Response of the ATLAS Tile Calorimeter to single isolated charged hadrons

Physics in Collision 2022
Tbilisi, Georgia
5-9 September 2022

Archil Durglishvili,
on behalf of the ATLAS Collaboration
High Energy Physics Institute of Tbilisi State University

Introduction

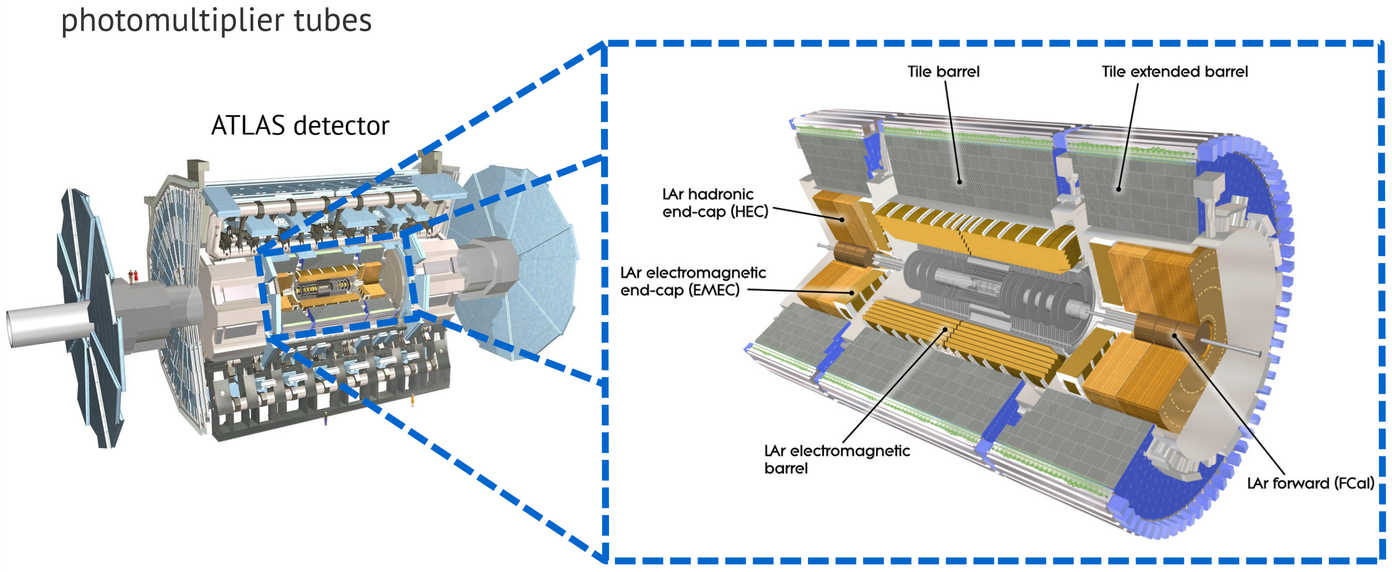
- The **ATLAS** [1] is a general-purpose detector at the **Large Hadron Collider** (LHC) [2] designed to reconstruct events from colliding hadrons.
- The **Tile Calorimeter** (TileCal) is the central hadronic calorimeter system of the ATLAS detector and provides essential input to the identification of **hadronic jets** and measurement of their energy and direction.
- The calibration and monitoring of the **calorimeter response** is of main importance for the reconstruction of hadronic jets with the ATLAS detector.
- The **performance of the TileCal system** can be probed via measurement of the **response to single isolated charged hadrons**.

Analysed data

- LHC proton-proton collision data at √s = 13 TeV collected in 2017
- **Special runs**
  - Negligible number of additional proton-proton interactions in the same and neighboring bunch crossings (pile-up).
  - Integrated luminosity of 144.9 pb^{-1}.
- The data is compared to simulated events generated using Pythia 8.186 [3] with the A14 tune [4] and the NNPDF23 LO parton distribution function set [5].

Tile Calorimeter

- The TileCal is a sampling calorimeter consisting of steel as absorber and plastic scintillators as active medium
- The scintillators are read-out by the wavelength shifting fibres coupled to the photomultiplier tubes

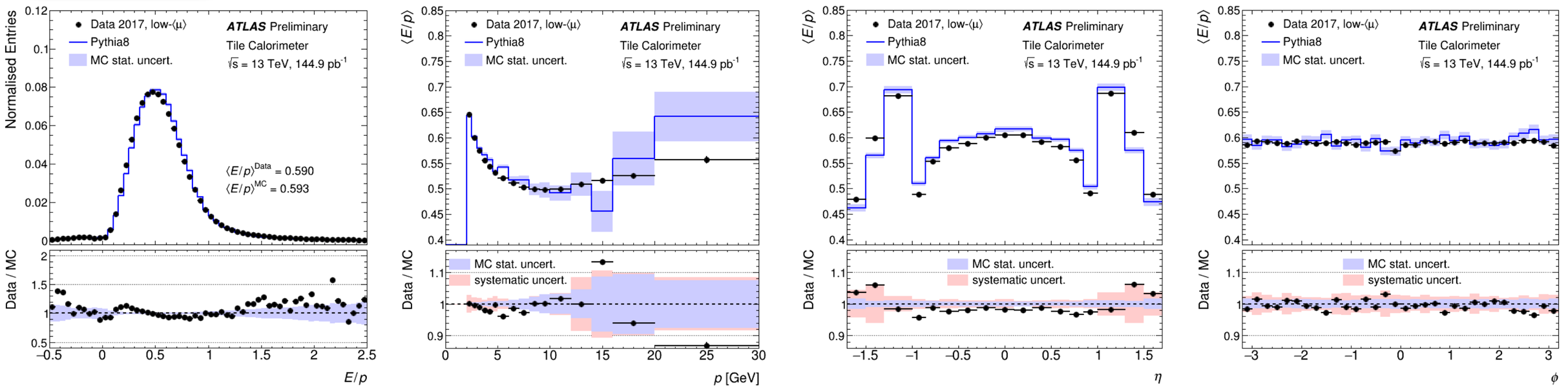


Calorimeter response

- **The calorimeter response is determined as the ratio of the energy deposited in the calorimeter (*E*) divided by the momentum measured in the ATLAS Inner Detector (*p*).**
- The particles in the analysis have a momentum below 30 GeV
  => precision of the measurement is dominated by the energy resolution.
- **The energy is reconstructed from topological clusters matched to a track in a cone of $\Delta R < 0.2$.**
- Reconstructed energy is calibrated at EM scale.
- **Track selection**:
  - Required to pass minimum quality criteria
  - $p > 2$ GeV
  - No other tracks within a cone of $\Delta R < 0.4$
  - Energy deposited in the electromagnetic calorimeter $E^{EM} < 1$ GeV
  - The fraction of energy deposited in the Tile Calorimeter $E^{Tile}/E^{Total} > 0.7$

Results

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ApprovedPlotsTileSingleParticleResponse#Single_hadrons



- The average of the *E/p* distribution is 0.5896 ± 0.0001 (0.593 ± 0.001) for data (simulation), only including statistical uncertainty.
  - The average of the *E/p* < 1 is expected due to non-compensating nature of TileCal.
- The simulation slightly overestimates the energy measured in the TileCal in central region ($|\eta| < 0.7$).
  - Similar results are obtained using charged pions from $W^{\pm} \to \tau^{\pm}(\to \pi^{\pm}\nu_{\tau})\nu_{\tau}$ events [6].
- The data/MC differences in the $|\eta| \sim 1.5$ region is due to crack scintillators and worse dead material knowledge in this region.
- Systematic uncertainty on the ratio covers effects due to contamination from neutral particles and energy mis-measurements due to energy loss in the dead material in front of the calorimeter.

Conclusions

The average of *E/p* measured in data is 0.5896 ± 0.0001 (stat), compared to an expected value of 0.593 ± 0.001 (stat) obtained using Pythia8 simulated multijet events. A good agreement between experimental and simulated results is observed confirming the goodness of the calorimeter energy calibration at the EM scale.

References

[1] ATLAS Collaboration, The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003
[2] L. Evans and P. Bryant, LHC Machine, JINST 3 (2008) S08001
[3] T. Sjöstrand, S. Mrenna and P. Skands, A brief introduction to PYTHIA 8.1, Comput. Phys. Commun. 178 (2008) 852, arXiv: 0710.3820 [hep-ph]
[4] R. D. Ball et al., Parton distributions for the LHC run II, JHEP 04 (2015) 040, arXiv: 1410.8849 [hep-ph]
[5] ATLAS Collaboration, ATLAS Pythia 8 tunes to 7 TeV data, ATL-PHYS-PUB-2014-021, 2014
[6] ATLAS Collaboration, Measurement of the energy response of the ATLAS calorimeter to charged pions from $W^{\pm} \to \tau^{\pm}(\to \pi^{\pm}\nu_{\tau})\nu_{\tau}$ events in Run 2 data, Eur. Phys. J. C 82 (2022) 223, arXiv: 2108.09043 [hep-ex]