T 30: Silicon Detectors III

Time: Tuesday 16:15–18:30 Location: KH 01.012

T 30.1 Tue 16:15 KH 01.012

Current and low-field carrier mobility in silicon sensors irradiated to extreme fluences — Christian Scharf[1], Peilin Li[1], •Heiko Markus Lacker[1], Ingo Bloch[2], and Ben Bruers[2] — [1]Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

We present a study of the forward and reverse currents in silicon pad diodes irradiated to extreme neutron fluences up to $1 \times 10^{18}\, n_{eq}/\mathrm{cm}^2$, similar to the expected fluences of tracking detectors at a future circular hadron collider.

At such fluences, the silicon bulk and the implant no longer behave like a typical pn diode. Excess free carriers are trapped at radiation-induced deep defects, compensating ionized shallow defects in the bulk. Consequently, carrier concentrations in the bulk decrease and become similar to those in intrinsic silicon, increasing the resistivity of the bulk. The interaction between ionized defects and free carriers leads to increased Coulomb scattering, causing a decrease in the low-field carrier mobilities with fluence.

To quantify the mobility degradation as a function of fluence and to obtain a qualitative understanding of the diode's electrical performance, current-voltage characteristics were measured at various temperatures. These measurements are compared to TCAD simulations using different radiation-damage models.

T 30.2 Tue 16:30 KH 01.012

The Production Database of the High-Granularity Timing Detector for the ATLAS Phase-II Upgrade — •Annika Stein[1], Luca Cadamuro[2], Martin Christiansen[1], Frederic Fischer[1], Jessica Höfner[1], Yun-Ju Lu[3], Lucia Masetti[1], Yuan-Yen Peng[4], Hendrik Smitmanns[1], and Song-Ming Wang[3] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]IJCLab, Frankreich — [3]Academia Sinica, Taiwan — [4]NTHU, Taiwan

The High-Granularity Timing Detector is being built as part of the Phase-II upgrade of ATLAS. It is based on Low-Gain-Avalanche-Detector sensors and provides the time of tracks in the forward region. Assembly and testing sites use the Production Database (ProdDB) to track components and their properties like measurements and part-to-part relations. To leverage dynamic updates of the ProdDB and local data, a python API client has been developed that ensures proper data structure and minimizes backend server load by running consistency checks on the client side before uploading. With the new user interface, we model the module assembly, module loading onto support units, and detector assembly processes. The tools integrate seamlessly into existing frameworks for quality control of modules (consisting of module PCB and two hybrids) as well as flexible PCB cables (flex tails). Applying module hybrid clustering algorithms on current-voltage curves to find matching components is possible. Furthermore, by running automated continuous integration pipelines, we also perform nightly reporting of part yields. In this presentation, the DB infrastructure, focusing on novel interface methods, will be explained.

T 30.3 Tue 16:45 KH 01.012

Radiation damage studies of the ATLAS ID Pixel detector at LHC — Arnulf Quadt, Steffen Korn, and •Marcello Bindi — II. Physikalisches Institut, Georg-August-Universität, Göttingen

By the end of 2025, the ATLAS ID Pixel detector, including its inner Insertable B-Layer (IBL), have integrated up to 2×10^{15} n-eq cm^{-2} substantially increasing sensor leakage currents. Since leakage current is a key indicator of detector health and a proxy for particle fluence, its accurate monitoring is essential. Because it is strongly temperature-dependent, simultaneous current and temperature measurements are needed to disentangle thermal effects from true radiation-induced bulk damage. I-V scans provide this information and allow early identification of abnormal currents or breakdown behaviour, which is critical for detector safety. Rising leakage currents affect operations through higher power dissipation, increased noise, and potential power-supply limitations.

This work presents leakage current data for the ATLAS Pixel detector, including results from IBL planar and 3D sensor technologies, before and after normalization to sensor volume and temperature correction. Temperature measurements from NTC thermistors on the hybrid flex are also discussed. All scans were recorded over multiple years in stable detector conditions, either without beam (e.g., winter shutdowns and technical stops) or during collisions alongside charge-collection measurements. A summary of the full Run-3 dataset will be shown, emphasizing the effects of radiation fluence and temperature inhomogeneities across detector layers, staves, and modules.

T 30.4 Tue 17:00 KH 01.012

Analysis of de-tuning behaviour of the ATLAS Insertable B-Layer during LHC Run 2 and Run 3 — •Johannes Klas[1], Kerstin Lantzsch[1], and Sergi Rodriguez Bosca[2] — [1]Universität Bonn — [2]CERN

Over time the ATLAS pixel detector has been re-tuned many times. Either due to a change of the tuning set-points, routine retuning after a shutdown, or, in the case of the 2014 installed Insertable B-Layer (IBL), due to de-tuning because of irradiation. Effects like the TID had a severe impact on the tuning of IBL at the start of LHC Run 2. While this concrete behaviour of the de-tuning was studied systematically during the start of Run 2 for IBL, it has not been done in such detail thereafter. Tuning data for the full Run 2 and partial Run 3 was collected and analysed to gain a better understanding of the de-tuning behaviour on a larger timeline and document the overall evolution of the relevant parameters.

T 30.5 Tue 17:15 KH 01.012

Luminosity measurements using the ATLAS Forward Proton (AFP) detector — Jan Broulim, Petr Fiedler, •Daniil Khmelnytskyi, and André Sopczak — CTU in Prague

The latest results of luminosity measurements using the ATLAS Forward Proton (AFP) detector are presented.

T 30.6 Tue 17:30 KH 01.012

ATLAS Forward Proton (AFP) detector operation challenges and ToF Run-3 performance — •Viktoriia Lysenko and André Sopczak — CTU in Prague

Operational and data quality challenges for the ATLAS Forward Proton (AFP) detector in 2025 are presented together with performance studies of the Time-of-Flight (ToF) detector during LHC Run-3 datataking.

T 30.7 Tue 17:45 KH 01.012

Towards ultra-thin hybrid pixel detectors via wafer-to-wafer bonding — Fabian Hügging[1], Janna Vischer[2], Jens Weingarten[2], Matthias Schüssler[1], •Maximilian Mucha[1], Thomas Fritzsch[3], Yannick Dieter[1], and Jochen Dingfelder[1] — [1]Physikalisches Institut, Universität Bonn, Deutschland — [2]Technische Universität Dortmund, Deutschland — [3]Fraunhofer Institute IZM, Berlin, Deutschland

Hybrid pixel detectors are a key technology for precise particle tracking in high energy physics in high rate and high radiation environments. Conventional hybrid detector assemblies rely on die-level bump bonding techniques, which impose limitations on the achievable detector area and the overall material budget. Wafer-to-wafer bonding provides an alternative by interconnecting sensor and readout wafers prior to dicing, enabling large-area devices and aggressive thinning of the bonded stack, while keeping the advantage of a separate development and optimization of both the sensor and readout wafer. This contribution presents ongoing work towards the realization of ultra-thin hybrid pixel detectors based on wafer-to-wafer bonding. An overview of the project and current progress is given. Particular emphasis is placed on the electrical characterization of silicon sensor wafers prior to bonding. Current-voltage (IV) measurements at wafer level are discussed to evaluate leakage current behavior and breakdown performance. The talk concludes with an outlook on the transition to bonded wafer stacks, including the preparations for wafer-level studies.

T 30.8 Tue 18:00 KH 01.012

Investigation of bond qualities in daisy chain wafers for Wafer-to-wafer bonded hybrid pixel detectors — •Janna Vischer[1], Yannick Dieter[2], Fabian Hügging[1], Kevin Kröninger[2], Maximilian Mucha[2], Matthias Schüssler[2], and Jens Weingarten[1] — [1]Technische Universität Dortmund, Dortmund, Germany — [2]Universität Bonn, Bonn, Germany

Semiconductor pixel detectors allow for precisely tracking ionizing particles in high-energy physics experiments and medical applications. Previously, during the manufacturing of hybrid pixel detectors, a common practice to combine the separately manufactured sensor and its readout chip is to bump-bond two single dies together. Wafer-to-wafer bonding is a new method in development for manufacturing hybrid pixel detectors, where whole detector wafers and chip wafers are bonded before being diced to their definite size. This promises detectors to have larger sensitive areas and a reduced thickness through thinning of the wafers after bonding.

To refine the Wafer-to-wafer bonding procedure low-cost non-detector daisy chain wafer stacks have been produced for proof of principle. This talk discusses recent results of measurements on one of those bonded wafer stacks. The resistivity of single bonds as well as bonds connected in daisy chains have been measured on wafer level to investigate spatial dependent deviances in preparation for the first Wafer-to-wafer bonded detectors.

T 30.9 Tue 18:15 KH 01.012

All-Silicon Modules - RDL development in FTD Cleanroom
— •Andreas Ulm, Marco Vogt, Hans Krüger, and Jochen Dingfelder — Physikalisches Institut der Universität Bonn, Bonn, Germany

Silicon Pixel Detectors are an essential part of most modern tracking systems for high energy physics as they can fulfill requirements of high spatial and time resolution, feasible power consumption and relatively low material budget. To cover large areas in the detector volume individual chips are glued together to create modules. These modules are easier to assemble to full tracking systems than what would be possible if all chips had to be installed individually, however gluing, additional flex PCBs, cooling and support structures and also structural silicon can introduce significant amounts of material.

To reduce the material budget of tracking detectors as far as possible, a new concept of module-building is investigated. By post-processing monolithic chip wafers, redistribution layers (RDL) can be built on top of the chips for electrical connections to several chips in a row. By using low power monolithic chips air cooling is feasible and mechanical support is not necessary for thin ladder structures of up to 15 cm in length with thicknesses around 200 micron .

This talk will discuss concepts, look into prototype production, and discuss early measurements and simulations of high speed differential lines for module-sized RDL.