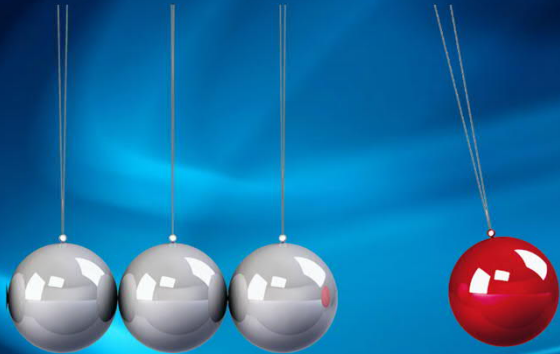




IMPACT of science on society and sustainable development

showcased by CERN



Barbora Bruant Gulejova

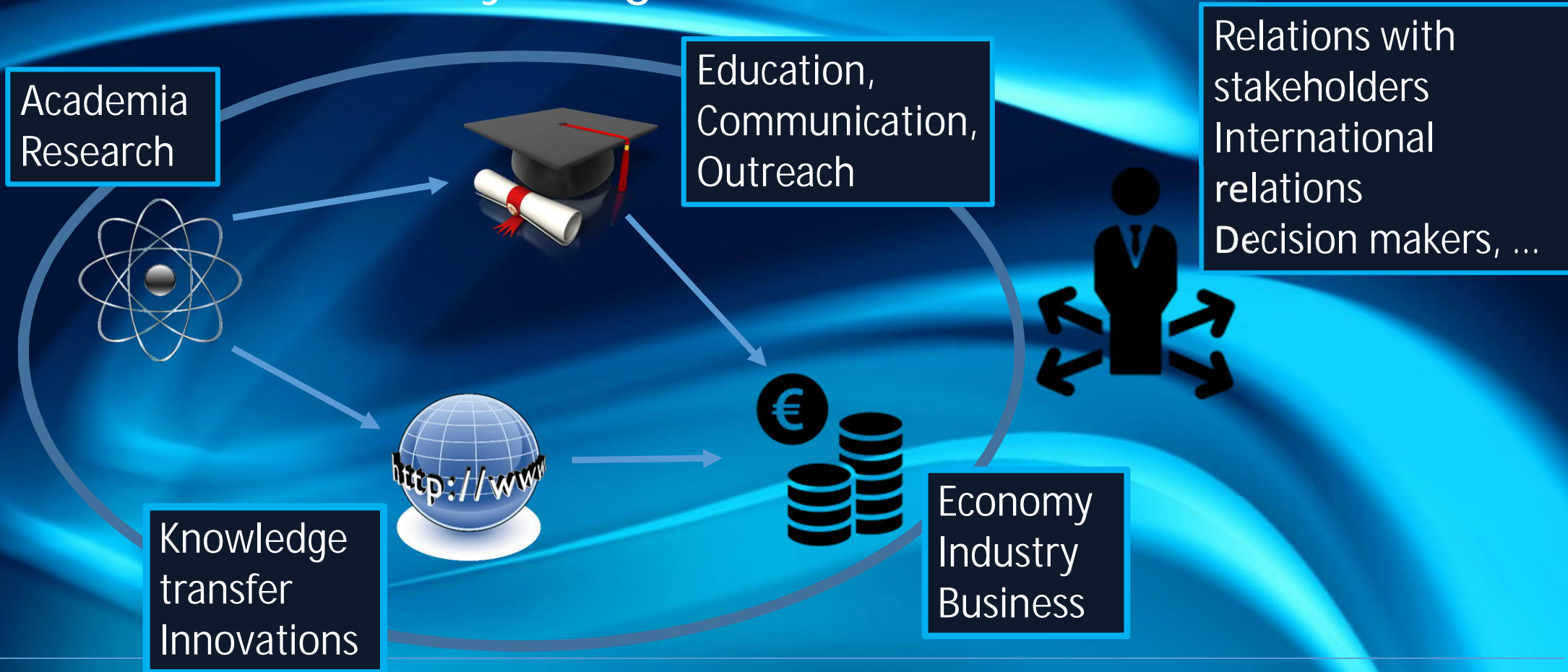
Motivation

- ❖ Important to see the whole picture
combining points of view / interests / drivers of all stakeholders
 - Scientists – curiosity, knowledge
 - Funders/decision makers/politicians – impact on society, return to industry, economy, education (– hopefully!)
 - Media / opinion makers – sensations, interesting information +
 - General public – what is it good for -how it influences their lives
 - Young generations – is it cool? Fun? Inspiration/motivation – important for their future

Possible to act timely
and turn bad publicity
into good publicity?

Motivation

Everything is interconnected...



Motivation

❖ Nowadays nothing is for granted!

❖ Scientific community must be ready to justify / convince / prove.

❖ Pressure on science/research funding - Research becoming extremely competitive

❖ Fashionable “Impact investing” - high profit making business balanced by those generating benefits for society (more sustainable): PR, reputation, good feeling (millionaires, ...)

IPPOG can take a chance ☺

Motivation

❖ How to measure / justify / quantify / demonstrate impact?

- DATA: it must be quantitative and verifiable – policy makers like numbers!
- Cost savings, audience, ...
- Changes your research had on policy documents, standards, protocols,...
- Testimonials / Quotes
- Evidence of public debate / media
- Licences, patents awarded and brought on the market...
- Investment funding awarded (for spin-offs, start-ups)



Source: Entrepreneurship network KT CERN: Why Impact Matters? <https://indico.cern.ch/event/630168/>

The impact of CERN



New brochure highlighting the main benefits of CERN's activities

SEVERAL UNIQUE RESEARCH FACILITIES

TRAINS ABOUT 1 000 HIGH-SCHOOL TEACHERS, 300 UNDERGRADUATE STUDENTS AND THOUSANDS OF YOUNG PHYSICISTS EVERY YEAR

166,000

ARTICLES IN THE WORLD PRESS WRITTEN ABOUT CERN

70% OF THE WORLD'S PARTICLE PHYSICISTS DO RESEARCH AT CERN

WELCOMES MORE THAN 120,000 VISITORS EVERY YEAR

PROMOTES OPEN SCIENCE

THE LHC IS THE MOST POWERFUL ACCELERATOR BUILT BY HUMANITY

ABOUT 600 PHD THESES BASED ON WORK AT CERN COMPLETED EVERY YEAR

ADVANCED TECHNOLOGIES WITH APPLICATIONS IN 16 DOMAINS

WWW INVENTED AT CERN

BREAKTHROUGH DISCOVERIES IN EXPERIMENTAL PHYSICS

MODEL OF EFFECTIVE AND PEACEFUL INTERNATIONAL COLLABORATION

16,000 SCIENTISTS OF MORE THAN 110 NATIONALITIES

The impact of CERN



- ❑ Scientific knowledge
- ❑ Innovation, knowledge transfer and the economy
- ❑ International collaboration
- ❑ Education and outreach

Scientific knowledge

Understanding of universe, addressing questions:

- Knowledge about smallest constituents of matter, their interactions and origin and evolution of Universe
- What is the composition of dark matter, making up 25% of the universe?
- Why is universe made of matter with almost no antimatter?
- Proposing big theories of understanding the nature: Supersymmetry, supergravity....

MAJOR DISCOVERIES AND INVENTIONS



Scientific knowledge

UNIQUE WORLD-CLASS FACILITIES

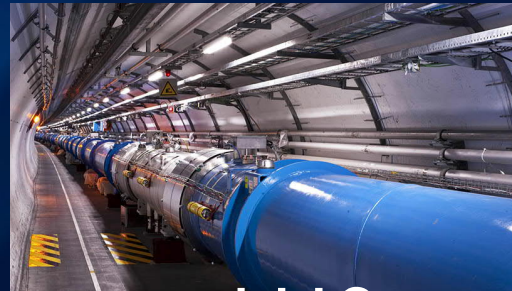
NOBEL PRICES

G. Charpak: Wire chamber

C. Rubbia: W, Z bosons

S. Van der Meer: Beam cooling

P. Higgs & F. Englert : Higgs boson



LHC

Most complex scientific instrument

Detectors

Data center

+ GRID – Big Data!

Antimatter factory, ISOLDE, CLOUD

900 peer reviewed research papers
600 PhD theses / year

Open Science



“CERN’s commitments to carry out purely fundamental research and to make all of its work public have ensured peaceful collaboration between scientists, from all countries.” Rolf Heuer, former CERN DG

❖ CERN provides open access to scientific publications, data and technologies free of charge



❖ Participates in the Open Source Software (OSS) initiative: bringing benefits like costs savings, improved reliability and adaptability

- CERN-extended model is Open Hardware Licences (OHL): knowledge-exchange in wide community of electronic designers

❖ SCOAP3 – Sponsoring Consortium for Open Access Publishing in Particle Physics

- open access peer reviewed journals – CERN papers

Digital Library Service - institutional repository, a disciplinary repository for the HEP and ILC community



Innovation, Knowledge transfer, Economy

Fundamental research at CERN is driver of innovation!

- ❖ CERN actively engages with experts in science, technology, industry to transfer its technology and know-how to accelerate innovation
- in 2015 know-how disseminated to 100 external partners (industry, labs, universities,...
- ❖ Knowledge Transfer group provides: advice, support, training, consultancy, network and infrastructure to ease KT, encouraging entrepreneurship, spin-offs, public-private R&D partnerships...
- ❖ CERN established a network of 9 Business Incubation Centres (BICs) throughout its Member States to assist entrepreneurs and small technology businesses in taking CERN technologies and expertise to the market
- ❖ There are currently 18 start-ups and spin-offs using CERN technologies with applications in domains as diverse as biotechnology, the oil and gas industry and material science



Innovation, Knowledge transfer, Economy

Fundamental research at CERN is driver of innovation!

- ❖ CERN Openlab has partnership with leading ICT companies (Huawei, Intel, Oracle, **Siemens**) who profit from Big Data storage and analysis and test their latest products



CERNopenlab



Doing business with **CERN**

- ❖ 50% of CERN's budget (500 MCHF) is invested into contracts with industry in its member states (R&D, know-how, experiences, methods brought back to the home countries + increased turn-over of companies)

- ❖ There are thousands of particle accelerators and detectors (originally invented as tools for research) in operation in the world of which only small percentage is used in basic research - applications from medical diagnosis, therapy to computer chip manufacture



(accelerators for society)

Innovation, Knowledge transfer, Economy

Ambitious scientific goals of PP require cutting edge instruments and innovative technologies that have many applications in many fields...



- ❖ WWW invention at CERN (1993) driven by need of better communication of scientist worldwide:
HUGE IMPACT: - # of internet users from 14 millions to 3.2 billions from 1993 till 2015
- contribution to 2,9% of world global GDP ~ 1672 billion US\$ (in 2011)

- ❖ World-wide LHC computing grid: 500 000 CPUs and 500 PB of data storage
> 200 computer centers in 35 countries

- ❖ CERN was pioneer in breakthrough technologies, such as touchscreen

- ❖ Inspiration for solar cells technology based on ultra high vacuum

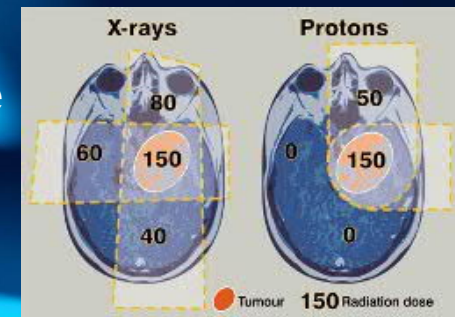


Innovation, Knowledge transfer, Economy

“CERN contributes to medical applications, with the goal of providing solutions to societal health challenges.” Fabiola Gianotti, CERN Director-General

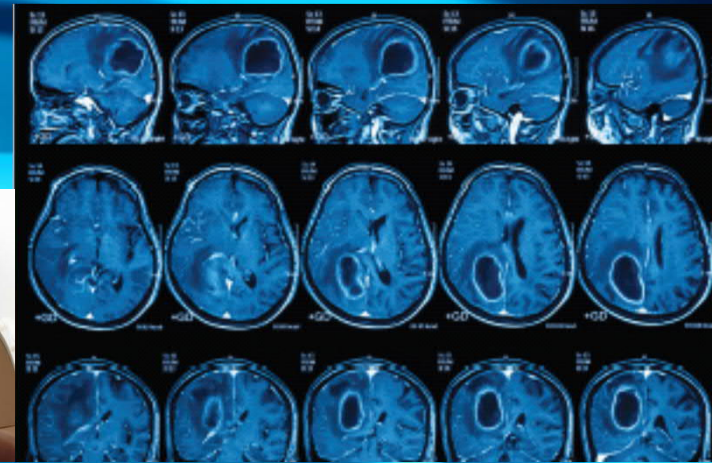
❖ Hadron therapy (HT)

- treating tumours with beams of protons and light ions reducing the radiation exposure of healthy tissue
- 3 HT centres in Europe built in collaboration with CERN
- CERN supports development of miniature linear accelerators for proton therapy



❖ Medical imaging: PET, MRI and others...

- PET using new type of dense scintillating crystals
- CERN has pioneer contribution to forerunner of PET
- PET and MRI imaging combined in single device thanks to new generation of CERN detectors



Innovation, Knowledge transfer, Economy

Medical applications and more....

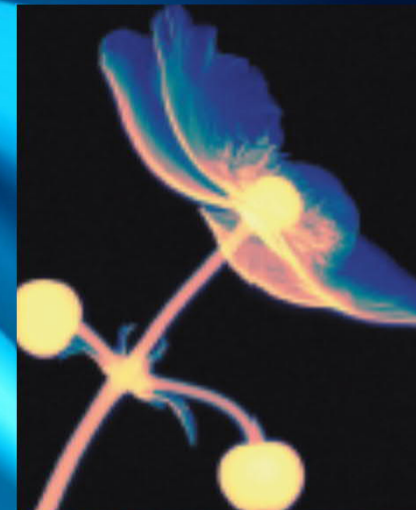
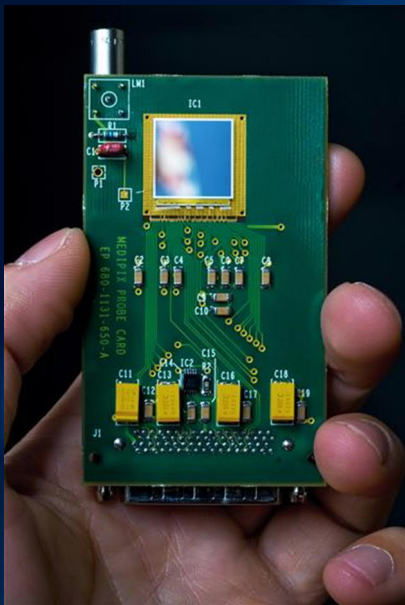
- ❖ Software for simulating particles interactions in detectors
 - used to calculate precise radiation dose for cancer treatment
 - space applications



Nice videos available:

<https://www.youtube.com/watch?v=XHpwMsutr-4>
<https://www.youtube.com/watch?v=MS590Xtq9M4>

- ❖ Pixel detector technologies "Medipix"
 - medical diagnostics
 - industrial processes
 - X-ray based material analysis (X-rays by detectors invented by Charpak in 1968 need fraction of dose required by photographic methods)
 - International Space Station




Innovation, Knowledge transfer, Economy

And many more applications in many fields...

- ❖ TERABEE – sensor technology used in drones to explore places with difficult access



- ❖ INVENIO – digital library and document repository used by  providing cloud based digital library system for UN

- ❖ CLOUD experiment could be mentioned: exploring the influence of cosmic rays on cloud formation in the Earth's atmosphere giving important input to global climate models



- ❖ Radiation protection – dosimeters



- ❖ UNOSAT satellite analysis technology hosted at CERN and supported by CERN IT infrastructure

International Collaboration

Science is a common language.

CERN's mission extends beyond science: it also aims to bring nations together

22 MEMBER STATES

6 ASSOCIATE MEMBER STATES

16 000 SCIENTISTS

110 NATIONALITIES

DIVERSITY

70% WORLD PARTICLE PHYSICS COMMUNITY



CERN MODEL

- ❖ Model for global cooperation and opened the way for other institutions that combine scientific excellence with science diplomacy.
- ❖ Spirit of open access, collaboration, tolerance and freedom of thought
 - CERN model serves as a 'blueprint' for open global collaboration
 - evokes calls for similar multinational research effort in other fields (CERN for oceans, human brain research, genomics, agricultural science).
- ❖ The successful and efficient management of Big, Global project as LHC lies in **SHARED PASSION FOR "NOBLE VALUES" (KNOWLEDGE)** and a common goal that draws collaborators together.
- ❖ "CERN model, UN and Global Public Goods" conference in UN in 2015



Big multinational companies ask how 4000 physicists, engineers and technicians of more than 110 nationalities, different languages, cultural and educational backgrounds manage to build LHC... ????

Science for peace

“CERN is a concrete example of worldwide, international cooperation and a concrete example of peace. The place which makes, in my opinion, better scientists, but also better people”

Fabiola Gianotti, CERN DG

- ❖ 16000 scientists from more than 110 nationalities work on research at CERN together in peace, irrespective of their religion or system of government, some from countries that are opponents at the political stage
- ❖ CERN - more than 60 years building peace through science.

☺ All important decision are being made in cafeteria!

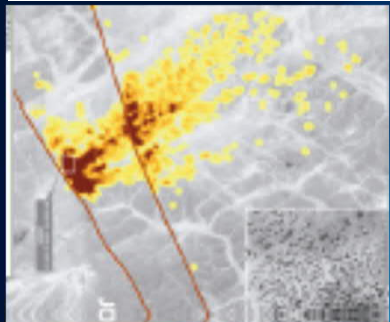


Science for peace

EXAMPLES

- ❖ During cold war, CERN served as a bridge between East and West: in 1968 agreement between CERN and Soviet IHEP Lab became a model for an agreement between USA and Soviet Union.

UNOSAT 
satellite imagery for all

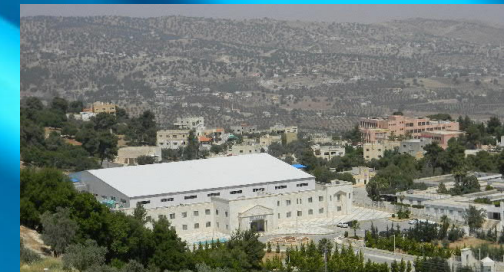


- ❖ UNOSAT programme of UNITAR hosted at CERN and supported by CERN IT infrastructure
 - satellite analysis technology
 - 15 years of humanitarian mapping: disaster risk reduction, regional capacity development
 - damage assessment, climate services, water and food security,...

“UNOSAT will have a vital role to play in the next 15 years as we want to achieve SDGs”

Ban Ki Moon, former UN SG

- ❖ SESAME: - light source in Jordan, CERN-like research facility in the Middle East
 - unique joint venture bringing together scientists from: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestinian Authority and Turkey.



Partnership

❖ CERN as an observer to UN General Assembly serves as a leading voice for global science

❖ CERN has cooperation with agreements with 8 UN organizations:
UNESCO, UNOSAT,
UNITAR, ITU,
WIPO, WMO,
WHO, UNOG
and IPU



❖ Participating in several platforms and initiatives, e.g. Geneva Peacebuilding Platform, Diplo Foundation, Club Diplomatique, Science Hub...

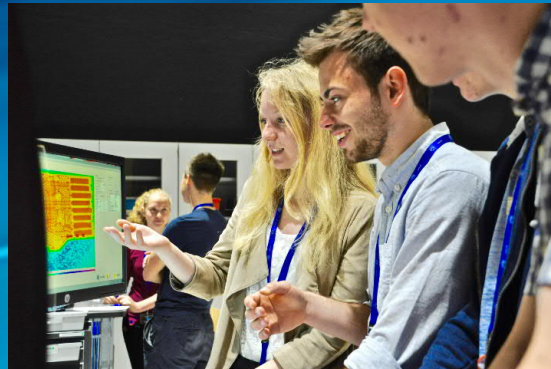
Education

Education – one of CERN's core missions: Inspiring the rising generation of new scientists

“There is nothing more enriching and gratifying than learning.”

Fabiola Gianotti, CERN DG

- ❖ Making high quality skills available to its Member States, through education, training and outreach with students, teachers and young researchers



Education

High school students and teachers

- **70 000 school children** visit CERN every year
- **10 000 teachers** have been trained at CERN since 2006 impacting more than a **million students**
- **4000 school students** each year perform hands-on experiments on modern physics at CERN S'Cool LAB
- **200-300 teams from schools** around the world engages in “Beamline for Schools” competition
- **15000 pupils in 46 countries** analyse real LHC data through “International Masterclasses”



Education

Young researchers

- **2 400 PhD students** are registered at CERN either in research, academia or industry
- **600 PhD thesis completed** every year, continuing their career in different domains:
 - steady stream of highly qualified young people with excellent technical skills and international experience for business and industry (80%).
- **300 undergraduate students** participate at summer internship programme
- **1000 highly trained and qualified young physicists and engineers** thanks to specialized CERN schools or opportunity to work at CERN on their high university studies
- **500 postdoctoral Fellows** working in research, applied physics, engineering and IT



Outreach

Visits and Exhibitions

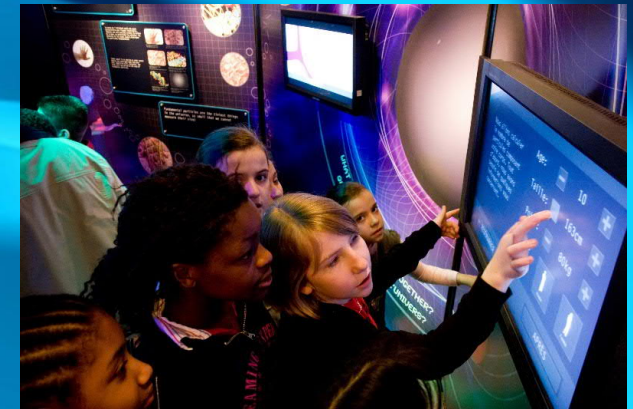
- ❖ 120 000 visitors per year
(half-day guided tour at CERN)



- ❖ 25 heads of state and 168 ministers made protocol visits between 2011 and 2015



- ❖ CERN travelling exhibitions:
76 locations in 15 countries
> million visitors from MS

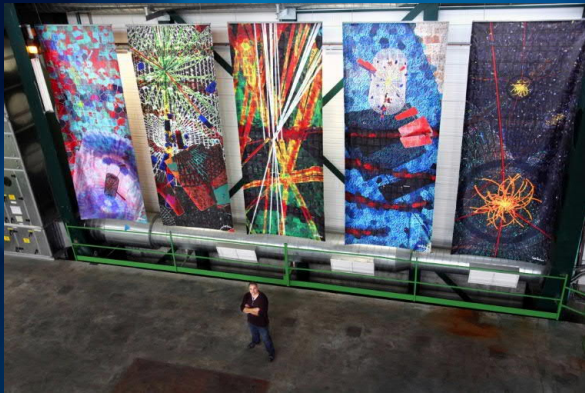


Outreach

MEDIA



- **500 visits** by world media per year
- **166 000 articles related to CERN** published in world's newspapers with 9.9 billion of potential readers
- **20 000 sessions** per day and **4.3 million unique visitors** yearly at CERN website
- **2 million mentions of CERN** per year on social media (Twitter, Facebook)



ARTS at CERN

- bringing Arts and Science closer
- attracting brilliant artists for 1-3 month residencies



UN Sustainable Development Goals (SDGs)

❖ 2030 Agenda for Sustainable Development, adopted by world leaders to transform our world



❖ 17 Sustainable Development Goals (SDGs)

- came into force in 2016
- each one with specific targets to be met over the next 15 years
- to end poverty, protect the planet and ensure prosperity for all

❖ CERN is de-facto contributing to the implementation of five SDGs





- ❖ March 24th in Geneva
- ❖ Aiming to accelerate the achievement of the SDGs
- ❖ G3iD's **SDG Solutions Fair**:
 - over 60 organizations, 800 visitors
 - showcasing and exploring solutions to SDG-related challenges



was there!



3 GOOD HEALTH AND WELL-BEING

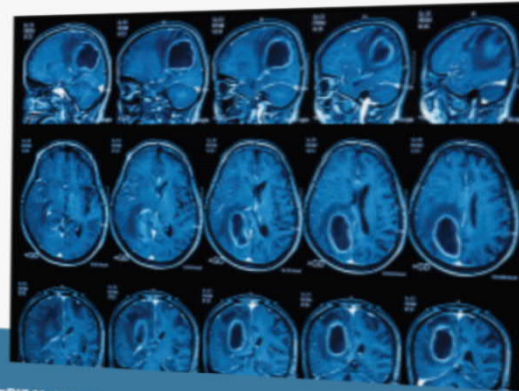
ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES

CERN's mission extends beyond science: it also aims to advance the frontiers of technology in all fields. The technologies and scientific advances behind high-energy physics have historically contributed to the field of medical and biomedical applications through developments in accelerators, detectors and computing. Future developments will continue to help address global societal challenges in healthcare, whether for therapy, medical imaging, medical and biomedical research, or biomedical technologies. While fundamental research in particle physics is CERN's core activity, the Laboratory actively contributes to the link between high-energy physics and the medical field.

Remarkable examples are particle accelerators used in hadron therapy for the treatment of tumours, medical imaging using scintillating crystals for PET scanners, pixel detectors for X-rays, simulation and computing tools for patients' treatment plans. CERN makes an increasing effort towards making these technologies more affordable for developing countries and available in challenging environments.

"Knowledge transfer to medical applications is a great way of fulfilling our mission to disseminate CERN's results to society as widely as possible."
 - Frédéric Bordry, CERN's Director for Accelerators and Technology & Chair of the Medical Applications Steering Committee

"CERN contributes to medical applications, with the goal of providing solutions to societal health challenges."
 - Fabiola Gianotti, CERN Director-General



MEDICAL APPLICATIONS

Particle accelerators, detectors, computing, and simulations developed for basic research in particle physics are at the heart of state-of-the-art healthcare techniques.



RADIATION PROTECTION

CERN utilizes its know-how in radiation detection and dosimetry for broader fields of application, in particular medical and industrial.



Find out more at www.cern.ch/kt and www.cern.ch/ir-sector



4 QUALITY EDUCATION



ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION AND PROMOTE LIFELONG LEARNING OPPORTUNITIES FOR ALL

Education and Open Science are CERN's core missions, inspiring the rising generation of new scientists. CERN contributes to making high quality skills available to its member states, through a diverse range of education, training and outreach programmes for students, teachers and young researchers.

70 000 school children visit CERN every year to learn and awaken their curiosity for the compelling questions about the universe - one of the main goals of fundamental research. 10 000 teachers have been trained at CERN since 2006 to keep up-to-date with the latest developments in particle physics and related areas, and experience a dynamic, international research environment. Through these teachers, more than a million students have been reached.

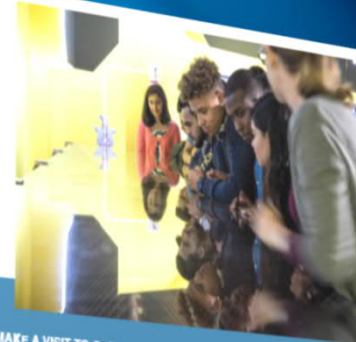
About 4 000 school students perform hands-on experiments on modern physics each year at CERN S'Cool LAB. In the "Beamline for Schools" competition, 200-300 teams from schools around the world compete to win a 10-day residency at CERN, where they get to carry out a science experiment. The "International Masterclasses" programme reaches 15 000 pupils in 46 countries, allowing them to become a researcher for a day and analyse real LHC data.

2 400 PhD students are registered at CERN either in research, academia or industry to advance the frontiers of technology. 600 PhD students complete their thesis every year, continuing their careers in different domains, thus providing a steady stream of highly qualified young people with excellent technical skills and international experience to business and industry.

CERN offers visits and exhibition programmes. About 120 000 visitors per year have the opportunity to go on a half-day guided tour at CERN. 25 heads of state and 168 ministers have made protocol visits between 2011 and 2016.

"There is nothing more enriching and gratifying than learning."

- Fabiola Gianotti, CERN Director-General



MAKE A VISIT TO CERN

CERN offers visits and exhibition programmes. About 120 000 visitors per year have the opportunity to go on a half-day guided tour at CERN.



HANDS-ON EXPERIMENTS AT CERN

Each year at CERN S'Cool LAB, 4 000 school students perform hands-on experiments within the field of modern physics.



Find out more at www.cern.ch/kt and www.cern.ch/ir-sector

SUSTAINABLE DEVELOPMENT GOALS

4 QUALITY EDUCATION



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



BUILD RESILIENT INFRASTRUCTURE, PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALIZATION AND FOSTER INNOVATION

Enhance scientific research and encourage innovation is CERN's core mission. CERN is a hub of world-class fundamental physics research, pushing the frontiers of human knowledge. Reaching ambitious scientific objectives requires the development of advanced instruments and new technologies, making CERN a driver of innovation.

The CERN Knowledge Transfer group provides advice, support, training, network and infrastructure to ease the transfer of CERN's know-how to industry and eventually society. The CERN Knowledge Transfer Fund bridges the gap between research and industry, so that society can benefit from science outcomes. CERN has also established a network of 9 Business Incubation Centres throughout its member states to assist entrepreneurs and small technology businesses in taking CERN technologies and expertise to the market.

CERN itself runs across the border of two nations, hosting the largest scientific infrastructure ever built. Here the World Wide Web was born, allowing an ever increasing number of scientists to share information. Other infrastructures include big data management systems used not only for the analysis of physics data but also for other applications like the UNOSAT maps.

Companies from all over the world contribute to the realisation and the maintenance of the experiments at CERN. Through such industrial actors, the Organization gives back resources and competences to society. Not only through procurement, but also through public-private partnerships, such as the CERN openlab in the IT sector.

**"CERN contributes to building a culture of entrepreneurship,
this culture has a concrete impact outside of CERN,
and there are currently 18 start-ups and spin-offs
using CERN technologies."**

- Fabiola Gianotti, CERN Director-General



INDUSTRY

The 27-km long Large Hadron Collider is the largest single machine in the world. Thousands of scientists, engineers, and technicians planned and built it over decades.



ENTREPRENEURSHIP

CERN cultivates a culture of entrepreneurship, supporting its staff so that business ideas become reality. It is expanding its network of Business Incubation Centres throughout its Member States.



Find out more at www.cern.ch/kt and www.cern.ch/ir-sector

SUSTAINABLE
DEVELOPMENT
GOALS

16 PEACE, JUSTICE AND STRONG INSTITUTIONS



PROMOTE PEACEFUL AND INCLUSIVE SOCIETIES FOR SUSTAINABLE DEVELOPMENT, PROVIDE ACCESS TO JUSTICE FOR ALL AND BUILD EFFECTIVE, ACCOUNTABLE AND INCLUSIVE INSTITUTIONS AT ALL LEVELS

For more than 60 years, CERN has been building peace through science. CERN is a centre of scientific excellence and provides a framework for peaceful scientific collaboration. 16 000 scientists from more than 110 nations work together at CERN, regardless of religious and political views.

According to the CERN Convention, all CERN's results and discoveries have to be made available and free of access for everybody. Transparency and open access to information are among the core values of CERN, and the Laboratory is accessible for every organisation willing to use its infrastructure and sharing these principles. For example, in cooperation with the UN, CERN provides the IT infrastructure that allows the UNOSAT programme to be at the forefront of satellite-analysis technology, e.g. for disaster-risk reduction or regional capacity development. Moreover, CERN helped build the SESAME light source in Jordan, which follows the CERN model and promotes scientific collaboration in the Middle East.

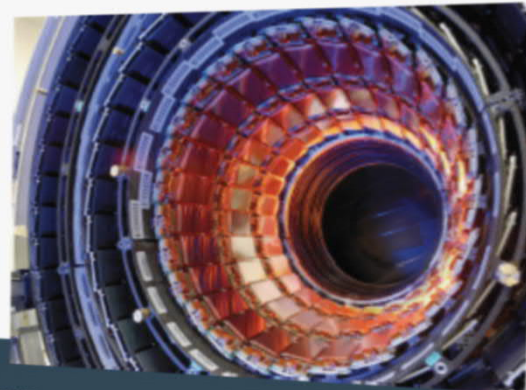
CERN is an effective, accountable and transparent institution, ensuring a participatory and representative decision-making, as well as public access to information.

"CERN's commitments to carry out purely fundamental research and to make all of its work public have ensured peaceful collaboration between scientists from all countries." - Rolf Hauer former CERN Director-General

"CERN is a concrete example of worldwide, international cooperation and a concrete example of peace. The place which makes, in my opinion, better scientists, but also better people."
- Fabiola Gianotti, CERN Director-General

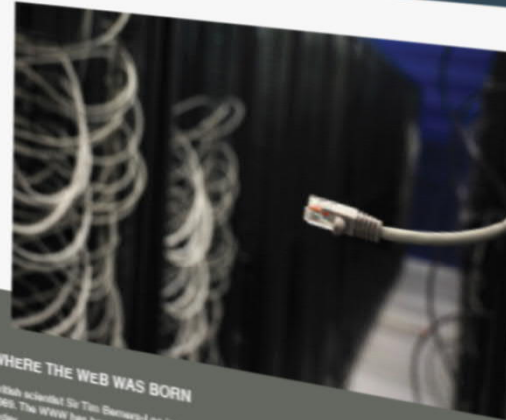


Find out more at www.cern.ch/kt and www.cern.ch/ir-sector



SESAME

SESAME is a synchrotron light source under construction in Jordan. Not only is SESAME an important scientific project, it also helps build bridges between diverse cultures across the Middle East.



WHERE THE WEB WAS BORN

British scientist Sir Tim Berners-Lee invented the World Wide Web (WWW) at CERN in 1989. The WWW has been central to the development of the Information Age we live in today.

SUSTAINABLE DEVELOPMENT GOALS

17 PARTNERSHIPS FOR THE GOALS



17 PARTNERSHIPS FOR THE GOALS



STRENGTHEN THE MEANS OF IMPLEMENTATION AND REVITALIZE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

CERN's mission extends beyond science: it also aims to bring people together. CERN has become a model for global cooperation and opened the way for other institutions that combine scientific excellence with science diplomacy.

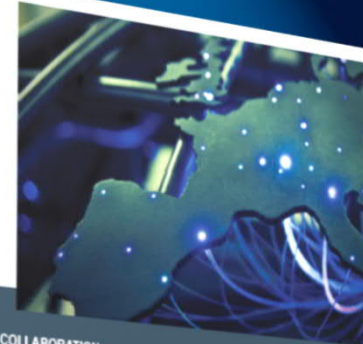
CERN brings nations together through science, and organises and sponsors international cooperation in research, promoting contacts between scientists and interchange with other laboratories and institutes. CERN is run by 22 member states and 6 associate member states, and its success is in large part due to its rich international collaboration. Thanks to a structured network of relations with other international organisations, CERN consolidates the importance of scientific education, technology, and innovation as a driving force in the economy and society.

CERN scientific excellence attracts about 70% of the world's particle physics community. Based on this spirit of open access, collaboration, tolerance and freedom of thought, the CERN model serves as a 'blueprint' for open global collaboration and evokes calls for similar multinational research effort in other fields. A bright example is the SESAME project in Jordan, creating a CERN-like research facility in the Middle East. SESAME is a unique joint venture that brings together scientists from its member states: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey.

CERN cooperates and has agreements with 8 UN organisations: UNESCO, UNOSAT, UNITAR, ITU, WIPO, WMO, WHO, UNOG, and IPU. Furthermore, CERN is also an observer to UN General Assembly.

“People from all over the world come here, bringing with them different cultures and different ways of working. This diversity is part of our strength, and it's something that we need to nurture constantly.”

- Fabiola Gianotti, CERN Director-General



COLLABORATION

The establishment of CERN in 1954 sent a strong geopolitical message of international post-war collaboration around a common goal. The Laboratory counts more than 12 000 scientific users.



INTERNATIONAL COOPERATION

CERN brings nations together through science and international cooperation. More than 110 nationalities work at CERN.



Find out more at www.cern.ch/kt and www.cern.ch/ir-sector

SUSTAINABLE DEVELOPMENT GOALS

Article in CERN Bulletin 12th April 2017

“CERN’s contribution to SDGs was a positive surprise for many participants, as the CERN impact on society and tackling global challenges like SDGs are still not widely known to the public.”

Did you know?

CERN at G3iD: tackling UN's Sustainable Development Goals



CERN representatives engaging with visitors of G3iD Solution Fair (Photo: Alan Dear/G3iD)

attended the United Nations' Geneva Global Goals innovation Day (G3iD) to show how CERN tackles UN's Sustainable Development Goals.

<https://home.cern/cern-people/updates/2017/04/cern-g3id-tackling-uns-sustainable-development-goals>

Conclusions

It is great to be part of science community!