A journey from the Infinitely Big to the Infinitely Small

Virginia Azzolini

- Conference will start shortly
- Switch off camera and microphone
- Open the *chat* tool (down-right)

Your virtual conference

Format

- Presentation (40 minutes in total)
- Questions and answers (20 minutes in total)

During presentation

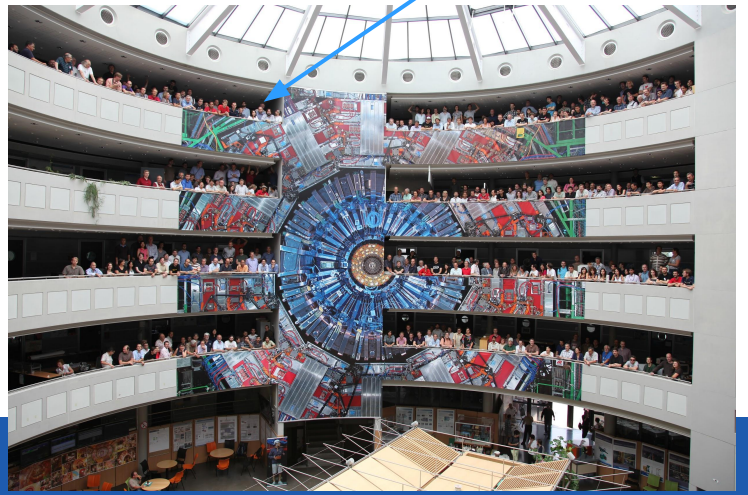
- Ask questions using the chat
- Use microphone or camera only if needed

After presentation

- Please fill out survey on Indico page
- Material and links available on Indico page

Hello!

I am a particle physicist
I studied in Italy, then I started traveling
I have been working at CERN since 2009 with the CMS experiment
I am an anomaly detection expert,
in a traditional way or
with machine learning technology



March 2010, first LHC collision…and me

CERN
What is it?

CERN is

a Scientific Laboratory, that devises its own solutions

a 

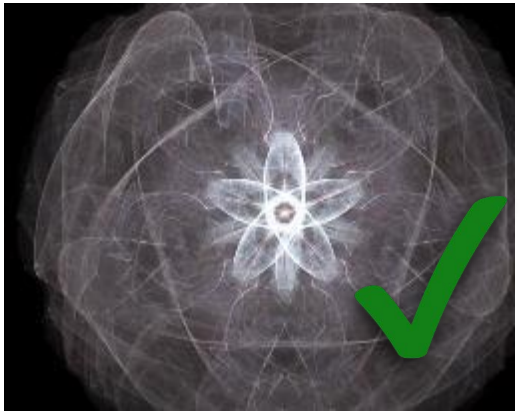
Laboratory

What does *CERN* stand for ?

1952 Conseil Européen pour la Recherche Nucléaire

1954 Organisation Européenne pour la Recherche Nucléaire

Nuclear?



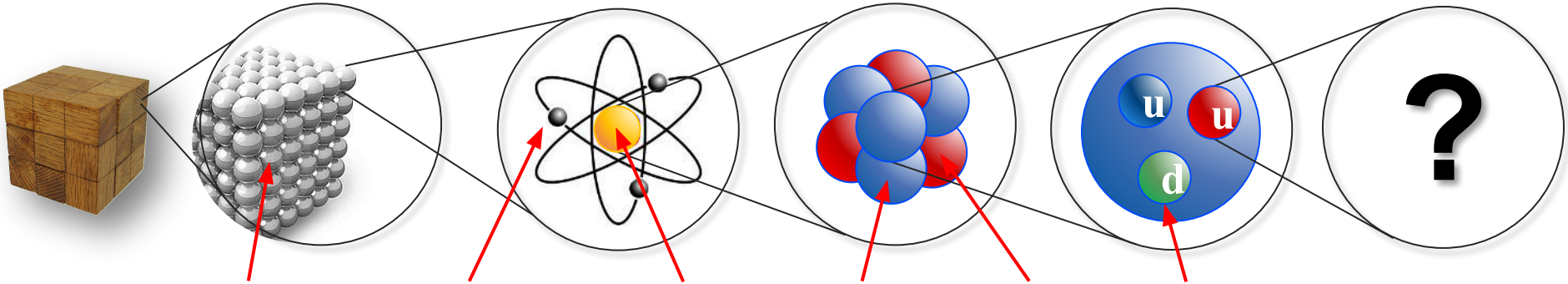
European laboratory for particle physics

we study the nucleus

CERN
What for?

Fundamental research

What is the matter made of ?



atom — 4^{th} - 5^{th} BCE

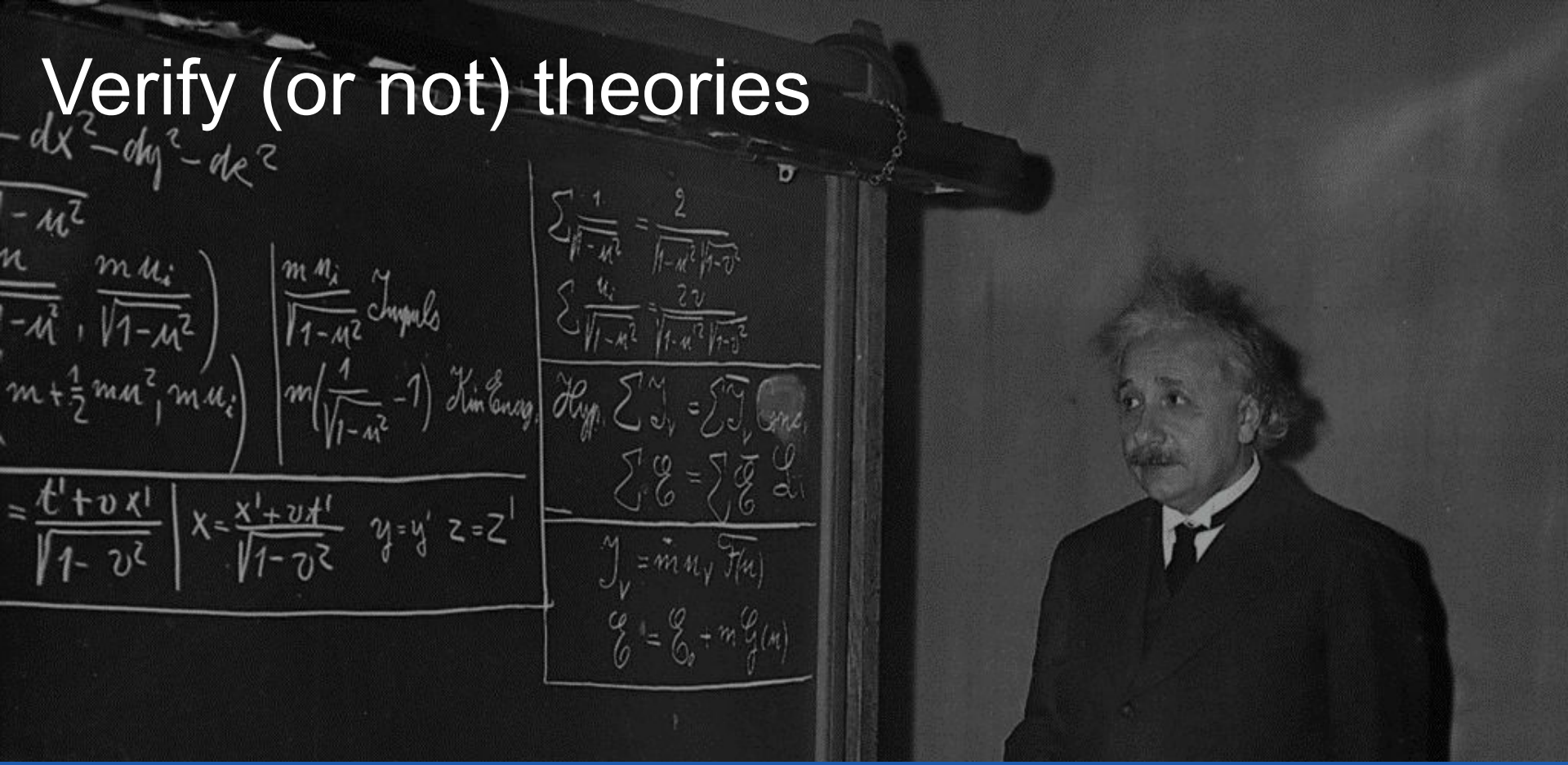
electron — nucleus — End of 19^{th} century

proton — neutron — Begining of 20^{th} century

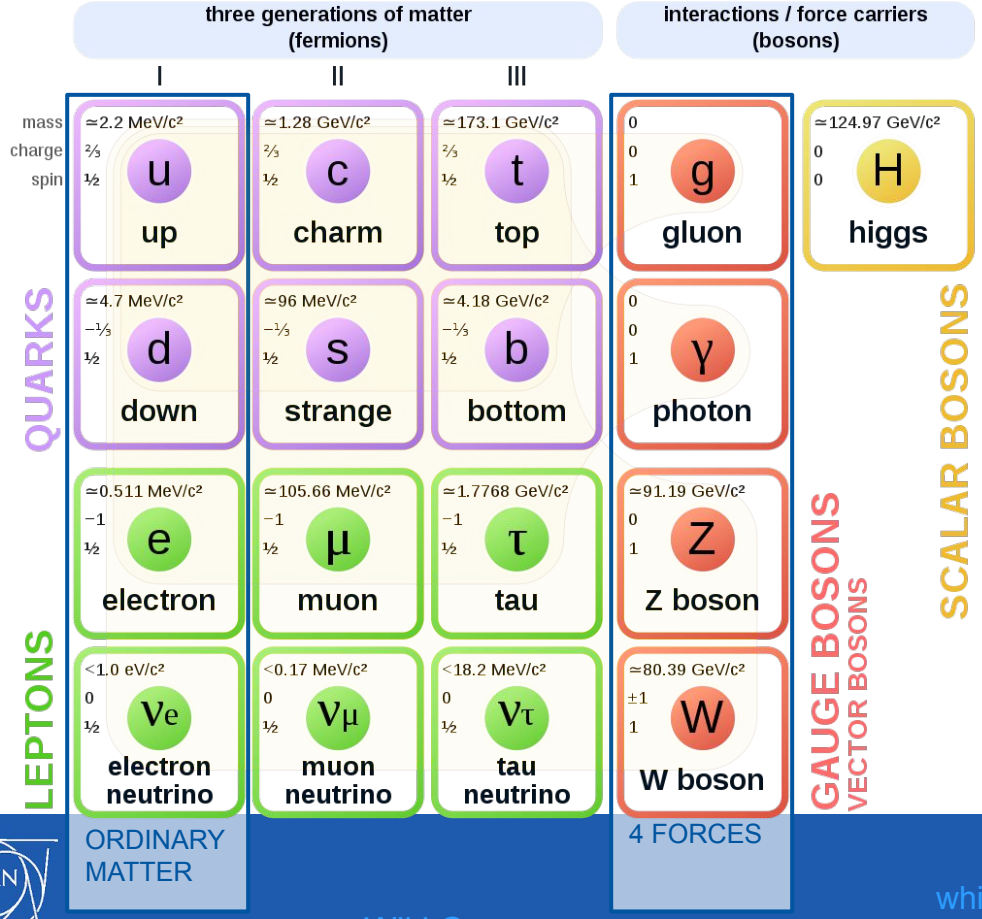
quark — 1960s

Video on CERN youtube channel: https://youtu.be/7WhRJV_bAiE

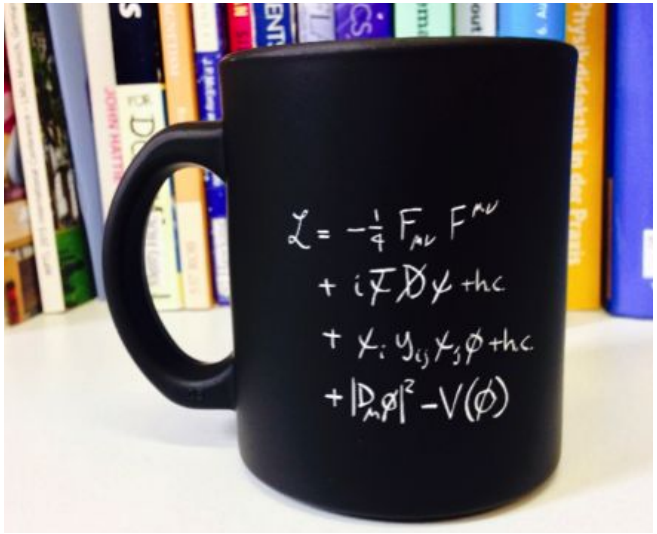
Verify (or not) theories



Standard Model and Lagrangian equation



source: Wiki Commons

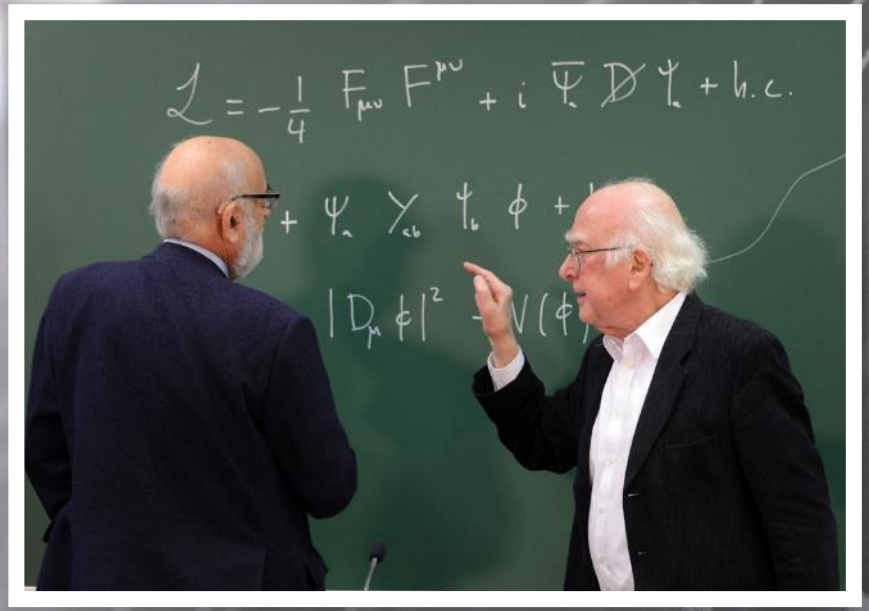


https://iopscience.iop.org/article/10.1088/1361-6552/aa5b25

which particle R U?

https://scoollab.web.cern.ch/sites/scoollab.web.cern.ch/files/ParticleGame/

Answering questions…



Higgs ?

The Higgs Field, explained - Don Lincoln
https://www.youtube.com/watch?v=joTKd5j3mzk
https://www.youtube.com/watch?v=1AamFQWwh94

The Higgs Discovery Explained - CERN:
Ep. 1: https://www.youtube.com/watch?v=so2nCu2Jkbc
Ep. 2: https://www.youtube.com/watch?v=pW4LTunlXS4
Ep. 3: https://www.youtube.com/watch?v=8-WFBGCvv-w
Ep. 3.5: https://www.youtube.com/watch?v=0USWORsTza0

Answering questions…

ANTIMATTER ?

AMS: https://home.cern/science/experiments/ams
AD: https://home.cern/science/accelerators/antiproton-decelerator

Answering questions…

Answering questions…

Collaborating … best practice

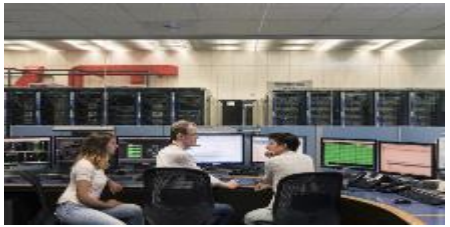
Team working

Listening to others' ideas

Share ideas

Observe and question

Find solutions



To ask questions

CERN
Who is it?

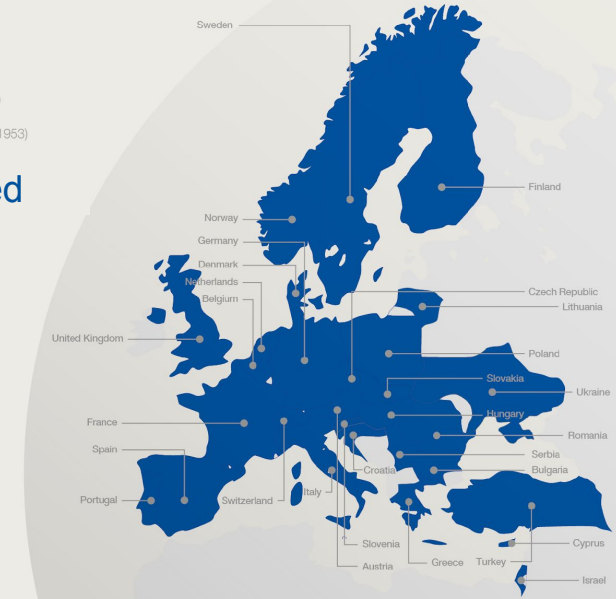
Member States

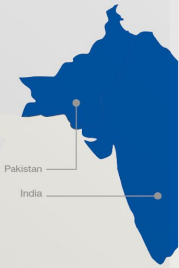
Budget (2020)
1,168 billion CHF
0,970 billion GBP
1,210 billion USD
a cup of coffee per inhabitant per year

- Austria (1959)
- Belgium (1953)
- Bulgaria (1999)
- Czech Republic (1993)
- Denmark (1953)
- Finland (1991)
- France (1953)
- Germany (1953)
- Greece (1953)
- Hungary (1992)
- Israel (2014)
- Italy (1953)
- Netherlands (1953)
- Norway (1953)
- Poland (1991)
- Portugal (1986)
- Romania (2016)
- Serbia (2019)
- Slovakia (1993)
- Spain (1961-1968, 1983-)
- Sweden (1953)
- Switzerland (1953)
- United Kingdom (1953)

Associated

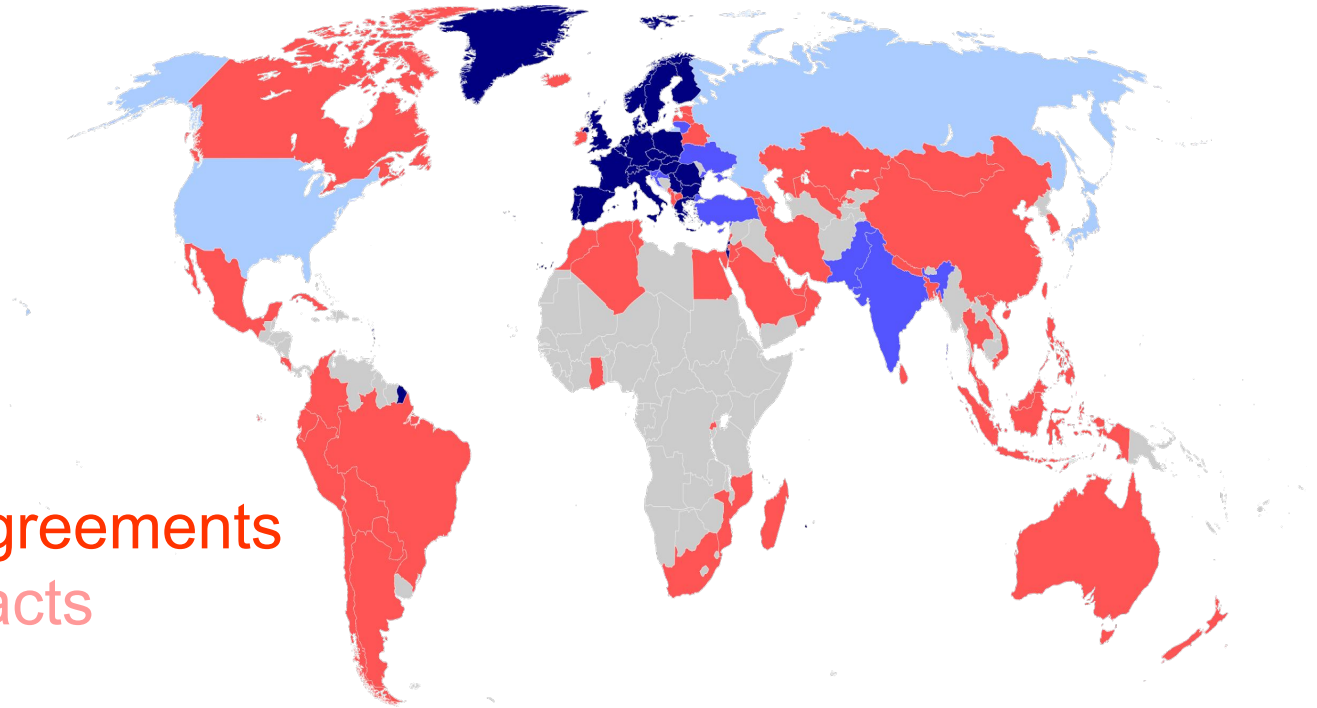
- Croatia (2019)
- Cyprus (2016)
- India (2017)
- Lithuania (2018)
- Pakistan (2015)
- Slovenia (2017)
- Turkey (2015)
- Ukraine (2016)



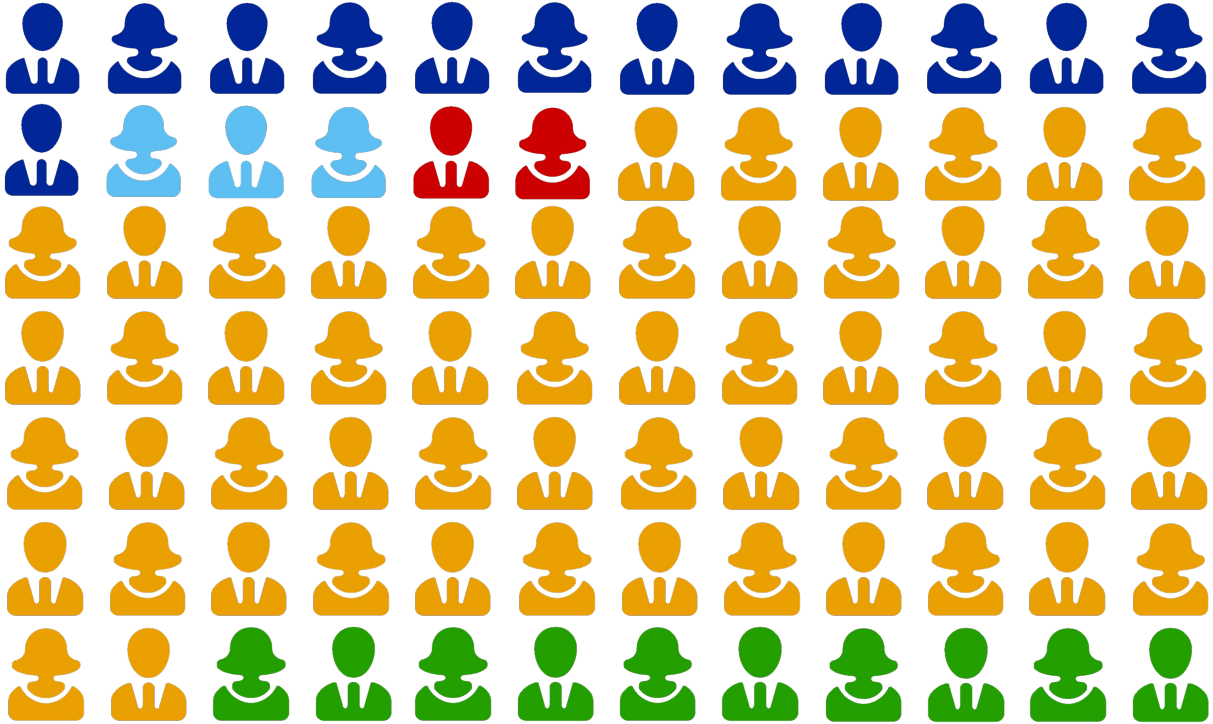


A world collaboration

23 members
8 associated
3 observers
61 cooperation agreements
scientific contacts



How many persons?



20 000!

2 600 staff

800 fellows

apprentices

550 students

15 000 physicists associated

2 000 external companies

And the general director ... is?

Dr. Fabiola Gianotti, Physicist

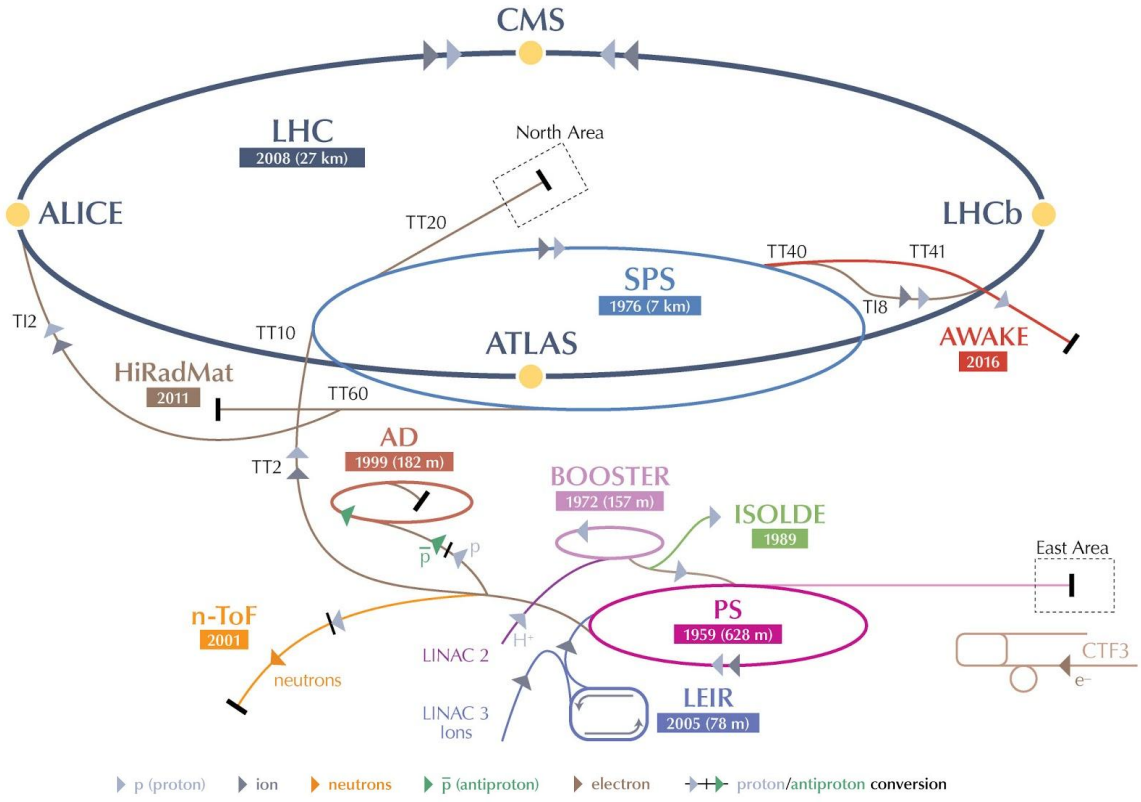
CERN
How does it work?

CERN recipe for fundamental research
(and win a Nobel Prize)

Accelerator + Detector + computing technology

share results

CERN's Accelerator Complex

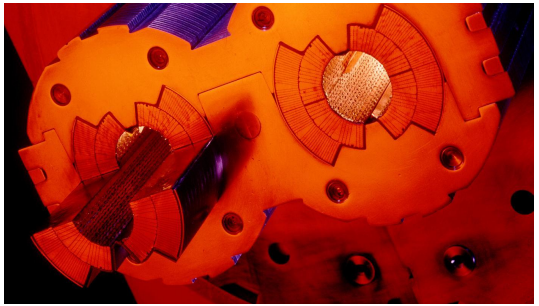


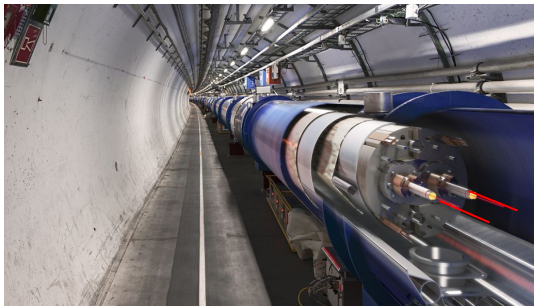
LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron ISOLDE Isotope Separator OnLine DEvice HiRadMat High-Radiation to Materials
AD Antiproton Decelerator CTF3 Clic Test Facility AWAKE Advanced WAKefield Experiment n-ToF Neutrons Time Of Flight LINAC LINear ACcelerator LEIR Low Energy Ion Ring

Video on CERN youtube channel:
https://youtu.be/pQhbhpU9Wrg

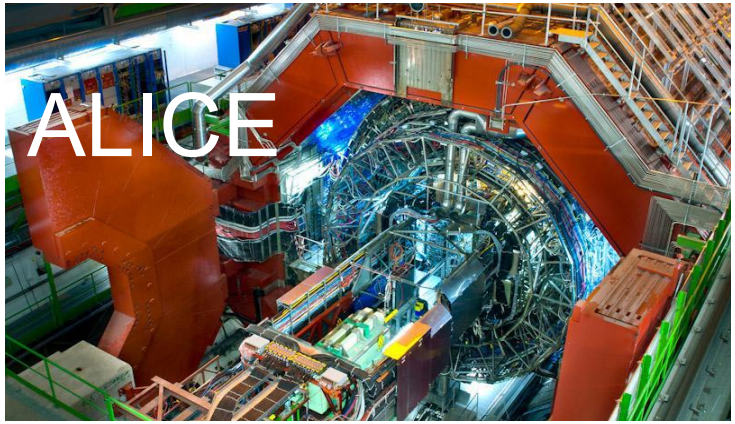
LHC : a record machine

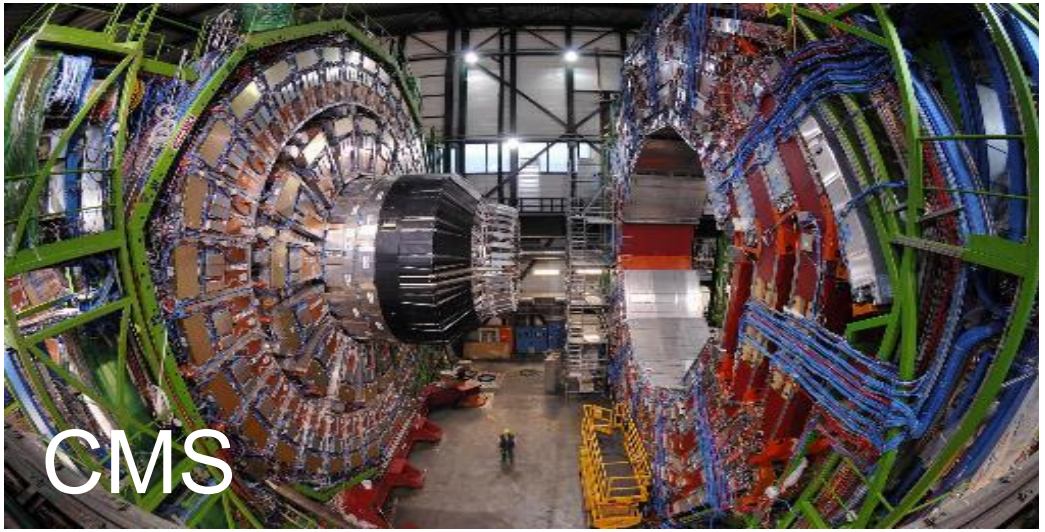
Largest machine : 27 km of circumference
Level of energy: 7 TeV
Highest vacuum: 10^{-13} Atm
Powerful magnets: 8.3 Tesla
Coldest temperatures: 1.9 K (-271.3°C)

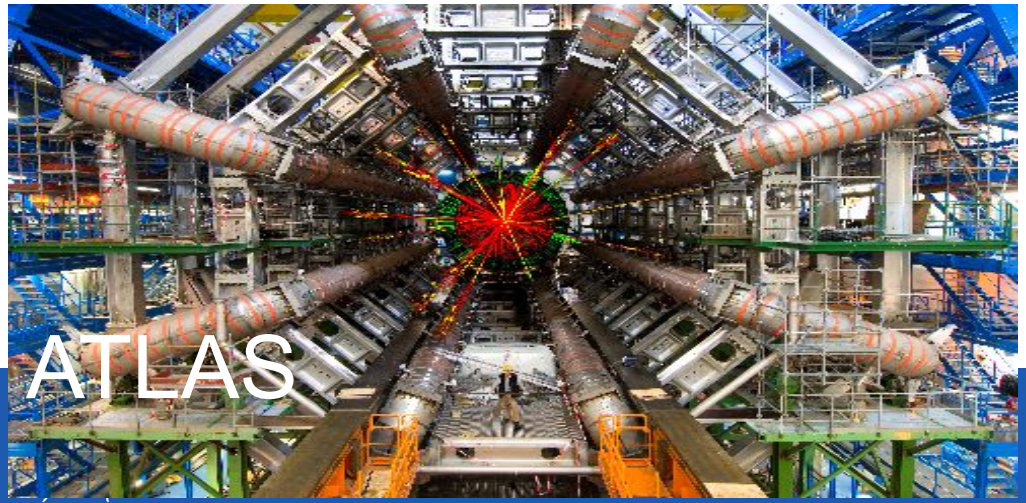


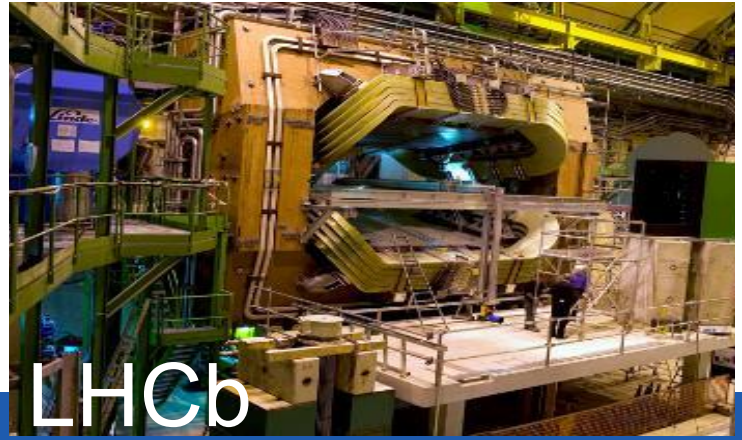


Detectors



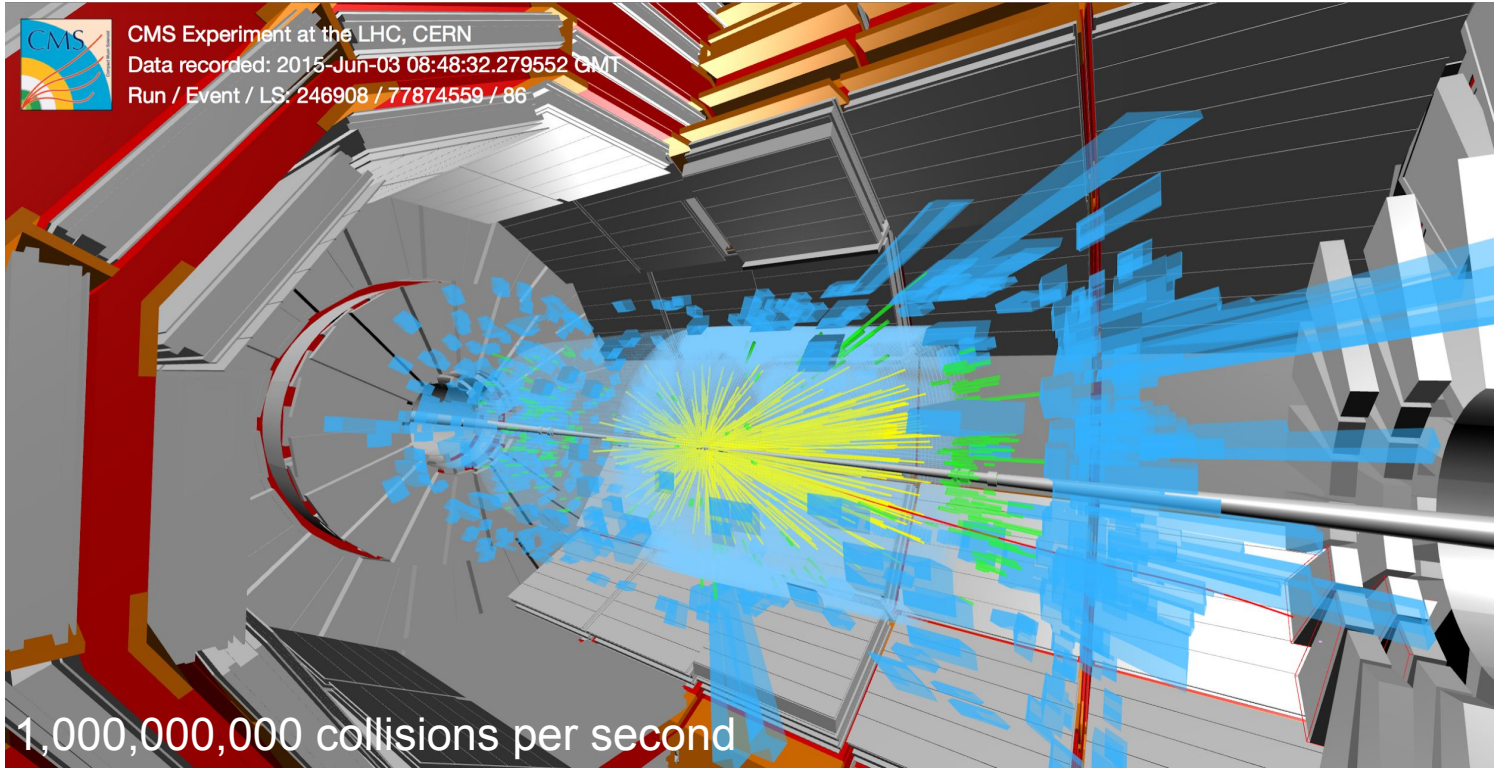






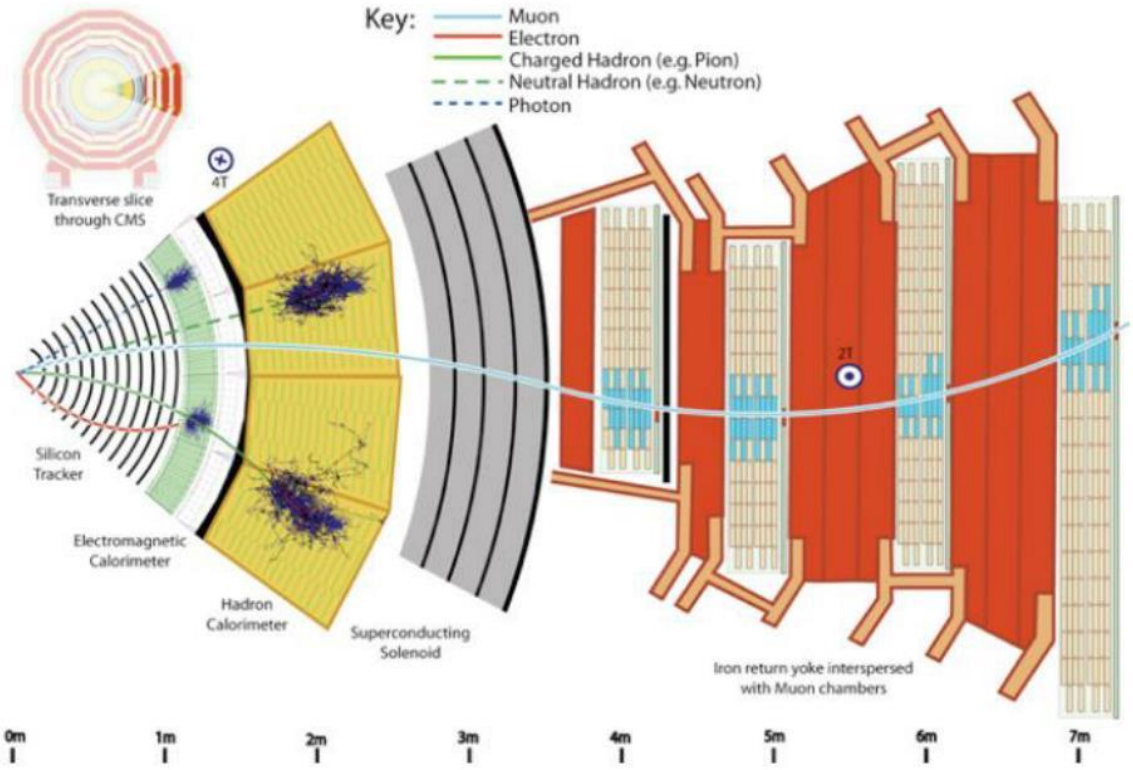
Who is this man?
https://www.youtube.com/watch?v=sB0_ohLM3Kg

Billions of Collisions

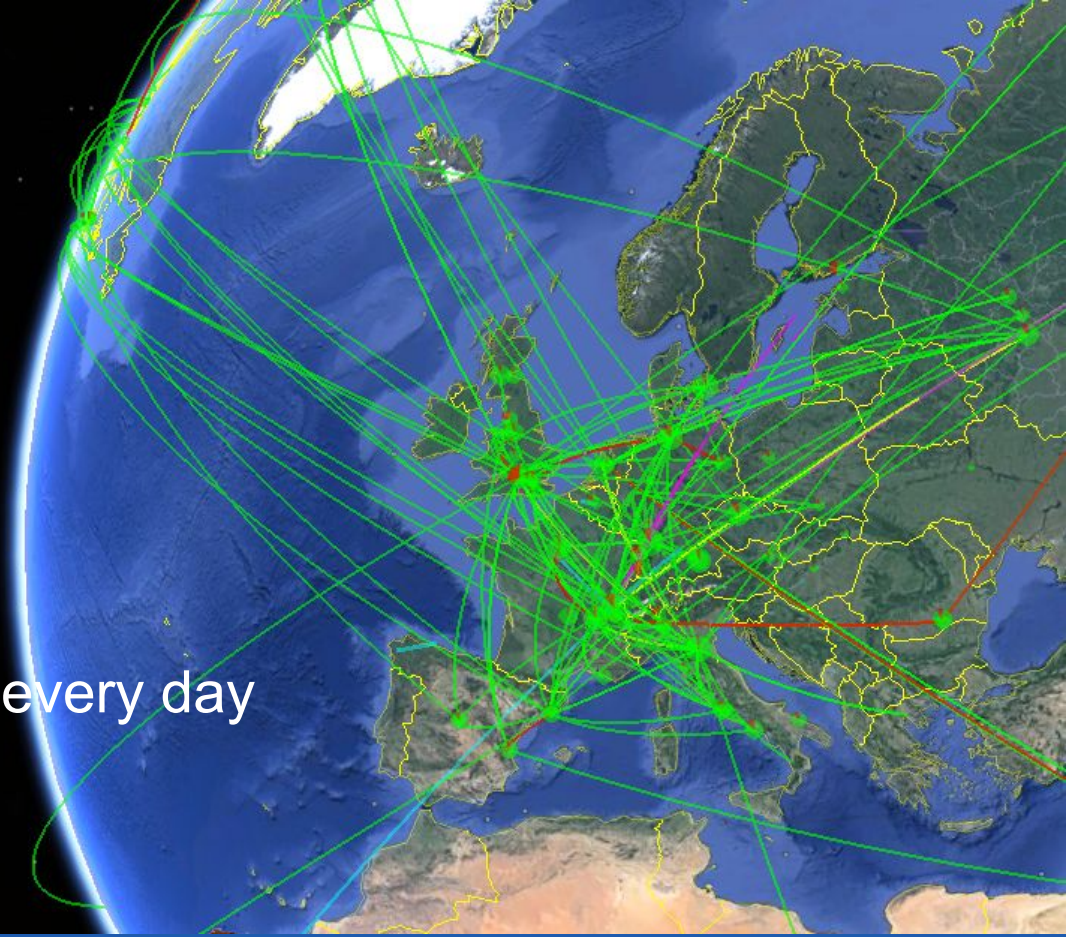


Tracks Detection

Particle Detection Tracks in CMS



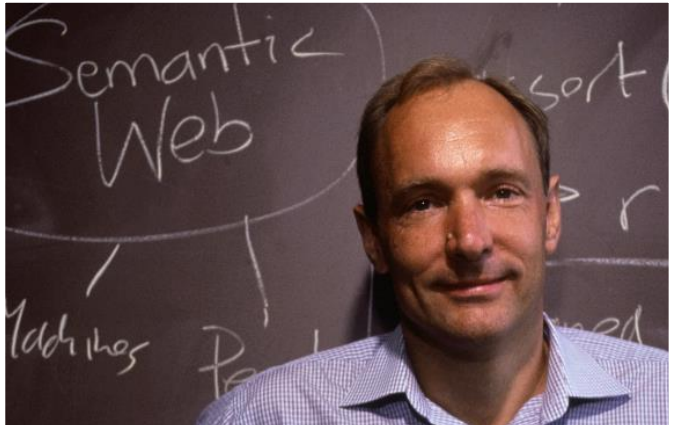
The largest computing grid



42 countries
170 data centers
Over 2 million tasks executed every day
1 million computer cores
1 storage exabyte

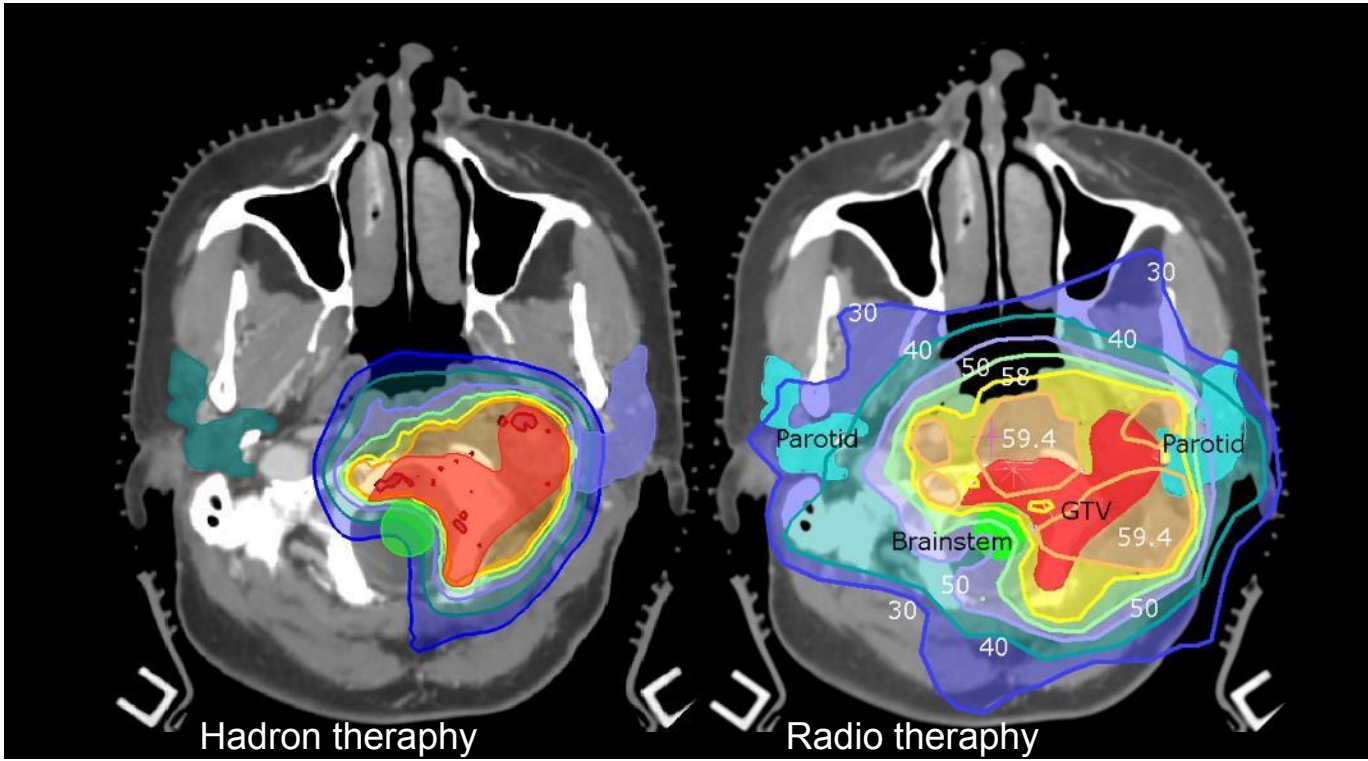
CERN
for me?

World Wide Web



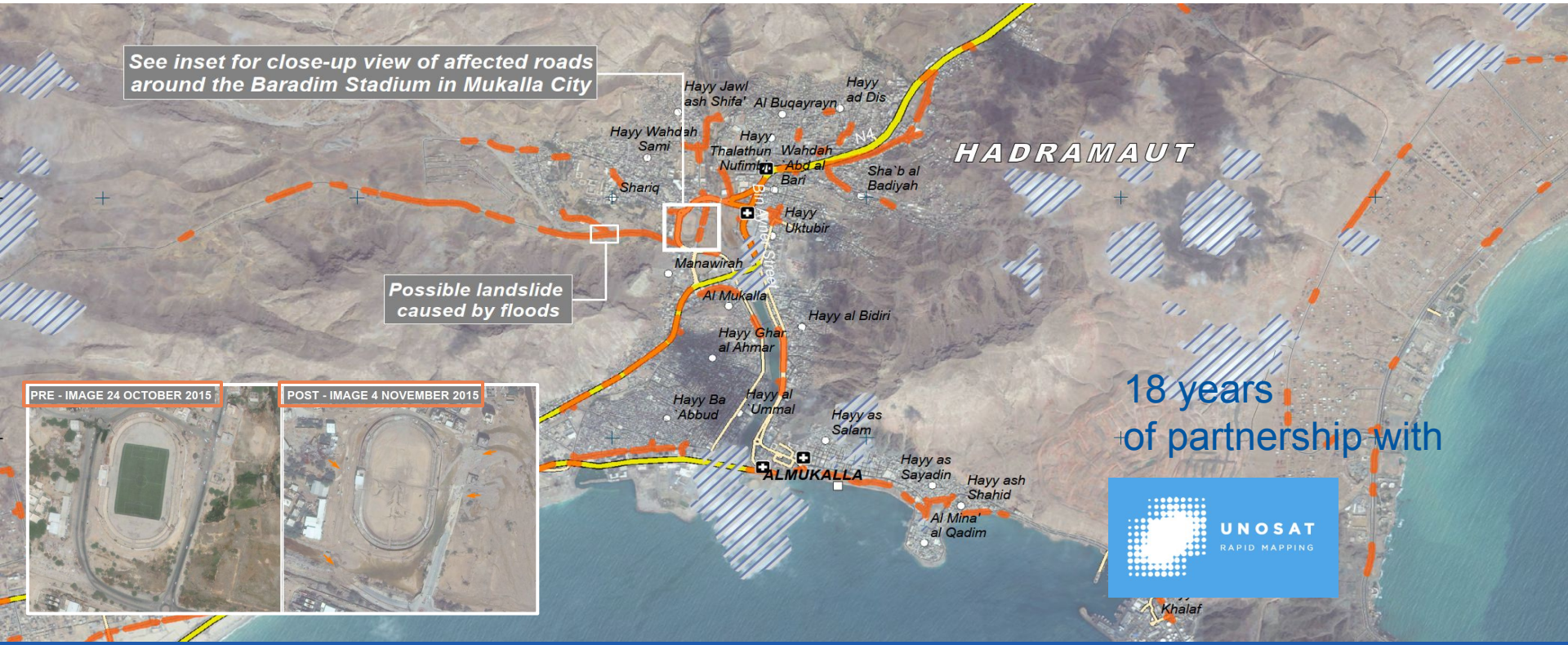
Sir Tim Berners-Lee

Medical applications



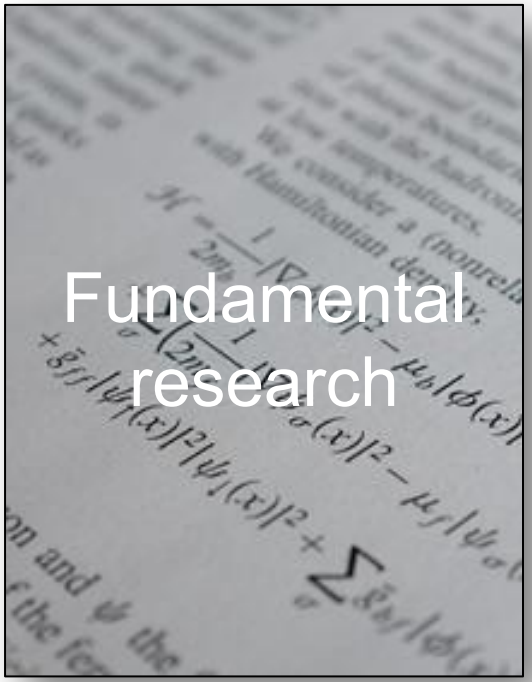
https://home.cern/tags/hadrontherapy
https://home.cern/tags/medical-applications

Humanitarian missions



https://unitar.org/unosat
https://unitar.org/maps

In a nutshell…



Thanks for your attention!

To learn further…

- home.cern
- visit.cern
- careers.cern

Thanks for filling up survey!

backup

Our innovations (some)

Medical applications

- PET / CT / MRI scan technologies
- Detectors, superconducting magnets, cryogenics, vacuum
- Radiation therapy: accelerators, detectors

Space applications

- High-radiation environment materials / devices

Other computing developments

- Data analysis & simulation frameworks
- Grid middleware
  Indico – meeting and conference management
- Invenio - digital library management

… and much much more

Who visits CERN

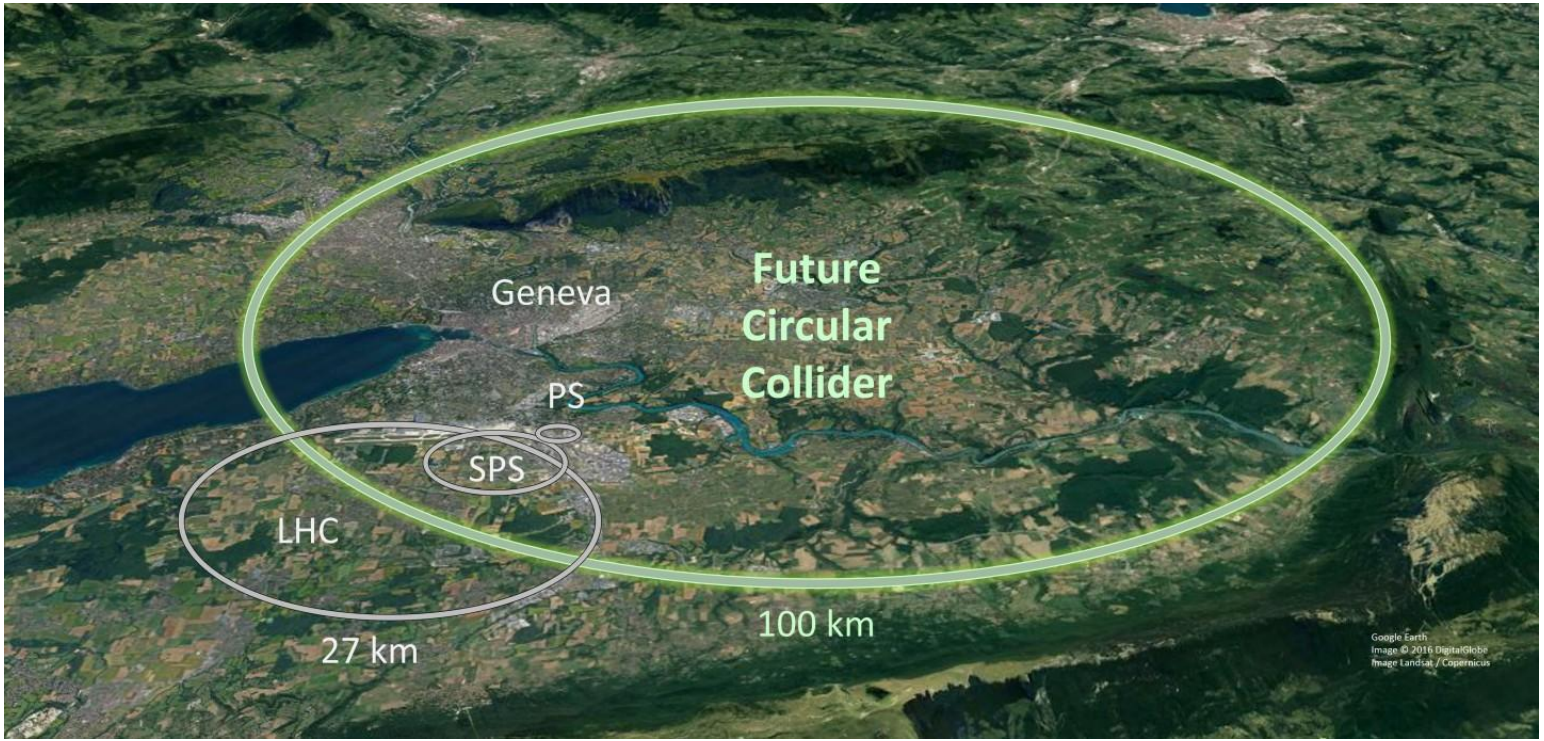
CERN is an open laboratory

with certain constraints and regulations

Every year, ~300’000 people visit CERN

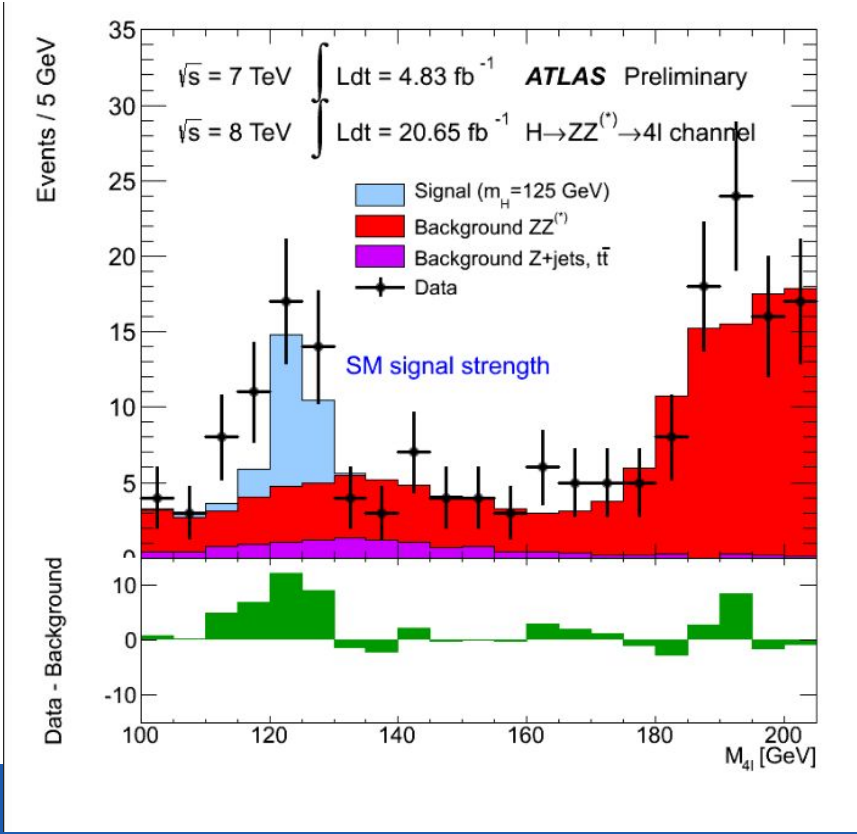
Open days September 2019: 75’000 people visited in 2 days!!!

CERN thinks bigger



https://cerncourier.com/a/cern-thinks-bigger/
https://home.cern/science/accelerators/future-circular-collider

Invariant mass peak? yes please



To make this graph we took all the collisions in which four muons, four electrons or two muons and two electrons were recognized inside the ATLAS / CMS detector (it depends) and for each of the events we calculated what the mass of the particle would have been " mother "from which these four particles could have come if they had been generated in the decay of an original particle.

Do you see that excess of events that accumulates around 125 times the mass of a proton? in blue? That's the sign of the existence of the Higgs boson, one of the traces that allowed us to declare its discovery in 2012!

What is the LHC power consumption?

The total power consumption of the LHC (and experiments) is equivalent to 600 GWh per year, with a maximum of 650 GWh in 2012 when the LHC was running at 4 TeV.

For Run 2, the estimated power consumption is 750 GWh per year.

The total CERN energy consumption is 1.3 TWh per year while the total electrical energy production in the world is around 20000 TWh, in the European Union 3400 TWh, in France around 500 TWh, and in Geneva canton 3 TWh.

Standard Model

	LEPTONS		QUARKS	
ORDINARY MATTER	ELECTRON	ELECTRON NEUTRINO	UP	DOWN
	MUON	MUON NEUTRINO	CHARM	STRANGE
	TAU	TAU NEUTRINO	TOP	BOTTOM

4 FORCES	GLUONS	PHOTONS	BOSONS	GRAVITONS
	Strong force	*Electromagnetic force*	*Weak force*	*Gravity*

which particle R U?
https://scoollab.web.cern.ch/sites/scoollab.web.cern.ch/files/ParticleGame/

Images: www.particlezoo.net

A