The ATLAS Level-1 Trigger

Overview and Status Report including Cosmic-Ray Commissioning

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on behalf of the
ATLAS Level-1 Trigger Collaboration

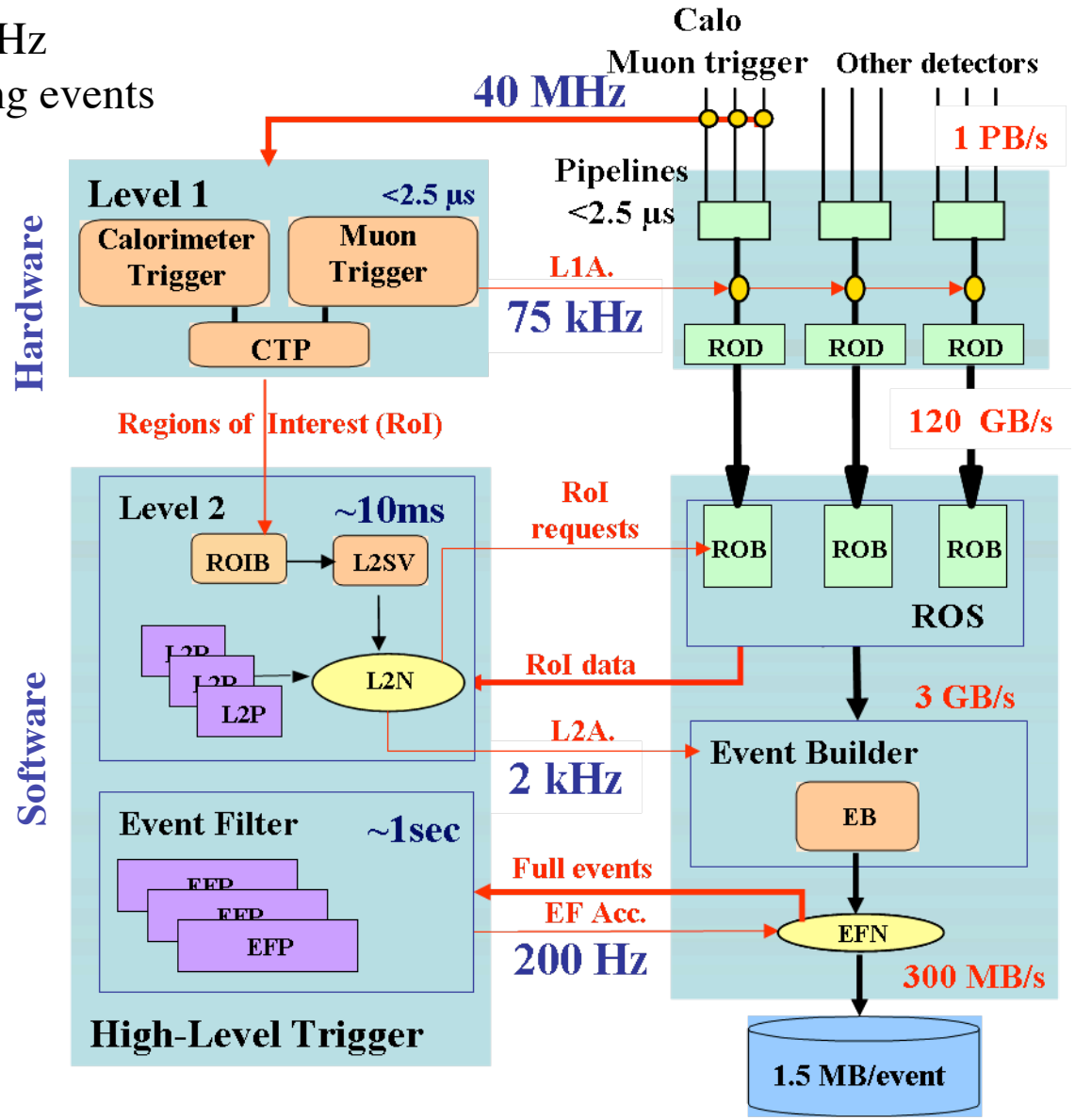
ATLAS Trigger and DAQ System

Reduce rate from 40 MHz to 200Hz
while retaining the rare, interesting events

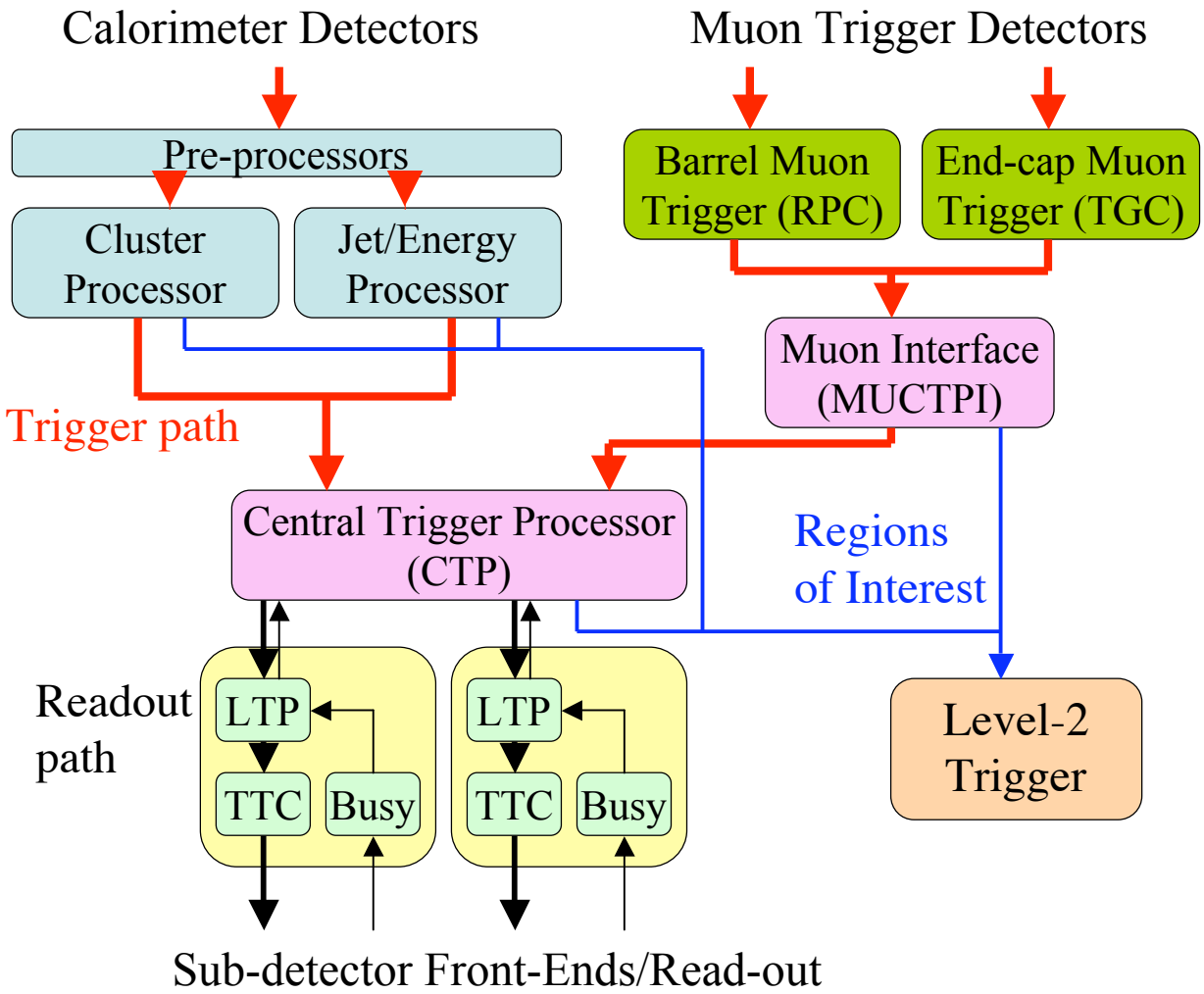
1) **Level 1** decision based on data from calorimeters and muon trigger chambers; synchronous at 40 MHz

2) **Level 2** uses Regions of Interest identified by Level-1 (< 10% of full event) with full granularity from all detectors

3) **Event Filter** has access to full event and can perform more refined event reconstruction

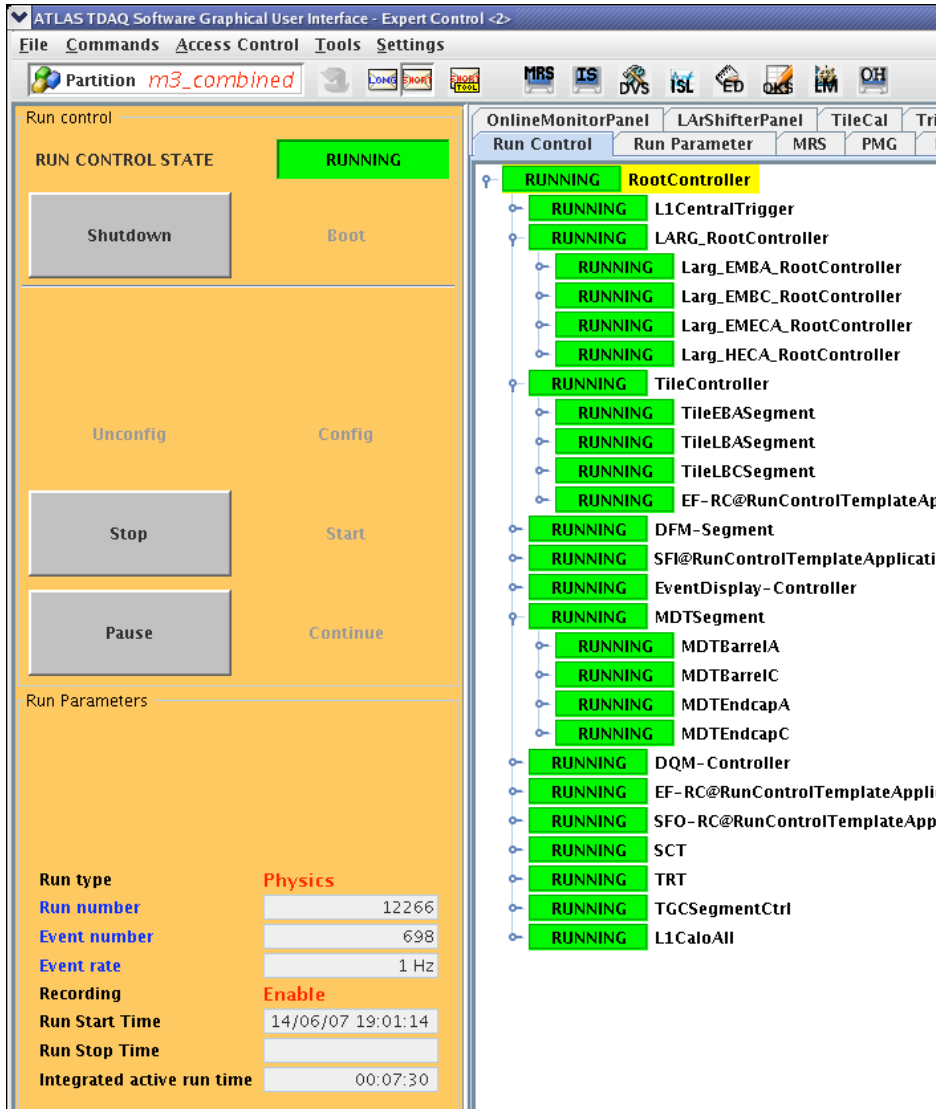


ATLAS Level-1 Trigger System
Trigger path

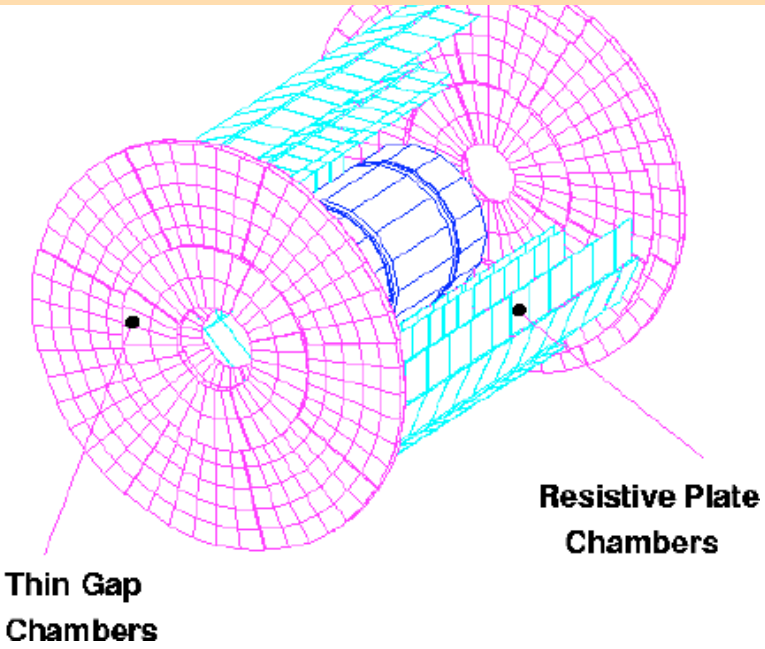


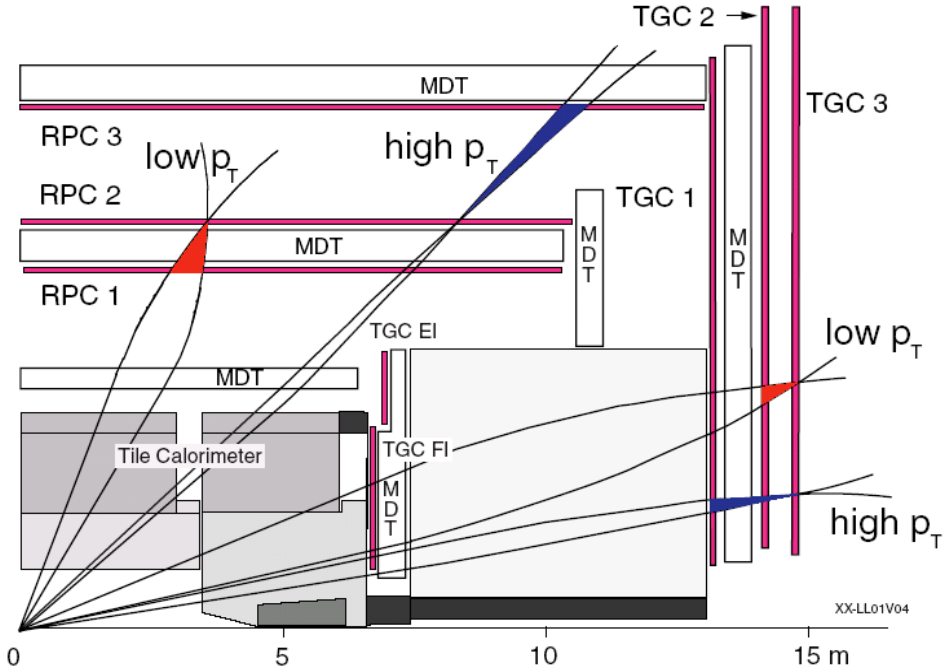
In Situ Cosmic-Ray Commissioning

- Recently (June 2007): combined cosmic-ray run with a large slice of ATLAS in situ
- Aim: Exercising full data recording chain, from detector to disk
- Level-1 triggers:
  - Barrel muon trigger
  - Endcap muon trigger
  - Temporary hadron calorimeter trigger
- Readout:
  - Silicon strips (noise)
  - Transition radiation tracker
  - Em calorimeter (Liquid Argon)
  - Hadronic calorimeter (Tiles)
  - Muon precision chambers (MDT)
  - Level-1 Barrel muon trigger (RPC)
  - Level-1 Endcap muon trigger (TGC)
  - Level-1 Calorimeter trigger
  - Level-1 Central trigger
- Level-2:
  - Muon algorithm from muon regions of interest (no rejection yet)



ATLAS Level-1 Muon Trigger



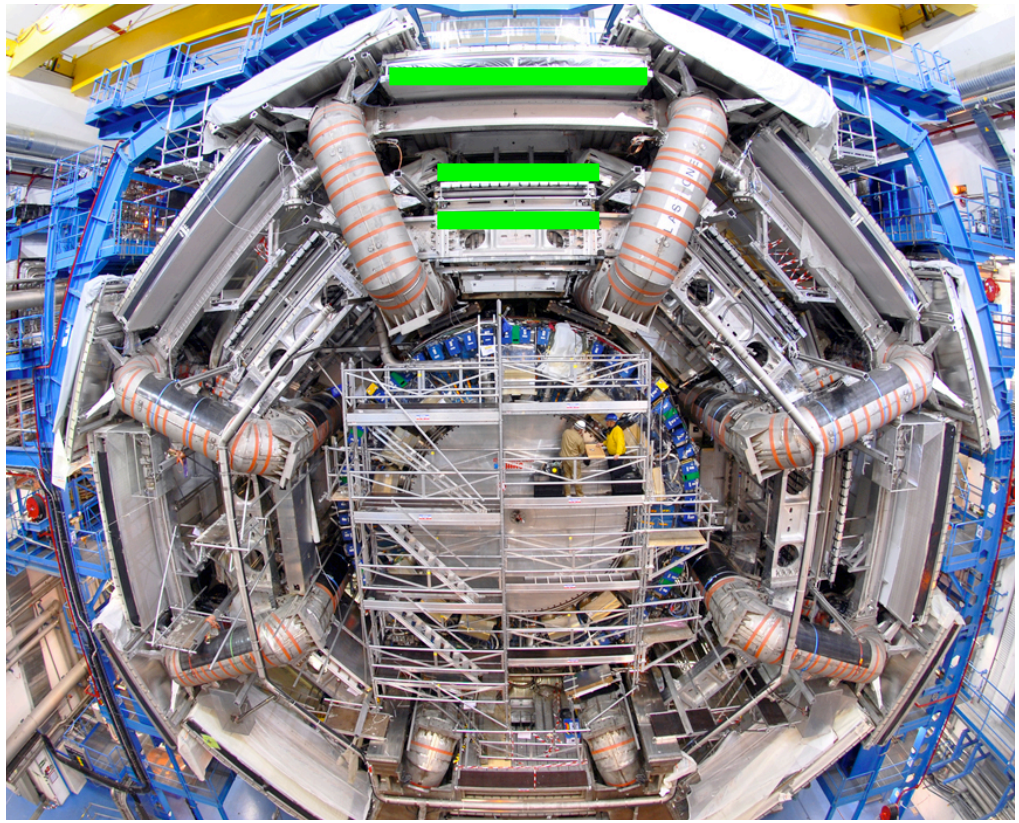


- Dedicated muon chambers with good timing resolution
  - Barrel: Resistive Plate Chambers (RPC)
  - Endcaps: Thin Gap Chambers (TGCs)
- Local track finding on-detector, candidate multiplicity calculation off-detector

- Two low-momentum (6-9 GeV), one high-momentum (9-35 GeV) layer
- Looking for coincidences in chamber layers within programmable *roads* (road width related to momentum)
- 6 programmable coincidence windows determine momentum threshold (using B-field deflection)

Level-1 Barrel Muon Trigger: Commissioning

- Most chambers installed and being commissioned
- Off-detector electronics in production
  - demonstrators used for commissioning
- Cosmic ray commissioning in June 2007: top sector provided cosmic ray trigger to Muon Interface and Central Trigger Processor through final trigger chain
  - rate: 120 Hz
- First time chambers are operated with final set-up: gas system, final cabling and power system, slow control
- Measured trigger latency: 1490ns from chamber to CTP output, as expected
- Synchronization tests between layers have been successfully performed

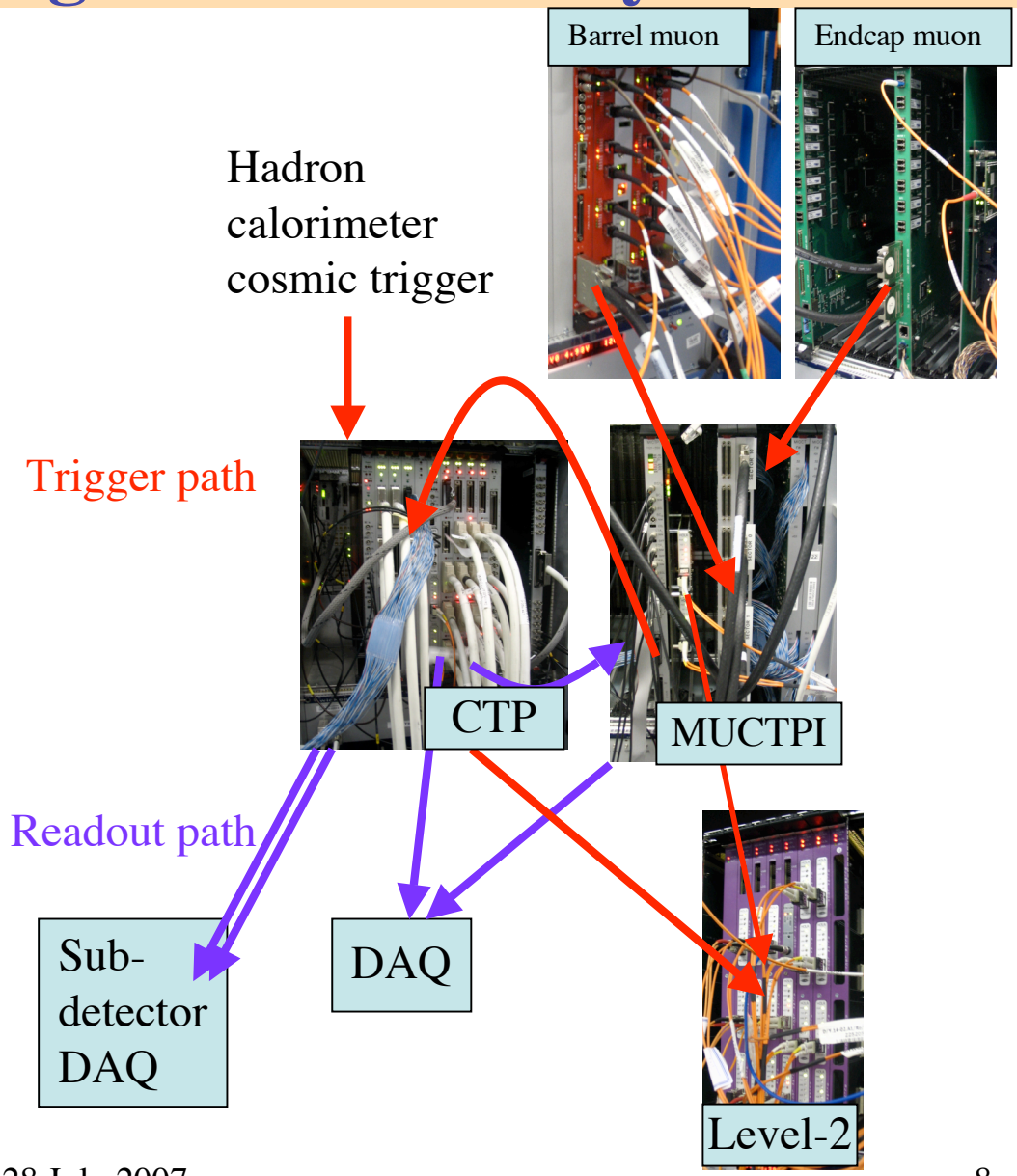


Level-1 Endcap Muon Trigger: Commissioning

- Chamber installation in full swing
- Final on-detector electronics being installed and commissioned
- Off-detector electronics being installed
- June 2007: Endcap muon trigger sector (inner layer) provided cosmic ray triggers (1-station coincidence)
  - sent trigger to Muon Interface and Central Trigger Processor through final trigger chain
  - Trigger rate: few Hz
- Measured trigger latency: 1550ns from chamber signal to output of the Central Trigger Processor, as expected
- Endcap muon trigger was integrated into DAQ system via final readout

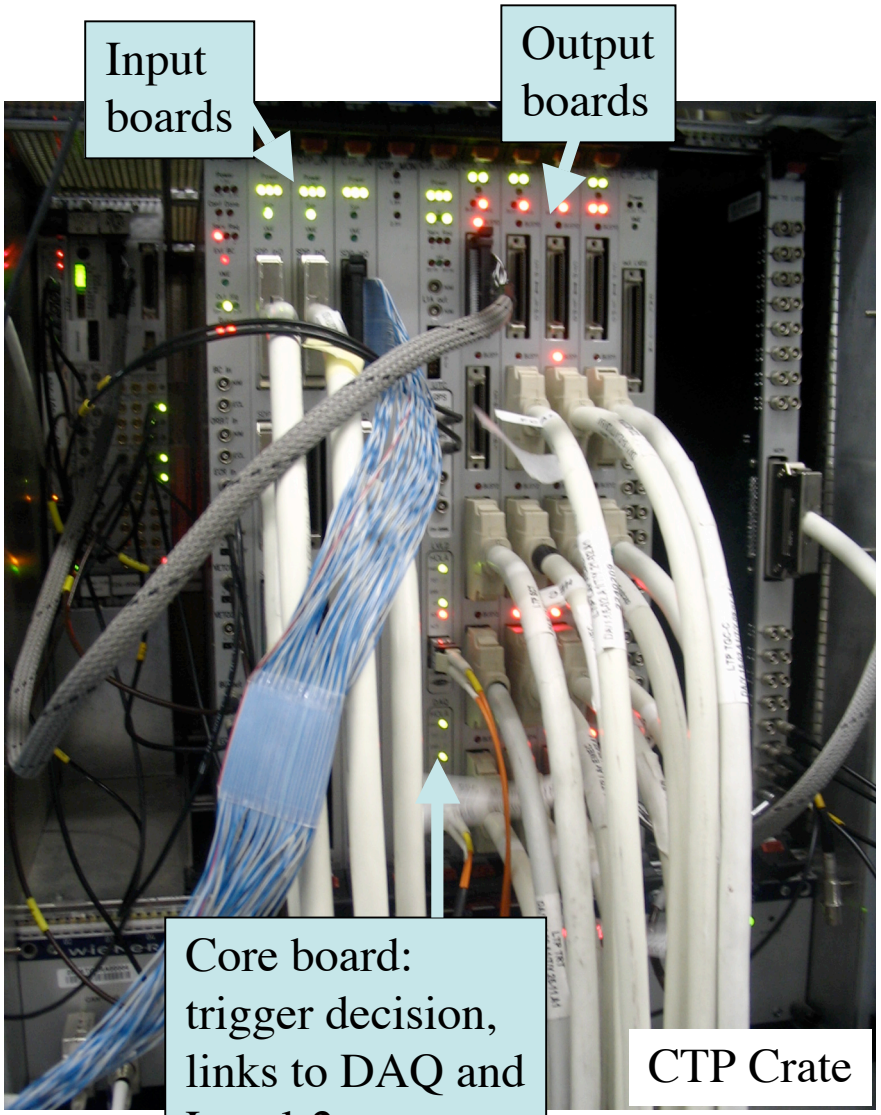
Setup of the Level-1 trigger during commissioning with cosmic rays

- Muon interface (MUCTPI):
  - receives muon trigger data from up to 208 muon trigger sectors
  - handles overlaps and sums muon multiplicities
  - sends muon multiplicities to Central Trigger Processor
  - crate with close to final boards installed
- Trigger inputs:
  - Muon interface (MUCTPI):
    - Barrel (RPC): 120Hz
    - Endcap (TGC): few Hz
  - Temp. hadron calorimeter cosmics (sub-Hz)

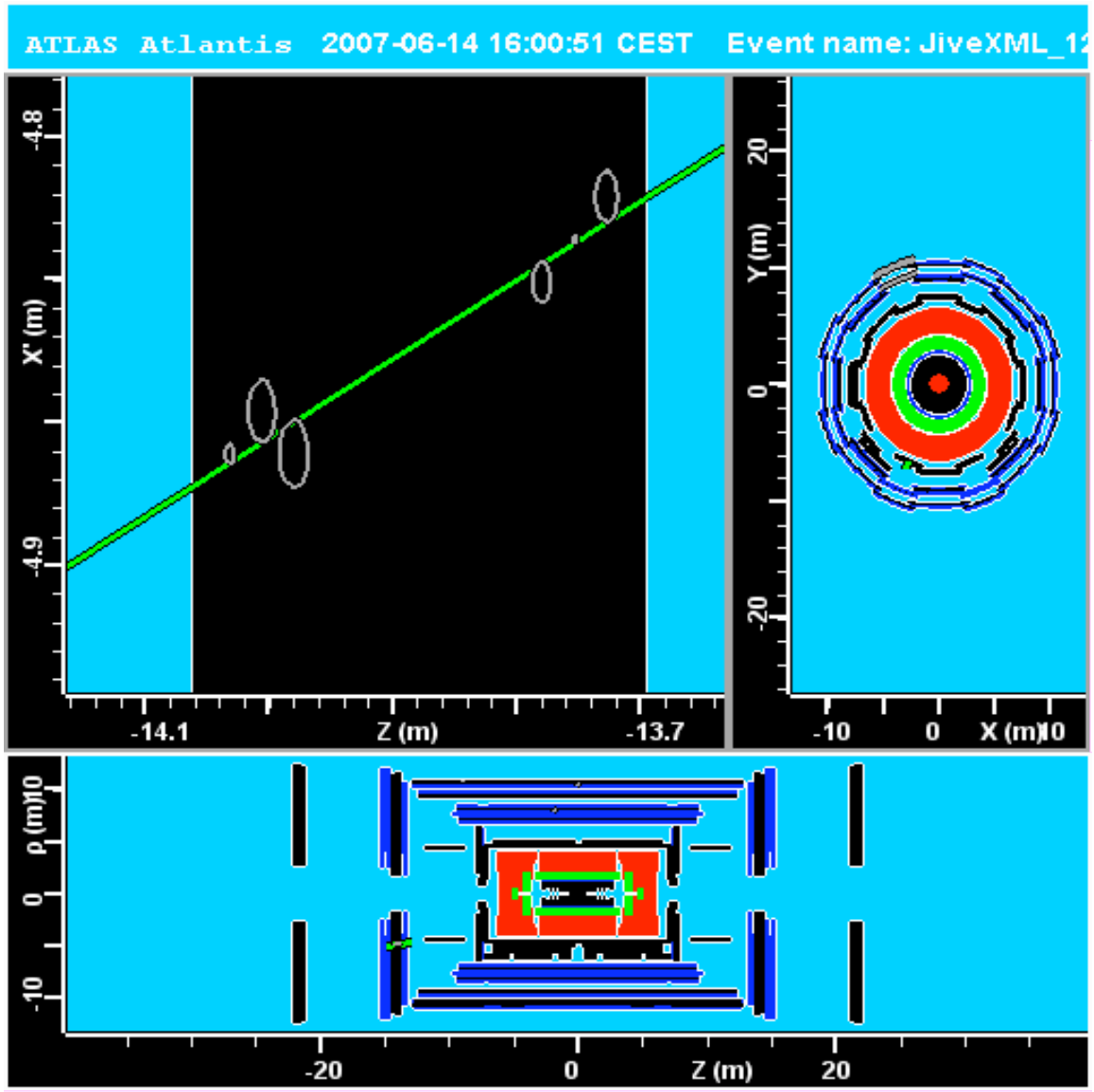


ATLAS Level-1 Central Trigger Processor

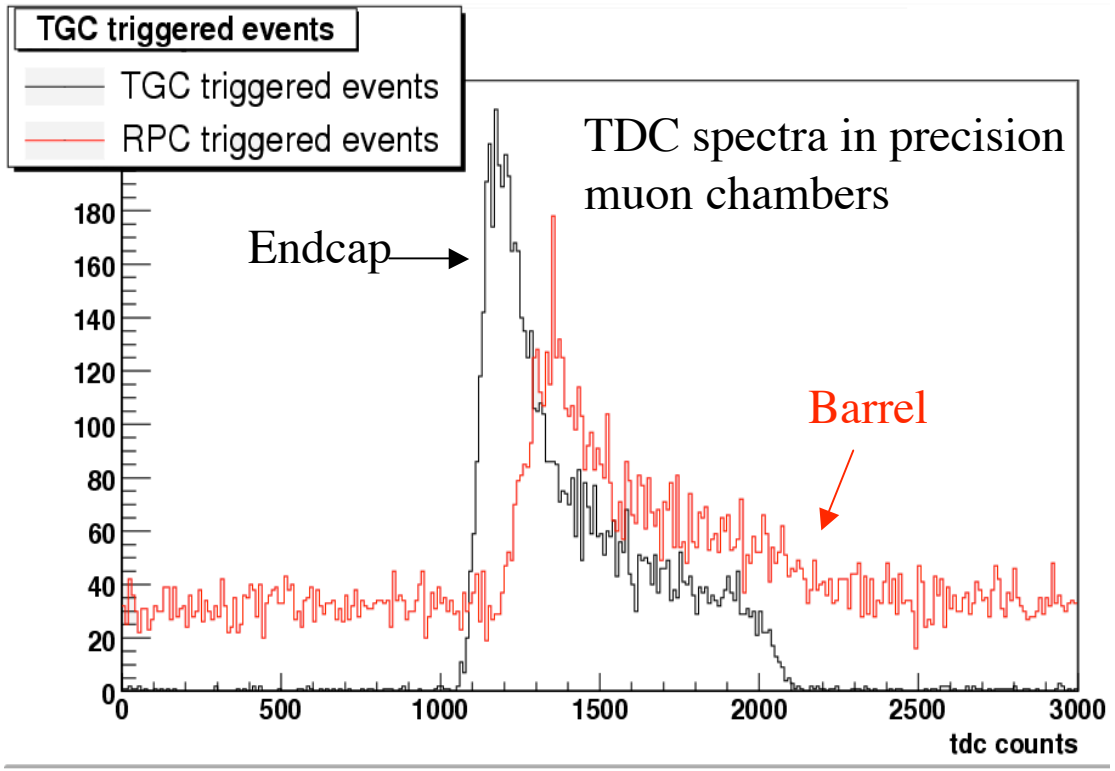
- Final crate installed at the experimental site since 2006
- Routinely used during cosmic runs and commissioning to provide a Level-1 trigger
- Central Trigger Processor is configured via the final trigger database



Endcap-triggered event with hits in precision muon chamber



Muon confirmation in the precision muon chambers



- Both, endcap- and barrel-triggered events have hits in the precision muon chambers with characteristic muon TDC spectrum
- Trigger from barrel reaches the precision muon chamber front-end electronics 130ns sooner than from endcap

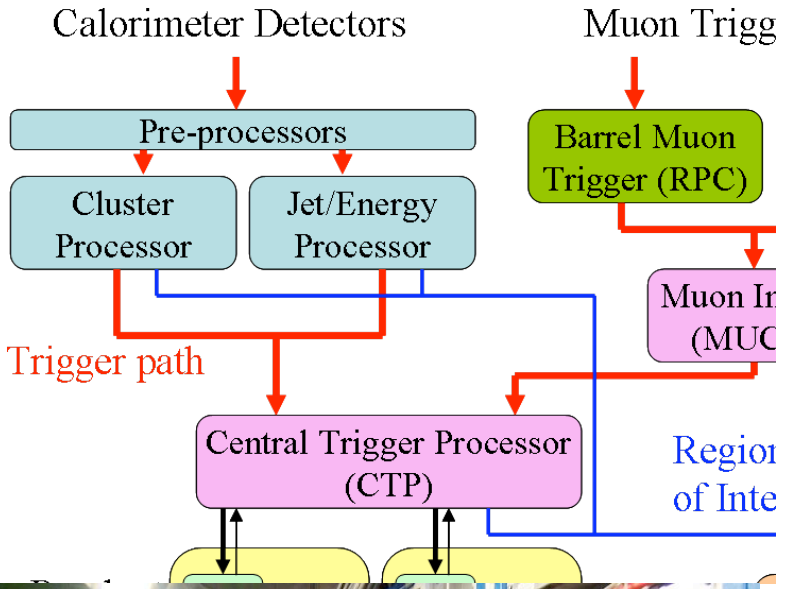
Muon confirmation on Level-2

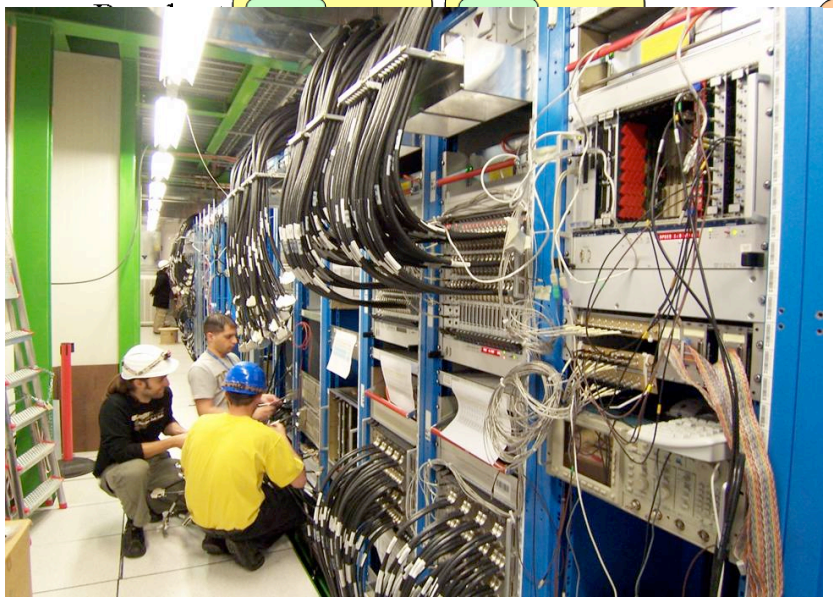
- Reconstruction and selection algorithms were running in the Level-2 trigger, seeded by regions of interest from Level-1

- See next presentation: R. Goncalo, “ATLAS High-Level Trigger”

Level-1 Calorimeter Trigger Status

- Installation is moving quickly:
  - Preprocessor 40% installed
  - Jet/energy processor installation almost complete
  - Cluster processor 50% installed
  - Complex cabling (analogue and digital) fully installed
  - All hardware will be installed by October
- Commissioning:
  - Vertical slices through the system
  - Tests of integration with Level-2 and DAQ ongoing
- June 2007 cosmic run: initial small test system (prepocessor and readout)
- Next cosmic run (end of August):
  - expect half system to be present
  - exciting time for commissioning the calorimeter trigger chains





Summary

- ATLAS first-level trigger system is based on data from the calorimeters and dedicated muon chambers
- It reduces the event rate of initially 40 MHz to less than 100 kHz with a latency of less than 2.5 microseconds
- Significant parts of the ATLAS Level-1 trigger system are already installed at the experimental site
- Regular combined cosmic-ray commissioning runs are undertaken with a substantial fraction of the ATLAS detector
- ATLAS Level-1 trigger is well on track to be fully operational for the first collisions in summer 2008