Electroweak measurements with the ATLAS detector

Krasnopevtsev D. a
on behalf of the ATLAS Collaboration

National Research Nuclear University MEPhI, 115409, Russia, Moscow

Abstract. ATLAS measurements of multi-boson production processes involving combinations of W, Z and isolated photons at 8 TeV are summarized. Standard Model cross section are measured with high precision by ATLAS and are compared to world averages. Production processes sensitive to vector-boson fusion and vector-boson scattering are also presented and used for the triple and quartic gauge boson couplings limits setting.

1 Introduction

Precision electroweak (EWK) measurements at the Large Hadron Collider (LHC) aim to validate Standard Model (SM) in new energy scale, to improve accuracy of known SM parameters and to estimate new physical contributions. The triple (TGC) and quartic (QGC) gauge boson couplings can be tested at the LHC through studies of multiboson production or through studies of vector boson fusion (VBF) and vector boson scattering (VBS) processes. This proceeding reports on recent ATLAS [1] studies using 20.3 fb⁻¹ of proton-proton collisions at a center of mass energy of 8 TeV. In the following, the most up-to-date measurements of 4 lepton and Wγγ cross sections will be reviewed, along with that of vector boson fusion with Z and vector boson scattering with WW. Studies of these processes are motivated by both theoretical and experimental considerations, as will be illustrated in the following sections.

2 Electroweak measurements

2.1 Inclusive 4 lepton production

The main goal of this study is to test validity of the SM through the interplay of QCD and EW effects for different 4 lepton (4l) productions [2]. The following productions could be observed at the LHC: qq originated 4l production, 4l from higgs decays, non-resonant ZZ to 4 leptons production. Leptonic channel is very clean. Background contribution is less than 10% and the impact of background uncertainty to the cross section is less than 1%. Combined cross section results are in agreement with SM predictions within statistical and systematic uncertainties Fig. 1(a). Discrepancies between signal strength and current LO prediction are interpreted as missing higher order correction to gg → 4l. This correction is extracted from data in M_4l > 180GeV region: μ_{gg} = 2.4 ± 1.0(stat.) ± 0.5(syst.) ± 0.8(theory).

aE-mail: Dimitriy.Krasnopevtsev@cern.ch
Figure 1: (a) The measured 4 lepton cross sections in extended phase space divided by the expected inclusive cross sections. The results per channel and for the three-channel combinations in the extended phase space [3]; (b) The measured cross sections for WW VBS region compared to the predicted standard model cross section [6]; (c) Comparison of the 95% CL limits on $\mathcal{J}^{\text{E}}_{\text{ET0}}/\Lambda^4$, $a^{\text{W}}_W/\Lambda^2$, and $a^{\text{W}}_W/\Lambda^4$ obtained by $W\gamma\gamma$ analysis in ATLAS and other different experiments [8].

2.2 Vector boson fusion Z

Vector boson fusion Z signal events also contain leptons as final state but they are accompanied by at least two high $p_T$ jets [4]. Strong production is dominant for this study and VBF process is a component of EWK $Zjj$ production. EWK components could be extracted using jets invariant mass distribution $M_{jj}$ and better $p_T$ balance of the $Zjj$ system. EWK results are in a good agreement with Powheg predictions and show that background-only hypothesis rejected with significance above 5 $\sigma$:
\[
\sigma_{\text{exp}} = 54.7 \pm 4.6(\text{stat})^{+9.8}_{-10.3}(\text{sys}) \pm 1.5(\text{lumi}) \text{ fb},
\]
\[
\sigma_{\text{theory}} = 46.1 \pm 0.2(\text{stat})^{+0.3}_{-0.2}(\text{scale}) \pm 0.8(\text{PDF}) \pm 0.5(\text{model}) \text{ fb}.
\]
Electroweak $Zjj$ production cross section results are used to test of anomalous triple gauge coupling (aTGC) limits on $\lambda_Z$ and $g_{1Z}$ parameters.

2.3 Vector boson scattering WW

VBS WW production is observed for the first time with a significance of 3.6 standard deviations and is sensitive to the mechanism of electroweak symmetry breaking as well as beyond the standard model physics [5]. Events with two reconstructed same-charge leptons and two or more jets are analyzed. Measured cross-sections are in agreement with theory prediction Fig. 1(b). Anomalous quartic gauge coupling (aQGC) limits on $\alpha_4$ and $\alpha_5$ parameters are set at 95% confidence level.
2.4 \( W\gamma\gamma \) production

\( W\gamma\gamma \) production [7] is the first measurements of triboson process in ATLAS. Signal events contain two isolated photons and \( W \) decayed into leptons. The largest backgrounds are jets faking photons and leptons and are estimated using data-driven techniques. Combined results show a statistical significance above three standard deviations for SM \( W\gamma\gamma \) process. Cross section is higher by 1.9 \( \sigma \) than SM NLO prediction in inclusive case. Better agreement is observed for the exclusive case. ATLAS anomalous quartic couplings limits for \( f_{E_0}^W \), \( a_W^{C_0} \), and \( a_W^0 \) are set for exclusive case and are better or similar to LEP and D0 collaborations Fig. 1(c).

3 Future electroweak measurements with ATLAS

A new run of the LHC has started recently during summer 2015 at an increased center of mass energy of 13 TeV. Recent EWK studies include the first \( W^\pm \) and \( Z \) production cross sections measured by ATLAS at the highest centre-of-mass energy ever available from a collider and show agreement with theoretical calculations based on NNLO QCD [9]. A variety of multi-boson channels studies have been started and more EWK measurement with ATLAS detector are expected to come soon.

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References