ATLAS Tile Calorimeter: simulation and validation of the response

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On behalf of the ATLAS Collaboration

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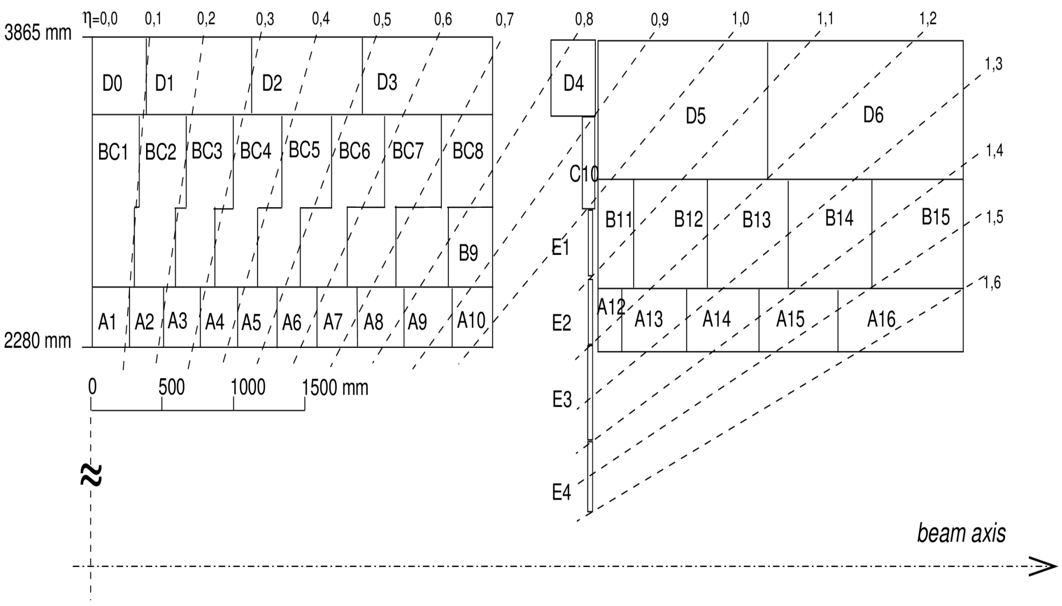
Tile Calorimeter in ATLAS

- Sampling hadronic calorimeter
  - Scintillator/Iron
- Position in ATLAS
  - From 2280 to 3865 mm in the radial direction
  - Covers $|\eta| < 1.7$
  - Full azimuth angle
- 3-dimensional cells
  - Three radial layers (A, BC/B, D)
  - $\Delta\eta \times \Delta\varphi = 0.1(0.2) \times 0.1$

More details in talks given by
Djamel Eddine Boumediene
Maria Fiascaris



TileCal simulations

SIMULATION

- Geant4
- Detector description
- Passage of particles through matter

↓ Collection of hits

DIGITIZATION

- Sampling fraction
- Digitization – 7 read-out samples spaced 25 ns
- Electronic noise, pile-up added to individual samples

↓ Read-out samples

RECONSTRUCTION

- Follows standard reconstruction of data
- Energy reconstruction (Optimal Filtering Method)
- Energy calibration

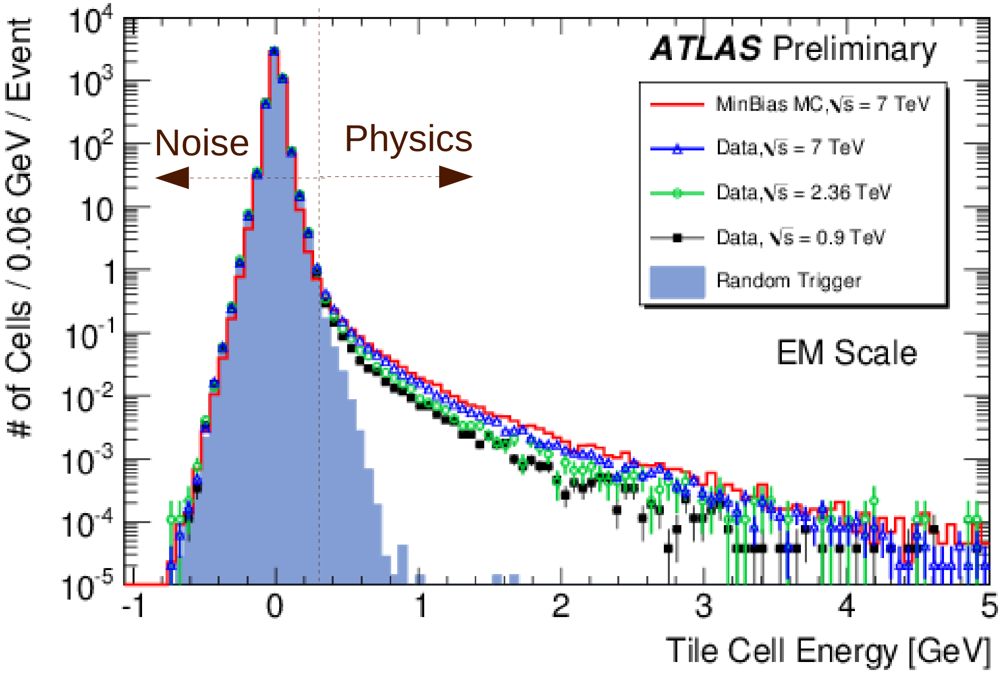
Cells at the EM scale

Electronic noise

- Good description important for the creation of topoclusters (clusters of cells based on noise significance)
- Deviations from the Gaussian shape observed during Run1
  - Low Voltage Power Supplies (LVPS)

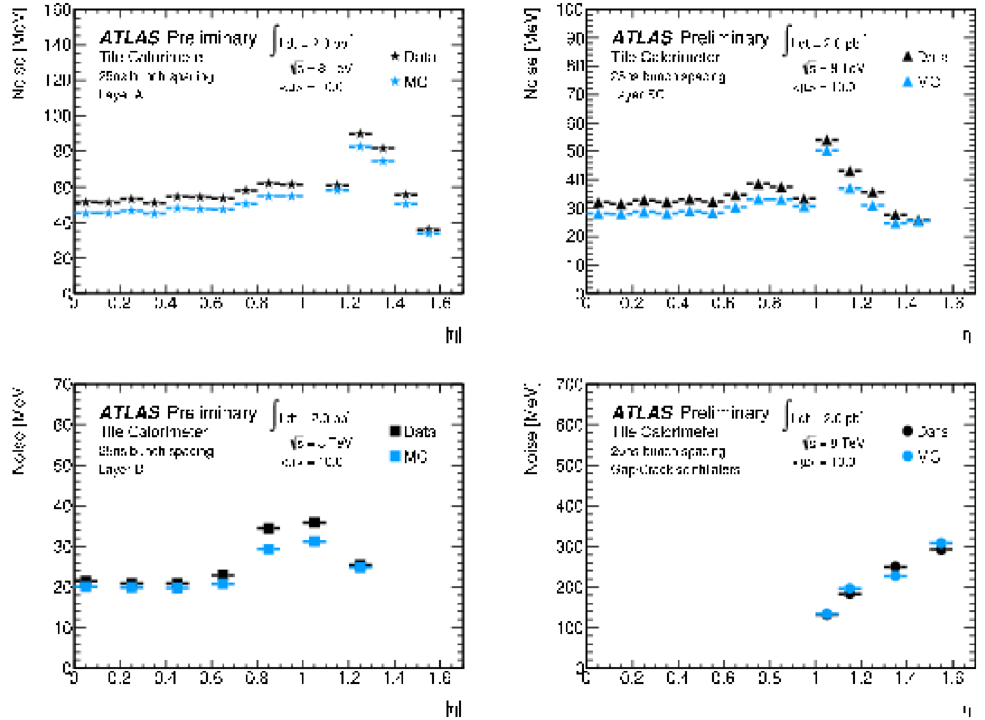
More details in talk given by **Maria Fiascaris**

- Cell noise modeled with double Gaussian function
- Electronic noise added to the individual samples in Monte Carlo
- Good agreement between data and Monte Carlo



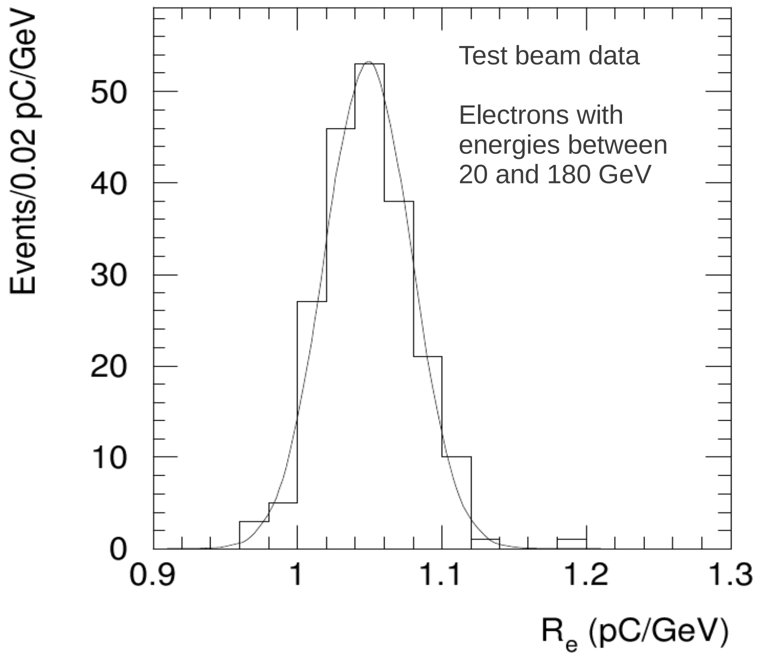
Pile-up term

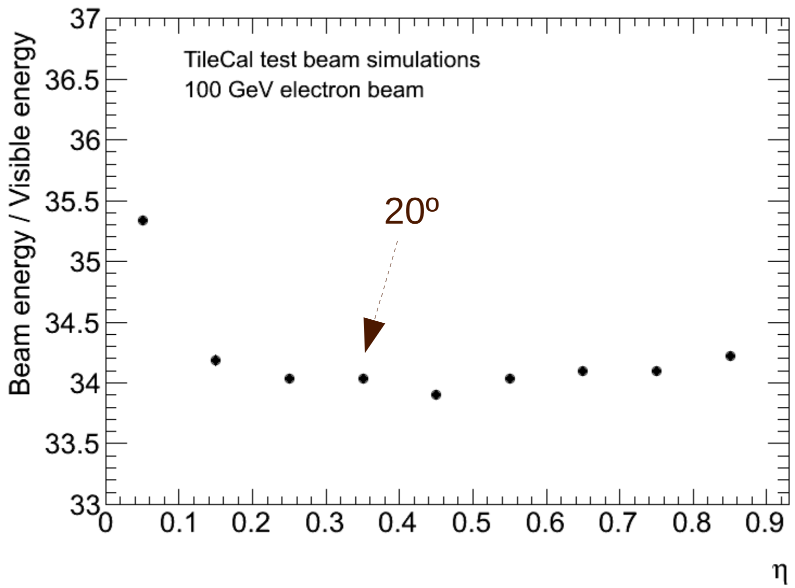
- Pile-up comes from multiple minimum bias collisions overlaid with the hard scattering process
- Varies with the radial layer and pseudorapidity
- Expected to scale with average number of low energy collisions like $\sqrt{\mu}$
- Agreement between data and Monte Carlo within ±20% in the region where pile-up is dominant
- Improved description of pile-up planned for Run2



Electromagnetic scale in TileCal

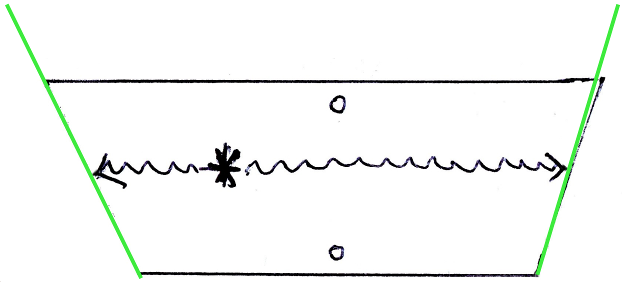
- Calibration of data and Monte Carlo to the electromagnetic (EM) scale uses 20 degrees electron beams



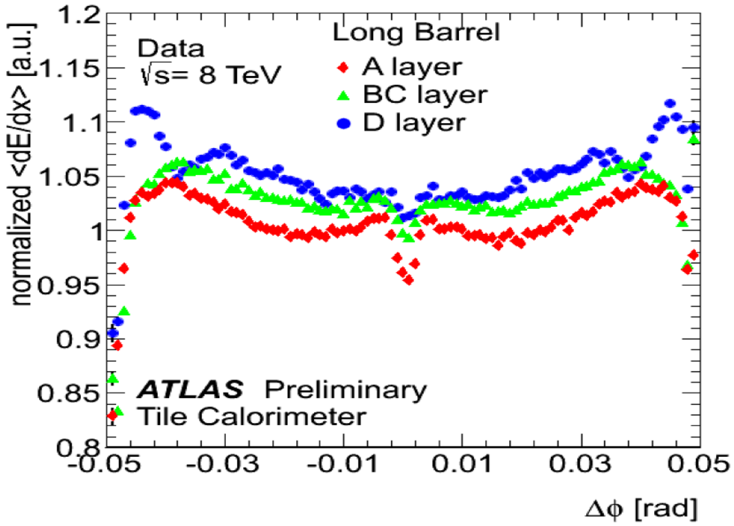


- Test beam measurements with pions and muons
  - Validation of the EM scale
  - Comparison with Monte Carlo predictions

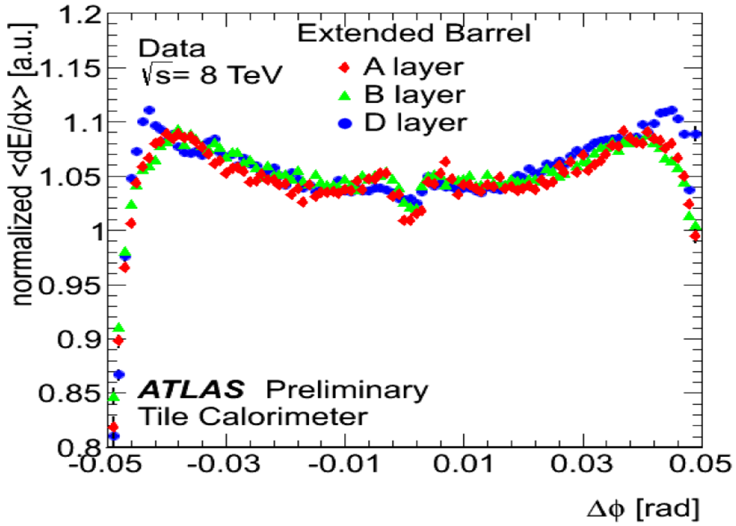
Light propagation in scintillating tiles



- Light propagation was recently implemented in the simulations
- Response of the photomultipliers is a function of the azimuth coordinate of the energy deposition point (so-called U-shape)
- Measurement of <*dE*/*dx*> proceeded with muons from $W \to \mu\nu$ decays



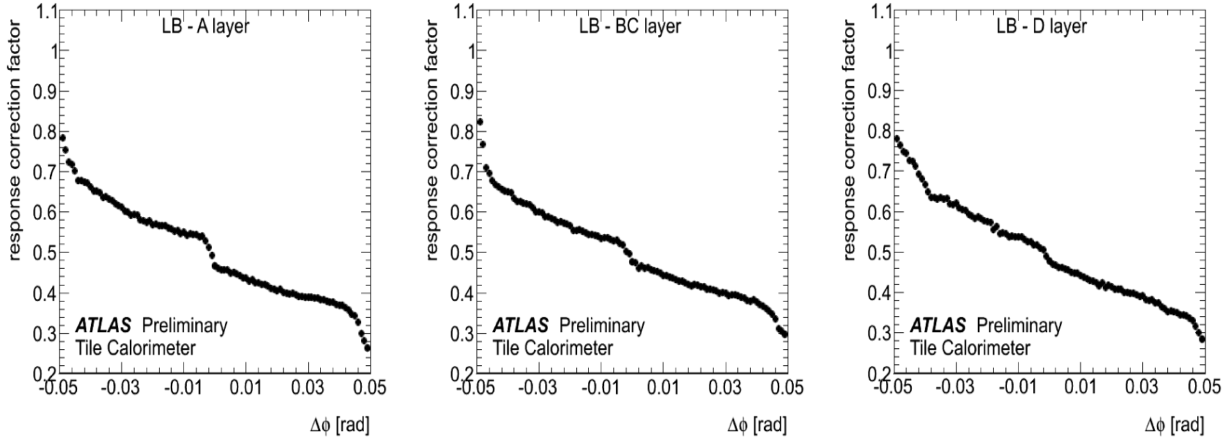
(a)



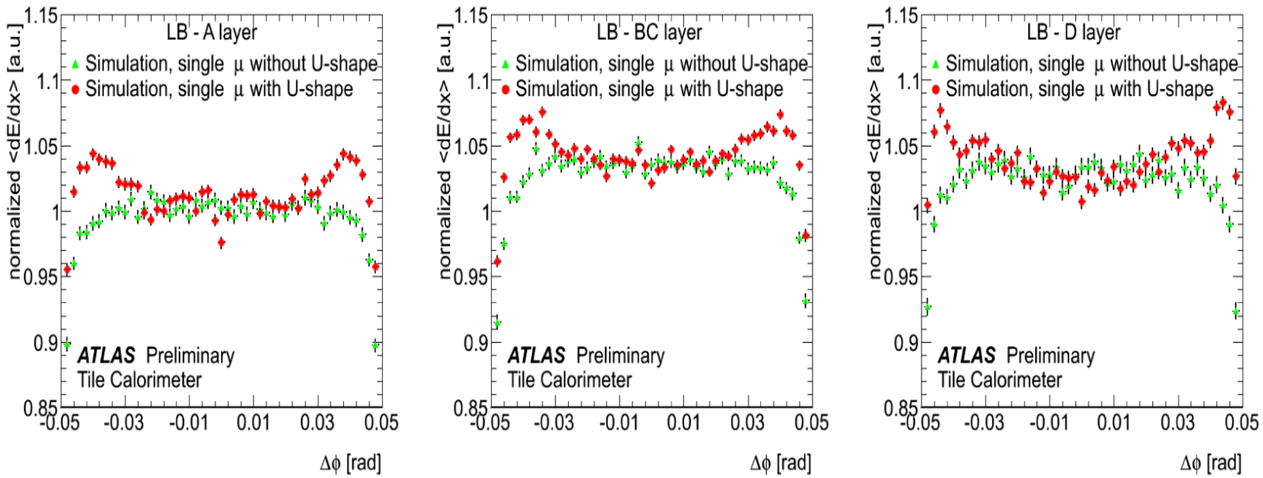
(b)

Implementation of U-shape in MC

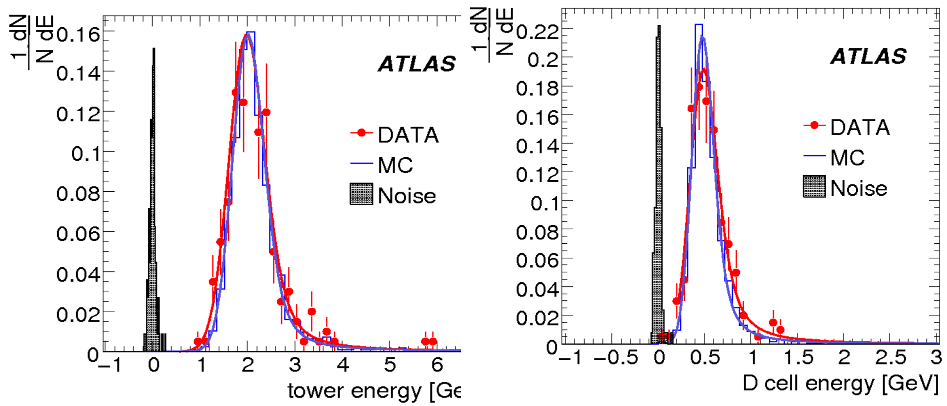
- Lookup table prepared from measurements in data and applied to Monte Carlo events

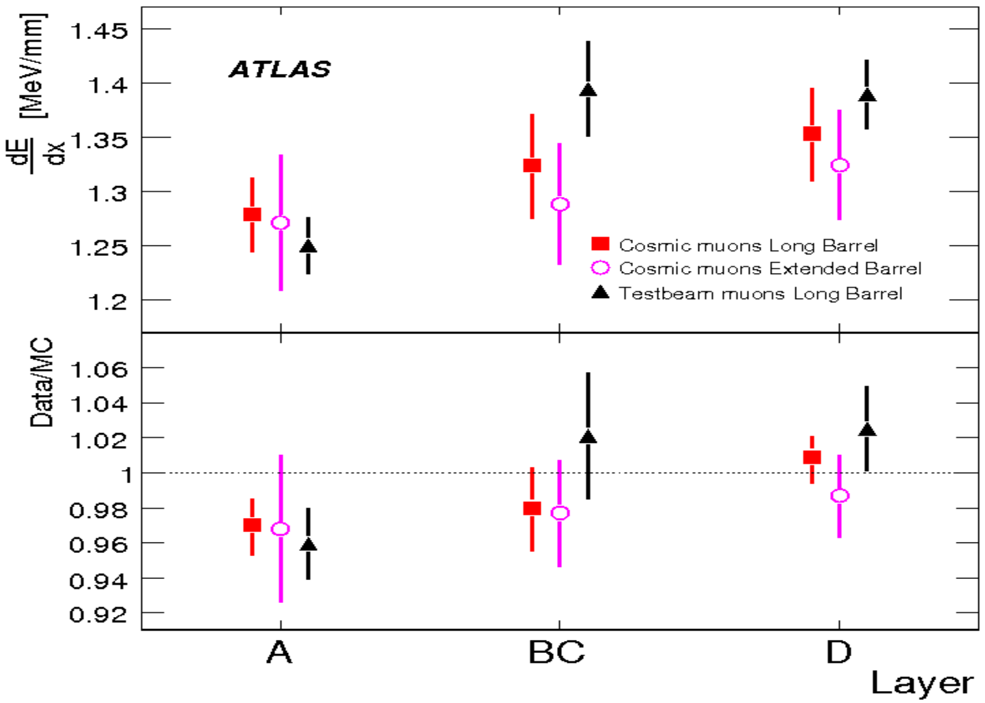


- Difference between energy distribution in simulations with and without U-shape



EM scale validation with muons

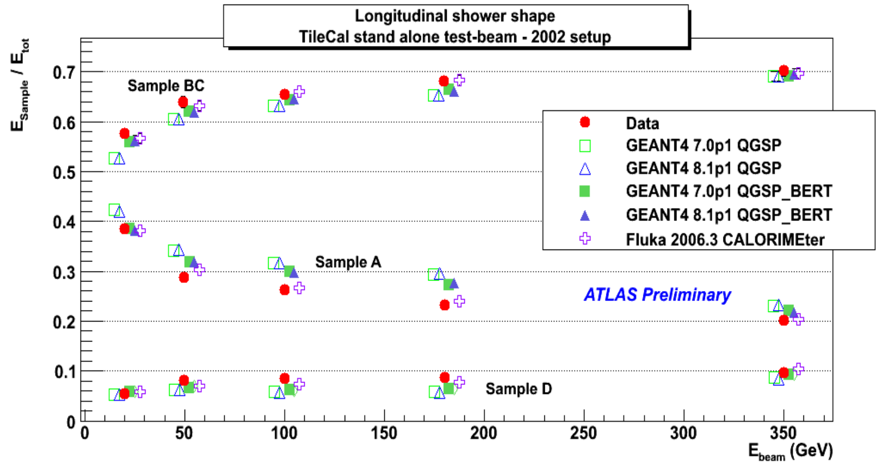


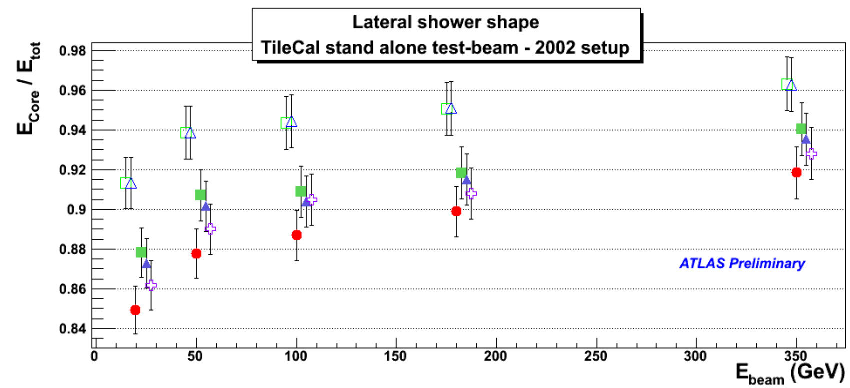


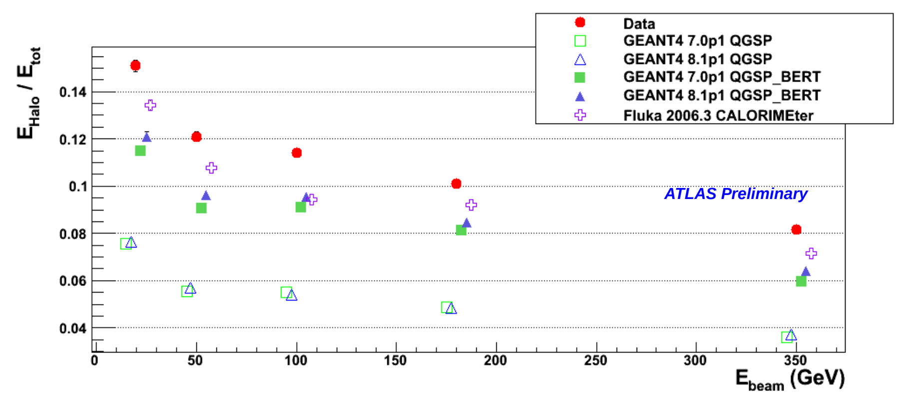
- Comparison between cosmic muons, testbeam and Monte Carlo per radial layer
- Truncated mean of muons' energy losses per path length in the cell (*dE*/*dx*)
- Agreement between data and MC to a few % level

Pions' shower shape

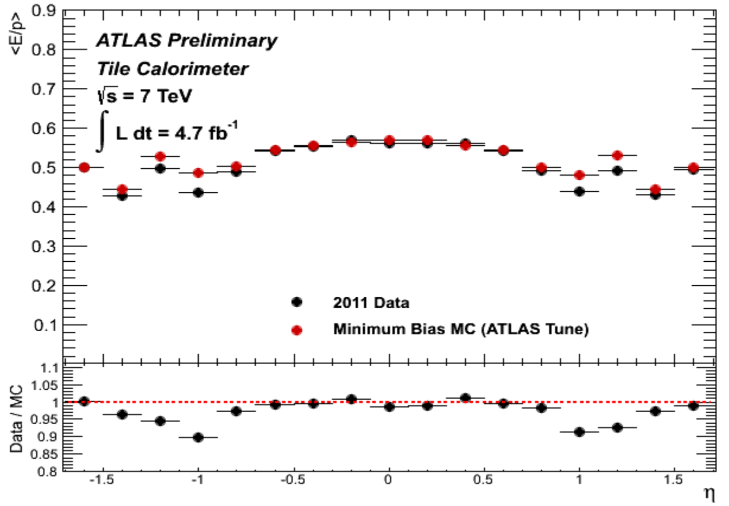
- Longitudinal and lateral shower shapes
- The agreement of shower characteristics defined the choice of Geant model
- Important element for the uncertainty of high p_T single hadrons in ATLAS
- Future plans
  - Comparison with new versions of Geant4
  - New measurements with the test beam

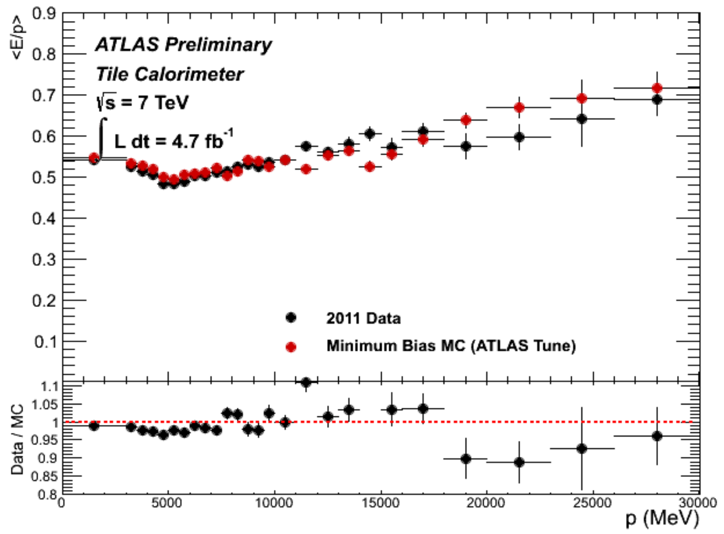






E/p measurements





More details in talk given by
Maria Fiascaris

- Single hadrons in TileCal, not interacting in Liquid Argon EM calorimeter
- Comparison between 2011 collisions data and Monte Carlo simulations
- Very good agreement except a gap region

Summary

- Noise description in the simulations
  - Good agreement for electronic noise
  - Pile-up noise higher in data compared to Monte Carlo, improved model planned for Run2
- Dependence of the energy released in TileCal on the radial angle $\Delta\varphi$ (U-shape)
  - Implemented in the simulations
  - Planned to be used in the next MC production
- Comparisons between measurements in test beam and Monte Carlo simulations show good agreement
  - Response of muons
  - Shower shapes of pions
  - *E*/*p* measurements