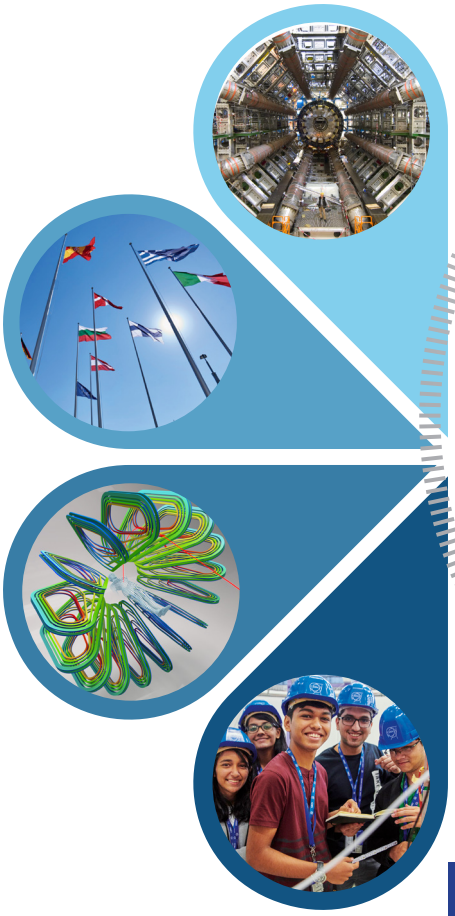


CERN: a model of European leadership and integration

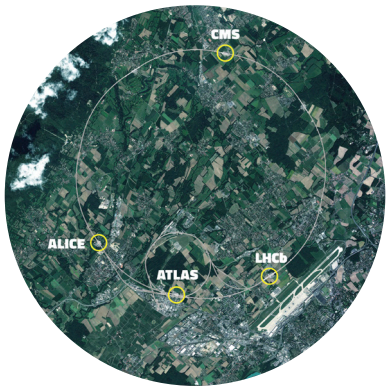
in science, technology and more

CERN (European Organization for Nuclear Research), located on the border between France and Switzerland, is the world's largest laboratory for high-energy particle physics[1].

History

CERN was founded in 1954, at the initiative of visionary politicians and scientists, with the twin goals of re-establishing scientific excellence in Europe after the war and counteracting the brain drain, and fostering peaceful collaboration among European countries through science. The founding Convention, which established CERN as a treaty-based intergovernmental Organization, was originally signed by 12 Member States.

Over the 70 years of its history, the Organization has succeeded in establishing Europe as the world leader in high-energy particle physics and related technologies and in maintaining that position over time.



CERN today

Today, CERN has 24 Member States[2],10 Associate Member States[3] and 4 Observers[4]. All member countries of the European Union (EU) are either Member or Associate Member States of CERN, except for Ireland, Luxembourg and Malta[5]. CERN is governed by its Council, which is composed of delegates from its Member and Associate Member States. The annual budget amounts to some 1.3 billion Swiss francs (BCHF)[6].

CERN is one of Europe's greatest achievements. Not only has it become the world-leading laboratory for high-energy particle physics, it is also a model of innovation in various fields relevant to society; training and education of younger generations; strong and mutually beneficial partnerships with industry; open science; and worldwide collaboration. In all these aspects CERN plays an important role of integrating its Member and Associate Member States through its federating mission and objectives.
However, CERN's future is potentially challenged by competition from China.

Founded in **1954**

24 Member States

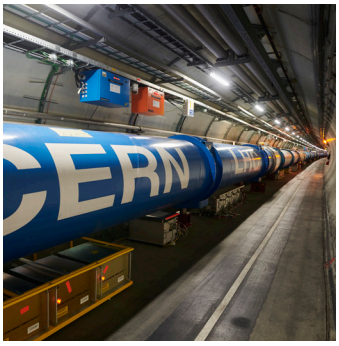
Budget **1.3** BCHF

Science

70 years of scientific research at CERN have led to groundbreaking observations, measurements and discoveries (notably the Higgs boson, in 2012), which have contributed in a significant way to humankind's understanding of the structure and evolution of the Universe. Several CERN scientists have been awarded the Nobel Prize in Physics. Currently, CERN runs one of the largest and most powerful research instruments ever built, the Large Hadron Collider (LHC), which is housed in a 27-km underground ring, mostly in France.

Technology and innovation

CERN's mission requires that it constantly push the limits of scientific knowledge and the in many fields at the innovation frontier and bringing major benefits to society. This is because,



in order to accomplish its ambitious scientific goals, CERN needs to build highly sophisticated and complex instruments (particle accelerators, particle detectors and advanced computing infrastructure) and develop breakthrough technologies in many fields, including superconducting magnets, fast electronics, vacuum, cryogenics, robotics, machine learning, artificial intelligence, quantum technologies, distributed computing and big data. These technologies are transferred to society without financial profit[7], for the benefit of all. The most famous example of this is the World Wide Web[8]. Other more recent examples include accelerators to treat cancer with ions and electrons, which are complementary to, and in some cases more effective than, conventional radiotherapy; the PET scanner, which was originally based on instrumentation developed at CERN; novel radioisotope production for medical imaging and treatment; vacuum technology, which is also used to build solar panels; superconducting cables for electric power transmission without losses; superconducting magnets for medical and nuclear fusion applications; and artificial intelligence for climate monitoring and modelling and for self-driving cars.

Relations with industry

Every year, CERN spends about 500 MCHF in mostly high-tech supply and service contracts with firms in its Member and Associate Member States, adjudicated through a competitive process, as well as in R&D partnerships with industry. As CERN requires many technologies that do not yet exist, it often develops them in-house, in collaboration with trail-blazing industries in the respective domain; once the technology has been mastered, series production is then transferred to industry. CERN is, therefore, a driver of innovation and has partnerships with industry that extend far beyond the simple client-supplier relationship. Indeed, European firms place a premium on collaboration with CERN, because its exacting requirements enhance their growth, quality, innovation and reputation, and the competencies gained are then passed down the line to other companies, fields and clients.

In addition, CERN has many collaborations mainly with European industry for the application of its innovative technologies outside particle physics. Recent examples include a cooperation agreement with Airbus for the use of CERN's high-temperature superconducting current leads for electric aircrafts; cooperation with a company in the Volvo group to deploy CERN's artificial intelligence and electronic developments for self-driving cars; and cooperation with MARS Bioimaging for the development of high-resolution medical imaging devices using CERN electronics. Moreover, CERN technologies currently underpin the activities of more than 30 start-ups.

Training and capacity building

At any moment in time, CERN is training some 5500 young people, including technicians and engineers across a large spectrum of competencies, IT professionals and physicists at the undergraduate, PhD and postdoc levels. Most of these people subsequently find jobs outside particle physics, about 50% of them in industry and the others in academia and other public institutions. CERN thus provides society with a continuous stream of talents in science, technology, engineering and mathematics (STEM), trained in a leading scientific laboratory and a truly international environment.

Worldwide collaboration

Some 17 500 people from all around the world work at CERN, representing more than 110 nationalities. Some come from countries in conflict, others from developing regions. For the latter, CERN represents an invaluable opportunity to access training and cutting-science and technology.

Public engagement education and outreach

CERN has a broad portfolio of initiatives aimed at inspiring the next generation of scientists, educating school students and teachers and, more generally, disseminating scientific knowledge and understanding to society. Every year, CERN's teacher programmes train about 1000 high school teachers. The IdeaSquare@CERN platform hosts teams of young European innovators and future entrepreneurs who harness CERN technologies to address societal challenges. Furthermore, with the advent of the CERN Science Gateway, the Organization's new flagship facility for scientific education and outreach, which opened to the public in October 2023, the number of visitors has increased from 150 000 people per year to almost 400 000 people from 175 countries in 2024.

Integration of activities in the Member and Associate Member States

Since its foundation, CERN plays an important role of creating synergies between its Member and Associate Member States via its mission and objectives, acting like the shared laboratory of all its Member and Associate Member States. This role covers not only science but all aspects of CERN's mission, including technology and innovation, partnership with industry, training, education and outreach. For example, between 2001 and 2006, under CERN's supervision, three leading European companies (Alstom in France, Ansaldo in Italy and Babcock-Noell in Germany) manufactured 1232 high-tech, new-generation superconducting magnets for the LHC, working closely together to exchange knowledge and experience in this unprecedented technology.

—

Groundbreaking scientific discoveries

—

Web, accelerators to treat cancer, PET scanner

—

500 MCHF spent in European high-tech industry every year

—

1232 high-tech superconducting magnets manufactured for LHC by European industry

—

5500 young people trained at any moment

—

17 500 people of **110** nationalities work at CERN

—

Relations between CERN and the European Commission

Over the years, CERN and the European Commission (EC) have built up a strong relationship based on common objectives and shared values, including the promotion of scientific and technological progress, training and education, integration of European countries, collaboration across borders and open science. The EU, represented by the EC, has the status of Observer in the CERN Council.

1000 high school teachers trained each year

400 000 visitors per year from **175** countries

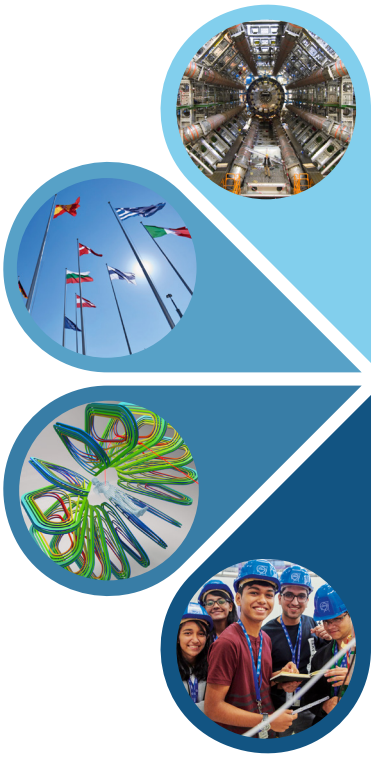
FCC **91 km** ring

53 BCHF invested in CERN by Member States to this date

The existing collaborations, which are based on the Horizon 2020 and Horizon Europe programmes, are extremely fruitful for CERN and the EC, as well as for the industrial and academic partners involved. EC funding of some 10 million euros per year supports these collaborations. As CERN begins to plan its next flagship project (described below), a more substantial involvement of the EU would be both crucial and appropriate, in order to maintain European leadership in a critical area of science and technology, and considering both the potential scientific, technological and societal spin-offs for Europe and the close alignment of CERN's goals and values with those of the EU.

CERN's future

CERN's core mission is to design, build and operate powerful particle accelerators and other high-tech infrastructure to accomplish its scientific goal of understanding the fundamental laws and constituents of the Universe. The current flagship facility, the LHC, will operate until 2041. The LHC has brought about a shift of world leadership in high-energy particle physics from the United States to Europe and has more than doubled the size of the international scientific community working at CERN. Given that CERN's ambitious projects have very long lead times (20-30 years), plans for the next facility are already starting to be laid.



In June 2020, the CERN Council updated the European Strategy for Particle Physics, the roadmap of the field, which is drawn up every 6-7 years. One of the main conclusions of that process was that the Future Circular Collider (FCC), a 91-km ring housing an electron-positron collider initially, and then a hadron collider, has the greatest scientific potential, and the CERN Management was thus mandated to perform a feasibility study that will be completed in 2025. The EC supported this study through a H2020 grant[9]. The final decision on whether or not to go ahead with the construction of the FCC should be taken by the CERN Council around 2028, also based on the funding prospects. Construction would then start in the early 2030s and physics exploitation would take place over the period 2045-2090. The FCC would thus maintain Europe's leadership in particle physics until the end of the century. The main physics objectives include unveiling the composition of dark matter (which makes up about 25% of the Universe), developing a detailed understanding of the Higgs boson, which is a very special particle related to the origin and possibly the fate of the Universe, and searching for new particles and forces that could help answer other outstanding questions.

Over the past 70 years, CERN's Member States have invested more than 53 BCHF in the Laboratory. This has given rise to unique scientific and technical infrastructure and personnel expertise, which today constitute the most solid of foundations for the next project. In addition, it is important to underline that CERN has an excellent record of building ambitious projects within budget, i.e. with cost escalations of less than 20%.

China is also considering building a similar accelerator. The Chinese authorities are fully aware of the scientific potential of such a facility, of the wide spectrum of cutting-edge technologies it will foster, of the workforce it will train and of the size of the community it will attract from all over the world. If China goes ahead with its circular collider project before CERN, Europe would likely lose its leadership in particle physics.

The total investment cost of the FCC 91-km tunnel and the first-stage collider is estimated to be around 15 BCHF in capital expenditure. The ongoing feasibility study needs to demonstrate, among other key goals, that the project is financially viable. The major source of funding will be the annual CERN budget. However, additional contributions from outside the CERN budget will be needed and could be provided by non-Member States that are historic partners of CERN (in particular the United States) as well as, potentially, private donors.

A significant contribution in the next EU Multiannual Financial Framework (MFF, 2028-2034) would also be crucial to make the project become a reality and to ensure it remains predominantly European in nature. As mentioned in Mario Draghi's recent report "The future of European competitiveness", *"refinancing CERN and ensuring its continued global leadership in frontier research should be regarded as a top EU priority, given the objective of maintaining European prominence in this critical area of fundamental research, which is expected to generate significant business spillovers in the coming years".* In the past, the EU has demonstrated its ability to finance large-scale, strategic projects offering great potential for European competitiveness (e.g. Copernicus, Galileo, ITER).

CERN plans to develop the FCC project in close collaboration with its principal stakeholders, including the EC if it becomes a significant partner.

The FCC development and implementation will require significant technological advances through strategic R&D programmes between CERN, academia, research centres and industry in cutting-edge fields. The project will also be a model for environment-aware, sustainable research. Previous and current projects at CERN have had huge socio-economic benefits and a detailed assessment of the FCC's socio-economic impact is being carried out in the context of the feasibility study.

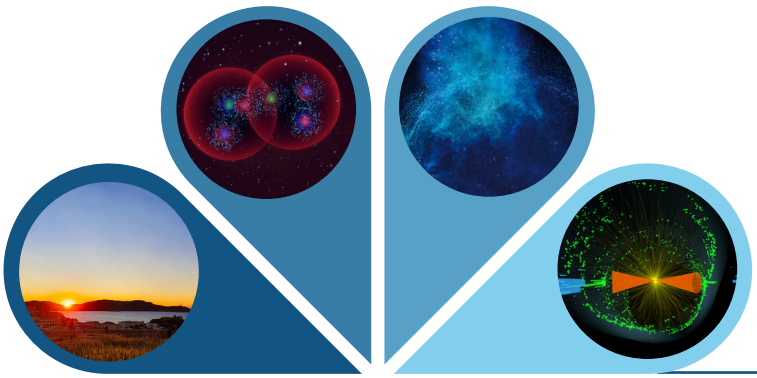
CONCLUSION

FCC feasibility study completed in 2025

Over the past 70 years, the Organization has succeeded in establishing Europe as the world leader in high-energy particle physics, and has been playing an increasingly strong role in other domains that are highly relevant to Europe's agenda, innovation, sovereignty, security and autonomy: CERN is a driver of many cutting-edge technologies, with wide applications for society; it is a major hub for STEM training and education; an example of successful partnership between fundamental research and industry; a platform for environmentally conscious and sustainable science; and a brilliant model of European integration and collaboration across borders.

At CERN's 70th anniversary ceremony on 1 October 2024, the EC President Ursula von der Leyen stated that *"CERN is the living proof that science fosters innovation and that innovation fosters competitiveness".*
Mario Draghi's report on "The future of European competitiveness" underlines that *"the success story of CERN exemplifies both the exceptional opportunities that could be missed without proper EU-level coordination and the potential for effective coordination among the Member States"* and that *"if China were to win the race and its circular collider were to start before CERN's, Europe would risk losing its leadership in particle physics, potentially jeopardizing CERN's future."*

As CERN prepares to develop its next flagship project, the Future Circular Collider, expanding its multi-faceted mission and consolidating Europe's leadership and values, a significant financial contribution from the European Union in the next MFF (2028-2034) would help stave off the competition from China and ensure a bright future for this unique European institution until at least the end of the 21st century.



[1]Particle physics is the most fundamental of all sciences, as it studies the smallest, indivisible constituents of matter and the Universe.
[2]Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom. France and Switzerland are CERN's Host States.
[3]Brazil, Croatia, Cyprus, India, Latvia, Lithuania, Pakistan, Slovenia, Türkiye and Ukraine.
[4]European Union, UNESCO, Japan, United States of America.
[5]Ireland will become an Associate Member State in the first half of 2025. Malta has signed a cooperation agreement with CERN in 2008. Discussions on a possible cooperation agreement are ongoing with Luxembourg, following the partnership agreed upon between the Luxembourg Institute of Science and Technology, the UN World Food Programme and CERN in October 2024 on AI to fight hunger.
[6]The CERN budget is provided by all Member States, based on their net national income. Associate Member States typically contribute 10% of what their share would be if they were Member States and do not have voting rights in the Council.
[7]The concept of open science is enshrined in CERN's founding Convention.
[8]The web was developed at CERN in the late 1980s by Tim Berners-Lee, then a CERN employee.
[9]FCC Innovation Study, H2020-INFRADEV, grant agreement 951754, with a financial contribution of about 3 million euros from the EC.