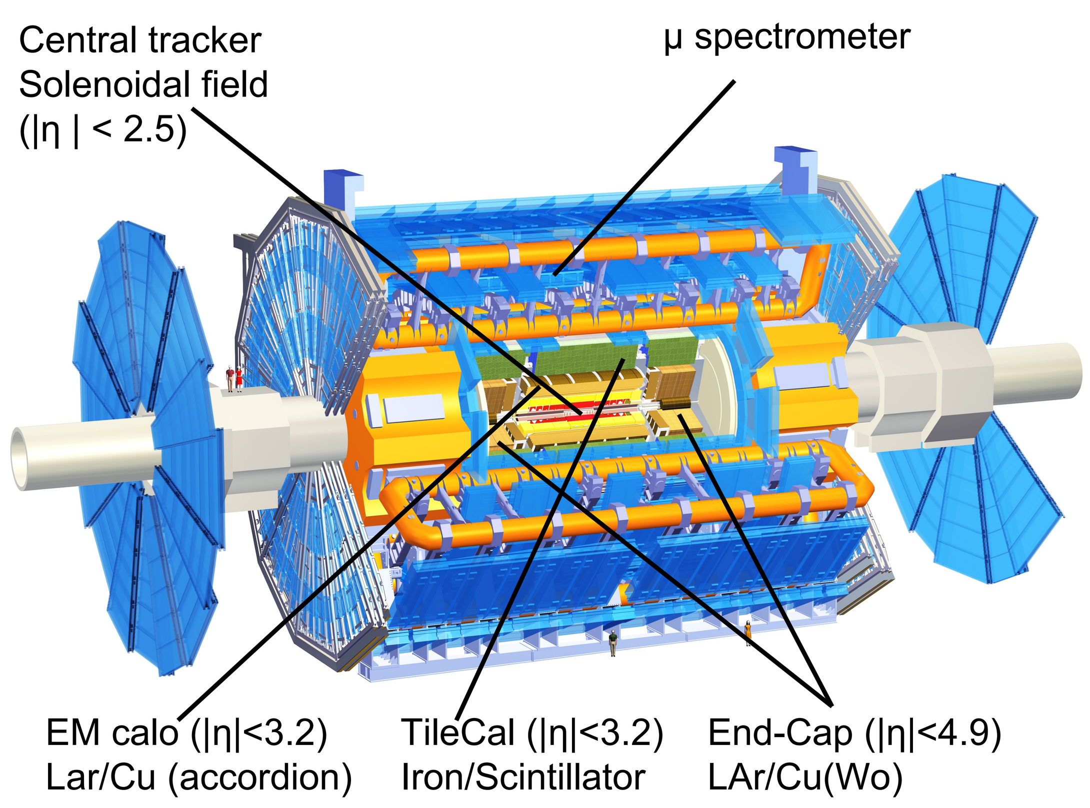
Jet energy scale calibration using gamma-jet events in the ATLAS experiment

On behalf of the Atlas collaboration: M. Cascella, INFN and University of Pisa

A precise calibration of the jet energy in the ATLAS experiment at LHC is fundamental for many physics issues. Di-jet and multi jet events will be used to cross-check the relative response across different pseudo-rapidity and transverse momentum regions. The photon+jet channel (being the one with largest cross section) is the first candidate to check "in situ" the jet absolute energy scale.
In events with photon and a recoiling jet, the transverse momentum balance can be exploited to estimate the jet energy using the measurement on the photon, whose scale is much better under control.
The main background to this channel is given by QCD events where one jet is misidentified as a photon. The status of this analysis with the data collected by ATLAS in 2010 will be presented.

The ATLAS detector

ATLAS is a multi-purpose detector designed to observe the particles produced in pp collisions at LHC.

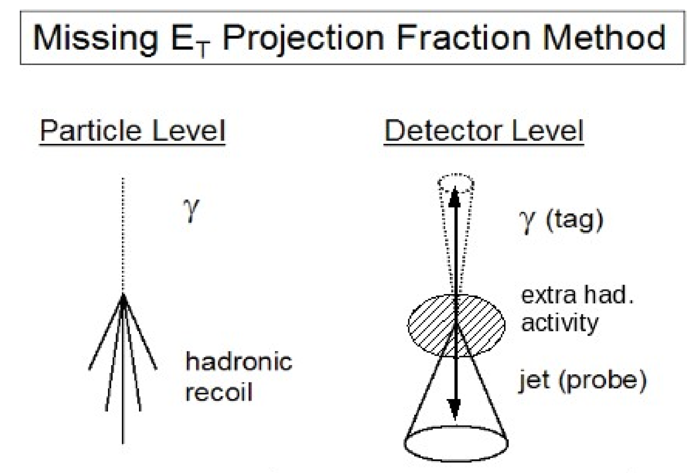


The MPF method

The missing ET projection fraction (MPF) technique exploit the transverse momentum balance of the photon and hadronic recoil to derive the detector response to hadronic jets.

The basic assumption is that the only missing ET in a γ-jet event arises from calorimeter non-compensation and signal losses due to noise suppression and dead material.

The MPF response is independent of the jet algorithm as it does not use the jet energy directly.



$$\vec{p}_{T,\gamma} + \vec{p}_{T,had} = \vec{0} \qquad \vec{p}_{T,\gamma} + R_{had}\vec{p}_{T,had} = -\vec{E}_T$$

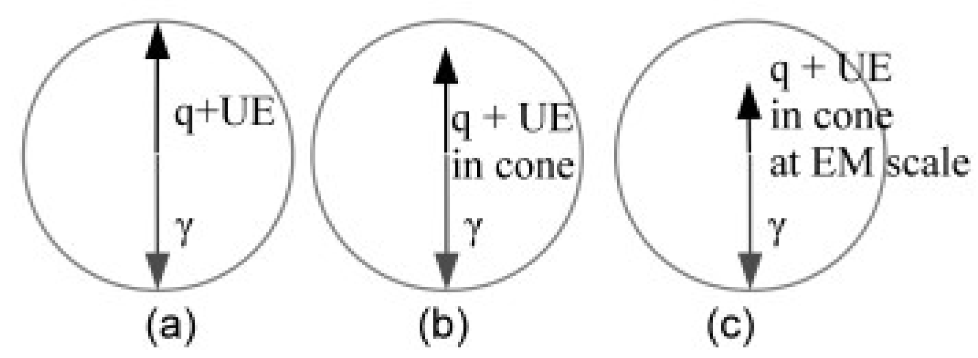
$$R_{had} = 1 + \frac{\vec{E}_T \cdot \vec{p}_{T,\gamma}}{\vec{p}^{\,2}_{T,\gamma}}$$

For back - to - back events : $R_{jet} \approx R_{had}$

The Direct Balance method

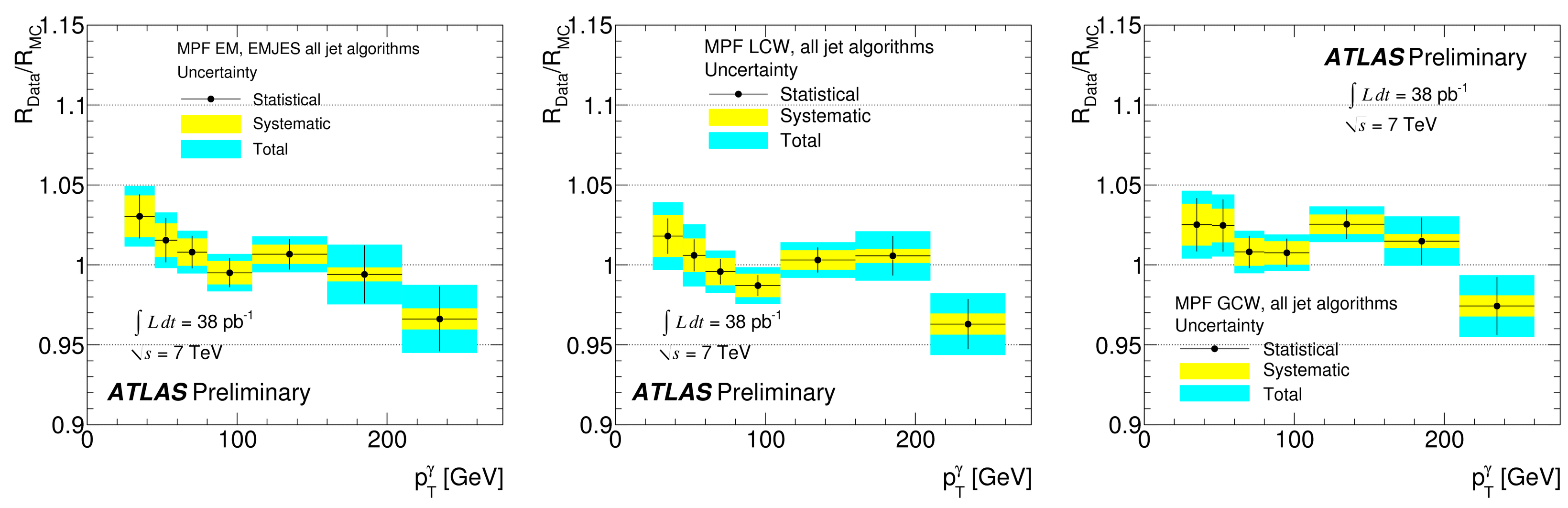
The direct p_T balance technique exploits the transverse momentum conservation between the photon and the jet.

The ratio of the jet p_T to the photon p_T ($R = p_T^{jet} / p_T^{\gamma}$) is used to estimate the jet response. Since the photon p_T is well measured, with good agreement between data and simulation, the ratio R is compared between data and simulation to validate the jet p_T calibration.



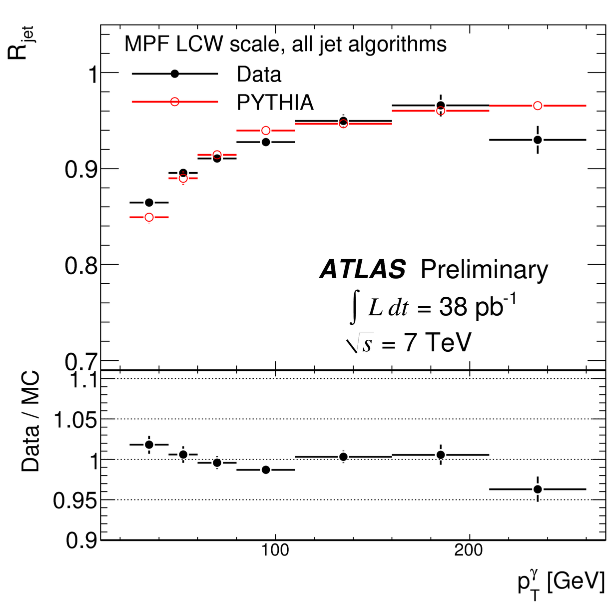
The Data/MC ration must be evaluated for each combination of jet algorithm and calibration scheme.

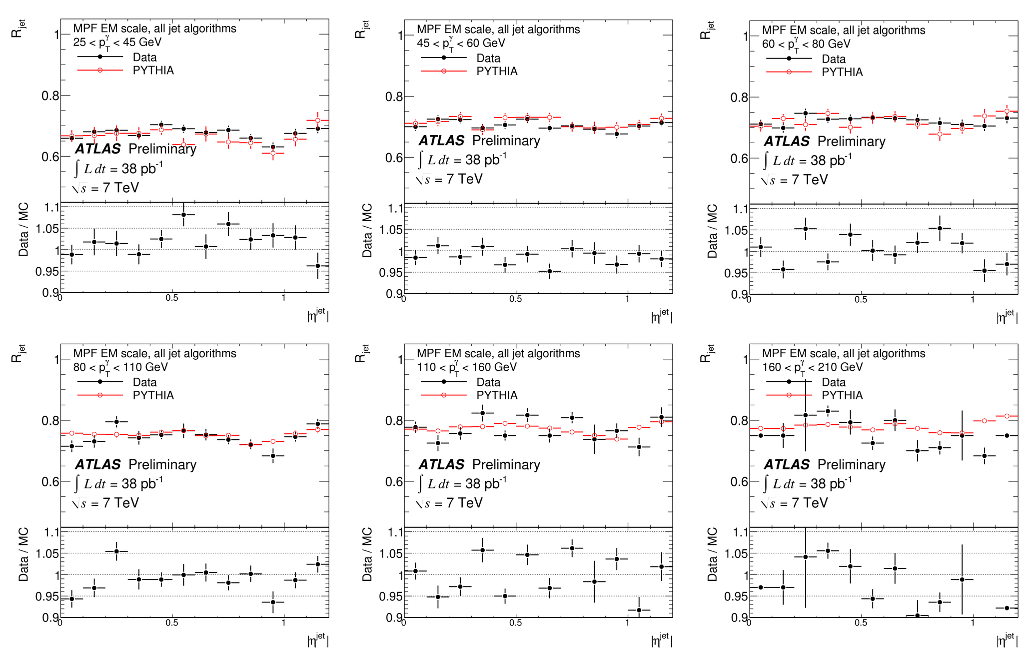
MPF results



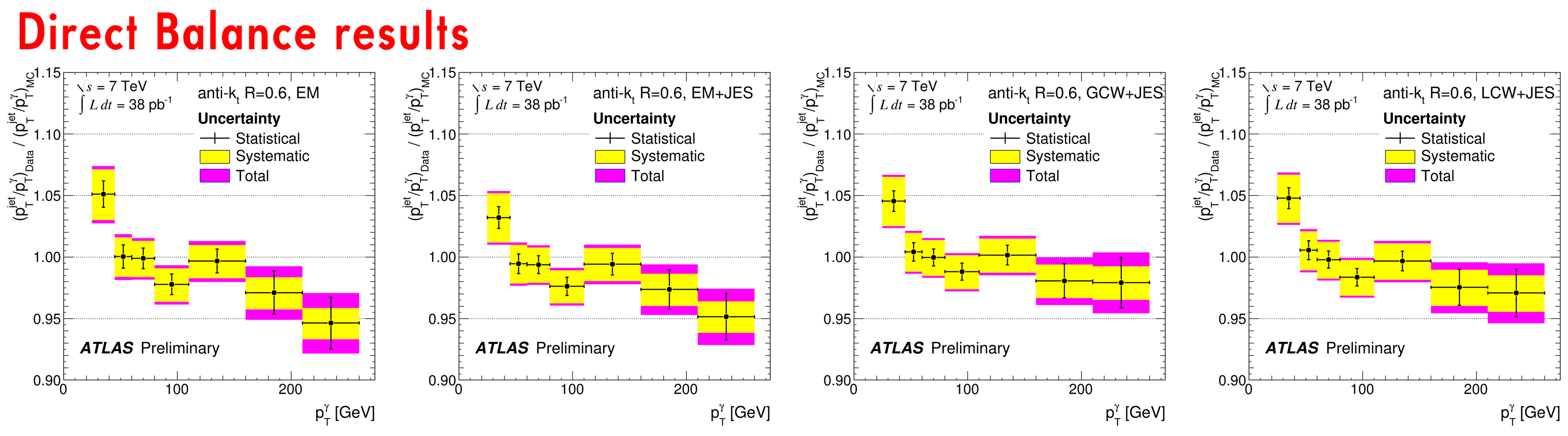
Ratio of response between data and MC, as determined using the MPF technique with the total uncertainty on the determination of the Data/MC ratio, for all energy calibration schemes.

Calorimeter response to jets measured in both data and MC using the MPF technique. The data/MC agreement is within ±5% (bottom). The results in shown as a function of p_T^{γ} (bottom-left) and of the jet pseudorapidity (bottom right)





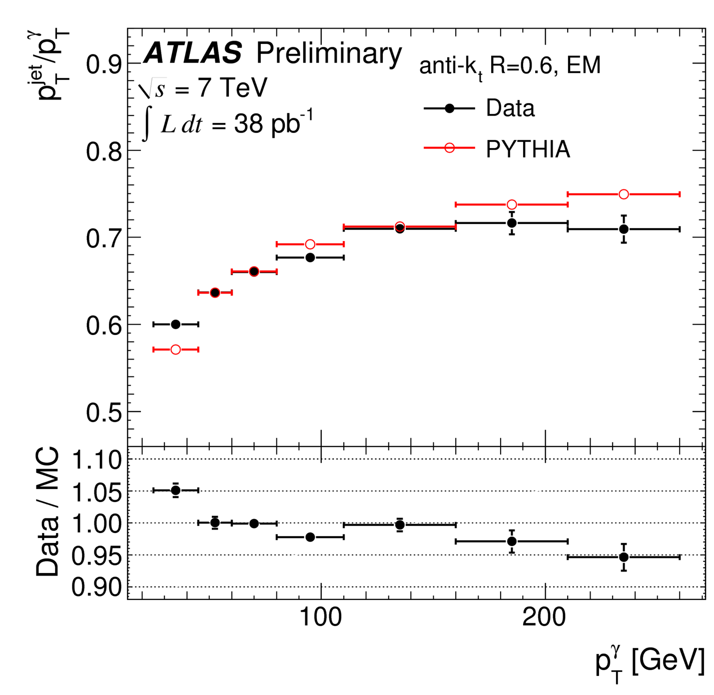
Direct Balance results

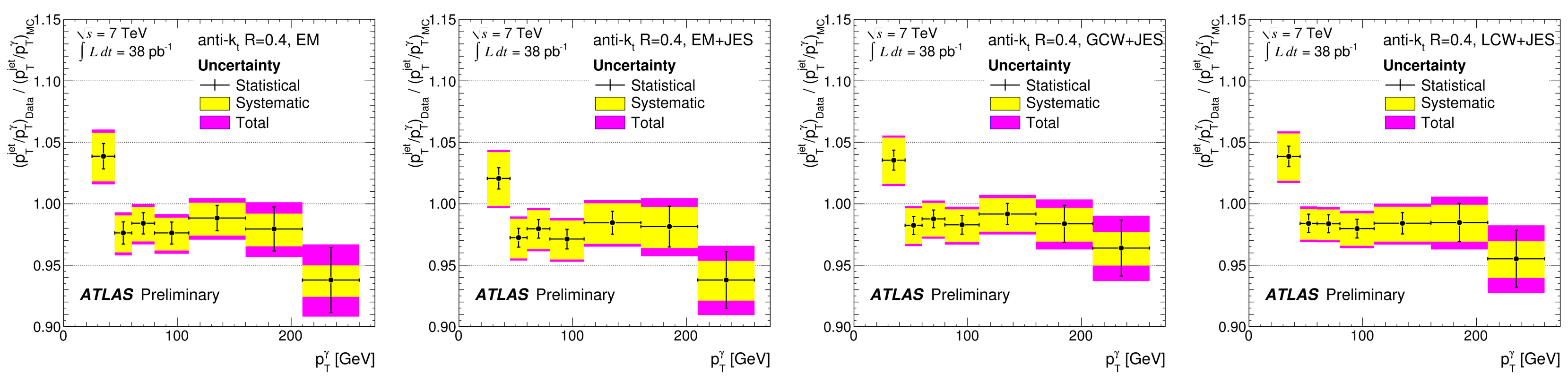


Ratio of (p_T^{jet} / p_T^{γ}) between data and MC, and the total uncertainty on the determination of the data/MC ratio, for anti-kt jets with R = 0.6 (top) and R = 0.4 (bottom) and all energy calibration schemes.

The 5% shift in the p_T^{γ} < 45 GeV range for the EM and EM+JES scale is consistent with the systematic uncertainty

Calorimeter response to jets measured in both data and MC using the direct p_T balance technique with the anti-kt algorithm with R = 0.6 The data/MC agreement is within ±5% (right).

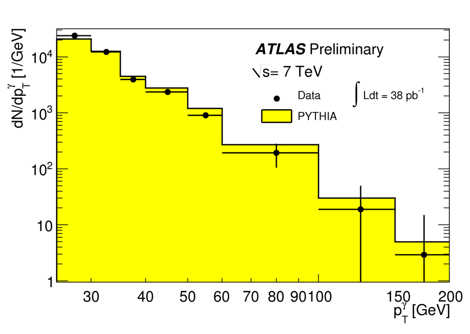




Event selection

- Event Level: Standard Model (jet) GRL; Primary vertex must have > 4 tracks; Pass loose photon trigger
- Photon: p_T^{γ} > 25 GeV; Tight photon selection; η^{γ} < 1.37; Isolation (corrected for leakage) < 3 GeV; photon not in problematic region
- Jet: η^{jet} < 1.2; Additional jet quality selection

Distribution of p_T^{γ} for events passing the described photon selection criteria normalized using the observed number of pre-scale corrected events.



References

The ATLAS collaboration, Determination of the ATLAS jet energy measurement uncertainty using photon-jet events in proton-proton collisions at √s = 7 TeV, ATLAS-CONF-2011-031

Contact

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Jet energy measurement

The Atlas calorimeters have calibrated to the electromagnetic energy (EM) scale using electron test beam. A small correction derived from in-situ calibration with Z → $e^+ e^-$ is also applied.

Three energy calibrations are used for data analysis of jets in ATLAS. The simple jet energy scale (JES) calibration factors and two weighting algorithms: the Global and Local Cell Weights (GCW and LCW), both exploiting the different density of electromagnetic and hadronic showers.

The GCW calibration derives weights for each cell in a jet by minimizing the overall jet resolution using a dijet MC simulation.

The LCW calibration method classifies calorimeter clusters as either electromagnetic or hadronic then correct their energy with weights derived from single pion MC simulation to account for the effects of non-compensation, signal losses due to noise thresholds in the clustering, and energy lost in non-instrumented regions. Jets are then built from these calibrated clusters.

The JES calibration is a calibration factor derived from the dijet MC simulation applied on top of the EM, GCW or LCW energy scales to restore the true jet energy. The resulting calibrated jets referred to as EM+JES, GCW+JES or LCW+JES.

Systematics

Systematic uncertainties arise due to differences between the data and MC. Uncertainties due to the soft radiation, in-time pile-up, background from jets identified as photons (fakes), missing calorimeter read-out regions and photon energy scale are studied.

- **Photon background** the response R is measured on a sample of dijets the systematics is the difference times the efficiency
- **Soft radiation suppression cuts** the selection is varied over a large range
- **In-time pile-up** the Data / MC ratio is measured as a function of the number of primary vertices
- **Impact of missing calorimeter read-out regions** the measurement is checked using a sample of events with no jets in problematic regions this produces no systematics.
- **Photon energy scale** The systematic uncertainty over the photon energy scale is propagated to the final result.

	Direct p_T balance (%)		MPF (%)	
p_T^{γ} range (GeV)	(45, 60)	(110, 160)	(45, 60)	(110, 160)
Photon Energy Scale	$^{+0.5}_{-0.3}$	$^{+0.5}_{-0.3}$	$^{+0.2}_{-0.5}$	$^{+0.3}_{-0.5}$
Dijet Background	±1.0	±0.4	±0.6	±0.1
Soft Radiation	±0.8	±0.9	±0.7	±0.4
In-time Pile-up	±0.8	±0.8	±0	±0
Total Systematic Uncertainty	$^{+1.6}_{-1.5}$	$^{+1.4}_{-1.3}$	$^{+0.9}_{-1.0}$	$^{+0.5}_{-0.6}$