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Front-end Electronics of the Forward Strip Detector for the ATLAS HL-LHC Upgrade

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The ATLAS Experiment will upgrade its tracker with an all-silicon Inner Tracker (ITk) for the HL-LHC, comprising pixel and strip detectors. The strip detector is based on silicon strip sensors, which are read out by low mass radiation-hard circuits carrying custom designed radiation-hard ASICs in 130 nm technology. The circuits are made from flexible PCB multi-layer copper polyimide constructions. The ASICs are glued onto the flex and connections are made by wire-bonding. This contribution discusses the evolution and electrical performance of various hybrid prototypes necessary to equip the forward region of the detector, as well as their final development.

Summary

The Large Hadron Collider (LHC) will upgrade to the High Luminosity LHC (HL-LHC), increasing the instantaneous luminosity at the interaction points of the two general purpose experiments, ATLAS and CMS. This increase motivates an upgrade of the trackers in both experiments, for two main reasons: the radiation levels and the track density. In order to cope with the radiation, different detectors have been developed and the electronics have been re-designed. The extra track density is tackled by increasing the granularity of the detectors, which ATLAS will solve by replacing the Inner Detector with an all-silicon Inner Tracker (ITk) and by decreasing the pixel size and strip length.

This submission focuses on the forward region of the strip detector. This forward region is covered by the two end-caps, composed of six discs to each side of the barrel. The discs are made from petals, structures with a wedge shape that provide cooling, mechanical support and power to the detector modules. In the case of the petals, due to the wedge shape, the detectors are arranged in 6 rings, from 0 to 5, covering different widths and occupancy regions by having sensors with different strip lengths and numbers.

The sensor strips are read out by digital front-end chips, which are named ABC (from ATLAS Binary Chip) and produced in a 130 nm CMOS process. The prototype chips are named ABC130, whereas the production chips are named ABCStar. The hybrid circuits holding the front-end chips are made from flexible PCB with multiple copper layers and polyimide as dielectric. The chips are glued onto the hybrids and the electrical connections of the back-end are made by wire-bonds.

All of the hybrid types required to cover the petals in the strip detector have been designed and tested. In this contribution we discuss the hybrids prototypes for rings 0, 1, 3, 4 and 5, as well as all the rings of the production hybrids. We will show our experience producing the bare hybrids in industry and performing the population of both passive components and chips in-house. In addition, we show the electrical performance of the various hybrids types and discuss the status of the designs for production hybrids with the ABCStar chips.

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