LHC
Una grande avventura

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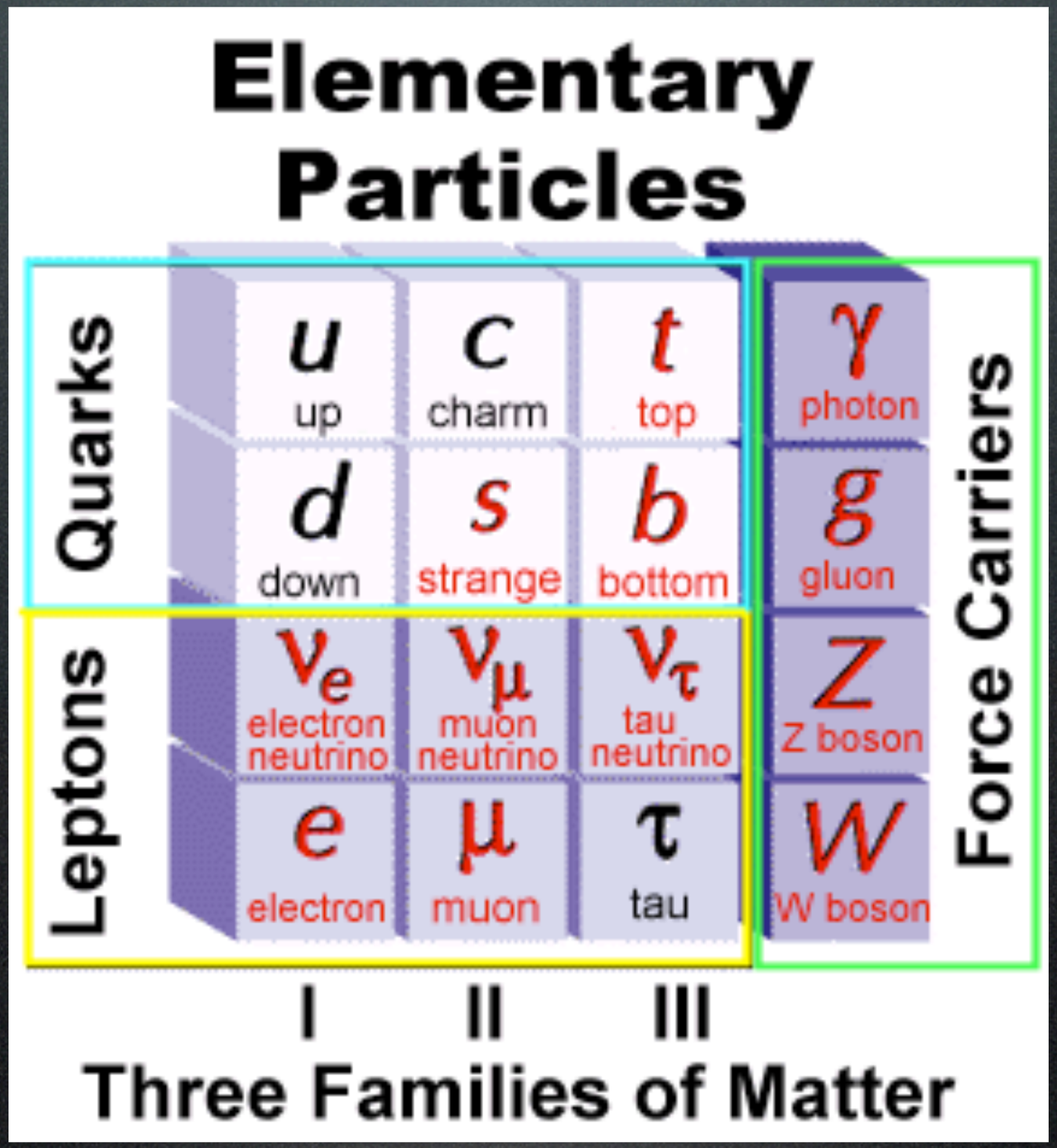
Indice

- Il meraviglioso e incompleto SM
- L’acceleratore del terzo millennio
- Gli esperimenti
- Il ruolo del nostro paese

I mattoncini del mondo



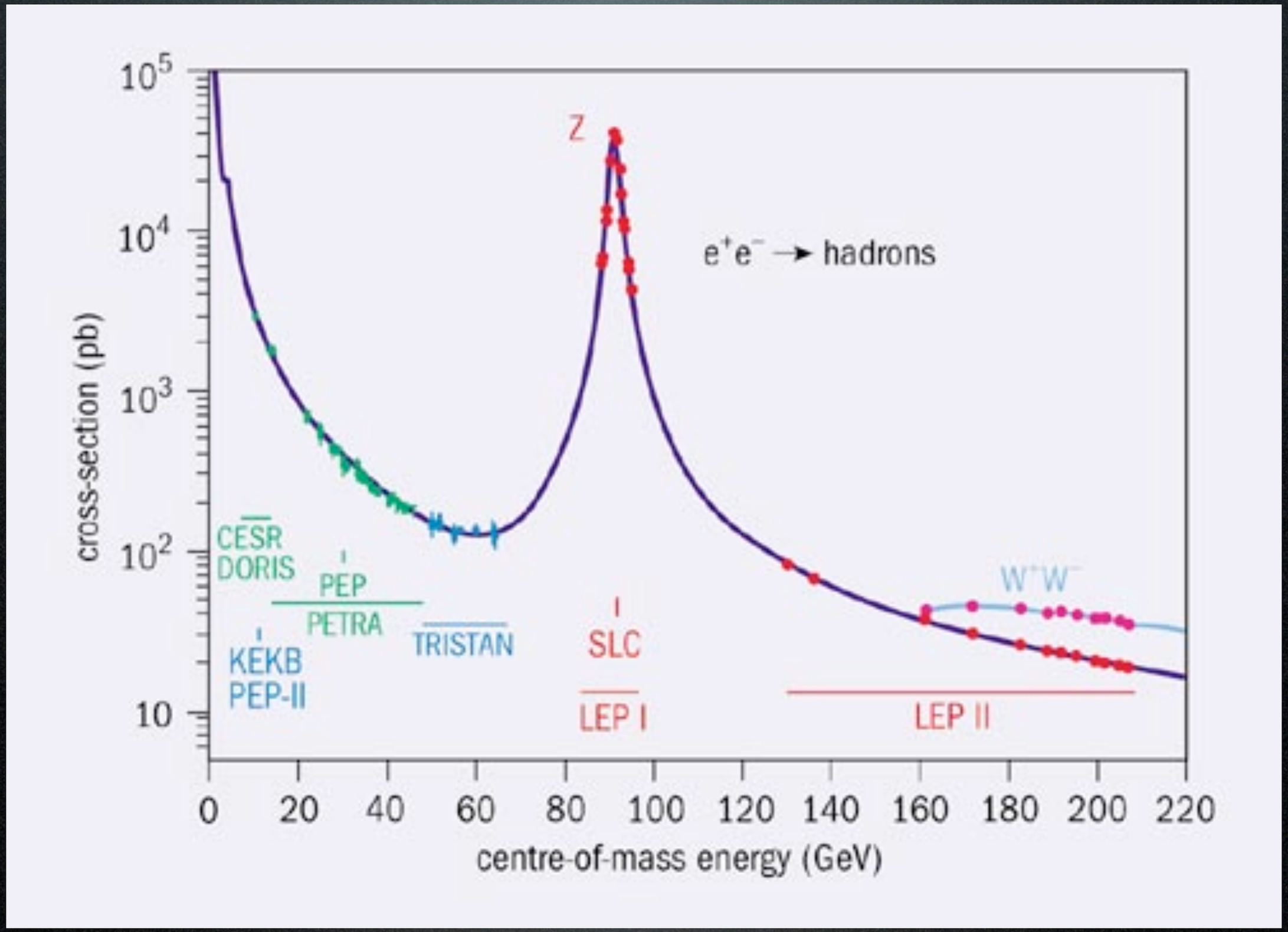
una serie di scoperte

- quarks : 1968 (SLAC)
- c(harm) quark: 1974 (BNL-SLAC)
- τ lepton : 1976 (SLAC)
- b(eauty) quark: 1977 (Fermilab)
- gluon : 1979 (Petra)
- W, Z : 1983 (CERN - Rubbia)
- t(op) quark : 1995 (Fermilab)
- ν_τ : 2000 (Fermilab)

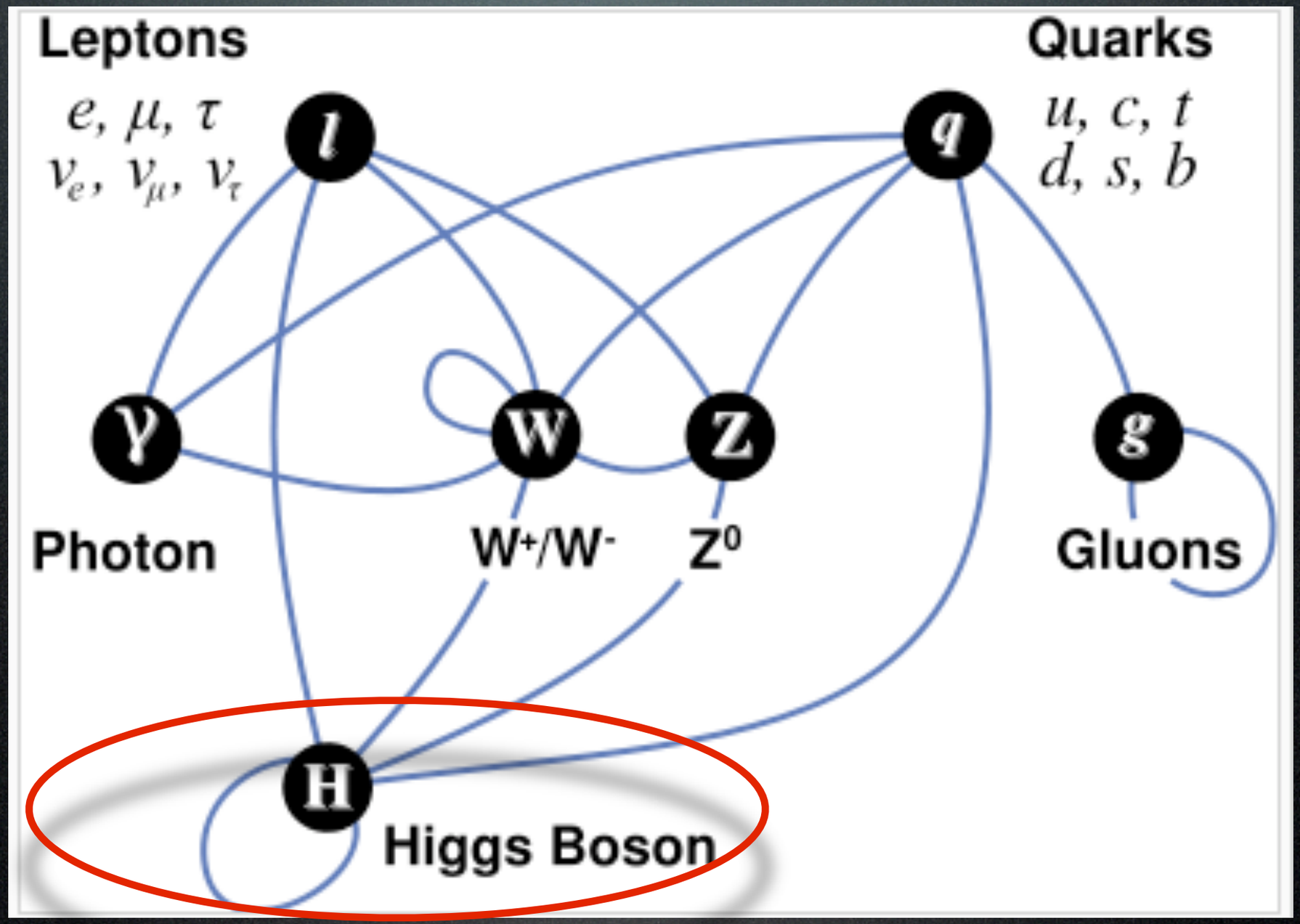
guidate da una teoria

- teorie non abeliane di gauge: Yang-Mills 1954
- Modello Standard: Weinberg-Salaam-Glashow 1967->
- Rinormalizzazione: ‘t Hooft- Veltman 1971
- Meccanismo di Higgs: Higgs 1964

la potenza di una teoria

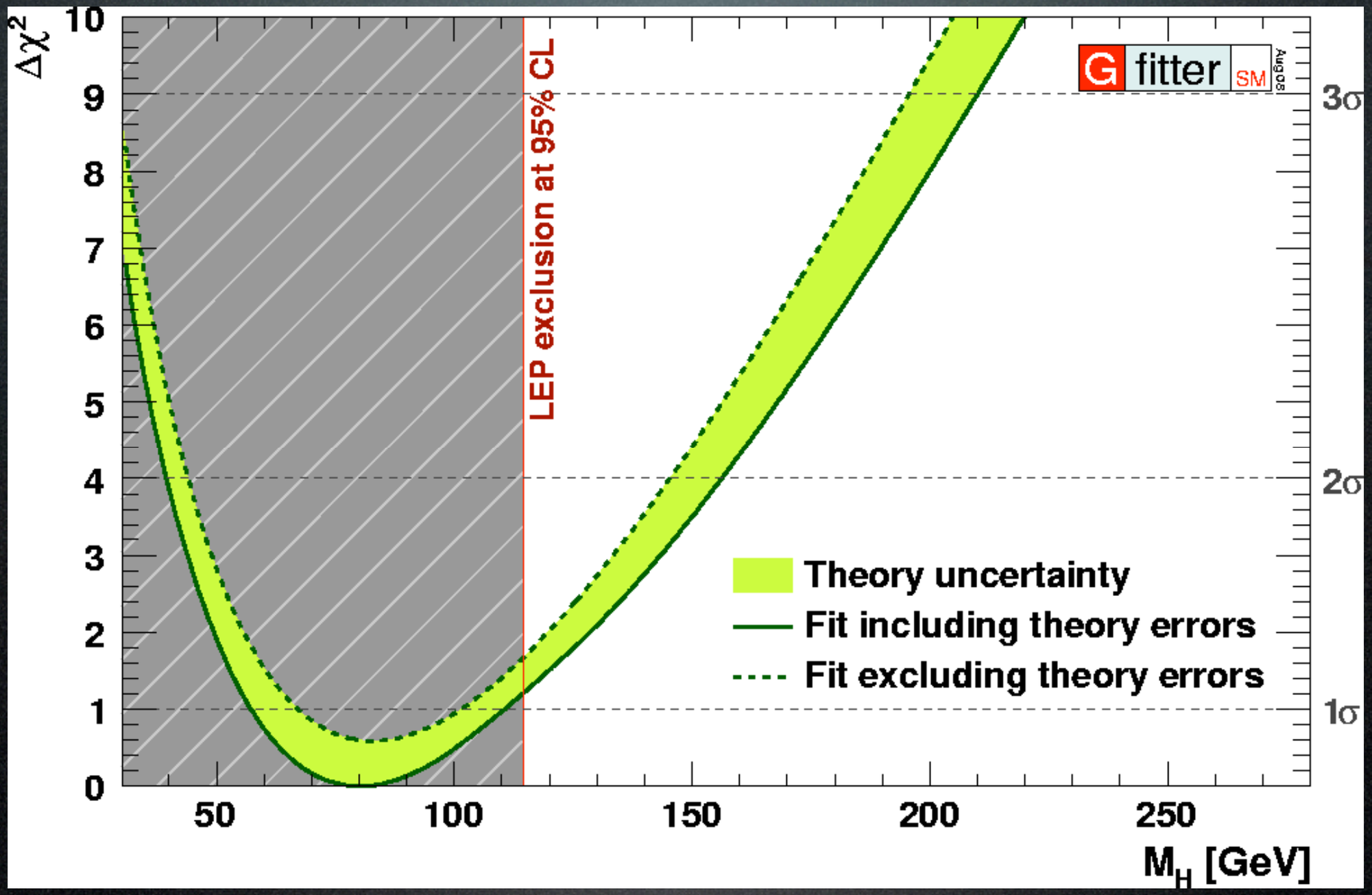


con un problema (molto serio)



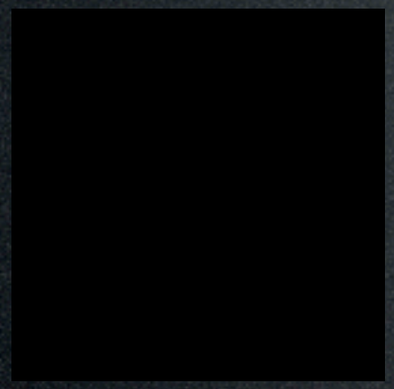
Higgs e' il sale dell'universo. Senza di lui niente avrebbe massa.

e dove e' ?

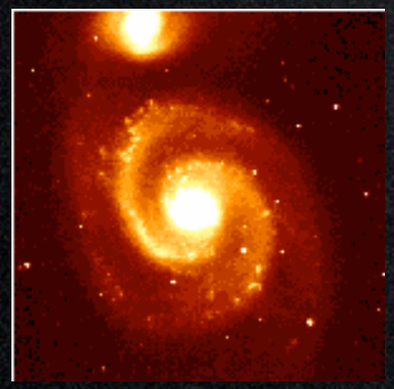


serve LHC per dircelo

una chiamata dal cosmo



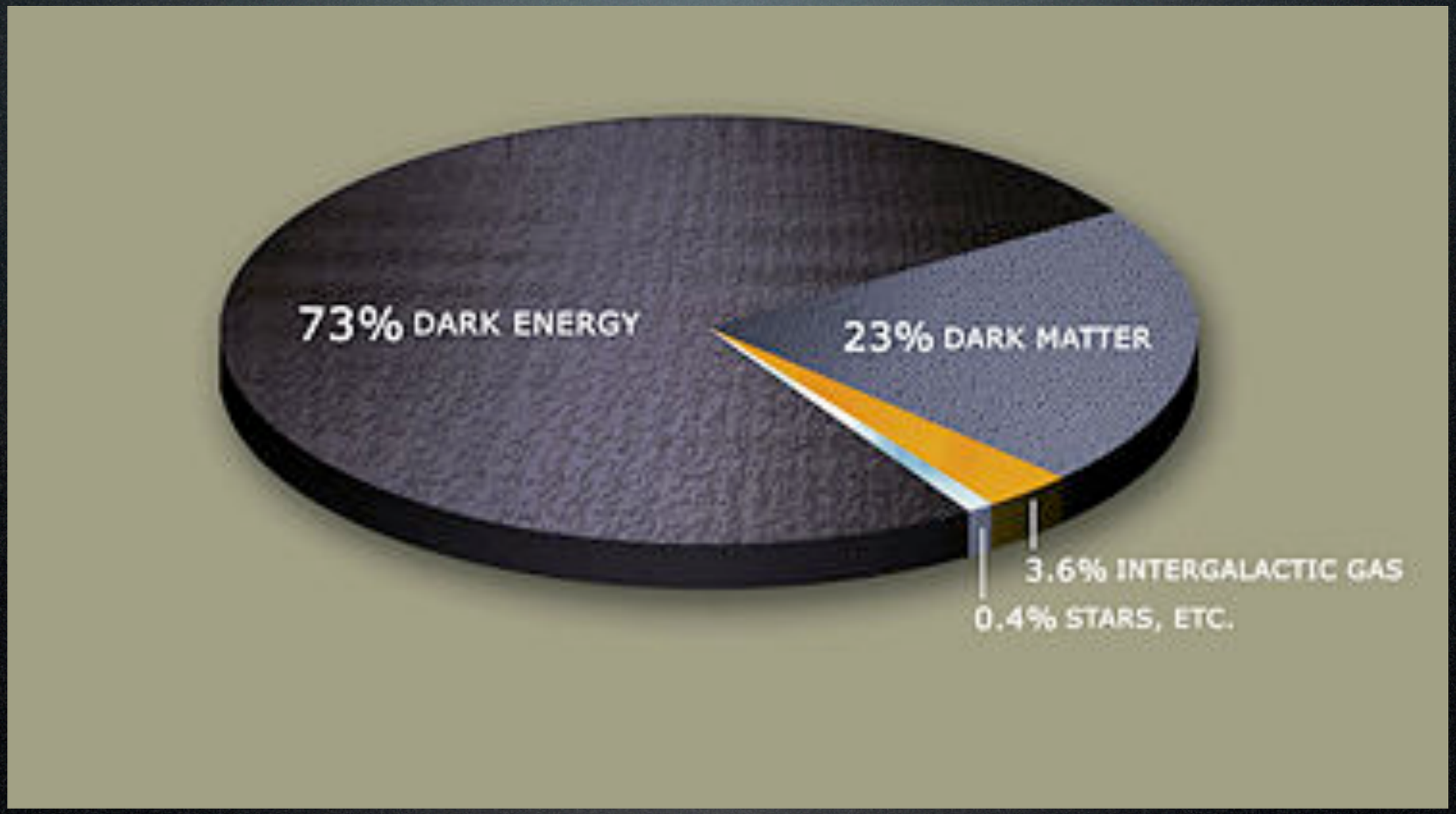
materia
oscura



materia
luminosa

rosso: materia da raggi X
blu: materia da effetti gravitazionali

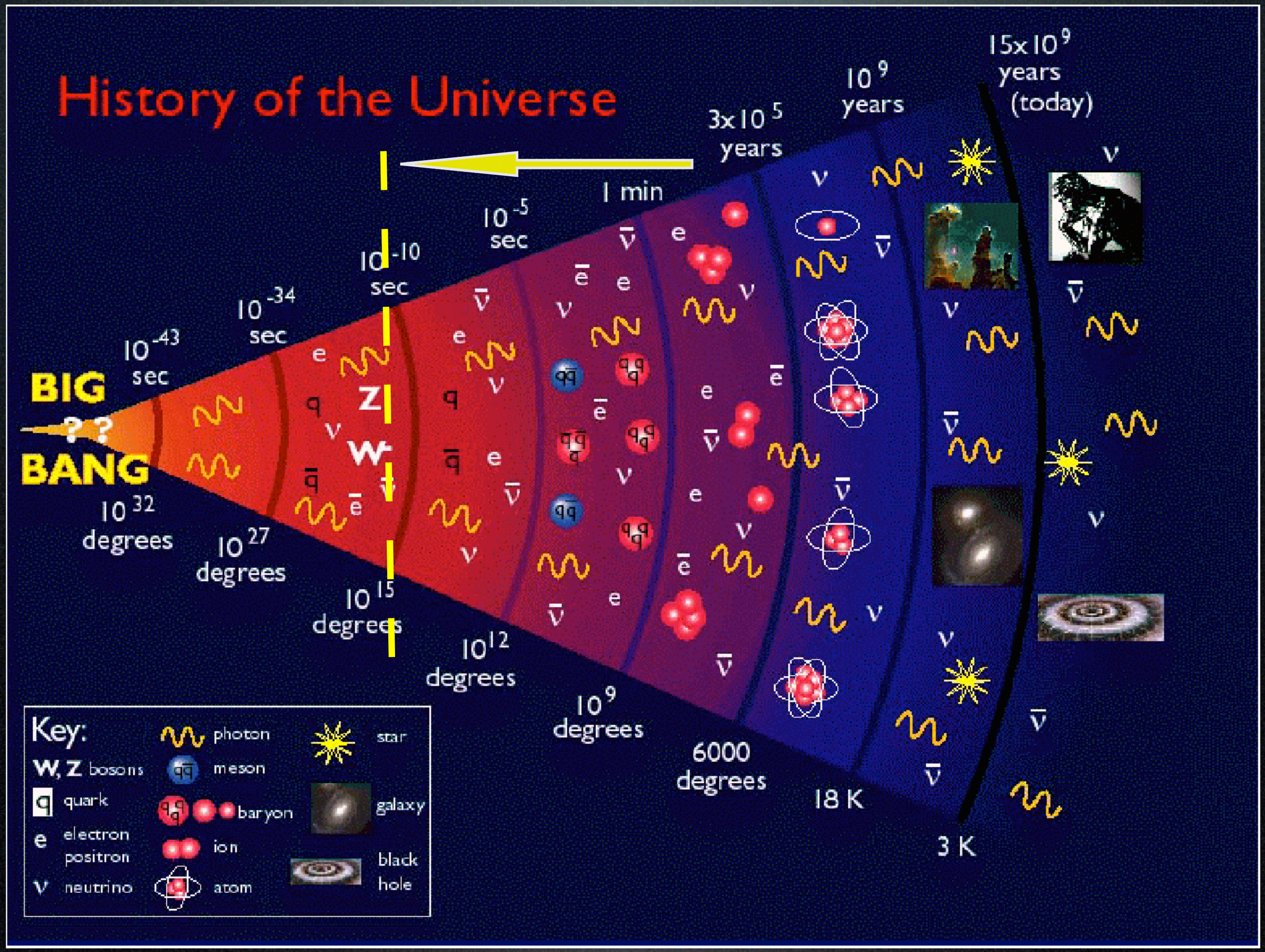
Houston, we have a problem



il 96% dell’universo e’ fatto di cose che non conosciamo

La risposta e’

- nella evoluzione dell’universo e i nostri acceleratori di particelle ci permettono di risalire indietro nel tempo


History of the Universe
BIG
??
BANG
10^-43 sec
10^-34 sec
10^-10 sec
10^-5 sec
1 min
3x10^5 years
10^9 years
15x10^9 years (today)
10^32 degrees
10^27 degrees
10^15 degrees
10^12 degrees
10^9 degrees
6000 degrees
18 K
3 K
Key:
W, Z bosons
quark
e electron positron
ν neutrino
photon
meson
baryon
ion
atom
star
galaxy
black hole

ricapitolando

- LHC per svelare il bosone di Higgs
- LHC per comprendere la materia oscura
- LHC per tornare indietro nel tempo

The LHC accelerator

- 1232 LHC dipoles, plus ~600 other smaller magnets

- E_{beam} = 7000 GeV ~ 7×10^{12} eV ~ 5 trillions 1.5V batteries

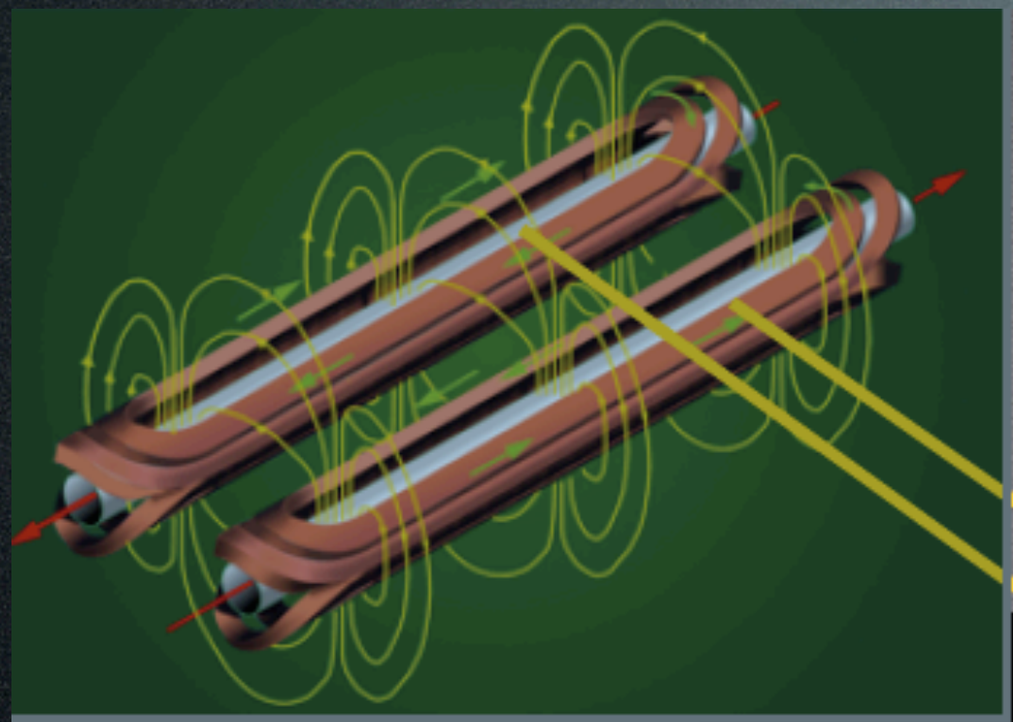
~ 100 M km of batteries,
about d[Earth-Sun]

- E_{beam} = 7000 GeV ~ 7500 $m_{proton}\, c^2$
  - $E=mc^2 / \sqrt{[1-v^2/c^2]}$ ➪ v = 0.999 999 99 c

- N_{proton} ~ 10^{11}/bunch x 2800 bunches/beam x 2 beams ~ 10^{14}

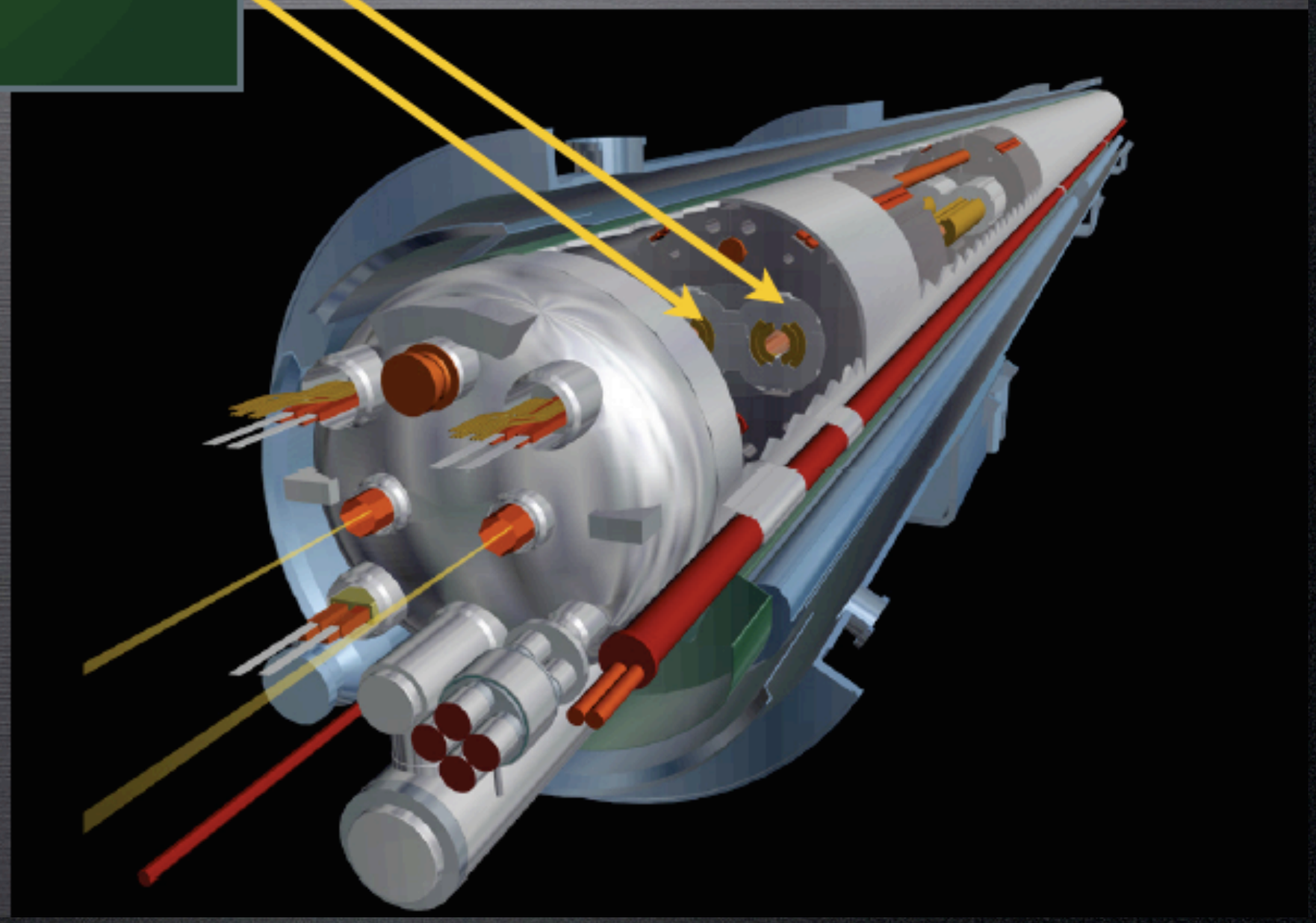
- Energy stored ~ 350 MJ ~ 100Kg of TNT

~ Treno ETR ad alta velocita'



The LHC dipole magnet

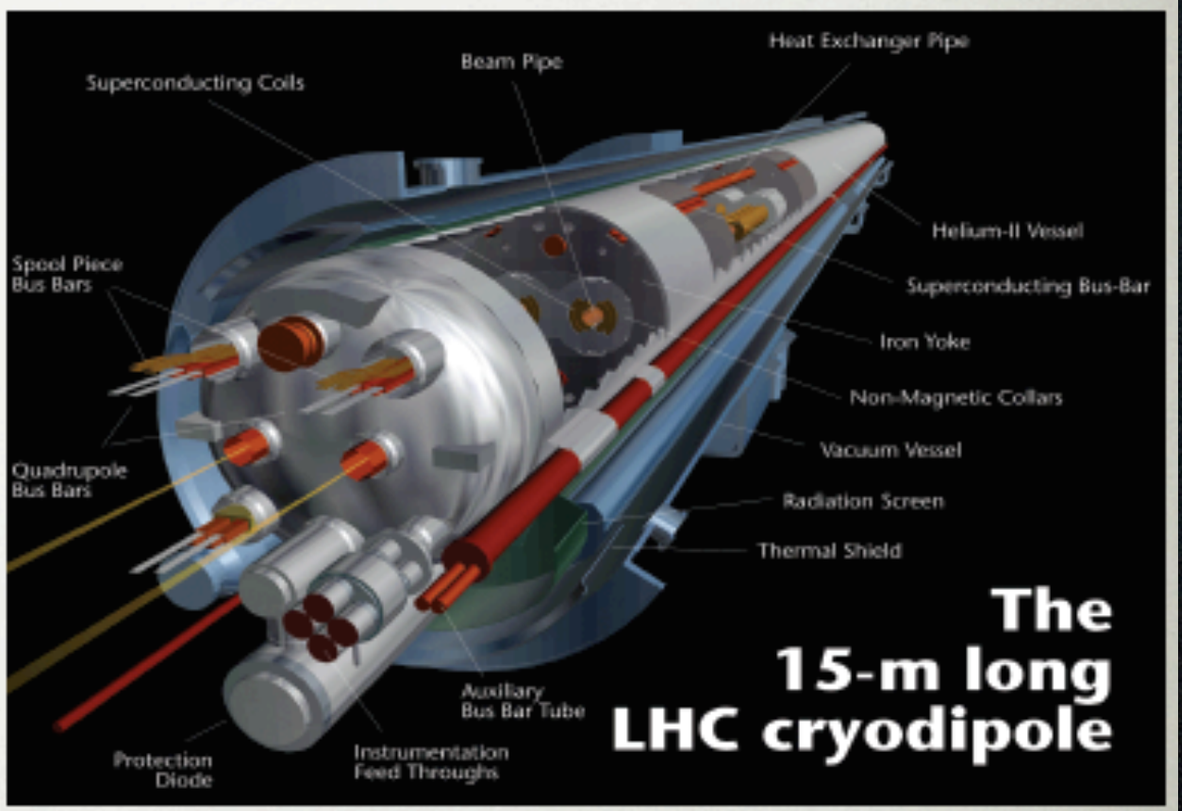
http://cerncourier.com/cws/article/cern/29011



- B field = 83,000 Gauss
  - Ni Ti SC cable

(Earth's field ~ 0.5 Gauss)

- T = 1.9K^0
  - superfluid liquid Helium
- 35 tonnes



- 15m long

- Stress at the collar: 150 MPa
  - ~ 22,000 psi
  - ~ 1,500 kg/cm^2

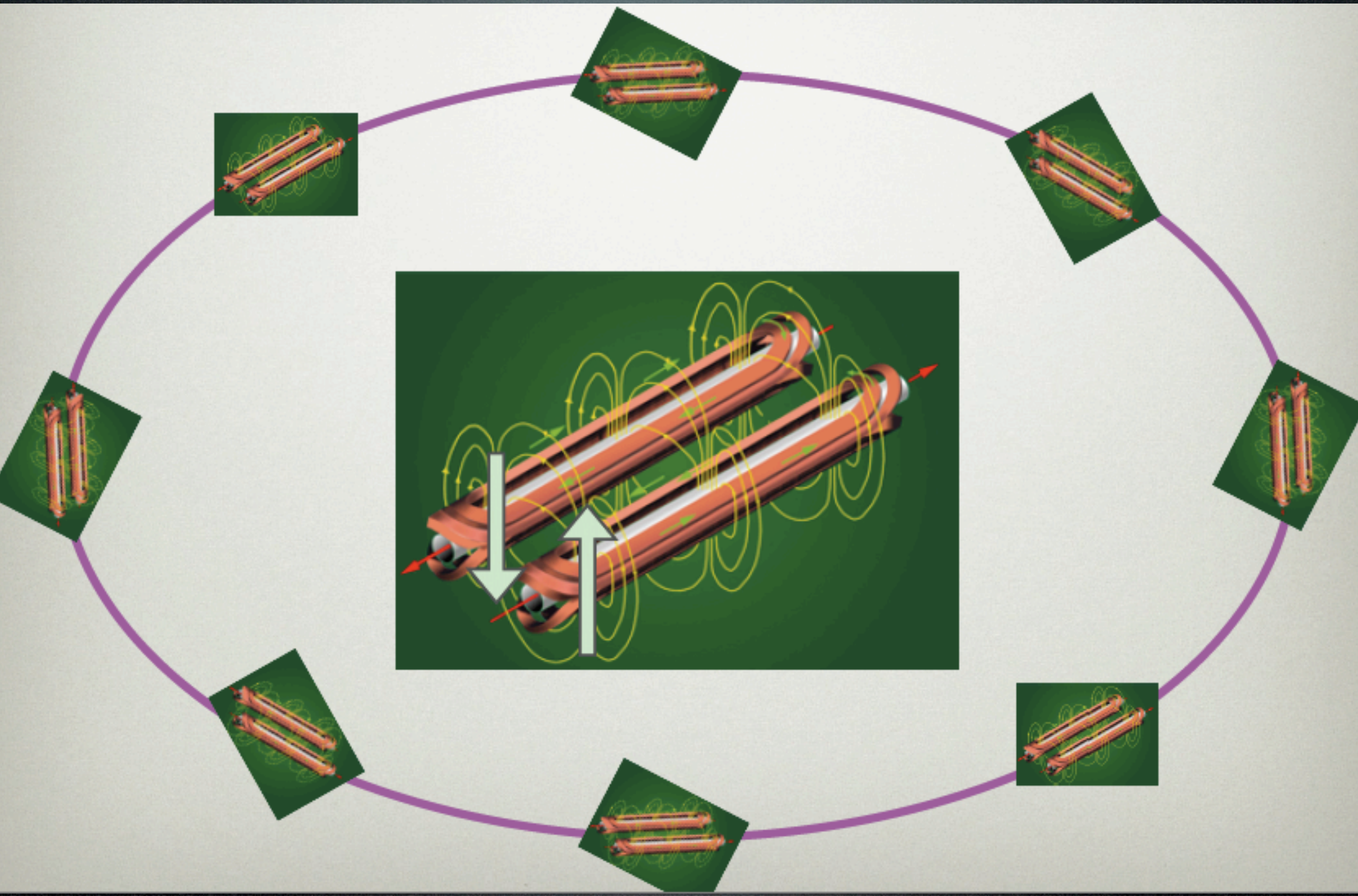
- Stored energy: 7 MJoule

A great lecture on LHC dipoles:

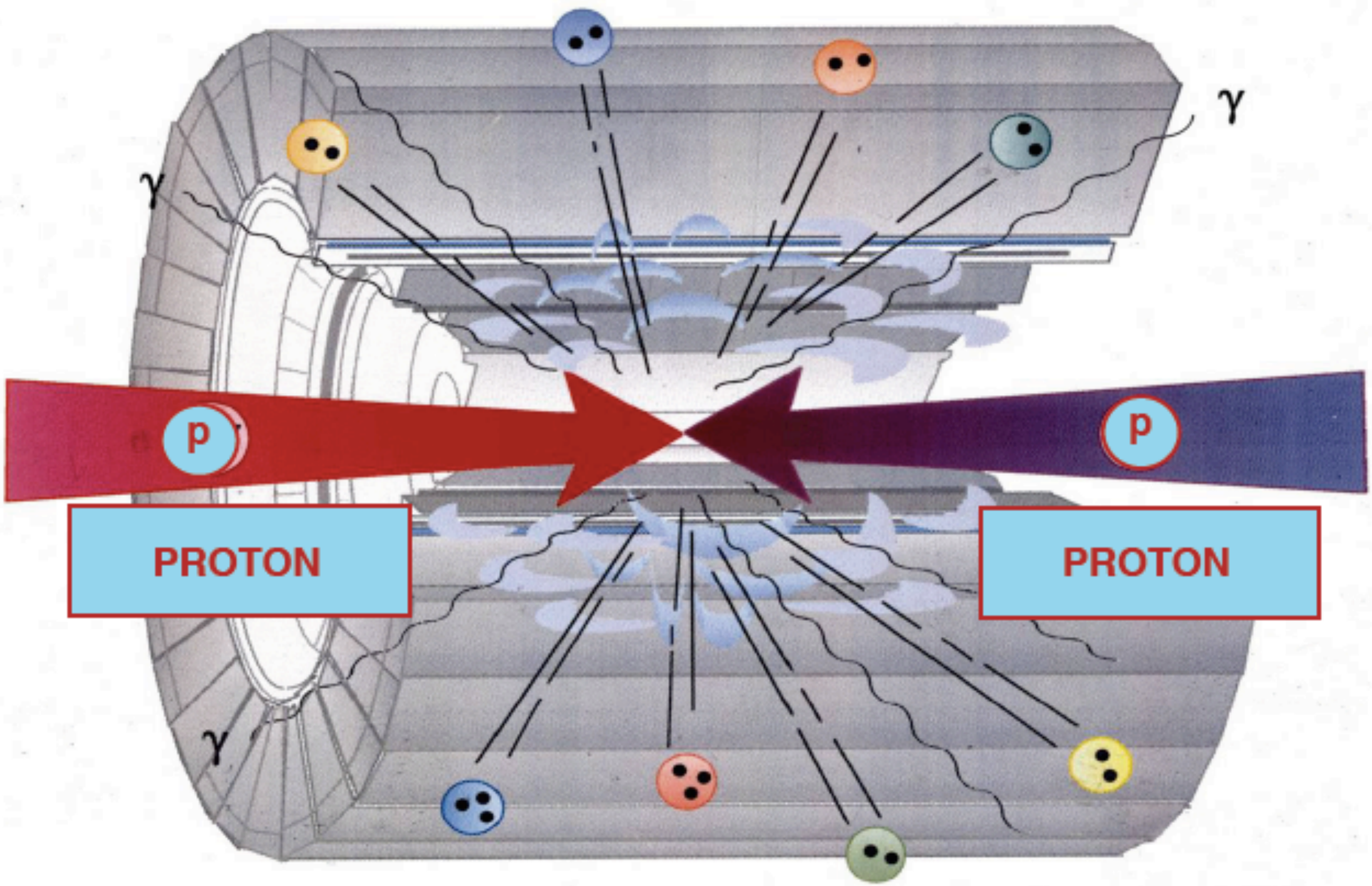
L.Rossi, slides: http://indico.cern.ch/materialDisplay.py?sessionId=18&materialId=0&confId=a042016

video: http://indico.cern.ch/materialDisplay.py?sessionId=18&materialId=1&confId=a042016

Questo e' LHC !



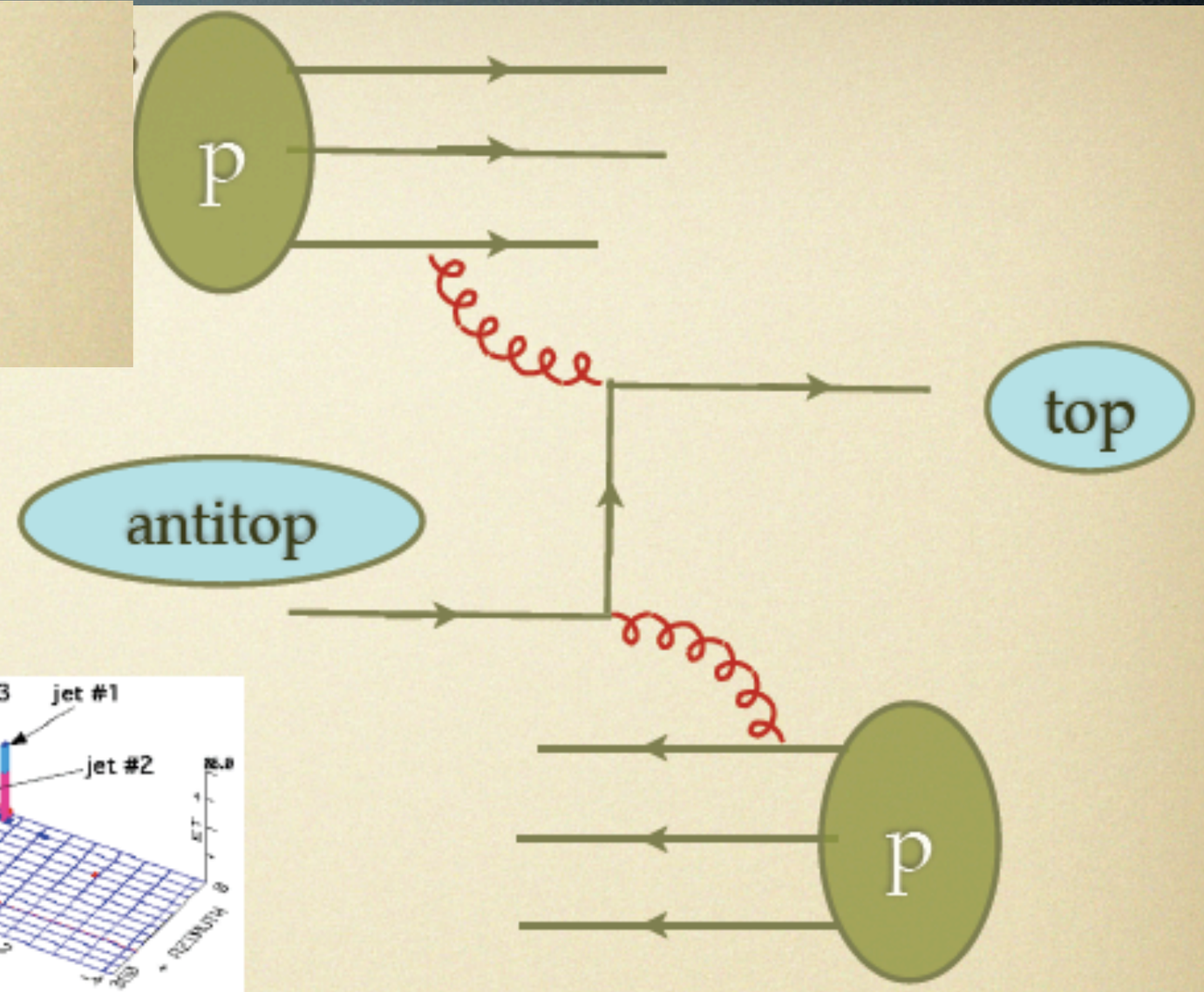
il concetto di esperimentoe' semplice

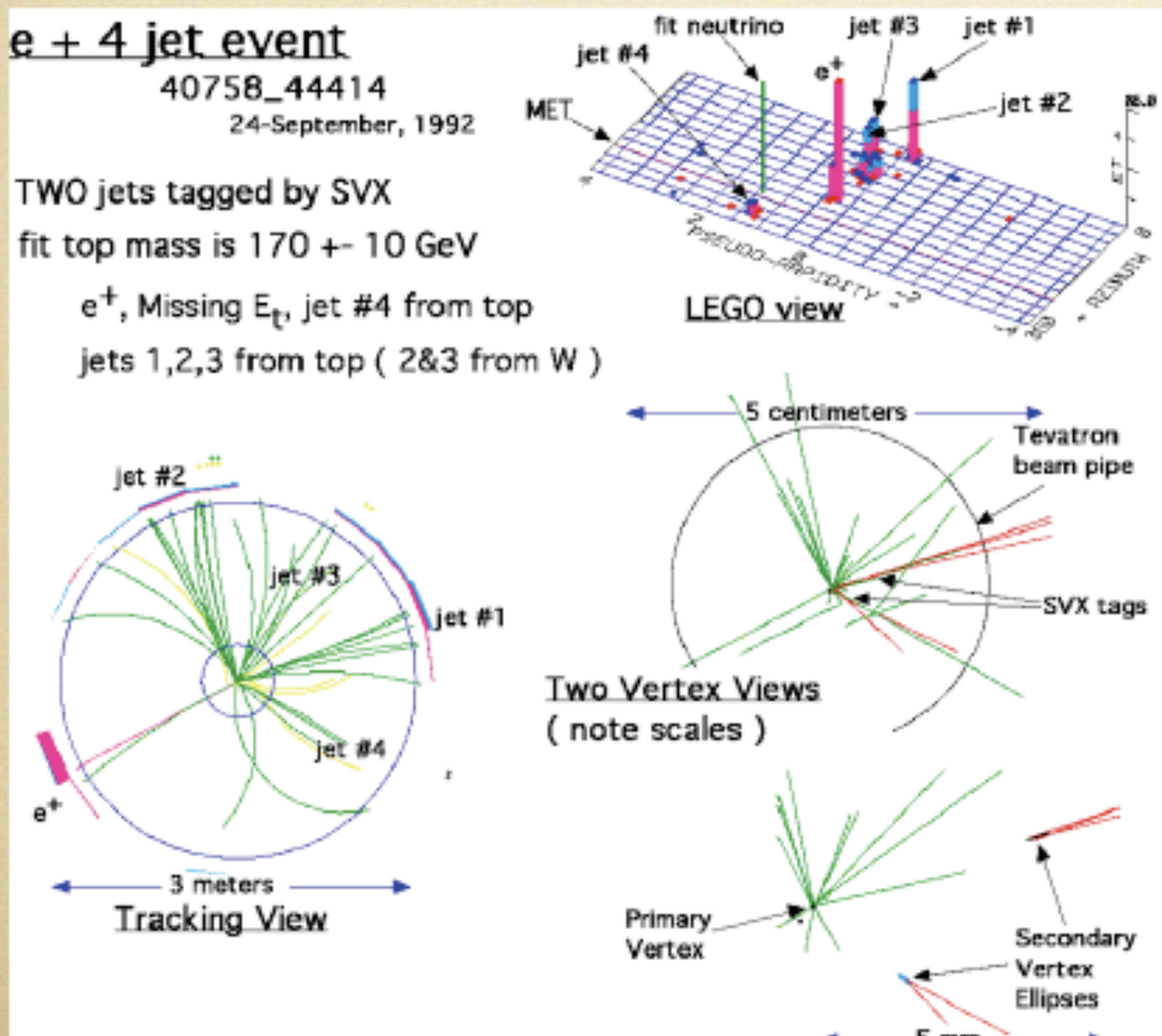


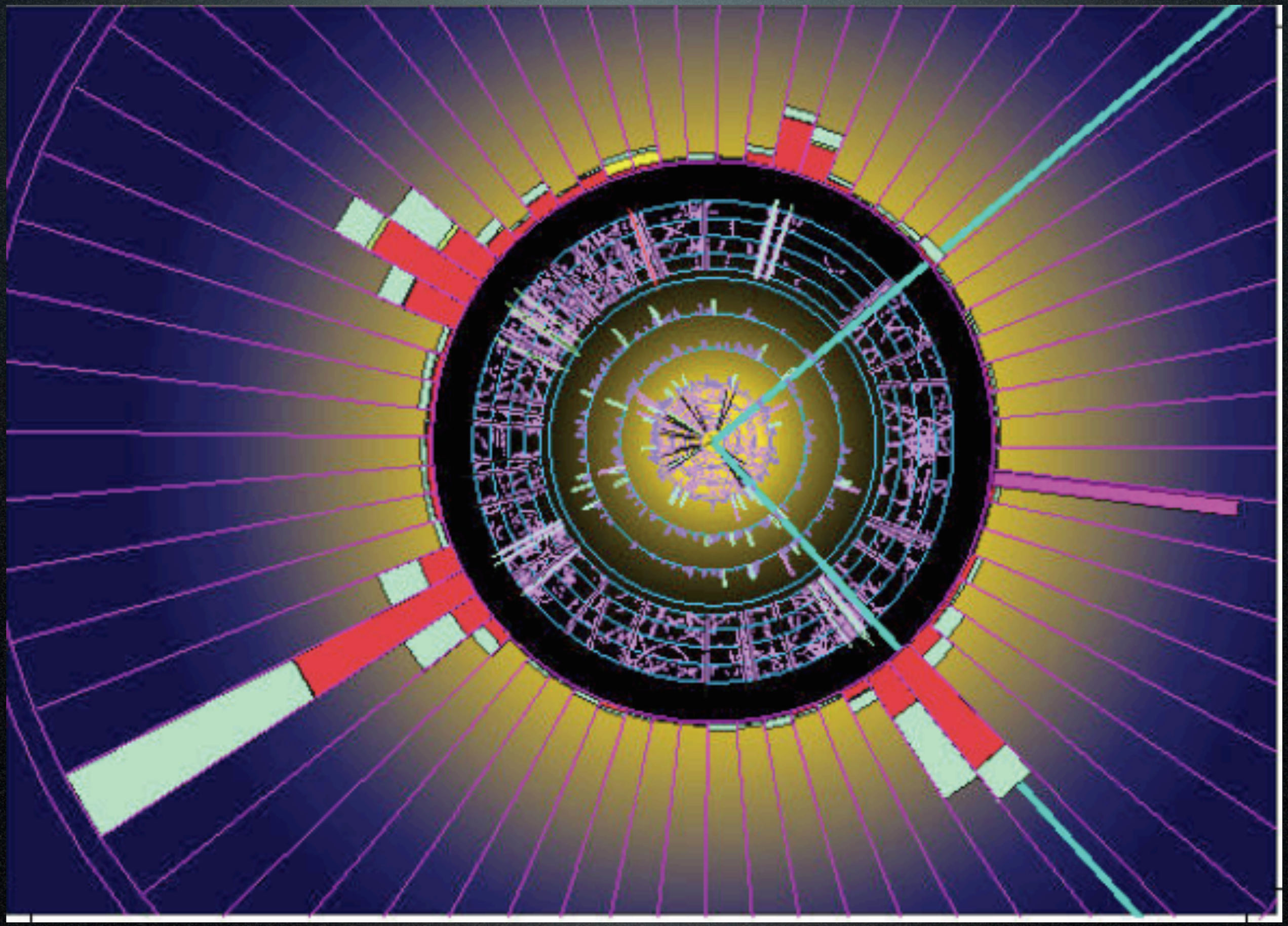
Un esempio da CDF (Fermilab)

gluon-gluon reactions:

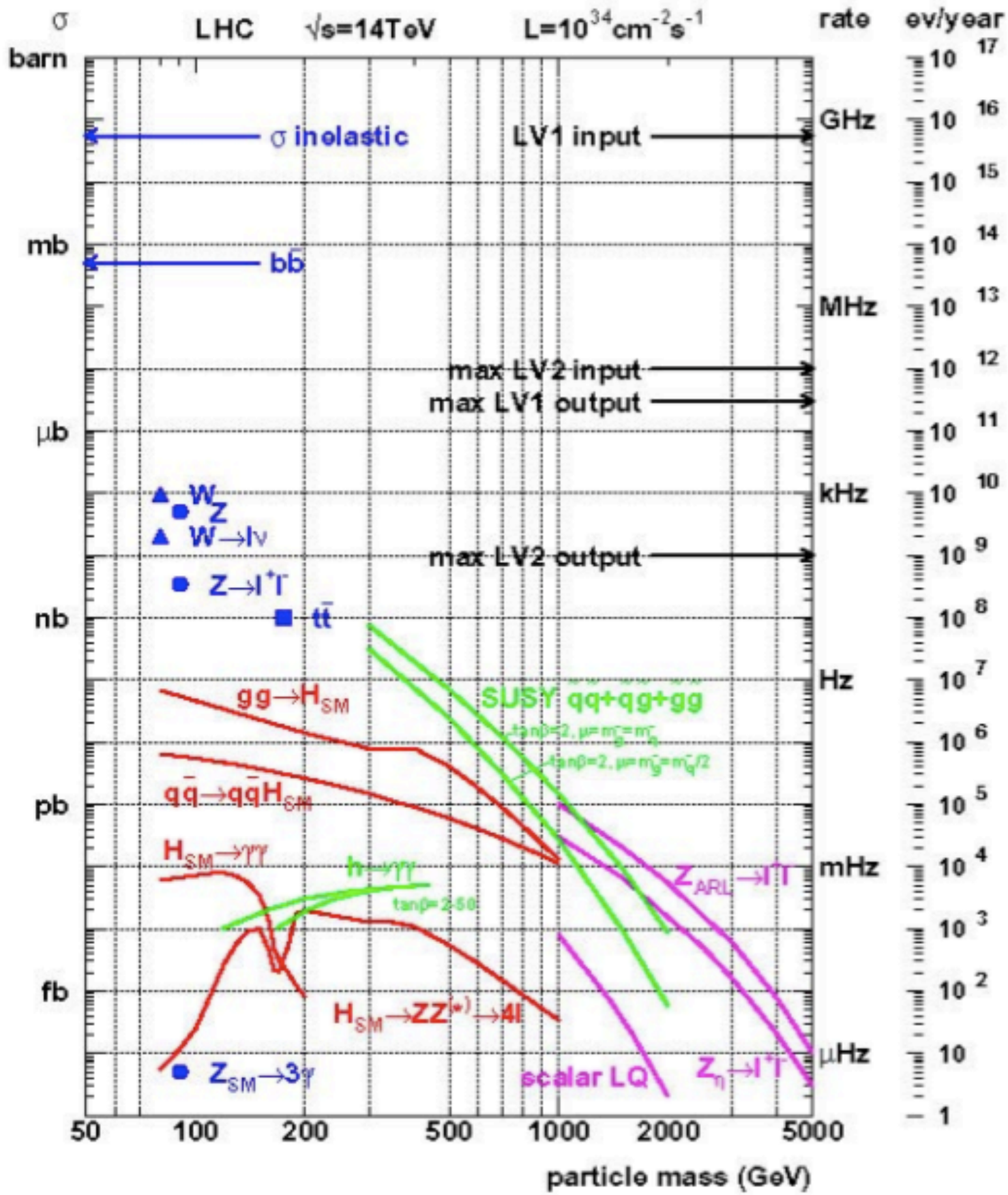
gg → top antitop







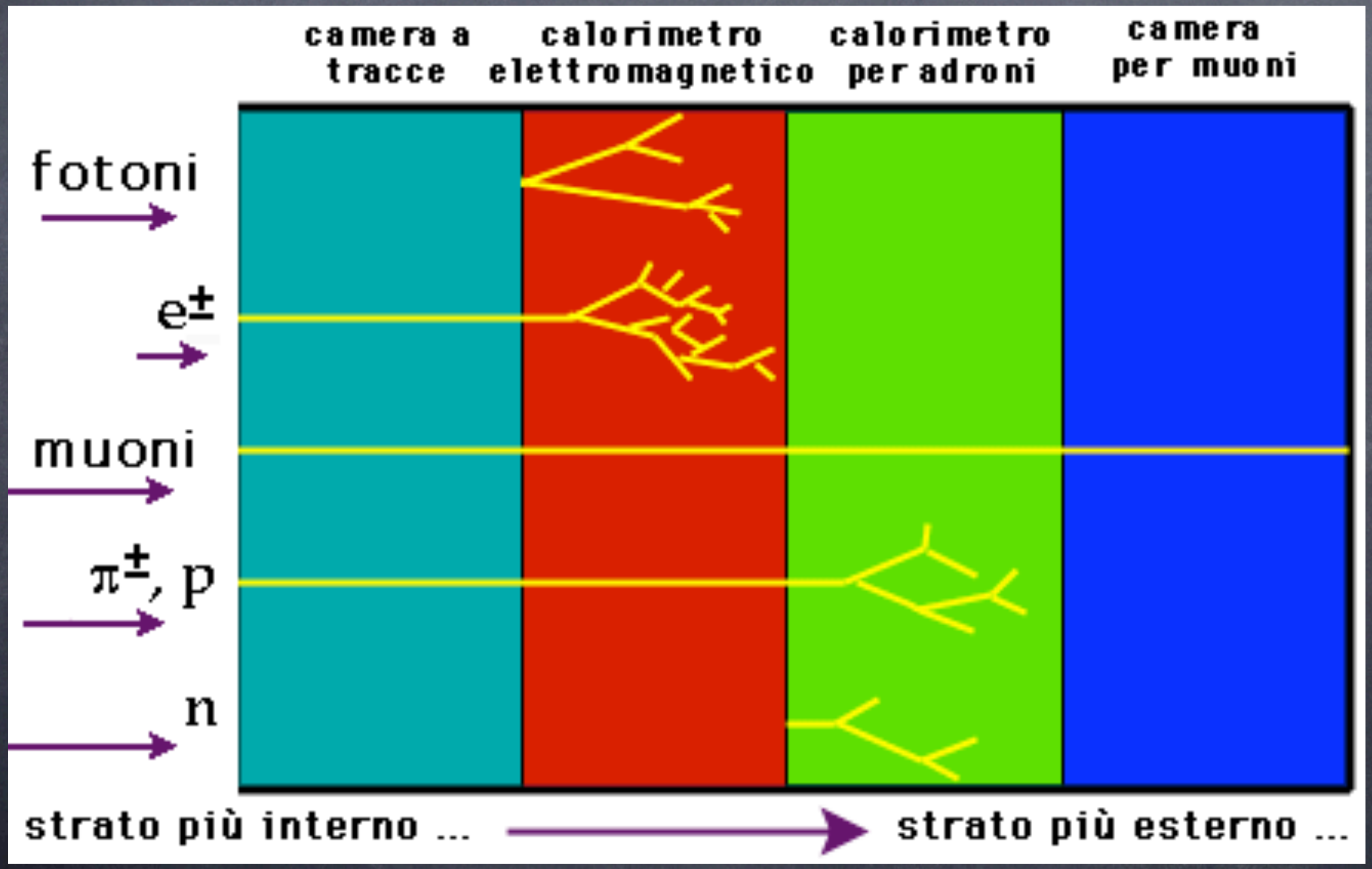
La sfida


σ
barn
mb
μb
nb
pb
fb
LHC
√s=14TeV
L=10^34 cm^-2 s^-1
rate
ev/year
GHz
MHz
kHz
Hz
mHz
μHz
σ inelastic
bb̄
LV1 input
max LV2 input
max LV1 output
max LV2 output
W
Z
W→lν
Z→l+l-
tt̄
gg→H_SM
qq̄→qq̄H_SM
H_SM→γγ
h→γγ
tanβ=2-50
H_SM→ZZ(*)→4l
Z_SM→3γ
SUSY q̃q̃+q̃g̃+g̃g̃
tanβ=2, μ=m_g̃=m_q̃
tanβ=2, μ=m_g̃=m_q̃/2
Z_ARL→l+l-
scalar LQ
Z_η→l+l-
50
100
200
500
1000
2000
5000
particle mass (GeV)

Un ago ! Quanta paglia ?

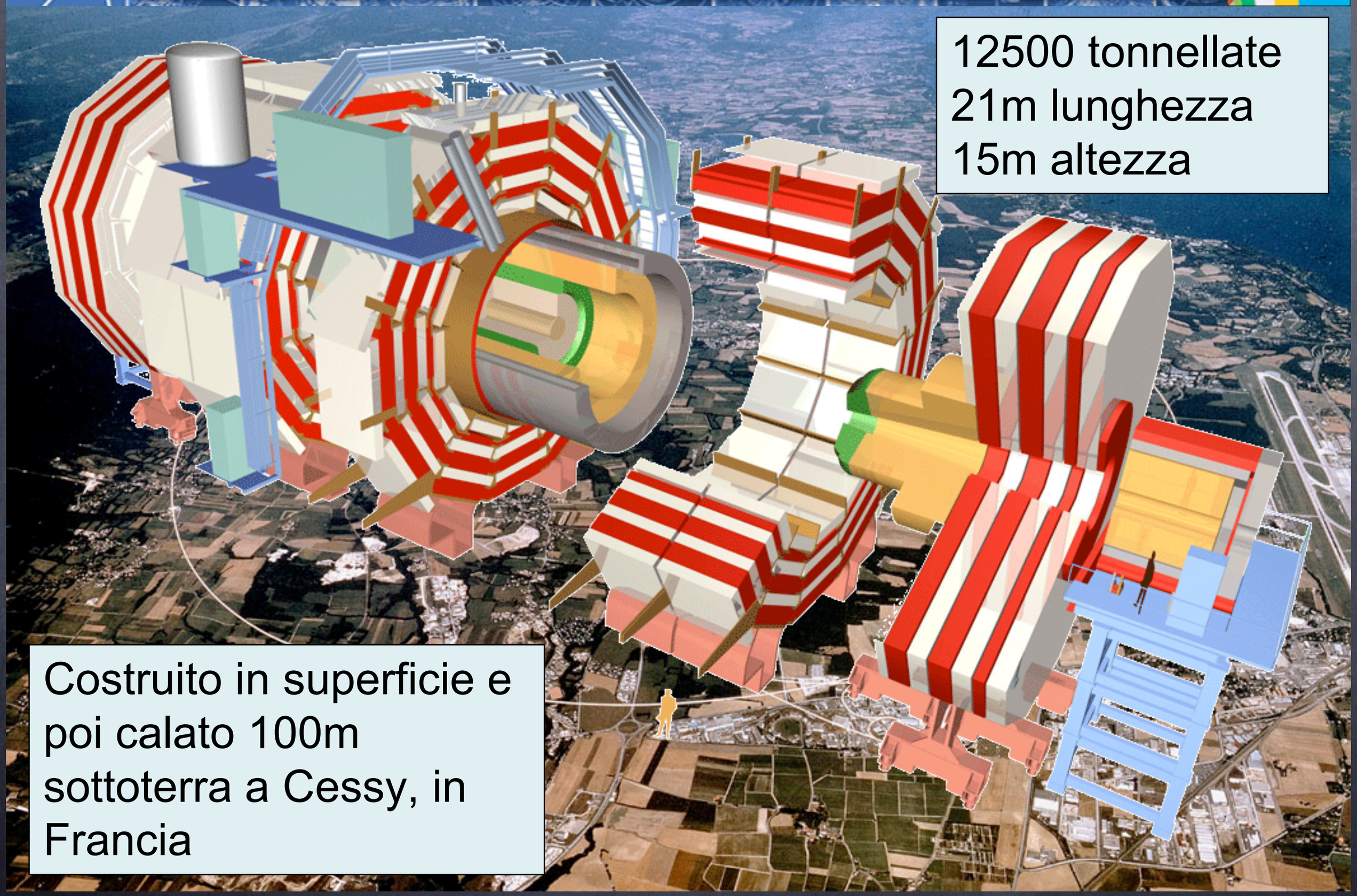
- 40 milioni di collisioni al secondo
- 1 Higgs prodotto ogni ora
- 1 segnale : 100000000000 fondi
- un nuovo paradigma del computing: GRID

per vedere un pianeta ci vuole un telescopio
per vedere una particella ci vuole una 'cipolla'



Il rivelatore cipolla

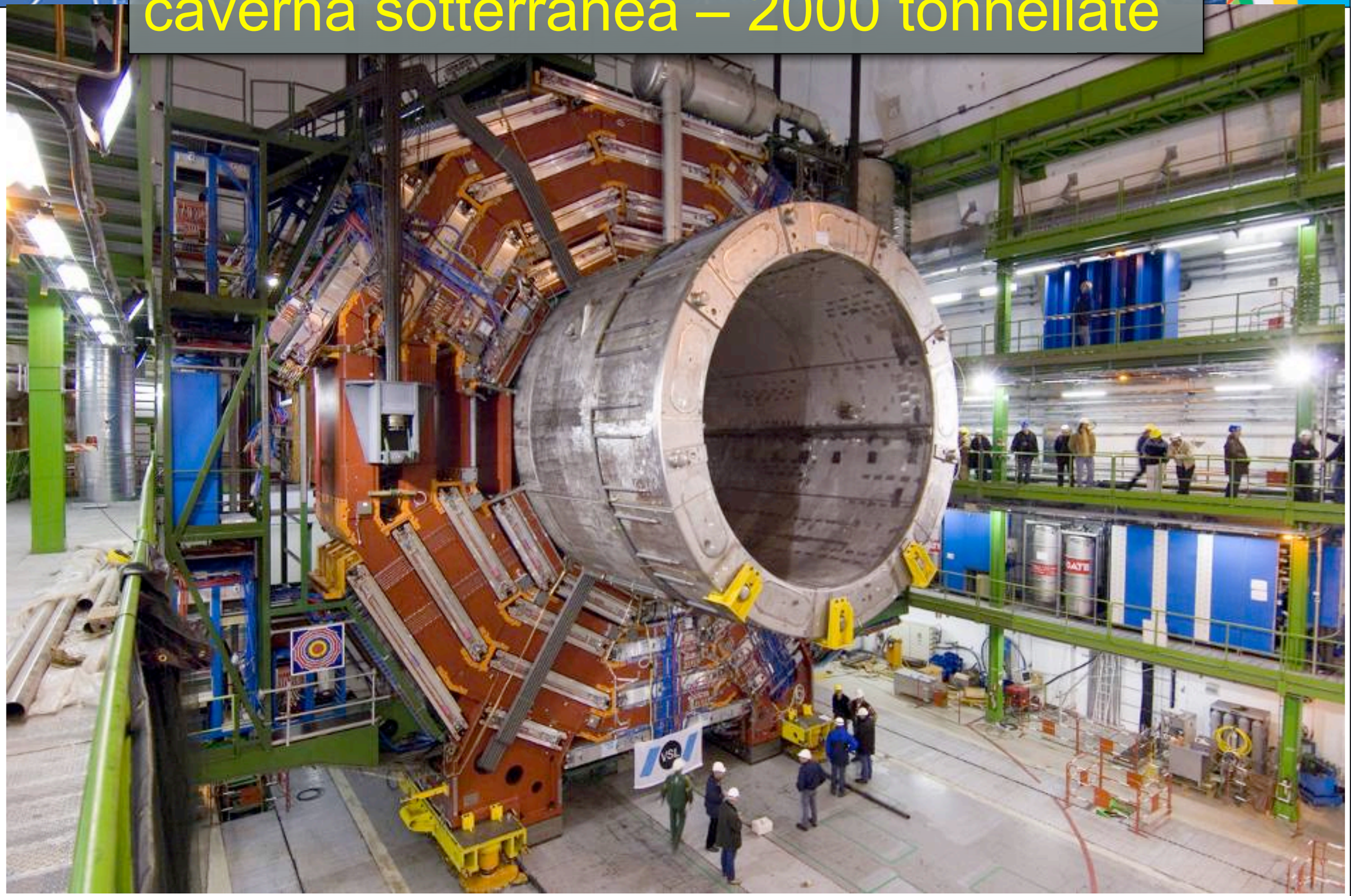
Compact Muon Solenoid (CMS)



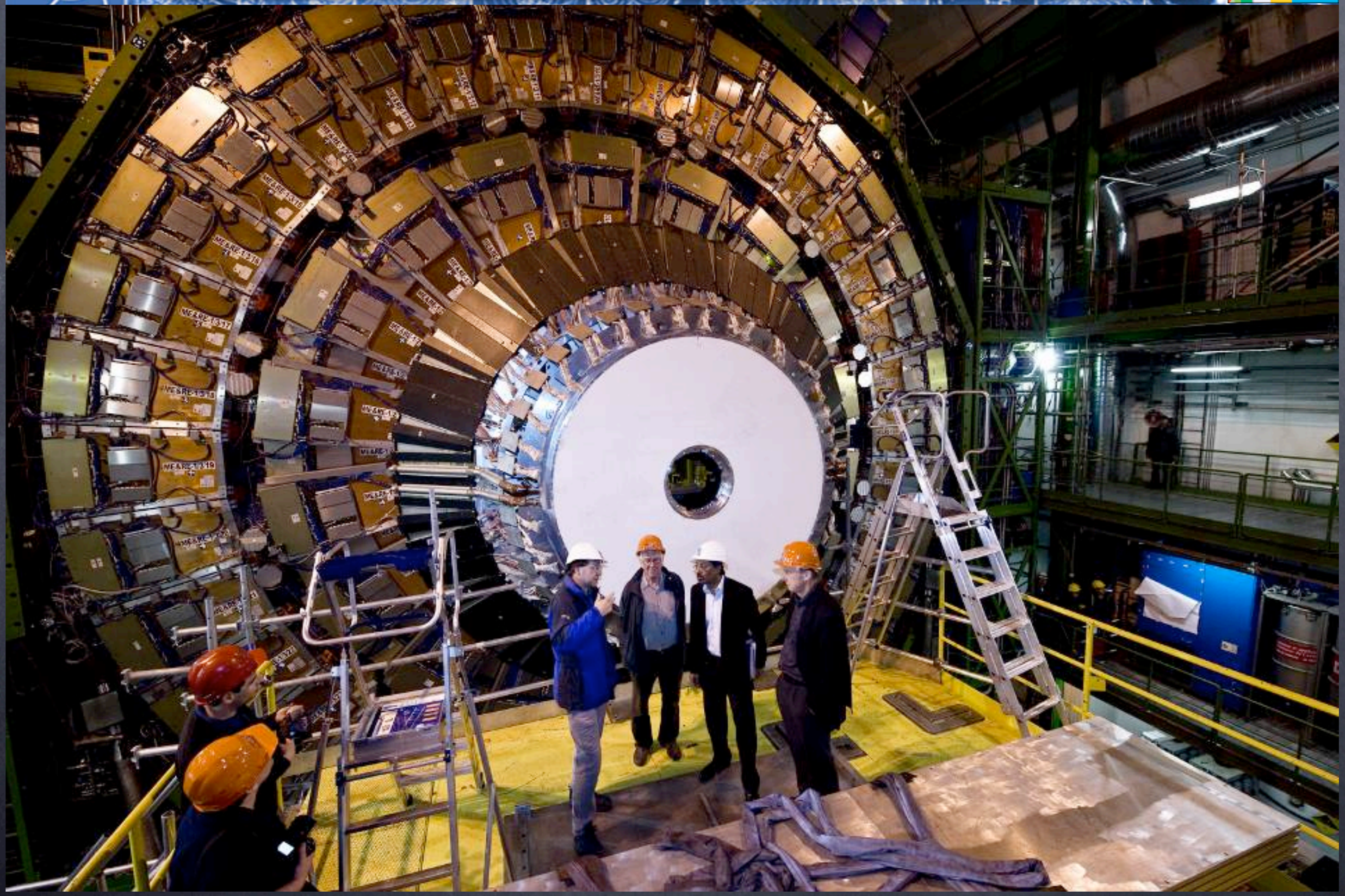
12500 tonnellate
21m lunghezza
15m altezza

Costruito in superficie e poi calato 100m sottoterra a Cessy, in Francia

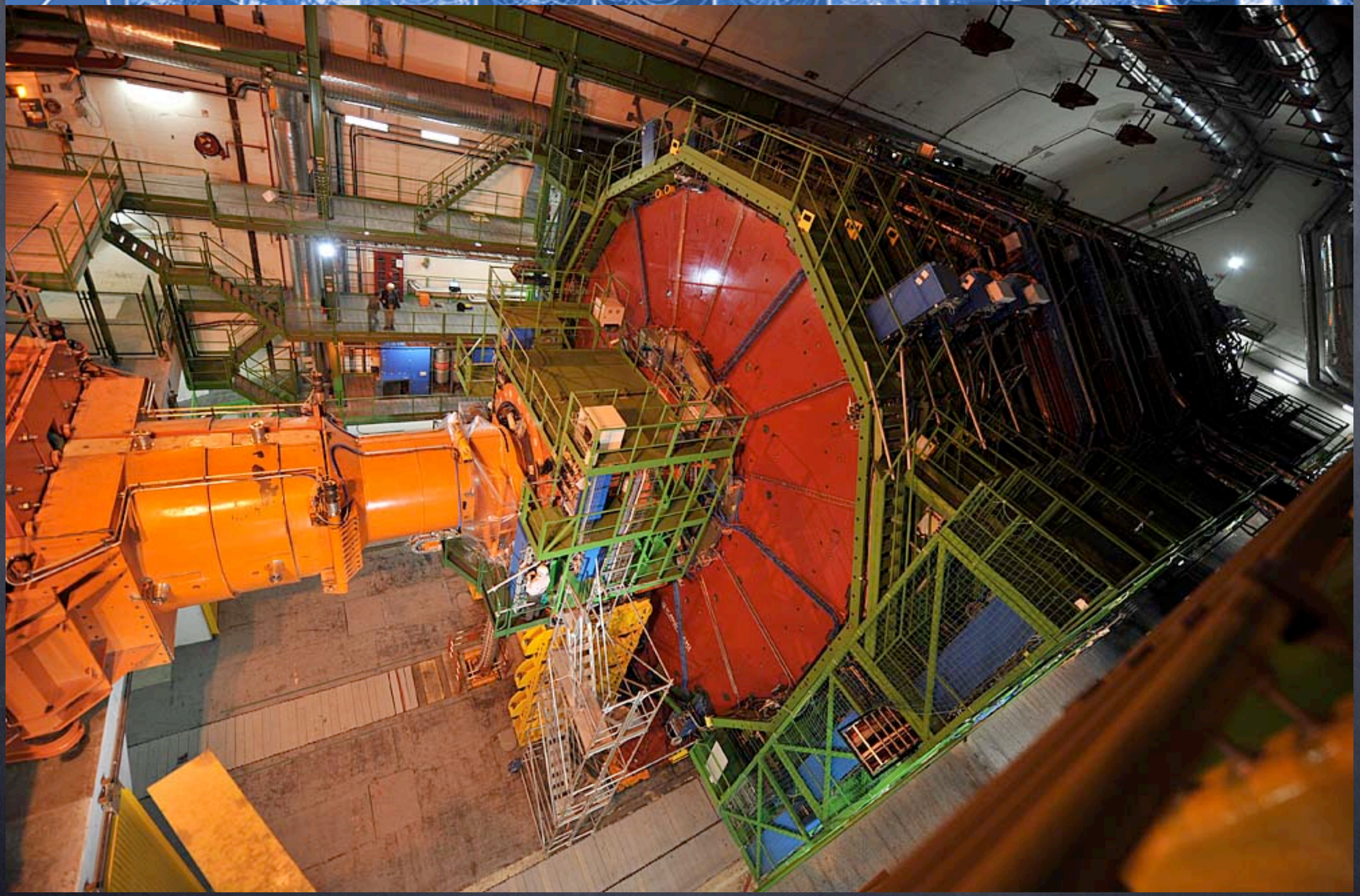
L'arrivo della ruota centrale nella caverna sotterranea – 2000 tonnellate



Il Prof. Higgs a CMS (2008)

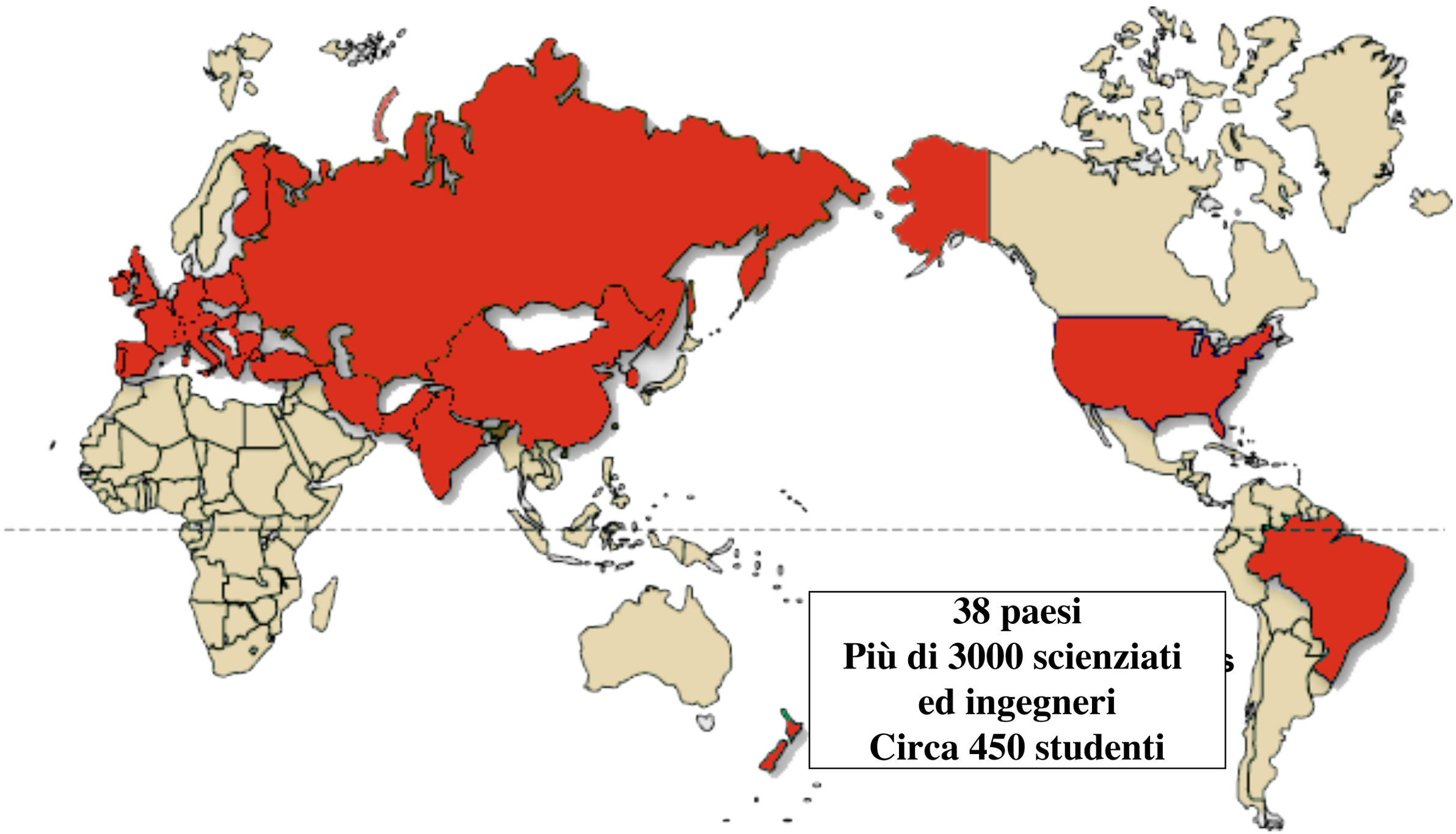


La caverna di CMS (Settembre 2008)



La collaborazione CMS

Un’avventura mondiale



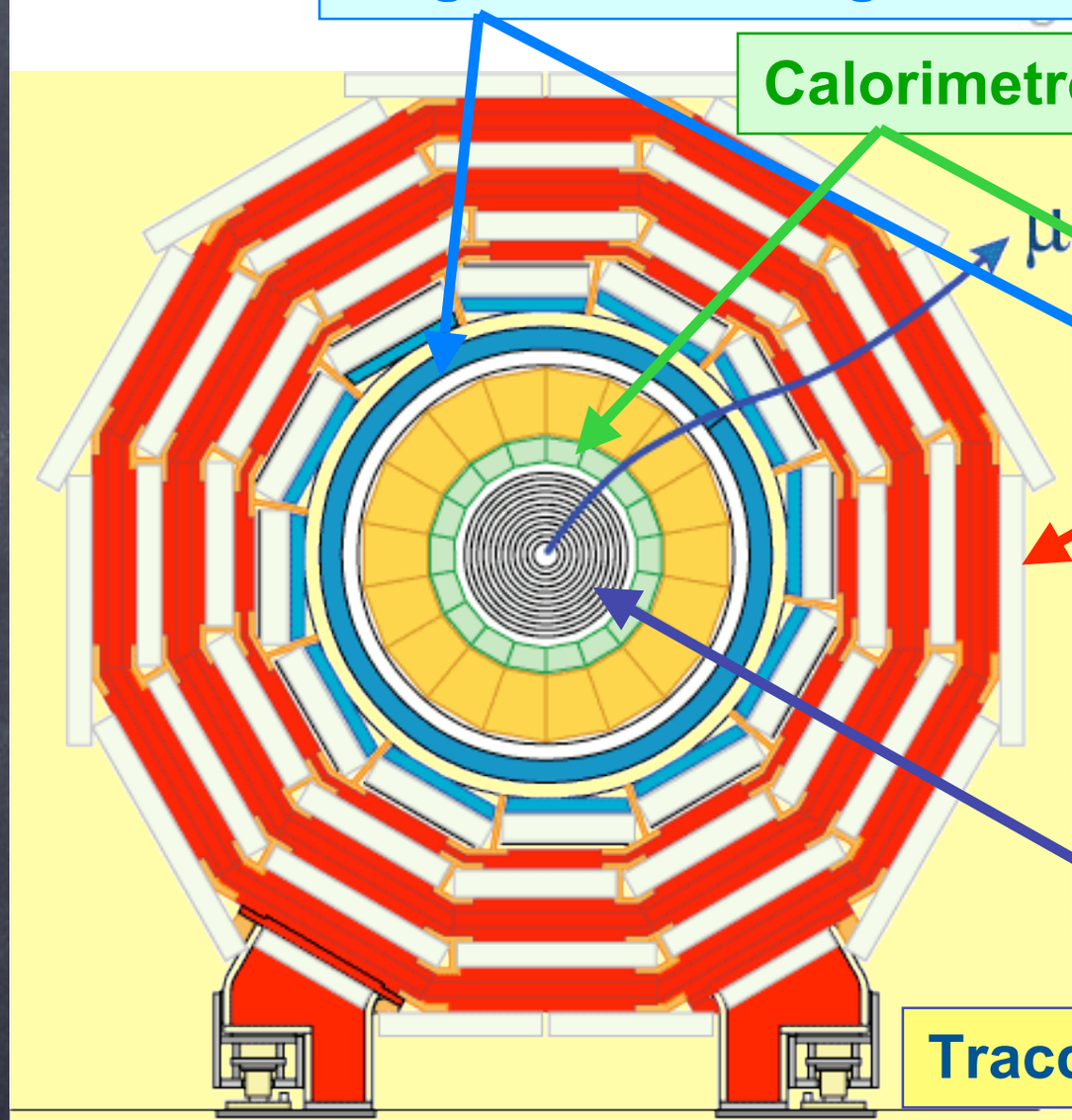
38 paesi
Più di 3000 scienziati ed ingegneri
Circa 450 studenti

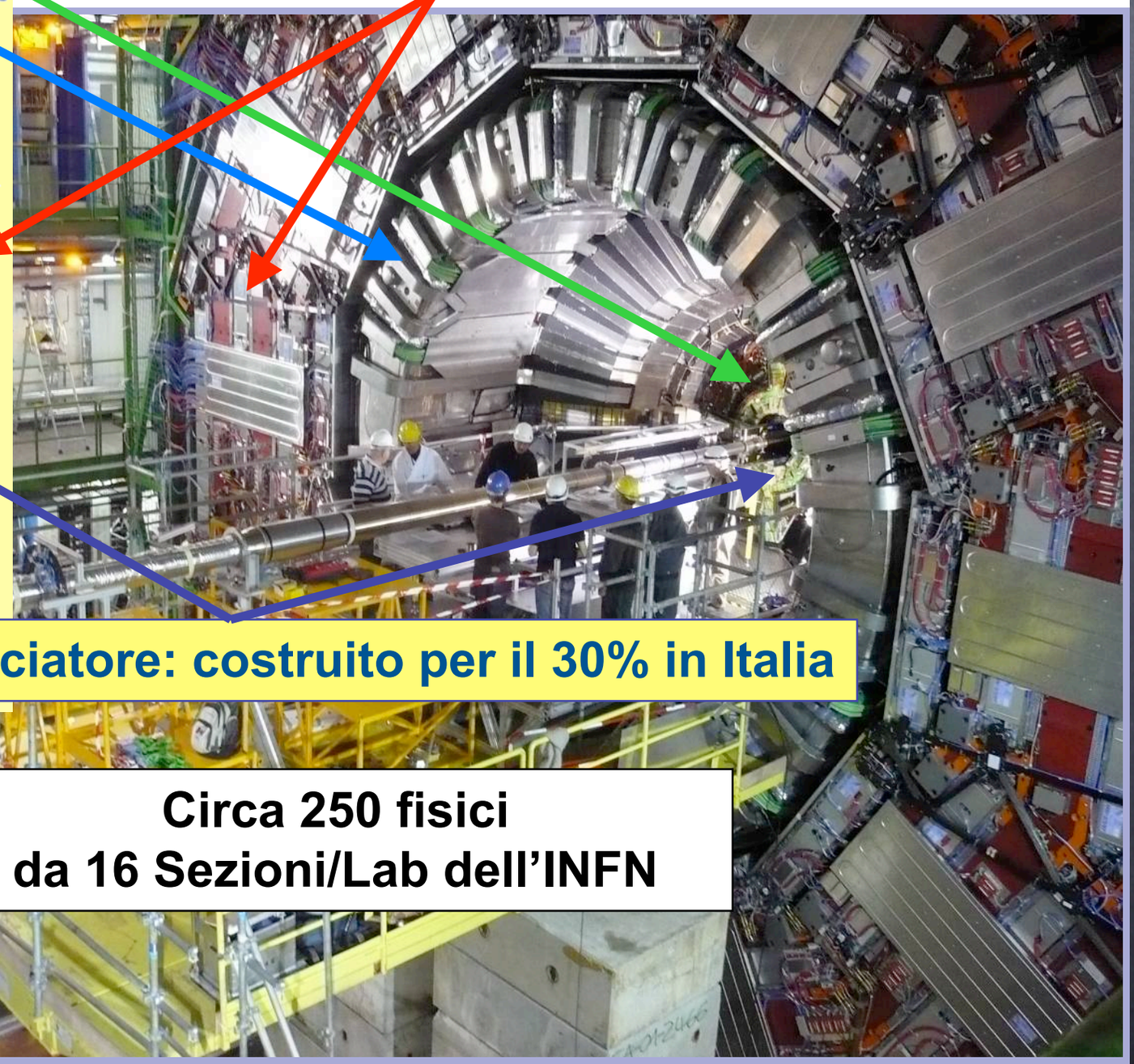
Il Contributo INFN a CMS

Magnete: tecnologia e avvolgimento cavo INFN&Ansaldo SC

Calorimetro elettromagnetico costruito per il 40% in Italia

Sistema per mu: costruito per il 50% in Italia



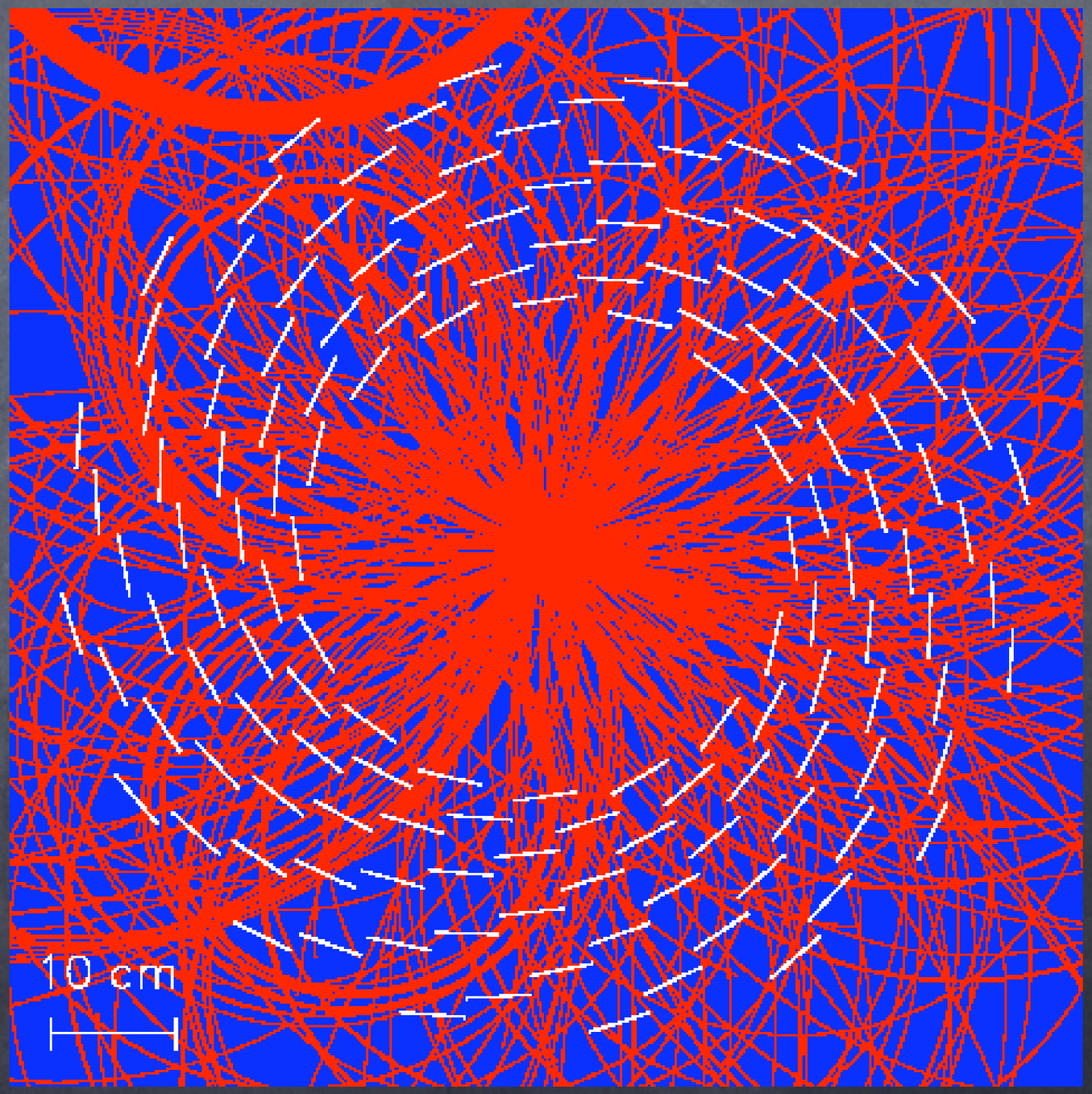


Tracciatore: costruito per il 30% in Italia

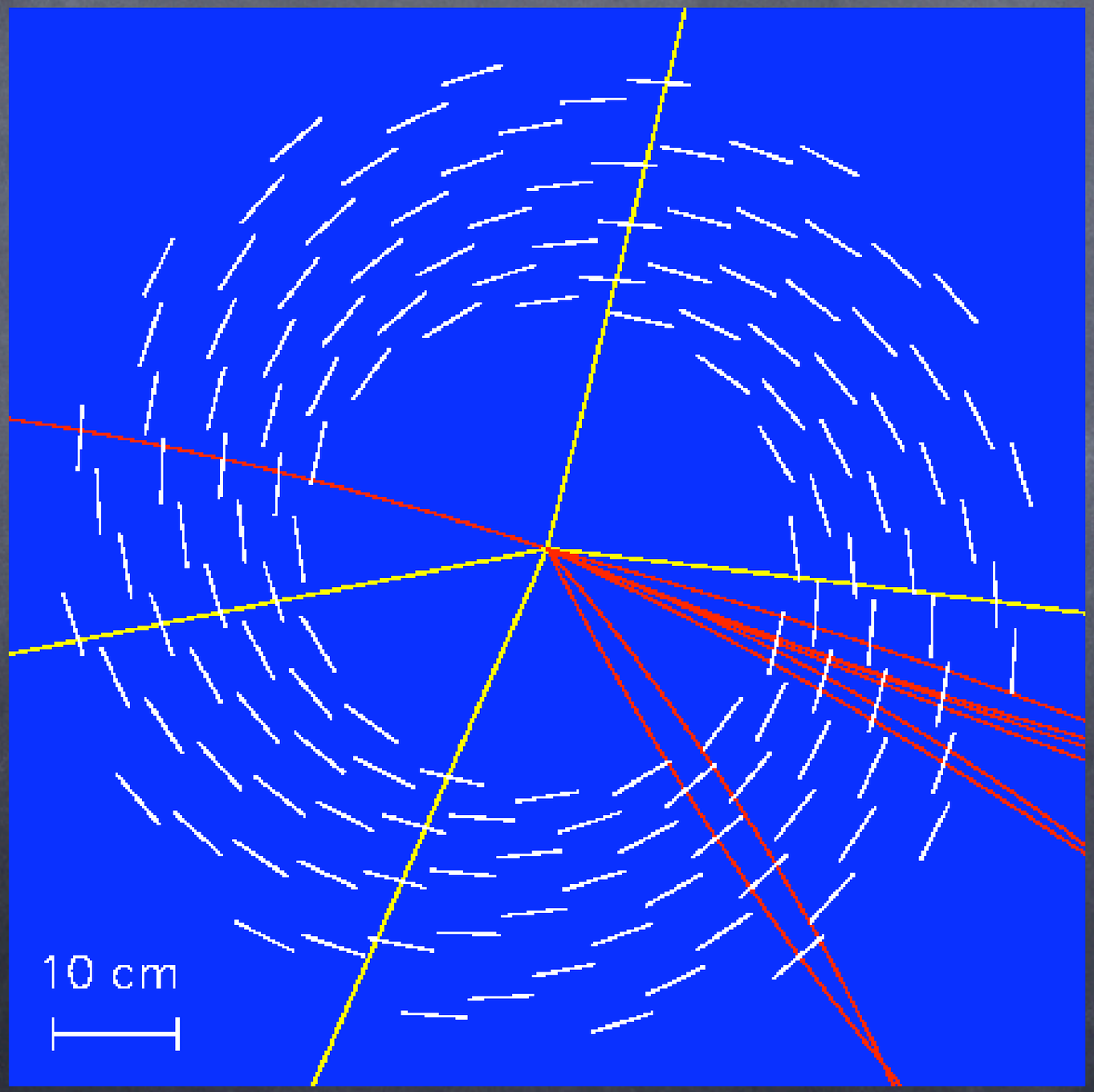
Circa 250 fisici
da 16 Sezioni/Lab dell'INFN

La vera scommessa o l'amara realta'

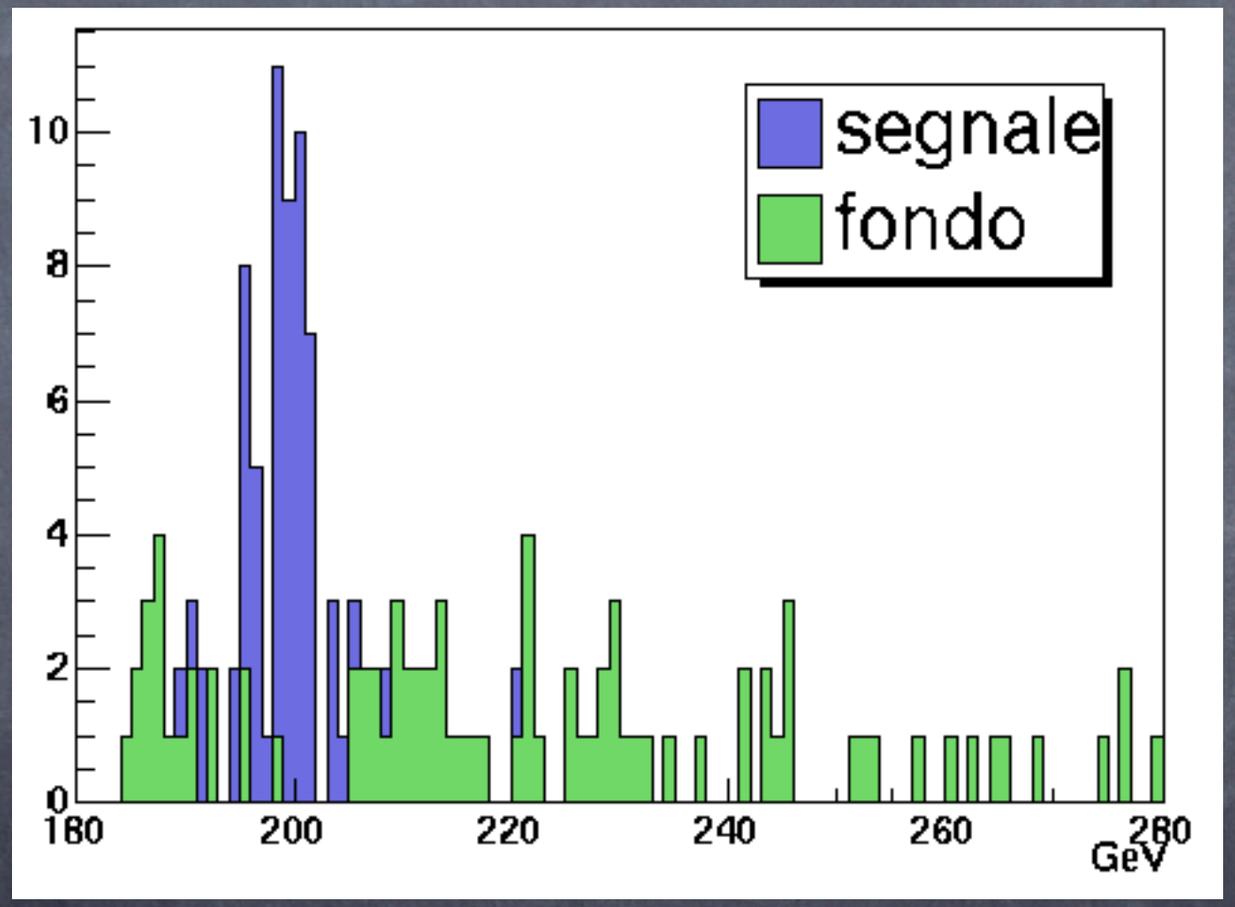
Evento a LHC dove bisogna trovare le quattro tracce (diritte) che formano un bosone di Higgs



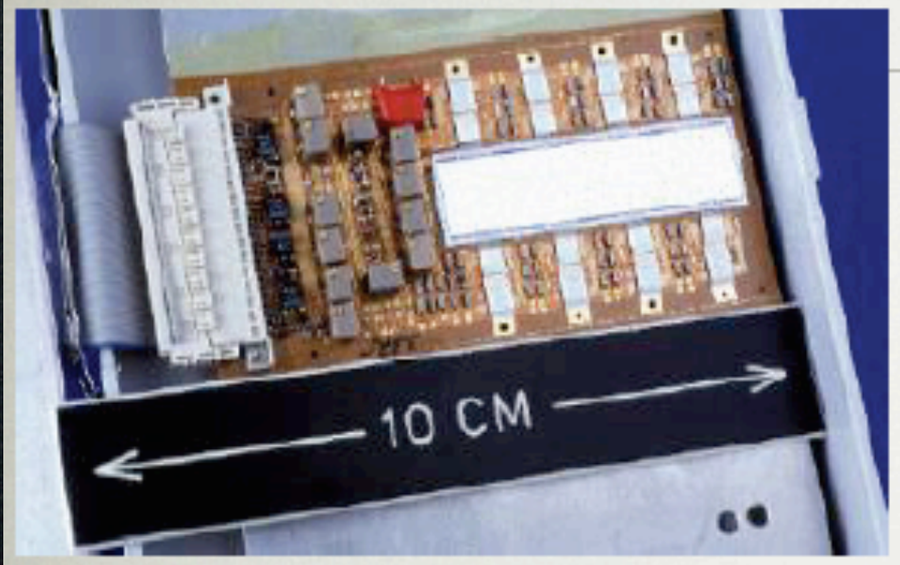
Potenza dell'intelligenza (e del computing)



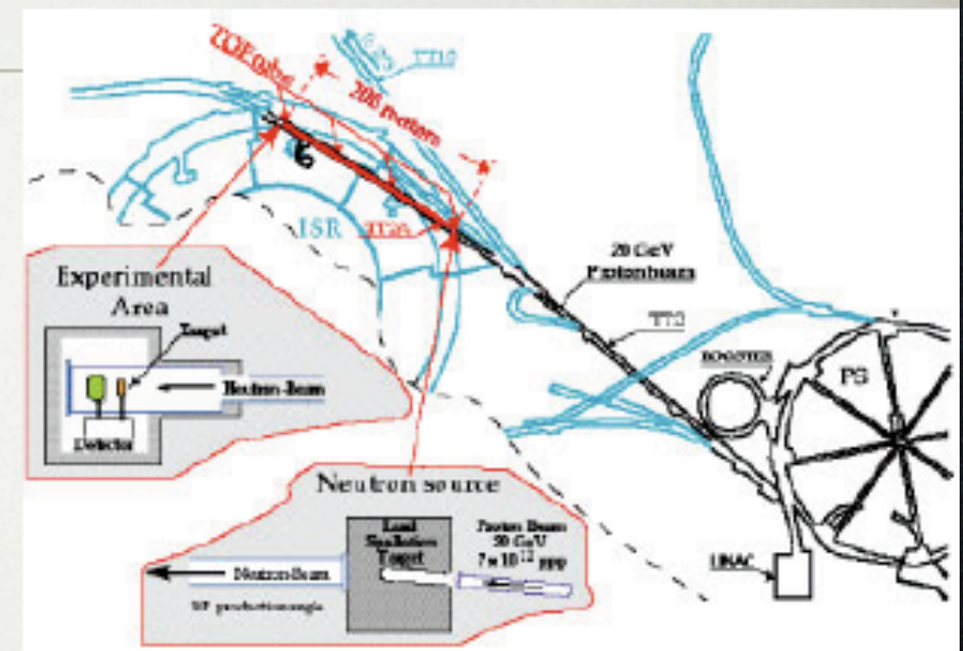
Se tutto andra' bene sara' cosi' (+/- !)



e a che altro serve ?

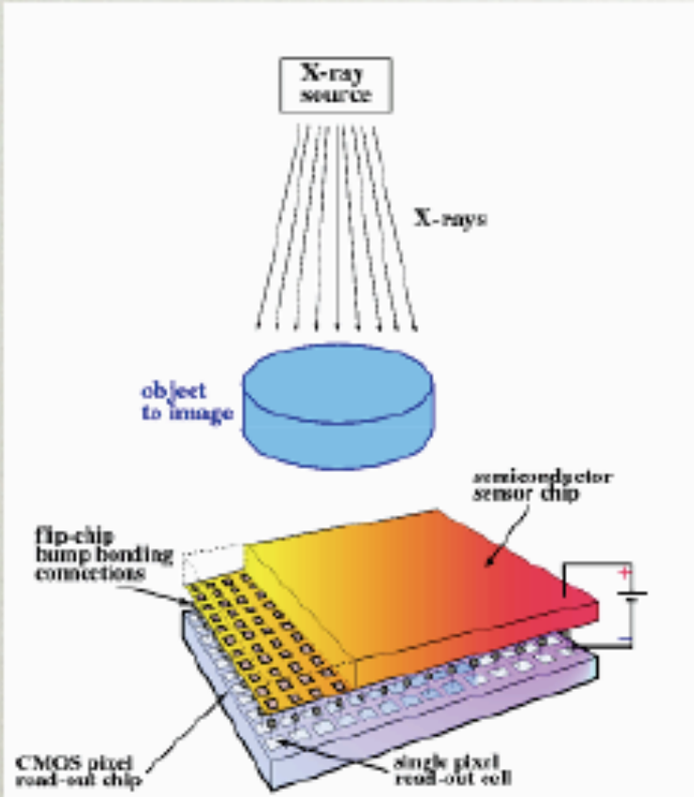


Silicon detector for a Compton camera in nuclear medical imaging

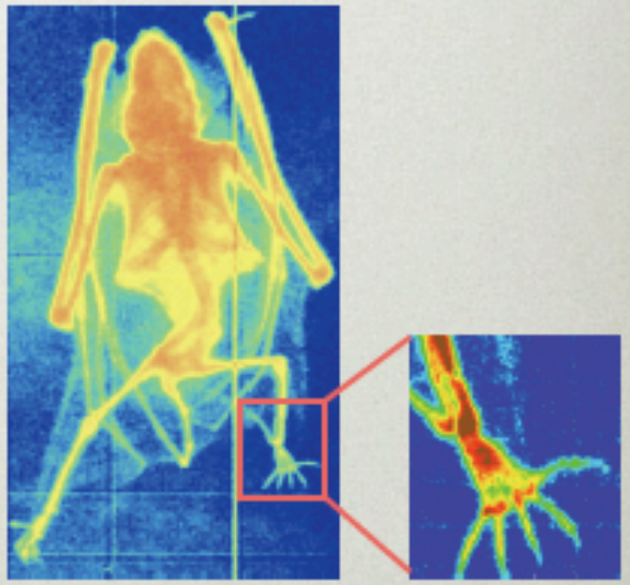


Radio-isotope production for medical applications

Thin films by sputtering or evaporation



Medipix: Medical X-ray diagnosis with contrast enhancement and dose reduction



Radiography of a bat, recorded with a GEM detector