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Characterization of Pre-Production Petals for the ATLAS Inner Tracker Strip Detector

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For the HL-LHC, the ATLAS experiment will replace its current Inner Detector with an all-silicon Inner Tracker (ITk), consisting of pixel and strip systems. In the end-cap, silicon sensor modules of the strip system are mounted onto support structures called "petals". To facilitate the assembly of petals, an automated system has been developed for mounting which streamlines the production process and ensures uniformity. This contribution presents the latest results from the assembly of the first ITk pre-production petals, including characterization of their electrical performance and studies of their robustness at very cold (≤ −35 ℃) temperatures.

Summary (500 words)

For the High-Luminosity upgrade of the Large Hadron Collider (HL-LHC), the ATLAS experiment will replace its current Inner Detector with an all-silicon Inner Tracker (ITk). The ITk will feature a pixel detector surrounded by a strip detector, with the strip system consisting of 4 barrel layers and 6 end-cap disks. The strip tracker will consist of 11,000 silicon sensor modules in the central region and 7,000 modules in the end-cap region, and each module is mounted onto larger, double-sided support structures called "petals"in the end-cap and "staves"in the barrel. The services associated with petals and staves provide optical readout, slow control, power, and cooling to the underlying modules.

To facilitate the assembly of these larger structures, an automated system has been developed for mounting modules onto petals which simplifies the production process and ensures uniformity across the international production clusters. The automated system consists of a programmable gantry robot capable of dispensing adhesive as well as lifting and placing modules with micron-level precision. Careful optimization of the choice of adhesive, its deposition pattern, and its dispensed volume has been performed to ensure sufficient coverage of each module's footprint while minimizing seepage, which can adversely affect electrical performance. Electrical isolation of neighbouring strip modules requires a placement accuracy of 50 microns; the automated system has been designed to meet this specification.

This contribution presents the latest results from the assembly of the first ITk pre-production petals. These results include post-loading metrology of the modules, confirming their placement accuracy, as well as electrical characterization of the modules before and after loading. This includes measurements of the current-voltage characteristics and of the channel input noise for each module, as shown in Figure 1, demonstrating that the loading procedure does not impact module performance.

This contribution also addresses the robustness of petals at temperatures below typical cold operating points, −35 ℃, which may occur in the case of catastrophic cooling failures during operation. It has been observed that thermal stress can lead to sensor cracking, resulting in high sensor currents and high input noise as shown in Figure 2. To address this, variations on the loading strategy have been tested —including on the choice of adhesive and its deposition pattern —and the performance of the resulting petals has been studied as function of the coldest temperatures exposed to those petals. The latest results of these studies and future directions will be presented.

Altogether, this contribution will address the considerations of the automated system's design and validation of the loading procedure for ITk strip petals. Additionally, it will describe the ongoing challenges due to sensor cracking and its mitigation strategies during loading. All these topics are highly relevant to ongoing and future silicon detector design.

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