

A central bright white point of light radiates outwards, surrounded by a dense, chaotic web of thin white lines. From this central point, several distinct, thicker white lines extend outwards, each ending in a fan-like spray of smaller white lines, resembling particle tracks or jets from a collision. The background is a dark blue gradient.

CERN



European Organization for Nuclear Research Organisation européenne pour la recherche nucléaire



What is CERN ?

Originally

- European Organization for nuclear research
- Funded in 1954 by 12 member states
- In order to “establish a world-class fundamental physics research organization in Europe.”

Nowadays

- 23 member states, not only from Europe
- 96 participating countries/organizations
- largest particle physics lab in the world

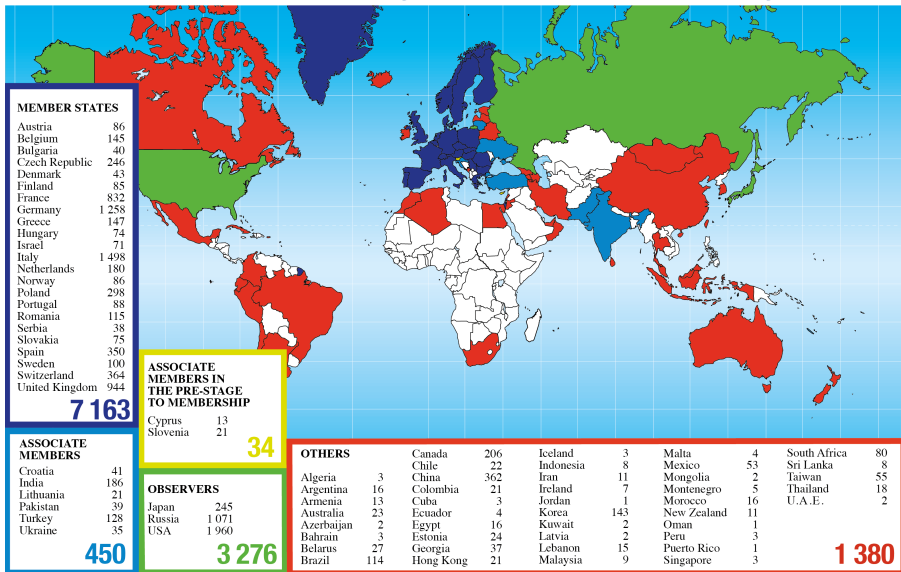


A few numbers

- 2300 staff members
- over 12500 collaborators
 - > 50% of particule physicists in the world
- 1 billion €/\$/CHF annual budget
- nobel prices : Sam Ting(76), Simon van der Meer(84), Carlo Rubbia(84), Jack Steinberger(88), Georges Charpak(92), François Englert(14), Peter Higgs(14)

A few numbers

Distribution of All CERN Users by Location of Institute on 27 January 2020

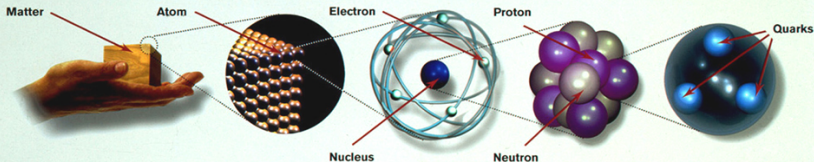




A few numbers

- 2300 staff members
- over 12500 collaborators
 - > 50% of particule physicists in the world
- 1 billion €/\$/CHF annual budget
- nobel prices : Sam Ting(76), Simon van der Meer(84), Carlo Rubbia(84), Jack Steinberger(88), Georges Charpak(92), François Englert(14), Peter Higgs(14)

The standard model



Matter particles
All ordinary particles belong to this group

These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators

LEPTONS			
FIRST FAMILY	<table border="1"> <tr> <td>Electron Responsible for electricity and chemical reactions; it has a charge of -1</td> <td>Electron neutrino Particle with no electric charge, and possibly no mass; billions fly through your body every second</td> </tr> </table>	Electron Responsible for electricity and chemical reactions; it has a charge of -1	Electron neutrino Particle with no electric charge, and possibly no mass; billions fly through your body every second
Electron Responsible for electricity and chemical reactions; it has a charge of -1	Electron neutrino Particle with no electric charge, and possibly no mass; billions fly through your body every second		
SECOND FAMILY	<table border="1"> <tr> <td>Muon A heavier relative of the electron; it lives for two-millionths of a second</td> <td>Muon neutrino Created along with muons when some particles decay</td> </tr> </table>	Muon A heavier relative of the electron; it lives for two-millionths of a second	Muon neutrino Created along with muons when some particles decay
Muon A heavier relative of the electron; it lives for two-millionths of a second	Muon neutrino Created along with muons when some particles decay		
THIRD FAMILY	<table border="1"> <tr> <td>Tau Heavier still; it is extremely unstable; it was discovered in 1975</td> <td>Tau neutrino Not yet discovered but believed to exist</td> </tr> </table>	Tau Heavier still; it is extremely unstable; it was discovered in 1975	Tau neutrino Not yet discovered but believed to exist
Tau Heavier still; it is extremely unstable; it was discovered in 1975	Tau neutrino Not yet discovered but believed to exist		

QUARKS	
Up Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	Down Has an electric charge of minus one-third; protons contain one, neutrons contain two
Charm A heavier relative of the up; found in 1974	Strange A heavier relative of the down; found in 1964
Top Heavier still	Bottom Heavier still; measuring bottom quarks is an important test of electroweak theory

Force particles

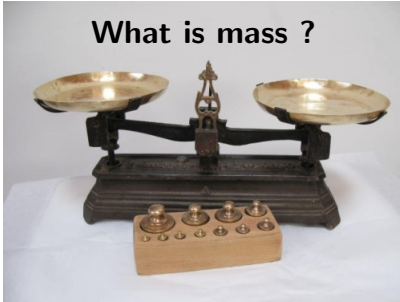
These particles transmit the four fundamental forces of nature although gravitons have so far not been discovered

<p>Gluons Carriers of the strong force between quarks</p> <p>Felt by: quarks</p> <p>The explosive release of nuclear energy is the result of the strong force</p>	<p>Photons Particles that make up light; they carry the electromagnetic force</p> <p>Felt by: quarks and charged leptons</p> <p>Electricity, magnetism and chemistry are all the results of electro-magnetic force</p>
---	--

<p>Intermediate vector bosons Carriers of the weak force</p> <p>Felt by: quarks and leptons</p> <p>Some forms of radio-activity are the result of the weak force</p>	<p>Gravitons Carriers of gravity</p> <p>Felt by: all particles with mass</p> <p>All the weight we experience is the result of the gravitational force</p>
--	---

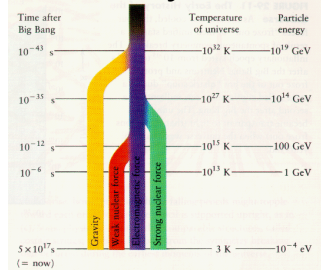
And many questions

What is mass ?

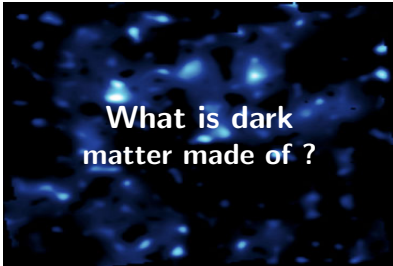


What happened to antimatter ?

How many forces ?



What is dark matter made of ?



And many questions

What is mass ?

Higgs Boson

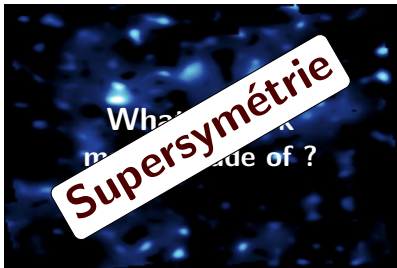


CP Violation

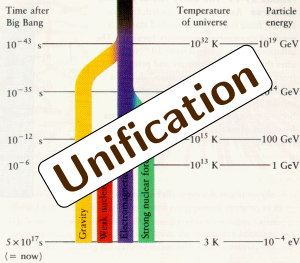
What happened to antimatter ?



Supersymétrie



How many forces ?



Which percentage of CERN staff deal with physics theories ?

- 1 > 80%
- 2 > 50%
- 3 < 20%
- 4 < 1%



Which percentage of CERN staff deal with physics theories ?

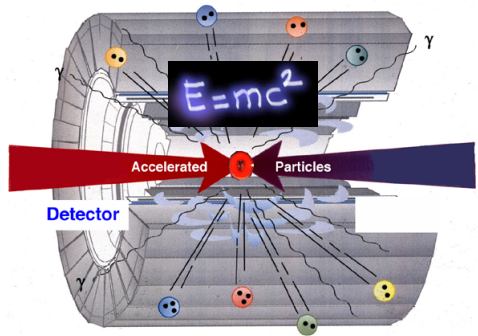
- 1 > 80%
- 2 > 50%
- 3 < 20%
- 4 < 1%



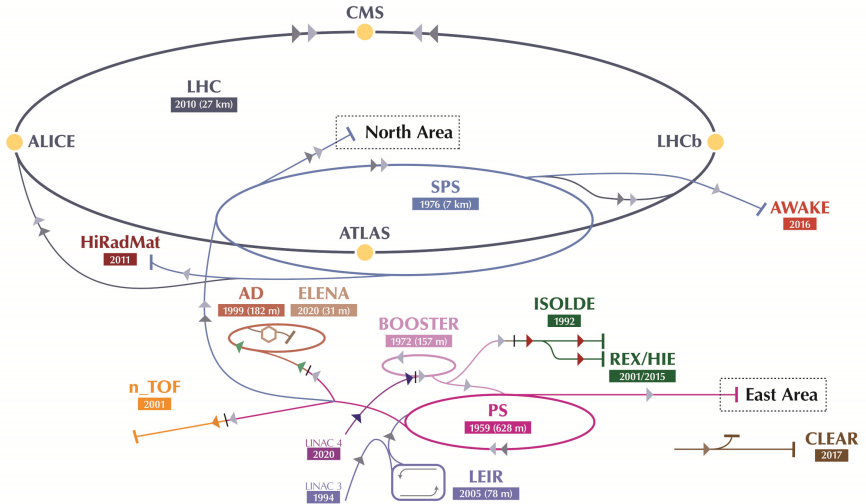
< 1% : ~20 theoreticians out of 2300 staffs

CERN concentrate on tools

- Accelerators
 - to create particles from kinetic energy
- Detectors
 - to observe these



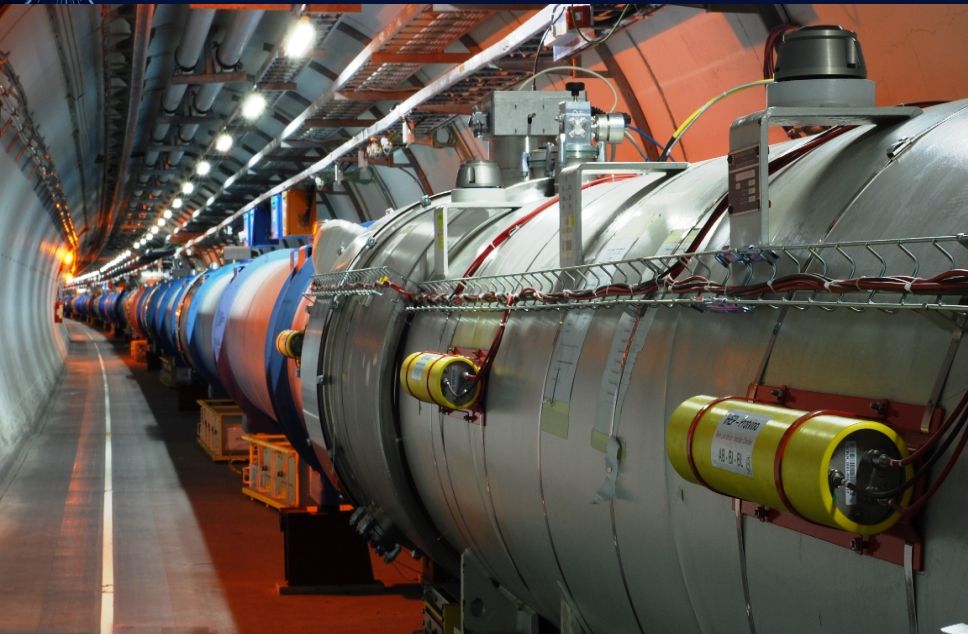
CERN facilities (simplified)



- Bigger = higher energy, lower losses



The LHC

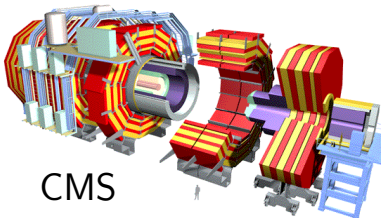
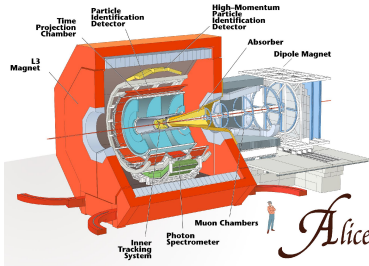
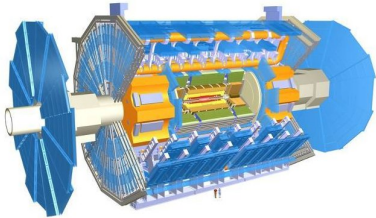


a few numbers

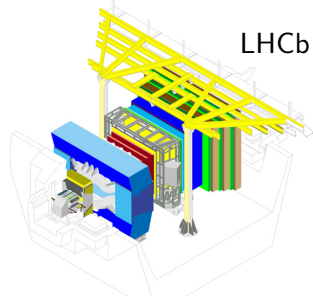
- 27 km long, 100 m underground
- 1.9 K i.e. -271.3°C
 - coolest place of the universe
- 1.013×10^{-10} mbar
 - emptiest place in the universe
- 14 TeV
 - full beam has energy of a high speed train

4 major detectors

Atlas



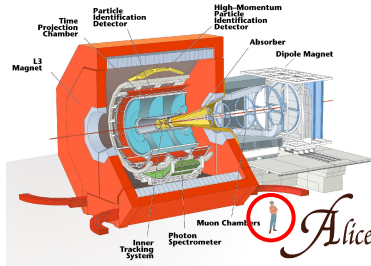
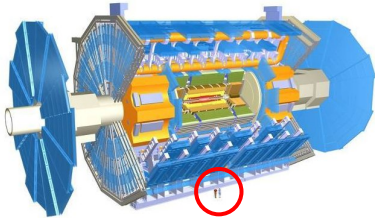
CMS



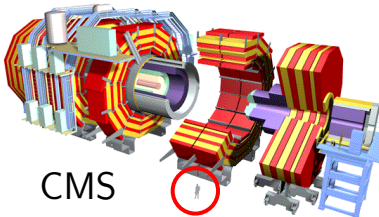
LHCb

4 major detectors

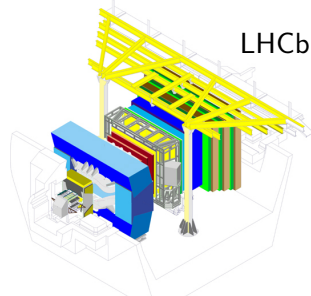
Atlas

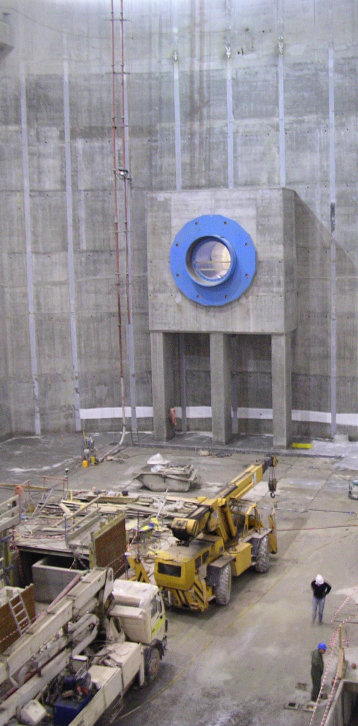


CMS



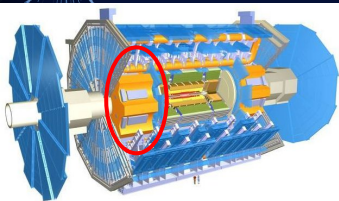
LHCb







Detectors are BIG



Which percentage of CERN staff deal with accelerators/detectors ?

- 1 > 80%
- 2 > 50%
- 3 < 30%
- 4 < 10%



Which percentage of CERN staff deal with accelerators/detectors ?

- 1 > 80%
- 2 > 50%
- 3 < 30%
- 4 < 10%



~25%, 75% work on the infrastructures



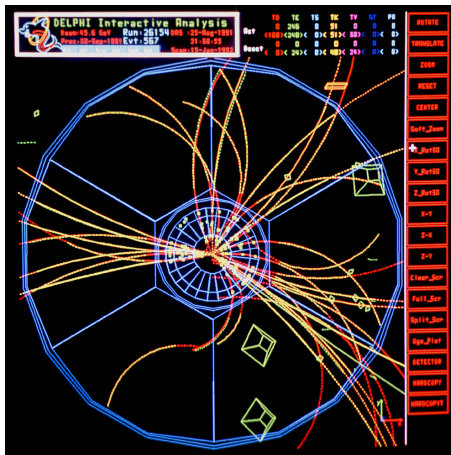
CMS Experiment at the LHC, CERN

Data recorded: 2010-Jul-09 02:25:58.839811 GMT(04:25:58 CEST)

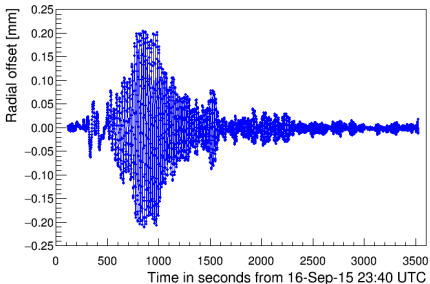
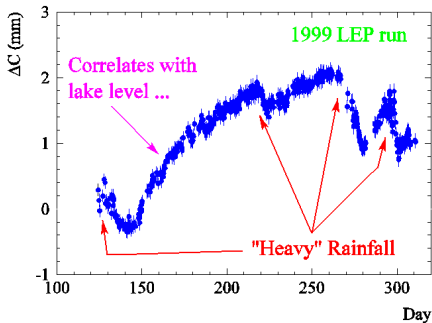
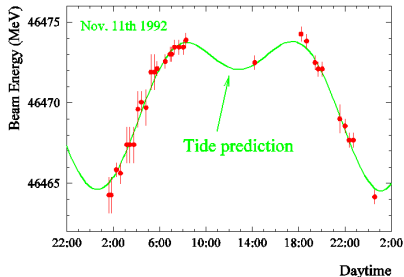
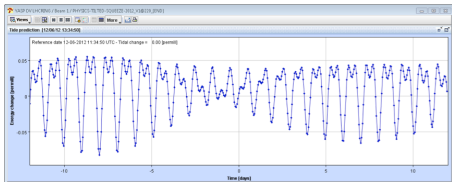
Run / Event: 139779 / 4994190

Analyzing collisions

- Reconstruction
 - tracks, vertices
 - particle identification
- Statistical analysis
 - vs simulations
- Scale
 - 10^9 collisions/s
 - 10^3 trajectoires/col
 - μm precision



A few examples of "noise"

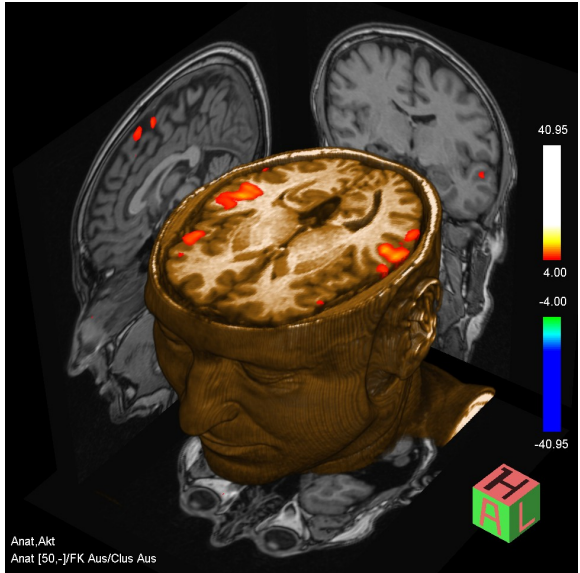
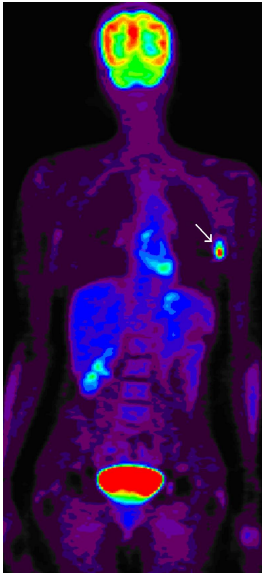




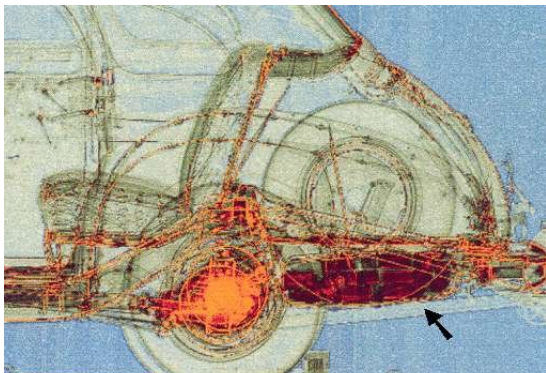
Technology transfers

- CERN is leader in many technologies
 - computer science, civil engineering, cold, vacuum, magnets, medical accelerators and imaging, ...
- Its convention ensures it's free knowledge
 - “results of its experimental and theoretical work shall be published or otherwise made generally available”
- This is how the “web” was free !

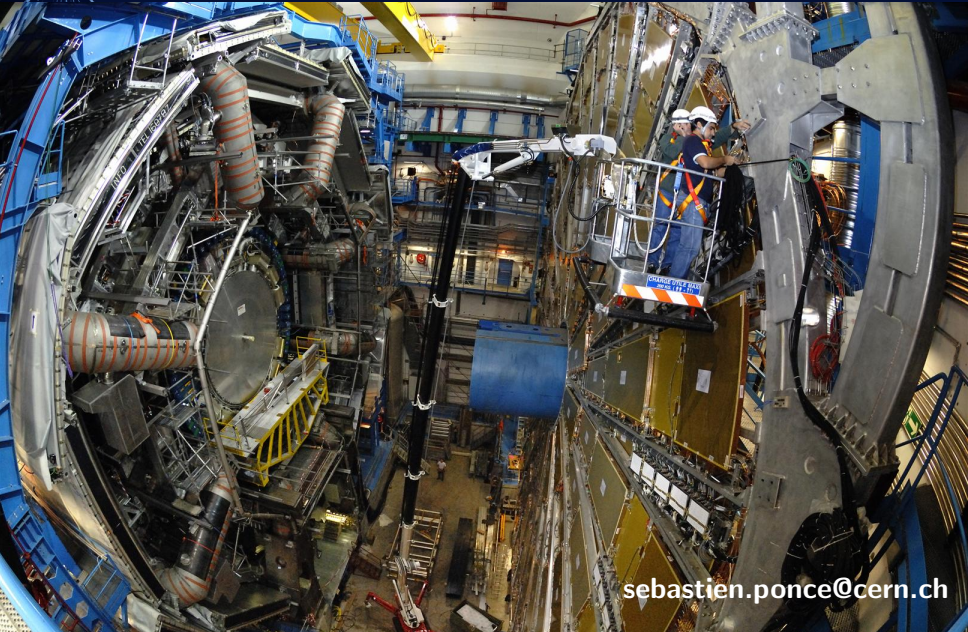
Medical field



Customs



Questions ?



sebastien.ponce@cern.ch