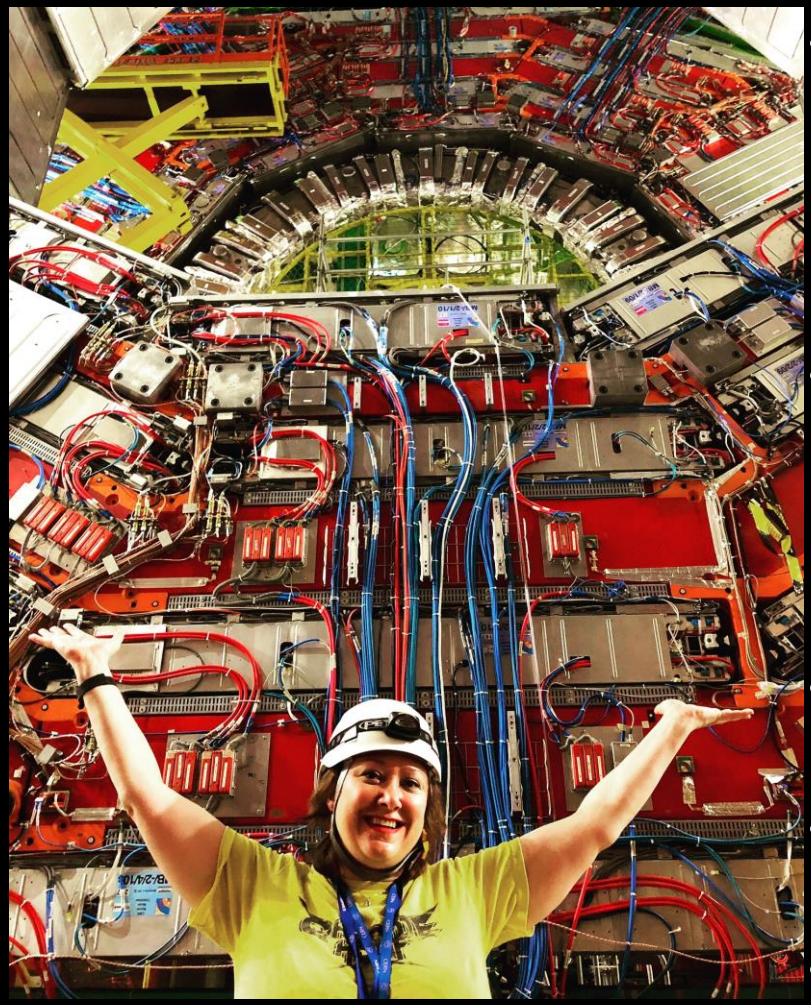
Welcome to CERN

Prof Dr Freya Blekman

Interuniversity Institute for High Energies (IIHE)

Vrije Universiteit Brussel



- From Amsterdam, NL
- Experimental physics at Universiteit van Amsterdam
- Ph.D. at Nikhef (NL), the Netherlands' national particle physics institute
  - Largely based in Chicago (USA)
- Imperial College London (UK)
- Cornell University (USA)
- Professor at Vrije Universiteit Brussel, Brussels (BE)

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freya.blekman@cern.ch

Physicists are world citizens

- Live in many different countries
- Travel to even more places for work
- Working with people from all over the world

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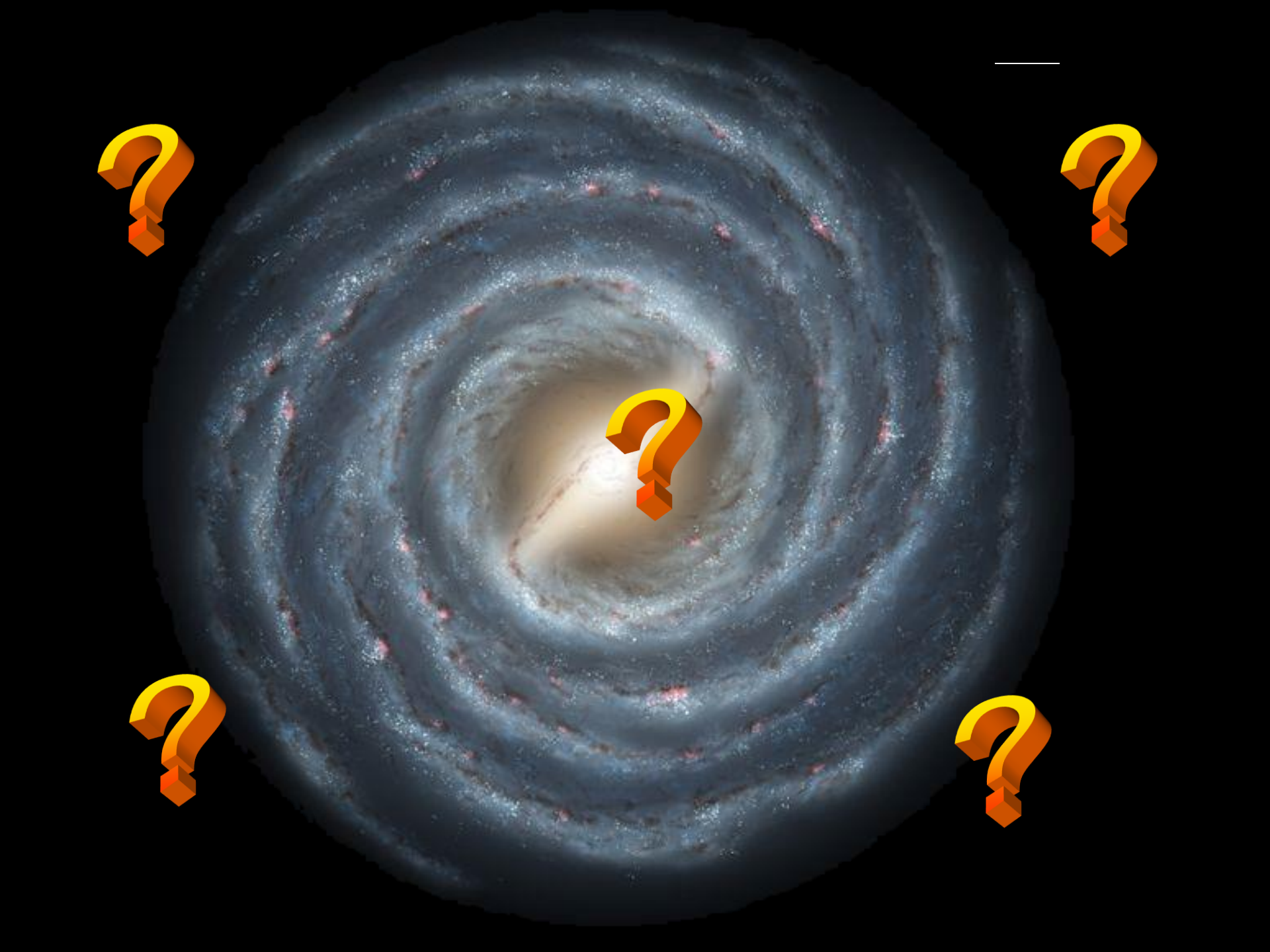

- Introduction
- CERN
  - What and Where is it?
  - Who works there?
  - What do we do there?
- Particle Physics
  - Questions, answers and the theory of everything...
- The Large Hadron Collider
  - The Compact Muon Solenoid

What is CERN ?

1953

Sur le terrain du futur institut nucléaire

Sous la conduite de M. A. Picot, les membres du Conseil européen pour la recherche nucléaire se sont rendus hier à Meyrin pour reconnaître le terrain où s'élèvera le Centre nucléaire (voir en Dernière heure)

(Photo Freddy Bertrand, Genève)

La Suisse du 30 octobre 1953

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Important dates

- 1949: first steps towards civilian research in nuclear technology
- 1952: foundation of CERN under auspices of UNESCO
- 1953: Signing of the CERN charta
- 1954 Completion of the ratification of the 12 member states

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Finances & member states

Contributions from Member States in 2019

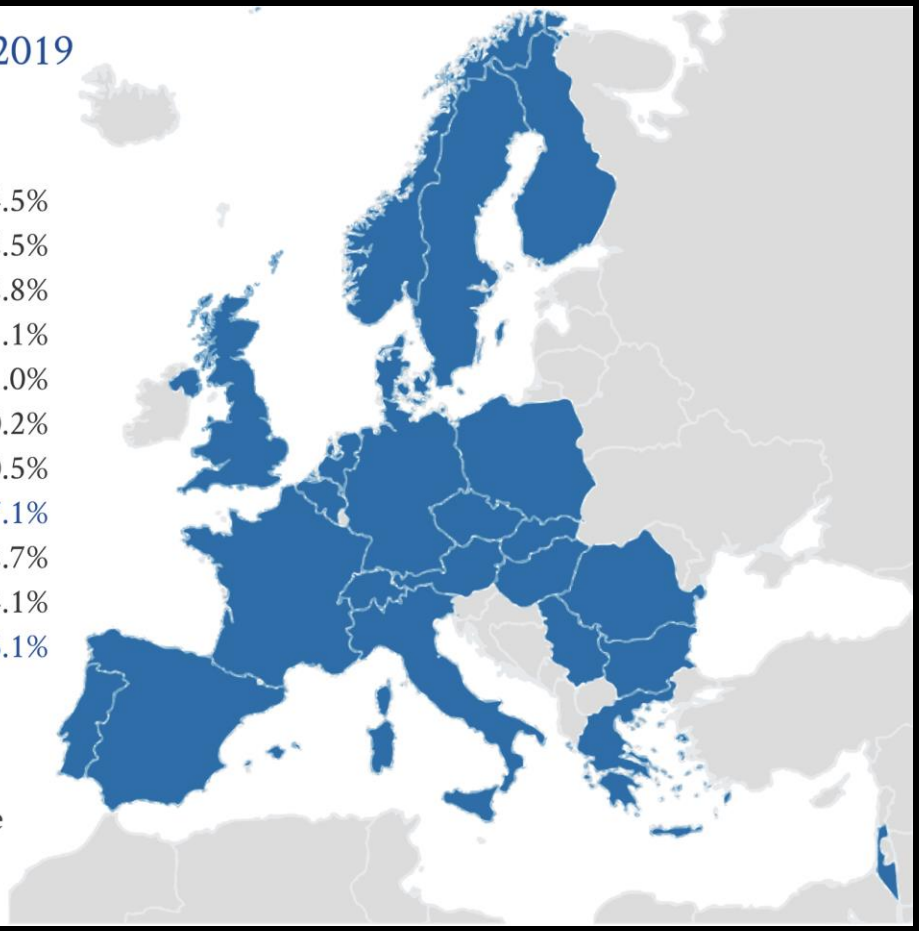
Annual budget: 1.17 billion CHF

Austria	2.1%	Netherlands	4.5%
Belgium	2.7%	Norway	2.5%
Bulgaria	0.3%	Poland	2.8%
Czech Republic	0.9%	Portugal	1.1%
Denmark	1.8%	Romania	1.0%
Finland	1.3%	Serbia	0.2%
France	14.0%	Slovakia	0.5%
Germany	20.6%	Spain	7.1%
Greece	1.0%	Sweden	2.7%
Hungary	0.6%	Switzerland	4.1%
Israel	1.7%	United Kingdom	16.1%
Italy	10.4%		

Associate Member States (~25 MCHF)

India, Lithuania, Pakistan, Turkey, Ukraine

Cyprus, Slovenia



Teacher programmes

National & International Teacher Programmes

Who works at CERN?

- 3000 people employed by CERN
  - Physicists, engineers, computer scientists, mathematicians, firemen, cooks, builders, technicians, secretaries, security, etc
- >10000 physicists associated with CERN
  - Including yours truly

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Who works at CERN?

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Who visits CERN

- CERN is an open laboratory
- Anyone is welcome to visit, ask questions, take photographs, etc
- Every year, 25,000 people visit CERN
- Open days September 2019, 75000 people visited in 2 days!!!

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What do we do at CERN?

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Basic vs applied research

- Two types of science research
  - Basic research (how do things work)
  - Applied research (how do I make...)

- CERN only does basic research
  - But usually we need to build things that do not exist yet...
- Applied research needs basic research

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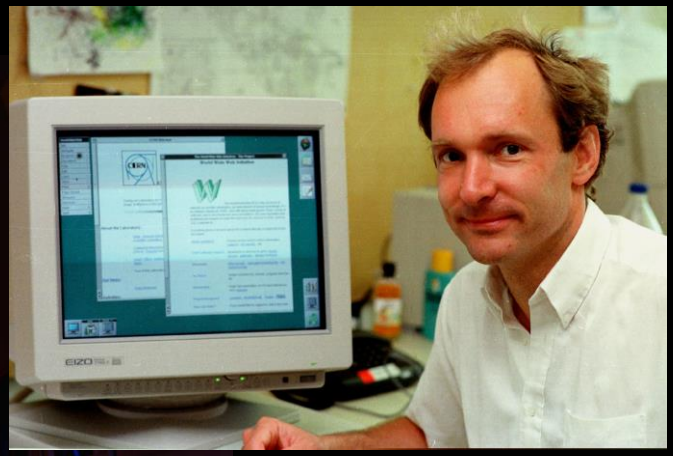
CERN - where the web was born



Tim Berners-Lee

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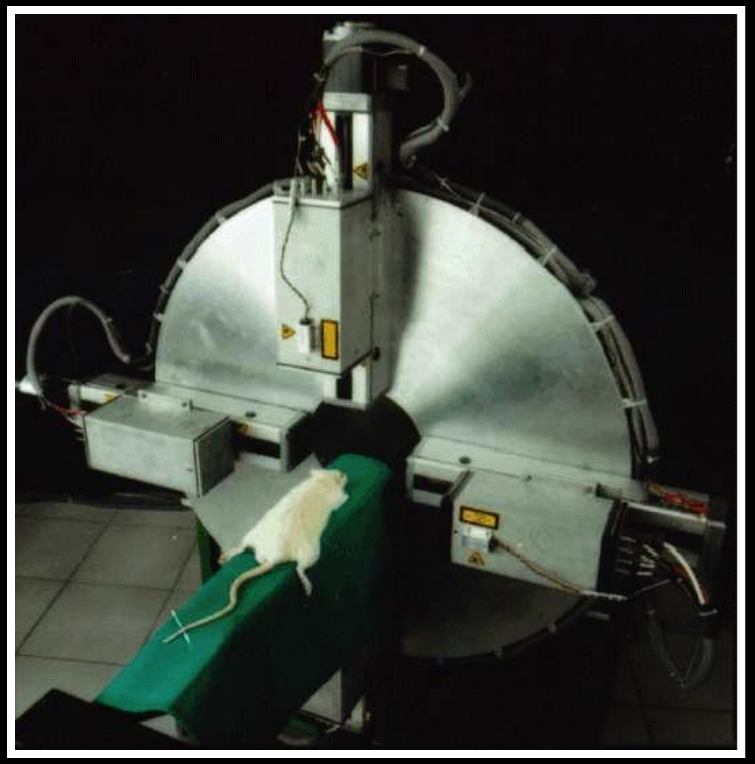
But also...

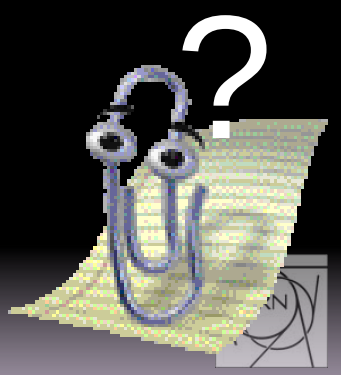
- PET scans
- Radiation therapy



- Loads of computing/internet development
  - GRID

Basic Questions

- What is everything around us made of?
- How does matter stick together?
- What, really, is mass?
  - And does the Higgs particle indeed play a role in the creation of mass?
- Are there really only 3 spatial dimensions?
- Are the smallest particles we know fundamental?
- Where did the anti-matter go?
- Where's the rest of the matter anyway?



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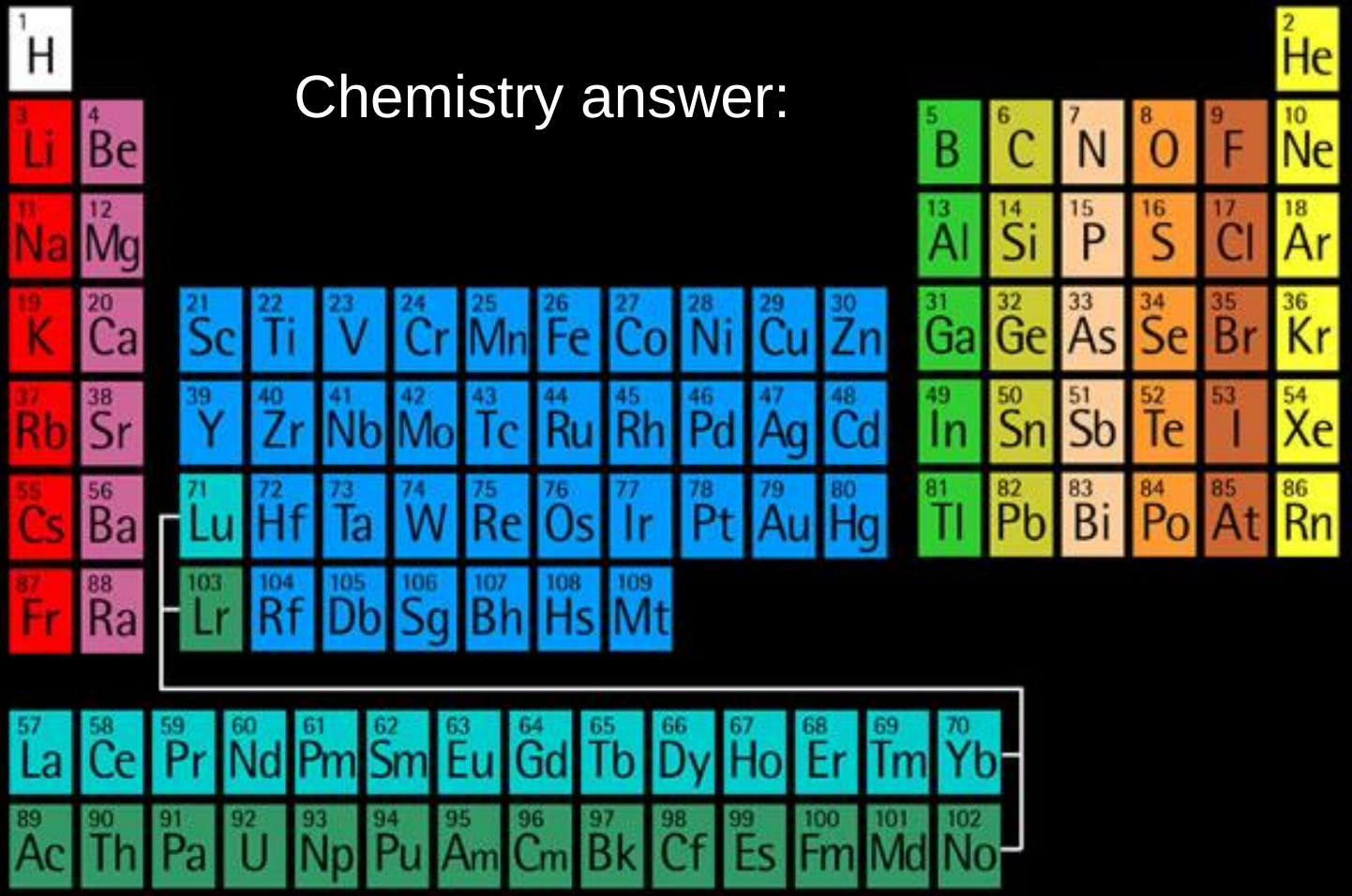
What is everything around us made of?

Chemistry answer:



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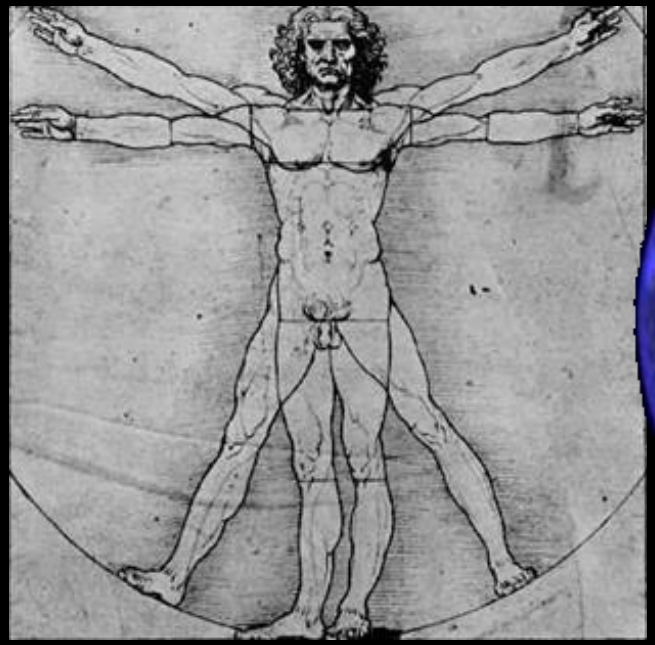
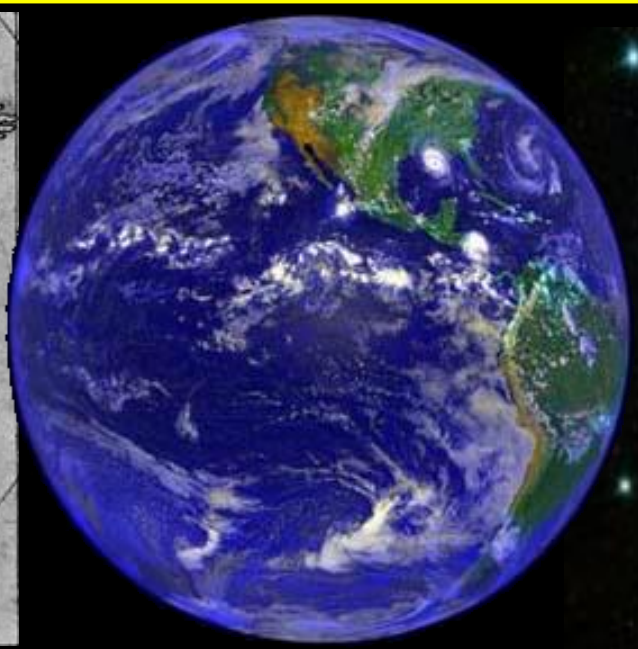
What are we made of?

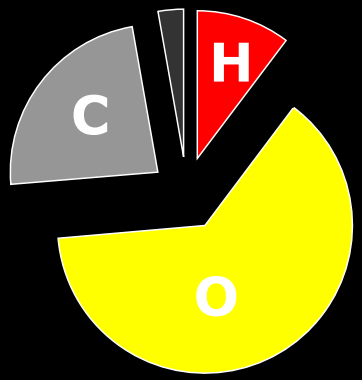


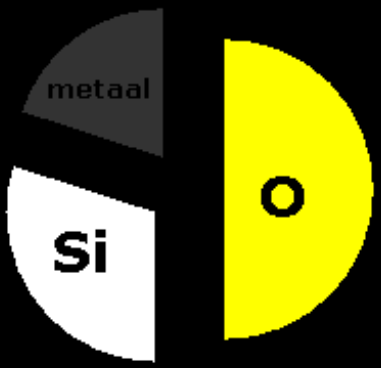
mainly water (H_2O)

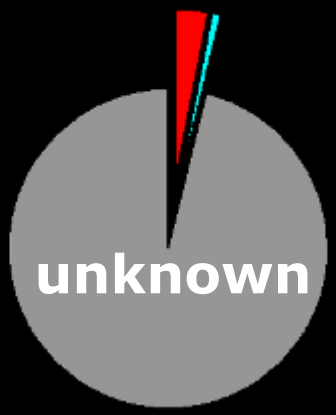


Lots of oxigen (oxides)

96% out there unknown!







waterstof en helium

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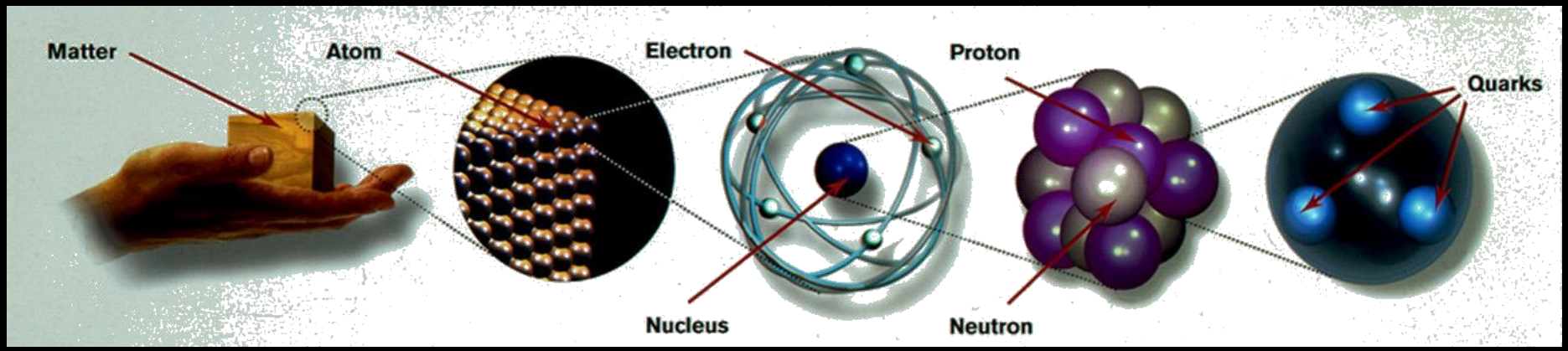
What is everything around us made of?

Physics answer:



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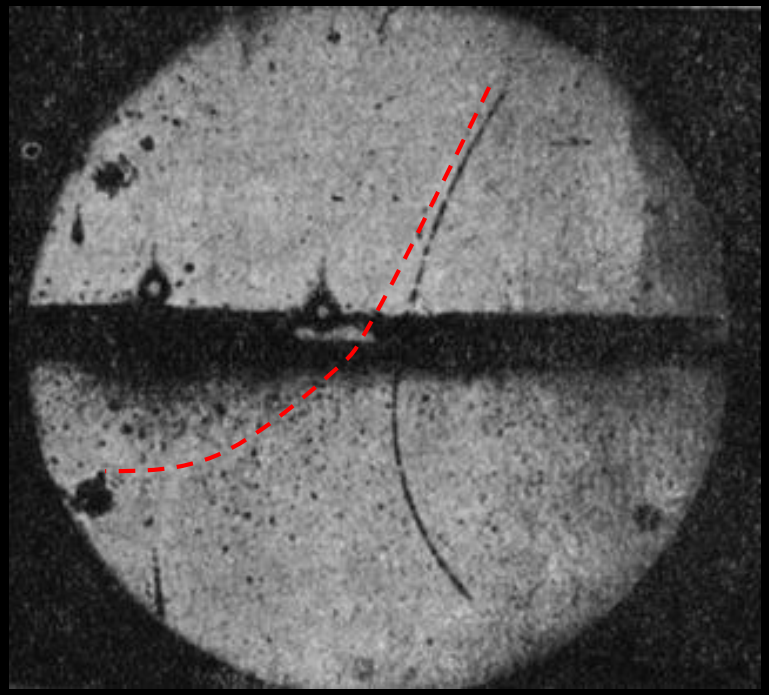
Anti-matter



- Anti-matter: discovered in 1923
  - Predicted by theory
- *Almost* same as matter... But oppositely charged
- Problem: at big bang there was just as much matter as anti-matter... Where did it go?

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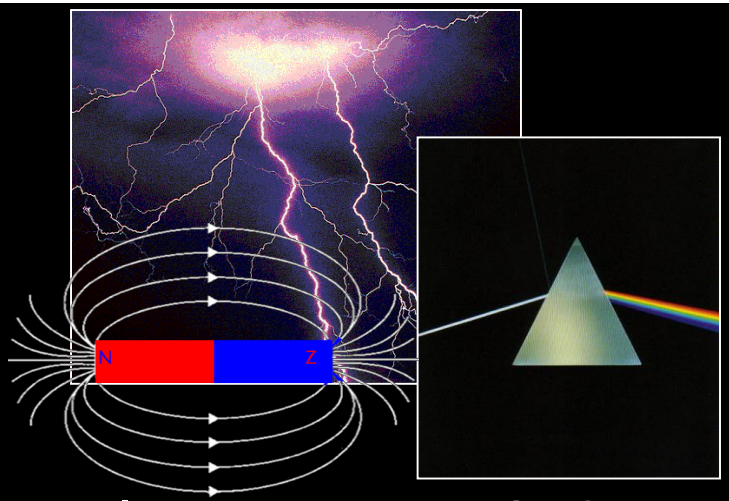
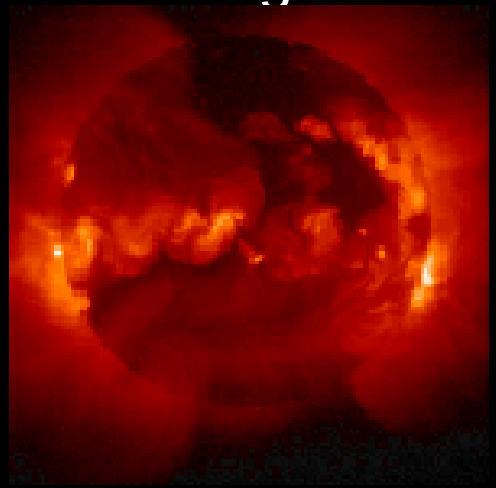
The four fundamental forces

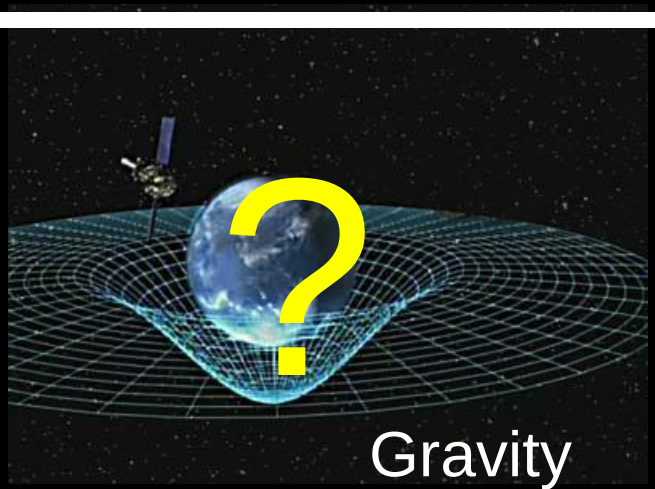


Electro-magnetic force

Strong force



Weak force



Gravity

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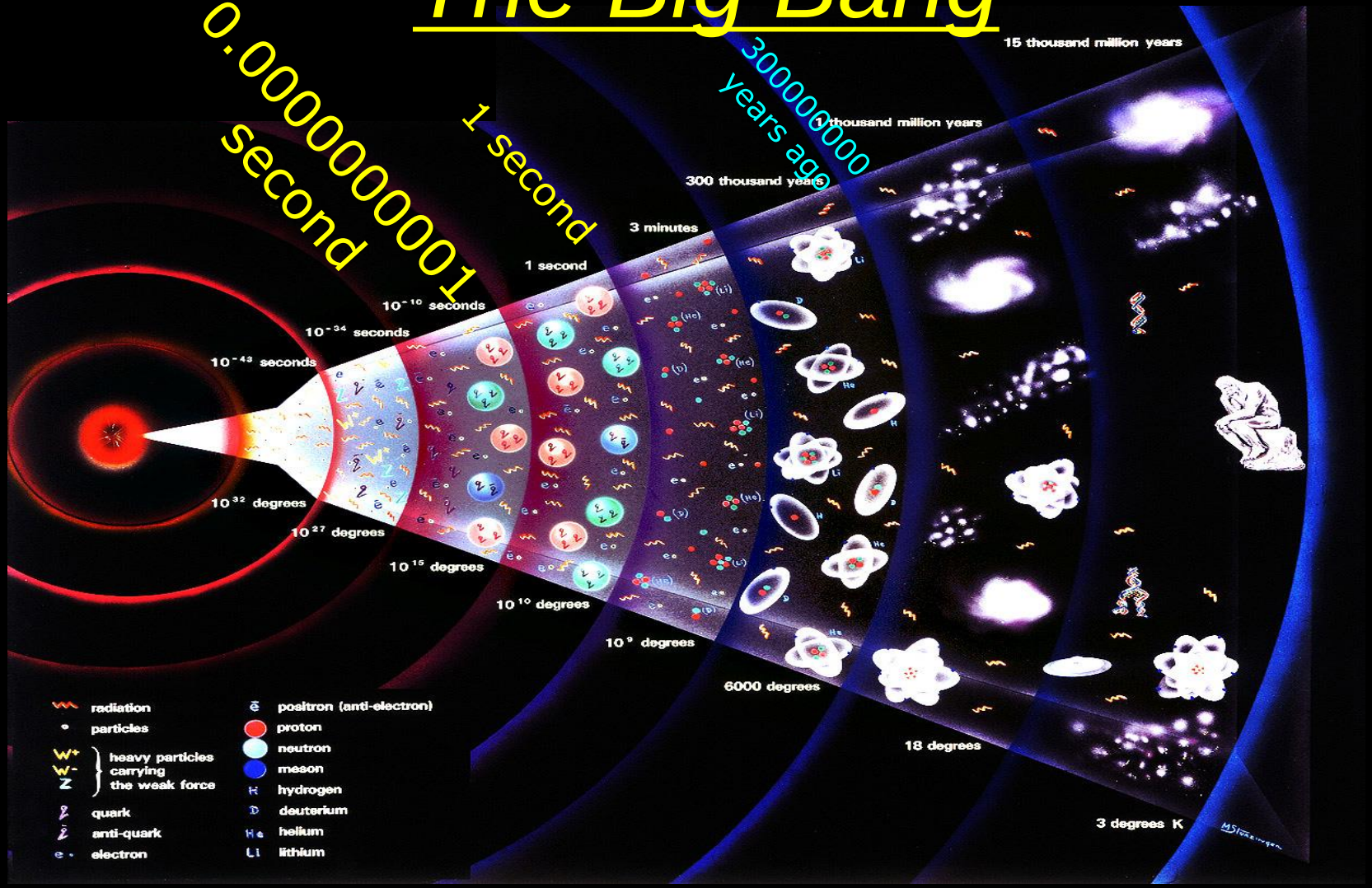
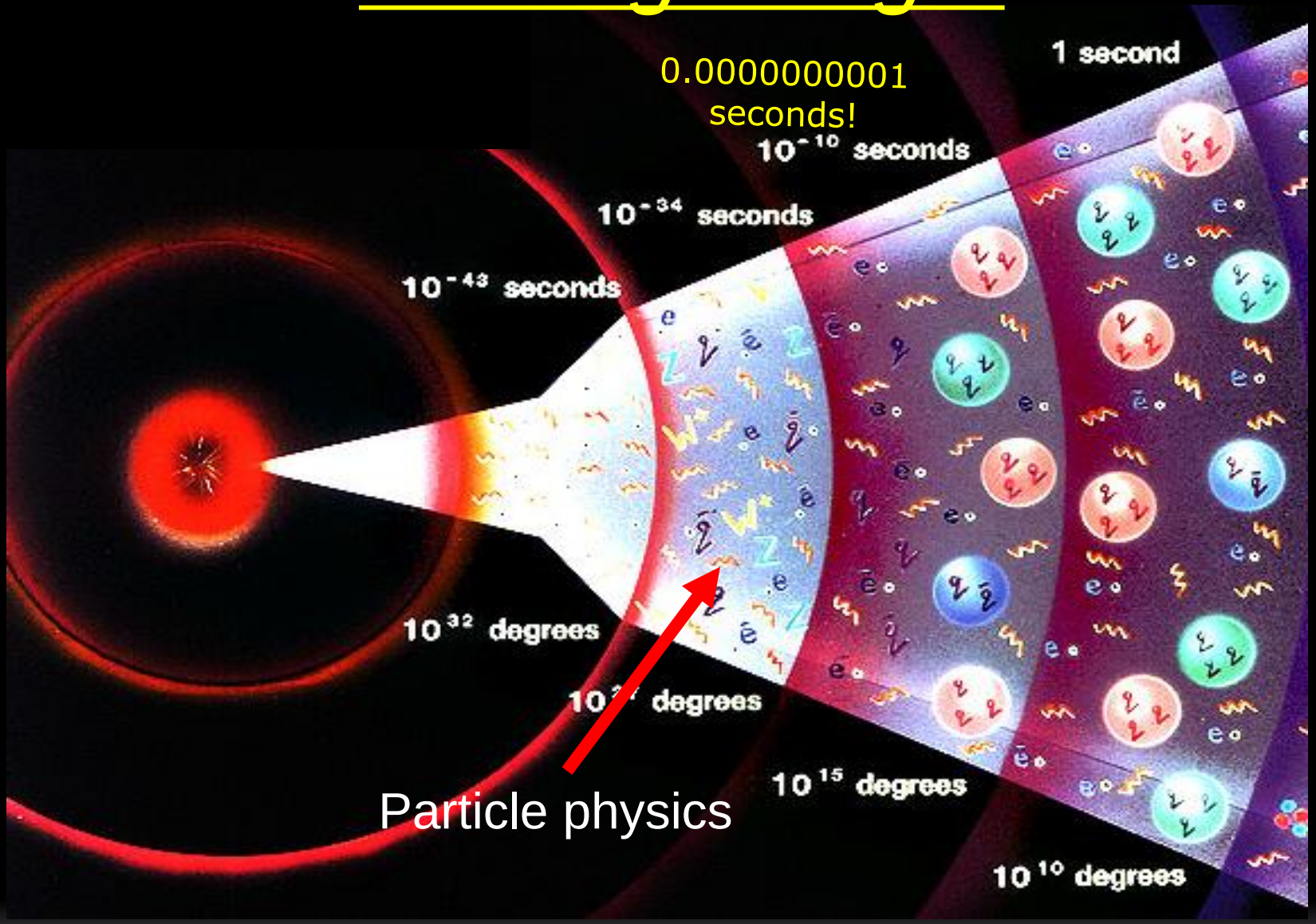
The Big Bang

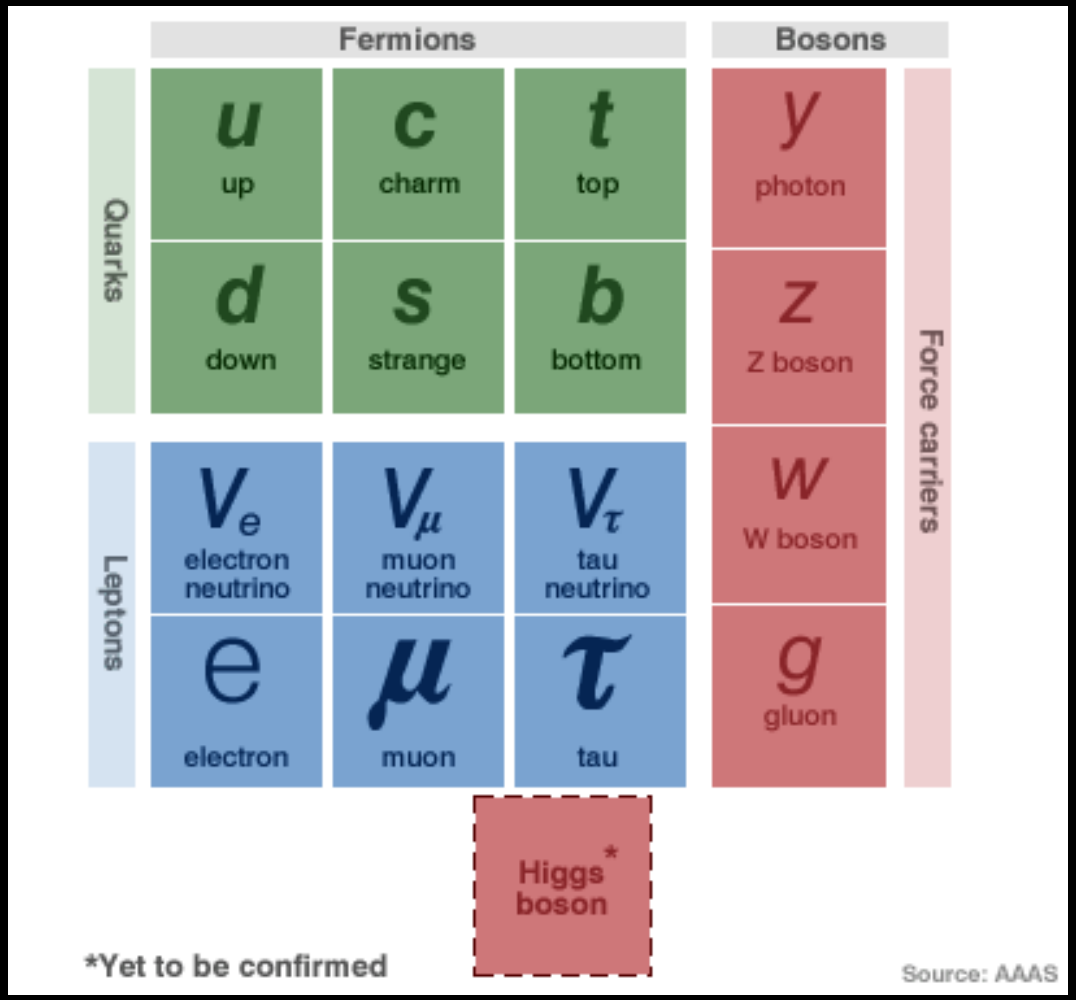

0.000000001 second
1 second
300000000 years ago
15 thousand million years
1 thousand million years
300 thousand years
3 minutes
1 second
10^{-10} seconds
10^{-34} seconds
10^{-43} seconds
10^{32} degrees
10^{27} degrees
10^{15} degrees
10^{10} degrees
10^{9} degrees
6000 degrees
18 degrees
3 degrees K
radiation
particles
heavy particles carrying the weak force
quark
anti-quark
electron
positron (anti-electron)
proton
neutron
meson
hydrogen
deuterium
helium
lithium

The Big Bang...

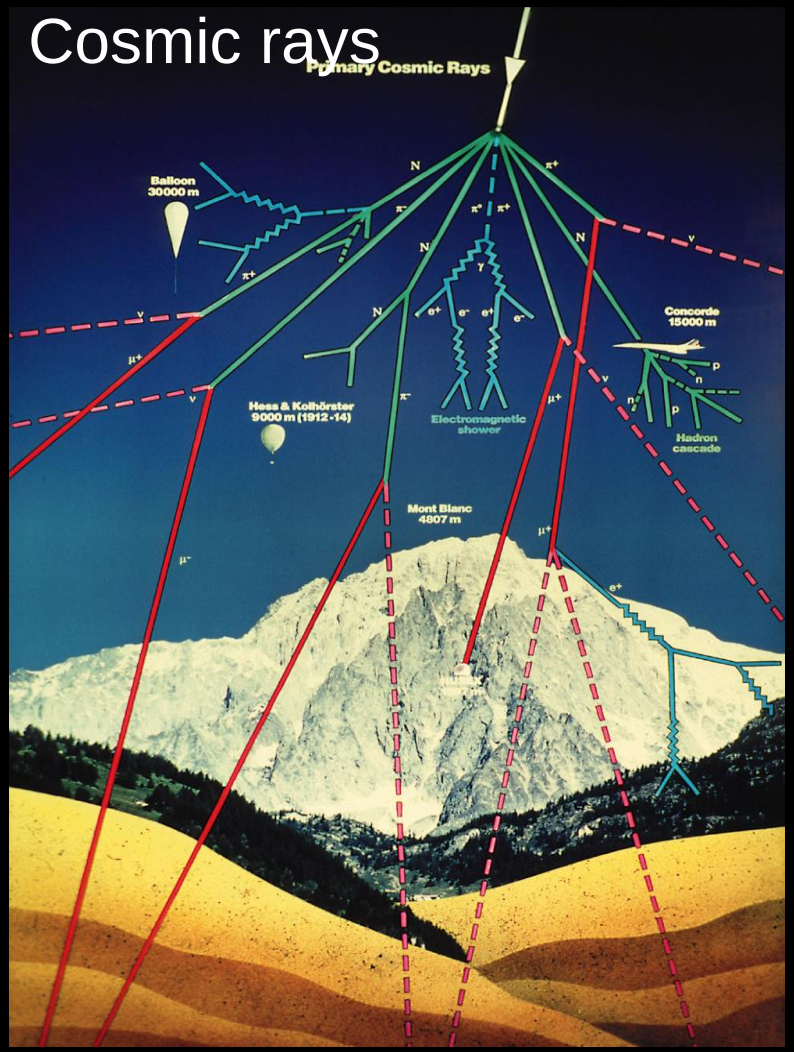

0.0000000001 seconds!
1 second
10^{-10} seconds
10^{-34} seconds
10^{-43} seconds
10^{32} degrees
10^{15} degrees
10^{10} degrees
Particle physics

The standard model

The modern periodic table



How do we know all this?

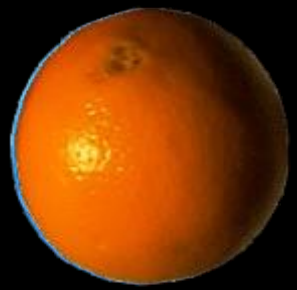


Accelerator experiments
Radioactivity experiments

And about 100 years of
hard work by many people...

Example collisions

oranges!



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Example collisions

But other things can happen too!

Needed: machine for searching

The Large Hadron Collider

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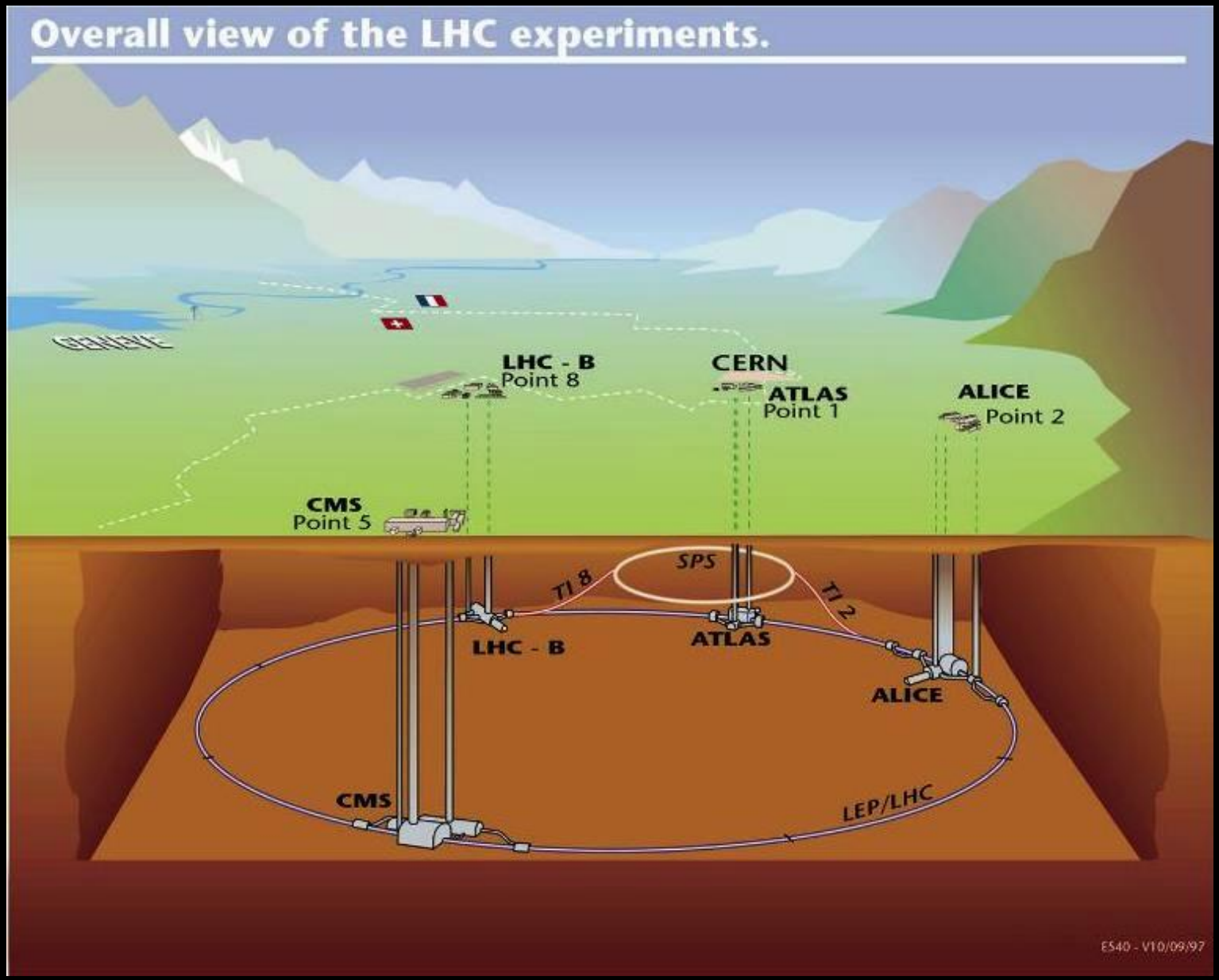

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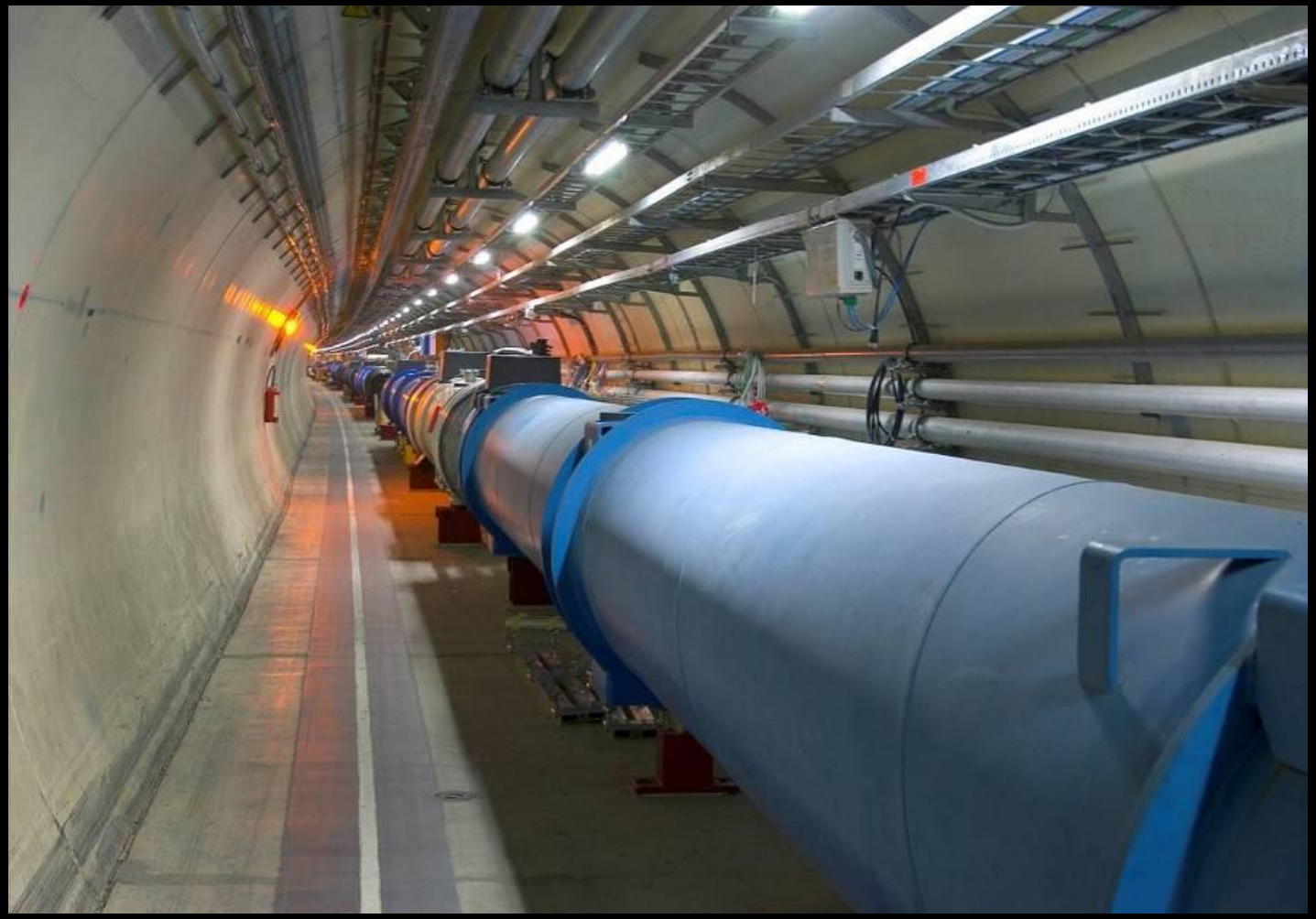
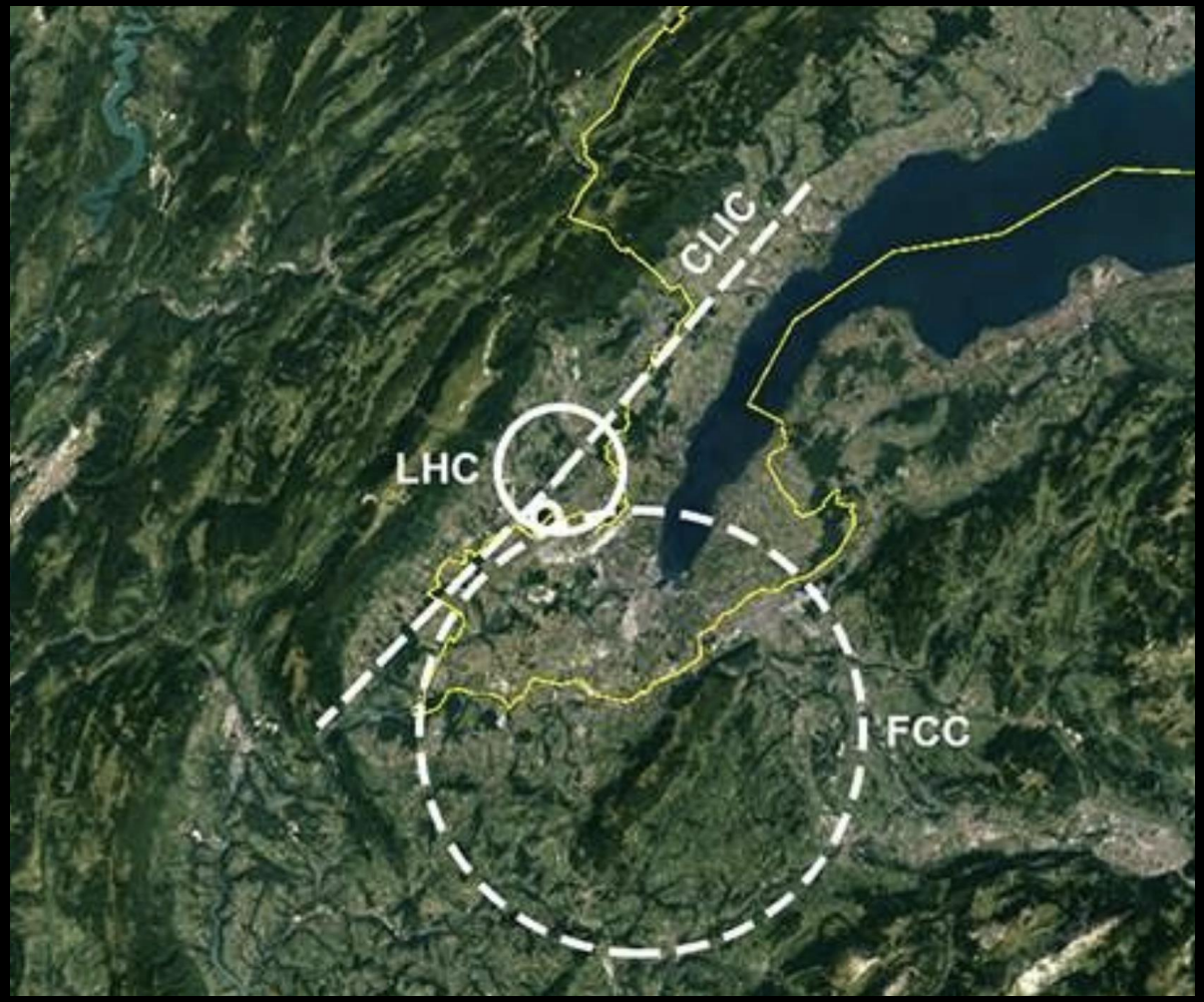
LHC in the tunnel



The future?



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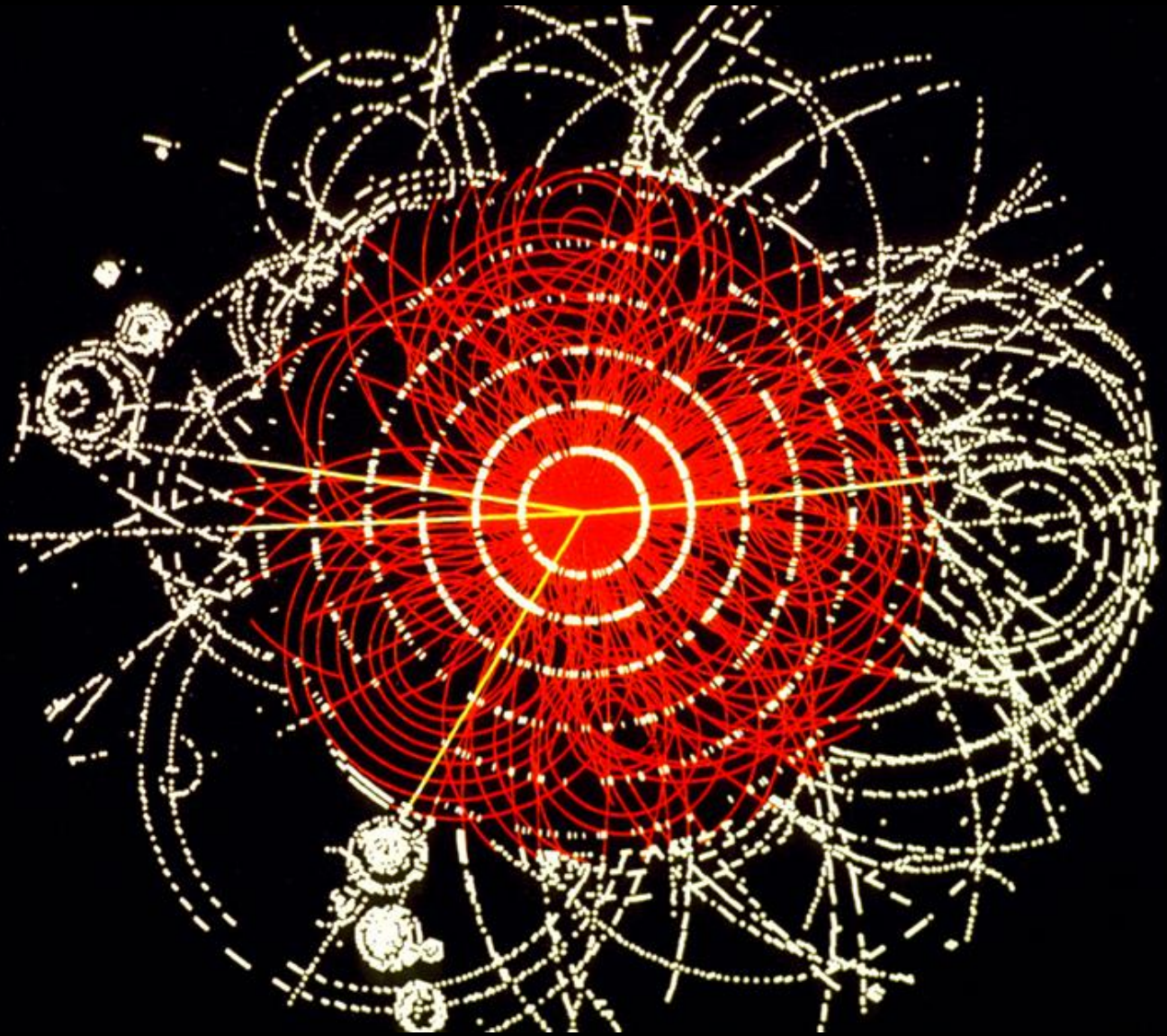
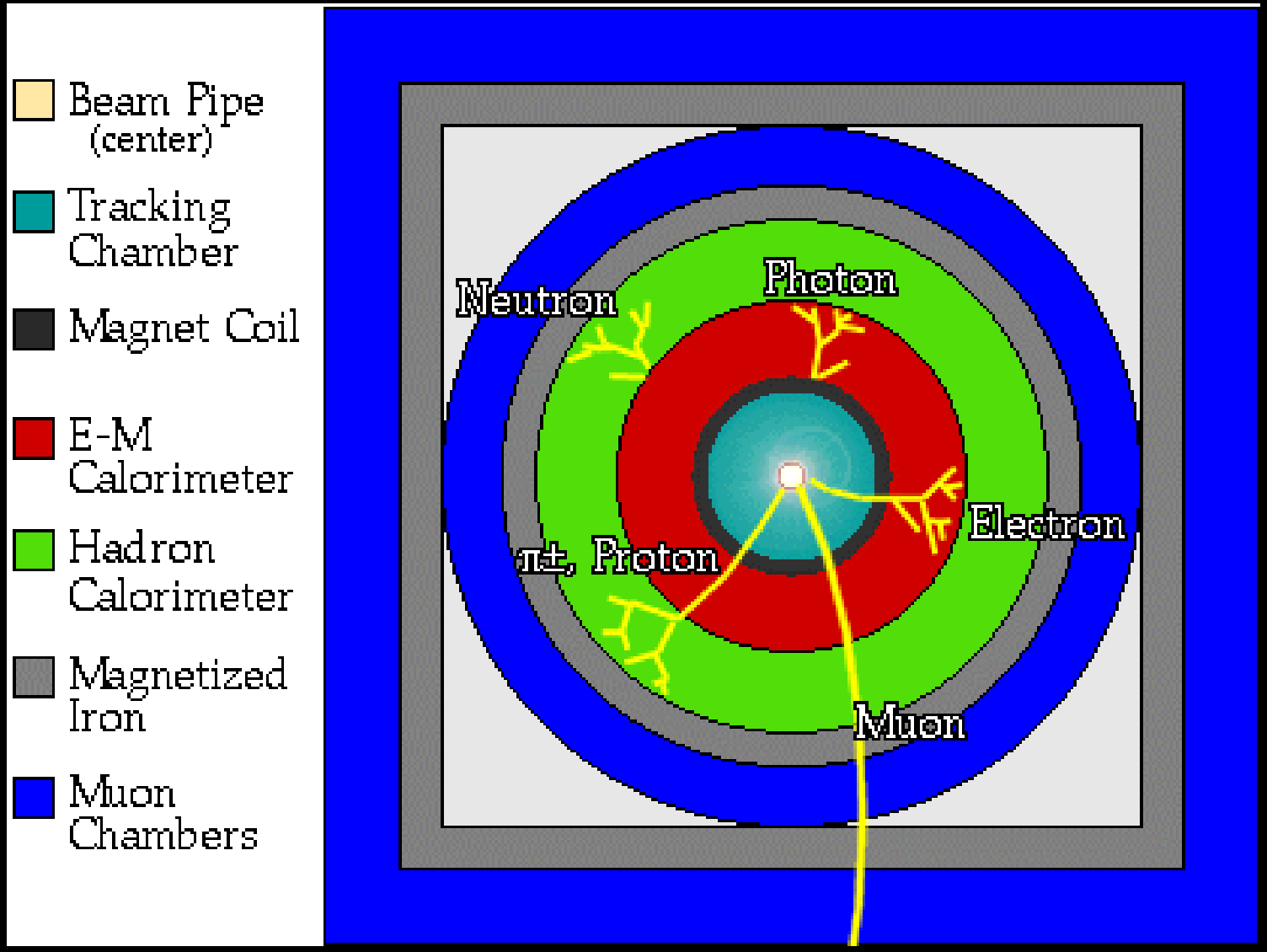


Experiment at particle accelerator: schematic



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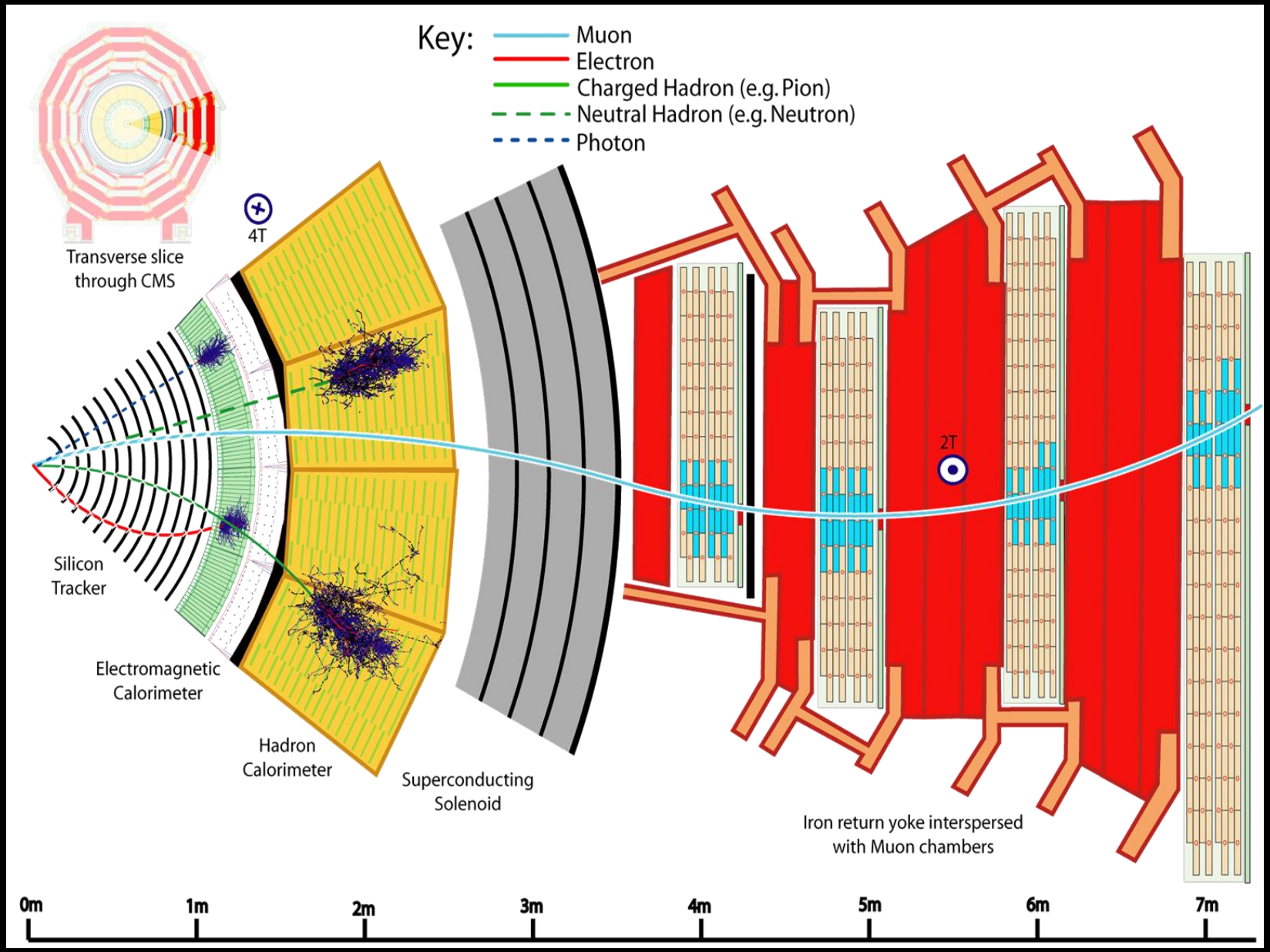
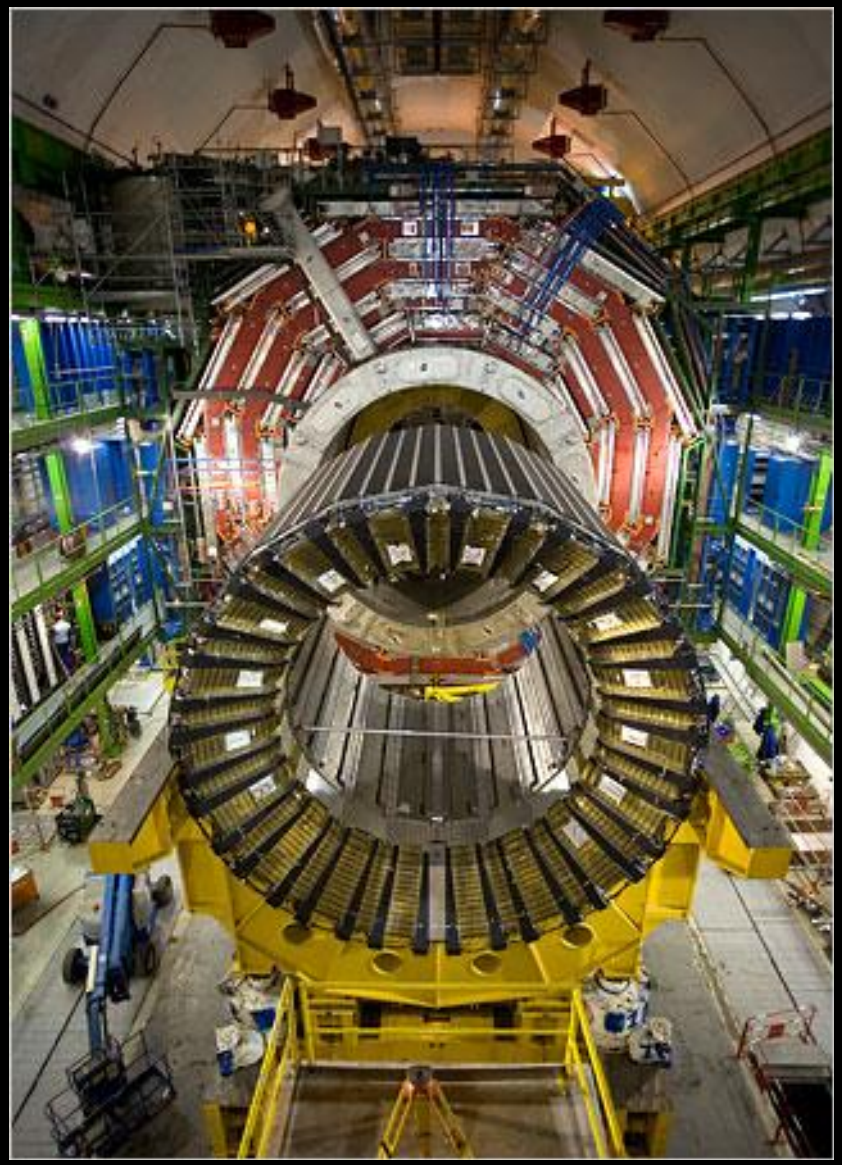

Key:
Muon
Electron
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon
Transverse slice through CMS
4T
2T
Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
Iron return yoke interspersed with Muon chambers
0m
1m
2m
3m
4m
5m
6m
7m



CMS

- Compact
- Muon
- Solenoid

- “Compact” is relative...

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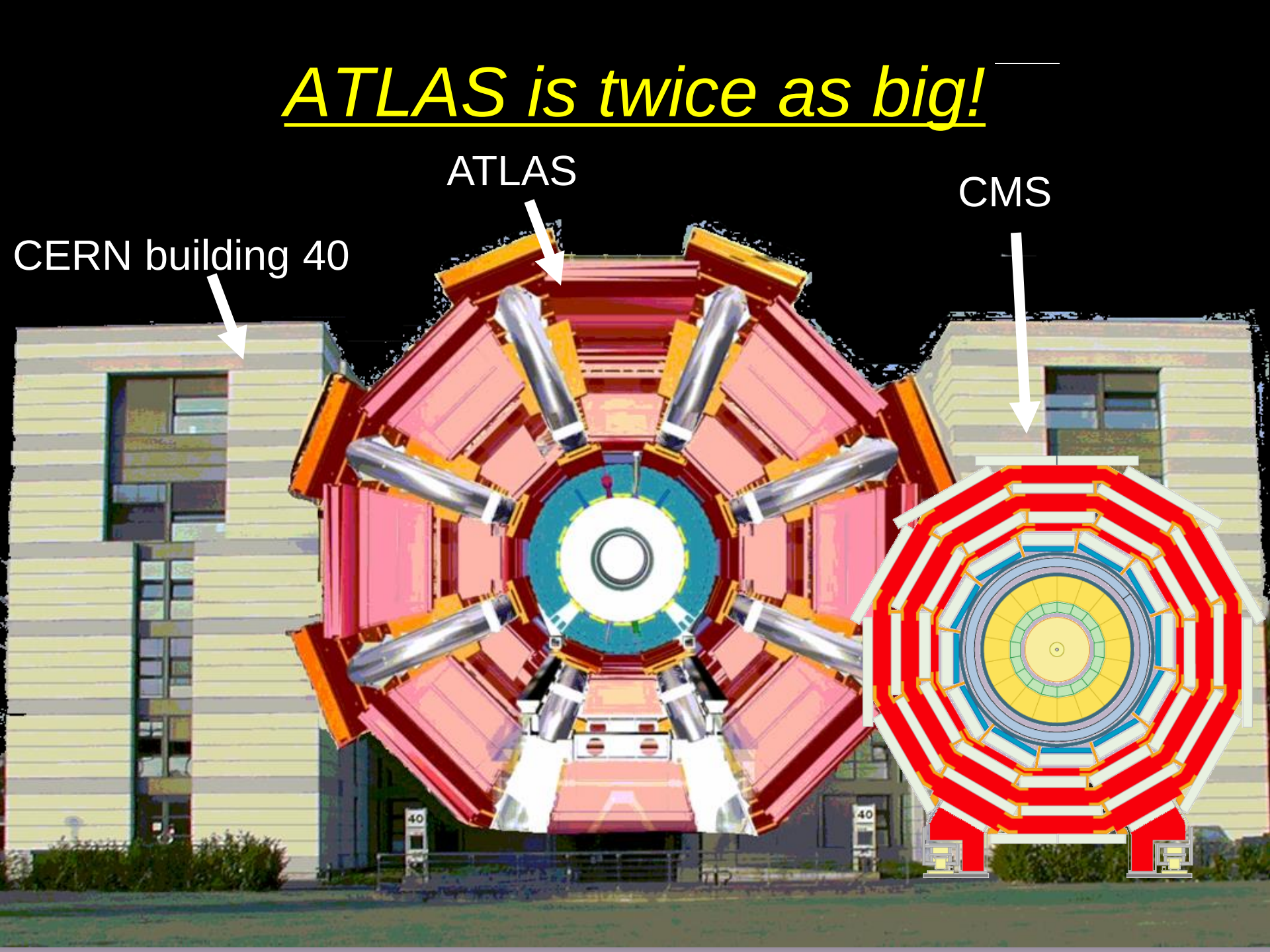
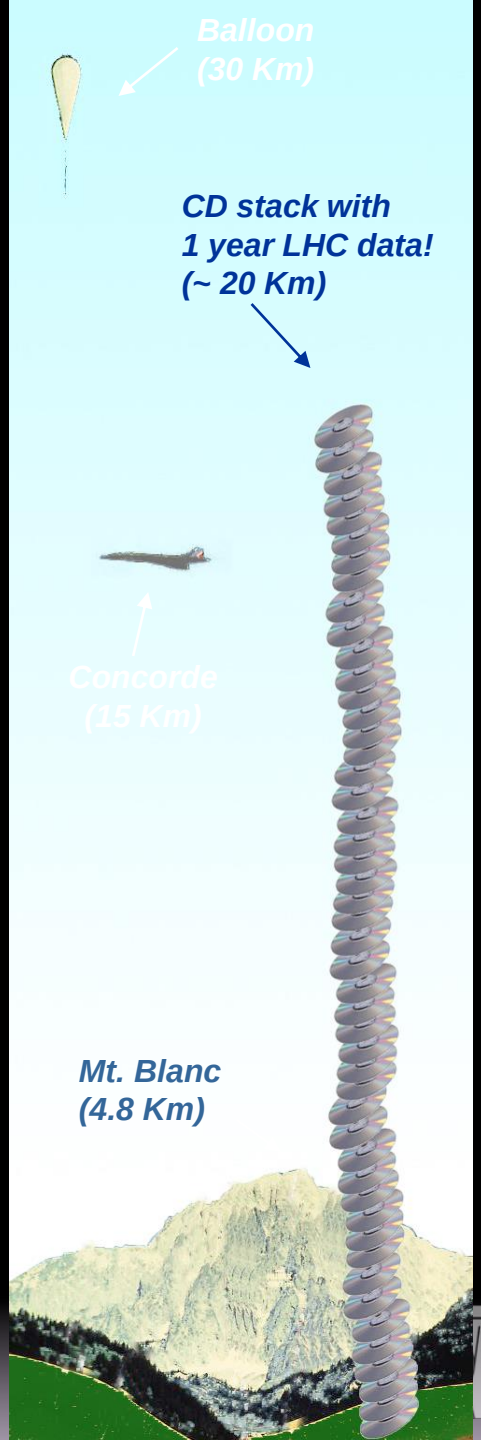
ATLAS is twice as big!



LHC experiments will produce **10-15 million GB** of data each year (about 20 million CDs!)

LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**.



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More open questions

- Are the quarks and leptons elementary particles?
- Are there other particles we have not seen yet?
- Why are the masses different?
- Matter/Antimatter asymmetry in universe?
- What about gravity? Or superstrings? Or extra dimensions?
- Properties of the neutrino?

Answering any *one* of these questions is worthy o a Nobel Prize!

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Dutch Language Teacher Programme

https://indico.cern.ch/event/761537/

25-29 September 2019
CERN
Europe/Zurich timezone

Search...

Overview
Timetable

Administrative Support:
Anita.Bens@cern.ch
+41 22 76 72775

The **Dutch Language Teacher Programme 2019** will take place from 25-29 September 2019. Lectures, [illegible]-site visits, exhibitions, and hands-on workshops will introduce its participants to cutting-edge particle physics. We hope our participants will go back to Belgium and the Netherlands as ambassadors, who pass on the subject to our next generation of physicists, engineers, IT specialists ...

Dutch Language Teacher Programme 2019:
https://indico.cern.ch/e/NLTP19

Teacher Programme Manager:
Jeff Wiener: 0041 75 411 9010

In case of emergency:
CERN fire brigade: 0041 22 76 74444

Starts 25 Sep 2019, 17:00
Ends 29 Sep 2019, 14:00
Europe/Zurich

CERN

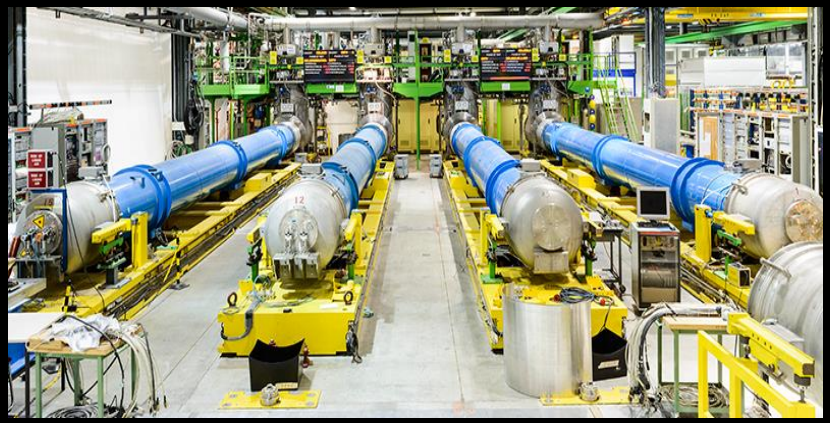
Gerjan Bobbink
Maarten Litmaath
Jeff Wiener

Information about the scientific programme and agenda will be made available under Timetable. More precise information concerning your arrival at CERN as well as a definite confirmation of your participation will be sent to you by e-mail. CERN is looking forward to welcoming you here in Geneva, Switzerland!

Thursday:

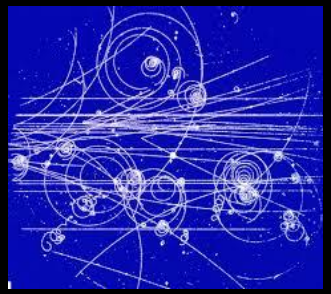
- Simulation

- Magnets



- Antimatter factury and Computing centre

- Make your own cloud chamber



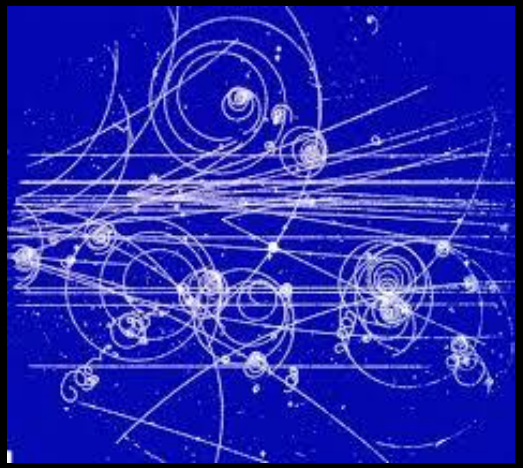
Friday:

- Detectors

- Physics

- Cryogenics!

- Make your own cloud chamber



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Saturday

Don't forget to have fun!

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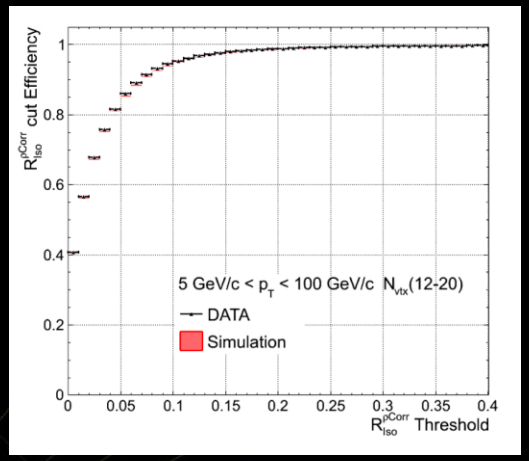
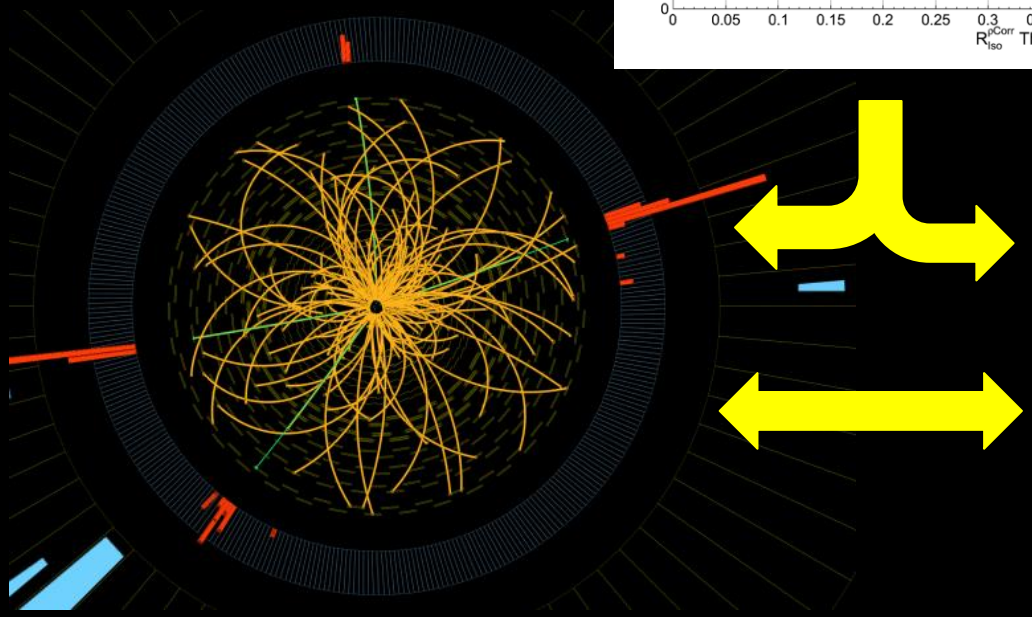
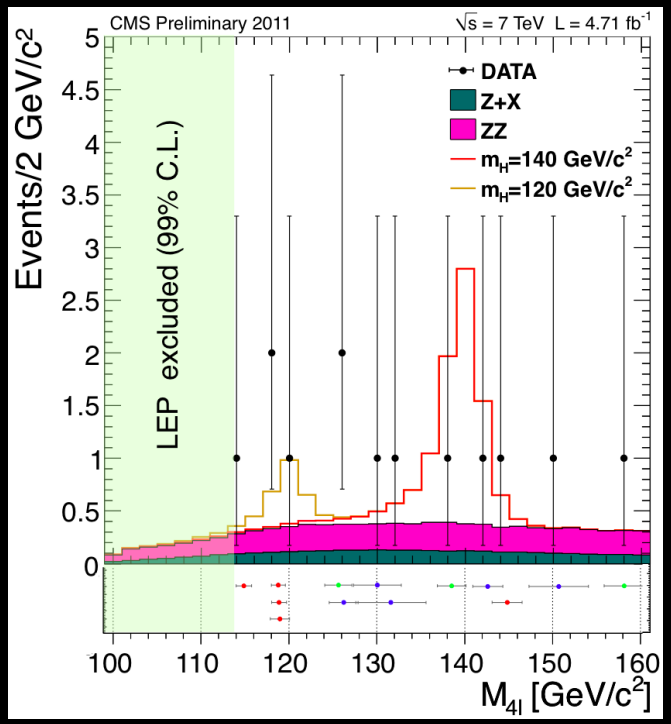
What do we actually do?







Belgium at CERN

One of the twelve CERN founding member states

- Belgium nowadays one of the 22 CERN member states
- CERN membership of 27 M€/year funded by Belgian Federal Government (FOD Economie)
- CERN Mandate:
  - Fundamental scientific research
  - Technology transfer
  - Training and educating STEM professionals of the future
  - International collaboration

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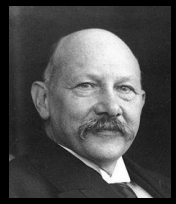
Nederland en Cern

Nederland is een van de 12 oprichters van Cern.

- Cornelis Jan Bakker Director General 1955-1960
  - Walter Hoogland Director of research 1989 -1994
  - Jos Engelen Director of research 2004 - 2008






Nederlandse wetenschappers hebben belangrijke bijdragen geleverd aan de ontdekkingen in deeltjes fysica en het onderzoek op CERN.

Nobel prijzen in de Natuurkunde codeeltjes fysica

1902 P. Zeeman & H. Lorenz: Zeeman effect (structuur in spectrale lijnen, kwantisatie van elektronenbanen)

1913 H. Kamerling Onnes: Superconductiviteit

1984 S. van der Meer: Cern Accelerator fysicus, stochastisch koeling

1999 M. Veltman and G. ‘ t Hooft: Renormalisatie theorie van electro-zwakke interacties

Directe rijksoverheidfinanciering voor CERN contributie
Experimenten op CERN wordt gesteund via NWO/FOM

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As a job:
Travel
Variation
Colleagues
Science

In school:
Liked science,
also art, history

University:
Experimental
Computers
Mathematics

For my PhD:
Exciting
Doing things first
See the world

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