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Searches for new heavy resonances in diboson final states with ATLAS at $\sqrt{s} = 13$ TeV

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Summary. — Searches for new heavy resonances decaying to WW, WZ, and ZZ bosons are performed, using Run-2 data of pp collisions at $\sqrt{s} = 13\,\text{TeV}$ collected with the ATLAS detector at the LHC. Three benchmark models are tested: a model predicting the existence of a new heavy scalar singlet, a simplified model predicting a heavy vector-boson triplet, and a bulk Randall-Sundrum model with a heavy spin-2 graviton. Cross-section limits are set at the 95% confidence level and are compared to theoretical cross-section predictions.

1. – Introduction

Fully leptonic diboson decay modes have the advantage of being well measured due to the good performance of lepton identification at ATLAS and the relatively low-background final states. However, they are mostly sensitive to new physics in low-mass regions and have limited sensitivities at high mass due to relatively smaller branching ratio (BR). In contrast, hadronic-decay final states of W, Z bosons probe for new physics in high-mass regions. The diboson resonance searches presented here incorporate semi-leptonic and fully hadronic-decay modes of the VV system as $\ell\ell qq$, $\nu\nu qq$, $\ell\nu qq$, $qqqq$ where $V = W$, Z and $\ell = e, \mu$ [1-3].

2. – Analysis strategy

Reconstructing these topologies is experimentally a challenging task because heavy resonances decaying to dibosons can produce a highly boosted system where the two quarks are emitted within a small opening angle, becoming harder to be distinguished in calorimeter-recorded hadronic showers as separate jets (Resolved analysis) and the two partially overlapping jets are therefore reconstructed as a single large-R jet (Merged analysis). Jet substructure techniques have been developed to extract the W/Z boson decayed hadrons out of the backgrounds and are deployed in all channels.

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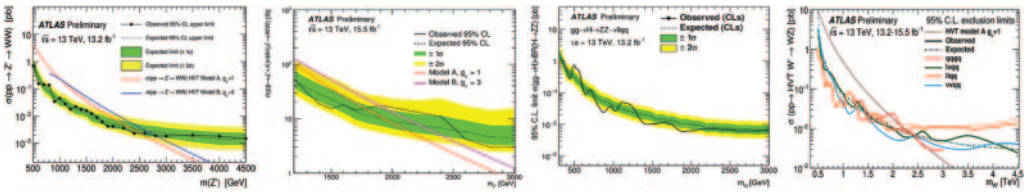

(a) HVT $Z' \to \ell\nu qq$ (b) HVT $Z' \to qqqq$ (c) H→ZZ→ $\ell\ell qq$ (d) $W' \to WZ$

Fig. 1. – Observed and expected 95% CL upper limits on the $\sigma \times BR$ for the models described in the text as functions of the resonance mass.

Concerning event selection highlights, in the $WV \to \ell\nu qq$ analysis, events with $E_T^{\text{miss}} > 100\,\text{GeV}$ and $p_T^{\ell\nu} > 200\,\text{GeV}$ are selected. The two bosons correspond to the two-body decay of a resonance so their p_T are expected to be close to half the reconstructed resonance mass, therefore this analysis exploits the quantities $p_T(J)/m_{\ell\nu J} > 0.4$ and $p_T(\ell\nu)/m_{\ell\nu J} > 0.4$, to reduce the background (mainly from W + jet events).

In the $VV \to qqqq$ mode only the Merged analysis is utilized, where the leading p_T large-R jet is required to exceed 450 GeV to ensure full trigger efficiency, and the mass of the jet pair, is required to be larger than 1 TeV. The pair of jets is required to have a small separation in rapidity, $|\Delta y_{12}| < 1.2$ to reduce the multi-jet background.

In the $ZV \to \ell\ell qq$ channel, 2 high-p_T leptons and at least 1(2) large-R(small-R) jet(s) with leading $p_T > 200(60)\,\text{GeV}$ are required. To reduce the background from the dominant Z + jets events, requirements on $\min(p_T^{\ell\ell}, p_T^J)/m_{\ell\ell J}$ and $\sqrt{p_T^2(\ell\ell) + p_T^2(jj)}/m_{\ell\ell jj}$ are applied in the merged and resolved analysis respectively, while in the $\nu\nu qq$ mode the selection is driven by $E_T^{\text{miss}} > 250\,\text{GeV}$ and a veto of charged lepton events.

Figure 1(a) and fig. 1(b) show the resulting observed and expected 95% CL upper limits on the production cross-section times BR for a heavy Z' in the vector-boson triplet (HVT) model context in the $\ell\nu qq$ and fully hadronic modes. Figure 1(c) shows the resulting limits for a heavy Higgs in the decay mode $gg \to H \to ZZ \to \ell\ell qq$. Figure 1(d) shows the limits for a new heavy vector boson W' decaying to WZ where the different limit curves correspond to different decay modes for the W and Z bosons.

3. – Summary and outlook

A search for heavy resonances decaying to dibosons in the fully hadronic and semi-leptonic channels has been performed using 15.5 and 13.2 fb^{-1}, respectively, of proton-proton collisions at $\sqrt{s} = 13\,\text{TeV}$. No evidence for new resonant production is evident, which is excluded at 95% CL up to a high-mass range depending on the model. For example, in the HVT context resonances with mass up to roughly 1.8, 2.4 and 2.2 TeV are excluded from the $qqqq$, $\ell\nu qq$ and $\ell\ell qq$ analysis, respectively. Searches are already in preparation to exploit the full 2015–2016 dataset of 36.1 fb^{-1}, which is expected to increase the sensitivity to new resonances.

REFERENCES

[1] ATLAS Collaboration, ATLAS-CONF-2016-055.
[2] ATLAS Collaboration, ATLAS-CONF-2016-062.
[3] ATLAS Collaboration, ATLAS-CONF-2016-082.