

ASSESSMENT OF THE SOCIO-ECONOMIC BENEFITS OF CERN ACTIVITIES

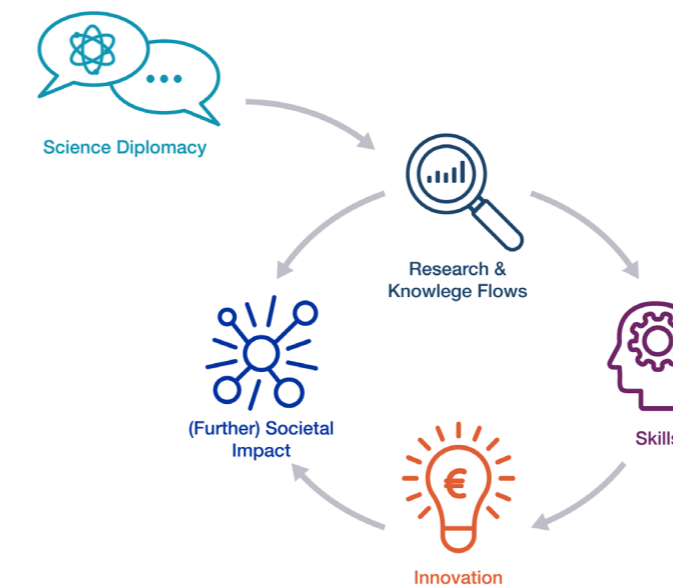


OVERVIEW

This booklet presents highlights from a study conducted by Technopolis and CSIL between February and December 2025.

The study demonstrates **CERN's socio-economic benefits**.

- It looks beyond just specific projects, programmes, or experiments, considering CERN as a research infrastructure that serves as a hub for various forms of engagement with the wider science and innovation community.
- It covers the past 20-30 years (based on available data) and complements past and ongoing studies related to the Future Circular Collider, which are largely forward looking.
- It examines CERN's socio-economic benefits from multiple perspectives by capturing evidence on different pathways (from research and knowledge flows to science diplomacy, see figure below) and focusing on the most compelling evidence and selected highlights from the study.



THE STUDY ANALYSES THE BENEFITS GENERATED BY CERN

- AS A RESEARCH INFRASTRUCTURE
- ALONG DIFFERENT PATHWAYS
- OVER THE PAST 20 TO 30 YEARS

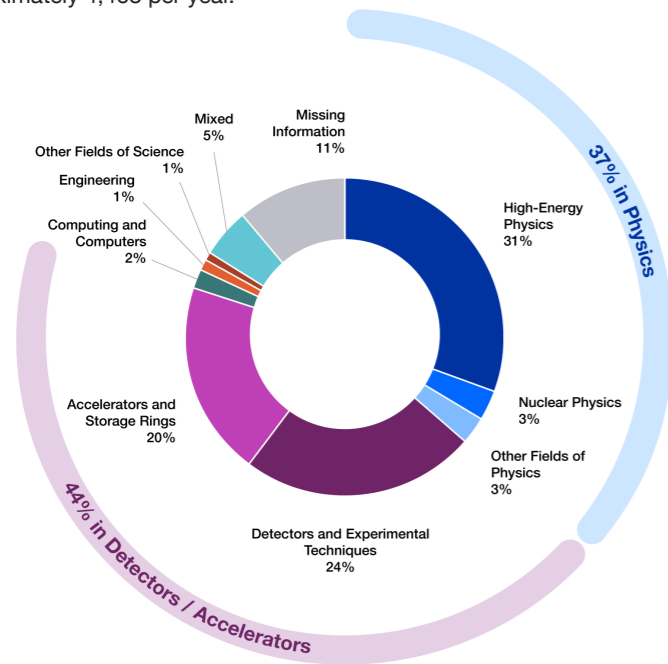
Conceptual framework: main benefit pathways

RESEARCH AND KNOWLEDGE FLOWS

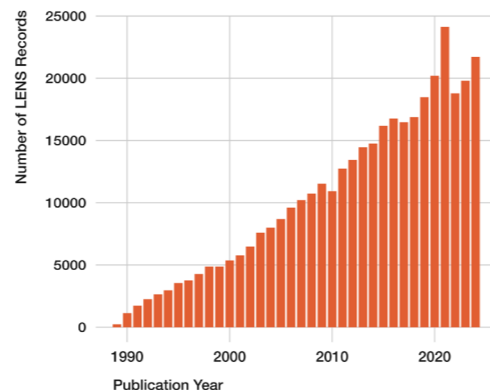
The core mission of CERN is to perform fundamental research in particle physics, with a particular focus on both theoretical and experimental aspects of high-energy physics. Its research activities are diversified and fit into an internationalised web of scientific collaborations. As such, CERN research is a major channel to create worldwide benefits beyond high-energy physics.

DISSEMINATION OF (CODIFIED) KNOWLEDGE

CERN's research activities produce a significant body of scientific and technical outputs, underscoring its contribution to advancement of fundamental knowledge. From 1989 to 2024, **CERN's research activities generated 160,860 scientific and technical outputs** ("CERN publications"),¹ averaging approximately 4,468 per year.



Scientific Disciplines of CERN Publications (1989-2024)



Number of publications citing CERN publications, 1989-2024 (not cumulative)

CERN's research activities (undertaken at and/or by CERN) exert significant influence beyond its immediate scientific community. From 1989 to 2024, **CERN Publications achieved an average citation rate of 38.8**, substantially exceeding the Nuclear and High-Energy Physics field average of 22.4 for the same period (LENS data).² This consistently high citation impact underscores CERN's leading role in advancing scientific knowledge.

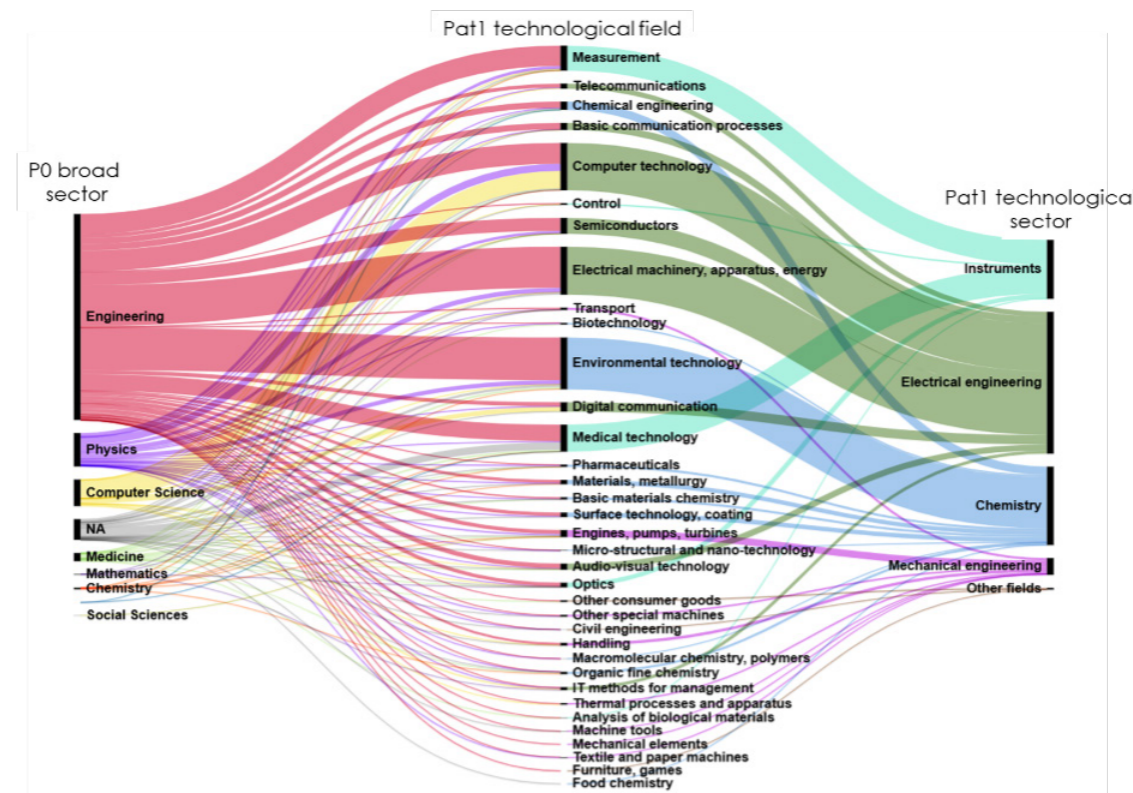
¹ Publications produced by authors directly affiliated to CERN and/or authors affiliated to other Institutions and who are directly involved in the Organization's research activities
² <https://www.lens.org/>

FLOW OF KNOWLEDGE FROM PUBLICATIONS TO PATENTS

Citation analysis shows that CERN publications primarily contribute to innovation through applied research fields with direct technological relevance.

An examination of the **CERN publications cited in patents** (left-hand side of the figure, P0) shows that the majority pertain to Engineering (67.1%), particularly within the "Detectors and Experimental Techniques" discipline. This showcases how CERN publications contribute to concrete engineering advances (e.g. sensor technologies, accelerator components, or data acquisition systems) that can then be directly adapted for industrial or medical applications.

The majority of **patents referencing CERN publications** are concentrated in the technological sectors of electrical engineering and chemistry (right-hand side of the figure, Pat1), while a smaller proportion pertain to fields such as mechanical engineering. Within the electrical engineering and chemistry domains, computer technology, electrical machinery, apparatus, energy, and environmental technology represent the principal areas of innovation, followed by advancements in medical technology.



Citing patents: from research area to technological field

CERN FACILITIES TO SUPPORT WIDER RESEARCH AND INNOVATION

The following cases exemplify how CERN accelerator facilities also **support research and innovation beyond particle physics**.

NOVEL PATHWAYS FOR NUCLEAR MEDICINE

The CERN MEDICIS facility produces unconventional high purity radionuclides for research in medical imaging and emerging cancer therapies. Many of these radionuclides can be produced only at CERN.

Key tangible benefits

- **Unique access to unconventional radionuclides** that enable new biomedical research.
- **High efficiency separation techniques** delivering safer, purer, and more reliable radionuclides.
- **Proven medical potential**, with CERN MEDICIS radionuclides already used in pre clinical cancer diagnosis and treatment studies.

TESTING SPACE TECHNOLOGY IN HARSH RADIATION ENVIRONMENTS

The CHARM facility recreates the harsh mixed radiation conditions found in space and particle accelerators, allowing industry and research institutes to test and validate electronics and full systems.

Supports fundamental physics and industrial R&D

- **300+ system level tests** in the past decade, including **172 in 2024**.
- **First ground irradiation test of a satellite model** (CELESTA CubeSat) in a fully representative mixed-field radiation environment took place at CHARM.
- **EU funded HEARTS project** positions CHARM as a leading European facility for testing space electronics with high energy heavy ions, with **20+ space users** accessing CERN facilities in the 2024–25 pilot runs.

ENABLING SPACE MISSIONS, MEDICAL ADVANCES, AND PARTICLE PHYSICS

The CLEAR facility provides high energy electron beams with unique characteristics for research in particle physics, space technology, medical applications.

- **Particle physics R&D:** A testbed for developing and improving advanced beam diagnostics and instrumentation.
- **Space missions:** the VESPER set-up at CLEAR is the only facility on Earth capable of reproducing Jupiter's extreme electron radiation environment and to enable ground testing for missions like the European Space Agency's **JUICE mission to Jupiter**.
- **Medical innovation:** Supports research into new cancer treatment methods, including **VHEE** and **FLASH radiotherapy**.

CELESTA: CERN Latchup and radmon Experiment Student sAtellite

CHARM: CERN High energy AcceleRator Mixed field facility

CLEAR: CERN Linear Electron Accelerator for Research facility

FLASH: Fast Light-Activated System for High-dose-rate radiation

HEARTS: High-Energy Accelerators for Radiation Testing and Shielding project

JUICE: Jupiter Icy Moons Explorer mission

MEDICIS: MEDical Isotopes Collected from ISOLDE facility

VESPER: Very energetic Electron facility for Space Planetary Exploration missions in harsh Radiative environments facility

INNOVATION

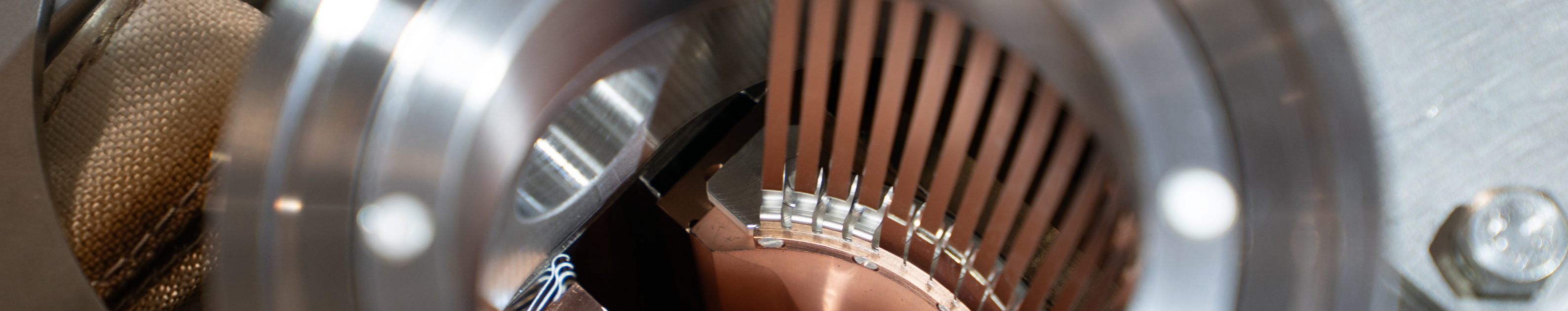
CERN's scientific advancements frequently facilitate technological progress, both directly and indirectly, and **the transfer of CERN technologies and expertise to wider society** is a core aspect of the Organization's efforts, offering innovative solutions across various domains.



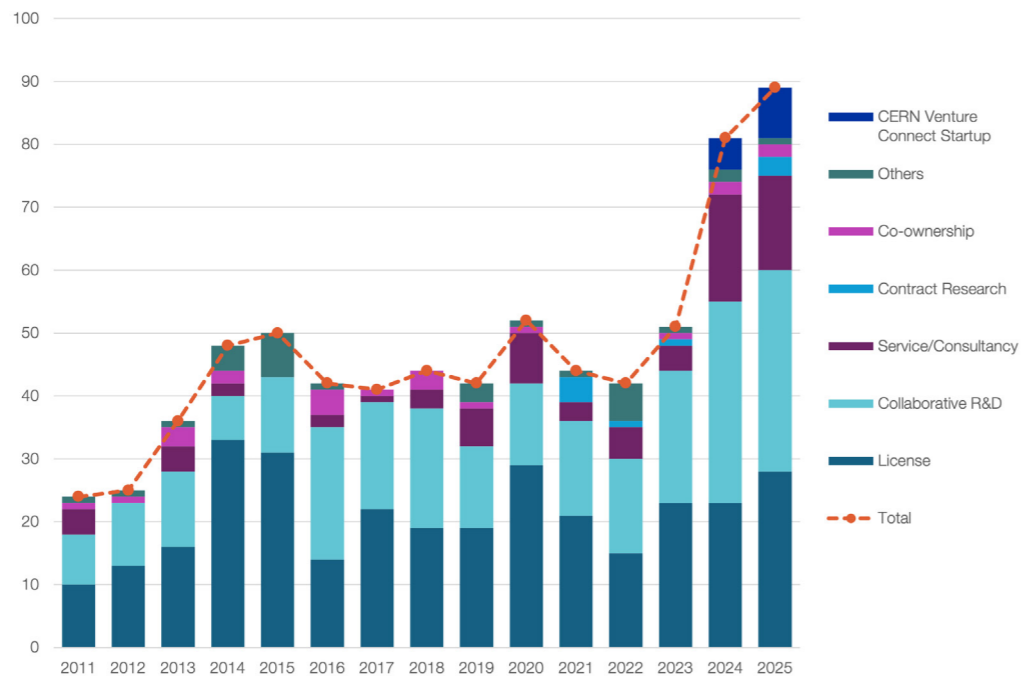
CERN's knowledge transfer ecosystem

CERN's technological ecosystem, which is centred on accelerators, detectors, and advanced computing systems, is supported by a diverse array of specialised expertise, including superconducting magnet technology, microelectronics, cryogenics, radiation monitoring, and data processing. These competencies have demonstrated significant relevance and applicability in various sectors such as healthcare, aerospace engineering, environmental applications, heritage conservation, and digital infrastructure.

CERN engages in a variety of knowledge transfer activities with innovation partners in academia, industry, and public institutions, enabling applications beyond particle physics.



Since 2011, CERN has signed over **700 contracts to support knowledge transfer**, including licences and collaborative R&D agreements.



CERN's knowledge transfer agreements over the years

CERN SUPPLIERS AND INNOVATION

Analysis indicates that firms securing their initial CERN order between 2016 and 2024 experienced **an additional 15% growth in patent stock and a 63% increase in intangible assets** (beyond that achieved by a control group of comparable firms) in the years following their first order.

Additionally, 54% of CERN suppliers (surveyed in 2024) reported entry into new markets as a direct result of their collaboration with CERN.

Supporting this, further evidence reveals that suppliers with a first CERN order between 2016 and 2024 observed **a 14% rise in turnover, a 13% increase in employment, and a 27% expansion in tangible assets** in the next five years, compared to similar companies not engaged with CERN.

A study from WIFO (2025)³ shows that on average, CERN's procurement activities for goods and services generate approximately **CHF 680 million in direct, indirect, and induced economic value added annually**. These effects are associated with investments in new infrastructure, equipment, taxes and social contributions, and regional household spending.

The study also shows that 13% of these economic effects flow beyond CERN Member States, due to the nature of global supply chains.

³ <https://www.wifo.ac.at/en/publication/435728/>

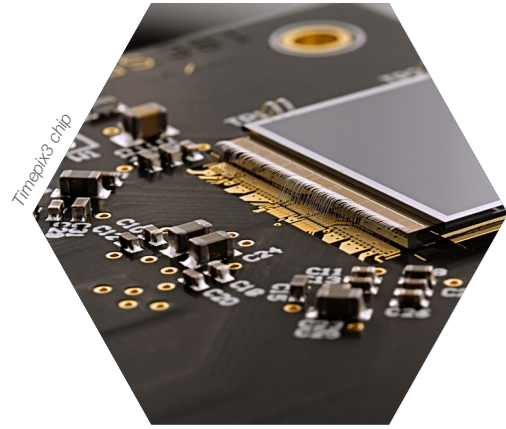
CERN-LINKED START-UPS

CERN is actively engaged in entrepreneurship support. About **100 start-ups linked to CERN** are currently tracked – these are founded by CERN alumni, using CERN technology or otherwise linked to CERN. This number likely underestimates the true figure, as indicated by the ~60 further self-reported start-ups from a CERN alumni survey.

According to Crunchbase,⁴ 27 of these **start-ups have collectively secured CHF 3.2 billion in funding** through various channels between 2008 and 2025, including venture capital, debt financing, and corporate investment rounds.

In 2025, start-ups in the CERN Venture Connect programme raised CHF 5.6 million in funding.

⁴ <https://www.crunchbase.com/>



Timepix3 chip

WIDER APPLICATIONS OF CERN TECHNOLOGIES

The following cases exemplify **technologies and innovations created to address CERN's needs that have found wider use** across multiple industries.

HIGH-RESOLUTION READ-OUT CHIPS FOR SCIENCE AND INDUSTRY

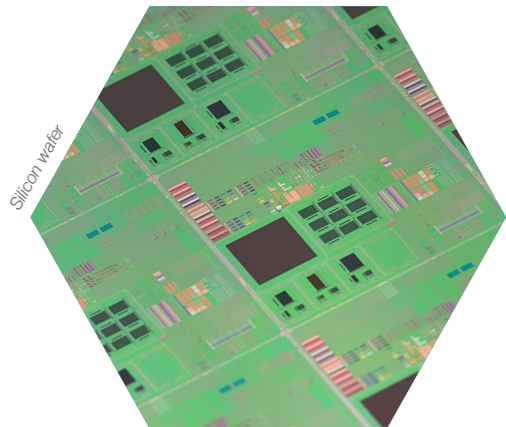
Medipix is a family of advanced detector read-out chips developed at CERN by the Medipix Collaborations, enabling high resolution, noise free particle imaging and detection across many fields.

Key Highlights

- **Three decades of development:** four Medipix collaborations since the 90s, driving **continuous chip innovation** and involving a total of ~40 different research institutes and universities.
- **Strong industrial uptake:** **30 active commercial licences** have generated **CHF 5M+ in royalties** and supported an estimated **CHF 100M+ in industry revenue**.
- **Financially sustainable model:** royalties are **reinvested** into research and development.
- **Wide impact:** the CERN-authored Medipix related publications have a high citation index and have supported the development of **73 patents by companies** such as Philips, ASML, Siemens. Applications span **medical imaging, brain tumour treatment, space radiation monitoring, nuclear safety, and cultural heritage**.
- **Rising demand:** **40% of all licences** were signed in the past three years, marking rapid recent growth.



Holding the chip for the Timepix3 school programme



Silicon wafer

TURNING ACCELERATOR EXPERTISE INTO CANCER TREATMENT

Hadron therapy uses protons and other ions to deliver radiation precisely to tumours, sparing nearby healthy tissue and enabling treatment of deep seated, radio resistant cancers.

Tangible impacts

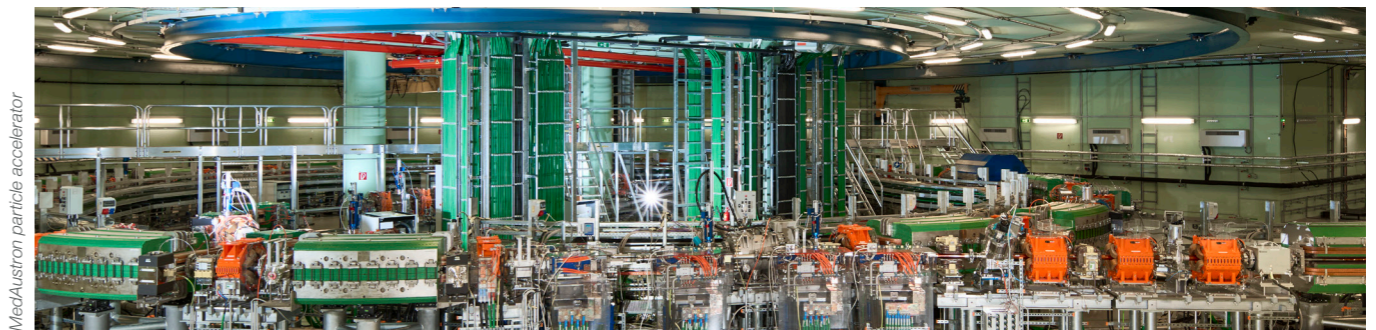
- **CERN's foundational role:** CERN's accelerator expertise and its collaboration with MedAustron, Onkologie-2000, and the TERA Foundation (via the 1996–2000 Proton-Ion Medical Machine Study, PIMMS), established the groundwork for two major hadron-therapy initiatives: **MedAustron** (Austria), and the National Centre of Oncological Hadrontherapy (**CNAO**) primarily supported by the National Institute for Nuclear Physics (INFN) (Italy).
- **Real clinical impact:** Together, these centres have treated **nearly 9,000 patients** with rare and hard to treat cancers since starting operation in 2011 and 2016, respectively.
- **Improving lives:** particle physics technology has enabled treatments that reduce side effects, shorten therapy times, and improve patient outcomes.

What made it possible:

- Dedicated scientists who drove the vision, built partnerships, and kept early efforts alive.
- CERN's collaborative, flexible environment, which helped unite governments, labs, and industry around a shared medical goal.



CNAO treatment room



MedAustron particle accelerator

ENABLING COLLABORATION AT SCALE

CERN has developed **collaborative tools that are widely adopted** across various research communities, including these three examples:

FREE, OPEN ACCESS TO GLOBAL RESEARCH

Zenodo is an open access research data repository that allows anyone worldwide to upload, share, and cite scientific outputs, data, and software using permanent DOIs. Zenodo is built and operated by CERN and the European OpenAIRE programme; the underlying technology is the CERN Invenio digital library framework.

Key Highlights

- **Trusted worldwide:** Supports **300,000+ researchers** across **7,500 organisations** and underpins the EU Open Research repository.
- **Extensive reach:** **45 million unique views** and **55 million unique downloads** accumulated until 2021.
- **The largest general purpose research repository:** in 2021, Zenodo reached **1 petabyte of stored data**.

FREE, OPEN SOURCE EVENTS MANAGEMENT PLATFORM

Indico is CERN's open source platform for organising conferences, workshops and meetings, and covering everything from registration to post event communication. Indico is built on the CERN Invenio digital library framework.

Key Highlights

- **Widely adopted:** Used by **400,000 users** across **300 servers** in **52 countries**.
- **Proven at scale:** Over **1 million events** organised on the CERN Indico platform by March 2023.
- **High user value:** A recent study estimated a **CHF 532 willingness to pay per event**, reflecting the strong demand for Indico's features.
- **Global impact:** Beyond CERN, more than **100,000 events each year** are managed via other Indico deployments worldwide.

OPEN SOURCE ENGINE FOR BIG DATA ANALYSIS

ROOT is an open source software framework developed at CERN for storing, processing, visualising, and analysing extremely large scientific datasets. It powers advanced techniques used to detect rare signals and anomalies in particle collision data.

Financial sector applications

- **Market manipulation:** the Commodity Risk Management Expertise Centre (CORMEC), the Wageningen University and CERN set up the **High Energy Physics Tools in Limit Order Book Analysis (HighLO)** project and adapted ROOT tools to help national regulators and exchanges detect market manipulation in **high frequency trading data**.
- **Real world use:** These ROOT based tools have been used by trading venues such as **Deutsche Börse** to strengthen market surveillance capabilities.
- **Surveillance software:** HighLO's **Market Surveillance Analytics Lab** software enables regulators to visualise suspicious trading patterns within their own datasets; it has attracted interest from exchanges including Eurex and is already supporting ongoing litigation related to market manipulation in Germany.





As one of the world's leading scientific institutes and a centre for excellence, CERN engages with many individuals and organisations each year. It provides an inspiring training ground for the current and future Science, Technology, Engineering and Mathematics (STEM) workforce, and stakeholders acquire skills during their engagement with CERN, especially due to the expertise available, the scale of projects, the interdisciplinary nature of work and the exposure to tools and techniques at the technological frontier.

The benefits are transmitted via a variety of mechanisms:

- Increasing skills and capabilities among users, including early-career researchers who have the opportunity to gain new skills and expand their network in a highly prestigious and challenging workplace.
- Providing suppliers to the facility with the opportunity to enhance their technical capabilities and knowledge through close collaboration and the demands of frontier science.
- Training new generations of experts, including physicists, engineers, computer scientists and technicians, through study programmes and hands-on research opportunities at CERN.
- Engaging with schools and teachers, in person, online and through the development of materials, to cultivate scientific curiosity and build foundational skills, including in STEM.

The study explored how skills are developed across different stakeholders engaging with CERN, and how this is carried across to other organisations and industries.

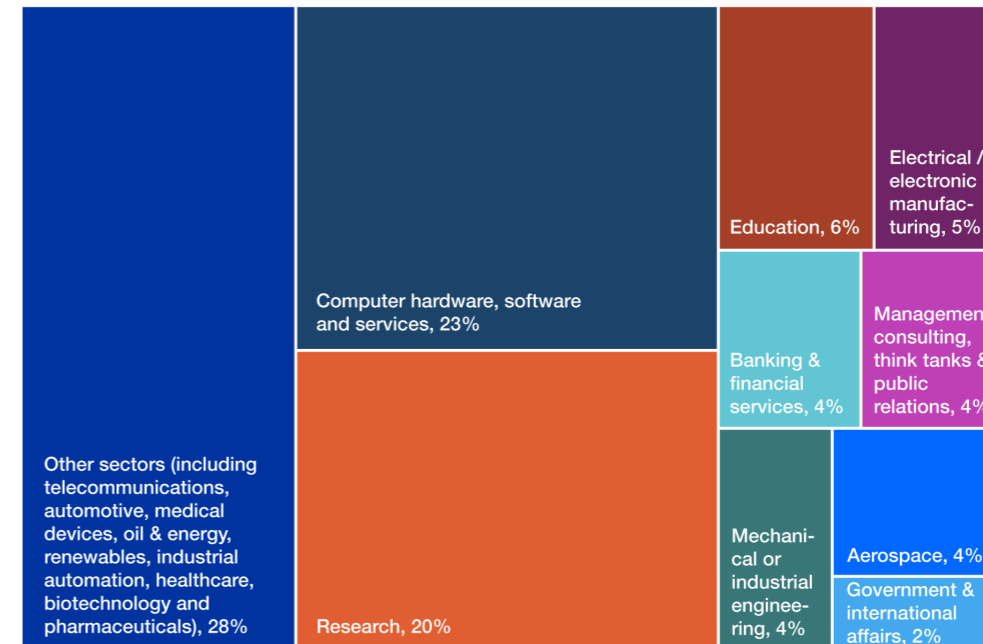
CERN ALUMNI

When departing from CERN, former members of personnel (including, students, fellows, graduates, staff, users and associates) leave with a comprehensive foundation of scientific knowledge, valuable transferable skills, and substantial experience in international collaboration. The transition of talent from CERN to the wider economy therefore facilitates significant spillover effects, contributing to broader societal and economic benefits.

According to the 2025 CERN Alumni Network survey, 95% of 982 respondents indicated that their **experiences and interactions with CERN have been beneficial in advancing their careers.**

CERN alumni are represented across a wide range of high-impact sectors, including computer software (11%), information technology and services (7%), mechanical or industrial engineering (4%), and financial services (3%). Around **three-quarters of CERN alumni move into industry.**

On average, CERN alumni report a **wage premium of 4%** (ranging from 2% to 6%).



Distribution of CERN Alumni (%), by industry (October 2025)

Source: CERN Alumni Network database statistics, October 2025. Includes past and current members of personnel.

CERN SUPPLIERS

CERN maintains a collaborative relationship with a diverse network of suppliers and industry partners. Although the procurement process itself is transactional, the broader implications of engaging with CERN extend well beyond the mere provision of goods and services.

Seventy percent of suppliers have developed advanced expertise in their respective domains following collaboration with CERN, especially within particle and photon detection, transport and handling, and health, safety, and environmental technologies (according to respondents of the CERN Procurement Survey 2024).

CERN MAINTAINS A COLLABORATIVE RELATIONSHIP

WITH A DIVERSE NETWORK OF SUPPLIERS

AND INDUSTRY PARTNERS

EDUCATION

CERN provides a **range of educational programmes** with the aim of fostering interest in science and equipping participants with essential skills. The programmes include short and long academic on-site courses, online courses, internships, competitions, and research opportunities.

- CERN offers **university students** a rich learning environment through academic programmes and hands-on research opportunities. Between 2017 and 2024, CERN trained and supported over 13,000 university students through various programmes.
- CERN offers many educational opportunities for **school students and their teachers**, from primary to high school, designed to cultivate scientific curiosity and build foundational skills in STEM and other subjects. To broaden access, CERN has developed several online learning programmes for high-school students. In 2024, CERN piloted an online particle physics course that reached 3,841 high-school students.
- Between October 2023 and December 2025 almost 60,000 participants joined one of the workshops at the new **education labs** at CERN Science Gateway.
- CERN's **teacher training** programmes are designed to bring teachers up-to-date with the latest developments in particle physics and related areas, and experience a dynamic, international research environment. Teacher training programmes have been attended by over 15,500 teachers from 112 countries or territories.
- CERN also provides **educational materials** for teachers, offering an online database of educational resources that teachers can access for free.



CERN-Solvay student camp

SCIENCE DIPLOMACY

CERN was established as one of Europe's earliest collaborative ventures. Although international diplomacy is not expressly within CERN's mandate, the Organization consistently practices openness and transparency in all its undertakings.

CERN was granted **observer status at the UN** General Assembly in December 2012.

Herwig Schopper,⁵ former Director General of CERN, suggests that "at CERN a new style of global cooperation has been developed, partly voluntarily, partly pushed by necessity". He explains the gradual evolution from small group experiments financed by CERN, through to the establishment of large-scale experiments running as independent international organisations and requiring new management structures and principles. The paper concludes that "the CERN model, exemplified by Large Hadron Collider (LHC) and its experiments, may provide a **new paradigm for future large projects to be realised on a global level**, perhaps even for industrial or other international projects", and that "in a world where the complexity of global actions increases continuously, the exploration of new ways of managing new challenges has a considerable social value independent of CERN's scientific success."

⁵ Schopper, H. (2009), LEP - The Lord of the Collider Rings at CERN 1980-2000: The Making, Operation and Legacy of the World's Largest Scientific Instrument, New York: Springer



CELESTIA radiation model inside the CHARM facility, at CERN

CERN and the European Space Agency (ESA)

CERN is also serving as a **blueprint for other organisations**.

Edoardo Amaldi (Secretary General of the provisional CERN, 1952–54), championed the creation of a (CERN-like) European collaborative effort for civil space, arguing that space exploration was beyond the capacity of individual nations. When ESA was established in 1975, its convention and organisational design mirrored CERN's constitution.

Over the past decade, CERN and ESA have started collaborating in a structured way in technological and scientific areas of mutual benefit.

CREDITS

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Note: All monetary figures are presented in Swiss Francs (CHF) and have been converted based on European Central Bank 2025 average exchange rates.

