

Why the Higgs boson matters

From afar it may seem entirely disconnected from the real world, but the Higgs boson is much more integral to life, the universe and, well, everything than you may think.

Have you ever contemplated why you weigh what you do? I am not alluding to the second doughnut you had the other morning, or the ill-advised chips on the way home from the pub, but rather the fundamental reason why the atoms that make up your body, and everything else in the world, have a certain mass. If you haven't, you are not alone - until recently, scientists hadn't thought much about it either.

Before the standard model of particle physics came along, the origin of mass was not even considered a problem; that an object had mass was simply assumed. But when scientists began probing objects at smaller and smaller scales, they discovered that it was not quite as simple as that: according to the standard model, fundamental particles should weigh nothing at all.

The standard model describes the behaviour and interactions of all of the most fundamental particles we have seen - and one other particularly elusive one that, physicists hope, we will see in the near future. The model was developed throughout the 20th century and finalised when the existence of quarks, the particles that make up protons and neutrons, was confirmed in the 1970s. At the time many of the particles predicted by the standard model were yet to be seen. Over the years since then, physicists have ticked these particles off, one by one, like items on a shopping list. Now they are left with just one remaining unfound particle - the Higgs boson.

Peter Higgs, a theoretical physicist at the University of Edinburgh, came up with the

idea of the Higgs field and its associated particle - the Higgs boson - in 1964. The field he proposed extends throughout the universe, and interacts with matter particles in such a way as to give them mass. After an interaction the field leaves behind a telltale sign - the Higgs boson. Finding a Higgs boson would prove that the Higgs field exists.

Two experiments that are part of the Large Hadron Collider (LHC) at CERN are searching for the Higgs boson. Thousands of people from all around the world — including physicists, engineers and even anthropologists [1] — work at CERN. If a Higgs boson is discovered there, there will be more than a few celebratory glasses of champagne — and an inevitable Nobel prize for Peter Higgs.

Elegant though the mathematics is that describes the Higgs mechanism, there is a chance that it does not actually describe nature. In this case, we have to look to slightly less elegant sounding ‘Higgsless’ models to discover the origin of mass. Some Higgsless models use extra dimensions to fix problems that would remain without the Higgs, while others use different mathematical tools. In fact, some physicists are more excited about the prospect of *not* discovering the Higgs, as this would leave the door open for other solutions that go beyond the standard model, and solve more problems than just the origin of mass.

So there are a few people at least for whom the discovery — or not — of the Higgs would be a momentous occasion. But what about the rest of us? Well, there are many practical reasons to care about the *search* for the Higgs — if not that actual discovery. From conception through to the first collisions and beyond, particle accelerators spark many technological advancements that can be applied to fields as wide ranging as medicine, sustainable energy development and security [2]. These advancements

would never have been made if we were not searching for as yet undiscovered particles like the Higgs.

However, one suspects that spin-off technologies and their economic benefits are not what the physicists at the LHC have in mind while running experiments and trawling data for signs of the Higgs boson. Peter Higgs said in an interview with the Guardian that he was drawn to theoretical physics in the first place because "It's about understanding! Understanding the world!" [3] His enthusiasm is not abnormal in the physics community, even if it can sometimes be dampened by long hours spent staring at a computer screen analysing data. As humans we have a natural curiosity about the world around us, and we should not suppress that curiosity simply because the practical benefits of following it are not clear at the outset. Without such a curiosity the modern world as we know it would not exist.

Many people, including Peter Higgs himself, subscribe to the view that science for the sake of understanding the world around us is inherently valuable. If however, you need a more concrete reason to care about the Higgs, allow me to paraphrase Carl Sagan [4]: everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives on the pale blue dot we know as Earth — and none of it would have ever existed without the Higgs boson.

1. "The Large Human Collider", Zeeya Merali, Nature News, 24 March 2010. Available from: <http://www.nature.com/news/2010/100324/full/464482a.html> (accessed 10/06/11)

2. "Particle physics — it matters", Institute of Physics. 28 May 2009. Available from: http://www.iop.org/publications/iop/2009/page_38211.html (accessed 10/06/11)
3. "The god of small things", Ian Sample, The Guardian. 17 November 2007. Available from: <http://www.guardian.co.uk/science/2007/nov/17/sciencenews.particlephysics> (accessed 10/06/11)
4. "Pale blue dot", Carl Sagan. Random House, 1994.