from TLD measurements in the water filled phantom. This work shows that an accurate dosimetric validation for stereotactic radiosurgery is possible for cases of multiple brain metastases using 3D printed anatomical phantoms. This opens up new opportunities for 3D high resolution dosimetry in radiation oncology.

V 179

Monitoring of cardiorespiratory signals using thermal imaging

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In critical care medicine, heart rate (HR) and respiratory rate (RR) are two paramount parameters to assess the well-being of patients. Since the current measurement modalities (e.g. ECG probes, chest straps, pulse oximeters) require attachment of sensors to the patient's body, they lead to discomfort and stress, especially in infants. Recently, camera-based vital sign monitoring has been studied. It shows a high clinical potential regarding feasibility and validity.
The current paper presents an approach for remote monitoring of cardiopulmonary signals (HR and RR) using thermal imaging [also known as infrared thermography (IRT)]. Monitoring of HR is based on the fact that cyclical ejection of blood flow from the heart to the head, via the thoracic aorta and the carotid arteries, leads to periodic movements of the head. For respiration monitoring, the temperature modulation around the nostrils was considered, since the exhaled air from the lungs is warmer than the inhaled air from the environment. For a clinical evaluation of this approach, a pilot study including ten healthy subjects (3 females and 7 males), between the ages of 23 and 50, was carried out. In addition to IRT, photoplethysmography (PPG) and piezoplethysmography were simultaneously recorded as reference methods.
An excellent agreement between thermal imaging and the references was achieved. Regarding HR, the root-mean-square error (RMSE) between IRT and PPG averaged 2.50 min^{-1} ± 1.03 min^{-1}. For RR, the RMSE between IRT and piezoplethysmography was smaller than 0.5 min^{-1}.
In sum, this work demonstrates that thermal imaging is capable of capturing the ballistocardiographic movements of the head and measuring the temperature fluctuation around the nostrils with a considerable accuracy. Therefore, IRT might be a promising, clinically relevant alternative for the currently available measuring modalities.

V 180

Thermography for perfusion analysis of the thoracic region after bypass grafting

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The use of the left internal thoracic artery for coronary artery bypass grafting (CABG) is associated with higher long-term patency rates compared to autologous saphenous vein grafts. However, due to the devascularisation of the thoracic region there is a potential of postoperative sternal wound infection, occurring in approximately 4 % of all patients. To this day, there is still no preoperative diagnostic procedure to estimate the risk of a wound healing disorder.
Thermography has proved to be suitable for medical imaging in breast cancer detection, brain mapping in neurosurgery, and dermatology among others. The measurement of thermal radiation is a highly sensitive, non-invasive and label-free methodology that allows for the identification of vital signs and the discrimination of normal from pathological tissue.
In this contribution, thermal imaging is used to quantify the perfusion of the thoracic region of patients before and after CABG. We propose a method for the assessment of blood flow by evaluating the skin temperature of the left and right breast areas in a comparative study 1 day before the surgery and 2 hours, 1 day, and 7 days after surgery, respectively. As expected, the examined group of patients showed a hypoperfusion of left chest wall, indicated by a significant temperature drop compared to the right breast area. Postoperative we observe a continuous convergence in the skin temperatures of the left and right breast areas as an effect of revascularization in the left thoracic region.
As a proof of concept, we show the feasibility to evaluate the perfusion of the thoracic region using contact-free thermal imaging. This lays the foundation for preoperative diagnostics in order to assess the risk of wound healing disorders.

V 182

Three-dimensional measurement of the blood flow in the umbilical cord using automated quantification of color doppler signals

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For the functioning of all organs and for the development of organ function during pregnancy, an adequate blood supply is an indispensable condition. Therefore, non-invasive color duplex sonography is used especially in the prenatal diagnosis to evaluate the blood flow phenomena in the umbilical cord and the unborn child itself. It is also essential in blood flow assessment of various postnatal diseases. However, previous color duplex sonography methods are lacking real quantification of blood flow volumes. Blood flow measurement using the non-invasive ultrasound encounter technical limits in specific applications where the vessel shape and location vary.
The aim of the project was the development of a hardware and software system capable to identify blood flow volumes in one or more vessels, regardless of their shape. This ought to be possible in dependency of the pulsation by using conventional 2D ultrasound technology. Thereby, the proper angle is essential for the pixelwise detection of blood flow velocity. Thus, the blood flow volume can be determined precisely as a function of area and solid angle corrected flow velocity.
The newly developed prototype system consists of two camera marker modules and a software tool, which enables the blood flow volume measurement with conventional 2D technology. Using the high-precision positioning, especially the rotational axes of the ultrasound transducer, the angle of vessels can be determined. Thanks to the precise solid angle determination, the flow volume can be quantified through the vessels using automated pixelwise counting. Moreover, the system is capable of a simultaneous determination of the solid angle in multiple vessels of a tissue and thus the exact blood flow in a tissue section can be identified. Tests with a calibrated flow phantom showed a highly significant correlation ($r = 0.99$) with the nominal value and the previously smallest deviation compared to other methods of blood flow volume measurements.

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Effect on 1-3 piezocomposite layout on resonance behavior of high-frequency ultrasonic transducers

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High frequency ultrasonic transducers based on 1-3 piezocomposites are essential prerequisite for medical diagnostics and non-destructive testing. In order to achieve superior image resolution, operating frequencies have to be increased, which requires reduction of transducer thickness. Furthermore, lateral layout dimensions have to be adjusted to prevent spurious resonance frequencies. Accordingly, these requirements for high-resolution imaging put high challenges on the manufacturing process of appropriate ultrasonic transducers.
In this contribution, the development of ultrasonic transducers with operating frequencies above 20 MHz is reported. For fabrication of fine-scale piezoceramic arrays, soft mold technique is used. The basis of this process are master molds structured by microsystems technologies like LIGA, SU8 and deep reactive ion etching (DRIE). In contrast to conventional dice-and-fill technique, these processes allow for free design of pillar geometry and spatial distribution. Master molds with circular pillars in hexagonal arrangement and different combinations of pillar diameters (40, 30, 20 µm) and interpillar spacings (10, 7.5, 5 µm) have been fabricated. Manufacturability of fine-scale 1-3 piezocomposites based on these master molds has been tested to shift spurious modes to frequencies approximately twice as operating frequency. Influence of pillar diameter and interpillar spacing on resonance modes are investigated by analyzing resulting transducers in respect of their frequency spectra. Experimental results will be explained in detail and compared to modelled data.

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Proton radiography for integrating positioning and treatment planning of small animals at an experimental proton beam

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Integrated small animal X-ray imaging and irradiation devices have facilitated image-guided pre-clinical radiooncological experiments. Here, a proton-based radiography method is proposed for in-line small animal treatment planning and positioning verification at an experimental proton beamline.
A double-scattered 125 MeV proton beam (10 x 10 cm² field size) and a flat-panel, scintillation-based dose detector (Lynx, IBA Dosimetry) were used to obtain planar scans of deceased mice positioned in a closed multi-modality bed. Two modes of image acquisition were used: absorption and scattering. In absorption mode, slabs of plastic with a water equivalent path length (WEPL) of 7.08 g/cm² were placed between object and Lynx detector. In scattering mode, all plastic slabs were removed. Digital, pixel-wise image processing was applied to combine the information. A WEPL calibration curve was obtained using plastic slices of known WEPL as objects. For verification, planar X-ray images of the same objects were acquired.
The proposed radiography technique allowed for detection of contours (e.g., mouse body, bed and background) and reliable automated (rigid) registration of proton radiography images to planar X-ray scans. Planar 2D radiological thickness maps of mice were obtained. Specific structures could be visualized with a spatial resolution of less than 1 mm, especially regions with high local density differences including lung, hind leg, jaws and skull.
The method appears suitable to position small animals for precise irradiation of subcutaneous (hind leg) and orthotopic (lung, brain) tumor models. Currently extended image analysis may enhance visualization of the animal's internal structure to facilitate in-line treatment planning.

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Continuous sleep-apnea screening in an unattended home-setting

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Portable monitoring is becoming more and more considered for screening of sleep apnea It is debated whether portable monitoring can match the diagnostic accuracy of in-laboratory polysomnography. Nevertheless, it shows high potential for continuous patient follow-up in order to adjust treatment strategies and to estimate treatment efficiency. Sleep apnea is common sleep disorder contributing to the development of clinically overt cerebro- and cardiovascular comorbidities. Hence, an accurate and appropriate diagnosis as well as a well-controlled patient-centered care is in the focus of both medical research and public health.
Scientific literature proved that features derived from electro cardiogram (ECG) signals (i.e. HRV indices) constitute of clinical value to discriminate different levels of severity of sleep apnea. A new wearable system including textile ECG electrodes was developed to replace conventional self-adhesive gel electrodes. This device enables an easy application of the electrodes with low impact on wearing comfort and avoiding skin irritation. The self-humidifying part included in the device enables to conduct long term (overnight) measurements and measurements on dry skin.
In this study, the validity and reliability of the ECG signal acquired with the textile ECG acquisition systems during an overnight visit of a sleep laboratory was evaluated by comparison to ECG data obtained from conventional gel electrodes in 100 patients with suspected sleep apnea. A very good agreement was observed for heart rate, RR intervals and heart rate variability. Furthermore, the significance of ECG data obtained from the new system as well as the conventional gel electrodes is evaluated with regard to the assessment of the severity of sleep apnea. Both approaches revealed a good agreement when compared to PSG as gold standard. Finally, preliminary data from the continuous ECG monitoring in a home setting is presented and discussed with regard to data obtained from screening in an in-laboratory setting.

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Detection of nightly snore events in OSA patients

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Snoring is understood as a respiratory sound, which is caused in the upper airway during sleep, and mostly appears in middle-aged men. Detection and classification of snore events can be helpful for diagnosis of obstructive sleep apnea (OSA). It is the most important form of sleep-related breathing disorders. Due to its high prevalence and its potential for developing cardiovascular diseases, resulting in increased morbidity. Improving methods for early diag-nosis and suitable therapy will lead to a more positive long-term outcome and will help to pre-vent sleep related breathing disorders. The purpose of this study is to describe and detect snore events during the night with a mobile lung sound monitor called LEOSound. Extensive recordings of nightly lung sounds (6 - 8 h) were realized with LEOSound. Additional to LEOSound, polysomnography data of every subject were recorded. The study includes 24 subjects with snore. The subjects are 21 men and 3 women aged between 38 – 81 years (mean: 57 years; std: 13 years). Their recordings were audiovisually analyzed by experts as reference for automatic detection. The detector for snoring includes different features which describes snoring volume, intensity, and entropy. The sound of snoring shows a high level of inter- and intraindividual variability, which results in differences in frequency and intensity. Although the automatic detection by LEOSound is pos-sible with a high accuracy and every subject was properly identified as snorer by the detector.

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Evaluation of patient compliance during BIPAP-ventilation

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An important therapeutic approach in Chronic Obstructive Pulmonary disease (COPD) is the nocturnal noninvasive biphasic positive airway pressure (BIPAP) ventilation. By now, there is no comfortable and objective method to monitor the acceptance of the patient to this ventilation, so the doctor is mainly reliant on his experience and the patient's feeling in the morning. A new technical system, (RespAccept, Thora Tech GmbH, Germany), which is able to monitor the ventilation overnight by comparing the pressure values supported by the ventilation machine with the pressure values generated by the patient, has been tested. The RespAccept-system is connected via two small tubes with the ventilation tube and measures the pressures near to the patient and near to the ventilator simultaneously. An algorithm compares both pressures in order to interpret an synchronous behaviour between patient and ventilator, whereby a high synchronism is classified as a good patient-compliance. After the measuring, the discrepancies of pressure values are illustrated in graphs for each breath cycle.
In our study, we investigated the pressure values recorded by the RespAccept-system by means of analysis of variance in order to find typical patterns and different parameter for the synchronism between patient and ventilator. Our aim was to facilitate the evaluation of the patient-compliance and the patient's well-being after the nocturnal ventilation based on the synchronism of patient and ventilation. This will support the doctors in verifying the adjusted ventilation parameters.

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Comparison of camera-based and contact based estimation of the respiratory rate

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The assessment of the respiratory rate serves as an essential indicator for changes in a patient's condition. Since respiration influences the electrical activity of the heart it is possible to estimate its rate from electrocardiographic (ECG) and photoplethysmographic (PPG) data. Although being non-invasive these methods require the connection of sensors to the patient's body. In recent years, advances have been made to measure respiration signals using a camera. In principle, these signals are either derived on the basis of evaluating motion (e.g. movements of the chest) or – similarly to PPG - by analyzing blood volume dynamics recorded remotely using camera-based PPG (rPPG). The contactless measurement of respiration signals is prone to artefacts (e.g. patient movements, changes in illumination) which renders common techniques (e.g., FFT, number of zero-crossings) to estimate the respiration rate often useless. An alternative is the estimation on the basis of the autocorrelation function of the respiratory signal. We conducted an evaluation study (10 subjects) to compare contact- and camera-based respiratory rate estimation by means of autocorrelation. The subjects were lying in a supine position and were asked to synchronize their respiration to a metronome. The frequency was varied from 10 to 30 bpm (6 different levels, each lasted 10 periods). ECG and PPG were recorded using a PLUX biosignals researcher system. Two cameras (iDS UI-3160CP) were used to derive videos of (1) the subject's face to provide an optimal measurement of rPPG and (2) the upper body including chest. Respiration signals were derived from the ECG, PPG, rPPG and body movements using various techniques (e.g. R-peak and RR-interval modulation, empirical mode decomposition (EMD)). It turned out that camera-based respiration rate estimation using EMD (i.e. from rPPG and movement signals) and autocorrelation results in a very good agreement to respiration rates estimated from contact-based signals.

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Time-frequency representations of combined EEG and MEG recordings during NREM sleep

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Polysomnography is an important tool in clinical medicine and in research. So far brain signals during sleep are recorded exclusively using electroencephalography (EEG). Since EEG and magnetoencephalography (MEG) are sensitive to complementary parts of neuronal signals the inclusion of MEG might lead to a better understanding of sleep patterns. But modalities such as MEG and functional magnetic resonance imaging (fMRI) require both experimental settings not well suited to sleep. The inherent noise produced during fMRI prevents the subjects to enter any level of sleep, whereas in MEG the restrictions in head and body position prevent normal body movements occuring during sleep. MEG systems are both available for seated and supine subject positioning.
A supine positioning in the MEG was chosen in this study to record sleep MEG together with PSG from 8 subjects during the first half of the night for a typical duration of 3.5 hours. Due to the limited time the REM sleep was not reached, but the observed NREM sleep was of sufficient quality for manual sleep staging of the PSG signals. The 125 MEG gradiometer channels were separated into 19 groups of neighbouring channels with each group consisting of 5-7 channels. The central channel of each group was selected for further processing.
The time-frequency representation of sleep EEG signals complements manual sleep staging particularly by quantifying persistent oscillatory activity, but exact determination of oscillation frequency is time consuming for a human scorer. A time-frequency representation was calculated for the selected 19 MEG channels using non-overlapping 20 s windows, which were further divided into 4 s windows. The average spectrum of the five 4 s spectra was the spectral estimate for the 20 s window. Time-frequency representations of EEG and MEG were compared. For the alpha, delta, and theta range MEG and EEG show similar overall patterns, but the relative amplitude between the oscillation bands can be different for MEG and EEG. This will be further investigated in a coupling analysis between EEG and MEG signals.

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NPH patients in Bern – gold standard in therapy and its shortcomings

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Normal pressure hydrocephalus, with an incidence of approximately 5.5/100,000, is a potentially reversible cause of dementia and impaired gait. The pathophysiological mechanisms are nebulous. Typically it is characterized by the triad of gait disturbance, urinary incontinence and memory impairment.
Standard criteria for the diagnosis of NPH are lacking. A combination of clinical evaluations (e.g. timed up and go test, tab test, external lumbar drain), imaging studies (e.g. ventriculomegaly, cerebral blood flow assessment, aqueductal CSF flow assessment) and possibly CSF dynamics tests (e.g. resistance to CSF outflow) lead to the diagnosis of NPH.
The standard treatment for NPH is ventriculo-peritoneal shunting. Up to 96% of patients report the subjective impression of overall improvement. On global objective rating scales (e.g. mRS) 65-77% of patients show an improvement. Impaired gait improves best with 83-89% improvement rate, 65-70% of patients present an improvement in incontinence and 44-48% on a test of memory. There is a possible decline of benefit of shunting over time. The risk for a serious adverse event is up to 22% and up to 30% of patients require at least 1 shunt revision. Complications include subdural hematomas (5%), shunt obstruction (17%), malpositioned distal catheter (3.5%), CSF infection (2.5%), malpositioned proximal catheter (1%) and intraventricular hemorrhage (0.5%).
The risks and benefits of shunting for NPH patients should be carefully weighed and discussed by the patient and treating physician.

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FEM modelling for bioimpedance controlled monitoring of Normal Pressure Hydrocephalus

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Hydrocephalus patients experience an accumulation of cerebrospinal fluid (CSF) in the ventricular space, usually associated with an increased intracranial pressure (ICP). In Normal Pressure Hydrocephalus (NPH), however, the ICP is not permanently elevated. In most cases, the therapy of choice is to implant a shunt to drain CSF from the ventricles through a passive pressure valve into another body compartment, like the abdomen. Common problems associated with the shunt therapy are over- and underdrainage. A bioimpedance system which monitors ventricular volume directly may help avoid these complications. It may also provide the possibility to use the volumetric information as an additional control parameter for an automated smart shunt. The envisioned sensor consists of six electrodes integrated on a drainage catheter surface.
The feasibility of the bioimpedance ventricular volumetry system has been evaluated using Finite Element (FE) anatomical models of the human brain obtained from an MRI dataset. A tetrahedral grid was generated and imported to COMSOL Multiphysics for processing. Tissue conductivity and permittivity were accounted for. Furthermore, in-vitro measurements have been performed using an Agilent LCR meter E4980A with agarose-gel and silicone-gel as parenchym phantoms. A current of 5 mA at 1 kHz to 1 MHz was injected and different voltage measurement configurations considered. Saline water was used as CSF substitute.
FEM simulations and in-vitro results show a reproducible negative correlation between measured impedance and ventricular volume. The measurement system is to be further validated using in a novel test bench for bioimpedance measurements of the craniospinal space, as well as by analysing the influence of CSF pulsatility.

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MRI flow measurements and what they tell us about hydrocephalus

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For a long time, CSF flows was mainly associated to continuous secretion and resorption flows. Knowledge of neuro-hydrodynamics has benefited considerably from the introduction of phase contrast magnetic resonance imaging (PC-MRI), which can provide CSF and blood flow measurements throughout the cardiac cycle. CSF, blood, and tissues interact in different kind of compartments (large, narrow, rigid, and compliant) associated inside the cranio-spinal system to different pressures: high pressure for arterial blood or low for the venous blood and the CSF. CSF motions results from cranio-spinal compliance and arterial and venous flows in the central nervous system. All these interactions generate intracranial pressure changes during cardiac cycle and mean that CSF and blood flows could depict the biomechanical state of the central nervous system. Hydrocephalus is the first pathology pointing CSF flow alterations: it is easy to identify a ventricular dilation in the brain it is more difficult to identify the origin of the dilation and find the good strategy to treat it when it is a pathological dilation! For many years, in collaboration with clinicians, we added PC-MRI sequences in the standard MRI protocols to bring complementary information about neuro-hydrodynamics' diseases. We study CSF flow, venous and arterial blood flows to identify and understand the potential origin of our hydrocephalus patients to help the neurosurgeons. The aim of this presentation is to expose a PC-MRI overview of our experience concerning normal and pathologic CSF and blood flows behaviors in the cranio spinal system.

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From first ideas to technical feasibility

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The use of phantoms in radiooncology becomes more and more important. Especially the increasing demand on accuracy in radiotherapy leads to further requirements for quality assurance devices. Not even rigid body phantoms but also anthropomorphic phantoms with realistic soft tissue organs are requested. To imitate organ movements these soft tissue parts should be movable reproducible on realistic paths.
New techniques in Medical Engineering can help to get from ideas to practical solutions. Especially 3d-scanning and 3d-printing allow technically feasible devices that can help to increase quality assurance. At DKFZ we have 2 different 3d scanners for varying applications with high resolution to generate 3d models of organs and all kinds of parts. In addition 3 different 3d printers are available to create 3d parts.
Various materials such as resin, ABS, PLA and PVA and also flexible material with different Shore hardnesses can be used to build challenging parts. These parts can on the one hand be used directly in anthropomorphic phantoms and on the other hand also as casting mould to fabricate flexible organs by using silicone materials.
The first talk of the focus session “Development and use of anthropomorphic phantoms in radiooncology” shows a brief overview about the technical possibilities to realize scientific ideas with 3d scanning and printing devices.

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From imaging to a realistic model

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To investigate the uncertainties introduced by motion in radiation therapy, anthropomorphic phantoms are needed. They allow for the simulation of the movements of organs during a course of radiation therapy in a reproducible way and the measurement of the radiation doses.
Therefore, we use DICOM-data of patients from which segmentations of the bones and organs are exported in the .stl-format and further processed. This is done with the software “Geomagic Freeform” or “Autodesk Inventor”, to develop a virtual model. In this process, modifications like underparts, cavities, connecting elements or casts for molds are designed. Different 3D printing techniques are exploited for the production of bone models and molds. In diverse casting processes using several different silicons, the organ models are produced. Different requirements as well as properties in the CT or MR imaging determine the choice of the silicon type. The requirements relate to the extensibility, the stabilization or the connection between the organ models and the placement of dosimeters like OSLDs or dosimetry films. Particular attention is paid to the fact that the anatomical conditions are used in a functional way. Using the contrast between different silicon types, localizers in the form of silicon dots can be integrated in the organ shells and allow for the validation of registration-tools.

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Gels in radiation oncology

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In radiotherapy the requirements for phantoms used for „End-to-End“- measurements have in-creased sharply over the last few years. Mainly rigid phantoms, consisting of materials with differ-ent densities, in which movements of tumours can be simulated by mechanical displacements, were used in the past. In contrast specific gels allow an optimization of movable models. Due to their composition gels show different elasticity and different signals in MRI and CT by adding soluble salts. Furthermore physiological systems, such as filling the bladder or rectum and ventilating a syn-thetic lung, can be placed inside of the phantom. Dosimetry gels have become very important for the development of anthropomorphic phantoms. Because of its three dimensional representation of dose distribution, different experiments can be evaluated by MRI without any further processing. It is also possible to use modified gels for Proton-therapy. In the process oxygen 18 causes a nuclear reaction, which synthesizes the beta emitter fluorine 18. This final product is used as a contrast me-dium in PET-imaging. In summary it is clear that using different kind of gels open up a new spec-trum in radio-oncology. They close a gap in the development and production of anthropomorphic phantoms using 3D-printing and elastomers. Due to the invention of hybrid imaging devices such as MR/PET, PET/CT and MR/LINAC all of these above-mentioned systems complement the con-struction of versatile phantoms.

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An anthropomorphic multimodality (CT/MRI) head phantom prototype for end-to-end tests in radiotherapy

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With magnetic resonance imaging (MRI) becoming an important part of the treatment process – not least recently in MR-guided radiotherapy – established phantoms (e.g. the Alderson head) were no longer sufficient for so called „end-to-end“ tests. Such tests covering every step from therapy planning to follow-up are required for quality assurance in radiotherapy. To meet this demand, a first anthropomorphic multimodality head phantom prototype was developed at the German Cancer Research Center (DKFZ) four years ago.
A set of patient computed tomography (CT) images was used as the basis for the anthropomorphic head shape. The phantom recipient consisting of epoxy resin was produced using the, at that time, advancing technique of 3D printing. The recipient was filled with a cranial bone surrogate (based on dipotassium phosphate), a brain surrogate (based on agarose gel) and a surrogate for cerebrospinal fluid (based on distilled water). A tumour volume was realized using normoxic dosimetric gel. In addition, the recipient included a nasal air cavity.
The entire workflow of a proton therapy treatment was successfully applied to the phantom. CT measurements revealed CT numbers agreeing with reference values for all surrogates. MRI showed the desired contrasts between different phantom materials especially in T2-weighted images (except for the bone surrogate). T2-weighted readout of the dosimetric gel allowed approximate proton range verification.
Fusing 3D printing with the usage of gels and designing phantoms based on patient imaging data enabled the development of an anthropomorphic multimodality head phantom prototype that successfully underwent every step in proton therapy treatment.

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A patient similar phantom in adaptive radiotherapy

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In radiotherapy the use of (measuring) phantoms is essential. Their main field of application is quality assurance. Simulations and measurements are performed in the phantom and the results are transmitted to humans. With continual developed state of the art and the more complex treatment techniques the complexity of standards on function and property of phantoms are also increasing. An anthropomorphic, deformable and multimodal pelvic phantom (ADAM Pelvic Phantom) has been developed for use in radiooncology. It is an in-house development and implementation at most real setup of tissue, organs and bones for simulating a human pelvis. The phantom allows a patient similar use in imaging and therapy. It allows controlled organ movements and provides the advantages of known materials and geometries. A number of CT scans were performed at the CT Dual Source (Siemens) for this phantom. The filling of the rectum, the bladder and the rotation of the whole phantom varied. With the aid of these datasets, the process of an adaptive planning from the elastic registration via the dose tracking to the adaptive replanning using the treatment planning system RayStation (RaySearch) was investigated. Due to the changed organ position and organ size as well as positioning of the phantom, local dose differences in the organs at risk and the target volume were achieved. However, the overall dose of the organs at risk and the target volume remained the same on average. These local dose differences could be avoided by adaptive replanning.

FS 130

Use of an elastic anthropomorphic phantom for the evaluation of a new patient positioning device

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The success of a radiotherapy treatment is correlated to an accurate positioning of the patient during beam application. Cone beam imaging as well as 3+ axis couch systems are in use for that. A new approach might be the use of a multi air pillow table top (MPD) in combination with an optical surface positioning system (Vision RT) allowing for a more accurate and individualized patient setup. According to the surface information, the air filling of the pillows can be varied. A more accurate patient surface positioning, is hopefully accompanied by a more accurate tumor position, which should be proofed with a suitable phantom. The framework of the phantom is built by a plastic skeleton, the connective tissue is made of agarose gel, the skin and most of the organs are made of different kinds of silicon, the lung is filled with Styrofoam bubbles and gel-filled glass flasks are used as artificial tumors. Besides an anthropomorphic behavior these components guarantee a sufficient contrast in CT and MR imaging for evaluation of shape, size and position inside the phantom. Treatment planning was done for 14 different patient setups. Based on that, Vision RT and the MPD were used to reproduce the patient position on the treatment couch. A subsequent cone beam imaging was done for verifying the positioning and for analyzing the difference between surface and tumor position. The elastic behavior of the phantom made it possible to do a realistic simulation of a surface positioning workflow. The phantom compounds are clearly visible and distinguishable in cone beam images and made it possible to verify and analyze the positioning. With the help of the elastic phantom an estimation of a possible benefit with the use of a new positioning device could be performed.

FS 131

Clinical requirements for a new sensor system inside the ear for diagnostic applications in sleep medicine

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Sleep medicine now has well defined 66 characterized sleep disorders, all being explained and listed in the International Classification of Sleep Disorders Manual (ICSD version 3, 2014) published by the American Academy of Sleep Medicine. This Manual also includes definitions and severity criteria for sleep disorders. Six main categories are listed. Diagnostic criteria usually comprise of patient complaints, symptoms, and daytime testing of sleepiness. The main reference method of investigation is an attended polysomnography in a sleep laboratory. However disorders in the group of circadian disorders or sleep-wake rhythm disorders require a recording of core body temperature beside activity monitoring for 24 hours. The physiological change of core body temperature with a nadir during the night is also impaired in patients with disorders or initiating and maintaining sleep (insomnia). A diagnostic tool allowing continuous and non-intrusive monitoring of core body temperatur with a sensor system placed inside the ear would be of very high interest.
A sensor placed inside the ear needs to be comfortable to be used during the night continuously and should not disturb sleep. If placed inside the ear such a system can analyze the pulse wave. Based on this signal it may be possible to obtain oxygen saturation. The recording of oxygen saturation is required for the detection of sleep related breathing disorder, more specifically sleep apnea. More respiratory problems during sleep, like hypoventilation related to COPD can be detected as well. The analysis of the pulse wave and pulse rate would allow to estimate sleep stages in terms of wake, light sleep, deep sleep and REM sleep. This might be a valid estimation as long as the patient does not show too many cardiac arrhythmias. An assessment of blood pressure changes during the night would allow insight on cardiovascular problems as well.

FS 132

Cardiorespiratory coupling in sleep apnea

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The cardio-respiratory component of a sleep polysomnography is provided mainly through the ECG and recordings of ventilatory processes such as nasal pressure. Their impact onto the final sleep medical report however is minuscule; ventilation while present is condensed into a single parameter: the apnea-hypopnea-index. The amount of information encoded into these components' dynamic about the state of the autonomic nervous system is largely ignored.
This contribution presents major methodological developments in sleep research by unlocking parts of this information through the study of cardio-respiratory coupling, especially in sleep apnea. In order to characterize the autonomic regulation during sleep, we analyze the mutual influence of the cardiac and respiratory oscillations in the phase and time-domain i.e. their synchronization and coordination. The resulting physio- as well as pathophysiological insight are presented.

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Analysis of tracheal sound signals for detection of sleep related breathing disorders

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For detection of sleep related breathing disorders (SRBD) based on actual guidelines measuring of airflow at the nose and mouse as well as respiratory effort at the thorax and abdomen is mandatory. This implies the application of several sensors which frequently led to discomfort for the patient during sleep. Also in certain cases signals are affected by artefacts due to body movements resulting in misclassifications of SRBD event types.
Therefore there is a need for alternative measurement techniques not disturbing sleep, easy to handle for patients, and who are capable to detect certain types of disturbed breathing pattern with high accuracy. We present a study testing a new single tracheal sound sensor for detection of SRBD.
The sensor *PneaVox*® (Cidelec, France) is an encapsulated combination of a pressure transducer and a microphone attached to the suprasternal notch of patients during sleep. By signal processing algorithms respiratory flow, respiratory effort, as well as snoring signals are extracted. These signals are going to be evaluated and different pattern of SRBD are classified. We tested the accuracy of *PneaVox*® under sleep lab conditions by comparing results with reference variables from standard polysomnography (PSG).
Out of 54 *PneaVox*® recordings made with PSG in parallel, *PneaVox*® failed in only n=4 cases. The majority of patients had a moderate to severe graded SRBD. Results of SRBD severity by *PneaVox*® correlated significantly with those from PSG ($p<0.01$) for certain event types. Regarding accuracy of *PneaVox*® 72.1% of apneas were classified correctly in comparison to the reference.
In summary, based on our study we found that the tracheal sound sensor *PneaVox*® is able to detect SRBD and to distinguish different event types of the disease with reasonable accuracy. The single sensor *PneaVox*® might become eligible for home testing of SRBD with low negative impact on sleep quality.

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Pulse wave analysis provides additional CV risk information to polysomnography in sleep apnoea patients

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In sleep most processes of the cardiovascular system are controlled by the autonomic nervous system. Several studies provide strong evidence that disturbed sleep is associated with increased cardiovascular (CV) risk. However, today sleep derived variables are not included in conventional cardiovascular risk assessment tools such as the Framingham or EU Risk Score. Photoplethysmographic pulse wave signals provide information about cardiovascular and autonomic function during sleep. In this study we aimed to compare conventional sleep related variables derived from polysomnography (PSG) and novel parameters obtained from finger pulse wave analysis for CV risk assessment in patients with obstructive sleep apnea (OSA).
362 patients (age=56.9±13, 32% female, BMI=30.3±6) undergoing conventional diagnostic PSG were studied. A Matching Pursuit based feature extraction algorithm, which uses signals derived from a single pulse oximeter sensor (SpO2 and photoplethysmographic pulse wave) was developed. The algorithm computed nine parameters (irregular pulse, hypoxic variation, vascular stiffness, cardio-acceleration, time of SaO2<90%, cardio-respiratory coupling, pulse wave amplitude variation, periodic symmetric desaturation, hypoxia induced cardio-acceleration), assumed to reflect multiple dimensions of autonomic activity and cardiorespiratory function and combined them to the final Cardiac Risk Index (CRI).
AHI, oxygen desaturation index and sleep stage N1 increased with CV risk classes whereas sleep time and REM sleep decreased (ANOVA, all $p<0.001$). Vascular stiffness, low cardiac- and pulse wave variability and increased CRI were associated with elevated CV risk class (ANOVA, all $p<0.001$).
In a Generalized Linear Model controlling for age, BMI and CRI, none of the PSG variables showed an independent association with elevated CV risk. In contrast, the highest tertile of CRI was associated with high/very high added CV risk class (OR 4.3 [95%CI, 1.8-10.6], $p=0.001$).
Photoplethysmopragphic pulse wave analysis improves CV risk classification on top of conventional PSG. Further development and validation of this approach is advocated for improved CV risk phenotyping during sleep.