Measurement of the $W^{\pm}Z$ Production Cross Section in p-p Collisions at $\sqrt{s} = 7$ TeV with the ATLAS Detector

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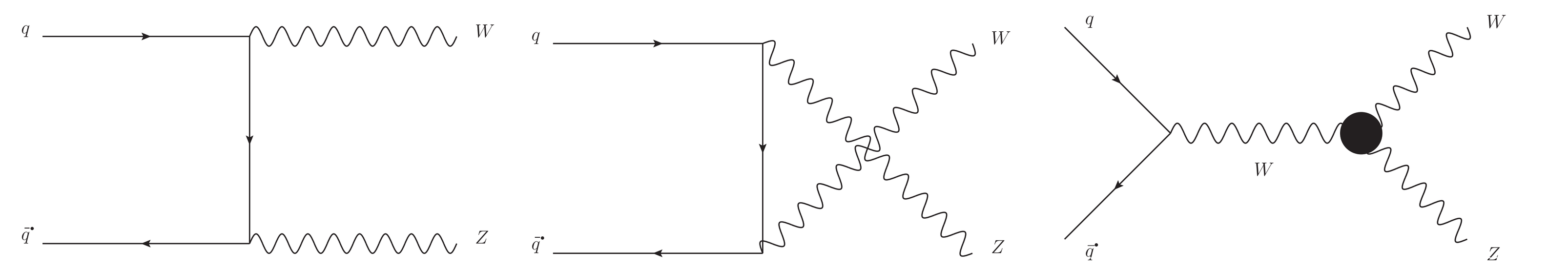
Abstract

We present a measurement of $W^{\pm}Z$ production in 1.02 fb^{-1} of pp collision data at $\sqrt{s} = 7$ TeV collected by the ATLAS experiment in 2011. A total of 71 candidates with a background expectation of 10.5±0.8(stat)$^{+2.9}_{-2.1}$(sys) events were observed for purely leptonically decaying bosons with electrons, muons and missing transverse energy in the final state. The total cross section has been determined to be $\sigma^{tot}_{WZ} = 21.1^{+3.1}_{-2.8}$(stat) $^{+1.2}_{-1.2}$(syst) $^{+0.9}_{-0.8}$(lumi) pb, in agreement with the Standard Model expectation of $17.2^{+1.2}_{-0.8}$ pb. Limits on anomalous triple gauge boson couplings have been derived.

Motivation



A measurement of $W^{\pm}Z$ production is an important milestone for the ATLAS collaboration. This channel provides an important test of the high energy behavior of the electroweak sector. Additionally, measurements of the triple gauge coupling could provide insight into potential new physics decaying into $W^{\pm}Z$.

Cutflow

Electrons:

- $p_T > 15$ (20) GeV for Z (W) decay product
- $|\eta| < 2.47$, outside crack in [1.37,1.52]
- calorimeter based isolation
- tighter identification for W decay product

Muons:

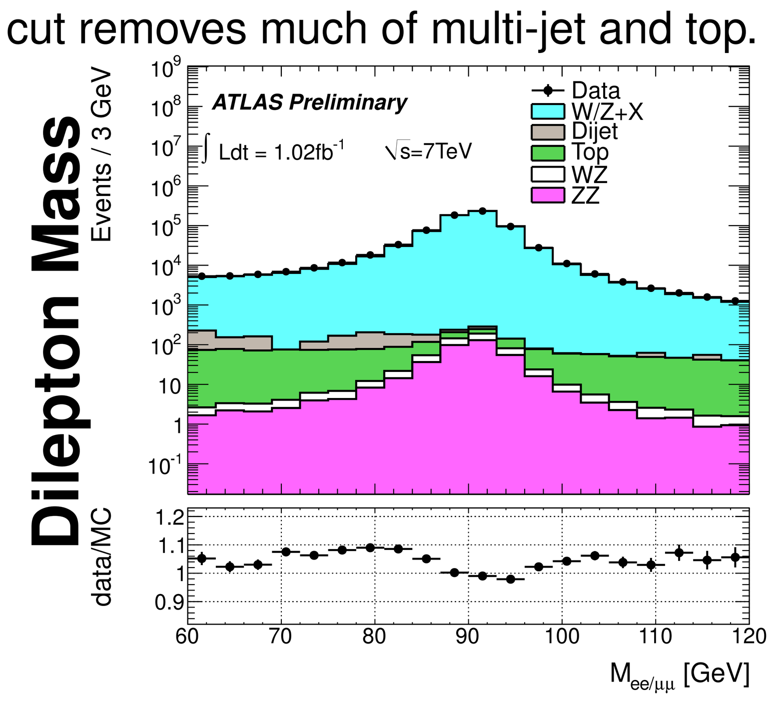
- $p_T > 15$ (20) GeV for Z (W) decay product
- $|\eta| < 2.5$
- track based isolation

Missing Transverse Energy:

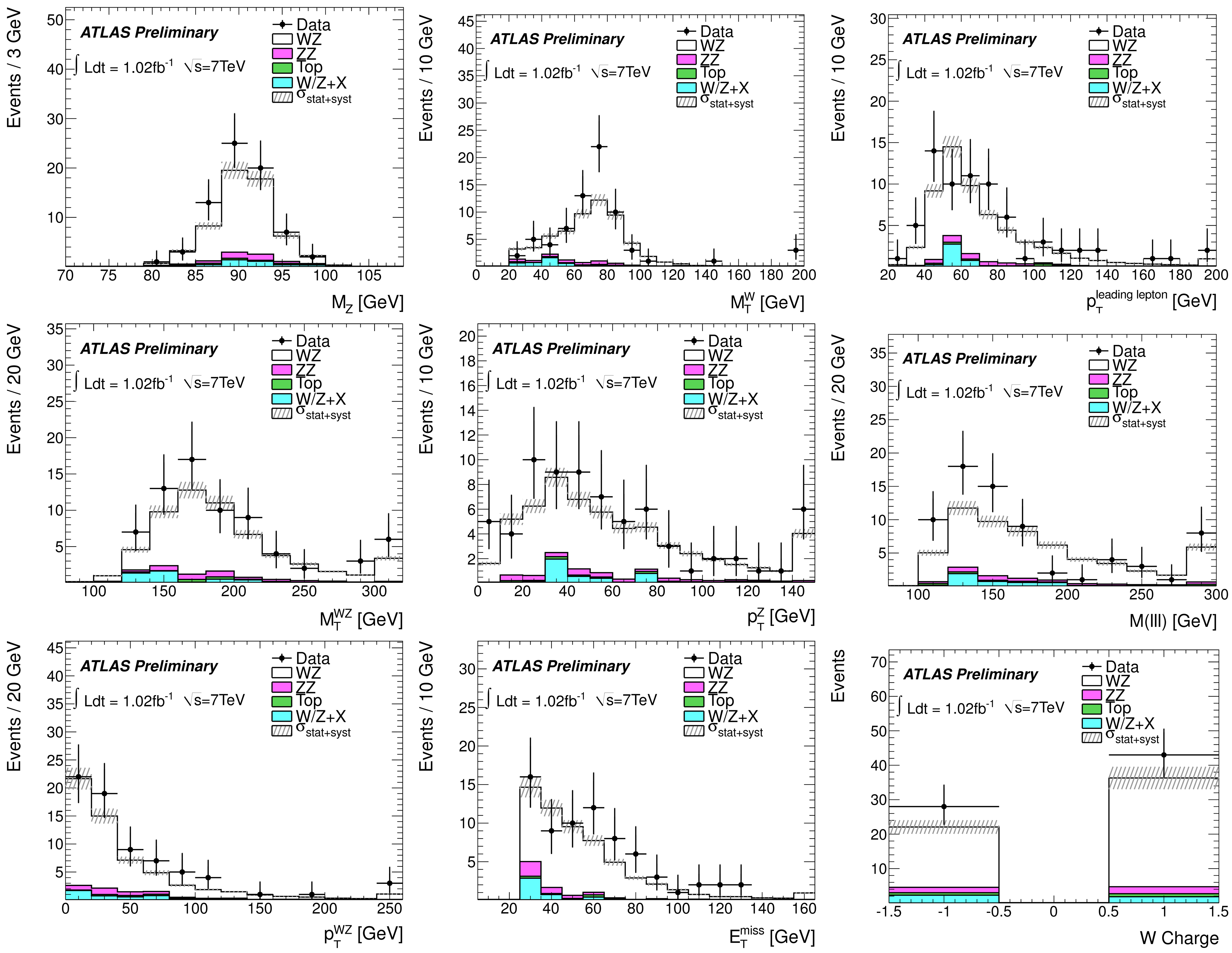
- from calorimeter clusters and reconstructed objects

Cut	Cumulative Acceptance	Relative Acceptance
μ or e trigger	78.9	78.9
Primary Vertex	78.7	99.8
$\|M_{\ell\ell} - M_Z\| < 10$ GeV	28.2	35.8
Three Leptons	12.3	43.7
$E_T^{miss} > 25$ GeV	10.0	81.2
$M_T^W > 20$ GeV	8.5	84.9
Trigger Match	8.4	99.5

A tight Z cut removes much of multi-jet and top.



$W^{\pm}Z$ Kinematics



Event Count

Final State	$eee + E_T^{miss}$	$ee\mu + E_T^{miss}$	$e\mu\mu + E_T^{miss}$	$\mu\mu\mu + E_T^{miss}$	Combined
Observed	11	9	22	29	71
Expected Signal	7.55±0.17	11.27±0.20	12.12±0.22	18.16±0.27	49.1±0.4±3.02
Total Background	3.08±0.49	1.98±0.24	3.82±0.56	2.44±0.21	10.5±0.8$^{+2.9}_{-2.1}$
ZZ	0.34±0.07	1.03±0.13	0.82±0.12	1.40±0.15	3.55±0.24±0.17
$W^{\pm}/Z + jets$	2.03±0.38	0.64±0.18	2.03±0.38	0.44±0.15	5.14±0.59$^{+2.97}_{-2.08}$
Top	0.26±0.10	0.31±0.09	0.41±0.12	0.60±0.15	1.58±0.23±0.10
$W^{\pm}/Z + \gamma$	0.49±0.28	-	0.56±0.39	-	1.05±0.48±0.08

Data Driven Backgrounds

- Z + jets is the largest background. It contains a 'fake' third lepton.
- Fake muons can come from heavy flavor decays.
- Fake electrons can come from misidentified jets.
- Isolation and object quality are used to define tight and loose leptons.
- The ratio of tight to loose fake leptons is measured in a events with a Z and low E_T^{miss}.
- This ratio is applied to the Z + loose lepton sample, after all other cuts.
- Extrapolation out of the low E_T^{miss} region is corrected via MC and checked in dijets.

Cross Section

Both the total and fiducial cross sections are obtained by a simultaneous log likelihood fit to the number of events in each channel. Systematic errors are modeled by Gaussian constrained nuisance parameters.

To measure a fiducial cross section, a common phase space is defined for all channels which closely matches the detector acceptance. The fiducial region is defined as: $p_T^{e,\mu} > 15$ GeV , $p_T^{e,\mu} > 15$ GeV, $|\eta^{e,\mu}| < 2.5$, $|M_{\ell\ell} - M_Z| < 10$ GeV, $M_T^W > 20$ GeV.

$$\sigma^{fid}_{WZ\to\ell\nu\ell\ell} = 118^{+18}_{-16}(\text{stat})^{+6}_{-6}(\text{syst})^{+5}_{-5}(\text{lumi})\text{pb}$$

$$\sigma^{tot}_{WZ} = 21.1^{+3.1}_{-2.8}(\text{stat})^{+1.2}_{-1.2}(\text{syst})^{+0.9}_{-0.8}(\text{lumi})\text{pb}$$

Anomalous TGC Fitting

The fiducial cross section is used to constrain anomalous triple gauge couplings. The triple gauge coupling terms allowed by C and P are:

$$\frac{\mathcal{L}_{WWZ}}{g_{WWZ}} = i\left[g_1^Z(W^{\dagger}_{\mu\nu}W^{\mu}Z^{\nu} - W_{\mu\nu}W^{\dagger\mu}Z^{\nu}) + \kappa^Z W^{\dagger}_{\mu}W_{\nu}Z^{\mu\nu} + \frac{\lambda}{m_W^2}W^{\dagger}_{\rho\mu}W^{\mu}_{\nu}Z^{\nu\rho}\right]$$

The standard model has $g_1^Z = 1$, $\kappa^Z = 1$ and $\lambda = 0$. A cutoff scale of $\Lambda = 3$ TeV is used to avoid unitarity violation. Each parameter is fit independently, assuming a Standard Model value for the others.

aTGC Parameter	Observed 95% C.I.
Δg_1^Z	[-0.21,0.30]
$\Delta\kappa^Z$	[-0.9,1.2]
λ	[-0.18,0.18]

Anomalous TGC Results