Welcome to CERN

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CERN IT
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Based on material graciously provided by

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What is CERN about?

- CERN
  - Original meaning: Conseil Européen pour la Recherche Nucléaire
  - Current meaning: European Organization for Nuclear Research

- Quick summary of its main goals
  - C → collaboration
  - E → education
  - R → research
  - N → new technologies

Important dates

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

Finances & member states

Contributions from Member States in 2019

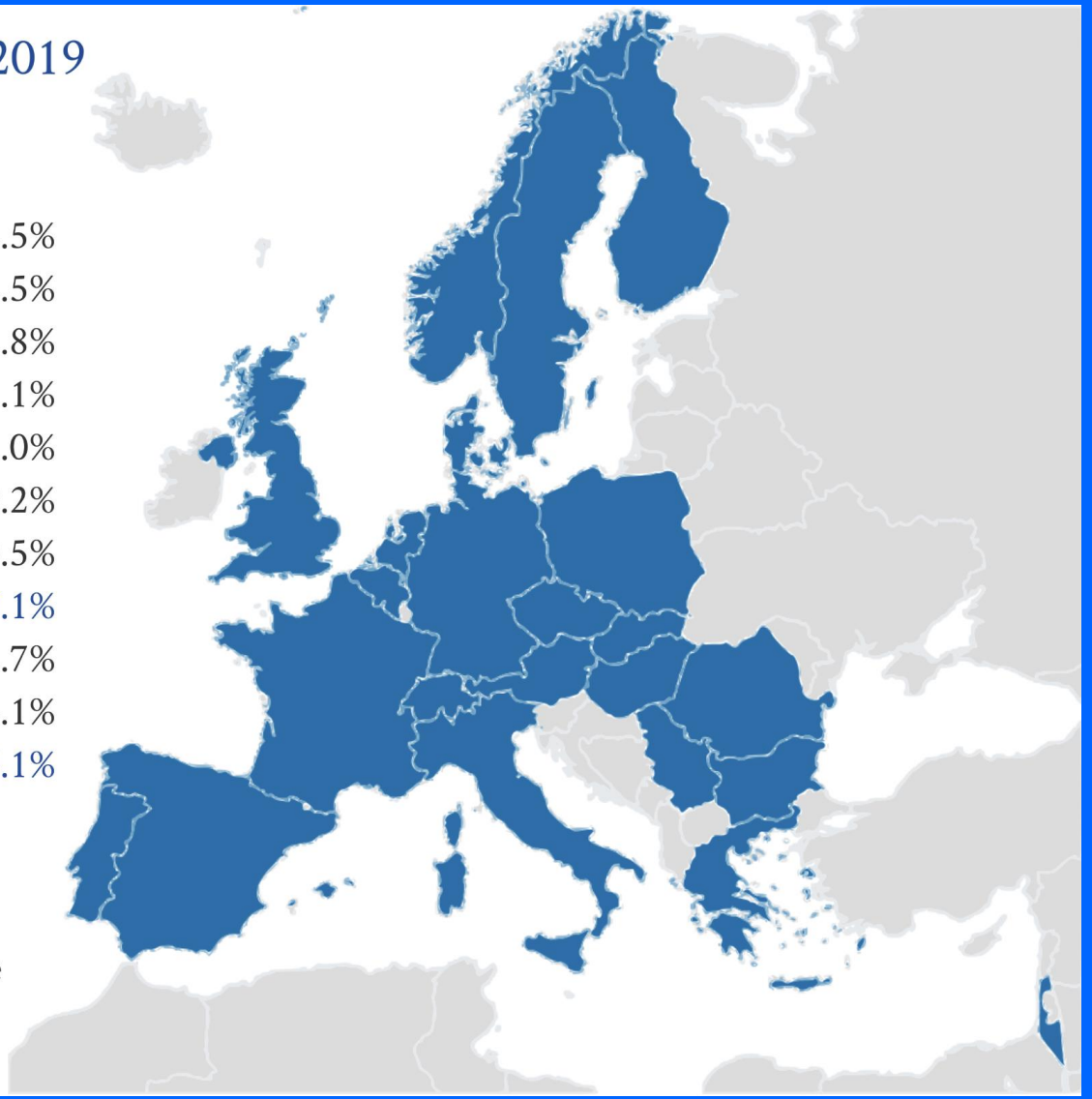
Annual budget: 1.17 billion CHF

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

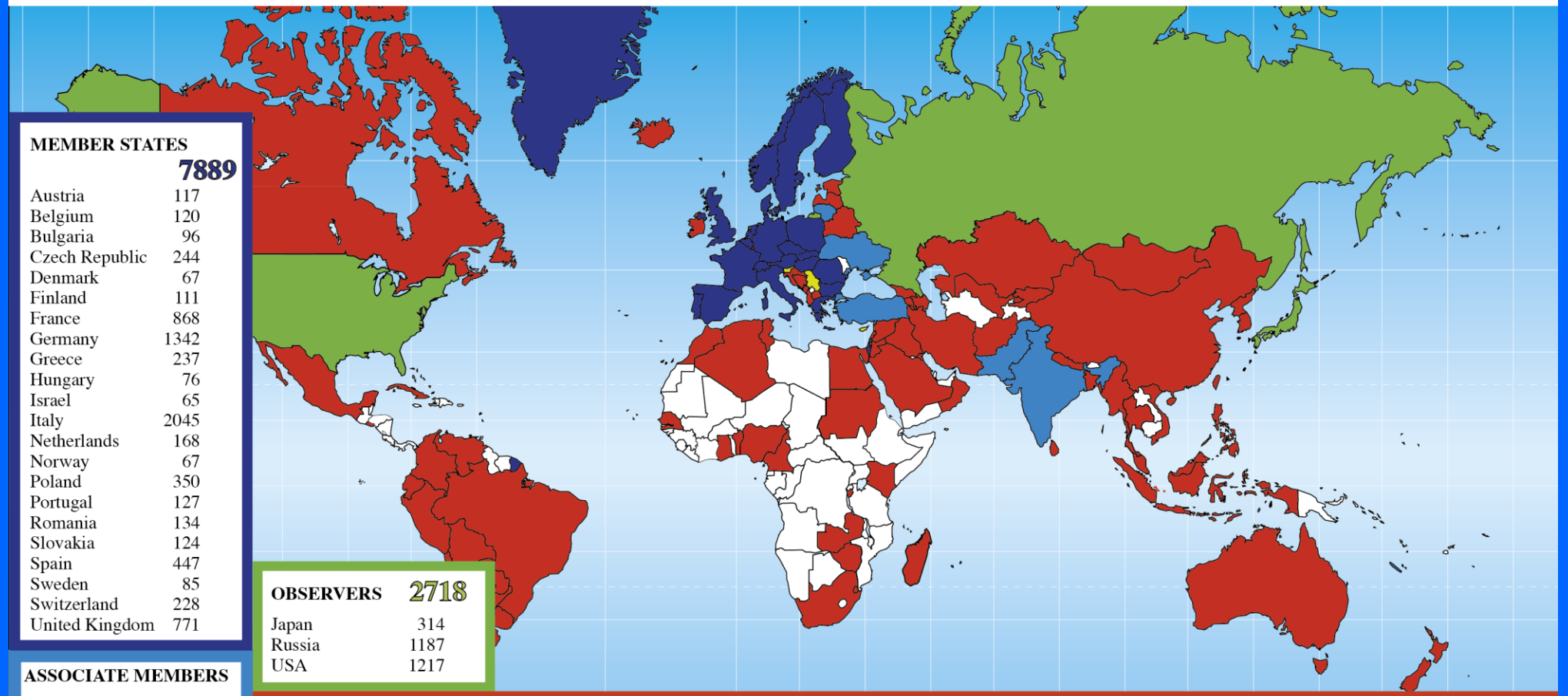


Observers: EU, JINR, UNESCO, Japan, Russian Federation, USA

Who works at CERN?

- 3000 people employed by CERN
  - Physicists, engineers, computer scientists, mathematicians, technicians, secretaries, fire brigade, health & safety experts, security, etc
- >10000 physicists associated with CERN
  - From all over the world!

Distribution of All CERN Users by Nationality on 24 January 2018



MEMBER STATES	7889
Austria	117
Belgium	120
Bulgaria	96
Czech Republic	244
Denmark	67
Finland	111
France	868
Germany	1342
Greece	237
Hungary	76
Israel	65
Italy	2045
Netherlands	168
Norway	67
Poland	350
Portugal	127
Romania	134
Slovakia	124
Spain	447
Sweden	85
Switzerland	228
United Kingdom	771

OBSERVERS	2718
Japan	314
Russia	1187
USA	1217

ASSOCIATE MEMBERS		745
India	357	
Lithuania	35	
Pakistan	65	
Turkey	173	
Ukraine	115	

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP	118
Cyprus	26
Serbia	57
Slovenia	35

OTHERS	1872																			
Afghanistan	1	Bolivia	4	Egypt	31	Kazakhstan	5	Mongolia	2	Philippines	3	Thailand	22
Albania	3	Bosnia & Herzegovina	2	El Salvador	1	Kenya	3	Montenegro	11	Saint Kitts and Nevis	1	T.F.Y.R.O.M.	2
Algeria	14	Brazil	135	Estonia	15	Korea Rep.	185	Morocco	20	Saudi Arabia	2	Tunisia	5
Argentina	27	Burundi	1	Georgia	46	Kyrgyzstan	1	Myanmar	1	Senegal	1	Uruguay	1
Armenia	19	Cameroon	1	Ghana	1	Latvia	2	Nepal	10	Singapore	4	Uzbekistan	4
Australia	31	Canada	161	Hong Kong	1	Lebanon	23	New Zealand	5	South Africa	56	Venezuela	10
Azerbaijan	10	Chile	20	Iceland	3	Luxembourg	2	Nigeria	3	Sri Lanka	6	Viet Nam	13
Bangladesh	11	China	510	Indonesia	11	Madagascar	4	North Korea	1	Sudan	1	Zambia	1
Belarus	48	Colombia	45	Iran	51	Malaysia	15	Oman	3	Swaziland	1	Zimbabwe	2
Benin	1	Croatia	41	Iraq	1	Malta	9	Palestine (O.T.).	7	Syria	1		
		Cuba	12	Ireland	16	Mauritius	1	Paraguay	2	Taiwan	51		
		Ecuador	6	Jordan	1	Mexico	82	Peru	7				

Who visits CERN

- CERN is an open laboratory
  - With certain constraints and regulations
- Every year, ~130’000 people visit CERN
- Open days September 2019: 75’000 people visited in 2 days!!!

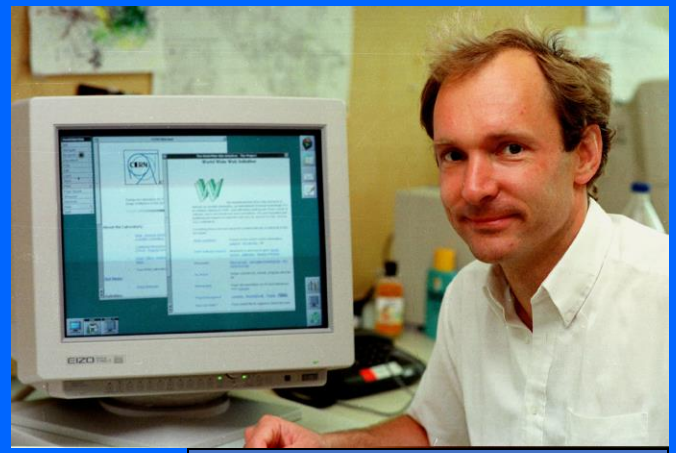
Basic vs applied research

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

- Applied research often builds on basic research

- CERN only does basic research
  - But we often need to innovate to build things that do not exist yet…

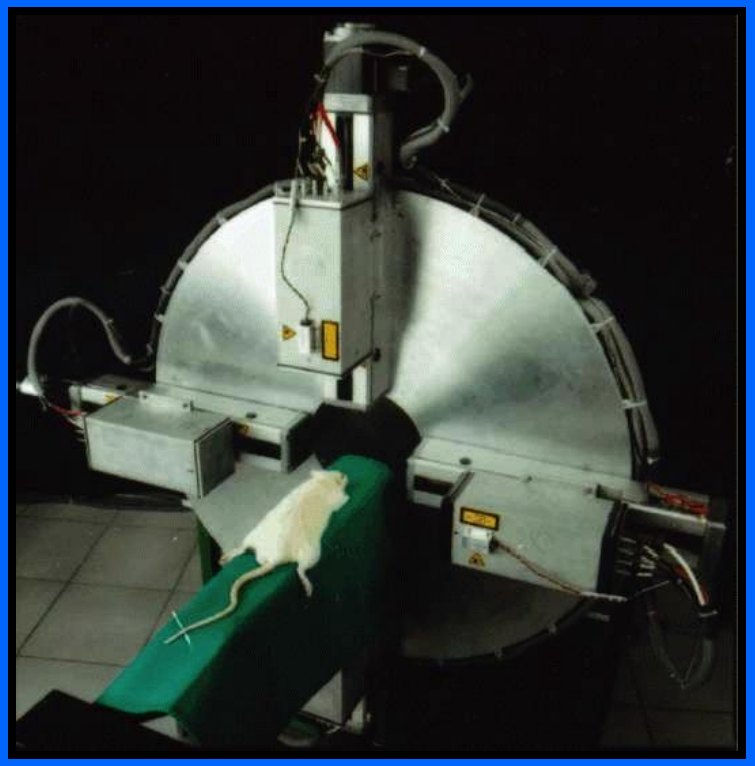
For example, the World Wide Web!



Tim Berners-Lee

But also…

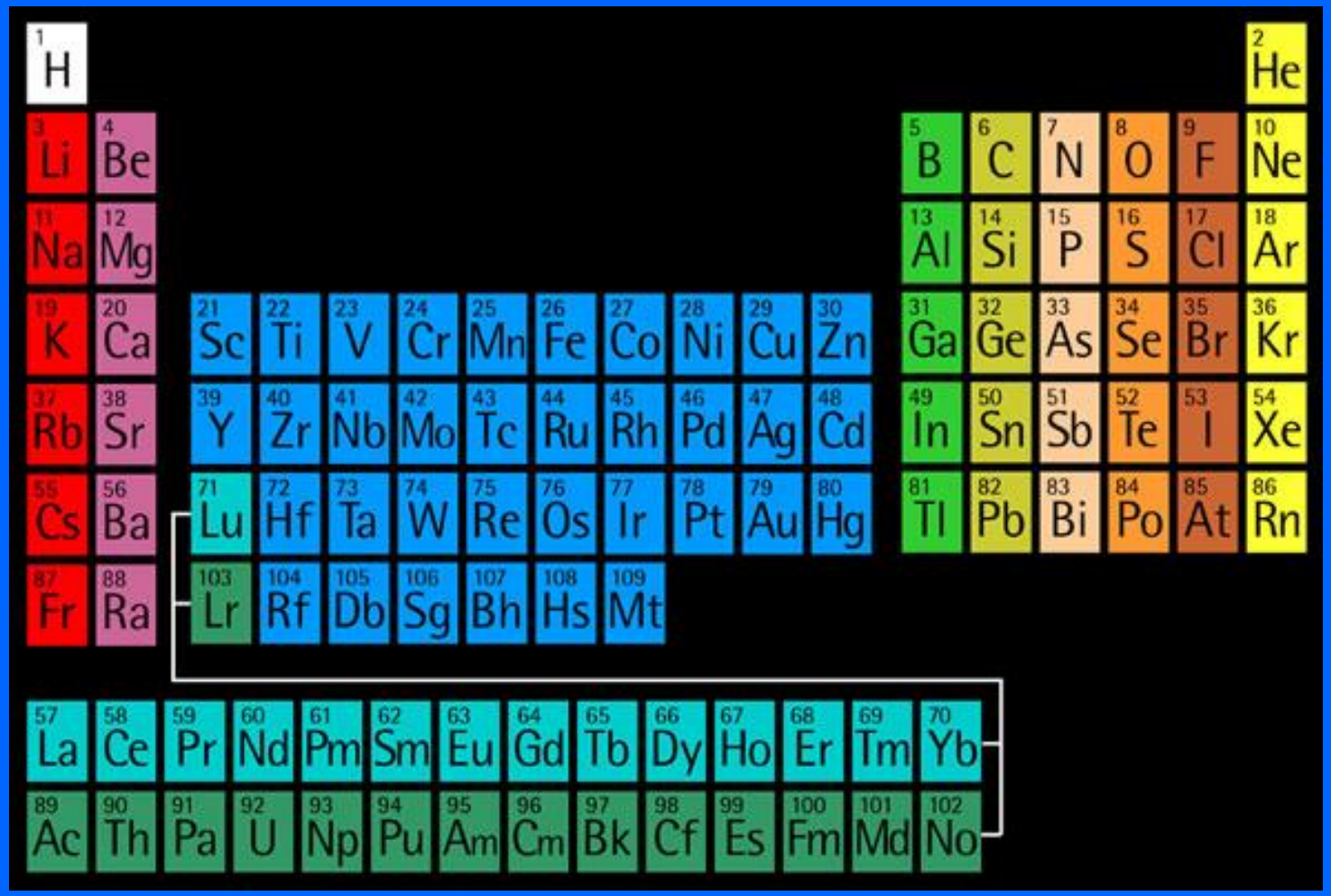
- Medical applications
  - PET / CT / MRI scan technologies
    - Detectors, superconducting magnets, cryogenics, vacuum
  - Radiation therapy: accelerators, detectors
- Space applications
  - High-radiation environment materials / devices
- Other computing developments
  - Data analysis & simulation frameworks
  - Grid middleware
  - Indico – meeting and conference management
  - Invenio – digital library management
- And more



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?

What is everything around us made of?



At different scales…

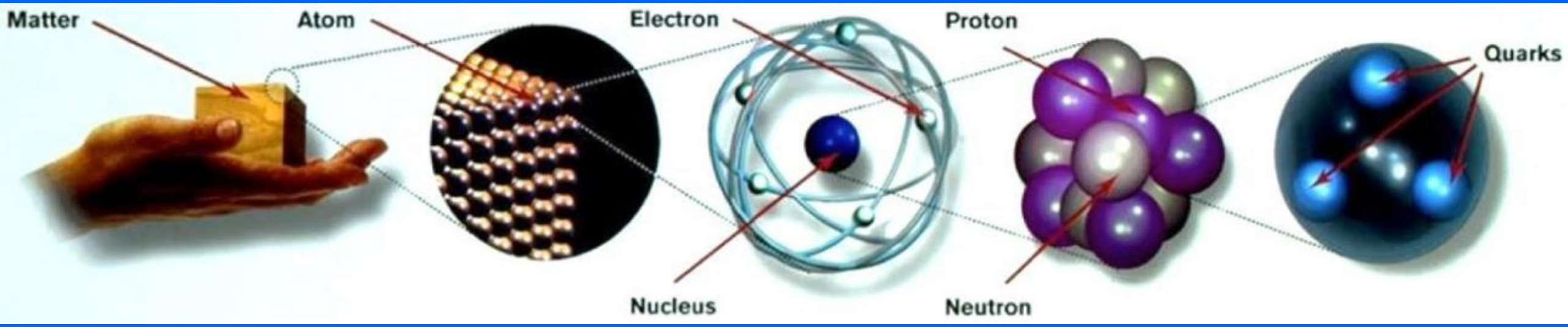
Mainly O, C, H

Mainly Fe, O, Si

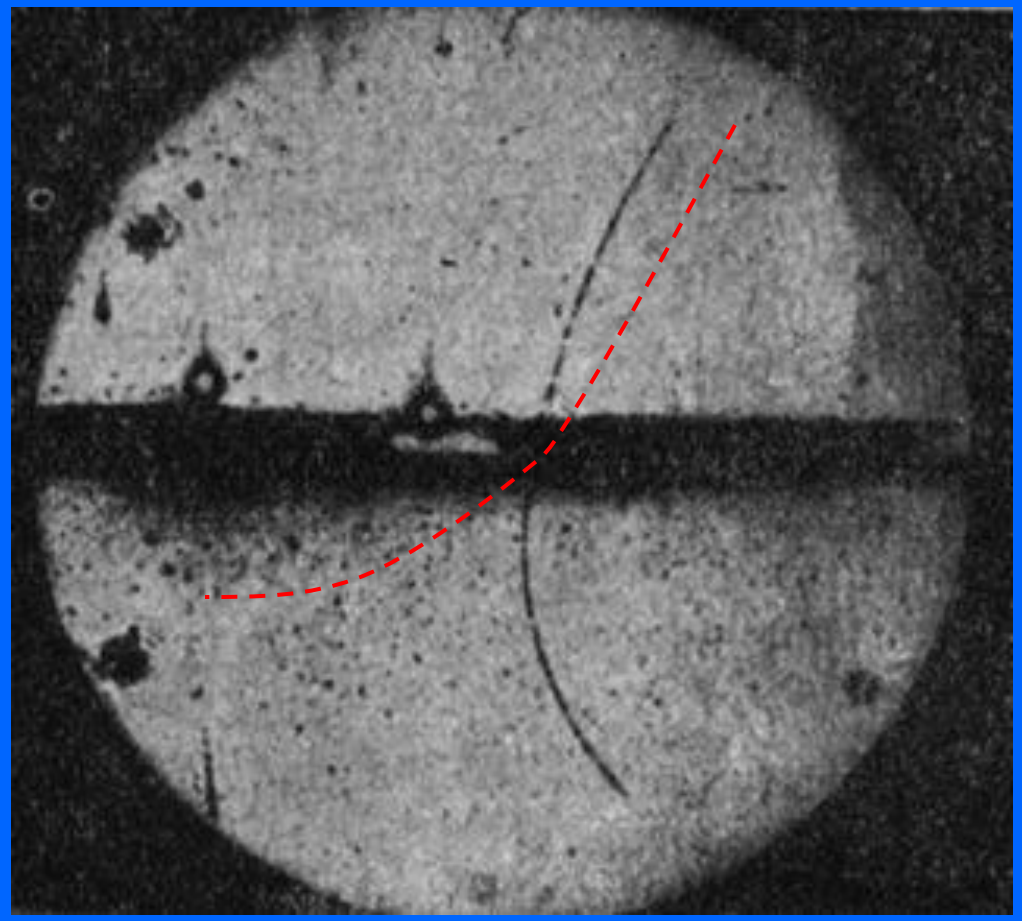
Mainly H and He

96% out there unknown!

What is everything around us made of?

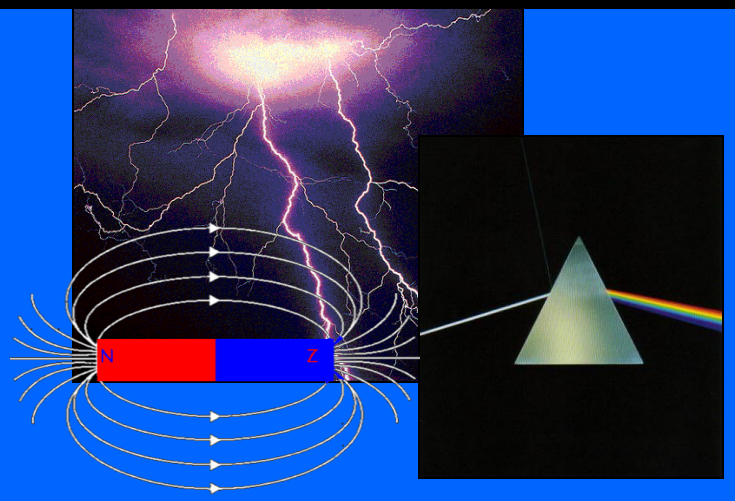


Anti-matter

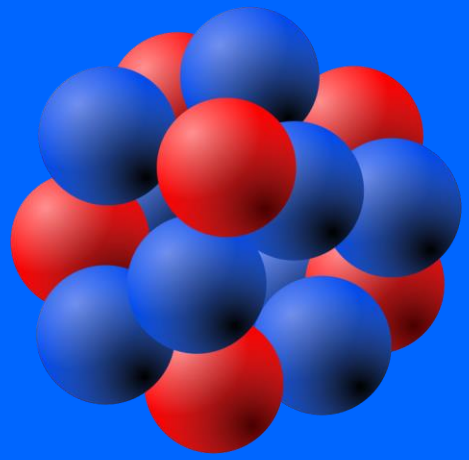


- Anti-matter: discovered in 1923
  - Predicted by theory
- *Almost* same as matter... But oppositely charged + some subtle effects
- Problem: at big bang there was just as much matter as anti-matter... Where did it go?

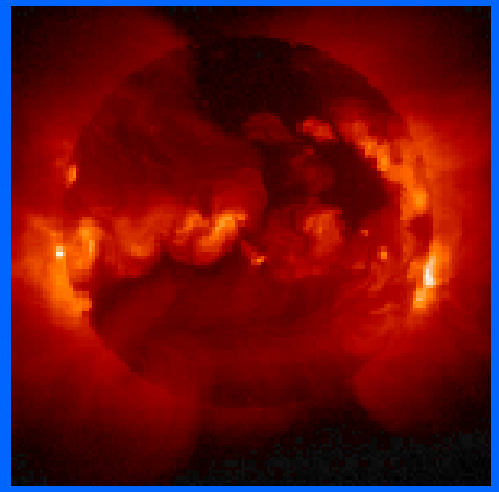
The four fundamental forces



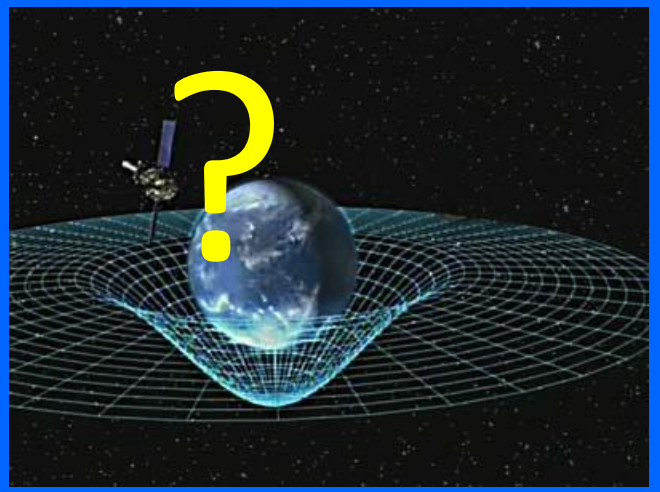
Electro-magnetic force



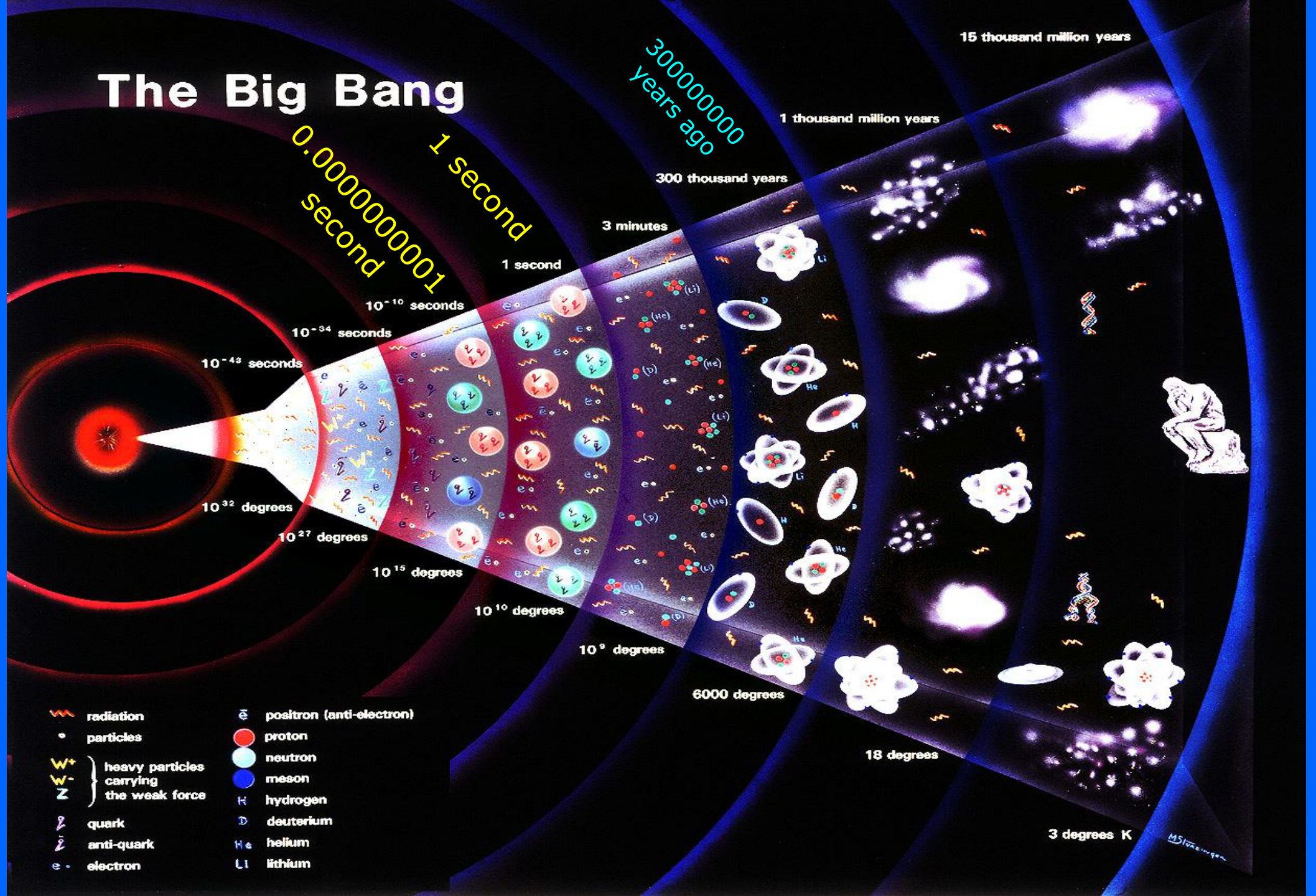
Strong force

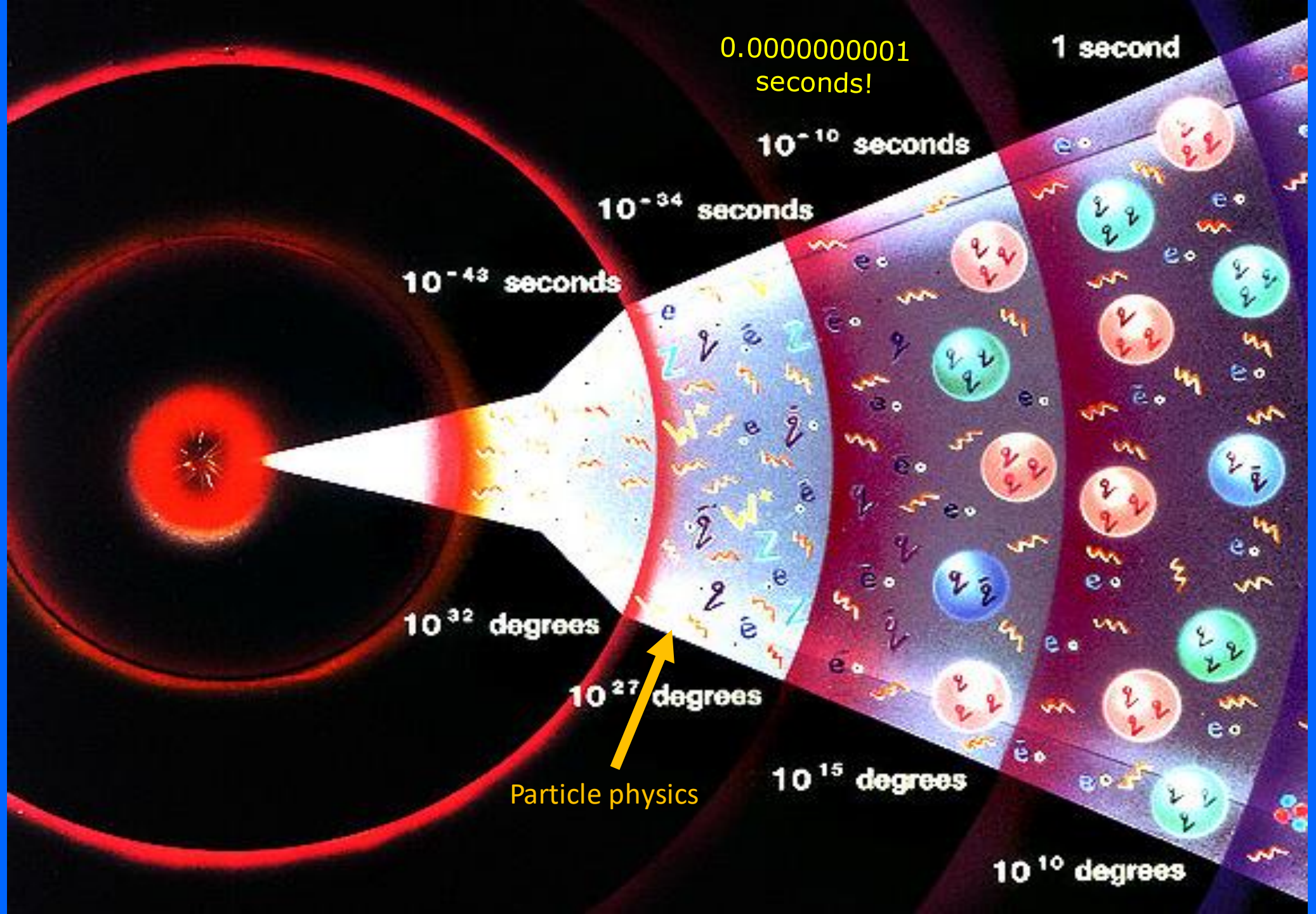


Weak force

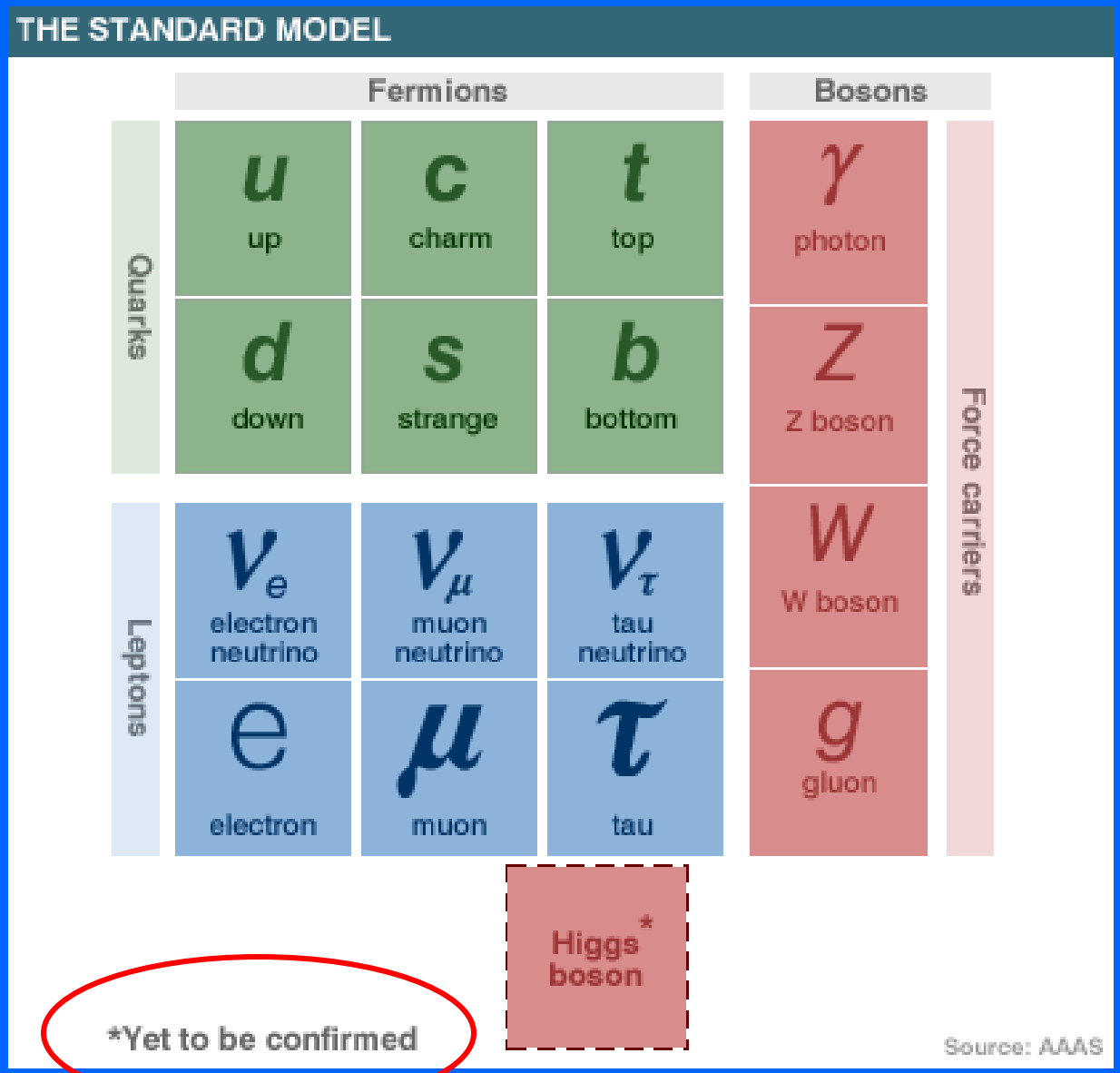


Gravity


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
W+ W- Z heavy particles carrying the weak force
quark
anti-quark
electron
positron (anti-electron)
proton
neutron
meson
H hydrogen
D deuterium
He helium
Li lithium

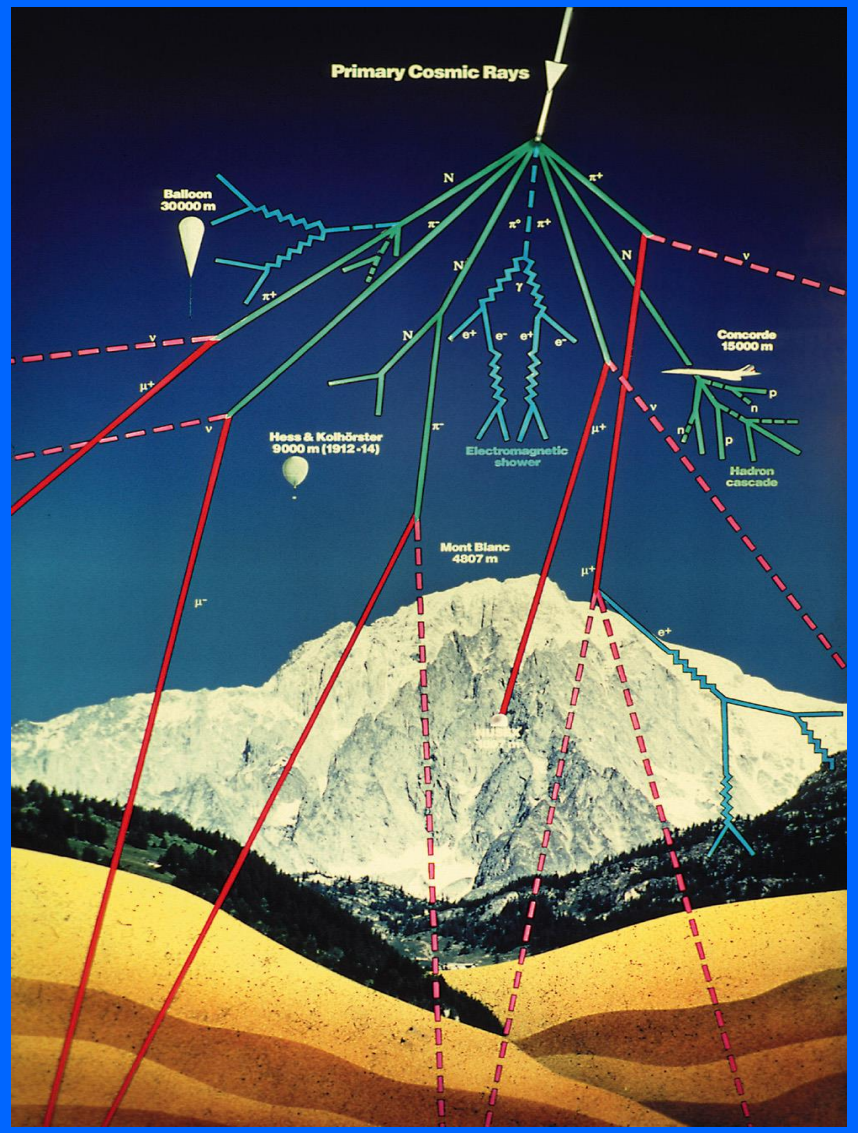

0.0000000001 seconds!
1 second
10^{-10} seconds
10^{-34} seconds
10^{-43} seconds
10^{32} degrees
10^{27} degrees
10^{15} degrees
10^{10} degrees
Particle physics

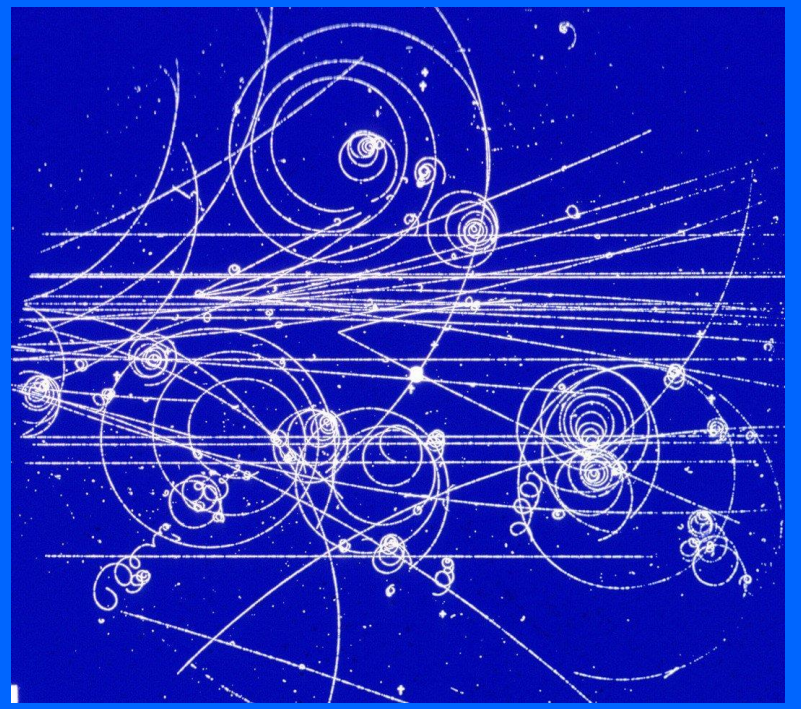
The standard model before July 4, 2012



How do we know all this?

Cosmic rays

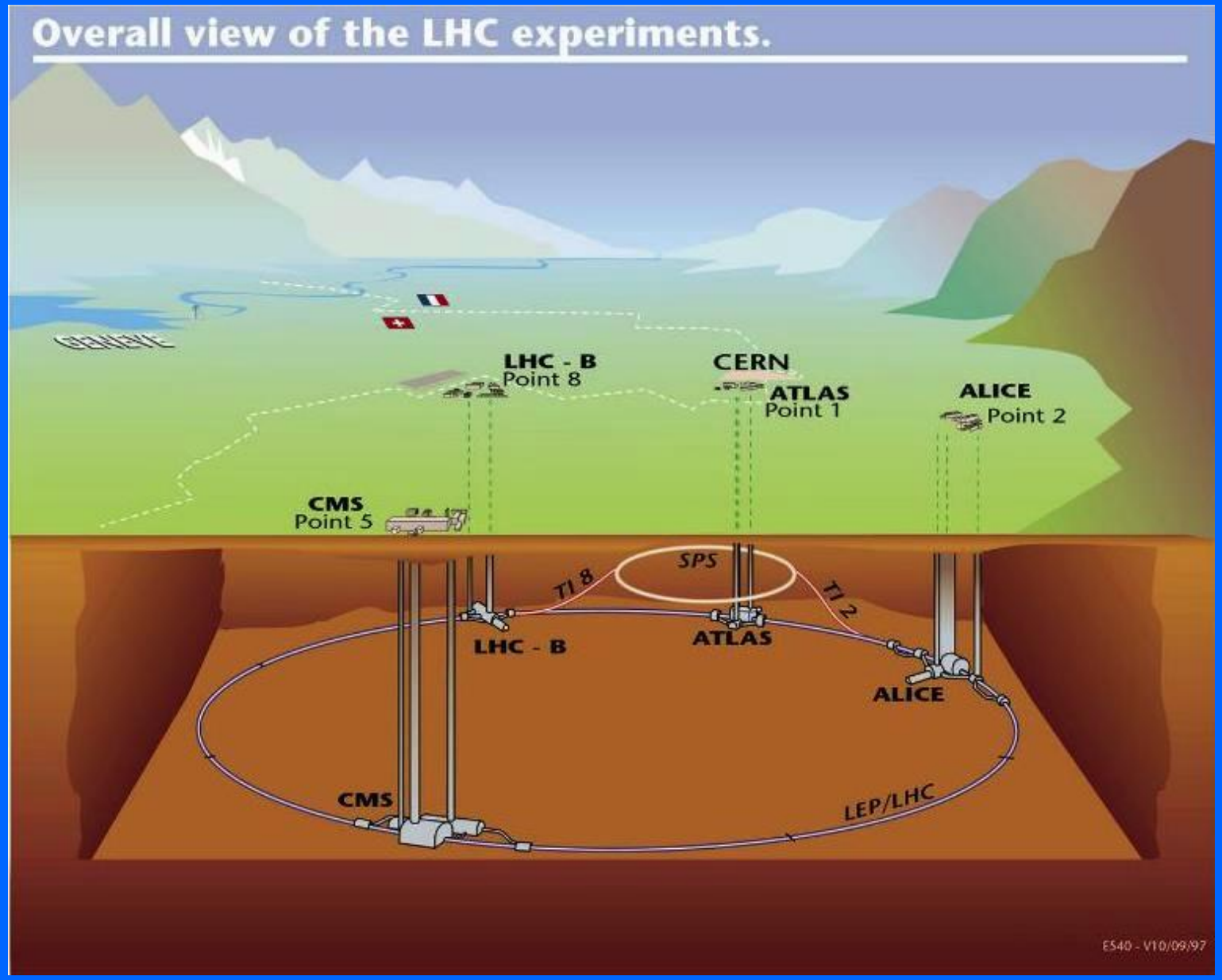




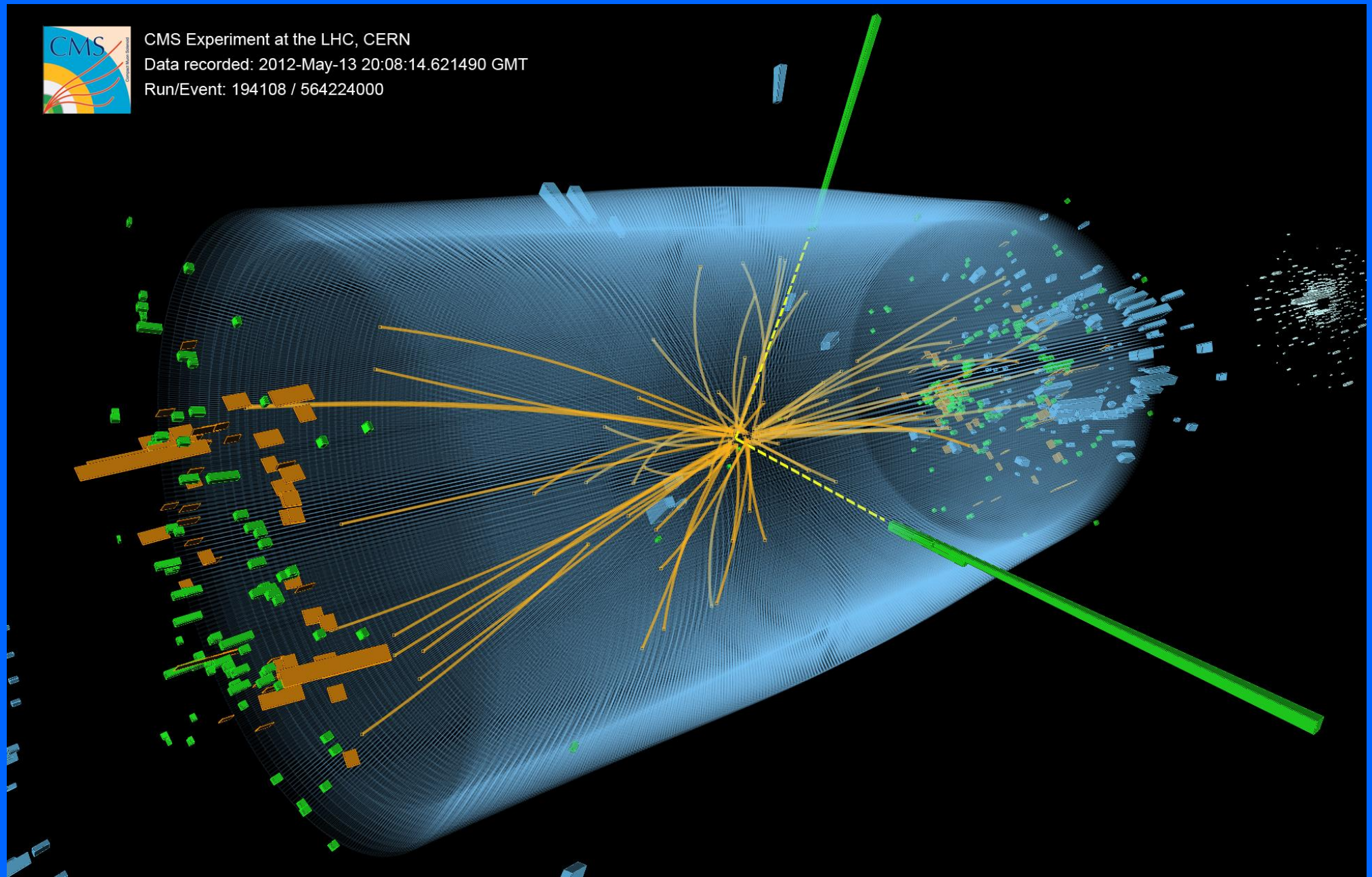
- Accelerator experiments
- Radioactivity experiments

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

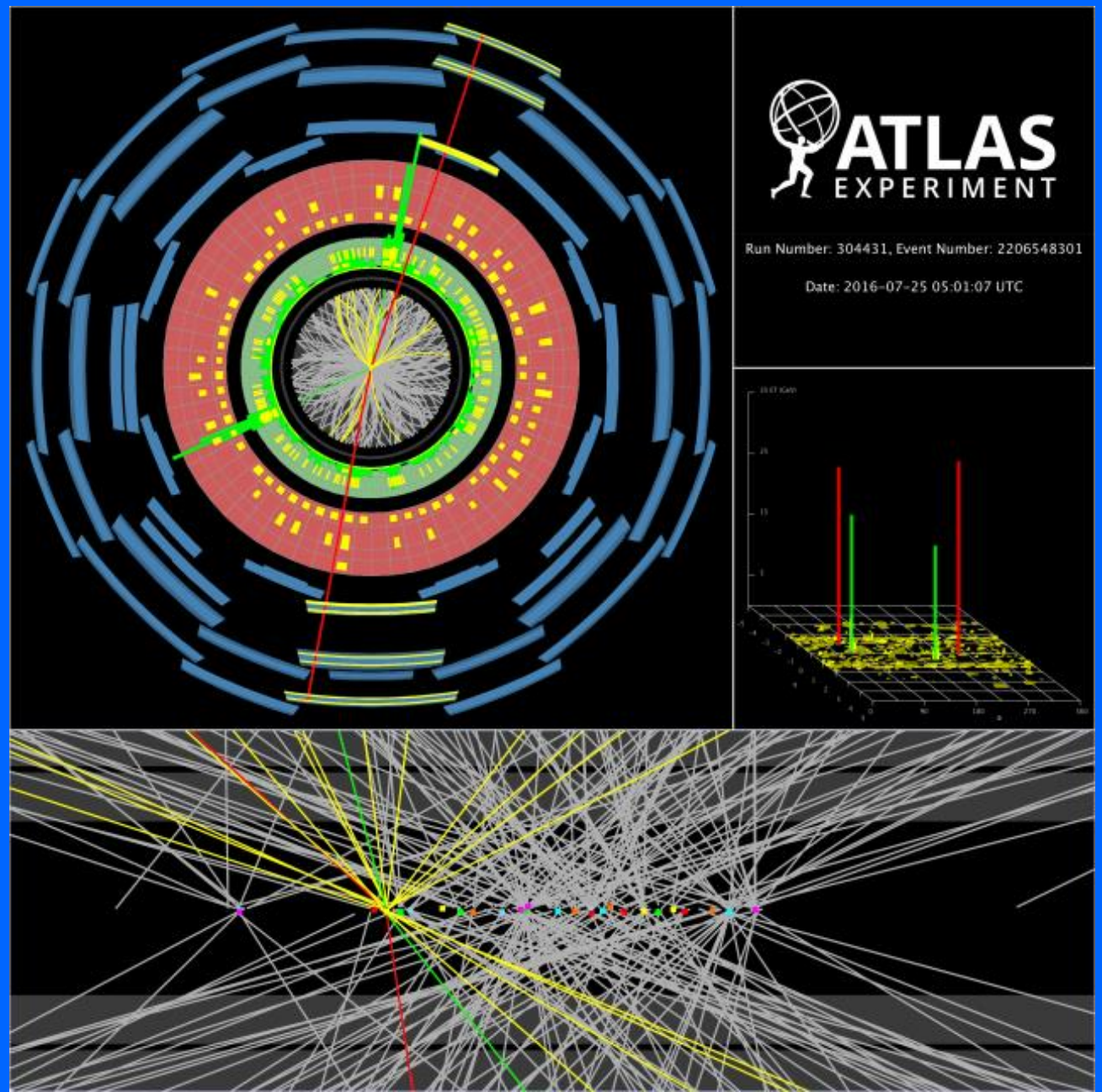
The Large Hadron Collider


Overall view of the LHC experiments.
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
ES40 - V10/09/97

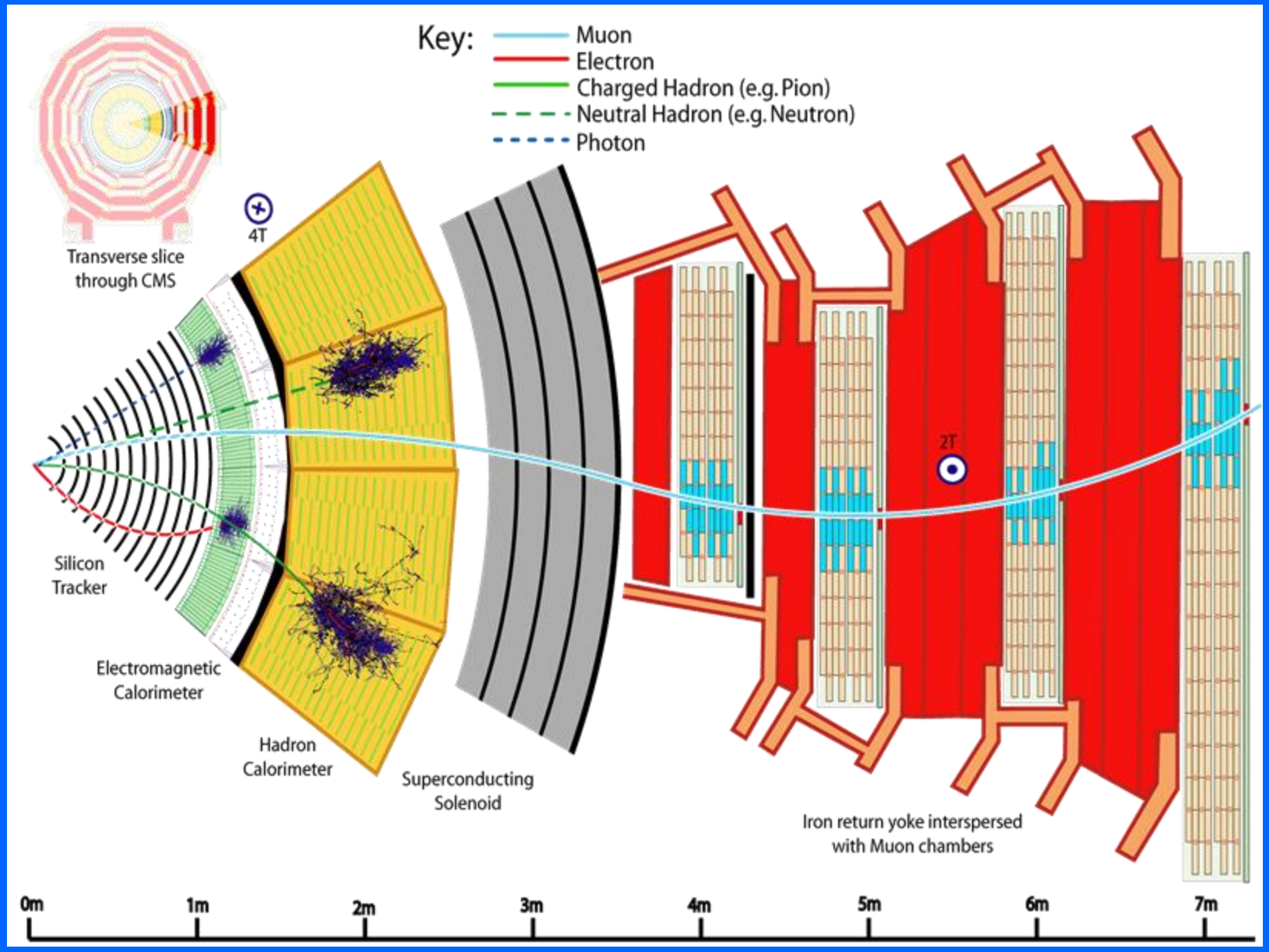
Huge experiments can investigate extremely small scales …



… by identifying what is produced in collisions!



Different detector layers help distinguish particle types



Computing challenges

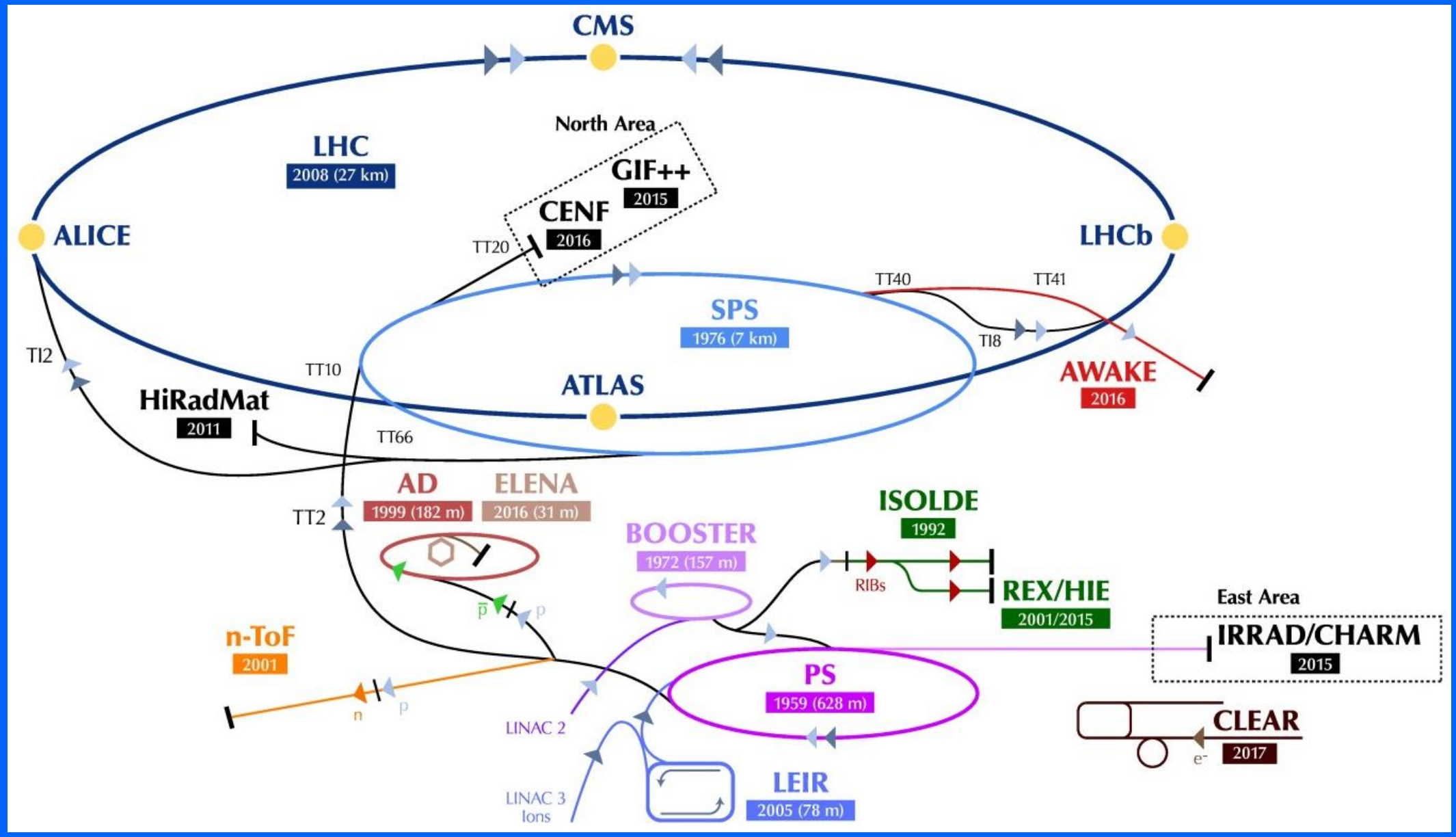
- The LHC experiments generate many tens of Petabytes per year
- To store and process such huge quantities of data, the experiments make use of a worldwide collaboration of partner universities and laboratories: the Worldwide LHC Computing Grid

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?

Solving any of these puzzles is worth a Nobel Prize!

Other accelerators and many more experiments



Even in space!

Summary

- CERN is about:
  - International collaboration
  - Fundamental research
  - Technology innovation
  - Knowledge sharing

- CERN has particle accelerators and many experiments to discover and study the building blocks of the universe

Enjoy your stay at CERN !