Jet Calibration in the ATLAS Experiment

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ATLAS EXPERIMENT http://atlas.ch

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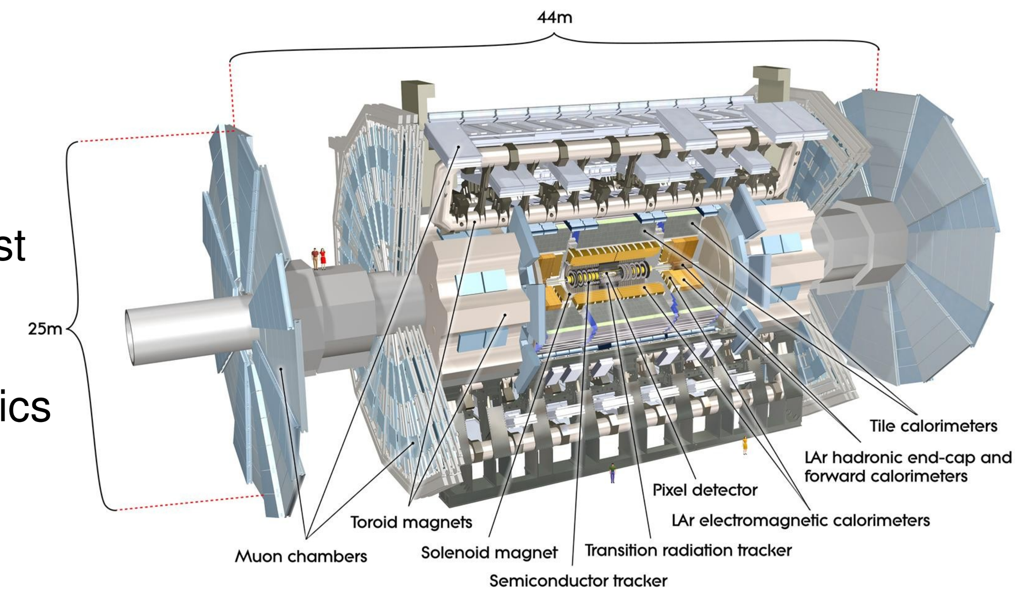
Introduction

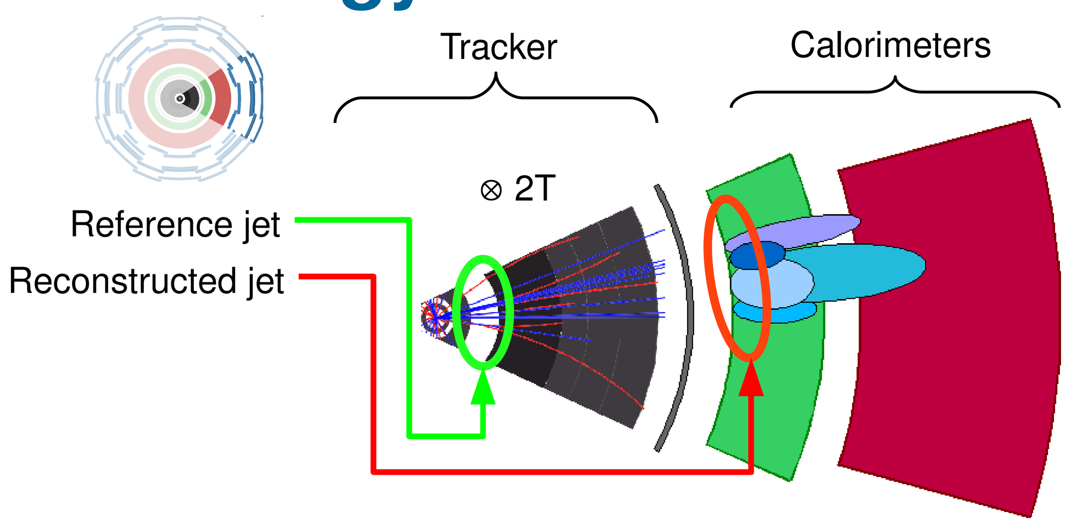


ATLAS is a general purpose experiment running at the new proton-proton collider LHC (CERN). In the rich physics program that will be covered, the search of Higgs boson(s) and of phenomena beyond the standard model (super-symmetry, exotic physics...) are two of the most important goals.

Most of the physics channels of interest will contain jets in their final state. QCD jets constitute also a background for almost all the physics channels of interest. The jets kinematics is linked to the one of the parton from which they emerge. For this reason, a good jet energy measurement is fundamental for the study of the interaction between elementary particles.

To reach the requested discovery potential of the experiment, the collaboration's goal is **1% precision on the jets energy scale**.

The Jet Energy Scale in ATLAS



Reference jet : built from all the stable particles (except ν and μ) coming from the quark (or the gluon) fragmentation.

The main reasons why we need a calibration for jets

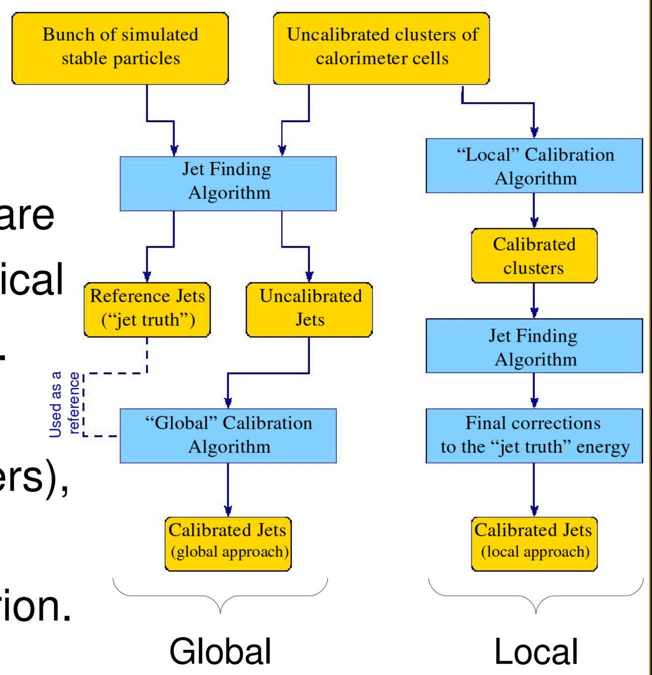
- at uncalibrated scale, the calorimeter response depends on the type of the particles (higher response for γ and e than for $\pi^{\pm}$) : this is called **non-compensation**;
- particles loose energy in **dead material** before reaching the calorimeters, or end up in non instrumented regions;
- some particles are bent out of the reconstructed jet by the tracker magnetic field.

As a result, E(Reference jet) ≠ E(Reconstructed jet) with large non-linearities and non-uniformities.

General concept of jet calibration in ATLAS

The jet calibration in ATLAS is based on a simulation of the fundamental processes producing jets (hadronisation), and of the detector response to the jet particles (interaction particle/matter).

The different steps of the calibration



- *Noise reduction*

Among the >10^5 cells only those with a significant signal are kept, and grouped together in **clusters** (according to topological criterion), or in **towers** (thin radial slices of the calorimeters).

- *Jet finding*

In calorimeters a jet appears as a bunch of clusters (towers), close to each-other. The jet finding algorithm groups these objects together according to spacial and/or kinematics criterion.

- *Calibration*

The goal is to correct the jet uncalibrated energy to bring it to the reference jet energy. Two main strategies have been studied : **global** and **local**

Calibration Strategies

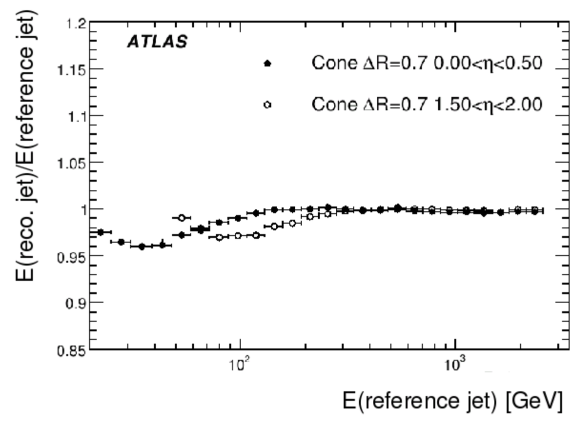
Example of a global calibration approach : energy density based cell calibration (known as "H1-method") [1]

The shower produced by a jet in the calorimeters has 2 component :
- *electromagnetic* (coming from e and γ) : dense and compact energy deposit,
- *hadronic* (n, p, $\pi^{\pm}$...) : broader energy deposit, and gives a too low signal in calorimeters.

Each cell i receive a correction w_i which depends on the energy density ρ it measured :

$$E(reco\ jet) = \sum_{i=cells} w_i(\rho) \times E_i$$

The weights w_i are obtained minimizing the difference between E(reco jet) and E(reference jet).
The plot on the right shows the linearity of the jet energy after calibration.
Before calibration, the non-linearity goes up to ~30%.



Example of calibration using H1-method, applied on a sample of QCD jets.

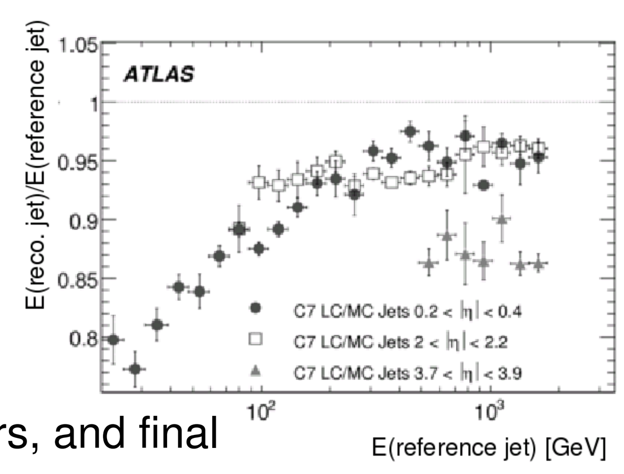
Example of a local approach: local hadron calibration [2]

The input for this calibration are clusters. The clustering of the energy deposit in calorimeters allows to make a relatively good matching between clusters and stable particles composing the jets (~1.6 particles per cluster).

Each cluster can be classified as mainly electromagnetic, hadronic or unknown, according to its shape (classification based on the predicted shape obtained in simulation for charged and neutral pions).

Clusters classified as hadronic receive the appropriate calibration weight, to bring back the measured energy to the "true" energy deposit in calorimeter (known from simulation).

Jets are built from the calibrated clusters, and final corrections are applied to reproduce the reference jet energy.



Local Hadron Calibration applied to QCD-jets. Here, the final corrections to bring the energy scale to the reference jet energy have not yet been applied.

Conclusion

Two of the main jet calibration methods that will be used to provide jet corrections for the ATLAS detector have been presented in this poster.

The global method is proven to recover the linearity of the energy measurement while improving the energy resolution in a wide range of Monte Carlo sample. The robustness of the method have been checked on jet samples with different quark content, shower model and event complexity.

The Local Hadron Calibration has been shown to recover the linearity of the calorimeter response with respect to the jet calorimeter energy deposit. The final corrections allows to go back to the reference jet energy.

The calibration methods presented in this poster are both based on the simulation of the detector response to jets. The validation of the corrections will heavily rely on in-situ measurements that will be performed as soon as the first data will be available. Some studies have already been performed on testbeam data [1].

References

[1] The ATLAS Collaboration, "Detector Level Jet Corrections", ATL-PHYS-PUB-2009-013, April 2009

[2] The ATLAS Collaboration, "Local Hadron Calibration", ATLAS-LARG-PUB-2009-001, January 2009