ATLAS experiment takes its first glimpse of the Higgs boson in its favourite decay

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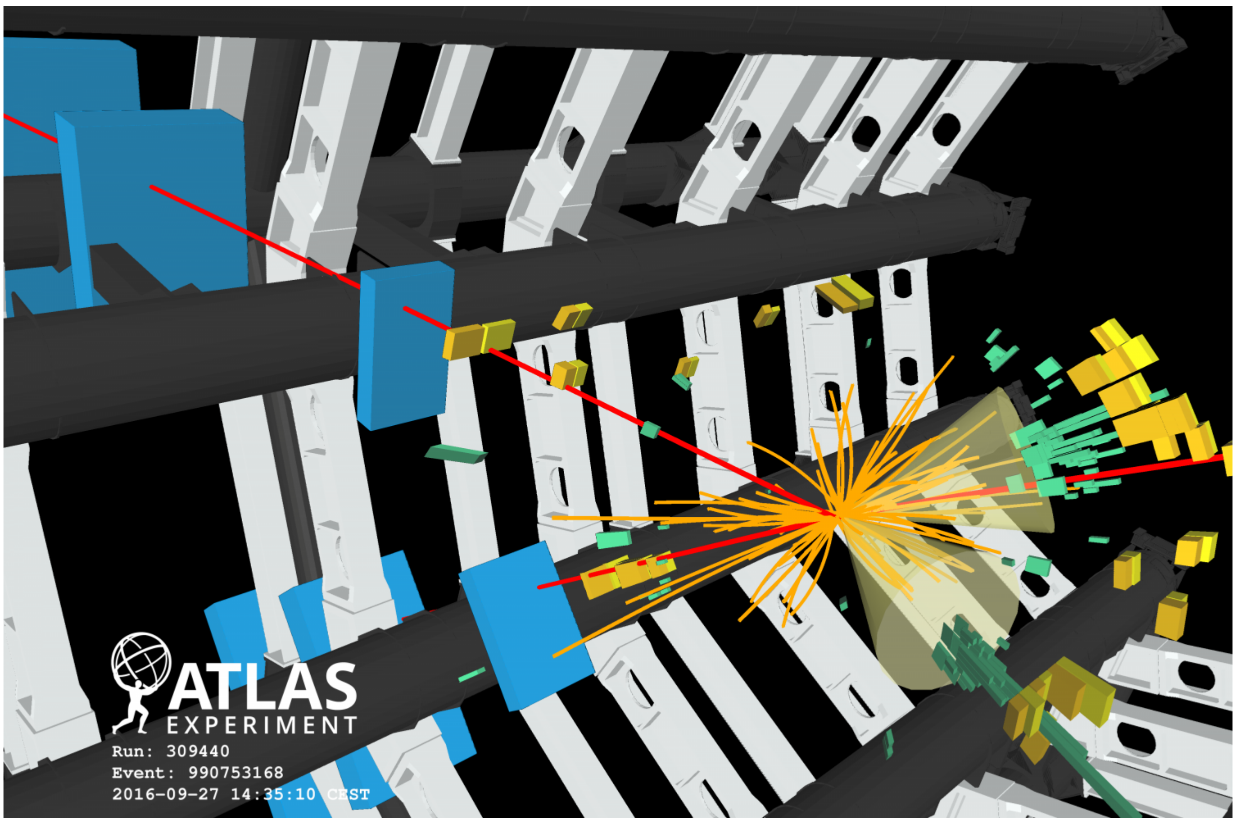


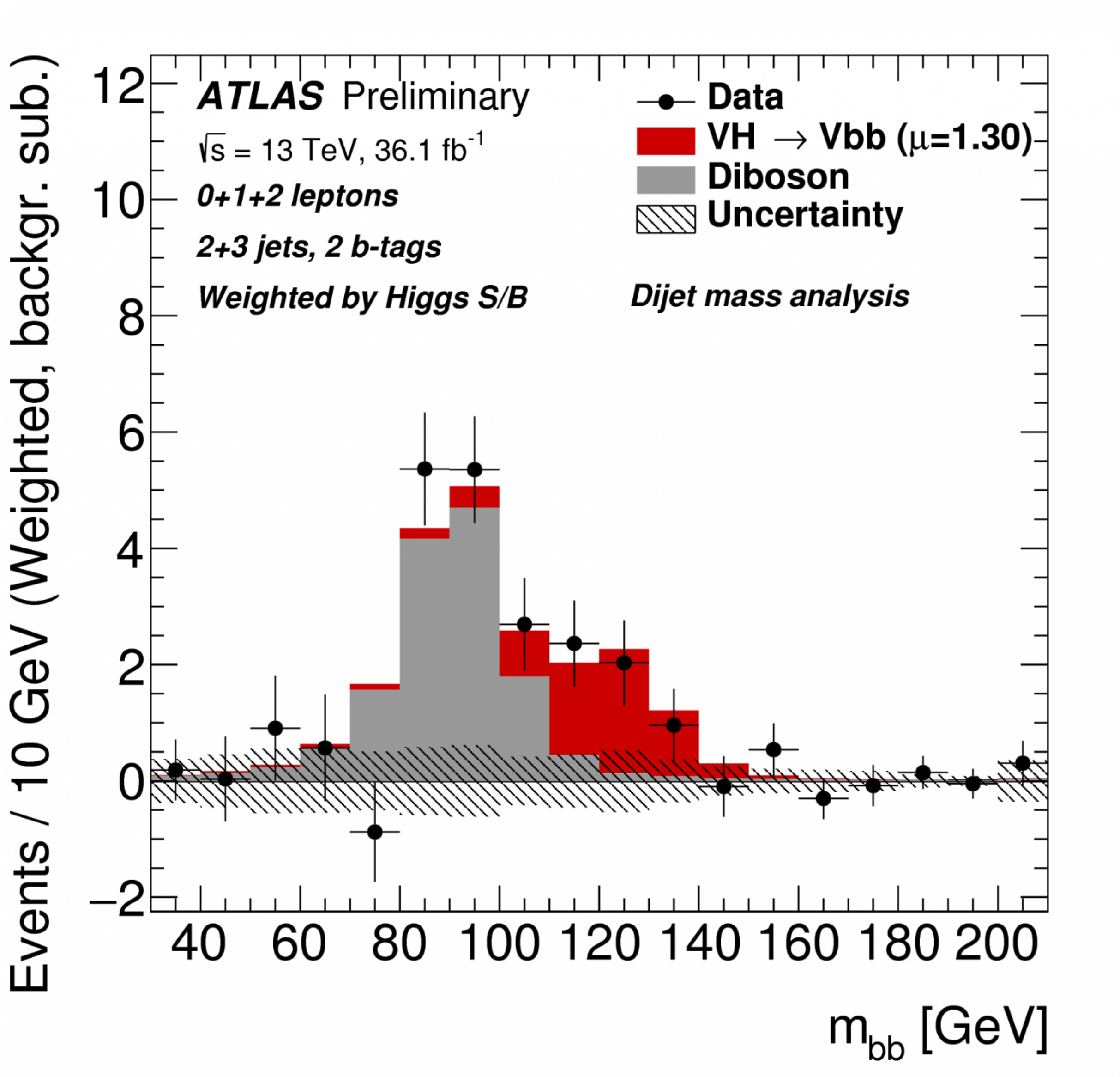
ATLAS event display of a Higgs boson decaying to two b-quarks. Credit: ATLAS Collaboration/CERN

Previously, the Higgs boson has been observed decaying to photons, tau-leptons, and W and Z bosons. However, these impressive achievements represent only 30 percent of Higgs boson decays. The Higgs boson's favoured decay to a pair of b-quarks (H→bb) was predicted to happen around 58 percent of the time, thus driving the short lifetime of the Higgs boson, and thus remained elusive. Observing this decay would fill in one of the big missing pieces of our knowledge of the Higgs sector and confirm that the Higgs mechanism is responsible for the masses of quarks; additionally, it might also provide hints of new physics beyond our current theories. All in all, it is a vital missing piece of the Higgs boson puzzle.

But after over 1 million H→bb decays in the ATLAS Experiment alone, why haven't researchers seen it yet? This seems especially strange considering that less frequent Higgs boson decays have been observed.

The answer lies in the abundance of b-quarks created in the ATLAS detector due to strong interactions. We create pairs of b-quarks 10 million times more frequently than we create a H→bb decay, which makes picking them out against that large background an extremely challenging task. We therefore look for H→bb decays when they are produced in association with another particle—in this case, a vector boson (W or Z). The more distinctive decays of vector bosons provide a way to reduce the large background. This leads to a much lower production rate – we expect to have created only 30,000 H→bb decays this way, but it provides an opportunity to spot this elusive decay.

Nevertheless, even in this condition, the background processes that mimic the H→bb signal are still large, complex and difficult to model. The ATLAS collaborators made a major effort to isolate the small H→bb signal from the large background. After selecting the collisions of interest, they were left with the expected number of around 300 H→bb events compared to 70,000 background events. Ultimately, they were hoping to see an excess of collision events over our background prediction (a bump) that appears at the mass of the Higgs boson.



A comparison of the excess of collision data (black points) over the background processes (which have been subtracted from the data), which clearly shows the H→bb decays (filled red area) and the well understood diboson Z→bb decay (grey area) used to validate the result. (Image:) Credit: ATLAS Collaboration/CERN

After analysing all the data ATLAS collected in 2015 and 2016, the researchers have finally achieved the level of precision to confirm evidence for H→bb with an observed significance of 3.6 σ when combining the Run 1 and Run 2 datasets. As shown in the figure, a bump is observed that is highly consistent with expectations, confirming many key aspects of the Higgs bosons behaviour. Next to the bump, there is a decay of a Z boson (mass of 91 GeV) to a b-quark pair, produced in a similar way as the Higgs boson, but more abundantly. It serves as a powerful validation of the analysis.

Spotting H→bb is just the beginning. Studies of this new decay will open a whole new window onto the Higgs, and may also provide hints of new physics beyond our current theories. Stay tuned to this channel.

More information: Evidence for the H→bb decay with the ATLAS detector: atlas.web.cern.ch/Atlas/GROUPS … ATLAS-CONF-2017-041/

Provided by ATLAS Experiment