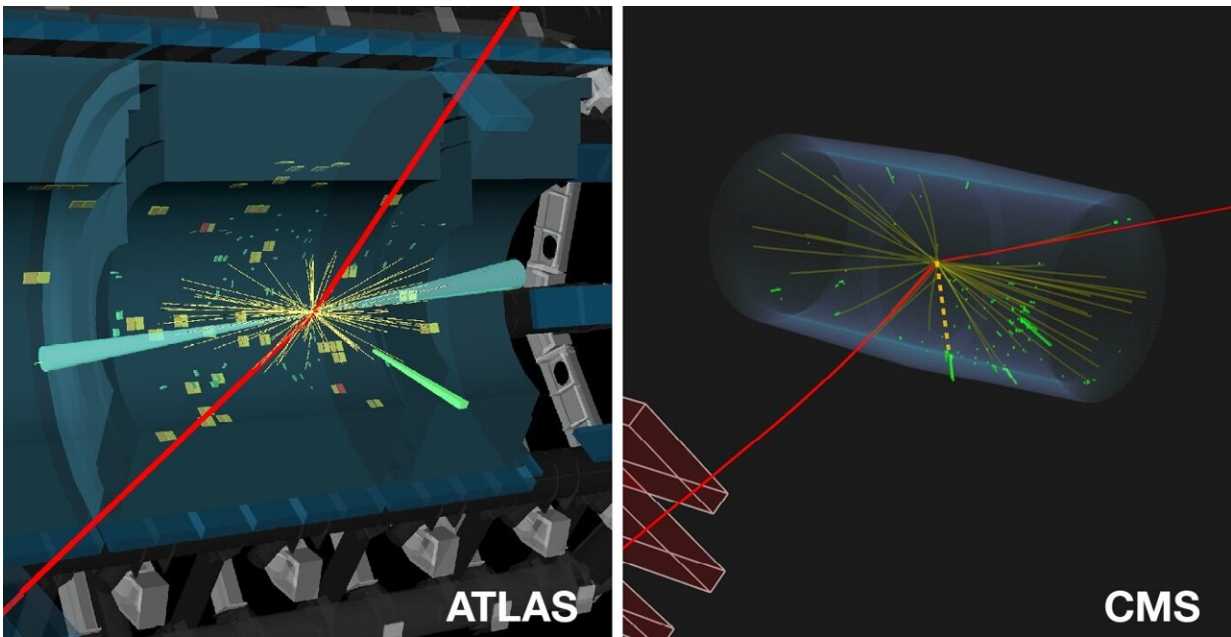


Experiments see first evidence of a rare Higgs boson decay

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Candidate events from ATLAS (left) and CMS (right) for a Higgs boson decaying into a Z boson and a photon, with the Z boson decaying into a pair of muons. Credit: CERN

The discovery of the Higgs boson at CERN's Large Hadron Collider (LHC) in 2012 marked a significant milestone in particle physics. Since then, the ATLAS and CMS collaborations have been diligently investigating the properties of this unique particle and searching to establish the different ways in which it is produced and decays into other

particles.

At the [Large Hadron Collider Physics \(LHCP\) conference](#) this week, ATLAS and CMS report how they teamed up to find the first evidence of the rare process in which the Higgs [boson](#) decays into a Z boson, the electrically neutral carrier of the weak force, and a photon, the carrier of the electromagnetic force. This Higgs boson decay could provide indirect evidence of the existence of particles beyond those predicted by the Standard Model of [particle physics](#).

The decay of the Higgs boson into a Z boson and a photon is similar to that of a decay into two photons. In these processes, the Higgs boson does not decay directly into these pairs of particles. Instead, the decays proceed via an intermediate "loop" of "virtual" particles that pop in and out of existence and cannot be directly detected. These virtual particles could include new, as yet undiscovered particles that interact with the Higgs boson.

The Standard Model predicts that, if the Higgs boson has a mass of around 125 billion electronvolts, approximately 0.15% of Higgs bosons will decay into a Z boson and a photon. But some theories that extend the Standard Model predict a different decay rate. Measuring the decay rate therefore provides valuable insights into both physics beyond the Standard Model and the nature of the Higgs boson.

Previously, using data from proton–proton collisions at the LHC, ATLAS and CMS independently conducted extensive searches for the decay of the Higgs boson into a Z boson and a photon. Both searches used similar strategies, identifying the Z boson through its decays into pairs of electrons or muons—heavier versions of electrons. These Z boson decays occur in about 6.6% of the cases.

In these searches, collision events associated with this Higgs boson decay

(the signal) would be identified as a narrow peak, over a smooth background of events, in the distribution of the combined mass of the decay products. To enhance the sensitivity to the decay, ATLAS and CMS exploited the most frequent modes in which the Higgs boson is produced and categorized events based on the characteristics of these production processes. They also used advanced machine-learning techniques to further distinguish between signal and background events.

In a new study, ATLAS and CMS have now joined forces to maximize the outcome of their search. By combining the data sets collected by both experiments during the second run of the LHC, which took place between 2015 and 2018, the collaborations have significantly increased the statistical precision and reach of their searches.

This [collaborative effort](#) resulted in the first evidence of the Higgs boson decay into a Z boson and a photon. The result has a statistical significance of 3.4 standard deviations, which is below the conventional requirement of 5 standard deviations to claim an observation. The measured signal rate is 1.9 standard deviations above the Standard Model prediction.

"Each particle has a special relationship with the Higgs boson, making the search for rare Higgs decays a high priority," says ATLAS physics coordinator Pamela Ferrari. "Through a meticulous combination of the individual results of ATLAS and CMS, we have made a step forward towards unraveling yet another riddle of the Higgs boson."

"The existence of new particles could have very significant effects on rare Higgs [decay](#) modes," says CMS physics coordinator Florencia Canelli. "This study is a powerful test of the Standard Model. With the ongoing third run of the LHC and the future High-Luminosity LHC, we will be able to improve the precision of this test and probe ever rarer Higgs decays."

Provided by CERN

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