Measurements of *b*-jet cross sections with the ATLAS Detector

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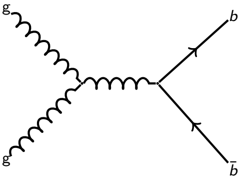
Outline

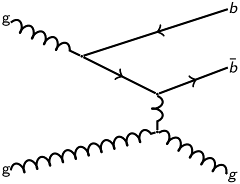
In this talk I shall go over:

- Why we want to look at *b*-jets in general.
- 2010 data b-jet inclusive and di-jet cross section measurement.
  - Eur. Phys. J. C (2011) 71:1846
- Motivations and progress on the 2011 data b-jet cross section

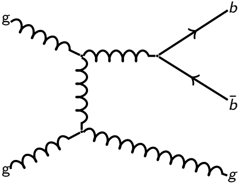
$b\bar{b}$ creation processes



Flavour creation



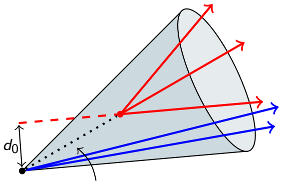
Flavour Excitement

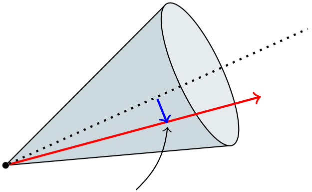


Gluon Splitting

- Each creation process has distinct characteristics.

b-tagging (1)



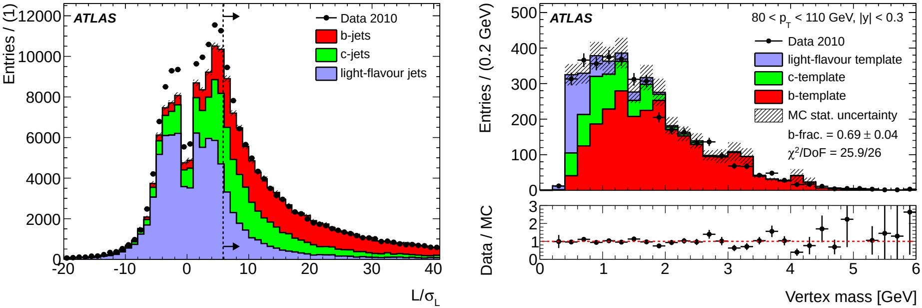


Vertex based *b*-tagging

Muon based *b*-tagging.

- For vertex based, SV0, *b*-tagging the signed decay length significance found for this vertex is assigned as the *b*-tag weight of the jet.
- For muon based, p_T^{rel}, *b*-tagging the relative p_T between the muon on the jet axis is used as the discriminate.

b-tagging (2)



- Perform a cut on the SV0 weight to enhance the *b*-jet content in the sample.
- Use the invariant mass of the tracks in the secondary vertex to separate light, charm and *b*-jets in a template fit.

Outline of the analysis (1)

The goal of the inclusive b-jet analysis was to measure:

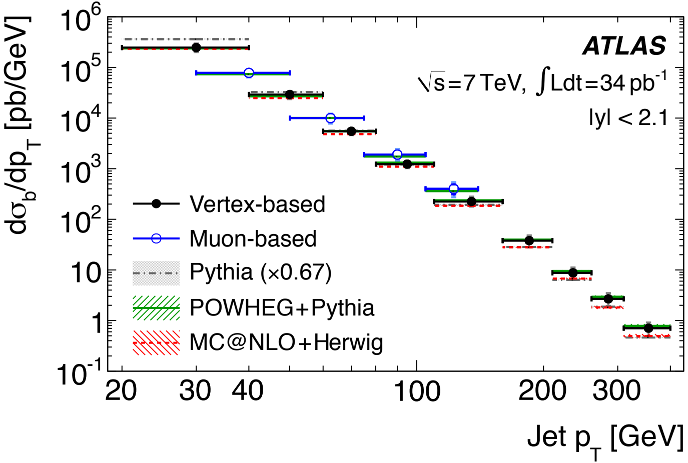
- The double differential inclusive b-jet cross section (b and $\bar{b}$) with a vertex based tagger (SV0):
- The single differential inclusive b-jet cross section (b and $\bar{b}$) with a muon based tagger (p_T^{rel}):

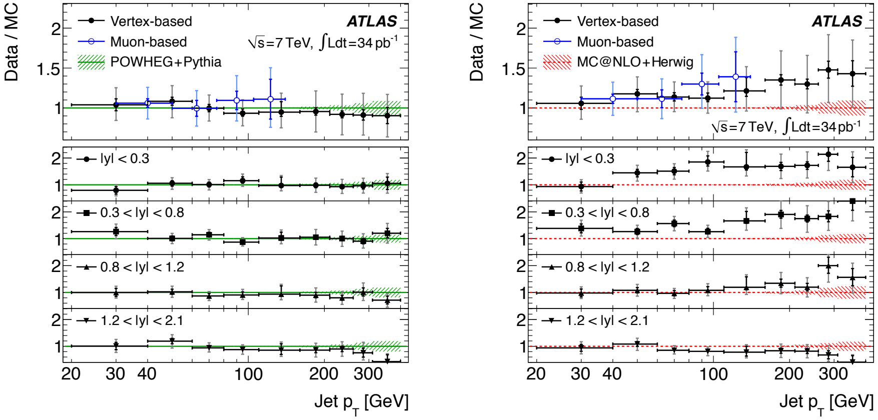
The goal of the di-jet analysis was to measure:

- The cross section with respect to $b\bar{b}$-dijet mass:
- The cross section with respect to $b\bar{b}$-dijet $d\Phi$, where $\Phi = |\Phi_1 - \Phi_2|$:
- The cross section with respect to $b\bar{b}$-dijet χ , where $\chi = exp(|y_1 - y_2|)$:

Outline of the analysis (2)

- Anti-$k_{\perp}$ jets are used with a distance parameter of 0.4.
- Jets are required to be within $|y| < 2.1$ in order for the tracks to be fully inside the acceptance of the inner detector.
- Truth b-jets are defined as a jet with a B-hadron with a $\Delta R < 0.3$ to the jet axis. If no B-hadrons are found, a c-hadron is looked for. If a c-hadron is found with $\Delta R < 0.3$, it is defined as a c-jet, if not the jet is defined as a light jet.


ATLAS
$\sqrt{s}$=7 TeV, $\int$Ldt=34 pb^{-1}
|y| < 2.1
Vertex-based
Muon-based
Pythia (×0.67)
POWHEG+Pythia
MC@NLO+Herwig
$d\sigma_b/dp_T$ [pb/GeV]
Jet p_T [GeV]
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
20
30
40
100
200
300


Data / MC
Vertex-based
Muon-based
POWHEG+Pythia
ATLAS
√s=7 TeV, ∫Ldt=34 pb-1
|y| < 0.3
0.3 < |y| < 0.8
0.8 < |y| < 1.2
1.2 < |y| < 2.1
Jet pT [GeV]
Data / MC
Vertex-based
Muon-based
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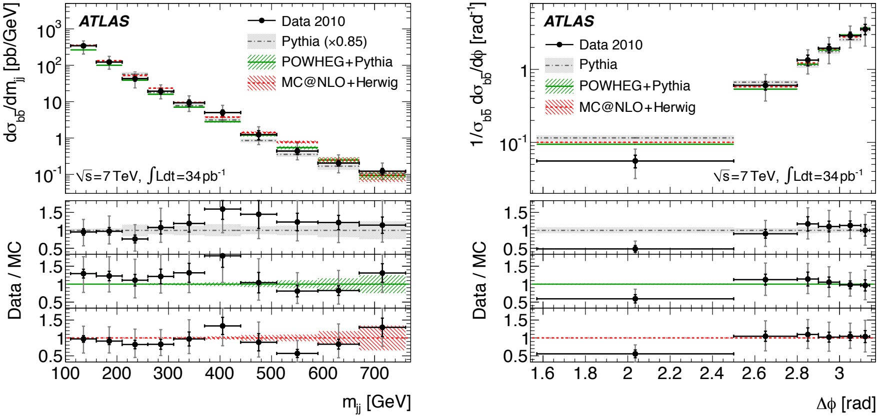
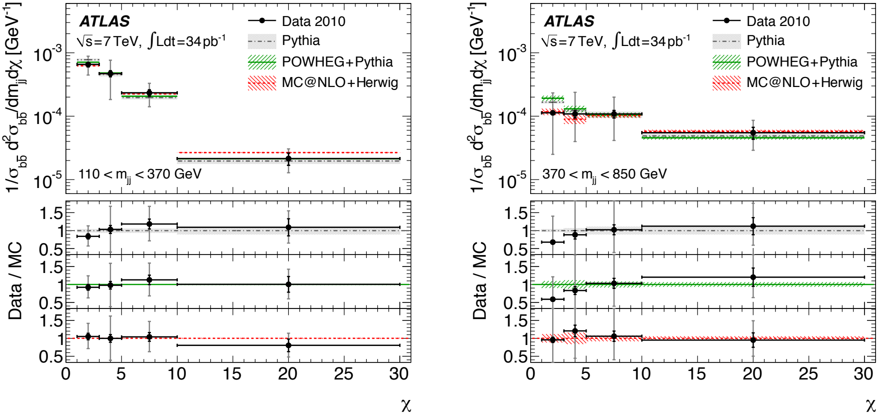
ATLAS
√s=7 TeV, ∫Ldt=34 pb-1
|y| < 0.3
0.3 < |y| < 0.8
0.8 < |y| < 1.2
1.2 < |y| < 2.1
Jet pT [GeV]

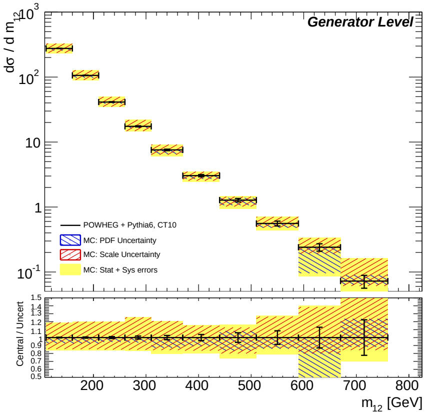

ATLAS
Data 2010
Pythia (×0.85)
POWHEG+Pythia
MC@NLO+Herwig
√s=7 TeV, ∫Ldt=34 pb⁻¹
dσ_bb̄/dm_jj [pb/GeV]
Data / MC
m_jj [GeV]
ATLAS
Data 2010
Pythia
POWHEG+Pythia
MC@NLO+Herwig
√s=7 TeV, ∫Ldt=34 pb⁻¹
1/σ_bb̄ dσ_bb̄/dφ [rad⁻¹]
Data / MC
Δφ [rad]


ATLAS
√s=7 TeV, ∫Ldt=34 pb-1
Data 2010
Pythia
POWHEG+Pythia
MC@NLO+Herwig
110 < mjj < 370 GeV
370 < mjj < 850 GeV
1/σbb̄ d2σbb̄/dmjjdχ [GeV-1]
Data / MC
χ

Motivation

- Even with the greater statistics available in 2011 data, the large systematic uncertainty related to b-tagging means there wouldn't be a worthwhile improvement on existing measurement.
- However, QCD produced $b\bar{b}$ is a large background for many important signals. Keeping this in mind, we have three reasons for another measurement:
  - Previous di-jet selection biased our sample heavily towards flavour creation in $b\bar{b}$ production.
  - Look at variables important for discovery searches.
  - Look at variables which will provide Monte Carlo authors useful information to improve their programmes.
- There is just a small team on this from UCL: Stephen Bieniek, Eric Jansen and Nikos Konstantinidis.

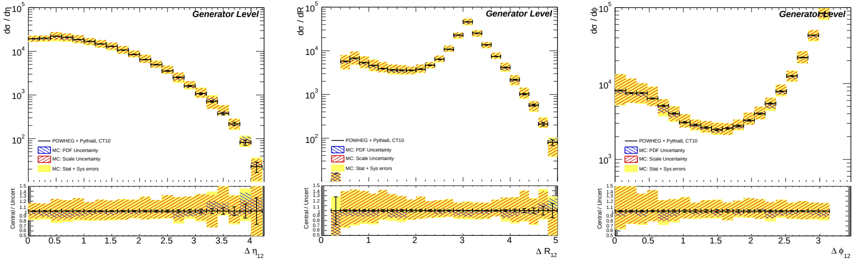
New di-b-jet selection



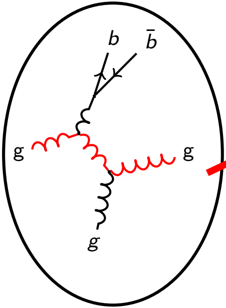
- PDF and Scale uncertainty was done by varying the input parameters and rerunning the event generation.
- Uncertainties we're derived by taking the difference between the central and varied curve.
- For PDF uncertainty, NNPDF (NNPDF20_100) and MSTW08 (MSTW2008nlo68cl) were used.
- For the scale uncertainty, the renormalisation and factorisation scales were varied by a factor of 2.

New search variables

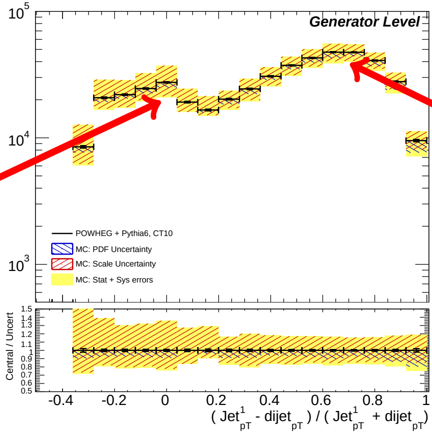
$\Delta\eta_{12}$ ΔR_{12} $\Delta\phi_{12}$

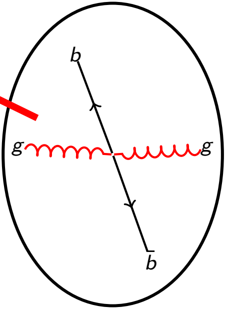


MC tuning variables



Gluon Splitting



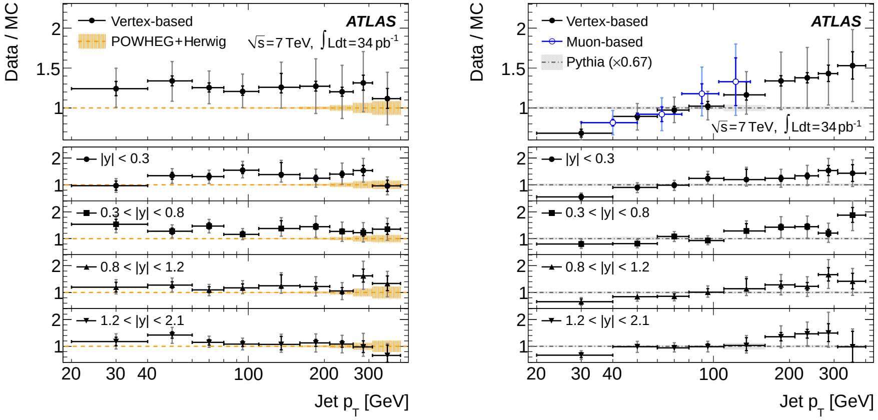


Flavour Creation

Conclusions and outlook

- 2010 analysis is finished and has the highest p_T reach.
  - CMS's most recent publications confirms our measurment up to 200 GeV.
  - Good general agreement between data and monte carlo.
  - POWHEG seems to provides a better description then MC@NLO.
  - Eur. Phys. J. C (2011) 71:1846
- The 2011 analysis is at a mature stage and should begin internal circulation soon.
- Any questions?

Backup slides


Data / MC
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POWHEG+Herwig
ATLAS
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|y| < 0.3
0.3 < |y| < 0.8
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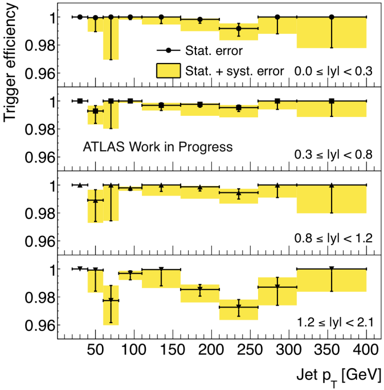
Jet pT [GeV]
Muon-based
Pythia (×0.67)

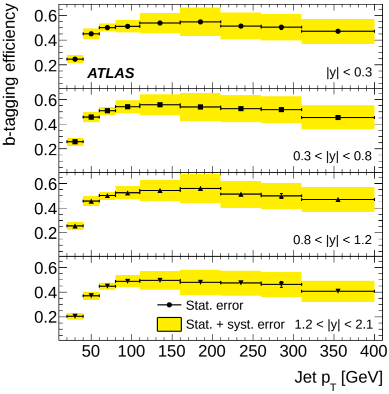
Trigger Efficiencies



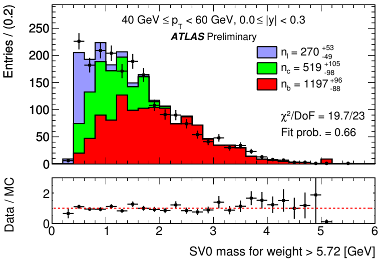
- Results shown for SV0 inclusive analysis, all bins more than 97% efficient.
- Dijet trigger inefficiency is negligible. For lowest bin event losses are 1 per 1000.

b-tagging efficiency (1)

- The *b*-tagging efficiency is based on Monte Carlo and uses the scale factor provided by the *b*-tagging working group.
- Scale factors are only provided up to 140 GeV, after this point the value of the last bin is used. Cross checks have been done to confirm data and MC agree at higher p_T.

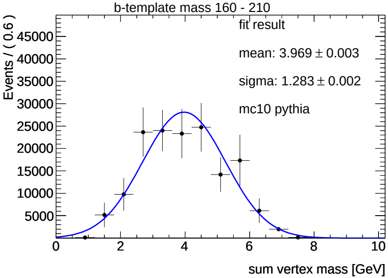


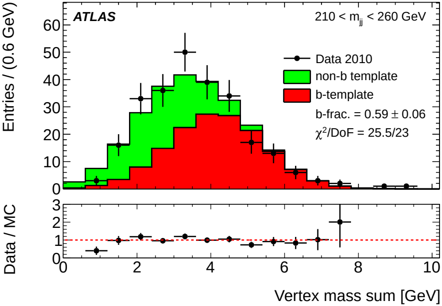
Purity fits: inclusive cross section



- Fit by minimizing a log-likelihood function which takes into account the statistical uncertainty on the data and on the MC templates.
- Perform the fit in bins of 200 MeV (incremented by 50 MeV until highest bin has at least 100 entries).
- Add discrepancies between data and MC as additional systematic uncertainties.

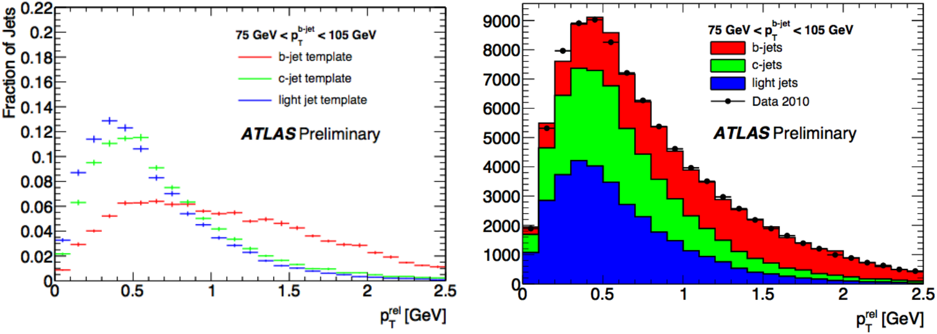
Purity fits: dijet mass





- Perform the purity fit on the sum of the SV0 mass of the two vertices.
- Because of low MC statistics, templates are fitted and a toy MC is used to generate new templates.
- Use TFractionFitter to fit two templates (*b*-jets and other jets) to the data.
- Systematic uncertainty on the templates is estimated by varying the fit parameters within the 1σ contour of the error ellipse.

Purity fits: pT Rel

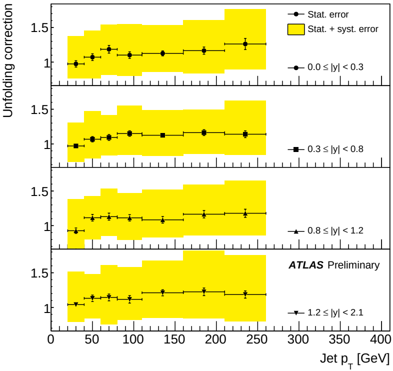


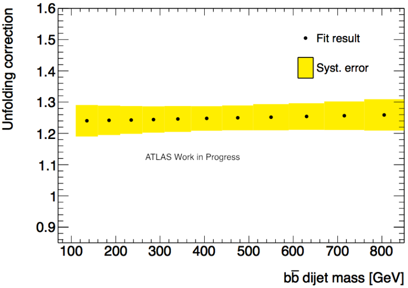
- Fit by minimizing a log-likelihood function
- b- and c-jet templates are obtained from MC. The light jet template is obtained from two data-driven methods.
  - 1) Using another b-tagging algorithm to tag light jets with muons in them. Contamination from b- and c-jets calculated in MC.
  - 2) Apply weights to tracks in jets based upon a simulation of decays-in-flight. These decays-in-flight are the dominant source of muons in light jets.

Unfolding correction (1)

- The unfolding is done with bin-by-bin correction factors using PYTHIA dijet Monte Carlo.
- The correction factors are produced by taking the ratio of reconstructed and true jets. Where true jets are particle jets containing muons and neutrinos.
- The predominant effects accounted for are:
  - Bin migration.
  - Remaining missing Energy from muons and neutrinos.

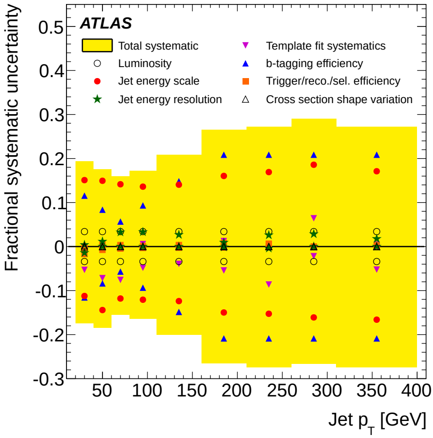
Unfolding correction (2)

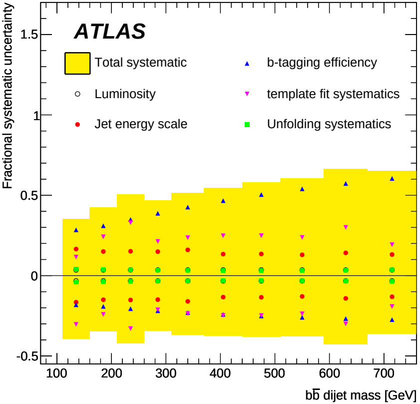




The greater than unity values for correction factors are primarily due to missing energy from muons and neutrinos.

Combined Systematics





- SV0 inclusive b-jet analysis plot with all the separate systematics
- SV0 dijet analysis with systematics grouped together, note that for dijet analysis the JES uncertainty is given as a separate systematic.