T 64: Pixel Detectors III

Time: Wednesday 16:00–18:15 Location: Tn

T 64.1 Wed 16:00 Tn

A Very Large HV-MAPS Tracking Telescope — •David Maximilian Immig for the Mu3e-Collaboration — Physikalisches Institut Universität Heidelberg

The MuPix-telescope is an evolving tracking telescope with very high rate capabilities that makes use of the most recent high-voltage monolithic active pixel sensor (HV-MAPS).
In the nominal setup, a DUT is sandwiched between three tracking layers of 100 μm thin HV-MAPS chips, at present MuPix10, complemented by scintillating tiles for additional time information. MuPix10 is a completely monolithic sensor with an active area of about 20 mm×20 mm, manufactured in the 180 nm HV-CMOS process at TSI Semiconductors with a pixel size of 80 μm×80 μm. Its trigger-less readout uses a column-drain architecture with on-chip zero suppression. 8b/10b encoded hit data is sent off the chip by three serial links with up to 1.6 Gbit/s each.
In the context of pixel sensor R&D this telescope is used to investigate efficiency, time resolution, and noise behaviour of different MuPix-like sensors. In this talk, the telescope concept is introduced. Highlights of several test beam campaigns at DESY and PSI will be presented which have been performed using a MuPix10-telescope.

T 64.2 Wed 16:15 Tn

The tracking detector of the P2 experiment at the MESA accelerator — •Lars Steffen Weinstock for the P2-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The Mainz Energy-recovering Superconducting Accelerator (MESA) will begin its operation in 2024. One of the experiments planned at MESA is P2. The goal of P2 is to determine the electroweak mixing angle with unprecedented precision at low energy scales by measuring the parity violating asymmetry in proton-electron scattering at low momentum. A key parameter for the analysis, the electron momentum transfer during scattering, is measured by the P2 tracker, which is placed inside the 0.6 T solenoid spectrometer. The tracker consists of eight identical modules utilising a total of 5000 novel High Voltage Monolithic Active Pixel Sensors (HV-MAPS) for precise track reconstruction. The event rate is expected to be 0.1 THz; This, in combination with the high number of readout channels, poses challenging requirements to the tracker front-end with regards to radiation hardness and data acquisition rate. This talk will give an overview of the P2 tracker, the requirements driving its design, and the current state of development.

T 64.3 Wed 16:30 Tn

Usability of the track reconstruction framework Corryvreckan for testbeam data and proton therapy — •Christopher Krause, Valerie Hohm, Jens Weingarten, and Kevin Kröninger — TU Dortmund, Dortmund, Deutschland

Pixel sensors with a high efficiency are necessary in the Inner Tracker of the ATLAS experiment for accurate track measurements and analysis. To measure the sensor's efficiency, an electron beam at the testbeam facility at DESY is used for irradiation. The generic framework EUTelescope was used for track reconstruction in the last years.

A new track reconstruction software, Corryvreckan, was published in 2017 with the intention of equally good track reconstruction capability, while also reducing external dependencies. It bears great similarity in its modular structure with the simulation software Allpix^2, creating a good compatibility between the two frameworks. The different implemented modules in Corryvreckan ensure its usability for track reconstruction and analysis in complex environments.

Further applications of track reconstruction with pixel sensors are investigated at TU Dortmund with regard to proton computed tomography. A comparison of reconstructed testbeam data with the EUTelescope and Corryvreckan software is presented in this talk, as well as the performance of Corryvreckan with low-energy protons used in proton therapy. The protons are simulated with Allpix^2.

T 64.4 Wed 16:45 Tn

Pixel front-end masking and its impact on tracking — Marcello Bindi, Jörn Grosse-Knetter, •Andreas Kirchhoff, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

During Run 2 of the LHC, the ATLAS tracking software masked non-working pixel modules for offline reconstruction. The masking itself is applied if a module does not receive hits (because it is inactive). To improve track reconstruction the number of holes should be reduced. Holes are defined as intersections of reconstructed tracks with sensitive detector elements that did not result in a hit. They are estimated by comparing the hits-on-track with the intersected modules. Inactive modules for example are excluded from the hole definition. As a consequence, a masked module is treated in the track reconstruction as if it received always a hit.

The aim of the ATLAS tracking group for Run 3 is to increase the granularity of the masking (moving from module to single front-ends) in order to reduce the number of pixel holes and increase the tracking efficiency. Hit maps collected at the end of each run were chosen as input of the new front-end masking mechanism. A new data base (DB) scheme was developed in order to integrate the module and the front-end masking information. This scheme will be presented in this talk together with the first studies that quantify the effect of the new masking on the track reconstruction efficiency.

T 64.5 Wed 17:00 Tn

Development of a Hybrid Pixel Detector Tracker for a Light Dark Matter Experiment at ELSA — Philip Bechtle, Klaus Desch, Markus Gruber, Matthias Hamer, Jochen Kaminski, •Leonie Richarz, and Tobias Schiffer — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn

Light Dark Matter Experiments based on dark bremsstrahlung are promising approaches to solve the mystery of unobserved dark matter in our universe. In these experiments an electron beam is shot onto a thin target, where aside from normal bremsstrahlung also possibly dark bremsstrahlung could be observed.

Due to the low signal cross-section in the parameter space where these experiments are typically sensitive, a large number of electrons on target is required. At the same time, for the reconstruction of single electron-target interactions a low number of such interactions per recorded event is advantageous. The electron stretcher accelerator (ELSA) in Bonn could provide both, as a very low number of electrons can be extracted at a high rate. A candidate for reconstructing the tracks of individual electrons in such a setup (and identifying dark bremsstrahlung via the momentum loss) is an ultrafast hybrid pixel detector. As a first step towards such a tracker, a setup using hybrid pixel modules with the Timepix3 ASIC is developed, providing spatial coordinates and timing information at a high readout rate.

In this talk the ongoing preparations of a first testbeam with such a detector will be presented, including elements of the development of the required readout system.

T 64.6 Wed 17:15 Tn

Software development for the ITk-Pixel module read-out and test system "BDAQ" — •Rafael Gonçalves Gama, Ali Skaf, Jörn Grosse-Knetter, Jörn Lange, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The Inner Tracker (ITk) is a new all-silicon detector which will replace the current ATLAS tracking system during the Phase II upgrade. The ITk innermost layers are composed by pixel modules, which comprise a new sensor and a new front-end chip, designed to cope with the challenging demands of the HL-LHC environment. This work consists of adding support for the BDAQ hardware platform to the ITk DAQ software. The BDAQ hardware is an affordable, yet powerful, FPGA-based electronics board designed by the University of Bonn for test and characterization of the new ITk front-end and upcoming generation chips. The work presented here enables the operation of this hardware in a centralized environment. Therefore, one can ensure that the same software, including the production-database interface, will be used during all the quality control steps throughout the prototyping, (pre-)production, construction and operation phases of the ITk. A new software library, based on the original BDAQ software package, was written to allow the hardware integration into the ITk DAQ software. A summary of the development process, as well as results of the BDAQ hardware integration, will be presented.

T 64.7 Wed 17:30 Tn

ITk-pixel prototype module assembly and testing — Baida Achkar, Sascha Böhlken, Raffael Gama, Jörn Grosse-Knetter, Tim Kanngiesser, Jörn Lange, •Silke Möbius, Arnulf Quadt, and Rüdiger Widera — II. Physikalisches Institut, Georg-August-Universität Göttingen

For the upgrade of the LHC to the High-Luminosity-LHC, the ATLAS tracking detector will be replaced with a pure silicon detector, the Inner Tracker (ITk), as the higher luminosity asks for radiation hard components that can deal with higher occupancies and radiation. Given the close proximity to the interaction point, the environment is especially challenging for the pixel detector, which is planned to feature 3D and planar radiation hard sensors and a new readout chip, allowing a faster and reliable readout of the sensors.

In order to characterize and test ITk-pixel prototype modules with the RD53A, a protoype chip, up to 200 modules are built and tested at several institutes. At a later stage, these modules will be integrated in a larger structure, a so-called demonstrator, to test the system functionalities.

Göttingen is responsible for the development of the core part of the tooling, needed for the gluing of the flex PCB in the assembly of the module and is involved in the assembly and testing itself.

This talk will give an overview over the ITk-pixel module building efforts and qualification measurements performed so far and also sketch the electrical tests performed in Göttingen.

T 64.8 Wed 17:45 Tn

Position resolution with 25 μm pitch pixel sensors — •Irene Zoi[1], Aliakbar Ebrahim[3], Finn Feindt[1], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Andreas Hinzmann[1], Caroline Niemeyer[1], Daniel Pitzl[2], Jörn Schwandt[1], and Georg Steinbrück[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]PSI, Forschungsstrasse 111, 5232 Villigen PSI, Schweiz

The pixel pitch for vertex detectors has constantly been reduced to cope with the experiments' necessities of achieving higher position resolution and maintaining low occupancy per channel. The spatial resolution takes advantage of a decreased pixel size but several factors, as radiation hardness, need to be considered in developing new prototypes. In the frame of the Phase-2 upgrade for the CMS pixel detector, the position resolution of 25 μm planar sensors has been investigated and compared to other existing measurements with various pitch size.

In this talk, the definition of resolution will be discussed as well as its significant dependence on the tracks selection criteria and the employed reference tracking system. For these measurements, three parallel planes of sensors have been used to achieve the necessary precision. The results are compared to what is obtained using a conventional test beam telescope. The dependence of the position resolution on the relative inclination between the incoming beam trajectory and the sensor is also presented.

T 64.9 Wed 18:00 Tn

Timing Study and Optimization of ATLASPix3 a full-scale HV-MAPS Prototype — H. Augustin[1], F. Ehrler[2], D.M. Immig[1], •D. Kim[1], L. Mandok[1], L.O.S Noethe[3], I. Perić[2], M. Prathapan[2], T.T. Rudzki[1], R. Schimassek[1], A. Schöning[1], and A. Weber[1,2] for the Mu3e-Collaboration — [1]Physikalisches Institut Universität Heidelberg — [2]Karlsruher Institut für Technologie — [3]Paul Scherrer Institut

For the high luminosity upgrade at the Large Hadron Collider (HL-LHC), ATLAS will replace its tracking system. The instantaneous luminosity, that increases by 5-7 times with respect to the current LHC value, causes challenges in terms of radiation tolerance and readout speed. For this upgrade, the Inner Detector will be replaced by an all-silicon tracking detector, the Inner Tracker (ITk).

As a candidate for the outermost pixel layer, the ATLASPix3 was developed. It is a full scale prototype designed in an 180 nm HV-CMOS process by TSI. The pixel size is 150 μm x 50 μm, resulting in an active matrix consisting of 132 x 372 pixels with a total active area of 19.8 mm x 18.6 mm.

This presentation focuses on the study and optimization of the time resolution of ATLASPix3. As a result of these measurements, a configuration is found which leads to an efficiency of 99.6 % with an uncorrected time resolution of 7.7 ns. After offline correction, this value can be improved to 4.5 ns.