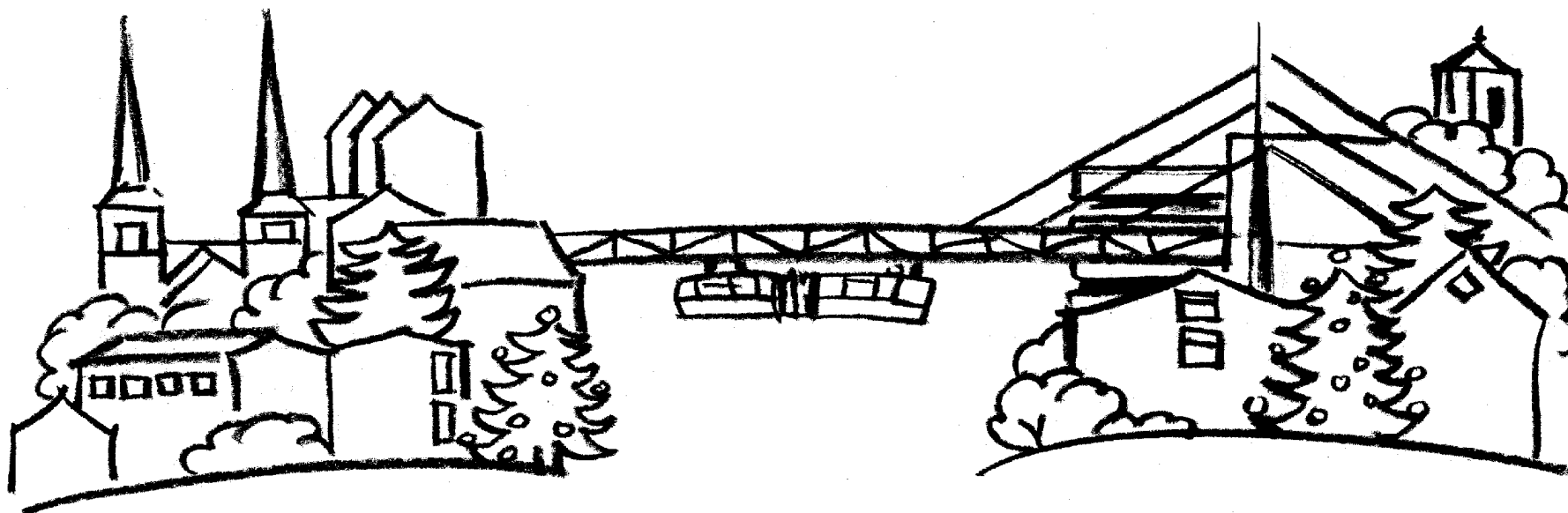




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Measurements of the production of jets in association with a W or Z boson with the ATLAS detector



Marisa Sandhoff
Bergische Universität Wuppertal
on behalf of the ATLAS Collaboration

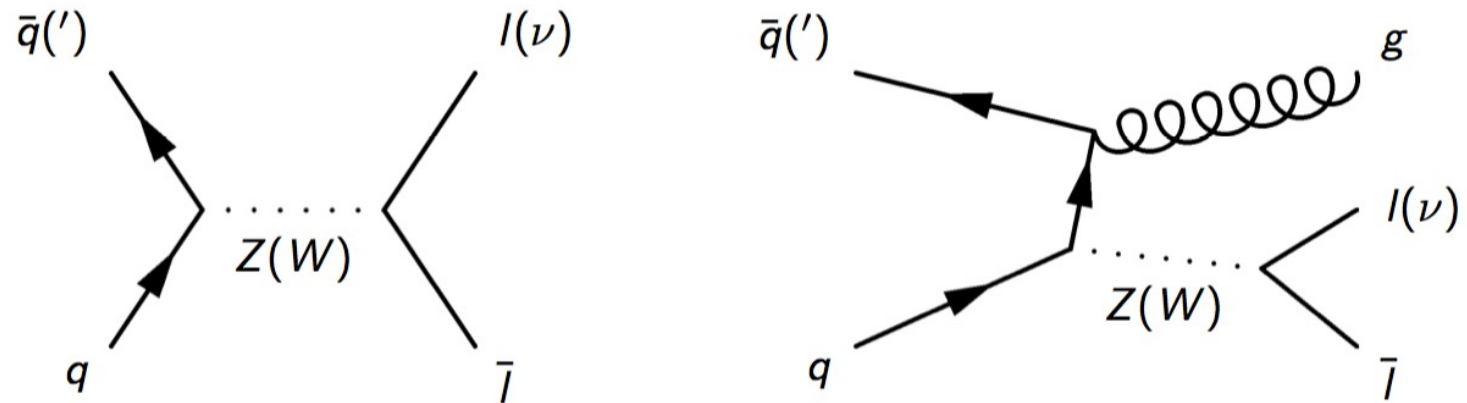


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- ◆ **Papers covered:**
 - ◆ **W+jets @ 7 TeV**
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Why study W+Jets, Z+Jets and their ratio?

- ◆ Production of W and Z bosons important standard candle at hadron colliders
- ◆ Clear experimental signature due to boson decay into 1 or 2 isolated charged leptons



- Study QCD effects in complex high multiplicity final states
- ◆ Important background processes for Higgs boson studies, top quark physics, searches for new phenomena etc.

W+jets and Rjets @ 7 TeV

- ◆ Entire 2011 dataset, integrated luminosity of **4.6fb⁻¹**
(1.8% uncertainty on luminosity (Eur. Phys. J. C 73 (2013) 2518))

- ◆ **W+Jets selection:**

- ◆ one lepton (e or μ)
 - ◆ $p_T > 25$ GeV,
 $|\eta| < 2.4$ for e (2.47 for μ)
- ◆ $E_T^{\text{miss}} > 25$ GeV
- ◆ $M_T > 40$ GeV

- ◆ **Jet selection**

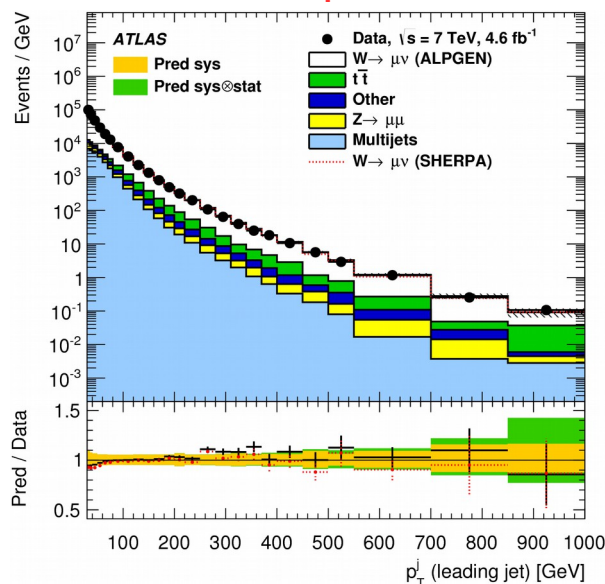
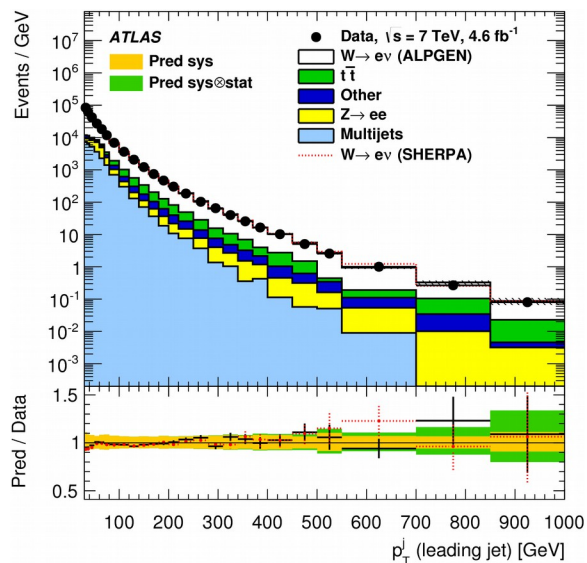
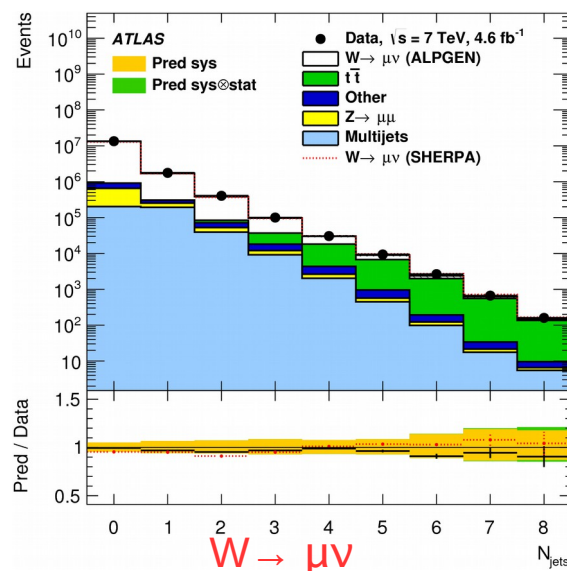
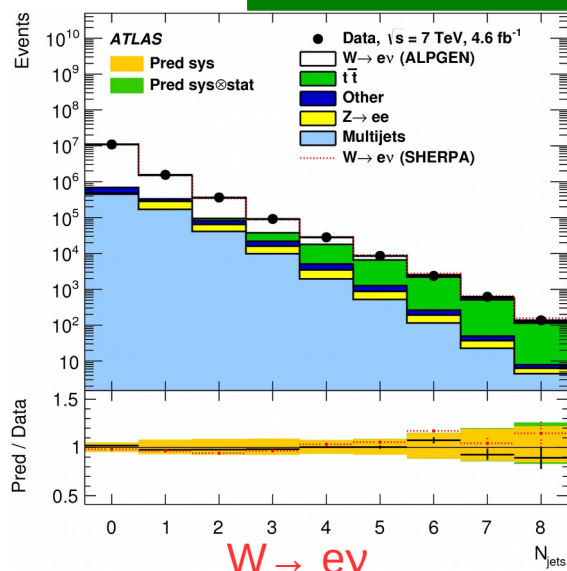
- ◆ Anti-kt, R=0.4
- ◆ $p_T > 30$ GeV, $|y| < 4.4$
- ◆ Overlap removal $\Delta R(l,\text{jet}) < 0.5$

- ◆ **Z+Jets selection:**

- ◆ two leptons (e, μ) with opposite charge
 - ◆ $p_T > 25$ GeV,
 $|\eta| < 2.4$ for e, (2.47 for μ)
- ◆ $66 \text{ GeV} < m_{\parallel} < 116 \text{ GeV}$
- ◆ $\Delta R_{\parallel} > 0.2$

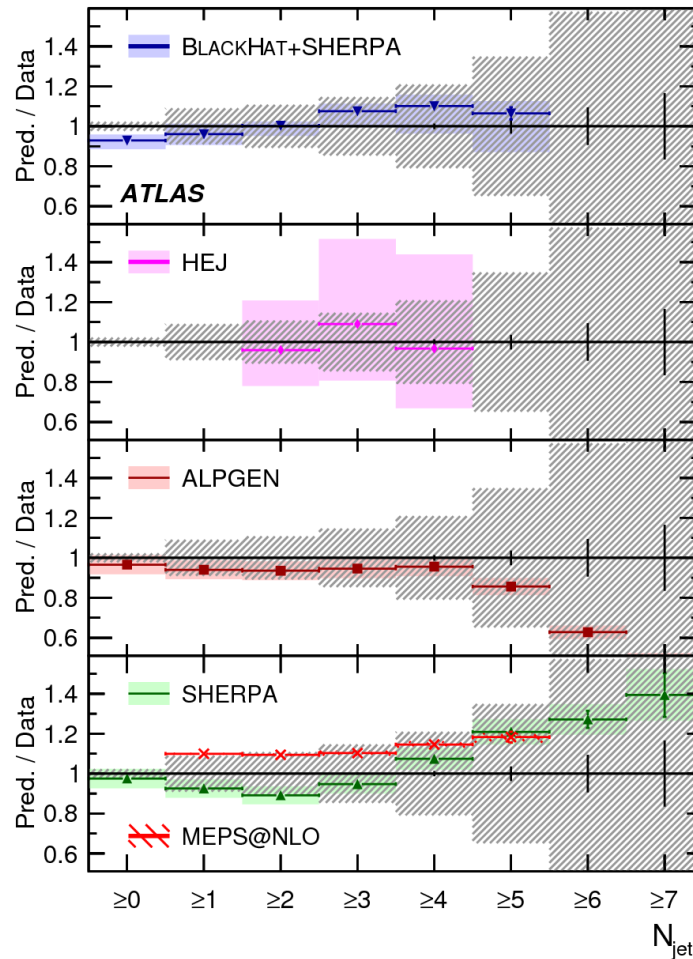
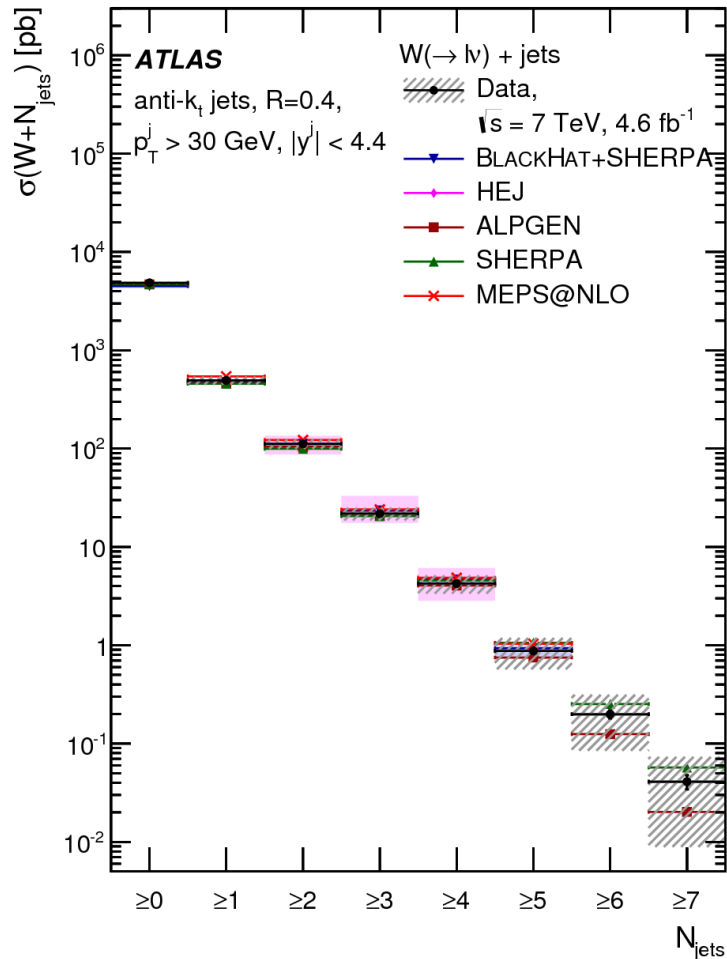
W+jets @ 7 TeV

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



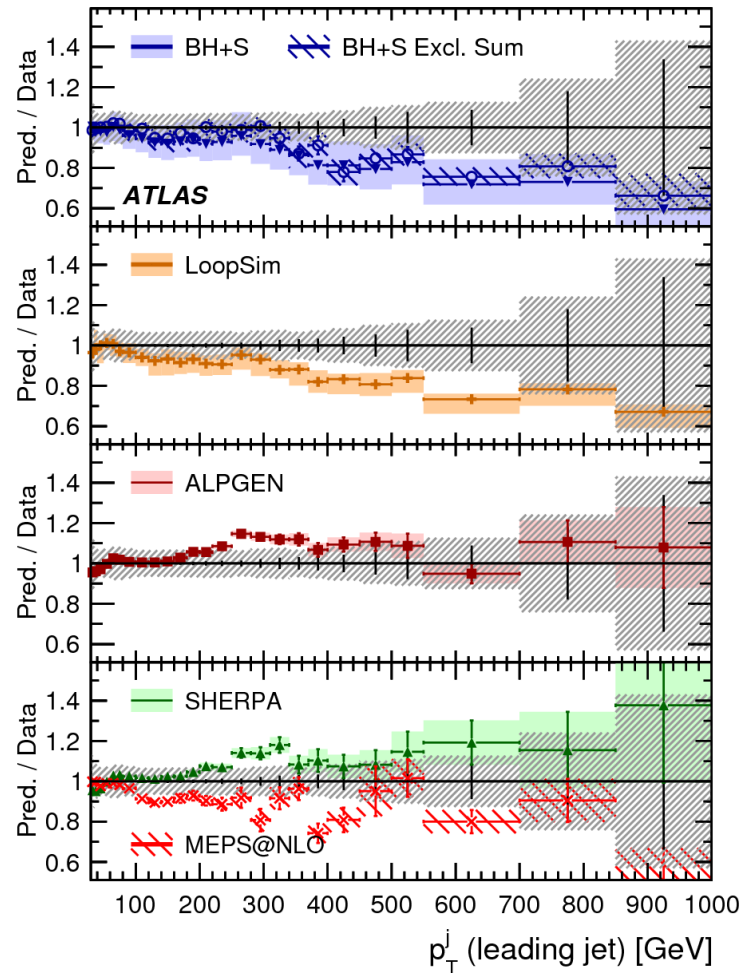
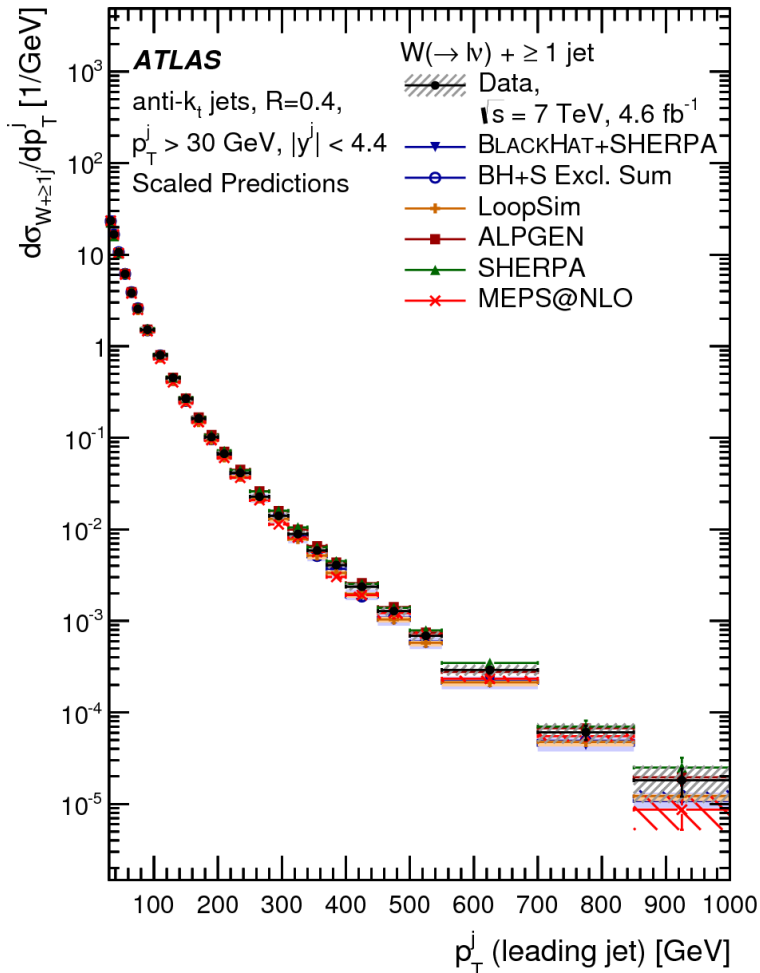
- ◆ Check pQCD and electroweak effects
 - ◆ Jets with p_T up to 1 TeV
 - ◆ Up to 7 jets
 - ◆ Five orders of magnitude as a function of jet multiplicity
 - ◆ Six orders of magnitude as function of jet p_T
- ◆ $t\bar{t}$ and multijet bkg are estimated data driven, all others based on MC simulations
 - ◆ Signal MC: Alpgen+Herwig and Sherpa 1.4
- ◆ Used iterative Bayesian unfolding
- ◆ Compare to theoretical predictions at particle level

W+jets @ 7TeV: N_{Jets}



- ◆ Good agreement for all jet multiplicities for BLACKHAT+SHERPA
- ◆ Different trends for more than 4 jets for ALPGEN and SHERPA, but good agreement within exp. errors

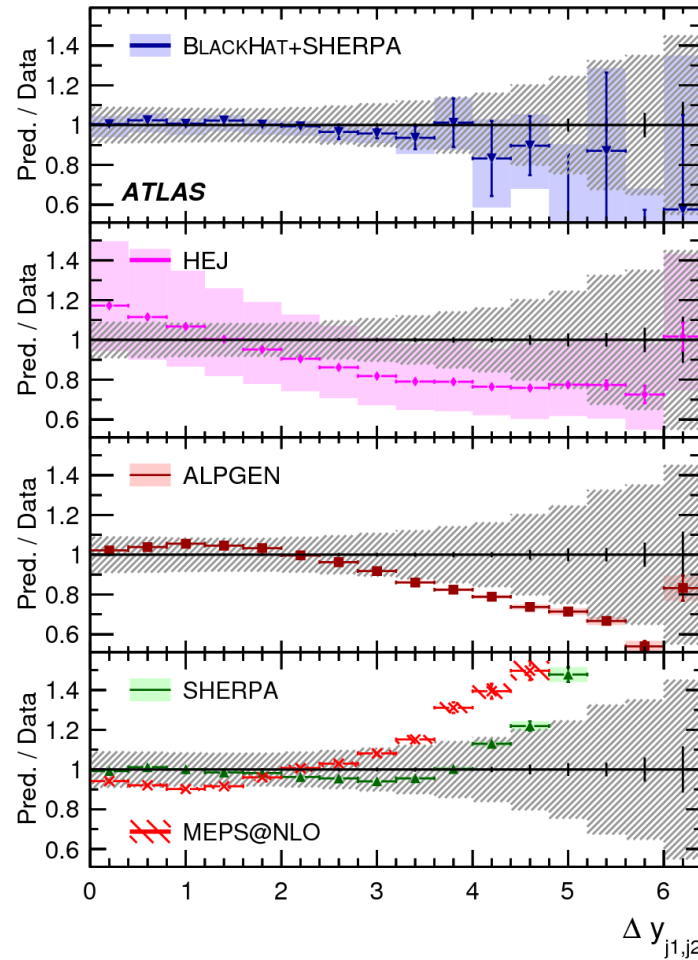
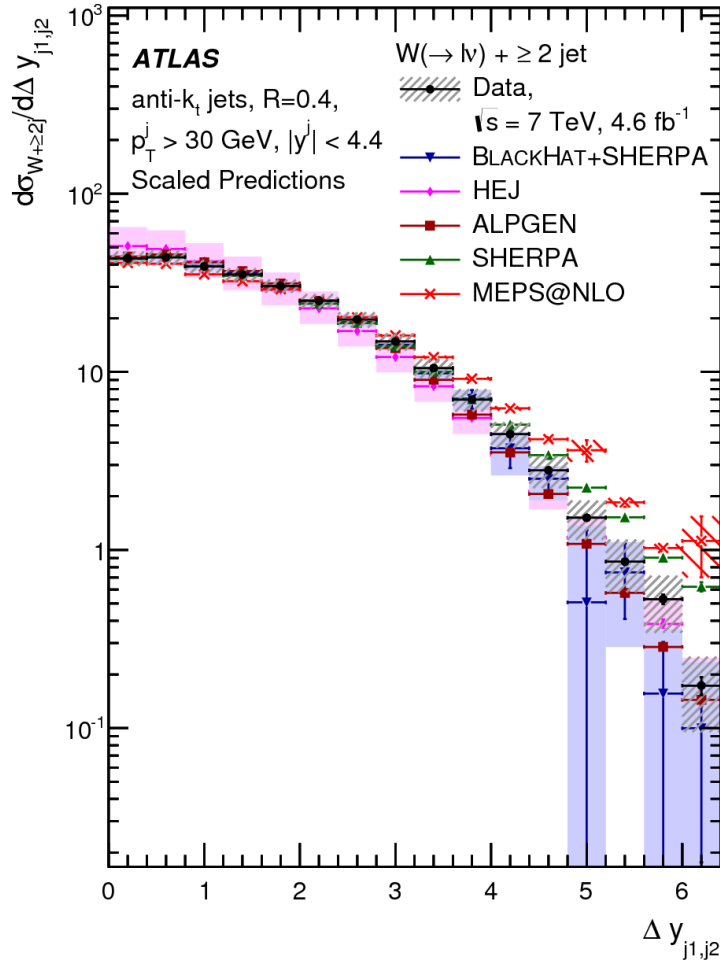
W+jets @ 7 TeV: p_T (leading jet)



- ◆ BLACKHAT +SHERPA and LoopSim underestimate data at high p_T
- ◆ Fair agreement for SHERPA and ALPGEN

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

W+jets @ 7 TeV: $\Delta y_{j1,j2}$



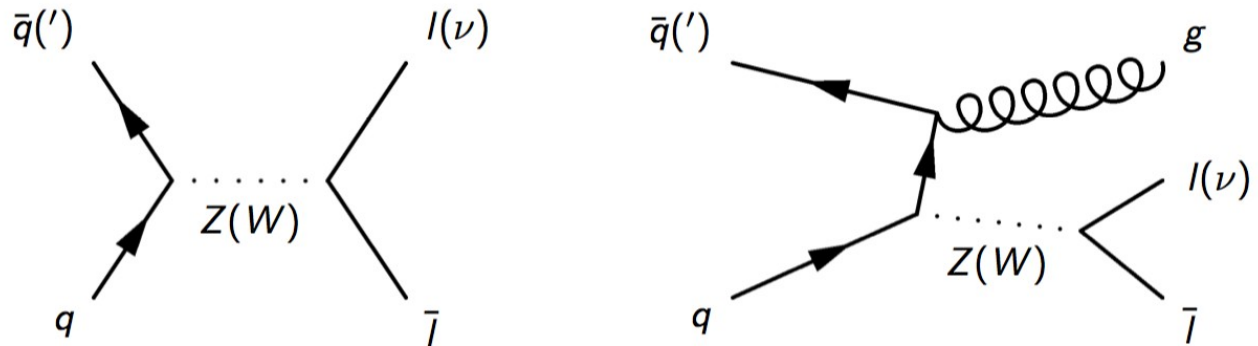
- ◆ Important for Higgs searches
- ◆ BLACKHAT+SHERPA, ALPGEN and HEJ underestimate large separations
- ◆ SHERPA overestimates these regions
- ◆ Best agreement for BLACKHAT+SHERPA and SHERPA

$\Delta y_{j1,j2}$: rapidity between jet 1 and jet 2

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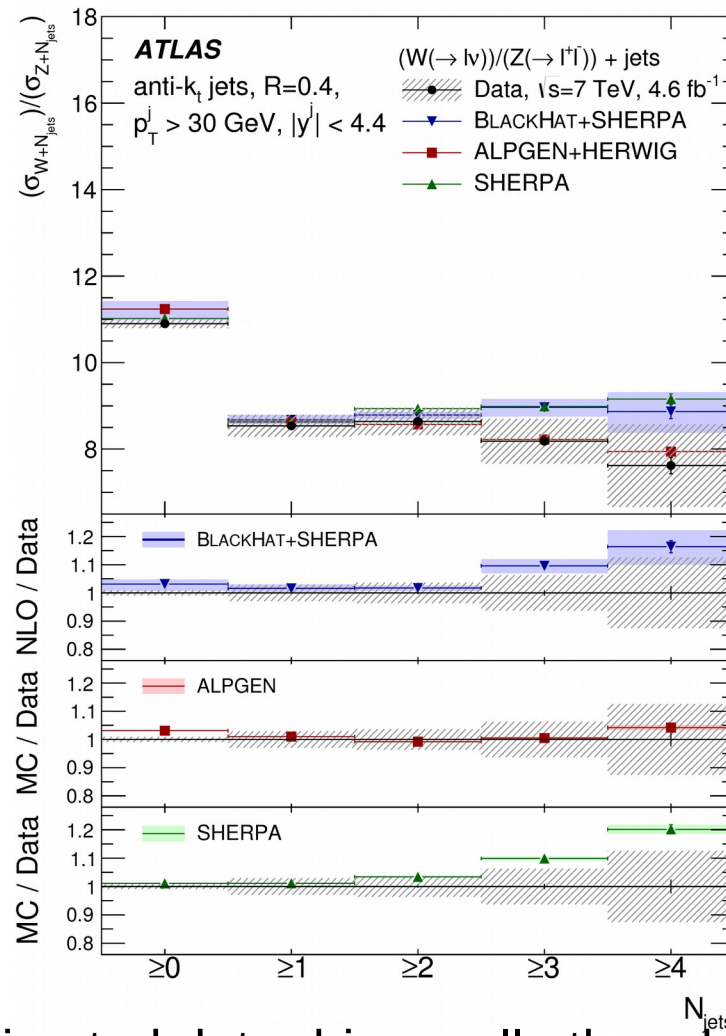
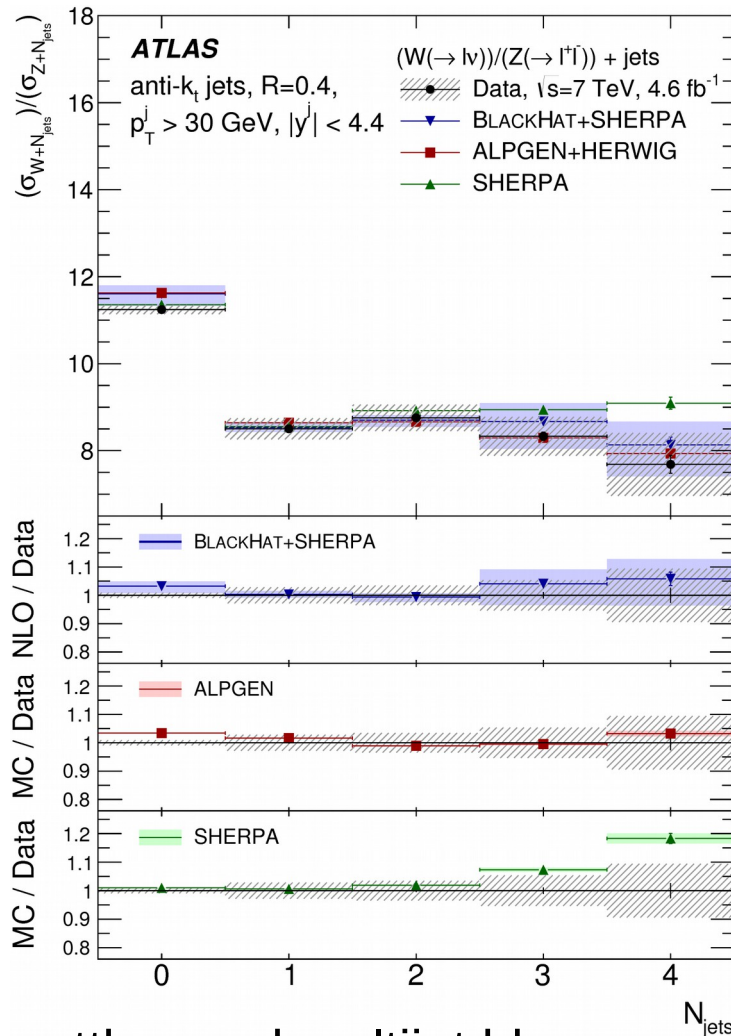
Ratio W+jets/Z+jets @ 7 TeV

- ◆ W+jets and Z+jets events are very similar!
- ◆ Most Feynman diagrams account for both W and Z production



- ◆ Small differences:
 - ◆ $m_w < m_z$, coupling, parton content, PDFs etc.
 - ◆ But **identical jet production**
- ◆ Calculating the ratio
 - ◆ Reduces many systematic errors (jet energy scale, hadronization etc.)
→ more precise test of perturbative QCD
 - ◆ Directly probes **differences** in kinematic distributions **between W and Z**

Ratio W+jets/Z+jets @ 7 TeV



Flat ratio W/Z for ≥ 1 additional jets

Theoretical predictions describe data well

SHERPA overestimates data at high jet multiplicities

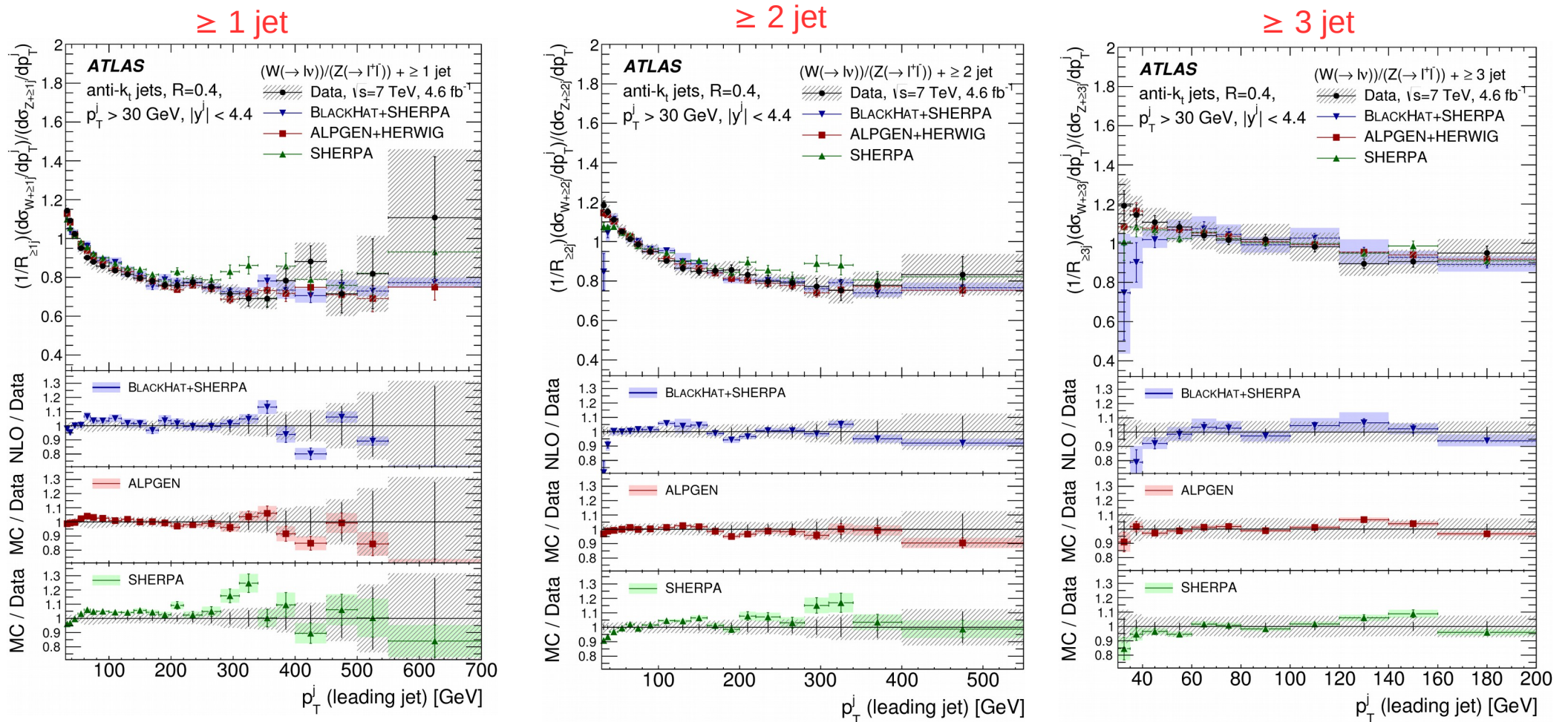
BLACKHAT+SHERPA better at excl. jet multiplicities

Good agreement for ALPGEN

- ◆ ttbar and multijet bkg are estimated data driven, all others based on MC
- ◆ Used iterative Bayesian unfolding to compare data to theoretical predictions

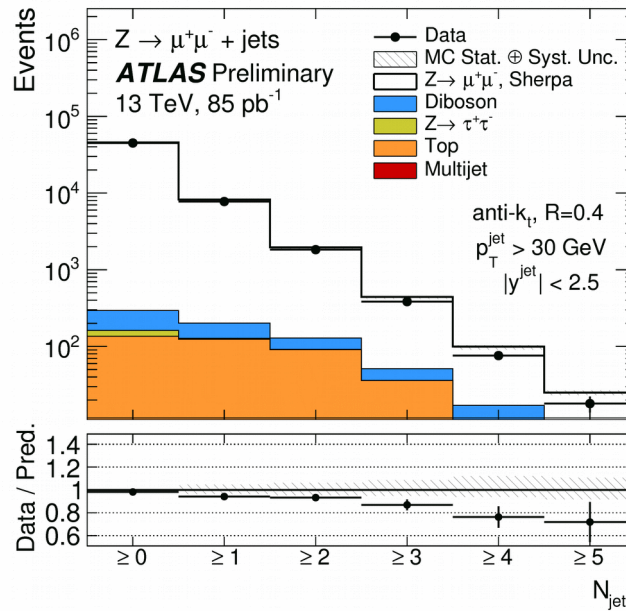
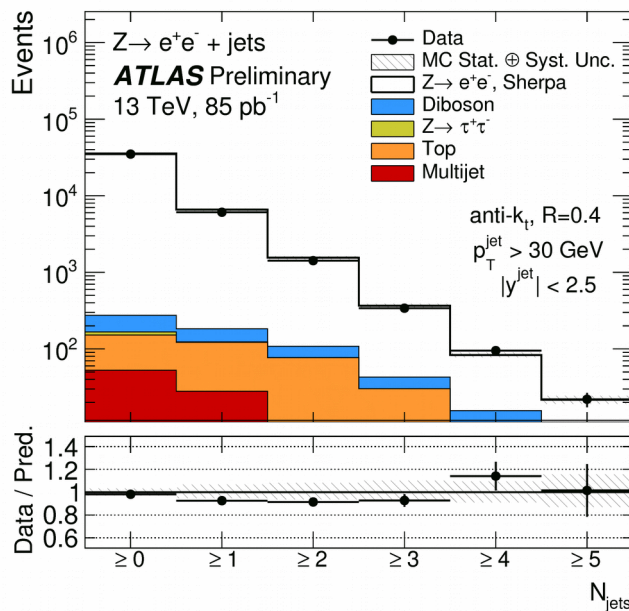
Ratio W+jets/Z+jets @ 7 TeV

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

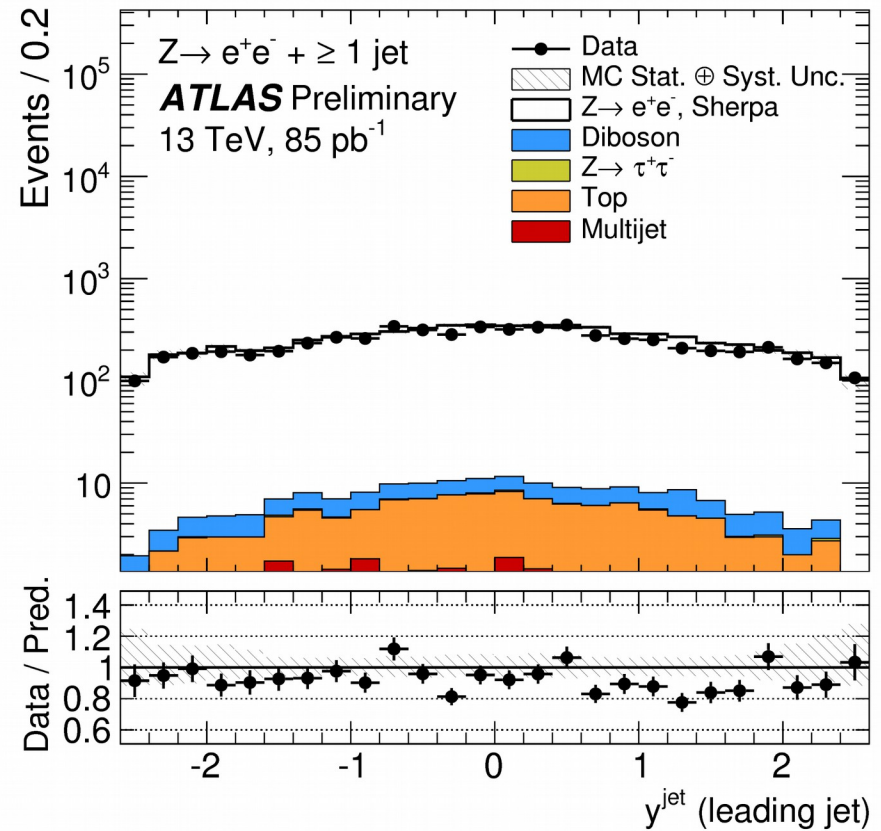
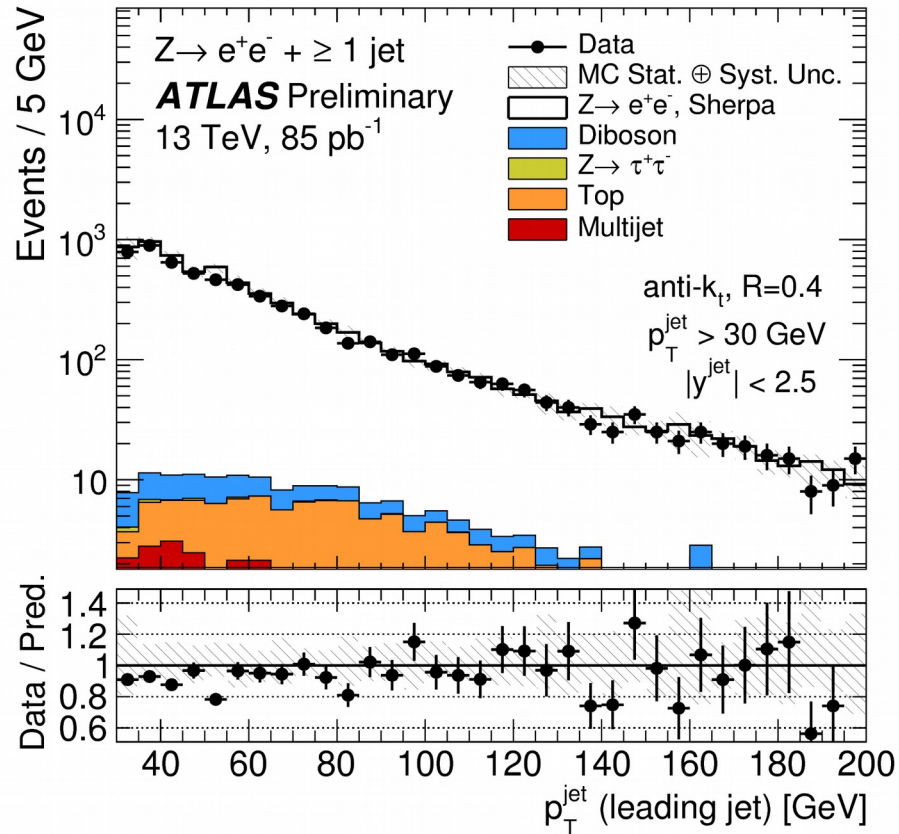


- ◆ $p_T^{\text{jet}}(\text{W+jets}) < p_T^{\text{jet}}(\text{Z+jets})$ because $m_W < m_Z$, more similar for more jets in event
- ◆ For small p_T all predicted shapes show different trends, best agreement for ALPGEN

- ◆ Data collected from June 13 to July 16 2015
 - ◆ 85 pb⁻¹ integrated luminosity
- ◆ Z decay into e⁺e⁻ and μ⁺μ⁻ with up to 4 jets



- ◆ Event selection according to 7 TeV selection (but only central jets with $|y| < 2.5$)
- ◆ Signal MC: Sherpa 2.1 and MadGraph+Pythia8
- ◆ Background estimation using MC

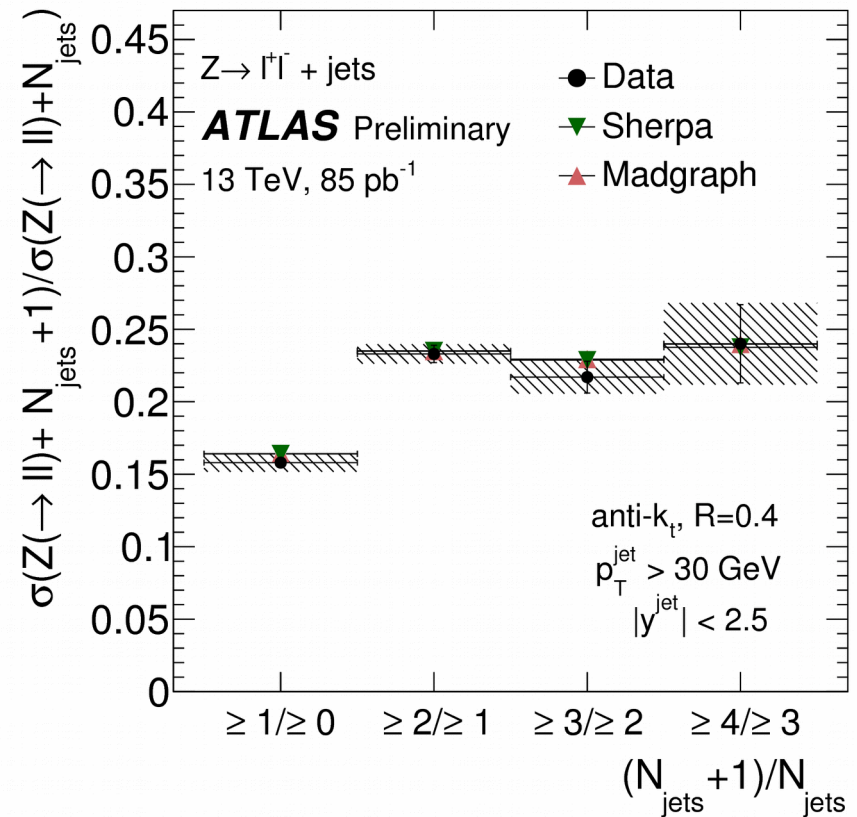
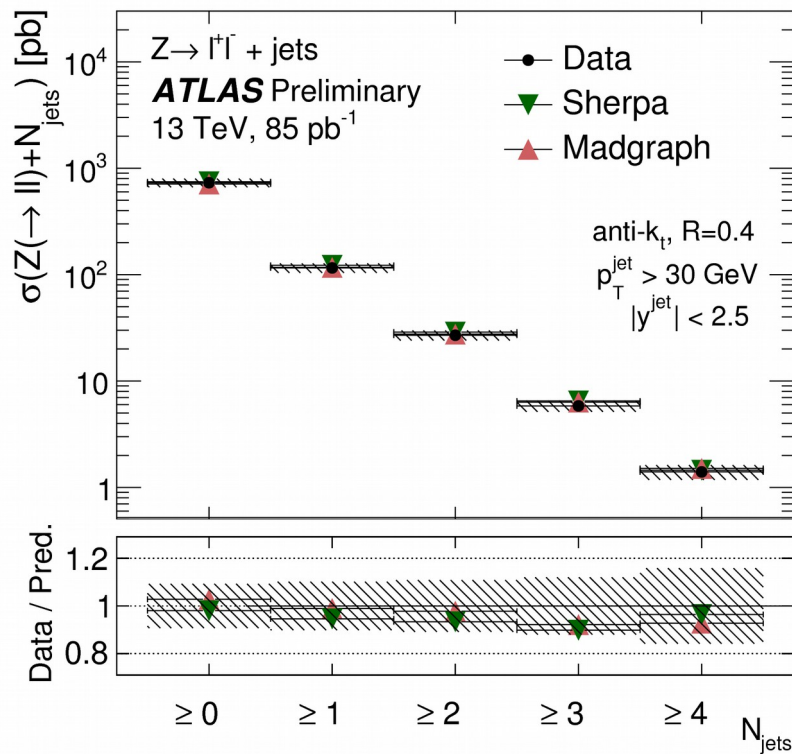


- ◆ Clean signal selection for $+ \geq 1 \text{ jet}$; good agreement of data and MC

Z+jets @ 13TeV

ATLAS-CONF-2015-041

- Bin-by-bin extraction of fiducial cross section at particle level
- Combined electron and muon channel
- reasonable agreement for SHERPA and MADGRAPH

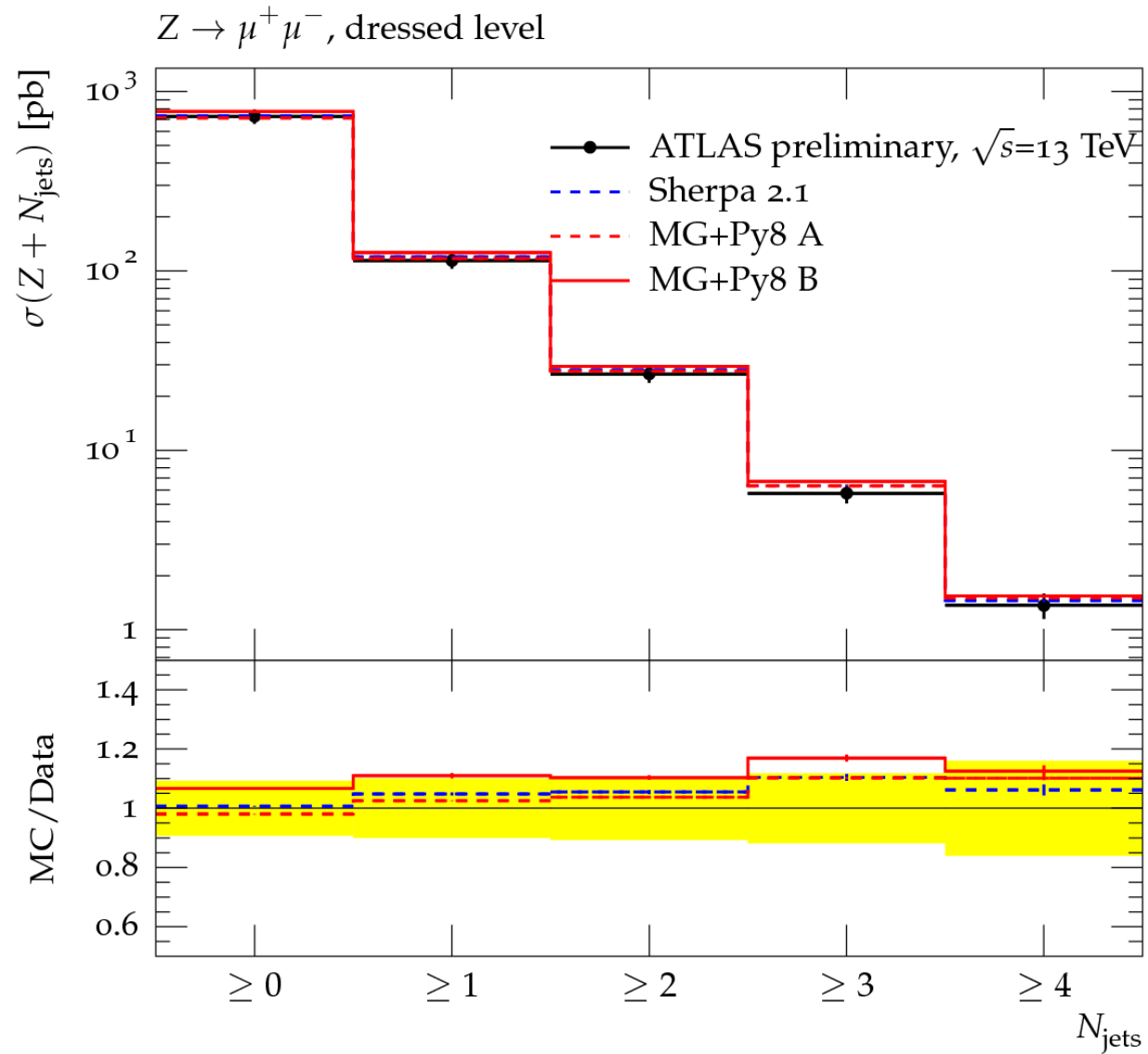


Summary

- ◆ Based on the entire 2011 dataset of pp collisions at 7 TeV with an integrated luminosity of 4.6 fb^{-1} ATLAS has measured:
 - ◆ Production of a W boson plus jets with up to 7 jets, including jet production up to p_{T} of 1 TeV
 - ▶ Comparison to various theoretical predictions
 - ◆ The ratio of W+jets and Z+jets production cross sections
 - ▶ Large cancellations of experimental systematic uncertainties and non-perturbative QCD effects
 - ▶ Being sensitive to differences between W and Z events
- ◆ Based on pp collisions at 13 TeV with an integrated luminosity of 85 pb^{-1} recorded in 2015 ATLAS measured:
 - ▶ The Z+jets fiducial cross section for events with up to 4 jets with a precision of 10% to 20%

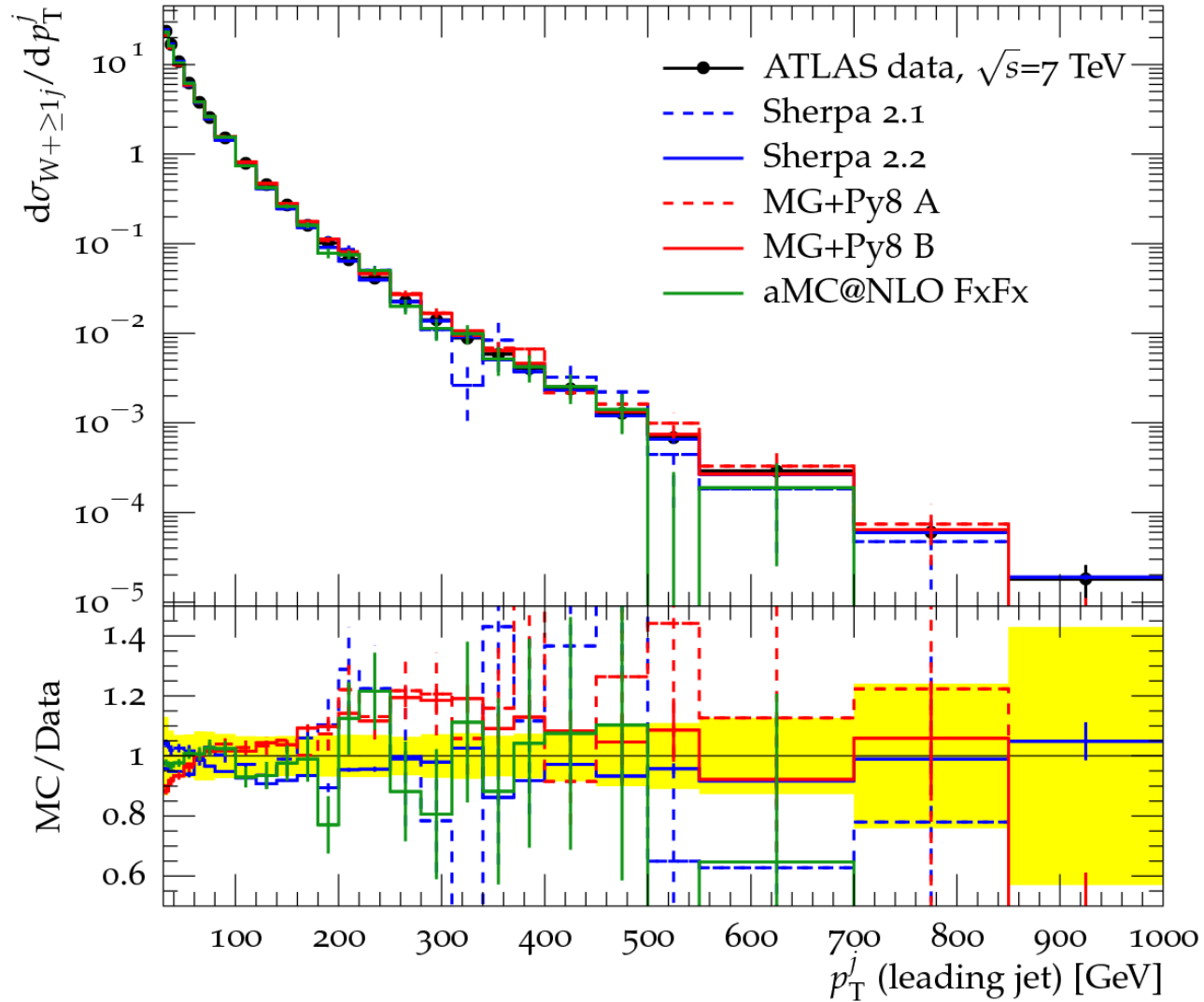
Backup

ATL-PHYS-PUB-2016-003

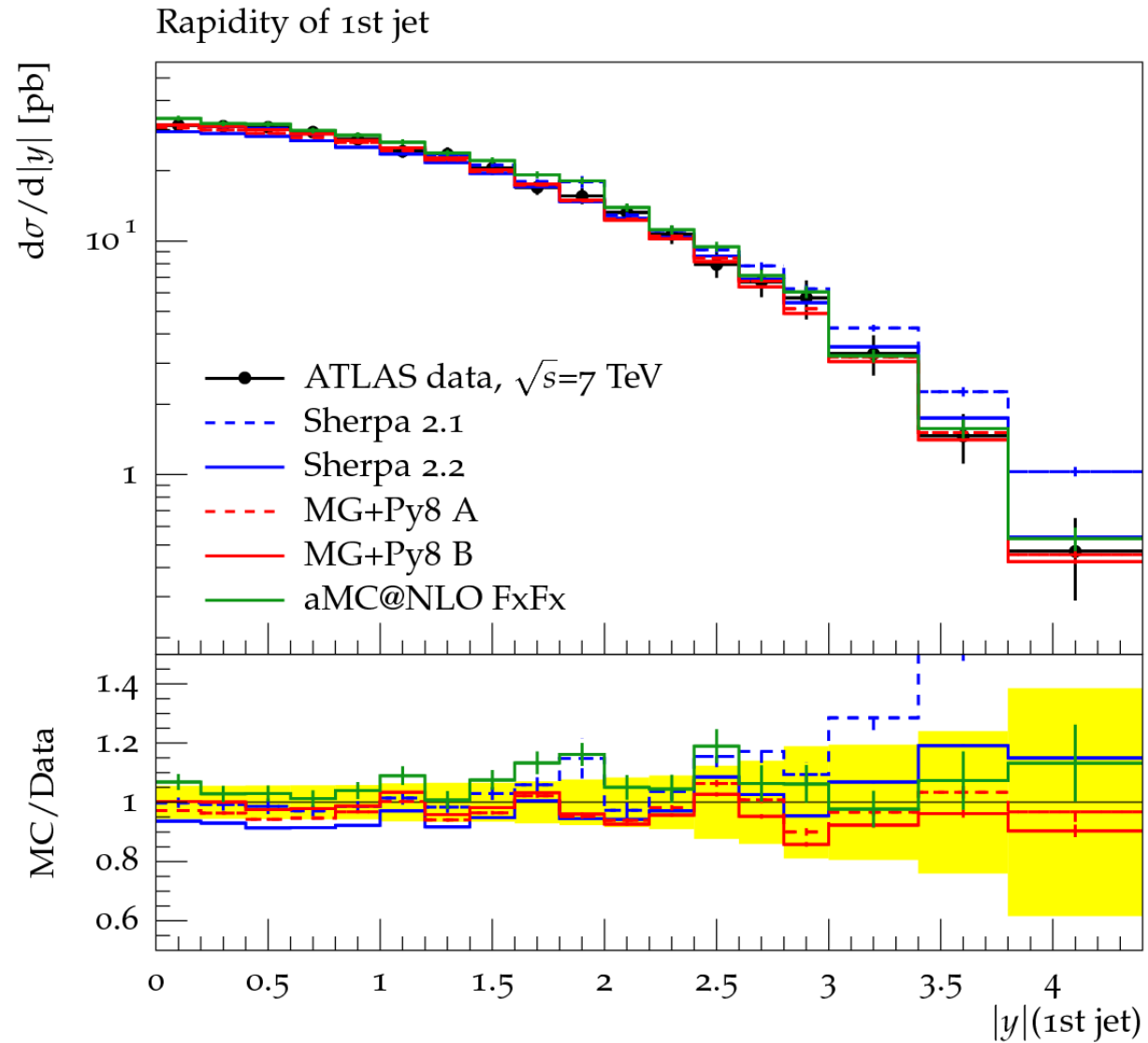


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$W \rightarrow e\nu$ (MC) vs $W \rightarrow l\nu$ (data), dressed level

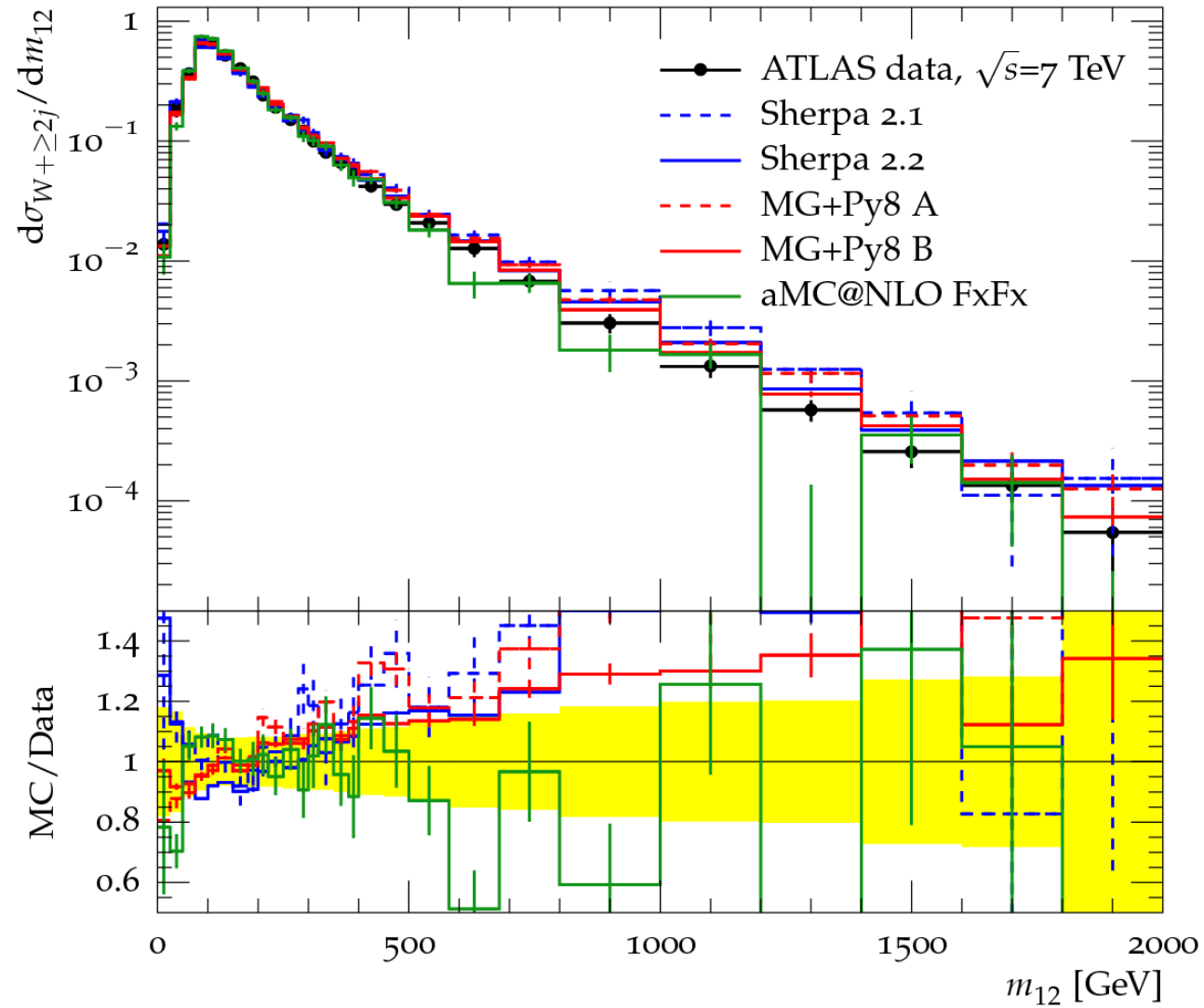


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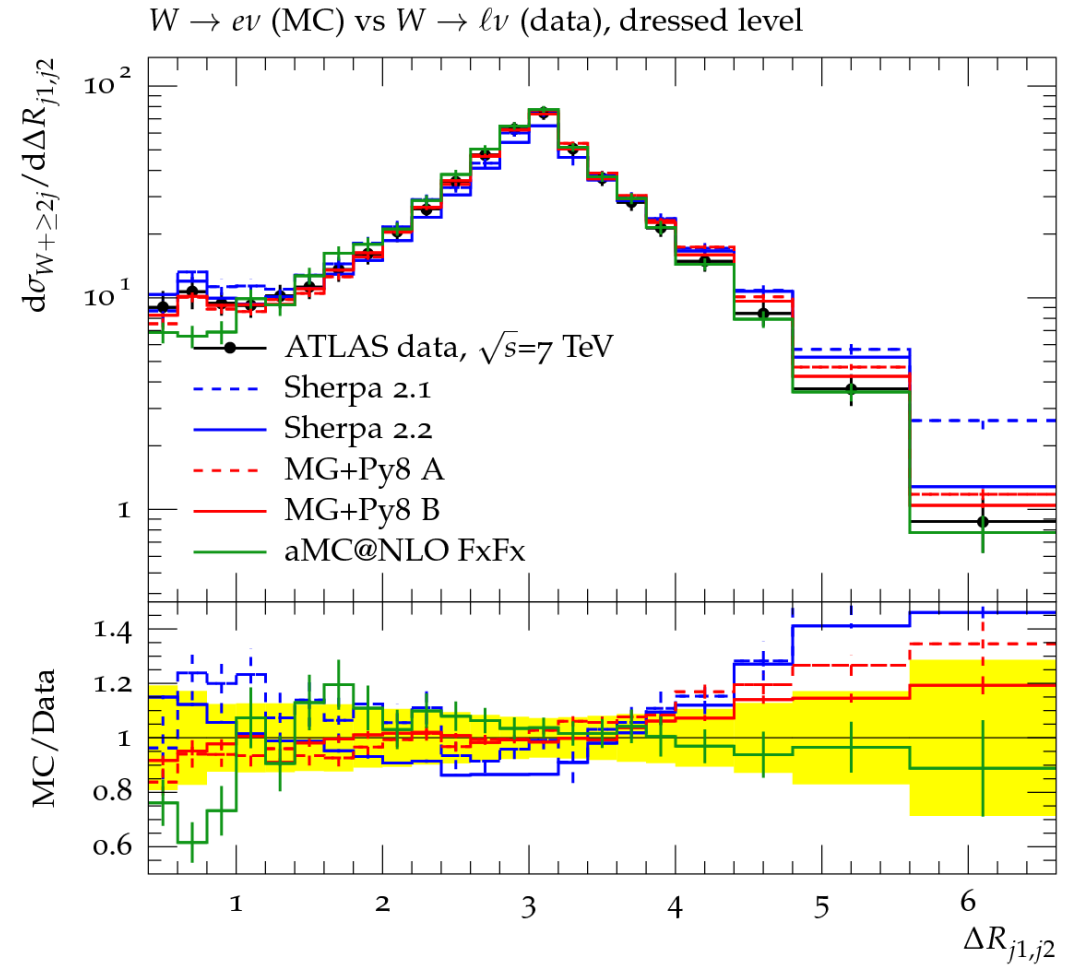
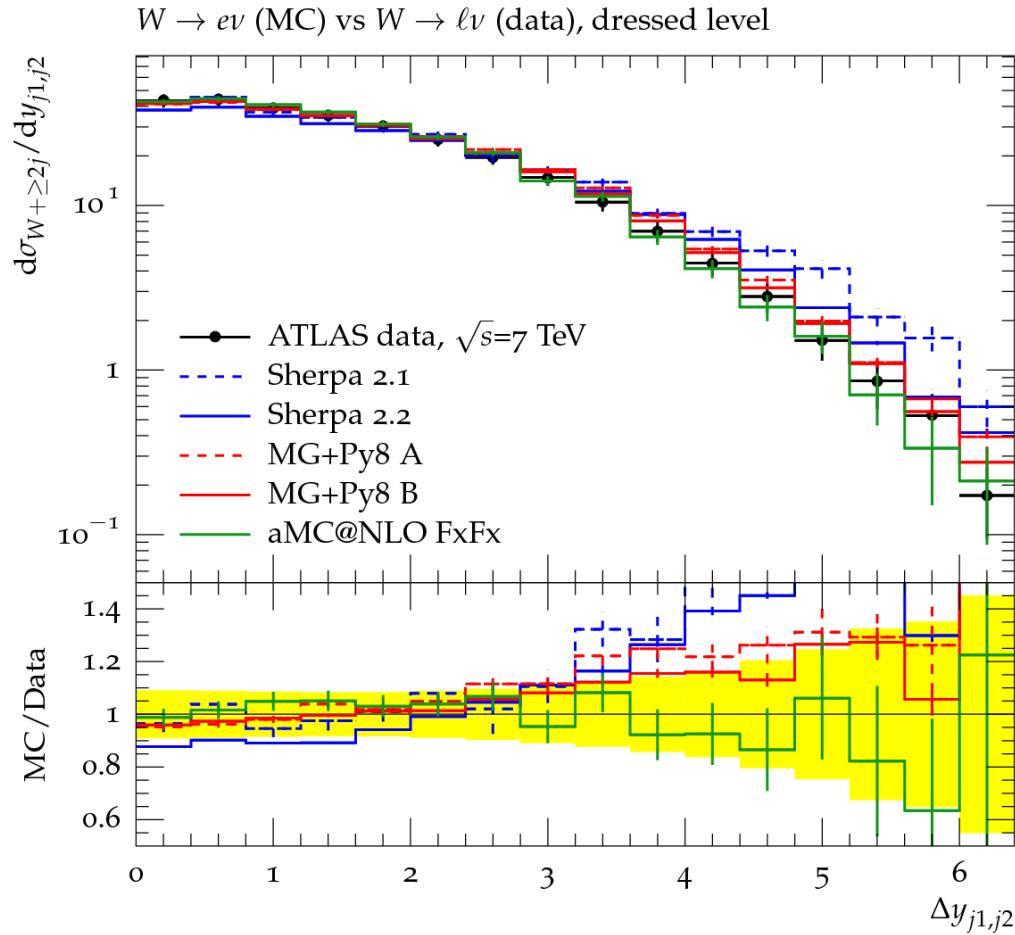


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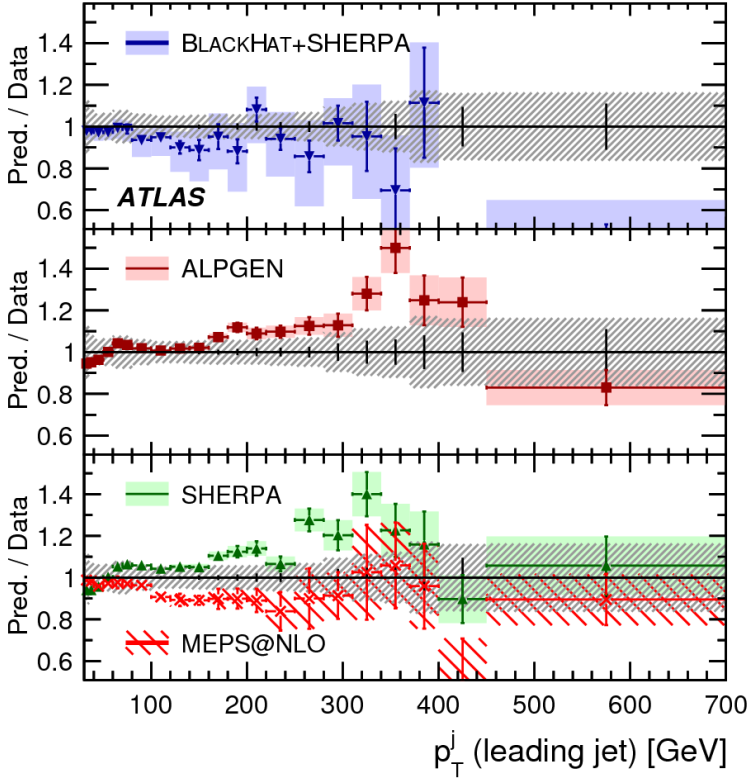
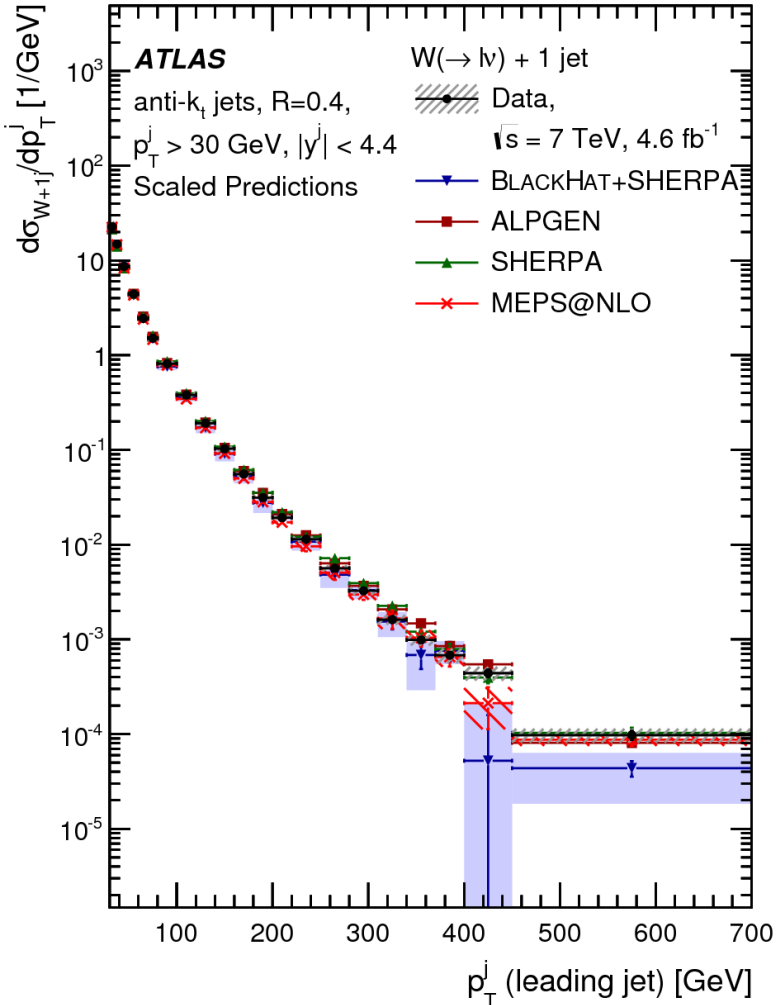
$W \rightarrow e\nu$ (MC) vs $W \rightarrow \ell\nu$ (data), dressed level



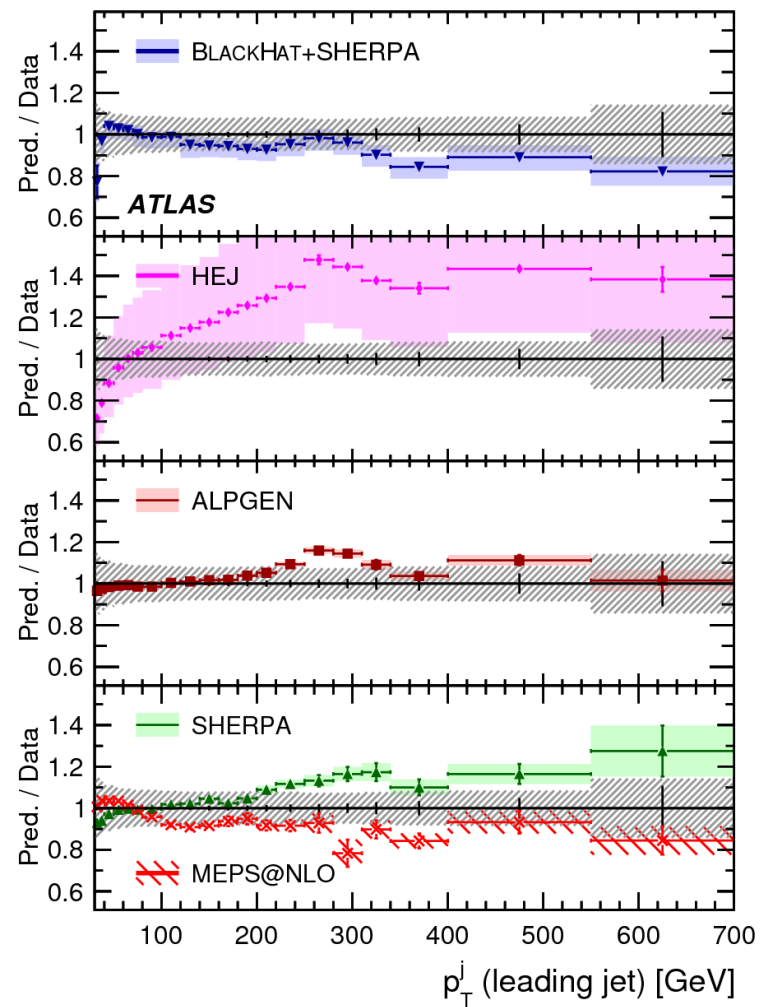
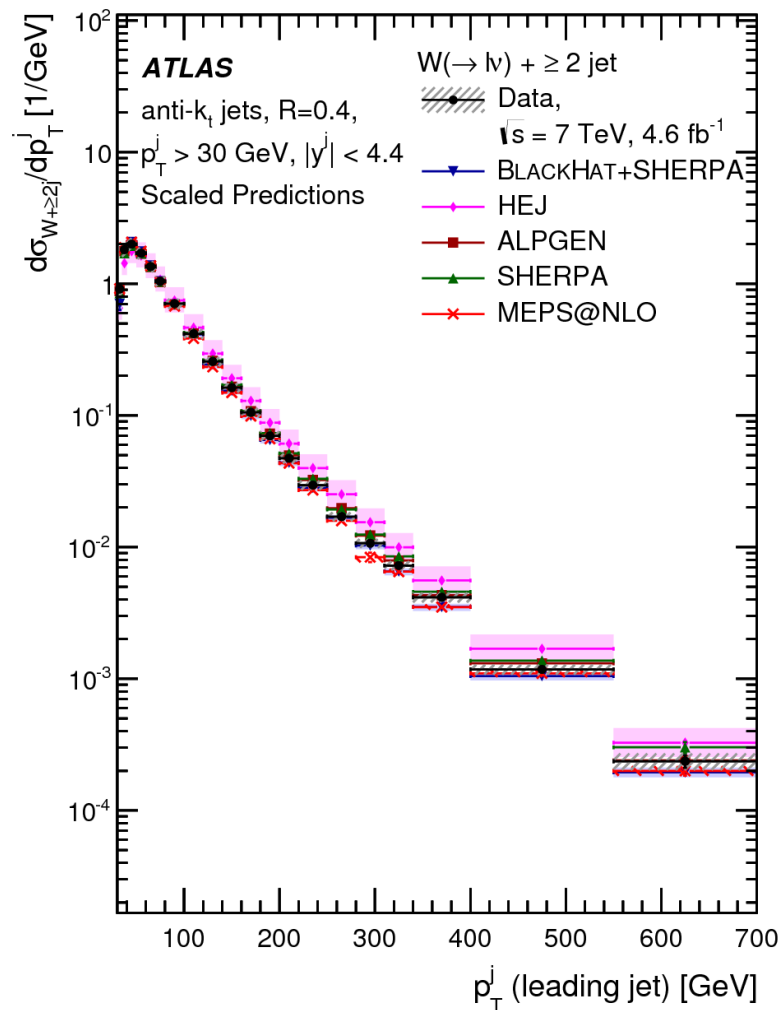
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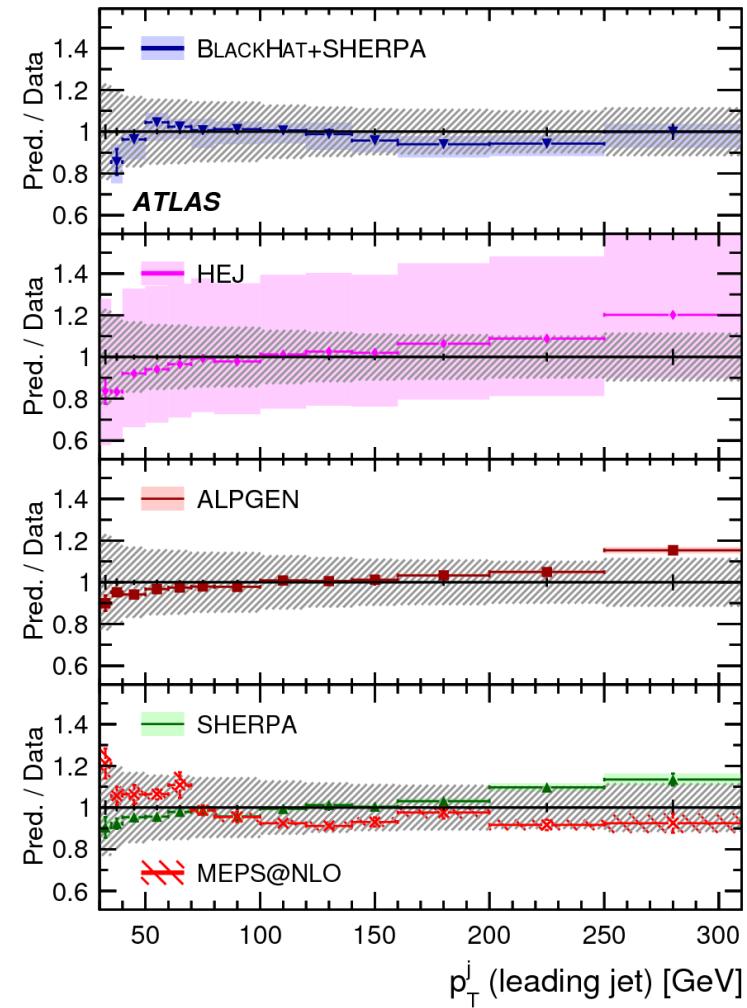
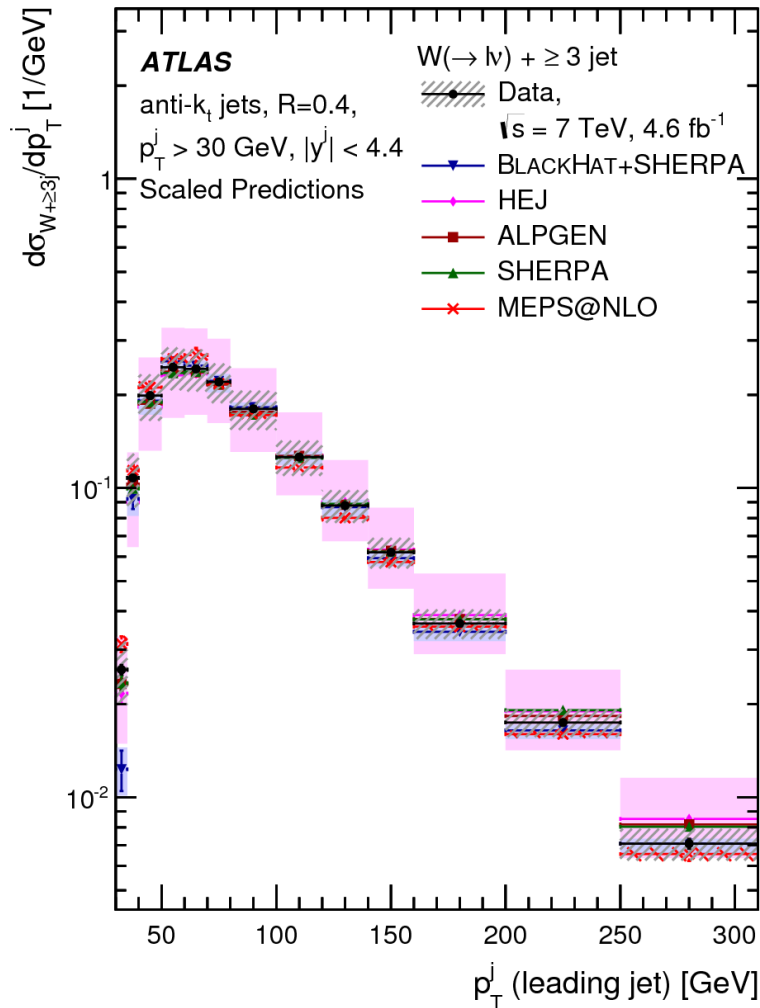
W+jets @ 7 TeV



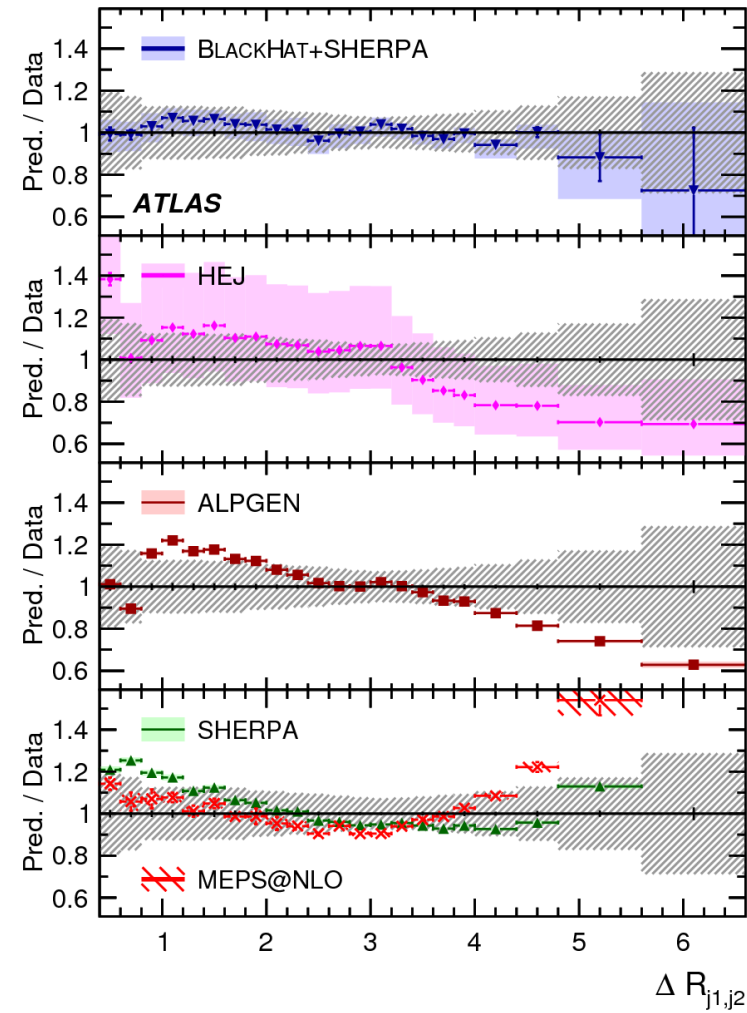
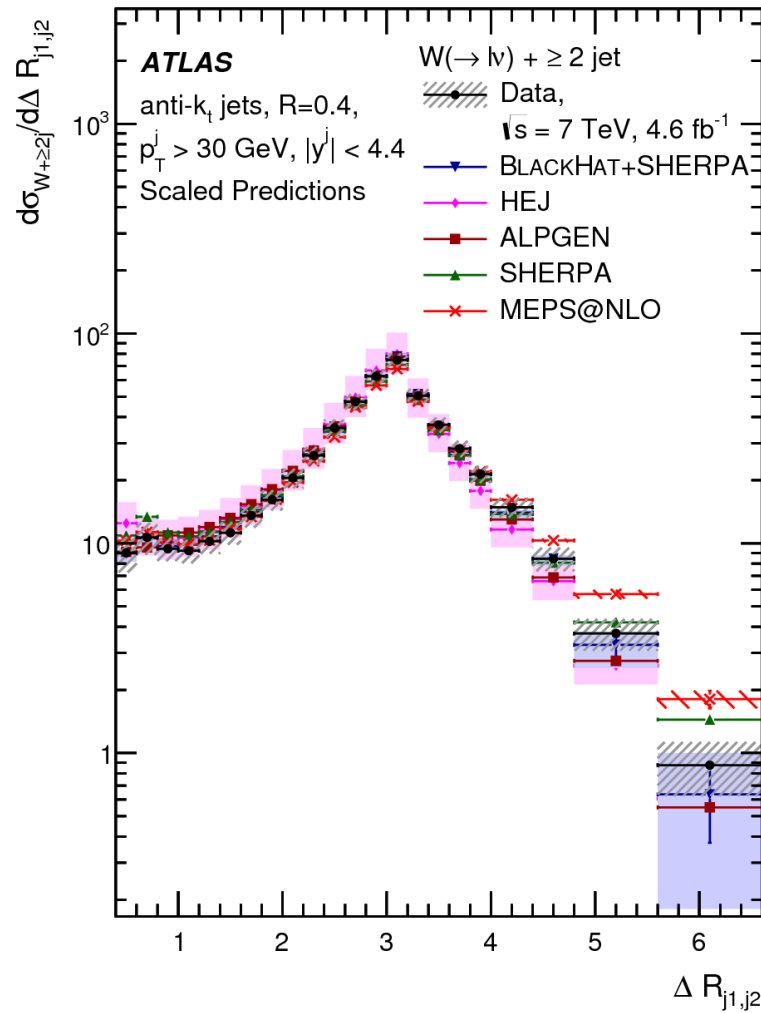
W+jets @ 7 TeV



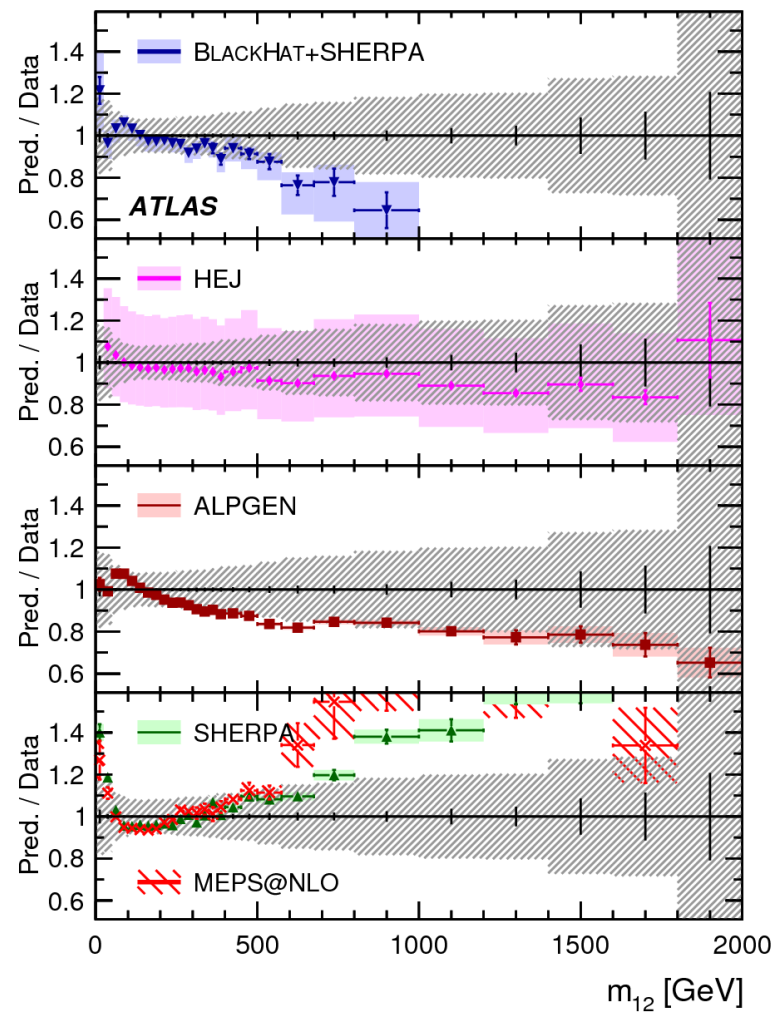
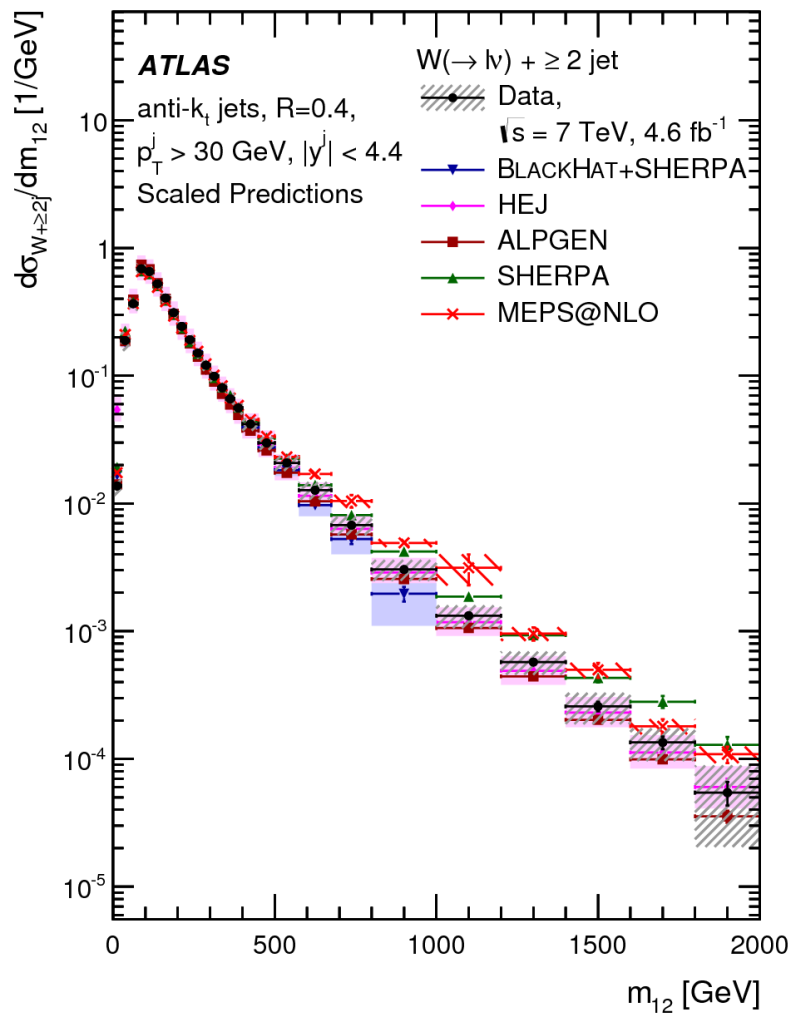
W+jets @ 7 TeV



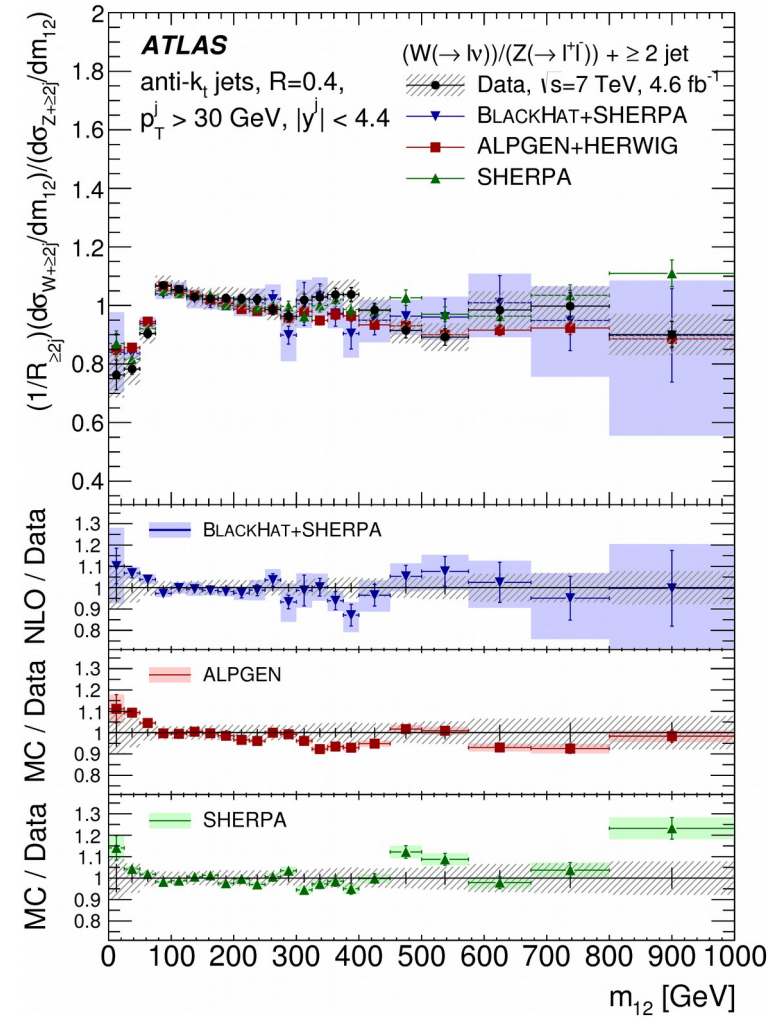
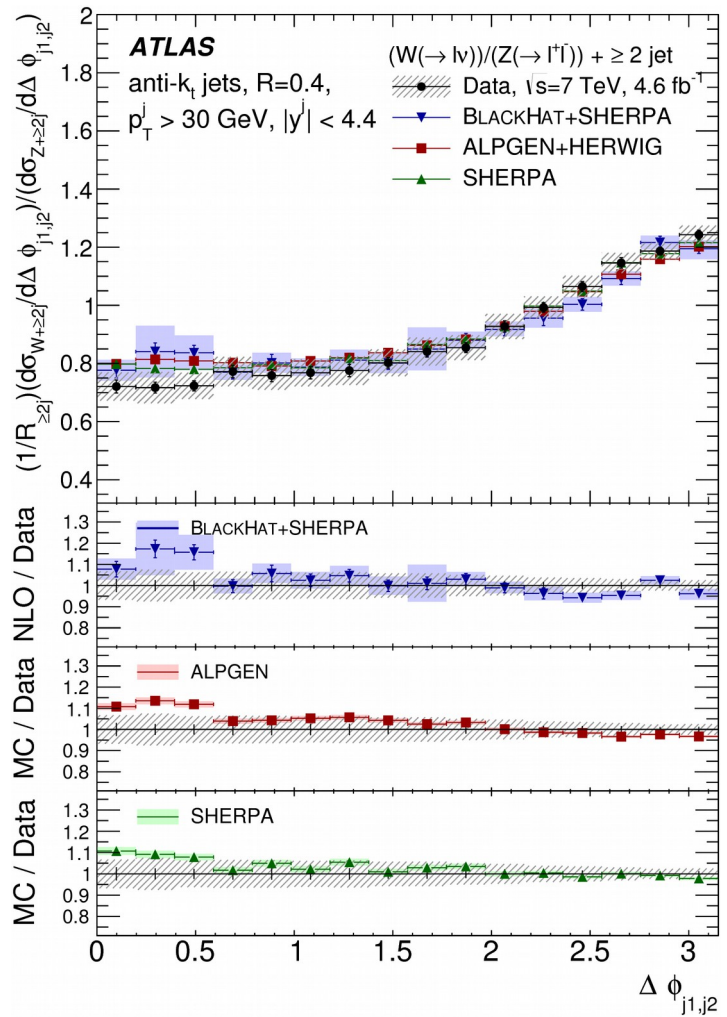
W+jets @ 7 TeV



W+jets @ 7 TeV



Rjets @ 7 TeV



Rjets @ 7 TeV

