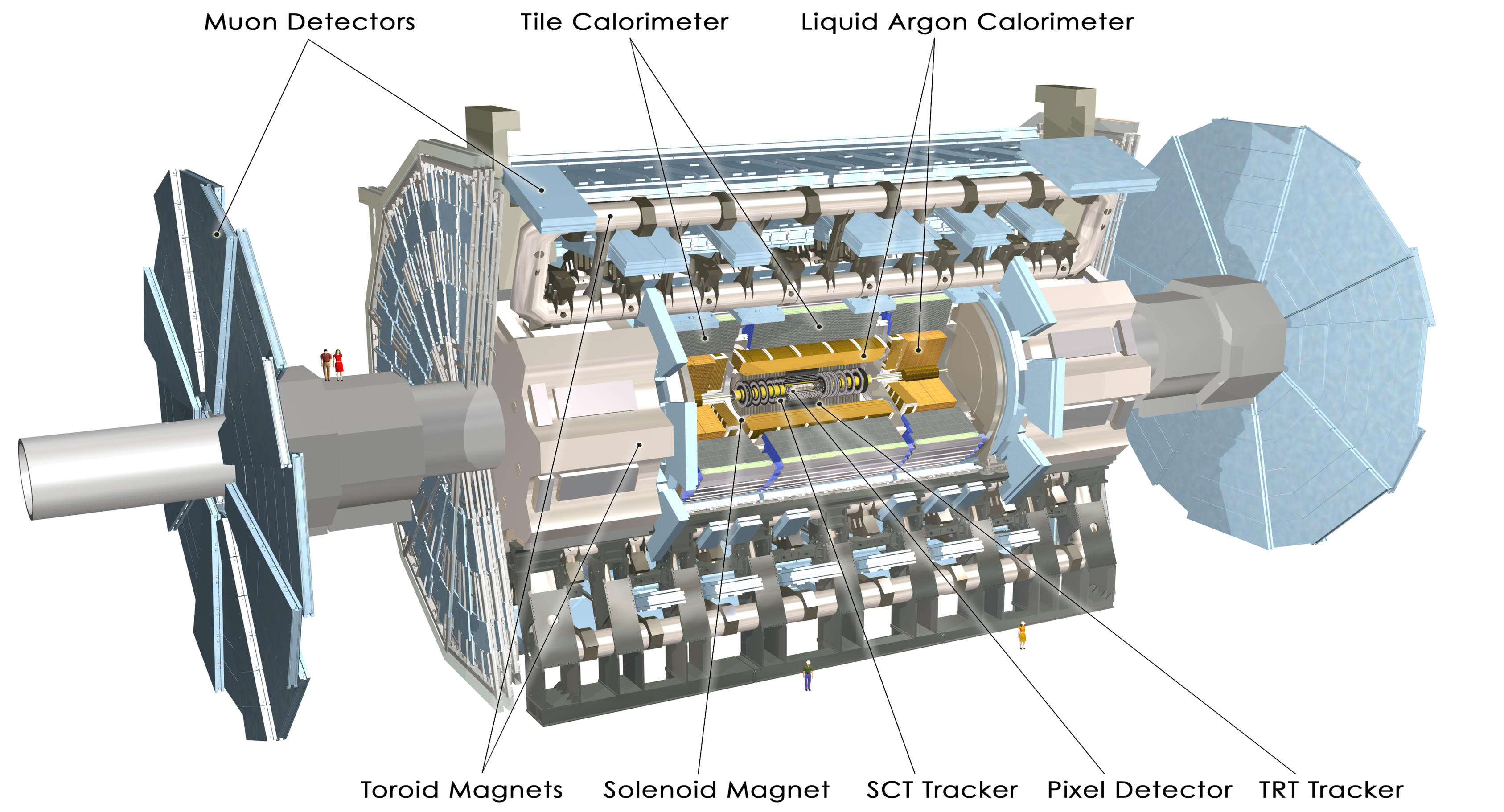
ATLAS High Level Calorimeter Trigger Software Performance for Cosmic Ray Events

by Denis Oliveira Damazio (Denis.Oliveira.Damazio@cern.ch),
Brookhaven National Laboratory, USA
on behalf of the ATLAS Collaboration

The ATLAS Detector @ LHC



ATLAS is one of the 6 detectors on the Large Hadron Collider. The LHC will collide bunches of protons with 14 TeV energy in the center of mass at the nominal luminosity ($10^{34}cm^{-2}s^{-1}$) at a rate of 40 MHz. This will generate up to 1G events per second. Most interesting higher pT events are rare and are immersed in a huge background of di-jet events. Since only 200 events can be saved per second, an efficient trigger system was built. Presently, the ATLAS subdetectors are taking commissioning and integration runs with cosmic rays, awaiting for the first LHC collisions later this year. The ATLAS trigger system could be run with the full detector for such exercise.

ATLAS has 3 different calorimeter technologies : a lead/liquid argon calorimeter (EM), copper/liquid argon (hadronic, large pseudorapidity) and iron/scintillating plates (hadronic, lower pseudorapidity), covering in total a region up to η=4.9.

The ATLAS Trigger and Data Acquisition System

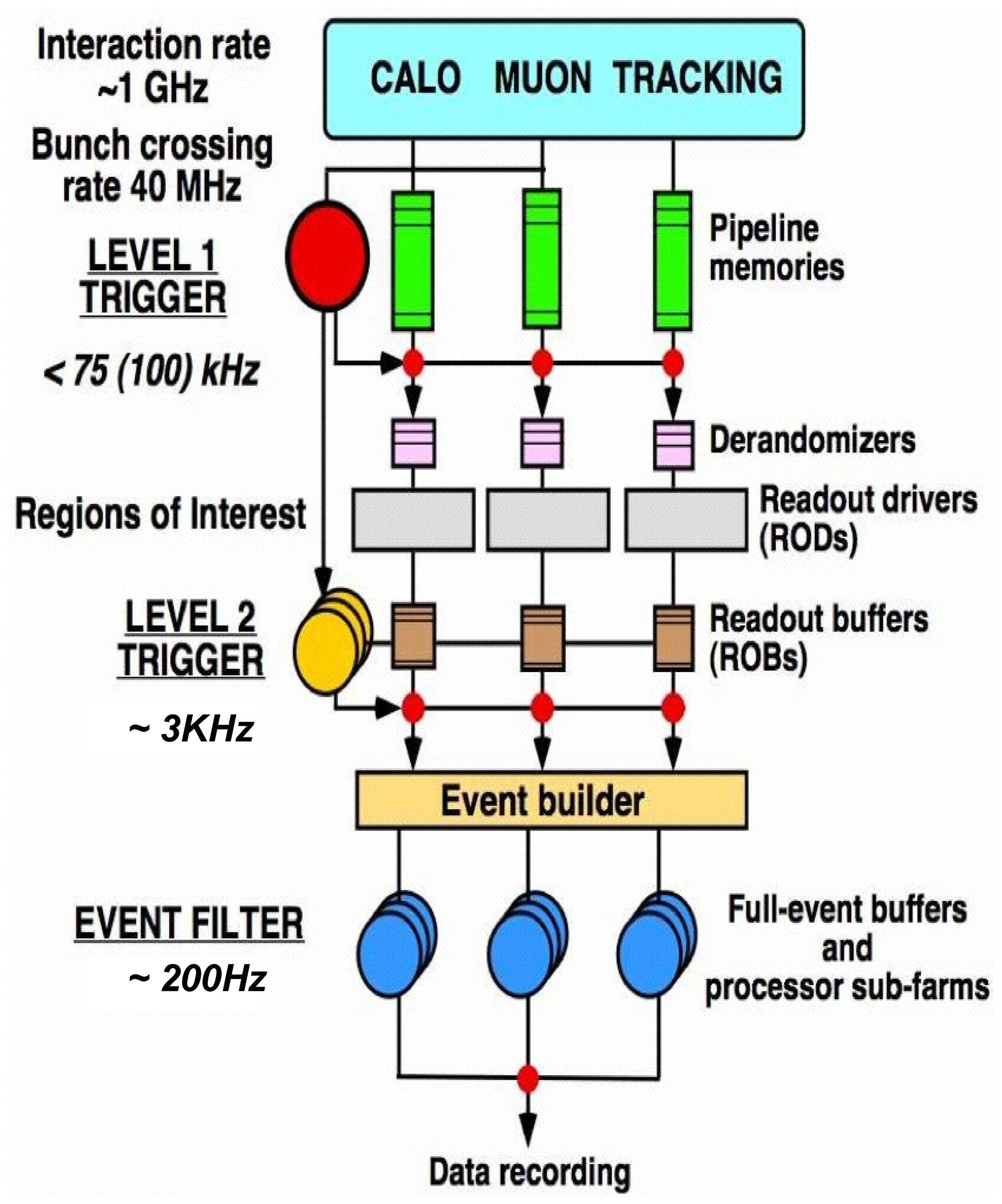
The calorimeter and Muon Systems are able to provide an analogue coarse granularity version of the detector readout. This is fast enough to be used by the Level 1 trigger system for starting the data acquisition process.

For the events accepted by the L1, the coordinates of the L1 fired regions, called Trigger Towers in the calorimeter case, are used to guide the Level 2 software algorithms. This is the so-called Region Of Interest (RoI) mechanism.

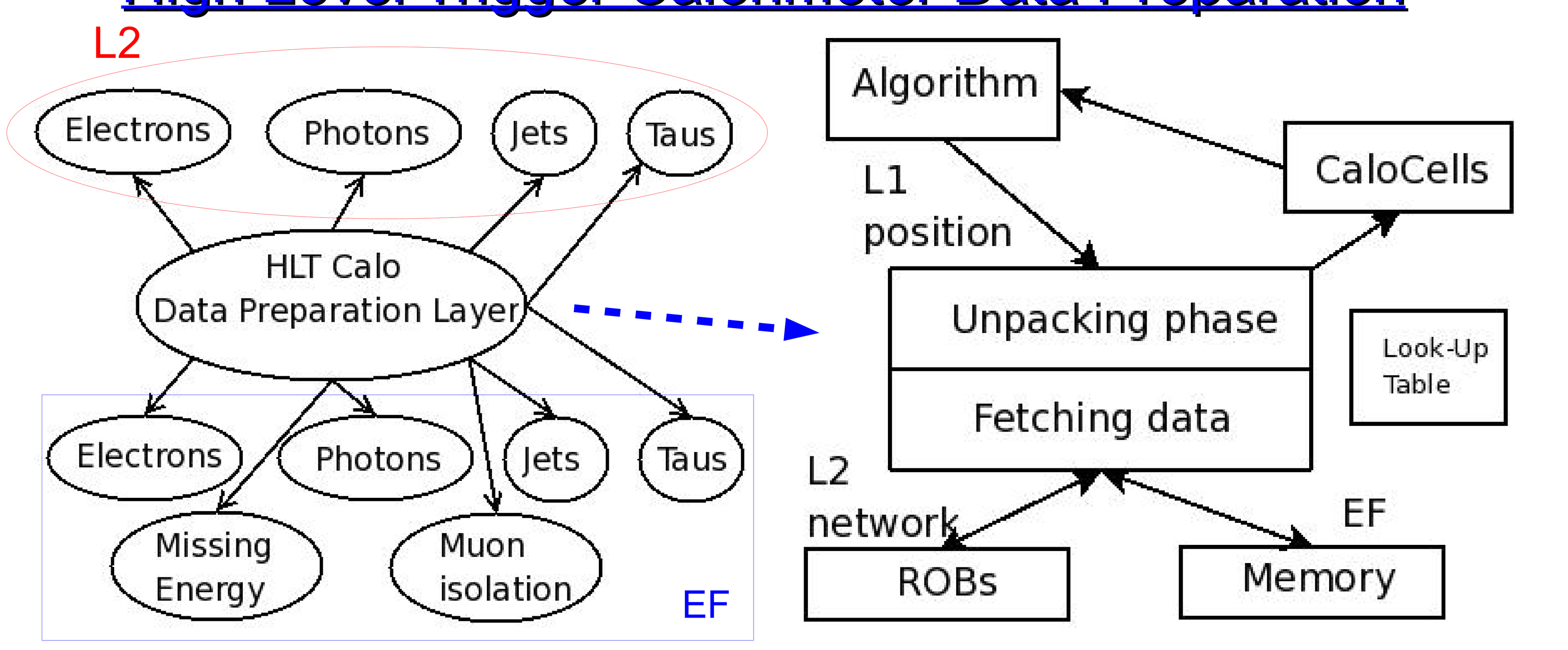
At L2, only a fraction (2%) of the detector at full granularity around the L1 seed is used (selective readout). This is done by requesting just a fraction of the Read Out Buffers (ROBs).

Approved events by the L2 are sent to the Event Filter farm. Data from all ROBs are gathered in a single memory block in the process called Event Building and sent to the EF nodes. These run offline reconstruction like algorithms using full detector at full granularity. The EF can also profit from most recent calibrations.

Since the L2 and the EF are built in software running in off-the-shelf PCs, they are commonly referred to as the ATLAS High-Level Trigger (HLT).



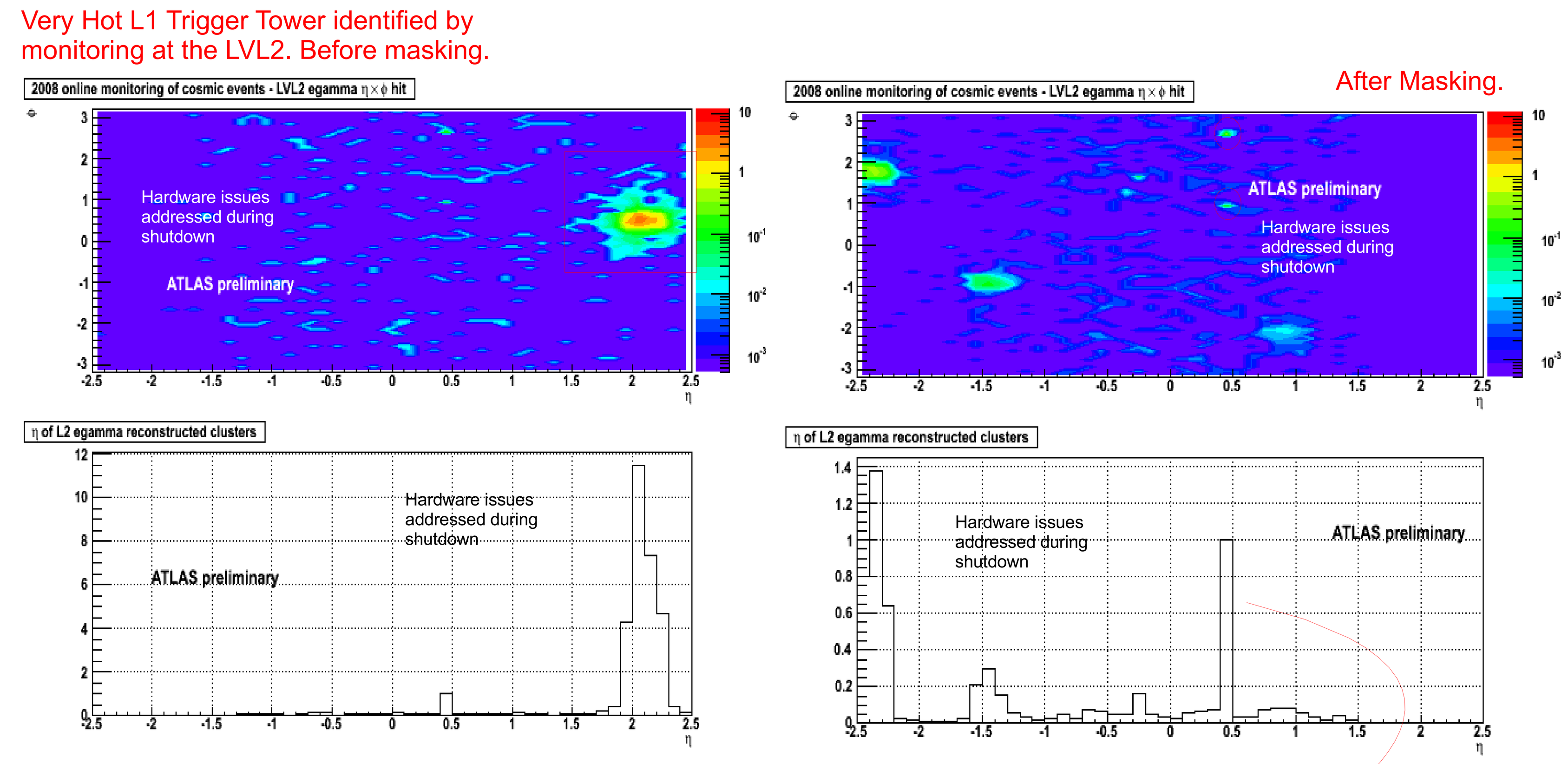
High Level Trigger Calorimeter Data Preparation



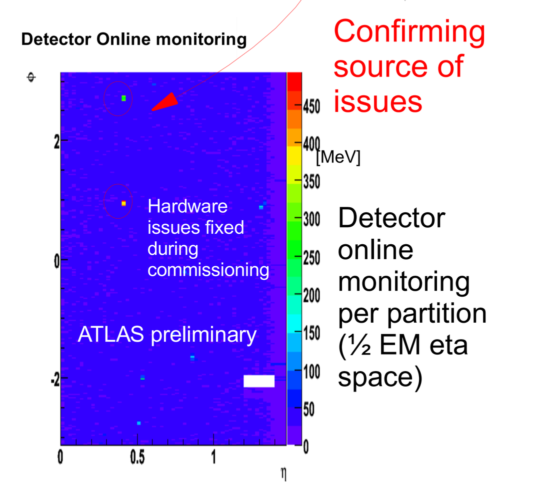
A common data preparation software layer is used by L2 and EF calorimeter algorithms, performing readout channels unpacking. The L1 position is used by the different trigger reconstruction algorithms to define (in detector coordinates) the RoI to be unpacked. For instance, a L2 photon algorithm uses a ($\Delta\eta$,$\Delta\phi$)=(0.4,0.4), whilst a L2 jet algorithm needs (1.0,1.0).

In the L2 case, data is fetched from the network. A Look-Up Table is used to find the ROBs containing the interesting data. For the EF case, this table finds the memory addresses for the different ROB fragments. The Unpacking phase converts the raw detector data into physically meaning objects, like calorimeter cell energies and associates its geometry. A group of such cells is provided as a vector, in an optimized organization for the algorithms processing. These elements are cached by the data preparation. In case of overlapping RoIs, data is unpacked only once for the intersection regions, improving the processing time of the second algorithm. Data is provided to electron, photon, jets, taus, missing transverse energy reconstruction and muon isolation algorithms. Different clustering strategies are used depending on the physics goals to be achieved.

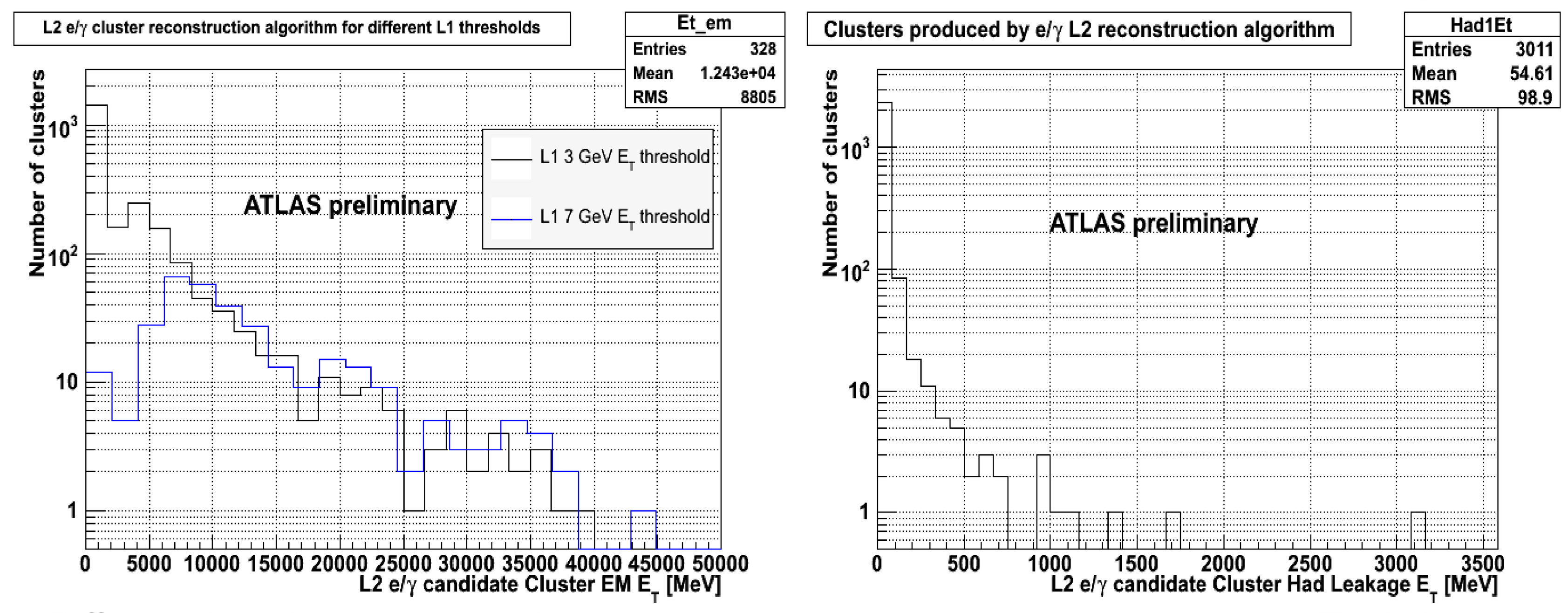
Online Monitoring : HLT and detector information



After the initial calorimeter assembly, less than 1‰ cells presented elevated noise level. Since the L1 system is working in an energy range inferior than its original design, hot Trigger Towers could be found. These could be masked in a run to run basis via the DAQ system. The hot cells can be also spotted in the calorimeter cell level monitoring. This way, it is possible to quickly track down sources of problems. These cells can also be masked in the HLT Calorimeter Data Preparation layer. Such noisy spots are being addressed during this year shutdown period.

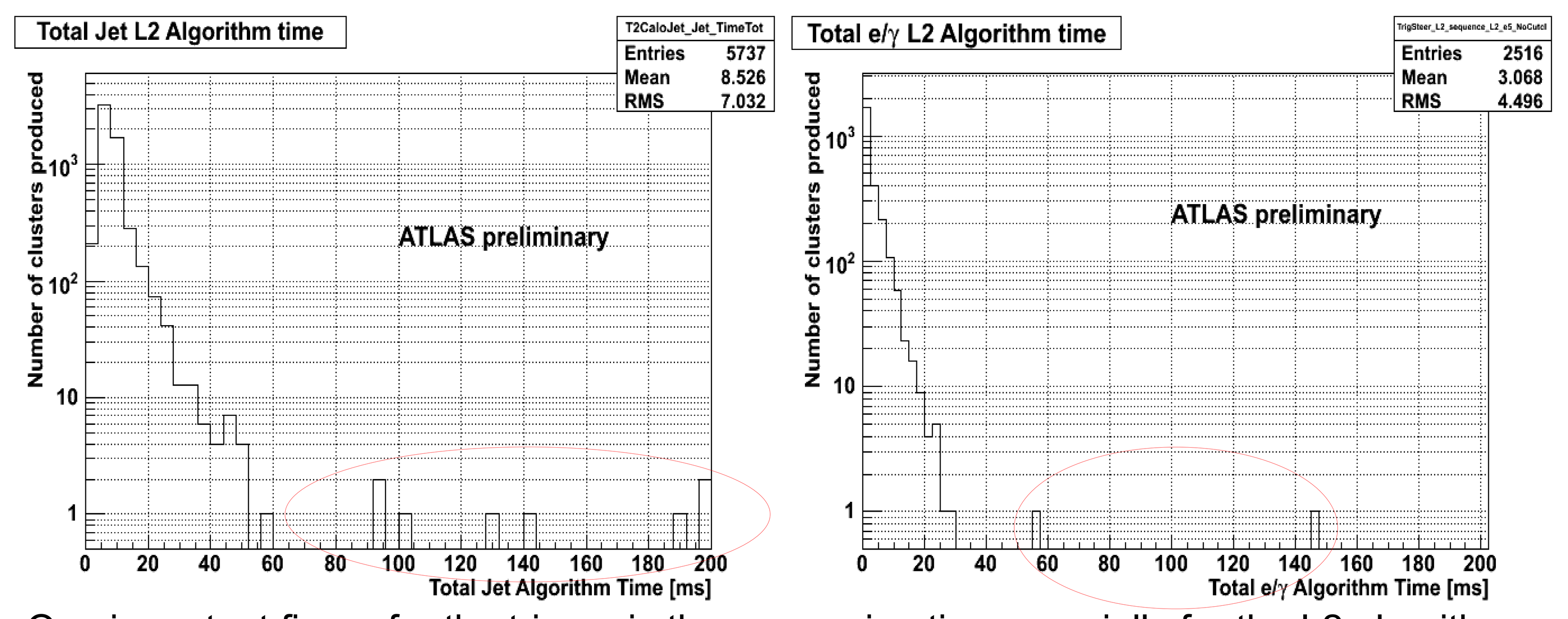


HLT Calorimeter Performance for Cosmic Rays



Different L1 trigger thresholds lead to more selective triggering at the HLT. Higher L1 thresholds help the HLT to avoid the detector noise line. The plot on the left above shows the energy deposited in the EM calorimeter as calculated by the L2 e/γ algorithm for two different L1 thresholds. The plot on the right shows the energy on the first layer of the hadronic section. The software is able to unpack the information from the different calorimeter technologies, providing this data in a common structure for the algorithms.

Online Algorithms Processing Time Performance



One important figure for the trigger is the processing time, specially for the L2 algorithms. Jets reconstruction algorithms need larger RoI (more time consuming for data unpacking) as it must loop over many cells to build a Jet cone. The e/γ algorithm with a smaller RoI, needs less processing time.

The first event in each machine of the L2 processing farm may be slower due to the loading of detector conditions. This can be spotted in both plots. We are presently addressing this issue, even though, thanks to the different buffers built into the data acquisition system, these cases are not problematic for the detector operation.

Conclusions and next steps

- The initial cosmic data taking period with the ATLAS detector was an excellent opportunity to exercise the HLT Calorimeter Algorithms. Electrons, photons, taus, jets, missing transverse energy and muon isolation algorithms could be studied.
- The online monitoring system helps to identify problems in the data taking and their sources (like noise regions in detectors). Immediate actions help to avoid beam time lost.
- The algorithm performance is consistent with what is expected. For instance, the L2 energy measurement is similar to the L1 for more energetic shower deposition. For too low L1 thresholds, the noise level degrades the performance, as expected.
- The time performance of the algorithms is well within the L2/EF budget.
- We are presently improving the monitoring to provide enough information to mask possible noisy cells in the HLT Calorimeter Data Preparation.

References

(1) .The ATLAS Collaboration, G. Aad et al., The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003. http://www.cern.ch/atlas

(2) DAQ, EF, LVLE2 and DCS Technical Progress Report LHCC 98-16. CERN, Switzerland, 1998.

(3) "Data preparation of the calorimeter based algorithms of the High-Level Trigger for the ATLAS experiment at the LHC". Damazio, D.O. On behalf of the ATLAS High-Level Trigger Calorimeter group. 10th ICATPP, Como, Italy, 2007.