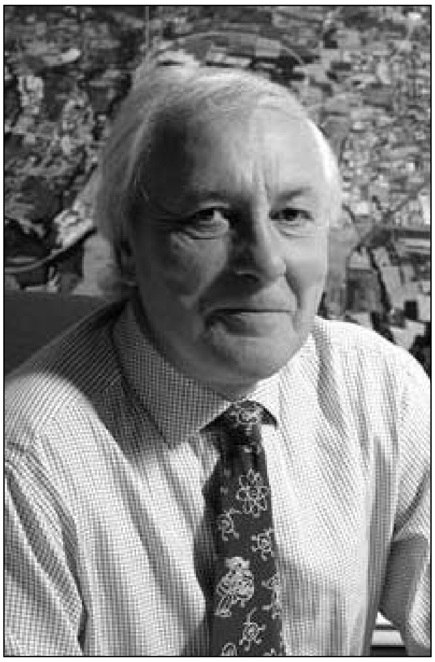
The Large Hadron Collider

Dr Lyndon Evans
LHC project leader



Later this year, Europe will inaugurate mankind's most ambitious scientific undertaking, the Large Hadron Collider (LHC) at the CERN laboratory near Geneva. Continuing a tradition of enquiry that dates back to the dawn of humanity, experiments at the LHC are poised to change profoundly our understanding of the Universe. In doing so, they are also pushing back the frontiers of technology in areas ranging from communication to medical imaging, they are setting a model for international collaboration on a global scale, and they are doing the kind of research that has the power to inspire, attracting a new generation of people into science.

Pure research is CERN's reason for being, but the curiosity that motivates CERN scientists requires them to develop cutting edge technology. The basic tool of particle physics is the particle accelerator, a device invented in the 1920s and 30s for basic research. Today, there are thousands of accelerators in the world, most of them in hospitals where they are used to treat cancer or produce medical isotopes, or in industry where they perform a wide range of tasks. Medical applications of particle physics technologies are in fact a recurring theme. Scanning techniques such as PET and MRI both owe much to research in particle physics. The sensors in PET scanners were first developed for experiments in particle physics, while MRI brings together techniques developed for a range of disciplines including particle physics.

One of the key technologies being developed for the LHC is Grid computing. Experiments at the LHC will produce unprecedented quantities of data, roughly the equivalent of a 20 km high stack of CD-ROMs every year. Analysing this data will be a global community of scientists. The LHC Computing Grid will give them seamless access to globally distributed resources of data storage and processing capacity. Through the GridPP project, the UK is a leading player in developing this new computing paradigm.

Pure research is the fundamental driver of innovation, without it, there would be no science to apply. Many are aware that the World Wide Web was invented at CERN by the British scientist Tim Berners-Lee to address the needs of particle physics. Fewer are aware that most of what we take for granted in today's technological society has roots in basic research. Electricity arose through Faraday's curiosity about a natural phenomenon, not through applied R&D on the candle. Without Einstein's curiosity about gravity, there would be no GPS, and without quantum mechanics, that most esoteric of sciences, we would have no electronic devices. Today, nobody can tell what innovation may arise from the fundamental science that the LHC provides, but it would be a foolish person who said there will be no practical benefit. I for one will not be joining the ranks of scientists like Rutherford, who infamously said that ideas of getting energy from atoms were moonshine.

CERN's founding convention states that the results of the laboratory's work 'shall be published or otherwise made generally available'. This is a message that has shaped CERN's relationship with the world. Throughout its history, the Organisation has always strived to share and exchange its knowledge with all areas of society that might benefit. We placed the basic concepts of the World Wide Web in the public domain on 30 April 1993, thus ensuring that everyone would have non-proprietary access to the Internet. Some of our detector technologies have been transferred to industry, which has further developed them for use in other areas, and in turn made them more attractive to us. Such exchanges are essential for particle physics, and for ensuring that advances made in the name of particle physics benefit society as a whole.

The United Kingdom was one of CERN's founder members in 1954, and has always been a strong supporter of the CERN ideal. Over the years, the UK's science, industry and culture have been enriched by membership of CERN. The UK was the first of CERN's Member States to organise trade fairs at the laboratory under the banner of 'Britain at CERN'. Today, the UK is a key player in the LHC project, with over 20 British Universities involved and UK scientists holding many key positions at CERN.

UK scientists are playing a prominent role in the construction of the large particle detectors that will record the results of particle collisions in the LHC, and are providing some of the most technologically advanced components. Examples include semiconductor particle detectors with fast electronics using deep sub-micron technology, crystals for accurately measuring high-energy photons, a detector for particle identification with unprecedented performance, and the electronics that has the mission of sifting out the interesting data from the millions of particle collisions that the LHC will produce every second.

CERN was founded with the ambition of producing world-leading research in Europe, and on principles of openness and inclusion. Today, CERN is the world's leading laboratory for research into the fundamental mysteries of nature - into the particles that make our Universe and the forces that bind them together. CERN's research has always been conducted with an open-door policy. Throughout the cold war, CERN scientists worked freely with their colleagues from behind the iron curtain. Today, some 9000 scientists from all over the world work together peacefully at CERN, regardless of politics, race or religion.

Their focus is the LHC, a machine that will collide particles of matter, protons, at high energy as a tool to address some of the most puzzling mysteries of the Universe. The LHC's first mission will be to complete a journey that began with Newton's description of gravity. Gravity acts on mass, but so far science is unable to explain why fundamental particles have the masses they have. The British physicist, Peter Higgs, has contributed to the most probable proposal to explain why some particles have mass and others do not. If he is right, there will be a 'Higgs' particle, which should quickly be found at the LHC.

Finding the Higgs particle would bring to a close an important chapter in our understanding of nature. Over the last four decades, physicists have pieced together a comprehensive understanding of the fundamental particles of matter and the forces that act between them. The Higgs particle is the last piece in the jigsaw of this so-called standard model, but as with all good stories, the conclusion of one chapter leads naturally into the next.

A welder closing one of the interconnects between LHC magnets

The standard model gives us a powerful description of the matter that makes up all we can see in the Universe, and the forces that give structure to atoms, people, planets and stars. But cosmological observations have shown that what we can see is only a small fraction of what must be out there. Visible matter seems to account for just 4% of what must exist, the rest is made up of dark matter and energy, about which we know very little. Experiments at the LHC could take our first steps into understanding this unknown 96% of the Universe.

Another fundamental question for the LHC concerns the mystery of antimatter. Big Bang theory tells us that in the first moments of the Universe there were equal amounts of matter and antimatter. Today there appears to be only matter. Matter and antimatter have annihilated, and only a tiny fraction of what was created remains to make the visible Universe. By making antimatter in our accelerators, we can address the question of what mechanism is responsible for this asymmetry. The LHC will also allow scientists to reproduce and study matter as it would have been just a tiny fraction of a second after the Big Bang, the primordial soup that existed when the Universe was too hot for nuclei and atoms to be formed, and that has condensed into the nuclear matter from which we are made.

When the LHC starts up in 2008, and results start to flow in the months and years that follow, the eyes of the world will be on CERN. This is a unique opportunity to attract young people into science, and to address the much-publicised deficit of physicists for UK industry. Society relies on physics. Industry relies on physics. The economy relies on physics. And our ability to attract young people into physics relies on those branches of the field, like particle physics, that are at the frontier of knowledge.

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