CMS

CMS status*
A Year before first collisions

Ludwik Dobrzynski

Laboratoire Leprince Ringuet, Palaiseau

1st Chinese-French Workshop on LHC Physics and Associated Grid Computing
11-16 December 2006

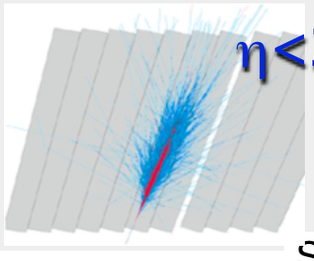
*slides courtesy of many people; particularly M. Della Negra, T. Virdee, D. Green, A. Ball, P. Sphicas, Ph. Bloch any many others

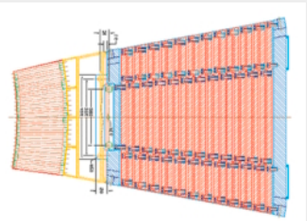
Outline

- Introduction
- Preparation for the Physics
- CMS achievement status
- The Magnet Test and the Cosmic Challenge : MTCC
- Sub-detectors status
- Conclusons

CMS design guides (Evian 1992)

CMS Design





SUPERCONDUCTING COIL

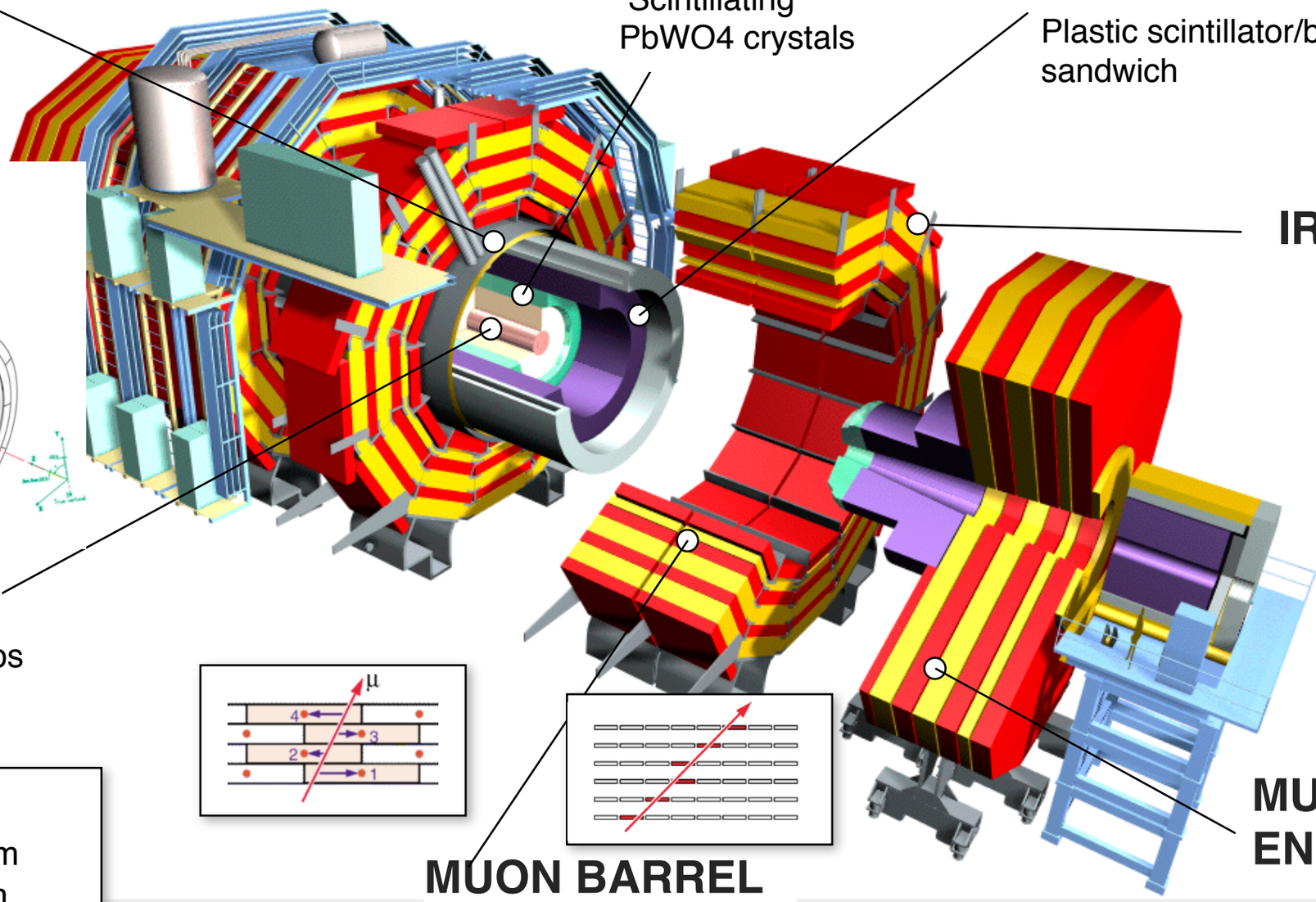
CALORIMETERS

ECAL

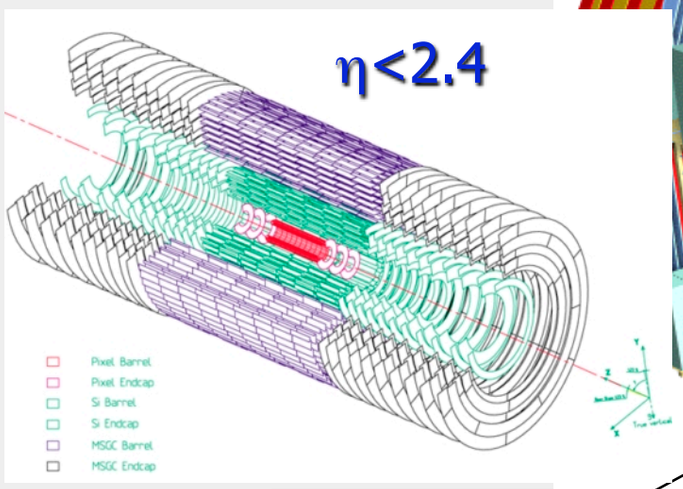
Scintillating PbWO4 crystals

HCAL

Plastic scintillator/brass sandwich



IRON YOKE



TRACKER

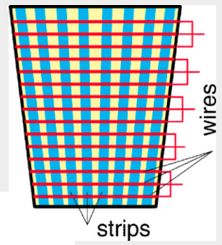
Silicon Microstrips
Pixels

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**)

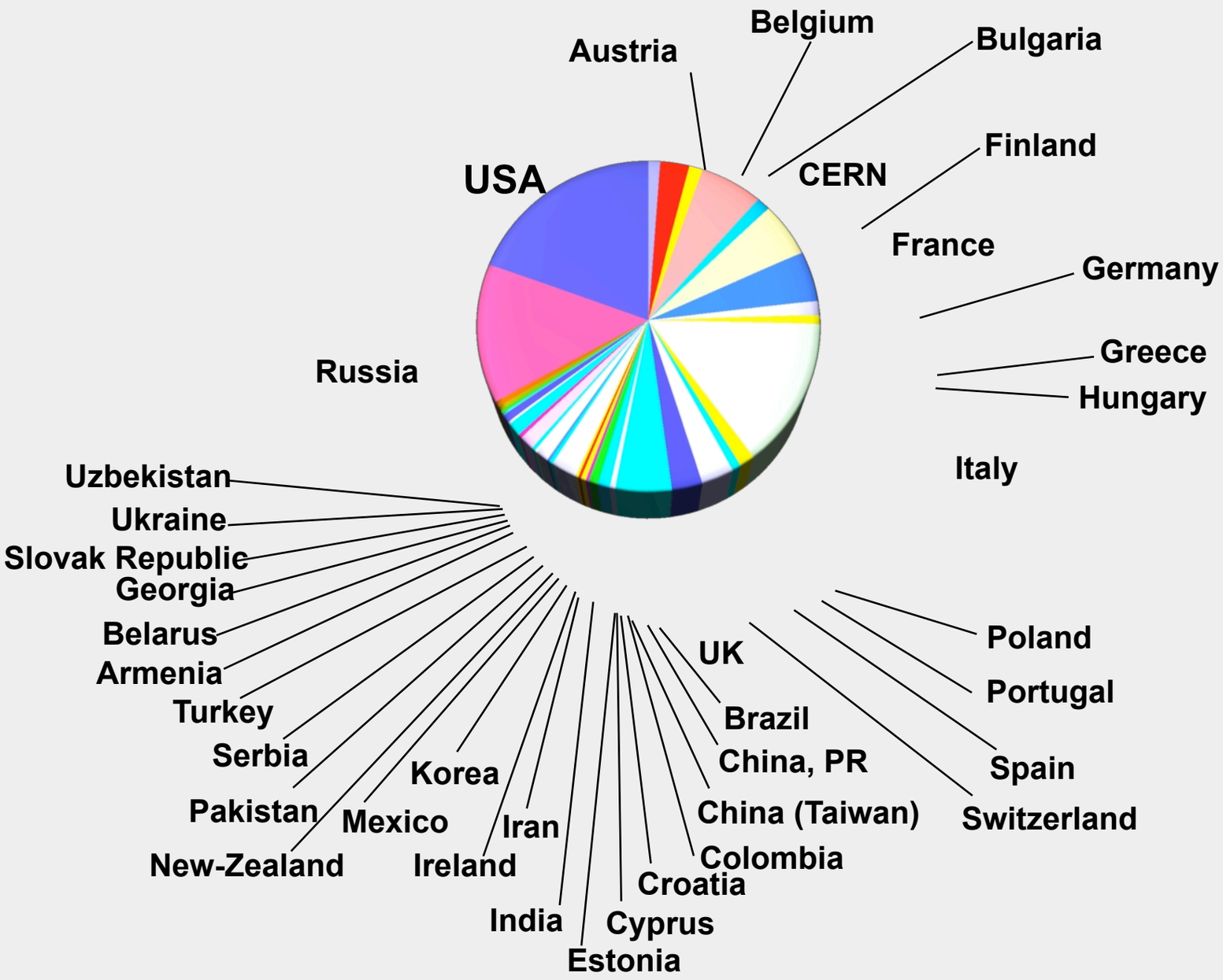
Resistive Plate Chambers (**RPC**)

The CMS Collaboration

	Institutions
Member States	61
Non-Mem. States	64
USA	49
Total	174

	Scientists
Member States	1055
Non-Mem. States	428
USA	547
Total	2030

Associated Institutes	
Number of Scientists	46
Number of Laboratories	8

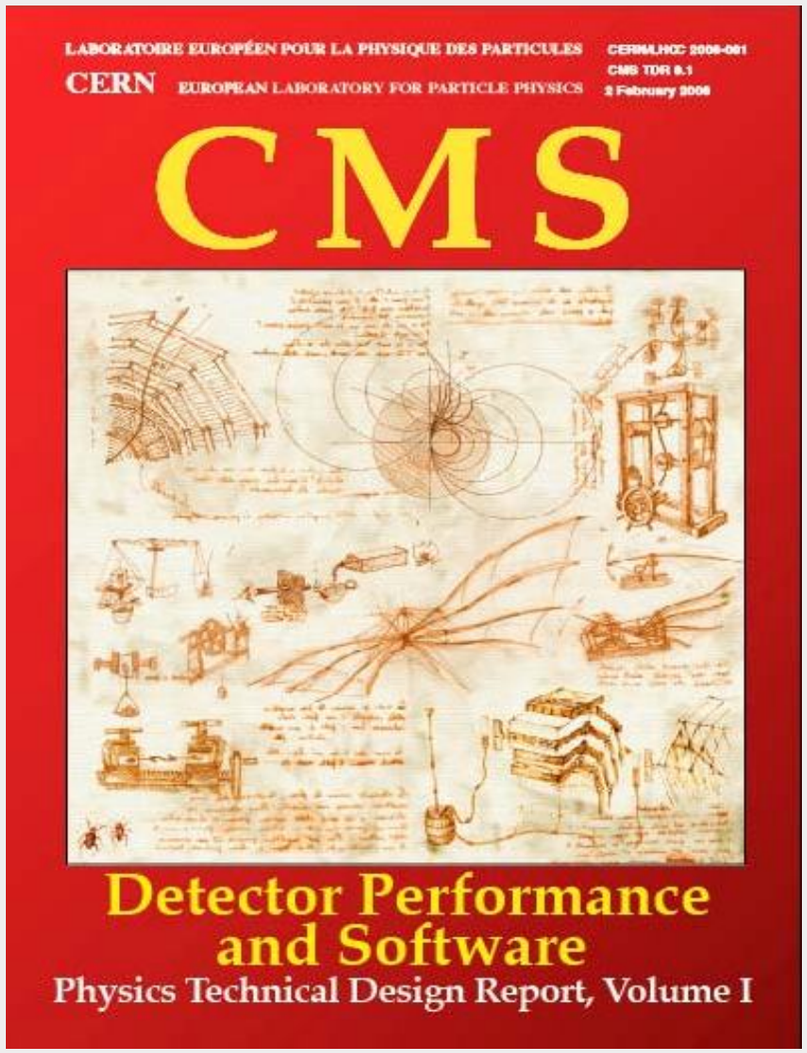


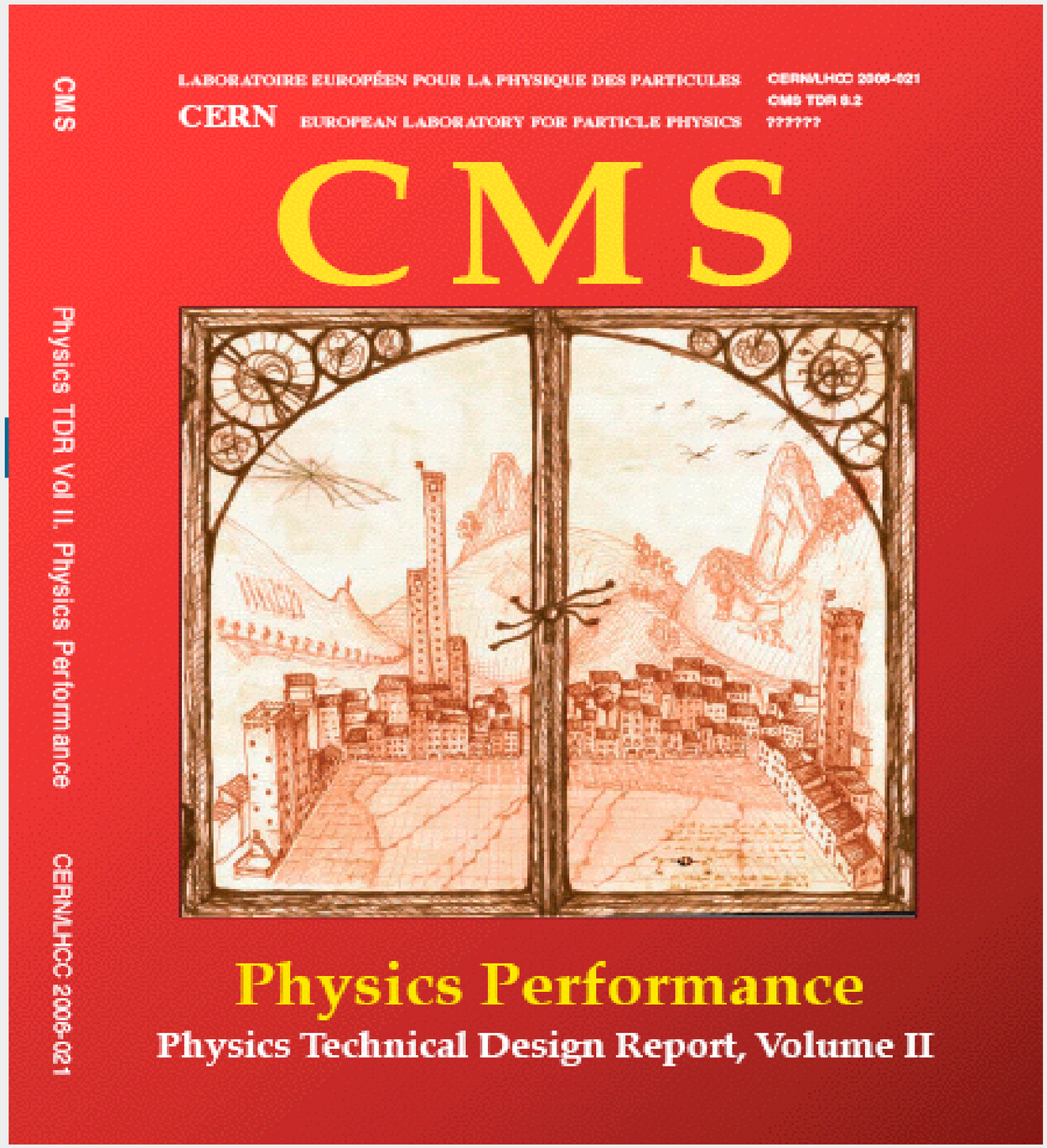
2030 Scientific Authors, 38 Countries, 174 Institutions

May, 04 2006/gm
http://cmsdoc.cern.ch/pictures/cmsorg/overview.html

Physics at LHC with CMS

See Talk of
Susan GASCON





650 pages
308 figures
207 tables
1.50 Kg

http://cmsdoc.cern.ch/cms/cpt/tdr/

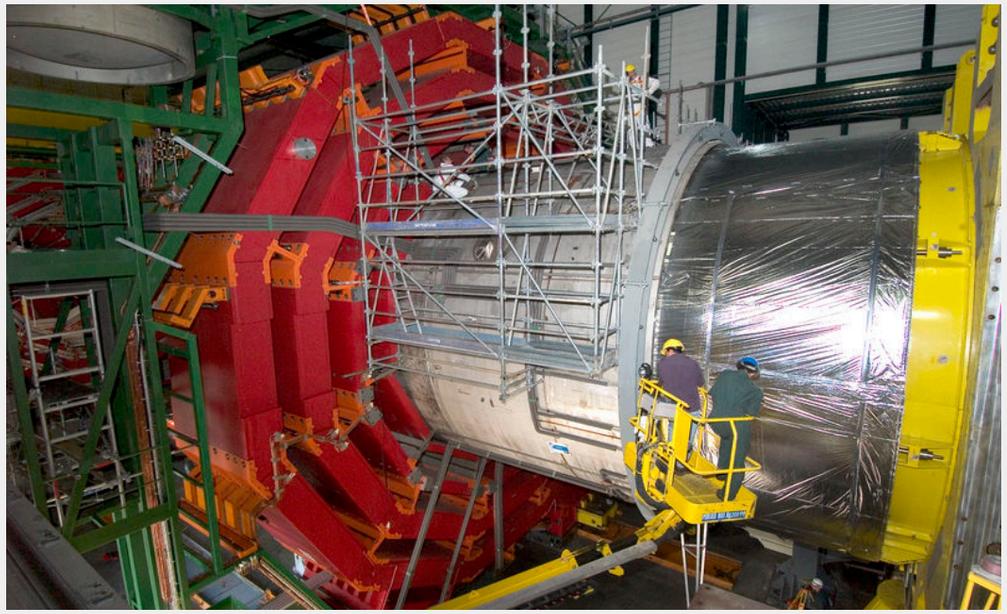
CERN/LHCC 2006-001

Published

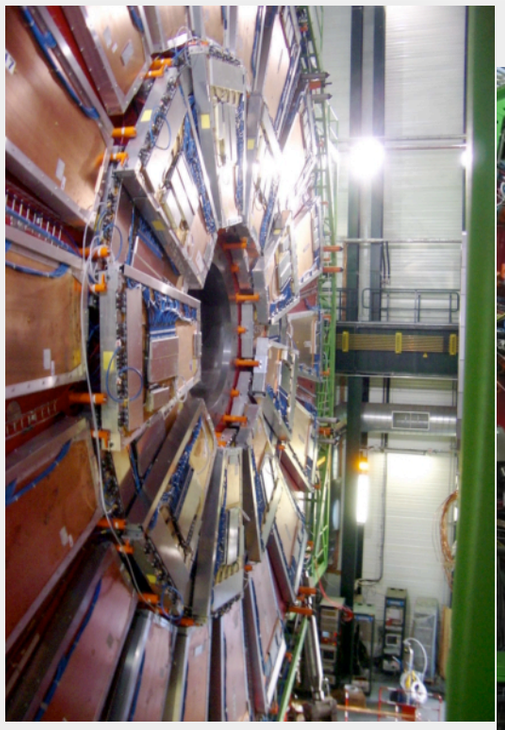
CERN/LHCC 2006-021

Published

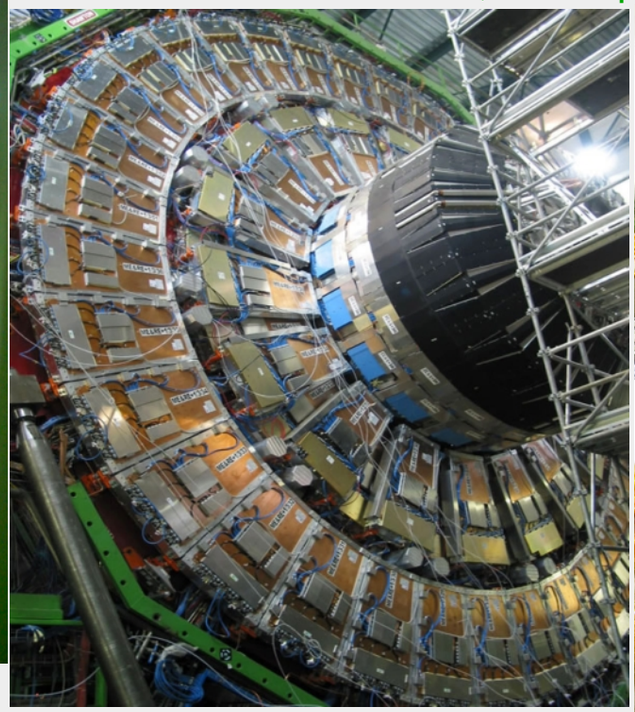
Overview of CMS integration progress (Summer 06)



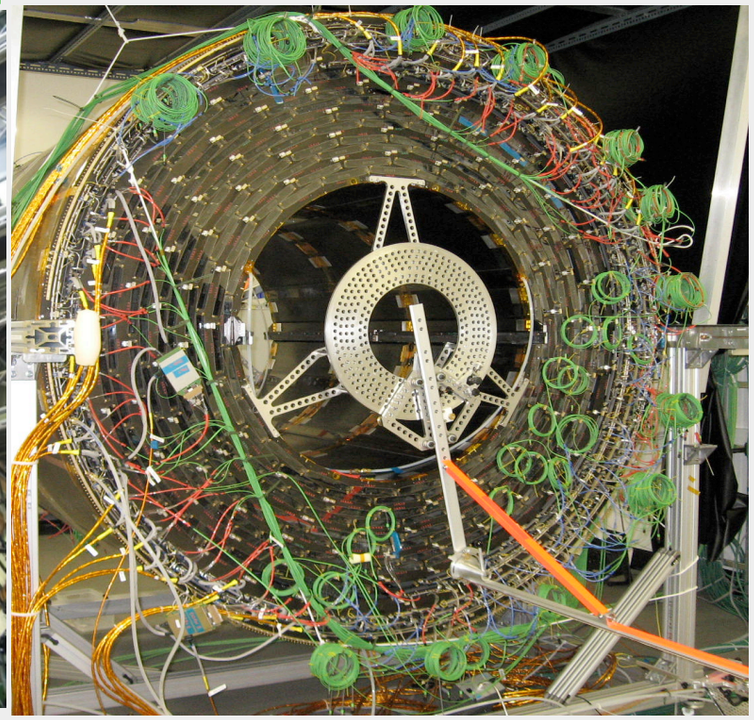
Coil inserted, 14. September 05



Cathode Strip chambers and yoke endcaps



Hadronic calorimeter, endcap



Tracker, outer barrel

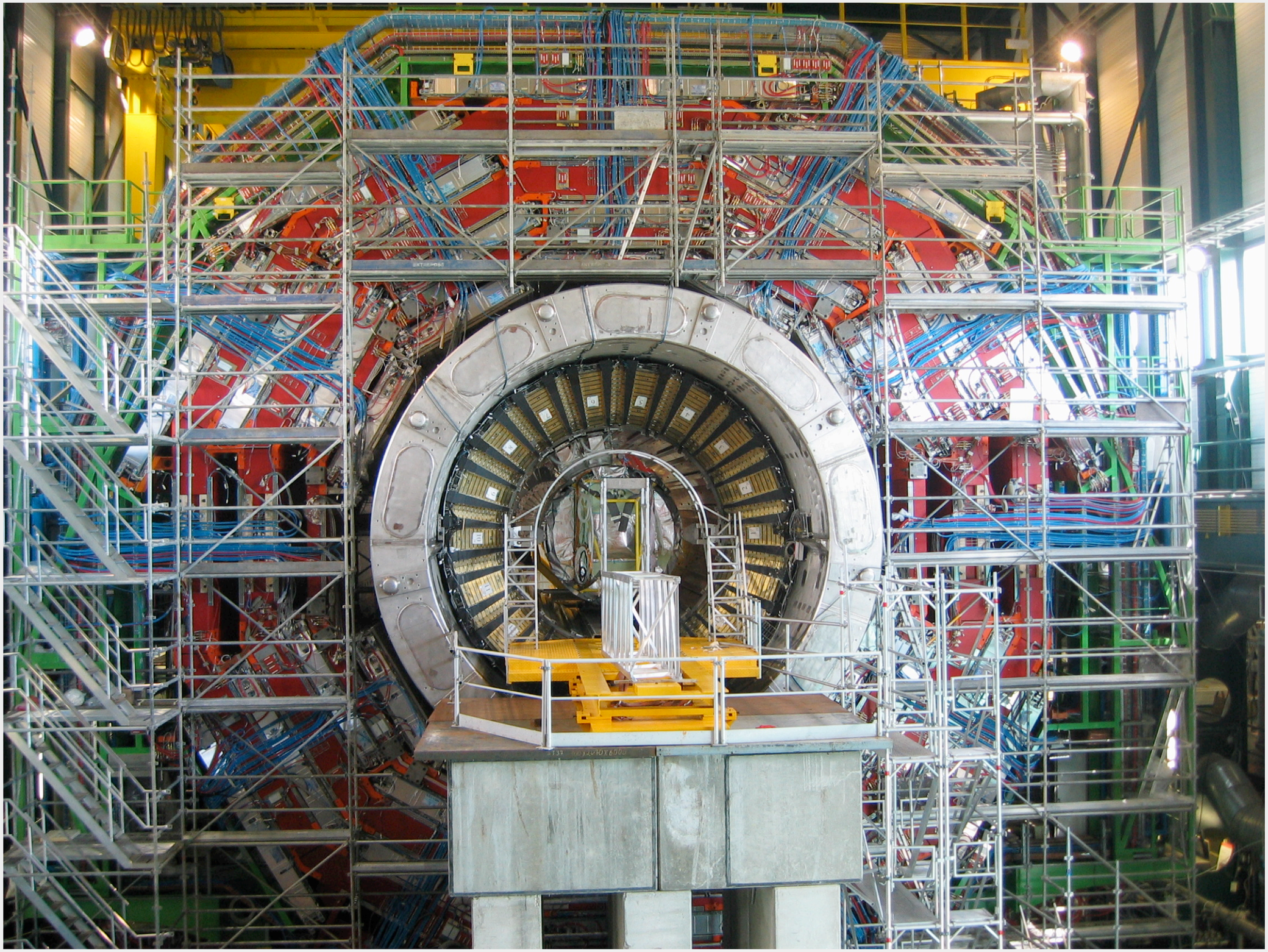
On critical path: ECAL crystal delivery (Barrel: Feb. 07, Endcaps: Jan. 08)
Pixel installation for 2008 physics run.

UX Cavern Status

Both Rotating Shieldings Ready

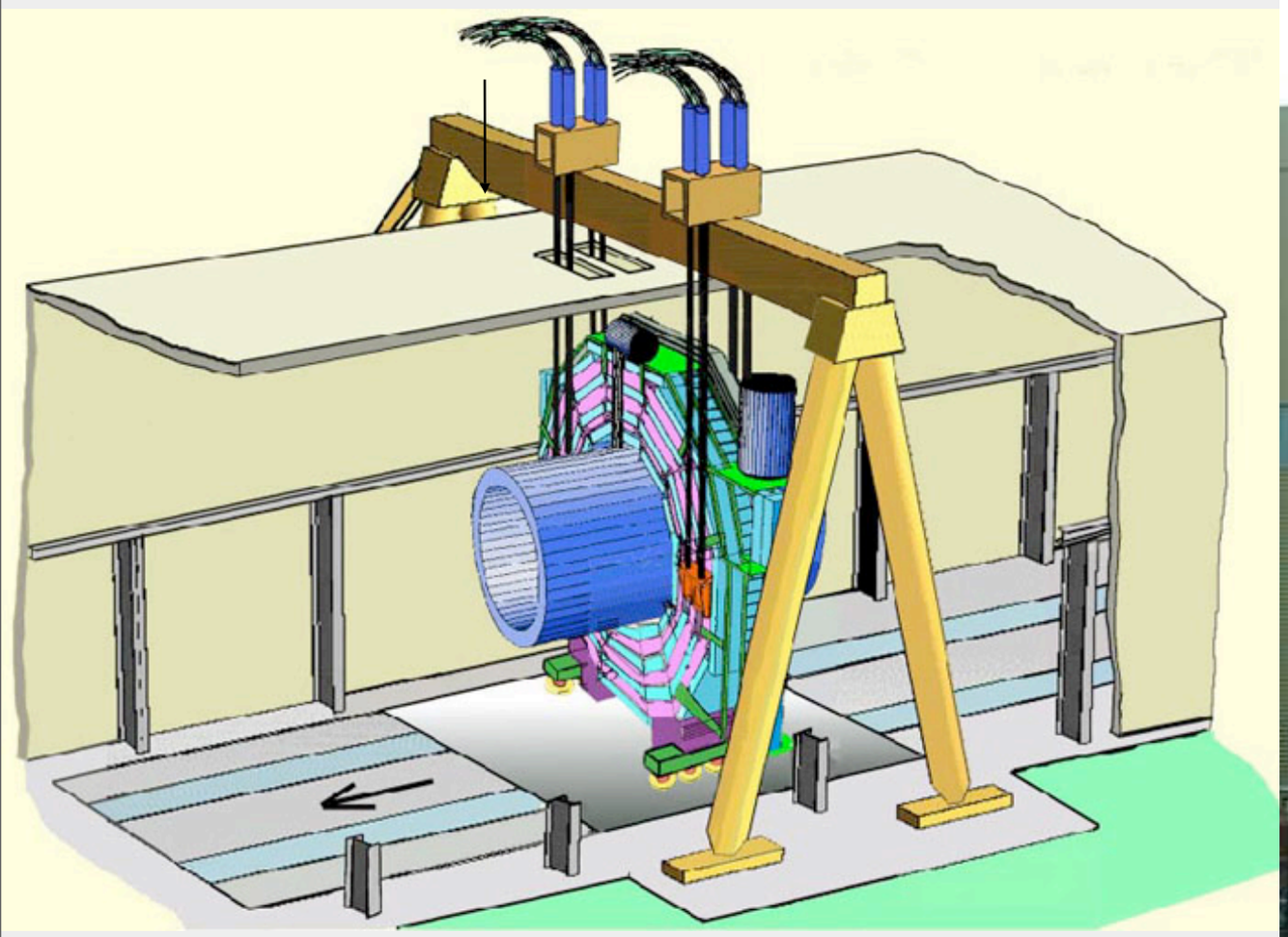
Cable Chains on positive side well advanced.

CMS in progress



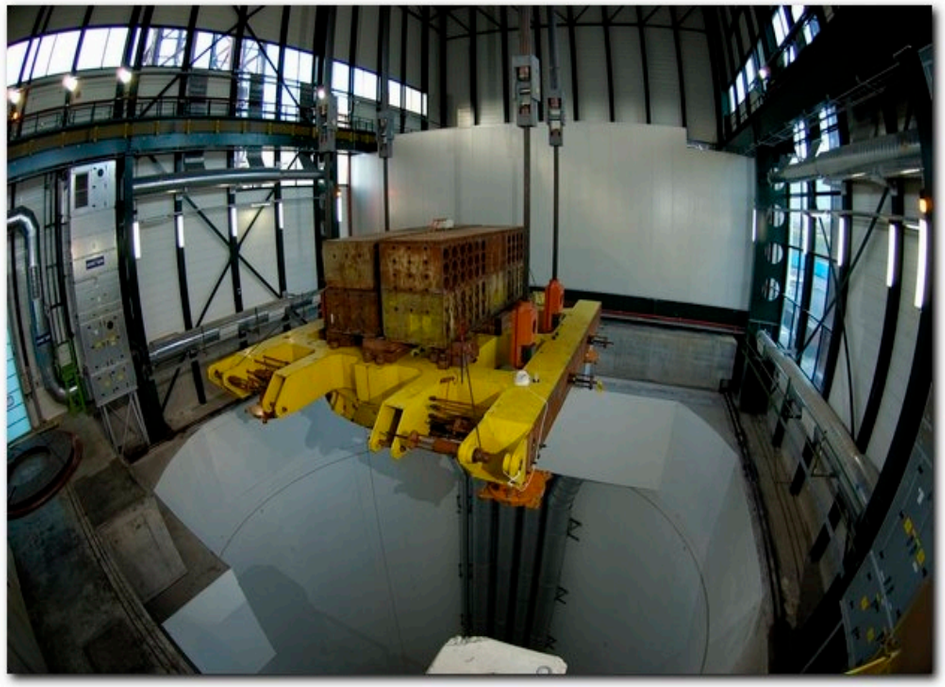
Transfer CMS Underground in 2006

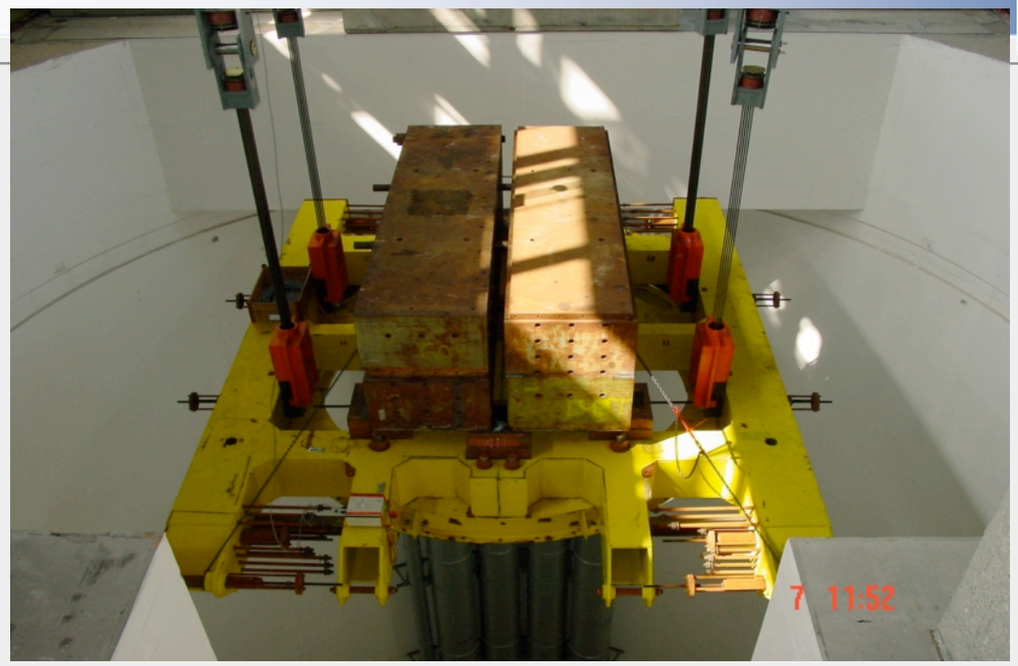
Gantry installed over PX56. load test in June and start HF lowering.

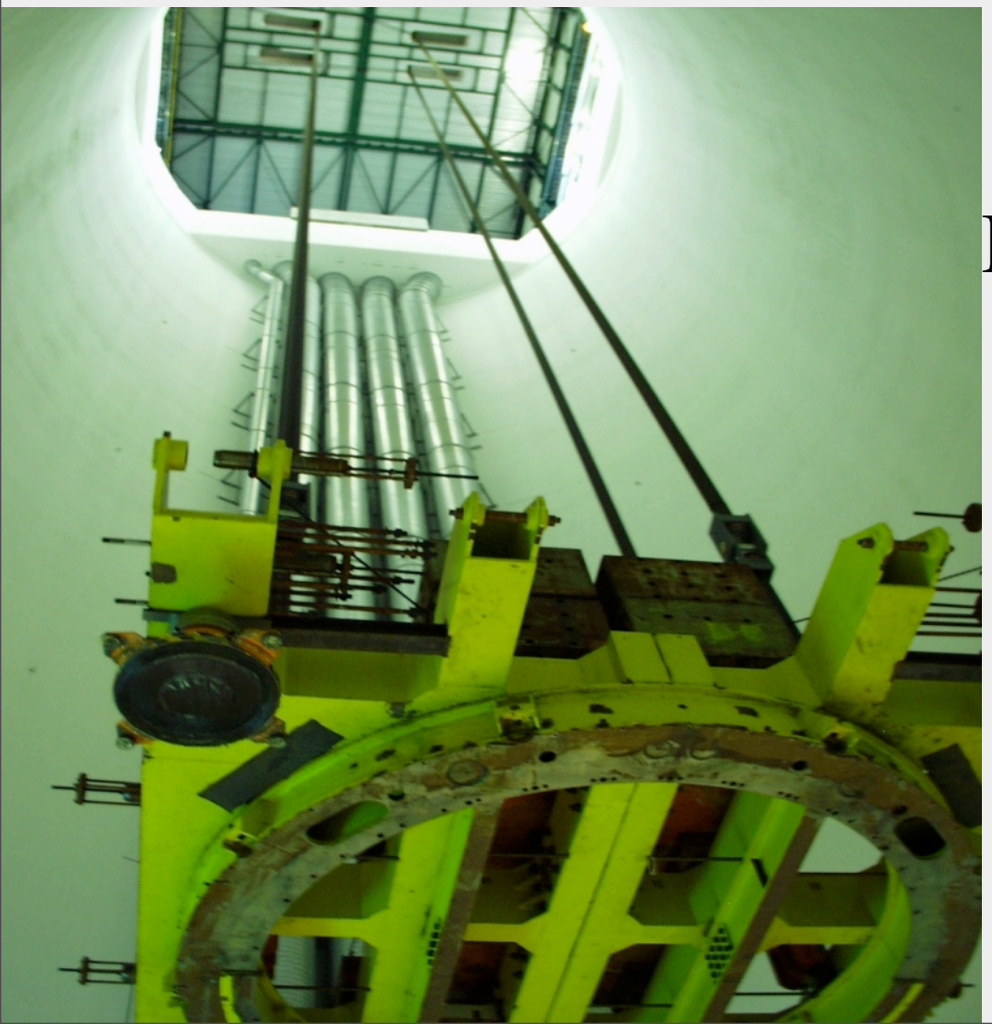


Start YB0 lowering (2000t): March 07

Lowering: Load Test (332 tons)







First Trial

Heavy Lowering: HFs

2 Nov

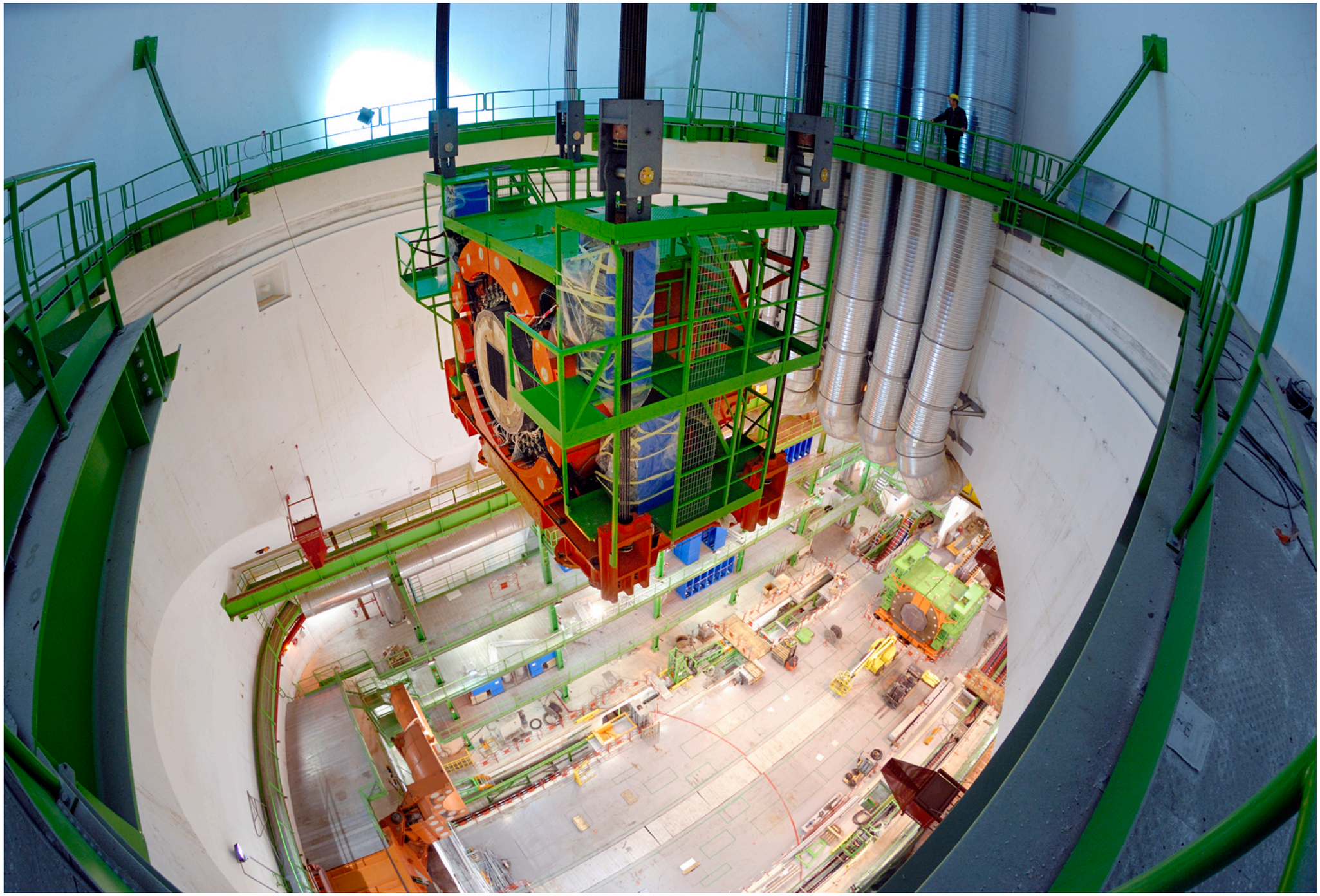
HF+ en route for UXC

HF+ arriving safely in UXC

9 Nov

both HF in UXC

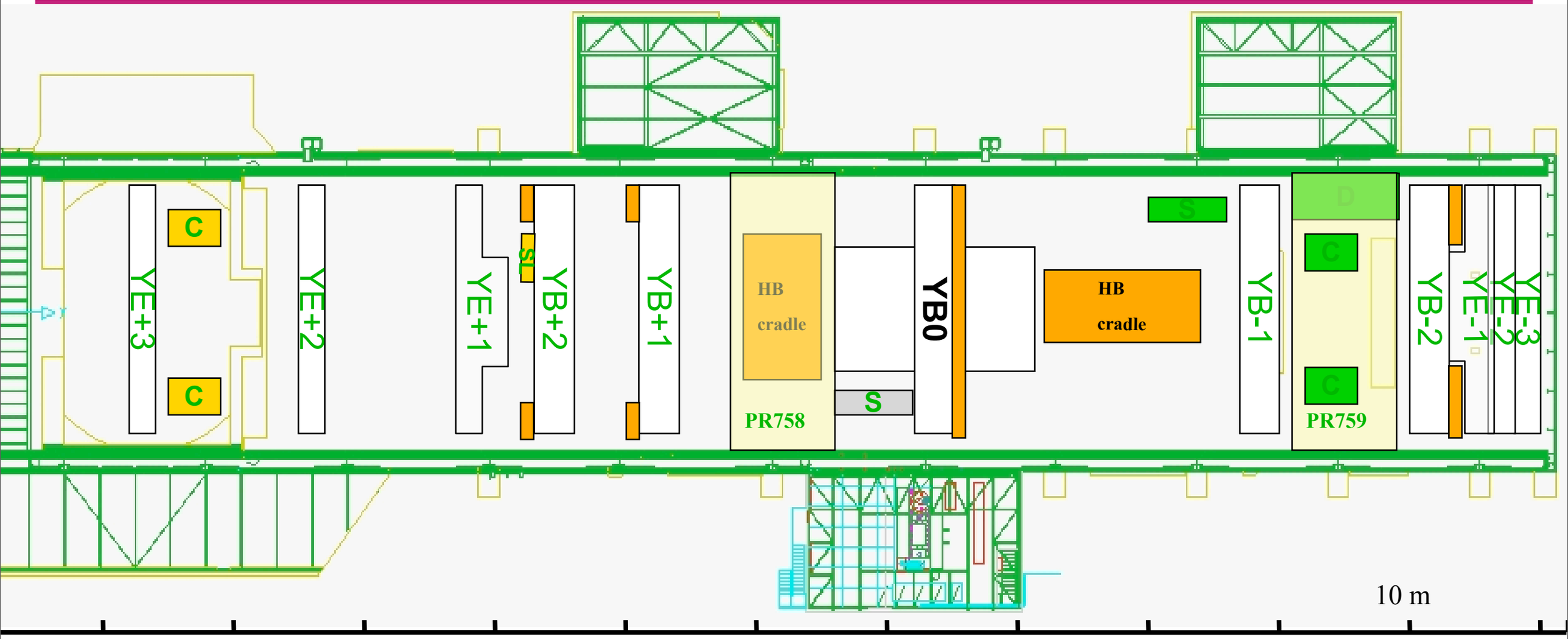
Second HF lowering (9 Nov 06)



HF landing into UXC55

Both HF's lowered into UXC

SX5 @ DATES:27/11-4/12

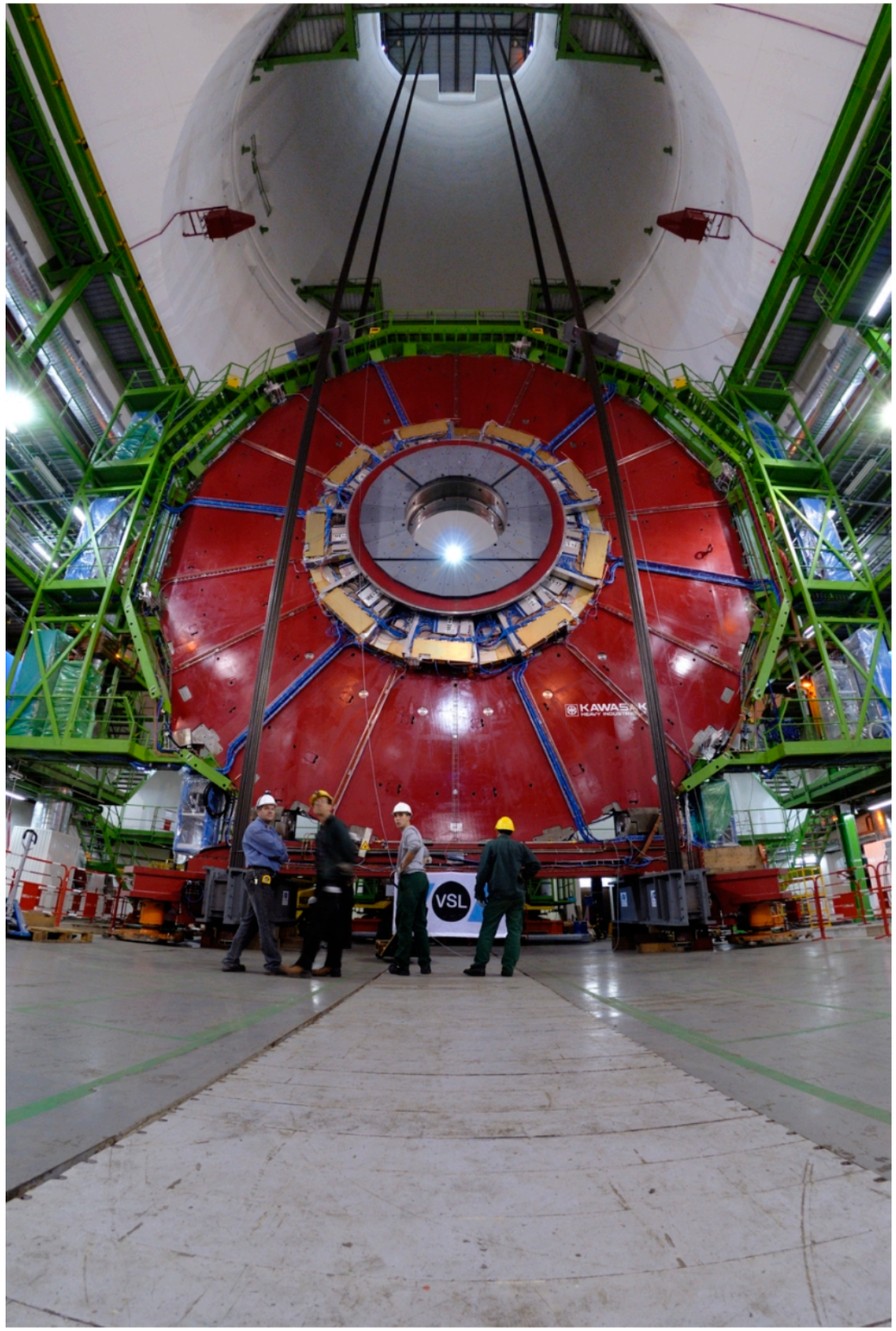


Heavy lowering: YE +3

30 Nov: YE+3 leaves SX5 and 11 hours touches down safely in UXC

Start YE+3 lowering (30 Nov 06)

YE+3 landing 8 hours later (30 Nov)



YE+3 in place

From Design to a working detector
MTCC

MTCC

Magnet Test and Cosmic Challenge

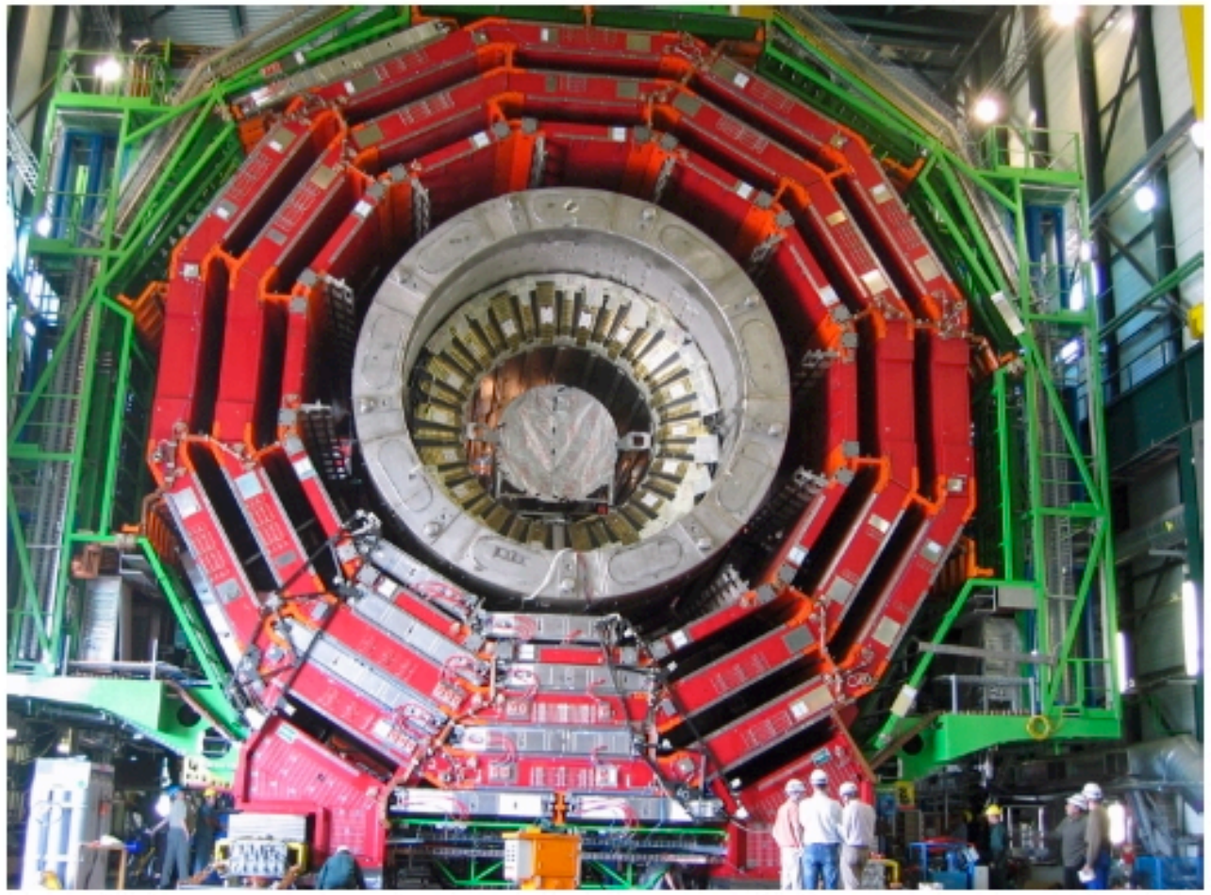
- ***Installation validation***
- ***Magnet Commissioning***
- ***Cosmic Challenge***
- ***Field Mapping***

The Compact Muon Solenoid Experiment
CMS Bulletin
CERN, CH-1211 GENEVA 23, Switzerland

Bulletins are available on CMS internal information server: http://cmsdoc.cern.ch/cms.html

Number 06-02
19 june 2006

Getting Ready for Cosmics

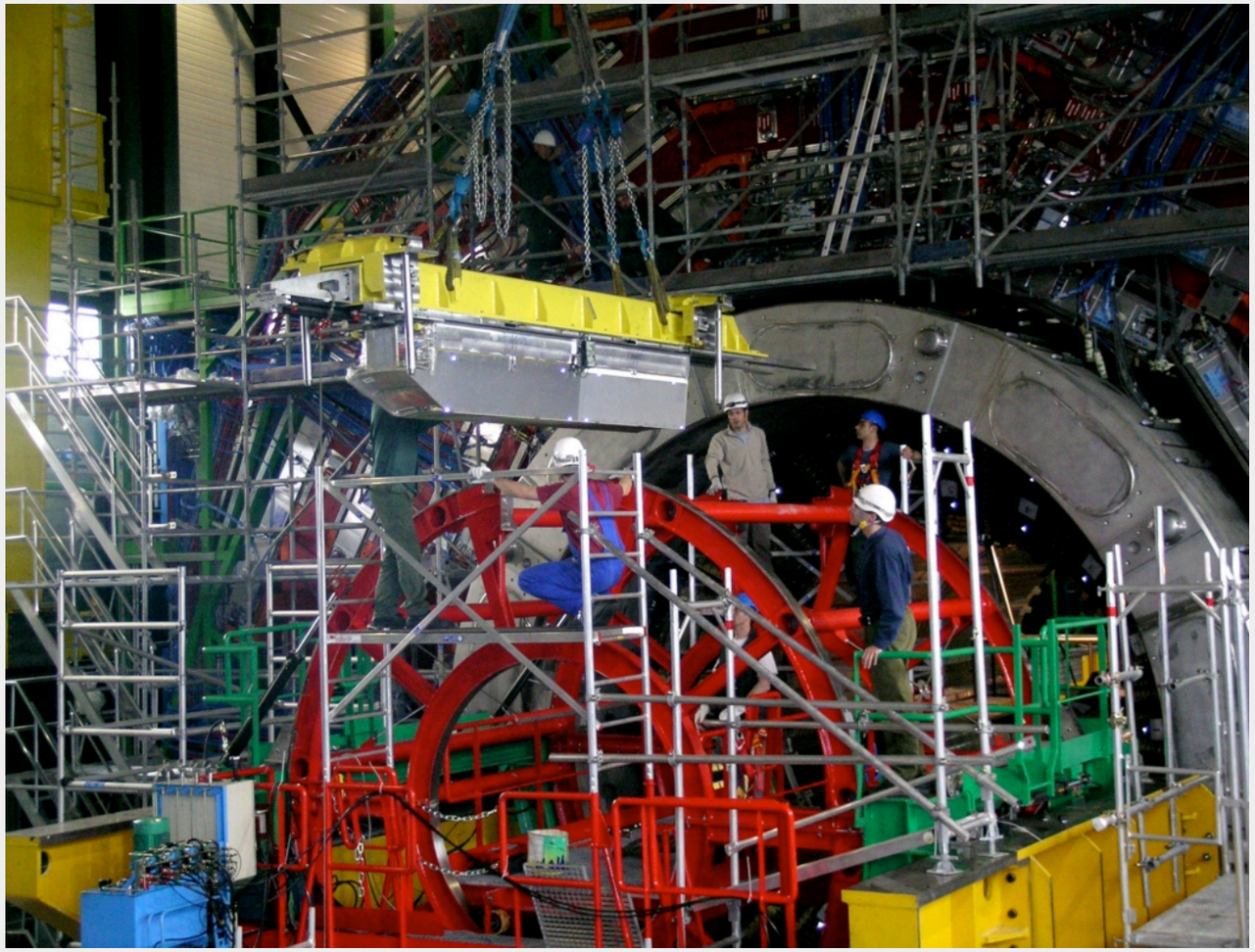


The CMS detector is being closed. The situation viewed from the -end (early last week) shows the YB-2 wheel (and YB-1) closed with the DT+RPC packages, the Barrel HCAL and the Tracker tube installed. Not visible are two 5M modules installed at the +end, and the endcaps systems.

CMS hadron calorimeter

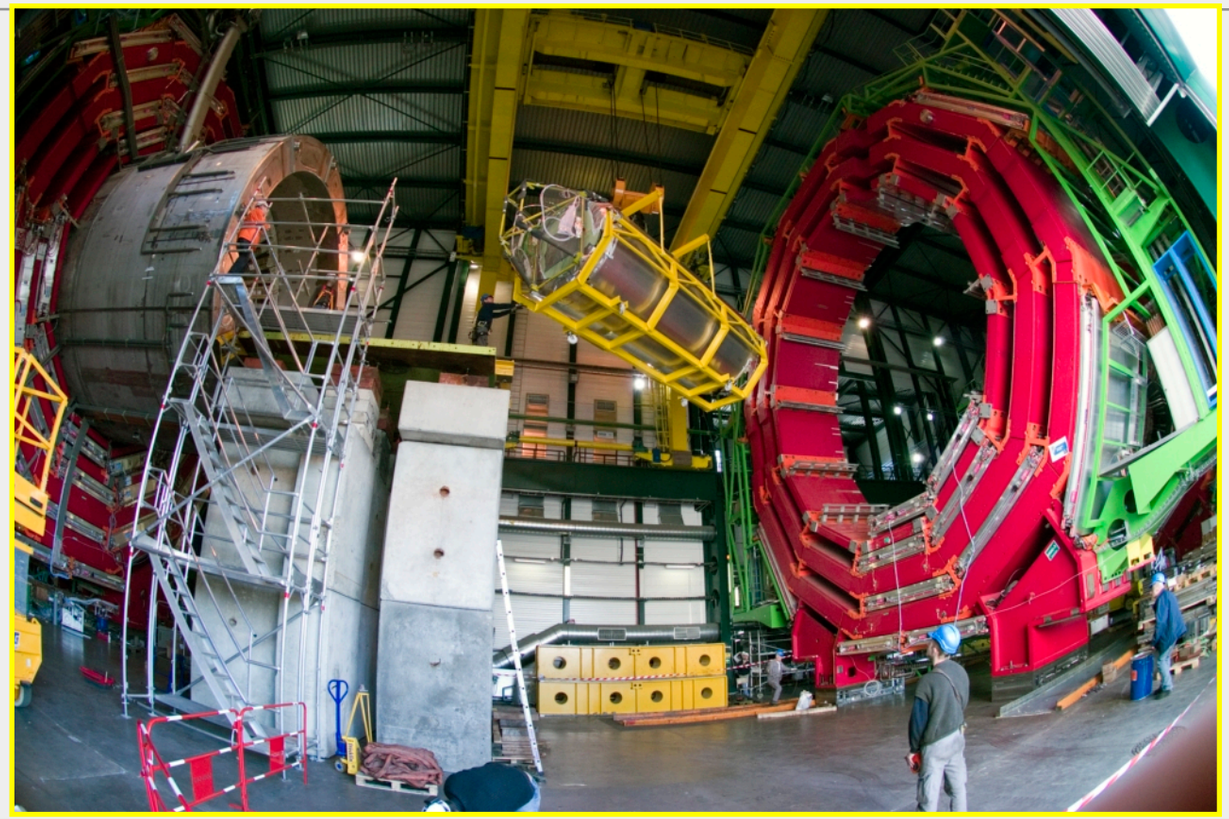
HB+ insertion complete on 3 April

2 EB supermodules inserted in HB+

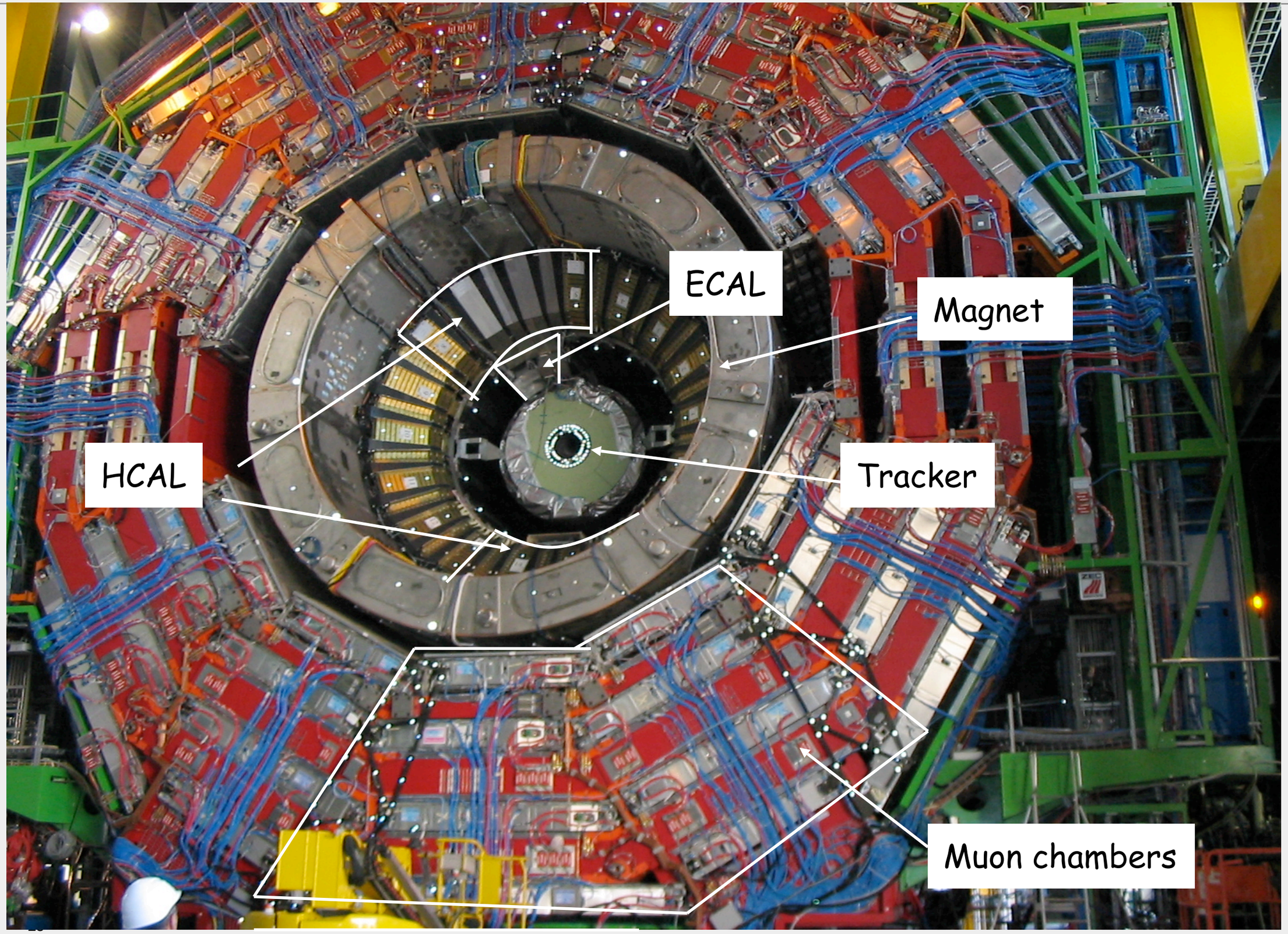


8-10 hours per supermodule

Tracker insertion

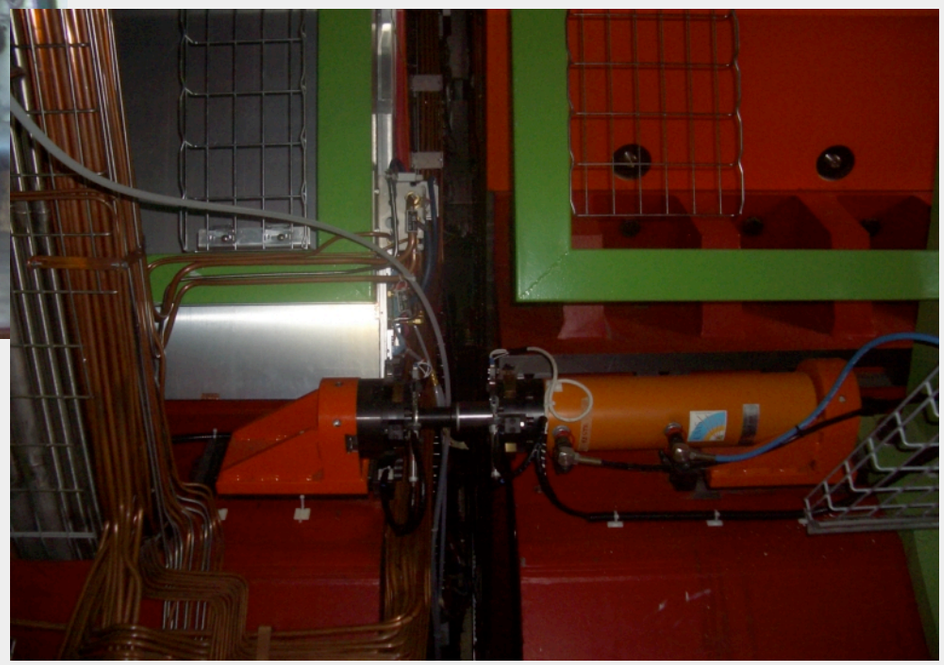


MTCC Configuration (Barrel)

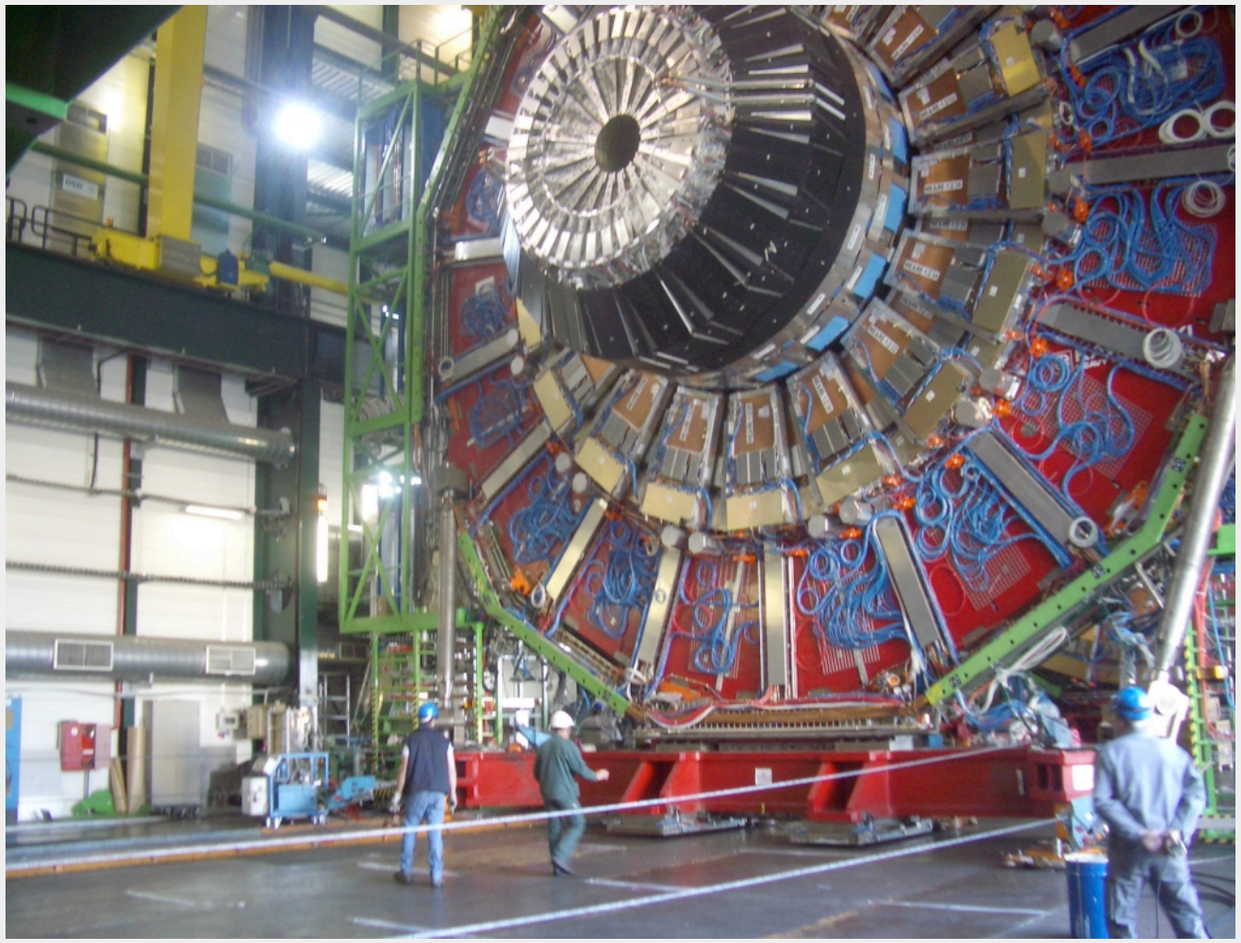


Closing Barrel wheels YB-1 and YB-2

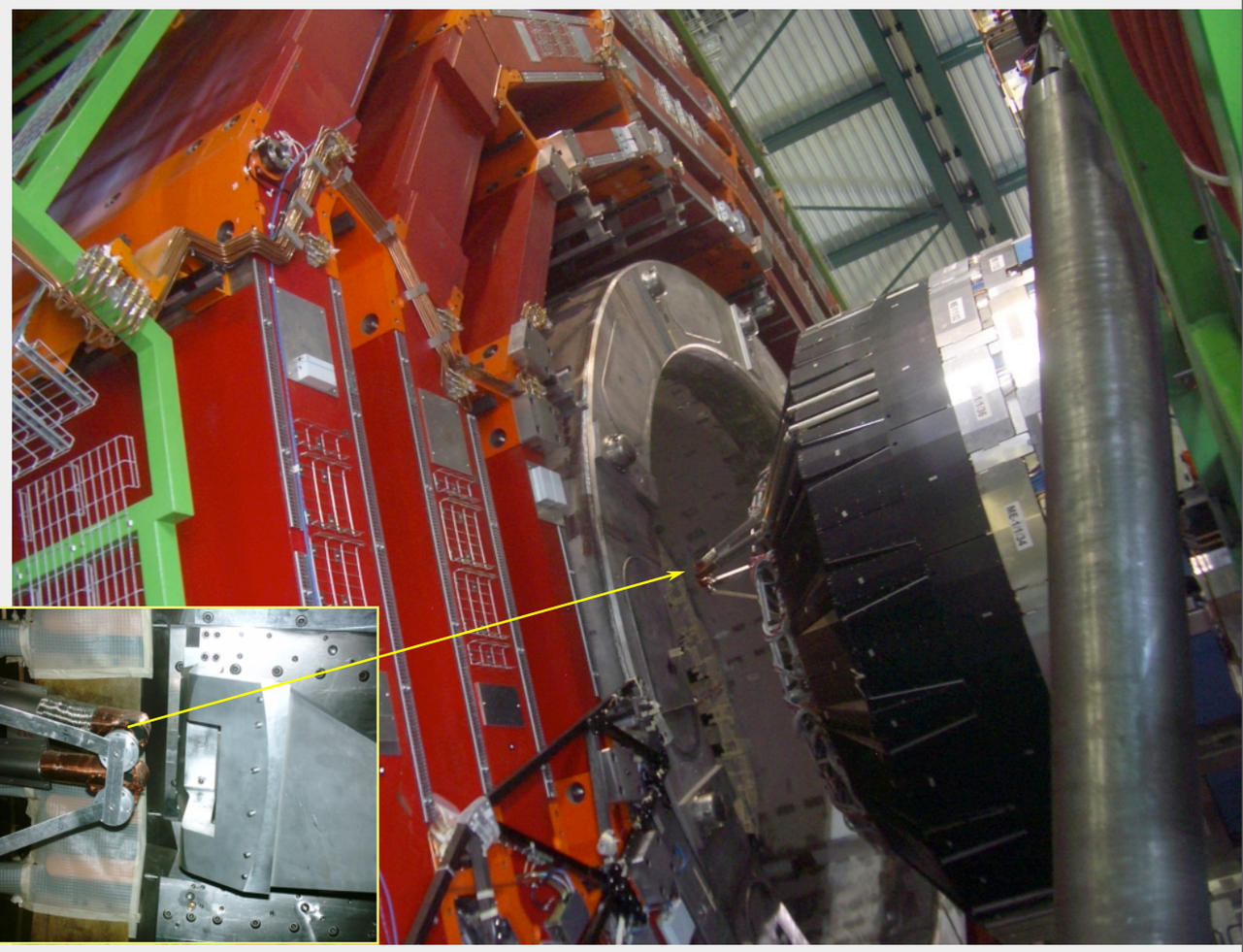
Both –end muon wheels are closed: airpads, grease pads
+ "proximity capture" hydraulic jacks



YE-1 disk closing

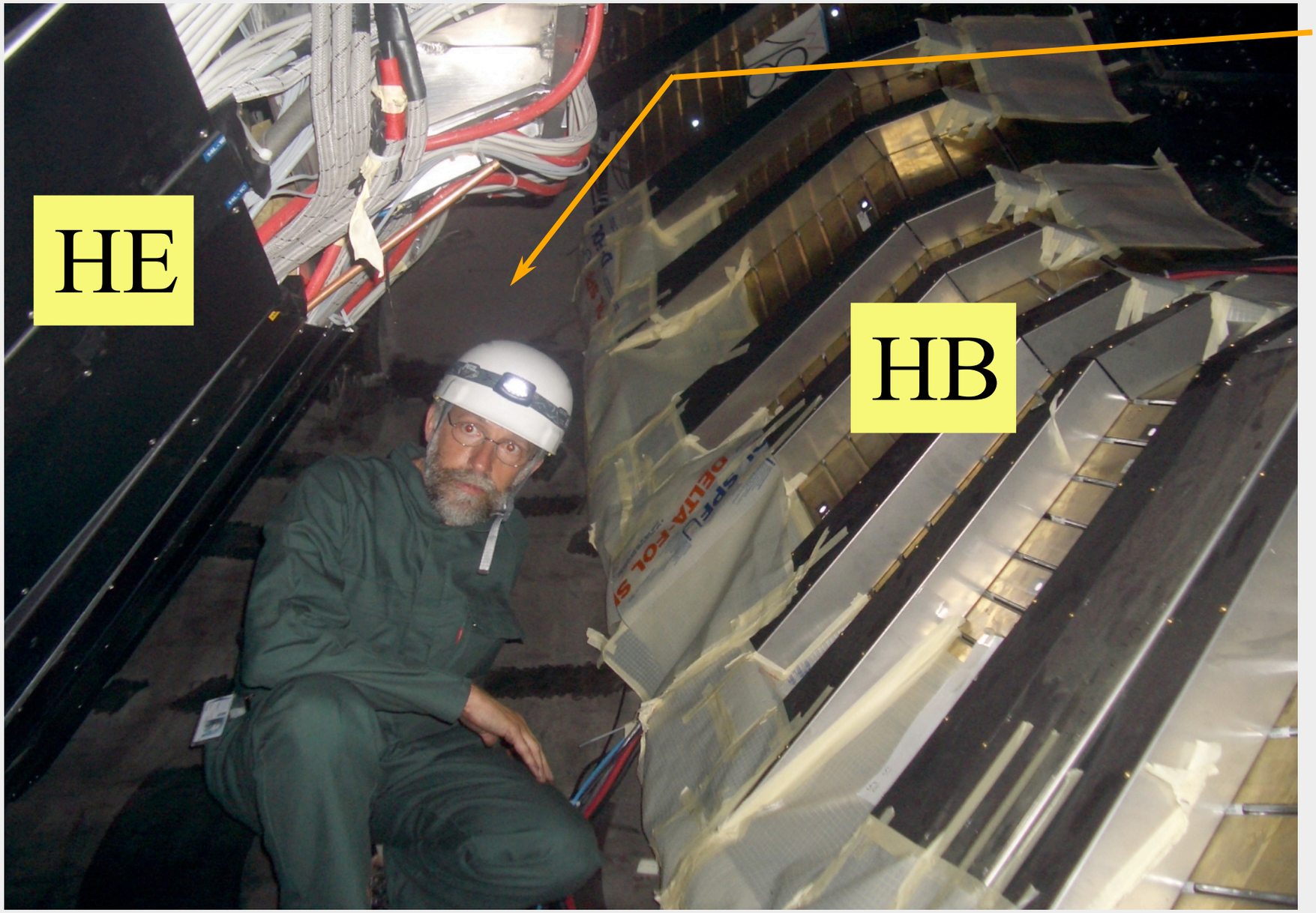


Heavier object, non-symmetric
Lever arm insertion in vac-tank



Completion of RE1/3, ME1/3
and RE 2/1, RE2/2 postponed until
after field-mapping (MTCC phase 2)

Verification of "no-go" zone?



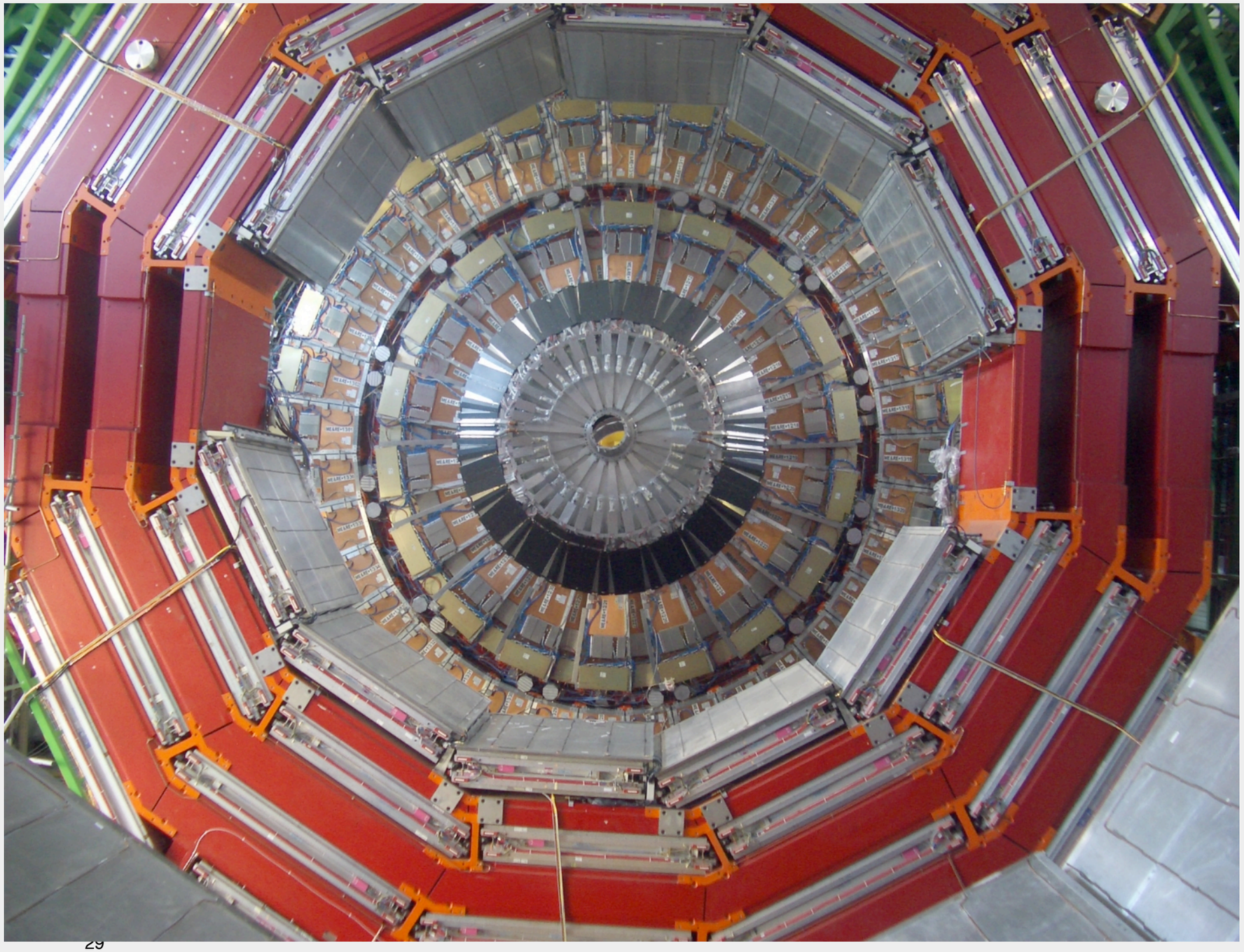
Integration coordinator

53 degree gap

~40mm when closed, field-off.

We will need people inside for YE+1 closing

+end closing



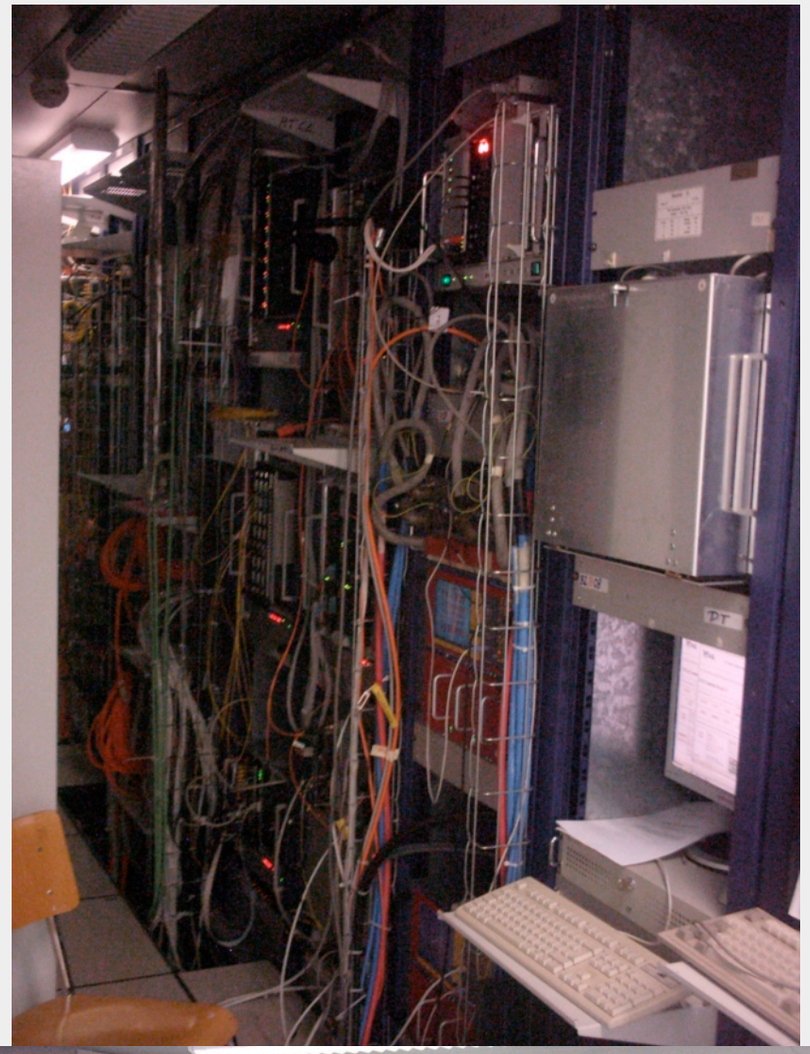
After YB0+ survey

+ end muon wheels YB+1 and YB +2 will be closed next

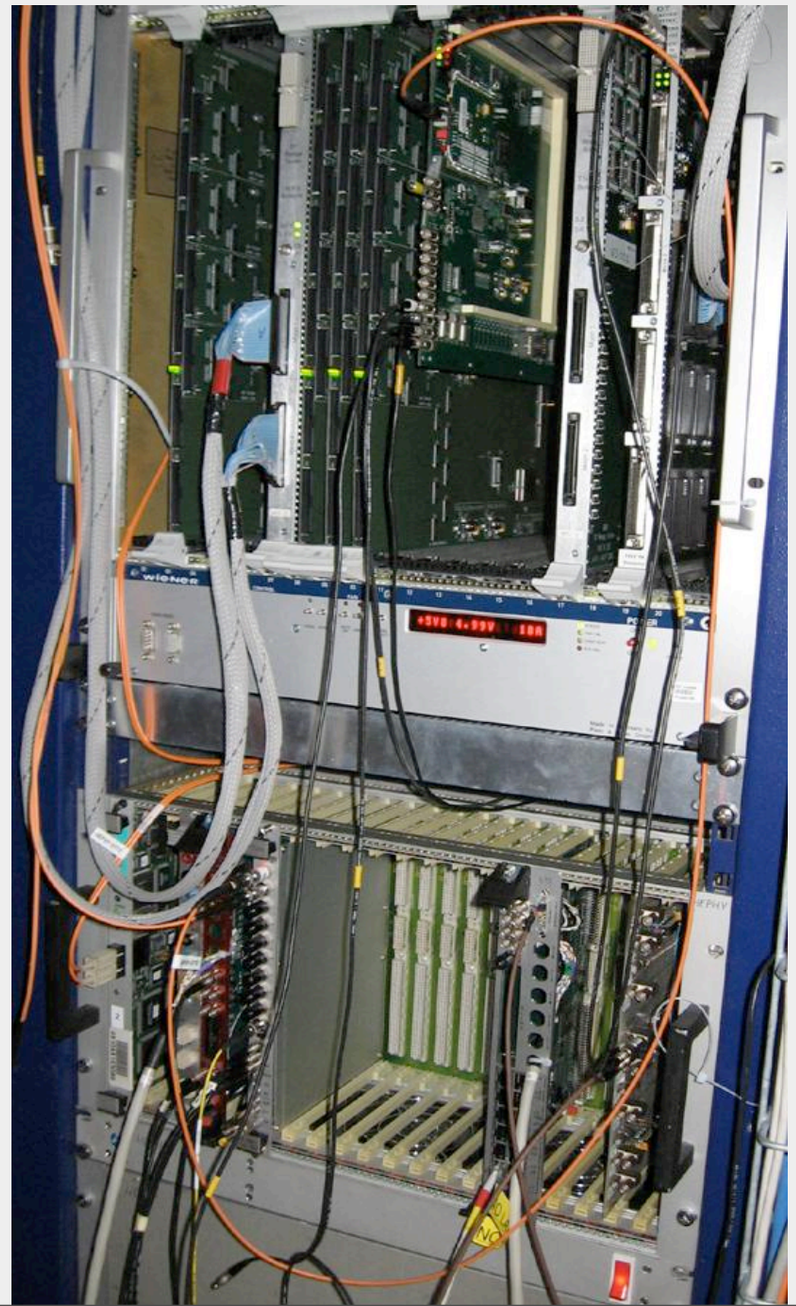
(allows final MTCC cabling to control barrack)

endcaps were closed by end of July

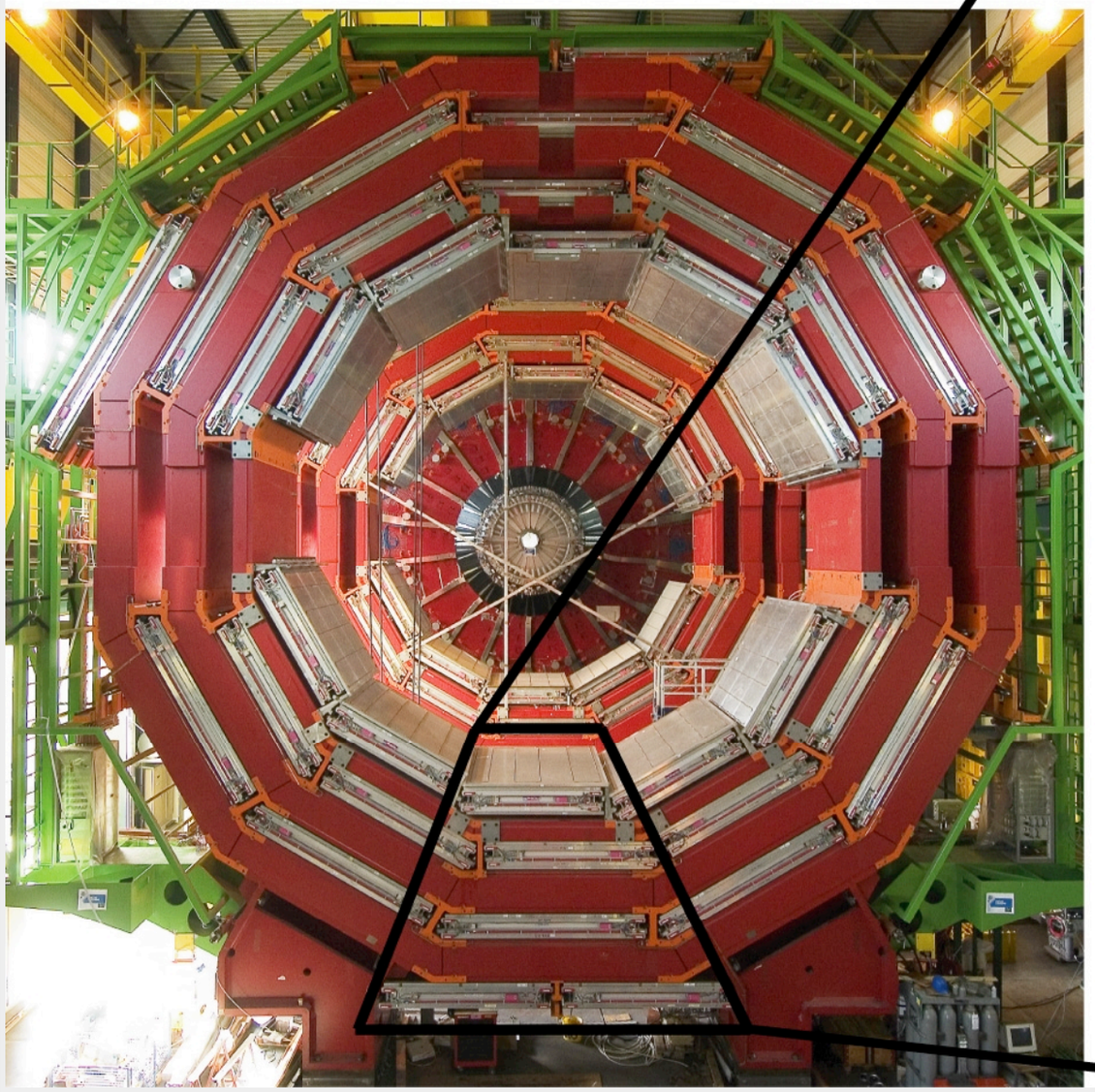
MTCC Commissioning

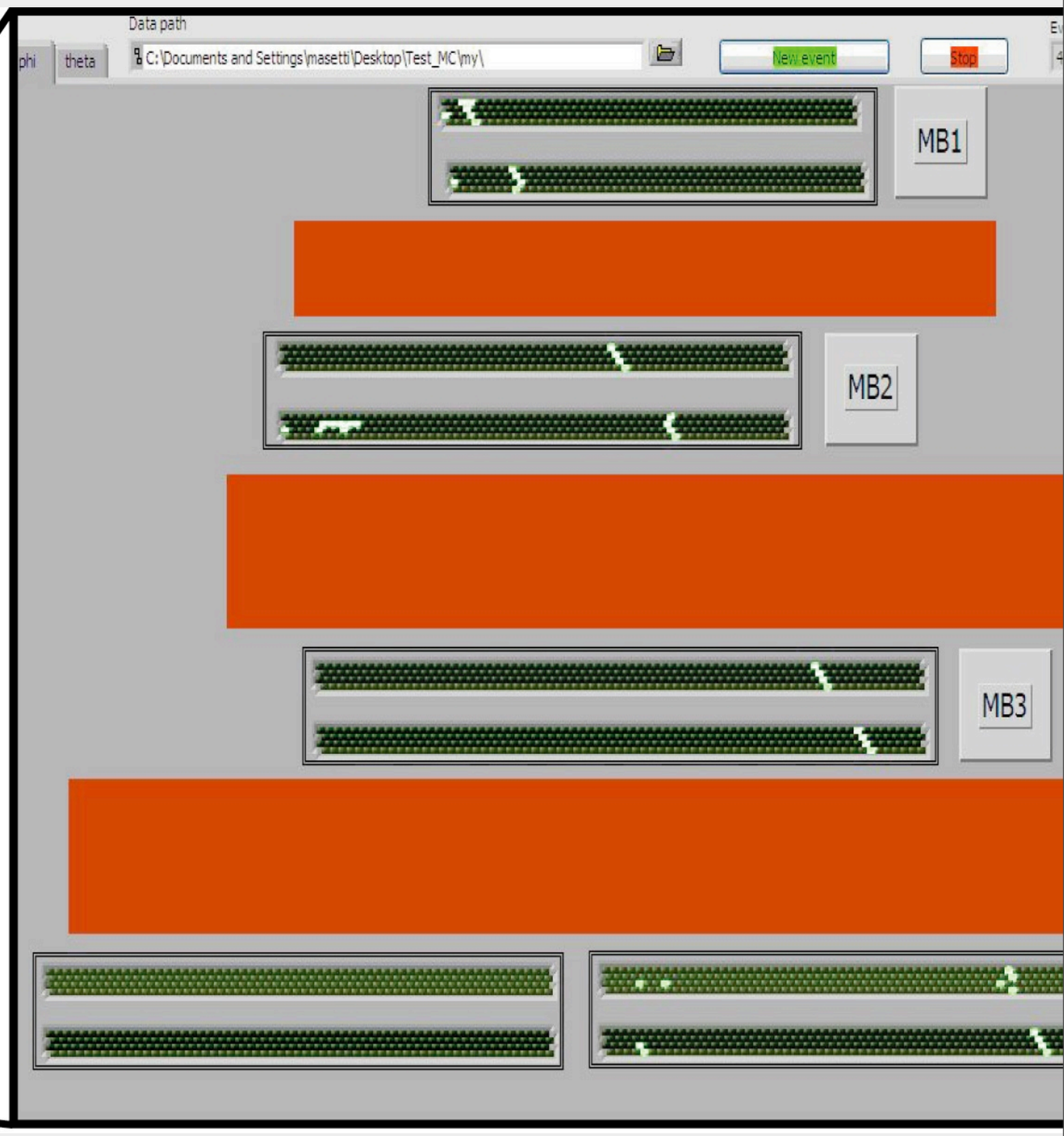


DT Trigger in MTCC



Cosmics signal in muon chambers





Run 2605 / Event 3981/ B 3.8 T/27.08.06

CERN PRESS RELEASE
13 September 2006

Mammoth CMS magnet reaches full-field at CERN

Tests show CMS detector will be ready for data

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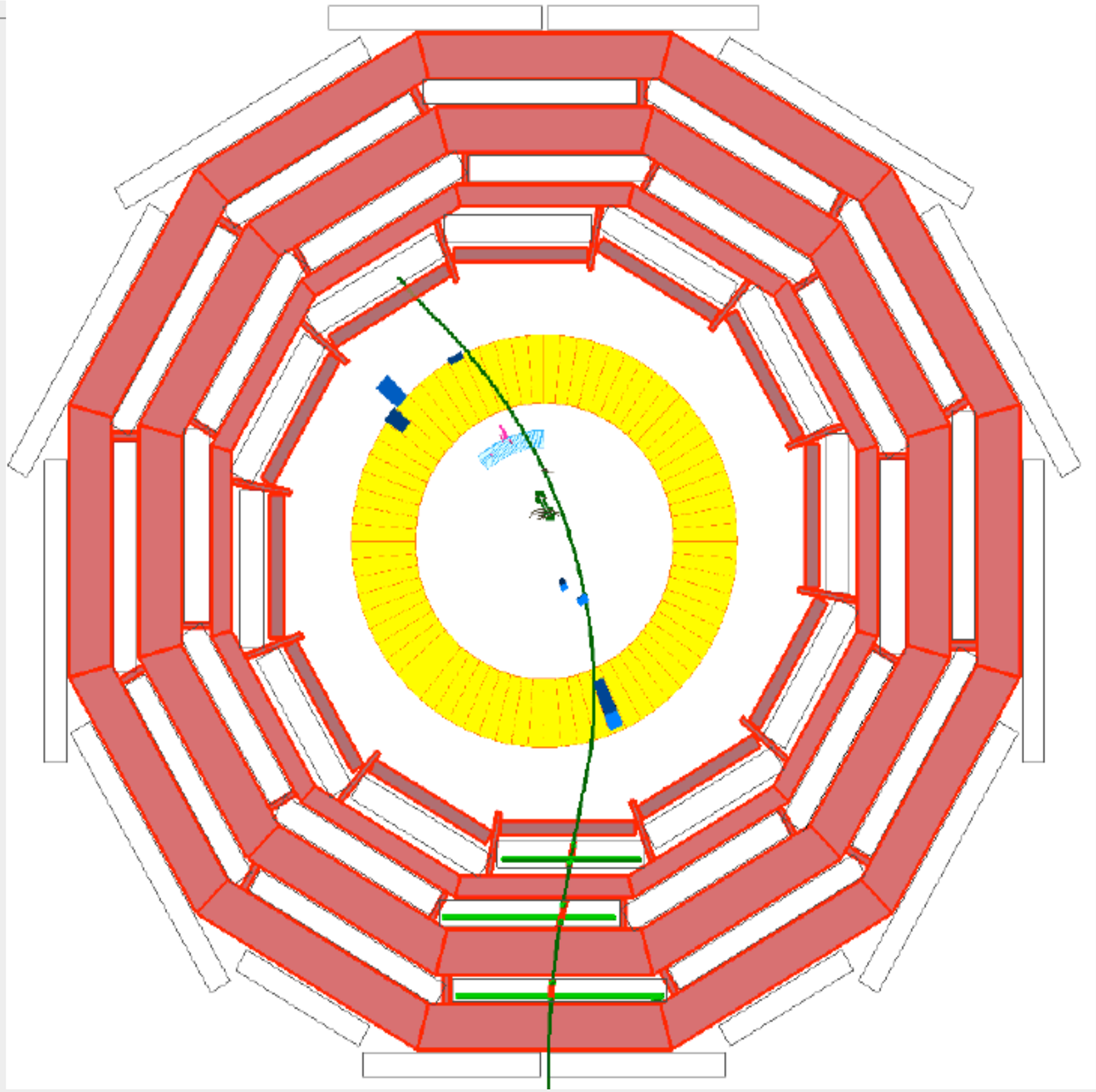
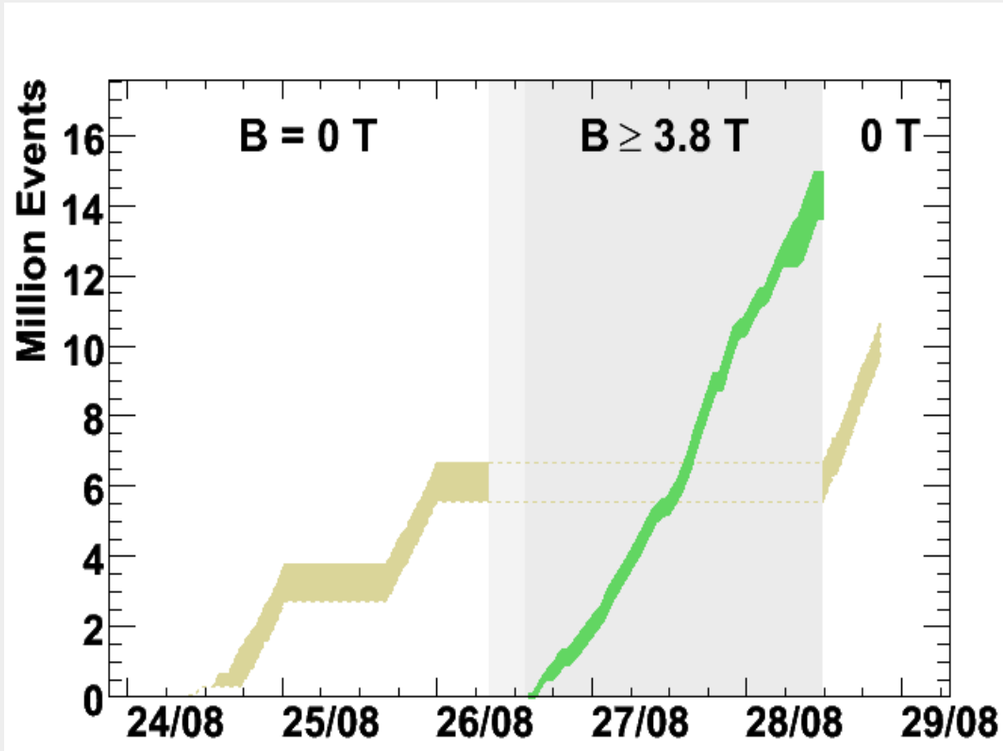


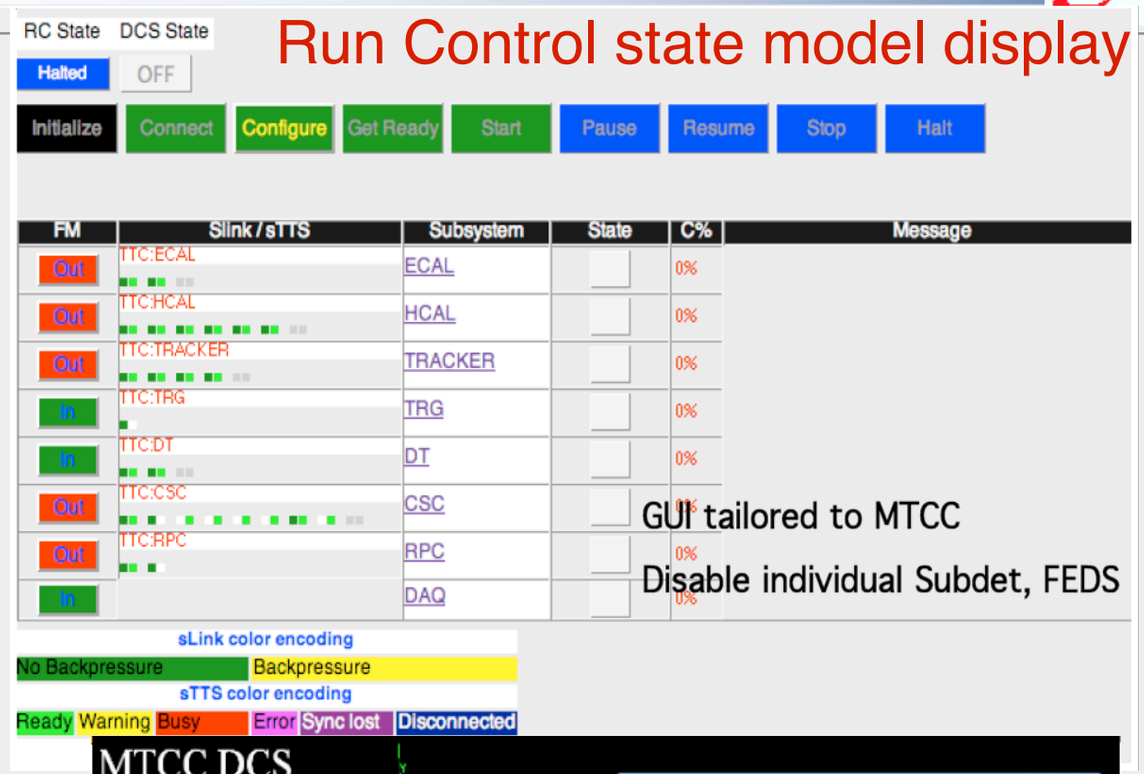
MTCC: Data Taking

2 years planning and preparation came down to 5 crucial days in August….
25M events recorded @ 90% eff.



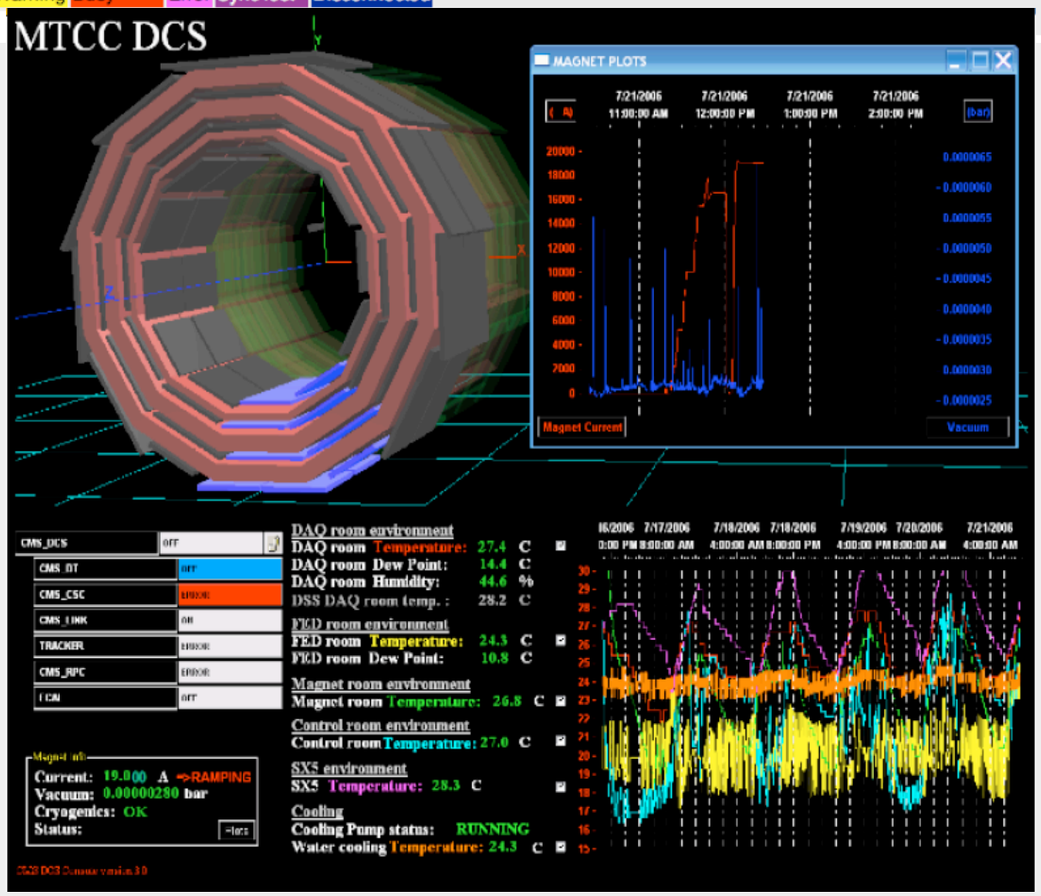
Diligent work by 100's of people in CMS (& some good fortune) transformed the "cosmic challenge" into a "cosmic success"

Run Control state model display



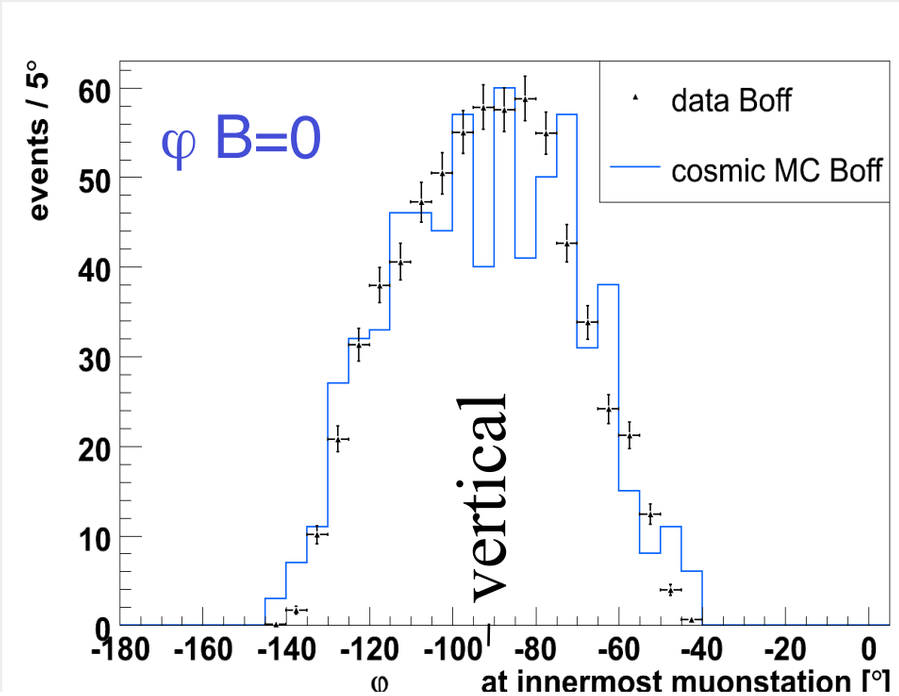
GUI tailored to MTCC

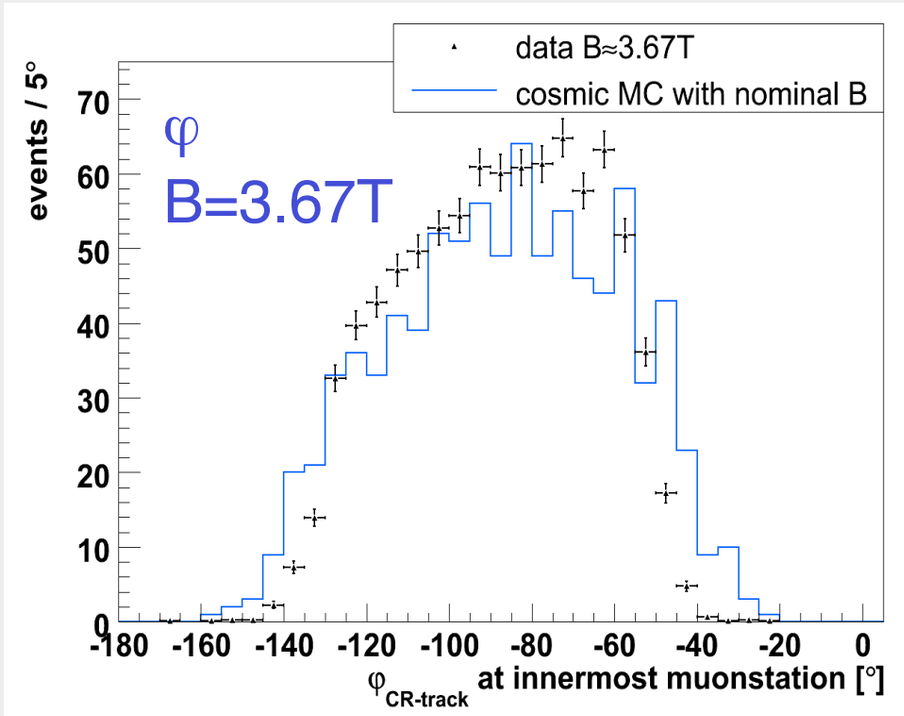
Disable individual Subdet, FEDS



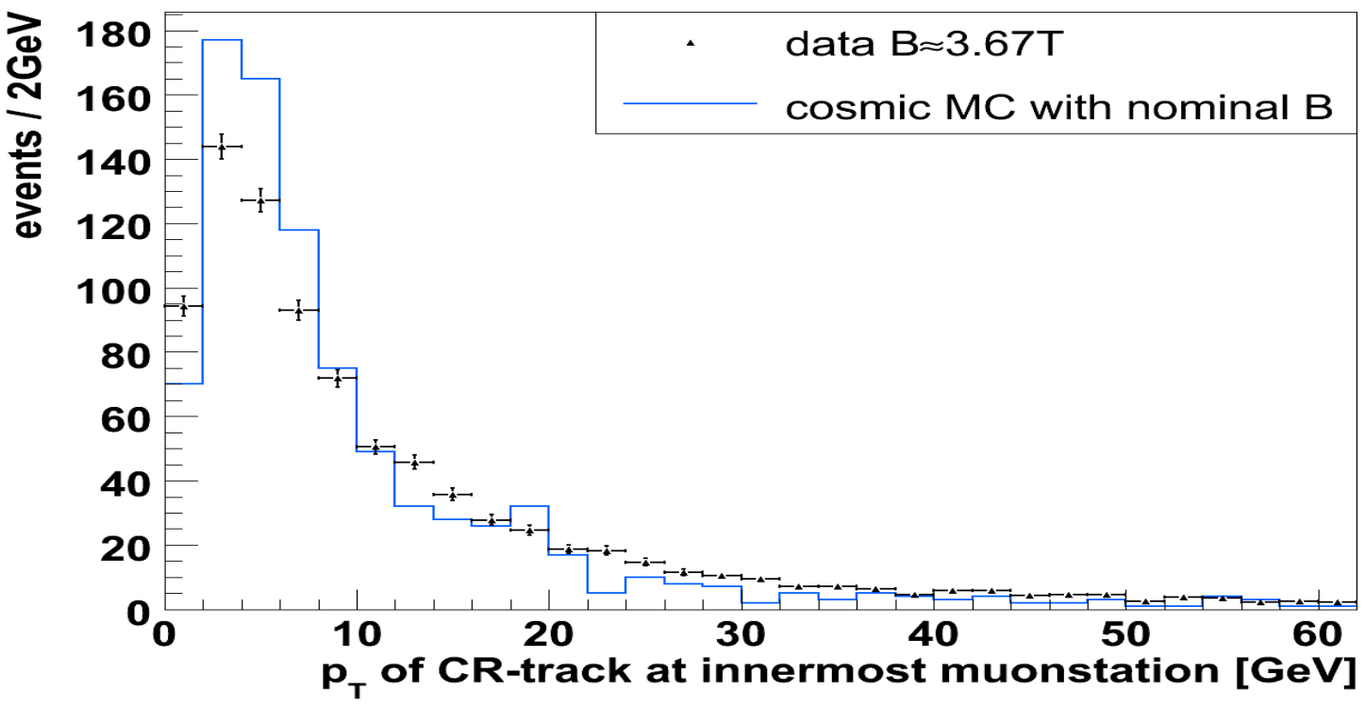
MTCC : First Look at Muon Data

Track parameters at innermost muon station
Data normalised to Montecarlo simulation





Preliminary



Tracks + field

Momentum!

Reasonable agreement between data and simulation.

Almost every aspect of final CMS from detector to CMSSW has to work to produce these plots.

MTCC II and re-opening

MTCC II was completed on time.

All original objectives, plus a few additional ones, were achieved.

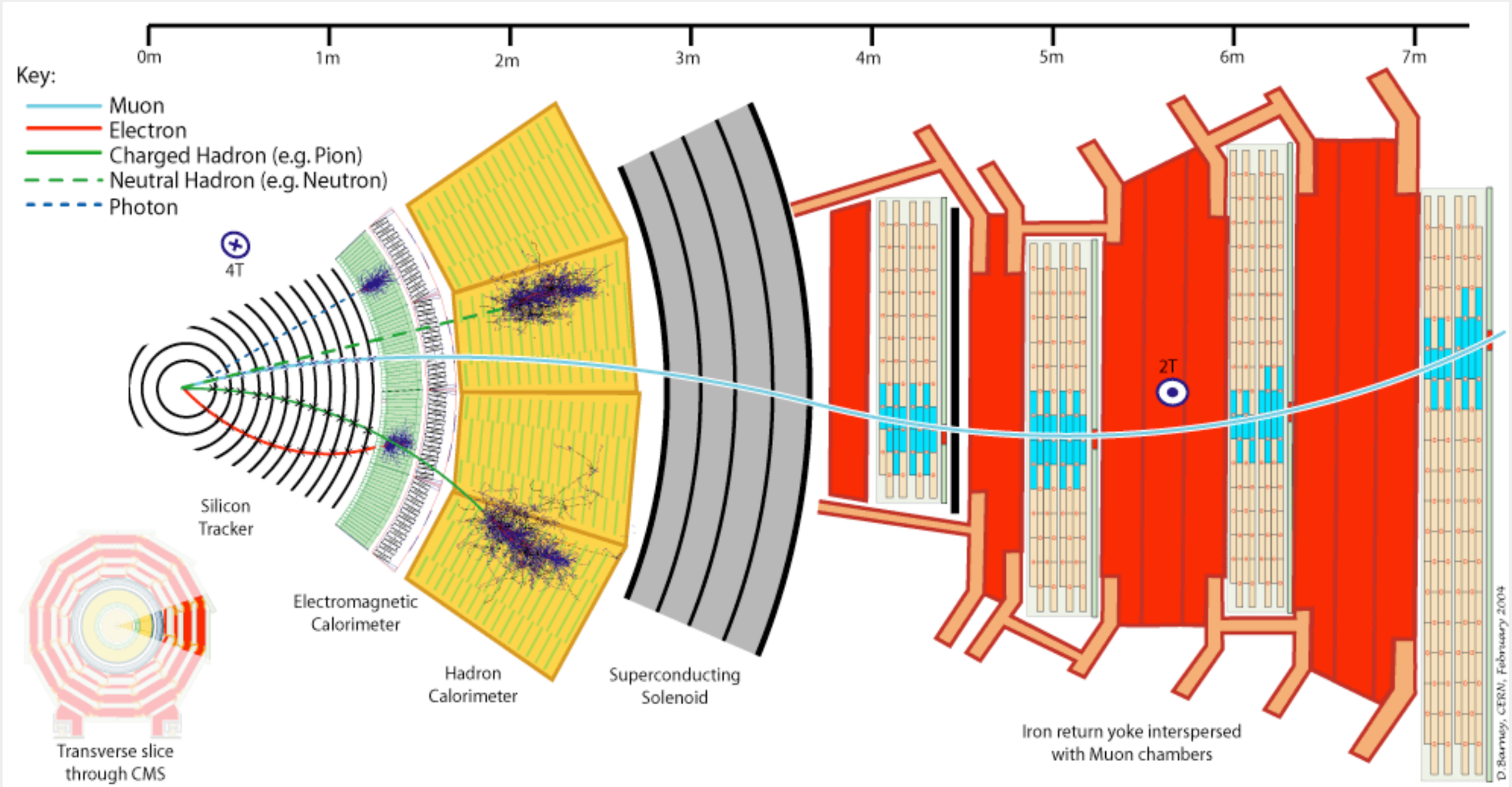
In particular: map the field with a precision of ~ 10^{-4}
complete magnet commissioning and check stability margins
measure detailed effect of magnetic field on HCAL and DT performance
integrate RPC FED
implement simple HLT filter algorithms.
exercise improvements to trigger and DAQ chains and data transfer
implement routine DQM + Event Display shifts with remote participation
commission RCT, GMT, and GT using HCAL, CSC, DT.

Detector was opened in 2 weeks as planned.

--> reach any element of CMS in 1 week, any 2 elements in 2 weeks.

Completes a 5 month long sequence, with a net delay of 2 weeks.

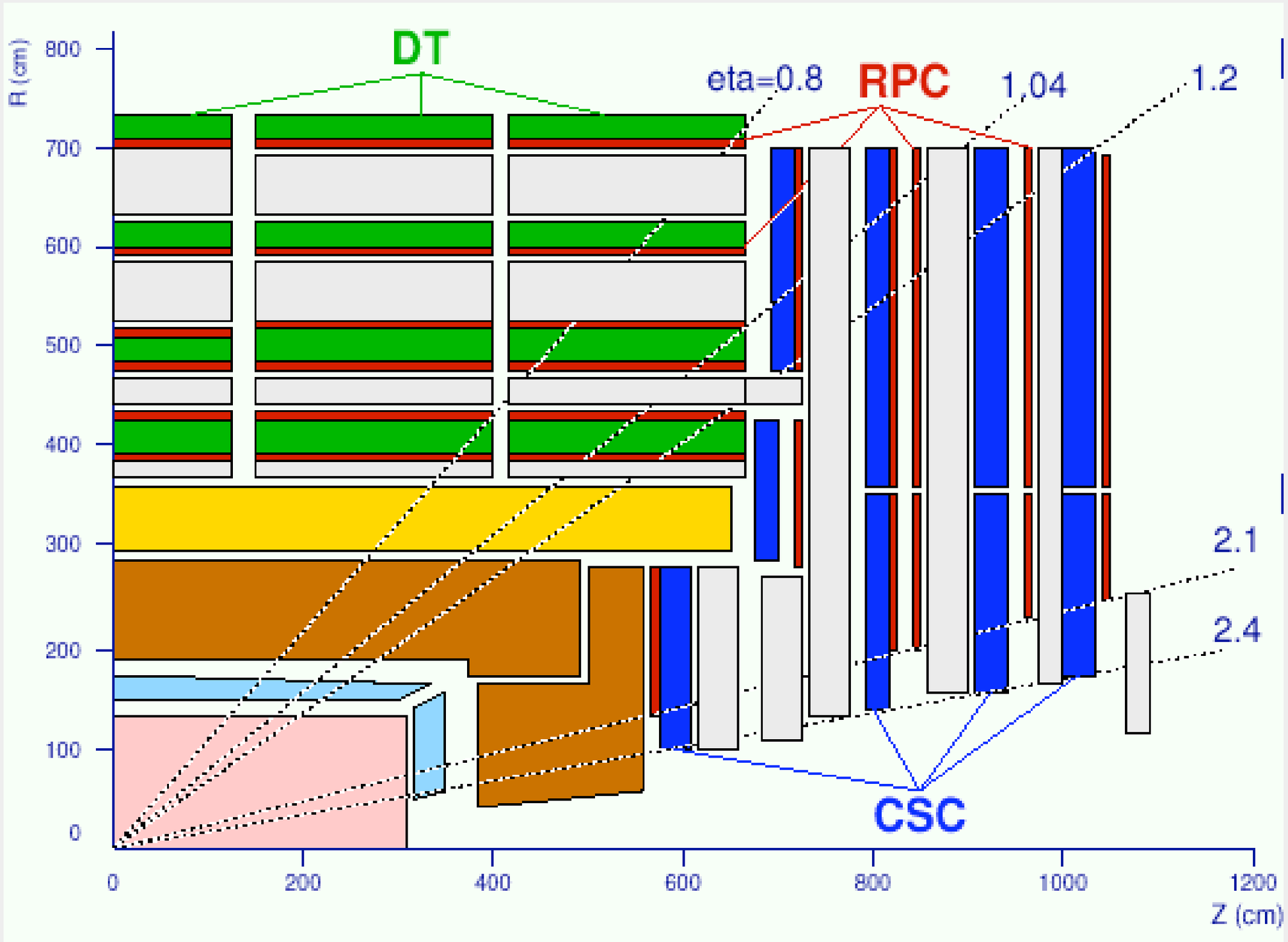
CMS sub-detector status



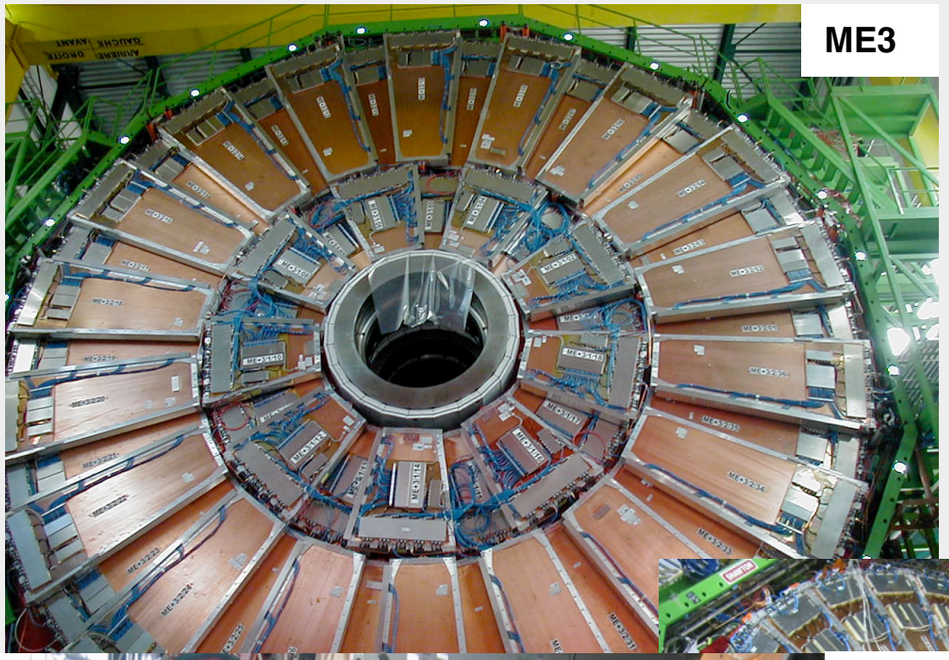
CMS MUON System

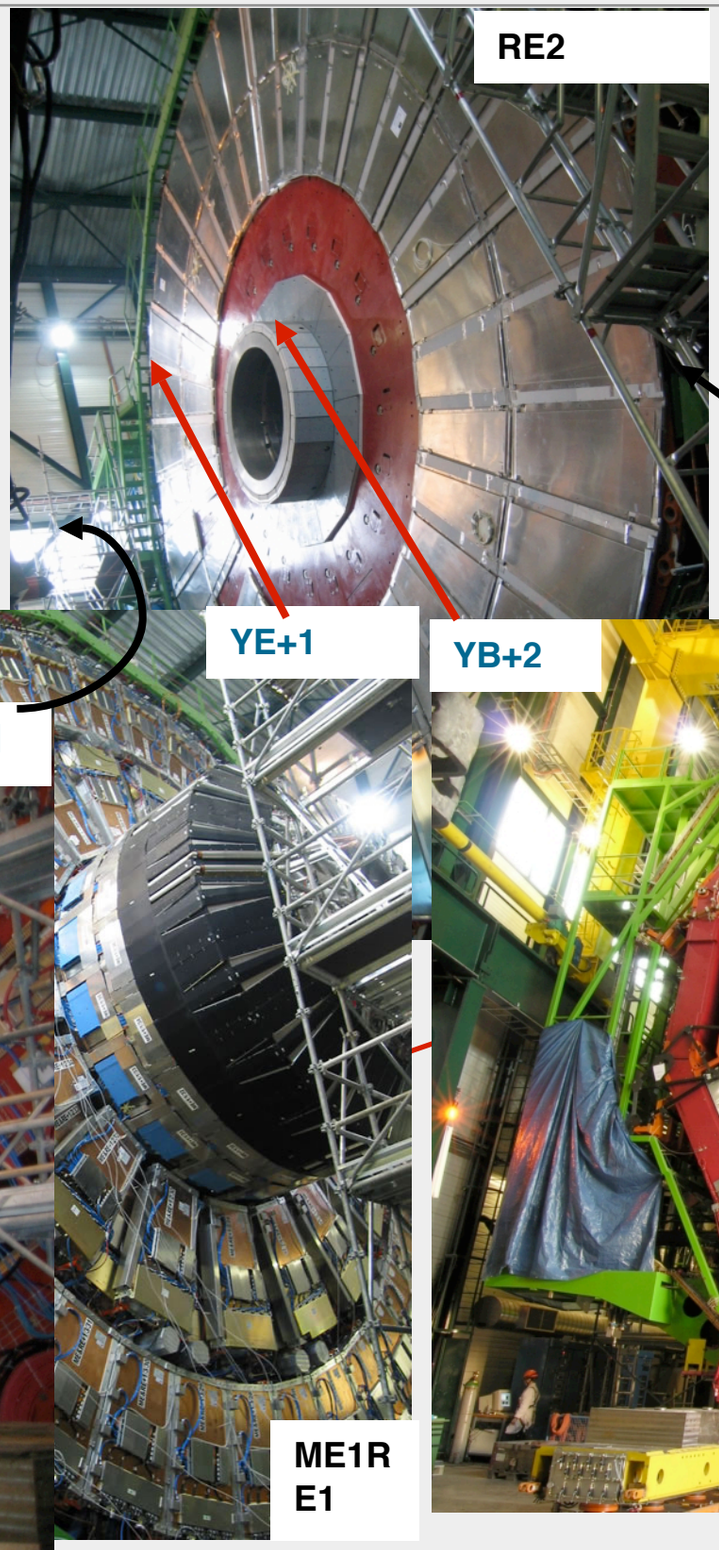
See *Yong BAN talk*

CMS muon system

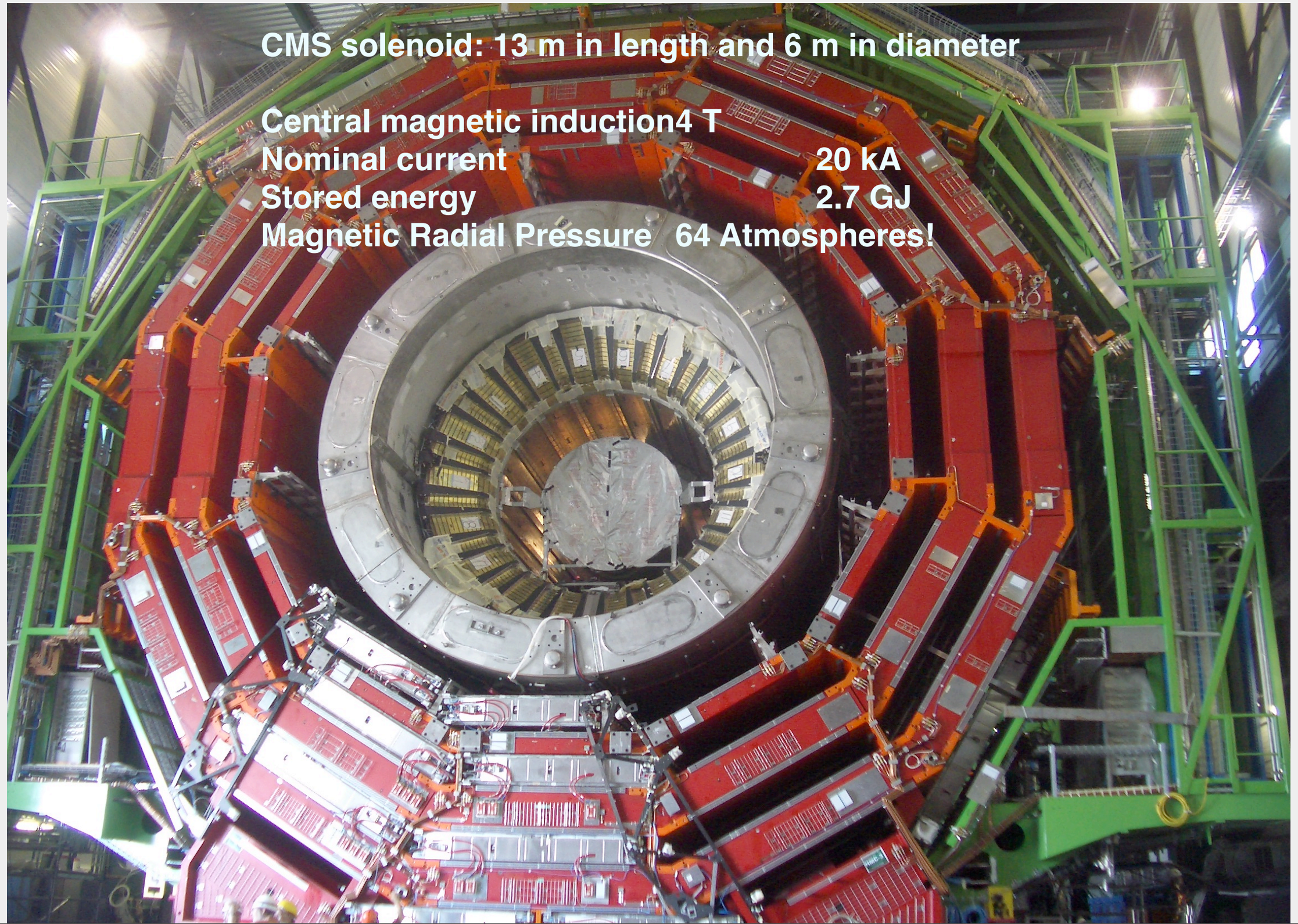


Muons Installation and Commissioning

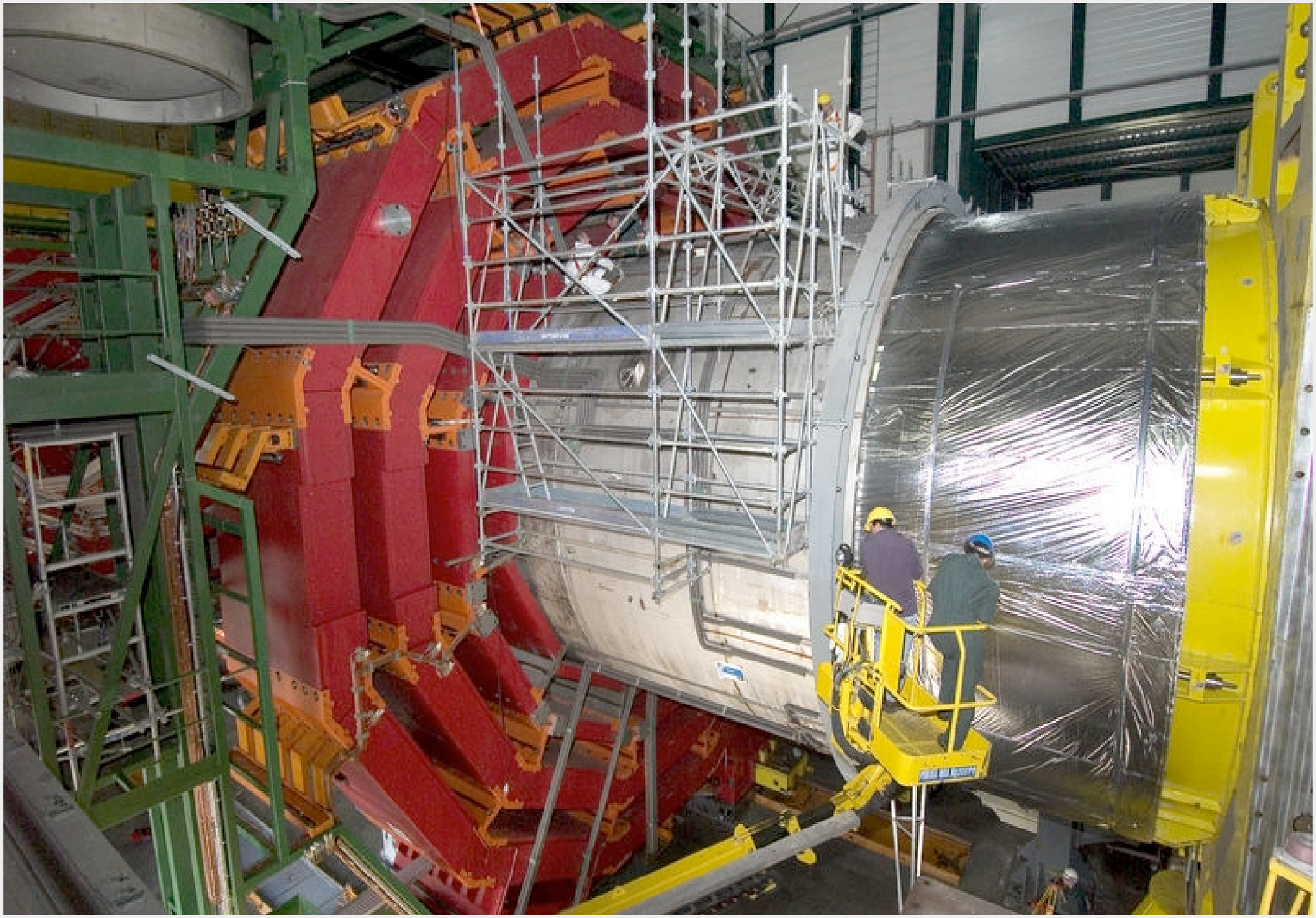




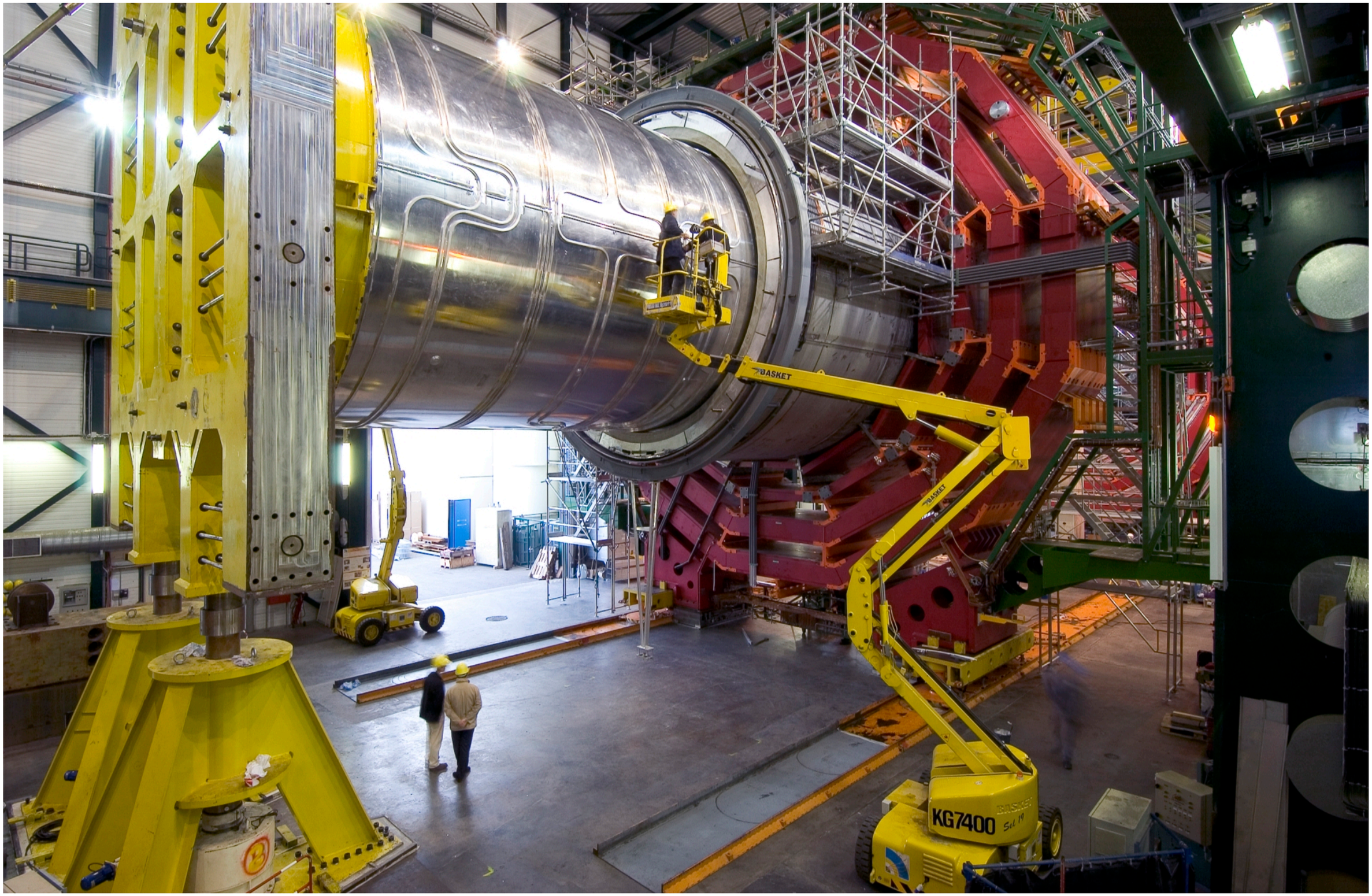
CMS solenoid: ready for physics



Coil has been inserted on 14 Sept.

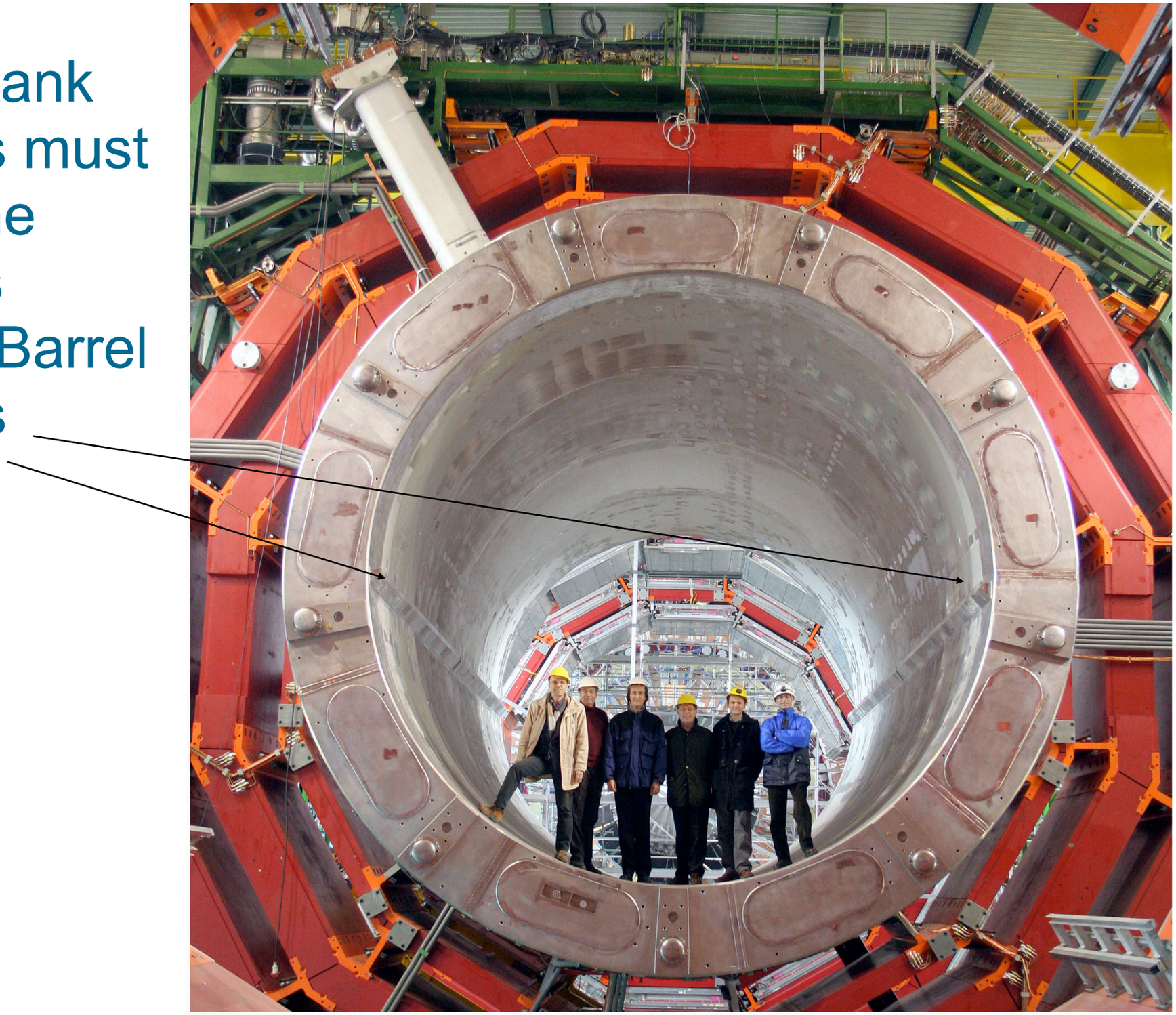


Inner Vac-tank Insertion Sept 05



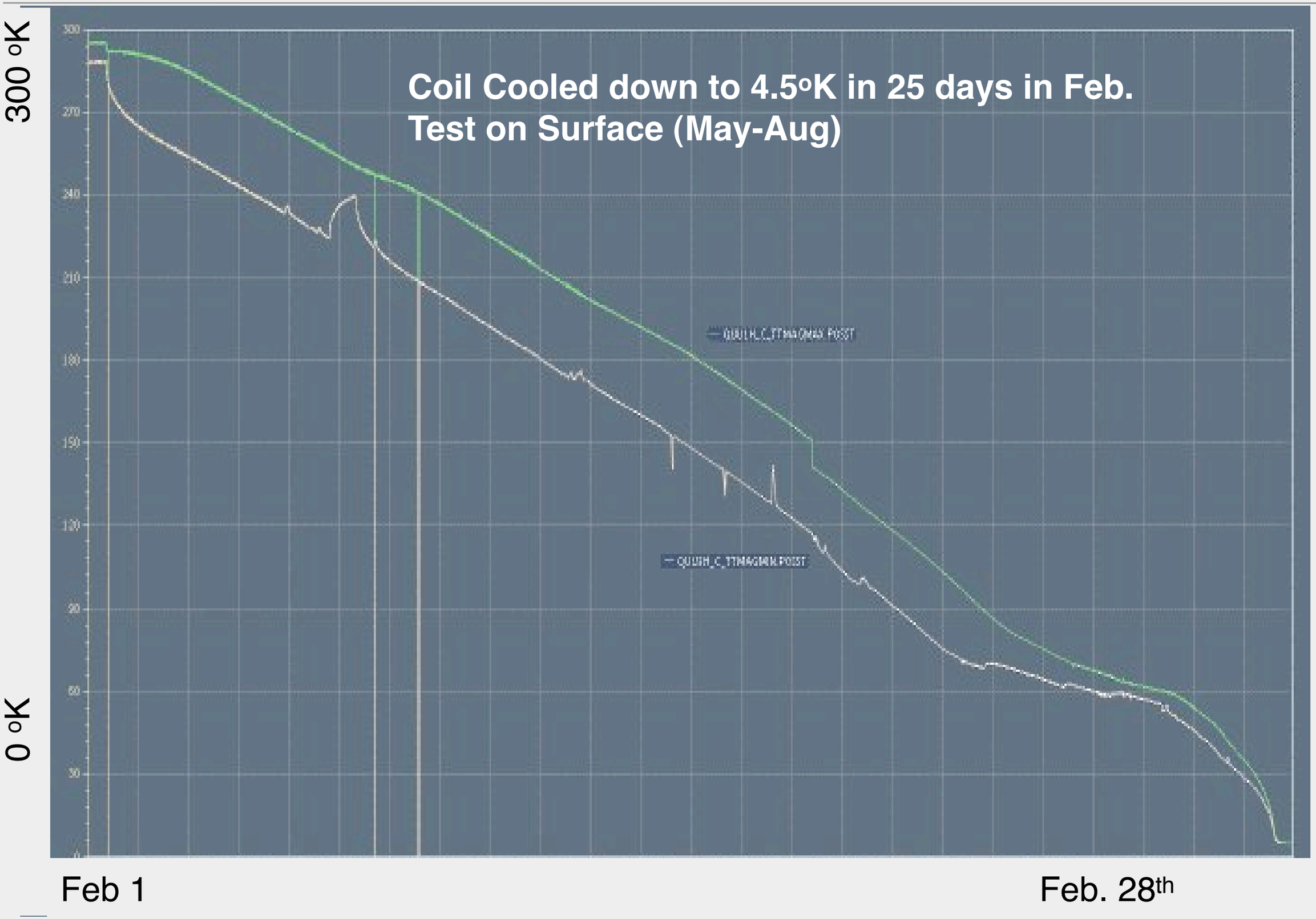
Closing of Vac-tank Jan06

Inner vactank and welds must support the 1000-tons Hadronic Barrel on its rails

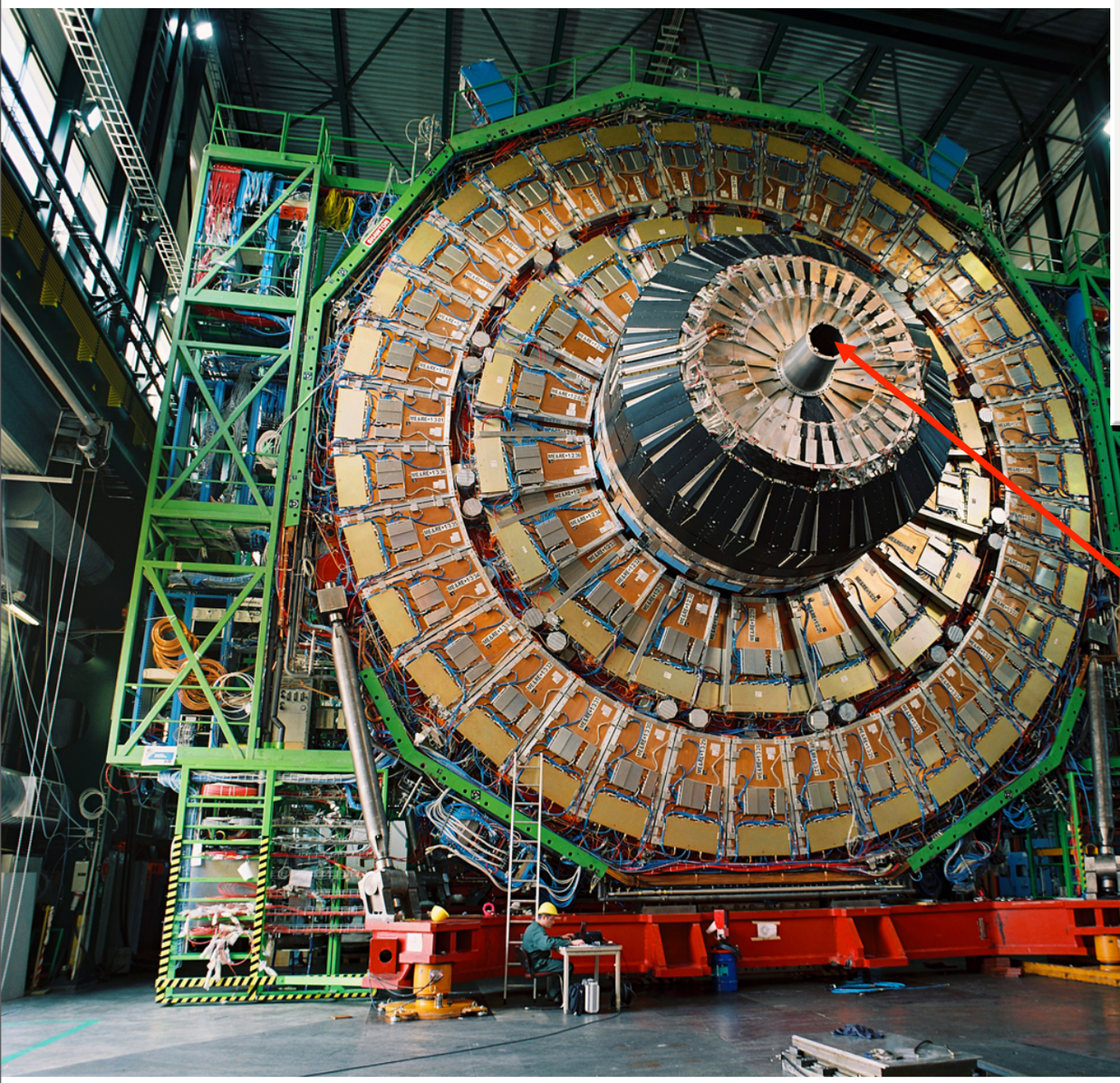


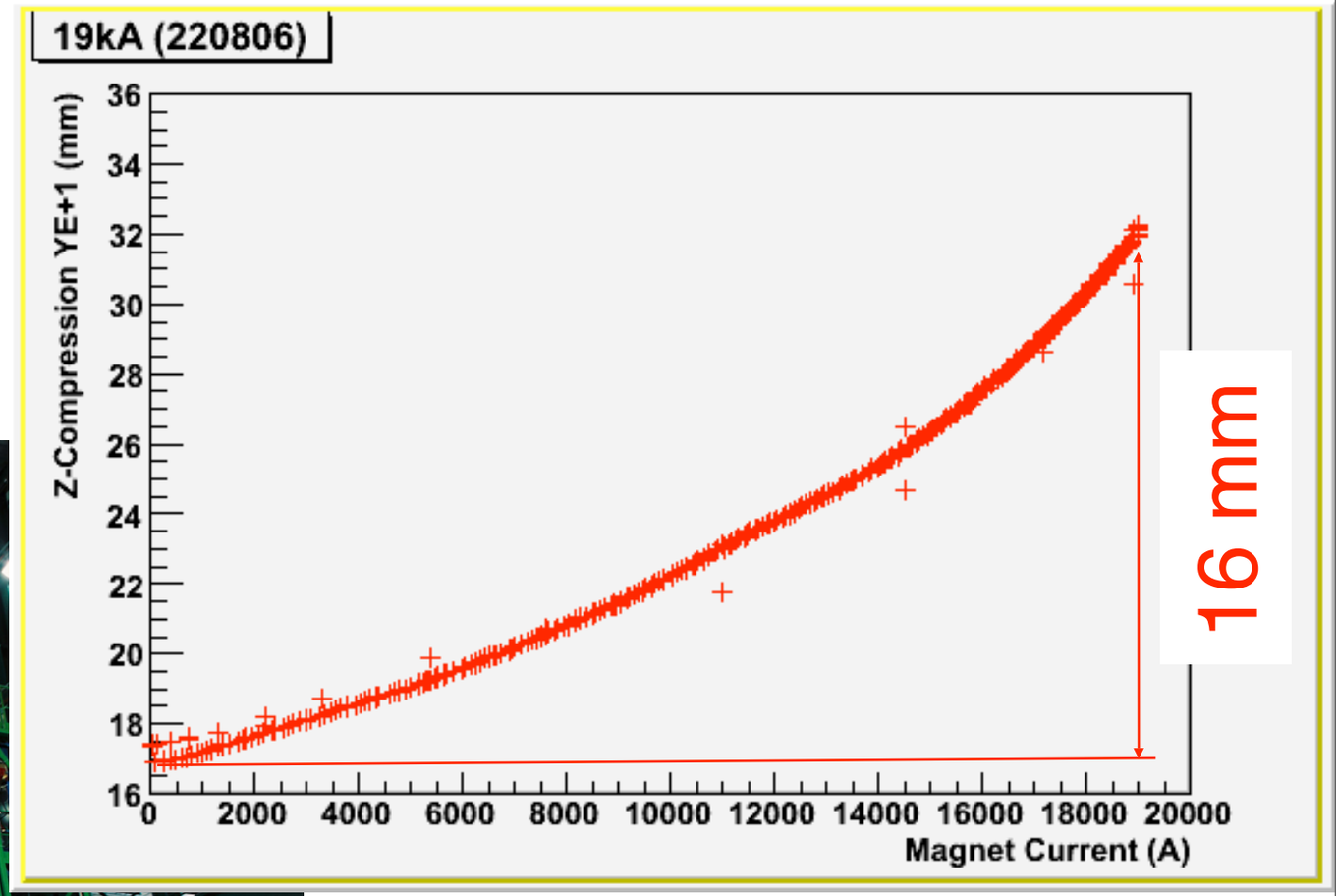
January 2006: End of the CMS Magnet Manufacturing

CMS Solenoid



Huge Magnetic Forces

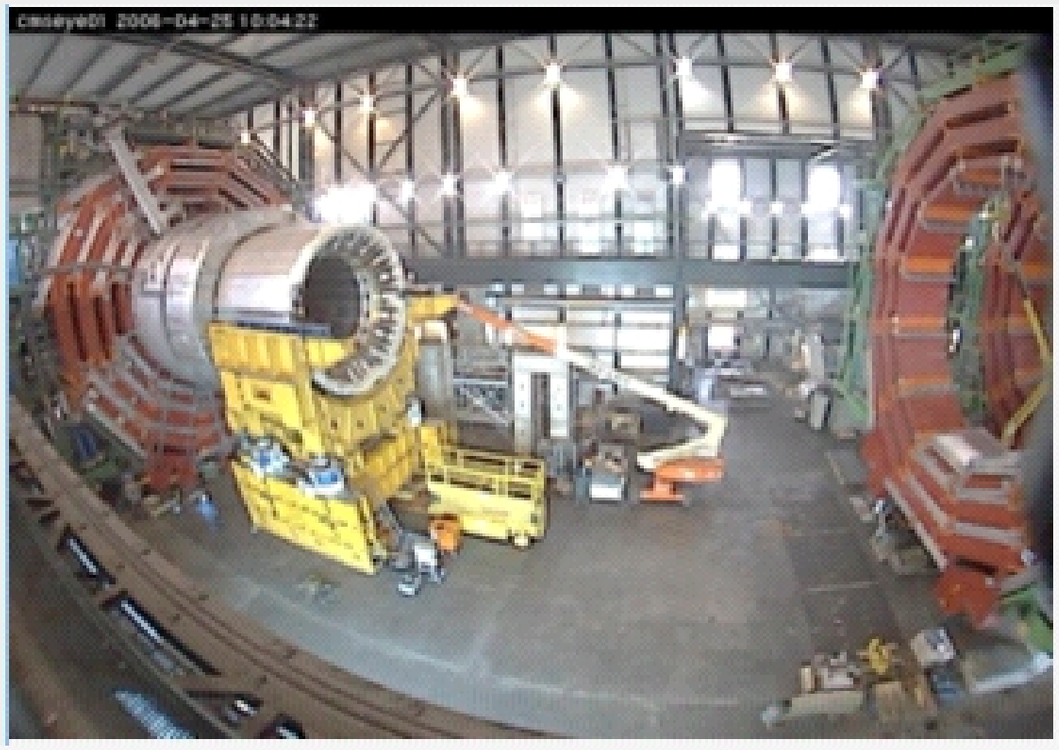


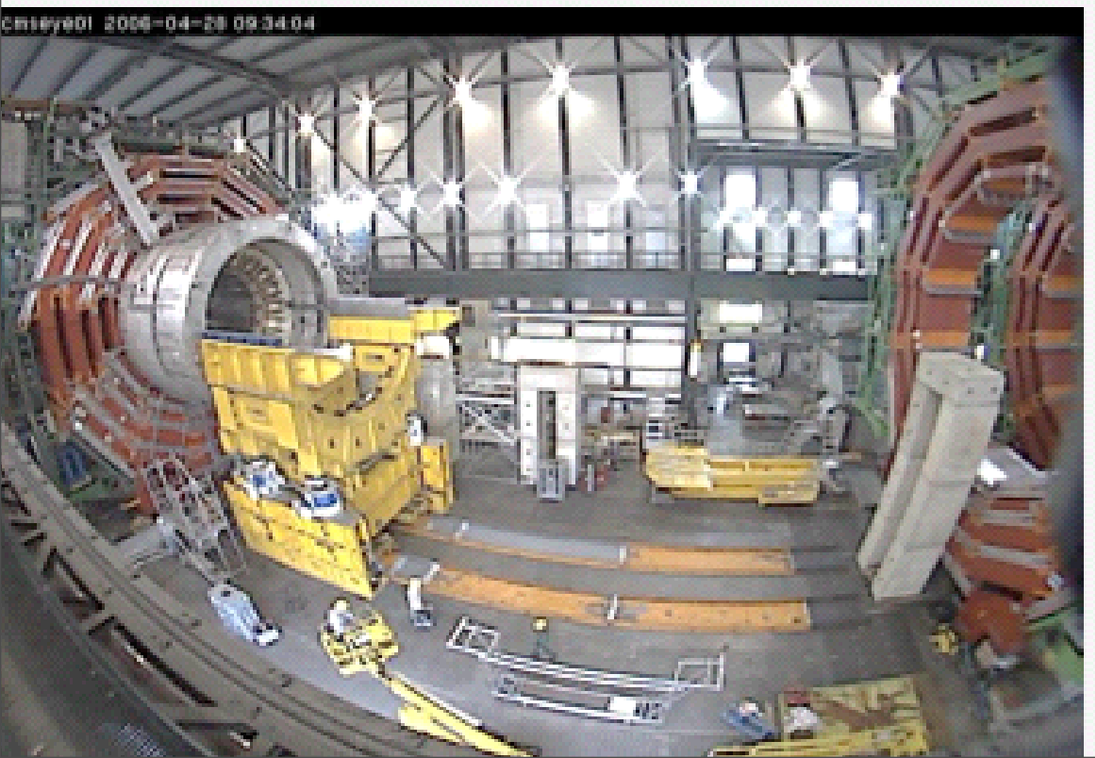


Due to the 10,000 tons magnetic attraction force, the Nose of the 600mm thick YE1 disk moves toward IP by 16mm!

CMS hadron calorimeter

HB+ insertion complete on 3 April





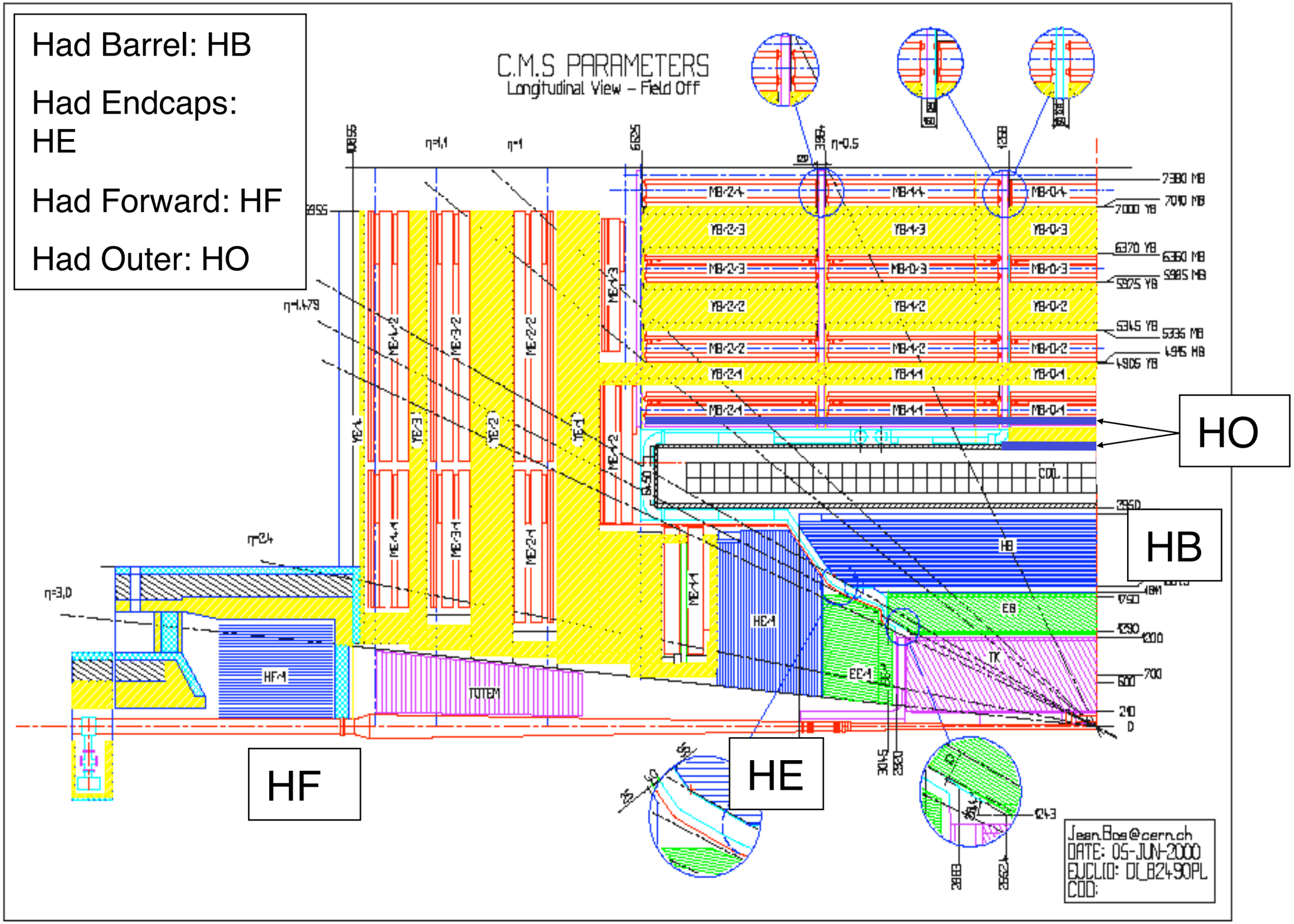
Hadronic Calorimeter: HCAL

Had Barrel: HB

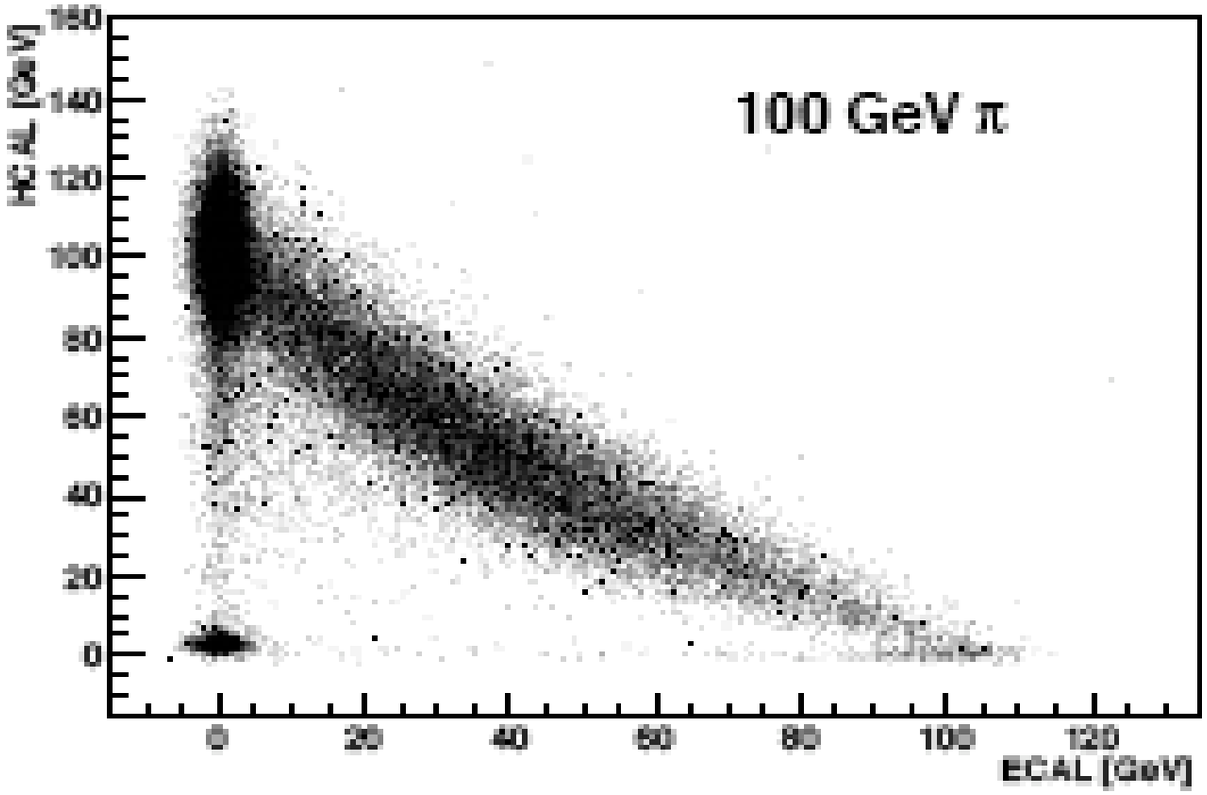
Had Endcaps: HE

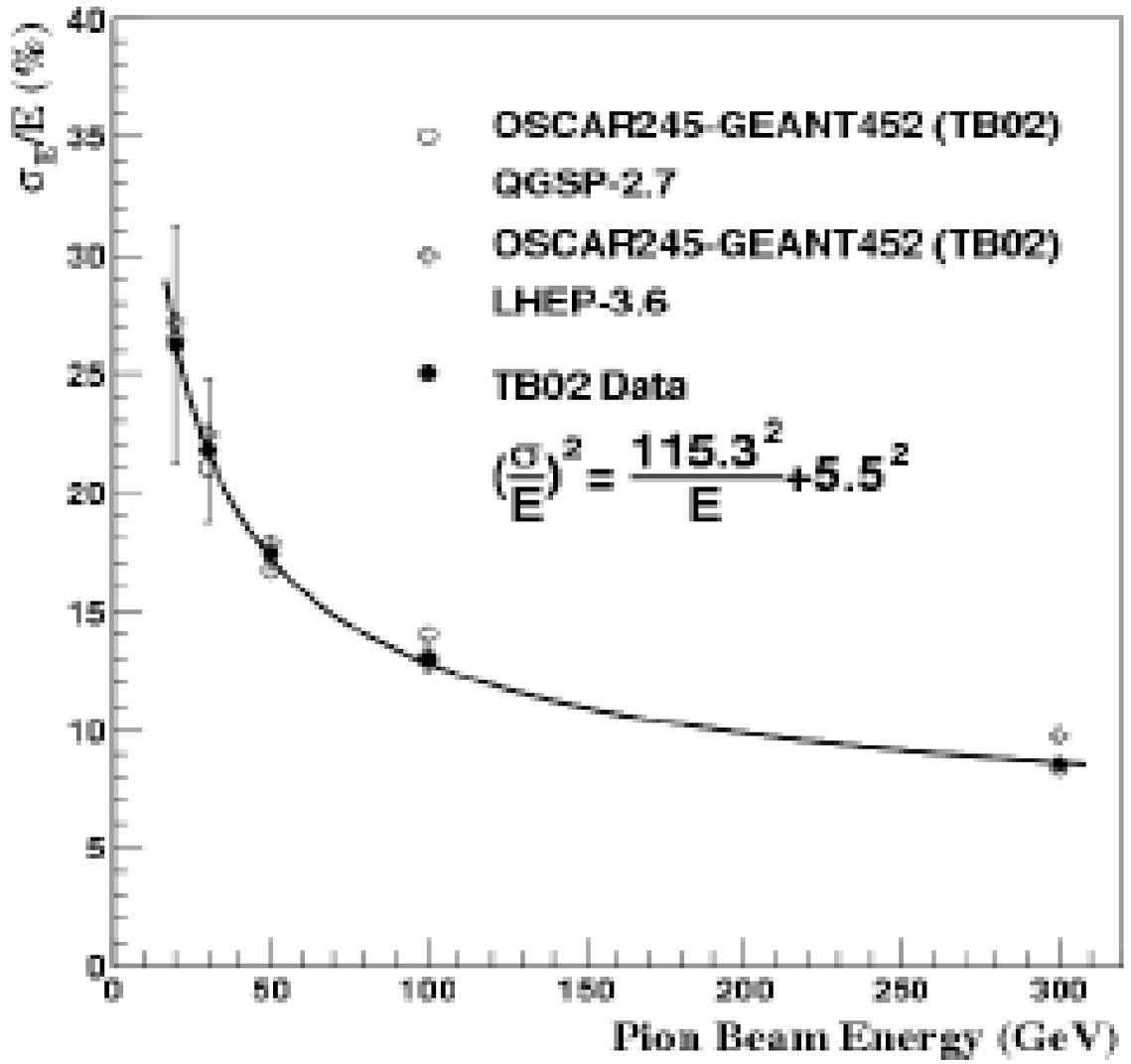
Had Forward: HF

Had Outer: HO



ECAL + HCAL Energy Resolution

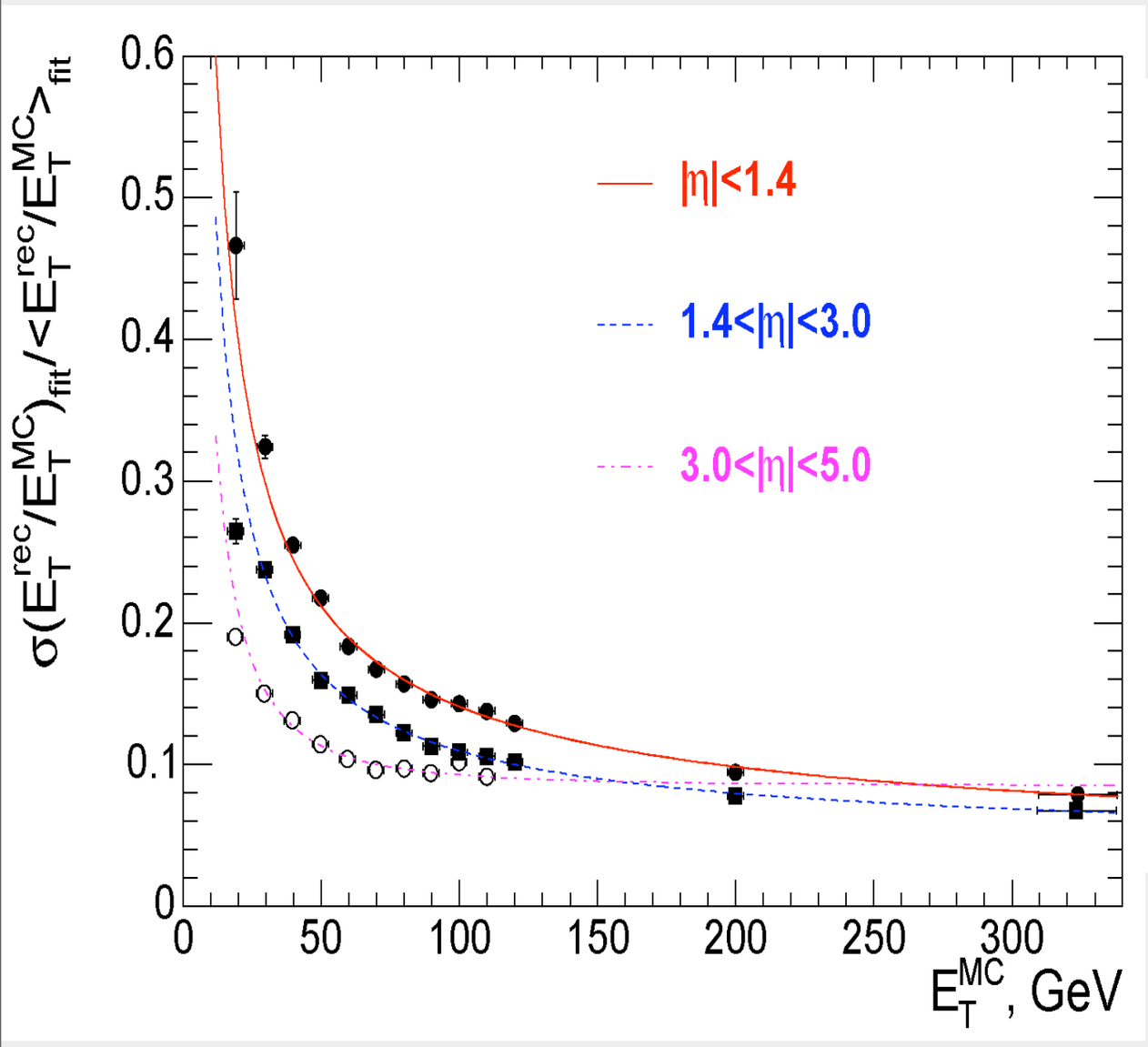




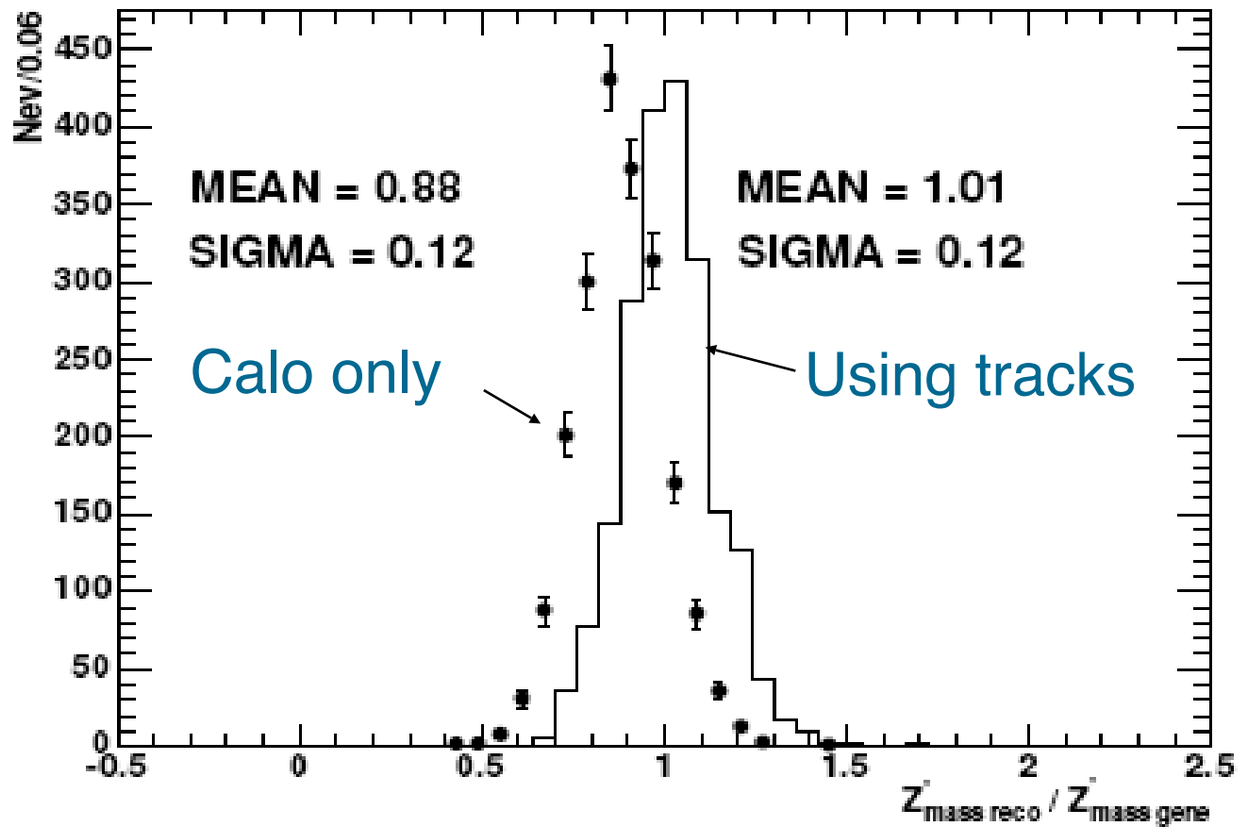
Combined Test ECAL SM + HCAL Wedge in Summer 06

Jet Reconstruction and Resolutions

Jet E_T resolution

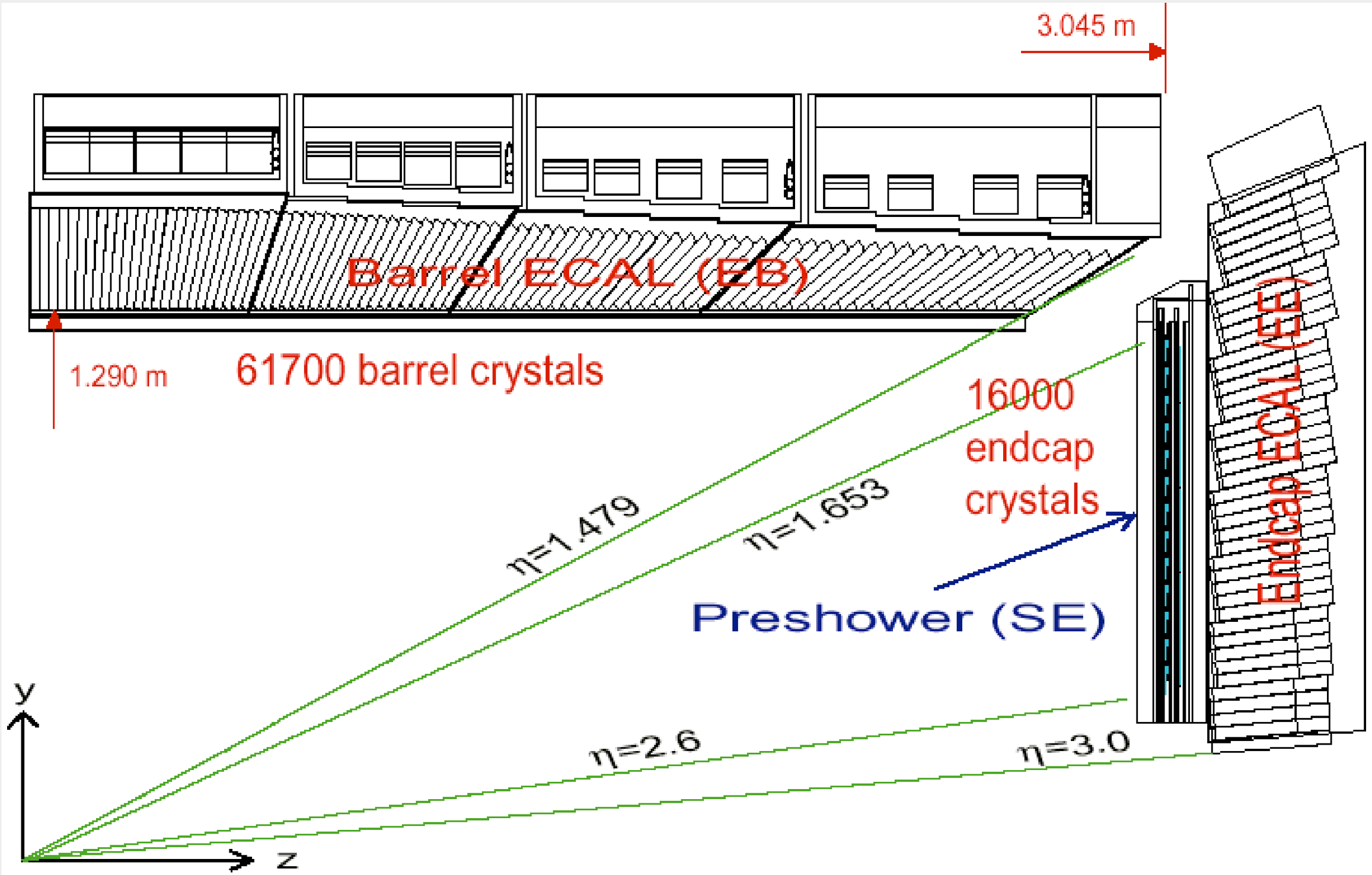


M_{jj} resolution at 120 GeV



M_{jj} resolution ≤ 15%

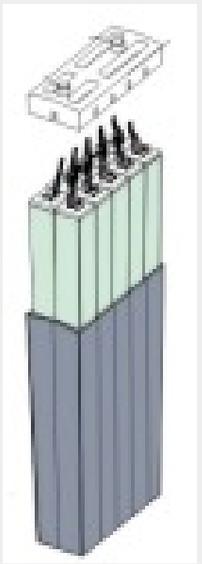
ECAL: PbWO4 Crystals

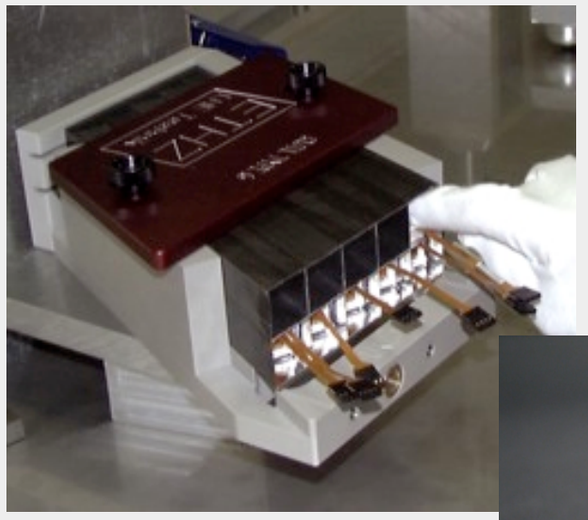


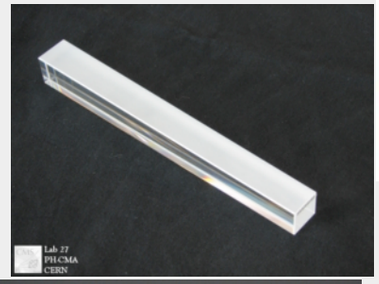
Calorimeter Construction

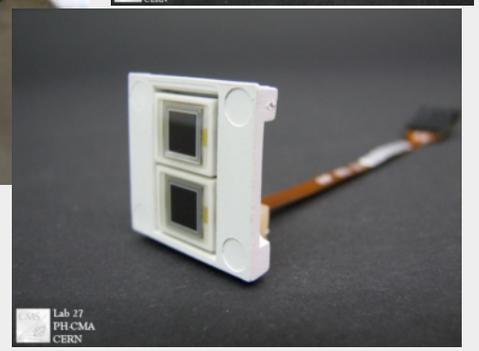
Assembly centers:
ENEA / INFN Rome and CERN EP-CMA

Submodule assembly (10 crystals



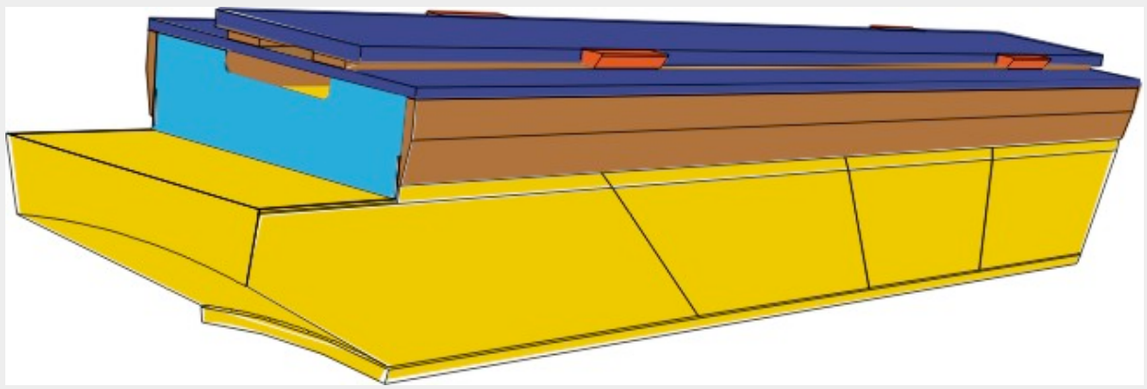




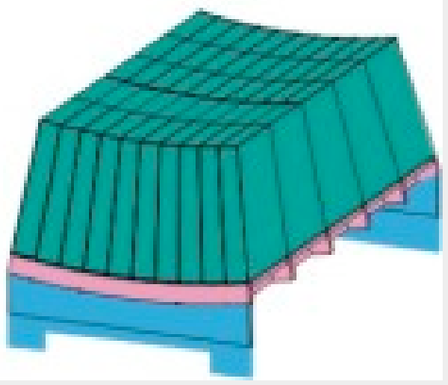


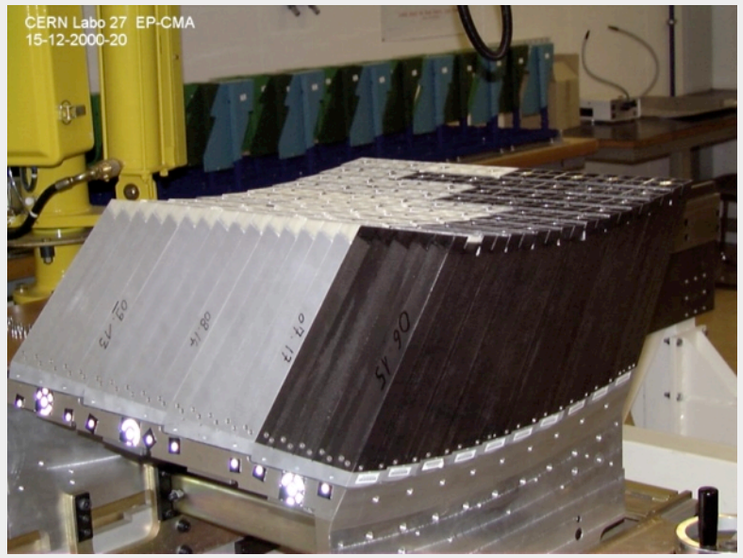
2 APDs/crystal

Super module (4 modules, 1700 crystal)



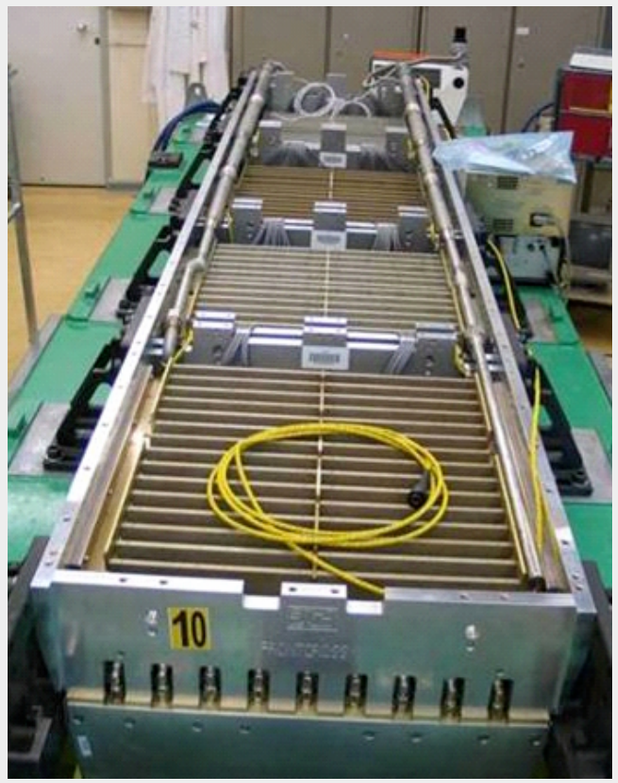
Module assembly
(400 / 500 crystals)



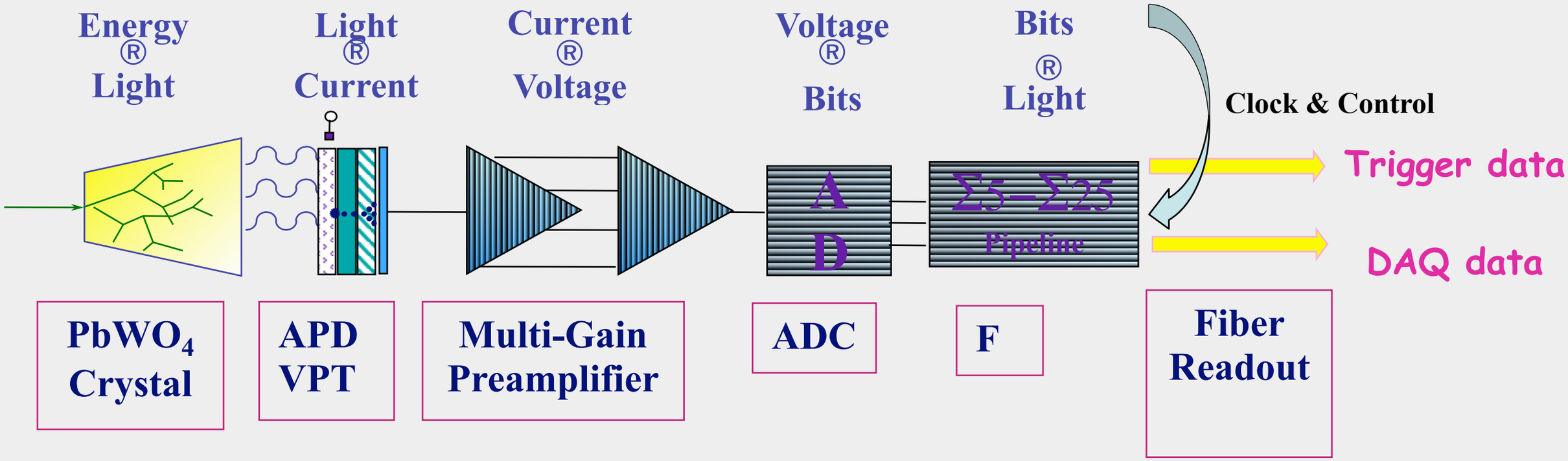


bare supermodule

mi-bare supermodule



Readout chain

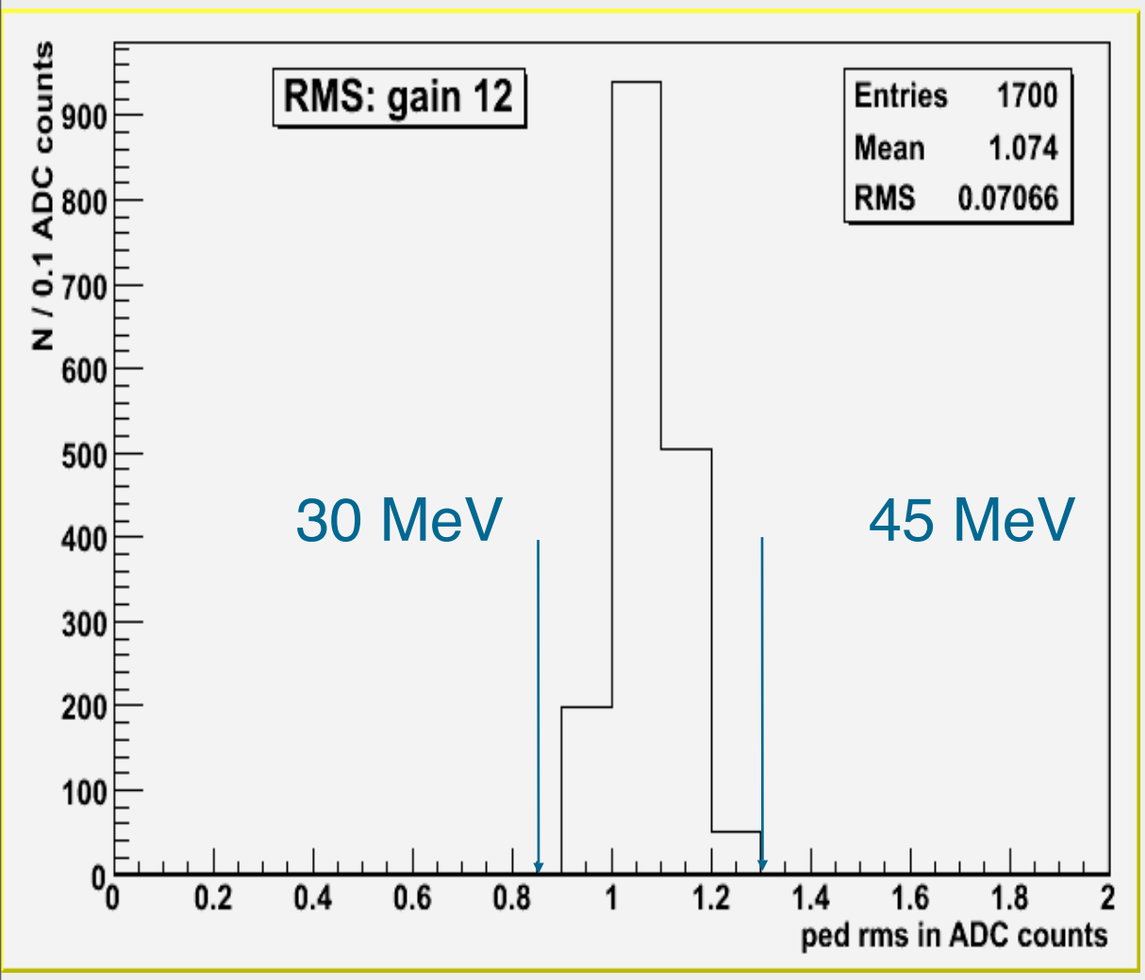


Front-End electronics block diagram: light to light readout chain

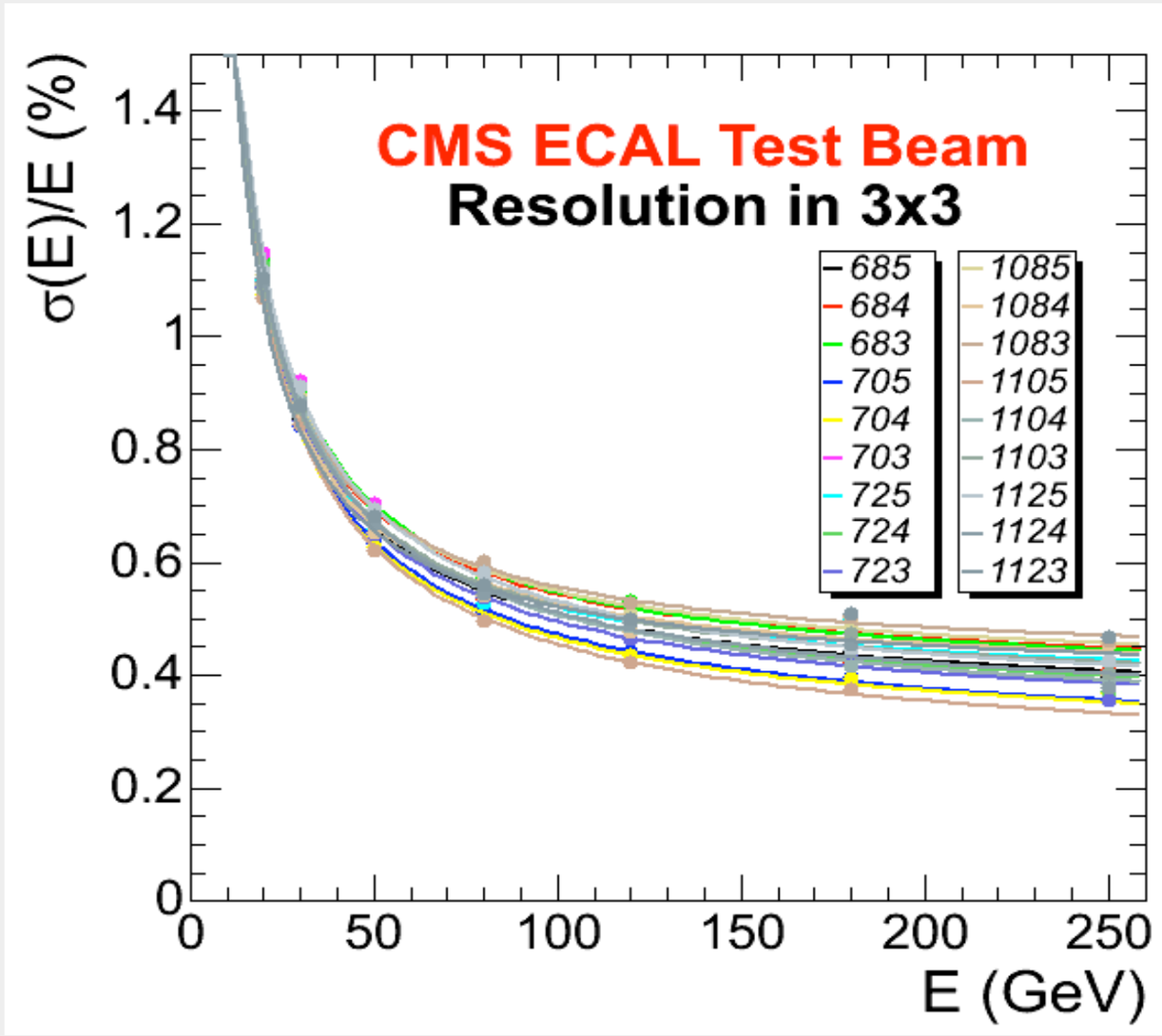
Architecture design based on 0.25 μm CMOS IBM technology

- ➔ Lower cost, faster turnaround
- ➔ Intrinsic radiation hardness

ECAL performance



Noise distribution of the 1700 channels of SM13

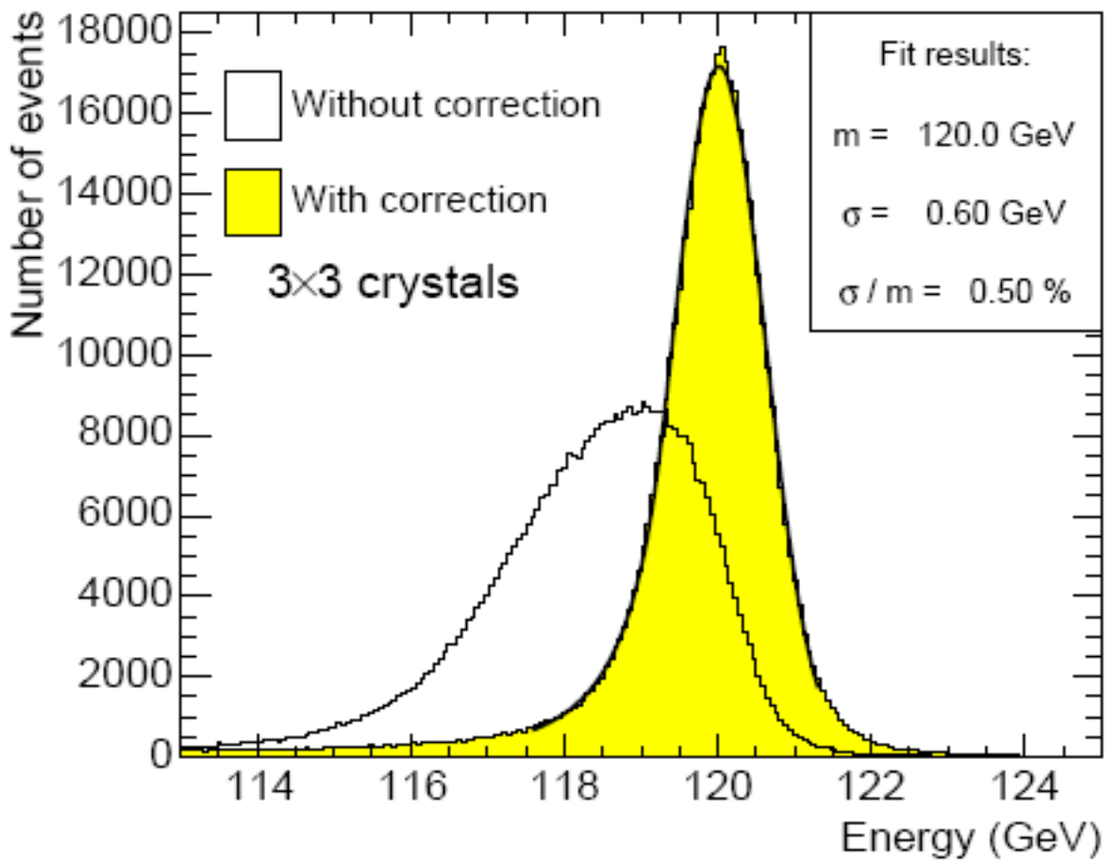


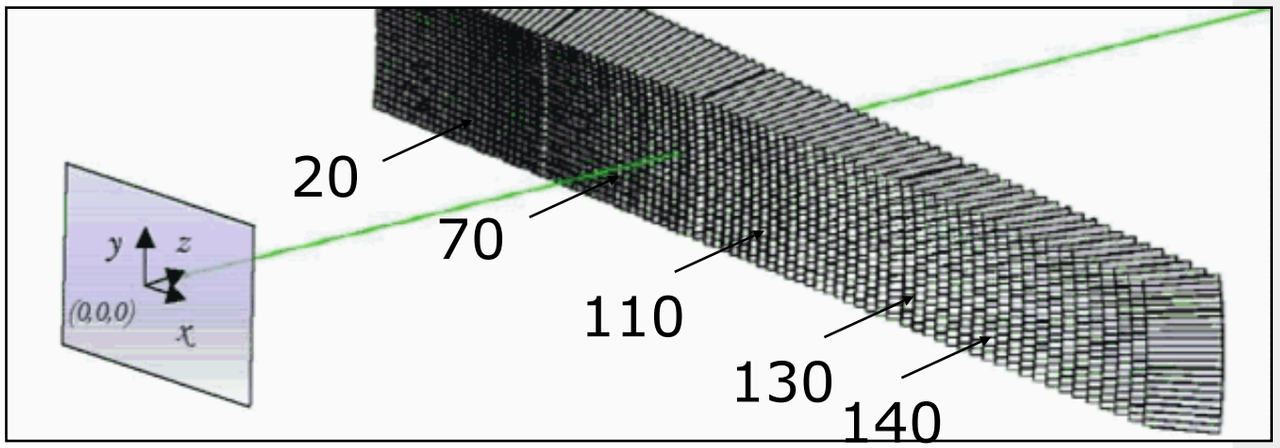
Energy resolution: 2004 test beam
18 crystals

$$\left(\frac{\sigma}{E}\right)^2 = \left(\frac{2.8\%}{\sqrt{E}}\right)^2 + \left(\frac{.125}{E}\right)^2 + (0.30\%)^2 \qquad (E \text{ in GeV})$$

Uniformity

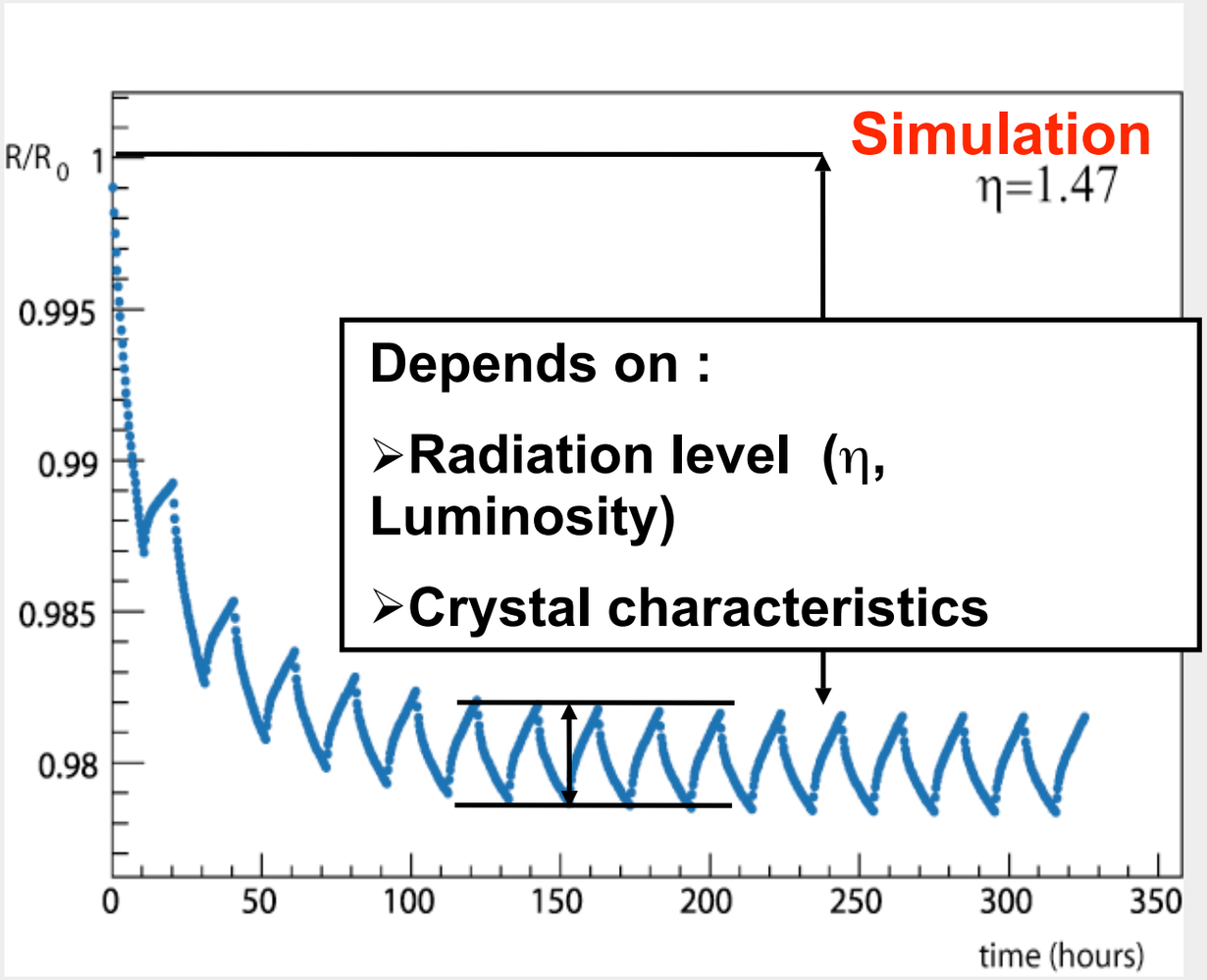
How well can we sum different part of the calorimeter together?





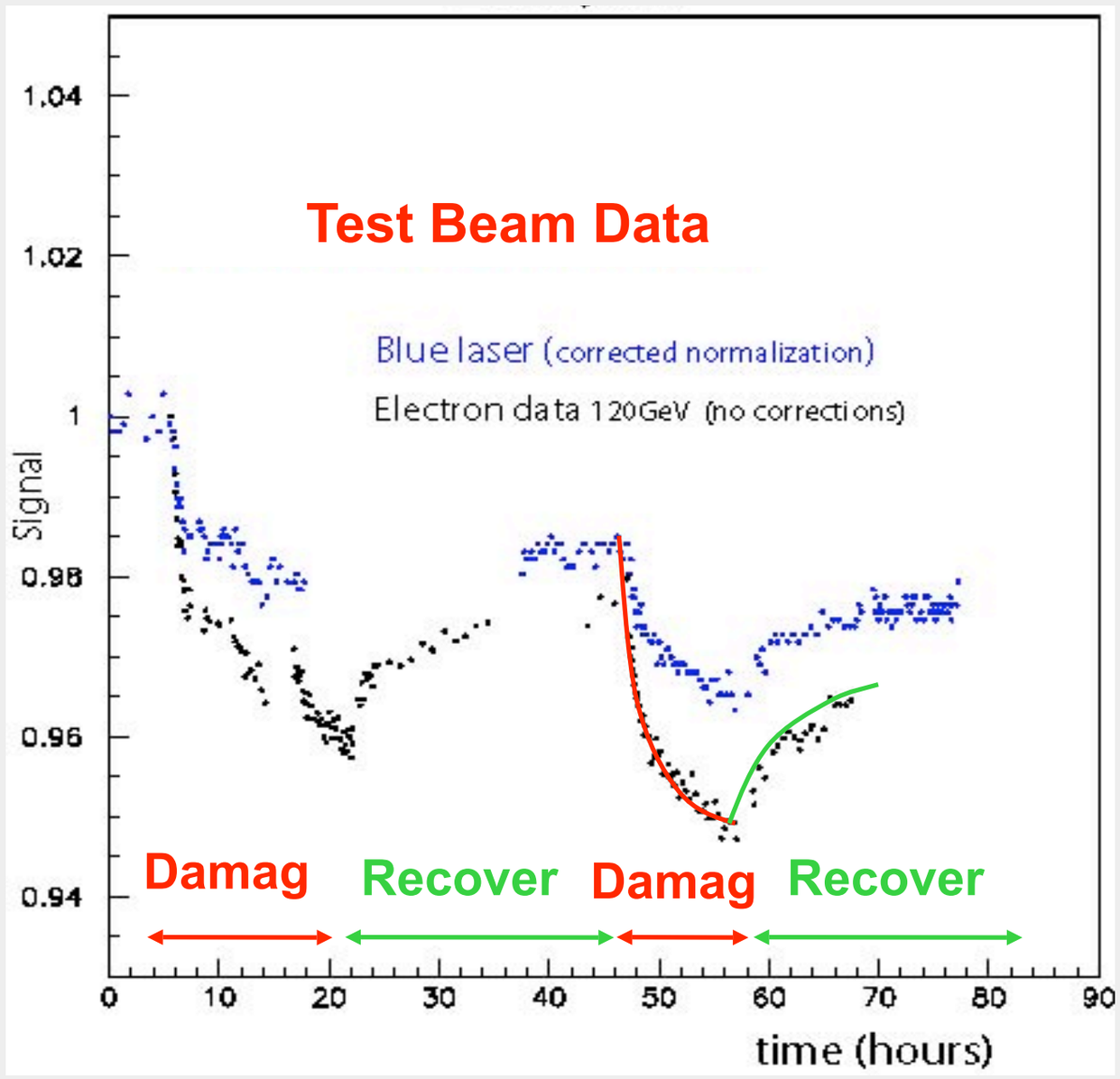
⇒ 2004 performance → 0.50% energy resolution at 120 GeV

Monitoring and Stability



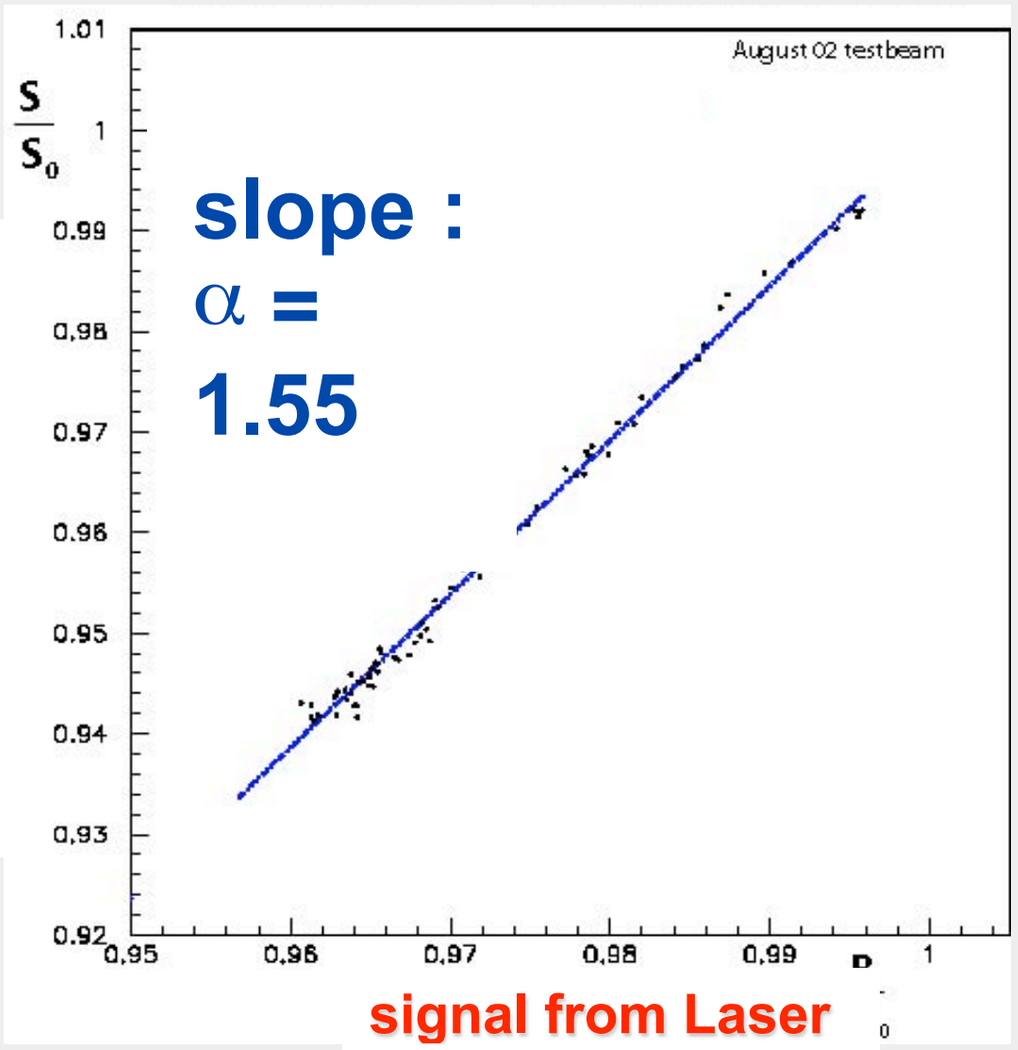
Depends on :

- **Radiation level (η, Luminosity)**
- **Crystal characteristics**

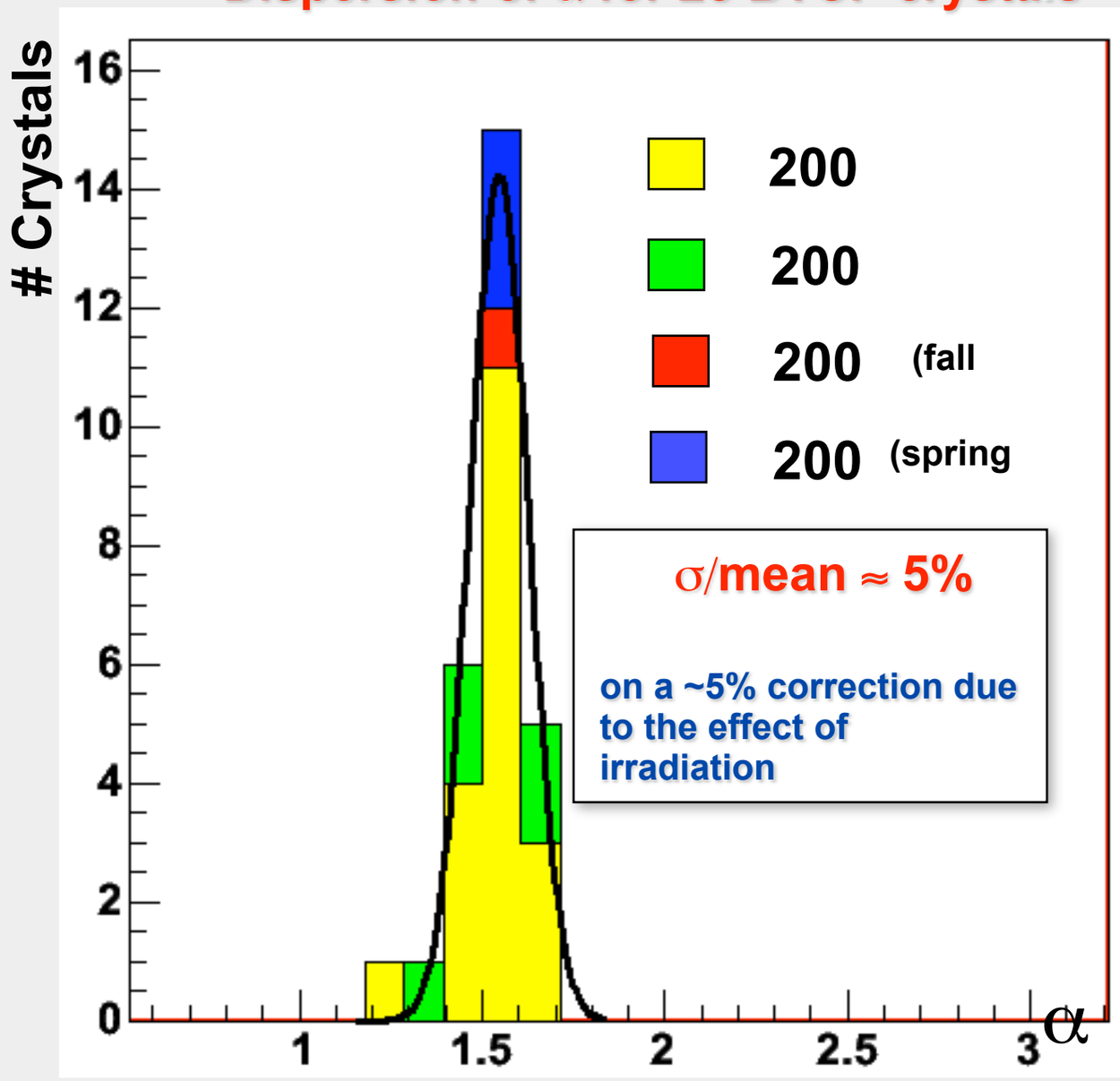


⇒ Damage-recovery cycle in sync with the ~12 hour LHC fill cycle

Monitoring and Stability



Dispersion of α for 28 BTCP crystals

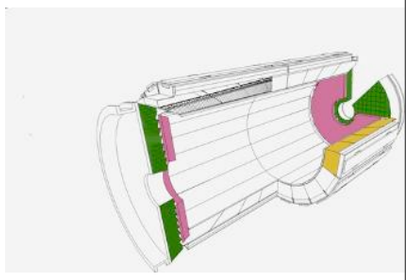


⇒ Coefficient for crystals have relatively small dispersion.

⇒ At startup use same parameters for all crystals from one producer.

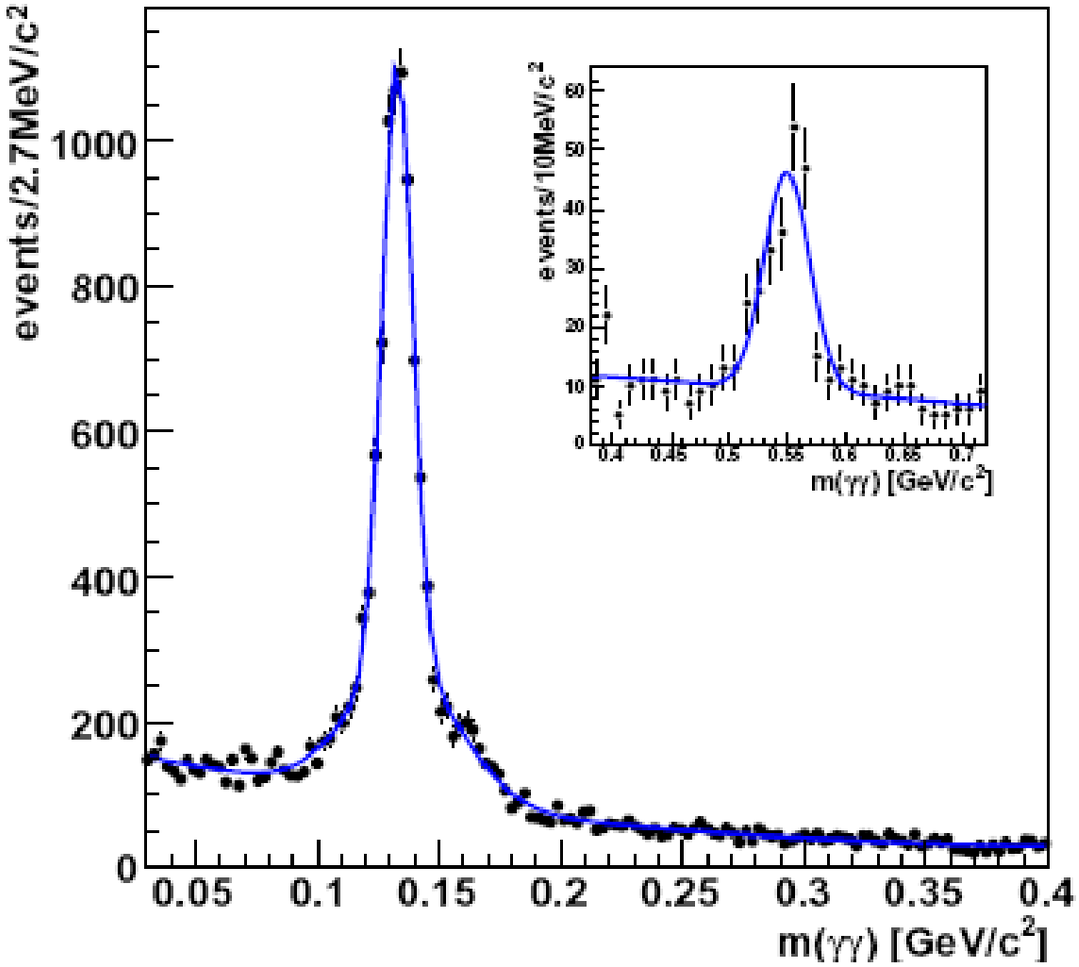
An in-situ determination of α is under consideration.

Test beam (H2)

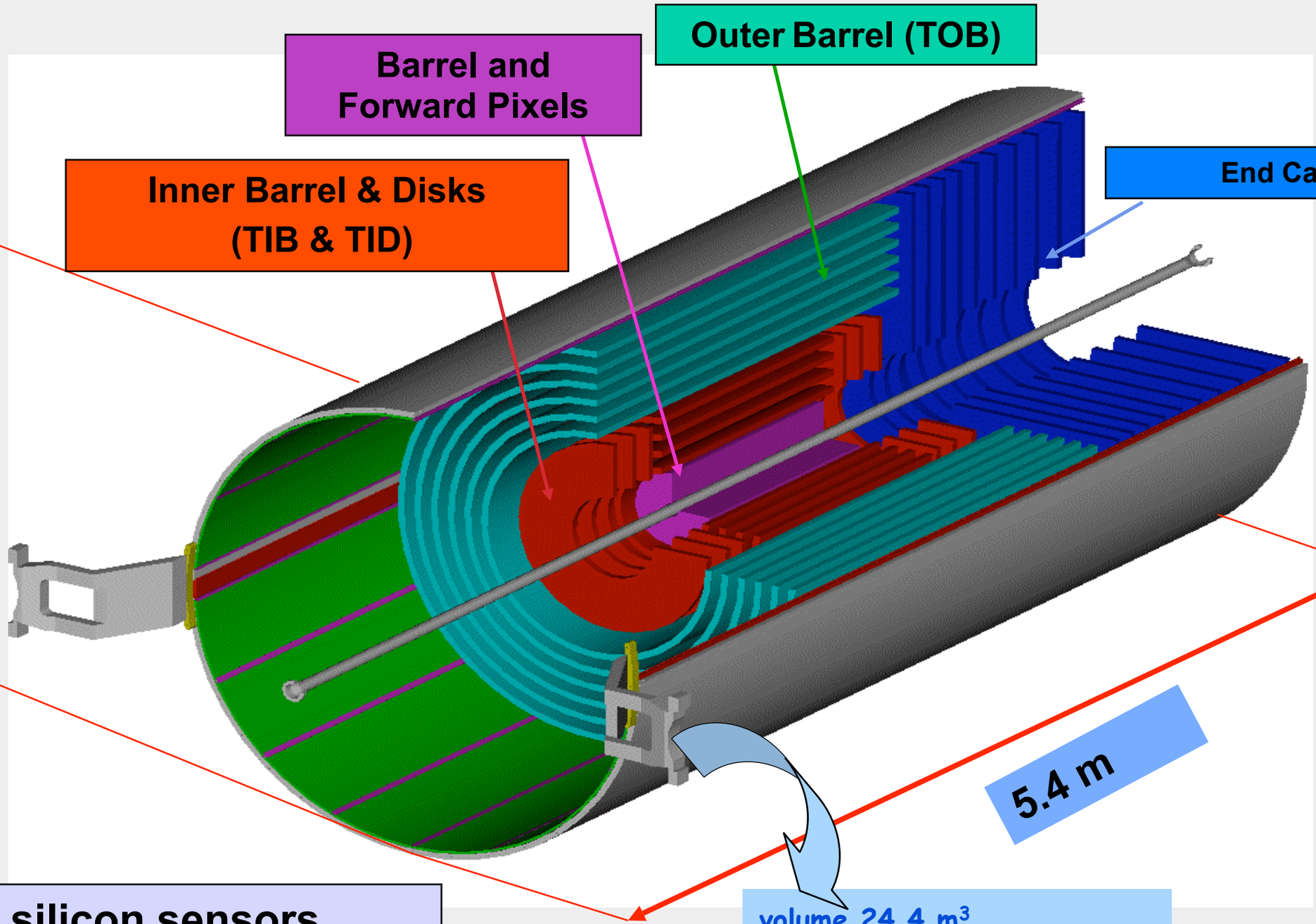


- One Supermodule tested together with HCAL PPPs
  - Many data with electrons, pions, kaons, protons, down to very low energy (few GeVs), see HCAL presentation

- At the end, one week with “neutral trigger”
  - Selecting charge exchange reaction
  - ~ 40 K π^0s and few hundred η



All Silicon Tracker

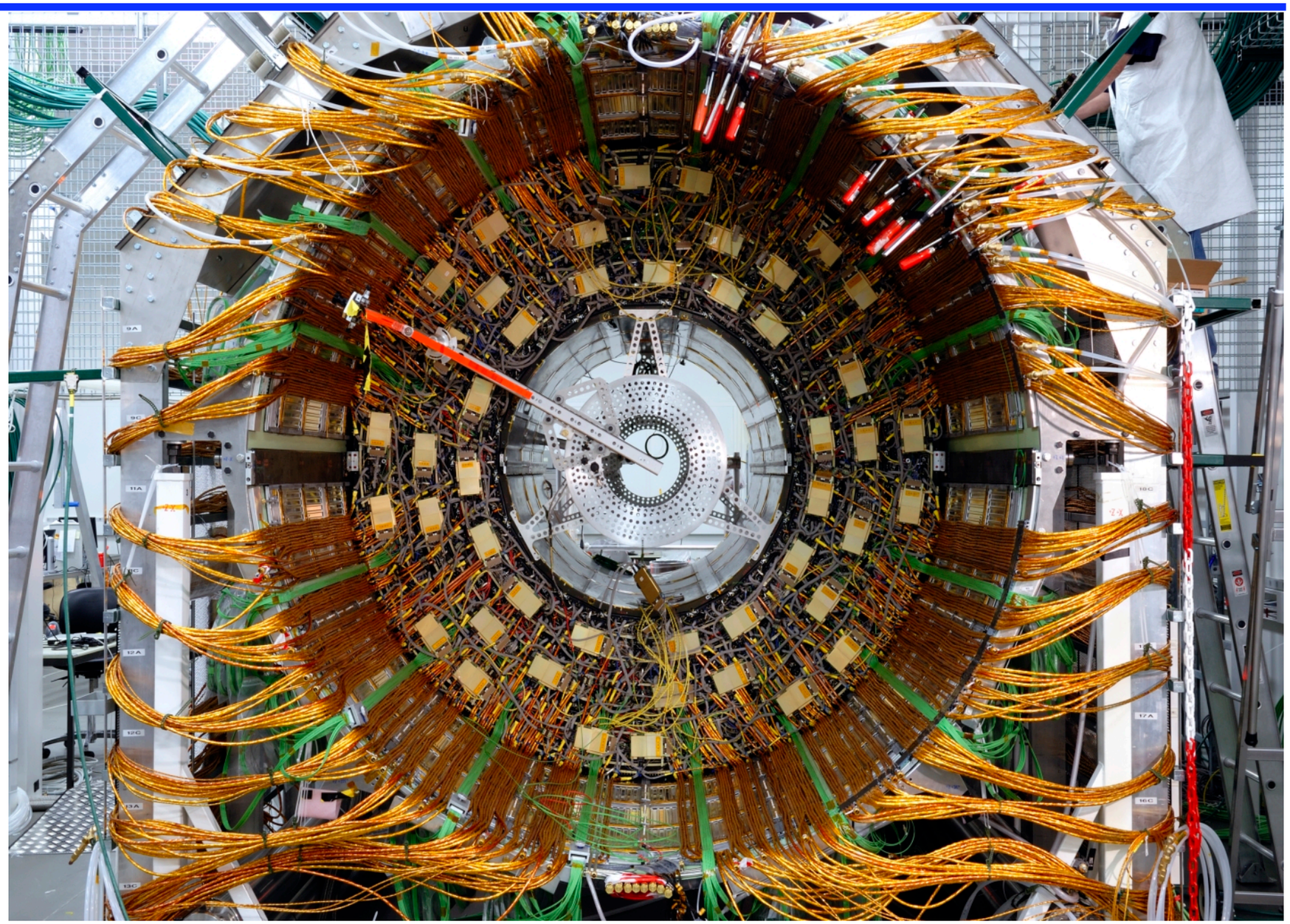


207m² of silicon sensors
10.6 million silicon strips
65.9 million pixels ~ 1.1 m²

CMS Tracker Status - December 06

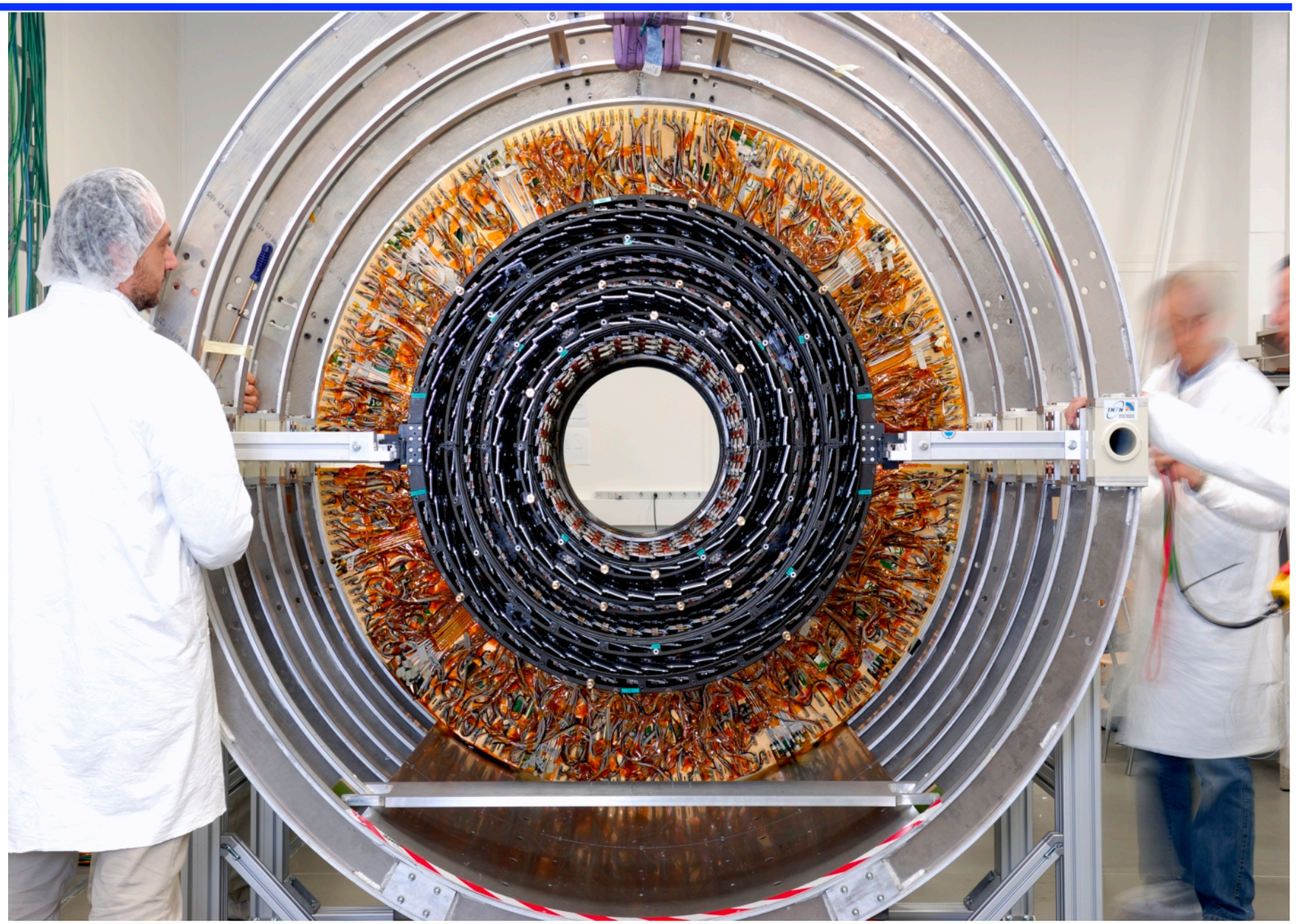
Completed

TOB +



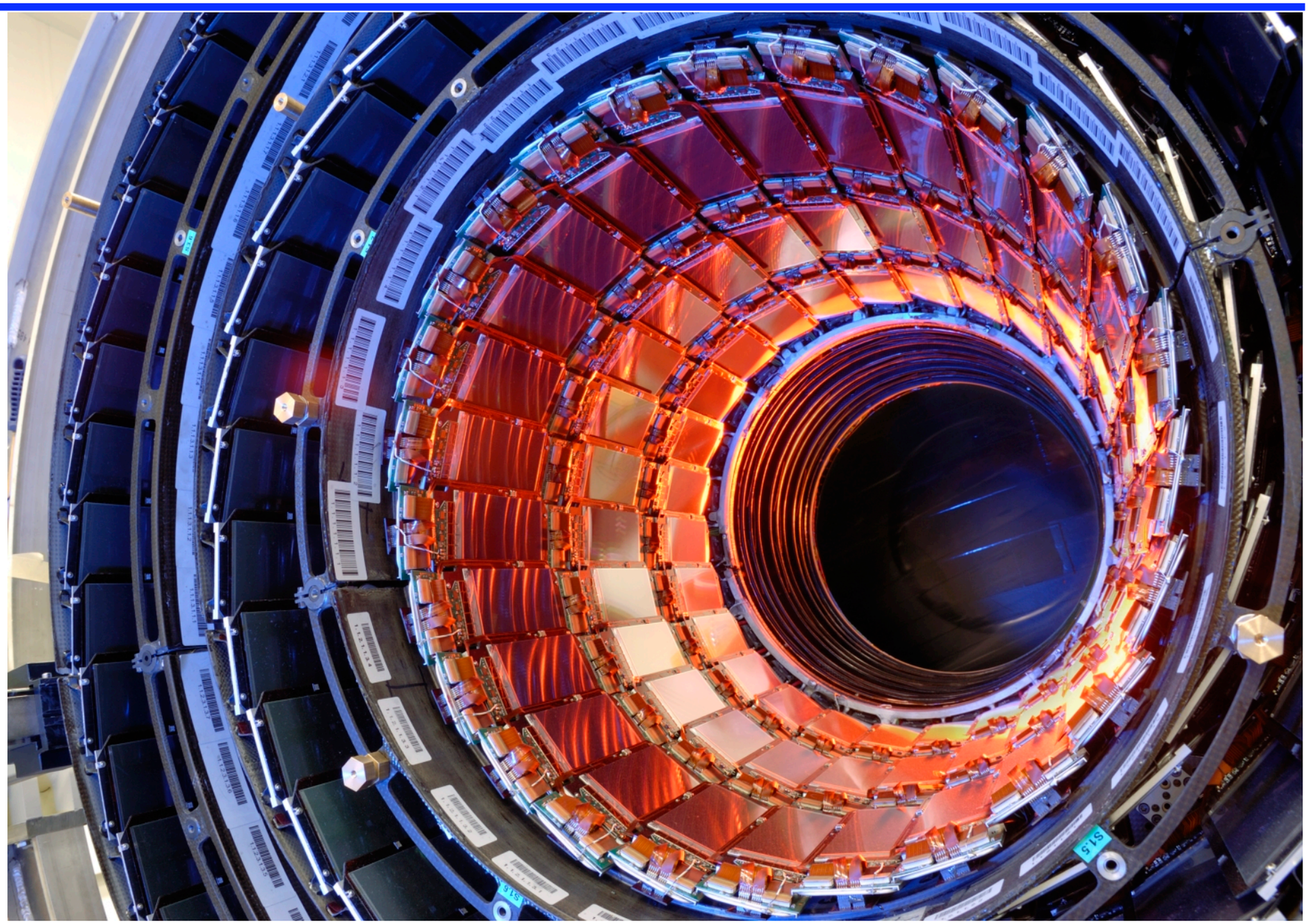
CMS Tracker Status - December 06

Completed
TIB / TID+



CMS Tracker Status - December 06

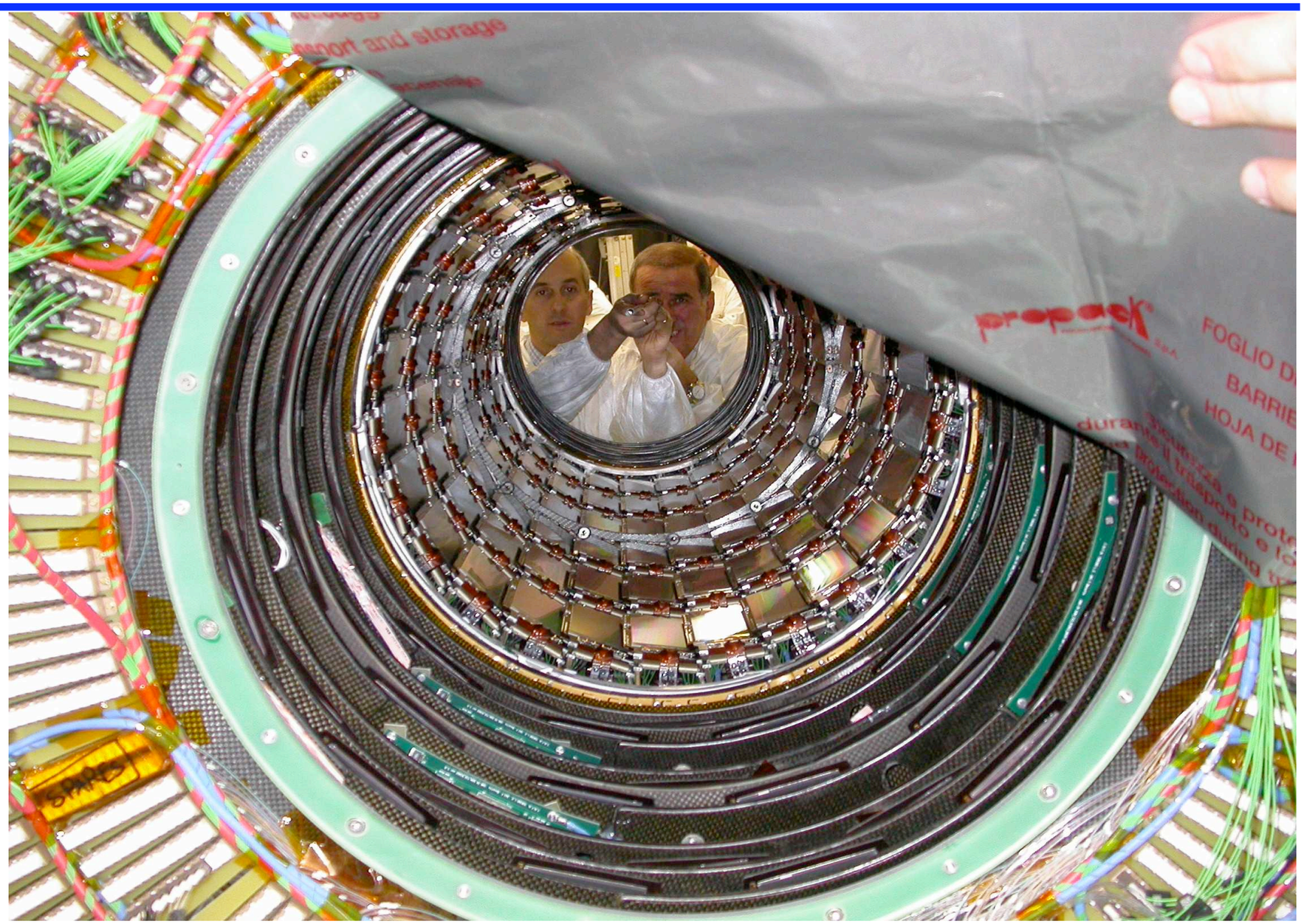
TIB / TID + showing TID



Peter Sharp CERN

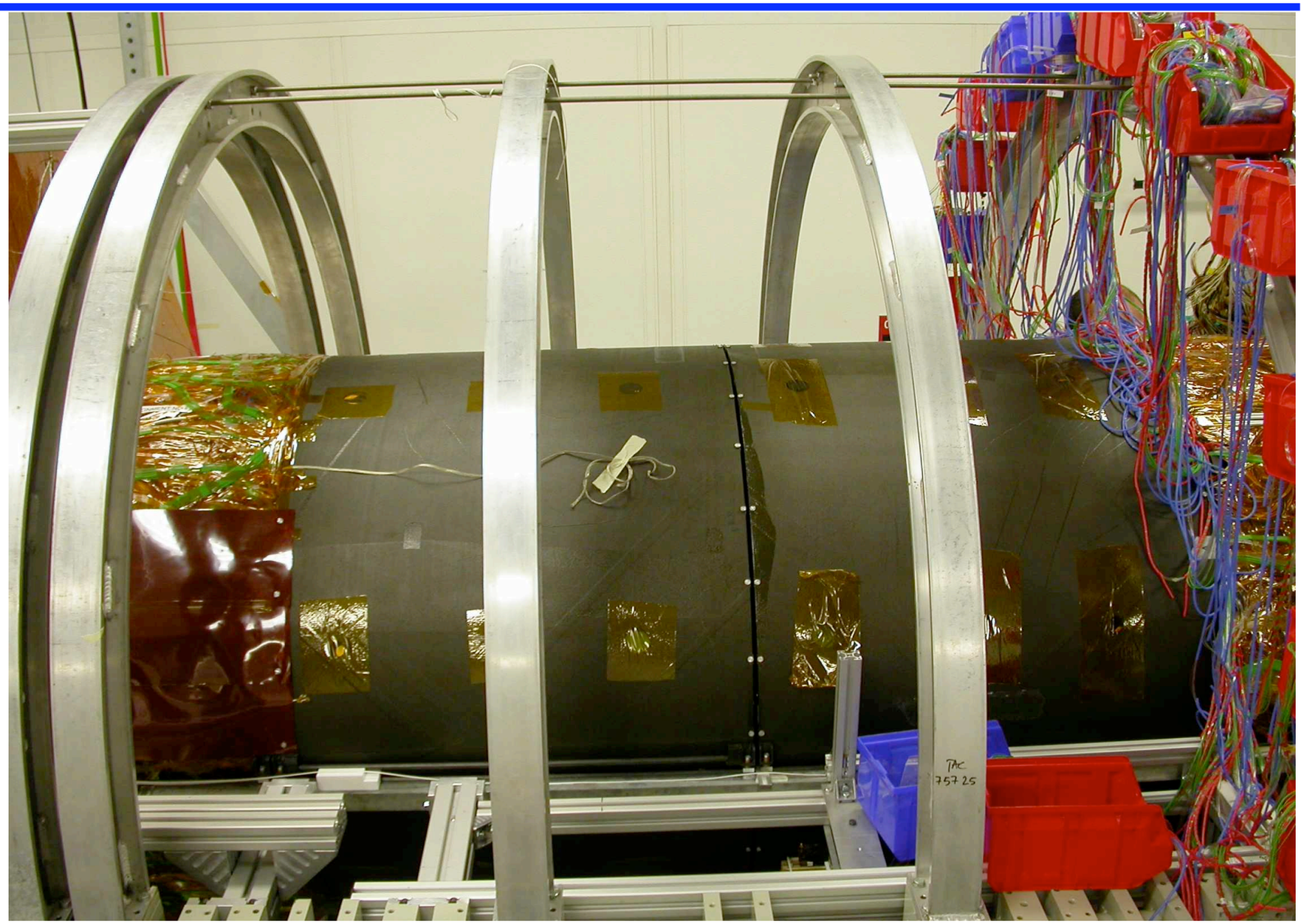
CMS Tracker Status - December 06

TIB+ and TIB- are about to be Aligned and Connected together outside the TST



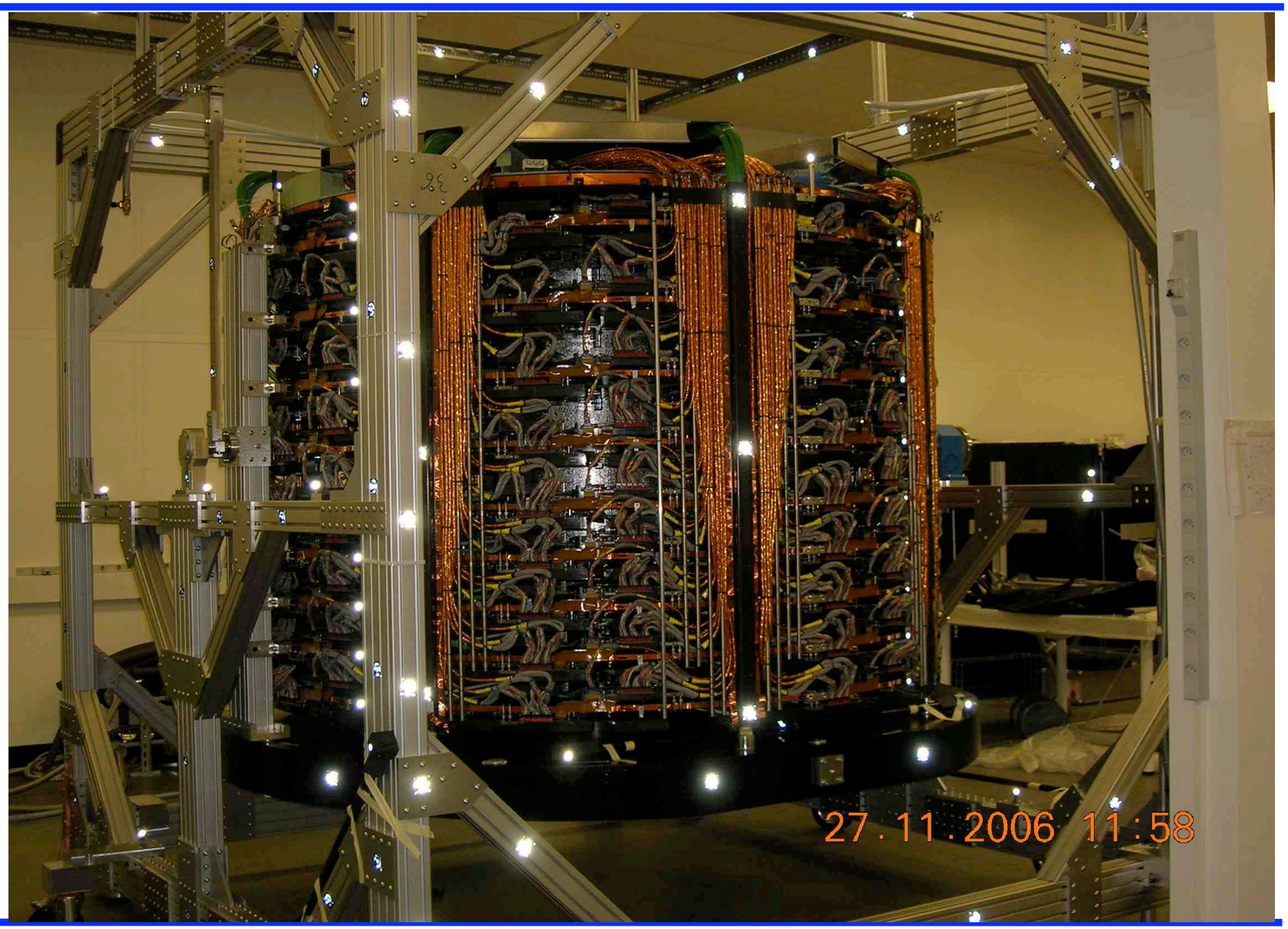
CMS Tracker Status - December 06

TIB+ and TIB- are Aligned and Connected together outside the TST



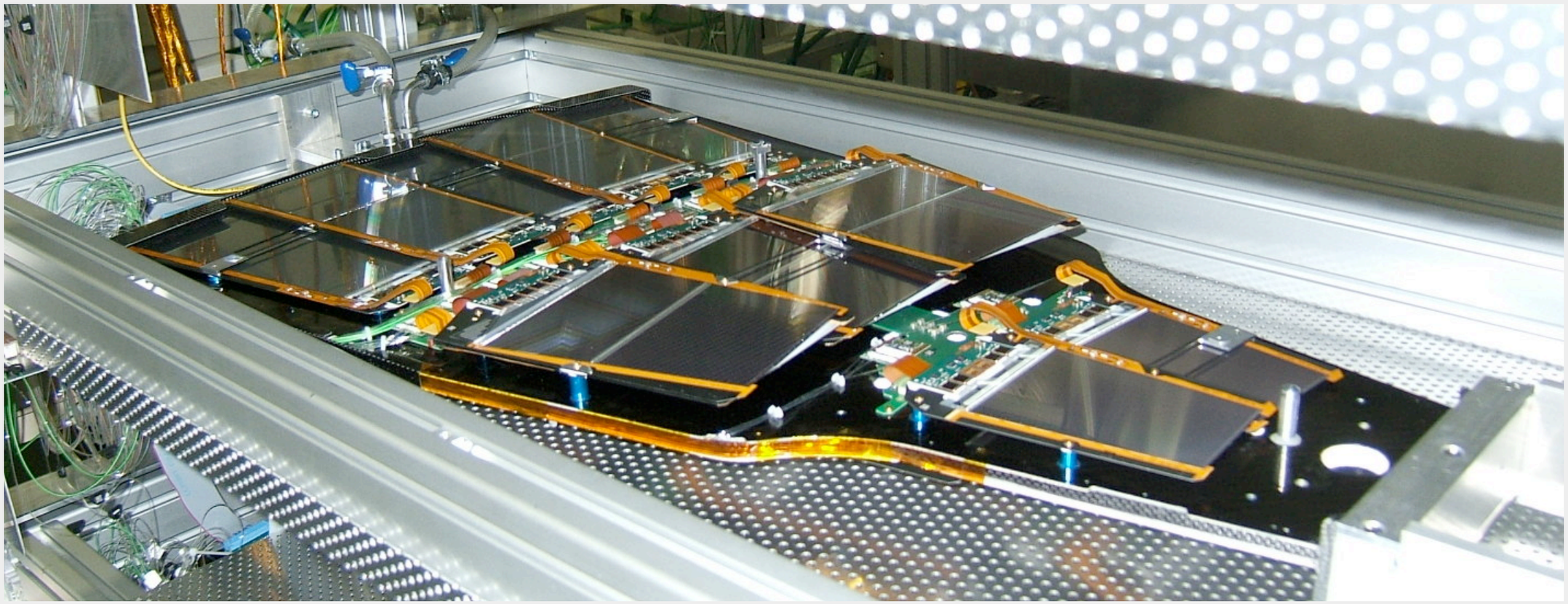
CMS Tracker Status - December 06

Completed TEC- at the TIF



Tracker End Cap (TEC): Petals

Germany, France, Belgium…



Today : All petals delivered
(Produced at a rate of 10 petals/week (Fr, Ge, Be).

CMS Tracker Status and Plans - December 06

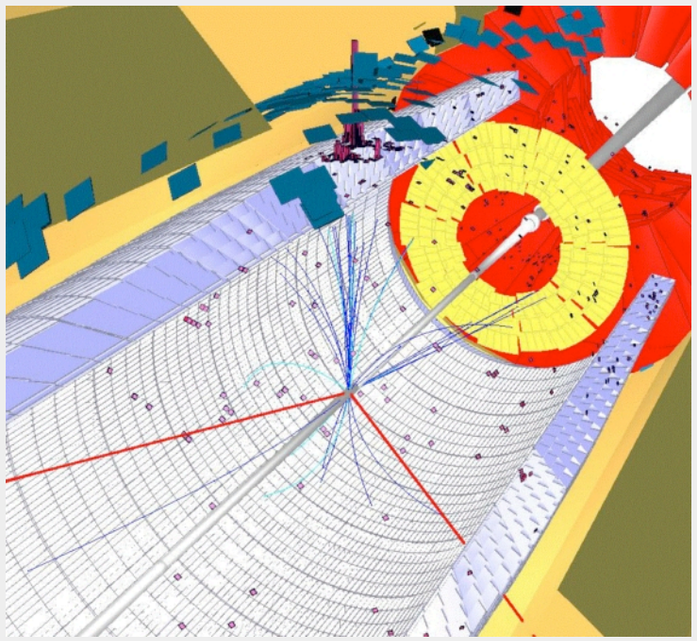
- All Sub - Detectors of the CMS Tracker are now at the Tracker Integration Facility (TIF)
  - TOB + Complete and Sector Test successful (27 October)
  - TIB + Complete and Sector Test successful (16 November)
  - TIB - Delivered to CERN from Pisa (27 October)
  - TEC + Delivered to CERN from Aachen (31 October)
  - TOB - Completed at TIF (20 November)
  - TEC - Completed at TIF (23 November)
- Many Complex tasks still to be completed before all of the Tracker is sealed inside the Tracker Support Tube (TST)
- Establish the Procedures to be followed before Integration

CMS Tracker Status and Summary - December

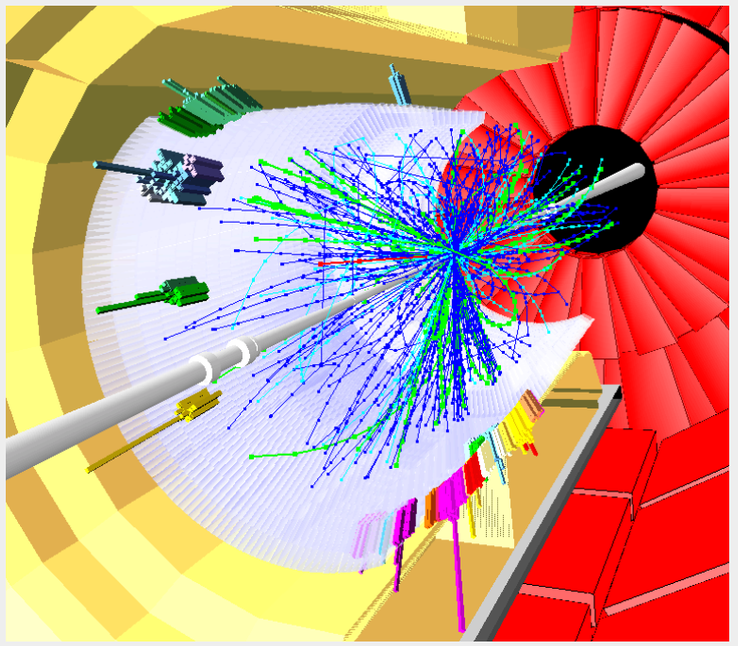
- **The Quality of the CMS Tracker Sub-Detectors is Excellent:**
- **Dead or Noisy Strips < 3 / 1000**
- **Signal:Noise > 25:1 in Peak Readout Mode**
- **Now Ensure that this Quality is maintained throughout the Integration of the Sub-Detectors into the TST**

What NEXT

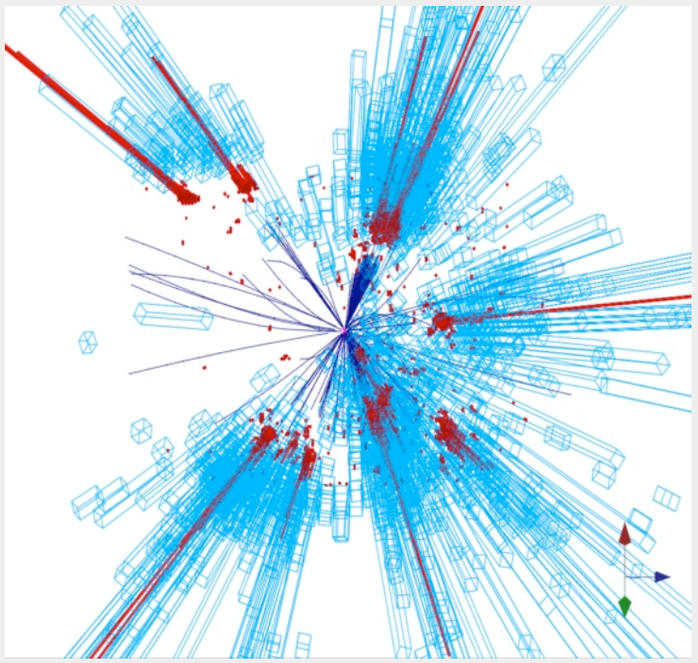
- *The Physics TDR is now finished for CMS*
- *MTCC was fully successfull*
- *Next objectives: CSA06 (on way) and preparing for the physics commissioning and first data.*
- *Have to maximalize experience & training for the real things in 2007*
- *An ambitious program ahead for the next Year*



SUSY events (LM4 point: leptons, missing E_T)



SUSY events (LM1 point: jets missing E_T)



Micro-Black Hole

CMS is rapidly coming together!

- *Major progress, particularly in this past year*
- *Now the full detector has to go down, be connected and become operational.*

- *Beam tube baked out on October 2007*
- *CMS ready for collisions at injection energy*

- *In one year the first collision results*

Backup

Conclusion: CMS Schedule v35.3 (Draft)

Magnet test/cosmic challenge:	Jul 06 - Sep06
Magnetic field mapping	Sep06 -Oct 06
USC ready for crates:	(Jul 06) Sep 06
Install and cable YE+/YB+ cable chains (&HF))	Jun 06 - Nov 06
HF lowering:	Nov 06
YE3+ lowering start	Nov 06
UXC ready for crates	Dec 06
First connection to USC	Dec 06
YB0 lowering	Feb 07
Partial final services available in UXC (Gas, LV)	Mar 07
YB0 services installation	Feb-Jun 07
EB installation	Mar-Jun 07
Tracker installation	Aug 07
Heavy lowering complete	Aug 07
Beam Pipe baked out/CMS Ready to Close	Oct 07

YB0 lowering, YB0 cabling and beampipe installation are key tasks
Good prospect to accommodate EB SM installation in UXC

Schedule overview: v35.3 draft

…giving maximum opportunity to refit SM's, without changing critical path