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Test Beam Studies of Barrel and End-Cap Modules for the ATLAS ITk Strip Detector before and after Irradiation

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The ATLAS experiment at the Large Hadron Collider is currently preparing for the High- Luminosity LHC (HL-LHC). In order to achieve the integrated luminosity of 4000 fb-1, the instantaneous luminosity is expected to reach unprecedented values. The radiation damage at the full integrated luminosity implies integrated hadron fluencies over 2x10ˆ16 neq/cm2 requiring a replacement of the entire existing Inner Detector. In order to cope with the occupancy and radiation doses expected at the HL-LHC, the ATLAS experiment will replace its Inner Detector with an all-silicon Inner Tracker (ITk), consisting of pixel and strip subsystems. The strip subsystem will be built from modules, consisting of one n+-in-p silicon strip sensor, manufactured by Hamamatsu Photonics, and one or two PCB hybrids containing the front-end electronics glued directly onto the active surface of the sensor. A power-board, containing an HV switch, a monitoring and control ASIC, and a DC-DC converter, is also glued to the sensor.

In the last three years, several prototype ITk strip modules have been produced and tested extensively using beams of high-energy electrons and charged pions produced at the DESY- II and CERN SPS test-beam facilities. Tracking was provided by EUDET telescopes, consisting of six Mimosa26 pixel planes, resulting in a track resolution of around 2 µm. The modules tested were built from two sensor types: the rectangular ATLAS17LS sensor, which will be used in the central barrel region of the detector, and the annular ATLAS12EC sensor, designed for the innermost ring (R0) of the forward endcap region. Every sensor geometry has been tested using both the final prototype version of the front-end electronics, known as “star” chipset, as well as a previous prototype chipset developed for lower trigger rate specification. Additionally, a dedicated carbon-fibre based mechanical support, similar to the final support structure, with two R0 modules positioned back-to-back has been measured, demonstrating space point reconstruction using the stereo angle of the strips. Finally, two R0 modules, one with each chipset, have been measured after radiation doses up to factor of 1.5 over the expected end-of-lifetime fluence of the ATLAS ITk.

Based on the large set of test beam data obtained, we will present results of thorough tests of the module performance, including charge collection, noise occupancy, detection efficiency, and tracking performance. Additionally, the excellent tracking resolution allows for detailed studies of various sensor features. The results give confidence that the ITk strip detector will meet the requirements of the ATLAS experiment at the Phase-II LHC Upgrade.

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