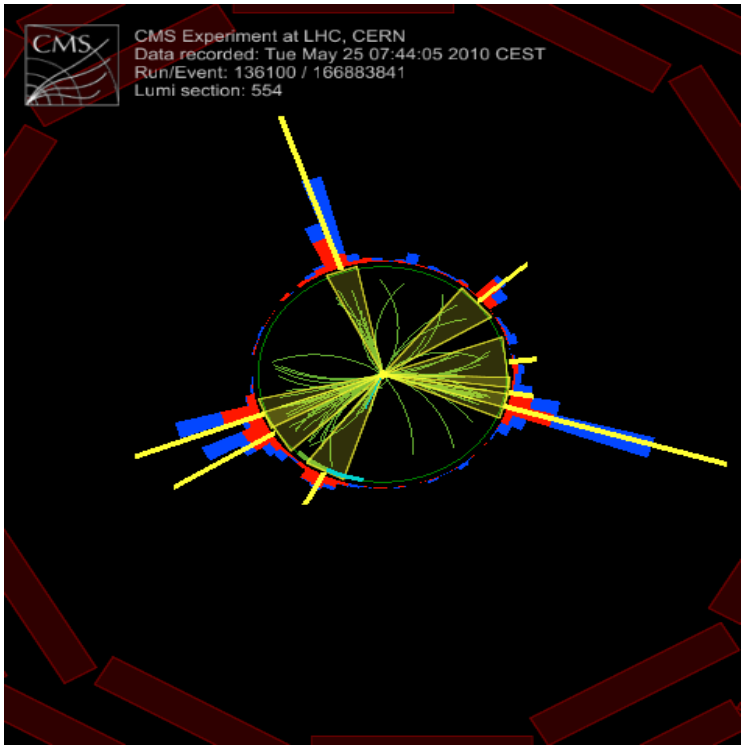
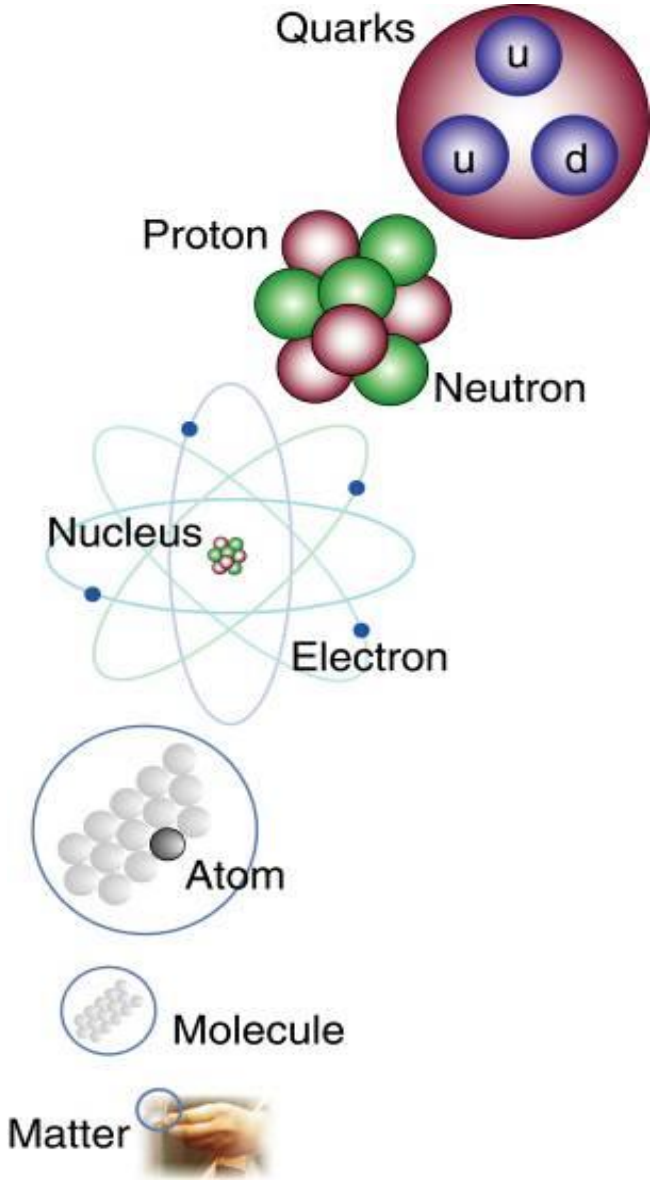
Introduction to CMS

Alexi Mestvirishvili
University of Iowa and CERN



October 2014 Georgian
teachers program

The study of elementary particles, fields and their interactions



matter particles

	1st gen.	2nd gen.	3rd gen.
QUARK	u up	c charm	t top
	d down	s strange	b bottom
LEPTON	ν_e e neutrino	ν_μ μ neutrino	ν_τ τ neutrino
	e electron	μ muon	τ tau

Gauge particles

Strong Force
g Gluon x8

Electro-Magnetic Force
γ photon

Weak Force
W^+ W^- W bosons
Z Z boson

scalar particle(s)
H Higgs ? ? • • •

Elements of the Standard Model

Basic principles

Need "general-purpose" experiment covering as much of the solid angle as possible ("4π") since we don't know how New Physics will manifest itsel

Detectors must be able to detect as many particles and signatures as possible: e, μ, τ, ν, γ, jets, b-quarks, ….

Momentum / charge of tracks and secondary vertices (e.g. from b-quark decays) are measured in central tracker (Silicon layers).

Energy and positions of electrons and photons measured in high resolution electromagnetic calorimeters. (~ 0.5% @ E_T ~ 50 GeV)

Energy and position of hadrons and jets measured mainly in hadronic calorimeters

Muons identified and momentum measured in external muon spectrometer (+central tracker) dp/p<1% @ 100GeV and <10%@1 TeV

Neutrinos "detected and measured" through measurement of missing transverse energy (E_T^{miss}) in calorimeters (hermeticity; good Missing Et resolution)

The Compact Muon Solenoid (CMS)

SUPERCONDUCTING COIL

CALORIMETERS

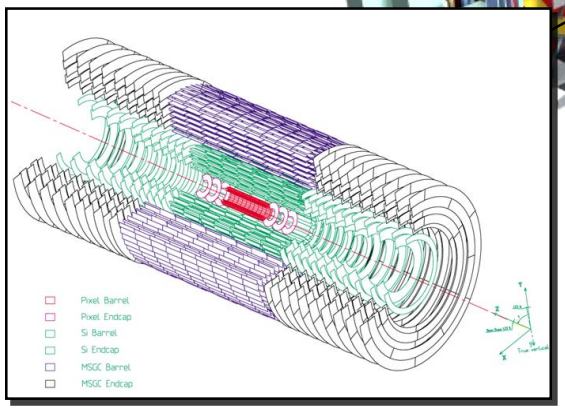
ECAL Scintillating $PbWO_4$ Crystals

HCAL Plastic scintillator copper sandwich

Total weight : 12,500 t
Overall diameter : 15 m
Overall length : 21.6 m
Magnetic field : 4 Tesla

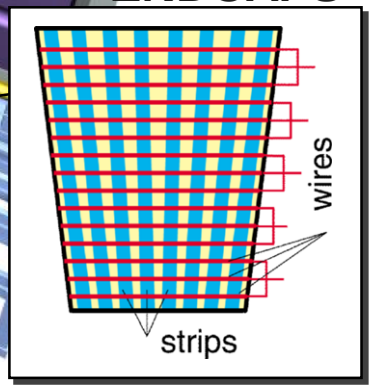
IRON YOKE

TRACKERs

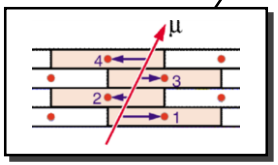


Silicon Microstrips
Pixels

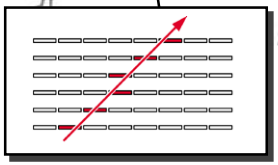
MUON ENDCAPS



MUON BARREL



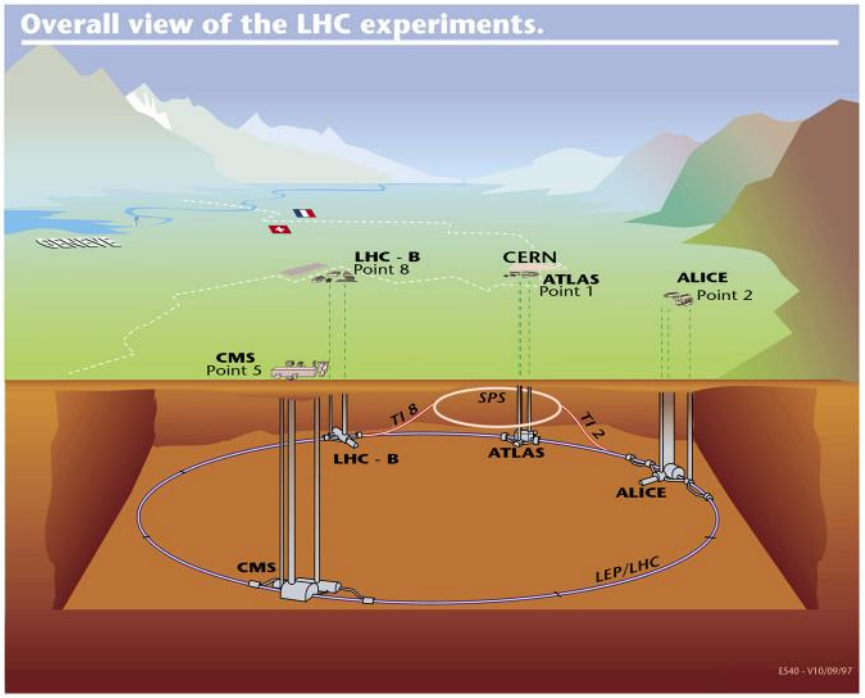
Drift Tube Chambers (**DT**)



Resistive Plate Chambers (**RPC**)

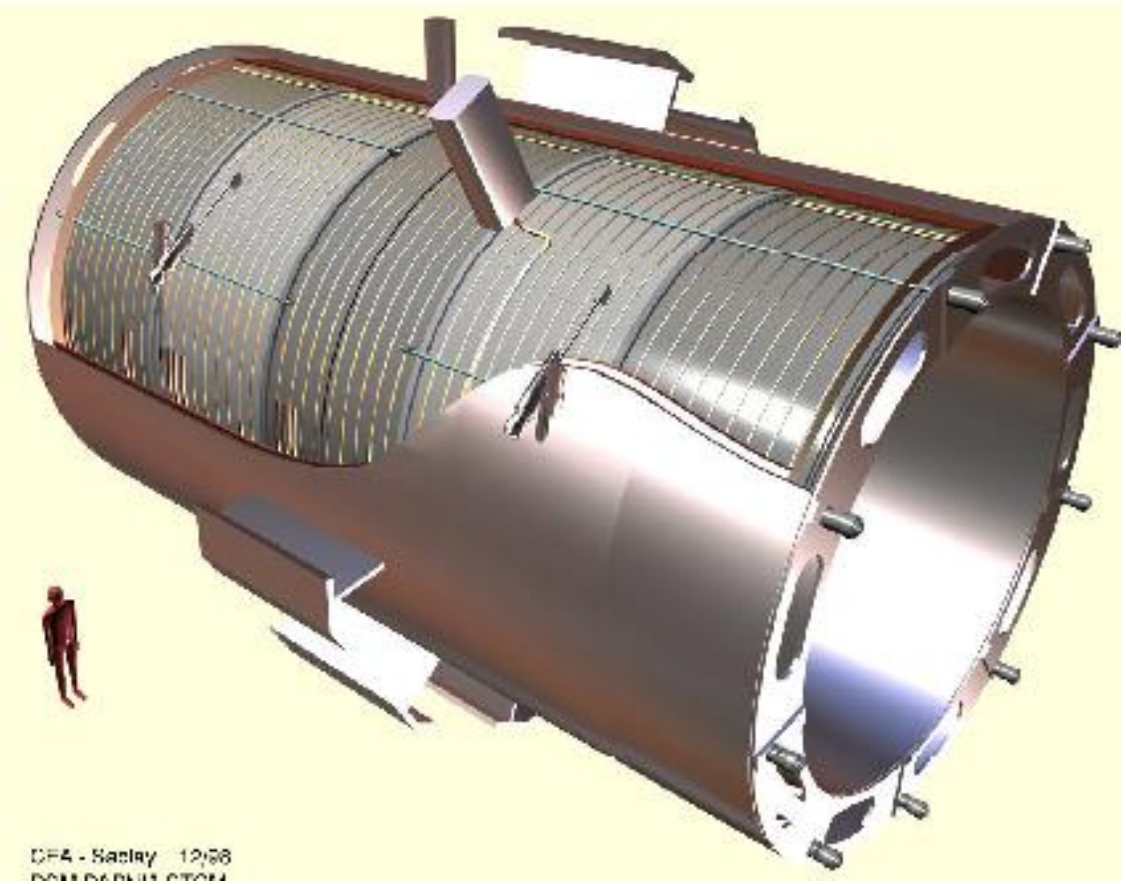
Cathode Strip Chambers (**CSC**)
Resistive Plate Chambers (**RPC**)

Total weight : 14,000 t
Overall diameter : 15 m
Overall length : 21.6 m

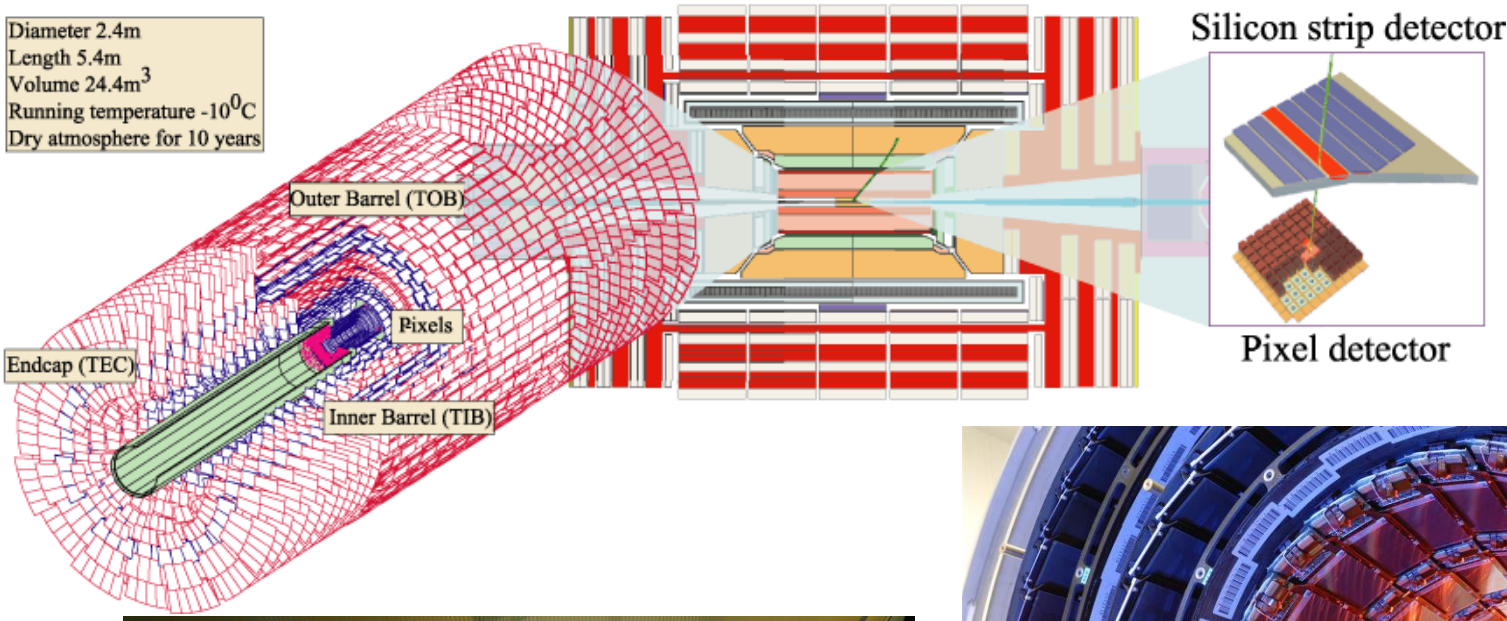


The Large Solenoidal Magnet of CMS

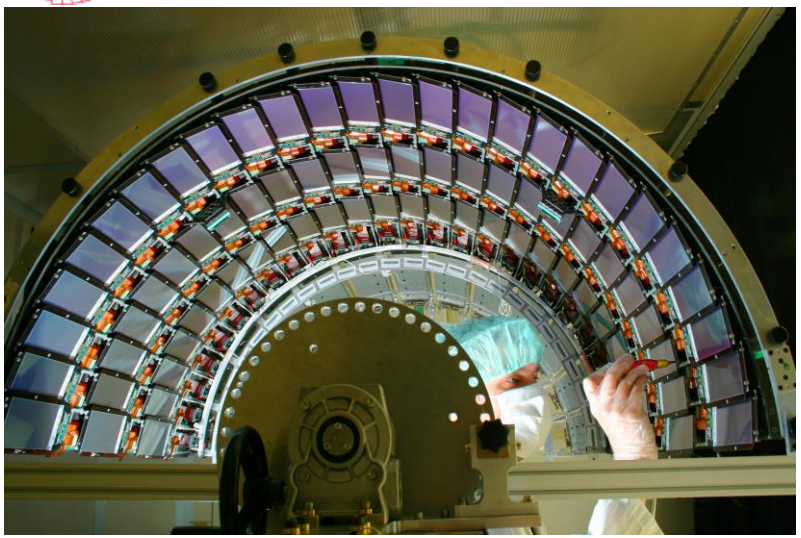
- Current of 20kA: Superconducting (NbTi) cable inside a huge cryostat operated at ~4K. B=4T
- Huge dimensions: 6m diameter x 12.5m length (built in 5 modules).

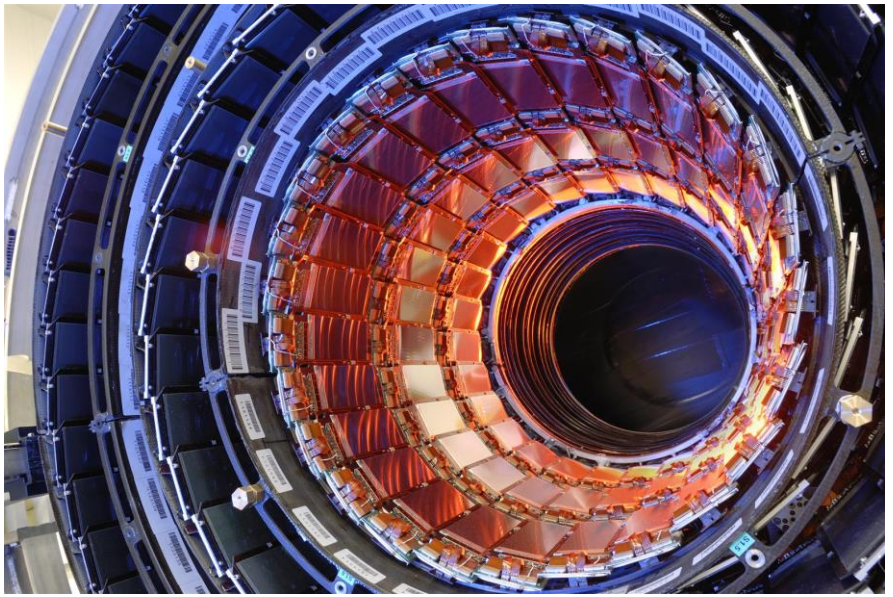


The Silicon Tracker.

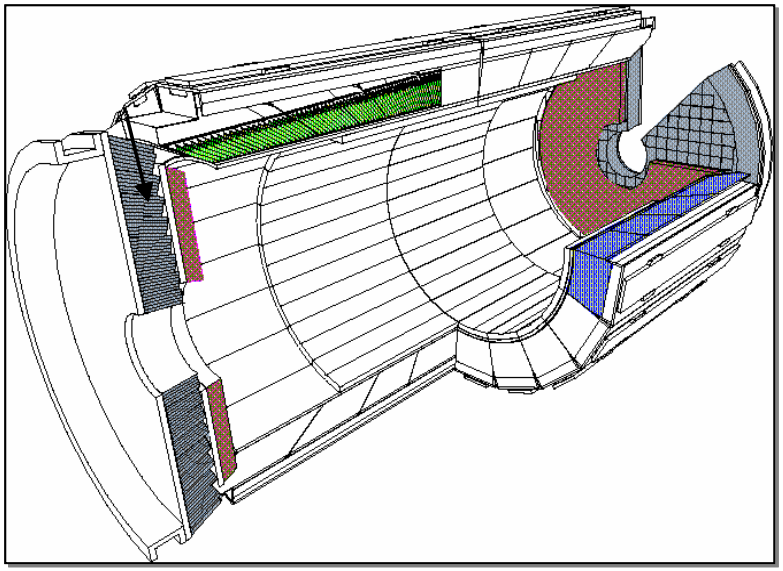


13 layers, 207 m^2,
10.6 M microstrips
and 65.9 M pixel

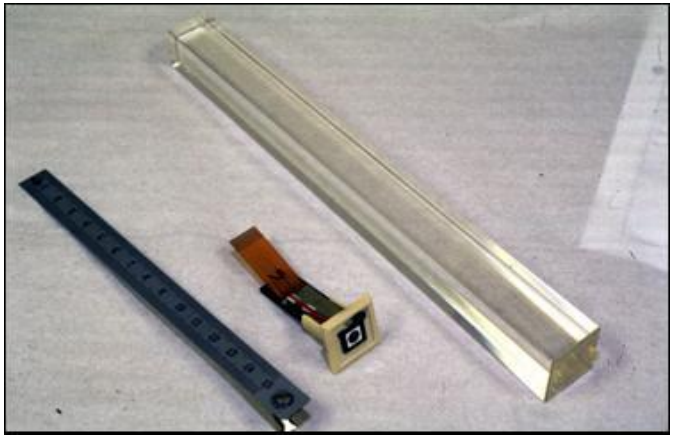


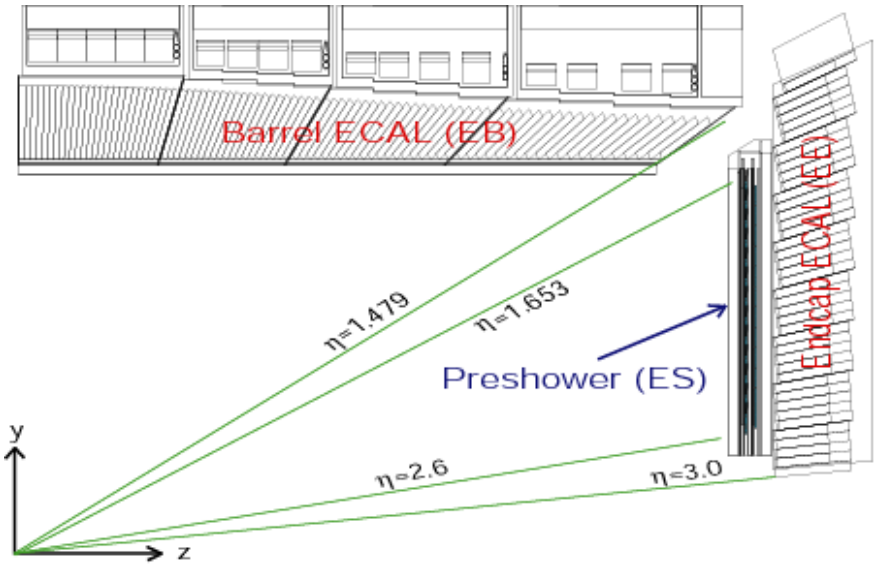


The Electromagnetic Calorimeter ECAL



Characteristics of $PbWO_4$
X_0 = 0.89cm
ρ = 8.28g/cm^3
R_M (Molière radius) = 2.2cm



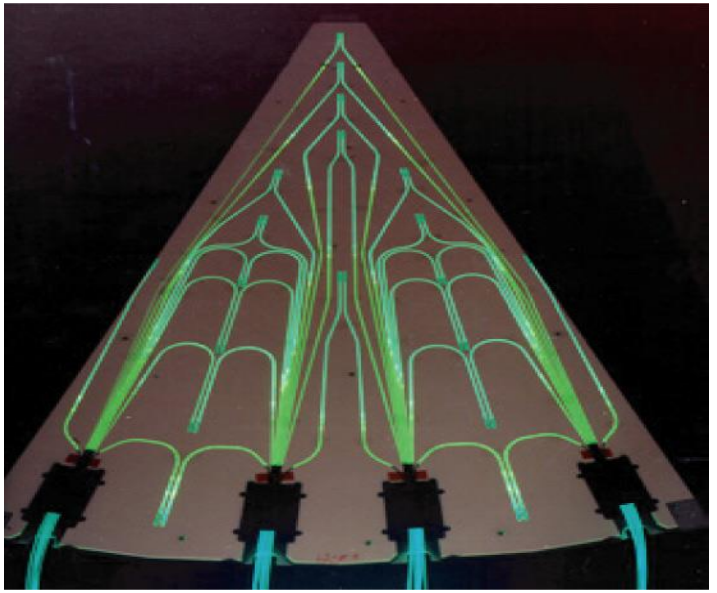


Parameter	Barrel	Endcaps
Coverage	**$\|\eta\|<1.48$**	**$1.48<\|\eta\|<3.0$**
$\Delta\phi$ x $\Delta\eta$	**0.0175 x 0.0175**	**0.0175 x 0.0175 to 0.05 x 0.05**
Depth in X_0	**25.8**	**24.7**
# of crystals	**61200**	**14648**
Volume	**8.14m^3**	**2.7m^3**
Xtal mass (t)	**67.4**	**22.0**

The hadron calorimeter HCAL

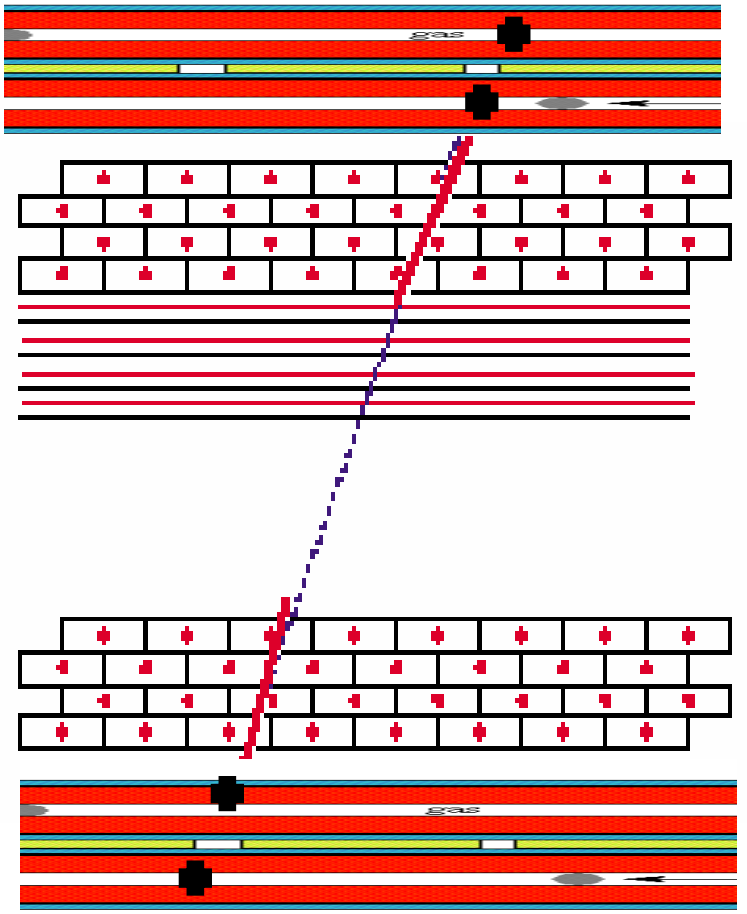
CMS HCAL is constructed in 3 parts:

- Barrel HCAL (HB)
  - Brass plates interleaved wit
  - plastic scintillator embedded with
  - wavelength-shifting optical fibres
  - (photo top right)
- Forward HCAL (HF)
  - Steel wedges stuffed with quartz fibres ~10000 channels total

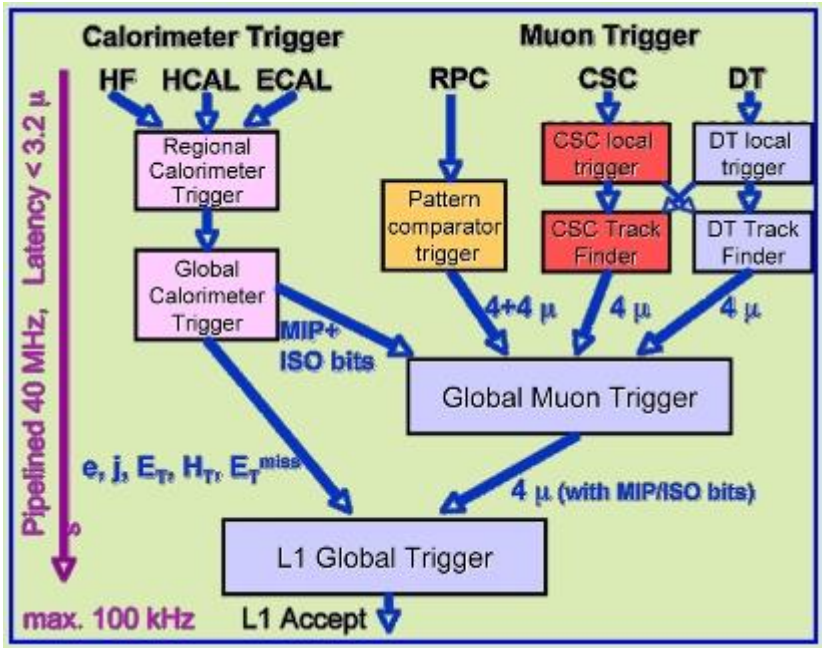


HB and HE

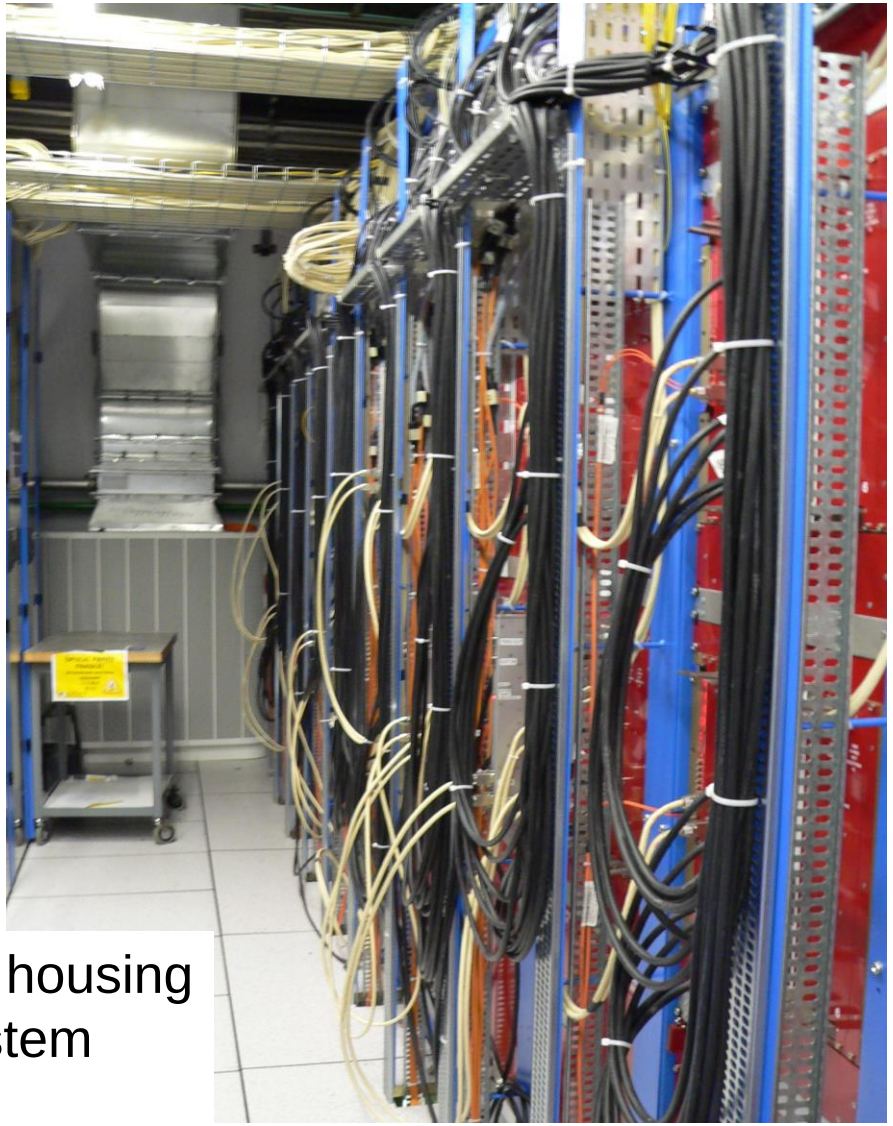
Muon Detectors



CMS trigger system

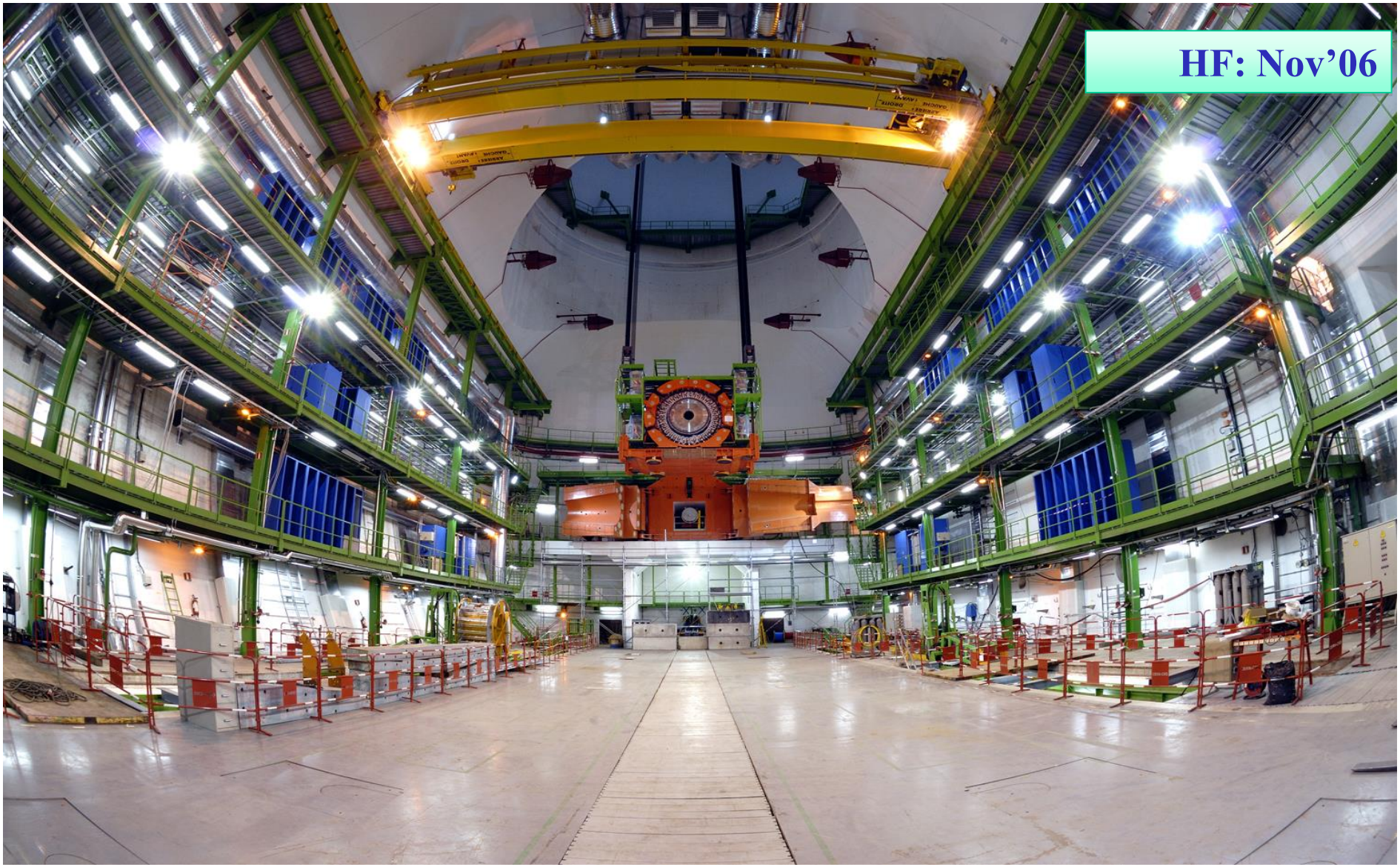


Schematic representation of the trigger system

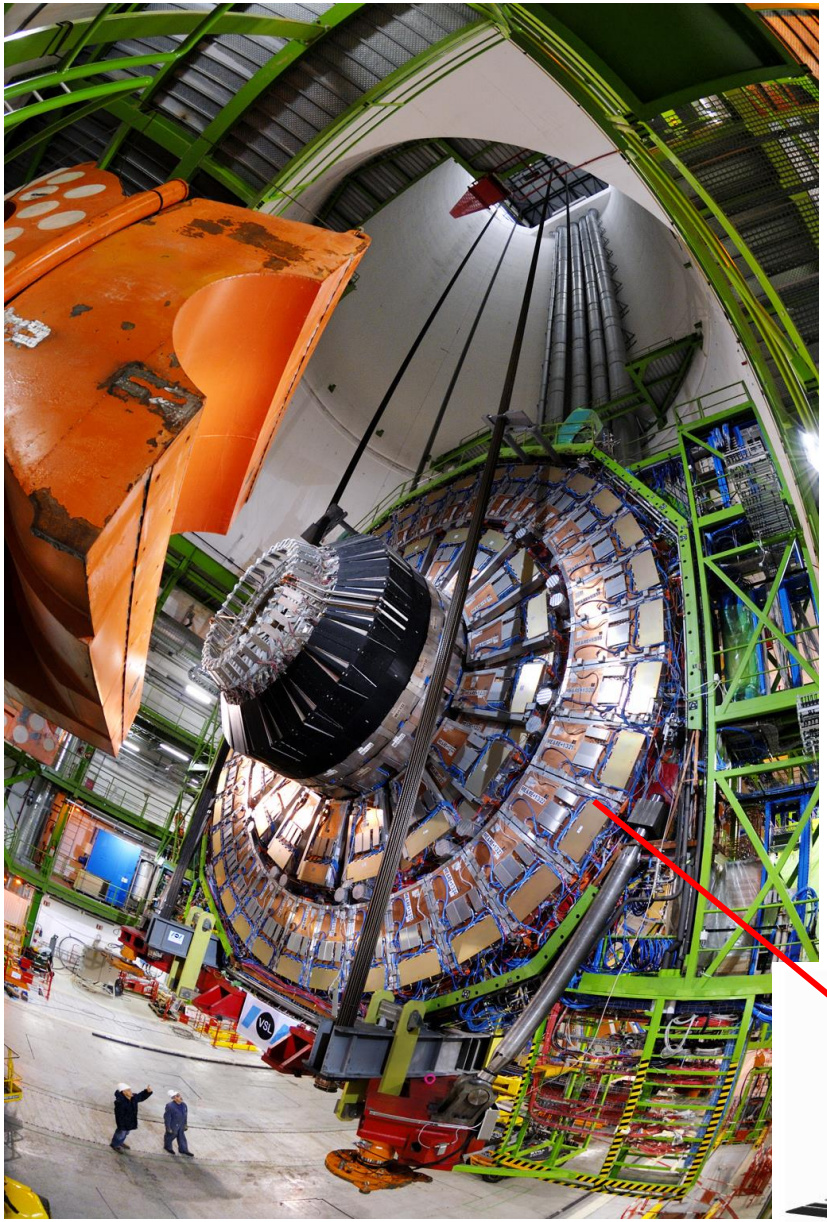


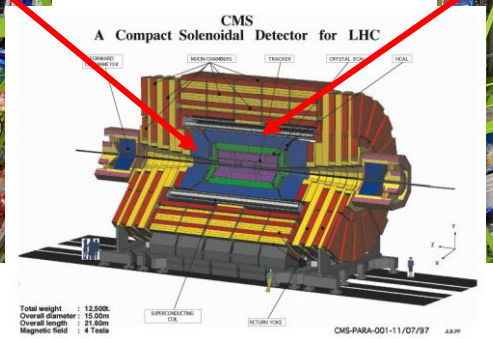
Racks and crates in SC housing FEE and trigger system

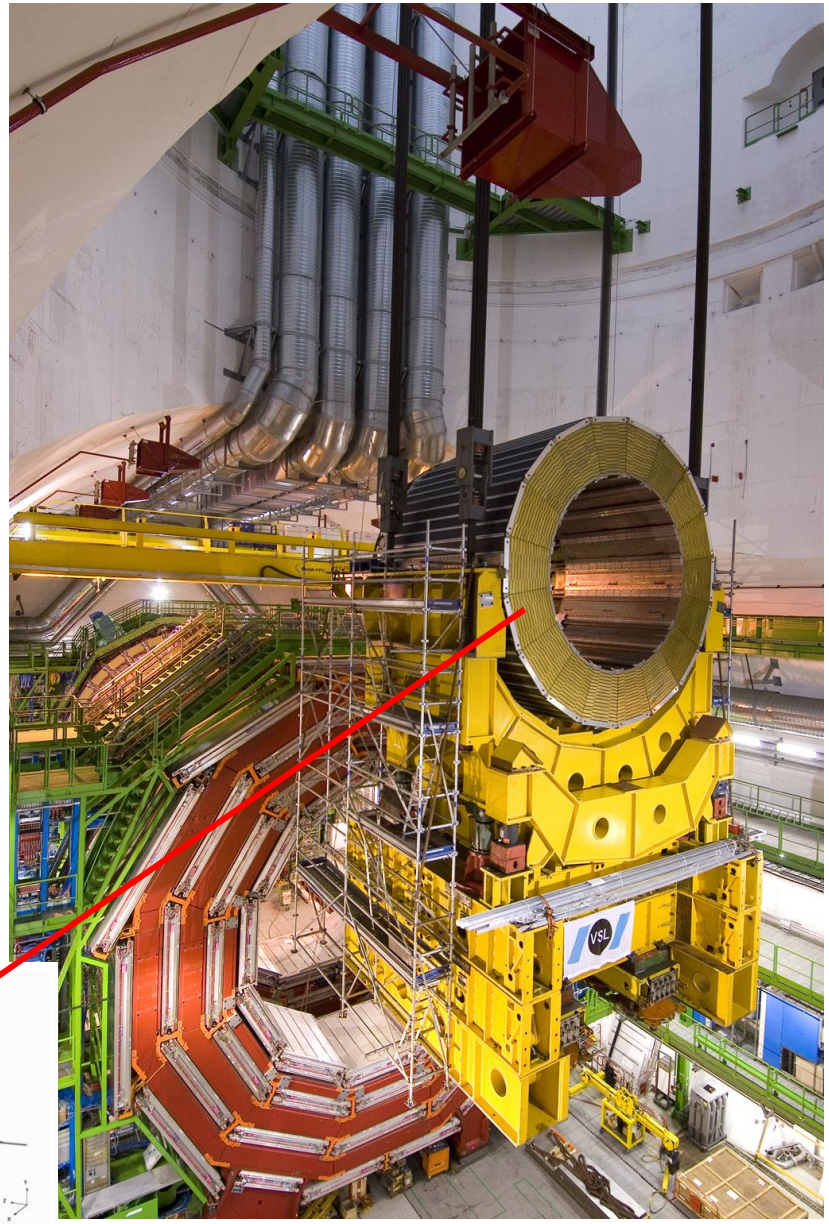
8 years ago.



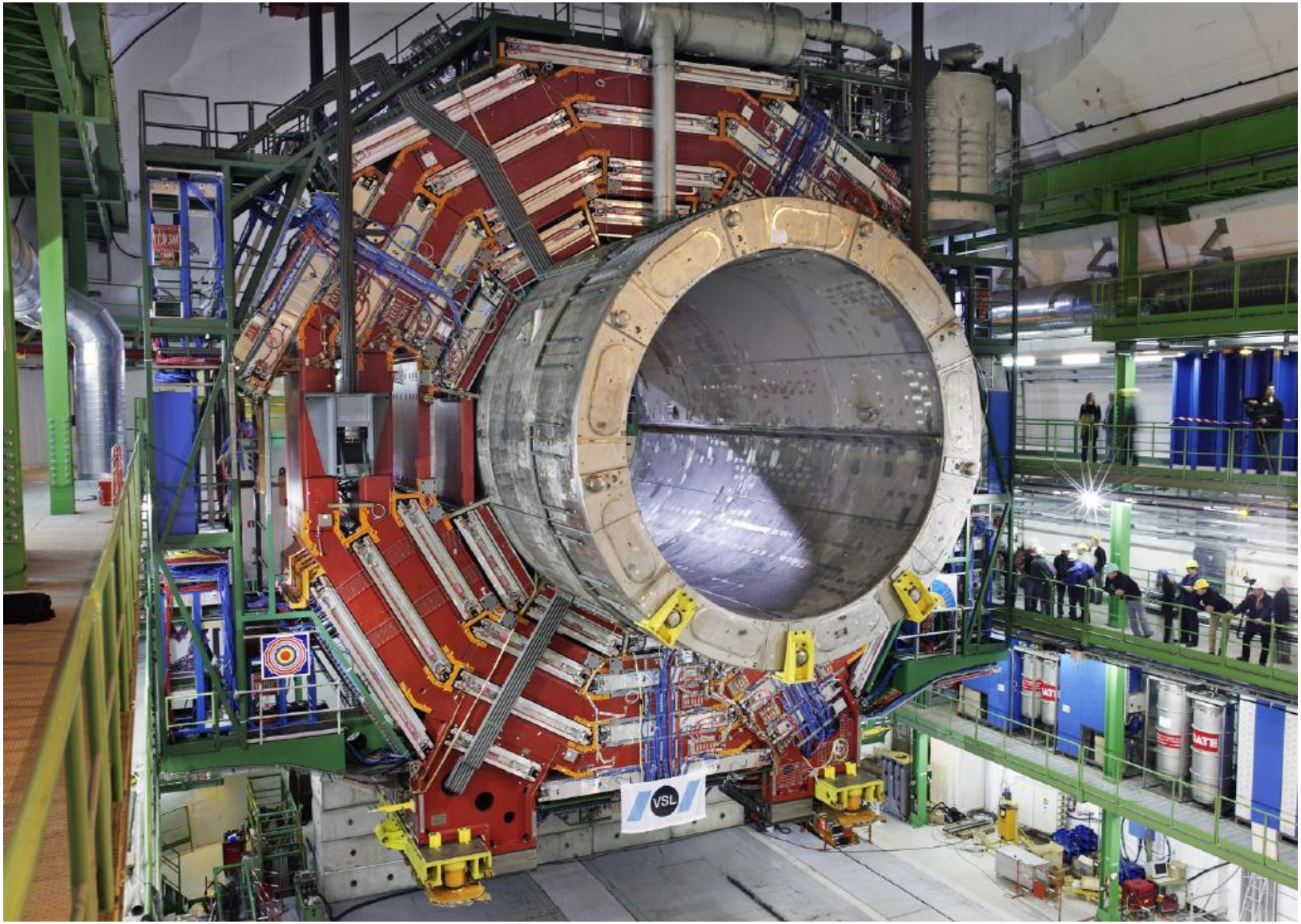
Lowering of YE1 and HB



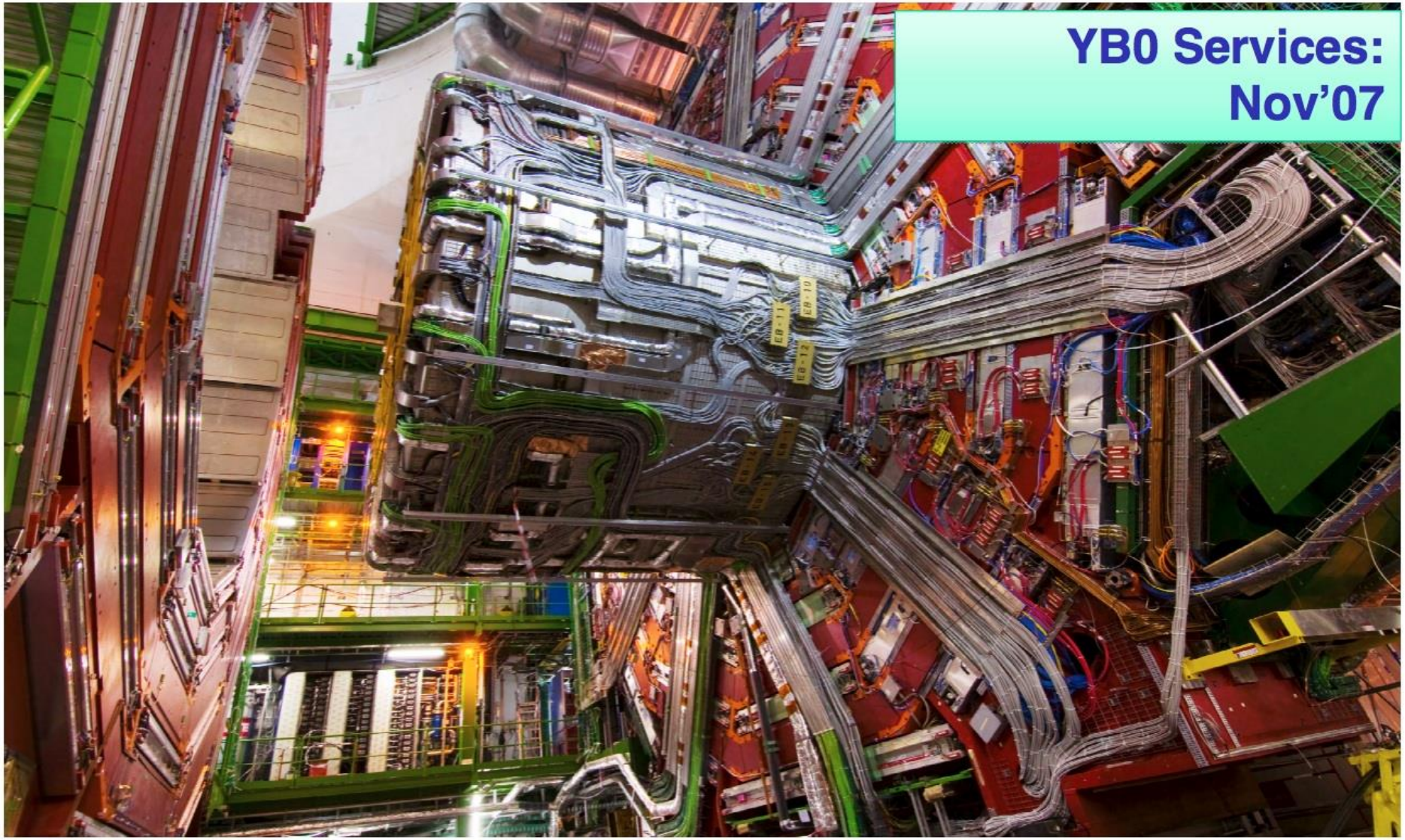




The heart of CMS lands safely (Feb07)

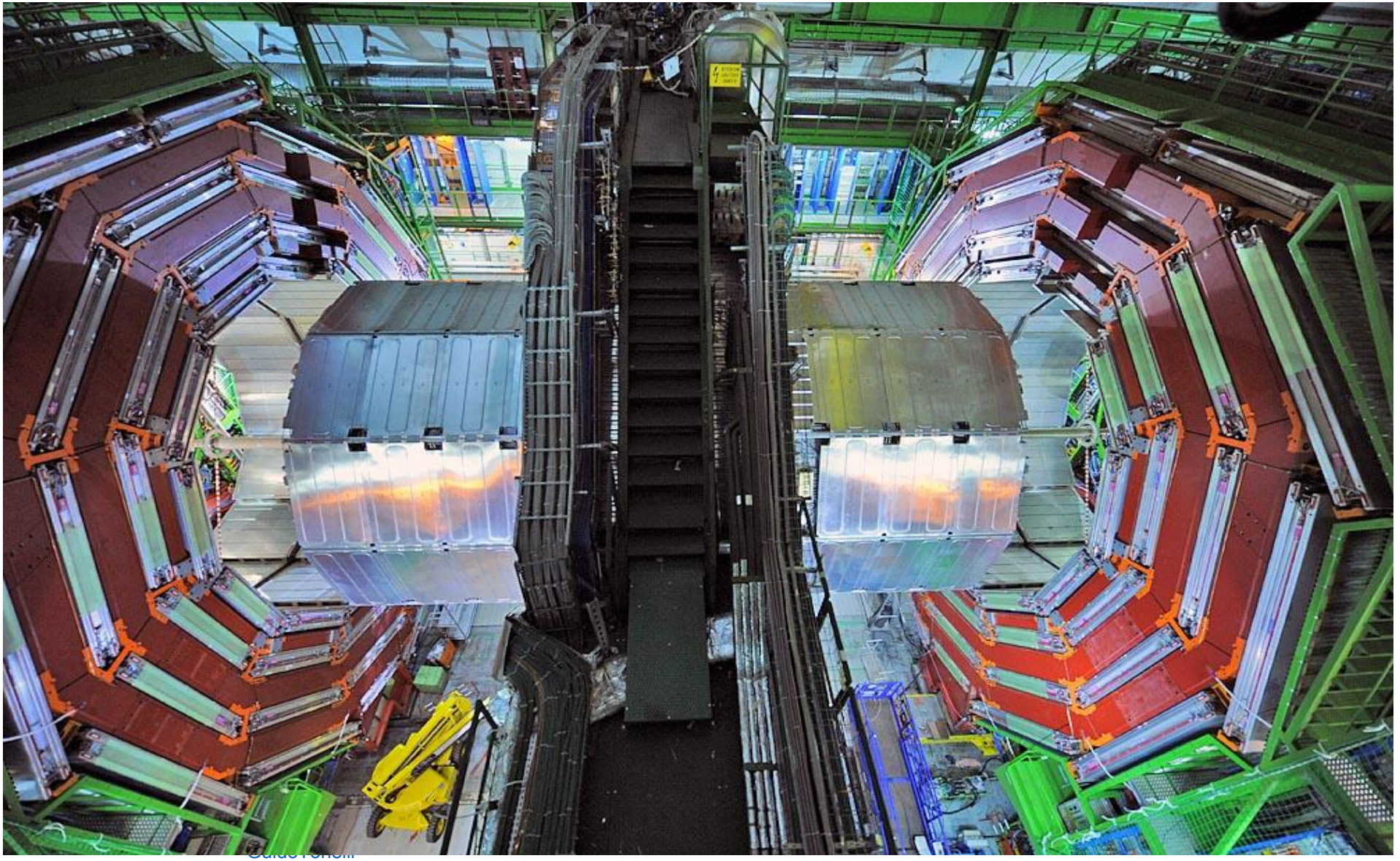


Installation of the services



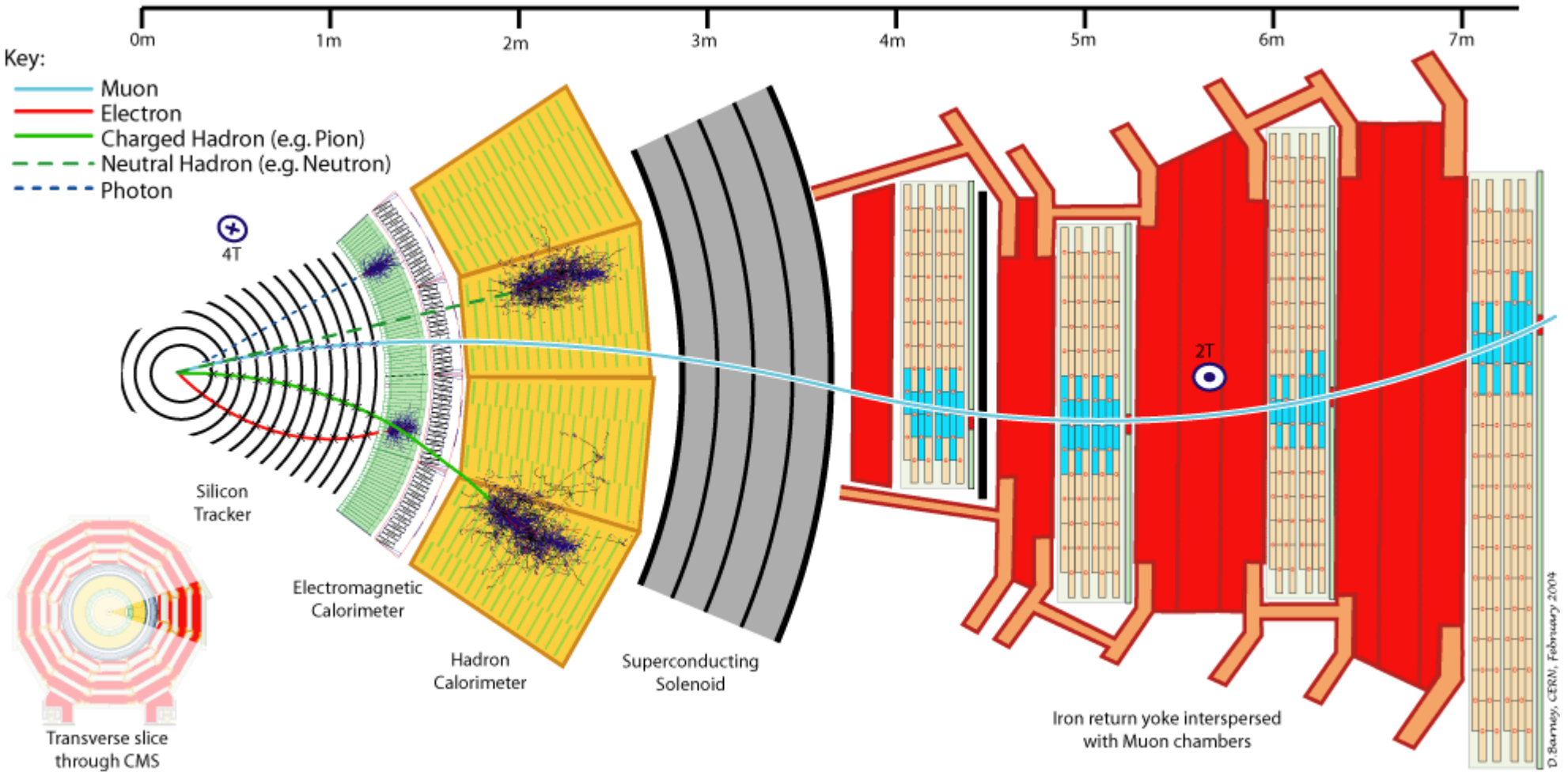
Installation of the tracker

It took 16 years to put everything together

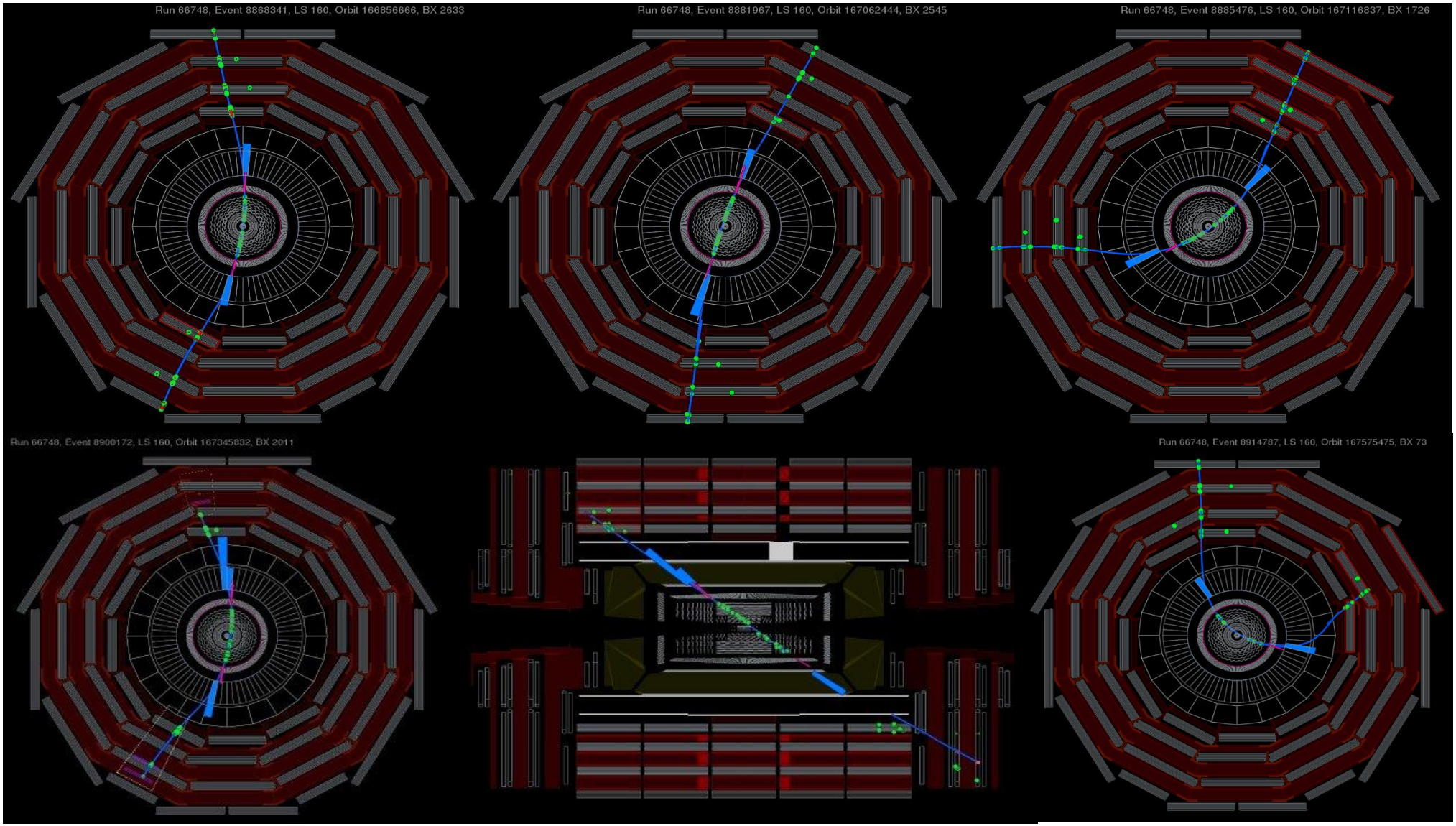


September 08: CMS is ready

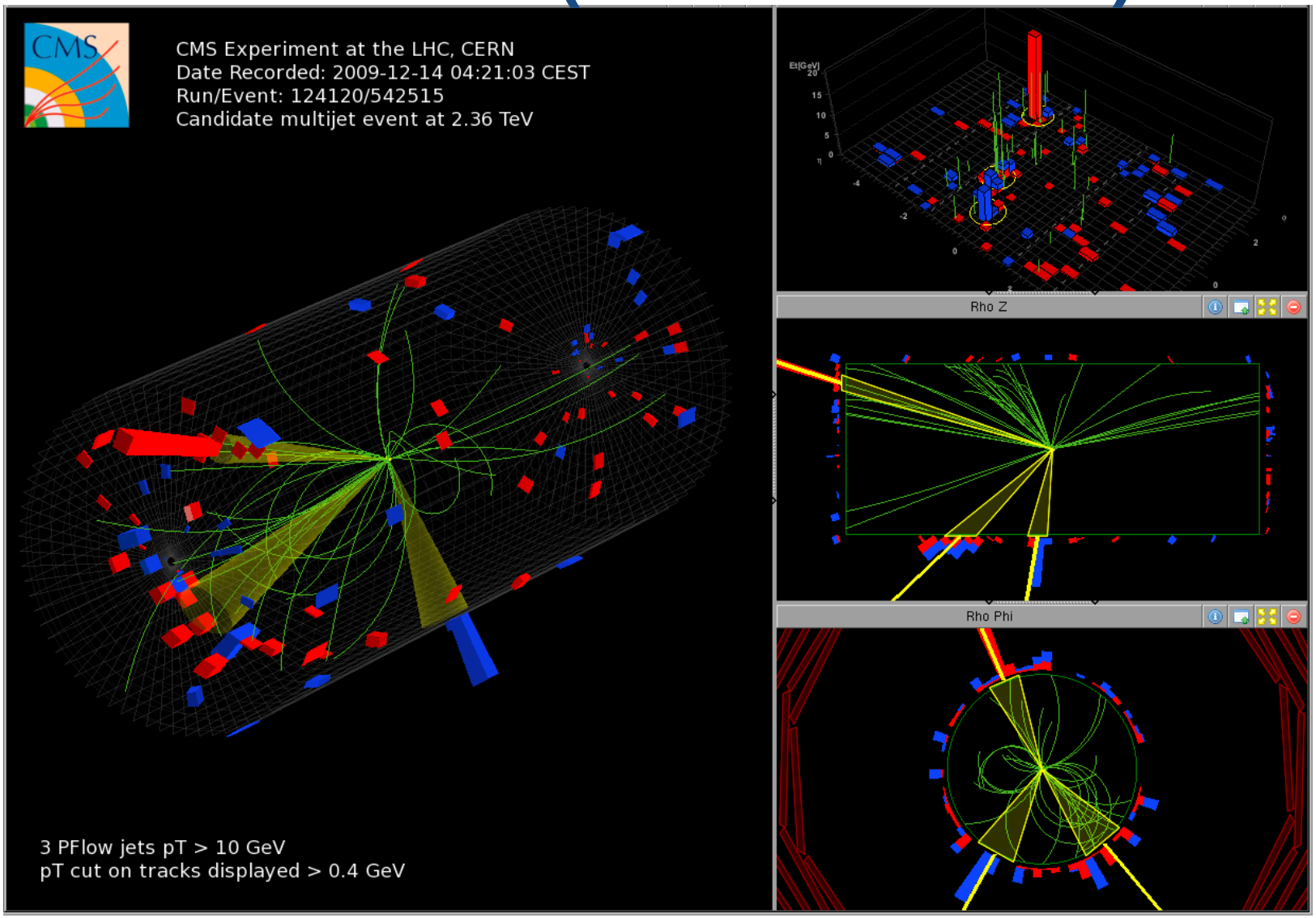
Different particles passing CMS experiment



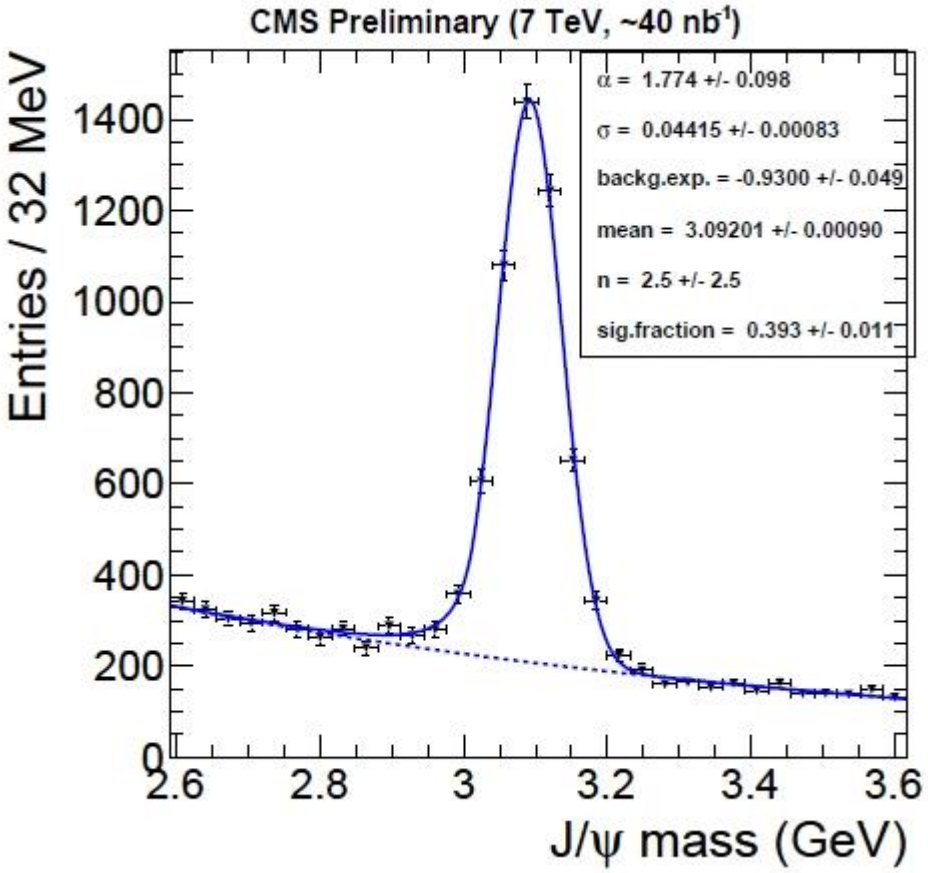
1 billion cosmics were recorded to study the most subtle features of our detector



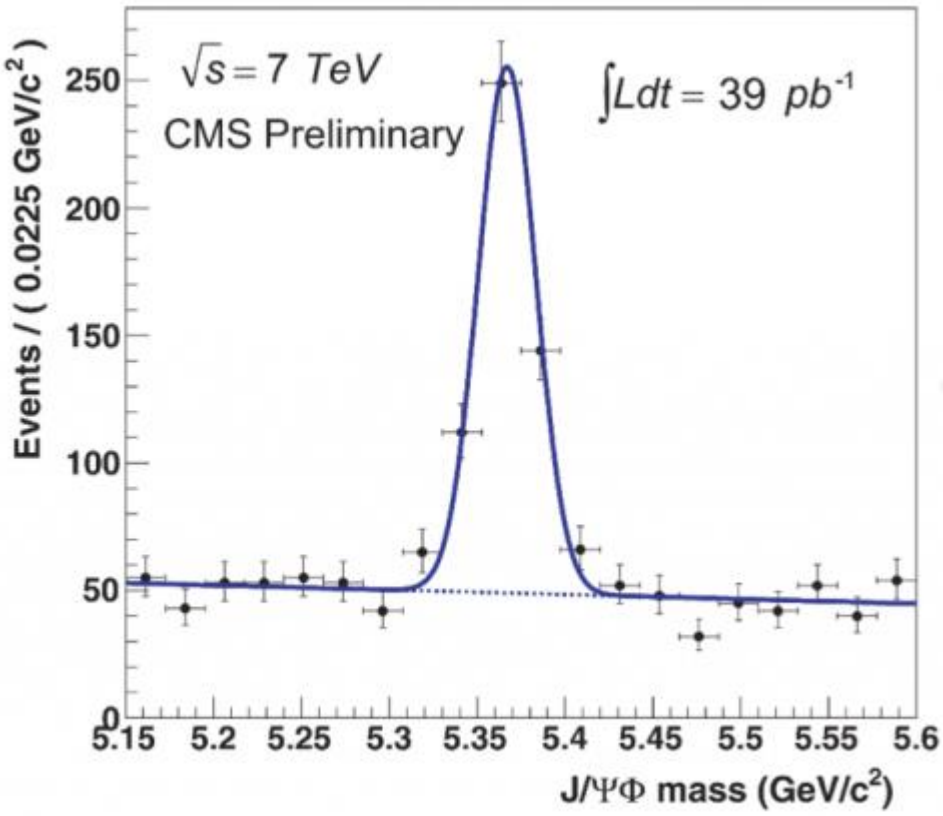
November/December 2009 first LHC collisions (0.9 and 2.36 TeV)



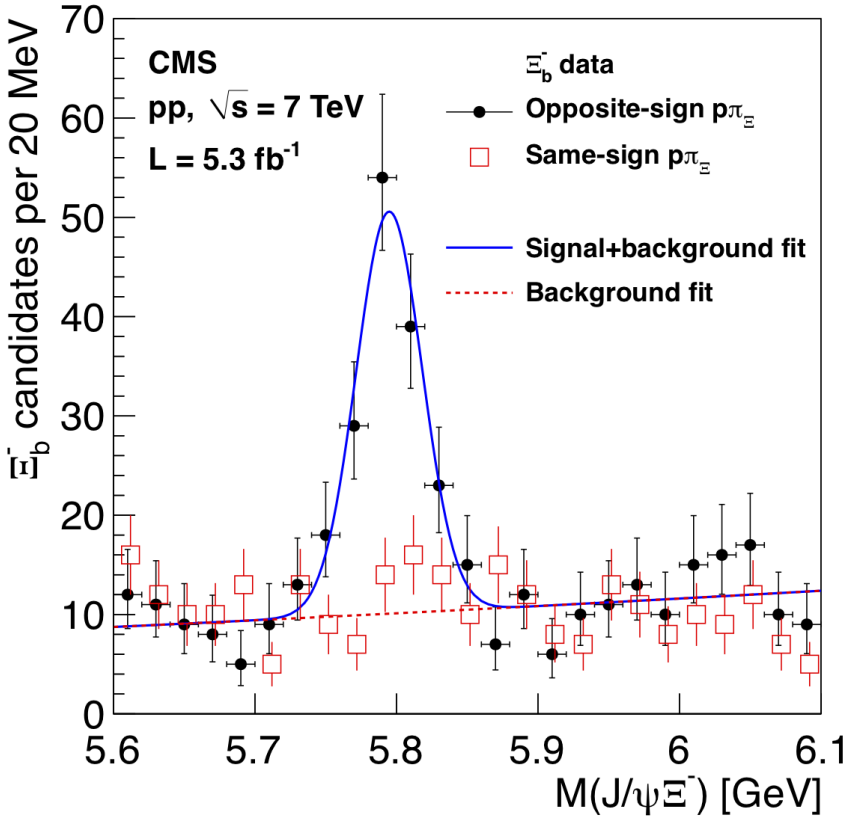
Reconstructed particles using CMS detector



B_s particle

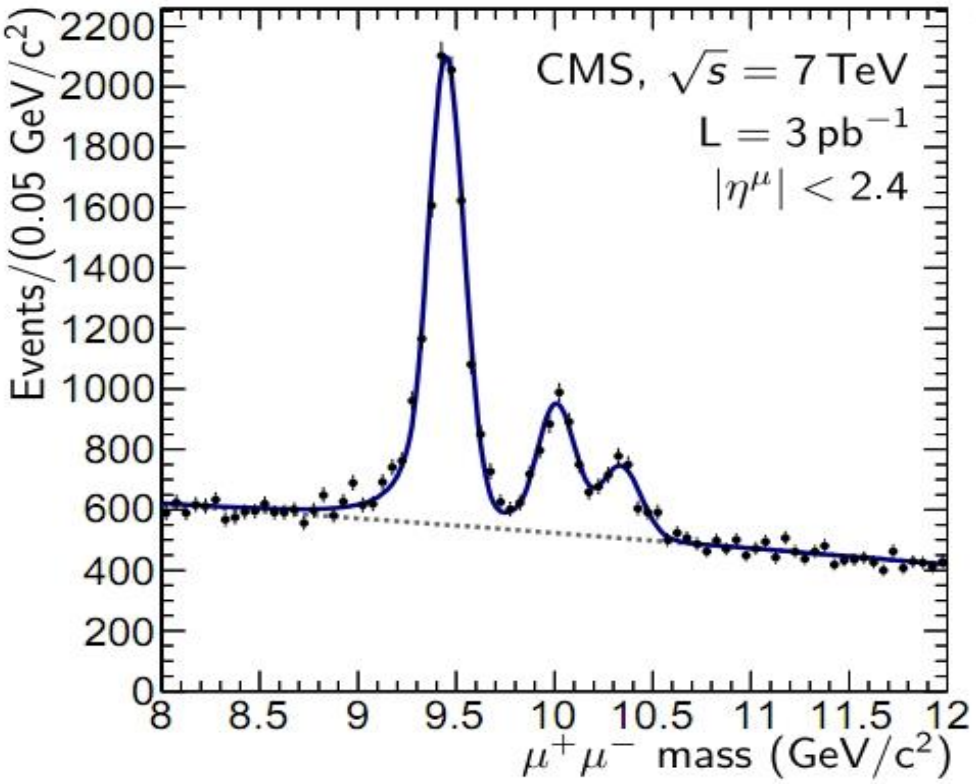


Reconstructed particles using CMS detector



Ξ_b particle

Upsilon particles - Y(1S,2S and 3S)



The new, heavy particle with mass around 125 GeV