T 76: Silicon Detectors VII

Time: Thursday 16:15–18:15 Location: KH 01.022

T 76.1 Thu 16:15 KH 01.022

High-resolution timing measurement of a TJ-Monopix2 DMAPS utilizing a 30ps TDC on FPGA implementation — •Rasmus Partzsch, Christian Bespin, Jochen Dingfelder, Fabian Hügging, Hans Krüger, Ramon Leiser, and Lars Schall — Physikalisches Institut der Universität Bonn, Bonn, Germany

The development and characterization of monolithic active pixel sensors with depleted substrates (DMAPS) in the last years lead the way to various applications in future tracking detectors. Increases in luminosity of high-energy physics experiments demand strict timing conditions on the detectors. To enable characterizations with precise timing, an on-FPGA time-to-digital converter utilizing a tapped delay line has been developed achieving a timing resolution down to 30 ps. TJ-Monopix2 is a large-scale DMAPS designed in TowerJazz 180 nm CMOS technology, and features a small charge collection electrode with a pixel size of 33 x 33 um^2. High-resistivity silicon substrate and high bias voltage capabilities allow for a full depletion of the sensitive volume and fast charge collection enabling operation in high-rate environments, especially after NIEL irradiation. Its successor chip, OBELIX, is designed for the BELLE II vertex detector upgrade (VTX).

This contribution outlines the implementation of the TDC as part of the readout system. Additionally, we present the latest test-beam results for TJ-Monopix2 after irradiation to 1e15 neq/cm^2 NIEL fluence, focussing on its timing performance.

T 76.2 Thu 16:30 KH 01.022

Development of a DMAPS-based beam telescope — •Wiebke Buhmann, Christian Bespin, Jochen Dingfelder, Fabian Hügging, Nico Klein, Hans Krüger, Rasmus Partzsch, Lars Schall, and Alexander Walsemann — Physikalisches Institut der Universität Bonn, Bonn, Germany

Testbeam telescopes serve as high-resolution tracking devices in beam test experiments. A new beam telescope is proposed to utilize depleted monolithic active pixel sensors (DMAPS) combining fast charge collection with high spatial resolution and low material budget.

The first iteration will use TJ-Monopix2 sensors that provide a spatial resolution of <10um and time resolution <2ns with 40MHz hit-timestamping. These characteristics make the telescope applicable for low momenta and high-rate beam environments.

In this contribution, the current development status regarding the data acquisition system, control software and mechanics will be presented. Additionally first test-beam results with TJ-Monopix2 optimized for these conditions will be shown.

T 76.3 Thu 16:45 KH 01.022

Characterization of the AstroPix v3 HVMAPS — Lennart Huth[1], •Stephan Lachnit[1], Richard Leys[2], Elizaveta Sitnikova[1], Simon Spannagel[1], and Nicolas Striebig[2] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Karlsruher Institut für Technologie KIT, Karlsruhe, Germany

AstroPix is a High-Voltage Monolithic Active Pixel Sensor (HVMAPS) designed for space-based medium-energy gamma-ray observatories like NASA's AMEGO-X. It aims to deliver a dynamic range from 25 to 700 keV with an energy resolution of 10 % at 122 keV. To achieve a high quantum efficiency, full depletion of the sensor is essential. Due to power and cooling restrictions in space, the power consumption of the sensor is limited to less than 1.5 mW/cm^2.

The third iteration of the sensor (AstroPix v3) consists of a 35×35 pixel matrix with a pixel pitch of 500 μm. It has been characterized at the DESY II Test Beam Facility in order to evaluate the detection efficiency, spatial resolution and depletion depth of the sensor using charged particles.

In this contribution, laboratory measurements and first results of this test beam campaign will be shown.

T 76.4 Thu 17:00 KH 01.022

Optimising high resolution time measurement in HVMAPS — •Alexander Schmidt for the HVMAPS HD-Collaboration — Physikalisches Institut Heidelberg

The phase 2 upgrade of the Mu3e experiment aims for a time resolution of 100ps to suppress coincidental background events. In the many-channel context of pixel sensors, time measurement circuits (TDCs) are constrained by size and current consumption.

This talk gives an overview on the current-capacitance based ramp approach to time measurement. Current HVMAPS prototypes, such as Telepix, achieve TDC resolution of 100ps at 125MHz base clock with minimal optimisation.

In this type of TDC, current consumption is largely driven by constant current sources. It can be reduced drastically by switched current sources. This talk demonstrates a circuit topology which avoids non-linearity typically introduced by switching transistors.

T 76.5 Thu 17:15 KH 01.022

Systematic studies of photon irradiated HV-CMOS MAPS towards the LHCb Mighty-Tracker — •Niclas Sommerfeld, Hannah Schmitz, Klaas Padeken, and Sebastian Neubert — HISKP Bonn

With the high luminosity upgrade to the LHC during LS3 the instantaneous luminosity at the LHCb experiment will be eventually increased by more than a factor of 6 to $1 \times 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ for Run 5. As a part of Upgrade II the LHCb downstream tracker (Mighty-Tracker) is foreseen to be instrumented with 10m^2 of HV-CMOS MAPS around the beam pipe. This is intended to meet the increased requirements in terms of granularity and radiation tolerance imposed by the higher luminosity.

As a part of the ongoing efforts to develop the HV-CMOS MAPS foreseen for the Mighty-Tracker, the impact of Total Ionizing Dose (TID) damage on key performance requirements is further investigated under experimental conditions. The results of systematic studies of in-house irradiated sensors are presented within this talk.

T 76.6 Thu 17:30 KH 01.022

Results from an HV-MAPS-Based Detector Prototype for Position-Resolved μSR Measurements — •Lukas Mandok for the HVMAPS HD-Collaboration — Physikalisches Institut, Heidelberg, Germany

Muon Spin Spectroscopy (μSR) is a well-established technique in material science for probing magnetic properties at the atomic scale. Conventional μSR spectrometers based on scintillators are fundamentally limited by coarse granularity and strict pile-up constraints, which restrict the usable muon rate and prevent spatially resolved measurements.

To overcome these limitations, we developed a pixel-based μSR detector using four ultra-thin HV-MAPS tracking layers based on MuPix11 sensor modules, which record incoming muons and decay positrons with high spatial precision. This enables accurate track reconstruction and a sub-millimeter determination of the decay vertex inside the sample. The approach further supports measurements of multiple samples and composite materials, while the resulting spatial information allows three-dimensional sample reconstruction and provides access to local magnetic fields by correlating vertex positions with the position-dependent precession signal.

The detector was operated several times at the πE3 beamline at PSI, demonstrating stable performance at beam intensities two orders of magnitude beyond the limits of scintillator-based systems. Its combination of high-rate capability and precise vertexing marks a significant step toward next-generation μSR spectrometers.

T 76.7 Thu 17:45 KH 01.022

Electrical Simulation and Characterization of All-Silicon Modules for CMOS Monolithic Pixel Detectors — Markus Cristinziani[1], Qader Dorosti[1], Stefan Heidbrink[2], Denise Müller[1], Noah Siegemund[1], •Darshil Vagadiya[1], Wolfgang Walkowiak[1], Jens Winter[2], and Michael Ziolkowski[2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor Physik, Universität Siegen

Silicon pixel detectors offer high spatial and temporal resolution with a low material budget. Traditional multi-chip modules add material through bump-bonding, flexible PCBs, cooling, and support structures. A new approach explores post-processing monolithic wafers with redistribution layers interconnecting multiple chips, enabling thin and lightweight structures based on low-power monolithic CMOS sensors. In current production, this concept is used in all-silicon modules that integrate four sensors cut from a single wafer and rely on the OBELIX monolithic active pixel sensor, which reduces component count and support low-material designs suitable for future collider environments. The research in Siegen focuses on the electrical performance of signal and data interconnections at high transmission speeds. Current structures reach 0.25 Gbps, with a target of at least 1 Gbps. Prototype measurements covering impedance, signal integrity, S-parameters, and electrical simulations of differential trace geometry, dielectric layers, and vias are used to identify speed limitations and guide optimization of the interconnection layout for higher data-rate operation.

T 76.8 Thu 18:00 KH 01.022

Thermomechanical Simulation of an All-Silicon CMOS Pixel Detector Ladder — •Nana Chychkalo, Joern Groesse-Knetter, and Arnulf Quadt — Georg-August-Universitaet Goettingen, Goettingen, Germany

This work investigates a new monolithic ladder concept for the All-Silicon CMOS pixel detectors, in which several chips are integrated into a single self-supporting silicon structure. This approach aims to reduce the material budget compared to conventional hybrid assemblies and offers a promising option for future high-luminosity experiments.

A key feature of this concept is the use of a Redistribution Layer (RDL) for both power delivery and data transmission across the ladder, eliminating the need for additional support circuitry. The combination of active CMOS areas and RDL components in a thin monolithic structure, requires, however, careful evaluation of the resulting thermal and mechanical behavior.

This contribution presents thermomechanical simulations performed to understand the ladder heat dissipation under realistic operating conditions. These studies are used to estimate cooling requirements and to define suitable air-cooling parameters for stable operation.