Commissioning of the ATLAS Level-1 Central Trigger

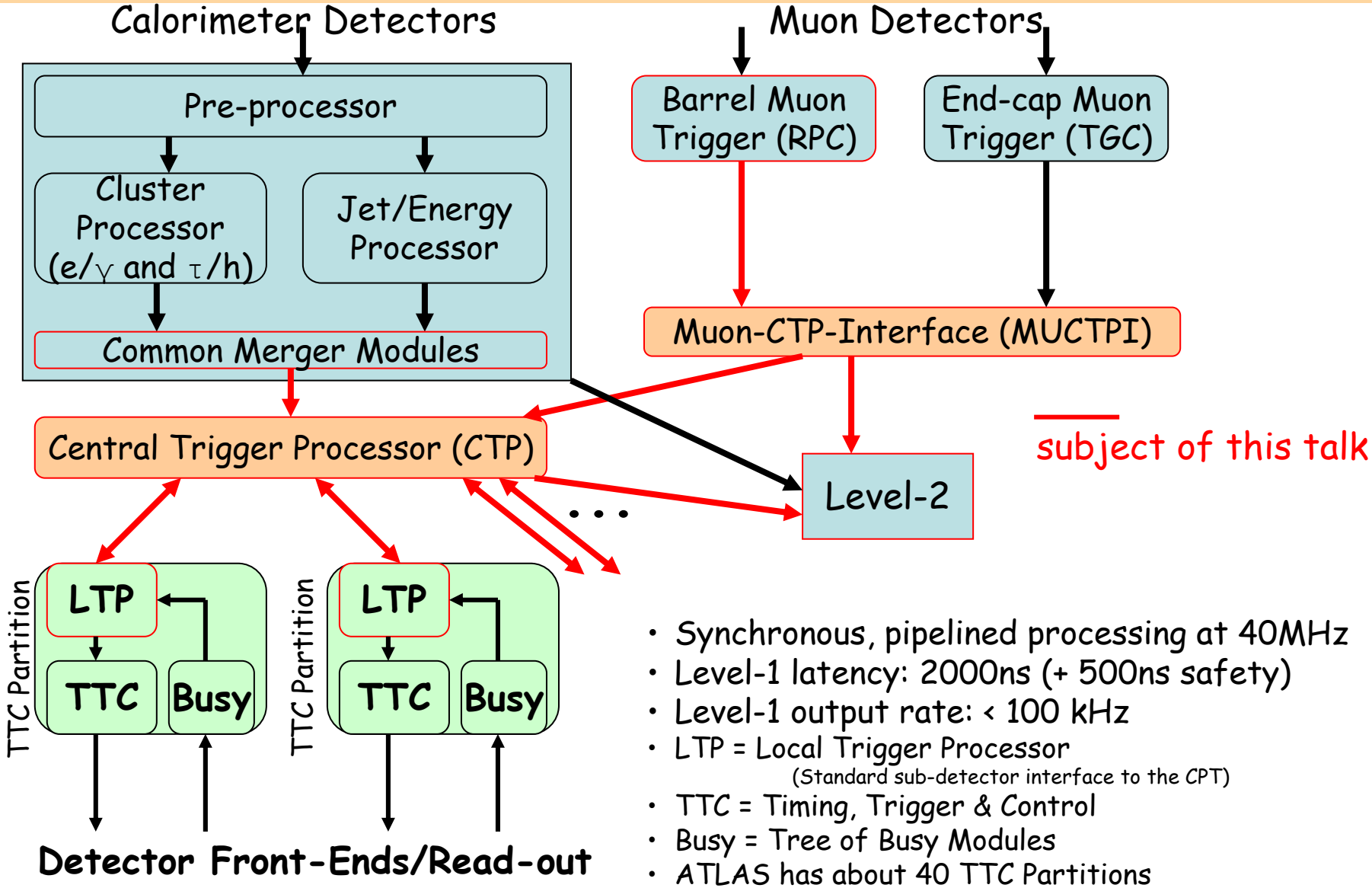
S. Ask[1], D. Berge[1], N. Ellis[1], P. Farthouat[1], P. Gallno[1], S. Haas[1], A. Krasznahorkay[1,2], T. Pauly[1], G. Schuler[1], R. Spiwoks[1], T. Wengler[3]

[1] CERN, Switzerland
[2] University of Debrecen, Hungary
[3] University of Manchester, UK

Overview

- Central Trigger installation status
  - Muon-to-Central-Trigger-Processor Interface (MUCTPI)
  - Central Trigger Processor (CTP)
- Commissioning and integration
  - Trigger inputs:
    - Level-1 Calorimeter Trigger (L1Calo)
    - Barrel Muon Trigger (RPC) and MUCTPI
  - Central Trigger Processor
  - Trigger outputs:
    - Distribution of trigger, timing and controls signals, read-out
      - CTP-Links to sub-system partitions
    - Level-2
  - Combined Cosmics with RPC, MDT (precision muon chambers), tile calorimeter (hadronic), Central Trigger
    - Results
- Conclusions and outlook

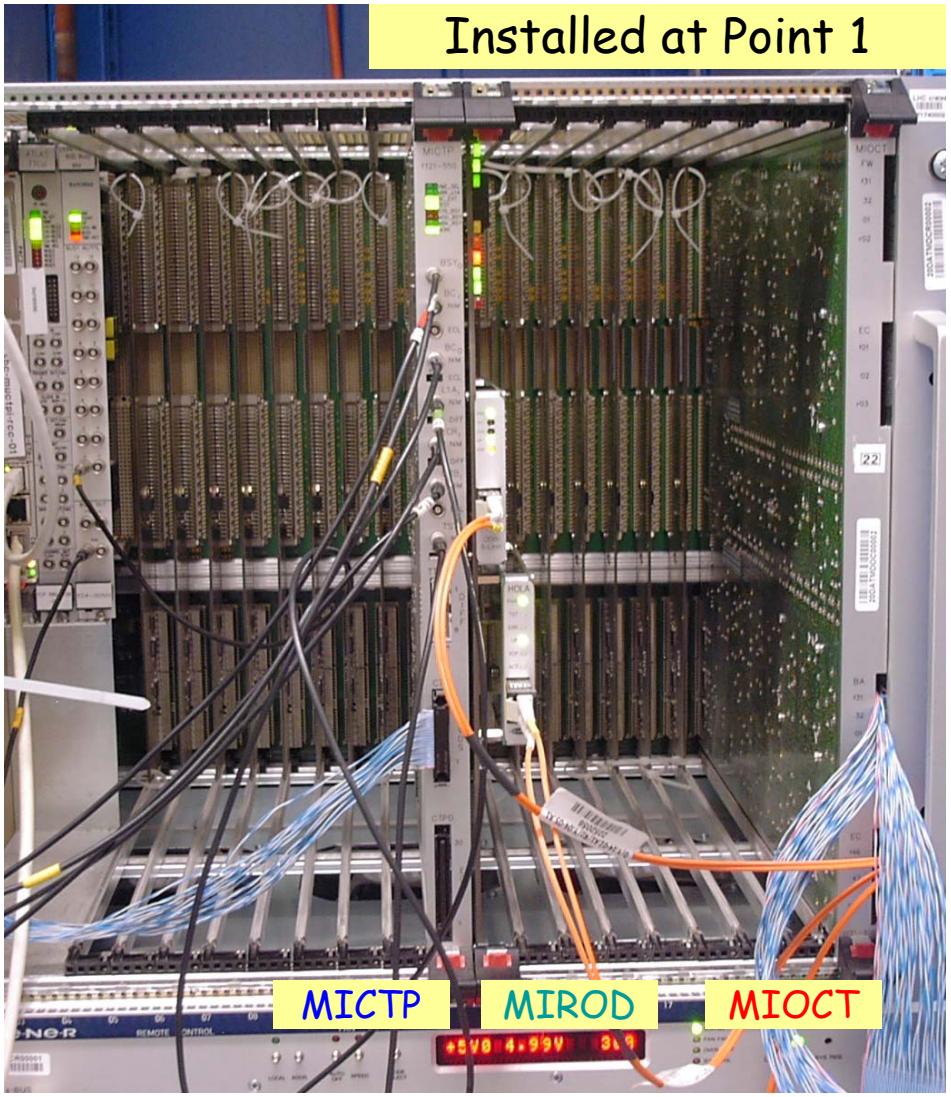
ATLAS Level-1 Trigger System



- Synchronous, pipelined processing at 40MHz
- Level-1 latency: 2000ns (+ 500ns safety)
- Level-1 output rate: < 100 kHz
- LTP = Local Trigger Processor
  (Standard sub-detector interface to the CPT)
- TTC = Timing, Trigger & Control
- Busy = Tree of Busy Modules
- ATLAS has about 40 TTC Partitions

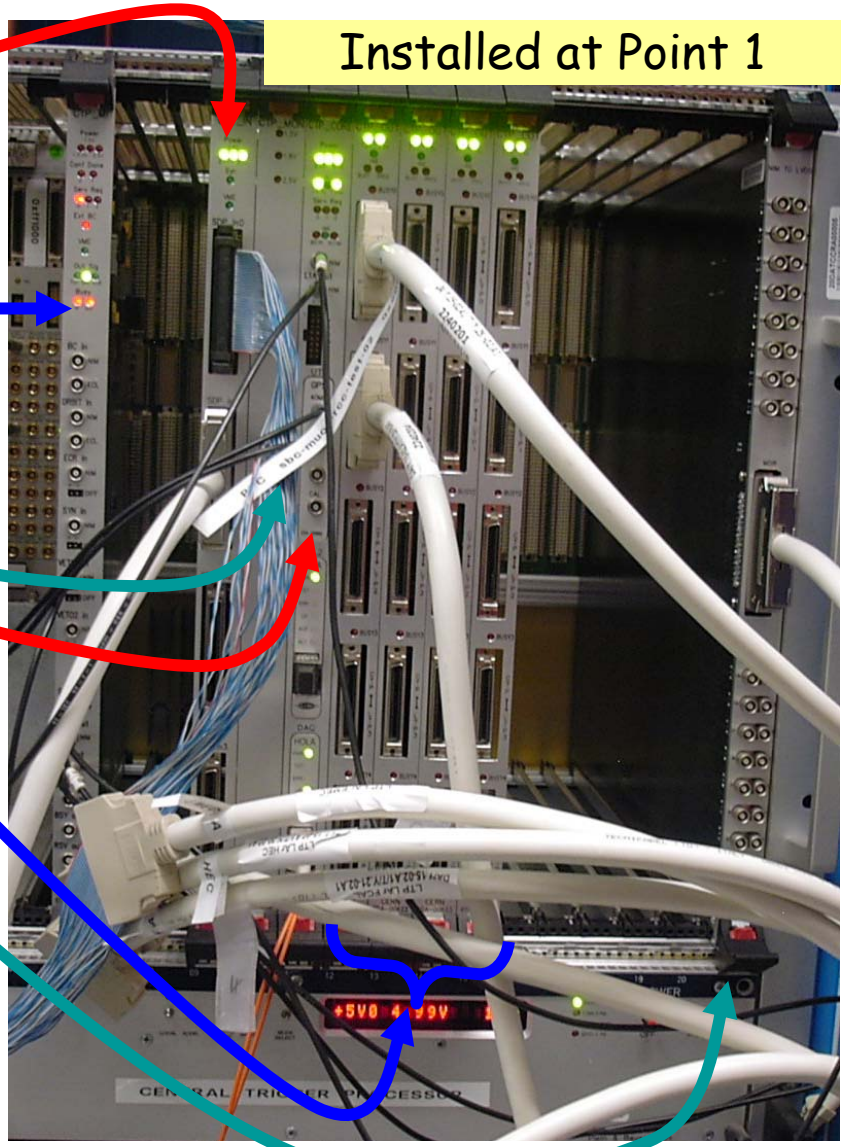
MUCTPI at Point 1

- Demonstrator installed
  - provides almost full functionality
  - missing some flexibility in overlap handling (see Stefan Haas)
- MIOCT:
  - Input module for octant. Current configuration allows 14 trigger sectors (out of 208) to be connected
  - Connected with 2 RPC prototype sector logic modules (see Riccardo Vari)
- MICTP: Timing distribution and trigger (muon multiplicities) output to CTP
- MIROD: S-Link output to Level-2 and ROS
- MIBAK: custom active backplane for readout and multiplicity summation



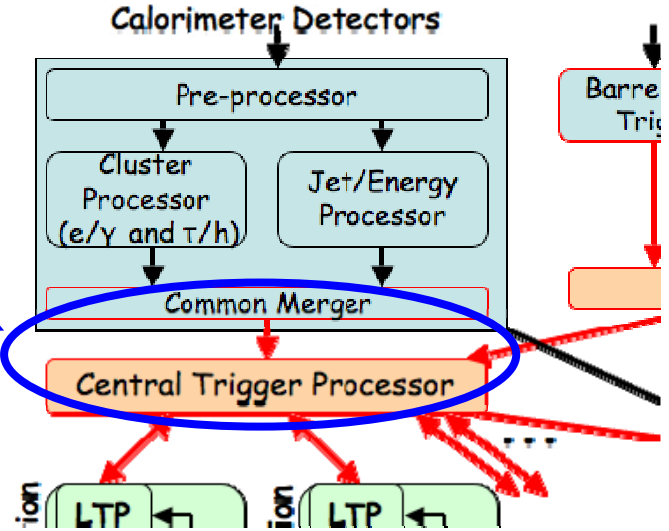
Central Trigger Processor at Point 1

- Final modules installed
- 1 CTP_IN for 4 trigger input cables
  - 2 more to come
- CTP_MI: Machine interface (clock and orbit input)
- CTP_MON: Monitoring of trigger input per bunch crossing ID
- CTP_CORE: Trigger decision according to trigger menu
- 4 x CTP_OUT: Output to sub-detectors
- NIM-to-LVDS converter module to connect individual trigger signals
- Two more CTP systems in laboratory for hardware test and software development



Trigger Inputs - L1Calo

- Integration test to CTP in July:
  - sent known pattern at 40MHz from L1Calo Common Merger Module (final) to CTP_IN
  - receival of patterns in CTP_IN memory and comparison with known pattern
  - no errors found over 15 minutes
  - minor firmware bug discovered in treatment of parity
  - two faulty cables discovered

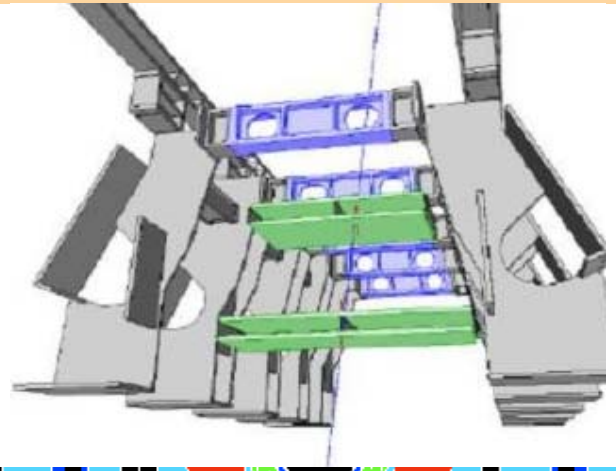


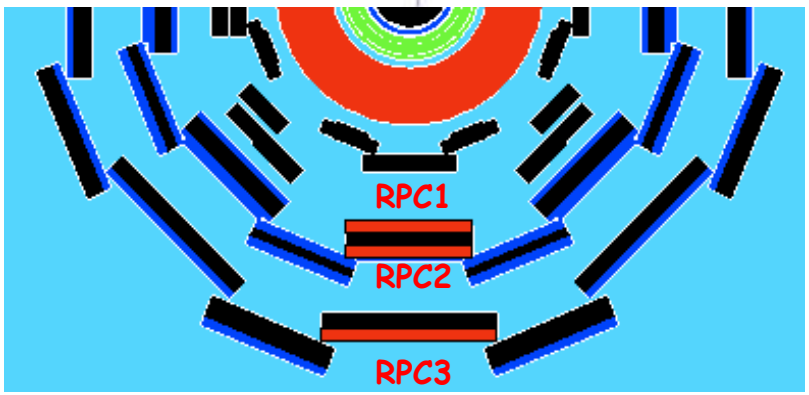
Trigger Inputs - RPC/MUCTPI

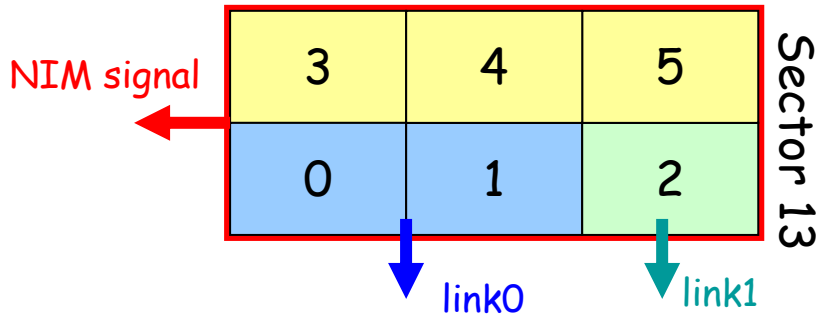
- Barrel Muon Trigger (RPC) Sector 13:
  - Sector 13 is so far the only sector fully equipped with cables and services
  - Barrel Middle and Barrel Outer Chambers used, defining **6 trigger towers**

- Connection between two RPC prototype sector logic modules and MUCTPI:
  - link0: towers 0+1
  - link1: tower 2
  - link from MUCTPI to CTP

- CTP:
  - one NIM trigger signal from sector 13
  - CTP configured to trigger on:
    NIM OR link0/link1

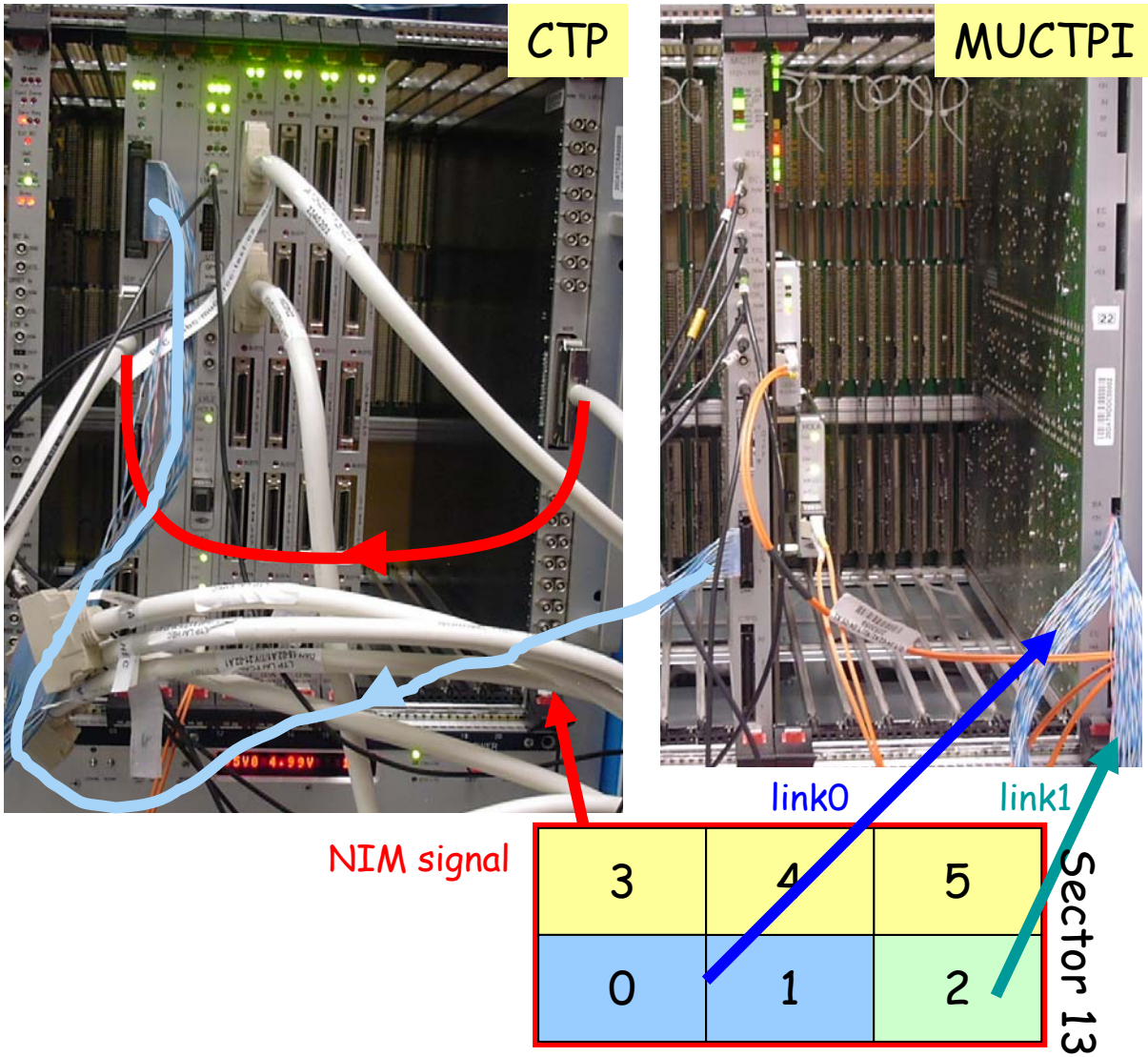






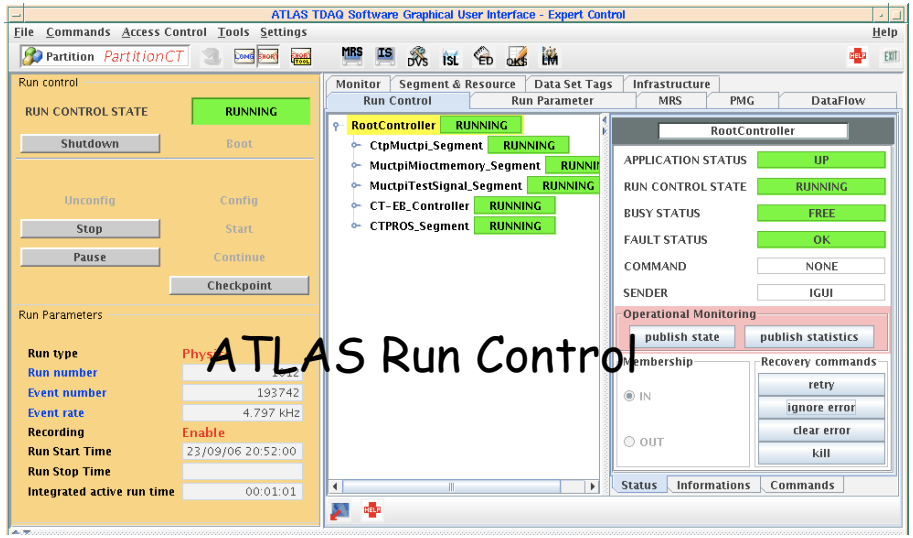
Trigger inputs - RPC/MUCTPI

- MUCTPI:
  - phase measured of link0 and link1 clock
  - link from MUCTPI to CTP
- CTP:
  - phase measured between MUCTPI input and clock
  - NIM signal delayed by 6 BC wrt MUCTPI signals
    - due to MUCTPI latency

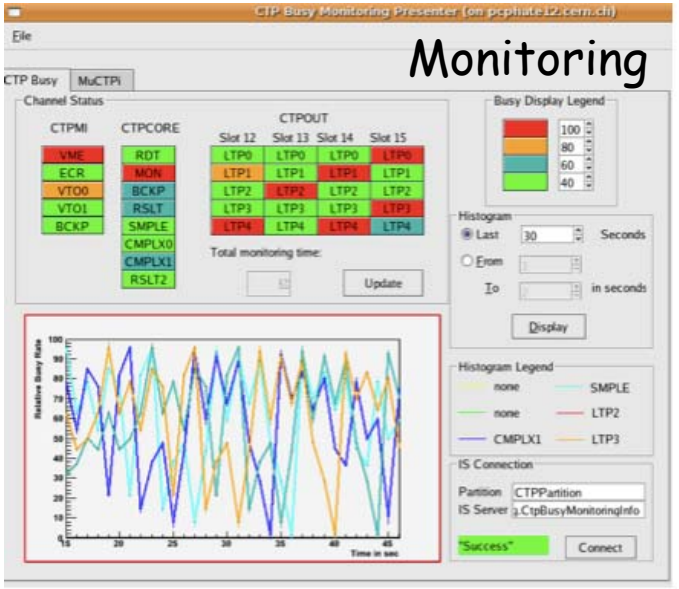


Central Trigger Processor

- Central trigger hardware well integrated with the ATLAS Run Control
- Configuration from trigger database possible
  - Simple trigger menu for integration with muons:
    - require at least one muon candidate from MUCTPI for any pt threshold
    - sector 13 NIM trigger
- GPS-timestamp for each accepted event from General-Machine-Time receiver
- Deadtime mechanism tested
- Basic monitoring tools:
  - deadtime
  - L1A counters in CTP and MUCTPI
  - Muon multiplicity counters in MUCTPI



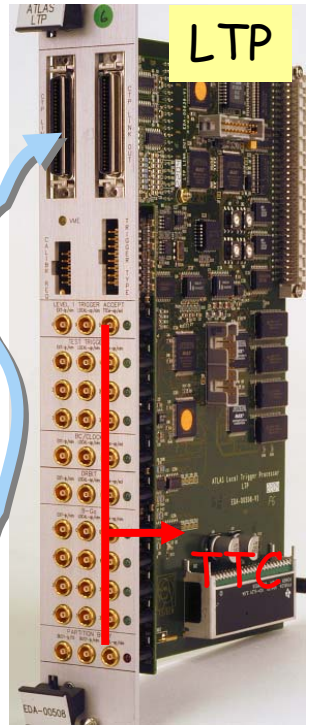
ATLAS Run Control



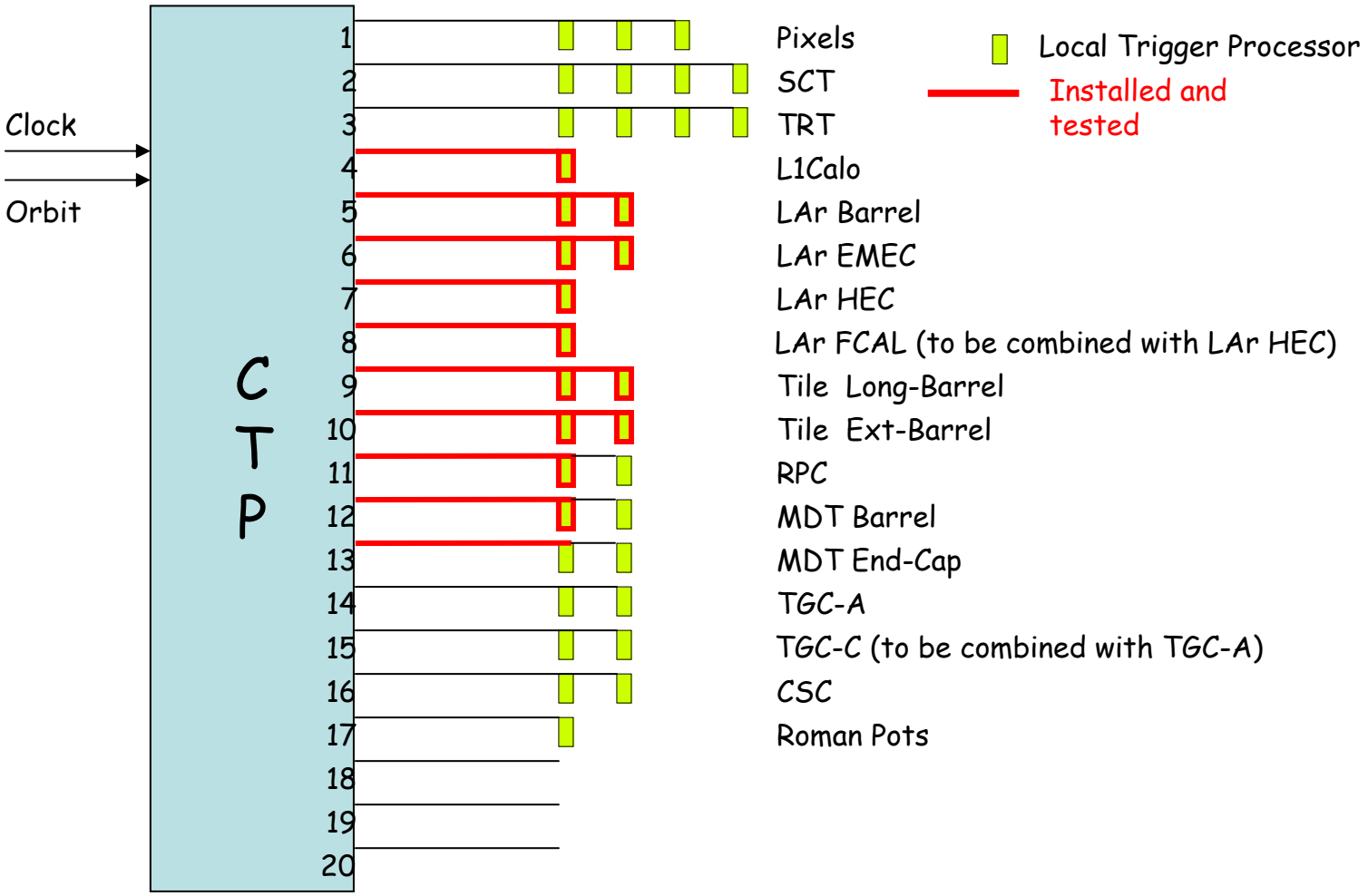
Monitoring

Distribution of trigger, timing and controls signals, read-out

- Signals:
  - Clock, Orbit, L1A, ECR (event counter reset)
  - BUSY (backpressure from readout)
- CTP:
  - Clock and orbit are received from machine (RF2TTC, see Sophie Baron) or generated internally
  - ECR generated periodically with 0.1-1Hz
  - Internal distribution in the CTP VME crate
- MUCTPI:
  - distribution directly via LEMO cables
- other sub-systems:
  - differential link (10-30m) between CTP_OUTs and sub-system Local Trigger Processor (LTP)



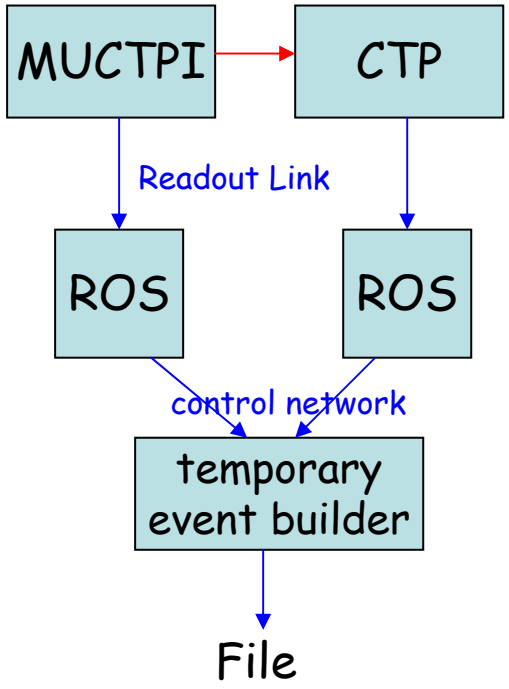
CTP Links to Sub-System Partitions



Readout of the Central Trigger

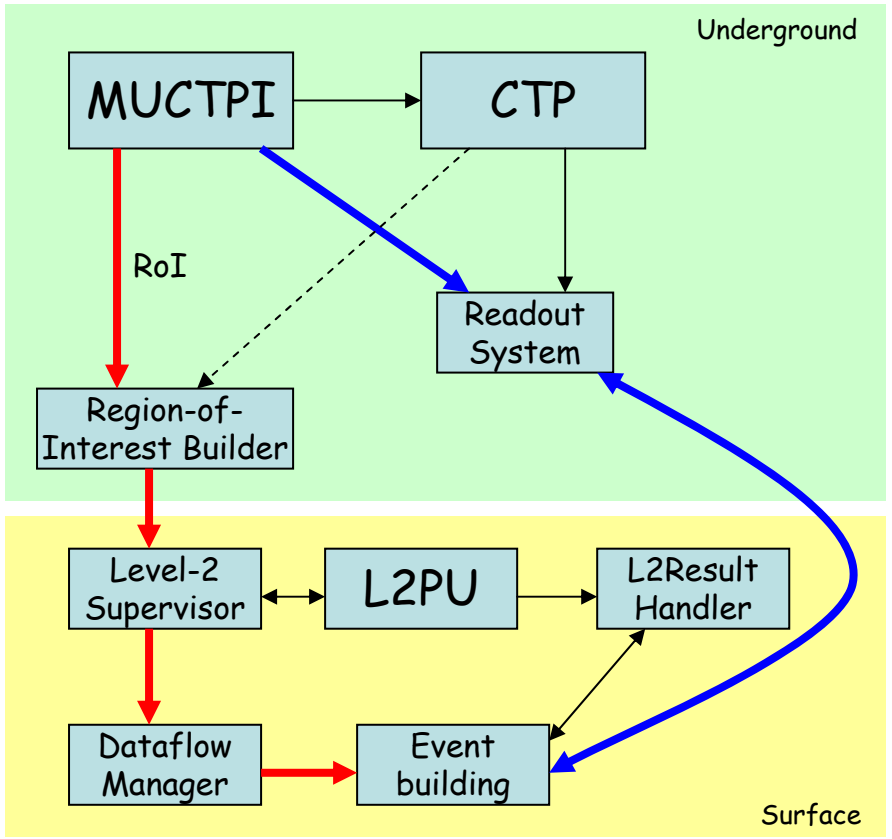
- Final readout links (S-Link) to Readout systems (ROS, 2 PCs)

- Connection tested in standalone mode:
  - consistency between the MUCTPI and CTP data
  - rate limited by temporary event building to about 25 kHz
  - backpressure mechanism functional



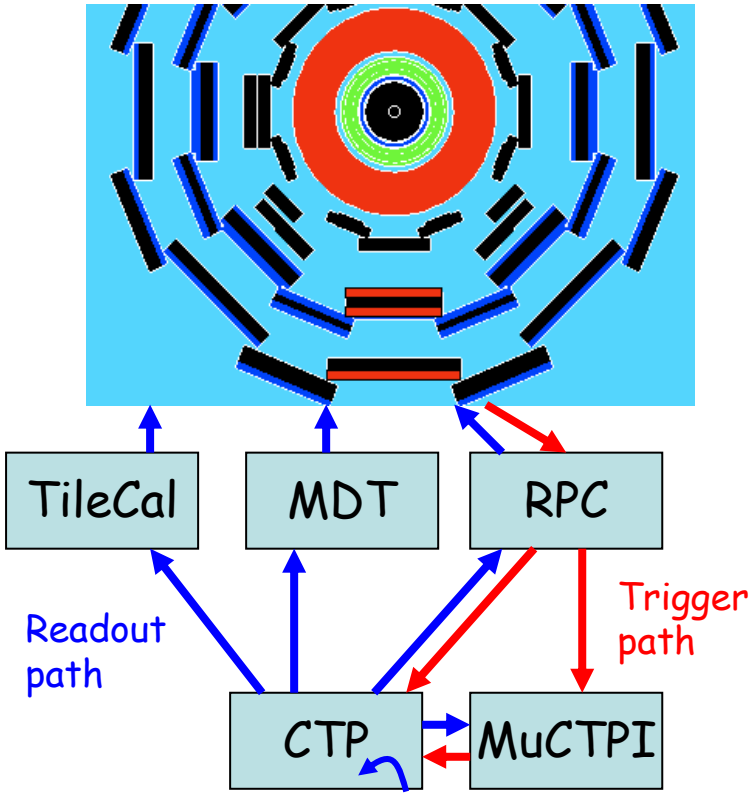
Integration with Level-2

- see also: Yuri Ermoline
- Test: Comparison of central level-1 trigger data from two different streams, after event building (in SFI):
  - trigger stream
  - readout stream
- Read out both streams at 20 kHz
  - rate limited by back-pressure from Level-2
  - no errors found
  - minor problem with identifiers found and fixed



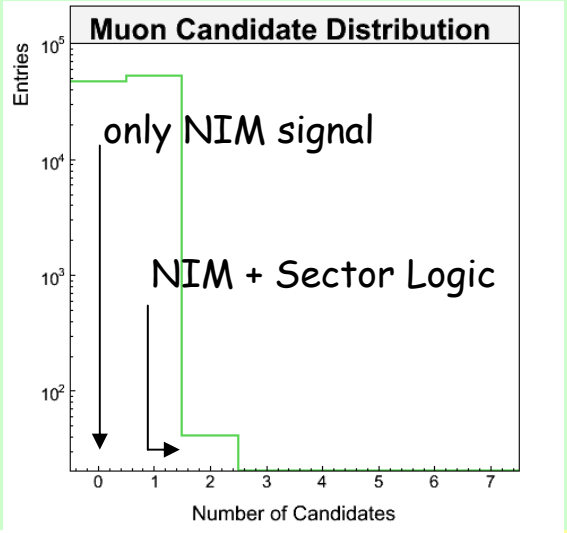
Combined Cosmics with RPC, MDT, Tilecal

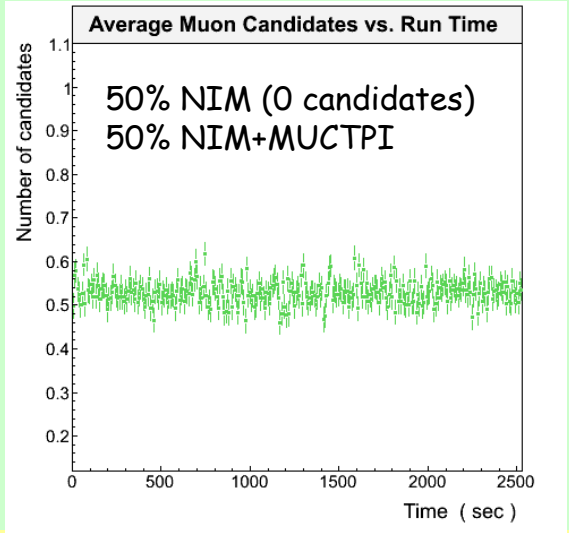
- Combined cosmics run with sector 13 in August
  - Temporary gas systems operational both for RPC and MDT
- Combined partition:
  - Trigger: RPC, MUCTPI, CTP
  - Readout: RPC, MDT, Tilecal, L1Central
    - timing-in: guess & try
  - about 500k events recorded at 40Hz

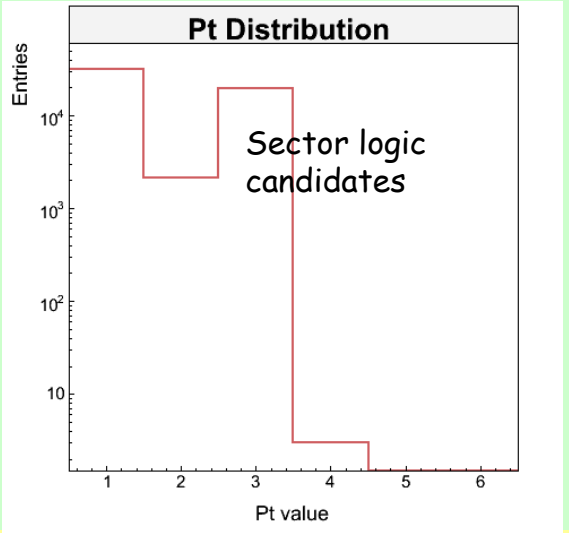


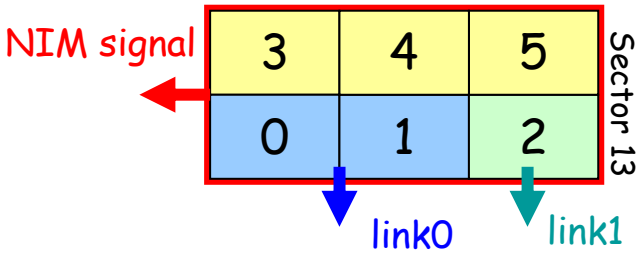
Results from combined cosmics: MUCTPI + CTP

MUCTPI

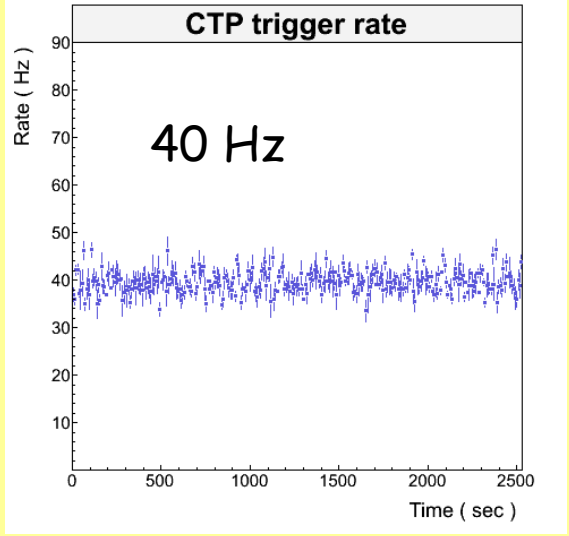


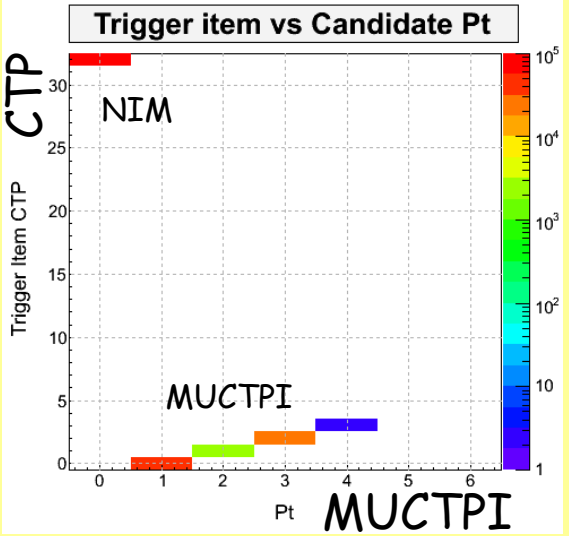




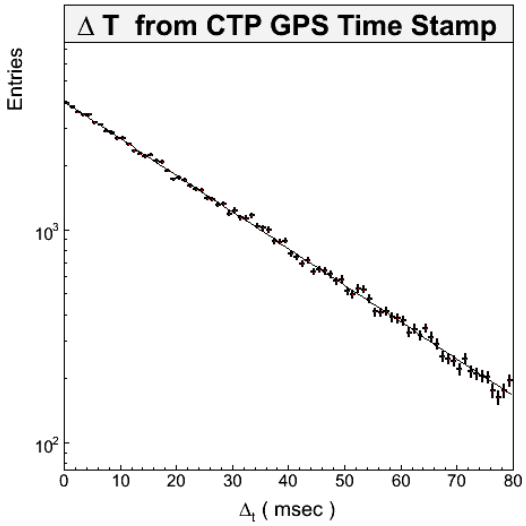


CTP



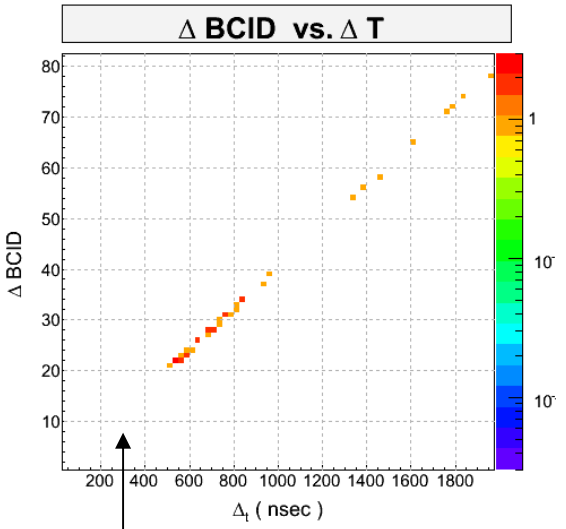


Results from combined cosmics: CTP



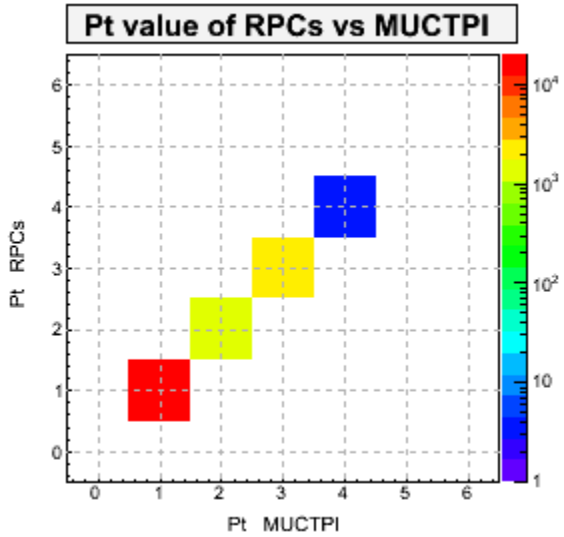
Time difference between consecutive events:

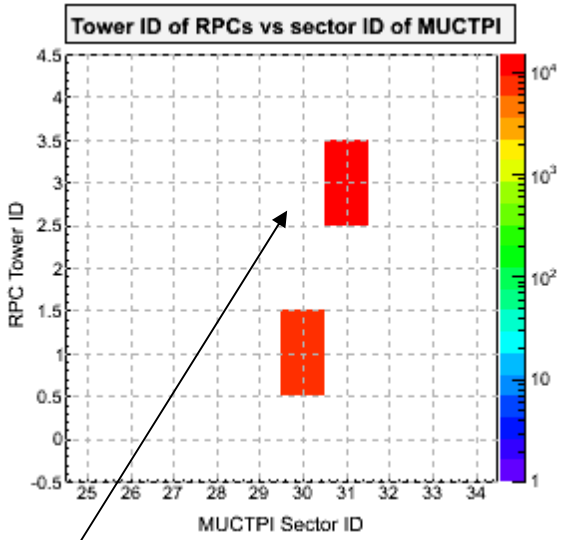
Exponential, as expected from cosmics



20 BC (500ns) of deadtime introduced

Results from combined cosmics: MUCTPI, CTP, and RPC

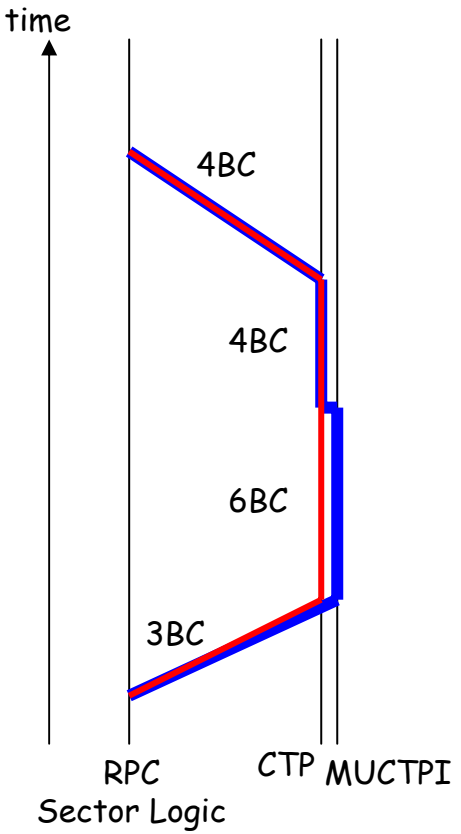




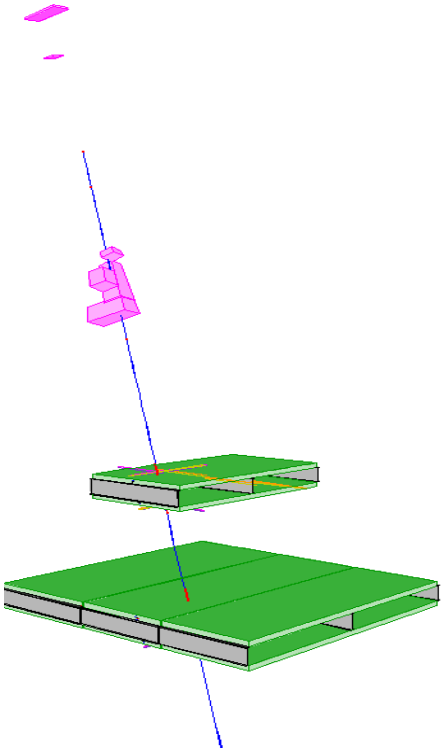
OK. Some bugs in sector decoding found

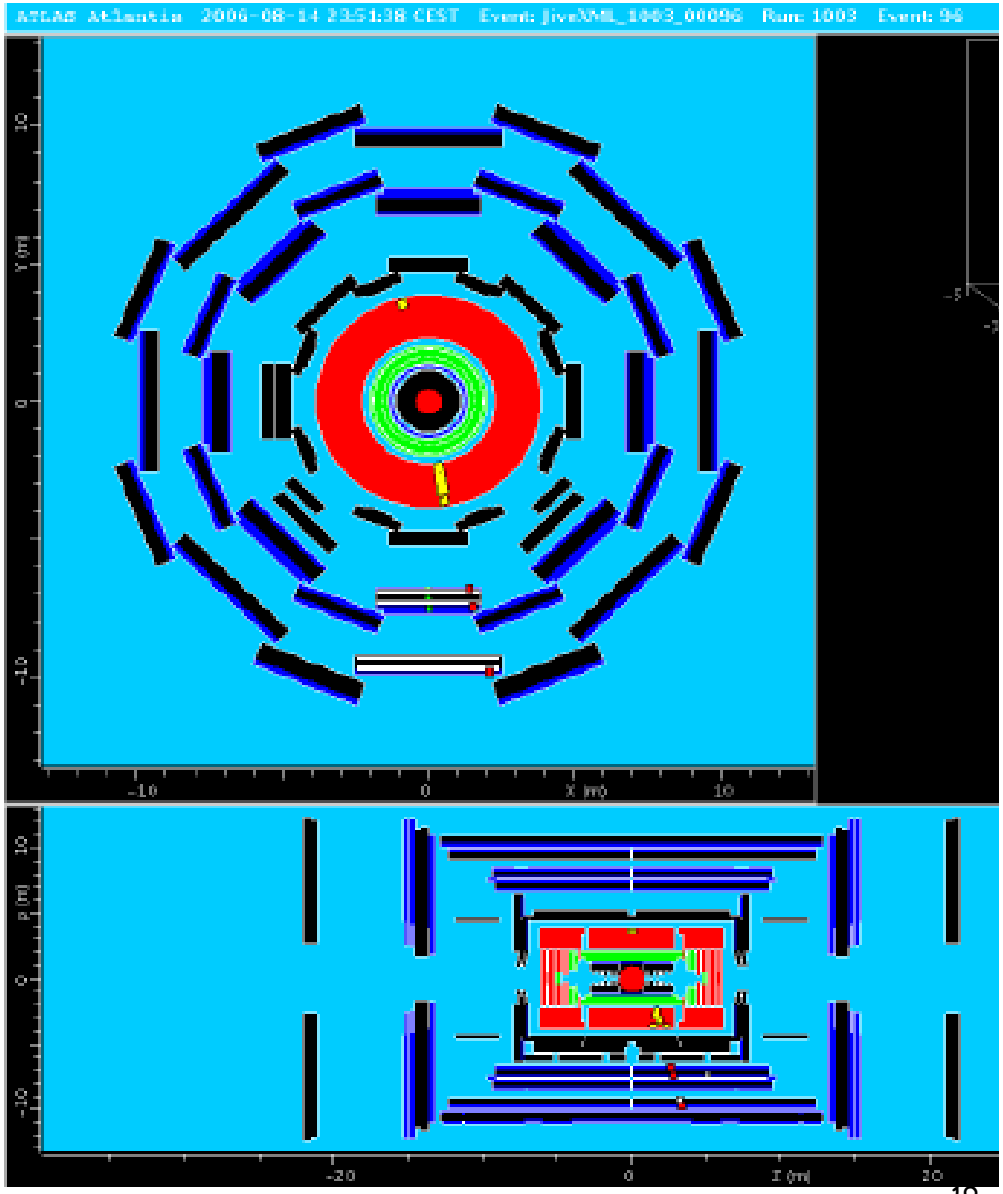
Level-1 latency

- RPC readout window: 1825-2000 ns (70-80 BCs)
  - from chamber hit to arrival of L1A
  - consistent with latency budget of 2000ns (+500ns safety)
- Trigger input:
  - RPC(SL) --> MUCTPI: 3 BC
  - MUCTPI: **6 BC** **OK**
  - RPC(NIM) --> CTP: 3 BC
    - delayed in CTP_IN by 6 BC to align with MUCTPI trigger inputs
- Trigger decision:
  - CTP: **4 BC** **OK**
- Trigger distribution:
  - CTP --> RPC: 4 BC



Combined cosmics: some results





Conclusions

- Level-1 Central Trigger (CTP and MUCTPI) is installed and functional at Point-1 with mainly final hardware

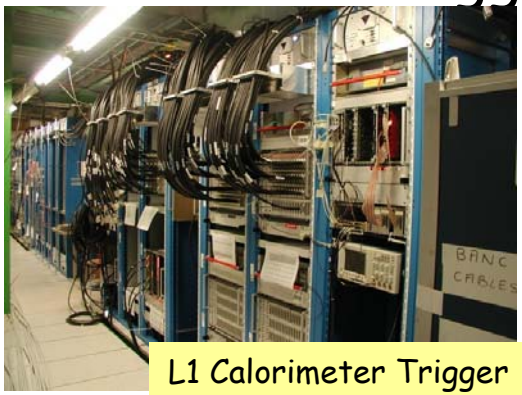
- A complete trigger and read-out chain has been successfully operated in the cavern with cosmics
  - CTP triggered on signals from barrel muon trigger (sector 13)
  - Read out RPC, MDT, Tilecal, CTP and MUCTPI

- First integration tests with Level-2 were successful

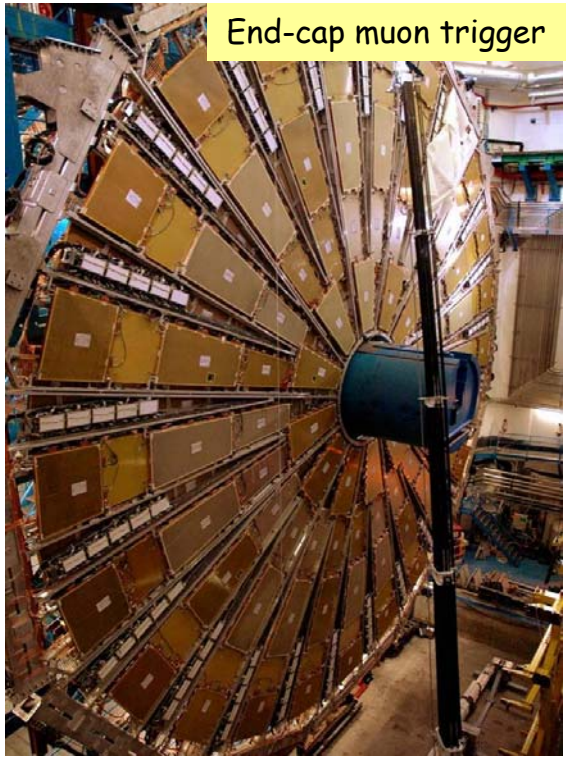
- Integration and commissioning is in full swing
  - More trigger inputs soon
  - More detectors to be read-out
  - Need systematic strategy of treating a bigger system (timing-in, monitoring, configuration, ...)

Outlook: Looking forward to ...

... receiving trigger signals from end-cap muon trigger and calorimeter trigger

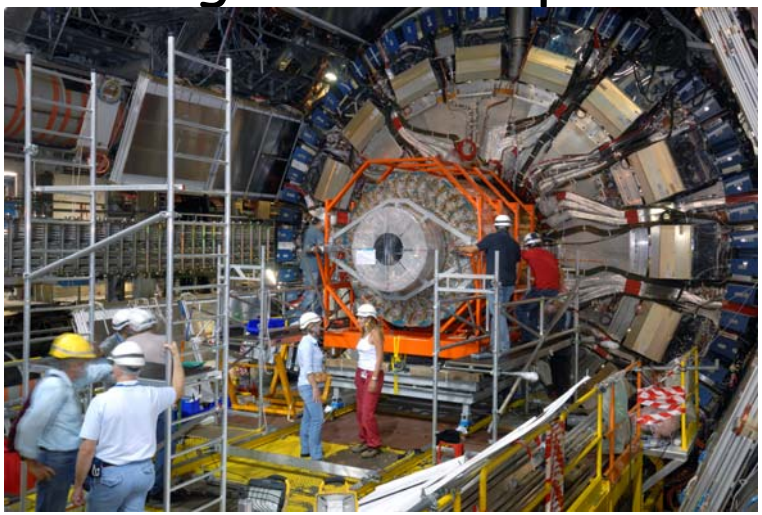


L1 Calorimeter Trigger



End-cap muon trigger

... reading out more parts of ATLAS



Integration and commissioning continues ...

backup

ATLAS Trigger DAQ