Discovery of a Higgs boson, a scalar particle whose associated field breaks electroweak symmetry and generates mass; EPS HEPP Prize awarded to the ATLAS and CMS Collaboration and to physicists who pioneered these experiments

The 2013 High Energy and Particle Physics Prize of the European Physical Society has been awarded jointly to the ATLAS and CMS collaborations for the discovery of a new heavy particle with the properties of the long-sought Higgs boson, and to three experimental physicists, Michel Della Negra (CERN, now at Imperial College London, UK), Peter Jenni (CERN, now at Univ. of Freiburg, DE) and Tejinder Virdee (Imperial College London, UK) for their pioneering and outstanding leadership rôles in the making of the ATLAS and CMS experiments.

The award ceremony will take place at the EPS-HEP 2013 conference in Stockholm (http://eps-hep2013.eu/) on 22 July.

In July 2012, the ATLAS and CMS collaborations announced the discovery of a new heavy particle. Its properties were strikingly similar to those of the elusive Higgs particle, predicted nearly 50 years ago by the work of three theoretical physicists Robert Brout, François Englert and Peter Higgs, who shared the EPS HEPP Prize in 1997. Experimental confirmation turned out to be a gigantic challenge, one that demanded numerous technological innovations and the worldwide collaboration of thousands of particle physicists and technicians to finally create instruments capable of definitively establishing the existence of the Higgs boson. The effort culminated in the making of two particle detectors, ATLAS and CMS, by far the largest and most complex detectors ever built. These unique instruments have been operating since 2009 at the LHC accelerator at CERN, the European Laboratory for Particle Physics, which provides particle beams at the highest energies and intensities ever reached in a laboratory on earth.

The discovery of the Higgs boson provides the last missing ingredient in the so-called Standard Model of particle physics, which was tested in detail in the past three decades. When the theory was first constructed, a major obstacle was met: the very same symmetries that form the basis of the theory required that all particles acting as force carriers have vanishing mass, whereas the carriers of the weak force are observed to have large masses. The Brout-Englert-Higgs mechanism solves this problem by a spontaneous breaking of the related symmetries, which in turn results in the force carriers becoming massive. The tell-tale signature of the remnant of this mechanism, the Higgs boson, has been eluding detection for nearly five decades.

Observing the Higgs boson has required the creation of experiments of unprecedented capability and complexity. At several thousands of tons, with one hundred million electronic channels each, the ATLAS and CMS experiments were conceived from the start, over twenty years ago, to observe the decays of the Higgs boson – or to definitively rule out its existence. The detectors have been designed to observe a billion proton-proton collisions per second, each creating hundreds of particles, and discern the signatures that correspond to the Higgs boson. Their creation has required the use, and in many cases the development, of cutting-edge technologies. In addition, the gigantesque structures were supplemented with appropriate software and computing systems that enabled the analysis of the vast amounts of data that had to be collected.

The prize recognizes the collective efforts of the ATLAS and CMS collaborations, as well as the three physicists who pioneered the two experiments. P. Jenni for the ATLAS experiment, and M. Della Negra and T. Virdee for the CMS experiment, contributed much to the conceptual design and led the teams that designed, constructed and commissioned the detectors over the

course of twenty years. These activities have required the collective efforts of over three thousand physicists, engineers and technicians from each experiment who also collected the data, analysed it and established that a Higgs boson, very much like the one in the Standard Model, exists.

The observation of a Higgs boson signifies the beginning of a new era. Despite the remarkable successes of the Standard Model, the theory can only explain a small part of what the Universe consists of. From observations, we know that most of the mass of the Universe is composed of a substance named dark matter, which is not contained within the Standard Model. Many extended theories, trying to explain what dark matter is made of, require the existence of several Higgs particles. The discovery by the ATLAS and CMS collaborations may thus be even more exciting and open a completely new chapter of particle physics.

Professor Thomas Lohse, the current secretary of the EPS HEPP Board from the Humboldt University Berlin, said, "The discovery of the new particle represents a dramatic breakthrough, achieved in an unprecedented world-wide effort of scientists. Exploring the new sector will keep us busy for many years to come and may well uncover something even more exciting".

Doctor Mauro Mezzetto, a member of the EPS-HEPP Board and Research Director at INFN-Padua, added "The discovery of the last missing element of the Standard Model that describes all the particles and three of the forces we know of, is a spectacular and also historical achievement. The High Energy Physics community can take pride in having designed and built the detectors that have taken full advantage of the CERN LHC and have allowed this extremely challenging search. We all look forward to more results from these experiments, especially in probing for new physics beyond the Standard Model".

Source and contact: Prof. Paris Sphicas, chair of the EPS-HEPP Board, Paris.Sphicas@cern.ch.

Original publications:

- "Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC", Physics Letters B 716 (2012) 1–29.
- "Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC", Physics Letters B 716 (2012) 30–61.

For further reading

- http://www.sciencemag.org/content/338/6114/1558.full
- M. Della Negra, P. Jenni, and T. S. Virdee, "Journey in the Search for the Higgs Boson: The ATLAS and CMS Experiments at the Large Hadron Collider", Science 338 (2012) 1560-1568.
- CMS Collaboration, "A New Boson with a Mass of 125 GeV Observed with the CMS Experiment at the Large Hadron Collider", Science 338 (2012) 1569-1575.
- ATLAS Collaboration, "A particle consistent with the Higgs Boson observed with the ATLAS Detector at the Large Hadron Collider", Science 338 (2012) 1576-1582.