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

Incontri di Fisica delle Alte Energie, Trieste 2017

Introduction

Searches for new heavy resonances decaying to WW, WZ, and ZZ bosons are performed, using Run-2 data of pp collisions at $\sqrt{s} = 13$ TeV collected with the ATLAS detector at the LHC. **The final states considered are X → VV →** $\ell\ell qq$**,** $\nu\nu qq$**,** $\ell\nu qq$**,** $qqqq$. 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.

Event Classification

Two complementary approaches utilized for the reconstruction of the VV decay:

- **Merged channel**: Heavy resonances decay to dibosons producing a highly boosted system where the two fermions are emitted within a small opening angle. The two quarks coming from the boson(s) produce partially overlapping jets reconstructed as a single jet.
- **Resolved channel**: Two separate jets are reconstructed.

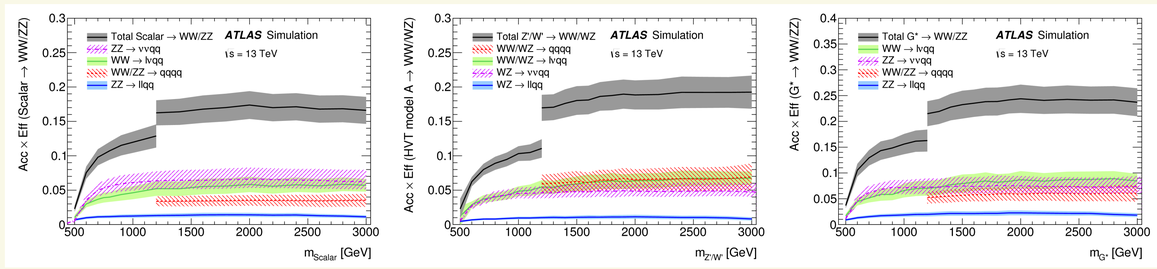
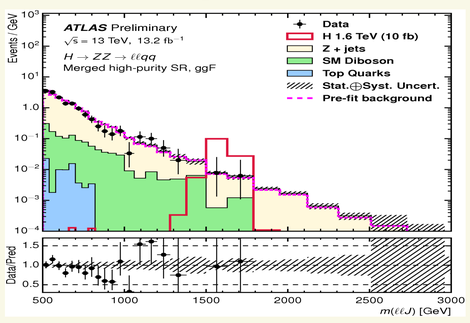


Figure: Signal acceptance × efficiency as a function of the resonance mass, for the different channels contributing to the searches for (left) a scalar resonance decaying to WW and ZZ, (middle) HVT decaying to WW and WZ and (right) bulk RS gravitons decaying to WW and ZZ

- Events in the merged regime are further categorized to Low (M_{J} cut) and High (D_2 substructure variable + M_{J} cut) purity signal regions and in the resolved analysis according to the number of b-jets

ZV→ $\ell\ell qq$,$\nu\nu qq$

- $\ell\ell qq$: Require 2 high-p_T leptons, at least 1 large-R jet with $p_T > 200$ GeV or 2 small-R jets with leading jet $p_T > 60$ GeV
- $\nu\nu qq$: Require $E_T^{\text{miss}} > 250$ GeV and veto charged lepton events



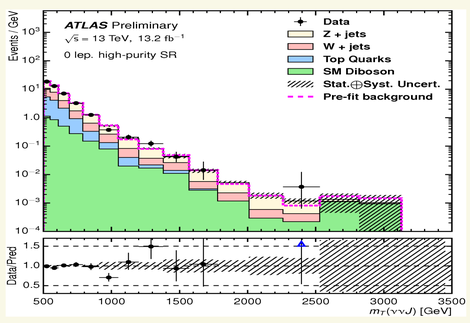
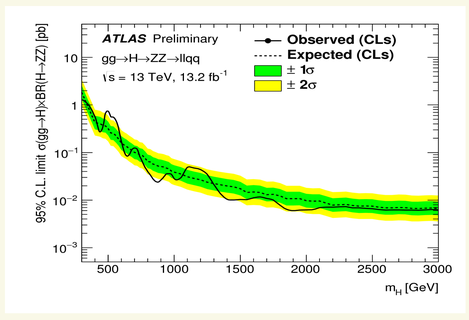


Figure: Comparisons of the observed and fitted distributions of the $M_{\ell\ell J}$ of the ggF H→ZZ→ $\ell\ell qq$, $\nu\nu qq$ for high-purity region



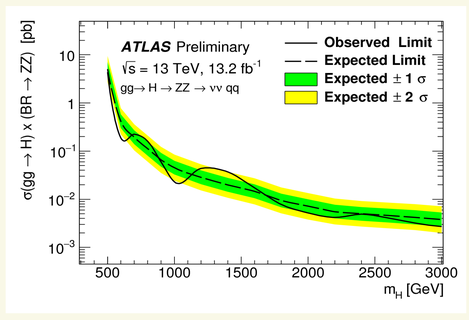
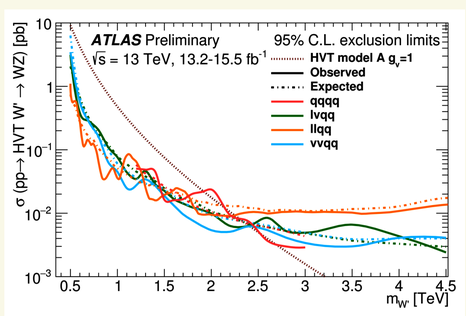


Figure: Observed and expected 95% CL upper limits on the production cross section of a heavy resonance at $\sqrt{s} = 13$ TeV times its decay branching ratio to ZV for ggF H→ZZ→ $\ell\ell qq$, $\nu\nu qq$ as functions of the resonance mass.

Summary

- Expected and observed limits on the $\sigma \times$ BR to WZ for a new heavy vector boson W' at $\sqrt{s} = 13$ TeV. The different limit curves correspond to different decay modes for the W and Z bosons.



Large-R jets and substructure

In the merged channel, jet-substructure techniques are used to identify the qq pair, reconstructed as a single large-radius jet.

Grooming: Reduces the effect of pileup and other noisy sources on the resolution with ***trimming*** algorithm

- Begin from an anti-k_T jet with radius parameter R=1.0
- Subjets are constructed with the k_T algorithm with $R_{subjet} = 0.2$
- Subjets with $p_T < 5\%$ of the large-R jet, are removed

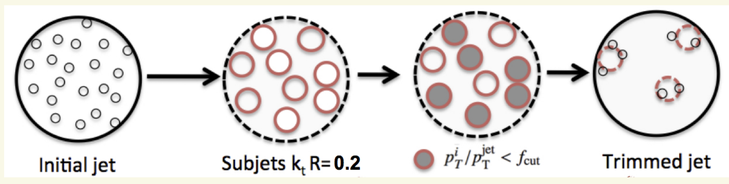


Figure: Schematic view of jet grooming using the trimming algorithm

WV→ $\ell\nu qq$

- Events selected with exactly one reconstructed lepton, at least one large-R jet and satisfy $E_T^{\text{miss}} > 100$ GeV, and $p_T^{\ell\nu} > 200$ GeV

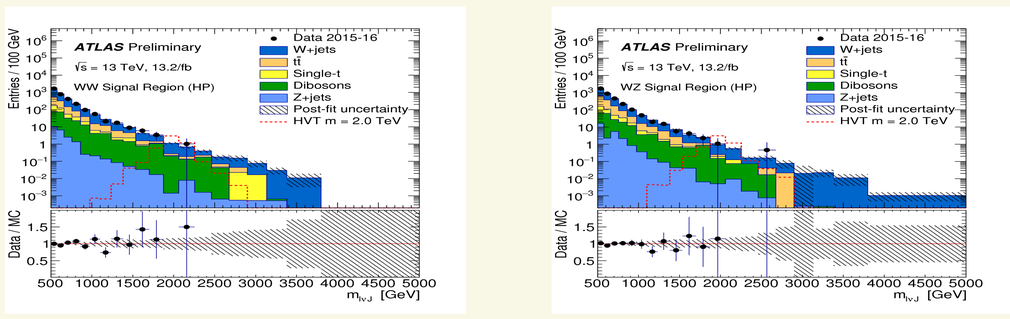


Figure: Post-fit $M_{\ell\nu J}$ distributions for the high-purity (HP) category in the (left) WW signal region and (right) WZ signal region.

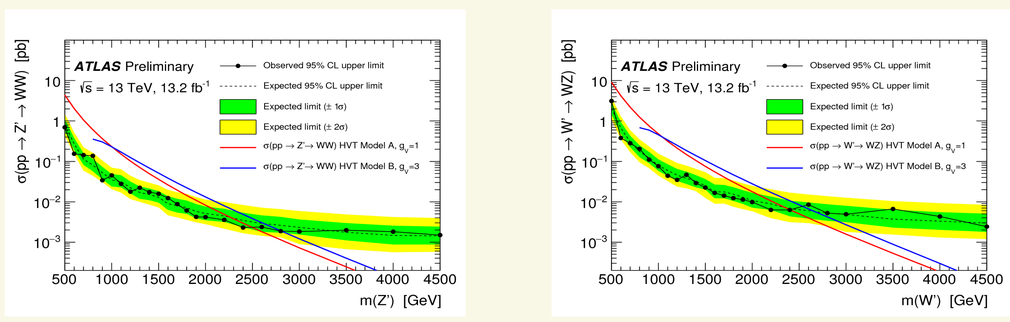


Figure: Observed and expected 95% CL upper limits on the production cross section times the branching fraction for HVT $Z' \to WW$ and $W' \to WZ$, as a function of the resonance mass.

VV→ $qqqq$

- Merged analysis only. Require 2 high-p_T large-R jets ($p_T > 450$ GeV, $p_T > 200$ GeV)
- Multi-jet is main background⇒Reduced requiring $|\Delta y(J, J)| < 1.2$

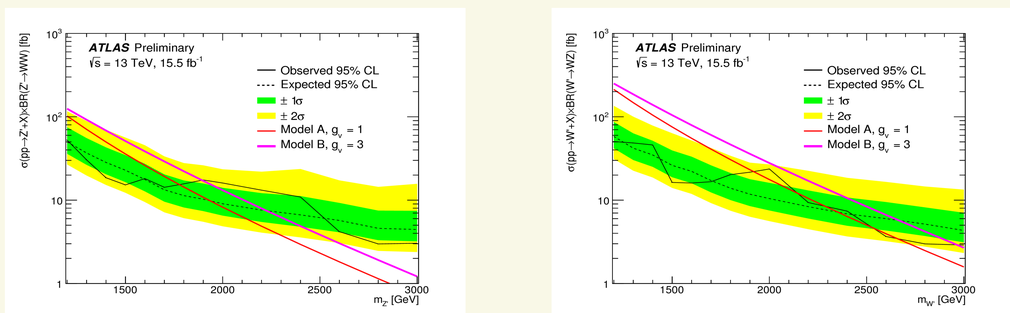


Figure: Observed and expected 95% CL limits on the cross-section times branching ratio to diboson final states for HVT (left)$Z' \to WW$ and (right) $W' \to WZ$.

References

- Individual results can be found in ATLAS-CONF-2016-055 , ATLAS-CONF-2016-062 and ATLAS-CONF-2016-082.

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