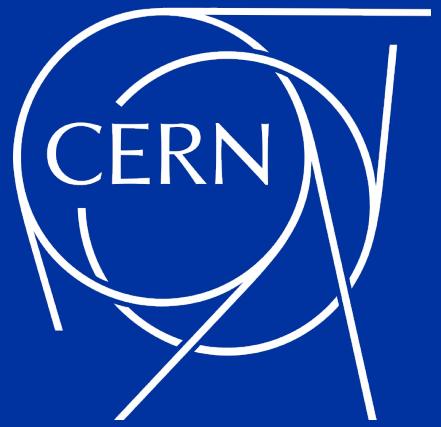

Welcome to CERN

Margherita Boselli

C
E
R
N

Conseil
Européen pour
la
Recherche
Nucléaire

European
Organization for
Nuclear
Research

https://timeline.web.cern.ch

- **1951** agreement among 11 countries (pioneers - Bohr-DK) - provisional council.
- **1952** Geneva was selected
- **29 September1954** The Organisation is officially born, 12 nations signed the convention. Beginning of construction works.
- First physics laboratory built across two countries CH and FR

C
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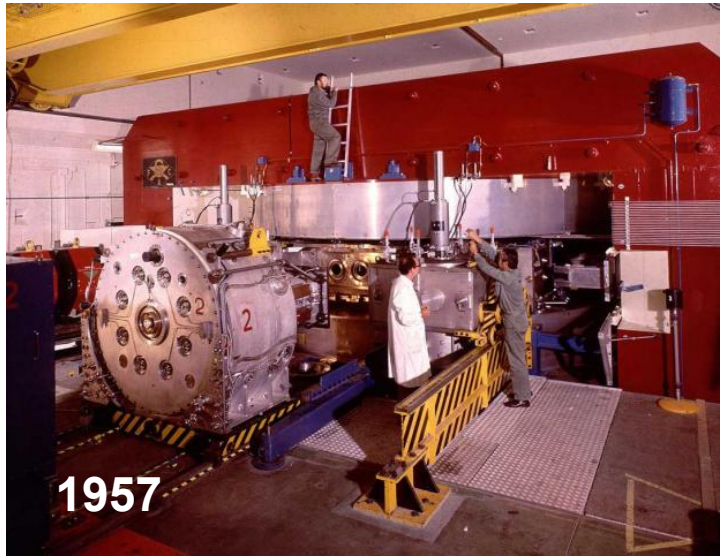
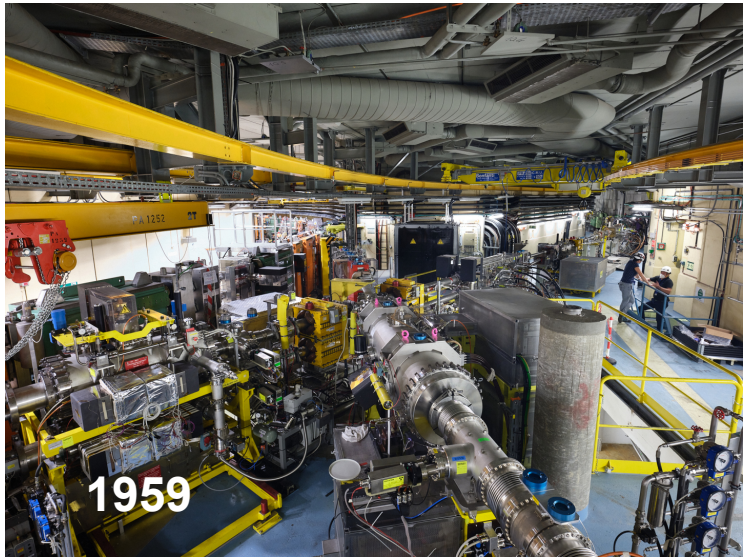
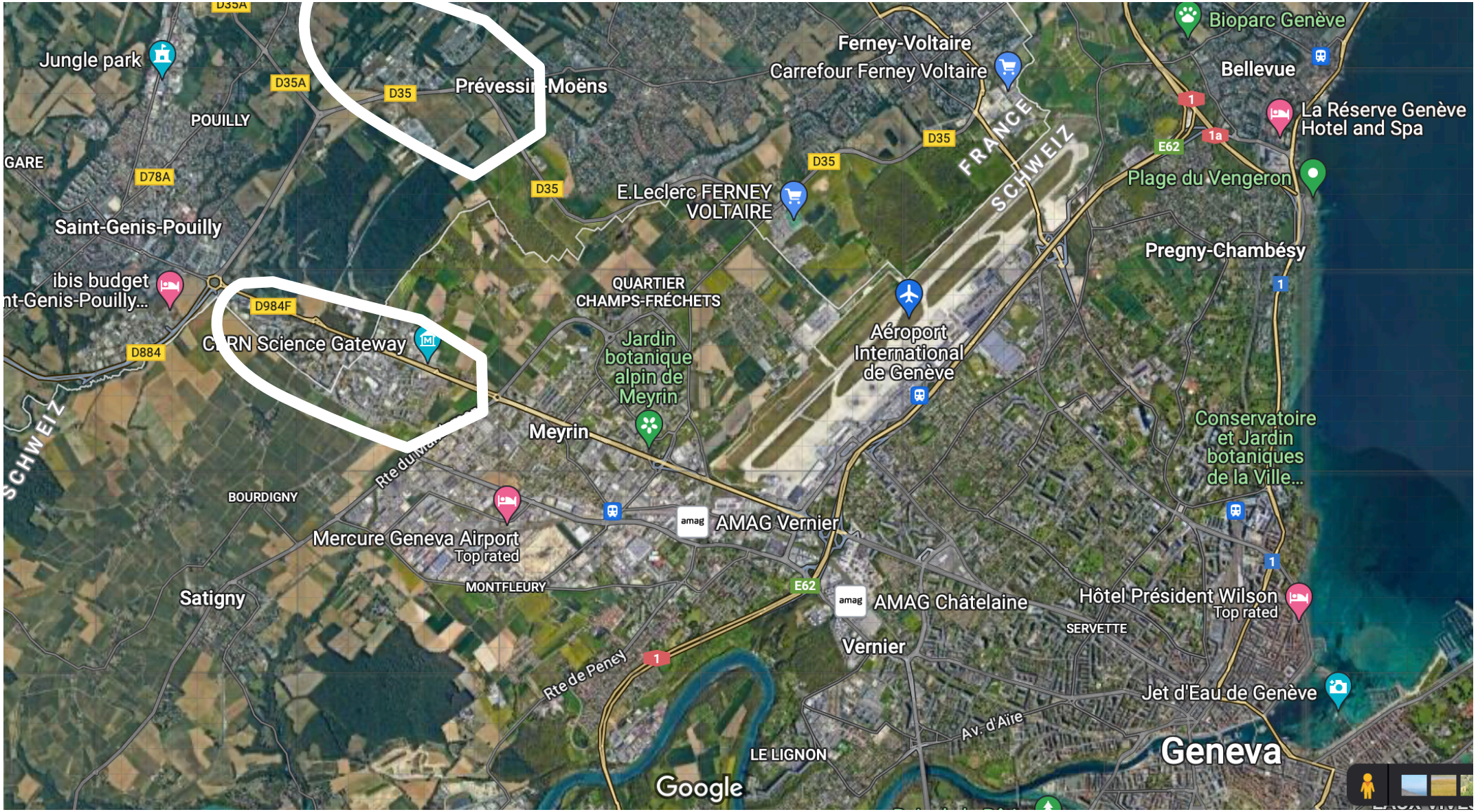
Conseil Européen pour la Recherche Nucléaire

European **Organization** for Nuclear Research






Jungle park
D35A
D35
Prévessin-Moëns
POUILLY
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Saint-Genis-Pouilly
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D984F
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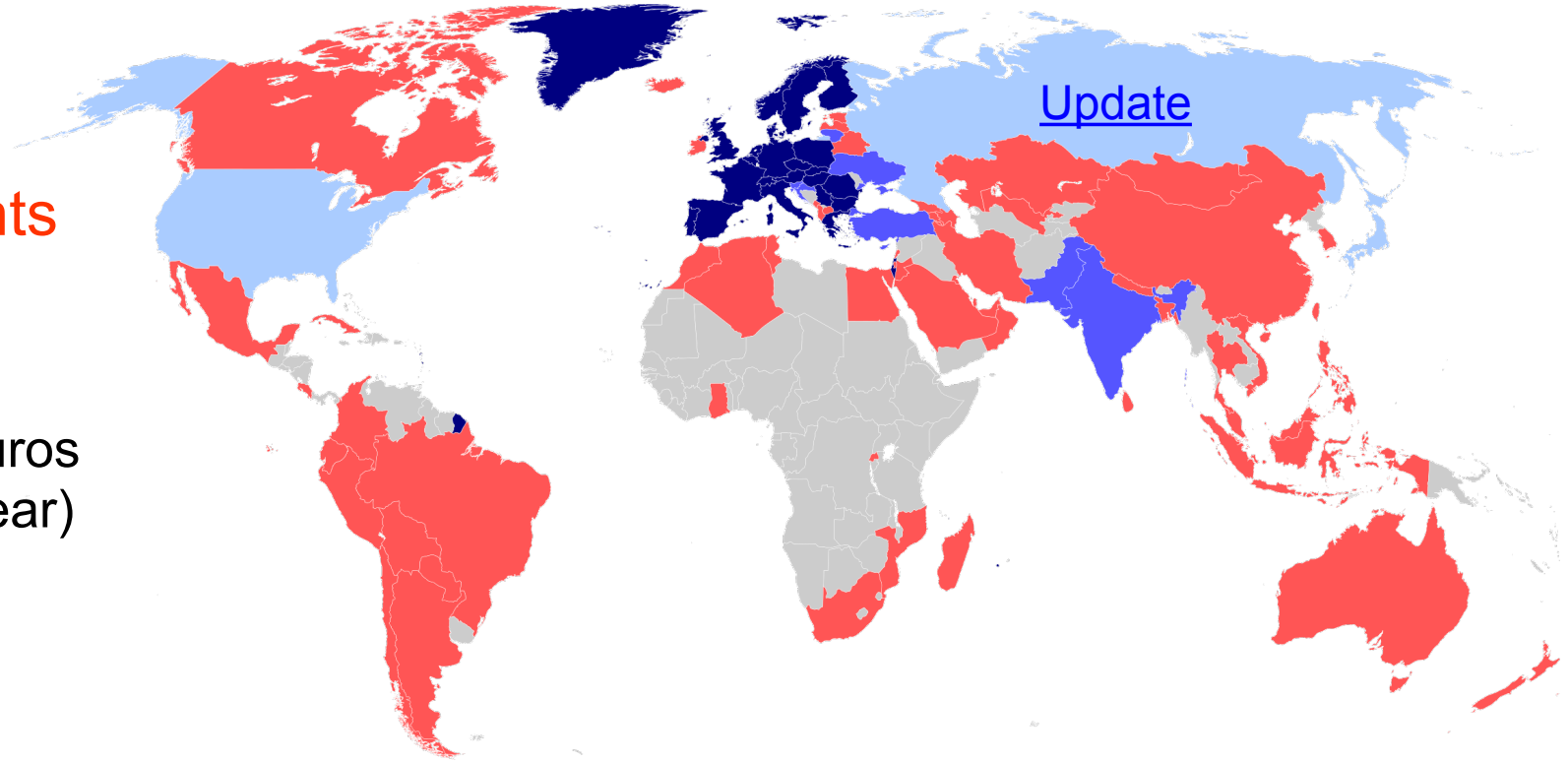
CERN Science Gateway
SCHWEIZ
Ferney-Voltaire
Carrefour Ferney Voltaire
D35
E.Leclerc FERNEY VOLTAIRE
FRANCE
SCHWEIZ
QUARTIER CHAMPS-FRÉCHETS
Jardin botanique alpin de Meyrin
Meyrin
Aéroport International de Genève
Bioparc Genève
Bellevue
1
1a
E62
La Réserve Genève Hotel and Spa
Plage du Vengeron
Pregny-Chambésy
Conservatoire et Jardin botaniques de la Ville...
BOURDIGNY
Rte du
amag
AMAG Vernier
Mercure Geneva Airport
Top rated
MONTFLEURY
Satigny
E62
amag
AMAG Châtelaine
Hôtel Président Wilson
Top rated
SERVETTE
Vernier
Rte de Peney
Jet d'Eau de Genève
Av. d'Aire
LE LIGNON
Geneva
Google

CERN now

23 member states
10 associate members
3 observers
61 countries with agreements



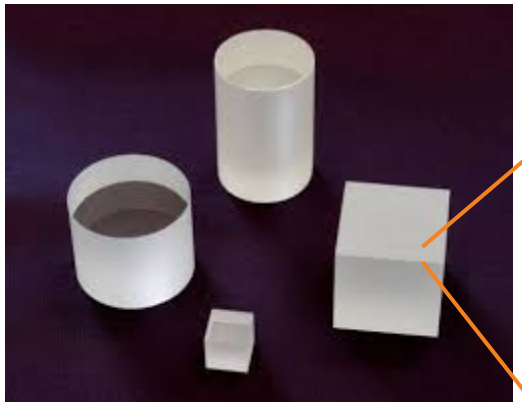
Budget in 2023: 1.23 billions of Euros
(123 M Euros IT, 2 Euro/person/year)
3558 members of personnel
13000 users

CERN mission

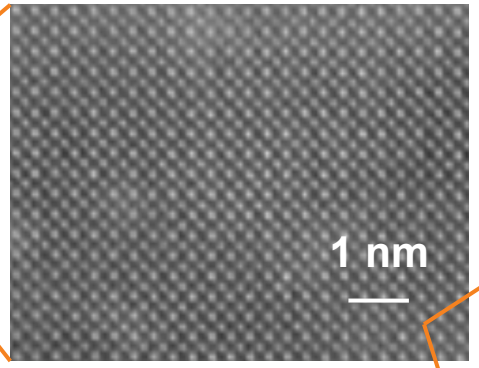
- Provide the facilities for frontend fundamental physics research: accelerators.
- Research in fundamental physics.
- Bring people together and push the frontiers of science and technology for the benefit of all.
- Education of future generations of scientists.

Research at CERN

Macroscopic matter

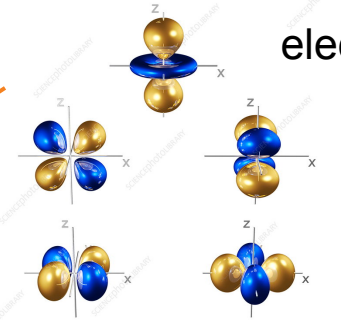


Atomic structure



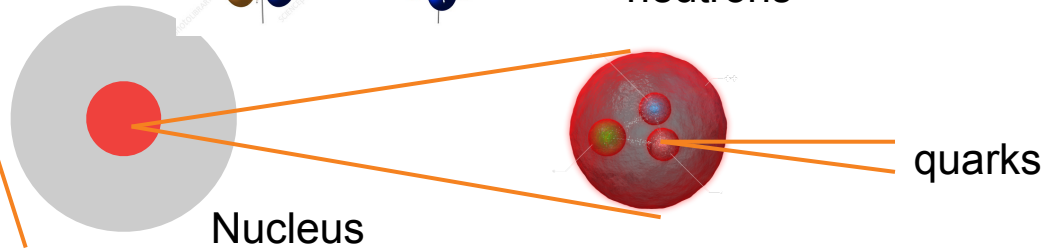
IV-V century BC

Scale 10^{-10}-10^{-15} m



electrons

protons and neutrons



Nucleus

quarks

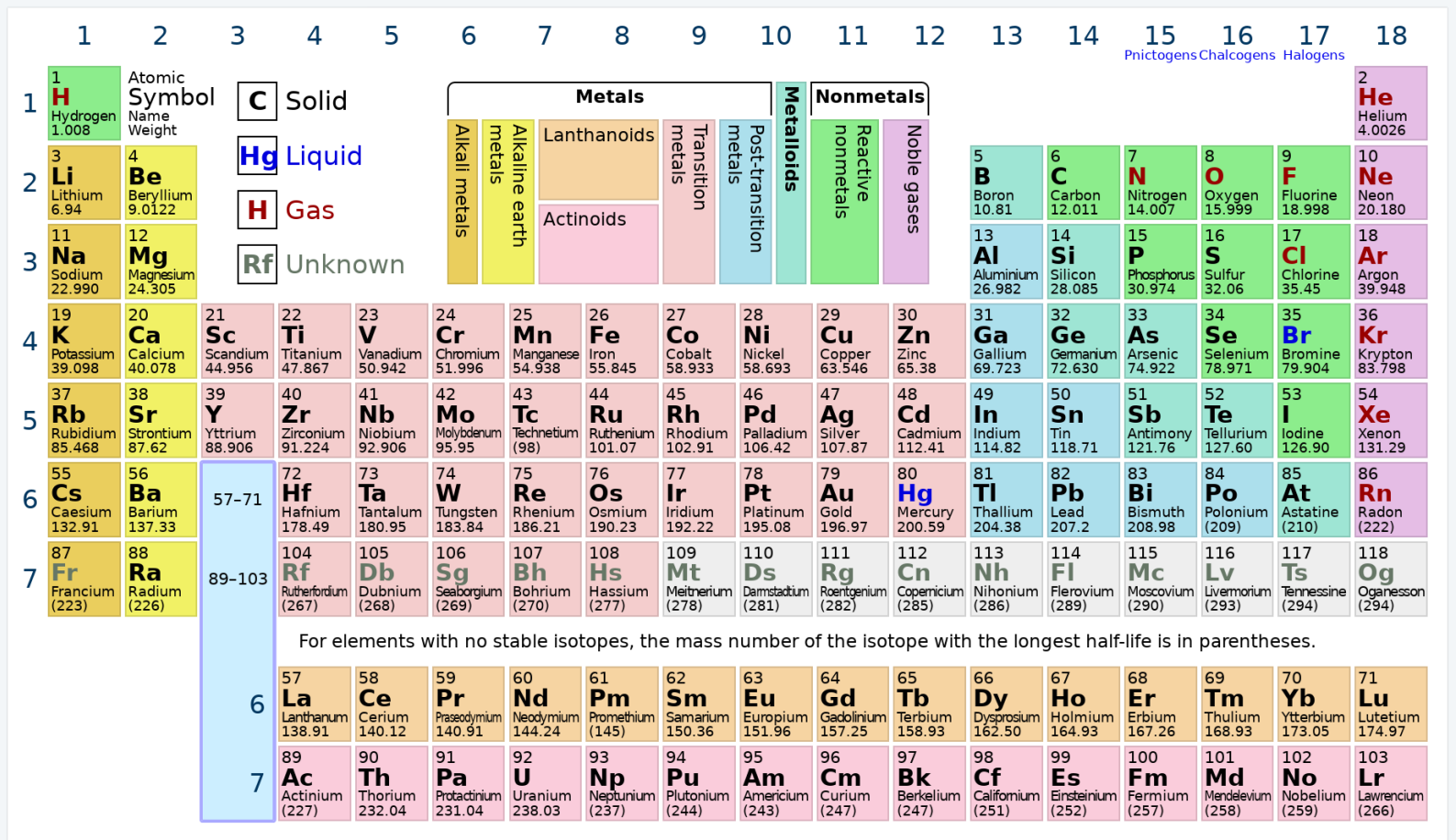
End of IXX century

Beginning of XX century

1960s

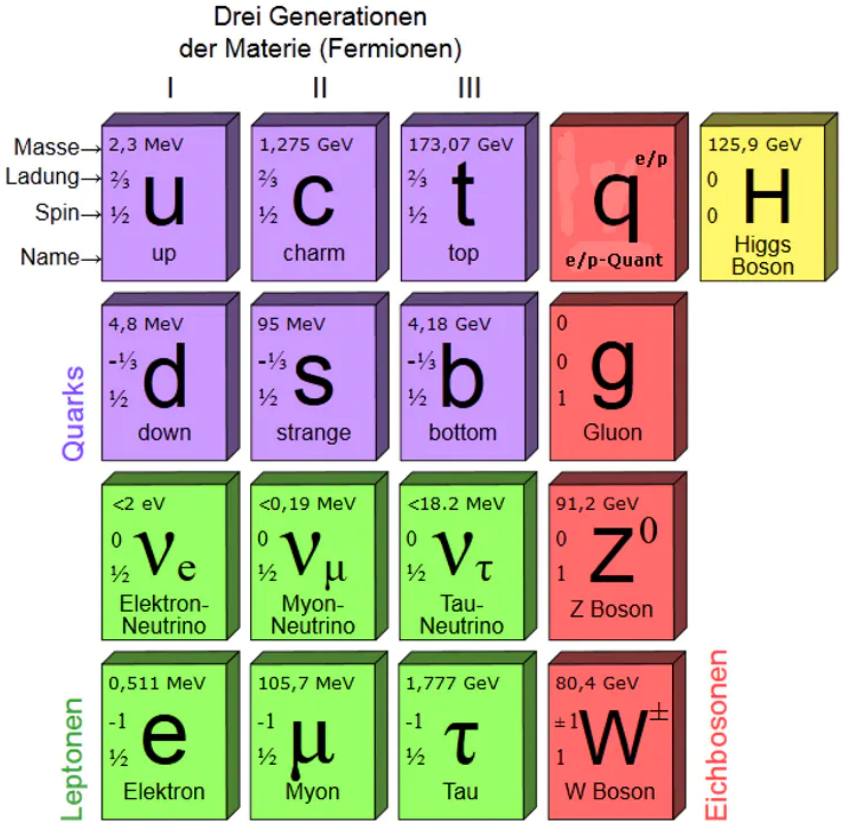
Fundamental constituents of matter and their interactions.

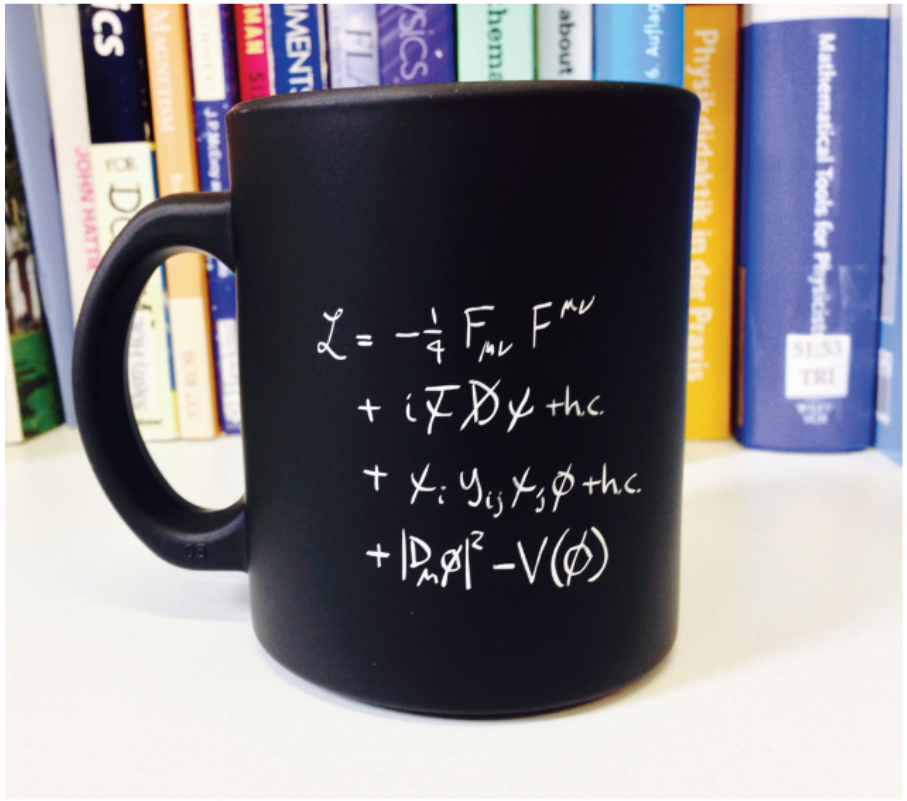
From the periodic table of elements



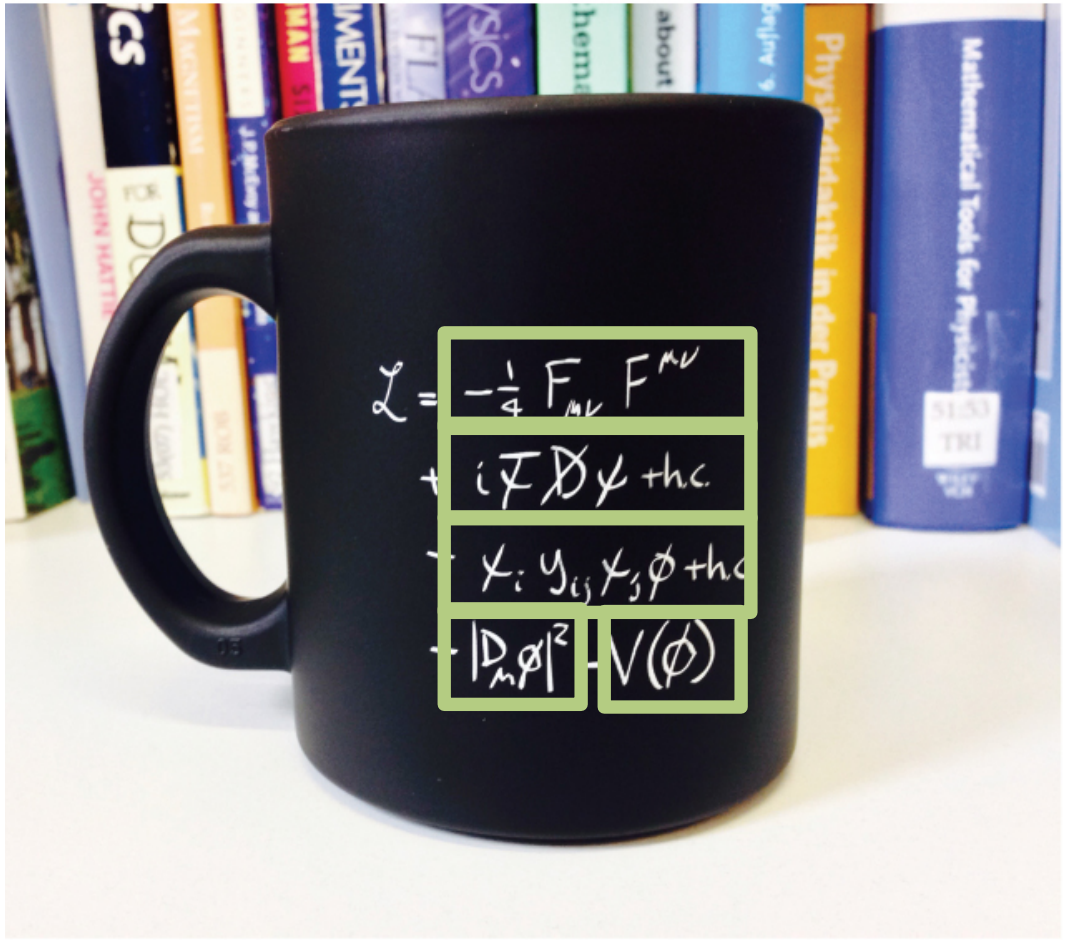
From https://ptable.com

To the standard model of particles





To the standard model of particles



Mathematical encoding of all interaction particles except for the Higgs boson.

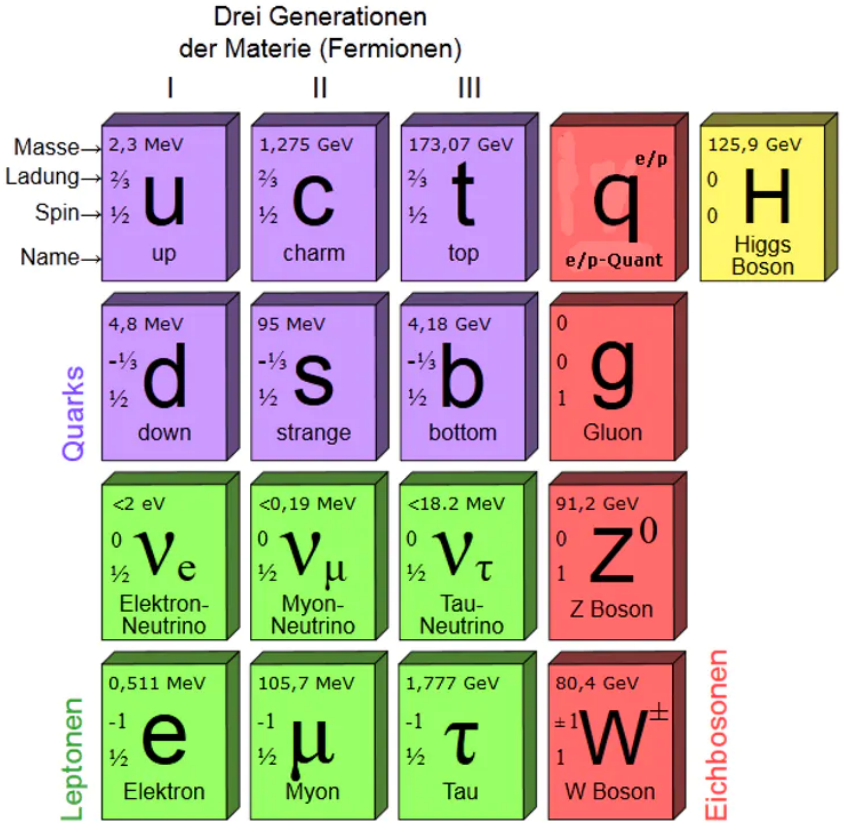
Interactions between interaction particles and mass particles. Radioactive decays are described by this term.

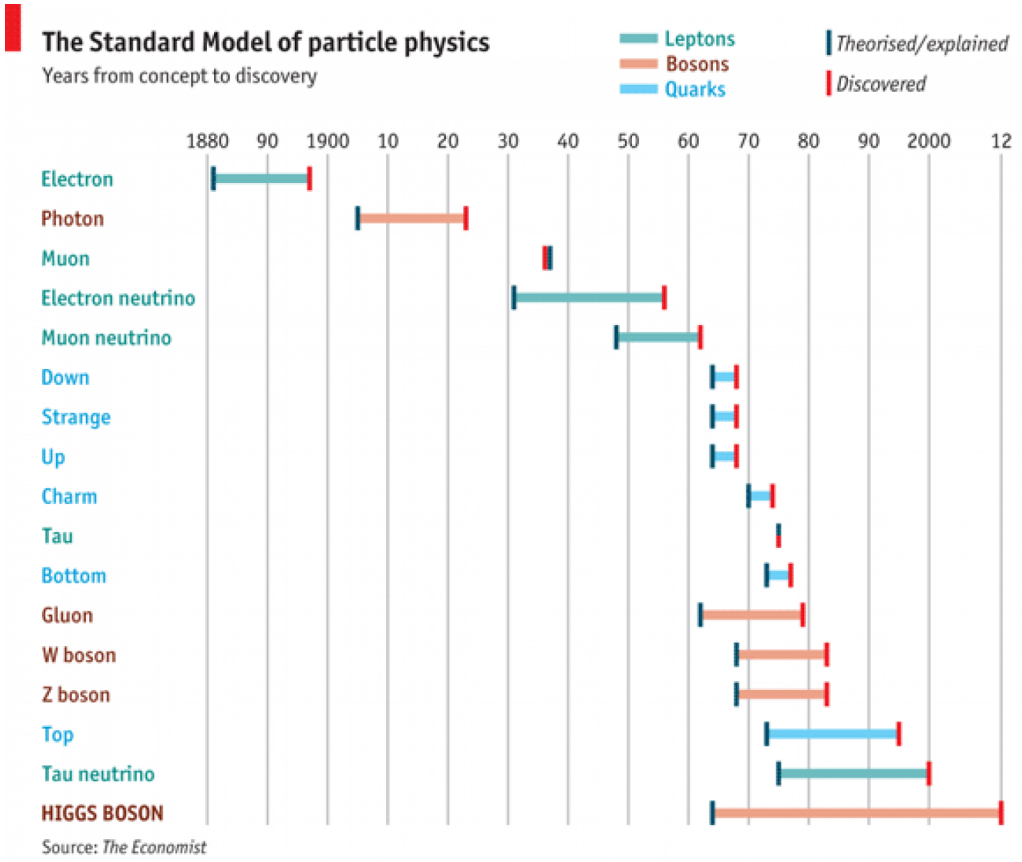
Interaction of mass particles with the Brout-Englert-Higgs field to obtain mass.

Coupling of the interaction particles with BEH field.

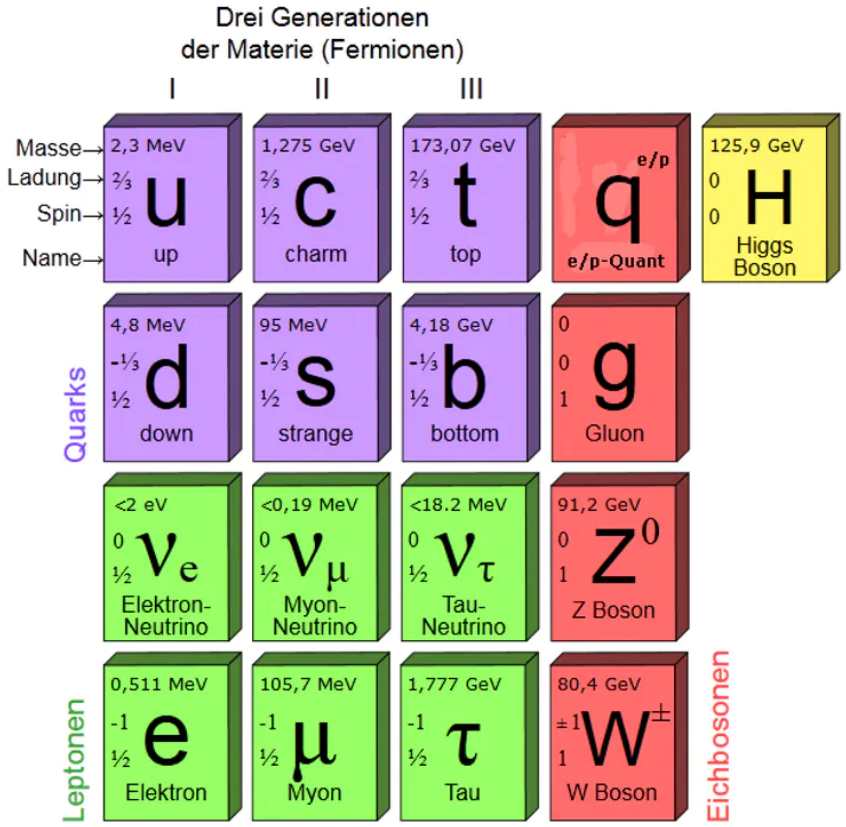
Potential of the BEH field.

To the standard model of particles





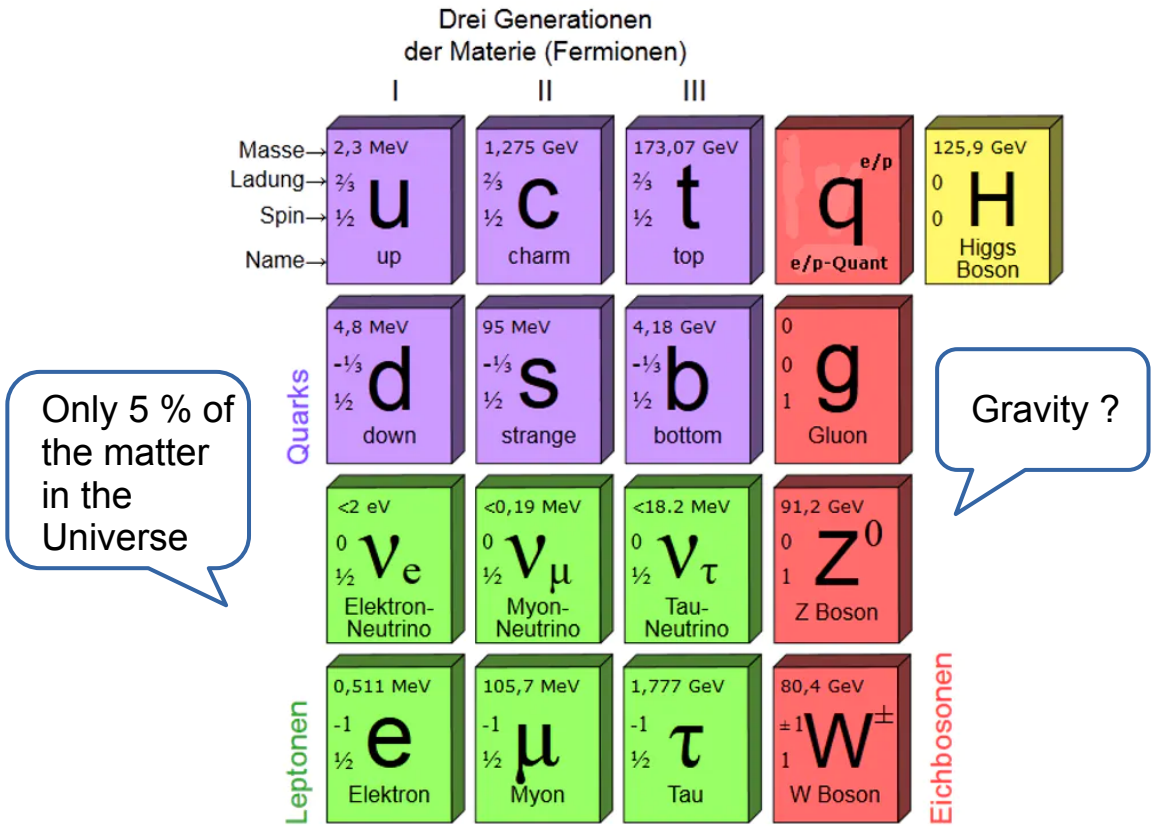
To the standard model of particles



- **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



Only 5 % of the matter in the Universe

Gravity ?

- **The SM is now a theory, confirmed by many experiments.**
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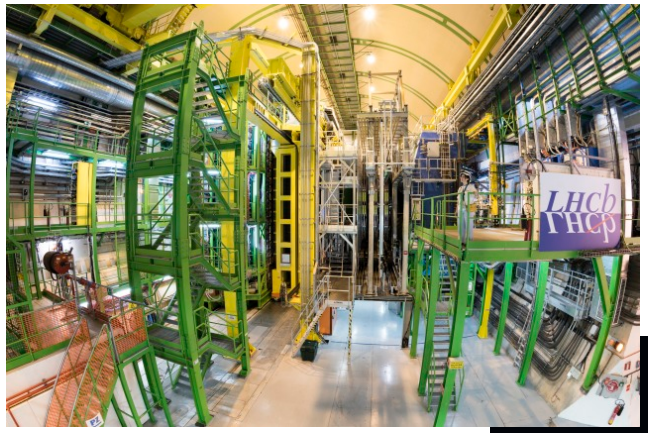
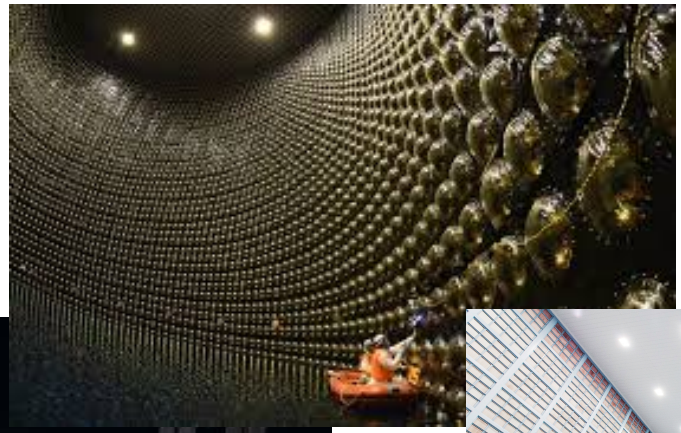
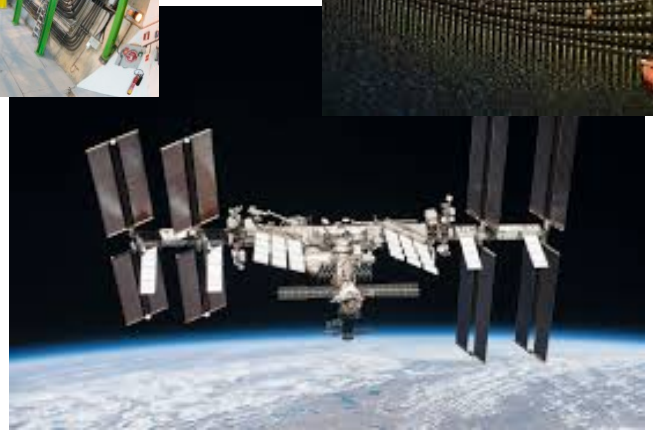
Different purposes – different laboratories

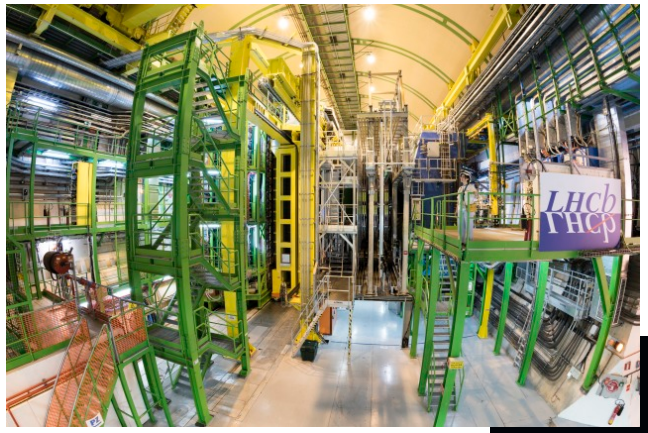


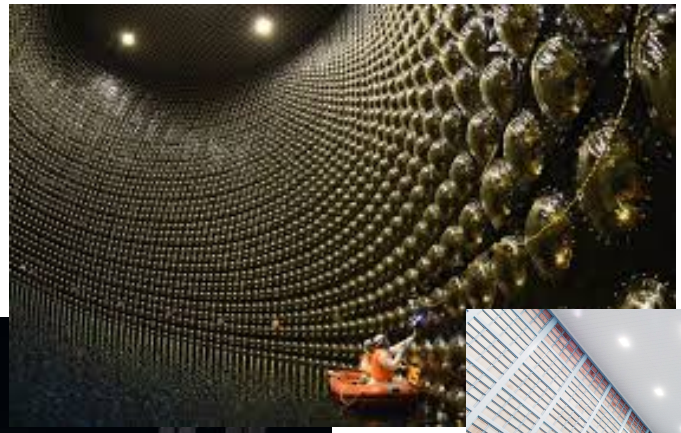


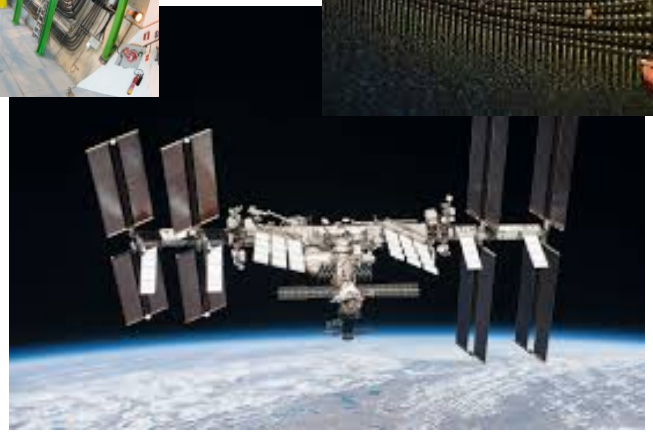


Particle accelerators have a prominent role in this picture

Different purposes – different laboratories



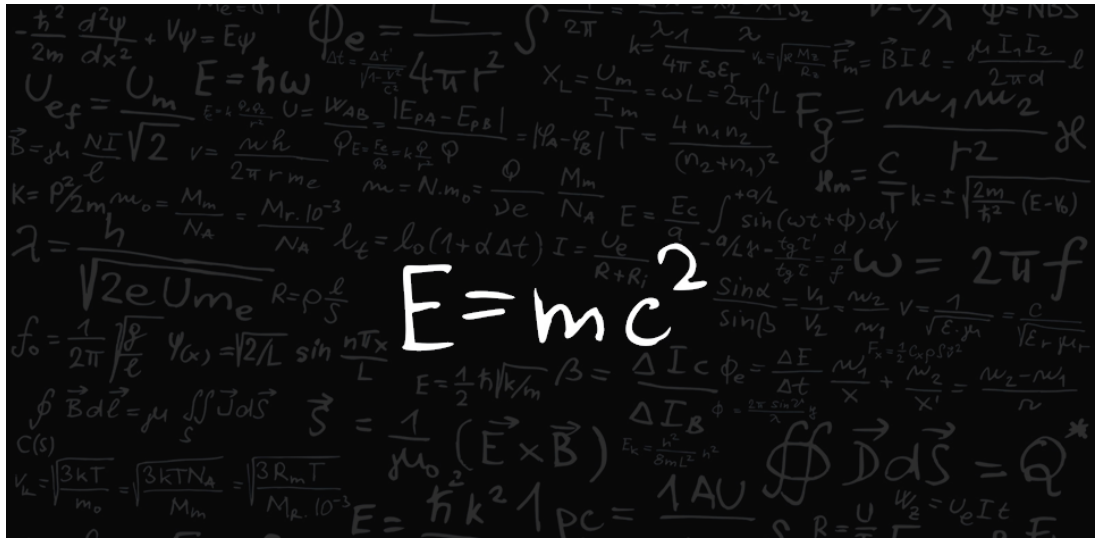




[Latest news!]

Particle accelerators have a prominent role in this picture

Why particle accelerators?

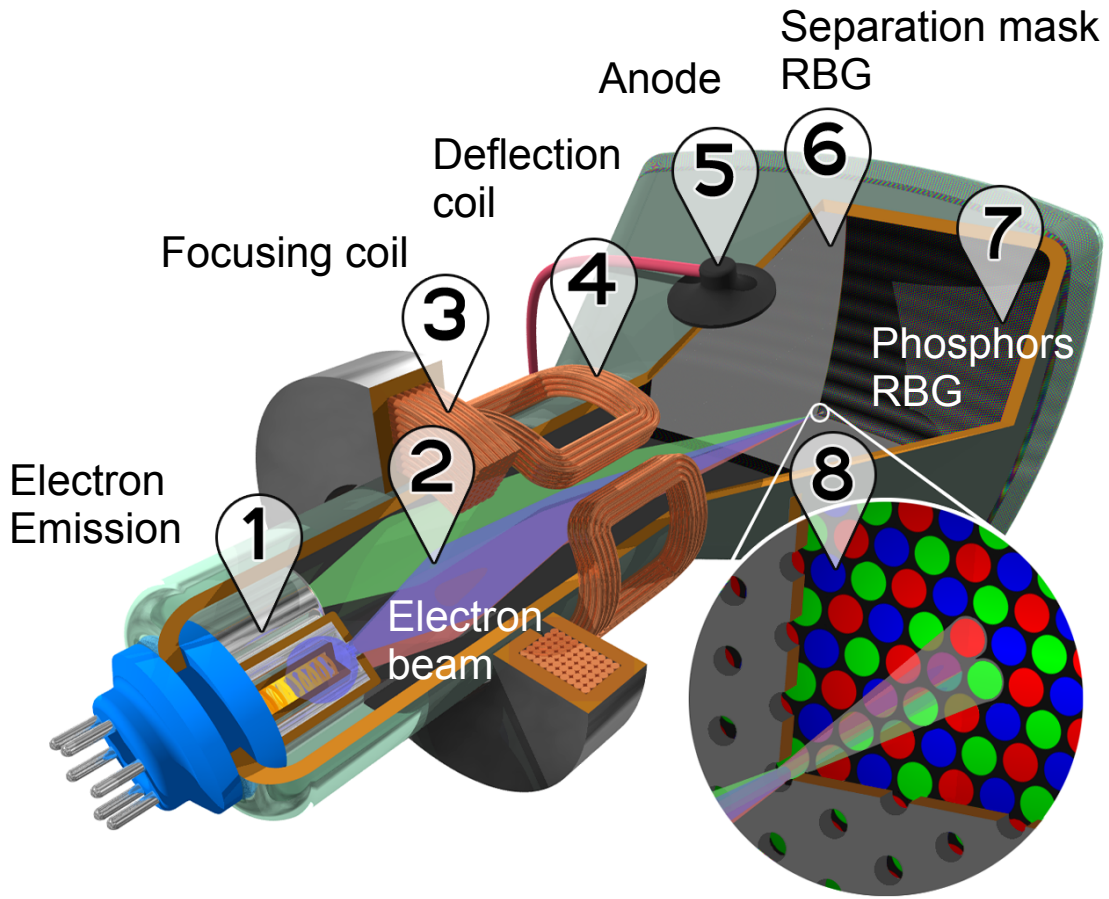


Energy ⟷ Mass

- **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.**

https://home.cern/resources/video/physics/heavy-ion-collision-event-animation

A particle accelerator



Fonte Wikipedia

Phosphors
RBG

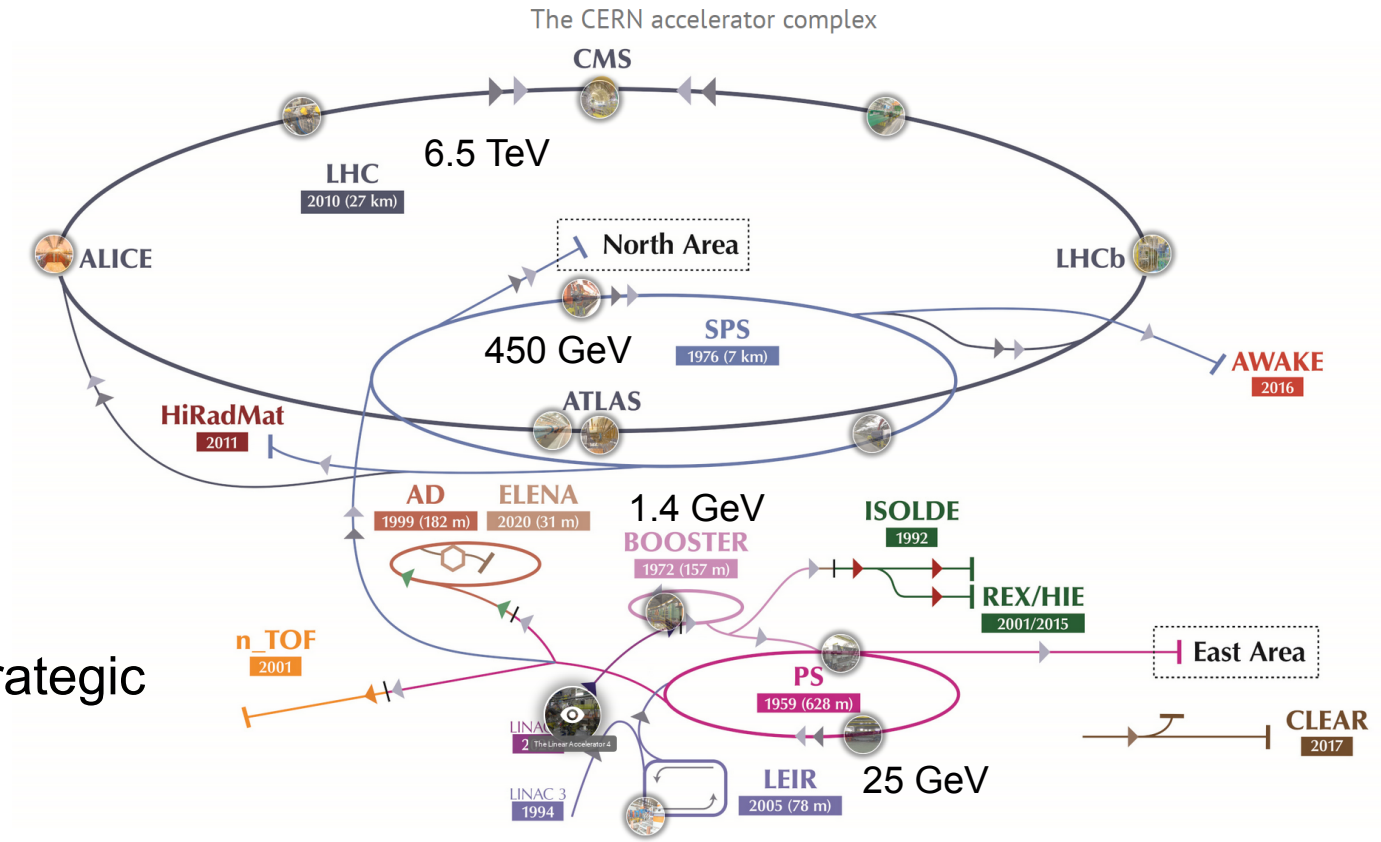
- Electrically charged particle source.
- Electric fields to accelerate.
- Magnetic fields to bend.

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.



CERN Accelerators

CERN has a complex of accelerators produce beams of :

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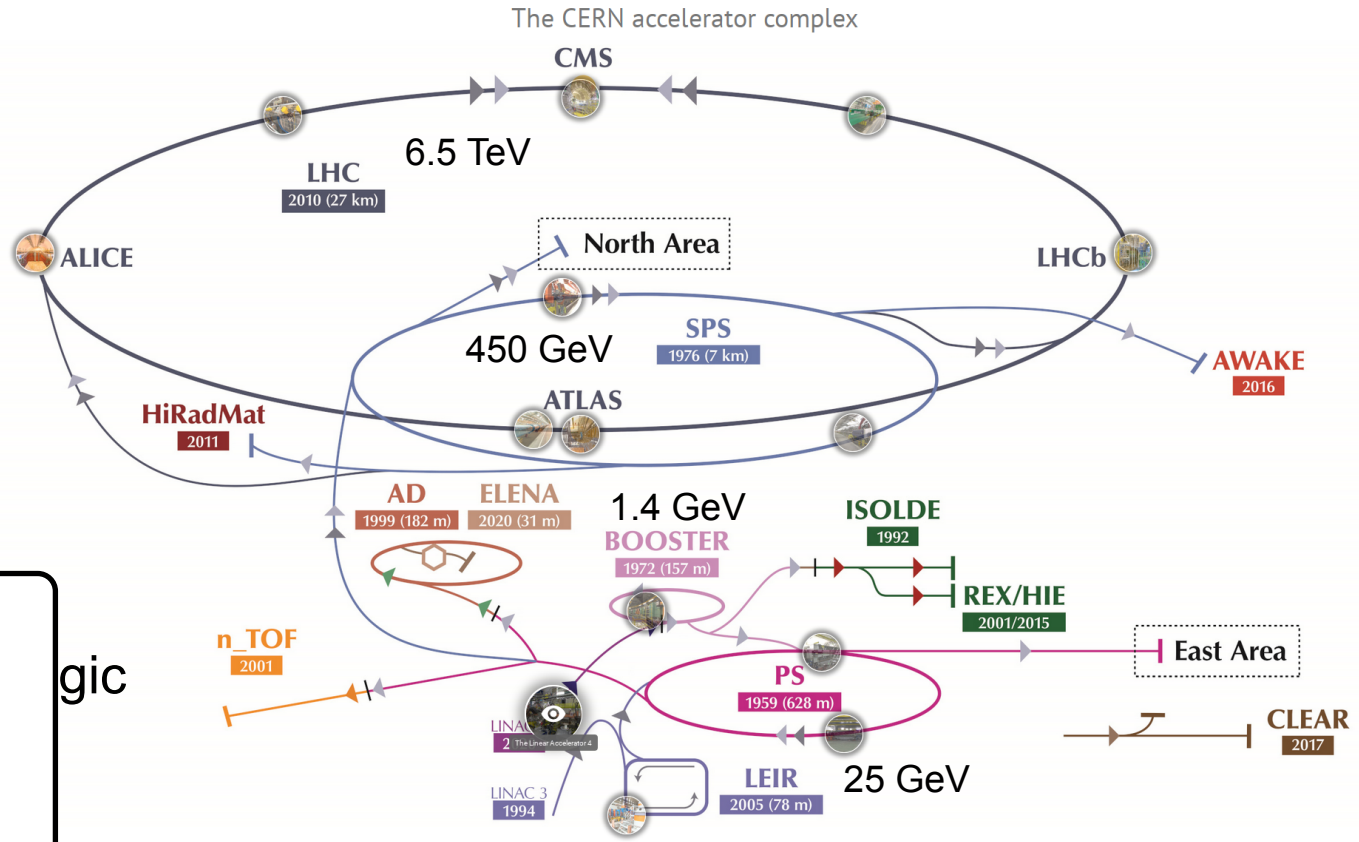
S gic
p

The eV is a unit of energy.

1 eV = 1 e * 1 V = 1.6 10-19 J



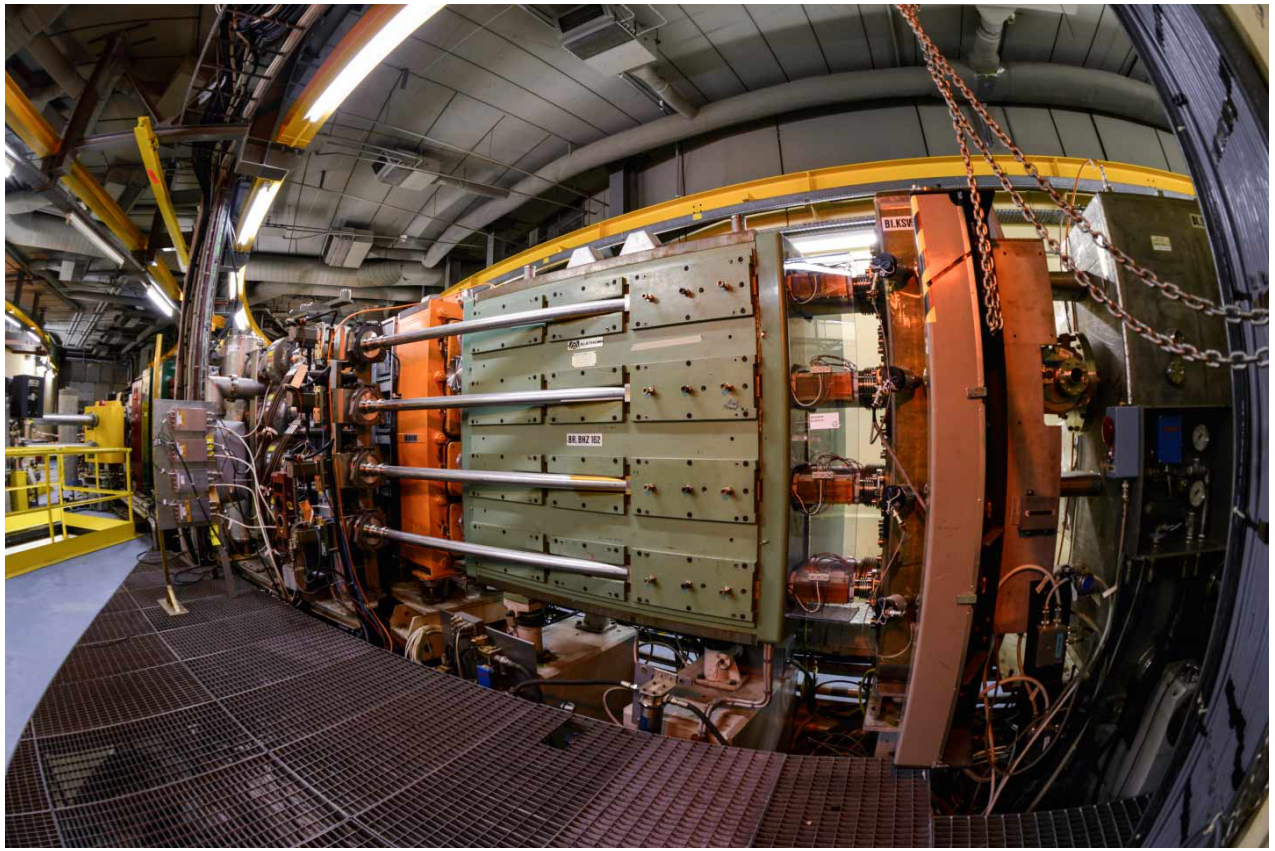
Step 1 : an H2 bottle and a linear accelerator

Gas bottle

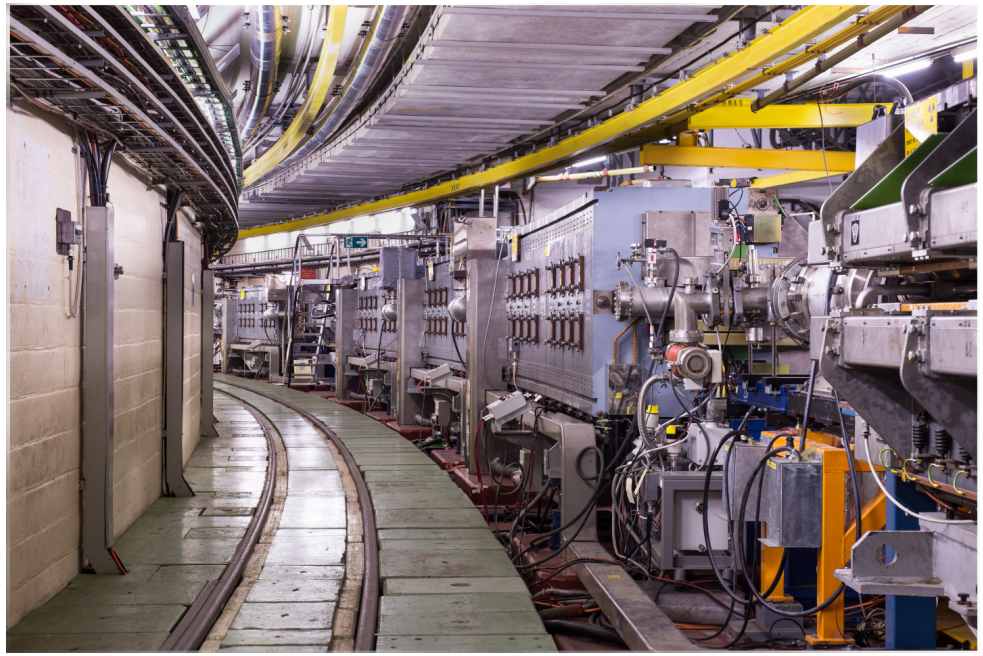
LINAC4 ca. 76 m, up to 160 MeV

Step 2 : The booster

The Booster consists in 4 superimposed synchrotrons that receive protons from the Linac4 at 160 MeV and accelerate them to 2 GeV. Radius 25 m.



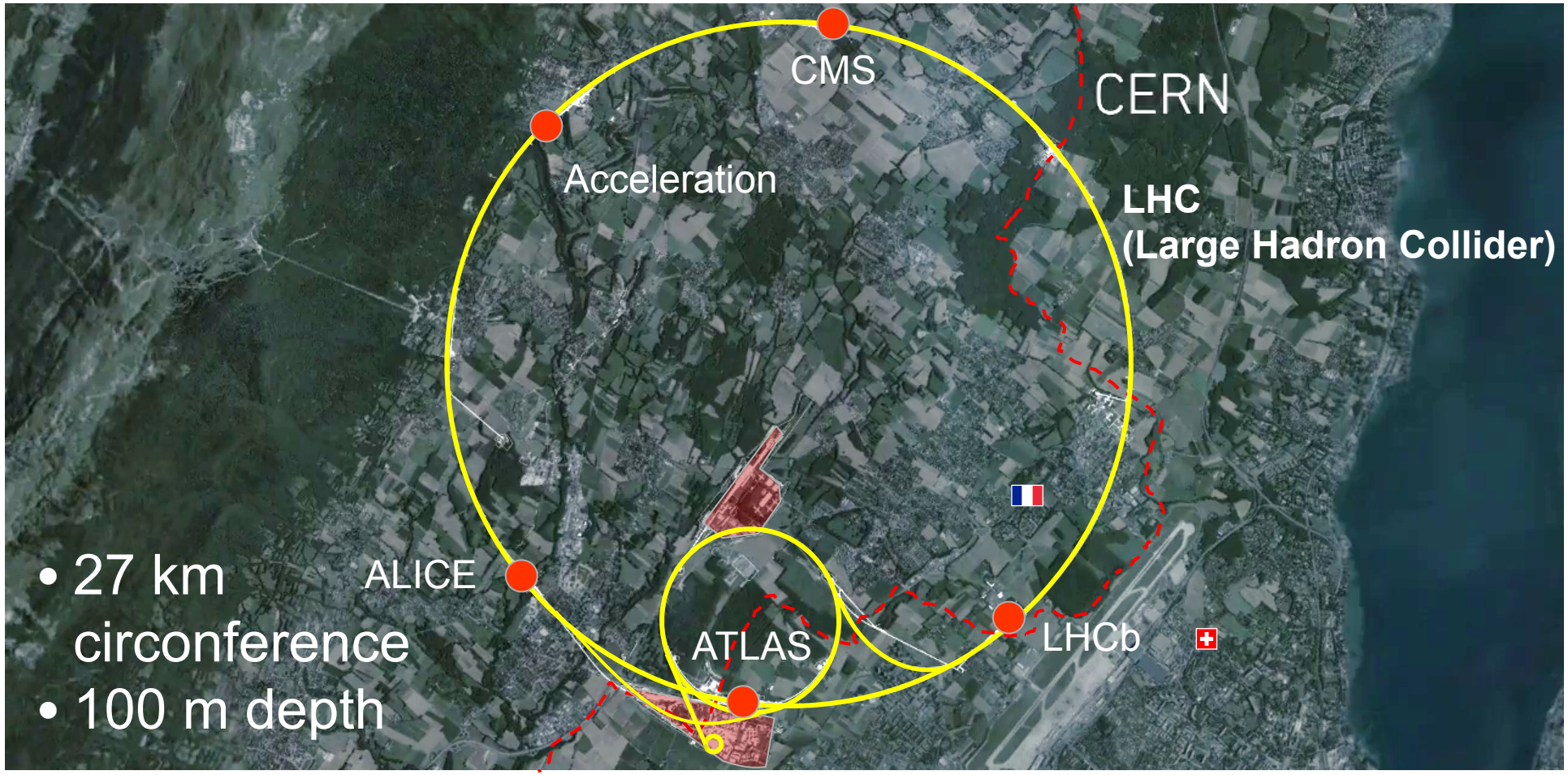
Step 3 : The PS and the SPS



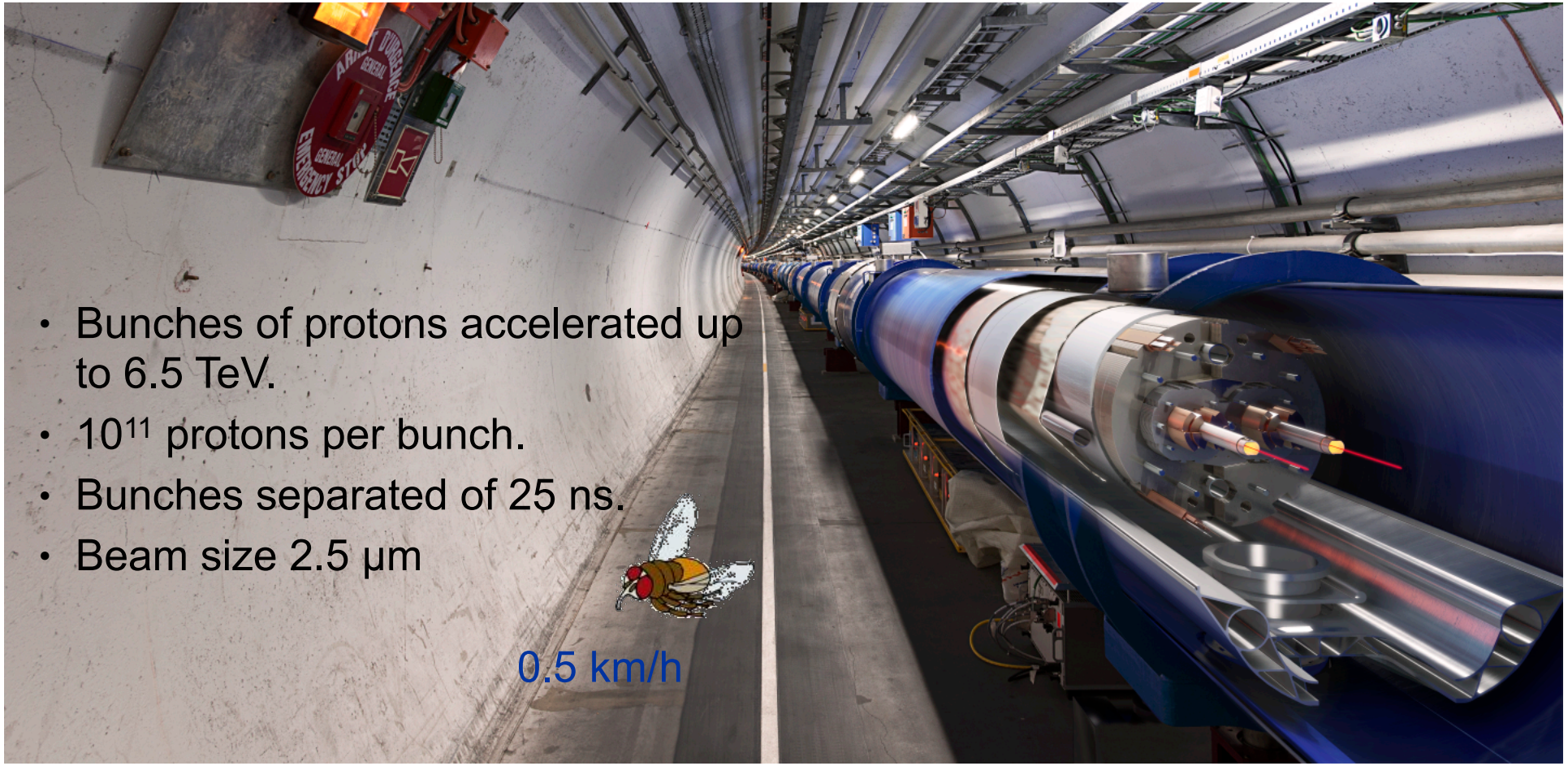
628 m of circumference, protons up to 26 GeV.

7 km of circumference, last step before the LHC, protons up to 450 GeV.

Final step : The Large Hadron Collider



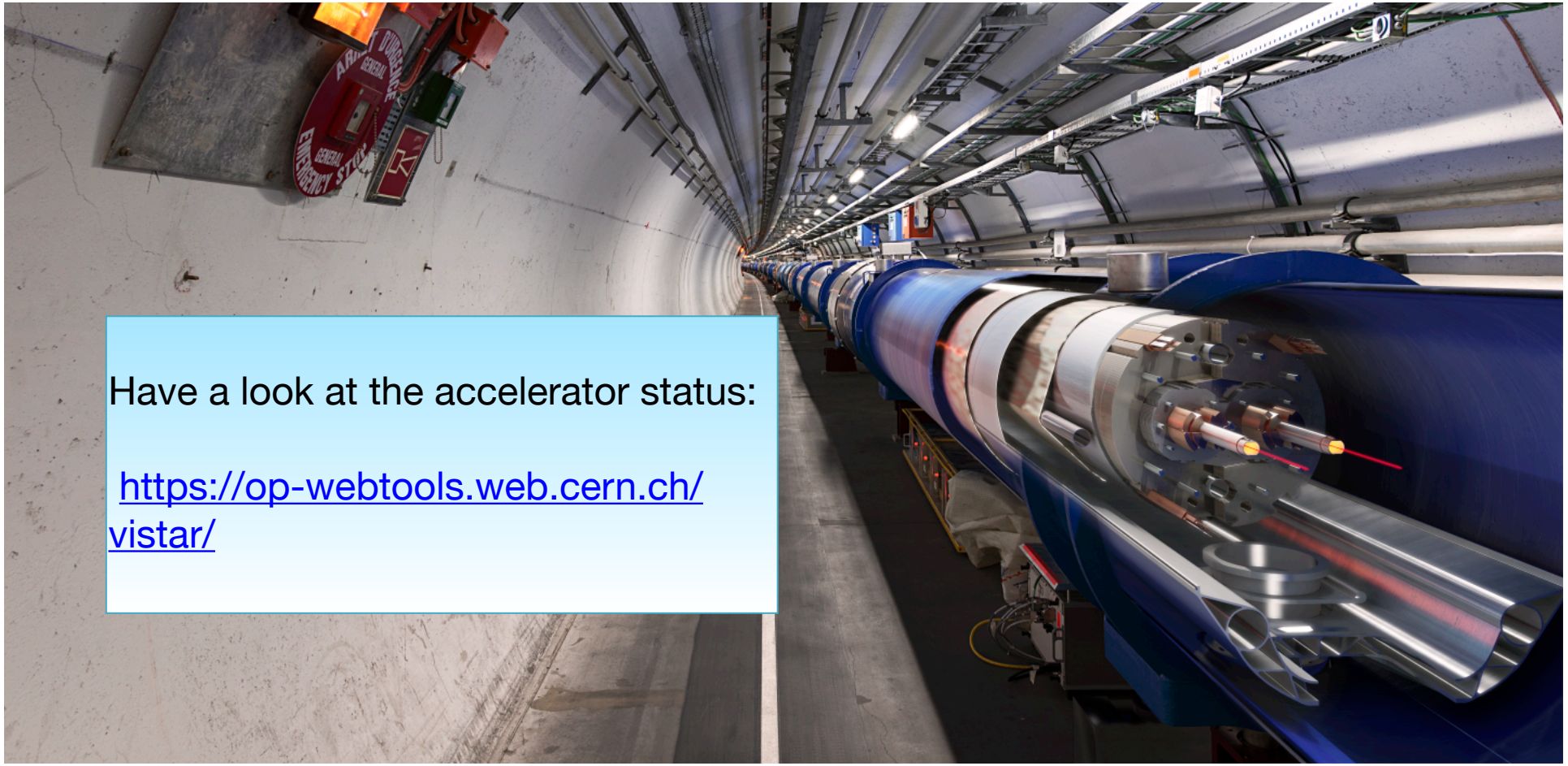
Final step : The Large Hadron Collider



- Bunches of protons accelerated up to 6.5 TeV.
- 10^{11} protons per bunch.
- Bunches separated of 25 ns.
- Beam size 2.5 μm

0.5 km/h

Final step : The Large Hadron Collider



Have a look at the accelerator status:

https://op-webtools.web.cern.ch/vistar/

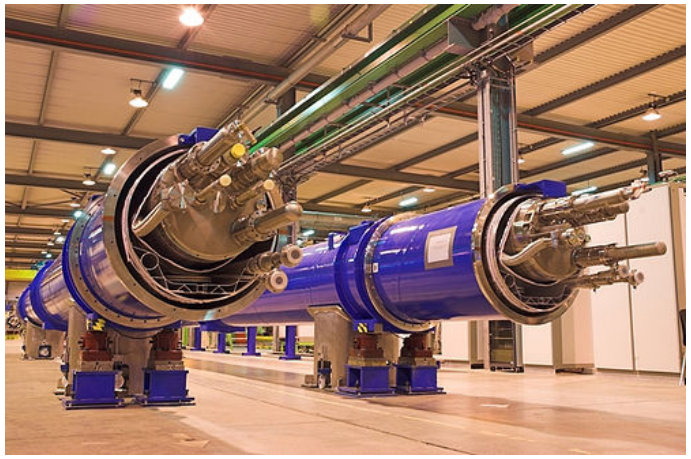
A bit of history

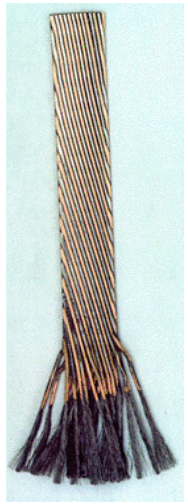
Images from L. Evans presentation 04/07/2022

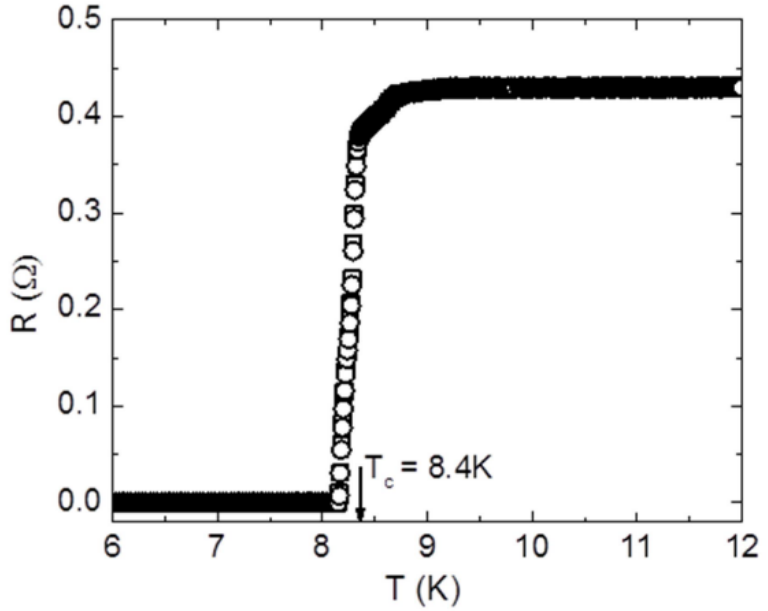
The technology required

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

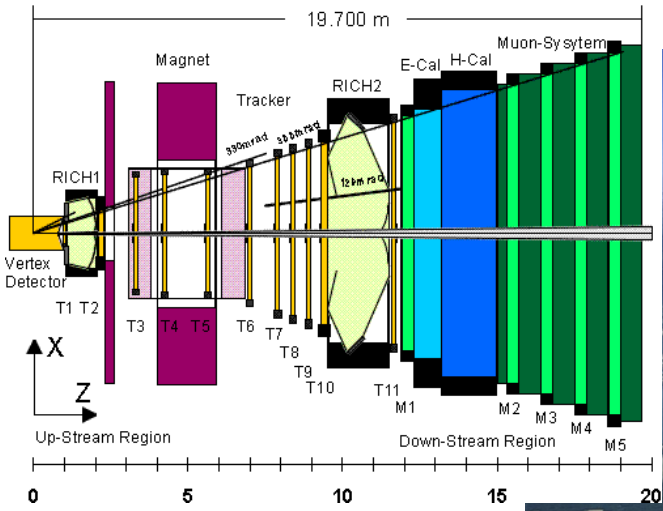
- 1232 magnets to bend the particles.
- 220 000 km of **superconducting wires.**
- Working temperature : 1.9 K (-271.3 C), superfluid Helium.

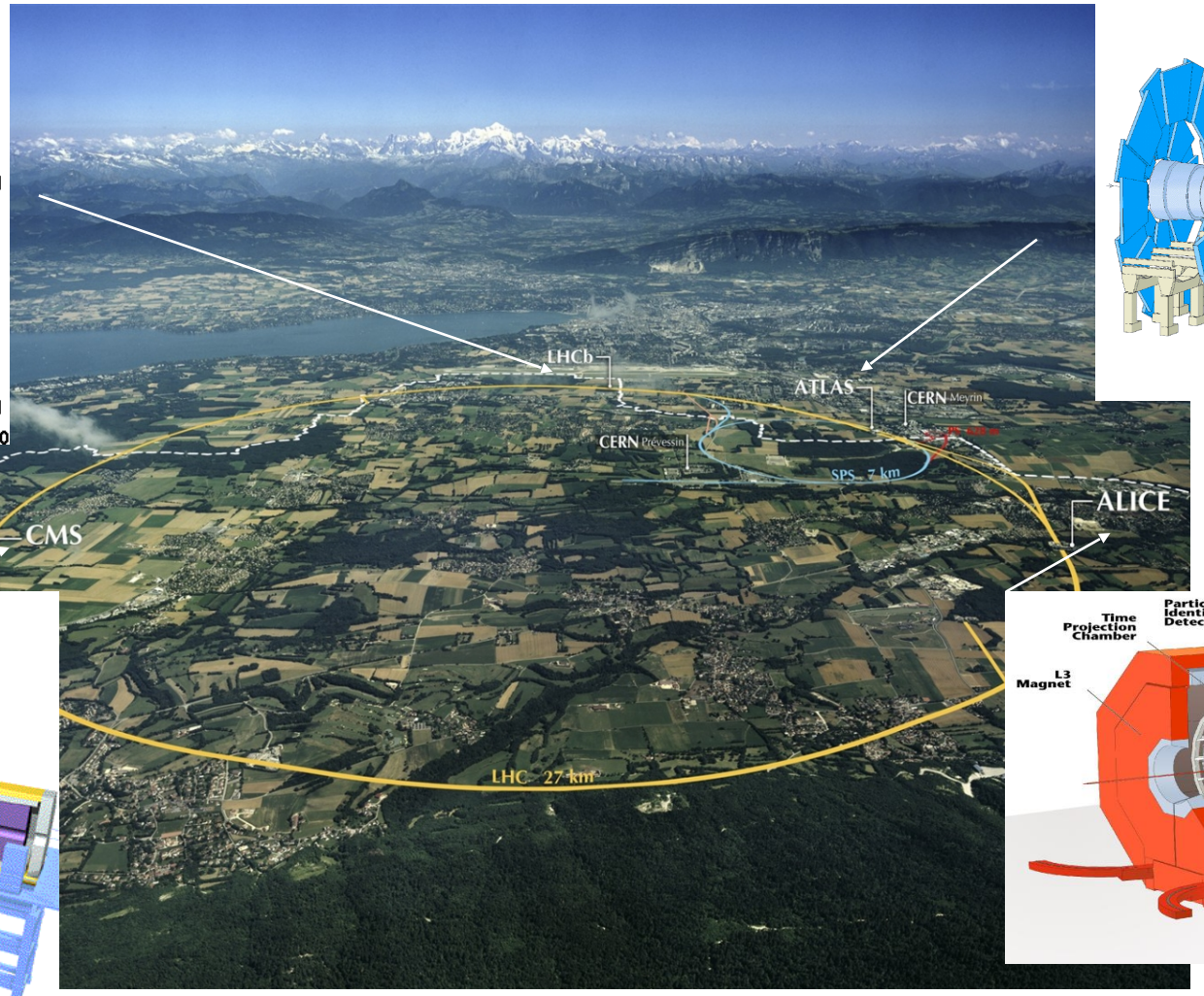


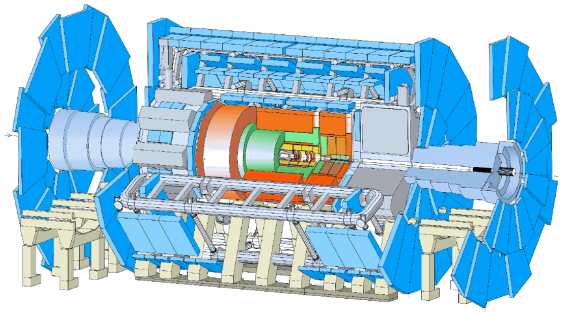


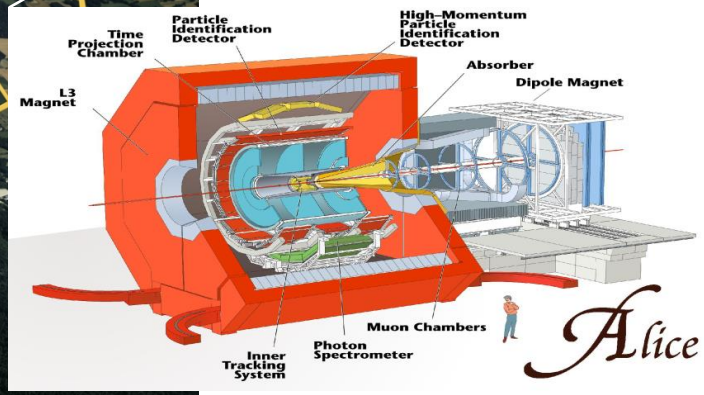


Experiments at the LHC

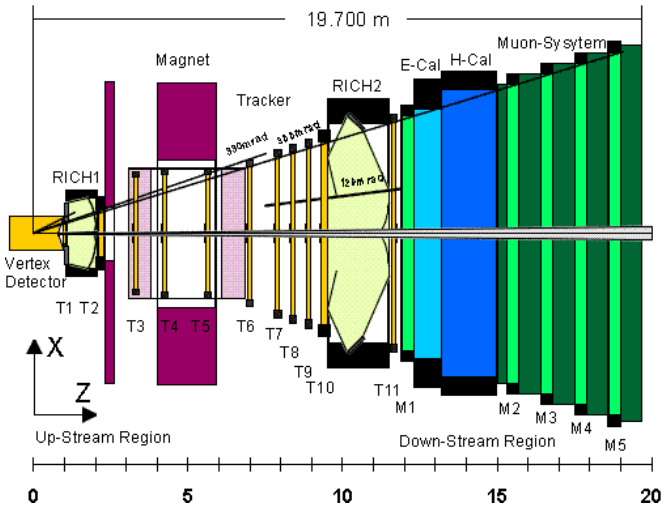


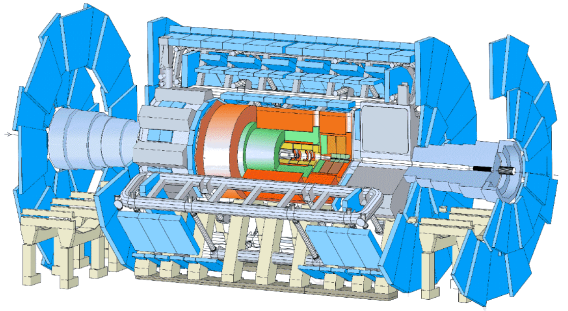






Experiments at the LHC

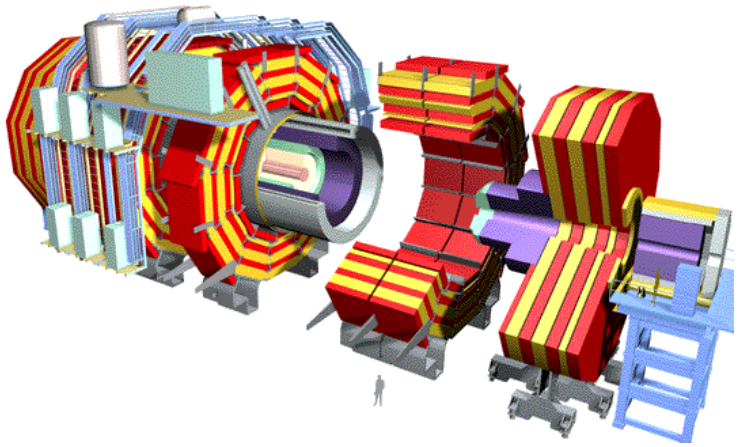


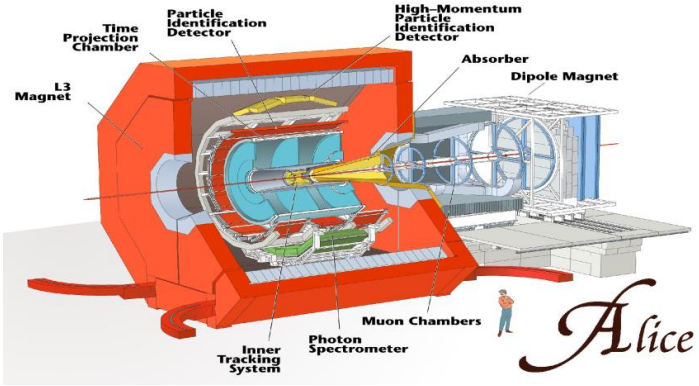


The experiments are international collaborations.

Many research institutions are involved in :

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

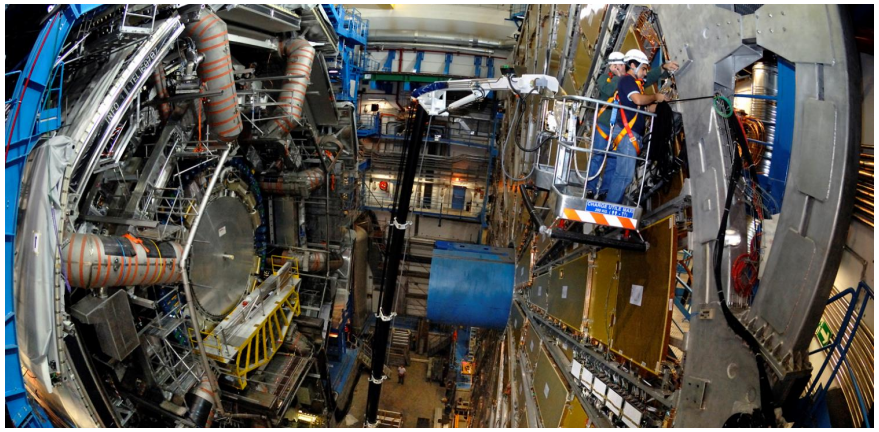


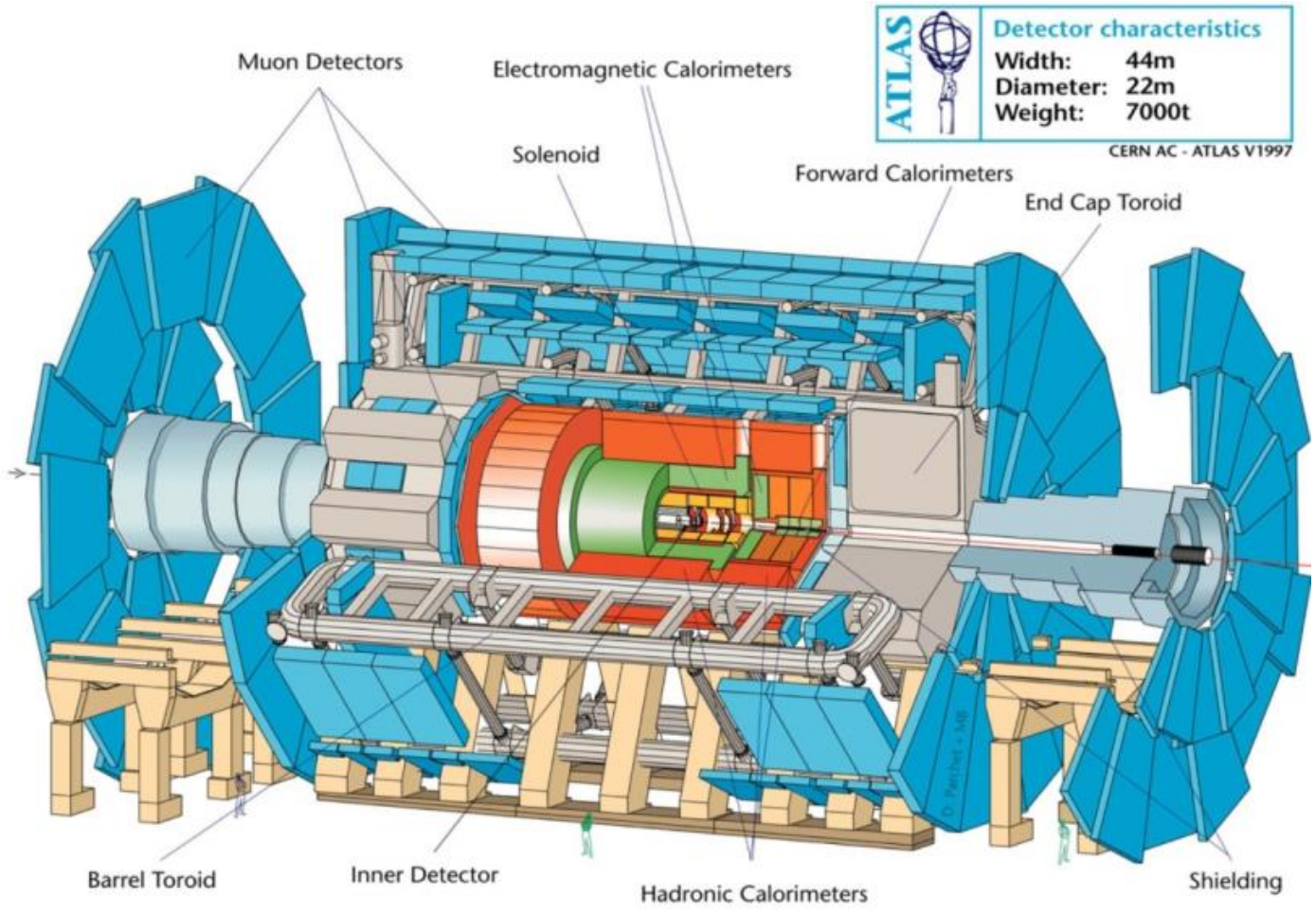


Each experiment has a specific purpose.

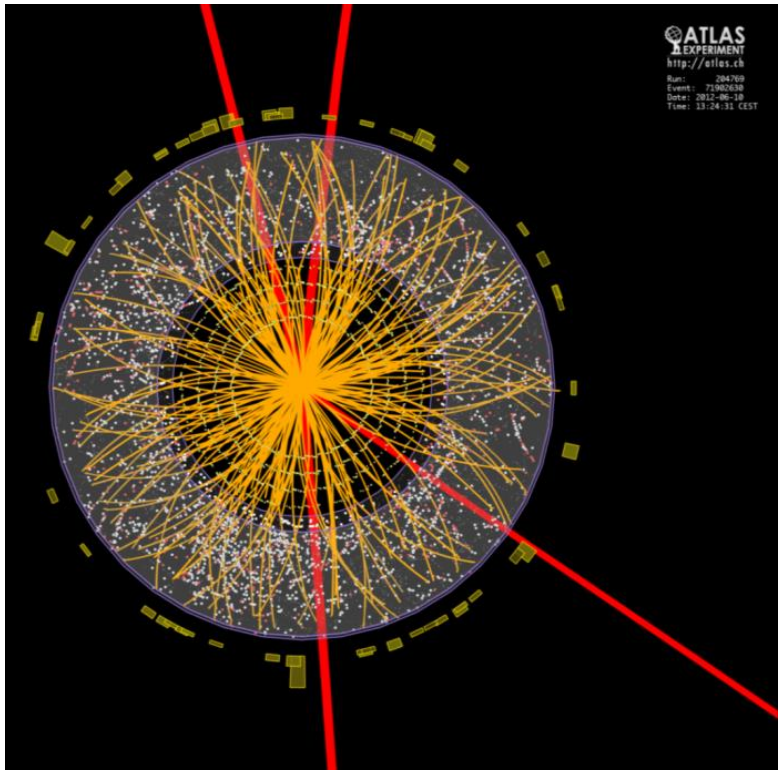
A few words about ATLAS

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





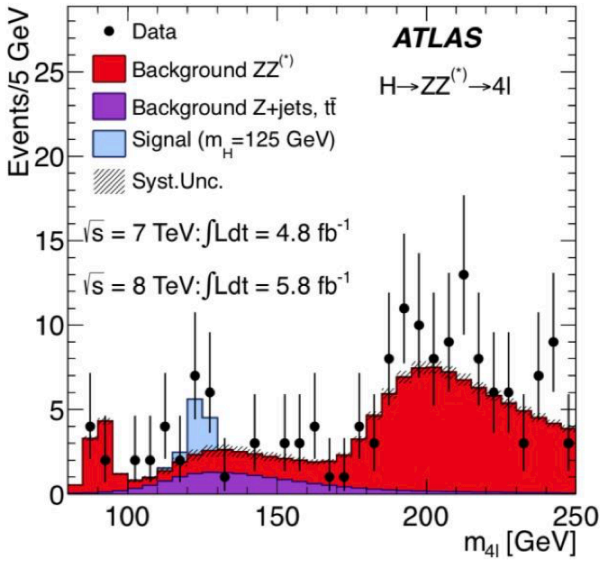
Detection of very rare events

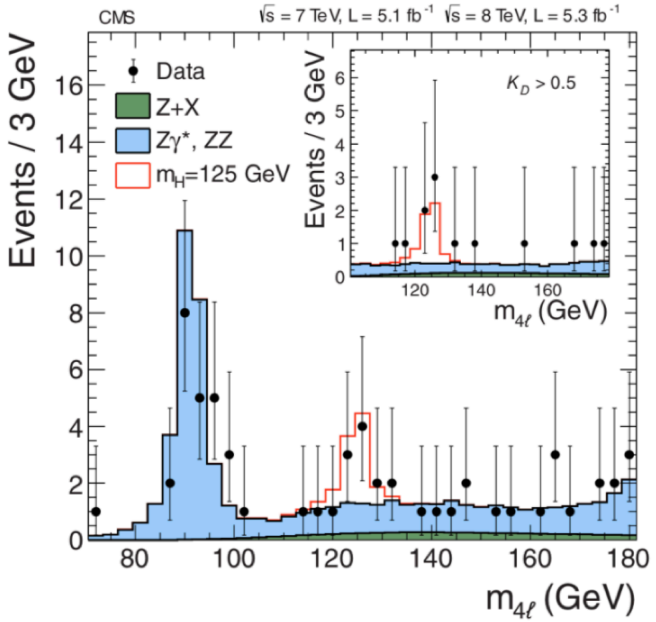


- Inside ATLAS or CMS there are 800 million pairs of protons colliding.
- Higgs events are expected only once for 10^{12} collisions.

41 coins

July 2012

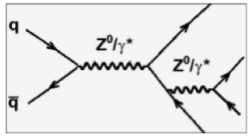


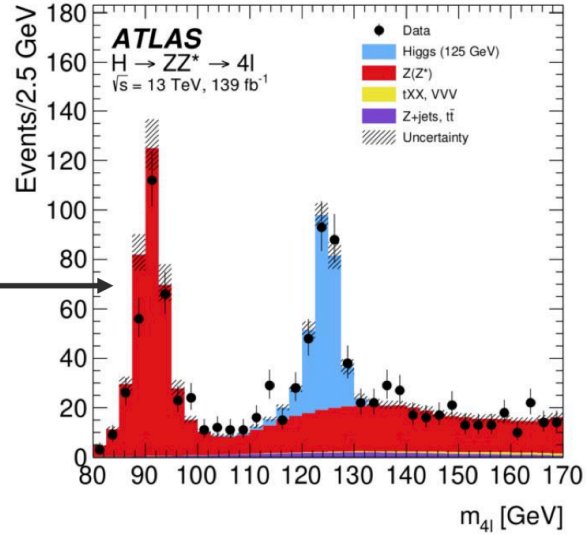


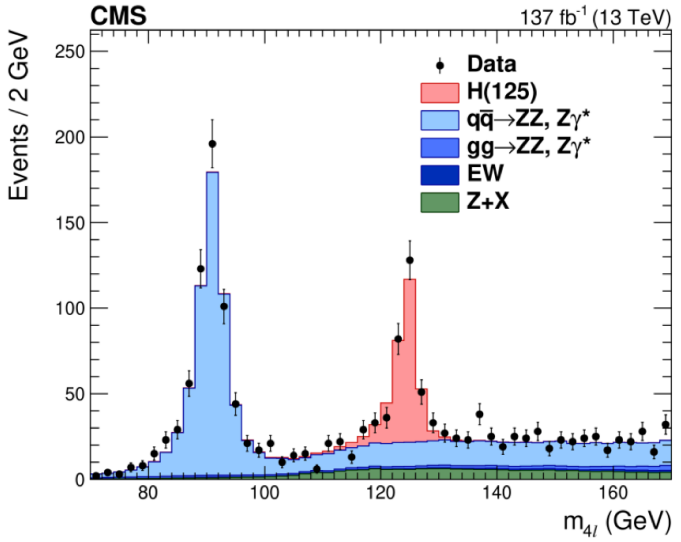
Images from F. Gianotti presentation 04/07/2022

Today

Peak at m_{4l} ~ 90 GeV from Z→ 4l production







Data filtering

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

0.1 s

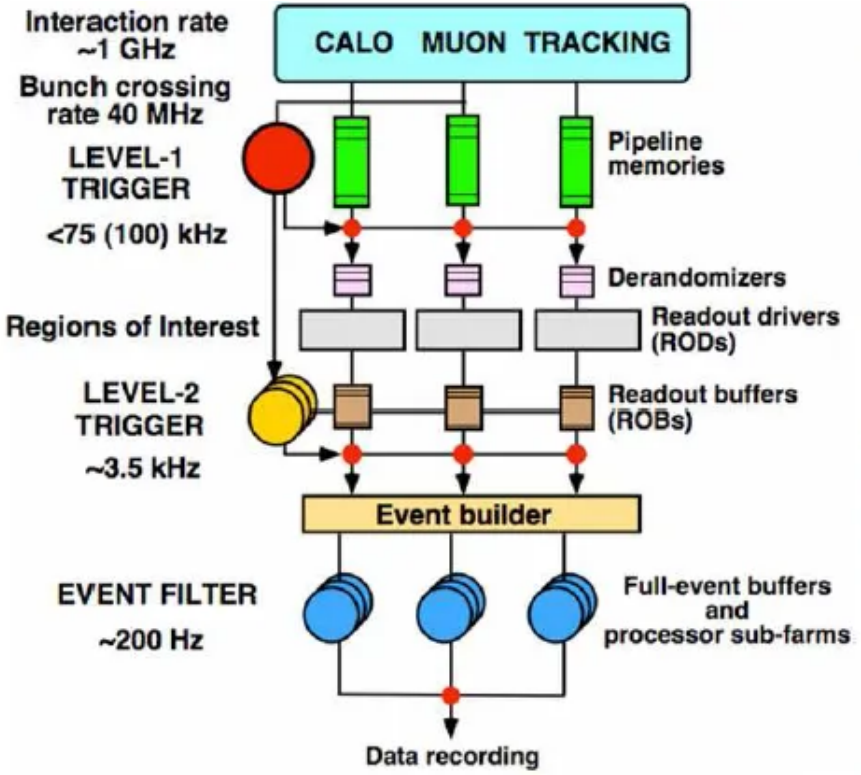
1 day

What would be the height ?

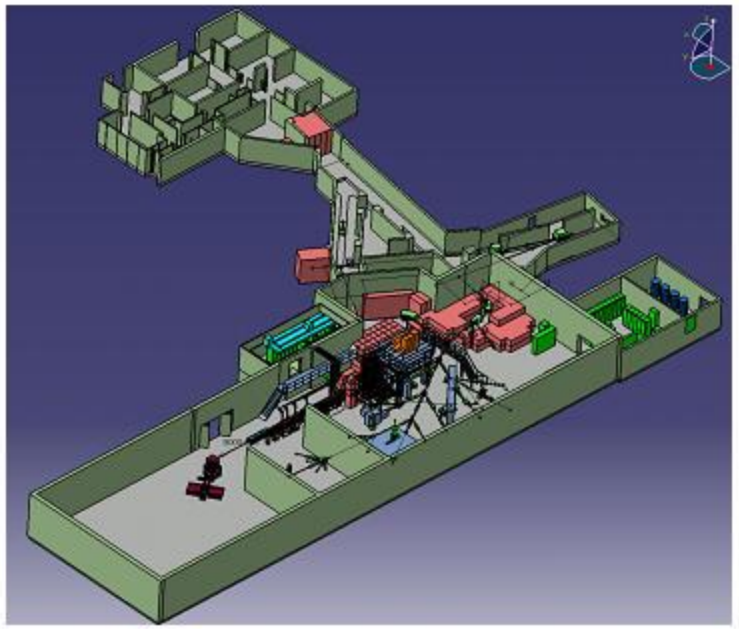
26 km

Data filtering

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

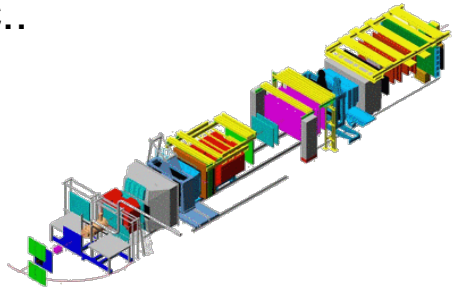


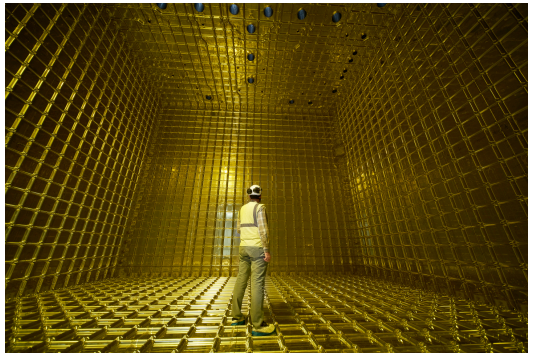
Other CERN experiments

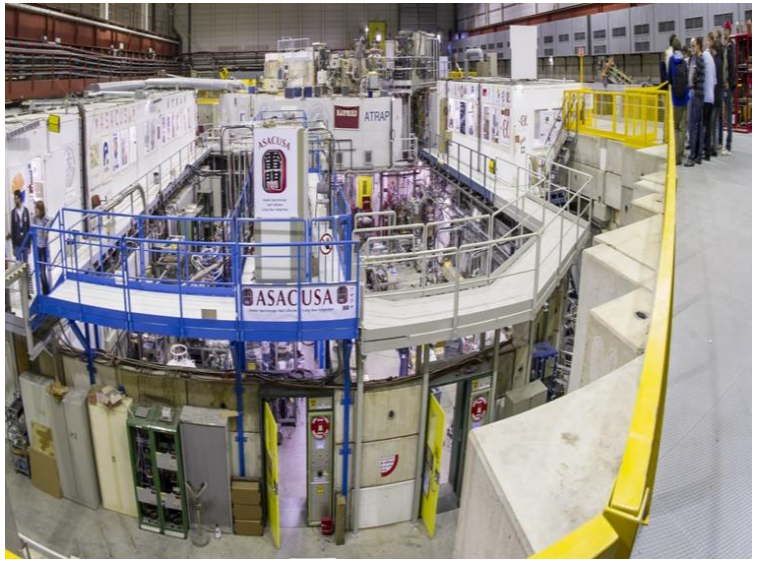


Isolde : Production and research with Isotopes

Fixed target experiments : R&D for detectors, COMPASS (Exploration of hadron structure), The Neutrino Platform, CLOUD, etc..



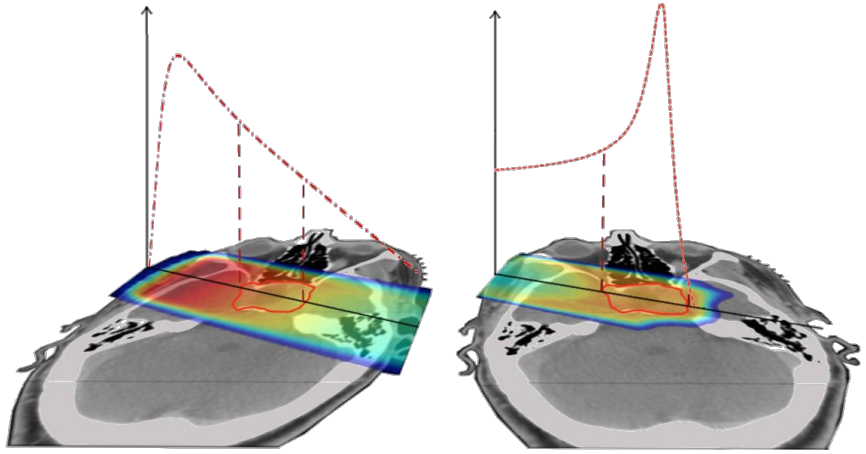




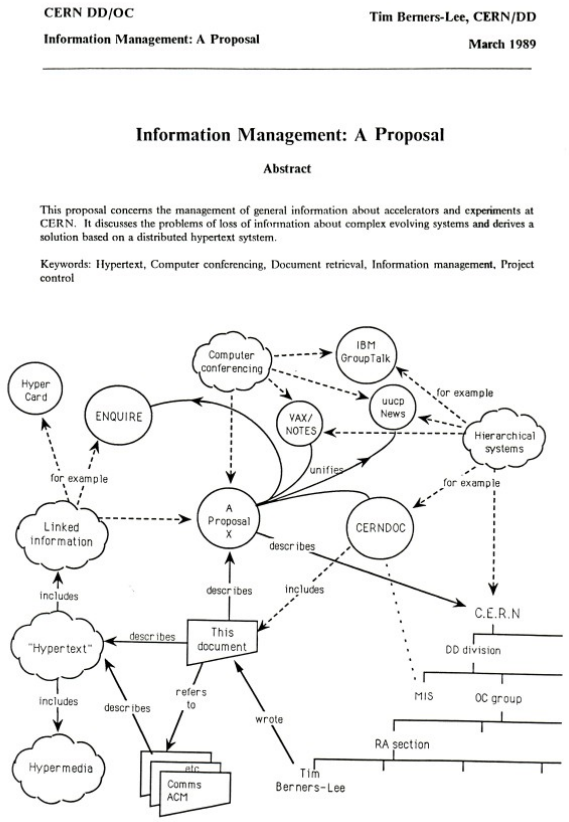
Antimatter Factory

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 sytstem.

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

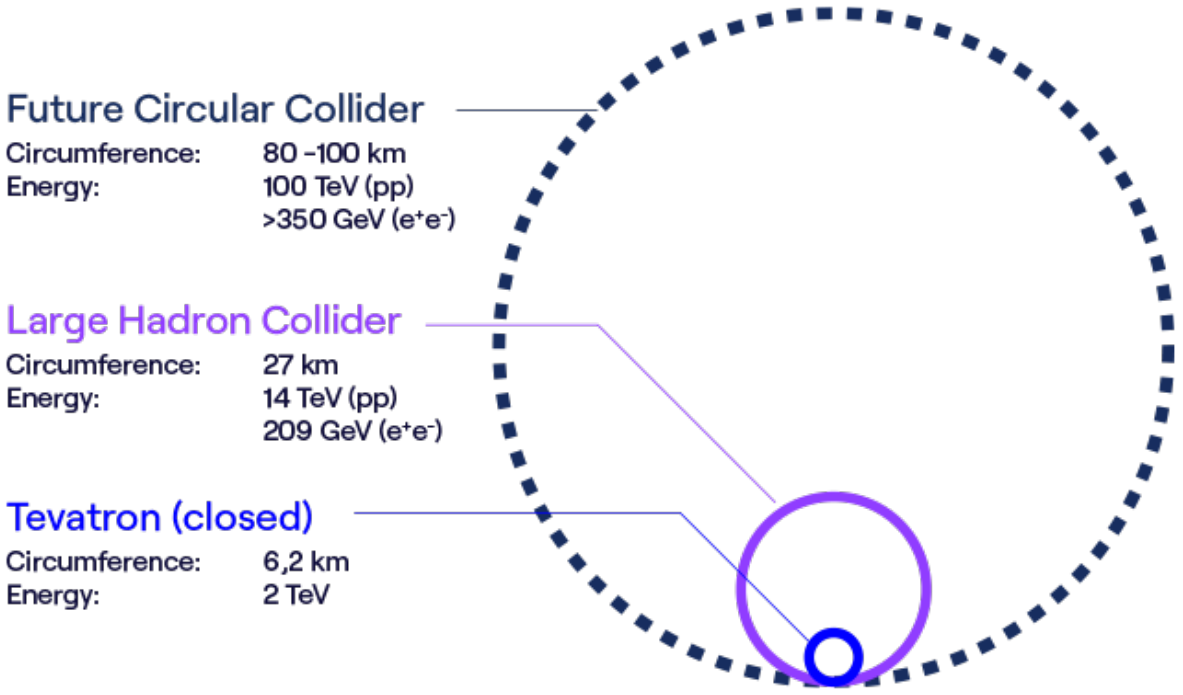
World Wide Web

And many others

The future

LHC will run until appr. 2040

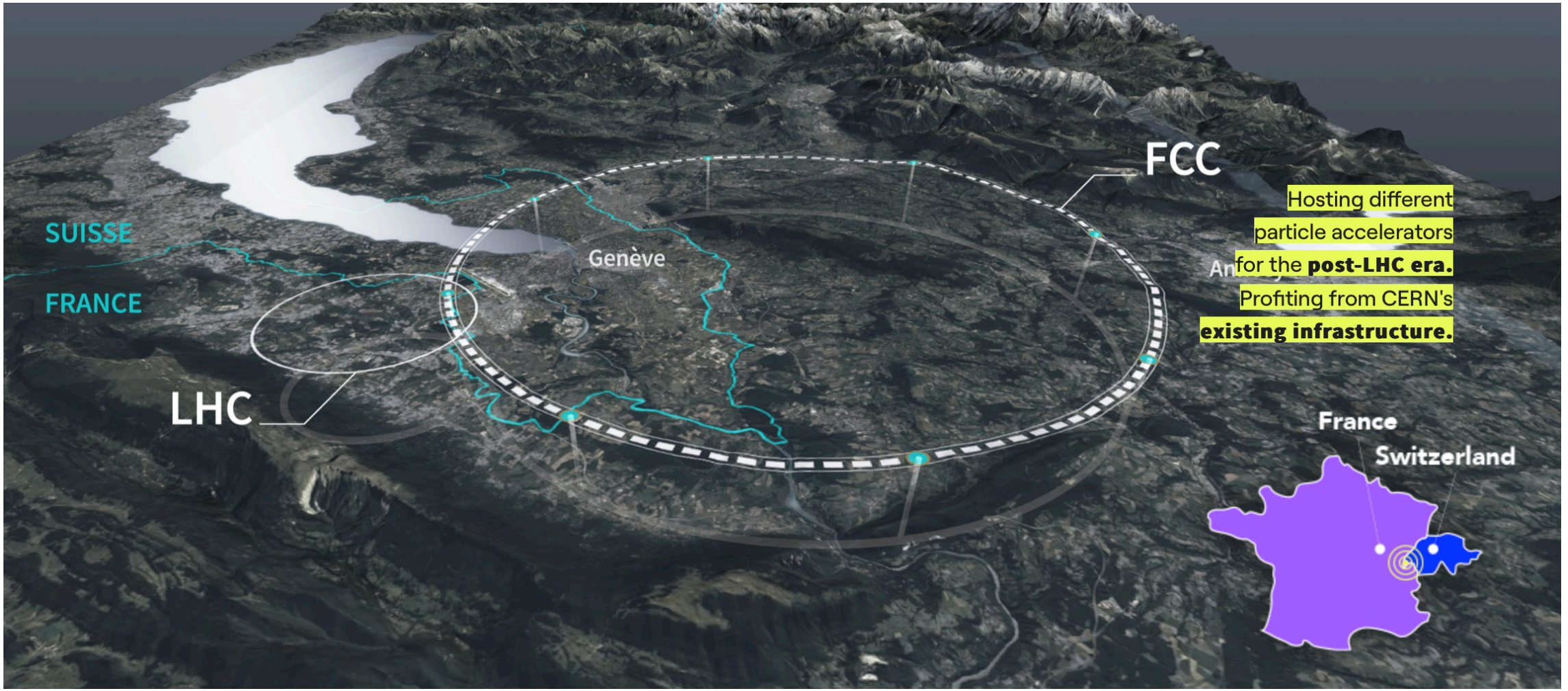
What's next after the LHC? The Future Circular collider - feasibility study on going.



Phase 1: FCC -ee beginning operation around 2045

Phase 2: FCC hh from 2070 on..

The future


SUISSE
FRANCE
Genève
LHC
FCC
Hosting different particle accelerators for the post-LHC era. Profiting from CERN's existing infrastructure.
France
Switzerland

The future

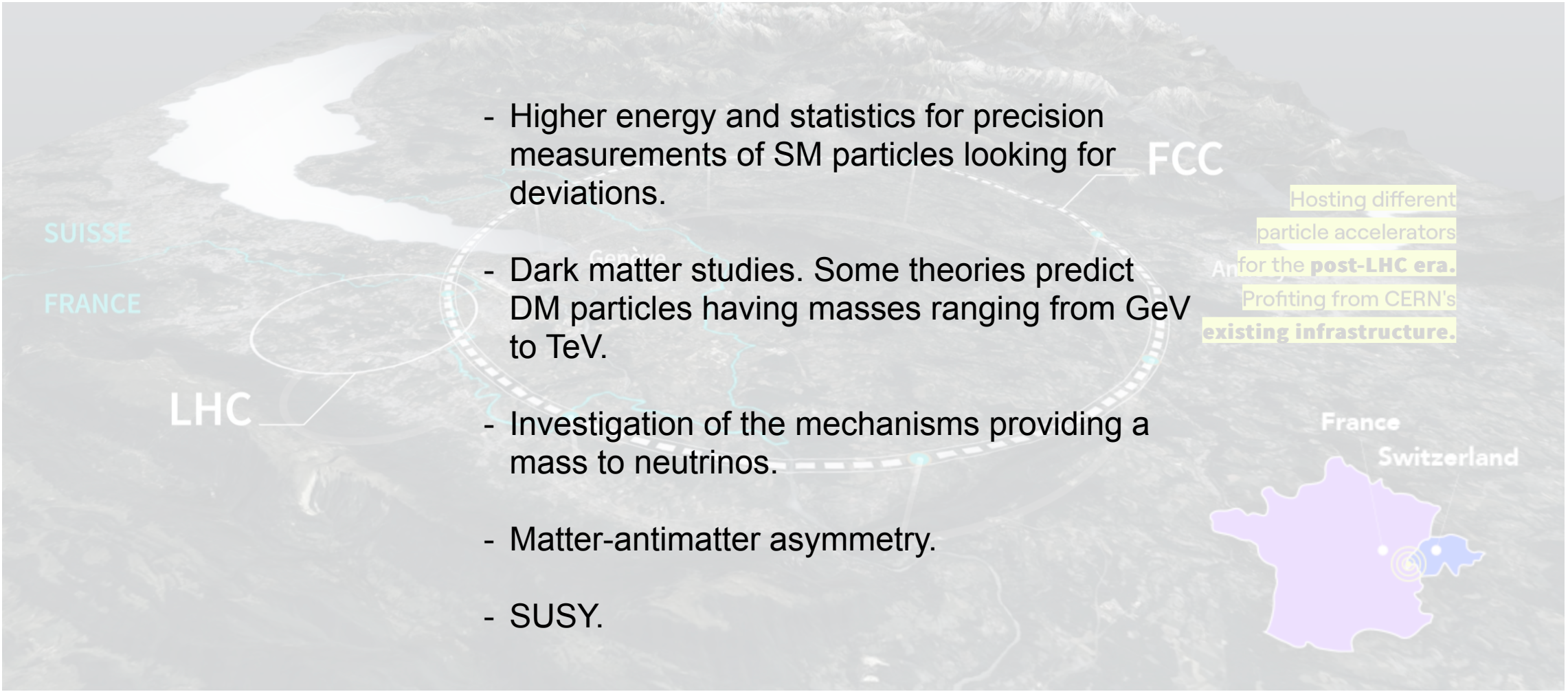
- Higher energy and statistics for precision measurements of SM particles looking for deviations.

- Dark matter studies. Some theories predict DM particles having masses ranging from GeV to TeV.

- Investigation of the mechanisms providing a mass to neutrinos.

- Matter-antimatter asymmetry.

- SUSY.



Enjoy your stay at CERN!

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