W and Z properties and cross sections measured with ATLAS

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1 Introduction

Precise measurements of W and Z production have been performed using the ATLAS detector [1] at LHC with data at a centre of mass energy $\sqrt{s} = 7$ TeV where large production rates of W and Z bosons are observed. The studies of the production of W and Z bosons provide the understanding of electroweak processes and stringent tests of QCD. The studies in this report used data with approximately 36pb^{-1} of integrated luminosity collected in 2010. The ATLAS detector consists of a tracking system inside a 2T solenoid magnet, calorimeters and muon spectrometers using approximately 3.9Tm toroidal magnets. The samples are collected by using unique signatures of Drell-Yan processes: $W^{\pm} \to l^{\pm}\nu$ and $Z \to l^{+}l^{-}$, where l stands for e, μ and τ. The lepton identifications (ID) have a very important role in the selection. Restrictions on reconstructed mass are applied to obtain pure samples. Samples of signals and backgrounds are simulated with several Monte Carlo generators and parton density functions (PDF). The details are described in the references.

2 Measurements

The inclusive cross sections of $W^{\pm} \to l^{\pm}\nu$ and $Z \to l^{+}l^{-}$ provide important testing ground of QCD, especially for the parameterisations of PDFs of the proton. The differential cross section for e and μ decay channels has been measured as a function of rapidity y or pseudo rapidity η [2]. Combined results of muon and electron channels for each process are shown in Figure 1. The data provide some PDF discrimination. The integrated cross sections are calculated for each channel in common fiducial phase space and extrapolated to the full phase space. Results are combined for each lepton flavour and for of W^{+} and W^{-} processes. The comparison of total cross sections $\sigma^{fid}_{W^{+}} \cdot \text{B}R(W^{+} \to l^{+}\nu)$ to $\sigma^{fid}_{W^{-}} \cdot \text{B}R(W^{-} \to l^{-}\overline{\nu})$ and combined W processes $\sigma^{fid}_{W^{\pm}} \cdot \text{B}R(W^{\pm} \to l\nu)$ to $\sigma^{fid}_{Z} \cdot \text{B}R(Z \to l^{+}l^{-})$ are shown in Figure 2. The data are

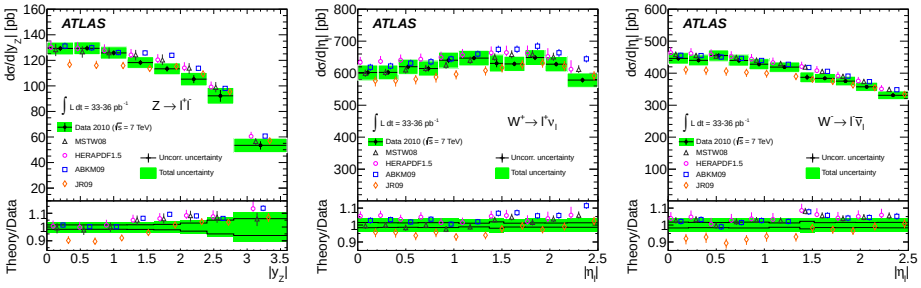

Figure 1: Differential cross sections for $Z \to l^+l^-$ process as a function of $|y_z|$ at left, and $W^+ \to l^+\nu$ and $W^- \to l^-\overline{\nu}$ as a function of $|\eta_l|$ at middle and right, respectively, where results from muon and electron processes are combined [2].

compared with several theoretical expectations. The ratios of total cross sections of the e and μ decay channels of W and Z are $R_W = Br(W \to e\nu)/Br(W \to \mu\nu) = 1.006 \pm 0.024(1.017 \pm 0.019)$ and $R_Z = Br(Z \to ee)/Br(Z \to \mu\mu) = 1.018 \pm 0.031(0.9991 \pm 0.0024)$, respectively, where the error is the total uncertainty and the world averages from PDG [3] are shown in the parentheses. As show in Figure 2, both results show a good agreement with the world average.

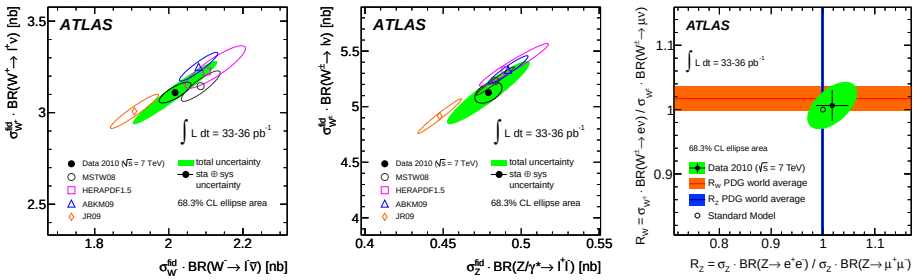

Figure 2: Ratio of total cross sections in the fiducial phase space between $W^+ \to l^+\nu$ and $W^- \to l^-\overline{\nu}$ (left), and between $W^\pm \to l\nu$ and $Z \to l^+l^-$ (middle). Comparison of ratios of e to μ decay channels of W and Z bosons (right) [2].

The polarisation of $W^+ \to l^+\nu$ and $W^- \to l^-\overline{\nu}$ was obtained by using the W decay angular distributions projected onto the transverse plane [4]. The angular distribution was analysed in terms of helicity fractions f_0, f_L and f_R in two ranges of W transverse momentum (p_{T}^W). Figure 3 shows the correlation between f_0 and $f_L - f_R$ in two p_{T}^W ranges. The results are in good agreement with theoretical predictions.

The cross section measurements of lepton channels are completed by the cross section of τ decay channel [5, 6]. This is shown in Figure 4 together with e and μ

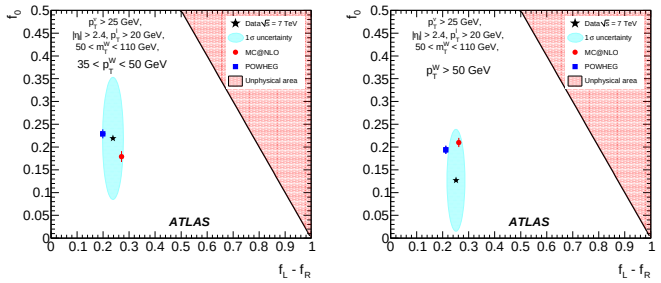

Figure 3: Polarisation of W boson in low p_T region (left) and high p_T region (right) [4].

decay channels. Although the results have slightly larger systematic errors than for e and μ, due to energy scales and lepton ID efficiencies, they agree well with theoretical predictions. Using the selected τ samples, the τ polarisation $P_\tau = (\sigma_R - \sigma_L)/(\sigma_R + \sigma_L)$

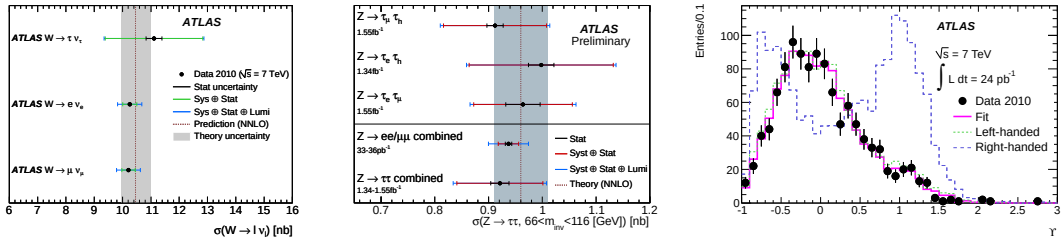

Figure 4: Cross sections for τ lepton channels of W and Z decay and τ polarisation in $W \to \tau\nu$ decay. The cross section of W boson decaying to τ leptons (left) [5], the cross section of Z boson decaying to τ leptons (middle) [6] and τ polarisation measurement (right) [7].

has been measured using one prong hadronic decays of τ leptons from $W \to \tau\nu$ [7]. The measurement is carried out by observing the charge asymmetry of τ lepton decaying to $\rho\nu$, $\Upsilon = (E_T^{\pi^-} - E_T^{\pi^0})/|\vec{P}_T^{\pi^-} + \vec{P}_T^{\pi^0}|$, since it is correlated with the τ polarisation. The Υ distribution is fitted by using two templates which are produced for left-handed τ and for right-handed τ separately. The results are shown in Figure 4 and are in good agreement with the Standard Model prediction.

The strange quark density of the proton is studied within a QCD framework jointly with inclusive deep inelastic scattering data from HERA [8]. The ATLAS data show sensitivity to the light quark sea composition at Bjorken $x \sim 0.01$. The results of the fit show that the strange quark density with respect to the down sea quark density $r_s = 0.5(s(x) + \overline{s}(x))/\overline{d}(x)$ is not suppressed. The result is compared with four theoretical expectations in Figure 5.

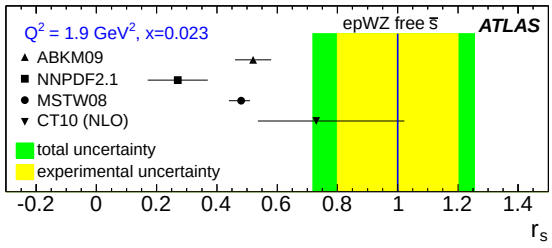

Figure 5: The ratio of the strange quark density to the down sea quark density in the proton at $Q^2 = 1.9GeV^2, x = 0.023$ and comparison with different PDF [8].

3 Summary

The studies of the production of W and Z bosons are carried out using data collected by the ATLAS detector mainly in 2010. The comparisons of the results with several theoretical expectations provide stringent tests of QCD and some contribution to improve the theoretical expectations. The analysis using data collected in 2011 and 2012 will provide more accurate results in near future.

References

[1] ATLAS Collaboration, JINST **3** (2008) S08003.

[2] ATLAS Collaboration, Phys. Rev. D **85** (2012) 072004

[3] Particle Data Group Collaboration, Phys. Rev. D **86** (2012) 010001.

[4] ATLAS Collaboration, Eur. Phys. J. C **72** (2012) 2001

[5] ATLAS Collaboration, Phys. Lett. B **706** (2012) 276

[6] ATLAS Collaboration, ATLAS-CONF-2012-006, http://cdsweb.cern.ch/record/1426991

[7] ATLAS Collaboration, Eur. Phys. J. C **72** (2012) 2062

[8] ATLAS Collaboration, Phys. Rev. Lett. **109** (2012) 012001