Global Sequential Calibration of jets at ATLAS

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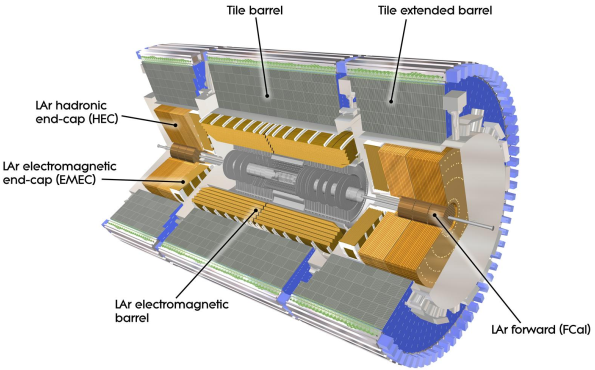
Outline

1. Introduction: Jet calibration
2. GSC description, derivation
3. GSC: punch-through correction
4. GSC Performance
5. Possible improvements

ATLAS detector



For the GSC, we will be using:

- Energy deposits in the hadronic calorimeter: Tile barrel and extended barrel
- Energy deposits in the EM calorimeters: LAr barrel and LAr end-cap
- Track information from the inner detector

Jet calibration

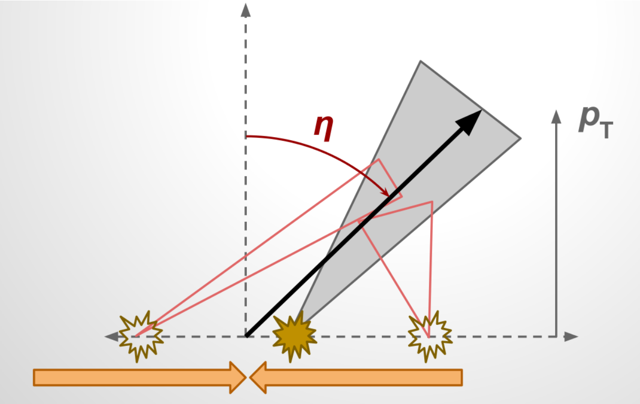
This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction

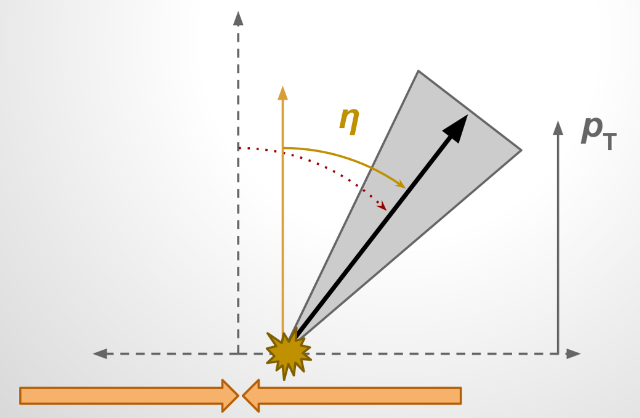


Corrects for the energy offset introduced by pile-up. Depends on μ and N_{PV}. Derived from MC.

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction
3. Origin correction



Changes the direction to point to the primary vertex. Does not affect the energy.

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction
3. Origin correction
4. Energy and η calibration

Calibrates the jet energy and pseudorapidity to the particle jet scale. Derived from MC.

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction
3. Origin correction
4. Energy and η calibration
5. GS calibration

Reduces the flavour dependence and improves the energy resolution.

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction
3. Origin correction
4. Energy and η calibration
5. GS calibration
6. Residual in-situ calibration

Derived in data and MC, only applied to data.

Jet calibration

This is a summarized description of the jet calibration flow in ATLAS:

1. **Get EM or LCW jets**
2. Pile-up offset correction
3. Origin correction
4. Energy and η calibration
5. GS calibration
6. Residual in-situ calibration
7. **Get calibrated EM or LCW jets**

GSC description

Global Sequential Calibration

- Apply jet-response sequential corrections derived in Monte Carlo on some jet properties after the JES calibration
- **Global:** response is parametrized as a function of p_{T}, η, and one property, x
- **Sequential:** once one correction is applied, repeat the procedure with another jet property to achieve optimal performance

Variables:

- f_{Tile0}: fraction of the jet energy deposited in the first layer of the hadronic calorimeter
- f_{EM3}: fraction of the jet energy deposited in the third layer of the EM calorimeter
- n_{Trk}: number of tracks with $p_{\mathrm{T}} > 1\mathrm{GeV}$
- trackWIDTH: $\frac{\sum_i [p_{\mathrm{T}}^{\text{track}i} \Delta R(\text{track}i,\text{jet})]}{\sum_i [p_{\mathrm{T}}^{\text{track}i}]}$
- N_{segs}: number of segments behind the jet in the muon chambers

- f_{Tile0} and f_{EM3}: calorimeter based, they improve the resolution of EM+JES jets
- n_{Trk} and trackWIDTH: track based, they reduce the flavour dependence
- N_{segs}: account for energy lost for jets that 'leak' beyond the hadronic calorimeter

GSC derivation

Derivation steps:

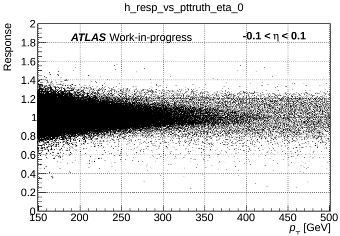
1. Calibrate jets to the JES, from MC samples
2. Create p_{T}-η bins, obtain the response and resolution from a fit (E-η bins for punch-through)
3. In each bin, we look at the response as a function of a variable 'x'
    - We have to ensure that we don't modify the JES for a given p_{T}-η bin!
4. We derive a correction factor that is a function of p_{T}, η, and x
    - We smooth the curves to be able to interpolate and remove fluctuations
5. This procedure is done for each of the 5 variables

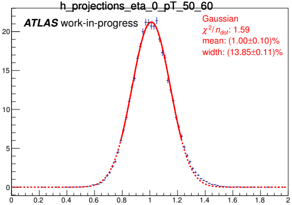
	f_{Tile0}	f_{EM3}	n_{Trk}	trackWIDTH	N_{segs}
EM+JES	$\lvert\eta\rvert < 1.7$	$\lvert\eta\rvert < 3.5$	$\lvert\eta\rvert < 2.5$	$\lvert\eta\rvert < 2.5$	$\lvert\eta\rvert < 2.7$
LC+JES	-	-	$\lvert\eta\rvert < 2.5$	$\lvert\eta\rvert < 2.5$	$\lvert\eta\rvert < 2.7$

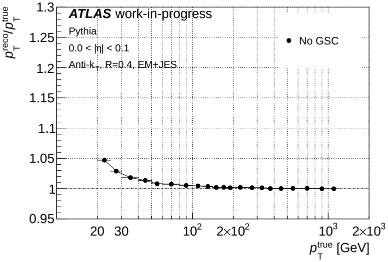
We will now revisit these steps in the next few slides

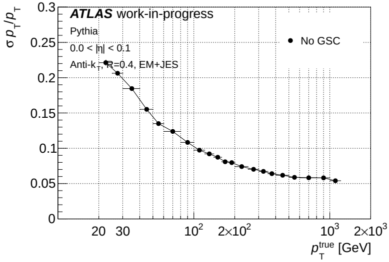
Steps I & II

- Steps of 0.1 in η: build 2-D histograms, save the information of each weighted jet
- Take 'slices' in p_{T} to produce Gaussian fits
- Use the response (bin by bin) to preserve, on average, the JES (more in the next slide)



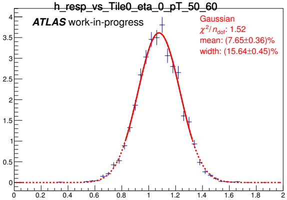


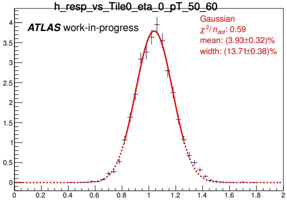


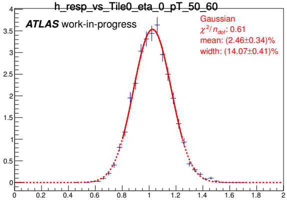


Steps III, IV & V

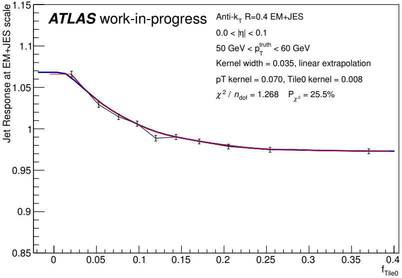
- In a given p_{T}-η bin, we further look at the response as a function of one of the variables







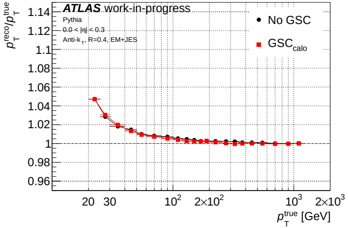
- We smooth the response to get the correction factors

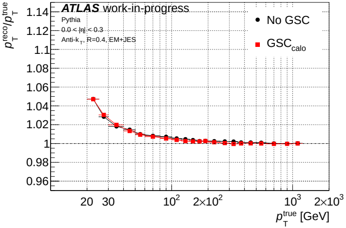


Resolution improvement (EM+JES)

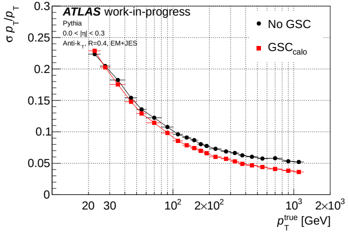
$R = 0.4$ $R = 0.6$

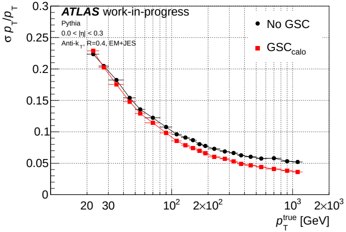
Response: Make sure the JES is preserved





Resolution

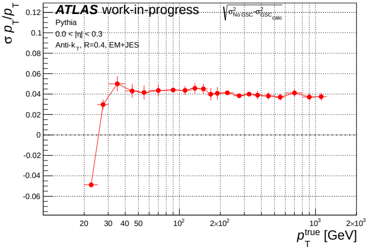


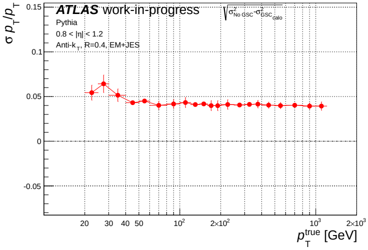


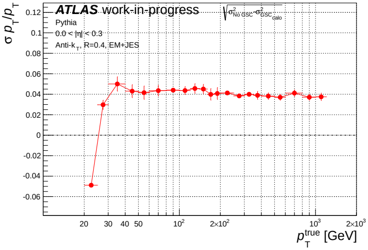
Resolution improvement (EM+JES)

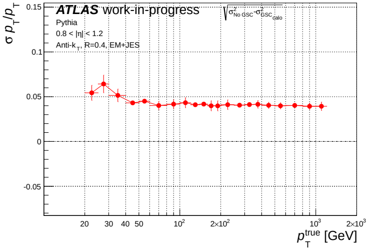
Difference in quadrature of the response width

$R = 0.4$ | $R = 0.6$





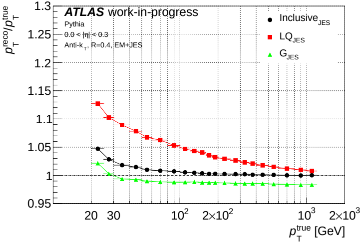


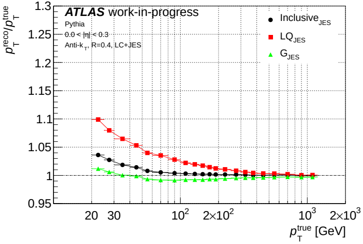


Flavour dependence

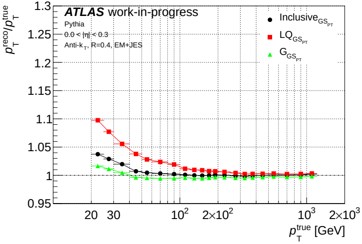
EM+JES LC+JES

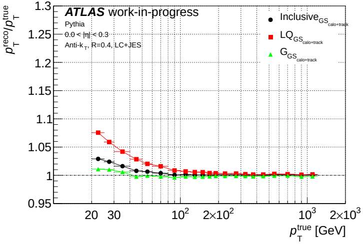
JES





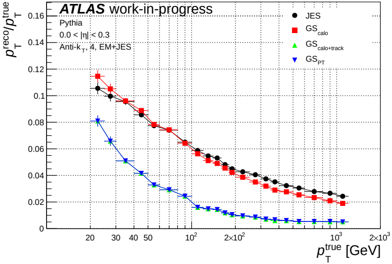
JES+GSC

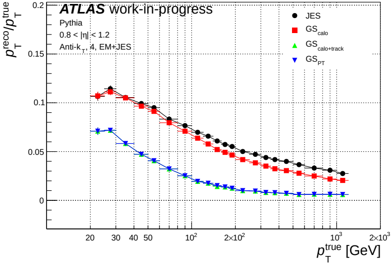




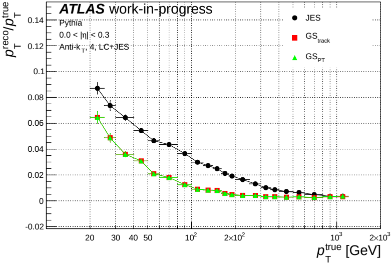
Flavour dependence

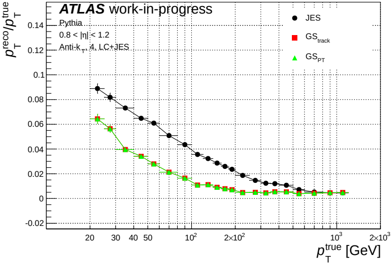
EM+JES





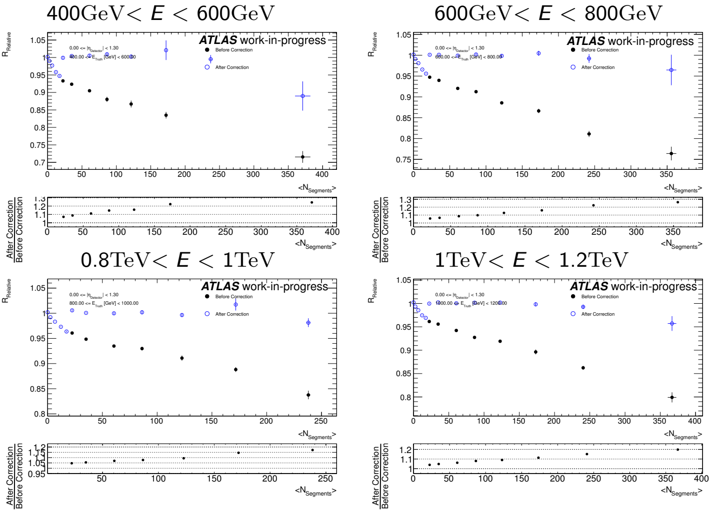
LC+JES





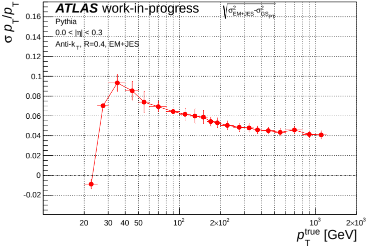
Punch-Through – Jet response – Plots by Shaun Gupta

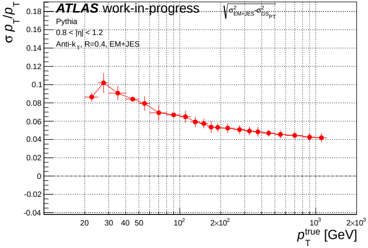
- Improvement only really noticeable at high-E. Very statistically limited
- Results shown here for EM+JES jets



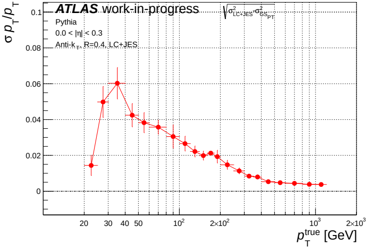
Overall resolution improvement

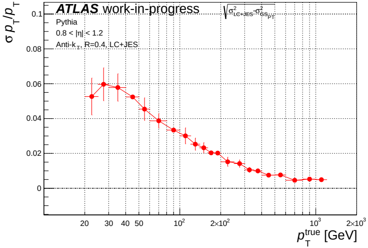
$R = 0.4$ EM+JES jets





$R = 0.4$ LC+JES jets





Conclusion

- The GSC is a MC-based series of 5 correction factors, applied sequentially to the p_{T} or energy jet response, based on global properties of jets
- It preserves the global JES for a given p_{T}-η bin
- It helps improve the resolution of EM and LC jets, based on calorimeter and track information
- It greatly reduces the flavour dependence of the jet response, based on track information
- It will very likely become a standard step in the jet calibration flow in ATLAS
- Room for improvement?
  - There is a certain degree of over-correction at low p_{T}, coming from the JES calibration
  - At low p_{T}: almost no gain in resolution in some cases
  - The punch-through correction greatly improves the energy response of jets that leak. However the uncertainties associated could perhaps be greatly reduced with further studies