An initial focus of research was to investigate the possible existence of the Higgs boson, a key part of the Standard Model of physics which is predicted by theory, but had not yet been observed before due to its high mass and elusive nature. CERN scientists estimated that, if the Standard Model were correct, the LHC would produce several Higgs bosons every minute, allowing physicists to finally confirm or disprove the Higgs boson's existence. In addition, the LHC allowed the search for supersymmetric particles and other hypothetical particles as possible unknown areas of physics.[63] Some extensions of the Standard Model predict additional particles, such as the heavy W' and Z' gauge bosons, which are also estimated to be within reach of the LHC to discover.[125]

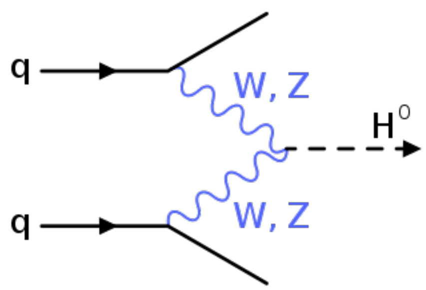
First run (data taken 2009–2013)

The first physics results from the LHC, involving 284 collisions which took place in the ALICE detector, were reported on 15 December 2009.[111] The results of the first proton–proton collisions at energies higher than Fermilab's Tevatron proton–antiproton collisions were published by the CMS collaboration in early February 2010, yielding greater-than-predicted charged-hadron production.[126]

After the first year of data collection, the LHC experimental collaborations started to release their preliminary results concerning searches for new physics beyond the Standard Model in proton-proton collisions.[127][128][129][130] No evidence of new particles was detected in the 2010 data. As a result, bounds were set on the allowed parameter space of various extensions of the Standard Model, such as models with large extra dimensions, constrained versions of the Minimal Supersymmetric Standard Model, and others.[131][132][133]

On 24 May 2011, it was reported that quark–gluon plasma (the densest matter thought to exist besides black holes) had been created in the LHC.[114]

Between July and August 2011, results of searches for the Higgs boson and for exotic particles, based on the data collected during the first half of the 2011 run, were presented in conferences in Grenoble[134] and Mumbai.[135] In the latter conference, it was reported that, despite hints of a Higgs signal in earlier data, ATLAS and CMS exclude with 95% confidence level (using the CLs method) the existence of a Higgs boson with the properties predicted by the Standard Model over most of the mass region between 145 and 466 GeV.[136] The searches for new particles did not yield signals either, allowing to further constrain the parameter space of various extensions of the Standard Model, including its supersymmetric extensions.[137][138]



A Feynman diagram of one way the Higgs boson may be produced at the LHC. Here, two quarks each emit a W or Z boson, which combine to make a neutral Higgs.

On 13 December 2011, CERN reported that the Standard Model Higgs boson, if it exists, is most likely to have a mass constrained to the range 115–130 GeV. Both the CMS and ATLAS detectors have also shown intensity peaks in the 124–125 GeV range, consistent with either background noise or the observation of the Higgs boson.[139]

On 22 December 2011, it was reported that a new composite particle had been observed, the χ_b (3P) bottomonium state.[117]

On 4 July 2012, both the CMS and ATLAS teams announced the discovery of a boson in the mass region around 125–126 GeV, with a statistical significance at the level of 5 sigma each. This meets the formal level required to announce a new particle. The observed properties were consistent with the Higgs boson, but scientists were cautious as to whether it is formally identified as actually being the Higgs boson, pending