Improving Jet Energy Resolution Using Track-Based Jet Response Corrections

Gastón L. Romeo
Universidad de Buenos Aires

Ariel Schwartzman (SLAC)
Ricardo Piegaia (UBA)

Hadronic Calibration Workshop 2009
Thursday 25 June 2009

Improving Jet Energy Resolution using Track-Based Jet Response Correction

Refresher

- Jet reconstruction and measurement in ATLAS has traditionally relied on calorimeter information only. A deeper insight may be achieved by looking at tracking information
- Although after the JES correction the average jet response is unity, on a jet-by-jet basis jets may be over- or undercorrected depending on therir topologies, particle content, out-of-clustering energy among other variables
- Tracking properties have been explored to extract jet-by-jet information in order to correct the response of each jet individually, in order to reduce the overall broadening of the response distribution and hence improve the jet transverse momentum resolution
- Track-based corrections are applied jet-by-jet *after* the JES, without altering the jet energy scale applied during reconstruction. It has the advantage not only that it can verified in-situ, but also the correction can be directly derived from data. Furthermore, the user can easily decide whether to apply it, and measure its performance and resolution improvement for his particular analysis.

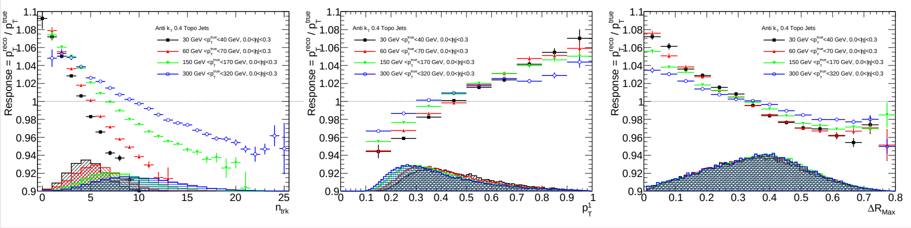
Track-Based Variables and Baseline Track Selection

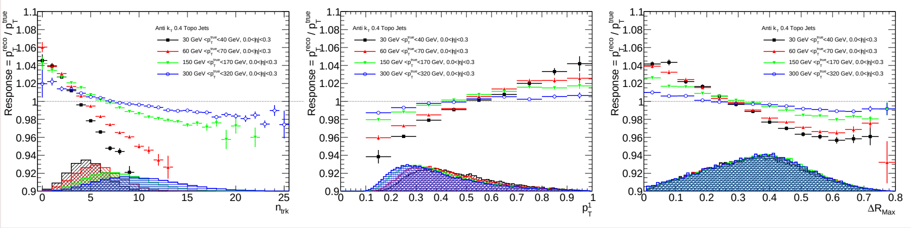
Physical effect	Track Variable	Description
Dead material	n_{trk}	Track multiplicity
$e/h > 1$	p_T^{tracks}	Total p_T carried by charged tracks
	Δ	p_T asymmetry between two leading tracks
	p_T^1	$p_T^{leading-track} / \sum p_T^{tracks}$
Out-of-cluster or out-of-cone Energy (OOC)	ΔR_{MAX}	Maximum distance between a pair of tracks
	$width$	Average ΔR of tracks to the jet axis
	$width_{p_T}$	Average ΔR of tracks to the jet axis, p_T weighted
	$width_{p_T^{-1}}$	Average ΔR of tracks to the jet axis, p_T^{-1} weighted

- The variables introduced previously depend on the tracks chosen for their calculation. Thus, selecting genuine tracks belonging to the jet is crucial
- Only tracks within a cone of radius 0.4 in $\eta - \phi$ around the jet axis are considered.
- All cuts have been studied for all proposed variables in order to analyse the potential performance and robustness of the technique (see ATLAS note).
  1. $p_T^{track} > 1$ GeV, $\chi^2/ndof < 3$
  2. Precision hits (Pixel + Silicon) > 6
  3. $IP_{xy} < 0.2$ cm (i.e. about $3 \times \sigma_{IP_{xy}}$), $IP_z < 0.45$ cm (i.e. about $3 \times \sigma_{IP_z}$)
  4. IP cuts would be removed for b-jets. (Flavour-dependent track-jet corrections)

Getting a Handle on Dead Material, $e/h > 1$ and Out-of-Cluster Effects

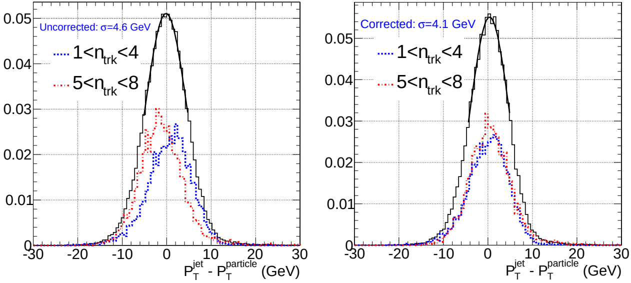
Response Sensitivity to n_{trk}, $0 < |\eta| < 0.3$, Anti-k_T 0.4 Topo jets at EM (*top*) and cell energy density weighting (H1-style) (*bottom*) scales



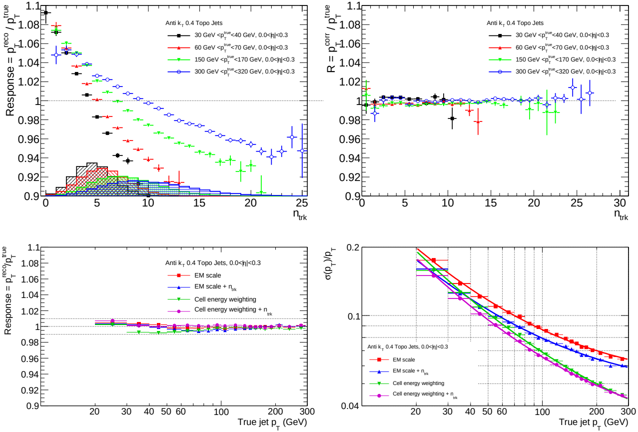


The mechanism behind jet transverse momentum resolution improvement

- The track multiplicity, n_{trk}, has been chosen to derive the correction since it was found to be the most promising variable among the set of track observables analysed.
- Since the response of jets varies significantly with n_{trk}, the transverse jet momentum resolution is artificially enlarged. Therefore, by correcting for this effect it should be possible to reduce the overall broadening of the response distribution and hence improve the jet transverse momentum resolution. (This argument holds for any other track variable)



$0.0 < |\eta| < 0.3$, Anti-k_T 0.4 Topo jets



- The response remains centered at 1 within 1% after applying the n_{trk} correction
- For EM jets we have found a consistent resolution improvement over the whole energy range ($11 - 10\%$ at low p_T). At high p_T, the more sophisticated H1 calibration seems to already account for the physical effects addressed by the tracking variables (10 and 1.5% at 35 GeV and 300 GeV respectively)

Summary, Conclusions and Future Prospects

- Track-based response corrections for Anti-k_T 0.4 Topo Jets have been studied for several η regions up to 2.0
- The track multiplicity, n_{trk} has been found to be the most sensitive variable. After a 2-D fit of the response in the $p_T - n_{trk}$ plane, we achieve a correction to p_T that brings about a $\approx$ 10 % in resolution at 35 GeV for H1-calibrated jets in the central region
- The improvement in resolution achieve $11 - 10\%$ for jets at the EM scale at low p_T. However these jets exhibit a systematic resolution improvement over the whole energy range. At high p_T, the more sophisticated H1 calibration seems to already account for the physical effects addressed by the tracking variables (1.5% at 300 GeV).
- Overall we have found the best resolution for H1 jets plus tracking corrections.

- Implementation in ATHENA: Migration of track-jet correction to `JetCalibTools`
- Data-driven n_{trk} correction
- Extend the present MC study to simulations including pile-up. Investigate the use of track-jets to select tracks in such a busy environment.
- n_{trk} features suggest that more information to enhance this technique may be provided by combining clusters' information to tracks in order to get a handle on which the cryostat effect is.

Extra Information

Extra Info

Documentation:

- ATLAS internal report
- Track-BasedJetCorrection Twiki page

Some Other Talks:

- http://indico.cern.ch/conferenceDisplay.py?confId=48840
- http://indico.cern.ch/conferenceDisplay.py?confId=48833
- http://indico.cern.ch/conferenceDisplay.py?confId=40776