The ATLAS Barrel Level-1 Muon Trigger Calibration

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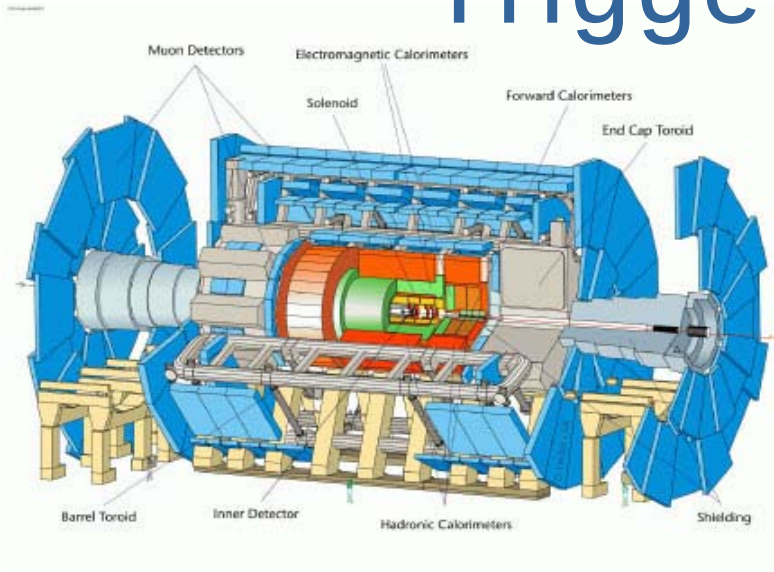
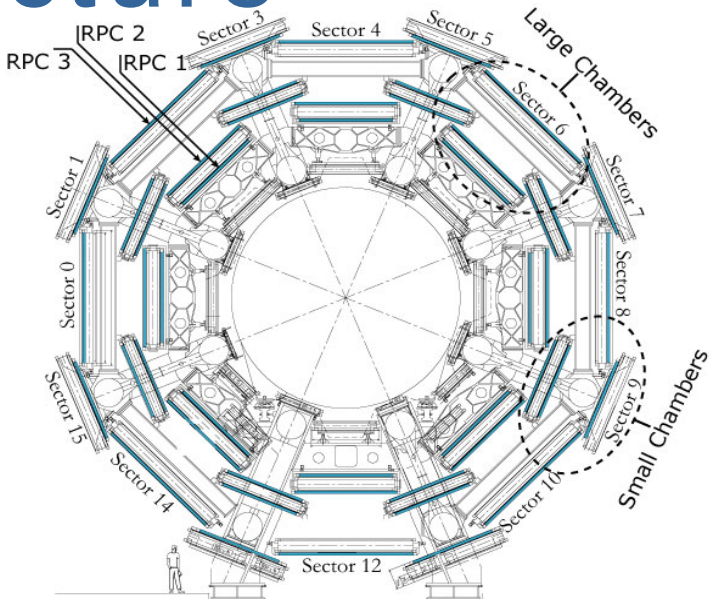
Valencia, LECC2006

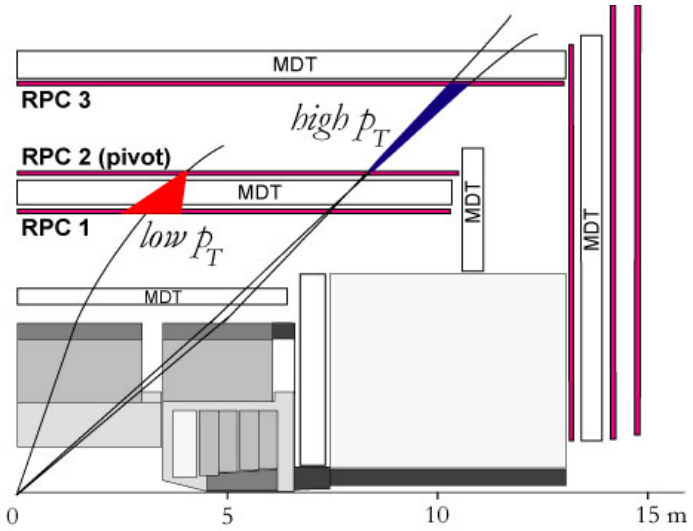
Trigger structure

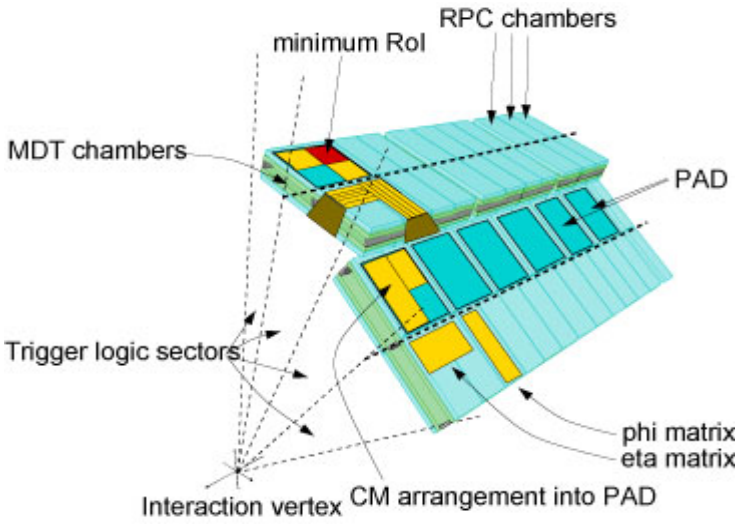




- Resistive Plate Chamber detectors, structured in concentric layers inside the air-core barrel toroid
- Each RPC station has two gas gaps (eta and phi orthogonal strips on each gap), so two layers of strips per each view
- Muon classification within three different programmable transverse momentum thresholds
- Bunch Crossing Identification (muon candidate tagging to the corresponding Bunch Crossing number for each event of interest)
- The algorithm looks for hit coincidences within different detector layers inside the programmed geometrical road which defines the transverse momentum cut, on two projections

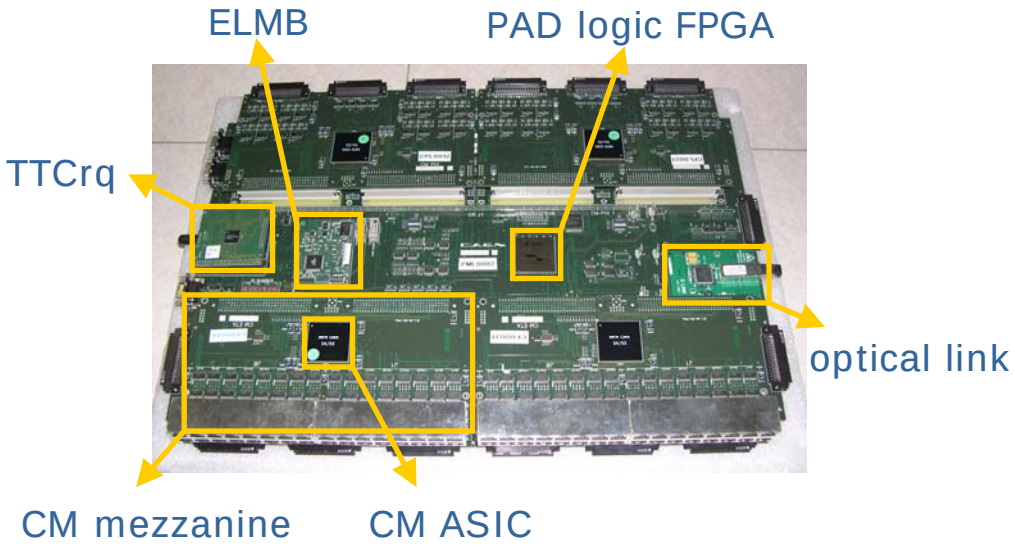
Trigger algorithm and segmentation

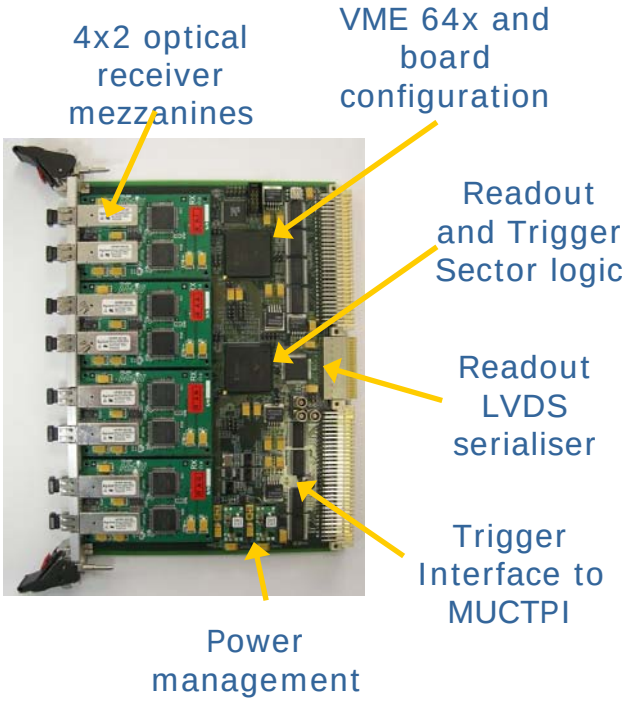




- Low p_T trigger (5.5 GeV/c) and high p_T trigger (10 GeV/c)
- Three programmable thresholds can be applied
- 1/4, 2/4, 3/4, 4/4 majority logic
- Algorithm performed in both eta and phi
- 2 half-barrel, 64 trigger sectors, 804 PAD, 1608 ROI

Trigger electronics

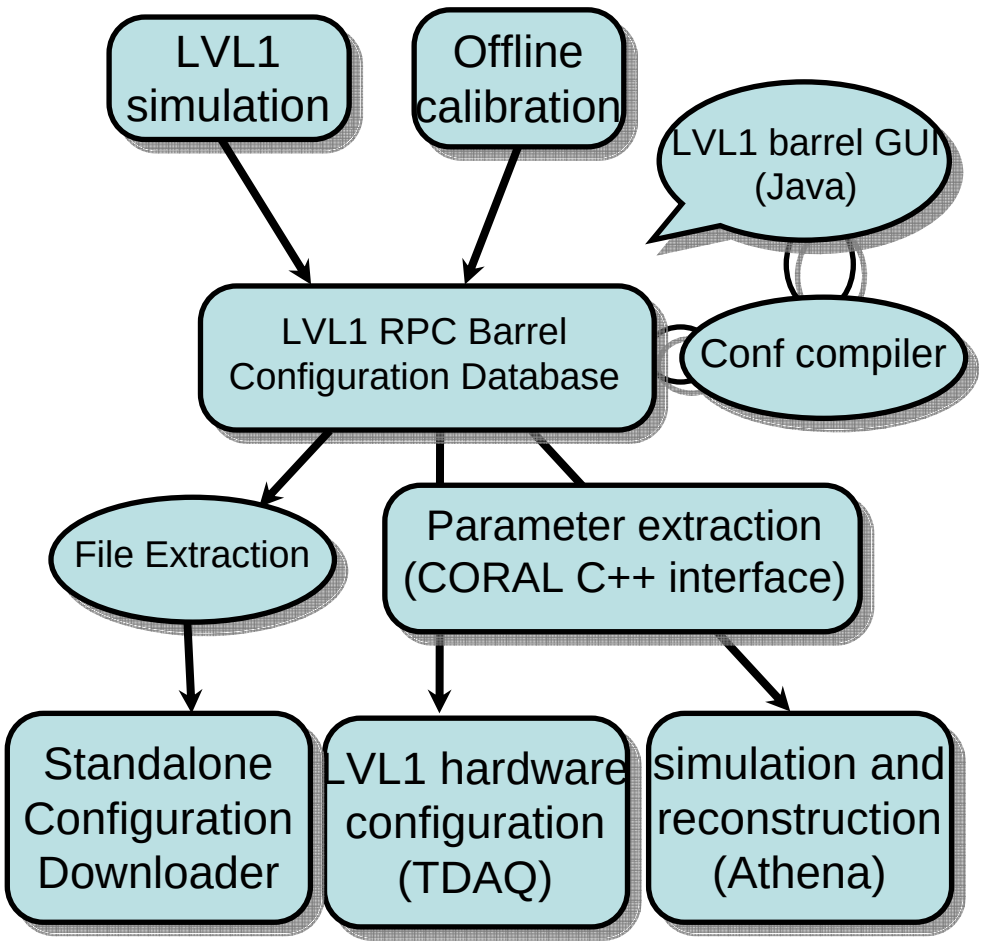




- ON-detector:
  - 804 front-end receiver and fan-out boxes (splitters)
  - 402 low-pt and 402 high-pt trigger processors
- OFF-detector:
  - 64 Sector Logic/RX modules + 64 Interface to MUCTPI boards
  - 402 Optical links
  - 32 RODs + 32 ROD backplanes

LVL1 system configuration

- On-detector and off-detector electronics uses an online configuration system, capable of storing:
  - timing constants
  - trigger constants (thresholds, majority levels, dead-time, ...)
  - readout constants (channel masking, readout windows)
  - hardware-specific parameters
- Trigger configurations can be stored on local memories for fast initialization of the system at start of run
- Interaction with online software, calibration and other offline software



Trigger calibration

- Requests:
  - Good trigger efficiency
  - Hit signals timing alignment within each trigger tower
  - Timing alignment between adjacent trigger towers (same trigger sector)
  - Timing alignment between different trigger sectors
- To be taken into account:
  - On-detector front-end to trigger electronics different cables lengths
  - Low-p_T trigger output pattern to high-p_T trigger input cables lengths
  - On-detector trigger algorithm processing time
  - Muons low-p_T station to high-p_T station time of flight in a trigger tower
  - On-detector to off-detector optical fibres different lengths

Trigger calibration parameters

- On-detector:
  - Front-end signals input delay pipelines: signals can be delayed in groups of 16 RPC adjacent strips from 0 to 16 BC (400ns) in steps of 3 ns
  - Used for timing alignment within one trigger tower (within one RPC station and between inner low-p_T and outer high-p_T station)
  - The four CM input clocks phase can be adjusted in time from 0 to 25 ns in steps of 1 ns (within each PAD)
- Off-detector:
  - Sector Logic input trigger signals can be shifted and aligned in steps of 1 BC
  - Used for timing alignment between different trigger towers (same or different trigger sector)
  - All 8 inputs to the Sector Logic are aligned in phase with the 40 MHz clock (done on the PAD)

Readout calibration

- Requests:
  - Trigger calibration
  - Event of interest selection with respect to the trigger input signal
  - Bunch Crossing Identification, tagging events with the correct Event and BC numbers, for all trigger towers
- To be taken into account:
  - L1A signal latency
  - Low-p_T readout output pattern to high-p_T readout input cables lengths
  - On-detector to off-detector optical fibres different lengths
  - Readout algorithm processing time

Readout calibration parameters

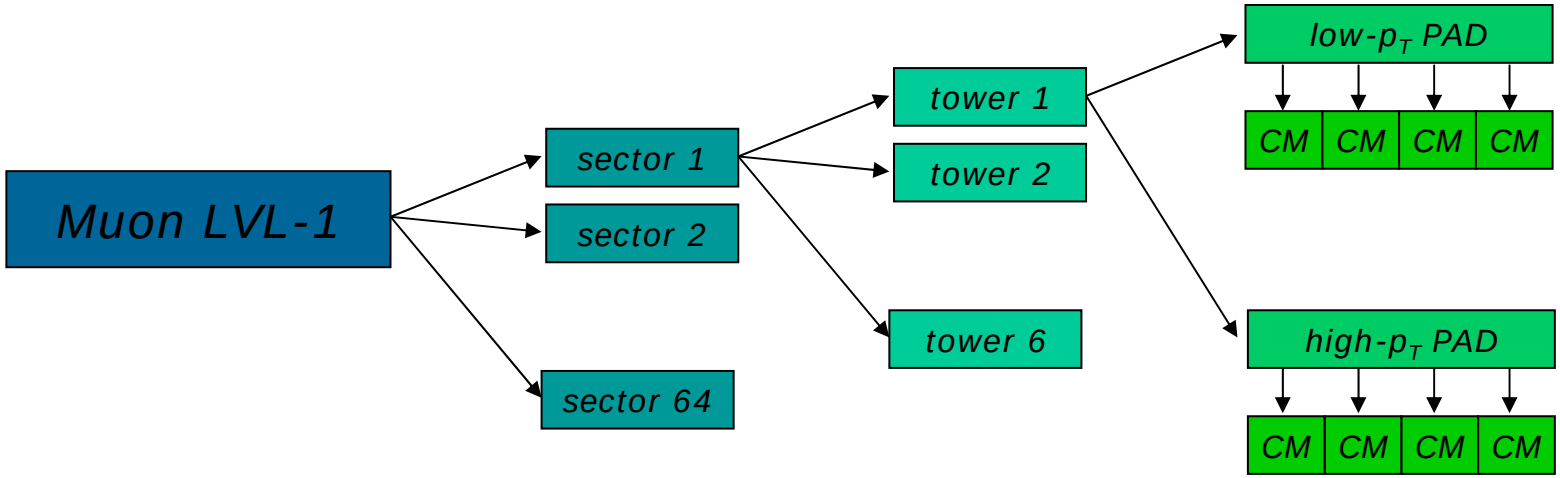
- On detector:
  - Readout window position: it can be shifted in time from 0 to 256 BCs in steps of 1 BC with respect to the L1A signal
  - Readout window width: it can be adjusted from 1 BC to 8 BCs
  - BC and Event counters preset: internal counters can be preset to the desired value to be loaded when a TTC reset signal arrives
  - TTC signals delay: each TTC signal can be adjusted in time and shifted from 0 to 25 ns in steps of 1 ns
- Off detector
  - Signals going to the Sector Logic are already aligned in time with the 40 Mhz clock phase

Calibration studies

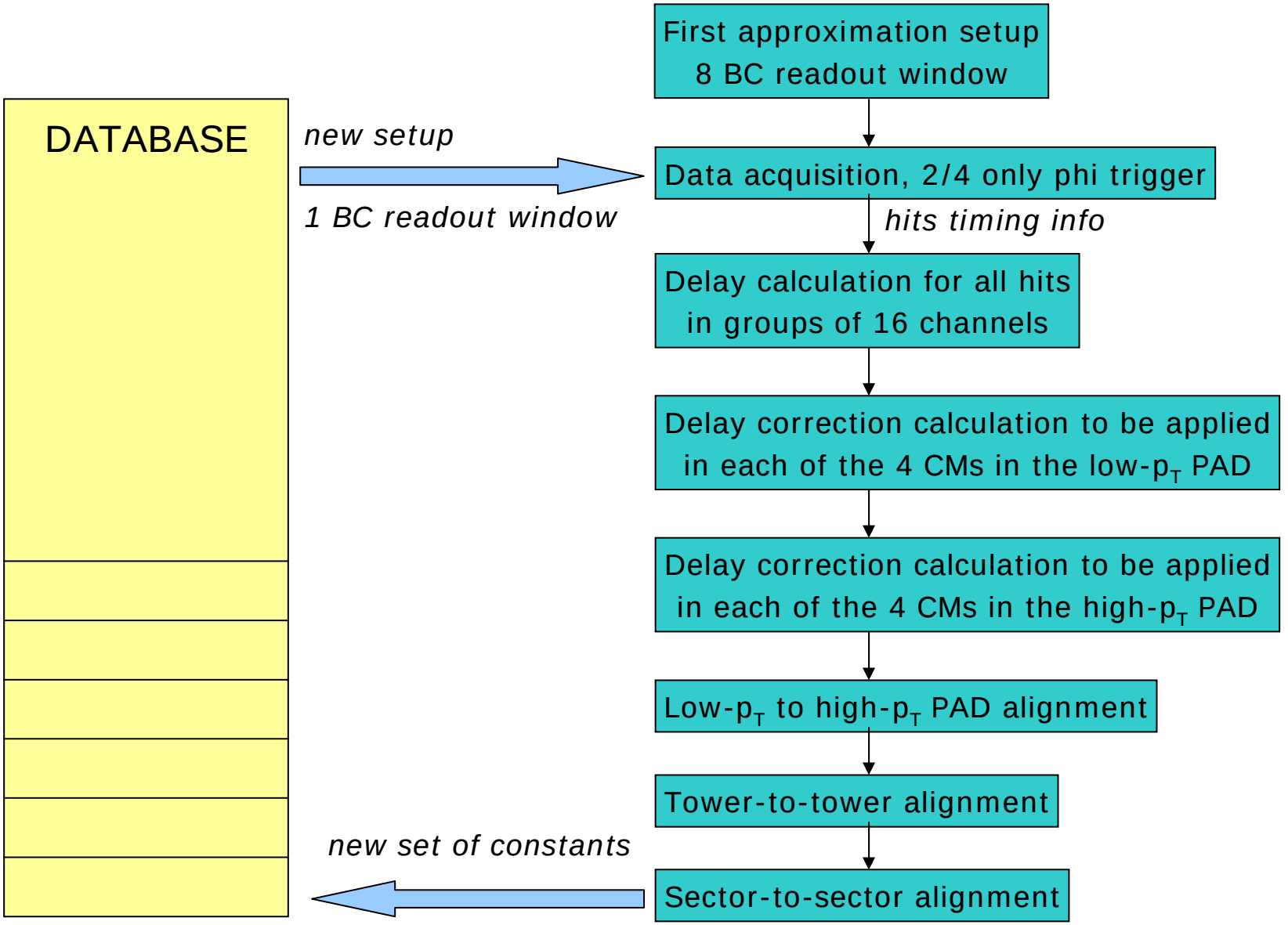
- Calibration system have been developed on the following CERN sites:
  - Muon test-beam (two trigger towers)
  - BB5 cosmic ray RPC test stand (one trigger tower)
  - ATLAS SX1 surface RPC test pulse system (one RPC station)
  - ATLAS sector 13 during the commissioning phase (three trigger towers, two trigger sectors)

Level-1 system calibration

- Calibration procedure is being developed using bottom-up approach, following the trigger structure
- Alignment is performed on each view (eta and phi) for in-plane, plane-to-plane, tower-to-tower and sector-to-sector
- Phi and eta views are aligned in steps of 1 BC
- Alignment between CMs is done using the pivot plane as reference distribution, and aligning the others to this reference
- O(25000) calibration constants to be calculated and used online
- Different calibration for cosmics and collisions

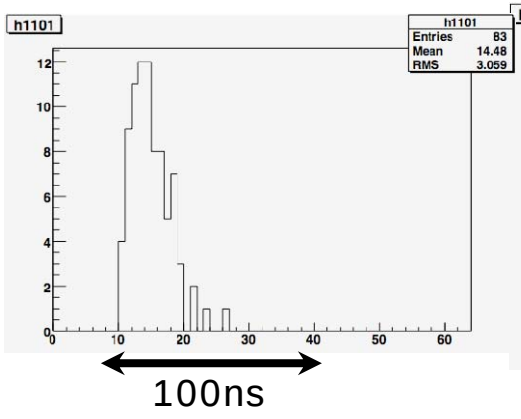


Calibration procedure

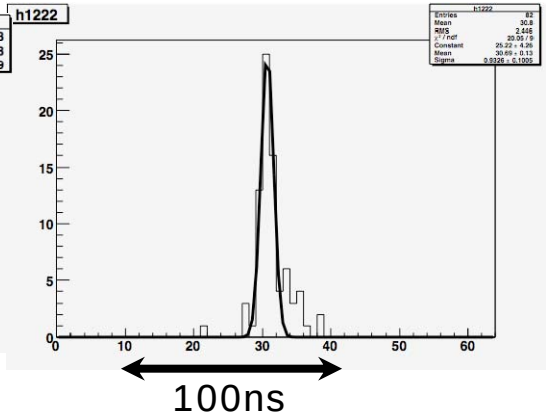


Calibration example

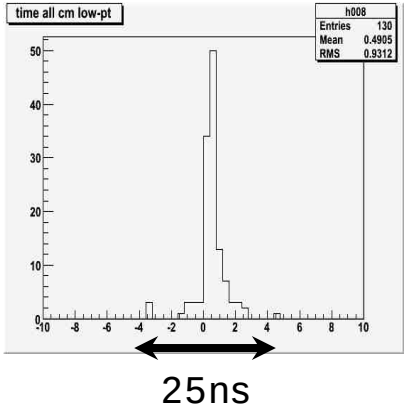
raw cosmics time distribution



time difference peak finder



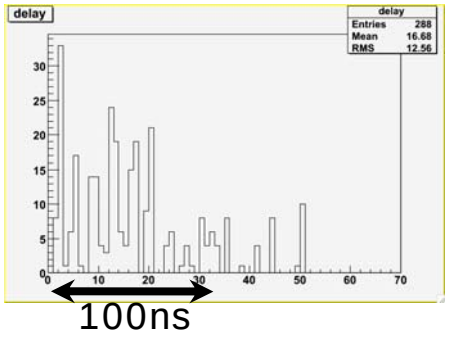
16-channel timing groups misalignement after calibration



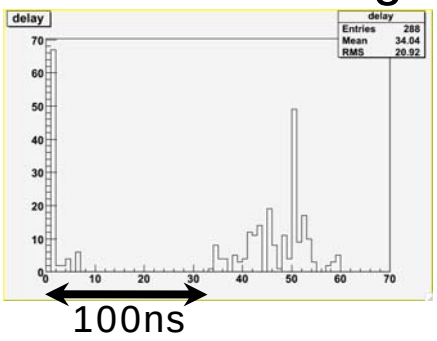
time unit on x-axis is 3.125 ns

calibration constant values/initial FE time misalignement

Sector 13 - Low



Sector 13 - High



Conclusions

- Calibration procedure has been developed so far for in-plane and plane-to-plane alignment
- Tower-to-tower and sector-to-sector calibration has started
- Sector 13 commissioning work:
  - Extensive studies on detector using standalone RPC or combined RPC-MDT tracking
  - Chamber efficiency using combined tracking
  - Check of cabling work, compare online-offline mapping
  - Studies of eta-phi matching
- Level-1 RPC barrel configuration database is being developed (DB structure built, now working on the interface with the configuration system and on the GUI)
- Configuration strategy in case of SEU for non-redundant registers (do not affect system functionality) to be defined