Oltre i confini esistenti: la caccia all'infinitamente piccolo con l'LHC al CERN di Ginevra.

Città di Schio

Spazi di confine
tema culturale 2016

Schio,
27 Ottobre 2016

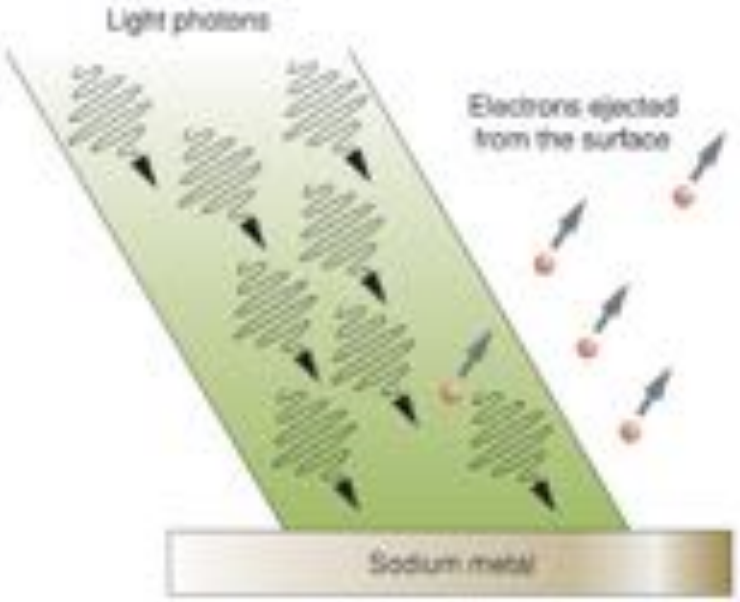
EuCARD²

EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453

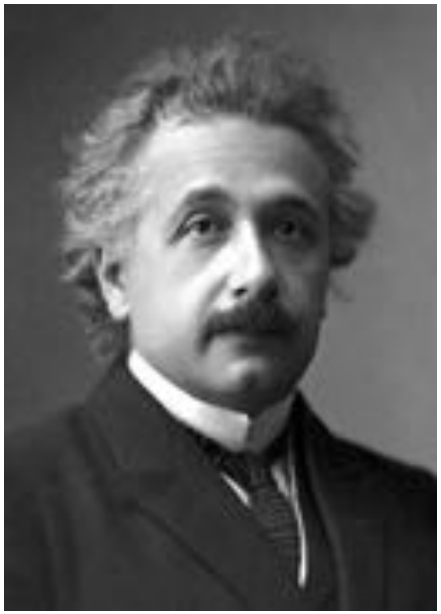
HiLumi
LARGE HADRON COLLIDER

Lucio Rossi
CERN
High Luminosity LHC
Project Leader

Einstein, «Annus Mirabilis» 1905: La Luce E' anche una particellA



www.daviddarling.info



Premio Nobel per la fisica del 1921 attribuito a Albert Einstein "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect".
Il fotone, il quanto di luce (ovvero di onda e.m.), fu «canonizzato»

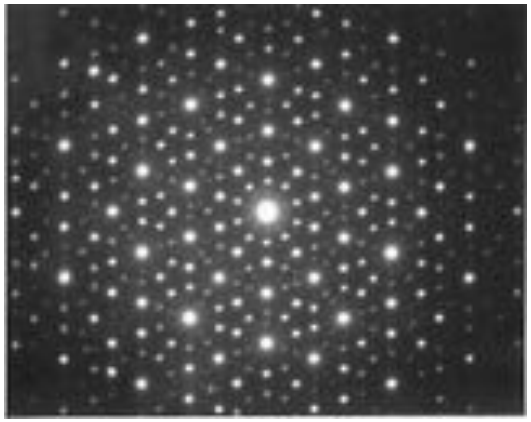
Louis De broglie, 1925: le Particelle sono anche onde…

$\lambda = h/p = h/mv$

The standing de Broglie waves set up in the first three Bohr orbits.

Louis de Broglie rivette il Nobel per la fisica nel 1929 "for his discovery of the wave nature of electrons".

Nano-technology



The periodic structure of a crystalline solid acts as a diffraction grating

Electron microscopes use electrons to illuminate a sample. In Transmission Electron Microscopy (TEM), electrons pass through the sample and illuminate film or a digital camera.

100 keV → λ = 2. 7 pm !

100 pm is actual resolution limit

LHC project

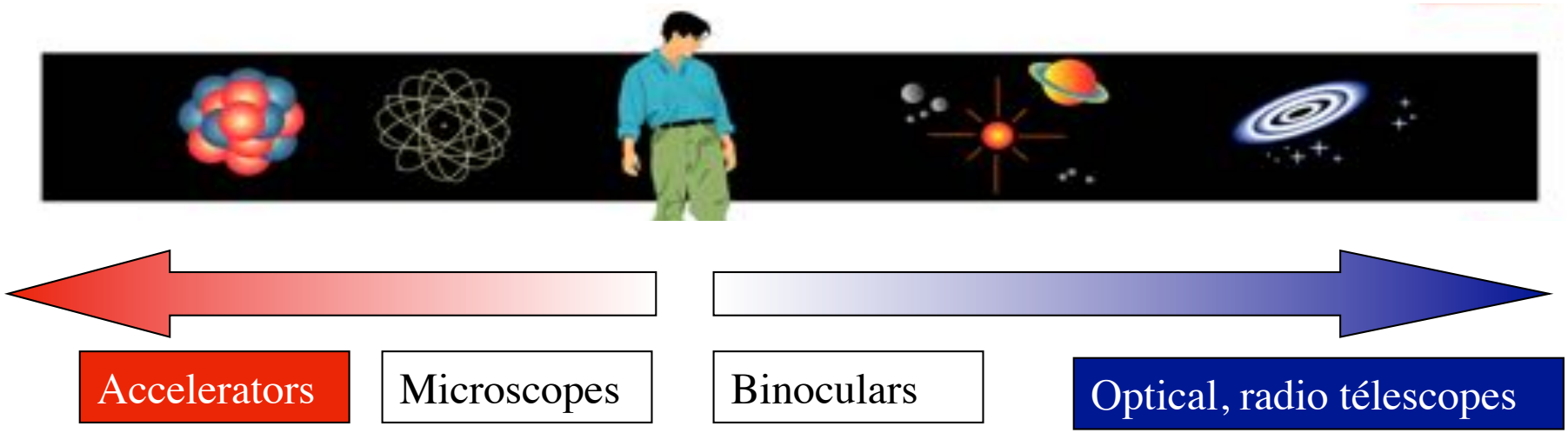
La vista piu' fine

Cosa è la fisica delle particelle elementari?

Perchè abbiamo bisogno di tecnologie di frontiera?

Fisica delle particelle: verso l'infinitamente piccolo …

LHC project



La Fisica dele Particelle osserva la materia nella sua più piccola dimensione. Gli acceleratori sono finissimi microscopi: ***atto-scopi!***

$\lambda = h/p$; @LHC: $T = 1$ TeV $\Rightarrow \lambda \cong 10^{-18}$ m

Gli acceleratori sono dei nano-nanoscopi

Ai nostri confini: gli estremi si toccano !

LHC project

Big Bang

Protone

Atomo

Raggio della Terra

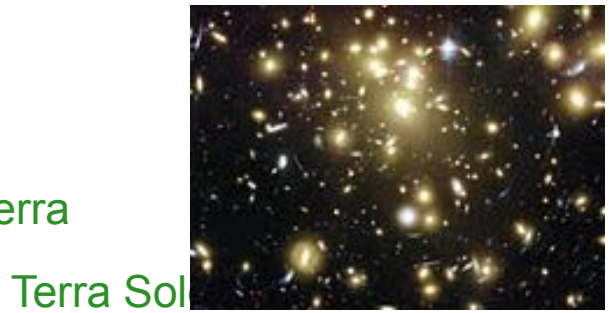
Distanze Terra Sol

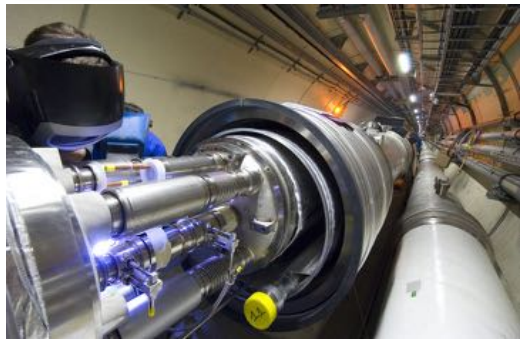
Raggio delle galassie

Universo

10^{-32} 10^{-28} 10^{-24} 10^{-20} 10^{-16} 10^{-12} 10^{-8} 10^{-4} 10^{4} 10^{8} 10^{12} 10^{16} 10^{20} 10^{24} 10^{28}

cm



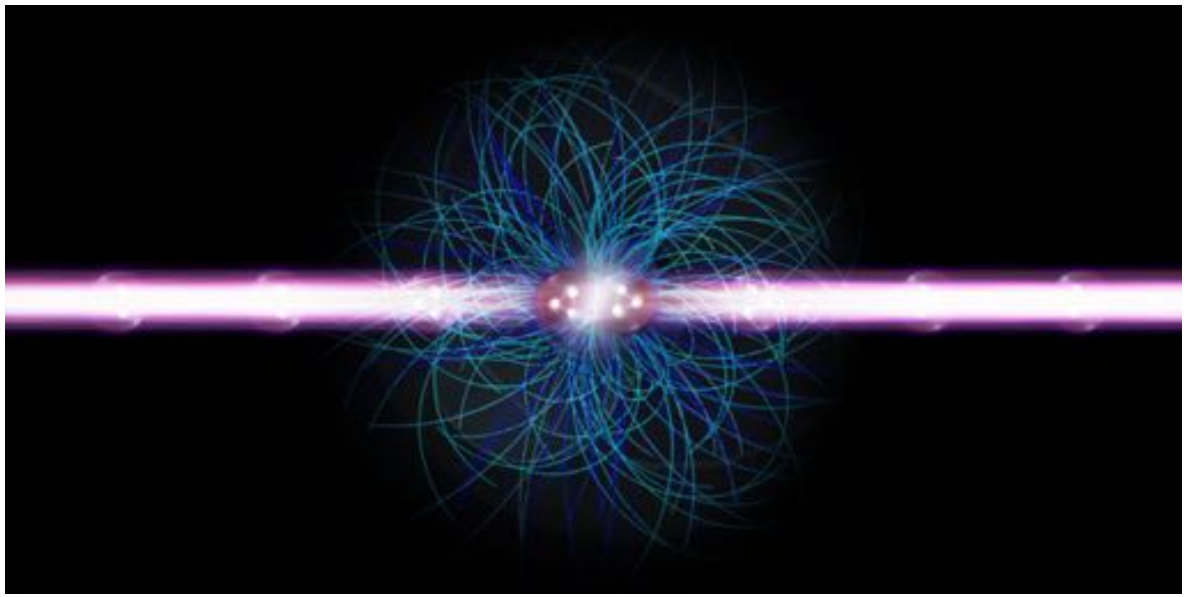


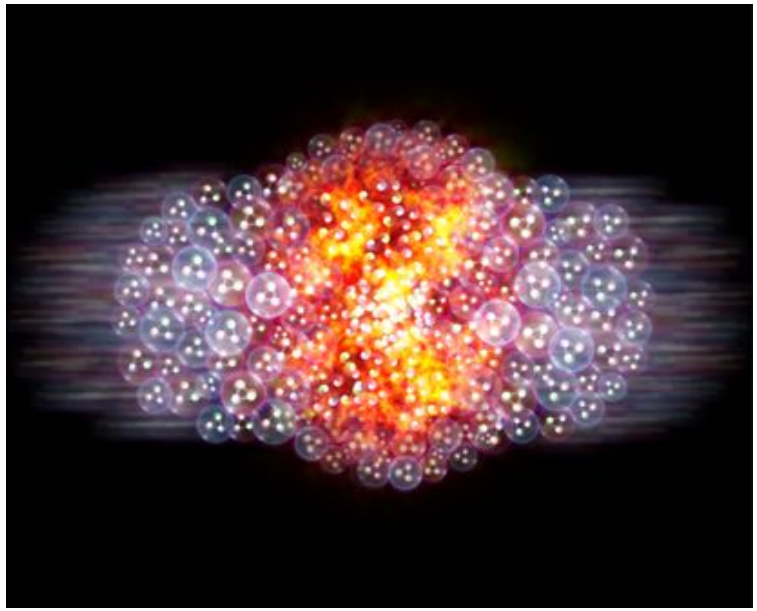
LHC

Attoscopio

AccelEratorI: macchine del tempo

- Viaggio indietro nel tempo $t_{\mu s} \cong 1/E^2_{Gev}$
- T ≅ 1 ps per creazione di particelle singole
- T ≅ 1 μs per fenomeni collettivi QGS (Quark-Gluon Soup)



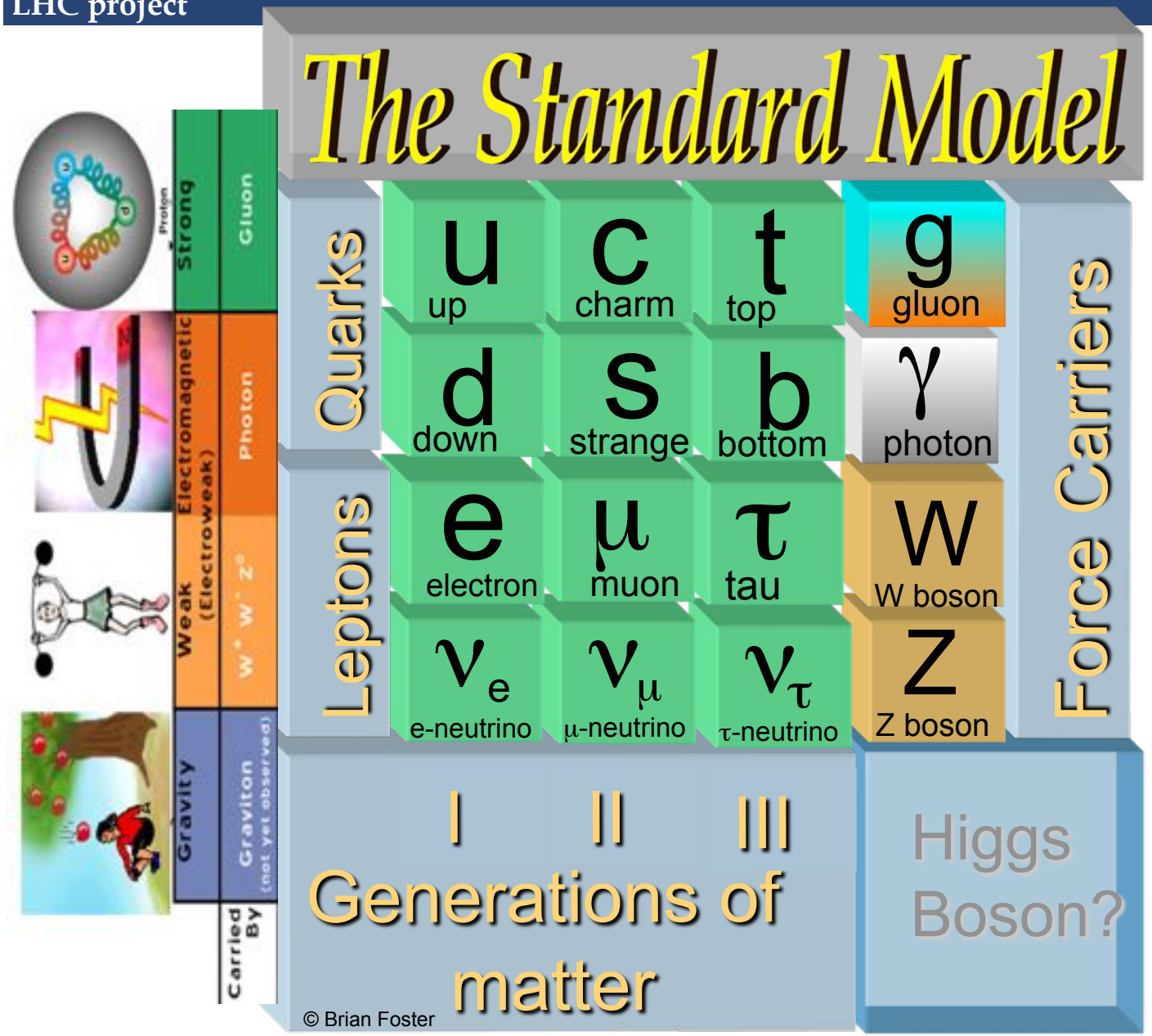


Come astrofisica!

La “summa” di 40 anni di ricerche : il modello standard

LHC project

CERN



Particelle

e

Forze

Cosa rimane quindi ?

- Il modello standard è una buonissima *descrizione* dellÚniverso alla scala delle particelle che conosciamo
  - Ma *non risponde* a molte domande
    - Perchè tante particelle?
    - Perchè diversi tipi di forza?
    - Cosa è la massa?
      - Perchè le particelle hanno la massa che hanno?

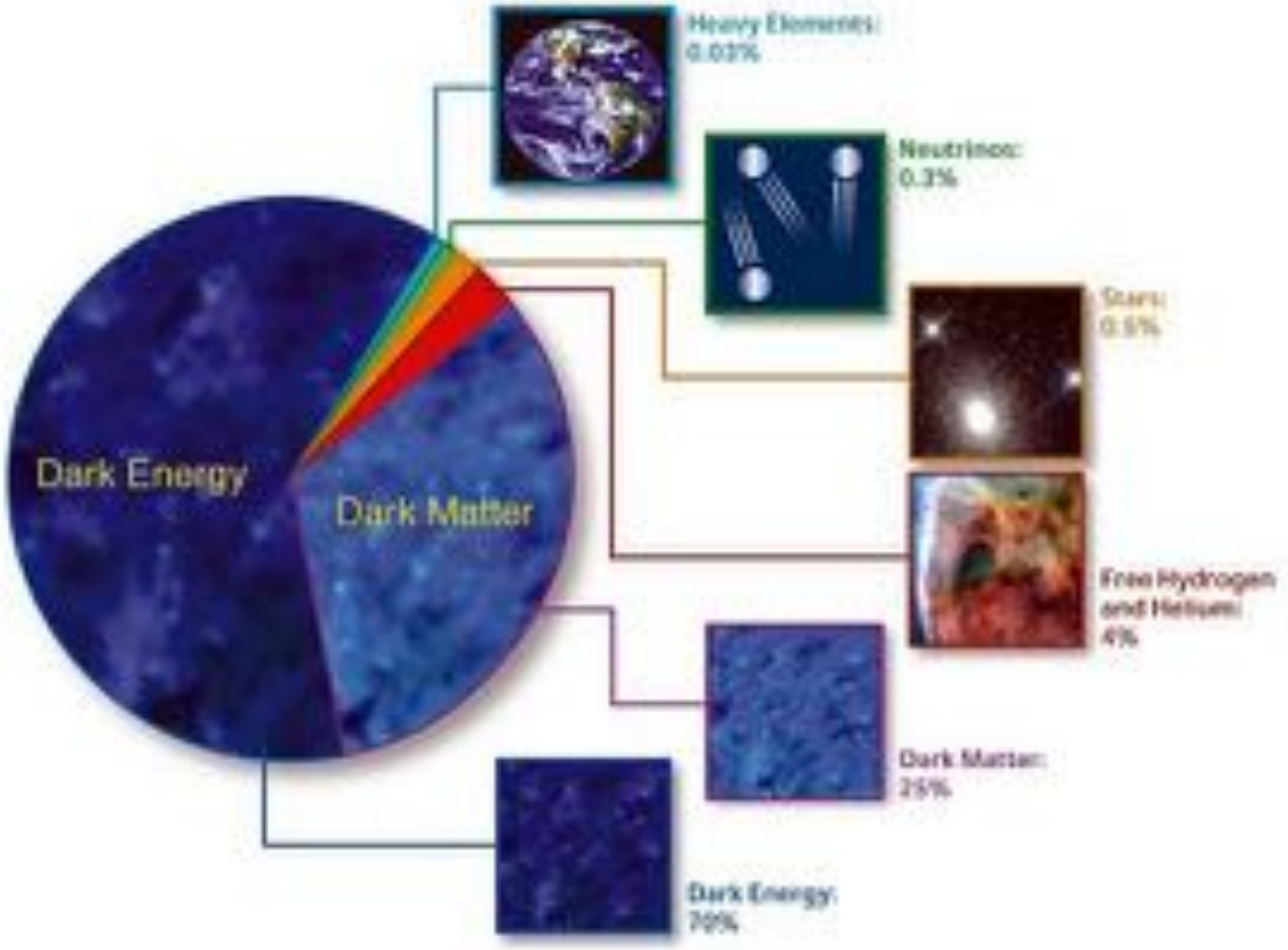
LHC !

i neutrini soo leggerissimi < 1 meV
elettrone: 511 eV
protone 1 GeV (1 miliardo di eV
quark top : 170 GeV !!!!
alcune particelle-forza (fotone) non hanno massa
altre particelle-forza (Z, W) sono massicci: 80-90 GeV


LHC project
Prove delLA meteriA oscura
CERN
Gasesous Matter
Collisione fra due ammassi di galassie @4500km/s
“Bullet Cluster” Clowe et al.
Direct evidence for collisionless Dark Matter
Chandra, Magellan, HST, Gravitational Lensing

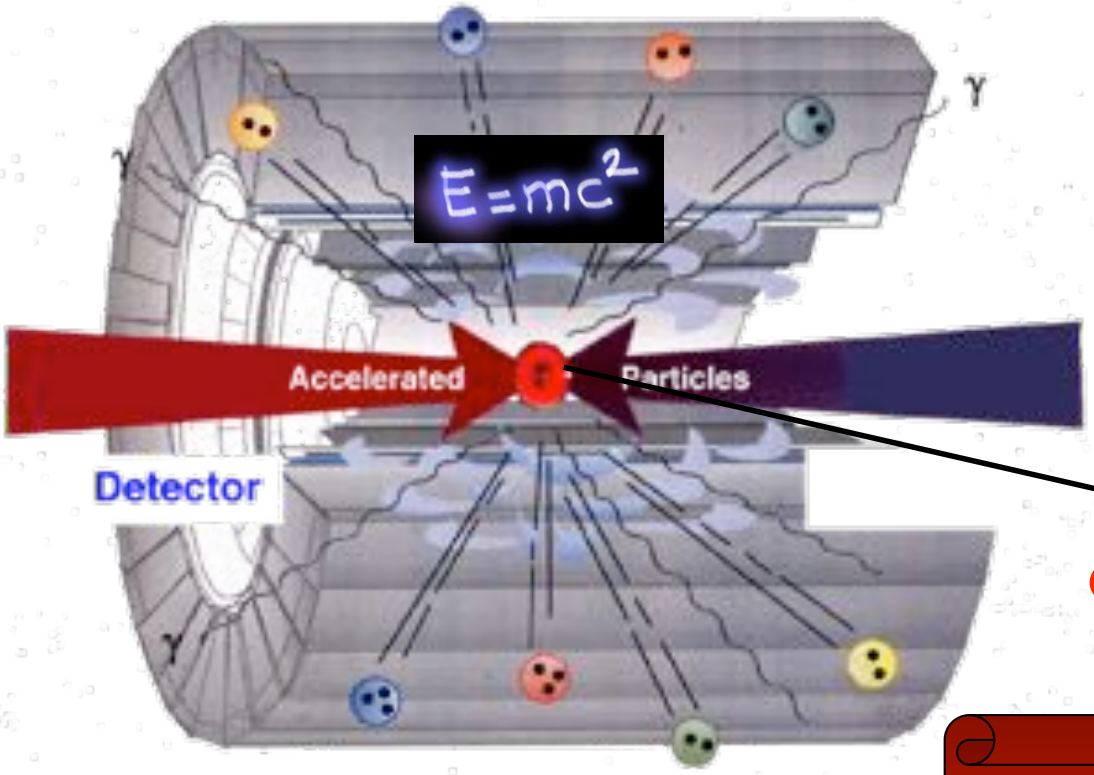
LHC project

Il contenuto massa –energia dell'universo



LHC project

Gli strumenti della HEP



1) Concentrate energy on particles (**accelerator**)

2) **Collide** particles (recreate conditions after Big Bang)

3) Identify created particles in **Detector** (search for new clues)

Entrambi richiedono tecnologie di punta (superconduttività, e molte altre)

LHC project

CERN

European Organization for Nuclear Research

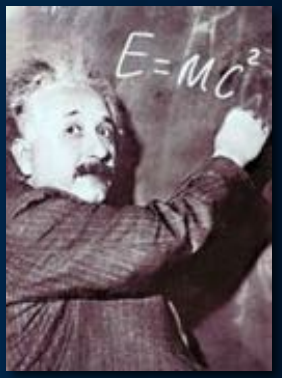
- Fondato nel 1954, oggi 21 stati membri
- Circa 11’000 utilizzatori da tutto il mondo
- ~900 M€ di budget annuale
- 2250 staff permanente + 1000 associati

2004: The 20 member states

The Mission of CERN

- **Push forward** the frontiers of knowledge

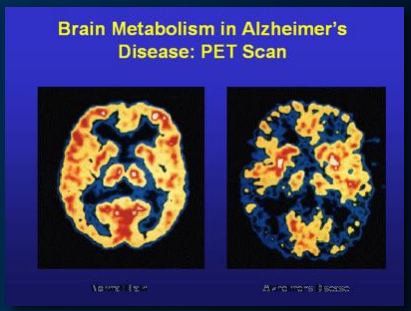
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



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

  Information technology - the Web and the GRID

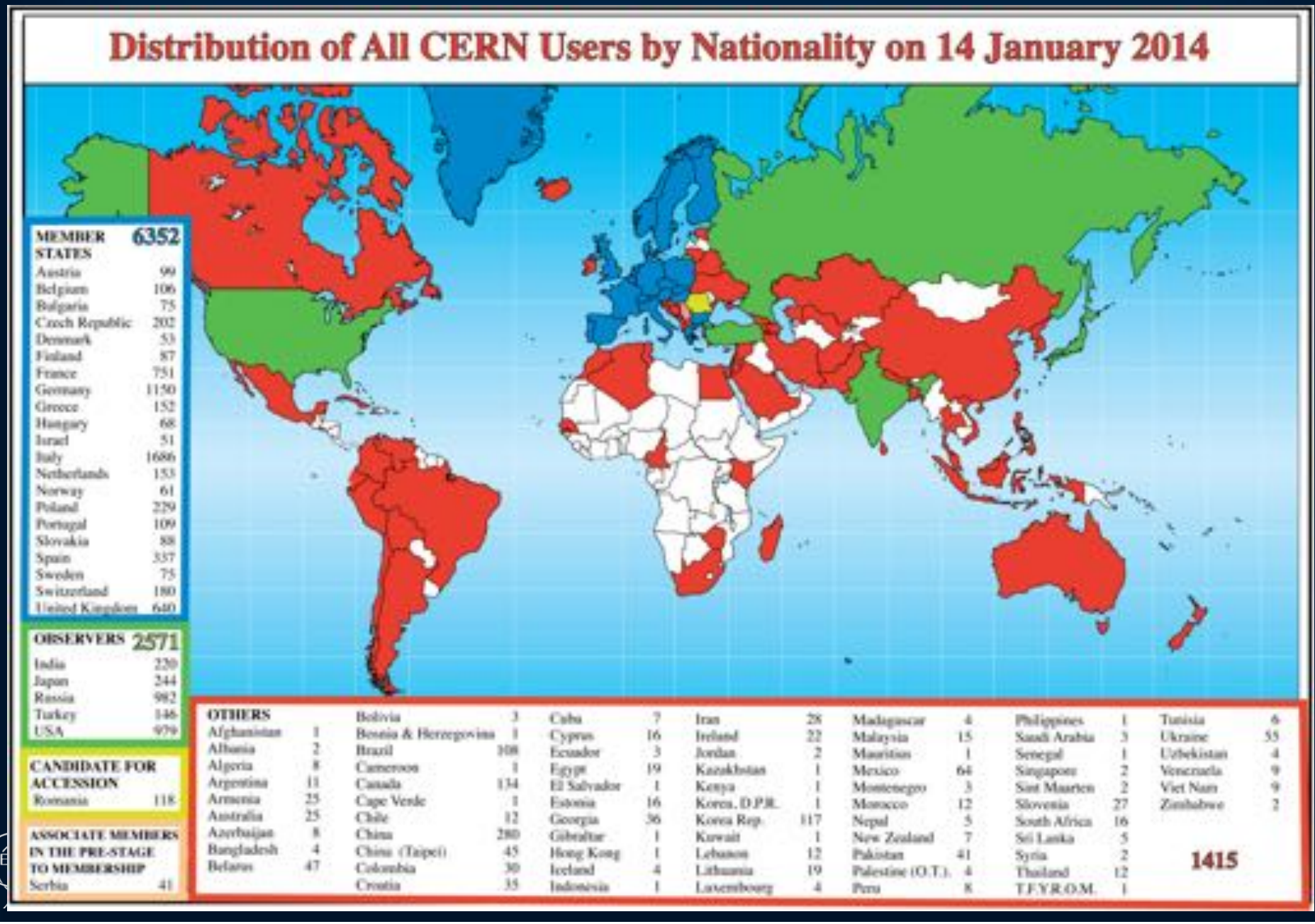
  Medicine - diagnosis and therapy



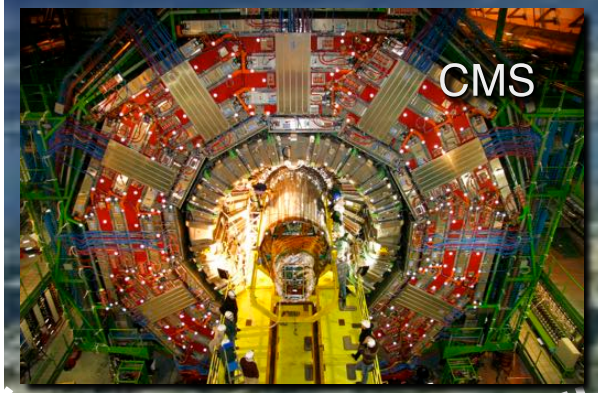
- **Train** scientists and engineers of tomorrow

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

Science is getting more and more global



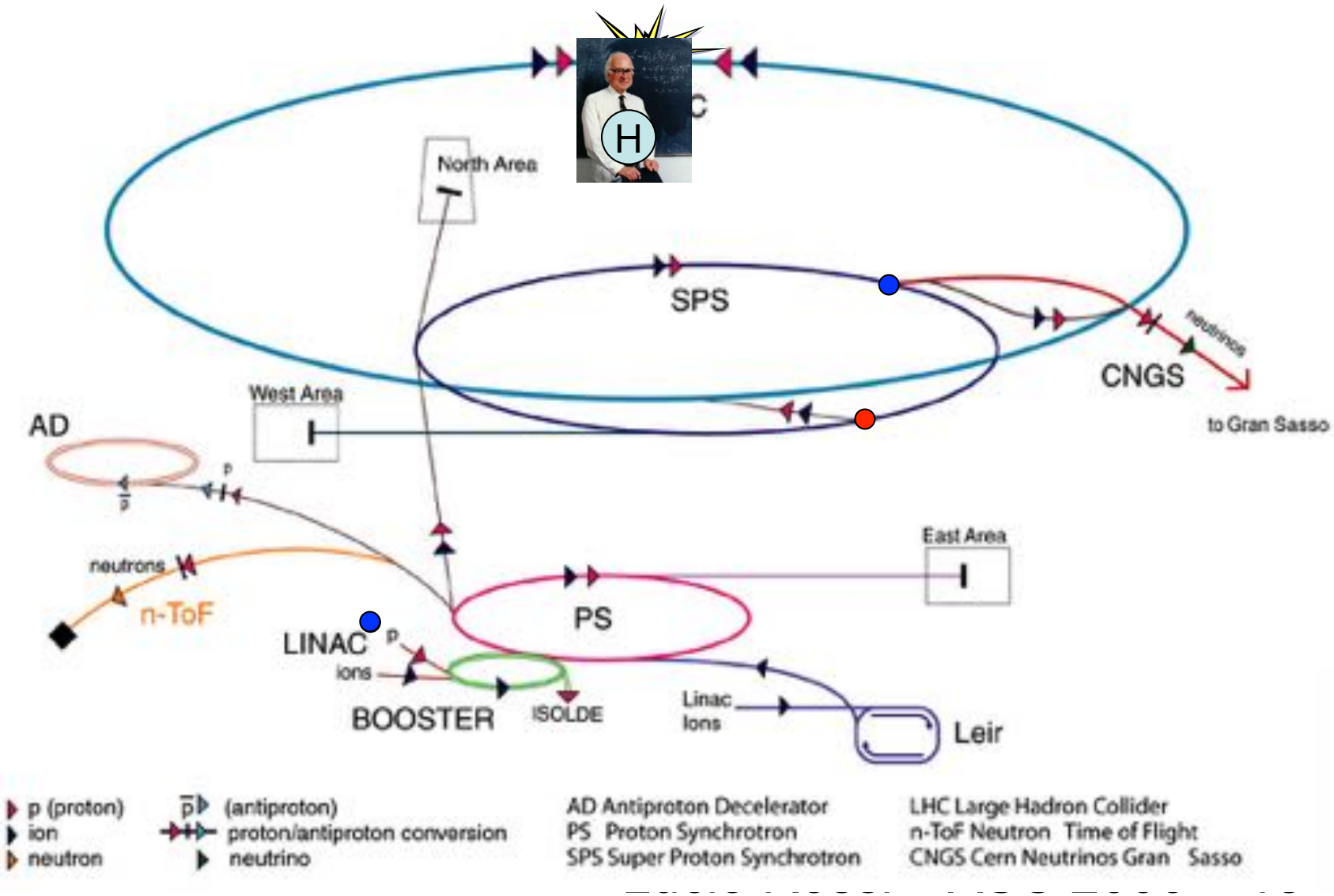
LHC: il gigante $E_{beam} \cong 0.3BR$ con 4 g ch



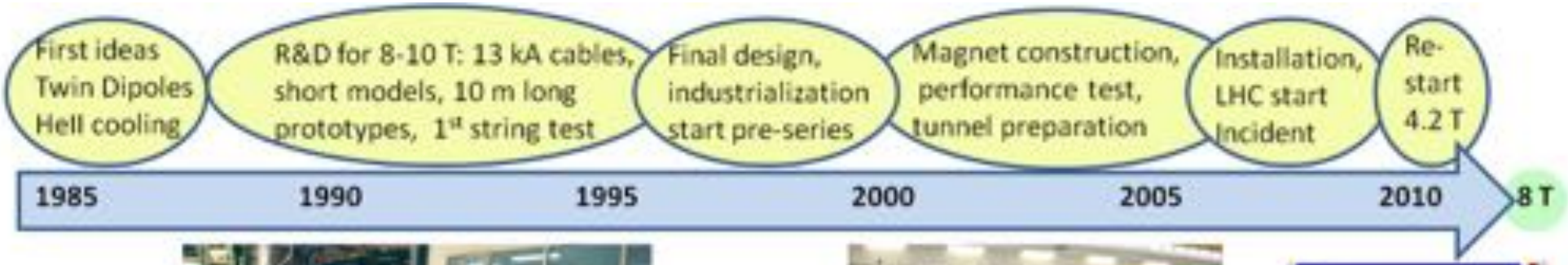
Esplorazione della nuova frontiera con collisioni adroniche

LHC project

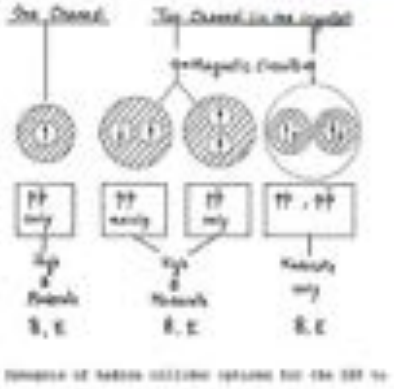
CERN: la catena di acceIratori



LHC: un progetto di 30 anni…



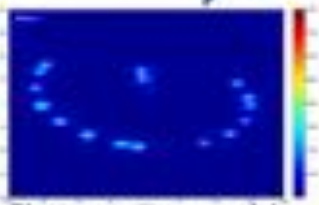
Magnet designs at first LHC workshop, 1984



First LHC dipole prototype on the test bench (June1994)

Final dipole cross section (frozen 1999)

Assembly of 15 m long coils in industry, 2003



First energy record in the proton beam, December 2009

Continuous magnet line installed in the 27 km LHC tunnel, 2006

LHC project

Superconduttivita':
un fenomeno di ordine

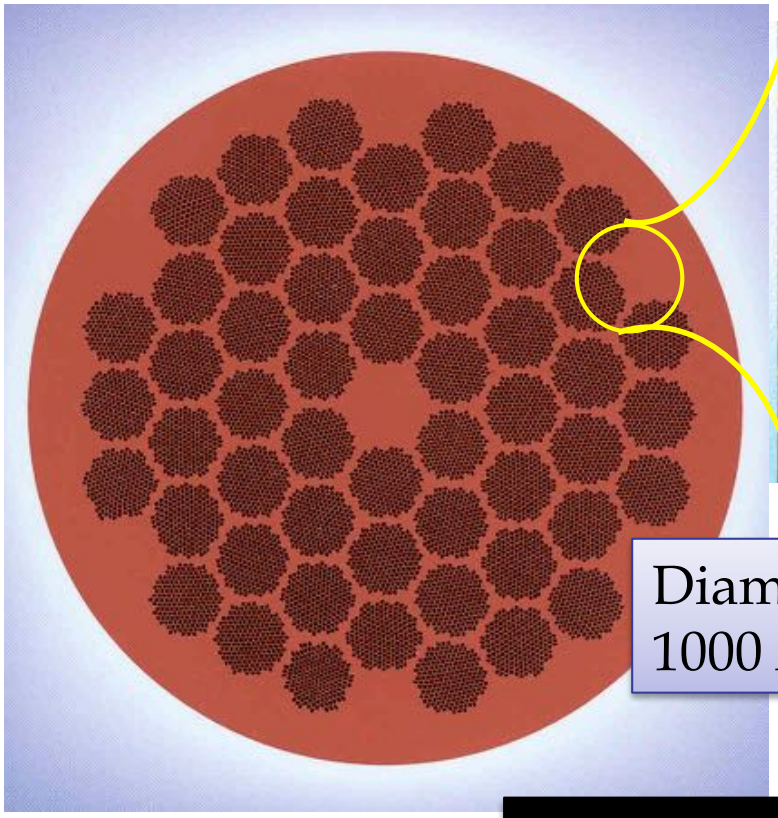
CERN

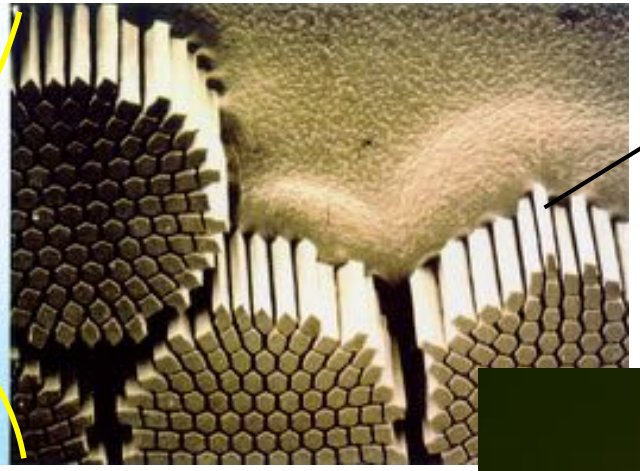
Elettroni in metallo normale (resisitivo)

Coppie di elettroni: metallo superconduttore
(fermions ⇒ bosons)

LHC project

Il superconduttore
7000 km di cavi Cu/Nb-Ti





Filamenti di Niobio-Titanio di 5-7 μm

Diametro 1 mm
1000 Ampères

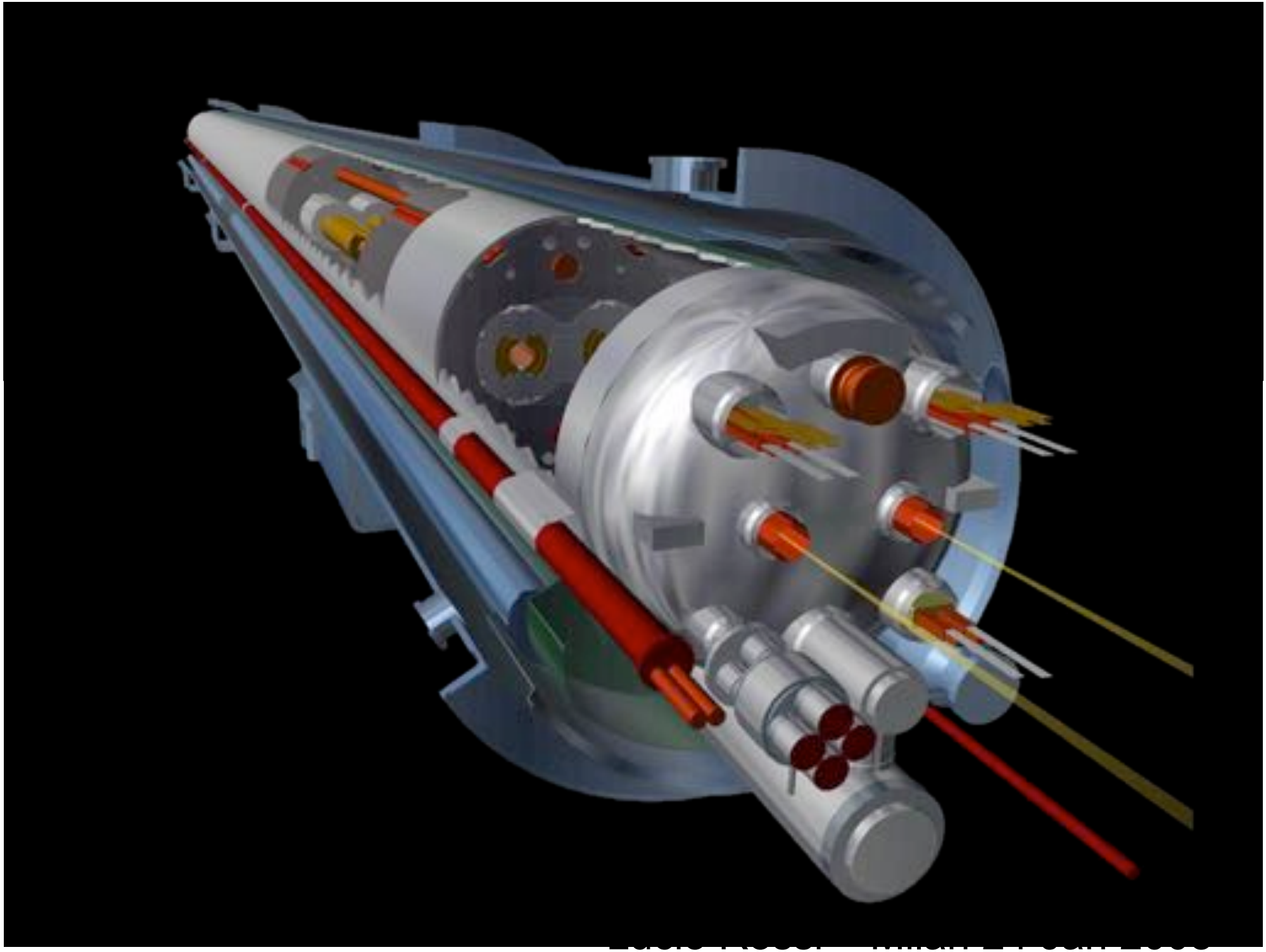
1x15 mm^2 – 30.000 A !!!

LHC project

LHC: 24 km di magneti superconduttori

1232 grandi magneti dipoli (15 m)

Altri 400 quadrupoli (7 m)

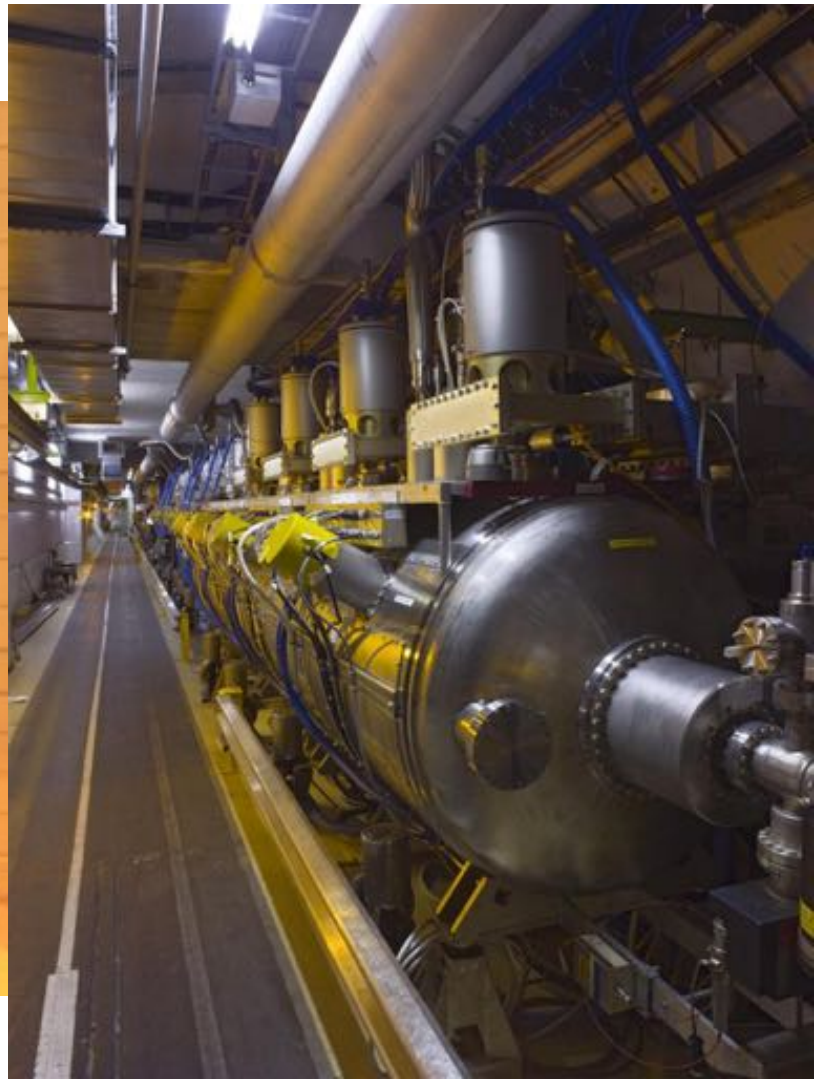


LHC project

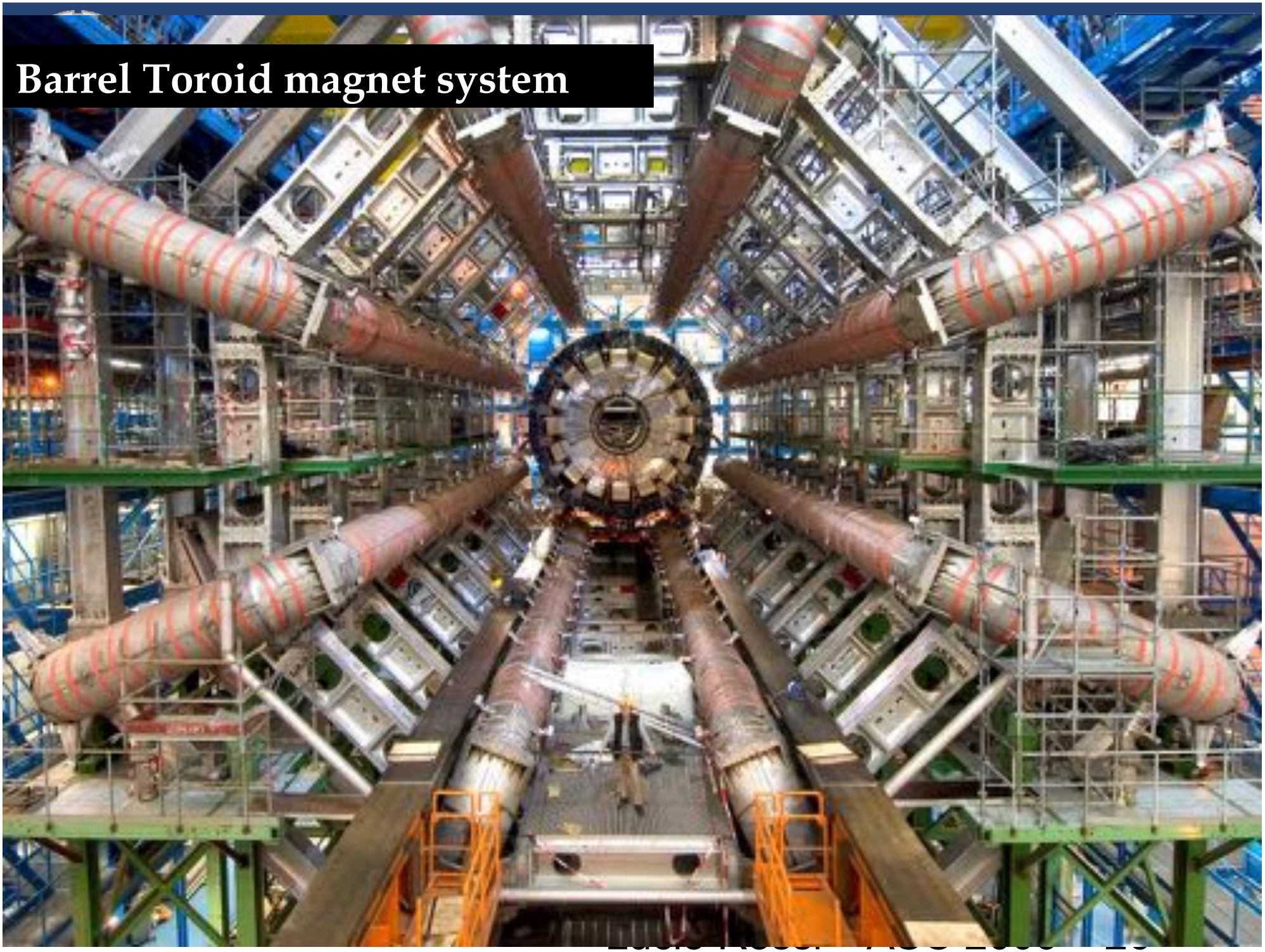
LHC: origini sono molto Italiane

LHC project

Cavità RF per accelerare in LHC sempre superconduttive

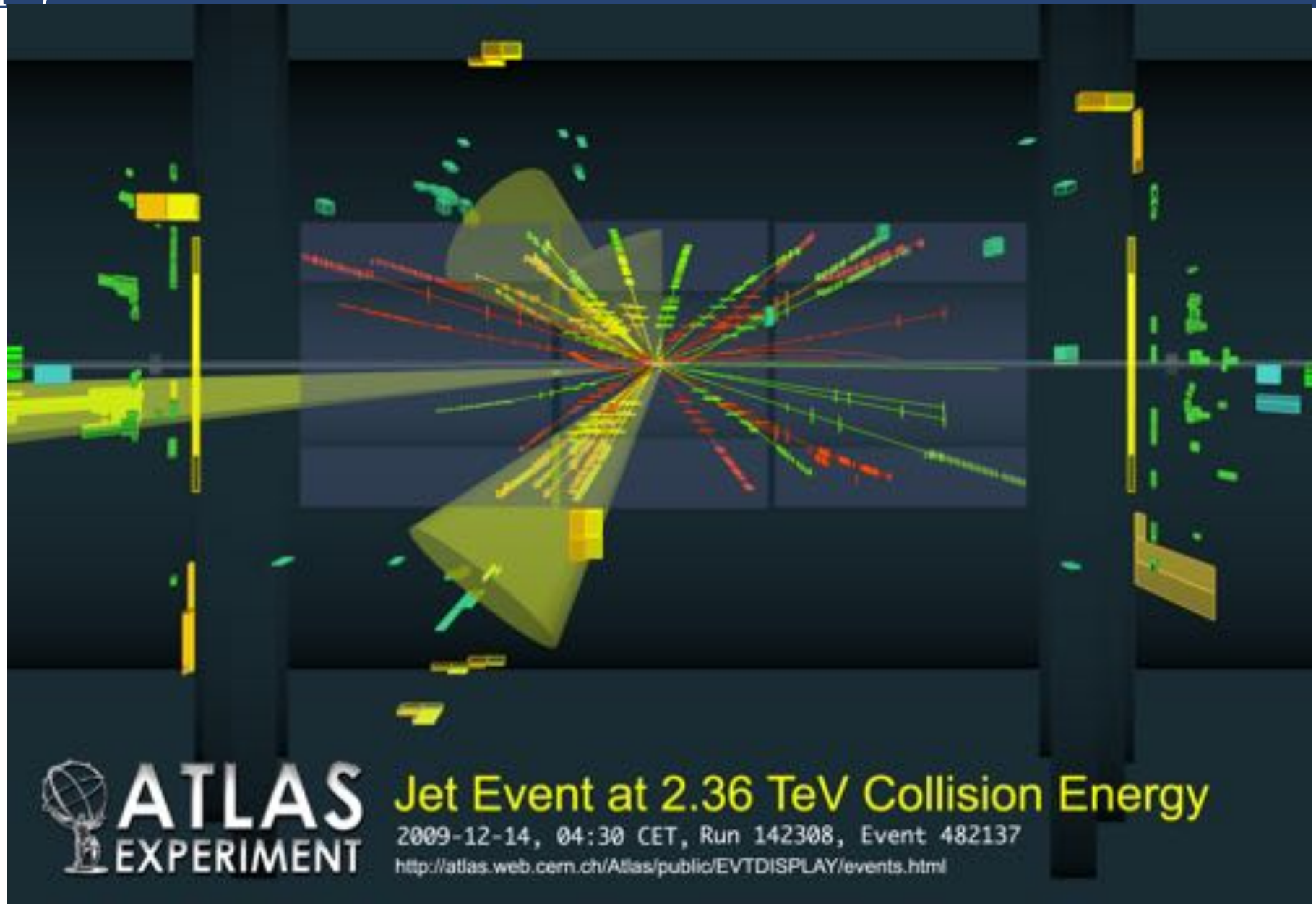


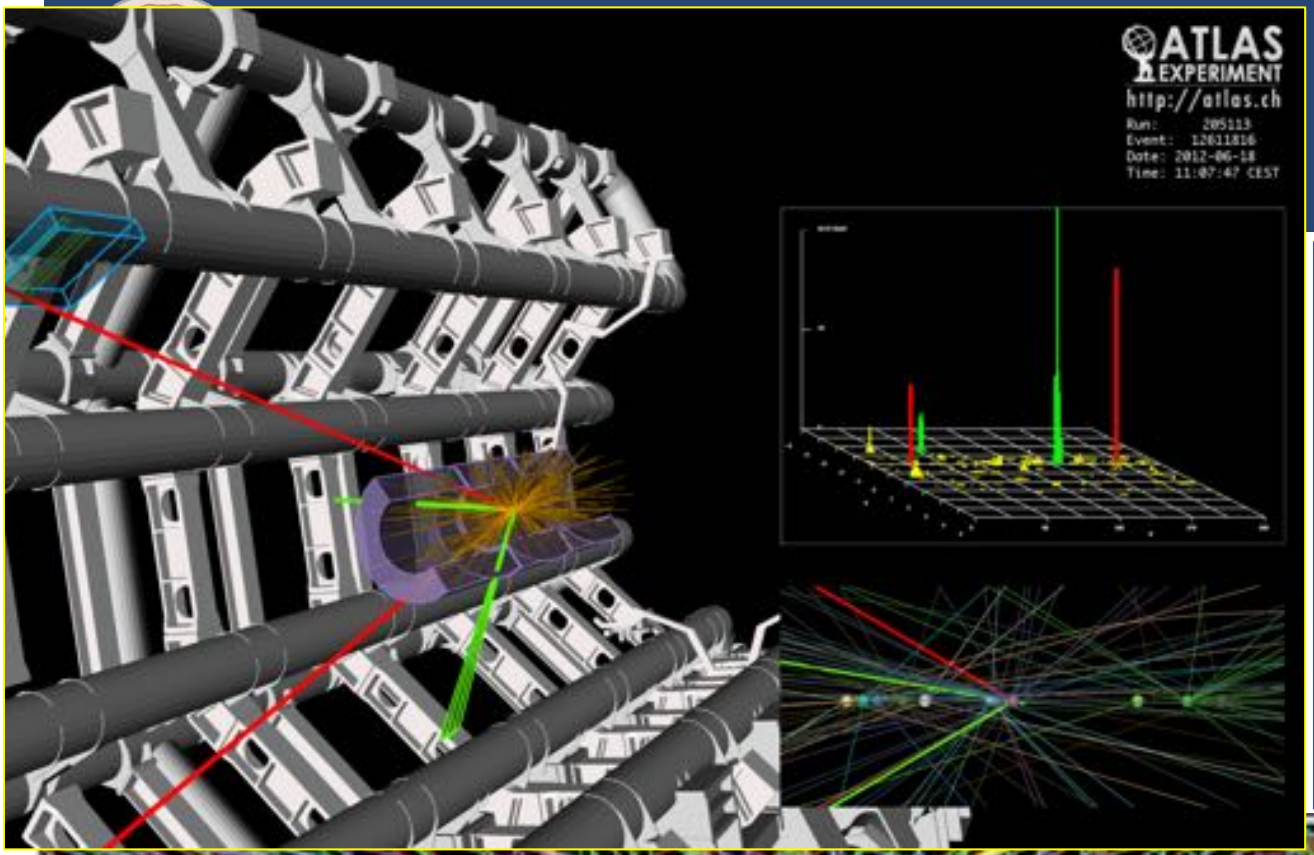
Barrel Toroid magnet system



LHC project

LHC: la ripartenza
I primi eventi





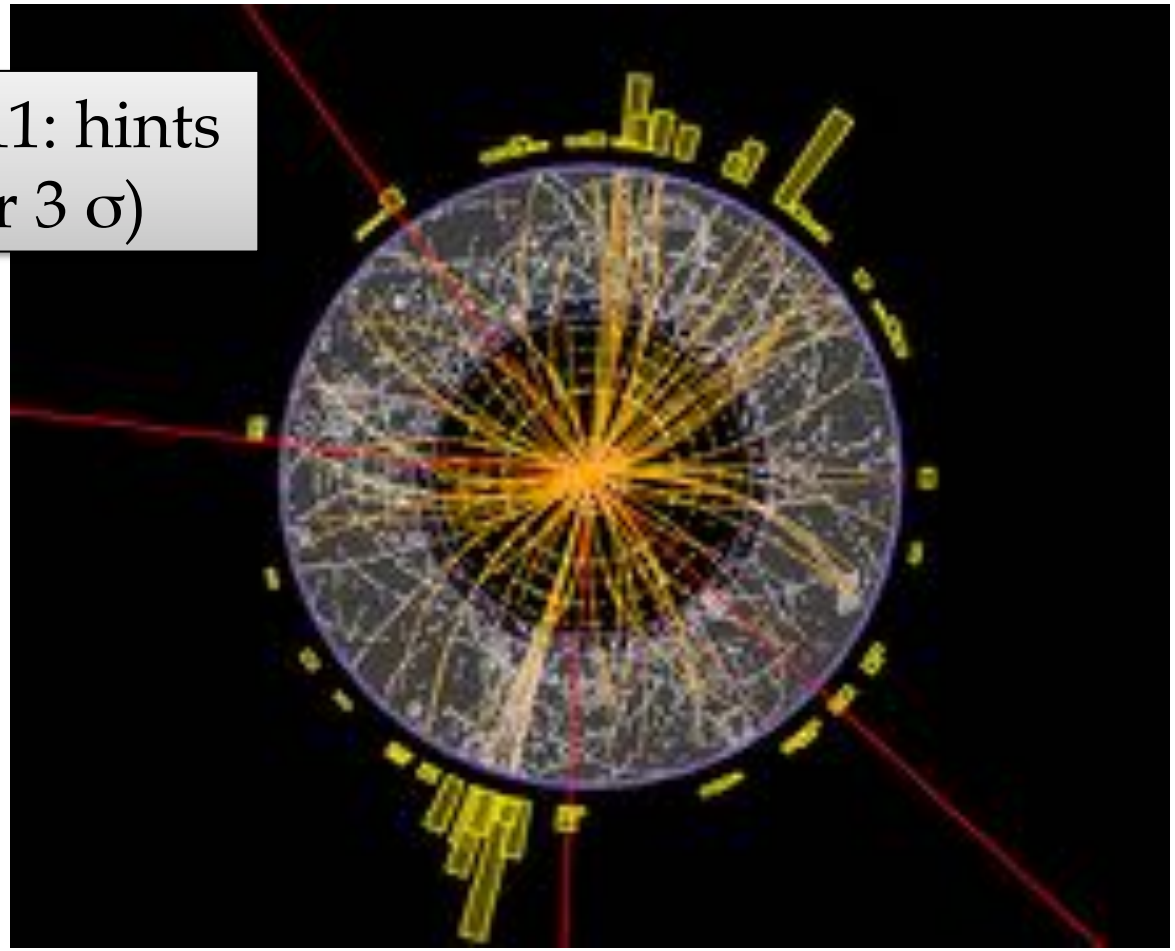
Higgs: l'ago nel pagliaio

Foto ripetuta 40 Milioni di volte al secondo

Z→ μμ event from 2012 data with 25 reconstructed vertices

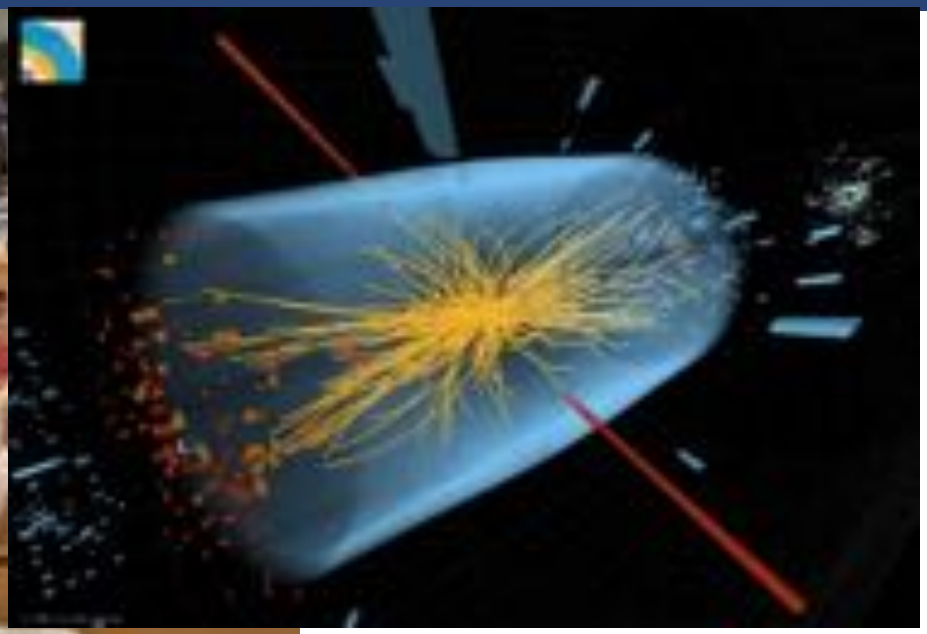
Ecco l'higgs (probabilmente…)

December 2011: hints of Higgs (near 3 σ)



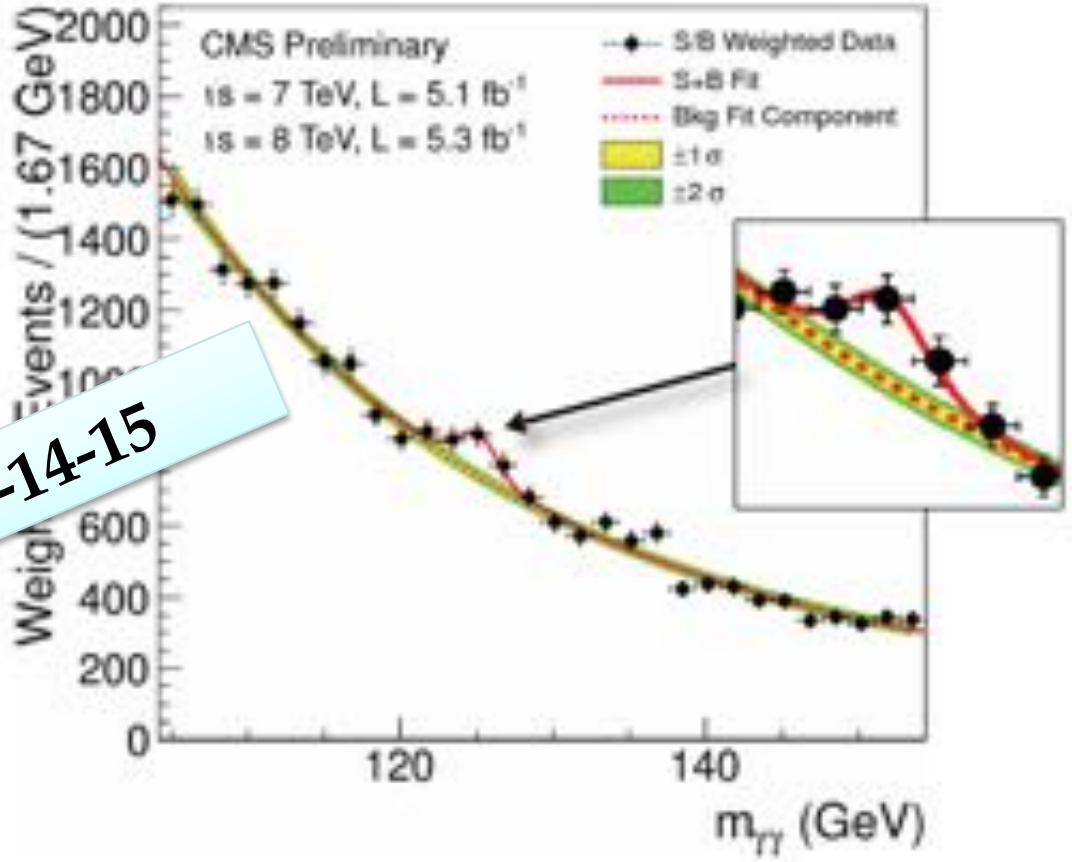
Higgs →2 Z→ 4 μ

4 luglio 2012 : Bosone catturato!



S/B Weighted Mass Distribution

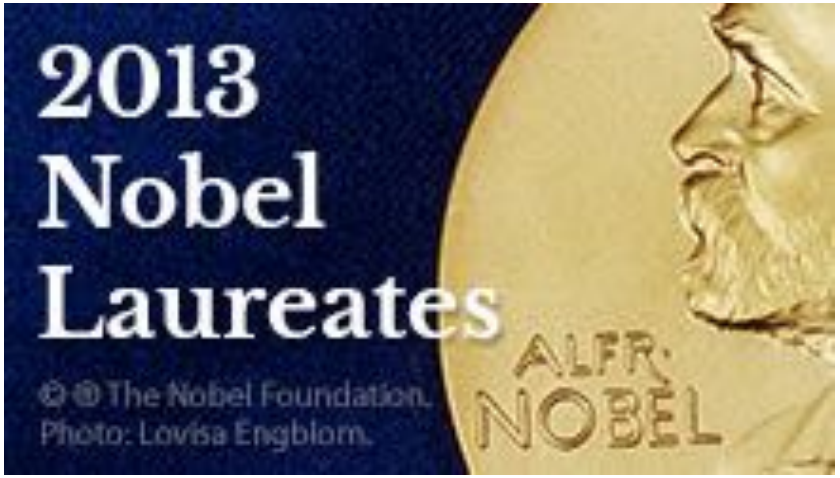
- Sum of mass distributions for each event class, weighted by S/B
  - B is integral of background model over a constant signal fraction interval



Piacenza 2013-14-15

Brout – Englert – Higgs mechanism Nobel 2013 pe rla fisica

LHC project

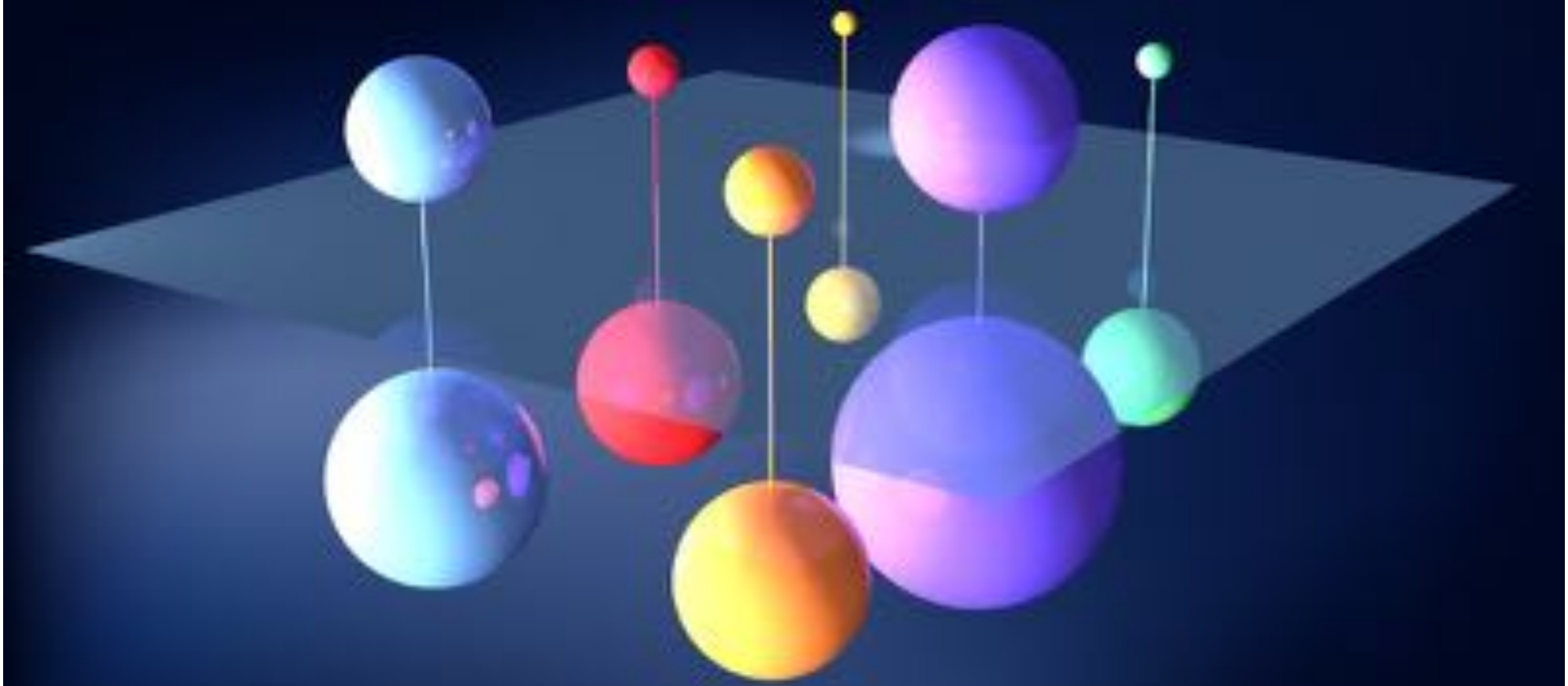


…for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider

LHC project

I teorici ci dicono che siamo instabili !

Un supermondo davanti a noi?

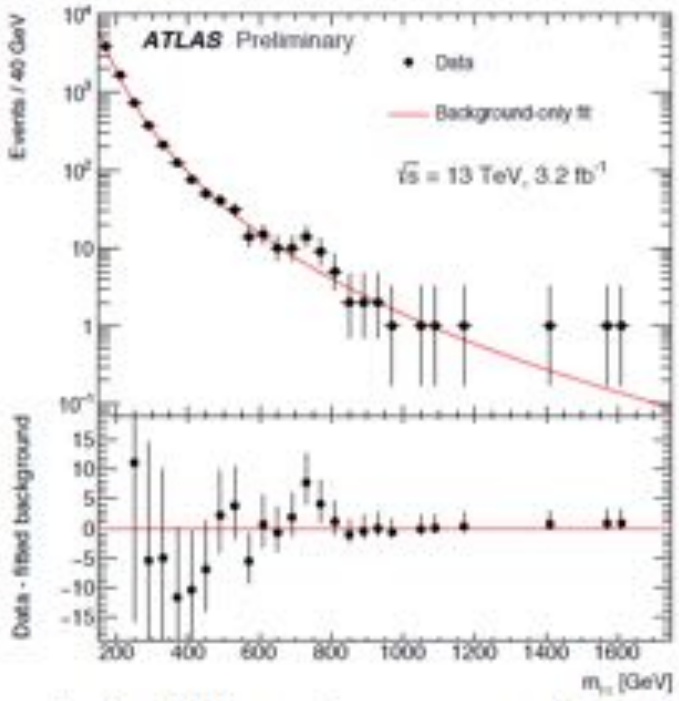


Luce sulla materia oscura?

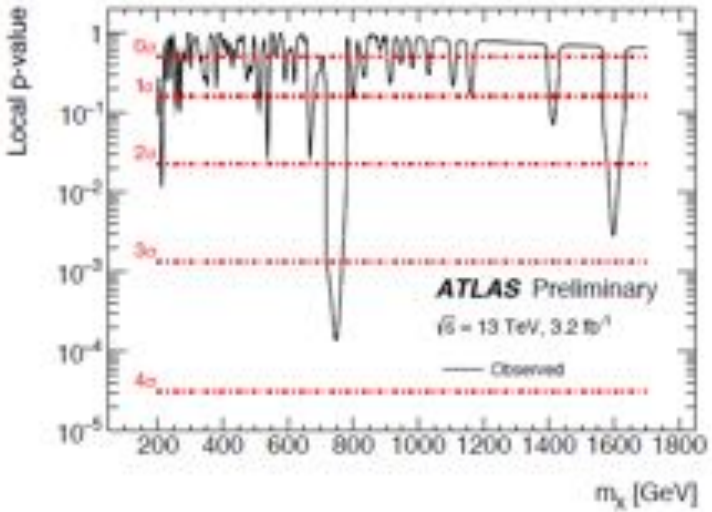
Primi risultati 2015 !
Seminario ATLAS 16.12.2015

Search for a **Two Photons Resonance** (II)

Results: Events with mass in excess of 200 GeV are included in **unbinned fit**



- **In the NWA search**, an excess of **3.6σ** (local) is observed at a mass hypothesis of minimal p_0 of 750 GeV

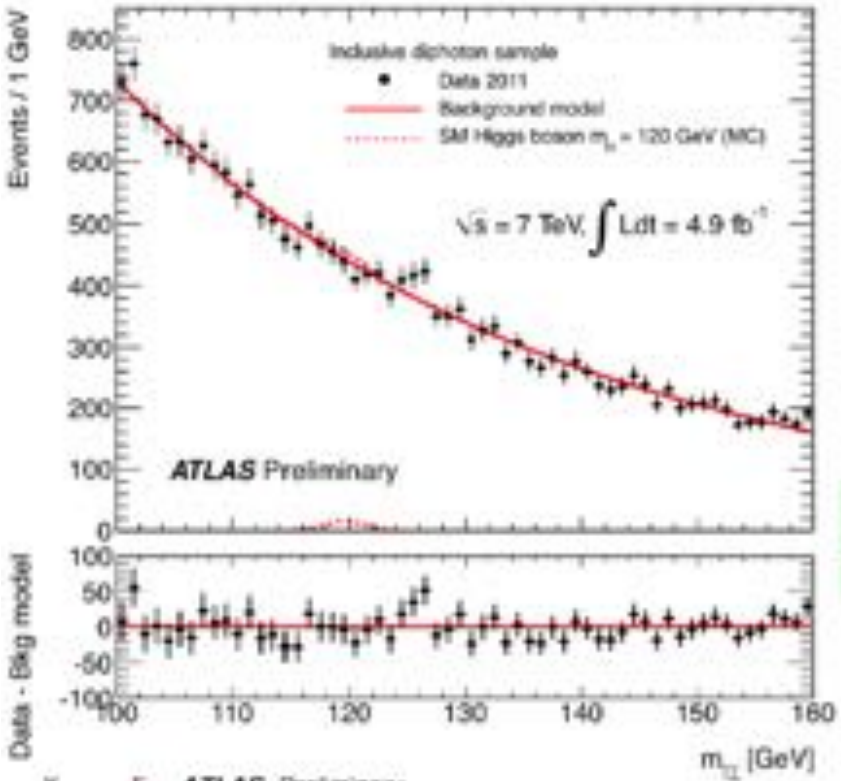


In the NWA fit the resolution uncertainty is profiled in the NWA fit and is pulled by 1.5σ

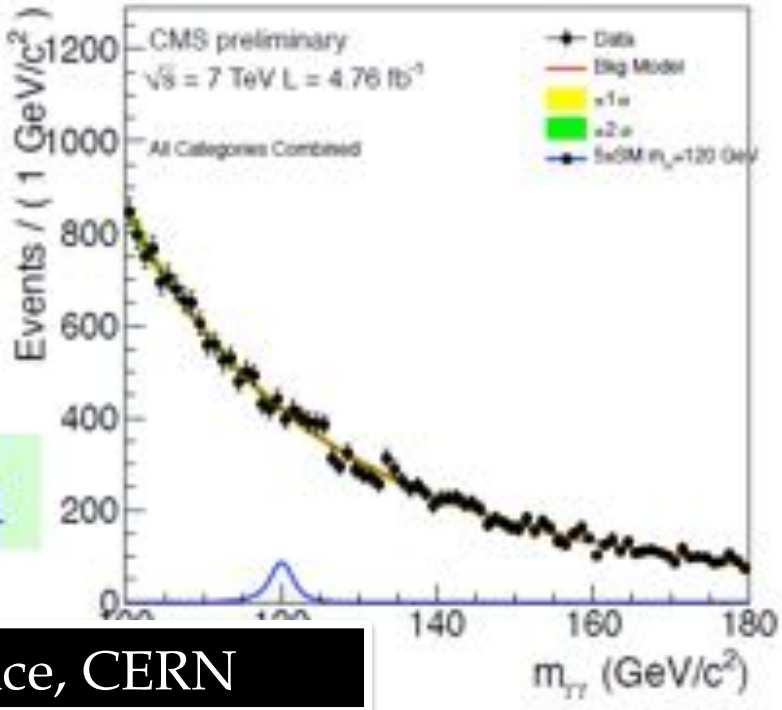
The data was then fit under a **LW hypothesis** yielding a width of approximately 45 GeV
(Approx. 6% of the best fit mass of approximately 750 GeV)

- As expected the local significance increases to **3.9σ**

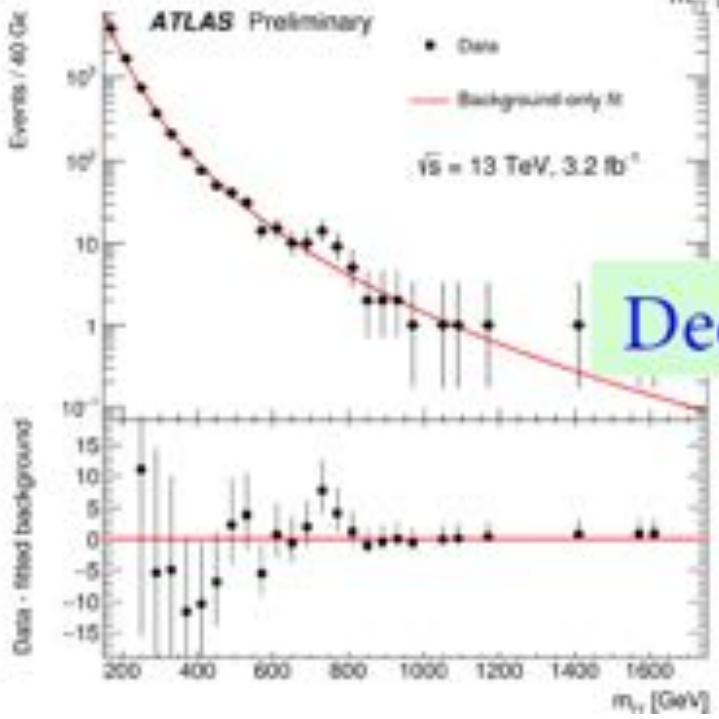
Cortesia Marumi Kado & ATLAS collaboration



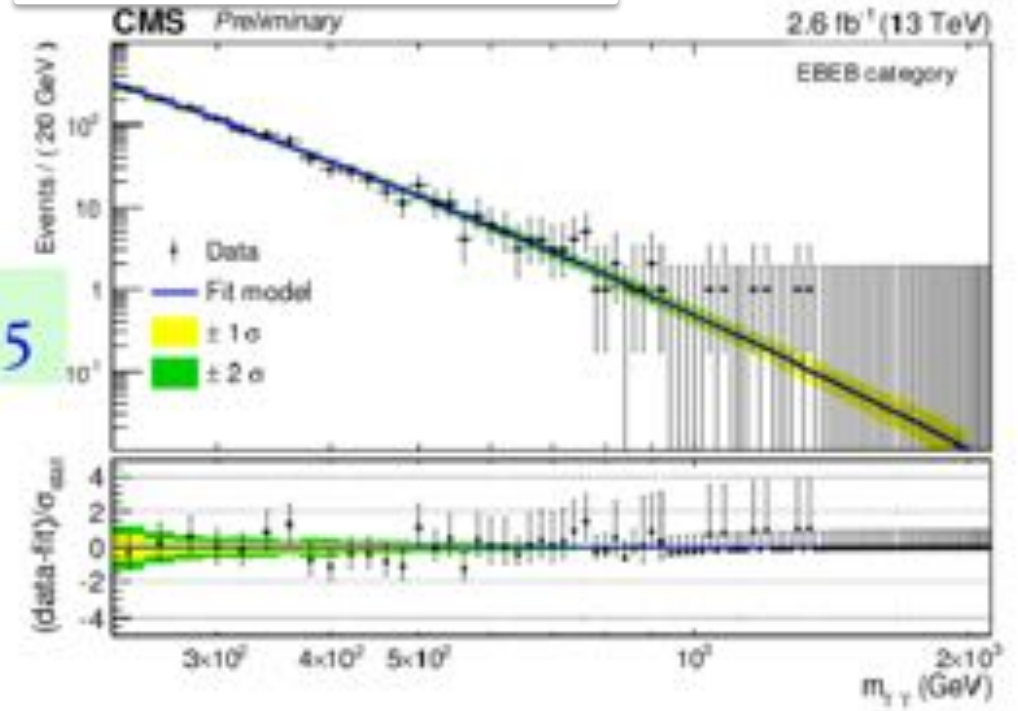
Dec 2011



G. Giudice, CERN



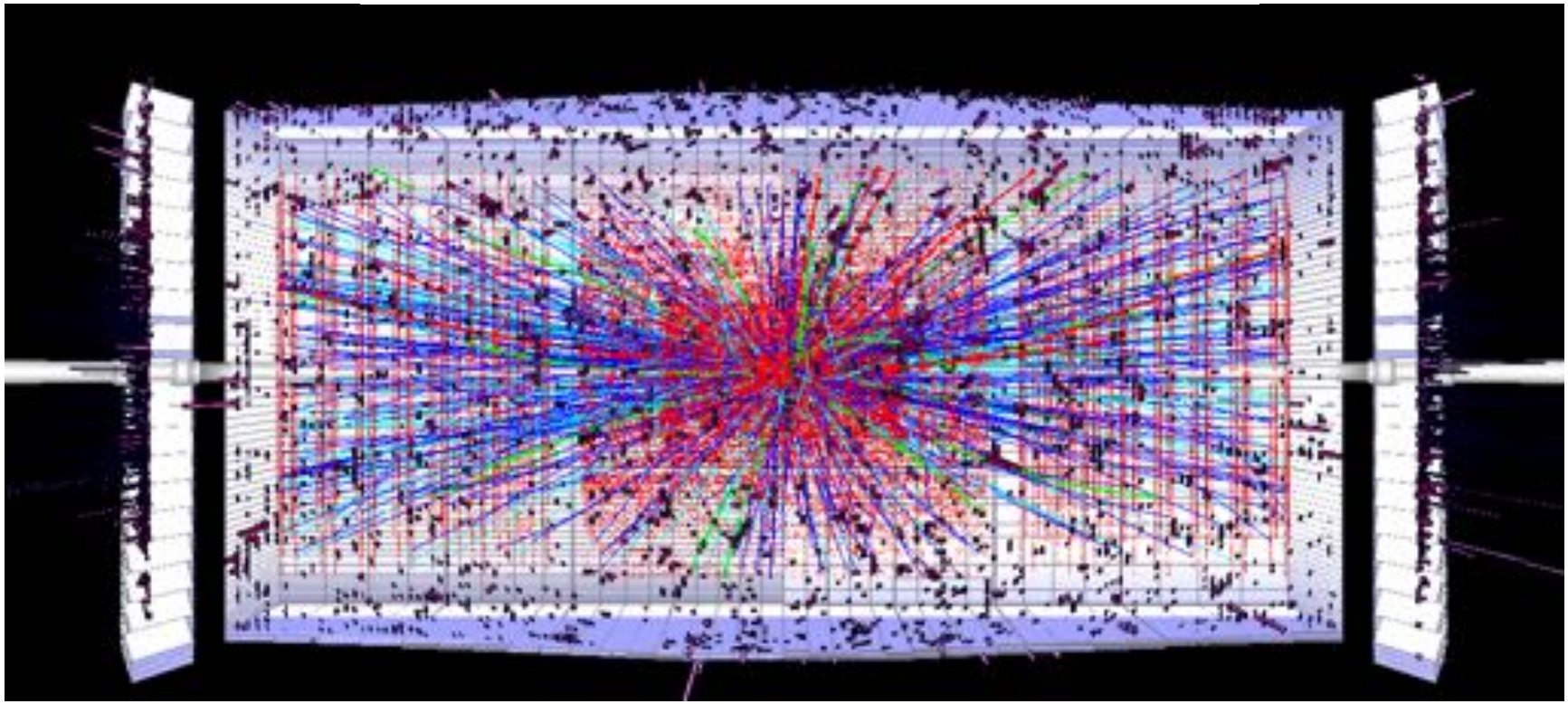
Dec 2015



LHC project

High Luminosity LHC

The HiLumi LHC Design Study (a sub-system of HL-LHC) is cofunded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404



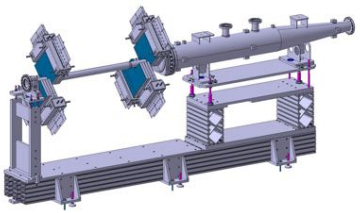
HiLumi: 1.2 km di nuova tecnologia

CIVIL ENGINEERING
2 new 300-metre service tunnels and 2 shafts near to ATLAS and CMS.

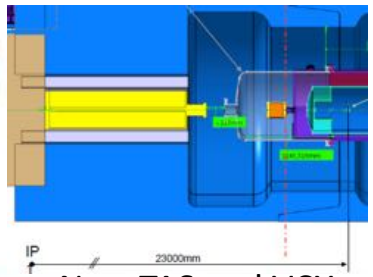
"CRAB" CAVITIES
16 superconducting „crab" cavities for each of the ATLAS and CMS experiments to tilt the beams before collisions.

Cryo@P1-P5

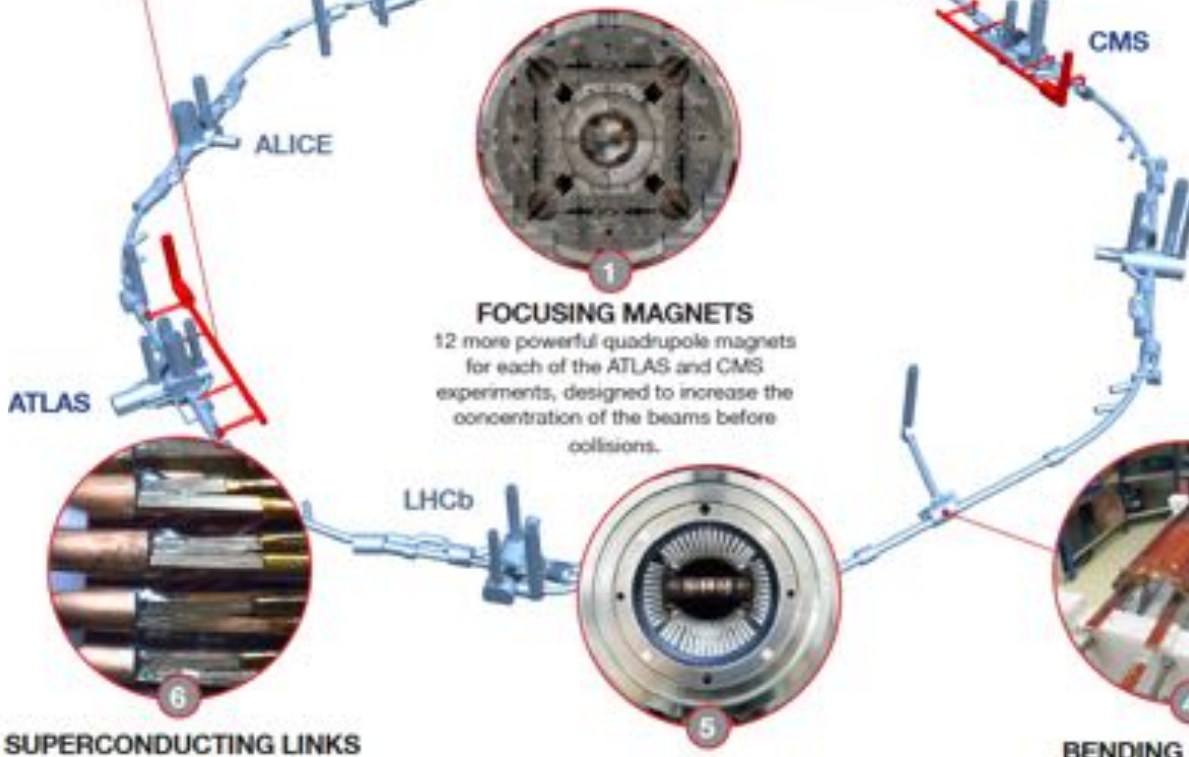
Cryo@P4



Beam diagnostics
BGV



New TAS and VCX



FOCUSING MAGNETS
12 more powerful quadrupole magnets for each of the ATLAS and CMS experiments, designed to increase the concentration of the beams before collisions.

SUPERCONDUCTING LINKS
Electrical transmission lines based on a high-temperature superconductor to carry current to the magnets from the new service tunnels near ATLAS and CMS.

COLLIMATORS
15 to 20 new collimators and 60 replacement collimators to reinforce machine protection.

BENDING MAGNETS
4 pairs of shorter and more powerful dipole bending magnets to free up space for the new collimators.

Eppur noon basta…
il nuovo progetto da 100 km!

LHC project

CERN

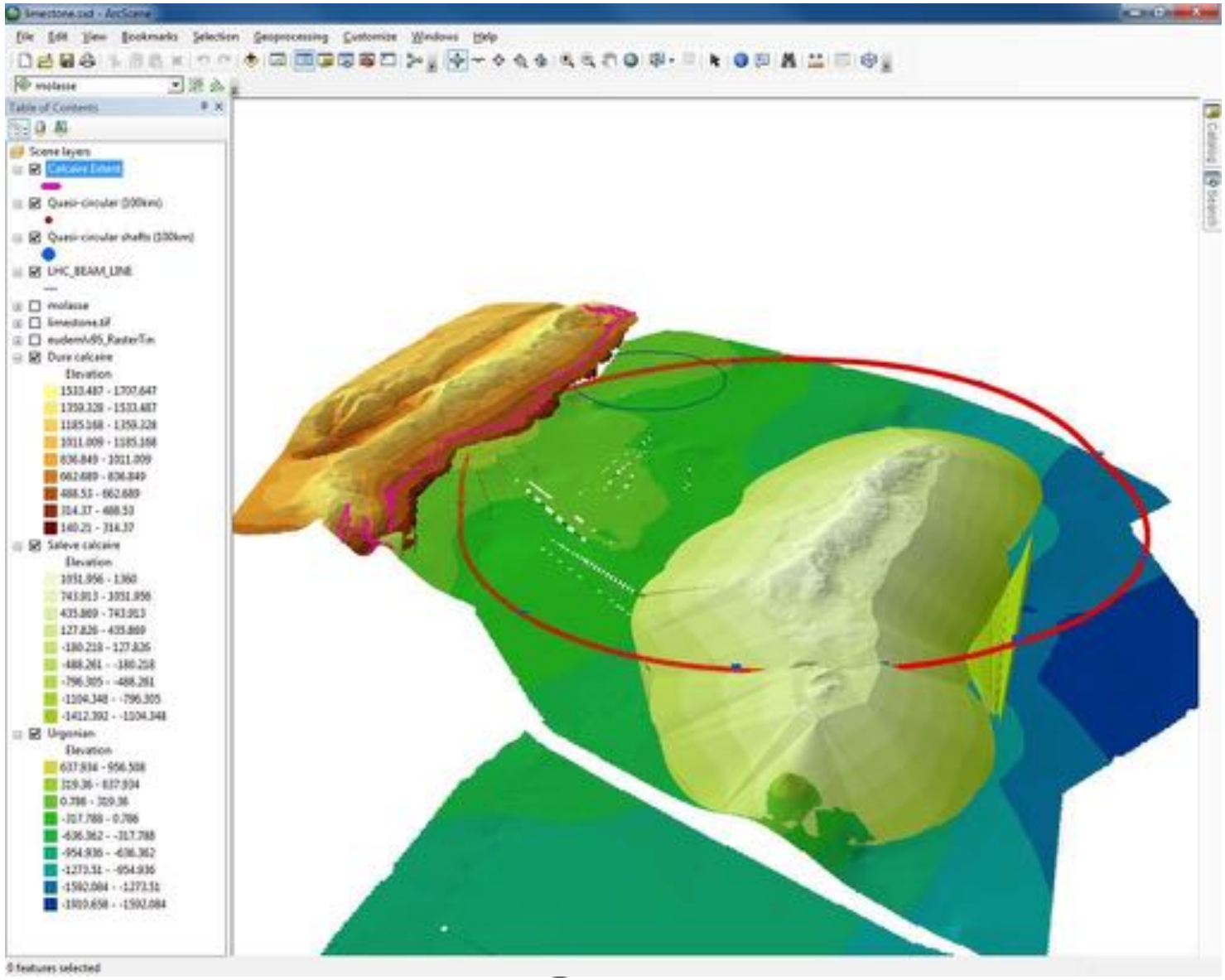
HE-LHC	FCC-hh	FCC-hh
27 km, **20 T**	80 km, **20 T**	100 km, **16 T**
33 TeV (c.o.m.)	100 TeV (c.o.m.)	100 TeV (c.o.m.)

LHC project

3D digital model of local geology

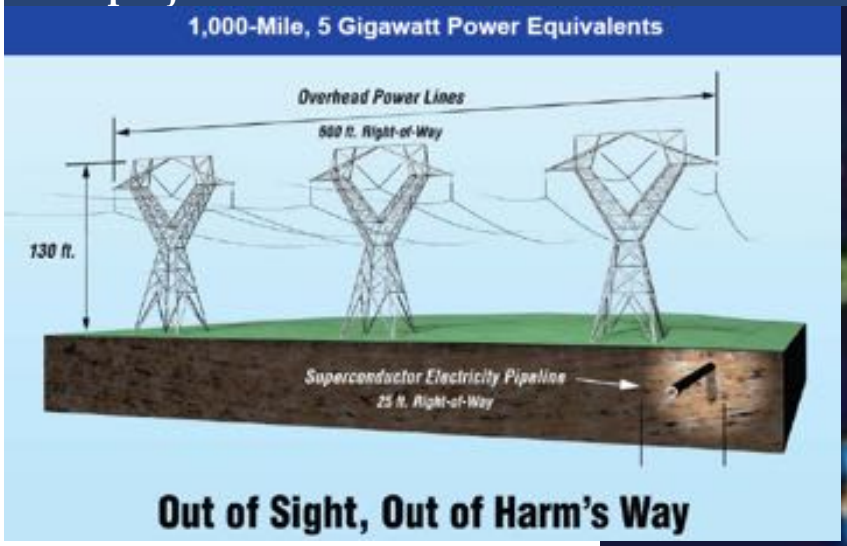
CERN

ARUP



LHC project

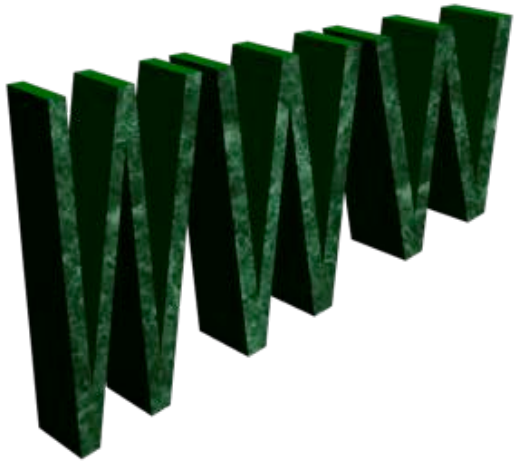
Una possibile applicazione di hilumi: trasporto energia



Courtesy Southwire Company

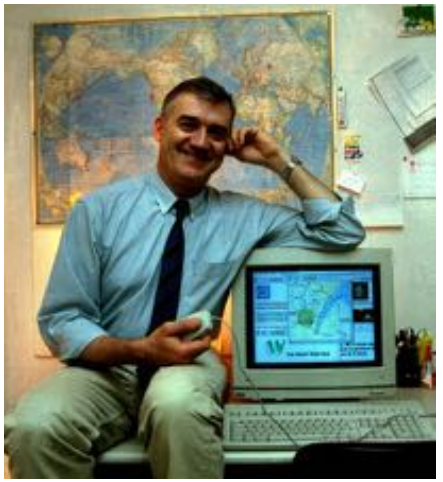
la valorizzazione della comunicazione:

LHC project



1989 il WEB
2009 la celebrazione

Tim Berners-Lee



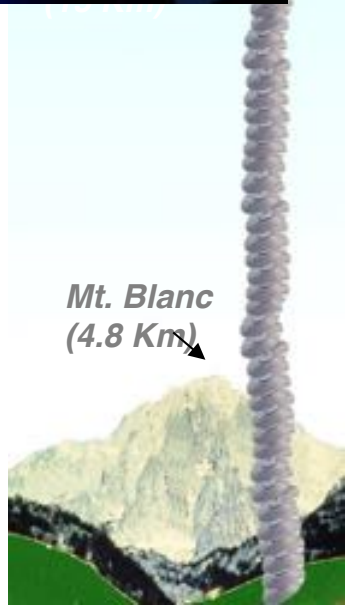
Robert Cailliau

Il successore del Web: GRID

LHC project

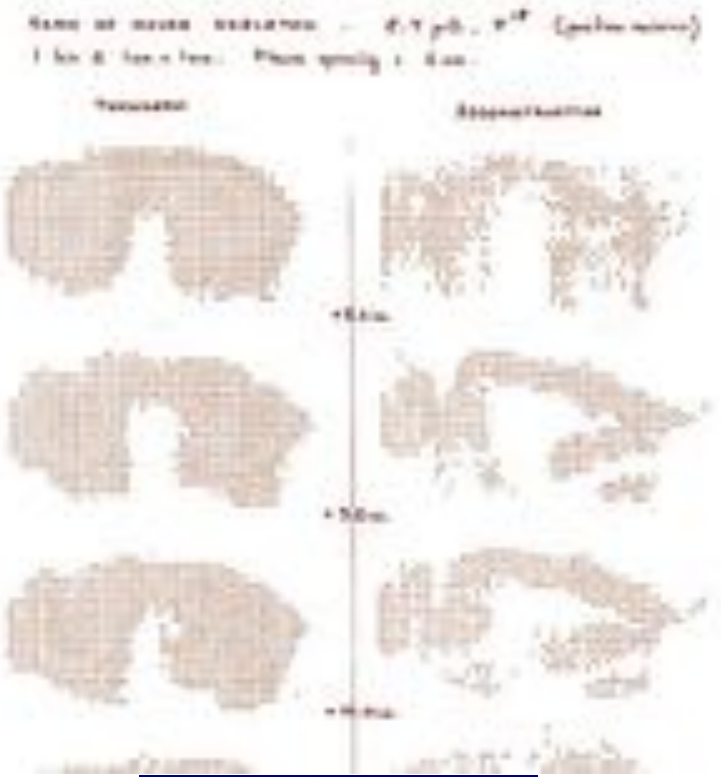
Il LHC computing GRID è un progetto finanziato dall'UE con l'obiettivo di construire la futura generazione di infrastruttura di calcolo per fornire una capacità di calcolo e analisi mai vista.

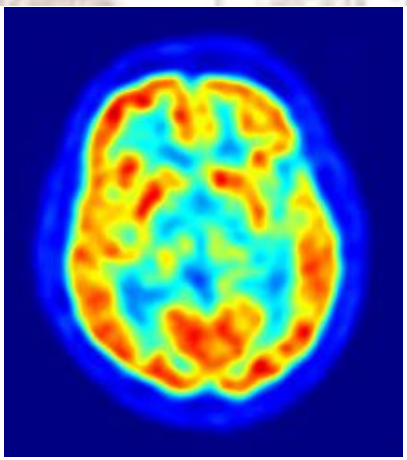
t une
données
~ 20 Km)



Le applicazionl mediche: PET

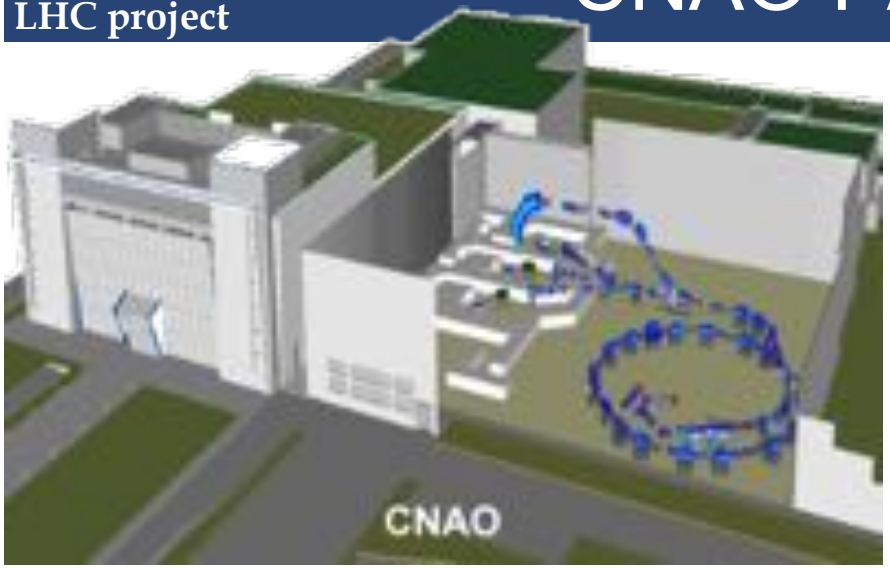
Prima immagine PET CERN, circa 1975



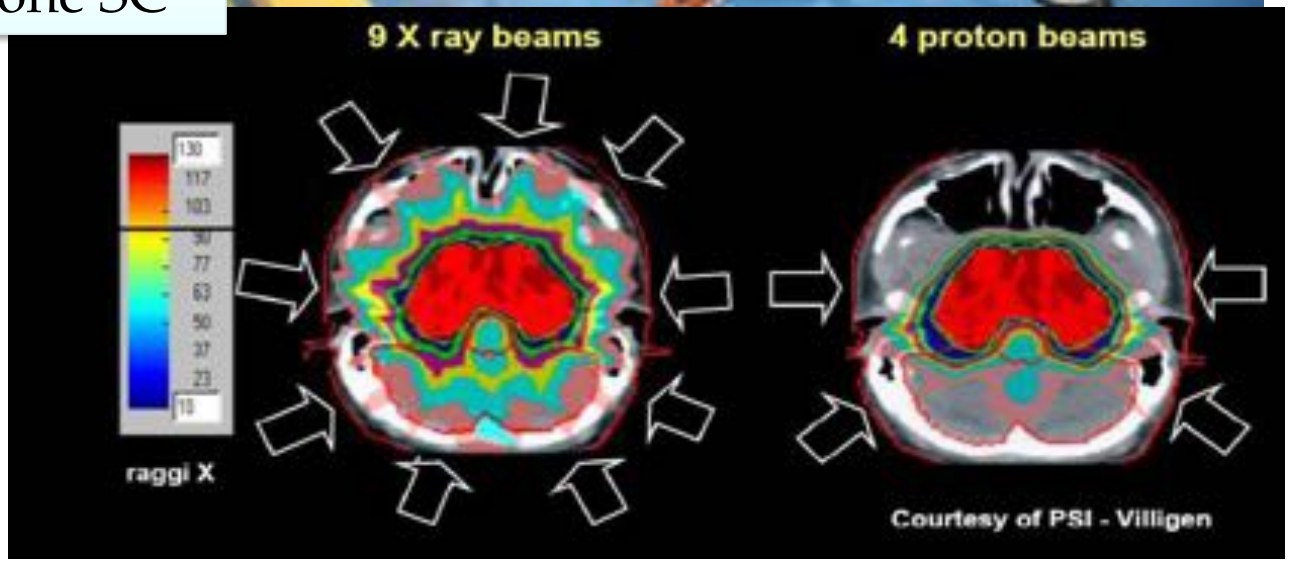


LHC project

Adroterapia Oncologica
CNAO PAVIA & PSI (CH)

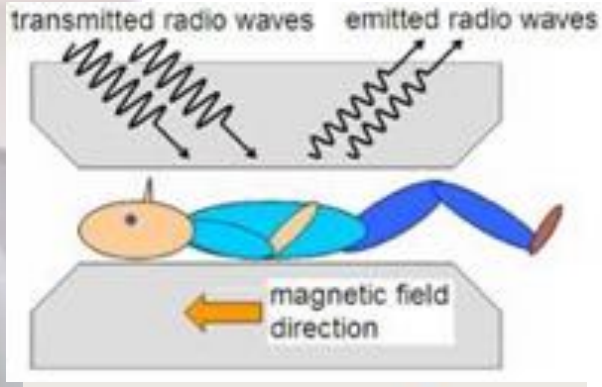


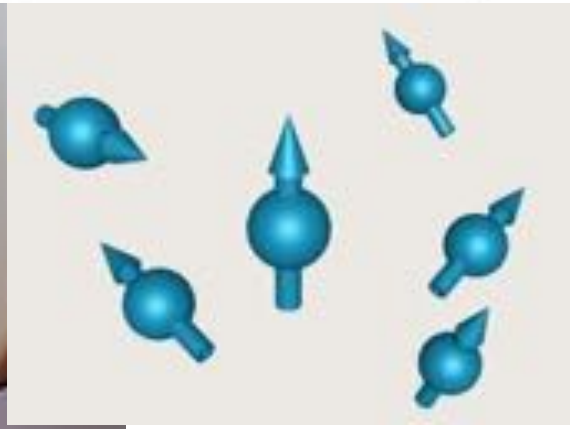
Ciclotrone SC

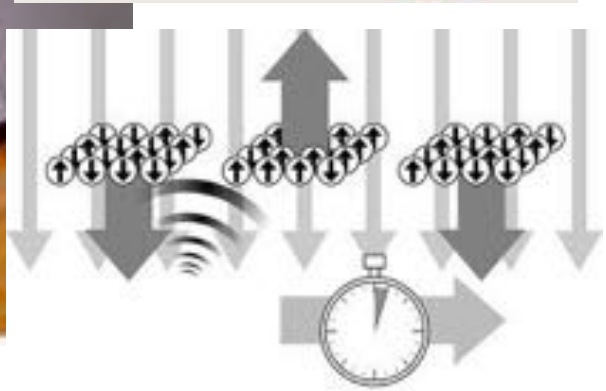


LHC project

La “grande” applicazionI sanitaria: Risonanza magnetica



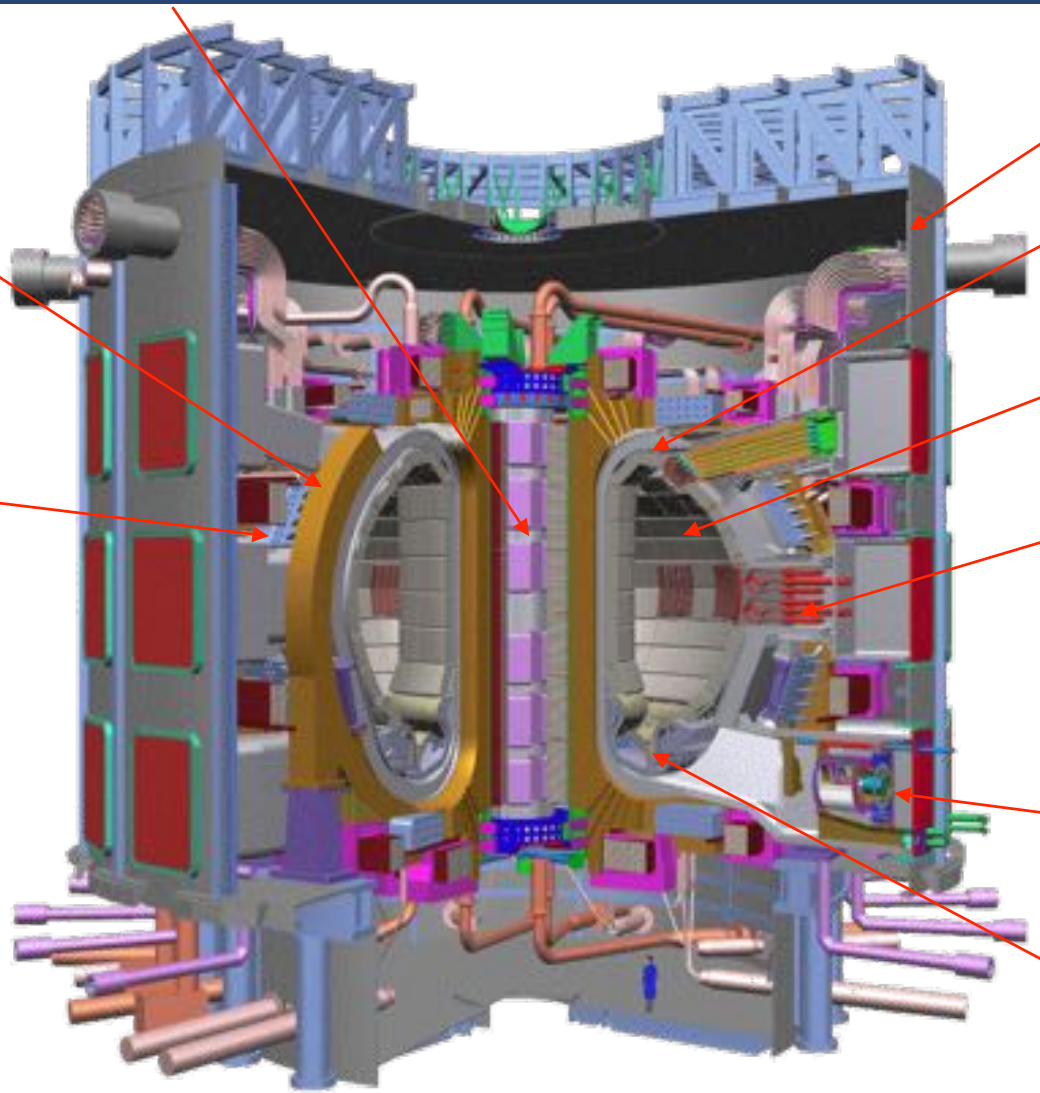




LHC project

ITER: L'Energia delle stelle

CERN



Major plasma radius 6.2 m

Plasma Volume: 840 m^3

Plasma Current: 15 MA

Typical Density: 10^{20} m^{-3}

Typical Temperature: 20 keV

Fusion Power: 500 MW

Machine mass: 23350 t (cryostat + VV + magnets)

- shielding, divertor and manifolds: 7945 t + 1060 port plugs
- magnet systems: 10150 t; cryostat: 820 t

MAGLEV

… e speriamo che la luce brilli su LHC ancora per molti anni a venire…