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Test Beam Characterization of Prototype Modules for the ATLAS Inner Tracker Strip Detector

After more than ten years of operations, starting from 2024 the LHC will be upgraded to the High-Luminosity LHC (HL-LHC). The HL-LHC will deliver a total integrated luminosity of up to 4000fb-1 in about ten years, with a peak luminosity five times higher than that which was reached before the current LHC shutdown. To cope with the higher radiation levels and pile up, the ATLAS experiment will replace the current tracking system with an all silicon detector, the Inner Tracker (ITk), consisting of inner pixel layers and outer strip layers.

The ITk Strip detector will operate in a much harsher environment than the current strip detector, the Semiconductor Tracker. For this reason, ATLAS has undertaken an intense R&D program to develop new radiation-hard silicon sensors and front-end chips. As part of this program, several test beams have been performed to characterize the performance of the prototype modules. A strip module is the basic building unit of the ITk Strip detector and is composed of an n+-in-p silicon strip sensor, the hybrids, which host the front-end chips, and a power board. The hybrids and the power board are glued directly to the silicon sensor.

In this contribution, test beam measurements obtained with several prototype modules are presented. Results of modules with a prototype version of the front end chip (ABC130) and the production version (ABCStar) are discussed. A few modules have been irradiated to approximately their end-of-lifetime fluence, and their performance is compared to the requirements for the ATLAS experiment. The measurements were performed at the DESY and CERN test beam facilities, with the use of EUDET-type pixel telescopes as reference systems. The main focus of the characterization lies on the performance of the sensors and front-end electronics, with results on efficiency, charge collection, noise occupancy and tracking performance.

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