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Recent electroweak results from ATLAS*

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Abstract

Recent measurements and searches in the electroweak sector of the Standard Model by the ATLAS experiment at the LHC are reported. The results are based on 20.3 fb^{-1} of proton-proton collisions at $\sqrt{s} = 8$ TeV for WW, WZ, ZZ, $Z\gamma$ and $Z\gamma\gamma$ production as well as on 3.2 fb^{-1} of proton-proton collisions at $\sqrt{s} = 13$ TeV for WZ and ZZ production.

Keywords: Standard Model, electroweak

1. Introduction

A precise measurement of the electroweak processes is very important to test the Standard Model. Especially measurements at new energy regimes could provide hints for new physics. Studying electroweak processes is also important to improve existing measurements of the Standard Model's electroweak parameters and to understand higher order effects not only in the electroweak sector but also in the quantum chromodynamics sector. Electroweak processes also represent significant backgrounds for various analyses which requires these processes to be understood as best as possible.
Recent electroweak results on diboson and triboson production in proton-proton collisions at $\sqrt{s} = 8$ TeV based on 20.3 fb^{-1} of data recorded by the ATLAS detector [1] in 2012 at the CERN Large Hadron Collider [2] as well as results at $\sqrt{s} = 13$ TeV based on 3.2 fb^{-1} of data recorded in 2015 are presented.

2. *WW* production at $\sqrt{s} = 8$ TeV

W boson pairs can be produced via quark antiquark annihilation or gluon gluon fusion. The latter process can also produce a Higgs boson which can decay into two W bosons. This contribution and interference with the non resonant process are taken into account in the simulations used for this study. The W bosons are reconstructed using the leptonic decay channels $W^+W^- \rightarrow l^+\nu_l l'^-\bar{\nu}_{l'}$ with $l, l' \in \{e, \mu\}$. This leads to three different fiducial phase spaces for the three final states which are denoted with ee, $\mu\mu$ and $e\mu$. In all three fiducial phase spaces the p_T of the leading lepton has to be greater than 25 GeV whereas the p_T of the subleading lepton has to be greater than 20 GeV. The absolute pseudorapidity, η, of electrons must be smaller than 2.47 while muons must have $|\eta| < 2.4$. The reconstructed mass $m_{e\mu}$ has to be greater than 10 GeV. The reconstructed mass $m_{ee/\mu\mu}$ has to be greater than 15 GeV and fullfil the relation $|m_Z^{\text{PDG}} - m_{ee/\mu\mu}| > 15$ GeV. The results for the measured fiducial cross section in each final state [3] can be seen in Table 1. Comparisons to different theoretical predictions of the fiducial cross sections are shown in Figure 1. Generally the predicted cross sections are smaller than the measured cross sections but compatible within the uncertainties.

The total cross section is obtained by extrapolating the fiducial cross section for all acceptance effects and correcting for the W branching fractions to leptons [3]. The combined total cross section is found to be $71.1 \pm 1.1(\text{stat})\,^{+5.7}_{-5.0}(\text{syst}) \pm 1.4(\text{lumi})$ pb and compatible with the NNLO prediction of $63.2\,^{+1.6}_{-1.4}(\text{scale}) \pm 1.2(\text{PDF})$ pb [4, 5] within about 1.4 standard deviations.

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Table 1: Measured fiducial WW cross section at $\sqrt{s}$ = 8 TeV and $\mathcal{L}$ = 20.3 fb^{-1} for each channel. [3]

Measured channel	Fiducial cross section [fb]
$\sigma^{e\mu}_{fid}$	$374 \pm 7(\text{stat})\,^{+25}_{-23}(\text{syst})\,^{+8}_{-7}(\text{lumi})$
σ^{ee}_{fid}	$73.4\,^{+4.2}_{-4.1}(\text{stat})\,^{+6.5}_{-5.6}(\text{syst}) \pm 1.5(\text{lumi})$
$\sigma^{\mu\mu}_{fid}$	$80.2\,^{+3.3}_{-3.2}(\text{stat})\,^{+6.4}_{-5.5}(\text{syst}) \pm 1.6(\text{lumi})$

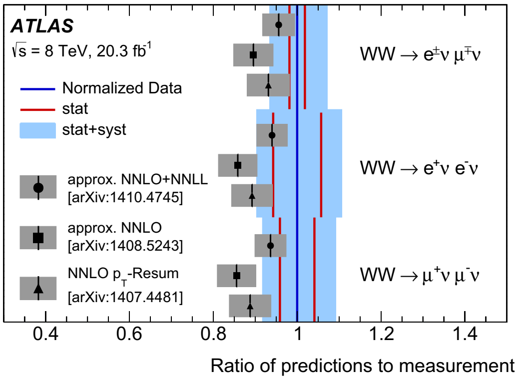

Figure 1: Theoretical predictions compared to measured fiducial WW cross sections at $\sqrt{s}$ = 8 TeV and $\mathcal{L}$ = 20.3 fb^{-1}. [3]

Differential cross section measurements have been performed as function of the leading lepton p_{T}. The result of this measurement can be seen in Figure 2. It is observed that except for high and very low values of p_{T} the predictions generally undershoot the data. The shapes of the unfolded data distributions agree with the predictions at the level of ±15 %.

Limits on anomalous triple gauge couplings (aTGCs) have also been set using the p_{T} distribution of the leading lepton. The results can be seen in Figure 5.

3. *WZ* production at $\sqrt{s}$ = 8 TeV and $\sqrt{s}$ = 13 TeV

Pairs of a W and a Z boson are produced in quark antiquark annihilation, where a contribution from the WWZ triple gauge coupling is included. The reconstruction is done in the channels $W^{\pm}Z \to l'^{\pm} \overset{(-)}{\nu}_{l'} l^{+} l^{-}$ with $l, l' \in \{e, \mu\}$. The four resulting final states will be denoted by eee, $e\mu\mu$, μee and $\mu\mu\mu$. The fiducial phase space is defined by the following four requirements. The p_{T} of the leptons from the Z boson decay has to be greater than 15 GeV whereas the p_{T} of the charged lepton from the W boson decay has to be greater than 20 GeV. Any charged lepton has to be within $|\eta| < 2.5$. Finally the reconstructed Z boson mass m_{ll} has to fulfill the relation $|m_Z^{\mathrm{PDG}} - m_{ll}| < 10$ GeV. The combined fiducial cross

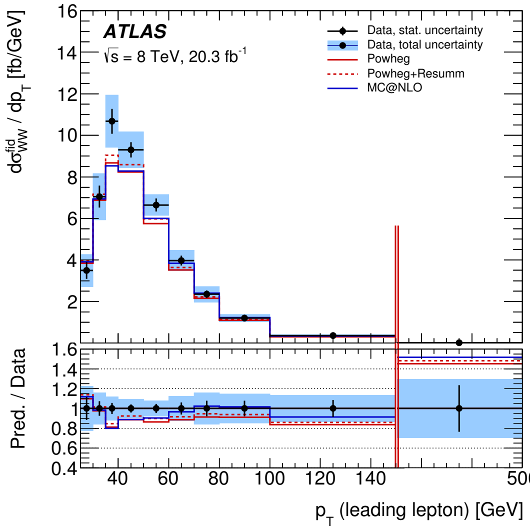

Figure 2: Theoretical predictions compared to the measured differential WW cross section of the leading lepton p_{T} at $\sqrt{s}$ = 8 TeV and $\mathcal{L}$ = 20.3 fb^{-1}. The lower plot shows the ratio between the theoretical predictions and the measured differential cross section. The red vertical line indicates a change of the bin size. [3]

section $\sigma^{fid.}_{W^{\pm}Z \to l'\nu ll}$ at $\sqrt{s}$ = 13 TeV is measured to be $63.2 \pm 3.2(\text{stat}) \pm 2.6(\text{syst}) \pm 1.5(\text{lumi})$ fb [6]. The NLO Standard Model prediction from Powheg+Pythia [7–9] is $53.4\,^{+1.6}_{-1.2}(\text{PDF})\,^{+2.1}_{-1.6}(\text{scale})$ fb. The measured cross section is larger than the Standard Model prediction as observed also at $\sqrt{s}$ = 8 TeV [10].
The combined fiducial cross section is extrapolated to the total phase space yielding a total cross section of $50.6 \pm 2.6(\text{stat}) \pm 2.0(\text{syst}) \pm 0.9(\text{theo}) \pm 1.2(\text{lumi})$ pb. A recent calculation of the $W^{\pm}Z$ production cross section with MATRIX [11] at NNLO shows a better agreement. Comparisons to this recent theoretical prediction for the total cross sections at $\sqrt{s}$ = 13 TeV, $\sqrt{s}$ = 8 TeV and $\sqrt{s}$ = 7 TeV are made in Figure 3.

Differential cross sections have been measured as function of the transverse mass m_{T}^{WZ} of the WZ system and of the transverse momentum p_{T}^{ν} of the neutrino. The results of this measurement are displayed in Figure 4. The measured cross section as function of the m_{T}^{WZ} is higher than the NLO prediction. Similarly, also the measured total cross section is higher than that predicted by a NLO calculation. Instead, the shapes of the experimental and theoretical distributions are in fair agreement. The p_{T}^{ν} distribution shows some disagreements between experiment and theory for $p_{\mathrm{T}}^{\nu} < 50$ GeV. This is most likely due to effects of higher order corrections beyond NLO.

Vector boson scattering (VBS) cross sections have

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