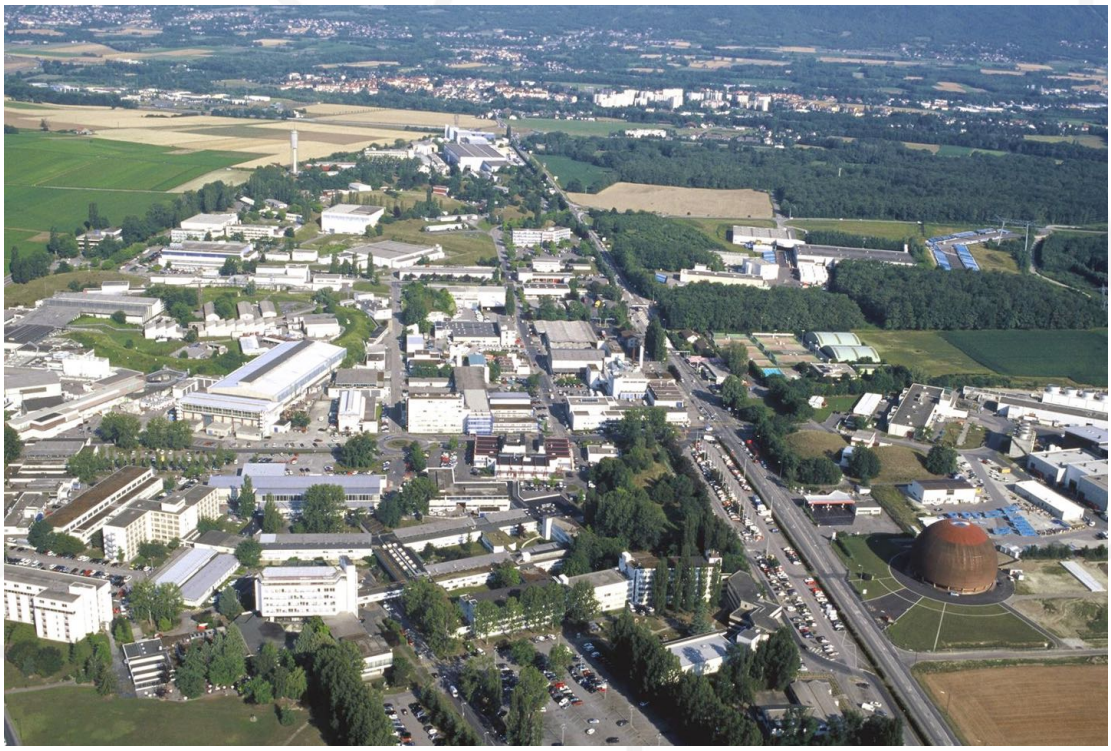
Welcome to the

Swiss High-School Students Internship Programme 2021

Hans Peter Beck – University of Bern

18/10/2021

CERN



C
E
R
N

Conseil Européen pour la Recherche Nucléaire

European **Organization** for Nuclear Research

- **1951** agreement among 11 countries
- **1952** Geneva was selected
- **1954** The Organization is officially born.
  Beginning of construction works
- First physics laboratory built across two countries CH and FR

https://timeline.web.cern.ch

C E R N

Conseil Européen pour la Recherche Nucléaire

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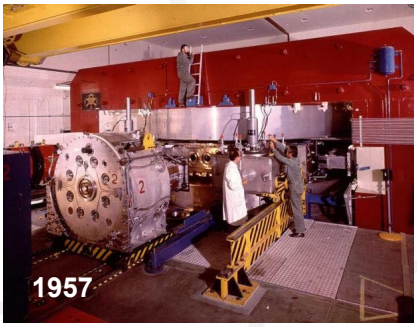
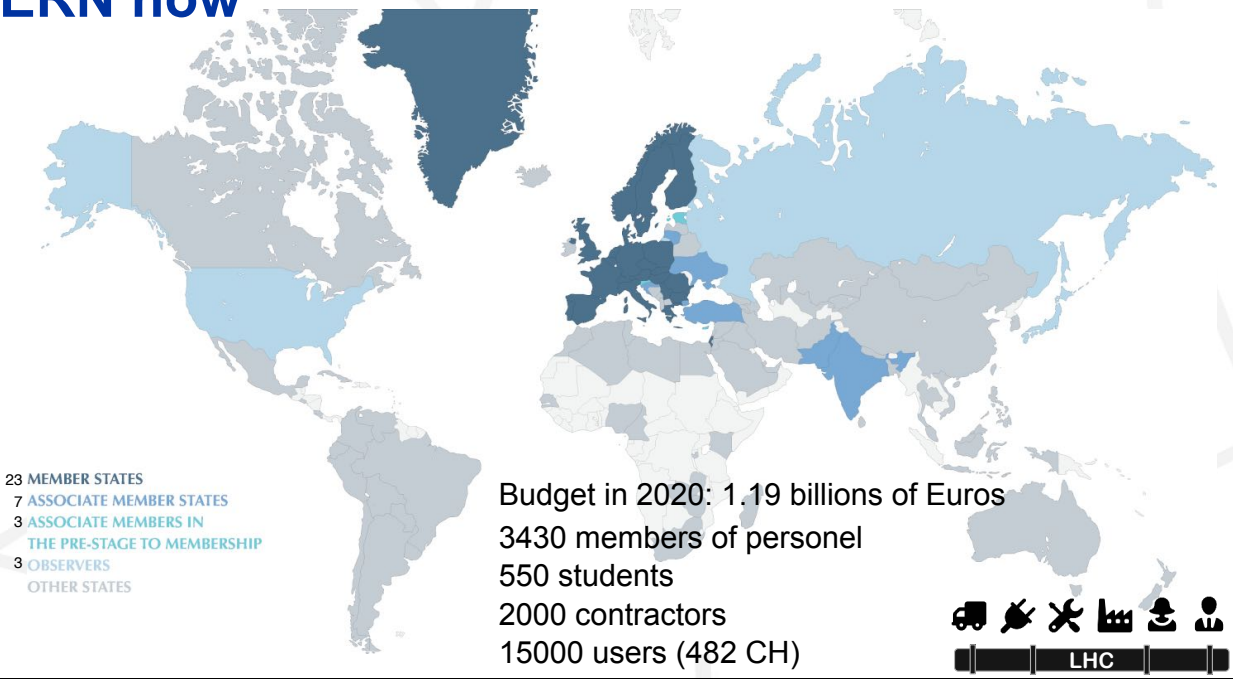


CERN now

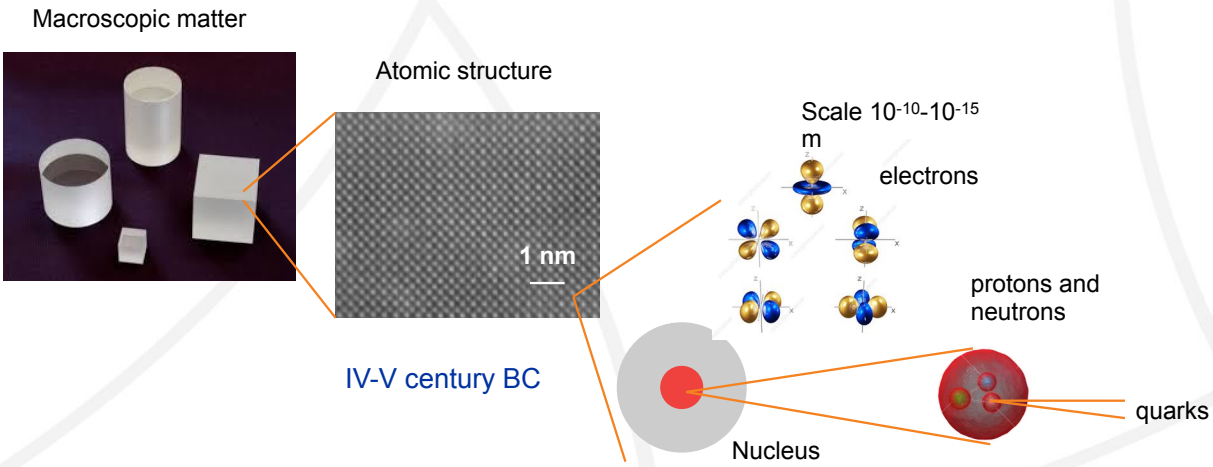


Budget in 2020: 1.19 billions of Euros
3430 members of personel
550 students
2000 contractors
15000 users (482 CH)

CERN mission

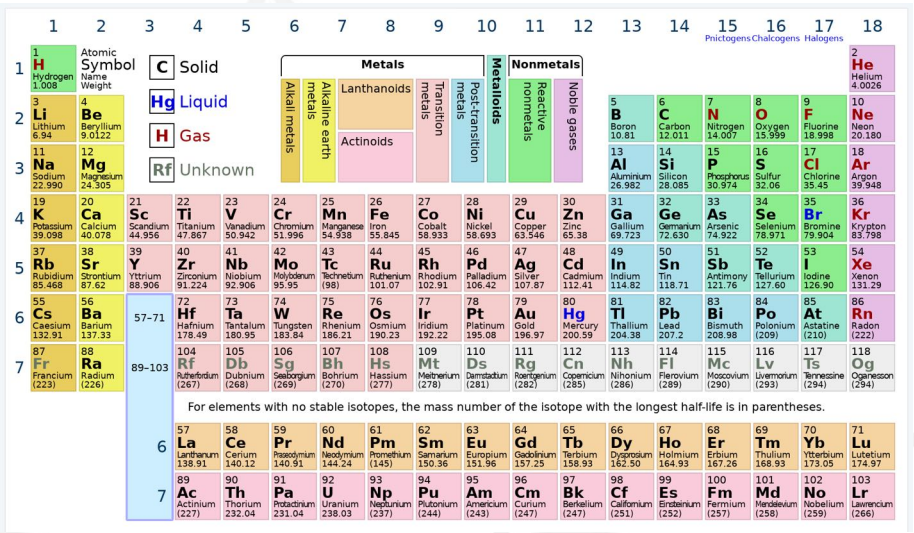
- Provide the facilities for frontend fundamental physics research : accelerators.
- Research in fundamental physics.
- Bring people together and push the frontiers of science and technology for the benefit of all.
- Education of future generations of scientists.

Research at CERN



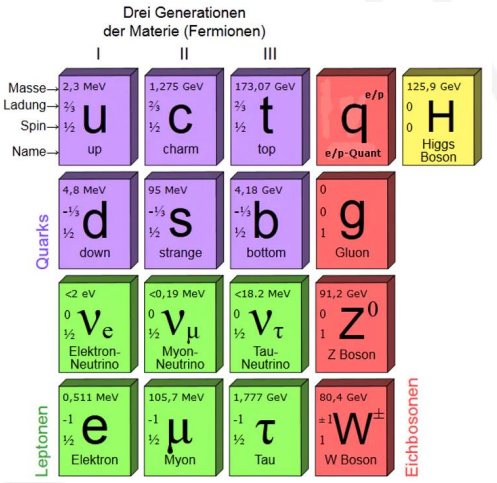
Fundamental constituents of matter and their interactions.

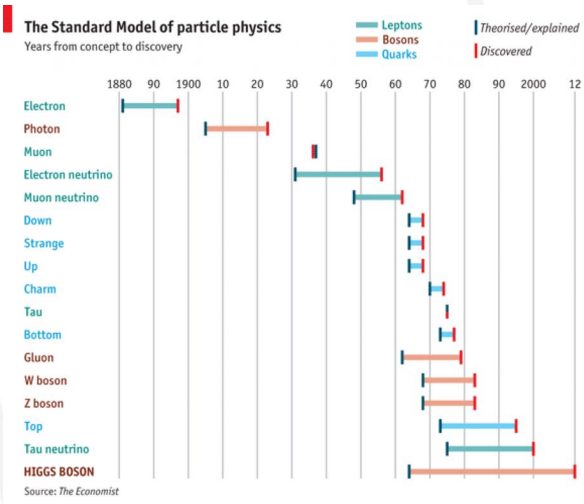
From the periodic table of elements



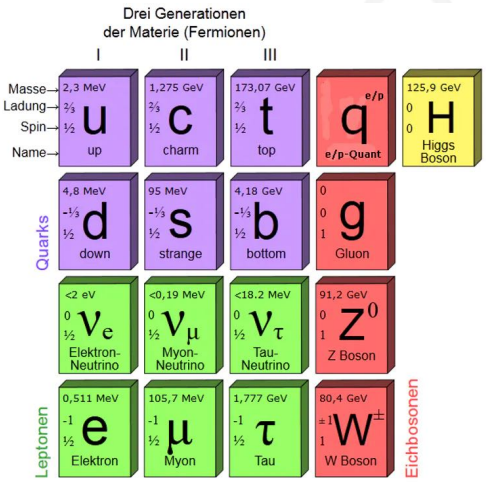
From https://ptable.com

To the standard model of particles





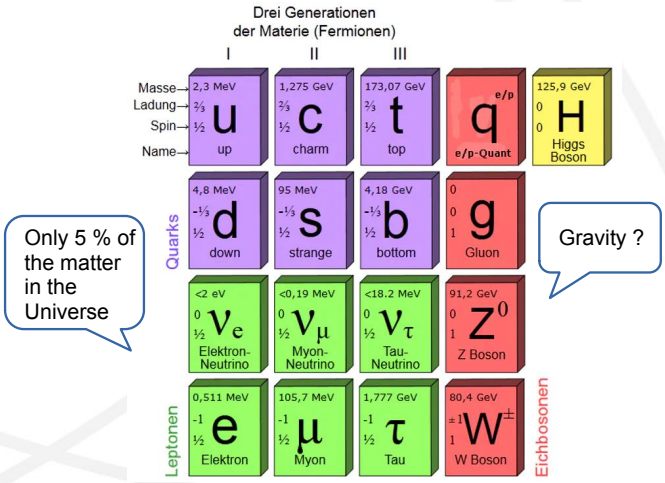
To the standard model of particles



- **The SM is now a theory, confirmed by many experiments.**
- **Is it all, or there is more ?**
- **How gravity can be integrated ?**
- **Why there is no more antimatter ?**
- **What is the dark matter and the dark energy ?**

For each of these particles there is an antiparticle !

To the standard model of particles



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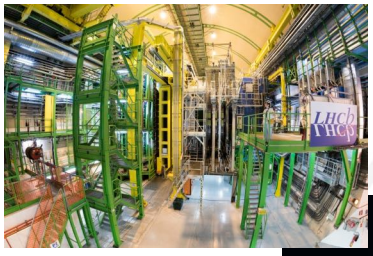
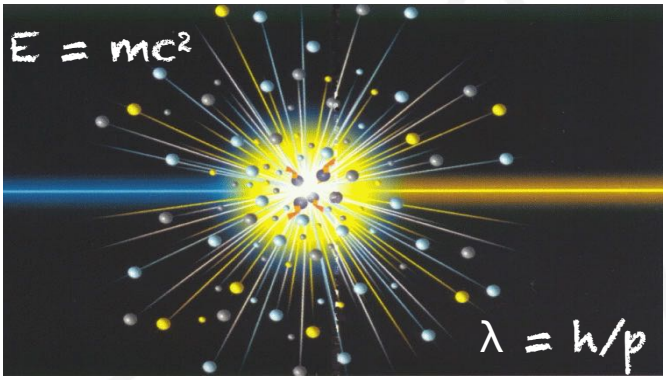
Different purposes – different laboratories





Particle accelerators have a prominent role in this picture

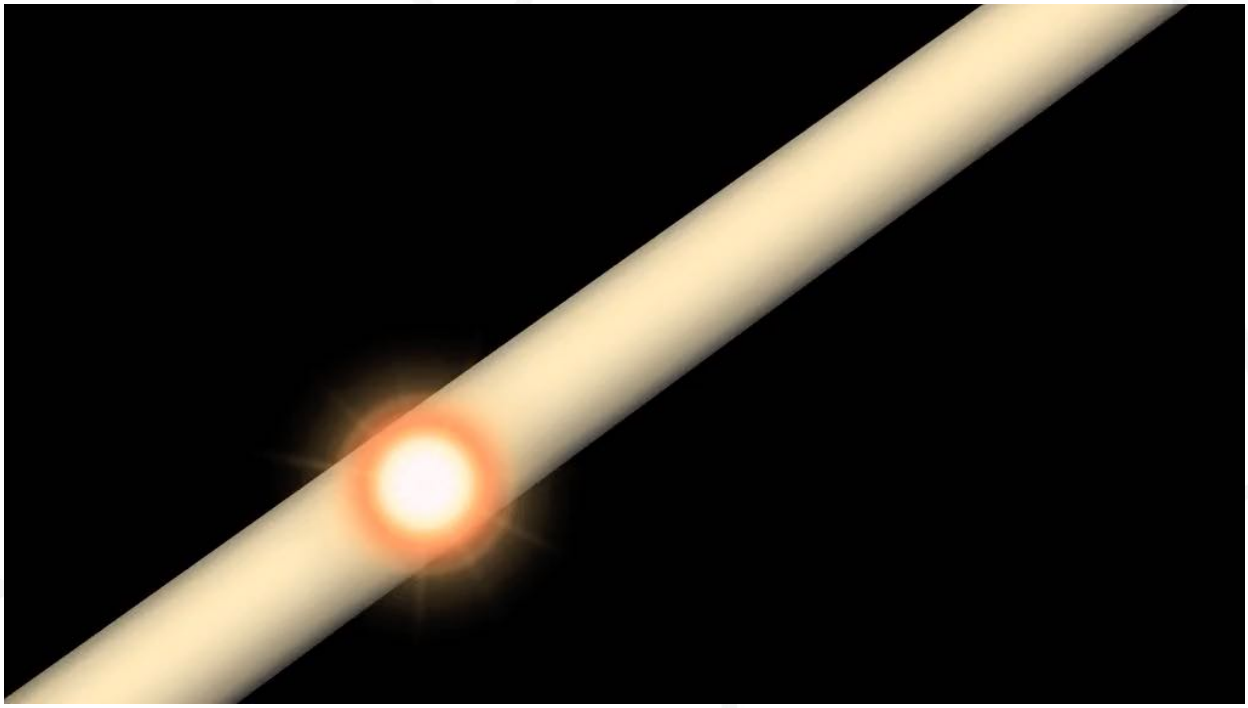
Why particle accelerators?



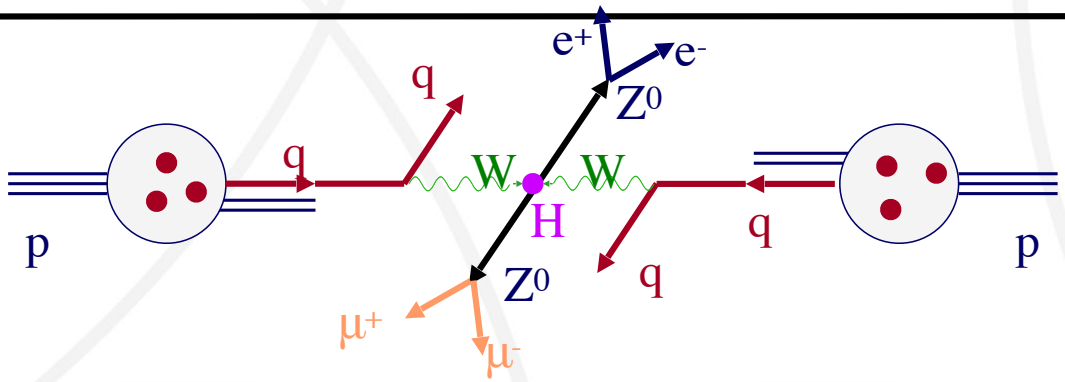
Energy ⟷ Mass

Momentum ⟷ Resolution

- **Particles are accelerated at almost the speed of light.**
- **The particles are made to collide.**
- **The products of these collisions are different from the initial particles.**
- **Particle detectors are our eyes to see the collision products.**



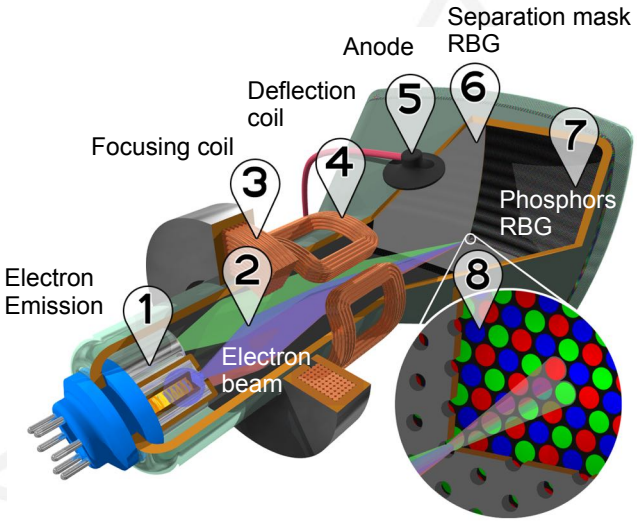
Higgs production in p-p collisions



Discovery 2012, Nobel Prize in Physics 2013

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"*.

A (old-fashioned) TV set is a particle accelerator



Fonte Wikipedia

Phosphors
RBG

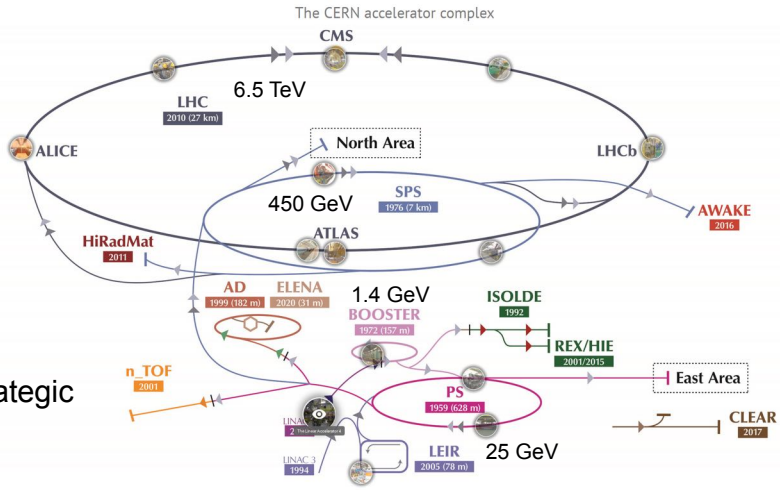
- Electrically charged particle source.
- Electric fields to accelerate.
- Magnetic fields to bend.

CERN Accelerators

CERN has a complex of accelerators produce beams of :

- Protons and anti-protons
- Ions
- Neutrons
- Isotopes

Several experiments are placed in strategic points of the accelerators.

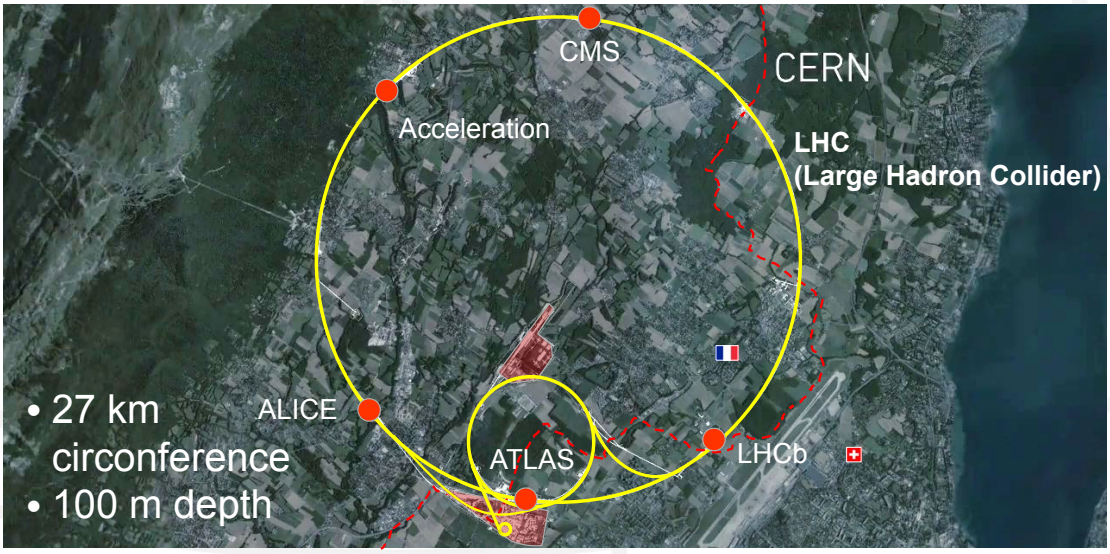


Step 1 : an H2 bottle and a linear accelerator

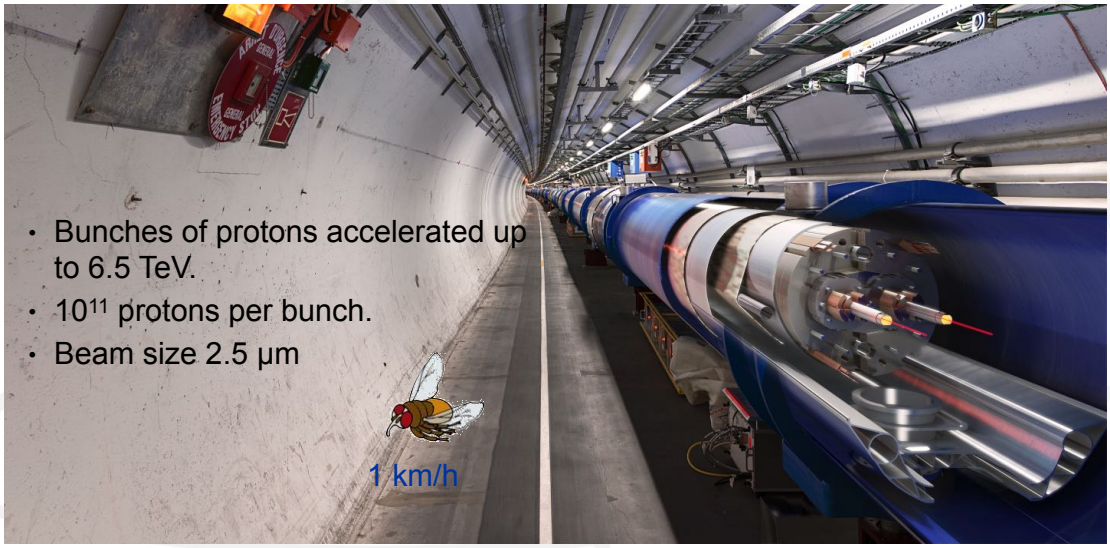
Gas bottle

LINAC4 ca. 76 m, up to 160 MeV

Final step : The Large Hadron Collider



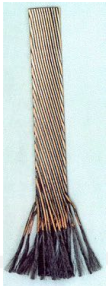
Final step : The Large Hadron Collider

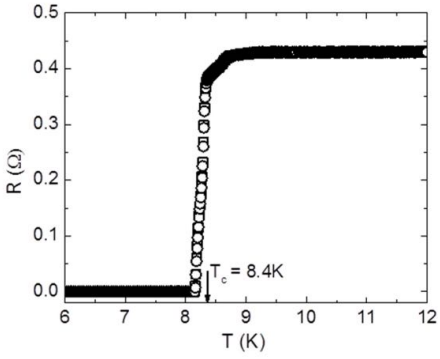


The technology required

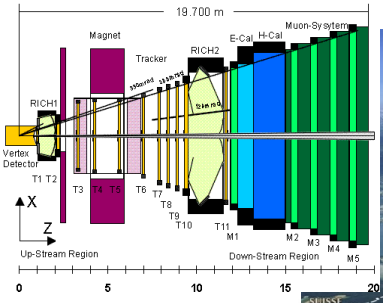
One of the main challenge of the LHC is the production and maintainance of the superconducting magnets.

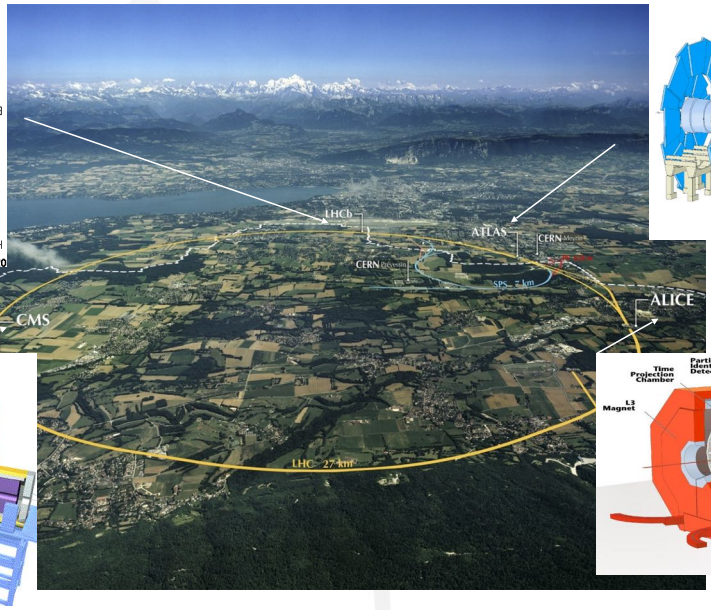
- 1232 magnets to bend the particles.
- 220 000 km of **superconducting wires.**
- Working temperature : 1.9 K (-271.3 C), superfluid Helium.

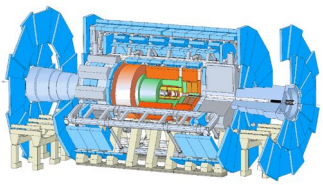


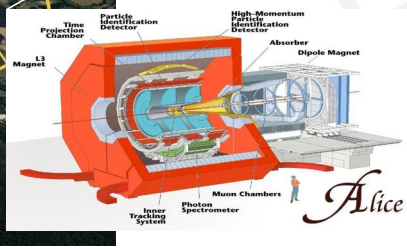


Experiments at the LHC









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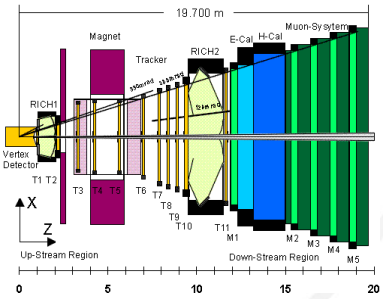
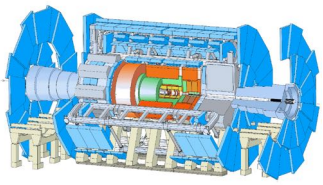


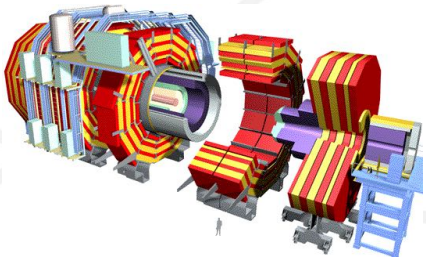
The experiments are international collaborations.

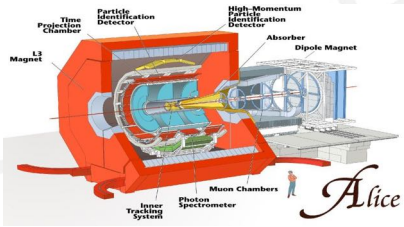
Many research institutions are involved in :

- Design
- Production
- Management
- Resources
- Data analysis etc..

Each experiment has a specific purpose.

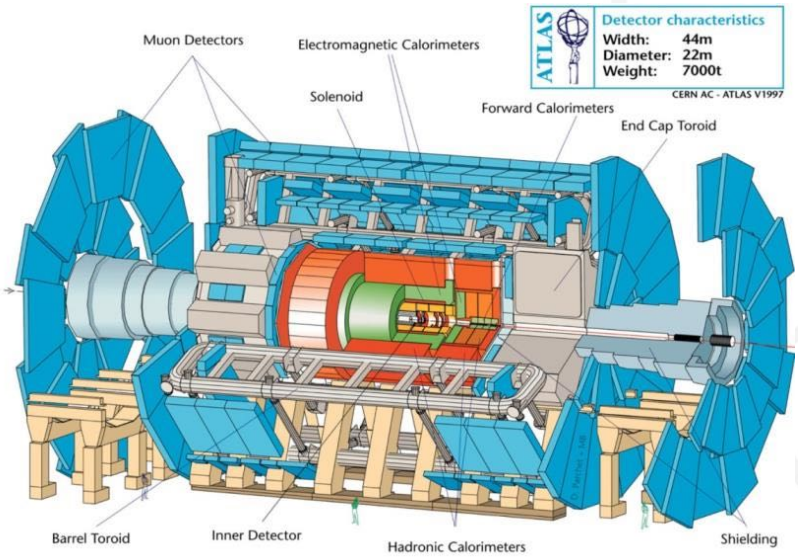




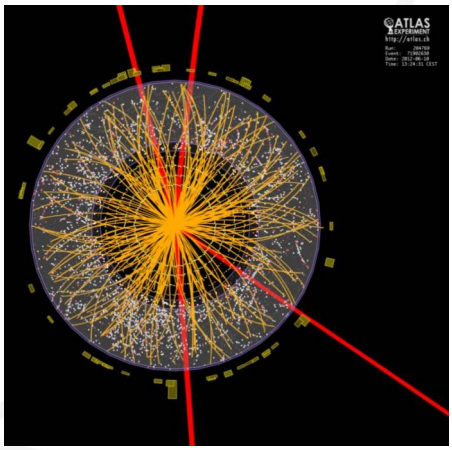


A few words about ATLAS

- Multipurpose detector.
- 46 m long, 25 m in diameter.
- 7000 tons (Eiffel's tower 7300)
- 100 sensors
- 3500 members from 35 countries



Detection of very rare events



- Inside ATLAS or CMS there are 800 million pairs of protons colliding.
- Higgs events are expected only once for 10^{12} collisions.

41 coins

Data filtering

The raw data of ATLAS comes with a rate of 80 TB/s

0.1 s

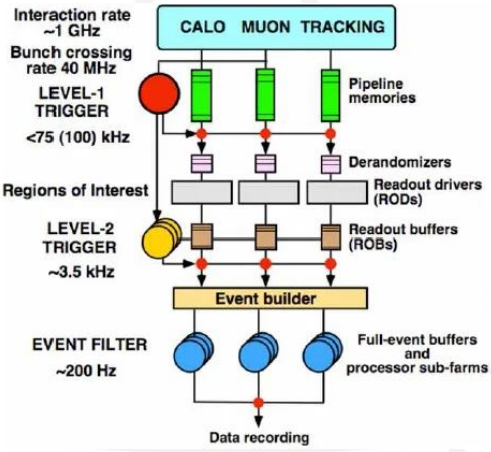
1 day

What would be the height ?

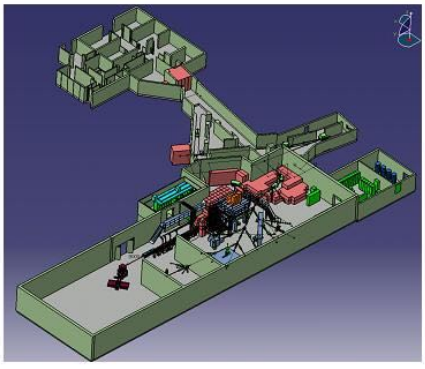
26 km

Data filtering

A system implemented in hardware and software reduces the data of 3 order of magnitudes.

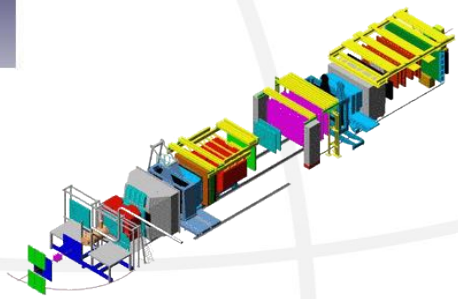


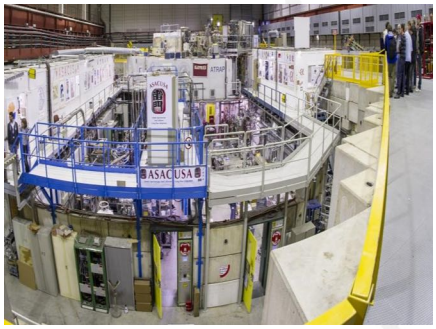
Other CERN experiments



Isolde : Production and research with Isotopes

Fixed target experiments : R&D for detectors, COMPASS (Exploration of hadron structure)

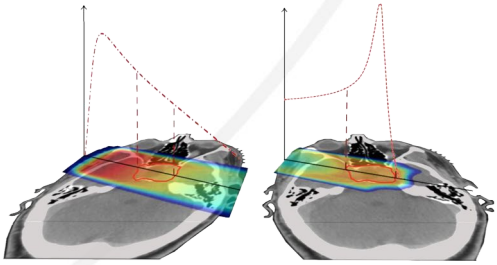




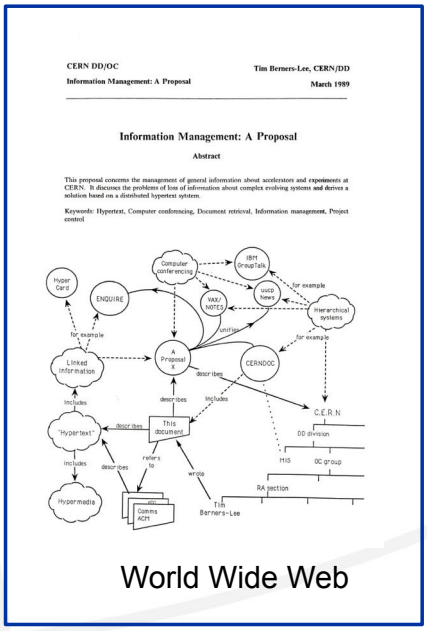
Antimatter Factory

Technological applications

X-rays Protons



Accelerators in medicin. Proton therapy



CERN DD/OC
Information Management: A Proposal

Tim Berners-Lee, CERN/DD
March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext system.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

World Wide Web

And many others

Switzerland and CERN

Strong involvement in the LHC experimental programme
ATLAS, CMS and LHCb
presently: ~ 90 scientists and > 60 PhD students

ATLAS:
University of Bern
University of Geneva

LHCb:
EPFL
University of Zurich

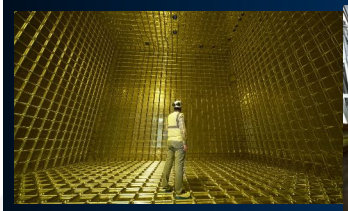
CMS:
ETH Zurich
PSI
University of Zurich

Innovative technologies developed
Swiss industry has played an important role

High performance computing farm (Tier-2) at the Swiss National Supercomputing Center (CSCS), in Lugano (TI), complemented with a farm at Uni Bern, as part of the world-wide computing Grid.
F Pauss

Switzerland and CERN

Important and diverse involvement in many non-LHC experiments
NA61/SHINE, ProtoDUNE, AMS, FASER, ArDM, CLOUD, SHIP, NA64, ISOLDE, ….

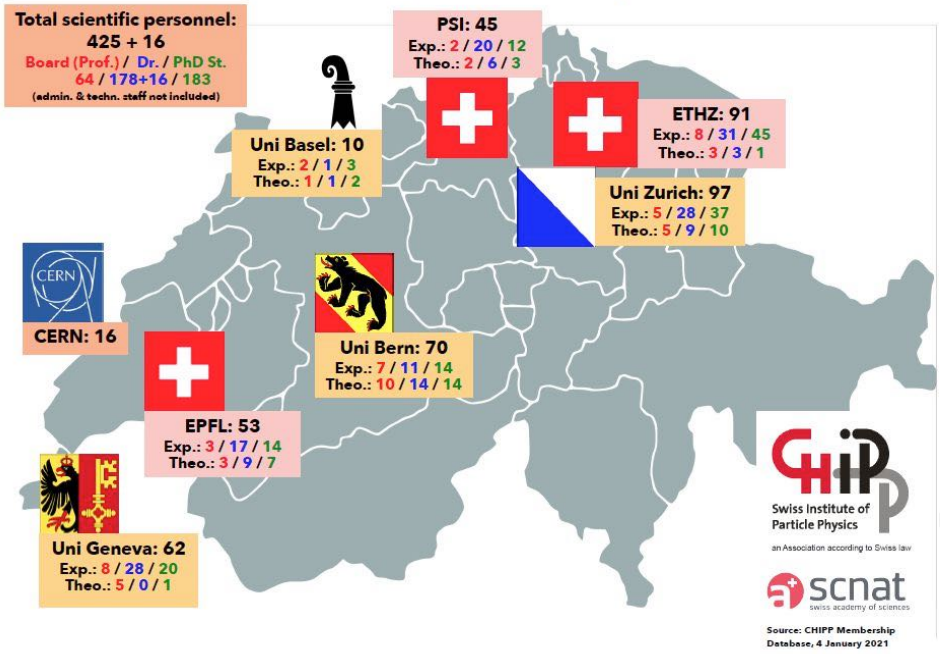


AMS flying on the ISS
(AMS control room at CERN)

CLOUD
Innovative technologies developed
Swiss industry has played an important role

HP Beck

Swiss Particle Physics Landscape 2021



Particle Physicists from all Swiss Universities Universities

Thank you very much !
Questions ?