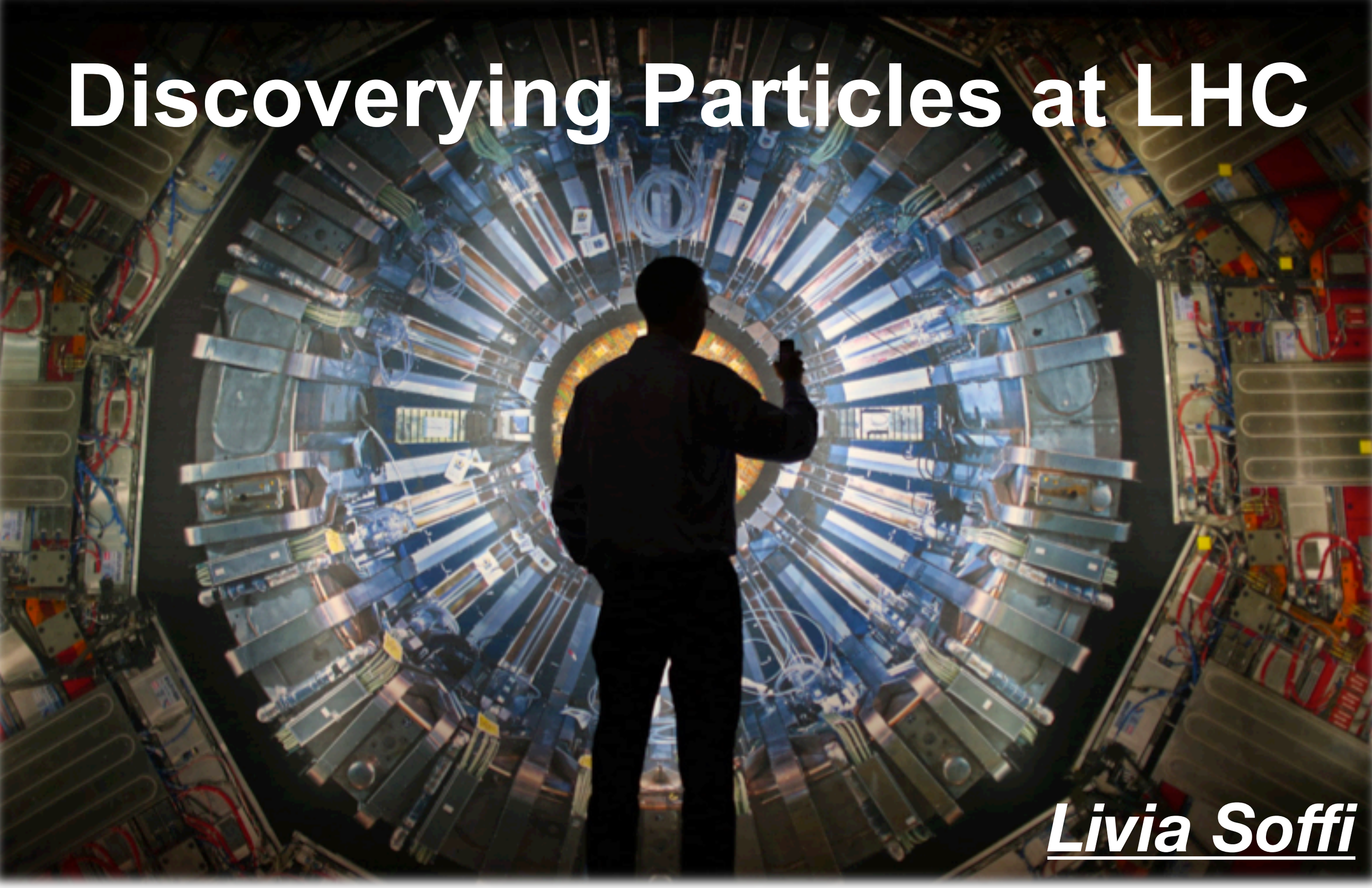
Discoverying Particles at LHC



Livia Soffi

INFN Istituto Nazionale di Fisica Nucleare Sezione di Roma

Particle identikit

Nelle collisioni si producono diversi tipi di particelle

Ogni particella lascia un segnale caratteristico diverso

Per ciascuna particella che si crea vogliamo misurare:

- La direzione
- L'energia
- La carica elettrica
- Sapere che particella e`

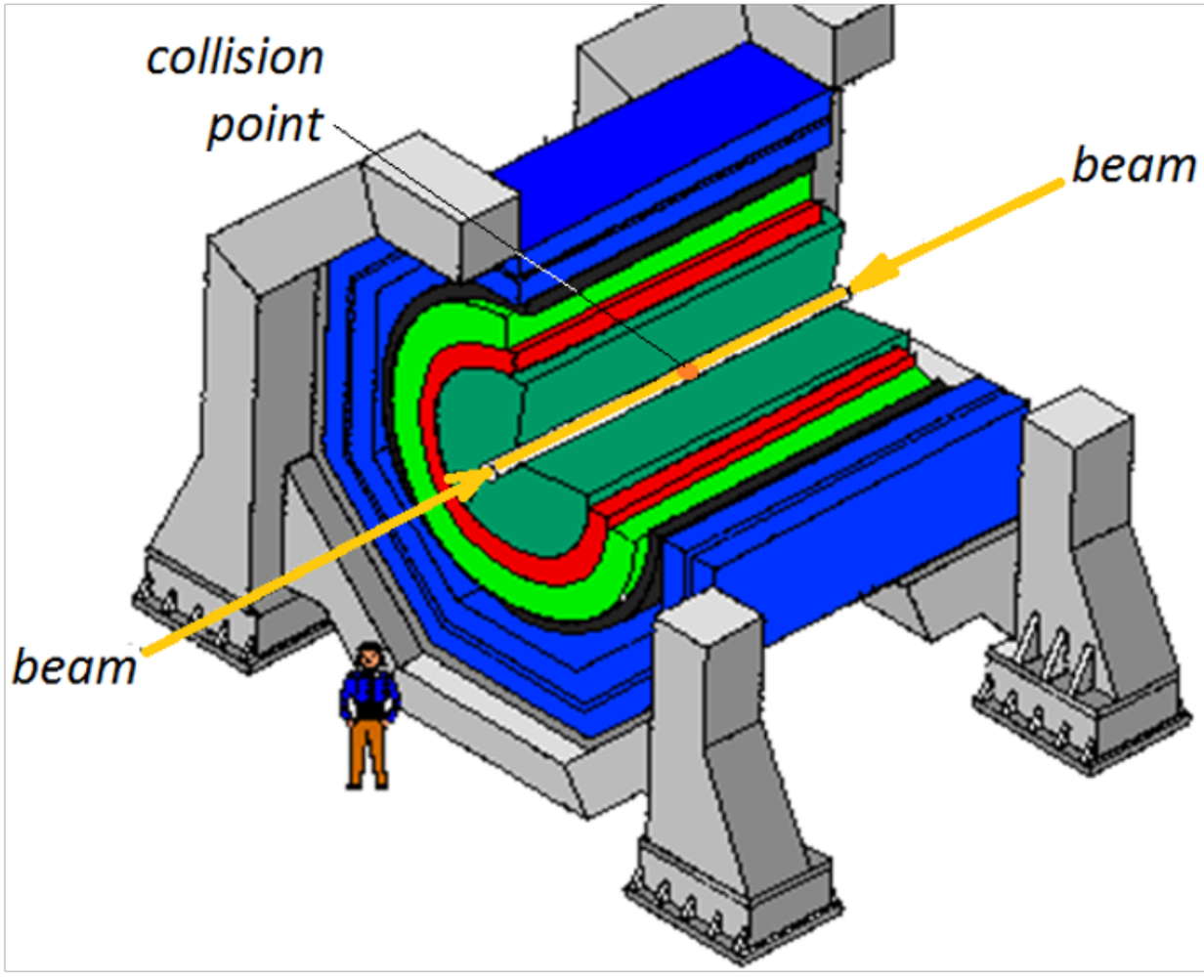
Come e` fatto un esperimento all'LHC

Un disegno generico di Atlas o CMS e` fatto cosi`:

→**Forma cilindrica** attorno al tubo del fascio

dall'interno verso l'esterno:

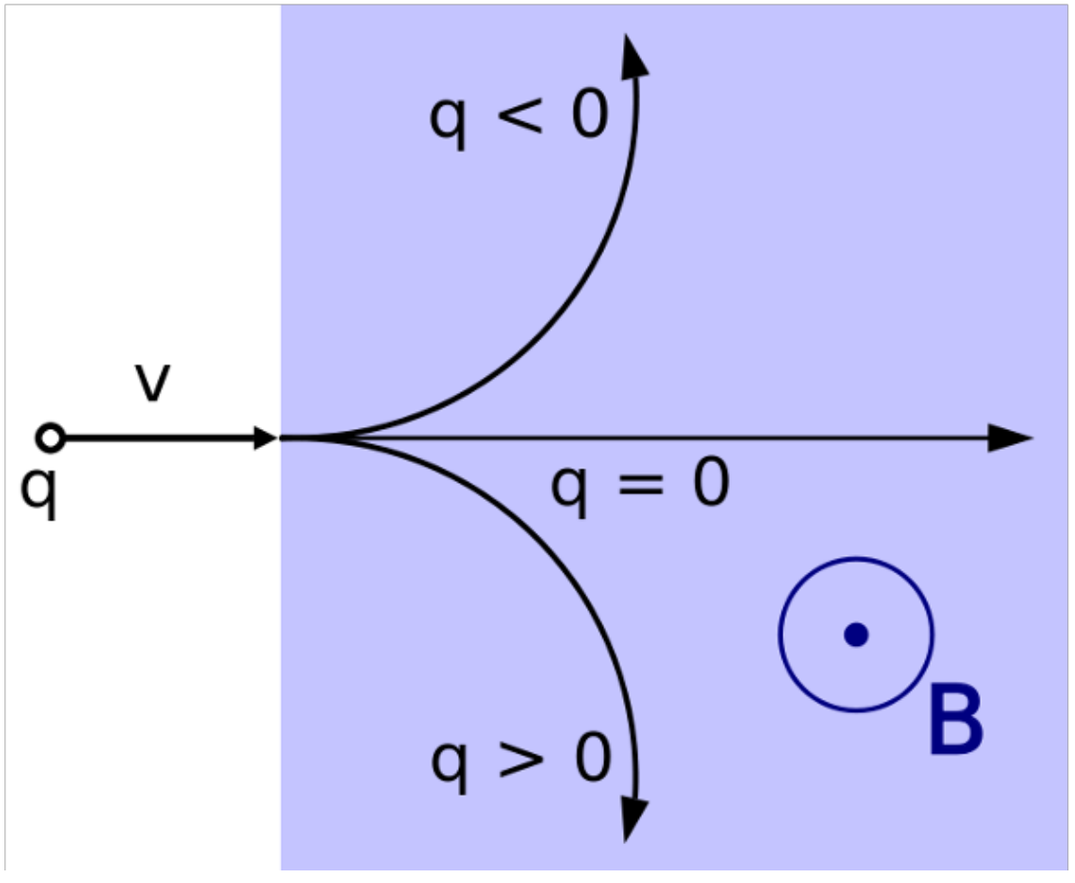
- Tracciatore
- Calorimetro elettromagnetico
- Calorimetro adronico
- Magnete
- Camere per muoni



Magnete

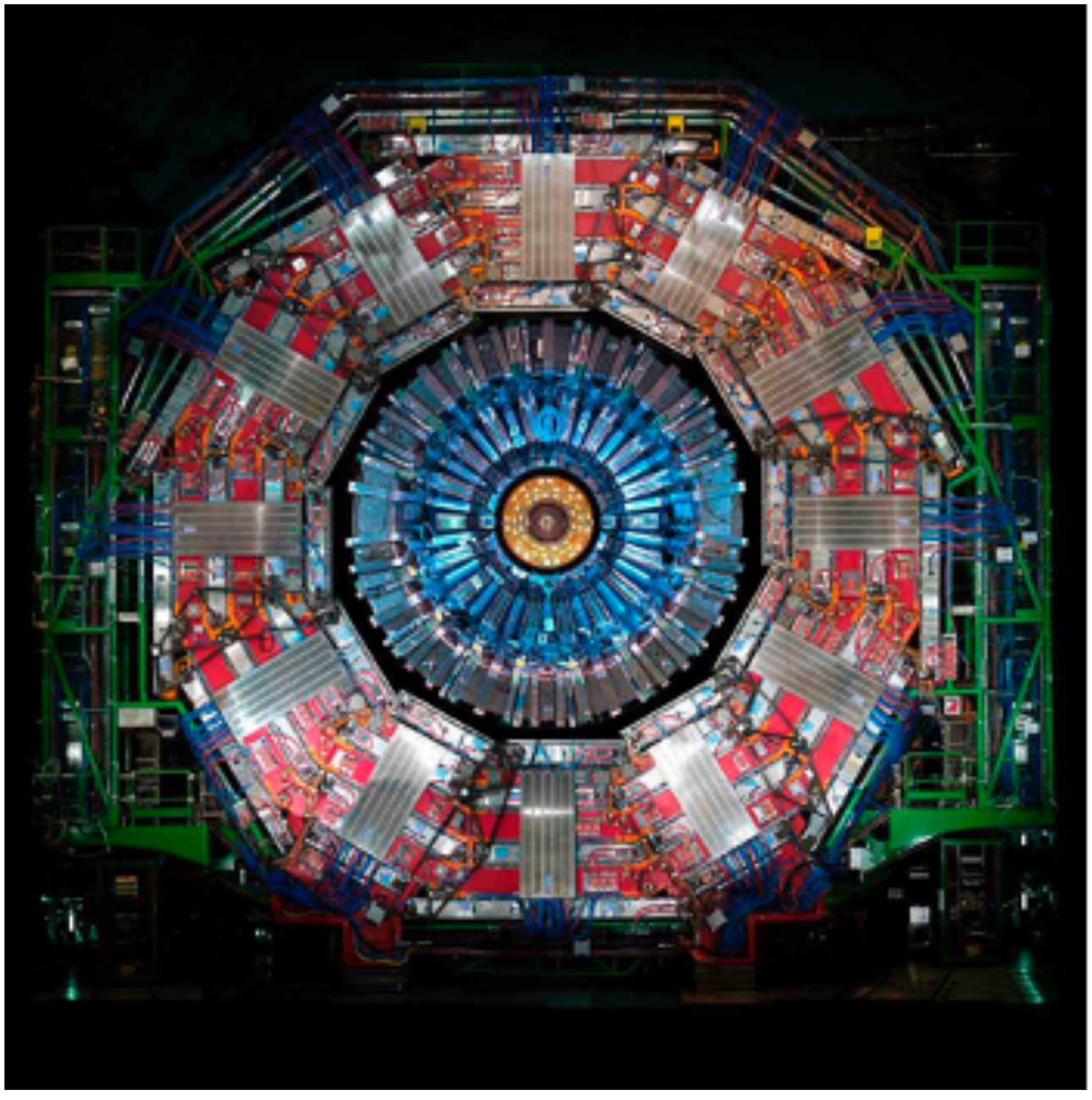
Il tracciatore e` immerso in un campo magnetico.

Usando la Forza di Lorentz: $\vec{F} = q\vec{v} \times \vec{B}$



possiamo misurare la carica delle particelle

CMS: Our beautiful experiment



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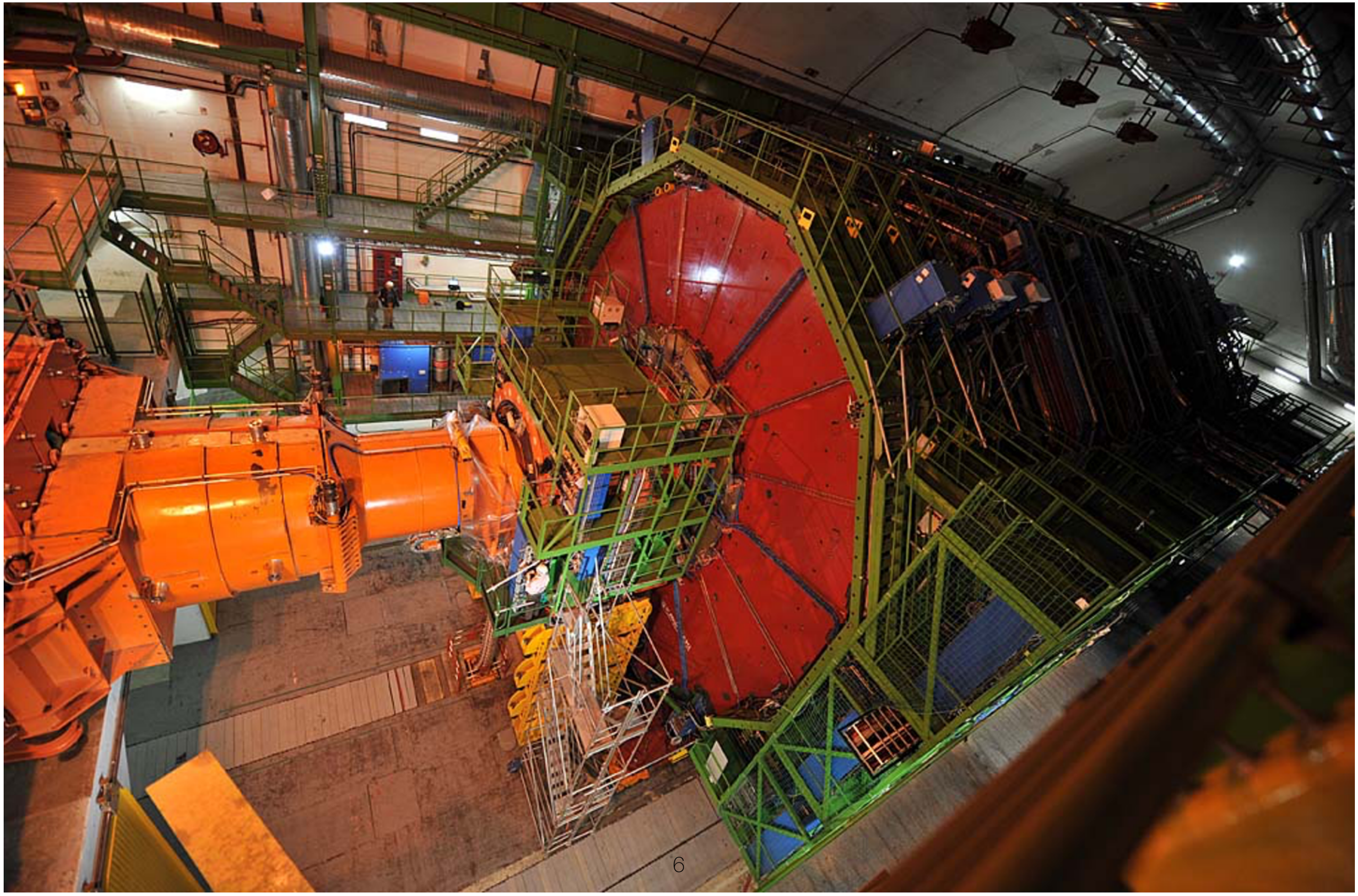
La caverna di CMS (Settembre 2008)

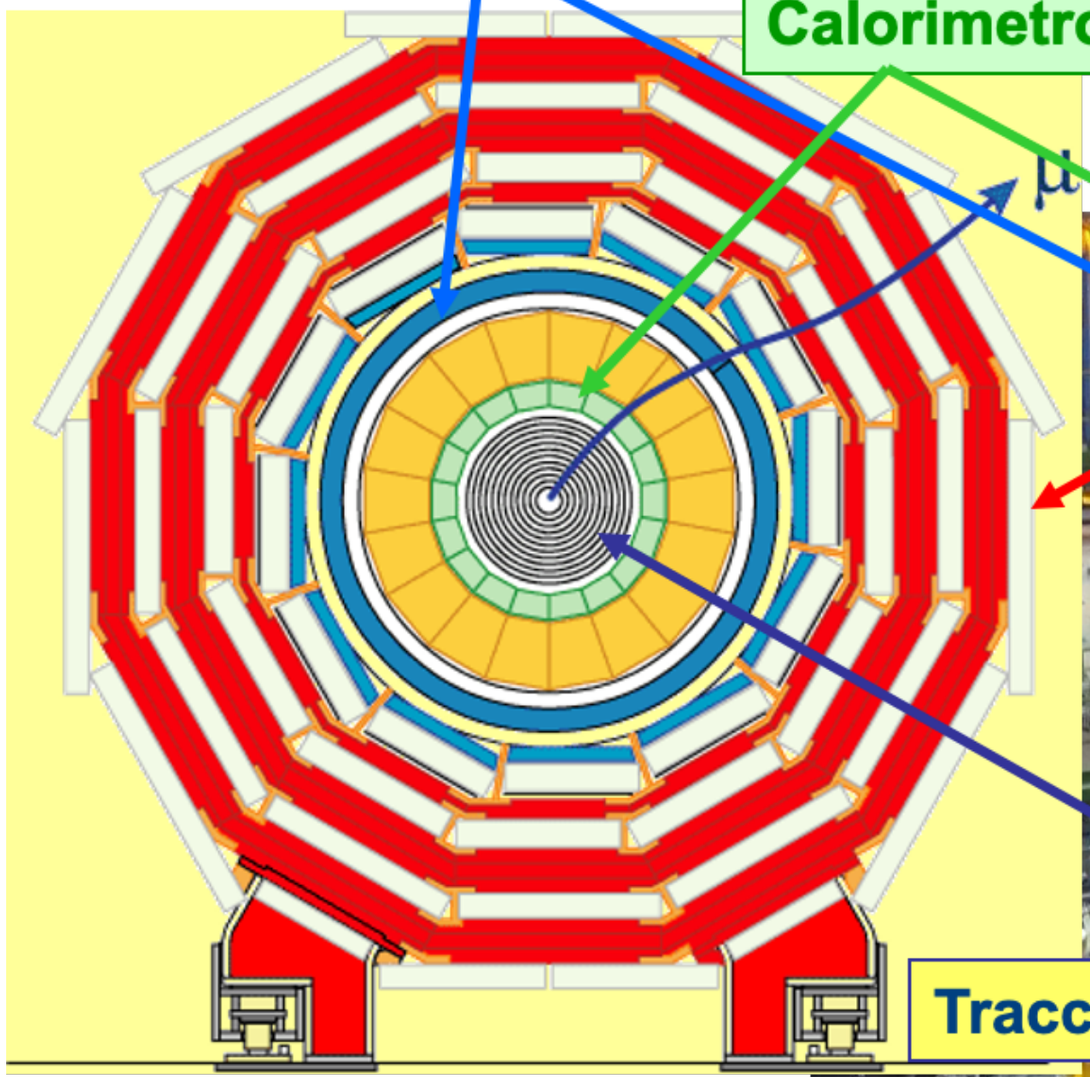


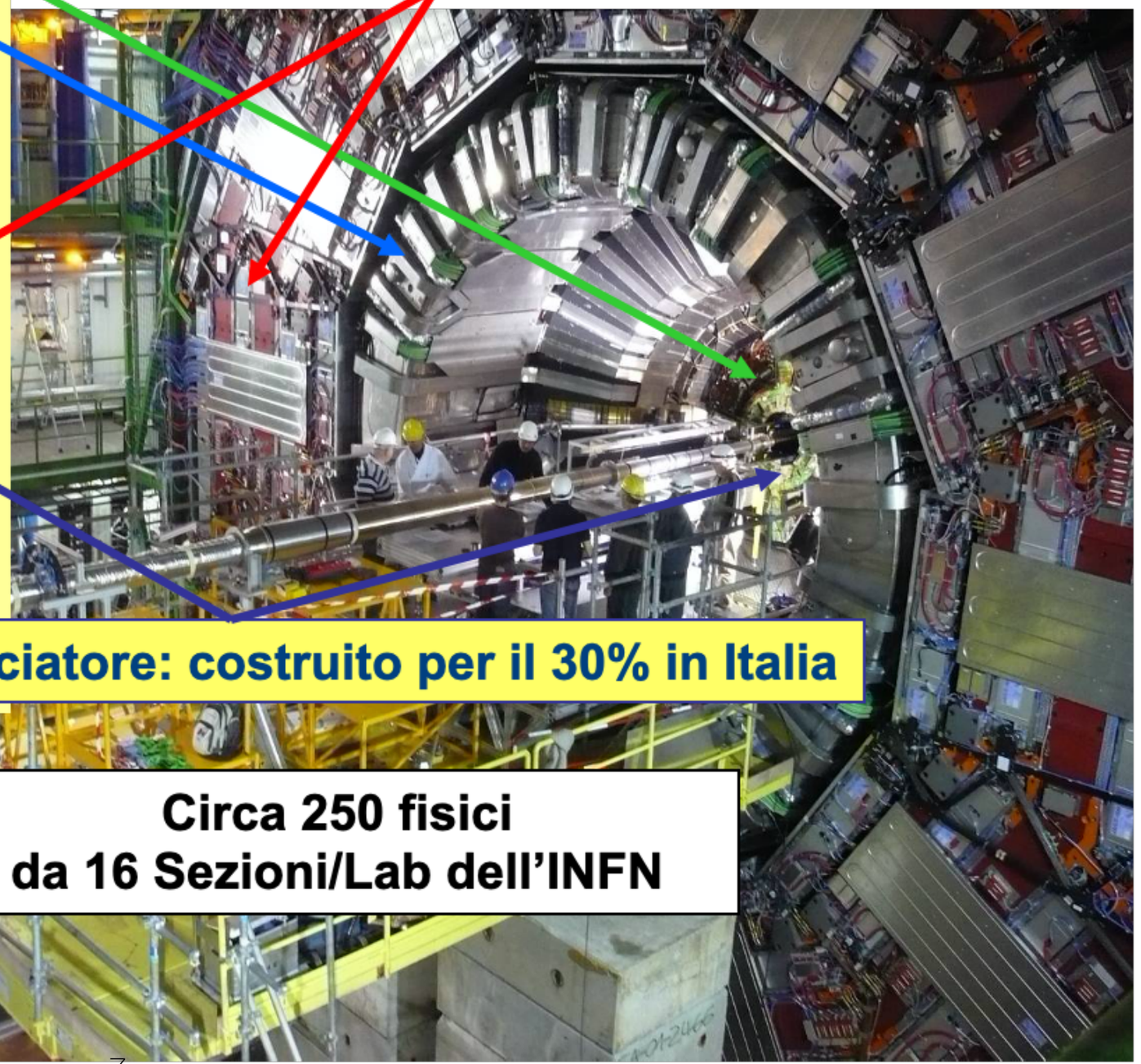
Il Contributo INFN a CMS

Magnete: tecnologia e avvolgimento cavo INFN&Ansaldo SC

Calorimetro elettromagnetico costruito per il 40% in Italia

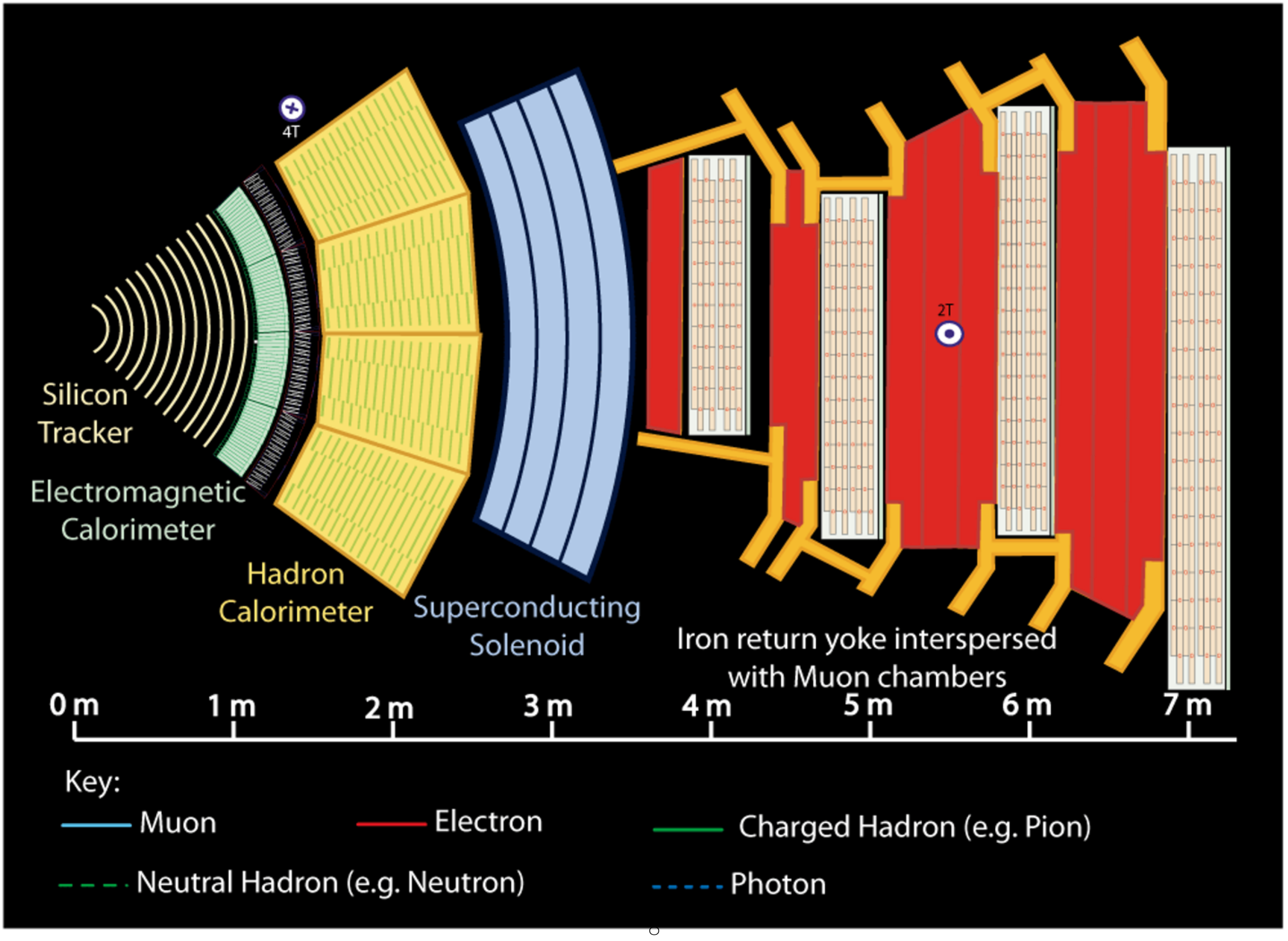
Sistema per mu: costruito per il 50% in Italia





Tracciatore: costruito per il 30% in Italia

Circa 250 fisici
da 16 Sezioni/Lab dell'INFN


4T
2T
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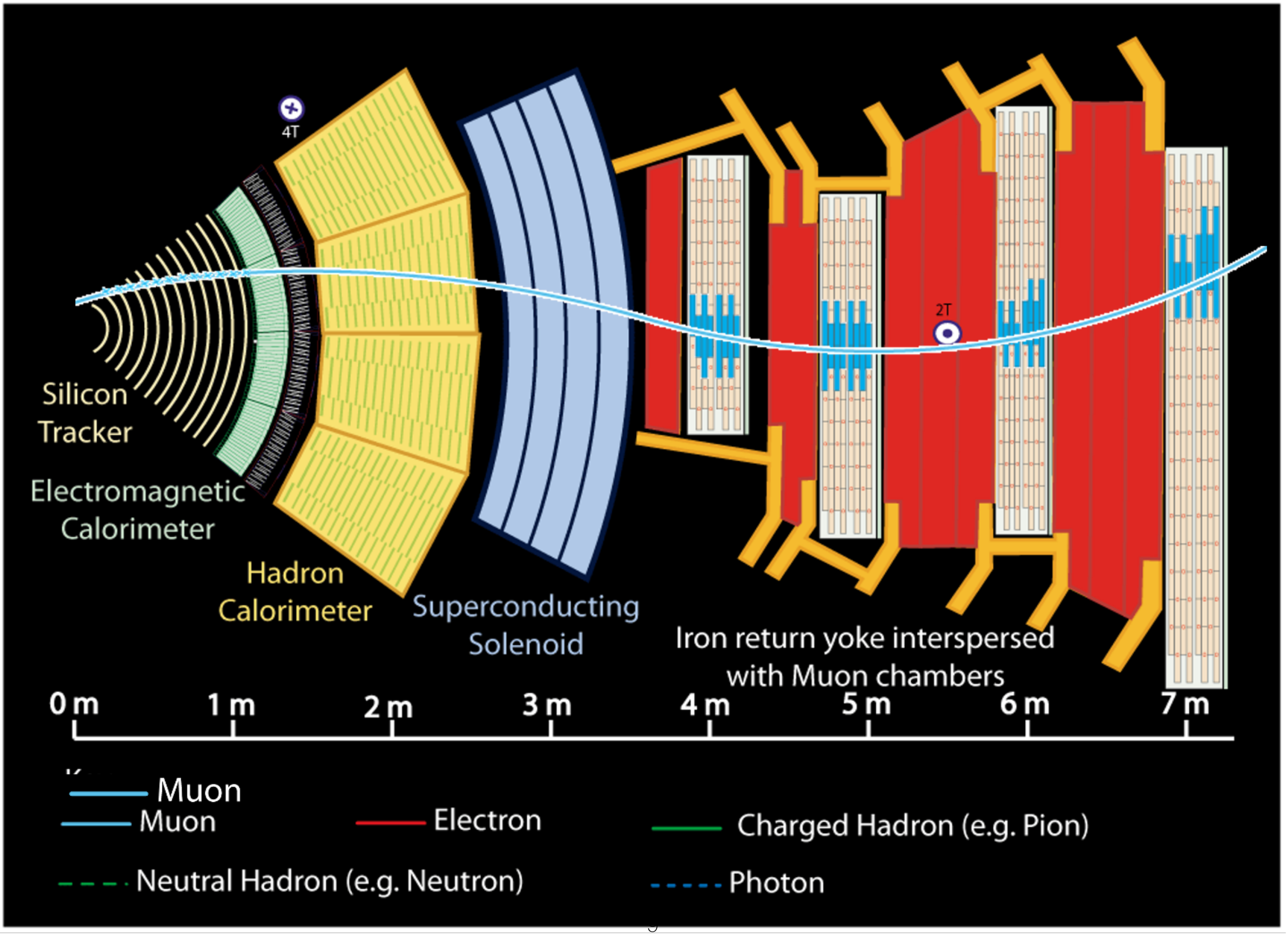
Tracker
Electromagnetic
Calorimeter
Hadron
Calorimeter
Superconducting
Solenoid
Iron return yoke interspersed
with Muon chambers
0 m
1 m
2 m
3 m
4 m
5 m
6 m
7 m
Key:
Muon
Electron
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon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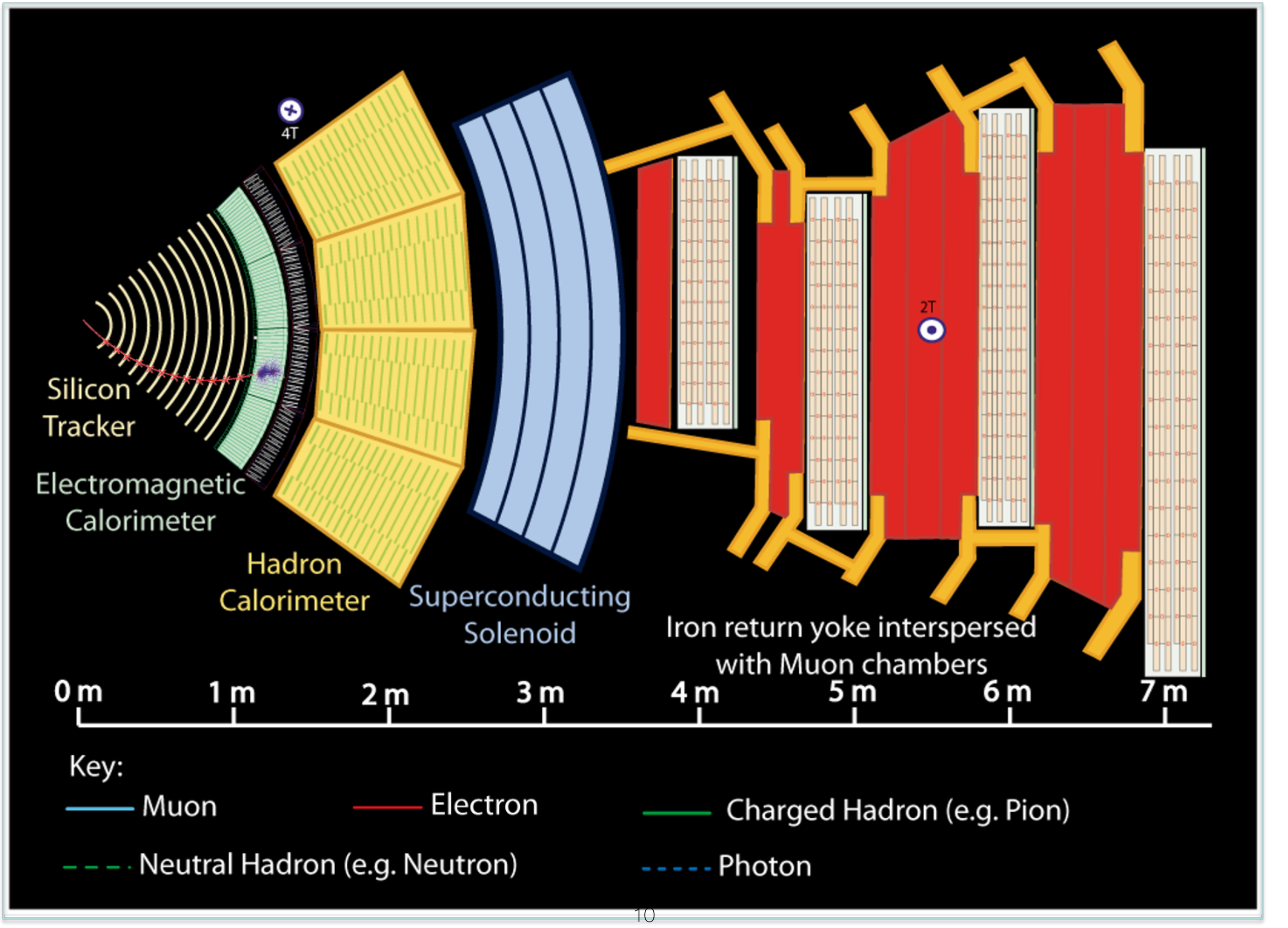
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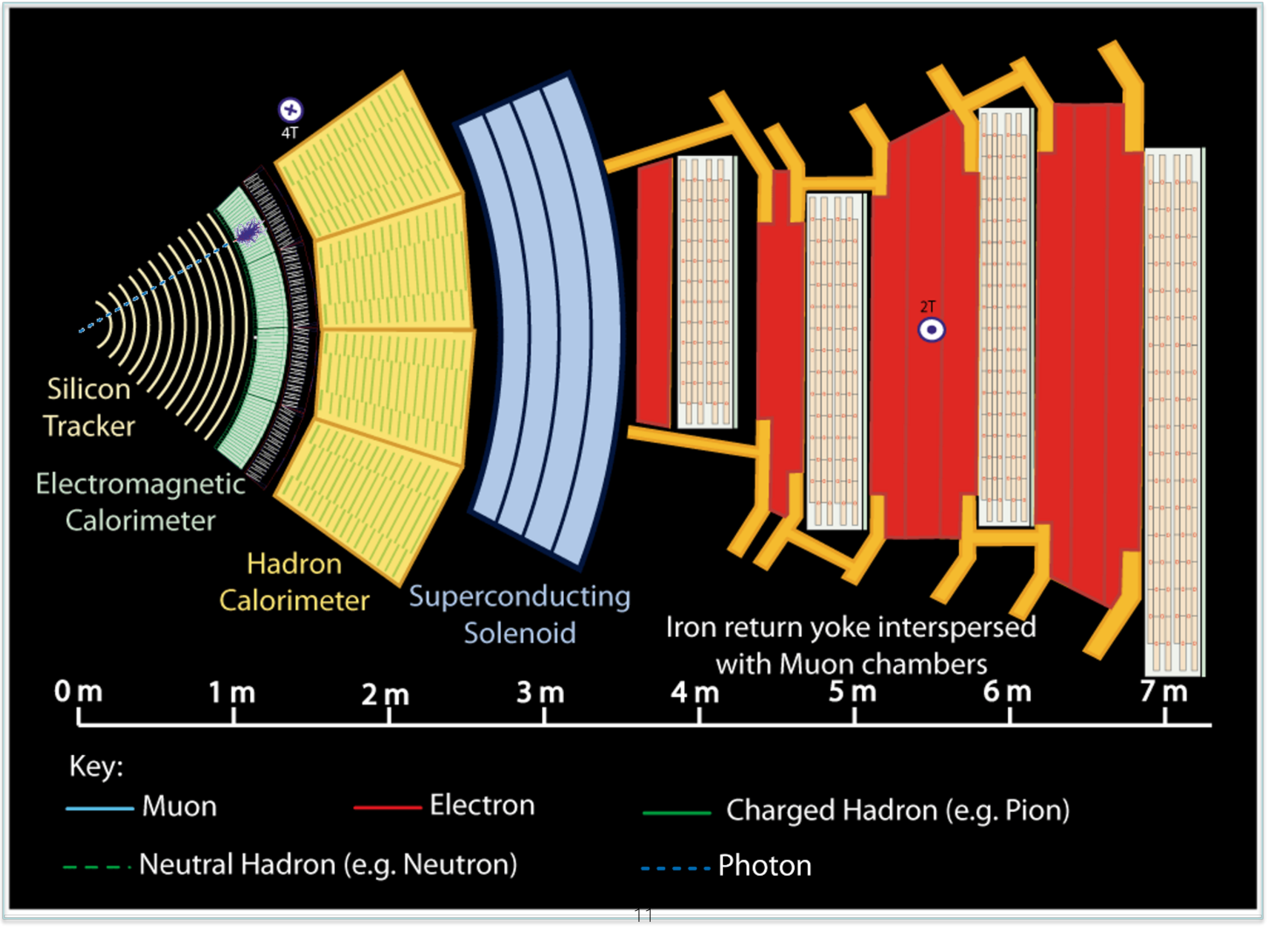
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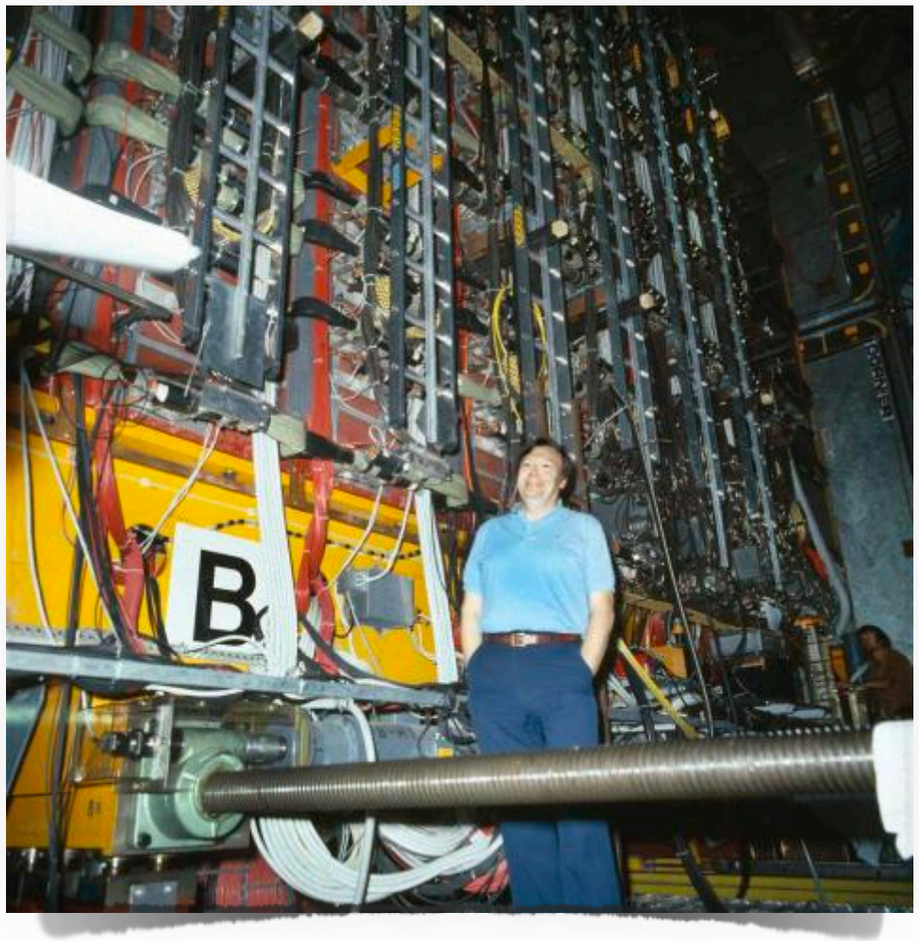
Photon

The W and Z bosons

- W and Z bosons are the particles mediator of the weak force

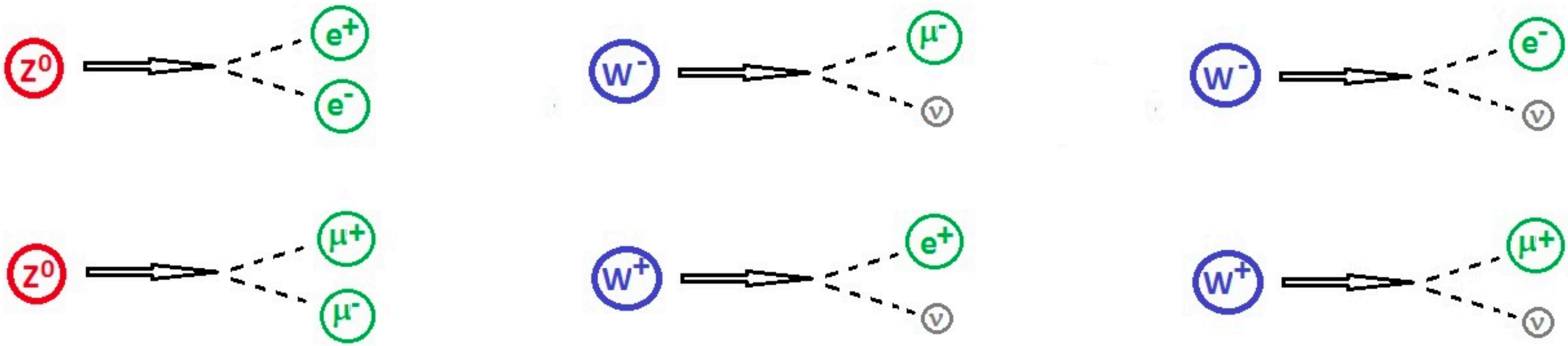
- They have been **predicted in the 1960`s** to explain the "beta" decays observed well before by Fermi.

- Theory predicted **W and Z masses around 100 GeV** and physicists at CERN built in early 1980`s the first most powerful collider able to reach such high energies: the SppS



Discovery of a new particle

- The **Z and W bosons** produced at LHC do not live long, but **decay immediately to other elementary particles that can be measured by the CMS and ATLAS detectors**



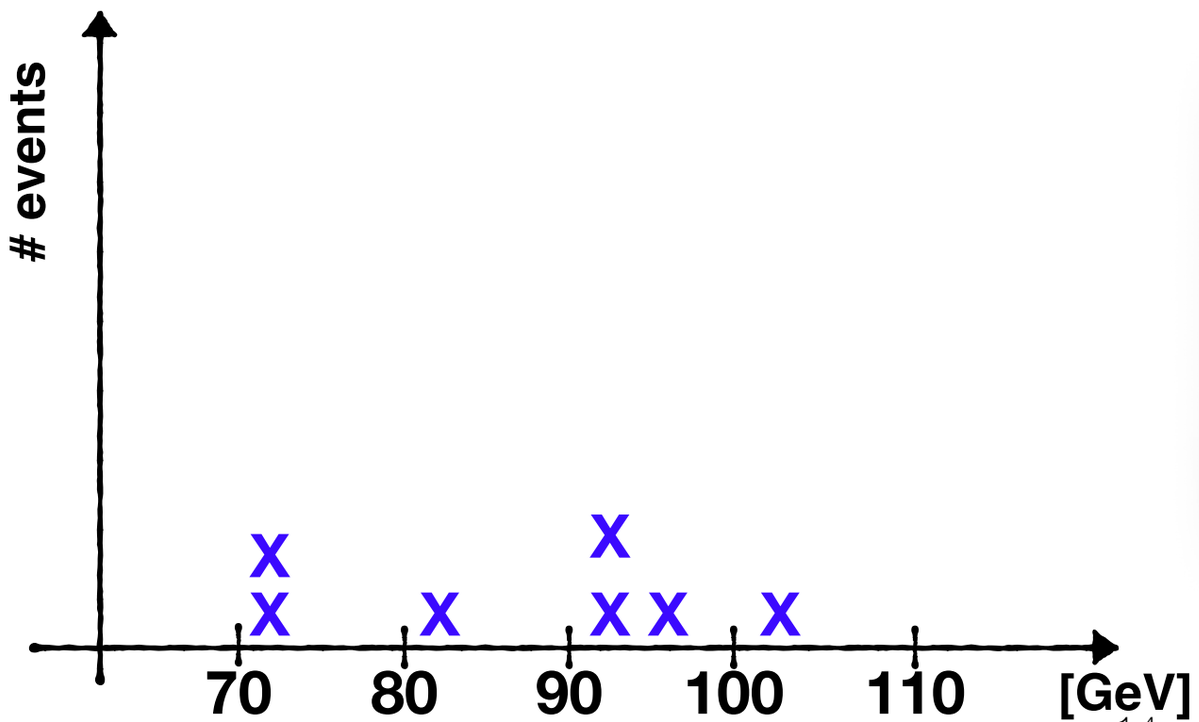
- So when in an LHC collision we produce a Z or W particle, **what we detect in the our experiments are only electrons and muons**!

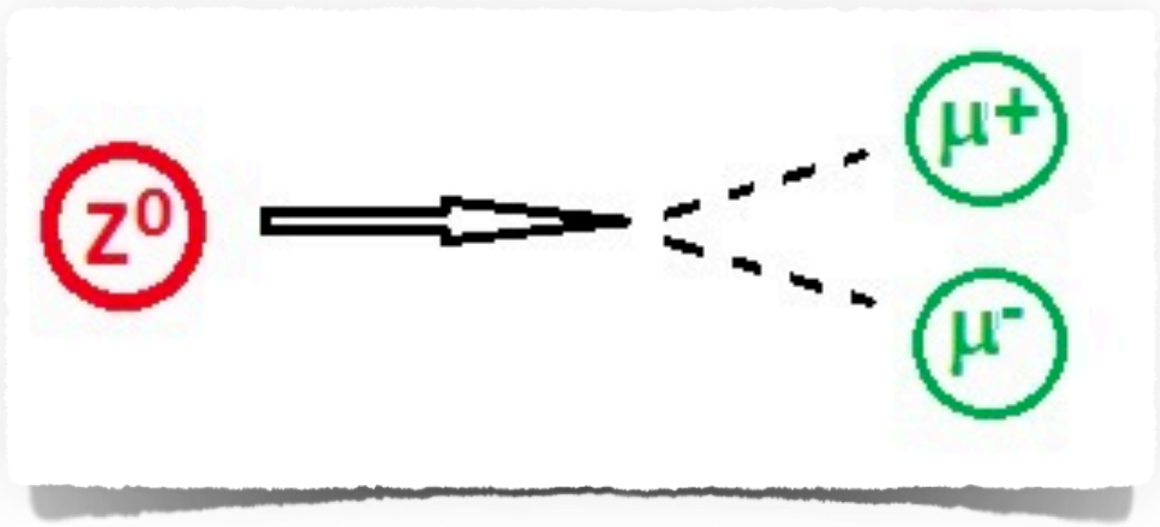
The Z boson mass reconstruction

- Measuring the **energies** and the **direction of production** of the two electrons or muons, we can compute the mass of the particle that have produced them in its decays:

$$m_X = \sqrt{2E_1E_2(1 - cos\theta)}$$

- In each **event** where we have two electrons/or muons we compute the Z mass with this formula and we fill an histogram of events:

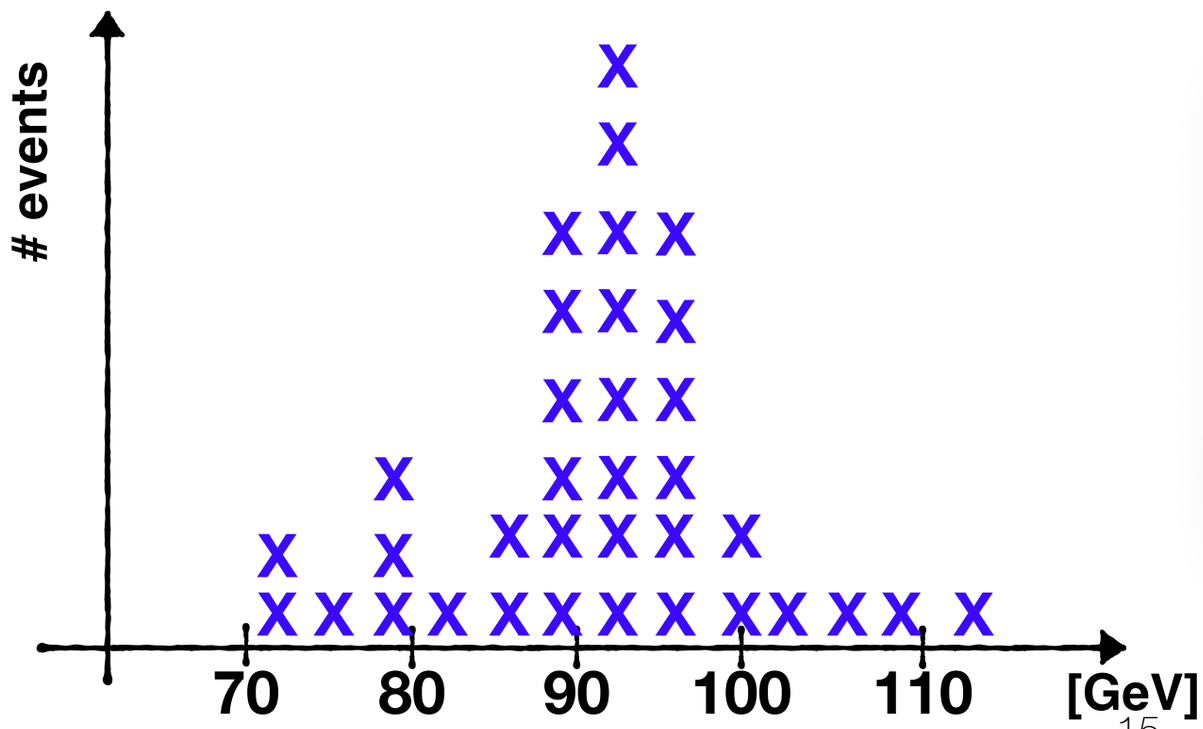


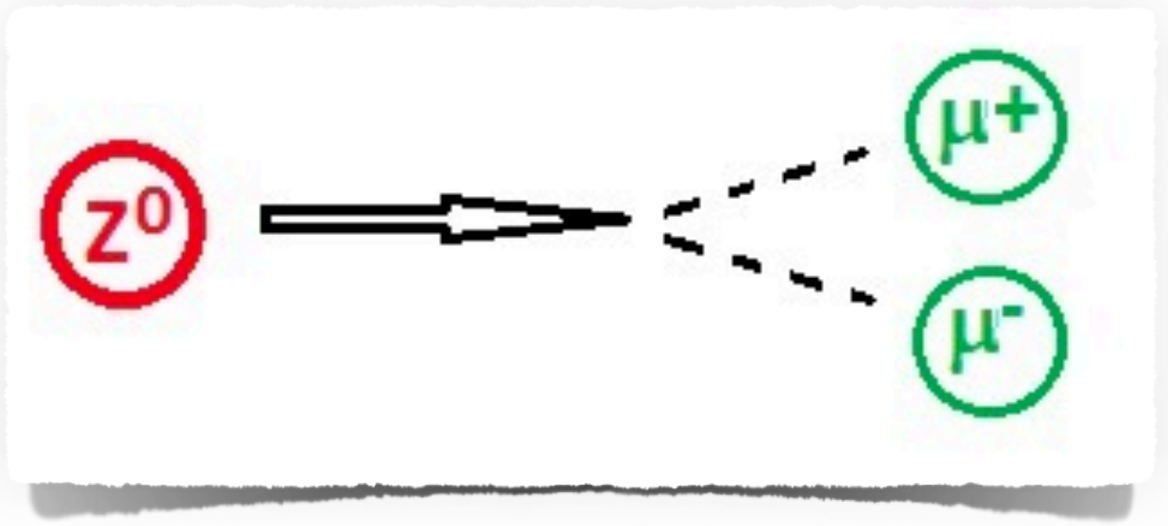


The Z boson mass reconstruction

- **A peak of events will appear close to the true value of the mass of the Z boson if the Z exists**

- **If the "excess" of events is significantly big.. we discovered a new particle"**



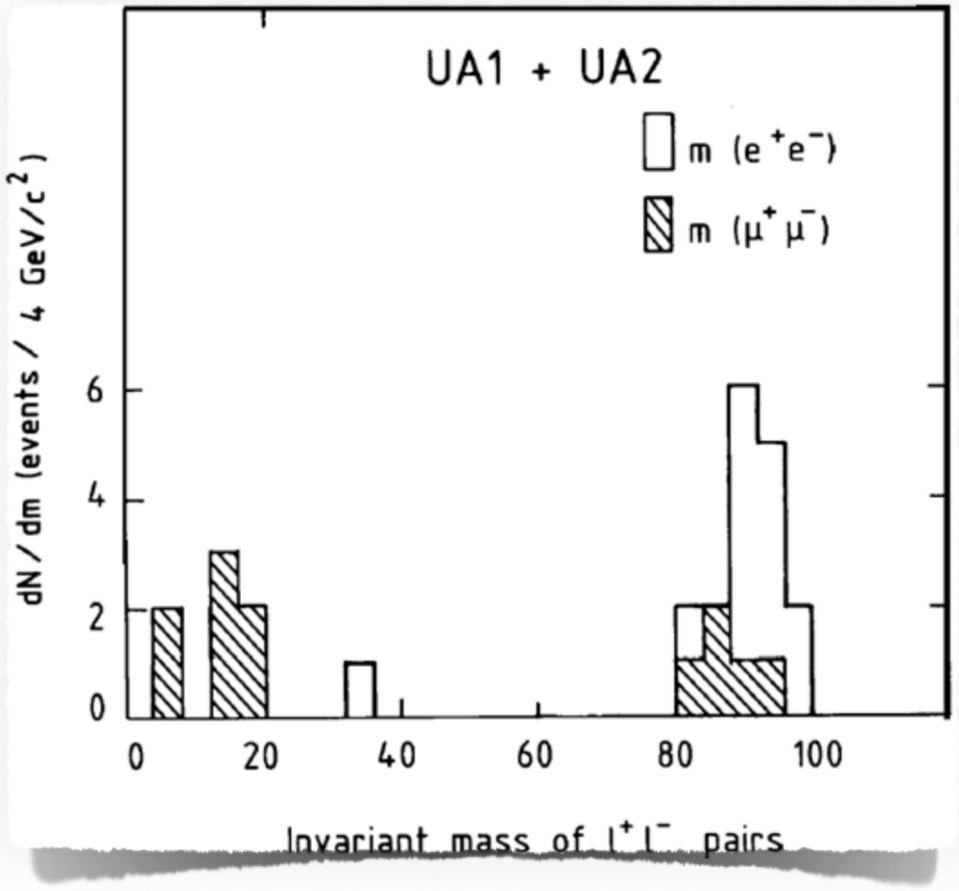


The Z boson Nobel Prize

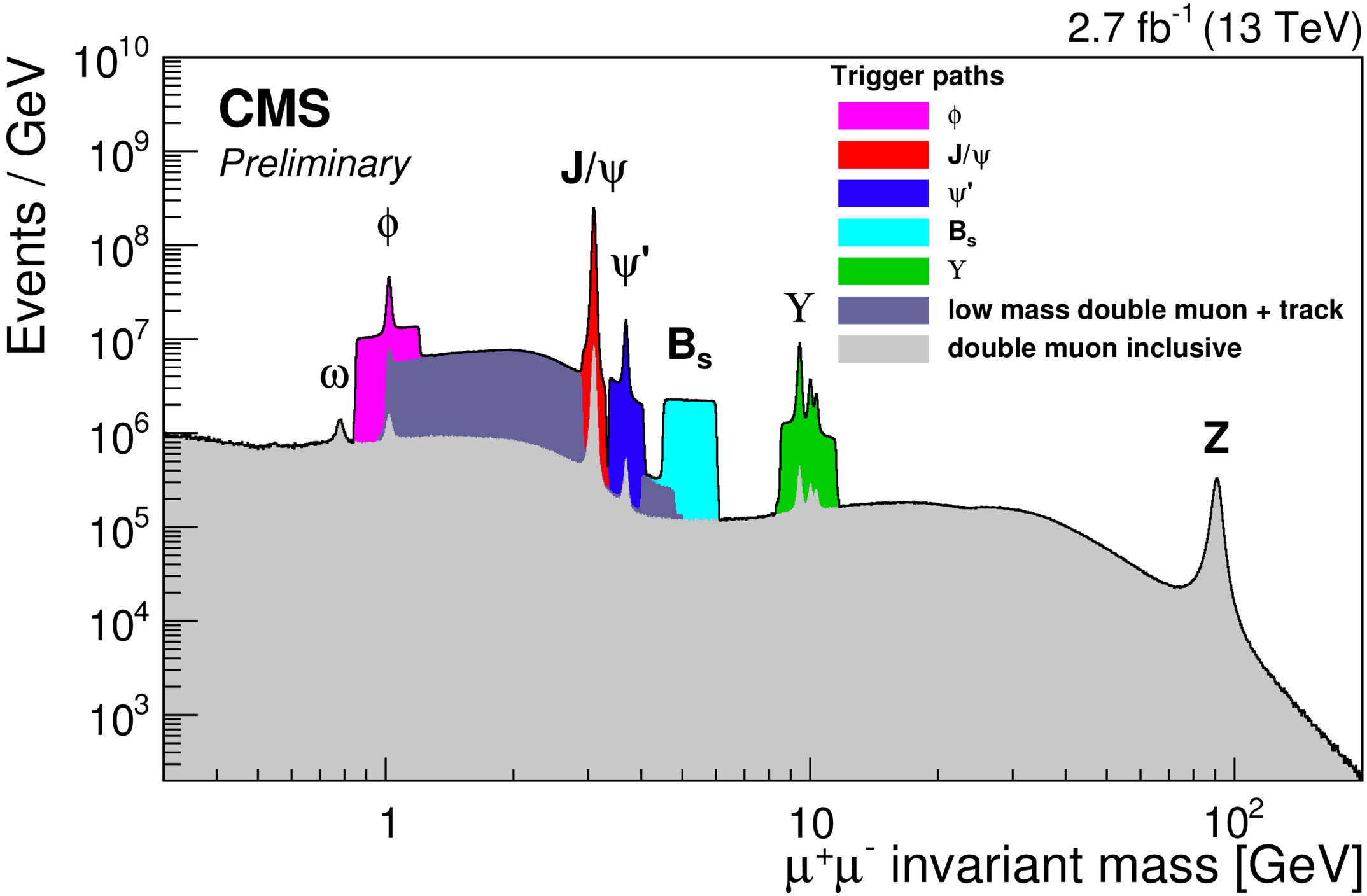
- A peak of events will appear close to the true value of the mass of the Z boson if the Z exists

- If the "excess" of events is significantly big.. we discovered a new particle"

- In 1983 The UA1 and UA2 experiments at CERN: discovery of the W and Z boson

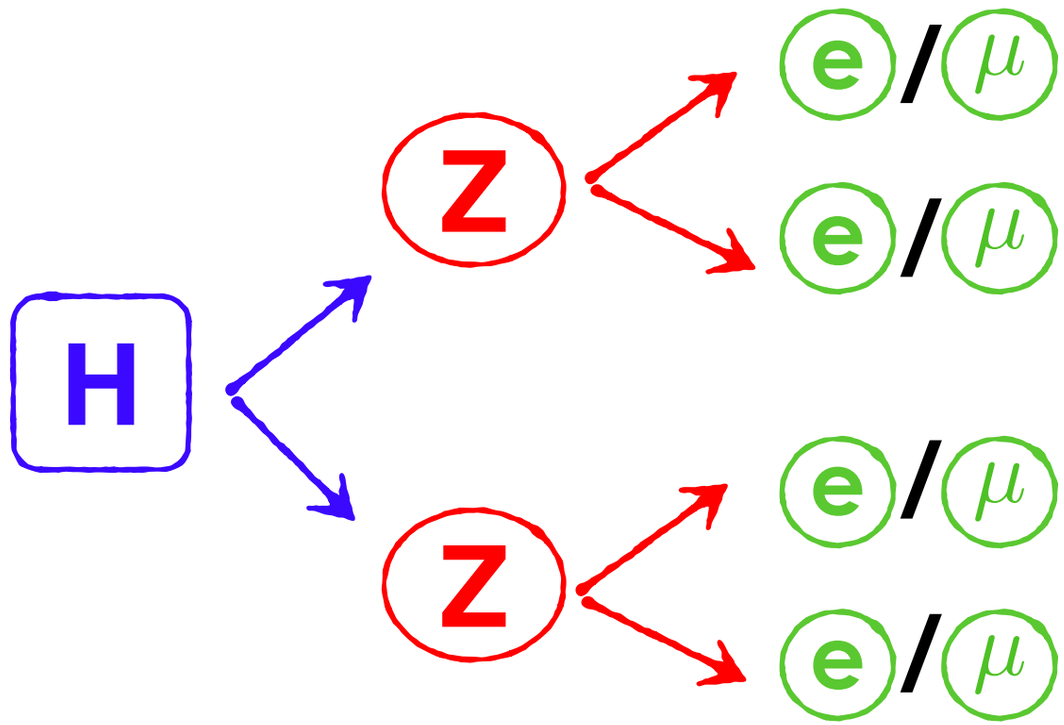


Many Resonances around!!



The Z boson and the Higgs discovery

- The discovery of the Z boson opened the opportunity to "use" the recently discovered particle for the quest of the Higgs boson:

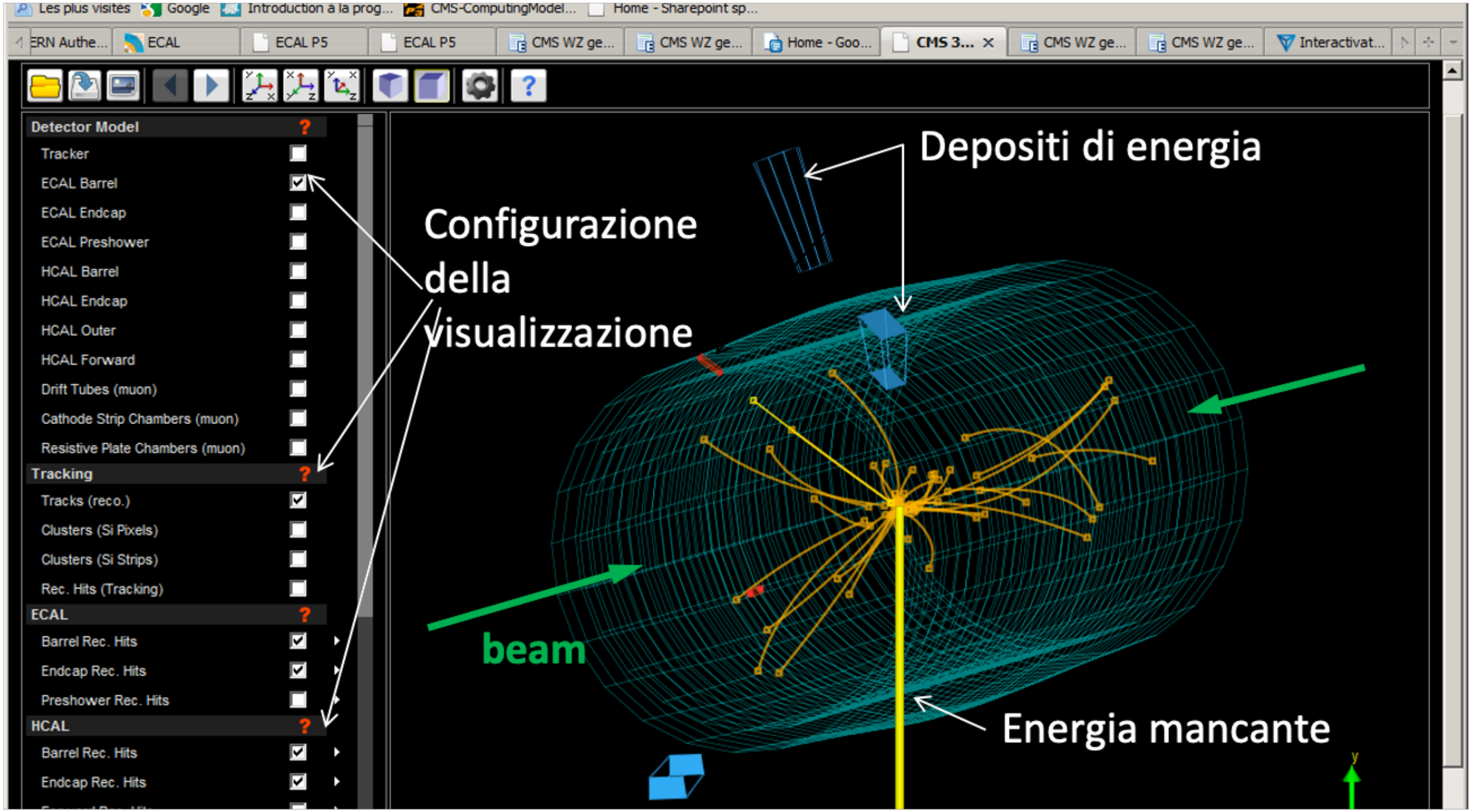


- Either decays of the **Z** to **electrons or muons** are considered

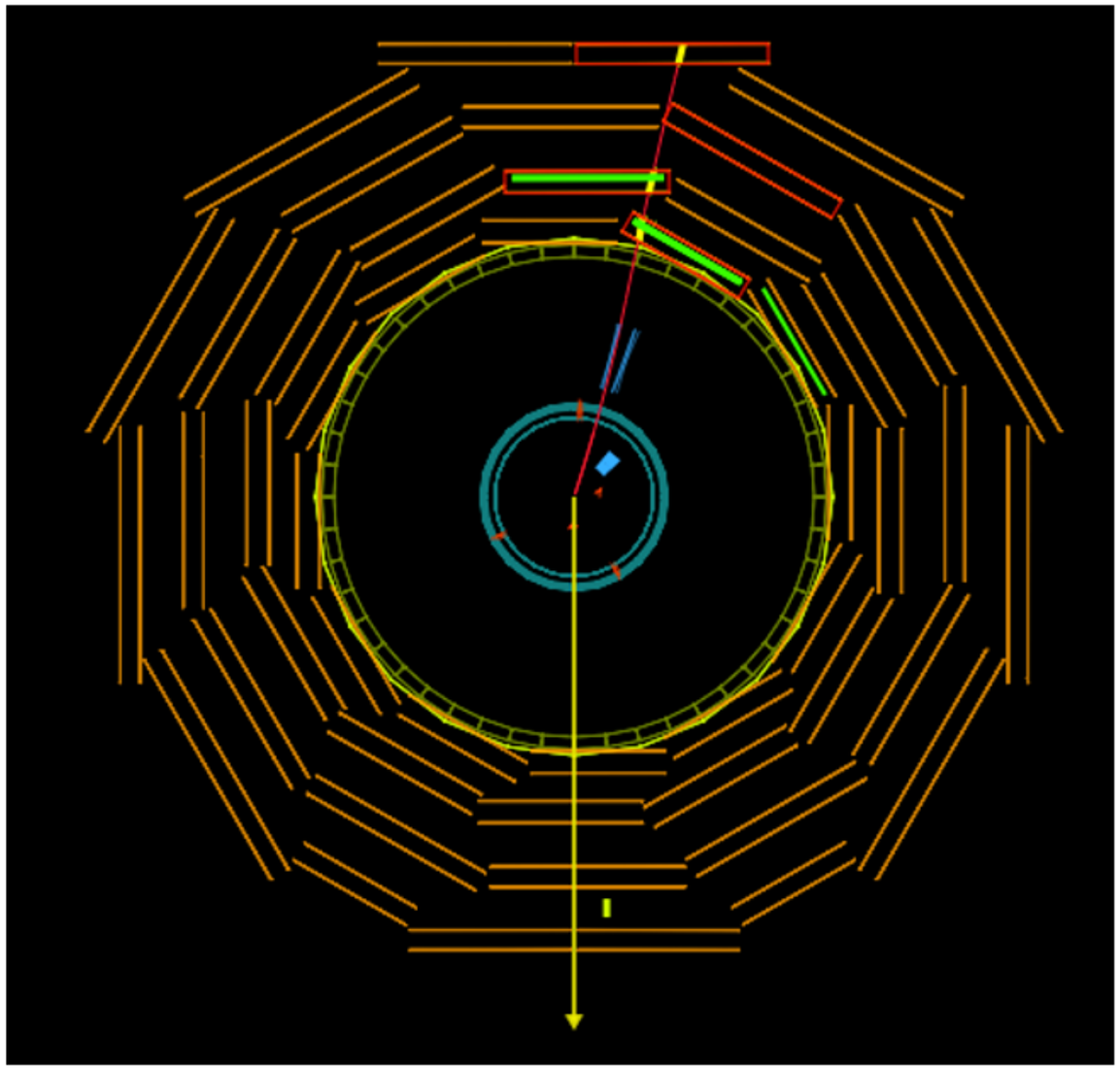
Now it`s your turn!!

- **Today we will look at the REAL DATA collected by CMS at LHC and we will try to "RE-DISCOVER" the Z and the W bosons.**
- **We will learn how to work in team in data analysis and how to present our own results like in a major physics conference!**

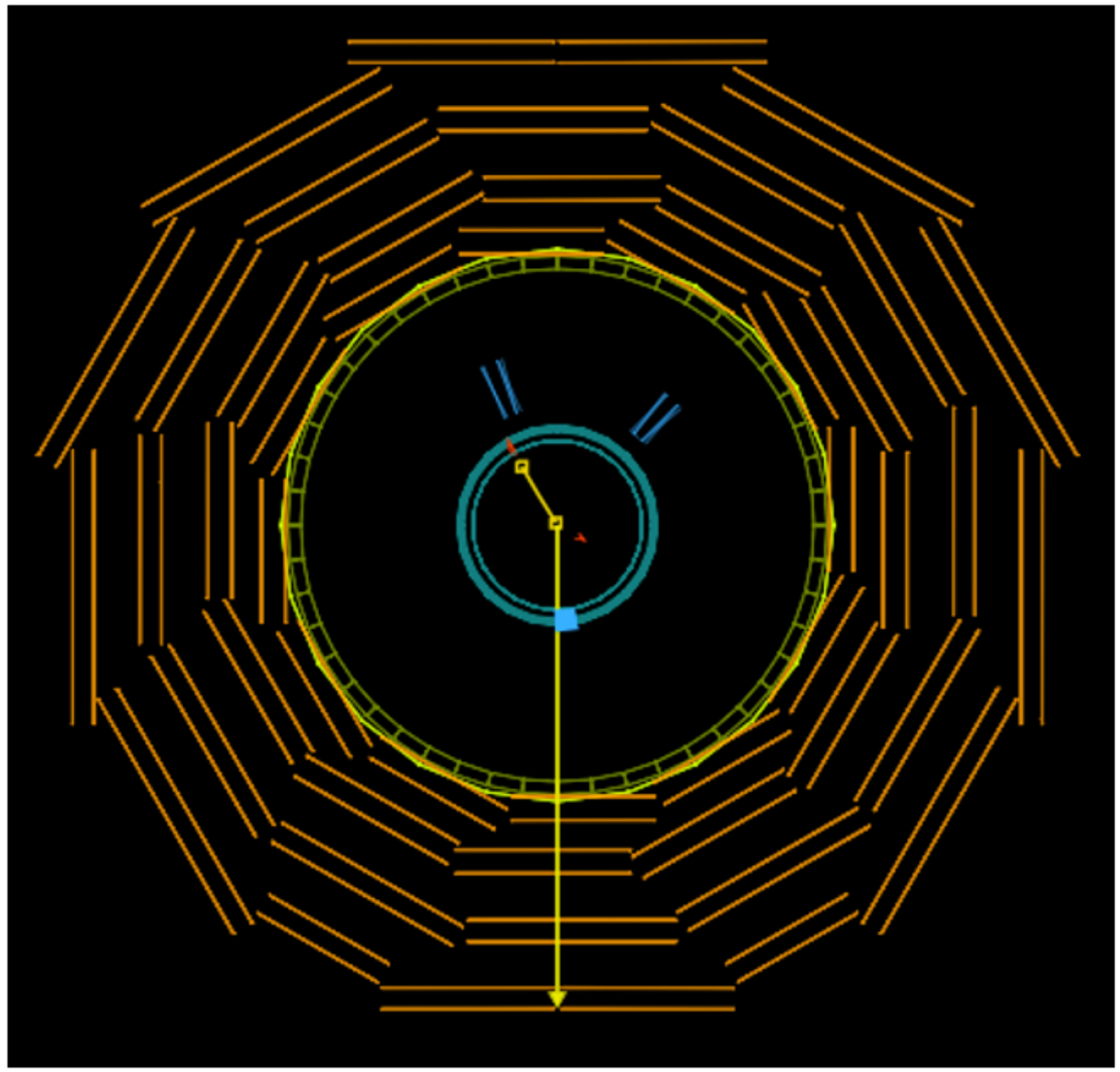
Programma di visualizzazione



Identificazione delle particelle in CMS

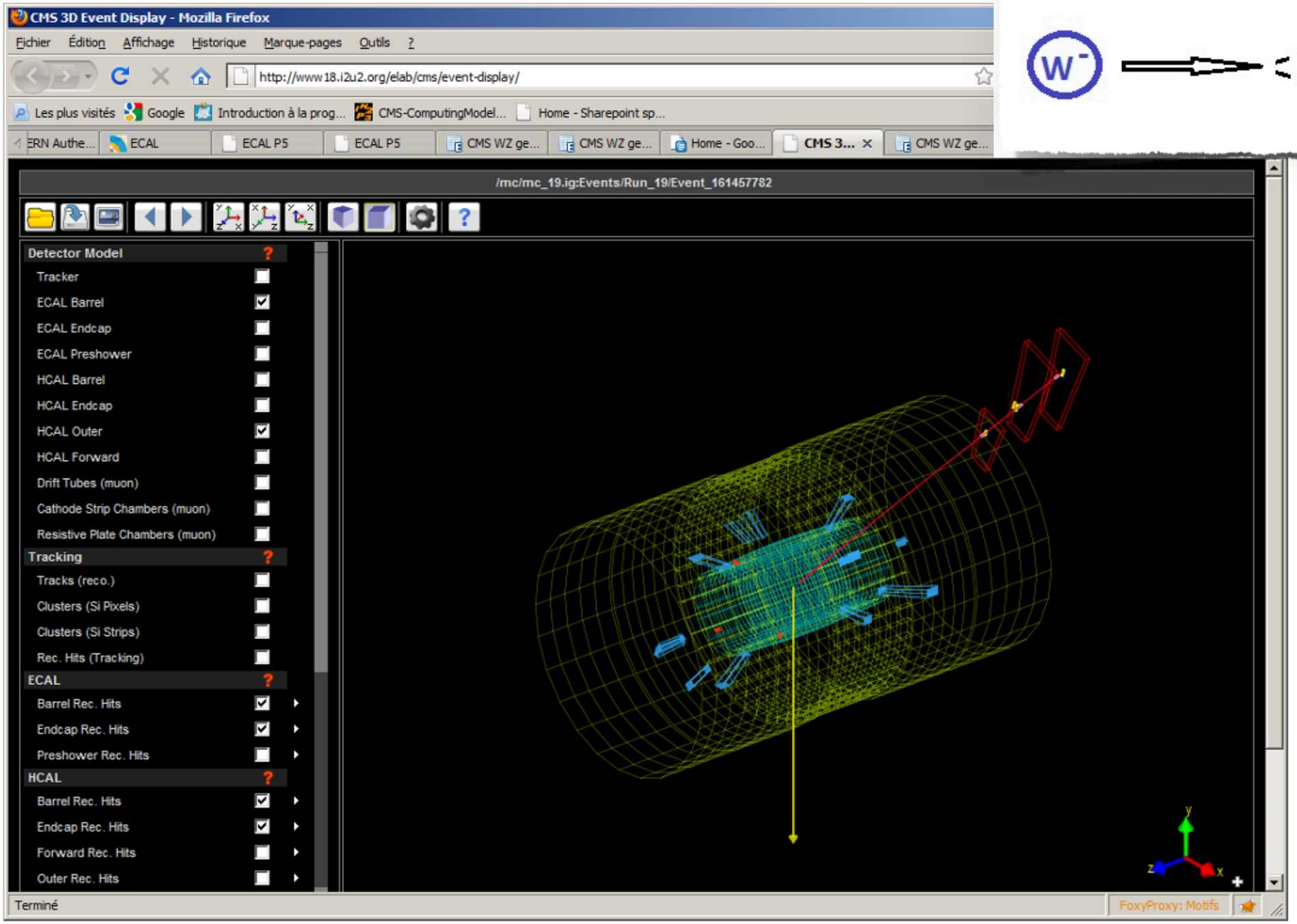


Muone (in rosso). L'energia mancante di rinculo e` rappresentata dalla freccia gialla. Potrebbe indicare un neutrino.



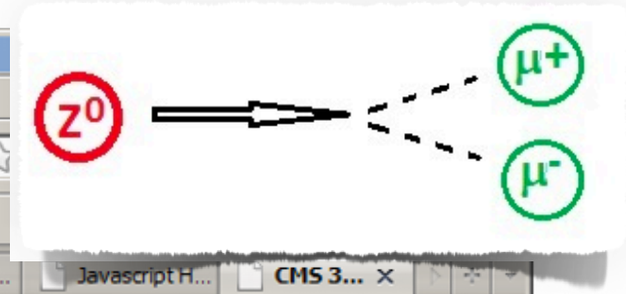
Elettrone (traccia gialla) si ferma nel calorimetro elettromagnetico (parallelepipedi azzurri). Piu` sono alti maggiore e` l'energia.

Un W decade in un muone e neutrino

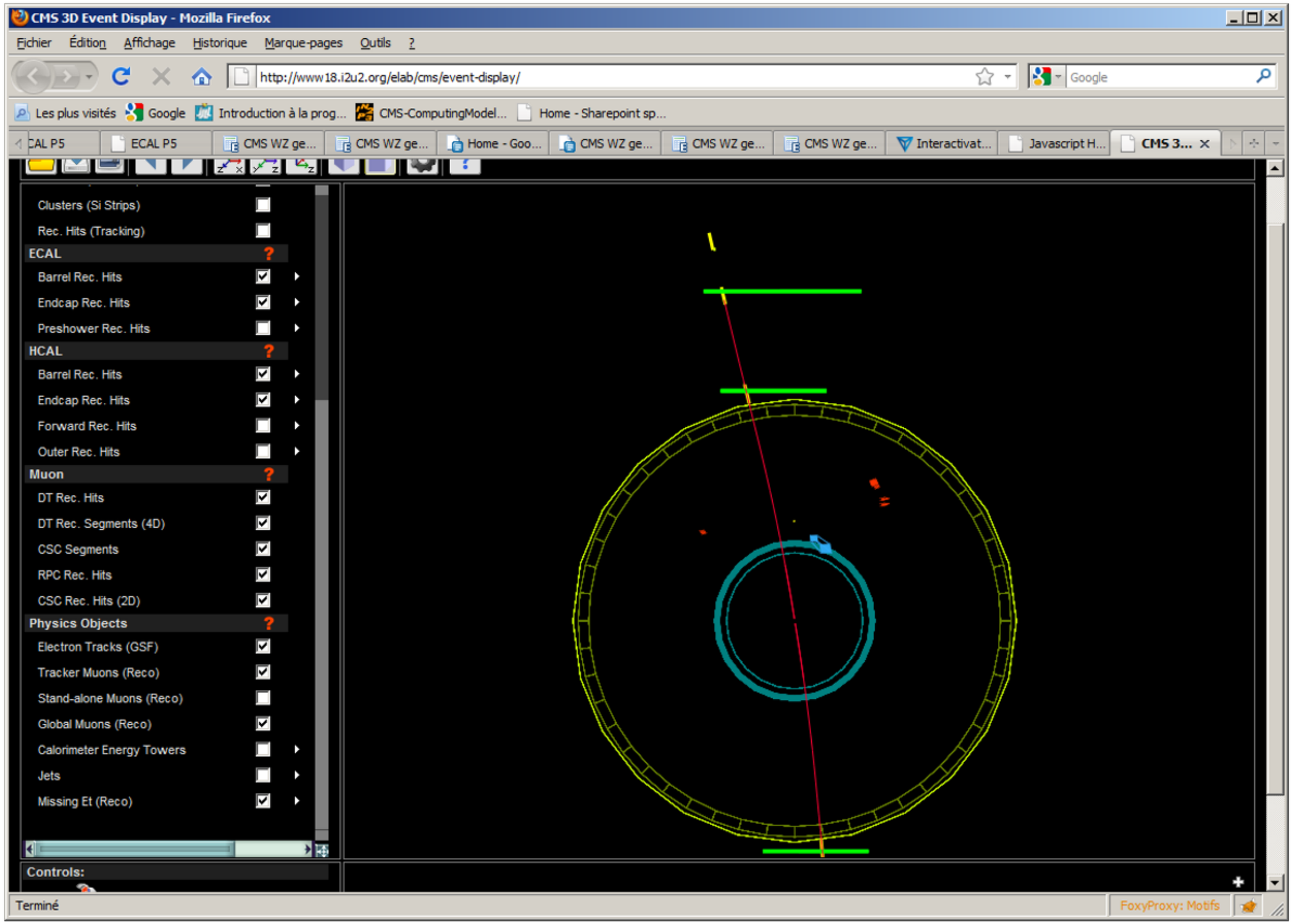


Signature: Signal in the muon detectors + missing energy

Uno Z^0 decade in due muoni



Misura della carica



Vista x-y → Senso orario → carica positiva