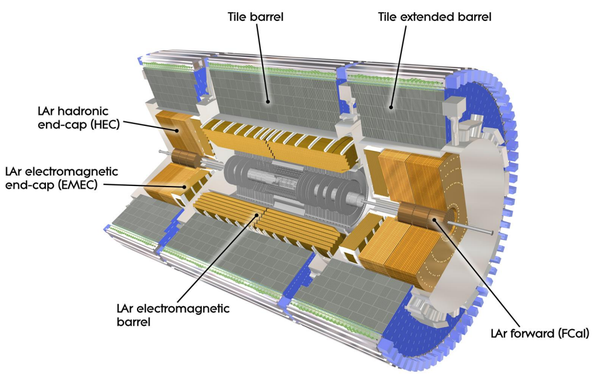
Europhysics Conference on High-Energy Physics 2011, Grenoble

Jet performance and jet cross section measurements at ATLAS

Jet production, governed by QCD, is by far the dominant process of the LHC proton-proton collisions. Measurements of jets is an important first step of the LHC program. Before we can expect to understand other fundamental physics, a good understanding of jets is required. Furthermore, with LHC's unprecedented center-of-mass collision energy of 7 TeV, and ATLAS's wide pseudo-rapidity coverage, we are probing QCD in a new kinematic regime. Impressive agreement is observed between data and theory.

The ATLAS Calorimeter

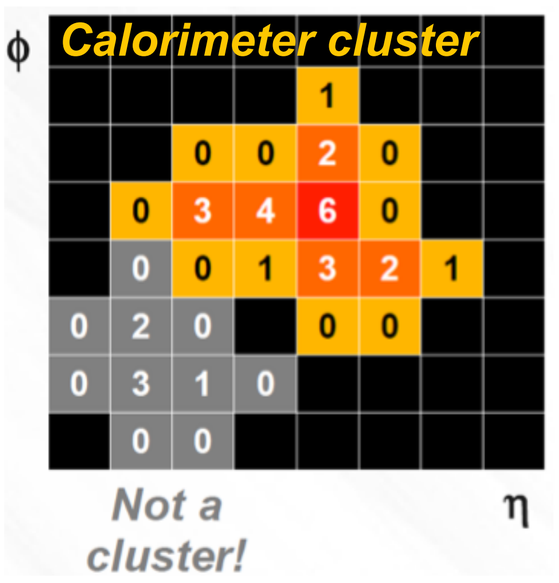


- ATLAS (A ToroidaL LHC ApparatuS) is a general purpose detector at the LHC
- Excellent calorimetry with 200 000 cells, covering $|\eta| < 4.9$ in pseudo-rapidity
- Design specification for the jet energy resolution is given by $\sigma/E = 0.5/\sqrt{E} \oplus 0.03$

Jet Reconstruction

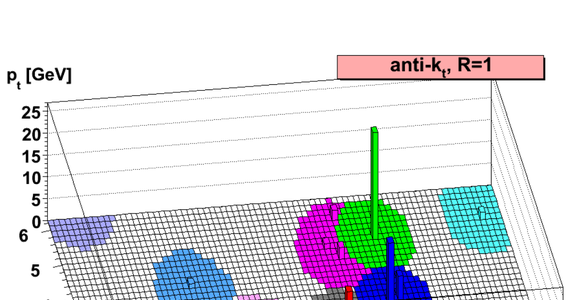
A. For most analyses at ATLAS, the ***jet input objects*** are 3-dimensional topological clusters, built from calorimeter cells, following a '4-2-0' noise-suppression technique:

1. Start with a seed cell with sufficiently large signal/noise: $|E| > 4\ \sigma_{noise}$
2. Include neighbouring cells with $|E| > 2\ \sigma_{noise}$
3. Include last layer of cells with $|E| > 0\ \sigma_{noise}$



B. Jets are built from the topological clusters using the **anti-k_T algorithm**:

- Produces regular, cone-like shaped jets
  → good for calibration!
- Infrared & collinear safe
  → NLO comparisons
- Distance parameter used R=0.4 and R=0.6
  → different sensitivity to non-perturbative effects, event topologies, pile-up ...
- Full recombination used
  → jet has mass, clusters treated as massless

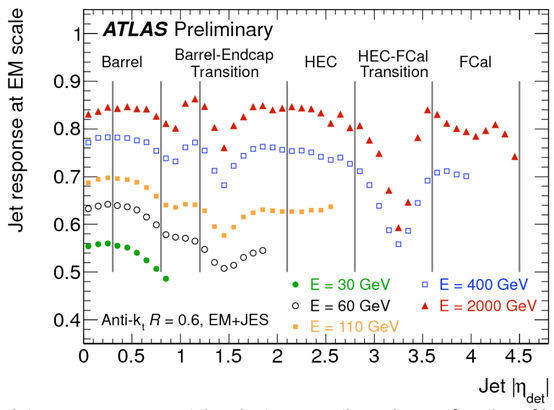


[Cacciari, Salam, Soyez: JHEP 0804:063, 2008]

Jet Calibration

Both the direction and the energy for jets are calibrated in three steps

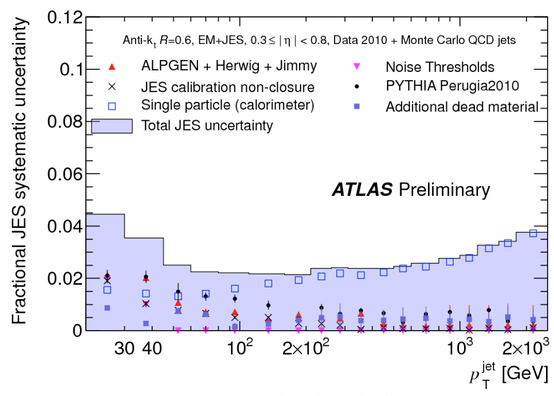
1. A correction removes additional energy due to ***pile-up*** (multiple *pp*-interactions). It is derived using *pp* collision data.
2. Each jet is corrected to ***point to the primary vertex*** of the event.
3. Jet energy and direction are corrected for the ***calorimeter response***, which is not unity mainly due to calorimeter non-compensation and material in front of calorimeter. This is the largest correction, and it is derived from simulations.



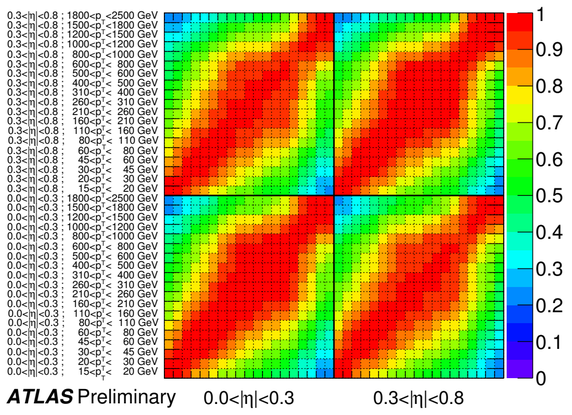
Jet energy response at the electromagnetic scale as a function of jet energy and pseudorapidity. The inverse of this response is the calibration factor applied.

JES uncertainty

The Jet Energy Scale uncertainty and its correlation are determined using a combination of *in-situ* techniques, test-beam measurements and results from detector simulations. Several uncertainty sources are identified and evaluated.

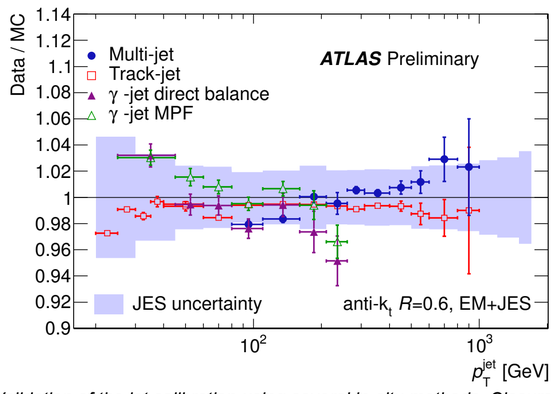


Jet energy scale uncertainty as a function of calibrated jet p_T for jets reconstructed in the central calorimeter region



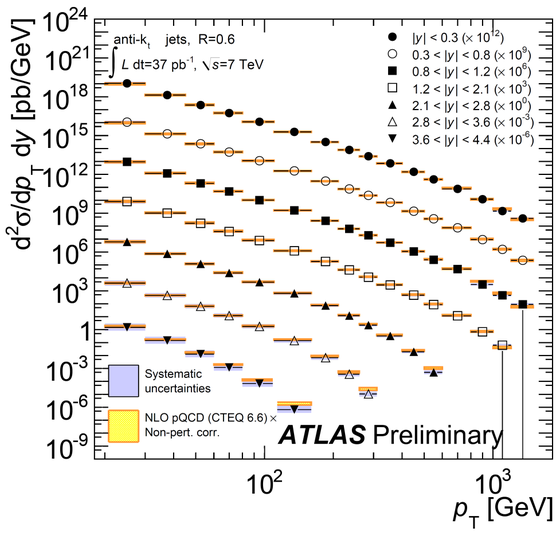
Correlation matrix of the JES uncertainty due to the calorimeter response. The correlation here is ~100% for jits with similar p_T and η, and ~30% for jets with very different p_T (20 GeV vs 2 TeV).

The MC-derived jet calibration is validated using a number of *in-situ* techniques:

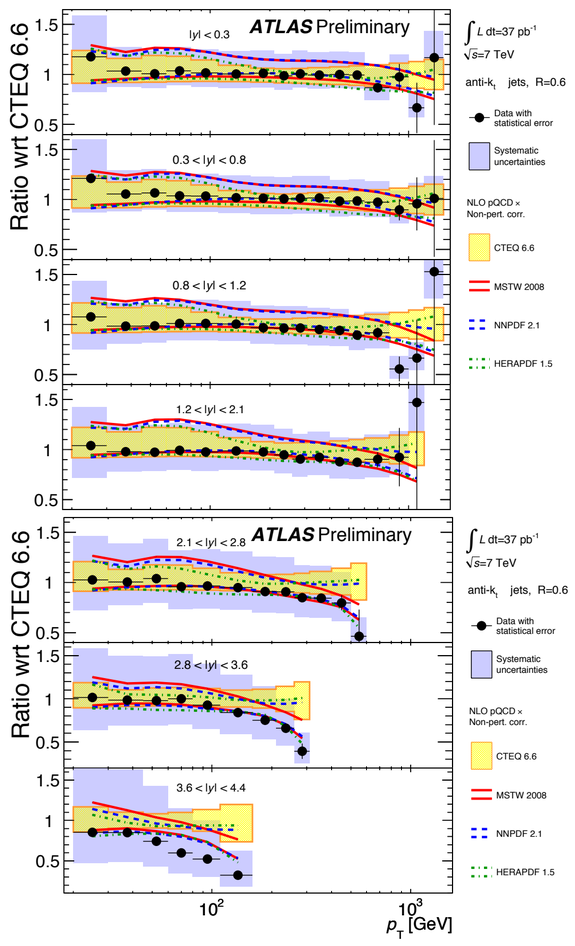


Validation of the jet calibration using several in-situ methods. Closure is observed well within the JES uncertainty.

Inclusive Jet Cross Section

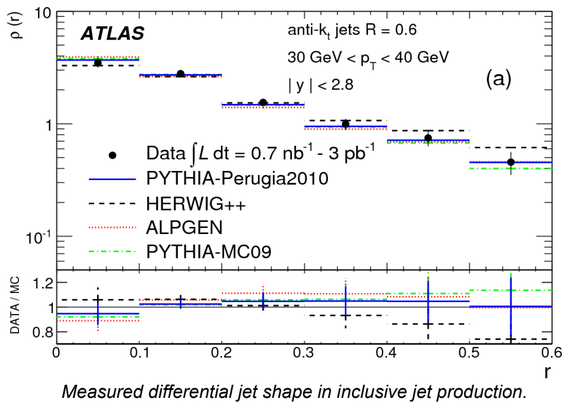


Inclusive jet double-differential cross section as function of jet transverse momentum (p_T) and rapidity (y).



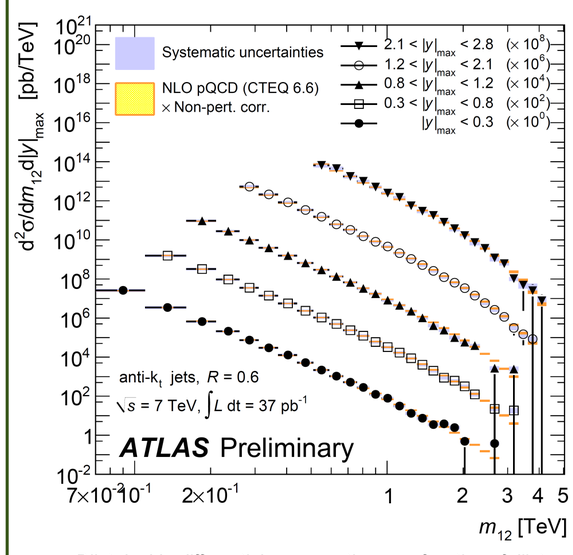
Inclusive jet cross section comparisons to theoretical predictions using different PDF sets. CTEQ 6.6 is chosen as the reference.

Jet Shapes

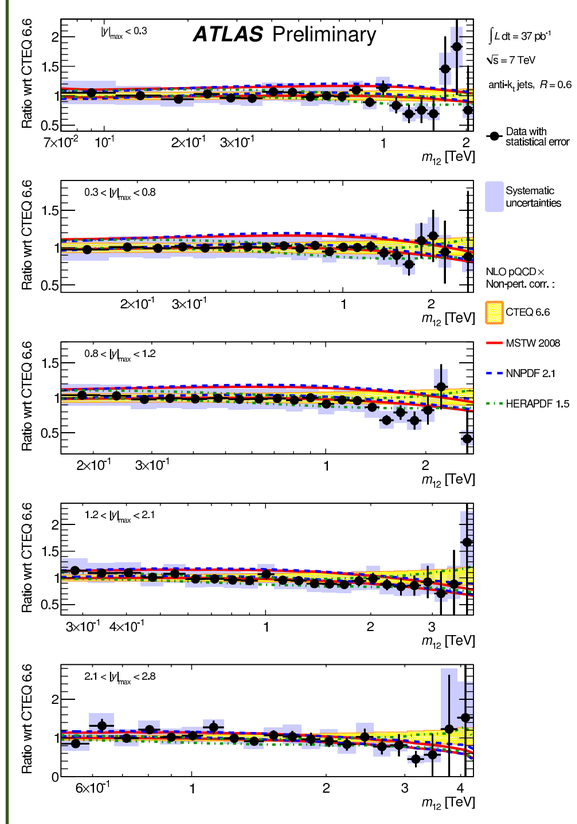


Measured differential jet shape in inclusive jet production.

Dijet Cross Section

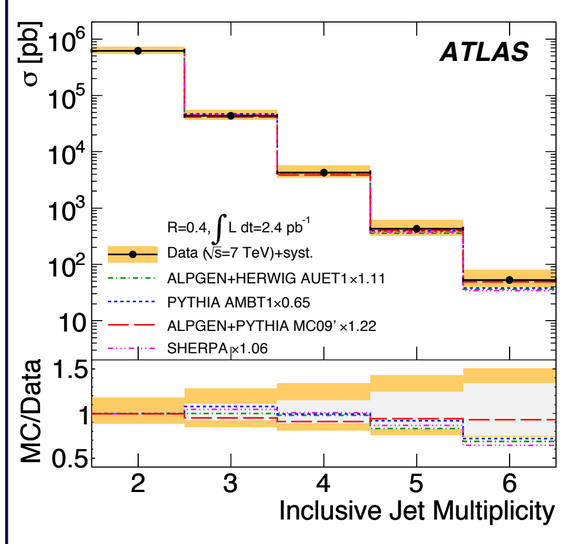


Dijet double-differential cross section as a function of dijet invariant mass and maximum rapidity of the two jets y_{max}.

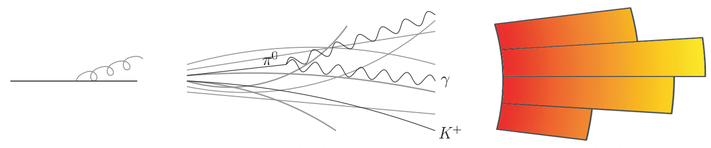


Dijet double-differential cross section as a function of dijet invariant mass and the maximum rapidity of the two jets. The NLO pQCD prediction using the MSTW 2008 PDF set is used as a reference.

Multi-jet Cross Section



Multi-jet cross section as a function of jet multiplicity.



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arXiv:1107.2092v1 *Measurement of multi-jet cross sections in proton-proton collisions at a 7 TeV center-of-mass energy*
Phys. Rev. D 83 (2011) 052003 *Study of Jet Shapes in Inclusive Jet Production in pp Collisions at s=7 TeV using the ATLAS Detector*

ATLAS-CONF-2011-032 *Jet energy scale and its systematic uncertainty in proton-proton collisions at s=7 TeV in ATLAS 2010 data*
ATLAS-CONF-2011-030 *In-situ jet energy scale and jet shape corrections for multiple interactions in the first ATLAS data at the LHC*
ATLAS-CONF-2011-067 *Determination of the ATLAS jet energy measurement uncertainties using tracks ...*
ATLAS-CONF-2011-028 *ATLAS Calorimeter Response to Single Isolated Hadrons ...*
ATLAS-CONF-2011-031 *Determination of the jet energy measurement uncertainty using photon-jet events ...*
ATLAS-CONF-2011-014 *In-situ pseudorapidity intercalibration for evaluation of jet energy scale uncertainty using dijet events ...*
ATLAS-CONF-2011-029 *Probing the jet energy measurement at the TeV-scale using the multi-jet balance technique ...*

Dag Gillberg (Carleton University), for the ATLAS Collaboration

Carleton UNIVERSITY

ATLAS EXPERIMENT