The reconstruction of jets, missing E_T and boosted heavy particles with ATLAS in Run II

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Outline

Preliminary studies of the first data collected by ATLAS at $\sqrt{s}$ = 13 TeV in June-July 2015 allow to test

- Jet reconstruction and calibration (6.4 pb^{-1})
- Large distance parameter jet substructure and jet tagging (≈ 50 pb^{-1})
- Missing transverse energy reconstruction (6.4 pb^{-1})

Experimental results were compared with the simulated ones

Inputs to jet reconstruction and the properties of the jets (ATL-PHYS-PUB-2015-036)

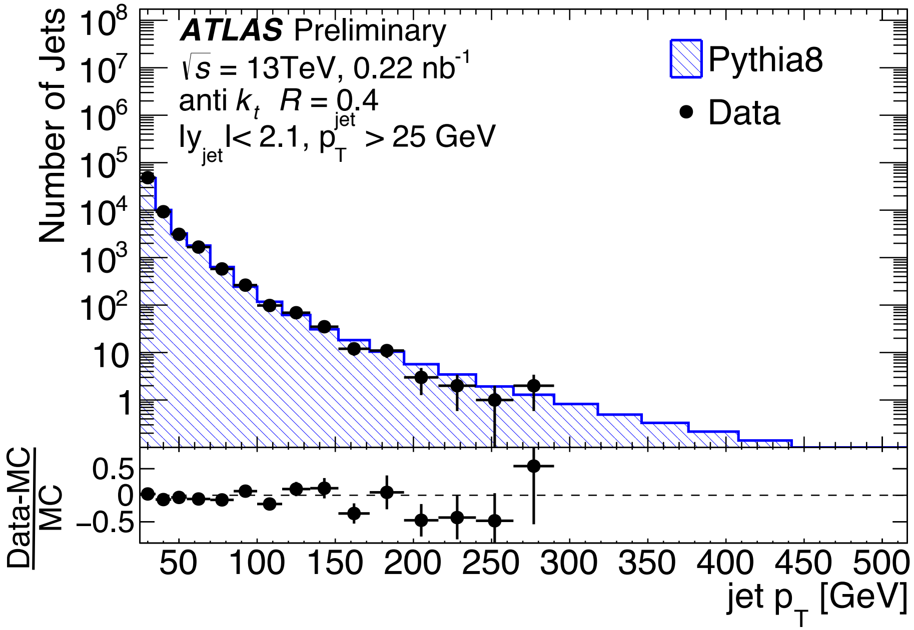
- The production of energetic jets of particles in p-p collisions is one of the most numerous processes observed at LHC
- In the analysis event, jet and track selection criteria were applied to both the MC simulation and to the data
- Jets with $p_T^{jet} > 25 GeV$ were considered

Jet reconstruction and calibration steps

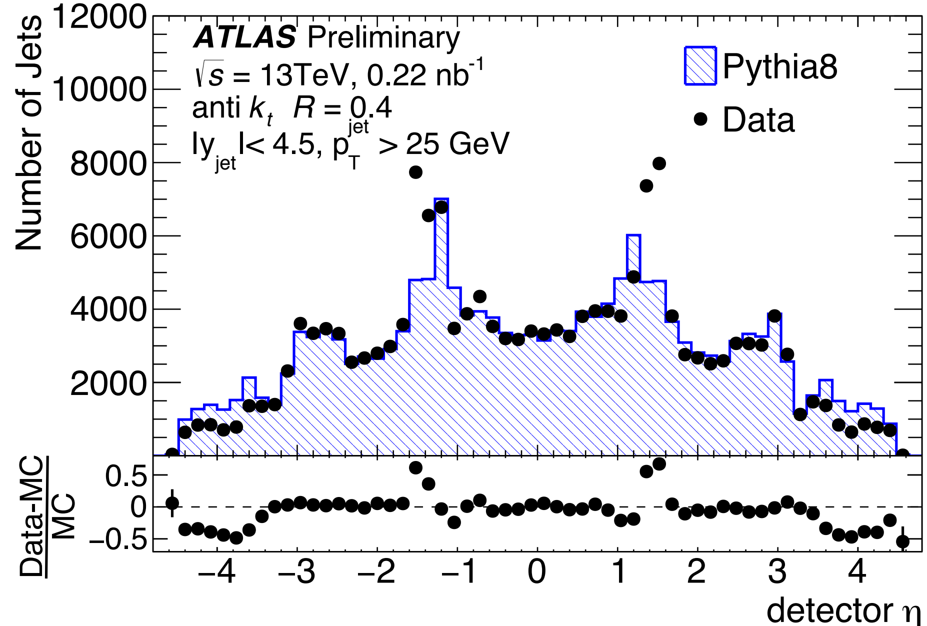
1. Finding and calibration of group of calorimeter cells topologically connected (topo-clusters)
2. Jet clustering of topo-clusters (anti-k_t algorithm, R = 0.4) and correction for pile-up
3. MC calibration of the jet vs. pseudo-rapidity
4. Residual calibration using in situ measurements.

Inclusive jet kinematic distributions

p_T^{jet} distribution



η_{det}^{jet} distribution

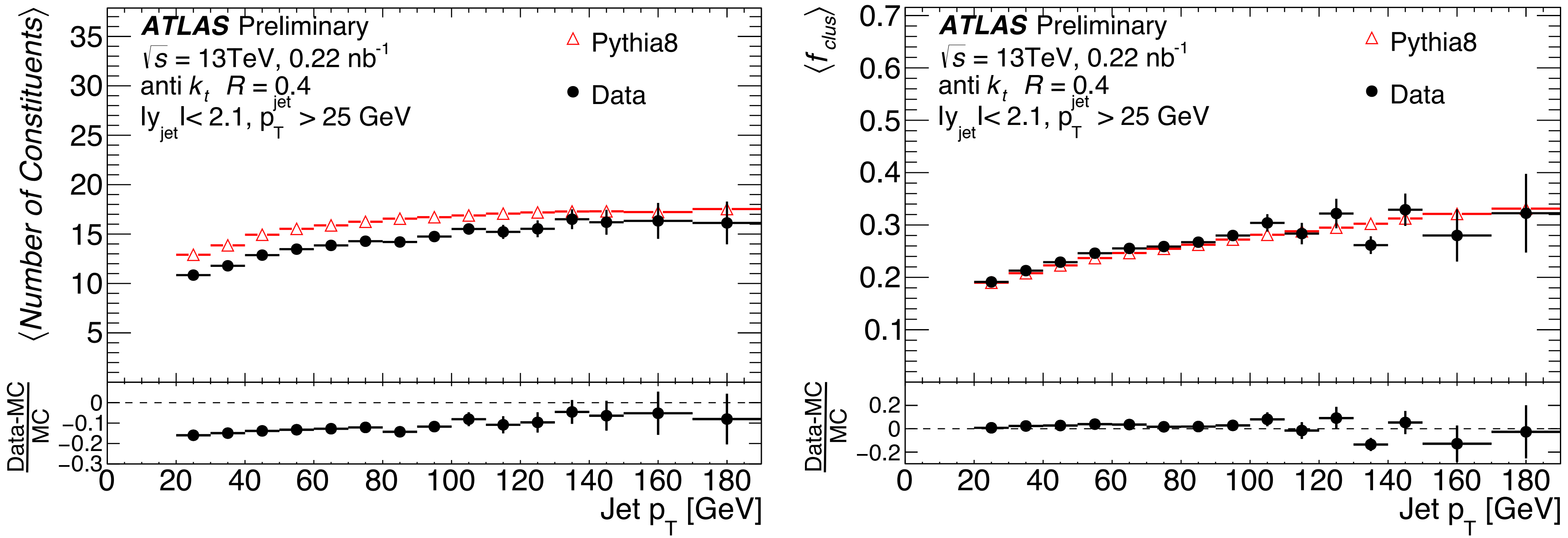


- Also the jet azimuth angle distribution is well modeled
- In general the MC simulation describes the data distributions to within about 10%.
- The disagreement in the gap region is due to the miss-calibration of the special scintillation counters

Inclusive jet kinematic distributions

Cluster multiplicity vs. p_T^{jet}

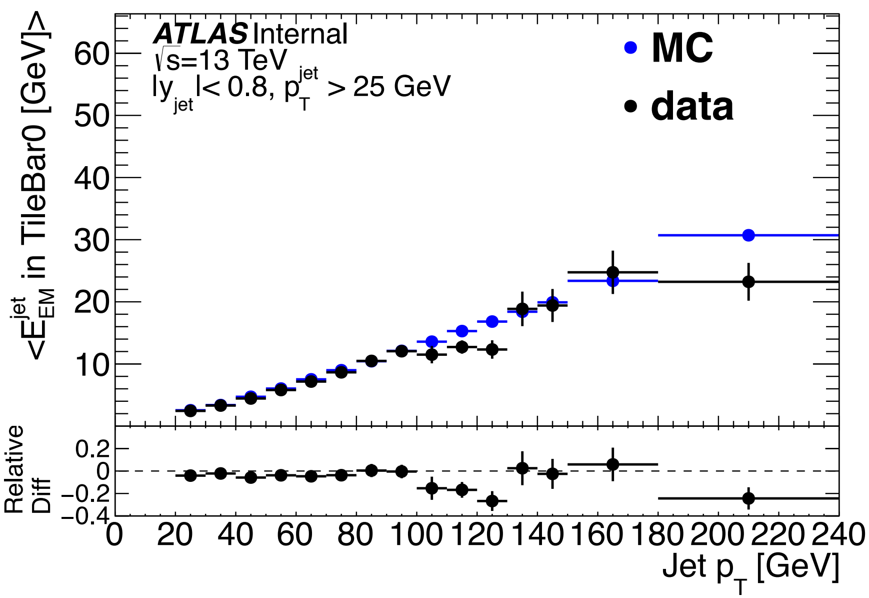
Fraction of the energy carried by the leading cluster vs. p_T^{jet}



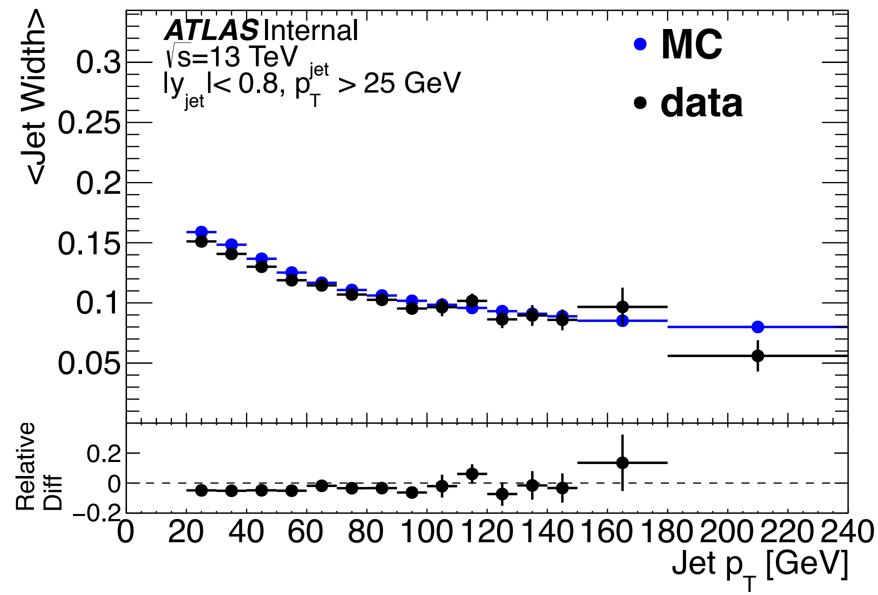
- The differences on the multiplicity is < 20%
- $< f_{clus} >$ is well modeled in MC. About 25 of the jet momentum is contained within a single cluster
- The multiplicity and the kinematic distributions of the charged particles associated to jets are well described in MC.

Longitudinal and transversal profiles

Energy deposited in Tilebar0 vs p_T^{jet}



Jets width vs p_T^{jet}

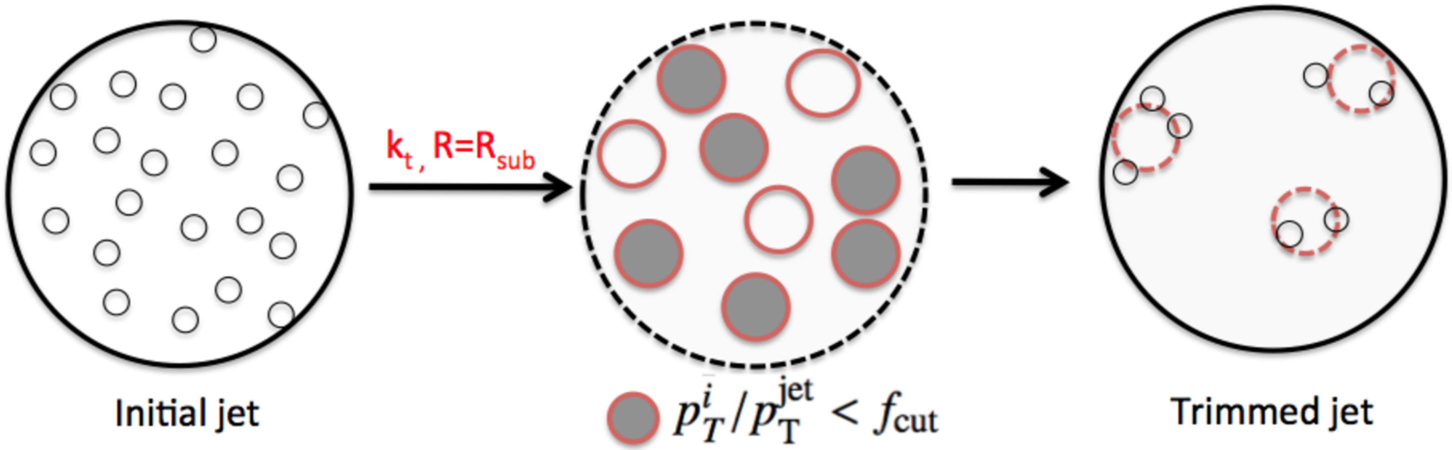


- Reasonable understanding of the longitudinal jet energy profile including the leakages into the muon system
- The average values of the calorimeter clusters and associated tracks width distributions are generally well modeled

Jet substructure performance (ATLAS-CONF-2015-035)

- Identification of hadronically decaying boosted objects (W, Z, H, top)
- The studies focused on jets with $p_T^{jet} > 200\,GeV$

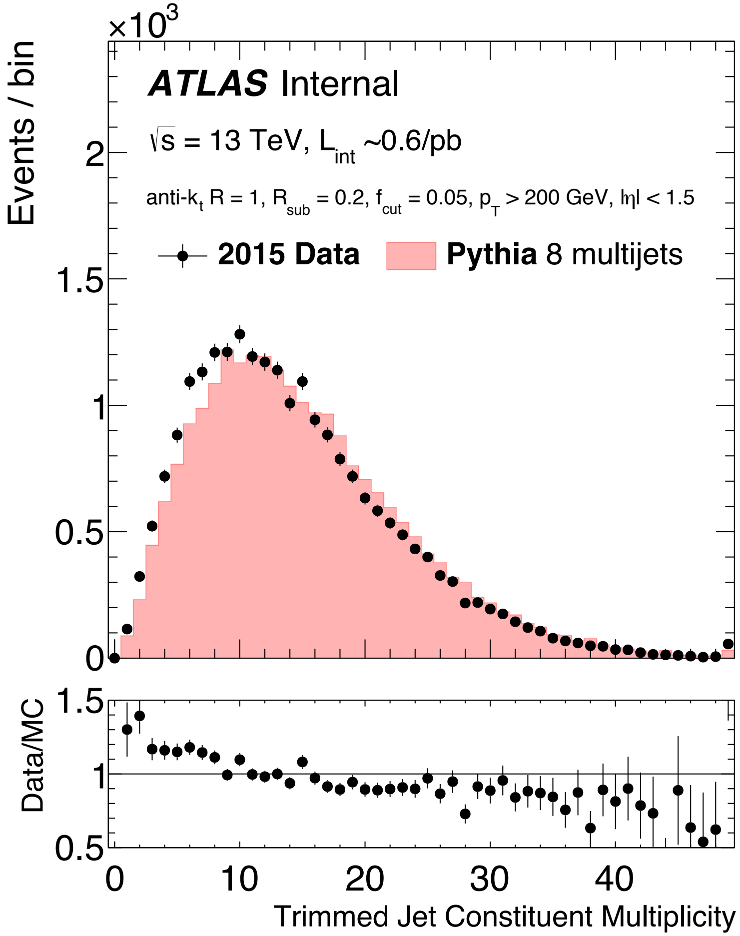
Reconstruction of large Radius Jets



- Energy depositions in the calorimeters are grouped into topological calorimeter-cell clusters (constituent) and then calibrated
- Trimmed Jets are built with the anti-k_t algorithm with R = 1.0 and trimmed using R_{sub} = 0.2 k_t sub-jets
- Sub-jets whose p_T fraction is less than f_{cut} = 5% of the jet p_T are removed (pile-up suppression)
- The trimmed jet p_T is further calibrated to account for the residual detector response

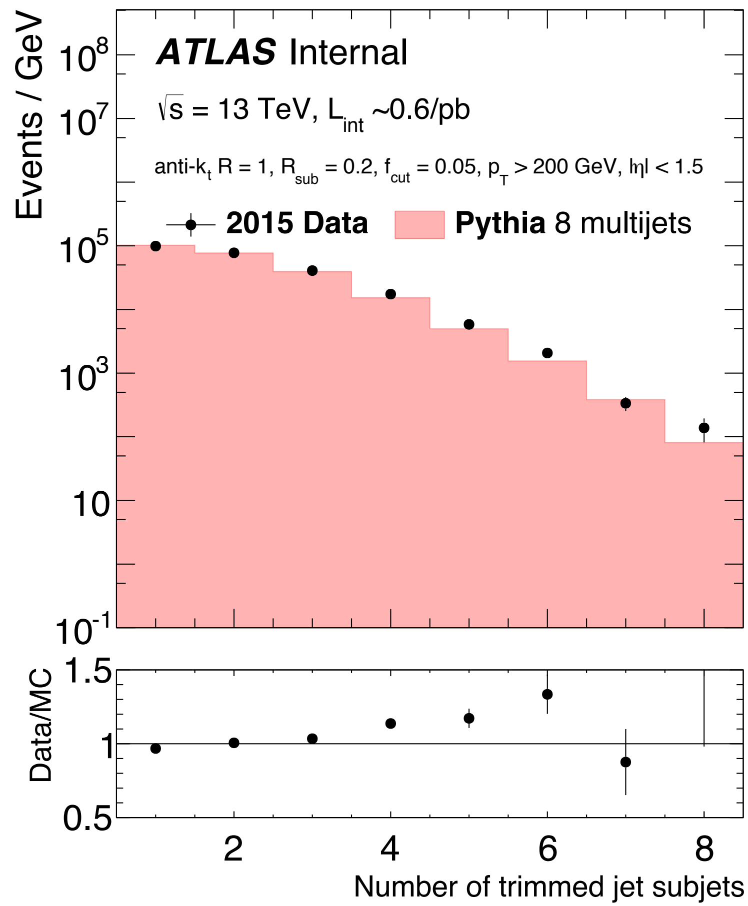
Constituents and Sub-jets

Jet Constituent



There are on average fewer clusters in data than in MC, but the level of disagreement is < 15%

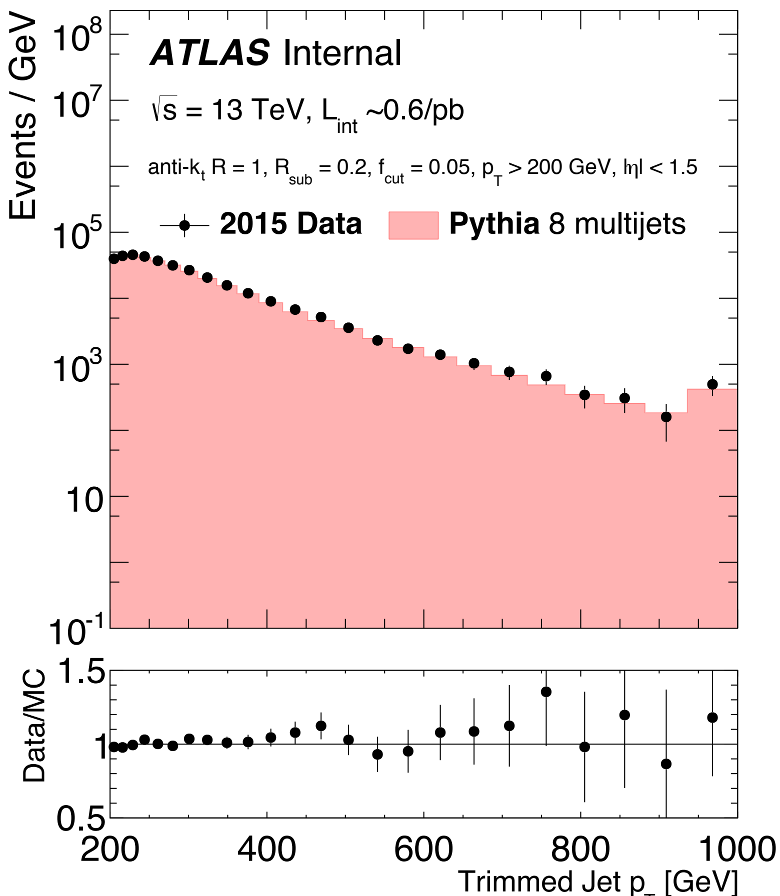
Jet Sub-jets



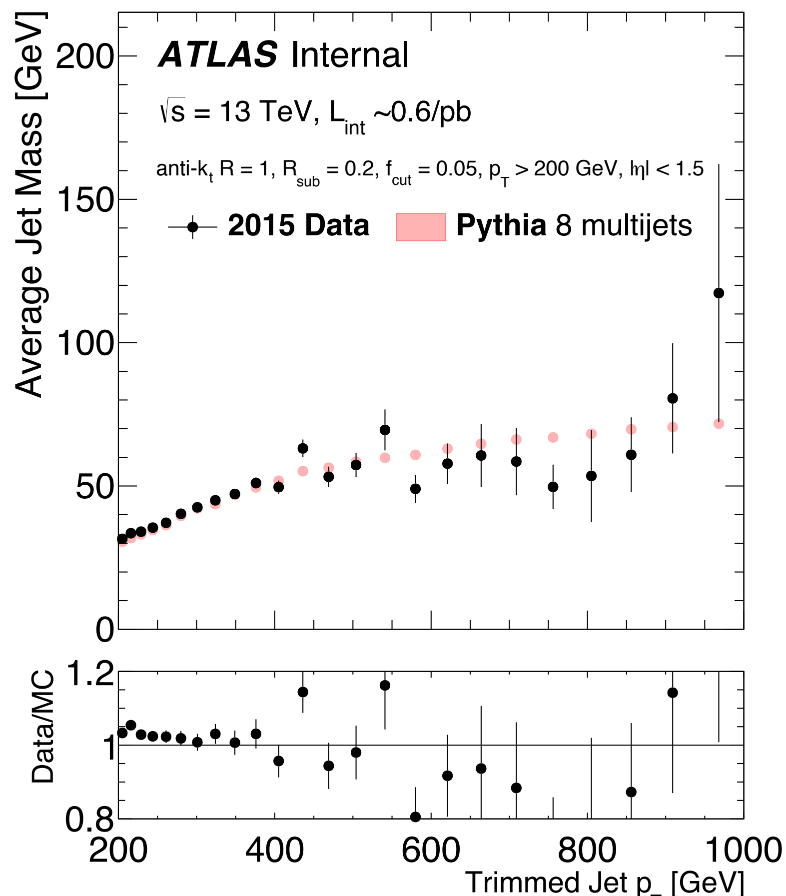
The agreement degrades for sub-jet multiplicity > 3

Large radius jets kinematics

Jet p_T (GeV)



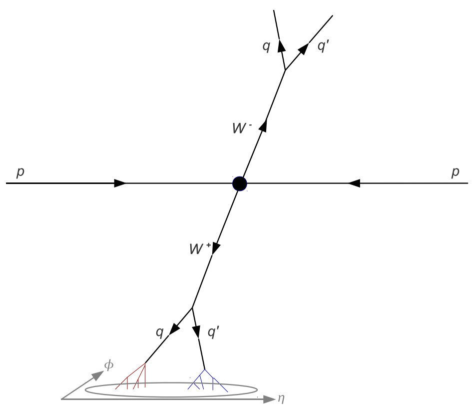
<Jet mass> vs p_T

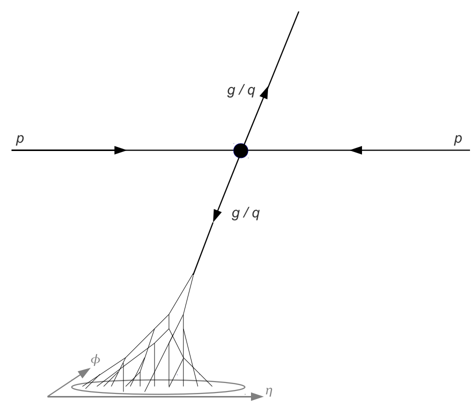


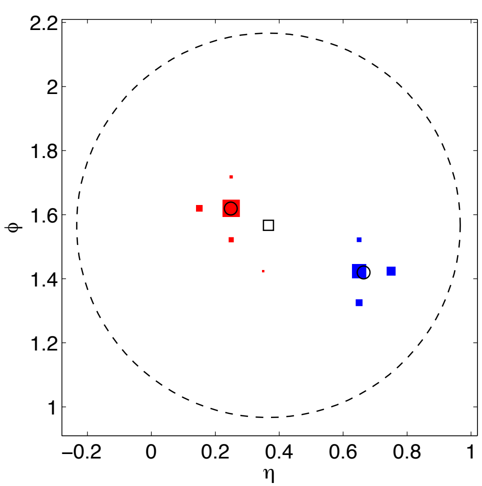
The average jet mass vs. p_T is modeled in MC within 5-10%

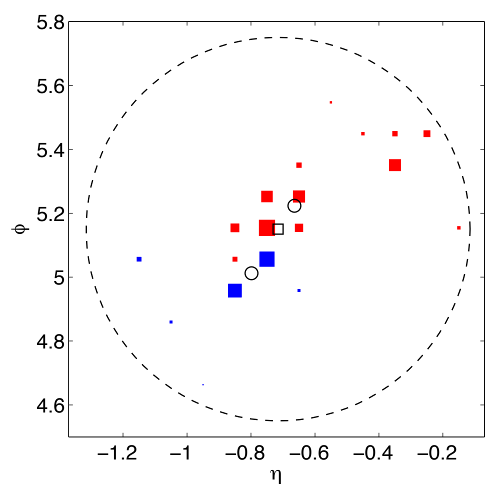
Substructure variables

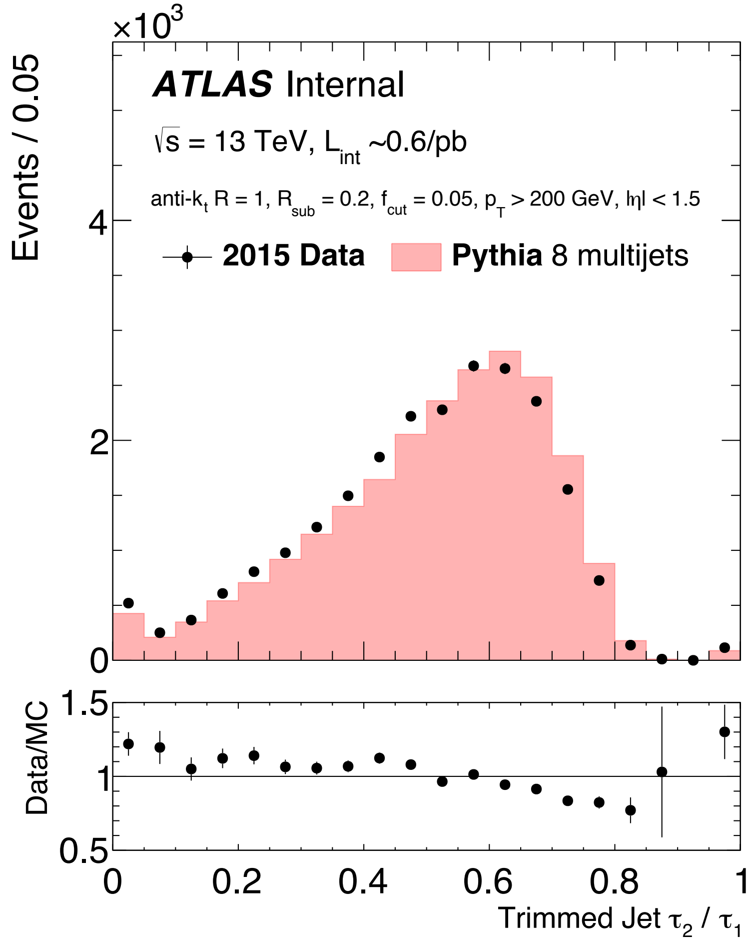
W jet **q jet** **τ_{21} N-subjettines ratios**











Typical differences of about 10-15% are observed

Missing transverse momentum reconstruction (ATLAS-CONF-2015-027)

- Indicative of weakly interacting stable particles in the final state
- Results obtained analyzing $Z \to \mu\mu$ decay events are presented

Missing E_T reconstruction

Event quantity based on momentum conservation in the transverse plane:

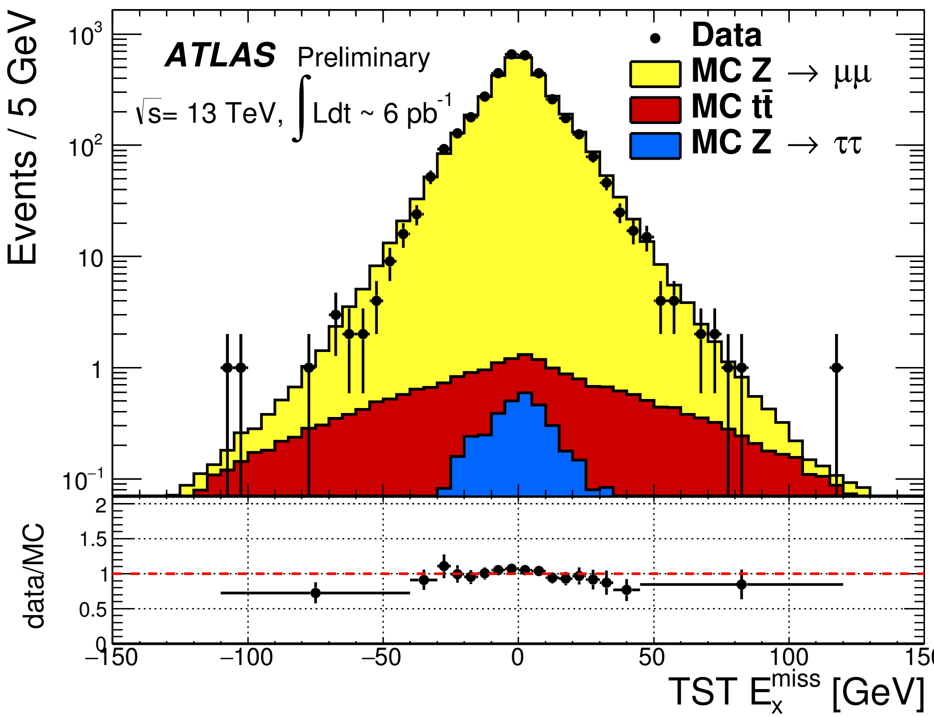
$$E^{miss}_{x(y)} = -\left(E^{jets}_{x(y)} + E^{e}_{x(y)} + E^{\gamma}_{x(y)} + E^{\tau}_{x(y)} + E^{\mu}_{x(y)} + E^{soft\,term}_{x(y)}\right)$$

- $E^{jets}_{x(y)}, E^{e}_{x(y)}, E^{\gamma}_{x(y)}, E^{\tau}_{x(y)}, E^{\mu}_{x(y)}$: sum of x(y) component of the momentum of all jets, electrons, photons, taus and muons, respectively (Hard Term's)
- $E^{soft\,term}_{x(y)}$: sum of x(y) component of the momentum of all tracks associated with the primary vertex but not matching to any HT object (Track-based Soft Term)
- The TST is relatively insensitive to pile-up effects but does not include contributions from neutral particles

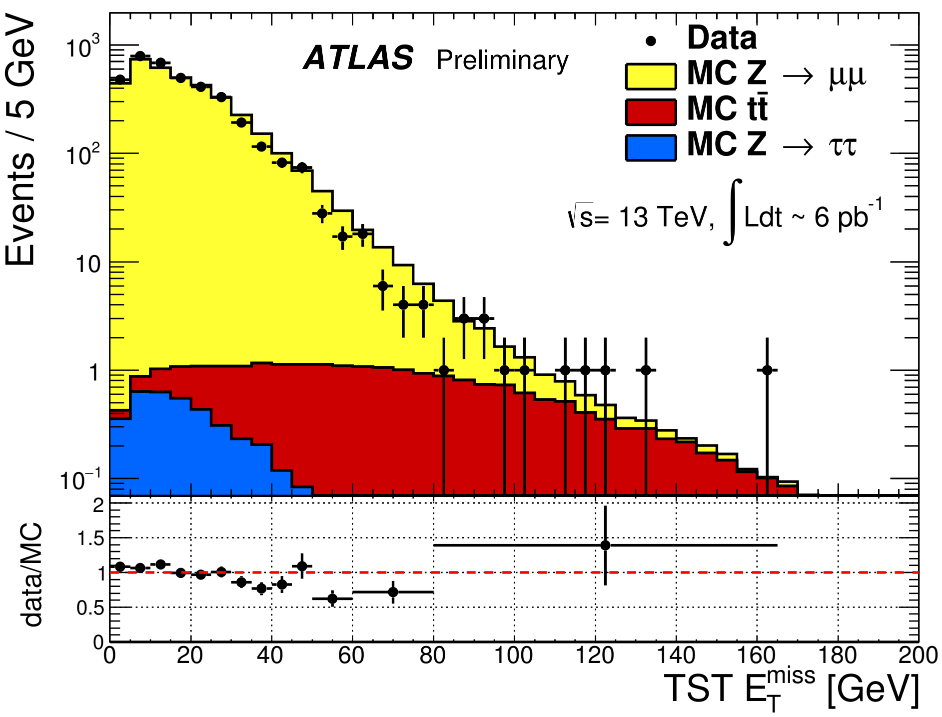
$$E^{miss}_{T} = \sqrt{\left(E^{miss}_{x}\right)^2 + \left(E^{miss}_{y}\right)^2}$$

E_T^{miss} distributions

E_x^{miss} distribution



E_T^{miss} distribution

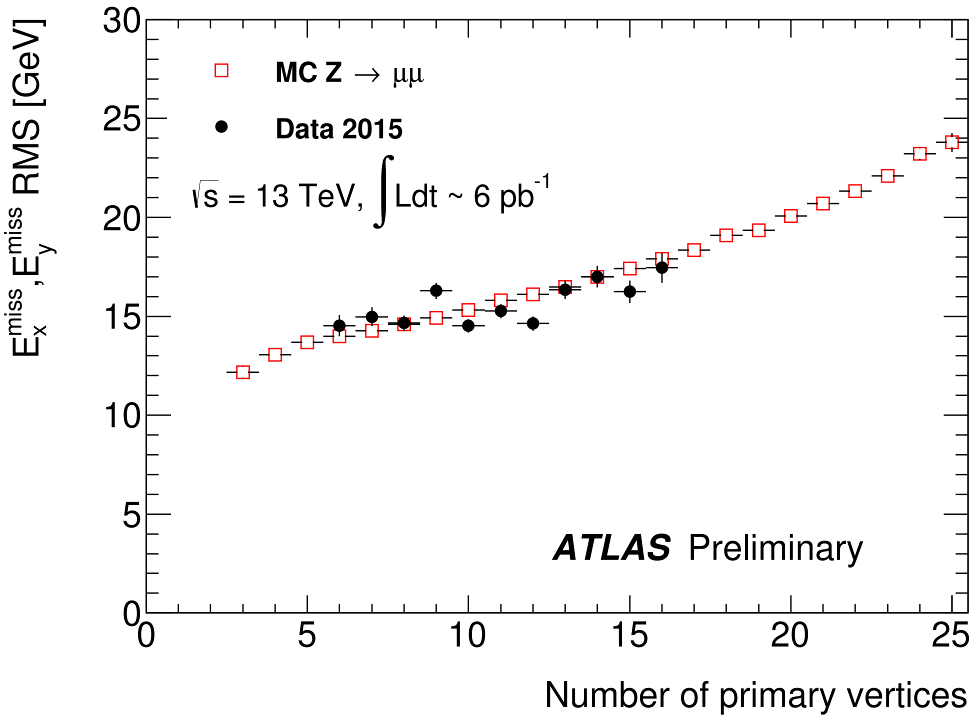


The agreement in the bulk of the distributions is within 20%

E_T^{miss} resolution

Resolution vs. Number of primary vertices

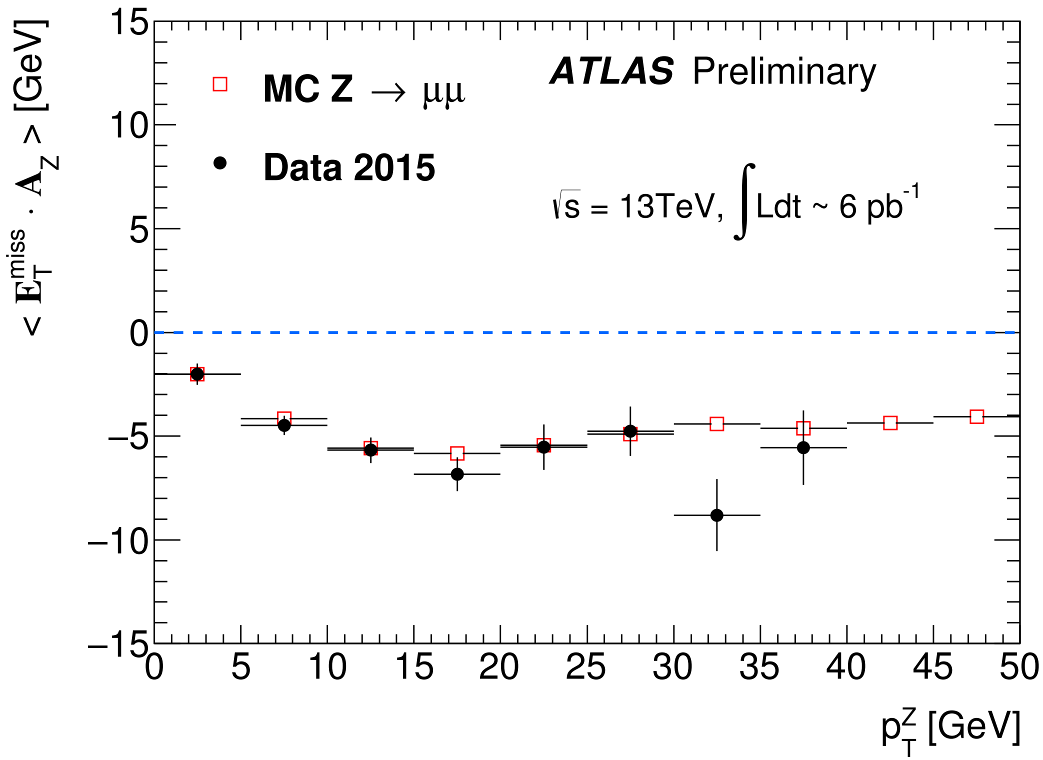
- In $Z \rightarrow \mu\mu$ events neutrinos are produced only through heavy flavour meson decays, so this channel has very little genuine E_T^{miss}
- The RMS of the distributions of $E_{x(y)}^{miss}$ is indicative of the resolution



E_T^{miss} scale

$\langle E_T^{miss} \cdot A_Z \rangle$ **vs.** p_T^Z

- In $Z \rightarrow \mu\mu$ events the mean value of E_T^{miss} projected onto the unit vector A_Z parallel to p_T^Z is a measure of the E_T^{miss} scale
- The negative bias of about 5 GeV observed in data and MC indicates an underestimation of the E_T^{miss} due to a) soft neutral particles and b) limited acceptance of the ID



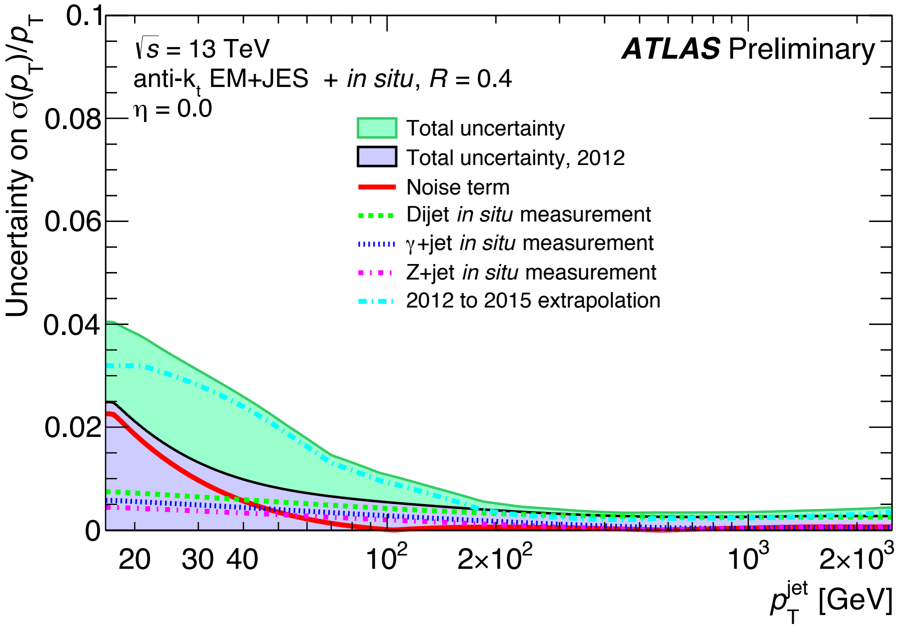
Summary

- ATLAS performance concerning Jet reconstruction, jet substructure and missing transverse energy has been studied and compared to MC results using first 13 TeV collision data
- Reasonable agreement between data and MC simulation is observed
- Few items require more investigations

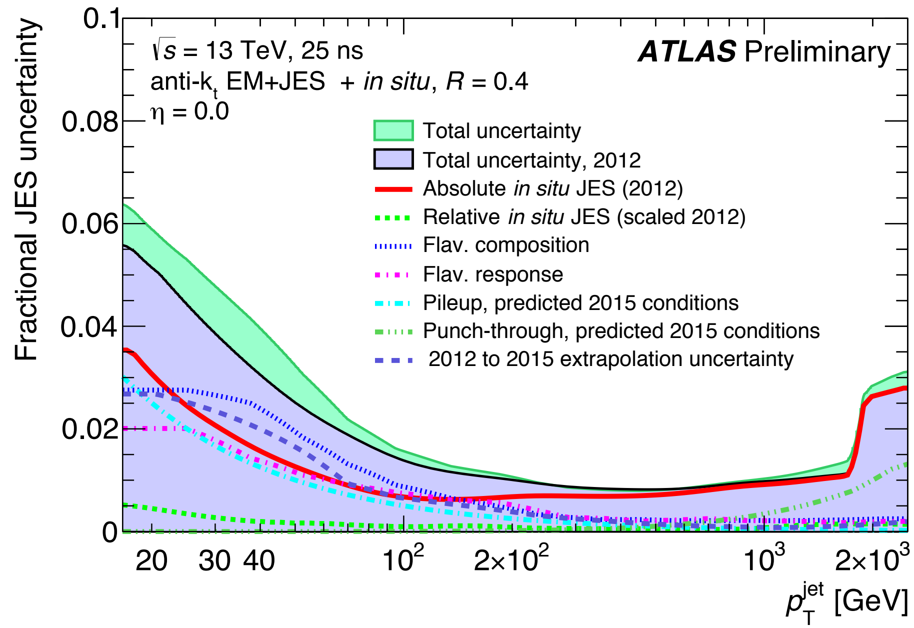
Backup

Expected Uncertainties on jet reconstruction in Run 2

Energy Resolution

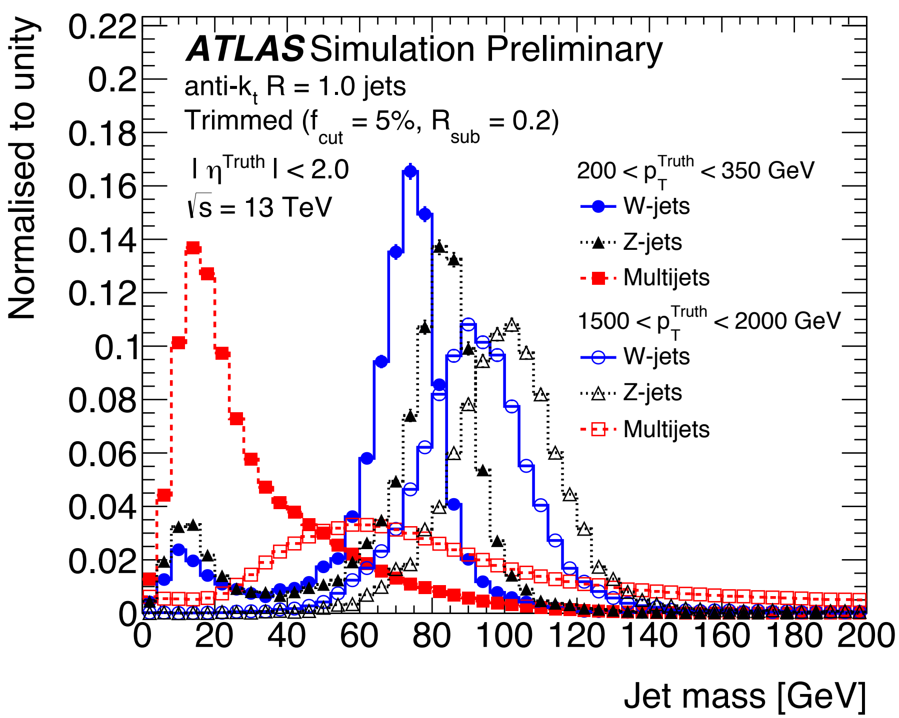


Energy Scale



Boosted, hadronically-decaying W and Z bosons

Un-calibrated jet mass distributions



W -jet signal efficiency versus multi-jet background rejection