



ATLAS Electroweak measurements of W and Z properties

Outline:

- Motivation for W/Z studies
- Inclusive W/Z cross-sections
- Lepton universality
- W charge asymmetry
- Polarization of the W
- $Z \rightarrow \mu\mu$ at 8 TeV

Joshua Moss (Ohio State University)
on behalf of the ATLAS Collaboration

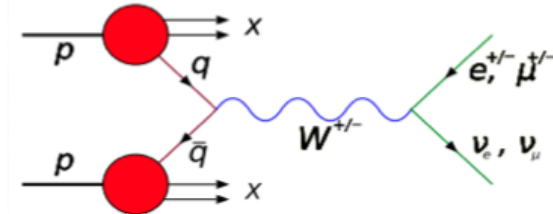
ICHEP 2012, Melbourne
6 July 2012



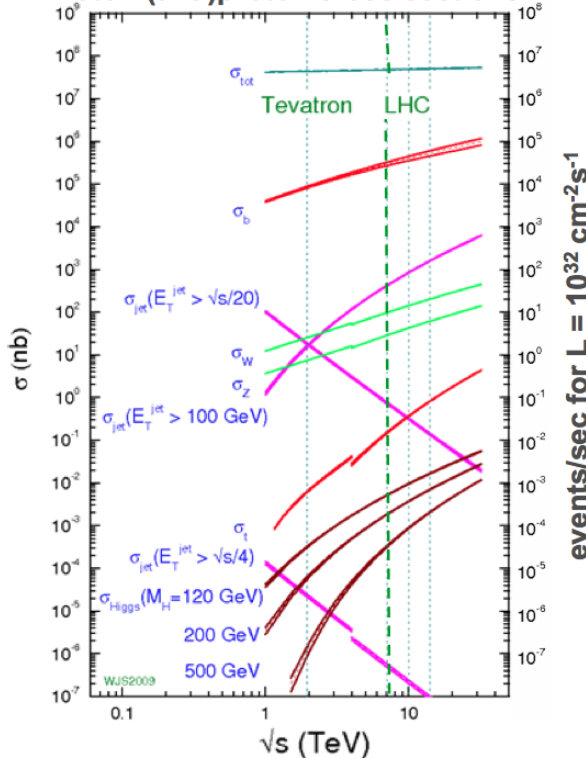
Motivation for W/Z Studies



- LHC is a W/Z factory → produced at high rates
- Leave clean signatures: isolated leptons, missing energy
- Good tool for validating the understanding of the detector
- W/Z are theoretically well understood

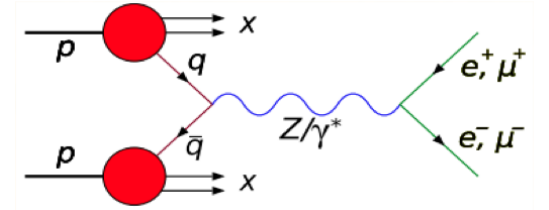


Proton-(anti)proton cross sections



W production - $10^7/\text{fb}^{-1}$

Z production - $10^6/\text{fb}^{-1}$



- Test pQCD predictions up to NNLO
- Precisions test of the Standard Model
 - Inclusive Cross sections
 - Lepton Universality
 - W Charge Asymmetry
 - Polarization of the W
 - τ Polarizations in W decays

Focus of this talk!

Talk by Sarah Demers (yesterday's session)



Inclusive Cross-sections

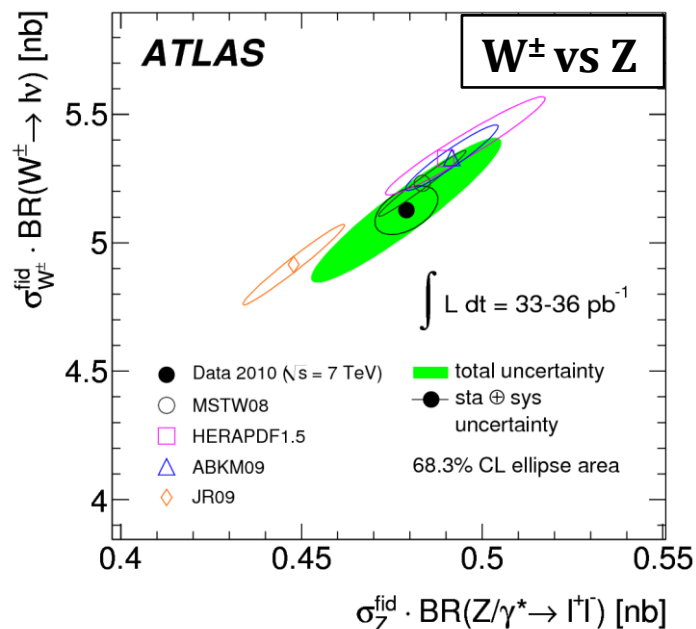
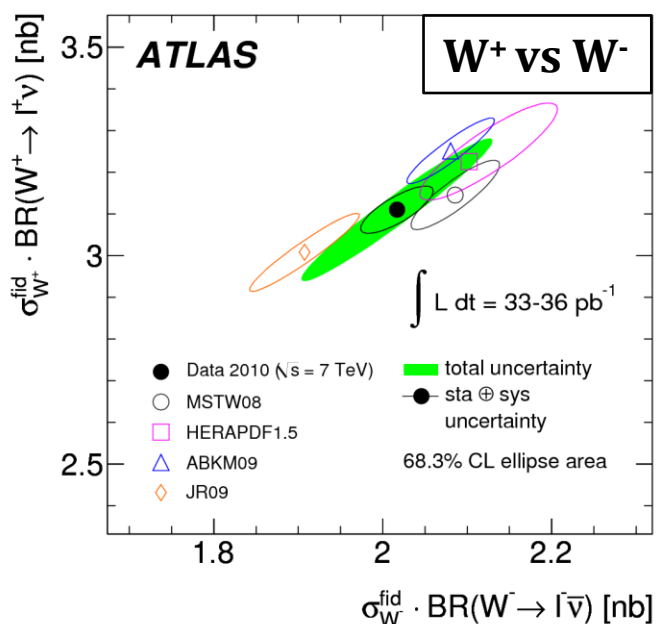


- Electron and muon channels combined in a common fiducial volume
- Full correlations taken into account in the combination
- Measurements are in good agreement with NNLO QCD calculations
 - W cross-section measurements tend to be a little low
 - Measured Z cross sections agree very well with predictions
- $\sim 1\%$ systematic uncertainty (fiducial), 3.4% luminosity uncertainty

Common
fiducial volume:
Lepton $p_T > 20 \text{ GeV}$
 $|\eta| < 2.5$
W: $m_T > 40 \text{ GeV}$
Z: $66 < m_{ll} < 116$
GeV

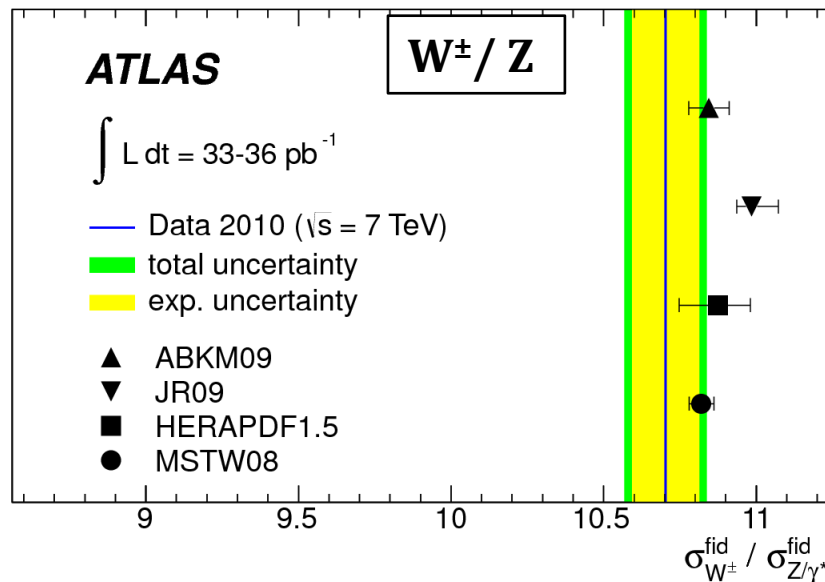
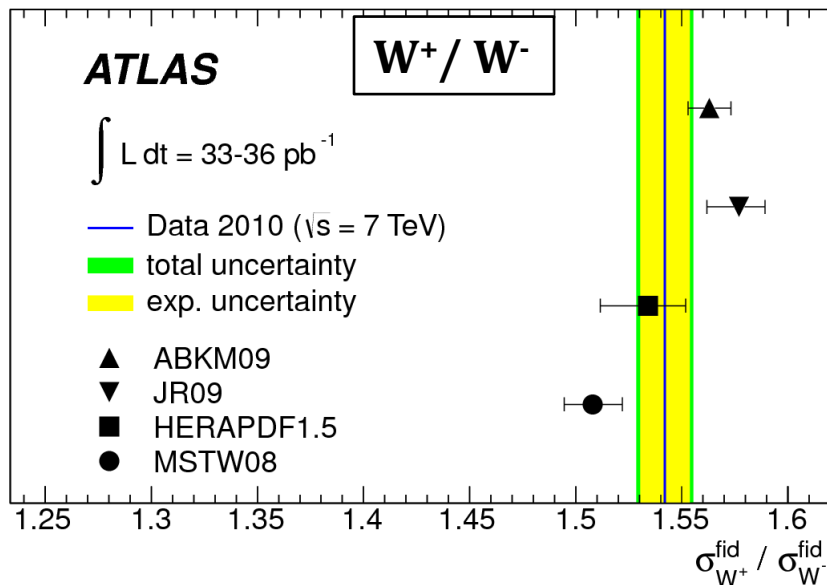
$\sigma_W^{\text{fid}} \cdot \text{BR}(W \rightarrow l\nu)$ [nb]				
	sta	sys	lum	acc
W^+	3.110 ± 0.008	± 0.036	± 0.106	± 0.004
W^-	2.017 ± 0.007	± 0.028	± 0.069	± 0.002
W^\pm	5.127 ± 0.011	± 0.061	± 0.174	± 0.005

$\sigma_{Z/\gamma^*}^{\text{fid}} \cdot \text{BR}(Z/\gamma^* \rightarrow ll)$ [nb]				
	sta	sys	lum	acc
Z/γ^*	0.479 ± 0.003	± 0.005	± 0.016	± 0.001



- Ratios provide a more precise test of the PDFs
- Luminosity and phase space extrapolation uncertainties cancel in the ratios
- Agreement with NNLO predictions
- Ratios have different PDF dependencies:
 - W^\pm/Z : sensitive to flavour composition of quark sea
 - W^+/W^- : sensitive to ratio of u/d valence quarks

	sta	sys	acc
W^+/W^-	1.542 ± 0.007	± 0.012	± 0.001
W^+/Z	6.493 ± 0.049	± 0.064	± 0.005
W^-/Z	4.210 ± 0.033	± 0.049	± 0.003
W^\pm/Z	10.703 ± 0.078	± 0.110	± 0.008



Lepton Universality

- W/Z production is independent of the decay flavor so ratios of the cross-sections can be a test of the ratios of the e and μ branching fractions
- Experimental accuracy of a few percent

$$R_W = \frac{\sigma_W^e}{\sigma_W^\mu} = \frac{Br(W \rightarrow e\nu)}{Br(W \rightarrow \mu\nu)}$$

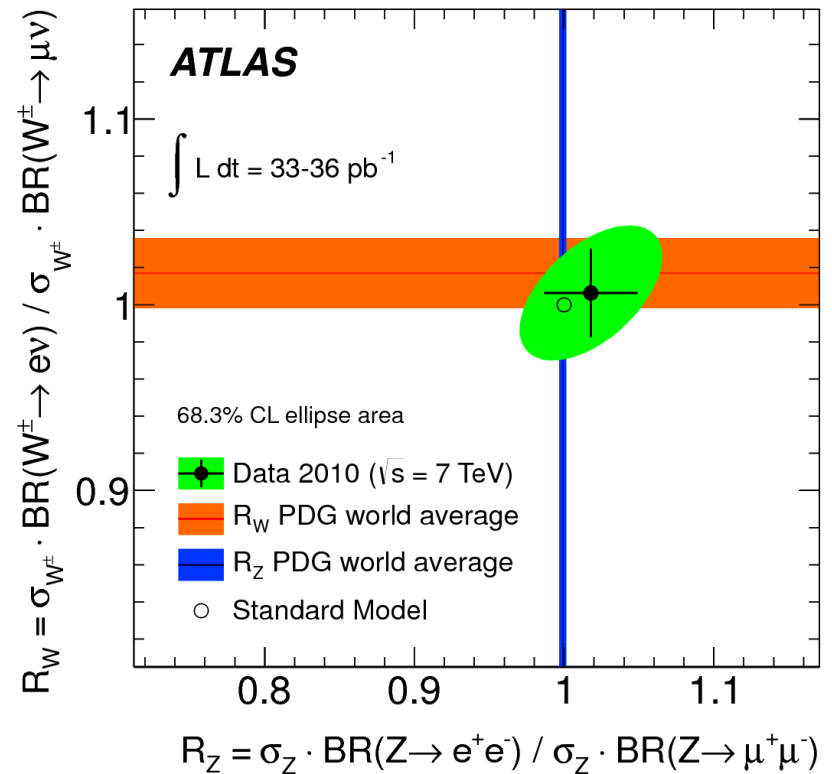
$$R_W = 1.006 \pm 0.024$$

$$\text{World Average: } 1.017 \pm 0.019$$

$$R_Z = \frac{\sigma_Z^e}{\sigma_Z^\mu} = \frac{Br(Z \rightarrow ee)}{Br(Z \rightarrow \mu\mu)}$$

$$R_Z = 1.018 \pm 0.031$$

$$\text{World Average: } 0.9991 \pm 0.0024$$

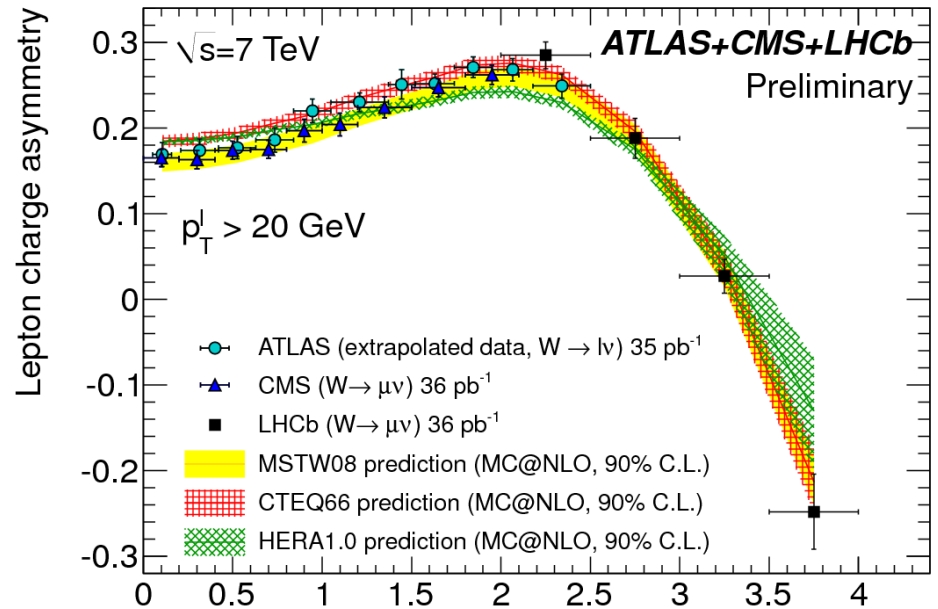
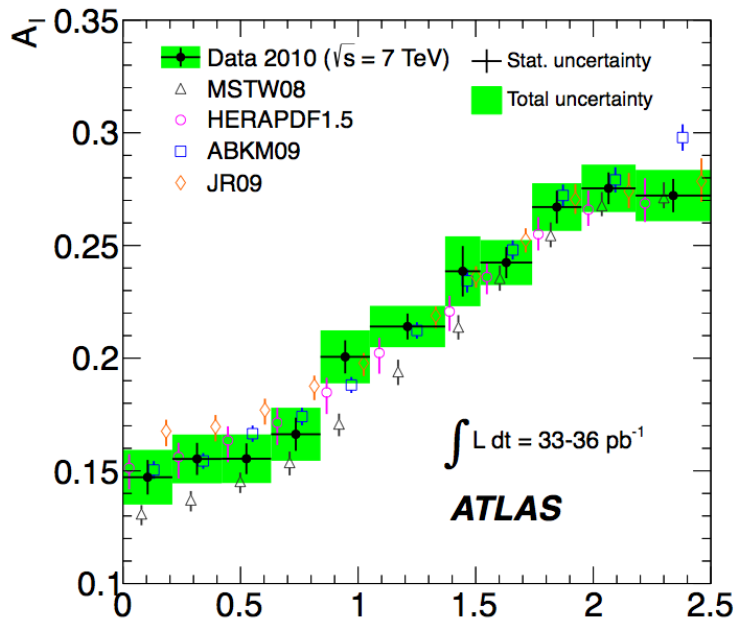


W Charge Asymmetry

- Uses differential cross-sections to probe PDF structure ($x \sim 0.001-0.1$)
- Sensitive to valence quark flavor fraction \rightarrow Usable to constrain u_v/d_v at low x
- Displayed ATLAS, CMS, LHCb results covers $|\eta|$ range up to 3.7

$$A_e(\eta_e) = \frac{d\sigma_{W^+}/d\eta_e - d\sigma_{W^-}/d\eta_e}{d\sigma_{W^+}/d\eta_e + d\sigma_{W^-}/d\eta_e}$$

Each experiment's result extrapolated to a common region and displayed on same plot



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$|\eta|$

ATLAS Electroweak measurements from w and z properties

ATLAS-CONF-2011-129

$|\eta|$



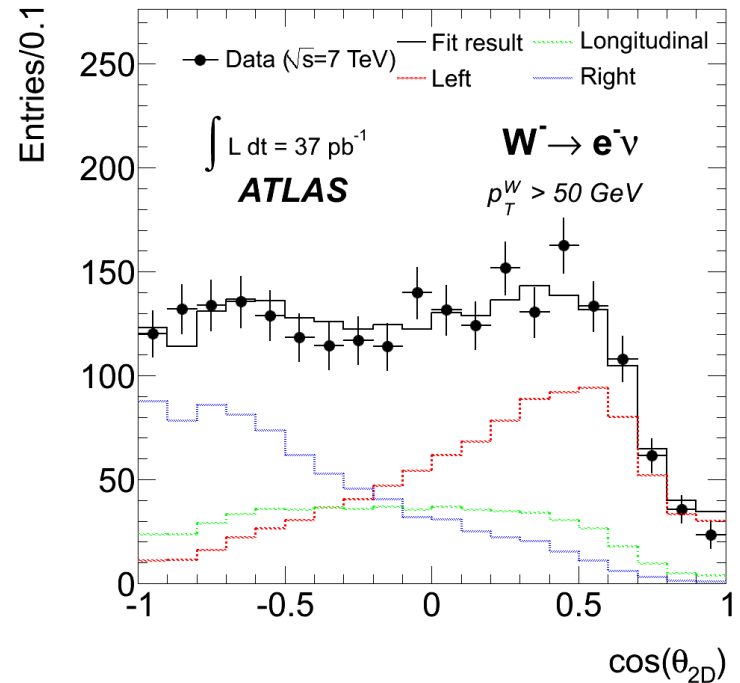
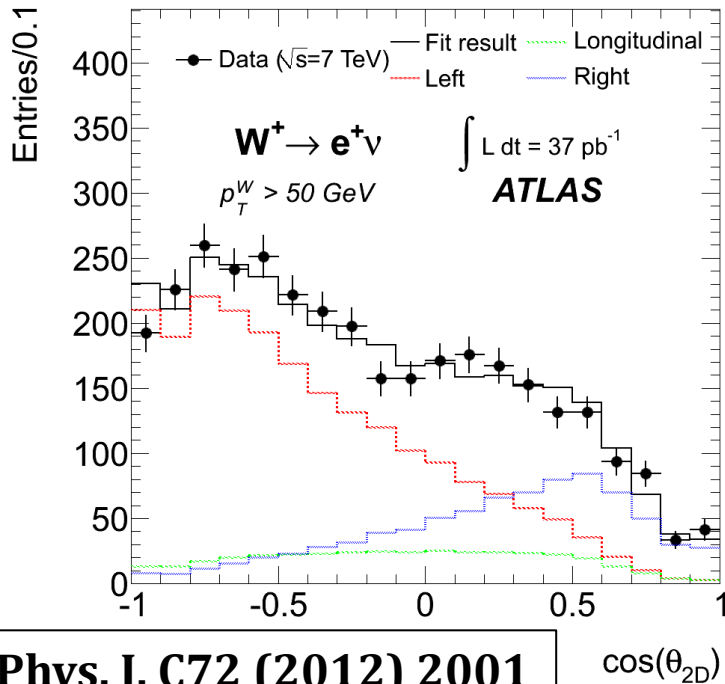
Polarization of the W

- Tests understanding of Prod. Mech.
- W-Polarization fractions: f_0, f_L, f_R
 - LO - predominantly left handed
 - NLO - all states
- Fractions give access to PDF predictions

Use angular variable dependent on transverse quantities only

$$\cos \theta_{2D} = \frac{\vec{p}_T^{\ell*} \cdot \vec{p}_T^W}{|\vec{p}_T^{\ell*}| |\vec{p}_T^W|}$$

- Measurements performed in two bins of W p_T : $35 < p_T < 50 \text{ GeV}$ & $p_T > 50 \text{ GeV}$
- Fit using templates for f_0, f_L, f_R (MC@NLO)



Eur. Phys. J. C72 (2012) 2001

$\cos(\theta_{2D})$

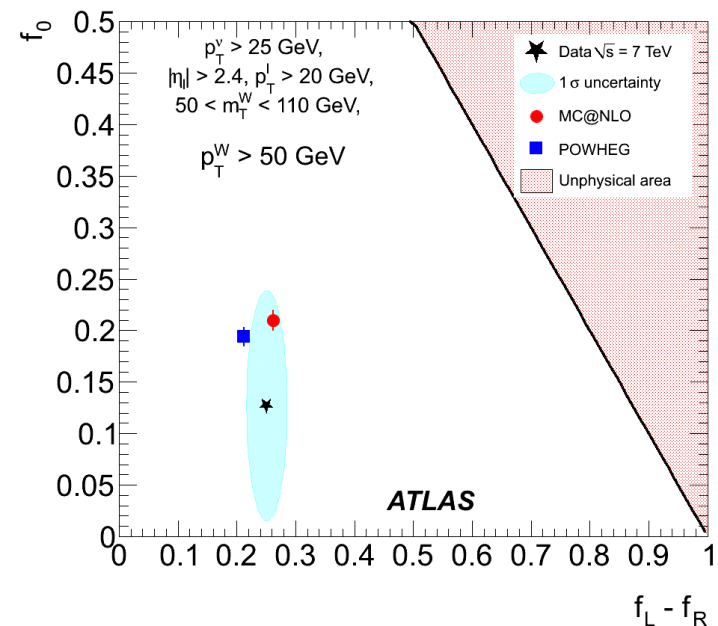
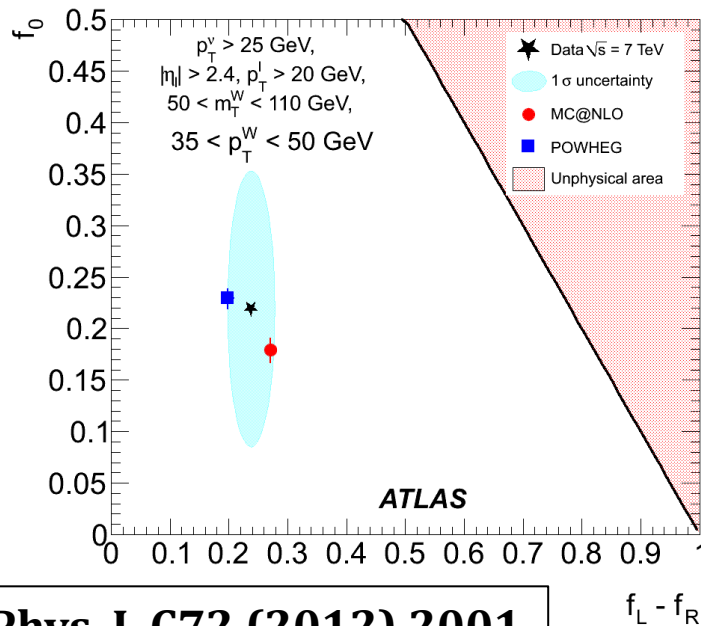
ATLAS Electroweak measurements from w and z properties

Polarization of the W

- Template systematic uncertainty using 2 generators: MC@NLO and PowHeg
- Measurement is sensitive to the uncertainties on lepton and missing E_T energy scales

	$f_L - f_R$ (%)	
	$35 < p_T^W < 50$ GeV	$p_T^W > 50$ GeV
Data	$23.8 \pm 2.0 \pm 3.4$	$25.2 \pm 1.7 \pm 3.0$
MC@NLO	27.1 ± 0.7	26.2 ± 0.5
POWHEG	19.9 ± 1.0	21.2 ± 0.8

	f_0 (%)	
	$35 < p_T^W < 50$ GeV	$p_T^W > 50$ GeV
Data	$21.9 \pm 3.3 \pm 13.4$	$12.7 \pm 3.0 \pm 10.8$
MC@NLO	17.9 ± 1.2	21.0 ± 1.0
POWHEG	22.9 ± 1.0	19.4 ± 0.8



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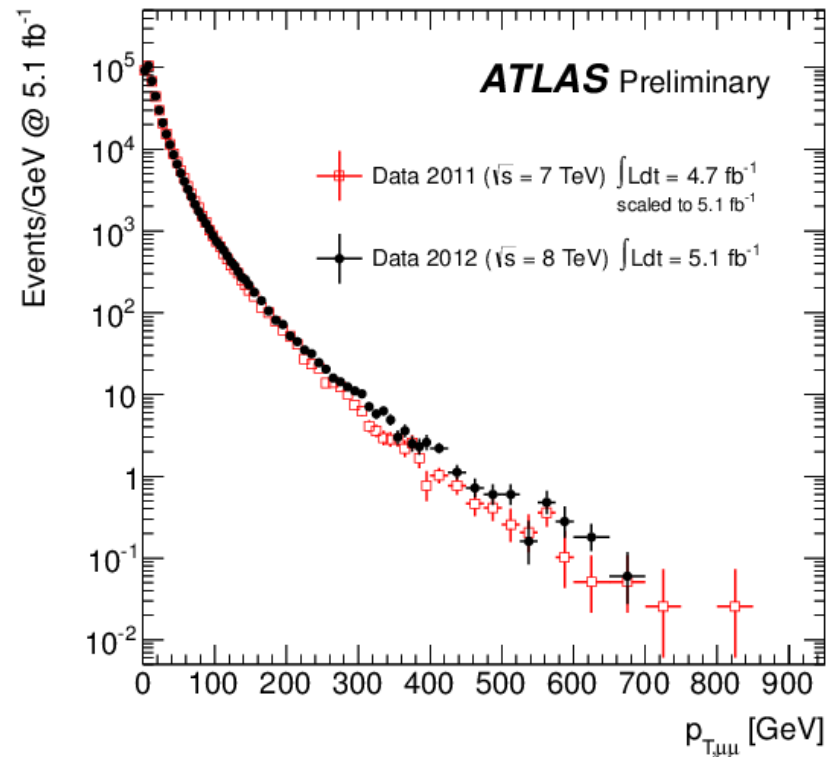
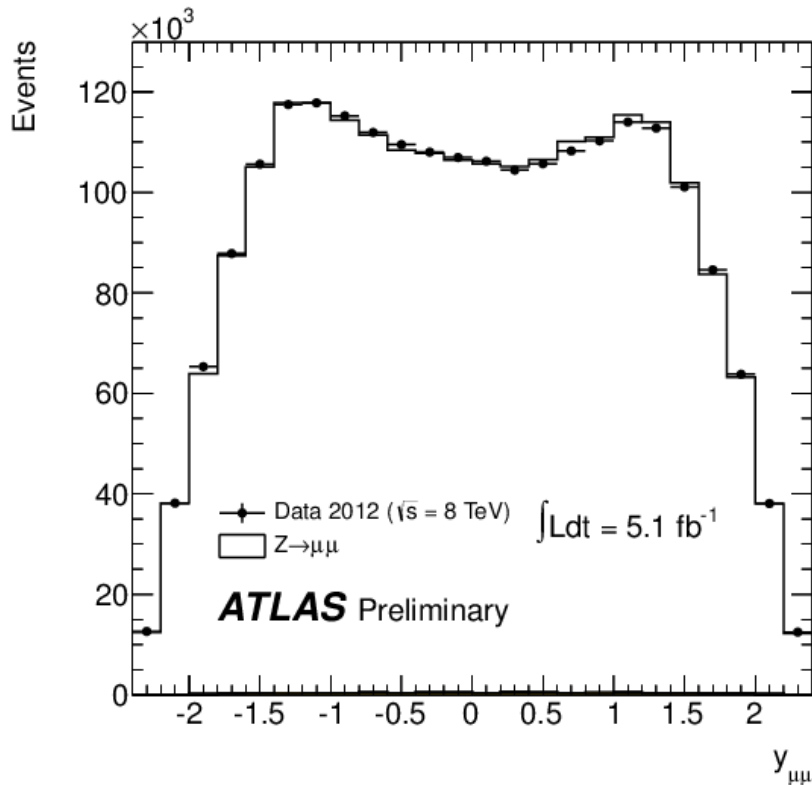


Z → μμ at 8 TeV



- 5.1 fb⁻¹ of data from 2012 at CM of 8 TeV
- Signal MC – PowhegBox with Pythia8 as parton shower and hadronization model
- 2.16 x 10⁶ Z's in the selection
- Muon selection: p_T>25GeV, |η|<2.4

Z's on shell: 66 < m_{ll} < 116 GeV





Summary



Precision measurements for W and Z bosons at ATLAS using 36 pb⁻¹ of data at 7 TeV

- Inclusive, combined cross-sections in good agreement with predictions
- Ratios constrain theoretical predictions on PDFs and test lepton universality
- W charge asymmetry measured
- Polarization of W bosons measured
- First ATLAS plots from Z→μμ at 8 TeV shown

