Higgs Boson

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Scientists at CERN have announced the discovery of a new subatomic particle, thought to be the Higgs Boson. Postulated in the 1960s, the Higgs Boson would explain why some particles have substance and thus fill a gap in the standard model of particle physics. The latter describes the behaviour of matter and energy since the Universe was about a hundredth of a billionth of a second old.

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1 Higgs Boson

On 4 July 2012, the discovery of a subatomic particle thought to be the long sought Higgs Boson was announced by scientists at CERN (European Organization for Nuclear Research).

The existence of the Higgs Boson was proposed by a number of scientists, including the British physicist Peter Higgs, to explain why some elementary particles have mass (mass is a property that manifests itself as weight in the presence of gravity). If the Higgs Boson has indeed been found then it would be the last elementary particle needed to "complete the set" that makes up the standard model of particle physics. Elementary particles (quarks, leptons and some bosons) make up matter and account for its properties. The standard model doesn't explain the origin of gravity though.

The Higgs Boson is thought to have originated when the Universe was about 10^{-11} ("ten to the minus 11" or 0.000 000 000 01) seconds old. While much of interest undoubtedly occurred in the first hundredth of a billionth of a second of the Universe's history, the discovery of the Higgs Boson would place on a more secure footing the standard model of particle physics that, at least in principle, explains how matter and energy have behaved ever since. That is not to deny that relatively recent isolated developments like the emergence of life are more appropriately described using other scientific models! While its importance should not be underestimated, the popular description of the Higgs Boson as the "God particle" is clearly hype.

The Large Hadron Collider at CERN works by accelerating and colliding subatomic particles called protons. The energy produced in such collisions is partly converted into material subatomic particles, a consequence of the equivalence of matter and energy embodied in Einstein's famous equation $E = mc^2$ (this really just equates energy and mass; the c-squared can be thought of as a conversion factor).

The Institute of Physics explains how the search for the Higgs Boson has been taking place:

> It's thought that the mass of the Higgs – which isn't predicted by theory and has to be determined by experiment – is very high, so the particle would take a huge amount of energy to produce. This is just one of the main aims of the Large Hadron Collider at CERN, the most powerful particle accelerator yet built.
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> CERN's announcement of December 2011 hints of the Higgs at around 124–126 GeV [gigaelectronvolts]. However the signal at this mass level was at best 2.6 standard deviations above the mean of the background fluctuations, whereas a discovery is only

considered to have been made when it reaches five standard deviations – the much-hyped “five sigma” level.[1]

A couple of points on the last paragraph:

1. The gigalectronvolt (a billion electronvolts) is a unit of energy often used to describe the mass of subatomic particles. This is fine because mass and energy are equivalent.

2. The term “five sigma” comes from statistics and means five standard deviations. The *Guardian* explains its significance:

> When they calculate whether a particular bump in the data is significant, particle physicists use a five-point "sigma" scale. One sigma means that the results are not too far from being random statistical fluctuations in the data. A three-sigma result counts as an observation, but only a full, five-sigma result means that scientists can count it as an official discovery. This means that there is less than a one-in-a-million chance of the result being a statistical fluke.[2]

2 Further reading

The Large Hadron Collider, CERN

CERN experiments observe particle consistent with long-sought Higgs boson, CERN, 4 July 2012

Higgs boson-like particle discovery claimed at LHC, BBC, 4 July 2012

Q&A: The Higgs boson, BBC, 4 July 2012

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1 http://www.iop.org/resources/topic/archive/higgs/index.html
2 http://www.guardian.co.uk/science/2012/jun/29/higgs-boson-rumours-fly-cern-results