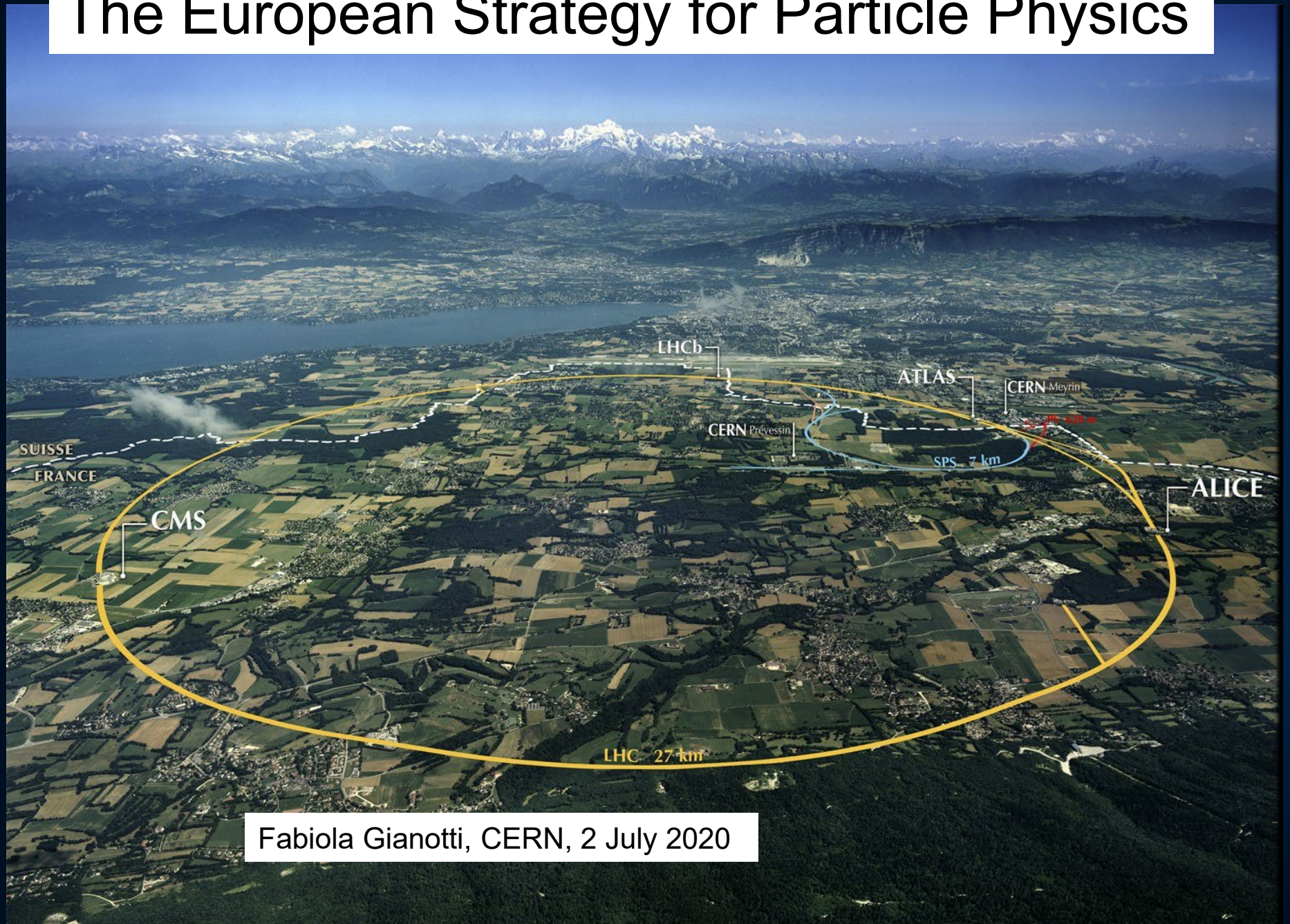
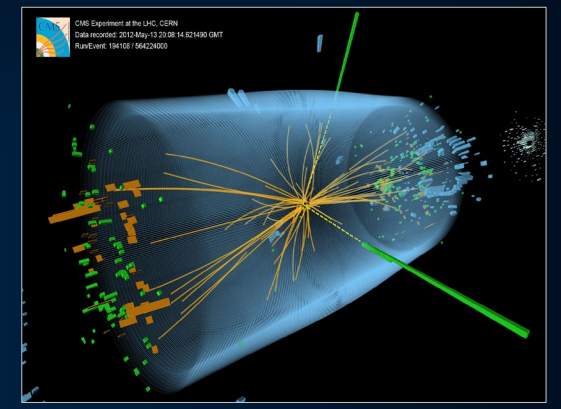
The European Strategy for Particle Physics





Fabiola Gianotti, CERN, 2 July 2020

Introduction

The ESPP is the process by which every ~ 7 years the European particle physics community updates the scientific priorities and strategy of the field.
It also makes recommendations on related activities: education, communications and outreach, technology transfer, relations with industry, organisational aspects, etc.

First ESPP in 2006; first update in 2013; second update 2020.

Bottom-up process involving the community. Driven by physics*, with awareness of financial and technical feasibility.

ESPP produces the European roadmap in the worldwide context of the field.
Note: particle physics requires global coordination, given the number, size and complexity of the projects → alignment of the European, US and Japanese roadmaps in recent years to optimise the use of resources

The Strategy is adopted by the CERN Council → on 19 June CERN's Council decided unanimously and enthusiastically to update the Strategy
Note: individual (major) projects require dedicated, separate approval

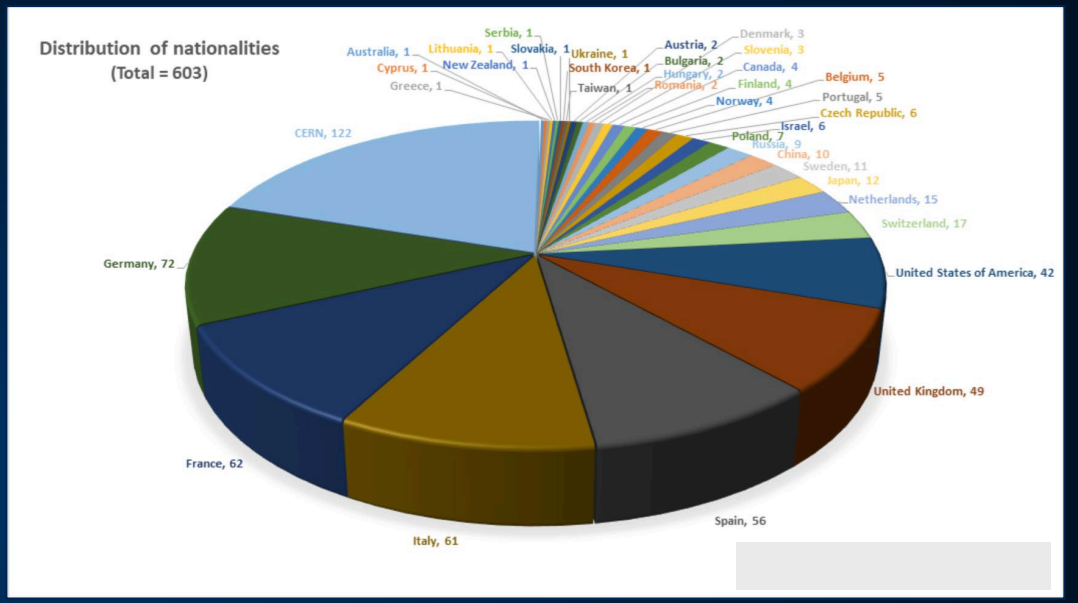
* The scientific input includes: physics results from current facilities from all over the world; physics motivations, design studies and technical feasibility of future projects; results of R&D work, etc.

A community-driven process

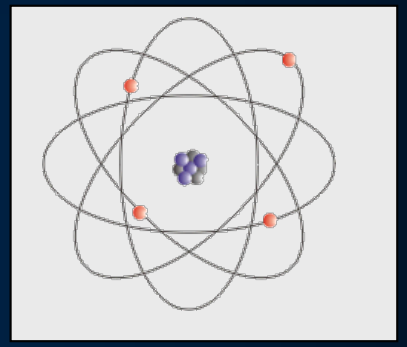
Open Symposium in Granada, Spain, 13-16 May 2019

Large attendance: ~ 600 people
(12% from non-European countries)

Very nice talks, many good discussions



Discovery of the Higgs boson at the LHC in 2012 → Nobel Prize in Physics in 2013



Note: a world without the Higgs boson would be very strange. Atoms would not exist → universe would be very different

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".*

Outstanding questions in today's particle physics

The Higgs boson is still a mysterious particle: special properties ("quantum numbers"), carries a new type of interaction → can be a door into "new physics". It can only be studied at high-energy colliders

95% of the universe is unknown (dark): e.g. 25% of dark matter

Why is there so little antimatter in the universe ?

What are the features of the primordial plasma permeating the universe ~10 μs after the Big Bang ?

Are there other forces in addition to the known four ?

Etc. etc.

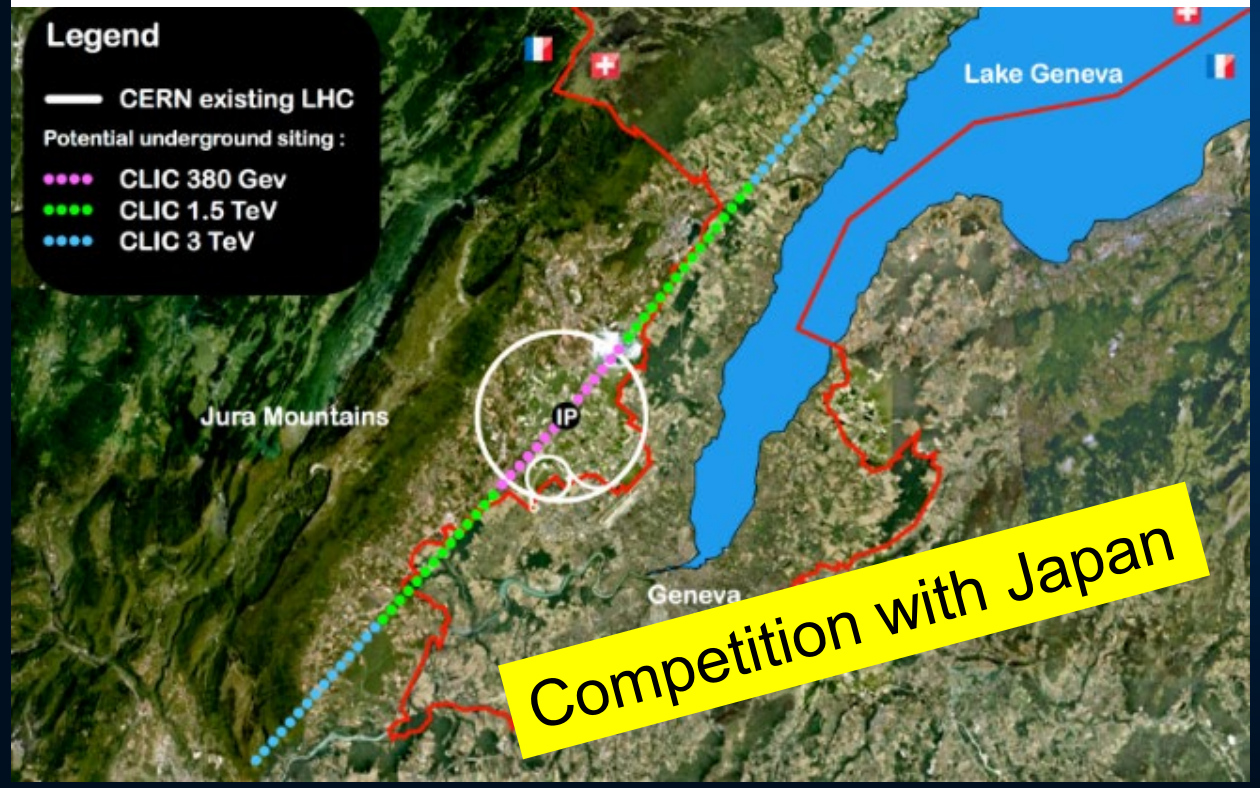
These and other crucial questions require future, more powerful colliders among other endeavours

Which accelerator after the LHC ?

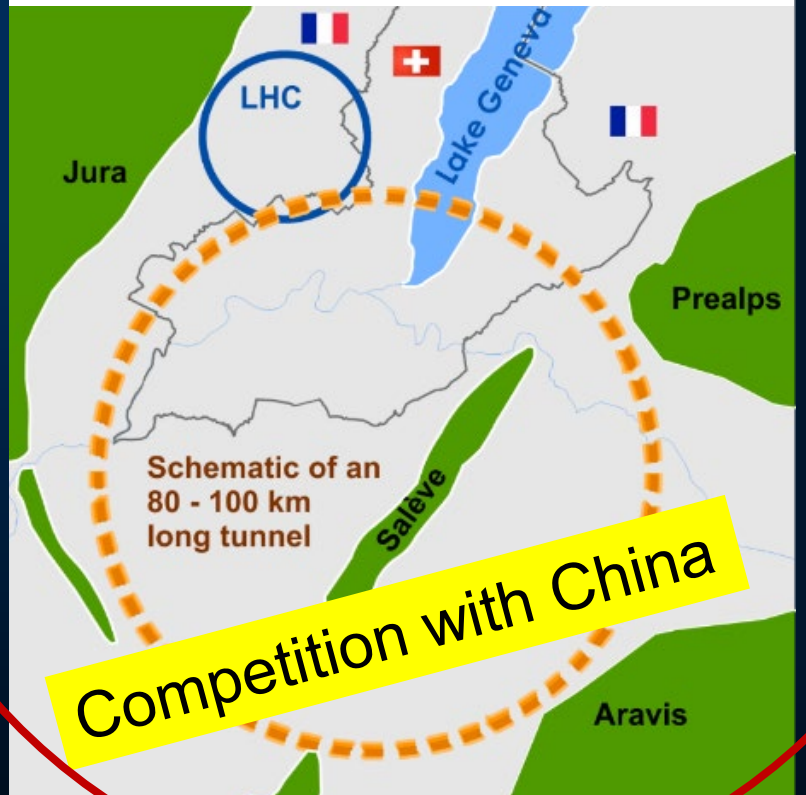
Various options for future, more powerful colliders being studied and the needed, advanced technologies being developed

→ 2020 ESPP recommends feasibility study of FCC

CLIC: e^+e^- linear collider 11 km → 50 km tunnel



FCC: Future Circular Collider: 100 km ring for e^+e^- and proton-proton collisions



Why a future collider at CERN (competition with Asia) ?

CERN should host an ambitious future collider:

- ❑ strong scientific case for it
- ❑ to maintain a leading role for Europe in fundamental physics and related technologies
- ❑ CERN has unique assets:
  - powerful infrastructure and outstanding personnel expertise, built over several decades
  - commitment of Member States → long-term budget stability
  - mission and tradition of international cooperation and open science (from founding Convention)

→ essential pre-requisites for a large, global project

Some of the main “recommendations” of the 2020 Strategy update: general points

Europe, through CERN, has world leadership in accelerator-based particle physics and related technologies. The future of the field in Europe and beyond depends on the continuing ability of CERN and its community to realise compelling scientific projects. This Strategy update should be implemented to ensure Europe’s continued scientific and technological leadership.

The European organisational model centred on closed collaboration between CERN and the national institutes, laboratories and universities in its Member and Associate Member States is essential to the enduring success of the field. The particle physics community must further strengthen this uniqe ecosystem of research centres in Europe.

Particle physics is “global”. The implementation of the Strategy should proceed in strong collaboration with global partners and neighbouring fields (nuclear physics, astroparticle physics, etc.)

Some of the main “recommendations” of the 2020 Strategy update: science

The successful completion of the high-luminosity upgrade of the LHC and the detectors should remain the focal point of European particle physics, together with the continued innovation in experimental techniques.

An electron-positron “Higgs factory” is the highest priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energies. Accomplishing these compelling goals will require innovation and cutting-edge technology:

-- ramp up accelerator R&D efforts, in particular for high-field superconducting magnets

-- investigate the technical and financial feasibility of a future ≥ 100 TeV hadron collider at CERN, with an e^+e^- Higgs and electroweak factory as a possible first stage. Feasibility study to be completed by next ESPP (~ 2026).

Strong support to other scientific activities: scientific diversity programme complementary to colliders, theory, neutrino physics, detector R&D, software and computing developments.

Some of the main “recommendations” of the 2020 Strategy update: impact on society

Support to Open Science: one of CERN’s core missions!

Environment: minimise impact of particle physics projects; continue to work on saving and re-use of energy

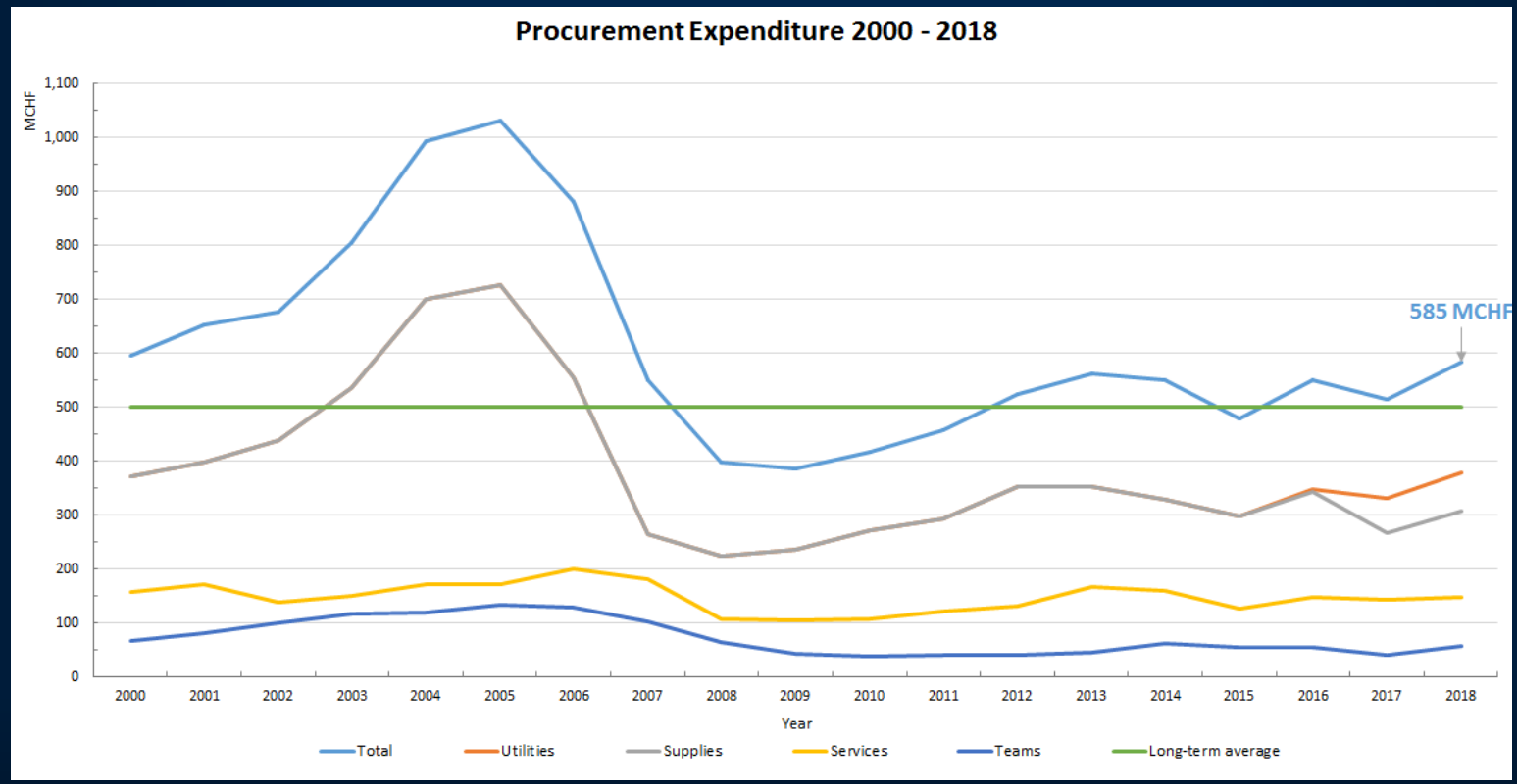
Training of early-career scientists: to create a pool of talents for particle physics and industry

Knowledge transfer to society: the particle physics community should engage with industry to facilitate kowledge transfer and technological development.

Support to public engagement, communications and outreach

Doing business with CERN: procurement expenditure

On average CERN's annual expenditure on procurement is 500 MCHF, mainly in high-tech European industry



Doing business with CERN: what do we buy ?

Civil engineering

- Construction
- Renovation of buildings
- Metallic structures
- Earthworks
- Roads

Electrical engineering and magnets

- Transformers
- Switchboards and switchgear
- Cables
- Automation
- Power supplies
- Magnets

Information Technology

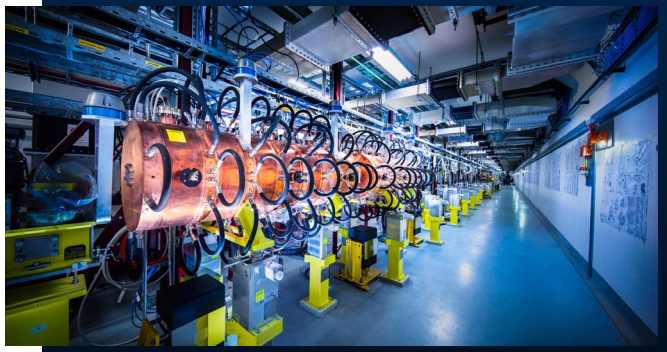
- Computing systems
- Servers
- Software
- Network equipment
- Personal computer equipment

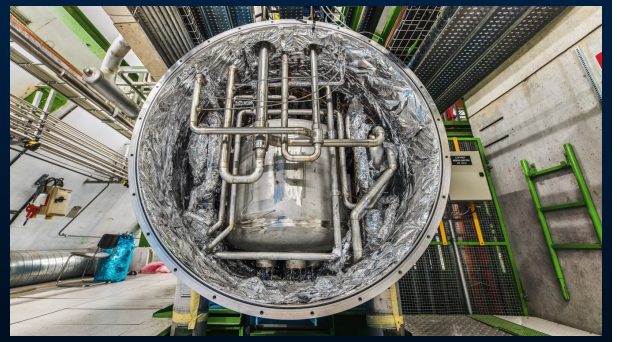
Mechanical engineering and raw materials

- Machining
- Sheet metal work and arc welding
- Special fabrication techniques
- Raw materials, finished and semi-finished products (plates, pipes, etc.)
- Offsite engineering and testing

Electronics and radiofrequency

- Electronic components
- PCBs and assembled boards
- LV and HV power supplies
- Radiofrequency plants
- Amplifiers





As well as

- Cryogenic and vacuum equipment
- Optics and photonics
- Particle and photon detectors
- Health and safety equipment,
- Transport and handling equipment
- Office supply, furniture
- Industrial services on the CERN site

Doing business with CERN: impact on suppliers

supplier survey (669 suppliers in 33 countries, 2017)

48%
improved products and services

42%
developed new products

55%
improved technical knowledge in their field

18%
found or opened a new market to address

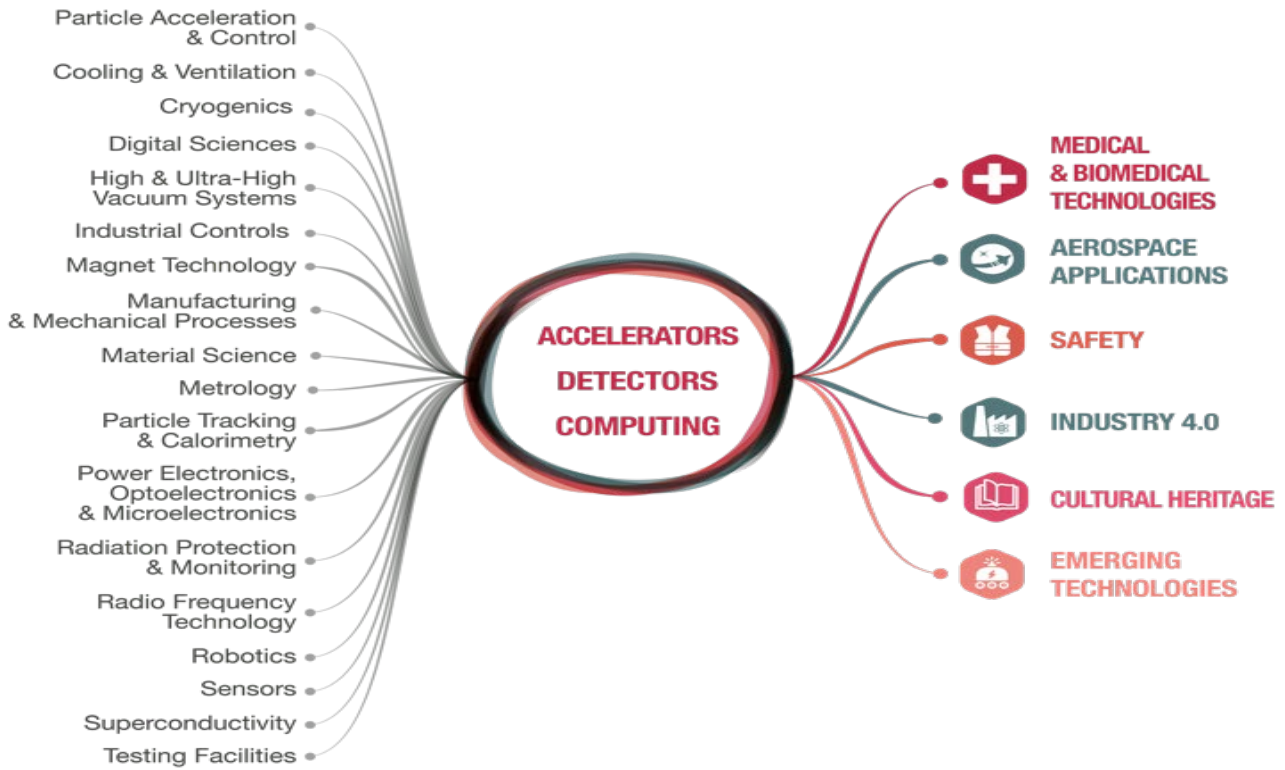
62%
used CERN as a marketing reference

CERN Knowledge Transfer (KT)

Dedicated group in place.

Goals is to maximise dissemination of CERN technologies and their impact on society
→ demonstrate importance to invest in fundamental research.

From CERN technologies…



… to society

The CERN Business Incubation Center Network
33 start-up based on CERN's technologies

Portugal and CERN

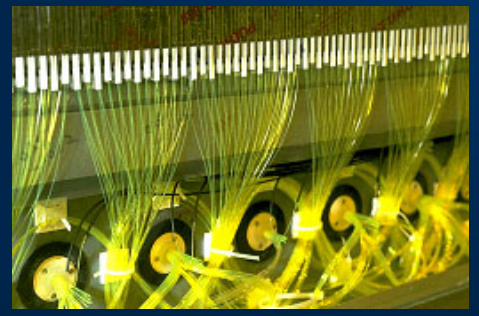
- Portugal joined CERN as a Member State in 1986 → today ~ 200 scientists work at CERN
- The Laboratório de Instrumentação e Física Experimental de Partículas (LIP) was created at the same time to carry out all activities related to experimental particle physics, involving researchers coming from universities as well as LIP's own scientific staff
- Strong participation in LHC (ATLAS, CMS) and other experiments (CLOUD, COMPASS, ISOLDE, nTOF) and strong partner in the GRID
- Strong participation in R&D programmes for medical application (Clear PEM, PET consortium)
- Training/Education:
  - Excellent example of engineer training programme
  - Very successful teacher training and outreach programmes
- Very balanced approach between contributions at CERN and investments at home and very good industrial relations

Contributions to the ATLAS and CMS experiments at LHC

LIP is a member of ATLAS since 1992

Major role in the construction of the TileCal Hadron Calorimeter and Trigger/Data Acquisition system, in collaboration with industry and technology institutes

Robot for fiber insertion.
600 000 fibers inserted in Lisbon and later in Coimbra

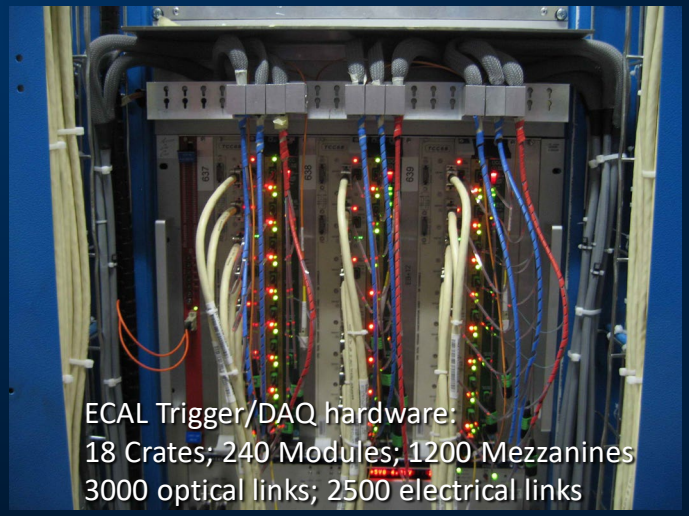


WLS optical fibers routing.
Fiber aluminization done in Lisbon

Detector Commissioning and Operation
Data analysis

LIP is a member of CMS since 1992

Major role in the construction of the Trigger and Data Acquisition of the Electromagnetic Calorimeter, in collaboration with industry and technology institutes



ECAL Trigger/DAQ hardware:
18 Crates; 240 Modules; 1200 Mezzanines
3000 optical links; 2500 electrical links

Detector Commissioning and Operation
Data analysis

Conclusions

The updated European Strategy for Particle Physics is visionary and ambitious, but also realistic and prudent.
It lays the foundations for a bright future for particle physics at CERN and in Europe, within the global context.
It will allow Europe to maintain its leading role in particle physics and related cutting-edge technologies.
It will provide great opportunities for the economies of the Member States and their industries.

José Mariano Gago, Minister for Science, Technology and Higher Education of Portugal, speaking at the Special Restricted Session of the CERN Council devoted to the approval of the first European Strategy for Particle Physics, Lisbon, 14 July 2006

"The next accelerator and the next focus for particle physics research must be in Europe. That is the only way to ensure that the best people throughout the world continue to come to Europe. If, for whatever variety of reasons, we dismantle or connive in the dismantling of what we have achieved at CERN, no-one will understand.
Europe's capacity in the field of particle physics will be dead for many, many years to come and the demise of particle physics would have serious consequences for European science as a whole.
I can tell you that there are many of us in Europe who will never allow that to happen."


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km
Thank You!
CERN