Open Schools Journal for Open Science

Vol 3, No 9 (2020)

CERN

D. Melissourgos, P. Mexis, S. Stefanopoulou

doi: [10.12681/osj.24430](https://doi.org/10.12681/osj.24430)

Open Schools Journal
for Open Science

CERN

D.Melissourgos[1], P.Mexis[1], E. Metaliki[1], S. Stefanopoulou[1]

[1] Ionideios Model High School, Piraeus, Greece

Summary

As a team, we decided to elaborate on the CERN center for scientific research. We are going to refer to topics such as; the history of the institute, the countries that have participated in the foundation of CERN, the main projects that take place there and lastly the contribution of our country, Greece, in the scientific research taking place there.

Keywords

CERN, laboratory, Nuclear Energy

The **European Organization for Nuclear Research** is a European research organization that operates the largest particle physics laboratory in the world. Established in 1954, the organization is based in a northwest suburb of Geneva on the Franco–Swiss border and has 23 member states. Israel is the only non-European country member.

The acronym CERN is also used to refer to the laboratory, which in 2016 had 2,500 scientific, technical, and administrative staff members, and hosted about 12,000 users. In the same year, CERN generated 49 petabytes of data.

At present, CERN's Member States are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. Romania is a candidate for accession. Israel is an Associate Member in the pre-stage to Membership. India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO have Observer status.

CERN's main function is to provide the particle accelerators and other infrastructure needed for high-energy physics research – as a result, numerous experiments have been constructed at CERN through international collaborations. The main site at Meyrin hosts a large computing facility, which is primarily used to store and analyse data from experiments, as well as simulate events. Researchers need remote access to these facilities, so the lab has historically been a major wide area network hub. CERN is also the birthplace of the World Wide Web. (wikipedia.org/wiki/CERN)

History

The convention establishing CERN was ratified on 29 September 1954 by 12 countries in Western Europe. The acronym CERN originally represented the French words for *Conseil Européen pour la Recherche Nucléaire* (European Council for Nuclear Research), which was a provisional council for building the laboratory, established by 12 European governments in 1952. The acronym was retained for the new laboratory after the provisional council was dissolved, even though the name changed to the current *Organisation Européenne pour la Recherche Nucléaire* (European Organization for Nuclear Research) in 1954.

CERN's first president was Sir Benjamin Lockspeiser. Edoardo Amaldi was the general secretary of CERN at its early stages when operations were still provisional, while the first Director-General (1954) was Felix Bloch.

The laboratory was originally devoted to the study of atomic nuclei, but was soon applied to higher-energy physics, concerned mainly with the study of interactions between subatomic particles. Therefore, the laboratory operated by CERN is commonly referred to as the European laboratory for particle physics (*Laboratoire européen pour la physique des particules*). (wikipedia.org/wiki/CERN)

Member States and International Relations

At the sixth session of the CERN Council, which took place in Paris from 29 June - 1 July 1953, the convention establishing the organization was signed, subject to ratification, by the twelve founding states Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and Yugoslavia, and entered into force on September 29, 1954. The Organization was subsequently joined by Austria (1959), Spain (1961-1969, re-joined 1983), Portugal (1985), Finland (1991), Poland (1991), CzechoSlovak Republic (1992), Hungary (1992), Bulgaria (1999), Israel (2014), Romania (2016) and Serbia (2019). The Czech Republic and Slovak Republic re-joined CERN after their mutual independence in 1993. Yugoslavia left CERN in 1961. Thus, CERN today has 23 Member States.

All Member States are represented in the CERN Council, the supreme governing body of the Organization. The Member States Relations Section coordinates day-to-day relations between the CERN Management and the Member States. A Management Liaison has been designated for each country from the senior staff to help maintain dialogue and information exchange.

They are listed below. Administrative relations with the two host states France and Switzerland are under the responsibility of the Relations with the Host States Service. (international-relations.web.cern.ch/stakeholder-relations/Member-State-Relations)

Scientific achievements

Several important achievements in particle physics have been made through experiments at CERN. They include:

- 1973: The discovery of neutral currents in the Gargamelle bubble chamber;
- 1983: The discovery of W and Z bosons in the UA1 and UA2 experiments;
- 1989: The determination of the number of light neutrino families at the Large Electron–Positron Collider (LEP) operating on the Z boson peak;
- 1995: The first creation of antihydrogen atoms in the PS210 experiment;
- 1999: The discovery of direct CP violation in the NA48 experiment;
- 2010: The isolation of 38 atoms of antihydrogen;
- 2011: Maintaining antihydrogen for over 15 minutes;
- 2012: A boson with mass around 125 GeV/c^2 consistent with the long-sought Higgs boson.

The 1984 Nobel Prize for Physics was awarded to Carlo Rubbia and Simon van der Meer for the developments that resulted in the discoveries of the W and Z bosons. The 1992 Nobel Prize for Physics was awarded to CERN staff researcher Georges Charpak "for his invention and development of particle detectors, in particular the multiwire proportional chamber". The 2013 Nobel Prize for Physics was awarded to François Englert and Peter Higgs for the theoretical description of the Higgs mechanism in the year after the Higgs boson was found by CERN experiments. (wikipedia.org/wiki/CERN)

World Wide Web

The World Wide Web began as a CERN project named ENQUIRE, initiated by Tim Berners-Lee in 1989 and Robert Cailliau in 1990. Berners-Lee and Cailliau were jointly honoured by the Association for Computing Machinery in 1995 for their contributions to the development of the World Wide Web.

Based on the concept of hypertext, the project was intended to facilitate the sharing of information between researchers. The first website was activated in 1991. On 30 April 1993, CERN announced that the World Wide Web would be free to anyone. A copy of the original first webpage, created by Berners-Lee, is still published on the World Wide Web Consortium's website as a historical document.

Prior to the Web's development, CERN had pioneered the introduction of Internet technology, beginning in the early 1980s.

More recently, CERN has become a facility for the development of grid computing, hosting projects including the Enabling Grids for E-science (EGEE) and LHC Computing Grid. It also hosts the CERN Internet Exchange Point (CIXP), one of the two main internet exchange points in Switzerland.

The first website at CERN – and in the world – was dedicated to the World Wide Web project itself and was hosted on Berners-Lee's NeXT computer. In 2013, CERN launched a project to restore this first ever website.

On 30 April 1993, CERN put the World Wide Web software in the public domain. Later, CERN made a release available with an open license, a more sure way to maximise its dissemination. These actions allowed the web to flourish. (home.cern/science/computing/birth-web)

The Higgs Boson

In the 1970s, physicists realised that there are very close ties between two of the four fundamental forces – the weak force and the electromagnetic force. The two forces can be described within the same theory, which forms the basis of the Standard Model. This "unification" implies that electricity, magnetism, light and some types of radioactivity are all manifestations of a single underlying force known as the electroweak force.

The basic equations of the unified theory correctly describe the electroweak force and its associated force-carrying particles, namely the photon, and the W and Z bosons, except for a major glitch. All of these particles emerge without a mass. While this is true for the photon, we know that the W and Z have mass, nearly 100 times that of a proton. Fortunately, theorists Robert Brout, François Englert and Peter Higgs made a proposal that was to solve this problem. What we now call the Brout-Englert-Higgs mechanism gives a mass to the W and Z when they interact with an invisible field, now called the "Higgs field", which pervades the universe.

Just after the big bang, the Higgs field was zero, but as the universe cooled and the temperature fell below a critical value, the field grew spontaneously so that any particle interacting with it acquired a mass. The more a particle interacts with this field, the heavier it is. Particles like the photon that do not interact with it are left with no mass at all. Like all fundamental fields, the Higgs field has an associated particle – the Higgs boson. The Higgs boson is the visible manifestation of the Higgs field, rather like a wave at the surface of the sea.

A problem for many years has been that no experiment has observed the Higgs boson to confirm the theory. On 4 July 2012, the ATLAS and CMS experiments at CERN's Large Hadron Collider announced they had each observed a new particle in the mass region around 125 GeV. This particle is consistent with the Higgs boson but it will take further work to determine whether or not it is the Higgs boson predicted by the Standard Model. The Higgs boson, as proposed within the Standard Model, is the simplest manifestation of the Brout-Englert-Higgs mechanism. Other types of Higgs bosons are predicted by other theories that go beyond the Standard Model.

On 8 October 2013 the Nobel prize in physics was awarded jointly to François Englert and Peter Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider". (home.cern/science/physics/higgs-boson)

Antimatter

In 1928, British physicist Paul Dirac wrote down an equation that combined quantum theory and special relativity to describe the behavior of an electron moving at a relativistic speed. The equation – which won Dirac the Nobel Prize in 1933 – posed a problem: just as the equation $x^2 = 4$ can have two possible solutions ($x = 2$ or $x = -2$), so Dirac's equation could have two solutions, one for an electron with positive energy, and one for an electron with negative energy. But classical physics (and common sense) dictated that the energy of a particle must always be a positive number.

Dirac interpreted the equation to mean that for every particle there exists a corresponding antiparticle, exactly matching the particle but with opposite charge. For example, for the electron there should be an "antielectron", or "positron", identical in every way but with a positive electric charge. The insight opened the possibility of entire galaxies and universes made of antimatter.

But when matter and antimatter come into contact, they annihilate – disappearing in a flash of energy. The Big Bang should have created equal amounts of matter and antimatter. So why is there far more matter than antimatter in the universe?

At CERN, physicists make antimatter to study in experiments. The starting point is the Antiproton Decelerator, which slows down antiprotons so that physicists can investigate their properties. (home.cern/science/physics/antimatter)

Permanent Exhibitions

CERN offers visitors the opportunity to explore at their own pace two permanent exhibitions. First being the Universe of Particles, which is installed in the Globe of Science and Innovation. Dedicated to CERN main missions it allows to explore the world of particles by immersing the visitor in a unique and spectacular ambiance. Secondly, there is Microcosm which is next to CERN's reception. This exhibition offers a discovery of CERN adventure. (visit.cern/exhibitions/permanent-exhibitions)

Universe of Particles

The purpose of the "Universe of particles" exhibition is for visitors to confront the great questions of contemporary physics, currently being explored by the CERN via the LHC and other accelerators.

The exhibition's innovative design plunges the visitor into the fascinating world of particles, from the infinitesimally large to the infinitesimally small, from the Big Bang to the present day. The bewildering environment is designed to force visitors to abandon conventional ideas and contemplate a field of research beyond their common experience.

They traverse luminous spheres representing the Universe of particles, each one containing an interactive kiosk illustrating CERN's quest for knowledge and recounting the international cooperation and technological advances which underpin this incredible research venture. At regular intervals, video shows recount the history of the Universe.

CERN started operating the LHC at 2010, one of the most sophisticated scientific tools ever built to explore new territories of knowledge. To share this exciting adventure with the general public, CERN opened a visitor center that was as high-tech and futuristic as its accelerator.

The "Universe of Particles" exhibition, installed in the Globe of Science and Innovation, was previewed to the media on 25 June 2010.

Conclusion

CERN is a big project the main missions of which are:

- To provide a unique range of particle accelerator facilities that enable research at the forefront of human knowledge.
- To perform world-class research in fundamental physics.
- To unite people from all over the world to push the frontiers of science and technology, for the benefit of all.

Author biographies

- Dimitris Melissourgos, is a 16year old student of Ionideios High School. He plays blasketball and has an interest in science and especially in chemistry.
- PantelisMexis, is also a student of Ionideios and Dimitris' classmate. He doesn't have much of an interest in science; however he is really fond of online video games and computers.
- Eirini Metaliki, is 17 years old and wants to get involved with biology in the future. She has visited CERN and would like to contribute in this big scientific project one day.
- Sofia Stefanopoulou, is a new classmate of ours. She loves mathematics and she would like to get involved with them in the future.

References

[1] home.cern/science/accelerators/high-luminosity-lhc, Retrieved: 15/03/20

[2] home.cern/science/computing/birth-web, Retrieved: 15/03/20

[3] home.cern/science/physics/antimatter, Retrieved: 03/04/20

[4] home.cern/science/physics/higgs-boson, Retrieved: 03/04/20

[5] international-relations.web.cern.ch/stakeholder-relations/Member-State-Relations, Retrieved: 15/03/20

[6] visit.cern/exhibitions/permanent-exhibitions, Retrieved: 03/04/20

[7] wikipedia.org/wiki/CERN, Retrieved: 15/03/20

Open Schools Journal
for Open Science