Measurements of vector bosons and vector bosons plus jet production with the ATLAS EXPERIMENT

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on behalf of the ATLAS Collaboration

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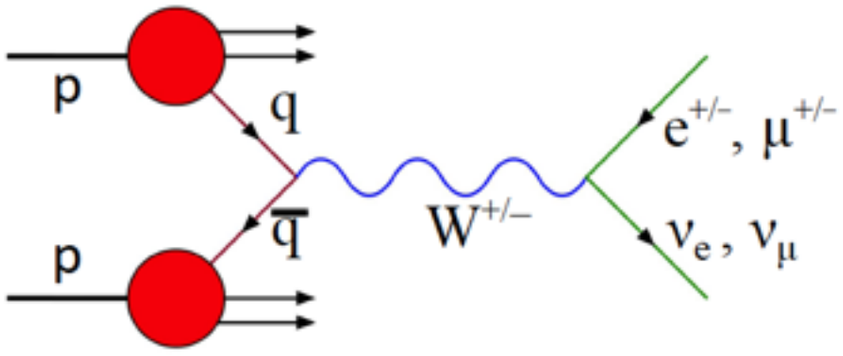
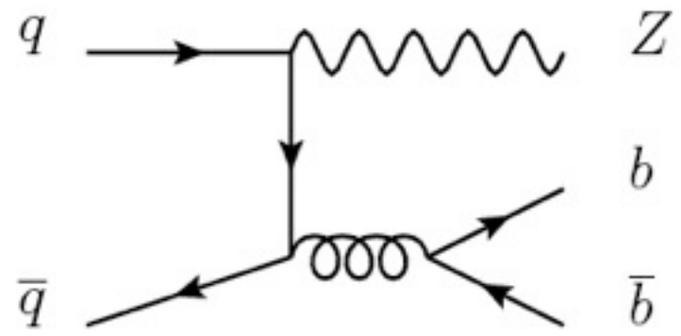
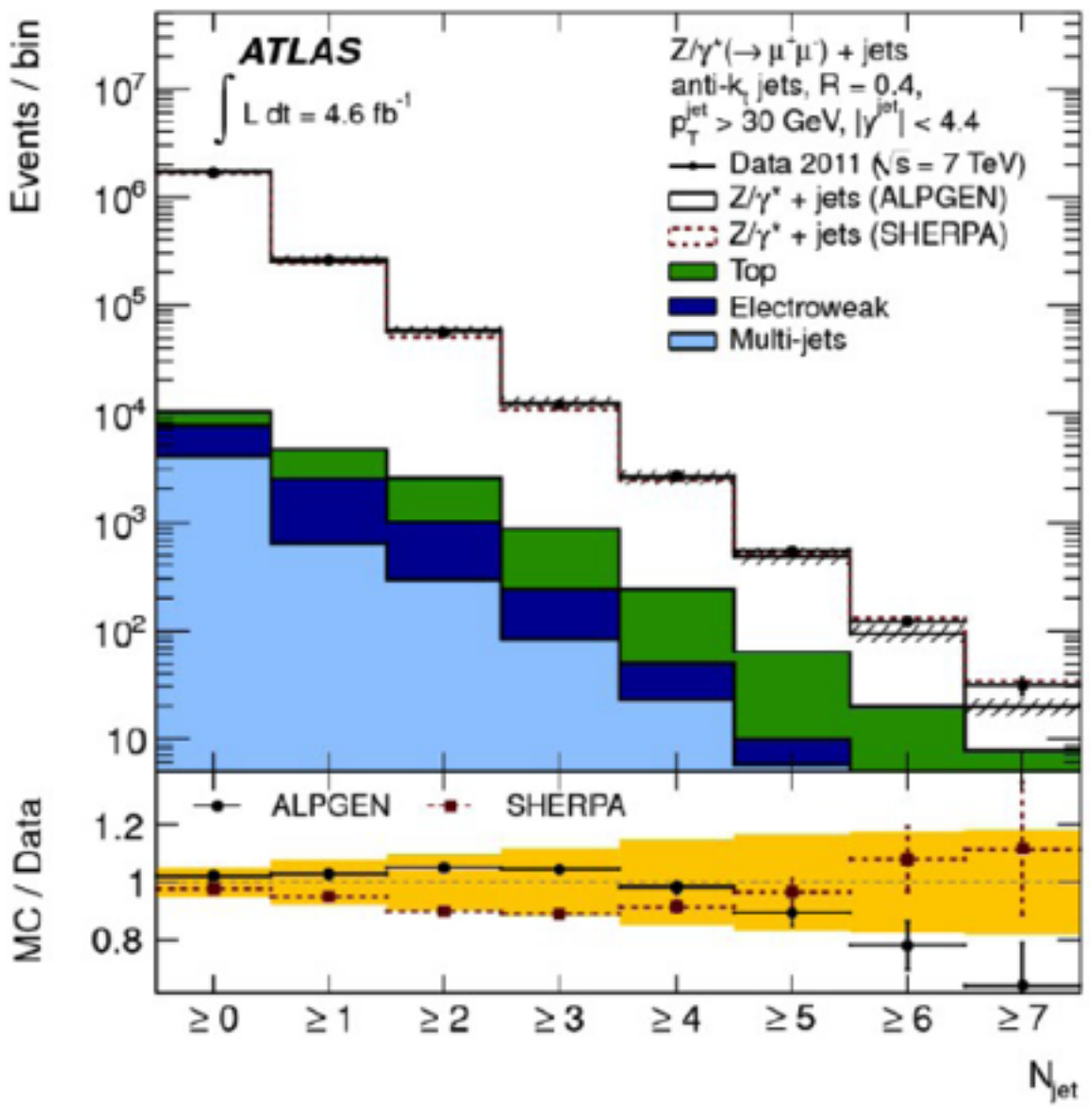
HEP2013, December 16th, 2013

Motivation





- Vector boson and vector boson + jet production:
  - Precision tests of pQCD calculations
  - Constraints on proton PDFs
  - Precision tests of Monte Carlo models
  - Important backgrounds for many searches at the LHC, we need to extrapolate their cross sections with high precision, needs to be well understood

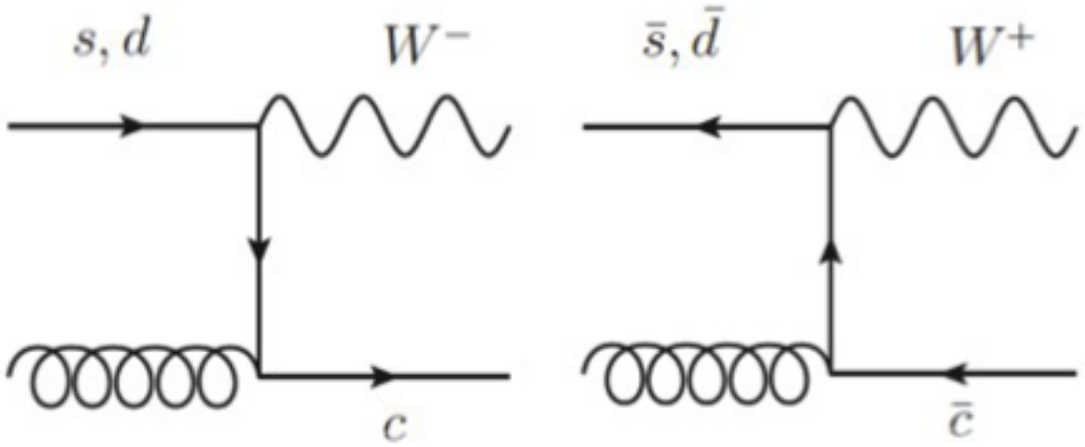


Measurement shopping list

- This talk covers measurements made using the 2011 ATLAS 7 TeV dataset of 5 fb^{-1}

• W+c	ATLAS-CONF-2013-045
• W+b	JHEP 06 (2013) 084
• Drell Yan at high mass	Phys. Lett. B 725 (2013) 223-242
• Φ^* in Z/γ^*	Phys. Lett. B 720 (2013) 32-51
• MC tuning using Φ^* in Z/γ^*	ATL-PHYS-PUB-2013-017
• Forward-backward asymmetry in Z/γ^*	ATLAS-CONF-2013-043
• Z+jets	JHEP 07 (2013) 032

W+c - How strange is strangeness



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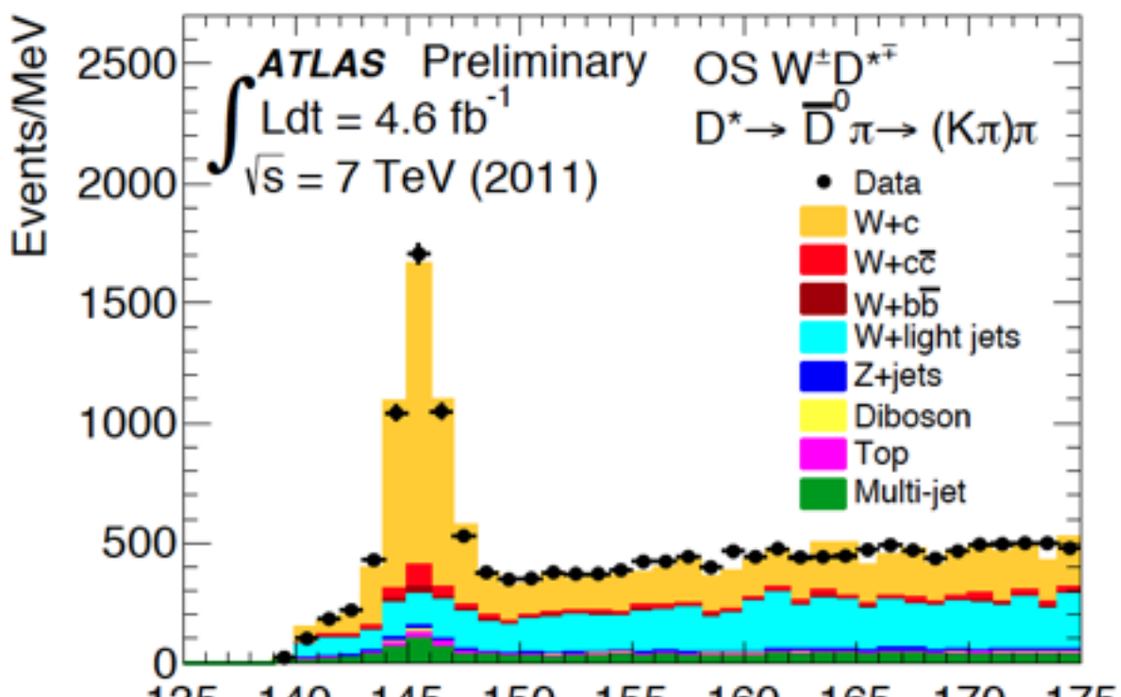
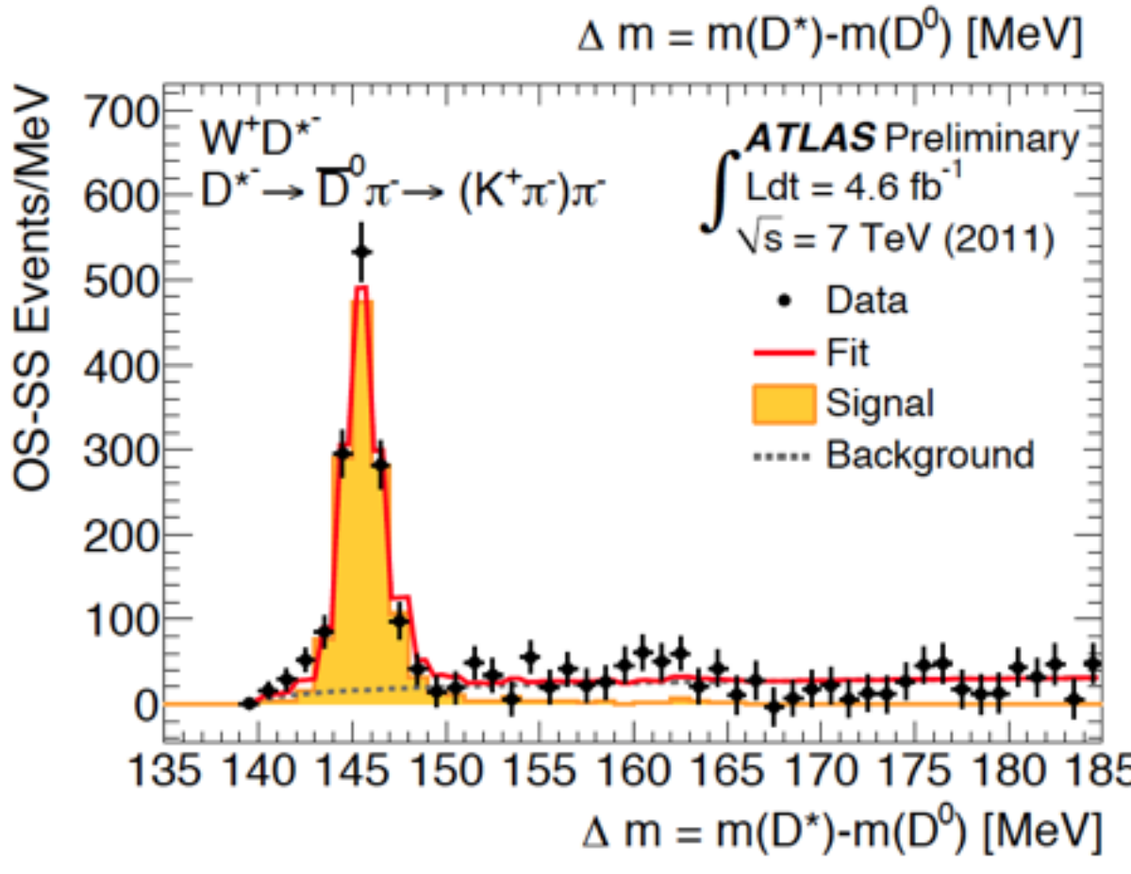
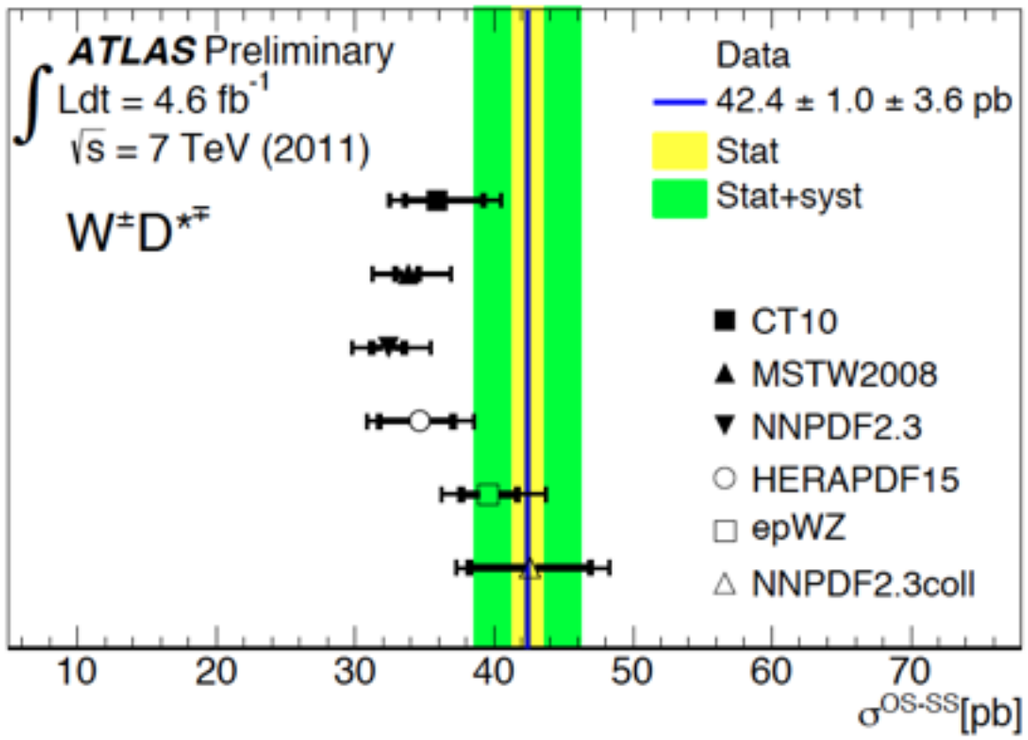
- Sensitive to strange PDF and s/s asymmetry
- Select events with a W and D* (no jets)
- Use the charge correlation between W and D* to extract the single charm contribution
- Measure OS-SS cross section
  - Inclusively and as a function of p_T and η
- Measure W-charge ratio



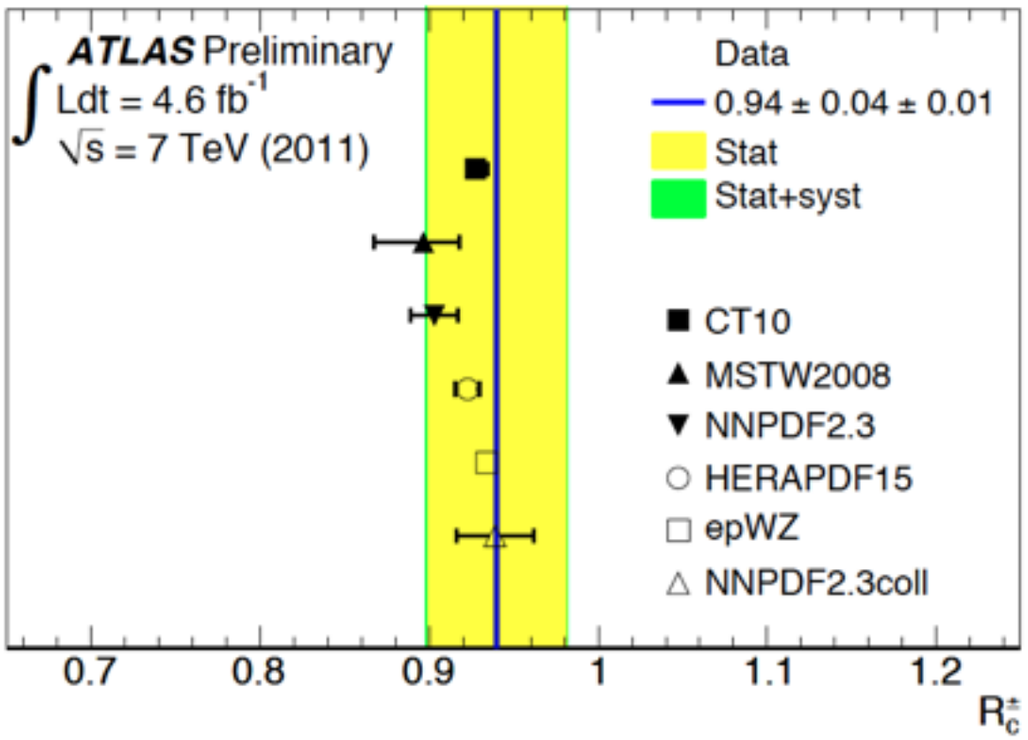


W+c

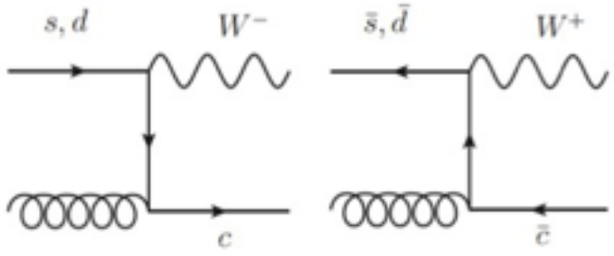
OS-SS cross section



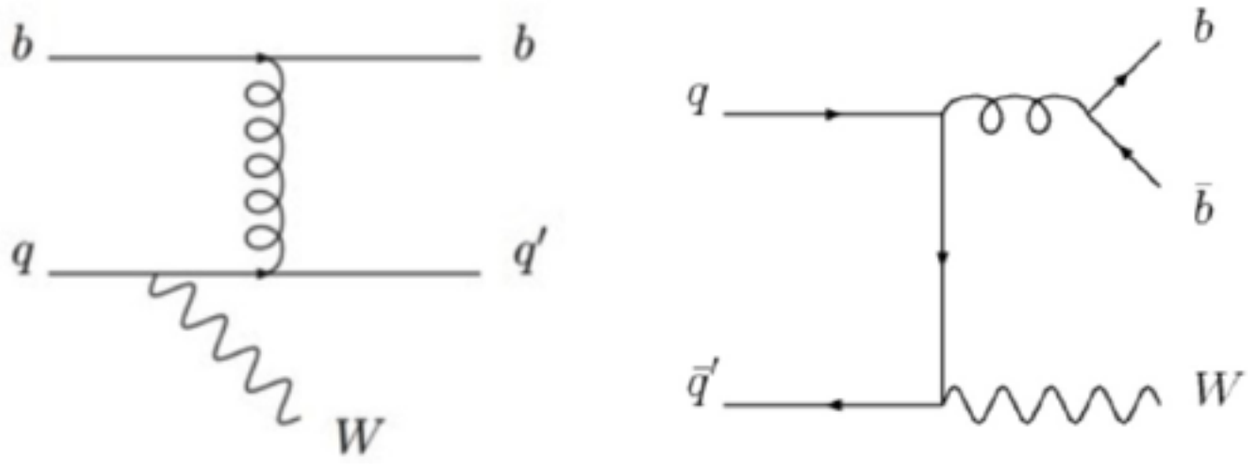
W Charge Ratio

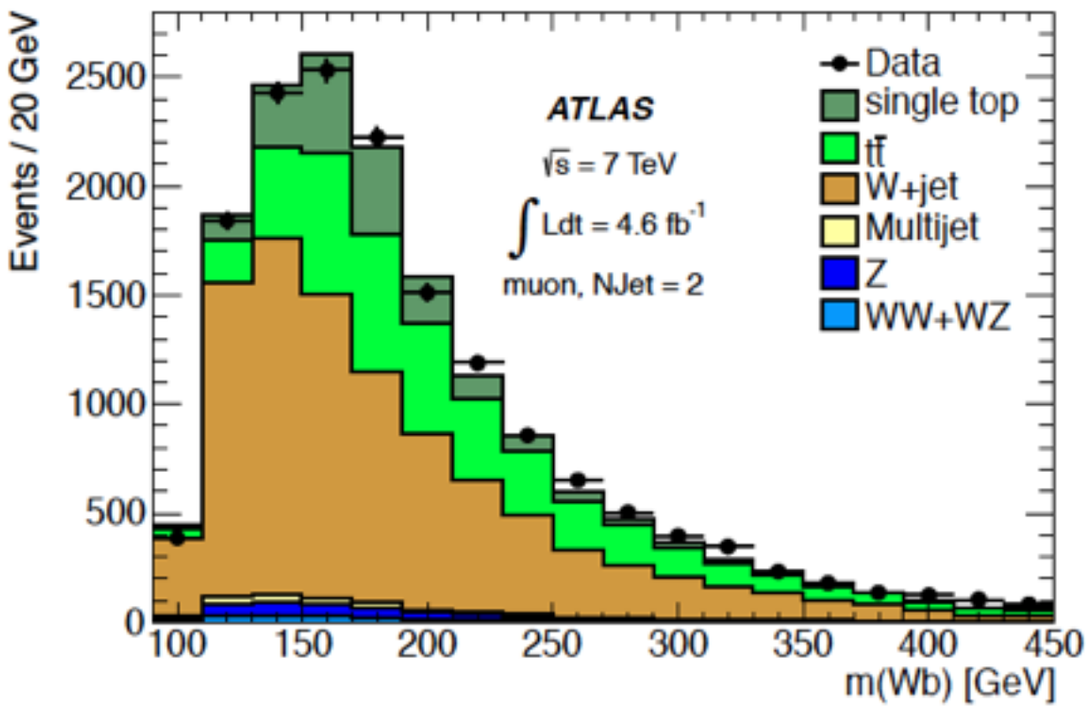


- Data (vertical line) in good agreement with epWZ and NNPDF2.3coll, which have enhanced strange contribution
  - epWZ fit includes ATLAS 2010 W and Z cross section data
  - Large strange contribution independently supported here
- Experimental precision on cross section is limited by tracking systematics (expect to improve for final result) - W charge ratio is limited by statistics

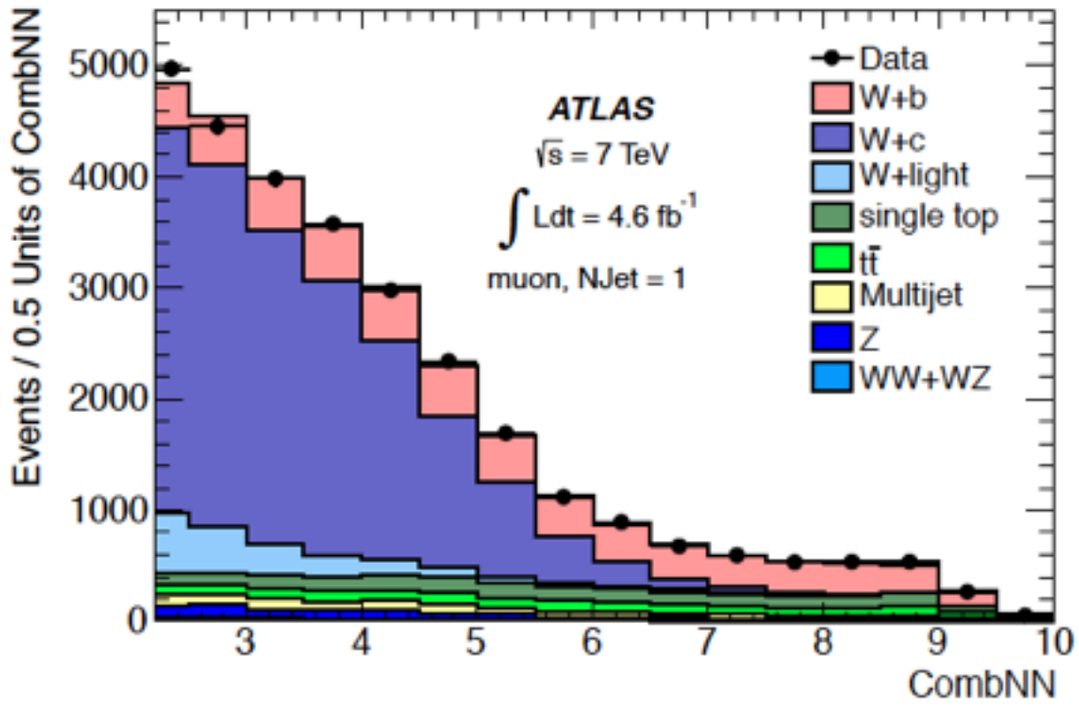


W+b



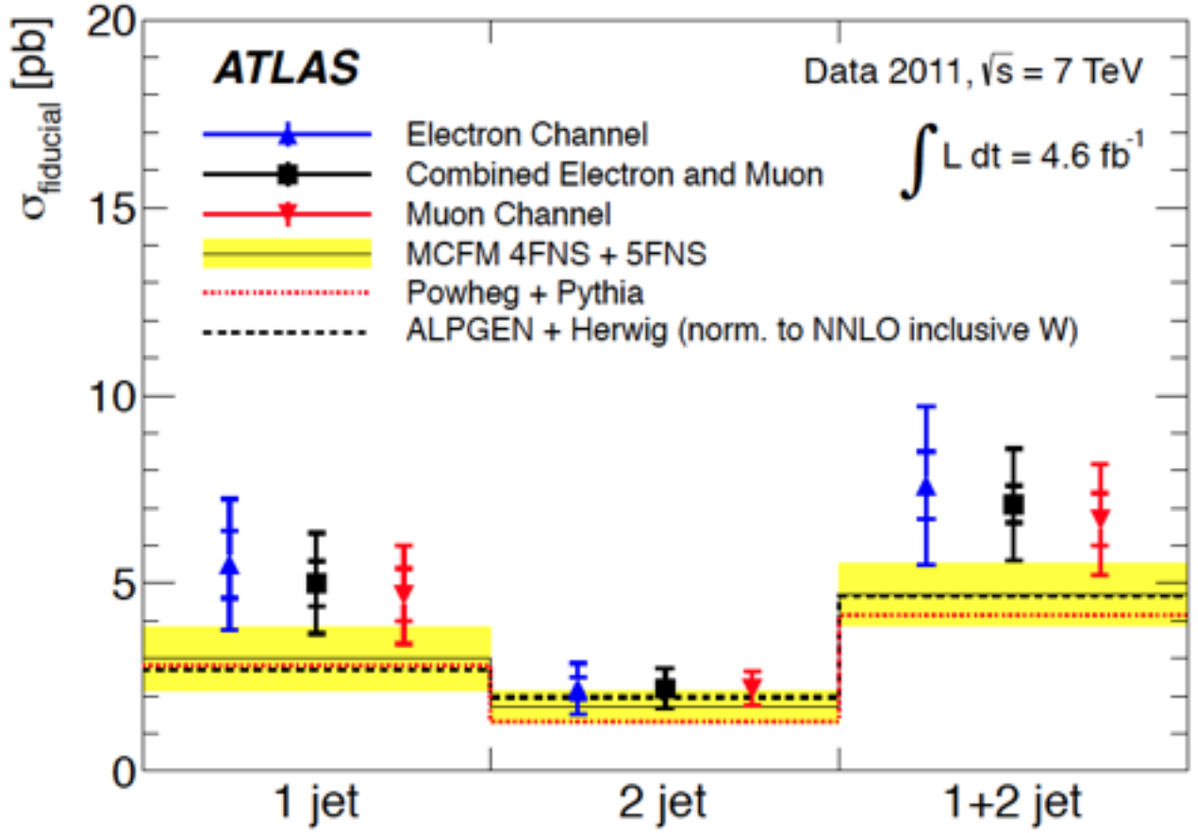


- pQCD with heavy flavour - which flavour scheme should be used?
- A large background for important processes, not least VH (H→ bb)



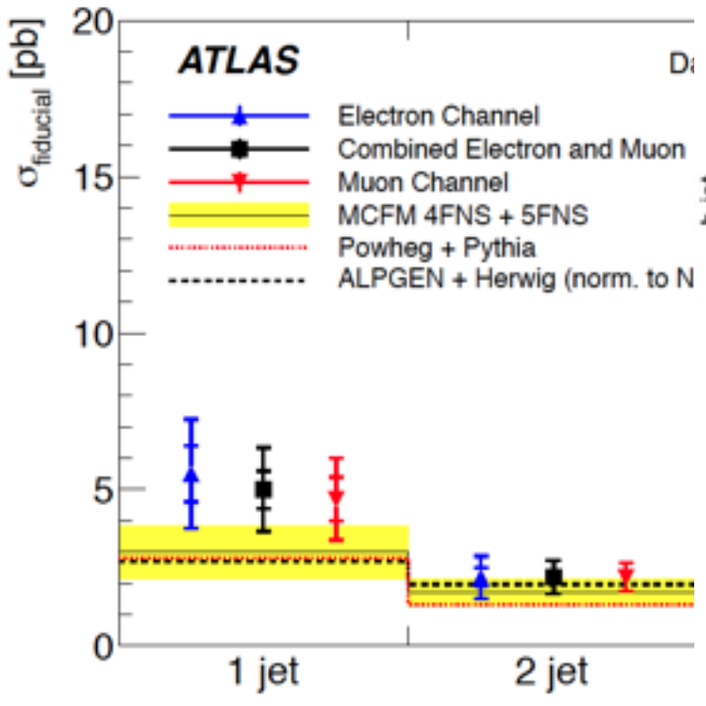
- Select events with a W and 1 or 2 jets, where exactly one jet is b-tagged
- Large backgrounds remain
  - Control region to estimate top and single-top
- Flavour template fit to extract the signal
  - b-tagging discriminant separates b, c and l

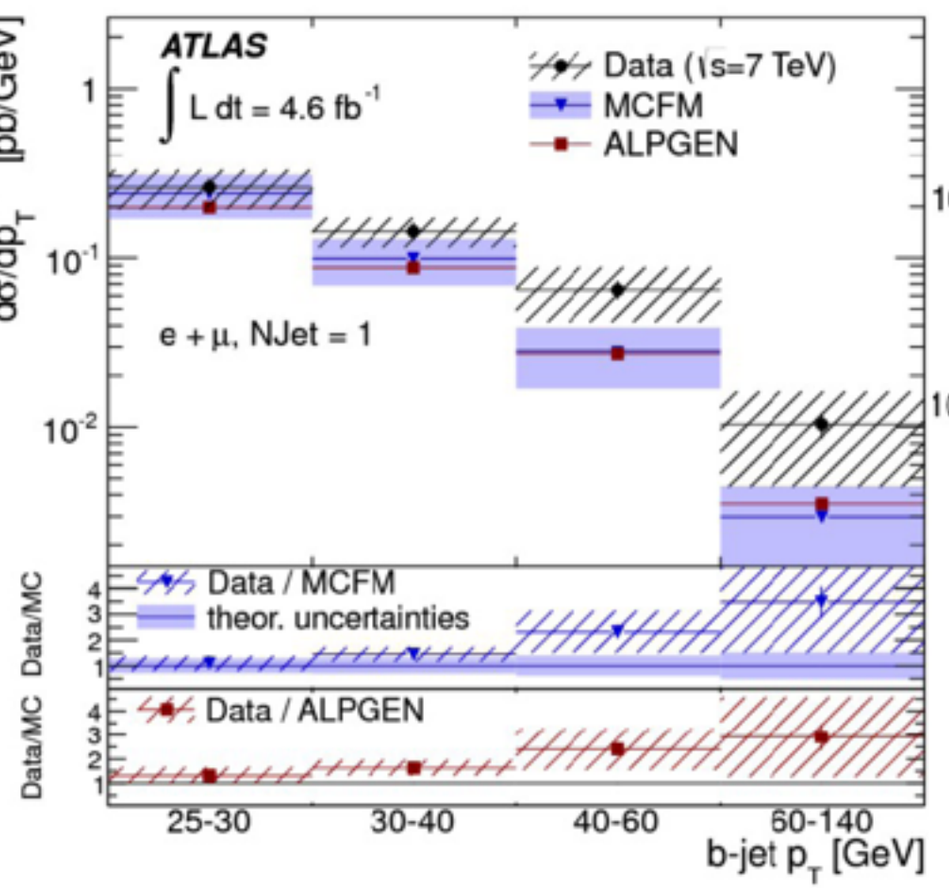
W+b

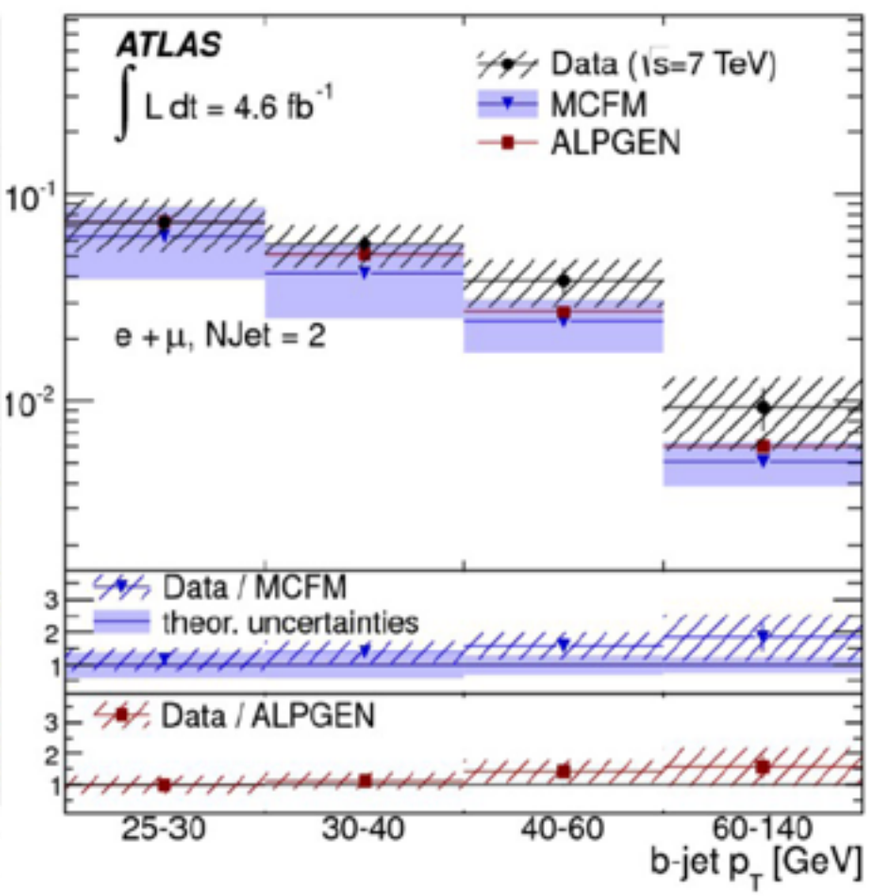


- Fiducial cross section measurement in good agreement in 2-jet bin, reasonable agreement in 1-jet bin, same story seen for measurement differential in b-jet p_T
- DPI component is not subtracted
- Compared to Alpgen (4FNS, normalised to NNLO), MCFM (4+5FNS, corrected for DPI, UE and PS) and Powheg+Pythia (4FNS, corrected for DPI)

W+b







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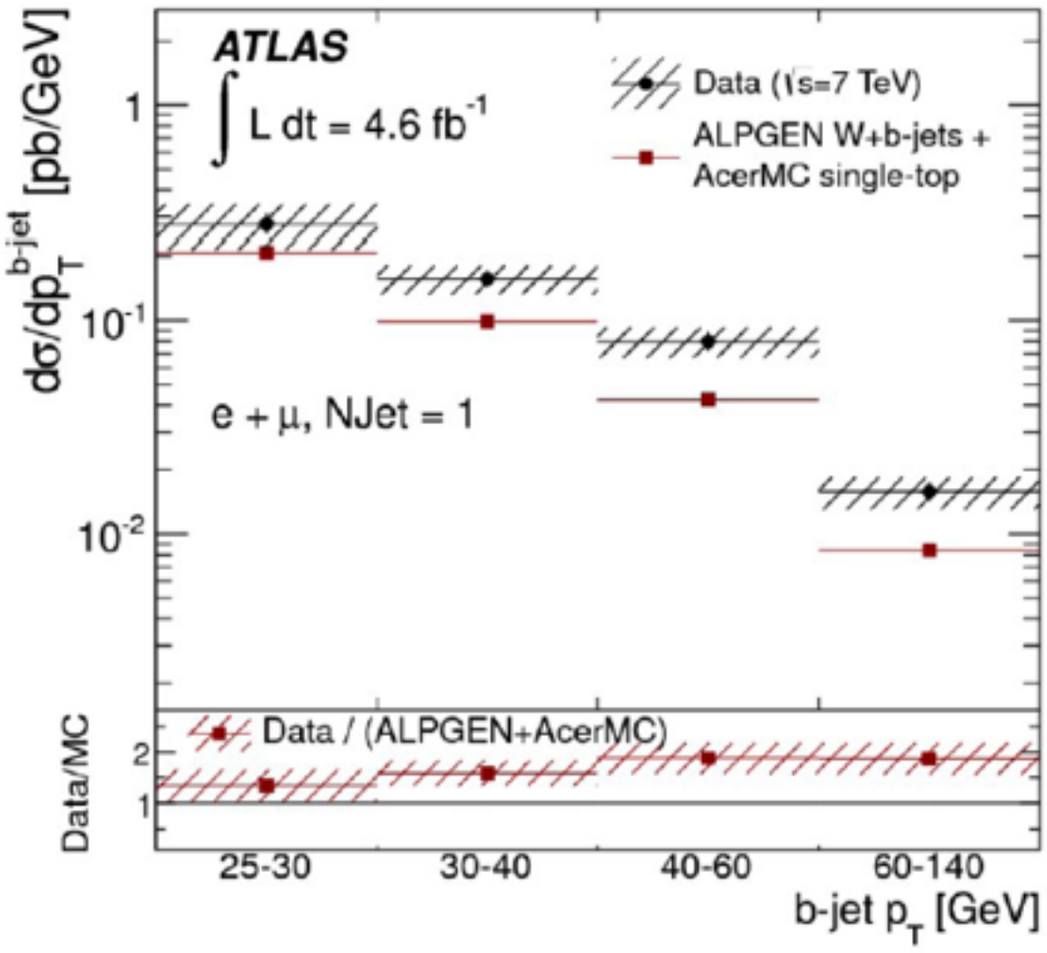
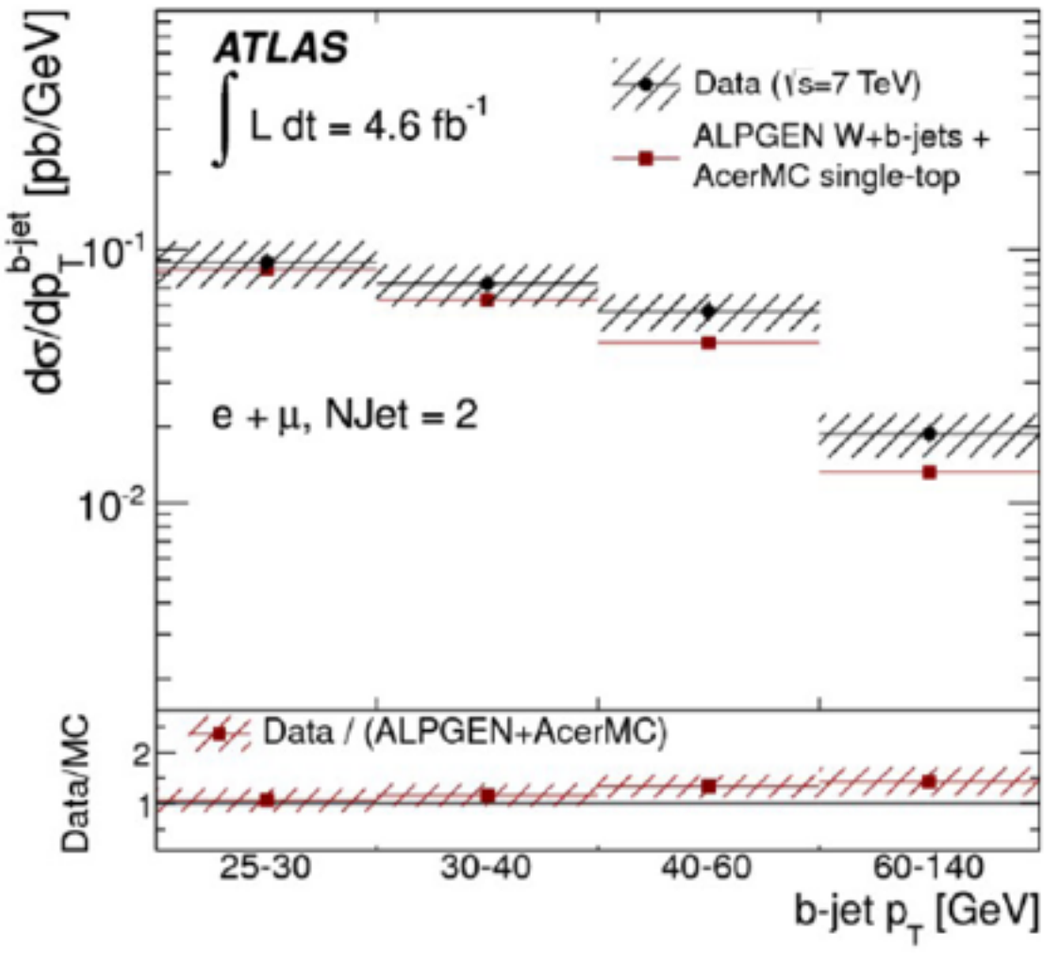
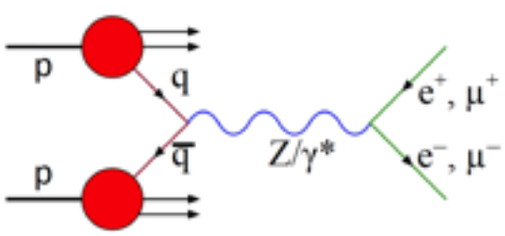
W+b

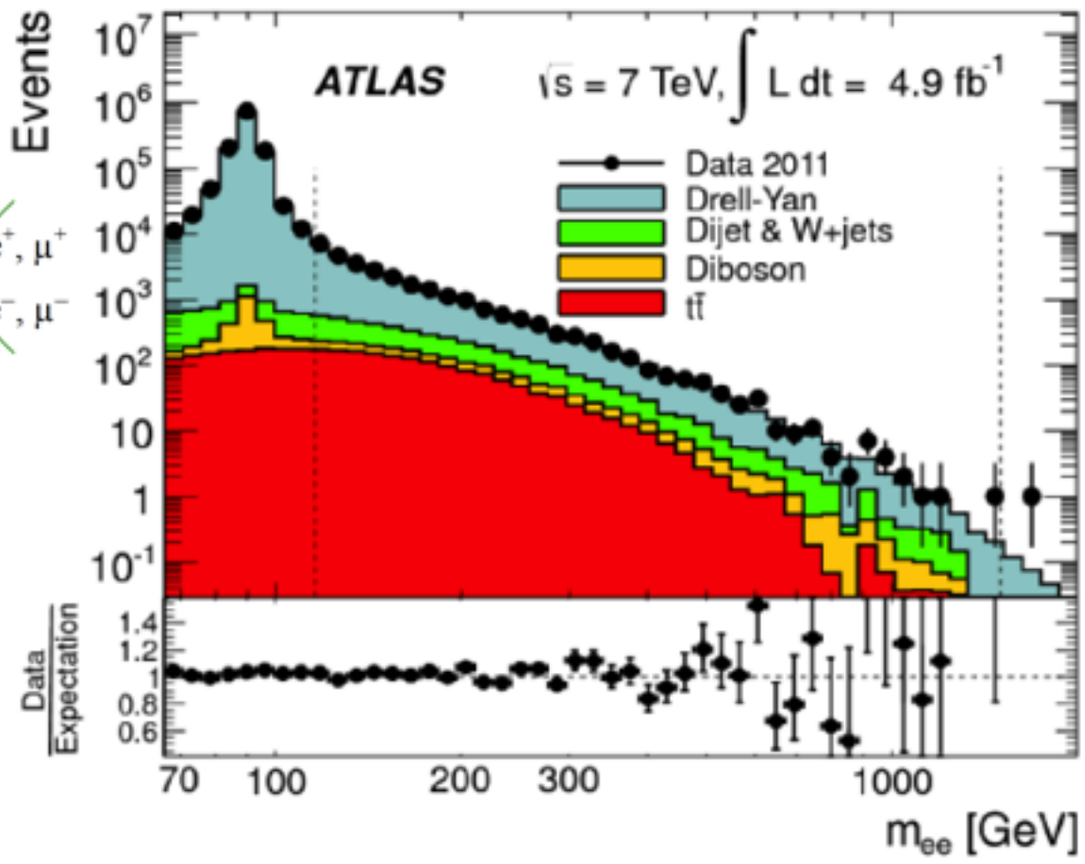


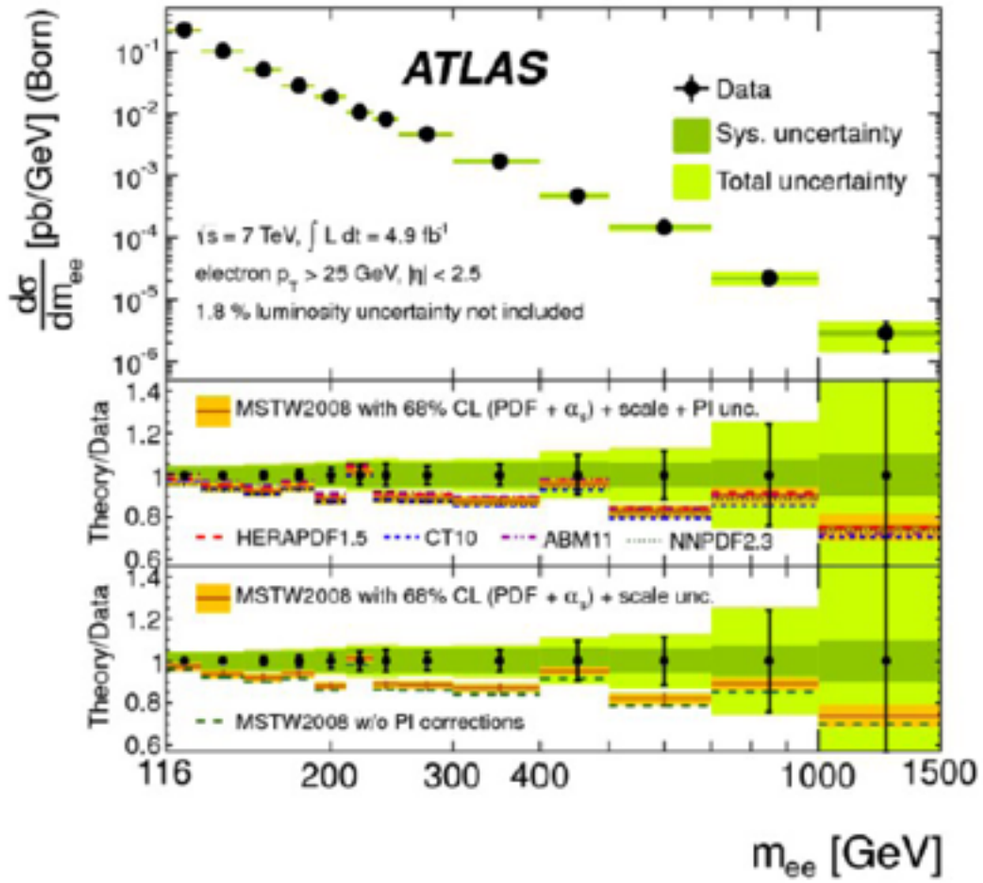


- Single top and signal flavour templates look very similar → large uncertainty
- Alternative presentation where single top component is not subtracted from data
  - Use ACER MC to estimate this contribution in comparison to theory
- Experimental uncertainty much improved

High mass Drell Yan

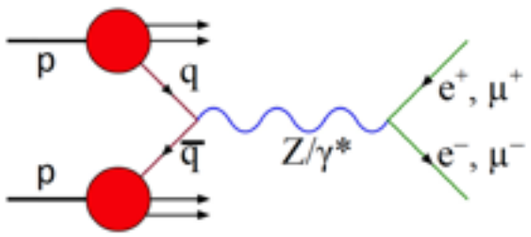






- Cross sections measured in a fiducial region:
  - $p_T > 25$ GeV, $|\eta| < 2.5$ and $116 < M_{ll} < 1500$ GeV
- Results compared to NNLO pQCD using FEWZ, including EW corrections, using different NNLO PDFs
- Predictions for all PDFs considered are consistent with the data
- With higher precision, some potential to constrain large x PDFs

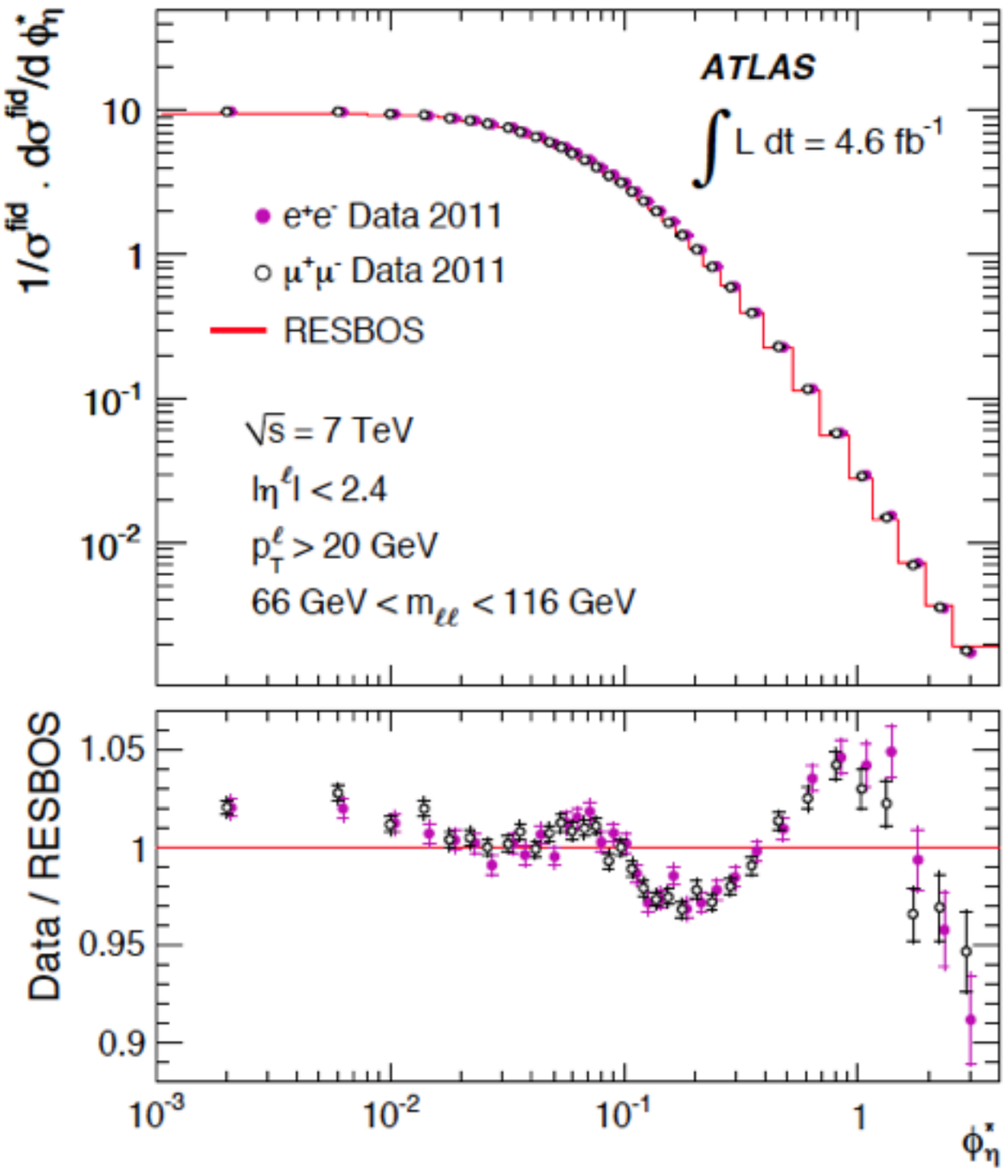
Φ* in Z/γ*



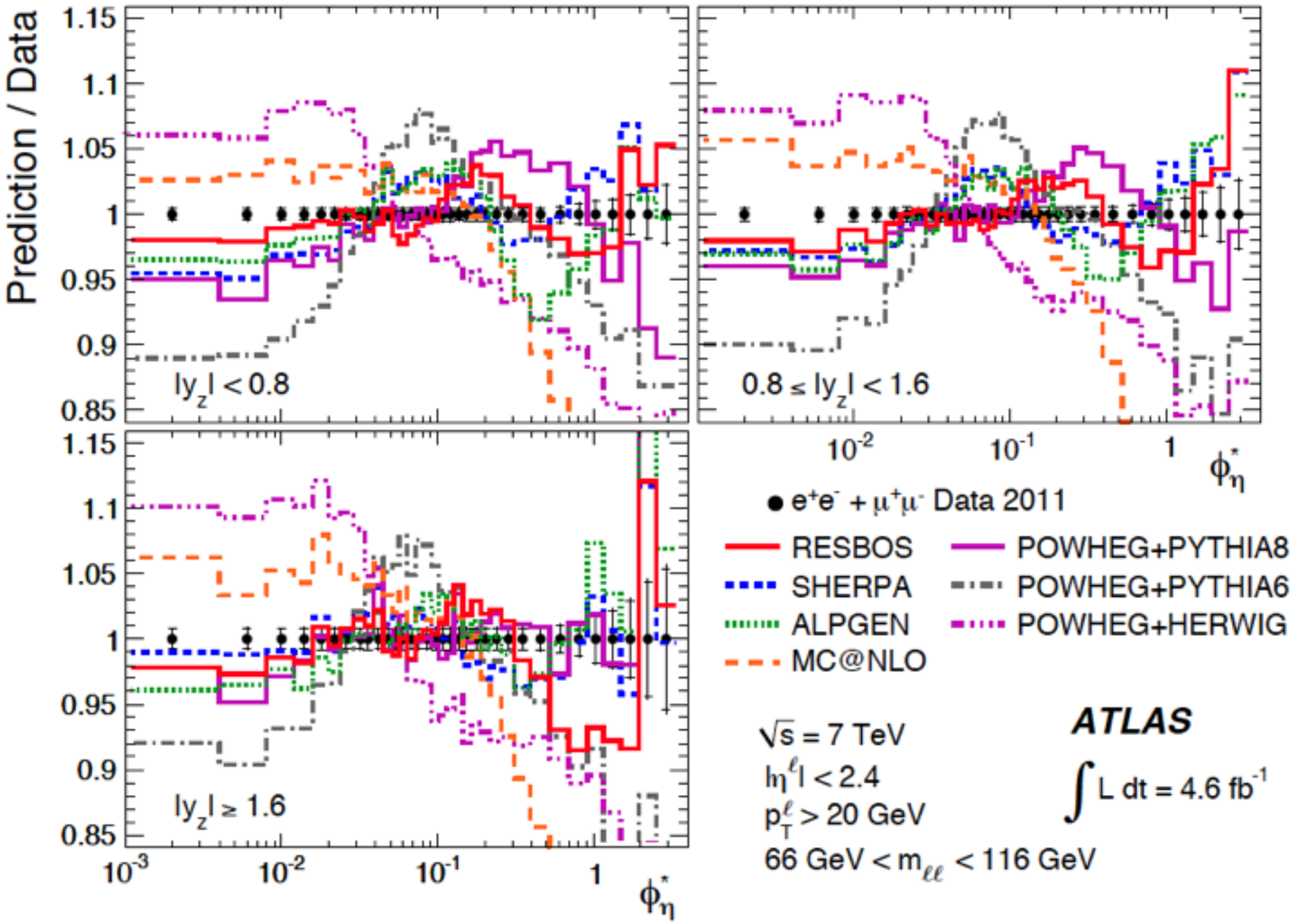
- Angular correlation between the final state lepton pair from Z/γ*

- An ideal probe of low p_T^Z Z production dynamics, precision relies only on angular measurements
  - Statistical precision ~0.3%
  - Systematic precision ~0.1-0.3%

- Two OS leptons with $p_T > 20$ GeV, $|\eta| < 2.4$ and $66 < M_{ll} < 116$ GeV



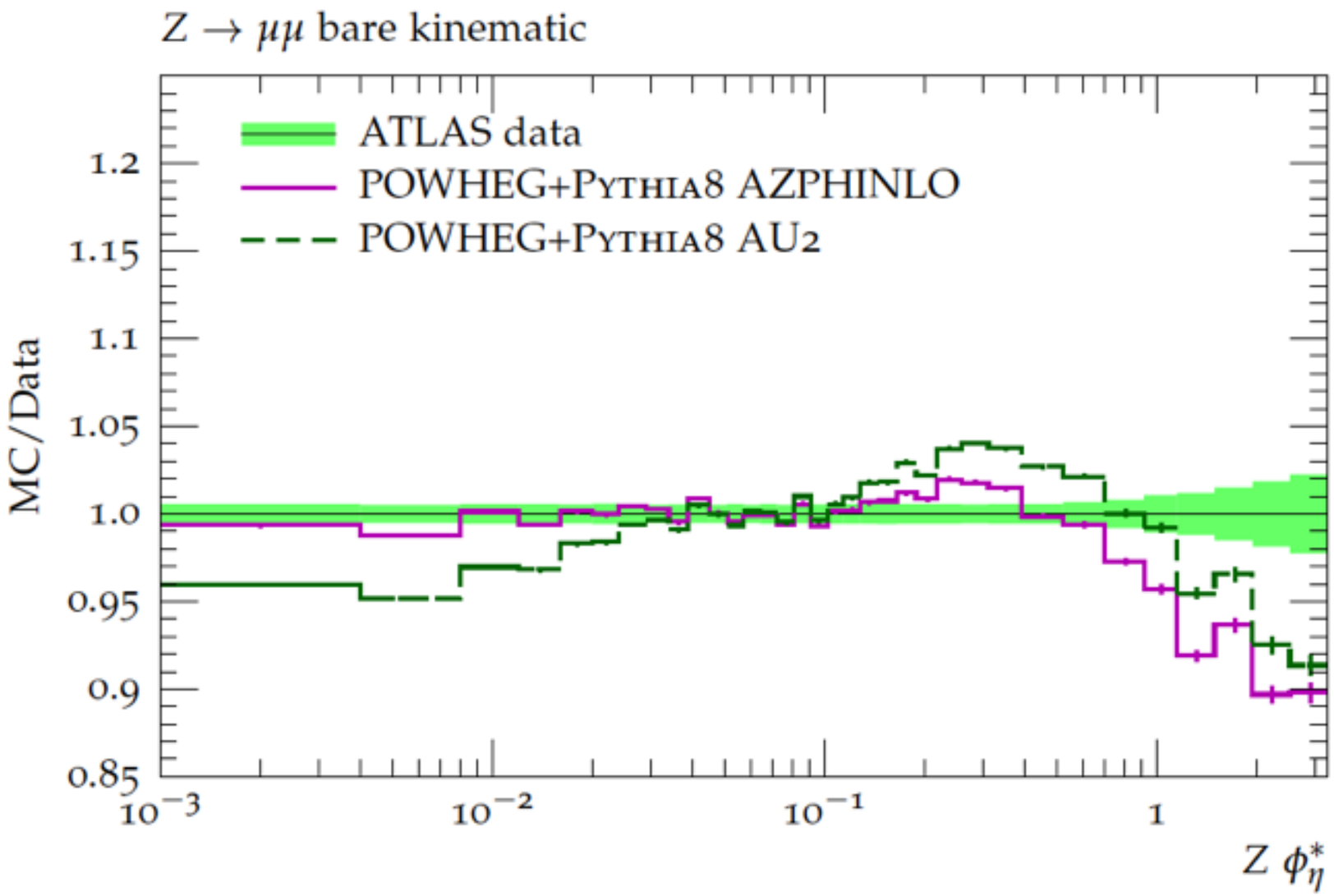
Φ* in Z/γ*



- Data compare to theory in 3 rapidity bins
- Central region is top left, with rapidity increasing clockwise

- A very precise measurement shows mostly good agreement with RESBOS, with SHERPA and ALPGEN also performing reasonably well
- MC@NLO has problems and only the latest POWHEG+PYTHIA8 is reasonable

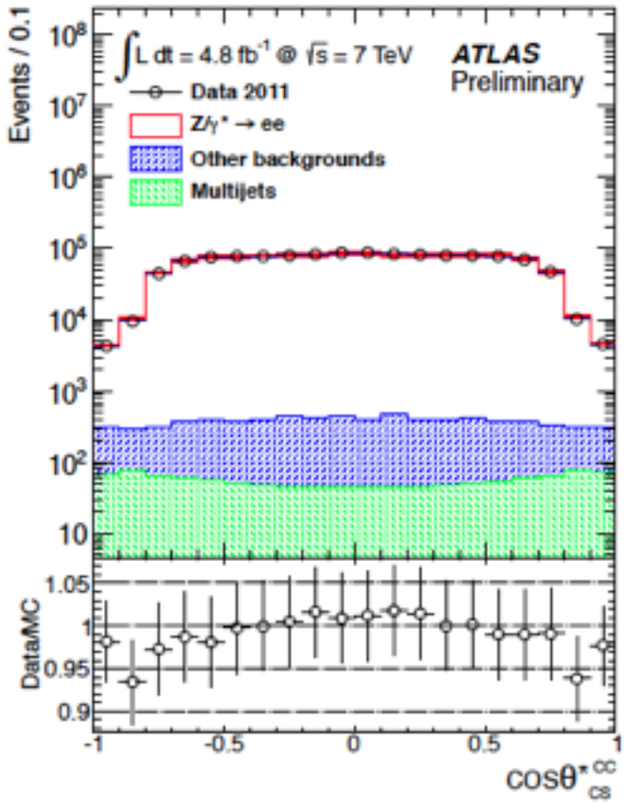
Φ* in Z/γ* - Tuning

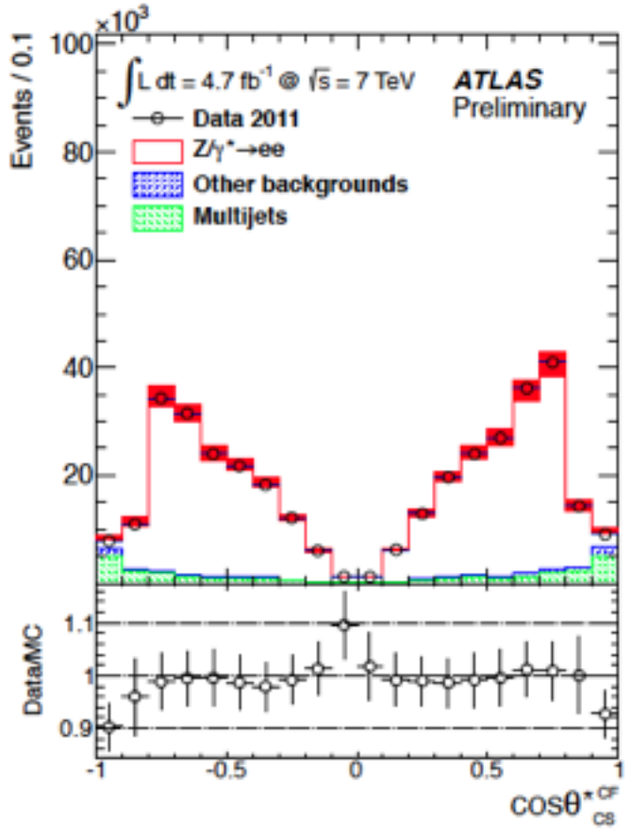


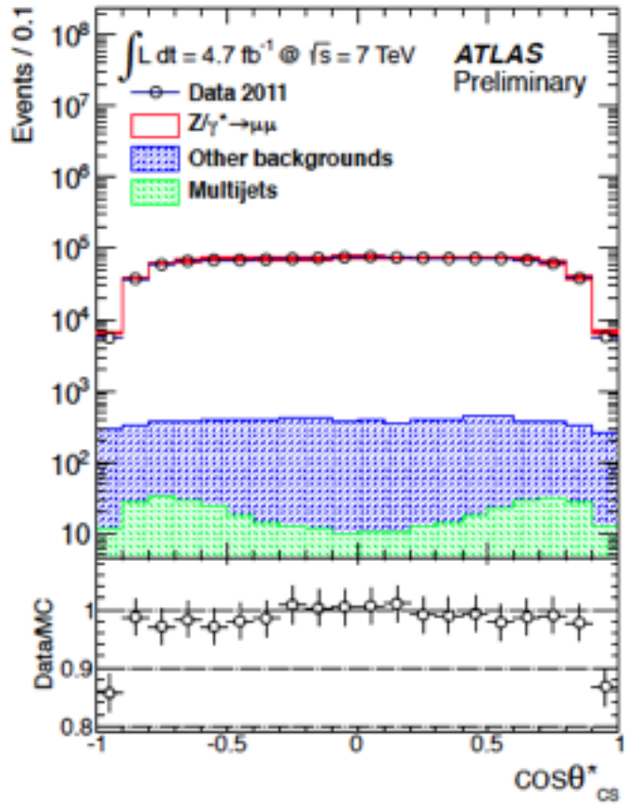
- Same data compared to the same POWHEG +PYTHIA8 tune (AU2)
- Use the data to tune the model and compare to that (AZPHINLO)

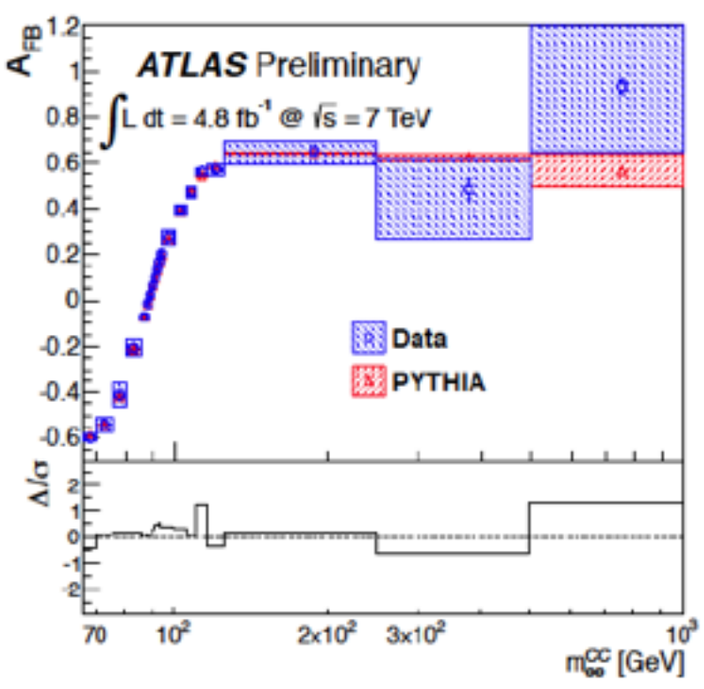
- The precise data have been used to tune the POWHEG+PYTHIA models, here focus on the POWHEG+PYTHIA8 result
- Much improved description, at the 1% level for most of the phase space

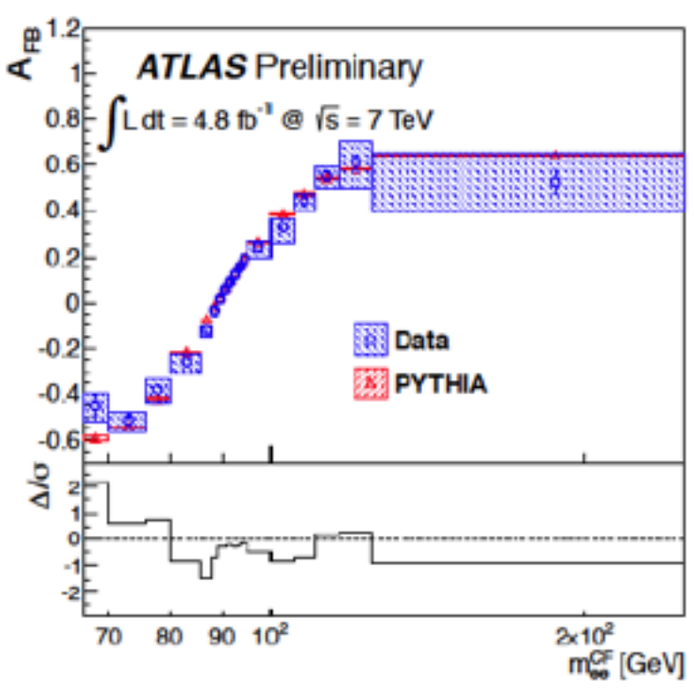
Forward-Backward Asymmetry

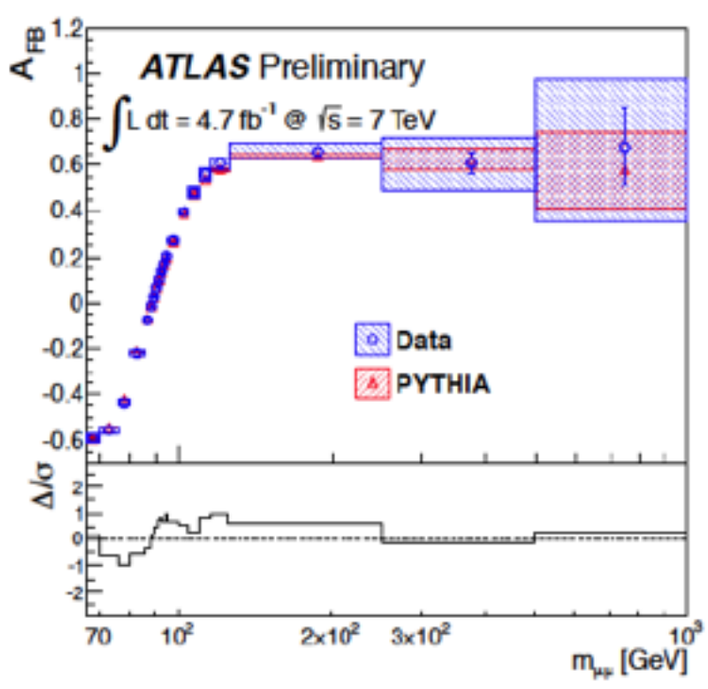






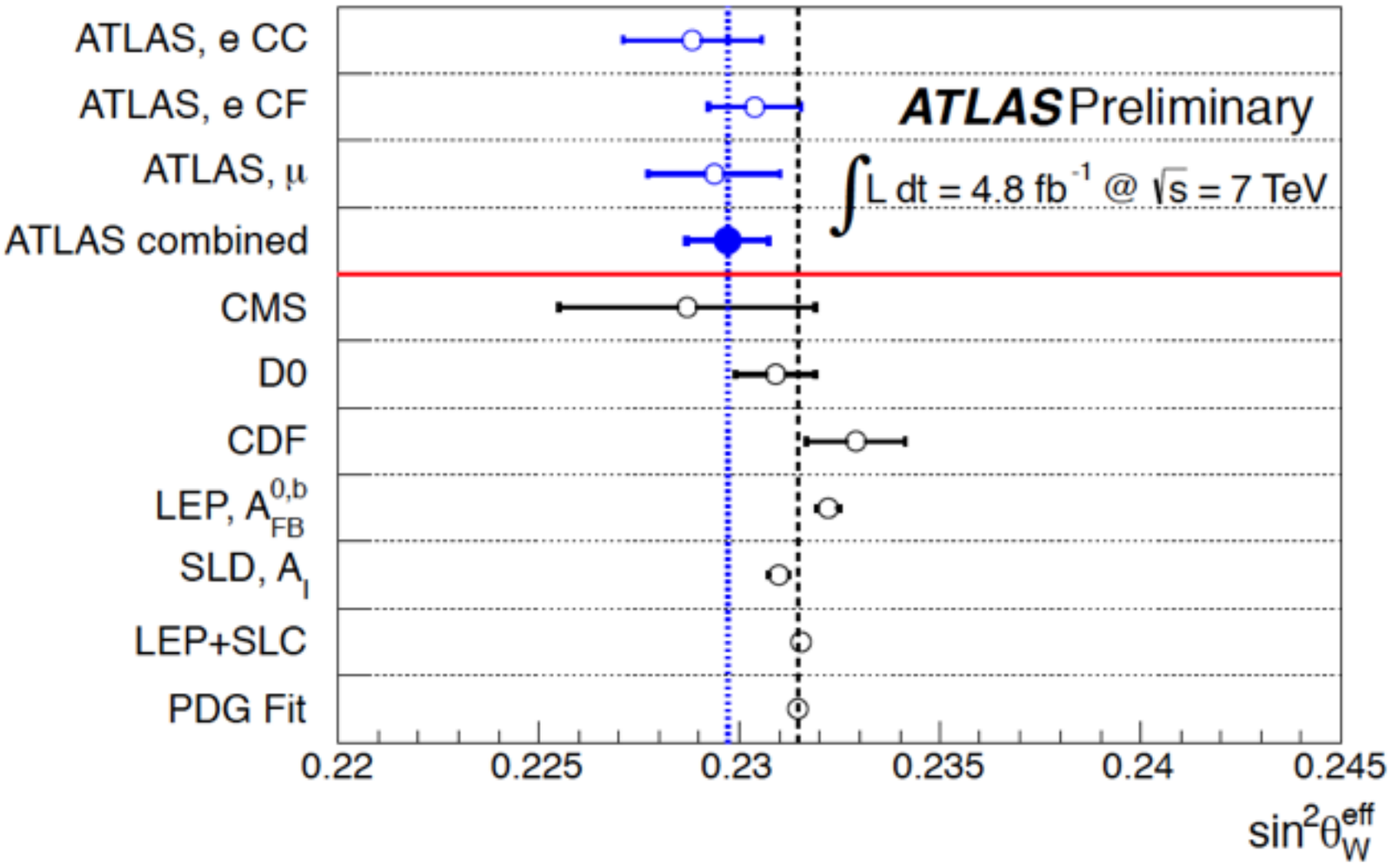






- Measure the decay angle cosθ* in the Collins-Soper rest frame
- Measurement of the Forward-Backward asymmetry compares well with Pythia

Forward-Backward Asymmetry

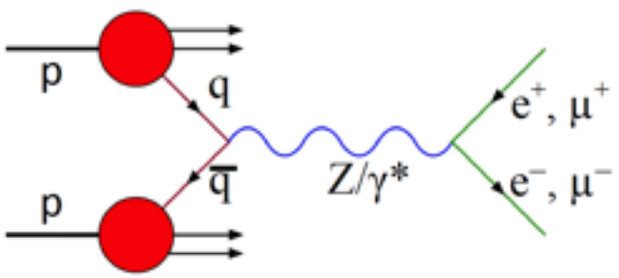


- Use the Forward-Backward asymmetry to extract the weak mixing angle
- MC templates with different input $\sin^2\Theta_W^{eff}$ values are fit to the data

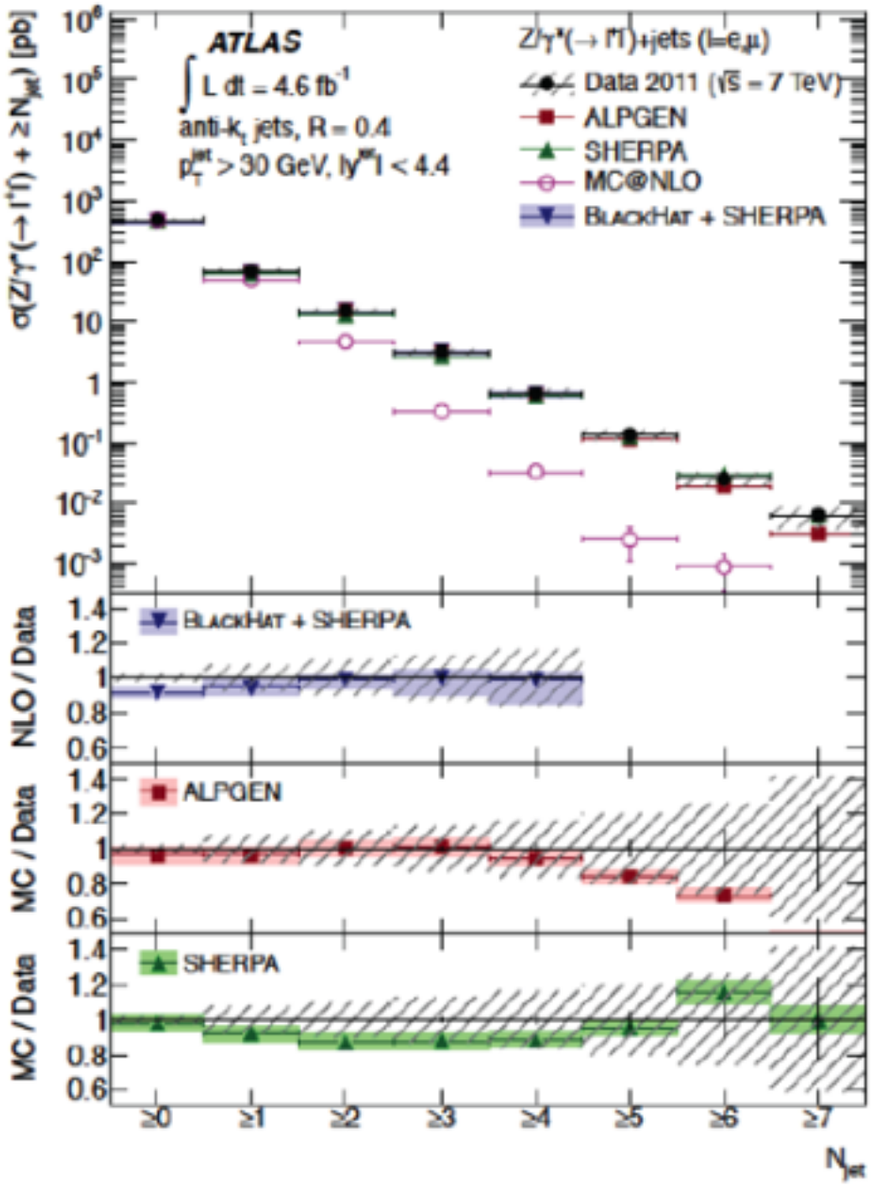
$$\sin^2\Theta_W^{eff}(\text{combined}) = 0.2297 \pm 0.0004\ (\text{stat}) \pm 0.0009\ (\text{syst})$$

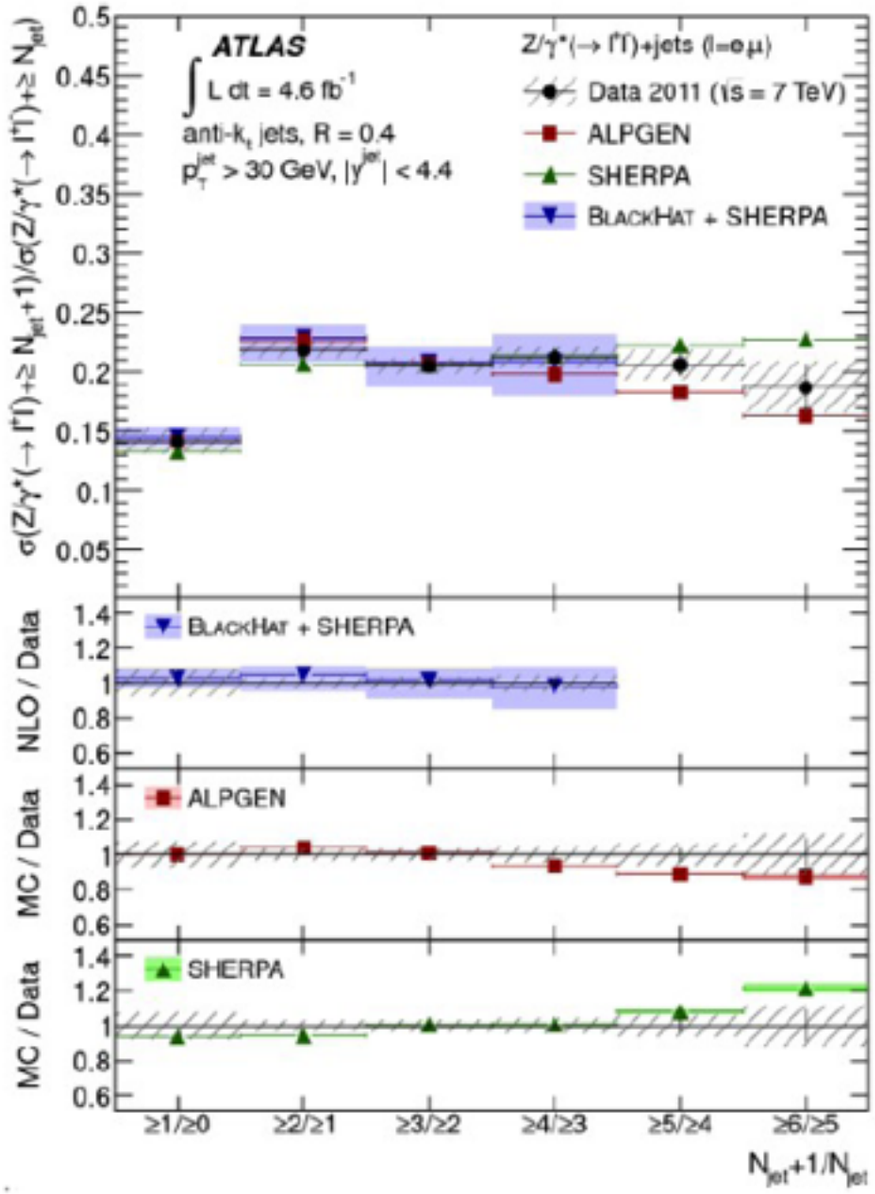
- Final uncertainty on $\sin^2\Theta_W^{eff}$ dominated by PDF uncertainty

Z+jets



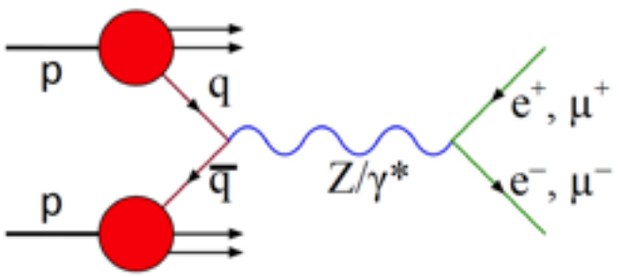
+ N_{jets}



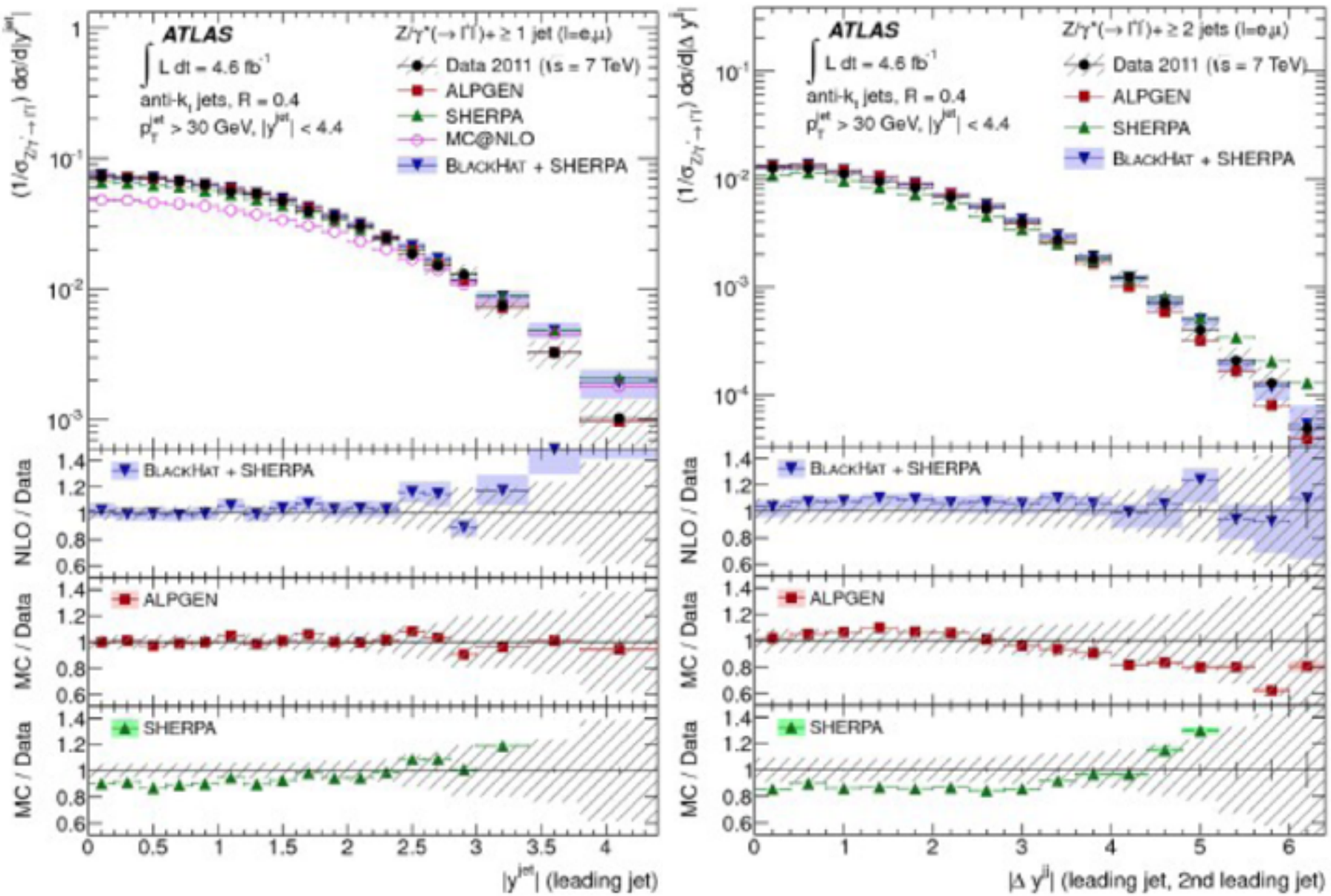


- Inclusive Z+jet cross sections measured and compared to model predictions
- Measured for increasing N_{jet} (left) and $N_{jet}+1/N_{jet}$ ratios (right)
- ALPGEN performs better at low multiplicity, SHERPA is better at high multiplicity

Z+jets

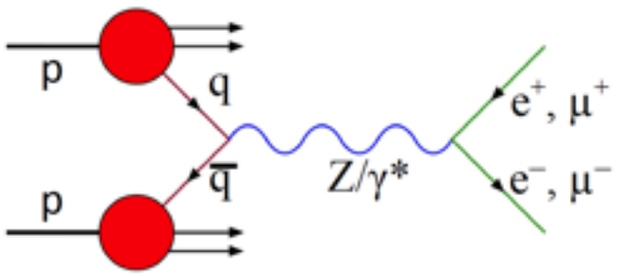


+ N_{jets}

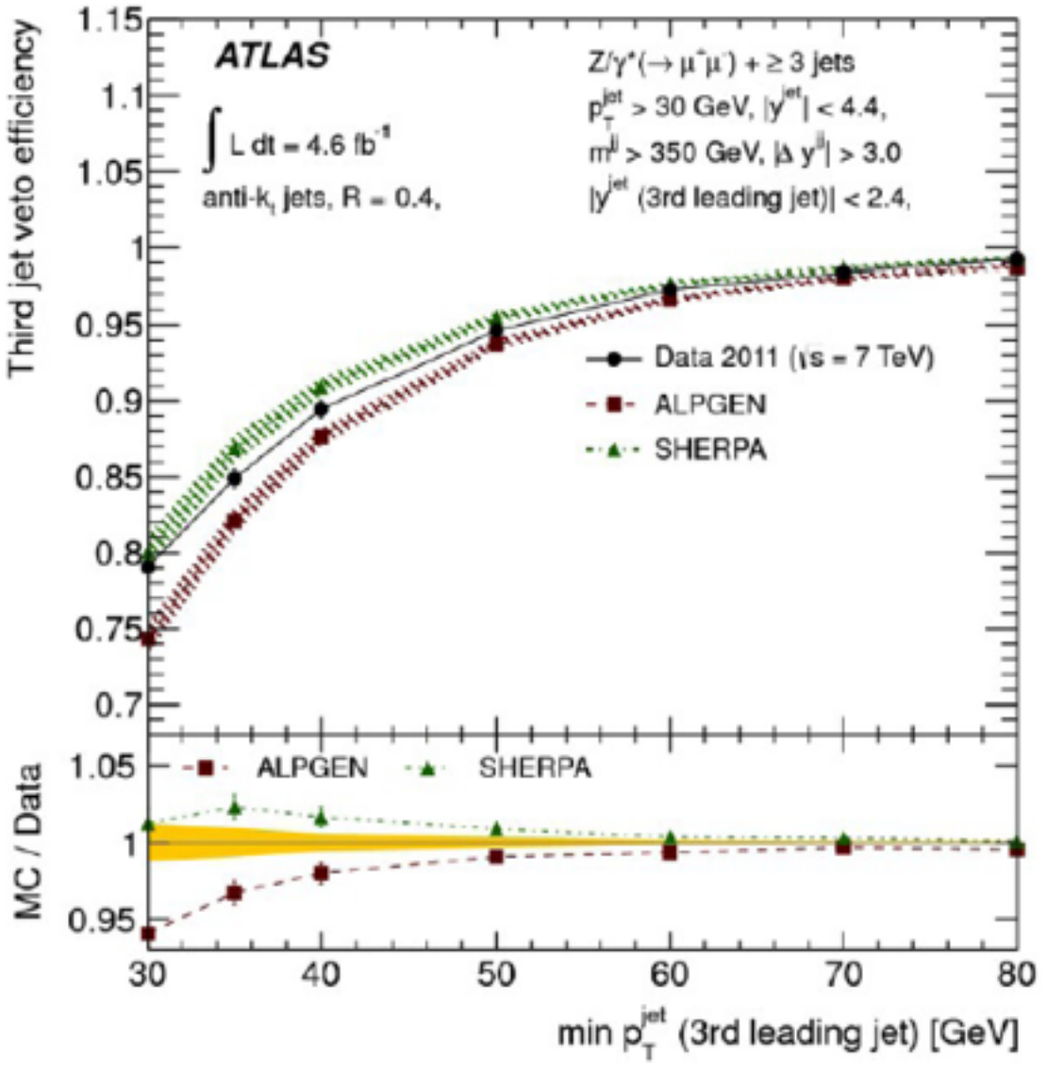


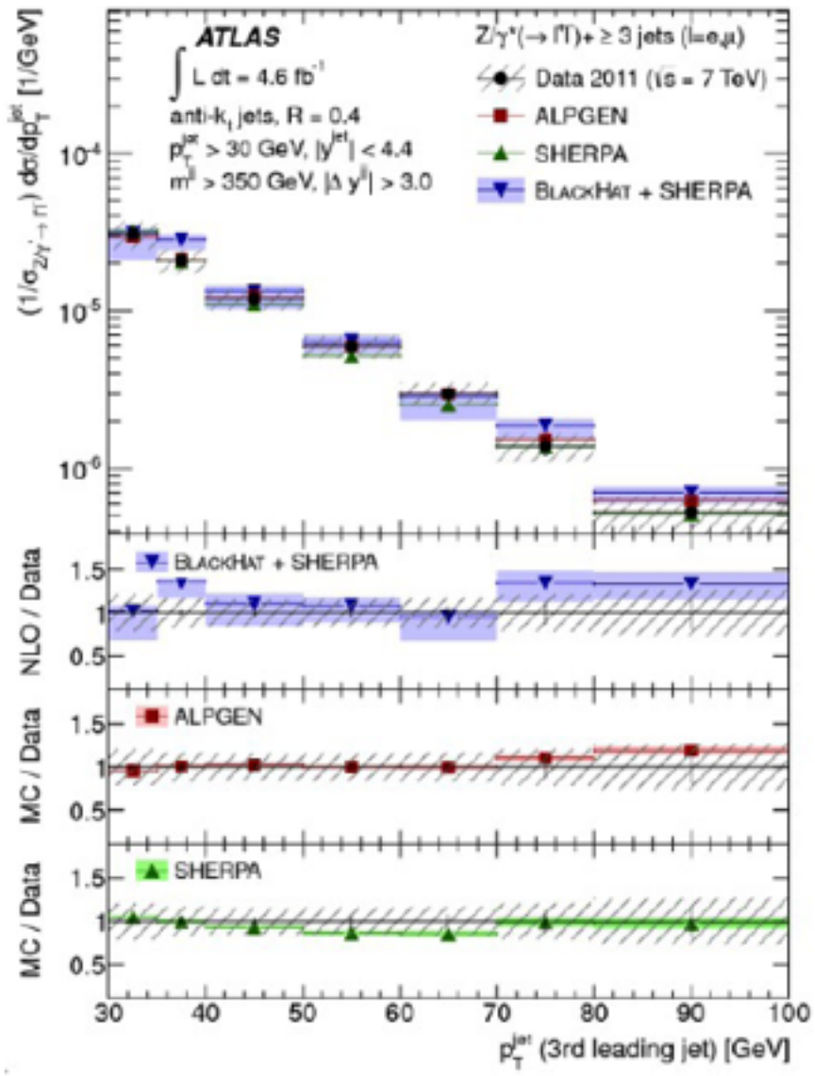
- Inclusive Z+1jet (left) and Z+2jet (right) cross sections measured as a function of jet rapidity and compared to the same models
- ALPGEN best for Z+1jet, but all models differ form data for Z+2jets

Z+jets



+ exactly 2_{jets}





- VBF Higgs analysis uses a veto on having a third jet in the event
  - Important to understand how well this veto is modelled
- Veto efficiency (left) is well described by SHERPA, reasonably well by ALPGEN but differences of a few% at low p_T
- The p_T of the third leading jet (right) seen to be the same few% below the data at the lowest p_T studied

Summary

- Many measurements of vector bosons and vector bosons + jets presented, only considering the 7 TeV 5fb^{-1} 2011 Atlas dataset

- PDF sensitivity seen in W+c (s and s/$\bar{s}$ asymmetry) and W+b measurements (FNS)
- Drell Yan at high mass consistent with all PDFs but improvements in precision in the future could yield constraints

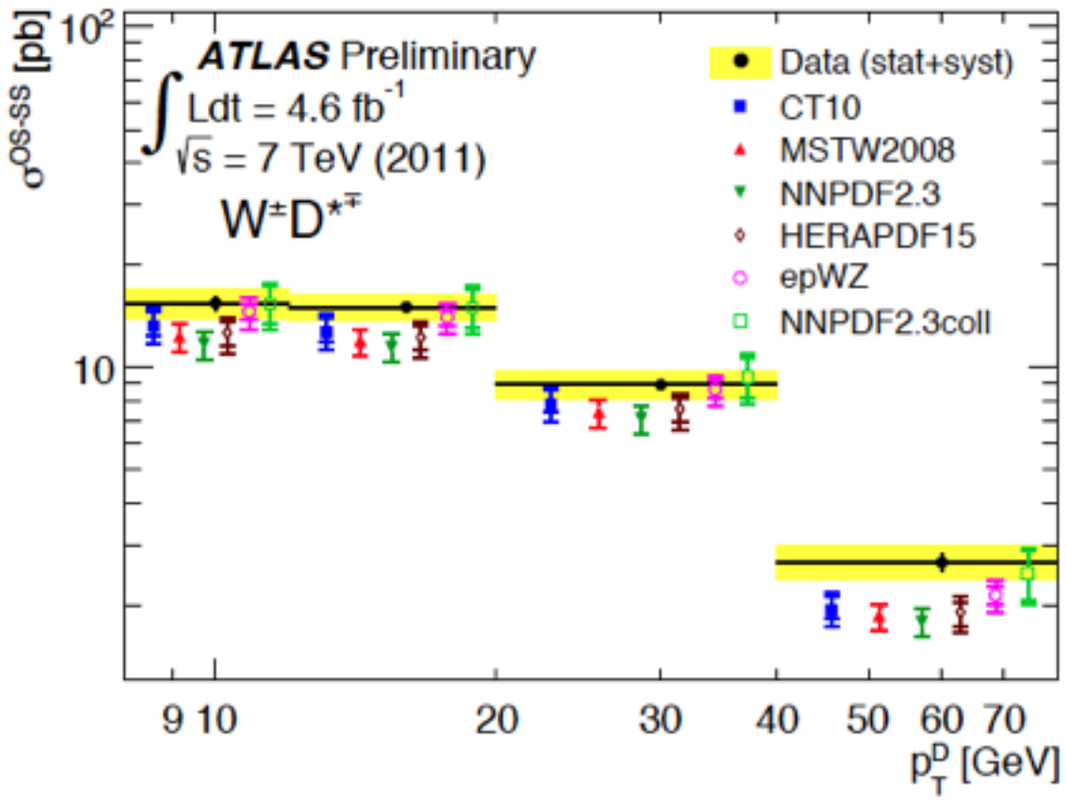
- Φ^* in Z/γ^* probes dynamics at low p_T with very good precision (~0.3% stat. and 0.1-0.3% syst.)
- Data used to tune POWHEG+PYTHIA models with good results

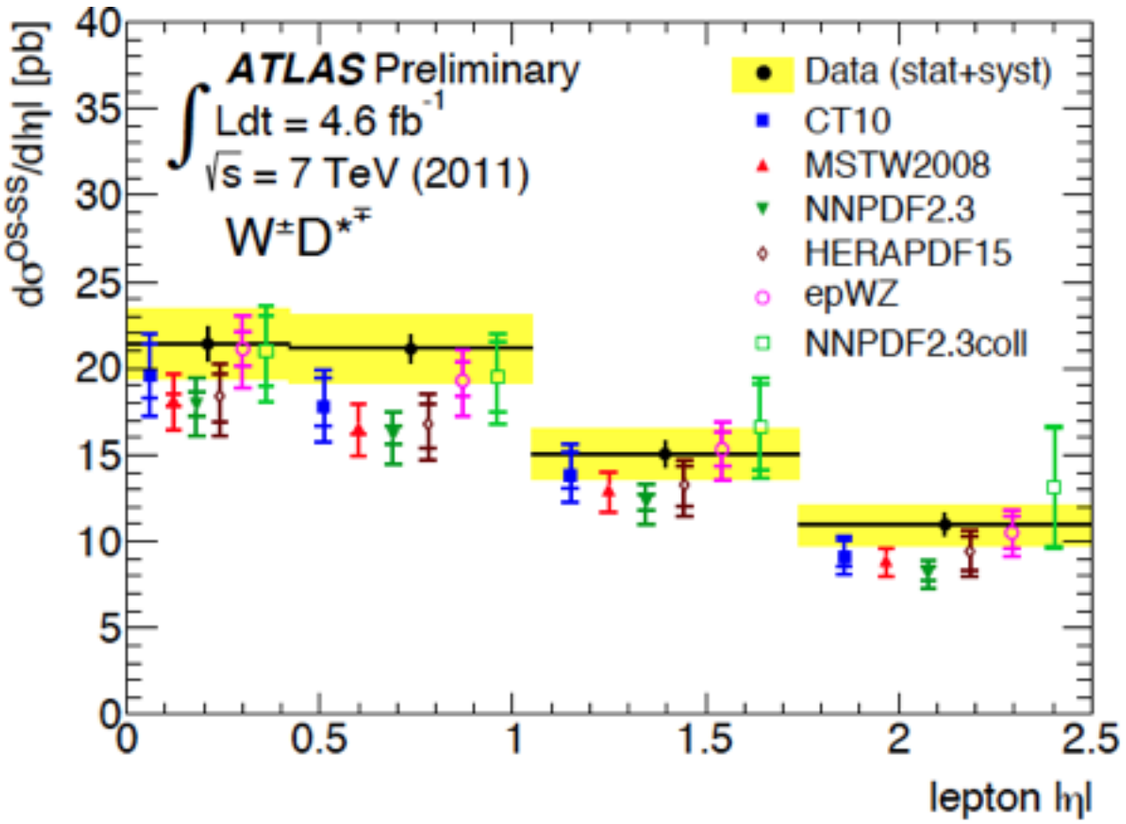
- Forward-backward asymmetry in Z/γ^* leads to an extraction of $\sin^2\Theta_W^{eff}$

- High precision Z+jets data used to test models as a function of jet multiplicity and to test models when exclusive jet multiplicity selections are used (e.g. VBF Higgs)

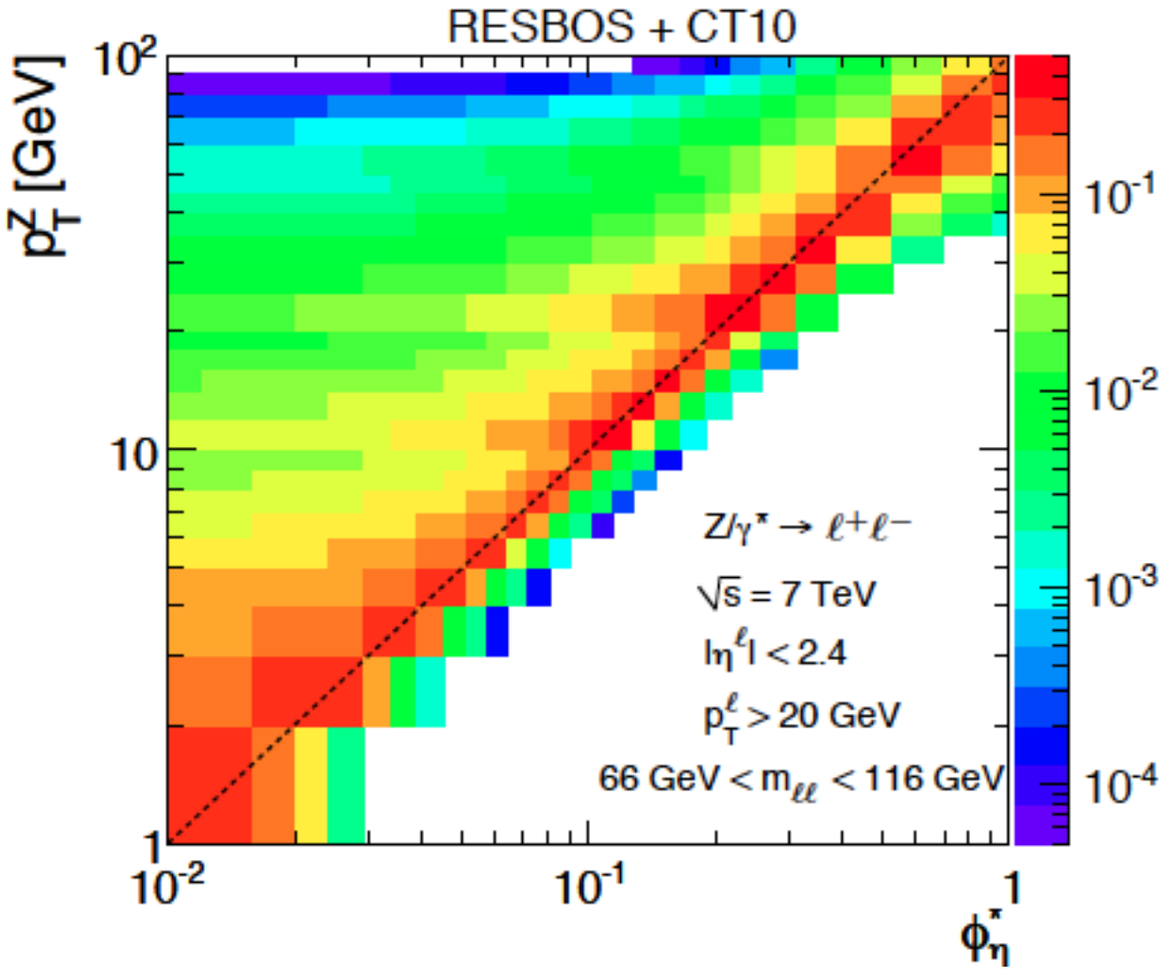
Backup

W+c PDF sensitivity





Φ^*



- Strong correlation between p_T^Z and Φ^*