Measurements of Vector Boson with Associated Jet production and Ratios with ATLAS

Rhys Owen[1,2] on behalf of the ATLAS Collaboration
University of Birmingham[1], Rutherford Appleton Laboratory[2]
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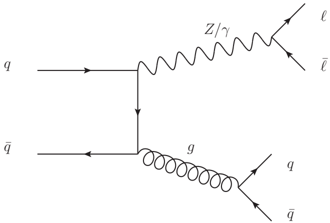
Science & Technology Facilities Council
Rutherford Appleton Laboratory

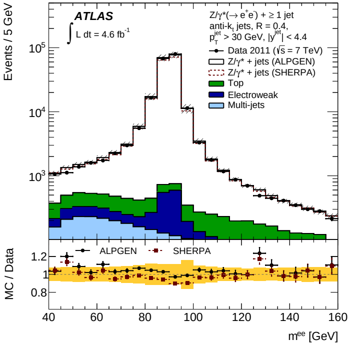
Outline

Introduction

- Vector boson + jet production is an important benchmark in hadron collider.
- The boson decay is a well understood tag
- Other event variables can then be used to test pQCD
- Practically this can provide feedback on various MC generators and tunes to be used in other analyses



General Analysis Strategy



	$Z(\rightarrow ee)$	$Z(\rightarrow \mu\mu)$
lepton p_T lepton $\|\eta\|$	$p_T > 20$ GeV $\|\eta\| < 1.37$ or $1.52 < \|\eta\| < 2.47$	$p_T > 20$ GeV $\|\eta\| < 2.4$
lepton charges lepton separation $\Delta R^{\ell\ell}$ lepton invariant mass $m^{\ell\ell}$	opposite charge $\Delta R^{\ell\ell} > 0.2$ 66 GeV $\leq m^{\ell\ell} \leq$ 116 GeV	
jet p_T jet rapidity y^{jet} lepton-jet separation $\Delta R^{\ell j}$	$p_T^{jet} > 30$ GeV $\|y^{jet}\| < 4.4$ $\Delta R^{\ell j} > 0.5$	

- W: $E_T^{miss} > 25\,GeV$, $m_T > 40\,GeV$
- Similar for all analysis (differences noted)

JHEP07(2013)032

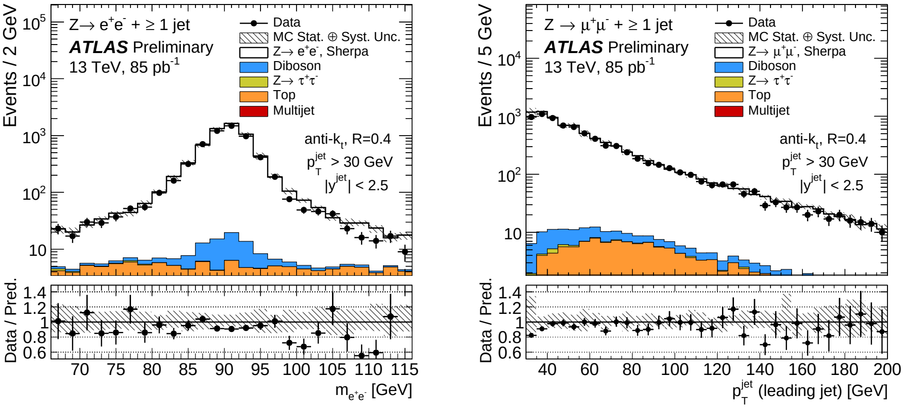
Particle Level and Monte Carlo

- Detector results are unfolded to particle level.
- Particle level results can then be compared with several MC generators and theory predictions.

- LO ME $<$ 4 Jets + PS
  - ALPGEN v2.13 + HERWIG v6.520
  - SHERPA v1.4.1
  - Madgraph5_aMC@NLO+Pythia8 CKKW-L A/B†
- NLO ME + PS
  - MC@NLO v4.01 + HERWIG. (+1 Jet)
  - Madgraph5_aMC@NLO with FxFx Merging (+2 Jets)†
  - Sherpa 2.X (NLO 0,1,2 Jets + LO 3,4 Jets)†
- Fixed order NLO Calculation
  - BLACKHAT + SHERPA
- Approx. NNLO
  - LoopSim ($W \geq$ 1Jets)
- Higher orders
  - HEJ ($W \geq$ 2Jets)

†New in Run 2!

Z + Jets @ 13 TeV



- First ATLAS analysis of V+Jets using 85pb^{-1} of data at 13TeV
- Fiducial selection following the Inclusive 13TeV analysis (lepton $p_T > 25$GeV)

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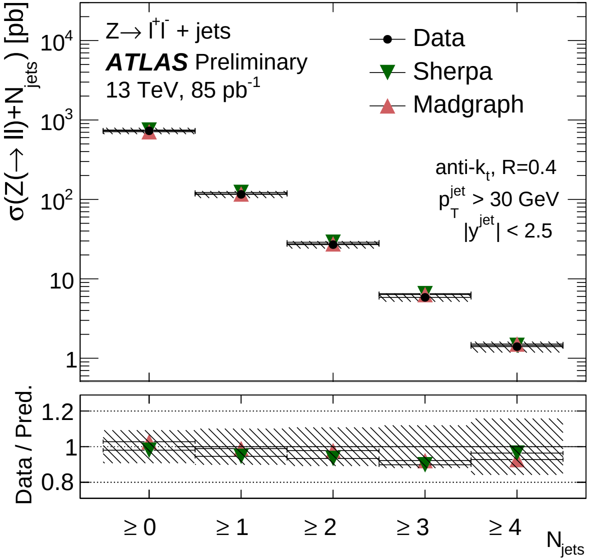
Z + Jets @ 13 TeV



- Using
  - SHERPA v2.1.1
  - MadGraph5 + aMC@NLO v2.2.2
- Systematic uncertainties 10% – 20% for ≥ 1 to ≥ 4 Jets
- Already good agreement between MC and Data @ 13TeV

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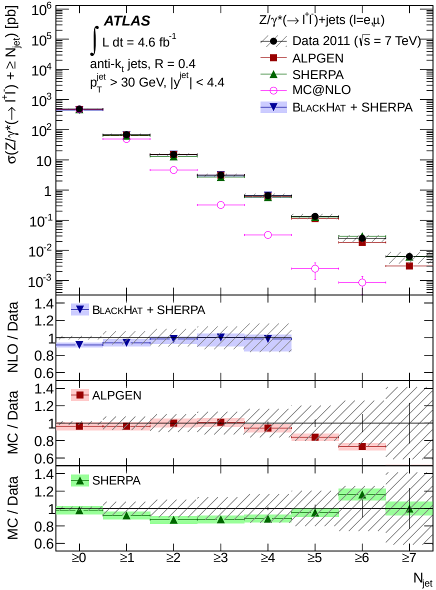
Z + Jets @ 7TeV



- Results here unfolded to particle level.
- Using 4.6fb^{-1} of 7 TeV data
- Systematic uncertainties 7% – 17% for ≥ 1 to ≥ 4 Jets

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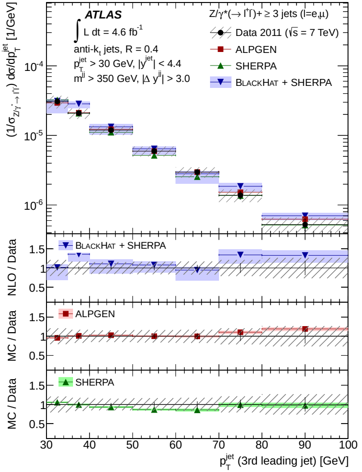
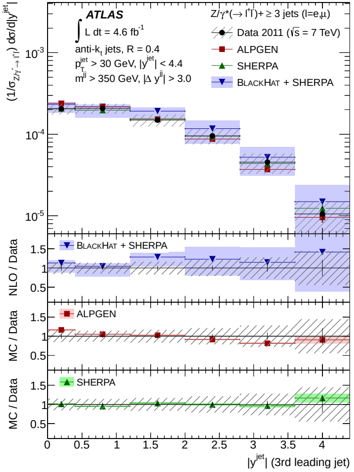
Z + Jets @ 7TeV





- 3rd jet is important for rejecting backgrounds in Vector Boson Fusion (VBF) Higgs selection.

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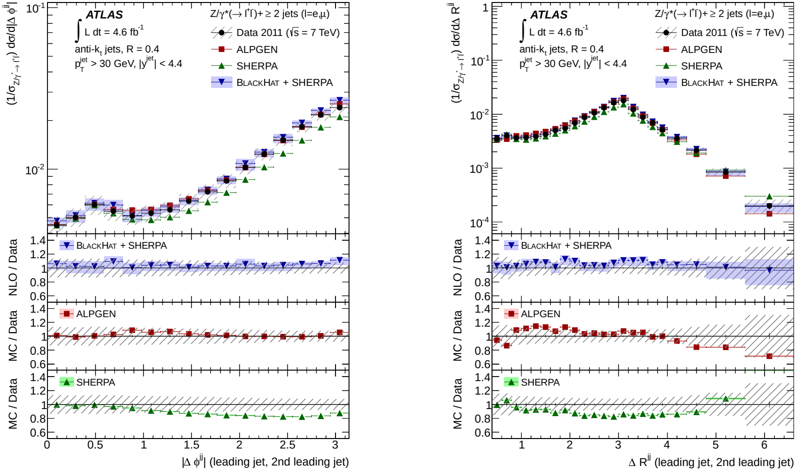
Z + Jets @ 7TeV



- SHERPA 1.4.1 starts to show greater deviations here

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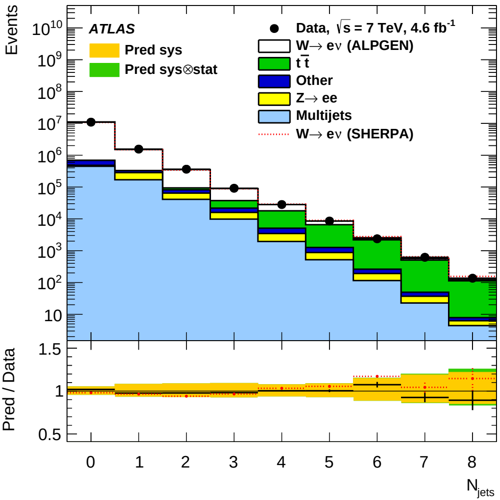
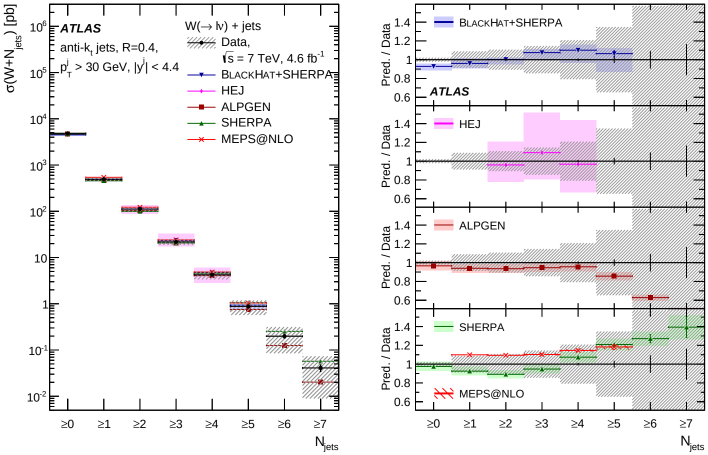
W + Jets @ 7TeV



- Challenging analysis
- Much larger background than $Z + Jets$
  - QCD Multijet
  - $t\bar{t}$
- Systematic uncertainties $8\% - 25\%$ for ≥ 1 to ≥ 4 Jets
  - Driven by backgrounds especially at high multiplicities

Eur. Phys. J. C(2015)75:82

W + Jets @ 7TeV



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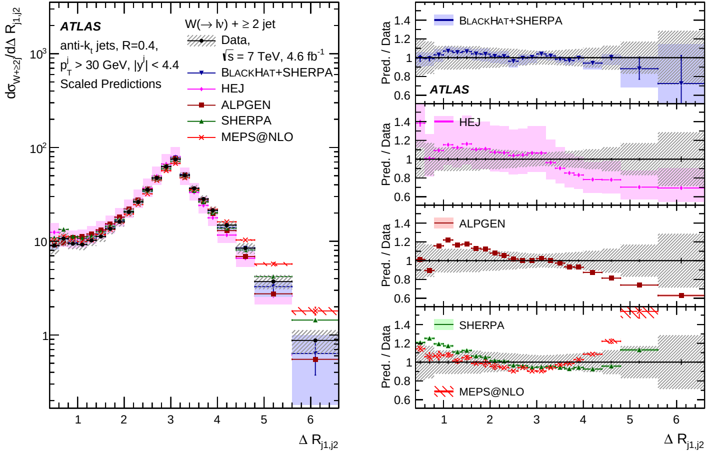
W + Jets @ 7TeV



- Again angular distributions show larger differences between predictions.

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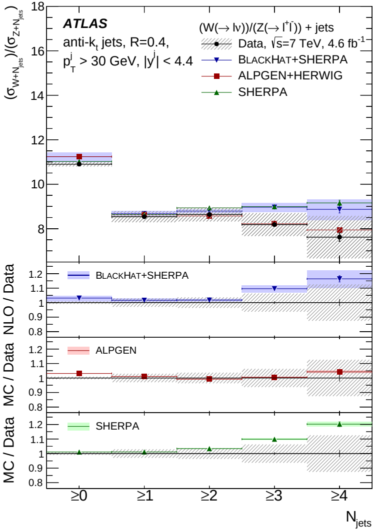
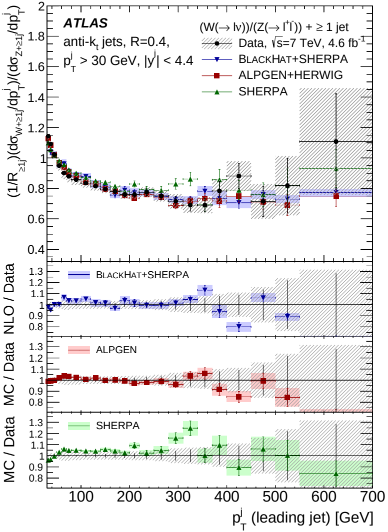
Ratio R_{Jets} W/Z@ 7TeV

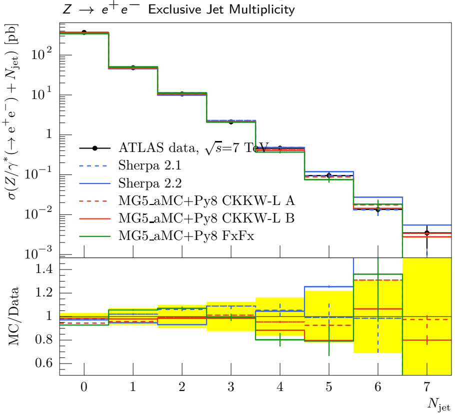




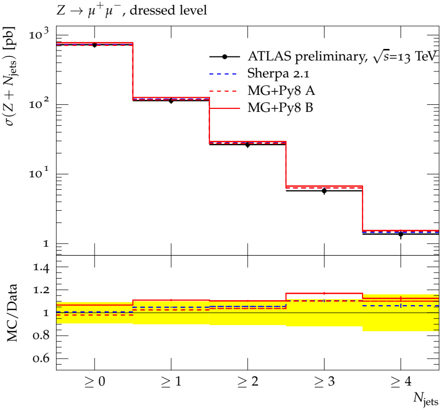
- Systematic uncertainties $1.2\% - 18\%$ for ≥ 1 to ≥ 4 Jets

Eur. Phys. J. C(2014)74:3168

Data vs MC Comparison for Run 2



7 TeV



13 TeV

- Unfolded results can also be used to investigate the performance of future generator developments.
- This information is invaluable for several other analysis for Run 2

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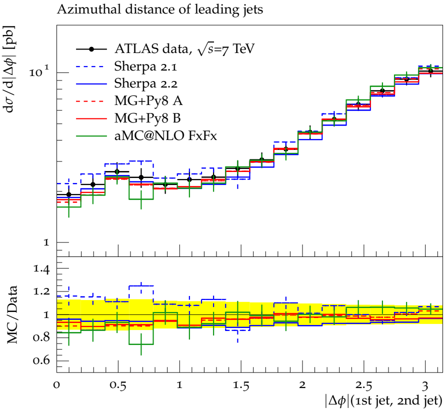
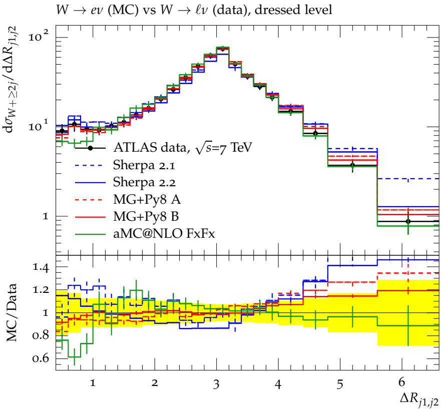
Data vs MC Comparison for Run 2



7 TeV Z + Jets



7 TeV W + Jets

- SHERPA 2.X shows improvement in these plots compared to the 1.X version.

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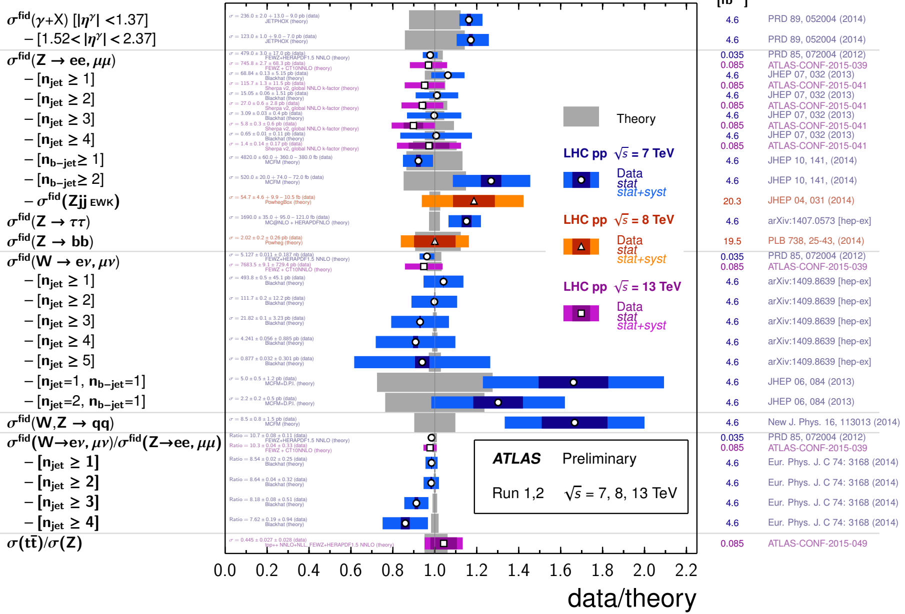
Vector Boson + X Cross Section Measurements

Status: Nov 2015



Conclusions

- Vector boson + Jet production measurements are a powerful tool.
- Provide unique tests on QCD
- Measurements also test Monte Carlo to be used in other analyses.
- Continues to be an important area for study at higher centre of mass energies in Run 2 building on the work which has already been done.