ST 5: Medical Imaging

Time: Tuesday 16:00–17:45 Location: STa

ST 5.1 Tue 16:00 STa

Numerical modeling helps patient-specific stent implantation for aortic coarctation — •Dandan Ma[1,3], Yong Wang[2,3], Mueed Azhar[1], Ansgar Adler[1,3], Michael Steinmetz[1], and Dandan Ma[1,3] — [1]University Medical Center Göttingen, 37075 Göttingen, Germany — [2]MPI for Dynamics and Self-Organization, 37077 Göttingen, Germany — [3]German Center for Cardiovascular Research (DZHK), Partner Site Göttingen, Germany

The coarctation of aorta (CoA, a local narrowing of the aortic arch) usually happens as a birth defect, interventional surgery has been considered as the treatment for re-coarctation. However the surgery procedure is usually carried out based on the doctor's experience and thus may lack of theoretical evaluation. In this study, we used visual stent planning to predict the deformed aortic geometry, based on the patient aortic geometry which was segmented and reconstructed from magnetic resonance image (MRI). We then used the lattice Boltzmann method to simulate the flows within undeformed and deformed aorta separately. Flow information from phase-contrast MRI (PC-MRI) measurements was used as boundary conditions. Both large eddy simulation (LES) and direct numerical simulation (DNS) were adopted to resolve the blood flow. Numerical results such as flow velocity, pressure drop and wall shear stress (WSS) were obtained. After comparison of the flow from LES, DNS and PC-MRI, we concluded that LES can obtain accurate aortic flow within acceptable simulation time. The numerical modeling is expected to improve the understanding of blood flow and to aid the Interventional therapy.

ST 5.2 Tue 16:15 STa

Dual-Energy-Computertomographie für präklinische Krebsforschung an einem Kleintierbestrahlungsgerät — •Andreas Grad[1,2], Manuela A. Duda[1,2], Stephanie E. Combs[1,3] und Jan J. Wilkens[1,2] — [1]TU München, Abteilung für Strahlenonkologie, Med. Fakultät und Klinikum Rechts der Isar, München, Deutschland — [2]TU München, Fachbereich Physik, Garching, Deutschland — [3]IRM, DRS, Helmholtz Zentrum München, Neuherberg, Deutschland

In der präklinischen Strahlentherapie von Mäusen sind qualitativ hochwertige CT-Bilder von großer Bedeutung. Mithilfe der Dual-Energy-CT-Bildgebung können Gewebetypen besser differenziert und die Dosisberechnung genauer durchgeführt werden.

Die Dual-Energy-Bildgebung wird am SARRP (Small Animal Radiation Research Platform, Xstrahl Ltd) durch die sequentielle Aufnahme von zwei CT-Datensätzen realisiert. Vor der Messung muss eine Kalibrierung durchgeführt werden, welche mit zwei Zylindern aus gewebeähnlichen Materialien erfolgt. Aus den daraus entstandenen Rekonstruktionen werden Kalibrierkoeffizienten berechnet, die die Umrechnungsfaktoren zwischen den aufgenommenen Projektionen und den Dual-Energy-Bildern darstellen.

Im Anschluss kann eine Probe / Maus mit denselben Parametern gemessen werden und mithilfe der Kalibrierkoeffizienten die Projektionsdatensätze zu Dual-Energy-Bildern verrechnet werden. Die Umsetzung und Optimierung von Dual-Energy-CT bildet hierbei den Schwerpunkt der Arbeit. Dafür werden Messungen am SARRP durchgeführt und am Computer simuliert, um verschiedene Parameter zu analysieren.

ST 5.3 Tue 16:30 STa

Simulation of uncertainties in the component properties of a proton CT — •Marius Hötting, Jens Weingarten, Kevin Kröninger, and Miriam Schwarze — TU Dortmund, Lehrstuhl für Experimentelle Physik IV

In current particle therapy planning computed tomography (CT) imaging is used to predict the relative stopping power (RSP) of protons in tissue. This conversion introduces a significant uncertainty on the range of the protons, which is fundamentally based on the different interaction processes of protons and photons. To minimize the uncertainties and avoid the conversion to Hounsfield units, several groups are pursuing the development of a proton CT systems. With a Geant4 simulation, a general setup of a pCT consisting of a tracking system in front of and behind the object under investigation and a WEPL detector is implemented. The influence of the uncertainties arising from different detector properties is presented and the correlation of different parameters is discussed. The main component of the investigation is the determination of the proton path within the phantom.

ST 5.4 Tue 16:45 STa

First measurements with an LGAD equipped prototype of a Time-of-Flight system — •Valerie Hohm, Kevin Kröninger, Sebastian Pape, and Jens Weingarten — TU Dortmund, Experimentelle Physik IV

To enhance the resolution of the treatment planning in proton therapy, proton computed tomography (pCT) is one approach. These systems usually consist of a tracking detector and a residual energy detector. The latter could be realised by a Time-of-Flight system, whose performance essentially depends on the time resolution of the used detectors.

As timing detectors Low Gain Avalanche Detectors (LGADs) are considered. They are n-in-p silicon sensors with an additional gain layer to multiply signal charges developed for the ATLAS experiment and CMS experiment upgrade. The internal gain layer supplies a typical amplification in the range of 10 to 30 for unirradiated LGADs and enables a time resolution up to 30 ps.

This talk focuses on the usage of LGADs in a Time-of-Flight system. First measurements with a prototype of such a system will be presented as well as an outlook of the feasibility of the system for the energy measurement in a proton tomography system.

ST 5.5 Tue 17:00 STa

A novel Detector for PET-applications — •Simon Peters[1], Konstantin Bolwin[2], Björn Gerke[2], Volker Hannen[1], Christian Huhmann[1], Klaus Schäfers[2], Christian Weinheimer[1], Nils Marquardt[1], and Tim Engling[1] — [1]Institut für Kernphysik, WWU Münster — [2]European Institute for Molecular Imaging, WWU Münster

Recently, a new type of PET detector has been proposed using a heavy organo-metallic liquid - TriMethyl Bismuth (TMBi) - as target material [1]. TMBi is a transparent liquid, 82% by weight of Bismuth. Due to the high Z number in Bismuth as the central atom of TMBi, 511 keV photons are converted efficiently to photo-electrons within the detector material. These photo-electrons produce both Cherenkov light and free charge carriers in the liquid. While the optical component enables a fast timing, a charge readout using a segmented anode can provide an accurate position reconstruction within the detector. The charge measurement requires a high level of purification, any electronegative contaminants can cause signal degradation and will produce noise within the detector. In addition to the purity requirements, the reactive nature of TMBi poses many challenges that need to be met until a fully functioning detector for PET applications can be realized. The talk will give an overview of the detection principle and discuss different purification techniques under investigation. This work is supported by the DFG, Project Number: WE 1843/8-1; SCHA 1447/3-1

[1] Yvon, D. et al. (2014). CaLIPSO: An novel detector concept for PET imaging.

ST 5.6 Tue 17:15 STa

EXPLORER – Opportunities and Challenges in Total Body PET Imaging — •Reimund Bayerlein, Benjamin Spencer, Eric Berg, Negar Omidvardi, Elizabeth Li, Xuezhu Zhang, Enette Mae Revilla, Jinyi Qi, Simon Cherry, and Ramsey Badawi — University of California Davis, US

Positron Emission Tomography (PET) is a powerful tool for molecular imaging, promoting enhancements in biological research and clinical care. However, the sensitivity of conventional PET scanners is limited by the short axial field of view (AFOV). This has been overcome by the EXPLORER total-body PET scanner which has a 194cm AFOV resulting in a 40-fold increase in sensitivity. This enables improved image quality, or reduced scan duration, or reduced radioactivity in the subject. It also permits total-body dynamic scanning, allowing total-body parametric imaging using kinetic modeling. Total-body PET therefore constitutes a ground-breaking tool to address open questions in biology and medicine. However, the large number of detectors and the widened acceptance angle dramatically increase the data sizes, setting higher demands on image reconstruction algorithms and hardware. Standard methods for attenuation and count-rate dependent data corrections are challenged, since there are a larger number of high-obliquity lines of response, which have stronger attenuation, and the dynamic range of the scanner is substantially increased. And with the whole body in the FOV, motion correction is more important. This contribution will describe the scanner design and the most pressing physics challenges and opportunities for EXPLORER.

ST 5.7 Tue 17:30 STa

Geometry optimization in X-ray propagation based phase contrast imaging — •Hanna Dierks and Jesper Wallentin — Division of Synchrotron Radiation Research, Lund, Sweden

X-ray microscopy and tomography using propagation-based phase contrast (PB-PC) is a powerful technique to study low absorption samples on the micrometer scale. The main benefit of the technique is an increased contrast given by edge enhancement, that is, by near-field interference fringes around sharp edges. In setups with a divergent source, a trade-off between the distance dependent flux and the source coherence must be made. We present a systematical experimental and theoretical investigation of this trade-off, based on experiments with two different setups with high-resolution detectors: a custom-built system with a Cu microfocus source and a commercial system (Zeiss Xradia) with a W source. The fringe contrast, CNR and fringe separation for a low-absorption test sample were measured for 130 different combinations of magnification and overall distances. We find that these figures-of-merit are sensitive to the magnification and that a theoretical optimum can be found that is independent of the overall source-detector distance. In general, we show that the developed theoretical models show excellent agreement with the measurements, if the X-ray source spectrum and the energy dependence of the detector sensitivity are considered. These results can be used for optimizing an imaging system, especially concerning the used magnification.