Determination of the Jet Energy Scale Uncertainty in the ATLAS Detector

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Jet Reconstruction and Calibration in ATLAS

The ATLAS detector uses sampling, non-compensating calorimeters [1]. Jets in the calorimeters are reconstructed from topo-clusters (topologically connected calorimeter cells) using the Anti-Kt algorithm with a distance parameter of R = 0.4 or R = 0.6. ATLAS uses different calibration schemes starting from the electromagnetic (EM) scale which correctly reconstructs the energy deposited by an electromagnetic shower. It is derived from test beam data, MC simulation and in situ measurement of the Z boson mass using Z->ee events. The Local Cell Weighting (LCW) scheme corrects each cluster for energy that can not be measured in the calorimeter (eg. from nuclear reactions), for energy losses in dead material and for energy losses due to noise thresholds. Clusters are classified as being of electromagnetic or hadronic nature and separate corrections are applied accordingly.

The Jet Energy Scale corrects for the following effects:

- Detector non-compensation
- Dead material
- Leakage of particles outside the calorimeters
- Particles outside of the reconstructed jet cone
- Noise thresholds & particle reconstruction efficiency

As compared to 2010, in 2011 the number of multiple proton-proton collisions increased and the noise thresholds in the calorimeter cells were increased. The detector geometry description in 2011 Monte Carlo is more detailed than in 2010.

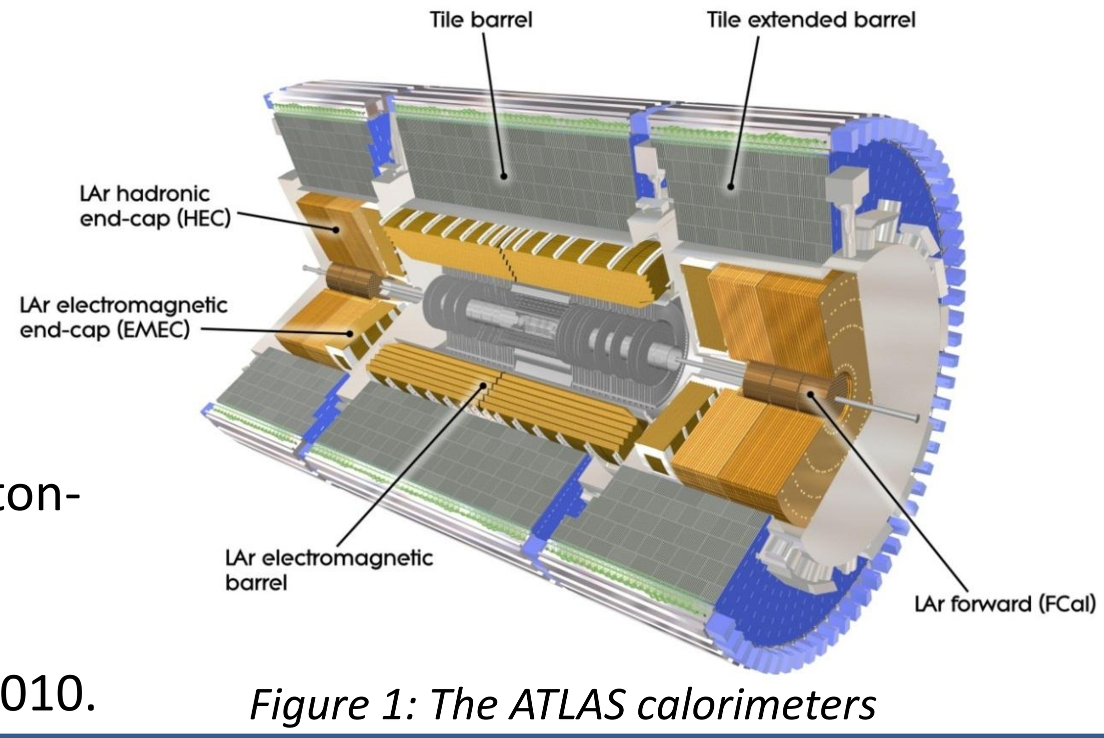

Figure 1: The ATLAS calorimeters

JES determination

The Jet Energy Scale consists of the following corrections:

- **Offset correction**: Energy due to multiple proton-proton collisions (pile-up) is subtracted.
- **Vertex correction**: The jet direction is corrected to point to the primary vertex.
- **Jet energy and eta correction**: based on comparison of truth p_T and reconstructed p_T in Monte Carlo simulations.

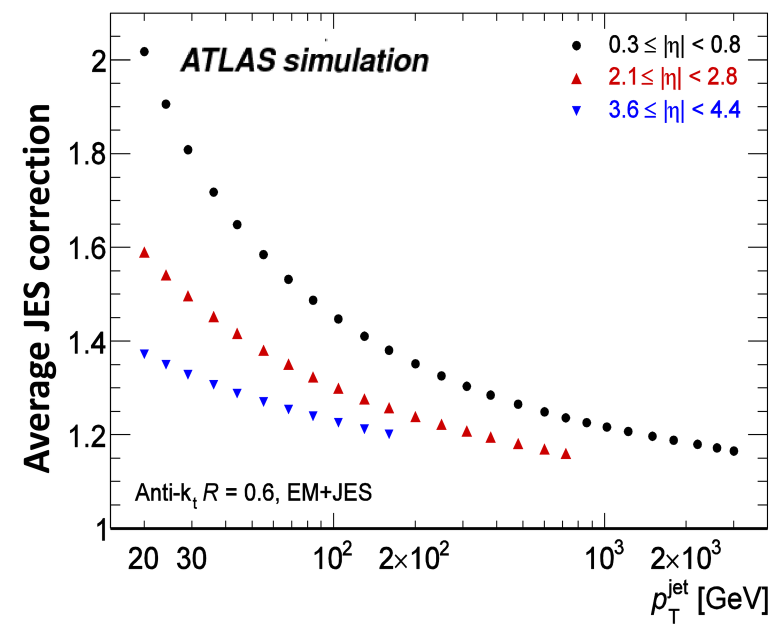

Figure 2 [2]: The average JES scale applied to Anti-Kt 0.6 EM scale jets

Jet Energy Scale Uncertainty

In 2010 the Jet Energy Scale uncertainty was estimated by systematic MC variations and using in-situ single hadron response measurements.

The uncertainty accounts for Monte Carlo generator differences, pile-up, noise thresholds, the effects of soft physics modelling, additional dead material and non-closure from the jets calibrated with the JES calibration.

Uncertainties due to differences between quark and gluon responses and to account for non-isolated jets are also derived.

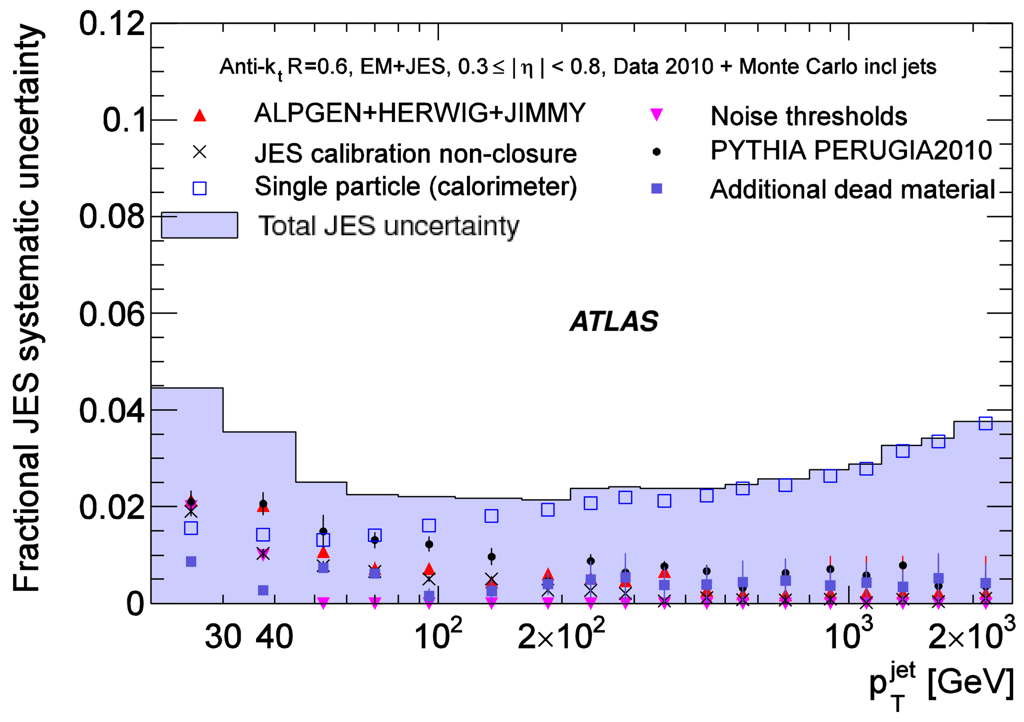

Figure 3 [2]: The Jet Energy Scale uncertainty derived using 2010 data and Monte Carlo simulations for Anti-Kt 0.6 EM+JES jets in 0.3 < |η| < 0.8

In-situ JES uncertainty

In-situ methods using a well calibrated reference object to probe the calibration of the jet can also be used to test the Jet Energy Scale uncertainty. Different reference objects provide sensitivity in different p_T ranges:

- **Z - Jet:** 10 GeV- 250 GeV: direct balance of the p_T of the Z and the jet (new analysis for 2011 data)
- **Photon - Jet:** 25 GeV – 800 GeV: the photon p_T is balanced against the jet p_T (direct balance) or the hadronic recoil (Missing E_T Projection Fraction, MPF)
- **Multi-jet balance:** 210 GeV-1.5 TeV: the p_T of one of more well calibrated jets is balanced against the p_T of the highest p_T jet.

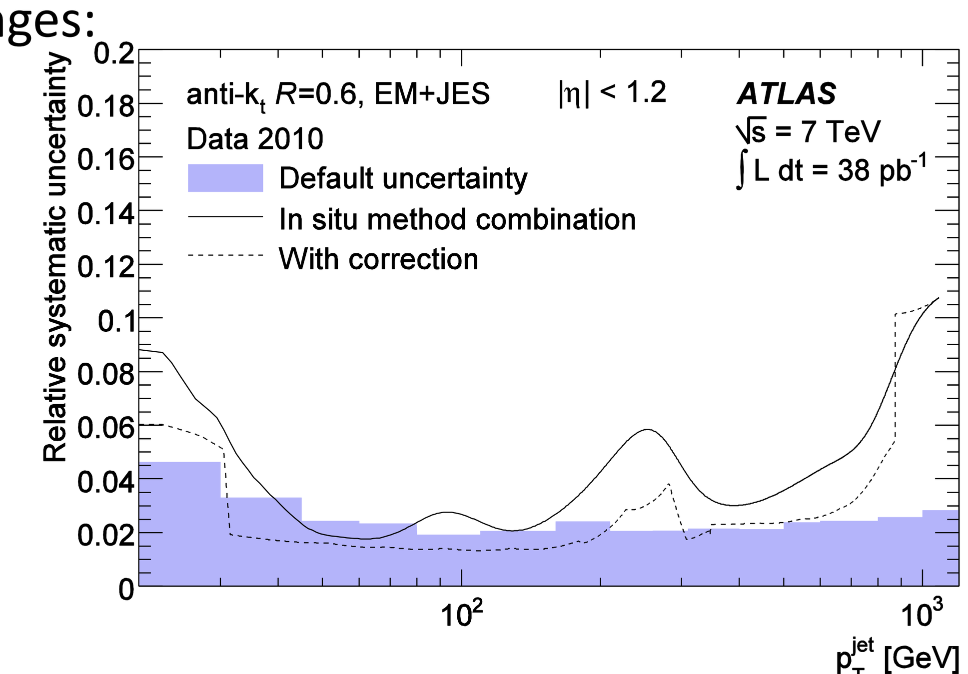

Figure 4: JES uncertainty derived from in-situ methods in 2010 data for Anti-Kt 0.6 EM+JES jets |η| < 1.2

In 2010 the non-closure from these methods and their uncertainties were used as a check of the Jet Energy Scale uncertainty.

In-situ methods in 2011 data

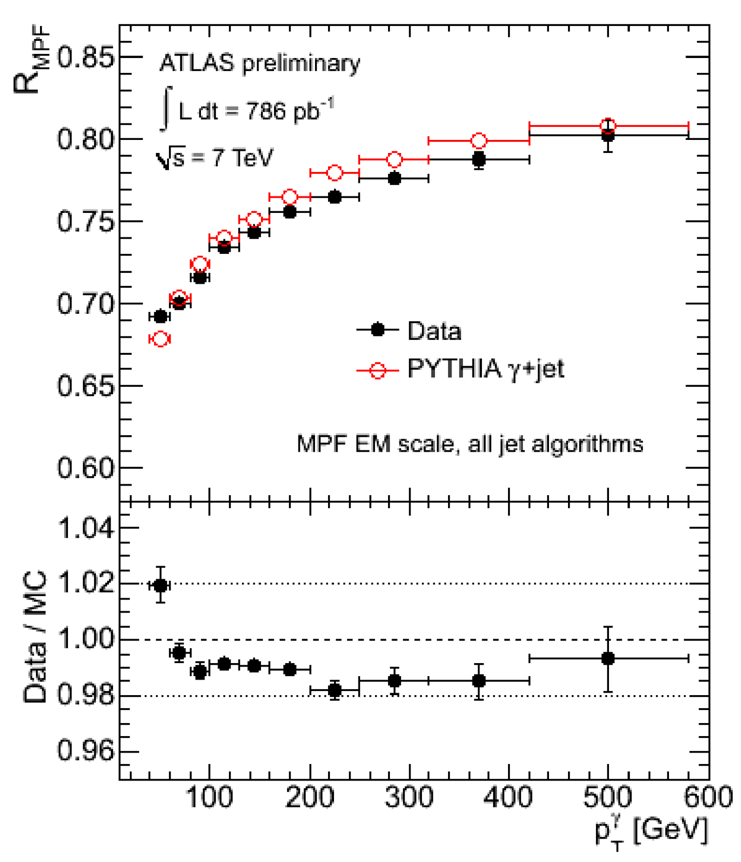

Figure 5: Jet response as a function of p_T of the photon determined from γ+jet events using the MPF method for Anti- Kt 0.4 EM+JES jets

In 2011 data the in-situ techniques measure a 1-2% lower jet response in data than in Monte Carlo simulations.

As can be seen in Figures 5 and 6 Z+jet and photon+jet methods give consistent results. The multi-jet balance can be used to assess the uncertainties in the TeV region.

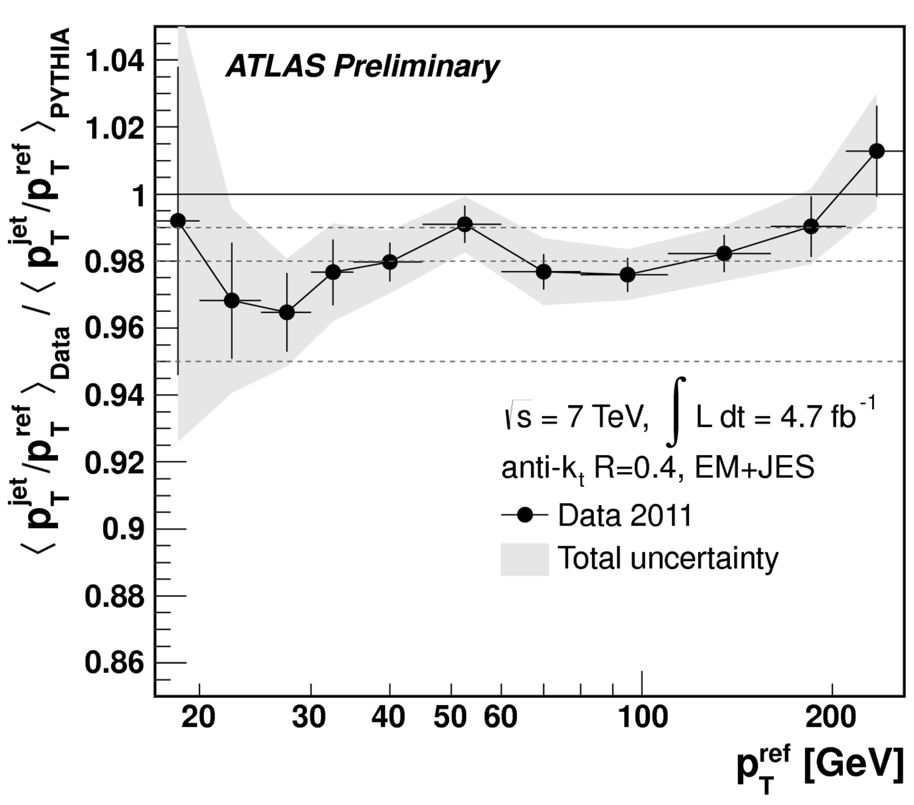

Figure 6: Data/MC ratio of jet response as a function of p_T of Z determined from Z+jet events for Anti- Kt 0.4 EM+JES jets

Conclusions

The Jet Energy Scale and its uncertainty were determined in 2010 data using systematic Monte Carlo variations and in situ single hadron response measurements. In 2010 data a Jet Energy Scale uncertainty of 2-4 % was obtained.

This uncertainty is confirmed for 2011 data using in-situ methods.

Acknowledgements

The ATLAS collaboration and the ATLAS Jet/EtMiss group

References

[1] ATLAS Collaboration, The ATLAS experiment at the CERN Large Hadron Collider, JINST **3** (2008) S08003

[2] ATLAS Collaboration, Jet energy measurement with the ATLAS detector in proton-proton collisions at √s = 7 TeV in 2010, arXiv:1112.6426v1