Particle Physics and The Higgs Boson

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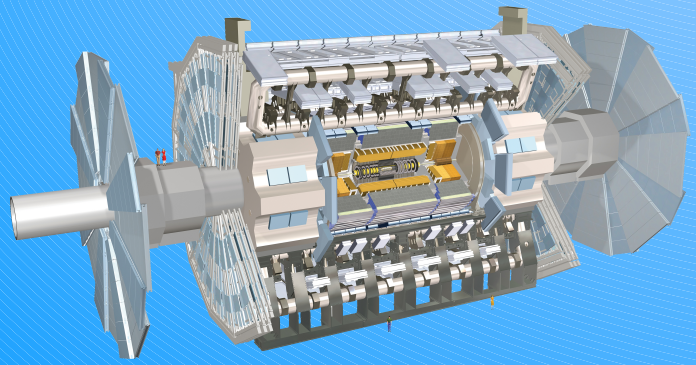
What is Particle Physics?

Particle physics is...
doing experiments and calculations to learn about the smallest things in the universe.

We call these tiny things 'particles' and they are the building blocks of the universe.
Everything we know about in the universe can be made up from just 17 different particles:

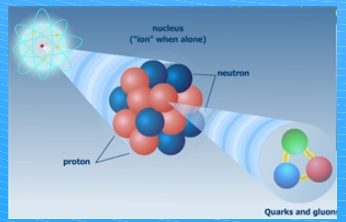
What experiments do we do?

We take particles that are very common, called protons, and put them in the biggest machine in the world.
This machine is called the LHC and is nearly 9km wide.
The LHC speeds up the protons until they are going incredibly fast - about 670,616,623 miles per hour - just 6 miles per hour slower than the speed of light.
Then it smashes them into each other in head-on collisions.
When this happens the protons are destroyed, creating an explosion a bit like a firework going off.
Out of this explosion lots of different, new (and perhaps rare) particles are created.
We build big machines (like fancy digital cameras the size of cathedrals) to look at these new particles to try to understand everything about them.
One of these machines is called the ATLAS Detector:



This is the ATLAS Detector. We use it to take pictures of particles so that we can learn about them.
Can you spot the 4 people in the picture to give you an idea of how big it is?

The atoms in you, me, and all the matter around us is made up of only 'protons', 'neutrons' and 'electrons'.
Protons and neutrons are made up of 'up quarks' and 'down quarks'.
These are all held together by 'gluons' and 'photons', and are given mass by 'Higgs bosons'.

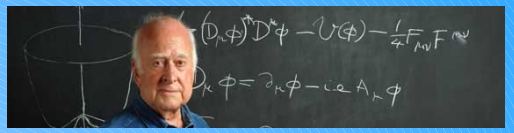


What is the Higgs boson?

The Higgs boson is...
the particle that we believe is responsible for giving other particles their mass.
It's the newest particle that has been discovered (its discovery was announced on the 4th of July 2012) and by discovering it we now know more about how the universe works. It's named after Peter Higgs, who came up with the idea of its existence.

What is mass?

The force of gravity pulls on things that have mass, and we feel that as something being heavy. The more mass something has, the heavier it is. Mass is the the amount of stuff something is made up of.



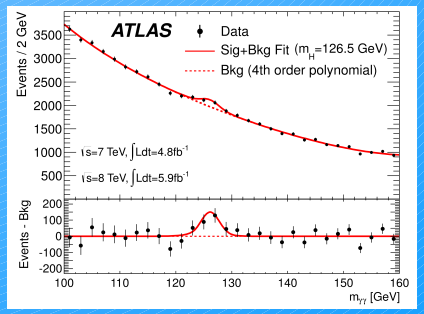
How does the Higgs Boson give things mass?

Higgs bosons make up a field, like an electric field, or magnetic field, or gravitational field, that is everywhere.
This field is called the Higgs field.
In the same way that electric or magnetic or gravitational fields can affect with certain objects (think of how a magnetic field can affect a piece of metal), the Higgs field affects certain particles in a way that looks to us like mass.
The more the Higgs field affects a particle the more mass that particle seems to have.
Mass is just a measure of how much something is affected by the Higgs field.

How can you tell if the Higgs Boson exists or not?

If a Higgs boson is created by colliding particles, then it will exist for such a short time that we will never be able to directly see it. However it will change into other particles, 2 photons for example (see the table opposite), that we will be able to see.
Unfortunately Higgs bosons aren't the only things that can create photons. Lots of things can create photons.
If we see 2 photons we won't know if they came from a Higgs boson or not, but we can measure them and work out what kind of Higgs boson could have produced them. For example, we can work out what the mass of the Higgs boson would have had to have been to create the 2 photons.
If we make a tally chart of all the Higgs boson masses that we calculate from pairs of photons then we can see if lots of them are concentrated at about the same mass.
If the Higgs boson really does exist then every pair of photons that has come from a Higgs boson will give the same mass for the Higgs boson.

On the right is just such a tally chart of Higgs boson masses.
This was made by using the ATLAS Detector to look for pairs of photons.



Something to think about: Do you think the plot above shows that the Higgs boson exists?
Something else to think about: How could you tell if a dice was weighted?