T 9: Silicon Detectors I

Time: Monday 16:15–17:45 Location: KH 01.012

T 9.1 Mon 16:15 KH 01.012

Particle Identification Based on the Time-over-Threshold with MuPix11 Sensors — •Effrosyni Zachou for the HVMAPS HD-Collaboration — Physikalisches Institut, Universität Heidelberg, Germany

The High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) extend the monolithic design concept by embedding the readout electronics in a deep n-well, enabling high voltage operation and fast charge collection via drift. The MuPix11 is a HV-MAPS chip with a pixel size of $80 \times 80\,\mu\text{m}^2$ that can be thinned to $50\,\mu$m, offering low material budget and precise spatial and time resolution.

The analogue pixel signal is digitised in the periphery, producing leading- and trailing-edge timing information from which the Time-over-Threshold (ToT) is computed. Since charged particles deposit different amounts of energy depending on their type and momentum, the ToT provides a useful proxy for measuring energy deposition and distinguishing different particles.

This work presents preliminary results from testbeam campaigns conducted at the Paul Scherrer Institute with the goal of systematically investigating the dependence of the ToT response on particle type and momentum. The measurements were performed with a setup consisting of four layers, each composed of four MuPix11 sensors mounted on a single printed circuit board. By reconstructing particle trajectories across the sensor planes, hits are associated with individual particles, enabling a track-based analysis of the ToT response.

T 9.2 Mon 16:30 KH 01.012

Noise Analysis in the MuPix11 Sensor for the Mu3e Experiment — •Antonios Kontopoulos, Heiko Augustin, and Andre Schöning for the Mu3e-Collaboration — Physikalisches Institut Heidelberg

The Mu3e experiment searches for the charged-lepton-flavour-violating decay $\mu^+ \to e^+e^-e^+$ with an ultimate single-event sensitivity on the BR of 10^{-16}, imposing stringent requirements on the noise performance of its ultra-low-mass vertex detector. The MuPix11, a high-voltage monolithic active pixel sensor (HV-MAPS), has been observed to exhibit spatially fixed noise features, necessitating a detailed characterisation of its noise behaviour.

In this contribution, a systematic noise study of MuPix11 is presented, based on cosmic data from the Mu3e vertex detector and quad-module measurements conducted at the Physics Institute in Heidelberg and the Paul Scherrer Institute. Noise characterisation is performed using a frequency-domain analysis to identify spectral features and coherent noise sources. A dedicated reconstruction framework is used to extract per-pixel noise rates, temporal correlations, and spatial noise maps.

First results reveal the dominant noise contributions under varying operating conditions and demonstrate the suitability of the developed methods for supporting sensor optimisation and the qualification of MuPix11 for integration into the Mu3e detector.

T 9.3 Mon 16:45 KH 01.012

An overview of the European XFEL's bespoke DSSC DEPFET single module detector characteristics and integration — •Mina Mohebbi[1,2], Erika Garutti[2], and Monica Turcato[1] — [1]European XFEL, Schenefeld, Germany — [2]University of Hamburg, Hamburg, Germany

The unique beam properties of the European XFEL, including its high brilliance and pulse structure, impose stringent requirements on X-ray imaging detectors in terms of dynamic range, signal-to-noise ratio, and readout speed. The DEPFET Sensor with Signal Compression (DSSC) detector, developed by an international consortium together with the European XFEL, addresses these challenges for soft X-ray detection in the 0.5-6 keV range. With a sensitive area of 241×251 mm^2, the DSSC enables single-photon sensitivity while providing a dynamic range of several thousand photons at frame rates up to 4.5 MHz. Although the full 1-megapixel DSSC system demonstrates excellent performance, its extensive and complex infrastructure limits portability and broader applicability. To overcome these constraints, a compact single-ladder system, the DSSCsm, has been developed. It features a 128×512 pixel sensitive area and incorporates a thermoelectric cooling design that removes the need for bulky cryogenic components. The DSSCsm preserves the dynamic range and fast readout capabilities of the full system while significantly reducing size, weight, and support requirements. This makes it well suited for experiments requiring an active area of 125×30 mm^2. This talk will present the DSSCsm design, operating infrastructure, and characterization and calibration techniques.

T 9.4 Mon 17:00 KH 01.012

Assembly and Characterization of the TRISTAN Detector for the KATRIN Experiment — •Christian Forstner for the KATRIN-Collaboration — TUM School of Natural Sciences - Physics Department, Garching, Germany

Sterile neutrinos, a minimal extension to the Standard Model of particle physics, are a promising dark matter candidate if their mass is in the keV-range. Following the completion of its neutrino mass measurement campaign, the Karlsruhe Tritium Neutrino (KATRIN) experiment will be equipped with a novel silicon drift detector array, the TRISTAN detector, to search for a keV-scale sterile neutrino signature in the tritium β-decay spectrum.
In this work, we report on the assembly of the TRISTAN detector, which consists of nine TRISTAN detector modules. The talk covers the module testing procedure as well as the characterization using photon and electron sources.

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T 9.5 Mon 17:15 KH 01.012

The mechanical rotation system of the P2 tracking detector — •Dhanushka Bandara for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Johann-Joachim-Becher-Weg 45, 55128 Mainz, Germany.

The P2 experiment will measure the weak mixing angle at low-momentum with unprecedented precision, using the parity violating asymmetry in electron-proton scattering. The experiment will take place at the Mainz Energy-Recovering Superconducting Accelerator (MESA), currently in the advanced stage of construction at Johannes Gutenberg University of Mainz.

A key component in the P2 experiment is the tracking detector, which measures the momentum transfer Q^2 of the scattered electrons. To allow for full azimuthal coverage with a limited size detector, a mechanical system is designed to rotate the tracker modules around the beam axis. The system should be operable in vacuum, withstand the intense radiation and provide precise movement. A scaled model is being built to study and understand the mechanics and the limitations of the rotational system.

This talk gives an overview of the P2 experiment and tracking detector, with the focus on the requirements and challenges of designing the tracker rotation system and how they are addressed.

T 9.6 Mon 17:30 KH 01.012

Mechanical, Thermal, and Electrical Design of the P2 Tracking Detector Modules — •Lucas Sebastian Binn for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg-University Mainz, Germany

The P2 Experiment at the new Mainz Energy-Recovering Superconducting Accelerator (MESA), which is currently under construction in Mainz, will measure the weak mixing angle $\sin^2\theta_W$ in elastic electron-proton scattering at low momentum transfer with unprecedented precision.

A key parameter for the analysis, the momentum transfer Q^2, and systematic effects, are measured by a low-mass tracking detector consisting of 4 identical modules arranged in two layers. Each module consists of two sensor planes, with silicon pixel sensors glued and wire-bonded on rigid-flex ladders, which are tensioned individually using a spring-loaded mechanism. A laminar flow of cool helium gas across the ladders provides the needed cooling of around 650 W per module. The sensors are read out using a radiation-hard ASIC (lpGBT) developed by CERN.

The mechanical, thermal, and electrical designs have been developed and are currently undergoing testing. For this purpose, dedicated prototypes and test stands for each area have been constructed.

This talk gives an overview of the P2 experiment tracking detector module design, covering the mechanical, thermal, and electrical aspects.