T 27: Silicon Detectors III (ATLAS + CMS production)

Time: Tuesday 16:15–18:15 Location: VG 0.111

T 27.1 Tue 16:15 VG 0.111

Production of Outer Barrel Pixel Detector Modules for the ATLAS ITk Pixel Detector – From Wafer Probing to Assembly — Yannick Dieter, Wolfgang Dietsche, Walter Honerbach, Fabian Hügging, Hans Krüger, •Maximilian Mucha, Matthias Schüssler, and Jochen Dingfelder — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

The High-Luminosity upgrade of the Large Hadron Collider (LHC) aims to enhance its performance by increasing luminosity by a factor of 5. This upgrade introduces unprecedented challenges for the ATLAS detector, driven by elevated hit rates and radiation levels far exceeding current operational conditions. To address these challenges, the ATLAS Inner Detector will be replaced with the new all-silicon Inner Tracking Detector (ITk).

The ITk production phase involves the assembly of approximately 10,000 hybrid pixel detector modules, each of which must meet strict quality requirements to ensure reliable performance. The process begins with functionality testing at wafer level, where roughly 700 wafers containing 131 readout chips each are characterized to ensure chip functionality. External vendors then hybridize the readout chips with silicon sensor dies to construct bare modules. Subsequently, these bare modules are assembled into fully operational ITkPix modules at dedicated institutes worldwide.

This talk provides an overview of the complete ITkPix module production chain, with a focus on wafer probing and assembly.

T 27.2 Tue 16:30 VG 0.111

Production of Outer Barrel pixel detector modules for the ATLAS ITk pixel detector - Quality control during electrical testing — Yannick Dieter, Jochen Dingfelder, Matthias Hamer, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, Maximilian Mucha, •Matthias Schüssler, and Alexandra Wald — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

With the upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC), the instantaneous luminosity will increase by a factor of 5 with respect to its design value from 2029 onward. This results in unprecedented hit rates and radiation levels which require major upgrades of the detectors at the HL-LHC to meet these challenging requirements.

For the upgrade of the ATLAS detector, a new all-silicon inner tracking detector (ITk detector) consisting of silicon strip and pixel modules will be installed to replace the currently operated Inner Detector. In total, approximately 10.000 new pixel detector modules have to be built and carefully tested to ensure that only functional detector modules are installed. During the 2-year production of the ATLAS ITk pixel detector, approximately 1200 pixel detector modules will be built and tested at the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. This large-scale production requires a dedicated quality control (QC) effort to assure the functionality of the final detector. This talk provides an overview of the electrical testing procedures for assembled modules that will be performed at the FTD in Bonn.

T 27.3 Tue 16:45 VG 0.111

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 $100 \times 25\ \mu m^2$ pixel size and 150 μm thickness is coupled to the chips via fine-pitch flip-chip bump bonding. Module production and quality control procedures are presented in this talk, including threshold tuning and data transmission tests of the readout chip, IV measurements for sensors, open bump bond identification, and thermal stress tests. In addition, the performance of pre-production modules is included in this presentation.

T 27.4 Tue 17:00 VG 0.111

From Kick-Off to Production - Aachen as an Assembly Center for the CMS Phase-2 Outer Tracker Upgrade — Max Beckers[1], Clara Ebisch[2], Lutz Feld[2], Nina Höflich[1], Katja Klein[2], Martin Lipinski[2], Daniel Louis[2], •Vanessa Oppenländer[2], Alexander Pauls[2], Oliver Pooth[1], Nicolas Röwert[2], Jan Terörde[2], Lennart Wilde[1], Michael Wlochal[2], and Wioletta Wyszkowska[1] — [1]3. Physikalisches Institut B, RWTH Aachen — [2]1. Physikalisches Institut B, RWTH Aachen

The new operating conditions of the future HL-LHC require a replacement of the complete silicon tracking system of the CMS experiment as part of the CMS Phase-2 Upgrade. For the Phase-2 Outer Tracker new so-called 2S modules have been developed that consist of two silicon sensors stacked on top of each other. By correlating the measured hits of both sensors, this module design enables the inclusion of tracking information in the Level-1 trigger at CMS for the first time. The production of 2S modules requires a careful and precise assembly. Within the CMS Collaboration the 2S module assembly is distributed over several institutes across the US, Europe and Asia. The RWTH Aachen University represents one of those assembly centers with a contribution of around 1000 2S modules. In the last two years the project went through several stages which include a so-called kick-off batch, a preseries and is now ramping up from pre-production to production. In this talk important results from the different stages will be presented as well as the qualification steps that have been carried out showing that the Assembly Center in Aachen is well prepared for production.

T 27.5 Tue 17:15 VG 0.111

Glue dispensing and assembly of CMS 2S modules at RWTH Aachen — •Lennart Wilde[1], Max Beckers[1], Nina Höflich[1], Oliver Pooth[1], Wioletta Wyszkowska[1], Lutz Feld[2], Katja Klein[2], Clara Ebisch[2], Michael Wlochal[2], Daniel Louis[2], Vanessa Oppenländer[2], Nicolas Röwert[2], Martin Lipinski[2], and Alexander Pauls[2] — [1]III. Physikalisches Institut B, RWTH Aachen University, Aachen — [2]I. Physikalisches Institut B, RWTH Aachen University, Aachen

For the Phase 2 Upgrade of the Compact Muon Solenoid (CMS) experiment, a full reconstruction of the Outer Tracker is planned, involving novel silicon detector modules. These modules, referred to as 2S modules, utilize two silicon strip sensors to facilitate both tracking and Level-1 trigger functionalities. To minimize the material budget associated with these modules, all components will be bonded using adhesive methods.

Among the numerous 2S modules produced in module production centers worldwide, RWTH Aachen University has taken the task of assembling approx. 1,000 2S modules. This introduces significant challenges related to maintaining high-quality standards throughout the assembly process while achieving peak production rates of up to four modules per day.

This presentation will introduce a new custom made glue dispensing device that enhances existing volumetric dispensing technologies. The proposed device employs readily available components and demonstrates superior repeatability compared to previously utilized systems.

T 27.6 Tue 17:30 VG 0.111

ATLAS ITk Strips sensor cracking mitigation efforts — Jan-Hendrik Ahrling, Sergio Diez, •Konstantin Mauer, and Ingrid Gregor — 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 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 detector modules.

The strip modules are glued onto local support structures. During the pre-production for the detector such fully loaded structures where thermal cycled below operational temperatures. A coefficient of thermal expansion (CTE) mismatch in the layers of a module in combination with the gluing method creates localized stress points at low temperatures. This results at fracturing of the sensor accompanied by an early sensor breakdown. To prevent the loss off several detector modules in certain cooling scenarios, a mitigation strategy was sought.

In this talk, alternative methods of loading modules onto the local support are presented which are reducing the amount of stress in the sensor. The measurements comparing these methods and their impact on sensor cracking are discussed.

T 27.7 Tue 17:45 VG 0.111

Module assembly for the ATLAS High Granularity timing detector — •Hendrik Smitmanns[1], Jessica Höfner[1], Annika Stein[1], Frederic Maximilian Matthias Silvan Fischer[1], Lucia Masetti[1], Theodorus Manoussos[1], Jan Ehrecke[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Antonin Zeman[2], Quirin Weitzel[2], and Steffen Schoenfelder[2] — [1]University Mainz, Insitut for Physics — [2]University Mainz, PRISMA+ Detector Lab

To meet the challenges of the High Luminosity Large Hadron Collider (HL-LHC), especially the increase of pile-up interactions, the ATLAS detector will need to be upgraded. One of the foreseen upgrades is the installation of the High-Granularity Timing Detector (HGTD). The HGTD will mitigate the effects of pile-up in the ATLAS forward region, providing a time resolution of about 30-50 ps per track. The active area consists of 2 double-sided disks per end-cap. Two 2x2 cm^2 Low Gain Avalanche Detectors (LGAD) bump-bonded to two ASICs and glued to a flexible PCB form the HGTD basic unit, the so-called module. Multiple modules are glued onto a support unit to form a detector unit, which will be built into the final detector at CERN. Pre-production started at the beginning of 2025 and over the next two years around 1000 modules, 10% of the total detector, will be assembled at Johannes Gutenberg University Mainz, as one of the six production sites. The full module assembly procedure with focus on wire bonding, metrology and the initial testing of the assembled modules is presented.

T 27.8 Tue 18:00 VG 0.111

Development of the Production Database of the High-Granularity Timing Detector for the ATLAS Phase-II Upgrade — •Annika Stein[1], Luca Cadamuro[2], Jan Ehrecke[1], Frederic Fischer[1], Jessica Höfner[1], Muhammad Imran[3], Yun-Ju Lu[4], Lucia Masetti[1], Muhammad Atif Shad Rao[3], Hendrik Smitmanns[1], and Song-Ming Wang[4] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]IJCLab, Orsay Cedex — [3]Experimental Physics Dep., CERN — [4]Academia Sinica, Taipei

During the production of components for the new High-Granularity Timing Detector, to be installed during the ATLAS Phase-II upgrade, assembly and testing sites need to keep track of the individual parts. The properties and measurement results, along with the relations between parts, need to be documented and readily accessible at different sites. There are metrology data, electrical measurements and binary files like images of parts to be recorded and retrieved in an efficient manner. Besides the work that is required on the backend-side of the application, i.e. the database with its tables and views, a special focus is laid on the visualization of results with the frontend application. Web tools like Grafana querying the database information through API requests, and customized webpages aiding the users in selecting the correct parts based on predefined labeling schemes are used to enter new information and display existing data.

In this presentation, the current status of implemented components, their attributes and relations, as well as the graphical interface will be explained.