

A SCIENTIFIC MISSION FOR THE 21ST CENTURY

The Future Circular Collider (FCC) is Europe's next-generation particle collider: a unique tool to explore the deepest mysteries of the Universe and to drive technology, innovation and skills for decades to come.

DECODING THE UNIVERSE

We now know that the Standard Model of particle physics —one of the great scientific achievements of the last century—describes only 5% of the Universe.

The origin of matter, the nature of dark matter and dark energy, and the early evolution of the Universe all remain largely unexplained.

The discovery of the Higgs boson at the LHC opened a new pathway to investigate these and other questions.

The FCC is the instrument that will allow Europe to pursue this frontier with unprecedented precision, sensitivity and discovery potential and to maintain world leadership in particle physics and related technologies.

THE FCC WILL

- Measure the Higgs boson and other key particles with unmatched precision.
- Search for new particles, new forces and potential dark-matter candidates.
- Probe the disappearance of antimatter in the early Universe.
- Explore entirely new phenomena through radical gains in energy, precision and sensitivity.

AN ENGINE OF INNOVATION

Building the FCC requires breakthroughs in superconducting materials, efficient radio-frequency systems, advanced vacuum technologies, precision detectors, AI-driven control systems, and sustainable cooling infrastructures. These technologies have direct relevance inter alia to medical imaging and therapy, fusion energy, transport electrification, industrial automation, and large-scale data centres.

AN INVESTMENT THAT PAYS OFF

CERN's high-tech procurement, training mission and industrial partnerships already generate substantial value for Europe. The FCC, through decades of construction and operation, will:

- Train thousands of early-career scientists, engineers and technicians each year,
- Stimulate high-tech industry via long-term procurement and co-development,
- Deliver a positive benefit-cost ratio, even under conservative assumptions.





Technology & innovation for Europe

The virtuous circle of basic science

CERN's ambitious scientific goals drive innovation across many enabling technologies. Famous examples are the World Wide Web and PET imaging. CERN technologies are transferred to society without financial profit, reinforcing Europe's leadership in strategically important fields.

The FCC will be the most extraordinary instrument ever built to study the fundamental constituents and laws of nature. Its tunnel will first house an electron-positron collider **FCC-ee** capable of extremely precise measurements. This may be followed by a proton-proton collider **FCC-hh** operating at unprecedented energies.

Partnership with industry

CERN spends around **500 MCHF** annually with European high-tech suppliers through competitive contracts and co-development. Past flagship projects such as the LHC mobilised over **6000 companies** across Europe.

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.

Companies place a premium on collaboration with CERN because its demanding specifications **enhance their growth, quality, innovation and reputation**. Competencies gained are then passed down the line to other companies, fields and clients.

Accelerating science and society

Of the tens of thousands of accelerators in use worldwide, only a few are used for particle physics. The rest support semiconductors, materials processing, radiotherapy, isotope production, imaging, and advanced X-ray light sources that underpin Nobel-prize-winning research. CERN's world-leading expertise in magnets, superconductors, vacuum, cryogenics, instrumentation and other technologies is already applied to gravitational-wave observatories, fusion energy, next-generation X-ray facilities, and medical accelerators.

This challenging project will boost innovation in:

- **Superconductors & magnets:** for fusion reactors, medical imaging and efficient power transport.
- **High-performance materials:** relevant to aerospace, automotive and advanced energy systems.
- **Vacuum and cryogenics:** with applications in hydrogen transport, refrigeration and industrial processes.
- **Advanced AI, electronics and robotics:** enabling safer, more efficient industrial operations.
- **High-efficiency RF systems:** essential for medical and industrial accelerators and for energy-efficient broadcasting.
- **Distributed computing and big data:** with applications in communications and large-scale data-handling.

Over the past 5 years, CERN has established over **250 knowledge transfer partnerships** across healthcare, aerospace, digital innovation, quantum technologies and environmental applications.

Examples include advanced superconducting systems with **Airbus**, computer-vision tasks for automotive applications with Volvo Cars-owned software company **Zenseact**, power-distribution R&D with **Meta**, and identification of energy-saving scenarios through data-driven energy efficiency audits with **ABB Motion**.

€440M of European Union co-funding since 2020 has supported 85 CERN-linked projects involving European industry.

Societal benefits & sustainability

A strong return on investment

Independent socio-economic assessments show that the FCC-ee (civil engineering & operation) yields a **benefit-cost ratio of at least 1.2**, even when only the most conservative benefit pathways are counted.

Economic contribution

The FCC-ee will create an estimated:

- **50 BCHF** direct and indirect economic effects
- **4 BCHF** through added household spending

Public willingness-to-pay studies show that the perceived FCC value **exceeds** the current annual contribution of Member States.

Training and upskilling

At any moment, CERN trains over **5,500 students, technicians and early-career researchers** across a large spectrum of competencies, most of whom move into industry, applied science and public institutions.

The FCC will extend this high-value skills pipeline throughout the 21st century, forming a key pillar of Europe's STEM workforce and innovation ecosystem.

Capacity building across Europe

CERN is the shared laboratory of all its 25 Member and 10 Associate Member States and has around 50 International Cooperation Agreements with additional countries and territories.

CERN's partnerships with universities, institutes and industries build durable **transnational value chains** and foster scientific and technological capacity in all participating countries.

The FCC will be developed under CERN's leadership with coordinated contributions from other large laboratories. Shared technology platforms will enhance **Europe's strategic capabilities** and strengthen its research and technology ecosystem, through:

- the repatriation of skilled personnel,
- long-term R&D programmes,
- cross-disciplinary collaboration and access to a world-leading scientific infrastructure.

Boosting trust in science

The deep questions in particle physics and the vast machinery required to address them inspire and attract young minds to science. The switch-on of the LHC in 2008 is estimated to have reached an audience of more than a billion people.

CERN's broad portfolio of inclusive education, communication and engagement activities is essential to strengthen public trust in science, foster critical thinking, and counter misinformation.

CERN's teacher programmes empower about 1000 high-school teachers per year, while its IdeaSquare platform hosts future entrepreneurs who apply CERN technologies to societal challenges.

The new CERN Science Gateway has increased the number of annual visitors to CERN to 400 000 people from 175 countries.

The value of physics to Europe

Physics-based activities in Europe are estimated to have employed 20M people and generated more than €7T of turnover in 2022 (growing by 47% since 2016), according to a recent report by the Centre for Economics and Business Research that was commissioned by the European Physical Society.

Sustainable by design

The FCC is an exemplar of sustainable research:

- Over **100 site-placement scenarios** for the FCC were evaluated for environmental impact.
- Despite its scale, **FCC-ee will use similar electricity to the LHC**, yet deliver vastly more data per unit of energy.
- The FCC-ee design is **100 000x more energy-efficient** than its predecessor LEP in terms of delivered data.
- The **OpenSkyLab initiative** is pioneering ways to transform excavation materials from the FCC tunnel into functional soils for greening, agriculture and forestry.
- CERN holds **ISO 50001** certification for continuous energy-performance improvement.
- The FCC-ee will be the first large scientific infrastructure to systematically adopt the Reliability, Availability, Maintainability and Safety concept, profiting all future first-of-a-kind projects such as a fusion reactor.



Feasibility, timeline & Europe's decision

Feasibility

The **FCC Feasibility Study** (1500 experts, 162 institutes, 38 countries) confirms that the project is **technically feasible**.

CERN has a strong record of delivering flagship projects **on budget** and with long-term industrial participation.

The estimated **15 BCHF** investment for the first stage, FCC-ee, would be spread over ~12 years.

Importantly, the 9 BCHF **tunnel and technical infrastructure may be reused** for a possible future hadron collider (FCC-hh), maximising sustainability and value.

A solid foundation for success

Europe's investment in CERN over the past 70 years has created unparalleled technical infrastructure and expertise.

The **LHC**, which placed Europe at the forefront of high-energy physics, completes operations in **2041**.

Given the **20–30-year lead time** of major scientific infrastructures, decisions on the next flagship facility must be taken now to ensure continuity, capability and leadership.

A collaborative, global endeavour

CERN brings together some 17 500 researchers from **110+ nationalities**, including countries in conflict and from developing regions.

Its results and data are **openly shared** for the benefit of all, making CERN a global model of scientific cooperation.

The FCC would secure continued world leadership in a critical area of groundbreaking science and technology, thus strengthening **European competitiveness and strategic autonomy**.

At a glance

FCC

90.7 km

Circumference

200 m

Average depth

4

Underground experiments

€4 B

Local economic impact

1.2

Benefit-cost ratio

CERN

1.3 BCHF

Annual budget

500 MCHF

Annual spending with European high-tech industry

12,405

Users from 110+ countries

2704

Staff members

1181

Graduates and fellows

400,000

Visitors annually

Timeline

