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
  - 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…

Academia Research

Knowledge transfer Innovations

Education, Communication, Outreach

Economy Industry Business

Relations with stakeholders
International relations
Decision makers, ...

Knowledge transfer
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HST 2017, 12th of July 2017, CERN
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, ...)
Motivation

“The problems cannot be solved with the same mind-set that created them.” A. Einstein

- Tackling global issues of today (climate, conflicts....)

- It is important that young generation knows and prepares solutions for tomorrow!
New brochure highlighting the main benefits of CERN’s activities

- **Severa Unique Research Facilities**
- **166,000 Articles in the World Press Written About CERN**
- **120,000 Visitors Every Year Welcomes More Than**
- **70% of the World’s Particle Physicists Do Research at CERN**
- **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**
- **WWW Invented at CERN**
- **Breakthrough Discoveries in Experimental Physics**
- **16,000 Scientists of More Than 110 Nationalities**
- **Advanced Technologies with Applications in 16 Domains**
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

- 1958: Rare pion decays
- 1968: Wire chamber
- 1973: Neutral currents
- 1983: W, Z bosons
- 1989: World Wide Web
- 1992: 3 generations of particles
- 2012: Higgs boson
Scientific knowledge

**NOBEL PRICES**
- G. Charpak: Wire chamber
- C. Rubbia: W, Z bosons
- S. Van der Meer: Beam cooling
- P. Higgs & F. Englert: Higgs boson

**UNIQUE WORLD-CLASS FACILITIES**
- LHC: Most complex scientific instrument
- Detectors
- Data center + GRID – Big Data!
- Antimatter factory, ISOLDE, CLOUD

Between 1936 – 2011
- 69 Nobel prices awarded in physics
- 24 of these in accelerators

900 peer reviewed research papers
600 PhD theses / year

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“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
Particle physics – from basic research to innovation and technology
Basic and applied sciences go hand in hand, relying on and challenging one another

- **Accelerator** can be used to:
  - treat a tumour
  - provide sustainable and cleaner source of energy
  - burn nuclear waste
  - harden materials for better tyres and more resistant plastic foils
  - implant ions in semi-conductors
  - map proteins
  - design new drugs
  - date archaeological findings...

- **Particle detector** can be 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

- Many tens of thousands of particle accelerators are operating for industrial purposes worldwide
- Only handful of pure research accelerators exist in the world
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.

- 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.
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 issue
  - 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

- **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

Nice videos available:
https://www.youtube.com/watch?v=lN3pB7lZbLA
https://www.youtube.com/watch?v=XHpwM5ttrk4
https://www.youtube.com/watch?v=MS590Xtq9M4
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

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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** 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.

- Other examples using CERN model of collaboration: JINR (DUBNA), ESO, EMBL
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 is the most powerful weapon which you can use to change the world"

Nelson Mandela
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 though “International Masterclasses”
- **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
Environment and Energy

PP in general (not only CERN)

- **Climate models**: UNOSAT, CLOUD, Ion beam / Accelerator Mass Spectroscopy (AMS)
  - measuring precise concentration of radioisotopes

- **Greener industrial processes / Reducing energy consumption**: Electron beam technology
  - coatings and adhesive surfaces for the packaging
    (high production speed, minimal energy consumption, reduced environmental impact)
  - lighter cars with less consumption…

- **Clean water**: Electron beam accelerators
  - purifying drinking water
  - treating waste water
  - high efficiency removal of NO\textsubscript{x} and SO\textsubscript{x} from the flue gasses of power plants
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**
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Some more thoughts
inspired by discussions in IPPOG

Impact of science is infinite – we don’t know it yet…

“Theory jam” – it takes even a century to verify the scientific hypotheses (atom, gravitational waves)
Higgs “only” 48 years, neutrinos “only” 26 years…

True value of knowledge – unmeasurable

- not to be forgotten when presenting studies of economic and societal impact – measured, quantified!
- these are just one part of the full image of the real impact

“Science behavior”

- Inherent ethical behavior – no fighting, no killing, no corruption…
- scientists aim for absolute truth - unlike in “real life” (truth is who is louder, question of belief)
- scientists describe things, accept what they measure, don’t decide or force them to be as like them to be…

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Huge impact on new generation:
- Improved mind-set of new generation
- Passion
- Scientific way of thinking
- Thinking out of the box
- Cooperative skills

"Reaching out to the broad public, to teachers, policy makers, science communicators and in particular to young generation is important to keep the light of science shining brightly in the world."

IPPOG
Robert Wilson – justifying building National Accelerator Laboratory (later Fermilab) in front of the Joint Committee on Atomic Energy

**Senator Pastore:** Is there anything connected with the hopes of this accelerator that in any way involves the security of the country?

**Robert Wilson:** No sir, I don’t believe so.

**Pastore:** Nothing at all?

**Wilson:** Nothing at all.

**Pastore:** It has no value in that respect?

**Wilson:** It has only to do with the respect with which we regard one another, the dignity of men, our love of culture. It has to do with are we good painters, good sculptors, great poets? I mean all the things we really venerate in our country and are patriotic about. **It has nothing to do directly with defending our country except to make it worth defending.**
Conclusions

It is great to be part of science community!

You are our ambassadors!