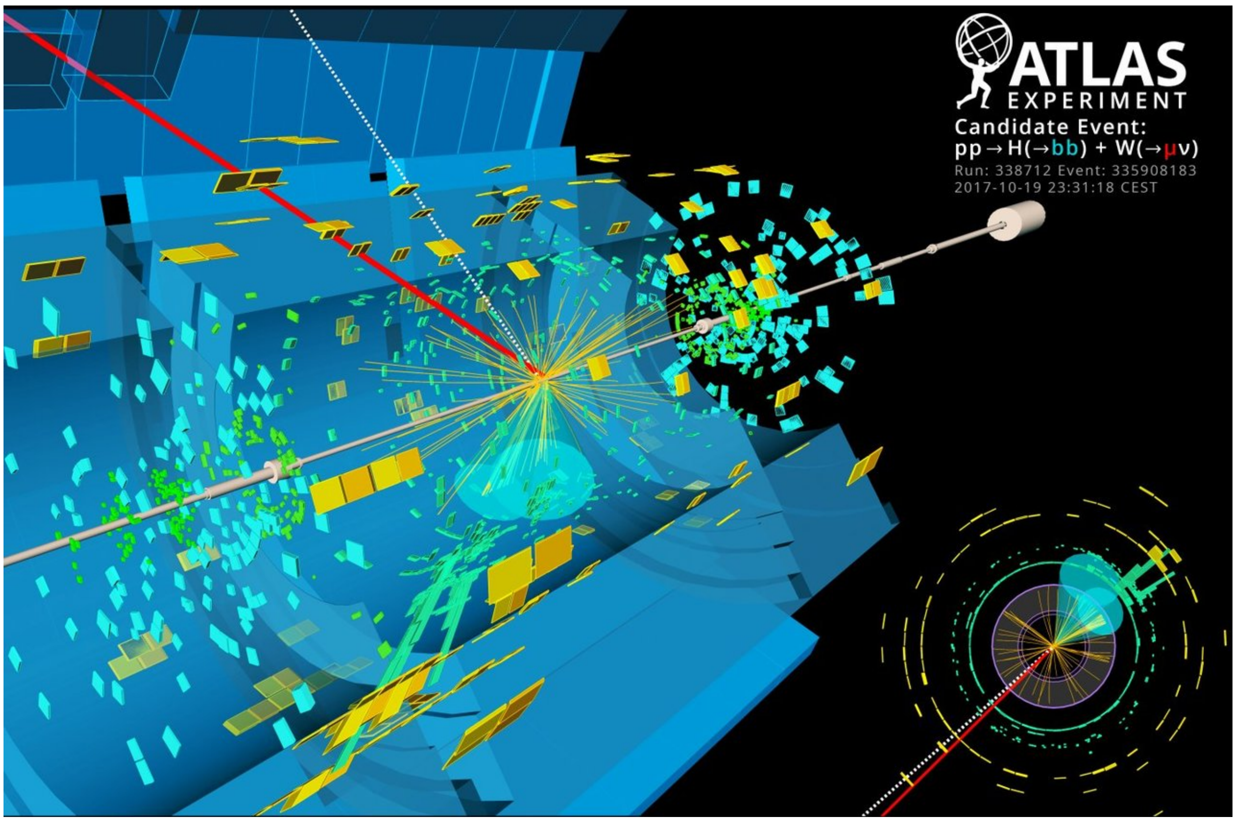
Long-sought decay of Higgs boson observed

August 28 2018



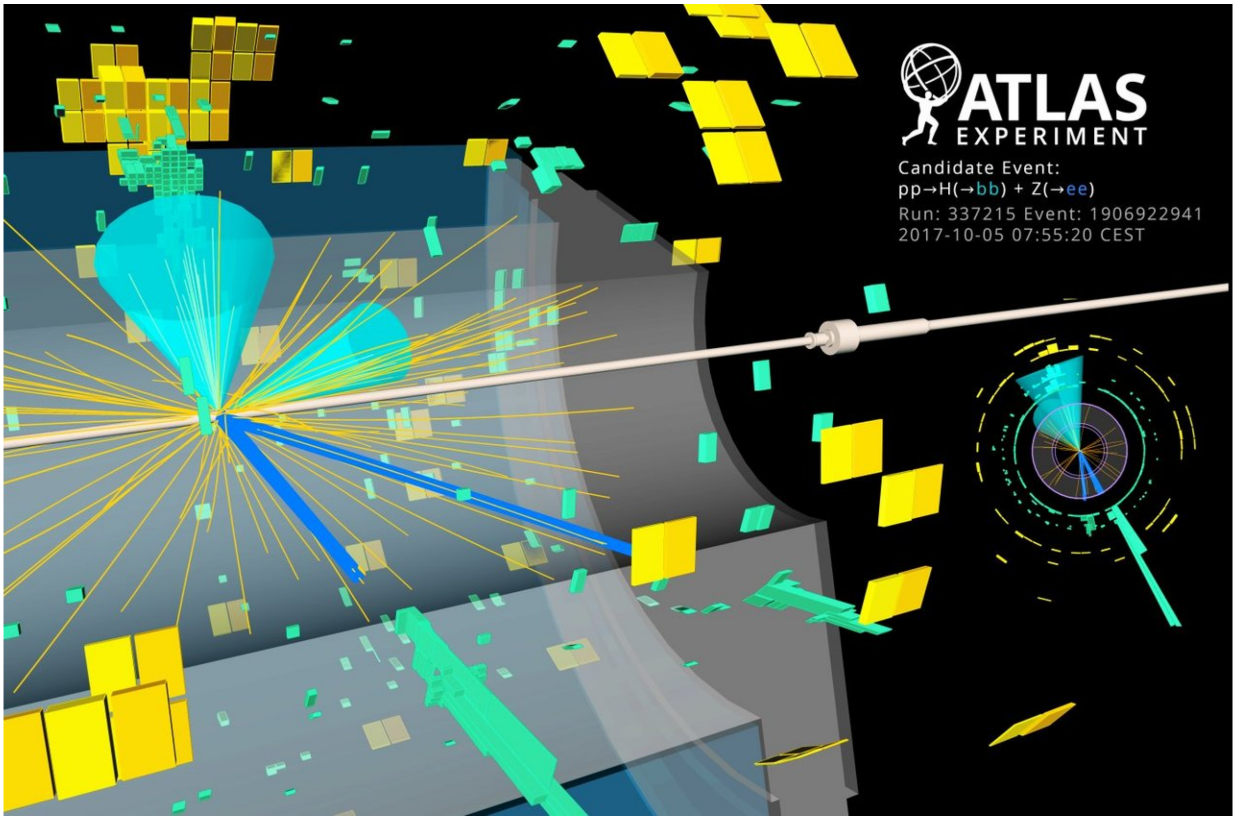
A candidate event display for the production of a Higgs boson decaying to two b-quarks (blue cones), in association with a W boson decaying to a muon (red) and a neutrino. The neutrino leaves the detector unseen, and is reconstructed through the missing transverse energy (dashed line). Credit: ATLAS Collaboration/CERN

Six years after its discovery, the Higgs boson has at last been observed decaying to fundamental particles known as bottom quarks. The finding, presented today at CERN by the ATLAS and CMS collaborations at the Large Hadron Collider (LHC), is consistent with the hypothesis that the all-pervading quantum field behind the Higgs boson also gives mass to the bottom quark. Both teams have submitted their results for publication today.

The Standard Model of particle physics predicts that about 60% of the time a Higgs boson will decay to a pair of bottom quarks, the second-heaviest of the six flavours of quarks. Testing this prediction is crucial because the result would either lend support to the Standard Model – which is built upon the idea that the Higgs field endows quarks and other fundamental particles with mass – or rock its foundations and point to new physics.

Spotting this common Higgs-boson decay channel is anything but easy, as the six-year period since the discovery of the boson has shown. The reason for the difficulty is that there are many other ways of producing bottom quarks in proton–proton collisions. This makes it hard to isolate the Higgs-boson decay signal from the background "noise" associated with such processes. By contrast, the less-common Higgs-boson decay channels that were observed at the time of discovery of the particle, such as the decay to a pair of photons, are much easier to extract from the background.

To extract the signal, the ATLAS and CMS collaborations each combined data from the first and second runs of the LHC, which involved collisions at energies of 7, 8 and 13 TeV. They then applied complex analysis methods to the data. The upshot, for both ATLAS and CMS, was the detection of the decay of the Higgs boson to a pair of bottom quarks with a significance that exceeds 5 standard deviations. Furthermore, both teams measured a rate for the decay that is consistent with the Standard Model prediction, within the current precision of the measurement.

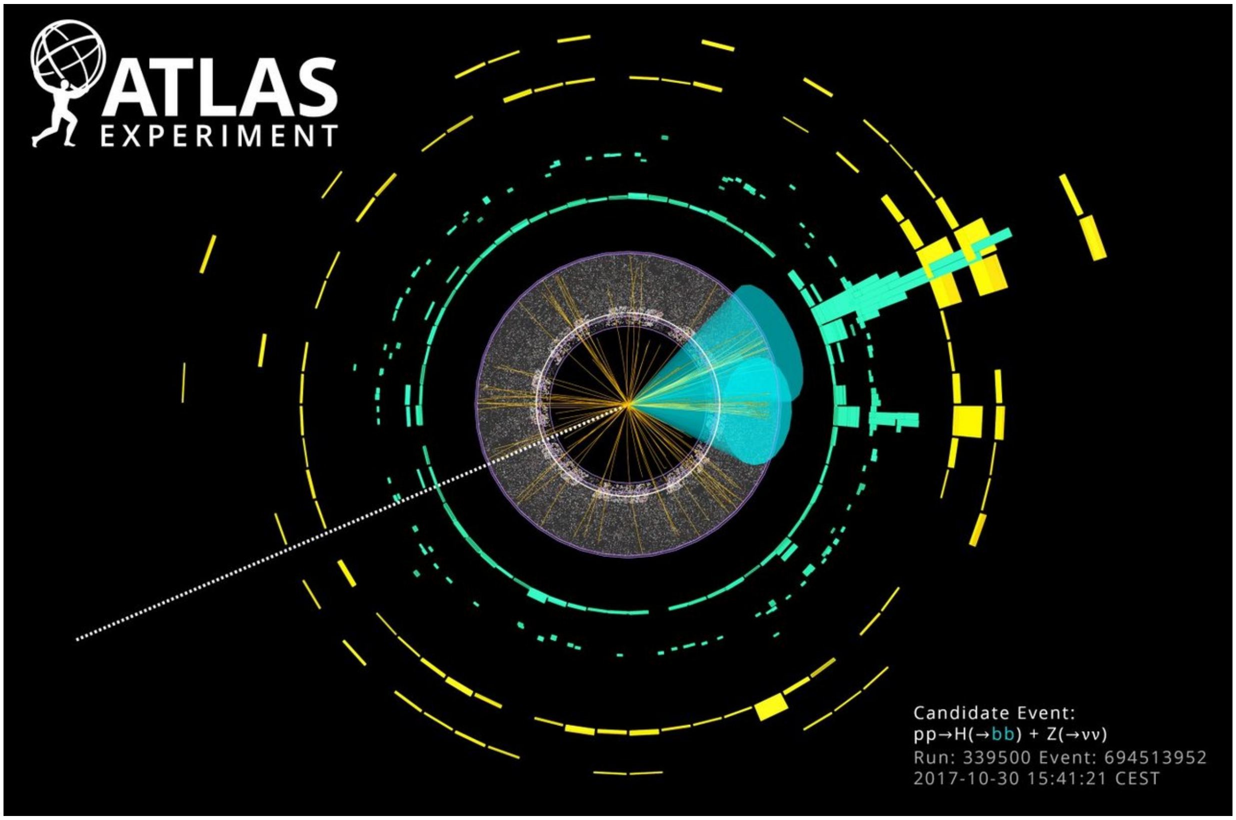


Candidate event display for the production of a Higgs boson decaying to two b-quarks. A 2 b-tag, 2-jet, 2-electron event within the signal-like portion of the high pTV and high BDTVH output distribution is shown (Run 337215, Event 1906922941). Electrons are shown as blue tracks with a large energy deposit in the electromagnetic calorimeter, corresponding to light green bars. Two of them form an invariant mass of 93.6 GeV, compatible with a Z boson. The two central high-pT b-tagged jets are represented by light blue cones. They contain the green and yellow bars corresponding to the energy deposition in the electromagnetic and hadronic calorimeters respectively, and they have an invariant mass of 128.1 GeV. The value of pTV is 246.7 GeV, and BDTVH output value is 0.47. Credit: ATLAS Collaboration/CERN

"This observation is a milestone in the exploration of the Higgs boson. It shows that the ATLAS and CMS experiments have achieved deep understanding of their data and a control of backgrounds that surpasses expectations. ATLAS has now observed all couplings of the Higgs boson to the heavy quarks and leptons of the third generation as well as all major production modes," said Karl Jakobs, spokesperson of the ATLAS collaboration.

"Since the first single-experiment observation of the Higgs boson decay to tau-leptons one year ago, CMS, along with our colleagues in ATLAS, has observed the coupling of the Higgs boson to the heaviest fermions: the tau, the top quark, and now the bottom quark. The superb LHC performance and modern machine-learning techniques allowed us to achieve this result earlier than expected," said Joel Butler, spokesperson of the CMS collaboration.

With more data, the collaborations will improve the precision of these and other measurements and probe the decay of the Higgs boson into a pair of much-less-massive fermions called muons, always watching for deviations in the data that could point to physics beyond the Standard Model.



Candidate event display for the production of a Higgs boson decaying to two b-quarks. A 2-tag, 2-jet, 0-lepton event within the signal-like portion of the high pTV and high BDTVH output (Run 339500, Event 694513952) is shown. The ETMiss, shown as a white dashed line, has a magnitude of 479.1 GeV. The two central high-pT b-tagged jets are represented by light blue cones. They contain the green and yellow bars corresponding to the energy deposition in the electromagnetic and hadronic calorimeters respectively. The dijet invariant mass of 128.1 GeV. The BDTVH output value is 0.74. Credit: ATLAS Collaboration/CERN

"The experiments continue to home in on the Higgs particle, which is often considered a portal to new physics. These beautiful and early achievements also underscore our plans for upgrading the LHC to substantially increase the statistics. The analysis methods have now been shown to reach the precision required for exploration of the full physics landscape, including hopefully new physics that so far hides so subtly," said CERN Director for Research and Computing Eckhard Elsen.

More information: Observation of Higgs boson decay to bottom quarks. arXiv:1808.08242 [hep-ex] arxiv.org/abs/1808.08242

Provided by CERN