Dijet production with a jet veto at ATLAS

J. Robinson[1]

[1] University College London

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Dijet production with a jet veto

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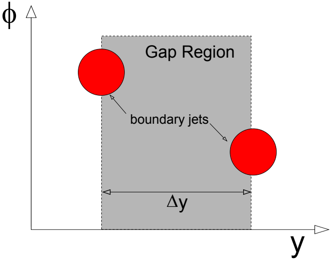
For dijet events, given a jet veto scale Q_0:

- We identify gap events as the subset of events that do not contain an additional jet with $p_T > Q_0$.
- The gap fraction measures the fraction of events that are gap events



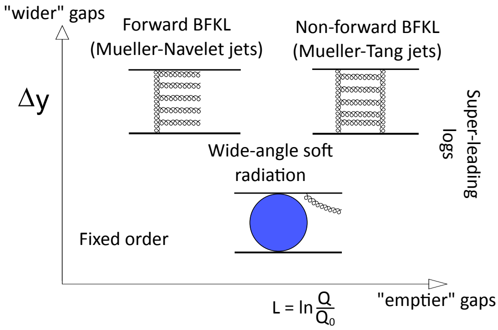
Data

- The results shown here were produced using 7 TeV pp data taken using the ATLAS detector from March until July 2010.
- The luminosity recorded by (non-prescaled triggers) for ATLAS for this period was $190 \pm 21 \text{nb}^{-1}$
- Updated versions of these results are being produced using full 2010 ATLAS run data.

Motivation

Motivation

- Sensitive (in the long term) to BFKL-dynamics, wide angle soft-gluon radiation, colour singlet exchange.
- Starting point for veto studies, can be extended to V+jets and new physics.
- Jet vetoes are used in VBF Higgs searches[1] (eg. the Higgs plus two jet analyses[2])



[1] V. Barger, R.J.N. Phillips, D. Zeppenfeld (1994) *Minijet veto: a tool for the heavy Higgs search at the LHC*: `arXiv:hep-ph/9412276`
[2] D. Rainwater, D. Zeppenfeld, K. Hagiwara (1998) *Searching for $H \longrightarrow \tau\tau$ in weak boson fusion at the LHC*: `arXiv:hep-ph/9808468`

Overall strategy

Event selection

The inclusive dijet sample is defined by requiring events which:

- Belong to a specific set of run periods in which detector, trigger and physics objects pass a data-quality assessment
- Have exactly one "good" reconstructed primary vertex (consistent with the beamspot and with ≥ 5 tracks)
- Using anti-k_T (R=0.6) jets (with jet kinematics corrected wrt the primary vertex):
  - no jets with $p_T > 20$GeV that fail the standard jet cleaning cuts
  - at least two jets with $p_T > 30$GeV and rapidity $|y| < 4.5$[1]

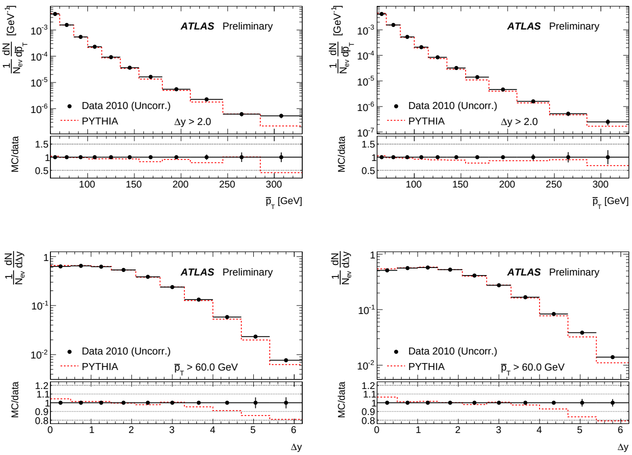
Event Identification

The inclusive dijet sample forms the set of events from which we measure the gap fraction, using Q_0=30GeV. Two different definitions of boundary jets:

- Selection A: highest p_T jets in the event.
- Selection B: most forward and most backward jets (which individually satisfy $p_T > 30$GeV) in the event.

We also have a requirement on the average p_T of the boundary jets: $\bar{p}_T > 60$GeV

Inclusive distributions (cross-check)



(a) Selection A

(b) Selection B

Figure 1: Inclusive boundary jet distributions

- Detector-level distributions, compared with simulated Monte Carlo
- Uncorrected data still gives reasonable agreement (sanity check)

Uncorrected gap fractions

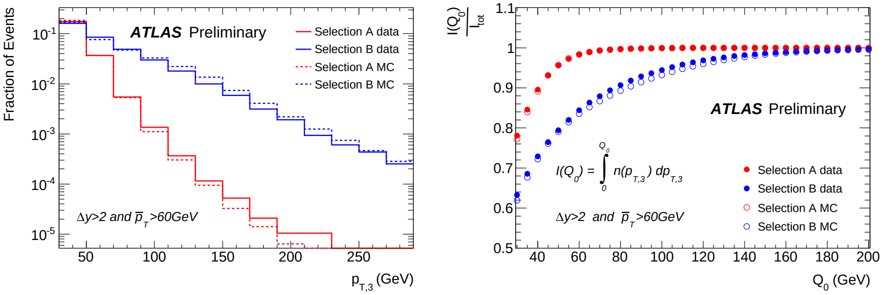


Figure 2: Gap fractions as a function of $p_{T,3}$ and Q_0

- Definition of boundary and veto jets makes a big difference to these spectra. In particular, for Selection B, the third jet can be harder than the boundary jets(!)
- For the same event, the two approaches can identify different boundary jets, thus probing different aspects of the underlying physics.
- Even without systematic uncertainties there is a reasonable agreement with the Monte Carlo

Systematic uncertainties in the gap fraction

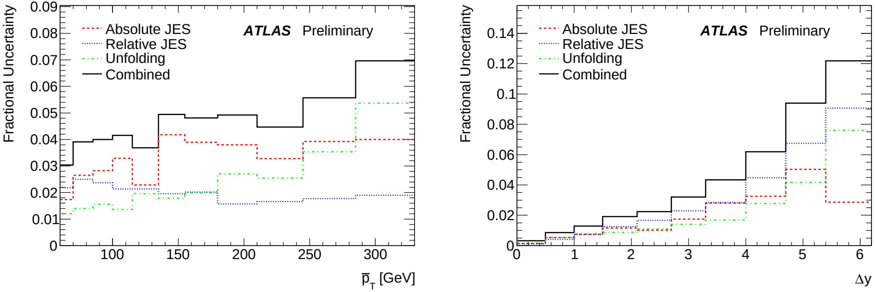
Systematic uncertainties

- Uncertainty from the absolute JES can be estimated by shifting the energy of each jet by $\pm 1\sigma$
- The relative JES is important because of a decorrelation between the JES uncertainty of the boundary jets and the jets between them (as we categorise events using a third jet veto)
- To estimate the maximum uncertainty due to this, we assume that the veto jets are fairly central and so, using the known absolute JES, we take the maximum decorrelation to be 3% if the most forward boundary jet has $|y| < 2.8$ and 10% if it has $|y| > 2.8$
- Additional systematic effects such as possible biases coming from the trigger strategy, the single vertex requirement and the effect of pile-up were studied and found to be negligible with respect to the jet energy scale and unfolding

Unfolding

As the effect of bin-by-bin unfolding turned out to be small in most cases, the effect of unfolding was considered together with the systematics

Systematic uncertainties in the gap fraction



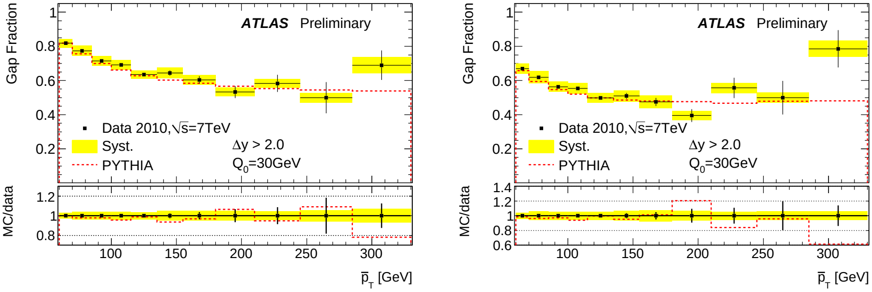
(a) Uncertainty as a function of $\bar{p}_T$, with $\Delta y > 2$

(b) Uncertainty as a function of Δy, with $\bar{p}_T > 60$GeV

Figure 3: Systematic uncertainties for Selection A

- At large Δy, the largest uncertainties arise due to relative JES effects
- Detector effects from the unfolding are important in the largest $\bar{p}_T$ and Δy bins where Monte Carlo statistics are poor
- The systematics due to the JES are very likely to be reduced for updated results with more data and an improved JES

Gap fraction vs. $\bar{p}_T$

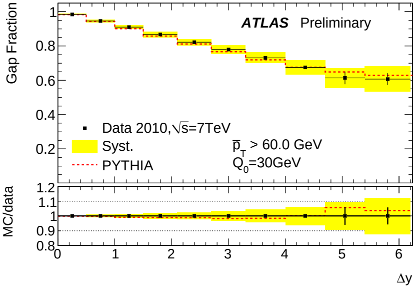


(a) Selection A

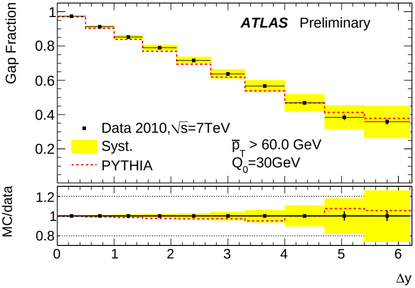
(b) Selection B

- With more data
  - These distributions can be produced in bins of Δy (the plots shown here are obviously dominated by the lowest Δy events)
  - For the lowest of these Δy bins, the plots will have much more data at large values of $\bar{p}_T$ [possibly $\times 100$]

Gap fraction vs. Δy



(a) Selection A



(b) Selection B

- With more data
  - These distributions can be produced in bins of $\bar{p}_T$ (the plots shown here are obviously dominated by the lowest $\bar{p}_T$ events)
  - For the lowest of these $\bar{p}_T$ bins, the plots will not have much extra data (due to trigger prescales) but systematic uncertainties are likely to be reduced, which will be particularly important at large Δy.

Summary

Current results (190nb^{-1})

- First measurement of jet veto physics in dijet events
- First (and so far the only!) ATLAS measurement using jets in the forward region
- Very good agreement with PYTHIA
- At large $\bar{p}_T$ we are currently statistically limited

Outlook

Updated results (more than 40pb^{-1})

- Larger statistics will allow gap fraction distributions to be produced for several Δy and $\bar{p}_T$ bins
- More complicated trigger strategy involving combinations of prescaled triggers
- Likely to have reduced systematics from forward jet energy scale and detector unfolding
- Additional studies of veto-scale dependence, including the possibility of lowering the veto scale to Q_0=20GeV
- New distributions to show the average number of jets in the "gap" region between the boundary jets
- Improved theory comparisons:
  - NLO comparison with POWHEG
  - Comparison to re-summed calculations with HEJ