High speed beams, heaps of excitement and hunting the Higgs boson

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DZero detector showing the large liquid argon calorimeter. (Credit: Fermilab)

(PhysOrg.com) -- If looking for the elusive Higgs boson particle is like searching for a needle in a haystack, research published last month has made the haystack smaller.

The Higgs boson is a particle, or set of particles, that might give others mass. The existence of the Higgs boson has been theorised but never recorded.

Scientists have now ruled out a quarter of the allowed mass range for the

Higgs Boson, in results presented at the International Conference on High Energy Physics, held in Paris from 22-28 July. This narrowing of the search range improves the chances of identifying the particle.

Dr Jonathan Hays and colleagues at Imperial College London were amongst over 600 physicists from around the world working on data from the DZero experiment at Fermilab's high-speed particle accelerator . Their findings, when combined with those from a second experiment at Fermilab called CDF, have confirmed that the Higgs boson will not have a mass between 158 and 175 GeV/c^2 (where 100 GeV/c^2 is equivalent to 107 times the mass of a proton).

Previous experiments and theories have provided researchers with a mass range of 114 to 185 GeV/c2 in which to search for the Higgs particle, which to date remains undiscovered.

So why look for the intangible, invisible, so far unidentified particle? Dr Hays, a STFC Advanced Fellow at Imperial who has worked on one of the experiments at Fermilab for a decade, explains his work.

What is the DZero experiment?

It is one of two experiments running at Fermilab's Tevatron in Chicago, which aims to make precise measurements of things we know about, detect new particles being produced that we haven't seen before, and fill in some of the gaps we have in our current physics theories.

The Tevatron is a huge, circular particle accelerator, similar to the Large Hadron Collider at CERN. It accelerates protons (the positively charged particles inside atoms) and antiprotons so they collide with each other, which annihilates them and produces energy and all sorts of other particles. DZero is named after one of the collision points in the accelerator, where the detector is positioned.

Imperial joined DZero in 1999 and I started working on the experiment in 2000. It takes years and years to plan something this big, then you spend years and years running the experiment and collecting data.

Did you have any technical glitches, like the LHC did?

There are always technical problems when you switch on a particle accelerator. You can't just sit down and design something, then build it, switch it on and expect it to work perfectly first time. You're only building one of them, so it's essentially a prototype. It takes time to exploit to its fullest. You need to see what happens, make adjustments.

It's performing exceptionally well now, producing exponentially more data every year. It's been running for ten years now, and produced five units of data up to last year. This time next year, we'll have ten units of data to analyse.

Some people were worried about the risks involved in switching on the LHC but at the Tevatron we didn't really have any media coverage claiming we might create a black hole. We're not a bunch of mad scientists sitting around cackling 'let's turn on the machine'. You can't be certain about anything, but the likelihood of a catastrophe is basically zero.

Are you looking for the Higgs particle?

Yes, finding or ruling out the existence of the Higgs is one of the major goals of the DZero experiment - it's the most interesting thing for me, it really captures people's imaginations. We can see from our theories that there is something unexplained, a bit left over, that looks like a particle - the Higgs particle. It is widely accepted among physicists that the Higgs particle (or something like it) exists, so now we just have to find it - or rule it out. In which case something stranger and more exciting need to be out there.

The idea of a Higgs boson has been around for over 40 years, so it’s not new. Although we had a big hint to suggest that way of describing things might be correct, when the W and Z bosons were discovered, there are still some theoretical niggles.

How did you get into particle physics?

I started out quite vaguely and slowly narrowed as I went along. Originally I thought I wanted to be a lawyer, but doing A Level physics I realised I was really interested in it. I thought I could do a physics degree, then I had the option of switching to law if it didn’t work out. I was interviewed by a journalist at the local paper when I was 18, about what my plans were, and I said I wanted to do research in physics. I have that documented, so it’s evidence of what I said!

I did my undergraduate degree at Imperial, a BSc in physics with a year in Europe. I did a year of research at the University of Erlangen in Germany. It was a great way to learn a new language, I think I’m lazy because I never managed to learn anything from tapes and books, but immersing myself in German really worked. I made a system for steering a proton beam in an accelerator, using a computer we rescued from a skip and some hardware I made myself. It was a great success, I even got to present my results at an international conference! That’s when I really got interested in particle physics. I did my PhD and postdoc here at Imperial, then went to Chicago to work with the Tevatron. I’m currently an STFC Advanced Fellow at Imperial, based in London.

I like the fact that particle physics is fundamental - it’s asking basic questions about the universe and how it works. Also, it’s very international, so I get lots of chances to travel. I got the travel bug after working in Germany during my degree, so that's a great bonus for me.

What is it like to work with the Tevatron?

DZero is a great experiment to work on, as there are lots of different jobs to do, so you can move around and be responsible for different things. I was in charge of the group that identifies electrons and photons and I also used to co-ordinate one of the systems responsible for reducing the number of events the detector records from millions per second to hundreds.

There is a team of six of us at Imperial working on the experiment now. Professor Gavin Davies, Dr Rick Jesik, Dr Per Jonsson, Dr Tim Scanlon, Nicholas Osman and myself.

Is there a rivalry between the Tevatron and the LHC?

I think a healthy rivalry keeps everyone on their toes, but it's important to work together. Many of us work on both - I also work on the CMS experiment at CERN. Also despite being sometime ri vals, w e combine data from DZero and CDF for the Higgs searches, so we have double, which really helps. Each instrument is better in different areas, with different techn ologies, so you ca n cross-check data, which is a real benefit. There's the 'Tevatron Higgs New Phenomena Working Group', which combi nes data from both experiments. Our Imperial team is very involved with this group, and that's where our latest results have come from.

What does the future hold?

It's an exciting time now, who knows what the future holds. The

Universe is there, so the Universe must work. The theory at some point has to fit with that, has to describe a Universe that makes sense. Where we are now, it makes sense but as we push the frontier, we will uncover questions that can only be answered by taking measurements. There are lots of great, interesting, inventive theories, and now we need data to work out what's a good idea but not right, and which theories are more plausible than others.

More information: Fermilab: www.fnal.gov/

Provided by Imperial College London