Scientific, Transportation and Communication Bodies

European Organization for Nuclear Research

The European Organization for Nuclear Research (CERN) is the world's largest particle physics center. Scientists working at CERN study basic subnuclear particles and the forces of matter in an effort to unlock the ultimate puzzles of the universe – how the universe began and what matter is made of. CERN has its seat in Geneva: the laboratory and its vast underground accelerators extend across the Franco-Swiss border. CERN's Director General is Luciano Maiani of Italy.

CERN, whose initials stand for "Conseil Europeén pour la Récherche Nucleaire" (European Council for Nuclear Research), was established in 1954 to reestablish a leading role for Europe in fundamental science after World War II. CERN has become a leading world research laboratory studying high-energy physics (50 percent of the world's particle physicists work on experiments at CERN). Ultimately it is hoped that CERN's experiments will lead to a number of basic concepts that could have enormous implications for man's understanding of physical processes on Earth: the origin and the functioning of the world from the Big Bang onwards. (The Big Bang is the explosion of primordial energy from which the universe is believed to have emerged some 15,000 million years ago.)

CERN scientists' work hinges on the use of powerful machines called particle accelerators and colliders to probe the atom and the forces that hold it together. With these machines, CERN researchers study two main areas:

1) The basic building blocks of the universe fundamental particles such as electrons and quarks from which all ordinary matter is made.

2) The relationship of the four fundamental forces of nature: gravity (responsible for the weight of matter and the motions of the stars and planets); electromagnetism (which manifests itself as heat, light, radio waves, etc.); the "strong force" (which binds atomic nuclei together), and the "weak force" (which controls radioactive decay and plays a key role in the functioning of the sun and other stars).

Large Electron-Positron Collider (LEP)

For 11 years until it was shut down in late 2000, CERN's largest effort in particle physics research was carried out in its electron-positron colliding beam accelerator, known as LEP (Large Electron-Positron Collider). Brought on line in 1989, the 27-km circumference LEP ring situated 110-meters underground was the world's most powerful instrument, capable of creating in the laboratory conditions similar to the first few hundred billionths of a second of the beginning of the universe. At LEP, beams of electrons and their antiparticles, positrons, were circulated in opposite orbits in a vacuum pipe located in the underground tunnel. Accelerated to nearly the speed of light, the beams were guided by magnets into a collision course to occur in each of four sites around the tunnel ring. In the collision of an electron and a positron, conditions similar to those that existed during the first moments of the universe in the Big Bang were created.

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Four separate experiments were carried out at LEP by scientists from all over the world, including from the United States, at the four large and complex detectors installed along the LEP tunnel where electrons and positrons collided. The detectors recorded the elementary particles resulting from the collisions, allowing scientists to understand the forces acting between them.

The experiments at the detector known as L3, which received funding from the United States, probed new energy regions to study new physics phenomena not predicted by theory. Similar experiments were carried out with the other three LEP detectors, named Aleph, Delphi and Opal.

The experiments at LEP enabled physicists to confirm the "Standard Model," the theory describing particle behavior to an extraordinary degree of precision. They also demonstrated conclusively that only three families of matter particles exist.

In November 2000, CERN announced that it would switch off the LEP accelerator and concentrate on the development of the world's highest energy particle the Large Hadron Collider (LHC). The LHC will be installed in the same underground tunnel as LEP.

The Large Hadron Collider

CERN is currently engaged in the most ambitious programme in its history – the Large Hadron Collider (LHC). This new research facility – a 27 kilometer circular particle accelerator – will smash protons and other nuclei together head on, creating conditions that have not existed since the Big Bang. Together with the detectors that will capture these collisions, the LHC is the most complex scientific instrument ever built. Construction of the LHC was approved by CERN's member states in December 1994 and began in 1998.

The first experiments are expected to begin in April 2007. They will probe questions such as what is the mysterious dark matter of the Universe made of? Why do particles have mass? And what was the Universe like in the first fraction of a second of its life, before matter started to cool down into the form it has today.

CERN and the Birth of the World Wide Web

The World Wide Web, the hypertext system to navigate on the Internet which opened up the existing global Internet infrastructure to millions of users worldwide, was first created in 1990 by a physicist working at CERN. The Internet is a linked network of computers around the world that evolved from a U.S. Advanced Research Projects Agency (ARPA) project during the 1960s. "The Web" - also known as WWW or W3 — is a user-friendly way of touring that network. The World Wide Web was developed to provide an easy method of exchanging data among physicists working in different countries around the world by linking the information on the Internet in a new way.

Web documents are composed using HTML — HyperText Mark-up Language. HTML documents can be directly linked to related materials. By "clicking" on HTML text, the user can leap to another document on the same computer — or on a different computer halfway around the globe. This new system of navigating the Internet was more intuitive than previous methods such as the "Gopher", which forced users to travel an often maze-like series of menus and submenus.

CERN served as a principal center for Web development in Europe until 1995 when it handed over future WWW development to the World Wide Web Consortium, a cooperative effort of the Massachusetts Institute of Technology (MIT) and the French National Institute for Research in Computer Science and Control.

The Large Hadron Collider is expected to open up a completely new field of physics research. It will use superconducting magnets to reach the highest energy proton collisions ever produced in a laboratory. Two of the principle goals of LHC research are the discovery of the "Higgs boson", which would explain the mystery of mass — why some things are heavier than others — and to find proof of the existence of supersymmetric particles, which would in turn resolve the problem of the missing mass of the universe.

Under the terms of a 1998 agreement between CERN and the U.S. Department of Energy and the National Science Foundation (NSF), the United States will provide several advanced accelerator elements for the LHC. Brookhaven National Laboratory agreed to develop and manufacture the LHC's 20 interaction-region dipole magnets, which will guide the LHC's two counter-rotating beams of protons into collision. In addition to Brookhaven, other U.S. partners on the project include the Fermi National Accelerator Laboratory (Fermilab) which is constructing 18 quadrupole magnets and Lawrence Berkeley National Laboratory which is working on superconducting cable and utility boxes for the magnet assemblies. The first 25-ton superconducting magnet from Brookhaven was delivered in January 2003.

New State of Matter

By colliding atoms of lead CERN physicists announced in February 2003 the creation of a new state of matter called quark-gluon matter in which the quarks and gluons that are normally trapped inside the protons were liberated. The new state of matter was created by smashing high-energy beams of lead ions into stationary targets in a range of experiments at CERN's Super Proton Synchrotron (SPS). The discovery is considered very important since this state of matter was predicted to exist millionths of a second after the Big Bang and the results generated at CERN are seen as an important step in understanding the very early universe.

Antimatter Decelerator

CERN experiments also use several smaller particle accelerators, along with extensive data processing facilities. It was at one of the older facilities, the Low Energy Antiproton Ring (LEAR) that the first atoms of antimatter were created in September 1995. These atoms were very fast moving and soon annihilated with matter.

The first atoms of antimatter were created at CERN in 1995. Research continues at the new Antimatter Decelerator facility started up in 2000.

A new facility, the Antimatter Decelerator (AD) was started up in August 2000. This "antimatter factory" will allow physicists to extend the research carried out at LEAR by creating thousands of atoms of antihydrogen. The AD decelerates particles rather than accelerating them. The idea is to trap the antiprotons and hold them at a virtual standstill, allowing physicists to compare with great precision the properties of matter and antimatter. Any slight disparity would open up a new field of physics research.

Nobel Prize for Physics

In 1984 two CERN physicists received the Nobel Prize for Physics after confirming a theoretical picture of nature that unifies electromagnetism with the weak nuclear force in the so-called electroweak force – they discovered the W and Z particles that theory had predicted as being the "carriers" of the weak part of the electroweak force.

In 1988 three U.S. scientists, including one working at CERN, were awarded the Prize for discovering an elusive subatomic particle that has opened new opportunities for research into the innermost structure of matter. They were working on neutrinos, particles that shower the Earth at or near the speed of light, passing right through the planet almost always undetected. Many astronomers believe that neutrinos or some other types of particle comprise most of the universe and could account for the so-called "missing mass" needed to explain whether the universe will eventually collapse upon itself. The present concept is that matter in the universe is moving outward due to the Big Bang and scientists are trying to determine if the universe has enough gravitational pull to halt this expansion and begin collapsing.

U.S. Policy

Although the United States is not a member of CERN, the U.S. became an observer state in 1997. U.S. scientists actively participate in CERN's programs and CERN's LEP's L3 experiment was largely funded by the United States and is run by an American scientist. American universities also participate in Opal and Aleph. The United

States has agreed to contribute $531 million to the Large Hadron Collider (LHC) project, and is the largest single contribution to the project. The U.S. also contributed to the Antiproton Decelerator which began operation in 1999.

Membership: at the beginning of 2000, CERN had 20 member-countries — Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, and the United Kingdom. The United States, the Russian Federation, Israel, Turkey, Japan, India and the European Commission and UNESCO have observer status.

Budget

In 2003 CERN had an annual operating budget of 1,280 million Swiss Francs.

CERN

Internet

www.cern.ch

Description of CERN, press releases, information about the World Wide Web, extensive links to other scientific and general information sources.

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