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The high-speed opto-electrical conversion system for the readout of the ATLAS ITk Pixel upgrade

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After Run III the ATLAS detector will undergo many upgrades to cope with the harsher radiation environment and increased number of proton interactions in the high luminosity phase of the LHC. One key project of this upgrade is the ATLAS Inner Tracker (ITk). The pixel detector of the ITk must be read out at 1,28Gb/s with a BER at 95%CL less than 10ˆ-12. The Optosystem performs opto-electrical conversion of signals from the pixel modules. We present recent results related to irradiation studies on Optosystem components, the powering system, the whole chain performance and the impedance measurement of the Optosystem.

Summary (500 words)

In the High Luminosity LHC (HL-LHC) the number of proton interactions per bunch crossing is set to increase by a factor of 5 to 7 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 quality of the electrical signals produced by the detector would be compromised by the differential loss along the cables connecting the detector to the counting room. 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 talk we present an introduction to the ATLAS ITk Optosystem and to its performance. The validation and signal quality checks of the Optosystem are gauged using many robust techniques, including monitoring of PRBS7 pattern and idle signal produced by the front-end electronics of the ITk Pixel. An estimate of the 95% Confidence Level Bit Error Ratio (BER) is used to quantify the goodness of the data transmission. Strict requirements on data quality impose that the BER must be less than 10ˆ-12 at 95% CL.

Moreover, results related to the powering of the Optoboards will also be reported: a new version of the dedicated powering board, including a DC-DC step down converter used to provide the Optoboards with the correct tensions, has been designed and tested.

Furthermore, the Optosystem will be placed in a high radiation area of a total dose of 50 kGy, meaning the components need to be radiation hard. Irradiation studies were performed at the Cyclotron facility at the Bern Hospital to assess the good functionality of the components in a challenging environment even at a total dose of 150 kGy, corresponding to a safety factor of 3.

Finally, the electrical characteristics performed using a TDR on all parts of the Optosystem will be presented.

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