ATLAS probes Higgs interaction with the heaviest quarks

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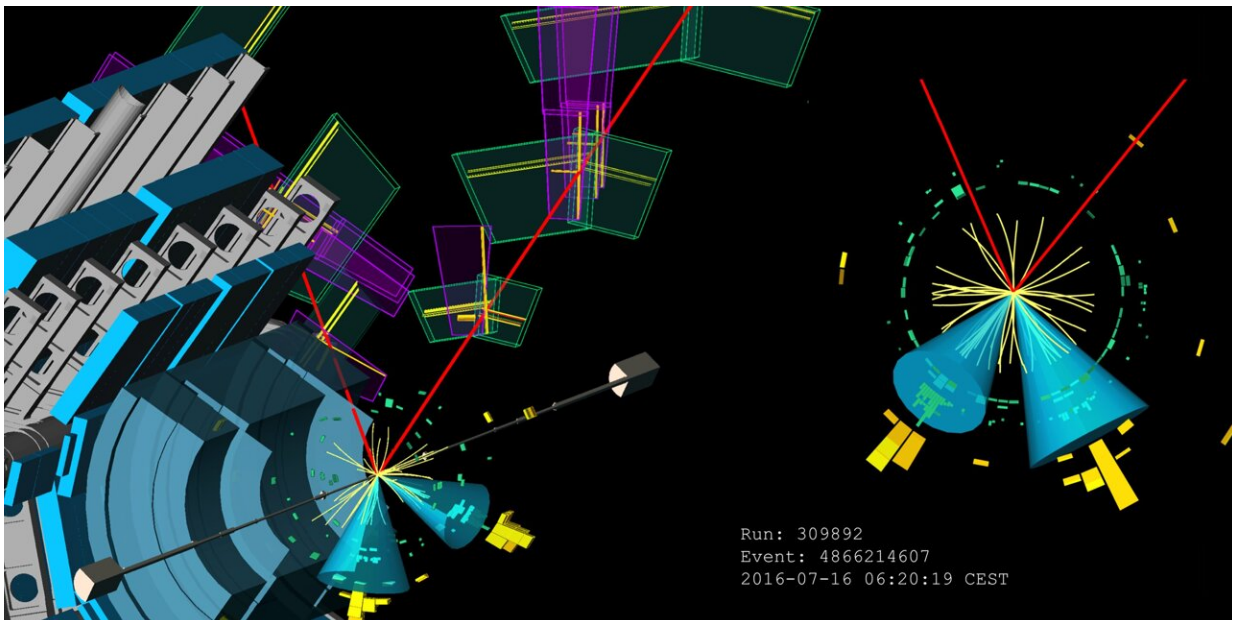

Candidate event for the ZH → μμ cc process, where a Z boson and a Higgs boson decay to two muons (red tracks) and two charm-tagged jets (blue cones). Credit: ATLAS collaboration

A central aim of the ATLAS Higgs physics program is to measure, with increasing precision, the strength of interactions of the Higgs boson with elementary fermions and bosons.

According to the theory of electroweak symmetry breaking, these interactions are responsible for generating the masses of the particles. The interaction strengths can be determined by precisely measuring the Higgs boson's production via and decay into the relevant particles.

At the recent International Conference on High-Energy Physics (ICHEP) 2024, the ATLAS collaboration presented improved measurements of the strength of Higgs boson interactions with the three heaviest quarks: top, bottom and charm.

The new results are based on a reanalysis of LHC Run 2 data taken in the years 2015–2018 with significantly enhanced analysis methods, including improved jet tagging.

But what are jets and why do they need to be tagged? When the Higgs boson decays into a pair of quarks, each quark fragments, creating a collimated spray of particles (mostly hadrons) that can be observed in the detector. The aim of jet tagging is to determine which type (or "flavor") of quark produced a given jet through detailed analysis of the jet's properties.

With new bespoke jet (or "flavor") tagging techniques for charm and bottom quarks, ATLAS researchers managed to significantly increase the sensitivity of their analyses. Together with other analysis improvements, they increased sensitivity to $H \rightarrow bb$ and $H \rightarrow cc$ decays by 15% and a factor of three, respectively.

Updated measurements of Higgs boson production in association with a W or Z boson and decays into a pair of bottom or charm quarks yielded the first observation of the WH, $H \rightarrow bb$ process with 5.3σ significance and a measurement of ZH, $H \rightarrow bb$ with 4.9σ significance. The Higgs boson decay into c quarks is suppressed by a mass factor of 20 relative to the decay into b quarks and thus is still too rare to be observed.

ATLAS sets an upper limit on the rate of the VH, H→cc process of 11.3 times the Standard Model prediction. These results are the most precise probes of these processes to date, and they are compatible with the Standard Model.

A new measurement of Higgs boson interaction with the top quark focused on Higgs production in association with two top quarks and its subsequent decay into a pair of bottom quarks. This challenging process features a very complex final state and suffers from large backgrounds.

The new analysis, which benefits from a refined understanding of the dominant background processes involving top quarks, improved the sensitivity by a factor of two and measured a signal strength for ttH, H→bb production of 0.81 ± 0.21, relative to the Standard Model prediction.

Further improved analysis techniques and new data from the ongoing Run 3 hold the promise of measuring these interactions with even greater precision. These advancements in the search for H→cc heighten anticipation for the High-Luminosity LHC (HL-LHC), where detecting this process enters the realm of feasibility.

More information: Read more in the ATLAS briefings here and here.

Provided by CERN

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