Welcome to CERN

Louis Rinolfi

Thanks to R. Heuer and D. Bertola

Programme of the visit

Visit at CERN – 10th January 2014

Programme:

13:00 Lunch at CERN

14:00 General presentation of CERN – Louis Rinolfi

15:00 Microcosm and bookshop

15:20 Bus start for CMS detector (Point 5 in Cessy)

16:00 Start CMS visit (3 groups)
Guides: Cristina Biino, Lars Sonnenschein, Marco Bozzo

17:00 Bus start for CTF3 (Meyrin)

17:30 Visit CTF3 (3 groups)
Guides: Davide Gamba, Wilfrid Farabolini, Jose Navarro Quirante

18:30 Bus start for Archamps

Practical information

- Do not hesitate to ask **questions**
- You can **take pictures and shoot film** everywhere
- **Microcosm** and Globe Exhibition **« A Universe of Particles »** freely accessible from 9am till 5pm from Monday till Saturday
- **CERN Shop** from 11am till 5pm (hall)

Where we are on our planet ?

What means “CERN” ?

1954

Conseil

Européen pour la

Recherche

Nucléaire

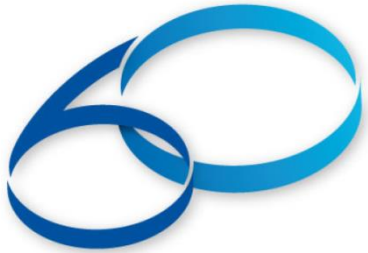
Nucléaire?

« L’Organisation s’abstient de toute activité à des fins militaires et les résultats de ses travaux expérimentaux et théoriques sont publiés ou de toute autre façon rendus généralement accessibles ».

Convention fondatrice du CERN

CERN's 60th Anniversary

2014



July 1st

- Celebration of the Anniversary of the Signature of the Convention at UNESCO in Paris

- September 29th
  - Celebration of the CERN Anniversary with highest level representatives from the MS, AMS, OBS, … at CERN

- Throughout the Year
  - Events in member states

60 years of fundamental Research at CERN

1954 → **2014**

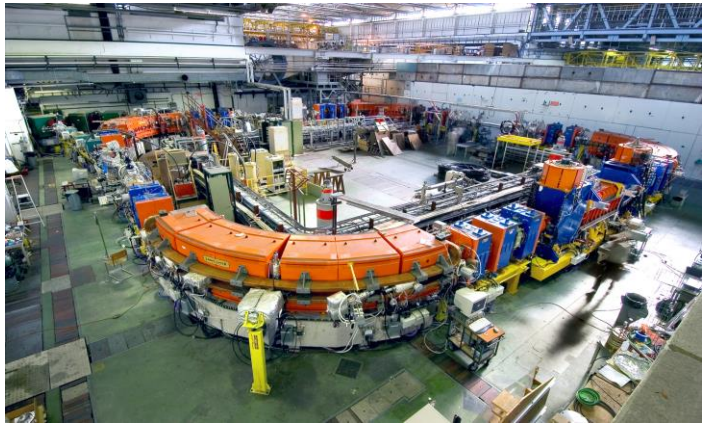
Civil engineering of PS worksite

Control room of PS complex

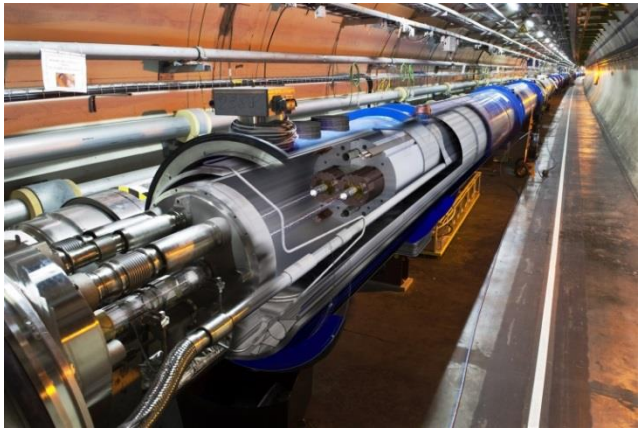
Control room of LHC complex

PS ring

LEAR ring



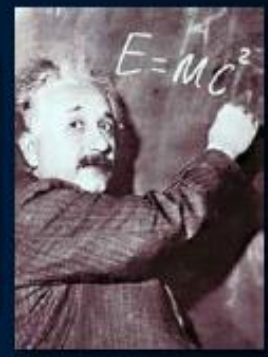
LHC ring



The Mission of CERN

- **Push back** the frontiers of knowledge

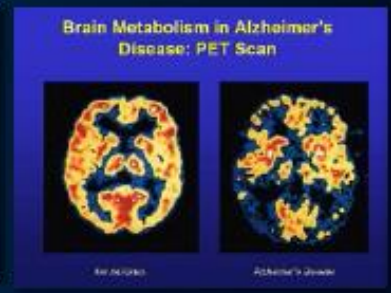
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- **Train** scientists and engineers of tomorrow

- **Unite** people from different countries and cultures

The twenty member states of CERN

until December 2013

CERN is opening the door …

- Membership for all countries independent of geographical location
- Associate Membership possible

- **Israel** welcomed to Membership by Council 12/2013

- **Romania** in accession to Membership since 2010
- **Serbia** Associate Member in the pre-Stage to Membership since 2012

- **Cyprus and Ukraine** Agreement concerning Associate Member (in the pre-Stage to Membership for Cyprus) in ratification process

- **Brazil, Russia, Slovenia, Turkey** Agreements under discussion
- **Pakistan** application received for associate membership

Some figures for personnel
(in 2012)

2 400 Staffs

1 000 Fellows and Associates

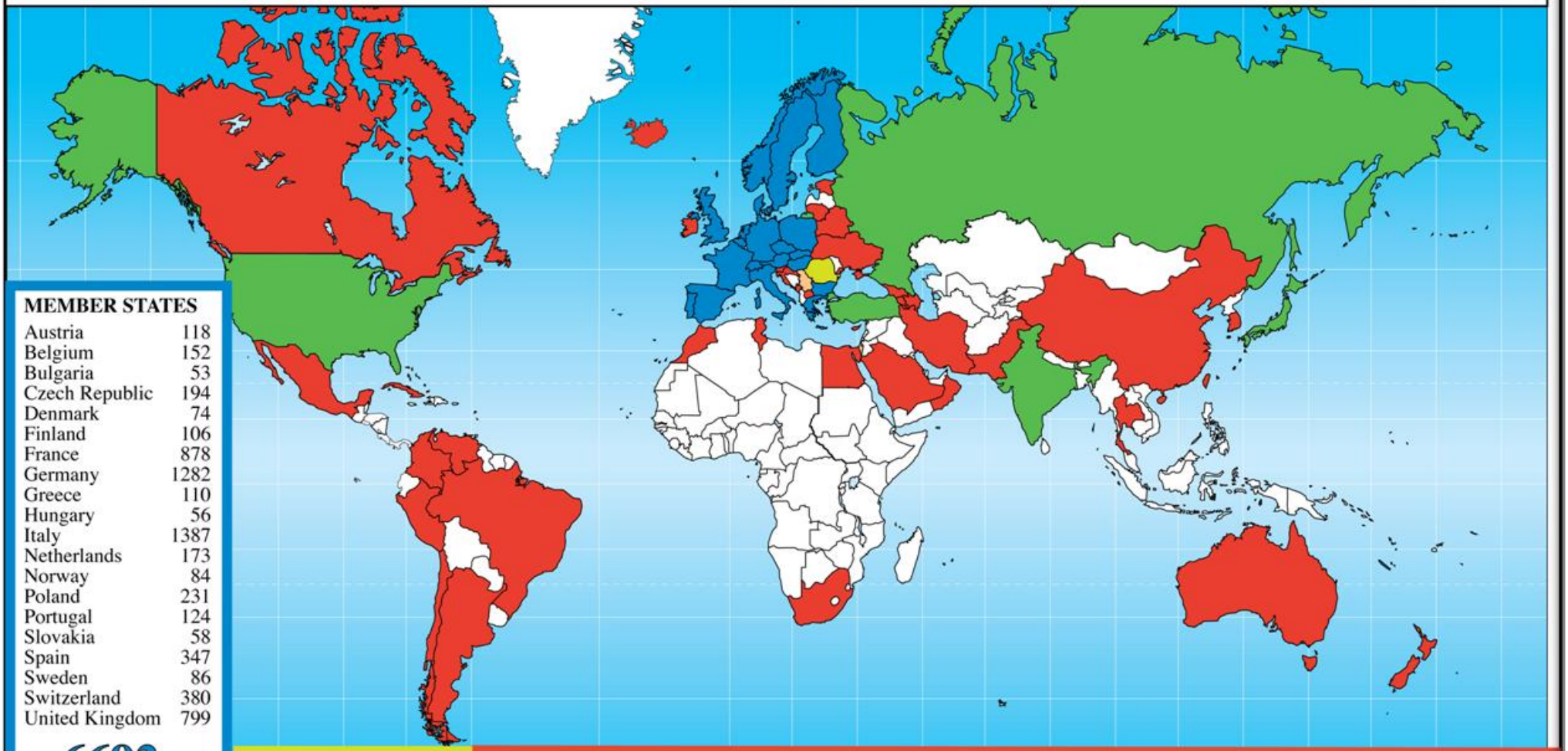
300 Students

2 000 Contracts with external companies

11 000 Users (mainly experimental physicists)

Thus >10 000 persons on the site

Distribution of All CERN Users by Nation of Institute on 3 September 2012



MEMBER STATES

Austria	118
Belgium	152
Bulgaria	53
Czech Republic	194
Denmark	74
Finland	106
France	878
Germany	1282
Greece	110
Hungary	56
Italy	1387
Netherlands	173
Norway	84
Poland	231
Portugal	124
Slovakia	58
Spain	347
Sweden	86
Switzerland	380
United Kingdom	799

6692

OBSERVERS

India	149
Japan	230
Russia	858
Turkey	95
USA	1788

3120

CANDIDATE FOR ACCESSION

Romania	89

ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP

Israel	67
Serbia	29

OTHERS

Argentina	20	Chile	6	Georgia	12	Morocco	5	T.F.Y.R.O.M.	2
Armenia	15	China	117	Iceland	1	New Zealand	9	Tunisia	1
Australia	33	China (Taipei)	70	Iran	21	Oman	1	Ukraine	21
Azerbaijan	2	Colombia	9	Ireland	9	Pakistan	20	Venezuela	1
Belarus	21	Croatia	22	Korea	96	Peru	2		
Brazil	105	Cuba	3	Lithuania	13	Saudi Arabia	3		
Canada	160	Cyprus	9	Malta	1	Slovenia	36		
		Egypt	10	Mexico	45	South Africa	25		
		Estonia	17	Montenegro	1	Thailand	5		

949

Some figures for the budget and spaces

Annual budget (2012)
1174 MCHF

~ 1 billion Euros

Superficies:

Buildings, roads and parking lots:	210 ha
Green spaces (closed):	100 ha
Spaces outside fences:	340 ha
Total	650 hectares

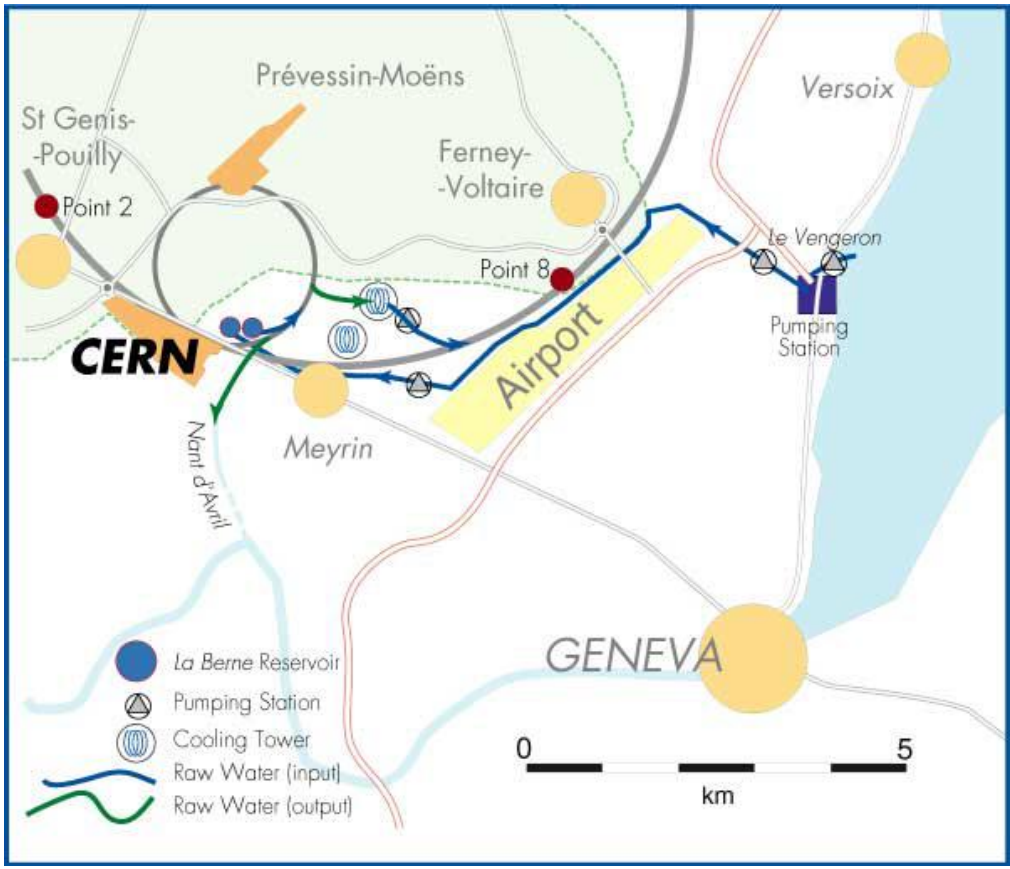
Electrical consumption in 2012

CERN	Maximum Power (MVA)	Annual consumption (GWh)
LHC	115	649
SPS (Prevessin)	75	416
PS complex (Meyrin)	42	197
Total	**195**	**1262**

Canton de Genève 3 TWh (ou 3000 GWh)

Water consumption in 2012

CERN	Annual consumption (m^3)
LHC	2 000 000
Remaining accelerators	3 000 000
Total	**5 000 000**



A small exercise !

Infinite large

meters, grams, seconds, amperes, volts, bytes, …..

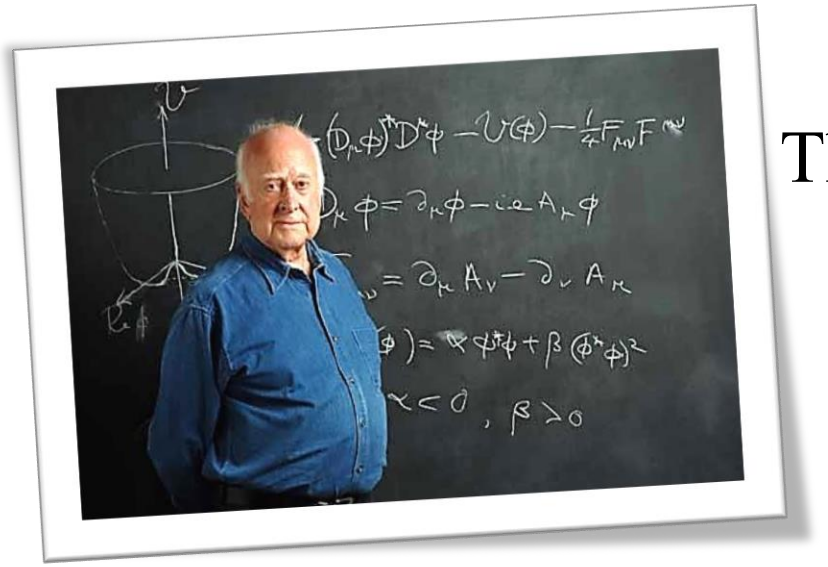
10^0	10^3	10^6	10^9	10^{12}	10^{15}	10^{18}	10^{21}	10^{24}
1	Kilo	Mega	Giga	Tera	Peta	Exa	Zetta	Yotta

Infinite small

meters, grams, seconds, amperes, Coulomb, …..

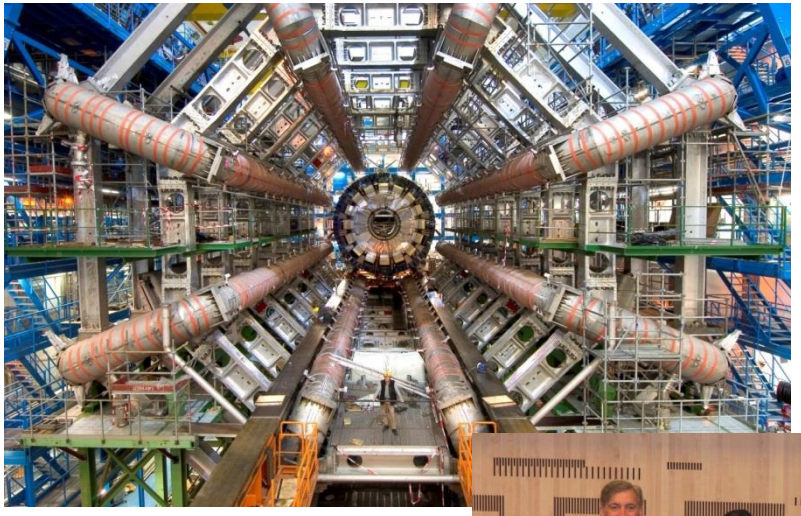
10^0	10^{-3}	10^{-6}	10^{-9}	10^{-12}	10^{-15}	10^{-18}	10^{-21}	10^{-24}
1	milli	micro	nano	pico	femto	atto	zepto	yocto

Three types of physicists at CERN



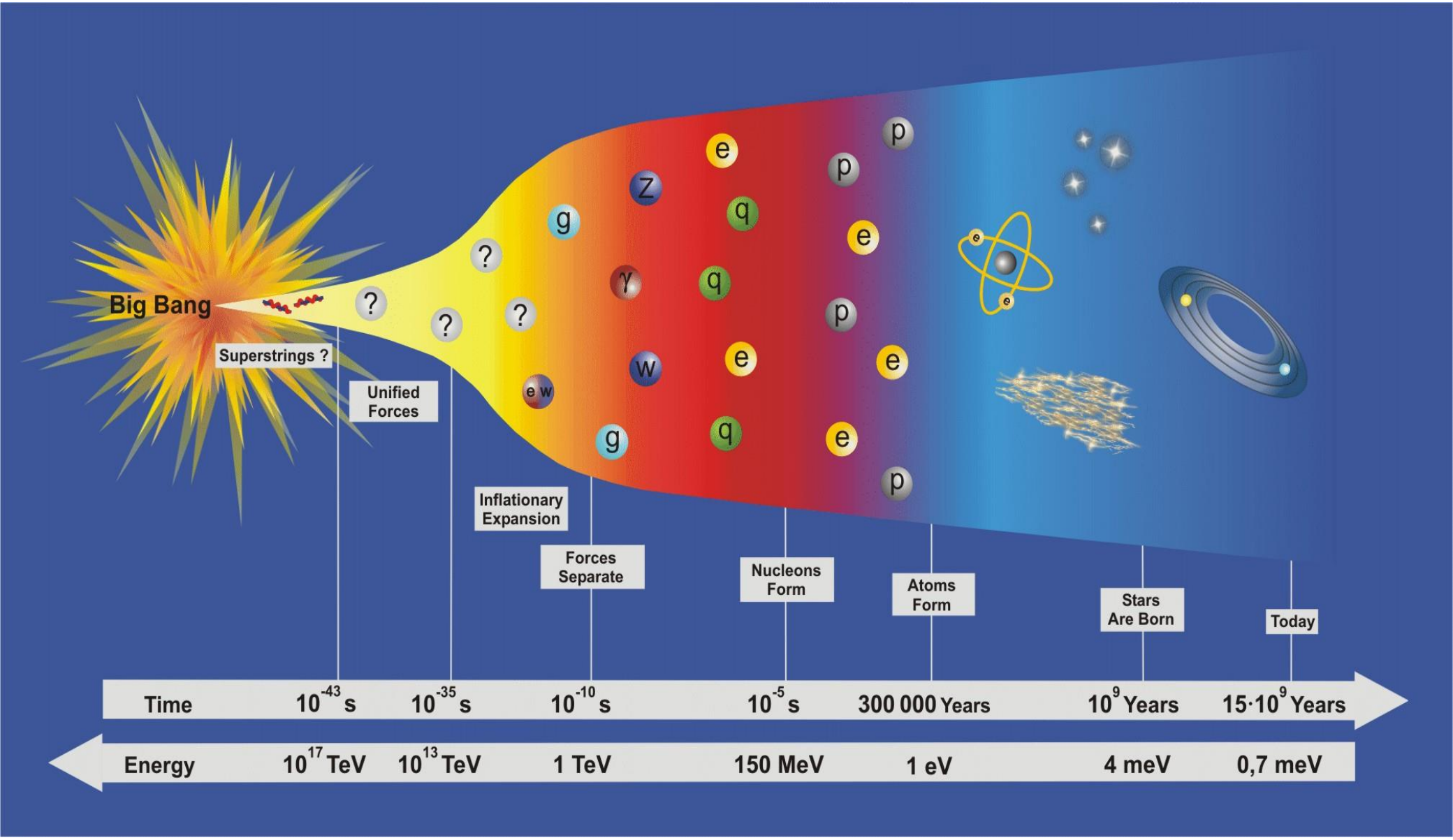
Theory

Experiments

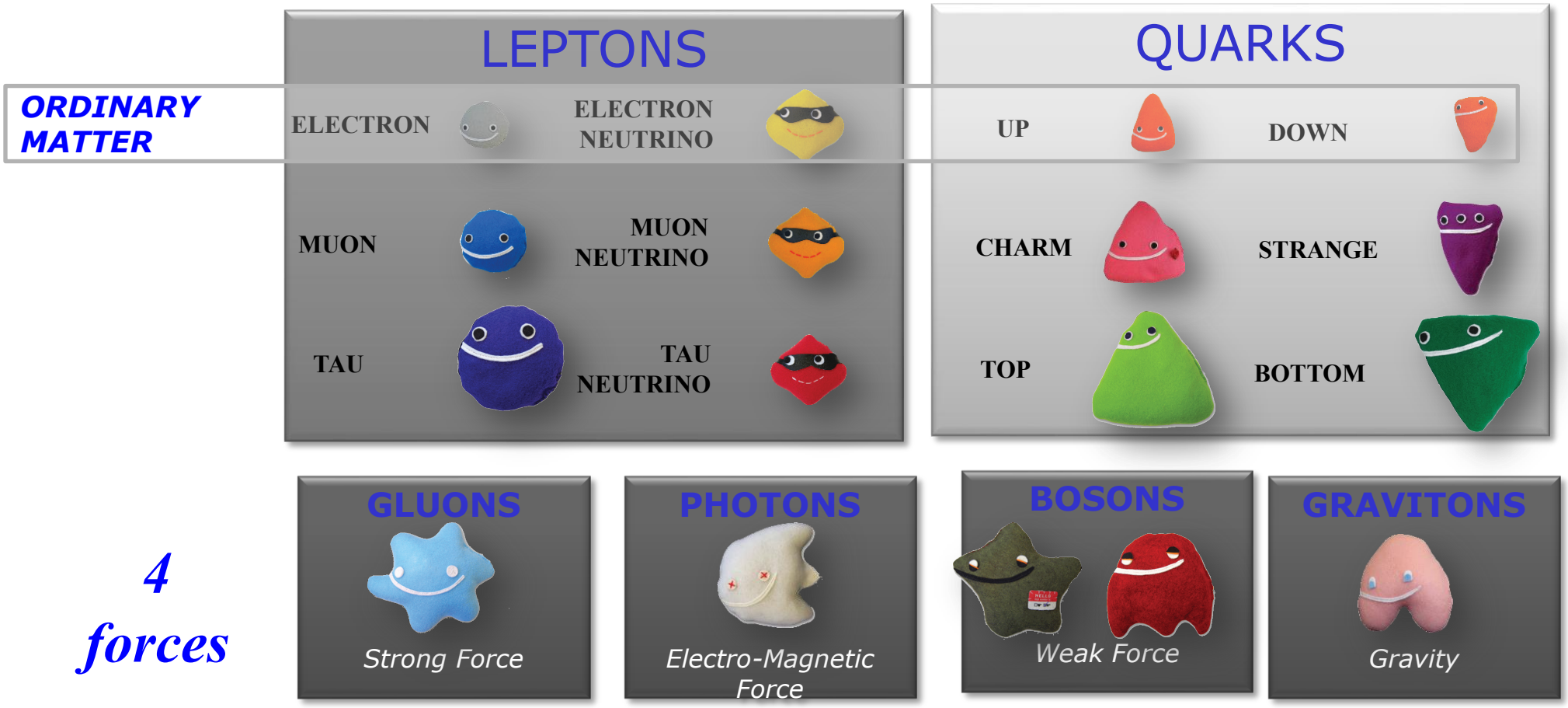


Machines

Schematic evolution of the Universe

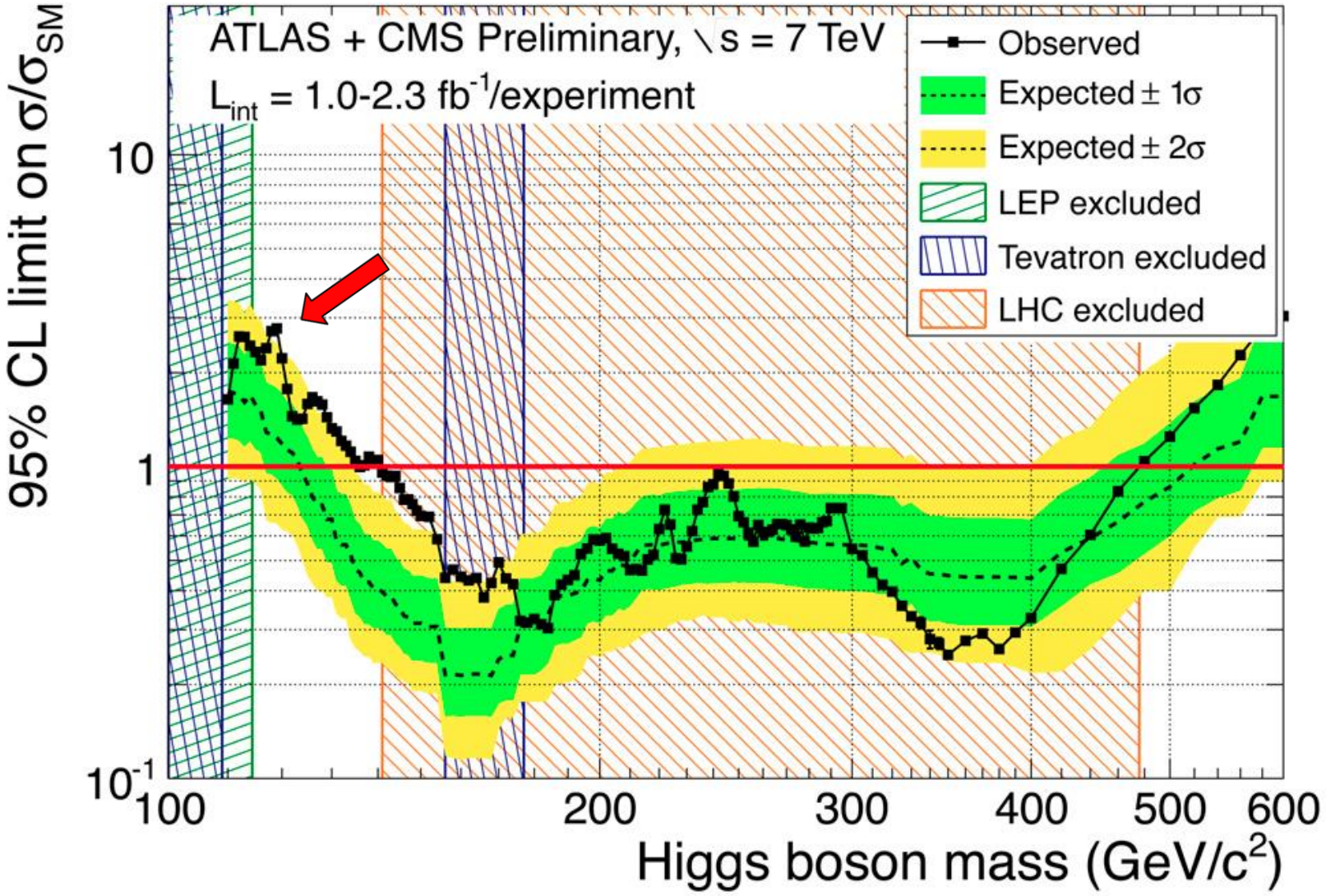


Particles in the Standard Model



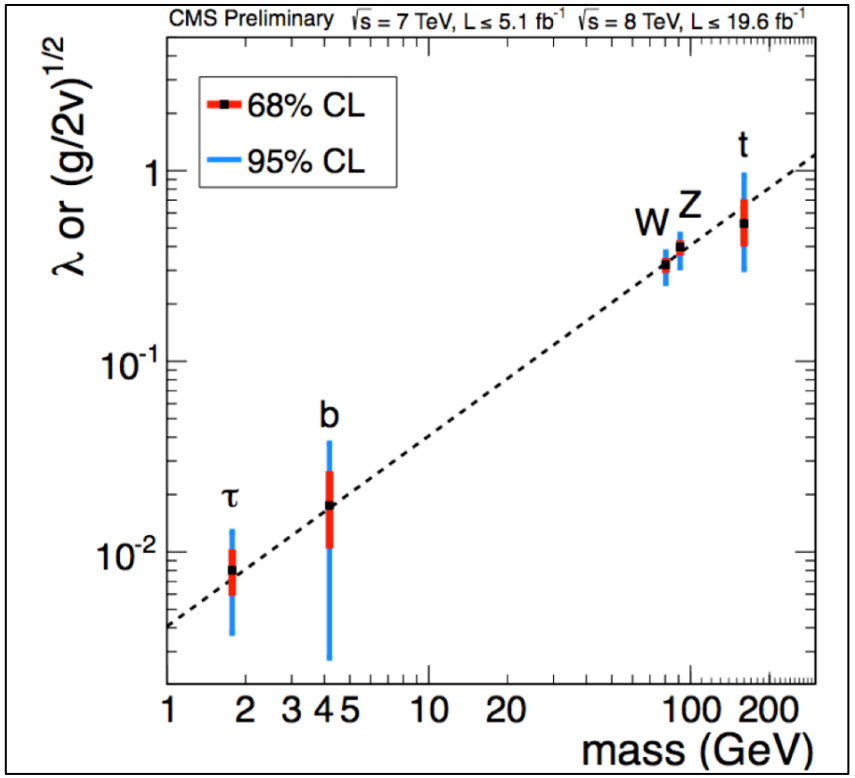
Images: www.particlezoo.net

Preliminary results at the end of 2011



The new particle is a Higgs boson

1) To accomplish its job (providing mass)
it interacts with other particles (in particular W, Z)
with strength proportional to their masses



It completes the Standard Model
=> describing 5% of the Universe !

The detailed study of the properties of this Higgs boson could give information on:
- Dark matter… ?
- Dark energy… ?

2) It has spin 0, it is representing a scalar field

Four main results from LHC

1) We have **consolidated** the Standard Model
   (wealth of measurements at 7-8 TeV, including the rare $B_s \rightarrow \mu\mu$ decay, very sensitive to New Physics)
   → it works BEAUTIFULLY …

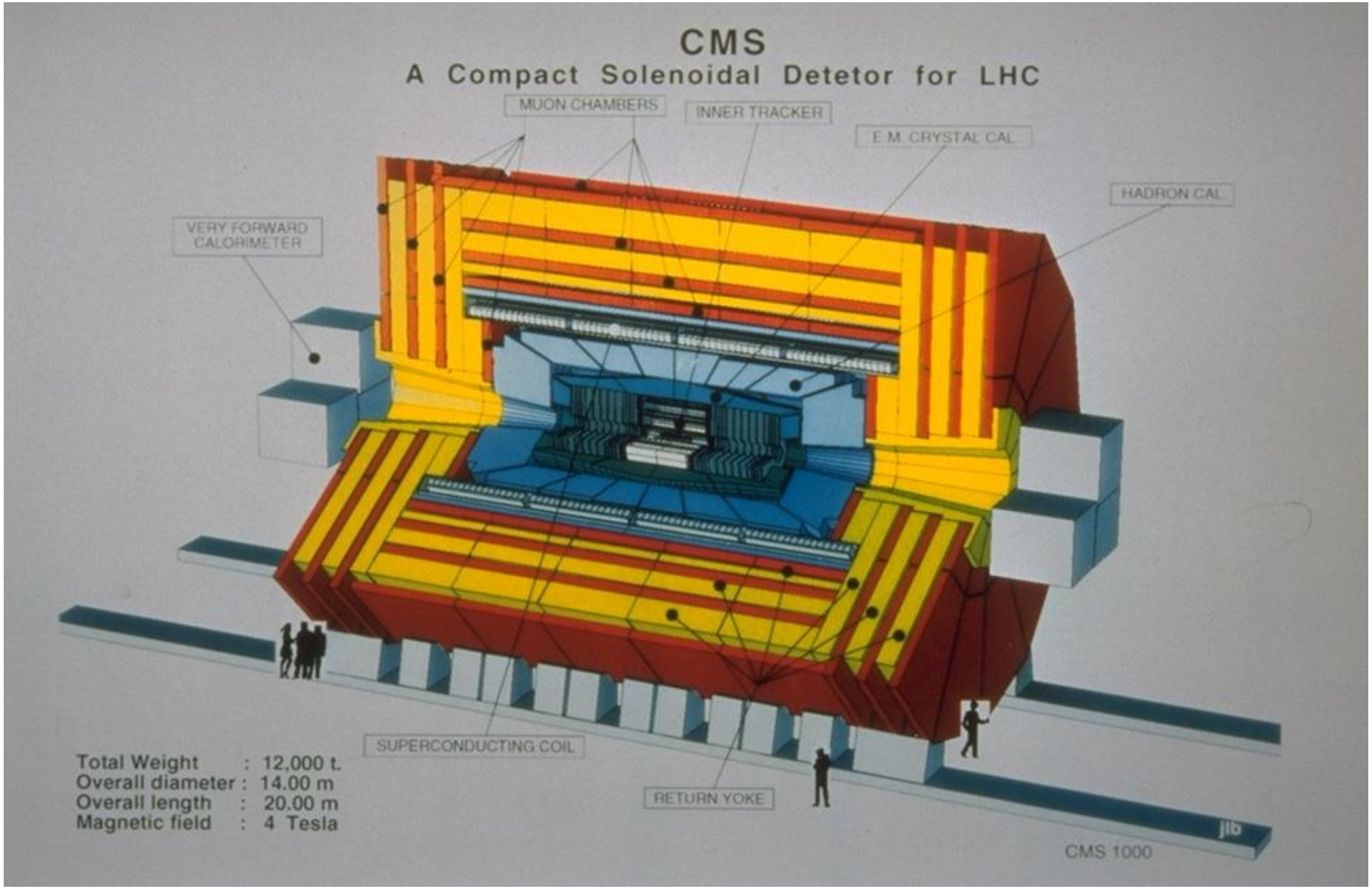
2) We have **completed** the Standard Model: Discovery of the messenger of the BEH-field, the Higgs boson discovery

   (over 50 years of theoretical and experimental efforts !)

3) We found interesting properties of the hot dense matter

4) We have no evidence of new physics (YET)

Detector for experiment



Number of events in the detector

The number of events for a particular type of event is given by:

$$\textit{Number of events} = L \times \sigma_{event}$$

σ_{event} is the likelyhood of producing a particular event
L is a measure of the total number of interactions

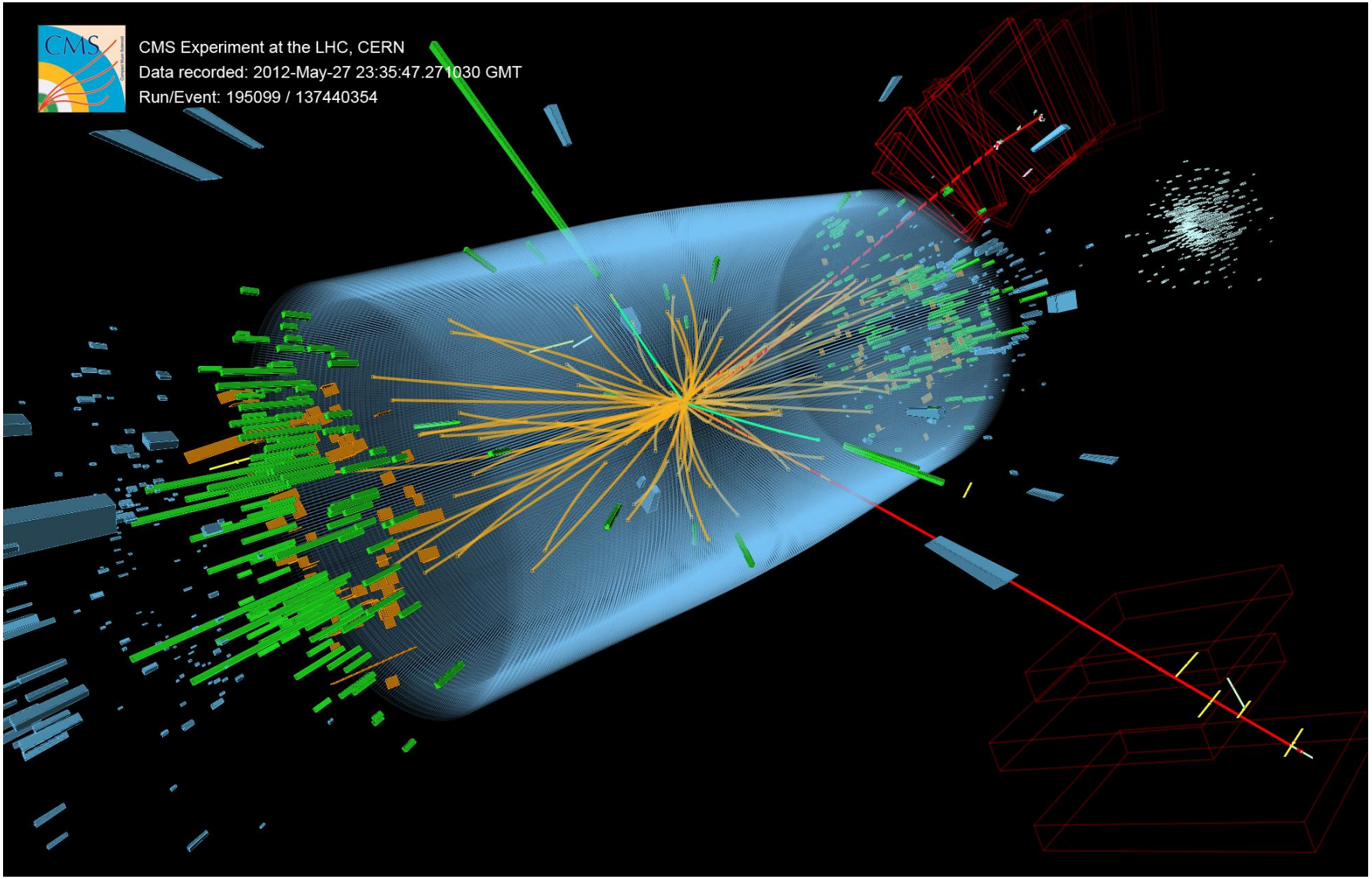
The unit of the cross-section (σ_{event}) is the barn (1 barn = $10^{-28}m^2$)

1mb = $10^{-31}m^2$
1μb = 10^{-34} m^2
1nb = 10^{-37} m^2
1pb = 10^{-40} m^2
1fb = 10^{-43} m^2

If the Cross-section to produce a given event is 1fb then we would need 1fb^{-1} of data to get 1 event!!

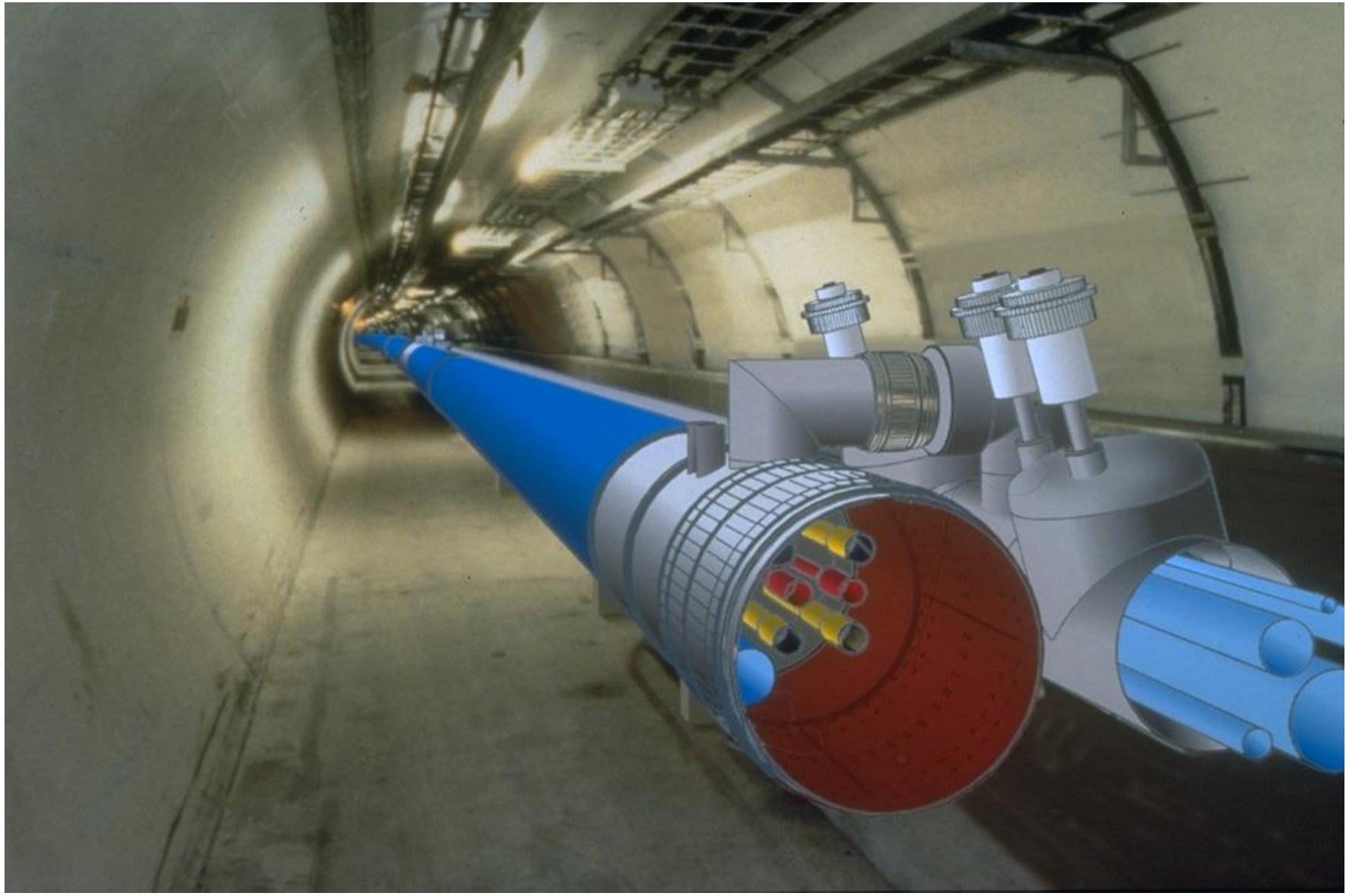
5.6 fb^{-1} of data represents: ~400 million million collision events ($4x10^{+14}$) of which approximately:
100 million produce W and Z's
1 million top quark events
20,000 Higgs …!
… a needle in a haystack

A « photo » taken by CMS detector

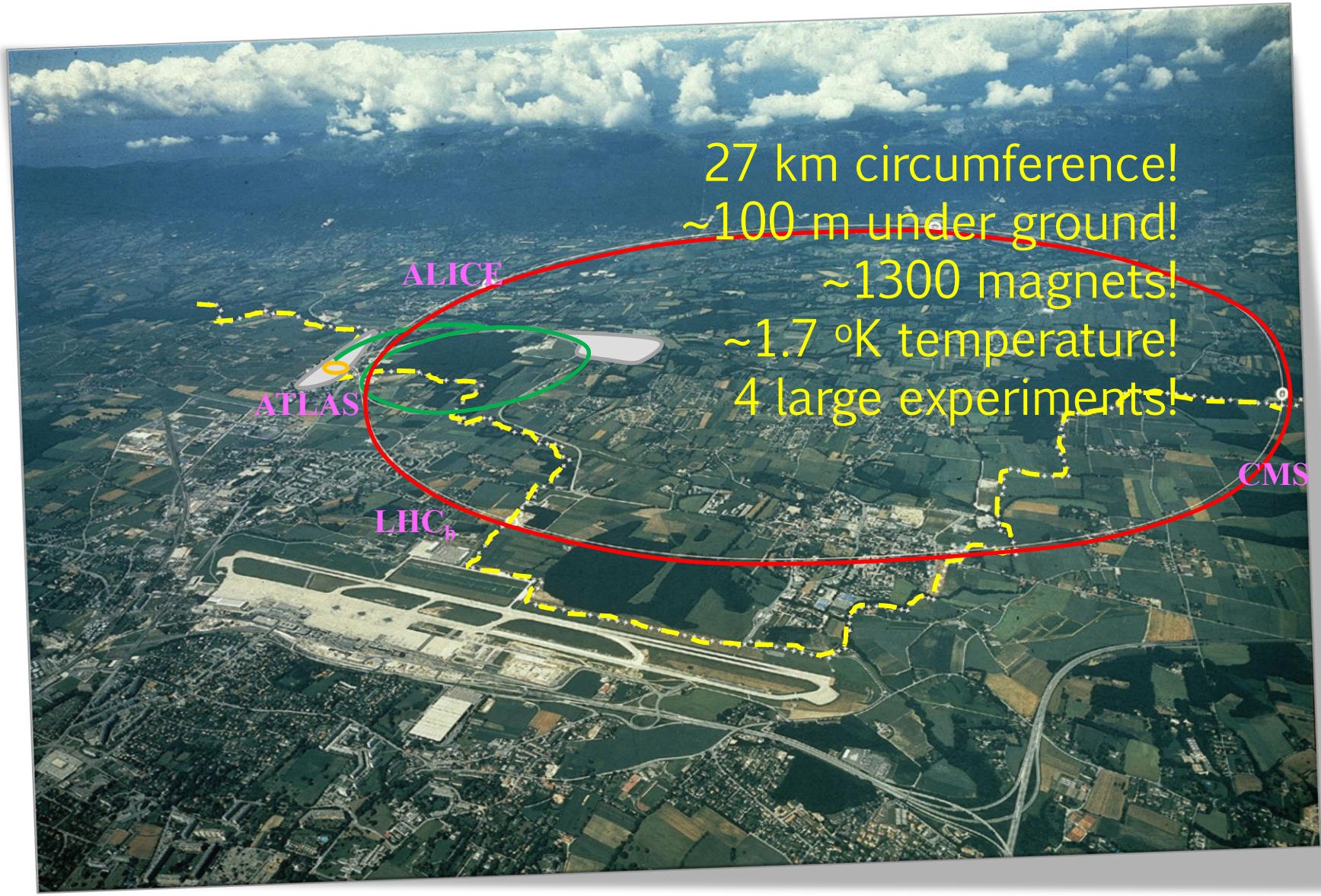


Higgs candidate: H->ZZ-> 2e2μ

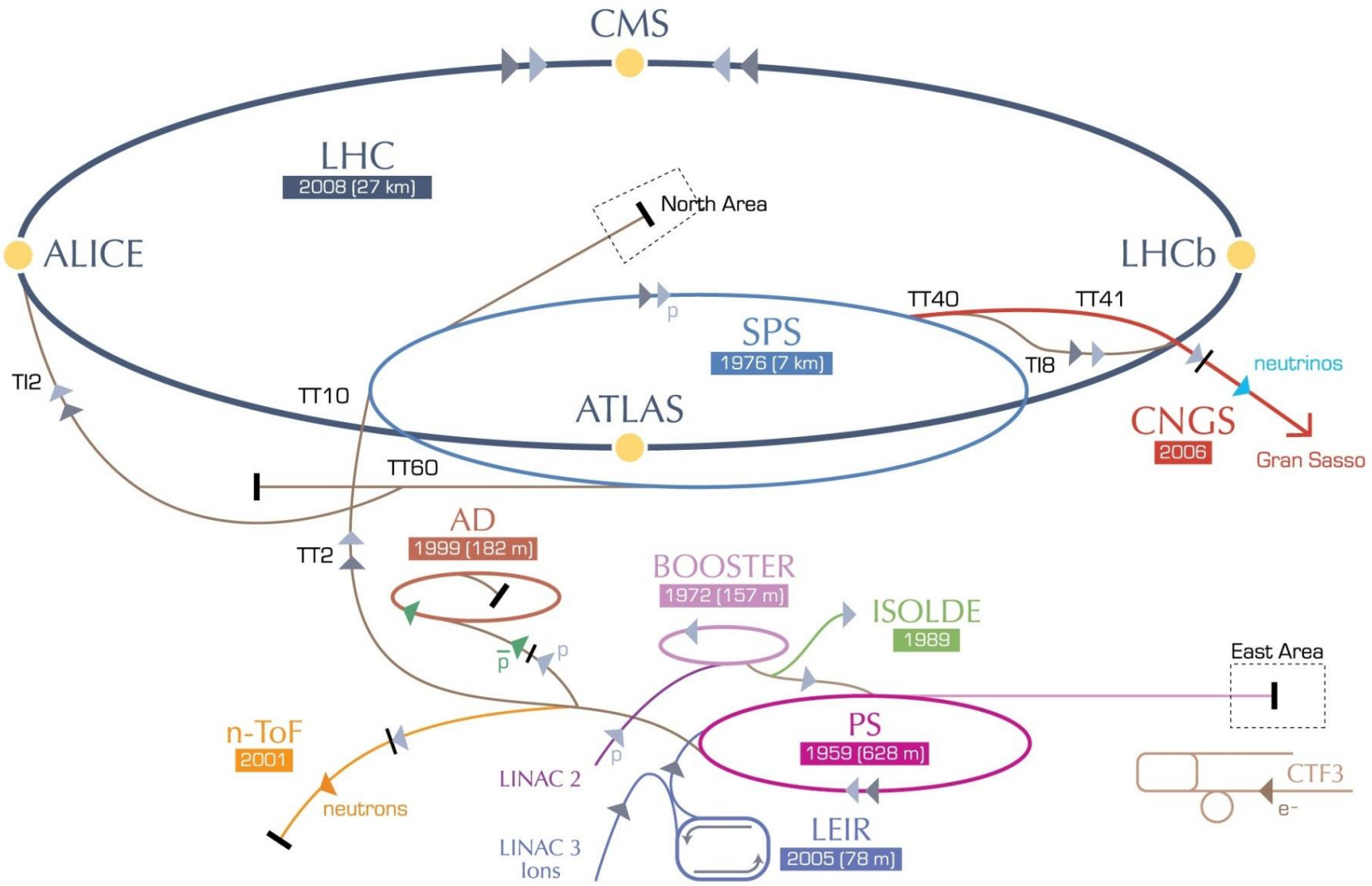
Particle accelerator for machine physicist



The LHC on the CERN site



Many particle accelerators on the CERN site



The Particle Physics Landscape at CERN

High Energy Frontier

LHC

Hadronic Matter

deconfinement
non-perturbative QCD
hadron structure

Low Energy

heavy flavours / rare decays
neutrino oscillations
anti-matter

Non-accelerator

dark matter
astroparticles

Multidisciplinary

climate, medicine

Non-LHC Particle Physics = o(1000) physicists / o(20) experiments

In the past few years

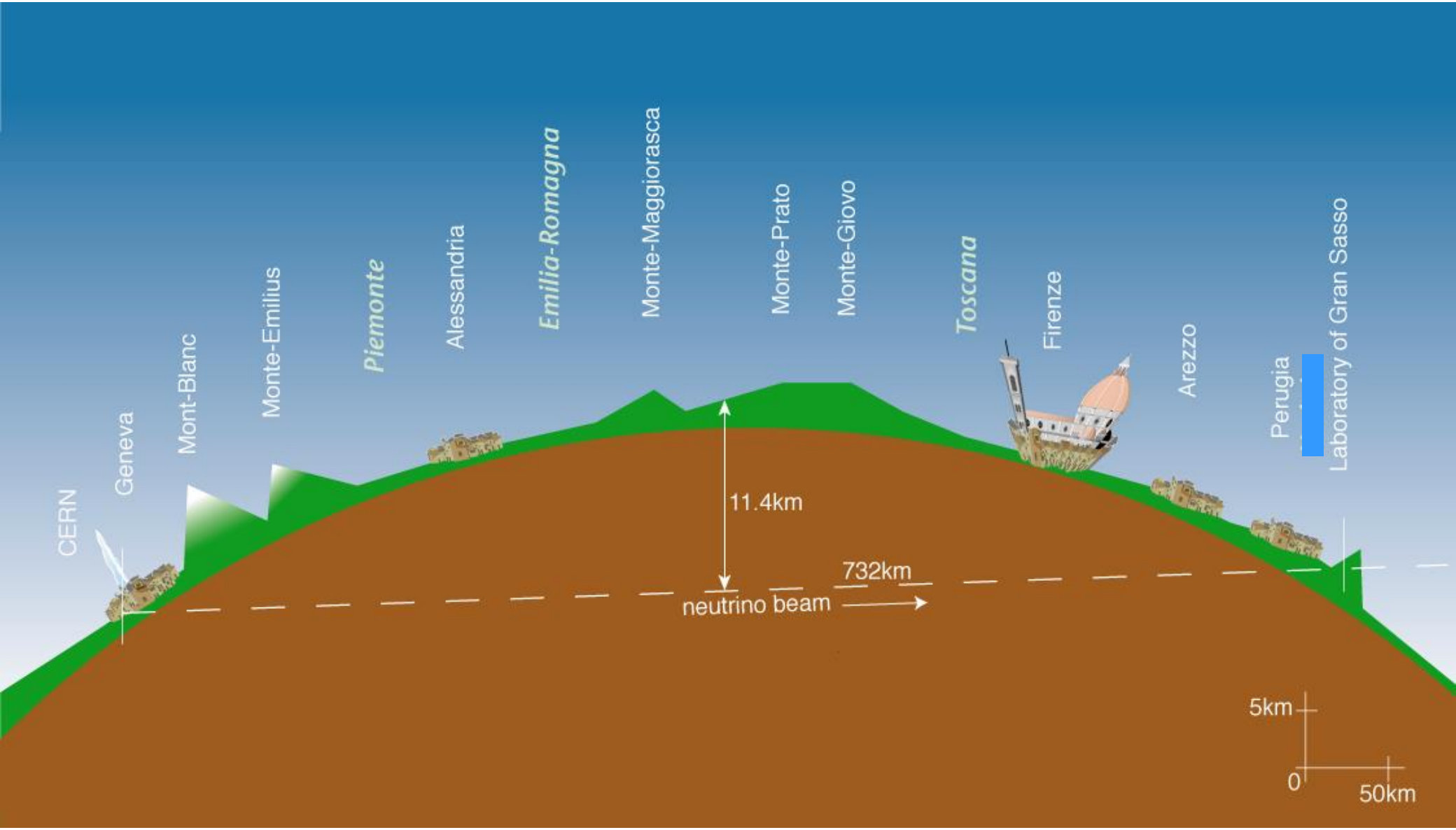
Several breakthroughs !

Steady progress of other programs

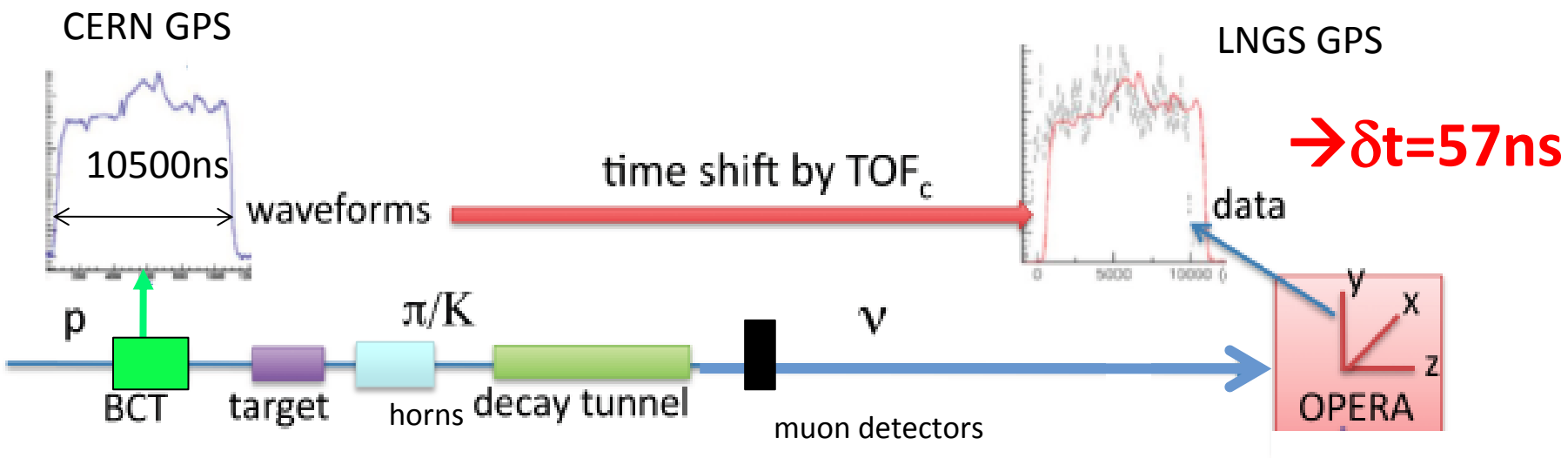
New mid-term and long-term projects started or in discussion

Complemented and supported by Theory

CERN Neutrino to Gran Sasso (CNGS)



Neutrinos faster than the light velocity ?



$$\delta v_\nu = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\delta x}{\delta t}$$

No ! It was an experimental error !

CERN and the antimatter

ALPHA experiment has captured 309 atoms of anti-hydrogen during ~17 mn

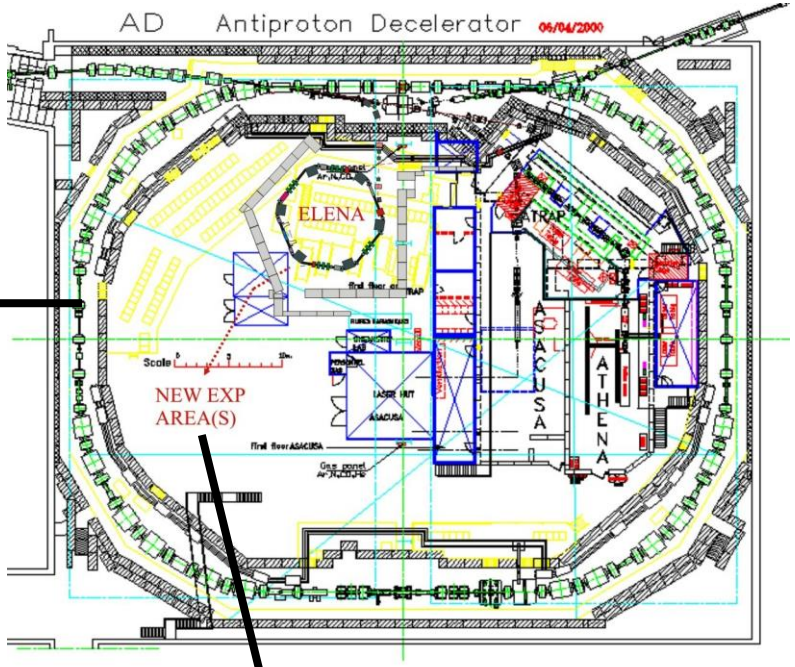
American “Angels and devils” of Ron Howard issued in 2009

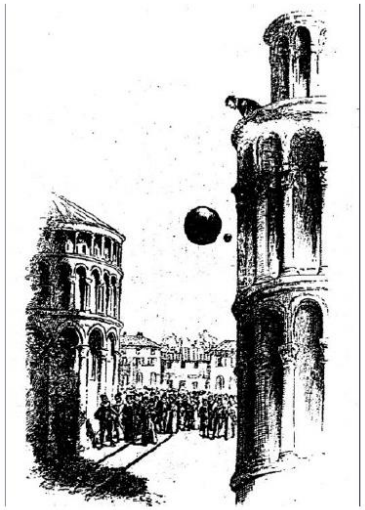
=> *Still science fiction !*

ELENA: Extra Low-Energy Antiproton ring

Measurement of the gravity on the antimatter

AD

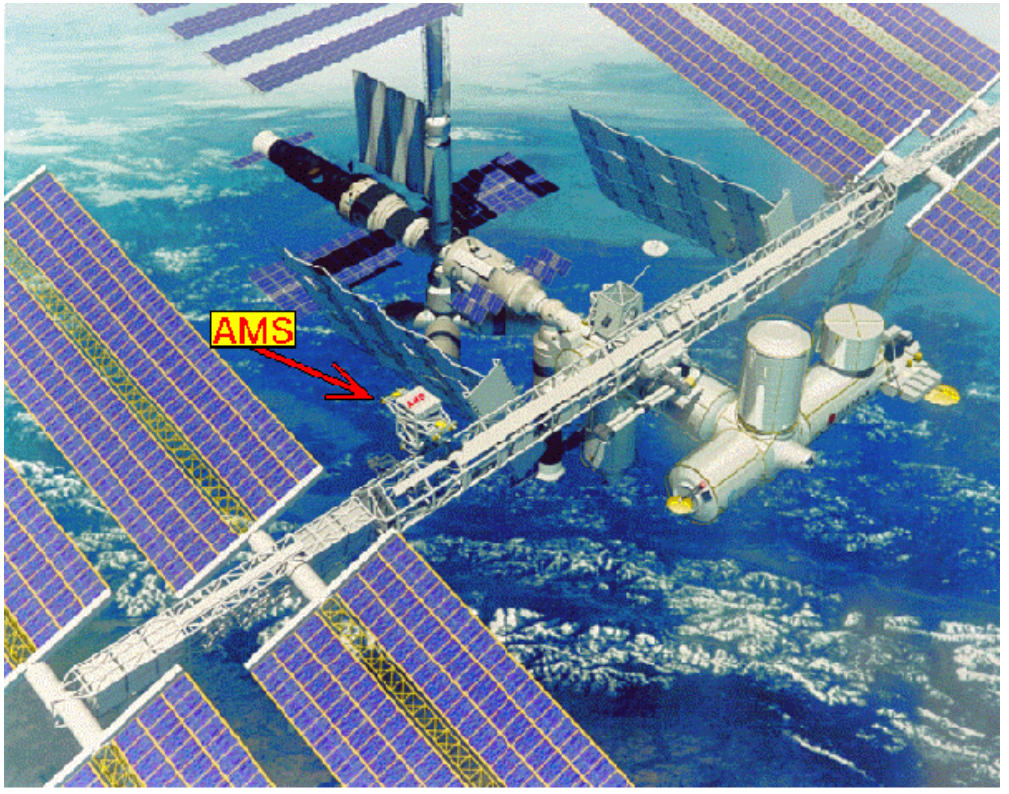




Antimatter in the space ?

AMS (Alpha Magnet Spectrometer) has been built at CERN and now is installed on the ISS (International Space Station)

Research of the antimatter, dark matter, …

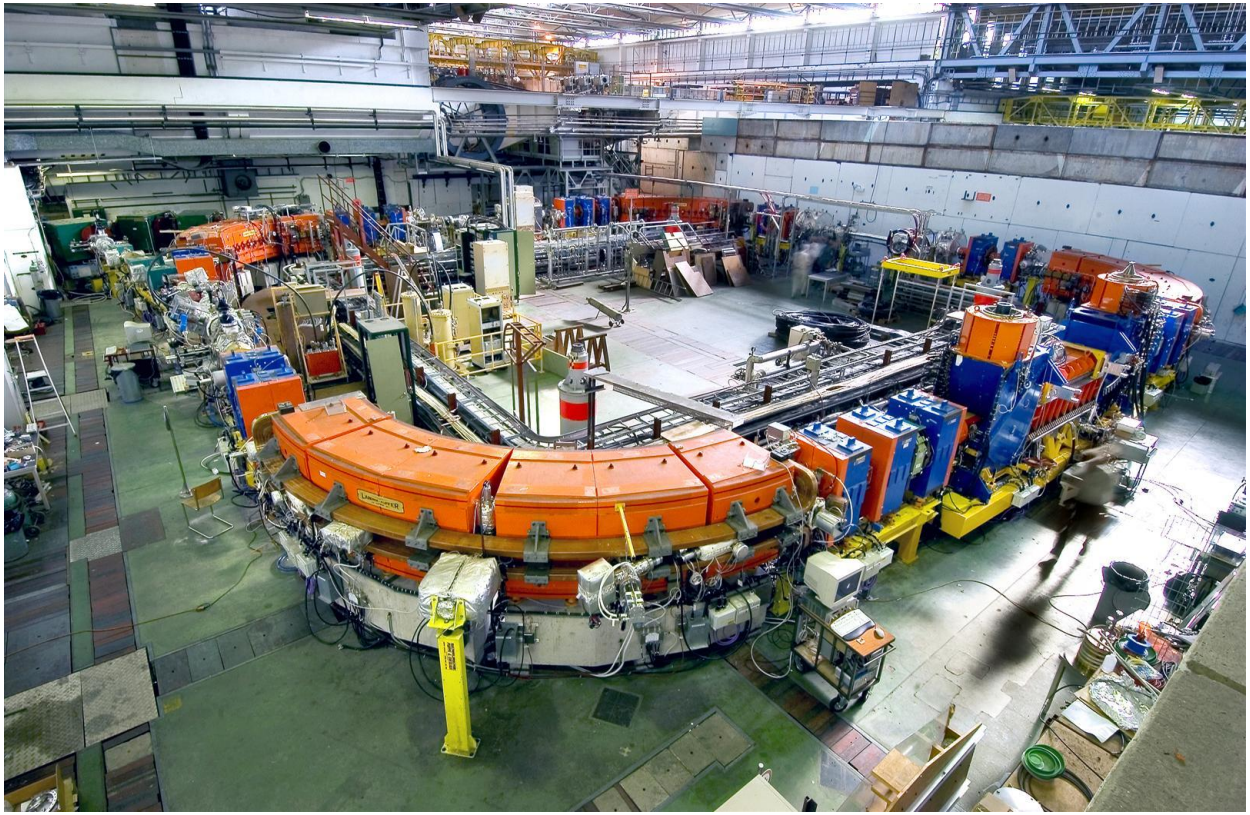


A views of AMS mounted on the International Space Station

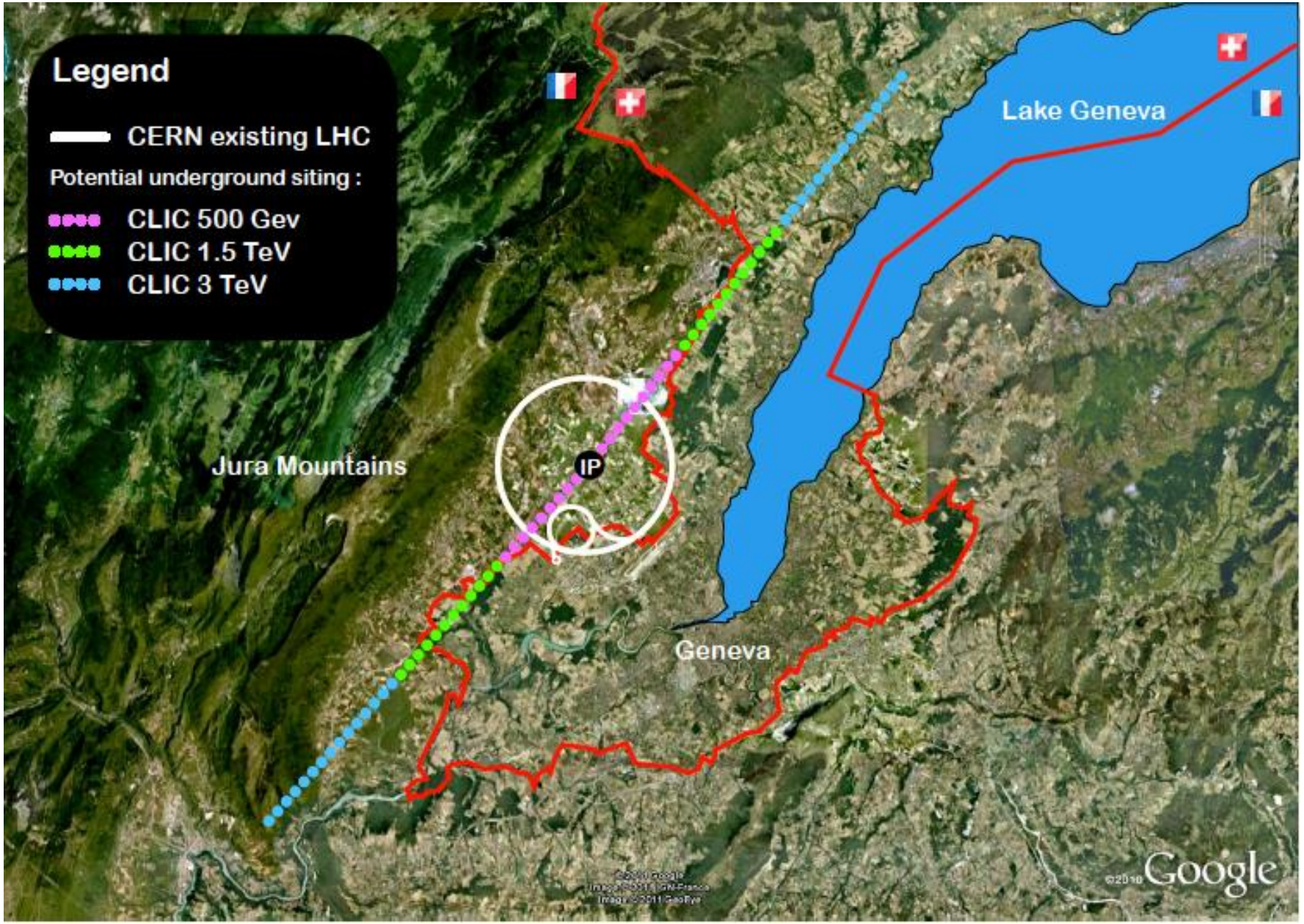
Steadily growing interest in hadron therapy

Interest/plans for new facilities in Bulgaria, Greece, Norway, Denmark, the Netherlands, UK, Spain

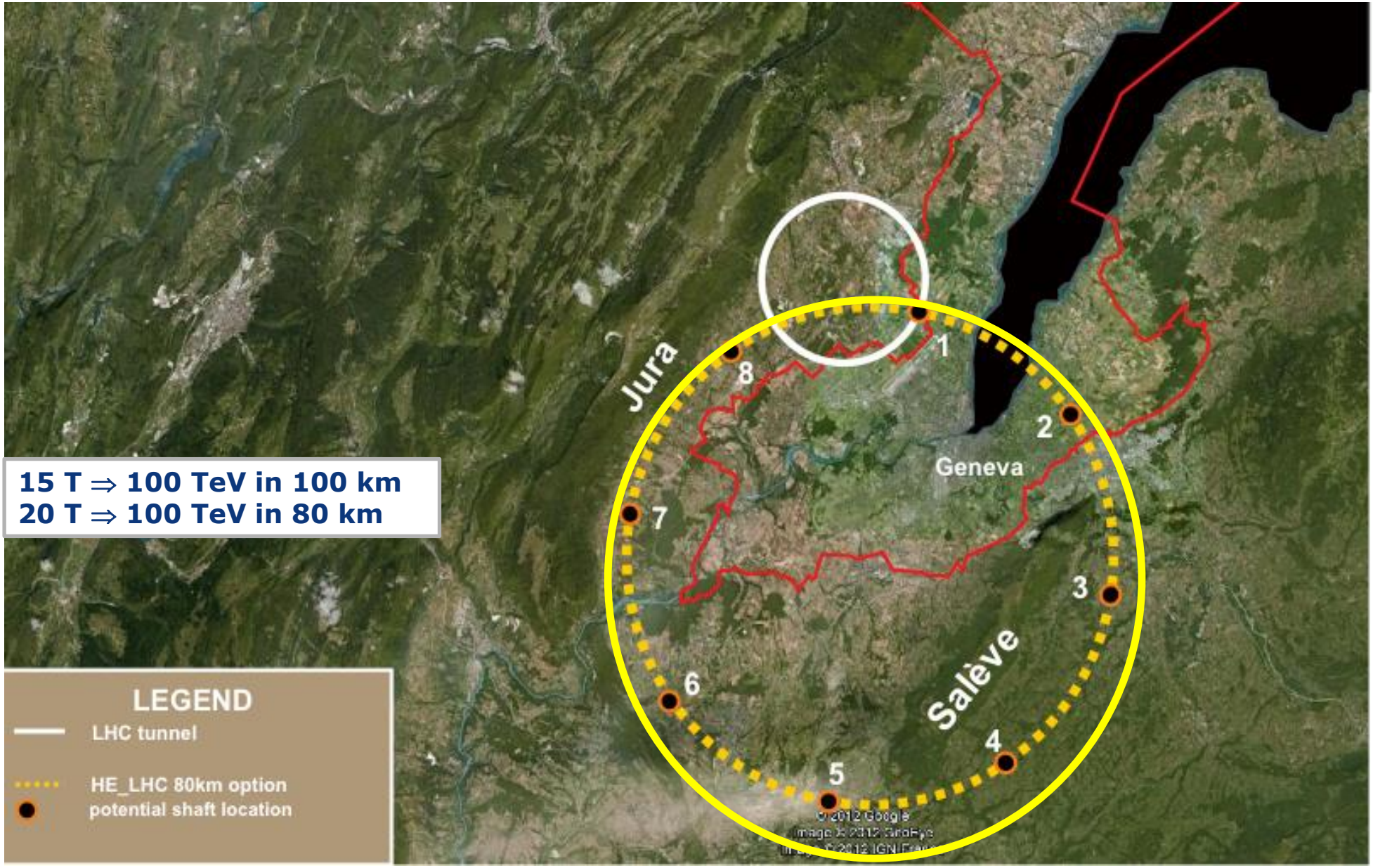
Need more research and biomedical studies with different ions (BioLEIR)



Compact Linear Collider (CLIC)

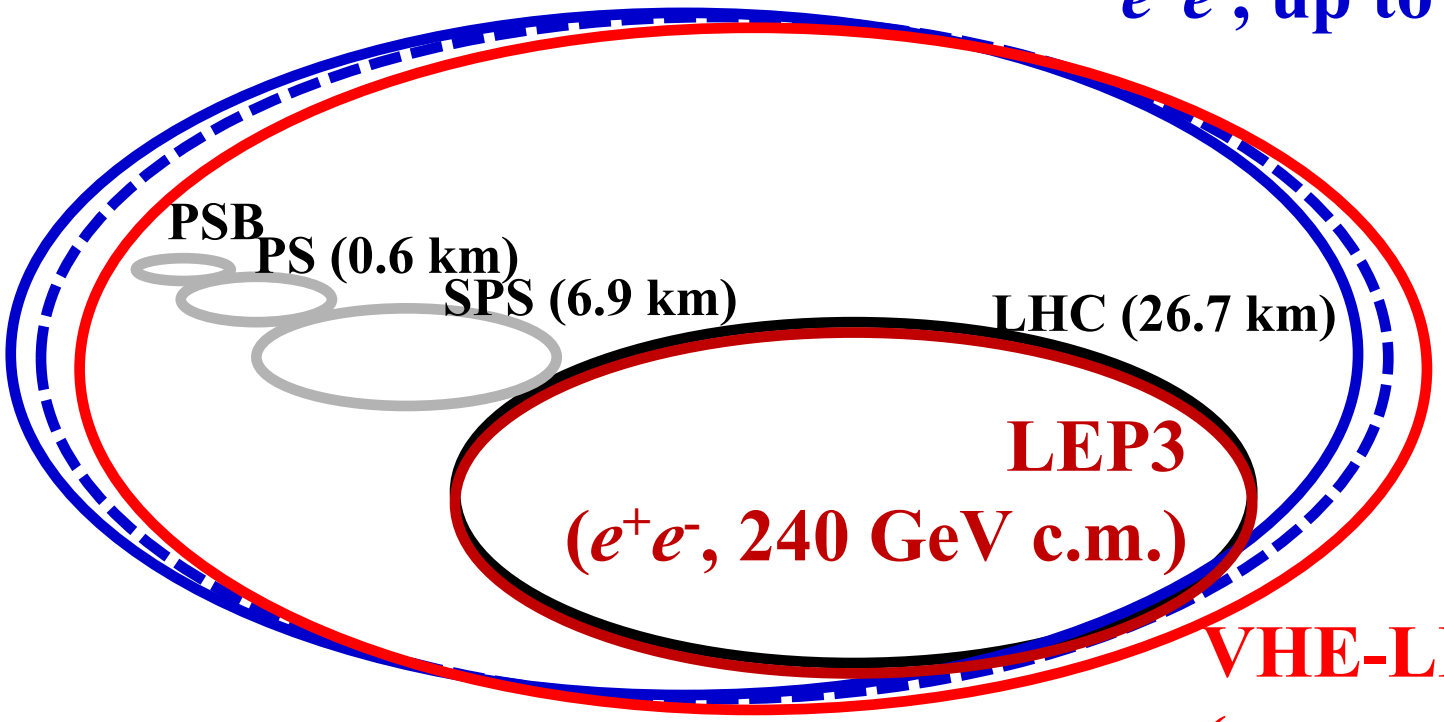


TLEP (Triple LEP) and VE-LHC (Very High Energy – LHC)



« Factories » to produce Higgs bosons

TLEP (80 km,
e^+e^-, up to ~350 GeV c.m.)

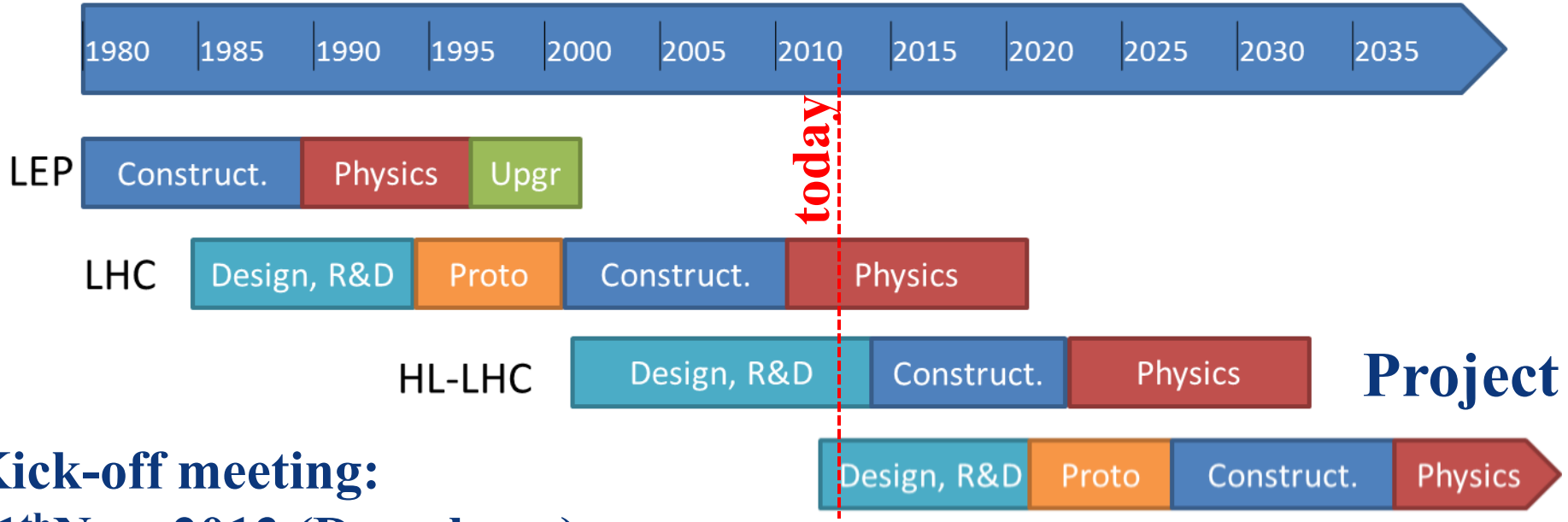


VHE-LHC
(*pp*, up to 100 TeV c.m.)

Also collisions: $e^{\pm}$ **(200 GeV) –** ***p*** **(7 & 50 TeV)**

A long strategy for the High Energy Physic

European Strategy: "CERN should undertake design studies for accelerator projects in a global context, with emphasis on ***proton-proton*** *and electron- positron* ***high-energy frontier machines.***"

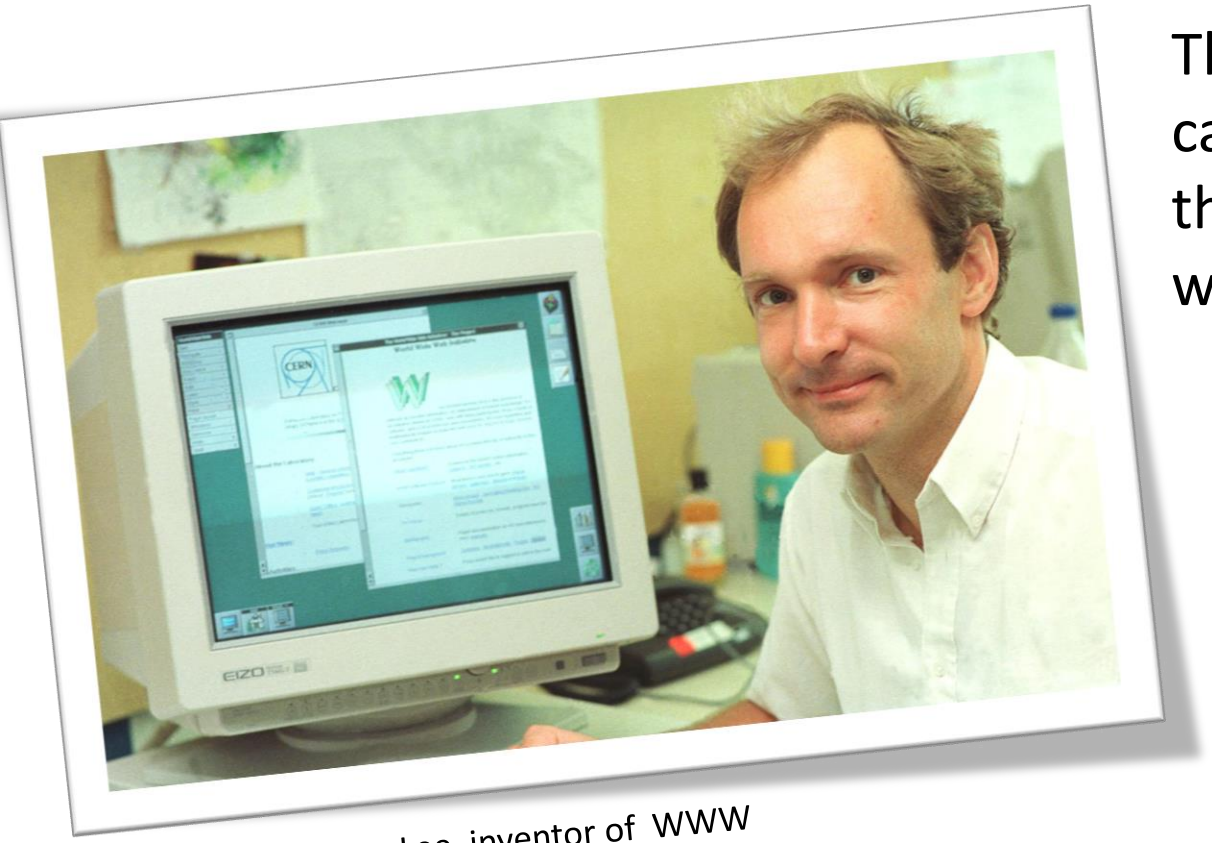


Kick-off meeting:
11thNov. 2013 (Daresbury)

FCC Study : p-p towards 100 TeV

FCC: Future Circular Colliders

The World Wide Web was invented at CERN

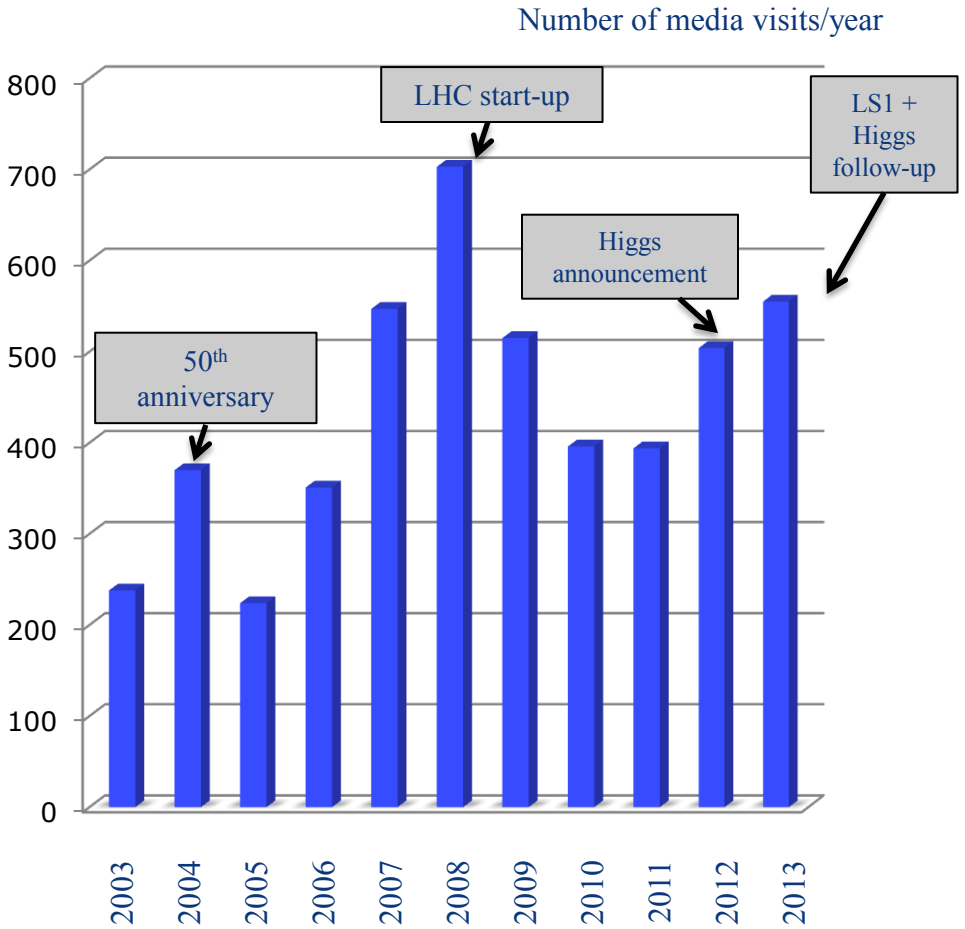


Sir Tim Berners-Lee, inventor of WWW

Developed in 1989:
The experimentalists did not carry out their magnetic tapes in their labs and the LHC project was in preparation!

Thank to the CERN, today everyone can access the www freely.

A high-profile year for communication



In 2013, **555 media** (representing 1210 journalists) visited CERN, including :

- 19 national media visits *(Reuters, El Mundo, RAI, RTBF, BBC, Le Monde, New Scientist, ORF, etc.)*
- 2 special visits for local and UN media

Major events organized by or with the communication group which had large media coverage:

- Famelab event
- TEDxCERN
- Prince of Asturias Prize
- Open Days
- Nobel Prize announcement
- Arts@CERN events

Example: Prince of Asturias Prize
≈ 2000 articles

And the Nobel prizes

Carlo Rubbia
et Simon van der Meer

"pour leur contribution décisive au grand projet qui a permis la découverte des particules W et Z, vecteurs de la force faible"

George Charpak

"pour son invention et le développement de détecteurs de particules, en particulier la chambre à fil proportionnelle"

Nobel prizes in Physics 2013

P. Higgs F. Englert R. Heuer

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".*

Many fundamental questions remain open

What is the origin of the mass of the particles ?

Why there is no antimatter in the space ?

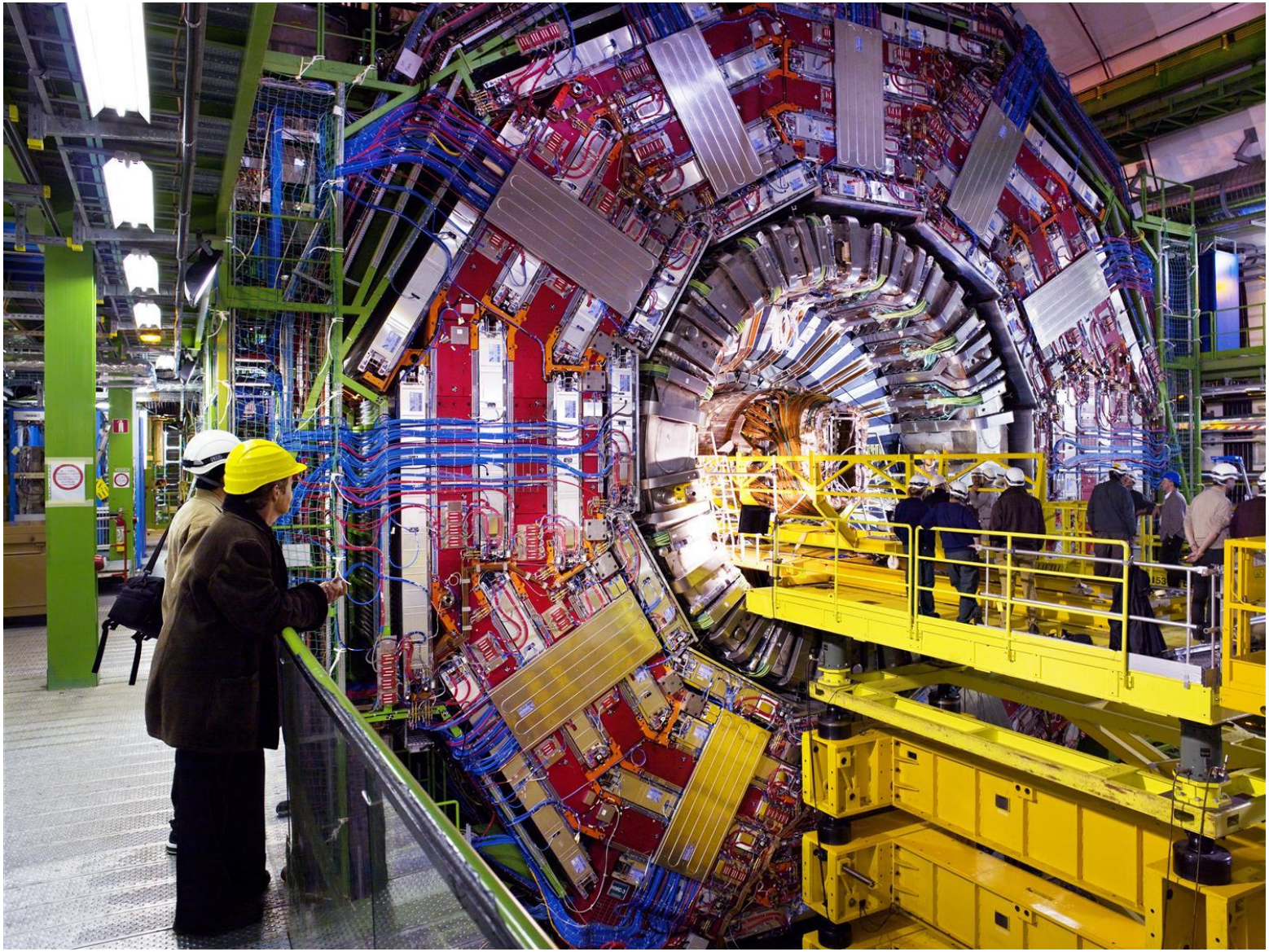
What was the state of the matter just after the Big-Bang ?

Why our existing models explain only 4% of the Univers estimated mass ?

And many more ……

Future is very exciting for the Science and for young scientists

Now it is time to visit CMS



Thank you very much for your attention