Readout and Trigger for the AFP detector at the ATLAS experiment at LHC

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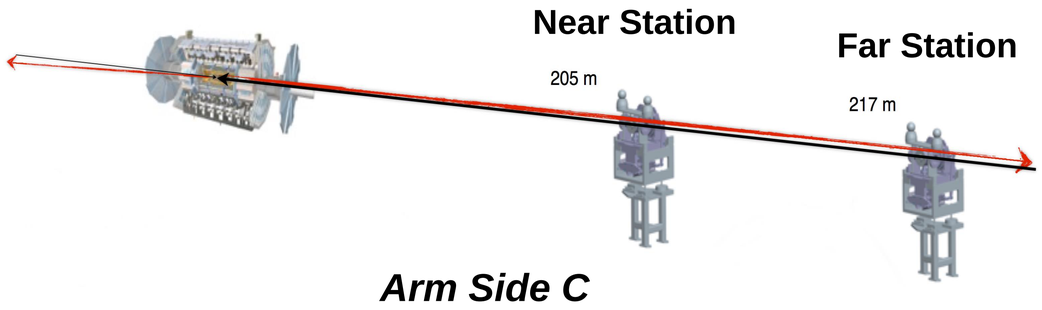
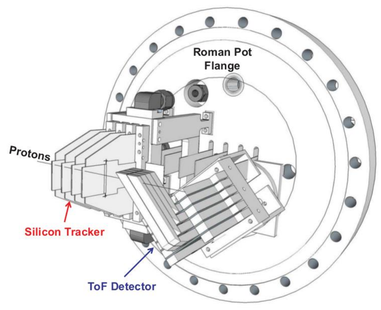
ATLAS Forward Proton (AFP) detector

AFP (ATLAS Forward Proton) is a new detector system in ATLAS that studies events with protons scattered quasi-elastically at very small angles. The final design assumes four Roman pot stations at a distance of 205 m and 217 m from the interaction point on both sides of the ATLAS detector. Two 3D Silicon tracker detectors and time-of-flight detector will be installed on each side. During the winter technical stop this year one arm with two stations was successfully installed, later commissioned and is since May 2016 successfully participating in data taking with ATLAS.

ATLAS Detector

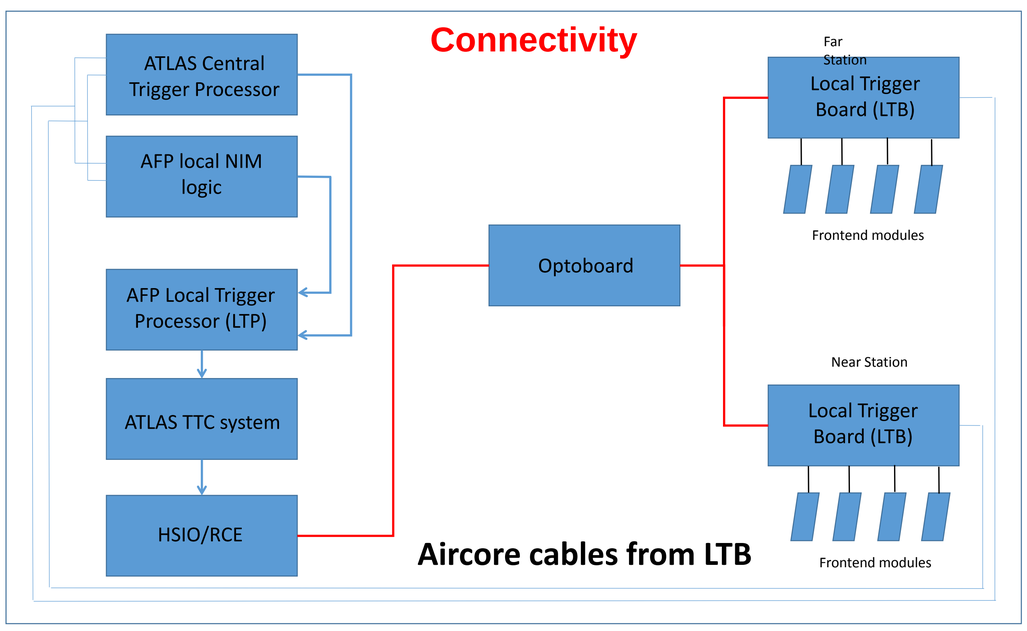




Detector specification

- 4 Si tracker pixel modules with 3D sensors (used also in ATLAS IBL) at each station
- Each module with 26880 pixels (250 um x 50 um)
- Time-of-flight detectors in the far stations for measurement of longitudinal vertex resolution in high intensity runs
- For data taking periods the Roman pots are placed very close to the beam (20 times beam width (4-8 mm)).

AFP Detector Trigger and Data Acquisition System (AFP TDAQ)



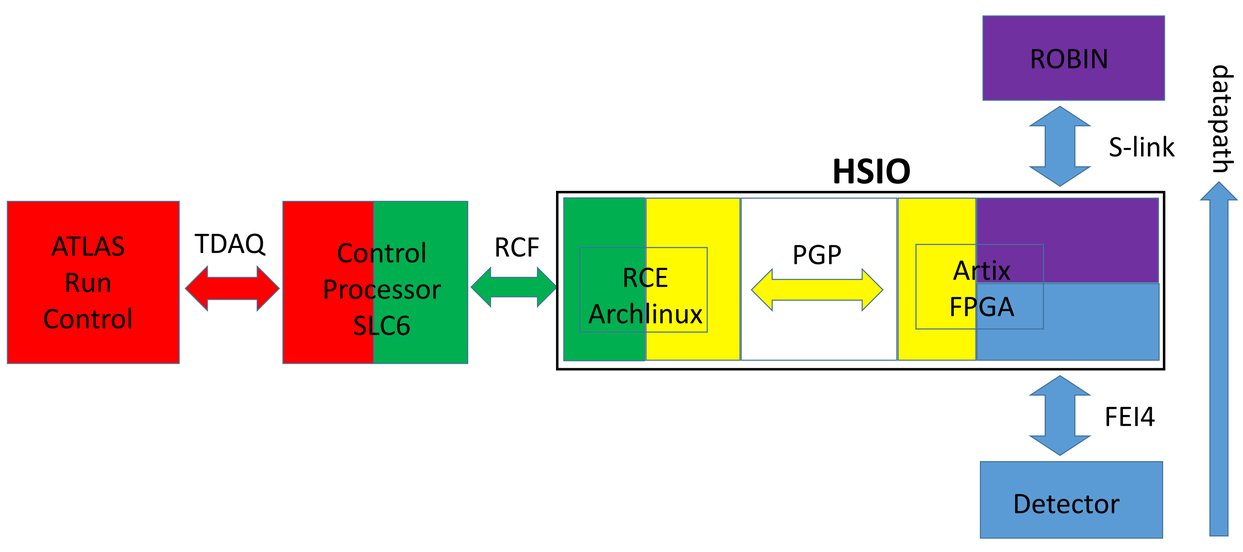
Trigger

- at least one fired pixel generates the trigger signal
- the hitbus chip on the LTB locally combines the signals from 3 of the 4 modules (OR, AND, majority vote)
- the hitbus synchronizes the signal to the LHC clock
- the trigger signals are sent via fast air-core cables to the CTP at the standard ATLAS latency (85 BCXs)
- at the counting house the signals are split for local and central trigger systems what allows standalone runs and participation in runs combined with other ATLAS subdetectors.

Readout

- the data is sent over 300 m optical fiber ribbons (1TX and 2RX per arm)
- the optoboard close to the AFP station converts optical signals to LVDS and drives them over 8 m to two LTB boards
- the hitbus chip at LTB applies fine timing to the LHC clock and configuration data
- the LTB is connected to the tracker modules via flat ribbon cables
- the frontends are configured at a 40 Mbps, the data is readout at 160 Mbps

System architecture



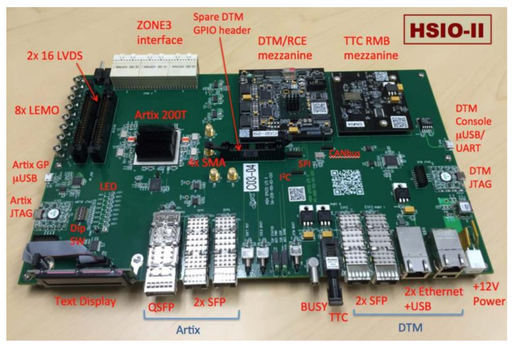
High Speed Input Output board (HSIO)

- Versatile DAQ board with many high-speed and low-speed I/O channels
- Xilinx Artix 200 FPGA
- mezzanine with ATLAS TTC interface
- mezzanine RCE (Reconfigurable Cluster Element)
  - Xilinx Zynq-based SoC with dual core ARM CPU
  - 1 GB memory, DMA interface to FPGA fabrics,
  - 2x 1Gbps Ethernet
  - Archlinux OS

Architecture

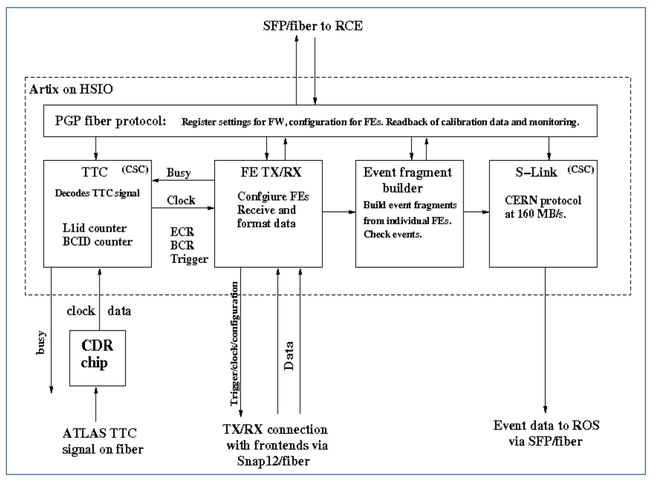
- ATLAS Run Control communicates with AFP Control Processor via TDAQ
- CP sends commands to the RCE and receives monitoring data from RCE
- The RCE connects to the HSIO's FPGA via a custom protocol PGP
- Configuration/calibration data/monitoring: via HSIO/RCE/CP.
- datapath – via FPGA (HSIO) only

HSIO firmware



All functionality required in HSIO for the integration with the ATLAS TDAQ is contained in a single Artix FPGA:

- S-link and TTC interface are implemented in firmware rather than using ATLAS-specific specialized hardware
- Event Fragment Builder creates ATLAS event fragments – one per arm
  - flags desynchronized events
  - resets desynchronized events (during ATLAS Event Counter Reset)
  - dynamically labels problematic FE modules (e.g. after SEU)
  - keeps track of triggers when the FE buffers are full
  - reports occupancies, error counters and status information to RCE
- Communication with RCE via custom PGP protocol at 3.125 Gbps



Conclusions and outlook

- **AFP - a new ATLAS subdetector to measure forward protons was installed and successfully commissioned this year**
- **The RCE based readout of the FrontEnd has been fully integrated with the ATLAS TDAQ system**
- **The AFP TDAQ system has been performing smoothly and efficiently**

Acknowledgements

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