ATLAS LAr Calorimeter: Construction, Integration and Commissioning

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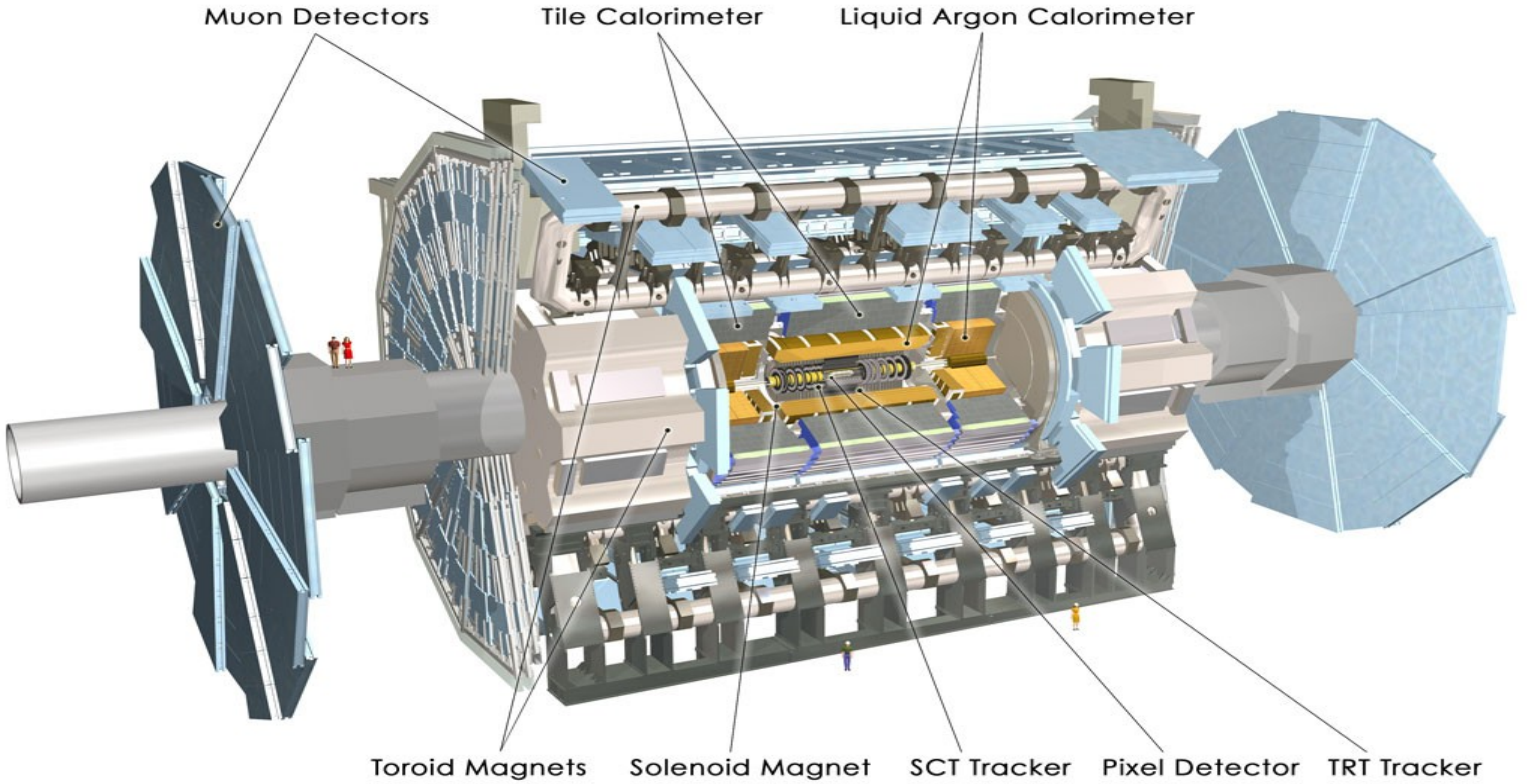
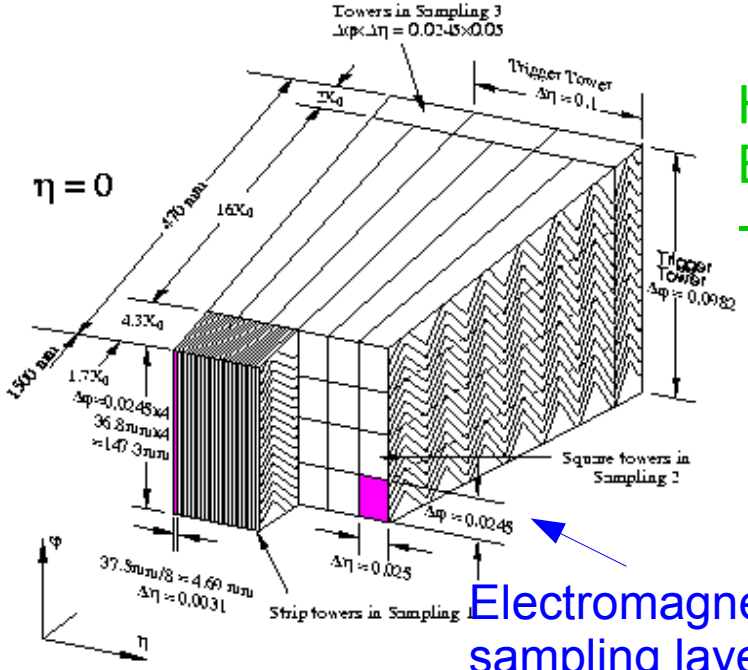
ATLAS Detector Commissioning



- The ATLAS subdetectors are being equipped with electronics after mechanical installation. Following standalone commissioning of the individual subdetectors, comes the integration phase in the ATLAS framework (DAQ, DB, monitoring).
- First cosmic data taking in combined mode with Inner Detector, Calorimeters and Muons sectors happened this year. Full readout electronics chain and DAQ operational and being commissioned now.
- The ATLAS detector commissioning aims to prepare the detector to the first LHC collisions.

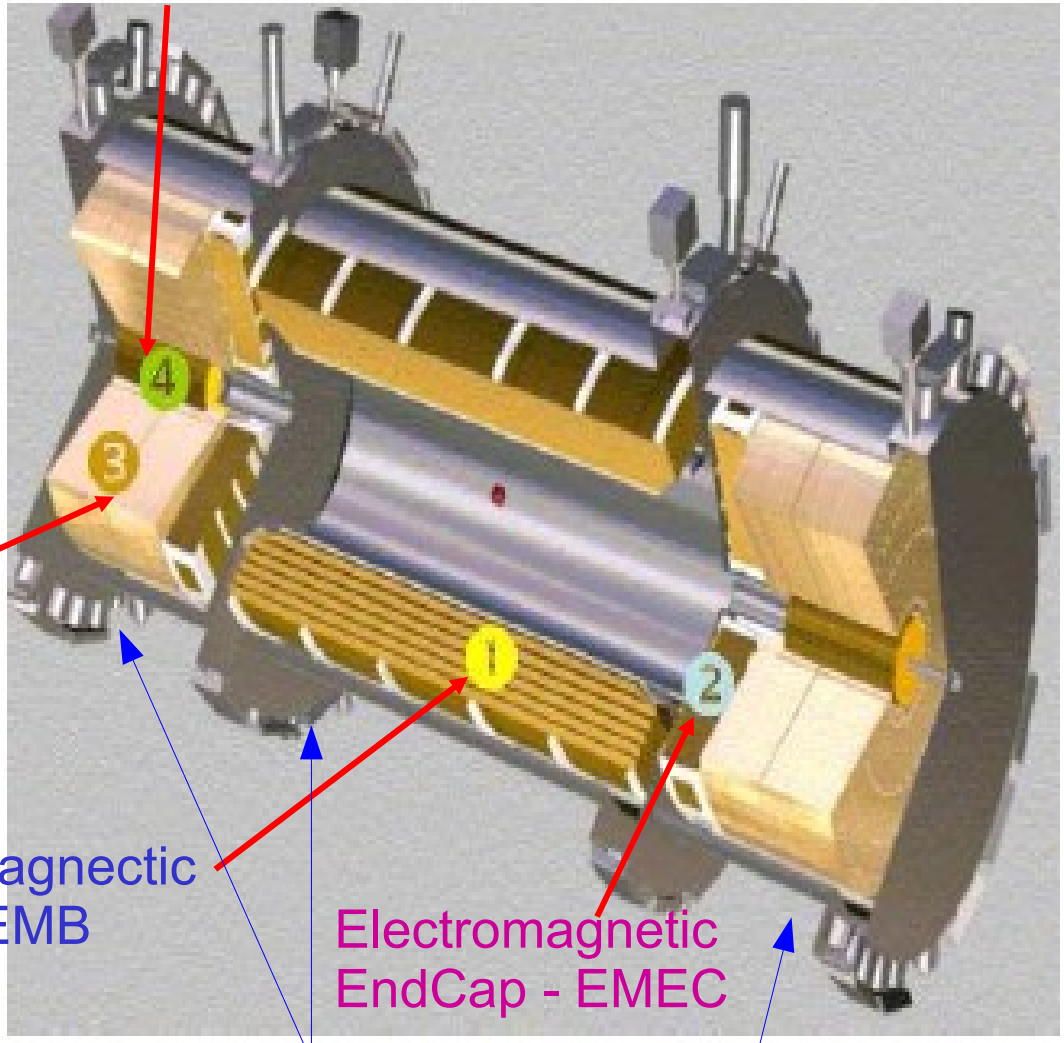
LAr Detector Description

- Different sections (EM, Hadronic and Forward) built inside 3 cryostats.
- Accordion shape lead absorber and LAr as sampling element. Different detector cell layers with different granularities.
- These are filled with LAr and already cooled to nominal temperature. High voltage is operational (EMB 80% and EMEC 100% nominal).



Electromagnetic part sampling layers in depth

Forward Calorimeter - FCal



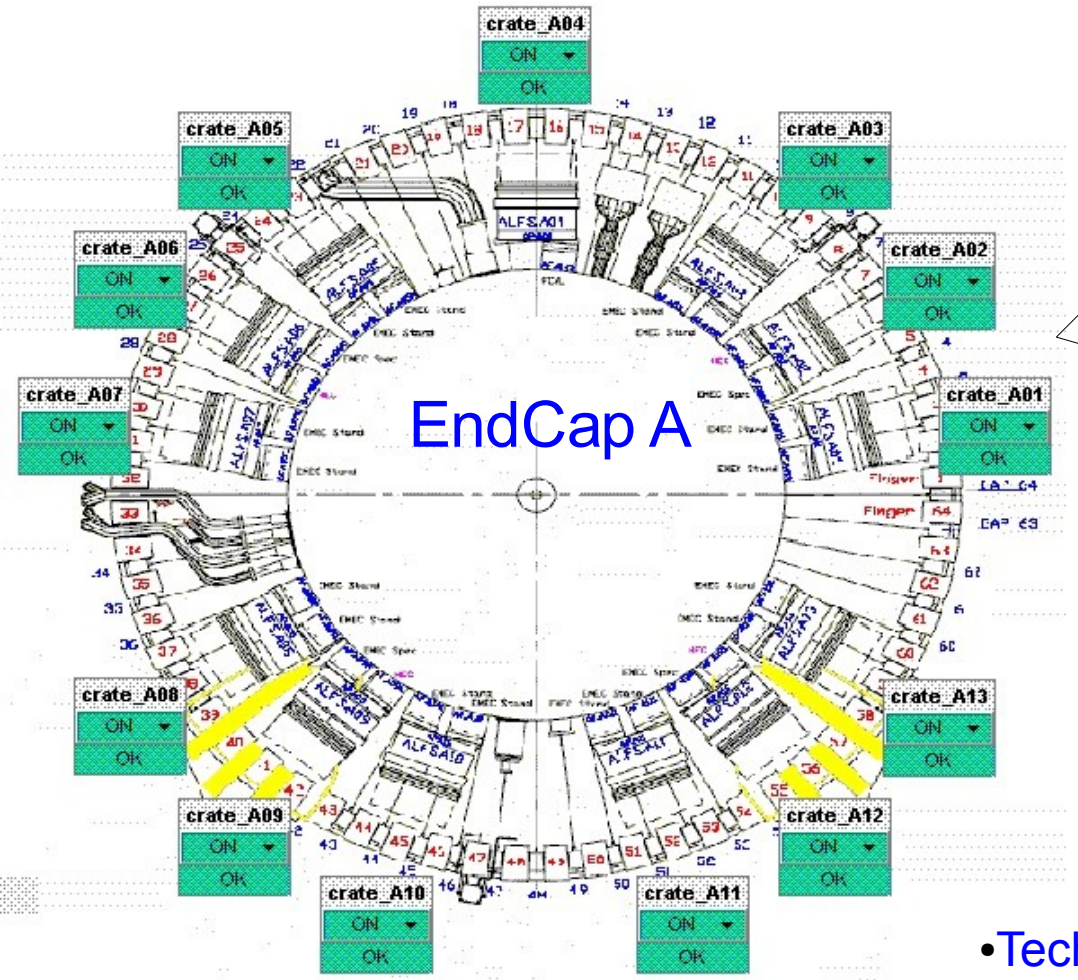
Hadronic EndCap - HEC

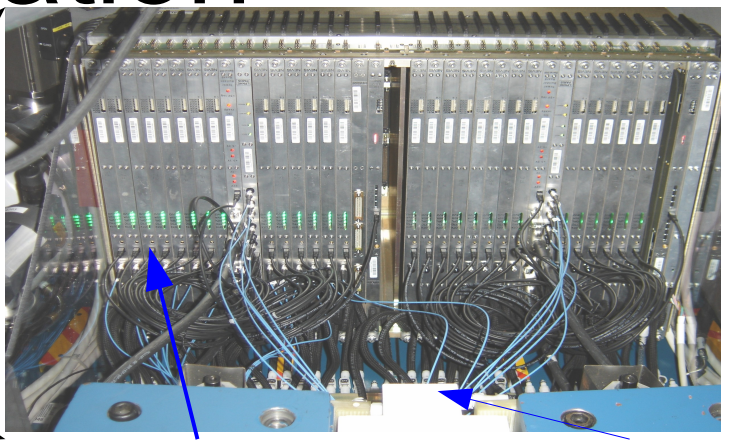
Electromagnectic Barrel - EMB

Electromagnetic EndCap - EMEC

3 cryostats

Electronics installation





Front-End Crate modules. LVPS

- 34/58 Front-End Crates already operational. EndCap-A has all 13 FECs running (above).
- Detector Control System also being integrated (Picture above).

- Technical cavern (USA15).
- Back-End already fully cabled. Used for calibration and cosmics DAQ.

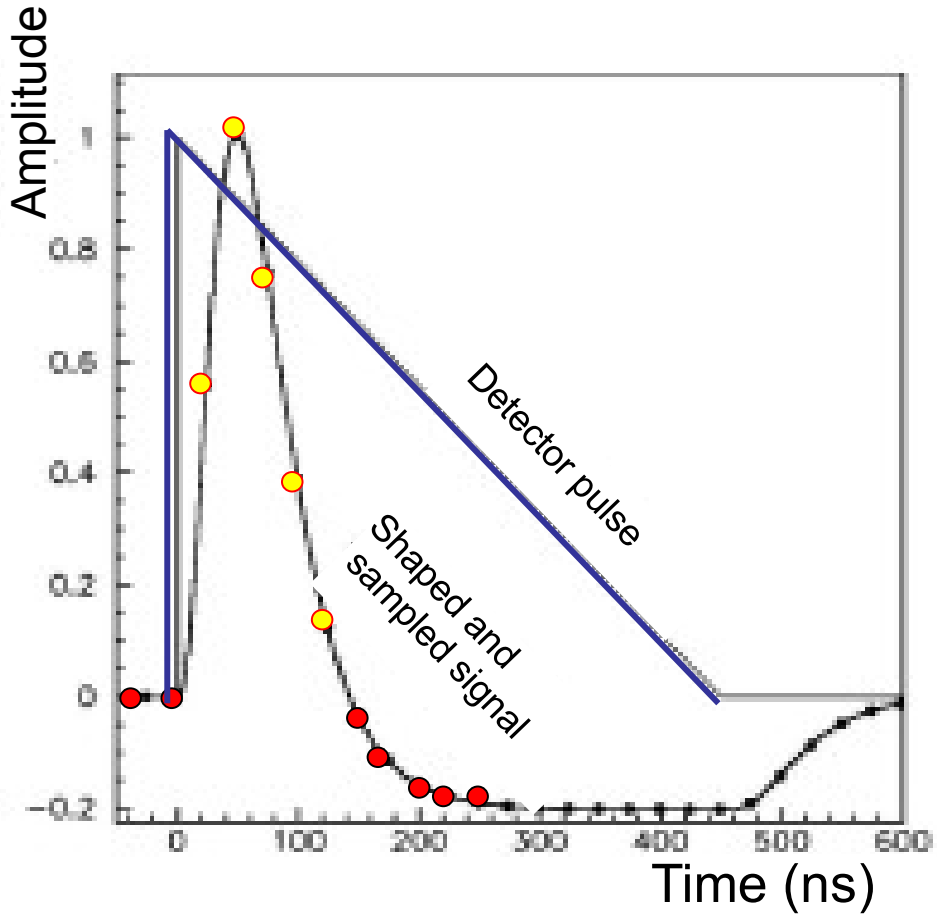
LAr Signal pulse

- Recorded LAr signal by electronics is a sampled wave at 25ns steps (bunch-crossing) modified by front-end electronics (shapers and gain).
- Current signal is injected by calibration system. It produces a pulse similar to physics, allowing for calibration of the Optimal Filtering (OF).
- Energy, time and signal quality (see expressions) for each signal are calculated by OF method. Iteration over phase is needed for cosmic data.
- Autocorrelation function is one of the important parameters for energy reconstruction (noise level study - pedestal)
- Ramp runs to measure electronics gain.
- Cross-talk between cells shall be identified.
- Pedestal/Cross-Talk, Optimal filter parameters stored in DB. Available for online/offline data reconstruction.
- Calibration runs taken regularly for 14 months now.

Energy : $E = \sum_{i=1}^{N} a_i (s_i - ped)$

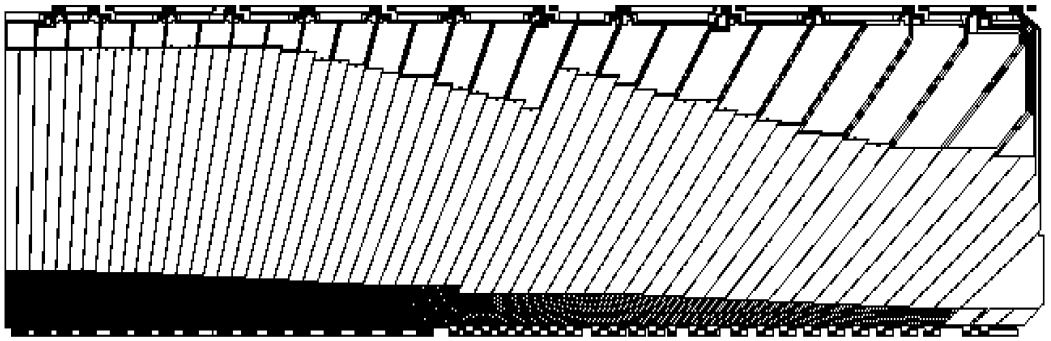
Peaking time: $E\tau = \sum_{i=1}^{N} b_i (s_i - ped)$

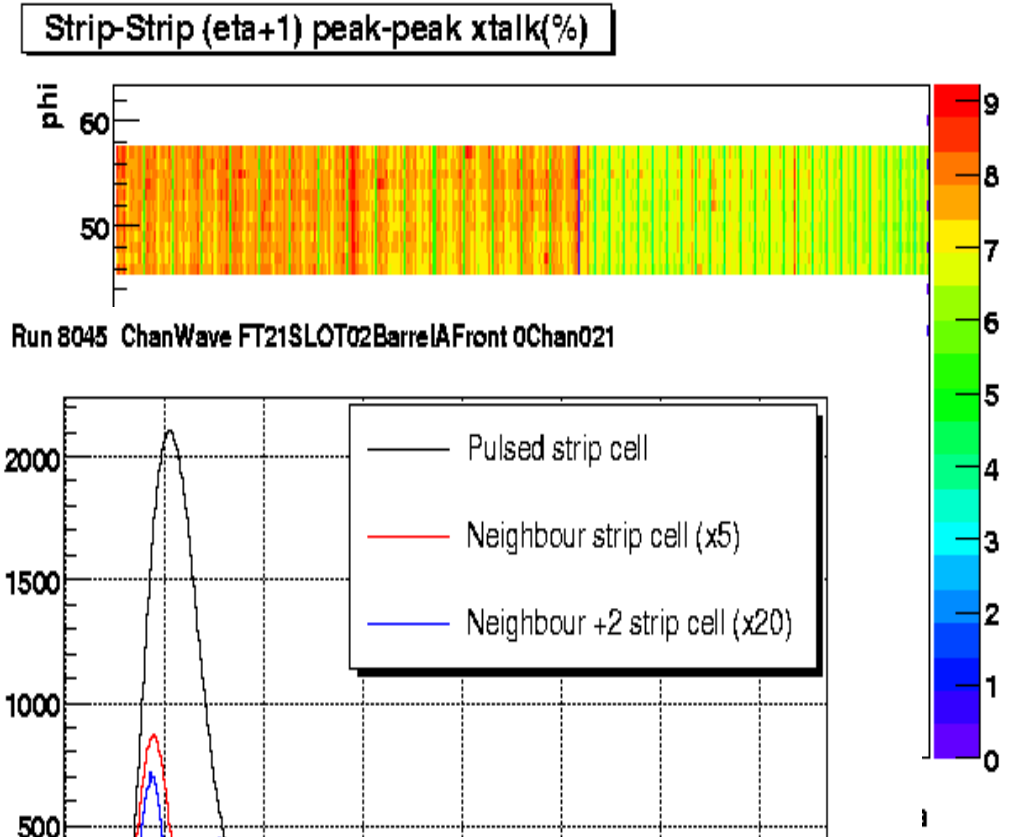
Quality factor : $\chi^2 = \sum_{i=1}^{N} (s_i - ped - E(g_i - \tau g_i'))^2$



Cross-talk studies by pulsing individual cells

Calorimeter cells :

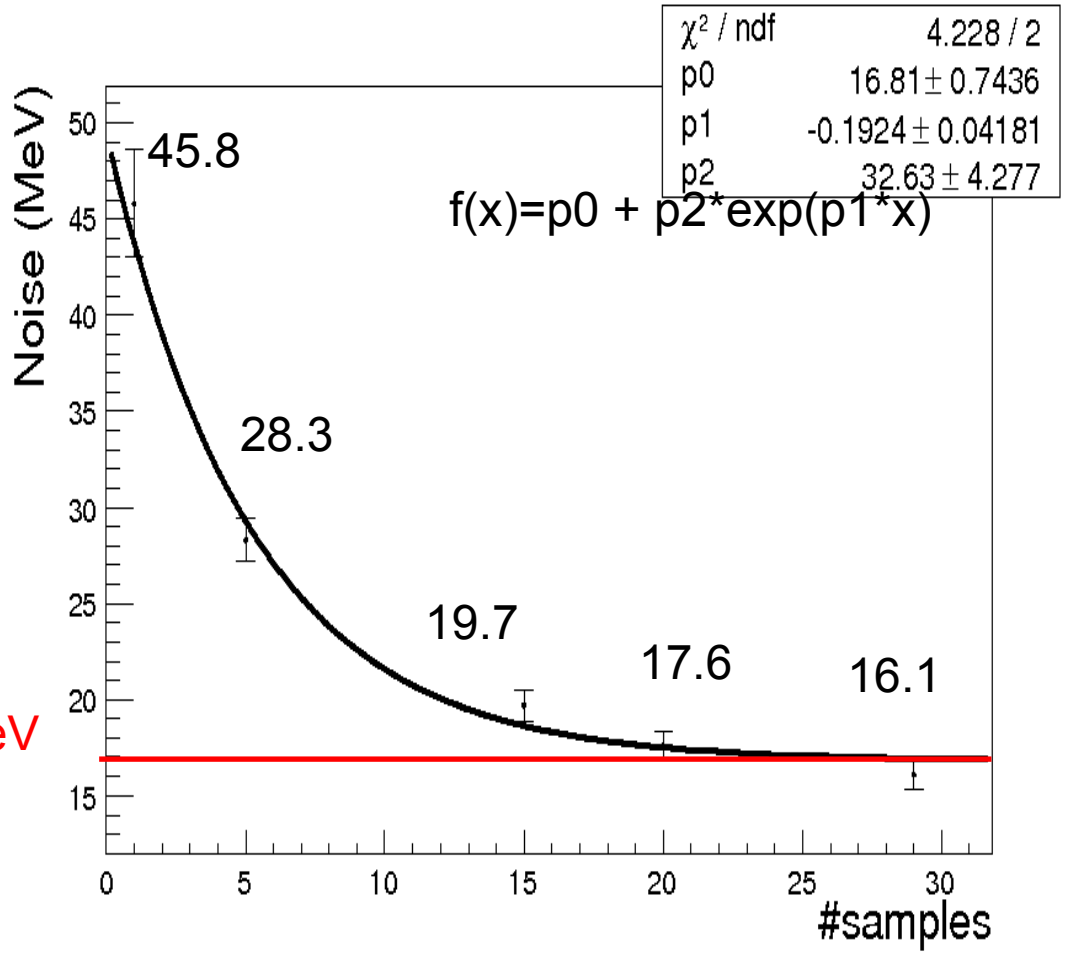




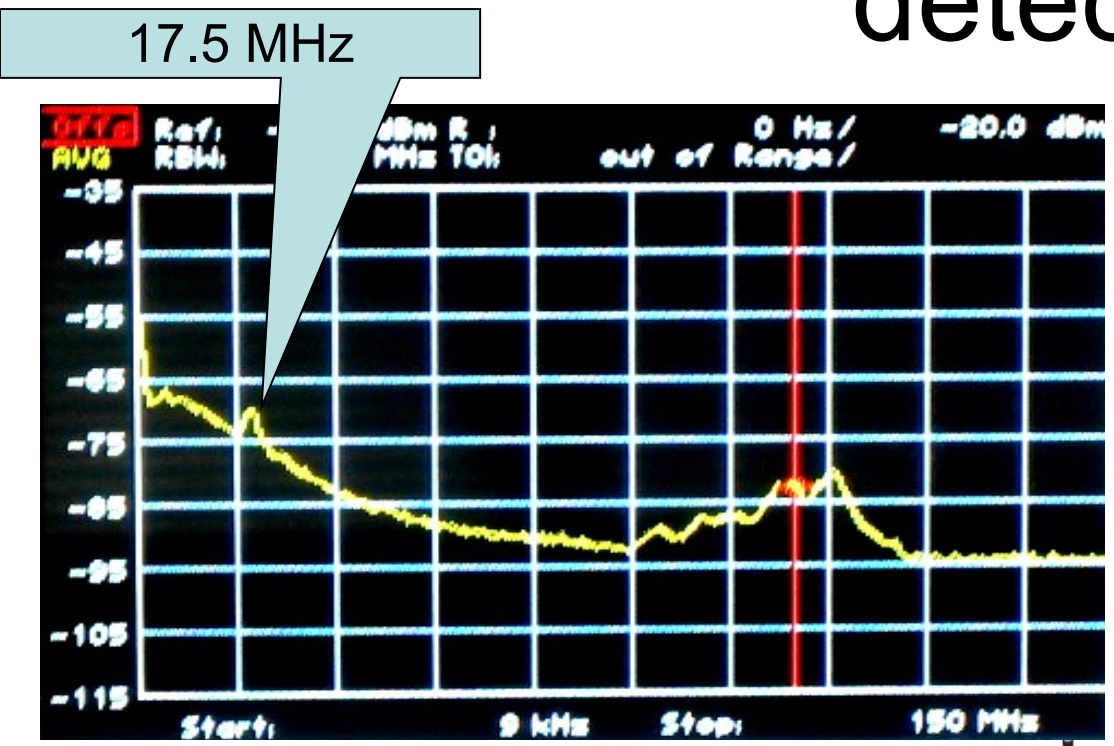
- Cross-Talk feature is expected by design.
- Signal is pulsed via calibration system into one cell and measured in cells around. Eg: Strip layer, cells very close together.
- Different kinds of cross-talk between cells are due to happen (capacitive, resistive, inductive).
- Cross-talk between neighboring strips of the order of 7.2% in the Barrel and 6.2% the EndCap (Note the multiplication factors in plot - x5, x20). This is taken in account in energy reconstruction, so, no calorimeter performance degradation. This was demonstrated during testbeams.

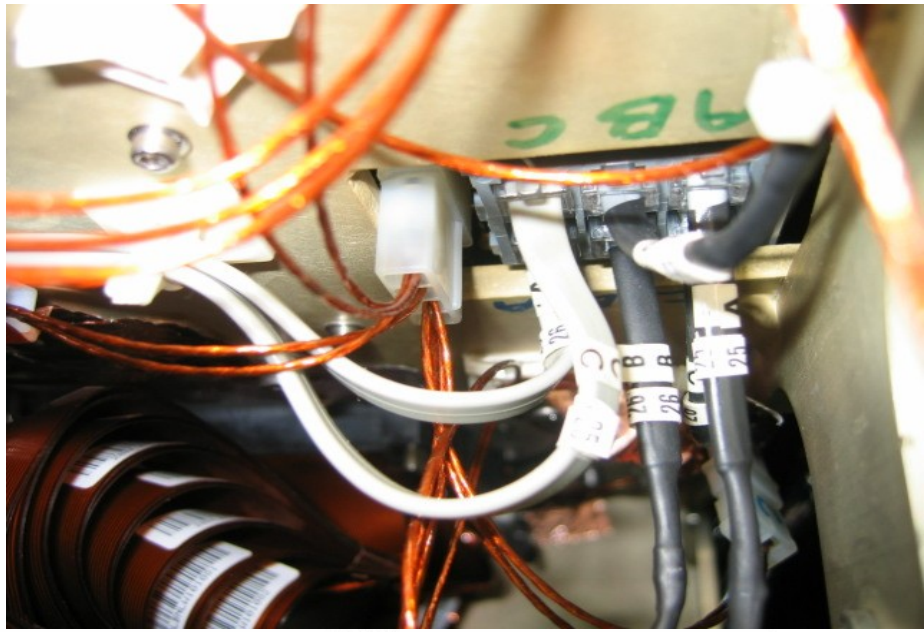
Noise studies with large number of samples.

- As can be seen, noise level can be kept low with more samples.
- Noise study may help to identify also hardware problems.
- Energy deposited by muons in LAr calorimeter is low (~230 MeV for the Barrel 2nd layer). Noise reduction is important for signal detection.
- Signal to noise ratio in this case is large enough to allow for cosmic muon detection.

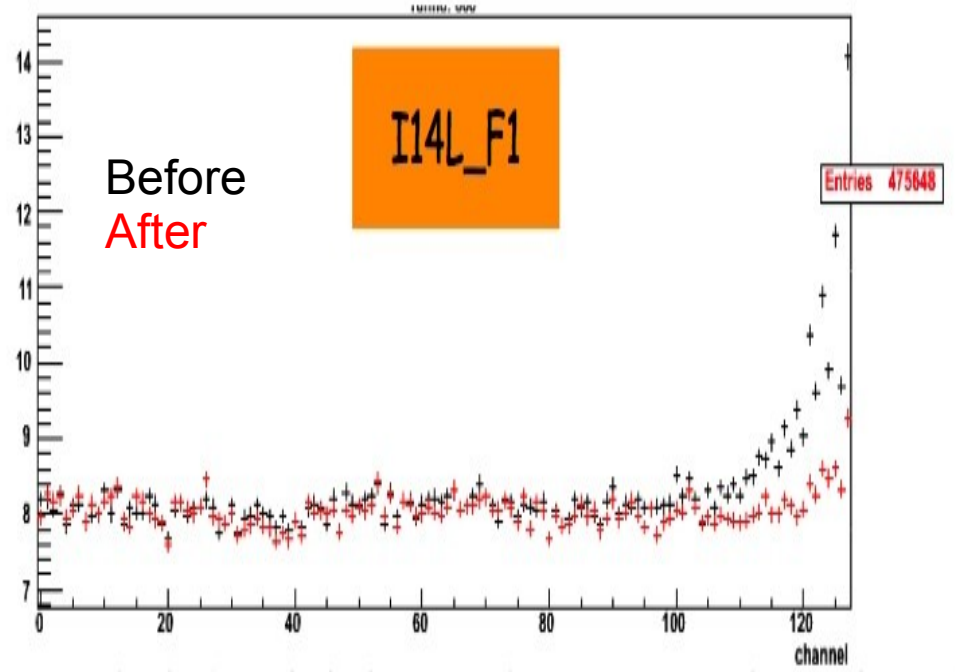


Searching for noise sources on detector



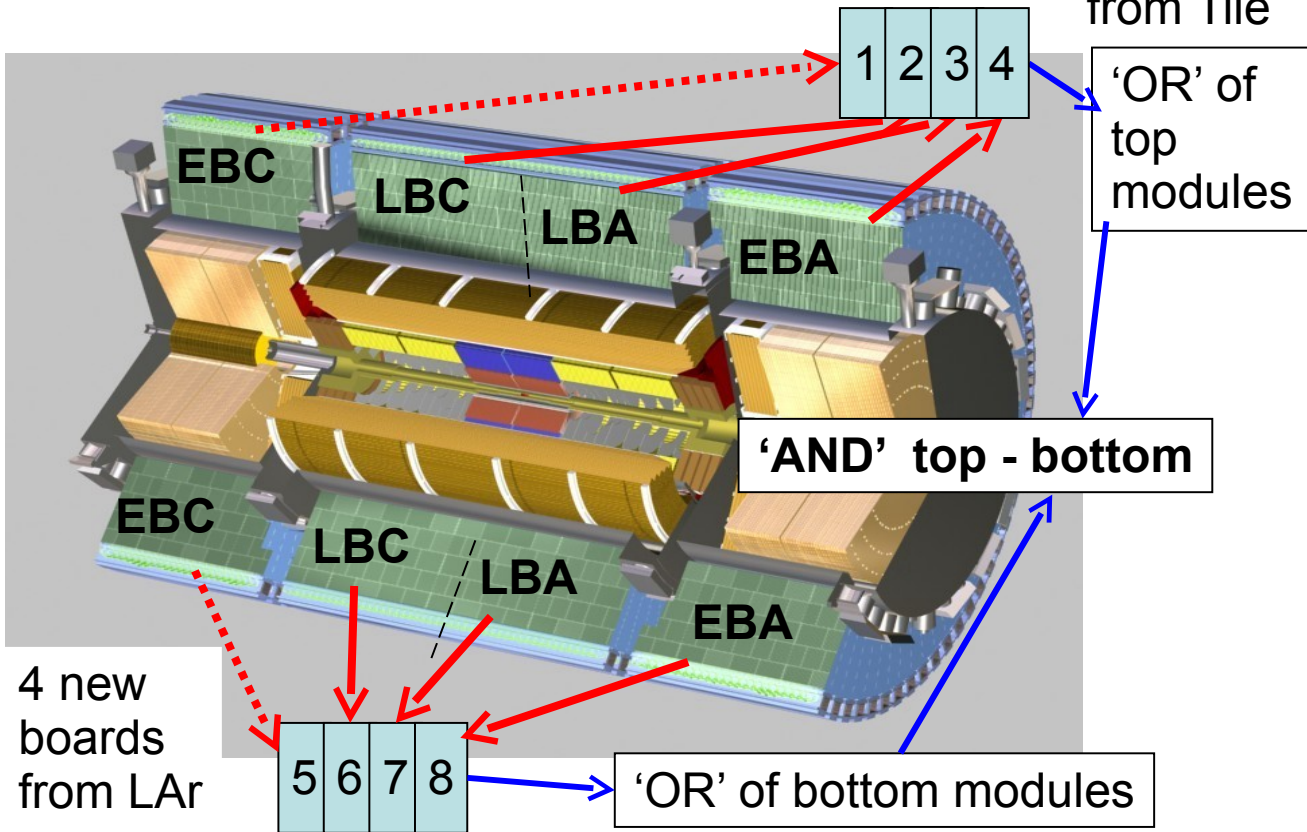


- Since many different ATLAS components are now operating together in the experimental hall, pick up noise sources appear and must be identified.
- Additional filter boxes had to be installed to reduce noise picked up from Feed-Through heating system. See Before and After.
- FEBs can be used (as they sample data at 40 Mhz) as scope to detect such failures.



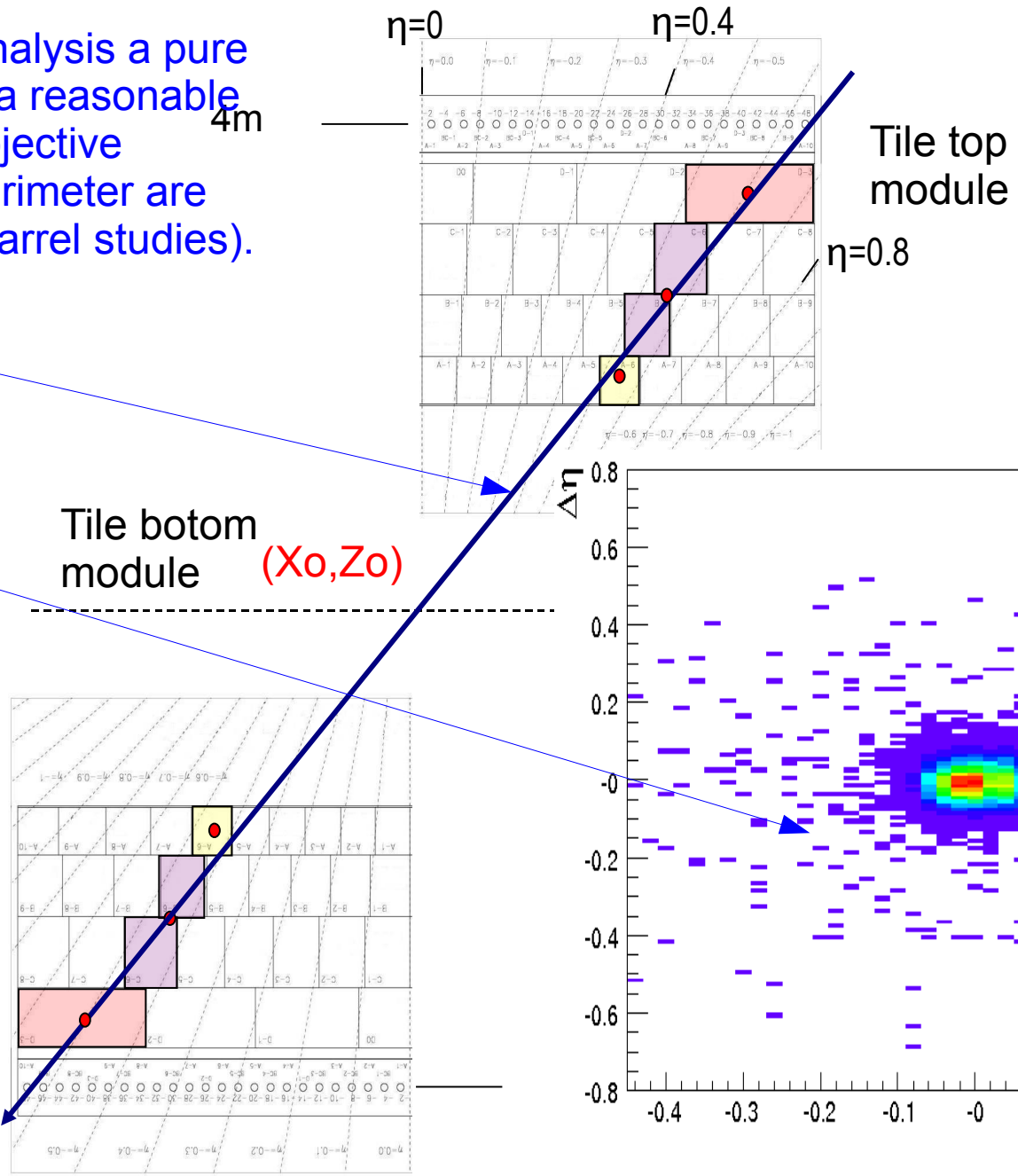
Cosmic rays commissioning
Calorimeter self-triggering

- Cosmic runs are the only possible workplace for detector commissioning prior to real LHC beams. Many important exercises can be performed.
- Atlas Level 1 trigger not designed to trigger on cosmic muons.
- During integrations exercises, Tile Calorimeter Trigger signals are used for subdetector self-triggering. Muons signal in this detector is larger (order of 2 GeV) allowing for good muon detection.
- Tile Calorimeter developed coincidence boards which allow for different trigger schemas.
- This “similar to LVL1” signal was used to trigger subdetectors.
- Top-Bottom coincidence is used.

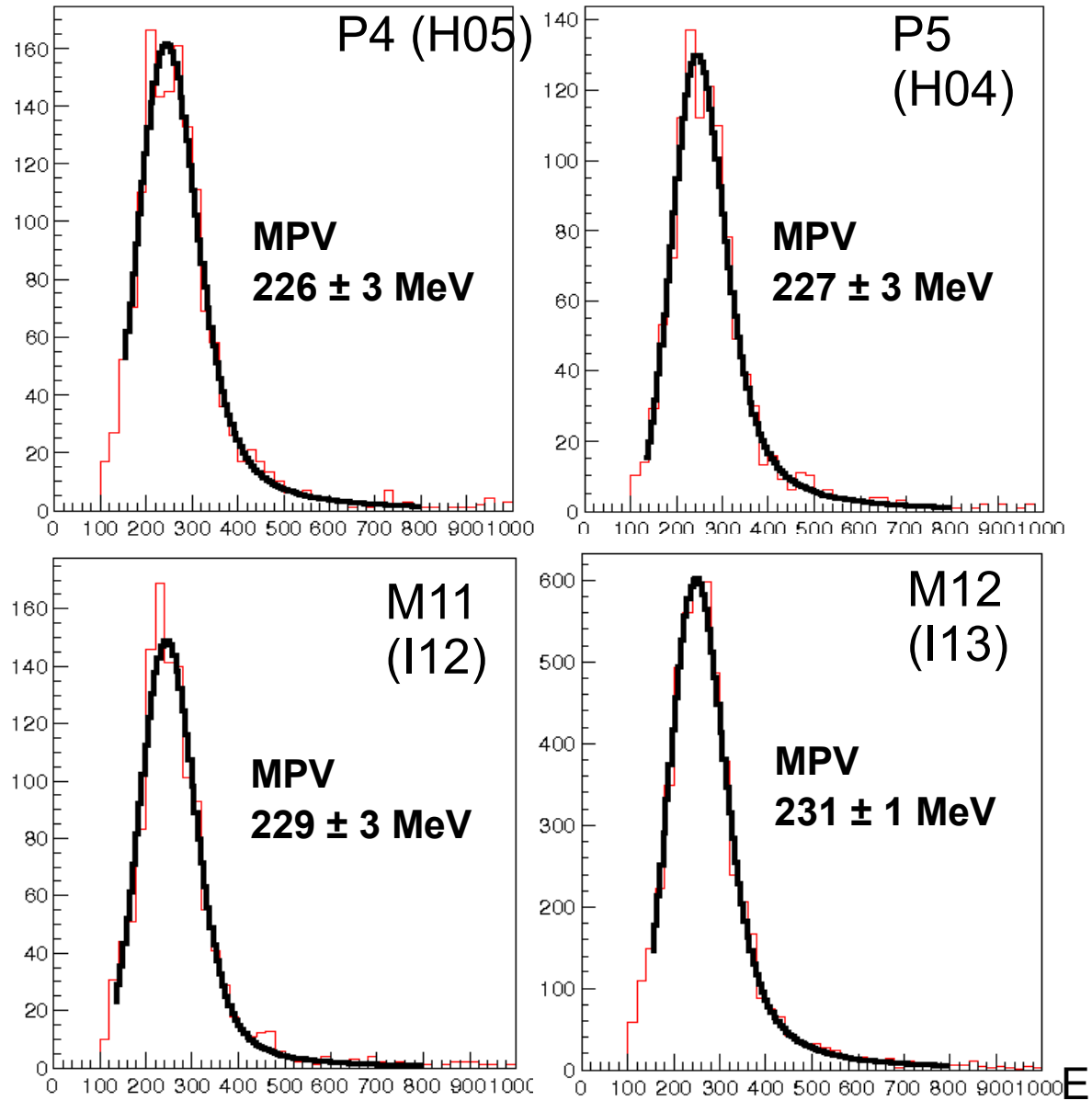


Cosmic muon analysis – Comparison of muon positions in LAr and Tile Calorimeter

- In order to use for analysis a pure cosmic sample,with a reasonable path in LAr cells, projective events from TileCalorimeter are used (specially for Barrel studies).
- LAr clusters found must be close to muon track identified by Tile.
- Picture shows (in eta/phi), distance between LAr cluster and muon track defined by Tile.
- Cosmics since August last year (now every weekend).

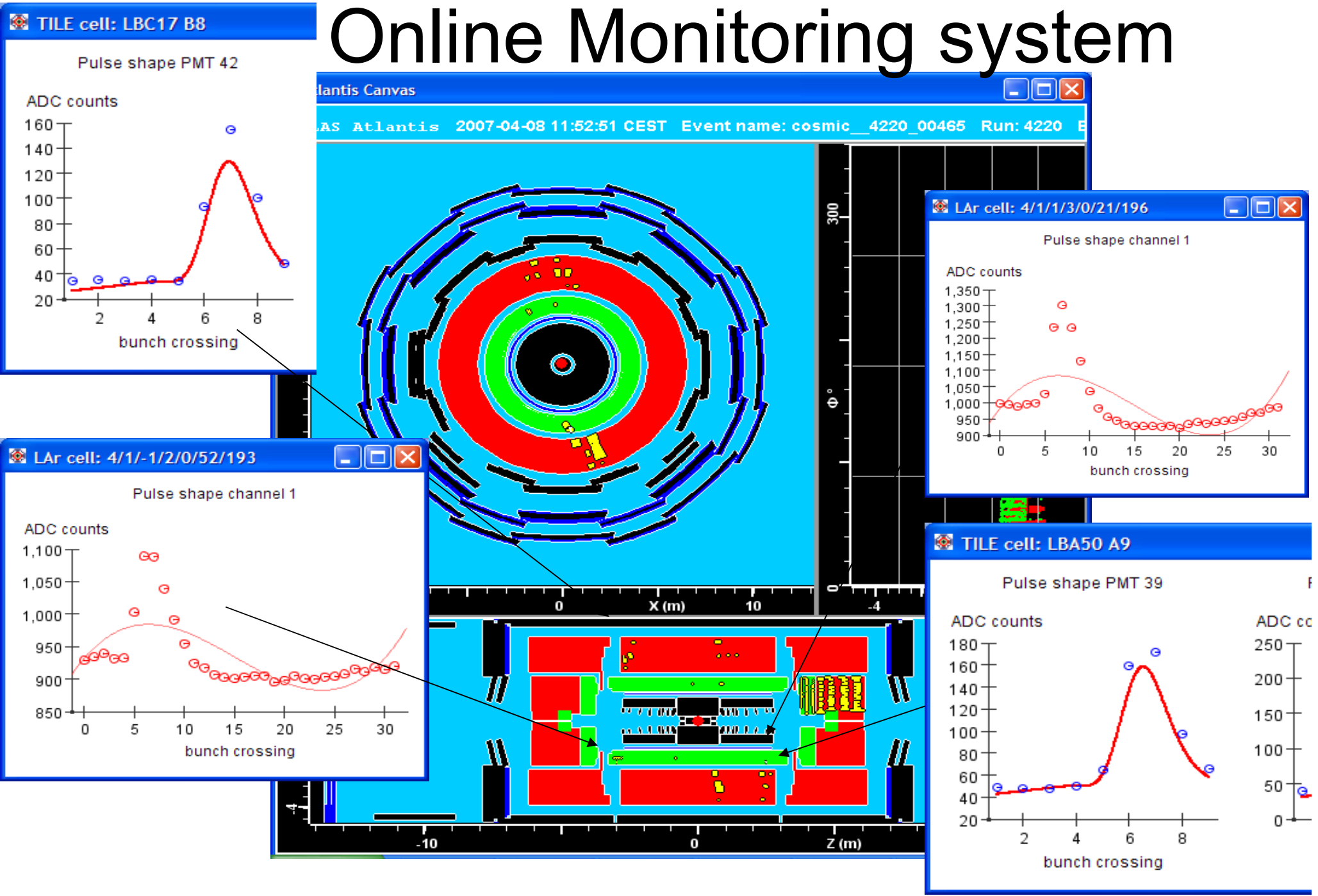


Energy Calculated for purified data sample

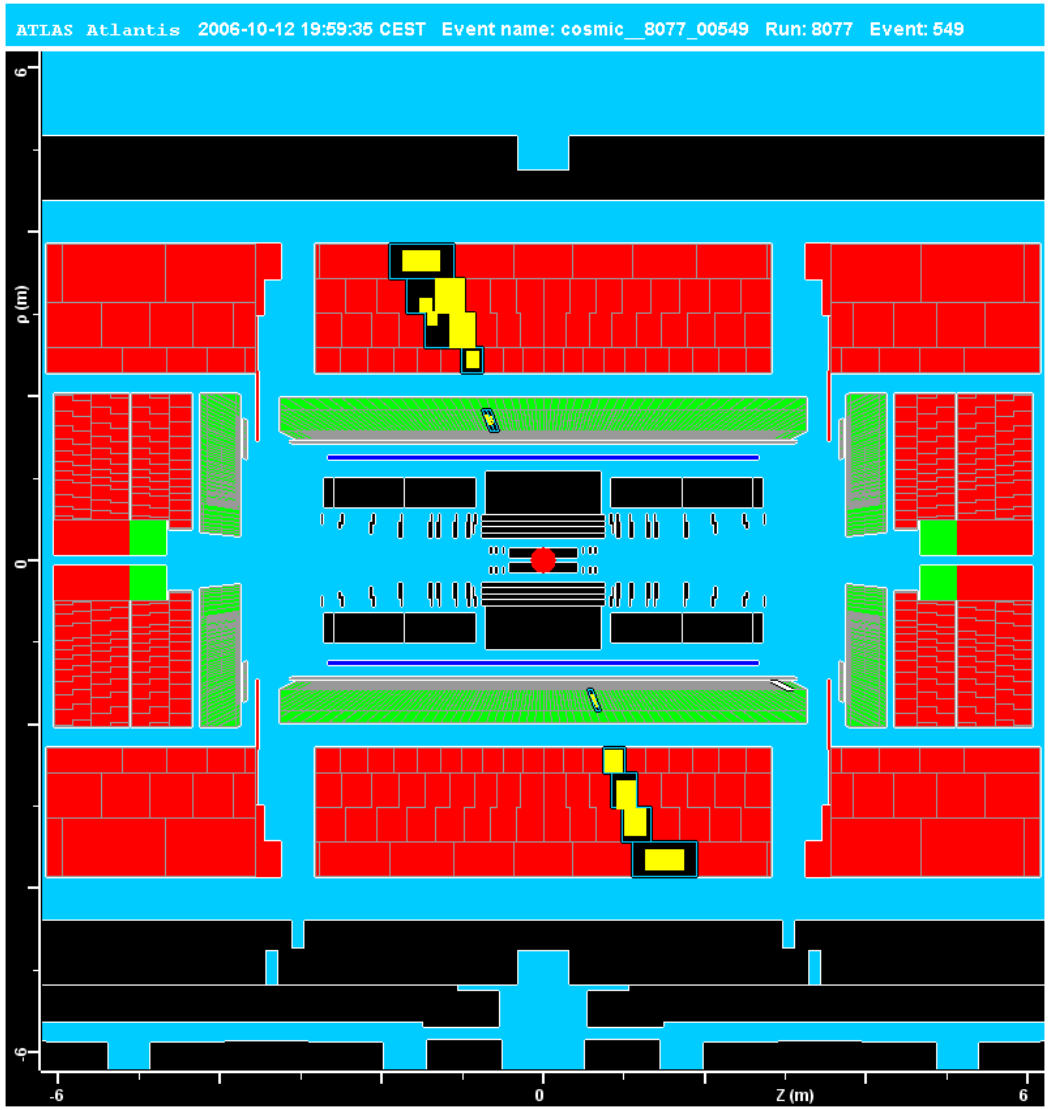


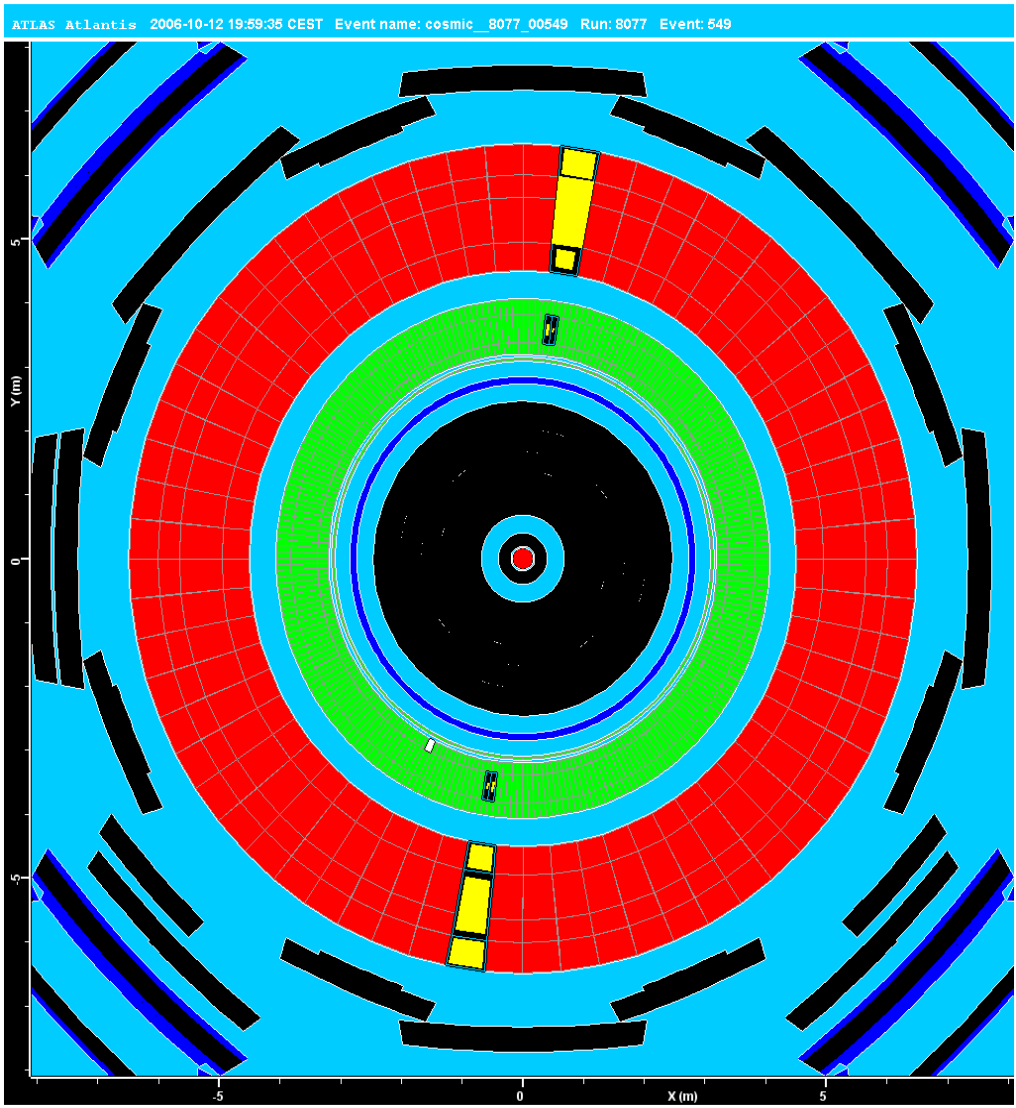
- Based on this offline purified (projective selected) sample found with the help of Tile Calorimeter identified track, one can calculate the energy deposited in the LAr cells by the muon.
- The results can be fitted with the expected Landau (folded with a gaussian due to electronics noise) to check its Maximum probability value.
- Here results by calorimeter sector for Barrel.

Combining info from both calos Online Monitoring system



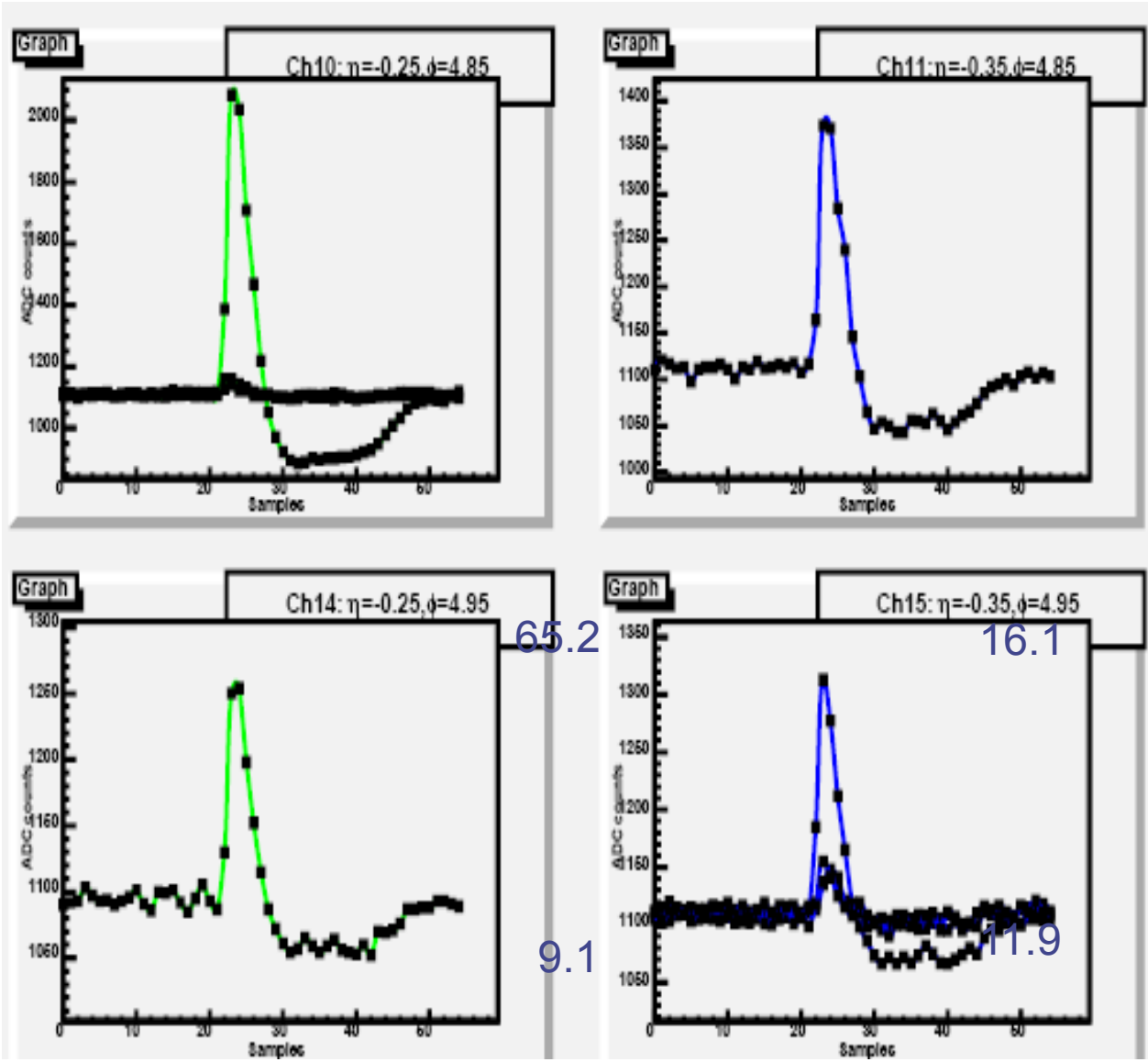
Another event in the EMB





Cosmic Data Taking through the LAr LVL1 output

- The main goal of the cosmic data taking for the LVL1 is to check the LVL1 readout values with the reconstructed energy in the cells that compose each of the Trigger Towers.
- We can also check the timing corrections to optimize cell->Trigger Tower analog summing.
- A standalone DAQ system with complete readout capability is being used while final system not available.
- This system is, however, very limited in terms of eta/phi coverage. We use 4 ADCs -> 2 on each side, giving us the possibility to look at 16 Trigger Towers at once.
- The Trigger Towers must be chosen prior to the run start up.



Concluding Remarks

- ATLAS detector undergoing commissioning and integration phase of its subdetectors.
- Liquid Argon calorimeters (Electromagnetic, Hadronic EndCaps and Forward sections) are in place with LAr and cooled. They are being equipped with Front-End Electronics (more than half of the detector is operational) and prepared for data taking.
- LAr Calorimeters are being commissioned with calibration and cosmic runs. Integration on ATLAS framework ongoing.
- Stability (over time) of the equipment and uniformity of detector response also being assessed.
- Tools developed to investigate calibration, delay stability and uniformity in common ATLAS software framework.

Concluding Remarks

- Due to increasing detector coverage, such tools will be fundamental to detect/fix problems and perform overall detector calibration.
- Cosmic ray events selection based on Tile Calorimeter information helps to identify real muons in Liquid Argon. First energy estimates for real physics events.
- Front-End Analog LVL1 Trigger Tower building system also cross checked and calibrated against Front-End digitally acquired signal.
- LAr Calorimeters will be fully equipped with Front-End Electronics in 3 months. Commissioning of whole detector will prepare calorimeter for first LHC beams.

Extra Slide

- In case we got time

Uniformity measurement based on Muon signal.

- Blue points are Sampling 2 cells length for each eta bin.
- Red crosses are the energy measured by muons (MPV) for that eta bin.
- Signal is consistent and can be correlated with cell size, as expected for muons.