**The Large Hadron Collider**
*The Re-Launch of the LHC*

**Dr Dan Faircloth, Rutherford Appleton Laboratory, UK**
When they actually start doing the collisions it's going to be very exciting because we're truly taking a step into the unknown, here. W e have never actually done this sort of experiment in this sort of detail before, so it's going to be fascinating to see what happens and it's going to be really interesting to see the results coming out of this machine.

**Dr Bruce Kennedy, Rutherford Appleton Laboratory, UK**

What everyone is hoping for is that the first stage of getting beam circulating goes smoothly as it did last year, and then we'll be able to move on fairly quickly and without incident, to having beams going in opposite directions and colliding.

The Large Hadron Collider launched in 2008, but part of the accelerator ring failed within weeks. The LHC was cooled to temperatures colder than outer space, the machine was started up for the first time and the final checks of the beam tunnel were being made. It was a world first. Dr Bruce Kennedy is part of a team at the Rutherford Appleton Laboratory that designed one of the LHC detectors.

*What was meant to happen was that CERN would fire a beam through the accelerator in one direction and make sure that all was well, then fire the other beam through in the opposite direction, doing those things separately, and that went remarkably well, I think, much better than anyone had really hoped. It just took a few hours to do that and achieve success. So, the next stage was going to be then bringing the two beams together so could circulate together and then actually and bring them into collision.*

But, before the beams were ever brought into collision, just two weeks after the start up, disaster struck. Particle accelerator engineer Dr Dan Faircloth describes what happened.

*What actually happened was it was a connection between two of the magnets. These magnets are 15 metres long, they are held at minus 270 degrees C, each one has ten thousand amps flowing through them, which is an incredibly high current, and they are superconducting, that's how they can allow this really high current to produce these hugely powerful magnetic fields required to bend the beam. And there was a little bit of superconducting wire connecting two of the magnets together and that developed a little tiny resistive region which meant it stopped being superconducting. And it was actually a spark in this tiny little interconnecting region where they hadn't planned to have such a huge failure, and the pressure release valve couldn't open in time and the pressure rose and it popped, basically, and over a tonne of helium was dumped into the tunnel.*

In the space of about one third of a second, this enormous release of energy created a powerful explosion.

*These magnets weigh between 20 and 30 tonnes, and the shock wave was enough to move some of those magnets half a metre or so off their mountings, and really completely disrupt the operation of that part of the ring. So, it was a major incident and cleaning it up took a long time, what also took much longer was going round the rest of the accelerator checking all interconnects and making sure this couldn't happen again. So that's a lot of the work that's been going on in past year or so in getting back to where we'd hoped to be 12 months ago.*

Scientists are now re-starting the machine after over year of repair work. The goal once again is to get two beams up to speed and collide them.

*Two beams of protons, one going clockwise, one anti -clockwise, will be brought together at four points around the circle of the ring, where they will collide, and its the collisions between the protons that give us the information we try to gather to understand what's going on at very small scales in the elementary particle world.*

Dr Dan Faircloth works at a particle accelerator called ISIS at the Rutherford Appleton Laboratory

*To start with, the first thing you need is something to produce particles, which is one of the areas in which I work. You need an ion source,and essentially, just think of it like a spark , and a spark produces the particles, we then take them and we push them faster and faster with electric fields. And, all the time we're trying to make them go faster, we also are having to focus them in and we focus them with magnetic fields. An accelerator is basically a whole series different bits of equipment that progressively push the beam faster and faster and faster and faster, until we get close to the speed of light.*

These will be the highest energy man-made collisions in history. Each beam of protons will have a total energy equivalent to a 400 tonne train traveling at nearly 100 mp/h. Engineers first use a combination of other accelerators to get the beam of protons up to speed.

*As the chain of accelerators go, it feeds into the proton synchrotron, then it feeds into the super proton synchrotron and then and only then after its got up to 450 GEV, it then feeds into the LHC, which is the main 27km ring. And this whole process, from the very first accelerator, to filling up the main LHC ring, actually takes a long time it take four and a half hours.*

*So, the two circulating beams are focused down into a size smaller than a human hair and when they interact one hundred billion protons are whizzing past each other in opposite directions – like in a crazy rush hour, they are whizzing past each other – but amazingly, of that one hundred billion protons, only about twenty hit head on each time the beam pulses go past each other in each interaction point.*

*When those particles do hit head on, that is what we're looking for. Because when they hit head on, all energy that has been stored in those particles by virtue of how fast we've been trying to make them go, is then converted into matter. And this is Einstein's equation, E=MC2. And all the energy is converted into matter and that is when we get this amazing explosion of particles, a whole new different family of particles are created, and that's what we're looking for, we're looking for new exotic particles into his explosion.*

*The reason that we're going to all this effort and this incredible expense to make two particles collide at such high energies is because this is replicating the conditions that existed at the Big Bang. In first millionth of a second after the Big Bang, particles were going as fast as this, and we can use this great big machine to create very, very, very high temperatures, essentially, because that's what temperature is, it's particles going very fast, we can use these conditions to study the moment of creation itself.*

For detector physicists like Bruce Kennedy, the year long wait has not been wasted time.

*It has meant that there has been extra time to really put the finishing touches to detectors. To do a lot more simulation work, so that when things do start up we'll understand a lot better what's going on. So, the time hasn't been wasted. As always, when you're installing a detector to a deadline, there are always things you would like to do, you would always like more time. So, we would like of course to have been running, and doing physics in this period, but having the extra time to increase our understanding of our detectors to make sure that everything is fully installed, working as well as possible, the time has been well spent.*

And for Dr Dan Faircloth the challenge is part of the job of an engineer. It takes a 300 strong team to keep the accelerator he works on, ISIS, working 24 hours a day, up to 200 days a year.

*Well, its hardly surprising that it didn't all go to plan all the way because this is a very complicated machine, and the more complicated you make something, the more likely it is to go wrong. ISIS has been running for over twenty years now and we're very used to things going wrong. You have to design in ways of coping with things breaking. The LHC was a brand new machine and, I don't know about you, but whenever I try something for the first time it doesn't always work and so it does not surprise me at all that it didn't work. But, we will make it work, we keep trying, we keep working out what went wrong and we  modify it and we try again and that is how science progresses, how research and engineering progresses which is why it's so exciting to work on.*