T 12: Silicon Detectors II

Time: Monday 16:15–18:15 Location: KH 01.022

T 12.1 Mon 16:15 KH 01.022

Testing infrastructure for the quality control of ITk Pixelmodules — •Ruben Förster, Jörn Grosse-Knetter, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

With the long shutdown of the Large Hadron Collider (LHC) and the subsequent upgrade to the High-Luminosity LHC (HL-LHC) starting soon, the ATLAS experiment will be undergoing extensive upgrades. A central element of this is the new Inner Tracker (ITk), an all-Silicon detector designed to cope with the increased particle flux, radiation levels, and data rates expected at the HL-LHC.

One of the subdetectors is the ITk pixel detector, composed of roughly 8 000 pixel modules that are now in the critical phase of production. As part of the German production cluster, the University of Göttingen is responsible for many of the later production and quality control testing steps for several hundred of these modules.

The testing infrastructure in Göttingen, including setups, procedures, and software for electrical and thermal testing, gluing, and metrology, has been improved and upgraded. The experience gained during production has led to more streamlined workflows and an overall increase in achievable throughput.

A central aspect of this is a newly constructed radiation-compliant electrical test stand, designed for routine operation in a production environment. Together with clear procedures, training of laboratory staff and simplified operator interfaces, this infrastructure places Göttingen in a strong position for the remaining ITk pixel module production.

T 12.2 Mon 16:30 KH 01.022

Electrical tests for the quality control of ITk Pixel modules — Ruben Förster, Jörn Grosse-Knetter, •Niklas Grün, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The Phase-II upgrade of the ATLAS experiment at the LHC includes a complete replacement of the current Inner Detector with the new all-Silicon Inner Tracker (ITk). The ITk is designed to operate at significantly higher luminosities, providing improved granularity, radiation hardness, and tracking performance for the HL-LHC environment. Its construction requires large-scale production, qualification, and integration of highly complex Silicon Strip and Pixel modules across several international sites.

The Pixel Detector modules feature a hybrid module design, meaning that the sensor is read out via frontend readout chips that are bump-bonded to the sensor. To secure high production standards and quality of the ITk Pixel modules, each of the Pixel modules faces multiple electrical QC check-ups between every major production step on top of non-electrical tests and metrology of the components.

In this contribution, work within the ITk Pixel module production chain is presented as carried out in Göttingen, which is one of the sites of the German production cluster. A focus will be placed on ensuring production quality, improving data-driven validation procedures, and contributing to the smooth operation of the module production workflow. In particular the electrical tests for the quality control of ITk Pixel modules are spotlighted.

T 12.3 Mon 16:45 KH 01.022

Production and Quality Control of CMS Phase-2 Inner Tracker Pixel Modules — •Chin-Chia Kuo, Massimiliano Antonello, Erika Garutti, Bianca Raciti, Jörn Schwandt, and Georg Steinbrück — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

A quad module for the Phase-2 upgrade of the CMS Inner Tracker is a hybrid detector consisting of four (2×2) CMS readout chips manufactured in 65 nm CMOS technology (RD53B_CMS) and a silicon pixel sensor. The sensor with 100×25 μm^2 pixel size and 150 μm thickness is coupled to the chips via fine-pitch flip-chip bump bonding. At the University of Hamburg, 500 quad modules for the CMS Tracker Endcap Pixel Detector will be assembled and qualified. Module production and quality control procedures are presented in this talk, including serial powering, threshold tuning, and data transmission tests of the readout chip, IV measurements for sensors, open bump bond identification, and thermal stress tests. The presentation will focus on grading criteria and the performance of pre-production modules.

T 12.4 Mon 17:00 KH 01.022

Core column issue investigation on ATLAS ITk pixel detector modules in Siegen — Markus Cristinziani[1], Qader Dorosti[1], Olivier Fox[1], Daniel Groth[1], •Luke Hammer[1], Stefan Heidbrink[2], Lasse Jäderberg[1], Nils Krengel[1], Leonie Krippendorf[1], Denise Müller[1], Jason Müller[1], Lina Reifenberg[1], Noah Siegemund[1], Waldemar Stroh[2], Darshil Vagadiya[1], Wolfgang Walkowiak[1], Jens Winter[2], Michael Ziolkowski[2], and Alessia Zuev[1] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor Physik, Universität Siegen

The High-Luminosity Large Hadron Collider (HL-LHC) upgrade will substantially increase the LHC's instantaneous luminosity, requiring a complete replacement of the ATLAS Inner Detector with the new all-silicon Inner Tracker (ITk). For the ITk pixel quad modules, a silicon sensor is connected to four front-end readout chips based on the ITkPix application-specific integrated circuit. During module production, characteristic inefficiencies in multiple columns of pixels, referred to as core column issues, were observed in ITkPix v1.1 and v2 quad modules. In this talk, results from dedicated investigations of these inefficiencies are presented. These studies in Siegen use and extend electrical testing tools developed by the collaboration. The observed response patterns are categorized and their impact on module performance is assessed. These investigations provide insight into the core column behavior observed during production and support quality assurance for reliable module operation in the future ATLAS ITk.

T 12.5 Mon 17:15 KH 01.022

2S module assembly in Aachen for the CMS Phase-2 Outer Tracker upgrade — Max Beckers[2], Clara Ebisch[1], Lutz Feld[1], •Nina Höflich[2], Katja Klein[1], Martin Lipinski[1], Daniel Louis[1], Oliver Pooth[2], Vanessa Oppenländer[1], Joëlle Savelberg[1], Michael Wlochal[1], and Wioletta Wyszkowska[2] — [1]I. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — [2]III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

In the context of the CMS Phase-2 upgrade, the complete Outer Tracker of the CMS detector will be replaced. The new Outer Tracker will contain two types of modules, 2S modules consisting of two silicon strip sensors and PS modules made from a silicon macro-pixel and a silicon strip sensor. In total, around 7600 2S and 6000 PS modules will be built and installed in the new outer tracker. These modules are currently under assembly in multiple assembly centers worldwide.
At the Physics Institutes IB and IIIB at RWTH Aachen University, approximately 1000 2S modules will be assembled, with over 100 already completed. The module assembly consists of multiple gluing and wirebonding steps, which have to be performed with high precision. The assembly is accompanied by various QC measurements, especially module readout and sensor-sensor alignment tests, to ensure consistent module quality.
In this talk, the 2S module assembly at RWTH Aachen will be presented, including the current status and details on the different assembly steps.

T 12.6 Mon 17:30 KH 01.022

2S module assembly progress and module test results for the CMS Phase-2 Tracker Upgrade — •Max Beckers[2], Lutz Feld[1], Nina Höflich[2], Katja Klein[1], Martin Lipinski[1], Vanessa Oppenländer[1], Oliver Pooth[2], and Joëlle Savelberg[1] — [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.

RWTH Aachen University will build around 1000 2S modules. After each assembly step different QC measurements and tests are performed. Different kinds of specifications needs to be respected. The assembled modules are then shipped to DESY, where they are thermally cycled in the "Burn-in" setup. In addition, a multi module cold box is available in Aachen to perform thermal cycles for up to 4 modules.

With over 100 modules built in Aachen and shipped to DESY the assembly process is currently ongoing. As more and more modules become available, the QC and test results are continuously monitored and can be evaluated in relation to the overall statistical. These results can be used to implement a module grading concept.

This talk presents the current assembly progress of 2S modules at Aachen together with results from QC measurements, module tests and thermal cycling.

T 12.7 Mon 17:45 KH 01.022

Petal Loading for the ITk Strip Endcap — •Mariana Vivas Albornoz — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The ATLAS detector will be upgraded for operation at the High Luminosity LHC. The upgrade of the detector includes the construction of a new all-silicon inner tracker (ITk) to effectively take data in an environment with increased pile-up and corresponding high occupancies. The ITk detector is composed of an outer silicon microstrip-based (strip) detector and an inner pixel detector. Both trackers are divided into a barrel region, around the interaction point, and two endcaps, extending into the forward regions. One strip endcap is being constructed at DESY. A strip endcap is composed of 192 petals holding 12 silicon module detectors in place. The assembly work for 96 petals is taking place at DESY. The silicon modules are loaded onto the petal cores via a multi-step procedure that requires careful handling and micrometer level precision. This contribution summarizes the steps and techniques involved in the loading task, and explains how precision during each step of the process is necessary for the overall functioning of the new ITk detector.

T 12.8 Mon 18:00 KH 01.022

Segement Test on ATLAS ITk Strips End Cap — •Konstantin Mauer — Deutsches Elektronen-Synchrotron DESY, Hamburg

The upcoming High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) will significantly increase its instantaneous luminosity. This will lead to a higher track density, a higher hit rate and 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 detector modules.

In the outer layers silicon strips modules are used and loaded onto local support structures. In the forward directions these are called petals. They are integrated into an End Cap (EC) mechanical structure at one of the two EC integration sites. After welding 16 petals to a cooling manifold, this segment will be fully powered and characterized using the final detector powering chain and readout devices.

With the production ramping up, petals are accumulating for fully populating the first segment. Thus, in summer 2026 the first segment test is scheduled. This talk presents ongoing preparations towards this milestone.