

Design and Implementation of a Hardware Monitoring Framework for the Tile Demonstrator at Point 1

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The Large Hadron Collider

- The LHC at CERN which spans 27 kilometres beneath the France-Swiss border is the largest and most powerful particle accelerator ever built.
- Since its commissioning, the LHC has achieved numerous milestones, most notably the 2012 discovery of the Higgs boson
- Figure 1 shows the CERN's accelerator complex and how its interconnected.
- The LHC accelerates protons and heavy ions to nearly the speed of light before colliding them.
- These collisions replicate conditions from the early universe, allowing scientists to probe the fundamental constituents of matter and the forces governing their interactions

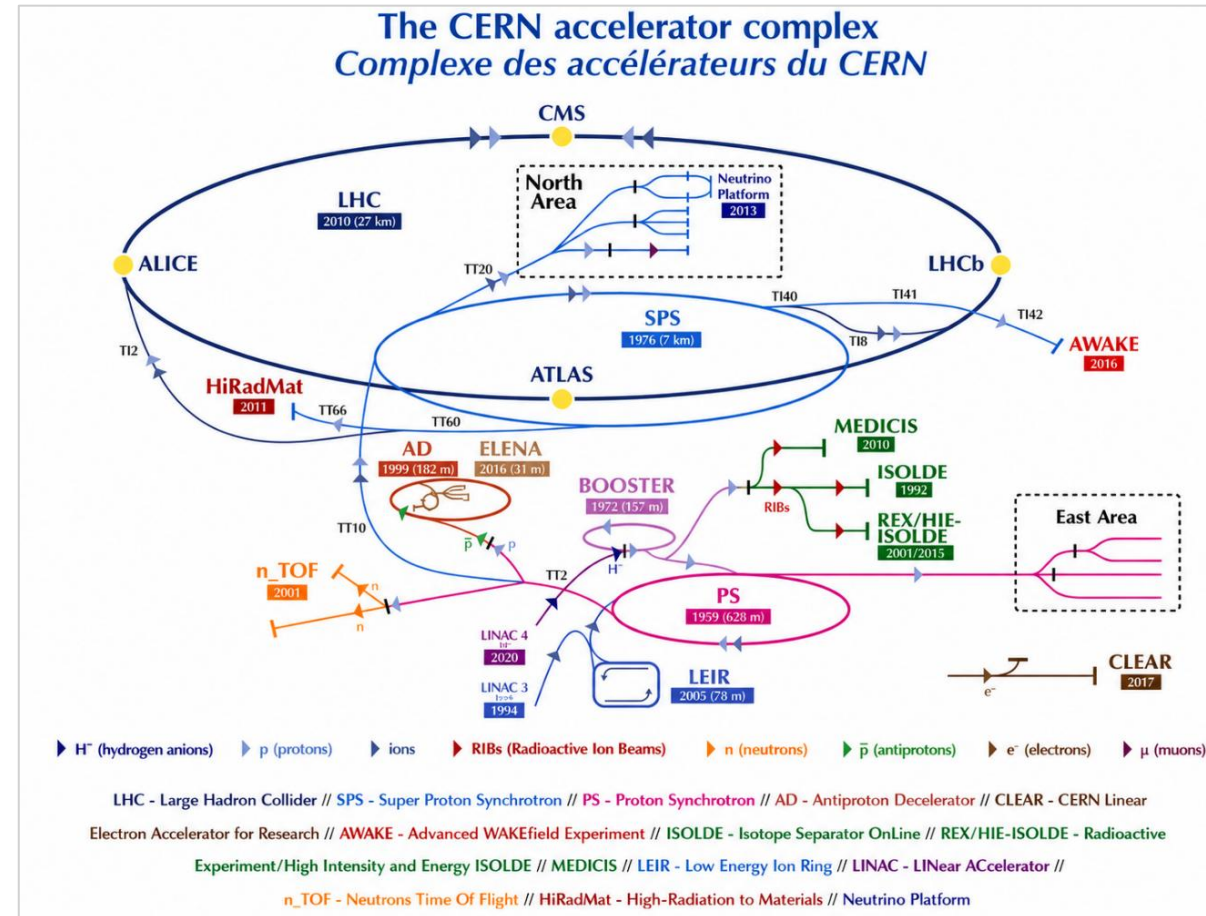


Figure 1: CERN's Accelerator Complex

The ATLAS Experiment and the Tile Calorimeter

- The ATLAS experiment is one of the two general-purpose detectors at the LHC.
- It plays a pivotal role in advancing particle physics.
- The Tile Calorimeter is the central hadronic calorimeter of the ATLAS detector.
- The calorimetry system plays a critical role in measuring the energy of hadrons and jets produced in high-energy proton-proton collisions.
- The electronic readout chain of the Tile Calorimeter shown in Figure 2 converts scintillation light signals generated by particle interactions within the detector into digitized data.

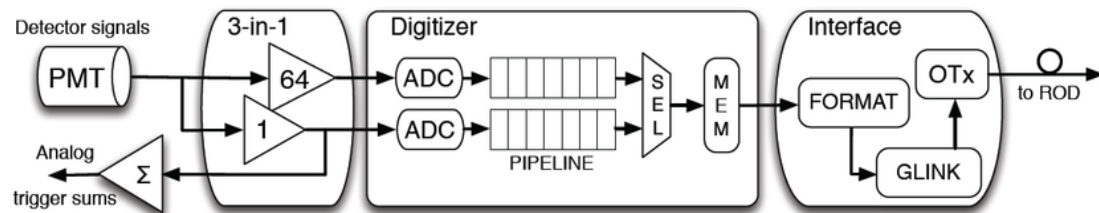


Figure 2: Current TileCal Electronic Readout Chain

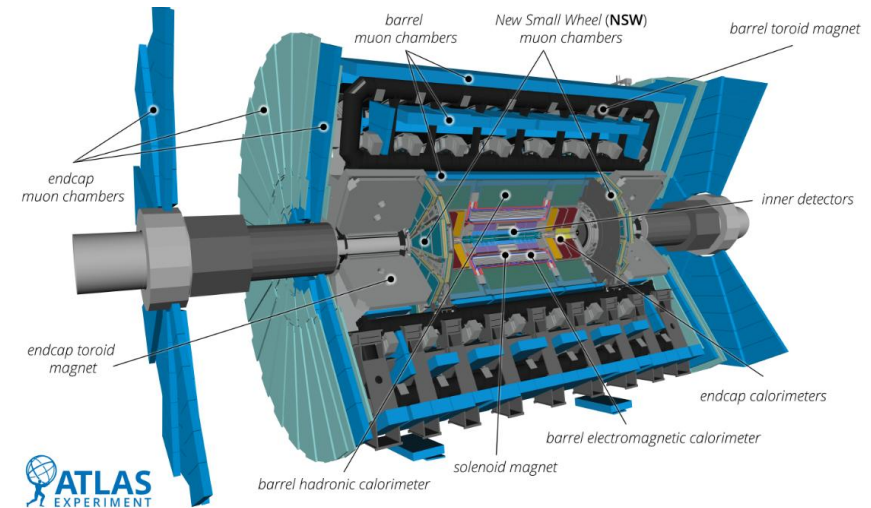


Figure 3: The ATLAS Experiment

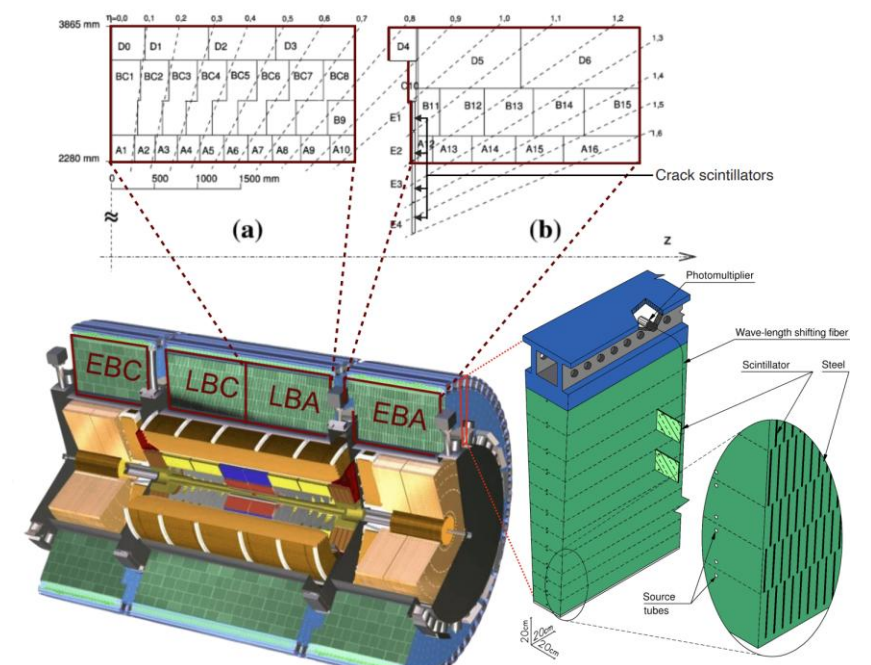


Figure 4: The Tile Calorimeter

ATLAS Phase II Upgrades for HL-LHC

- The LHC is set to undergo a major upgrade between 2027 and 2030 into a version called the HL-LHC.
- The HL-LHC will significantly increase particle collision rates, with up to ~170 proton–proton interactions per bunch crossing.
- This creates a much harsher environment for the ATLAS detector, requiring substantial upgrades to maintain performance, stability, and data quality.
- The Tile Calorimeter readout chain upgrade is a critical advancement aimed at addressing the challenges posed by the HL-LHC.
- This enhanced system introduces a comprehensive redesign of the data acquisition architecture to meet the demands for higher precision, greater data rates, and improved reliability.

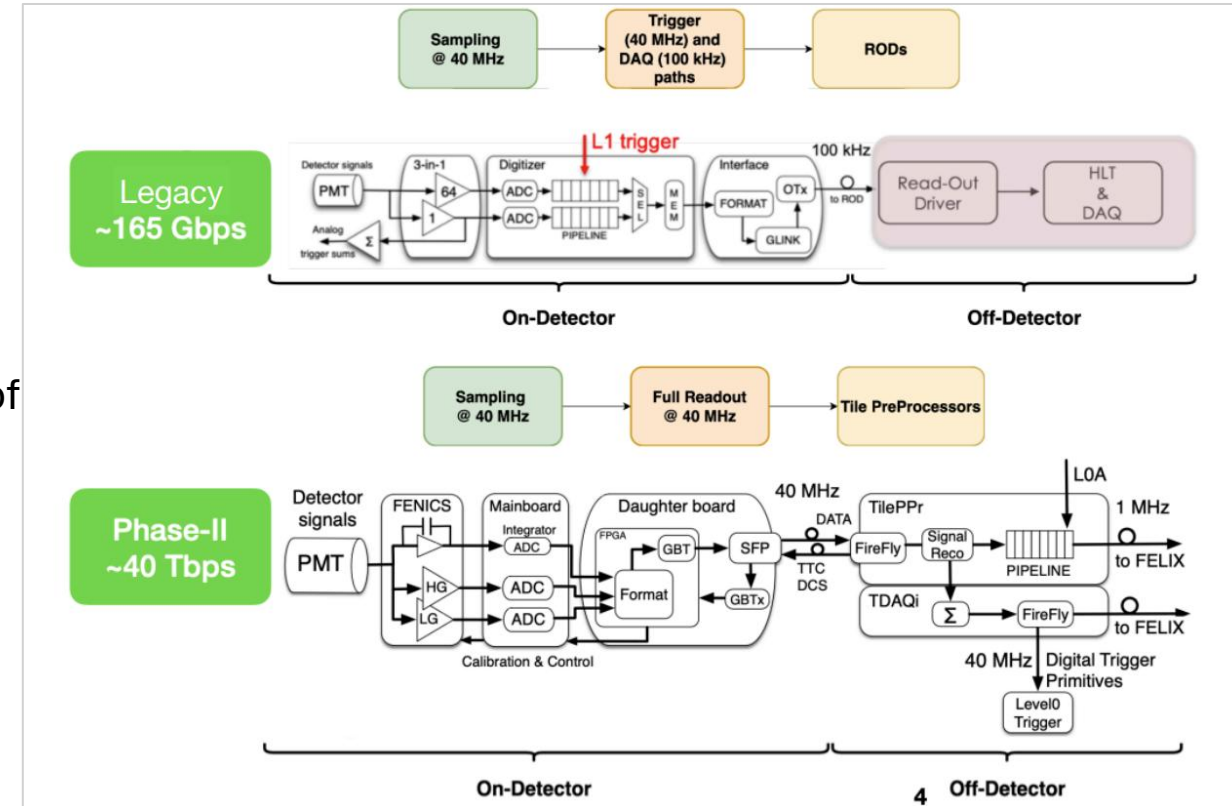


Figure 5: TileCal Readout Chain for Phase 2 Upgrade vs the Legacy

The Tile Demonstrator

- The Demonstrator project was introduced as an intermediate step to validate the proposed ATLAS Phase II Upgrade architecture before full deployment.
- The Tile Demonstrator Module serves as a prototype system which integrates;
 - upgraded on-detector electronics
 - Off-detector electronics
 - Existing ATLAS Data Acquisition DAQ infrastructure.
- This hybrid approach allows the Demonstrator module to be installed and operated within the current detector environment while simultaneously evaluating the performance of the future HL-LHC electronics architecture.

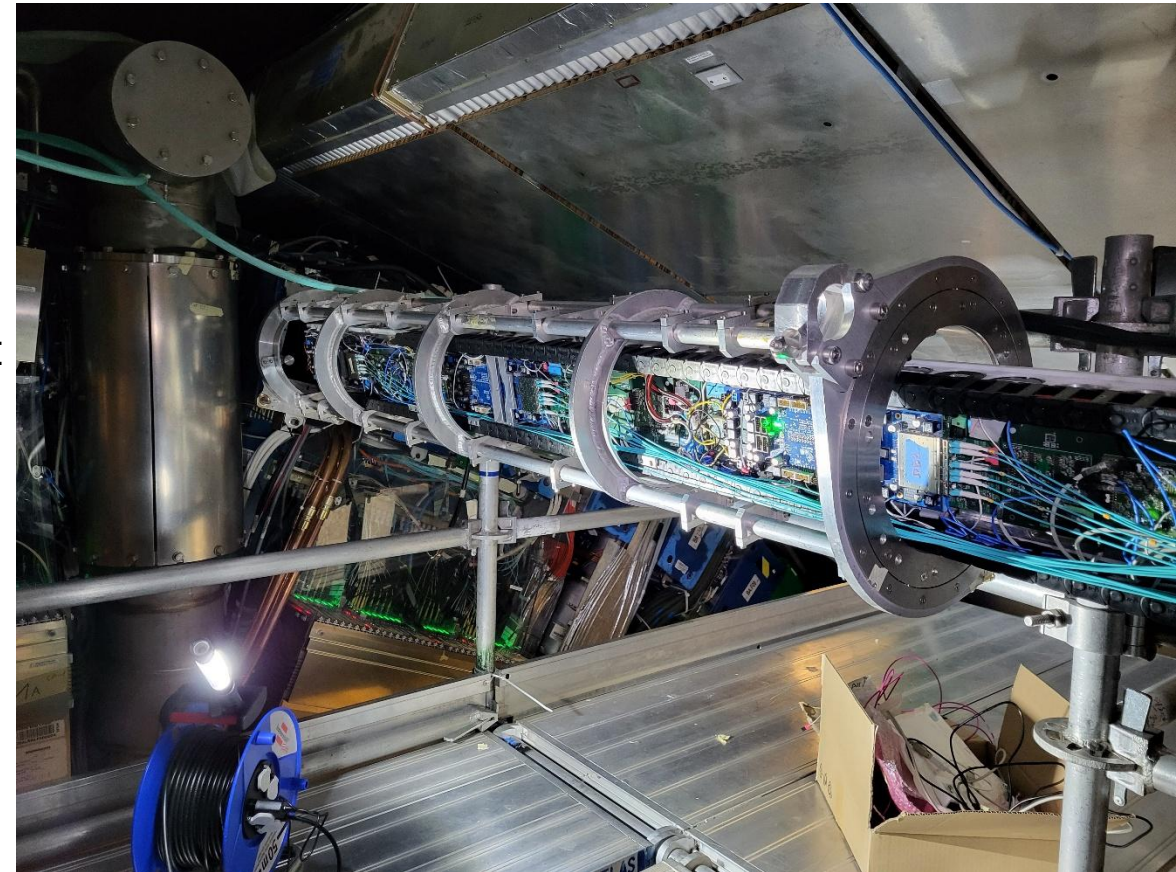


Figure 6: The Tile Demonstrator Module at Point 1

Design of the Tile Demonstrator Monitoring Framework

- The developed framework follows a clear data flow as shown in Figure 7.

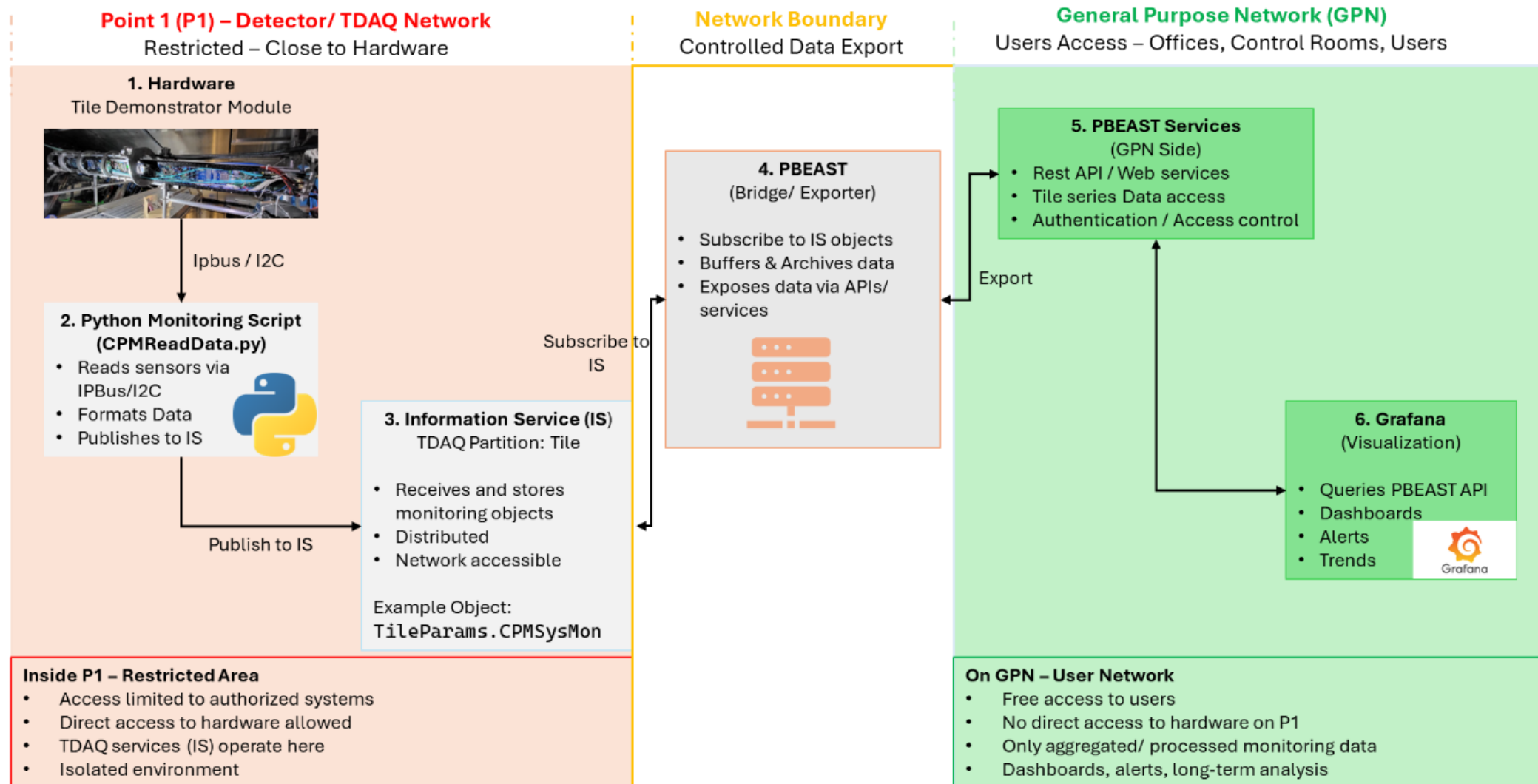


Figure 7: Tile Demonstrator Monitoring Framework Design

The ATLAS Information Service

- The ATLAS Information Service (IS) is used to share information between applications in a distributed environment.
- The IS is built around a Information repository, which serves as the central storage location for information published by various applications within ATLAS.
- This repository enables three primary modes of interaction, as illustrated in Figure 8.
- To integrate the Tile Demonstrator hardware sensor monitoring tool with the ATLAS IS, it was necessary to define custom information types.
- This was achieved using the OKS Schema Editor.
- It is the standard tool provided within the CERN TDAQ software environment for creating and managing Information Service schemas.

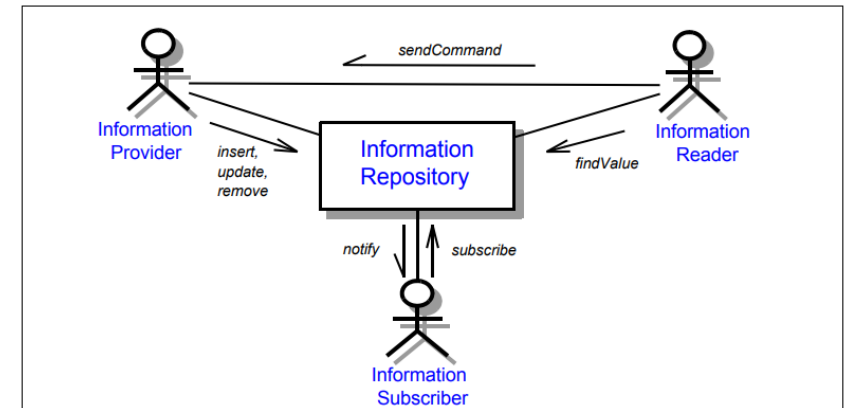


Figure 8: The ATLAS IS Design Architecture

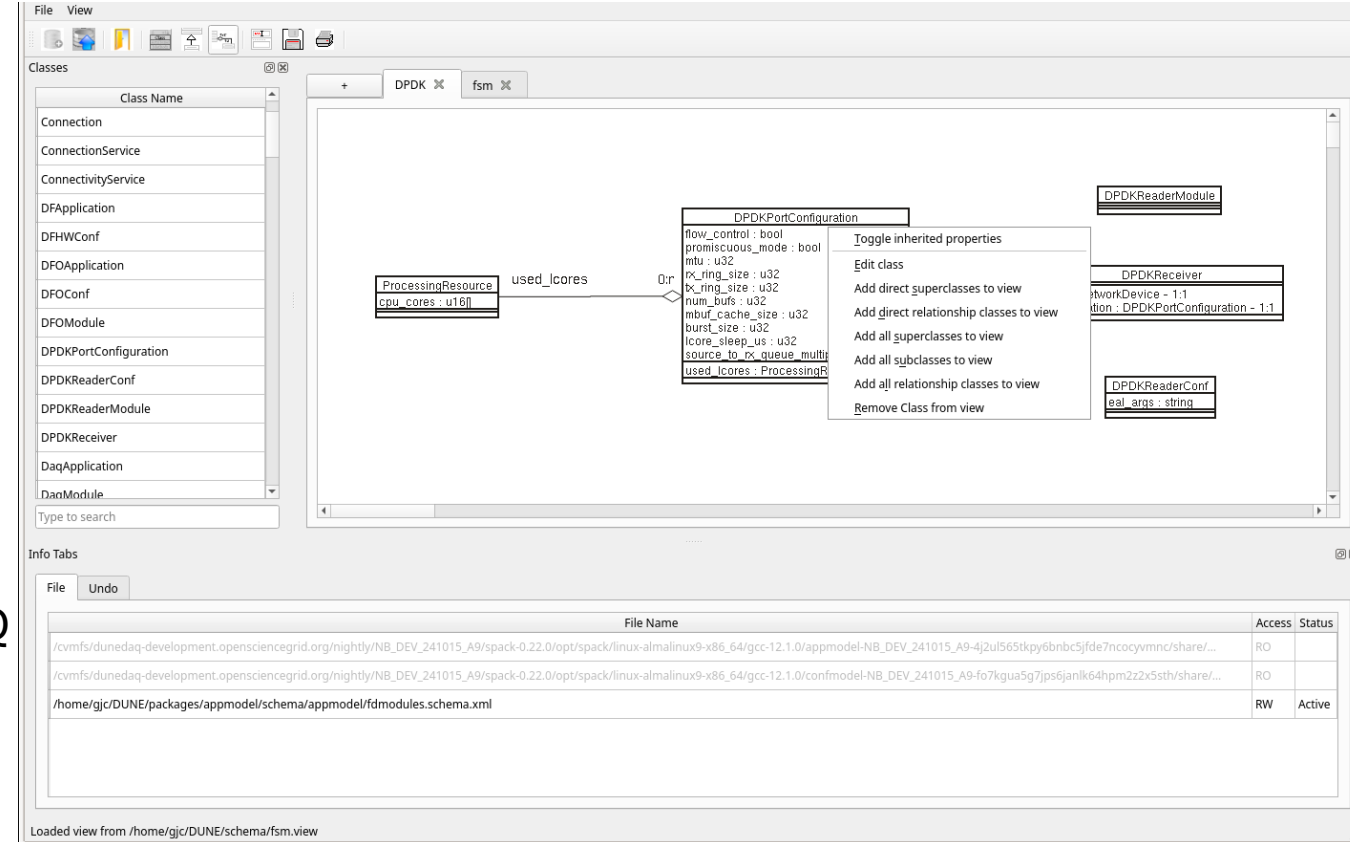


Figure 9: OKS Schema Editor

A Persistent Back-End for the ATLAS Online Information Service (P-BEAST)

- The developed monitoring framework for the Tile Demonstrator module makes use of PBEAST.
- PBEAST is a tool that provides the following services withing the ATLAS TDAQ;
 - persistent storage
 - historical analysis
 - Exporting information across the network boundary from the protected ATCN environment to the GPN
 - Acts as a data source to Grafana

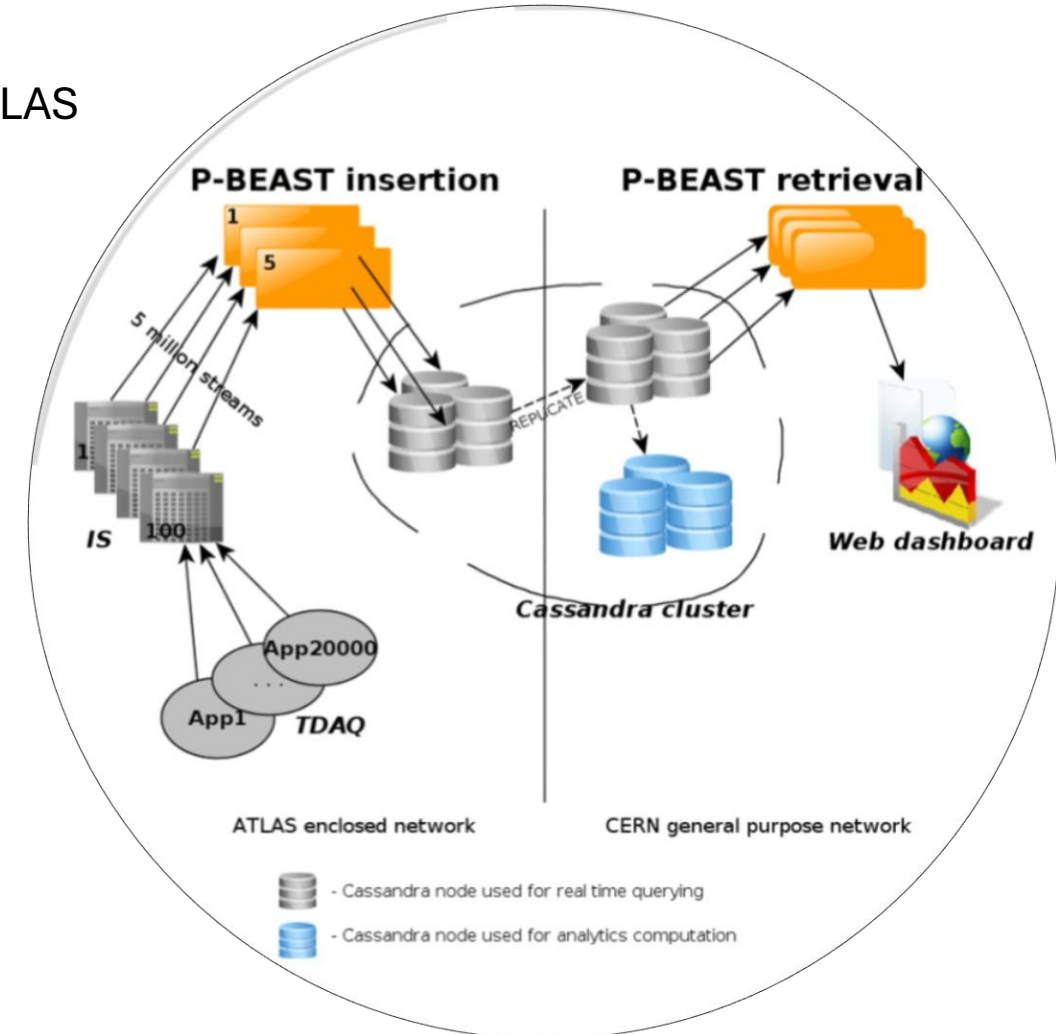


Figure 10: PBEAST Architecture

The ATLAS Tile Standalone Partition

- During the development and validation phase of the monitoring framework, testing was performed within the Tile Standalone Partition of the ATLAS TDAQ system.
- The Partition provides an isolated environment that allows developers and detector experts to test new software and firmware without affecting the operation of the main ATLAS data acquisition infrastructure.
- Control of the Tile Standalone Partition was achieved through the ATLAS TDAQ Control Panel as shown in Figure 11.

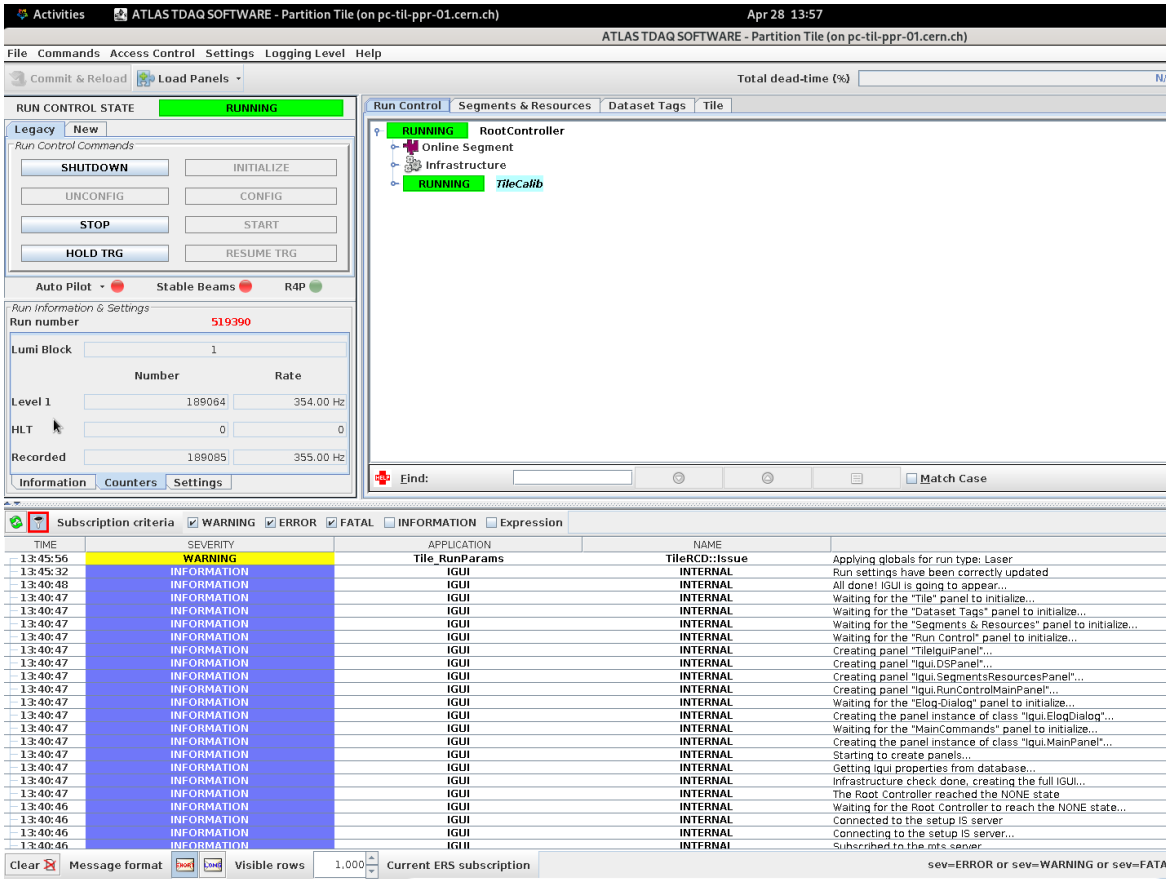


Figure 11: ATLAS TDAQ Partition Control Panel

Monitoring Results (Hardware Sensor Data)

- Grafana was used as a visualization tool to display the monitored hardware sensor data coming from the Tile Demonstrator module.
- The Grafana dashboard shows sensor data from different components of one of the modules on the Demonstrator called the CPM;
- The displayed metrics include
 - Firely Optical Transceivers
 - Power Manager Module
 - CPM FPGA
 - Onboard Temperature Sensors

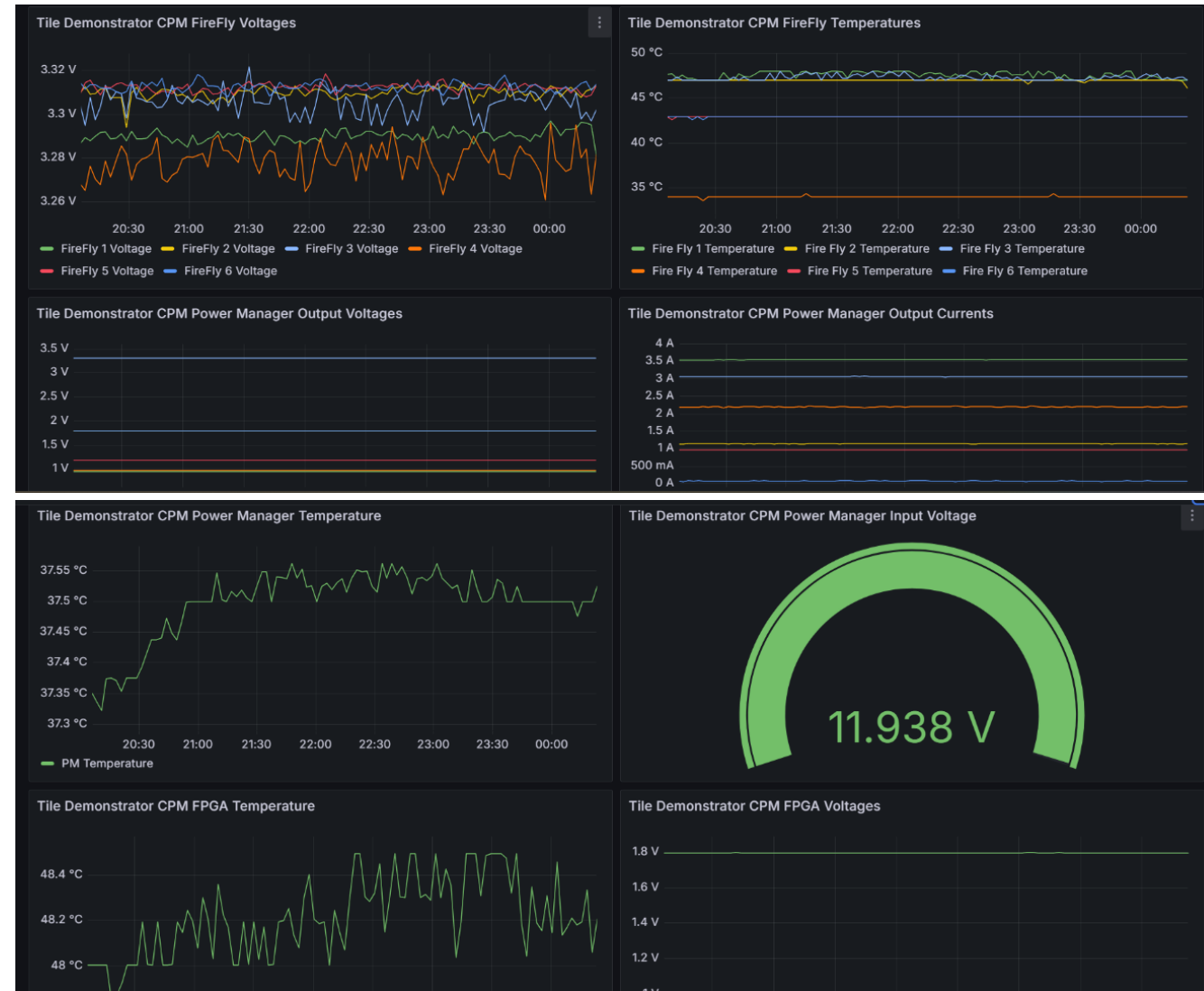
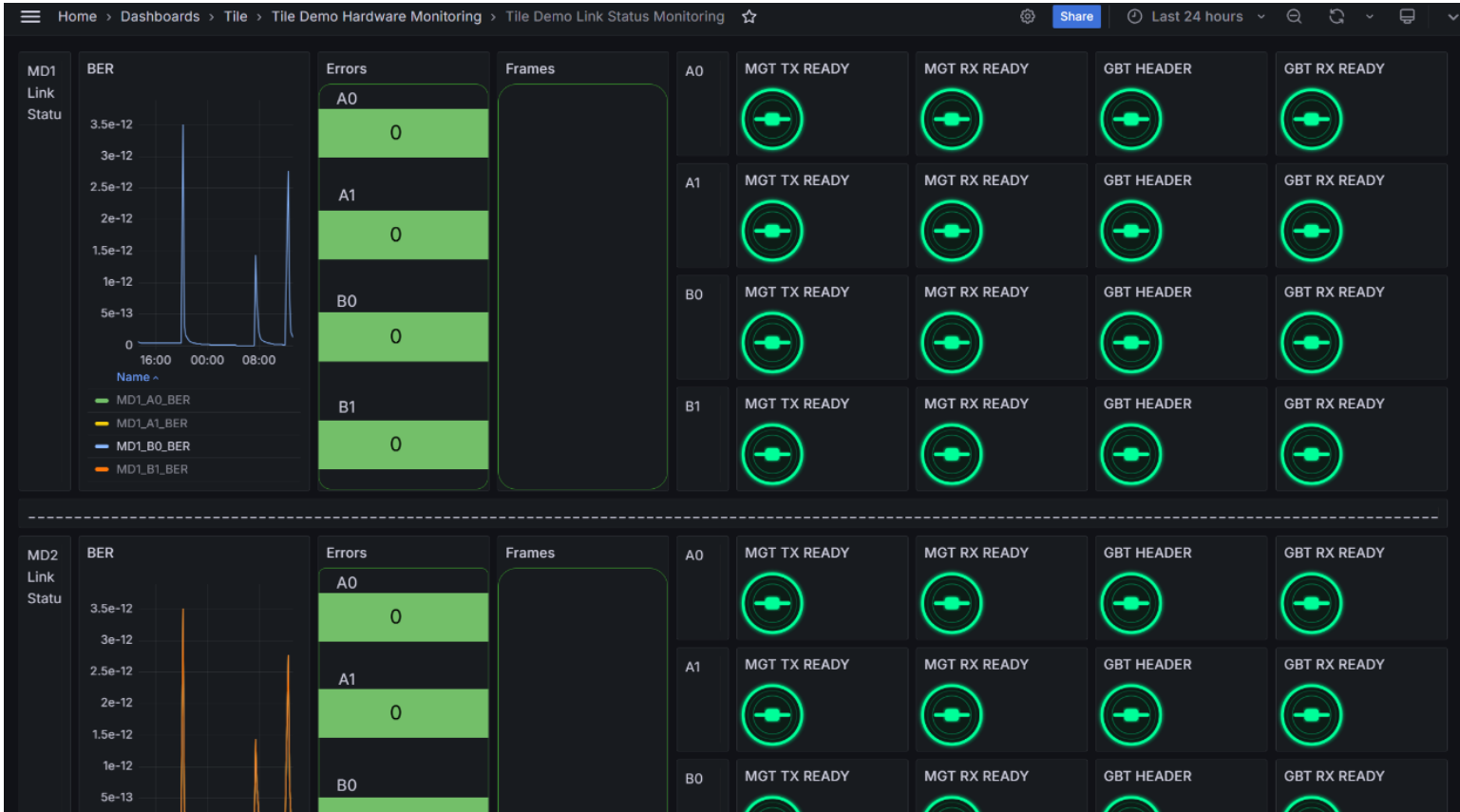


Figure 12: Tile Demonstrator Hardware Sensor Data

Monitoring Results (Link Status Monitoring)

- The Grafana dashboard in Figure 13 shows link status data for all the optical links connecting the CPM and the Mini Drawers.
- Bit Error Rate graphs are also included together with error counts for each link.



Icon Key



-- Link Ready



-- Link Not Ready

Figure 13: Tile Demonstrator Link Status Data

THANK YOU

Questions?

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