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Electrical performances of pre-productions staves for the ATLAS ITk Strip Detector Upgrade

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The ATLAS experiment is currently preparing for an upgrade of the inner tracking detector for High-Luminosity LHC. The new tracker, ITk, employs an all-silicon detector with outer Strip layers. The building block of the ITk Strip barrel is the stave which consists of a low-mass support structure hosting the common electrical, optical and cooling services as well as 28 silicon modules. In this contribution, we outline the challenging aspects of the stave pre-production testing phase at Brookhaven National Laboratory. The electrical characterization of these staves, hosting the final design of both front-end electronics and ASICs, will be discussed in detail.

Summary (500 words)

To face the higher radiation levels foreseen at the HL-LHC, the inner tracker of the ATLAS detector will be replaced by an all-silicon Inner Tracker (ITk) consisting of an innermost Pixel and an outer Strips Detectors. This outer Strip tracker consists of a four-layer barrel and six discs to each side, assembled with silicon-strip staves. An ITk Strip stave consists of 14 modules mounted on either side of a carbon composite support structure, which provides mechanical support and houses the necessary electrical, optical, and cooling components. A module consists of one silicon sensor, one or two low-mass polyimide circuit boards, called hybrids and one power board. The hybrid hosts the readout ASICS: ten 256-channel front-end chips called ABCStars and one control chip called HCCStar. The Star refers to the star topology of interconnection between the HCCStar and ABCStar chips: each ABCStar chip has a direct (point-to-point) data path to the HCCStar, enabling fast readout. The powerboard provides a DC-DC converter with air coil for stepping down the voltages to those required by the on-detector electronics as well as voltage, current, temperature control and monitoring via a dedicated AMAC chip.

Half of the ITk Barrel Strip Detector will be assembled at Brookhaven National Laboratory (BNL) between 2023 and 2026. To fulfill the new requirements for HL-LHC, modules and staves construction and testing techniques have been extensively prototyped. The ITk production is preceded by two pre-production phases, PP-A and PP-B. During PP-B, the final layout and design of all parts are supposed to be adopted. BNL started assembling and testing PP-A ITk's staves in the first trimester of 2022 and will be initiating the assembly of PP-B staves towards the end of the second trimester of 2022. Prototyping staves built at BNL have been fundamental to investigate the limitations of the previous stave layout and of the prototyping ASICs. For this reason, the pre-production phase will give us a new opportunity to study and understand the final detector before mass production will start. In this presentation, we want to focus on the electrical characterization of pre-production staves. Staves performance, in terms of gain and noise will be deeply investigated both at room and cold temperature. As these staves will be hosting the final version of the HCCStar chipset, the signal integrity at the designed data rate of 640 Mbit/s will also be discussed. In addition, the performance of the new AMAC chip (AMACStar) will be presented, with focus on high voltage bias return current and temperature measurements

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