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The Optosystem: validation and testing of the high-speed optical-to-electrical conversion system for the readout of the ATLAS ITk Pixel upgrade

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After Run III the ATLAS detector will undergo a series of upgrades to cope with the harsher radiation environment and increased number of proton interactions in the high luminosity LHC. One of the key projects in this suite of upgrades is the ATLAS Inner Tracker (ITk). The pixel detector of the ITk must be read out accurately and with extremely high rate. The Optosystem performs optical-to-electrical conversion of signals from the pixel modules. We present recent results related to the performance of the data transmission chain pivoted on the Optoboards and to the design, testing and production of the Optopanels.

Summary (500 words)

In the High Luminosity LHC (HL-LHC) the number of proton interactions per bunch crossing is set to increase drastically and so the amount of radiation components are exposed to will also increase. The ATLAS detector will perform a suite of upgrades to cope with these challenges. The ATLAS Inner Tracker (ITk) will provide high precision tracking while being resistant to the high levels of radiation it will receive over its lifetime. The ITk Pixel is at the very heart of the experiment and, critically, the data from the modules must be read out and sent to the ATLAS counting rooms with high precision. The distance of this data transmission is too great for electrical signals alone due to attenuation. So, an optical-electrical conversion system known as the Optosystem was proposed as a solution.
The Optosystem takes electrical signals from the front-end sensor modules (uplink) via twinax cable to the Optopanels. These are four mechanical structures, located at each end of the ATLAS detector. Each Optopanel houses 28 Optoboxes and these house the Optoboards. The Optoboard can be considered the heart of the Optosystem. These devices host four signal recovery ASICs (Gigabit Channel Receivers, GBCRs), four ASICs for signal aggregation (low power Gigabit Transceivers, lpGBTs) which pass the uplinks to a final ASIC for optical conversion (VTRx). The command-and-control lines coming towards the front-end modules (downlinks) undergo the reverse process.

In this poster we present an introduction to the ATLAS ITk Optosystem and to its performances. The validation and signal quality checks of the Optosystem are gauged using many robust techniques, including Bit Error Ratio Tests (BERT) on the uplinks. Strict requirements on data quality impose that the BER must be less than 10ˆ-12 at 95% CL.
The results of an irradiation campaign, carried out at the Bern medical cyclotron, with the aim of investigating the radiation hardness of the ASICs on the Optoboard and the impact of radiation damage on the data transmission will be reported.
The powering of the Optoboards has also been studied: two separate DC-DC step down converters, used to provide the Optoboards with the correct tensions, have been designed and tested.
The progress on the construction and testing of the Optoboxes will be outlined.
Finally, a Graphical User Interface (GUI) has been developed to allow easy control over the complex Optoboards and the overall Optosystem. Information about the integration of this GUI with the software under development for the ITk Pixel System Test will be provided.

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