The TileCal PreProcessor Interface with the ATLAS Global Data Acquisition System at the HL-LHC

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Abstract

The Large Hadron Collider (LHC) has envisaged a series of upgrades towards a High Luminosity LHC (HL-LHC) delivering five times the LHC nominal instantaneous luminosity, that will take place throughout 2026-2028, corresponding to the Long Shutdown 3. During this upgrade, the ATLAS Tile Hadronic Calorimeter (TileCal) will replace completely on- and off-detector electronics adopting a new read-out architecture. Signals captured from TileCal are digitized by the on-detector electronics and transmitted to the TileCal PreProcessor (TilePPr) located off-detector, which provides the interface with the ATLAS trigger and data acquisition systems.

TilePPr receives, process and transmits the data from the on-detector and transmits it to the Front-End Link eXchange (FELIX) system. FELIX is the ATLAS common hardware in all the subdetectors designed to act as a data router, receiving and forwarding data to the SoftWare Read-Out Driver (SWROD) computers. FELIX also distributes the Timing, Trigger and Control (TTC) signals to the TilePPr to be propagated to the on-detector electronics. The SWROD is an ATLAS common software solution to perform detector specific data processing, including configuration, calibration, control and monitoring of the partition

In this contribution we will introduce the new read-out elements for TileCal at the HL-LHC, the interconnection between the off-detector electronics and the FELIX system, configuration and implementation for the test beam campaigns, as well as future developments of the preprocessing and monitoring status of the calorimeter modules through the SWROD infrastructure.

Keywords: ATLAS, Tile Calorimeter, HL-LHC, TilePPr, FELIX, SWROD, DAQ

1. Introduction

The Tile Calorimeter (TileCal) is the central section of the hadronic calorimeter of the ATLAS detector at the LHC [1]. It is a sampling detector constructed of steel and scintillating tiles with fibers, and readout by 9852 PhotoMultipliers Tubes (PMTs).

To prepare for the challenges of high-luminosity running, a full replacement of the TileCal on- and off-detector electronics is planned. A total of 1792 link pairs will be received by the off-detector TilePPr modules. The reconstructed energy, the time, and a quality factor for each cell will be sent out to the data network for event aggregation and storage [2].

2. The TileCal PreProcessor (TilePPr)

TilePPR is the core element of the back-end electronics. Provides the interface between the front-end electronics and the ATLAS global data acquisition as well as the trigger systems and capable to read up to 384 PMT channels.

It is composed by an ATCA Carrier board that is equipped with four Compact Processing Modules (CPM) and one Trigger and Data Acquisition interface (TDAQi). Along with these components, a Tile Computer-on-Module (TileCoM) is connected into the ATCA carrier board. 32 TilePPr modules are needed to operate the complete TileCal detector.

The CPMs are responsible of the distribution of the LHC clock and the TTC command towards the on-detector electronics, control and read-out of the Tile modules, as well as the cell energy reconstruction and transmission of data to TDAQi and FELIX[3].

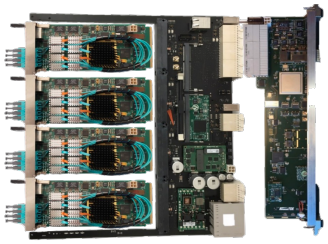

Figure 1: Tile PPr system equipped with 4 CPMs and a TDAQi.

TileCoM provides remote configuration of on-detector electronics, interface the TilePPr with the ATLAS Trigger and Data Acquisition (TDAQ) system and with the ATLAS Detec-

tor Control System (DCS)[4]. TDAQi receives reconstructed energy from the CPMs and creates the trigger primitives for L0Calo, L0muon and the global systems.

3. Front End LInk eXchange (FELIX)

FELIX system has been developed to be the primary interface between the front-end electronics and the DAQ system of the detector, acting as a router for the transfer of the data packets from the front-end electronics[5]. This is the uplink path which reaches up to 9.6 Gbps in Full Mode configuration. This path demands high data bandwidth due to the amount of data coming from the detector.

FELIX will also serve as a provider of the trigger acceptance signal and clock information from the TTC system to the drawers in the detector. This is the downlink, which reaches data rates up to 4.8 Gbps in GBT latency optimized protocol given that in opposition of the downlink case, we need deterministic latency in this path to properly recover the LHC clock.

TileCal complete readout system will be composed of 161 bidirectional links with FELIX, where 128 of them will be used for data readout, 32 for trigger primitives monitoring and 1 for the Interface of the LAser system to the New Acquisition infrastructure (ILANA).

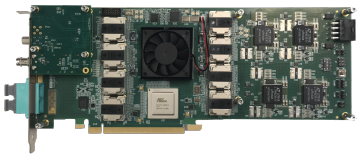

Figure 2: FELIX card (FLX-712) used for Phase-I systems [5]

4. SoftWare Read-Out Driver (SWROD)

SWROD is envisaged to act in the ATLAS dataflow as the handler between the FELIX system and the ATLAS HLT schema[6].

Each subsystem has custom functions in SWROD regarding the data processing, formatting, verification and monitoring that were previously performed by the custom electronics like the RODs used during Run 1 and Run 2.

TileCal custom build function will be responsible for TTC information, data integrity and small data processing, as well as to provide for online monitoring to the Data Quality Monitoring Display (DQMD).

5. Test Beam period

Data acquired by the electronics of the upgrade module located in the TestBeam area is sent to the PPr demonstrator. This data is then formatted into a new data packet that is forwarded to FELIX. FELIX captures this packet and publish it via network at which point SWROD subscribes and captures the data packets to be saved into the system in the ATLAS event format for offline processing.

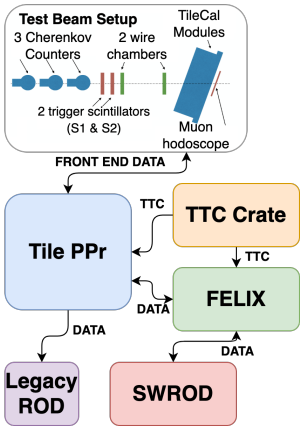

Figure 3: The TileCal test beam area setup for the Phase-II upgrade.

For further verification of the data received, same data that is captured from the front-end electronics and received in the PPr demonstrator is sent to one of the ROD inputs from the legacy system to be analyzed and compared.

6. Conclusions

Future test beam periods will be followed by a numerous amount of upgrades for the readout. Tile PPr demonstrator will be replaced by the final prototype design composed by an ATCA crate with an ATCA carrier, TDAQi and CPM.

CPM will provide the data output received by FELIX, at the same time FELIX will provide the TTC signals to the CPM to be propagated into the front-end electronics Monitoring systems of the acquired data will be implemented into the DQM system in TDAQ with the help of SWROD.

Further test of the electronics and the readout path will validate the design and provide access to the installation of FELIX and SWROD into P1 to capture data from the Tile demonstrator located in the ATLAS Experiment for the Run 3.

References

[1] ATLAS Collaboration, The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003. doi:10.1088/1748-0221/3/08/S08003.

[2] A. Camplani, ATLAS Trigger and Data Acquisition Upgrades for the High Luminosity LHC, PoS LeptonPhoton2019 (2019) 055. doi:10.22323/1.367.0055.

[3] F. Carrio Argos, Design of the Compact Processing Module for the ATLAS Tile Calorimeter, Tech. rep., CERN, Geneva (Nov 2020). arXiv:2011.02684, doi:10.1109/TNS.2021.3085490.
URL https://cds.cern.ch/record/2743571

[4] M. G. D. Gololo, F. C. Argos, F. Martins, B. M. Garcia, Firmware developments on the TileCoM for the phase-II upgrade of the ATLAS tile calorimeter, Journal of Physics: Conference Series 1690 (1) (2020) 012054. doi:10.1088/1742-6596/1690/1/012054.
URL https://doi.org/10.1088/1742-6596/1690/1/012054

[5] Panduro Vazquez, William, Felix: the new detector interface for atlas, EPJ Web Conf. 245 (2020) 01037. doi:10.1051/epjconf/202024501037.
URL https://doi.org/10.1051/epjconf/202024501037

[6] S. Kolos, W. P. Vazquez, G. Crone, New Software-Based Readout Driver for the ATLAS Experiment, Tech. rep., CERN, Geneva (Oct 2020). arXiv:2010.14884, doi:10.1109/TNS.2021.3083987.
URL https://cds.cern.ch/record/2742929