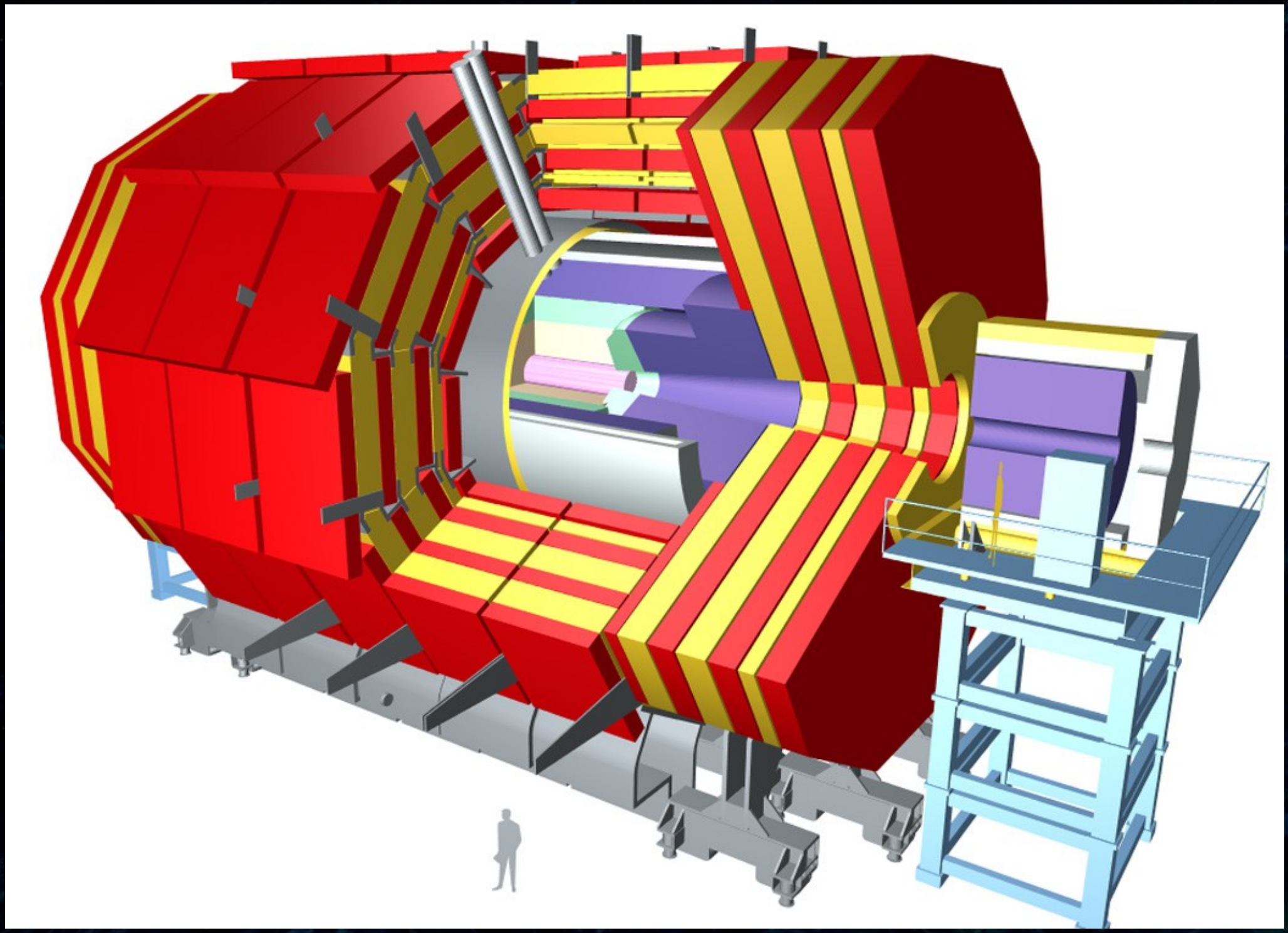
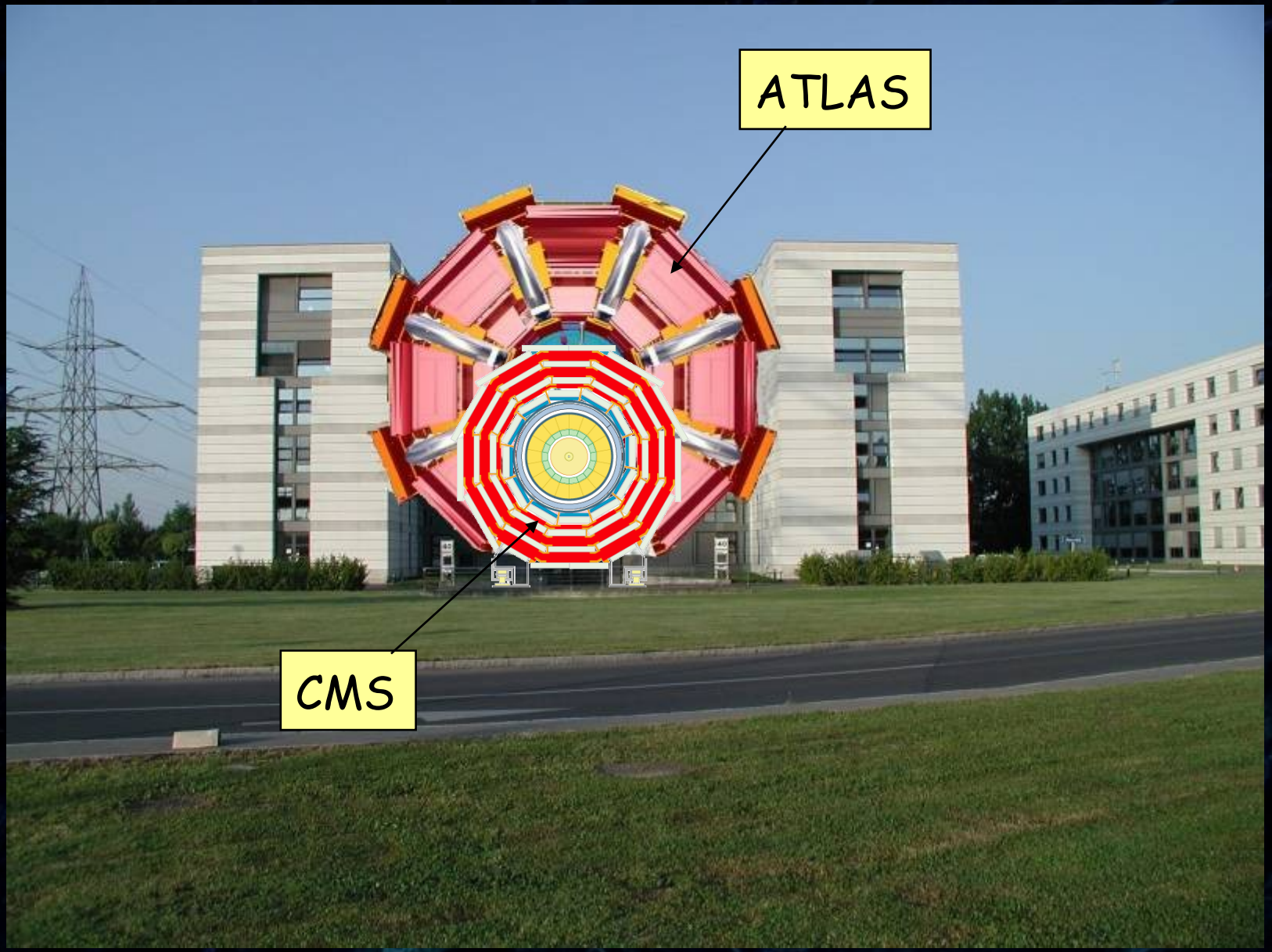
The Compact Muon Solenoid Detector

Piotr Traczyk

CERN



Compact

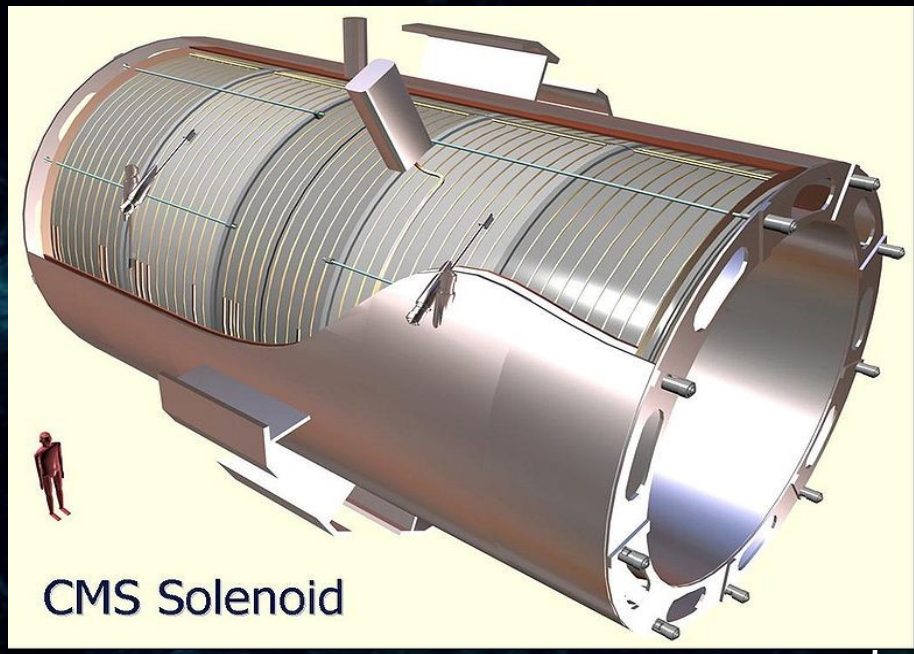


Muon

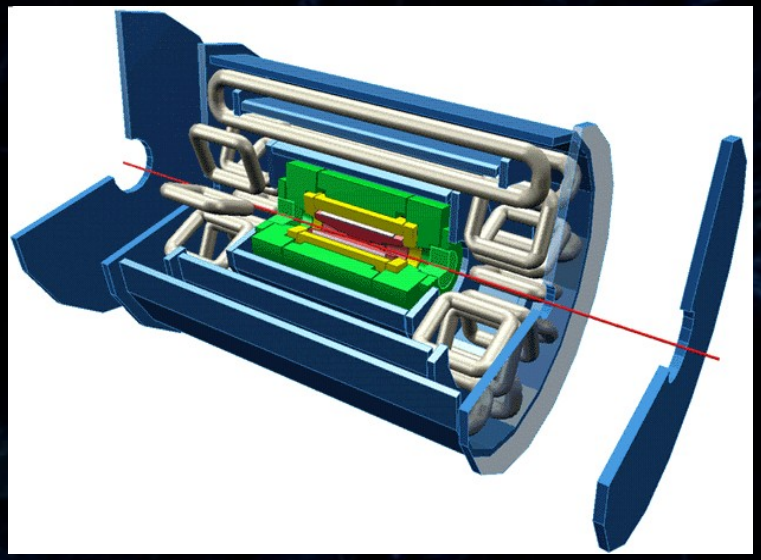
- The CMS detector was designed to provide optimal measurement of muons
- Muons give a relatively „clean" signal
- They appear as decay products of other particles in many of the processes we want to study

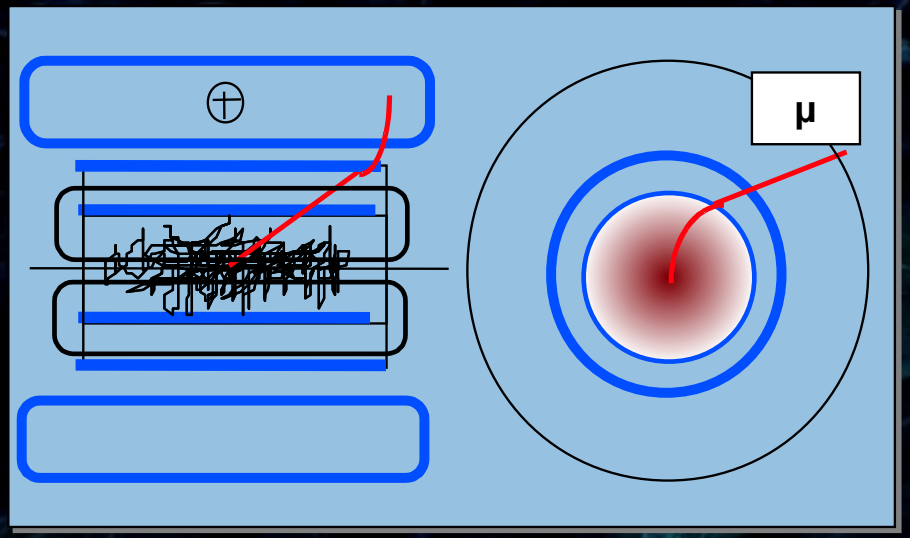
Solenoid

- 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 ~4K
- 13m length, 6m inner diameter – enough to fit the tracker and calorimeters inside
- (cost ~80 MCHF)

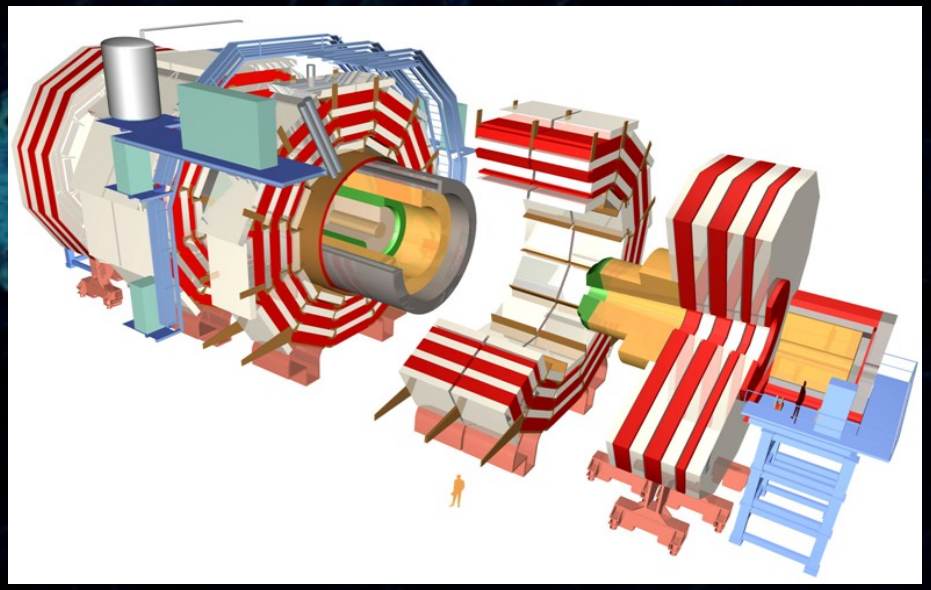


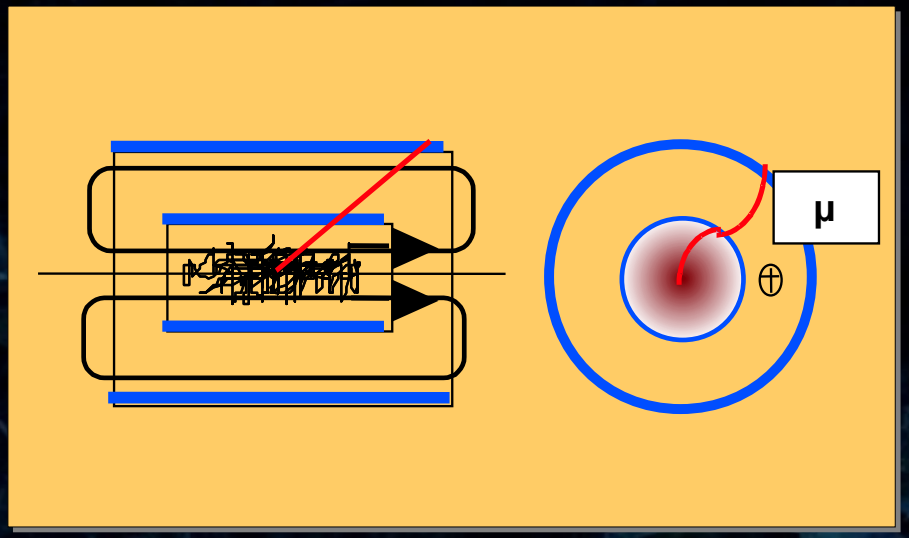
ATLAS A Toroidal LHC Apparatus



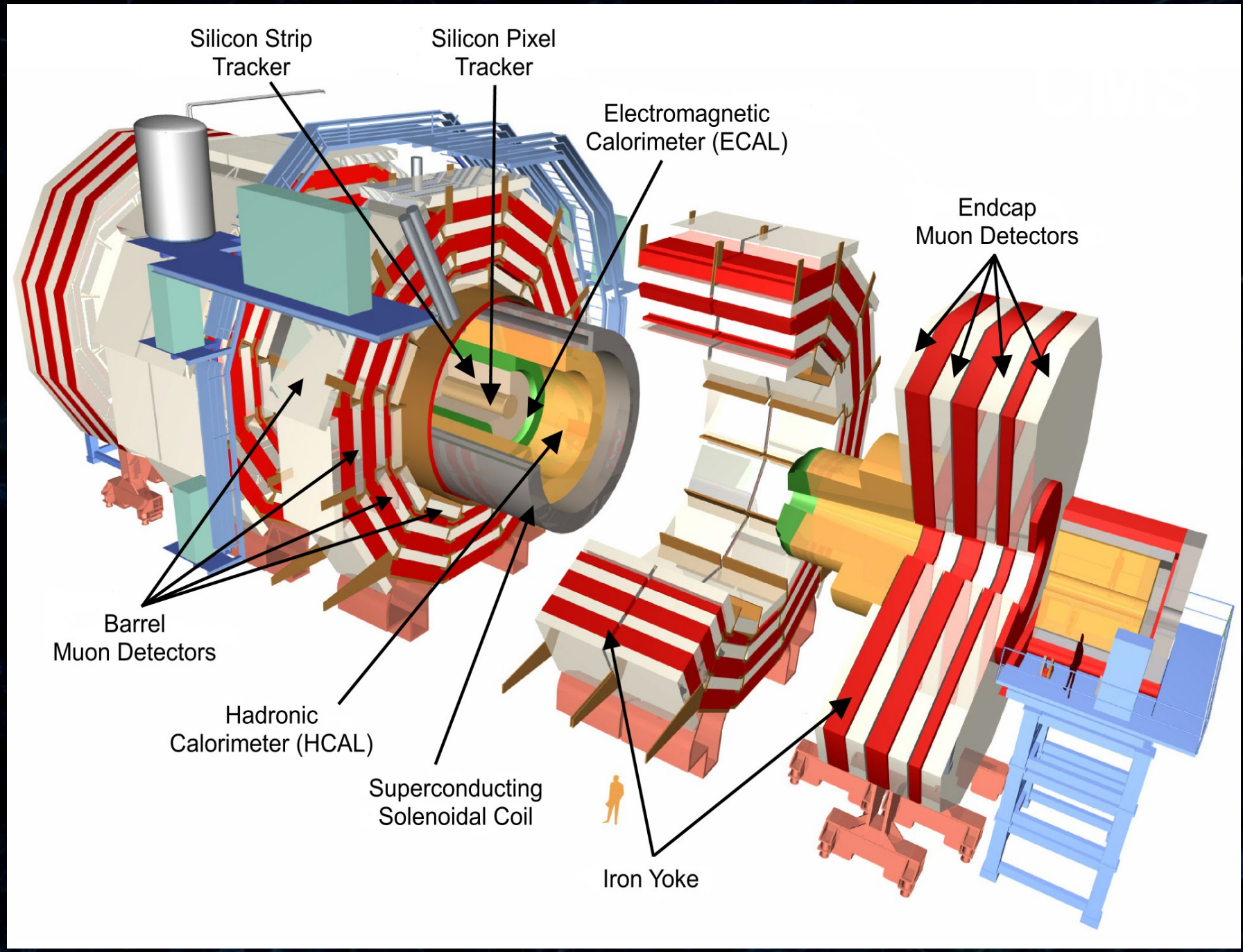


CMS Compact Muon Solenoid



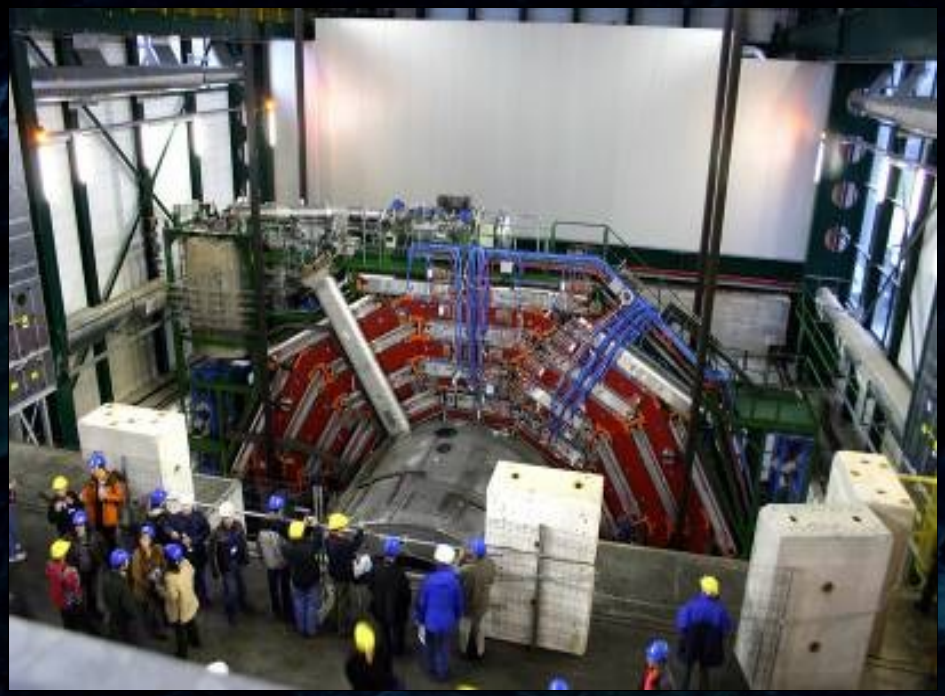


CMS detector overview



Construction of CMS

- The detector was assembled on the surface
- Piece by piece lowered 100m down into the underground cavern



Two ways to detect a particle

(in CMS)

See the track

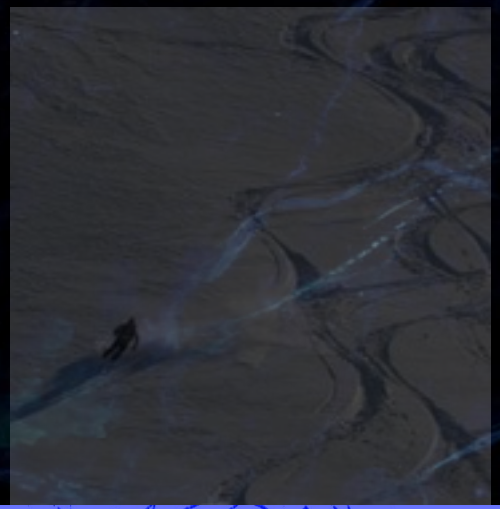
Or

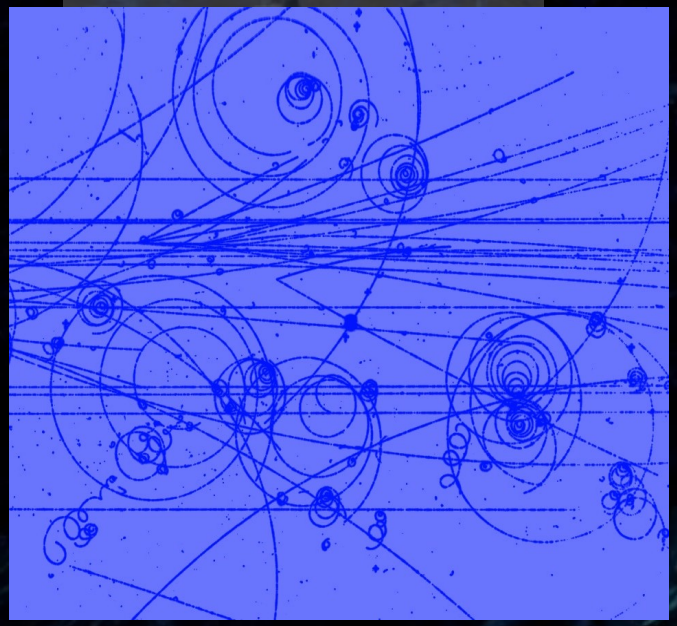
Catch

Two ways to detect a particle

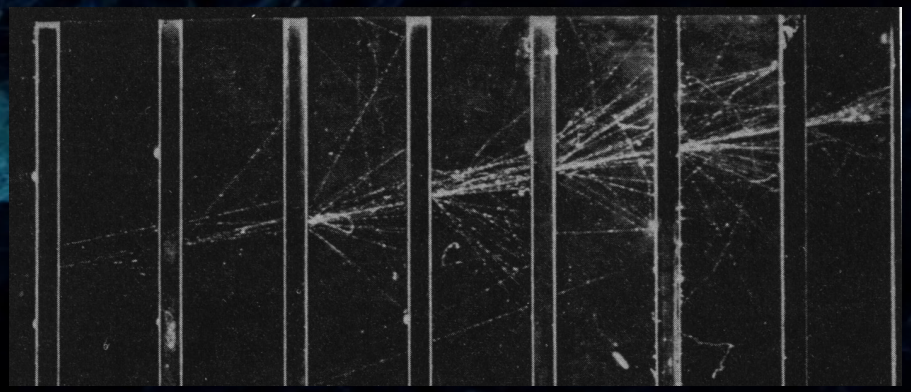
(in CMS)

Tracking detector



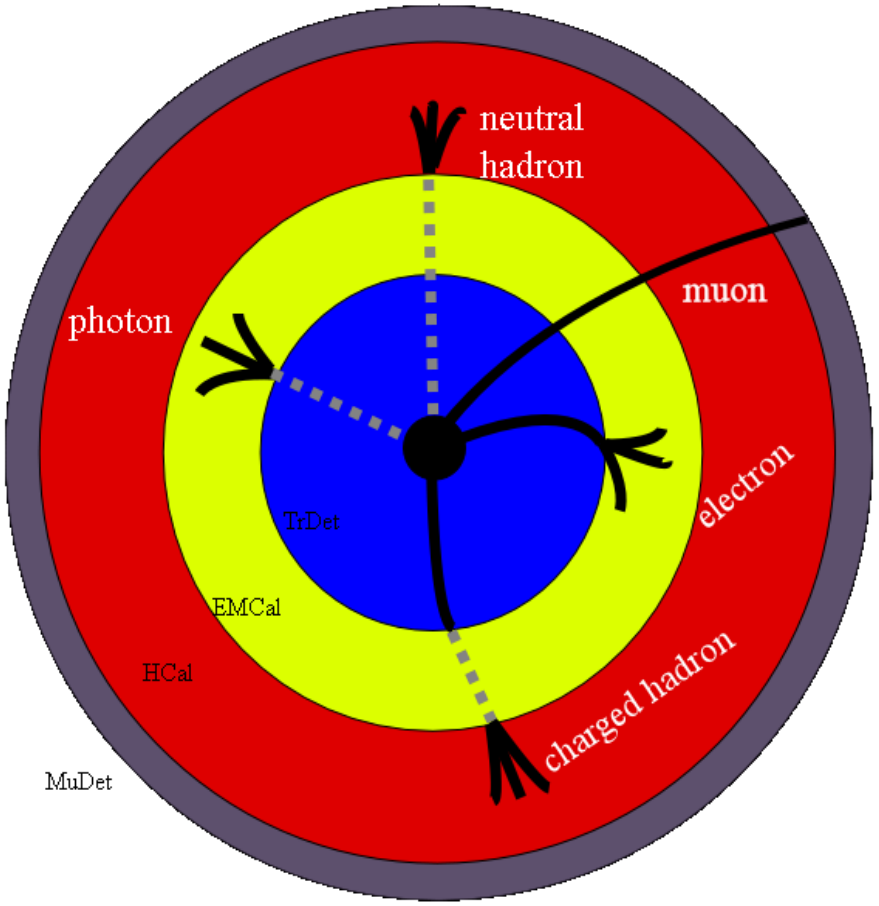


Or



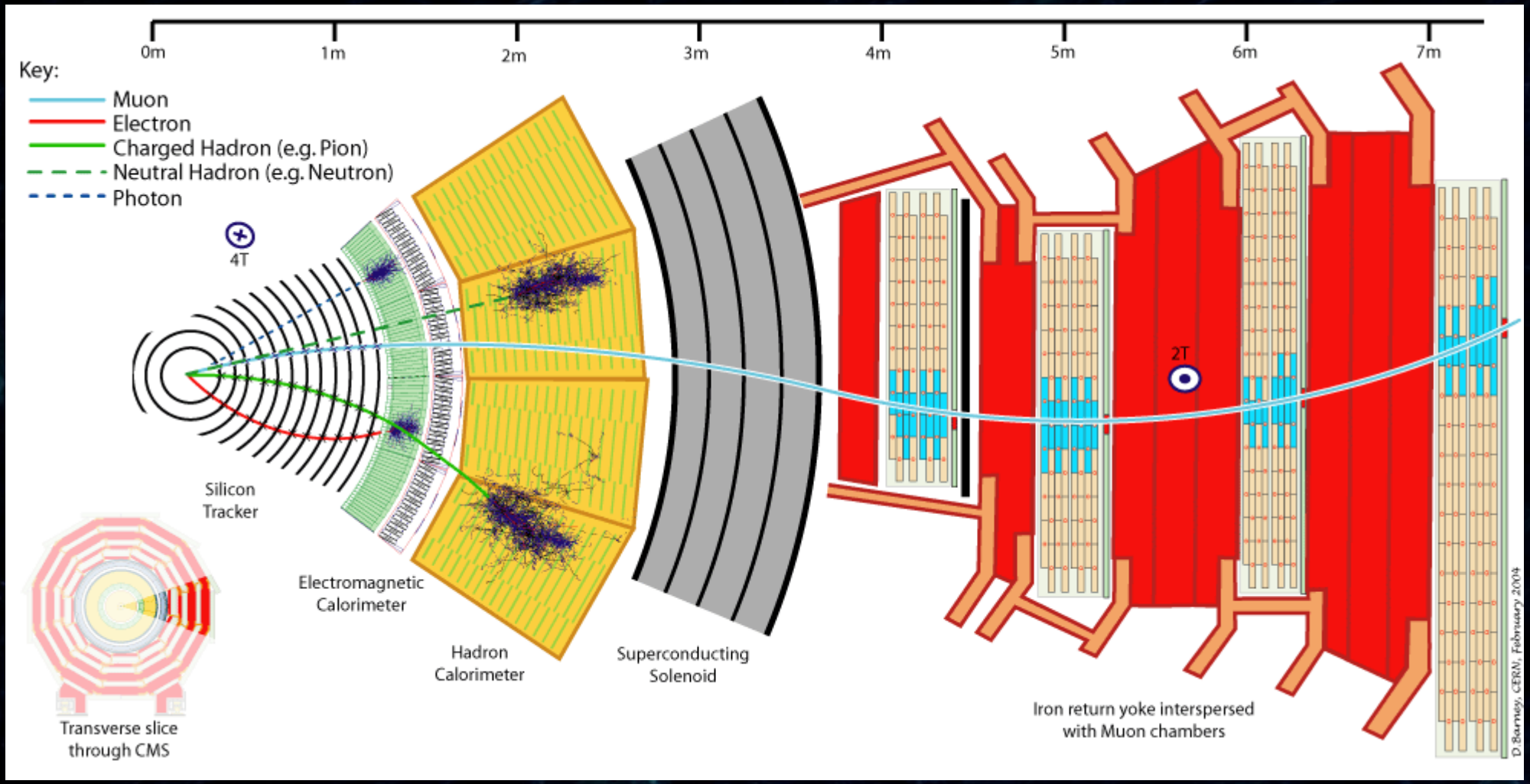
Calorimeter

Particle detectors are like...



MuDet: muon detectors
TrDet: trace detector + vertex detector
EMCal: elekcromagnetic caloriméter
HCal: hadron caloriméter

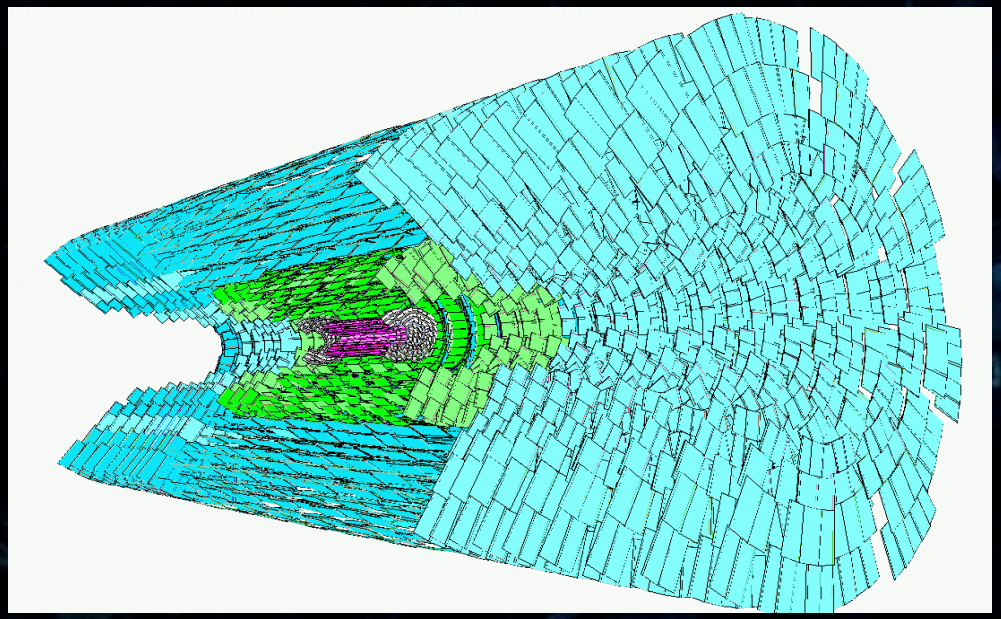
Particle identification in CMS

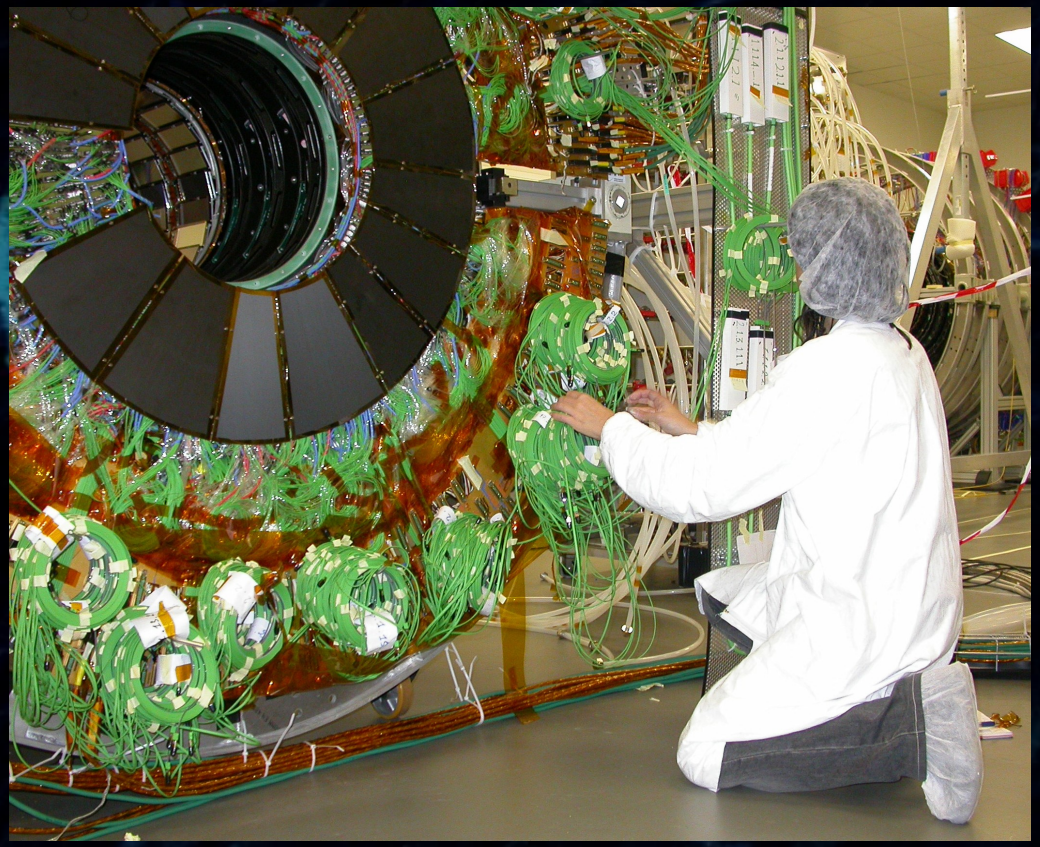


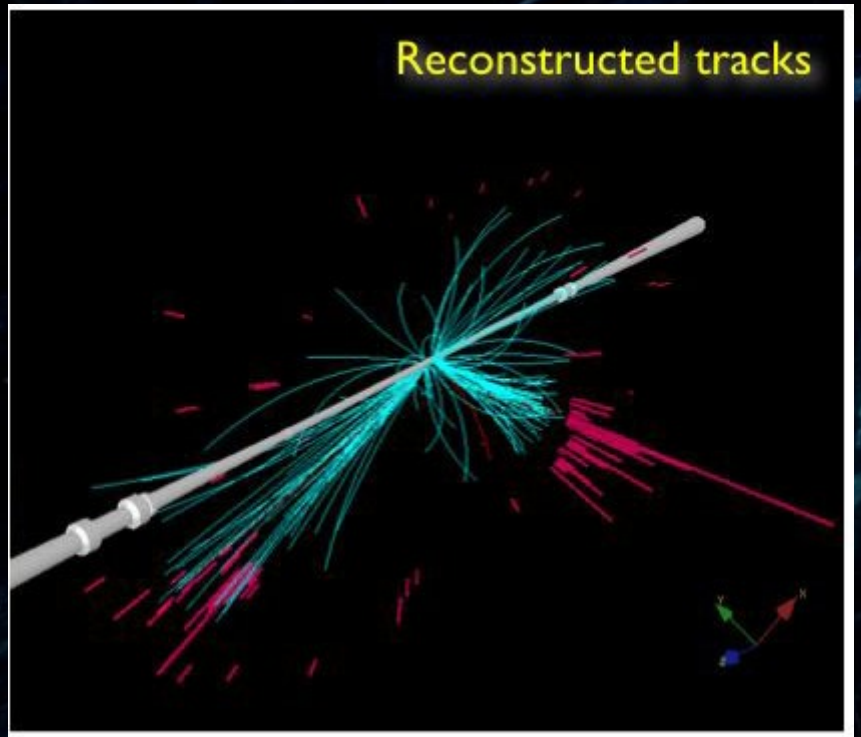
The Tracker

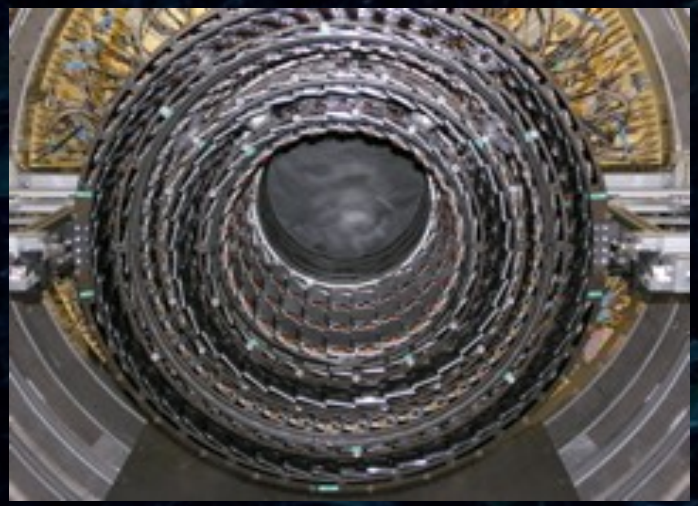
- Measures the trajectories of charged particles, result – momentum measurement and secondary vertex finding
- The biggest silicon detector in history
- Over 220m^2 of silicon
- 75 milions of read-out channels
- Inner part – 3 layers of pixel detectors, outside part 10-11 layers of silicon microstrips

Tracker



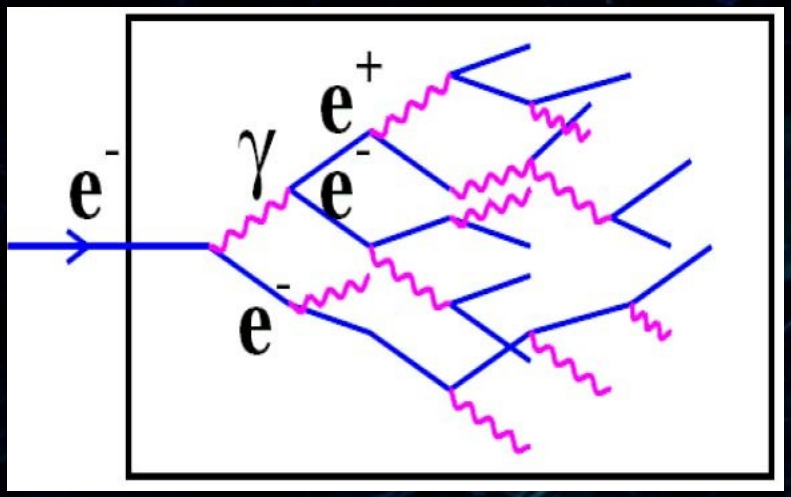


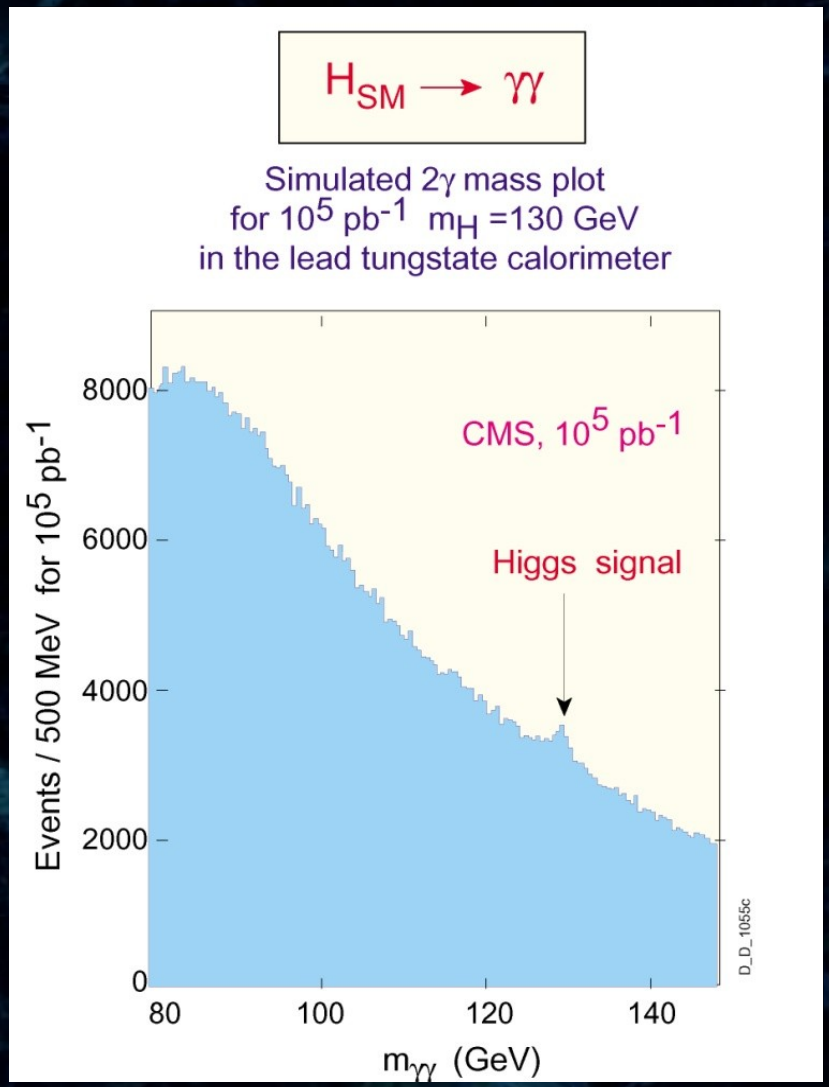


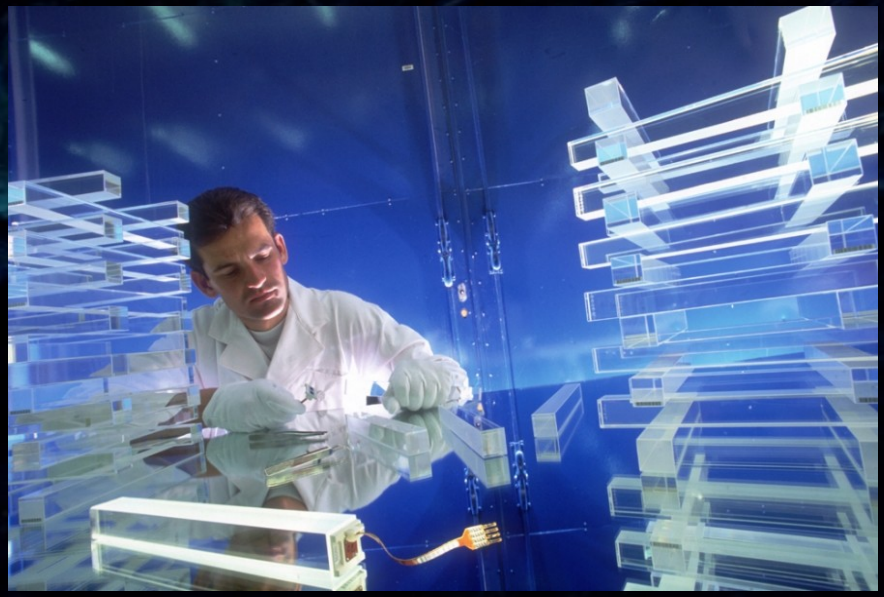


Electromagnetic Calorimeter

- Electron and photon energy measurement
- ~80 000 $PbWO_4$ crystals
- The crystals are at the time the absorber and the scintillator
- Very good energy resolution







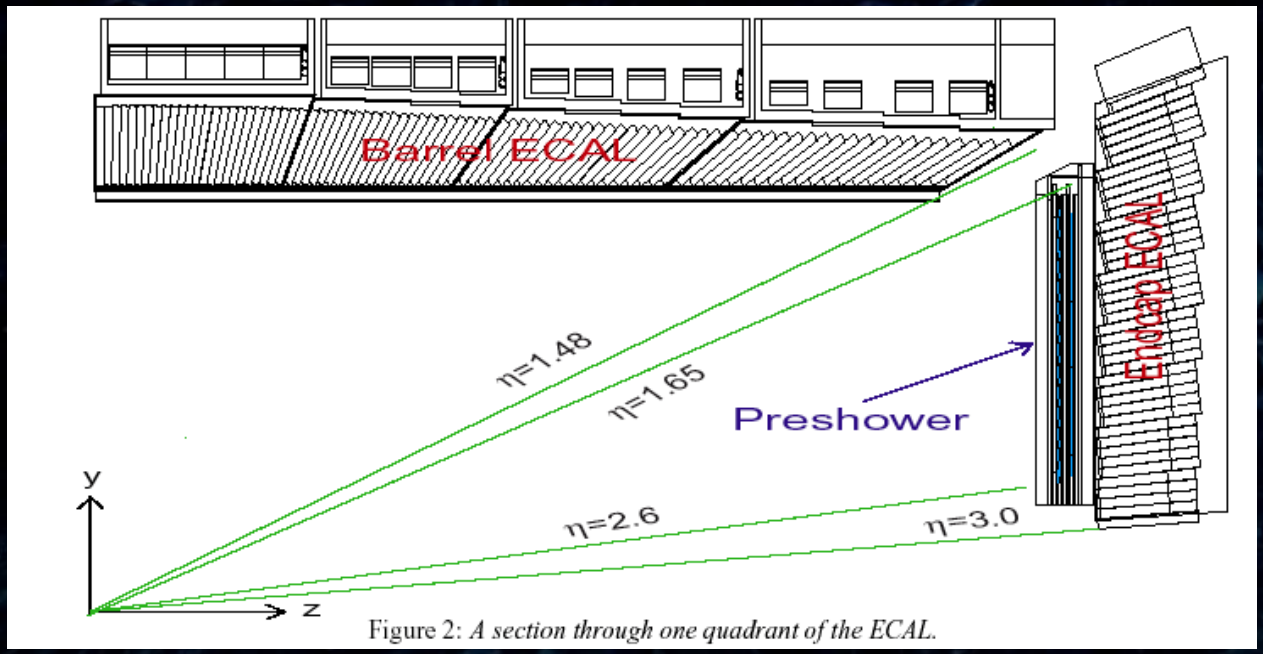
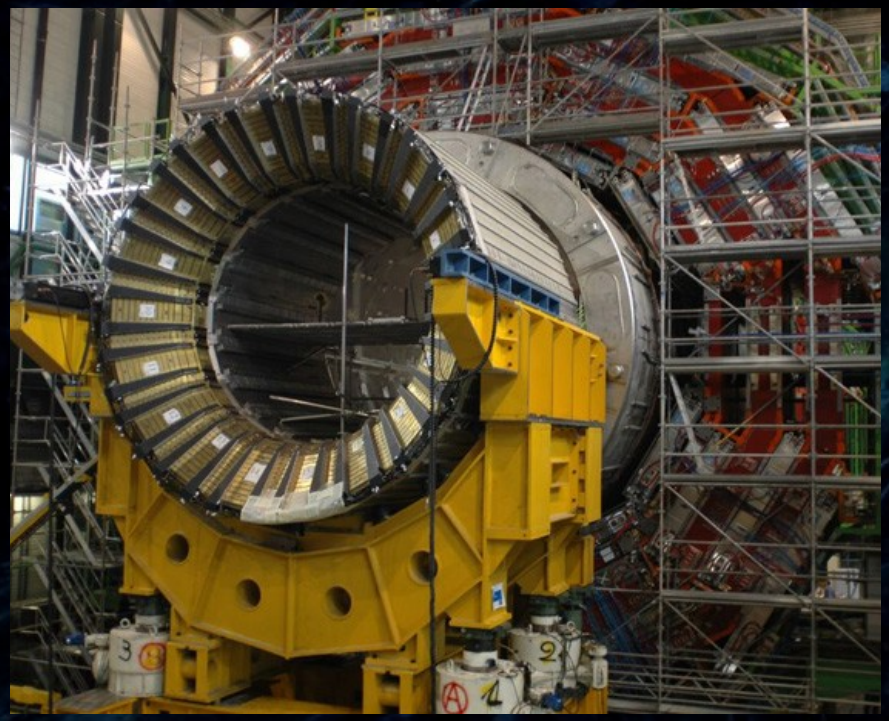
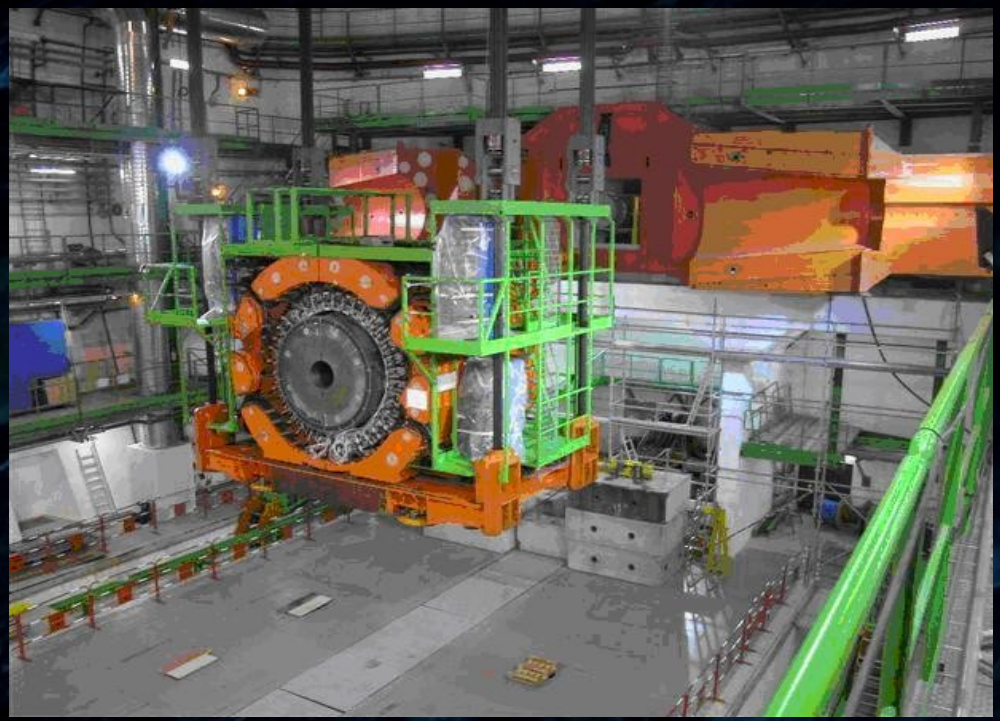


Figure 2: *A section through one quadrant of the ECAL.*

Hadron Calorimeter

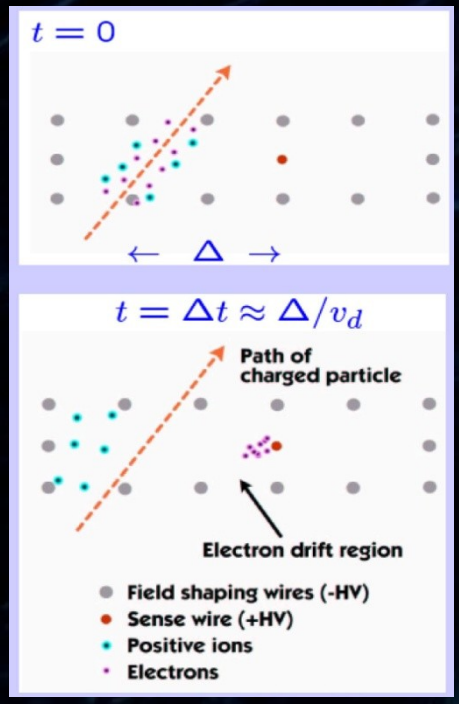
- Jet energy measurement
- Brass absorber interleaved with scintillator layers
- Steel blocks with embedded quartz fibers in the „forward" part

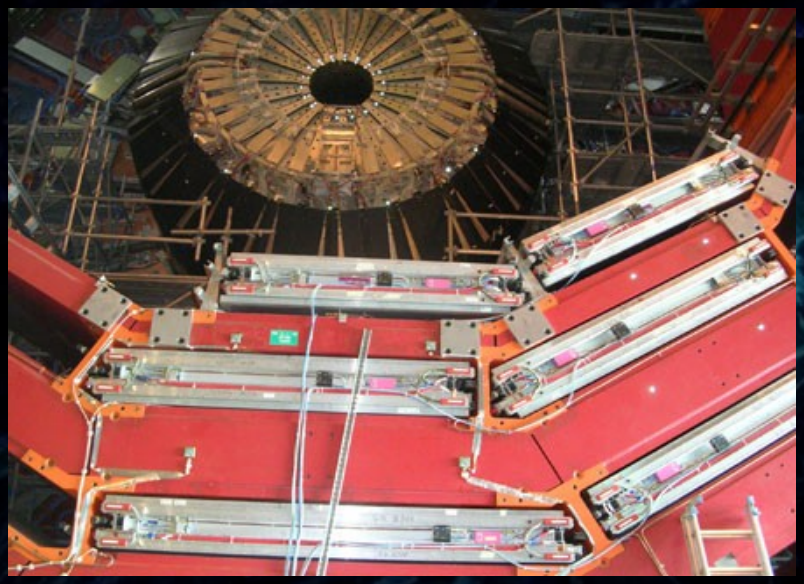


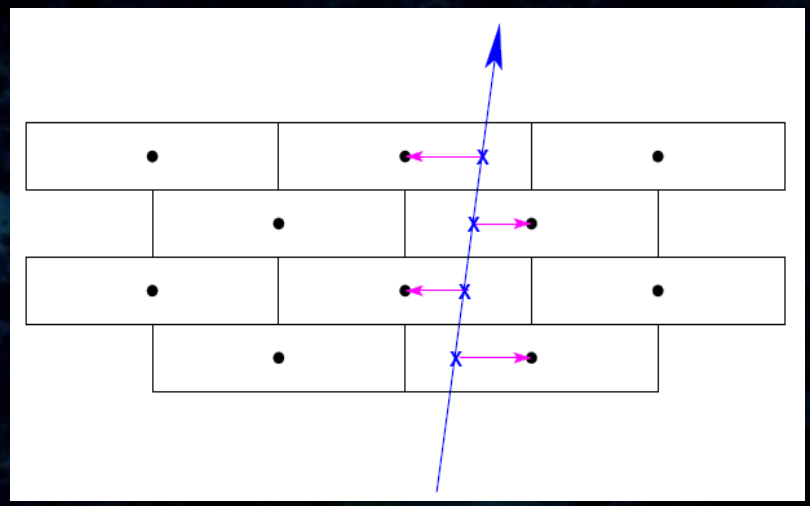


The Muon System – Drift Tubes

- 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

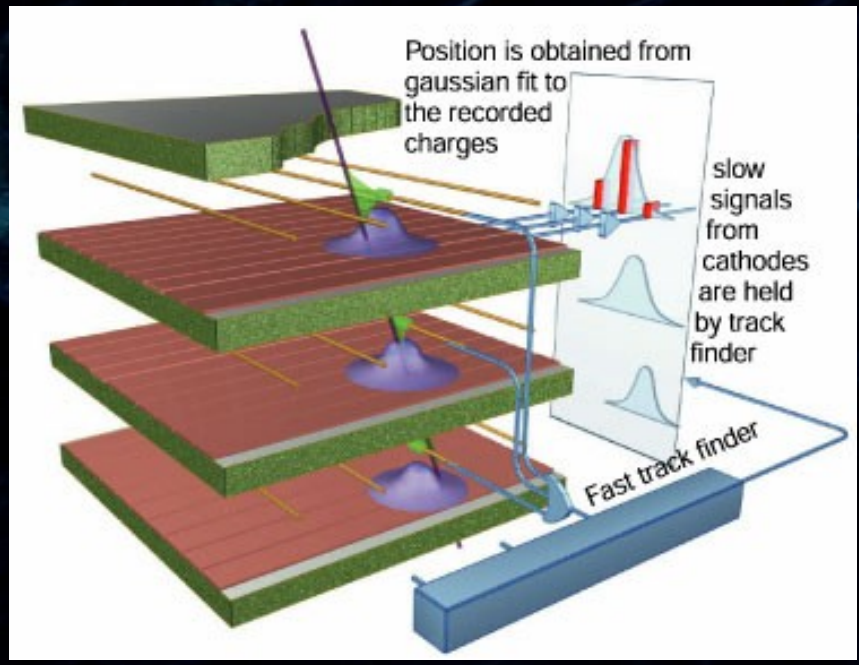




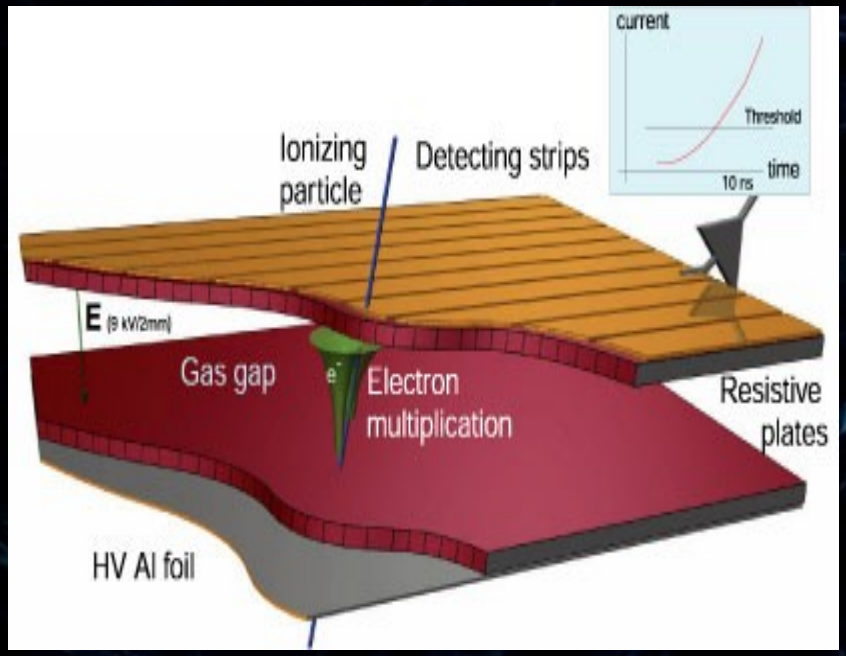


Cathode Strip Chambers (CSC)

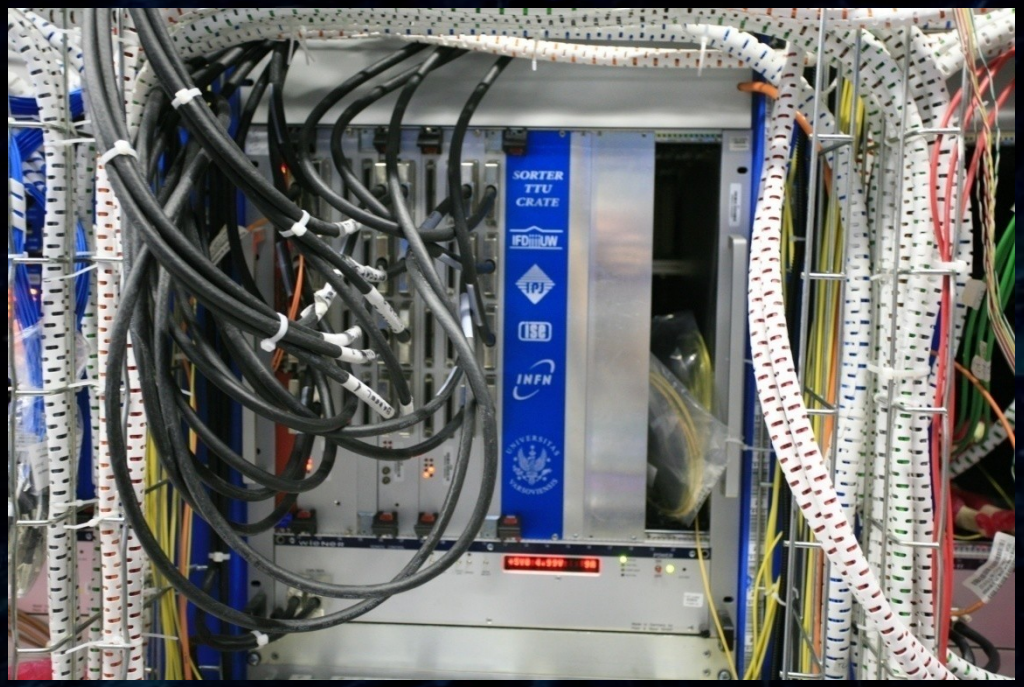
- Muon trajectory measurement in the endcaps
- Gaseous detector with layers of anode wires and cathode strips

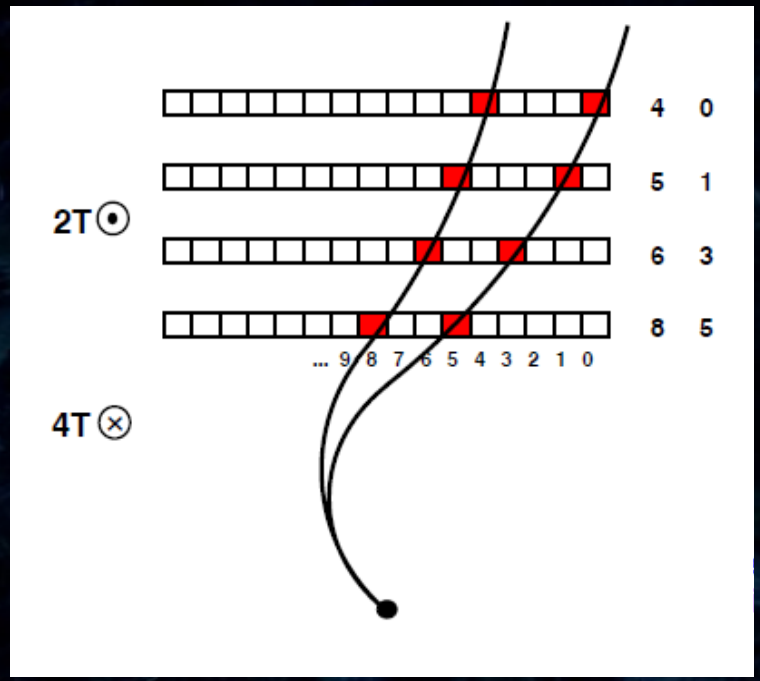


Resistive Plate Chambers (RPC)

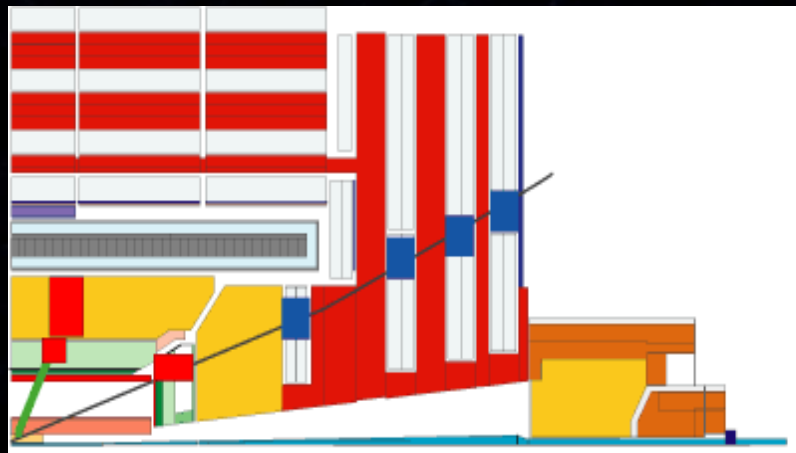


- Aim – fast estimation of muon momentum for the trigger system
- Logic - predefined pattern comparation



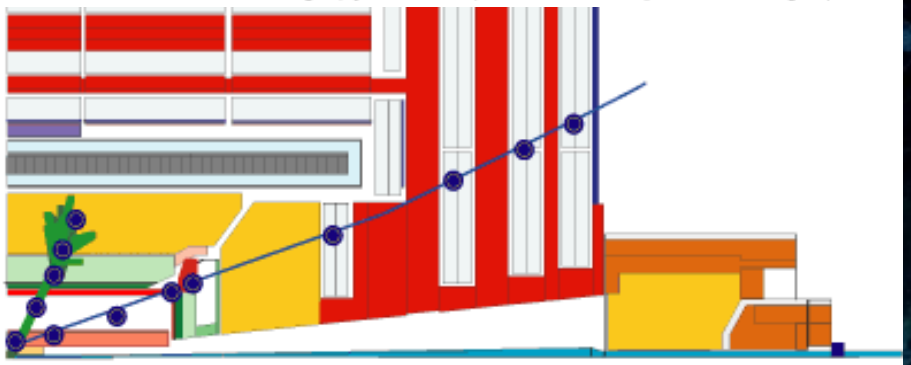


Trigger



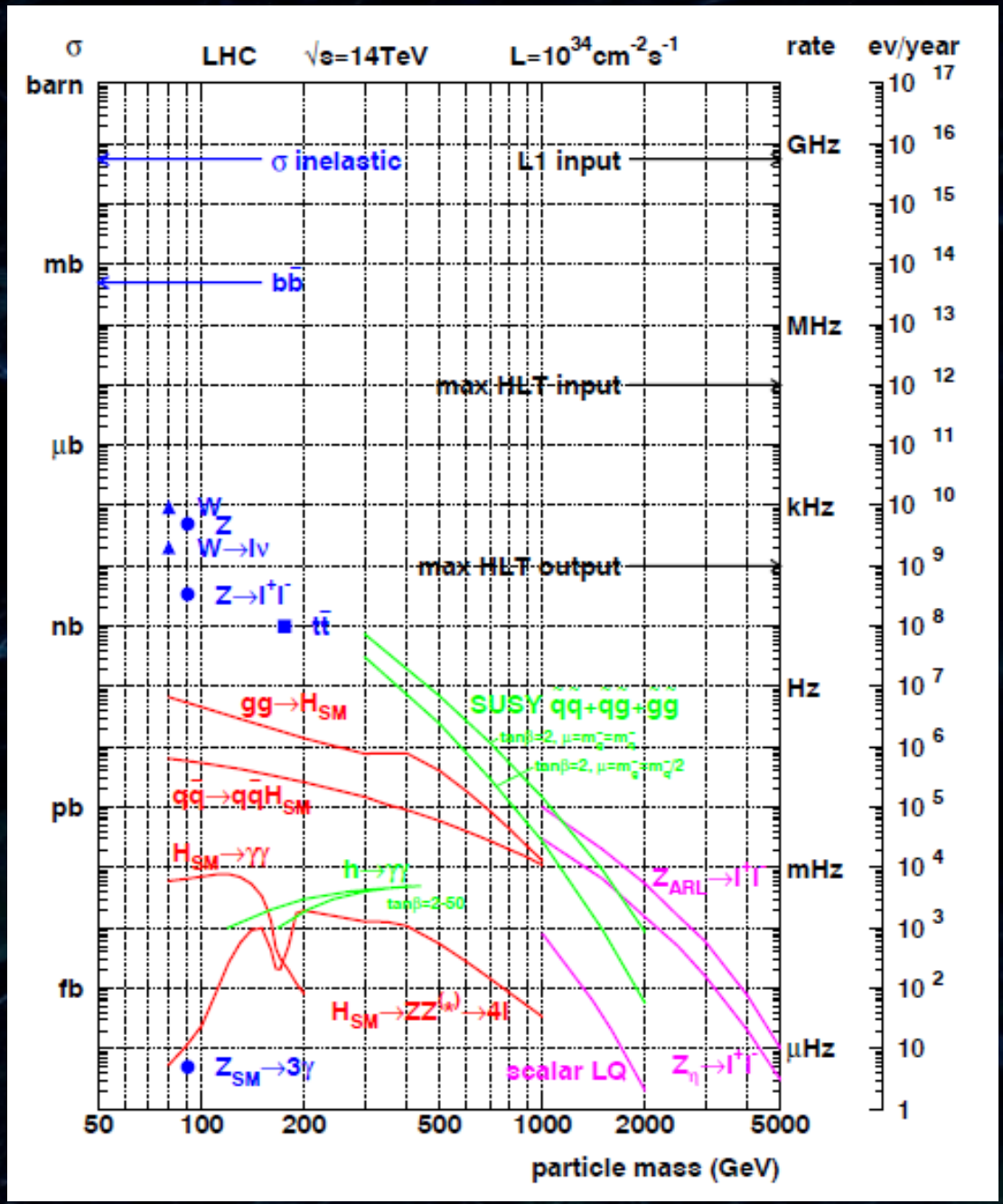
Level-1 trigger. 40 MHz input :

- 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

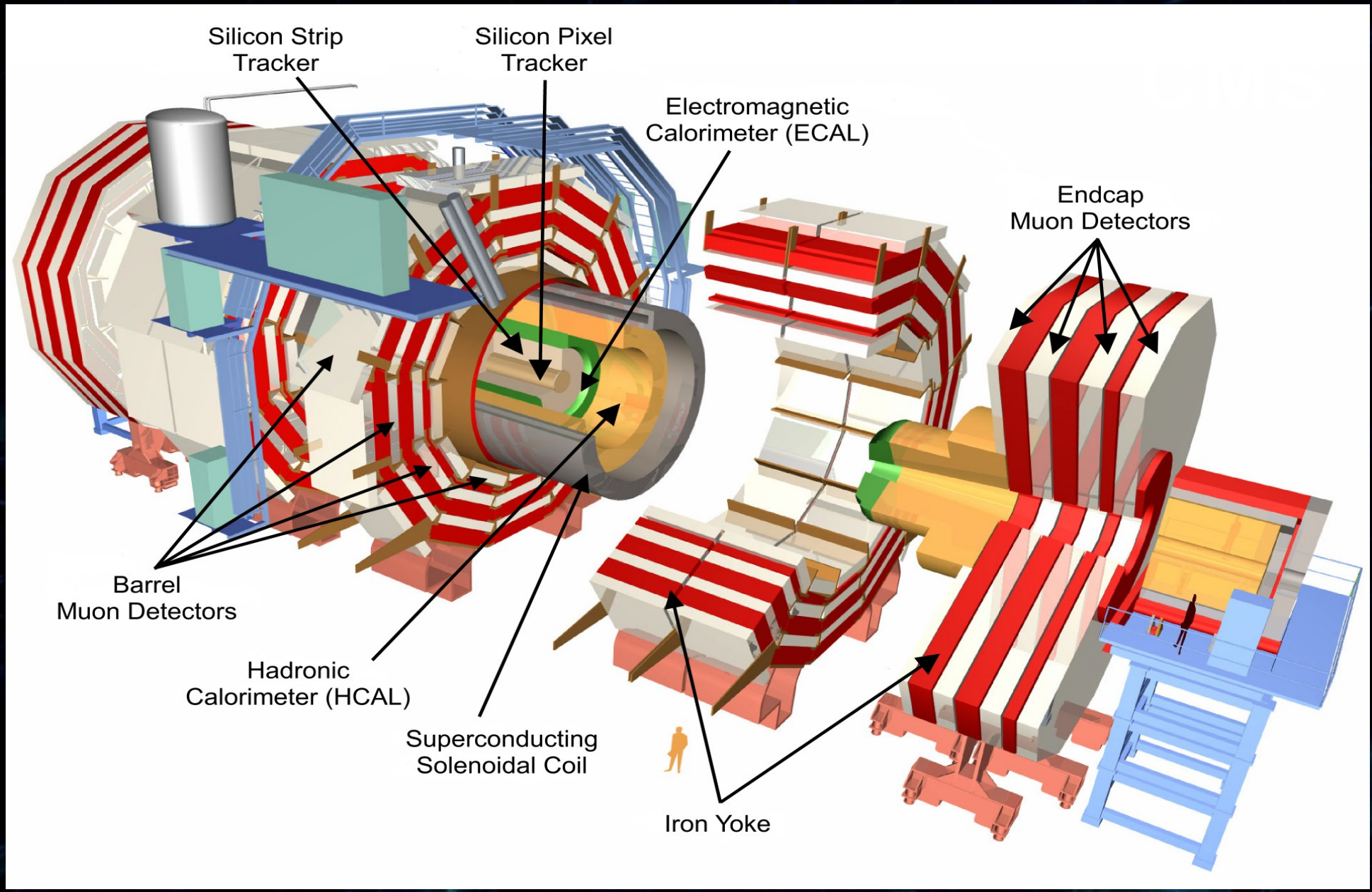


High trigger levels (>1). 100 kHz input :

- 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