Probing physics beyond the Standard Model with the ATLAS Experiment

July 17 2017

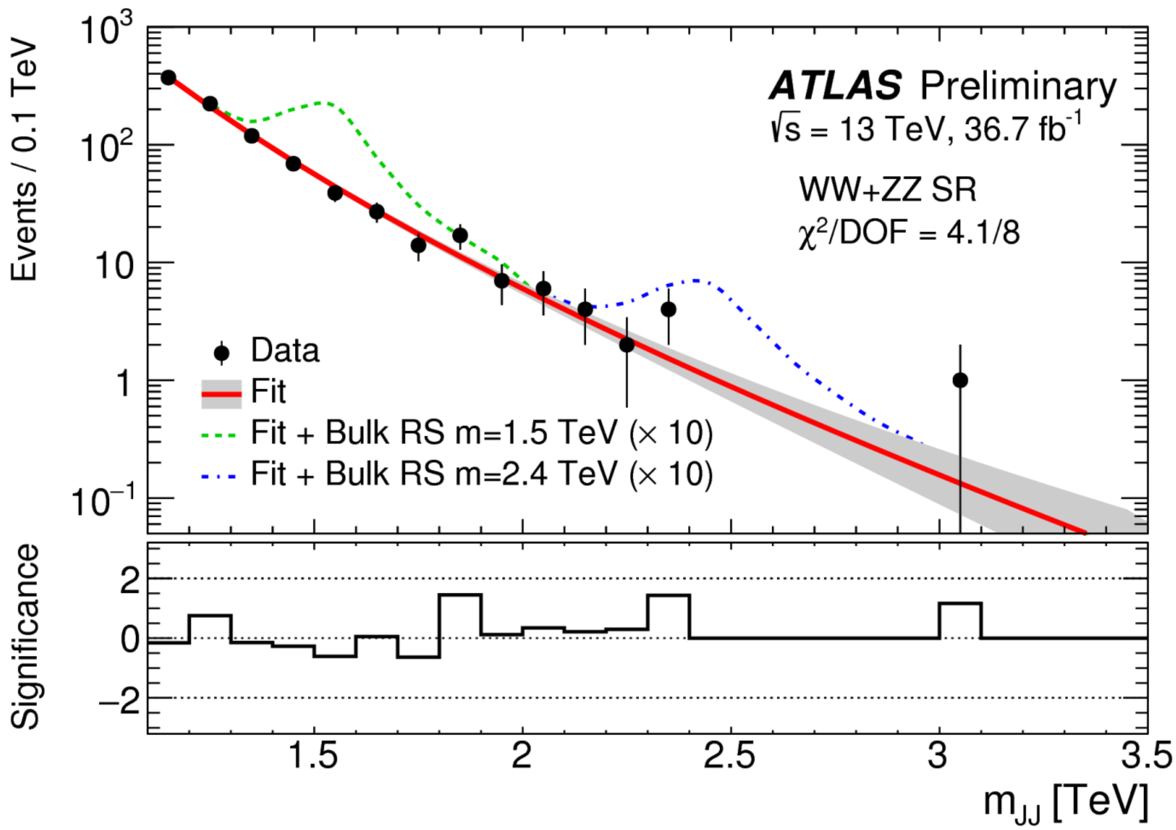

Figure 1: The reconstructed mass of the selected candidate events decaying to WW or ZZ bosons, with the qqqq final state. The black markers represent the data. The blue and green curves represent the hypothesized signal for two different masses. The red curve represents the Standard Model processes. Credit: ATLAS Collaboration/CERN

Although the discovery of the Higgs boson by the ATLAS and CMS Collaborations in 2012 completed the Standard Model, many mysteries remain unexplained. For instance, why is the mass of the Higgs boson so much lighter than expected, and why is gravity so weak?

Numerous models beyond the Standard Model attempt to explain these mysteries. Some explain the apparent weakness of gravity by introducing additional dimensions of space in which gravity propagates. One model goes beyond that, and considers the real world as a higher-dimensional universe described by warped geometry, which leads to strongly interacting massive graviton states. Other models propose, for example, additional types of Higgs bosons.

All these models predict the existence of new heavy particles that can decay into pairs of massive weak bosons (WW, WZ or ZZ). The search for such particles has benefited greatly from the increase in the proton–proton collision energy during Run 2 of the Large Hadron Collider (LHC).

The W and Z bosons are carrier particles that mediate the weak force. They decay into other Standard Model particles, like charged leptons (l), neutrinos (ν) and quarks (q). These particles are reconstructed differently in the detector. Quarks, for instance, are reconstructed as localized sprays of hadrons, denoted jets. The two bosons could yield several combinations of these particles in the final states. The ATLAS Collaboration has released results on searches involving all relevant decays of the boson pair: ννqq, llqq, lνqq and qqqq (where the lepton is an electron or muon).

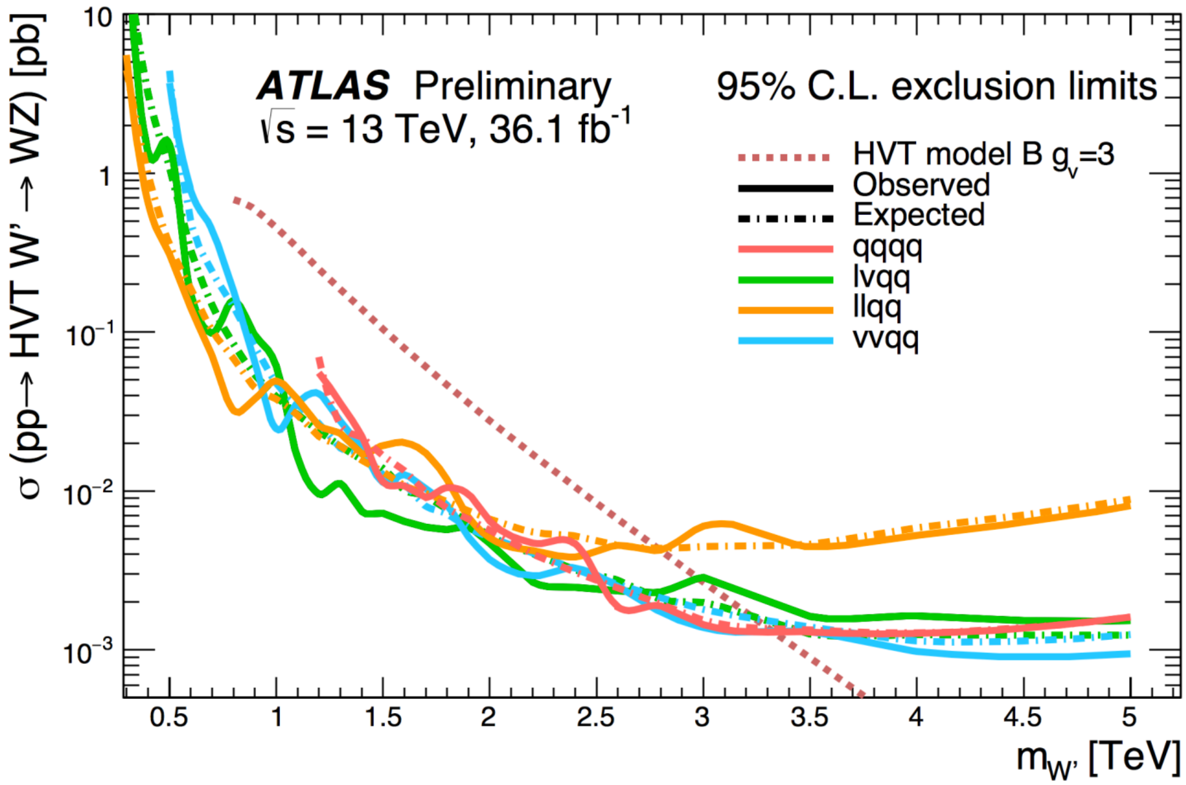

Figure 2: The limit on the cross-section times branching ratio of hypothetical particle described by one of the models for the different final states. Credit: The limit on the cross-section times branching ratio of hypothetical particle described by one of the models for the different final states.

What do these searches have in common? In each, at least one of the bosons decays into a pair of quarks. When the sought-after particle is very massive, the two bosons from its decay are ejected with such high momenta that their respective decay products are collimated and the pair of quarks merge into a single large jet. This phenomenon provides a powerful means to distinguish the new physics signal from strong-interaction Standard Model processes. Figure 1 shows the distributions of the reconstructed mass of the candidate particle. Figure 2 shows the limit on the cross-section times branching ratio of a hypothetical particle described by one of the models.

So far, no evidence of a new particle has been observed. The search continues with increased sensitivity as ATLAS collects more data.

More information: ATLAS Experiment: atlas.cern/

Provided by ATLAS Experiment