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The services chain for the upgrade of the Inner Tracker Pixel detector of the ATLAS experiment –full services from pixel modules to optical readout for the Outer Barrel sub-system

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For the high-luminosity upgrade of the ATLAS Inner Tracking detector, a new pixel detector will be installed to increase bandwidth and to cope with higher radiation, among other challenges. In this contribution, the design aspects and qualification of the data transmission from pixel modules to optical readout are presented. A focus is put on the data cable bundles and their performance for one of the Pixel sub-systems, the Outer Barrel. The development of a custom system for production testing of the bundles is discussed. Finally, in preparation of the detector integration, developments regarding functionality and connectivity testing are analyzed.

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. Besides 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 implementation 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 to the module flex PCBs inside the detector. It is composed of different custom flex-rigid circuits 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 then connect to the readout hardware hosted in racks.

For the inclined units, a new rigid flex board for 1.28Gb/s links had to be developed to accommodate mechanical constraints applicable on the type-1 data services. In view of the production of the services, a test system was developed for the series production quality control of the type-1 data bundles. This contribution will cover these developments and explain the strategy for verifying signal and power connectivity during integration.

Several qualification tests with single service components and full OB chain systems were completed with unirradiated and irradiated components and will be covered in this contribution. Difficulties selecting the

optimal settings for the up to 6m long e-links and the strategies employed will be explained.

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