THE LARGE HADRON COLLIDER SWITCH ON

PARLIAMENTARY AND SCIENTIFIC COMMITTEE BREAKFAST BRIEFING ON TUESDAY 20TH FEBRUARY

Working at CERN

CERN provides an exciting environment for people working in a variety of roles

British scientists have played leading roles in CERN operations and management from its inception in the 1950s. John Adams, who joined CERN in 1953 from the Atomic Energy Research Establishment at Harwell, was CERN's leading accelerator designer and engineer, eventually becoming Director General in 1976. With fellow Brit, Mervyn Hine, he built the accelerators that were to establish CERN as the leading particle physics laboratory in the world.

At one stage, three of the four LEP experiments were led by UK physicists: Wilbur Venus (DELPHI), David Plane (OPAL) and Peter Dornan (ALEPH), while Chris Llewellyn-Smith, as Director General between 1994 and 1998, saw the LHC through its final stages of approval. Roger Cashmore was Director for Collider Programmes from 1999 to 2003, overseeing the running of LEP and co-ordinating the LHC programme.

Today, you'll also find UK people working in CERN's extensive outreach programme, in IT, technology transfer and all aspects of management. And, of course, CERN runs on the fuel provided by the efforts of PhD students who come to CERN to work for short periods. Many of them are attracted by the international atmosphere, Geneva's central European location, the mountain scenery – and of course the ski-ing!

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Dr Lyn Evans

Lyn Evans has been at CERN for 34 years, working first on the SPS. He is now responsible for ensuring that the LHC will be up and running by 2007.

Everyone knows what a nightmare installing a new kitchen can be. The builders have knocked down the walls, the units have been delivered but the plumbing isn't ready. So you'll have some sympathy for Lyn Evans who found himself "in a considerable state of frustration" waiting for the arrival of the cryogenic system for the LHC. Until it's installed the rest of the systems can't be put in place. The thousands of magnets have been arriving and have been piled up around the CERN site. A delay at this critical stage of construction means that the rest of the collider complex must be commissioned more quickly. The collider is divided into eight octants, and rate of delivery of the many components was meant to ensure that the eight sections were tackled in series. "We have had to revise our planning and put in more teams, but we will meet the deadline for the physicists," assures Lyn.

Lyn has been project leader for the LHC since it was first proposed in 1983 and is considered CERN's most experienced accelerator expert. He first came to CERN in 1970 as a Fellow, joining John Adam's team in 1971 to build the SPS. "The really big challenge came in the late 1970s to turn the thing into a proton-antiproton collider," recalls Lyn. "The challenge was to make it into a storage ring that could keep antiprotons circulating for hours. It was amazing it worked so well."

In the 1980s, Lyn also worked on the Tevatron, the US's proton-antiproton collider, heading off to Fermilab during the CERN winter shutdown (Fermilab projects shut down in the summer when electricity is expensive due to air conditioning). Towards the end of the decade he also became responsible for both the running of the SPS and LEP. So what Lyn doesn't know about accelerators probably isn't worth knowing.

However, Lyn nearly didn't become a physicist: "Actually I went to university in Wales to do chemistry but found it too difficult; there was too much to remember whereas I could work out physics from first principles." He did his PhD on producing plasmas with high-power lasers, and after his fellowship at CERN finished he nearly went to work on nuclear fusion at the JET laboratory in Culham. But the challenge of the proton-antiproton collider project was too much of a lure and Lyn has remained at CERN ever since, settling with his family on the French side of the border. "I've been living in France for 34 years now and I'm beginning to get used to the French lifestyle," he jokes.

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Particle physics and the LHC

Dr Tara Shears
Royal Society University Research Fellow

To really understand the universe you need to understand its origins, and that means understanding the behaviour of the most fundamental constituents of matter that were produced in the Big Bang some fourteen billion years ago. This is the quest that drives particle physicists to create huge particle accelerators that probe what happened at the earliest times in the Universe. The Large Hadron Collider (LHC) is the newest particle accelerator of all and should provide answers to some of the most fundamental questions in science today.

Particle physicists are great reductionists, and believe that everything, all matter in the universe, consists of the same fundamental constituents – twelve types of matter particles, which are thought to interact via four fundamental forces. The behaviour of most of these fundamental forces and particles are encapsulated mathematically in a theory known as the "Standard Model" – for the very good reason that all experimental observations made so far agree with Standard Model predictions. It is a remarkably successful theory.

However, good as the theory is, it is also incomplete as it offers no explanation for many of the fundamental properties of matter and features of the universe. It doesn't predict the number of fundamental particles that have been observed, include gravity, or even explain why particles possess a characteristic mass. The theory doesn't explain where all the antimatter originally produced in the Big Bang has gone and why the universe is now dominated by matter. Even more worryingly, the theory only categorizes the observable universe, which is a paltry 4% of the total. Of what remains, a quarter is assigned to mysterious "dark matter", whose presence is inferred from the extra gravitational attraction observed between galaxies. The rest is ascribed to the even more elusive "dark energy", thought to be responsible for the acceleration of the universe but whose nature is unknown.

To learn more we need to return to the very early universe to study the fundamental particles whose behaviour holds the key to these mysteries. It is impossible to study the early universe directly. Instead the very energetic, hot conditions near to the Big Bang can be momentarily recreated using particle accelerators. This is why the LHC, a new particle accelerator based at CERN, the European centre for particle physics, which will start operating later this year, is so important. What makes the LHC notable is that it is the most powerful particle accelerator ever built – so powerful in fact that it will be capable of recreating conditions last seen a billionth of a second after the Big Bang when its powerful proton beams collide together. These collisions won't be rare either. They will occur forty million times a second at four points around the 27km long LHC circular accelerator. At each of these four points an experiment has been built whose purpose is to record information about any particles produced in a collision – much like taking a three dimensional digital snapshot that can be later analysed with a computer and compared to Standard Model hypotheses to determine if anything unusual has happened. Of these four experiments, two (ATLAS and CMS) are general purpose in nature and designed to detect almost anything. The others have been designed with a more specific task in mind: ALICE to investigate a state of matter called quark-gluon plasma which existed in the universe a fraction of a second after the Big Bang; LHCb to investigate why the universe now consists of matter and not antimatter.

Finding the answer to any of the questions posed before demands an intensive search through all the data that the LHC experiments produce – and this too is not without challenge. The experiments will produce a million times more information than the world annual book production each year, an amount that requires approximately one hundred thousand computers to analyse. Processing this much data is such a problem that a new distributed computing paradigm, called the Grid, has been developed to solve it. Armed with the Grid, the LHC and the four experiments, particle physicists are ready to observe and interpret the very early universe. This year should see our first steps towards understanding some of the deepest mysteries in science.

In discussion the following points were made:

Could the Grid become a hackers' paradise? Presumably there are systems in place to protect it? In order to use the grid one has to obtain a digital certificate to authorise access. The security system is now trusted by all of the 10,000 collaborators and is paramount. When data is returned it is accompanied by a proxy of the original certificate which acts like a passport. Grid security has never been breached yet.

The technology and costs of the cooling were queried in the light of future potential demands for energy for the LHC. 130MW is the current consumption which is a considerable reduction on the 200MW previously required.

What is the public response, if any, to the presence of radiation arising from the LHC, especially in relation to the well known outcry of protest against the occasional telephone mast? CERN, which crosses the Swiss-French border, has always had a very open policy with regard to public relations and there has never been any problem with the public that has not been amicably resolved.

Computerisation is a vital part of this project, have CERN therefore ever approached Whitehall with a view to providing them with some advice on this matter? Is there any prospect of using CERN computer technology to aid the NHS for example? The facilities available at CERN are made known to a wider audience and a technology transfer policy is already in place and each member state has a technology transfer officer. The UK has been very pro-active in this regard and possibly more so than other Member States. There are never enough funds but a high priority will be given to funding the LHC from the available resources. The budget has been constant over time in spite of the increases in power generation and CERN strives to live within its budget allocation for scientific research.