PROCEEDINGS OF SCIENCE

Semi-leptonic ZZ/ZW Diboson Final State Search at 8 TeV with ATLAS *

Samuel Meehan †
The Enrico Fermi Institute, The University of Chicago
E-mail: samuel.meehan@cern.ch

Processes involving pairs of bosons in the final state play an important role in a wide range of measurements and searches at the LHC. Presented here is a search for high mass diboson resonances in the semi-leptonic *ZZ*/*ZW* channel, interpreted in terms of bulk Randall-Sundrum gravitons decaying to a pair of *Z* bosons, using 7.2 fb^{-1} of 8 TeV center of mass energy data produced by the LHC and collected with the ATLAS detector. Upper limits on the cross section times branching ratio are set at the 95% confidence level in a graviton mass range from 300 GeV to 2 TeV and a lower limit on the graviton mass is found to be 850 GeV.

The European Physical Society Conference on High Energy Physics
18-24 July, 2013
Stockholm, Sweden

*The search presented here is fully documented in ATLAS-CONF-2012-150 found on CDS at http://cds.cern.ch/record/1493489

†On behalf of the ATLAS collaboration.

PoS(EPS-HEP 2013)112

1. Introduction

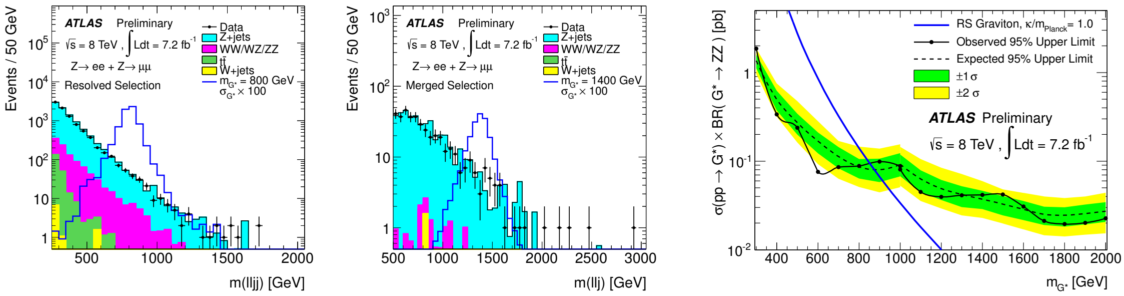
Many extensions of the Standard Model [1, 2] predict the existence of heavy resonances that couple to pairs of electroweak gauge bosons (W and Z). The subsequent decays of the W and Z bosons, into either leptons or quarks, offer distinct high transverse momentum (p_T) signatures that allow for searches to be made. Furthermore, the semi-leptonic final state, in which the final state includes a high-p_T W or Z boson decaying hadronically, offers increased statistics for the probing of higher mass scales and an important venue for testing jet substructure techniques that are becoming increasingly important to searches at the LHC. Searches of this variety have previously been performed both at the Tevatron [3] and LHC [4]. They have been surpassed by this latest search [5] at ATLAS [6] using 7.2 fb^{-1} of data at a center of mass energy of 8 TeV.

2. Search Summary

This analysis is focused on searching for diboson resonances in the $\ell\ell q\bar{q}$ final state across the broad mass range of 300 GeV to 2 TeV. The $Z \to \ell\ell$ decay is initially identified as a pair of well reconstructed, isolated, and prompt same flavor electrons or muons (requiring the pair to have opposite charge in only the muon channel) whose combined invariant mass is within 25 GeV of the Z boson mass. This removes the large multijet background, leaving Standard Model Z+jets as the primary background, with small contributions from $t\bar{t}$ and Standard Model diboson production. To increase sensitivity to the resonant signal, the high-p_T characteristics of the resonance decay are used to impose kinematic selections on both the leptonic and hadronic decay products of the boson pair. The first selection used to identify the signal decay is a lower bound on the transverse momentum of the dilepton system. However, due to the large mass range covered in the search, the hadronic final state topology of the signal is very different below and above a mass of 1 TeV. Below 1 TeV, the $W/Z \to q\bar{q}$ decay is reconstructed using two anti-k$_T$($R = 0.4$) jets [7]. However, above 1 TeV, this decay becomes merged in the calorimeter and it becomes beneficial to reconstruct the W/Z boson as a single massive jet. This divides the search into *resolved* and *merged* selection regions. The signal is identified by using the azimuthal separation of the two highest p_T jets and the invariant mass of the dijet system in the resolved selection and the p_T and invariant mass of the leading jet in the merged selection. In both selections, no requirement is made on the missing transverse energy of an event. After performing the selection, the 4-body $m(\ell\ell, jj)$ or 3-body $m(\ell\ell, j_1)$ invariant mass, analogous to the mass of the diboson resonance, is formed and used to perform the search for resonant excesses.

3. Results

After the optimization is performed using a Monte Carlo estimate of the background composition, the qualitative understanding of the background is confirmed by a comparison to data as in Figure 1(a) and Figure 1(b). However, after the full selection, the final background is parametrized by performing a binned fit of the reconstructed invariant mass of the four-vector reconstructed from the leptonic $Z \to \ell\ell$ boson decay and the hadronic $W/Z \to q\bar{q}$ decay, that being a single or two jet system using the function $f(m; p_{0,1,2,3}) = p_0 \cdot \frac{(1-x)^{p_1}}{x^{p_2+p_3 \cdot \ln(x)}}$ where x is the reconstructed diboson resonance mass m (in units of 8 TeV) and $p_{0,1,2,3}$ are four free parameters. This background estimation is used to initially perform a search with the BUMPHUNTER algorithm [8] in all mass windows for the largest excess in data above the smooth background hypothesis. In both the resolved and merged selection regions, no significant deviation is found from the smooth background hypothesis.



(a) (b) (c)

Figure 1: The comparison of the Monte Carlo estimated backgrounds to data for combined electron and muon channels for the resolved (a) and merged (b) selections with theoretical signal predictions. Note that the search is performed using a background estimation taken directly from a smooth fit to data. Figure (c) shows the expected and observed 95% confidence level upper limits on $\sigma(pp \to G^*) \times BR(G^* \to ZZ)$ [5].

Since these results are consistent with a background-only hypothesis, Bayesian limits are set on $\sigma(pp \to G^*) \times \mathrm{BR}(\mathrm{G}^* \to \mathrm{ZZ})$ for the benchmark bulk Randall-Sundrum G* signal. These limits, shown in Figure 1(c), are generated for signal mass points between 300 GeV and 2 TeV using the fitted background estimation, with systematic uncertainties from the background fit and signal modelling integrated into the likelihood function with nuisance parameters.

4. Conclusion

A search for heavy diboson resonances has been performed using 7.2 fb^{-1} of pp collision data taken in 2012 by the ATLAS experiment at a center of mass energy of 8 TeV. No evidence of resonance like excesses above the smooth background hypothesis is observed in the reconstructed resonance mass spectrum, and 95% confidence level upper limits are set on the production cross section for signal masses between 300 GeV and 2 TeV. This constraint is used to set a lower limit on the bulk Randall-Sundrum G* mass of 850 GeV.

References

[1] H. Davoudiasl, J.L. Hewett and T.G. Rizzo, Phys. Lett. B 473, 43 (2000)

[2] L. Randall and R. Sundrum, Phys. Rev. Lett. 83, 3370 (1999)

[3] CDF Collaboration, Phys. Rev. D 85, 012008 (2012)

[4] ATLAS Collaboration, Phys. Lett. B 712, 331 (2012)

[5] ATLAS Collaboration, ATLAS-CONF-2012-150, http://cds.cern.ch/record/1493489 (2012)

[6] ATLAS Collaboration, JINST 3, S08003 (2008)

[7] M. Cacciari, G.P. Salam, and G. Soyez, JHEP 0804, 063 (2008)

[8] G. Choudalakis, arXiv:1101.0390 (2011)