Discoverying Particles at LHC

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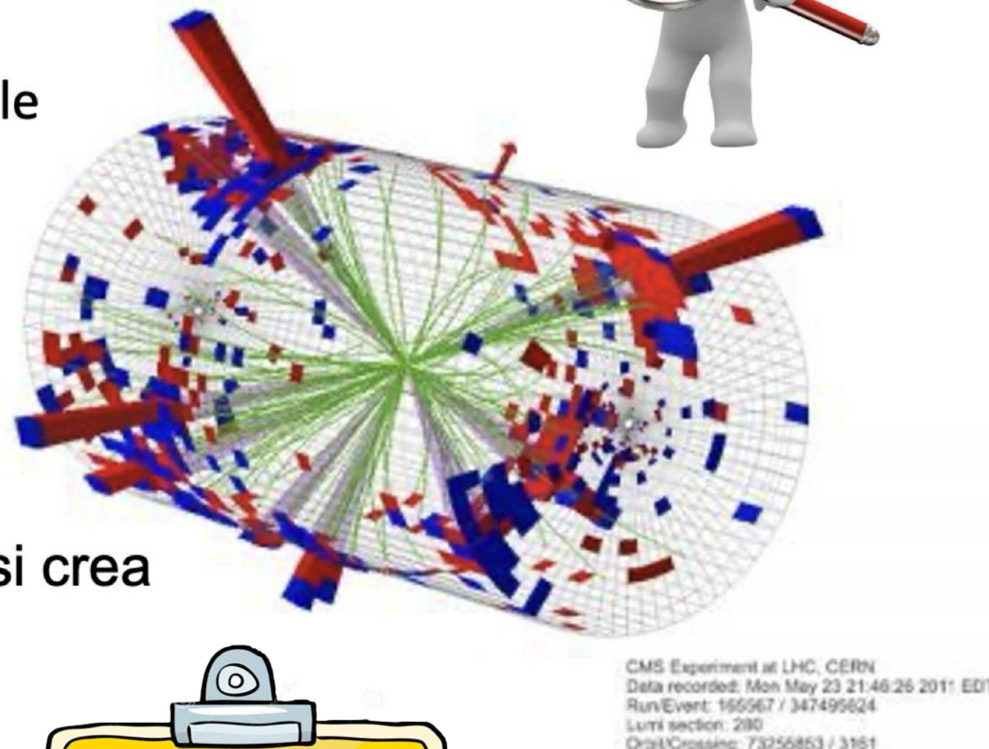
Particle identikit

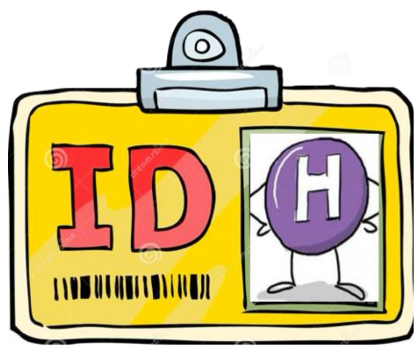
Nelle collisioni si producono diversi tipi di particelle

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`



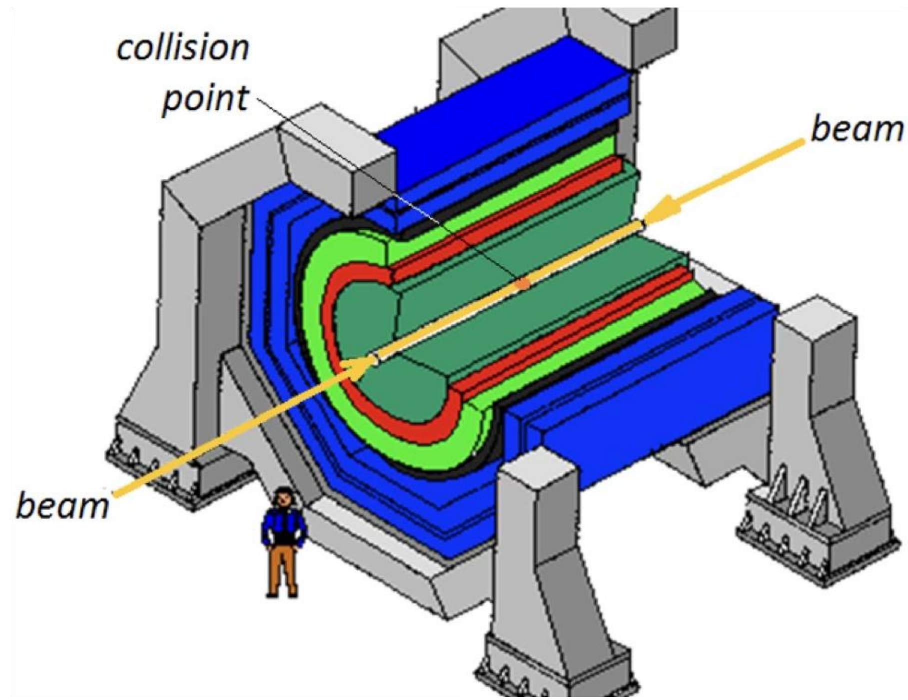
Come e` fatto un esperimento all'LHC

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

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

dall'interno verso l'esterno:

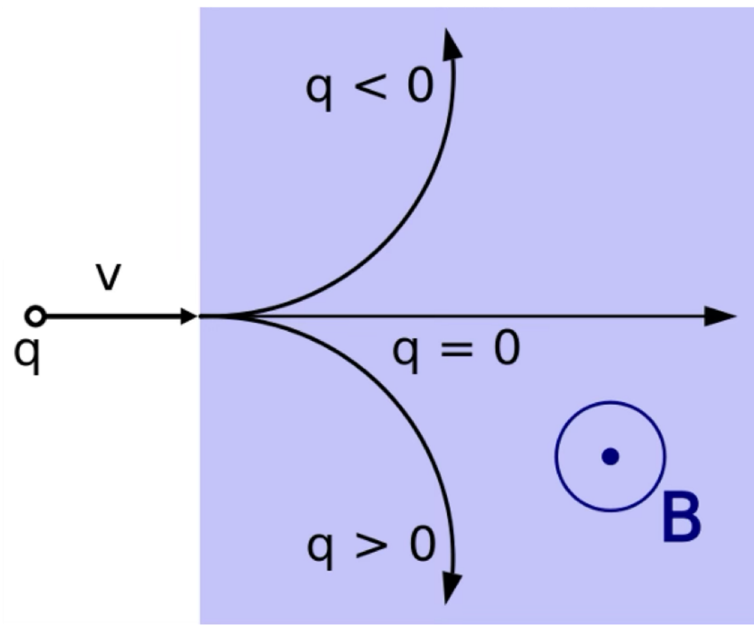
- Tracciatore
- Calorimetro elettromagnetico
- Calorimetro adronico
- Magnete
- Camere per muoni



Magnete

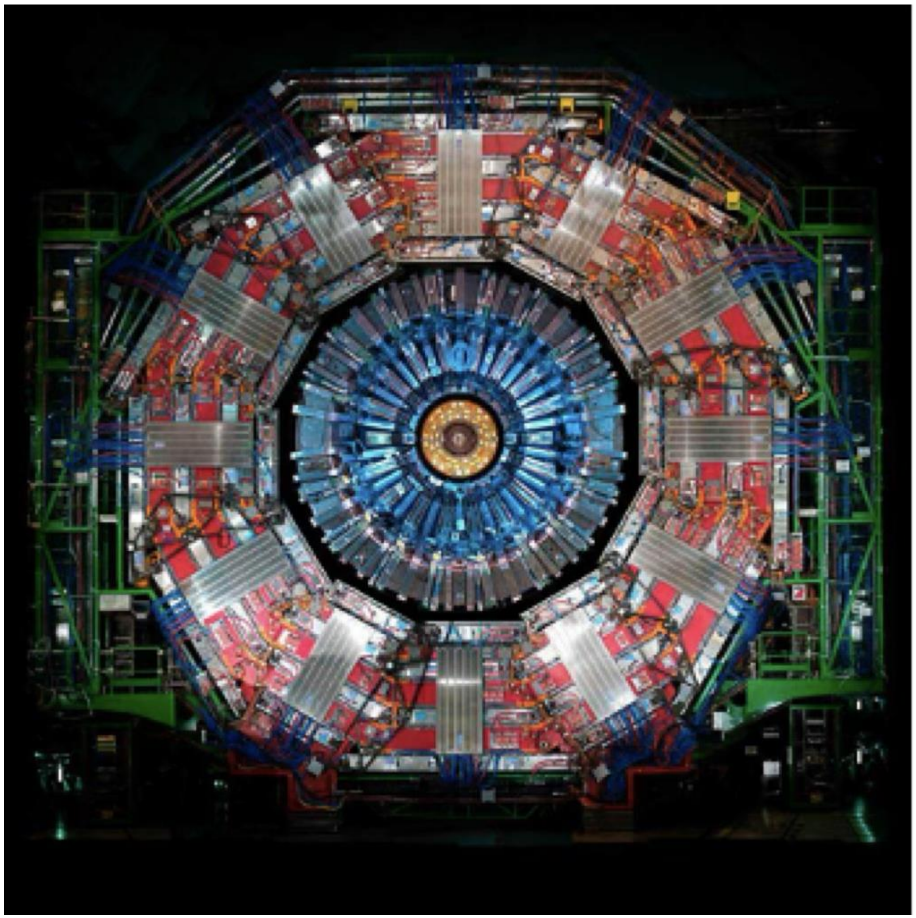
Il tracciatore e` immerso in un campo magnetico.

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



possiamo misurare la carica delle particelle

CMS: Our sophisticated camera



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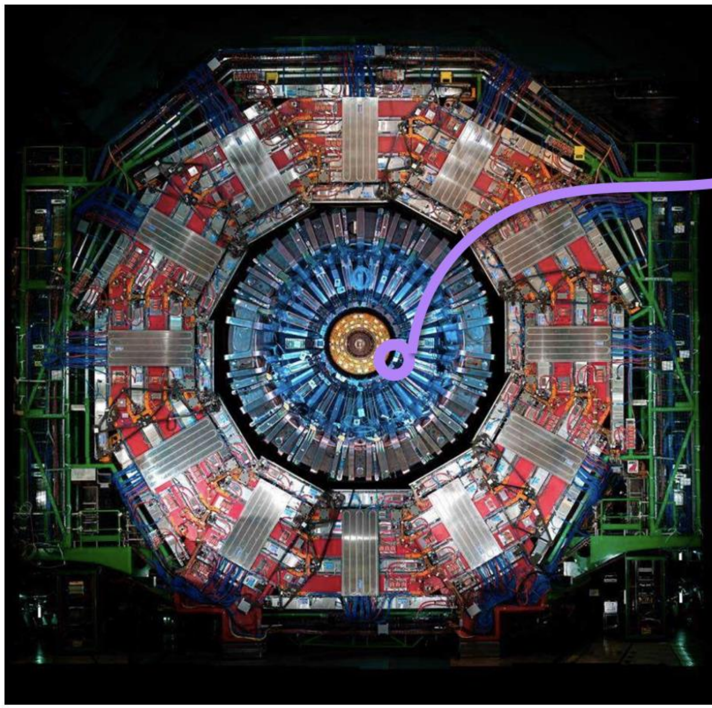
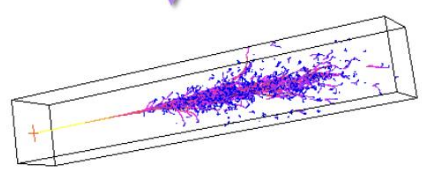
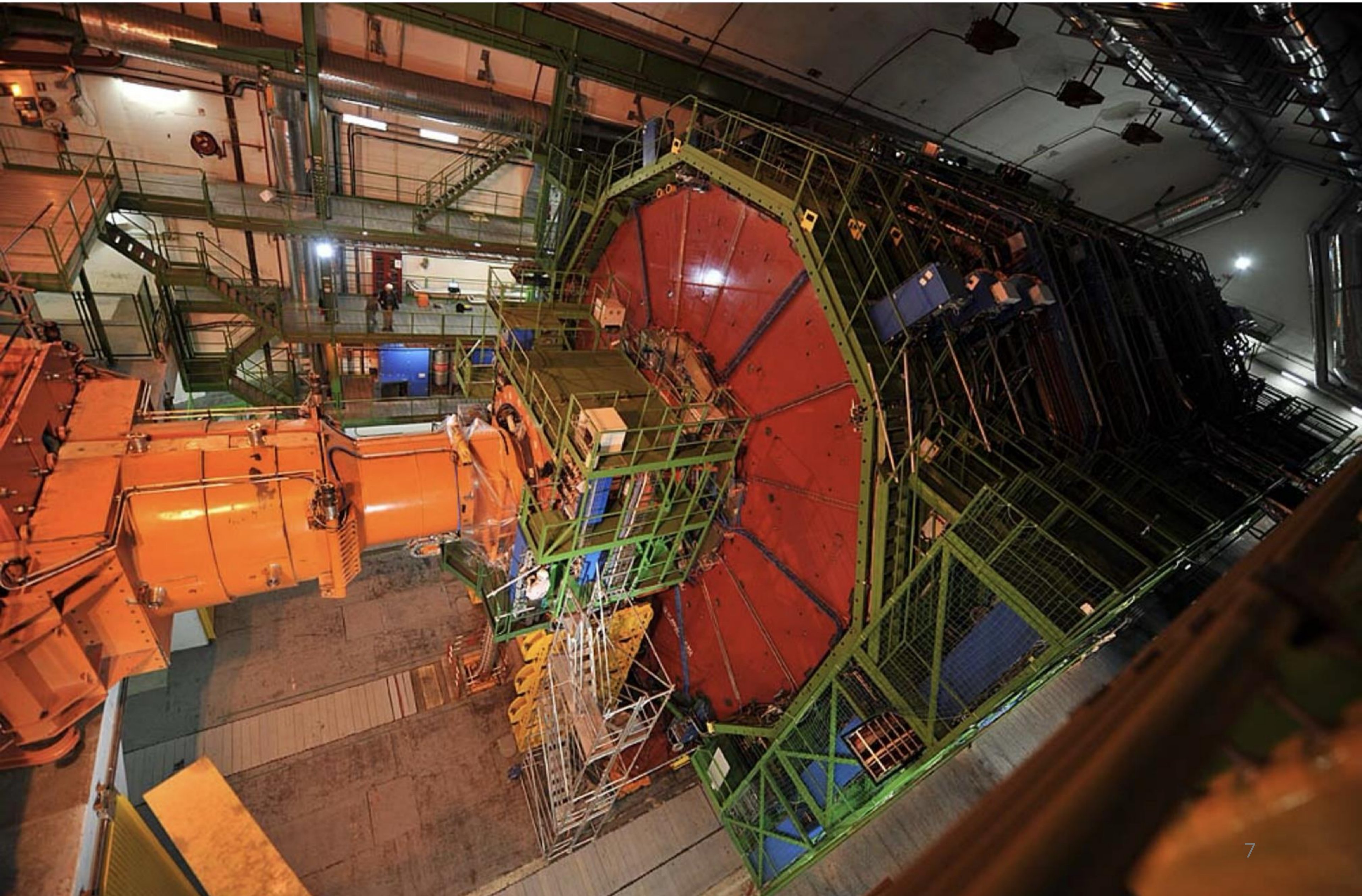
Cristallo DI ECAL (calorimetro elettromagnetico)

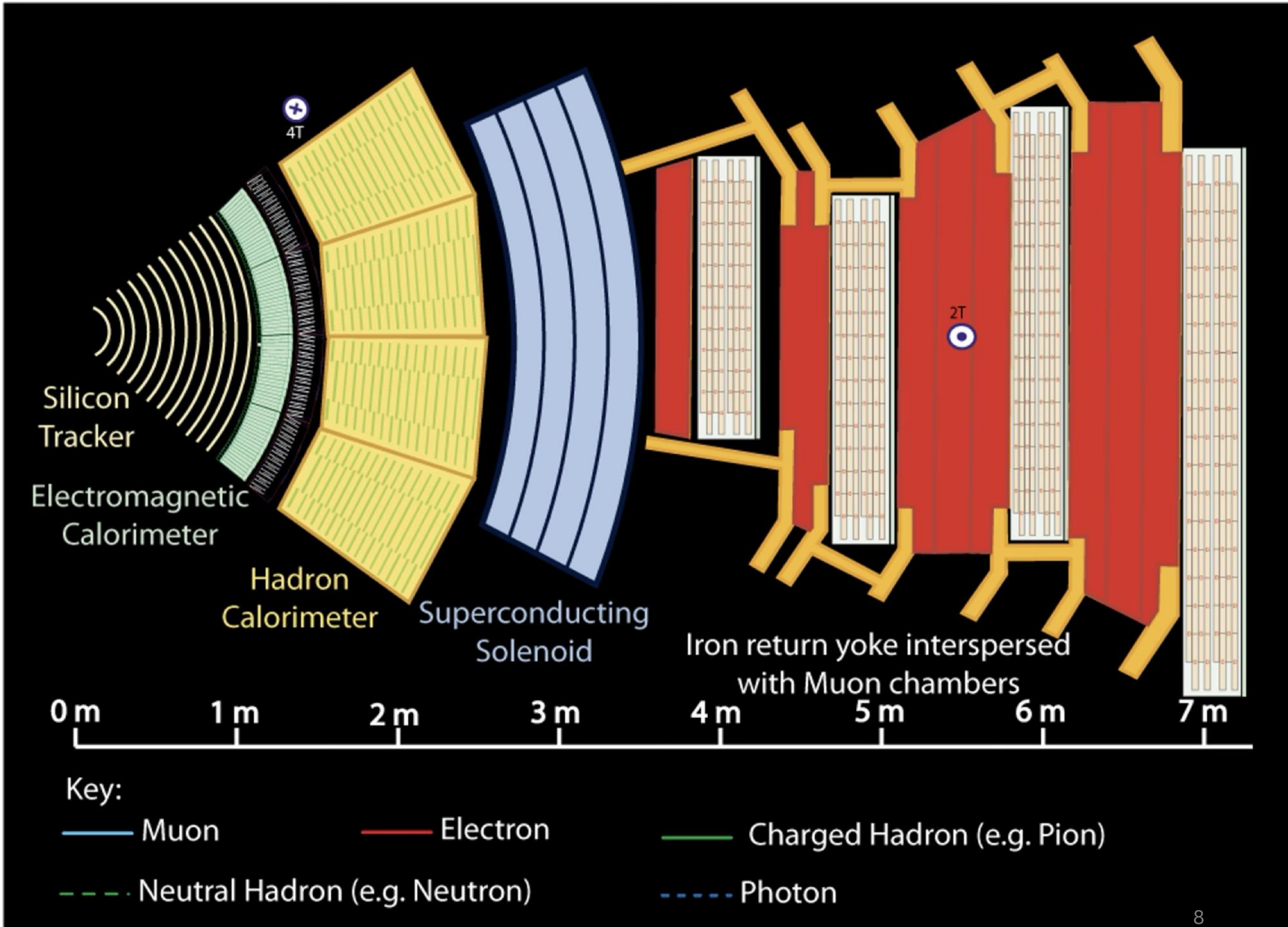




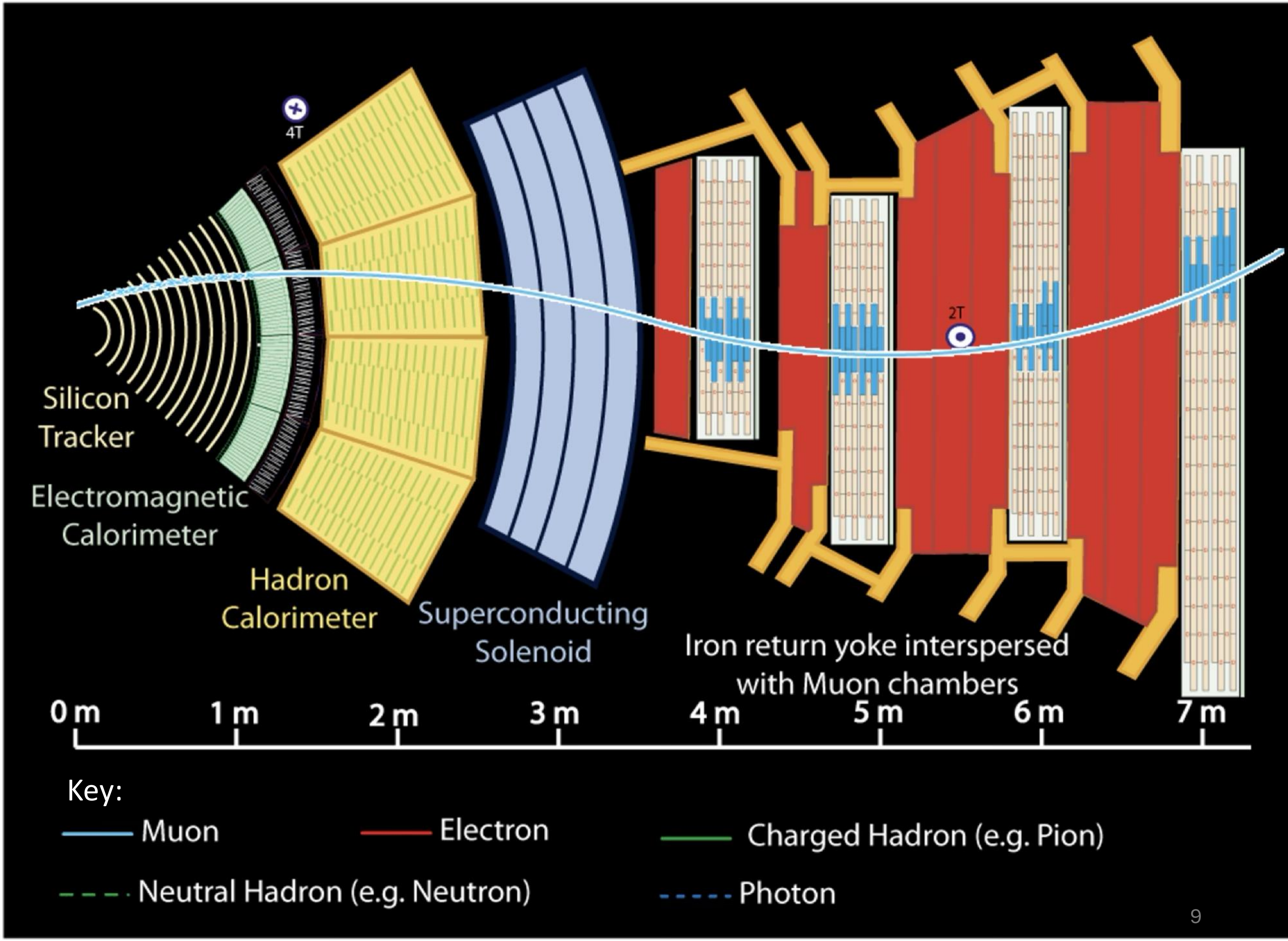
Fotoni ed elettroni interagiscono con il materiale, frammentandosi in una cascata di particelle. Misurando l'energia depositata da questi prodotti secondari, è possibile risalire all'energia del fotone o dell'elettrone iniziale.

La caverna di CMS (Settembre 2008)





4T
2T
Silicon 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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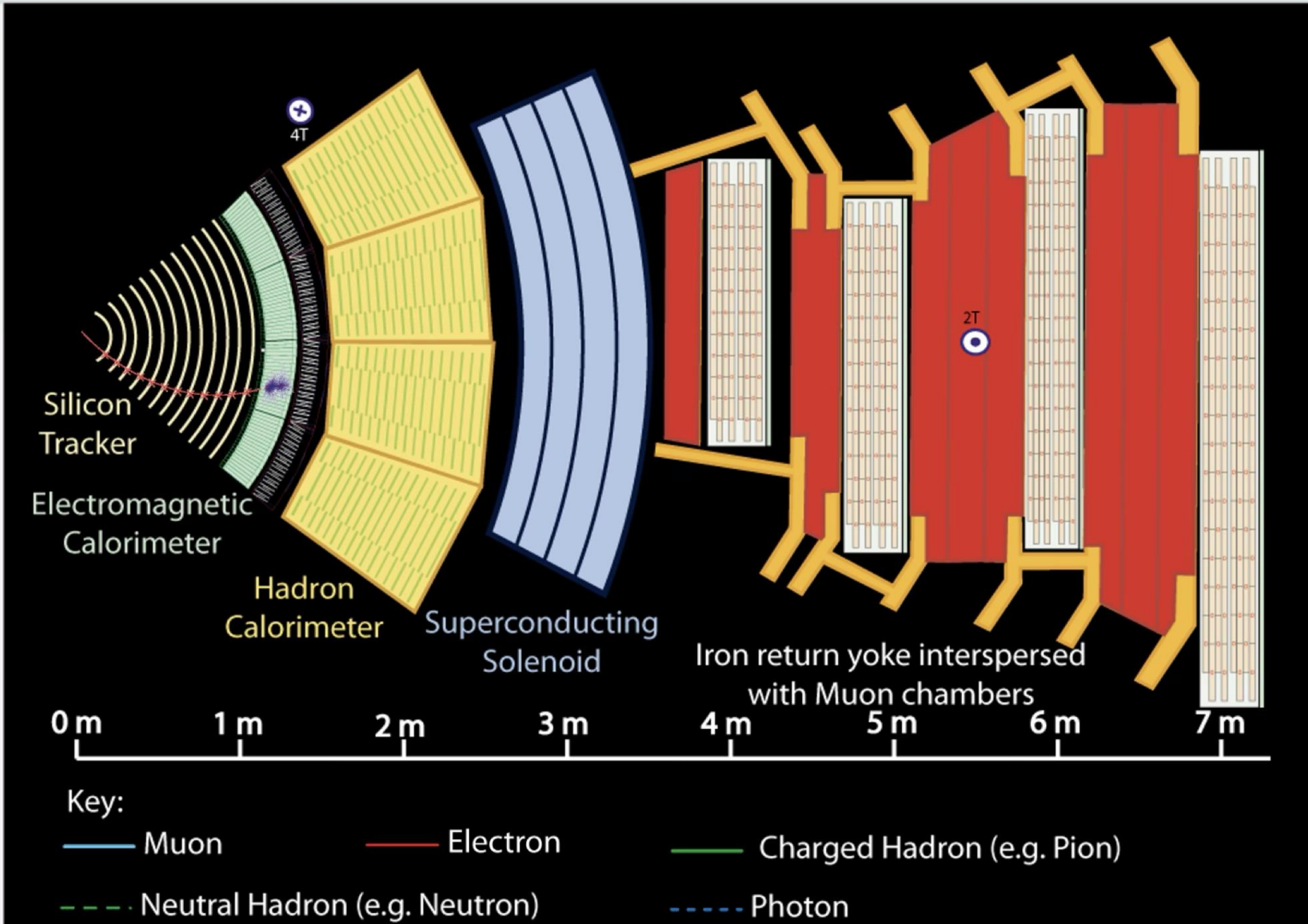
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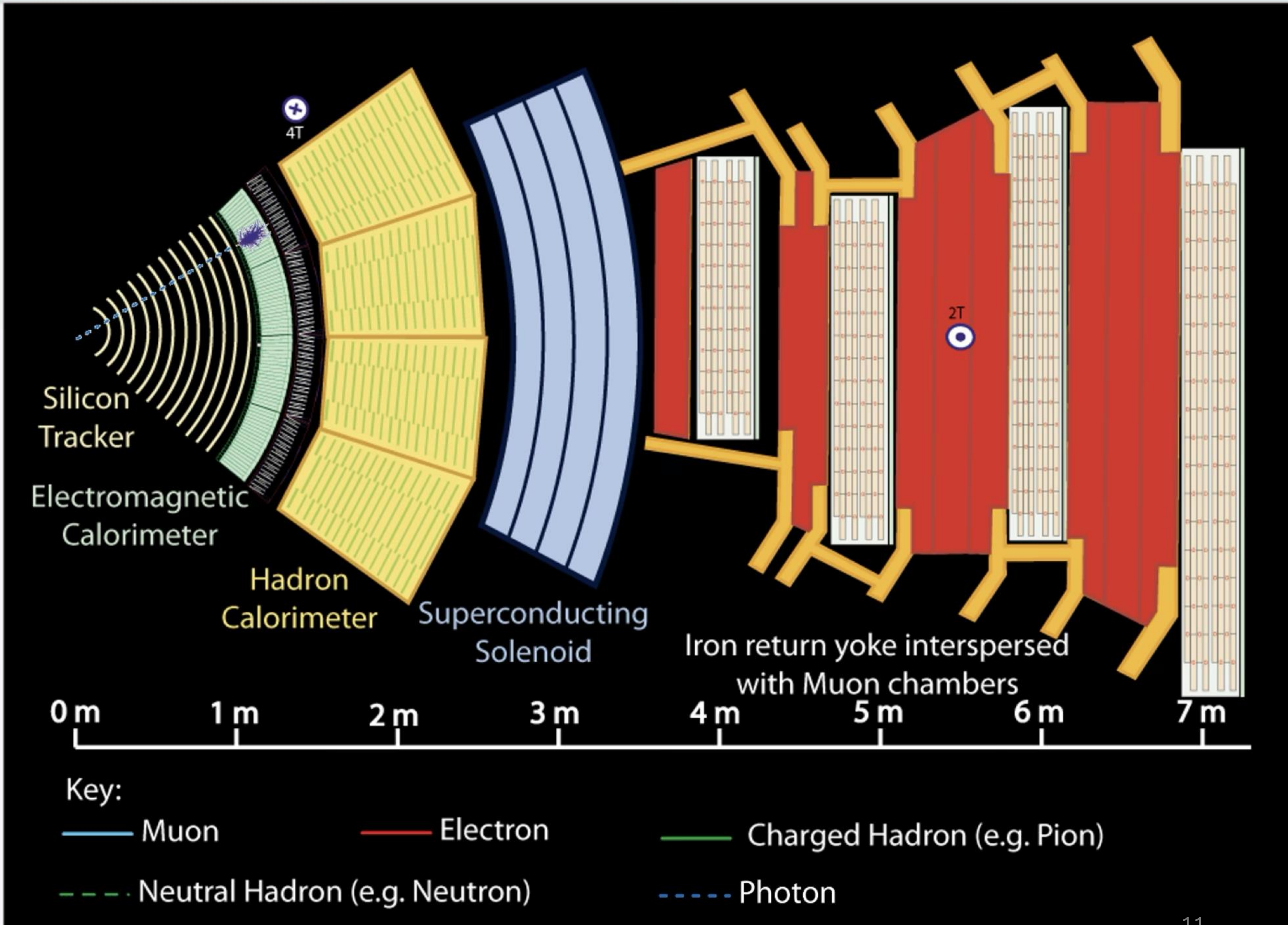
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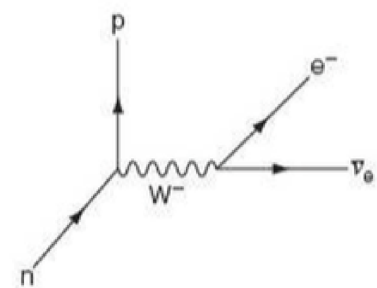
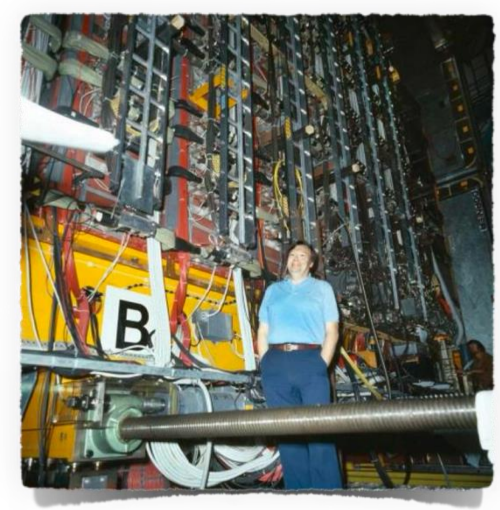
The W and Z bosons

- **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**

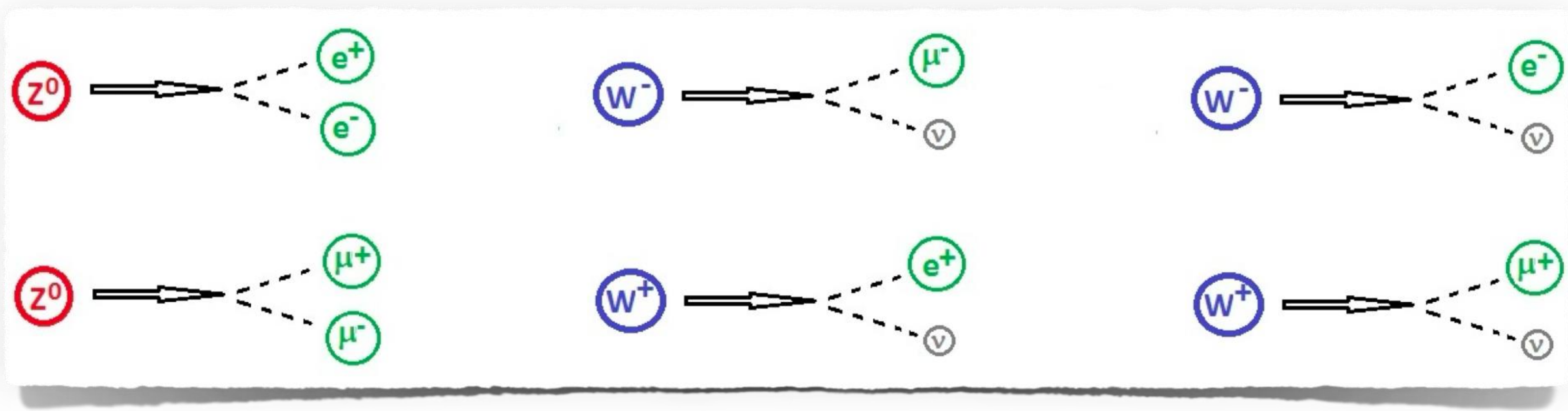


- Theory predicted **W** and **Z masses** around **100 GeV** and physicists at **CERN** built in early **1980's** the first most powerful collider able to reach such high energies: the **SppS**



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**



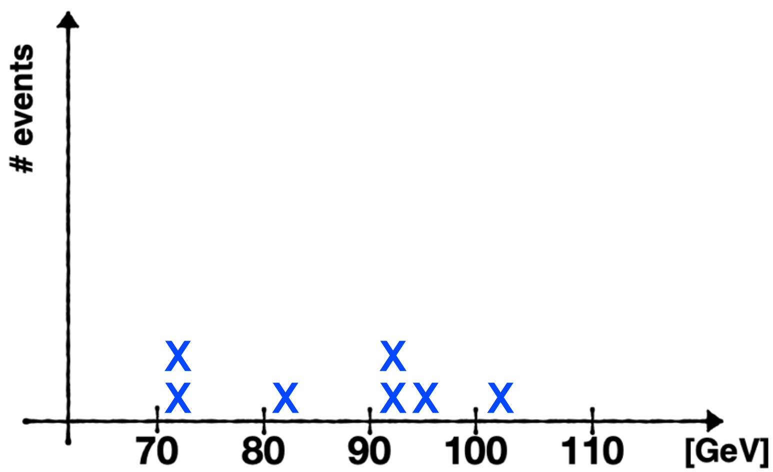
- So when in an LHC collision we produce a Z or W particle, **what we detect in the our experiments are only electrons and muons**!

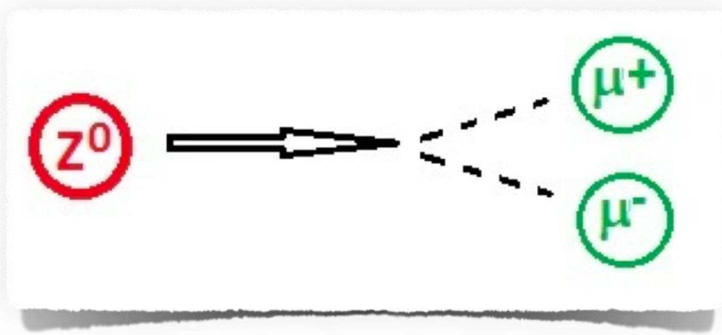
The Z boson mass reconstruction

- 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:

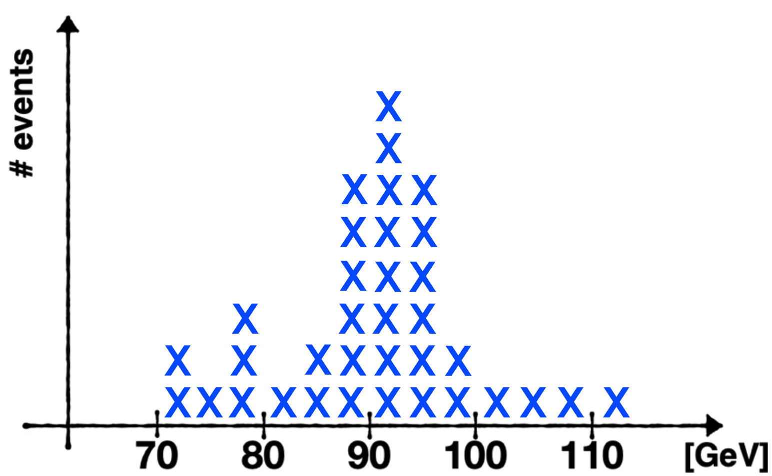


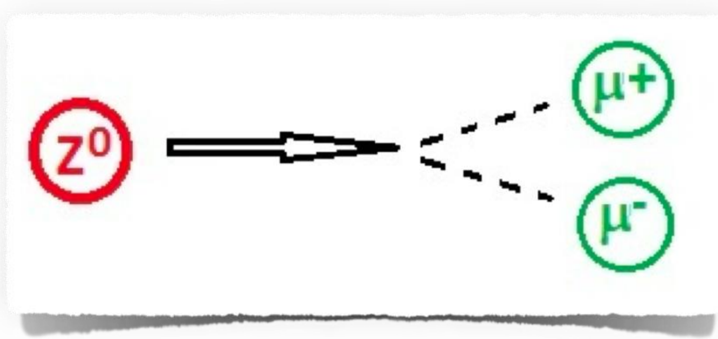


The Z boson mass reconstruction

- 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**



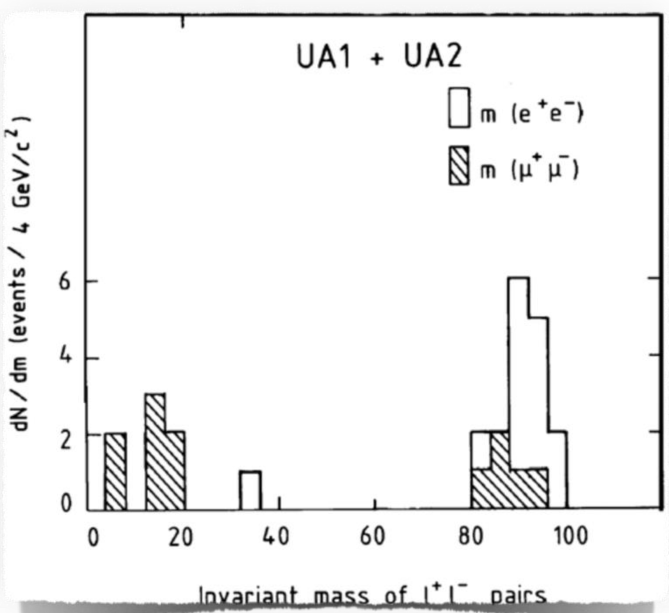


The Z boson Nobel Prize

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

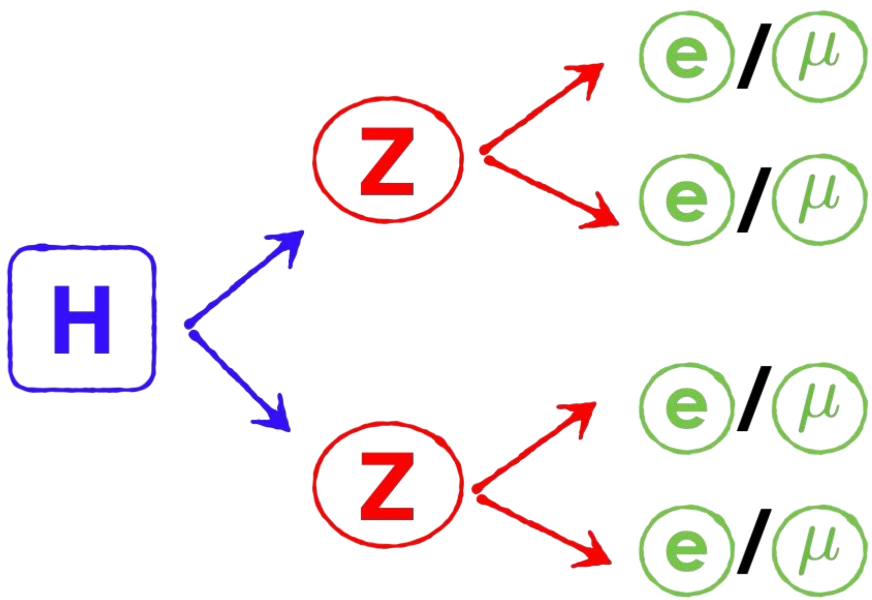
- If the "**excess**" of events is **significantly big** → we discovered a **new particle**

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



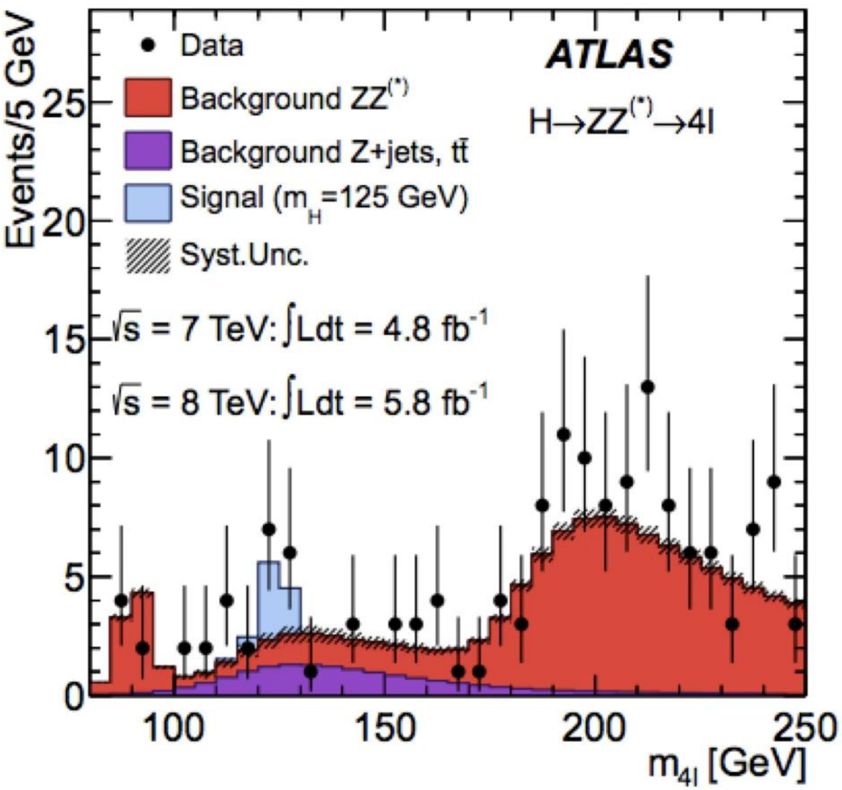
The Z role in the Higgs discovery

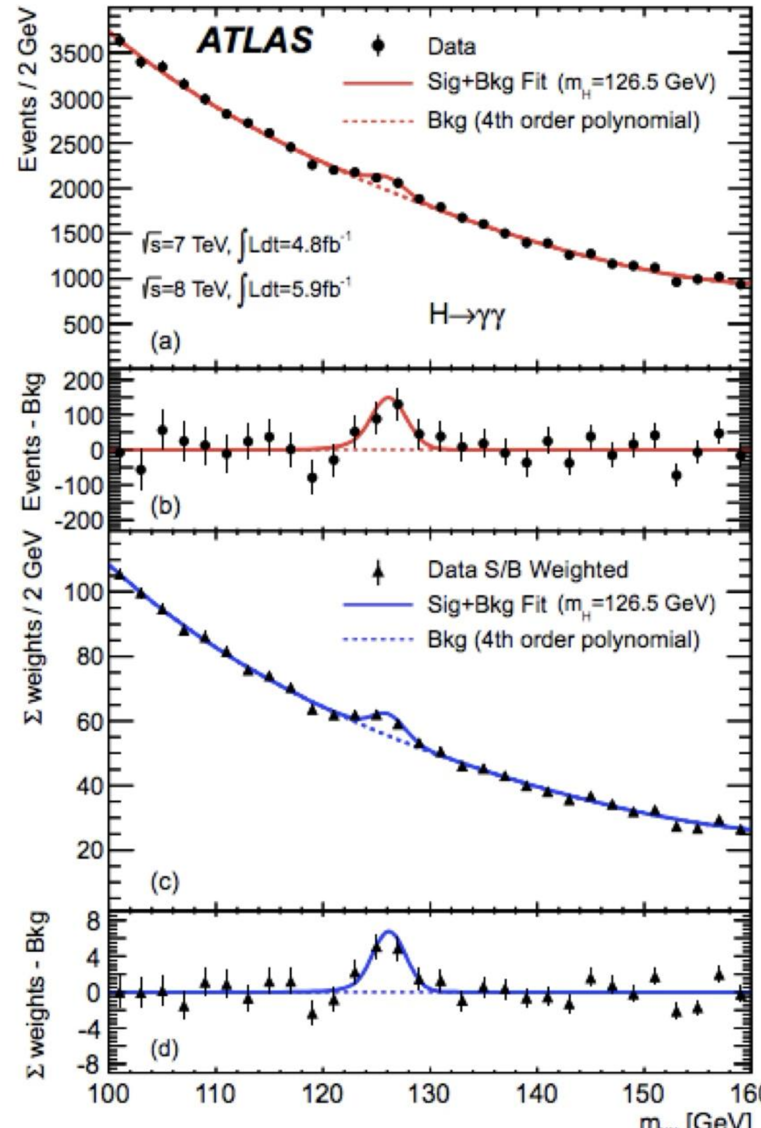
- The discovery of the Z boson opened the opportunity to “use” the recently discovered particle for the quest of the **Higgs boson**:



- Either decays of the Z to electrons/muons are considered

The Higgs discovery





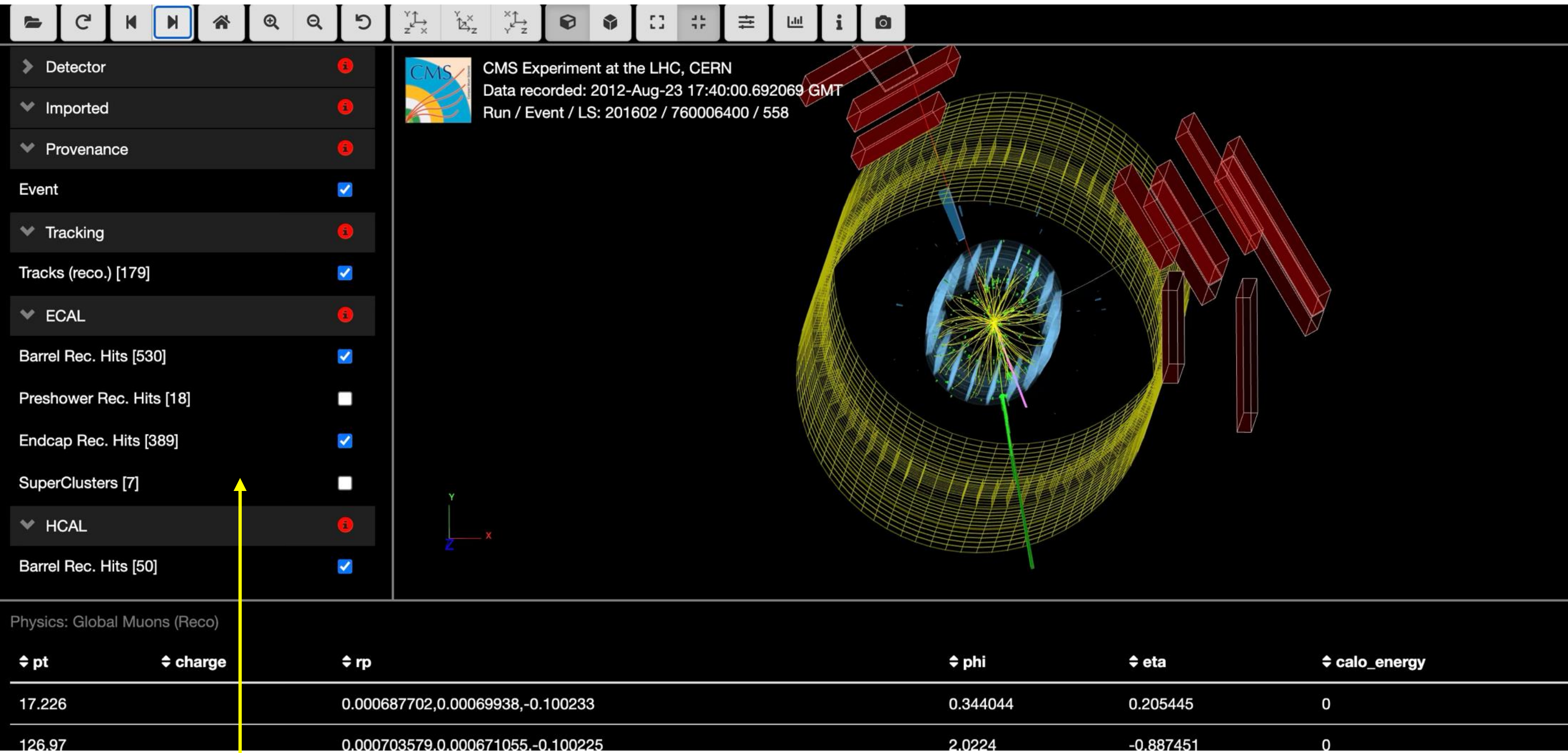
Now it's your turn!

- 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 boson**

- We will learn how to **work in team** in **data analysis** and how to **present our own results** like in a **major physics conference**!

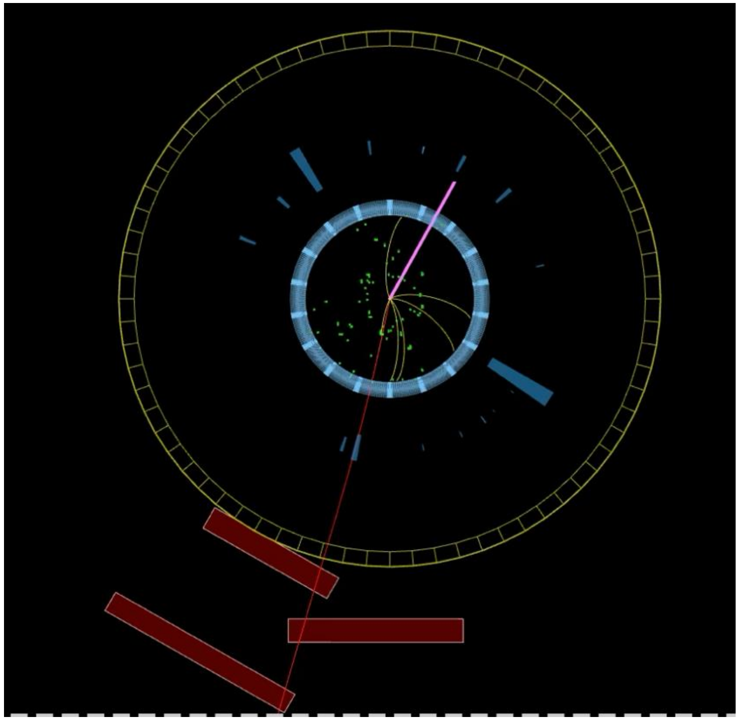
iSpy tool – CMS event

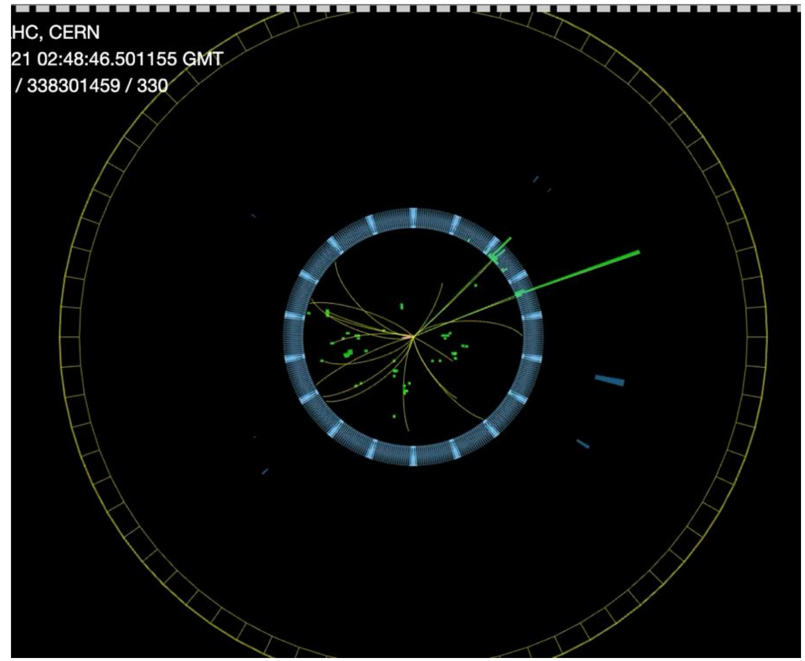
Different planes views



Subdetectors and physics objects visualization

Particles Identification



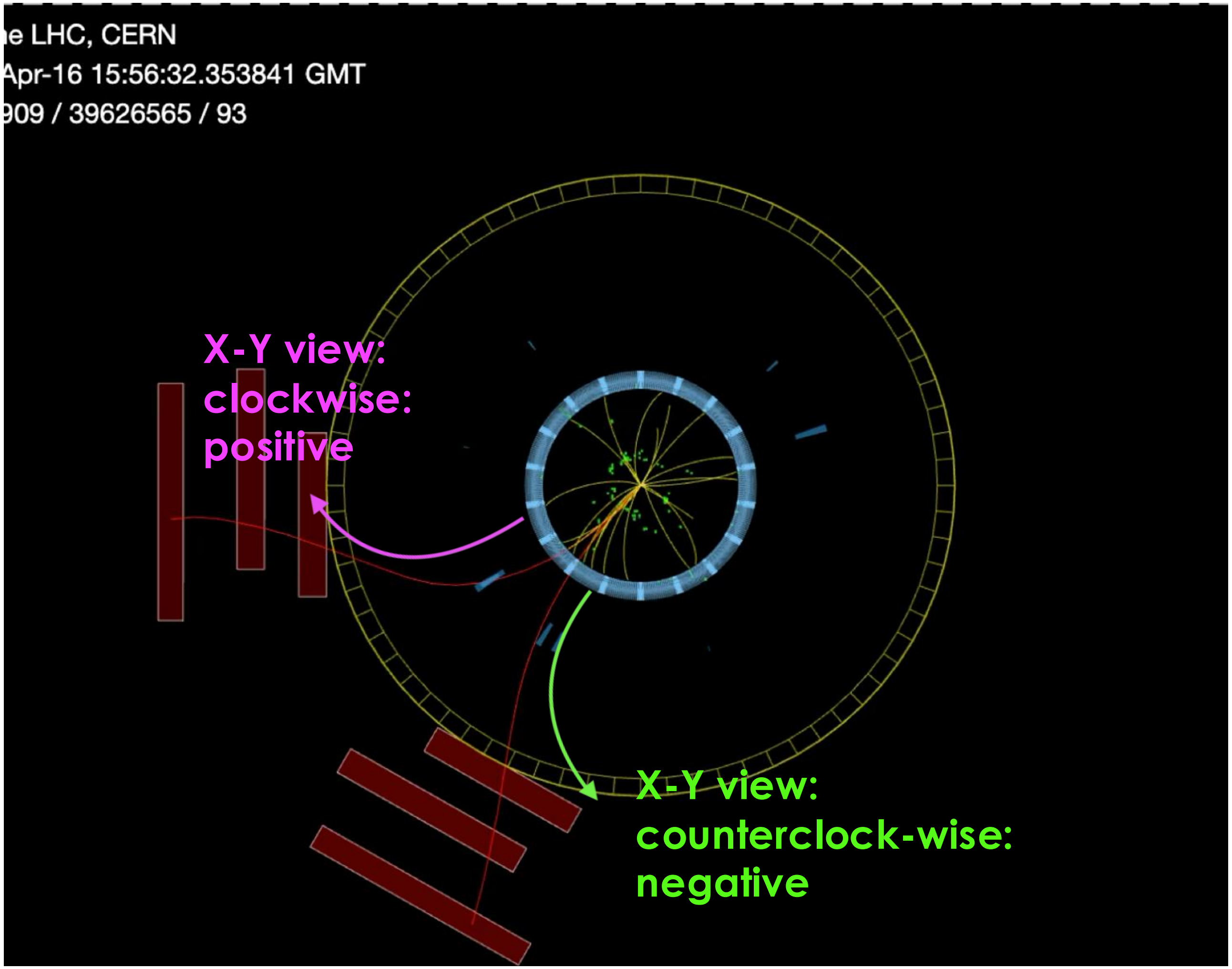


Muon μ

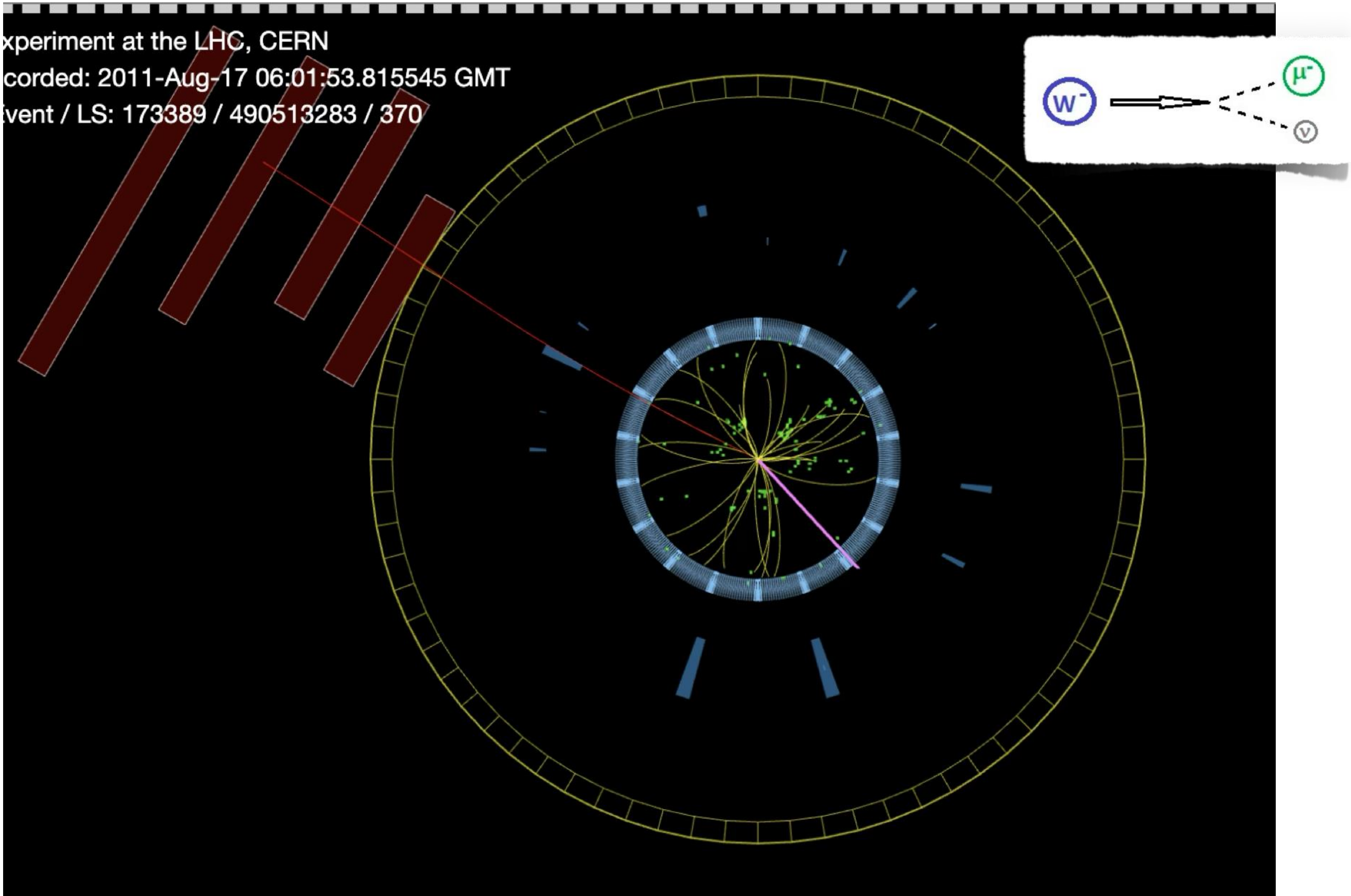
Neutrino ν

Electron e

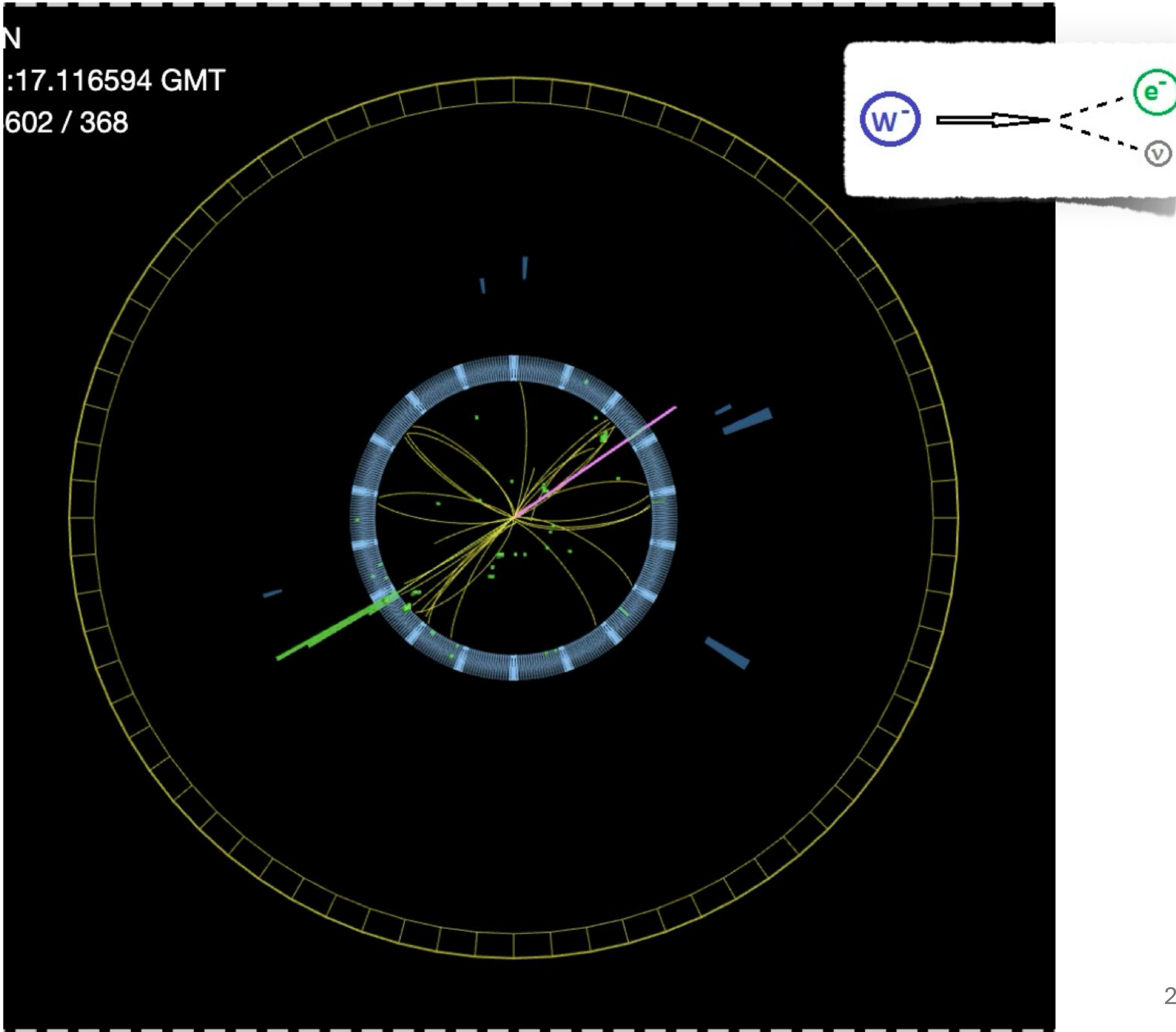
Charge Identification



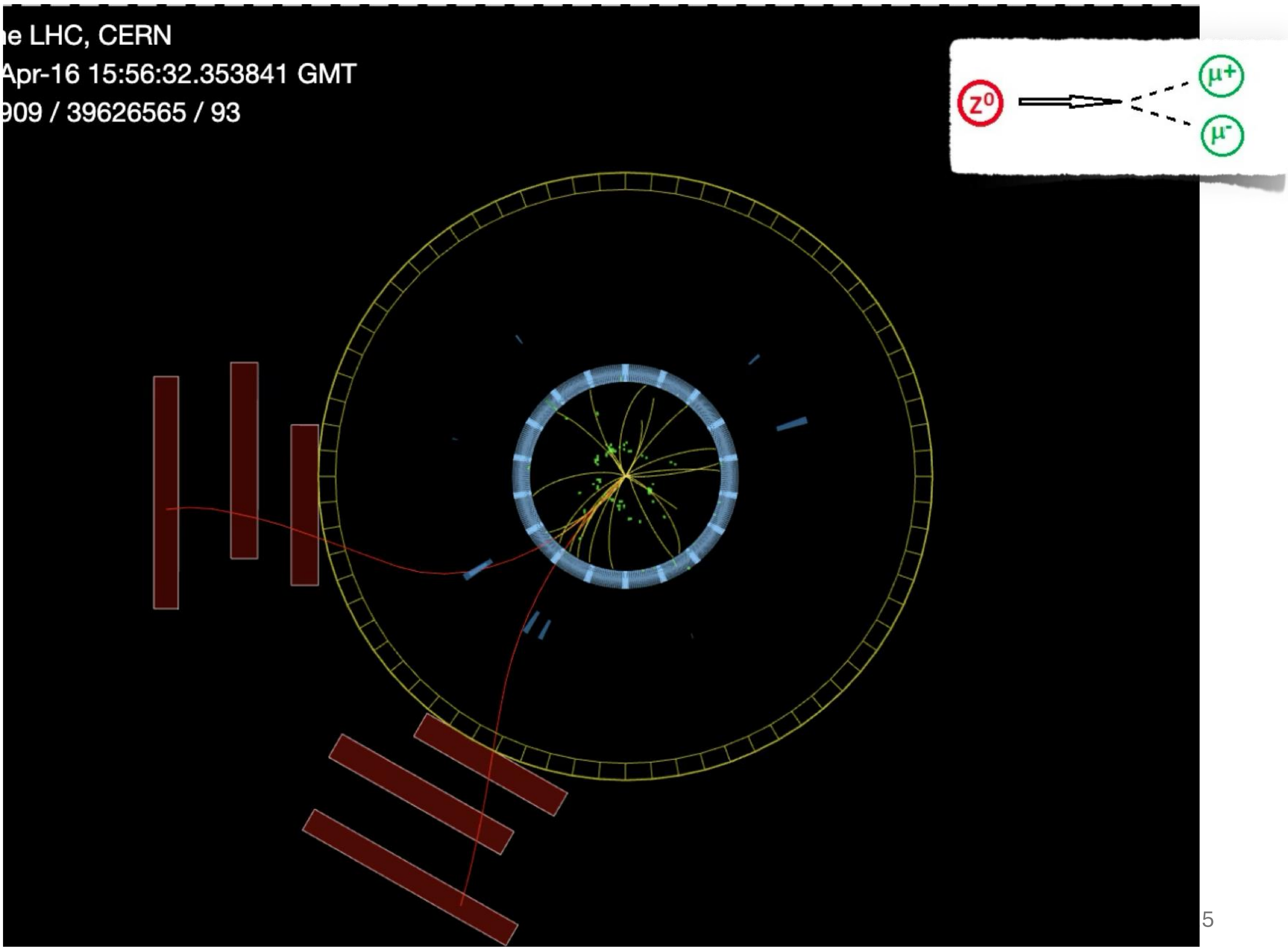
W $\rightarrow \mu + \nu$



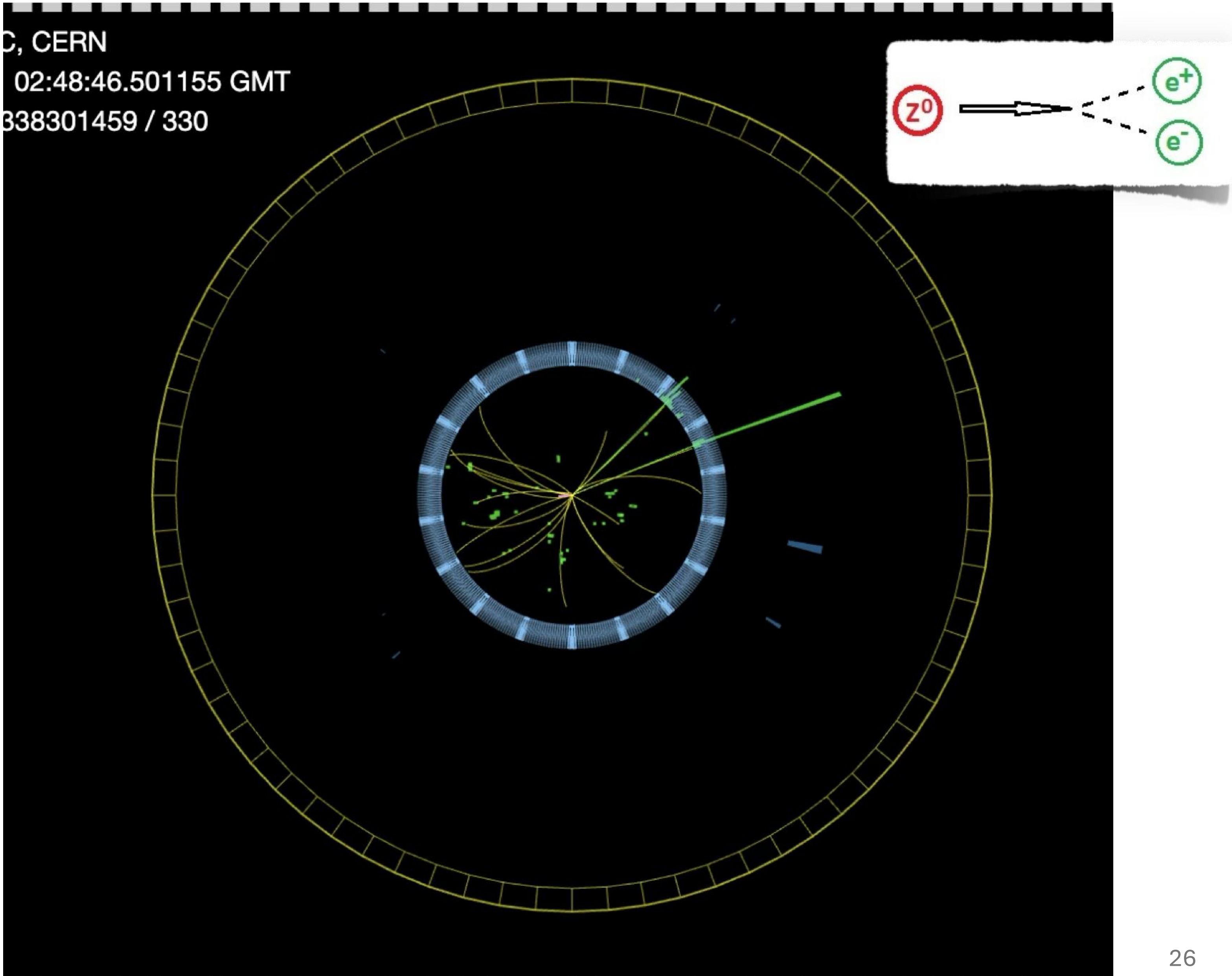
$\mathbf{W} \rightarrow e + \nu$



$Z \to \mu + \mu$



$Z \to e + e$



BACKUP

Many resonances around!