Welcome to CERN

Louis Rinolfi

Thanks to D. Bertola, F. Briard, P. Collier

Agenda of the visit

- 30 minutes presentation
- Visit of CMS cavern and detector
- Visit Linacs and CTF3

Other practical informations

- 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)

What means « CERN»?

1954

Conseil

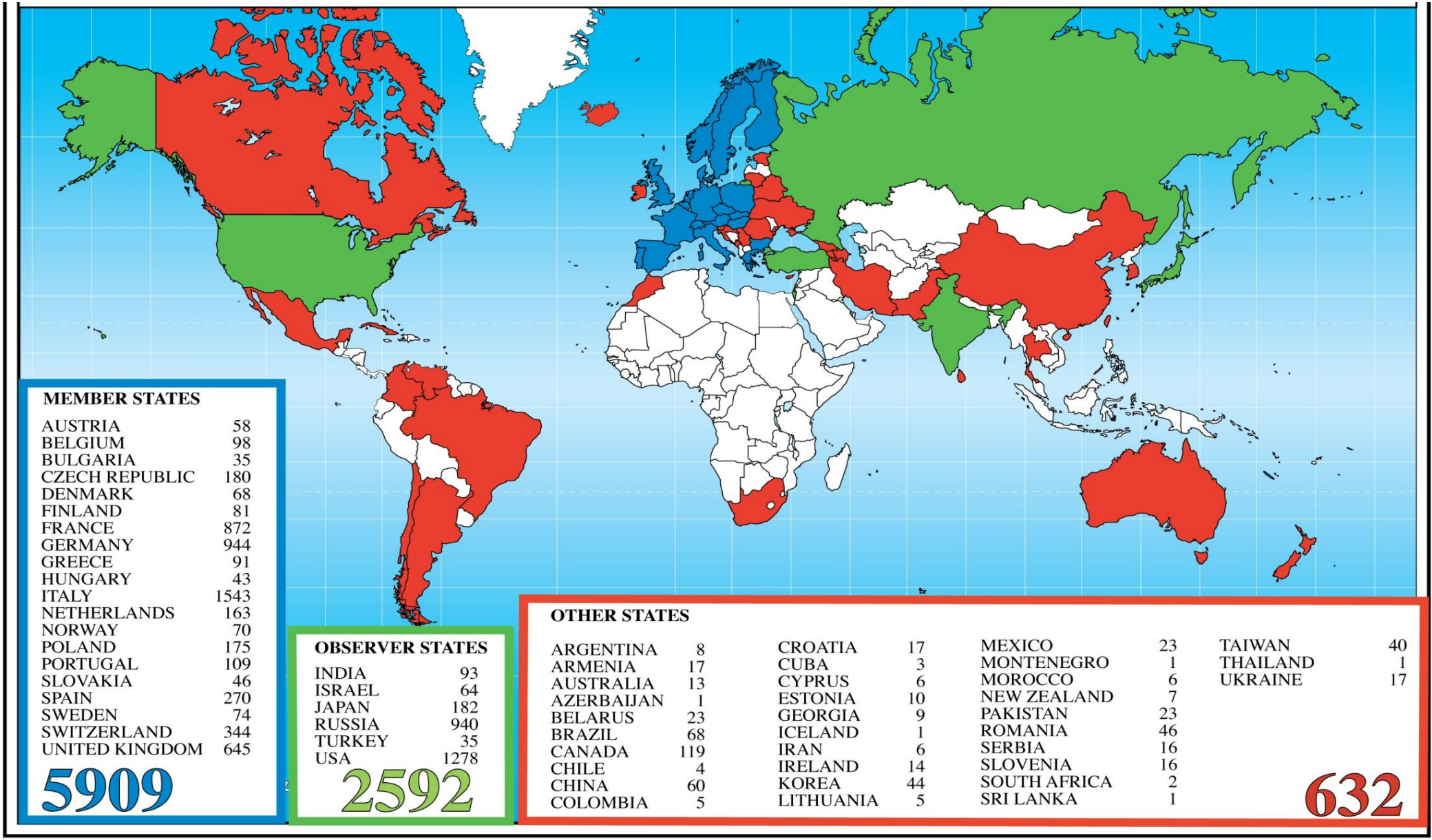
Européen pour la

Recherche

Nucléaire

CERN member states

CERN users



MEMBER STATES

AUSTRIA	58
BELGIUM	98
BULGARIA	35
CZECH REPUBLIC	180
DENMARK	68
FINLAND	81
FRANCE	872
GERMANY	944
GREECE	91
HUNGARY	43
ITALY	1543
NETHERLANDS	163
NORWAY	70
POLAND	175
PORTUGAL	109
SLOVAKIA	46
SPAIN	270
SWEDEN	74
SWITZERLAND	344
UNITED KINGDOM	645

5909

OBSERVER STATES

INDIA	93
ISRAEL	64
JAPAN	182
RUSSIA	940
TURKEY	35
USA	1278

2592

OTHER STATES

ARGENTINA	8	CROATIA	17	MEXICO	23	TAIWAN	40
ARMENIA	17	CUBA	3	MONTENEGRO	1	THAILAND	1
AUSTRALIA	13	CYPRUS	6	MOROCCO	6	UKRAINE	17
AZERBAIJAN	1	ESTONIA	10	NEW ZEALAND	7		
BELARUS	23	GEORGIA	9	PAKISTAN	23		
BRAZIL	68	ICELAND	1	ROMANIA	46		
CANADA	119	IRAN	6	SERBIA	16		
CHILE	4	IRELAND	14	SLOVENIA	16		
CHINA	60	KOREA	44	SOUTH AFRICA	2		
COLOMBIA	5	LITHUANIA	5	SRI LANKA	1		

632

CERN objectives

Fundamental research
in the Particle Physics:

- elementary constituents of the matter

- fundamental forces controlling them

- origin and structure of the Universe

Checking existing theories:

ORDINARY MATTER

LEPTONS

ELECTRON

ELECTRON NEUTRINO

MUON

MUON NEUTRINO

TAU

TAU NEUTRINO

QUARKS

UP

DOWN

CHARM

STRANGE

TOP

BOTTOM

4 forces

GLUONS

Strong Force

PHOTONS

Electro-Magnetic Force

BOSONS

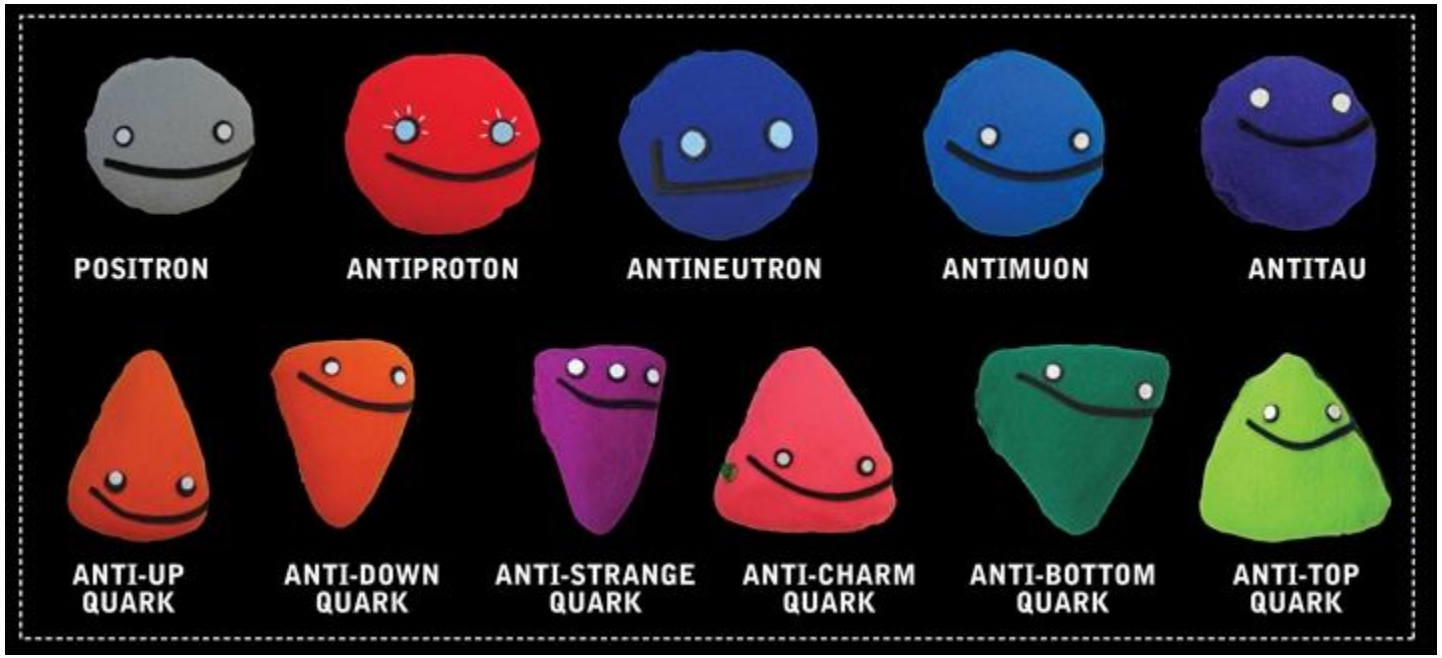
Weak Force

GRAVITONS

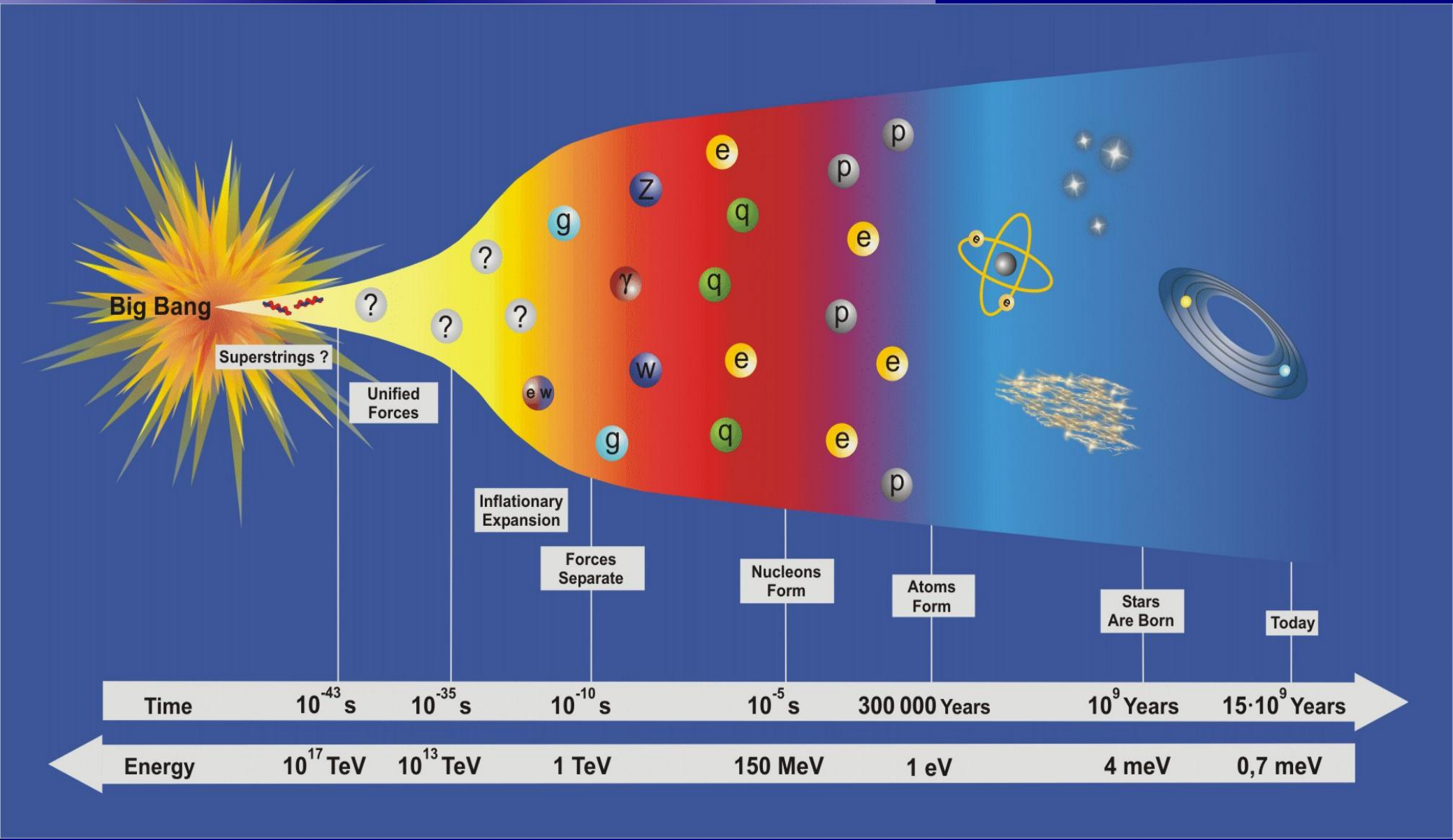
Gravity

Images: www.particlezoo.net

And all anti-particles ….



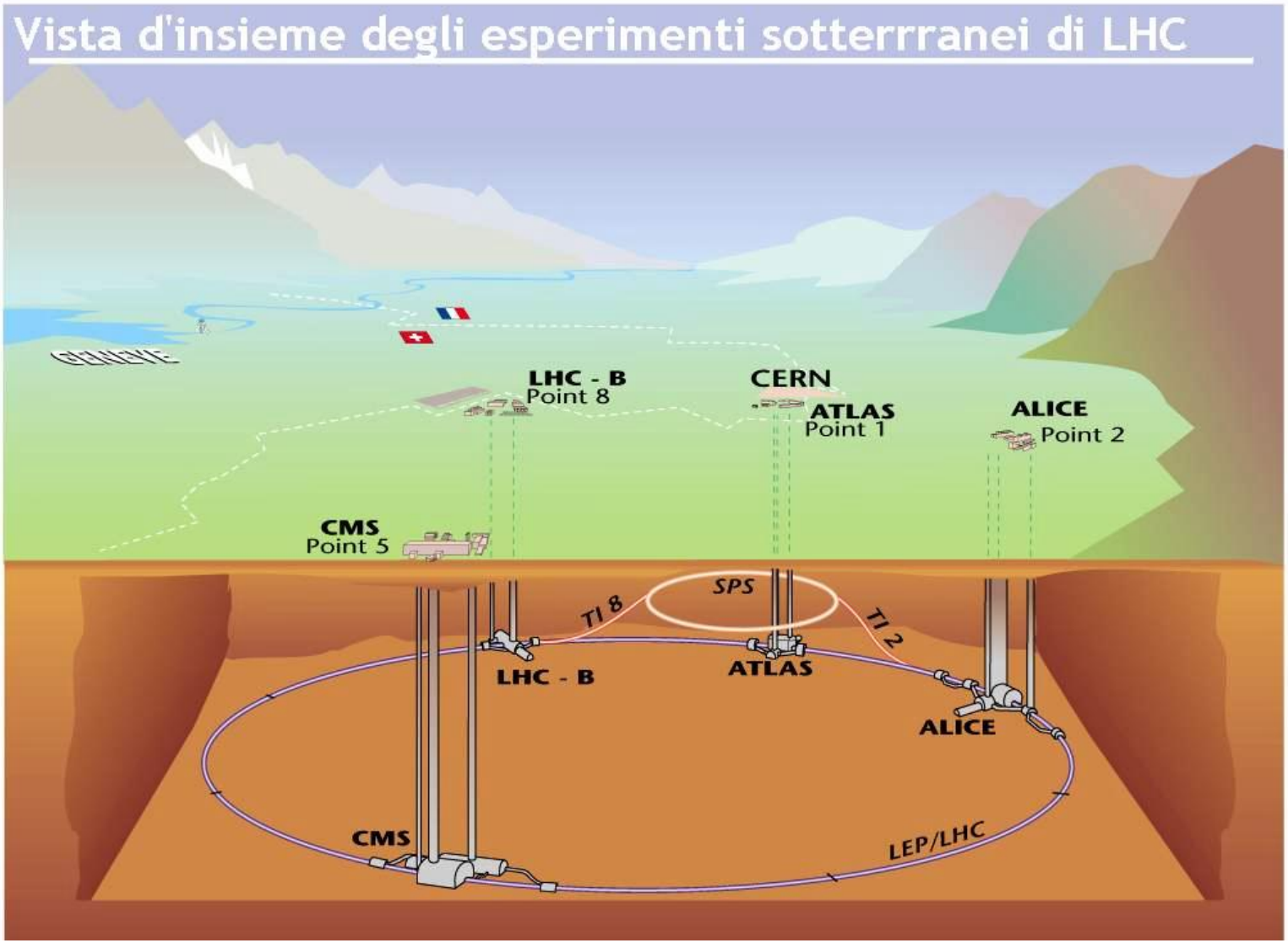
Evolution of the Universe



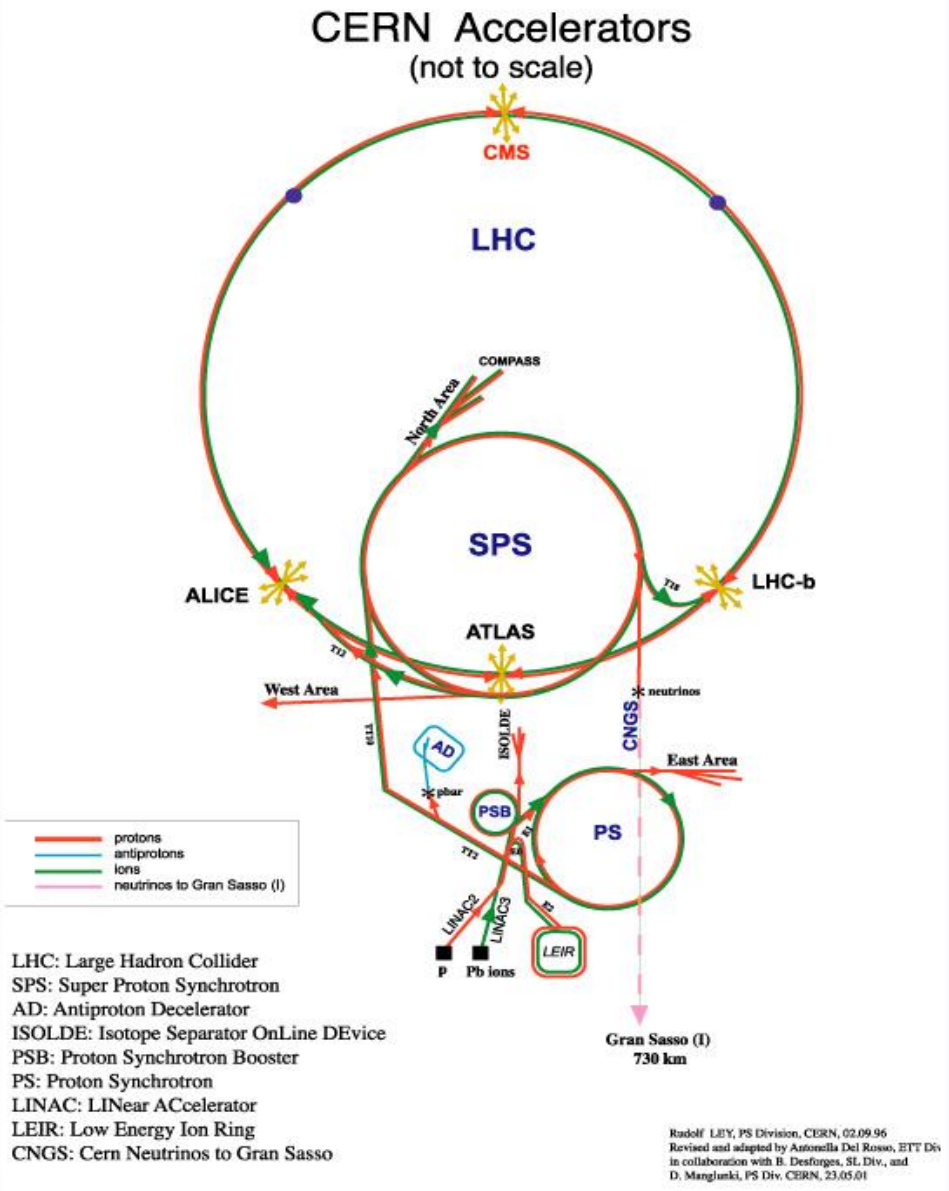
Open questions of Particle Physics:

- the Supersymmetry (SUSY)
- the origin of mass and the Higgs boson
- the dark matter
- the matter – anti-matter asymmetry
- the quark – gluon plasma

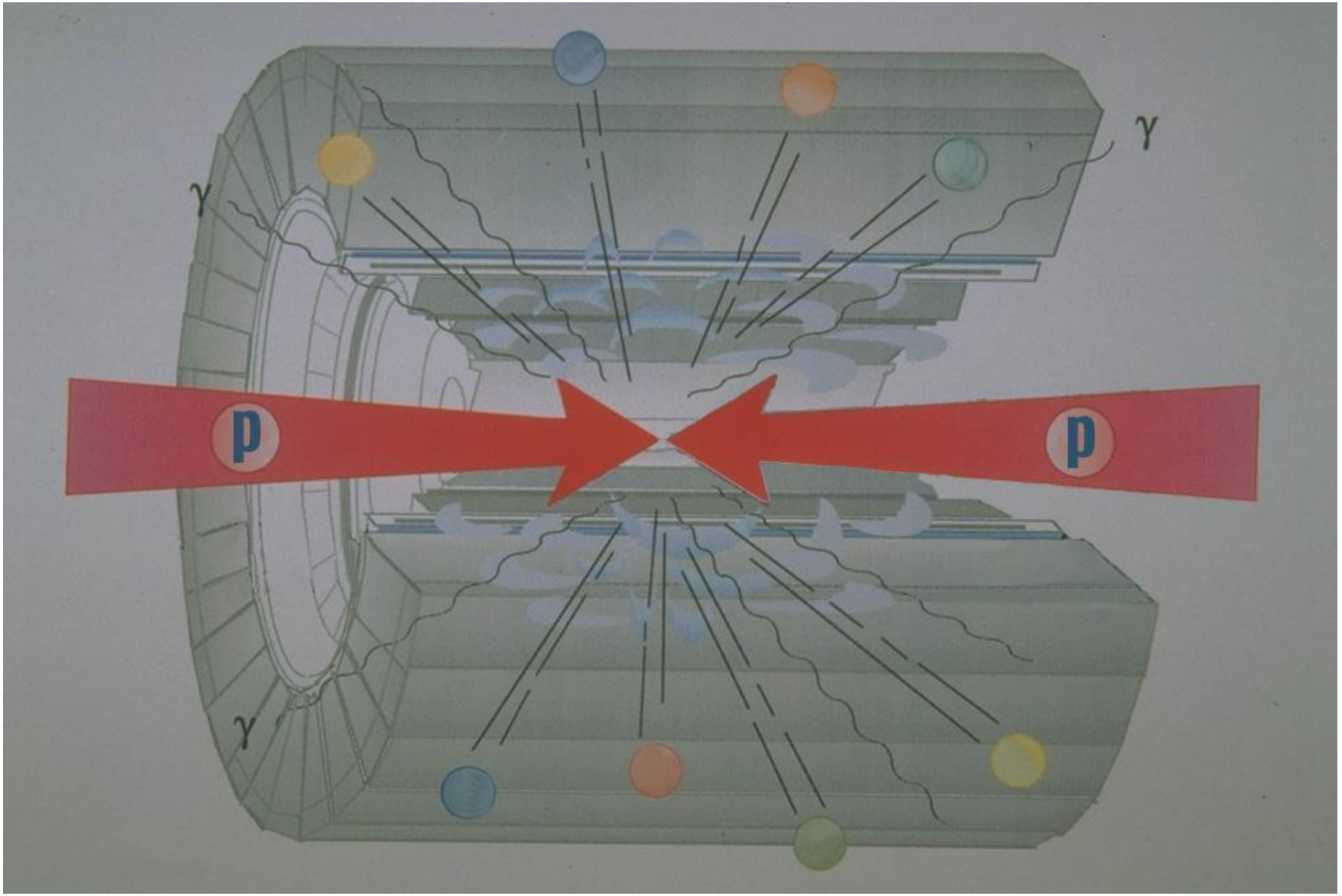

CMS
LHCb
ALICE
ATLAS
YOU ARE HERE


Vista d'insieme degli esperimenti sotterrranei di LHC
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

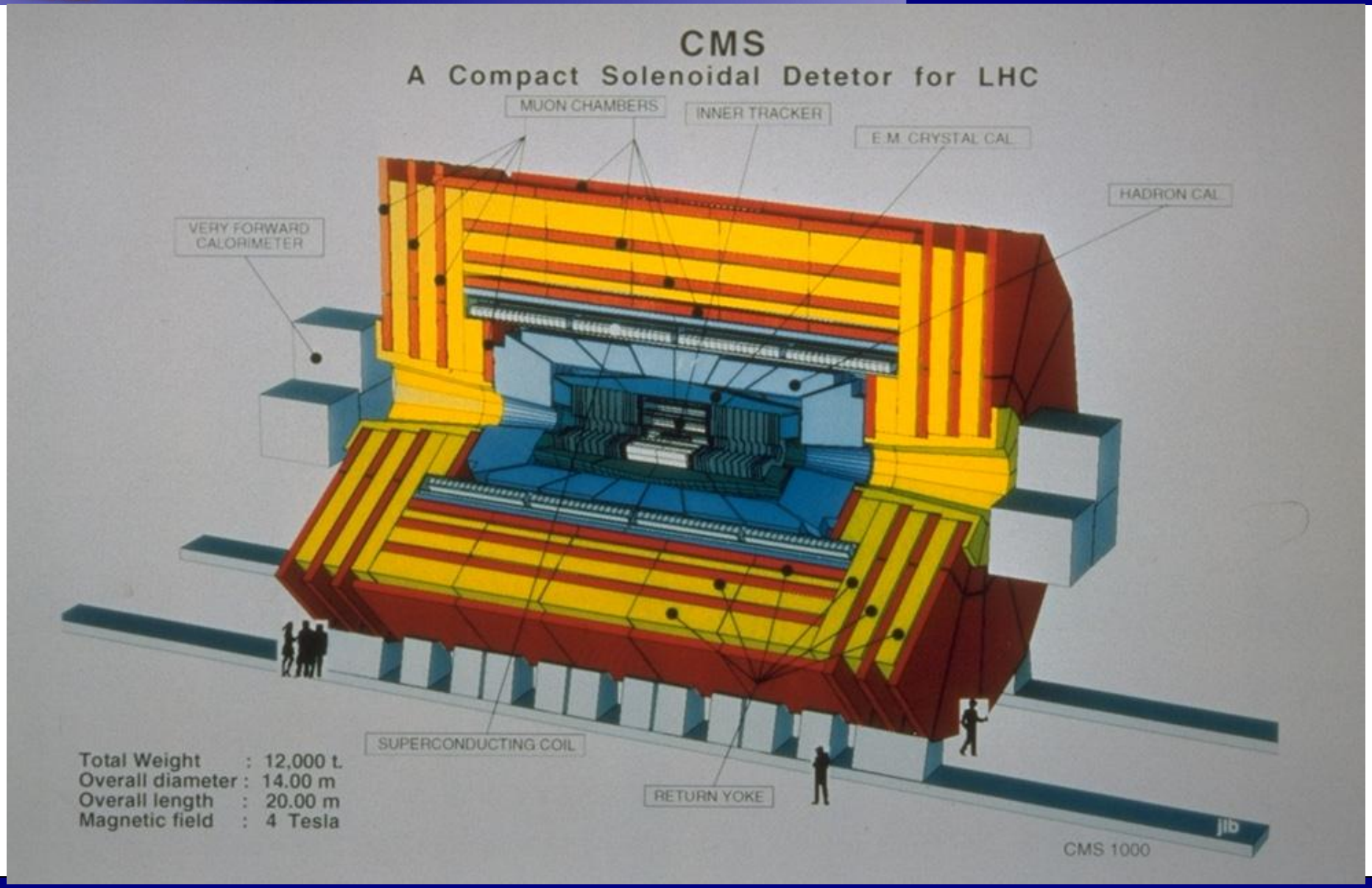
CERN Accelerators complex

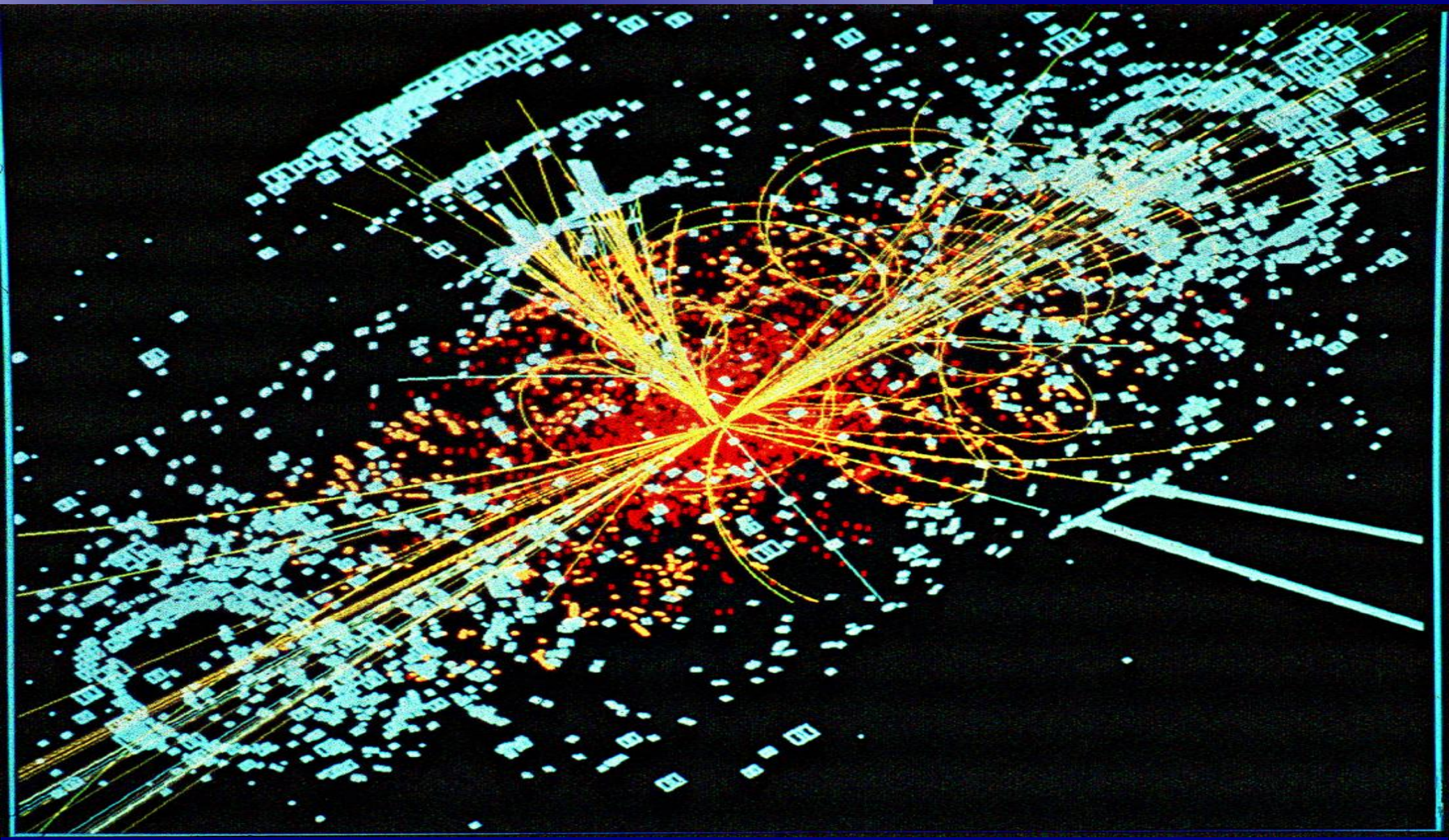


Colliding beams



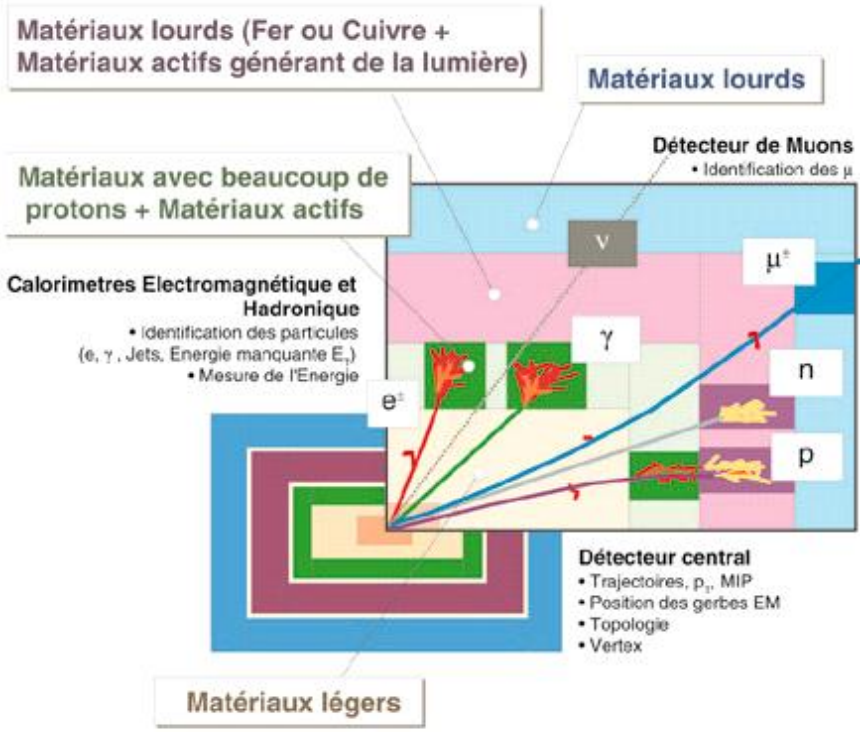
The CMS detector





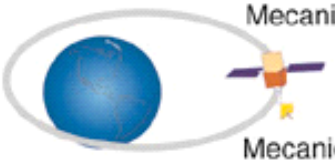
Different layers in the detector

Détecteurs au LHC



Chaque couche du détecteur permet d'identifier et de mesurer l'impulsion ou l'énergie des particules produites dans la collision

L'unification des forces



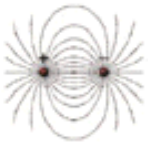
Mecanique terrestre

Mecanique celeste

Gravitation Universelle

Masse inertielle et masse gravitationelle

(I. Newton, 1687)



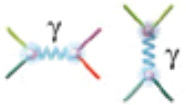
Electricité

Magnetisme

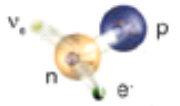
Electromagnetisme

Onde electromagnetiques (photon)

(J.C. Maxwell, 1860)



Electromagnetisme



Force faible

Electroweak

Les boson intermediaires W, Z

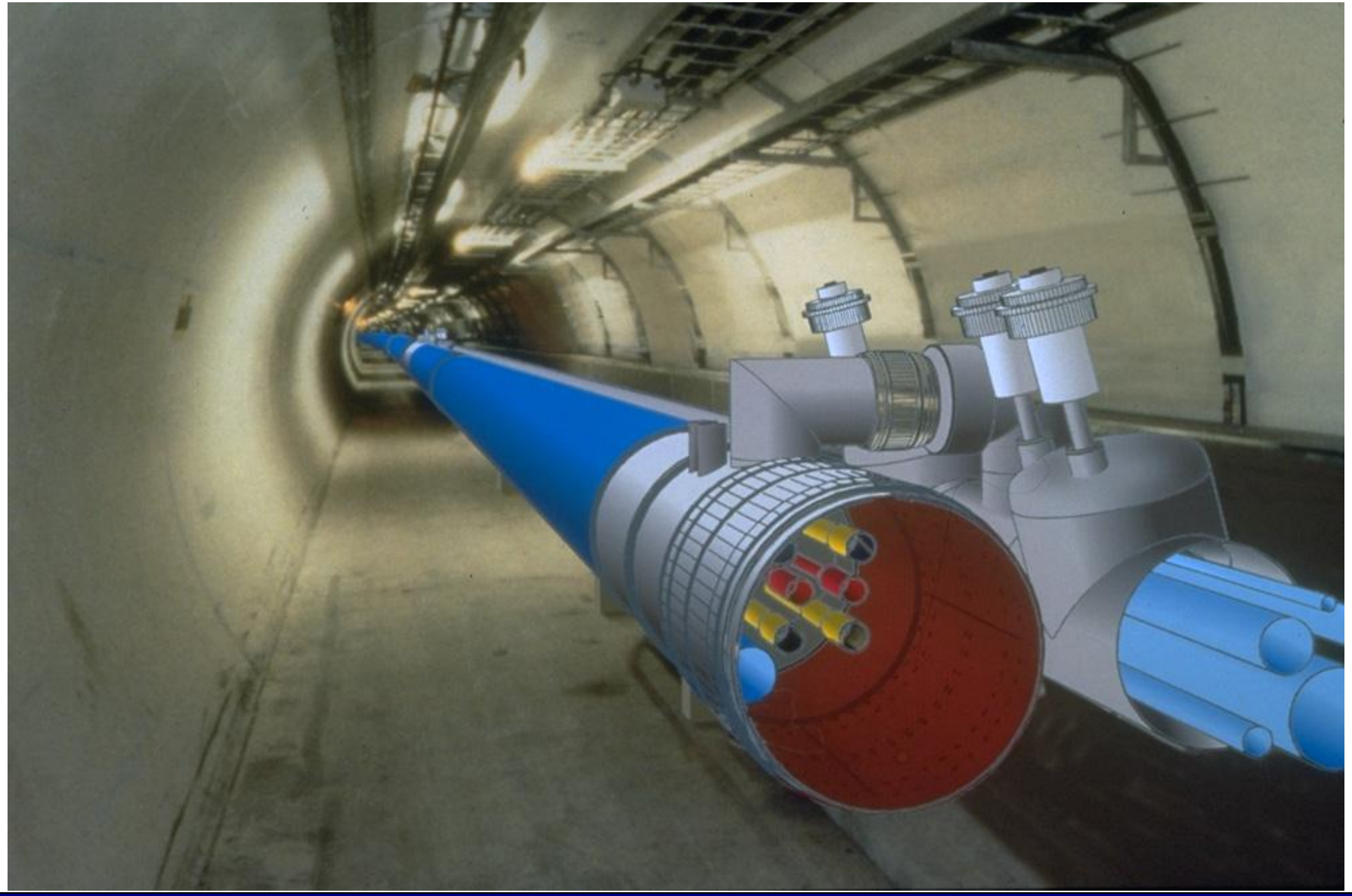
(1970-83)

?

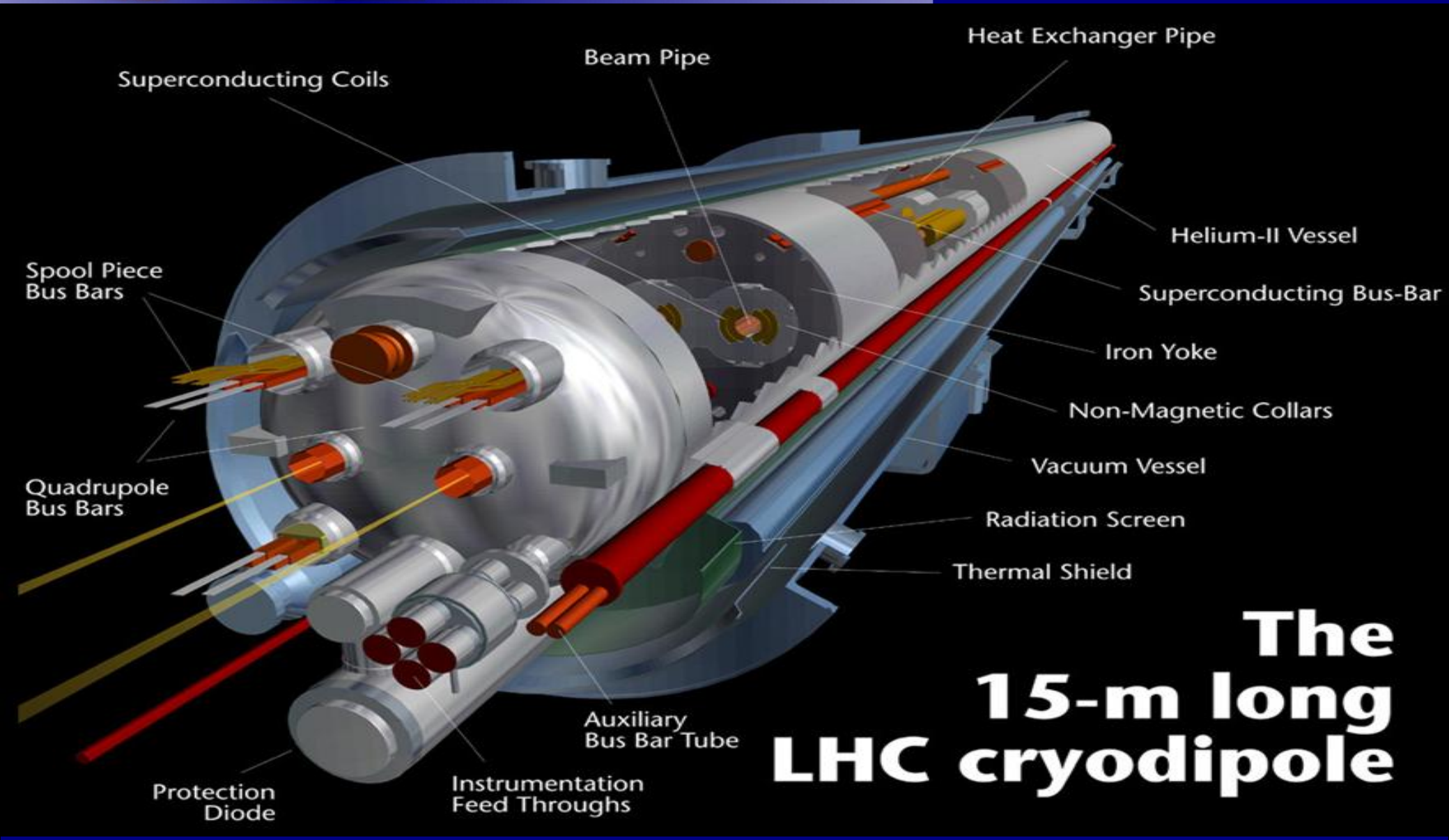
Sonder des distances plus petites fait apparaître des regularités plus profondes

DESCRIPTION UNIFIEES

LHC model



LHC dipole


Heat Exchanger Pipe
Beam Pipe
Superconducting Coils
Helium-II Vessel
Spool Piece
Bus Bars
Superconducting Bus-Bar
Iron Yoke
Non-Magnetic Collars
Quadrupole
Bus Bars
Vacuum Vessel
Radiation Screen
Thermal Shield
The
15-m long
LHC cryodipole
Auxiliary
Bus Bar Tube
Protection
Diode
Instrumentation
Feed Throughs

Approved Construction Projects

Linac4 : Approved in 2007 as a replacement to Linac2

- Energy 160 MeV (cf 50 MeV in Linac2) Doubles the space charge tune shift limit at injection into the booster
- H- Injection : CERN is one of the few labs still using protons
- Construction well underway – Installation and Commissioning 2013-2014
- Connection to PSB depends on finding a ~7 month shutdown of LHC after 2014.

HiRadMat: Materials testing Facility

- Needed for LHC robustness tests – collimators etc. but generally useful.
- Installation complete, initial commissioning underway.

Elena: Extra Low-Energy Antiproton ring

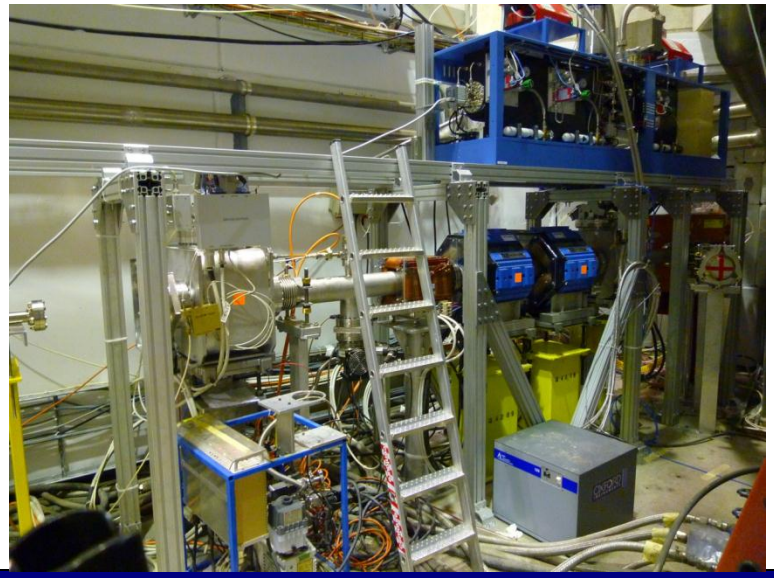
- Post decelerator, downstream from AD
- Momentum at extraction 13.7 MeV/c (Energy 0.1 MeV)
- ~15MCHF Materials cost + 70 MY (Men-Years)

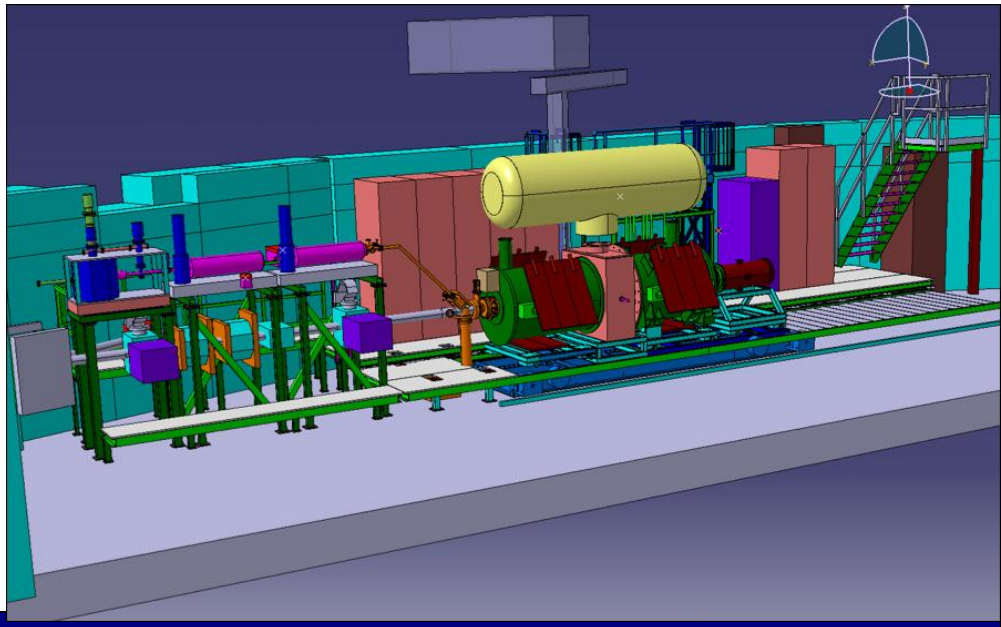
HIE-Isolde: Energy Upgrade for Radioactive beam Post-Accelerator

- Initial upgrade to 5.4 MeV/u (in 2015), Final Energy 10 MeV/u around 2018
- Construction of ¼–wave cavities, cryostats and cryogenic plant for the Linac.
- 35MCHF total budget with ~1/2 from external sources (17.7 MCHF cost of linac)

AD = Antiproton Decelerator

- **4866 hours of physics**
- **Beam availability: 76%, AD uptime: 82%**
- **Good progress towards microwave spectroscopy of trapped anti-hydrogen at ALPHA**
- **First beams delivered to the new AEgIS experiment (antimatter gravitational studies)**





Neutrinos:

- LOI presented to SPSC to re-construct the PS Neutrino facility
- Laguna Study starting up (EU) for a future Long baseline facility
- Combination of these into one facility will also be studied
- Activities on Beta Beams and Neutrino Factories continuing …

Novel Acceleration Research: Proton driven Plasma Wave Acceleration:

- EUROnnac setup as a network for plasma acceleration, beam and laser
- LOI submitted to SPSC
- CERN Unique in having a high energy (450GeV) proton beam available
- High stored energy in the beam– 100x more than SLAC e- facility
- Demonstrate acceleration of an electron beam using proton drive beam

LHeC : 60/120GeV e+- on 7TeV Protons. Strongly supported by ICFA

- Ring-ring and linac-ring options
- Both written up (with the physics) in a conceptual design report
- If agreed to continue, choice of option and directed R&D will be needed.

DRAFT 1.0
Geneva, September 3, 2011
CERN report
ECFA report
NuPECC report
LHeC-Note-2011-003 GEN

A Large Hadron Electron Collider at CERN

Report on the Physics and Design
Concepts for Machine and Detector

LHeC Study Group

THIS IS THE VERSION FOR REFEREEING, NOT FOR DISTRIBUTION

http://cern.ch/lhec

LHeC Study Group

J. Abelleira Fernandez[10,15], C.Adolphsen[39], S.Alekhin[40,11], A.N.Akai[01], H.Aksakal[30], P.Allport[17], J.L.Albacete[37], V.Andreev[25], R.B.Appleby[23], N.Armesto[38], G.Azuelos[26], M.Bai[47], D.Barber[11], J.Bartels[12], J.Behr[11], O.Behnke[11], S.Belyaev[10], I.BenZvi[47], N.Bernard[16], S.Bertolucci[10], S.Bettoni[10], S.Biswal[32], J.Bluemlein[11], H.Boettcher[11], H.Braun[48], S.Brodsky[39], A.Bogacz[28], C.Bracco[10], O.Bruening[10], E.Bulyak[08], A.Bunyatian[11], H.Burkhardt[10], I.T.Cakir[54], O.Cakir[53], R.Calaga[47], E.Ciapala[10], R.Ciftci[01], A.K.Ciftci[01], B.A.Cole[29], J.C.Collins[46], J.Dainton[17], A.De.Roeck[10], D.d'Enterria[10], A.Dudarev[10], A.Eide[43], E.Eroglu[45], K.J.Eskola[14], L.Favart[06], M.Fitterer[10], S.Forte[24], P.Gambino[42], T.Gehrmann[50], C.Glasman[22], R.Godbole[27], B.Goddard[10], T.Greenshaw[17], A.Guffanti[09], V. Guzey[28], C.Gwenlan[34], T.Han[36], Y.Hao[47], F.Haug[10], W.Herr[10], B.Holzer[10], M.Ishitsuka[41], M.Jacquet[33], B.Jeanneret[10], J.M.Jimenez[10], H.Jung[11], J.M.Jowett[10], H.Karadeniz[54], D.Kayran[47], F.Kocac[45], A.Kilic[45], K.Kimura[41], M.Klein[17], U.Klein[17], T.Kluge[17], G.Kramer[12], M.Korostelev[23], A.Kosmicki[10], P.Kostka[11], H.Kowalski[11], D.Kuchler[10], M.Kuze[41], T.Lappi[14], P.Laycock[17], E.Levichev[31], S.Levonian[11], V.N.Litvinenko[47], A.Lombardi[10], C.Marquet[10], B.Mellado[07], K.H.Mess[10], S.Moch[11], I.I.Morozov[31], Y.Muttoni[10], S.Myers[10], S.Nandi[26], P.R.Newman[03], T.Omori[44], J.Osborne[10], Y.Papaphilippou[10], E.Paoloni[35], C.Pascaud[33], H.Paukkunen[38], E.Perez[10], T.Pieloni[15], E.Pilicer[45], A.Polini[04], V.Ptitsyn[47], Y.Pupkov[31], V.Radescu[13], S.Raychaudhuri[27], L.Rinolfi[10], R.Rohini[27], J.Rojo[24], S.Russenschuck[10], C.A.Salgado[38], K.Sampei[41], E.Sauvan[19], M.Sahin[01], U.Schneekloth[11], A.N.Skrinsky[31], T.Schoerner Sadenius[11], D.Schulte[10], H.Spiesberger[21], A.M.Stasto[46], M.Strikman[46], M.Sullivan[39], B.Surrow[05], S.Sultansoy[01], Y.P.Sun[39], W.Smith[20], I.Tapan[45], P.Taels[02], E.Tassi[52], H.Ten.Kate[10], J.Terron[22], H.Thiesen[10], L.Thompson[23], K.Tokushuku[44], R.Tomas.Garcia[10], D.Tommasini[10], D.Trbojevic[47], N.Tsoupas[47], J.Tuckmantel[10], S.Turkoz[53], K.Tywoniuk[18], G.Unel[10], J.Urakawa[44], P.VanMechelen[02], A.Variola[37], R.Veness[10], A.Vivoli[10], P.Vobly[31], R.Wallny[51], G.Watt[10], G.Weiglein[12], C.Weiss[28], U.A.Wiedemann[10], U.Wienands[39], F.Willeke[47], V.Yakimenko[47], A.F.Zarnecki[49], F.Zimmermann[10], F.Zomer[33]

About 150 Experimentalists and Theorists from 50 Institutes
Tentative list

Thanks to all and to
CERN, ECFA, NuPECC

Draft LHeC CDR completed (~600 pages)
TDR by 2014,
Could have first beam by 2022

What is a fb^{-1} ?

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

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

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 ($4 \times 10^{+14}$) of which approximately:
100 million produce W and Z's
1 million top quark events
20,000 Higgs … if it is there!
… a needle in a haystack

Proton Luminosity in 2011

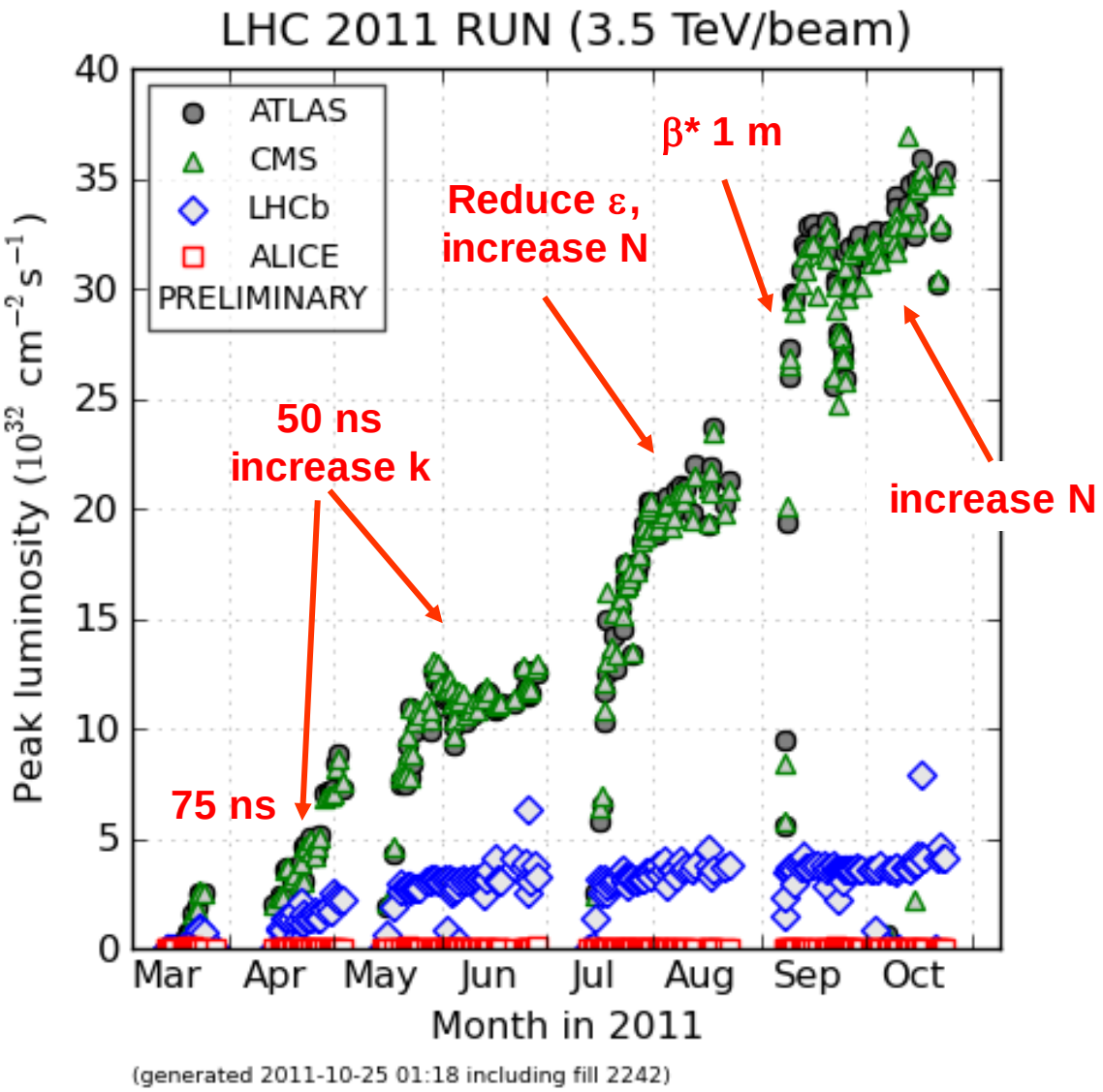
Peak luminosity

3.6×10^{33} $cm^{-2}s^{-1}$

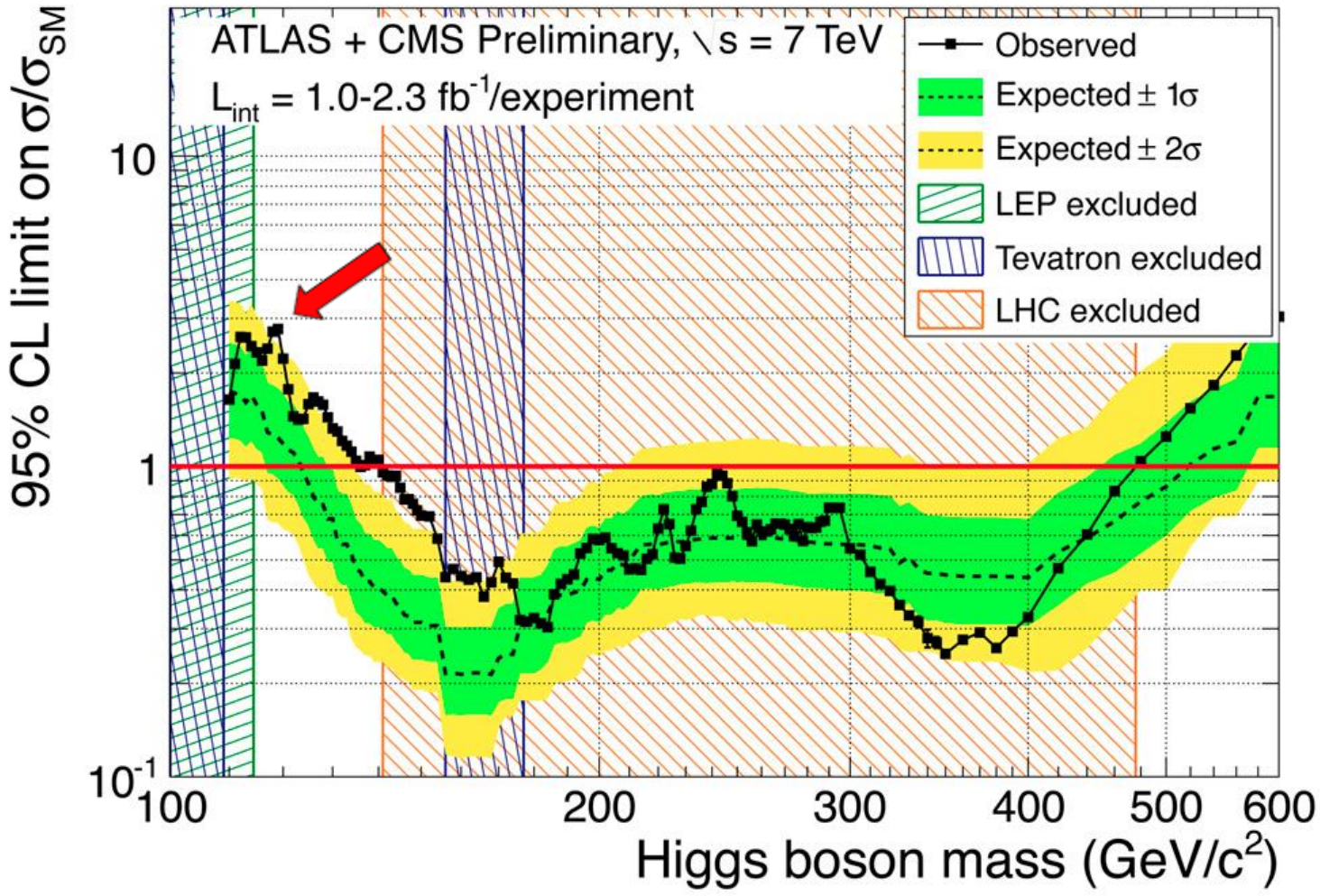
1380 bunches

Stored Energy in each beam >100MJ

LHCb luminosity limited to ~3.5×10^{32} $cm^{-2}s^{-1}$ by leveling (beams collide with transverse off



Preliminary results at the end of 2011



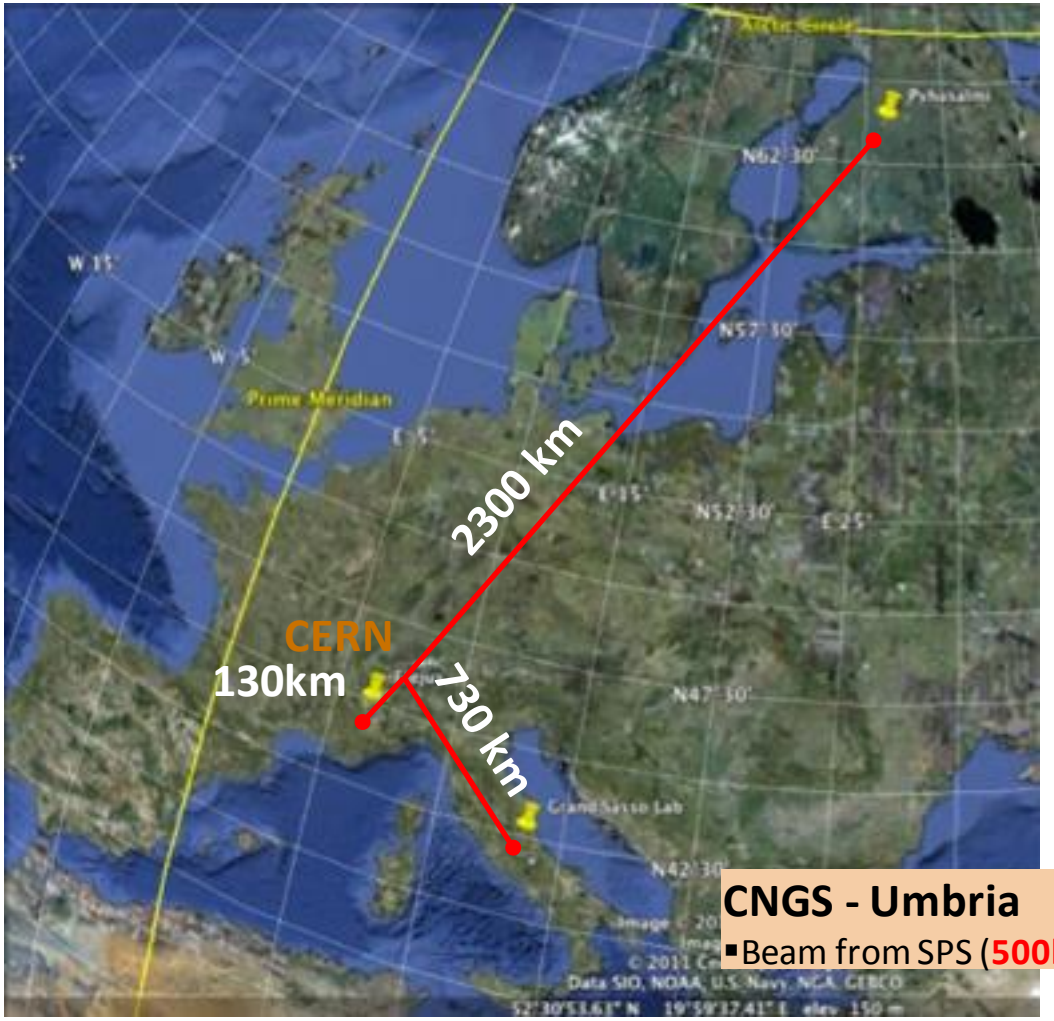
ν-Beams: Long Baseline options from CERN

Laguna design Study 2011-2014 - Large underground detectors

CN2PY (Pyhasalmi)
- Initial : beam from SPS (500kW - **750kW**)
- Long term: **LP-SPL + HPPS - 2MW**

CN2FR (Frejus)
- **HP-SPL + accumulator ring (5 GeV – 4 MW)**

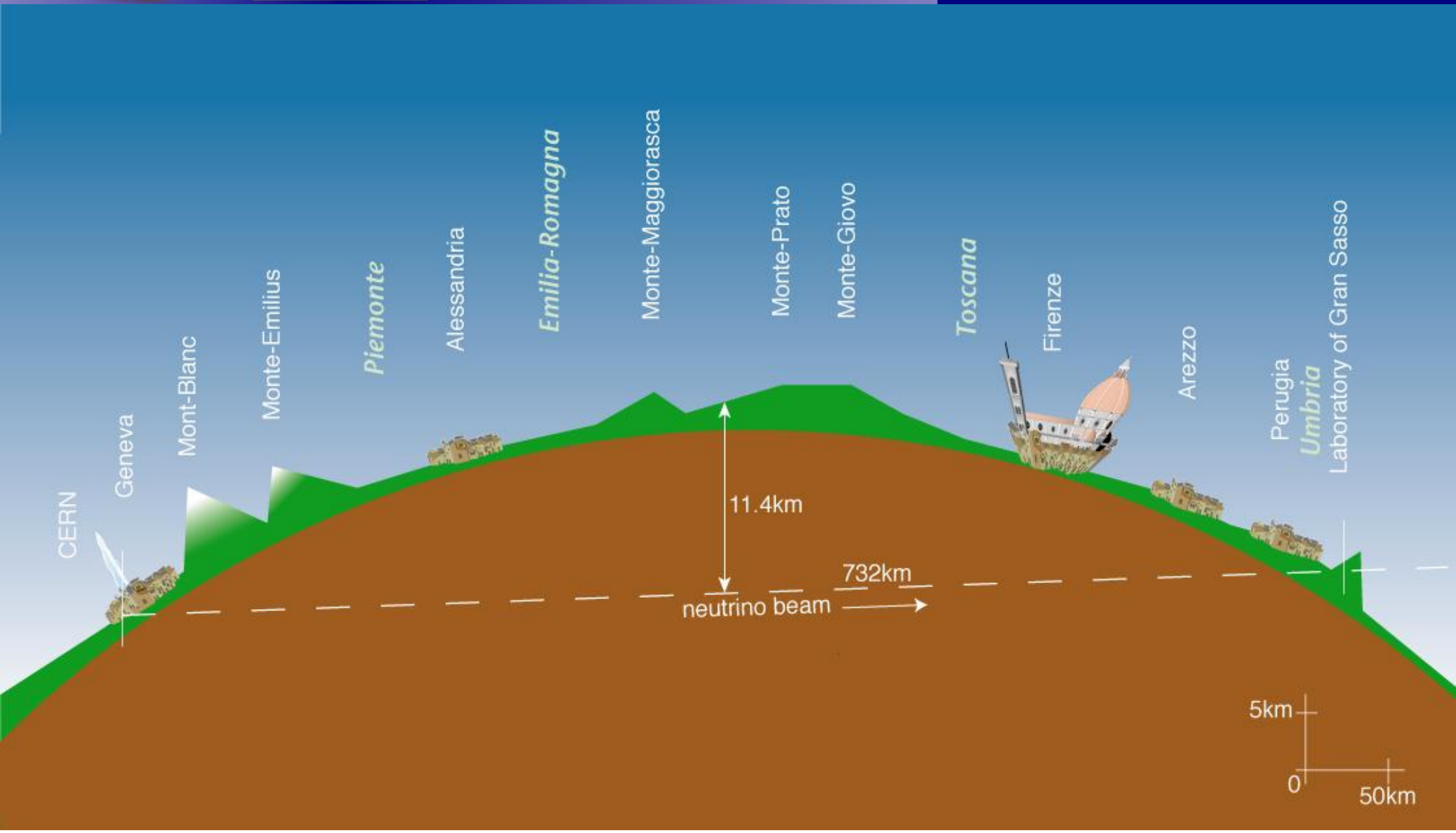
Synergy with β-beam (γ=100)



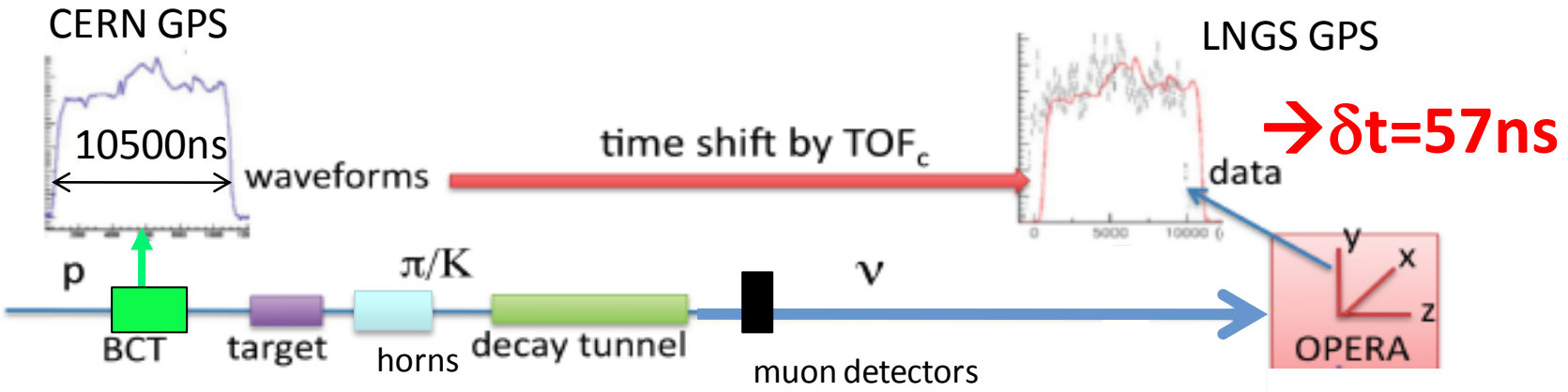
CNGS - Umbria
- Beam from SPS (**500kW**)

CERN Neutrino to Gran Sasso

CNGS



CNGS activities as a consequence of the OPERA results on the neutrino velocity measurements



CNGS nominal beam is 10500ns long

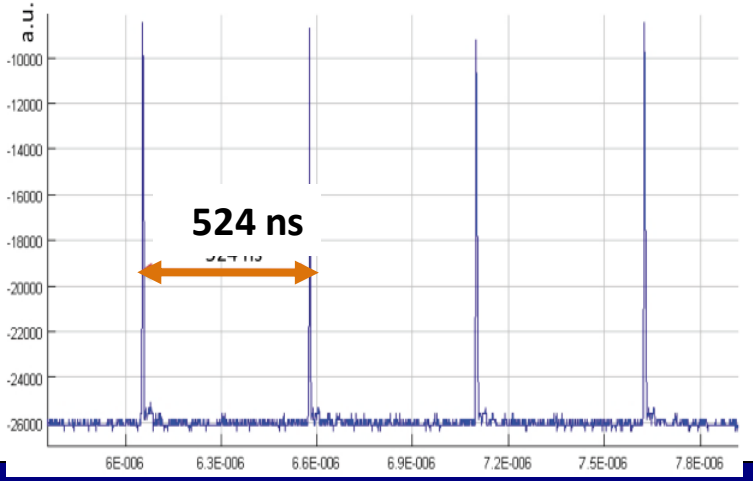
- A lot of statistics needed for time of flight analysis
- Many possible systematic effects along the secondary beam line

$$\delta v = (x_2 - x_1) / (t_2 - t_1)$$

→ Send LHC type bunched beam to CNGS

- Precise timing of each neutrino interaction
- Many systematic effects excluded
  - bunched beam was set up very efficiently
  - operation from 21 Oct to 6 Nov 2011
  - 4 bunches, each 2ns long, separated by 524ns

→ Results included in final OPERA paper



Courtesy E. Gschwendtner

Higgs or not Higgs boson ?

Neutrino faster than the light ?

96 % of the mass of the Universe unknown ?

Future is very exciting for the Sciences and for young scientists