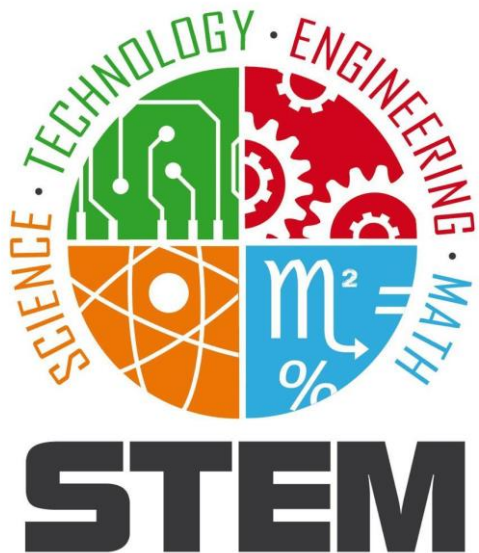


# *Role of (particle) physics / science for sustainable society*

*Barbora Bruant Gulejova*

Université Bern / CERN



# *Outlook*

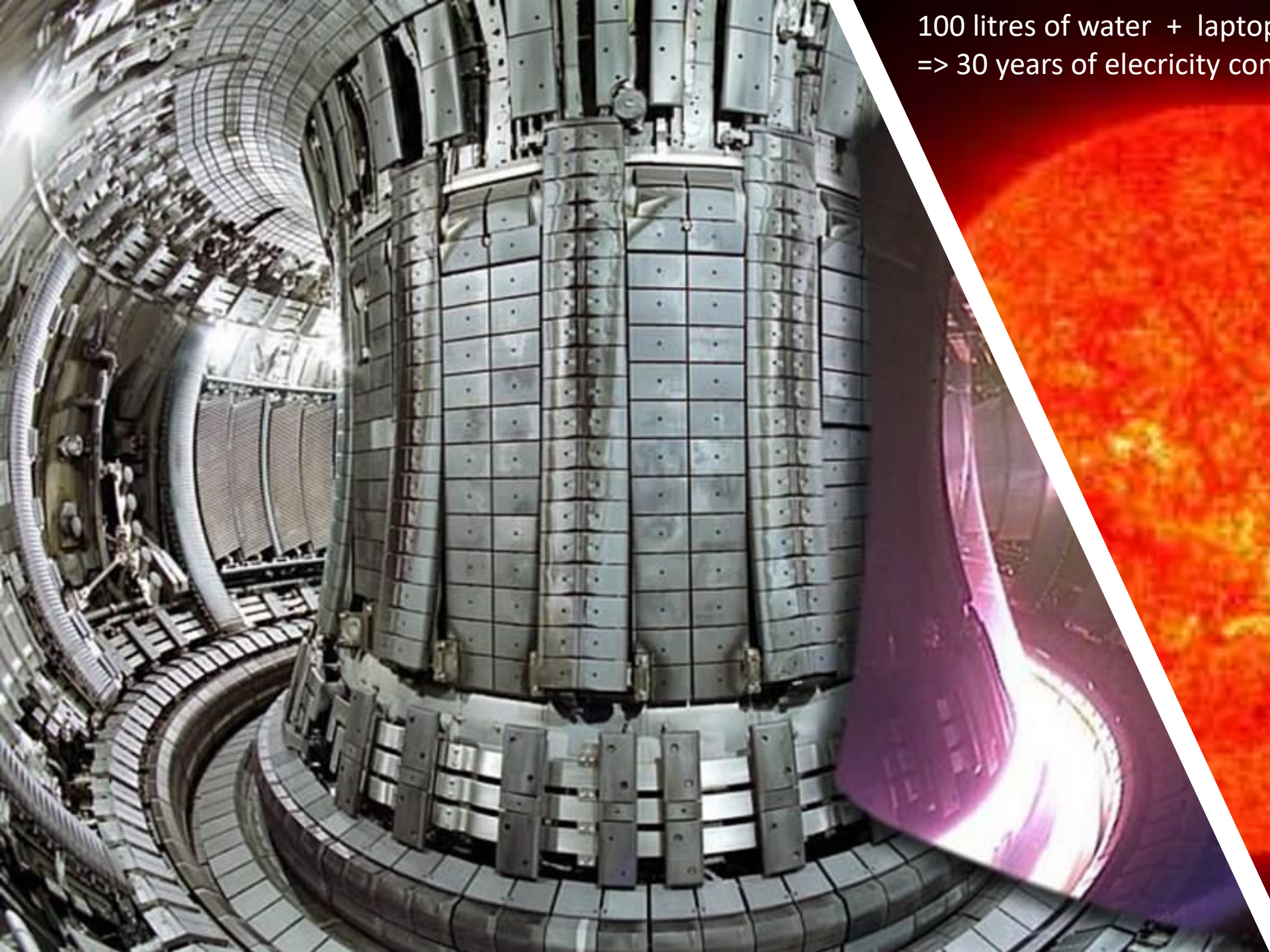
- ❑ Impact of particle physics on sustainable development
- ❑ Case of Switzerland
- ❑ Perception of Sustainable Development & Sciences
- ❑ Future generation and education

# *UN Agenda 2030 – 17 SDGs*



*Impact of (particle) physics  
on society and  
sustainable development*



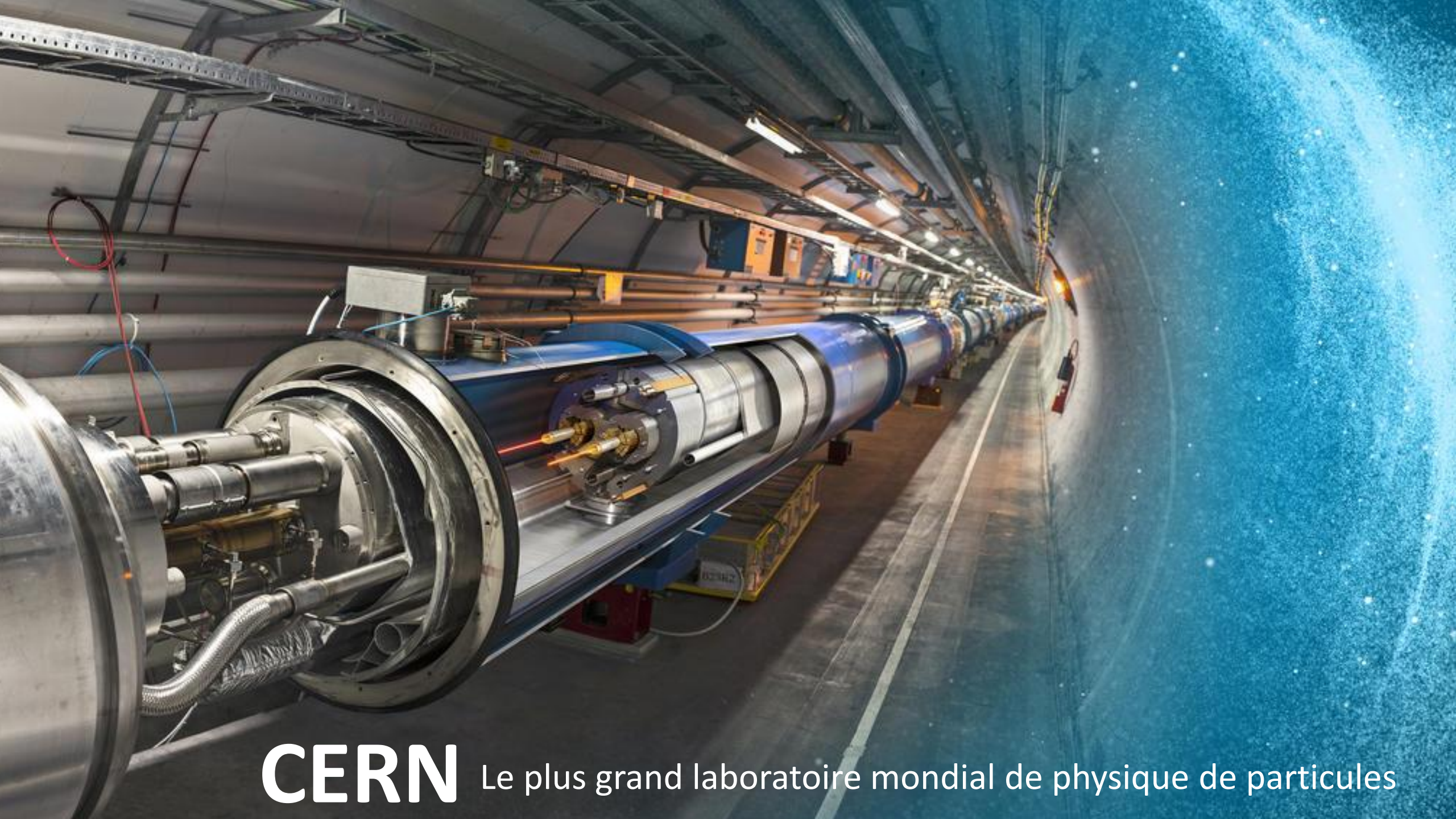


100 litres of water + laptop battery  
=> 30 years of electricity consumption by European citizen



**FUSION**





**CERN** Le plus grand laboratoire mondial de physique de particules

*Higgs boson  
and  
sustainable development?*



4. July 2012

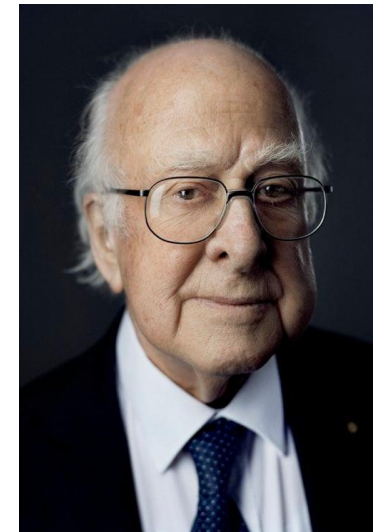
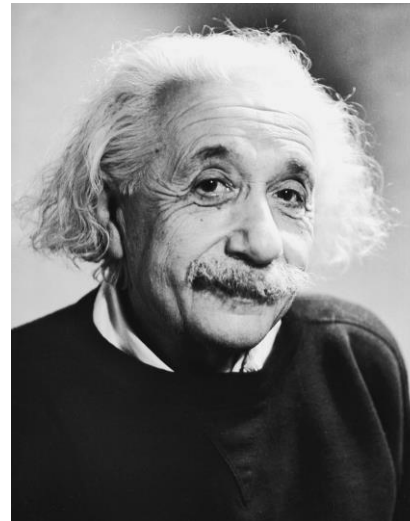
# Prix Nobel



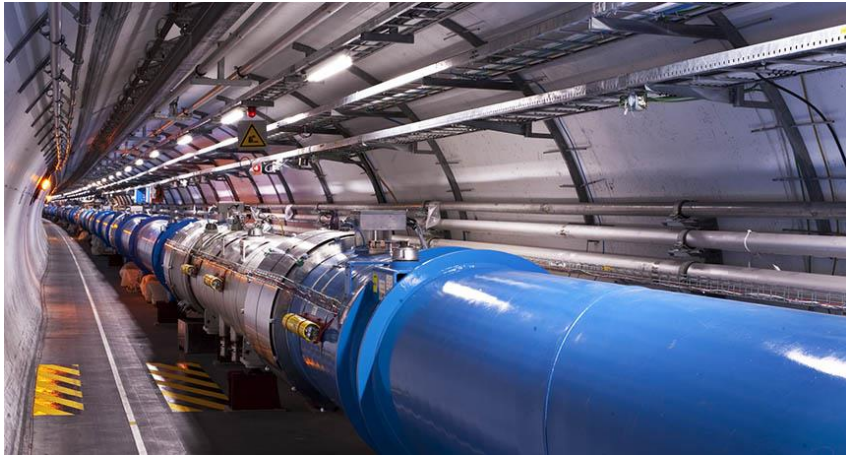
Peter Higgs



# *Why should society be also happy?*



# Worldclass unprecedented scientific instruments



ACCELERATORS



DETECTORS



BIG DATA

## Push the frontiers of science and technology

=> Innovations, Spin-offs, Start-ups...



# *Particle Physics in Industry*



Many tens of thousands of particle accelerators and detectors operating in industry worldwide

Particle detector is used to:

- restore partial sight to the blind
- visualize the brain activity
- validate new drugs in preclinical trials
- confirm the efficacy of cancer treatment
- spot the location and content of suspicious cargo
- detect contraband radioactive materials

Accelerator is used to:

- treat a tumour
- provide sustainable and cleaner source of energy
- burn nuclear waste
- harden materials (better tyres, resistant plastic foils)
- implant ions in semi-conductors
- map proteins
- design new drugs
- date archaeological findings...

# CERN: Driver of Innovation



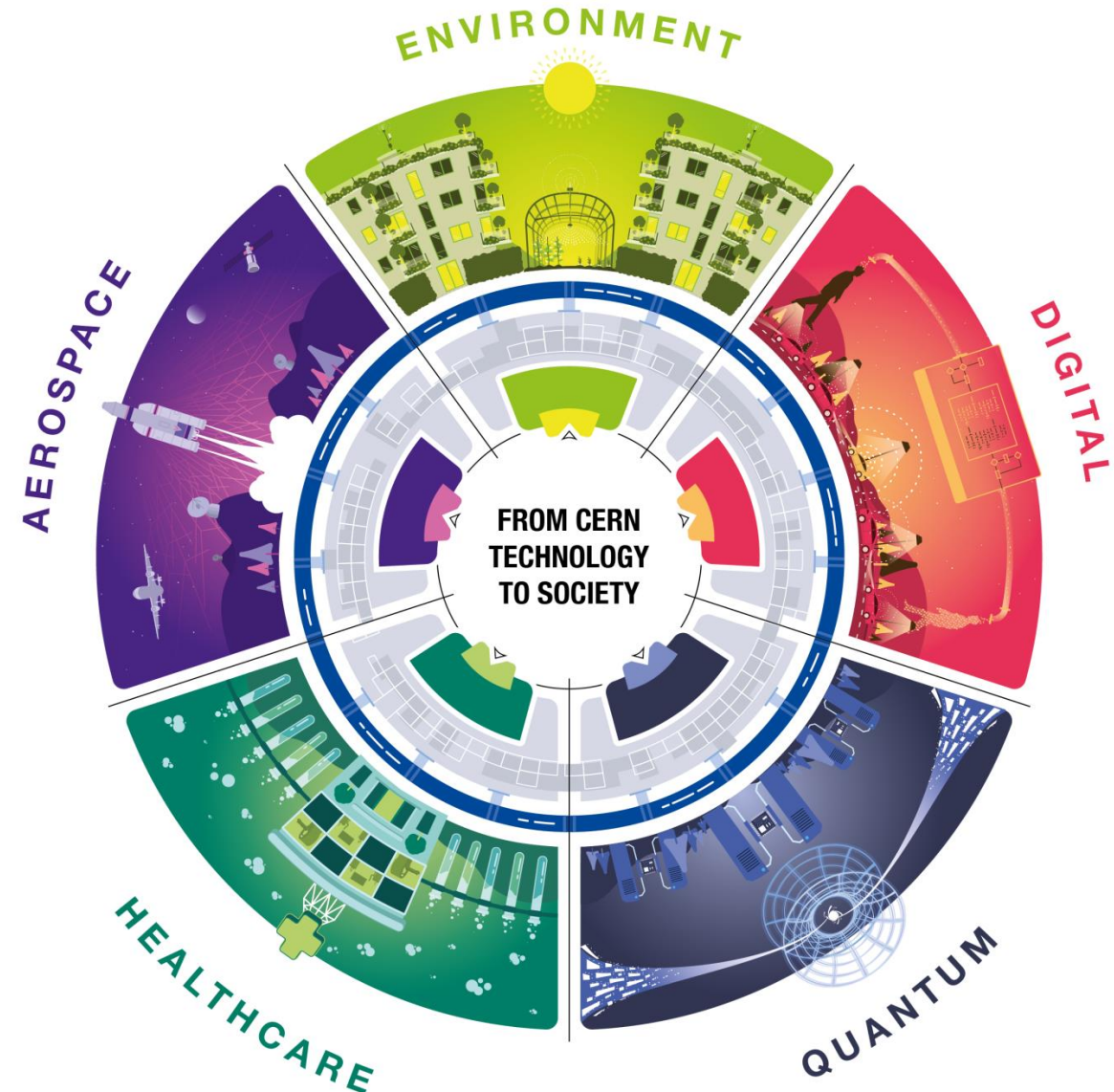
Knowledge Transfer



- > 30 start-ups and spin-offs using CERN technologies
- > 100 external partners with CERN know-how (industry, labs, universities)
- > 10 CERN Business Incubation Centers

Task force for COVID 19

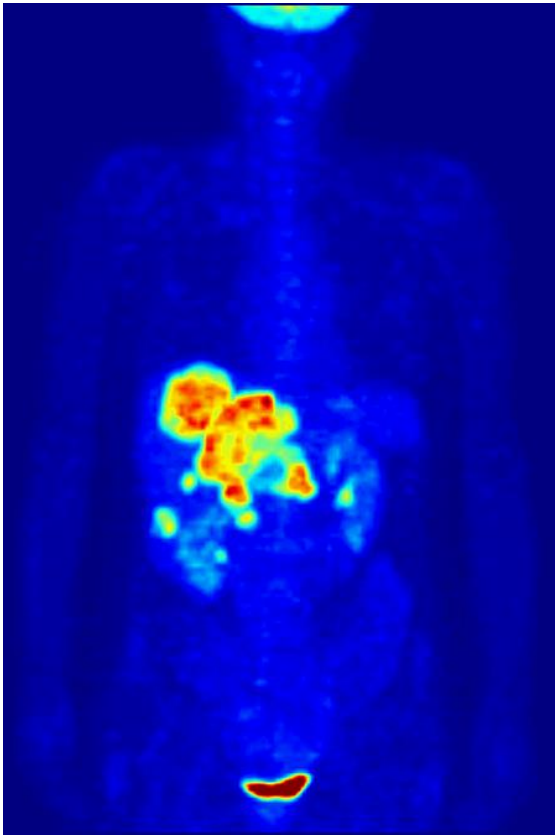
Innovation Programme on Environmental Applications



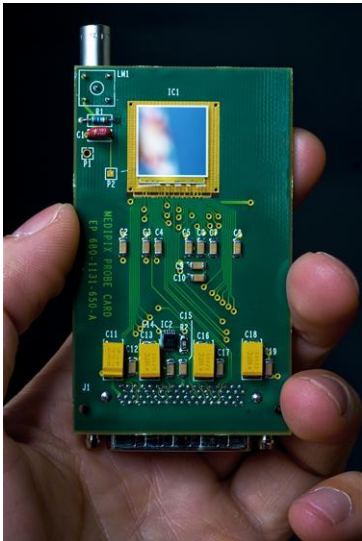


# Medical applications

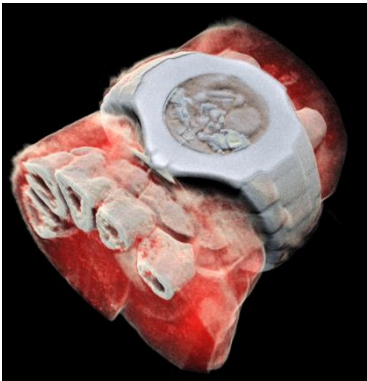
Medical imaging: PET  
(positron emission tomography)



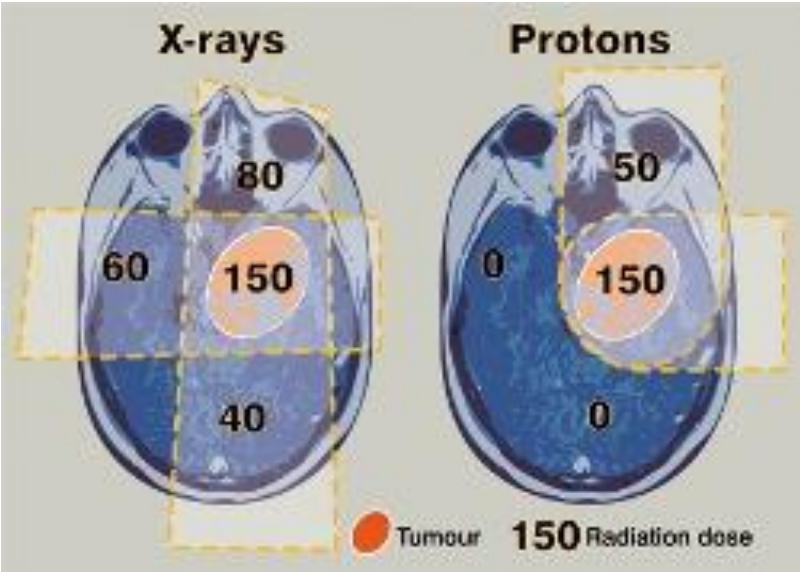
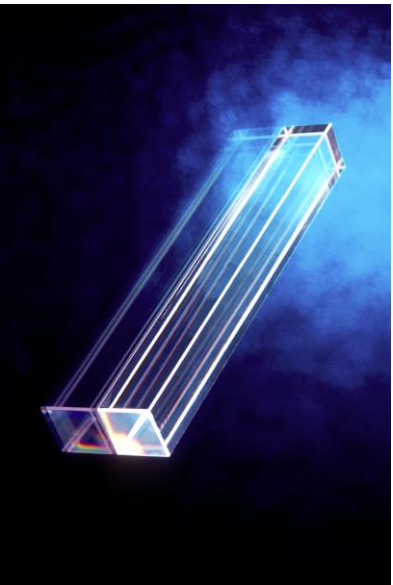
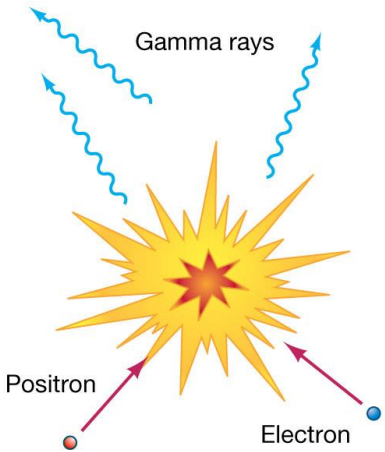
Medipix



3D colour X-ray  
of human



Cancer therapy: protons, électrons, radioisotopes...



# *Digital and electronic applications*



Data preservation of UN library

**INVENIO**



Partnership with  
ICT leaders

**Google**

**IBM**

**SIEMENS**

**ORACLE**

**intel**



# *Environmental applications*



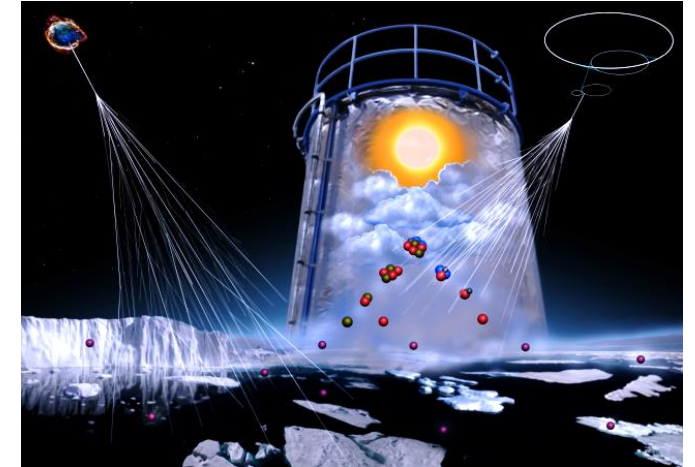
Reduction of pollution from  
marine engines



Solar panels heating Geneva airport



CLOUD experiment – Climat simulations



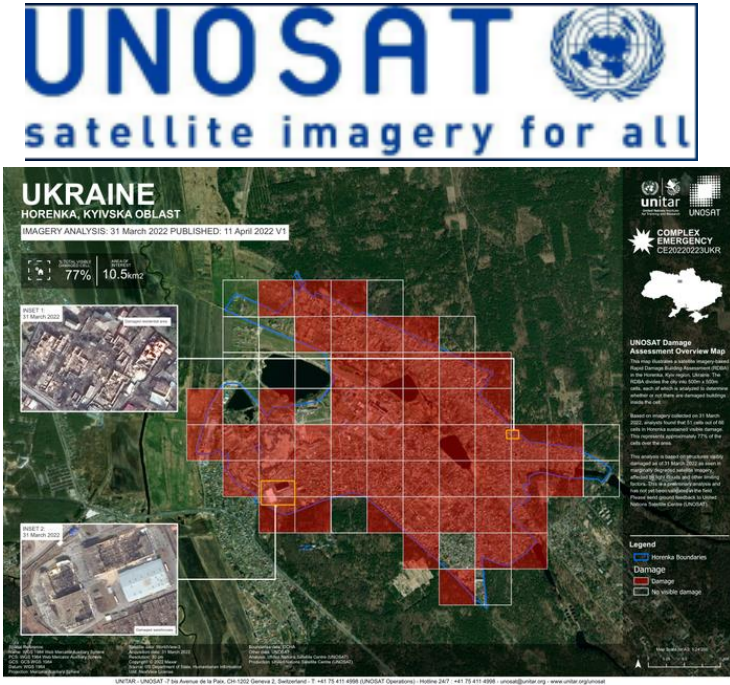
Energy efficiency





# Humanitarian and cultural applications

Humanitarian mapping



Virus detection



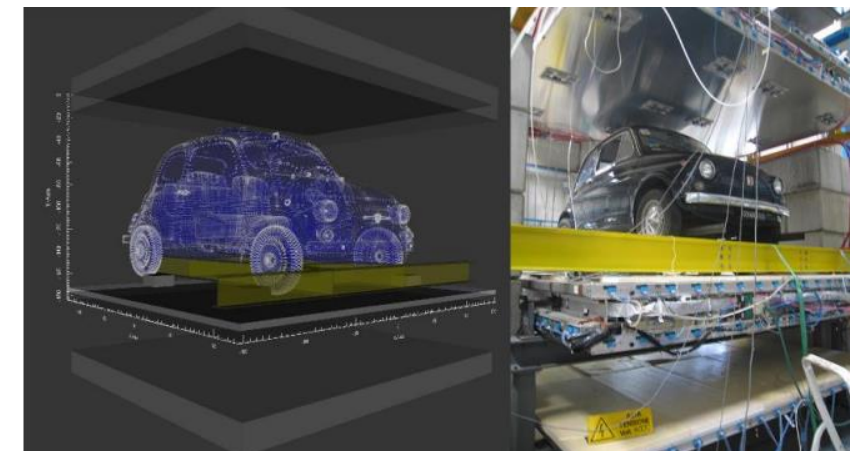
Archeology and culture



Detection of frauds on financial markets



Suspicious cargo detection





# *CERN = 70 years of science for peace*

«CERN model» of epistemic open global peaceful collaboration for noble goal,  
the knowledge for benefit of humanity

A 'blueprint' for other organisations (SESAME, SEEIIST, ESO... )

UN, Geneva, 2015:

High-level summit **“CERN model, UN and Global Public Goods”**

Suggesting the CERN model as a possible inspiration to tackle global challenges /SDGs.



CERN is the only science organization  
to be:

Observer to UN General Assembly

Leading voice for global science



# *CERN : inspiring new generation of scientists*

- **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:
- **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



**Steady stream of highly qualified young people** with excellent technical skills and international experience for **business and industry** (80%).

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







# G3 GENEVA GLOBAL GOALS INNOVATION DAY

- 24<sup>th</sup> March 2017 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



## 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."

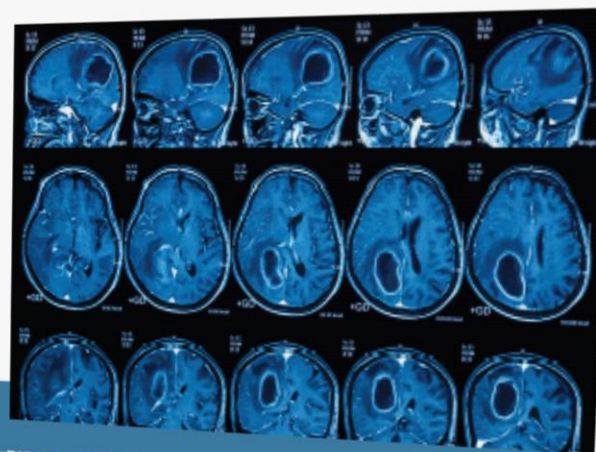
- Frédéric Barary, CERN's Director for Accelerators and Technology & Chair of the Medical Applications Steering Committee

"CERN contributes to medical applications, with the goal of providing solutions to societal health challenges."

- Fabiola Gianotti, CERN Director-General



Find out more at [www.cern.ch/kt](http://www.cern.ch/kt) and [www.cern.ch/ir-sector](http://www.cern.ch/ir-sector)



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

SUSTAINABLE  
DEVELOPMENT  
GOALS



## 4 QUALITY EDUCATION



## 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](http://www.cern.ch/kt) and [www.cern.ch/lr-sector](http://www.cern.ch/lr-sector)

SUSTAINABLE  
DEVELOPMENT  
GOALS

GOALS  
DEVELOPMENT  
SUSTAINABLE

Find out more at [www.cern.ch/kt](http://www.cern.ch/kt) and [www.cern.ch/lr-sector](http://www.cern.ch/lr-sector)

# 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 their 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](http://www.cern.ch/kt) and [www.cern.ch/ir-sector](http://www.cern.ch/ir-sector)

SUSTAINABLE  
DEVELOPMENT  
GOALS



Find out more at [www.cern.ch/kt](http://www.cern.ch/kt) and [www.cern.ch/ir-sector](http://www.cern.ch/ir-sector)

GOALS  
DEVELOPMENT  
SUSTAINABLE





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 Heuer 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](http://www.cern.ch/kt) and [www.cern.ch/ir-sector](http://www.cern.ch/ir-sector)

SUSTAINABLE  
DEVELOPMENT  
GOALS



SESAME

SESAME is a synchrotron light source under construction in Jordan. Not only is SESAME an important scientific project, it is also helping 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.

13<sup>th</sup> IPPOG meeting 20-22 April 2017, Lisbon

23

# 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](http://www.cern.ch/kt) and [www.cern.ch/ir-sector](http://www.cern.ch/ir-sector)

SUSTAINABLE  
DEVELOPMENT  
GOALS

GOALS  
DEVELOPMENT  
SUSTAINABLE

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Article in CERN Bulletin 12<sup>th</sup> 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.”

How about scientific community?  
Did you know?

# *CERN de facto contributes to 5+ SDGs*



Indirectly to  
many more  
(probably all)!



# *No solutions to any SDG without*



## Innovations & New Technologies

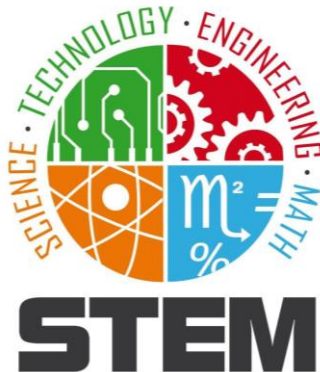
coming from

## Basic Sciences & Research



# MINT

Physics  
Engineering  
Mathematics  
Chemistry  
Biology  
Informatics



## International Year of Basic Sciences for Sustainable Development

In partnership with



# *Innovation and Switzerland*

Innovation pathway: Lab / Uni ➡ Industry ➡ Technology / Product / Solution

What is the country with highest global innovation index?

## Switzerland

Long tradition of investment to science centers and best scientists  
= **Swiss strategic asset** (given high salaries!)

**BUT: most of them hired from abroad!**



**EPFL**

**ETH** zürich

**csem** centre suisse d'électronique  
et de microtechnique



 **Empa**  
Materials Science and Technology

**IBM**

**ABB**

  
**LA ROCHE-POSAY**  
LABORATOIRE PHARMACEUTIQUE

 **COMSOL**

 **Hitachi Energy**



# Contribution of physics to Swiss Economy

**Physics-based industry (PBI)** is 2<sup>nd</sup> largest contributor to Swiss economy after finance doing better then trade and construction sectors...

*SPS Focus on Impact of Physics on Society*

	1	2	3	4	5	6	7
CH	PBI	Production	Trade	Construction	Financial Services	Sum (1-5)	Total (full economy)
2019							
GVA (Billion CHF)	91.5	122.4	105.4	32.0	69.9	421.2	701.6
%	13.0	17.4	15.0	4.6	10.0	60.0	100
FTE (Thousand)	417	640	504	313	204	2078	4237
%	9.8	15.1	11.9	7.4	4.8	49.0	100
GVA/FTE (kCHF)	219.4	191.3	209.1	102.2	342.6	202.7	165.6

Need of innovation and science expertise in industry is rising!

- Technologies are more and more complex
- Today, innovation is needed during the whole production process

## Advantages of business with research centers like CERN

- Turnover increase

***Each CHF 1 invested by CERN in the contract with high-tech company brings an additional 3 CHF to the company***

- New know-how, products, markets...
- Credibility and good name

# Misperception of role of physics in society



“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.**”

This lack of awareness is valid in general about positive impact of physics to society.



To implement SDGs, the UN assigns the **SDG Regional Coordinators (RCs)**  
Only experts on international relations, economy, law and social sciences are eligible  
**Physicists or experts in other basic sciences are not eligible**



Swiss high-schools are obliged to teach about **sustainable development**.  
This is happening **only during classes of geography and economics**.  
Lack of SDGs related materials in science education =>  
**Students situate SDGs outside of physics and other basic sciences.**

**Physics is often perceived as:** boring, abstract, complicated, hard,  
only for elite, only for men, does not pay, what careers?...



# *Important new challenge*



# *Contra-productive reality*



Interest of youth to study basic sciences is falling!

- Especially in physics and engineering
- Especially girls

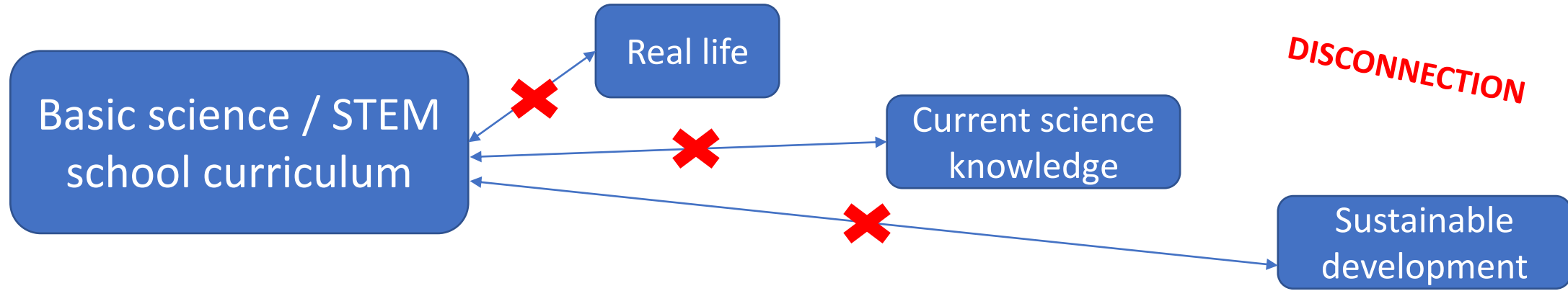
And to make matters worse:

- **Jobs** in STEM are growing 3 times faster than in any other sector;
- 7 million of new STEM jobs in Europe in 2025 **but** not enough skilled people to fill them!
- **Even today** Swiss high-tech companies have difficulties to recruit engineers!

It is crucial to inspire and motivate **new generation of physicists, engineers and technically skilled specialists** to bring solutions for SDGs!



# How do raise the interest of youth in physics?



**Context** - based physics education is the key!

*“While fraction of students (population!) is generally interested in physics, science & technology, the rest could become interested **in relation to nature and humans, applications and relevance for society, e.g. sustainability.**”*

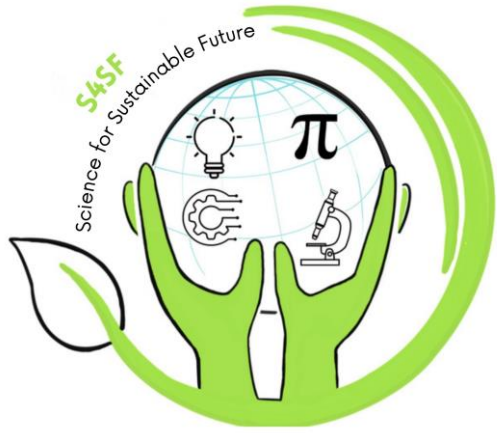
*PhD study of Sarah Zoechling, CERN*

**Modern physics, cutting-edge technologies and its applications increase interest**

*Study from UK & Germany schools exposed to particle physics*

**Industry** is the path from science to citizen => provides the context 

**Powerful, but so far unexplored avenue in physics outreach!**

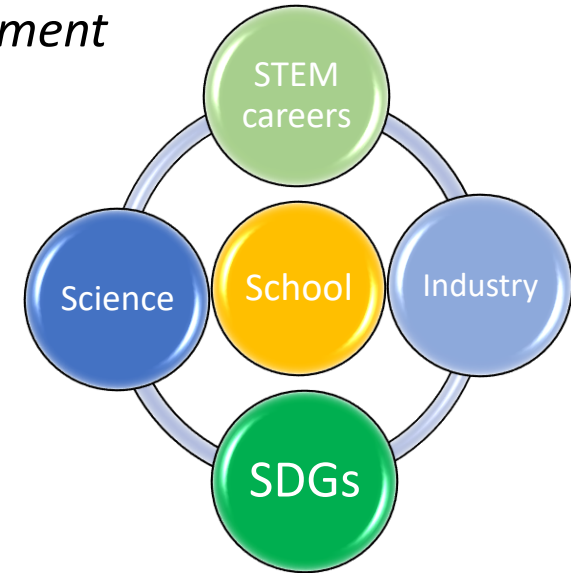


# Youth@STEM4SF

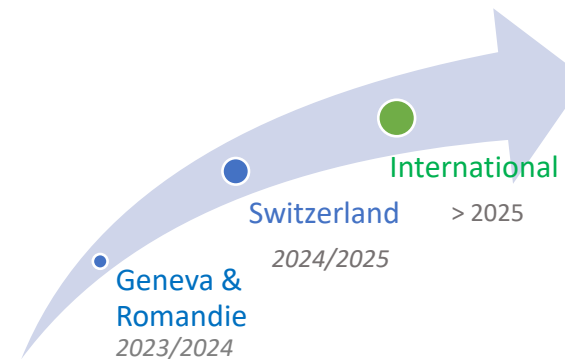
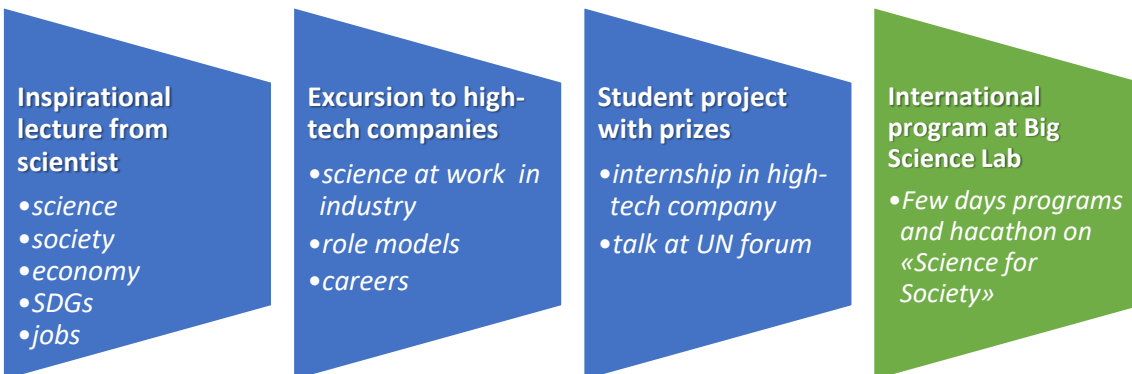
*"There is no sustainable future without new generation of scientists"*

*New first-of-its-kind program aiming to:*

- ☐ *engage young talents in physics / STEM*
- ☐ *inspire future society leaders on value of science*



- ✓ *brings physics to high-schools in context with real life, society and sustainable development*
- ✓ *shows physics at work in industry*
- ✓ *provides physics and engineering female and male role models*
- ✓ *shows vast career opportunities*
- ✓ *Measured impact and strategic data aiming to shape the education system*





# Youth@STEM4SF First Swiss Pilot



Knowledge Partners

Gymnase de Bugnon, Lausanne

11 May 2023





# Youth@STEM4SF First Swiss Pilot



**Considerable impact, especially on girls...**

*50% of students found new perspective of their career which they didn't envisage before!*

*60% of students claim that they will act as scientifically literate citizens and / or ambassadors for science in society in their future life /career!*

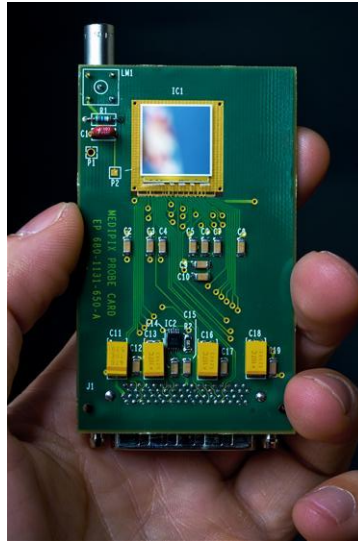


*There is no sustainable development without  
physics and new generation of scientists*

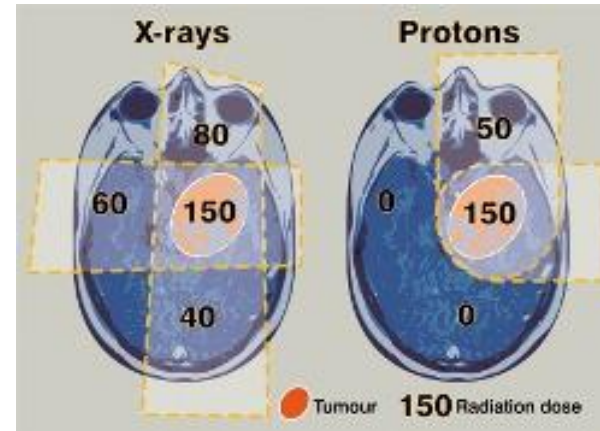
Medical imaging  
PET, IRM



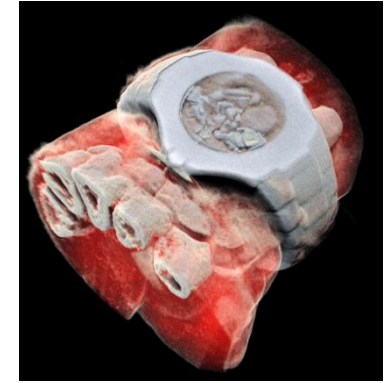
Medipix



Cancer proton therapy



3D colour X-ray

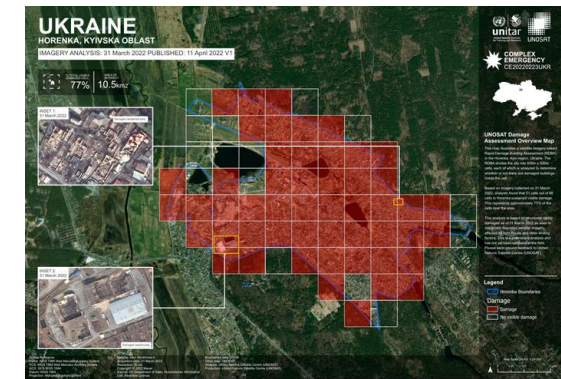


Touchscreen

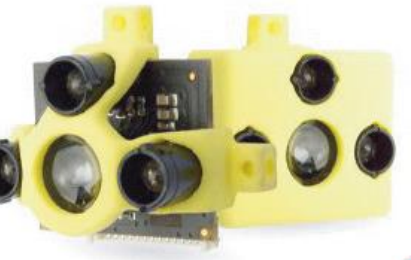


**INVENIO**  
UN digital library

**UNOSAT**  
satellite imagery for all



Terabee Drones



Virus detection

