



Single Boson Production and Electroweak Processes at LHC with the ATLAS detector

Dimitra Tsionou

On behalf of the ATLAS Collaboration

IRFU CEA/Saclay

2-7 June LHCP 2014, New York

Overview

- ▶ Z p_T measurement
- ▶ Z +jets production
- ▶ High m_{ll} Drell-Yan
- ▶ Low m_{ll} Drell-Yan

Z production

- ▶ $Z \rightarrow 4l$

Z rare decays

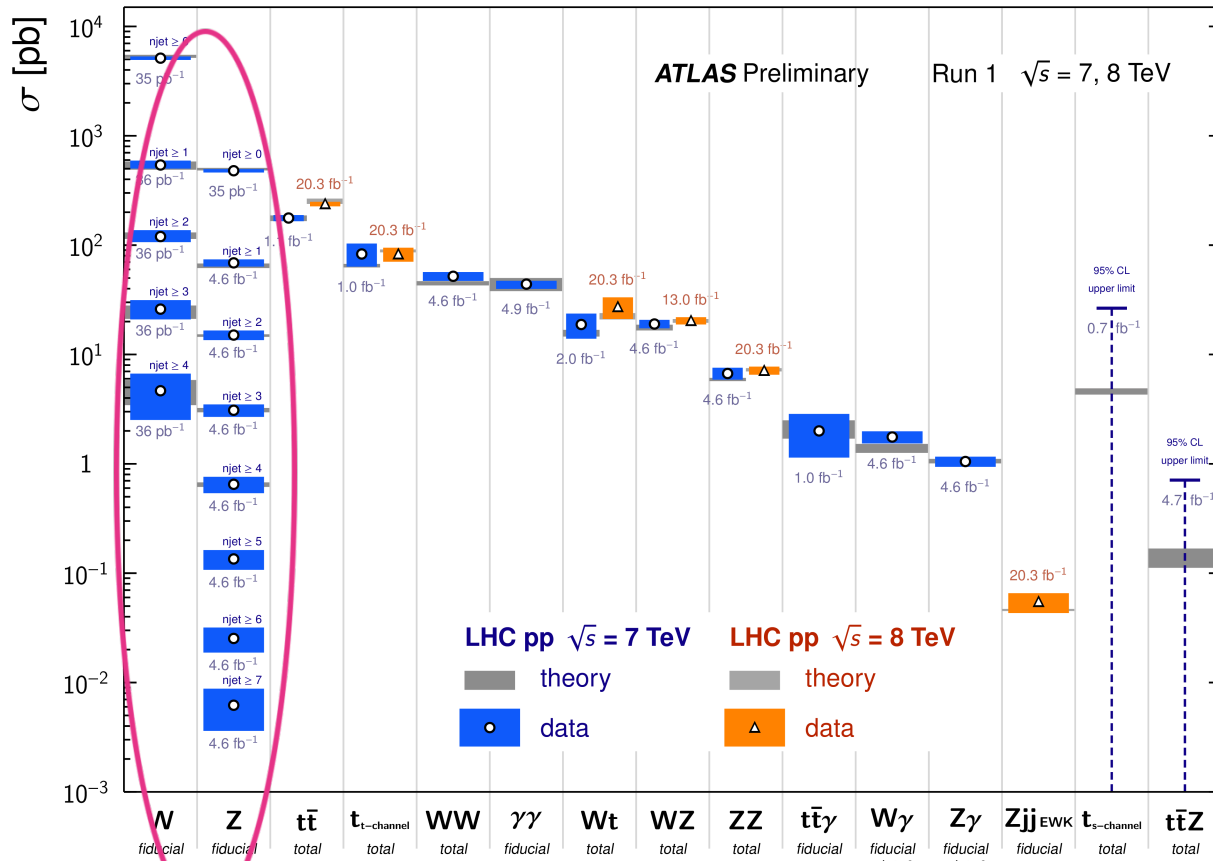
- ▶ $W+c$ / $W+D$

W production

Why W/Z measurements?

Standard Model Production Cross Section Measurements

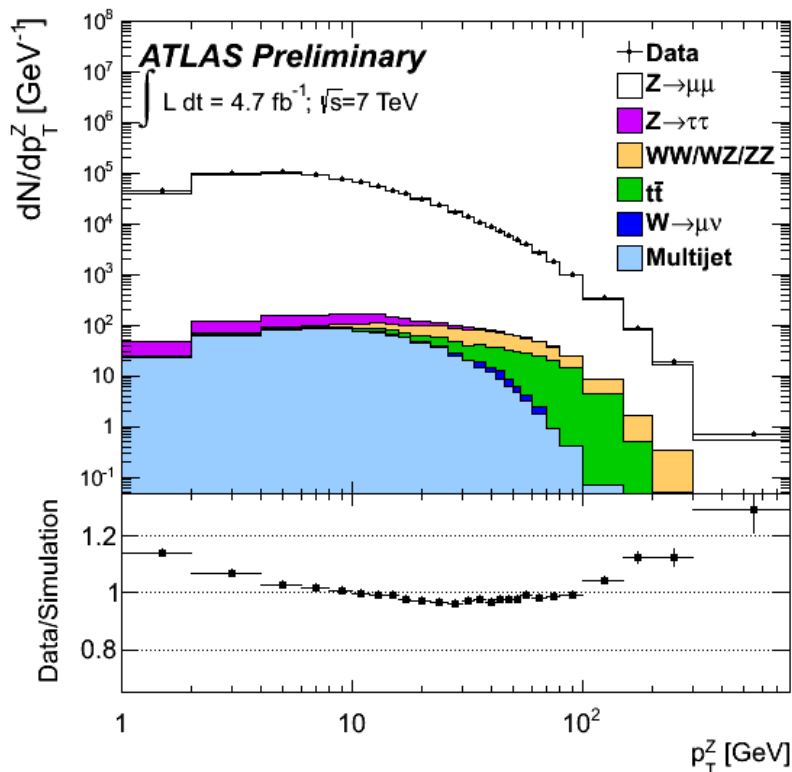
Status: March 2014



- ▶ Tests on perturbative QCD and EWK
- ▶ Constrain parton density functions of protons
- ▶ Background to Higgs and many New Physics phenomena
- ▶ Benchmark processes for detector calibration

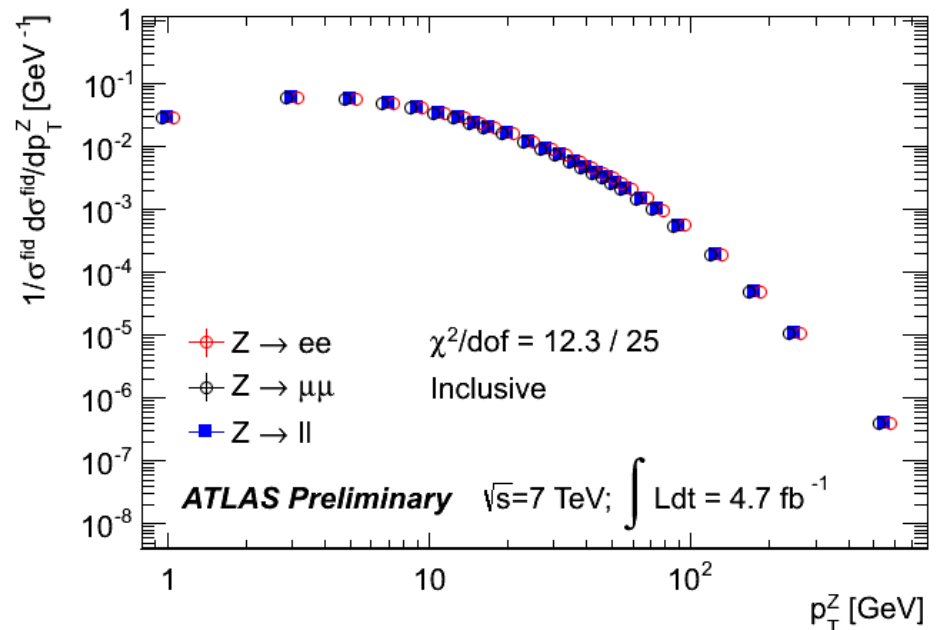
Measurement of the Z/γ^* transverse momentum

- ▶ Motivation → Measurement of W mass
- ▶ Very clean signature and high cross section



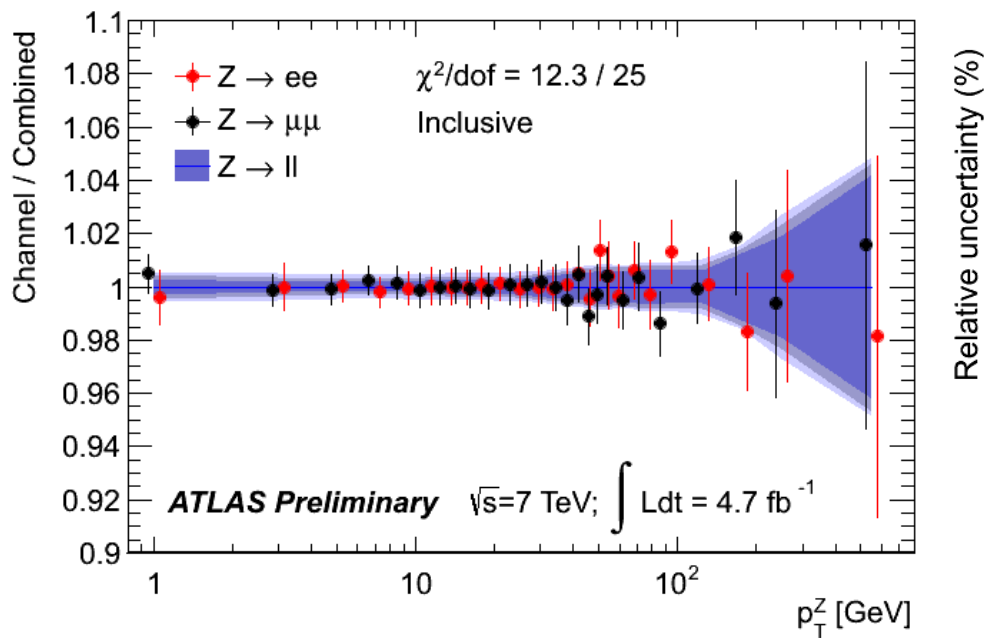
- ▶ Measurement in fiducial region

▶ $p_{T,l} > 20 \text{ GeV}, 66 < m_{ll} < 116, |\eta| < 2.4$

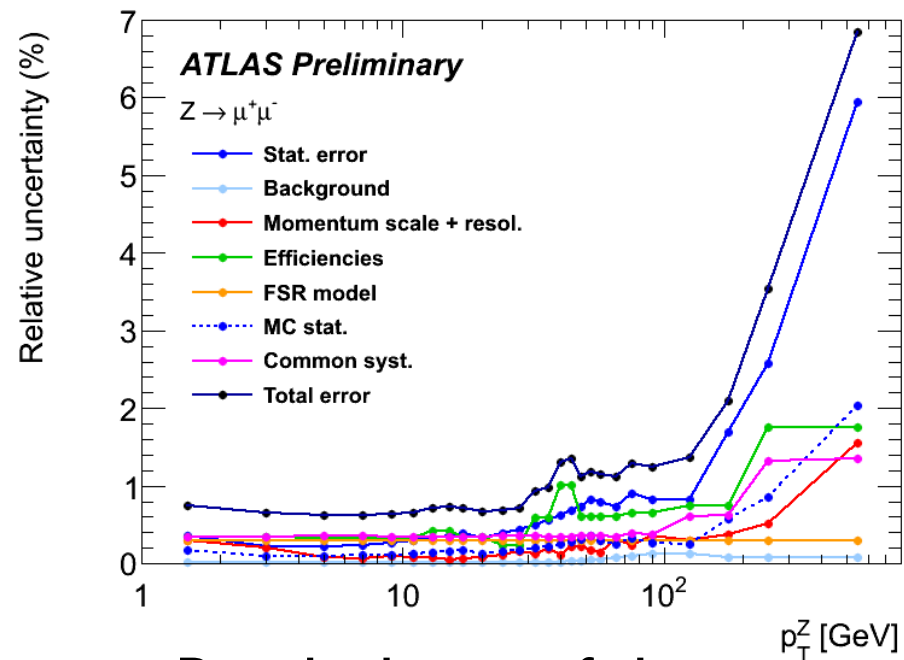


Measurement of the Z/γ^* transverse momentum

- ▶ Measurement in fiducial region
 - ▶ $p_{T,l} > 20$ GeV, $66 < m_{ll} < 116$, $|\eta| < 2.4$



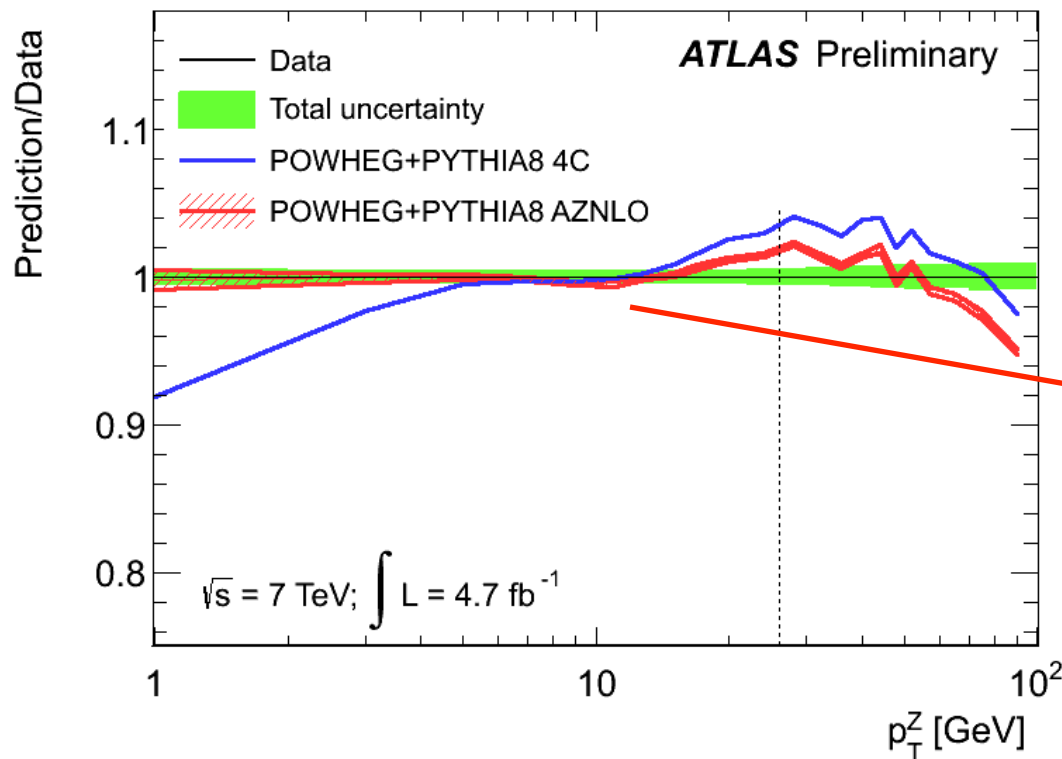
- ▶ 0.5% precision up to 30 GeV



- ▶ Break-down of the systematic uncertainties

Measurement of the Z/γ^* transverse momentum

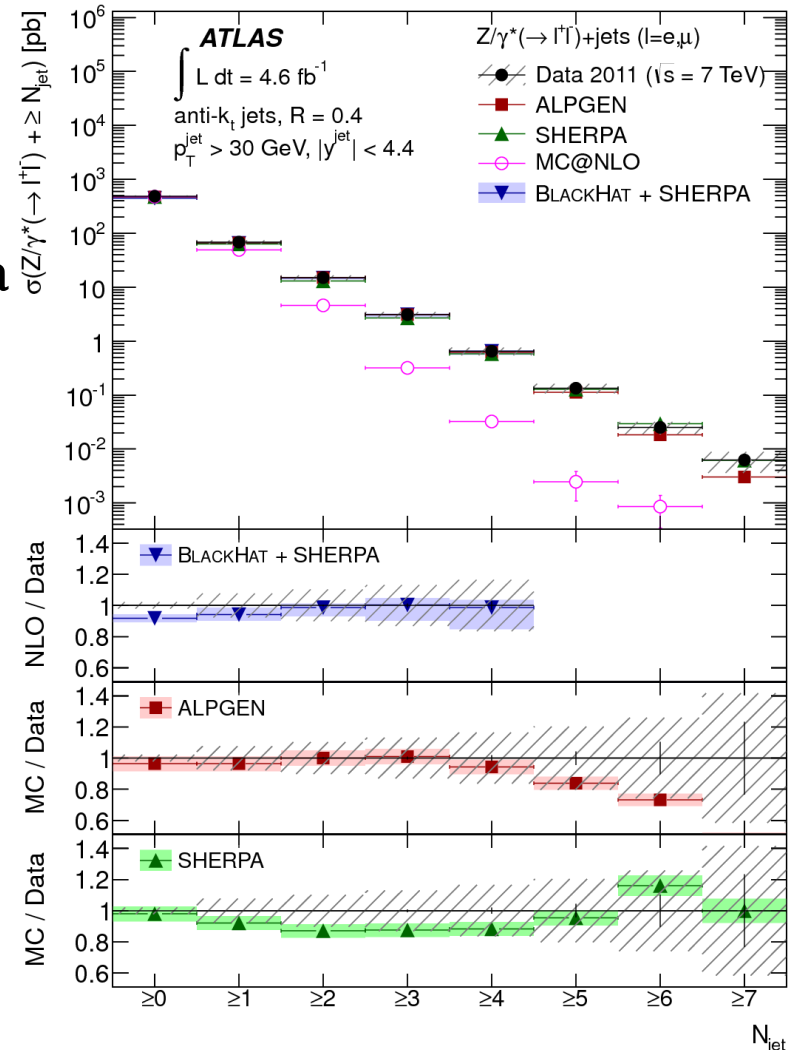
- ▶ Needed for MC tuning \rightarrow W mass measurement



PowhegPythia
description of p_T^Z
after tuning

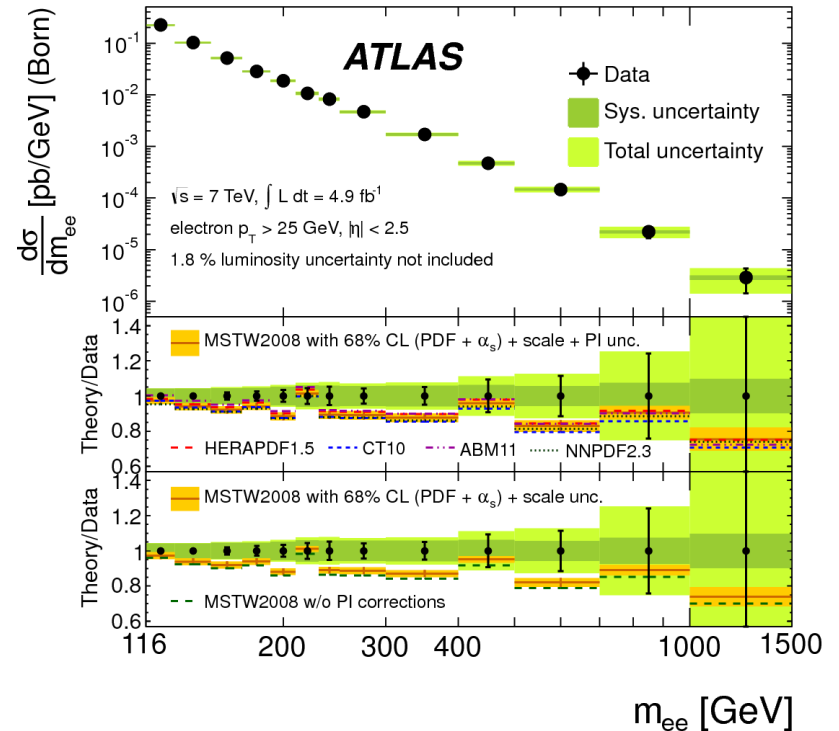
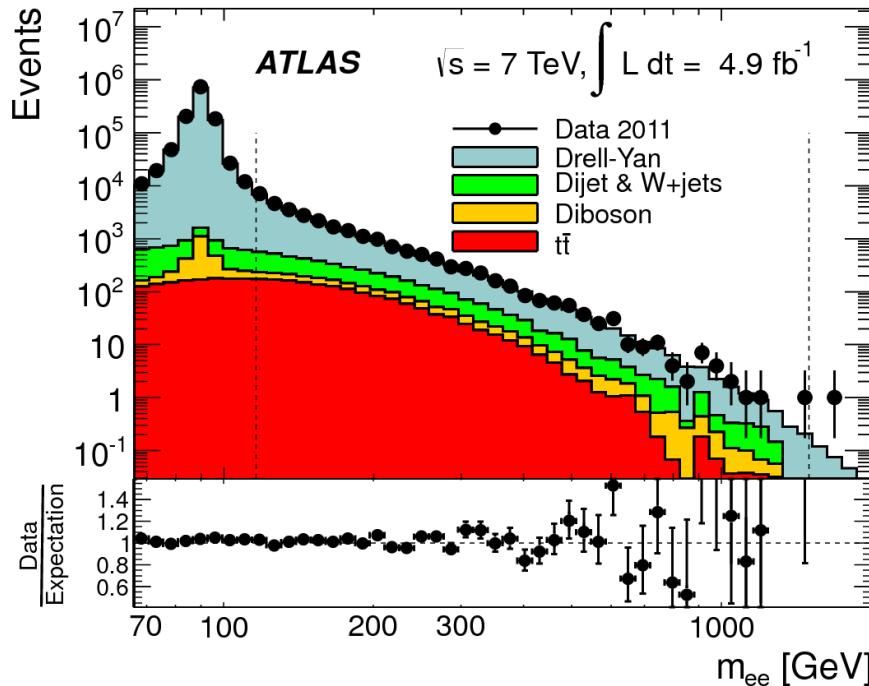
Z+jets Production

- ▶ Measurement possible for high jet multiplicity and also for high energy regime
- ▶ Good agreement with BlackHat+Sherpa
- ▶ Alpgen, Sherpa describe the data
- ▶ MC@NLO fails to predict the jet multiplicity
- ▶ Unfolded data compared to
 - ▶ BlackHat+Sherpa (NLO)
 - ▶ Alpgen+Herwig (up to 5 partons at ME level + PS, CTEQ6L PDF)
 - ▶ Sherpa (up to 5 partons at ME level +PS, CT10)
 - ▶ MC@NLO (1 additional parton + PS, CT10)



High m_{11} Drell-Yan Production

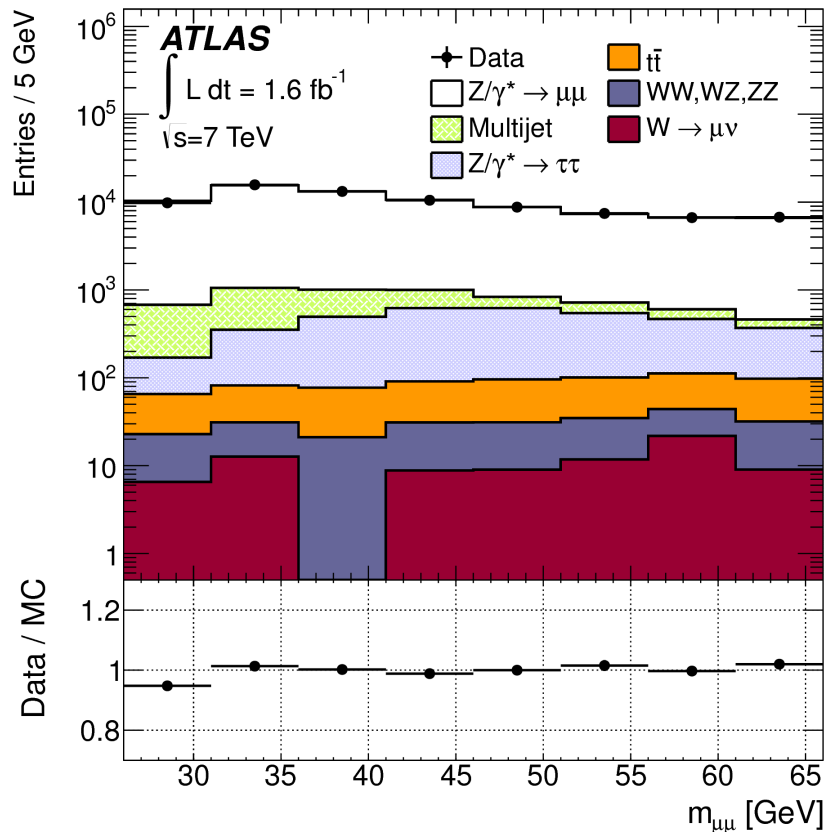
- ▶ Mass spectrum sensitive to PDFs (antiquarks at large x)



- ▶ Comparison with NNLO prediction from FEWZ
- ▶ Tension in low region but still compatible with data

Low m_{ll} Drell-Yan Production

- ▶ Low m_{ll} Drell-Yan production dominated by electromagnetic coupling of $q\bar{q}$ to virtual photons



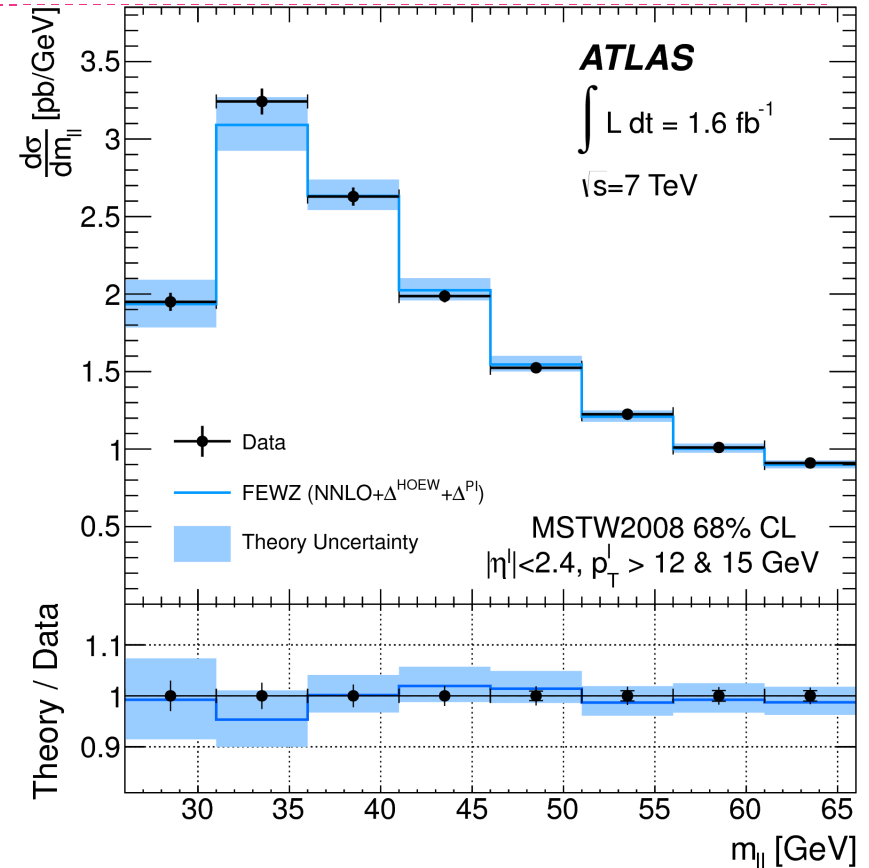
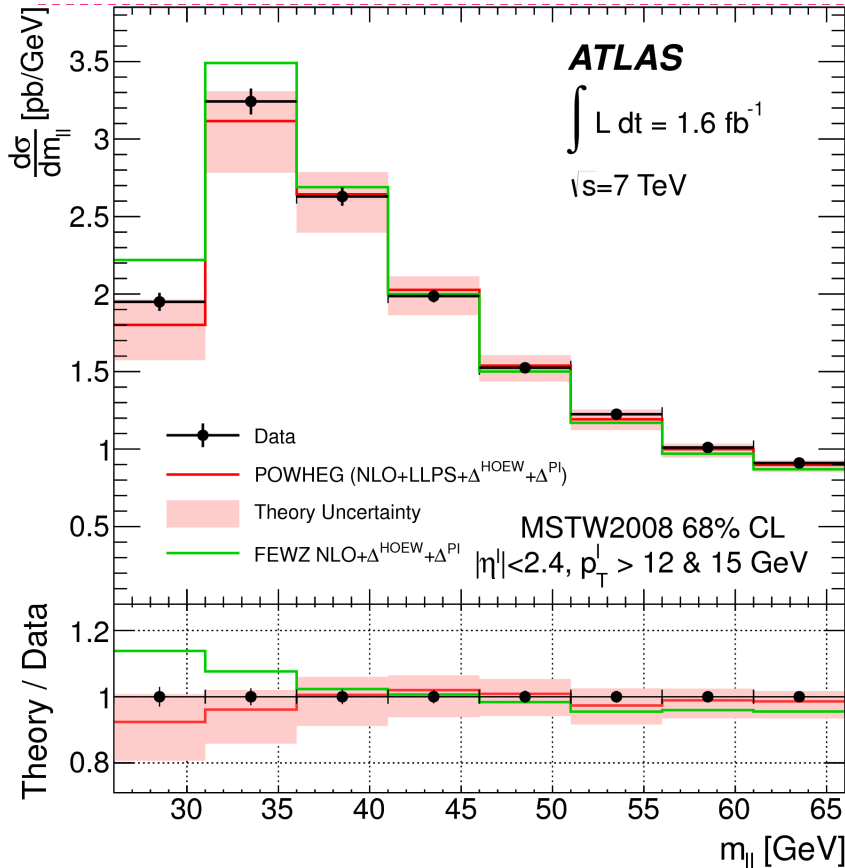
▶ Nominal analysis

- ▶ 2011 data, 1.6 fb^{-1} (trigger requirements), electron & muon channels
- ▶ $26 < m_{ll} < 66 \text{ GeV}$, $|\eta| < 2.4$, $p_T > 15/12 \text{ GeV}$

▶ Extended analysis

- ▶ 2010 data, 35 pb^{-1} , muon channel
- ▶ $12 < m_{ll} < 66 \text{ GeV}$, $|\eta| < 2.4$, $p_T > 9/6 \text{ GeV}$

Low m_{ll} Drell-Yan Production (2)



- Compared to FEWZ (N)NLO and Powheg (NLO+LL parton shower)
- Good description of data within theoretical uncertainties

Z → 4l Cross Section Measurement

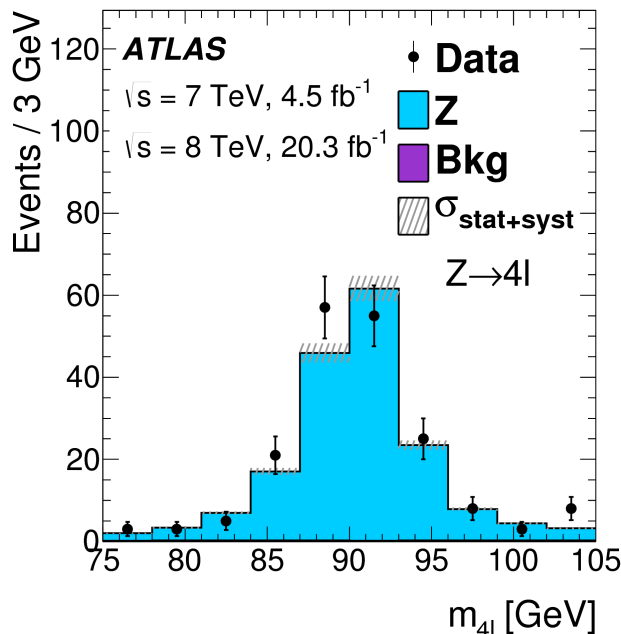
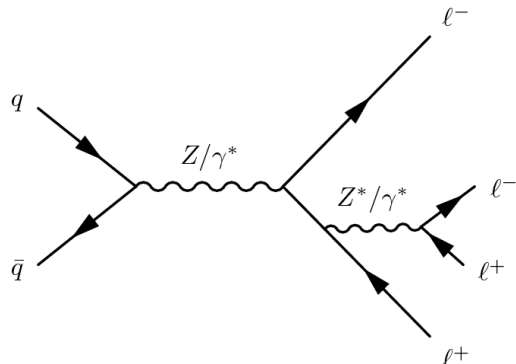
- ▶ Z → 4l production cross section in $m_{ll} > 5$ GeV and $80 < m_{4l} < 100$ GeV

	Cross section [fb] @ 7 TeV
Measured	76 ± 18 (stat) ± 4 (syst) ± 1.4 (lumi)
Theory	90.0 ± 2.1

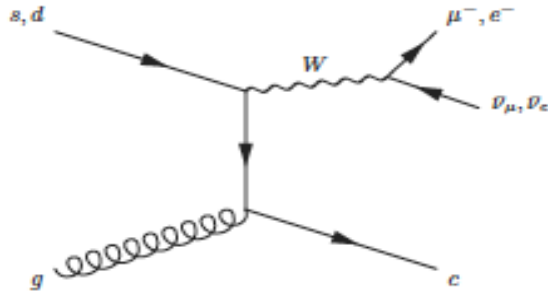
	Cross section [fb] @ 8 TeV
Measured	107 ± 9 (stat) ± 4 (syst) ± 3.0 (lumi)
Theory	104.8 ± 2.5

- ▶ Branching fraction for Z → 4l

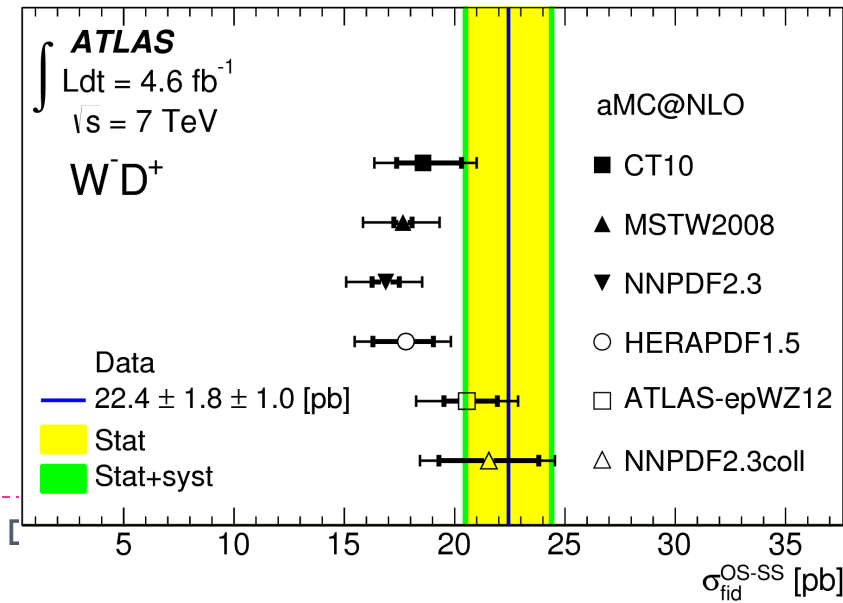
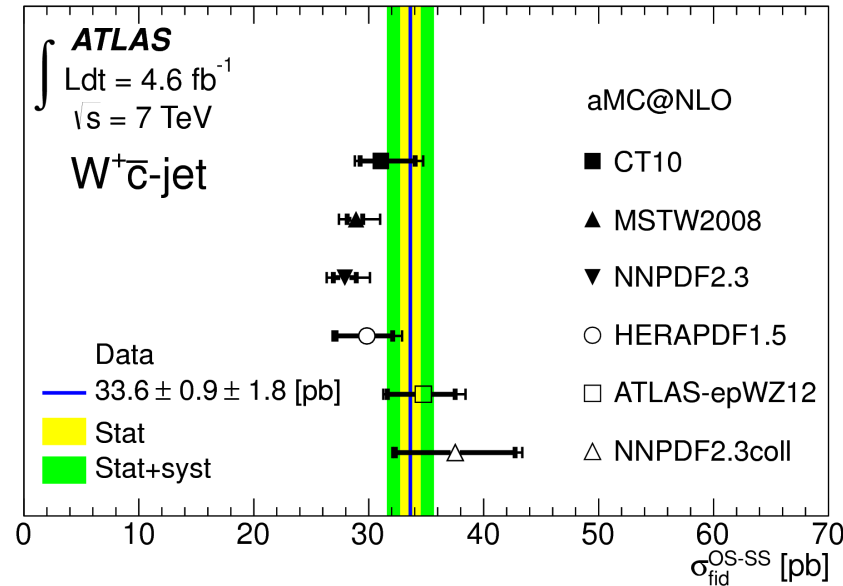
Measured	$(3.20 \pm 0.25$ (stat) ± 0.13 (syst)) $\times 10^{-6}$
Theory	$(3.33 \pm 0.01) \times 10^{-6}$



$W+c$ / $W+D^{(*)}$ Production

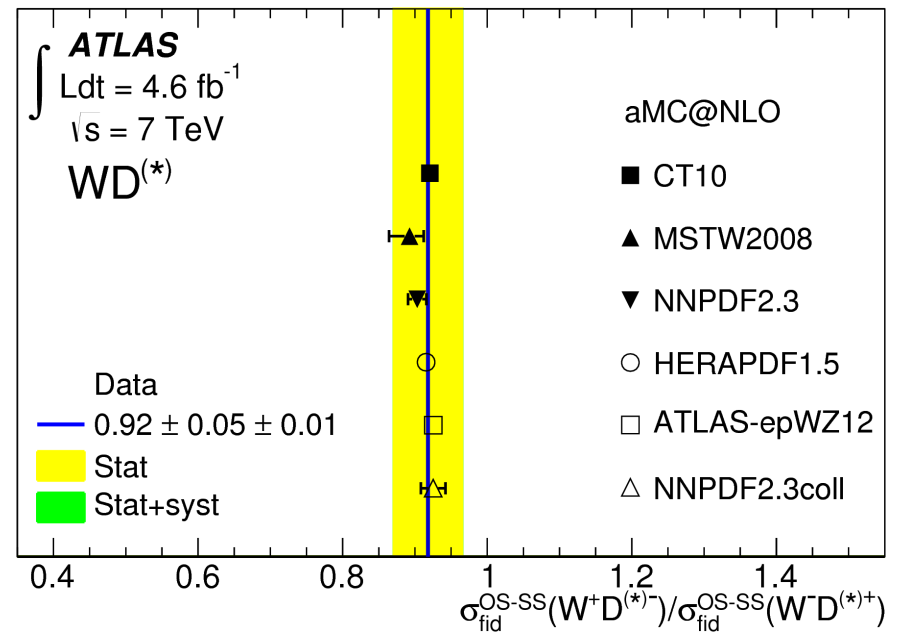
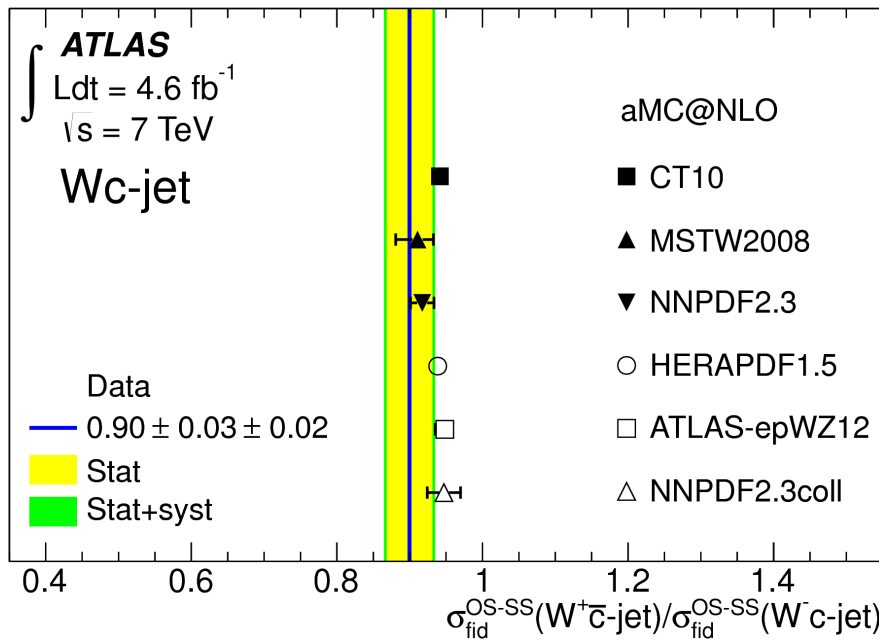


- ▶ Directly sensitive to s-quark PDF
- ▶ Analysis looking for $W+c$ jet and $W+D^{(*)}$ mesons
- ▶ (Opposite – Same) Sign pairs studied
- ▶ Data better described with PDF with unsuppressed s-quark distribution (ATLAS-epW12, NNPDF2.3coll)



W+c / W+D(*) Production

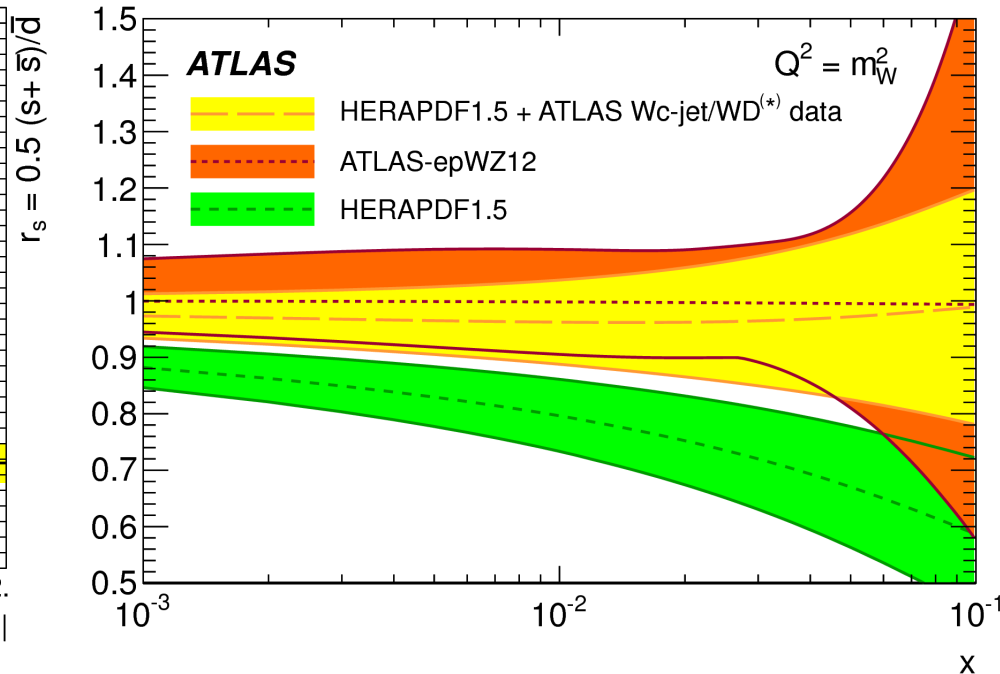
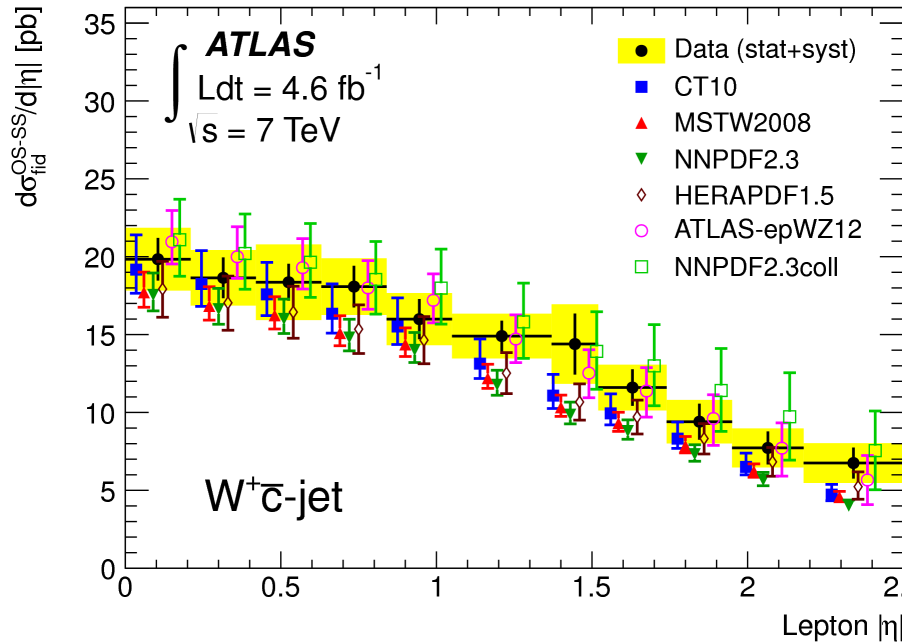
- ▶ Charge asymmetry measured for the W+c jet and W+D(*) production



- ▶ Data in good agreement of the prediction of aMC@NLO with different PDF sets

W+c / W+D^(*) Production

- ▶ Differential cross section as a function of lepton pseudorapidity
- ▶ Use W+c/W+D^(*) data to fit the strange-to-down sea quark distributions
 - ▶ s/sbar-quark density suppressed compared to dbar-quark density for HERAPDF1.5
 - ▶ ATLAS data favour a symmetric light-quark density over the whole x-range of the measurement

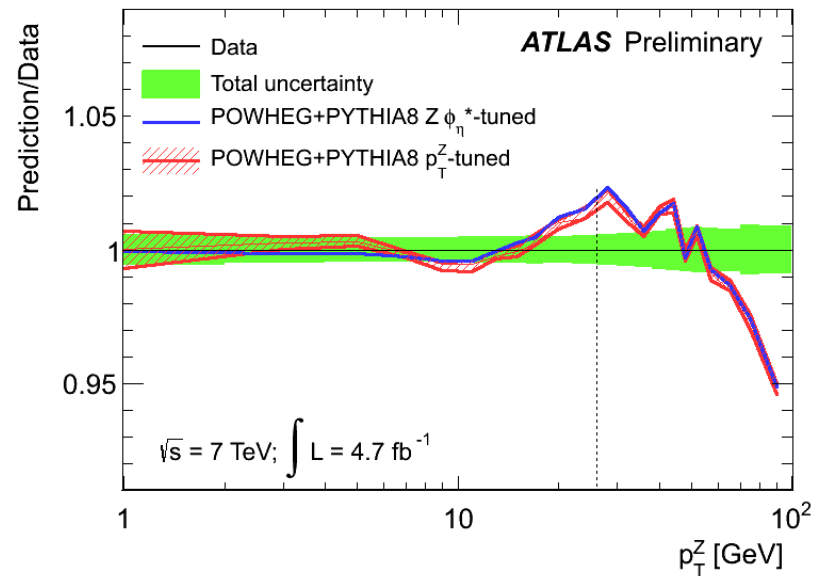
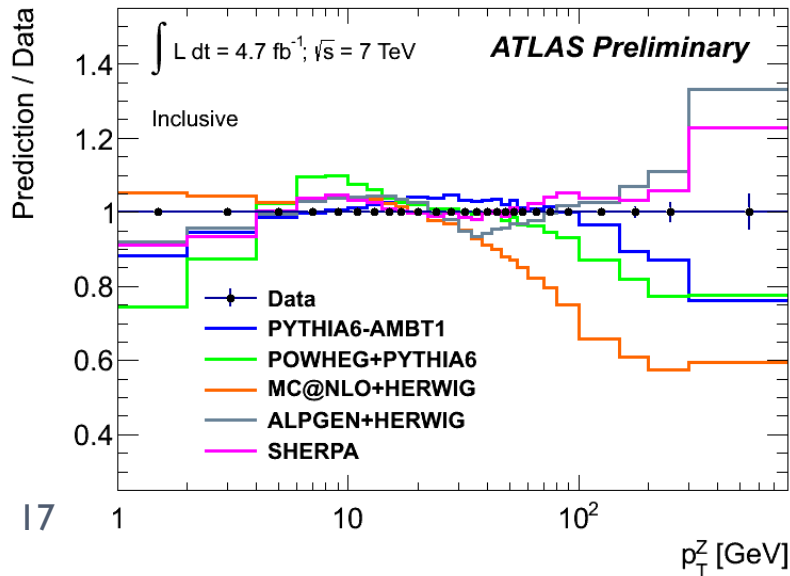
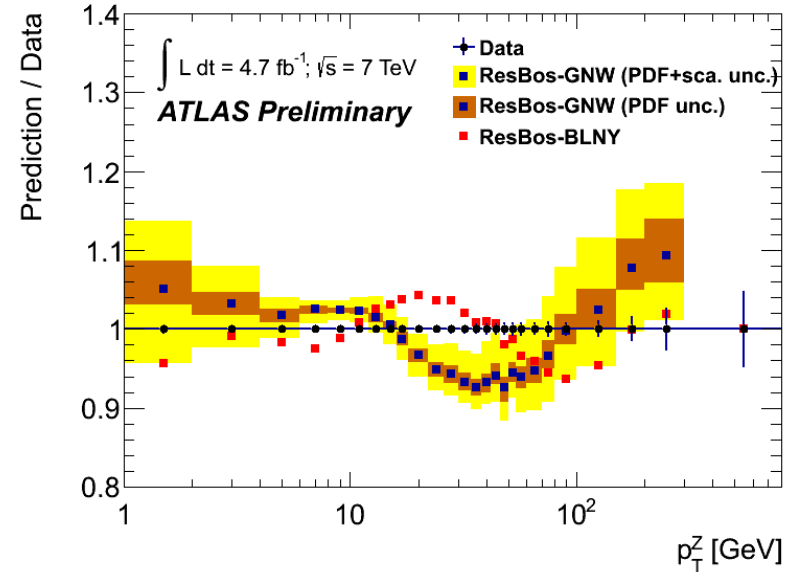
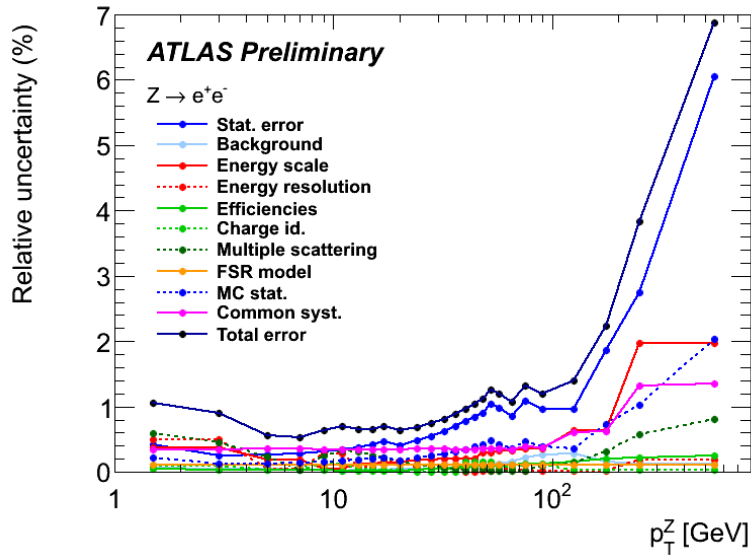


Conclusions

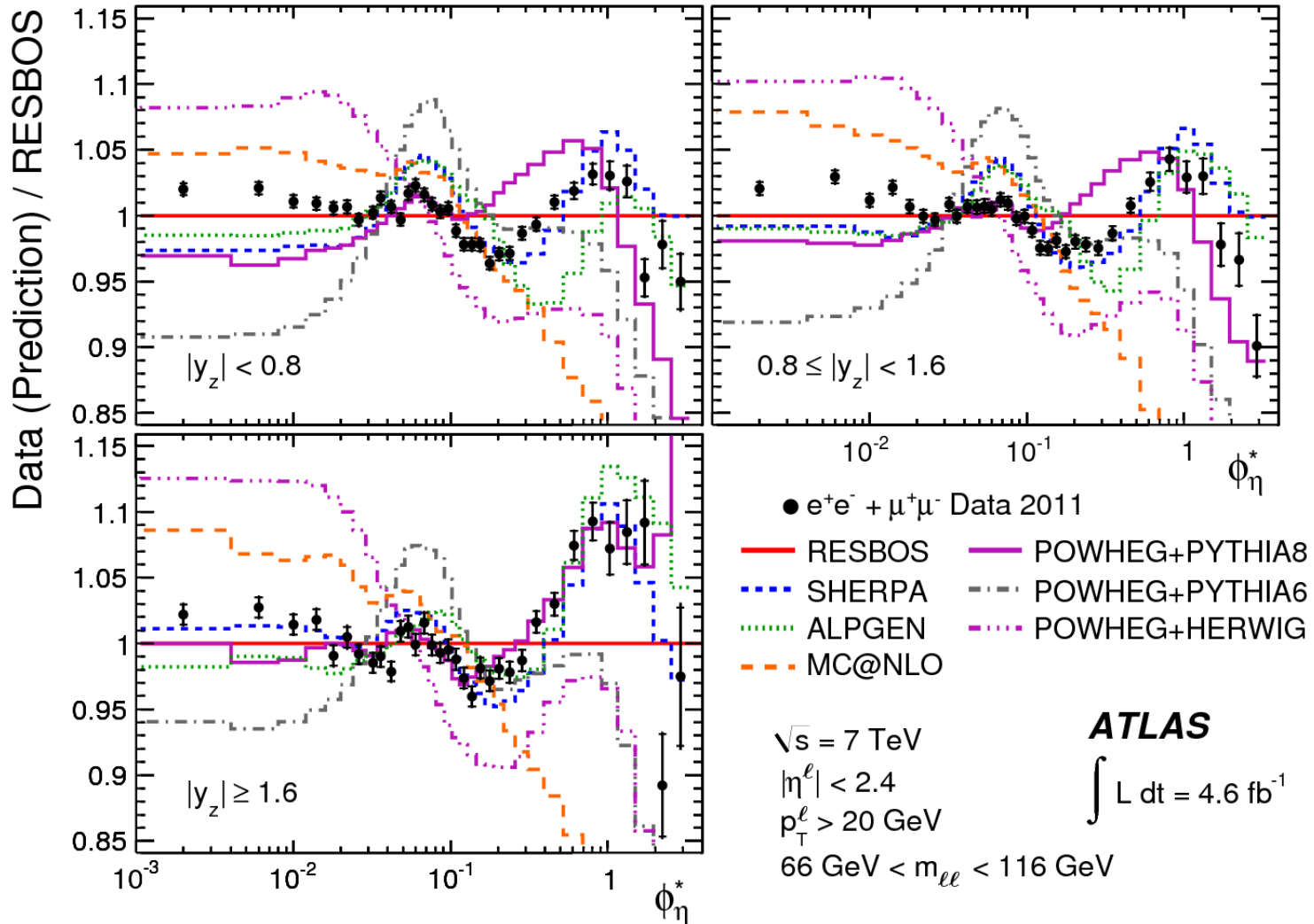
- ▶ Measurements of W & Z production
 - ▶ Provide important tests of pQCD
 - ▶ Require excellent understanding of the detector performance
 - ▶ Can provide better handling of the backgrounds for many interesting measurements
- ▶ High precision of the data challenges the SM prediction
- ▶ Data useful to constrain the parton density distributions of the proton

BackUp

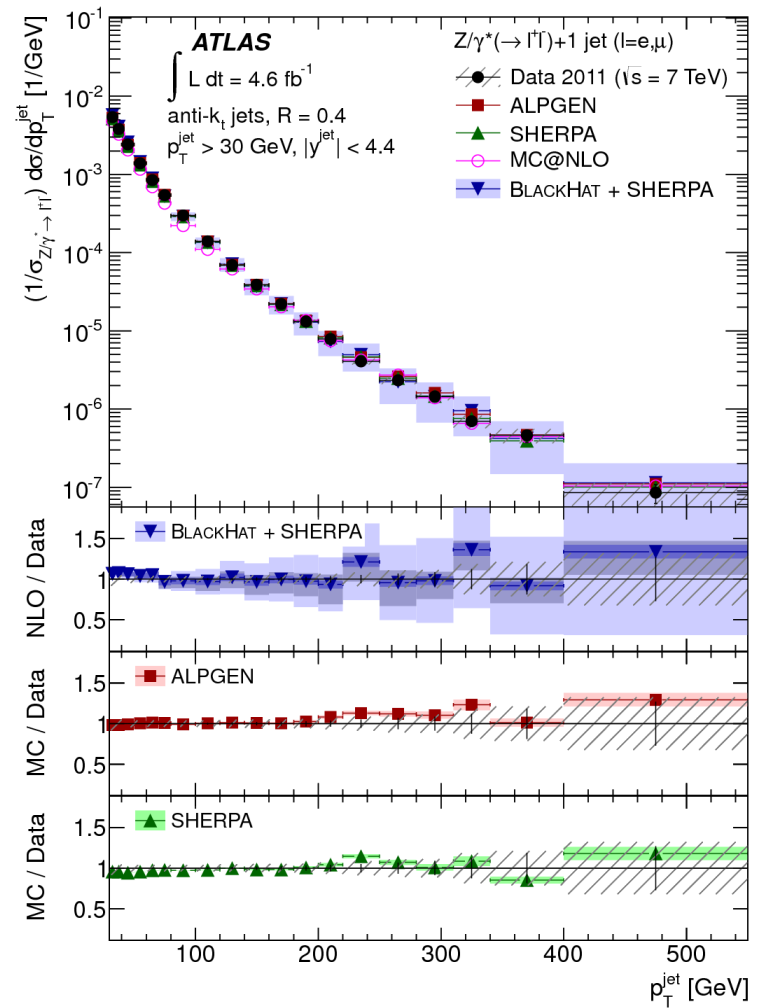
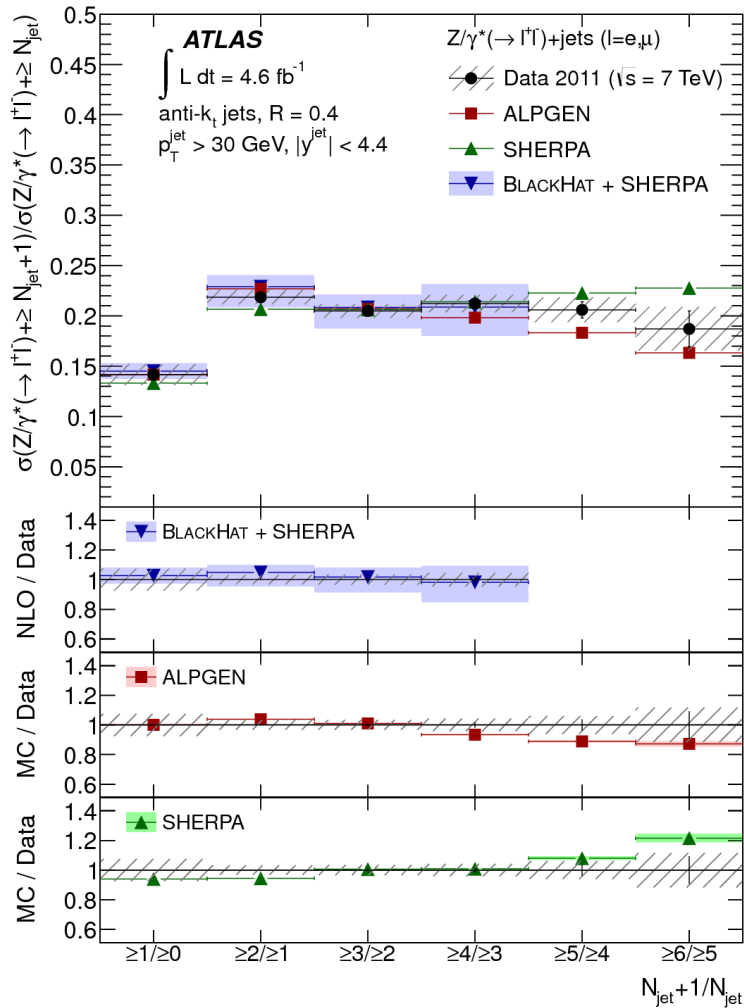
Z pt



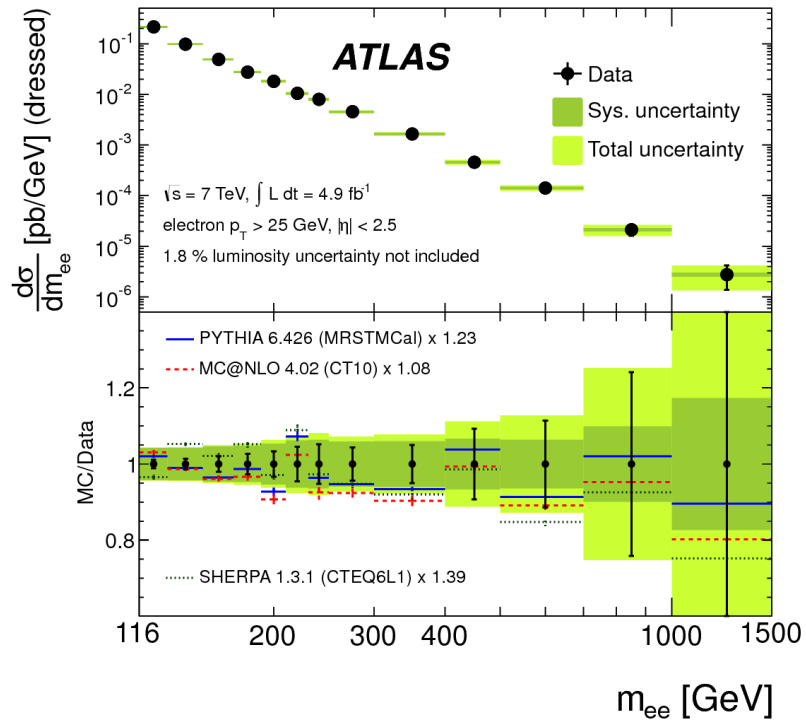
Z ϕ^*



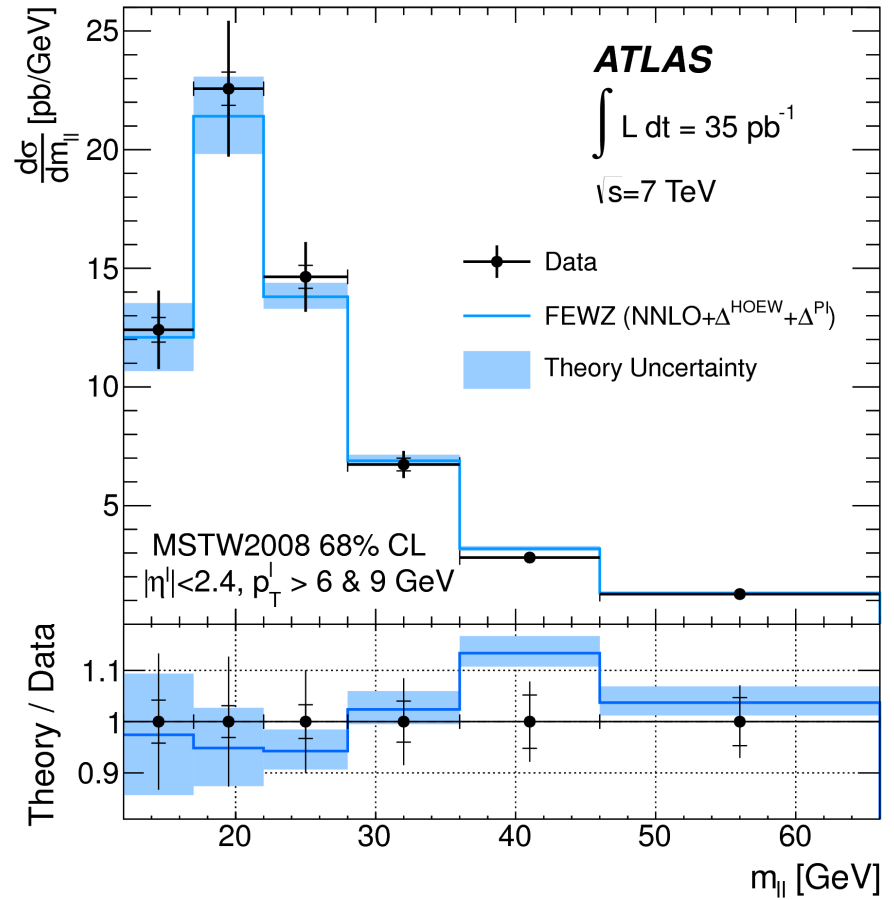
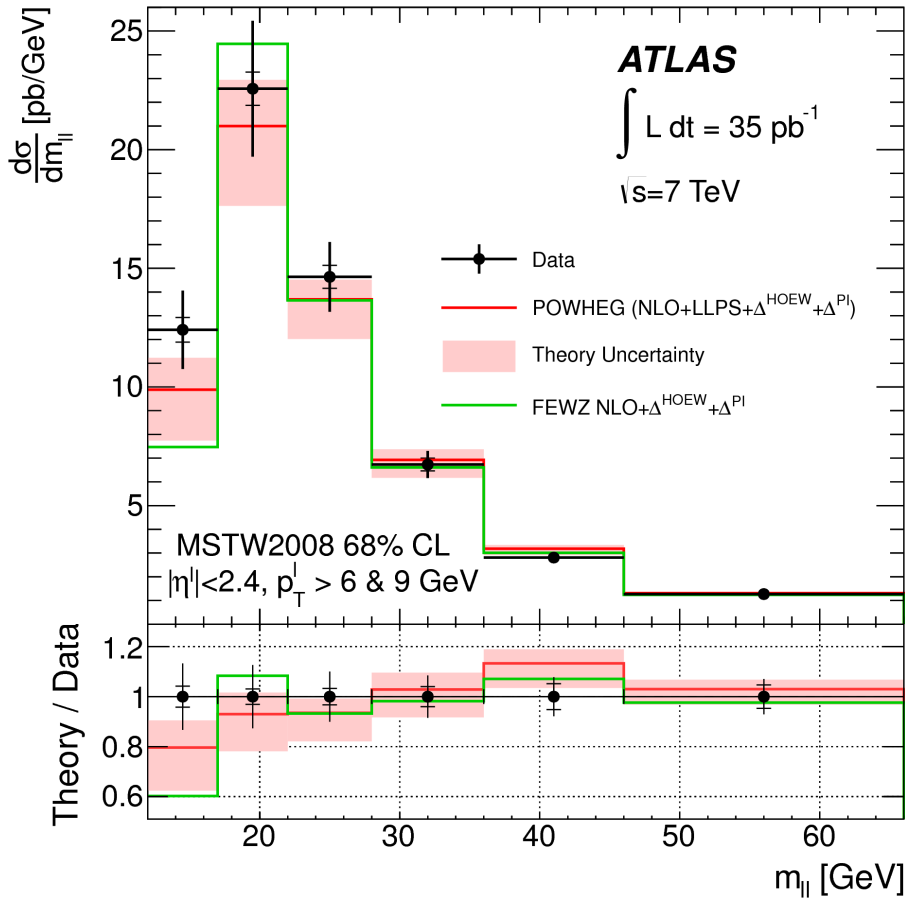
Z+jets



High M_{ll} DY



Low m_{ll} extended



Z→4l analysis selection

▶ Electrons

- ▶ $p_T > 7$ GeV
- ▶ $|\eta| < 2.47$
- ▶ Isolation $E_T^{\text{cone20}}/p_T < 0.2$ (0.3) for 8 (7) TeV
- ▶ $d_0/\sigma_{d0} < 6$

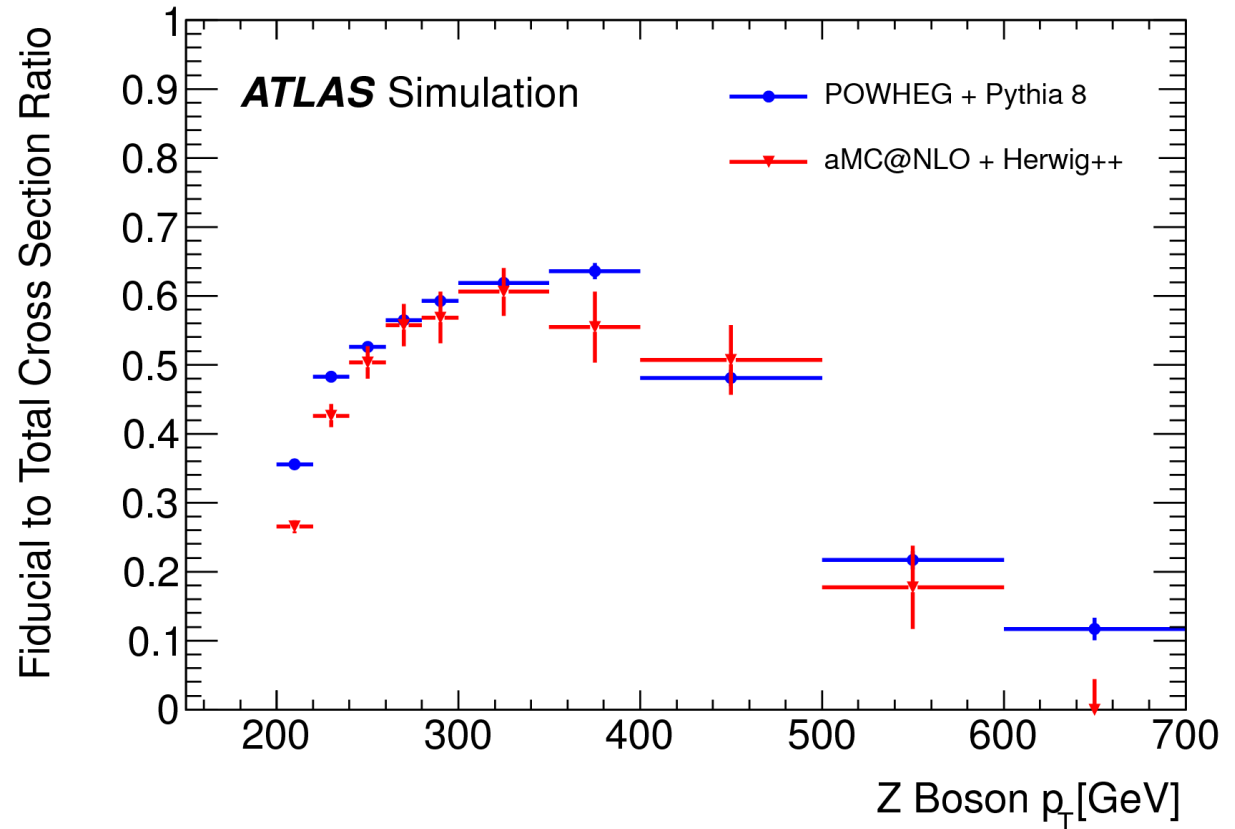
▶ Muons

- ▶ $p_T > 4$ GeV
- ▶ $|\eta| < 2.7$
- ▶ Isolation $E_T^{\text{cone20}}/p_T < 0.3$
- ▶ $d_0/\sigma_{d0} < 3.5$

▶ Leptons pairs

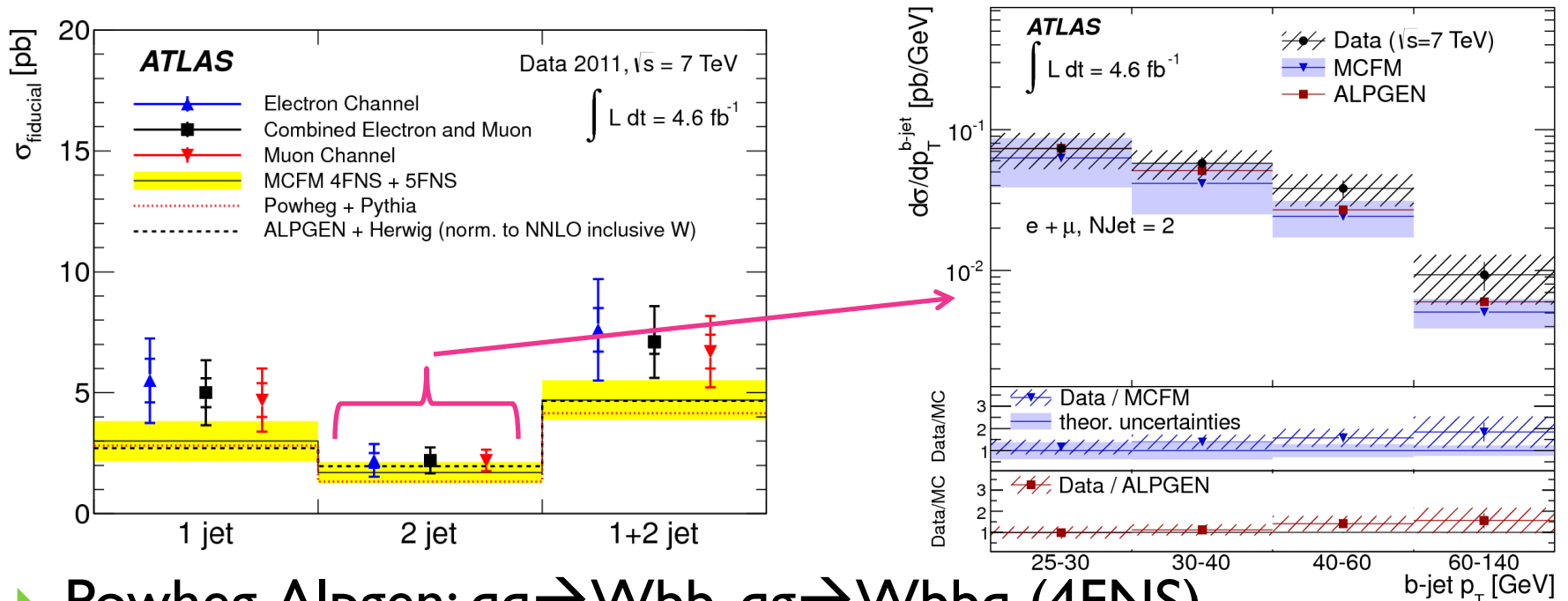
- ▶ 2 opposite sign, same flavour pairs
- ▶ $\Delta R > 0.1$ for SF pairs, $\Delta R > 0.2$ for OF pairs
- ▶ $p_{T,1} > 20$ GeV, $p_{T,2} > 15$ GeV, $p_{T,3} > 10$ (8) GeV for e (m)
- ▶ $m_{12} > 20$ GeV, $m_{34} > 5$ GeV
- ▶ $80 < m_{4l} < 100$ GeV

Z → bb analysis selection



W+b Production

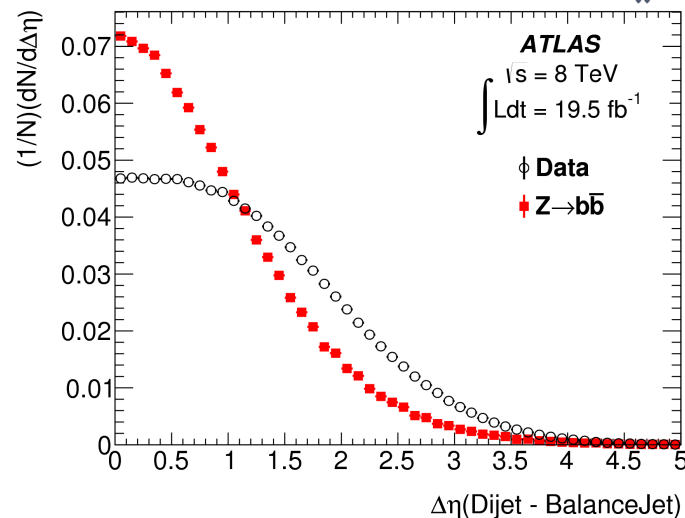
- ▶ W+b cross section measured in exclusive 1jet, 2jet and 1+2 jet bins ($p_T^{bjet} > 25$ GeV, $|\eta^{bjet}| < 2.1$)



- ▶ Powheg, Alpgen: $qq \rightarrow Wbb, qg \rightarrow Wbbq$ (4FNS)
- ▶ MCFM: Includes also $bq \rightarrow Wbq, bg \rightarrow Wbqq$ (5FNS)
- ▶ Agreement with theoretical prediction

Z → bb Cross Section Measurement

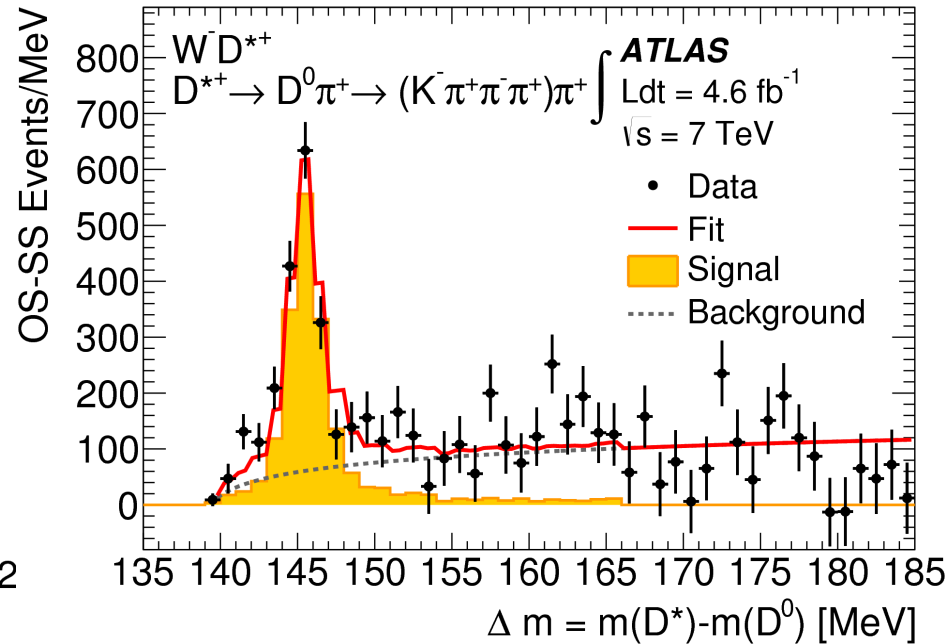
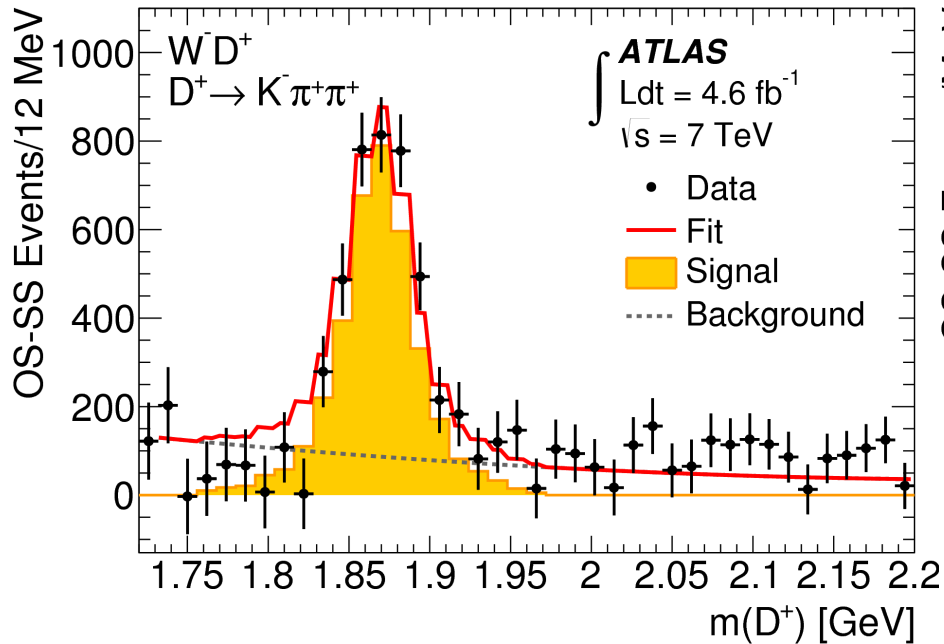
- ▶ submitted to Phys.Lett.B, arXiv:1404.7042
- ▶ Cross section measured for
 - ▶ 2 b-jets with $p_T > 40$ GeV, $|\eta| < 2.5$
 - ▶ Dijet system: $\Delta R_{jj} < 1.2$, $p_{T,jj} > 200$ GeV, $60 < m_{jj} < 160$ GeV



	Fiducial cross section [pb]
Measured	2.02 ± 0.20 (stat) ± 0.25 (syst) ± 0.06 (lumi)
POWHEG	$2.02^{+0.25}_{-0.19}$ (scales) $^{+0.03}_{-0.04}$ (PDF)
aMC@NLO	$1.98^{+0.16}_{-0.08}$ (scales) ± 0.03 (PDF)

- ▶ In good agreement with the NLO +parton shower prediction

W+c/W+D(*) analysis selection



W+b analysis selection

