Performance of jet reconstruction and calibration in first ATLAS data at a centre-of-mass energy of 7 TeV

Sebastian Eckweiler - Johannes-Gutenberg-Universität Mainz
on behalf of the ATLAS Collaboration

Jets in ATLAS

Jets are reconstructed using the Anti-k_T algorithm with a distance parameter R = 0.6.
Jets presented on this poster use topological clusters as inputs. These are dynamically formed, three-dimensional clusters of calorimeter cells that are formed around seed-cells whose energy is significantly above the noise expected for a given cell.

Jet Selection and Calibration

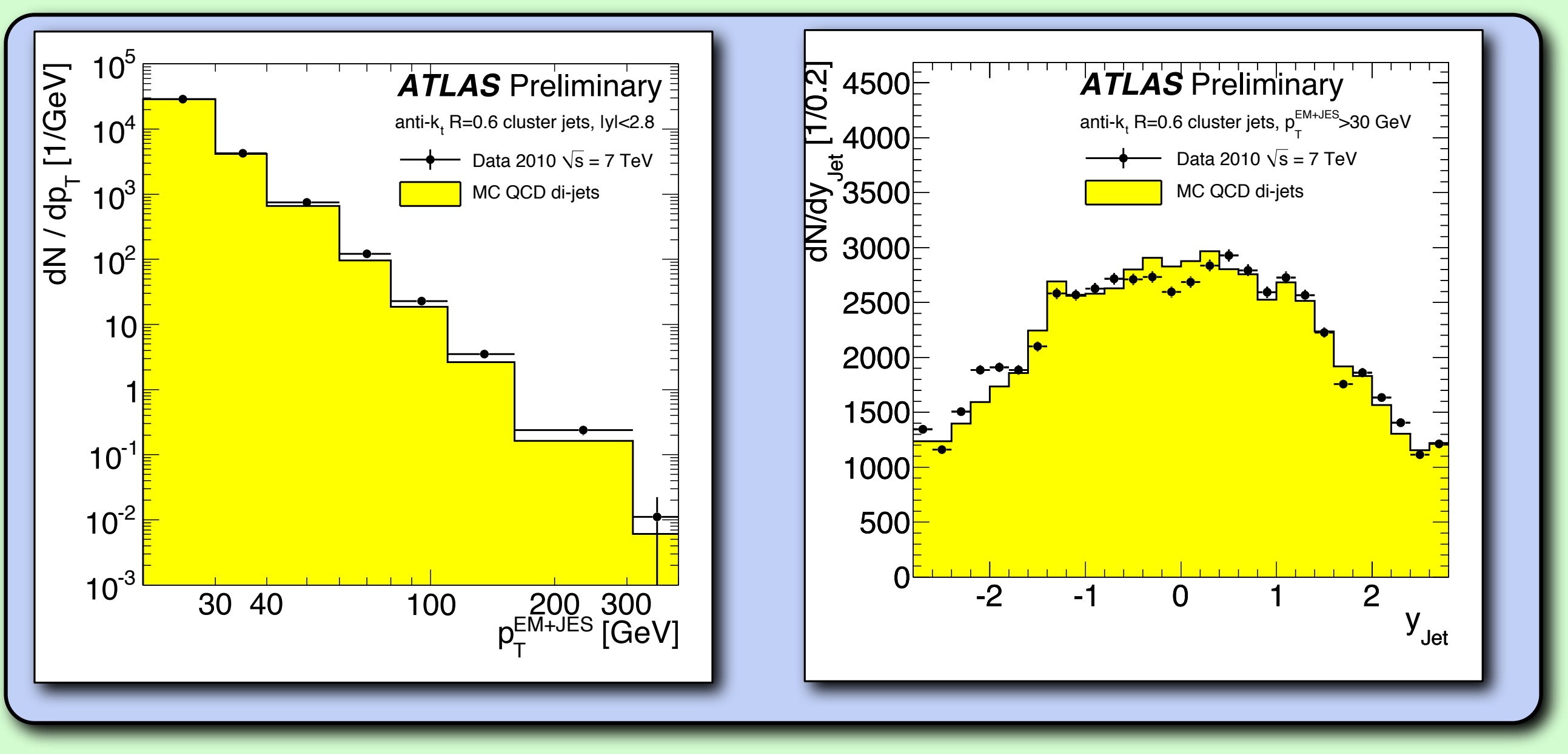
Jets undergo a very efficient chain of selection criteria to suppress jets heavily affected e.g. from noise bursts in certain detector regions:

- the minimum number of cells containing 90% of the energy of the jets must be larger than 5 for jets which deposit more than 80% of their energy in the HEC
- the cell signal quality factor, representing the fraction of cells with a poor signal quality, defined by the pulse shape must be smaller than 0.8 for jets which deposit at least 95% of their energy in the EM calorimeters
- all jets must have an energy-squared-weighted cell timing of less than 50ns

In early data the calibration scheme employed by ATLAS consists of simple (p_T, η)-dependent calibration, referred to as *EM+JES*. In this scheme each jet is scaled by a scalar factor as a function of p_T and η.
The calibration factors itself are derived from Monte Carlo (MC).

The figures to the right show basic kinematic distributions of jets in data, corresponding to an integrated luminosity of approximately 400μb^{-1}.

The overall agreement to MC predictions is reasonable, though data shows a slightly harder p_T spectrum than predicted by PYTHIA.



Inputs to jet reconstruction

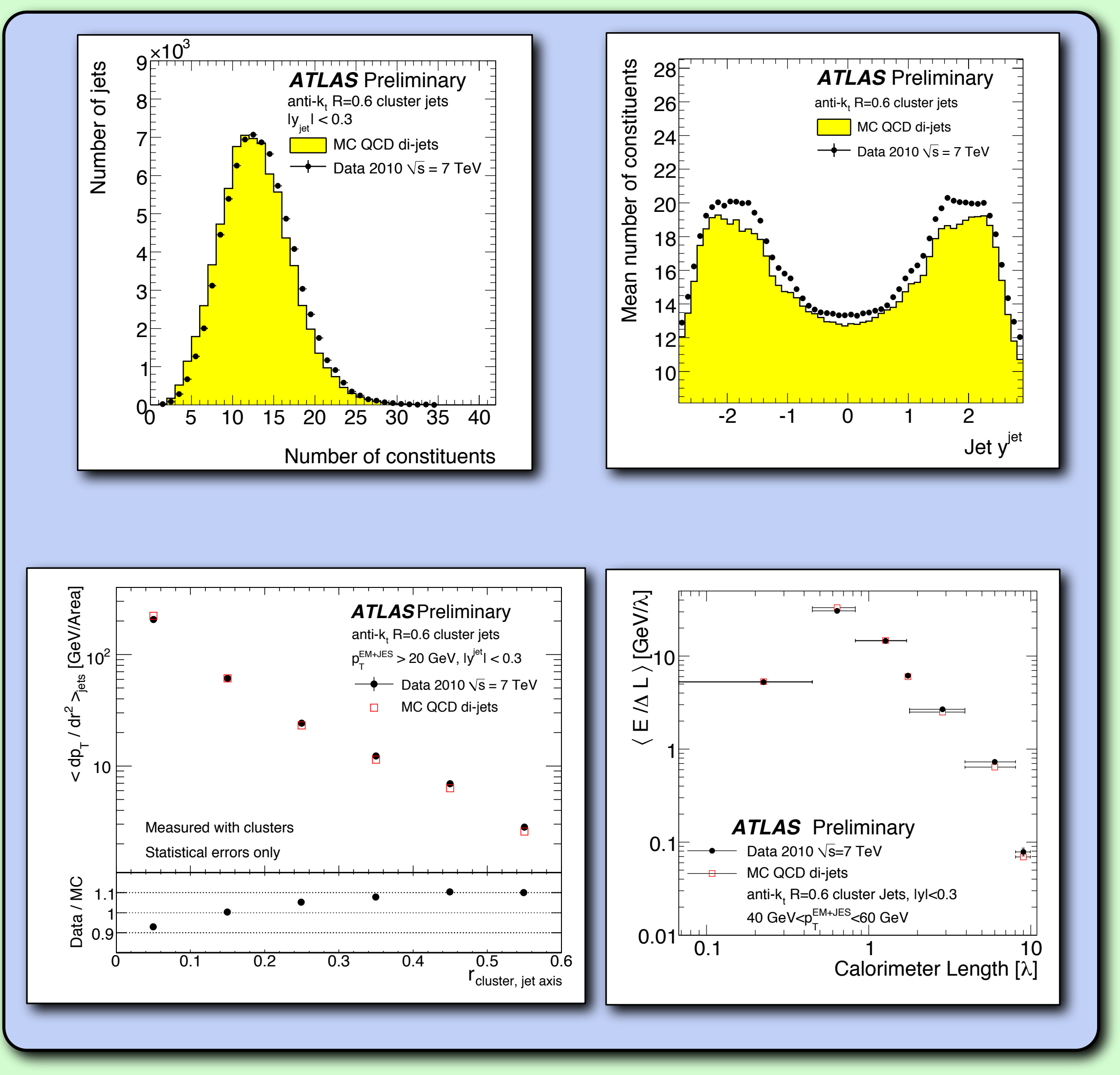
In order to a achieve realistic description of jets in the MC simulation, the characteristics of the inputs to jet reconstruction have to be reasonably well modeled.
The figures below show the average number of constituents jets are made of as a function of jet rapidity and the number of constituents for jets in the central region. While the MC describes the overall shape of both distributions reasonably well, it is obvious that jets in data are generally built from more constituents than the simulation predicts.

Jet width and depth

The internal structure of jets provides detailed information on how well physics and detector simulation describe reality.
The figures to the right show the transverse and longitudinal profile of jets as measured in data and compare to the Monte Carlo prediction.
The transverse jet shape is measured summing up the energy in annuli with area A around the jet axis:

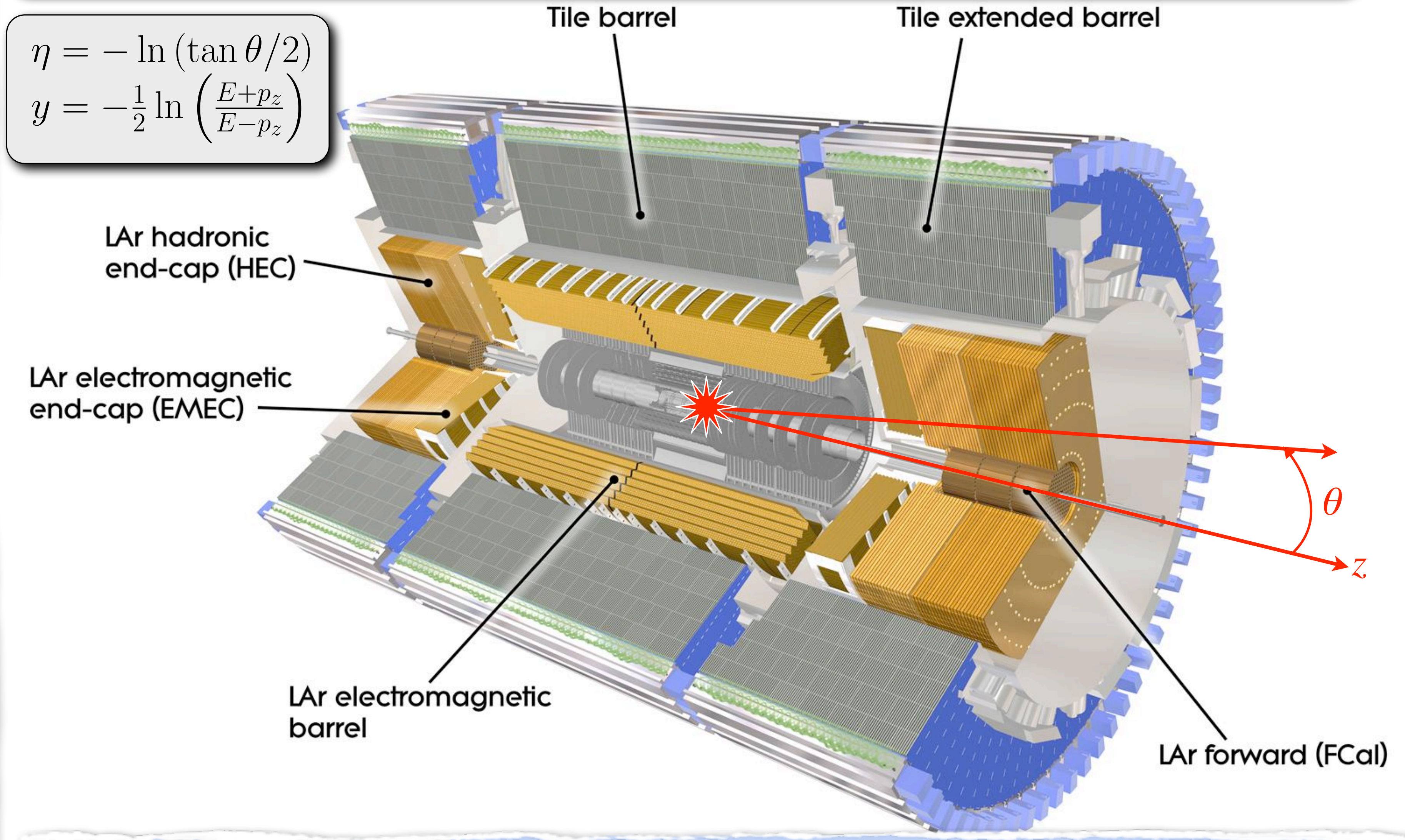
$$\left\langle \frac{1}{r}\frac{dp_T}{dr} \right\rangle_{jets} = \frac{1}{A}\frac{1}{N_{jet}} \sum_{jets} p_\mathrm{T}(r - \Delta r/2, r + \Delta r/2)$$

For the longitudinal profile, we measure the energy deposition of jets in different longitudinal calorimeter segments, normalized to the absorption length traversed in the given layer.
Both plots show a good overall agreement, but also small but significant discrepancies.
Jets in data turn out to be slightly wider and also penetrate deeper into the calorimeters.



The ATLAS Calorimeters

$$\eta = -\ln(\tan\theta/2)$$
$$y = -\frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right)$$



Jet Calibration Schemes

For future data analysis ATLAS is studying more sophisticated calibration schemes than the simple p_T-η dependent scheme already described.
Those schemes throughout make use of more detailed information about a given jet and thus are also able to improve the energy resolution significantly. Three different schemes are being investigated in early data:

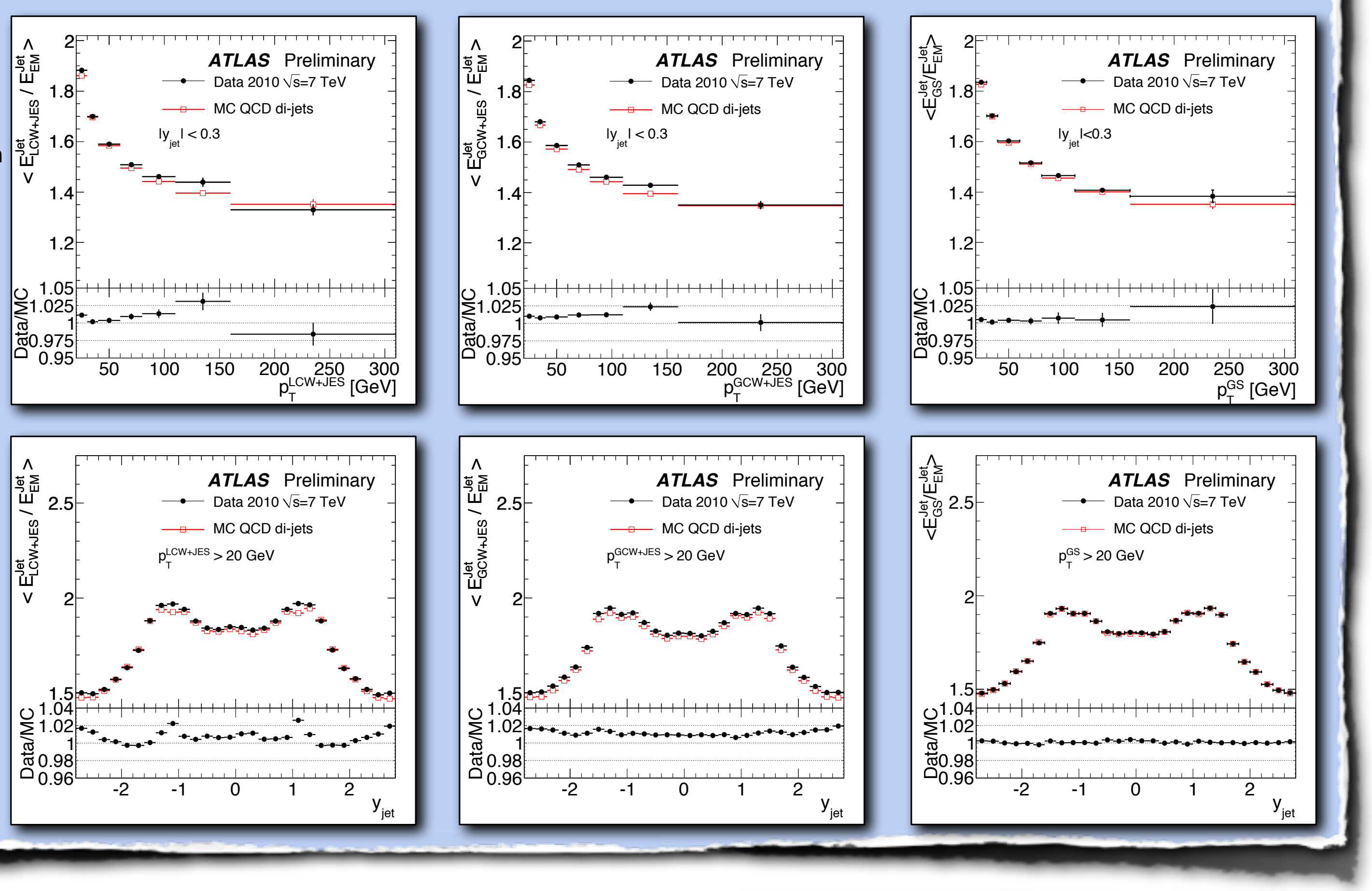
- **Global sequential calibration (GS):** On top of the simple *EM+JES* calibration scheme, this method makes use of longitudinal and transverse jet properties to improve the resolution, while leaving the mean energy scale unchanged.
- **Global cell energy-density weighting (GCW+JES):** This scheme attempts to correct for the non-compensating nature of the calorimeters by weighting each jet constituent cell according to their energy density.
- **Local cluster weighting (LCW+JES):** This method calibrates clusters independently from the jet they belong to. Similarly to the GCW+JES scheme clusters classified as hadronic or electromagnetic and weighted accordingly.

To evaluate the modeling of the properties used for each calibration scheme, the jet energy before and after calibration is compared in data and MC.

The figures to the right show this comparison as function of p_T and versus jet rapidity.
The decreasing trend as a function of p_T is due to the increasing electromagnetic scale, while the behavior versus y_{jet} reflects the properties of the varying calorimeter systems.

The comparisons of MC to data show very encouraging results!

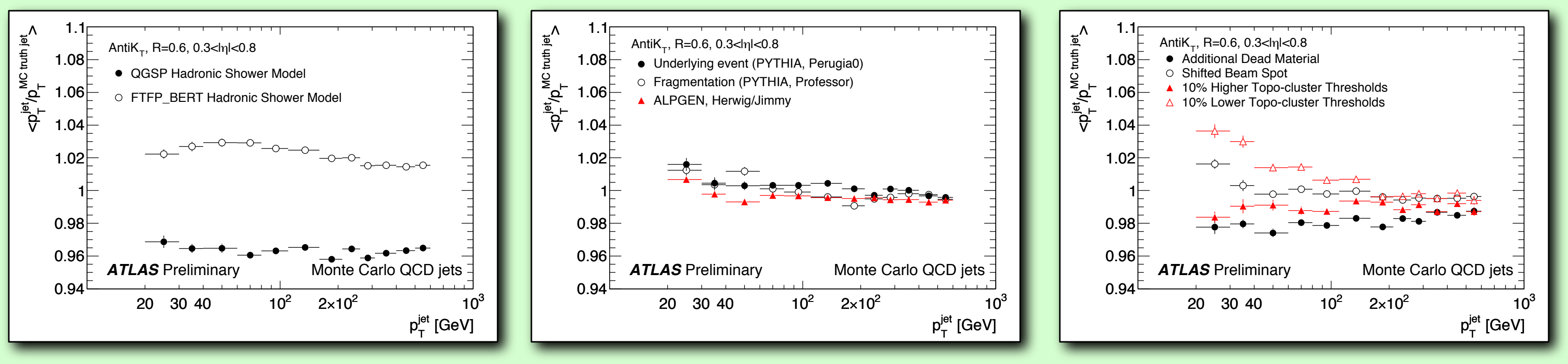
The agreement for all calibration schemes is on the 3% level across the studied p_T and rapidity regions.
Even better agreement for the GS calibration scheme suggests, that the herein used quantities are better modeled.



Jet Energy Scale Uncertainty

The amount of data provided by the LHC is not yet sufficient for fully data-driven methods such as Photon/Z + Jet balance. Therefore the uncertainty on the jet energy scale is evaluated from studying a variety of MC predictions, each describing distinct features of the physics and detector simulation differently from the nominal MC simulation:

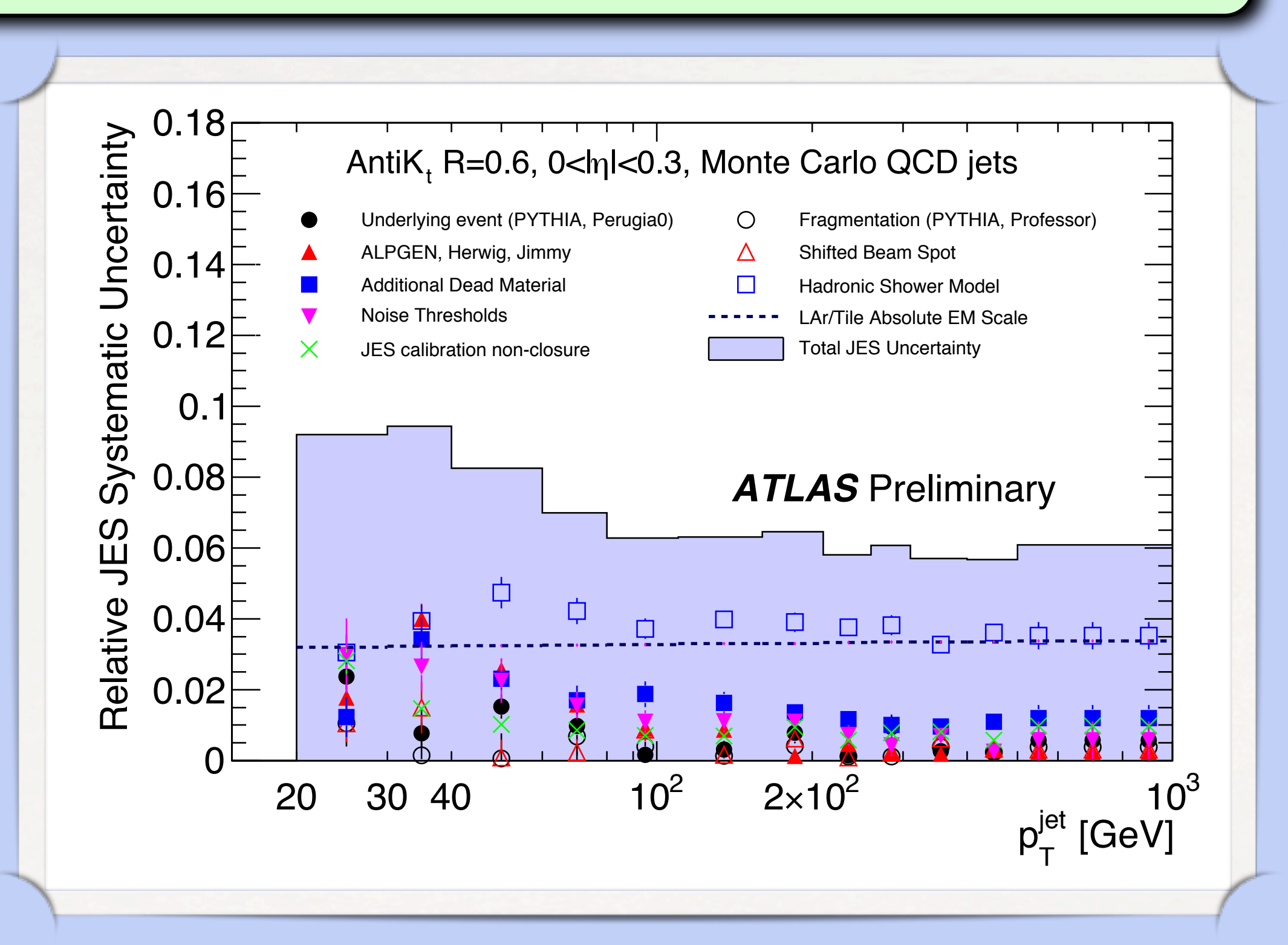
Uncertainties from hadronic shower model | **UE, Fragmentation, Event Gen.** | **Detector description effects**



Summarizing all effects

Summarizing all of the above effects the figure to the right shows the total uncertainty as a function of p_T:

This is just below 10% for very low jet p_T and decreases to a minimum of **6% above ~200** GeV!



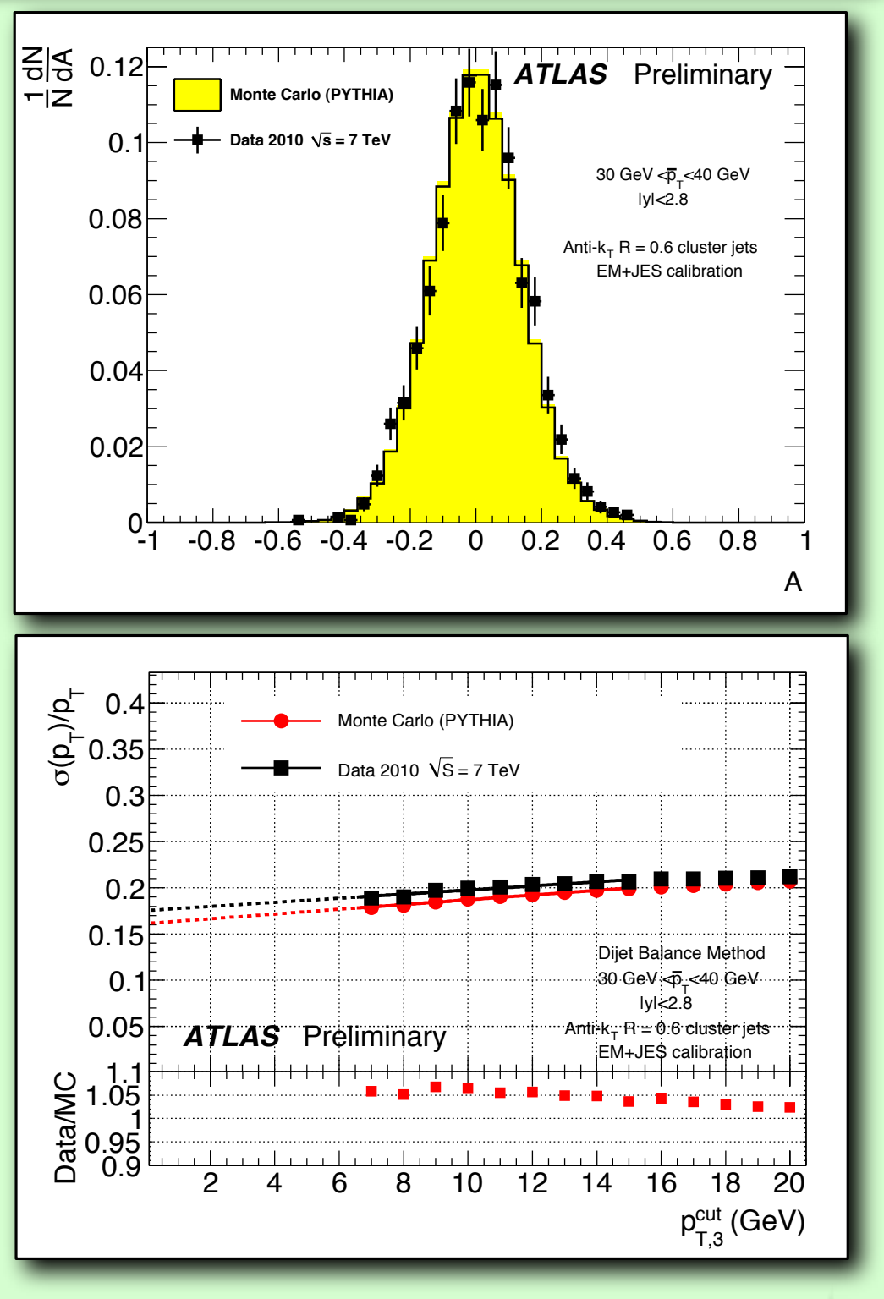
Measuring Jet Resolution in Data

The jet energy resolution can be measured in data using rather clean dijet events.
To determine the resolution one measures the p_T-asymmetry of the two leading jets per event, defined as

$$A(p_{T,1}, p_{T,2}) = \frac{p_{T,1} - p_{T,2}}{p_{T,1} + p_{T,2}}$$

which is shown on the right.
Where $p_{T,1}$ and $p_{T,2}$ are the randomly ordered p_T's of the two jets.

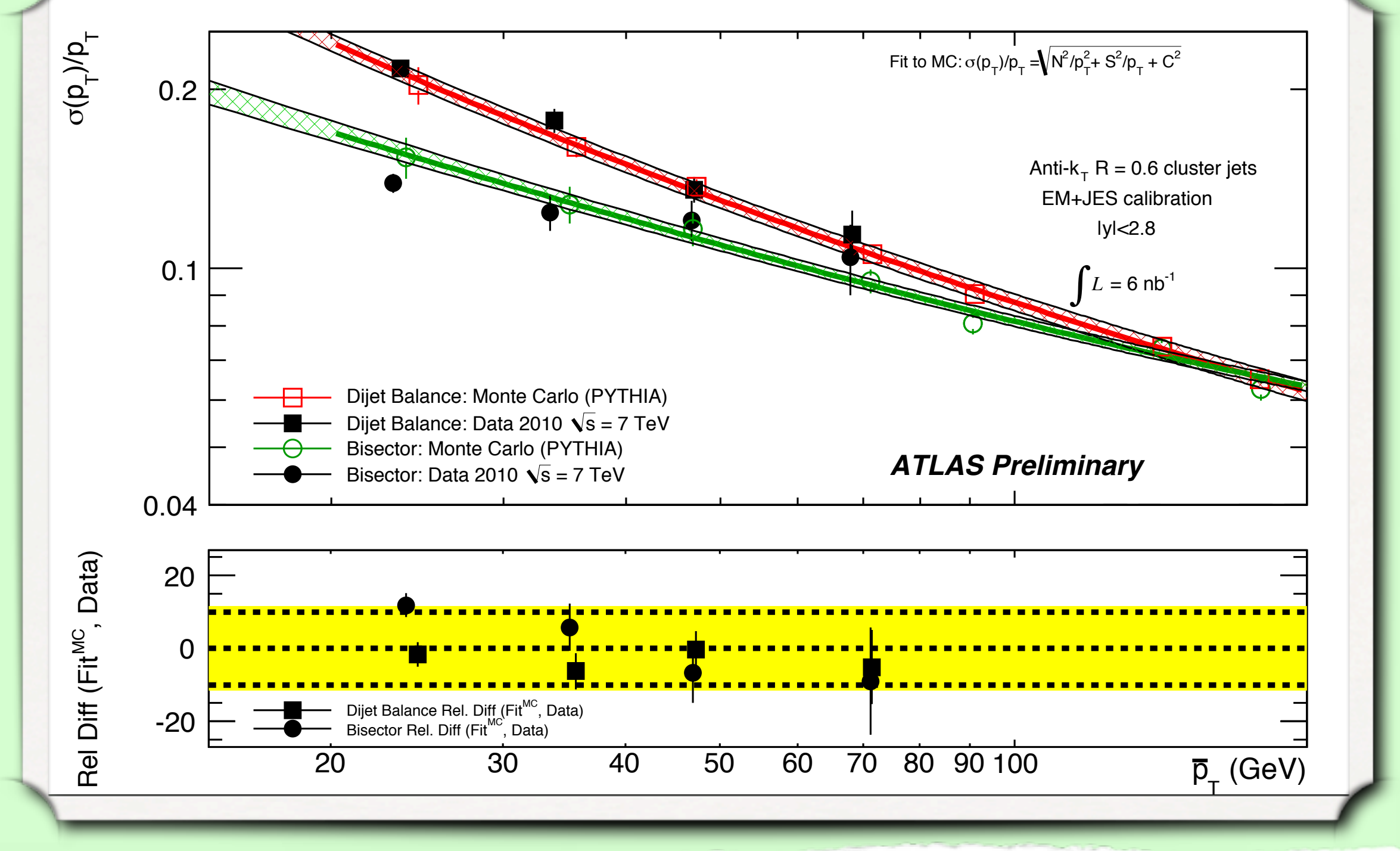
To avoid an inherent bias from additional jets in the event that spoil the p_T balance, the selected events must not have an additional jet above a certain value $p_{T,3}^{Cut}$.
The full procedure is done with varying values of $p_{T,3}^{Cut}$ and in a final step the resolution for each $p_{T.Mean}$ bin is extrapolated to $p_{T,3}^{Cut} \rightarrow 0$.



Results:

The method is still statistically limited due to the necessarily tight event selection.

Comparing the method in data and MC reveals an agreement on the level of **14%** for the jet energy resolution.



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