Fermilab

Frequently Asked Questions About the Higgs Boson

What is a Higgs field? What is a Higgs boson?

The Higgs field is like a giant vat of molasses spread throughout the universe. Most of the known types of particles that travel through it stick to the molasses, which slows them down and makes them heavier. The Higgs boson is a particle that helps transmit the mass-giving Higgs force field, similar to the way a particle of light, the photon, transmits the electromagnetic field.

How long have physicists been looking for the Higgs boson?

More than two decades. It started with the LEP experiments at CERN in the 1990s, continued with the Tevatron experiments at Fermilab and now continues with the Large Hadron Collider (LHC) experiments at CERN. A discovery of the Higgs boson would be just the beginning of a new era of particle physics research. Scientists would then focus on understanding in detail the interactions of the Higgs boson with other particles, testing the predictions made by theorists and looking for unexpected phenomena.

What would the world look like without the Higgs boson or a similar particle?

You wouldn't recognize the world. Without the Higgs boson or something like it giving mass to the basic building blocks of matter, electrons would zip about at the speed of light. They would not form unions with protons or other would-be nuclei to make atoms. No atoms means no chemical reactions, no molecules, no ordinary matter as we know it, no template for life. We would not exist.

How do physicists create a Higgs boson?

A high-energy particle accelerator such as the Tevatron or LHC can recreate the extreme energies of the very early universe, generated shortly after the Big Bang. Scientists collide particles at these energies to produce other particles, including a Higgs boson, using Einstein's famous relation $E=mc^2$. At the Tevatron or LHC, only about one collision per trillion will produce a Higgs boson.

How do physicists know when they've found a Higgs boson?

The Higgs boson, like other heavy particles, decays into lighter particles, which then decay into even lighter particles. This process can follow a certain number of paths, and it's more likely to decay through some paths than others. The decay paths also depend on the particle's mass.

Physicists compare the decay paths they observe after a particle collision to the decay paths they've simulated with computers and mapped out for a possible range of Higgs masses. When they

observe a decay path that looks similar to the one they've predicted – when they see a match – it's a good sign that the particle that decayed is the particle they predicted.

By adding up the energy of all the lighter particles appearing in a particular decay path, scientists can determine the Higgs boson's mass.

How is the Higgs boson related to the Big Bang?

About 13.7 billion years ago, the Big Bang sent massless particles and radiation energy zooming through the universe. Scientists theorize that fractions of a second later, part of the radiation energy congealed into the Higgs field.

When the universe began to cool, particles acquired mass from the Higgs field, slowed down and began to bunch up to form composite particles and, eventually, atoms.

How did the Higgs boson get the nickname "the God particle"?

Nobel laureate Leon Lederman, a Fermilab physicist, wrote a book in the early 1990s about particle physics and the search for the Higgs boson. His publisher coined the name as a marketable title for the book. Many scientists dislike the nickname.

What countries are involved in the Tevatron's CDF and DZero experiments?

CDF: Canada, Finland, France, Germany, Greece, Italy, Japan, Korea, Russia, Slovakia, Spain, Switzerland, Taiwan, the United Kingdom and the United States.

DZero: Brazil, China, Colombia, Czech Republic, Ecuador, France, Germany, India, Ireland, Korea, Mexico, the Netherlands, Russia, Spain, Sweden, Ukraine, the United Kingdom and the United States.

How is Fermilab involved in the LHC?

Fermilab supports CERN's CMS experiment by providing about 1,000 US CMS scientists and engineers, computing facilities, office and meeting space as well as the LHC Remote Operation Center. Fermilab helped design and build the CMS detector as well as equipment for the LHC accelerator. Fermilab scientists are analyzing data taken by the LHC and working on upgrades for both the detector and the accelerator. About one third of the approximately 900 members of the two Tevatron experiments, CDF and DZero, are also members of the two largest LHC experiments, ATLAS and CMS.