Searches for new heavy gauge bosons in 2011 ATLAS data

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1 Abstract

The ATLAS detector at the Large Hadron Collider has been used to search for high-mass states decaying to a charged lepton (electron or muon) and a neutrino, or into two oppositely-charged leptons. Results are presented using approximately 200 pb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV from 2011, and no excess with respect to Standard Model expectations is observed. 95% C.L. mass limits are set on the Sequential Standard Model W' (Z') of 1.70 (1.41) TeV and 1.12-1.26 TeV on E_6 motivated Z' models.

2 Introduction

Several extensions of the Standard Model predict new heavy gauge bosons, charged and neutral. The benchmark models considered for these searches are the Sequential Standard Model (SSM) W' and Z' [1], plus E_6 grand unified theory models for Z' [2]. The ATLAS detector [3] has been used to search for the decays of these bosons in leptonic final states, where lepton in this note refers to an electron or muon.

3 W' Search

This search selects events with a lepton and significant missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$). To discriminate signal from background, the transverse mass is used:

$$m_T = \sqrt{2 p_T E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos \varphi_{l\nu})} \tag{1}$$

which would display a Jacobian peak that falls sharply above the resonance mass. The results shown here focus on the muon channel, which was updated with 205 pb^{-1} of data from early 2011 [4]. For the limit setting, the electron channel results from 36 pb^{-1} of data recorded in 2010 [5] are included.

Muon candidates are required to pass quality cuts in the Inner Detector and Muon Spectrometer to remove fakes and ensure well-reconstructed muons. They are further required to be isolated from other tracks in the Inner Detector and have track impact parameters consistent with the primary vertex in the event. The primary background comes from Standard Model W production, and the other main backgrounds are from Standard Model sources of dimuons, particularly Drell-Yan production, when one muon falls outside the detector acceptance, is not reconstructed, or fails the selection criteria. These backgrounds are taken from simulation and the cross sections are corrected to NNLO or near-NNLO. After the track quality and isolation requirements, background from QCD dijets and cosmic rays is found to be negligible. Figure 1 (left) shows the m_T spectrum for selected events, which is in good agreement with Standard Model expectations.

Limits are then set on σB at the 95% C.L. using the frequentist CL_s approach [6]. Systematic uncertainties are included; the largest uncertainty on the signal comes from the modeling of $E_{\mathrm{T}}^{\mathrm{miss}}$ with pileup, while the largest uncertainty for the background is the theoretical cross section at high m_T. The combined effect of the systematic uncertainties on the resulting limit is ∼1%. Figure 1 (right) shows the combined limit from the electron and muon channels on σB as a function of $M_{W'}$, with the theoretical cross section for the W'_{SSM} overlaid. The resulting mass limit is 1.70 TeV at the 95% C.L.

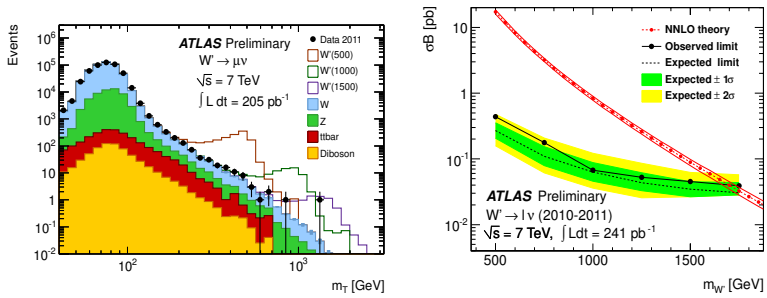

Figure 1: Transverse mass m_T for muon events passing the W' analysis selection (left). The open histograms show the expected contributions from three W'_{SSM} mass hypotheses. Limits on σB as a function of $M_{W'}$ combining the muon channel results described here with the electron channel results from 2010 (right). The red curve shows the theoretical cross-section, with errors, for the W'_{SSM}.

4 Z' Search

This search selects events with two leptons in the final state and looks for a resonance peak in the high invariant mass ($m_{\ell^+\ell^-}$) region. These results are based on 164 (236) pb^{-1} of data in the electron (muon) channel [7].

Electron candidates are required to pass identification criteria to reduce the contribution of fake or non-prompt electrons, and muons are required to pass criteria similar to the W' analysis above. The dominant background in both channels is Standard Model Drell-Yan production. In the electron channel, the next largest background is from QCD dijets, while for muons, Standard Model diboson production (WW,WZ,ZZ) is next. Background from QCD dijets and cosmic rays was found to be negligible in the muon channel. All backgrounds are taken from simulation except the QCD dijet background in the electron channel, which is estimated from data using two independent methods. Simulated background cross sections are scaled to NNLO or NLO, and the sum of backgrounds is normalized to the observed data in the Z peak. Figure 2 (left) shows the $m_{\ell^+\ell^-}$ distribution for electrons after the analysis selection; no significant excess above the Standard Model expectations is observed.

Limits are then set on σB at the 95% C.L. using a template fitting method and Bayesian statistics [8]. Systematics are included as nuisance parameters and marginalized. Since the background expectations are normalized to data in the Z peak, mass independent sources of systematic uncertainty cancel. The remaining mass-dependent uncertainties are dominated by those on PDFs and k-factors; as in the W' analysis, the total impact on the final limit is at the level of ∼1%. Figure 2 (right) shows the combined limit from the electron and muon channels on σB as a function of $M_{Z'}$, with theoretical cross sections for the Z'_{SSM} and the range for the E_6 models considered. The observed 95% C.L. mass limit for the Z'_{SSM} is 1.41 TeV, while the limits for the E_6 models are shown in Table 1.

Model	Z'_ψ	$Z'_{\rm N}$	Z'_η	Z'_I	$Z'_{\rm S}$	Z'_χ
Mass limit [TeV]	1.116	1.142	1.150	1.203	1.230	1.259

Table 1: Combined mass limits at 95% C.L. on the E_6-motivated Z' models.

5 Conclusions

The ATLAS detector at the Large Hadron Collider was used to search for high-mass states with ∼200 pb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV, and no excess with respect to Standard Model expectations is observed. 95% C.L. mass limits were set on the SSM W' (Z') of 1.70 (1.41) TeV and 1.12-1.26 TeV on E_6 motivated Z' models. Updated

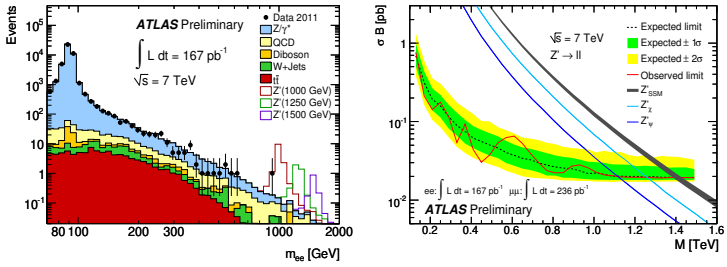

Figure 2: Invariant mass for dielectron events passing the Z' analysis selection (left). The open histograms show the expected contributions from three Z'_{SSM} mass hypotheses. Limits on σB as a function of $M_{Z'}$ combining the electron and muon channels (right). The curves show theoretical cross sections for various models.

results of these searches using $\sim$1 fb^{-1} of data are described in [9] and [10] and set 95% C.L. mass limits of 2.15 (1.83) on the SSM W' (Z').

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