Implementation of the DAQ software in the ALTI Module of the ATLAS TileCal

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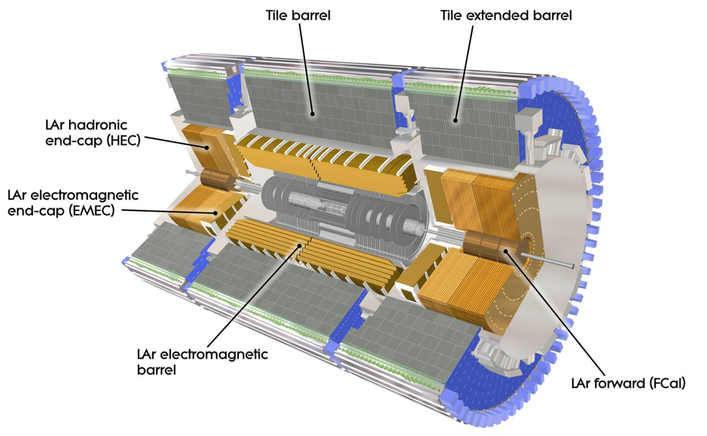
Introduction: The TileCal DAQ software for the ALTI module has been integrated into the TileCal DAQ software and it is being validated at CERN

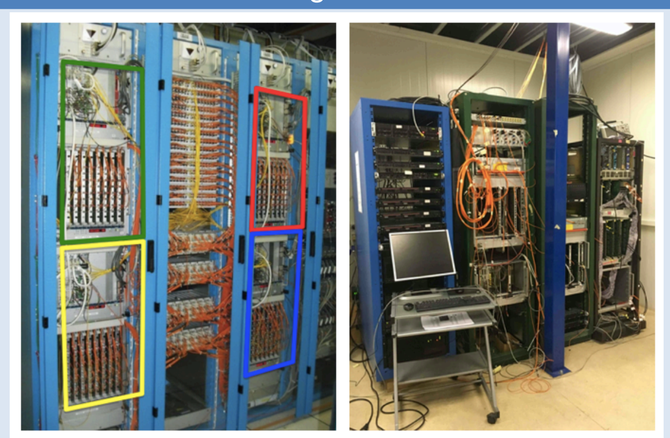
The ATLAS Tie Calorimeter



The Tile Calorimeter (TileCal) is the central hadronic calorimeter (|eta|<1.7) of the ATLAS experiment at the Large Hadron Collider (LHC) [1]

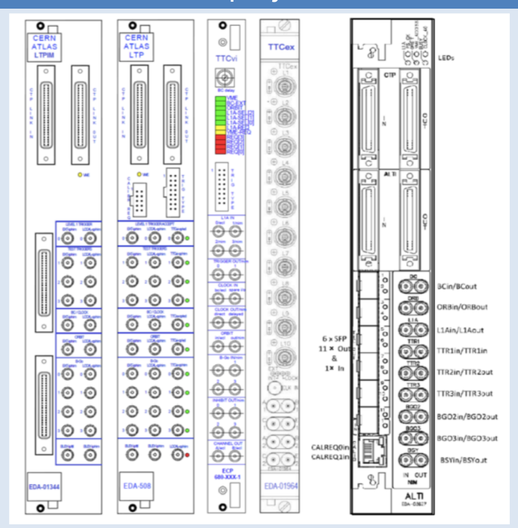
- It is made out of iron plates and plastic scintillators
- It is divided into three cylinders along the beam axis, each of which is azimuthally segmented into 64 wedge-shaped modules, staggered in the ϕ direction
- TileCal online software is a set of Trigger and Data Acquisition (TDAQ) software, and its main purpose is to readout, transport and store physics data originating from collisions at the LHC

Test bench for ALTI software testing



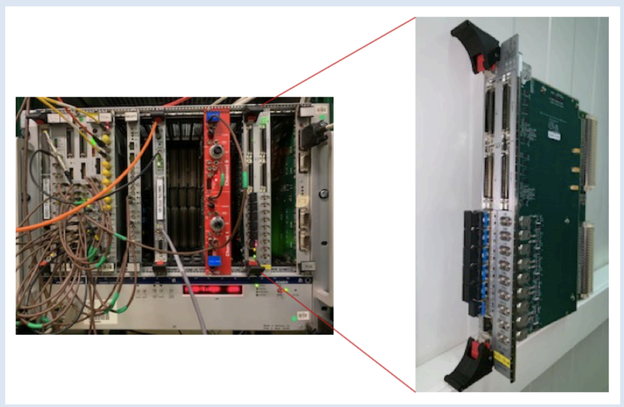
- A test bench (right figure) has been set up in a lab at CERN, for the development and testing of the TileCal software for ATLAS Local Trigger Interface (ALTI) module [2]
- To be deployed in ATLAS TileCal Timing, Trigger and Control (TTC) TTC crates (left figure)

Motivation for the ALTI project



- The ATLAS Local Trigger Processor (LTP) receives timing and trigger signals from the CTP through the Link-in cable and distributes them into the TTC system of the sub-detector through NIM outputs
- The ATLAS LTP interface (LTPi) module provides an interface between the CTP and LTP to allow combined parallel running between various sub-detectors as opposed to the ATLAS global run
- The ATLAS TTC VME bus interface (TTCvi) module serves the purpose of configuring the FE electronics and interface the local and the global TTC system
- The TTC emitter (TTCex) is a laser-based module which converts TTCvi commands into optical signals that arrive to the FE and BE electronics
- It has become increasingly difficult to produce spares for the four TTC legacy modules and not possible to reproduce modules for new Phase-1 upgrade sub-detectors, due to obsolete components

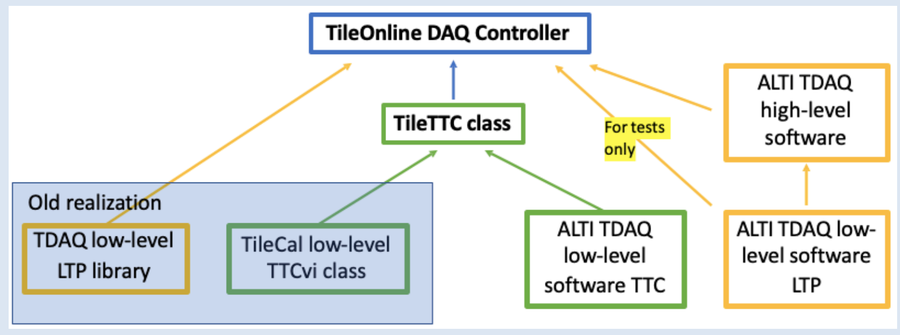
The TTC crate and ALTI



- The ALTI module is a new electronic board, designed for the ATLAS experiment, a part of the TTC system
- It is a 6U VME module which integrates the functionalities of four legacy modules, currently used in the experiment: LTP, LTPi, TTCvi and the TTCex
- ALTI module will provide the interface between the Level-1 Central Trigger Processor and the TTC optical broadcasting network to the front-end electronics of each of the ATLAS sub-detectors
- There has been a need to develop and integrate the TileCal ALTI software in the Tile online software
- Performance tests and maintenance of the ALTI module software are currently in progress, in preparation for Run 3 data-taking period

ALTI Software

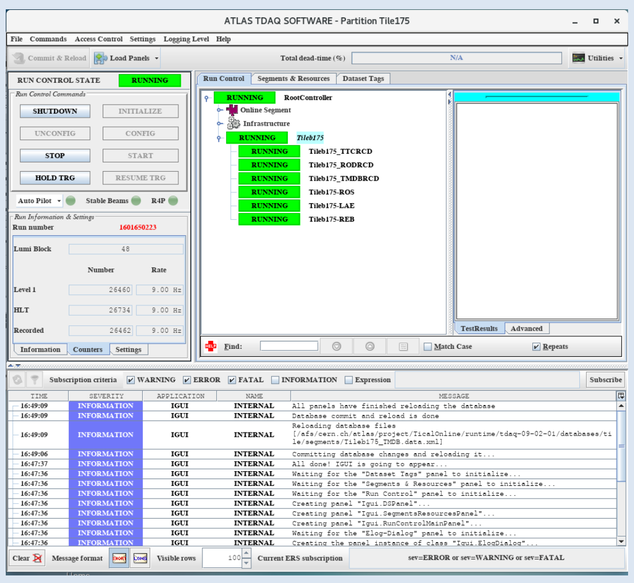
- The TDAQ system provides the software infrastructure for Level-1 trigger, DAQ and HLT systems
- The software packages include the low-level software for control, configuration and monitoring of the modules
- High-level run control application software, built on top of the low-level APIs is also included in the ATLAS TDAQ
- VME-addressable TTC legacy modules (LTPI, LTP and TTCvi) and other modules, have a similar low-level software organization
- The ALTI module has its low-level software organized in a similar way
- The ALTI package depends on several software packages specific to the TDAQ Read Out Driver Crate DAQ and the Level-1 Central Trigger



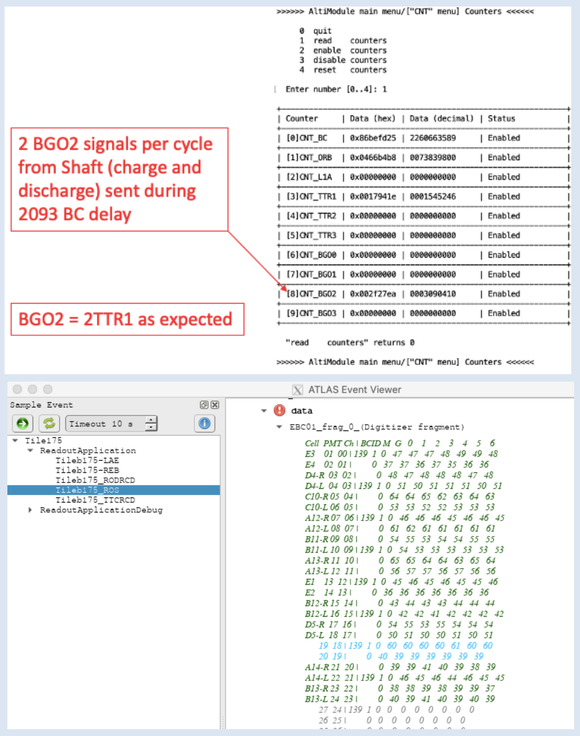
- The TileCal ALTI low-level software has been developed in order to provide access to the ALTI functionalities
- The TileCal online software consists of 29 packages in total
- 6 TileCal software packages have been modified and the addition of the new TileTTC class, allows access to the TTCvi and the ALTI low-level software
- TileConfiguration, TileVMEboards, TileModules, TileMB, TileCIS and TileDVS packages were modified to be compatible with TileTTC class, which has been included inside the TileVMEboards package
- The database has been modified to include new variables for the TileTTC class

Development tools: C++ (main programming language), Java, GitLab and OKS (Object Kernel Support) - an object-oriented database with storage based on XML

ALTI tests

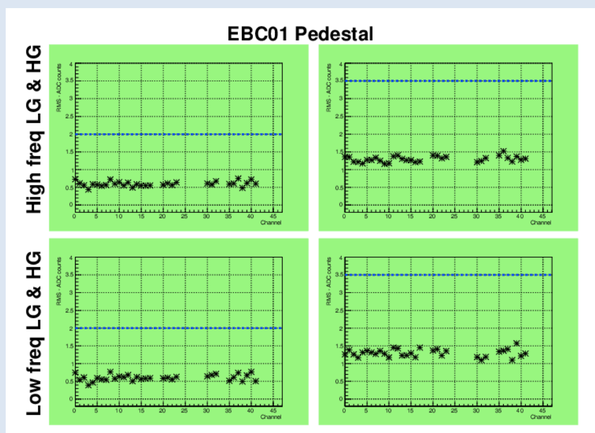


- ALTI's Pattern Generator (PG) implemented to be TileCal specific
- On running the partition, the HLT rate is around 120 Hz, as it was on TTCvi setup
- PG from FPGA generates TTR1 signals every 3564 Bunch crossings (BC) as expected



- The Event Viewer, displays data collected during the Run
- Data was discarded during the Charge Injection Scan (CIS) Run, might indicate the possibility of the trigger word not being correctly programmed for ALTI. The Read-Out Driver fails to retrieve the L1ID and the BCID, and is not able to correlate the BCID with the data from the drawer, and then discards it.

Tile DVS tests



- Diagnostic and Verification System tests were successful for pedestals
- CIS tests fail, as seen in the Event Viewer and this is under investigation
- More tests are being conducted in order to validate the software

Summary

- During LS2, TileCal is undergoing maintenance and upgrades in preparation for Run 3 (2021-2024) data-taking period.
- As part of the ATLAS Phase-1 upgrade, TileCal is replacing the legacy TTC system with the new ALTI TTC system.
- The ALTI module integrates the functionalities of four legacy TTC modules: LTP, LTPi, TTCvi and the TTCex.
- The TileCal ALTI online software has been developed and rigorous tests are currently being conducted with the ALTI system, to ensure high performance and efficiency during the Run 3 data-taking period. Commissioning in the USA15 counting room, will take place upon the completion of tests in the lab.

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References:
[1] The ATLAS Collaboration. ATLAS tile calorimeter: Technical Design Report ATLAS. Geneva: CERN; 1996. Available from: ATLAS tile calorimeter
[2] Haas S, et al. ALTI specification review and preliminary design review. 2018. Available from: ALTI