T 61: Silicon trackers 3

Time: Wednesday 16:00–18:00 Location: Geb. 30.22: kl. HS B

T 61.1 Wed 16:00 Geb. 30.22: kl. HS B

Results from the pre-producton of the ITk Outer Barrel Bare Cell — •Nico Klein, Klaus Desch, Matthias Hamer, Florian Hinterkeuser, Alexandra Wald, and Dominik Hauner — Rheinische Friedrich-Wilhelms-Universität Bonn

The high luminosity upgrade for the Large Hadron Collider at CERN requires a complete redesign of the current tracking detector of the ATLAS experiment. The new Inner Tracker, the ITk Detector, will consist of a silicon pixel detector and a silicon strip detector. The ITk Pixel Detector is divided into three subsystems, the Outer Barrel (OB), Outer Endcaps and Inner System. In the OB, modules are loaded on cells (pyrolytic graphite tiles that are glued to an Aluminum-Graphite cooling block) before they are mounted on the local supports. These cells have a crucial role in the thermal performance of the modules, as they provide the connection between the modules and the cooling system. In order to meet the demanding requirements that are placed on the cooling system of the ITk Pixel Detector, the production of the Bare Cells goes through several quality control tests. In this talk I will present the results of the QC tests that have been performed on the pre-production OB bare cells.

T 61.2 Wed 16:15 Geb. 30.22: kl. HS B

Quality control at wafer level and thermocycling of ATLAS ITk pixel detector modules during the production phase — Patrick Ahlburg, Yannick Dieter, Fabian Hügging, Hans Krüger, Konstantin Mauer, •Maximilian Mucha und Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Germany

The upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC) presents significant technological challenges. The HL-LHC will see an increase in instantaneous luminosity by a factor of 5, leading to higher hit rates and radiation levels than ever before. To cope with these demanding conditions, extensive upgrades to the detectors are necessary. As part of the upgrade, the ATLAS Inner Detector will be replaced by a new all-silicon inner tracking detector (ITk detector) consisting of silicon strip and hybrid pixel modules. In total, approximately 10.000 new pixel detector modules have to be built and carefully tested to ensure that only fully functional detector modules will be installed. The QC process starts already at wafer level. For the hybrid modules, 131 readout chips on approx. 700 wafers have to be tested for their functionality.

This talk provides an overview of the fully automated testing procedures developed for the ATLAS ITk pixel detector modules at the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. It focuses on the wafer probing setup and the module-level thermocycling setup, which are crucial for ensuring the functionality and quality of the detector modules.

T 61.3 Wed 16:30 Geb. 30.22: kl. HS B

TID Irradiation of the ATLAS ITkPix readout chip — Patrick Ahlburg, Yannick Dieter, Fabian Hügging, Hans Krüger, •Konstantin Mauer, Maximilian Mucha, Marco Vogt, and Jochen Dingfelder — Physikalisches Institut, University of Bonn, Germany

The upcoming High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) will significantly increase the instantaneous luminosity. This will lead to a higher track density, a higher hit rate and thus an increased amount of radiation damage in the experiments.

For this reason, the ATLAS experiment will be upgraded and a new all-silicon inner tracking (ITk) detector has been designed, consisting of strip and pixel modules. The pixel modules are used in the innermost layers of the detector and have a hybrid design where a sensor is read out with a dedicated readout chip called ITkPix. Both components are designed to be radiation hard. The readout chip itself has to withstand up to 700 Mrad TID damage in SiO_2.

In this talk an X-ray irradiation campaign to verify the radiation hardness and characterize the performance of the production version of the ITkPix will be presented.

T 61.4 Wed 16:45 Geb. 30.22: kl. HS B

Integration Tests with Module Prototypes for the Phase-2 Upgrade of the CMS Outer Tracker — •Lea Stockmeier, Alexander Dierlamm, Ulrich Husemann, and Stefan Maier — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

To deal with the increased luminosity of the HL-LHC, the CMS experiment will be upgraded until 2028. During this Phase-2 Upgrade, the CMS Outer Tracker will be equipped with modules each assembled with two silicon sensors. Depending on the position in the tracker, these silicon sensors are pixel or strip sensors. The modules with two strip sensors are called 2S modules while those assembled of one macro-pixel and one strip sensor are called PS modules. In the endcap region these modules are mounted on structures called "dees". Four dees will be combined to one "double-disc" which provides the hermetic coverage of one detector plane.

During the prototyping phase of the modules, integration tests are performed with the purpose of testing the integration procedure itself as well as the module functionality on the final detector structures. For example, the electronic noise of the modules can be taken to check the performance of the modules on the supporting structures.

This talk summarizes an integration test performed at DESY (Hamburg) with six PS and seven 2S modules on a prototype dee in cooperation with other CMS working groups.

T 61.5 Wed 17:00 Geb. 30.22: kl. HS B

Database and test procedures for the production of CMS 2S modules at RWTH Aachen — •Max Beckers[2], Christian Dziwok[2], Lutz Feld[1], Nina Höflich[2], Katja Klein[1], Alexander Pauls[1], Oliver Pooth[2], Nicolas Röwert[1], Martin Lipinski[1], Vanessa Oppenländer[1], and Tim Ziemons[2] — [1]I. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — [2]III. Physikalisches Institut B, RWTH Aachen University

For the CMS Phase-2 Outer Tracker upgrade, new silicon strip detector modules consisting of two silicon strip sensors, so-called 2S modules, are developed and produced. This process is distributed along multiple assembly centers worldwide. To ensure consistent module quality, many specifications need to be respected. This includes different kinds of tests and measurement results.

RWTH Aachen University will build around 800 2S modules. The production requires well-organised procedures. To guarantee the transparency and traceability of the production conditions and module quality many data are recorded and analysed.

This talk presents the latest results from the assembly process, with a focus on the quality control measurements that are taken on different test stands. The measurement results are compared with specifications. Details about the data handling with the local and central CMS construction database are given.

T 61.6 Wed 17:15 Geb. 30.22: kl. HS B

Thermal Cycling of ATLAS ITk Modules with the DESY Coldbox — Sören Ahrens[1], •Lukas Bayer[1], Ben Bruers[2], Sergio Díez-Cornell[1], Torsten Kuelper[1], Jonas Neundorf[1], and Elizaveta Sitnikova[1] — [1]DESY, Hamburg, Germany — [2]DESY, Zeuthen, Germany

In the course of the upcoming High Luminosity upgrade for the LHC, also the Inner Detector of the ATLAS experiment will receive an upgrade to the new Inner Tracker (ITk). Its two endcaps, one of which will be assembled at DESY, consist of individual modules with silicon strip sensors, hybrid read-out chips and power boards. Prior to the integration of these modules into the larger detector structures, they have to run through a series of quality control steps, including thermal cycling and electrical tests, to ensure full functionality at operation temperature. For this purpose, DESY has developed controlled testing environments, so-called coldboxes, and also provided them to other institutions in the ITk community. Each coldbox features electromagnetic shielding, low humidity conditions and temperature control for up to four modules at the same time, and can be paired with high-voltage power-supplies. In this talk the functionality of the coldbox will be discussed, as well as the thermal cycling procedure and its importance for the ITk production chain.

T 61.7 Wed 17:30 Geb. 30.22: kl. HS B

Simulation and measurement of humidity-induced breakdown in silicon sensors — Ingo Bloch[2], Ben Brüers[2], Heiko Lacker[1], Peilin Li[1], Ilona Stefana Ninca[2], and •Christian Scharf[1]

— [1]Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

Humidity exposure of silicon sensors, which do not have a special treatment of the top oxide/nitride layer, can lead to early electrical breakdown. The cause has been long known to be the humidity-dependent mobility of impurity ions on the outer oxide/nitride surface, which can alter the potential at the surface. However, the exact mechanisms that lead to electrical breakdown are poorly studied.

This work focuses on TCAD simulations of the guard ring region of planar silicon diodes, where breakdown can be located by hot-electron emission microscopy. The effect of humidity is simulated by adding a resistive layer on top of the oxide/nitride and adjusting the mobilities of the charge carriers in the layer. To verify the results of the TCAD simulations, TCT measurements in the guard ring region and accompanying Allpix Squared simulations have been performed.

The simulations together with the measurements are targeted to contribute to a better understanding of the mechanism and the relevant parameters driving the humidity-induced early breakdown.

T 61.8 Wed 17:45 Geb. 30.22: kl. HS B

Simulation and measurement of charge transport near the Si-SiO_2 interface of silicon sensors — Ingo Bloch[1], Ben Brüers[1], Heiko Lacker[2], •Peilin Li[2], Ilona Stefana Ninca[1], and Christian Scharf[2] — [1]Deutsches Elektronen-Synchrotron (DESY) — [2]Humboldt Universität zu Berlin

Some of the n-in-p silicon sensors for the ATLAS Inner Tracker (ITK) strip detector show signs of early breakdown at high humidity. To investigate the breakdown mechanism, Transient Current Technique (TCT) measurements are conducted in the region between the sensor's guard ring and edge ring, where the breakdown has been observed through hot-electron emission microscopy. Picosecond laser pulses of 660 nm photons are focused on the sensor surface, generating free electrons and holes near the surface. These free charges drift in the local electric field and induce transient currents, which are measured as a function of the laser position and the applied bias voltage. To reproduce the measurements, charge transport at the Si-SiO_2 interface has been implemented in the simulation framework Allpix Squared. The electric and weighting fields have been simulated with Synopsys Sentaurus TCAD. By comparing the measurements to the simulations, a qualitative estimation of the discrepancy between the TCAD-simulated and actual electric fields can be achieved. The results of this analysis help to validate the TCAD simulation against measurements and to gain understanding of surface TCT measurements in the guard ring region of sensors, enabling further exploration of the humidity dependence of surface breakdown.