Forward jet physics at ATLAS

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Introduction

ATLAS

- ATLAS (A Toroidal LHC ApparatuS) is a general purpose detector at the LHC with calorimeters spanning $|\eta| < 4.9$ in pseudo-rapidity
- A variety of different calorimeter technologies are used in different regions of the detector
- Reconstructing physics objects (jets) which are coherent across the whole detector is non-trivial!
- The studies discussed here used 37pb^{-1} of 7 TeV data collected in March-December 2010
- The jets used in these studies are constructed from clusters of calorimeter cells using the Anti-k_t algorithm

Jet energy variations

Jet energy response

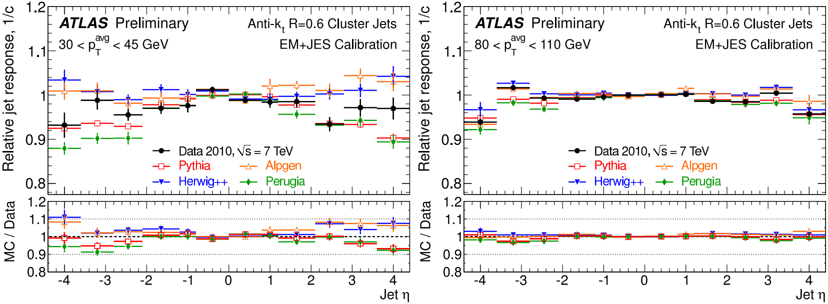
- Jet energy response is dependent on η due to changing calorimeter technology, and differing amounts of dead material.
- Calibration corrections need to be applied to ensure uniform calorimeter response to jets
- These corrections need to be validated in-situ given the complex calorimeter geometry and dead material distribution

Dijet balancing

- In a pure dijet event we expect $\Delta\phi = \pi$ and that the two jets be balanced in p_{T}.
- Requiring one jet to be in a central reference region ($0.1 < |\eta| < 0.6$), we use p_{T} balance to study the relative response of the other jet.
- The correction factor ($1/c$), required to bring the probe jet to the same scale as the reference jet is given by

$$\mathcal{A} = \frac{p_{\mathrm{T}}^{probe} - p_{\mathrm{T}}^{ref}}{p_{\mathrm{T}}^{avg}} \qquad \frac{p_{\mathrm{T}}^{probe}}{p_{\mathrm{T}}^{ref}} = \frac{2+\mathcal{A}}{2-\mathcal{A}} = 1/c \tag{1}$$

η intercalibration comparisons

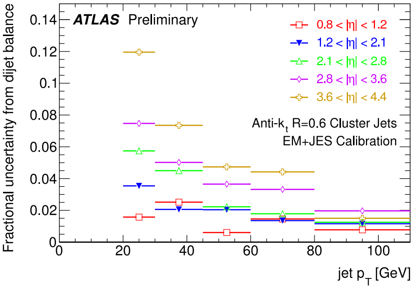


(a) $30\text{GeV} < p_T^{avg} < 45\text{GeV}$ (b) $80\text{GeV} < p_T^{avg} < 110\text{GeV}$

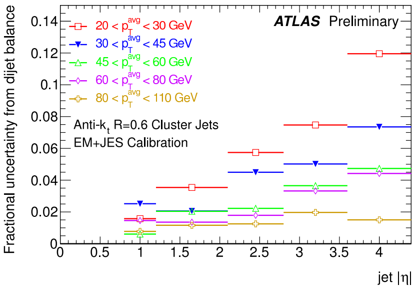
Figure 1: Calibration correction factors for two different p_T^{avg} ranges

- Large spread of MC predictions in forward region at low p_T
- Reflects a real uncertainty in the truth distributions (not a detector effect).

Jet response uncertainty



(a) Uncertainty in the jet response as a function of jet p_{T}



(b) Uncertainty in the jet response as a function of jet η

Figure 2: Uncertainty in the jet response as a function of jet η and p_{T}

- The dijet balance has a large physics modelling uncertainty as a result of this spread
- Uncertainty calculated as RMS spread of MC about the data (accounts for our current lack of knowledge about the physics)

Forward Inclusive Cross-section

Background

- Jet cross-sections and properties are key observables in high-energy particle physics.
- Inclusive single-jet (and dijet) double differential cross-sections (as a function of y and p_{T}) were measured for Anti-k_t R=0.4 and R=0.6 jets
- The central region jet cross-section ($|y| < 2.8$) was one of the first published ATLAS measurements (Eur, Phys. J. C. `http://arxiv.org/abs/1009.5908`)

Extension to the forward region

- Help constrain low-x PDFs
- Extend the existing cross-section analysis with the first measurements in a new kinematic regime
- Improve understanding of the forward region
- Provide access to possible BFKL behaviours (small-x resummation)
- Information about quark structures could also show up in forward scattering

Overall Strategy

Event and jet selection cuts

- Event is part of a set of "good" runs in which all relevant detector components were working properly
- There must be ≥ 1 primary vertex reconstructed from ≥ 5 tracks which is consistent with the beamspot position
- Standard jet cleaning cuts are applied to remove fake jets caused by calorimeter noise or background
- Each jet is required to be in an event that passed a (jet y and p_{T} dependent) trigger

Forward region

- The forward region is divided into two rapidity bins based on detector geometry
- The transition bin ($2.8 < |y| < 3.6$) covers the transition between the endcap and the FCAL
- The boundaries of the forward bin ($3.6 < |y| < 4.4$) ensure that any offline jets here are fully contained in the FCAL

Trigger Strategy

Each bin in p_T and y uses triggers such that all jets in it fall on the efficiency plateau.

- Low threshold triggers were heavily prescaled with increasing machine luminosity
- Due to problems with trigger software or machine configuration, some triggers cannot be used in certain data-taking periods
- $\rightarrow$ Appropriate trigger for each bin changes with run period

Transition bin

No trigger is fully efficient in the transition bin, but the combination of central **OR** forward is.

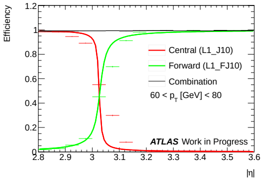


Figure 3: Central and forward trigger efficiencies

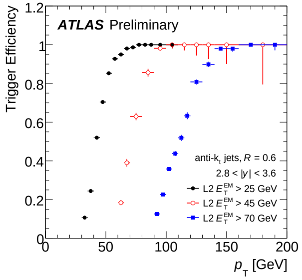
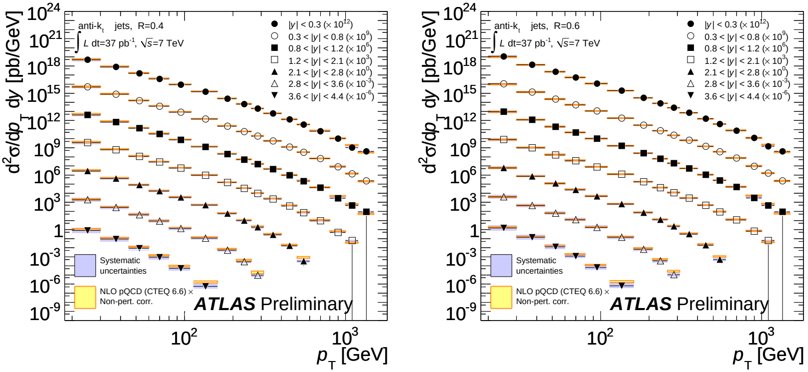


Figure 4: Trigger efficiency in the transition bin

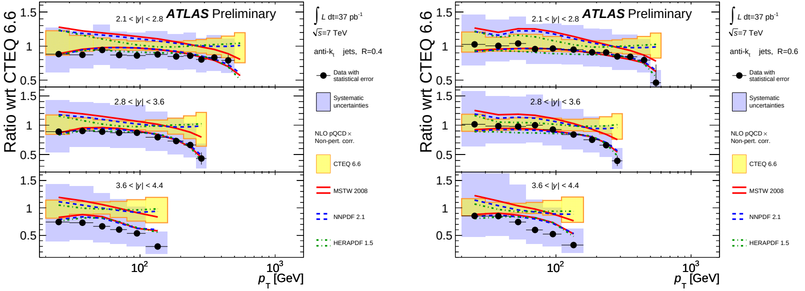
Inclusive single jet cross-sections



(a) Anti-k_t jets (R=0.4) (b) Anti-k_t jets (R=0.6)

Figure 5: Inclusive single-jet double differential cross-sections

Inclusive single jet cross-sections



(a) Anti-k_t jets (R=0.4)

(b) Anti-k_t jets (R=0.6)

Figure 6: Inclusive single-jet double differential cross-sections - ratio to NLO pQCD

- Small differences can be seen at high jet p_{T} and $|y|$
- Data and theory predictions are generally in agreement within the experimental and theoretical uncertainties.

Jet response

- For jets with $|\eta| < 2.8$ and $p_{\mathrm{T}} > 60$ GeV, the relative response is well understood. Data and Monte Carlo show good agreement
- For jets with lower p_{T} or larger $|\eta|$, there are significant deviations between different Monte Carlos
- There is an η-dependent uncertainty in the jet response due to this uncertainty in the physics modelling

ATLAS-CONF-2011-014: `http://cdsweb.cern.ch/record/1338578/`
In-situ pseudorapidity intercalibration

Jet cross-section

- The use of the full 2010 ATLAS dataset allows a large, new kinematic regime to be investigated
- In particular, the forward region ($2.8 < y < 4.4$) has never previously been explored with such precision at a hadron-hadron collider.
- Data and theory predictions generally agree to within their uncertainties.

ATLAS-CONF-2011-047: `http://cdsweb.cern.ch/record/1338578/`
Inclusive jet and dijet cross-sections