Welcome to CERN

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CERN IT

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Based also 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 by the 12 founding states

Finances & member states

Contributions from Member States in 2019

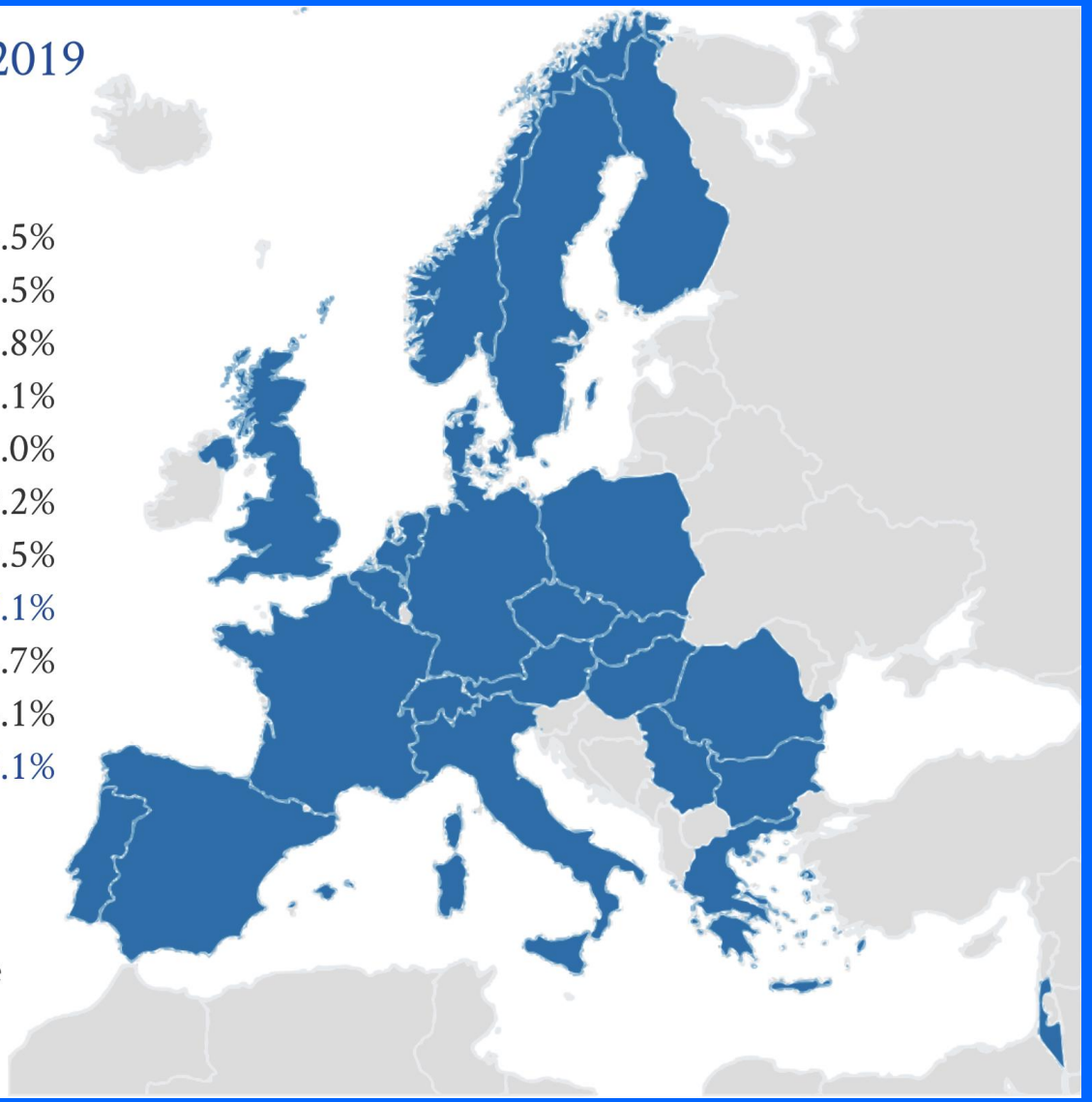
Annual budget: 1.17 billion CHF

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

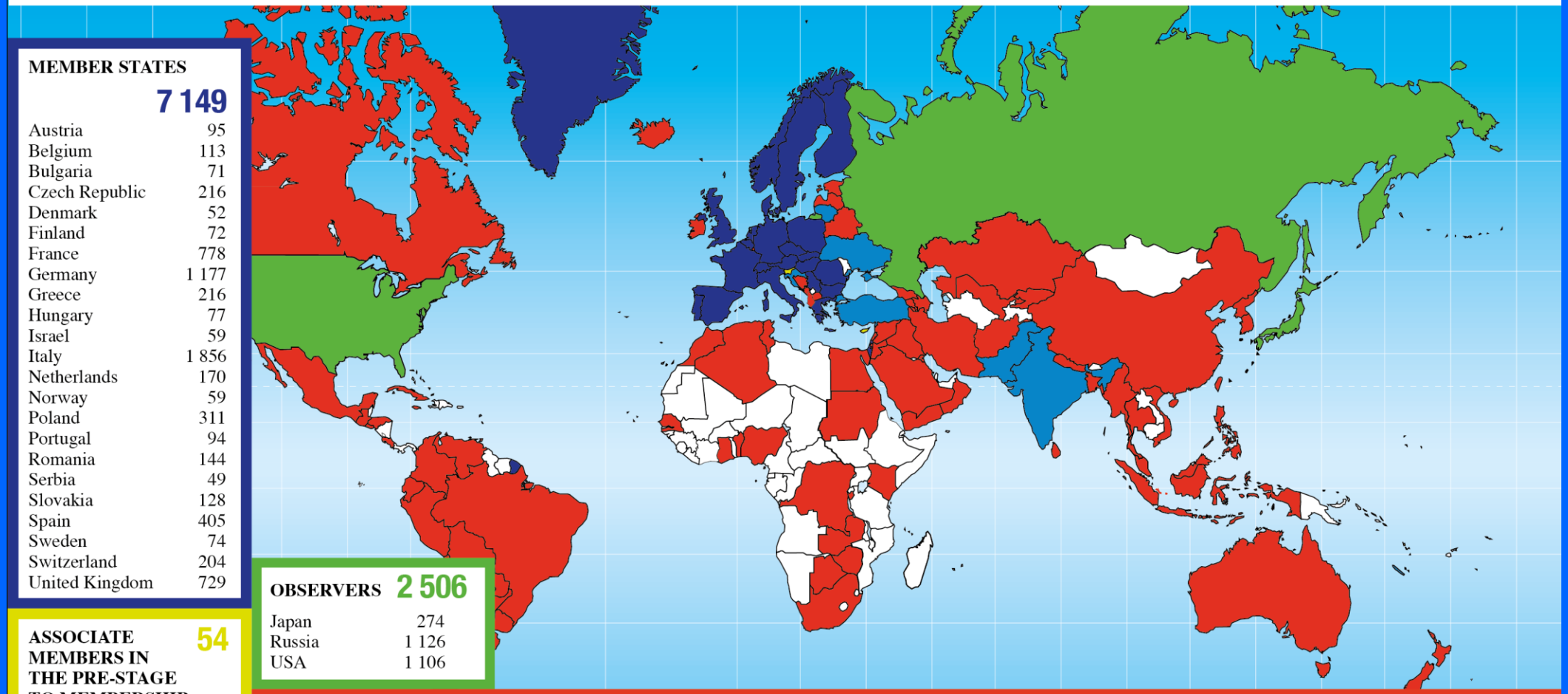


Observers: EU, (JINR), UNESCO, Japan, (Russian Federation), USA

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 27 January 2020



MEMBER STATES **7 149**

Austria	95
Belgium	113
Bulgaria	71
Czech Republic	216
Denmark	52
Finland	72
France	778
Germany	1 177
Greece	216
Hungary	77
Israel	59
Italy	1 856
Netherlands	170
Norway	59
Poland	311
Portugal	94
Romania	144
Serbia	49
Slovakia	128
Spain	405
Sweden	74
Switzerland	204
United Kingdom	729

OBSERVERS **2 506**

Japan	274
Russia	1 126
USA	1 106

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP **54**

Cyprus	21
Slovenia	33

ASSOCIATE MEMBERS **770**

Croatia	47
India	367
Lithuania	31
Pakistan	63
Turkey	162
Ukraine	100

OTHERS

Albania	4	Bolivia	2	Egypt	26	Ireland	14	Montenegro	8	Saint Kitts and Nevis	1	Uzbekistan	3
Algeria	8	Bosnia & Herzegovina	2	El Salvador	1	Jamaica	1	Morocco	26	Saudi Arabia	2	Venezuela	10
Argentina	22	Bostwana	1	Estonia	16	Jordan	2	Myanmar	1	Senegal	1	Viet Nam	10
Armenia	18	Brazil	121	Georgia	54	Kazakhstan	12	Nepal	8	Singapore	4	Yemen	1
Australia	28	Burundi	1	Ghana	1	Kenya	1	New Zealand	6	South Africa	54	Zambia	1
Azerbaijan	7	Canada	155	Gibraltar	1	Korea	161	Nigeria	2	Sri Lanka	6	Zimbabwe	1
Bahrain	3	Chile	21	Guatemala	1	Kyrgyzstan	1	North Korea	3	Sudan	2		
Bangladesh	5	China	569	Hong Kong	1	Latvia	4	North Macedonia	2	Syria	2		
Belarus	49	Colombia	35	Honduras	1	Lebanon	23	Oman	1	Taiwan	47		
Benin	1	Congo	1	Iceland	5	Luxembourg	3	Palestine	7	Thailand	24		
		Costa Rica	1	Indonesia	11	Malaysia	19	Paraguay	1	Tunisia	5		
		Cuba	16	Iran	46	Malta	5	Peru	6	Uruguay	1		
		Ecuador	11	Iraq	1	Mexico	80	Philippines	4				

1 822

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!!!

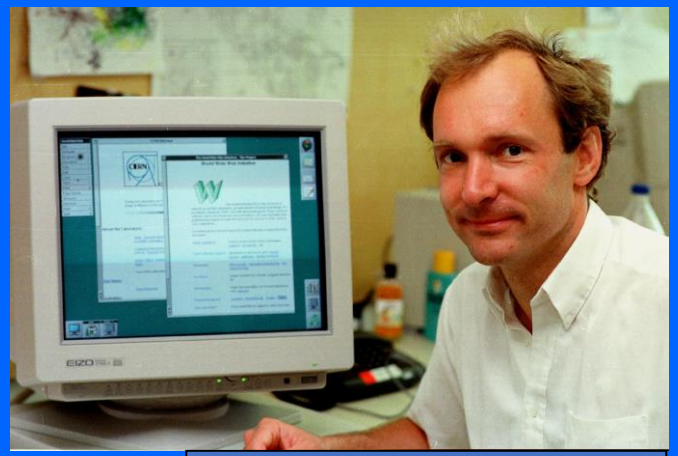
Basic vs applied research

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

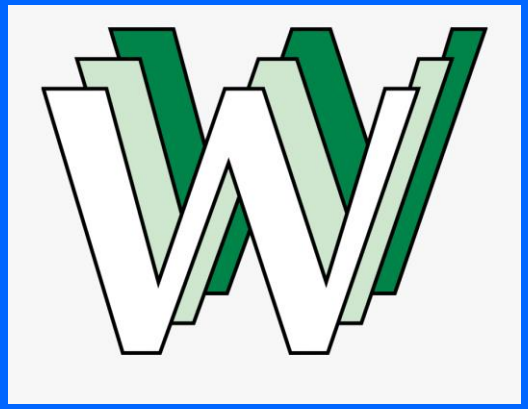
- Applied research often builds on basic research

- 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, Zenodo – digital library management
- And more

CERN against COVID-19

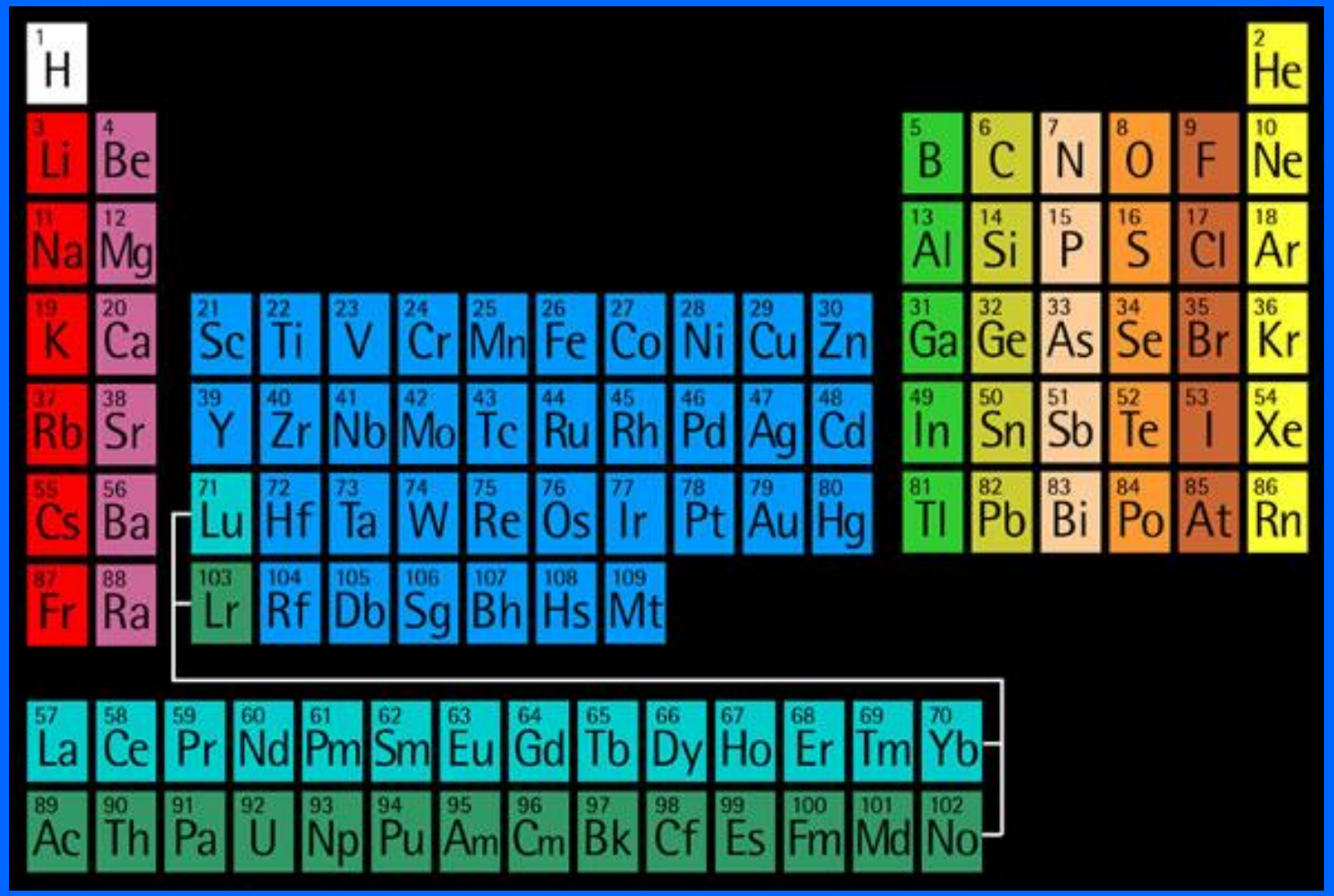
Reuse CERN techniques and technologies to help the global battle against the COVID-19 pandemic:

- Low-cost ventilators for breathing devices
- Zenodo space for fast and easy publication of research data sets and results
- Using part of WLCG for Folding@Home
- …

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…

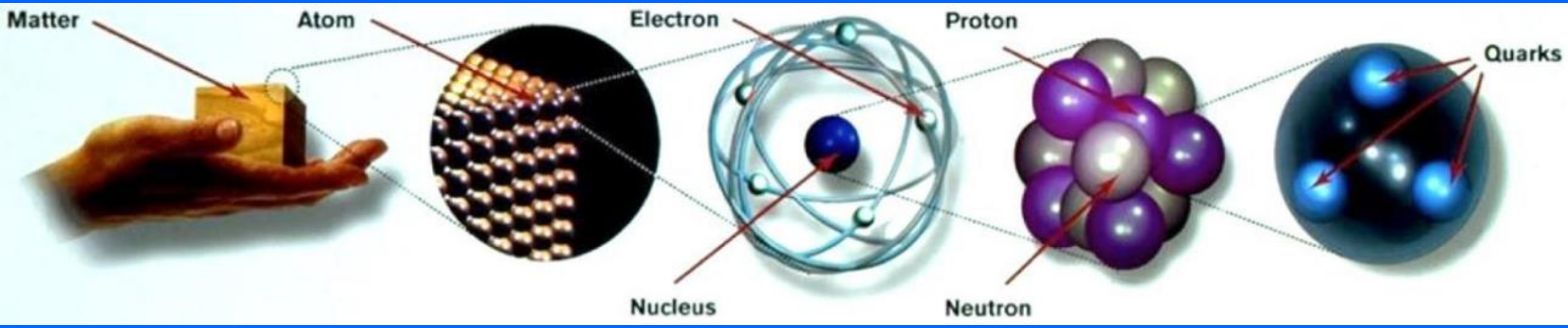
Mainly O, C, H

Mainly Fe, O, Si

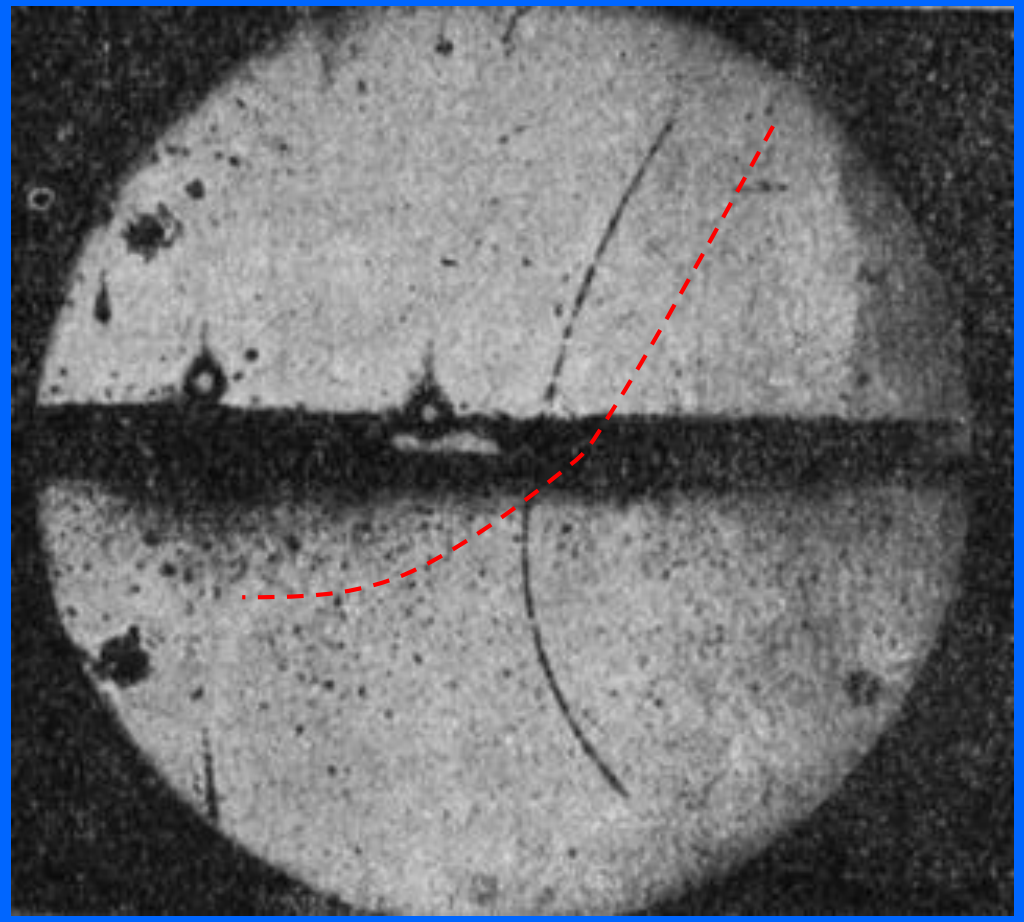
Mainly H and He

96% out there unknown!

What is everything around us made of?

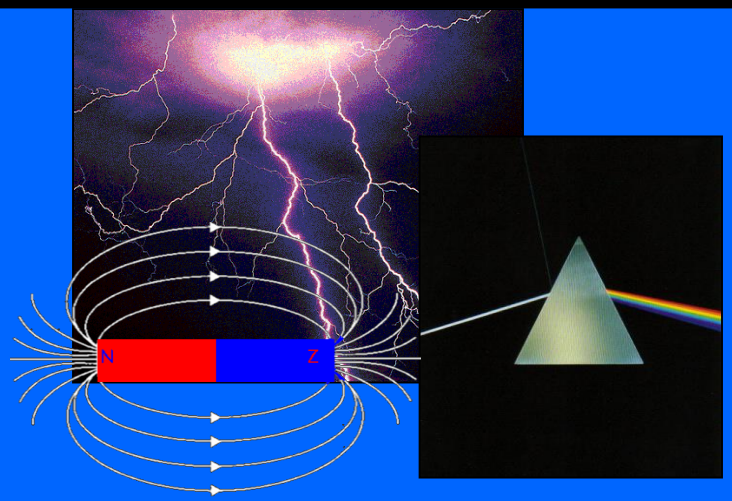


Anti-matter

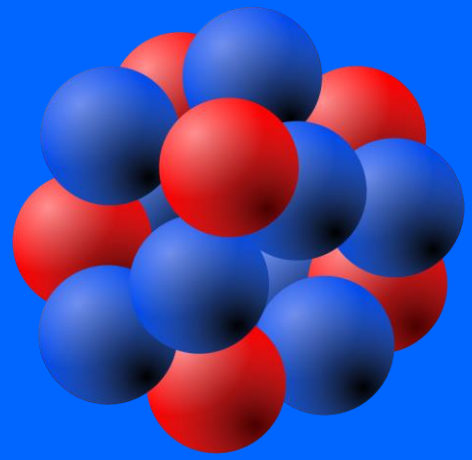


- Anti-matter: discovered in 1923
  - Predicted by theory
- *Almost* the same as matter... But oppositely charged + some subtle effects…
- Problem: at the Big Bang there would have been just as much anti-matter as matter... Where did all that anti-matter go?

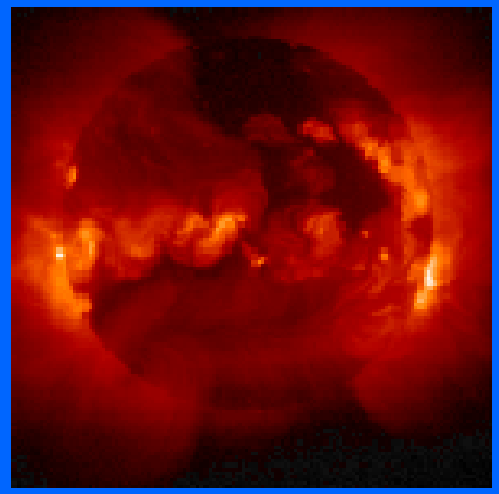
The four fundamental forces



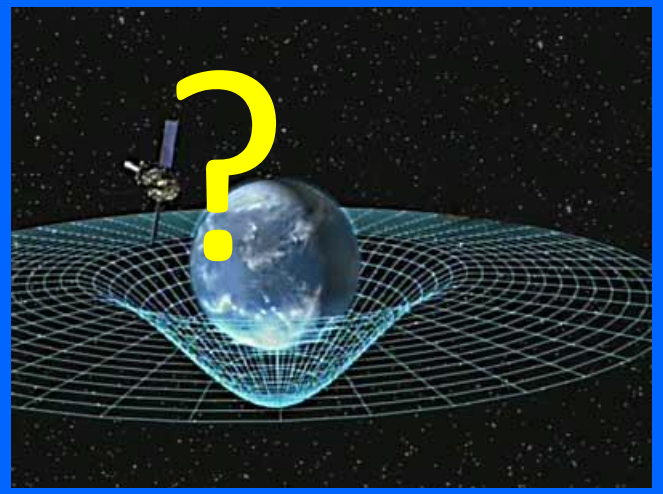
Electro-magnetic force



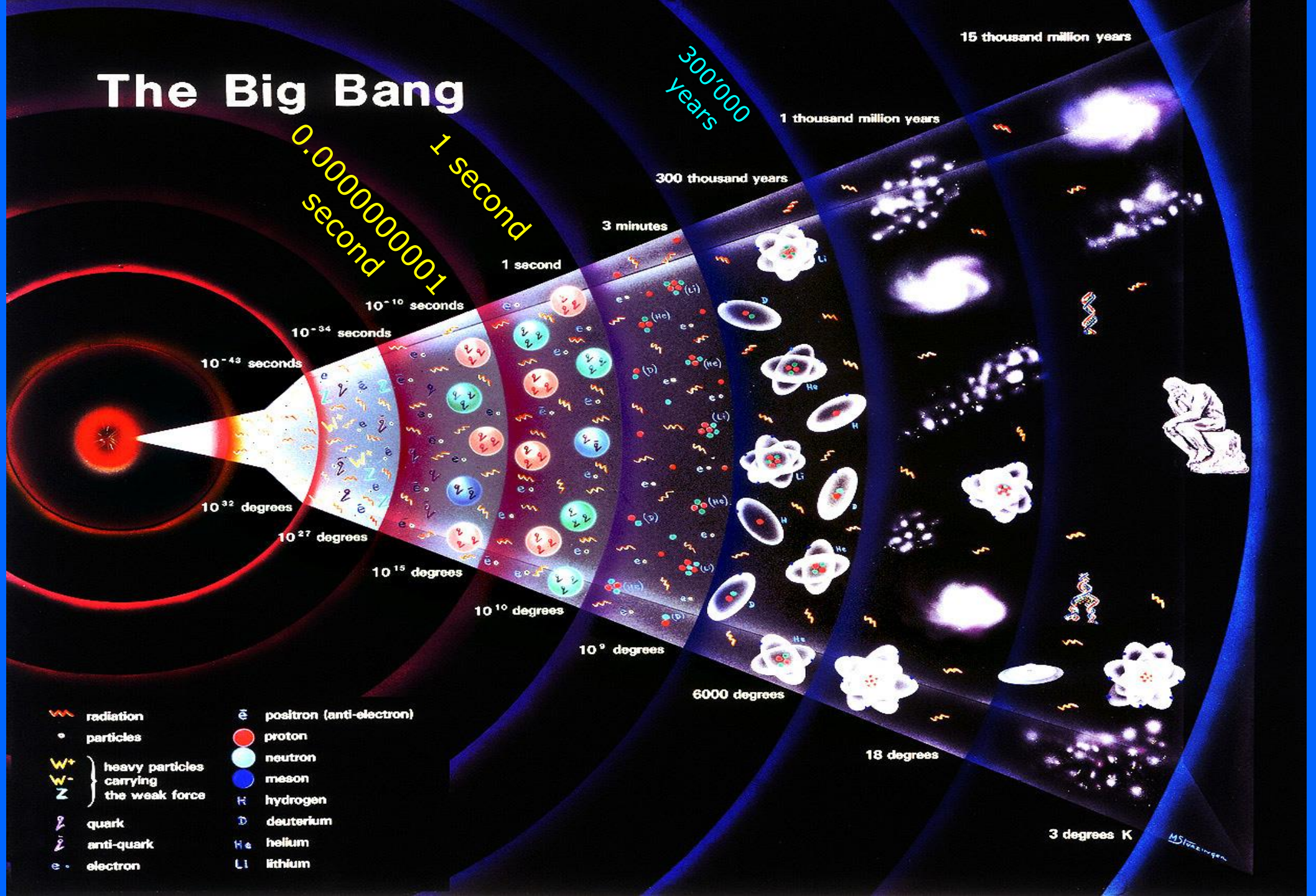
Strong force

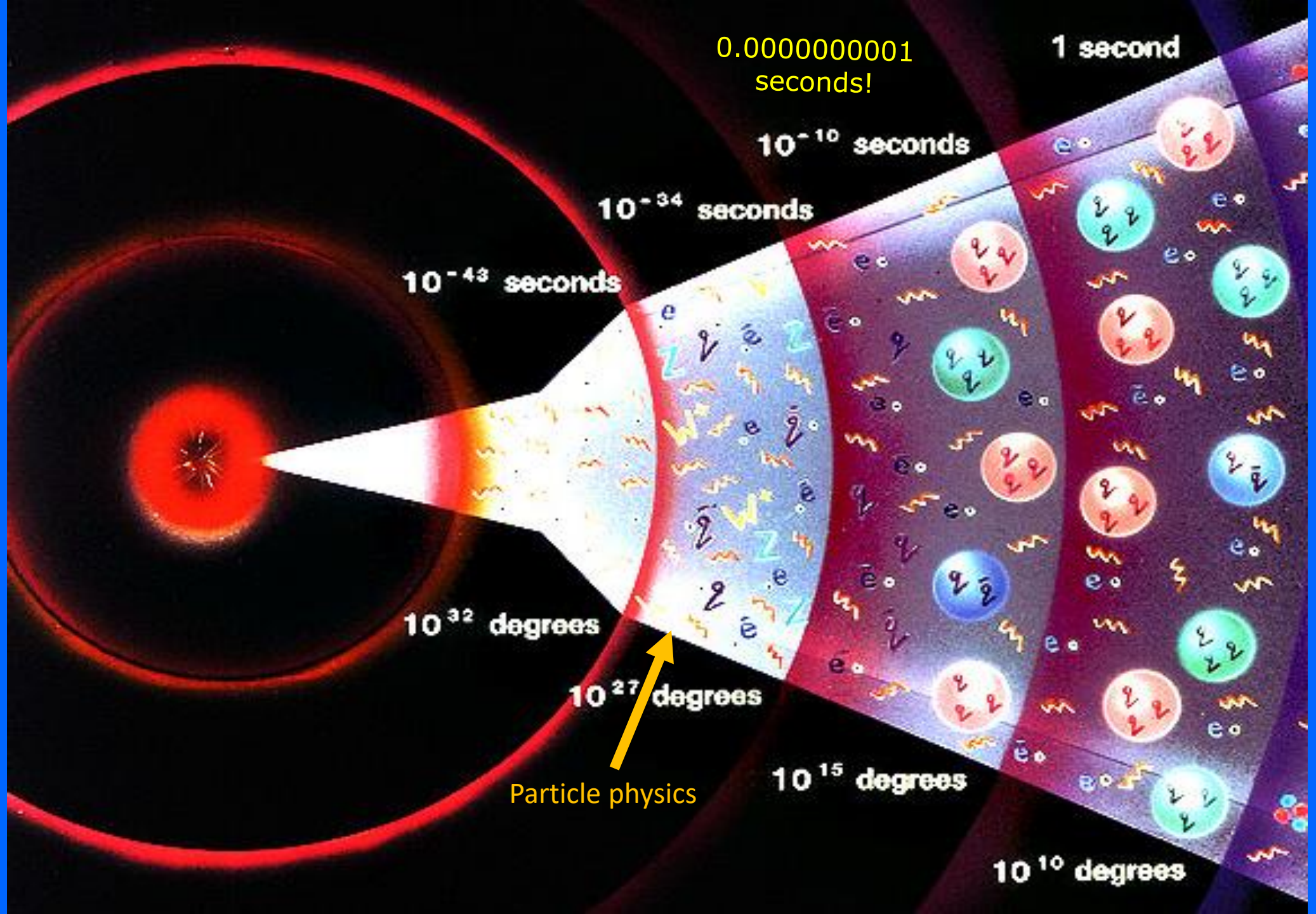


Weak force

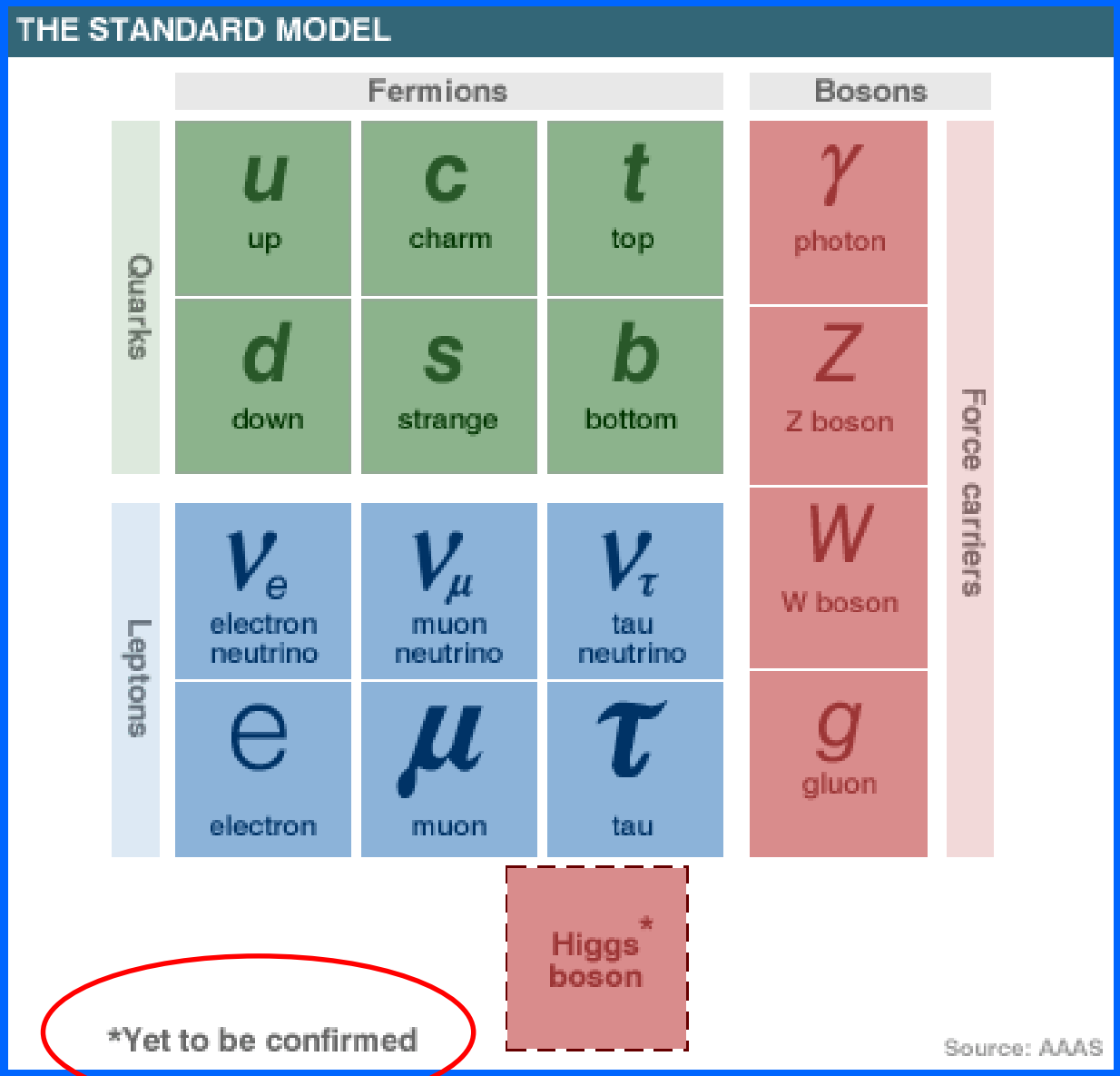


Gravity


The Big Bang
0.000000000001 second
1 second
300'000 years
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
e- electron
positron (anti-electron)
proton
neutron
meson
H hydrogen
D deuterium
He helium
Li lithium

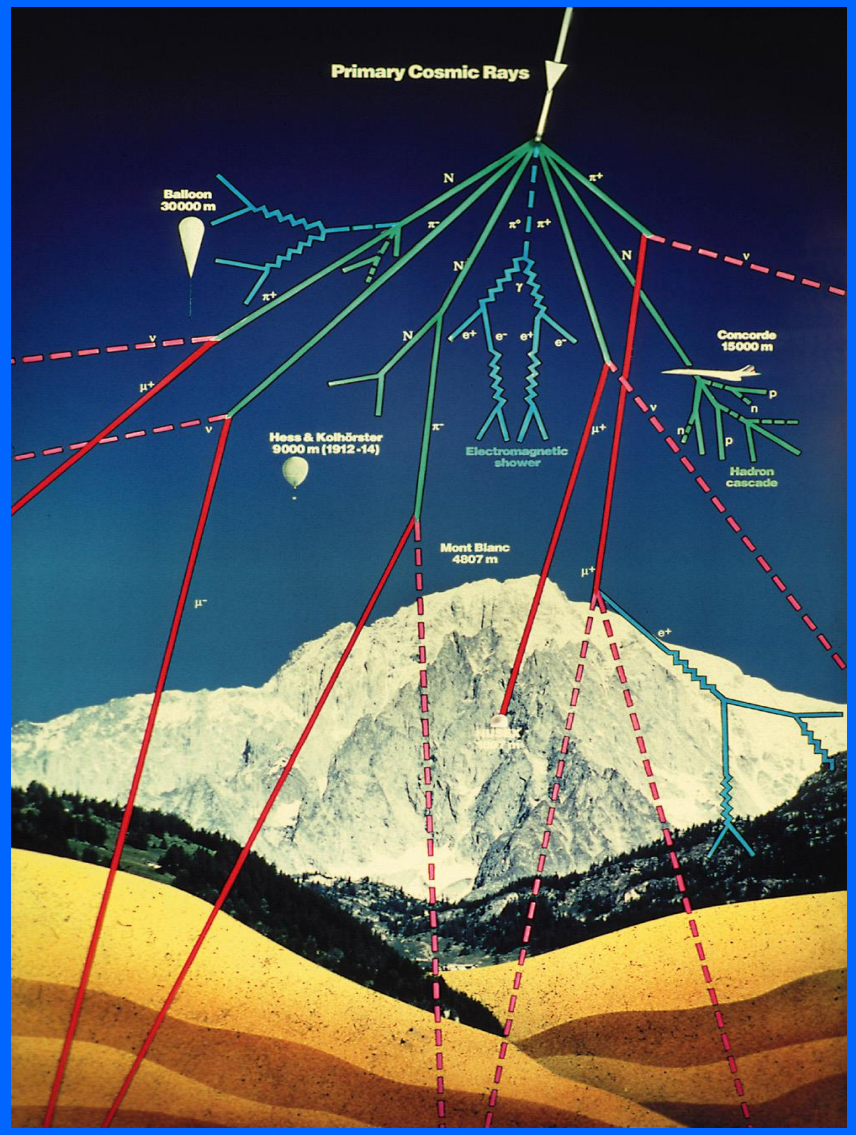

0.0000000001 seconds!
1 second
10^{-10} seconds
10^{-34} seconds
10^{-43} seconds
10^{32} degrees
10^{27} degrees
10^{15} degrees
10^{10} degrees
Particle physics

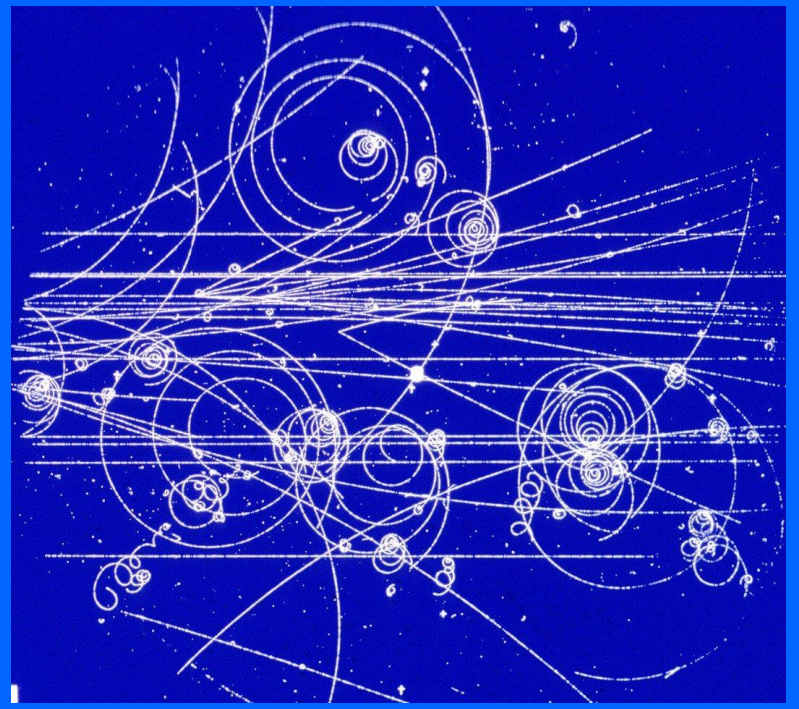
The standard model before July 4, 2012



How do we know all this?

Cosmic rays

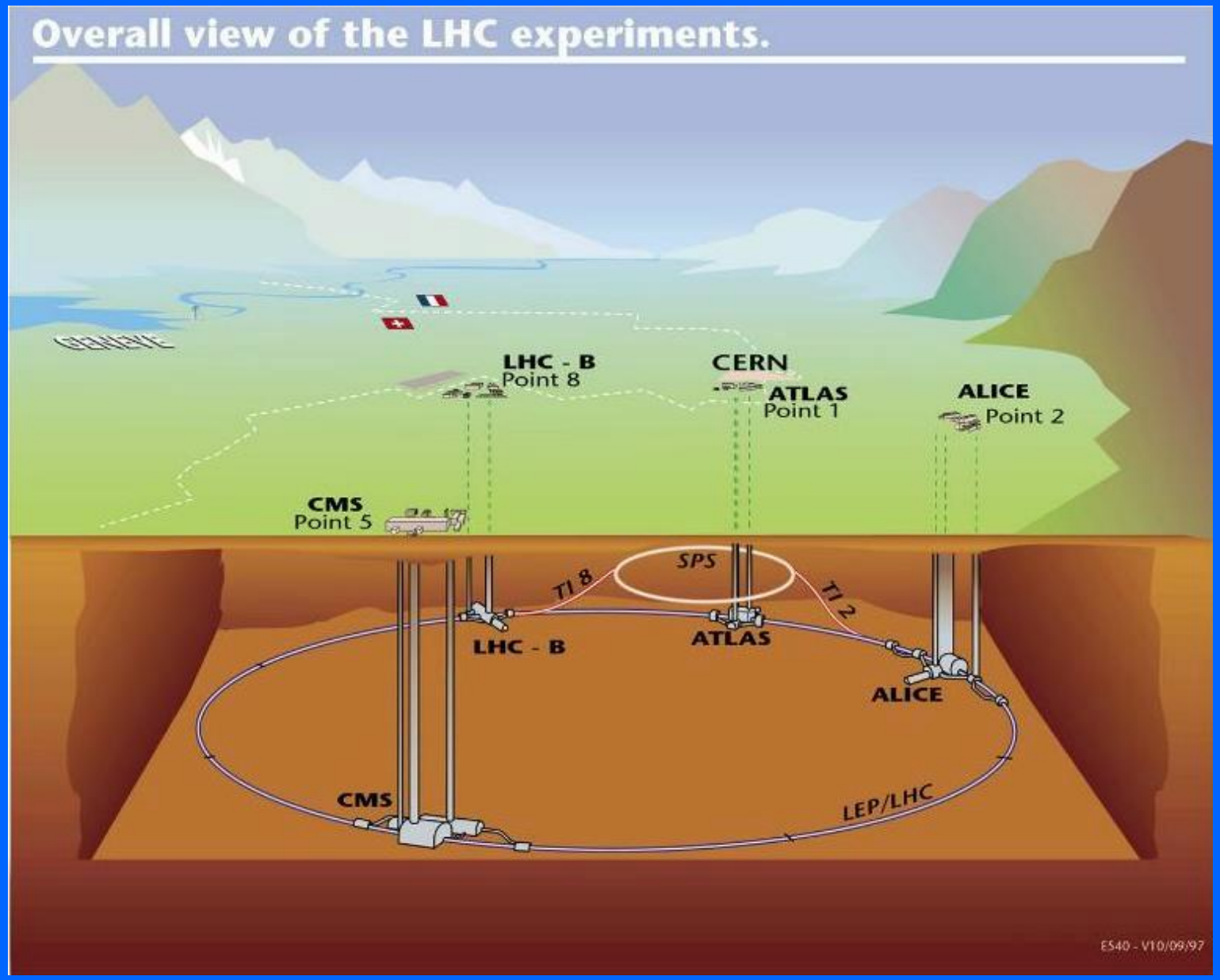




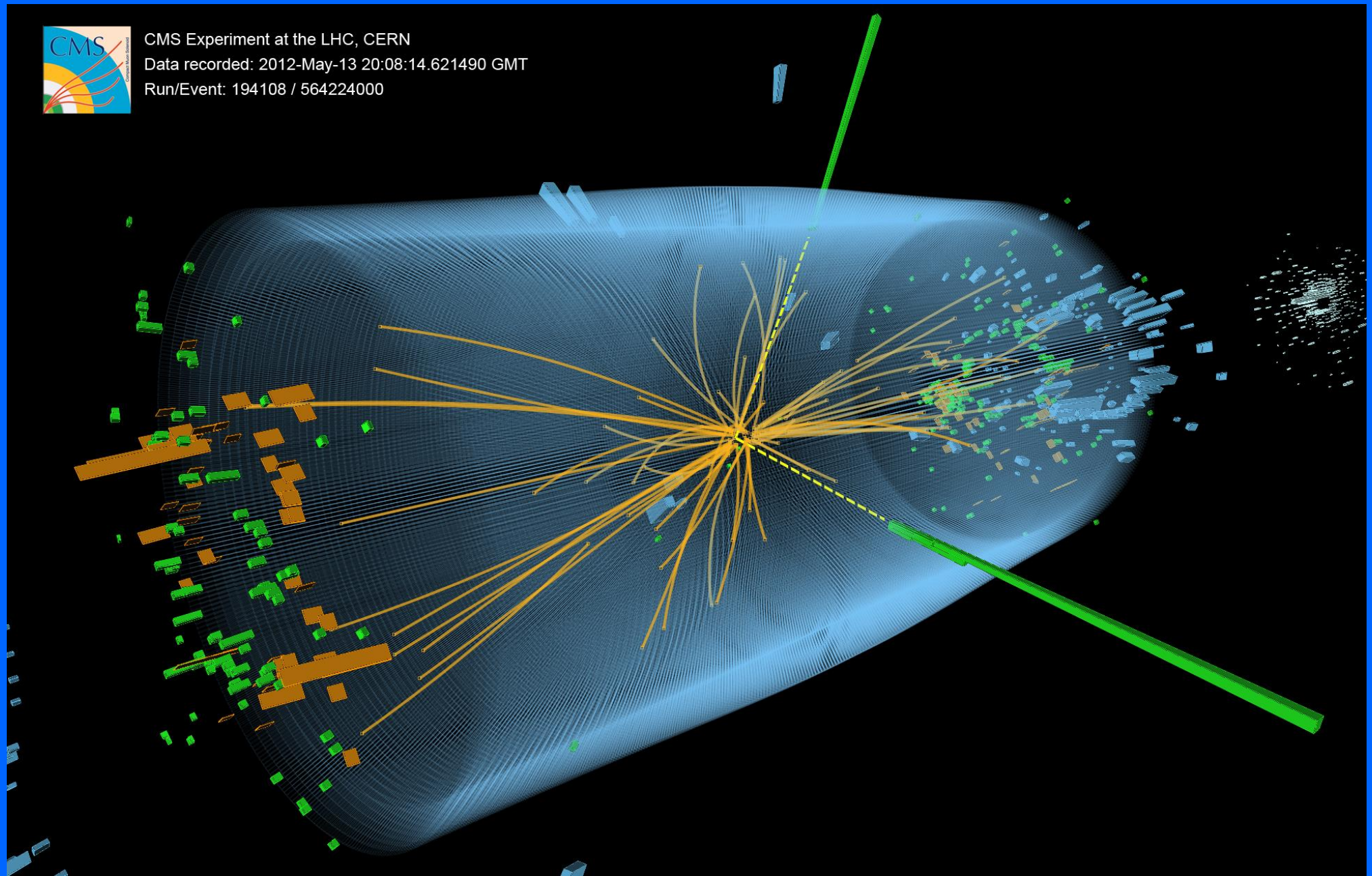
- Accelerator experiments
- Radioactivity experiments

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

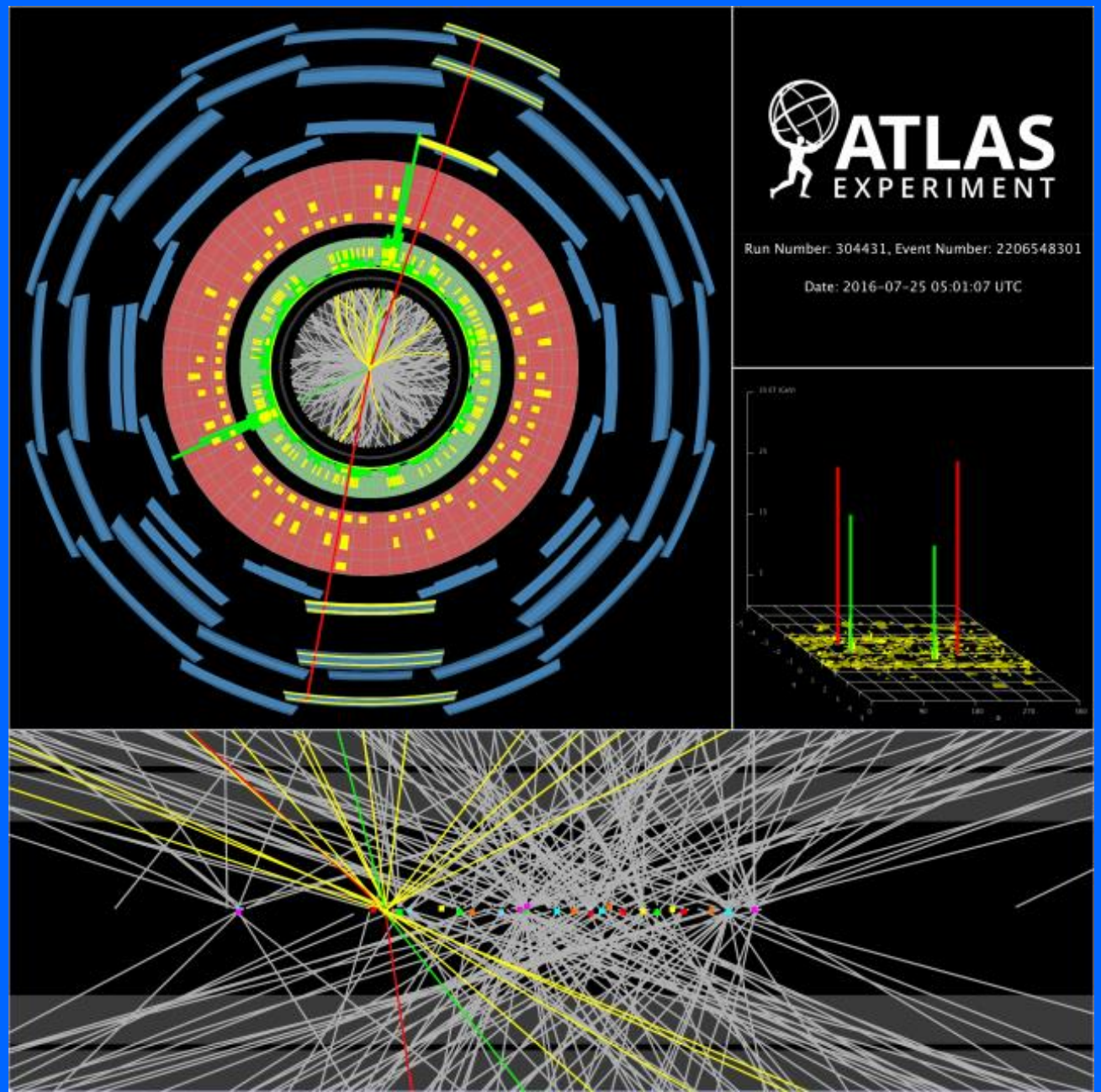
The Large Hadron Collider


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
E540 - V10/09/97

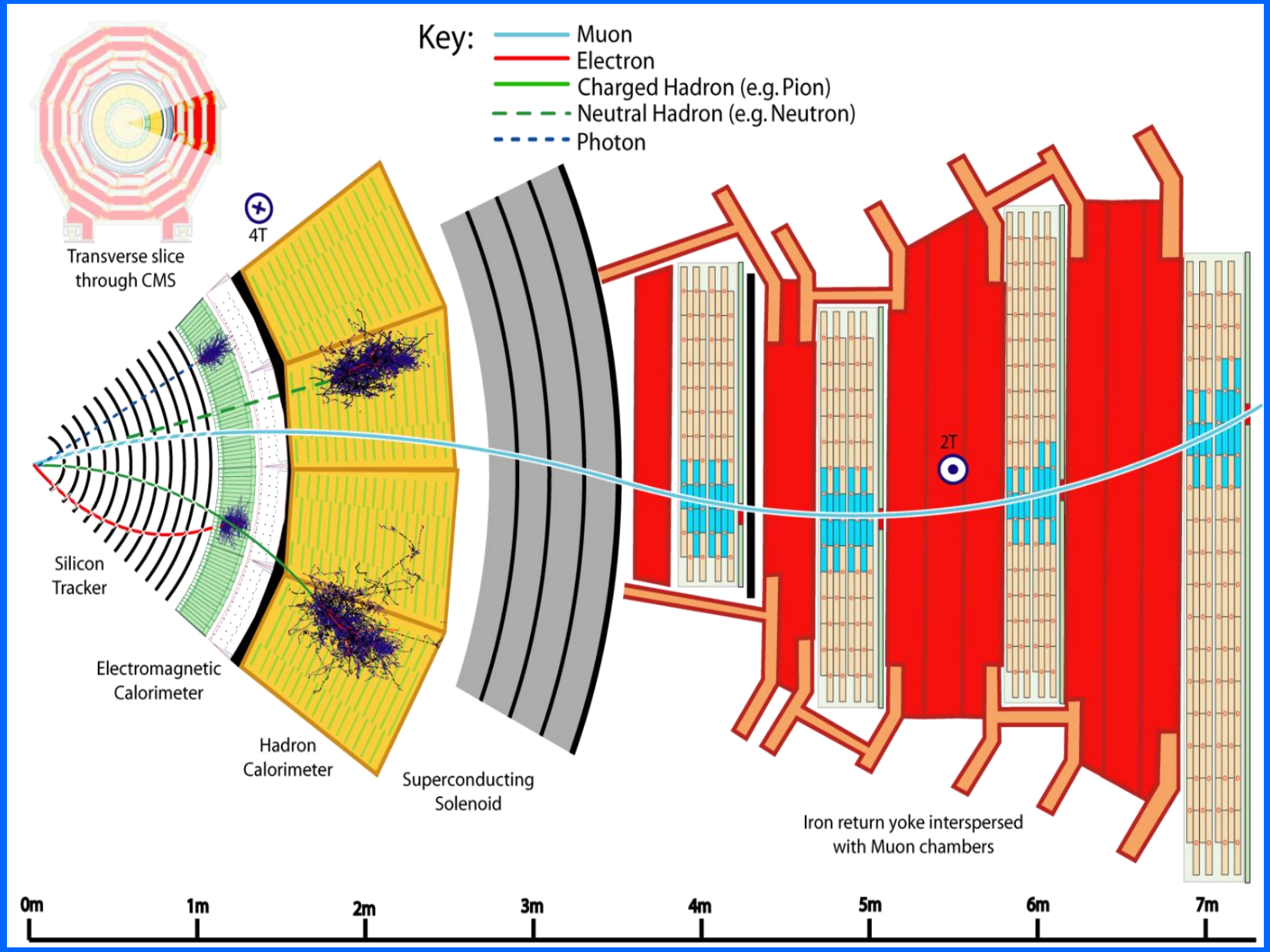
Huge experiments can investigate extremely small scales …



… by identifying what is produced in collisions!



Different detector layers help distinguish particle types



Computing challenges

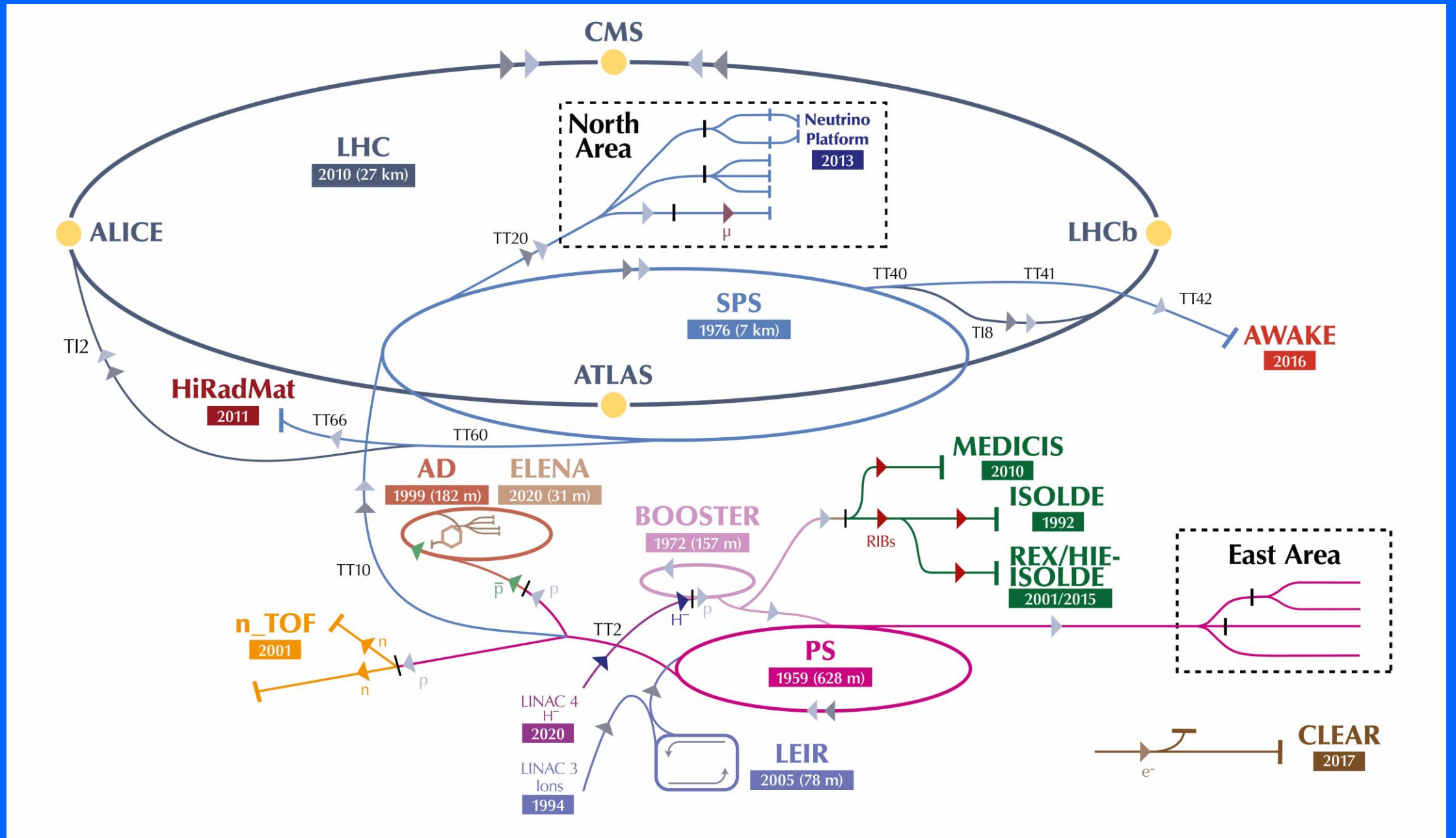
- The LHC experiments generate > 100 Petabytes per year
- To store and process such huge quantities of data, the experiments make use of a worldwide collaboration of partner universities and laboratories: the Worldwide LHC Computing Grid

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 !