T 39: Pixel Detectors II

Time: Tuesday 16:00–18:35 Location: Tn

Group Report T 39.1 Tue 16:00 Tn

A timing layer for EUDET-type beam telescopes — •Annika Vauth[1], Erika Garutti[1], Ingrid-Maria Gregor[2,3], Keerthi Nakkalil[2], Jörn Schwandt[1], and Simon Spannagel[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]Universität Bonn, 53012 Bonn, Deutschland

EUDET-type silicon pixel telescopes are widely used as test beam infrastructure to provide precision reference tracking for detector development, for example at the DESY II test beam facility. They each feature six tracking planes equipped with Mimosa26 sensors.

Experiments at future facilities demand excellent time and space resolution to be combined in a single detector. The R&D on these novel detectors requires the availability of a new reference system at test beams that is also capable of precise time resolution. Within the research program of the Cluster of Excellence Quantum Universe, our group will equip the existing telescopes with an additional plane providing timing resolution in the order of tens of picoseconds.

In this contribution, the short- and mid-term plans for such an upgrade will be presented: The timing layer will use LGADs bump-bonded to a dedicated readout chip and integrated in the already vastly used EUDAQ2. In the first stage the Timepix4 chip will be used, which will allow a resolution on the order of nanoseconds.

T 39.2 Tue 16:20 Tn

Testing and Characterization of RD53A Quad Modules — •Lars Schall, Michael Daas, Fabian Hügging, David-Leon Pohl, and Jochen Dingfelder — Physikalisches Institut, University of Bonn, Germany

The increased data rate and radiation level expected for the High-Luminosity upgrade of the Large Hadron Collider (LHC) demands the ATLAS Experiment to upgrade its detector systems. To maintain an excellent tracking performance in the high occupancy environment and cope with the increased total radiation fluence the improved Inner Tracker (ITk) will consist of all-silicon detectors. The ITk will be built largely of quad modules. As part of the ITk preproduction program RD53A quad modules are assembled and tested. The RD53A readout chip is a half-size prototype for testing purposes only, developed by the RD53 collaboration. Four RD53A readout chips interconnected with one large sensor tile yield a quad module.

First results from the ongoing tests and characterizations of RD53A quad modules are presented. Special emphasis is put on electrical tests and tuning procedures of digital quad modules. Further measurements procedures for RD53A quad modules with sensors will be discussed.

T 39.3 Tue 16:35 Tn

Radiation Damage Measurements of the Hybrid Pixel Readout Chip RD53A — •Marco Vogt, Jochen Dingfelder, Florian Hinterkeuser, Tomasz Hemperek, Fabian Hügging, Hans Krüger, Konstantinos Moustakas, Piotr Rymaszewski, Mark Standke, and Norbert Wermes — Physikalisches Institut der Universität Bonn

After the phase-2 upgrade of the LHC at CERN, the instantaneous luminosity will be increased by a factor of ~7. New detector systems are required which are able to deliver hit information at drastically increased data rates and cope with unprecedented radiation levels of almost 1 Grad.

The RD53 collaboration will provide the pixel readout chips for the innermost tracking detector layers of both ATLAS and CMS. The half- and full-scale prototype chips RD53A and ITkPixV1 have been manufactured in a 65 nm CMOS process.

Irradiation campaigns with X-rays and radioactive sources indicate that the radiation damage of RD53A is significantly dose rate dependent. It is therefore necessary to improve the radiation models to further optimize the design and make better predictions about the degradation of detector performance during its lifetime, prior to the submission of the final production chip.

In this contribution, the ongoing low-dose-rate irradiation campaigns and their results will be presented.

T 39.4 Tue 16:50 Tn

Characterization of RD53A modules using x-ray fluorescence — •Sascha Dungs[1,2], Kevin Kröninger[1], Susanne Kühn[2], Lingxin Meng[2], and Heinz Pernegger[2] — [1]TU Dortmund, Experimental Physics IV — [2]CERN

As part of the Phase-II upgrade of the ATLAS detector, the current tracking detector will be replaced by an all-silicon detector, the Inner Tracker (ITk). For this, a new generation of silicon hybrid pixel modules are currently being developed. There are different techniques to investigate the properties of these modules. X-ray fluorescence can be used for energy calibration. An x-ray source is pointing on a target material, which leads to emission of photons with monochromatic energy. By using various target materials a wide energy range can be evaluated.

In this talk, results of x-ray fluorescence measurements of unirradiated and irradiated planar pixel modules with RD53A readout chips will be presented.

T 39.5 Tue 17:05 Tn

A study of the LHCb mighty tracker concept for upgrade 2 — •Hannah Schmitz, Klaas Padeken, and Sebastian Neubert for the LHCb-Collaboration — Rheinische Friedrich-Wilhelms Universität Bonn

After the HL-LHC upgrade in long shutdown 4 the instantaneous luminosity of the HL-LHC is up to $1.5 \cdot 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ at point 8. Therefore, the LHCb tracking system has to be upgraded. The three tracking stations of its downstream tracking spectrometer are thus studied with focus on a hybrid detector technology, where silicon pixels and scintillating fibres are installed in one module. This is known as the mighty tracker.

During long shutdown 3 (upgrade 1b) the inner part ($3.9\,\mathrm{m}^2$) of the tracking stations is planned to be replaced by a silicon pixel detector, surrounded by scintillating fibres in the outer part, to cover the region of highest particle density. The pixels are based on HV-CMOS technology and have a size up to $100\,\mu\mathrm{m} \times 500\,\mu\mathrm{m}$. In upgrade 2 the silicon part is planned to be expanded up to a size of $18.1\,\mathrm{m}^2$ in total.

This presentation covers first results of the mighty pixel studies and plans for the mighty tracking detector.

T 39.6 Tue 17:20 Tn

Design and cooling of the tracking detector of the P2 experiment — •Michail Kravchenko for the P2-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The P2 Experiment aims to measure the weak mixing angle $sin^2\theta_w$ at low momentum transfer Q^2 by measuring the parity violating asymmetry in elastic electron-proton scattering. It will be carried out at the Mainz Energy-recovering Superconducting Accelerator (MESA), which will provide a 150 μA beam of alternatingly polarized 150 MeV electrons with excellent beam stability. While the main asymmetry measurement is performed with integrating Cherenkov detectors, the tracking system is developed in order to determine the average momentum transfer of the electron and to reconstruct individual electron tracks for systematic studies. It will be built using High Voltage Monolithic Active Pixel Sensors (HV-MAPS) made of silicon thinned to 50 μm. HV-MAPS allow reducing the material budget to a minimum by integrating the readout on the sensor substrate. The tracking detector modules will be cooled by the gas flow, and helium is selected as a coolant. The current state of the P2 tracking detector design development and of the results of the computational fluid dynamics (CFD) simulation for evaluating the cooling efficiency are presented.

T 39.7 Tue 17:35 Tn

The development and first measurements of a laboratory readout system for the DEPFET pixel detector module — •Patrick Ahlburg, Florian Bernlochner, Jochen Dingfelder, Tomasz Hemperek, Hans Krüger, Botho Paschen, and Norbert Wermes — University of Bonn

The DEPFET PiXel Detector (PXD) is successfully operated in the innermost layers of the Belle II experiment at the SuperKEKB e^+e^-collider in Japan. The PXD-DAQ is optimized for the requirements of a full scale detector operating in Belle II. In this talk, the development of a laboratory readout system (BDAQ-PXD) for a single PXD module is shown. BDAQ-PXD is intended as an easily accessible lab test system for irradiation- and test-beam setups using a custom designed readout board (BDAQ53). The lab test system will help gather information about the behavior of DEPFET pixel detector modules in dedicated tests. The implementation of the firmware and the first measurements with the system in a test-beam conducted at DESY are presented in this talk.

T 39.8 Tue 17:50 Tn

Irradiation burst study of Belle II PXD module components — Jochen Dingfelder[1], Georgios Giakoustidis[1], Martin Hensel[2], Matthias Hoek[3], Florian Lütticke[1], Botho Paschen[1], •Jannes Schmitz[1], and Marike Schwickardi[4] for the Belle II-Collaboration — [1]University of Bonn, Germany — [2]HLL of Max-Planck-Society, Munich, Germany — [3]University of Mainz, Germany — [4]University of Göttingen, Germany

The Belle II detector started recording collision data in spring 2019. During physics runs in 2019 and 2020, unexpected irradiation burst events occurred, which exposed the inner detectors and especially the PXD (PiXel Detector) to unwanted levels of prompt irradiation. Dedicated measurement campaigns were carried out at the Mainz Microtron (MAMI), which aimed to reproduce the observed effects of irradiation bursts on the PXD in Belle II. To this end, a focused high intensity (800 nA) pencil beam of 855 MeV electrons was used to irradiate full system demonstrators in several spatially confined fiducial regions. In this talk, the results of these campaigns will be presented and compared to the observed impact of the irradiation bursts on the PXD modules installed inside Belle II.

T 39.9 Tue 18:05 Tn

Commissioning and Time Resolution Studies of a Timepix3 Tracking Plane in the DESY II test beam facility — •Keerthi Nakkalil[1], Annika Vauth[2,3], Ingrid Gregor[4,1], and Simon Spannagel[5] — [1]University of Bonn, Bonn, Germany — [2]DESY, Hamburg, Germany — [3]University of Hamburg, Germany — [4]DESY, Hamburg, Germany — [5]DESY, Hamburg, Germany

Test beam infrastructure plays an indispensable role in the R&D and prototyping of key detector technologies. At the DESY II test beam facility, the EUDET-telescopes based on the Mimosa26 monolithic active pixel sensors (MAPS) has been a workhorse for detector developments providing unparalleled tracking resolution for the test beams for over a decade. Our goal is to integrate Timepix3 tracking planes into the existing telescope at the DESY II test beam facility to perform track time-stamping at the nanosecond scale.

In this talk, the results of the studies undertaken to understand the general characteristics of the Timepix3 ASIC such as noise performance, threshold, and gain dispersion will be presented. Furthermore, the tracking resolution studies performed at the test beam facility will also be shown.

T 39.10 Tue 18:20 Tn

Mu3e inner tracker prototyping — •Thomas Rudzki for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The Mu3e experiment searches for the lepton flavour violating decay $\mu \rightarrow eee$ with an ultimate aimed sensitivity of 1 event in 10^{16} decays. This goal can only be achieved by reducing the material budget per tracking layer to $X/X_0 \approx 0.1$ %. High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) which are thinned to 50 μm serve as sensors. Gaseous helium is chosen as coolant.

This talks presents the results of recent prototyping which verified that such an ultra-thin tracker can be constructed for the inner tracker. The construction and commission of this prototype were used to establish the quality assurance procedure for the final production. In addition, the helium cooling system was tested by heating the prototype with the nominal heat load.