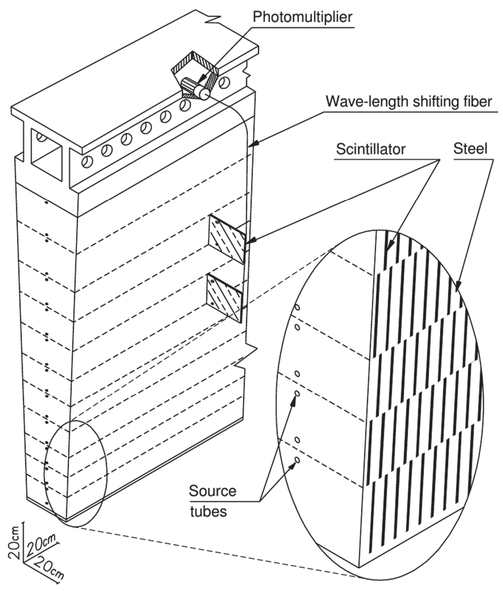
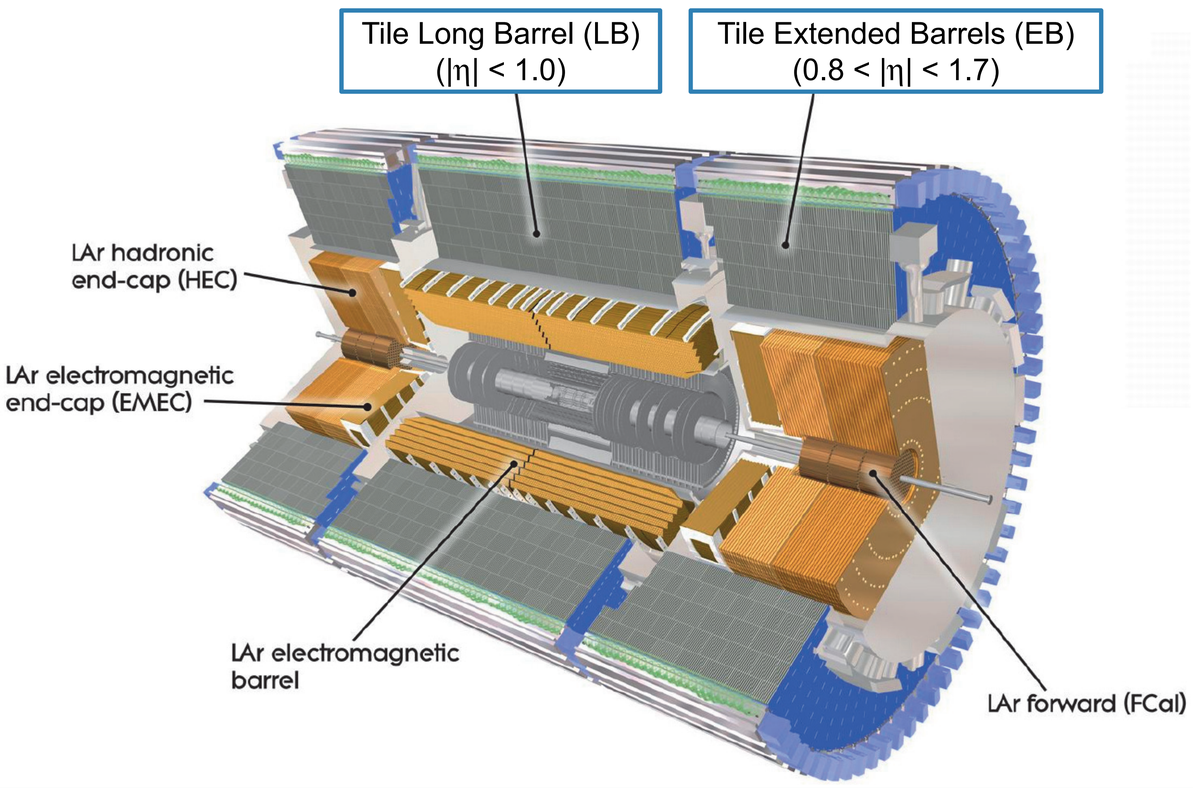
Performance of the ATLAS Tile Calorimeter

Alexander Solodkov, IHEP, Protvino, Russia
on behalf of the ATLAS Collaboration

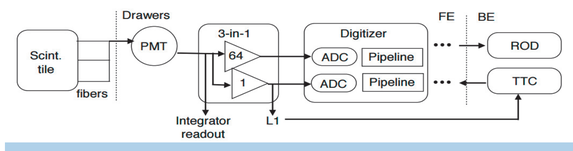


The ATLAS Tile Calorimeter

- Hadronic sampling calorimeter using steel as absorber, scintillating tiles as an active medium and wave length shifting fibers
- Divided into long barrel (LB) and two extended barrels (EB) with overall dimensions of ~12 m length and 4.25 m (2.28 m) outer (inner) radius
- Granularity:
  - 64 wedge-shaped modules $\Delta\varphi = 0.1$
  - 3 radial layers: A ($\Delta\eta$=0.1), BC($\Delta\eta$=0.1), D($\Delta\eta$=0.2) and special layer E (single scintillators in the gap between LB and EB)
- Each normal cell is readout by two photomultiplier tubes (PMT) to achieve uniform response; 5k cells, 10k PMTs
- Dynamic range of PMT: 10MeV to 750 GeV
- Performance goals:
  - Energy resolution for jets $\sigma/E = 50\%/\sqrt{E}\oplus 3\%$
  - Linear within 2% (4 TeV jets)
  - Hermetic coverage for E_T^{miss} reconstruction



Energy reconstruction and calibration procedure



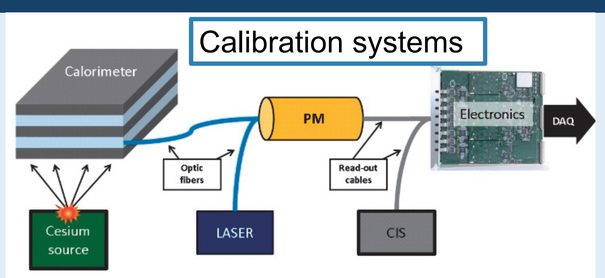
- The signal from the PMTs is shaped and amplified using two gains (1:64) with 10-bits ADCs each 25 ns

Amplitude and time are reconstructed using Optimal filtering algorithm

$$A = \sum_{i=1}^{n=7} a_i S_i \qquad A\tau = \sum_{i=1}^{n=7} b_i S_i$$

$$E[\text{GeV}] = A[\text{ADC}] \times C_{\text{ADC}\to\text{pC}} \times C_{\text{laser}} \times C_{\text{Cs}} \times C_{\text{pC}\to\text{GeV}}$$

$C_{\text{pC}\to\text{GeV}}$ was measured at the test beam

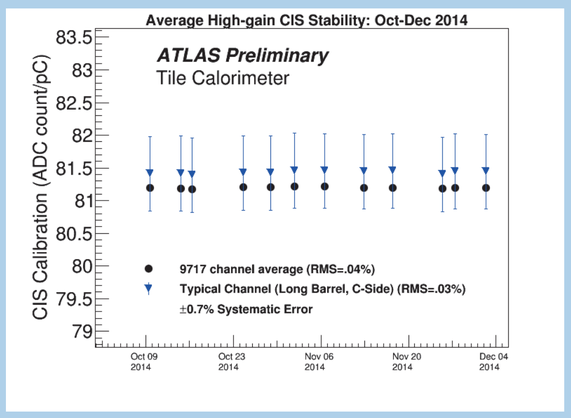


Minimum Bias system

- The system uses the integrator readout and measures the detector response to the minimum-bias events
- It is used for monitoring of the instantaneous luminosity in ATLAS

The Charge Injection System (CIS)

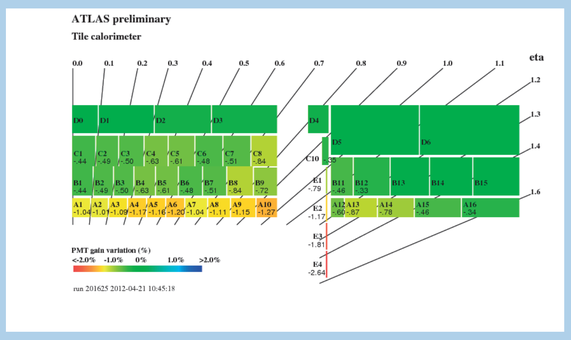
- Injects a known charge in readout chain and measures $C_{\text{ADC}\to\text{pC}}$ factor for low and high gain ADCs connected to PMT



- Typical uncertainty is 0.7%
- The conversion factor is stable in time at the level of 0.02%

The Laser system

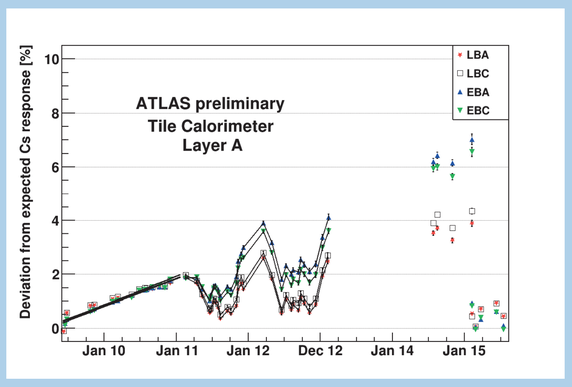
- Sends light of adjustable intensity to PMT and measures PMT gain variation C_{laser} between two Cesium scans



- Precision of the measurement is better than 0.5% for each channel
- The maximum drift is observed in the E and A cells which are the cells with the highest energy deposit

The Cesium system

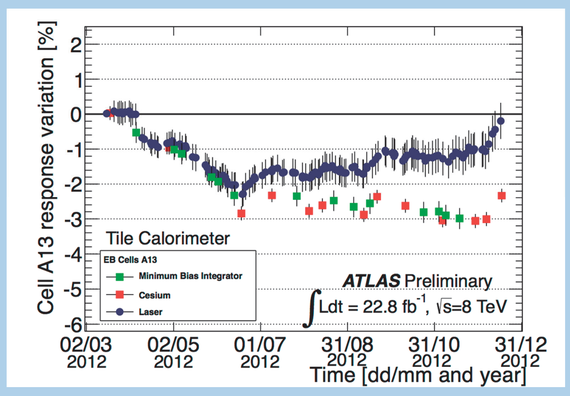
- Uses movable ^{137}Cs γ-source and integrator readout



- In first scan (June 2009 and February 2015) calorimeter is equalized and in subsequent scans C_{Cs} is calculated as a ratio of measured to expected signals
- Precision of the measurement is better than 0.3% for each channel

Combination of calibration systems

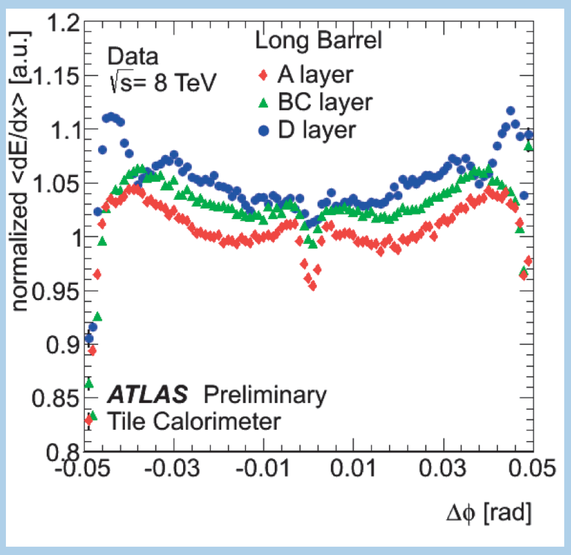
- Each of the Tile calibration systems tests a different part of the signal path, allowing to identify the source of deviation



- The difference between Laser and Minimum Bias (or Cesium) response gives the effect of the scintillators irradiation (~ -2% max in 2012)

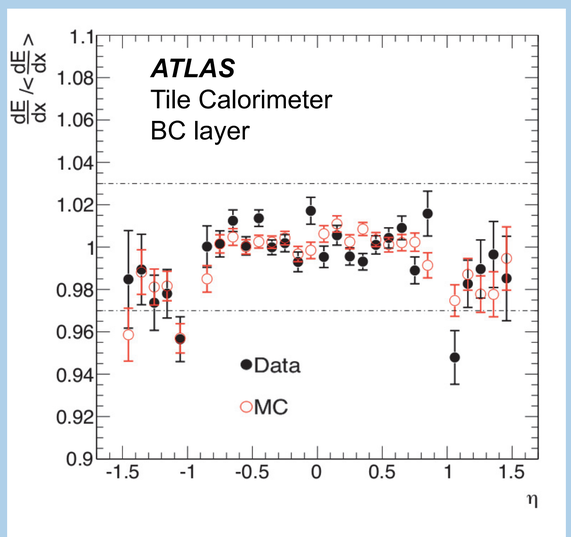
Performance

Tile response in phi ("U-shape")



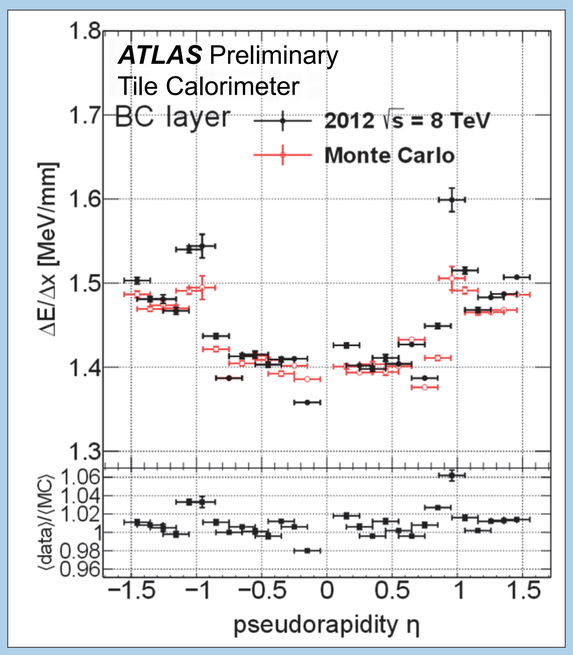
- The values of *dE/dx* obtained from collision events with muons produced in W → μν decays as a function of $\Delta\varphi$ - difference between muon impact point and cell center
- U-shape obtained with RUN1 data was used to improve MC simulation for RUN2

Cosmic Muons



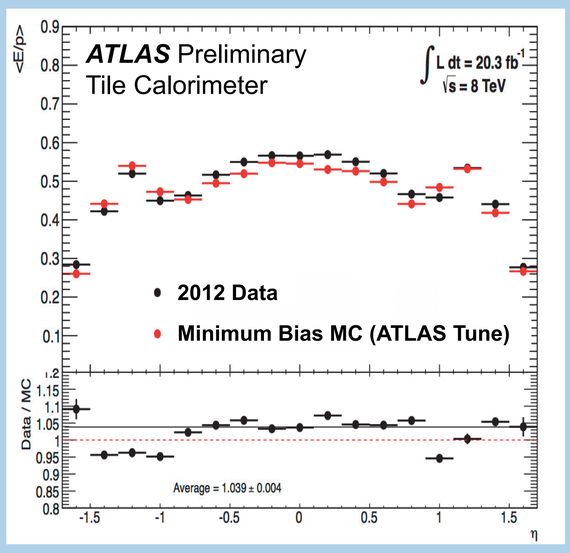
- Uniformity of the cell response to cosmic muons, expressed in terms of normalized truncated mean of *dE/dx*, as a function of η for radial layer BC
- The response is integrated over all cells in each η bin
- The results for data and MC are normalized to their averages

Collision Muons



- *dE/dx* for muons from W → μν decays in layer BC
- 2012 collision data, MC and their ratio
- Data/MC agreement is worse in the cells with higher pileup noise contribution (in gap region between LB and EB)

Single hadrons



- Energy over momentum (*E/p*) as a function of η for isolated tracks, where *E* is measured by the Tile Calorimeter and *p* by the Inner Detector
- 2012 data and MC agree within 5% except point at η = -1.5 where disagreement is 9%