ST 5: Physics and Technology for Radiation Detection

Time: Wednesday 15:50–17:20 Location: ZEU/0146

ST 5.1 Wed 15:50 ZEU/0146

Measuring the beam energy at a proton therapy facility using ATLAS IBL pixel detectors — •Isabelle Schilling[1], Claus Maximilian Bäcker[1,2,3,4], Christian Bäumer[1,2,3,4], Carina Behrends[1,2,3,4], Marius Hötting[1], Jana Hohmann[1], Kevin Kröninger[1], Beate Timmermann[2,3,4,5], and Jens Weingarten[1] — [1]TU Dortmund University, Department of Physics, D-44221 Dortmund — [2]West German Proton Therapy Centre Essen, D-45122 Essen — [3]West German Cancer Center, D-45122 Essen — [4]University Hospital Essen, D-45122 Essen — [5]Clinic for Particle Therapy, University Hospital Essen, D-45122 Essen

The accurate measurement of beam range for quality assurance (QA) in proton therapy is important for optimal patient treatment. Conventionally used detectors mostly calculate the energy by detecting the depth dose distribution of the protons. In contrast to this, the ATLAS pixelated silicon detector measures the deposited energy in the sensor for individual protons, allowing the determination of the Linear Energy Transfer (LET). The restriction on the dynamic energy range of the measurement is given by the readout chip. Hence, there are different ways to use the detector whose applicability is being examined. An absorber with different thicknesses is used to investigate the variation of the charge production in the sensor and perform an energy calibration relative to the NIST PSTAR database. In comparison, this talk also presents measurements of the LET per pixel along the trajectory of individual proton, all performed at the West German Proton Therapy Centre Essen.

ST 5.2 Wed 16:05 ZEU/0146

Development of a Compton Camera with detection of electrons' interaction point and energy in the scattering layer using Cherenkov photons — •Kaveh Kooshk[1], Reimund Bayerlein[2], Ivor Fleck[1], Ulrich Werthenbach[1], and Michael Ziolkowski[1] — [1]Universität Siegen, NRW, DE — [2]University of California Davis, CA, US

A Compton Camera can be a great real-time imaging asset for Proton Beam Therapy cancer treatment and radio-immunotherapy. The main goal is imaging of gammas above 0.5 MeV, which cannot otherwise be resolved by conventional detectors such as SPECT with good efficiency. To that end, we designed an experimental setup which reconstructs Compton electron's energy and direction using coincident detection of Cherenkov photons. In order to calibrate the energy estimation, we built a device which separates electrons with energies up to 2.28 MeV from a 90Sr/90Y source to a very small spectrum using a magnetic field. The electrons subsequently undergo Cherenkov effect in a PMMA radiator, in contact with a 8x8 SiPM array with $3x3mm^2$ sized read-out channels. A separation resolution of 10 to 20% has been achieved for 7 different energy beams from 0.8 MeV to 2 MeV. The number of Cherenkov photons, detected in coincidence from SiPm's time-over-threshold signal within a time-window of 10 ns, is used to estimate the electron energy. The results are compared with a mean value available from theory.

ST 5.3 Wed 16:20 ZEU/0146

Neutron Detection With Coated Semiconductors — Kevin Alexander Kröninger, •Alina Johanna Landmann, Ruben Trimpop, and Jens Weingarten — TU Dortmund University, Department of Physics, Otto-Hahn-Str.4a, 44227 Dortmund

3He is a popular element in neutron detection. However, the world is suffering from an extreme 3He-shortage which increases the need for alternative detection methods. Coated semiconductors represent a promising alternative in high flux particle fields. Typical environments with high particle fluxes are found at (research) reactors. To make use of semiconductor detectors in lower particle flux environments, the detection efficiency has to be increased significantly. In Geant4 simulations, we investigated various neutron converting materials and possible detector layouts capable of increasing the detection efficiency. A first prototype with a single converter layer on top of a silicon sensor was built to investigate the detection principle. Further studies concerning the thin film coating process for the different converting materials have been performed and will be presented.

ST 5.4 Wed 16:35 ZEU/0146

Neutron dosimetry with diamont sensors — •Jennifer Schlüss, Kevin Kröninger, Jens Weingarten und Alina Landmann — Technische Universität Dortmund, Dortmund, Germany

Neutron dosimetry is becoming increasingly relevant in proton therapy. From to the neutrons released, conclusions can be drawn about the deposited energy in the body. However, neutron dosimetry is complicated because neutrons are electrically neutral particles and cannot ionize directly. Neutrons must therefore be converted to charged particles before they can be detected. One way to convert neutrons is with the help of diamond sensors. The natural carbon isotope ^{12}C captures fast neutrons ($E_{kin} > 5MeV$). This produces alpha particles which can be detected in the diamond detector itself. To make the detector more sensitive to thermal neutrons, an attempt is made to coat the detector with a converter material such as ^{6}LiF. The simulation tool Geant4 will be used to test carbon capture reactions as a tool for further detector development. A multi-spectrum will then be used to perform neutron dosimetry with the goal of implementing a multi-spectrum detector for neutron dosimetry. To characterize the detection of fast neutrons, the diamond sensor will be tested in a later step with a simple readout in a neutron field.

ST 5.5 Wed 16:50 ZEU/0146

Fast neutron detection in proton beam therapy using SciFi detectors — •Martin Lau, Justus Beckmann, Kevin Kröninger, Alina Johanna Landmann, Jennifer Schlüss, and Jens Weingarten — TU Dortmund University, Department of Physics, Germany

Proton beam therapy is a rapidly growing field, due to the precise dose distribution within the patient. There are however many uncertainties regarding the range of proton beams. A simulation study showed, that the proton beam depth in a water phantom could be reconstructed by tracking the fast neutron trajectories emitted along the beam during irradiation. Fast neutrons undergo less scattering in material. This leads to a more precise reconstruction of their trajectories. Due to the difficulty of fast neutron detection, the potential use of SciFi detectors from the LHCb upgrade are investigated to track fast neutrons in a clinical environment due to their high spatial resolution. To determine the applicability of scintillating fibres for fast neutron detection in a clinical setting, the neutron detection capabilities and the resulting light yields of these fibres are investigated through GEANT4 simulations. Parallel, we will be testing the actual SciFi detector matt for practical uses during irradiation.

This talk will present the first results of the simulations, necessary for the reconstruction of the beam. Additionally, first studies of the actual SciFi detector system were performed, which will also be presented.

ST 5.6 Wed 17:05 ZEU/0146

A novel silicon photomultiplier in 350 nm CMOS technology with virtual guard rings and improved geometric efficiency — •Jonathan Preitnacher[1], Wolfgang Schmailzl[1], Sergei Ageev[2], and Walter Hansch[1] — [1]Bundeswehr University Munich, Neubiberg, Germany — [2]The Moscow Engineering Physics Institute-Kashira Hwy, 31, Moscow, Russland, 115409

Silicon photomultipliers (SiPM) are solid-state detectors that can resolve single photons and that are used in various applications like high energy physics or the fields of medical imaging. The implementation of virtual guards is an established technique in full costume SiPM designs to increase the geometric efficiency and therefore the photon detection efficiency (PDE). We present a novel approach applying virtual guard rings in a standard CMOS 350 nm process, improving the geometric efficiency by up to 45% compared to a guard ring design of the same process. We compare both approaches, presenting PDE measurements and additional characteristics of the devices like the breakdown voltage or the dark count rate. In a third design, we coupled the SiPM on the same chip to a costume low-power integrated amplifier to improve the pulse height and the slew rate. Measurements are presented to compare the photon time resolution of the SiPM designs with and without the amplifier.