T 90: Silicon trackers 4

Time: Thursday 16:00–18:00 Location: Geb. 30.22: kl. HS B

T 90.1 Thu 16:00 Geb. 30.22: kl. HS B

Test beam characterization of the H2M chip designed in a 65 nm CMOS imaging process — •Sara Ruiz Daza[1,3], Rafael Ballabriga[2], Eric Buschmann[2], Michael Campbell[2], Raimon Casanova Mohr[2], Dominik Dannheim[2], Ana Dorda[2], Finn Feindt[1], Philipp Gadow[2], Ingrid-Maria Gregor[1,3], Karsten Hansen[2], Lennart Huth[1], Iraklis Kremastiotis[2], Stefano Maffessanti[1], Younes Otarid[2], Christian Reckleben[1], Judith Schlaadt[1], Simon Spannagel[1], Tomas Vanat[1], Gianpiero Vignola[1,3], and Håkan Wennlöf[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland — [3]University of Bonn, Bonn, Germany

The Tangerine project is studying monolithic active pixel sensors (MAPS) that are manufactured using a 65 nm CMOS imaging process. To investigate this technology and explore the design challenges of porting a hybrid pixel de- tector architecture into a monolithic chip, the H2M (Hybrid-to-Monolithic) test chip has been developed. The chip matrix consists of 64x16 square pixels with a size of 35x35 μm2. The sensor is designed in the so-called n-gap layout to enhance fast charge collection. The H2M chip can operate in four different acquisition modes: ToT, ToA, Photon Counting, and Triggered mode. The characterization of these modes provides a fundamental understanding of the analog/digital front-end designs. This contribution presents the validation and characterization of all four readout modes in the laboratory. It also presents first results on detection efficiency, spatial resolution, and time resolution obtained in test beam campaigns.

T 90.2 Thu 16:15 Geb. 30.22: kl. HS B

Laboratory Characterization of an H2M Monolithic Pixel Detector Prototype — Rafael Ballabriga[3], Eric Buschmann[3], Michael Campbell[3], Raimon Casanova Mohr[3], Dominik Dannheim[3], Ana Dorda[3], Finn Feindt[2], Philipp Gadow[3], Ingrid-Maria Gregor[2], Karsten Hansen[2], Lennart Huth[2], Iraklis Kremastiotis[3], Stefano Maffessanti[3], Lucia Masetti[1], Younes Otarid[3], Christian Reckleben[2], Sara Ruiz Daza[2], •Judith Schlaadt[1,2], Simon Spannagel[2], Tomas Vanat[2], Gianpiero Vignola[2], and Haakan Wennloef[2] — [1]JGU, Mainz, Germany — [2]DESY, Hamburg, Germany — [3]CERN, Meyrin, Schweiz

In the context of developing monolithic active pixel sensors (MAPS), the H2M (hybrid-to-monolithic) project represents the joint effort of CERN, DESY and IFAE to design and test a monolithic chip with an integrated hybrid pixel detector architecture. This pixel sensor was designed and fabricated in a 65nm CMOS imaging process and consists of 64 x 16 square pixels with a 35um pitch. It makes use of the so-called n-gap layout which improves the charge collection from pixel edges and corners. The laboratory characterization of the first prototypes started in August 2023 with a particular focus on the trimming DAC as it allows for threshold adjustment for each individual pixel with a 4-bit resolution. On this basis, a procedure was implemented to determine the optimal setting for each pixel and eventually minimize the threshold dispersion for the whole matrix. This contribution presents preliminary results of the described measurements.

T 90.3 Thu 16:30 Geb. 30.22: kl. HS B

Charge Collection Studies for HV-MAPS — •Ruben Kolb for the HD-HVMAPS-Collaboration — Physikalisches Institut Universität Heidelberg

High-Voltage Monolithic Active Pixel Sensor (HV-MAPS) technology, developed for high-rate applications, unites precise spatial and time resolution. It combines active detector volume and readout on one chip. The TelePix1 is an HV-MAPS test chip that realizes amplifier and comparator as in-pixel electronics.

The charge deposition and charge collection process in this sensor is investigated to inform further designs of HV-MAPS. In particular, this talk focuses on disentangling the contribution of drift and diffusion to the signal. To achieve this goal, the Time-over-Threshold (ToT) and cluster size of sensors with varying thicknesses are studied, exploring their dependence on the applied high voltage. Pixel-to-pixel variations necessitate a calibration of the sensors before comparison. The calibrated signal was studied for a 4 GeV electron beam and electrons from a ^{90}Sr source. For both sources, a significant contribution of diffusion to the signal size is observed, especially in the low signal region.

T 90.4 Thu 16:45 Geb. 30.22: kl. HS B

Temperature dependence study of data link stability of MuPix11 — •Florian Schlötzer for the HD-HVMAPS-Collaboration — Physikalisches Institut Universität Heidelberg, Germany

For the Mu3e experiment the need for detectors with the ability to handle a high rate of muon decays is crucial. High-Voltage Monolithic Active Pixel Sensor (HV-MAPS) achieves an accurate time and spatial resolution combined with a high readout capability, fitting this requirement. It combines sensor and readout-electronics in one ultra-thin chip. The MuPix11 is a fully developed HV-MAPS chip used for the construction of the tracking detector for the Mu3e experiment.

In the Mu3e experiment the sensors will be operated in a large temperature range, which will influence their performance. This talk focuses on the data integrity and the stability of data links for a temperature range from -20°C to 80°C. The signal quality is studied with the help of eye diagrams and the adjustable parameter space of the data transmitter is checked for stable ranges. A linear decrease of the signal amplitude is observed with increasing temperature, yet a stable operation without transmission errors can be achieved in all cases.

T 90.5 Thu 17:00 Geb. 30.22: kl. HS B

In-pixel charge collection study with an epitaxial MALTA2 sensor, a depleted monolithic active pixel sensor — •Lucian Raphael Fasselt — Deutsches Elektronen Synchrotron (DESY), Zeuthen, Germany — Humboldt Universität zu Berlin, Berlin, Germany

MALTA2 is a depleted monolithic active pixel sensor (DMAPS) designed for radiation-hard future tracking application and is produced in the modified Tower Semiconductor 180 nm CMOS technology. The sensing layer of the $36.4 \times 36.4\,\mu m^2$ pixels consists of either high resistivity epitaxial or Czochralski silicon. The small collection electrode features a small pixel capacitance and offers low noise. A MALTA beam telescope consisting of multiple sensor planes is used to track minimum ionizing particles with 4.1 μm spatial and 2.1 ns timing resolution.

In this contribution an epitaxial sensor is characterised with in-pixel resolution in terms of hit detection efficiency and cluster size at fine threshold steps. Data was taken at the CERN SPS test beam campaign in 2023. A reconstruction of the signal amplitude from binary hit data is performed. From there, a two dimensional map of the collected charge is obtained and quantifies the effect of charge sharing at the pixel boundaries. The presented method provides an in-beam alternative to grazing angle studies or Edge-TCT for also determining the depletion depth.

T 90.6 Thu 17:15 Geb. 30.22: kl. HS B

Irradiation studies of HV-CMOS MAPS for the LHCb Mighty Tracker — •Hannah Schmitz, Klaas Padeken, Niclas Sommerfeld, and Sebastian Neubert — University of Bonn

The upgraded LHCb downstream tracker (Mighty Tracker), foreseen to be installed during LS4 of the LHC, will consist of six layers HV-CMOS MAPS with a total size of 18m^2 covering the central part of the acceptance close to the beampipe. For the pixel (MightyPix) a commercial 180nm process and a chip size of 2cm $\times$ 2cm with a pixel size of 55μm $\times$ 165μm is foreseen. Characterization of a first version and other engineering prototypes are ongoing. HV-CMOS MAPS are optimal sensors to fulfill the requirements that encounter the Mighty Tracker. Due to the increased instantaneous luminosity from 2×10^{33}cm^{-2}s^{-1} to 1.5×10^{34}cm^{-2}s^{-1} the downstream tracker has to withstand an irradiation of 3×10^{14}MeVn$_{\mathrm{eq}}$cm^{-2} and a high occupancy. Additionally, a time resolution $\leq$ 3ns is required to operate the trigger-less 40MHz DAQ implying up to 5Gbit output rate per chip. Furthermore, a low power consumption of $\leq$ 150mW and a low material budget is needed. Fulfilling these requirements is necessary to ensure a precise tracking. In this presentation irradiation studies of HV-CMOS MAPS are presented. An irradiation campaign with a 14MeV proton beam at the Bonn cyclotron was performed. The operation and further analysis of the sensor was done with the newly developed readout system MARS.

T 90.7 Thu 17:30 Geb. 30.22: kl. HS B

Exploring Thermal Neutron Detection Capabilities with

HV-MAPS — •Damini Suresh Babu for the HD-HVMAPS-Collaboration — Physikalisches Institut Universität Heidelberg

^{10}B coated silicon sensors allow to construct incredibly compact thermal neutron detectors, as per the following neutron capture reaction, $^{10}B + n \rightarrow {}^{4}He + {}^{7}Li$. For the first time the usage of High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) is studied for this purpose. HV-MAPS offer the combination of readout and detection on a common silicon die and are produced in a commercially available 180 nm HV-CMOS process. Preliminary research is underway with the MuPix11 chip with an active size of 20×20 mm.

Feasibility tests include a study of the sensor response to large energy depositions with the help of α particles. The α and γ particles are also discriminated based on the observable cluster size and measured deposited charge. In this talk, the first results obtained with an ^{241}Am source are presented.

T 90.8 Thu 17:45 Geb. 30.22: kl. HS B

The role of the overhang structure at the guard rings before and after X-ray irradiation — •Sinuo Zhang, Tomasz Hemperek, and Jochen Dingfelder — Physikalisches Institut,Universität Bonn, Bonn, Deutschland

In high energy physics, the silicon pixel sensors manufactured in commercial CMOS chip fabrication lines have been proven to have a good radiation hardness and spatial resolution. Along with the mature manufacturing techniques and the potential of large throughput provided by the foundries, the so-called "passive CMOS" sensor has become an interesting alternative to standard planar sensors, in particular for large-area applications.

The overhang structure consists of polysilicon and metal layers, which are implemented on the guard rings. As a part of the guard-ring design, it plays an important role in shaping the potential and the electric field distribution at the surface of the silicon sensor, and influences the IV characteristics and the breakdown performance. In this presentation, the effect of the overhang structure will be discussed based on the measurements of the test structures and the corresponding TCAD simulations, for irradiated and unirradiated cases.