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.