The CMS Detector
Status and Prospects

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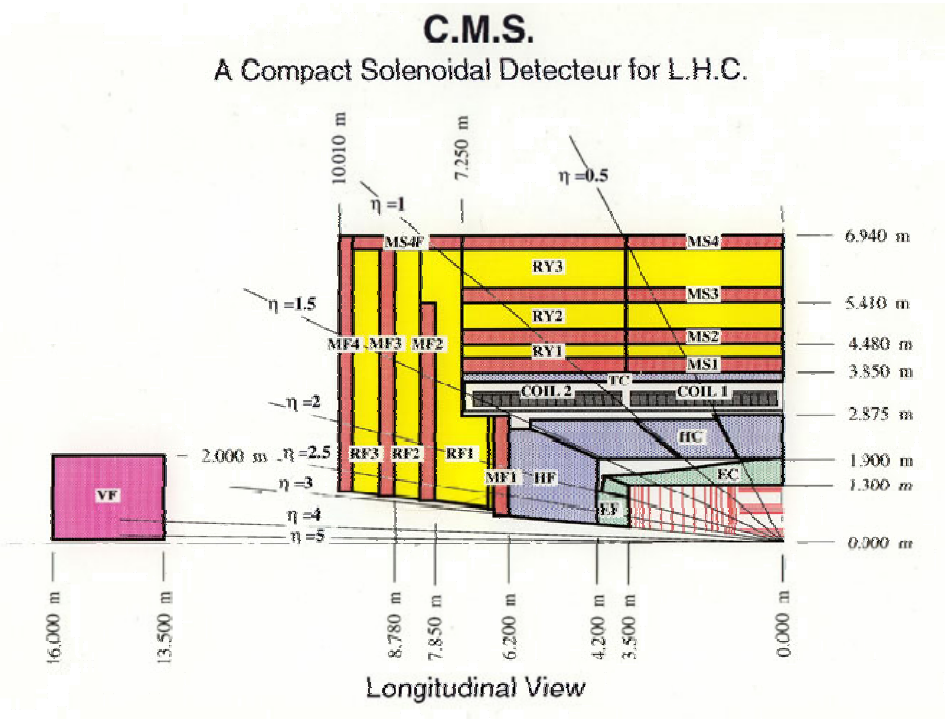
On behalf of the CMS Collaboration

APS April Meeting --- April 14, 2007

A Compact Muon Soloniod

- Philosophy:

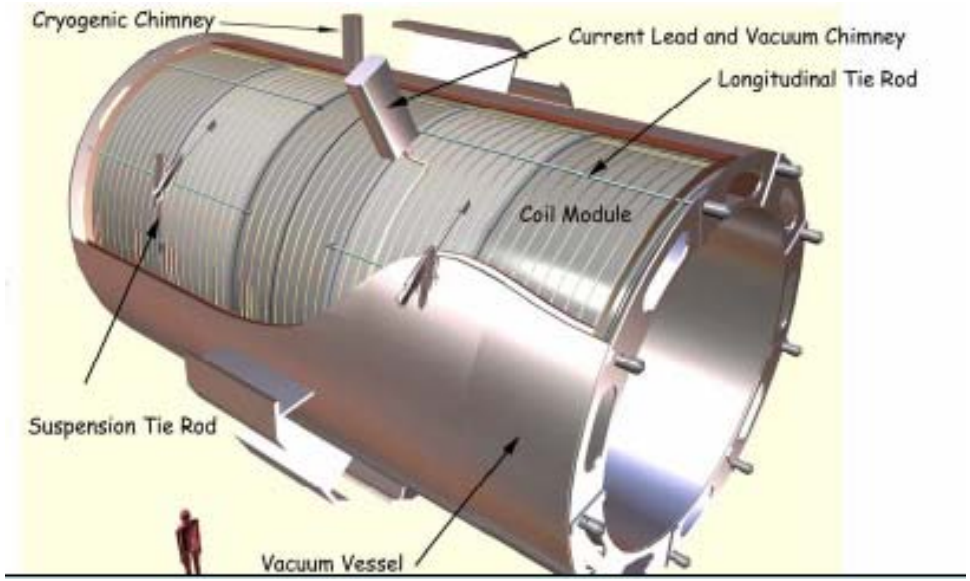
  "At the core of the CMS detector sits a large superconducting solenoid generating a uniform magnetic field of 4 T. The choice of a strong magnetic field leads to a compact design for…"



- Single long solenoid magnet containing calorimeters and inner tracker
- Muon momentum measurement performed using return flux from solenoid passing through a barrel and endcap iron yoke.

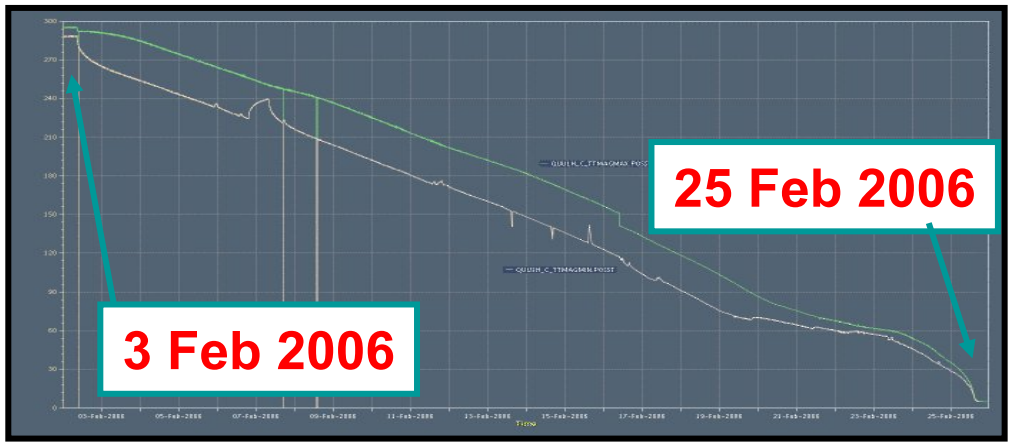
CMS Solenoid

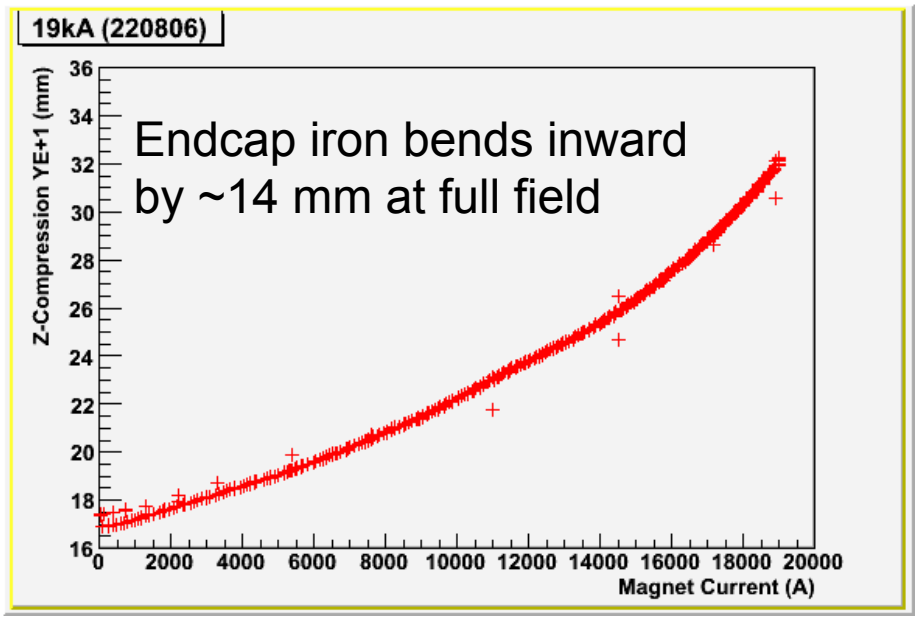
Magnetic length	12.5 m
Free bore diameter	6 m
Central magnetic induction	4 T ≈100,000 times earth magnetic field
Temperature	4.2 degrees Kelvin
Nominal current	20 kA
Stored energy	2.7 GJ
Magnetic Radial Pressure	64 Atmospheres



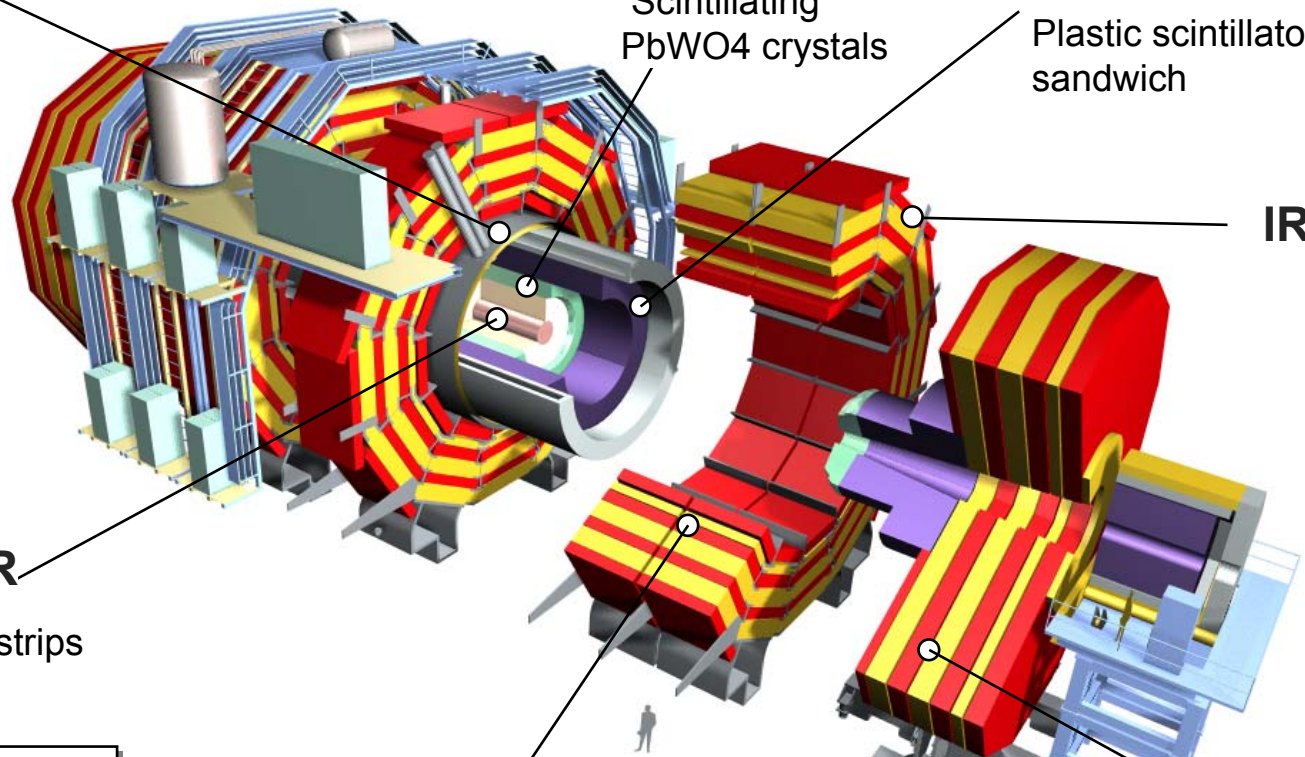
Magnet History

Testing the Magnet





Not a magnet alone…



SUPERCONDUCTING COIL

CALORIMETERS

ECAL
Scintillating PbWO4 crystals

HCAL
Plastic scintillator/brass sandwich

IRON YOKE

TRACKER
Silicon Microstrips
Pixels

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

MUON BARREL

Drift Tube Chambers (**DT**)

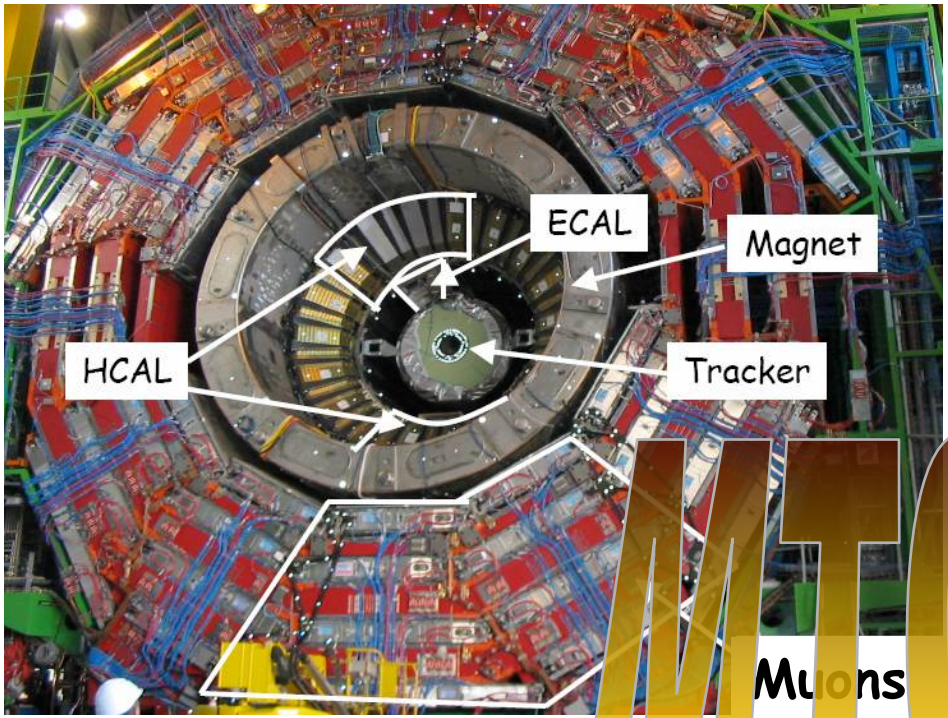
Resistive Plate Chambers (**RPC**)

MUON ENDCAPS

Cathode Strip Chambers (**CSC**)

Resistive Plate Chambers (**RPC**)

The Cosmic Challenge



- The magnet test period was also a test for the detectors: sections of all subdetectors participated in a "cosmic challenge"

MTCC

- Shakedown test
  - Installation/commissioning
  - Operations
  - Working as a combined detector

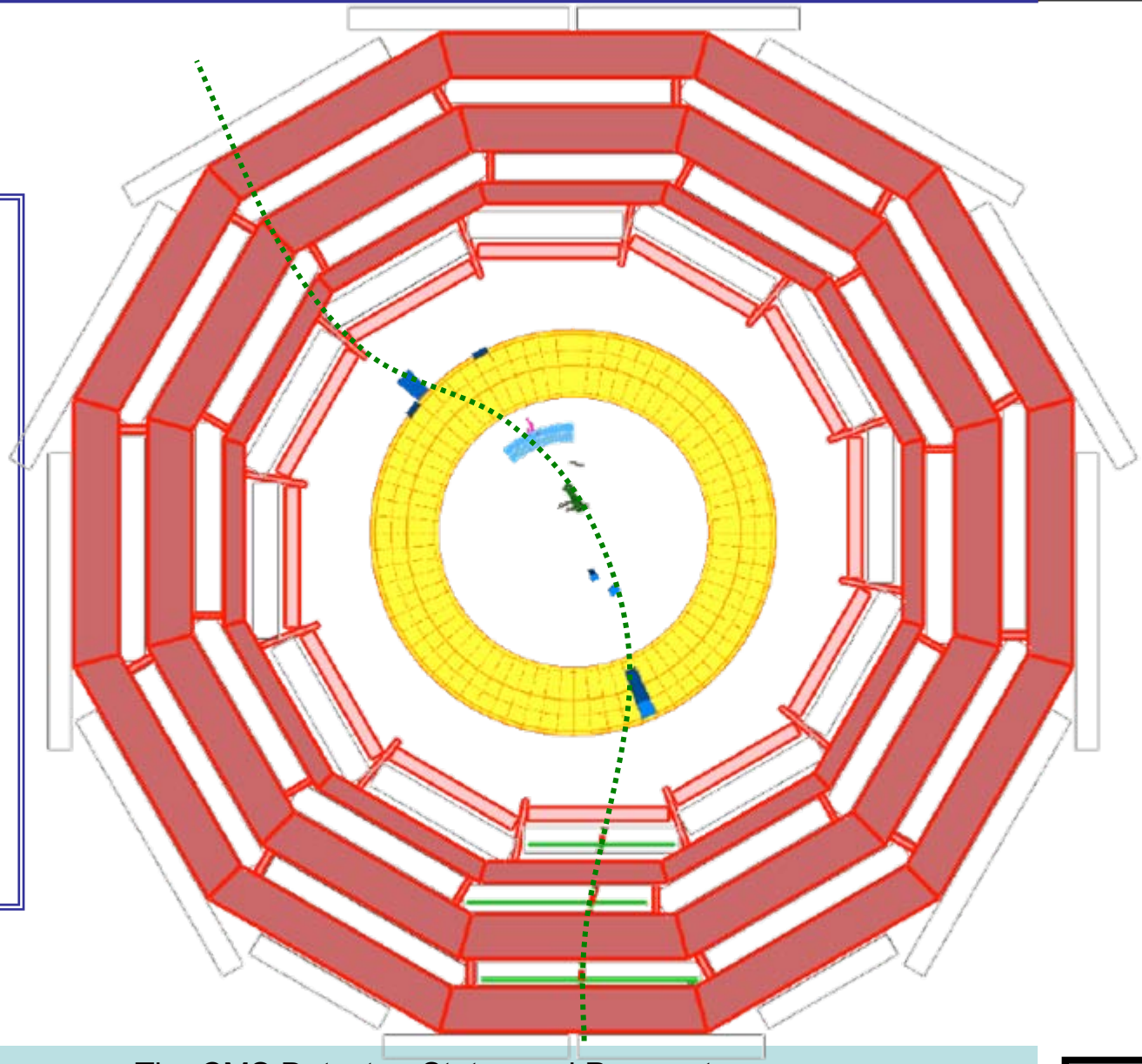
MTCC Outcome in a single slide

Statistics

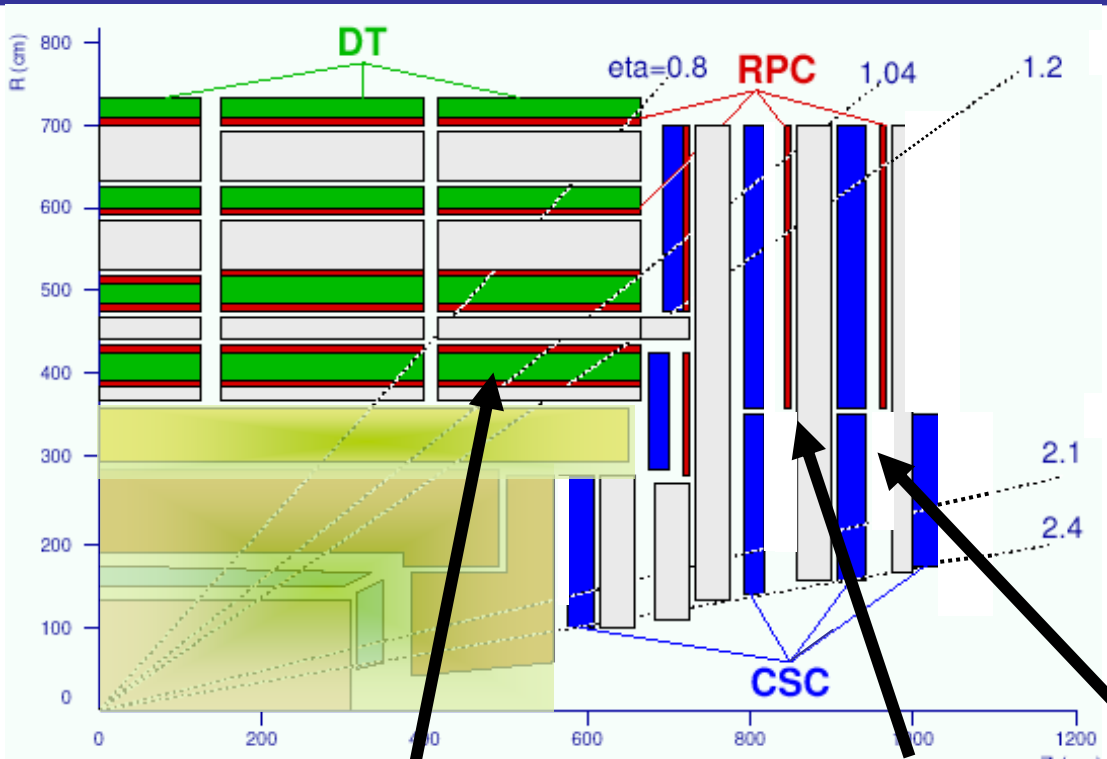
~ 230 million events written to tape

~ 41 million events at full field

~ 50 million events with all subdetectors (1M at full field)



The Muon Systems

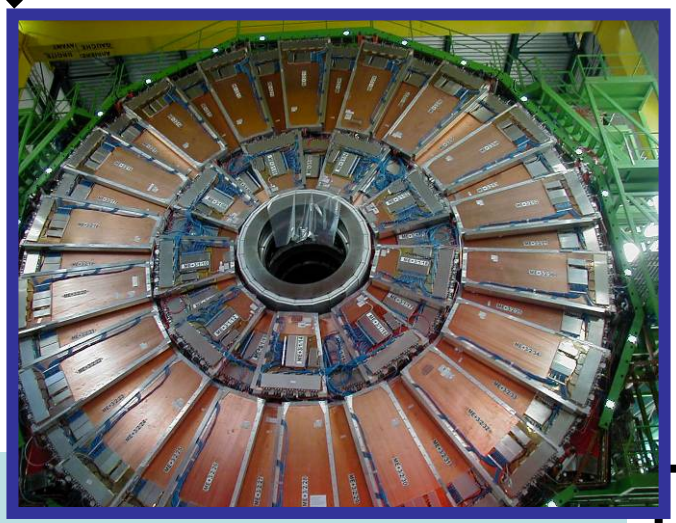


Central (|η|<1.2)

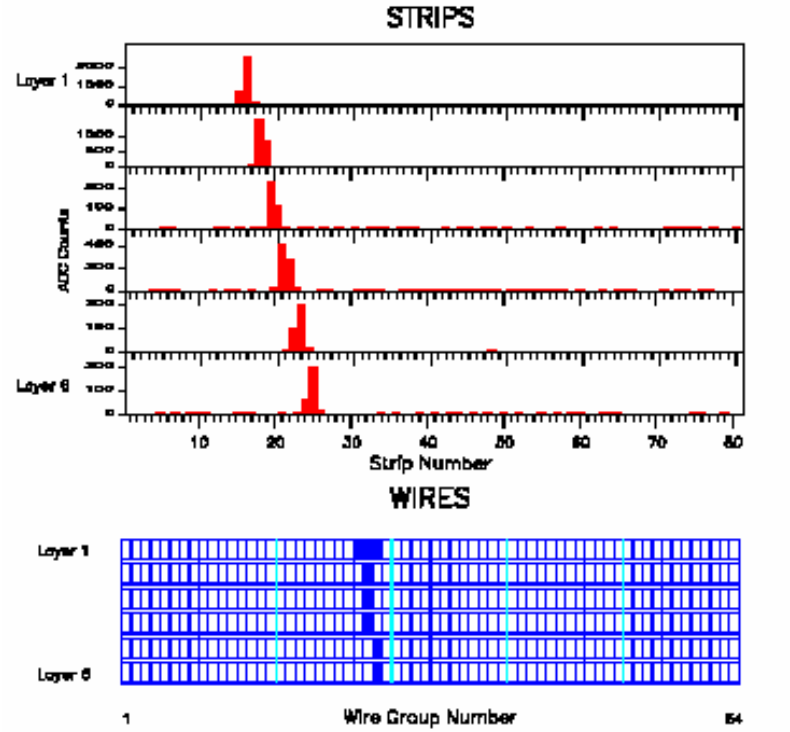
- Drift Tubes (DT)
- Barrel Resistive Plate Chambers (RPC)

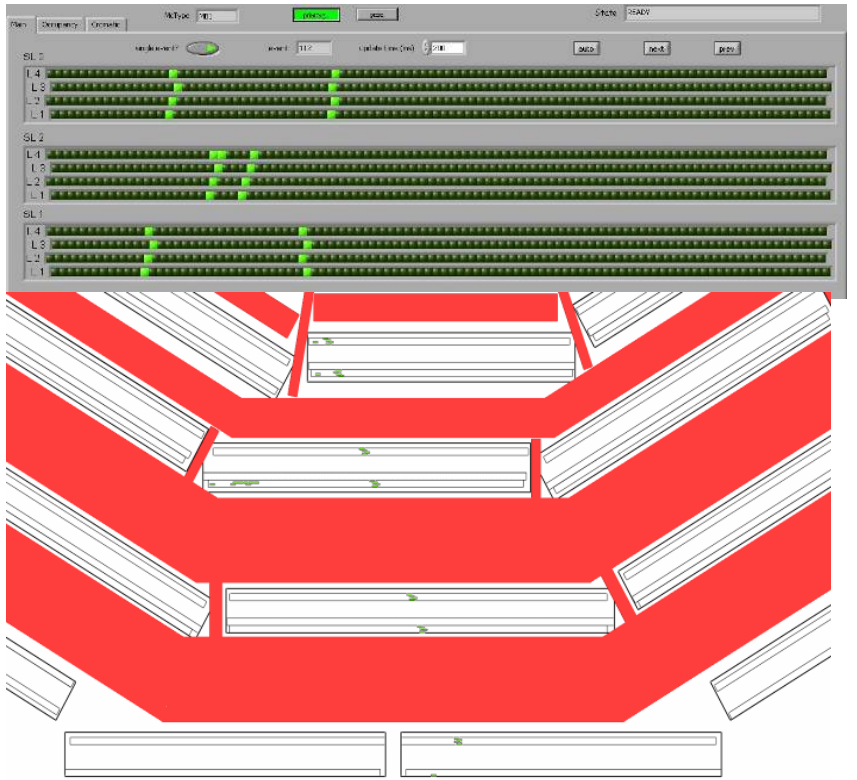
Endcaps (0.9<|η|<2.4)

- Cathode Strip Chambers (CSC)
- Endcap RPCs



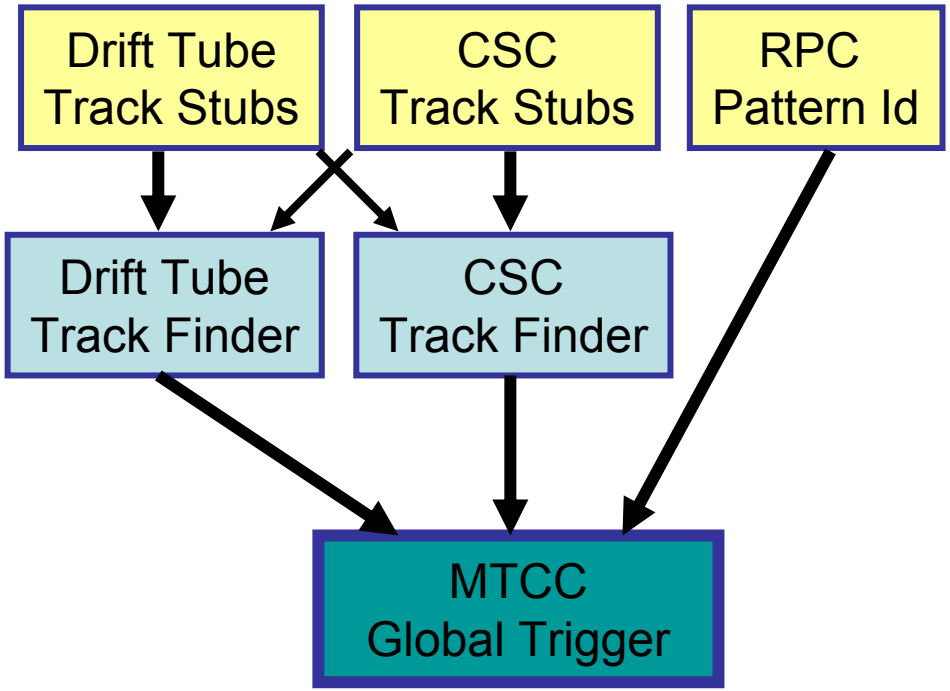
Commissioning

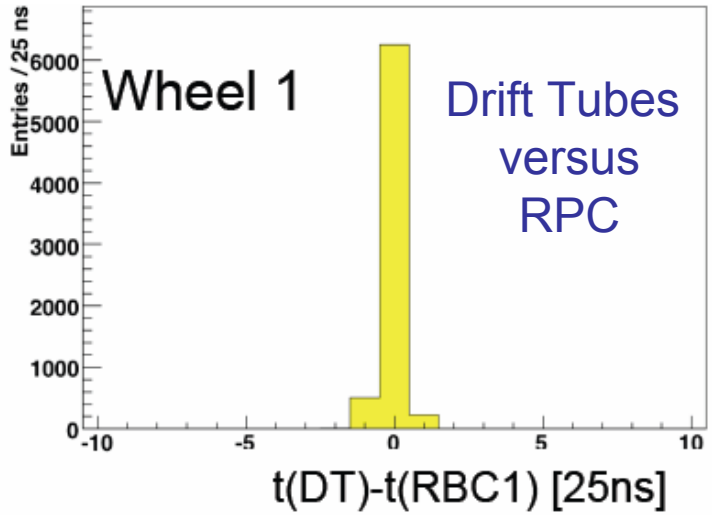


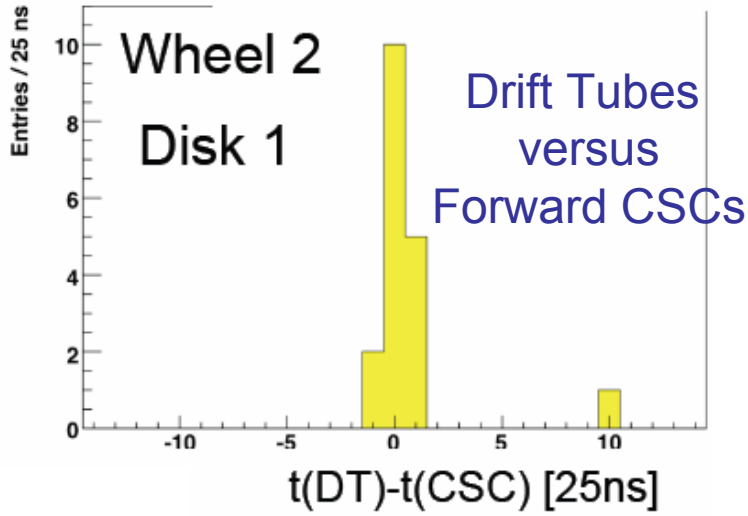


- Commissioning and operation of the muon chambers began in 2004 with the operation of the first CSCs installed on the iron.
- Both the CSCs and DTs operated successfully in local mode well before beginning the Cosmic Challenge

Trigger Synchronization

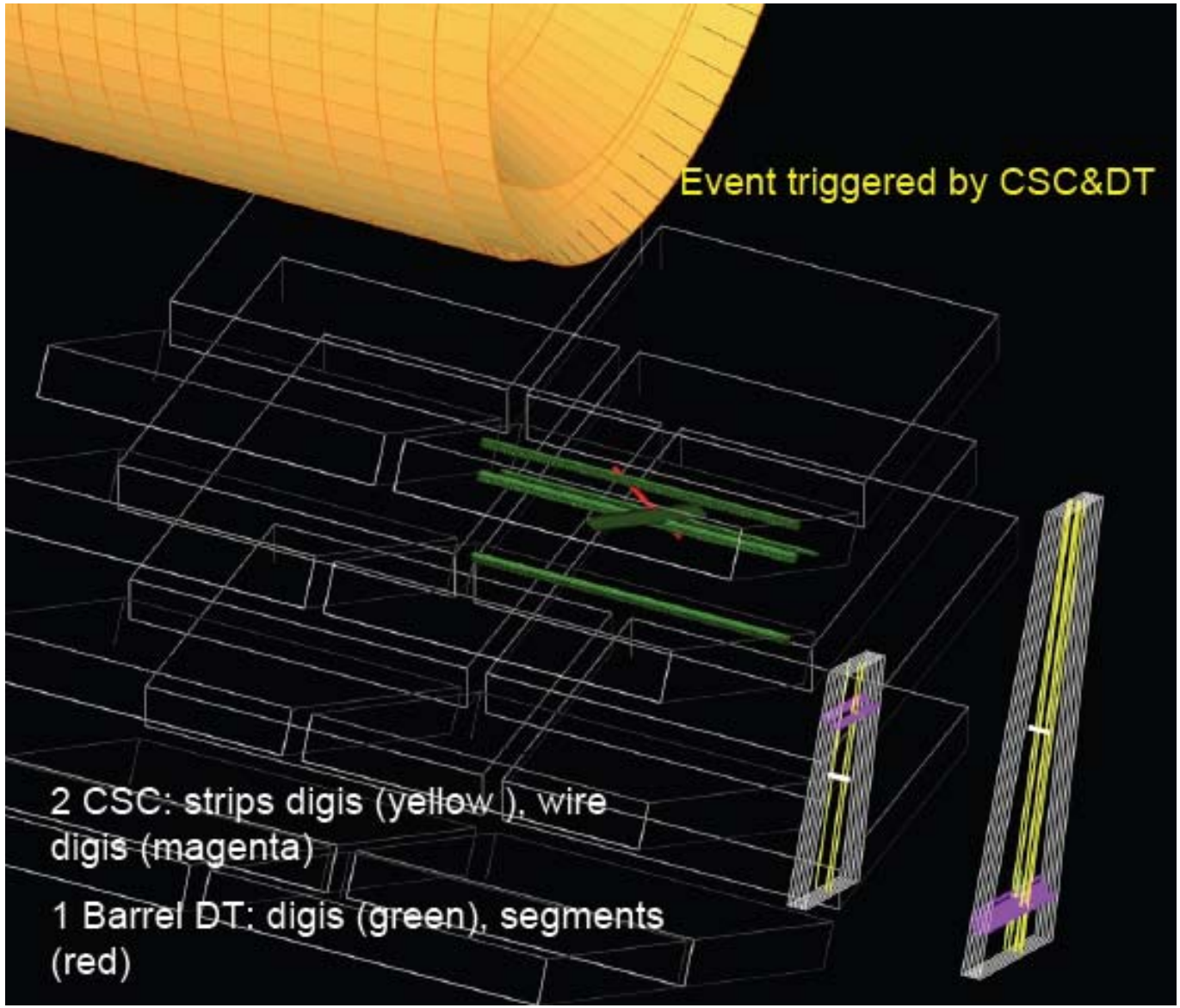




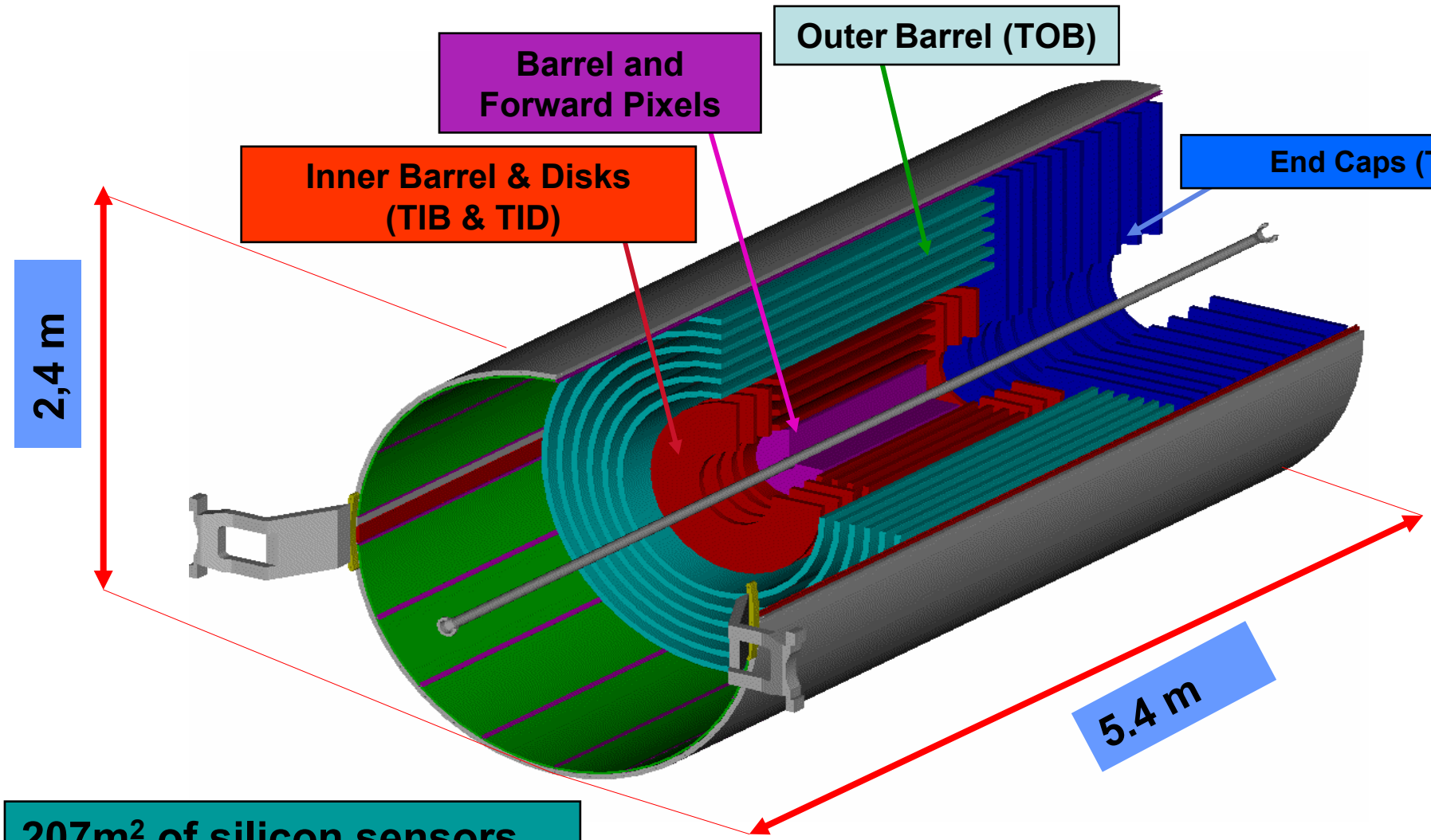


- MTCC was a *more* challenging environment for synchronization than LHC
  - Cosmic muons are not synchronized to the LHC clock!
  - Cosmic muons don't come from the center of the detector!

Cosmic Challenge Results



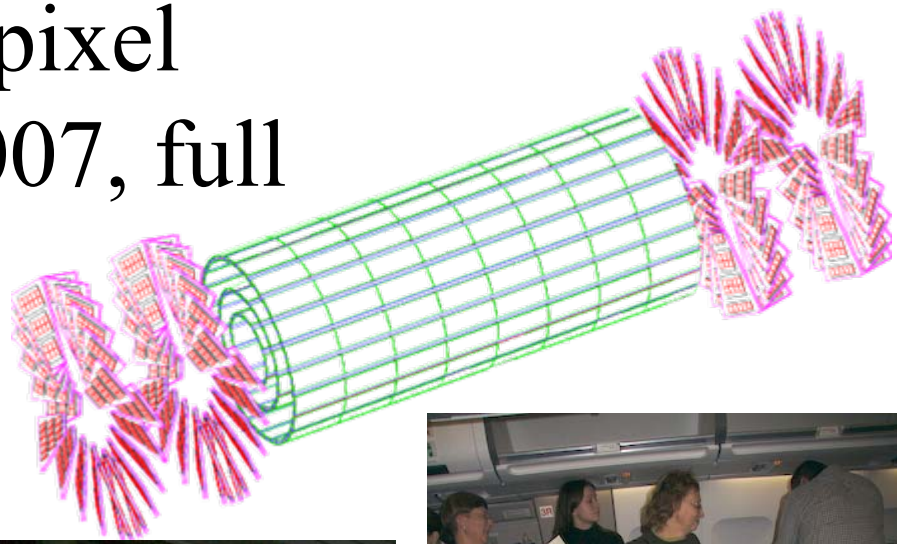
CMS All-Silicon Tracker



207m² of silicon sensors
10.6 million silicon strips
65.9 million pixels ~ 1.1 m²

The Pixel Tracker

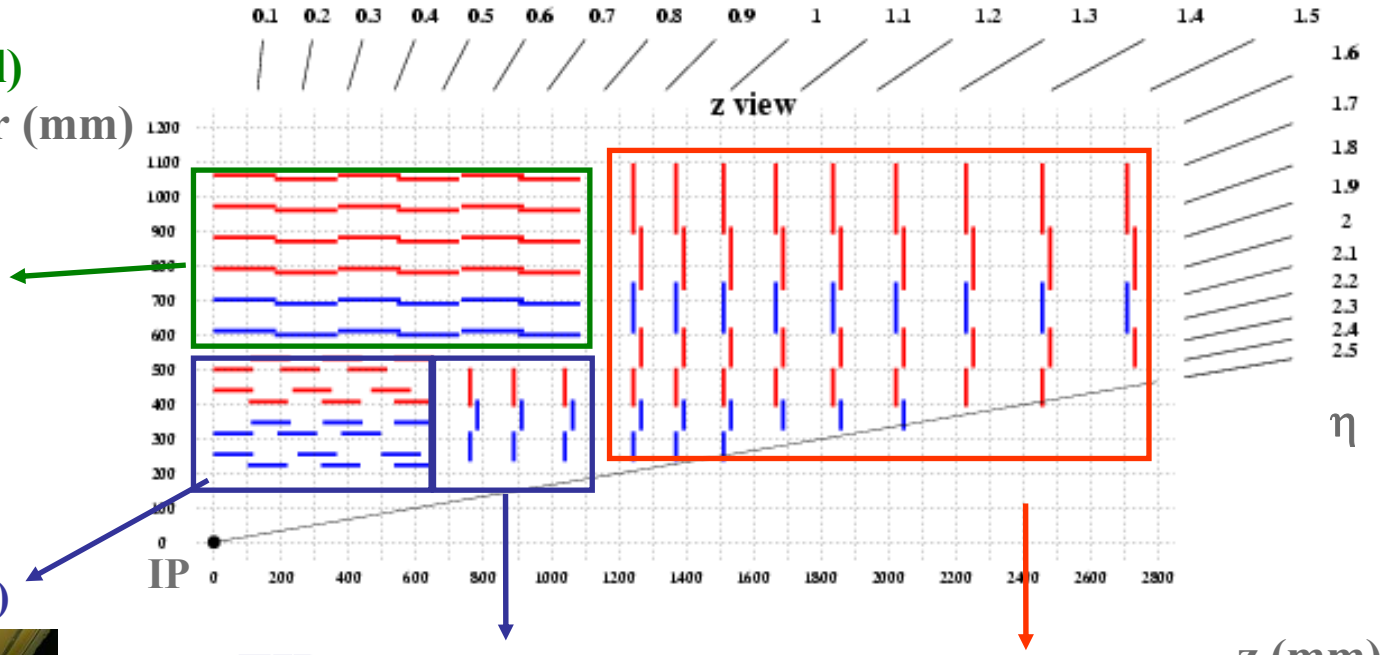
- Partial installation of pixel system expected in 2007, full system in 2008.



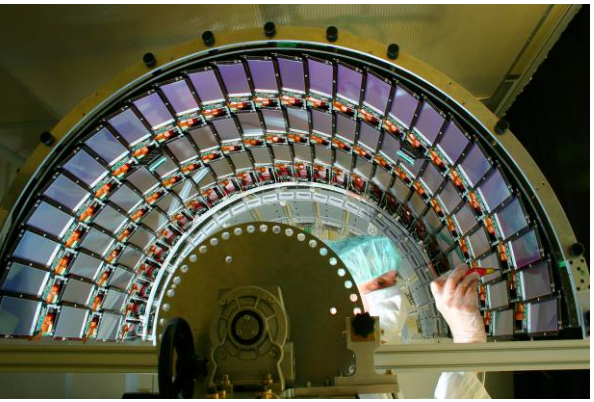
Photos courtesy of John Conway

CMS Silicon Strip Tracker

TOB (Outer Barrel)

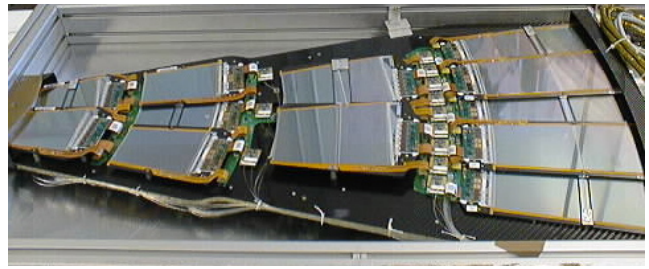


TIB (Inner Barrel)

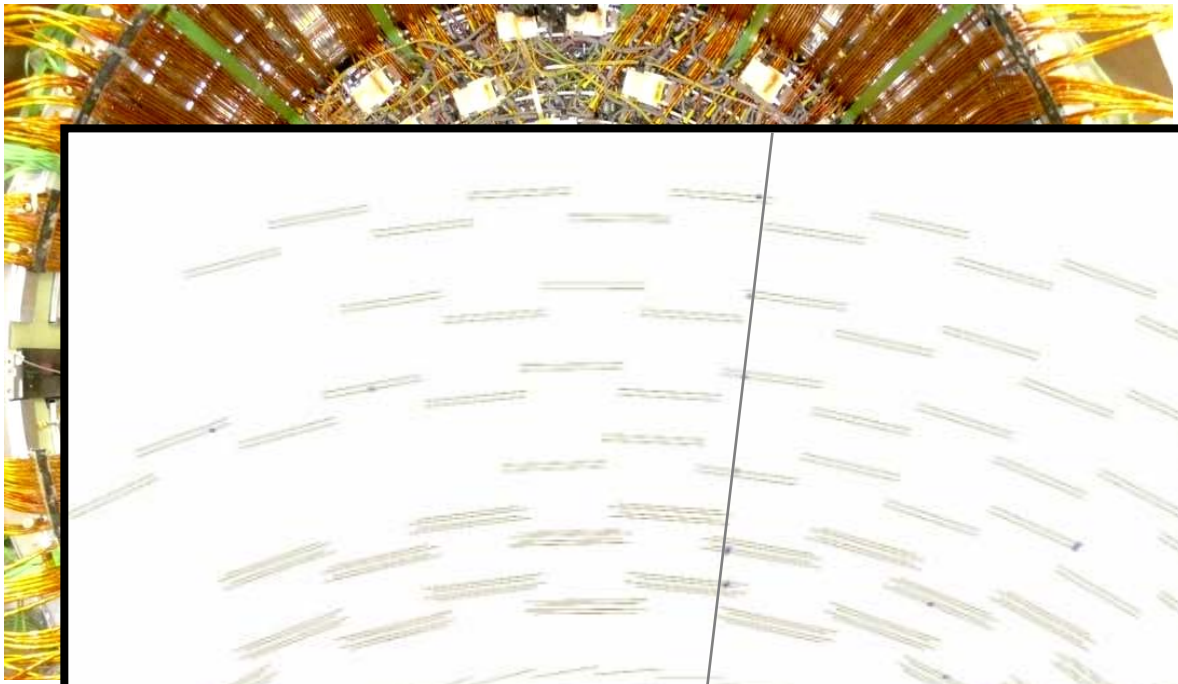


TID (Inner Disks)

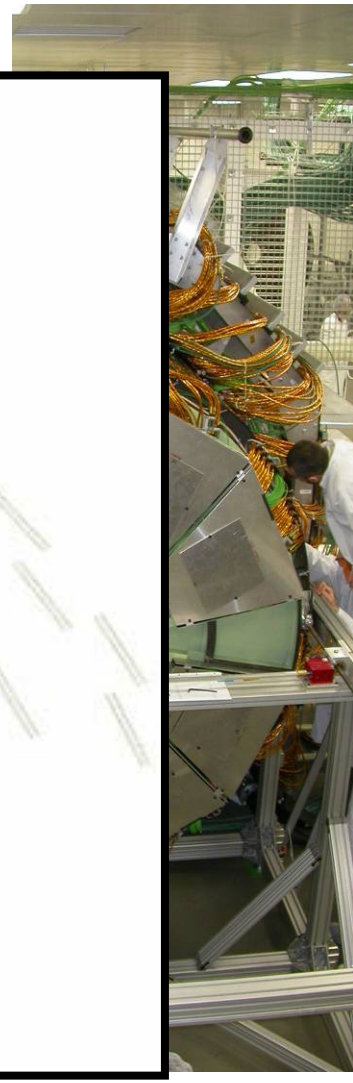
TEC (EndCap)



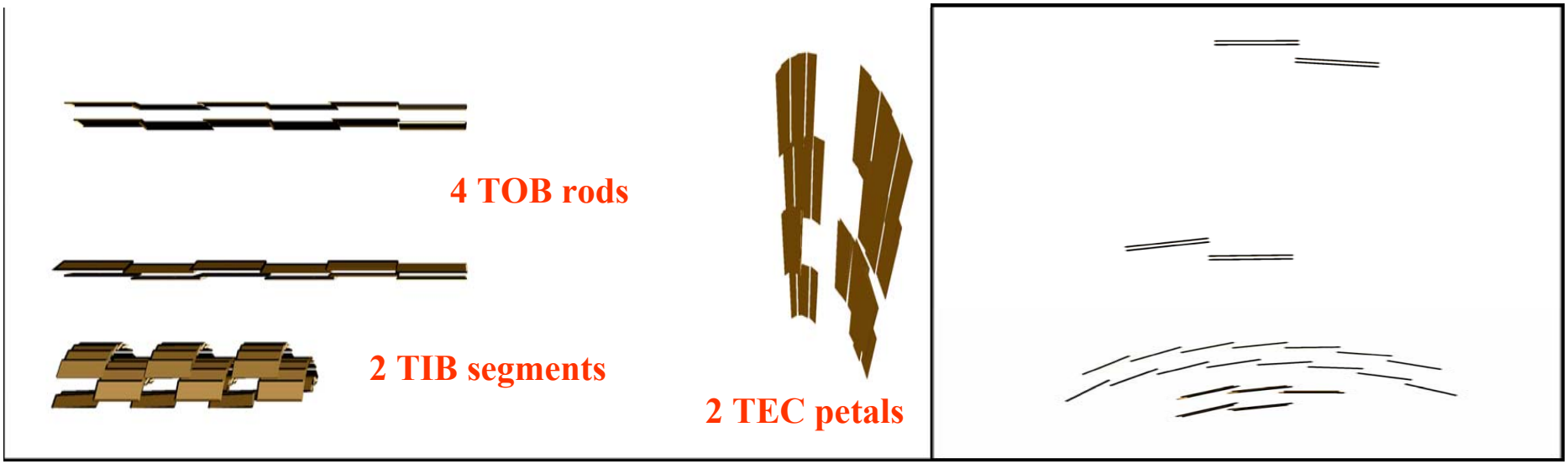
Tracker Integration



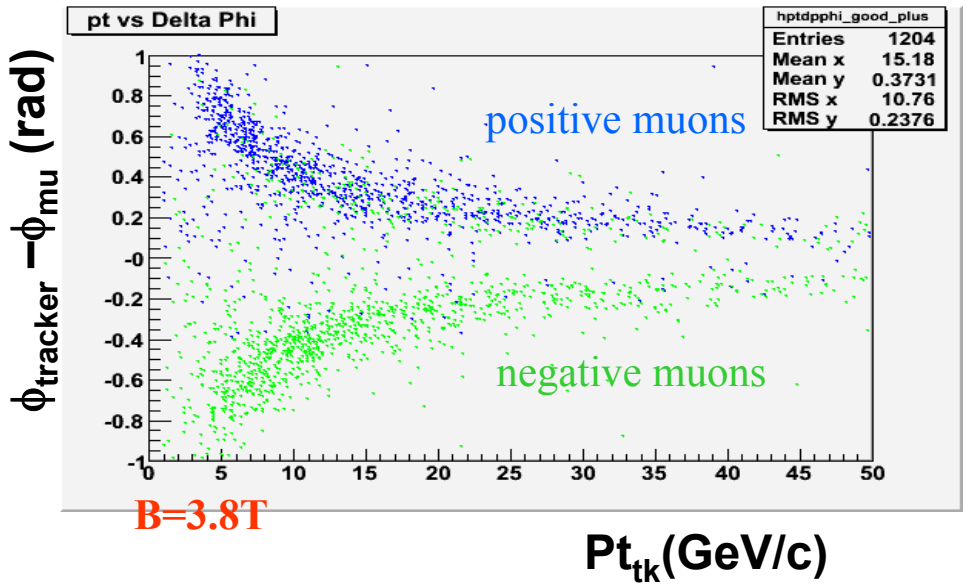
TEC+ Insertion



Tracker at MTCC



- A small section of the tracker was inserted for the first period of MTCC
- Provided both operational and mechanical integration practice
- ~9000 tracks reconstructed in MTCC dataset



The Calorimeters of CMS

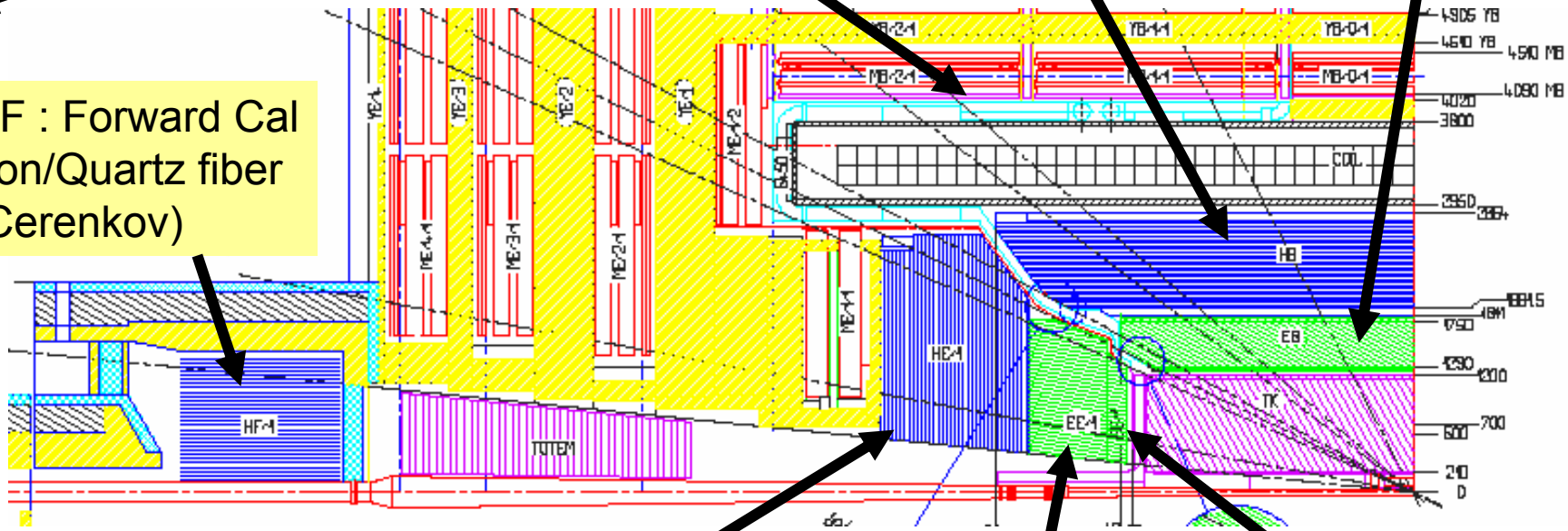
ZDC : Tungsten/ Quartz

HO : Outer HCAL Magnet/Scintillator

HB : Barrel HCAL Brass/Scintillator

EB : Barrel ECAL $PbWO_4$ Crystals

HF : Forward Cal Iron/Quartz fiber (Cerenkov)

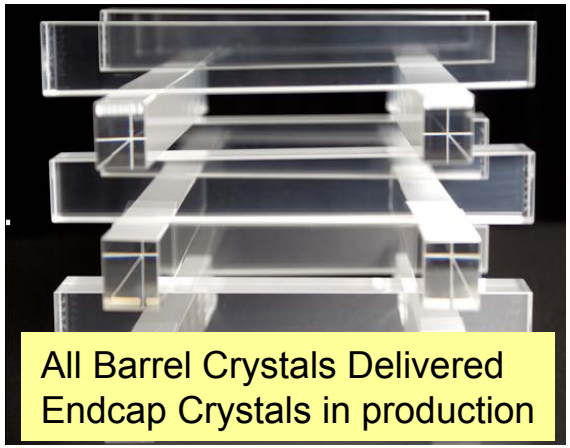


HE : Endcap HCAL Brass/Scintillator

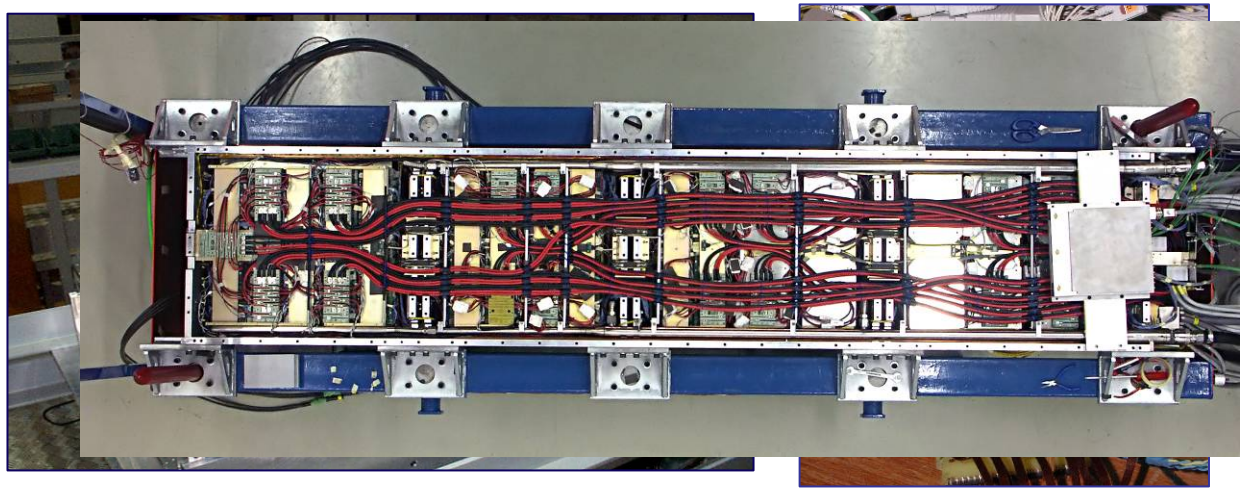
EE : Endcap ECAL $PbWO_4$ Crystals

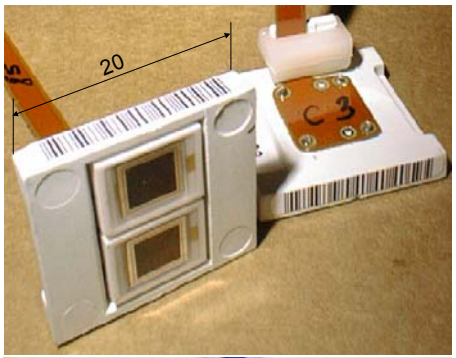
ES : Endcap Preshower Pb/Silicon Strips

The CMS Electromagnetic Calorimeter



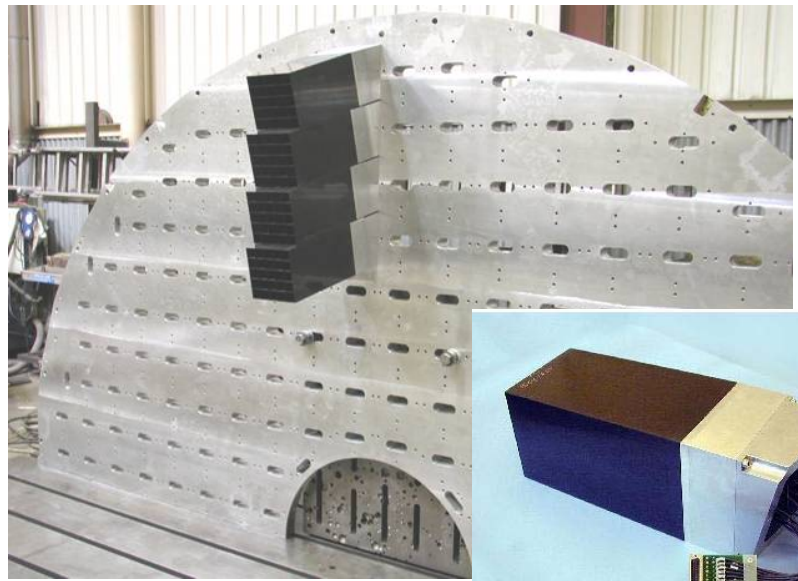
All Barrel Crystals Delivered
Endcap Crystals in production





Barrel: Avalanche Photodiode (APD)

Gain ~ 50
QE ~ 70%

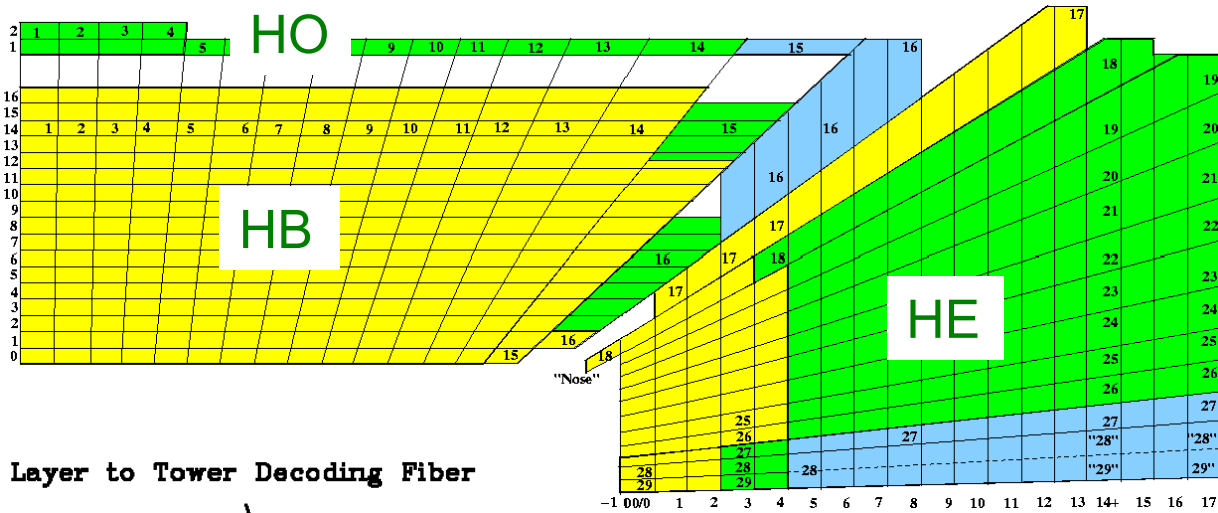


Endcap: Vacuum Phototriode

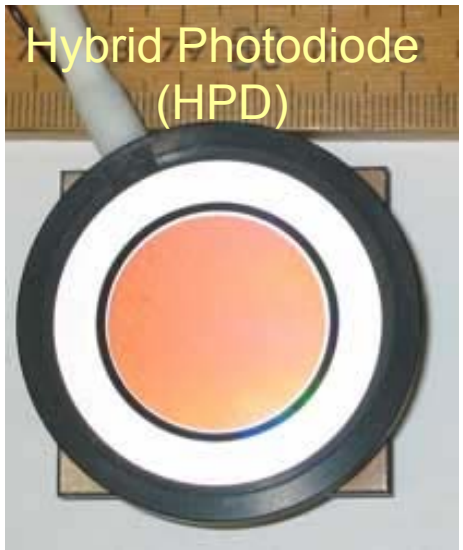
Gain ~ 10
QE ~ 20%

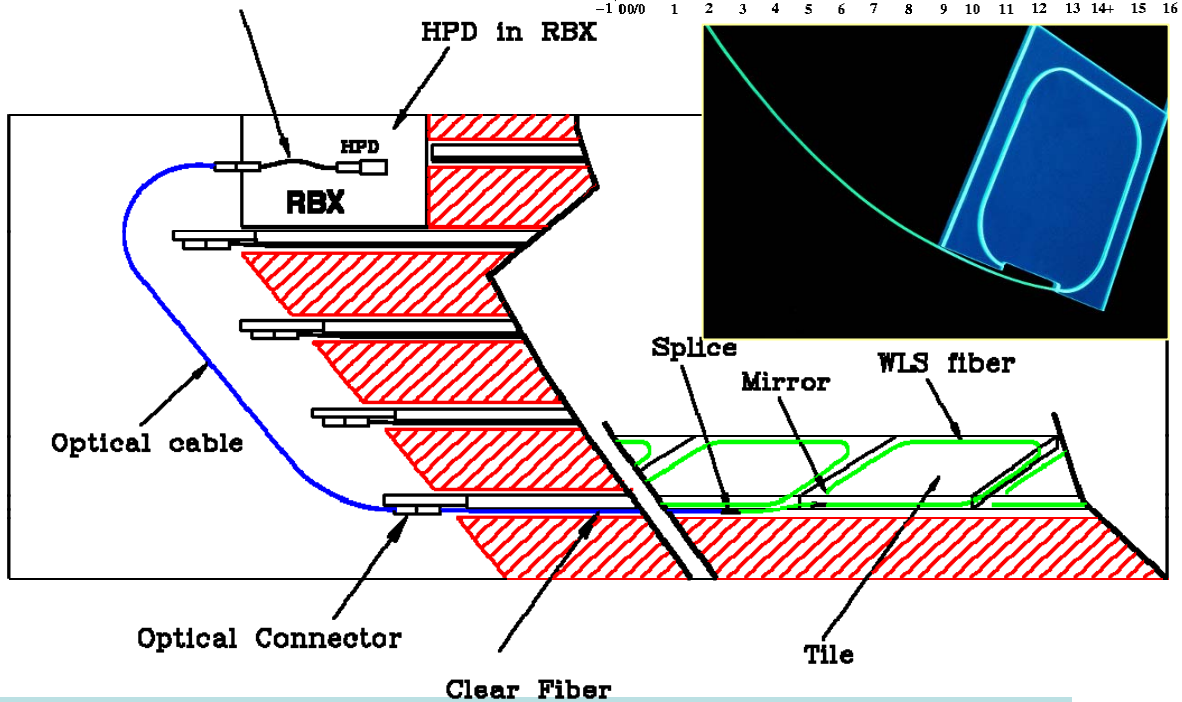
Radiation Hard

HCAL Segmentation and Coverage

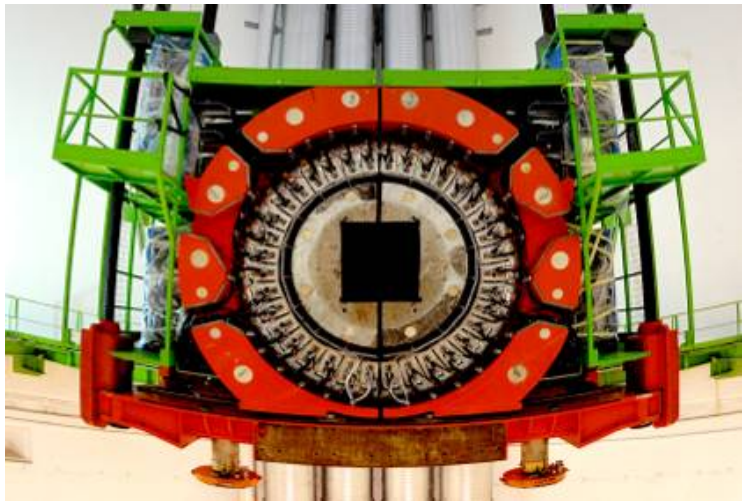


Layer to Tower Decoding Fiber

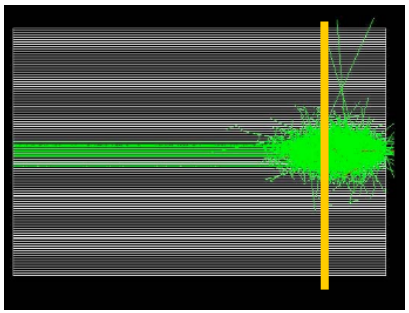




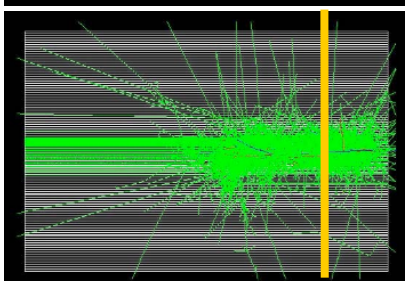
Forward Calorimeters



HF

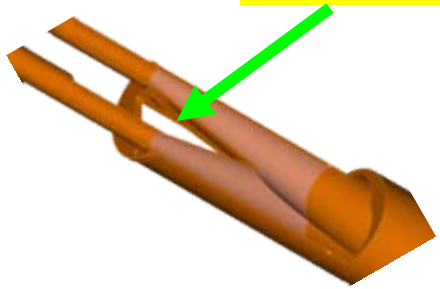


100 GeV electron



100 GeV pion

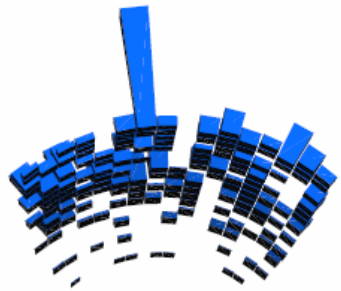
Zero-Degree Calorimeter



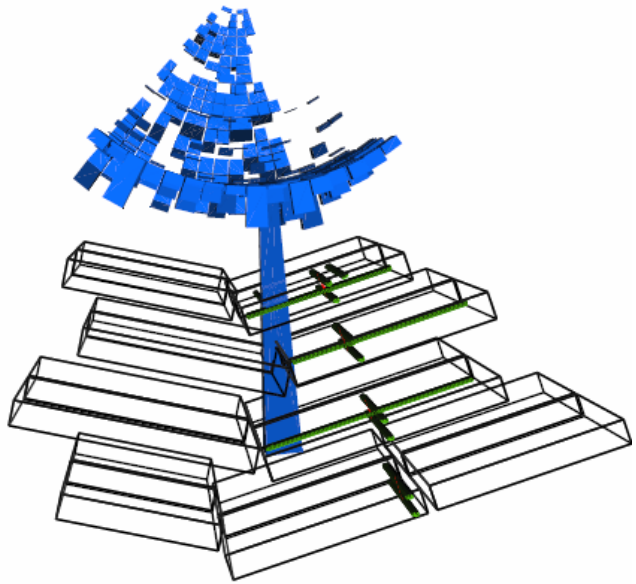
Hadronic section important for CMS Heavy Ion program

EM section important for diffractive and forward physics

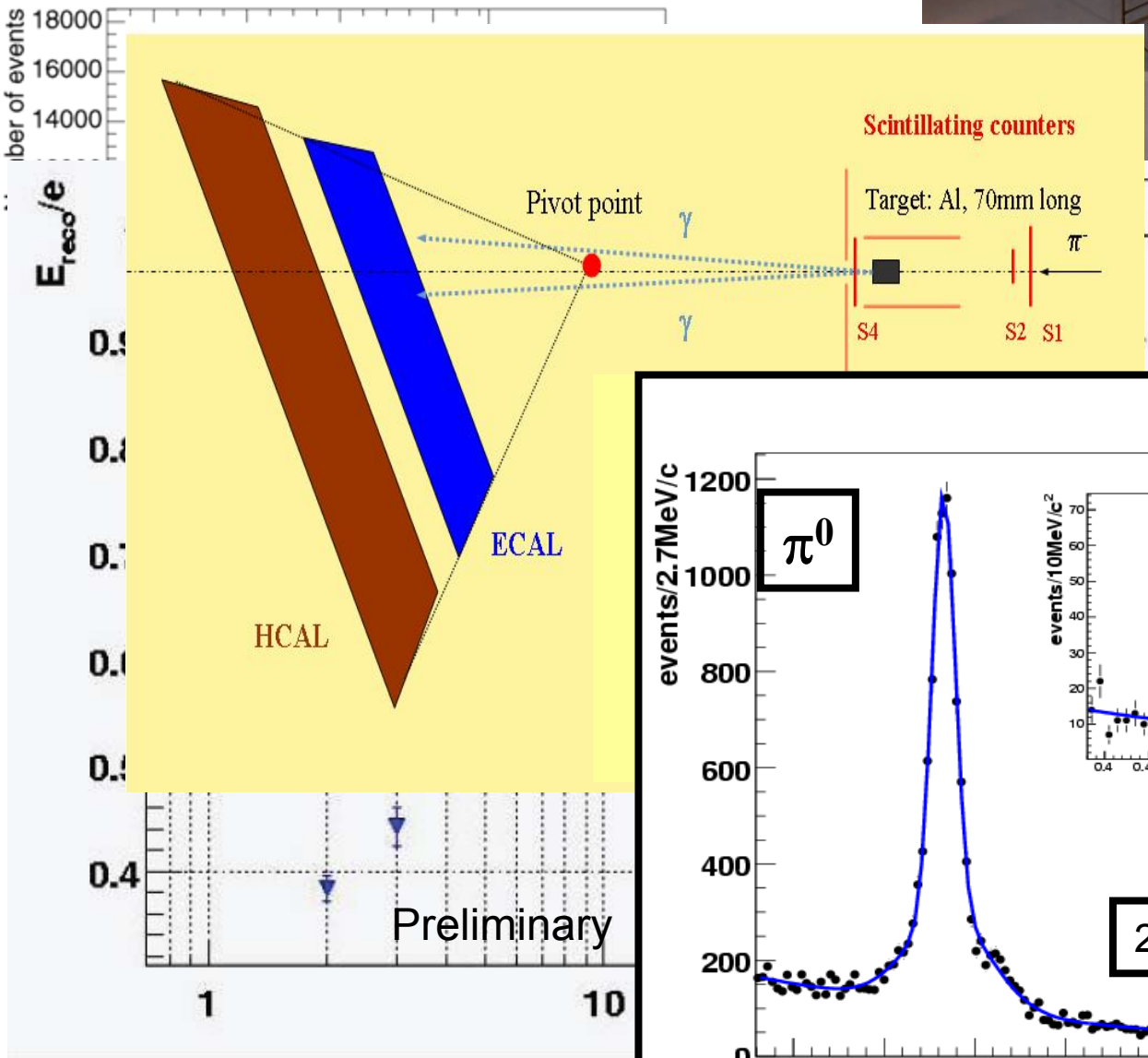
Calorimeters at MTCC

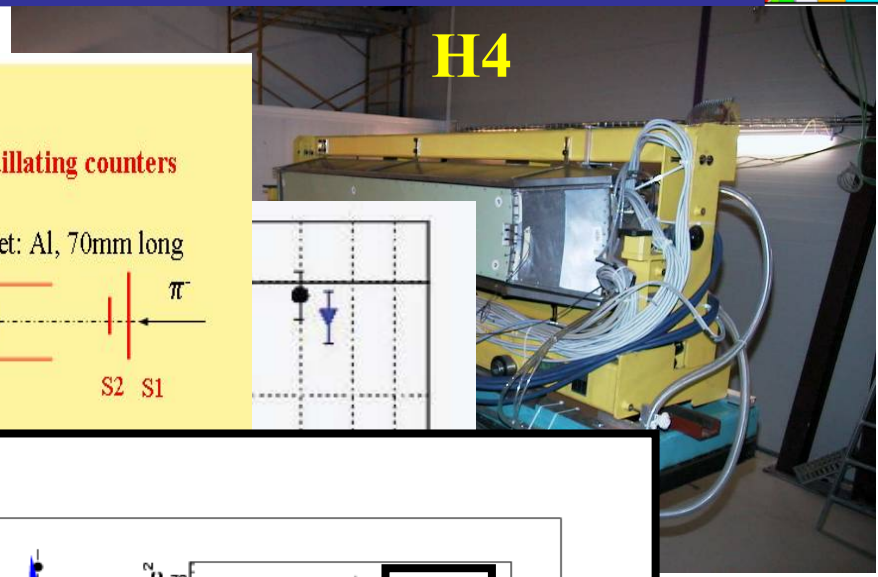


HCAL – triggered cosmic muon



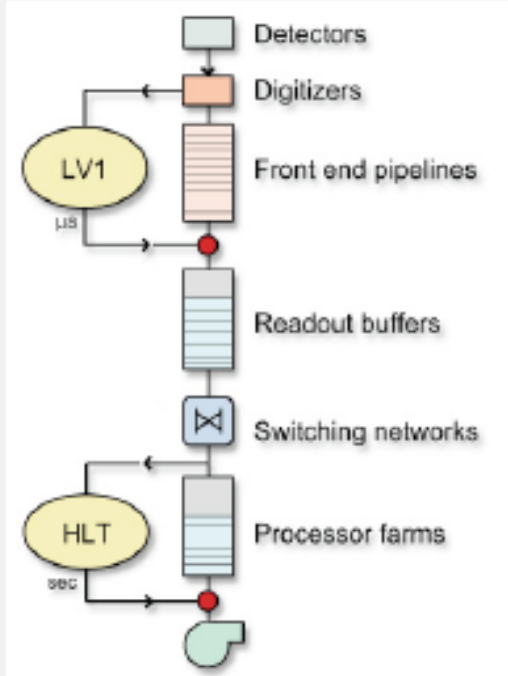
Testbeam Proving Ground





The Trigger and DAQ Systems

- CMS is designed with only one level of hardware trigger.
- The events are read out and built using mostly commodity networking hardware at an event rate of 100 kHz.
- Software-based "High-Level Trigger" provides filtering down to O(100 Hz)

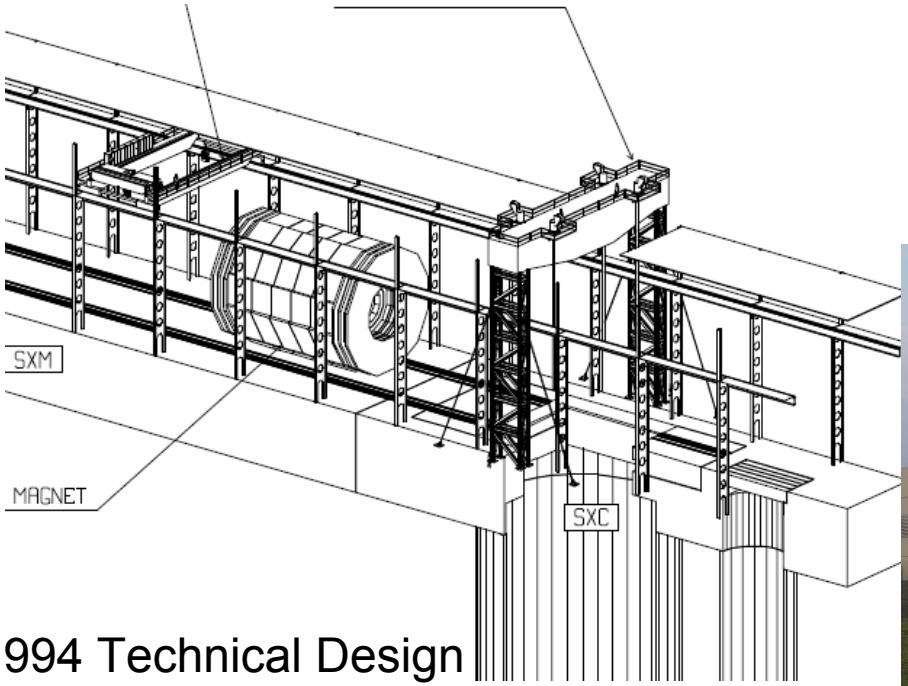


two trigger levels

Level-1 (~μs) 40 MHz
High-Level (ms-sec) 100 kHz
Event Size ~ 10^6 Bytes

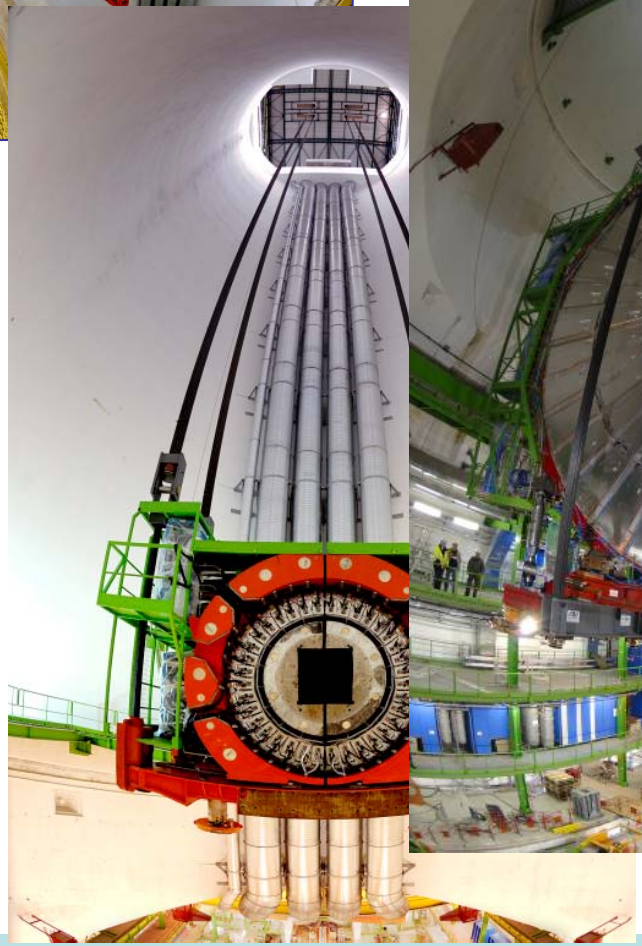
Into the Cavern

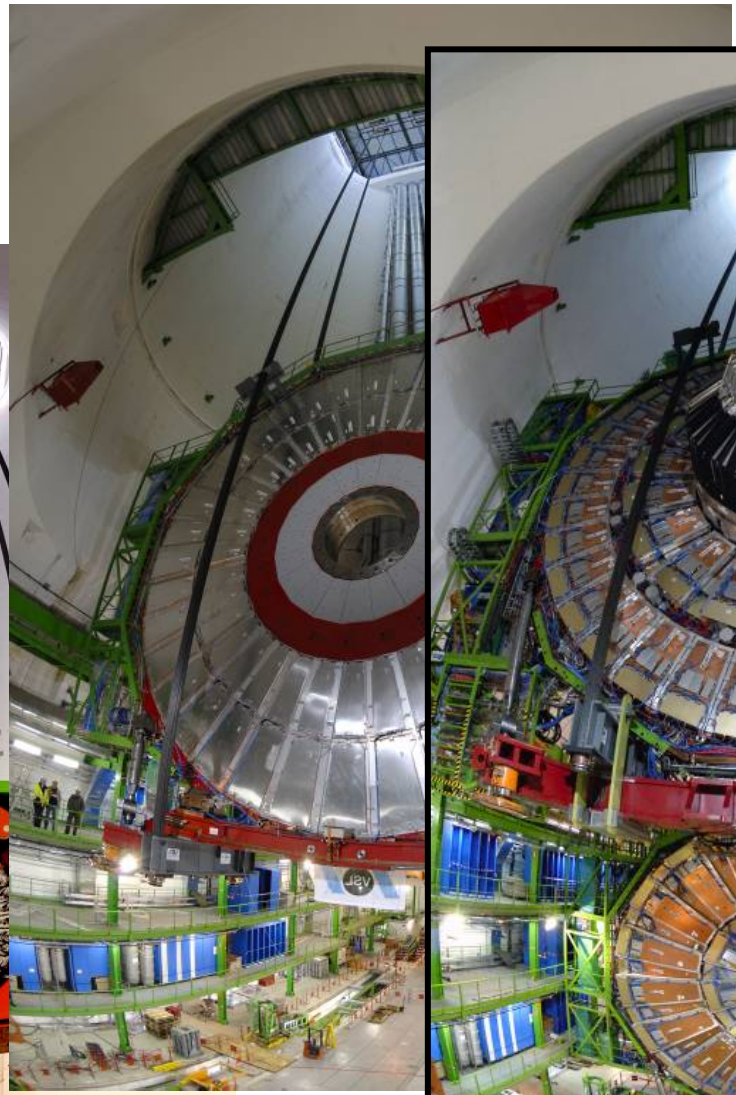
- The CMS integration plan has always envisioned the assembly of the detector on the surface, followed by lowering into the experimental cavern.

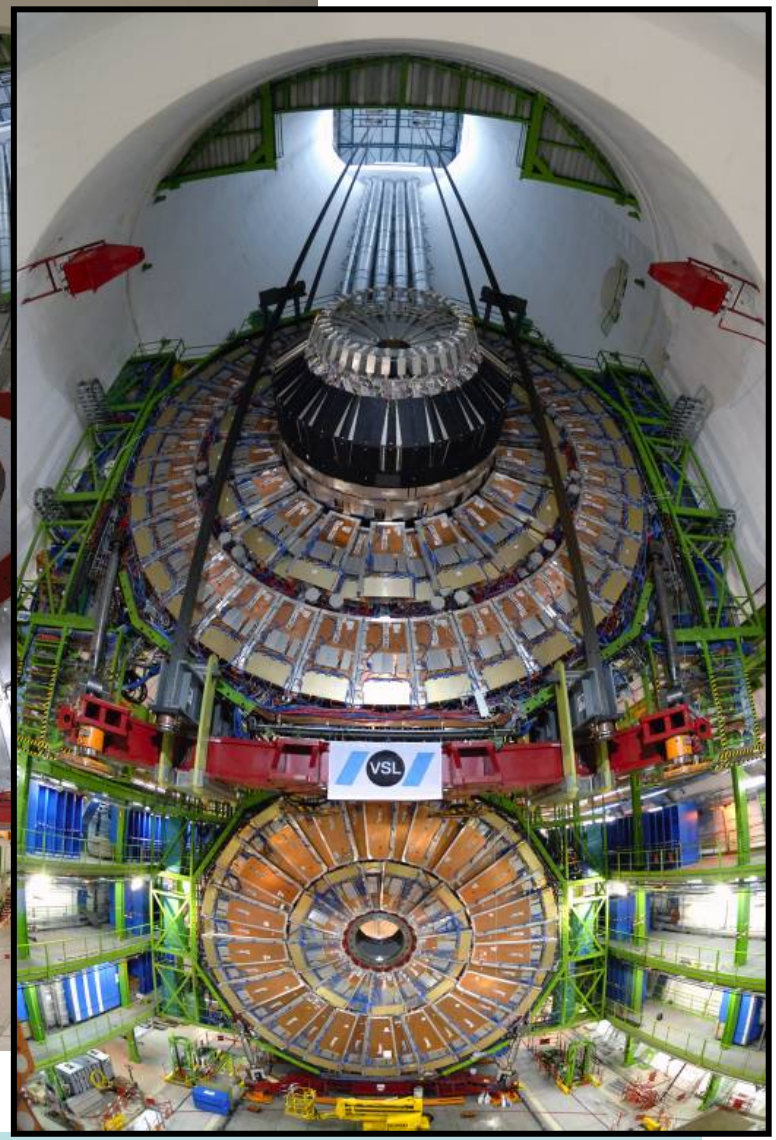


1994 Technical Design

CMS Descending…

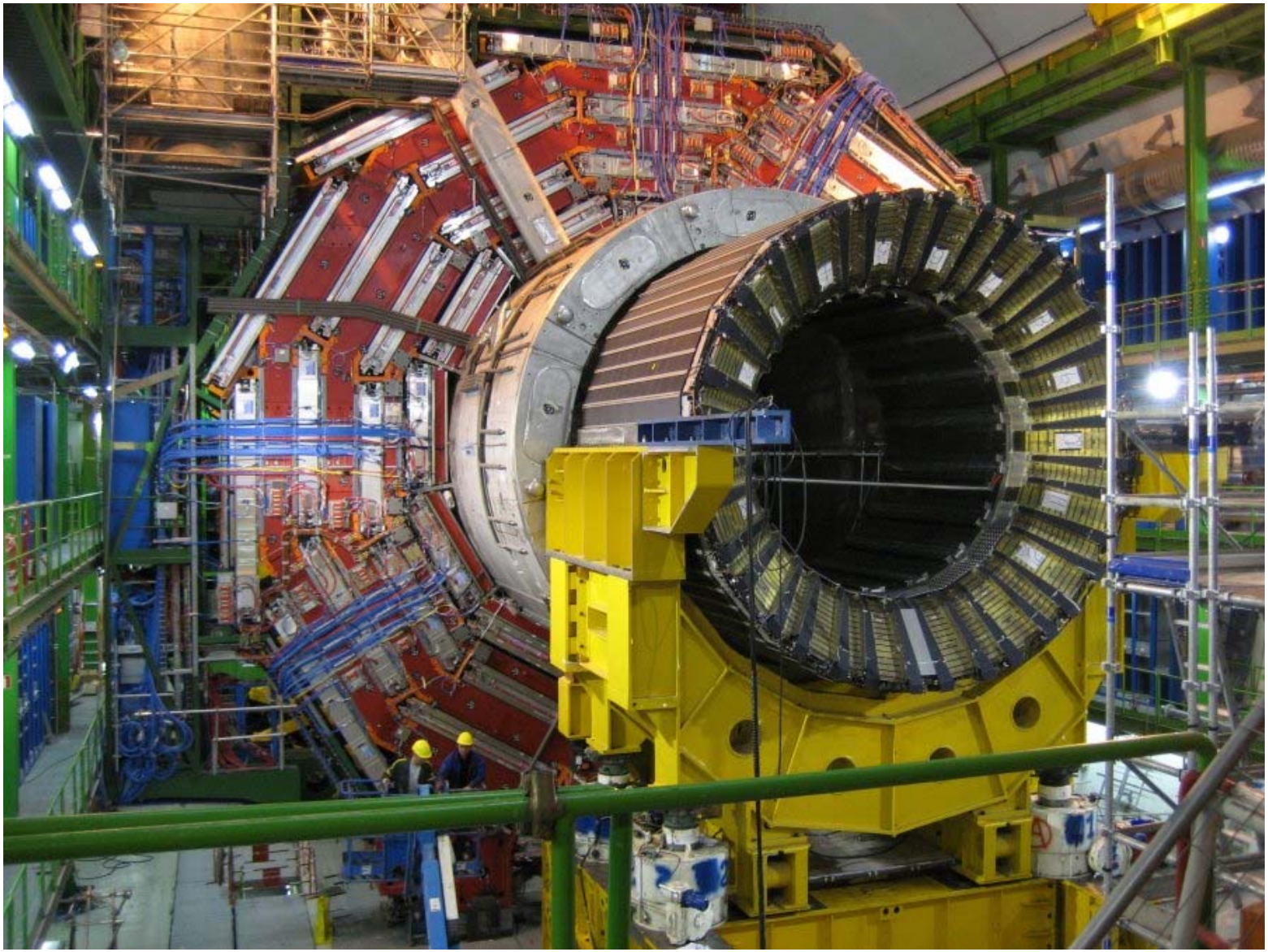




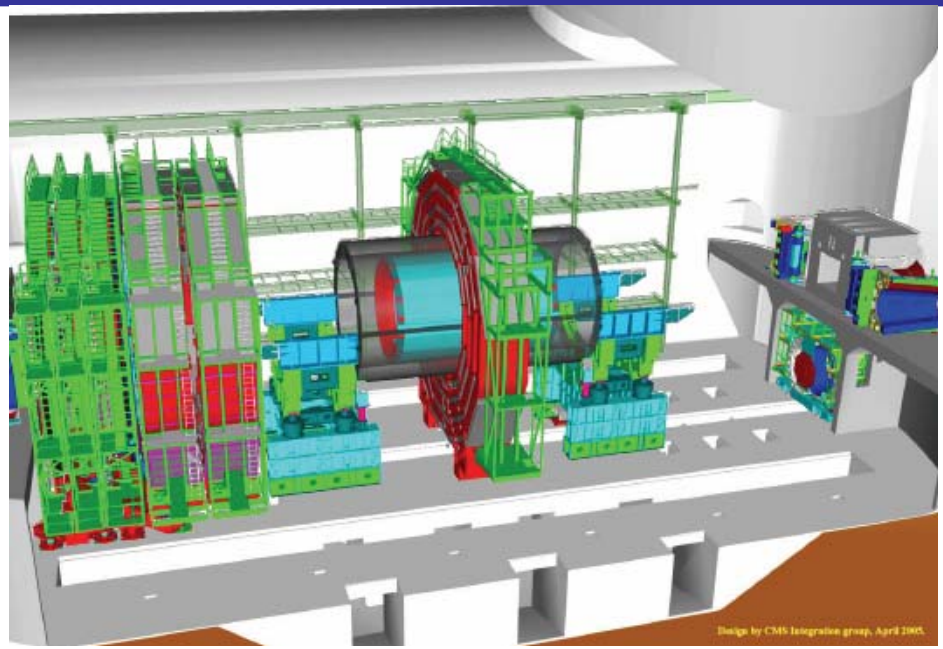


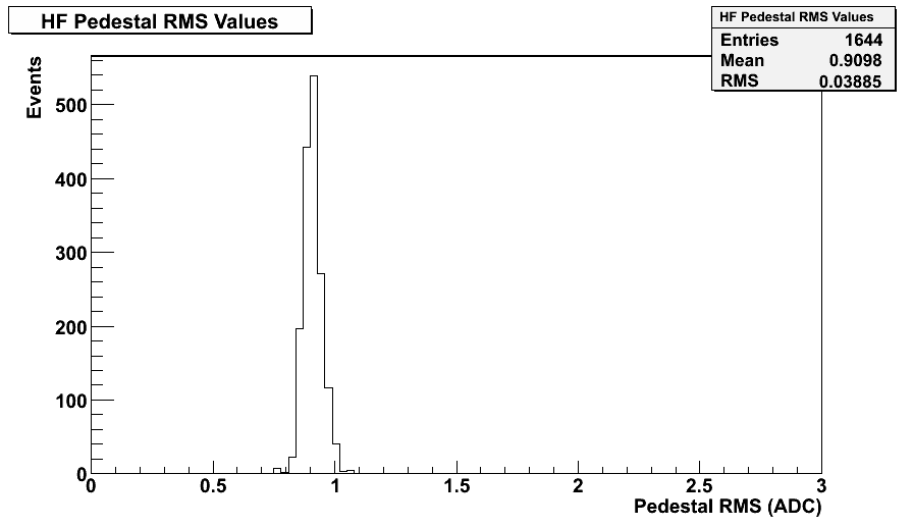
Lowering the Magnet

CMS Today (actually 2 weeks ago)

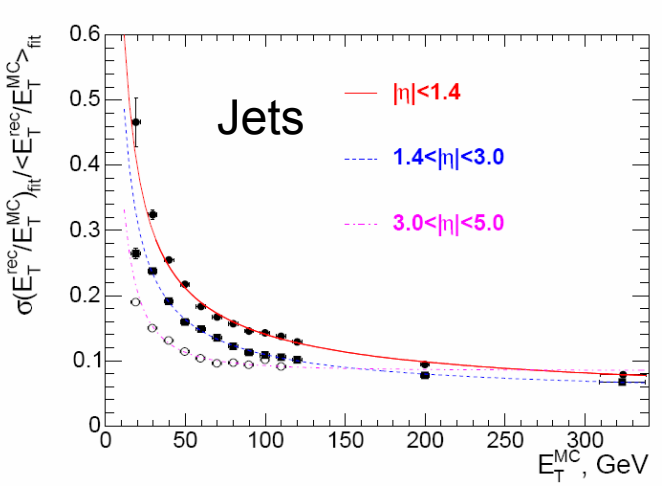


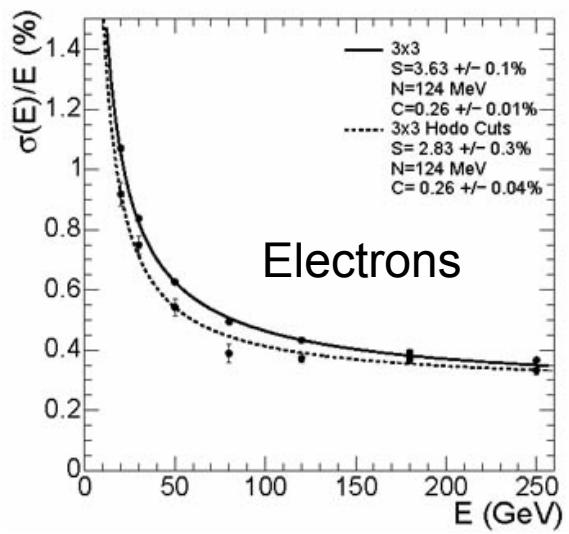
Installation and Commissioning

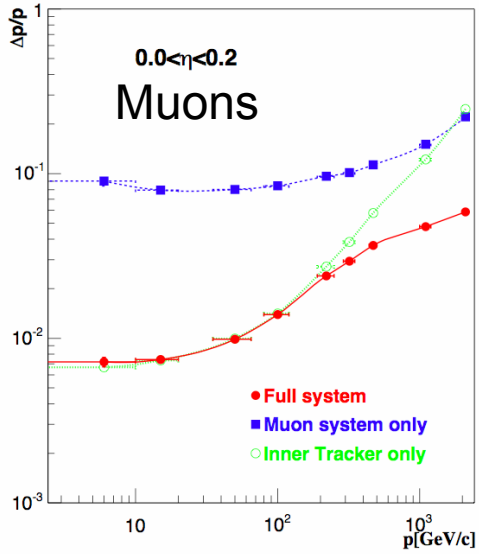




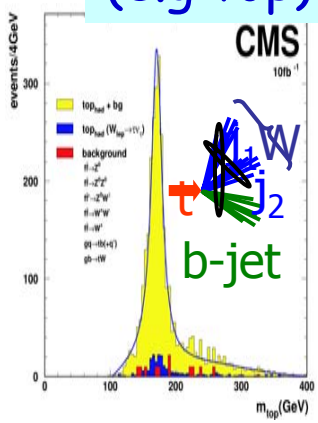
The Payoff



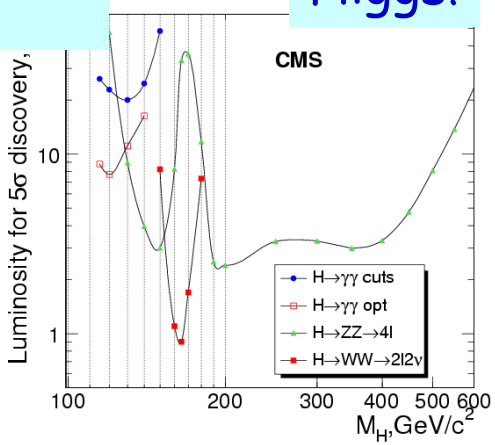




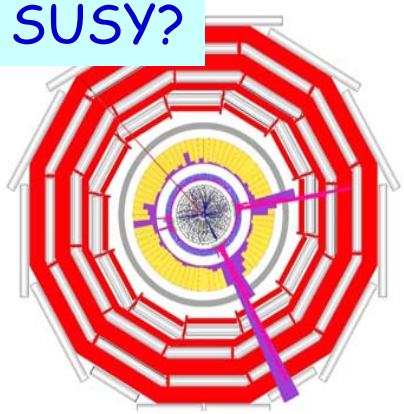
Precision measurements (e.g top)



Higgs!



SUSY?



QGP?