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Outer Barrel services chain characterization for the ATLAS ITk Pixel Detector

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For the high-luminosity upgrade of the ATLAS Inner Tracking detector, a new pixel detector will be installed to allow for a bigger bandwidth and cope with the increased radiation among other challenges. This contribution will present the evaluation of the Outer Barrel Pixel layer services chains. A full data transmission study covering data merging will be presented from the pixel module all the way to the FELIX data acquisition system, using most of the components foreseen for the detector. Challenges and results of the services chain of the Outer Barrel will be highlighted.

Summary (500 words)

In the high-luminosity era of the Large Hadron Collider, the instantaneous luminosity is expected to reach unprecedented values, resulting in about 200 proton-proton interactions in a typical bunch crossing. To cope with the resulting increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk). The innermost part of ITk will consist of a pixel detector, with an active area of about 14 m^2.
The layout of the pixel detector is foreseen to have five layers of pixel silicon sensor modules in the central region and several ring-shaped layers in the forward regions. Beside the challenge of radiation hardness and high-rate capable silicon sensors and readout electronics many system aspects have to be considered for a fully functional detector. The modules will be powered serially in chains up to 14 modules to reduce the power consumption. Both stable and low mass mechanical structures and high-rate capable services are important.

This contribution focuses on the results of the services realization for the outer central layers of the detector, the Outer Barrel (OB). The OB will have 4472 pixel quad modules, arranged on 158 light-weight carbon fibre local support structures (longerons and inclined-half rings). The services chain extends from the FELIX data acquisition system all the way to the module flex PCBs inside the detector. It is composed of custom flex-rigid circuits (type-0 and type-1 OB services) which vary for longerons and inclined half-rings. These so-called PP0s and pigtails are then connected with adapter PCBs to custom twinax cables, and terminated to PCBs with the ASICs that recover data, GBCR, serialize and deserialize data, lpGBT (low power Gigabit Transceiver), and that transform light into electrical signals, VTRx. Optical fibres connect then to the readout hardware hosted in racks.

In the presentation, the latest results and full evaluation of the services chain tests between pixel modules with the most recent front-end chip and the readout system are presented. Important qualification steps of the system design and its operation are discussed. The lack of physical space in the detector means that in the OB either one or two front-end chips receive the data from the others and it comes all out in one or two links at 1.28 Gbps. The functionality of this so-called data merging is crucial for the verification of the data transmission chain. Moreover, the operation of several quad modules at full speed and including the opto-components is important. These key aspects for future operation of the detector are measured and analysed in detail. The outcome of these tests is relevant to fully qualify the services chain, aiming to continue with the pre-production and production phases for several flavours of these detector components.

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