Fachverband Strahlen- und Medizinphysik (ST)

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Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle Kunsthalle und H48; Poster B1)

Georg-Simon-Ohm-Prize Talk

ST 2.1	Tue	9:30–10:00	Kunsthalle	**Exploring Gamma-detected Magnetic Resonance Imaging** — •Robin Yoël Engel

Fachsitzungen

ST 1.1–1.9	Mon	15:00–17:30	H48	**X-ray Imaging**
ST 2.1–2.1	Tue	9:30–10:00	Kunsthalle	**Georg-Simon-Ohm-Prize Session (joint session PRV/ST)**
ST 3.1–3.5	Tue	10:15–11:30	Kunsthalle	**Gamma Imaging**
ST 4.1–4.8	Tue	14:00–16:00	Poster B1	**Poster session**
ST 5.1–5.6	Wed	9:30–11:15	Kunsthalle	**Dosimetry and MRI**
ST 6.1–6.7	Wed	15:00–17:00	H48	**Radiation Therapy**
ST 7	Wed	17:30–19:00	H48	**Mitgliederversammlung Fachverband Strahlen- und Medizinphysik**

Mitgliederversammlung Fachverband Strahlen- und Medizinphysik

Mi, 3. April 2019 17:30–19:00 H48

ST 1: X-ray Imaging

Time: Monday 15:00–17:30 Location: H48

ST 1.1 Mon 15:00 H48

Dynamic X-ray Imaging at the Munich Compact Light Source — •Regine Gradl[1], Martin Dierolf[1], David Kutschke[2], Lin Yang[2], Otmar Schmid[2], Franz Pfeiffer[1], and Kaye S. Morgan[1,3] — [1]Chair of Biomedical Physics and Munich School of BioEngineering; Institute for Advanced Studies, Technical University of Munich, Garching, Germany — [2]Comprehensive Pneumology Center, Institute of Lung Biology and Disease, Helmholtz Zentrum München, Neuherberg, Germany — [3]School of Physics and Astronomy, Monash University, Clayton, Australia

In vivo dynamic respiratory phase-contrast x-ray imaging in small animal models is a powerful research tool, which can be used to increase physiological understanding, and accelerate new therapies towards the clinics. Previously, these experiments were mainly limited to synchrotron facilities. Here we present results for dynamic in vivo x-ray phase-contrast imaging obtained in a laboratory environment using the Munich Compact Light Source. By employing inverse Compton scattering instead of permanent magnet undulators, it is possible to shrink the storage ring to a few meters in circumference, generating brilliant, partially coherent and quasi-monochromatic x-rays. Two different experimental set-ups for dynamic phase-contrast imaging have been implemented at this source. Firstly, a grating interferometer which is used for imaging repeated motion (e.g. the breath cycle of a mouse) and secondly, a propagation-based imaging set-up for detecting irreversible changes. This presentation will describe the set-ups and current applications of these laboratory-based imaging systems.

ST 1.2 Mon 15:15 H48

Dose-compatible grating-based phase-contrast mammography on mastectomy specimens using a compact synchrotron source — Elena Eggl[1,2], •Lisa Heck[1,2,3], Susanne Grandl[4], Martin Dierolf[1,2], Klaus Achterhold[1,2], Franz Pfeiffer[1,2,4], and Julia Herzen[1,2] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany — [3]Chair of Experimental Physics IV, TU Dortmund, Germany — [4]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

Although the introduction of screening mammography has reduced the mortality rate of breast cancer, many women still undergo unnecessary subsequent examinations due to inconclusive diagnoses. In breast imaging, the low soft-tissue contrast of conventional attenuation-based images can be improved by phase-contrast imaging. Here, the diagnostic performance of multimodal grating-based mammography on four freshly dissected breast specimens and one mammographic accreditation phantom was evaluated at a compact synchrotron source. We found enhanced diagnostic information in monochromatic grating-based phase-contrast and dark-field images while the applied dose was lower or equal to the clinical dose. Microcalcifications could be identified equally well at significantly reduced dose in the monochromatic images. The results indicate that compact synchrotron sources can bring benefits to clinical imaging for mammography.

ST 1.3 Mon 15:30 H48

Evaluation of X-ray Dark-Field Signal for Imaging Ex-situ Human Lung Specimens and Structure Size Determination — •Kirsten Taphorn[1], Fabio De Marco[1], Jana Andrejewski[1], Konstantin Willer[1], Christian Braun[2], Alexander Fingerle[3], Franz Pfeiffer[1,3], and Julia Herzen[1] — [1]Chair of Biomedical Physics, Department of Physics and Munich School of BioEngineering, TUM, Garching, Germany — [2]Institute of Forensic Medicine, Ludwig-Maximilians University, München, Germany — [3]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TUM, Munich, Germany

Grating-based x-ray dark-field (XDF) imaging accesses information on small-angle scattering properties of the sample. However, the appearance of different pathologies in XDF lung imaging is not yet known. To elucidate this question, we report the design and implementation of a preclinical study on ex-situ human lung specimens with a Talbot-Lau interferometric setup that provides a field-of-view comparable to an x-ray chest radiography system. We constructed a device for lung ventilation as well as a thorax phantom and performed measurements of ex-situ human lung specimens. Furthermore, we investigated the spectral XDF signal of several phantom materials and found a correlation with mean chord length (MCL) obtained from micro CT, a medically approved size measure for alveolar structure. Structural lung diseases are known to effect changes in MCL. Thus, we show that a prediction of structural properties using spectral XDF imaging is possible, potentially enhancing the diagnostic power of XDF lung imaging.

ST 1.4 Mon 15:45 H48

Improved Grating Interferometer for Dynamical Imaging at the Munich Compact Light Source — •Johannes Brantl, Martin Dierolf, Christoph Jud, Klaus Achterhold, and Franz Pfeiffer — Chair of Biomedical Physics, Department of Physics and Munich School of BioEngineering, Technical University of Munich, 85748 Garching, Germany

X-ray grating interferometry allows the measurement of three complementary image modalities, attenuation, phase contrast and dark field. In the default acquisition scheme, phase and absorption grating have to be translated relative to each other resulting in a stepping curve. This can limit the visualisation of dynamical systems even if the flux is sufficiently high to allow for short exposure times. This is the case at the Munich Compact Light Source (MuCLS) [1], where a synchrotron-like X-ray beam is produced by inverse Compton scattering. Despite the high flux, dynamical imaging could so far only been performed for periodic processes, e.g. for in-vivo phase-contrast imaging of the respiratory system of mice [2], due to the limited stepping speed. The extension to temporal measurements of non-periodic dynamical systems is achieved by upgrading the current setup with a piezo actuator for stepping. We will present first results of imaging dynamical processes on the subsecond scale.

[1] Eggl, Elena et al., "The Munich Compact Light Source: initial performance measures", J. of Synch. Rad. 23 (2016): 1137-1142.

[2] Gradl, R., et al. "Dynamic in vivo chest x-ray dark-field imaging in mice", IEEE Trans. Med. Imag. (2018).

ST 1.5 Mon 16:00 H48

Characterization and optimization of a small animal in-vivo grating-based dark-field CT scanner — •Stephan Umkehrer[1], Katharina Hellbach[2], Ali Önder Yildirim[3], Julia Herzen[1], and Franz Pfeiffer[1,4] — [1]Chair of Biomedical Physics and Munich School of BioEngineering, TU Munich, Garching — [2]Department of Radiology, University Hospital, LMU Munich, Munich — [3]Comprehensive Pneumology Center, Institute of Lung Biology and Disease, Helmholtz Center Munich, Munich — [4]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Munich

In contrast to conventional X-ray attenuation, grating-based dark-field imaging provides sample small-angle scattering information. Especially for early detection of lung diseases, such as pulmonary emphysema, pulmonary fibrosis, or pulmonary carcinoma the dark-field signal provides promising diagnostic value. Using in vivo radiography, structural pathologic changes in the lung tissue due to alveolar structure change can be observed by a decreased dark-field signal. Even though research has been very successful concerning the increased sensitivity of the dark-field signal compared to conventional absorption contrast the diagnostic potential of dark-field computed tomography (CT) for early pulmonary disease detection and assess has to be investigated. In this presentation, we will describe the recent progress of the first preclinical small animal in-vivo dark-field CT scanner, which was developed in collaboration with Bruker MicroCT (former Skyscan).

15 min. break

ST 1.6 Mon 16:30 H48

K-edge subtraction imaging at a compact synchrotron source — •Stephanie Kulpe[1,2], Martin Dierolf[1,2], Eva Braig[1,2,3], Benedikt Günther[1,2], Klaus Achterhold[1,2], Bernhard Gleich[2], Julia Herzen[1,2], Ernst Rummeny[3], Franz Pfeiffer[1,2,3], and Daniela Pfeiffer[3] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany — [3]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

About one third of all deaths worldwide can be traced back to cardiovascular diseases, for which digital subtraction angiography (DSA) is an important diagnostic radiological procedure. An alternative to DSA is K-edge subtraction (KES) imaging, which can eliminate image artifacts caused by patient movement. As highly brilliant, monochromatic X-rays are desirable for this method, it has been limited to synchrotron facilities so far, restraining the feasibility in clinical routine. Compact synchrotron X-ray sources based on inverse Compton scattering, which have been evolving substantially over the past decade, provide X-rays with sufficient brilliance that meet spatial and financial requirements affordable in laboratory settings or for university hospitals. In this study, we demonstrate a first proof-of-principle KES imaging experiment using the Munich Compact Light Source (MuCLS), the first user-dedicated installation of a compact synchrotron X-ray source worldwide. We believe that KES at a compact synchrotron source can become an important tool in pre-clinical research.

ST 1.7 Mon 16:45 H48

3D X-ray phase-contrast Histology — •Josef Scholz[1,2], Lorenz Birnbacher[1,2], Christian Petrich[1,2], Franz Pfeiffer[1,2], and Julia Herzen[1,2] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany

The study of diseased tissue in anatomical pathology usually includes laborious pre-preparation processes, in particular staining and sectioning of the samples taken, before examination using light microscopy. Here, the sectioning process by itself causes a distortion of the individual slices and the subsequent arrangement of the 2D data results in anisotropic voxel sizes of the reconstructed 3D volume. Due to the comparably high sensitivity of grating based X-ray setups in terms of soft tissue variations, grating-based X-ray phase-contrast computed tomography (gbXPC-CT) constitutes a promising complementary method in histopathology, allowing for preliminary examination and localisation of diseased areas before sectioning non-destructively. Therefore, a resolution below 10 microns over a scan volume sufficient to the specimen size while not exceeding reasonable scan times has to be achieved, which remains a challenging problem using conventional lab sources. The presentation will show first results using a high-sensitivity gbXPC-CT setup.

ST 1.8 Mon 17:00 H48

Hematein-based X-ray suitable Stain enables 3D Visualization of the Cell Nuclei — •Katharina Scheidt[1], Mark Müller[1], Melanie A. Kimm[2], Simone Ferstl[1], Sebastian Allner[1], Klaus Achterhold[1], Julia Herzen[1], Franz Pfeiffer[1,2], and Madleen Busse[1] — [1]Department of Physics and Munich School of Bioengineering, TU Munich, Germany — [2]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

The current gold standard for the investigations of anatomical structures on a cellular level is histology which is limited to two-dimensional imaging and often shows disruption of the cell architecture due to the sectioning of the tissue. In contrast to that, non-destructive 3D imaging methodologies such as X-ray microscopic and nanoscopic CT struggle with the weak attenuation of soft tissue hampering their application in virtual 3D histology. The presented nucleus-specific X-ray stain provides a visualization of anatomical structures in three dimensions whereby it addresses specifically the cell nuclei. With this technique, the real 3D morphology and the spatial distribution of cell nuclei is maintained. Together with a newly developed laboratory nanoscopic CT system, 3D visualization in nanometer range is possible. Furthermore, the staining technique is compatible with conventional 2D histology as microscopic slides can be derived from the very same stained soft-tissue sample and further counter staining is possible.[1]

[1] M.Müller, A.M.Kimm et al., Non-destructive high-resolution 3D virtual histology enabled through a cell nucleus-specific stain for X-ray computes tomography. Sci. Rep., 2018, manuscript accepted.

ST 1.9 Mon 17:15 H48

Bismuth-Oxo-Clusters as Novel X-Ray Stain for Soft-Tissue Samples — •Toni Bürkner[1], Madleen Busse[1], Mark Müller[1], Melanie A. Kimm[2], and Franz Pfeiffer[1,2] — [1]Department of Physics and Munich School of BioEngineering, Technical University of Munich, 85748 Garching, Germany. — [2]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, Technical University of Munich, 81675 Munich, Germany.

X-ray absorption-based micro-computed tomography enables 3D imaging with micrometer resolution[1]. This technique is commonly used in material science and is interesting for medical and biological sample screening as it is a non-destructive imaging method. The big drawback of soft-tissue samples is their missing contrast, which is mandatory to visualize internal structures on a microscopic scale, which will enable compatibility with conventional 2D histology [2,3]. Contrast agents (stains) and staining protocols are developed to overcome this problem and enhance the contrast. Within this work, we present a novel staining method based on bismuth-oxo-clusters, which was especially developed for soft-tissue X-ray imaging . Different clusters were synthesized and tested on various soft-tissue samples such as whole mouse organs, e.g. spleen and kidney.

[1] Stock, S. R. (2009). Micro-Computed Tomography - Methodology and Applications. CRC Press, Boca Raton, FL.

[2] M. Müller et al, PNAS 114 (2017) 12378-12383.

[3] M. Busse and M. Müller et al, PNAS 115 (2018) 2293-2298.

ST 2: Georg-Simon-Ohm-Prize Session (joint session PRV/ST)

Time: Tuesday 9:30–10:00 Location: Kunsthalle

Prize Talk ST 2.1 Tue 9:30 Kunsthalle

Exploring Gamma-detected Magnetic Resonance Imaging — •Robin Yoël Engel — CERN, Geneva, Schweiz — C.v.O. University of Oldenburg, Germany — HS Emden-Leer, Germany — Laureate of the Georg-Simon-Ohm-Prize 2019

In 2016, the proof of principle for a new method of imaging was presented (Nature 537.7622 (2016): 652-655.), which uses many elements of traditional Magnetic Resonant Imaging, but replaces the detection of RF induction signals with that of the anisotropic gamma-emission from a hyper-polarized radioactive noble gas. Since gamma-radiation is in comparison very easy to detect, this method is sensitive to concentrations of imaged nuclei that are up to ten orders of magnitude lower than those needed in conventional MRI. Therefore, it has the perspective of combining the advantages of nuclear tracers, as they are used in SPECT and PET, with the higher spatial resolution of MRI. In addition to a software for numerical simulations of the spin precession and nuclear emission behavior during magnetic resonance experiments on hyper-polarized radioactive xenon, dedicated setups were developed. The main setup is designed for magnetic resonance experiments on hyper-polarized xenon, capable of using both the anisotropic gamma emission from radioactive nuclei as well as induction signals from stable isotopes for detection. It utilizes an existing low-field MRI-scanner and Si-PMT based gamma detectors in combination with elements from a spin-exchange optical pumping setup developed for hyper-polarized MRI on stable Xenon. This talk introduces the principle of gamma detected MRI and presents the developments within the frame of this master thesis.

ST 3: Gamma Imaging

Time: Tuesday 10:15–11:30 Location: Kunsthalle

ST 3.1 Tue 10:15 Kunsthalle

Coincident Detection of Cherenkov Photons from Compton Scattered Electrons for Medical Applications — Hedia Bäcker[1], •Reimund Bayerlein[1], Ivor Fleck[1], Todd Peterson[2], and Ayman Salman[1] — [1]Universität Siegen, Deutschland — [2]Vanderbuilt University, Nashville, USA

There has been an increasing interest in an efficient gamma detector for medical applications: Proton beam therapy and nuclear medicine could benefit from the ability to detect higher energetic gamma-radiation (>1MeV). One possible detector would be a Compton Camera. Coincident detection of energy and position of both the electron and the scattered gamma allows to reconstruct the incoming gamma momentum to lie on the surface of a cone. Intersection of many cones yields information on the gamma source location. A novel concept for the detection of the high energetic Compton-scattered electron is proposed. Using coincident detection of Cherenkov photons generated by the electron in an optically transparent radiator material an estimation of the scattering vertex, the electron energy and momentum is possible. A proof of principle is presented showing the coincident detection of Cherenkov photons created by electrons in PMMA on a 8x8 Silicon-Photomultiplier array. The coincidence timing resolution is in the order of 250 ps. Spatial sensitivity for the electron source location will be demonstrated using accumulated and single coincident events. The influence of radiator material and thickness will be presented together with a comparison of obtained results with theoretical estimations.

ST 3.2 Tue 10:30 Kunsthalle

Advances in a Silicon Photomultiplier Readout of a Compton Camera — •Tim Binder[1,2], Maria Kawula[1], Silvia Liprandi[1], Giavanni Paolo Vinci[1], Florian Schneider[2], Katia Parodi[1], and Peter G. Thirolf[1] — [1]Ludwig-Maximilians-Universität, Munich, Germany — [2]KETEK GmbH, Munich, Germany

Silicon Photomultipliers (SiPM) have moved into the focus of a variety of applications to substitute photomultiplier tubes (PMT) due to their limitations in some areas. SiMPs can be operated in medical applications with the presence of magnetic fields, e.g. PET/MRI, or, because of their compact package size, where PMTs would introduce intolerable amounts of dead material, e.g. in a Compton camera (CC) scatter detector. Our CC prototype was developed for online range verification in hadron therapy. The absorber component of the prototype, a monolithic $LaBr_3$:Ce crystal (read out by a multianode PMT), will alternatively be read out by SiPMs, while the currently used scatterer, consisting of six layers of double-sided silicon strip detectors (DSSSD), can alternatively be substituted by a pixelated GAGG scatterer with SiPM readout to provide common readout and data processing of the whole CC. Furthermore, a $CeBr_3$ crystal is under investigation as a cost-effective and low-background alternative to $LaBr_3$:Ce. In this work results of the characterization of the SiPM readout (including the readout electronics) will be presented. Furthermore, a summary of the characterization of the $CeBr_3$ absorber will be given. This work is supported by the DFG Cluster of Excellence Munich Centre for Advanced Photonics (MAP) and the Bayerische Forschungsstiftung.

ST 3.3 Tue 10:45 Kunsthalle

Single Plane Compton Imaging — •Boyana Deneva[1], Katja Roemer[1], Guntram Pausch[2,3], Andreas Wagner[1], Wolfgang Enghardt[2,3,5], and Toni Koegler[2,3,4] — [1]HZDR, Institute of Radiation Physics, Dresden, Germany — [2]HZDR, Institute of Radiooncology - OncoRay, Dresden, Germany — [3]OncoRay-National Center for Radiation Research in Oncology, Dresden, Germany — [4]Technische Universität Dresden, Dresden, Germany — [5]German Cancer Consortium (DKTK), partner site Dresden, Germany

The gamma camera and its utilization in SPECT have established themselves as key technologies for radionuclide imaging in nuclear medicine. Despite the advances in the imaging techniques, there are still physical limits to the camera performance manifested mainly by the constant trade-off between spatial resolution and detection efficiency due to the used collimator. To overcome these limitations, the concept of the "Single Plane Compton Imaging" was developed, based on the idea of the "Directional Gamma Radiation Detector". A setup for the investigation of this novel concept was developed at the Helmholtz-Zentrum Dresden - Rossendorf. Based on a GAGG:Ce scintillator array read out by digital silicon photomultipliers, the setup delivers spatial information about activity distributions. Experimental results will be shown acquired with the new setup for energies, relevant for the nuclear medicine. Also, the first results of image reconstruction of an activity distribution using the MLEM method based on experimental data will be presented and compared to predictions obtained from particle transport calculations performed with GEANT4.

ST 3.4 Tue 11:00 Kunsthalle

Evaluation and Optimization of a Semi-Monolithic Detector Concept in Positron Emission Tomography (PET) — •Michael Hammerath, Florian Müller, Christian Gorjaew, David Schug, and Volkmar Schulz — RWTH Aachen University, Physics of Molecular Imaging Systems, Aachen, Germany

PET is a medical imaging technique using positron-emitting tracers to examine a patient's metabolism. Two γ-particles - created by electron-positron annihilation - are detected by scintillation detectors. The impinging position, arrival time, and energy of the γ-particles are measured to reconstruct the tracer distribution.

We present a novel semi-monolithic detector concept to combine the intrinsic depth of interaction (DOI) information of a monolithic scintillator with the high photon density of segmented scintillator arrays. One detector block consists of 8 LYSO slabs of dimensions 3.9 mm x 32 mm and 12 mm or 19 mm height. The slabs were optically coupled to a digital SiPM, covering a single row of pixels each. The detector block under test was stepwise irradiated with a fan beam collimator setup. Impinging γ-events were positioned separately along the planar and DOI direction employing the supervised machine learning algorithm gradient tree boosting. Spatial resolutions of 1.2 mm and 1.9 mm for the planar direction as well as 1.8 mm and 2.7 mm for the DOI direction were achieved for the crystals of 12 mm and 19 mm height. A dedicated energy calibration was used to determine the energy resolution. For first-photon trigger, energy resolutions of 12.1% for slabs of 12 mm and 11.1% for slabs of 19 mm height were achieved.

ST 3.5 Tue 11:15 Kunsthalle

Timing Performance of a Detector Based on Semi-Monolithic Scintillators for Positron Emission Tomography (PET) — •Christian Gorjaew, Florian Mueller, Michael Hammerath, David Schug, and Volkmar Schulz — RWTH Aachen University, Physics of Molecular Imaging Systems, Aachen, Germany

PET uses a β^+-decaying tracer material to resolve metabolic processes in an organism by detecting the two γ-photons of the e^+e^--annihilation along a line of response (LOR) with a ring-shaped arrangement of scintillation detectors. Precise time information is utilized to enhance the signal-to-noise ratio by restricting the annihilation position to a smaller region on the LOR (Time-of-Flight PET). Among others, the scintillator crystal's geometry can have significant impact on the performance of the detector, especially on the timing performance. Hence, we investigated the time resolution of a novel detector concept based on semi-monolithic scintillator slabs. This concept aims to combine the good energy and time resolution of pixelated scinitllators and the precise 3D-positioning accuracy of monolithic ones. We studied two detectors built up of 12 mm and 19 mm high LYSO scintillators coupled to a digital SiPM (PDPC, DPC 3200-22-44) and developed a time calibration. The achieved time resolution is reported. After correction of runtime differences caused by electronics and scintillator, coincidence resolving times down to 226 ps FWHM could be reached, approaching values of the best PET systems on the market. Furthermore, we implemented a maximum likelihood algorithm to estimate the interaction time of the annihilation photons more precisely.

ST 4: Poster session

Time: Tuesday 14:00–16:00 Location: Poster B1

ST 4.1 Tue 14:00 Poster B1

investigation of intrinsic property of 4 layer DOI PET detector — •Munetaka Nitta[1], Giulio Lovatti[1], Geroge Dedes[1], Mohammad Safari[1], Tim Binder[1], Juliana Martin[1], Peter Thirolf[1], Taiga Yamaya[2], and Katia Parodi[1] — [1]Ludwig Maxmilians University, Munchen, Germany — [2]National institutes for quantum and radiological science and technology, Chiba, Japan

We have started to design an in-beam PET system for the project of "small animal proton irradiator for research in molecular image-guided radiation-oncology (SIRMIO)". The PET system should be designed to image positron emitters induced by proton beam. To achieve both uniform high image resolution in field of view and high sensitivity, we require a PET detector with high spatial resolution and depth of interaction (DOI) information. As the structure of DOI PET detector, the 4-layer DOI PET detector which is developed by national institute of radiological science in Japan is a leading candidate for the PET system. As a scintillator, both LYSO and GAGG are candidates for the PET detector. LYSO is commonly used for PET detector but contains natural radioactive isotope of Lu-176 which provides random coincidence for PET measurement as noise event. Such noise events might not be negligible because of the limited number of induced positron emitters. Although density of GAGG is lower than LYSO, GAGG does not contains such natural radioactive isotope. In this study, we carried out optical Monte Carlo simulation of both LYSO and GAGG based 4-layer DOI PET detector to investigate dependency of scintillation material on intrinsic property of the PET detector by Geant4.

ST 4.2 Tue 14:00 Poster B1

Contrast-Enhanced Spectral Mammography with a Compact Synchrotron Source — Lisa Heck[1,2,3], •Mirko Riedel[1,2], Martin Dierolf[1,2], Christoph Jud[1,2], Elena Eggl[1,2], Thorsten Sellerer[1,2], Korbinian Mechlem[1,2], Benedikt Günther[1,2], Klaus Achterhold[1,2], Bernhard Gleich[2], Stephan Metz[4], Daniela Pfeiffer[4], Franz Pfeiffer[1,2,4], and Julia Herzen[1,2] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany — [3]Chair of Experimental Physics IV, TU Dortmund, Germany — [4]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

Contrast-enhanced spectral mammography (CESM) based on K-edge subtraction (KES) helps to identify uncertain findings in mammography as second-level examination. Here, the commonly used dual-energy KES imaging technique and a two-material decomposition method were used to perform CESM with a mammographic accreditation phantom at a compact synchrotron source. For a better evaluation of the laboratory results, clinical CESM images were also performed. Improved image quality has been accomplished with both aforementioned methods while the spectral approach achieved even better results than the KES. Exemplarily, we demonstrate the reduction of the applied dose by up to 66% compared to the clinically applied dose. These promising results underline the potential of this novel type of X-ray source and of the spectral approach to improve the diagnostic quality of CESM and to reduce the applied dose in clinical examinations.

ST 4.3 Tue 14:00 Poster B1

Phase-sensitive water fat separation in frequency-modulated bSSFP cardiac CINE — •Anne Slawig, Tobias Wech, Thorsten Bley, and Herbert Köstler — Institut für diagnostische und interventionelle Radiologie, Universitätsklinikum Würzburg, Deutschland

Balanced steady state free precession (bSSFP) is widely used for assessing cardiac function in MRI, as it provides fast imaging with high SNR and excellent contrast. The main drawbacks include banding artefacts caused by field inhomogeneity and the hyperintense fat signal. The former have been shown to be eliminated by using a frequency-modulated bSSFP acquisition (1). Further on, fat and water signal can be separated in standard bSSFP imaging by a phase sensitive approach (2). Here we present a combination of both methods, which allows the reconstruction of banding free, water-only and fat-only images of the whole cardiac cycle (CINE imaging). Cardiac images of a healthy volunteer were acquired for 20 cardiac phases using an ECG log and the phase-sensitive separation was applied. In standard bSSFP measurements severe off-resonance artefacts were observed, ultimately resulting in major swaps between water and fat. The combination of the frequency-modulated measurement with the phase-sensitive separation approach showed no off-resonance artefacts and a good separation of water and fat throughout all frames of the cardiac cycle.

[1] Benkert T et al., Magn. Reson. Med. 2015;73:182-194
[2] Hargreaves BA et al., Magn. Reson. Med. 2003;50:210-213

ST 4.4 Tue 14:00 Poster B1

Using ultraviolet light for velocity determination of magnetic nanoparticles in external magnetic fields. — •Jörg Fusenig[1], Robert Englert[1], Sven Mantowsky[1], Tobias Roth[1], Hellmut Hupe[1], and Marc Schneider[2] — [1]Trier University of Applied Sciences, Engineering and Technology, D-54293 Trier — [2]Saarland University, Biopharmaceutics and Pharmaceutical Technology, D-66123 Saarbrücken

This contribution deals with the linear transportation of magnetic nanoparticles by the use of a linear moving field device. To understand the acting forces and how they are affected by the viscosity, the transport process through transparent cylindrical tubes filled with different media can be monitored. In order to access the velocity of the magnetite particles, a stand-alone device equipped by an ultraviolet light transmission tool is developed. Locally differing volume concentrations within the moving particle cloud lead to a time-dependent change in the attenuation of the transmitted light which is a measure for the clouds velocity. Simultaneously, the magnetic flux density is recorded with a set of hall sensors. The device is immersible in water, as the field exciting coils are fully submerged in a flow-through vessel to transfer power losses. We test the performance of the setup by a comparison with a commercial UV/Vis spectrometer and a magnetometer, respectively.

ST 4.5 Tue 14:00 Poster B1

Performance of a monolithic scintillator studied under realistic conditions in a Compton Camera system — •Giovanni Paolo Vinci, Tim Binder, Silvia Liprandi, Maria Kawula, Katia Parodi, and Peter G. Thirolf — Ludwig-Maximilans-Universität München

The Compton Camera (CC) prototype under commissioning in Garching aims at providing an online beam range verification tool using the prompt γ rays emitted by excited nuclei during the irradiation of tissue with a particle beam. Currently, we are working with 50x50x30 mm^3 monolithic $LaBr_3$:Ce or $CeBr_3$ scintillators as CC absorber component, read out by multianode photomultipliers. These configurations show excellent energy, spatial and timing resolutions.

In realistic conditions, however, the Compton electrons, generated in the scatterer, consisting of 6 layers of 0.5 mm thick double-sided Silicon strip detectors (DSSSD), may reach the scintillator, since the thickness of the DSSSD array is not enough to stop them. So far, the determination of the photon interaction position in the absorber crystal was studied only with individual collimated γ sources. Yet, it remains to be explored how the resolution is affected by either an electron and the Compton scattered photon or two photons impinging simultaneously onto the crystal. This work will present a study of these two scenarios using simultaneous irradiation by a collimated ^{204}Tl electron source and collimated ^{137}Cs or ^{60}Co photon sources.

This work is supported by the DFG Cluster of Excellence Munich Centre for Advanced Photonics (MAP).

ST 4.6 Tue 14:00 Poster B1

Investigation of the dependency of properties of a 4-layer DOI PET detector on the scintillator material — •Munetaka Nitta[1], Giulio Lovatti[1], Georgios Dedes[1], Sodai Takyu[2], Mohammad Safari[1], Tim Binder[1], Giovanni Vinci[1], Taiga Yamaya[2], Katia Parodi[1], and Peter G. Thirolf[1] — [1]LMU, Munich, Germany — [2]NIRS-QST, Chiba, Japan

We have started to design an in-beam PET system for the Small animal proton irradiator for research in molecular image-guided radiation-oncology (SIRMIO) project. The PET will image positron emitters generated by the proton beam or externally injected with radioactive tracers. To achieve both uniform high image resolution and high sen-

sitivity, we require a PET detector with high spatial resolution and depth-of-interaction (DOI) identification capability. Here, the 4-layer DOI PET detector developed by the NIRS is a leading candidate. As a scintillator material, both LYSO and GAGG are candidates. LYSO is commonly used for PET detectors, but contains the radioactive isotope of Lu-176 which provides random coincidences for PET measurement as background. Such noise events might not be negligible due to the limited yield of generated positron emitters for pre-clinical treatment. Although the density of GAGG is lower than for LYSO, GAGG does not contain such radioactivity. In this study, we carried out simulations using Geant4 of both LYSO and GAGG-based 4-layer DOI PET detectors to investigate the dependency of the PET detector properties on the scintillator material. This work is funded by the European Research Council (ERC) under grant agreement number 725539.

ST 4.7 Tue 14:00 Poster B1

Reichweitenbestimmung für therapeutisch eingesetzte Protonen: optische Messung im Vergleich zu herkömmlichen Messmethoden. — •Jan Michael Burg[1], Hilke Vorwerk[2] und Klemens Zink[1,2,3] — [1]THM Gießen — [2]UKGM, Gießen/Marburg — [3]FIAS, Frankfurt

Die Therapie mittels Protonen findet immer häufiger Einsatz in der modernen Strahlentherapie. Bei der Qualitätssicherung dieser Anlagen ist einen wiederkehrende dosimetrische Fragestellung, das Bestimmen der energieabhängigen Reichweiten der eingesetzten Protonen. Die herkömmliche Messung mittels beweglicher Ionisationskammern in Wasser ist, je nach geforderter Ortsauflösung und Anzahl der zu messenden Energien, sehr zeitintensiv. Es konnte in einem Experiment am Marburger Ionenstrahl-Therapiezentrum bereits gezeigt werden, dass es mittels einer hochempfindlichen Kamera möglich ist optische Photonen zu detektieren, die während der Bestrahlung eines Wasserphantoms entstehen. Da diese Methode das gesamte Strahlprofil in einer Messung aufnimmt ergibt sich ein deutlicher Zeitvorteil gegenüber der schrittweisen Messung mittels Ionisationskammern. In dieser Arbeit soll die optische Reichweitenbestimmung mit herkömmlichen Methoden im Detail verglichen werden. Das Auflösungsvermögen und die Zeitersparnis für die Reichweitenmessung, im Vergleich zu herkömmlichen Messmethoden, wurden bestimmt. Darüber hinaus wurde geprüft ob sich die optische Messmethode auch zum charakterisieren des Peak-to-Pateau Verhältnisses eines Bragg-Peak eignet.

ST 4.8 Tue 14:00 Poster B1

Determination of the photon interaction position in a monolithic scintillator applied in a Compton Camera system — •Maria Kawula[1], Silvia Liprandi[1], Tim Binder[1,2], Rita Viegas Rego[1,3], Ben Hoyle[1], Katia Parodi[1], and Peter G. Thirolf[1] — [1]LMU München, Munich, Germany — [2]KETEK GmbH, Munich, Germany — [3]University of Coimbra, Portugal

The LMU Compton Camera is being developed for ion beam range verification during particle therapy. The system detects prompt gamma rays produced after tissue irradiation. The camera consists of a scatterer (6 layers of double-sided Si-strip detectors) and a monolithic $LaBr_3$(Ce) scintillator as an absorber, read out by a multianode photomultiplier. To determine the photon interaction position in the scintillator the "Categorical Average Pattern" (CAP) algorithm [1] is used. This algorithm is based on the comparison of every recorded photon event with a reference library of 2D light amplitude distributions obtained by scanning the scintillator front surface with tightly collimated ^{60}Co and ^{137}Cs sources respectively in 10404 positions (400 photopeak events per position are acquired). A second method based on Convolutional Neural Networks (CNN) is under development. The reference library acquired for the CAP algorithm is used as training data. The architecture of the network as well as a quantitative comparison of CAP and CNN in terms of computational time, memory consumption and obtained spatial resolution will be presented. This work is supported by the DFG Cluster of Excellence Munich Centre of Advanced Photonics (MAP).

ST 5: Dosimetry and MRI

Time: Wednesday 9:30–11:15 Location: Kunsthalle

ST 5.1 Wed 9:30 Kunsthalle

Status and prospects of the TL-DOS project — •Robert Theinert[1], Frank Busch[2], Myriam Heiny[1], Kevin Kröninger[1], Florian Mentzel[1], and Jörg Walbersloh[2] — [1]TU Dortmund, Dortmund, Germany — [2]Materialprüfungsamt NRW, Dortmund, Germany

The Monitoring Service at the Materialpruefungsamt NRW in Dortmund develops a new thermoluminescence dosemeter system for the application in large-scale individual dose monitoring. The Experimentelle Physik IV at the TU Dortmund participates in this project, called TL-DOS, especially in the development of an automated analysis of the data.

The TL-DOS system serves as a compact system including different types of dosemeters, e.g. whole and partial body dosemeters and a neutron dosemeter, both for application in routine and clinical dosimetry. All dosemeters are based on the principle of thermoluminescence and uses LiF:Mg,Ti as sensitive material.

This talk presents the TL-DOS project with its different types of newly developed dosemeters as well as advanced analysis techniques for thermoluminescence dosimetry, e.g. glow curve analysis using multivariate methods.

ST 5.2 Wed 9:45 Kunsthalle

Entwicklung eines Thermolumineszenz Neutronendosimeters zur Messung der Ganzkörperdosis Hp(10) — •Myriam Heiny[1], Frank Busch[2], Kevin Kröninger[1] und Jörg Walbersloh[2] — [1]TU Dortmund, Dortmund, Deutschland — [2]Materialprüfungsamt NRW, Dortmund, Deutschland

Basierend auf dem Prinzip der Thermolumineszenz wird in der Personendosismessstelle des Materialprüfungsamtes NRW zusammen mit der TU Dortmund das Dosimetersystem TL-DOS zur Überwachung von beruflich strahlenexponierten Personen entwickelt. Dieser Vortrag bezieht sich auf das TL-DOS Neutronendosimeter. Das System besteht aus LiF:Mg,Ti Detektoren, einer Albedokassette und einem Auslesegerät. Das Auslesen der Detektoren wird bei den bisherigen Systemen bei 290°C durchgeführt. Um jedoch keine Information zu verlieren und die Detektoren vollständig zu löschen, werden die verwendeten Detektoren bis 380°C aufgeheizt. Zur Auswertung kann die entstandene Glühkurve in ihre einzelnen Peaks zerlegt und analysiert werden. Das Dosimetersystem mit seinen Detektoren und dem Messprofil wird in einigen Neutronen- und Photonenfeldern charakterisiert und hinsichtlich der vorgegebenen Grenzen für die deutsche Bauartzulassung geprüft. Die Ergebnisse der Bestrahlungen in den Neutronenreferenzfeldern werden mit herkömmlichen Albedodosimetern verglichen. Wodurch gezeigt werden kann, dass ein Neutronendosimeter auf Basis des TL-DOS Systems die physikalischen und messtechnischen Anforderungen erfüllt. In dem Vortrag werden die aktuellen Ergebnisse vorgestellt.

ST 5.3 Wed 10:00 Kunsthalle

Unsicherheiten und Erkennungsgrenzen von Spektrometer basierten Umgebungsdosimetern — Annette Röttger und •Patrick Kessler — Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland

Die Entwicklung eines neuen Sekundärnormals in der Umgebungsdosiemetrie mit geringen Unsicherheiten und Erkennungsgrenzen – auch bei sehr niedrigen Dosisleistungen – ist ein wichtiger Aspekt beim Verständnis von Strahlungsfeldern in der Umwelt.

Neuartige Szintillationsmaterialien wie $CeBr_3$ besitzen eine gute Energieauflösung (< 4 % bei 662 keV) bei einer hohen Effizienz. Dies ermöglicht sehr niedrige Nachweisgrenzen und damit die Bestimmung geringer Aktivitätskonzentrationen künstlicher Nuklide.

Anhand eines konkreten Beispiels – vergleichbar mit einem realistischen Szenario – werden die Eigenschaften eines $CeBr_3$-basierten Detektorsystems mit denen einer Hochdruckionisationskammer verglichen. Durch eine statistische Analyse wird gezeigt, dass sich dieses System als Sekunärnormal in der Umgebungsüberwachung sehr gut eignet. Zusätzlich werden Hinweise für den optimalen Einsatz eines solchen Systems gegeben.

ST 5.4 Wed 10:15 Kunsthalle

Development of a UAV based spectro-dosimetric system —

•Maksym Luchkov, Patrick Kessler, Stefan Neumaier, and Annette Röttger — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

In the framework of the EMPIR project 16ENV04 "Preparedness", PTB is developing a spectrometer based dosimetric system that can be operated while attached to an unmanned aerial vehicle (UAV). This is important for a radiological emergency situation where UAV can cover a large area much faster than a ground squad, therefore minimizing the workers' exposition to ionizing radiation.

The dosimetric system consists of a $CeBr_3$ scintillation detector which records spectra every two seconds into a database and converts them to dose rate information. The system also measures global position, height above ground and can send this information to a ground base where additional data treatment is possible.

The paper presents the results from a ground measurement campaign on PTB's premises, where an uncollimated free field irradiation facility was operated. The artificial dose rate increase at the reference point was ranging from 60 to 400 nSv/h. The standard deviations of the measured dose rates in 2 s intervals are in the order of 10-30 % and the results agree well with the reference values.

The remarkable performance of the dosimetric system demonstrates the ability of metrologically accurate two-second long dose rate measurements with the well-characterized spectro-dosemeter.

15 min. break

ST 5.5 Wed 10:45 Kunsthalle

Ion-Implanted Ra-226 as a primary Rn-222 emanation standard — •Florian Mertes[1], Stefan Röttger[1], Annette Röttger[1], Reinhard Heinke[2], Tom Kieck[2], Nina Kneip[2], Dominik Studer[2], and Klaus Wendt[2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig — [2]Johannes Gutenberg-Universität, Mainz

The PTB investigated the use of ion-implanted Ra-226 as a primary standard for the generation of reference Rn-222 atmospheres. Ra-226 was implanted after laser-ionization at the RISIKO mass-separator of the Johannes Gutenberg-University Mainz. Implantation was carried out into tungsten and aluminum targets at 30 kV acceleration potential. Since the Rn-222 nucleus has a recoil energy of about 86 keV after the decay of Ra-226, a fraction of the generated Rn-222 can escape from the target. Absolute determination of implanted Ra-226 activity was carried out with defined solid-angle α-spectrometry. The fraction of escaping Rn-222, the emanation factor, was determined by γ-spectrometry with HPGe- and solid-state scintillation-detectors. Thereby, the implanted source was compared to a second implanted source that was sealed against Rn-222 escape. The emanation factor is directly calculated by comparing Rn-222 progeny and Ra-226 count rate ratios of the respective sources. The emanation factors appear to be unaffected by relative humidity and temperature changes. With these sources and an appropriate reference volume, stable Rn-222 activity concentrations in the regime below $300\,\mathrm{Bq \cdot m^{-3}}$ can be generated at uncertainties not exceeding 3 % (k = 1).

ST 5.6 Wed 11:00 Kunsthalle

Image guided steering of a magnetically coated swimmer with Magnetic Particle Imaging — •Anna C. Bakenecker[1], Anselm von Gladiss[1], Michael Herbst[2], Heinrich Lehr[2], Matthias Graeser[3,4], Mandy Ahlborg[1], Thomas Friedrich[1], and Thorsten M. Buzug[1] — [1]Institute of Medical Engineering, University of Lübeck, Germany — [2]Bruker Biospin MRI GmbH, Ettlingen, Germany — [3]Section of Biomedical Imaging, University Medical Center Eppendorf, Hamburg, Germany — [4]Insititute of Biomedical Imaging, Technical University Hamburg, Germany

Magnetic actuation is of great interest for the local delivery of therapeutics towards regions which are difficult to access. A 3D printed swimmer, which is coated with magnetic nanoparticles was developed. This swimmer of mm-size can be used as an untethered transporter through the vascular system. The steerability as well as the simultaneous visualization of the swimmer is demonstrated by using magnetic particle imaging (MPI). MPI is a very promising imaging technique, because it enables three-dimensional real-time imaging of magnetic nanoparticles without ionizing radiation. It is highly beneficial for the combination with magnetic actuation, since the magnetic fields of MPI scanners cannot only be used for the image acquisition but for magnetic actuation as well. The steerability of the swimmer in a vessel phantom is demonstrated and MPI images of the moving swimmer are shown.

ST 6: Radiation Therapy

Time: Wednesday 15:00–17:00 Location: H48

ST 6.1 Wed 15:00 H48

Entwicklung eines SiPM-basierten Detektorsystems für die Reichweiteverifikation in der Protonentherapie unter Nutzung des Single Plane Compton Imagings — •Marc Iltzsche[1,3], Boyana Deneva[1,3], Wolfgang Enghardt[1,2,3,4], Benjamin Lutz[1], Guntram Pausch[1,2], Katja Roemer[1], David Weinberger[1], Andreas Wagner[1] und Toni Kögler[1,2,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]OncoRay - National Center for Radiation Research in Oncology, Germany — [3]Technische Universität Dresden, Germany — [4]German Cancer Consortium (DKTK)

Die sehr präzise Partikeltherapie ist aufgrund der charakteristischen Tiefendosisverteilung besonders anfällig für Reichweiteungenauigkeiten. Eine Verifikation der Strahlreichweite ist daher wünschenswert.

Neben klassischen Methoden, wie der PT-PET, wurden Methoden entwickelt, welche die bei der Bestrahlung prompt emittierten hochenergetischen Photonen nutzen. Eine Kombination dieser Methoden könnte die Genauigkeit der Reichweitebestimmung verbessern.

Die Verhältnisse an einem therapeutischen Protonenbeschleuniger stellen jedoch hohe Anforderungen an den Messbereich, die Energie- und Zeitauflösung sowie die Lastverträglichkeit eines Detektorsystems.

Im Rahmen dieser Arbeit wurde die Anwendbarkeit des SPCI-Prinzips für die Reichweiteverifikation untersucht. Erste Messungen am Elektronenlinearbeschleuniger ELBE, sowie am Universitäts-Protonentherapie Dresden, zeigten dabei eine deutliche Abhängigkeit der gemessenen Energiespektren vom Einfallswinkel der Photonen.

ST 6.2 Wed 15:15 H48

Quantifizierung des Effekts der Bragg-Peak-Verbreiterung durch heterogenes Lungengewebe in der Protonentherapie von thorakalen Tumoren — •Kilian-Simon Baumann[1,2], Veronika Flatten[1,2], Uli Weber[3], Rita Engenhart-Cabillic[1,4] und Klemens Zink[1,2] — [1]Universitätsklinikum Gießen und Marburg, Klinik für Strahlentherapie und Radioonkologie, Marburg, Deutschland — [2]Technische Hochschule Mittelhessen, Institut für Medizinische Physik und Strahlenschutz, Gießen, Deutschland — [3]GSI Helmholtzzentrum für Schwerionenforschung, Abteilung Biophysik, Darmstadt, Deutschland — [4]Marburger Ionenstrahl-Therapiezentrum (MIT), Marburg, Deutschland

Heterogene Strukturen im sub-millimeter Bereich wie Lungengewebe führen zu einer Verbreiterung des Bragg-Peaks. Wird diese Verbreiterung in der Bestrahlungsplanung von Lungenkarzinomen nicht berücksichtigt, kann dies die Dosisverteilung im Patienten signifikant beeinflussen. Jedoch kann die Verbreiterung auf Grundlage konventioneller CT-Bilder kaum berücksichtigt werden, da die Strukturen des Lungengewebes nicht ausreichend aufgelöst werden. Mithilfe einer Dichtemodulation der CT-Voxel, die mit der Lunge assoziiert sind, kann die Verbreiterung reproduziert und somit der Einfluss auf reale Patientenpläne analysiert werden. Anhand mehrerer Patientenpläne konnte gezeigt werden, dass es bei einer Nichtberücksichtigung der Bragg-Peak-Verbreiterung zu einer Unterdosierung des Tumors und einer Überdosierung distalen Normalgewebes kommen kann. Je kleiner ein Tumor ist und je tiefer er in der Lunge liegt, desto größer ist dieser Effekt.

ST 6.3 Wed 15:30 H48

Activation of Titanium Samples in Proton Therapy — •Claus Maximilian Bäcker[1,2,3,4], Aaron Bley[1], Christian Bäumer[2,3,4], Pedro Fragoso Costa[3,4,5], Marcel Gerhardt[1], Ken Herrmann[3,4,5], Samantha Kauer[1,2,3,4], Kevin Kröninger[1], Christian Nitsch[1], Hilda Milani Siregar[1], Beate Timmermann[2,3,4,6], Jens Weingarten[1], and Azad Yazgan[1,2,3,4] — [1]TU Dortmund, Lehrstuhl für Experimentelle

Physik IV, 44227 Dortmund — [2]Westdeutsches Protonentherapiezentrum Essen, 45122 Essen — [3]Westdeutsches Tumorzentrum, 45122 Essen — [4]Universitätsklinikum Essen, 45122 Essen — [5]Universitätsklinikum Essen, Klinik für Nuklearmedizin, 45122 Essen — [6]Universitätsklinikum Essen, Klinik für Partikeltherapie, 45122 Essen

Titanium is one of the most commonly used materials for implants. These implants might be activated in nuclear interactions of protons during proton therapy. Different radionuclides can be produced during the irradiation of those implants. For this study, simplified titanium samples are irradiated with clinical proton beams at different energies.

The activity of the produced radionuclides is measured using low-level gamma-ray spectrometry. With these results the nuclear activation cross sections can be calculated. Furthermore, activated titanium samples are scanned with preclinical PET/CT imaging. The PET/CT imaging method is used to estimate the β^+ activity in the samples. The delayed response of secondary radiation from titanium might be used for in-vivo dose verification with off-line PET.

ST 6.4 Wed 15:45 H48

Studies of target reconstruction in proton therapy with prompt gamma energy-time templates — •Marius Walther, Arno Straessner, and Olga Novgorodova — Institut für Kern- und Teilchenphysik, TU Dresden

Proton therapy is one of the most promising technologies to treat cancer cells inside the human body. A major problem of this therapy are range uncertainties that lead to large safety margins for the treatment. Prompt gamma rays that are created from the interaction between the proton and the material are a good tool for range verification in real time and are currently researched.

To tackle the statistical problem that clinical environments encounter when using e.g. a pencil-beam scanning mode, an unfiltered energy- and time-resolved detection of all generated prompt gamma rays is proposed. This leads to the loss of the spatial information that comes from using a slit in front of the detector. However, the energy-time spectra allow a reconstruction of the local material composition and thus of the dose profile. Based on simulations, a template method is developed and tested on a reduced set of target materials. A first statistical benchmark will be presented in this talk.

15 min. break

ST 6.5 Wed 16:15 H48

First test results with a PETSys-based setup for highly segmented Prompt Gamma detection. — •Oliver Köchel[1], Olga Novgorodova[1], Rainer Hentges[1], Andreas Glatte[1], Benjamin Lutz[2], Katja Römer[2], Guntram Pausch[2], and Arno Straessner[1] — [1]IKTP, TU Dresden — [2]HZDR, Dresden

Radiation therapy requires controlling range and dose during treatments. Therefore, in vivo dosimetry is very attractive and has seen many approaches and developments in recent years, with prompt gamma ray detection being one of them. Prompt gamma rays exhibit emission energies of 2-8 MeV. A small prototype for a prompt-gamma detector was developed based on a highly segmented 4x4 scintillator matrix with 6mmx6mm BGO crystals read out by a SiPM array. Based on the experience with BGO crystals, new detectors made of CeBr3 and GAGG(Ce) crystals were assembled with a SiPM array and tested with a TOFPET2 kit developed by PETSys electronics. The kit originally aims at PET applications and allows measurements of energy and arrival time of photons. We present first assembly experience, optimization procedures and laboratory tests based on measurements with radioactive sources.

ST 6.6 Wed 16:30 H48

Modelling the physical mechanism for thermal enhancement of radiation therapy — •Adriana De Mendoza, Jens Karschau, Sona Michlikova, and Damian McLeod — OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital C. G. Carus, TU Dresden, HZDR, Dresden, Germany.

Radiation therapy (RT) is one of the pillars in the fight against cancer. It is a potent killer of cancer cells, but at the cost of collateral damage to healthy tissue. Previous studies found that combination of RT with local hyperthermia (HT) can not only reduce whole tissue toxicity but also improve control of tumor growth. We here propose a consistent model to further understand the thermal enhancement of RT on the basis of theoretical as well as mechanistic explanations. We propose that the main driver of the thermal enhancement ratio is sub-lethal cellular damage caused by mild HT. Using a three-stage cell model [(A)<->(*)->(D): alive, activated, dead] we explain that cells are prepared to die through a reversible transition, and then die in a non-reversible process if the right amount of additional energy is applied. Including the appropriate thermodynamic considerations, we show that TER is proportional to the energy deposited in the process (A)<->(*), finding the same exponential dependence on temperature that was found empirically by other authors. Our model reproduces to good precision different experimental data sets from in-vitro and in-vivo studies for simultaneous application of moderate HT and RT.

ST 6.7 Wed 16:45 H48

Physical dose enhancement of gold nanoparticles and their impact on water radiolysis in radiotherapy — •Benedikt Rudek[1,2], Aimee McNamara[2], Hilary Byrne[3], Zdenka Kuncic[3], and Jan Schuemann[2] — [1]Physikalisch-Technische Bundesanstalt — [2]Massachusetts General Hospital — [3]University of Sydney

Gold nanoparticle (GNP) radio-sensitization is a promising technique to increase the dose deposition in the tumor while sparing neighboring healthy tissue. The sensitization is most pronounced for keV x-rays, where the mass energy-absorption coefficient of gold is up to 150 times larger than that of soft tissue. Measurements in vitro and in vivo also showed an effect on cell survival and tumor control for other modalities such as MV photons and proton beams, where the physical dose enhancement by GNPs is expected to be negligible. Most simulation studies have, thus, focused on photon irradiation of isolated GNPs in water neglecting experimental evidence of GNP clustering within cells. In a systematic study, we use the Monte Carlo simulation tool TOPAS-nBio to model the GNP radio-sensitization within a cell as a function of GNP concentration, size and clustering for a wide range of energies for photons, protons and carbon ions. Moreover, we include water radiolysis and subsequent chemistry as implemented in Geant4-DNA. While the physical dose enhancement for 10MeV protons at 1% GNP concentration was only 0.07% compared to 62% for 50keV photons, we find the yield of reactive oxygen species change by up to 15% which could partly explain the experimental dose enhancement for protons.

ST 7: Mitgliederversammlung Fachverband Strahlen- und Medizinphysik

Time: Wednesday 17:30–19:00 Location: H48

Gemäß Geschäftsordnung des Fachverbands Strahlen- und Medizinphysik findet während dieser Mitgliederversammlung die Wahl der Leitung des Fachverbands statt.