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ITk Pixel System Test of the ATLAS Experiment

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The ATLAS collaboration will replace its inner detector by an all-silicon tracker for the HL-LHC.
The new pixel detector will cover a sensitive area of 13m2 with about 9000 modules, made of planar and 3D silicon sensors bump bonded to new Front-End ASIC.
The modules are loaded on carbon structures in the form of (half)rings and staves.

Electrically functional prototypes of these local supports based were built and extensive system-level tests were carried out evaluating serial powering, grounding and shielding, monitoring, and the overall performance of the multi-module systems.

In this contribution the results of these system tests are presented.

Summary (500 words)

The ATLAS experiment at CERN's Large Hadron Collider is one of the experiments in high-energy physics. The High Luminosity Phase of the LHC is expected to start in 2029 and last for 10 years. It will provide ten times more data to increase the discovery potential of the LHC. The expected luminosity of up to 7.5 x 1034 cm-2s-1 will be a factor 7.5 higher than that of the nominal LHC one, corresponding to ˜200 additional proton-proton pile-up interactions per bunch crossing.
The radiation is expected to reach unprecedented values, with non-ionizing fluence of 1e16 neq/cm2 and ionizing dose of 5 MGy.
To cope with the resulting increase in occupancy, bandwidth, and radiation damage, the current ATLAS Inner Detector will be replaced by an all-silicon Inner Tracker (ITk), composed by a strip and a pixel system.

The new pixel detector will cover a sensitive area of 13m2 by about 9000 modules, made of planar and 3D silicon sensors bump bonded to readout with new Front-End ASIC, developed by the RD53 Collaboration and it features improved tracking performance, radiation hardness compared to the current detector and serial powering in order to save material in the servicing cables.

Thin n-in-p planar sensor technology is used. The thickness of the sensor is 100 um or 150 um and pixel size 25x100 umˆ2 or 55 x 50 umˆ2 depending on the layer.
3D sensors will be used for the innermost layer and thin planar sensors elsewhere.

The pixel modules are loaded with the backside of the Front-End chips in contact with light-weight, thermally conductive carbon-fiber based structures in the form of (half) rings or staves.
The data from the modules will be driven from the front-end chip to the opto-electrical conversion system with high-speed transmission parallel lines running at 1.28 Gb/s per data link.
Data sharing is foreseen for some of the layers.

Tracking performance will be improved due to the reduced amount of material, thanks to light carbon fiber structures,
CO2-based cooling with thin Ti tubes walls, data link sharing and a novel serial powering scheme.
The ITk pixel detector will operate at around -35 C and is designed also
to sustain the expected large number of temperature cycles during its lifetime.

Extensive system-level tests of these structures were carried out evaluating serial powering, grounding and shielding, system monitoring, and the overall performance of the multi-module detector systems.
Development of the system test encompasses specific challenges associated with Data Acquisition electronics

with optical readout, a scalable Detector Control System and Interlock System. These two latter systems include signals from multiple silicon pixel-modules, environmental sensors, cooling plants and power supplies.

The integration of many different electronics components makes the results very interesting for the audience.

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