Electroweak di-boson production in ATLAS

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1 Introduction

In the LHC era, it is crucial to gain a good understanding of the electroweak sector of the Standard Model (SM). Determining the cross-sections of electroweak processes is therefore of great importance, both as prerequisites to Higgs-Boson searches as well as measurements in their own right. For this conference, several new measurements with the data from proton-proton collisions at $\sqrt{s} = 7$ TeV taken in 2010 and 2011 with the ATLAS detector[1] have been prepared: A measurement of the isolated di-photon cross-section[2] using 37 pb^{-1} collected in 2010 and a measurement of the $W^{\pm}Z$ production cross-section[3] using 205 pb^{-1} collected in 2011. In addition and for a complete view of the electroweak sector, the already published measurements of the $W\gamma$ and $Z\gamma$ cross-sections[4] and the WW cross-sections[5] are presented as well.

2 Di-photon cross-section

Di-photon final states in proton-proton collisions may occur through quark-antiquark t-channel annihilation ($q\overline{q} \rightarrow \gamma\gamma$), or via gluon-gluon interactions ($gg \rightarrow \gamma\gamma$) by a quark box diagram. Even though the latter is of higher order, the high gluon flux at the LHC causes the two contributions to be comparable.

In the selection of the photon pair candidates a fiducial acceptance region is required in pseudorapidity, $|\eta_\gamma| < 2.37$, excluding the barrel/endcap transition region $1.37 < |\eta_\gamma| < 1.52$. In addition, photon candidates are required to have a transverse momentum of more than 16 GeV. The opening angle of the photons must be $\Delta R_{\gamma\gamma} > 0.4$, and both photons have to be isolated: the transverse energy in a cone of angular radius $R < 0.4$ must be $E_T^{iso(part)} < 4$ GeV. The background, consisting of hadronic jets and isolated electrons, is estimated with fully data-driven techniques and subtracted. The selection of the control sample for this procedure is the main source of systematic uncertainty for this measurement.

Results of the measurement[2] are shown in Figure 1 and compared with theoretical predictions from the DIPHOX and ResBos NLO generators. In the $\mathrm{d}\sigma/\mathrm{d}\Delta\varphi_{\gamma\gamma}$

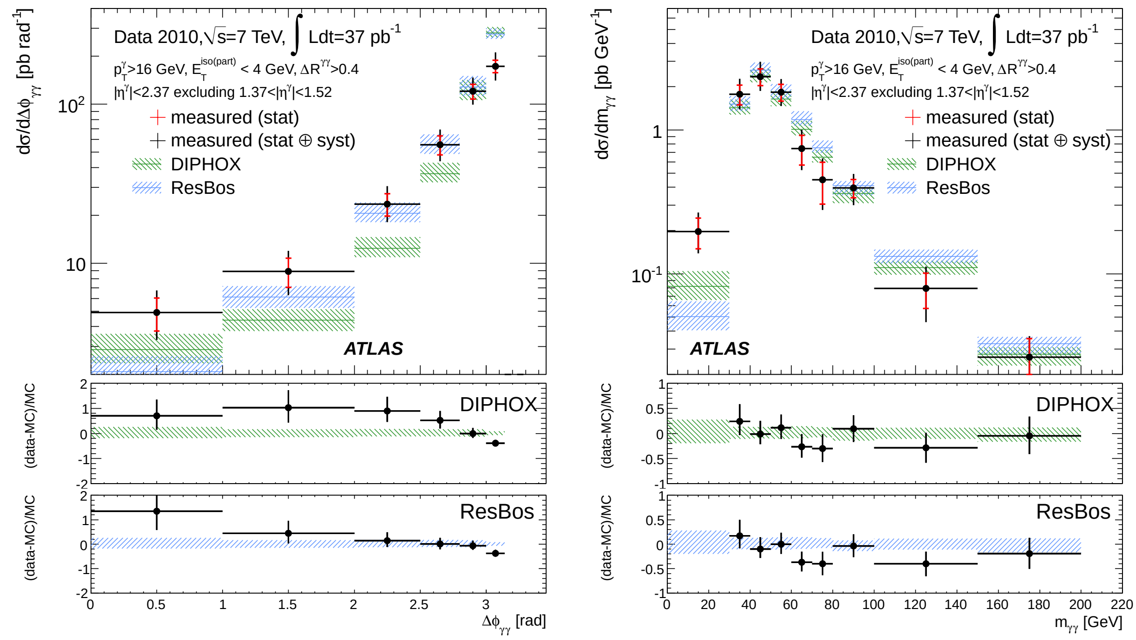

Figure 1: Differential di-photon cross-section $\mathrm{d}\sigma/\mathrm{d}\Delta\varphi_{\gamma\gamma}$ and $\mathrm{d}\sigma/\mathrm{d}m_{\gamma\gamma}$

differential cross-section the spectrum is broader towards low values of $\Delta\varphi_{\gamma\gamma}$ than NLO predictions, consistent with observations at the TeVatron[6, 7]. This effect leads to the related discrepancy in the $\mathrm{d}\sigma/\mathrm{d}m_{\gamma\gamma}$ spectrum, which otherwise agrees well with predictions.

3 $W^{\pm}Z$ cross-section

The $W^{\pm}Z$ cross-section is measured using 205 pb^{-1} of pp collision data taken in 2011[4]. In the analysis, three reconstructed leptons (e, μ) are required, two of which must have the same flavor, opposite sign, and an invariant mass within 10 GeV of the Z mass. In addition, the missing tranverse energy $E_{T,miss}$ is required to be larger than 25 GeV. In total, 12 candidates with an expected background of 2 events are observed.

The final result for the combined fiducial cross-section in this region is $\sigma^{fid}_{WZ\rightarrow\ell\nu\ell\ell} = 96^{+37}_{-30}(\mathrm{stat})^{+15}_{-14}(\mathrm{syst}) \pm 5(\mathrm{lumi})$ fb, with $\ell = e, \mu$, the dominant systematic uncertainty being the description of pile-up conditions for $E_{T,miss}$ with about 11%. Extrapolating to the total cross-section gives $\sigma^{tot}_{WZ} = 18^{+7}_{-6}(\mathrm{stat})^{+3}_{-3}(\mathrm{syst})^{+1}_{-1}(\mathrm{lumi})$ pb, which agrees well with the Standard Model prediction of $16.9^{+1.2}_{-0.8}$ pb.

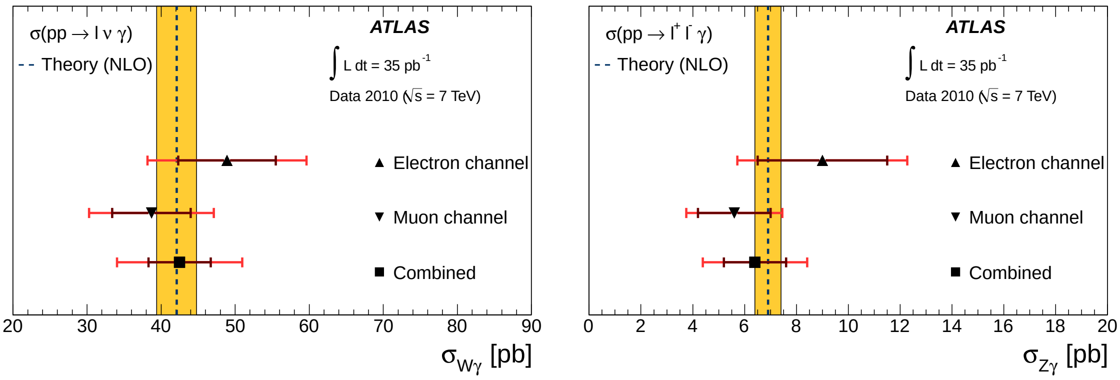

Figure 2: Summary of $Z^0\gamma/W^{\pm}\gamma$ cross-section measurements.

4 $Z\gamma/W^{\pm}\gamma$ cross-section

Using 35 pb^{-1} of ATLAS data from 2010, the $Z\gamma/W^{\pm}\gamma$ cross-section measurement[3] closely follows the $W^{\pm}$ and Z cross-section analyses, but requires one additional photon with a $p_T > 15$ GeV. To suppress the contribution of Final State Radiation (FSR) the ΔR between lepton and photon must be $\Delta R(\ell, \gamma) > 0.7$. The main backgrounds are estimated from data using a two-dimensional sideband method, being one of the main systematic uncertainties together with the uncertainty of photon identification efficiency. The measured cross-sections are compared to the SM predictions generated by NLO theory in Figure 2 and agree well within uncertainties.

5 W^+W^- cross-section

With 34 pb^{-1} of collision data from 2010 a first measurement at ATLAS of the W^+W^- production cross-section is undertaken[5]. The analysis requires exactly two well-reconstructed oppositely charged leptons (ℓ = e, μ) and excludes the Z resonance peak and low-mass resonances for leptons with same flavour. In addition, the component of the missing transverse energy perpendicular to the lepton closest in φ must be larger than 20(40) GeV for leptons with different(same) flavour. Finally, all events with jets with $p_T > 20$ GeV are vetoed. The main systematic uncertainties stem from this jet veto (7.5%) and from the lepton selection and identification (4%). The background components are estimated using Monte Carlo and data driven methods for the $t\bar{t}$ and W+jets components. The cross-section is then determined by a maximum-likelihood fit combining the three channels. The resulting cross-section is $\sigma_{W^+W^-} = 41^{+20}_{-16}(stat) \pm 5(syst) \pm 1(lumi)$ pb, in good agreement with the QCD-NLO SM prediction of 44 ± 3 pb.

6 Conclusion

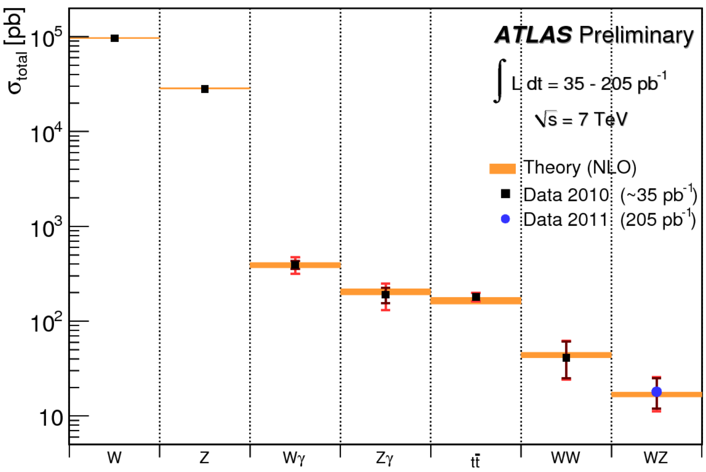

Figure 3: Summary of Electroweak measurements.

With collision data from the LHC taken in 2010 and 2011, we present measurements of $W\gamma$, $Z\gamma$, W^+W^-, $W^\pm Z$ and $\gamma\gamma$ production cross-sections. In Figure 3 these measurements are summarized and compared to NLO predictions. No deviations from Standard Model predictions are observed. For direct $\gamma\gamma$ production, differential cross-sections with respect to $m_{\gamma\gamma}$ and $\Delta\varphi_{\gamma\gamma}$ are shown. The next step will be updating all measurements using 2011 data, and setting limits on anomalous triple-gauge couplings.

References

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