



Status of the ATLAS Calorimeters and the First Level Calorimeter Trigger

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Content

- Overview
- Status of the LAr Calorimeter (MPP, MZ, DD)
- Status of the Tile Calorimeter
- First Level Calorimeter Trigger (HD, MZ, B)

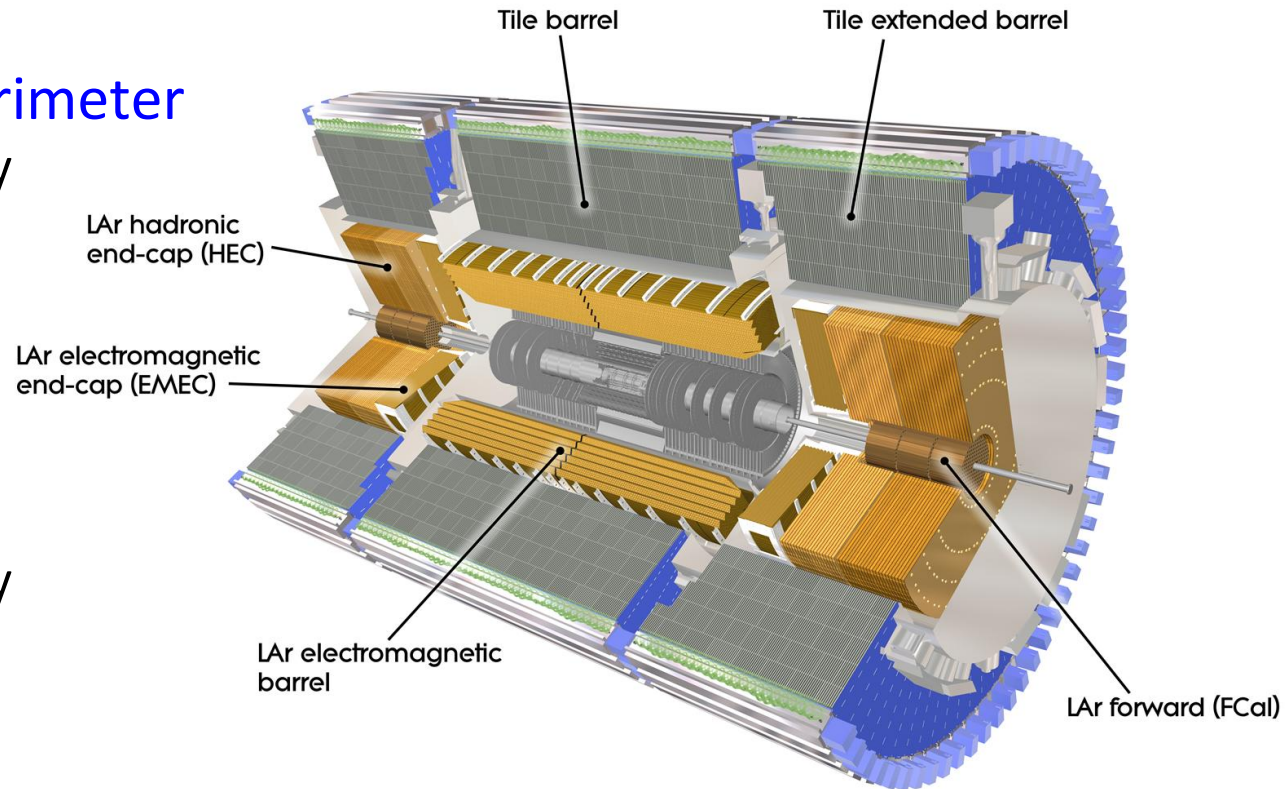
The ATLAS Calorimeter System

Electromagnetic Calorimeter

- Liquid Argon Technology
- 120 000 Channels

Hadronic Calorimeter

- Liquid Argon Technology
 - 70 000 Channels
- Tile Calorimeter
 - 10 000 Channels

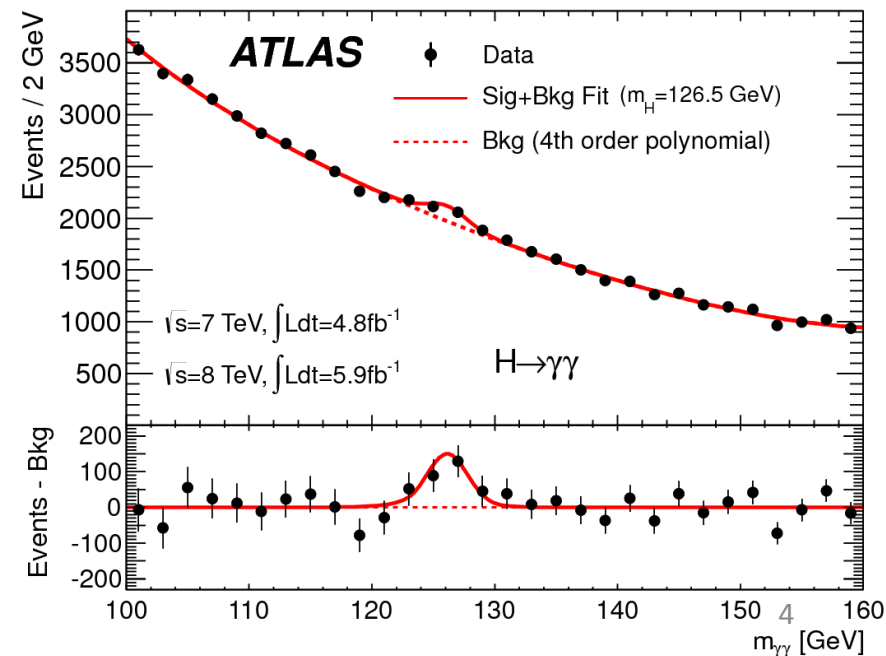
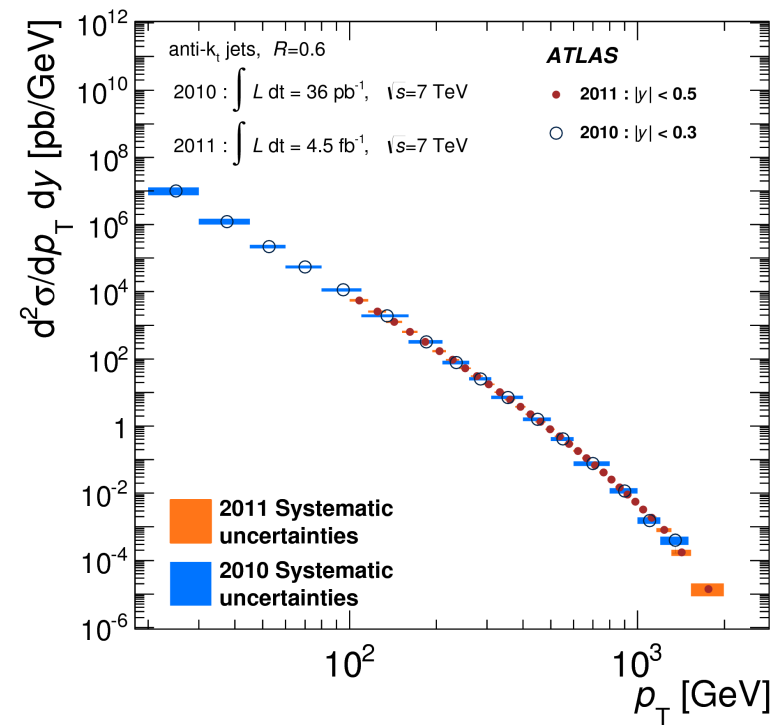


Resolution

- EM: $\sigma(E)/E = 10\%/\sqrt{E} \oplus 0.7\%$
- Had. (jets): $\sigma(E)/E = 50\%/\sqrt{E} \oplus 3\%$

Performance in Run-1

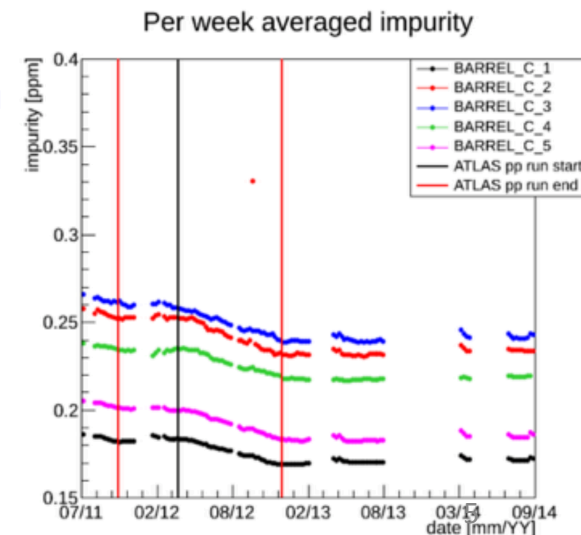
- Excellent performance during run 1
- Few broken channels
- Jet energy scale uncertainty $\sim 1\%$
- Electron energy scale $< 0.5\%$



Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	95.0%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	98.3%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.8%
LVL1 Calo trigger	7160	100%
LVL1 Muon RPC trigger	370 k	100%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	96.0%
RPC Barrel Muon Chambers	370 k	97.1%
TGC Endcap Muon Chambers	320 k	98.2%

LAr Calorimeter: Hardware

- **Front End Electronics**
 - 25 FE cards have been inspected and fixed, very few replaced with spares, mostly recovery of single broken channels
 - Broken transceivers replaced
- **Replacement of Low Voltage Power Supplies**
 - All 58 LVPS replaced, refurbished and reinstalled
- **Replacement of High Voltage Power Supplies in EndCaps**
 - Shorter ramp up time
 - Current reading for lumi measurement
- **Infrastructure and Detector Control System**
 - More robust FE cooling system
- **Purity and temperature**
 - Stable during run-1 and LS1, monitoring improved
- **Software**
 - Various improvements



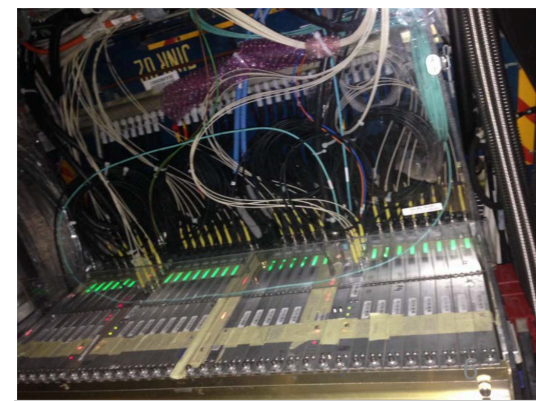
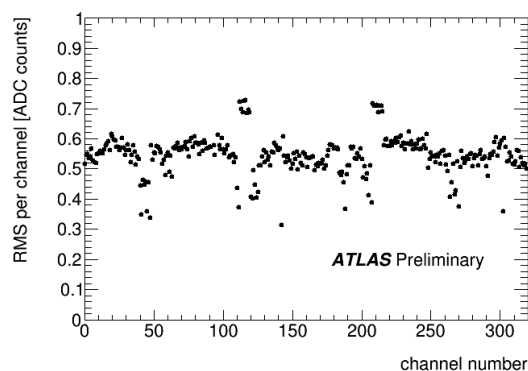
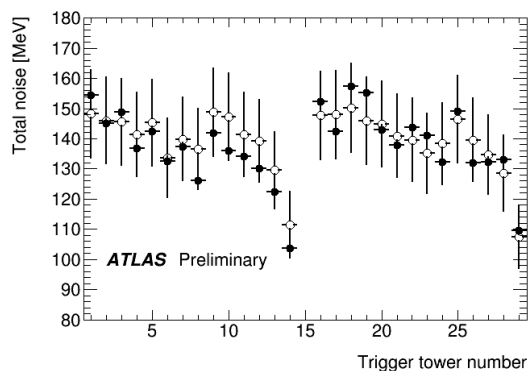
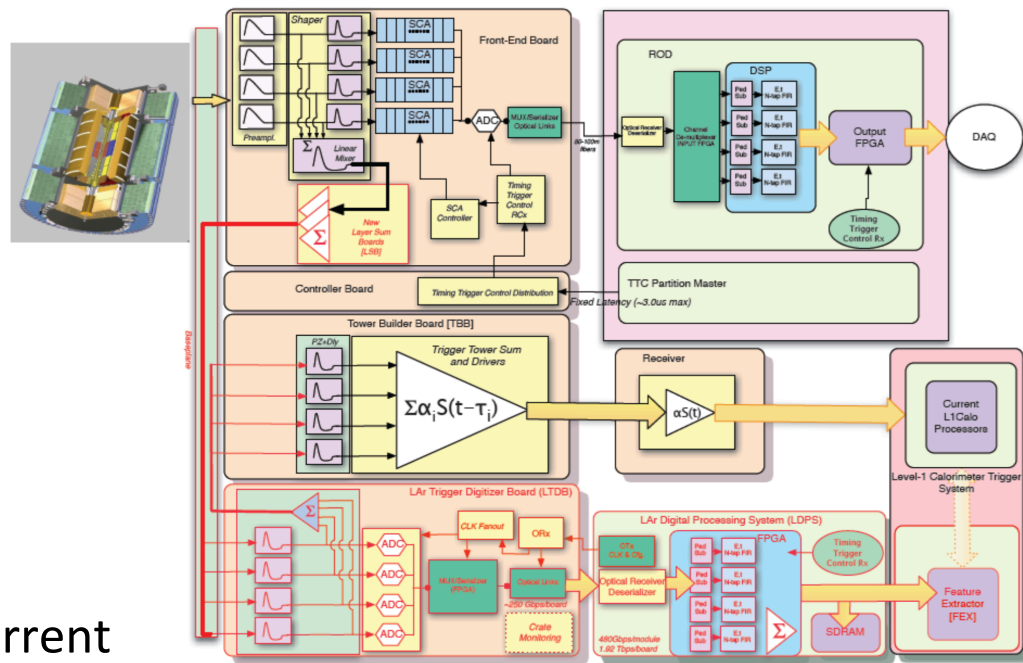
LAr Calorimeter: Preparation for Phase-1 upgrade

Trigger Upgrade during LS2

- Digital signals for L1Trigger
- Higher granularity

Status

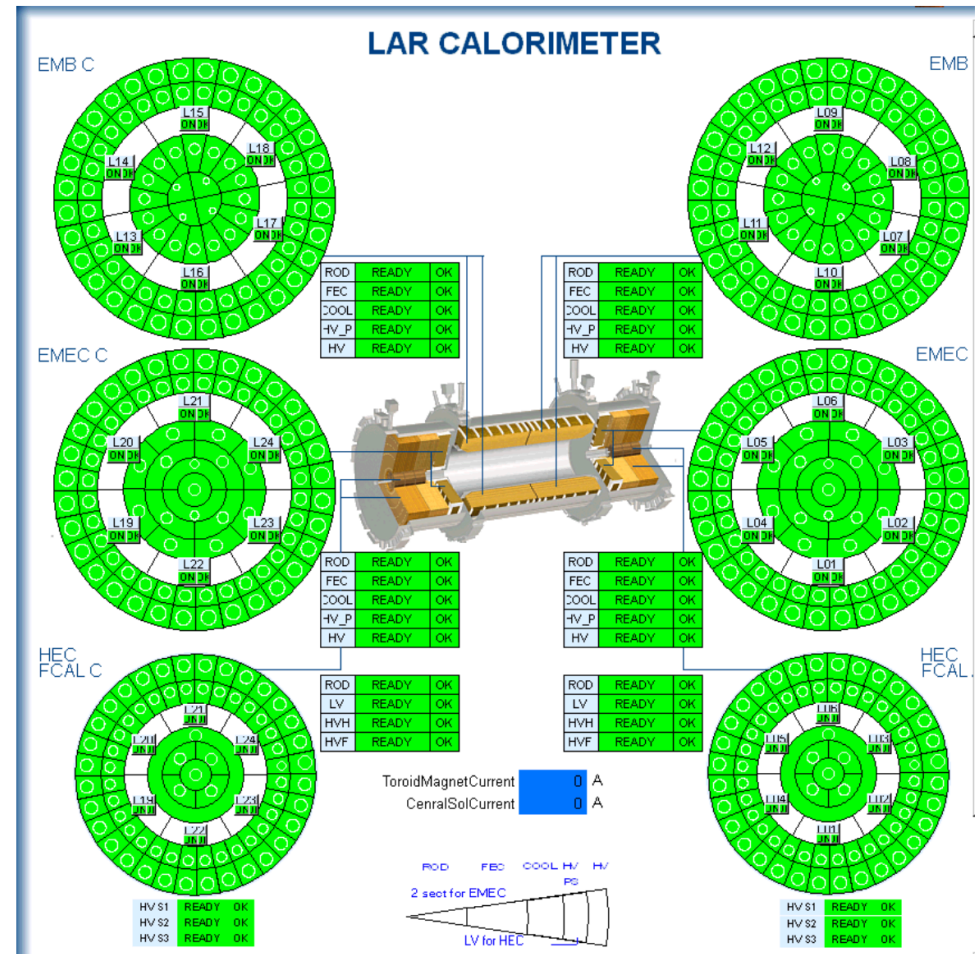
- 2 Demonstrators built
- Installed in current system
- Changes to FE and BE electronics
- Tested not to be detrimental to current system



LAr Calorimeter: Readiness for Run 2

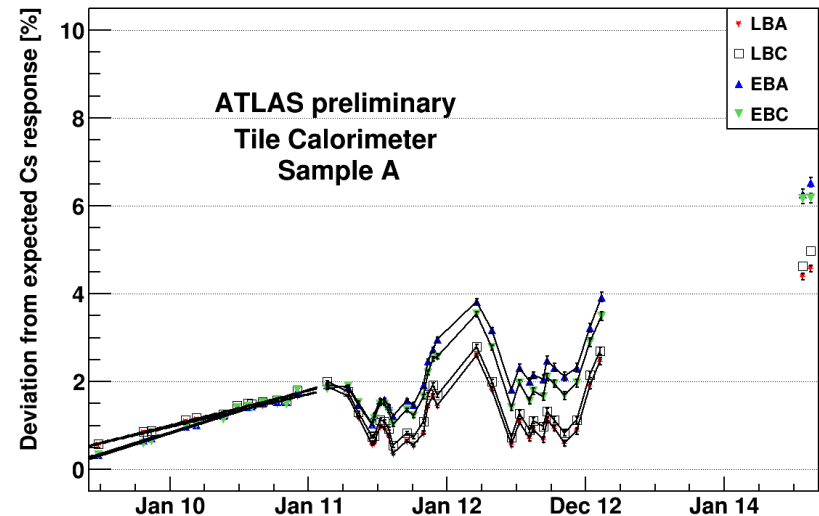
Overall Status:

- Few things to be finished
- Basically ready for run 2

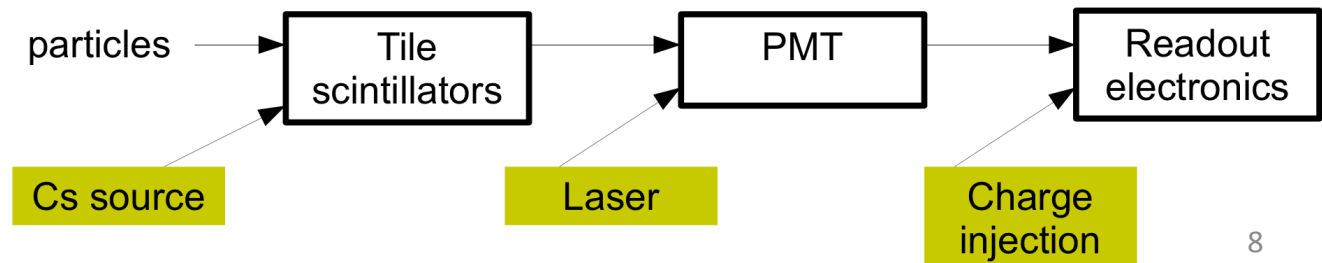


Tile Calorimeter: Hardware

- Installation of new LVPS
 - No trip since then and less noise
- 1 module lost (0.46% of cells)
- Improvement of DAQ
- Calibration system
 - Fix of Cs calibration system, now re-establishing absolute scale
 - New laser calibration to improve control of system stability
 - laser and noise calibration from data in physics runs



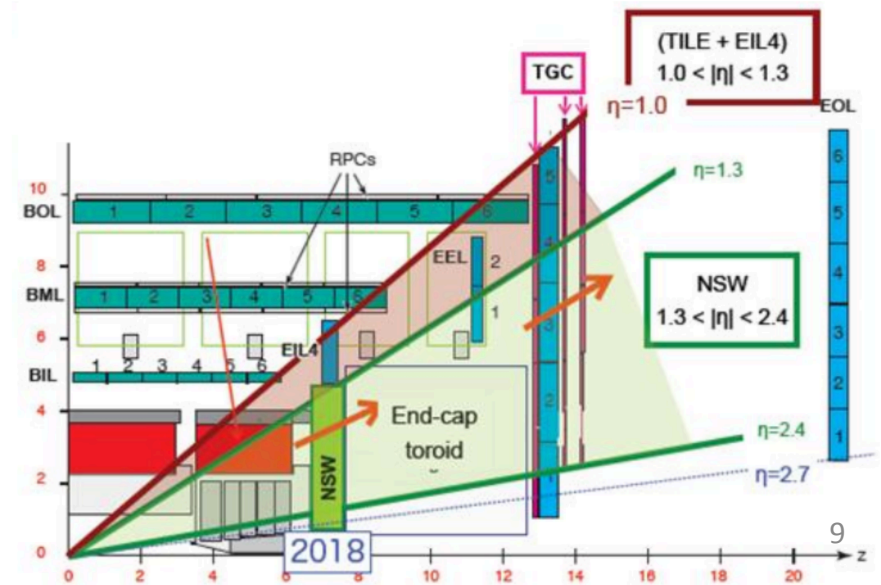
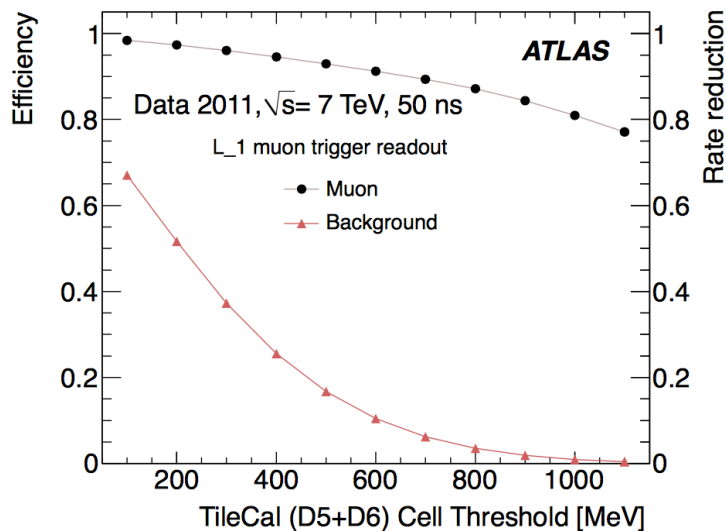
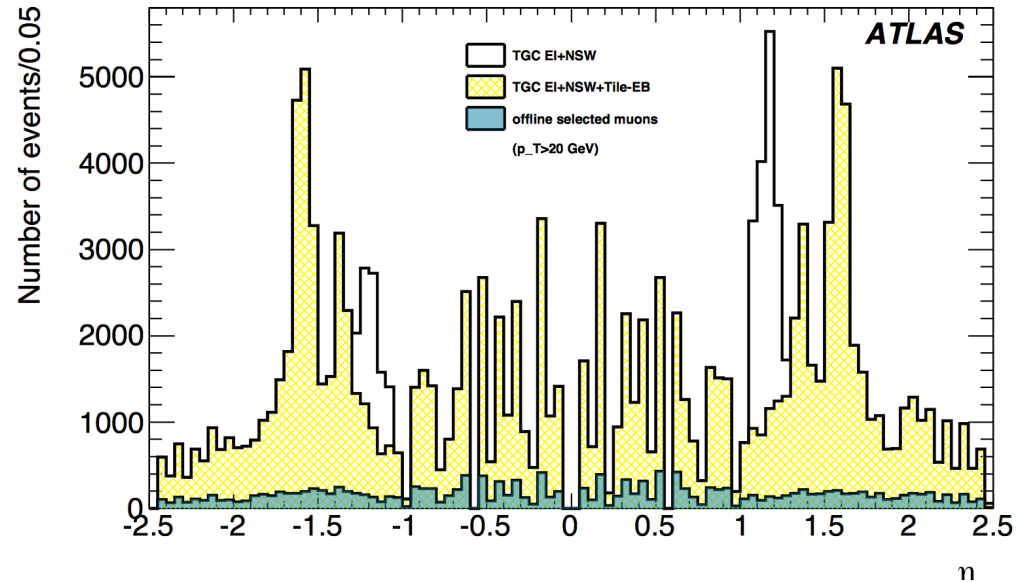
Signal and
calibration chain



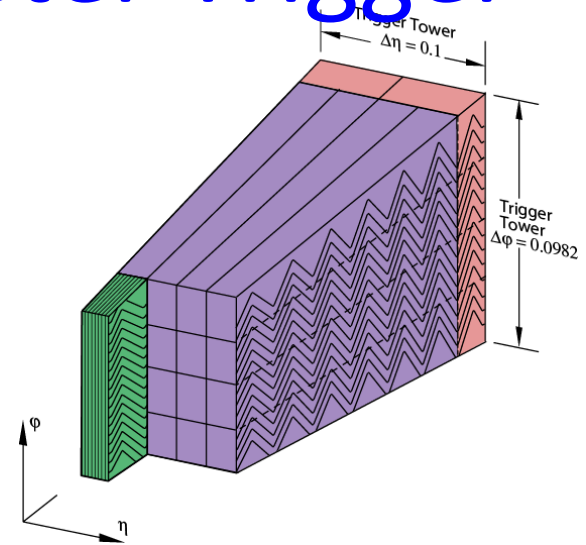
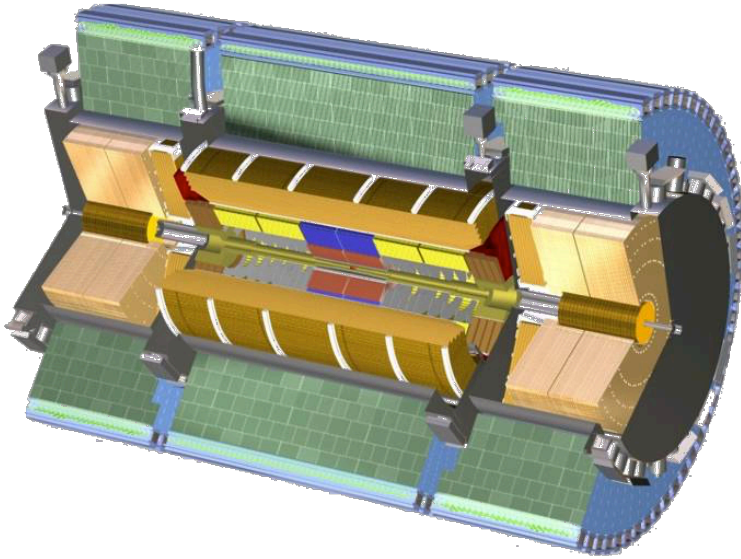
Tile-Muon Trigger

Include Tile Information to reduce Muon Trigger Rate

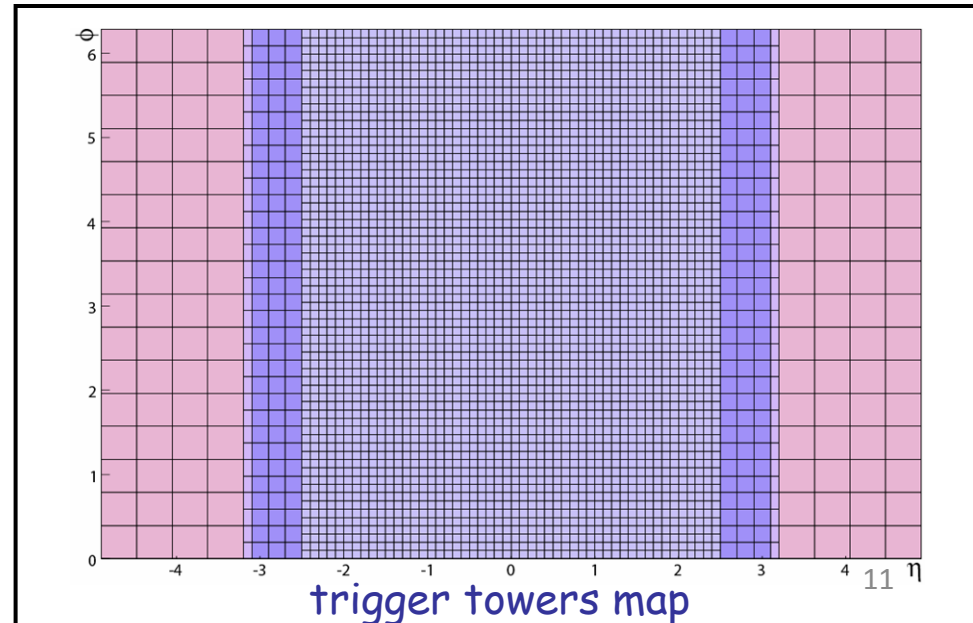
- Coincidence Electronics designed
- Production started
- Ready for 25ns operation



Level-1 Calorimeter Trigger

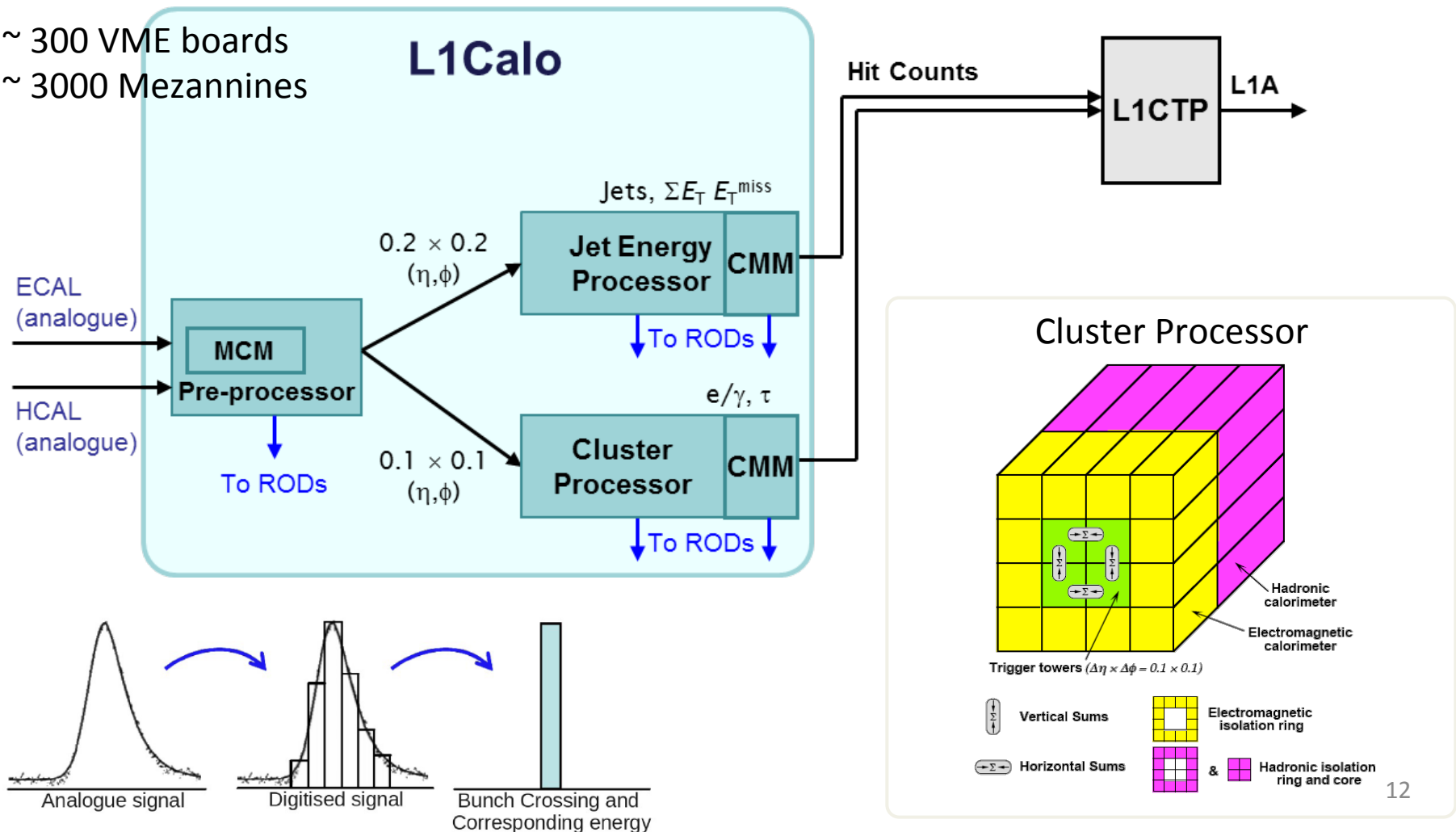


- Combining cell information into 7200 analogue Trigger Towers
- Uniform granularity
 $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$
- 2 Layers: EM and HAD

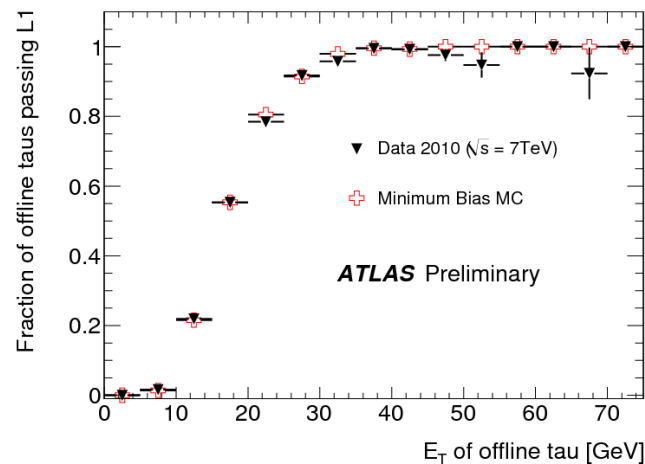
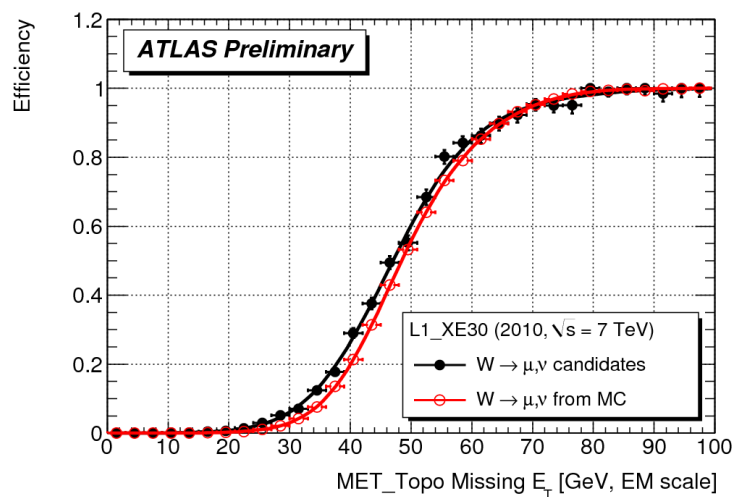
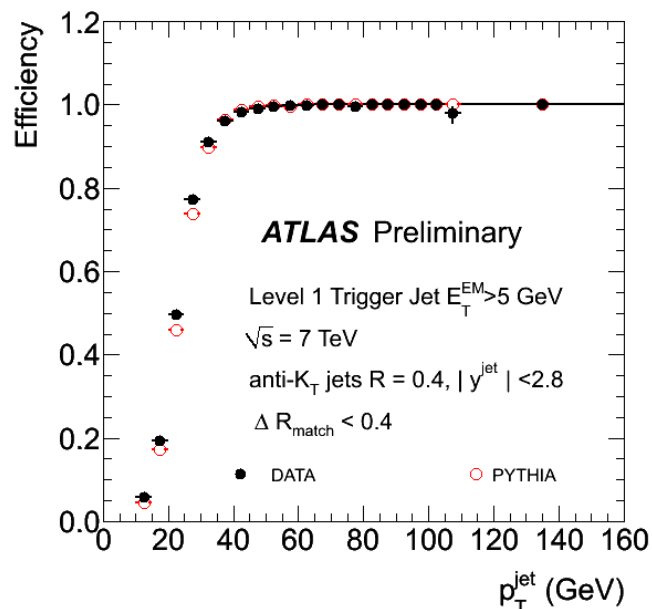
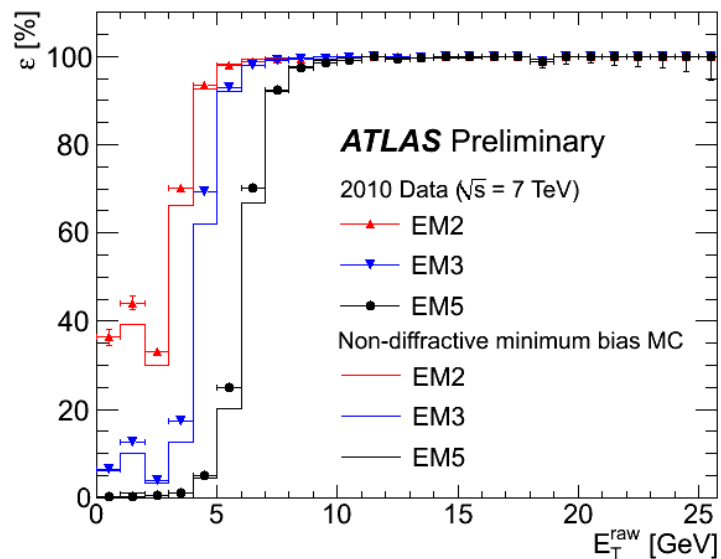


Level-1 Calorimeter Trigger: Run 1 Architecture & Algorithms

~ 300 VME boards
~ 3000 Mezzanines

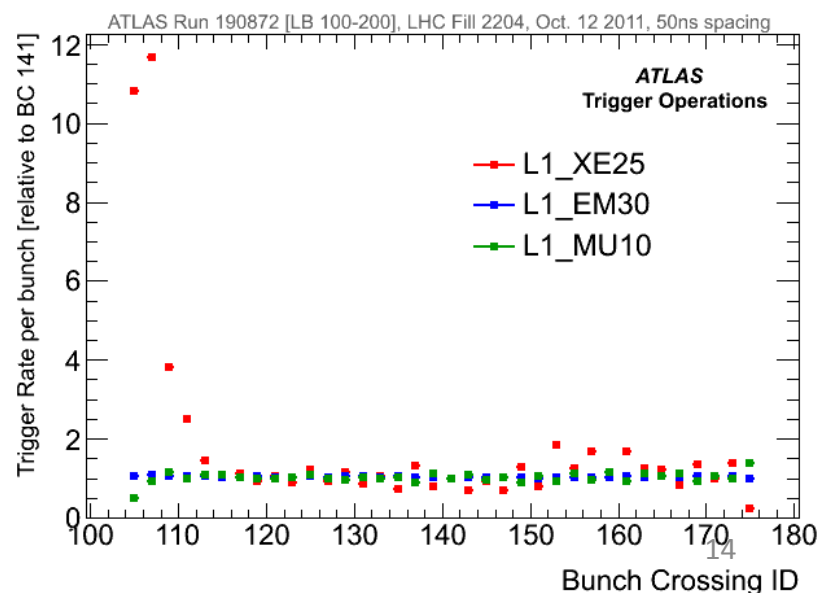
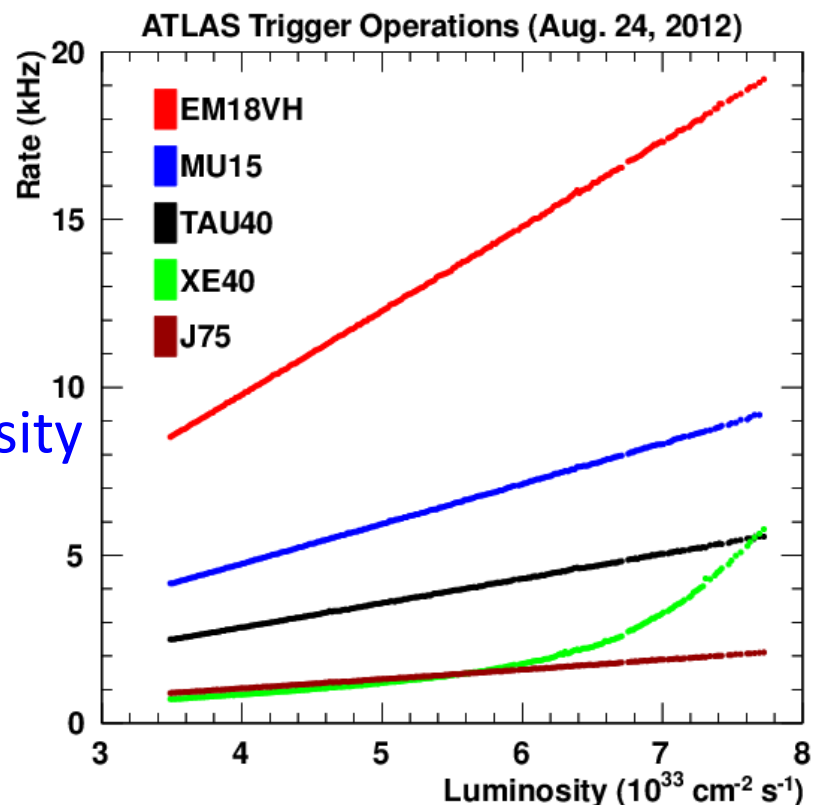


Efficiencies during Run 1



Run 1 System: Lessons learned

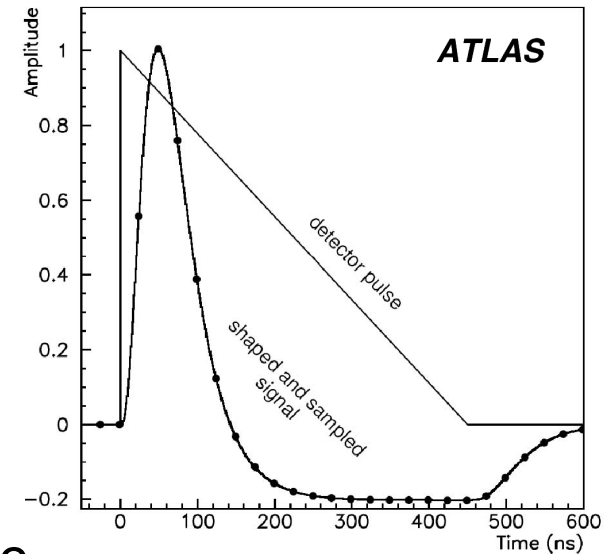
- Trigger Rates scale linear with luminosity
- Except
 - E_{T}^{miss}
 - multijet trigger
 - i.e. triggers which involve many trigger towers
- Effect restricted to first few crossings in a bunch train
 - Understood as convolution of bunch pattern and signal shape (next slide)



Pile-up effect

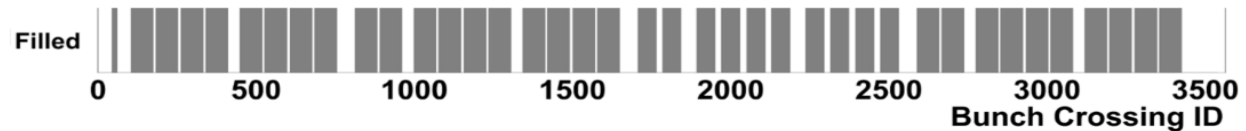
- LAr electronics produces bipolar pulses
- Pulses influence base line for many BCs (out of time pile-up)
- Overlap of many events per bunch crossing (in time pile up)
- Net-effect is 0 due to bipolar pulse shape

LAr pulse shape

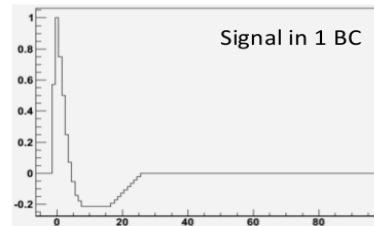


LHC bunch structure

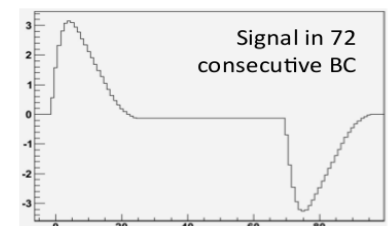
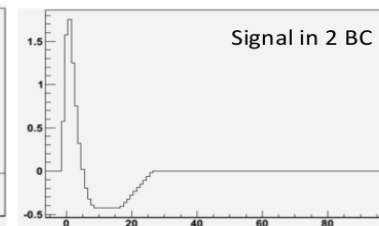
LHC 50ns filling scheme: 1318 filled BCs in bunch trains



- Only in time pile up at beginning of bunch train
- Enhanced baseline
- Effect amplifies with the number of involved TTs
- No effect for electrons
- Big effect for E_T^{miss}

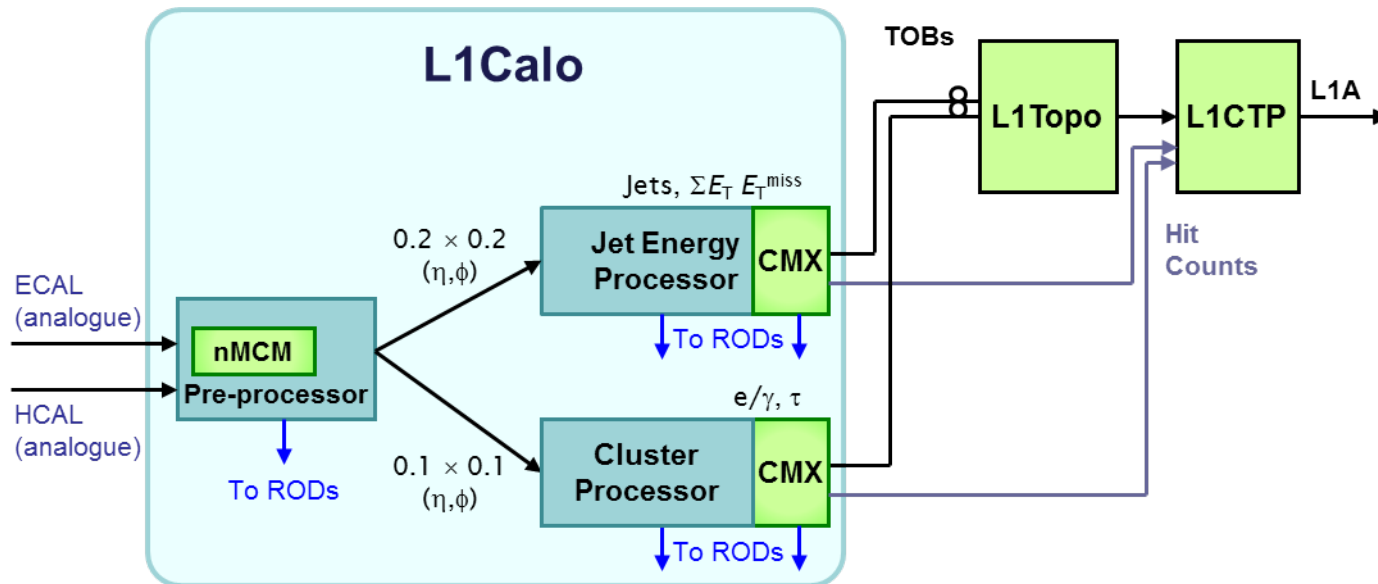


From Martin Wessels

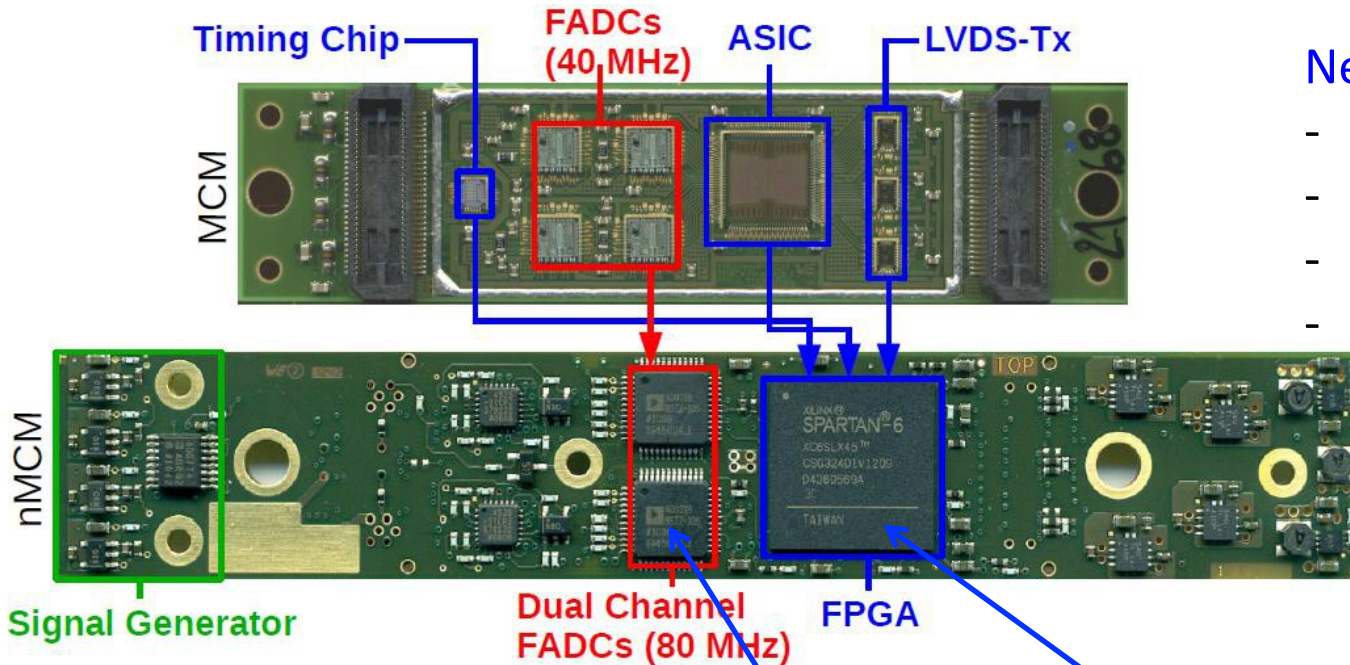


Bunch Crossing ID

L1Calo Upgrade during LS1



MCM -> nMCM



New development

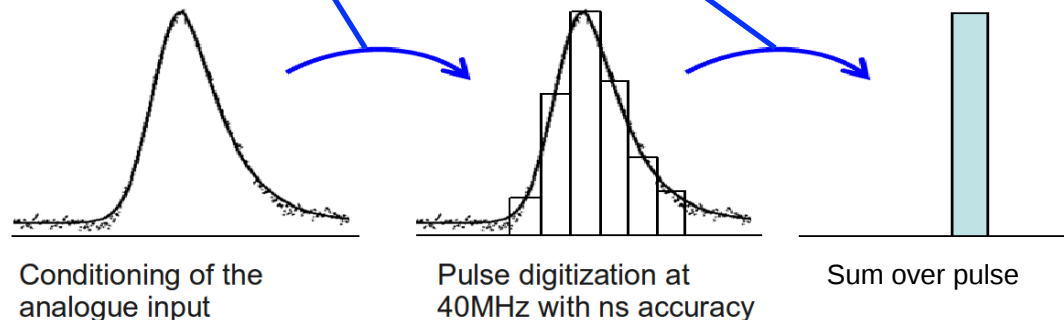
- ASIC -> FPGA
- 4 ADCs -> 2 dADCs
- Remove Phos4 chip
-

Better hardware

- operational stability

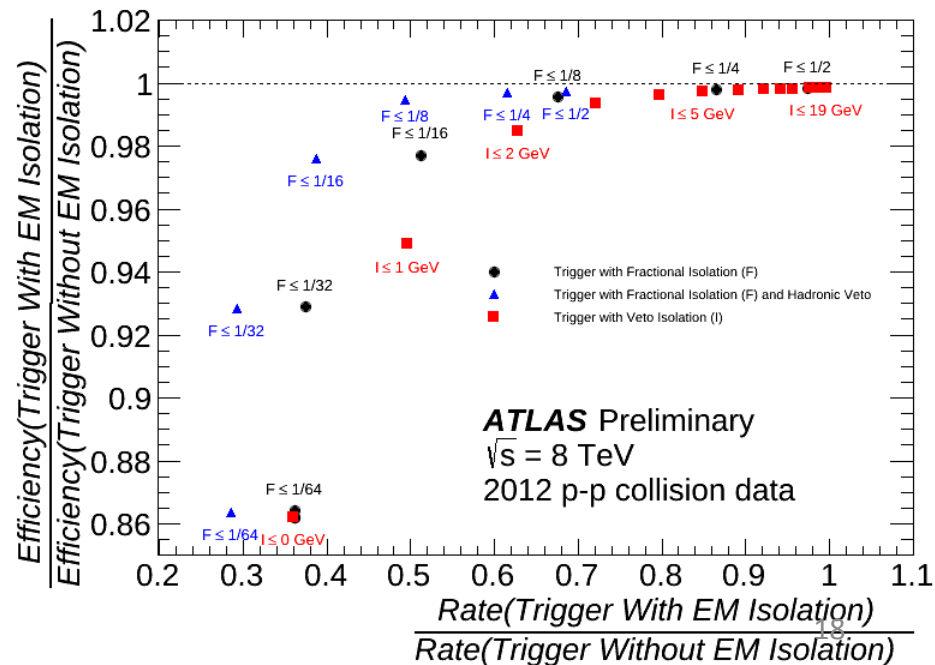
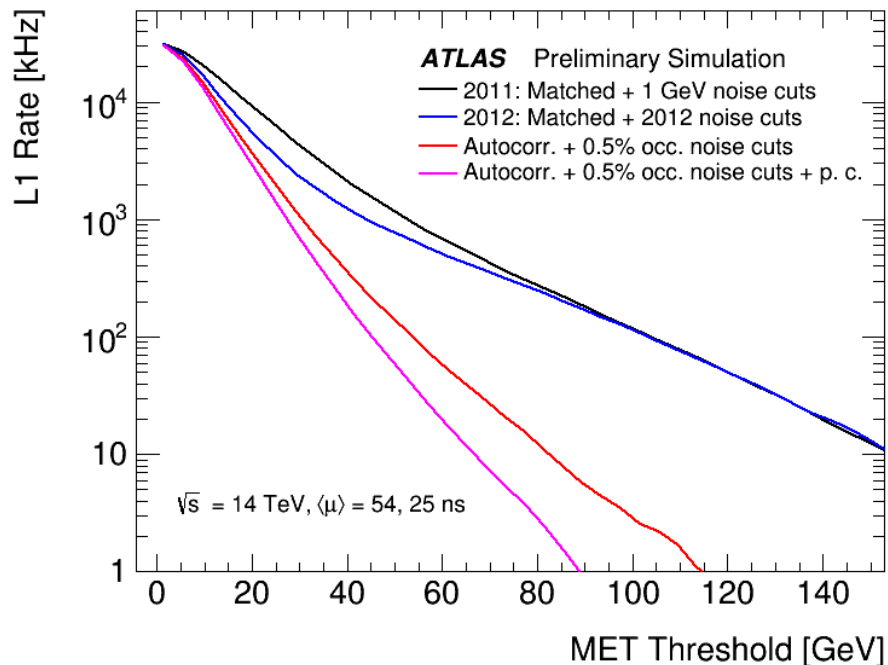
More flexibility

- Better digital filter
- pile-up substr.
- sat. BCID
- calibration



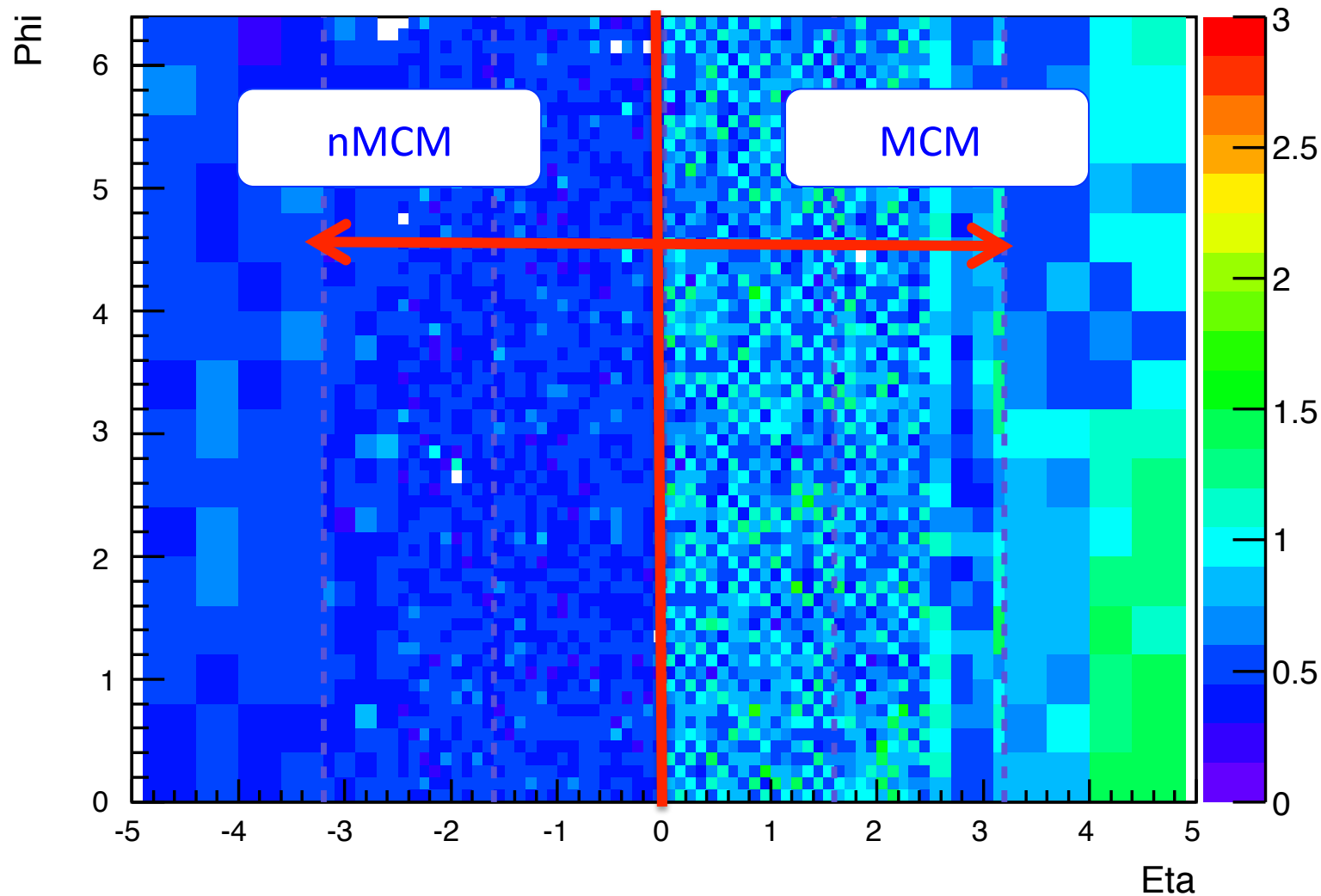
Expected Performance improvements

- Lower E_T^{miss} rates: Better pile-up suppression
 - Autocorrelation filters, dynamic pedestal subtraction
- Better efficiency vs rate working point for electrons
 - Fractional isolation



nMCM noise

PED Sigma Had. Channels

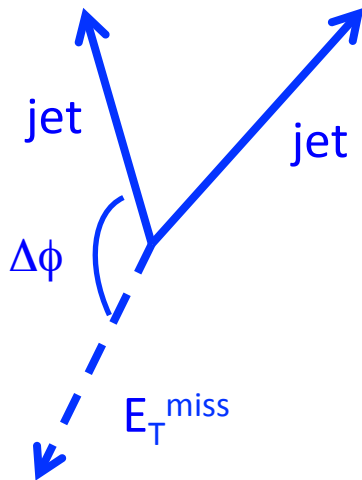


L1Topo

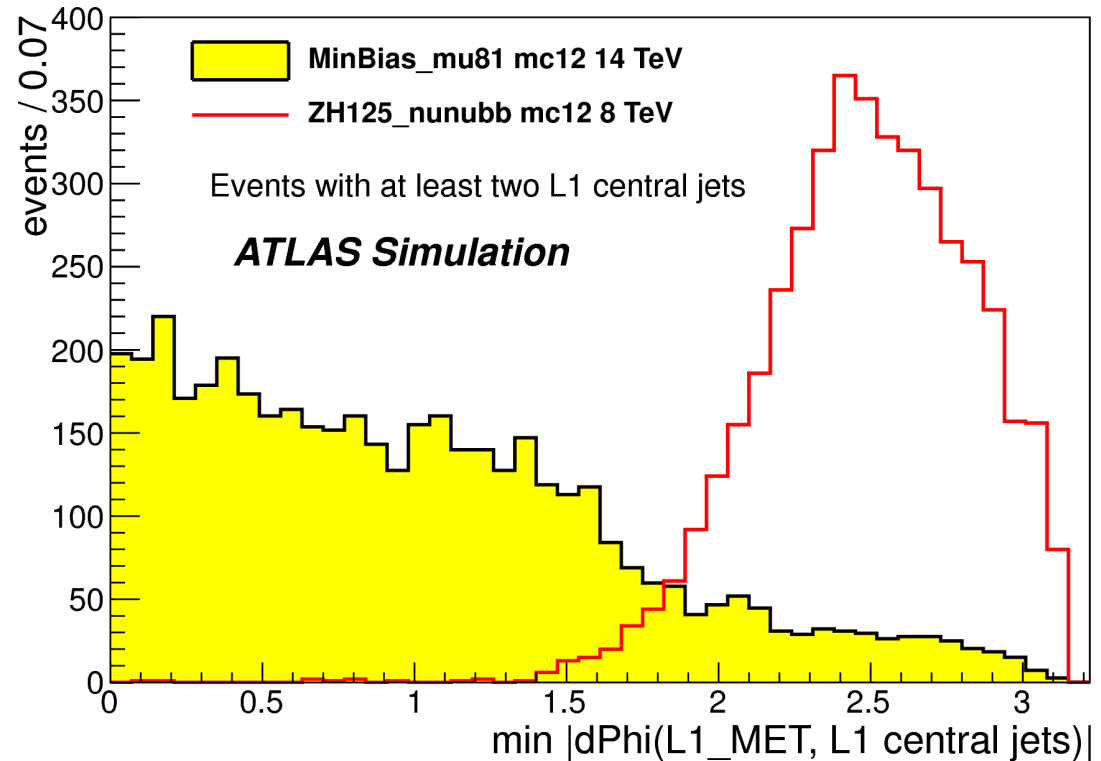
Run-1: threshold trigger

Run-2: evaluate topological
event information

Example: $ZH \rightarrow \nu\nu b\bar{b}$



Substantial enhancement
of trigger capabilities



Uses: electrons, taus, jets, E_T^{miss}

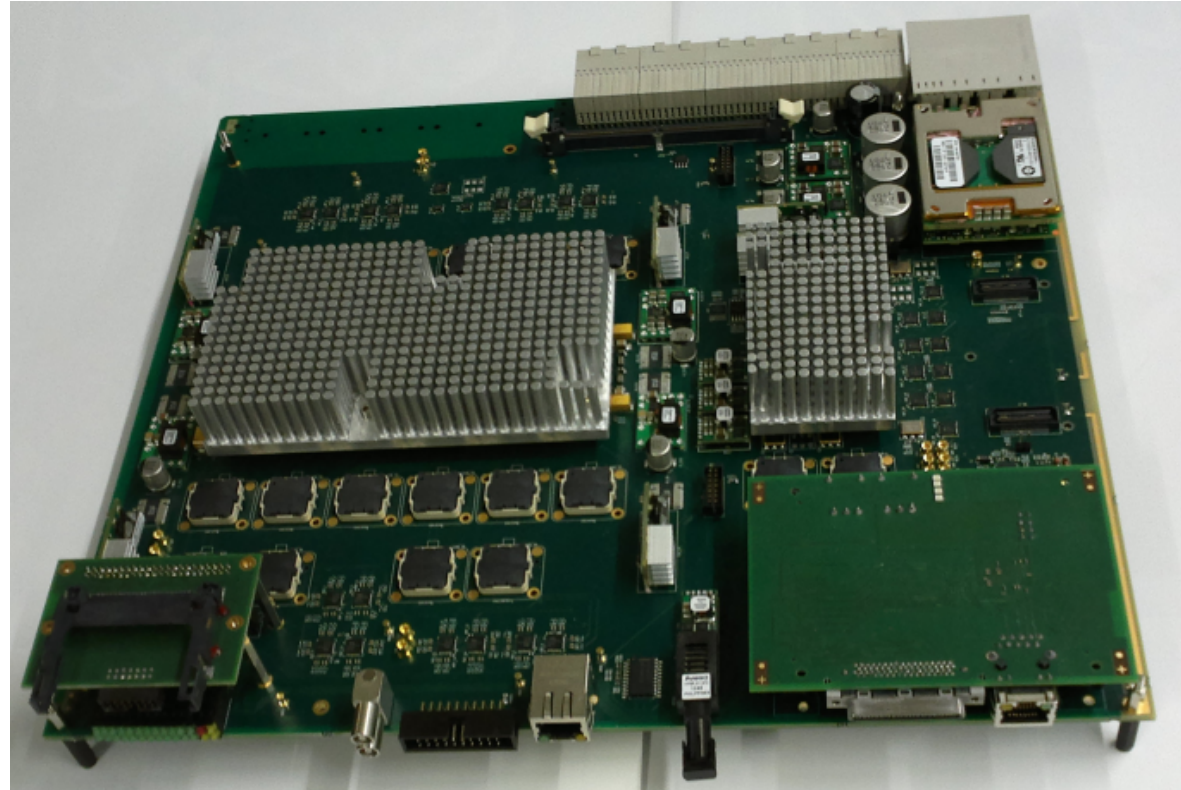
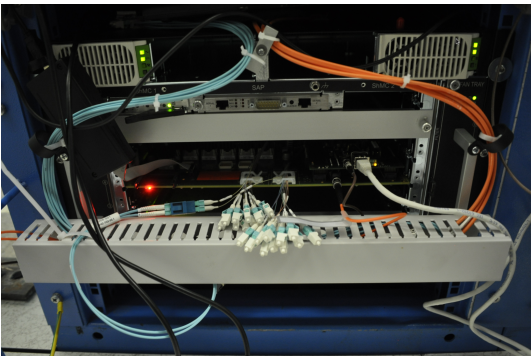
Topological Algorithms:

$\Delta\phi$, Δh , ΔR , m_{inv} , m_T , E_T^{miss}

L1Topo Hardware

Entered new territory in many different areas

- 2 ATCA modules (1 exists so far)
- Medium density of optical links
- High density of tracks on PCB
- 24 layer PCB
- 2 big FPGAs



We went through a long history of prototype and production boards:
These boards are extremely difficult to build.

Level-1 Calorimeter Trigger: Status

- Legacy Hardware
 - commissioned and calibrated
- nMCM
 - Hardware installed
 - Firmware and Software almost there
- CMX
 - Hardware installed
 - Firmware and Software largely there
- L1Topo
 - 1/2 boards installed (2nd just arrived)
 - Firmware and Software converging
- Software/Database/Calibration
 - Converging, calibration major effort for the next 2-3 years

Summary

- Calorimeters
 - Repair of broken channels
 - New PS for better operational stability
 - Many improvements of DAQ, SW, Monitoring
- Calorimeter Trigger
 - New functionality to cope with pile-up
 - Topological Processing