T 89: Pixel Detectors IV

Time: Thursday 16:00–18:00 Location: Tn

T 89.1 Thu 16:00 Tn

Spatial Hit Resolution of Planar Pixel Sensors for the CMS Phase 2 Upgrade — •Finn Feindt[1], Aliakbar Ebrahimi[3], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Caroline Niemeyer[1], Daniel Pitzl[2], Georg Steinbrück[1], Jörn Schwandt[1], and Irene Zoi[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]Paul Scherrer Institut, Forschungsstrasse 111, 5232 Villigen PSI, Schweiz

For the High Luminosity upgrade of the Large Hadron Collider (HL-LHC), the CMS Pixel Detector will be upgraded to withstand 1 MeV neutron equivalent fluences ϕ_{eq} of up to 2.3×10^{16} cm^{-2} at a distance of 2.8 cm from the beam, corresponding to an integrated luminosity of 3000 fb^{-1}. It has to enable tracking and vertex finding in an environment of high track multiplicity with up to 200 proton-proton collisions per bunch crossing. Planar n^{+}-p pixel sensors prototypes with pixel sizes of 50×50 μm^2 or 25×100 μm^2 and an active thickness of 150 μm were investigated and their spatial hit resolution was measured in the DESY II test beam. The investigated sensors were irradiated with protons or neutrons, to fluences up to $\phi_{eq} = 7 \times 10^{15}$ cm^{-2}. The spatial hit resolution is studied as a function of the track angle and charge pixel threshold. It is compared for different fluences ϕ_{eq} and sensors with different layouts of the pixel implants. The results of this study serve as input to the final decision on the layout of planar pixel sensors for the HL-LHC upgrade of CMS.

T 89.2 Thu 16:15 Tn

Qualification of the Hybridization Process for the ATLAS ITk Module Production — •Michael Daas, Tomasz Hemperek, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, David-Leon Pohl, Lars Schall, Mark Standke, Marco Vogt, Norbert Wermes, and Jochen Dingfelder — Physikalisches Institut der Universität Bonn

The Large Hadron Collider (LHC) at CERN will be upgraded for higher luminosities in 2025. The increased luminosity poses new demanding requirements for its detectors. Alongside the accelerator, the ATLAS experiment and all its subdetectors will be upgraded as well.

This talk gives an overview of the qualification process for the hybridization of the pixel detector modules for the upgraded ATLAS Inner Tracker (ITk). This part of the ITk preproduction program is based on the RD53A readout ASIC prototype, developed by the RD53 collaboration.

In the scope of the Hybridization Market Survey (MS), hybrid double chip modules consisting of two RD53A readout chips interconnected with a single, larger sensor tile via high-density, fine-pitch bump bonding have been produced by several vendors. A comprehensive measurement program, consisting of physical and electrical tests, measurements with radioactive sources, as well as thermal stress testing has been conducted in order to assess the quality of the different hybridization processes and vendors. Finally, recommendations for the suitability of all examined vendor combinations have been put forward.

T 89.3 Thu 16:30 Tn

High Rate Studies on 2S-Modules for the CMS Tracker Upgrade — •Christina Klauda[1], Tobias Barvich[1], Alexander Dierlamm[1], Ulrich Goerlach[2], Ulrich Husemann[1], Stefan Maier[1], Thomas Müller[1], Marius Neufeld[1], Andreas Nürnberg[1], Rudolf Schimassek[1], Hans Jürgen Simonis[1], Julian Stanulla[1], and Pia Steck[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Institut Pluridisciplinaire Hubert Curien (IPHC)

Starting in 2027 the luminosity of the LHC will be strongly increased. This high luminosity requires the Phase 2 Upgrade of the CMS experiment with improved properties for the new detector components. The outer region of the silicon tracker will consist of so-called 2S Modules. The modules have to meet the requirement of readout trigger rates of up to 750 kHz.

To guarantee a triggered readout at a sufficient rate the 2S Modules will be tested at a dedicated beamline. The setup will be placed at the Cyrcé cyclotron of the IPHC in Strasbourg. Here a bunched proton beam at a frequency of 42.5 MHz is produced, a value close to the bunch crossing rate of 40 MHz at LHC. As a reference for the efficiency measurements a beam telescope setup is necessary. The sensor used for the telescope is the ATLASPix3, which is supposed to reach the required readout rates of at least 750 kHz.

This presentation will briefly introduce the monolithic ATLASPix3 sensor, the telescope setup developed for testing the 2S Modules, and will present the first results.

T 89.4 Thu 16:45 Tn

The next ATLAS Hybrid Detector Readout Chip ITkPix - Performance and Quantitative Analysis — •Mark Standke, Michael Daas, Yannick Dieter, Tomasz Hemperek, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, David-Leon Pohl, Lars Schall, Marco Vogt, Jochen Dingfelder, and Norbert Wermes — PI Bonn - Nussallee 12, 53115 Bonn

ITkPixV1.1 is the first working full-scale 65 nm hybrid pixel-detector read out prototype developed by the RD53 collaboration. Hybrid pixel detectors are micro electronic devices, which are soldered together at pixel level. The two separate entities are used for highly efficient and fast charge sensing (sensor), of the charge carriers from ionizing radiation, while the second chip is used to read out the deposited charge (read out chip). ITkPix consists of more than one billion transistors with high triplication ratio in order to cope with high particle and therefore radiation densities at the heart of ATLAS. The chips will be located as close as possible to the interaction point to optimize impact parameter resolution. ITkPix features a single low power, low noise analog front-end to ensure high readout speeds and low detection thresholds. A failure of such chips at the heart of ATLAS is assumed to be hard to correct. Therefore, thorough testing is necessary. For this purpose, Bonn has developed a fast and versatile simulation, testing and analysis environment, making small- and large-scale testing for ITkPix possible. This talk will give an overview over the testing environment, while summarizing the latest findings and performance of ATLAS's future inner tracker performance driver, ITkPix.

T 89.5 Thu 17:00 Tn

Pixel track reconstruction for the Phase-2 CMS tracker — •Elias Paknejad[1], Alexander Schmidt[1], Xavier Coubez[1], and Adriano Di Florio[2] — [1]RWTH Aachen University, Physics Institute III A, Aachen, Germany — [2]University of Bari, Department of Physics, Bari, Italy

The new geometry of the Phase-2 CMS detector and the high data rates collected by its pixel tracker require significant improvements in the track reconstruction algorithms in order to cope with the conditions at the High-Luminosity LHC. The algorithms are being adapted to run on Graphics Processing Units (GPUs) in addition to the traditional CPU implementations.

In this presentation, the customized track reconstruction algorithms and results of the first performance studies are presented. The results show that the high pile-up conditions at the HL-LHC represent significant challenges in particular in the online trigger system, such that further improvements are necessary in the future.

T 89.6 Thu 17:15 Tn

ATLAS ITk-Pixel read-out systems with FELIX and lpGBT — Jörn Grosse-Knetter, Arnulf Quadt, and •Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

The ATLAS Phase II upgrade ITk-Pixel read-out chain is based on the use of ITkSoftware commanding the ITkPix front-end (FE) chips through FPGA off-detector communication boards, called FELIX and high-speed transceiver chips called lpGBT. This work describes the road-map, and the relevant intermediate steps, enabling the achievement of the final system. An lpGBT FPGA full-featured emulator using a Xilinx Ultrascale+ KCU116 development board is used as an alternative to the real lpGBT ASIC, included in the CERN VLDB+ boards or other prototypes of the final Pixel optoboards.

Waiting for the ITkPix, modules with the prototype FE RD53A were used. These modules are connected either to the lpGBT emulator implemented in a KCU116 with a mezzanine board, or to the lpGBT ASIC (e.g. VLDB+), through a special Breakout Board, which was also designed in-house. Furthermore, in order to configure lpGBT

ASIC or Emulator, a Java GUI application was also developed using an existing USB-I2C dongle. All these developments aim, in particular, at the operation of and test measurements with an RD53A demonstrator, a small prototype system containing about 100 FEs, on the way to the target ITk-Pixel full-scale readout system. Details of the different system components are given, along with the different experimentation setups that were tested.

T 89.7 Thu 17:30 Tn

Bump bond stress tests with ITk-Pixel-style daisy-chain modules through thermal cycling — •Steffen Korn, Jörn Grosse-Knetter, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

For the upgrade of the LHC to the HL-LHC, the Inner Detector will be replaced by the fully silicon-based Inner Tracker Detector (ITk). The pixel detector of the ITk uses hybrid modules where sensor and readout chips are connected by bump bonds. Early ITk module prototypes highlighted these bump bond connections as a possible point of failure in future ITk Pixel modules when exposed to thermally induced stress. In order to investigate this issue, daisy chain modules with realistic bump bond pitch and modules with read-out-chips were tested before and during exposure to thermal stress through cycling in a thermal shock chamber using a dedicated in-situ method in Goettingen. The results of these tests using different modules with different assembly options are presented in this talk.

T 89.8 Thu 17:45 Tn

Characterization of Prototype Pixel Sensors for the CMS Inner Tracker at the High-Luminosity LHC — •Anna Liisa Puchert[1], Aliakbar Ebrahimi[2], Finn Feindt[1], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Daniel Pitzl[3], Peter Schleper[1], Jörn Schwandt[1], Georg Steinbrueck[1], and Irene Zoi[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Paul Scherrer Institut, Villingen, Switzerland — [3]Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg

During the shutdown from 2025 to 2027 (LS3), the Large Hadron Collider (LHC) will undergo an upgrade. The luminosity will be increased to up to 7.5×10^{35} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$. Consequently, the data rate as well as the particle flux through the detector will be increased. The silicon tracker of the CMS experiment will therefore need to be completely replaced. The sensors for the CMS Inner Tracker (IT) will have to fulfil stringent requirements, including high efficiency for hit detection ($>$ 99 %) and excellent spatial resolution till the end of their lifetime. We report on performance measurements on prototype sensors. For this purpose, some of the sensors were irradiated to simulate the radiation after a certain runtime. The tests for efficiency and spatial resolution were performed at the DESY II test beam in Hamburg. Even after an irradiation of 2.1×10^{16} $\mathrm{n_{eq}/cm^2}$, which approximately corresponds to the expected particle flux after 3000 fb^{-1} for the first layer, the tested sensors still meet the requirements in terms of efficiency and resolution at bias voltages below 800 V.