



Round Table on «Lessons from big science projects» The Large Hadron Collider (LHC) at CERN

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CERN, Geneva, Switzerland

Monaco ITER International Fusion Energy Days
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CERN, an international governmental organization with 20 Member States

CERN Geneva
Staff 2500
Budget ~1 Beuro



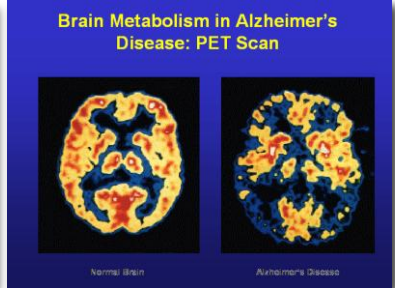
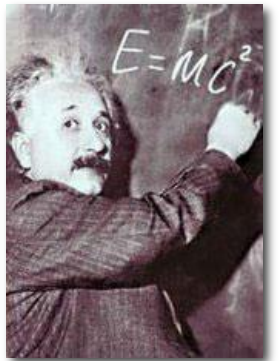
Member States (Dates of Accession)

 AUSTRIA (1959)	 DENMARK (1953)	 GREECE (1953)	 NORWAY (1953)	 SPAIN (1/1961-12/1968-1/1983)
 BELGIUM (1953)	 FINLAND (1991)	 HUNGARY (1992)	 POLAND (1991)	 SWEDEN (1953)
 BULGARIA (1999)	 FRANCE (1953)	 ITALY (1953)	 PORTUGAL (1986)	 SWITZERLAND (1953)
 CZECH FR (1993)	 GERMANY (1953)	 NETHERLANDS (1953)	 SLOVAK FR (1993)	 UNITED KINGDOM (1953)



The missions of CERN

- **Push forward** the frontiers of knowledge
- **Develop** new technologies
- **Train** scientists and engineers of tomorrow
- **Unite** people from different countries and cultures





Discovery of Higgs boson made the news, from science journals to the media

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ELSEVIER

PHYSICS LETTERS B

Available online at www.sciencedirect.com
SciVerse ScienceDirect

The cover features two scientific plots. The top plot shows the ratio of signal to background events, $S/(S+B)$, weighted by 1.5 GeV, as a function of the Higgs boson mass m_H in GeV. The data points (black dots) are fitted with a solid line (S+B fit). A magnifying glass highlights a region around 125 GeV. The plot includes two background components: $\sigma_{1\sigma}$ (yellow shaded area) and $\sigma_{2\sigma}$ (green shaded area). The bottom plot is the ATLAS 2011-12 search for the Higgs boson at $\sqrt{s} = 7-9$ TeV. It shows the local significance p_0 on a logarithmic scale versus m_H in GeV. The observed significance is shown as a solid black line, and the expected significance for a 1-sigma discovery is shown as a blue shaded area. Horizontal dashed lines indicate significance levels of 2-sigma, 3-sigma, 4-sigma, 5-sigma, and 6-sigma.

<http://www.elsevier.com/locate/physletb>

The Economist

JULY 7TH - 13TH 2012 Economist.com

- In praise of charter schools
- Britain's banking scandal spreads
- Volkswagen overtakes the rest
- A power struggle at the Vatican
- When Lonesome George met Nora

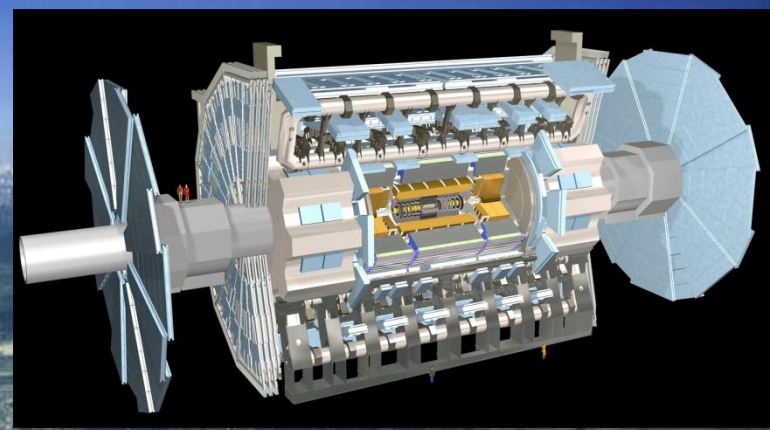
A giant leap for science

The cover of The Economist features a man in a dark suit jumping over a vibrant, colorful nebula in space. The man is holding papers, and the scene is set against a starry background.

Finding the Higgs boson



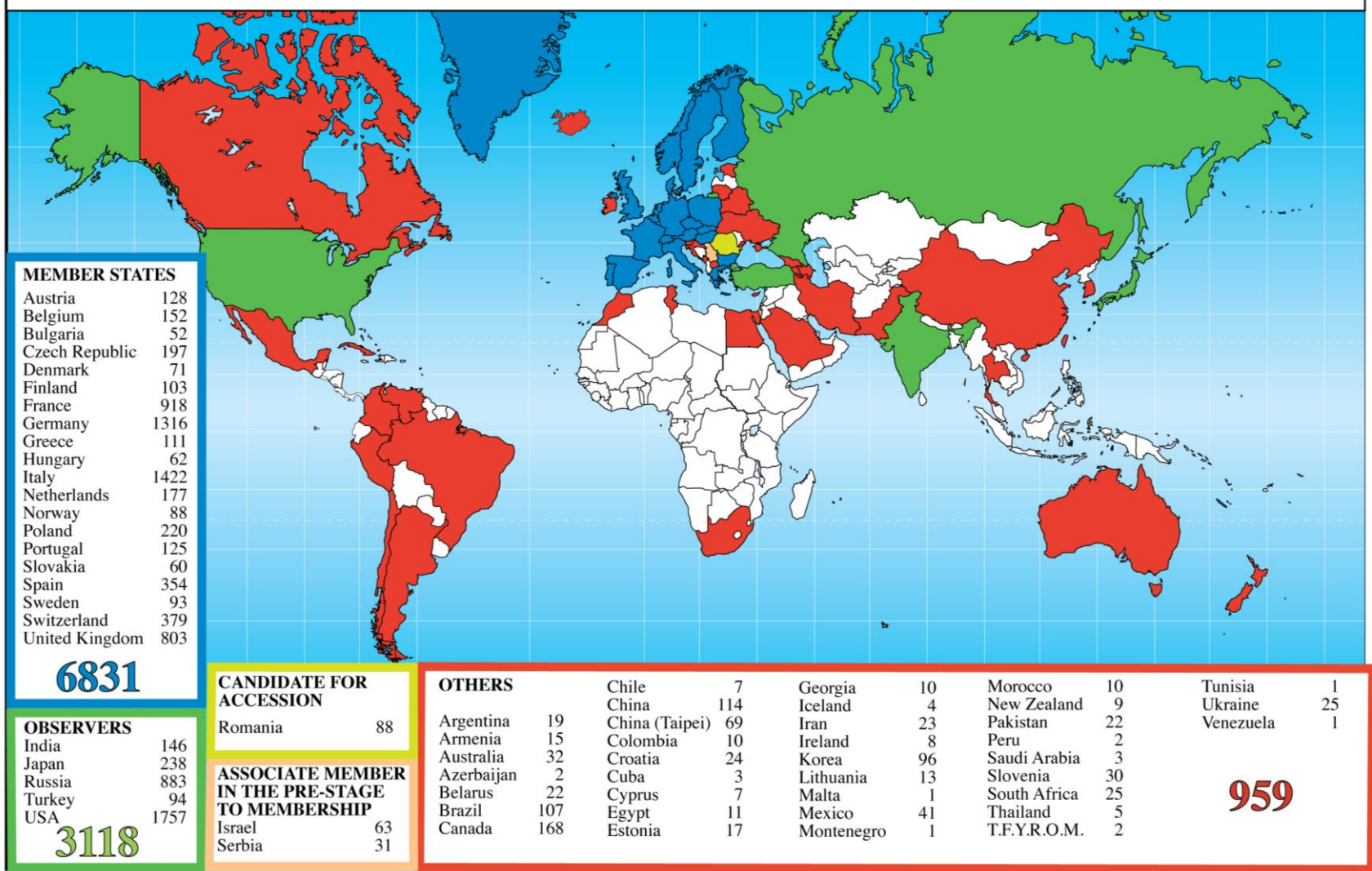
The LHC, largest scientific instrument in the world... 27 km in circumference





...serving the community of particle physicists
12'000 users from around the world

Distribution of All CERN Users by Location of Institute on 14 January 2013

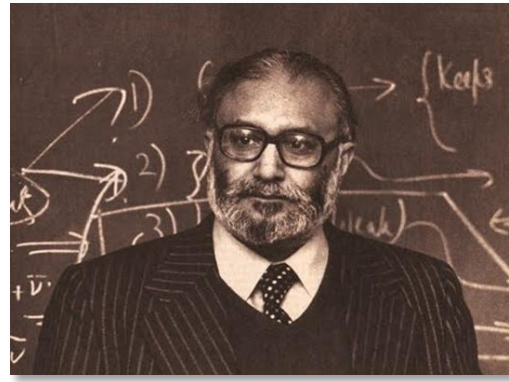
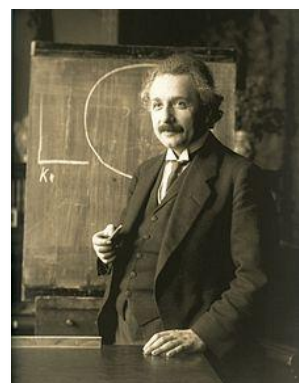
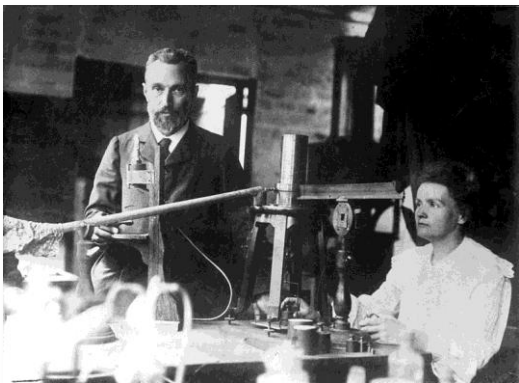




Particle physics is international

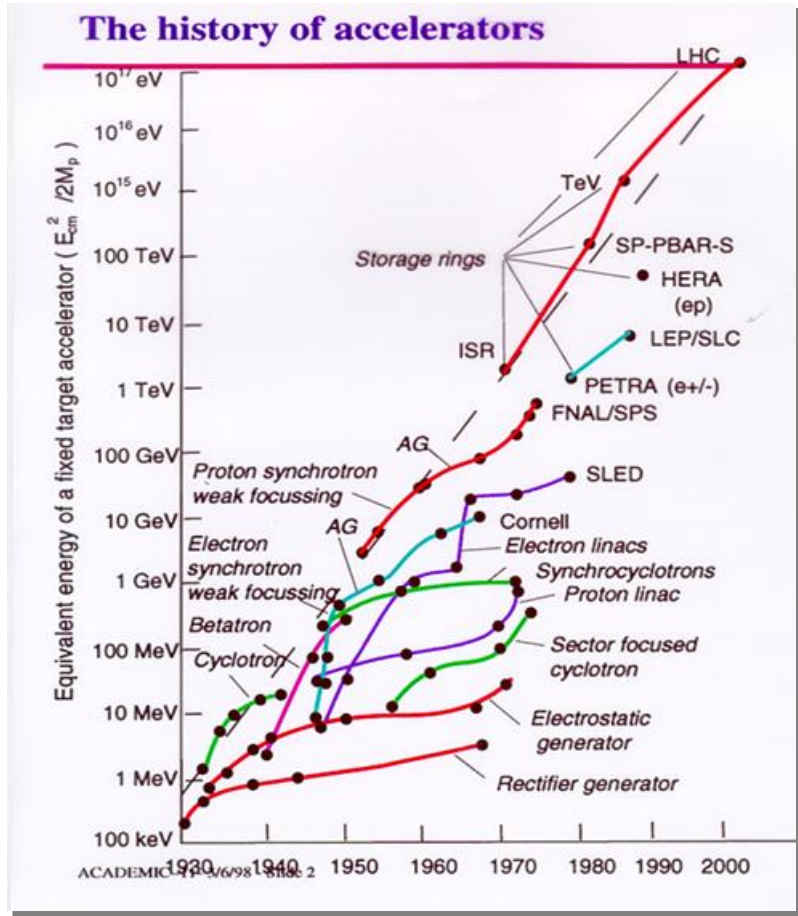
- **By nature**

Science has no national borders



- **By necessity**

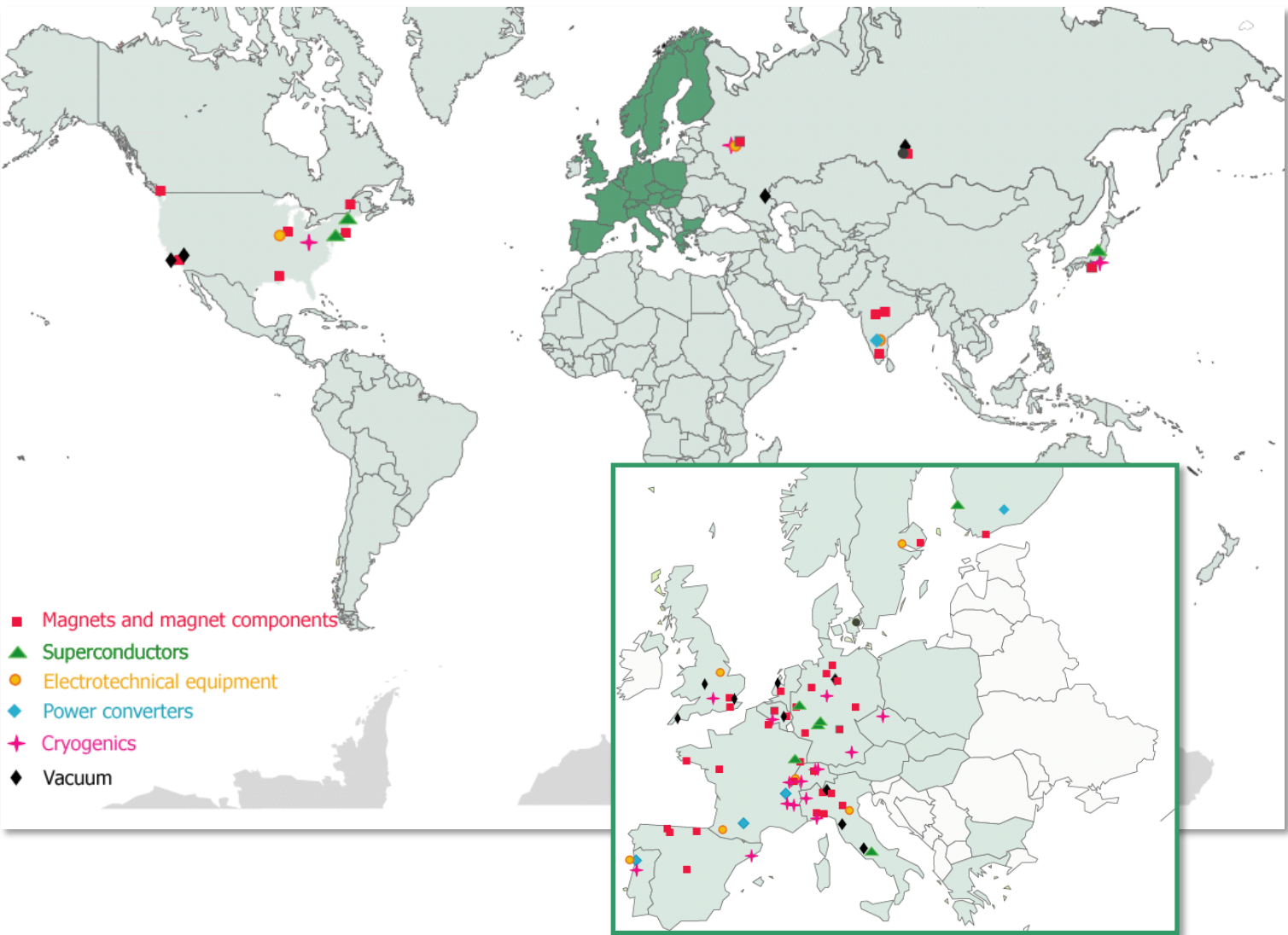
Pooling resources to afford large instruments





LHC engineering & technology are also international

100 major high-tech industrial contracts

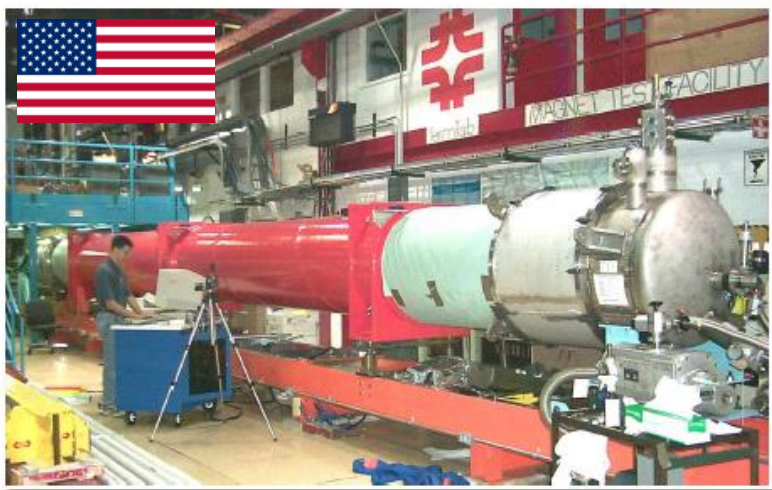




In-kind contributions

LHC detectors ~ 80 % (Member and non-member states)

LHC accelerator ~ 15 % (Non-member and host states)





A central issue: managing in-kind contributions

- **Definition & allocation**

- Match project needs, technical competencies, economic and political interests
- Achieve cost effectiveness w. r. to world market prices
- Preserve “fair return” to Member States

- **Execution**

- International procurement and local culture: importance of involving local institutes (not just funding “Domestic Agencies”) in follow-up of high-tech supplies
- Project team (“IO”) must maintain sufficient in-house resources to handle emergency situations which **will** occur: non-conformities, QA problems, delays, company insolvencies...



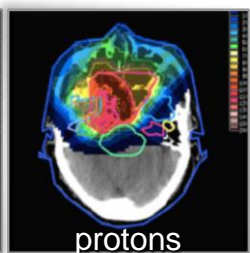
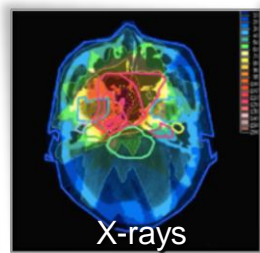
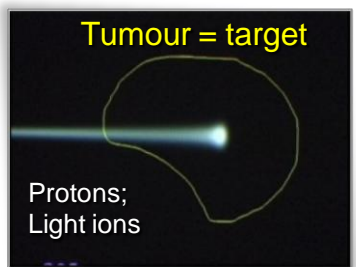
Science for the citizen [1/3] Knowledge and technology transfer

• Accelerators and detectors for medicine

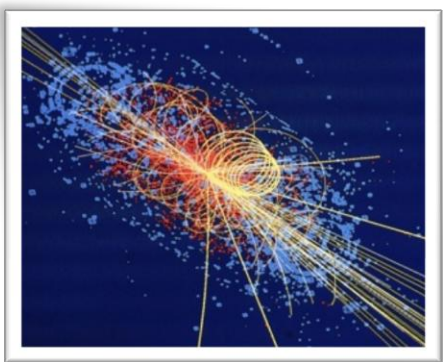


Hadron Therapy

Accelerating particles
~30'000 accelerators worldwide
~17'000 used for medicine



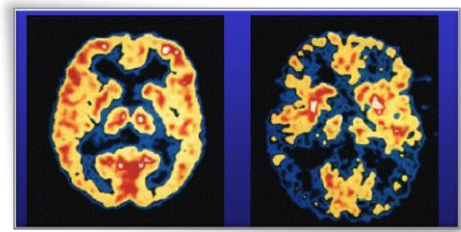
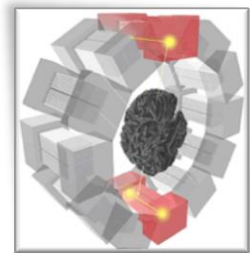
>70'000 patients treated worldwide (30 facilities)
>21'000 patients treated in Europe (9 facilities)



Imaging

PET Scanner

New breast imaging.
Clinical trial in Portugal.
(ClearPEM)



Detecting particles

Normal brain

Alzheimer's disease



Science for the citizen [2/3]

Knowledge and technology transfer

- **Patenting or free access?**

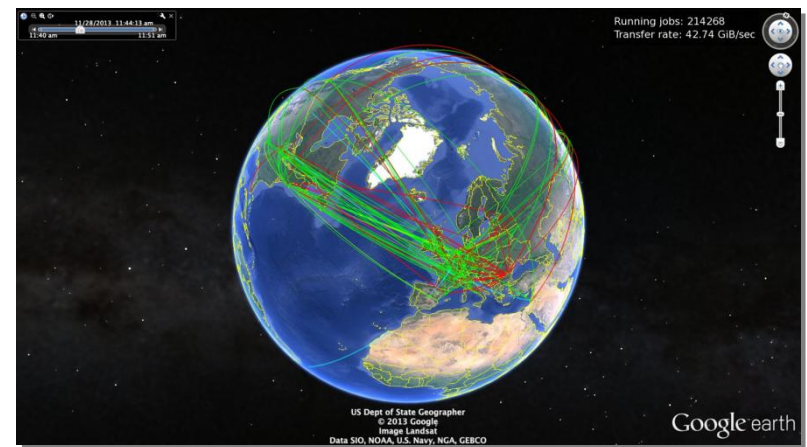
- **The WWW**

Internet for everyone



- **GRID computing**

also used for geosciences,
climatology, pollution analysis
pharmacology *in silico*,
epidemiology,...



- **Open Access Publishing**

SCOAP3 initiative: 10 open-access journals in particle physics

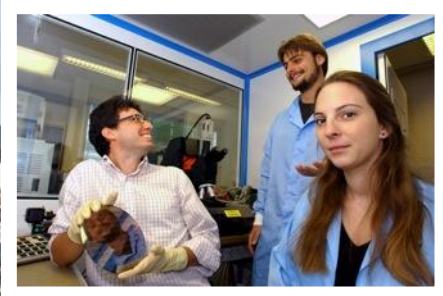


Science for the citizen [3/3]

Knowledge and technology transfer

- **Education & training programs**

Students
Doctoral and technical students
Summer student programme
Short-term internship programme



Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

School Teachers
International and National Programmes





Conclusions

The sole end of science is the honor of the human mind...

Carl Gustav Jacobi

- ...however, large scientific projects such as the LHC and ITER
- require massive investment of human and material **resources** and high level of **organization**
- stimulate **R&D** in critical technologies beyond the pre-existing state-of-the-art
- are powerful factors of **international cooperation**
- provide important **training** opportunities
- generate important **technological spin-offs** contributing to solve some of the important issues facing society