

The Compact Muon Solenoid Detector

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CALTECH/CERN

Compact Muon Solenoid

In three parts:

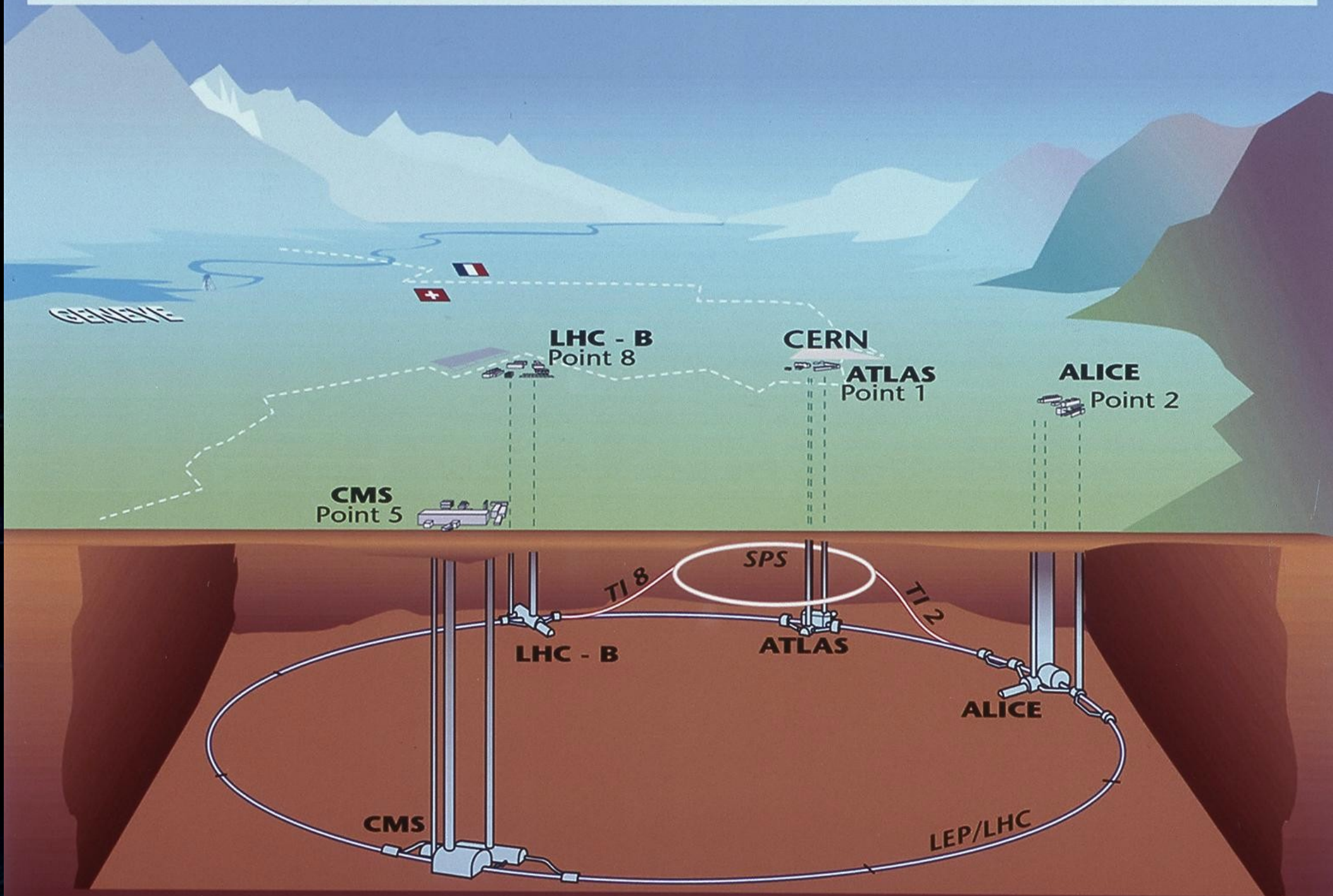
1. What is it
2. How it works
3. How it was built

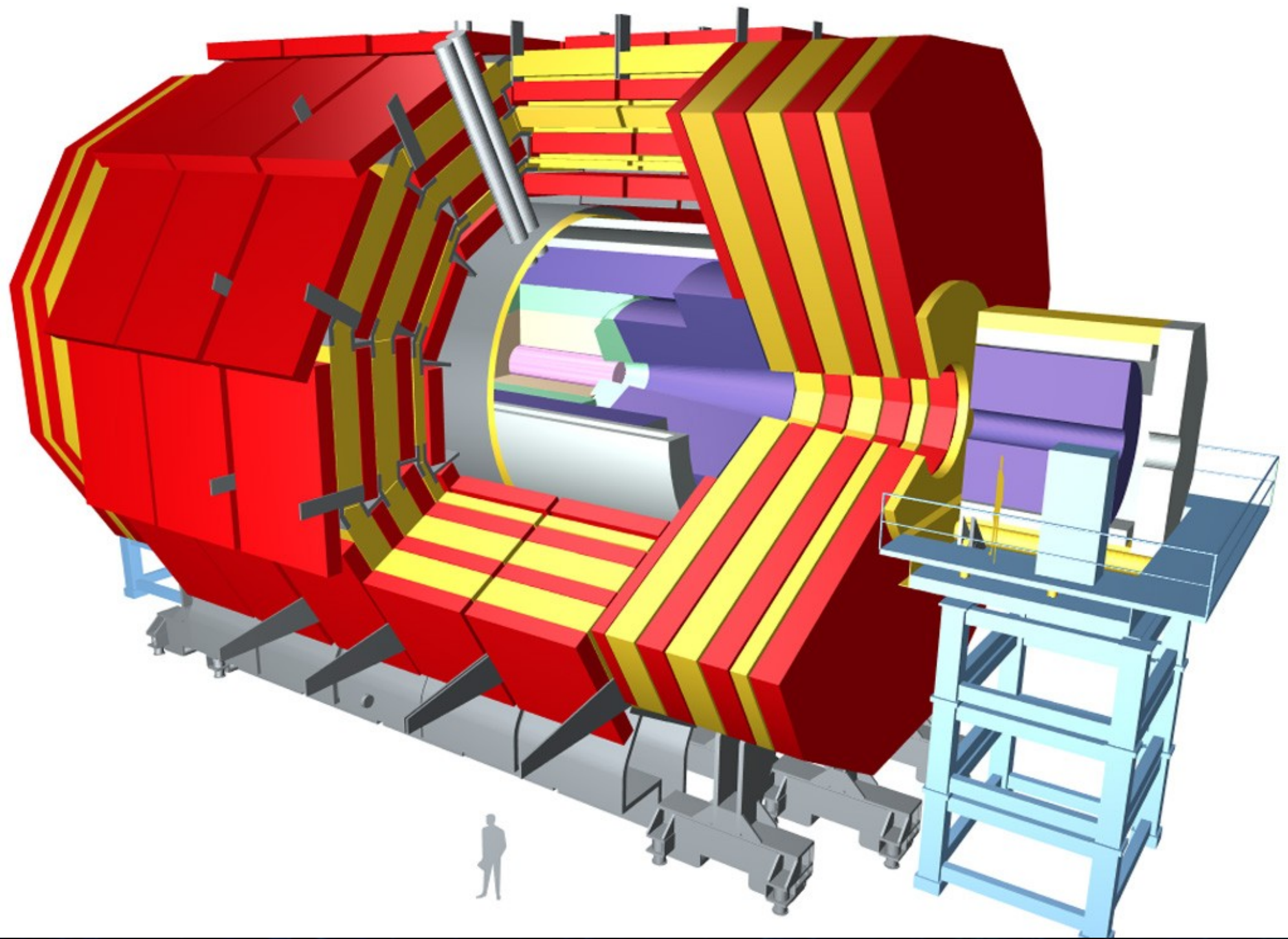
Compact Muon Solenoid

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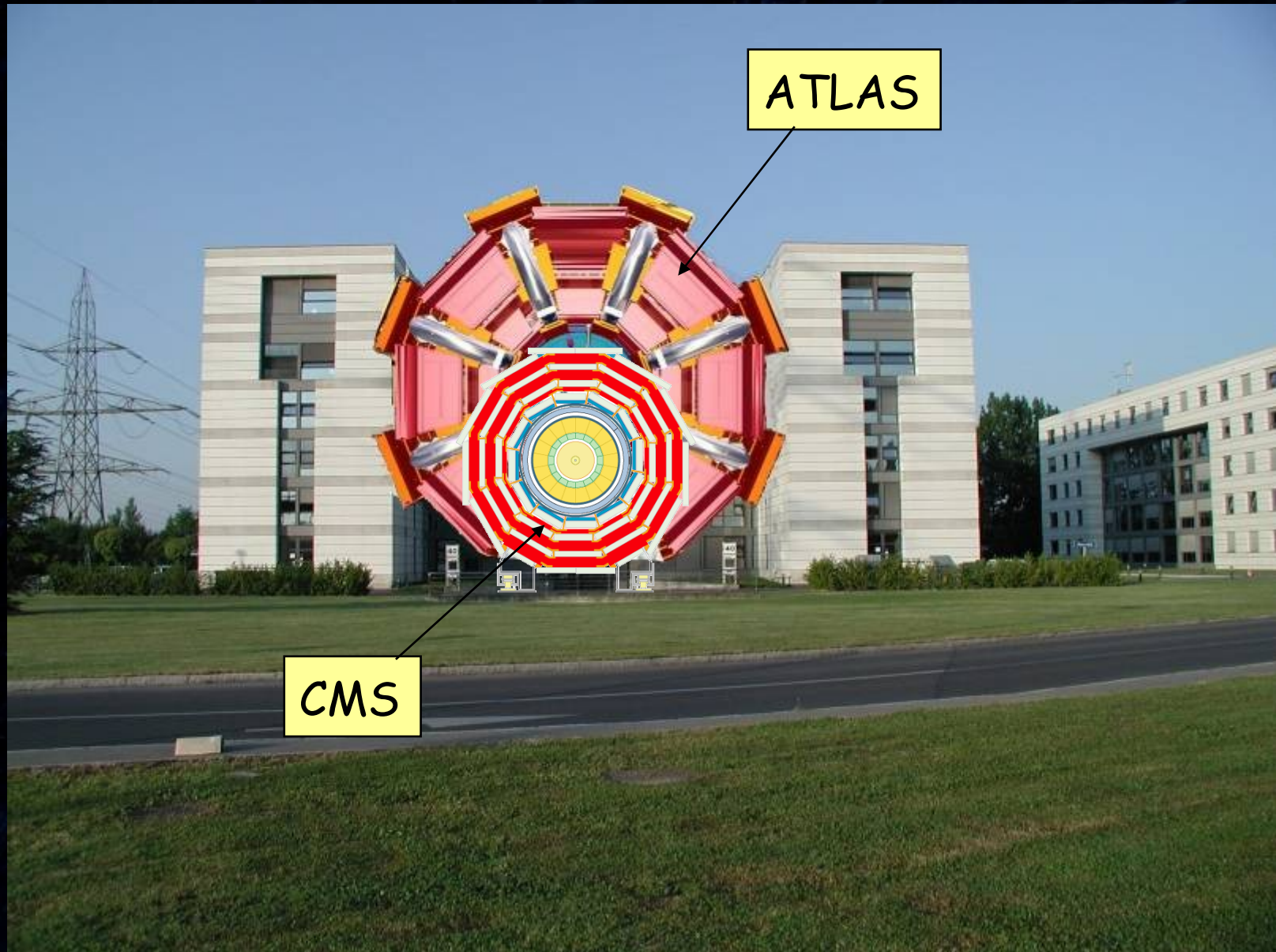
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Overall view of the LHC experiments.





Compact

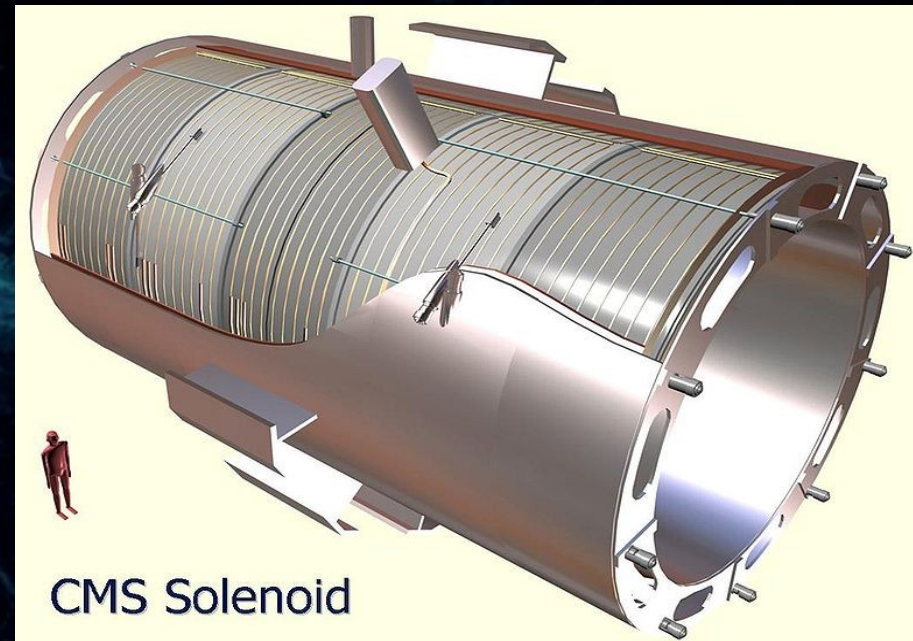


Muon

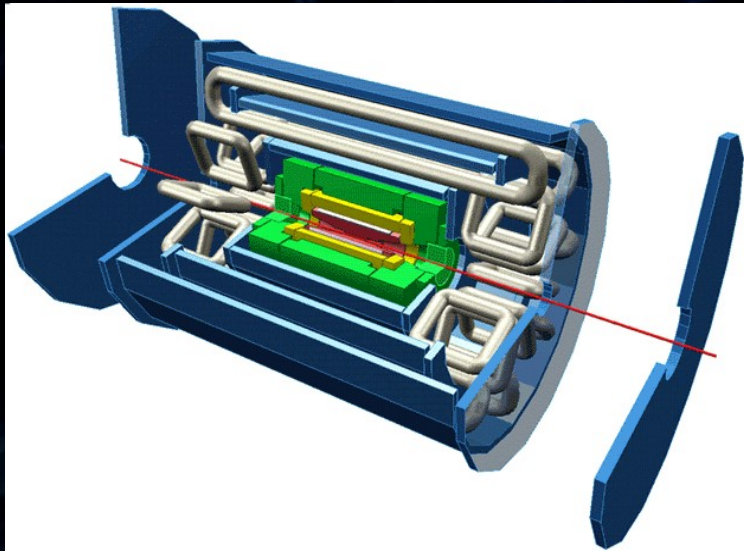
- The CMS detector was designed to provide optimal measurement of muons
- Muons give a relatively „clean“ signal
- They appear as decay products of other particles in many of the processes we want to study

Solenoid

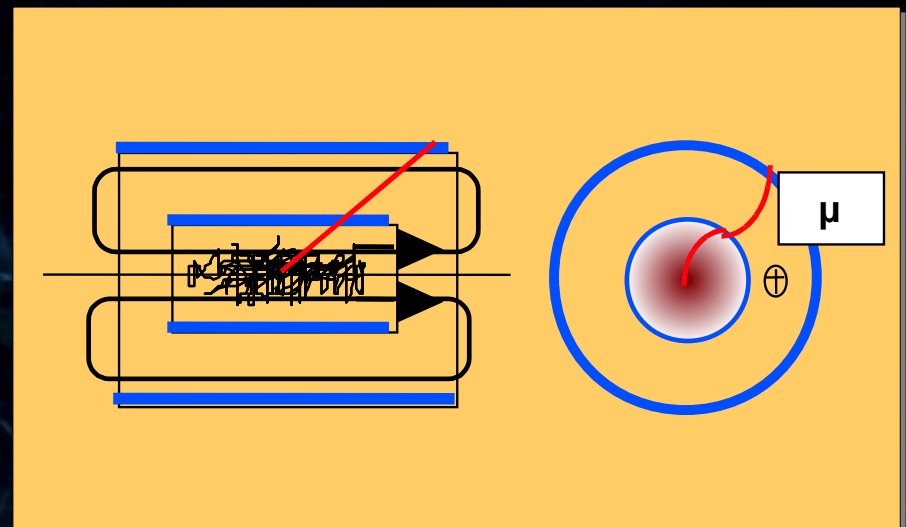
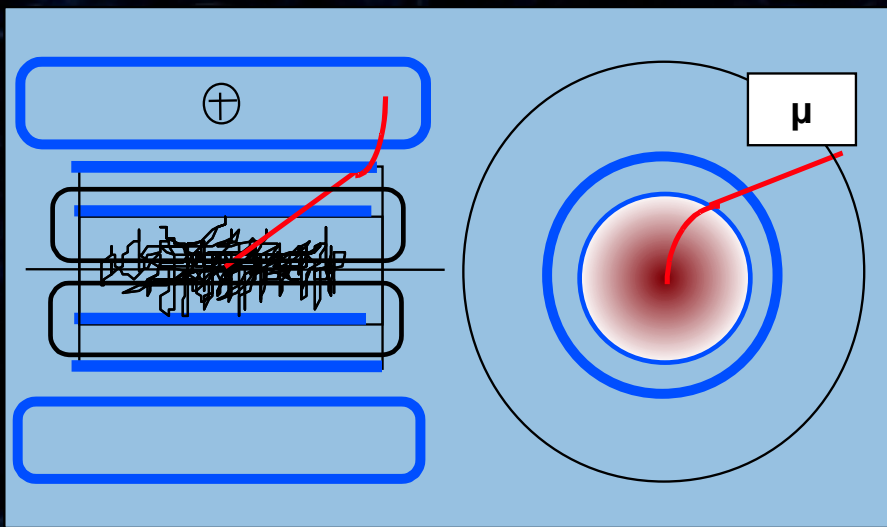
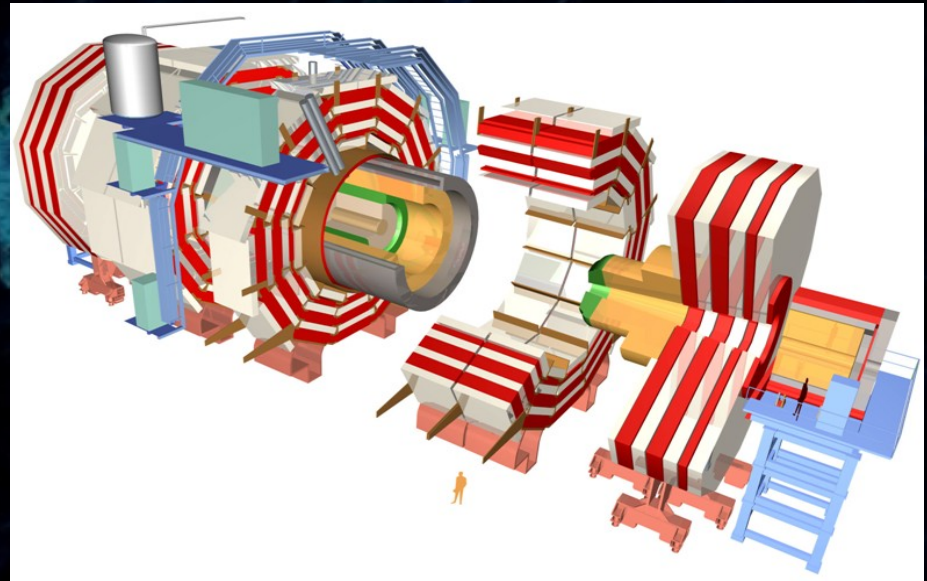
- CMS is built around a superconducting solenoid generating a magnetic field of 4 Tesla
- The current necessary for this - 20 kA...
- Superconducting NbTi wire cooled to $\sim 4\text{K}$
- 13m length, 6m inner diameter - enough to fit the tracker and calorimeters inside
- (cost ~ 80 MCHF)



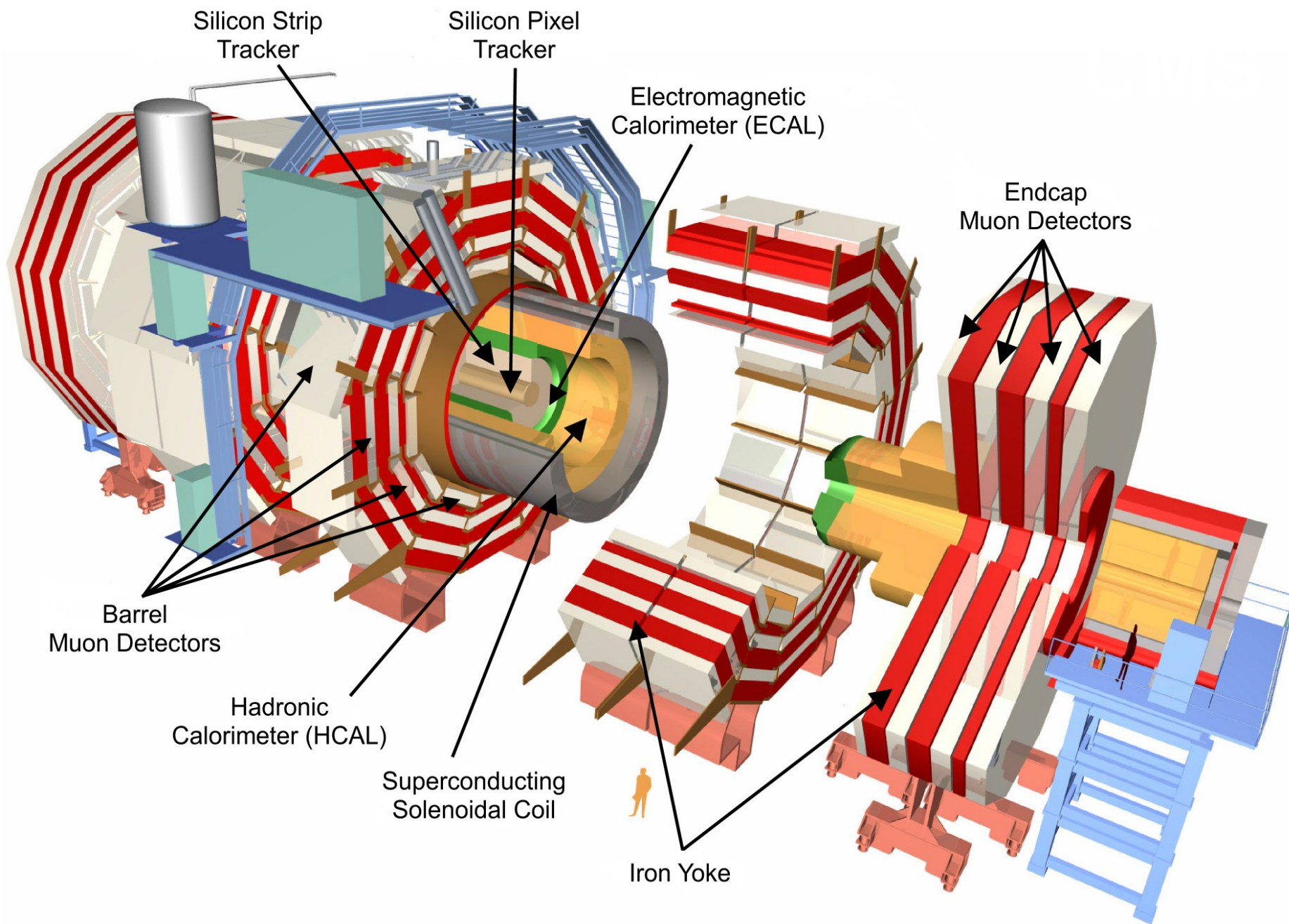
ATLAS A Toroidal LHC Apparatus



CMS Compact Muon Solenoid



CMS detector overview



Compact Muon Solenoid

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Two ways to detect a particle

(in CMS)

Two ways to detect a particle

(in CMS)

See the track



Or

Catch



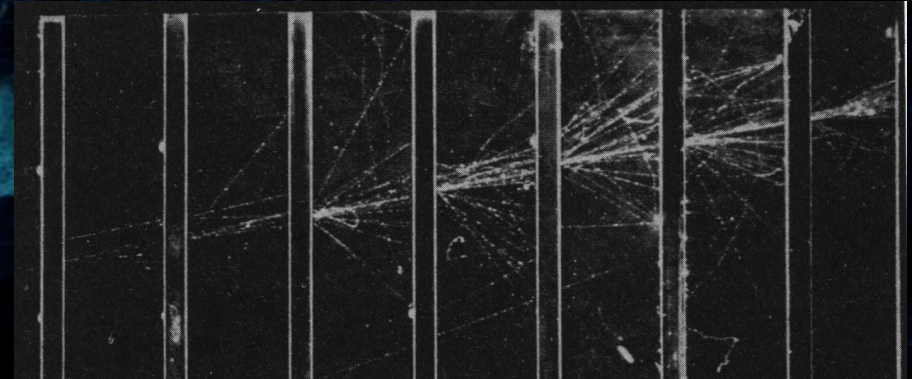
Two ways to detect a particle

(in CMS)

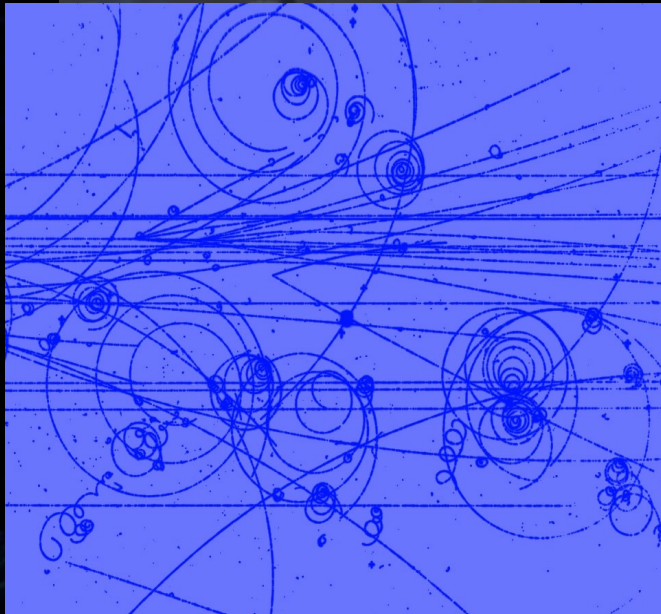
Tracking detector



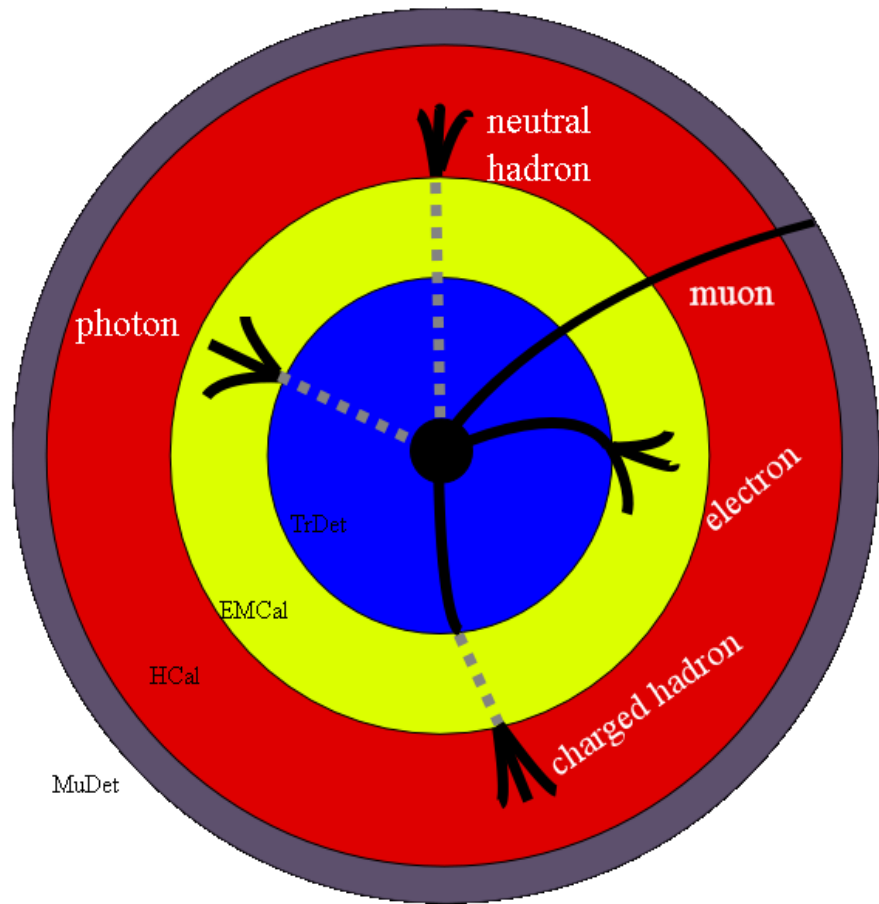
Or



Calorimeter



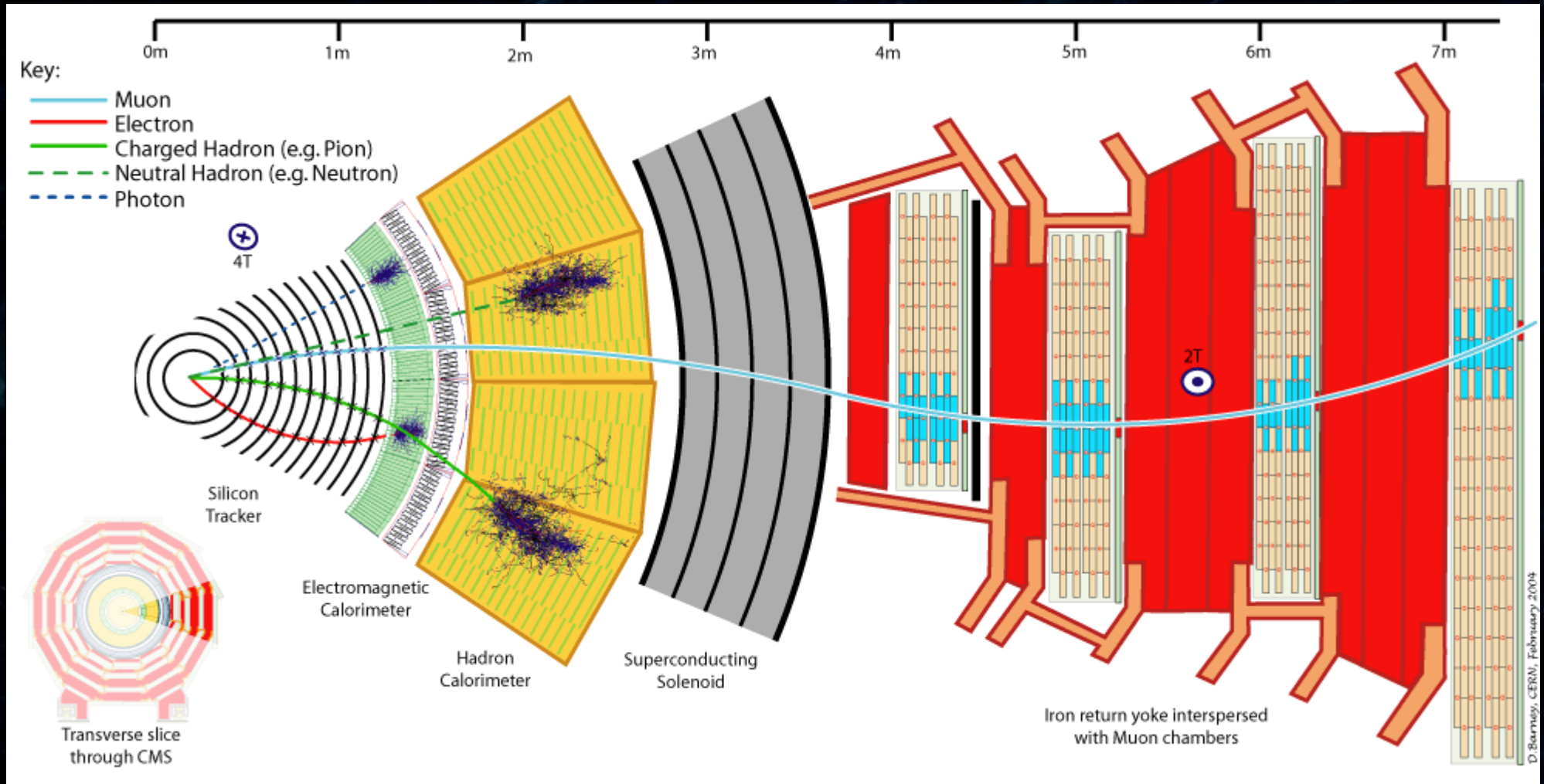
Particle detectors are like...



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



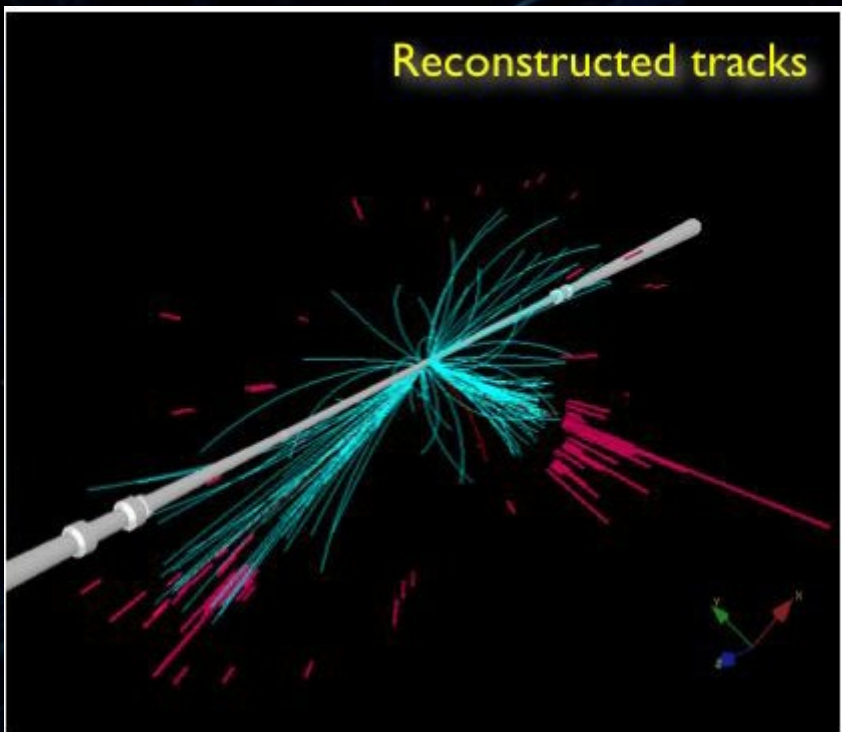
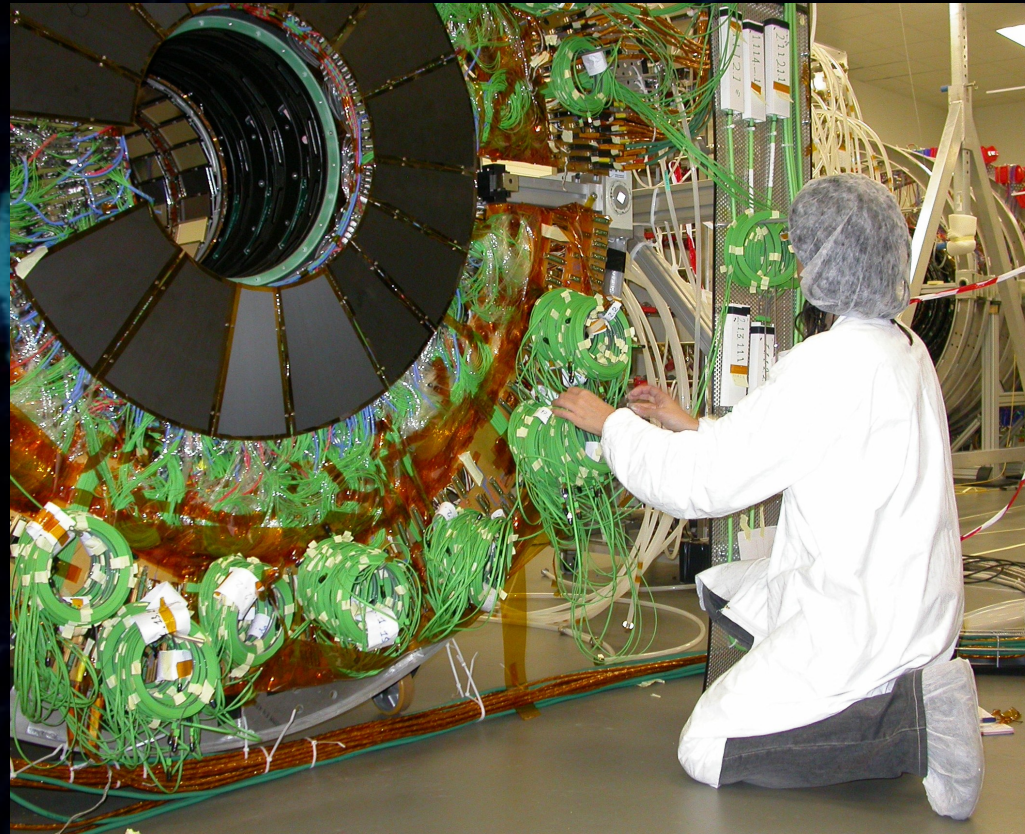
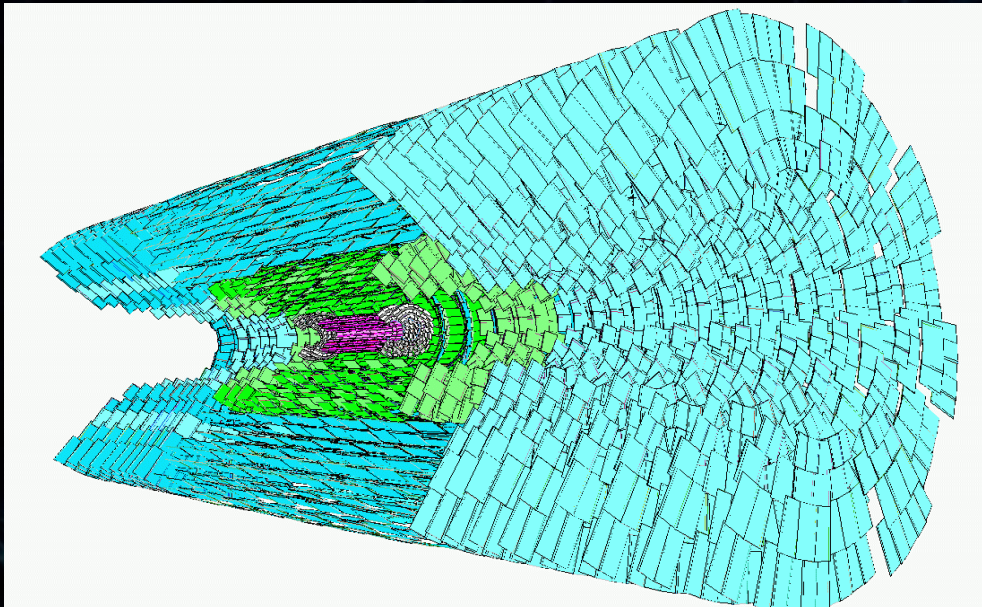
Particle identification in CMS



The Tracker

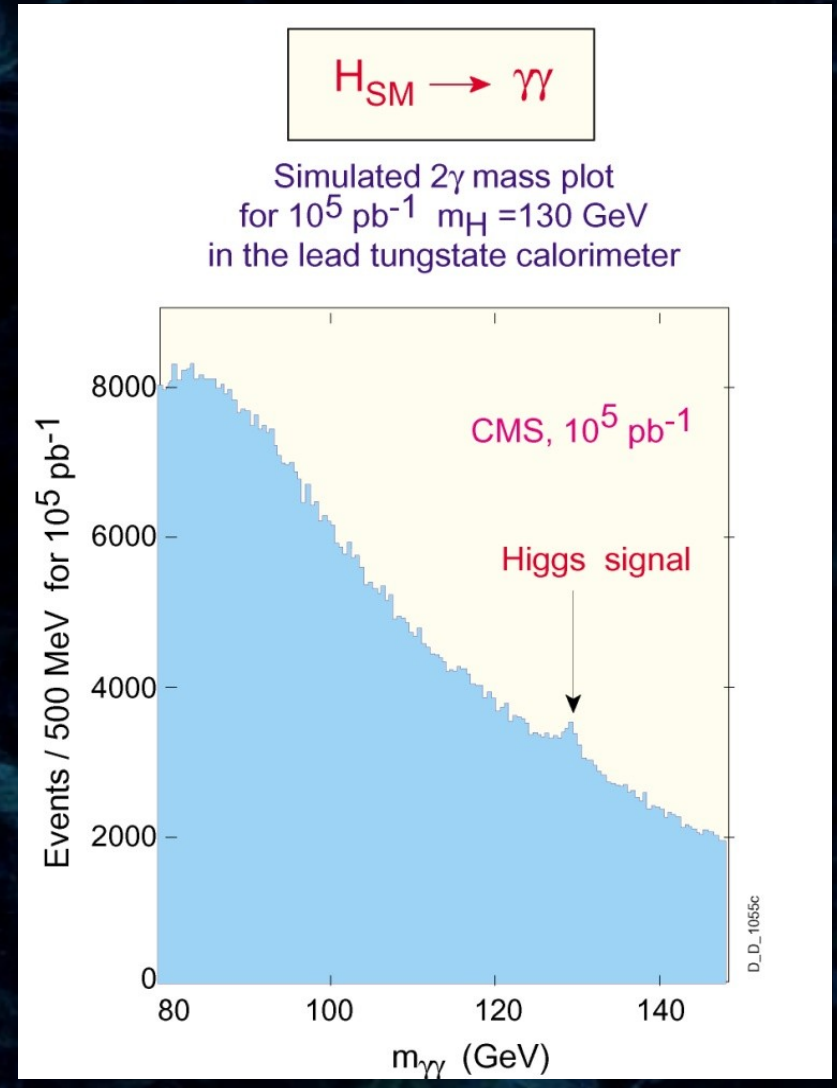
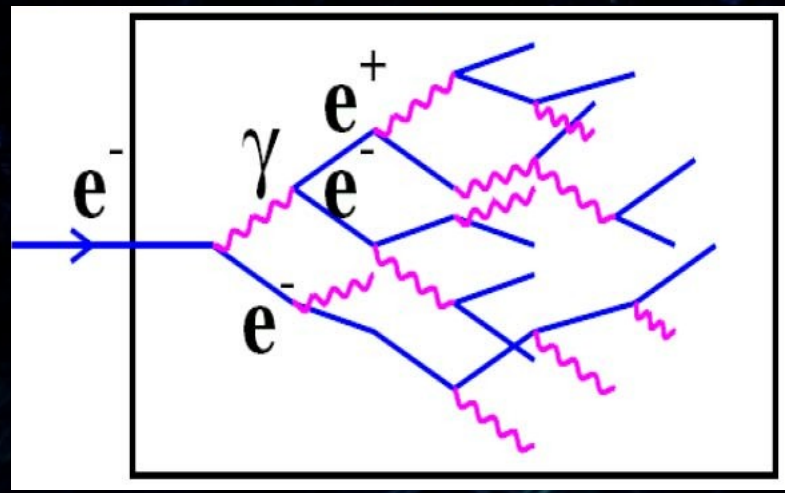
- Measures the trajectories of charged particles, result - momentum measurement and secondary vertex finding
- The biggest silicon detector in history
- Over 220m² of silicon
- 75 millions of read-out channels
- Inner part - 3 layers of pixel detectors, outside part 10-11 layers of silicon microstrips

Tracker



Electromagnetic Calorimeter

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



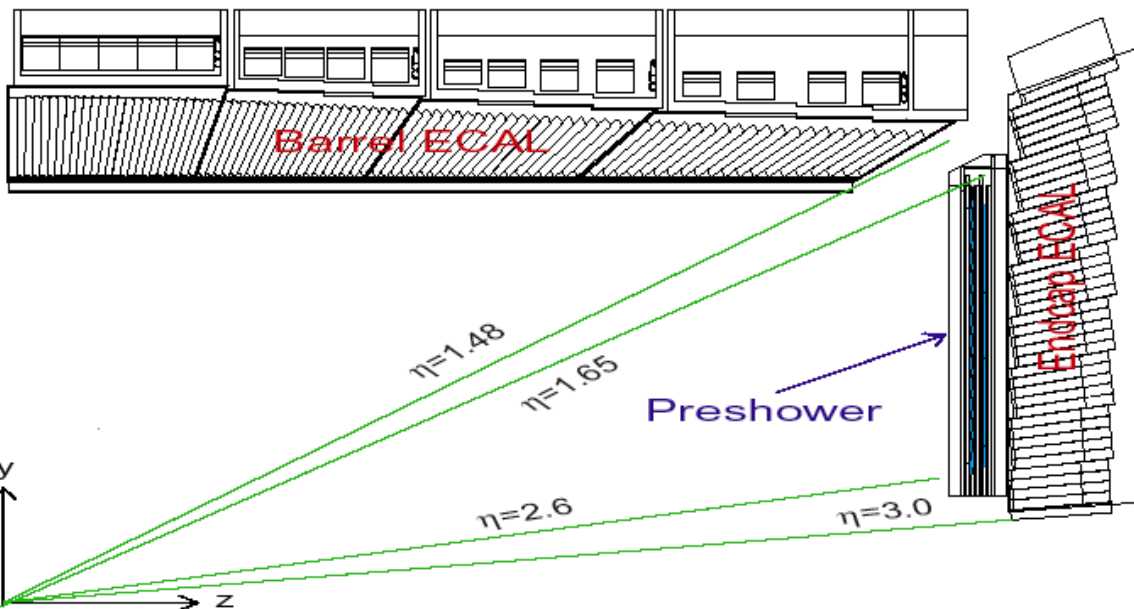
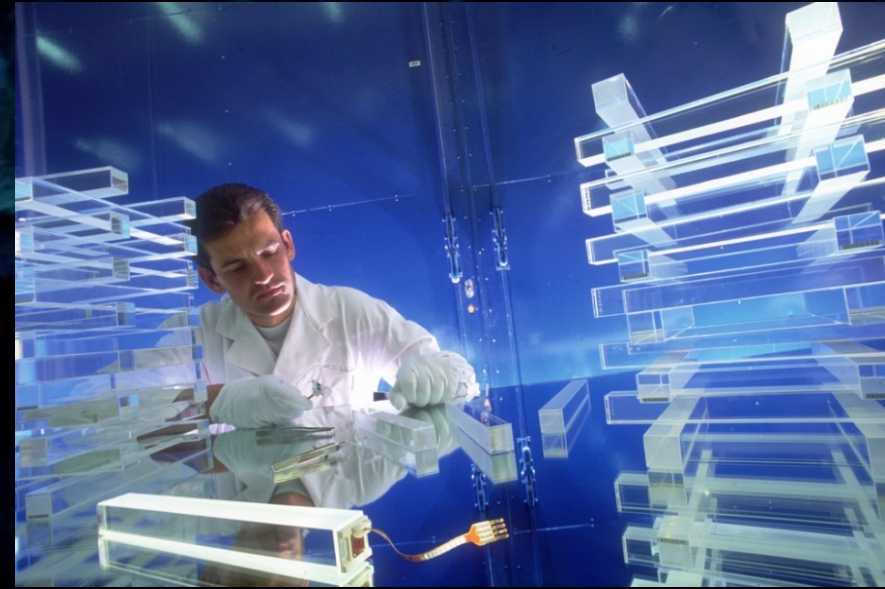


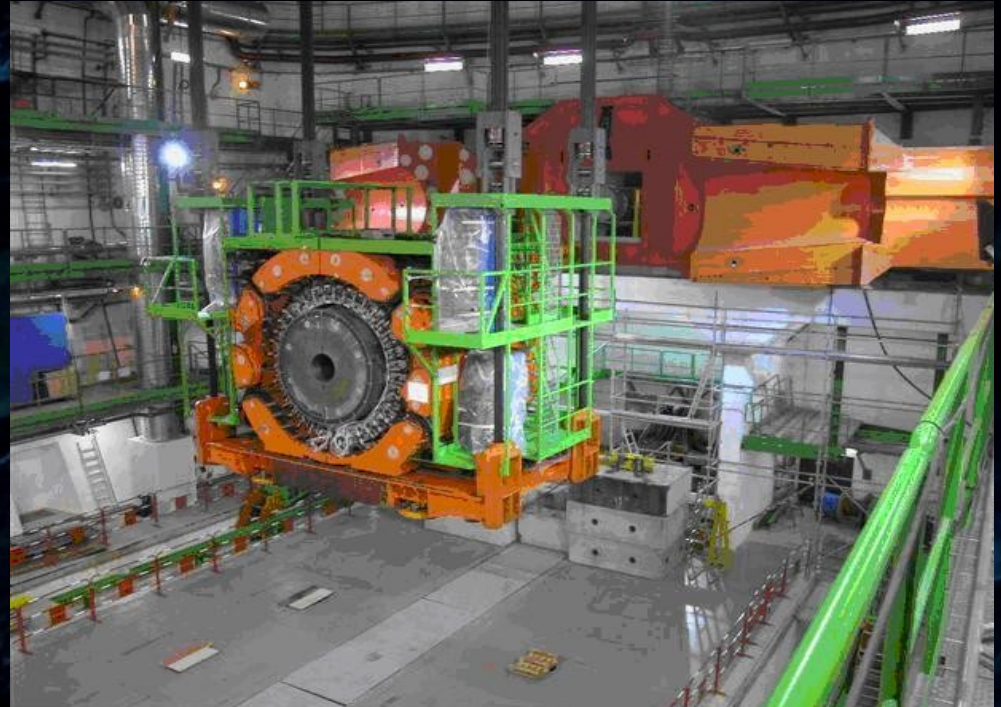
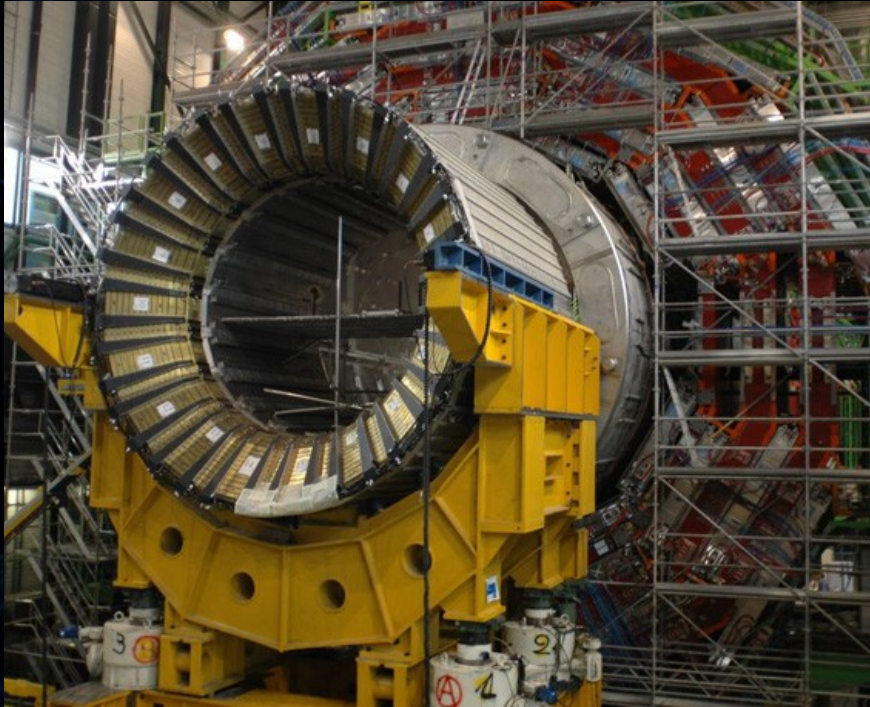
Figure 2: A section through one quadrant of the ECAL.



CMS
Lab 27
PH.CMA
CERN

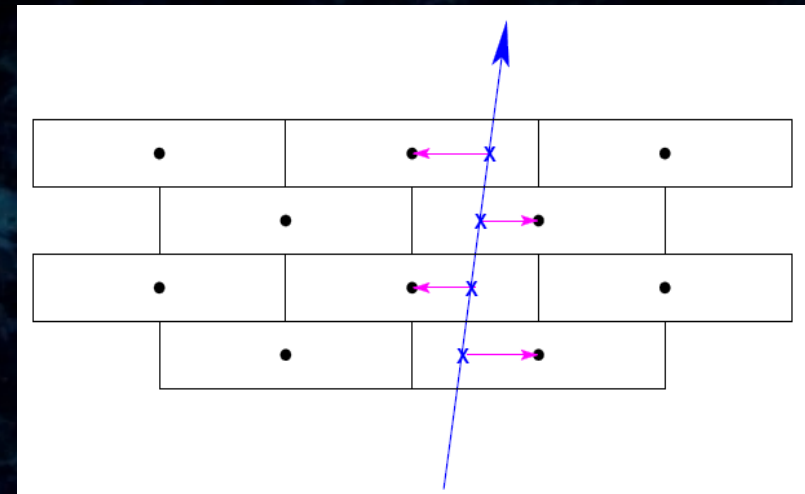
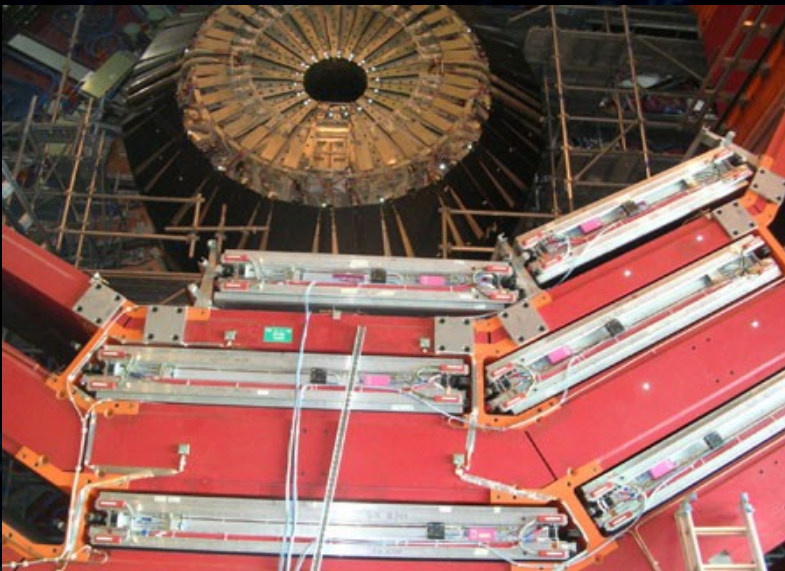
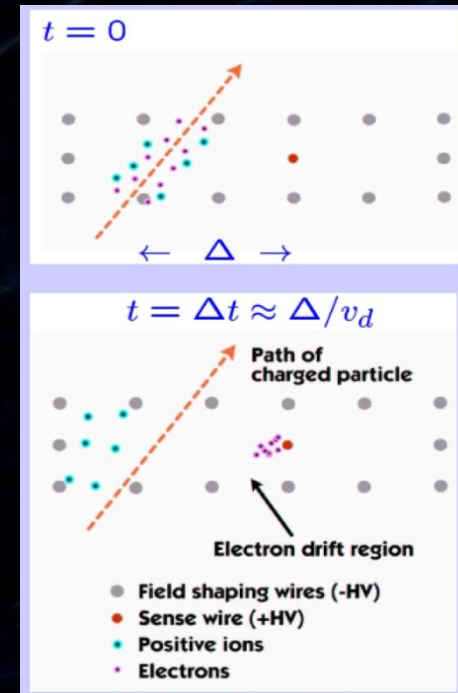
Hadron Calorimeter

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



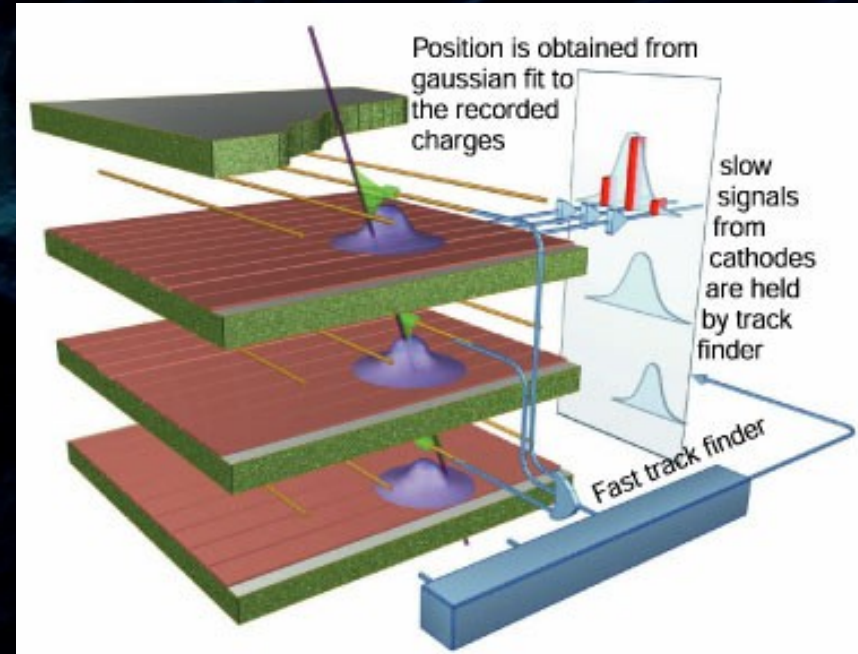
The Muon System - Drift Tubes

- 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

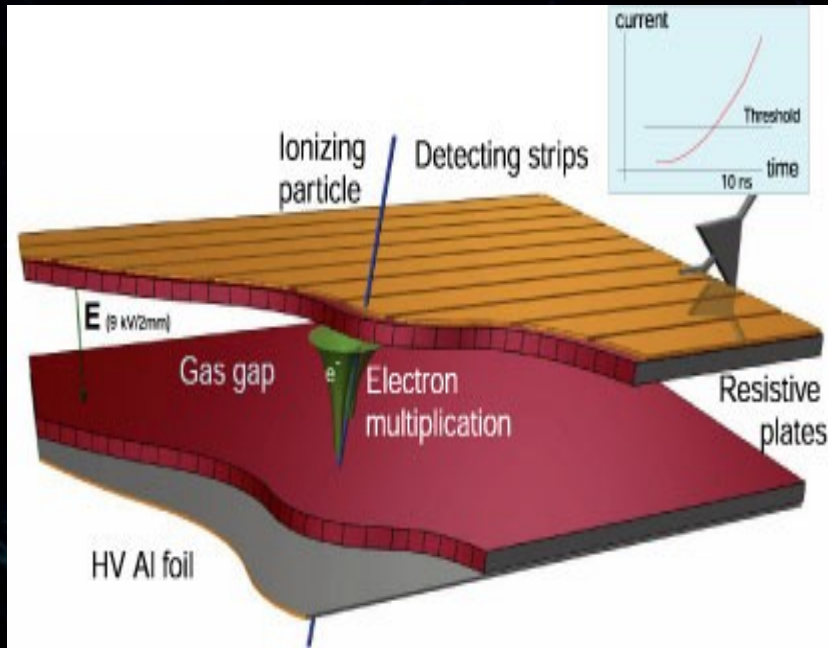


Cathode Strip Chambers (CSC)

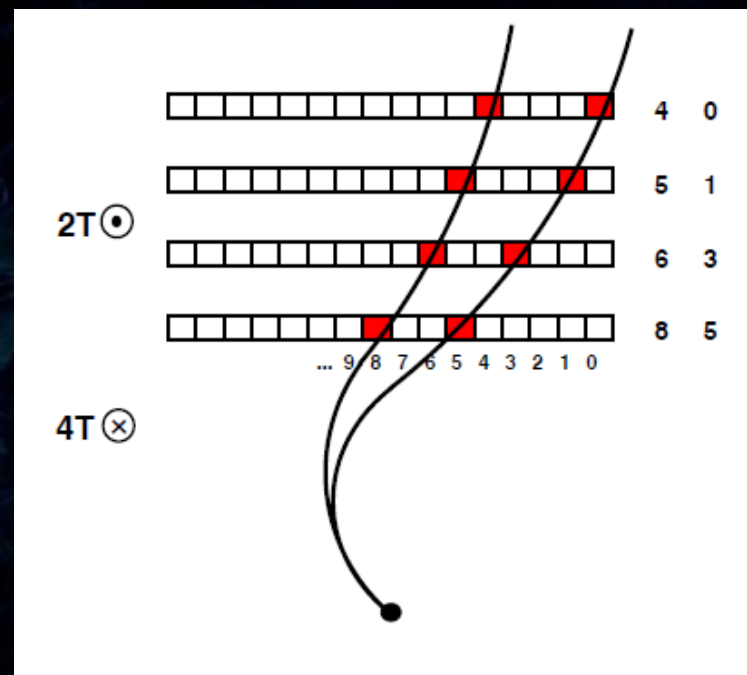
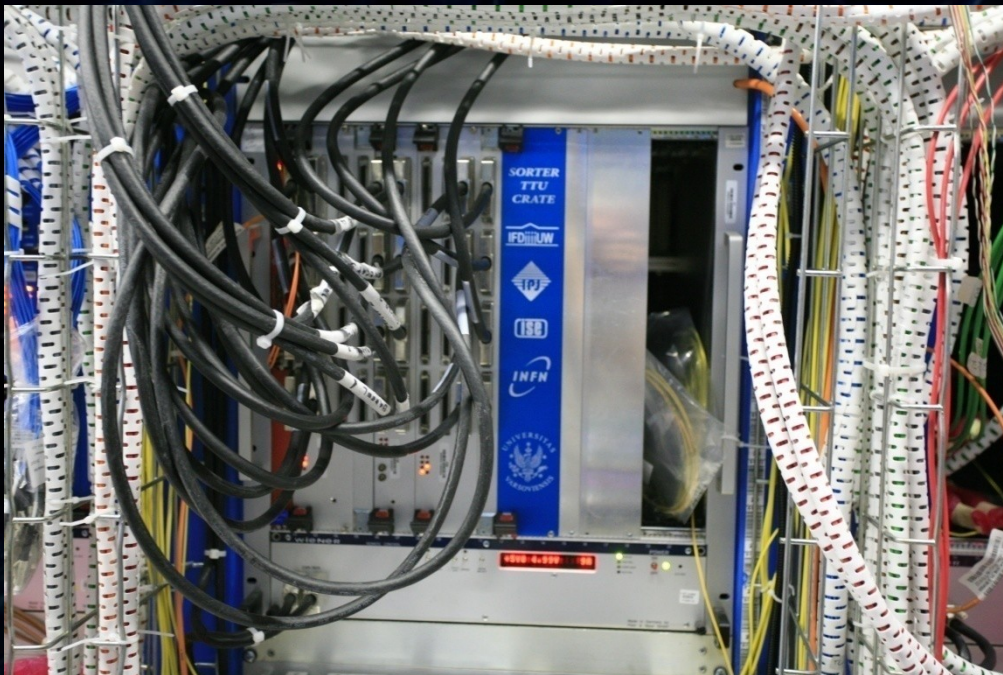
- Muon trajectory measurement in the endcaps
- Gaseous detector with layers of anode wires and cathode strips



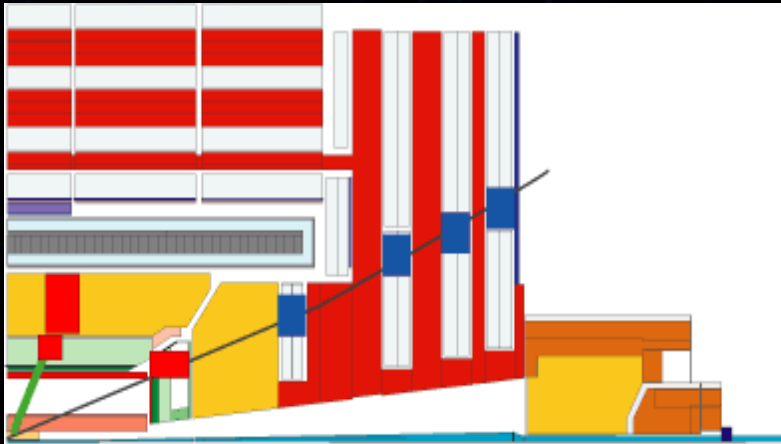
Resistive Plate Chambers (RPC)



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

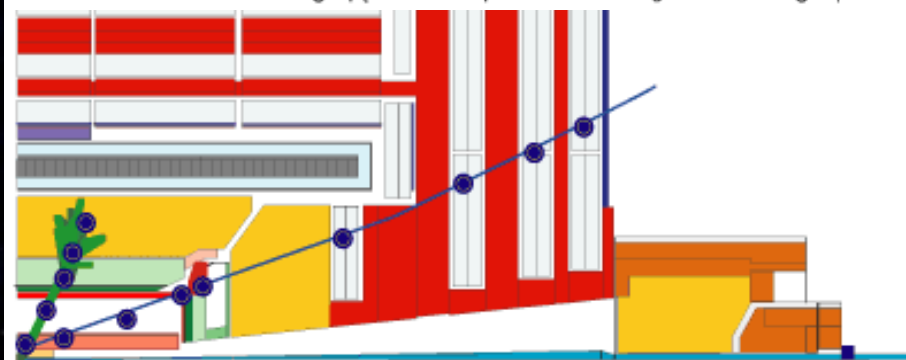


Trigger



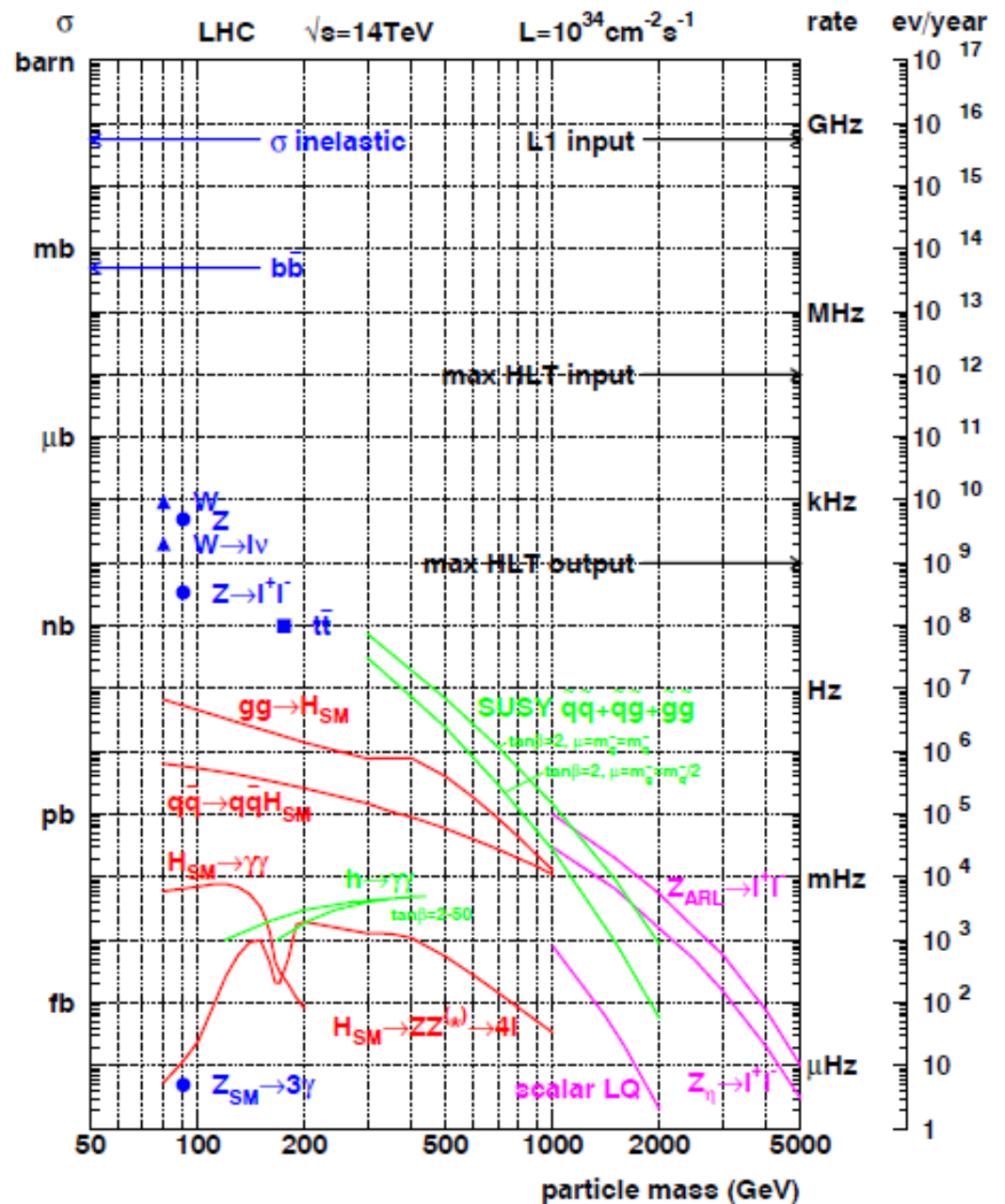
Level-1 trigger. 40 MHz input :

- 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



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1998

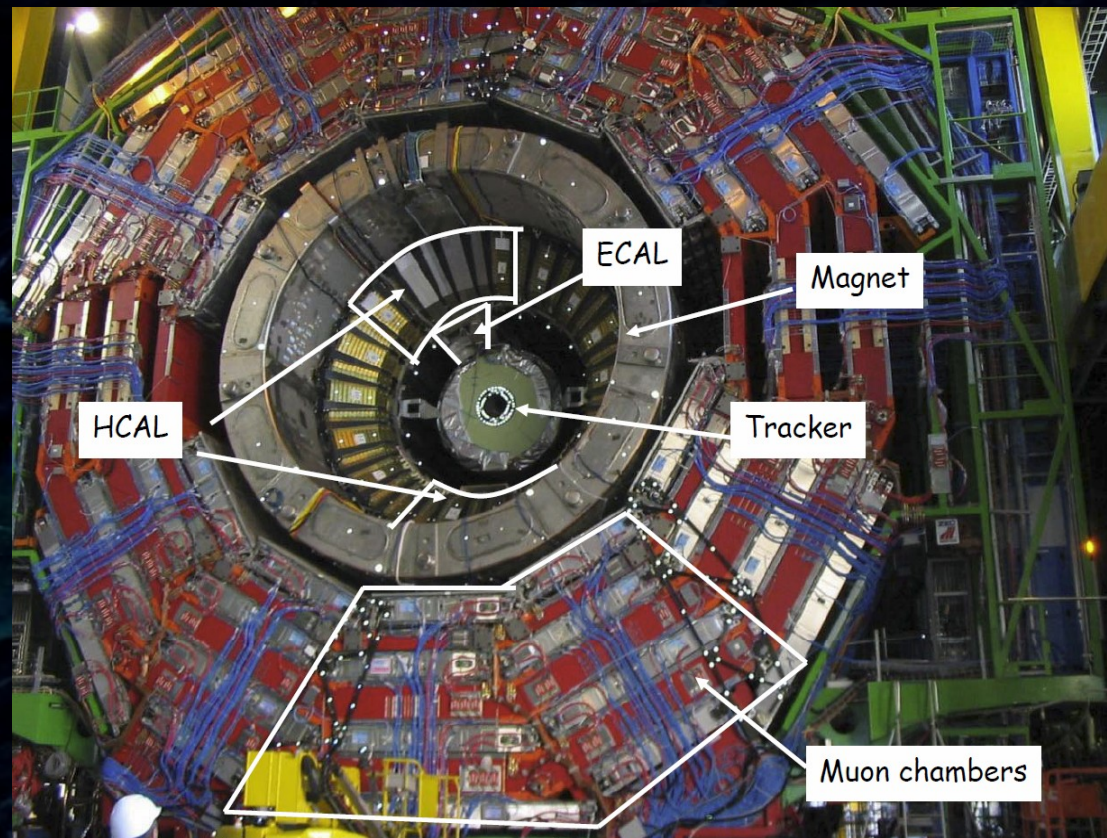
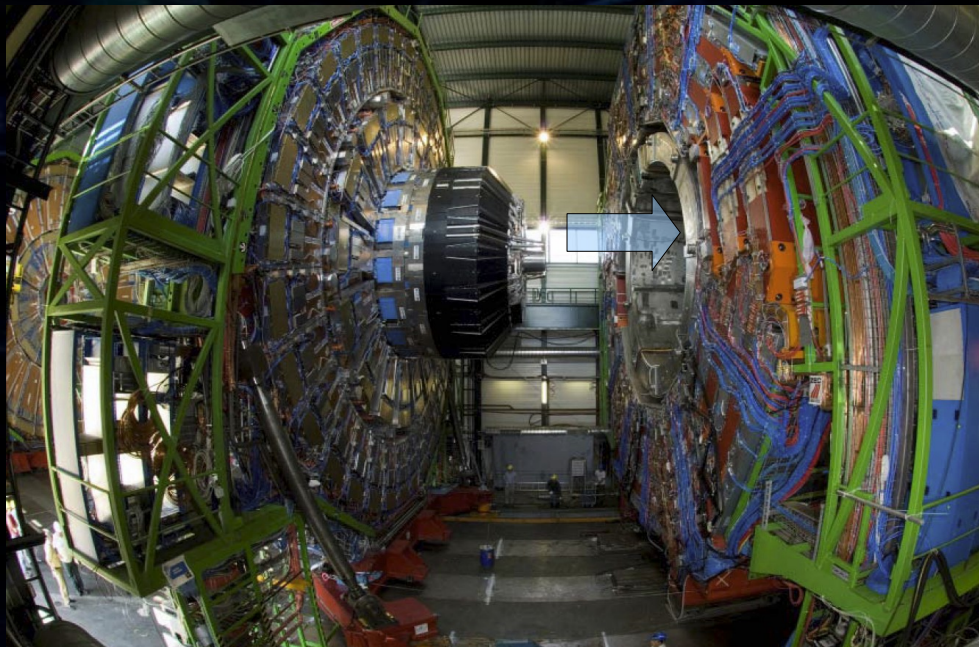


2000

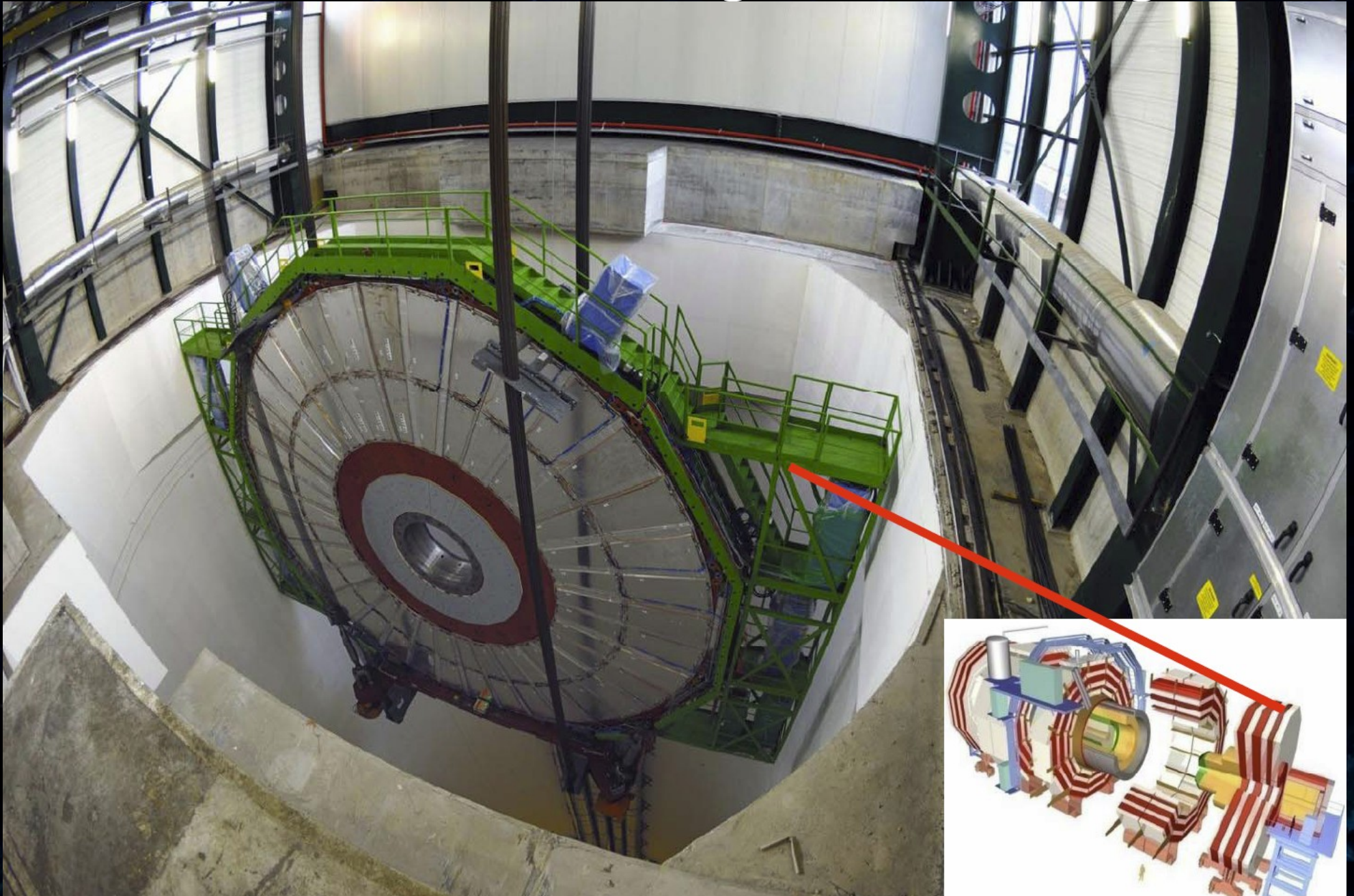


2006

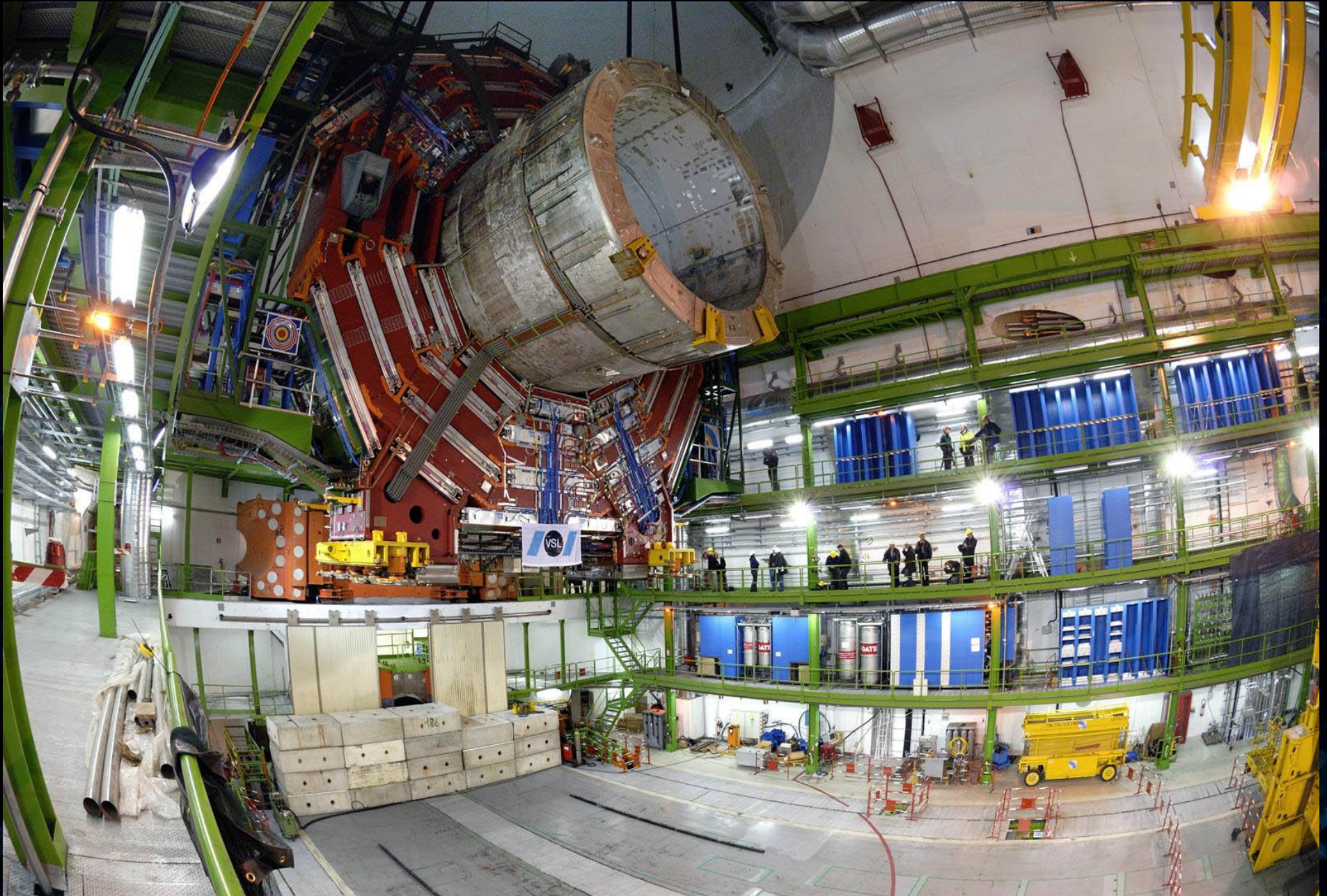
- The detector was assembled and operated still in the surface hall
- MTCC - Magnet Test and Cosmic Challenge



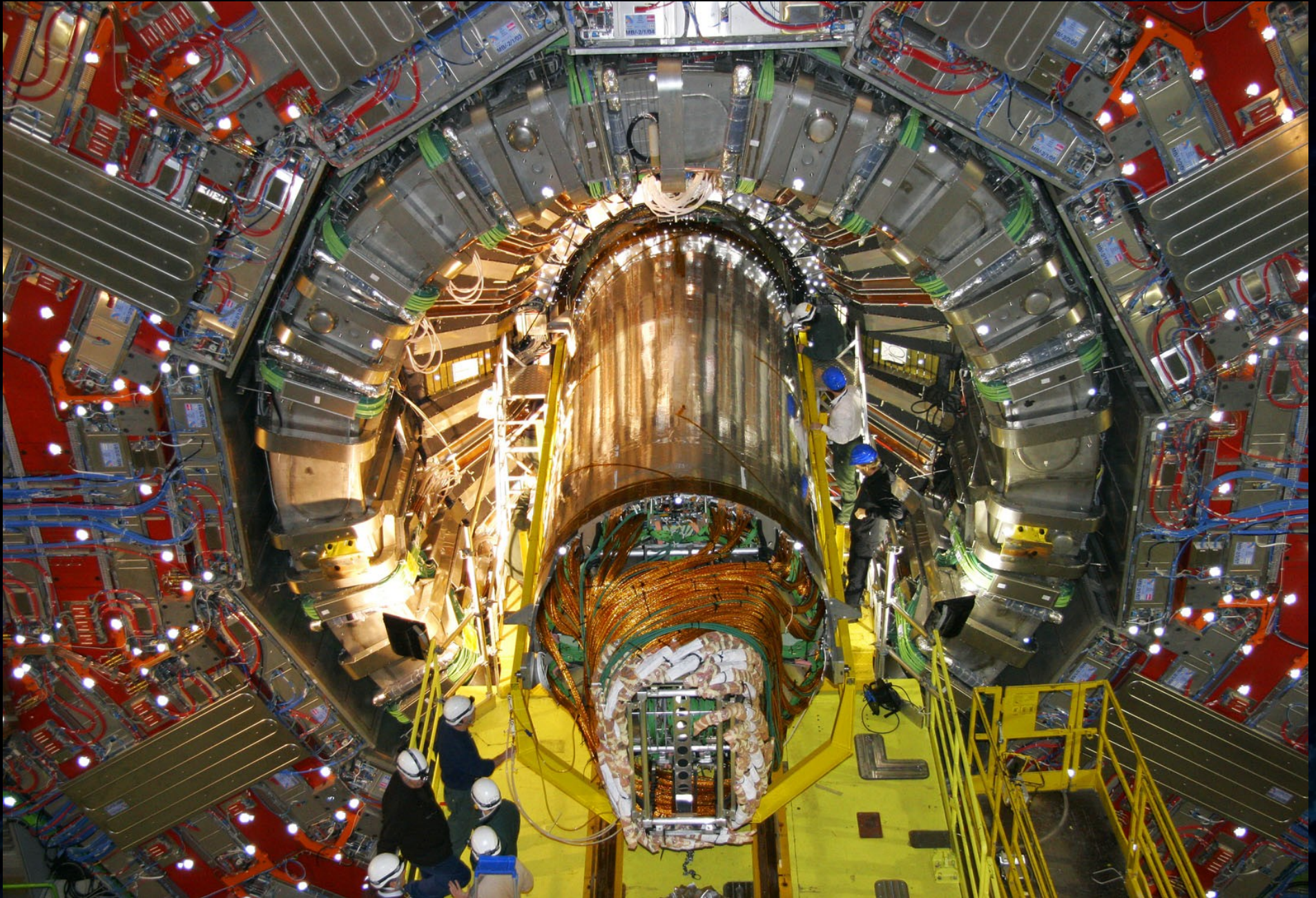
End of 2006 - lowering 100m underground



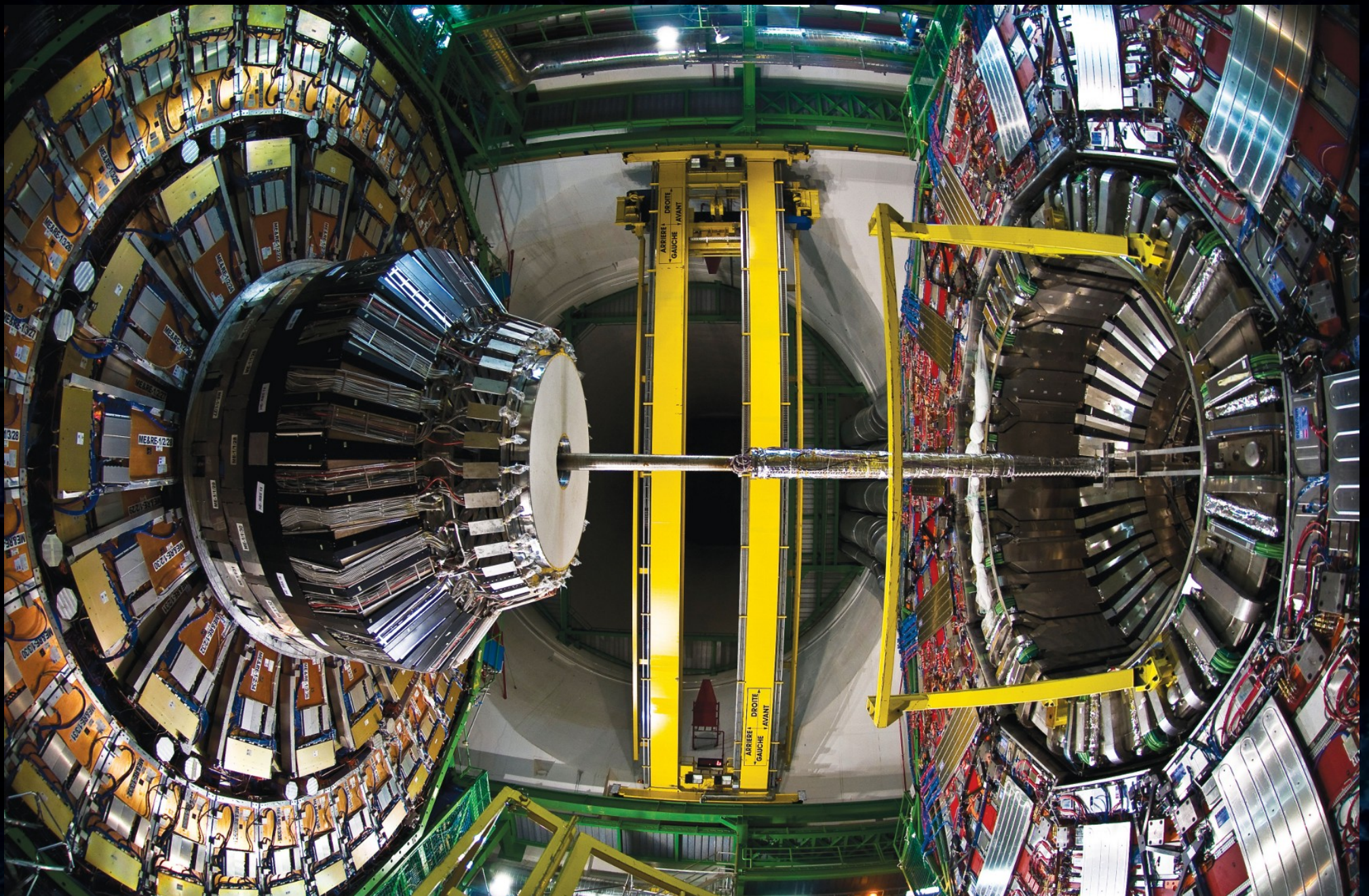
Feb 2007 - lowering the central wheel



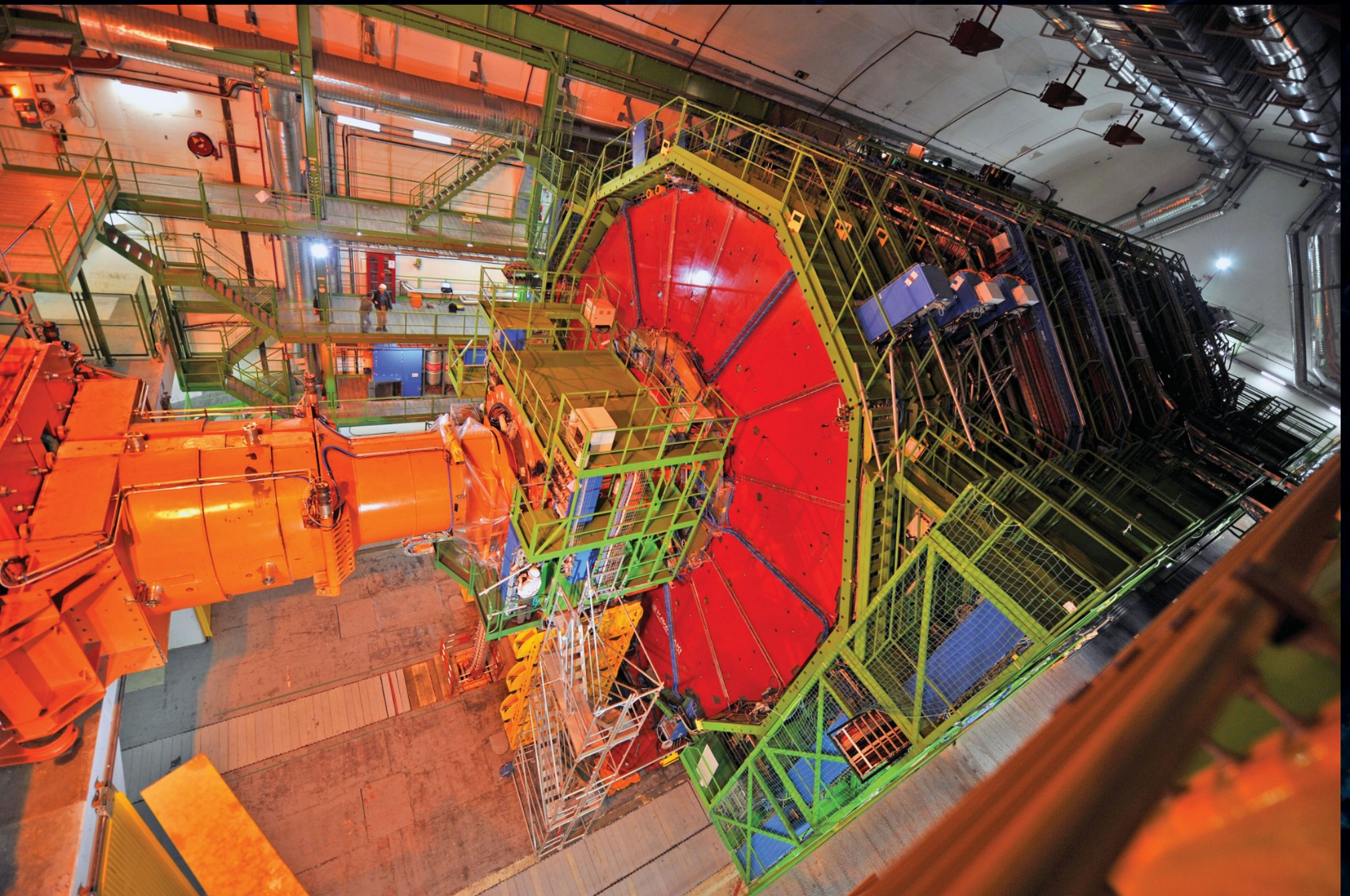
March 2008 - inserting the Tracker



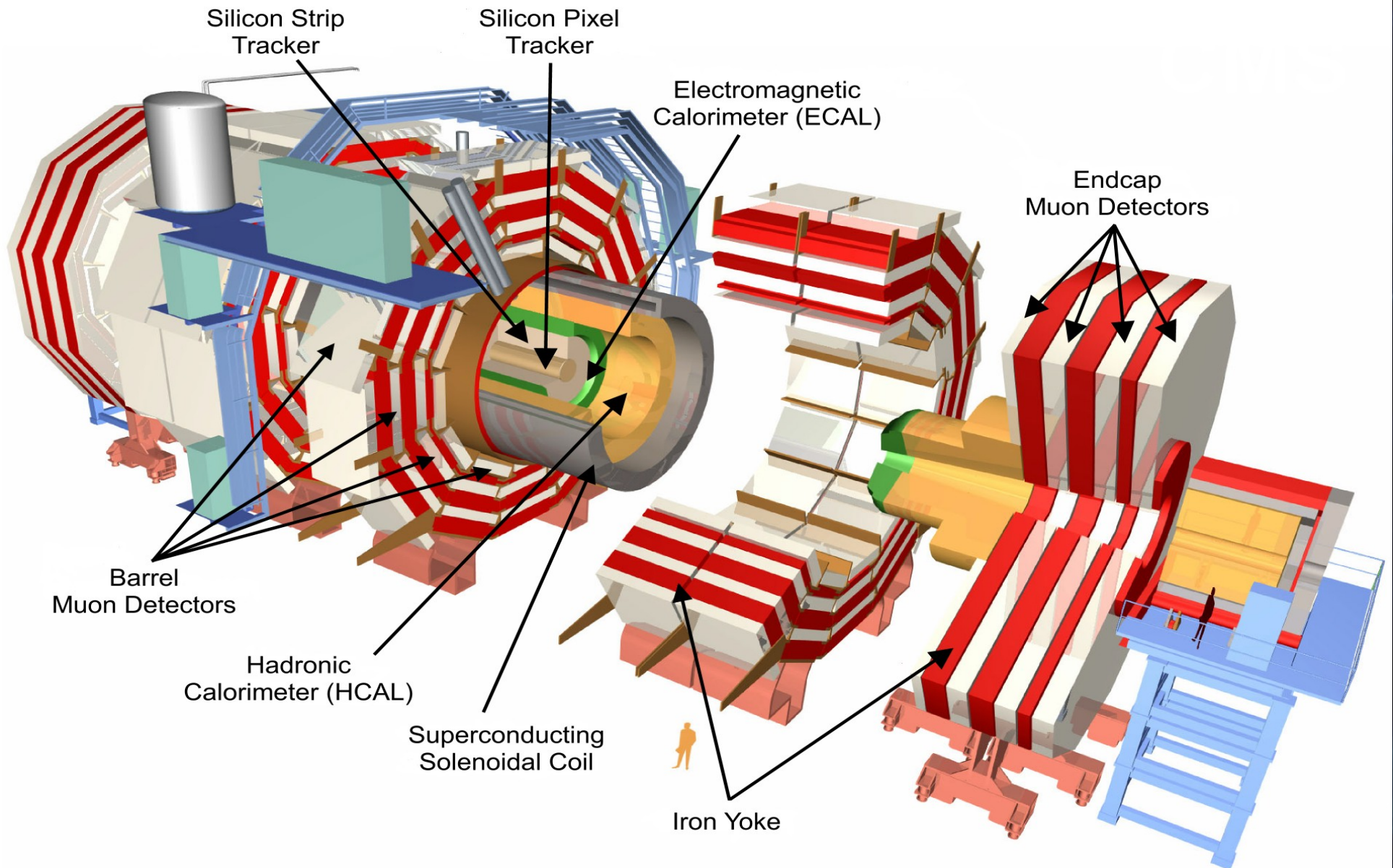
June 2008 - installation of the beam pipe



Sept 3rd, 2008 - Final closure



Once more:



The End

