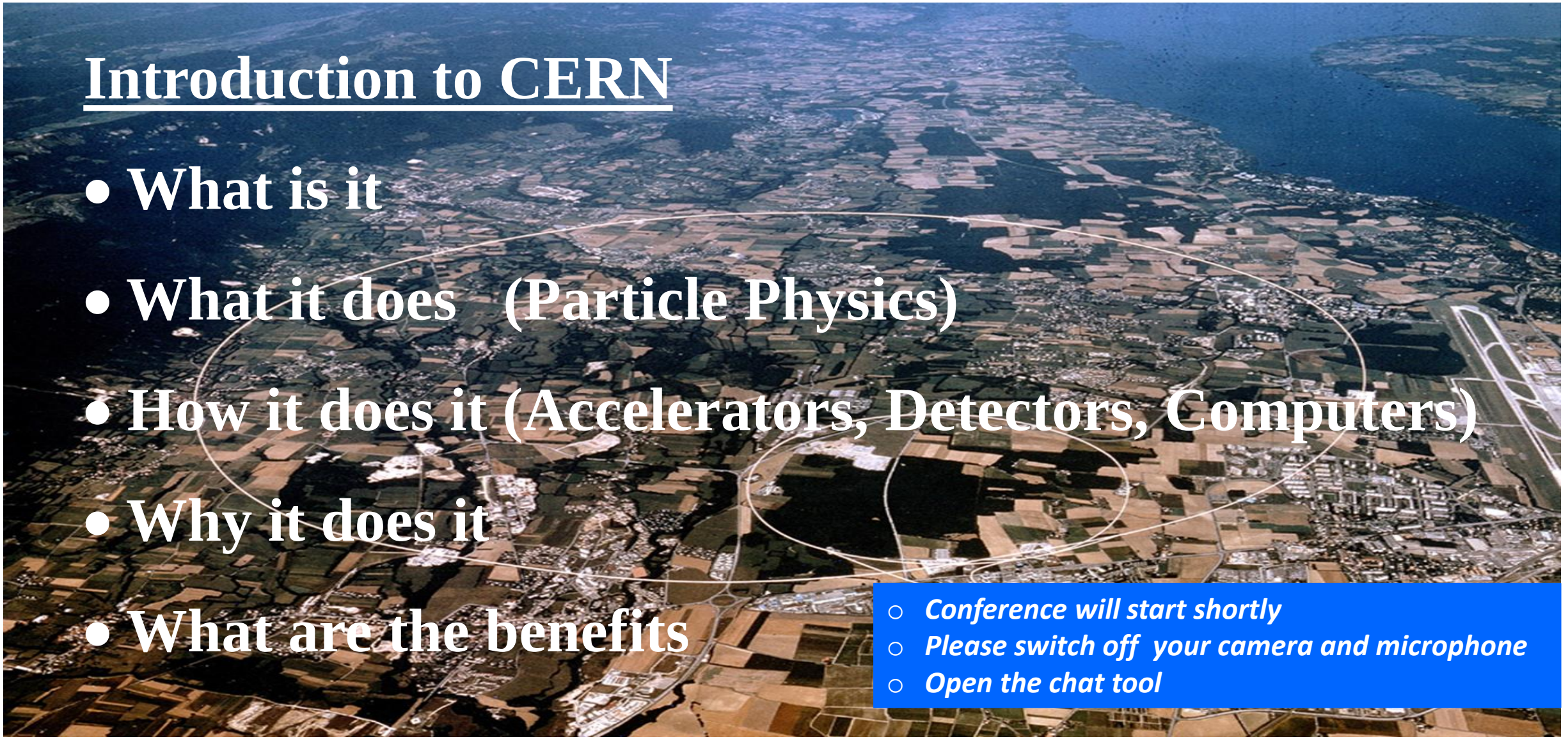
Welcome to CERN!



Introduction to CERN

- What is it
- What it does (Particle Physics)
- How it does it (Accelerators, Detectors, Computers)
- Why it does it
- What are the benefits

- *Conference will start shortly*
- *Please switch off your camera and microphone*
- *Open the chat tool*

Dr. Rachel Maria Avramidou

Info about the 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

Who I am

I am a detector physicist working with the ATLAS experiment

What is CERN

The largest research centre for particle physics!

Founded in 1954

Initially 12 members

Counts

- **2600 staff**
- **800 fellows/apprentices**
- **15000 users**
- **550 students**

23 member states

Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Spain, Israel, Sweden, Switzerland, United Kingdom

Associate Member States in the pre-stage to Membership
Cyprus and Slovenia

Associate Member States
Croatia, India, Lithuania, Pakistan, Turkey, Ukraine

Observers
EU, Japan, JINR, Russian Federation, UNESCO, USA

More than 40 states with co-operation agreements/scientific contacts

What is CERN

- **Budget: ~ 1 billion euros**
- **State contribution according to GDP**

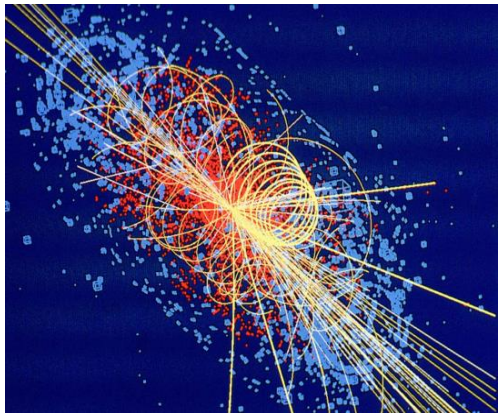
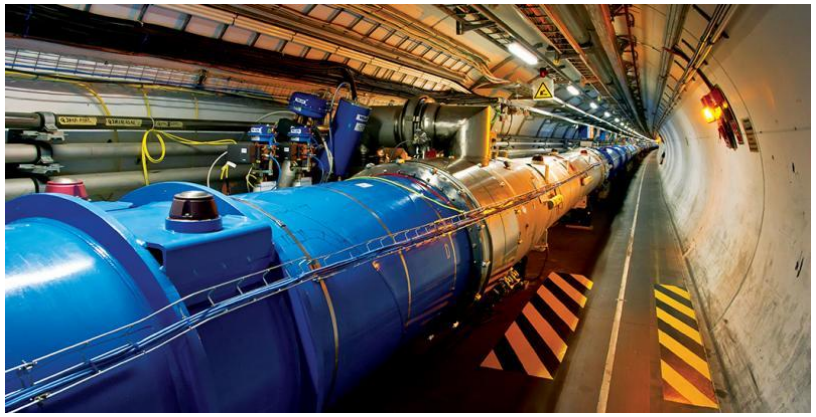
A cup of coffee per European citizen per year

What CERN does

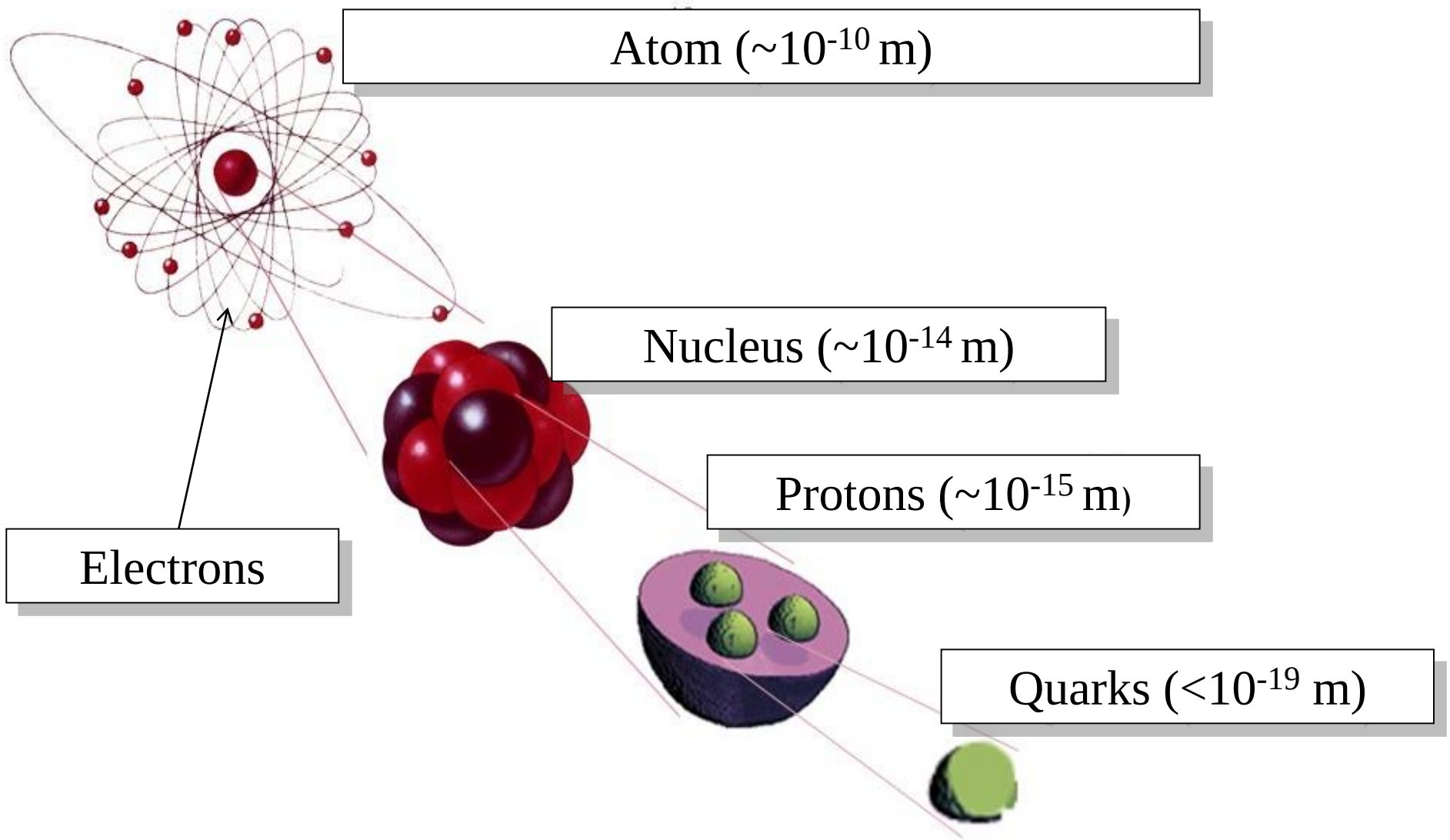
Fundamental research in particle physics:

- **Matter components (and forces)**
- **Universe origin and structure**
- **Open questions related to the origin of mass, dark matter, Big Bang, antimatter, etc.**

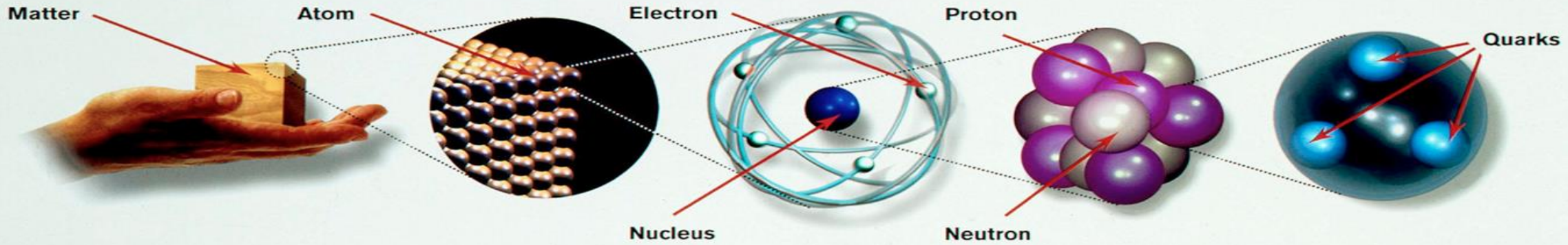


The components of the matter



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	**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	**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	**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

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the strong force

Photons
Particles that make up light; they carry the electromagnetic force

Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of electro-magnetic force

Intermediate vector bosons
Carriers of the weak force

Felt by: quarks and leptons

Some forms of radio-activity are the result of the weak force

Gravitons
Carriers of gravity

Felt by: all particles with mass

All the weight we experience is the result of the gravitational force

GRAPHICS: PETER CROWTHER

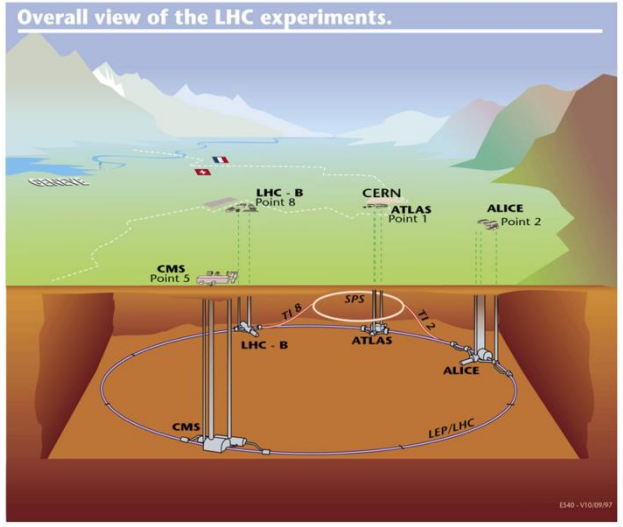
How CERN does it

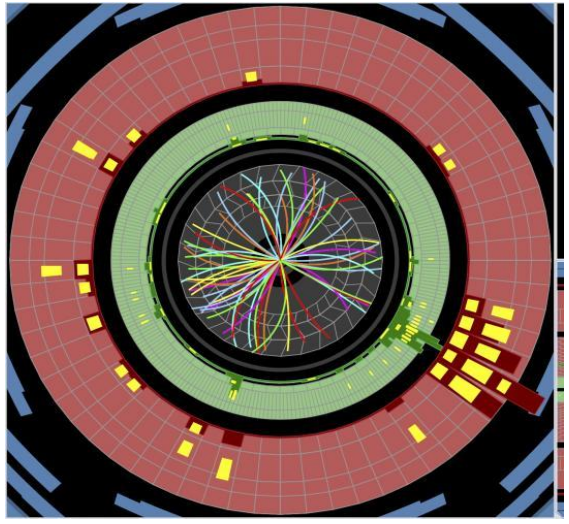
Accelerators: Accelerate particles

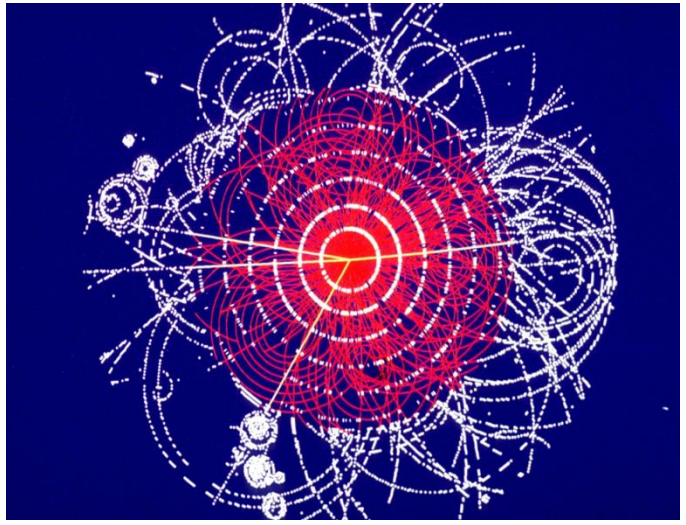
Collisions: Energy transformation into matter: $E = mc^2$

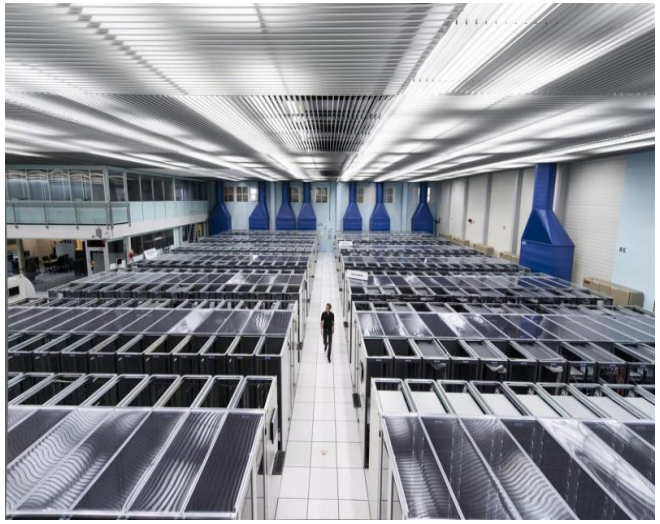
Detectors: Identify and measure particles

Computers: Analyse data

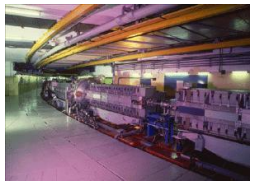




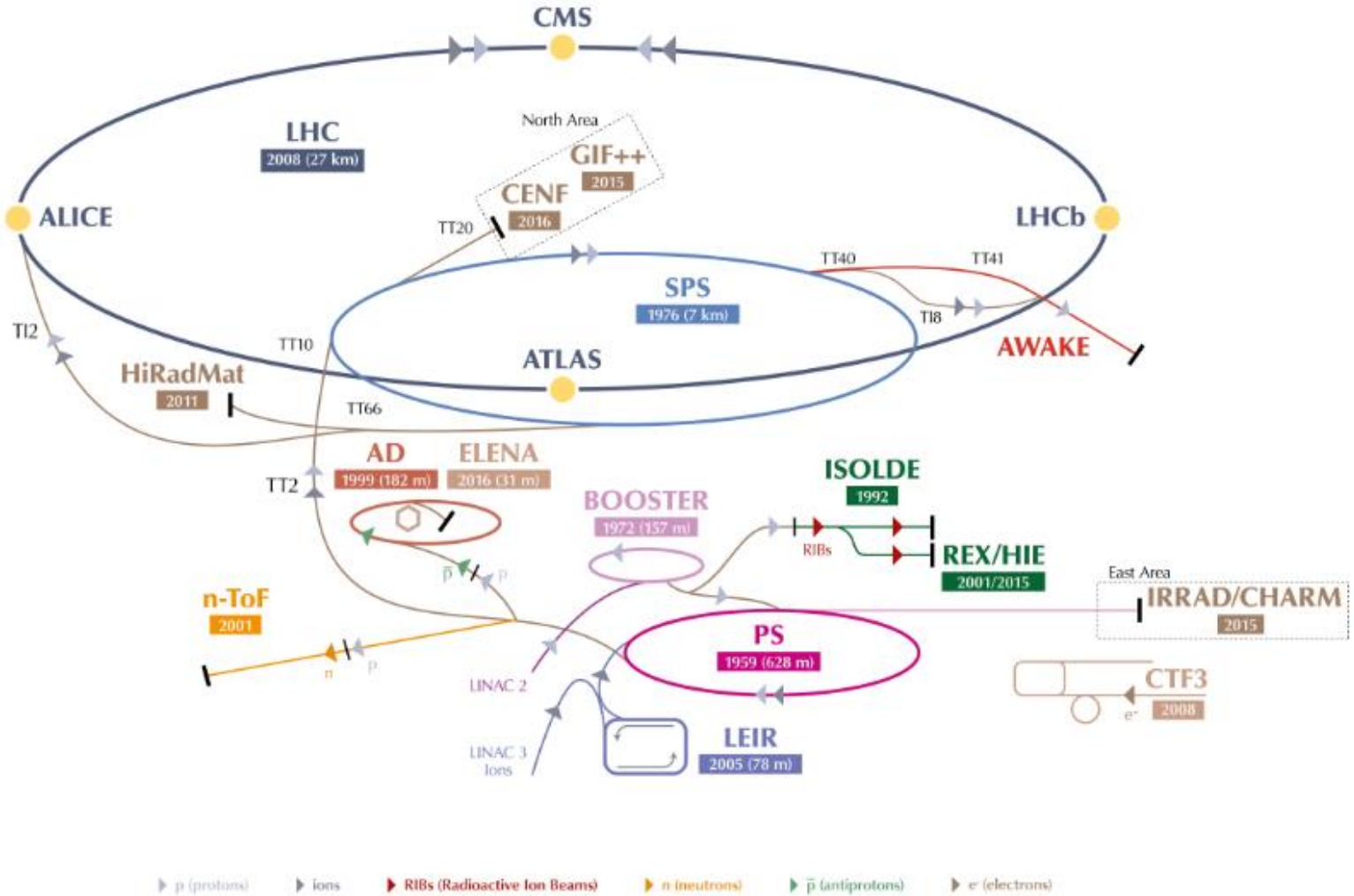




The accelerator complex



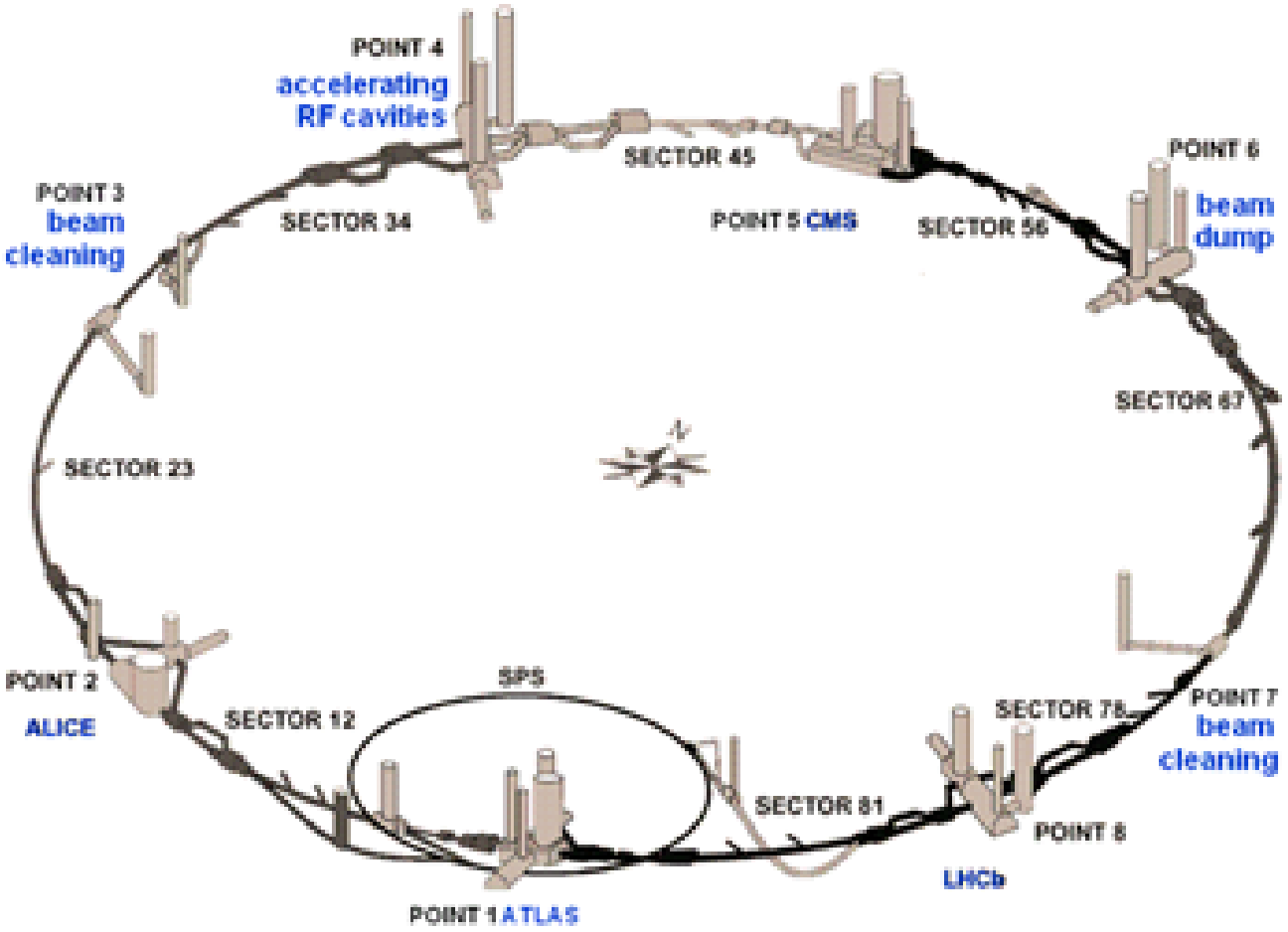
7 TeV
5 LHC
450 GeV
4 SPS
26 GeV
3 PS
1.4 GeV
2 BOOSTER
50 MeV
1 LINAC 2



http://home.web.cern.ch/about/accelerators

Large Hadron Collider (LHC)

- **The largest and most powerful particle accelerator**
  - **27 km**
  - **~100 m underground**



Proton/Pb ion beams

Opposite directions/collisions in 4 points

~1600 superconducting magnets

Superconductor Nb-Ti

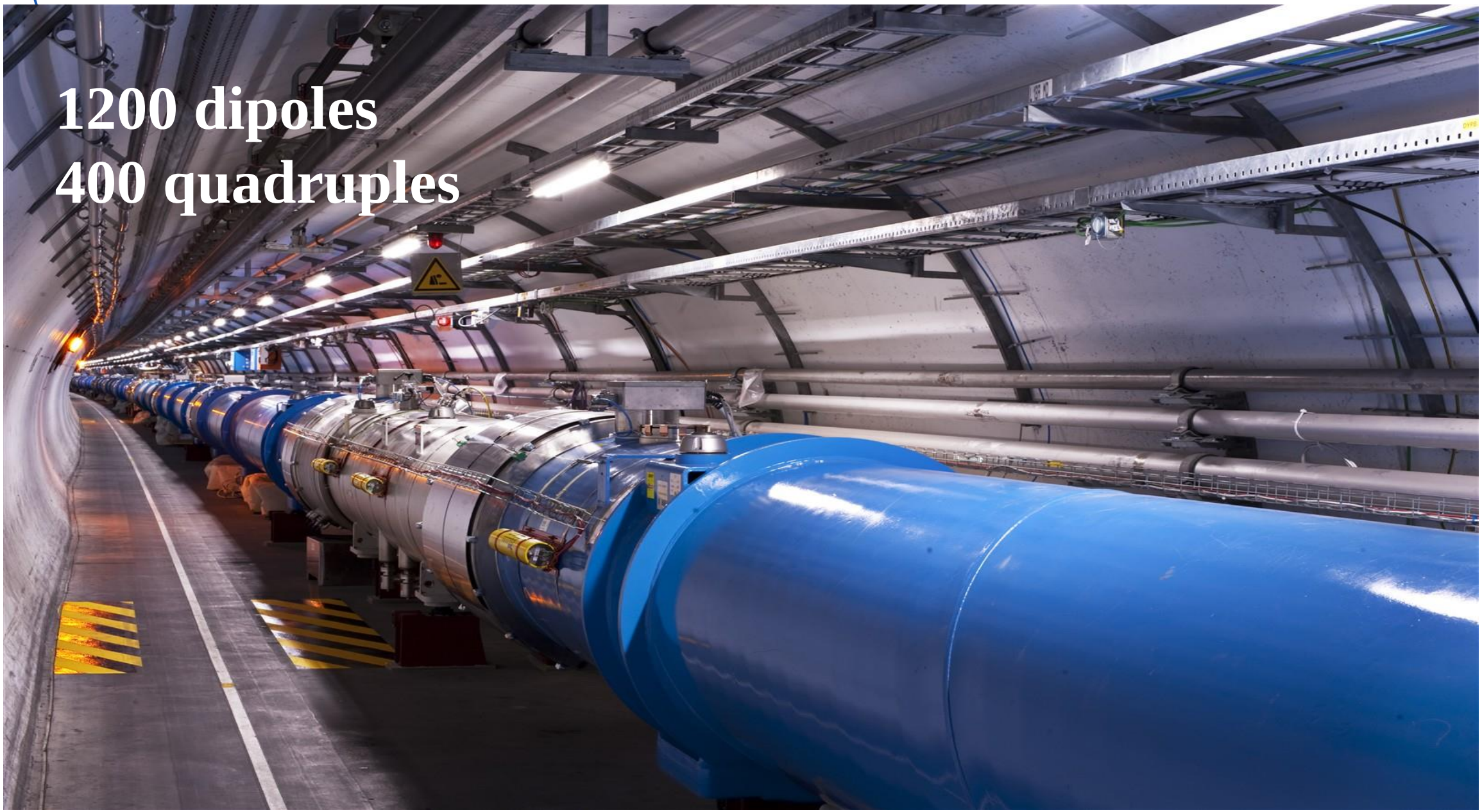
Operation at 1.9^{o}K

The coolest place in the Universe!

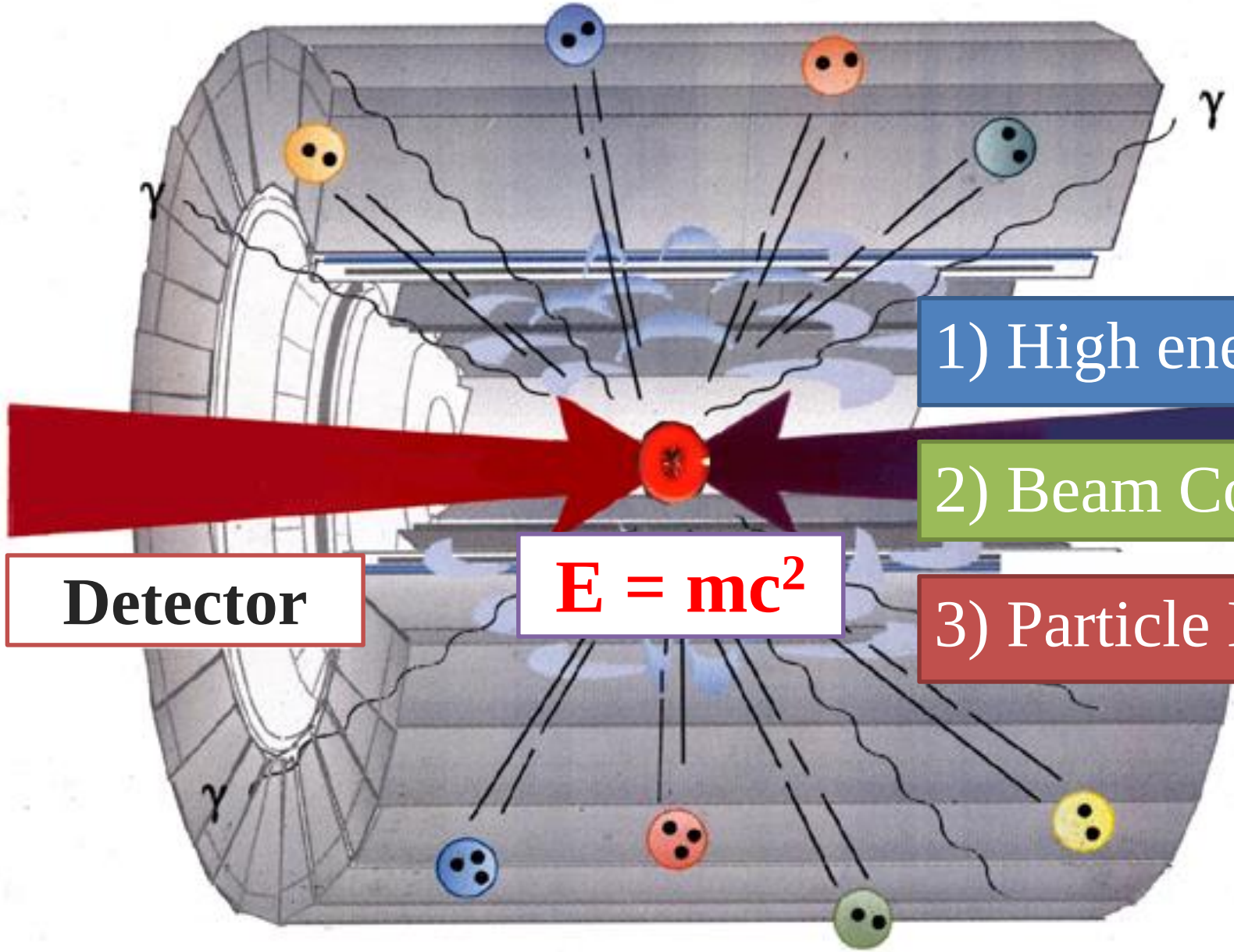
14 TeV collision energy

99.9999991% of the speed of light

Large Hadron Collider (LHC)



LHC Experiments



1) High energy beams

2) Beam Collisions

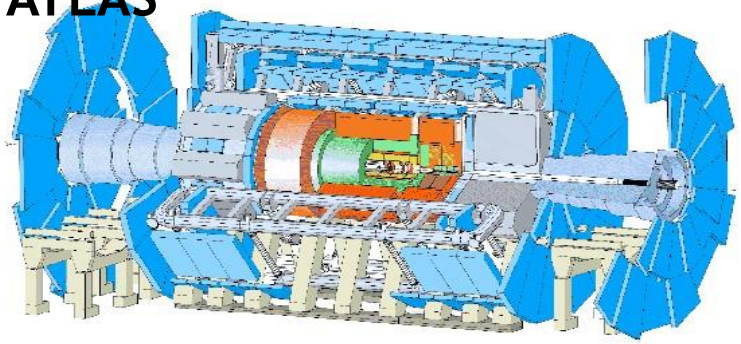
3) Particle Identification

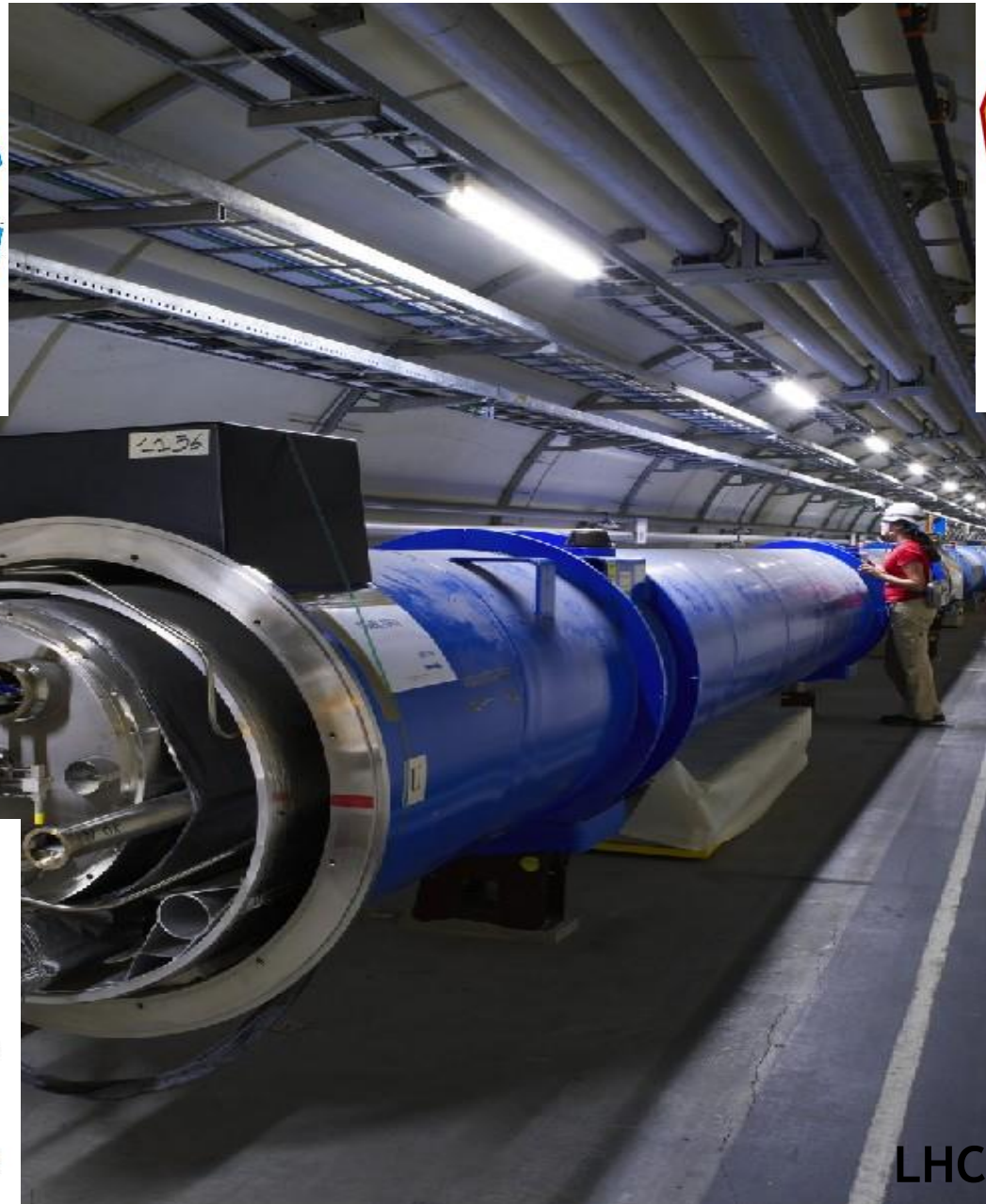
Detector

$E = mc^2$

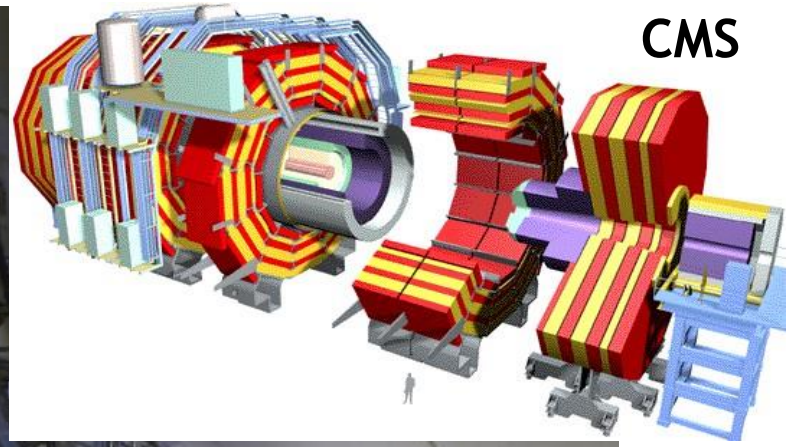
The LHC Experiments

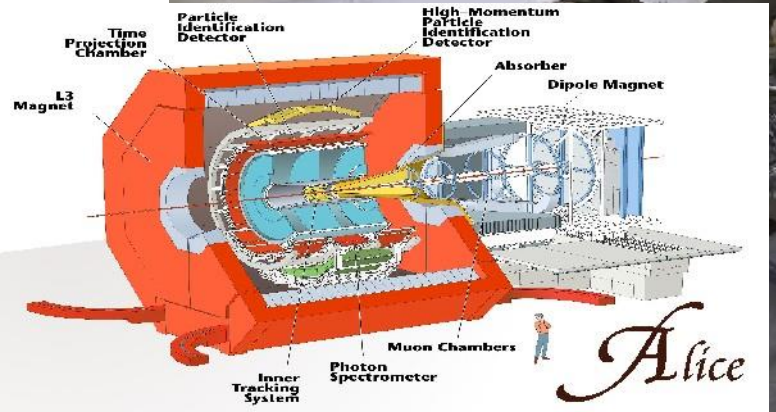
ATLAS

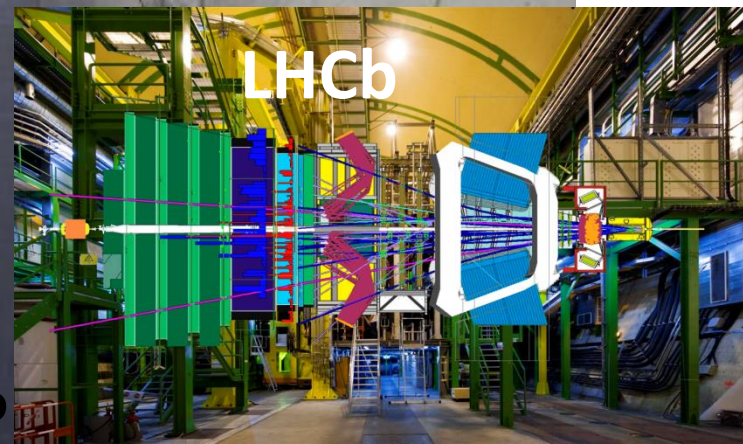




CMS

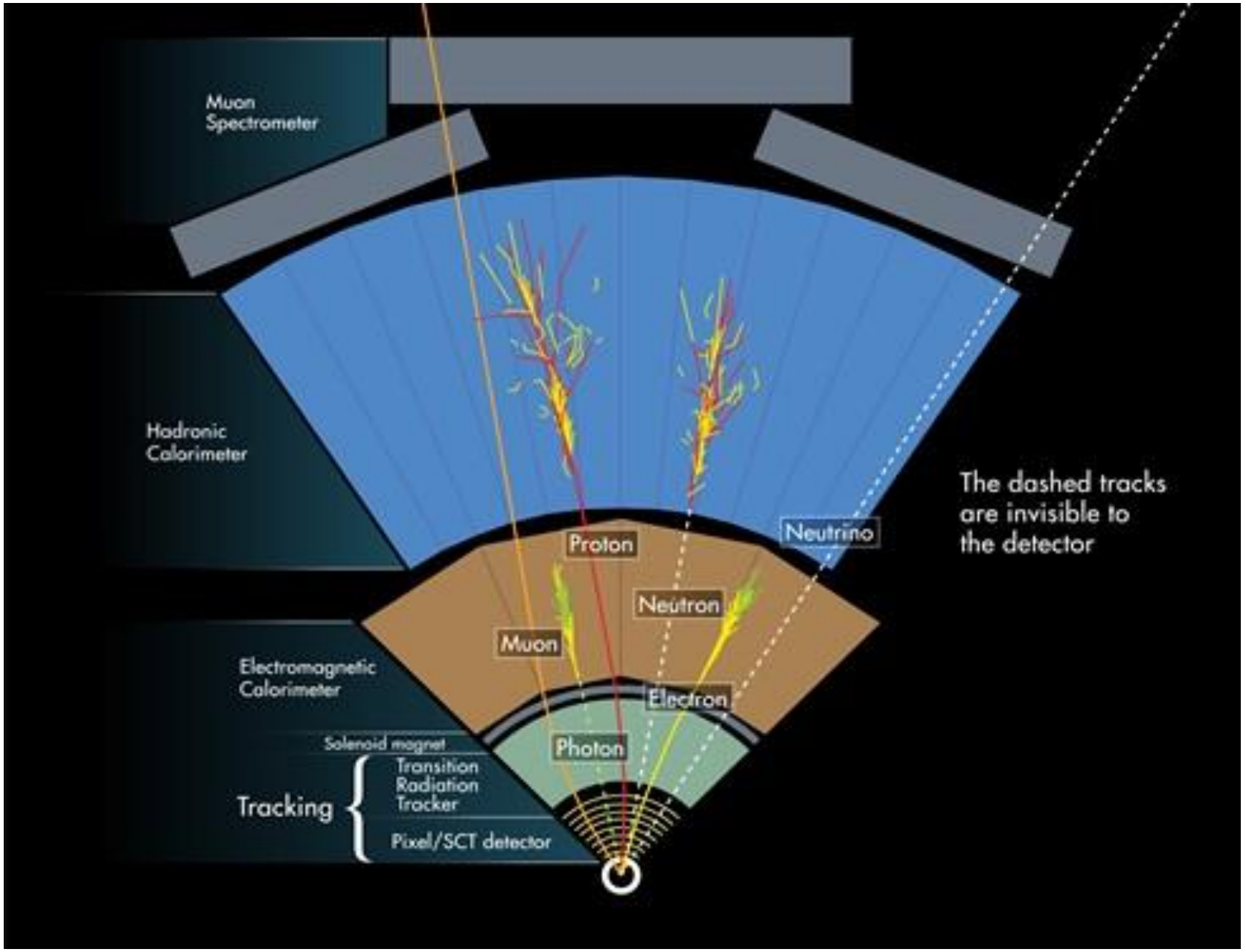




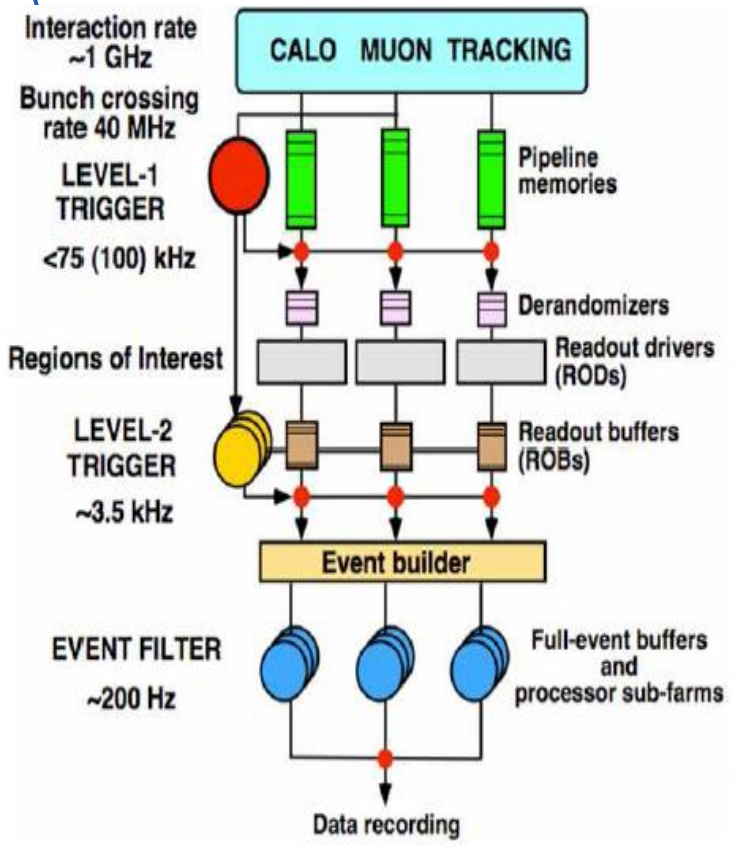


LHCb

Particle detection



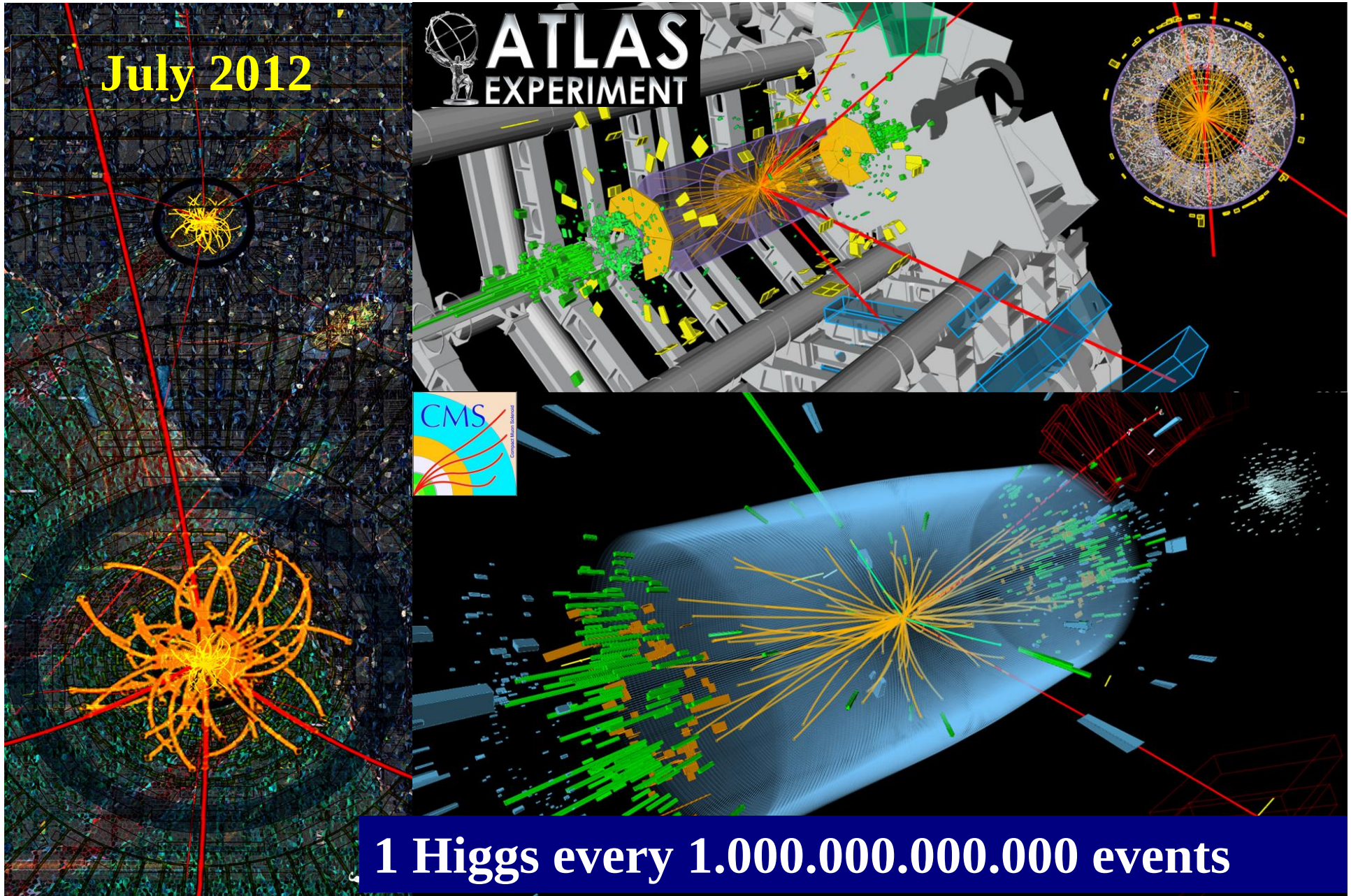
Data recording



- ~2000 bunches of 100 billion protons/beam
- 40 million times/s
- 20 collisions each time
- 800 million collisions/s

- ~1 MB storage space/collision
  - After filtering, data of 100 collisions/s
- 10^{10} collisions/year
  - 10 petabytes storage space/year

The Higgs Boson Discovery

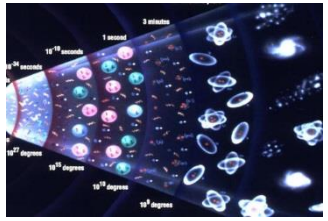
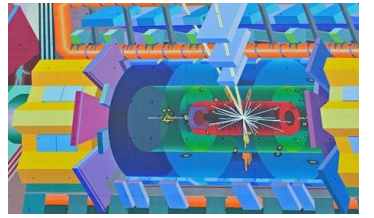


Computing Centre

The mission of CERN

- **Conduct** fundamental research
- **Develop** new technologies
  - Accelerators and particle detectors
  - Medicine
    - Diagnosis and therapy (PET, hadron therapy)
  - Informatics
    - WWW, computing grid
  - Technology

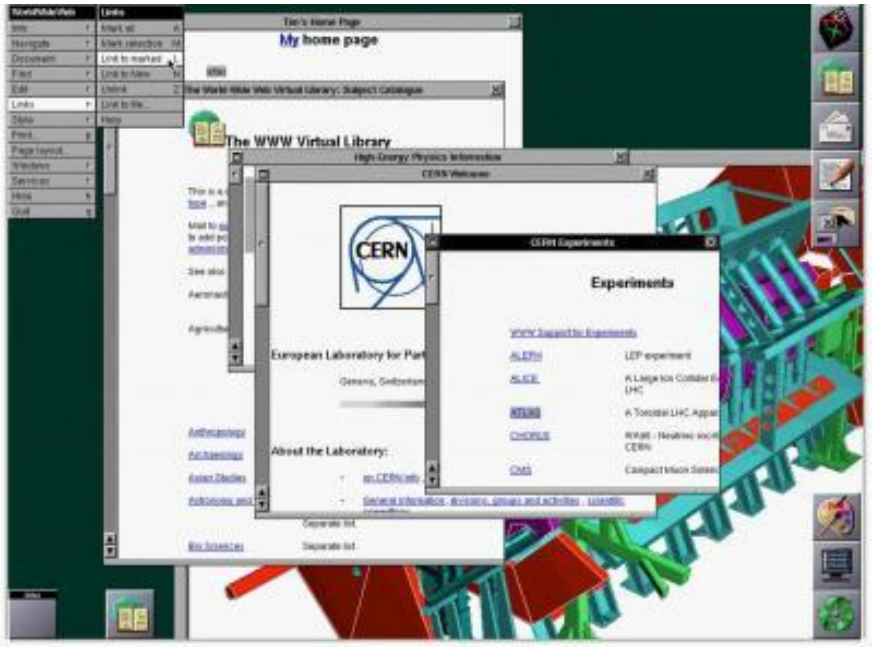
    Superconducting magnets, ultra vacuum, low temperature
- **Train** scientists, engineers, technicians and teachers
- **Brings together** people from different countries and cultures

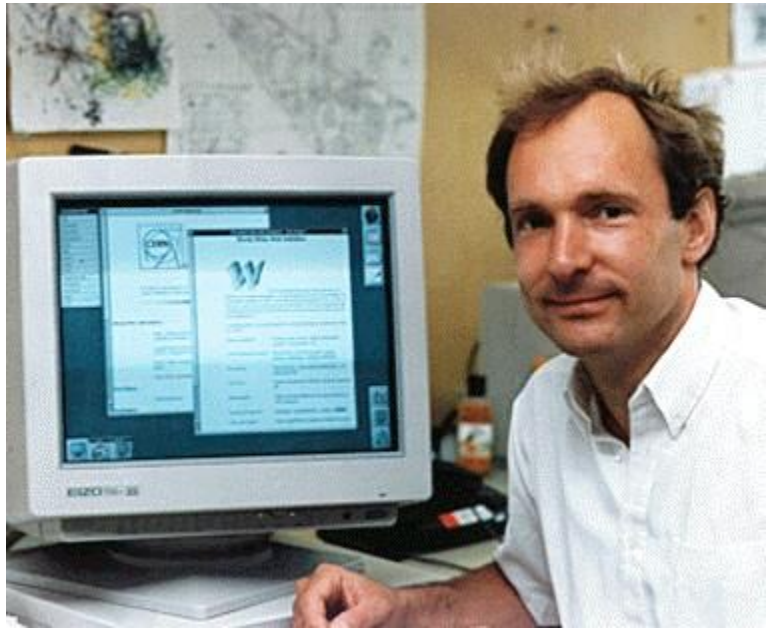





The benefits of CERN

- World Wide Web (1989)
  - Sir Tim Berners-Lee
  - Purpose the communication of the scientists for information and ideas exchange





World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access

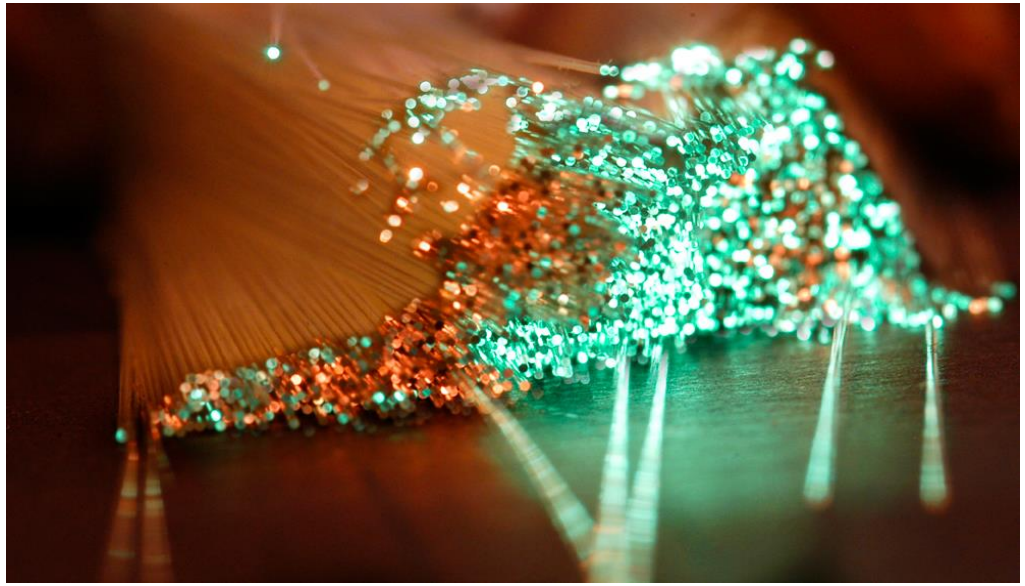
Everything there is online about W3 is linked directly or indirectly to this document, including an executive summar news , Frequently Asked Questions .

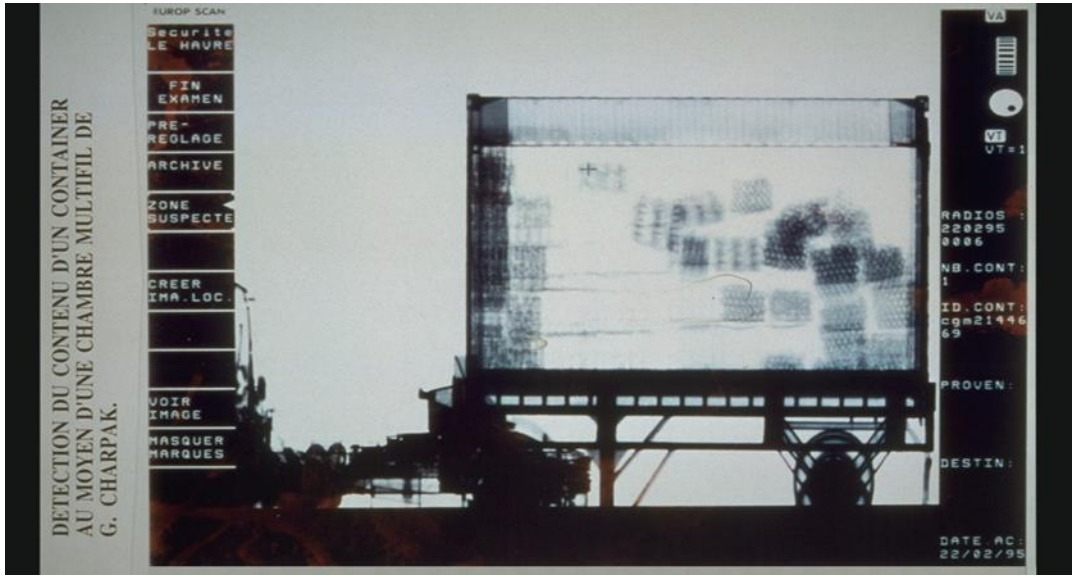
What's out there?
Pointers to the world's online information, subjects , W3 servers, etc.
Help
on the browser you are using
Software Products
A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , To
Technical
Details of protocols, formats, program internals etc
Bibliography
Paper documentation on W3 and references.
People
A list of some people involved in the project.
History
A summary of the history of the project.
How can I help ?
If you would like to support the web..
Getting code
Getting the code by anonymous FTP , etc.

The benefits of CERN

Medical applications

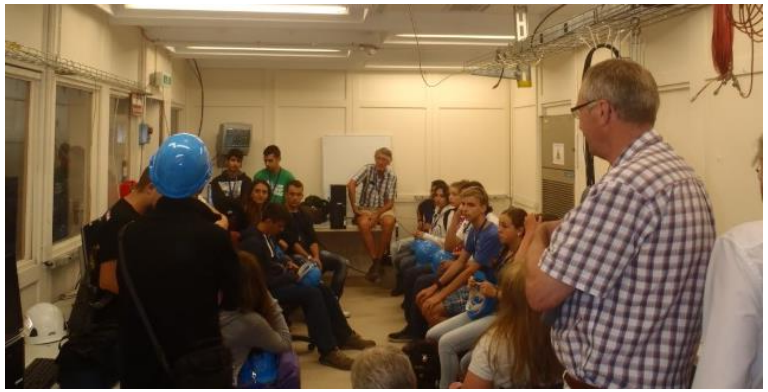
Development of novel technologies





CERN competition for schools

- Competition for high-school students
- The teams propose their physics experiment!
- Two teams will be invited to CERN to conduct their experiment on the beamline with the support of CERN scientists



Video: http://cds.cern.ch/record/1757251

http://beamline-for-schools.web.cern.ch/

Student opportunities

- Summer Student Programme
- CERN Openlab Summer Student Programme
- Short-term Internship Programme
- Administrative Student Programme
- Technical Student Programme
- Doctoral Student Programme
- Marie-Curies PhD positions

https://careers.cern/students

Thank you for your attention!

Useful Links

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

www.cern.ch

Questions;