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A radiation tolerant Data link board for the ATLAS TileCal upgrade

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We describe the latest (last?) full functionality revision of the high-speed data link board for the ATLAS TileCal phase 2 upgrade. It is highly redundant, using two Kintex-7 FPGAs and two Molex QSFP+ electro-optic modules. The FPGAs are remotely configured through two radiation-hard CERN GBTx deserialisers (GBTx), which also provide the LHC-synchronous system clock. The four QSFP+ uplinks transmit data at 10 Gbps. Virtually all single-point error modes are removed, and a combination of triple-mode redundancy, internal and external scrubbing will adequately protect against radiation-induced errors.

Summary

We have developed a fully functional version of a high-speed data link board for the ATLAS TIleCal phase 2 upgrade, with high redundancy and fault tolerance. One link board is mounted in each TileCal mini drawer. At start up, after FPGA configuration, the front-end boards and the high voltage levels will be configured. During the run all calorimeter data is transferred off the detector, leaving all trigger selection to the off detector electronics. The link board is also responsible for setting up the different calibration modes.

The key components are two Kintex-7 FPGAs, remotely programmable via two CERN developed radiation hard gigabit deserialisers (GBTx) and two Molex QSFP+ electro-optic modules connected via roughly 100m fiber to a patch panel. There one of the electro-optic modules is connected to the off detector electronics. If a permanent link failure occurs the other module will be chosen.

One of the four 4.8 Gbps QSFP+ down links is connected with a rad hard GBTx deserializer, which provides the system clock and remote configuration for the FPGAs. The other three down links are sent directly to the FPGA. Here we use the full GBT protocol to achieve high reliability. The 4 uplinks transmit data at a 10 Gbps rate using a simpler CRC based protocol. One fiber can read out PMT data from one of the two PMTs connected to each calorimeter cell, providing a redundancy factor of 8. This redundancy is required to remove almost all single point error modes. However, to transmit all data you need to read out both PMTs. i.e. the redundancy factor for full readout is thus 4. At the off detector side it is 2.

Triple Mode Redundancy and internal and external scrubbing greatly reduce uncorrected SEU errors in the expected radiation environment. Only a few unrecoverable errors per year are expected in the full system of 1024 link boards. This will be verified in radiation tests.

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