WW, WZ and Wγ Cross Section Measurements at ATLAS

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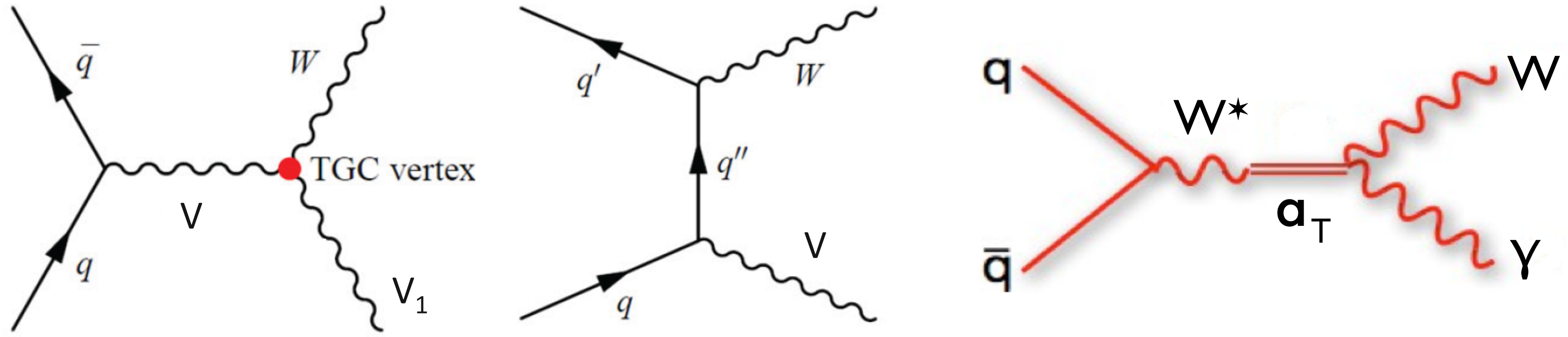
Introduction

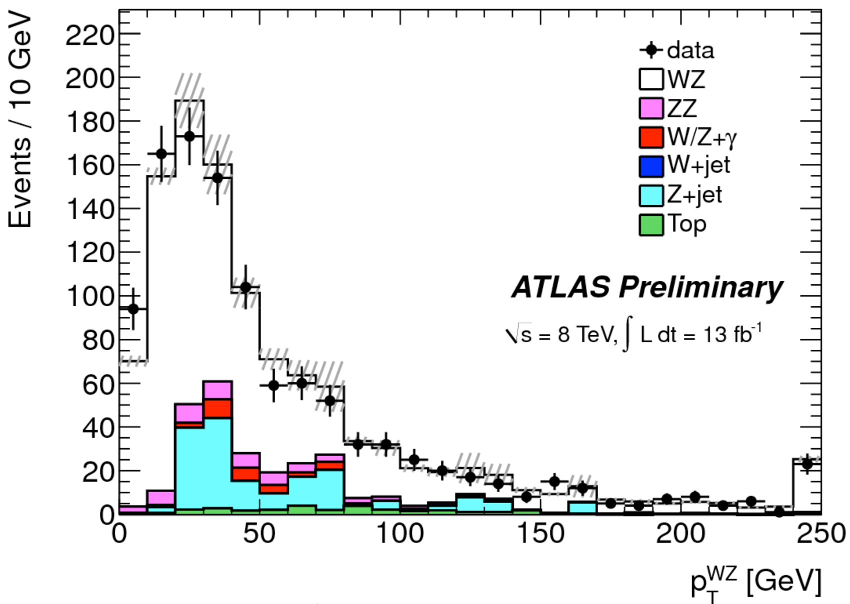
- Why are we interested in the diboson cross section measurements?
  - Precision test of SM predictions -> anomalous triple gauge couplings (aTGC) ?
  - Extended to search for new particles: heavy bosons, technicolor particles, graviton …
  - Better understanding the diboson backgrounds for Higgs measurements and other BSM searches.
- Diboson processes:



Leptonic WZ Cross Section Measurement

ATLAS-CONF-2013-021

- Signature: trileptons with a pair of leptons from Z and high missing transverse energy.
- Selections:
  - p_T cuts: 15 GeV (two leptons from Z), 20 GeV (lepton from W)
  - $E_T^{miss} > 25$ GeV
  - $m_T^W > 20$ GeV
  - Z mass cuts: $|m_{ll}-m_Z| < 10$ GeV
- Backgrounds: Z+jets (dominant), ZZ, W/Z+γ, top…



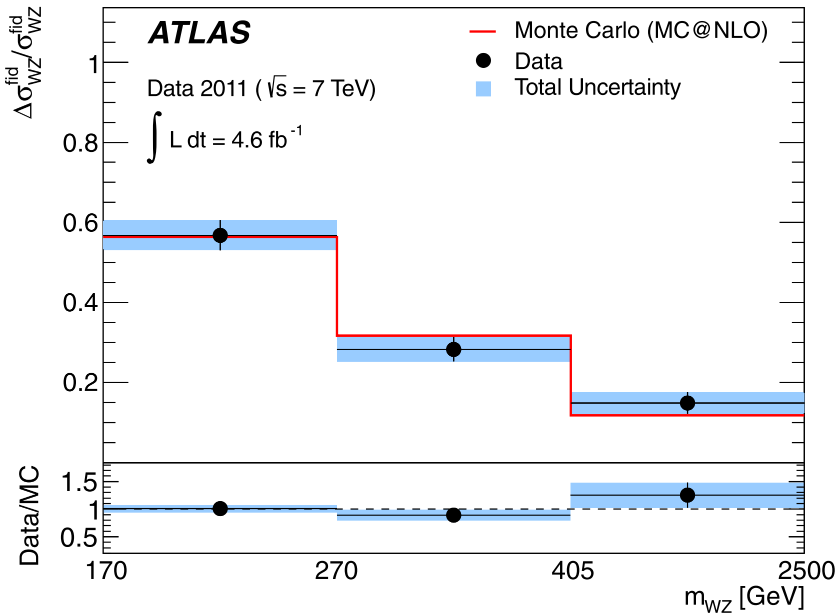
13 fb^{-1}, 8 TeV

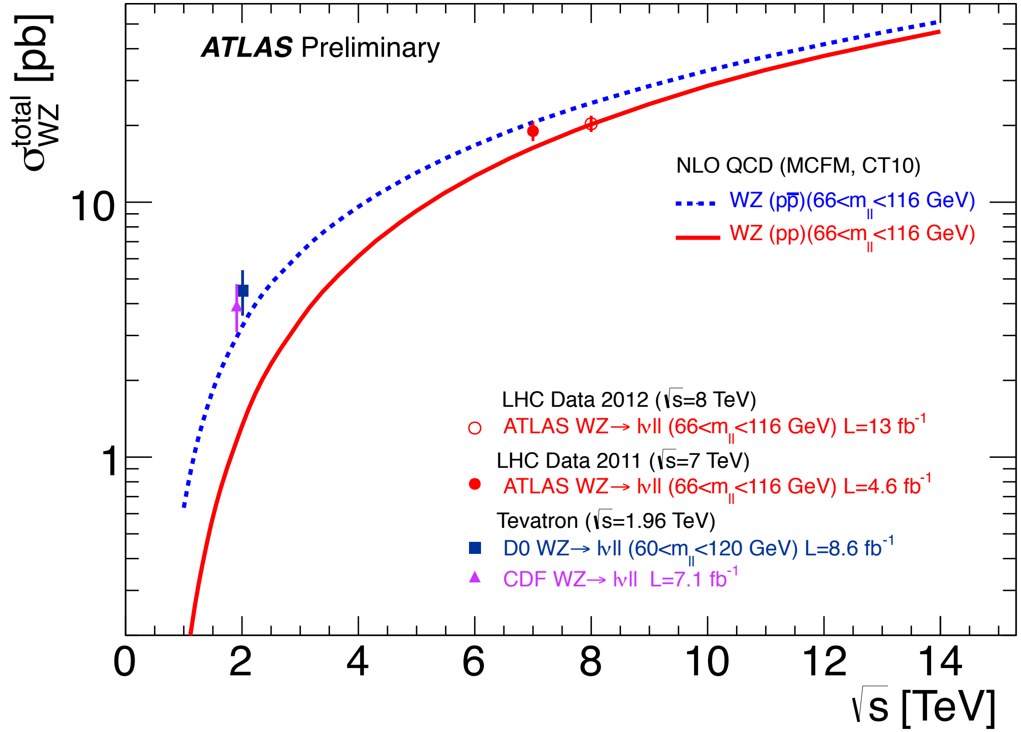
Final State	eee	eeμ	eμμ	μμμ	Combined
Observed	192	270	298	334	1094
Background	60 ± 4 ± 11	55 ± 4 ± 10	87 ± 5 ± 11	75 ± 5 ± 14	277 ± 9 ± 24
Expected signal	144 ± 12	199 ± 16	200 ± 16	276 ± 21	819 ± 34
Expected S/B	2.4	3.7	2.3	3.7	3.0

WZ Cross Sections

Eur. Phys. J. C (2012) 72:2173
ATLAS-CONF-2013-021

Normalized unfolding fiducial cross section at 7 TeV





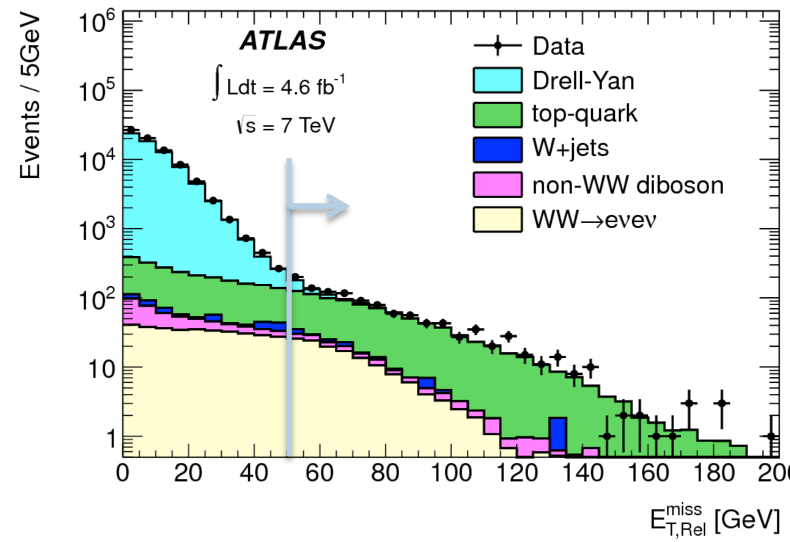
- Total cross sections:

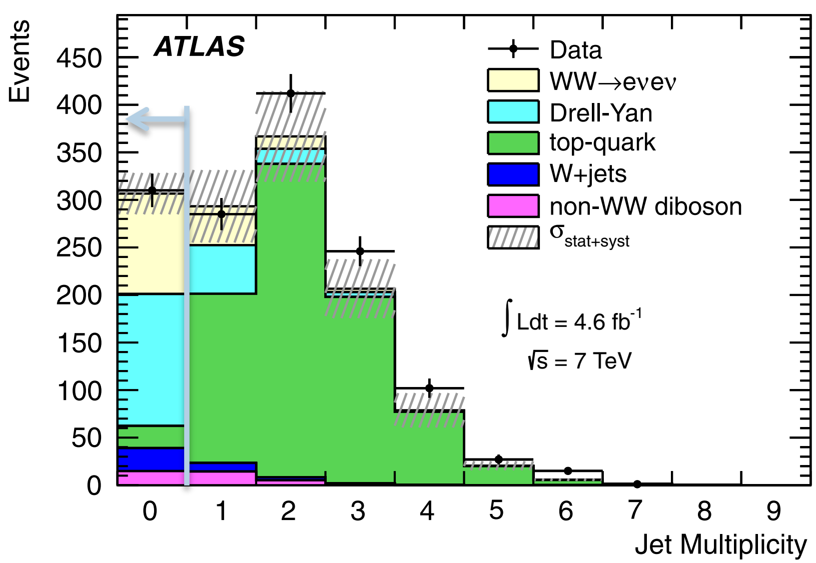
	Measured (pb)	SM expectation (pb)
7 TeV	$19.0^{+1.4}_{-1.3}(\text{stat.}) \pm 0.9(\text{syst.}) \pm 0.4(\text{lumi.})$	$17.6^{+1.1}_{-1.0}$
8 TeV	$20.3^{+0.8}_{-0.7}(\text{stat.})\ ^{+1.2}_{-1.1}(\text{syst.})\ ^{+0.7}_{-0.6}(\text{lumi.})$	20.3 ± 0.8

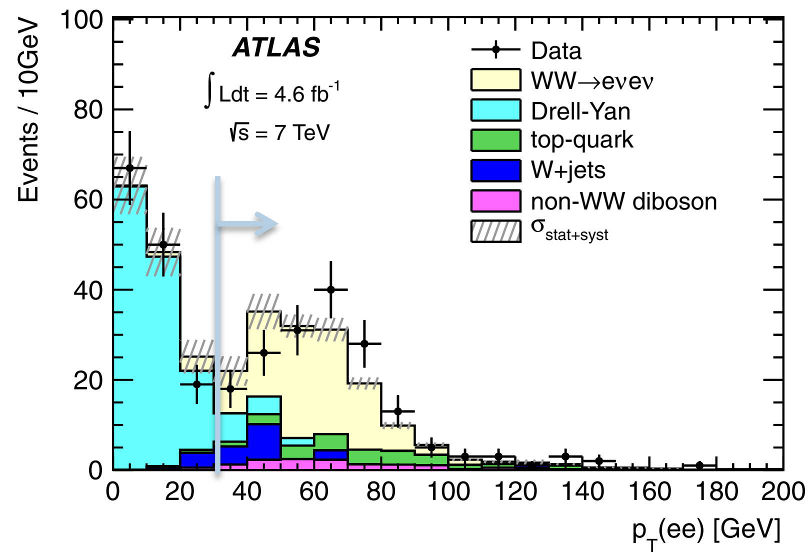
Leptonic WW Cross Section Measurements

Phys. Rev. D 87, 112001 (2013)

- Candidate events: two opposite sign charged leptons and large missing transverse energy
- Backgrounds: dominated by Drell-Yan and tops
  - Drell-Yan: suppressed by modified missing transverse energy, Z mass and $p_T(ll)$ cuts
  - Tops: reject events with at least one jet

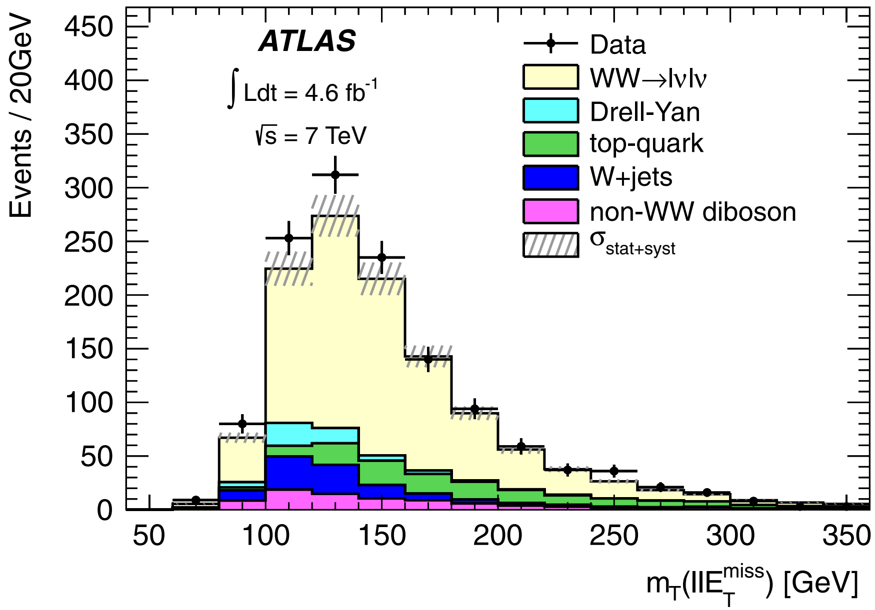


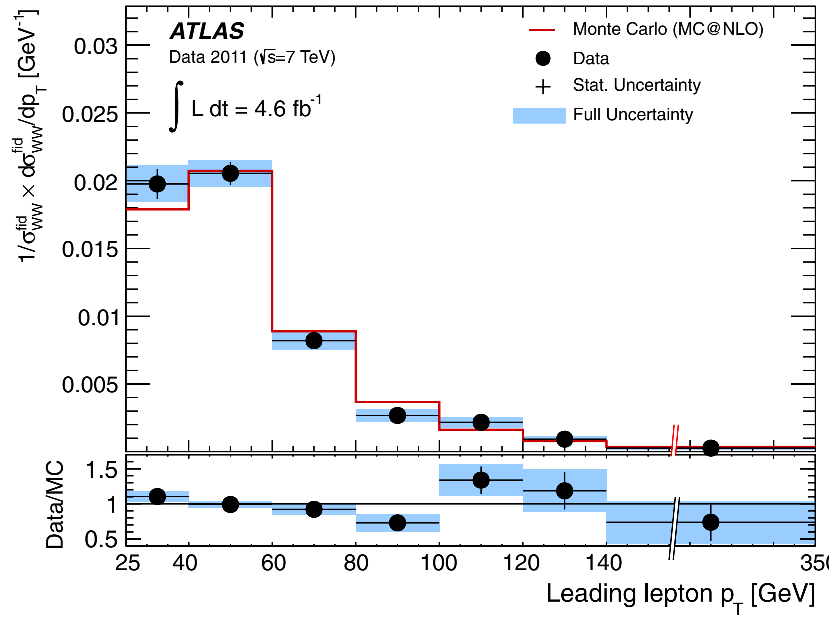




WW Cross Sections

Phys. Rev. D 87, 112001 (2013)



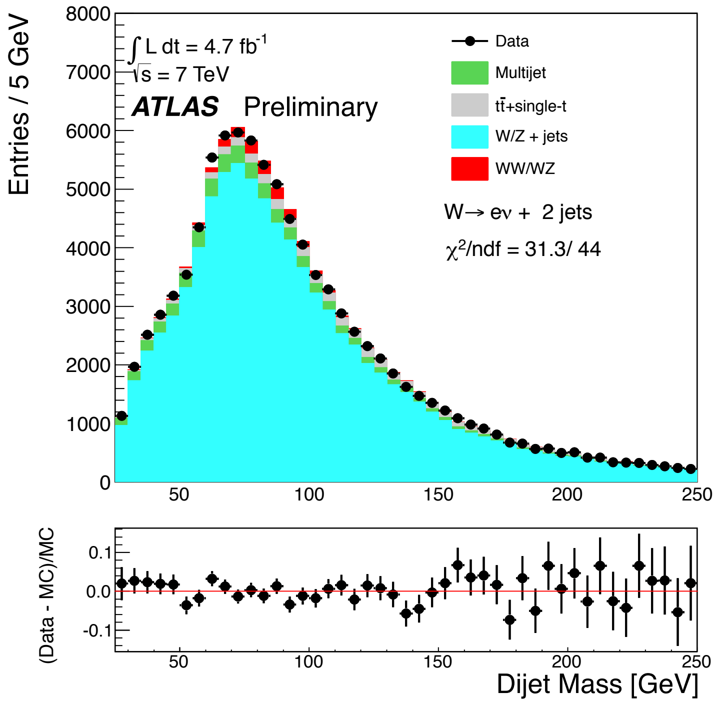


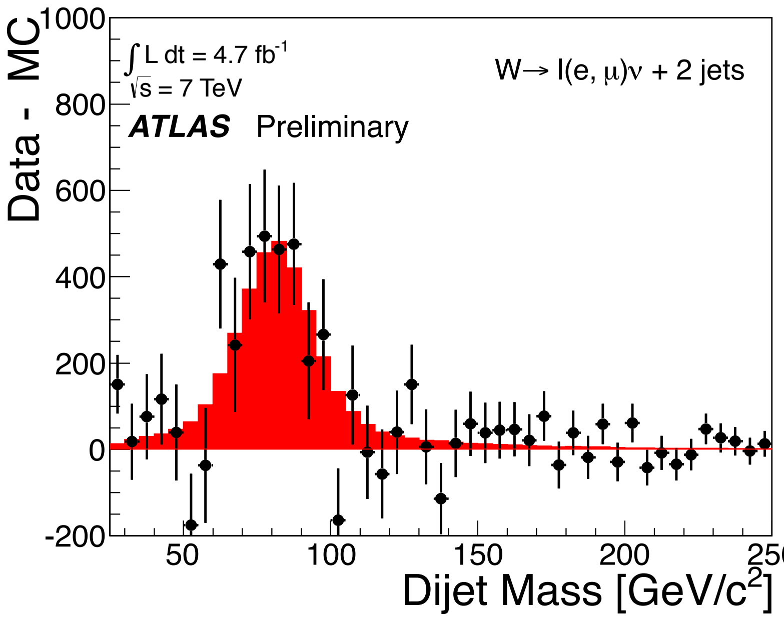
- Measured total cross section in good agreement with SM NLO prediction.

	Measured (pb)	SM prediction (pb)
ee	$46.9 \pm 5.7 \pm 8.2 \pm 1.8$	$44.7^{+2.1}_{-1.9}$
μμ	$56.7 \pm 4.5 \pm 5.5 \pm 2.2$	$44.7^{+2.1}_{-1.9}$
eμ	$51.1 \pm 2.4 \pm 4.2 \pm 2.0$	$44.7^{+2.1}_{-1.9}$
Combined	$51.9 \pm 2.0 \pm 3.9 \pm 2.0$	$44.7^{+2.1}_{-1.9}$

WW+WZ Semileptonic Analysis (ATL-CONF-2012-157)

- Require one lepton, high missing transverse energy and two jets
  - Measure combine WW+WZ cross section
  - Better σ x BR (~6 times compared to fully leptonic channel)
  - Similar signal to VH(bbar).
- Challenging analysis with high background from W+jets (S/B < 3%)
- Need to understand the shape of invariant mass of two jets





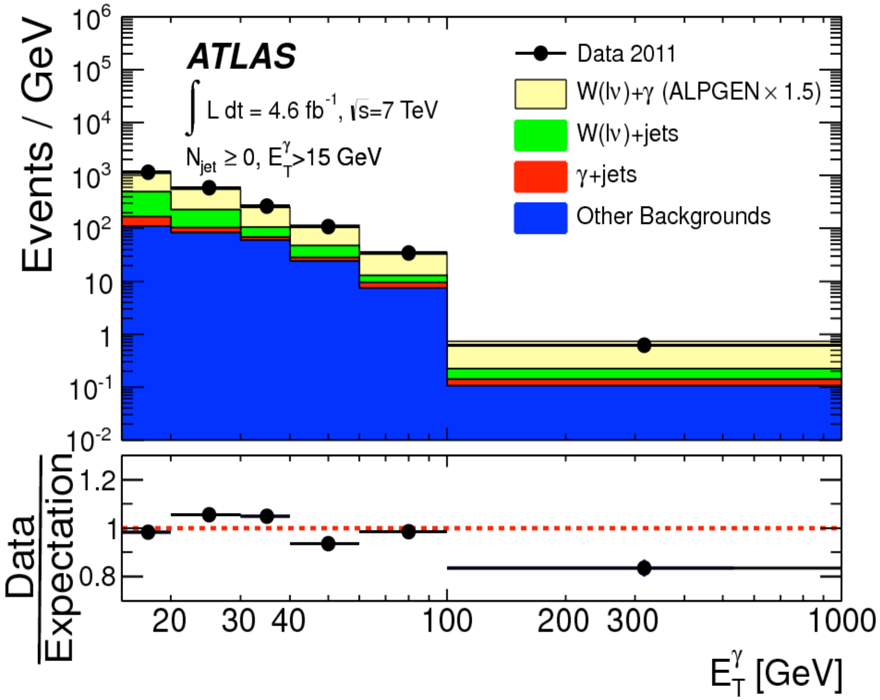
Sigma (WW+WZ): 72 ± 9 (stat) ± 15 (syst.) ± 13 (MC stat) pb
SM prediction: 63.4 ± 2.6 pb

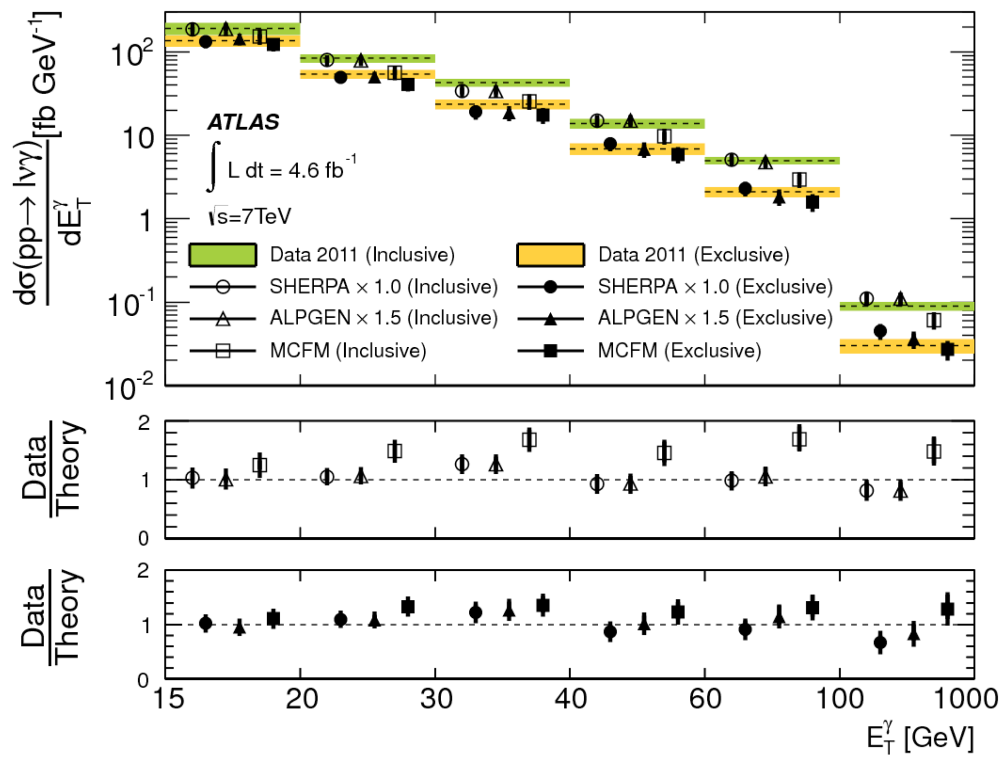
Signal significance:
Observe: 3.3σ
Expected 3.0σ

Wγ Cross Section Measurement

Phys. Rev. D 87, 112003 (2013)

- Signature: a lepton, high missing transverse energy and a gamma.
- Major backgrounds from W+jets, γ+jets and Z+X (electron channel).





Measure inclusive (N_{jet} >= 0) and exclusive (no jets with E_T > 30 GeV and |η| < 4.4) cross sections -> better comparison to predicted cross section from MCFM

Anomalous Triple Gauge Couplings

- Effective Lagrangian to describe anomalies at WWV vertex

$$L/g_{WWV} = ig_1^V(W^*_{\mu\nu}W^\mu V^\nu - W_{\mu\nu}W^{*\mu}V^\nu) + ik^V W^*_\mu W_\nu V^{\mu\nu} + \frac{i\lambda^V}{M_W^2}W^*_{\rho\mu}W^\mu_\nu V^{\nu\rho}$$

- In SM:
  - $g_1^Z = \kappa_Z = \kappa_\gamma = 1$
  - $\lambda_Z = \lambda_\gamma = 0$

coupling	parameters	channel
$WW\gamma$	λ_γ, $\Delta\kappa_\gamma$	WW, $W\gamma$
WWZ	λ_Z, $\Delta\kappa_Z$, Δg_1^Z	WW, WZ

- Form factor to reserve the unitarity

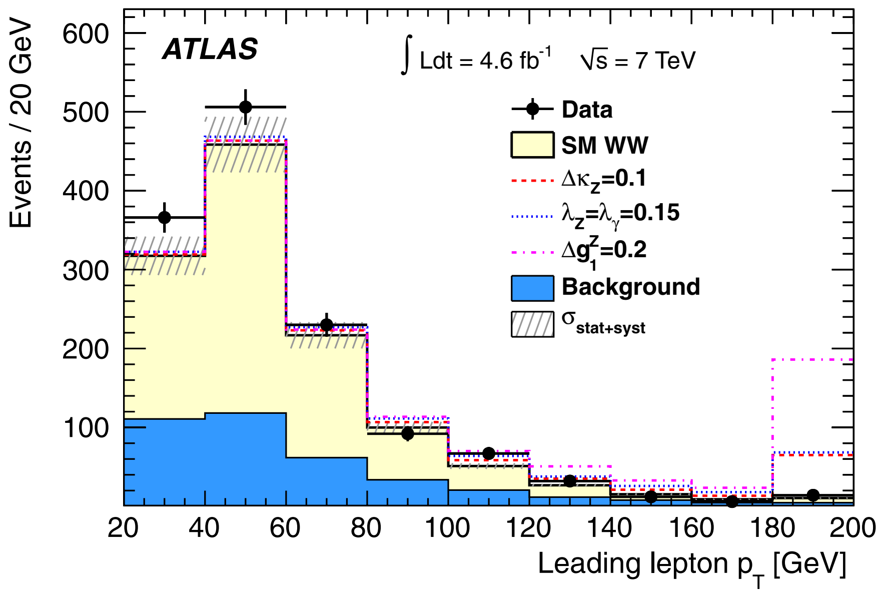
$$\alpha(\hat{s}) = \frac{\alpha_0}{(1+\hat{s}/\Lambda^2)^n}$$

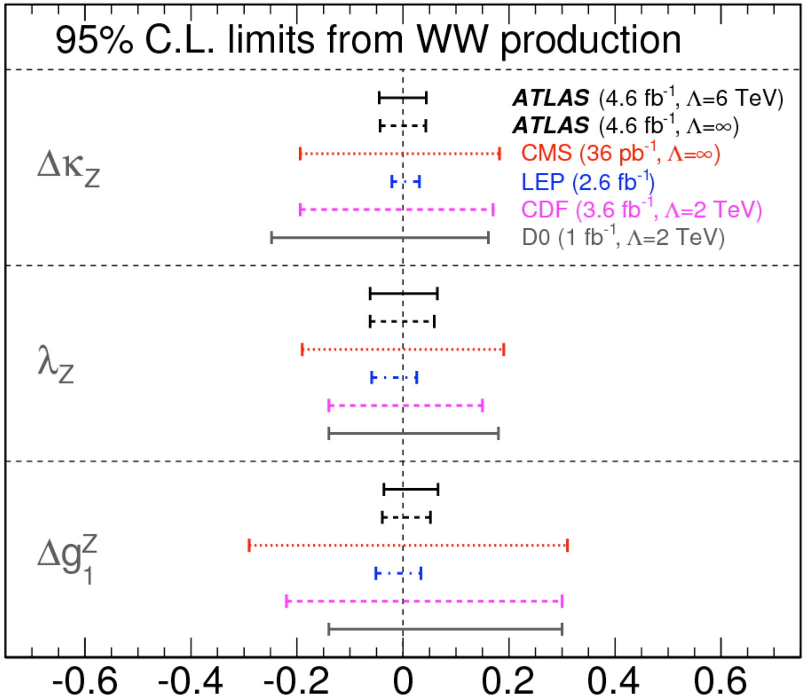
- aTGC effects enhance the rate at high scale (p_T, invariant mass) or modify the angular distributions

aTGC Limits from WW Leptonic Measurement

Phys. Rev. D 87, 112001 (2013)

- Use reconstructed leading lepton p_T distribution to obtain 95% CL cross section limits.
- Compare 95% CL limits on the couplings between experiments
  - Tighter than Tevatron (higher energy)
  - Approaching the precision of LEP combined results

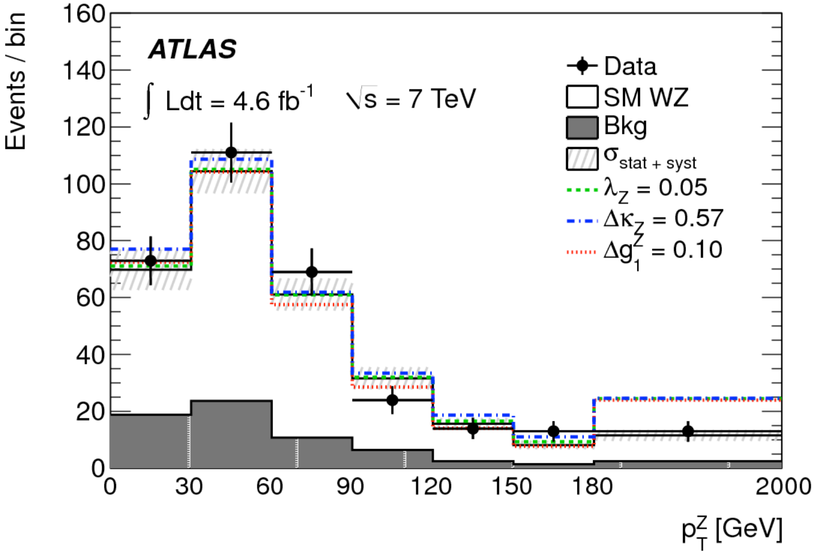


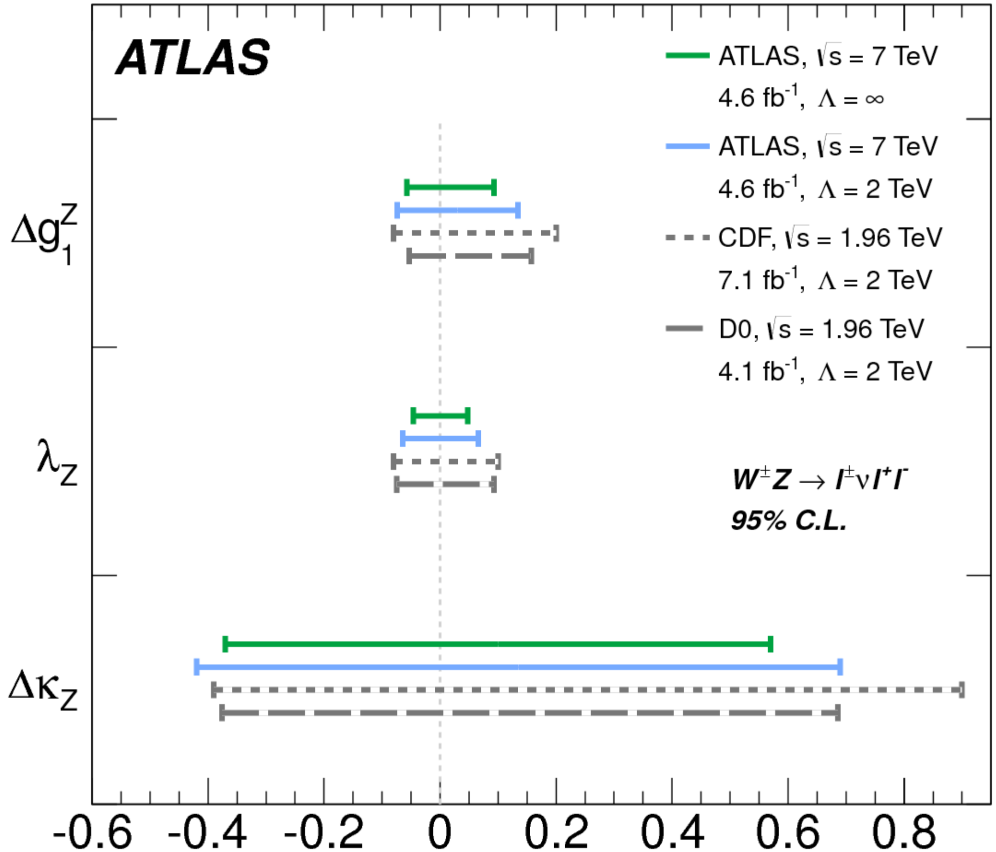


aTGC Limits from WZ Measurement

Eur. Phys. J. C (2012) 72:2173

aTGC parameters constrained using 7 TeV data

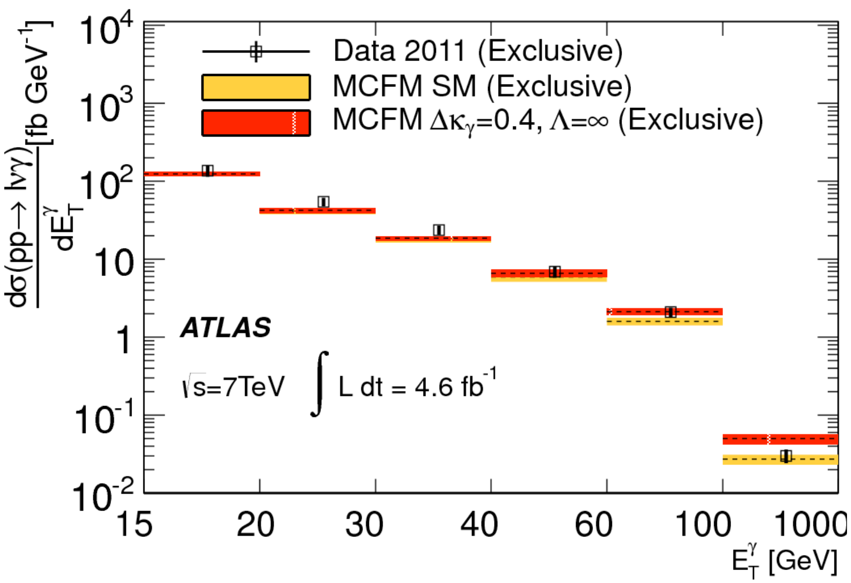


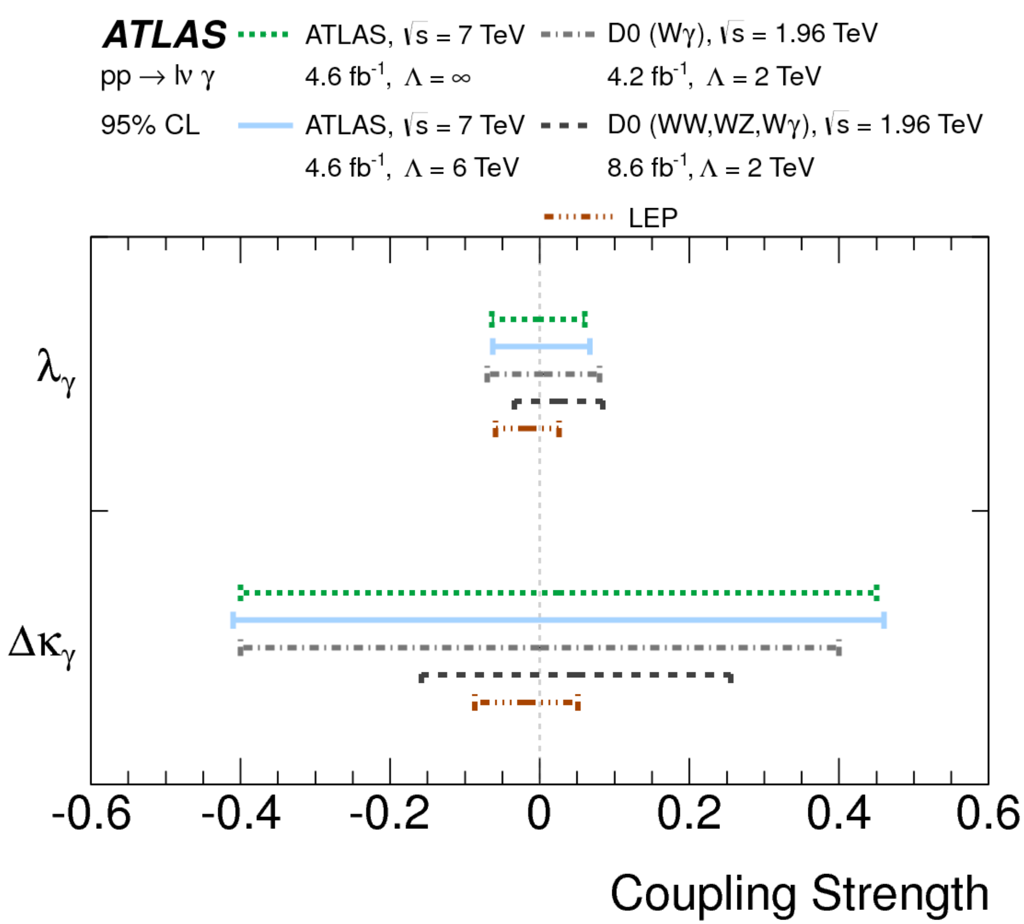


- Comparable with Tevatron results

aTGC Limits from Wγ Measurement

- aTGC effect is shown at high gamma E_T bins.
- Comparable to Tevatron results.

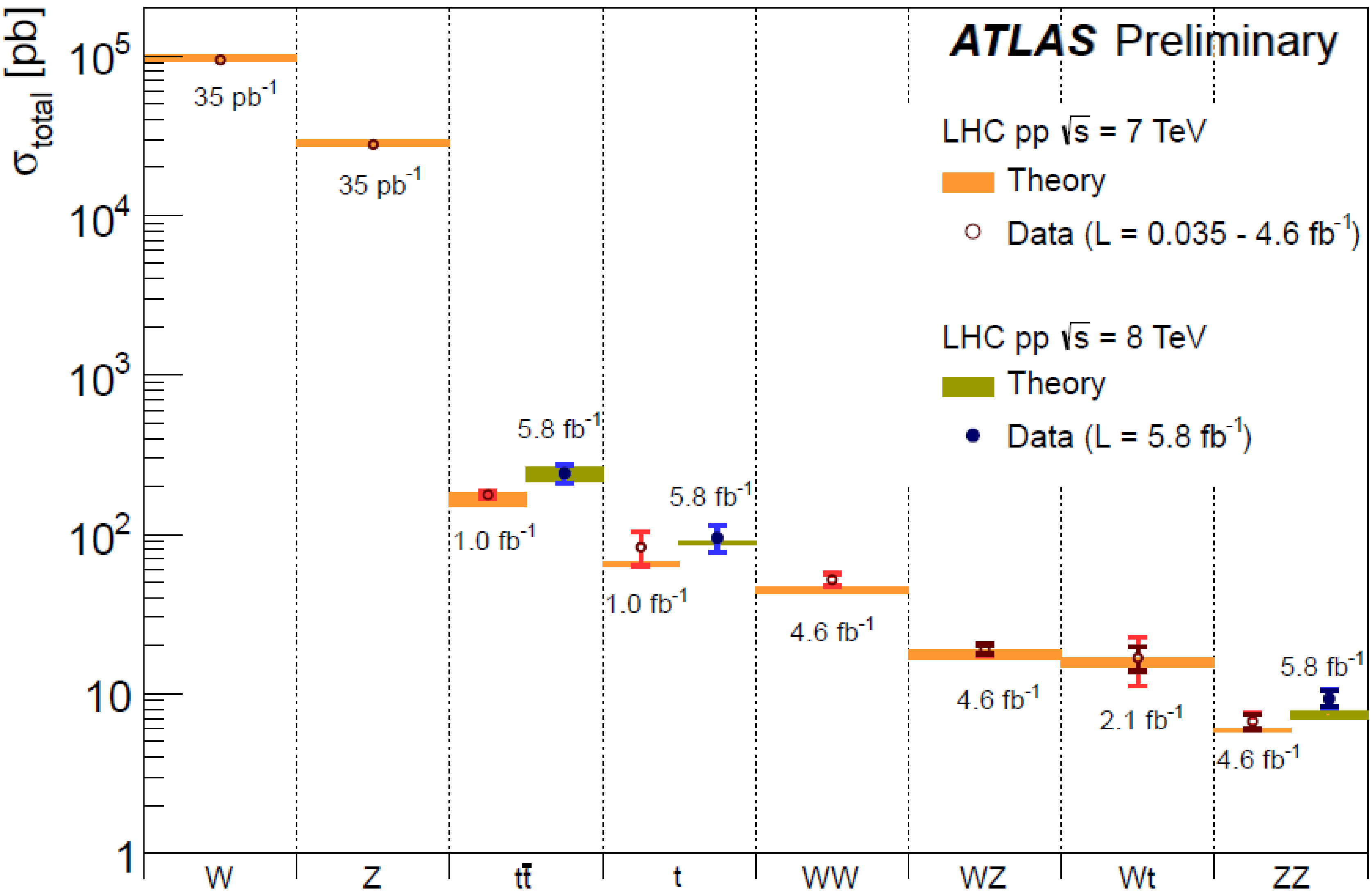




Summary

- Cross section measurements of WW, WZ and Wγ are performed using 7 TeV and 8 TeV proton-proton collision data.
- No deviation from the SM expectation is found in these final states and the stringent limits on the aQGC couplings are set.
- More 8 TeV results are coming: update the cross sections and aTGC limits to full 2012 data.

Backup



ATLAS Preliminary
LHC pp √s = 7 TeV
Theory
Data (L = 0.035 - 4.6 fb-1)
LHC pp √s = 8 TeV
Theory
Data (L = 5.8 fb-1)
σtotal [pb]
10^5
10^4
10^3
10^2
10
1
35 pb-1
35 pb-1
5.8 fb-1
1.0 fb-1
5.8 fb-1
1.0 fb-1
4.6 fb-1
4.6 fb-1
2.1 fb-1
5.8 fb-1
4.6 fb-1
W
Z
tt̄
t
WW
WZ
Wt
ZZ