b-jet cross-section with associated vector boson production

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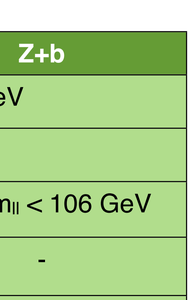
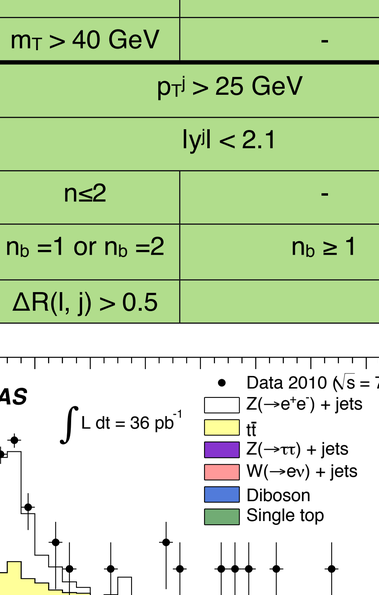


Introduction

- W/Z+b-jets is an important test of pQCD
  - Small cross-section (esp. for Z+b-jets)
  - Large backgrounds (esp. for W+b-jets)
- Important background to many searches
  - H->bb
  - Supersymmetry
- Poorly constrained theoretically
  - b-jet can be produced in either initial or final states
- Use 35 pb^{-1} of 2010 data



Feynman diagrams illustrating the main contributions to Z+b production. Production can occur with either b-quark in the initial state or with explicit final state production of a bb pair

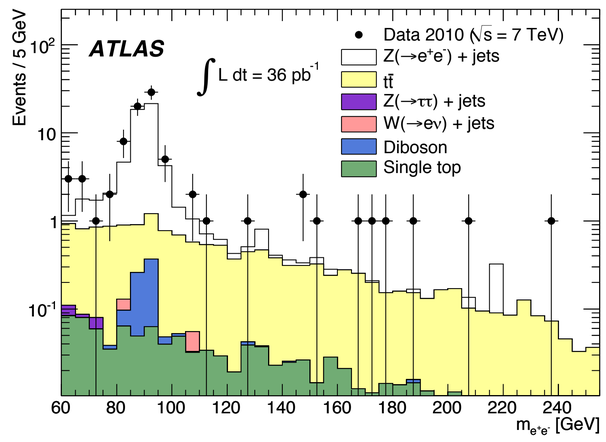
Fiducial Cross-section

- Measure fiducial cross-sections for robust theory comparison
- Statistically limited, Z+b-jets measures inclusive b-jet cross-section
- Large W+b-jet cross-section: measure differential cross-section, but add jet veto to control backgrounds

	W+b	Z+b
Lepton p_T	$p_T^l > 20$ GeV	
Lepton η	$\|\eta^l\| < 2.5$	
Dilepton mass	-	$76 < m_{ll} < 106$ GeV
Neutrino p_T	$p_T^\nu > 25$ GeV	-
W m_T	$m_T > 40$ GeV	-
Jet p_T	$p_T^j > 25$ GeV	
Jet y	$\|y^j\| < 2.1$	
Jet multiplicity	n≤2	-
b-jet multiplicity	$n_b = 1$ or $n_b = 2$	$n_b \geq 1$
Lepton-jet separation	$\Delta R(l, j) > 0.5$	

Event Selection

- Use single e,μ triggers
- Select Z events using invariant mass of two isolated leptons
- Select W events by requiring a single isolated lepton, MET and MTW
  - suppress large QCD background with tight isolation cut



Di-electron mass distribution for events with at least one jet with $p_T > 25$ GeV and $|y| < 2.1$. Signal and background contributions estimated from MC are shown. The QCD background, estimated from data, is not shown.

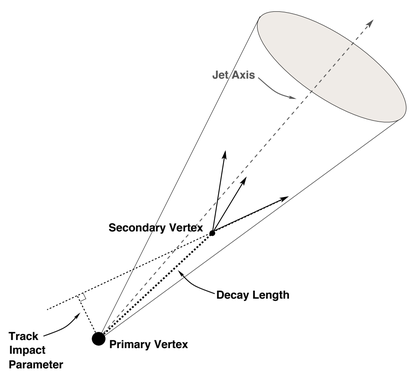
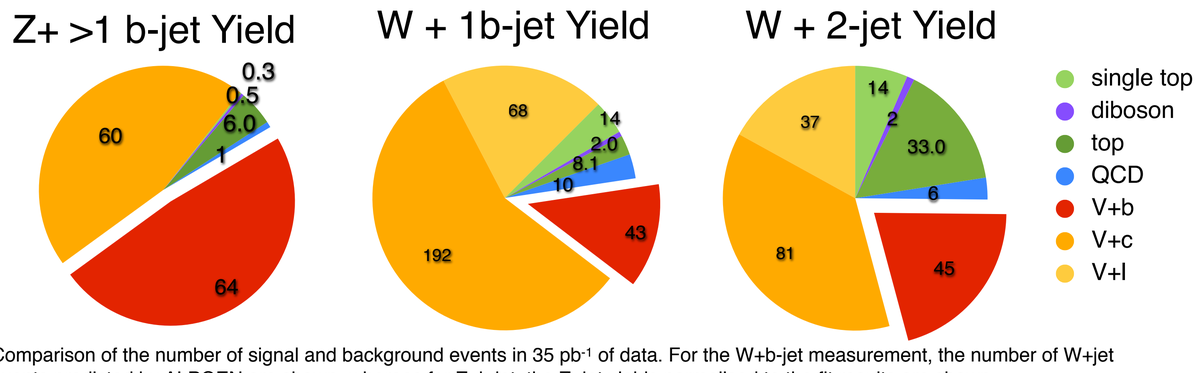


Illustration of the identification of the secondary vertex in a jet containing a b-hadron

- Identify b-jets by cutting on the decay length significance of the reconstructed secondary vertex
- Require a significance of > 5.85
  - ~50% b-jet efficiency in a ttbar sample
  - 10x c-jet rejection
  - 20x light-jet rejection
- Calibrate the efficiency using the muon p_T relative to the jet axis

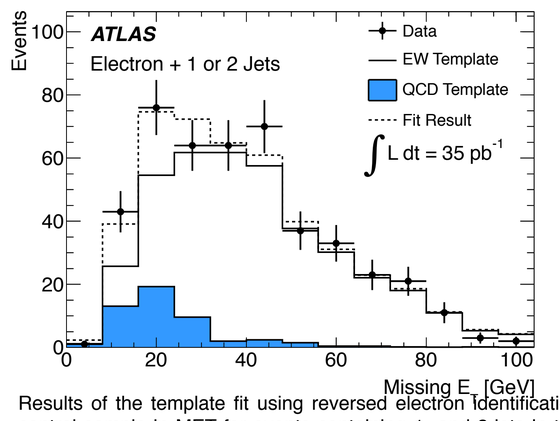
Yields and Backgrounds



Comparison of the number of signal and background events in 35 pb^{-1} of data. For the W+b-jet measurement, the number of W+jet events predicted by ALPGEN are shown, whereas for Z+b jet, the Z+jet yields normalised to the fit results are shown.

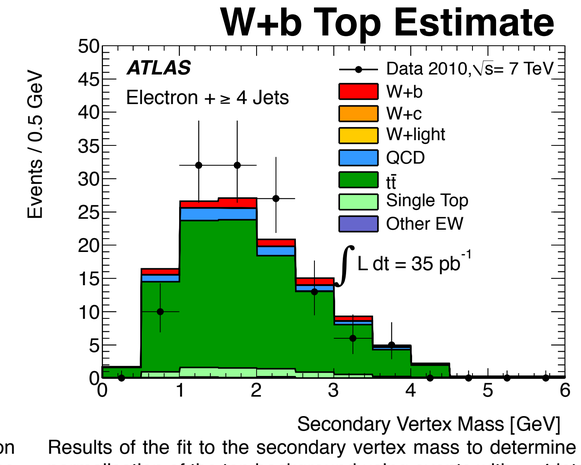
- Z+jets (high S/B):estimate backgrounds from MC, QCD from data
- W+jets has lower S/B: estimate QCD and top from data
- Top: normalise in control region with >4 jets; extrapolate to signal region with MC, decreases uncertainty from b-tagging efficiency
- QCD: estimate by fitting MET distribution uses templates obtained by reversing certain electron ID cuts (7% uncertainty on cross-section)

W+b QCD Estimate



Results of the template fit using reversed electron identification control sample in MET for events containing 1- and 2-jets in the electron channel of the W+b-jet cross-section measurement. The dashed line shows the result of the fit

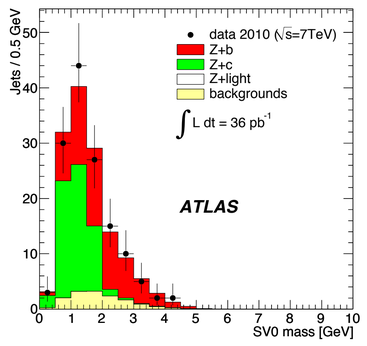
W+b Top Estimate



Results of the fit to the secondary vertex mass to determine the normalisation of the top background using events with >- 4 jets. The result is extrapolated to events with 1- or 2-jets using Monte Carlo simulation.

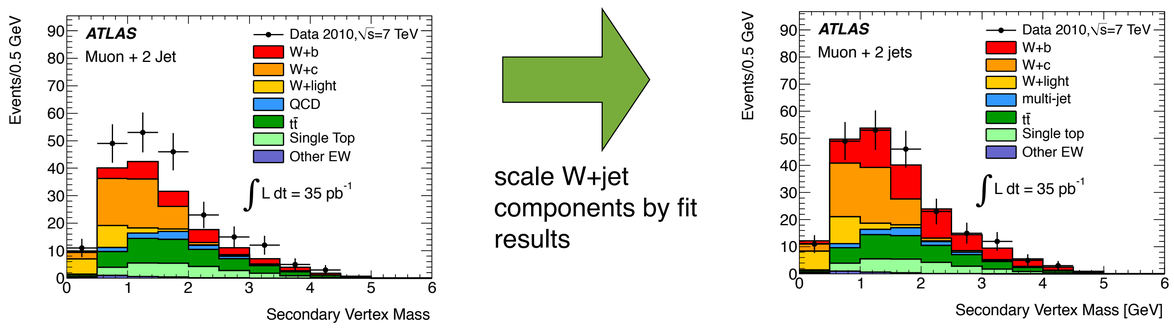
Fitting to extract the b-fraction

- Fit the mass distribution of the secondary vertex to determine fraction of W+b/c/l jets
- Estimate template shapes from MC
- Estimate systematic uncertainties on shapes by comparing data and MC in control regions



Secondary vertex mass distribution for b-tagged jets in the selected Z+b events. The Z+b, c and light jet contributions are normalised to the fit results. The total contribution from other backgrounds is also shown.

Comparison of the secondary vertex mass distribution in the W+b-jet muon+2 jet channel before and after normalisation by the fit reults



Results and Uncertainties

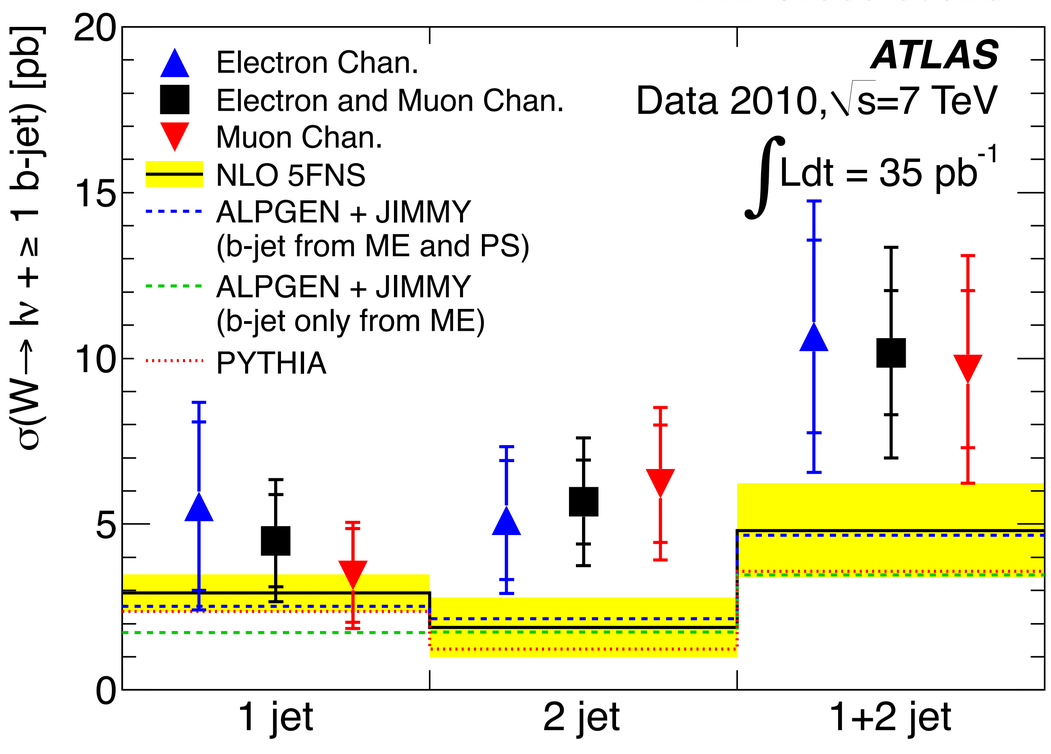
- Use Alpgen to unfold measured yields to fiducial cross-sections
- Largest contributions to the systematic uncertainty include
  - b-tagging efficiency:10% (12%) for Z+b (W+b)
  - model dependence (~10%) due to uncertainties MC modelling of b-jet p_T spectrum and dR between pairs b-quarks

Z+b Cross-section

	Value
Sherpa	3.29 ± 0.04 (stat) pb
ALPGEN	2.23 ± 0.01 (stat) pb
MCFM	3.88 ± 0.58 (stat) pb
ATLAS	$3.55^{+0.82}_{-0.74}$ (stat) $^{+0.73}_{-0.55}$ (syst) ± 0.12 (lumi) pb

Comparison of theoretical predictions for the average number of b-jets produced in association with a Z boson to the measured ATLAS result.

W+b Cross-section



Comparison of theoretical predictions for the W+b-jet cross-section to the measured ATLAS result. Results are shown separately for the electron and muon channels and for each jet multiplicity as well as for the combinations . Both statistical (inner band) and systematic (outer band) uncertainties are indicated. The yellow band indicates the total uncertainty on the NLO calculation obtained by combining the renormalisation and factorisation scale uncertainties with those on the PDFs and non-perturbative corrections.

Conclusion

- First measurements from ATLAS of the W/Z cross-section with associated b-jet production
  - Total combined statistical and systematic uncertainties are 20-30%
- Z+b-jet cross-section is consistent with theoretical expectations
- W+b-jet cross-section is measured to be slightly in excess of predictions

References and Further Reading

1. The ATLAS Collaboration, **Measurement of the cross section for the production of a W boson in association with b-jets in pp collisions at sqrt(s) = 7 TeV with the ATLAS detector,** arXiv: 1109.1470, Sept 2011, Submitted to PLB.
2. The ATLAS Collaboration, **Measurement of the cross-section for b-jets produced in association with a Z boson at sqrt(s)=7 TeV with the ATLAS detector**, arXiv:1109.1403, Sept 2011, Submitted to PLB.