Enabling research

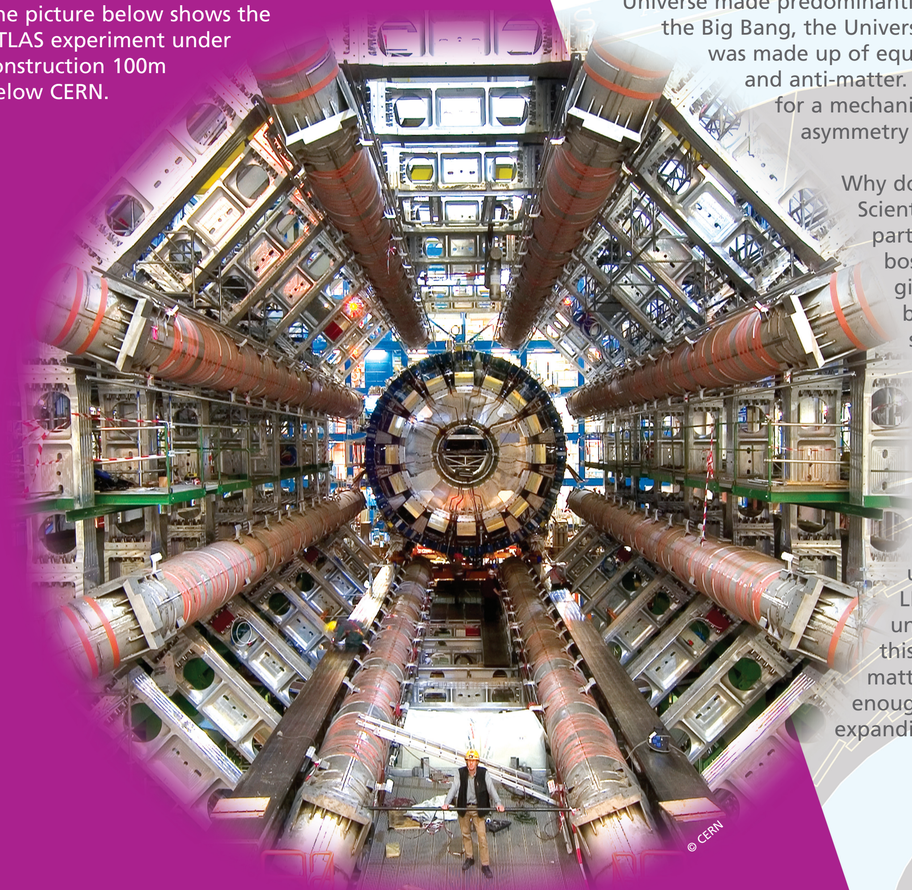
Particle Physics and the Large Hadron Collider

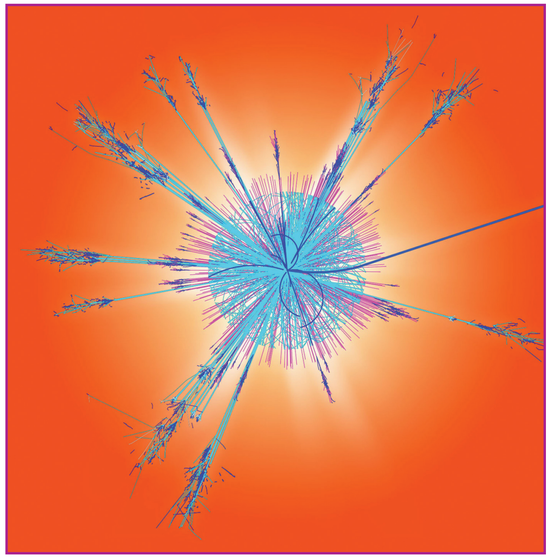
The Large Hadron Collider (LHC) is a new, high energy particle collider being built at the European Particle Physics Laboratory, CERN, near Geneva. It is the world's largest international physics collaboration and will help scientists to study the fundamental building blocks of our Universe, such as the nature of mass, the differences between matter and anti-matter and the search for 'dark matter'.

The LHC will be the highest-energy collider ever built, smashing together protons travelling at 99.999999% of the speed of light! These collisions will produce new particles, reproducing conditions similar to those immediately after the Big Bang, when the Universe was only a billionth of a second old.

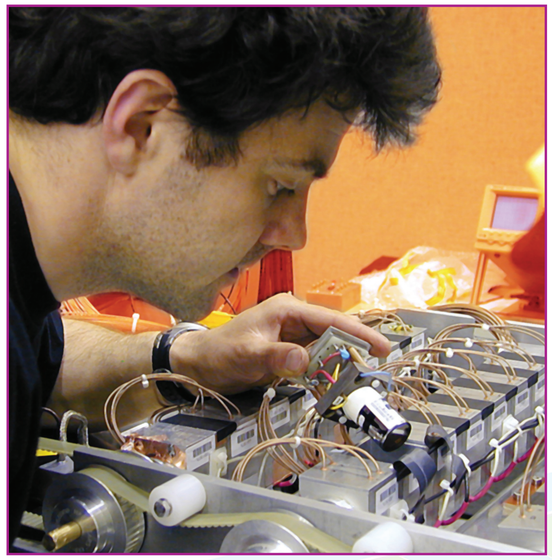
Four different detectors are being constructed to sift through the debris of these collisions in the search for new particles. Staff at the CCLRC are taking a leading role in the construction and running of three of them.

The picture below shows the ATLAS experiment under construction 100m below CERN.





Simulated collision of two protons in the ATLAS experiment. © CERN



A CCLRC engineer testing one of the main components of the CMS electromagnetic calorimeter at the CCLRC Rutherford Appleton Laboratory, before its installation at CERN.

Science challenges

The LHC will help shed light on some of the most fundamental questions in science. Why is the Universe made predominantly of matter? Just after the Big Bang, the Universe was very different – it was made up of equal amounts of matter and anti-matter. Scientists are looking for a mechanism to explain the asymmetry which we see today.

Why does matter have mass? Scientists believe that a particle, known as the Higgs boson, is responsible for giving all particles mass, but it has never been seen before. If such a particle exists, the LHC will make it detectable.

The visible matter in the Universe only accounts for a tiny fraction of the total, leaving 96% of it unaccounted for. The LHC will help us understand the nature of this mysterious 'dark matter' and whether there is enough to keep the Universe expanding.

Construction challenges

The LHC experiments use several types of detector nested inside each other like a 'Russian Doll', with the proton collisions occurring at the centre. The ATLAS detector is one of the largest - measuring 44m long and 22m high, it is as large as a five storey building! CCLRC staff have built 730 silicon tracker modules for ATLAS - giant silicon chips, 12cm by 6cm, which record where charged particles pass through them. To produce accurate information, the construction of each module must be precise to less than the width of a human hair.

Data challenges

Once collisions begin in 2007, each experiment will produce a data volume equivalent to a one-mile-high pile of compact discs, every second! However, only a fraction of this data actually contains new physics: CCLRC scientists and engineers are leading the design and construction of some of the cutting-edge high-speed electronics needed to sift through all the collision data in order to keep the interesting data for further analysis. Even after sifting, the volume of the remaining data each experiment records per second is the equivalent of 10,000 Encyclopaedia Britannica!

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