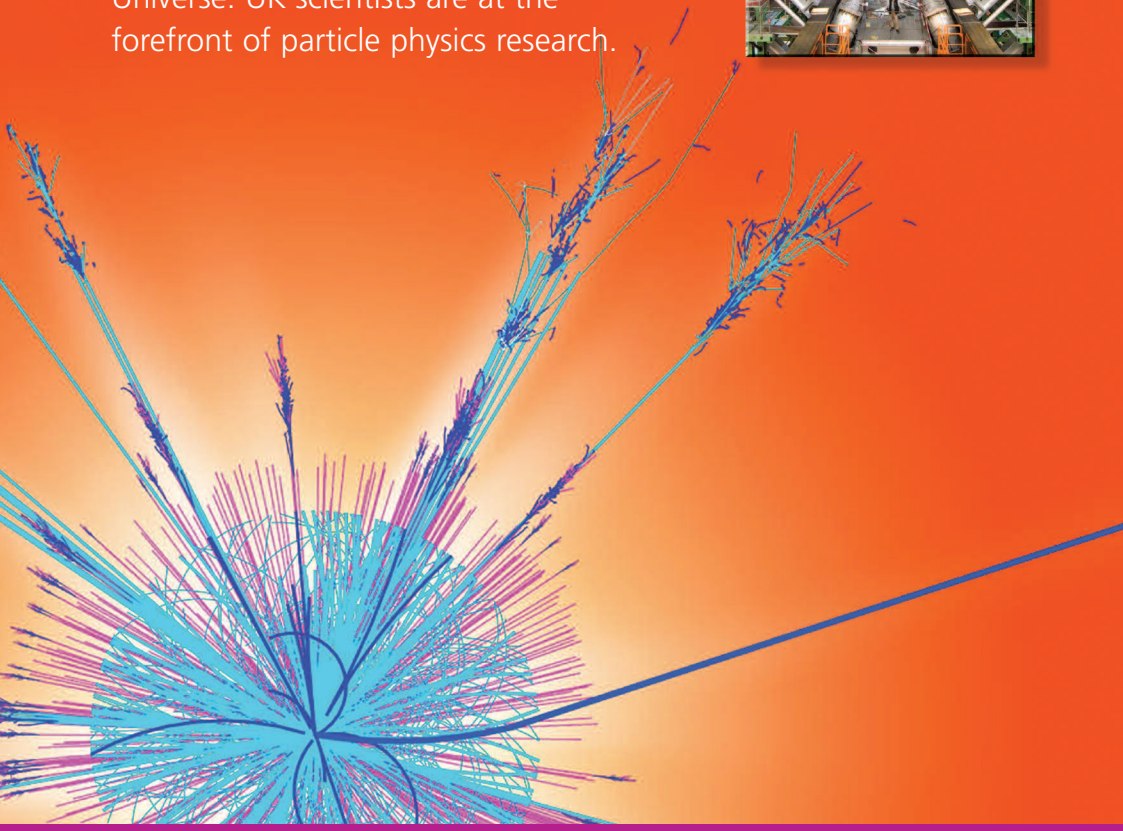
CCLRC

What is particle physics?

Particle Physics is a journey into the heart of matter. Using the biggest, most sophisticated experiments, particle physicists study the tiniest of particles to understand the nature and origins of the Universe. UK scientists are at the forefront of particle physics research.



Council for the Central Laboratory of the Research Councils

The CCLRC's role in **Particle Physics**

CCLRC scientists are furthering their understanding of the universe through a variety of large experiments. The nature of mass, the differences between matter and anti-matter, the oscillations of neutrinos and the search for dark matter are some of the highlights. The programme typically involves large facilities shared between many countries, with the European Particle Physics Laboratory (CERN), in Geneva, being the prime example.

CCLRC staff work with groups from Universities in the UK, providing engineering and electronic expertise for the planning and construction phase, as well as operating and analysing the data from the experiments. There are groups developing new sorts of detectors, and working on the 'GRID', a computing infrastructure designed to share precious computing power worldwide.

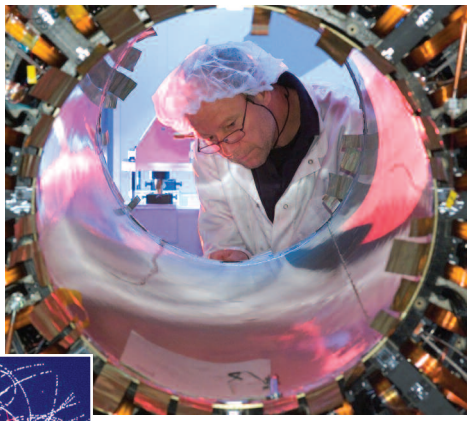
CCLRC scientists are working on a new neutrino experiment at Fermi National Accelerator Laboratory (Fermilab), USA. The Main Injector Neutrino Oscillation Search (MINOS) is designed to study ghostly particles called neutrinos and in particular to study how the three different types are able to transform one into the other.

Recently, research has started into how to build new types of particle accelerator. One example is the International Linear Collider, a proposed machine with two giant electron guns, each over 10km in length, firing electrons and positrons (their antimatter counterparts) to collide in the centre. Another is a new Neutrino Factory – a unique demonstrator is to be built at the CCLRC Rutherford Appleton Laboratory, in Oxfordshire, to test the technology before the factory is built.

A CCLRC scientist working on one of the ATLAS detector modules. Courtesy CERN

The CCLRC's role in the **Large Hadron Collider**

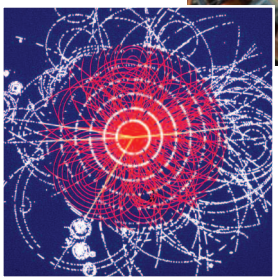
The Large Hadron Collider (LHC) is a new, high energy particle collider being built CERN. It is the world's largest international physics collaboration and will help scientists to study the fundamental building blocks of our Universe, such as the nature of mass, the differences between matter and anti-matter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



Courtesy CERN

Above: Work on the SCT Barrel of ATLAS – part of the inner detector.

Left: Simulation by the ATLAS experiment of the decay of a Higgs boson into 4 muons (yellow tracks).



Courtesy CERN

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.

It will also help to 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 seen today. Why does matter have mass? Scientists believe that a particle, 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.

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

The LHC experiments use several types of detector nested inside each other like a 'Russian Doll', with the 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.

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.

CCLRC

The Council for the Central Laboratory of the Research Councils is one of eight UK research councils and is one of Europe's largest multidisciplinary research organisations supporting scientists and engineers across the world. It operates world-class large scale research facilities, provides strategic advice to the government on their development and manages international research projects in support of a broad cross-section of the UK research community.

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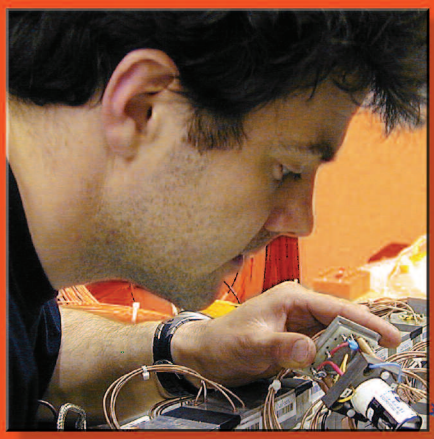

Above: A CCLRC engineer testing one of the main components of the CMS electromagnetic calorimeter before its installation at CERN.

Front page background picture: Simulated collision of two protons in the ATLAS experiment. Courtesy CERN

Front page inset: The ATLAS experiment under construction 100m below CERN. Courtesy CERN