The Compact Muon Solenoid Detector

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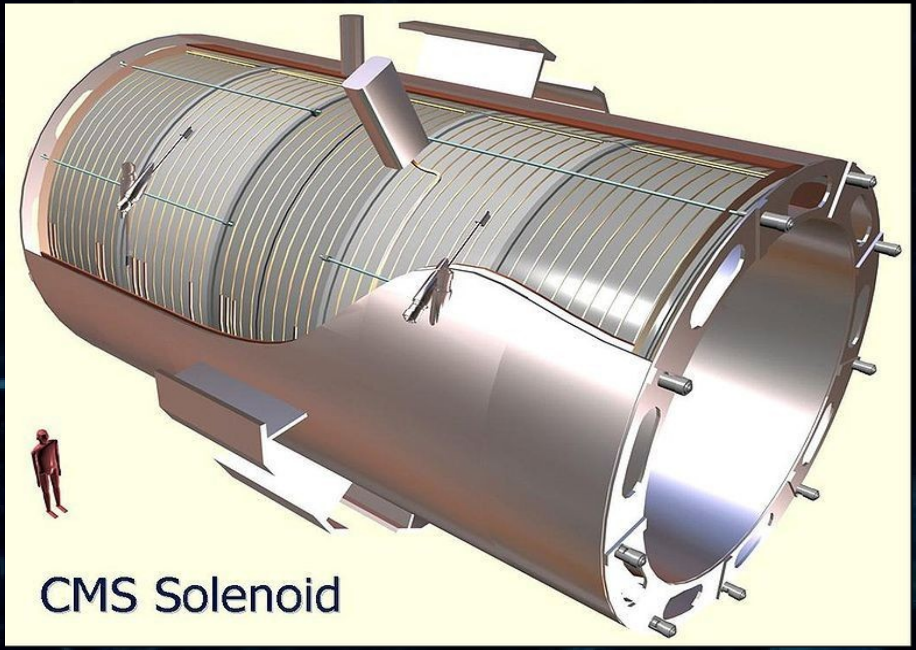
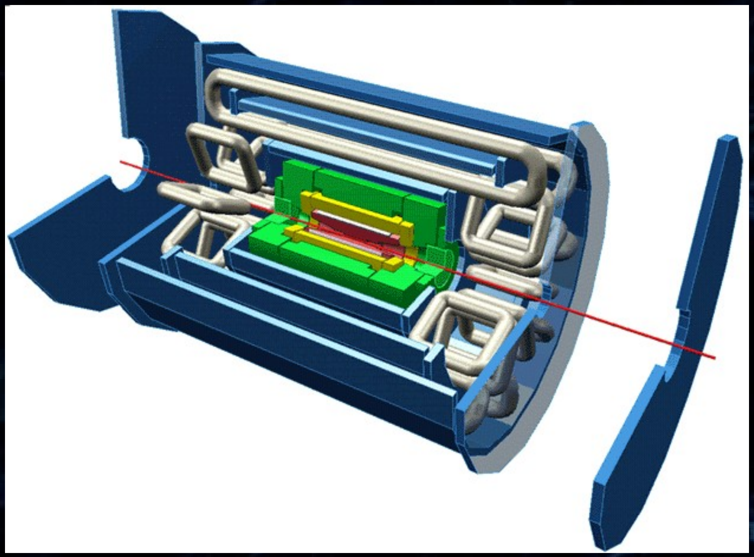
The S in CMS - Solenoid

- CMS is built around a superconducting solenoid generating a magnetic field of 4 Tesla
- The current necessary for this – 20 kA...
- Superconducting NbTi wire cooled to ~4K
- 13m length, 6m inner diameter – enough to fit the tracker and calorimeters inside
- (cost ~80 MCHF)

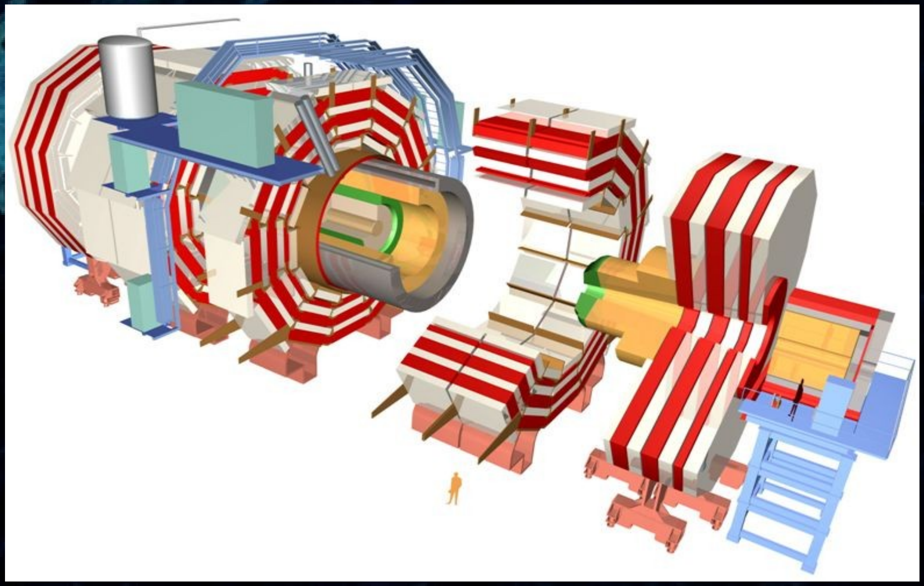


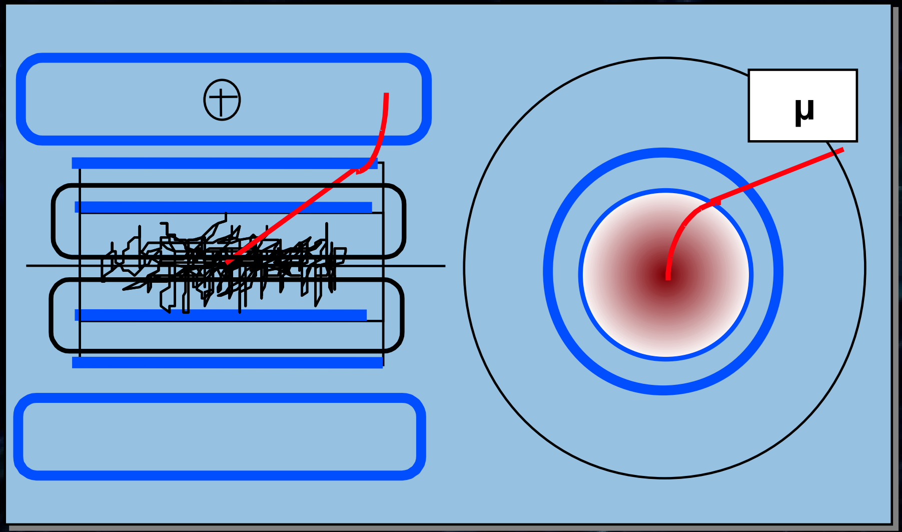
Magnets in particle detectors

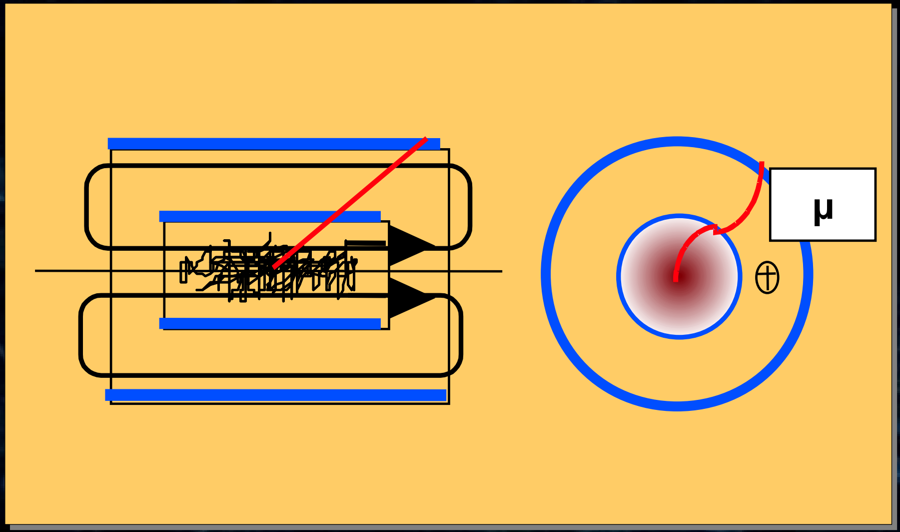
ATLAS A Toroidal LHC Apparatus



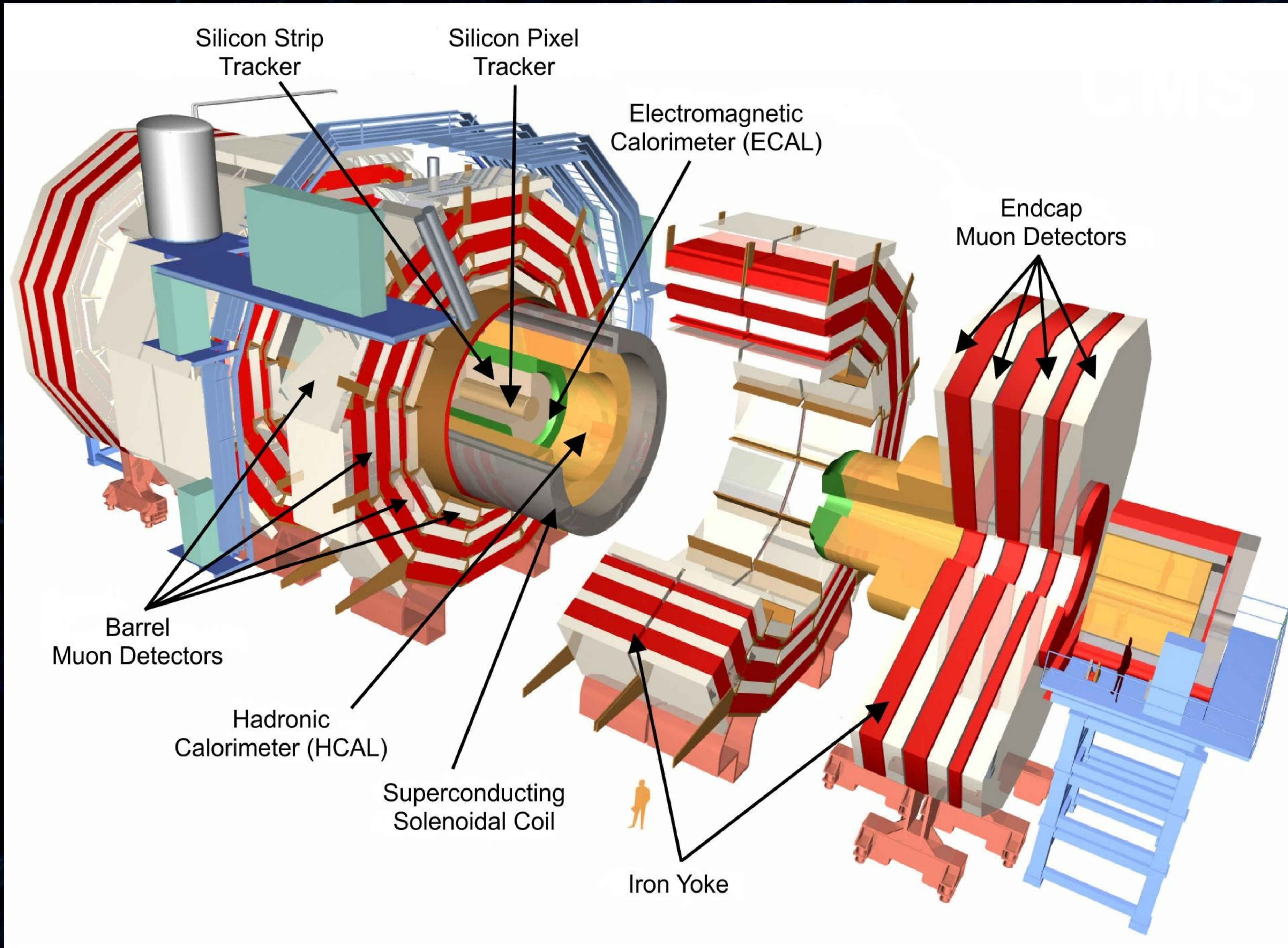
CMS Compact Muon Solenoid







CMS detector overview



Two ways to detect a particle

(in CMS)

Two ways to detect a particle

(in CMS)

See the track

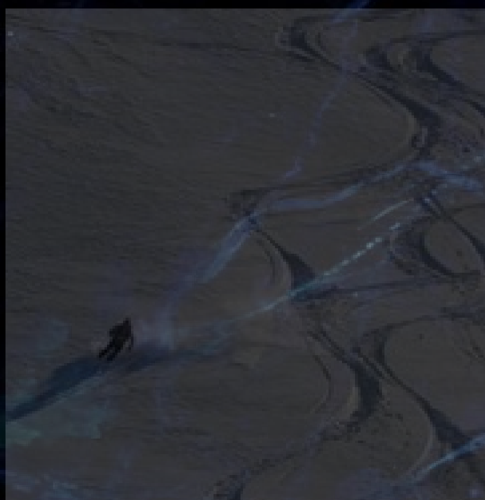
Or

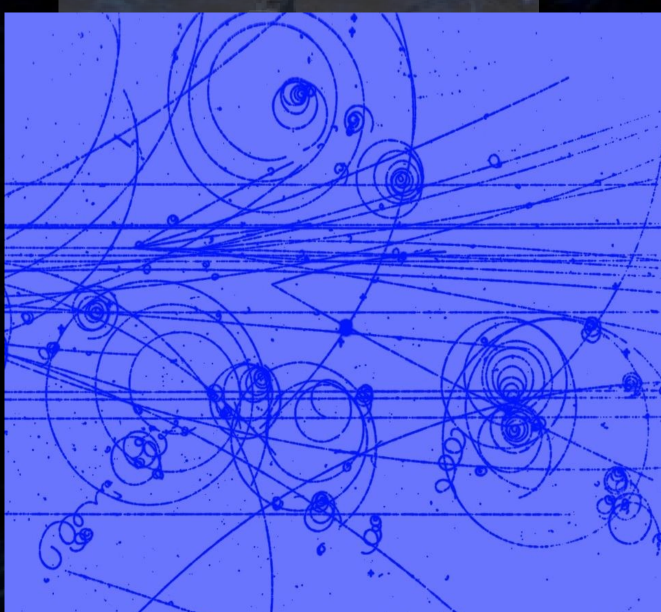
Catch

Two ways to detect a particle

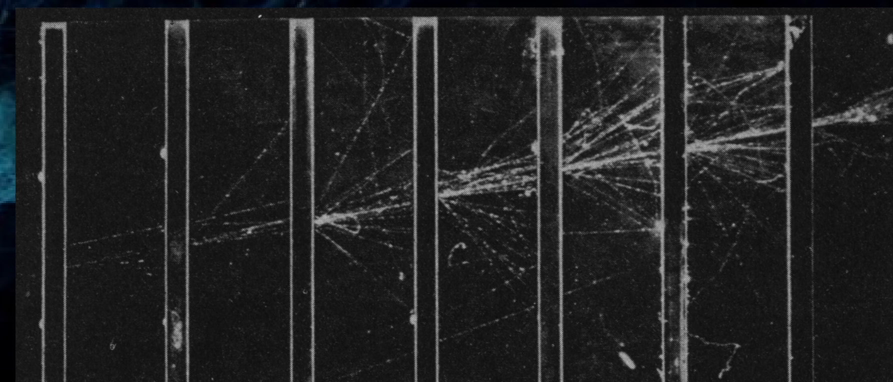
(in CMS)

Tracking detector

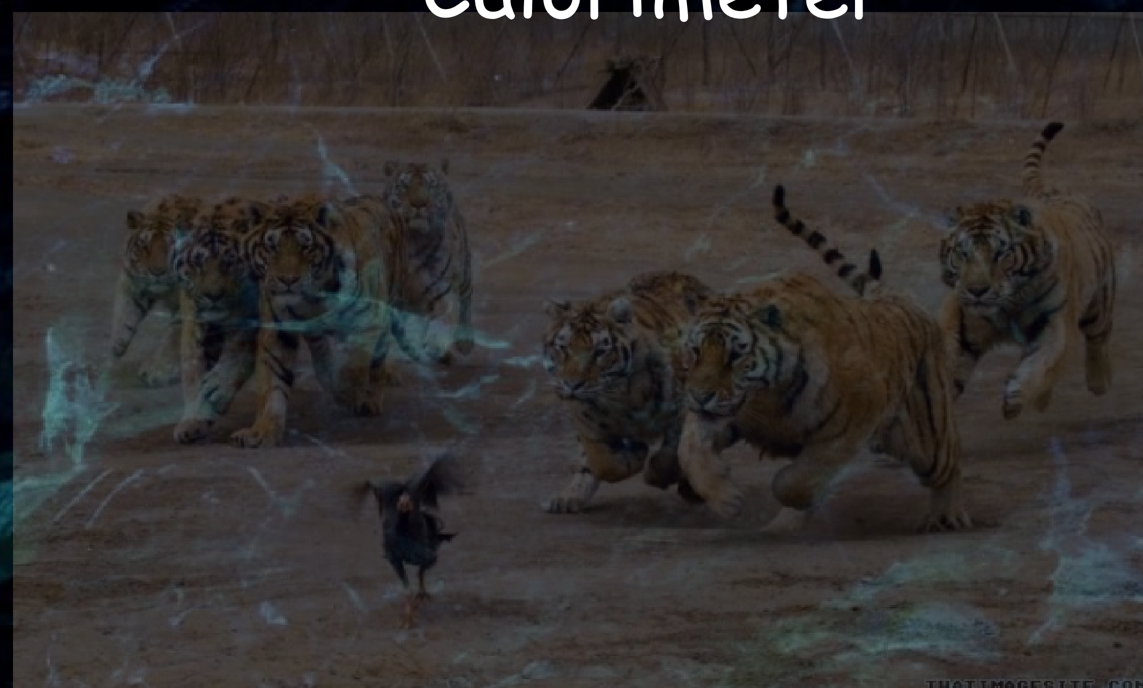




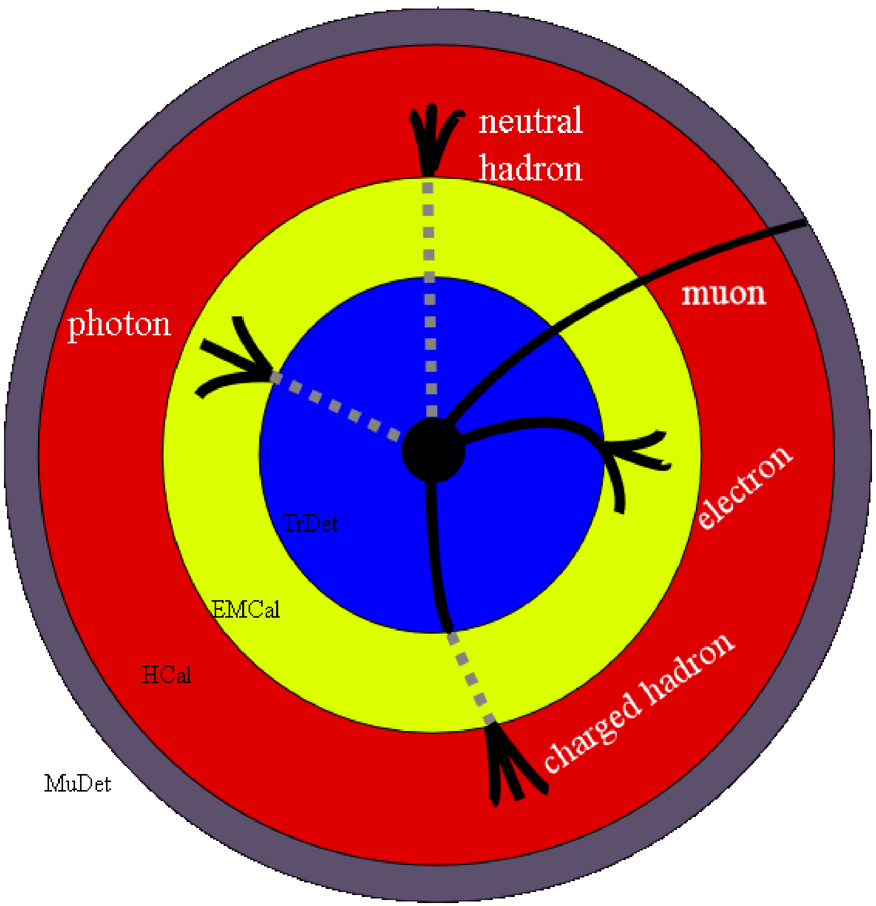
Or



Calorimeter

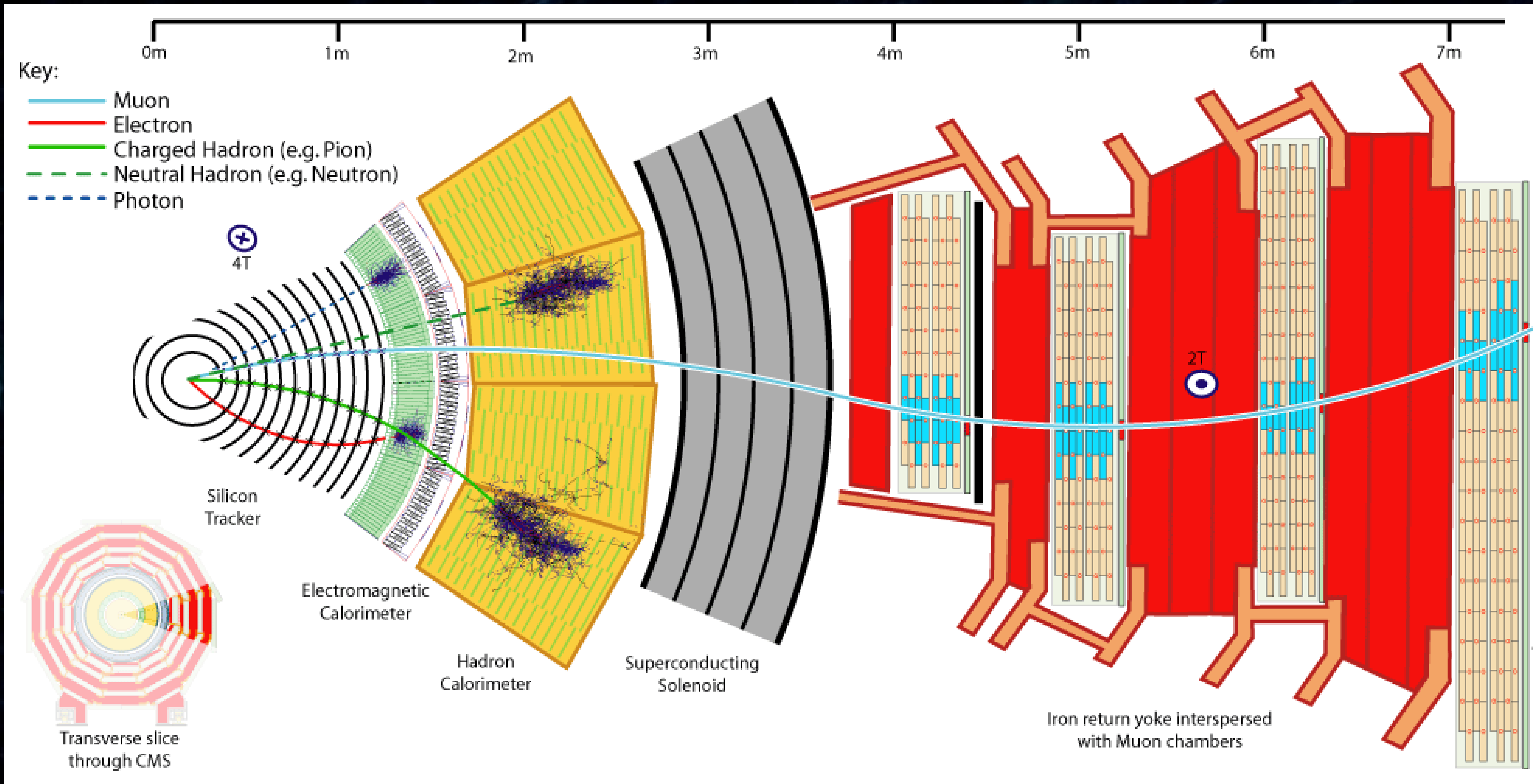


Particle detectors are like...

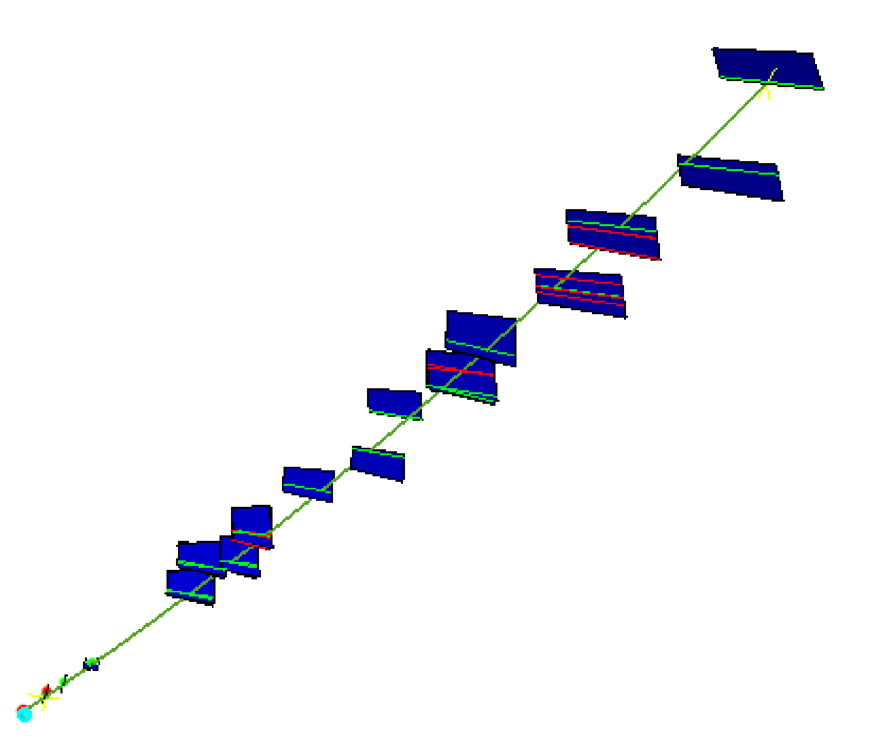


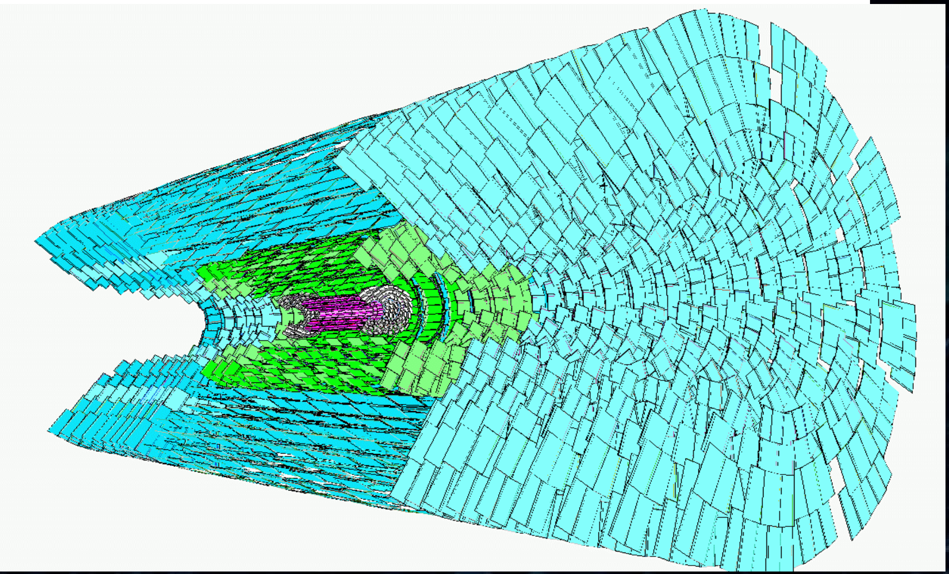
MuDet: muon detectors
TrDet: trace detector + vertex detector
EMCal: elekcromagnetic calorimĂ©ter
HCal: hadron calorimĂ©ter

Particle identification in CMS



The Inner Tracker



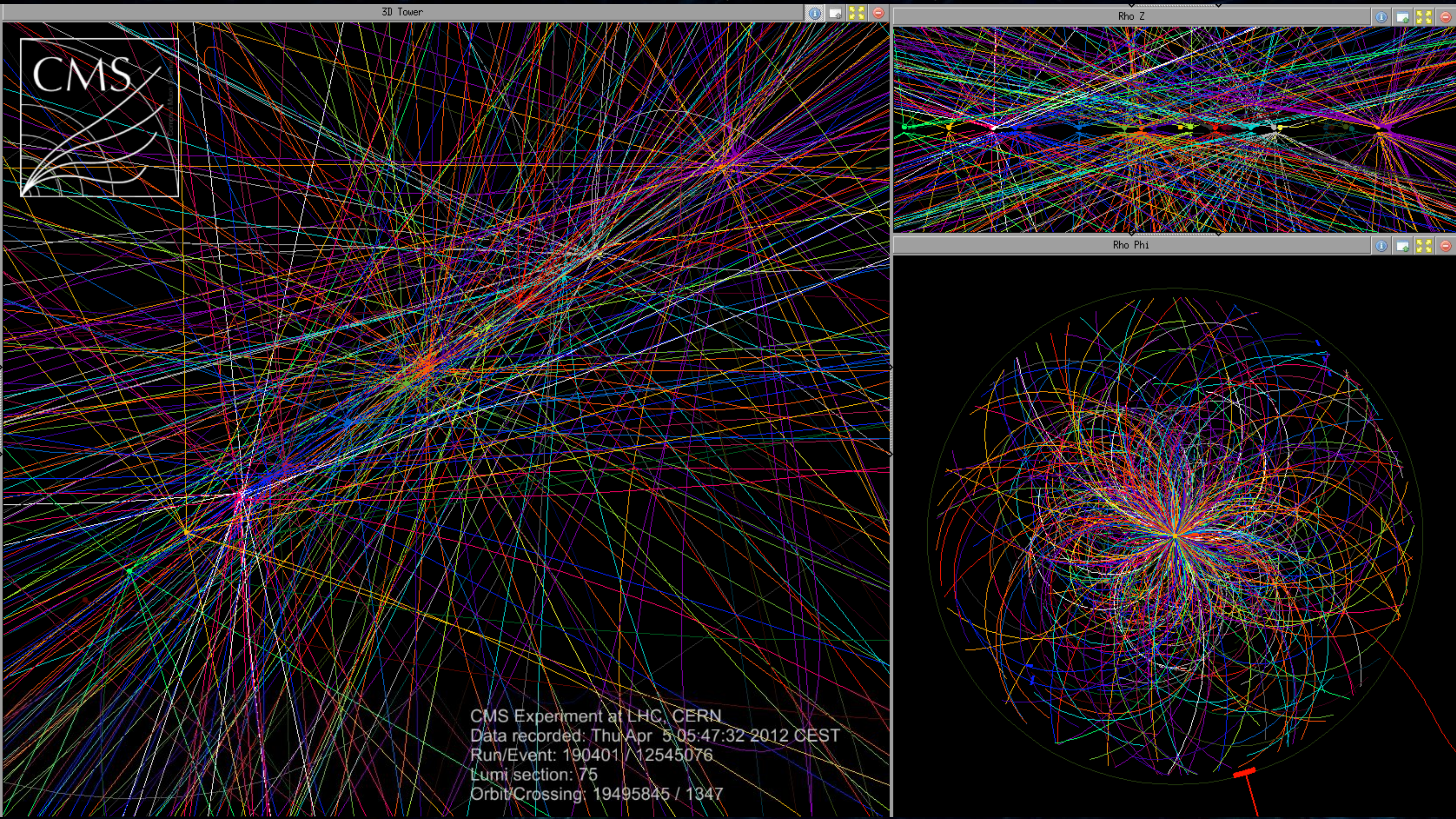


- Measures the trajectories of charged particles

  momentum = 1/curvature

- The biggest silicon detector in history, over 220m^2 of silicon
- Inner part – 3 layers of pixel detectors, outer part 10-11 layers of silicon microstrips
- 75 milions of read-out channels

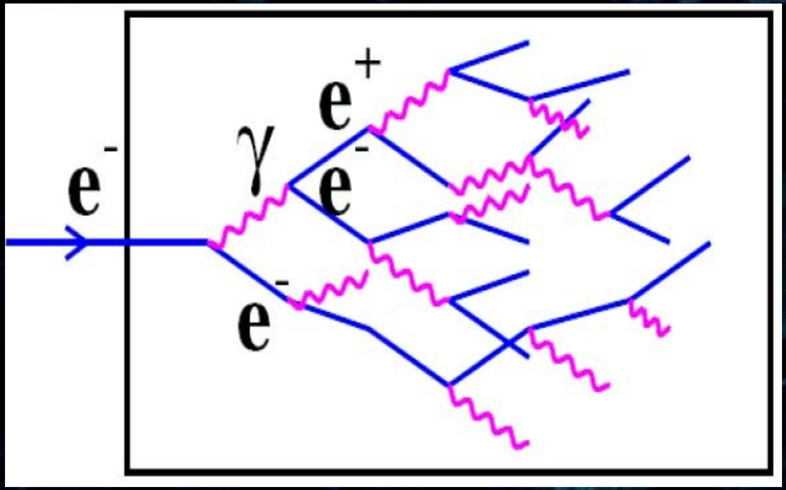
Event „pile-up"

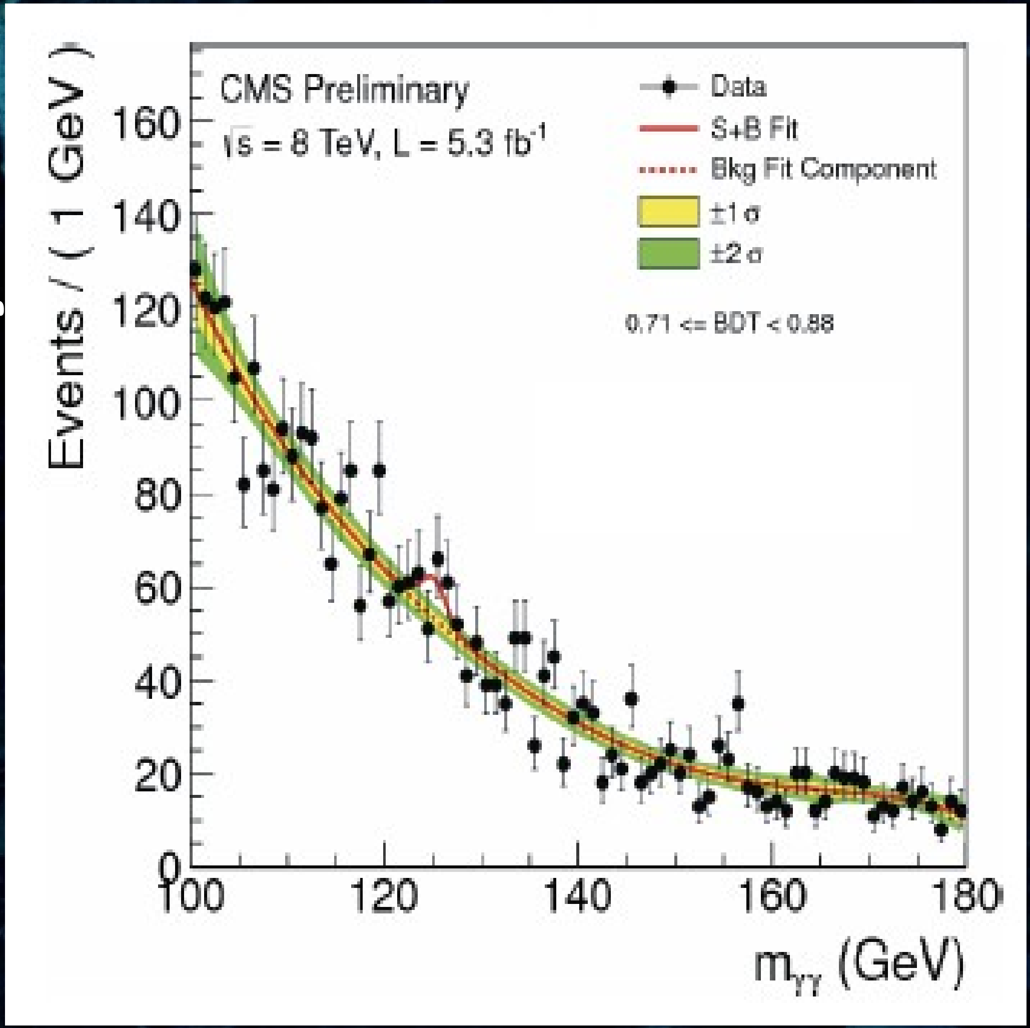


In the LHC, several proton-proton collisions can occur in a single bunch crossing (The image shows an event with 29 reconstructed vertices)

Electromagnetic Calorimeter

- Electron and photon energy measurement
- ~80 000 $PbWO_4$ crystals
- Homogeneous detector - crystals act as both the absorber and the scintillator
- Very good energy resolution





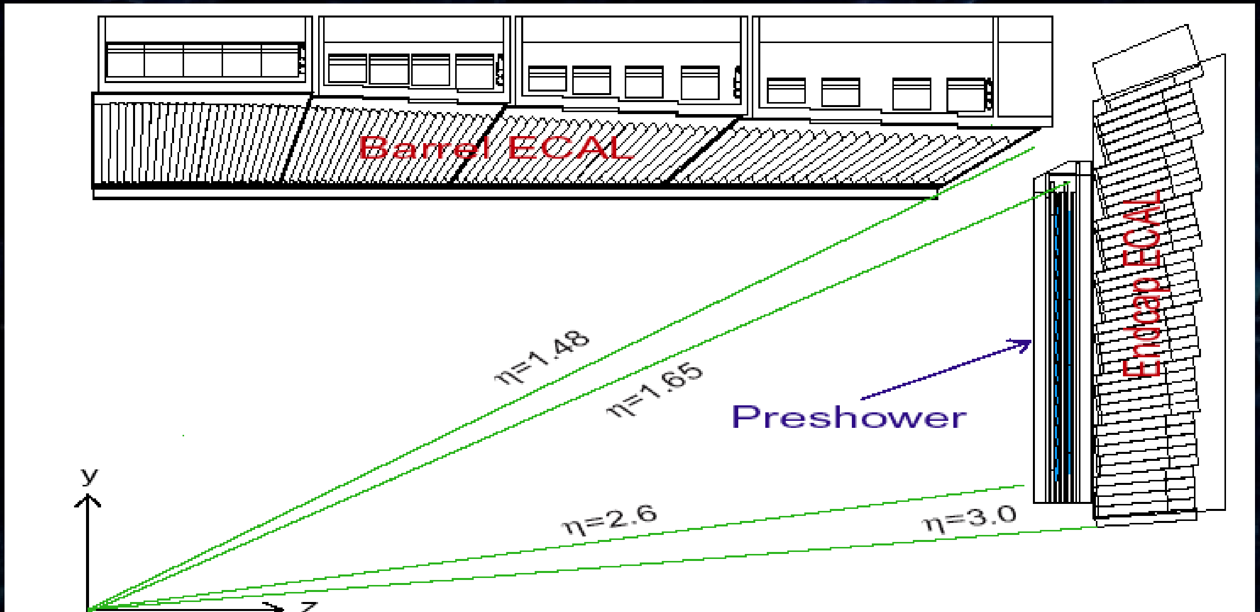
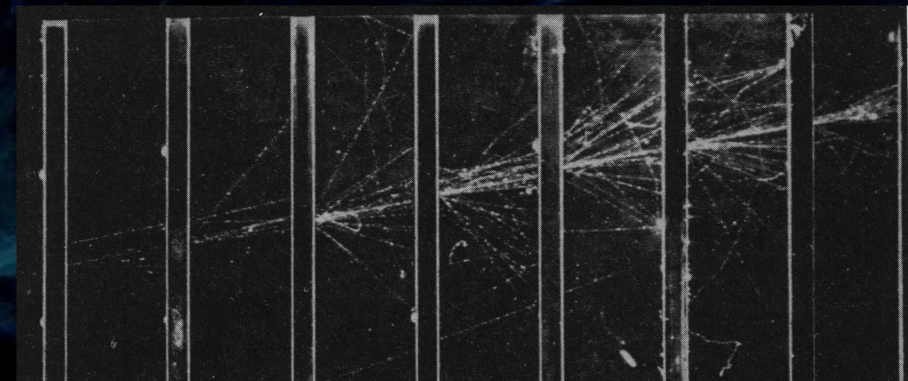


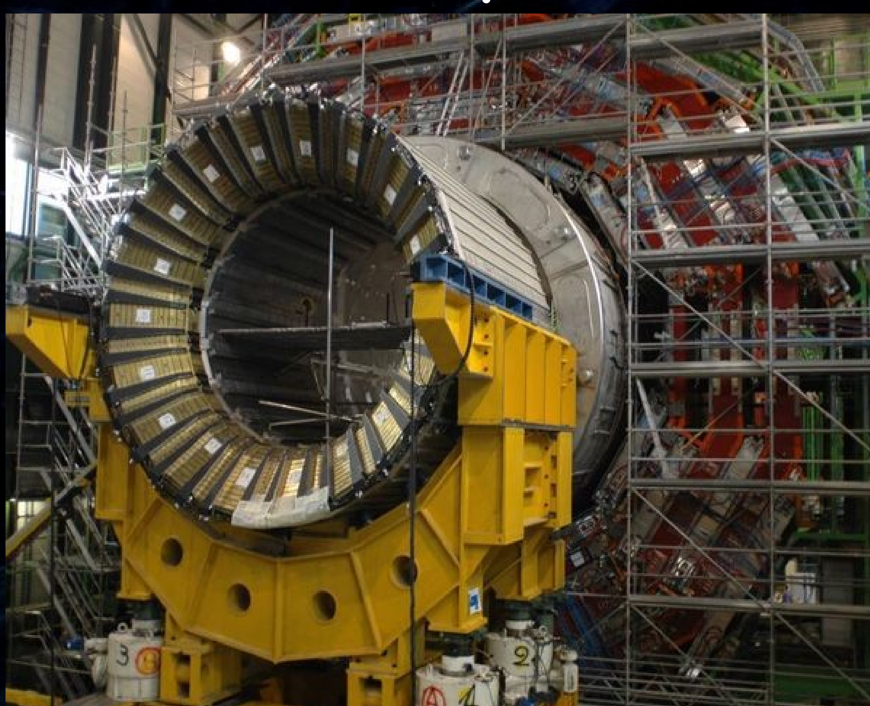
Figure 2: *A section through one quadrant of the ECAL.*

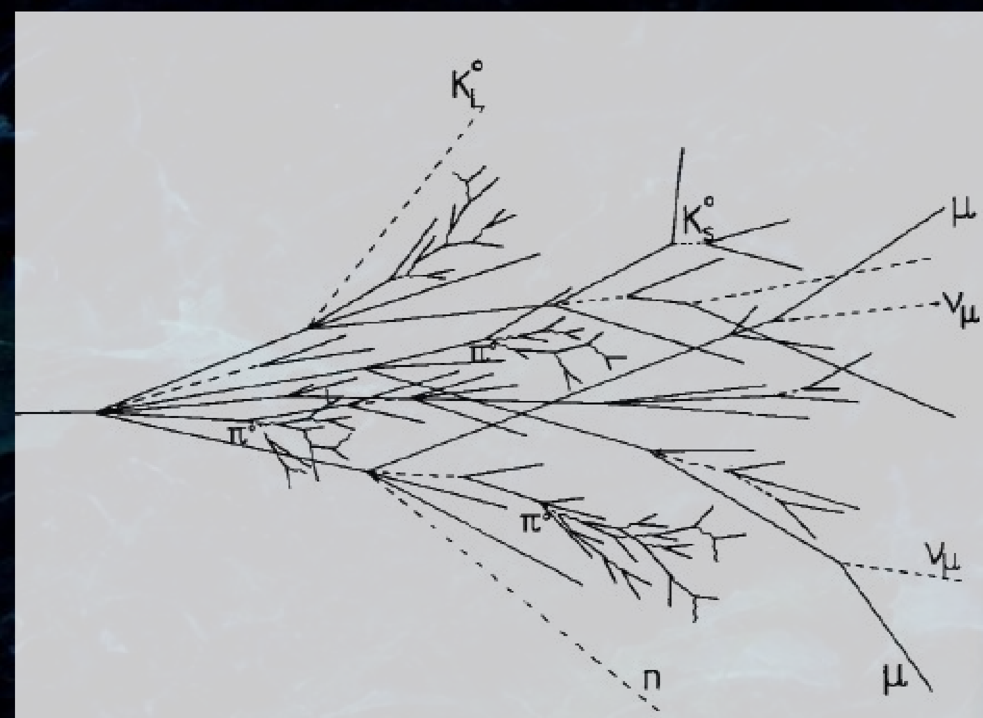
Hadron Calorimeter

- Jet energy measurement
- Brass absorber interleaved with scintillator layers

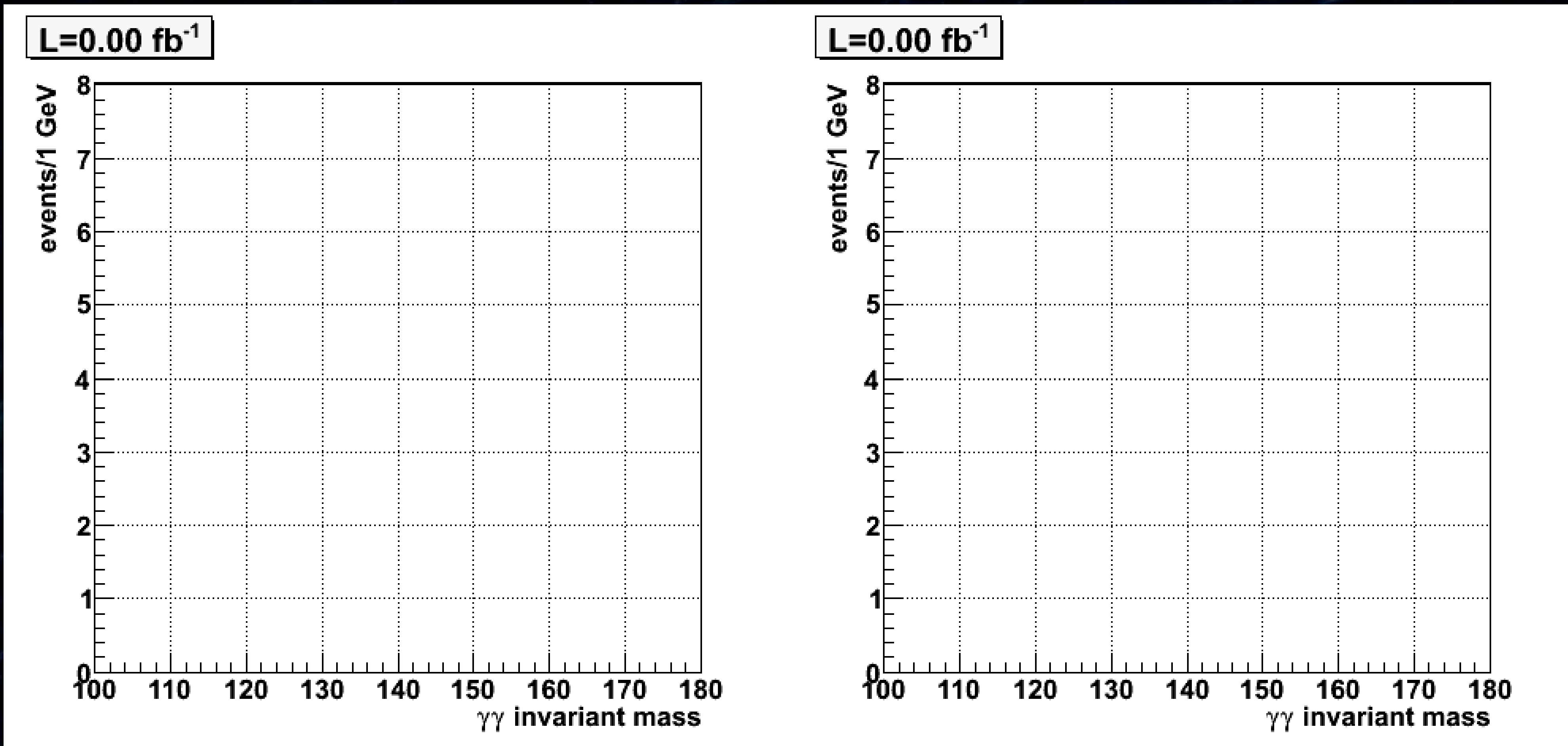


- Steel blocks with embedded quartz fibers in the „forward" part





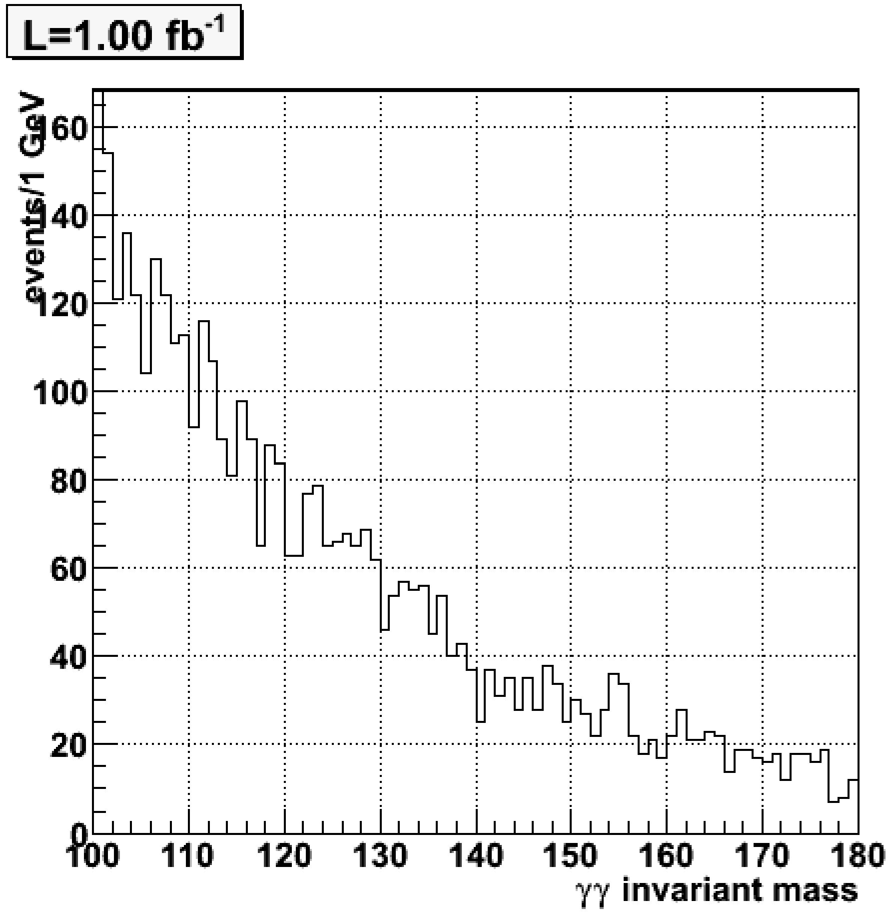
The H → γγ channel

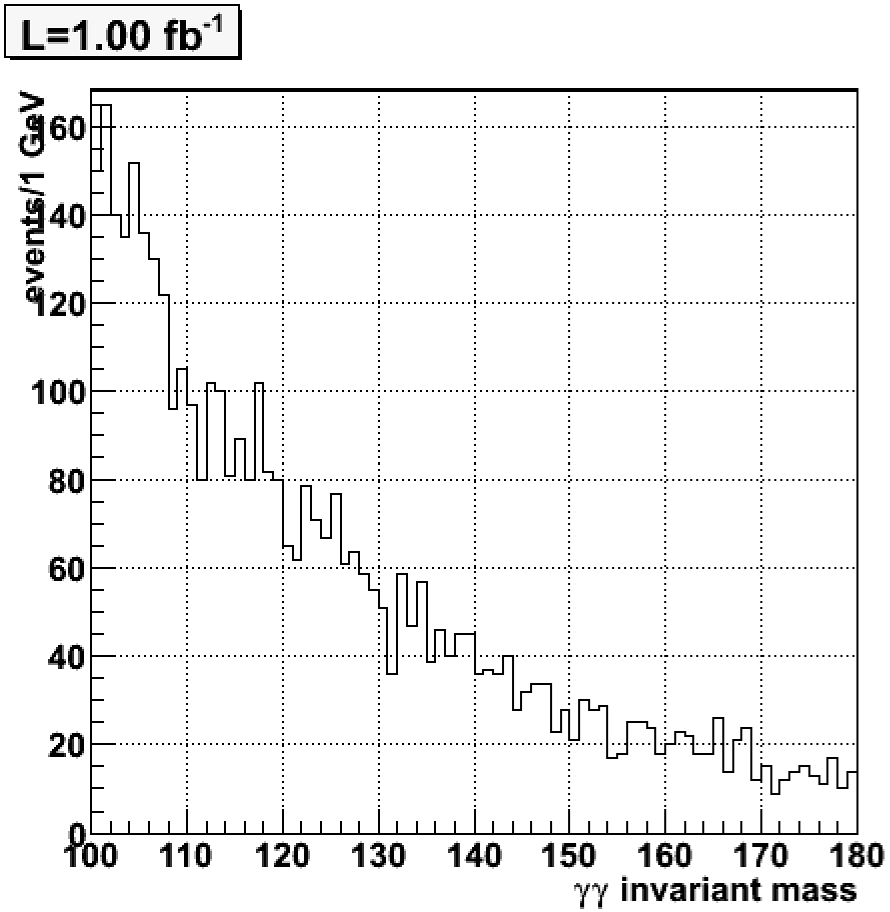


One of these plots contains the (simulated) Higgs boson signal.

Can you spot it?

The H → γγ channel





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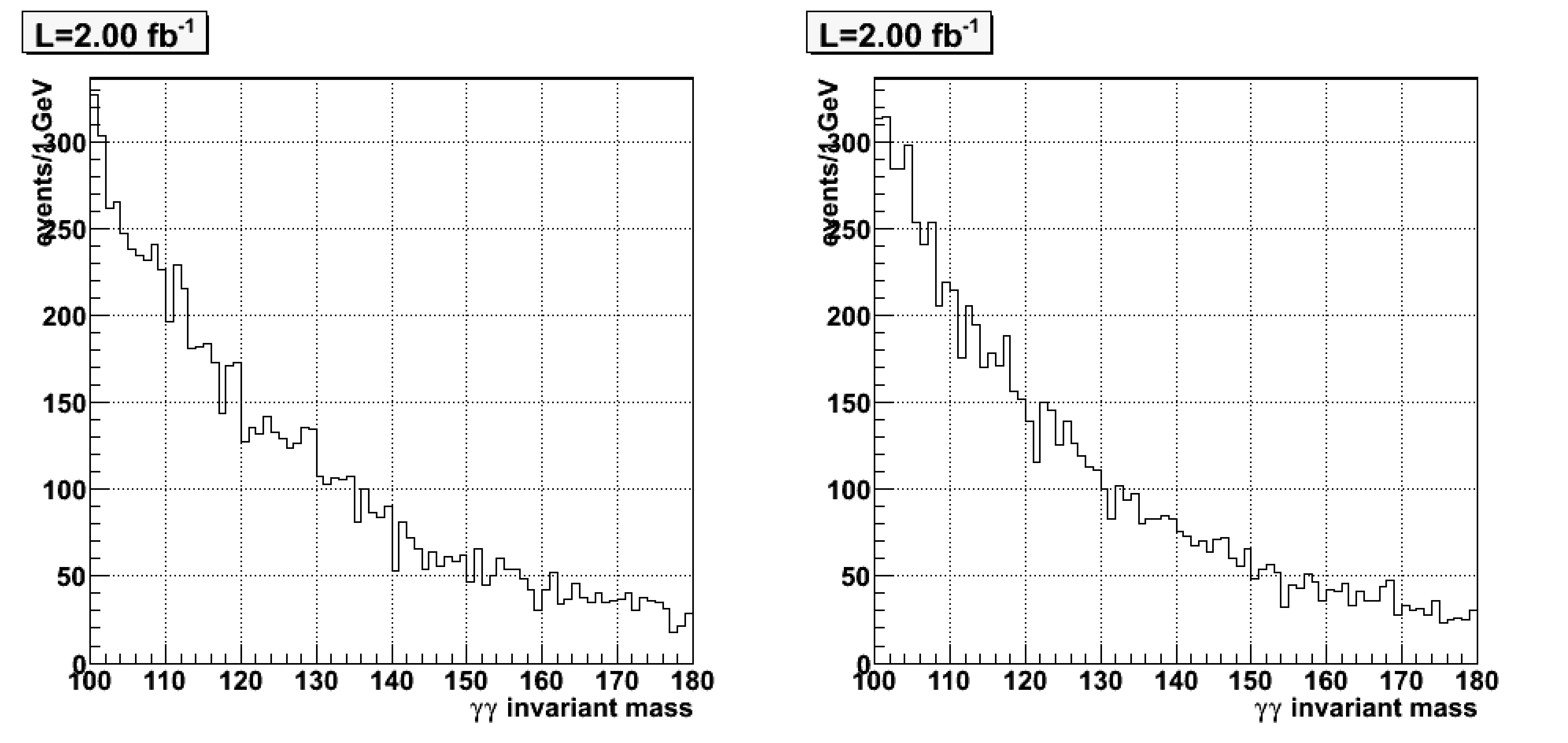
The $H \rightarrow \gamma\gamma$ channel



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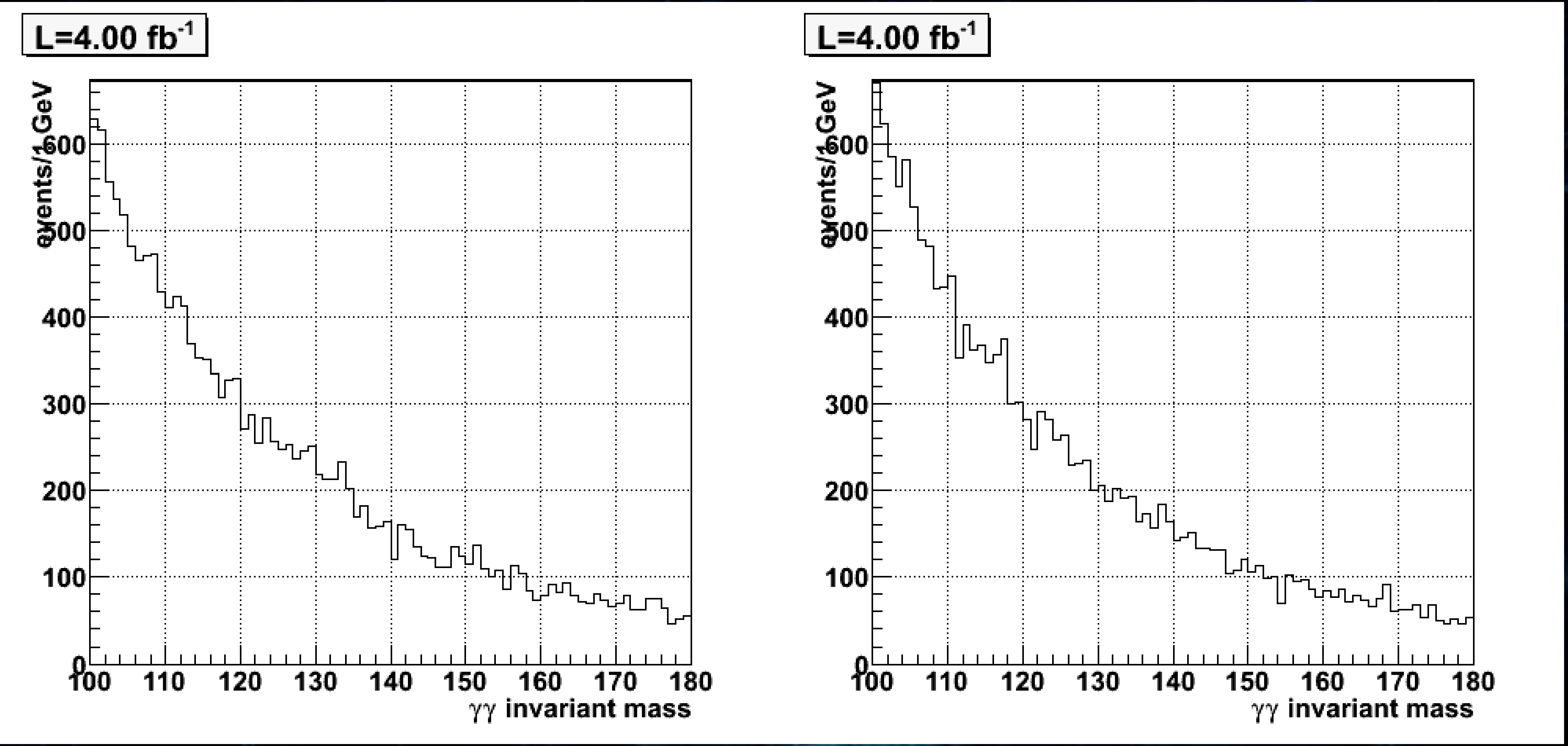

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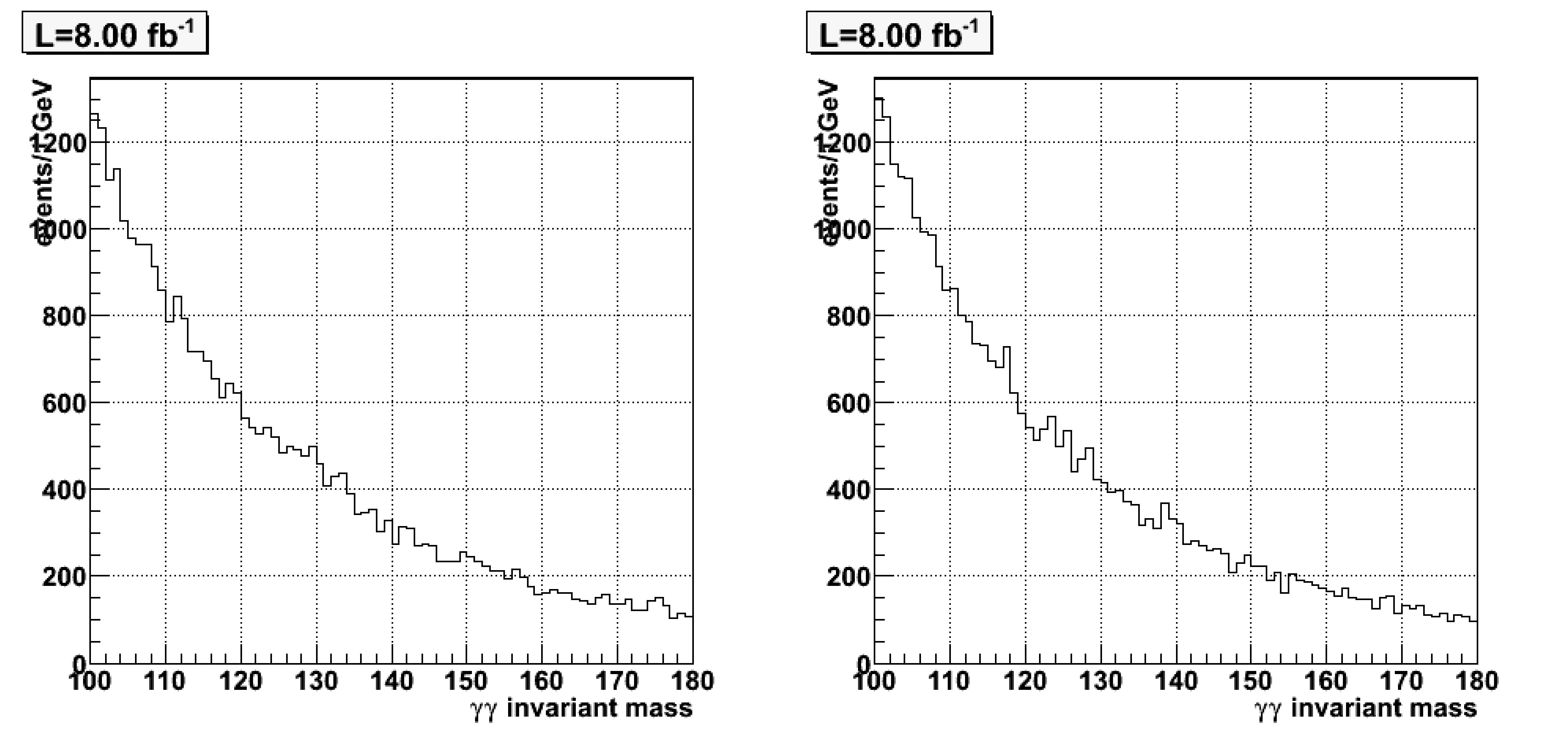

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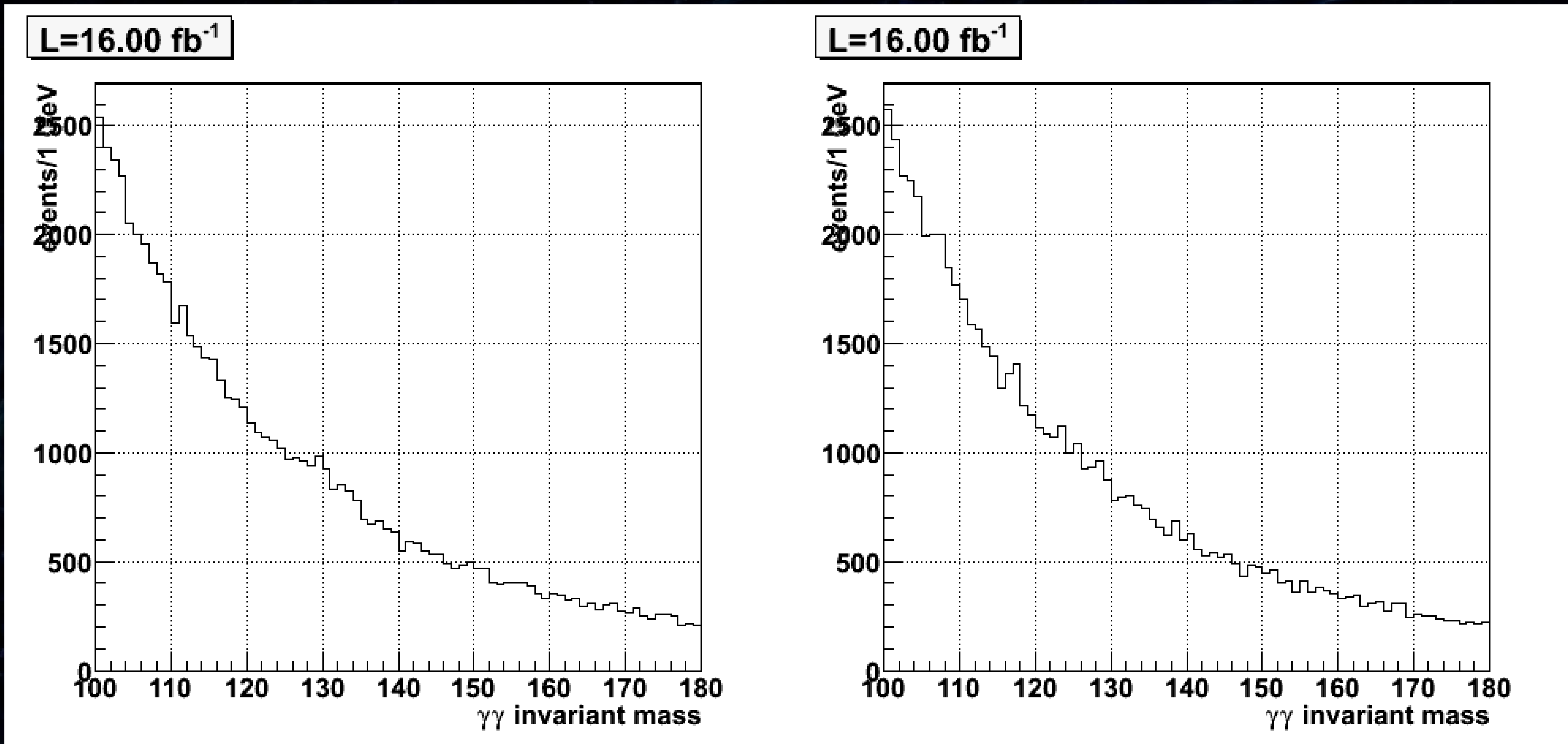

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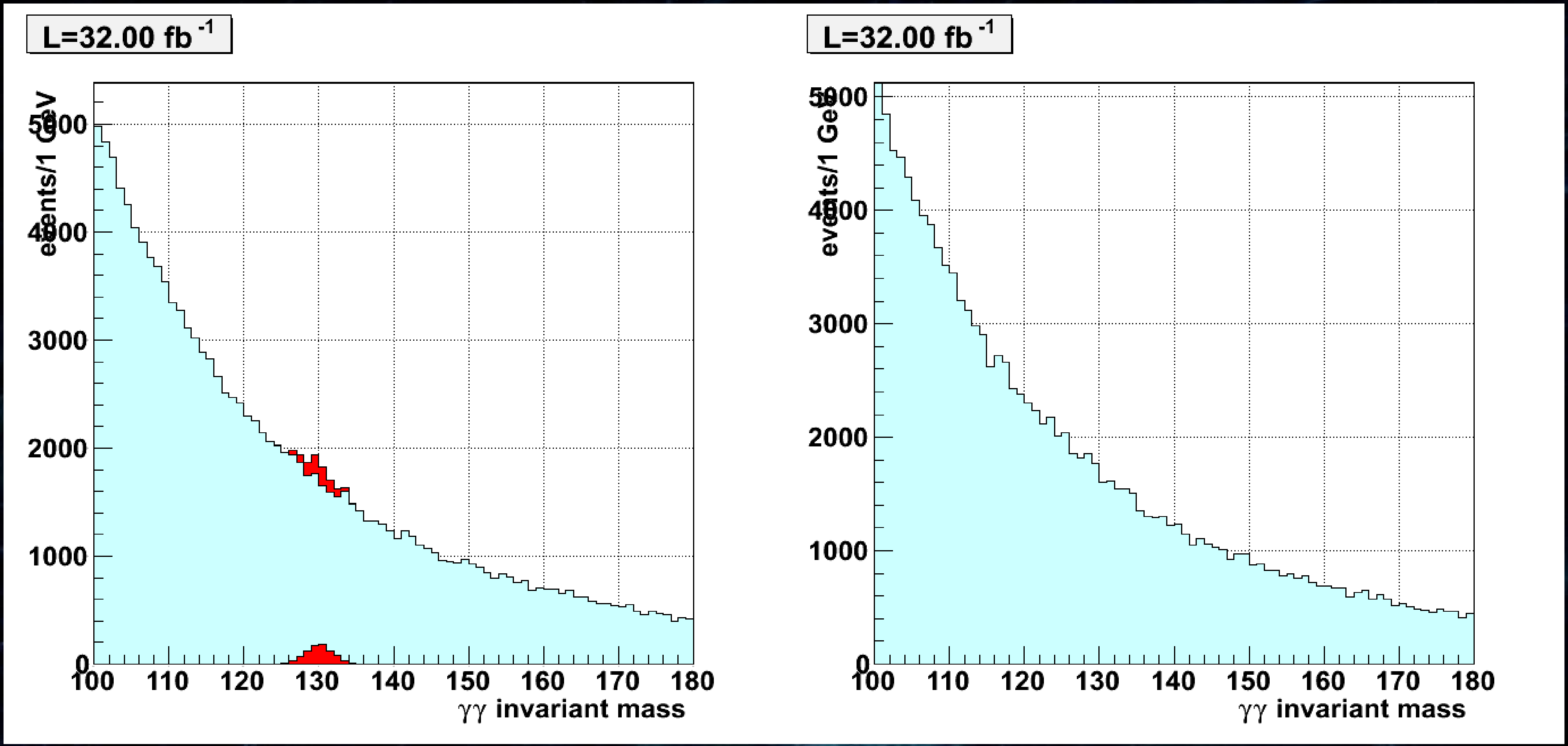

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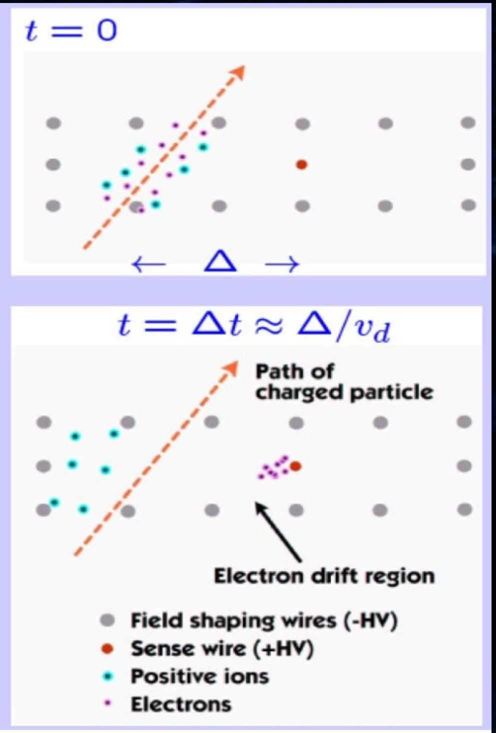
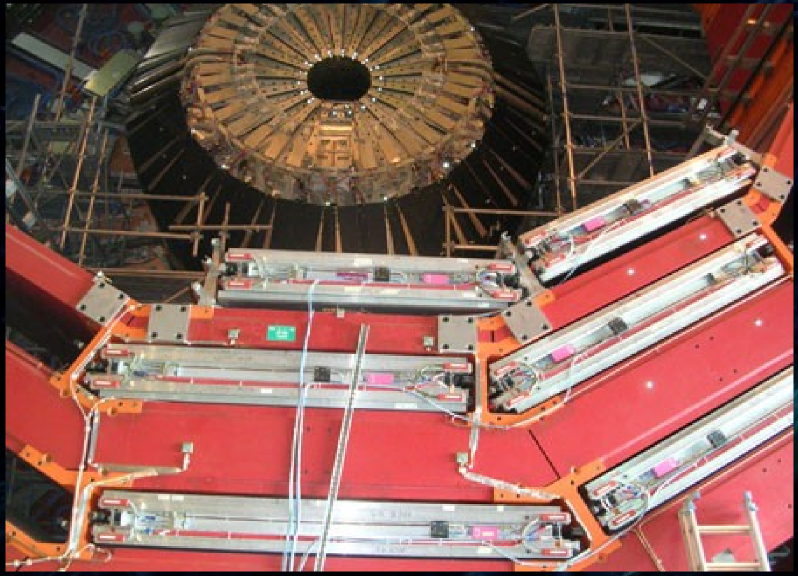
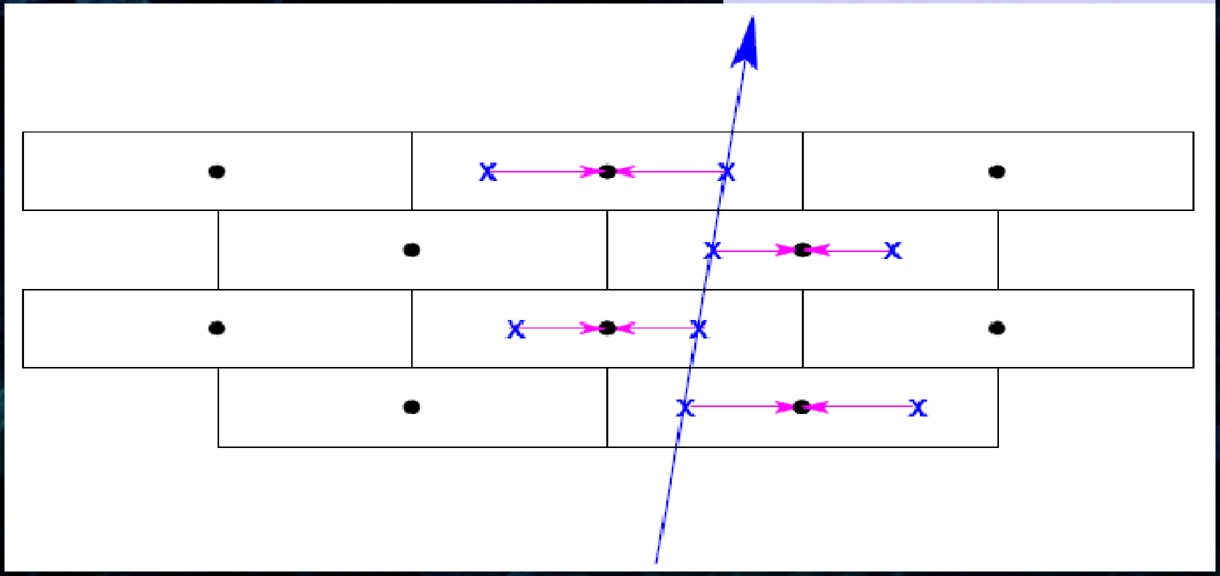
Can you spot it?

The Muon System – Drift Tubes

- Muon trajectory measurement (barrel)
- Measured quantity – drift time of electrons produced by the passing muon
- Known drift velocity → distance measurement (~50-200μm precision)
- Alignment very important

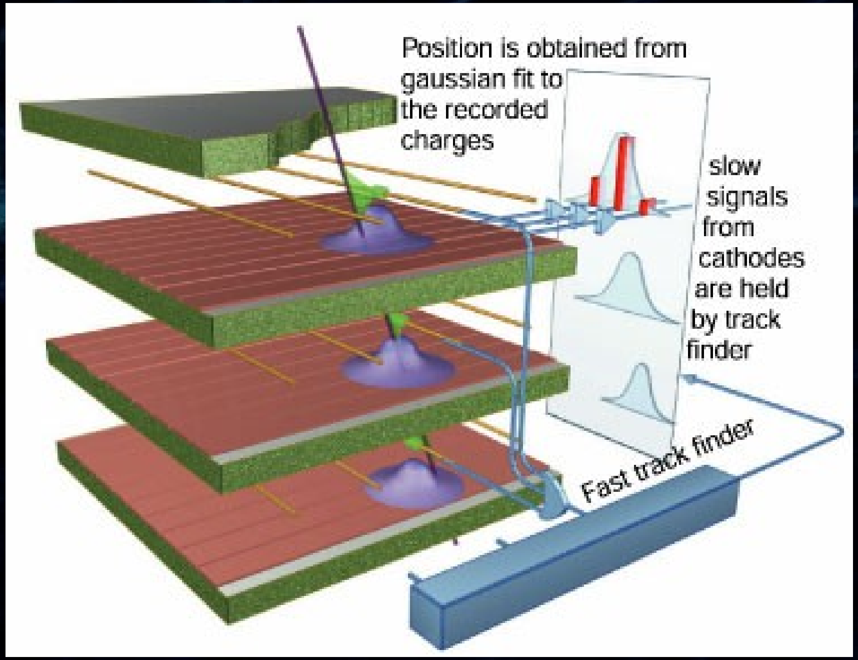




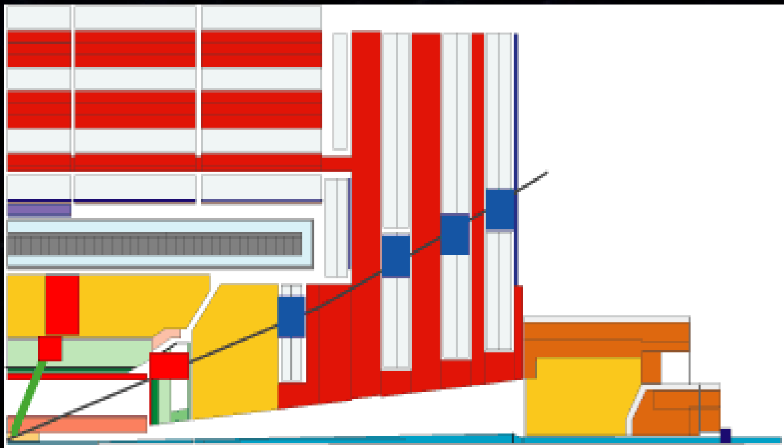


Cathode Strip Chambers (CSC)

- Muon trajectory measurement in the endcaps
- Gaseous detector with layers of anode wires and cathode strips

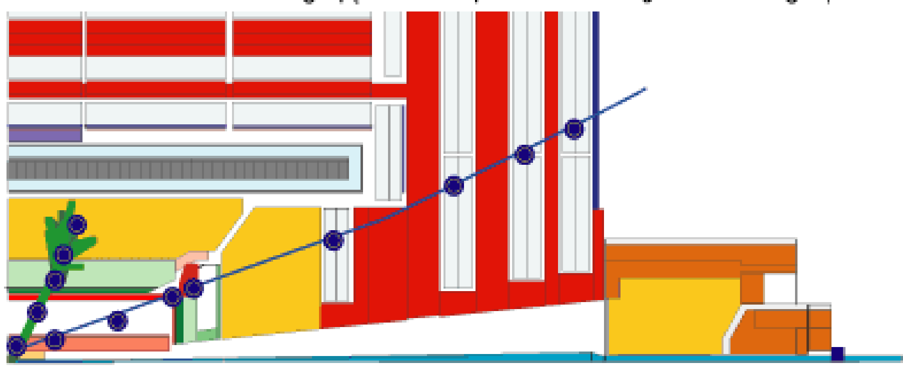


Trigger



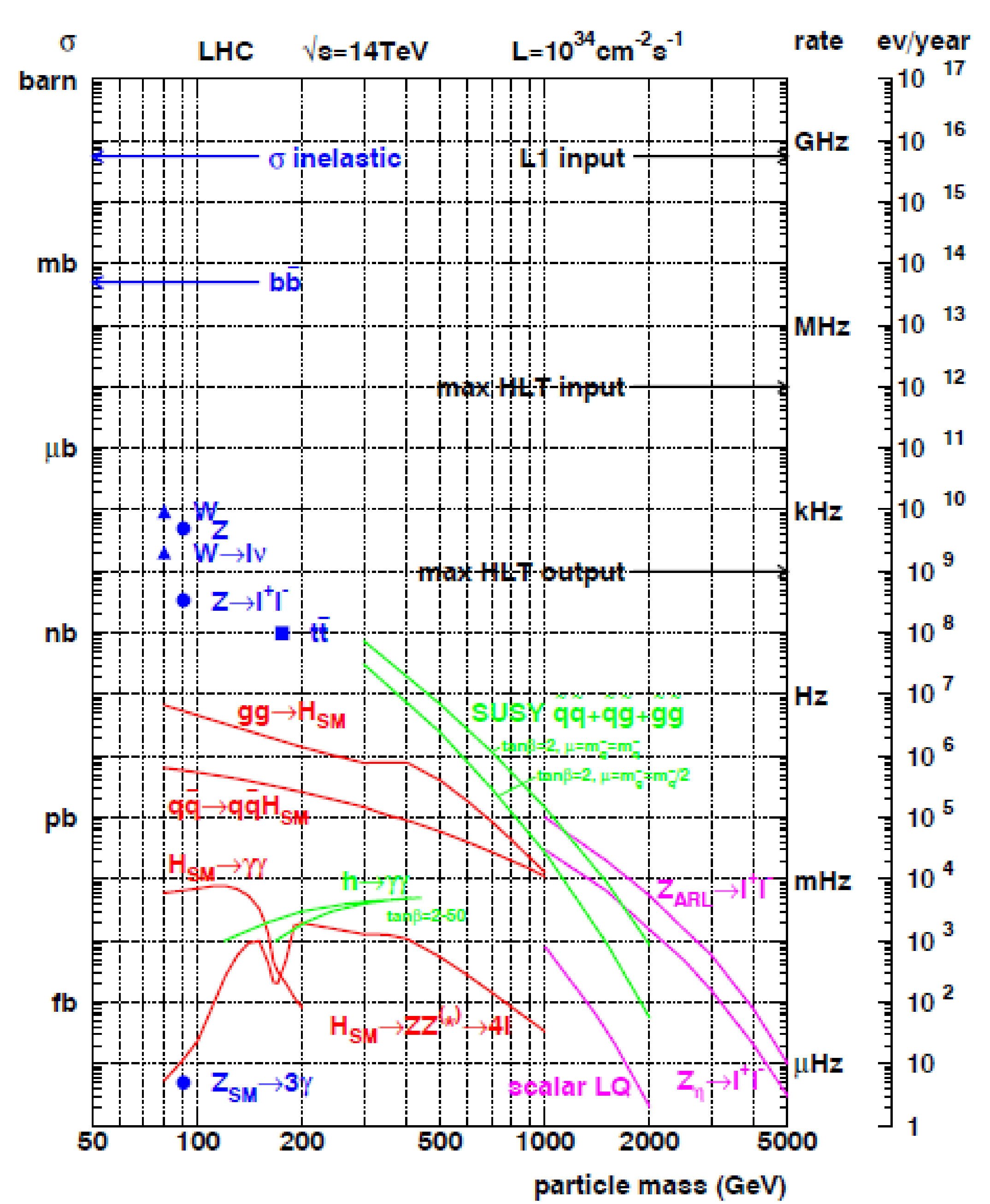
Level-1 trigger. 40 MHz input :

- Specialized processors (25 ns pipelined, latency < 1 s
- Local pattern recognition and energy evaluation on prompt macro-granular information from calorimeter and muon detectors
- Particle identification: high p_t electron, photon, muon, jets, missing E_T

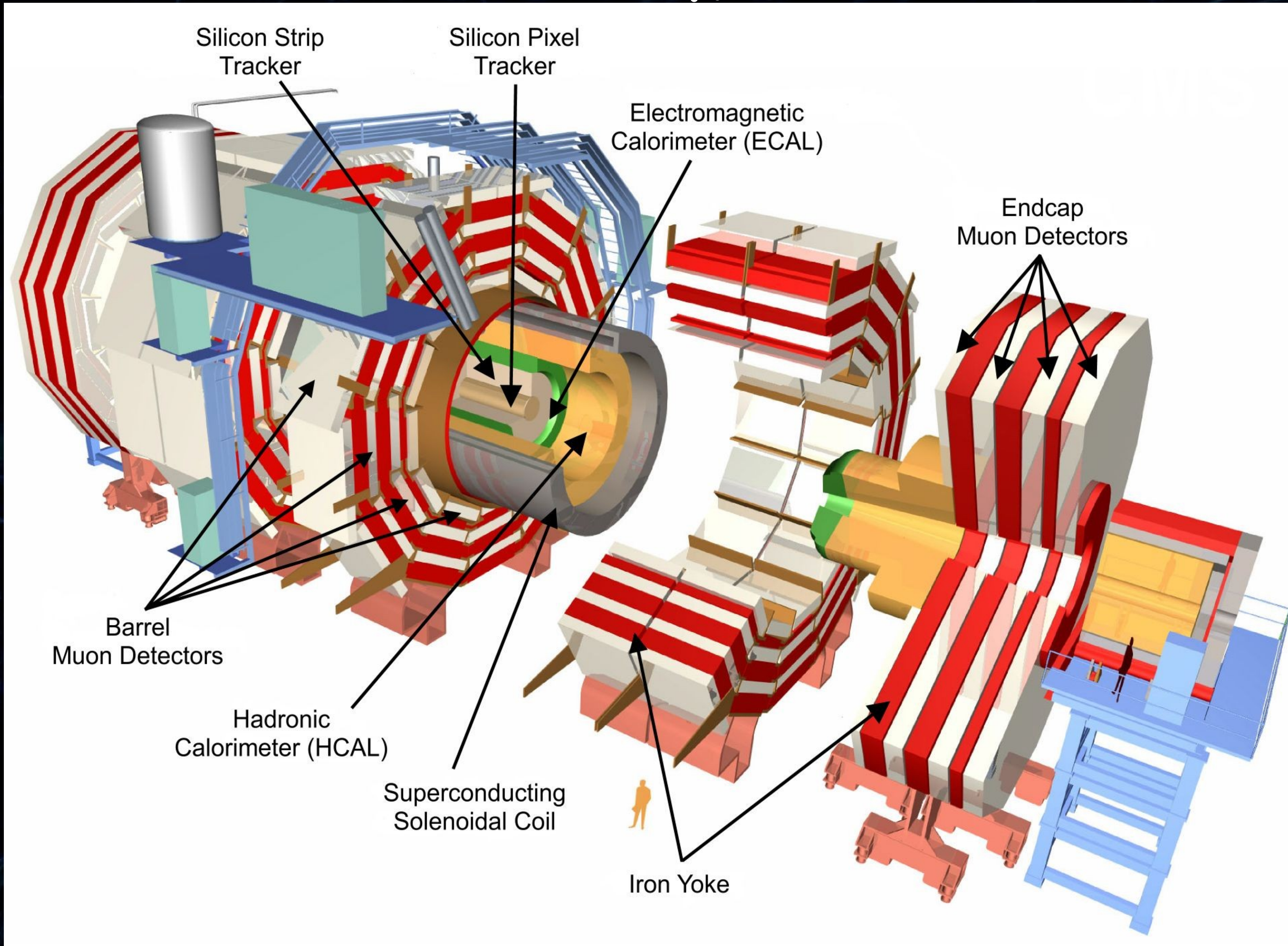


High trigger levels (>1). 100 kHz input :

- Large network of processor farms
- Clean particle signature. All detector data
- Finer granularity precise measurement
- Effective mass cuts and event topology
- Track reconstruction and detector matching
- Event reconstruction and analysis



Once more:


Silicon Strip
Tracker
Silicon Pixel
Tracker
Electromagnetic
Calorimeter (ECAL)
Endcap
Muon Detectors
Barrel
Muon Detectors
Hadronic
Calorimeter (HCAL)
Superconducting
Solenoidal Coil
Iron Yoke

The End