Measurement of the jet energy resolution in ATLAS

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A measurement of the jet energy resolution has been performed in 2010 at the ATLAS detector, on 35±1 pb^{-1} proton-proton collisions. Dijet events in data and simulations[1] were analysed in two in-situ analyses: the *dijet balance* and the *bi-sector* method [1]. Jets are reconstructed from calorimeter signals. Calorimeter cells build three−dimensional topological clusters, that feed the anti-k$_T$ algorithm, used for jet reconstruction. The basic energy scale is the *EM-scale*, not corrected for hadron response. EM-scale jets are calibrated to the jet energy scale by simulation-based calibrations (Table 1).

Calibration	Input	Characteristics
EM+JES	EM-scale jets pileup corrected	jet-by-jet correction, function of η and p$_T$ robust, developed for first data
GS (Global Sequential)	EM+JES scale jets	uses internal properties of jets to improve resolution
GCW (Global Cell weights)	EM-scale jets	corrections as function of energy density of cells in reconstructed jets
LCW (Local Cluster weights)	EM-scale clusters	uses internal properties of clusters to identify and calibrate the hadronic component

Table 1: Summary of calibration schemes used in the 2010 ATLAS analyses [2].

The dijet balance technique measures the asymmetry A between the transverse momenta ($p_{T,1}$, $p_{T,2}$) of the dijet system. A is measured in bins of $\overline{p}_T = \frac{p_{T,1}+p_{T,2}}{2}$ and y and fitted with a gaussian fit, whose standard deviation σ_A gives the resolution $\frac{\sigma_{p_T}}{p_T}$:

$$A(p_{T,1}, p_{T,2}) \equiv \frac{p_{T,1}-p_{T,2}}{p_{T,1}+p_{T,2}} \qquad \sigma_A = \frac{\sqrt{\sigma^2_{p_{T,1}}+\sigma^2_{p_{T,2}}}}{\langle p_{T,1}+p_{T,2}\rangle} \simeq \frac{\sigma_{p_T}}{\sqrt{2}p_T}$$

This relation holds for jets in the same rapidity region, where $\langle p_{T,1}\rangle = \langle p_{T,2}\rangle \equiv p_T$ for transverse momentum conservation. It can be extended to different rapidity regions. The main assumption of this method is the purity of the dijet sample, as the method relies on p_T balance at particle level. Thus, $\frac{\sigma_{p_T}}{p_T}$ is corrected for soft radiation effects.

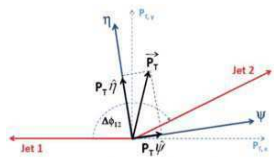

Figure 1: Variables used in the bi-sector method, defined in the plane transverse to the beam axis. [1]

[1]Generated with PYTHIA, passed through a full GEANT 4 simulation of the ATLAS detector.

The bi-sector method looks at the vector sum $\vec{P_T}$ of the transverse momenta of the dijet system, and its components (Figure 1). In a true dijet event, $\vec{P_T} = 0$. Initial state radiation, final state radiation and calorimeter resolution cause fluctuations of $\vec{P_T}$, resulting in a finite variance. Initial state radiation is isotropic; instrumental effects and soft radiation emission mostly affect the ψ component.
The p_T resolution is extracted from the difference of the variances of the projections:

$$\frac{\sigma_{p_T}}{p_T} = \frac{\sqrt{\sigma_\psi^{2\,calo} - \sigma_\eta^{2\,calo}}}{\sqrt{2}p_T\sqrt{cos\Delta\phi_{12}}}$$

for jets in the same rapidity region. It can be extended to different rapidity regions. The main assumption of this method is the isotropy of radiation which has been studied. Any deviation from it is taken into account as a systematic uncertainty of the method.

The results from the two in-situ methods show an agreement within $2-3\%$ on both simulation and data. Their systematic uncertainties have been studied, and the combined uncertainty ranges from 8% at 30 GeV to below 4% at $p_T > 70$ GeV.
The fractional transverse momentum resolution is parametrized[2] as:

$$\frac{\sigma_{p_T}}{p_T} = \frac{N}{p_T} \oplus \frac{S}{\sqrt{p_T}} \oplus C$$

Both data and simulations have been fitted with such a model, and agree within 10% for all calibration schemes. This analysis also shows the better resolution obtained by the Global Cell weighting (GCW), Local Cluster weigthing (LCW) and Global Sequential (GS) calibration in comparison with the EM+JES scheme (Figure 2).

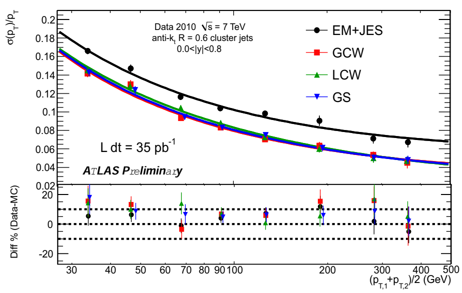

Figure 2: Fractional jet energy resolution as a function of $\overline{p}_T$ for events with two jet in the same rapidity bin for all JES schemes (Table 1). The lines show the fits on data for each scheme respectively. The lower plot shows the relative difference between Monte Carlo and the data results. From twiki.cern.ch/twiki/bin/view/AtlasPublic/Jet ResolutionPreliminaryResults

References

[1] The ATLAS Collaboration, ATLAS-CONF-2010-054.

[2] The ATLAS Collaboration, ATLAS-CONF-2011-032.

[2] The noise (N) term parametrizes fluctuations of noise and pile-up from multiple p-p interactions; the stochastic (S) term parametrizes fluctuations in the amount of energy sampled from the hadron shower; the constant (C) term includes fluctuations that are constant in energy.