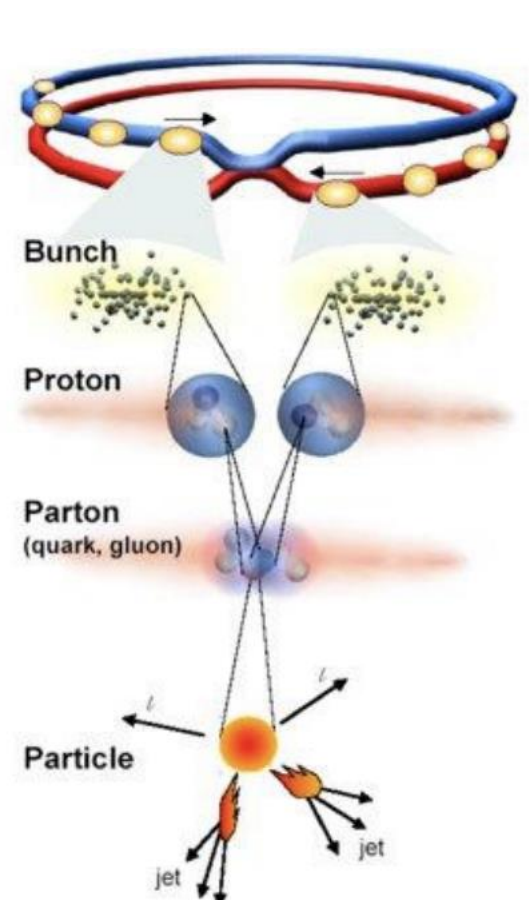


ATLAS TDAQ for Phase-I Upgrade



Proton-Proton	
Protons/bunch	10^{11}
Beam Crossing	25 ns
Beam energy	6.5 TeV
Luminosity	$10^{34} \text{cm}^{-2}\text{s}^{-1}$

ATLAS Event Rate:
 10^9 interactions/s
25 Pile up events / crossing
Interested Event:
~2 kHz
Higgs:
1 per 3 hours

Fig.1 ATLAS Event Rate

After the current LHC shutdown (2019-2022) the ATLAS experiment will operate in an increasingly harsh collision environment, motivating a series of upgrades. In order to improve the capacity and flexibility of the detector readout system, the Front-End Link eXchange (FELIX) system has been developed. FELIX acts as interface between the data acquisition system and new or upgraded trigger and detector front-end electronics. FELIX is also interfaced with the detector control and TTC (Timing, Trigger and Control) system.

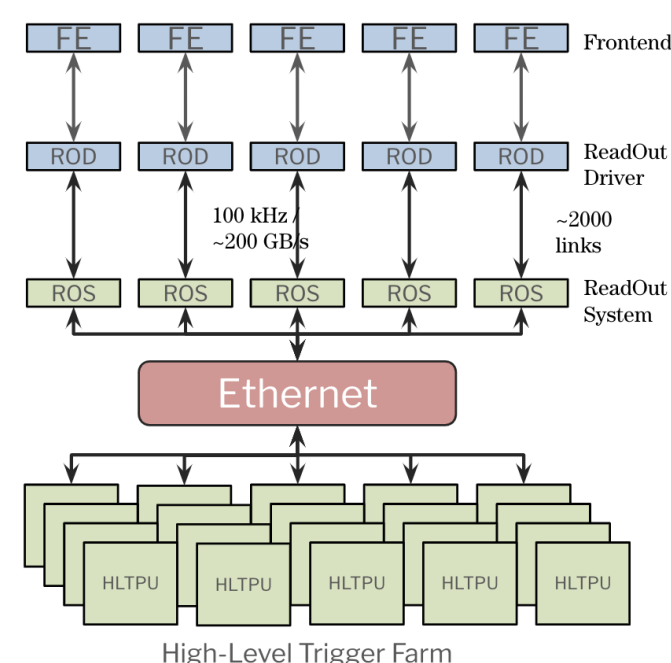


Fig.2 ATLAS TDAQ system in 2015-2018

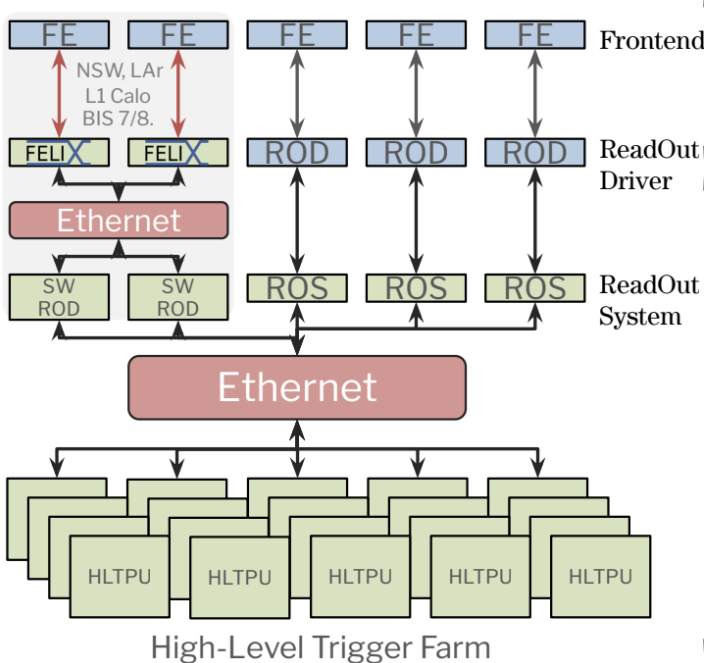


Fig.3 Upgrade ATLAS TDAQ system in 2022-2025

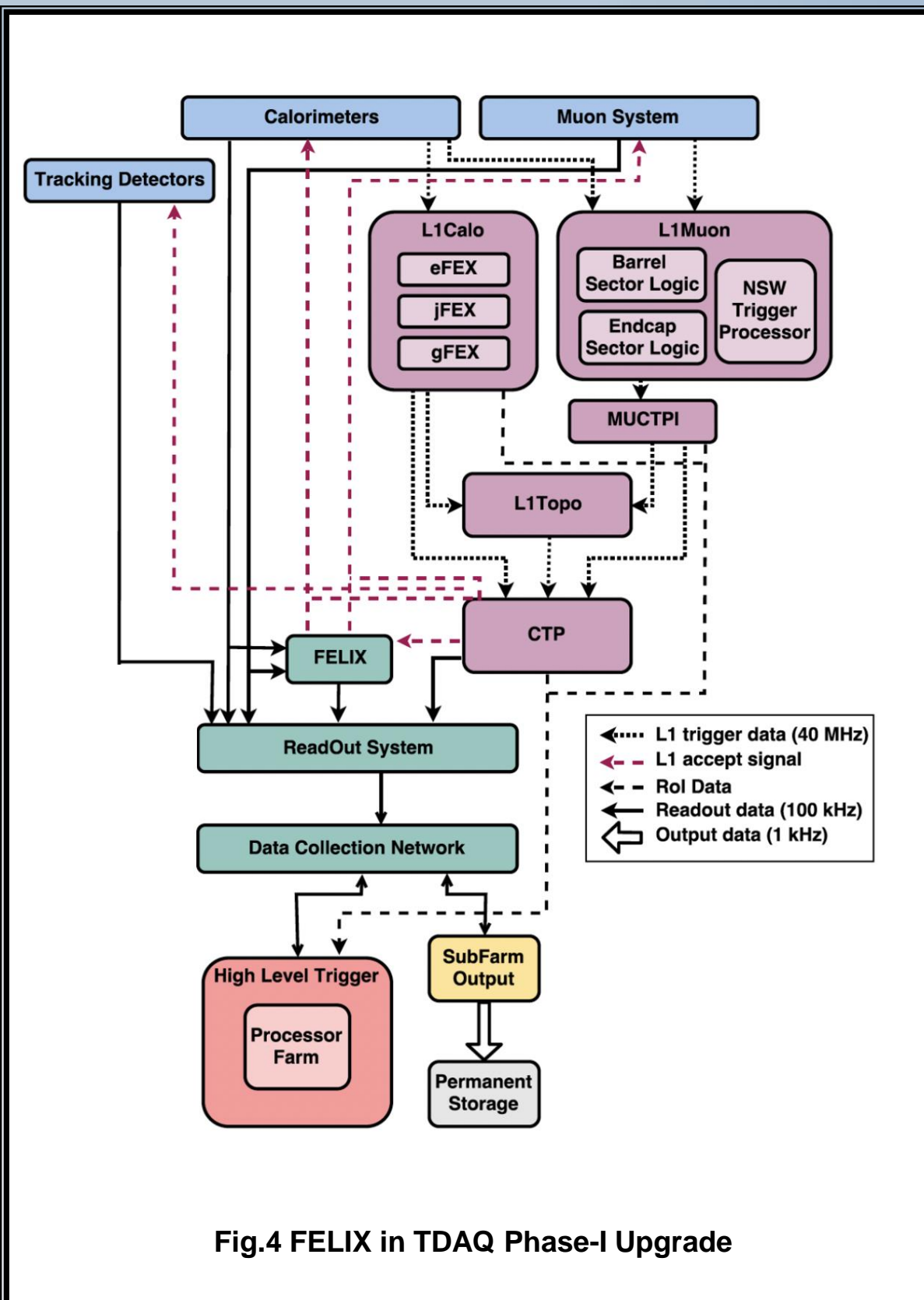


Fig.4 FELIX in TDAQ Phase-I Upgrade

FELIX System

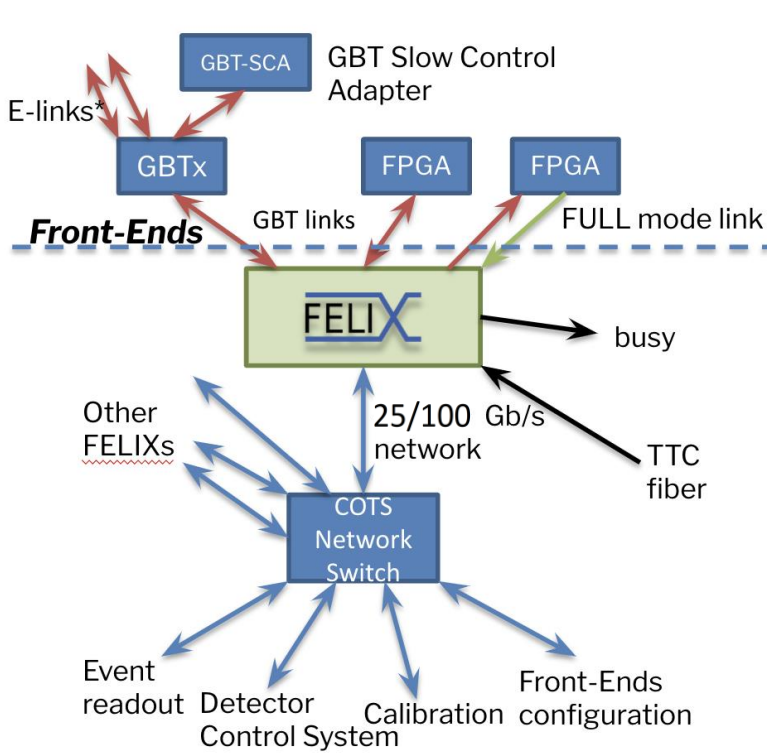


Fig.5 FELIX Functionalities.

FELIX is a router between front-end serial links and a commodity network for detector control, configuration, calibration, monitoring and event data. The TTC distribution has been integrated



Fig.6 Picture of FLX-712 Card

FLX-712 hardware

- Xilinx Ultrascale FPGA
- 24/48 duplex optical fibers for FE
- PCIe Gen3 x 16 lanes

FELIX firmware supports both of GBT mode and Full mode

•GBT mode

- Firmware to interface FELIX to GBTx ASICs
- GBTx = radiation hard chip aggregating FE electrical links, coupled to optical transceiver
- GBT = protocol used by the GBTx
- One link (4.8 Gb/s) divided into several e-links
- Up to 24 GBT links per FLX-712

•Full Mode

- Firmware to interface the FELIX to other FPGA-base systems
- Up to 24 channels per FLX-712, 9.6 Gb/s each

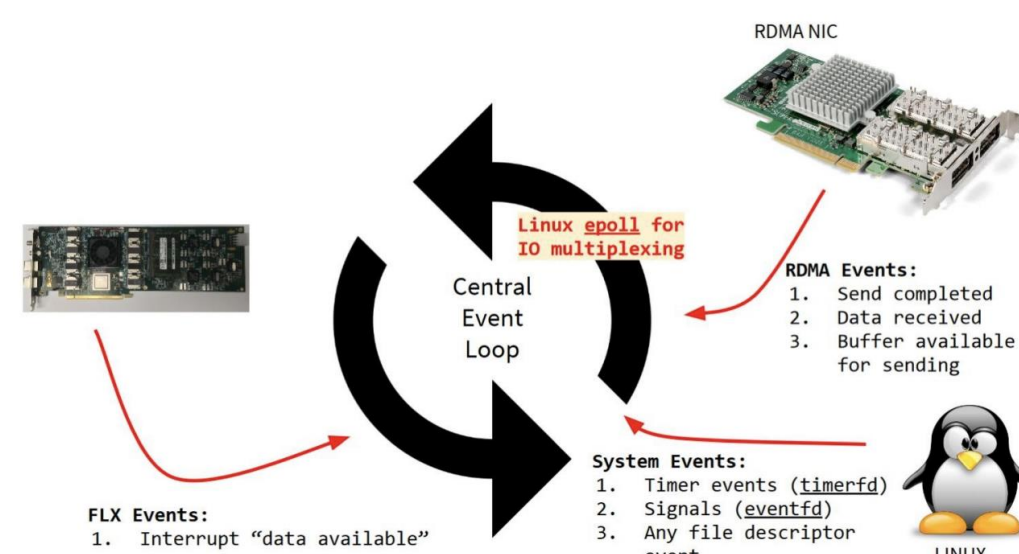


Fig.7 FELIX Software

- Each FELIX server hosts up to two FELIX cards and one NIC.
- Low level software has been developed for basic configuration and monitoring.
- High level software has been developed for data rate and channel monitoring.

Performance, Integration and Commissioning

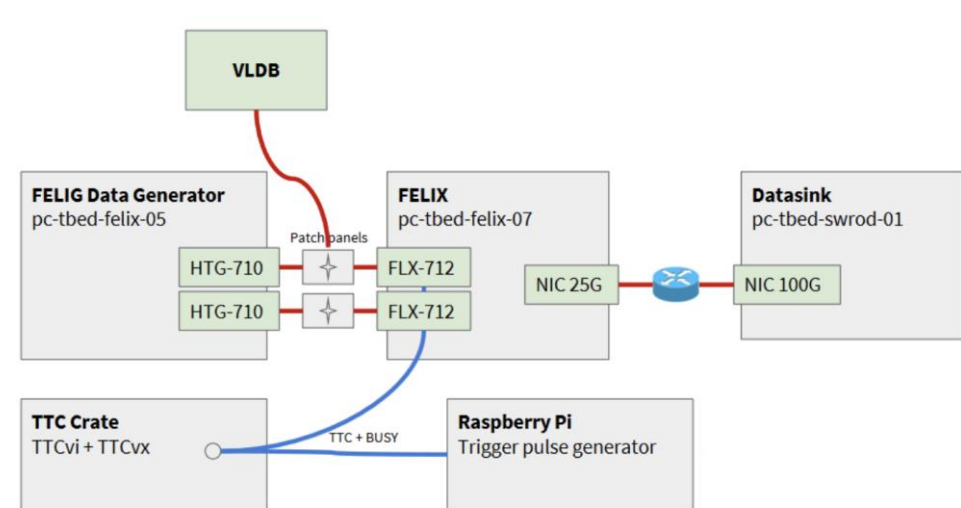


Fig.8 Test with GBT mode

GBT mode:

- The transmission is stable, and the parallel communication is reliable during multi-hours operation which is longer than the average LHC fill time
- BUSY signal propagation correctly handled
- Emulator Ramp-up demonstrated rates 50% above expectation

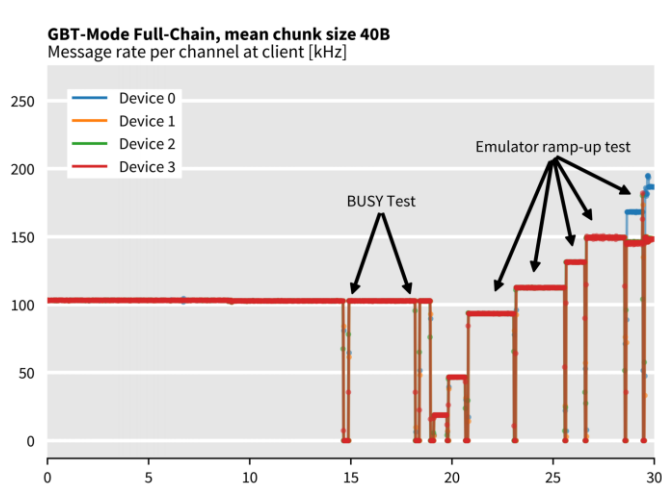
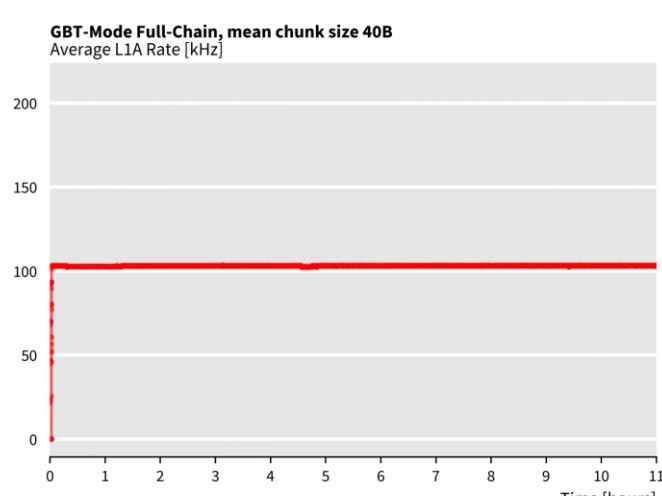


Fig.9 GBT mode Testing

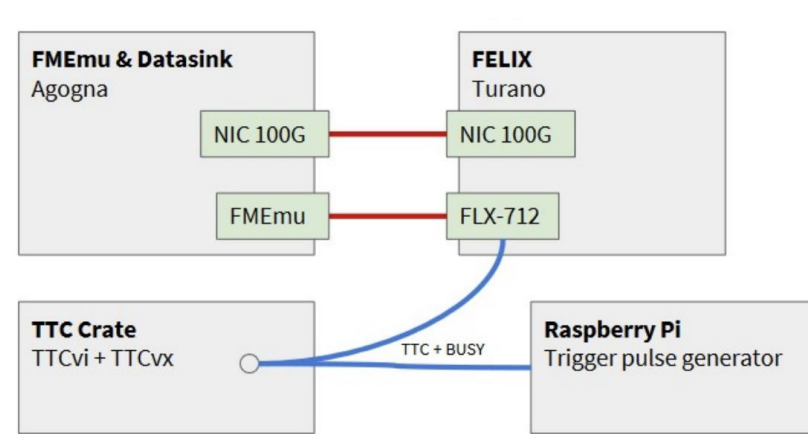


Fig.10 Test with FULL mode

FULL mode:

- The transmission is stable during multi-hours operation which is longer than the average LHC fill time

Stress test:

- Backpressure shows up at ~ 200 kHz

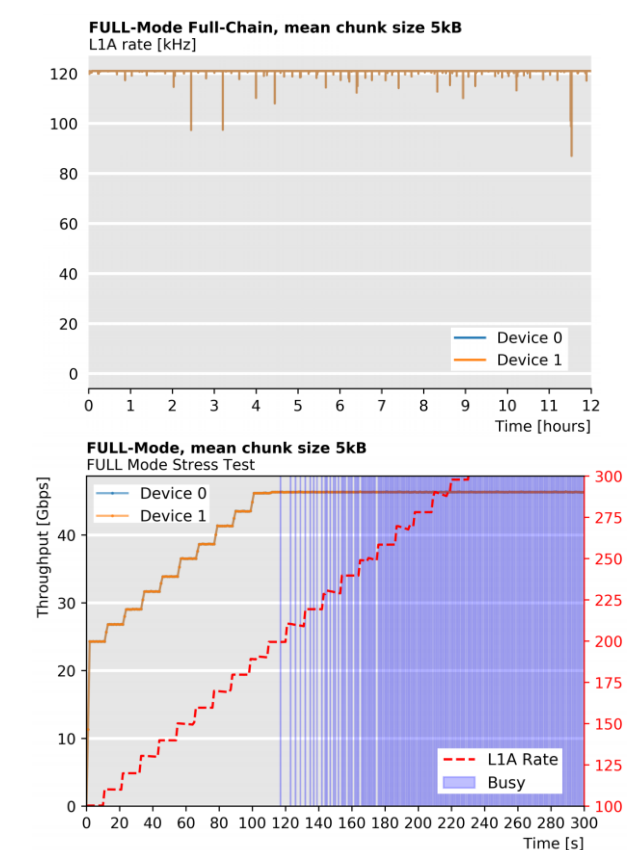


Fig.11 FULL mode Teseting

- Performance tests results show FELIX can fully meet the requirements in 2022-2025
- More than 200 FELIX cards have been delivered and tested, installation is ongoing
- Commissioning and deployment are ongoing, software development is progressing