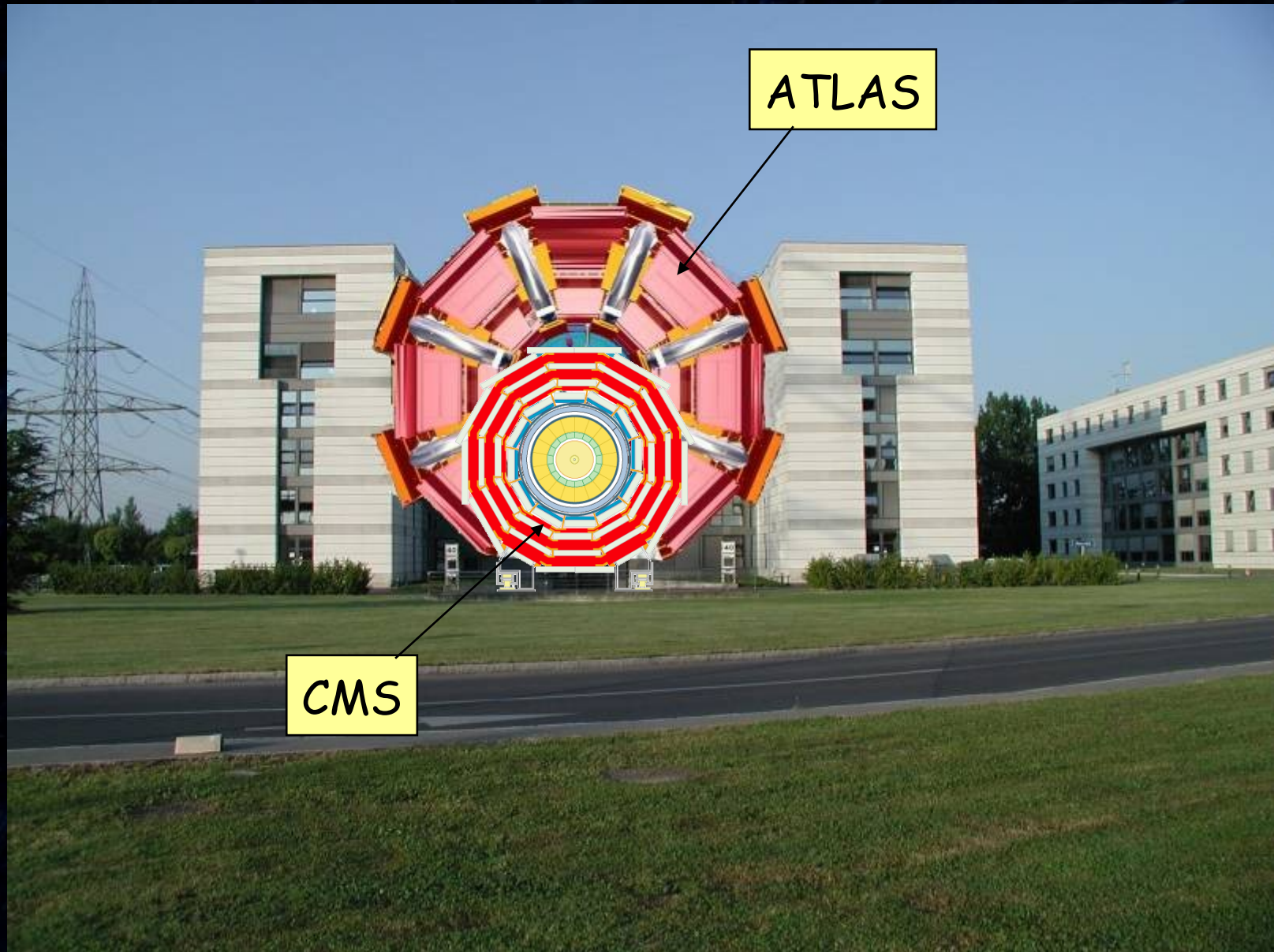


The Compact Muon Solenoid Detector

Piotr Traczyk
Uni Torino/CERN

Compact

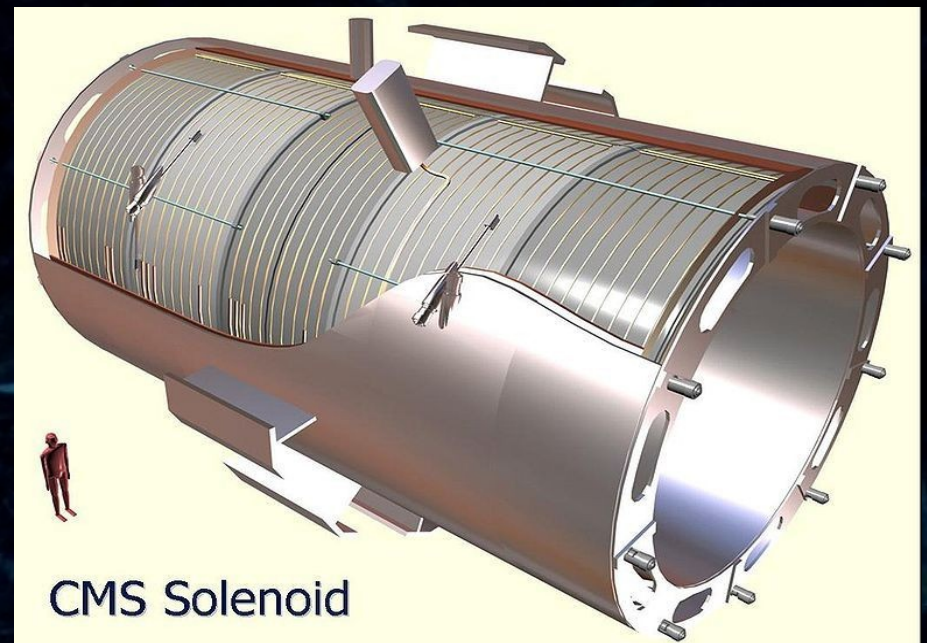


Muon

- The CMS detector was designed to provide optimal measurement of muons
- Muons give a relatively „clean“ signal
- They appear as decay products of other particles in many of the processes we want to study

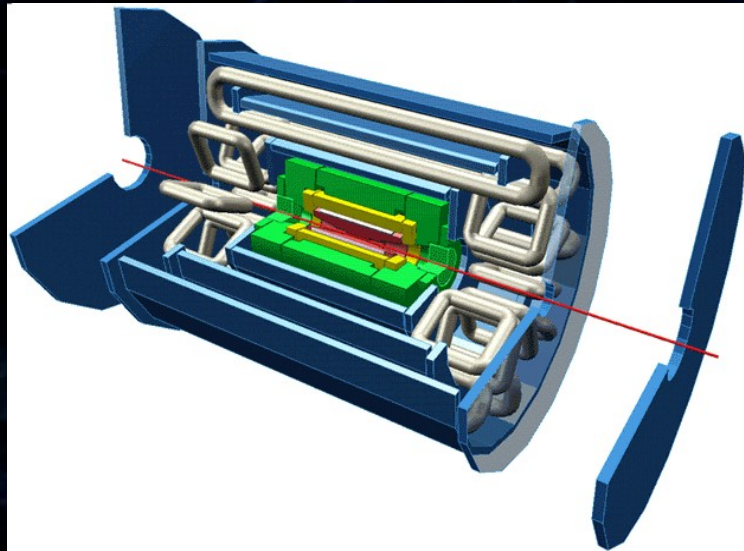
Solenoid

- 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 $\sim 4\text{K}$
- 13m length, 6m inner diameter - enough to fit the tracker and calorimeters inside
- (cost ~ 80 MCHF)

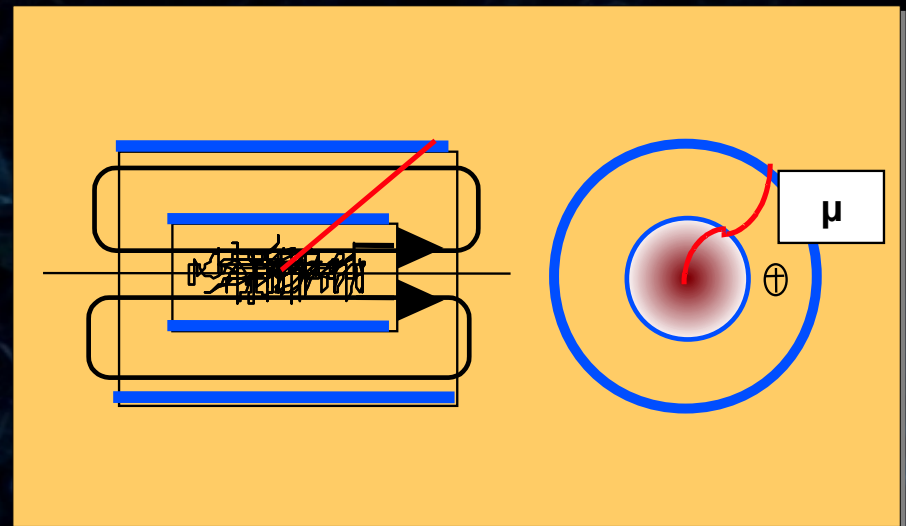
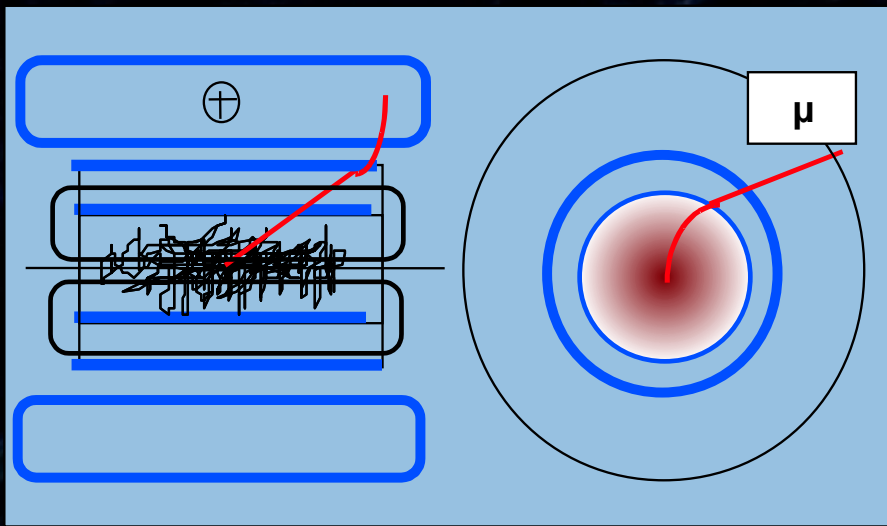
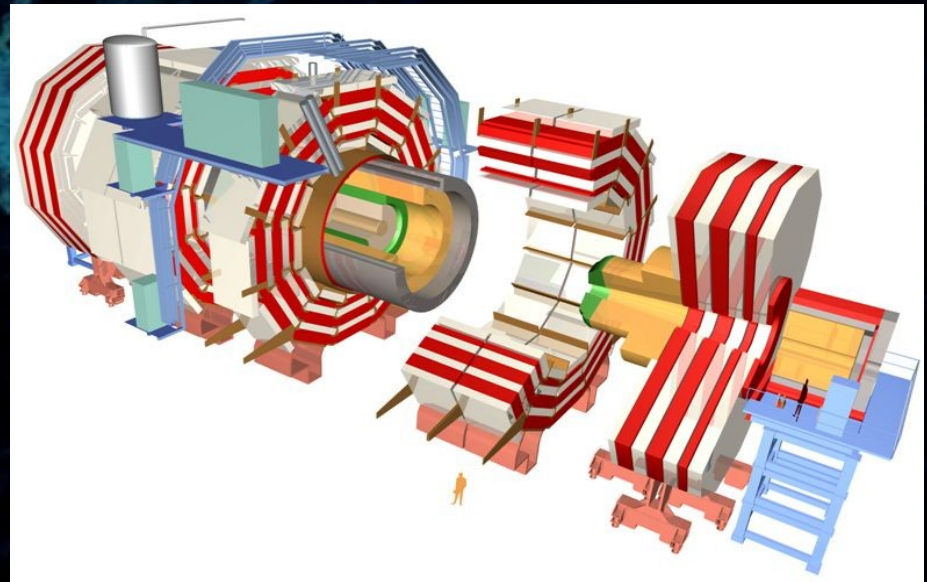


Magnets in particle detectors

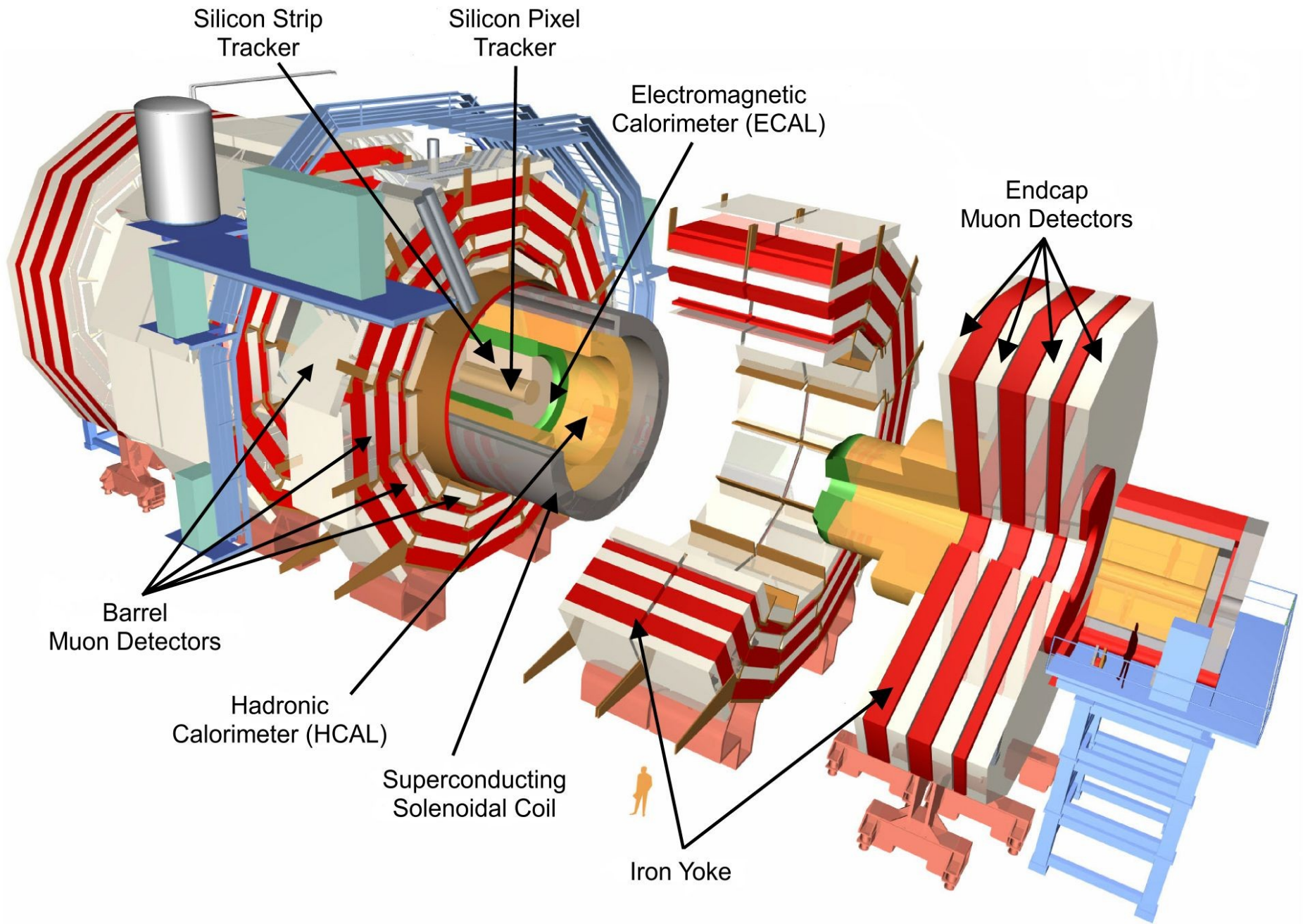
ATLAS A Toroidal LHC Apparatus



CMS Compact Muon Solenoid

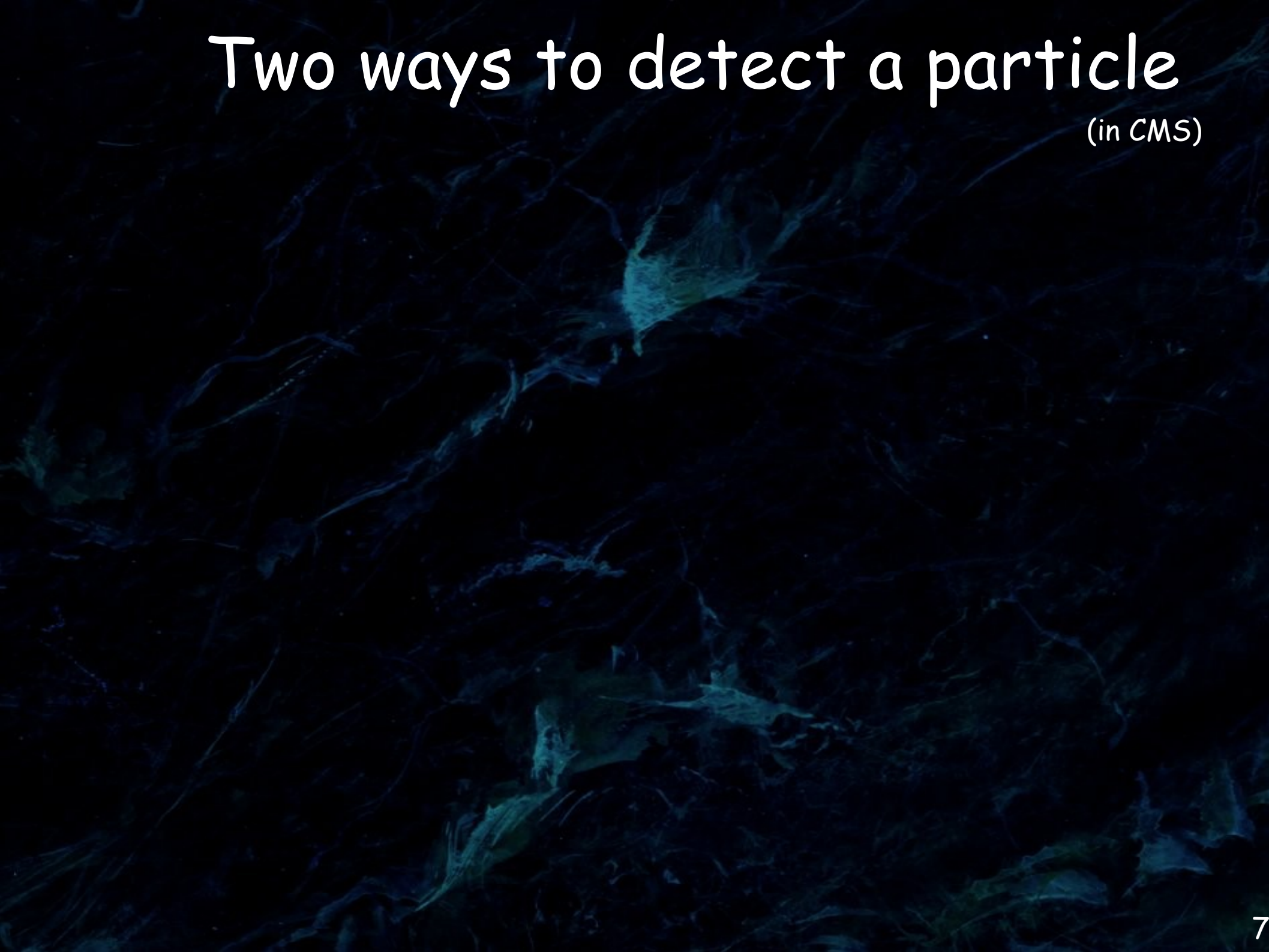


CMS detector overview



Two ways to detect a particle

(in CMS)



Two ways to detect a particle

(in CMS)

See the track



Or

Catch



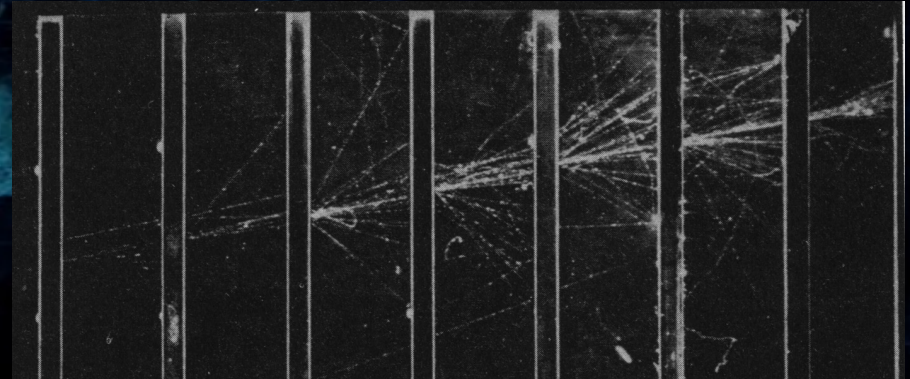
Two ways to detect a particle

(in CMS)

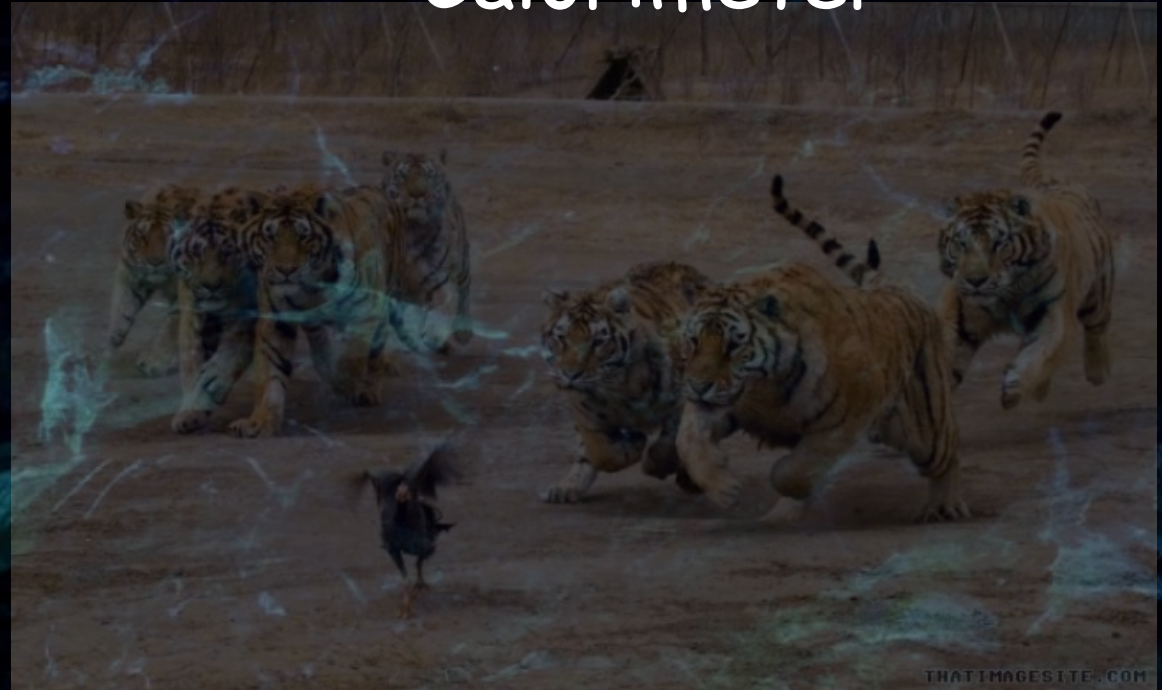
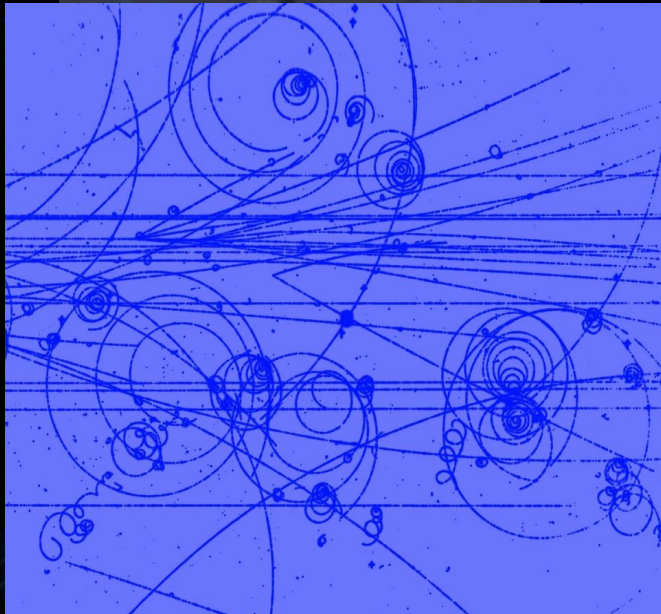
Tracking detector



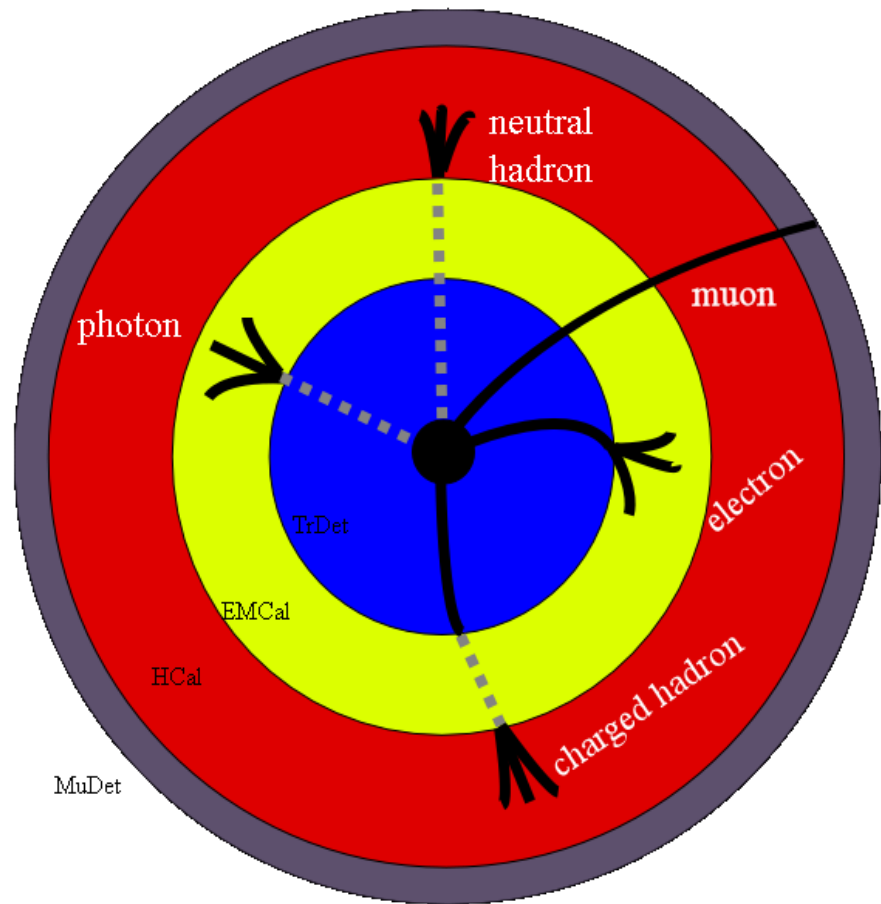
Or



Calorimeter



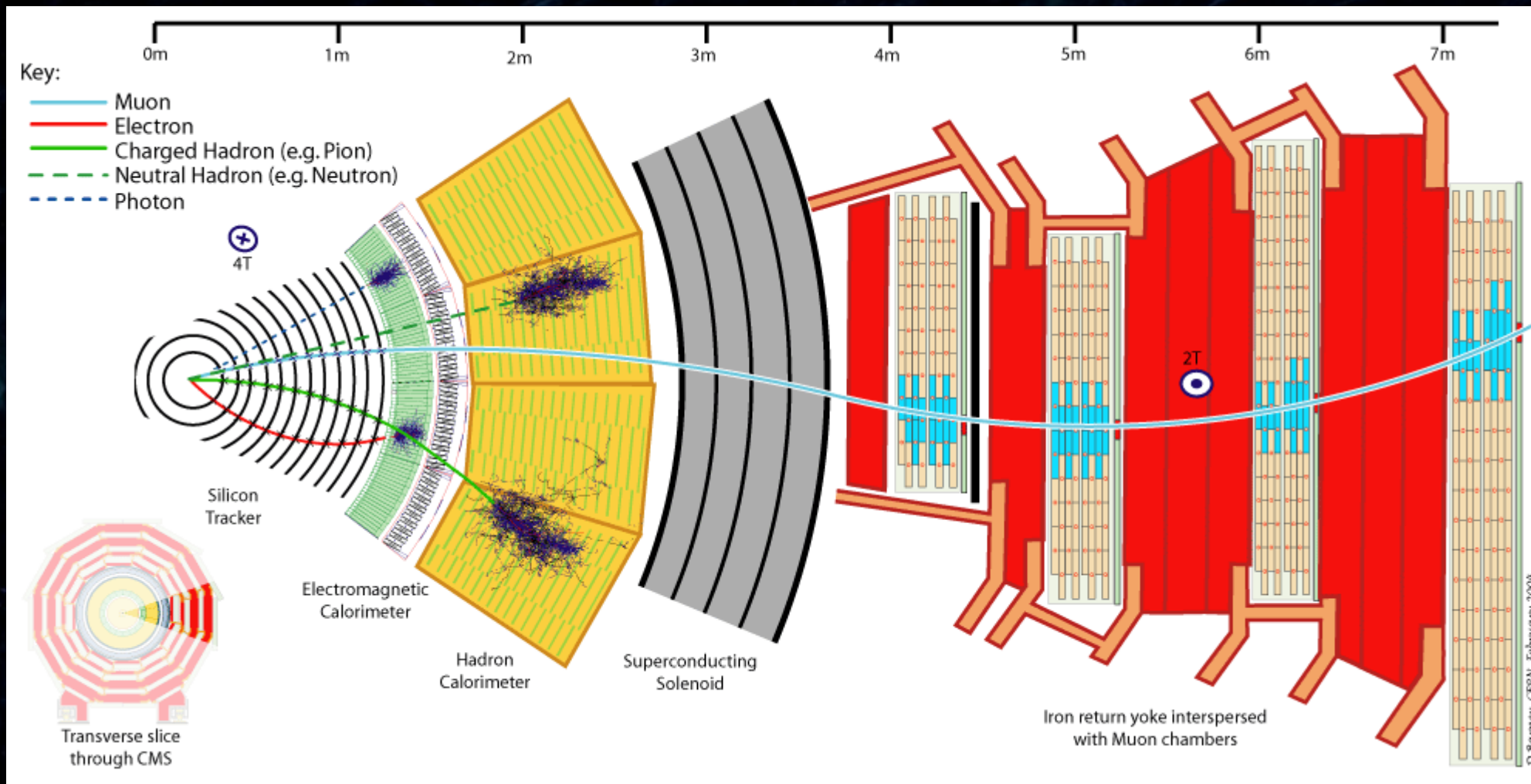
Particle detectors are like...



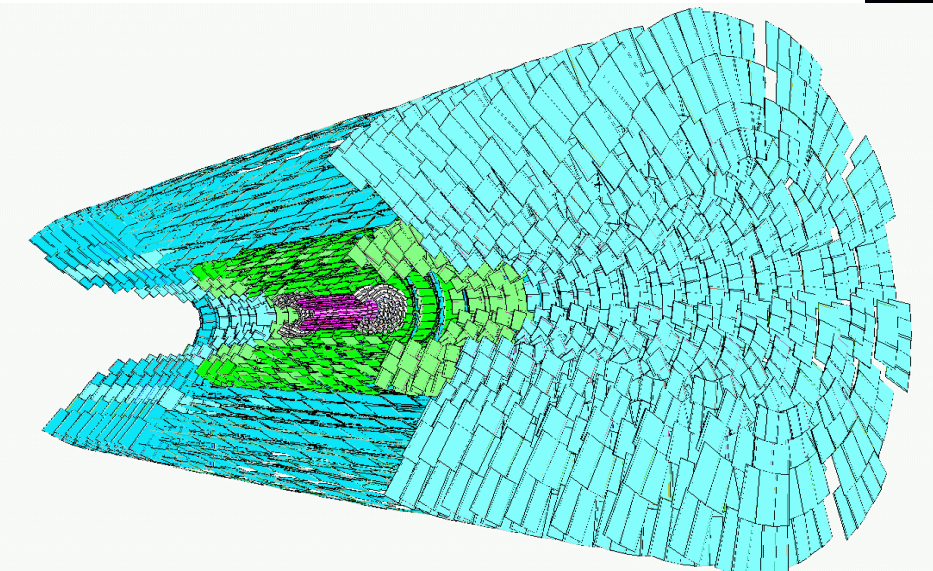
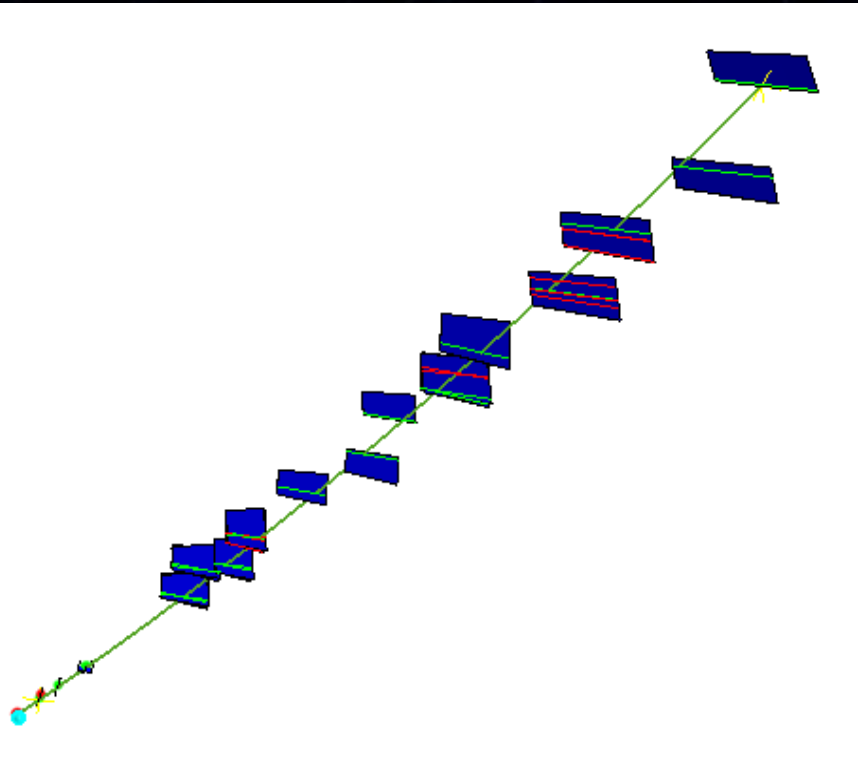
MuDet: muon detectors
TrDet: trace detector + vertex detector
EMCal: elektromagnetický kaloriméter
HCal: hadron kaloriméter



Particle identification in CMS

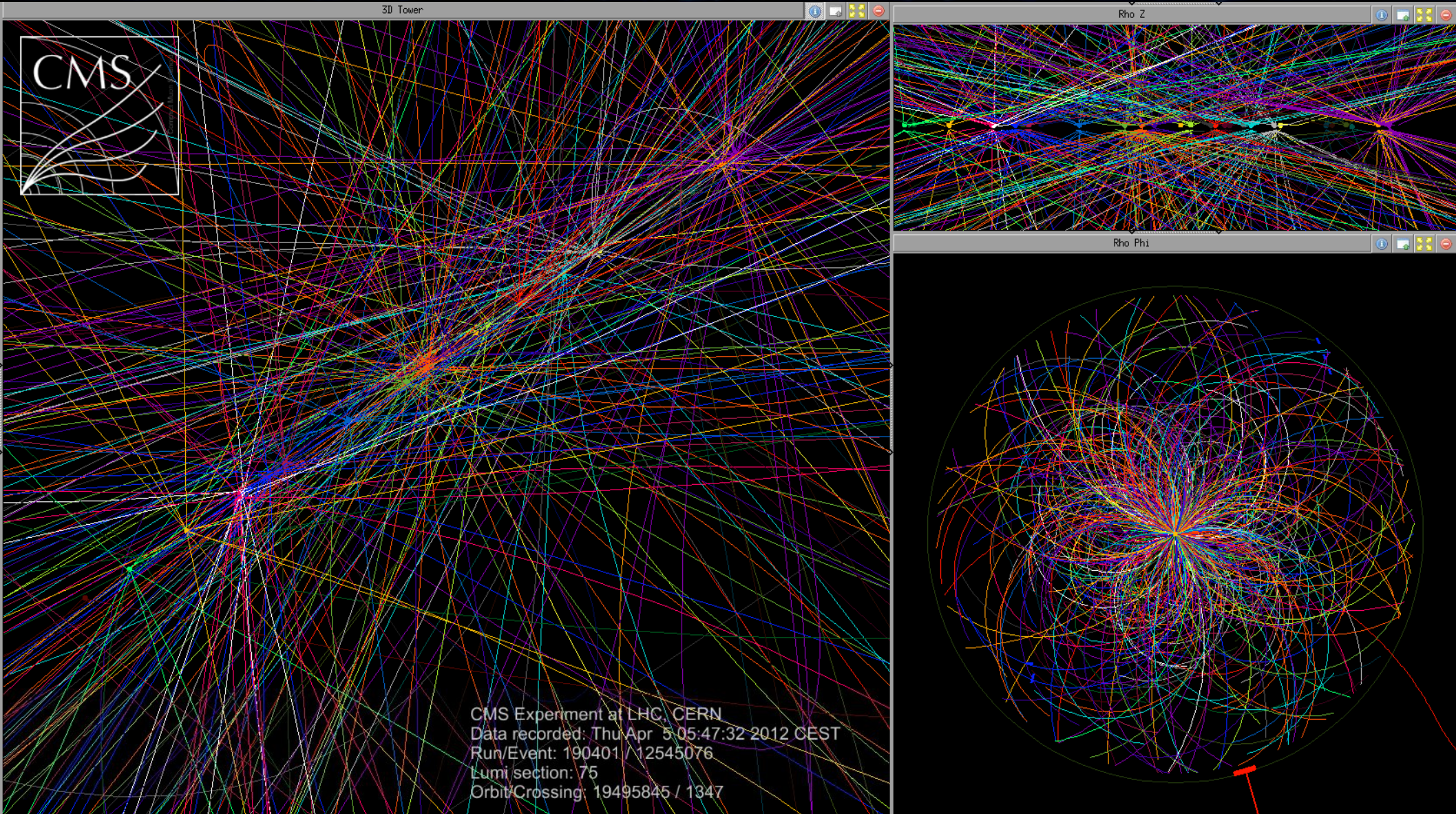


The Inner Tracker



- Measures the trajectories of charged particles
momentum $\sim 1/\text{curvature}$
- The biggest silicon detector in history, over 220m² of silicon
- Inner part - 3 layers of pixel detectors, outer part 10-11 layers of silicon microstrips
- 75 millions of read-out channels

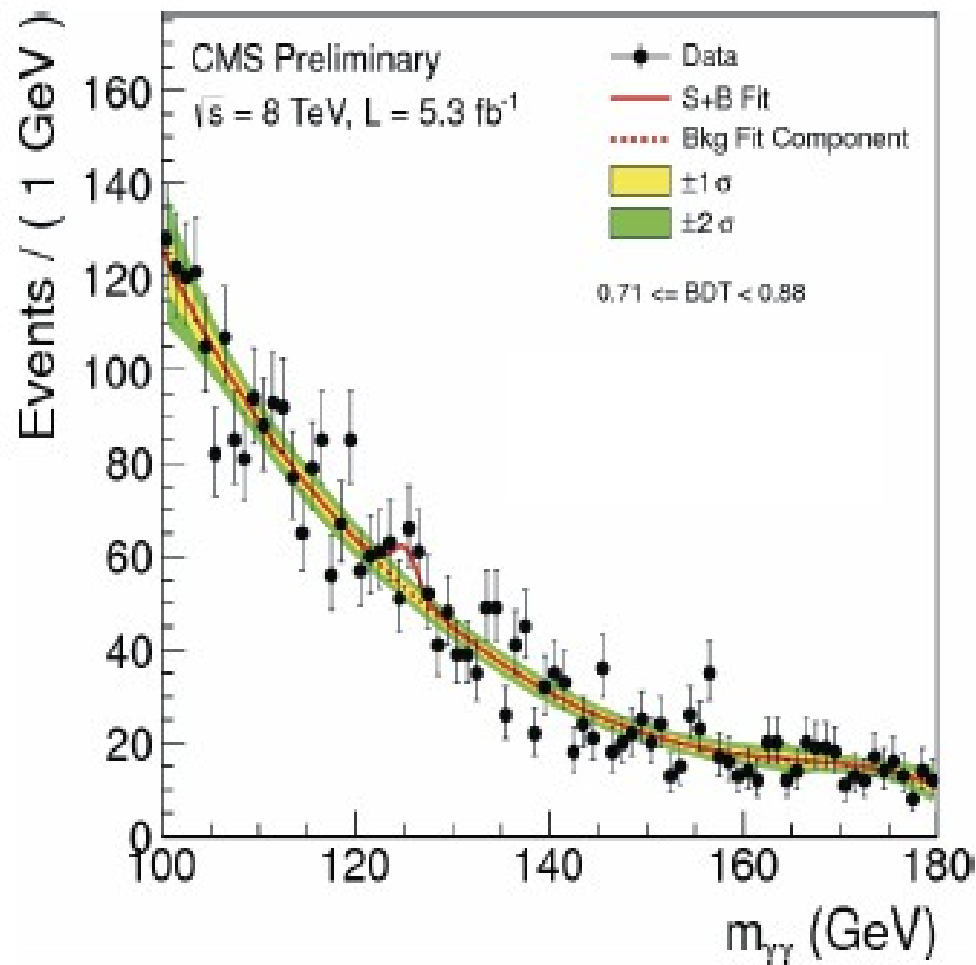
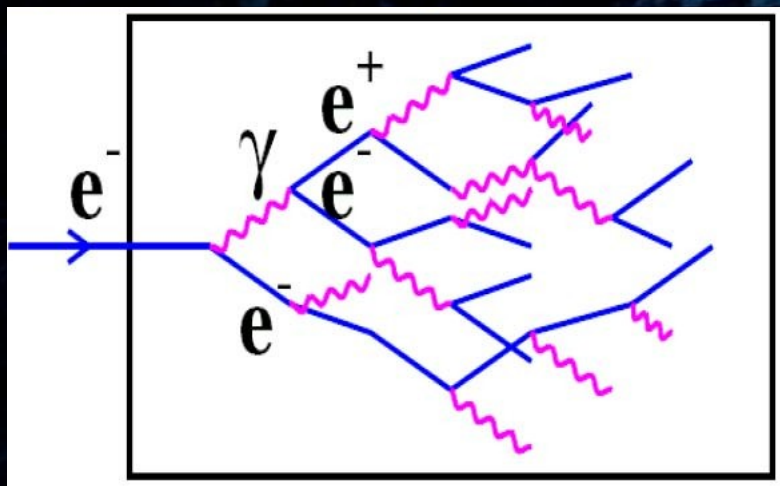
Event „pile-up“

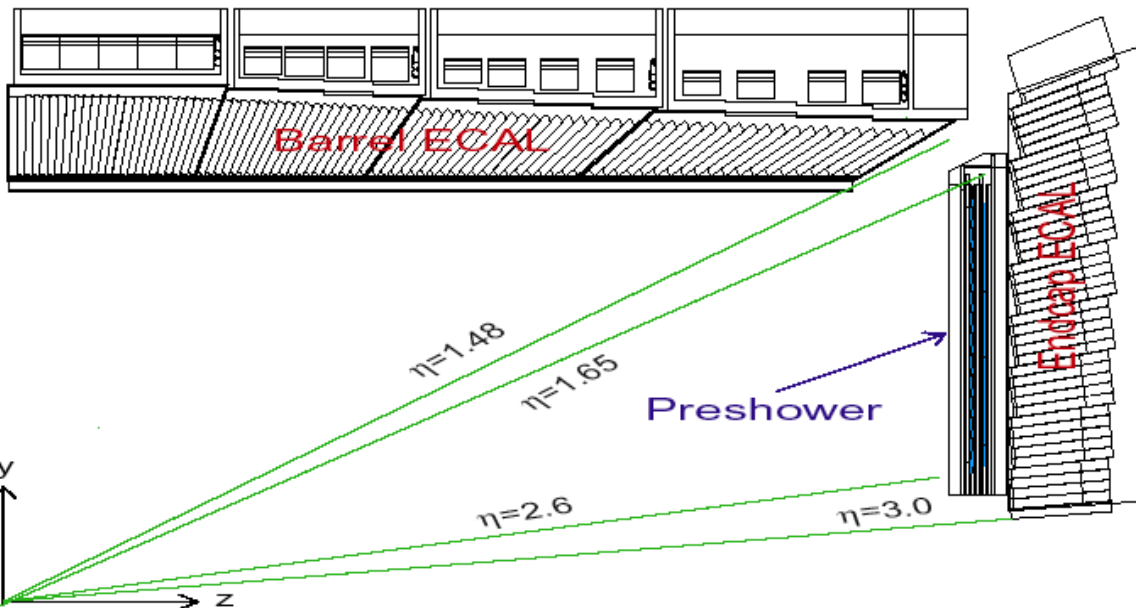
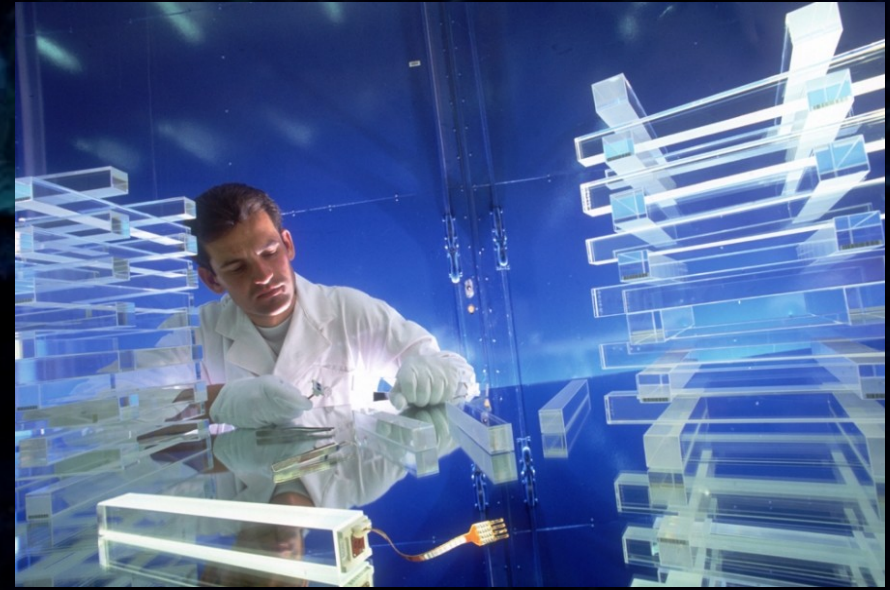


In the LHC, several proton-proton collisions can occur in a single bunch crossing (The image shows an event with 29 reconstructed vertices)

Electromagnetic Calorimeter

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

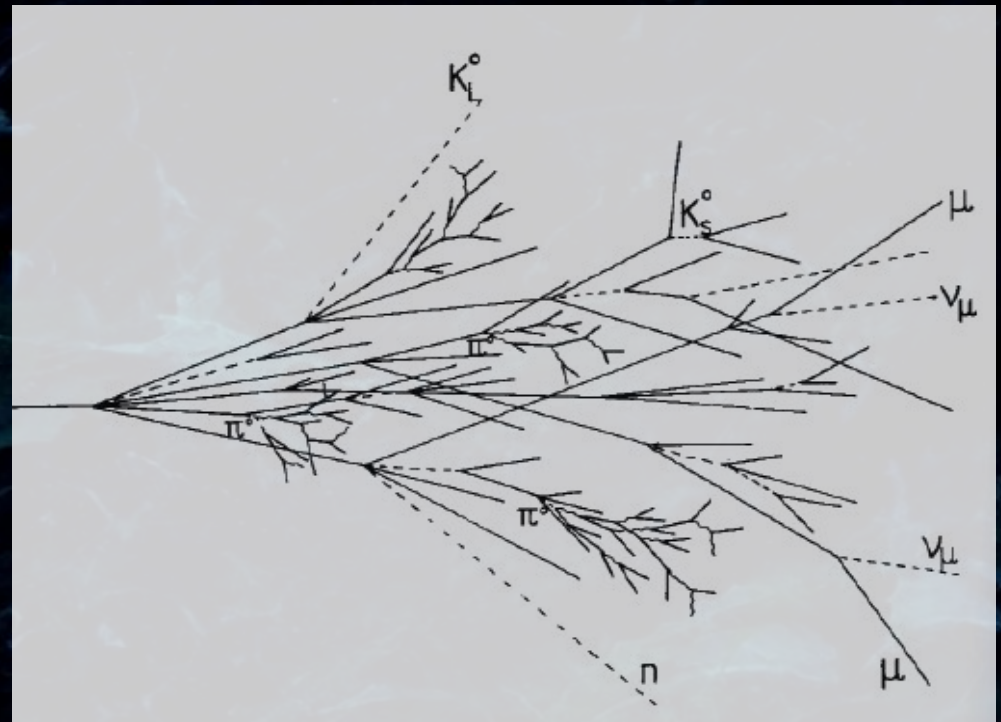
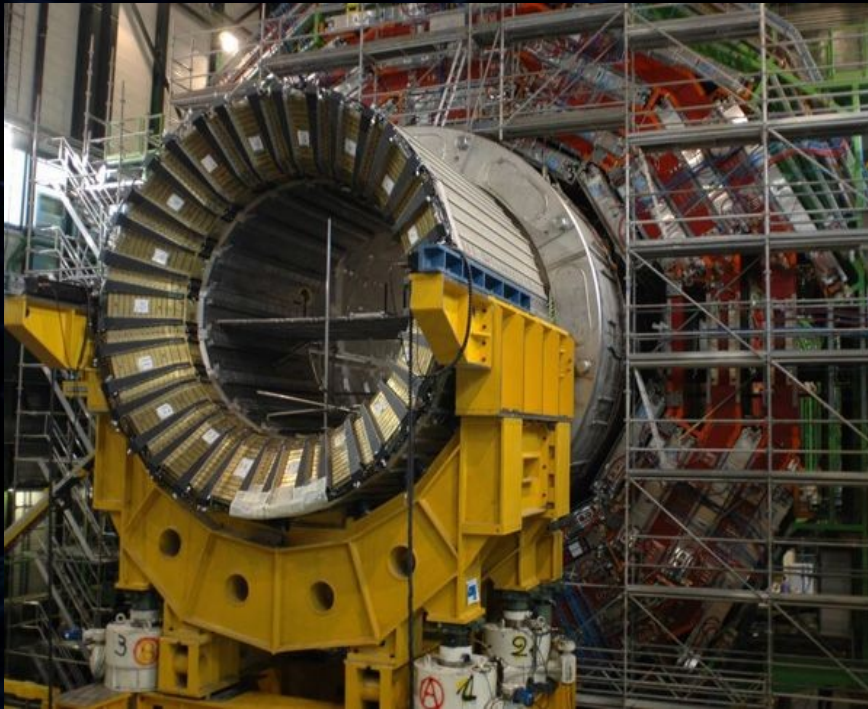
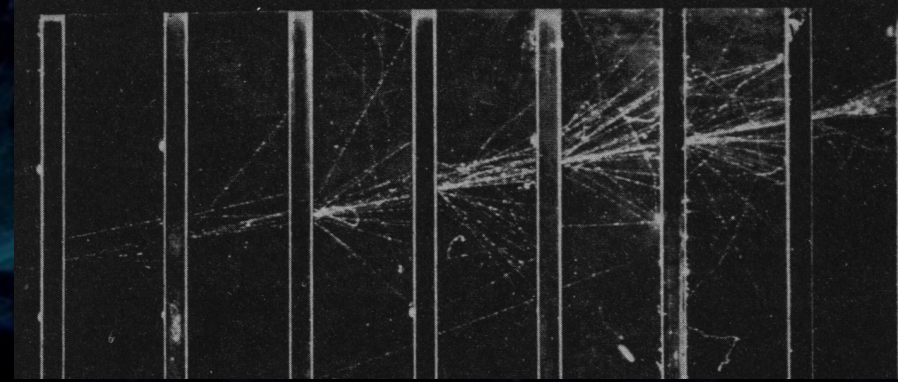




CMS
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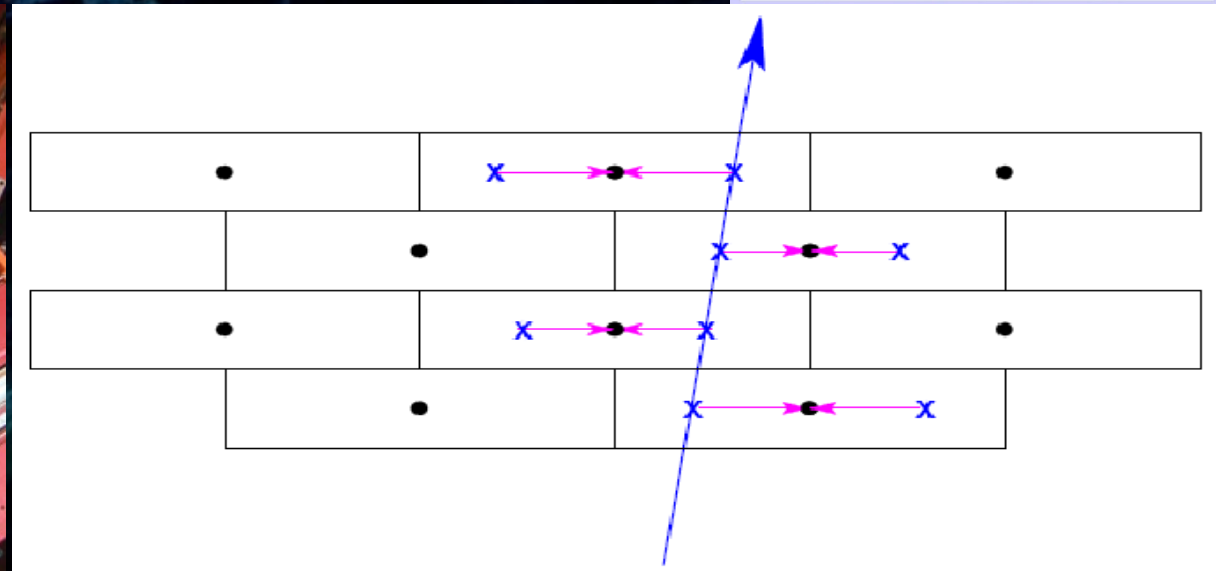
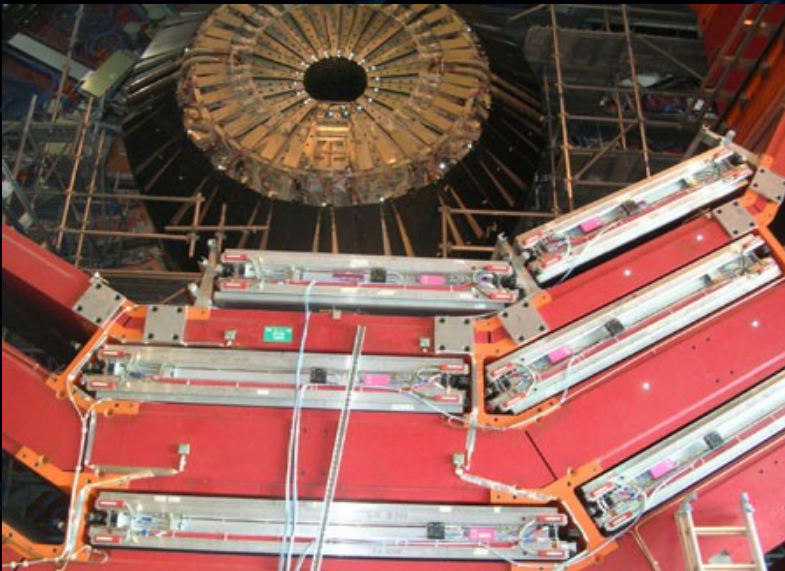
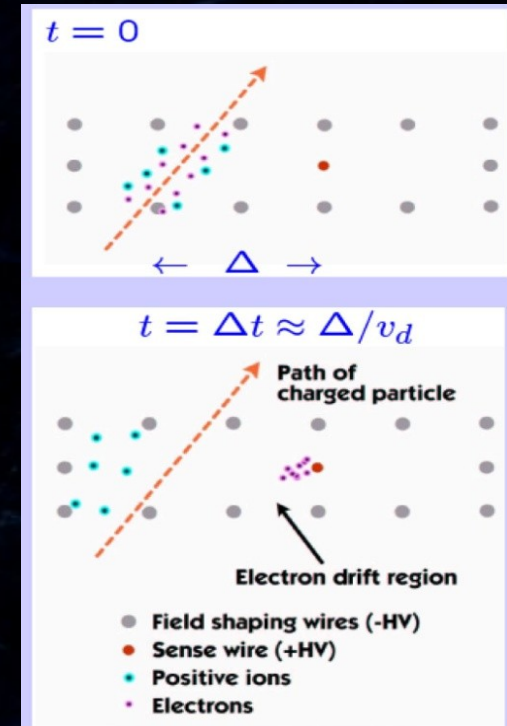
Hadron Calorimeter

- Jet energy measurement
- Brass absorber interleaved with scintillator layers
- Steel blocks with embedded quartz fibers in the „forward“ part



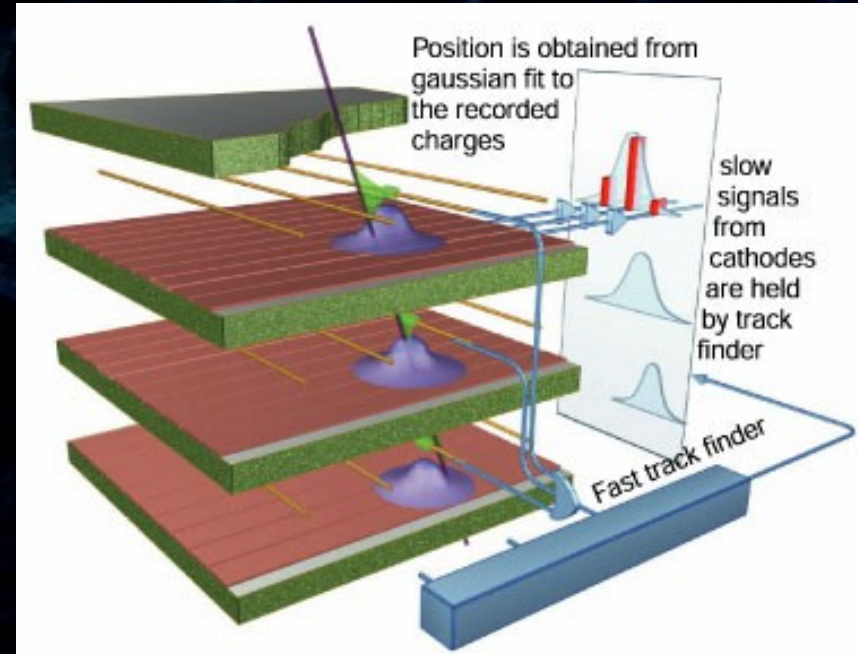
The Muon System - Drift Tubes

- Muon trajectory measurement (barrel)
- Measured quantity - drift time of electrons produced by the passing muon
- Known drift velocity \rightarrow distance measurement ($\sim 50\text{-}200\mu\text{m}$ precision)
- Alignment very important

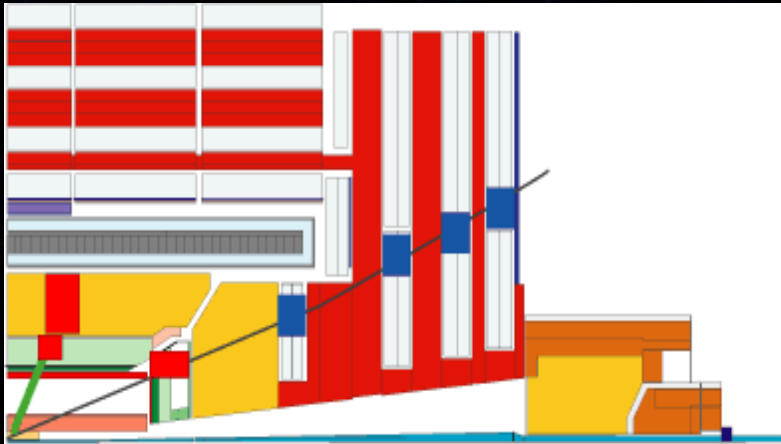


Cathode Strip Chambers (CSC)

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

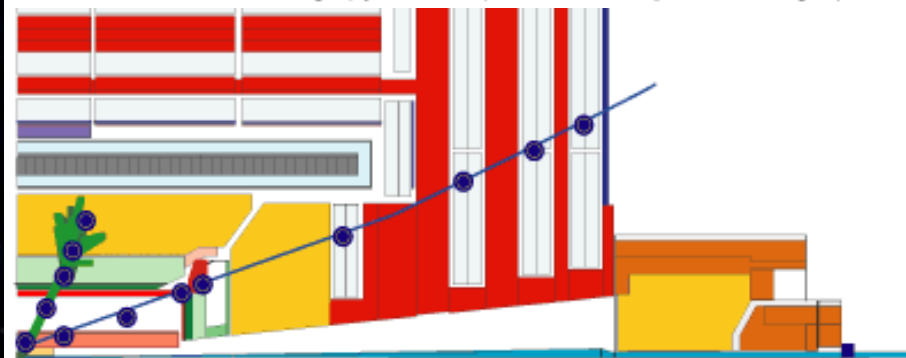


Trigger



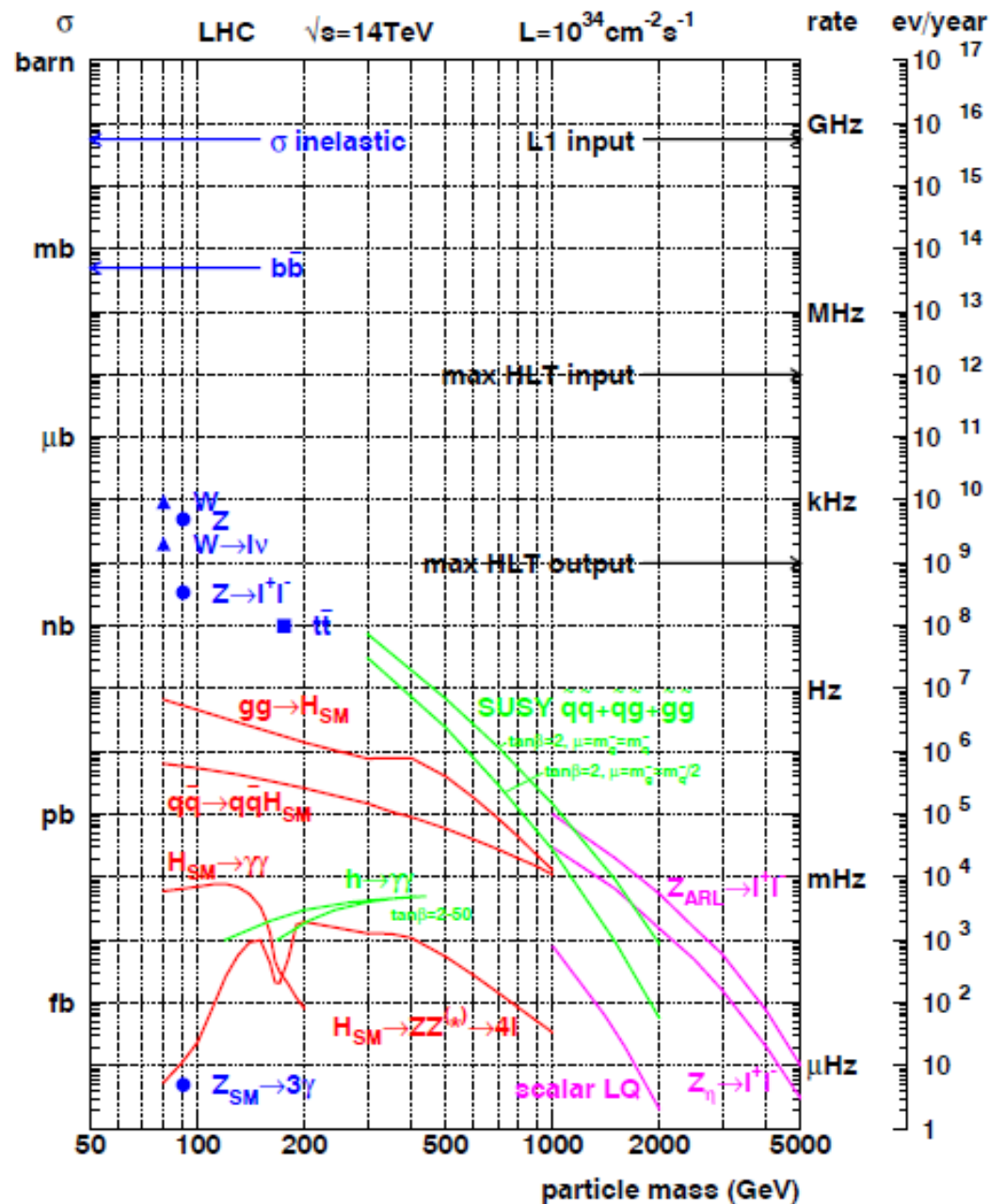
Level-1 trigger. 40 MHz input :

- Specialized processors (25 ns pipelined, latency < 1 μ 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



A proton-proton collision as seen by CMS



CMS Experiment at the LHC, CERN

Data recorded: 2012-May-27 23:35:47.271030 GMT

Run/Event: 195099 / 137440354

