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A big step towards ATLAS ITk: Performance Characterization of the very first Loaded Local Support Structures

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In order to fulfill the demands of the High-Lumi LHC, the whole ATLAS experiment will undergo a major upgrade.

The current Inner Detector will be replaced by its all-silicon successor - the Inner Tracker (ITk).

The smallest feature complete detector units of the ITk are so-called Loaded Local Supports (LLS).

These LLS have now been tested for the first time, in a complex test-setup, which includes all the features the future ITk will comprise - just in smaller scale.

This contribution will report on the results of the very first tests of this key element of the new ATLAS ITk.

Summary (500 words)

To meet the demands of the High-Luminosity LHC (HL-LHC), the ATLAS Inner Detector will be replaced with the all-silicon Inner Tracker (ITk), designed for enhanced granularity, reduced material budget, and coverage up to $|\eta| < 4$. A critical step in this transition is validating the performance of the detector's smallest feature-complete building block - the Loaded Local Support (LLS).

An LLS is a lightweight carbon-fiber structure hosting up to 36 hybrid silicon modules. The LLS makes use of several novel technologies: powering of the front-end ASICs via Serial-Powering (SP-) chains, and evaporative CO₂ cooling via embedded titanium pipes - concepts used for the first time on such a large scale.

To qualify these innovations, a dedicated test environment has been developed, including a complete readout and control chain (electrical signals up to 1.2 Gbit/s), optical conversion, a PLC processing interlock signals, and a Detector Control System (DCS), which allows for comprehensive hardware controlling and monitoring. This contribution reports on the commissioning of this test setup, the qualification procedures applied to LLS structures, and results from the very first pre-production LLS. These include performance metrics such as noise, data integrity, thermal response, and robustness under repeated thermal cycling (from -55°C to 40°C).

These results mark major milestones in validating the LLS concept with production-type components and allowing to start eventually with the detector production. They provide valuable insight into the performance of the future ITk, ensuring the system's robustness and reliability, thus standing out as one of the key-components in the efforts of the ATLAS Phase-II upgrade.

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