The ATLAS Tile Hadronic Calorimeter performance in the LHC collision era

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on behalf of the ATLAS Tile Calorimeter group

2011, June 9th

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ATLAS Tile Calorimeter Overview

Calibration and Performance

Conclusions

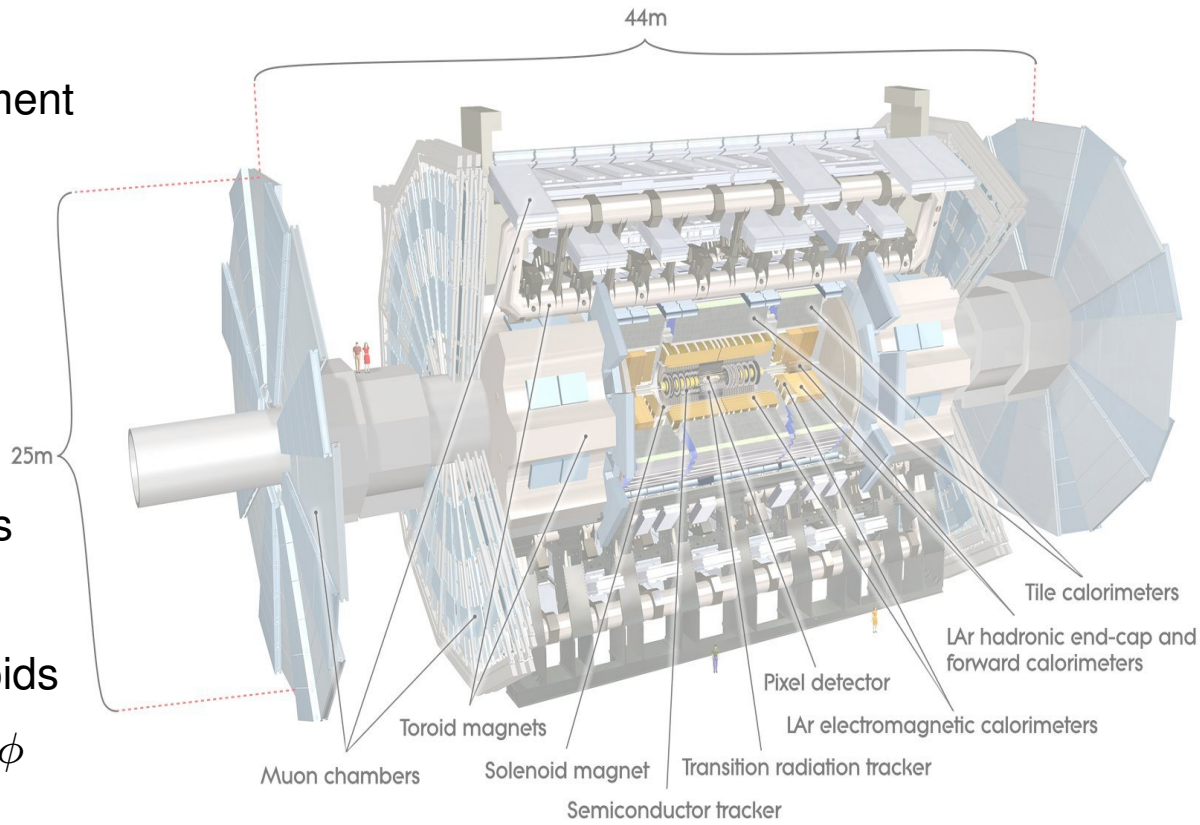
- (Very) Brief overview of ATLAS
- Description of Tile Calorimeter and current Operational Status
- Signal Reconstruction*
- Calibration Systems* *
- Performance with Cosmic Muons*
- Performance with Collision Data

Each * stands for a specific talk on the respective subject (will be linked in the slides)

The ATLAS experiment

A general purpose experiment

- vertex detector and central tracker
- superconducting solenoid
- electromagnetic and hadronic calorimeters
- muon spectrometer
- superconducting toroids
- high hermeticity (full ϕ and $|\eta| < 5$)



The ATLAS experiment

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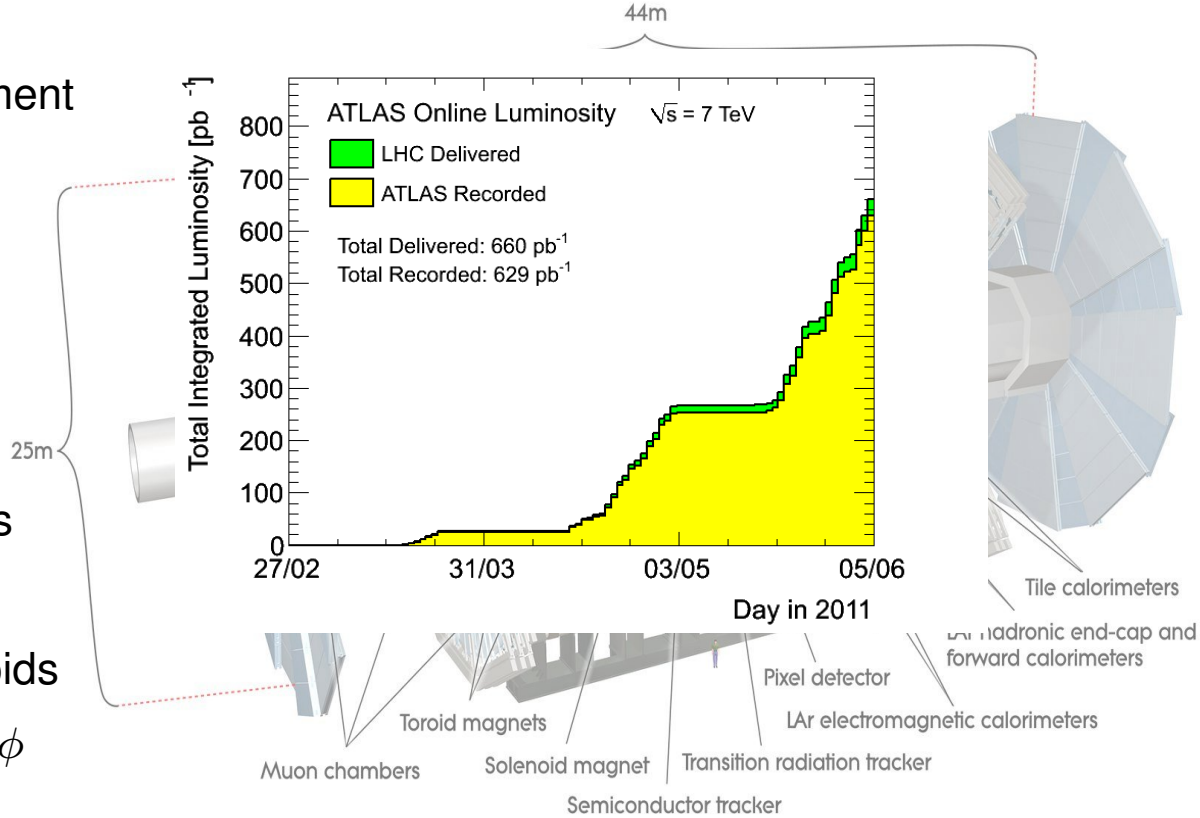
In 2011 already $\sim$630 pb^{-1} collected!



Reached peak luminosity of 1.26×10^{33} cm^{-2}s^{-1}
See ATLAS public page

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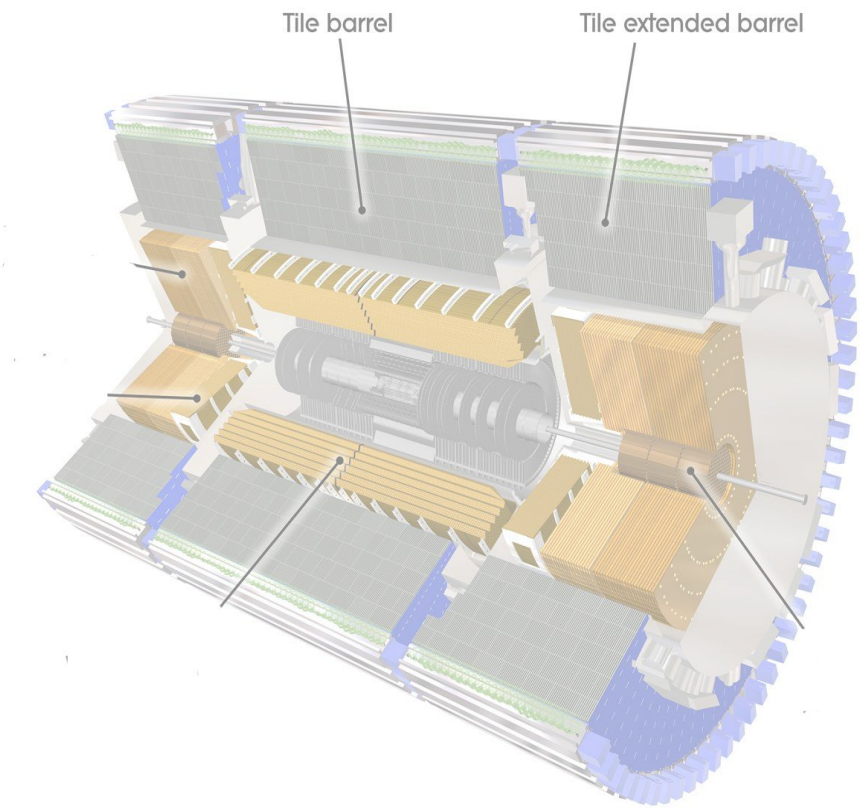

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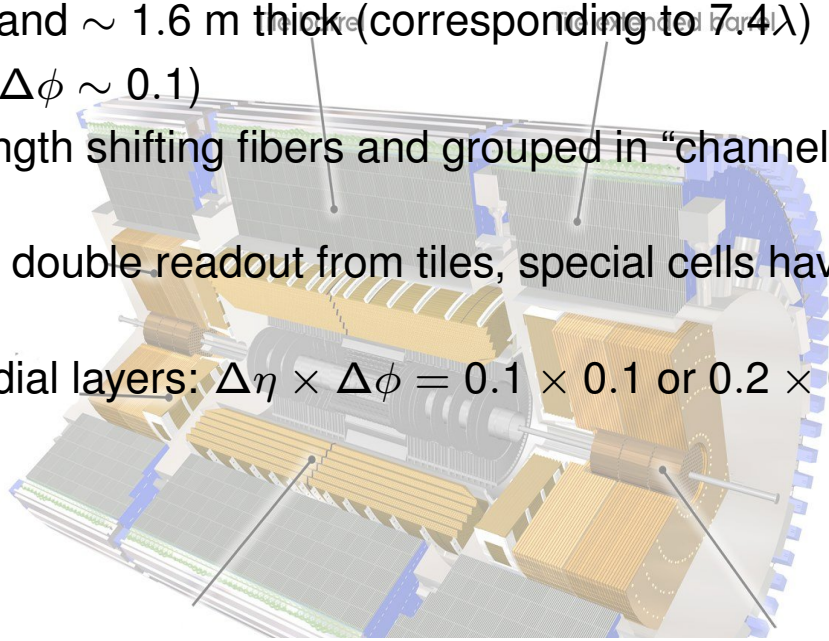
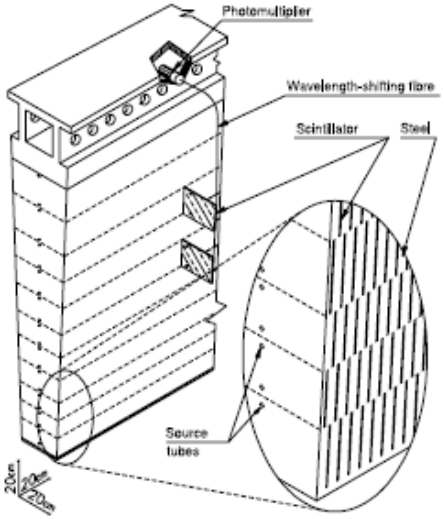
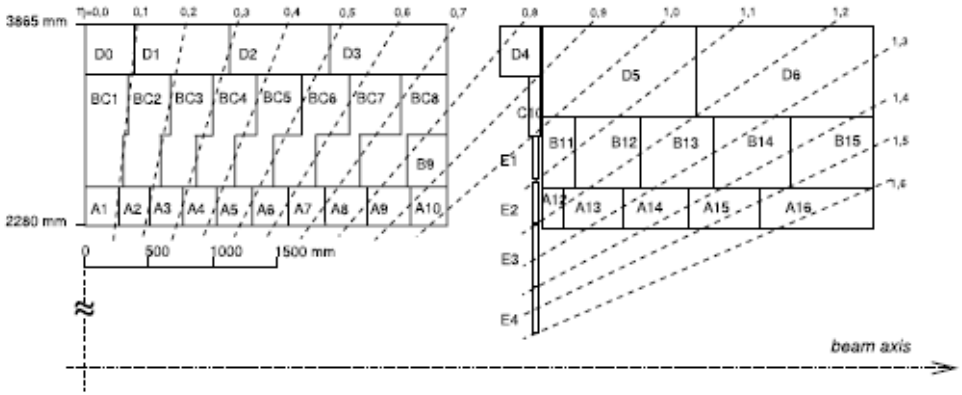
Sampling calorimeter made of steel plates and scintillating tiles

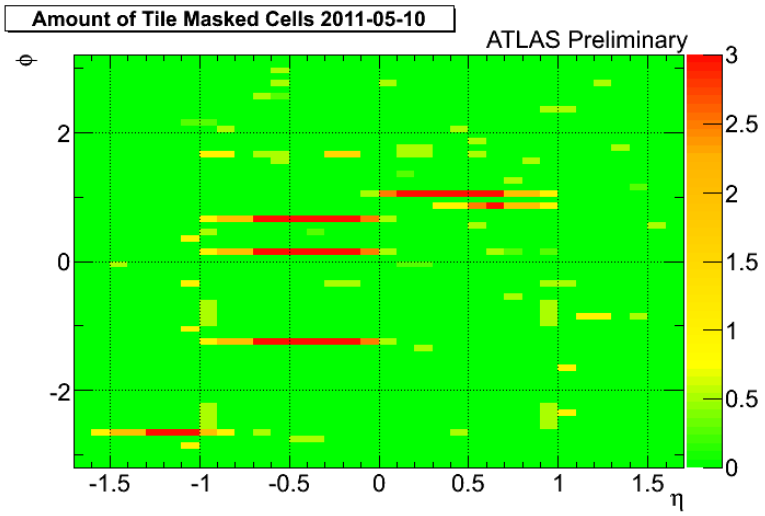
- $\sim$ 12 m long (covers $|\eta| < 1.7$) and $\sim$ 1.6 m thick (corresponding to 7.4λ)
- 64 modules along the azimuth ($\Delta\phi \sim 0.1$)
- tiles signal collected via wavelength shifting fibers and grouped in "channels" read by PMTs
- standard "cells" are formed with double readout from tiles, special cells have single readout
- 9856 channels, 5184 cells, 3 radial layers: $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ or 0.2×0.1 for A&B/C and D cells respectively







Tile Calorimeter Status

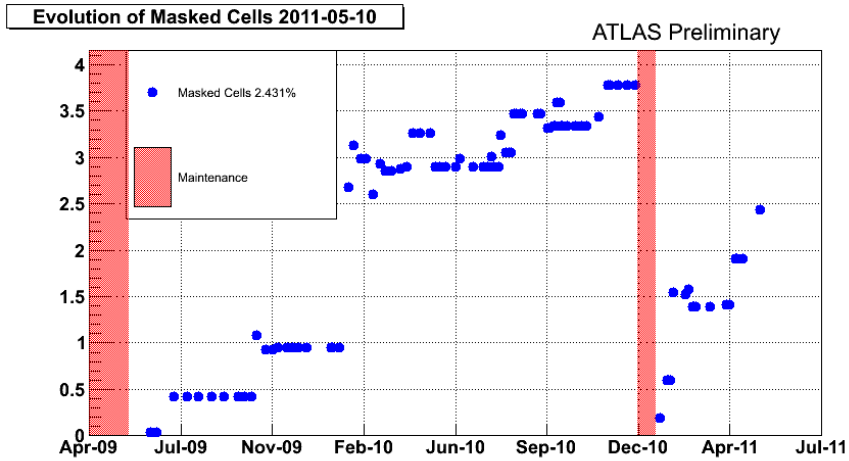


Not 100% of the 5184 cells of TileCal can be used for physics: sometimes intervention is needed, serious fixes can be done only during LHC shutdown periods

- η vs ϕ map of TileCal showing the number of masked cells per towers (1 tower = 3 cells)

On May 2011

- 2.4% of cells are masked, 2.1% of them are off (5 full modules)
- before 2010 winter maintenance 3.8% of cells were masked



Signal Reconstruction

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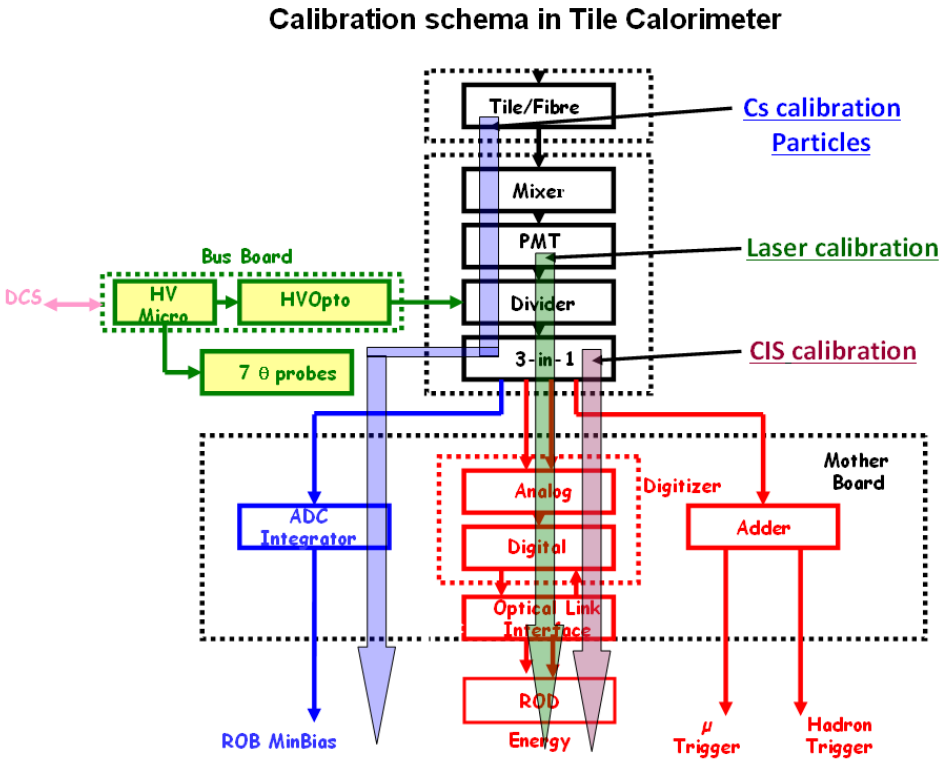

- Signal collected from tiles to PMTs through WLS fibers
- PMT output is shaped with a passive shaping circuit and amplified separately in High and Low Gain branches (in proportion 64:1)
- HG and LG signals are sampled at the LHC bunch-crossing frequency (40 MHz) and digitized
- A gain switch sends HG or LG to the ReadOut Driver Boards (RODs) outside the experimental hall

- Signal properties (amplitude, time, pedestal) for each channel are reconstructed on-line with a weighting algorithm

see also the talk during the Trigger and Data Acquisition Systems Session on Signal Reconstruction and eventually the poster on Electronics Upgrade

Signal Reconstruction

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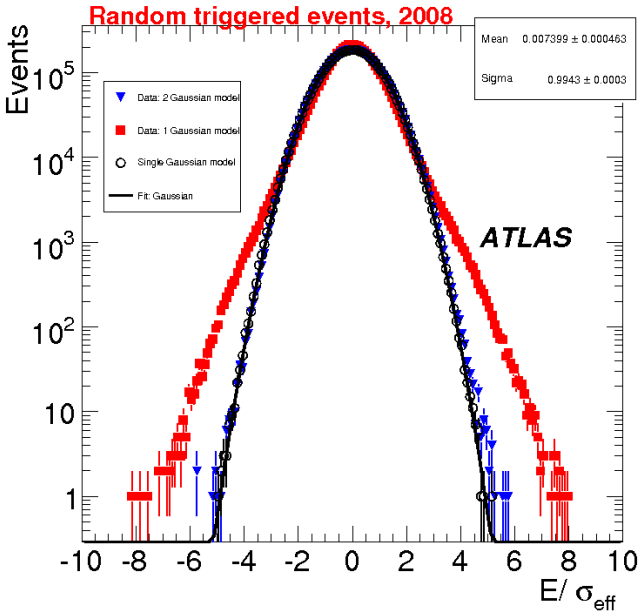
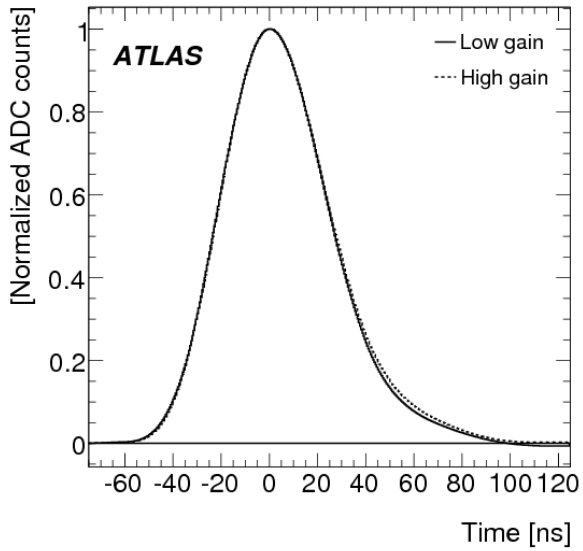
- signal amplitude and time are computed combining seven sequential digitized weighted signals
- the signal amplitude is then scaled with factors coming from calibration systems (see next slides) to get the energy value



Reference signal pulse shape from Test Beam π's used in the signal reconstruction algorithm



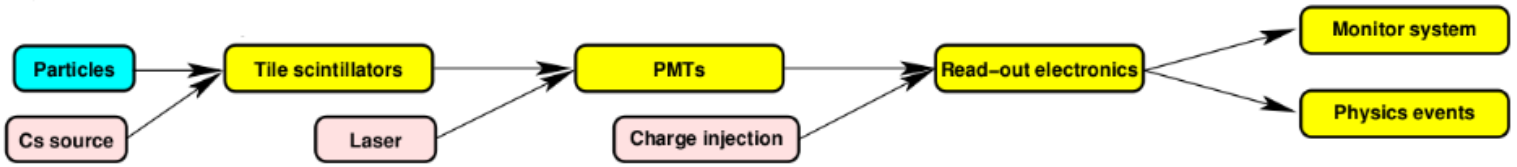
Noise is measured in pedestal runs and random triggered events

- Double gaussian description for cell noise probability distribution to discriminate between signal and noise

TileCal Calibration System

TileCal is provided with three calibration systems used to derive the value for the energy measured in each channel (E_{ch}) from the signal amplitude in ADC counts (A)

$$E_{ch} = A \cdot C_{ADC \to pC} \cdot C_{pC \to GeV} \cdot C_{Cs} \cdot C_{laser}$$



* **Charge Injection System** gives the ADC to pC conversion factor
* **Cesium System** to maintain PMTs gain stability and linearity of readout electronics, together with the **Integrator System**
* **Laser System** to monitor PMT stability to light

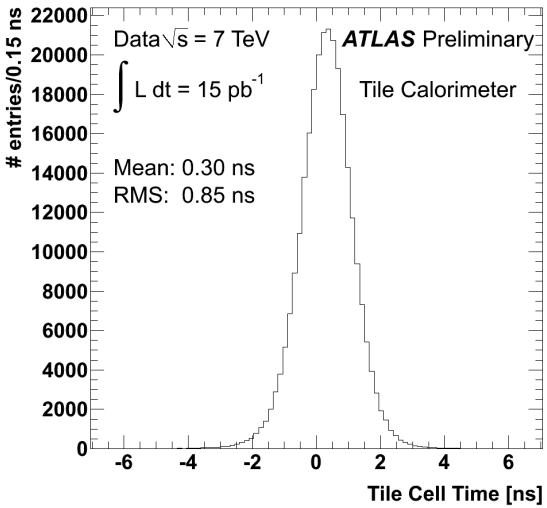
The factor $C_{pC \to GeV}$ comes from Test Beam calibration of 11% of modules using beams of high energy electrons to set the EM energy scale to 1.05 pC/GeV

see also today's session talks on Integrators and Laser System

Timing

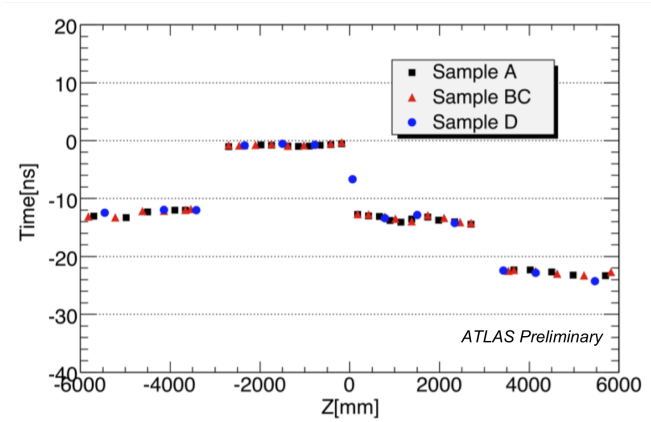
Accurate timing is important for the reconstruction algorithm performance

- with the Laser System time synchronization wrt a reference channel was set for the four partition
- with Cosmic-ray and single beam data the inter-partition timing and global timing were then set

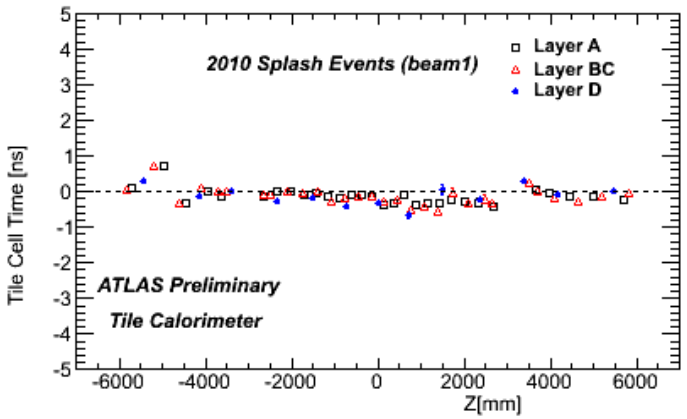


Cell time distribution (in LG) for cells belonging to topoclusters of reconstructed jets with $p_T > 20$ GeV

single beam 2008



single beam 2010

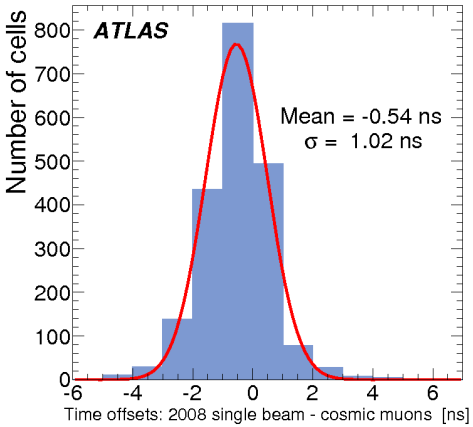


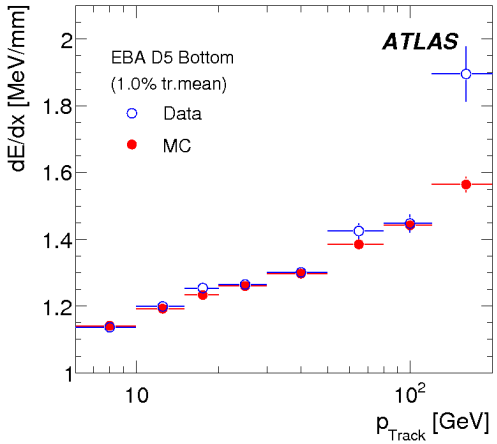
Precision is better than 1 ns

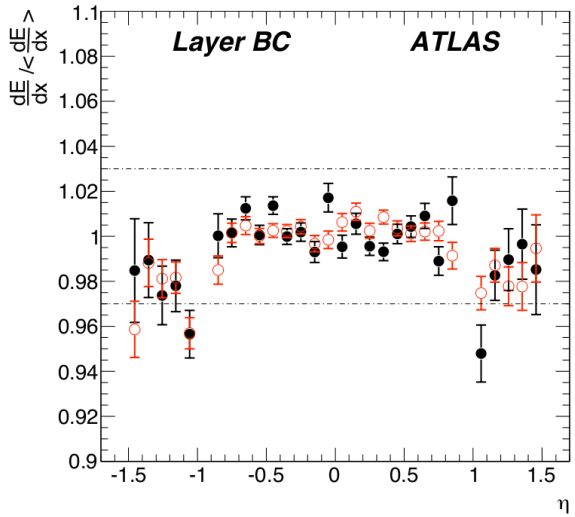
Performance with Cosmic Muons

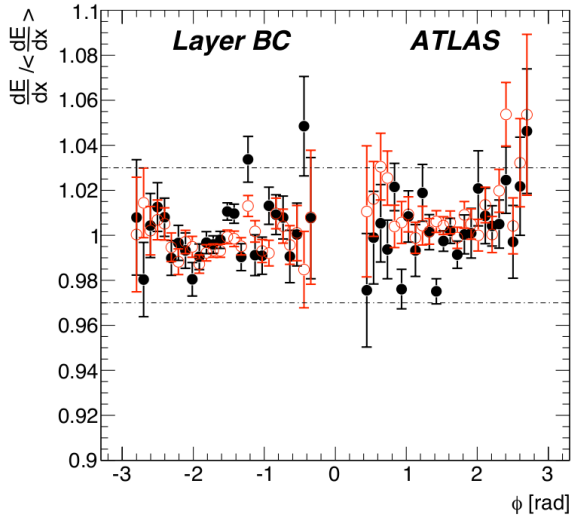
Cosmic Muons are used for several analysis

- Validation of timing performance
- Uniformity of detector response
- Test EM scale calibration







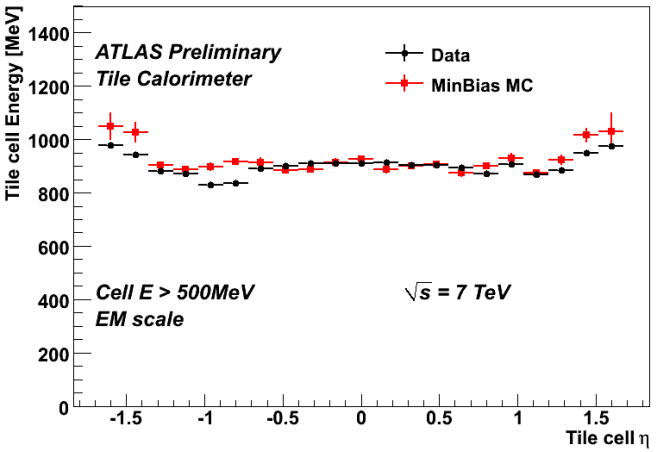


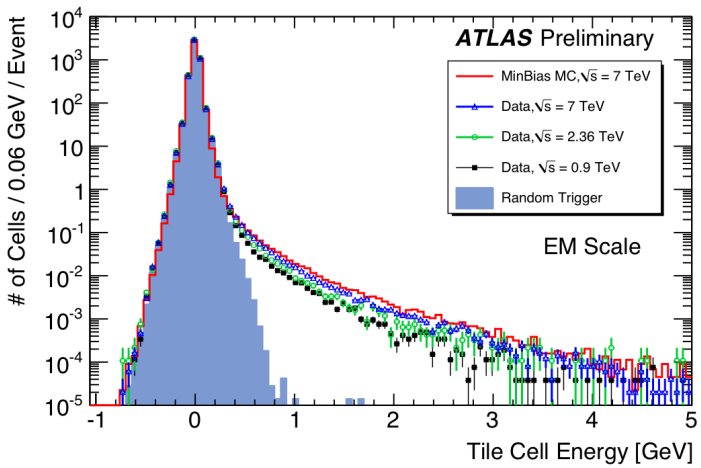
see also today's session talks on
Calibration with Cosmic Muons

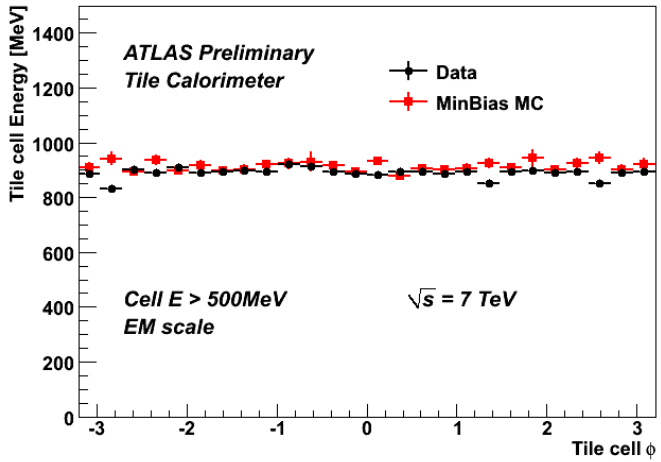
Performance with Collisions

From December 2009 data taken at increasing center of mass energy (0.9, 2.36 and 7 TeV)

- Minimum Bias triggered events
- Good agreement between Data and MC
- Good uniformity between modules (ϕ distribution), small differences between Barrel and Extended Barrel partitions (η distribution)



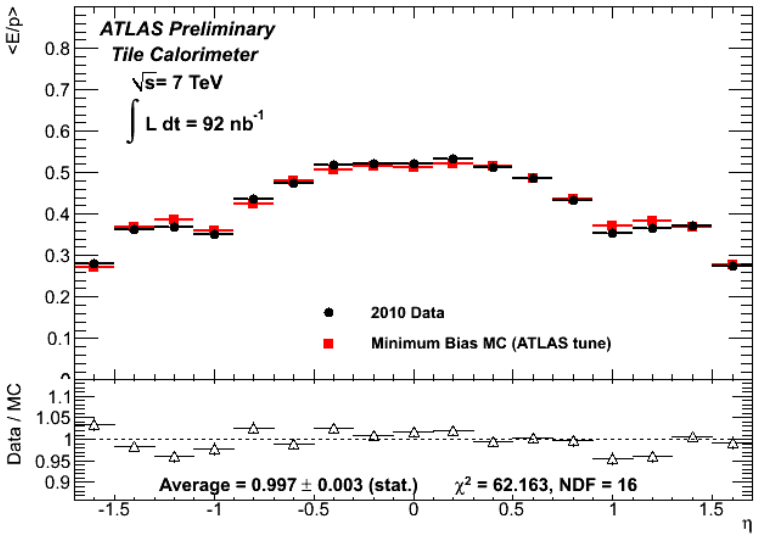


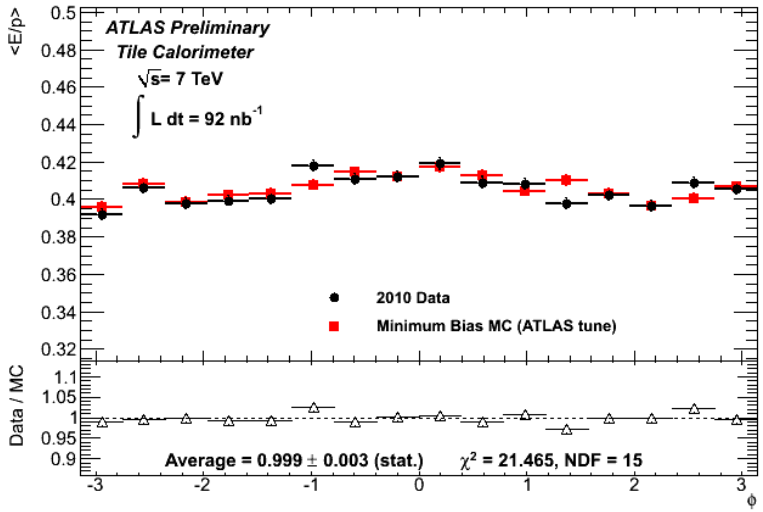


Performance with Collisions

Response to Single Pions showering in TileCal has been studied

- Isolated tracks measured in the Inner Detector
- Particles are “mips” in the Electromagnetic Calorimeter





Conclusions

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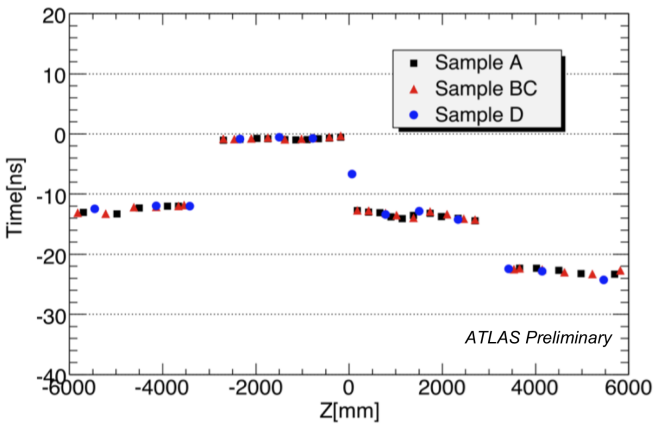
TileCal is performing well during first years of data taking, fulfilling its design goals

- response is uniform within 2-3% in η and ϕ
- energy scale uncertainty - in TileCal - is conservatively considered to be 4%
- time synchronization between cells is well below 1 ns and has been verified with single beam and cosmic muons
- the calibration systems are performing well and response shows a good stability in time

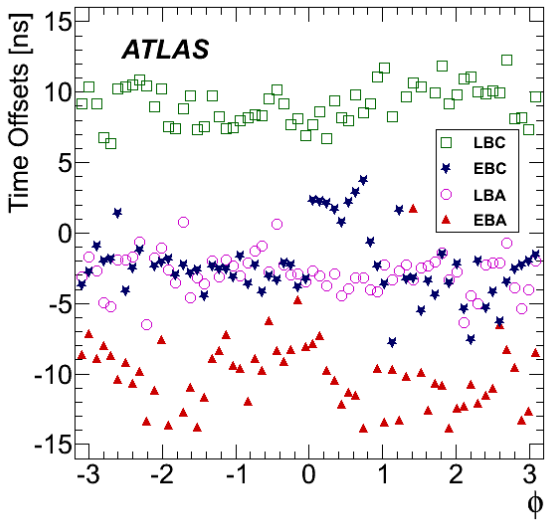
BACKUP SLIDES

Timing

single beam 2008



cosmic muons



The same discrepancies between partitions are observed