

Welcome to CERN

Maarten Litmaath
CERN IT

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Based on material graciously provided by

Prof Dr Freya Blekman

DESY and University of Hamburg

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

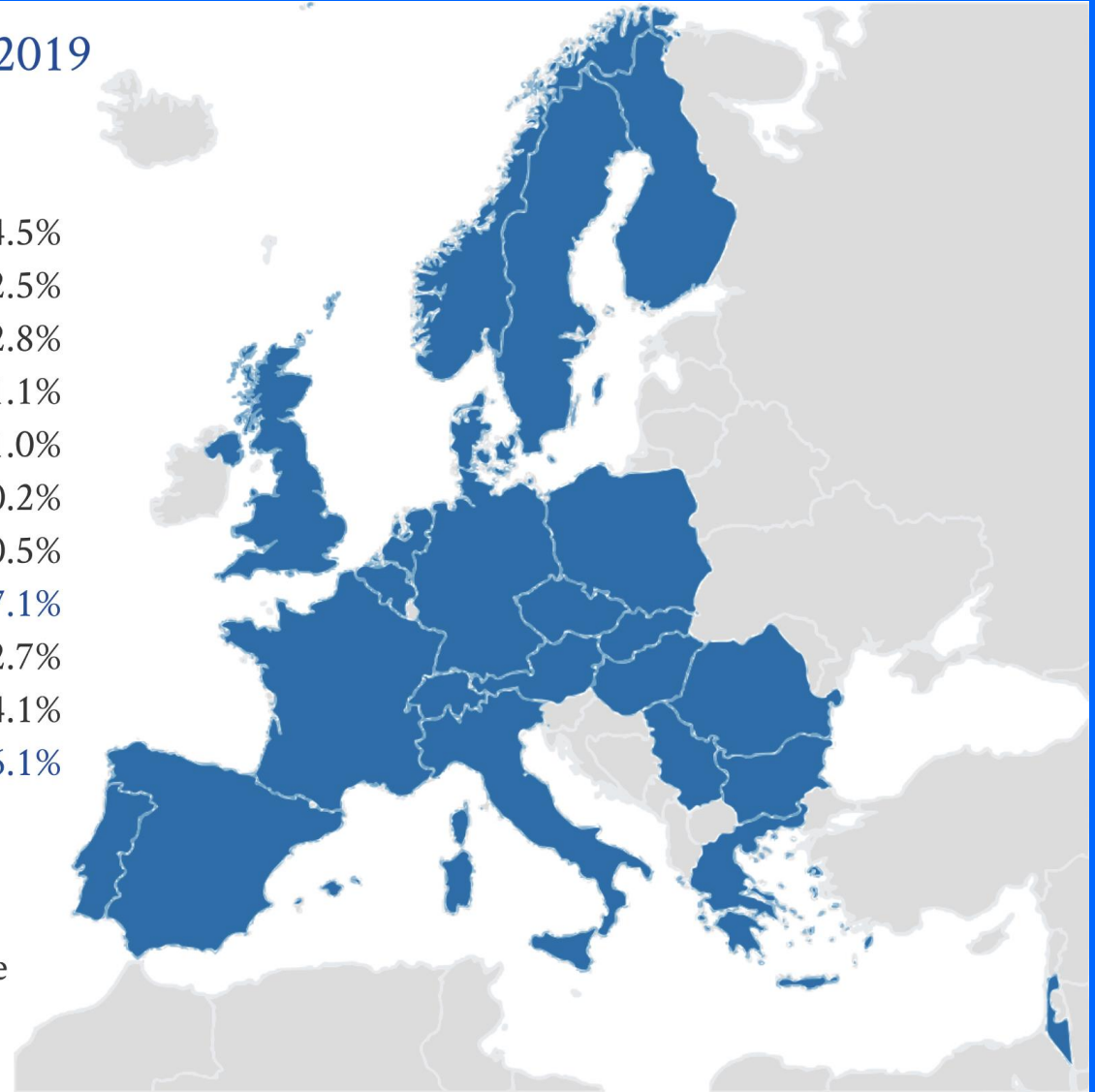
Annual budget: 1.17 billion CHF

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

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

OBSERVERS

2 506

Japan	274
Russia	1 126
USA	1 106

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

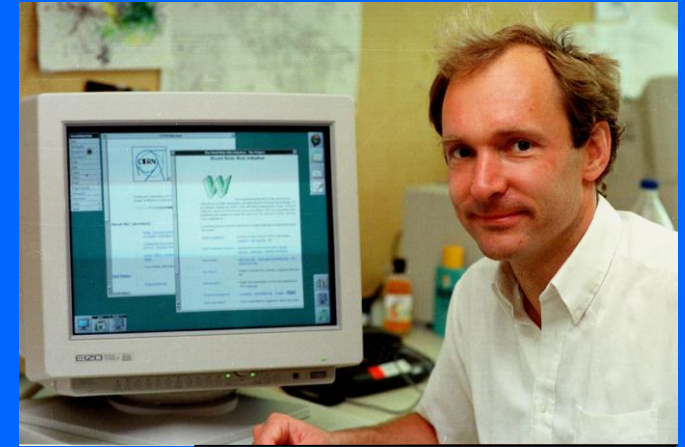
Who visits CERN

- 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?

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt									
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

At different scales...



Mainly O, C, H



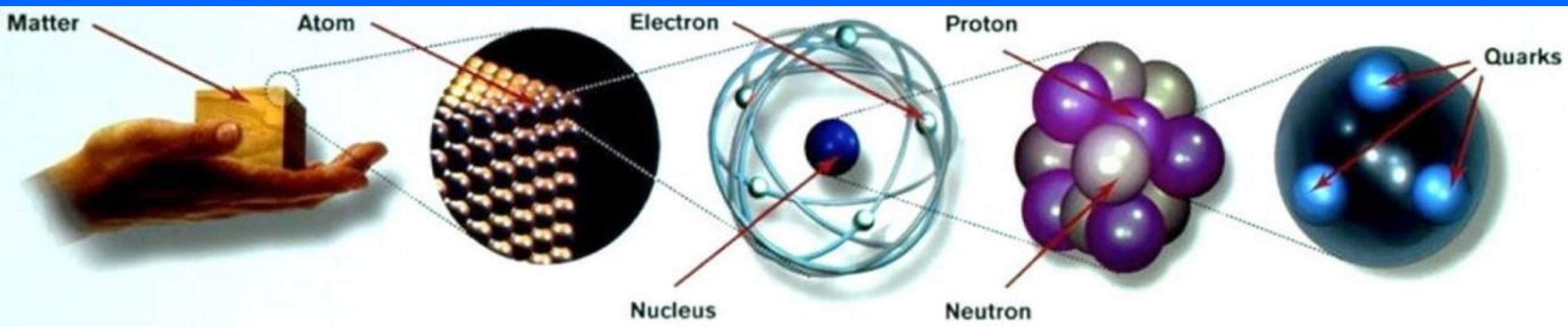
Mainly Fe, O, Si



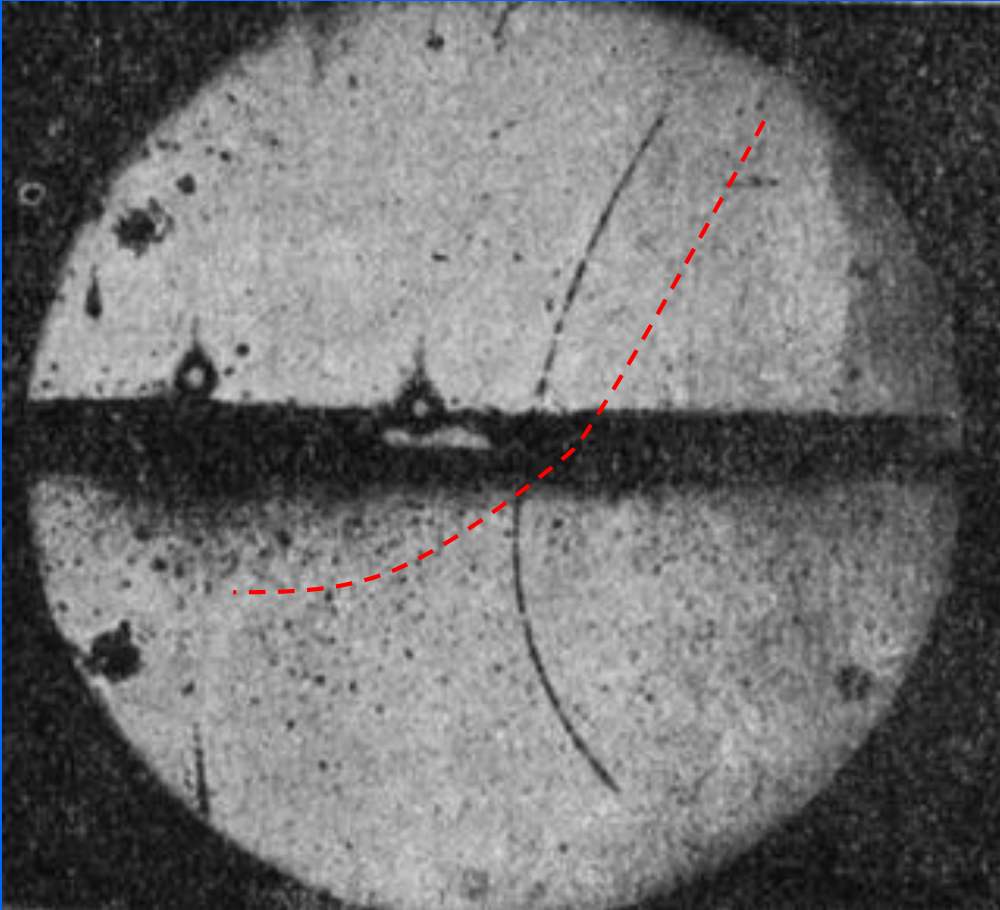
Mainly H and He

96% out there unknown!

What is everything around us made of?

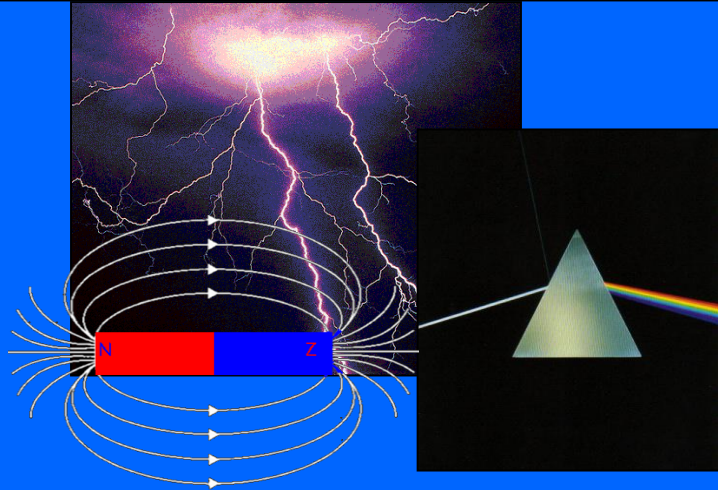


Anti-matter

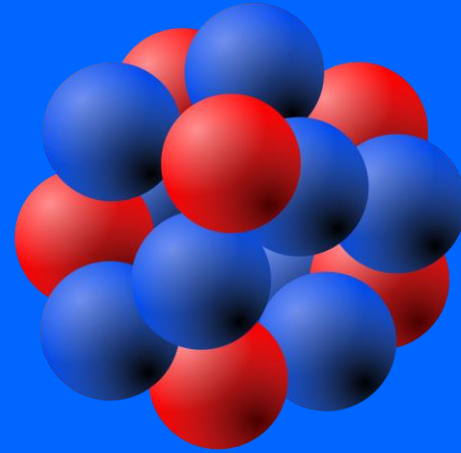


- Anti-matter: discovered in 1923
 - Predicted by theory
- *Almost* same as matter...
But oppositely charged + some subtle effects...
- Problem: at the Big Bang there would have been just as much anti-matter as matter... Where did all that anti-matter go?

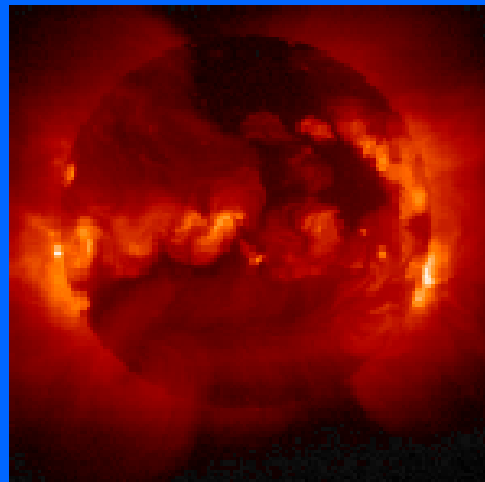
The four fundamental forces



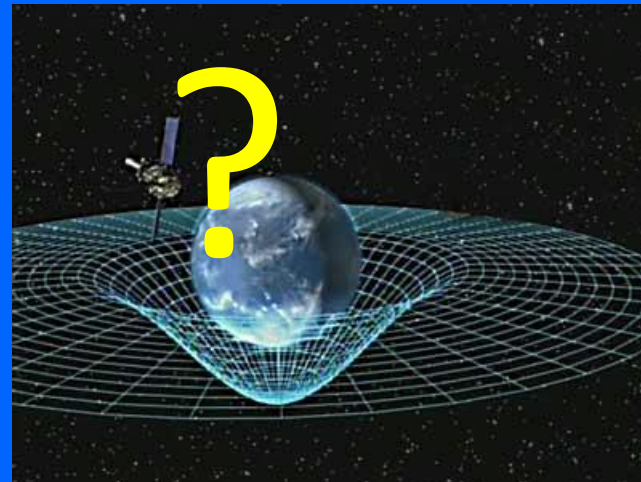
Electro-magnetic force



Strong force

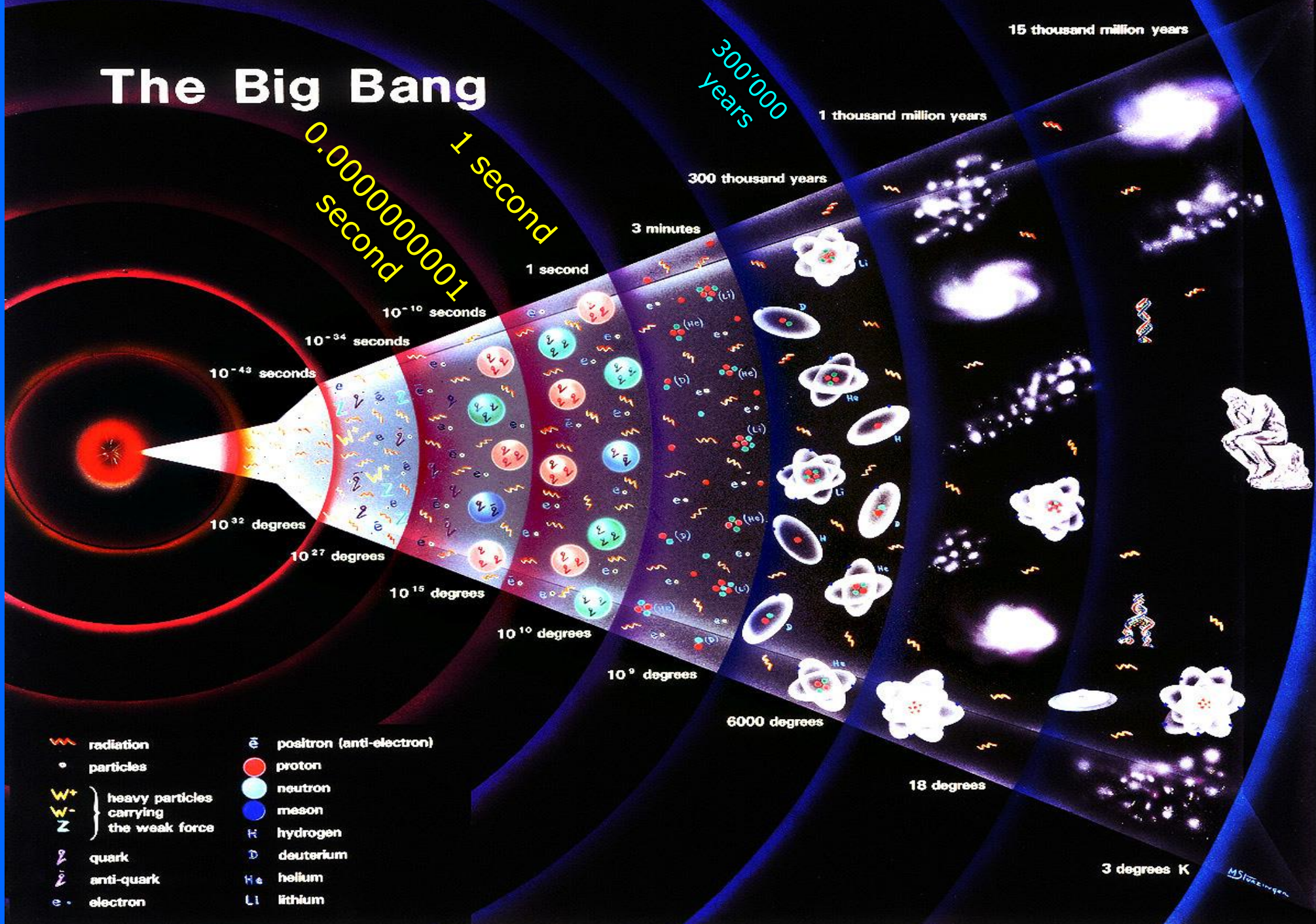


Weak force

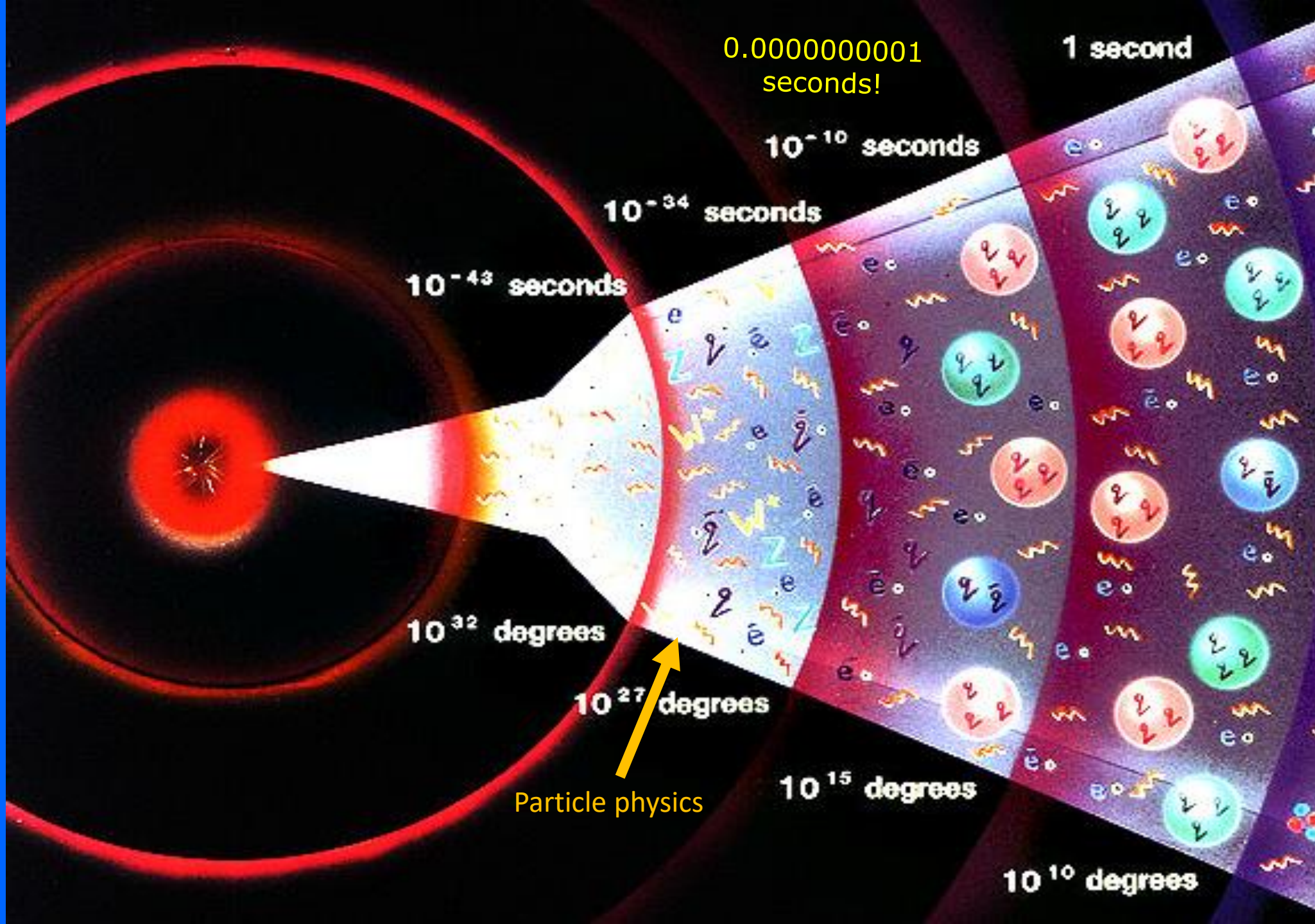


Gravity

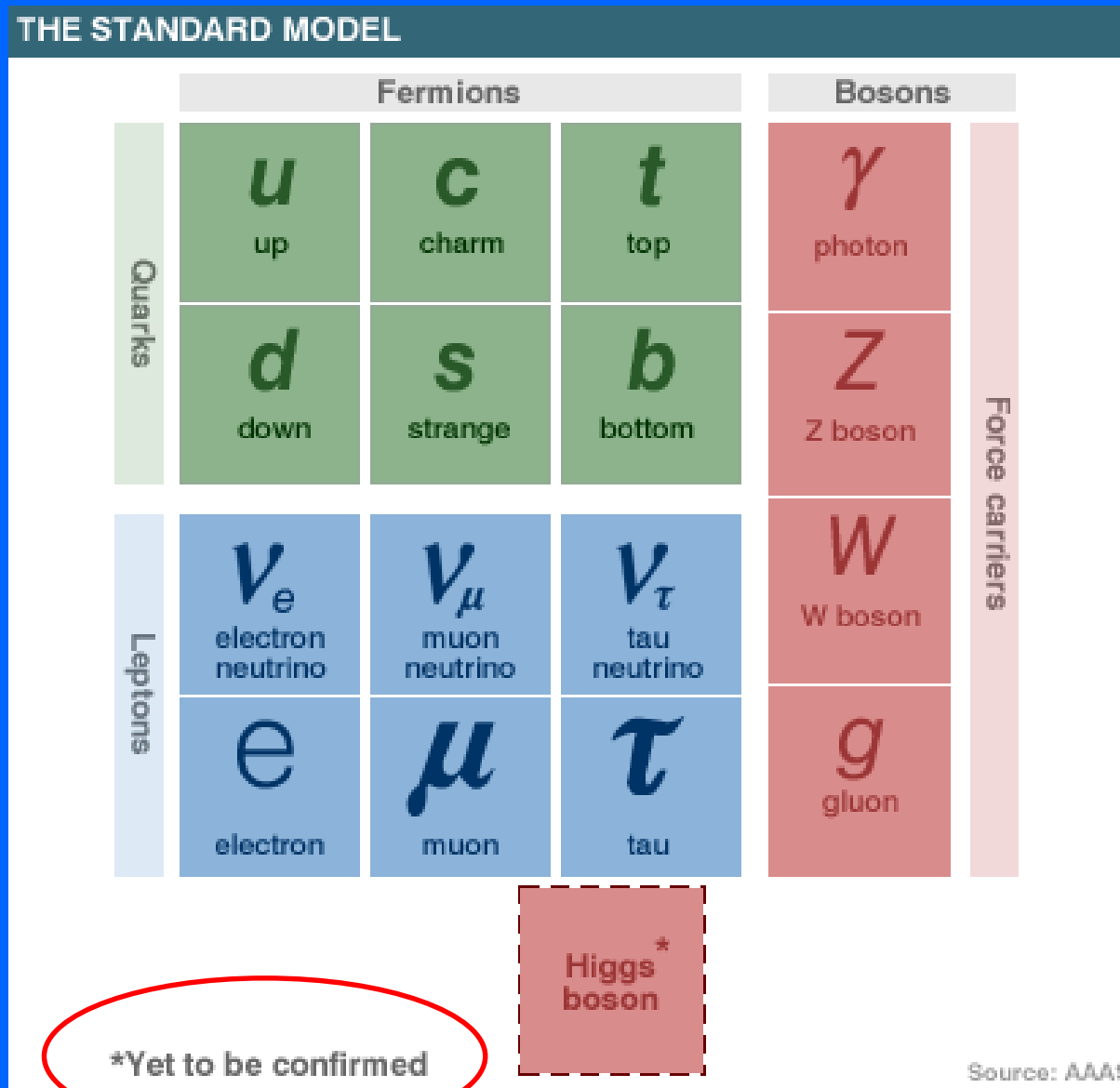
The Big Bang



- | | |
|---|--------------------------|
| radiation | positron (anti-electron) |
| particles | proton |
| heavy particles carrying the weak force | neutron |
| | meson |
| | hydrogen |
| quark | deuterium |
| anti-quark | helium |
| electron | lithium |

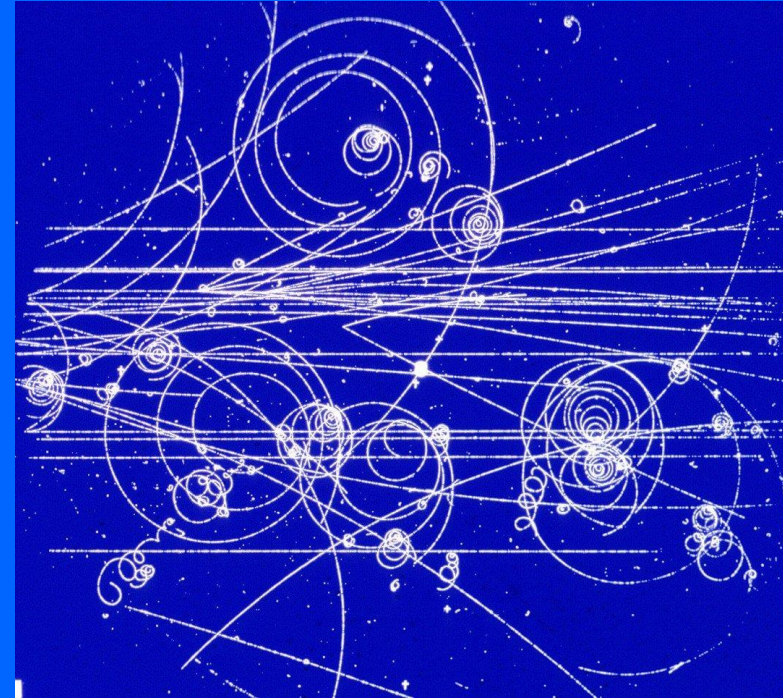
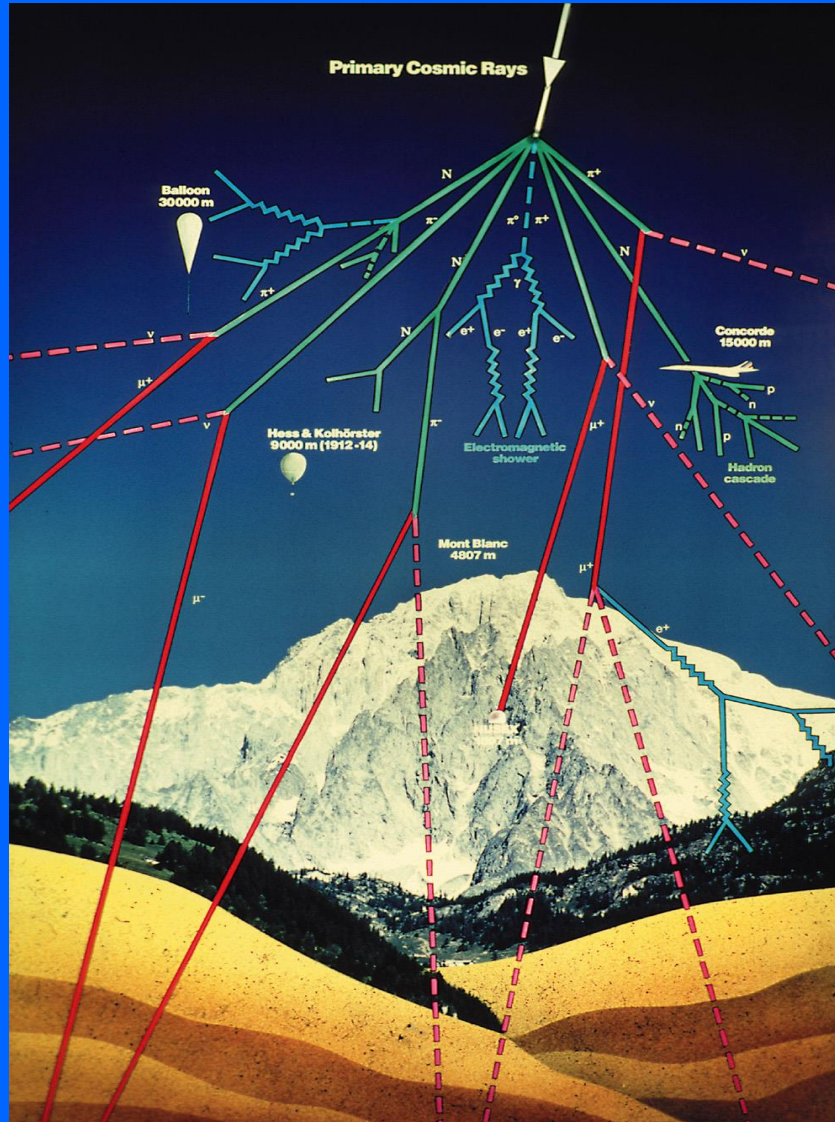


The standard model before July 4, 2012



How do we know all this?

Cosmic rays



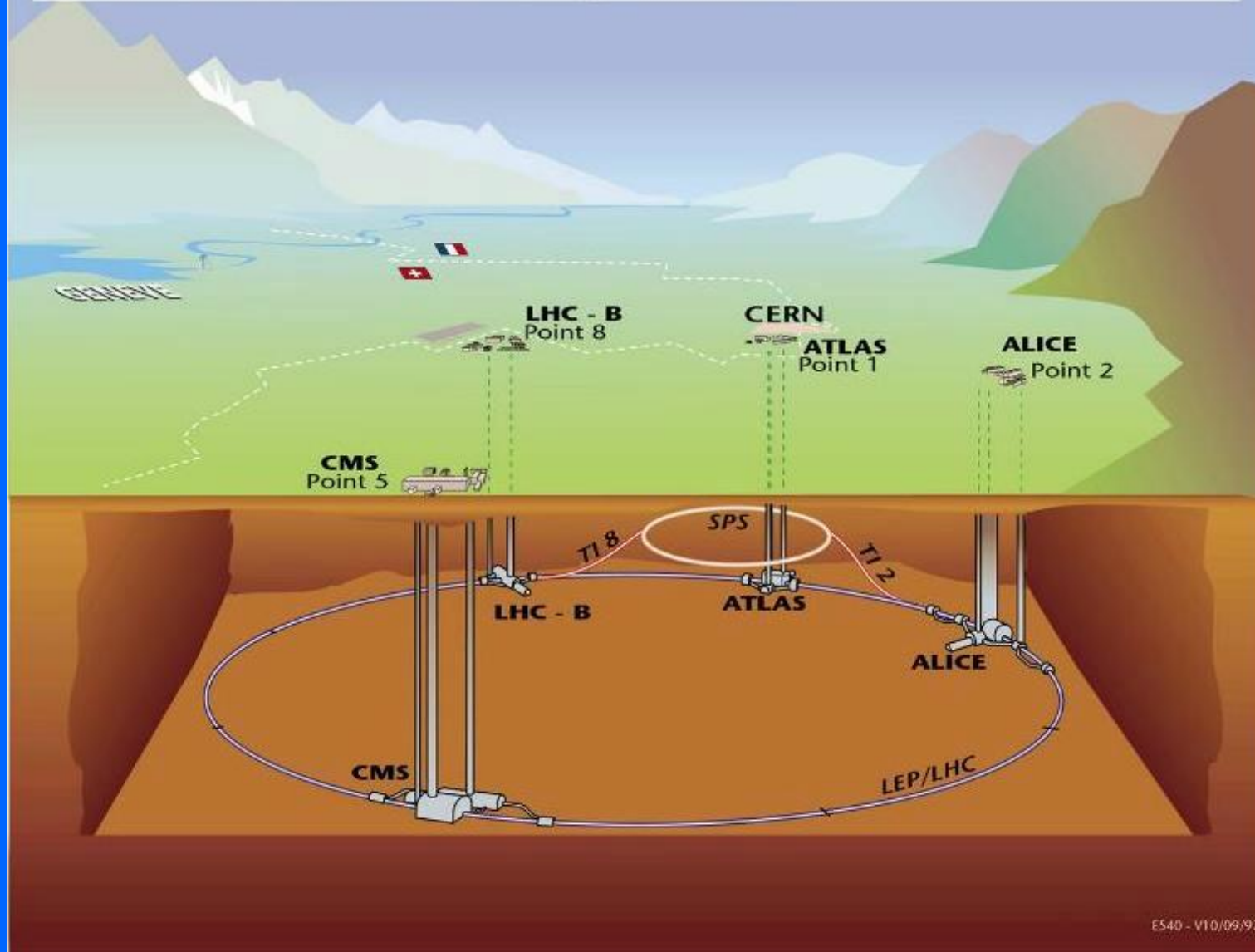
- Accelerator experiments
- Radioactivity experiments

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

The Large Hadron Collider



Overall view of the LHC experiments.



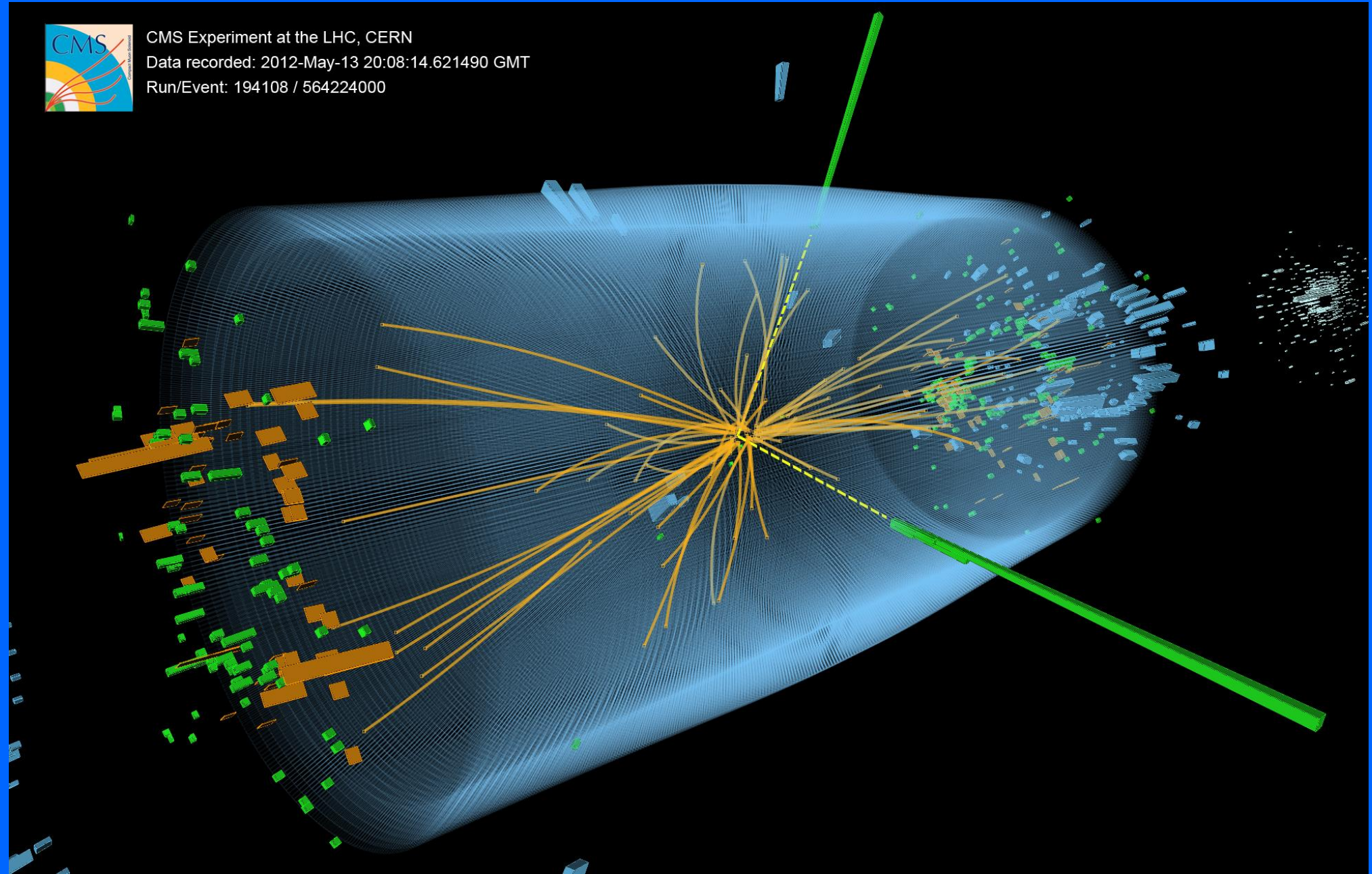
Huge experiments can investigate extremely small scales ...



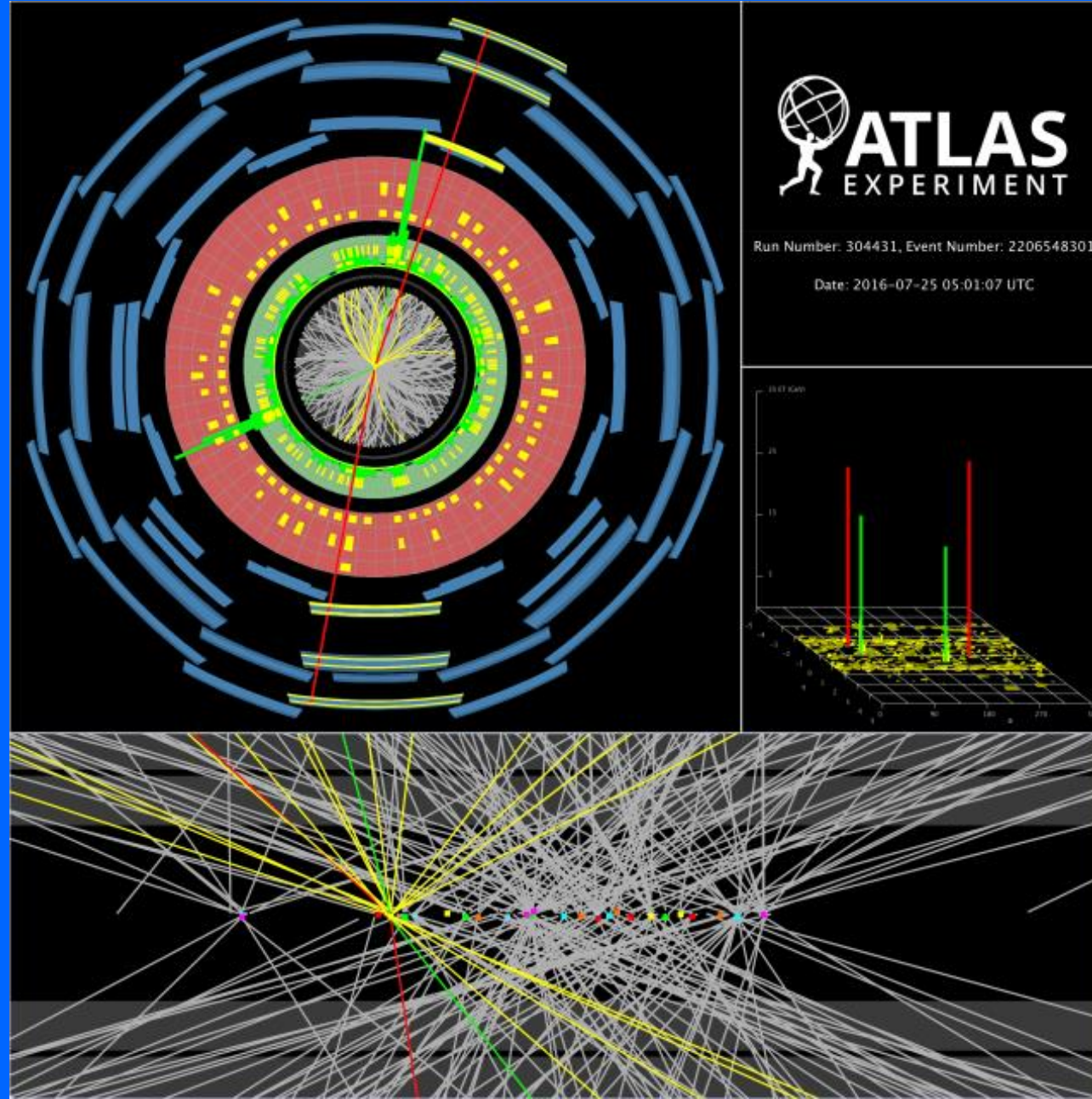
CMS Experiment at the LHC, CERN

Data recorded: 2012-May-13 20:08:14.621490 GMT

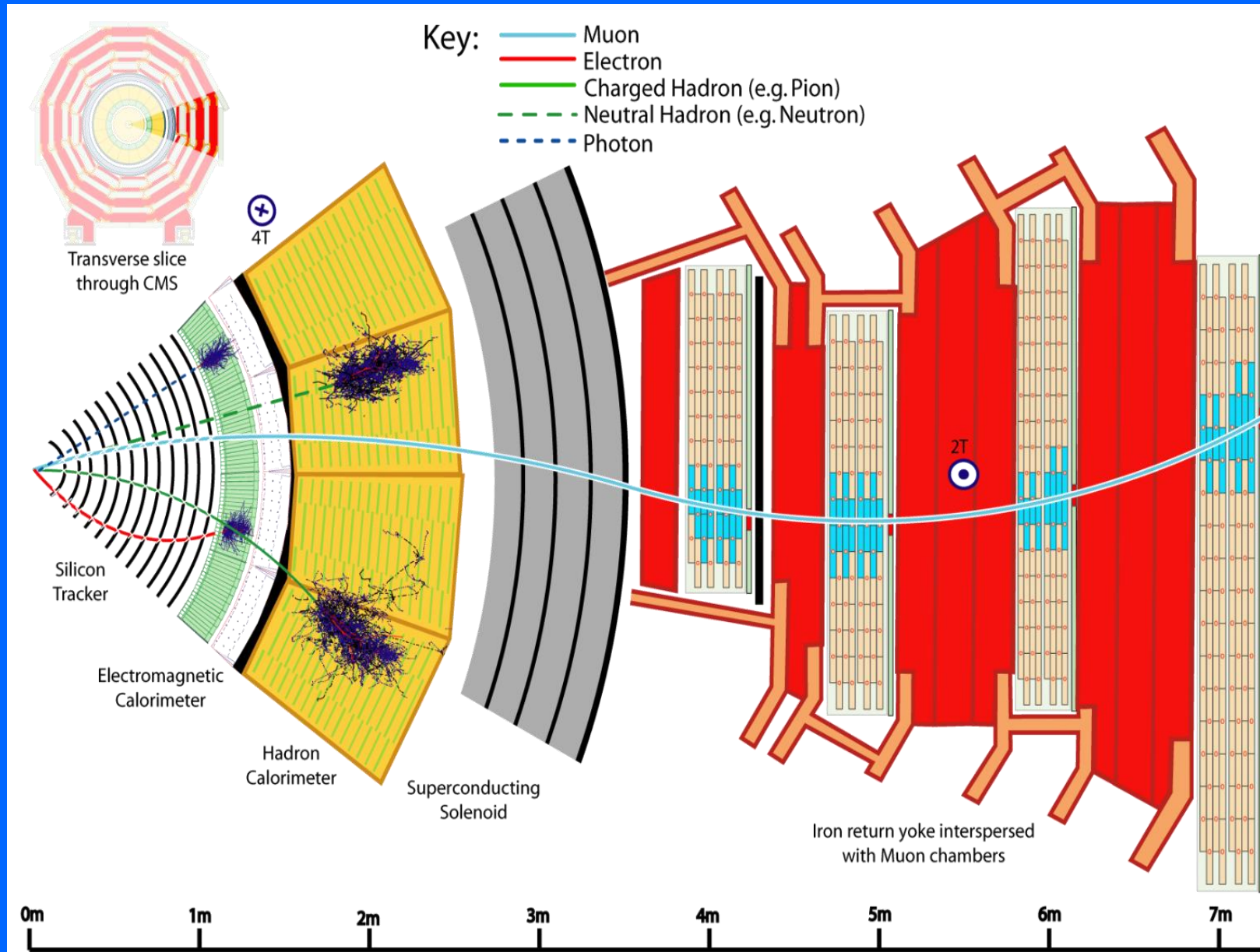
Run/Event: 194108 / 564224000



... 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**

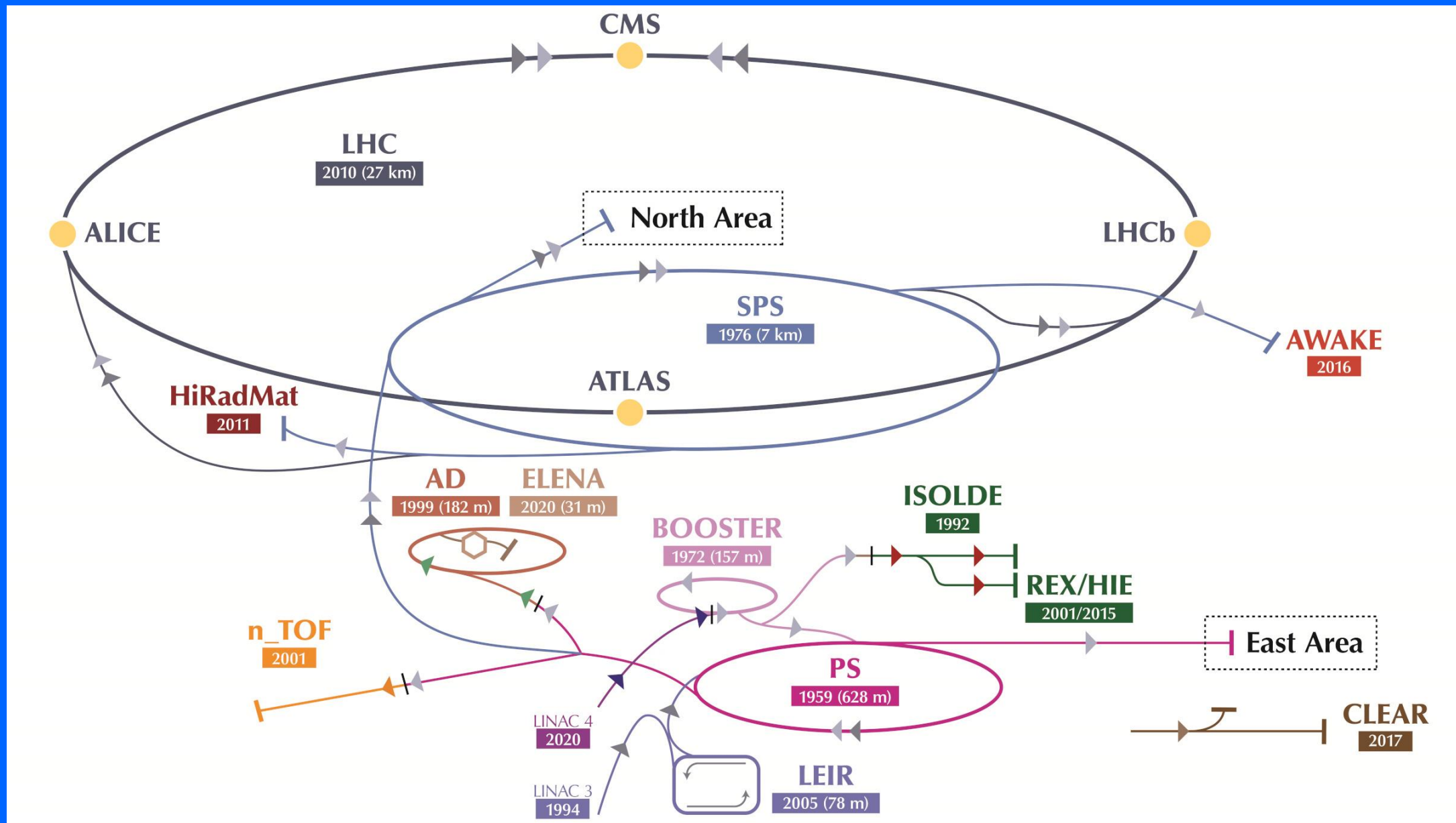


More open questions

- 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 !