2006 Aspen Winter Conference
"Particle Physics at the Verge of Discovery"
Feb. 15, 2006

# Status of the LHC Detectors and Plans for Commissioning

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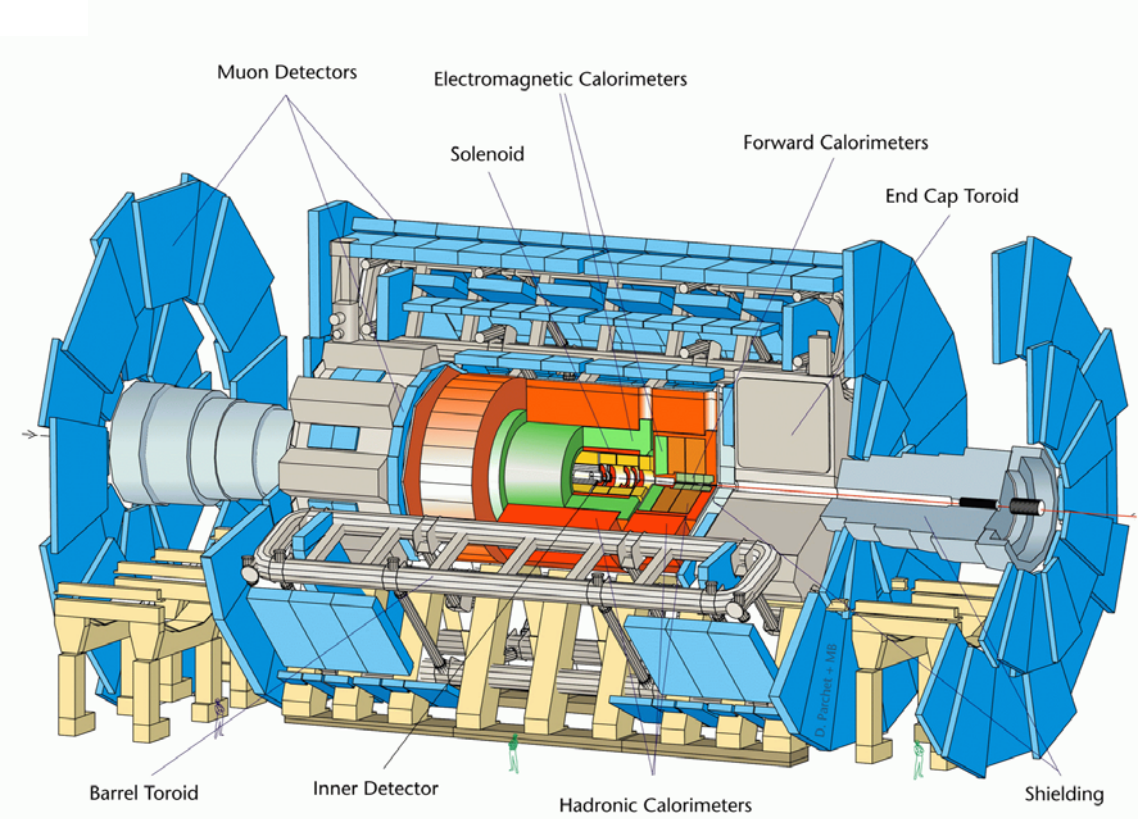
Boston University

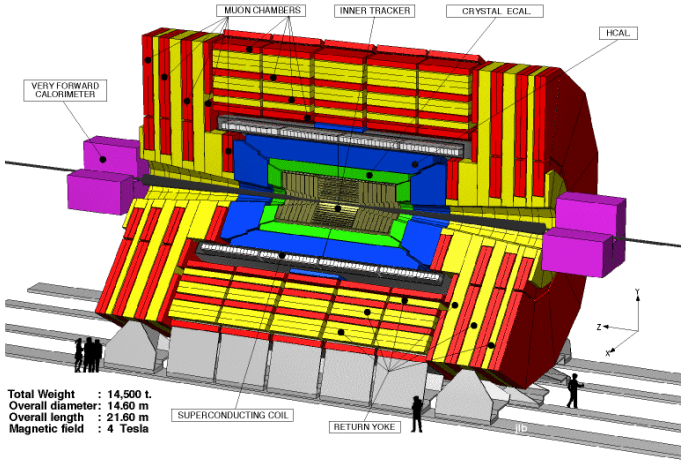

Thanks to Peter Jenni for providing ATLAS material.


P3: LHCb
P1: ATLAS
P5: CMS
f=11.245 kHz
T=88.924 μs
P7: ALICE

# Detectors: Overview




- muon detectors
- tracking in B field
- EM calorimetry
- hadron calorimetry




A Toroidal Large hadron collider ApparatuS (ATLAS)
7 kTons 0.5 T toroid,
2 T solenoid, $(25\ m)^2 \times 46\ m$

magnet=40% of $$,
good stand-alone muon res.

Compact Muon Solenoid (CMS) 14 kTons
4 T solenoid,
$(15\ m)^2 \times 22\ m$

magnet=25% of $$,
high res.tracker & ECAL

# Detector Technology

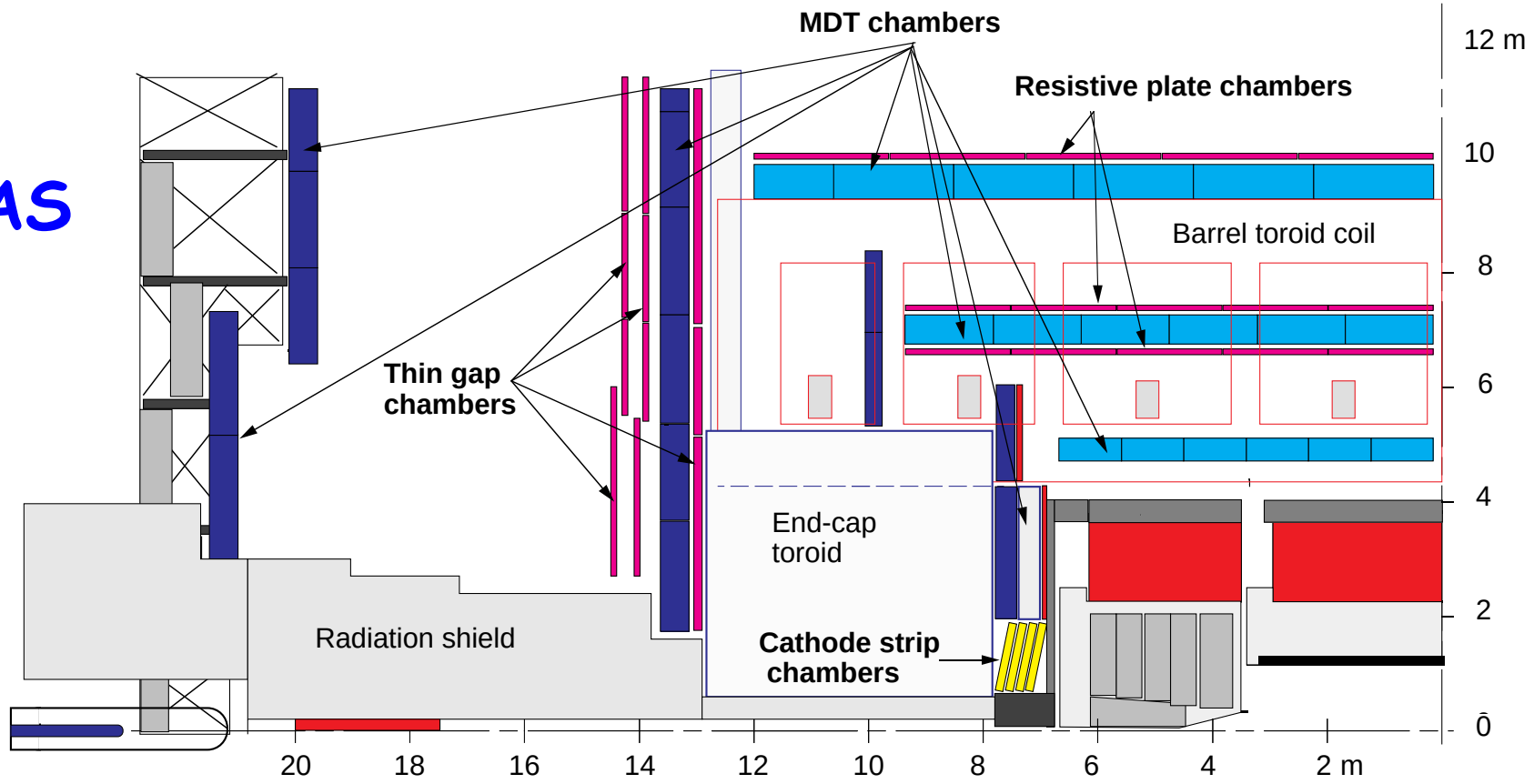
ATLAS


CMS

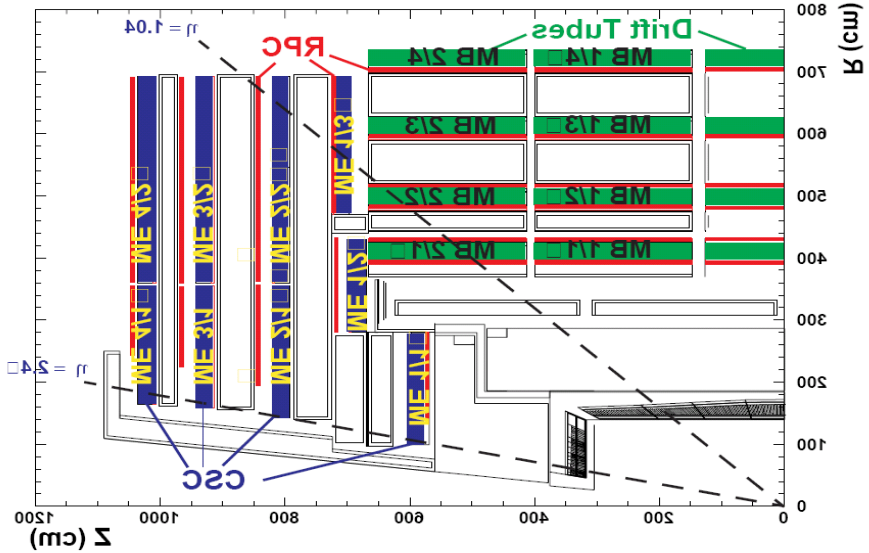
| | | | |
|---|---|---|---|
| Tracking | inner | pixels | pixels |
| | barrel | silicon strips/ straw tubes | silicon strips |
| | endcap | silicon strips/ straw tubes | silicon strips |
| ECAL | barrel | liquid argon / Pb | crystals ($PbWO_4$) |
| | endcap | liquid argon / Pb | crystals ($PbWO_4$) |
| HCAL | barrel | scintillator / Fe | scintillator / brass |
| | endcap | liquid argon / Cu | scintillator / brass |
| | forward | liquid argon / Cu-W | quartz / Fe |
| Muon | barrel | drift tubes<br>+resistive plate (trigger) | drift chambers<br>+resistive plate (trigger) |
| | end cap | drift tubes, cathode strip<br>+ thin gap (trigger) | cathode strip<br>+ resistive plate (trigger) |

# Detector Size Octant Comparison

## ATLAS

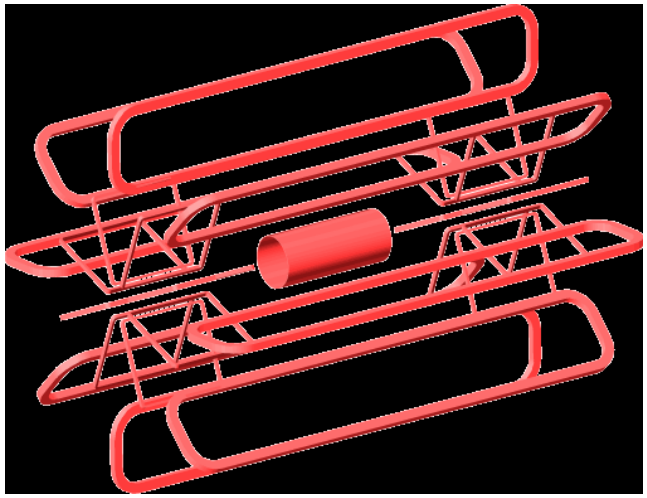



## CMS



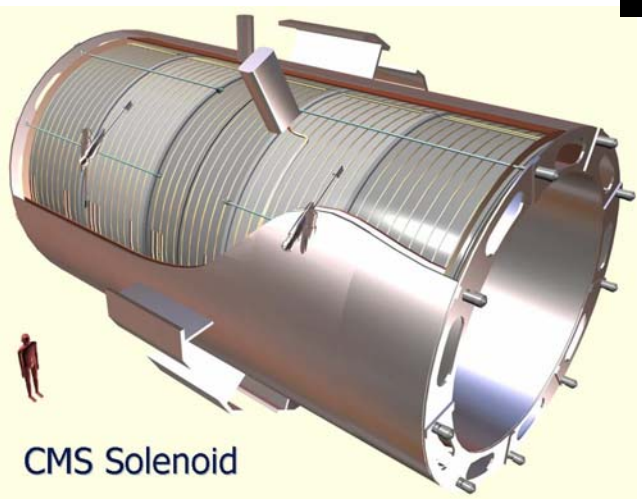
# Magnet

## ATLAS



| | |
|---|---|
| **barrel toroids** | |
| length | 25 m |
| outer diameter | 20.1 m |
| peak field | 4 T |
| current | 20.5 kA |
| **endcap toroids** | |
| length | 5 m |
| outer diameter | 10.7 m |
| peak field | 4 T |
| current | 20.5 kA |
| **solenoid** | |
| length | 5.3 m |
| radius | 1.2 m |
| field | 2 T |
| current | 7.6 kA |
| stored energy (total) | 1.6 GJ |
| superconductor length | 78 km |

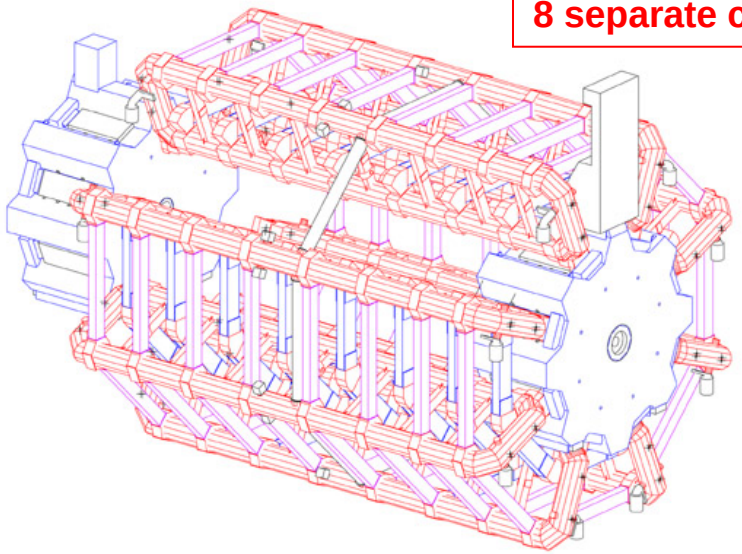
## CMS

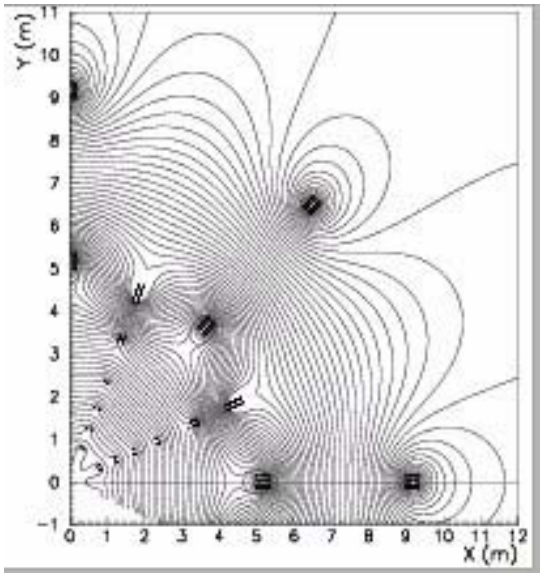



| | |
|---|---|
| length | 13 m |
| diameter | 5.9 m |
| coil turns (4 layers) | 2112 |
| superconductor length | 43 km |
| current | 20 kA |
| field | 4 T |
| length | 13 m |
| inductance | 12.6 H |
| stored energy | 2.5 GJ |

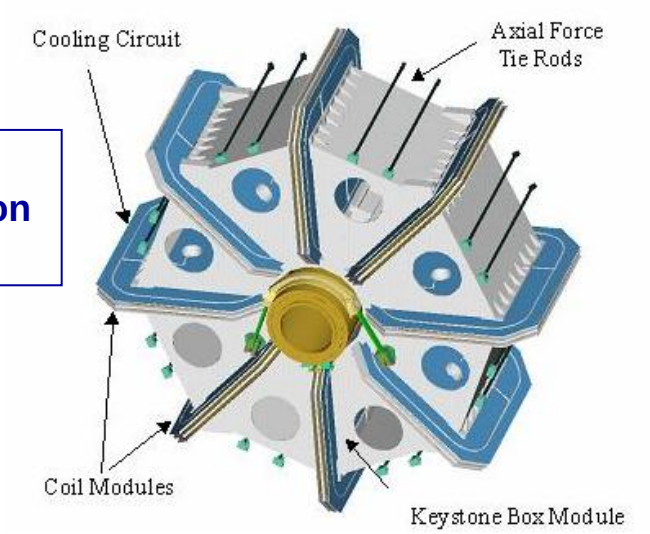
# ATLAS Magnet

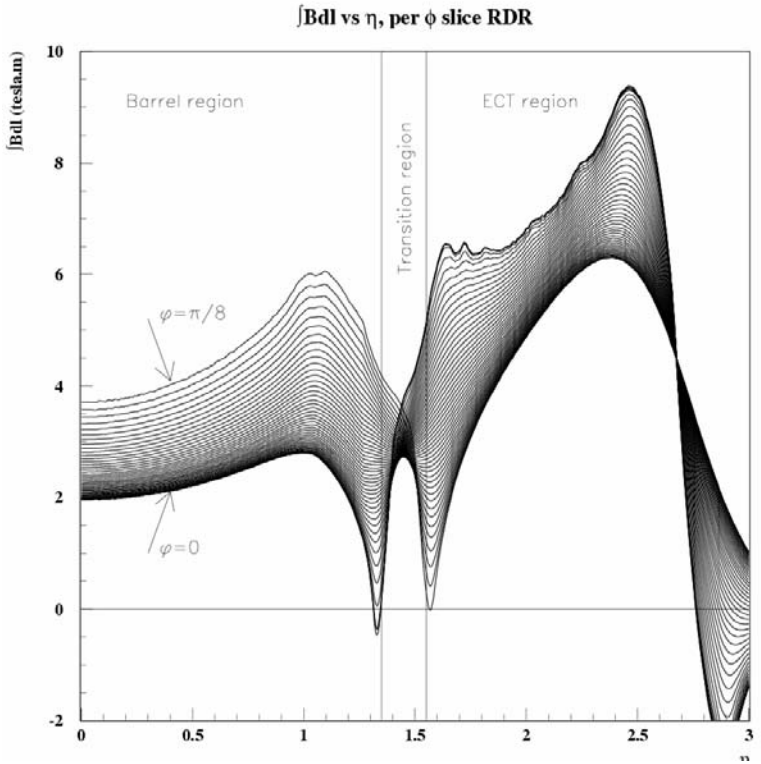
**Barrel Toroid:**
**8 separate coils**






**End-Cap Toroid:**
**8 coils in common cryostat**

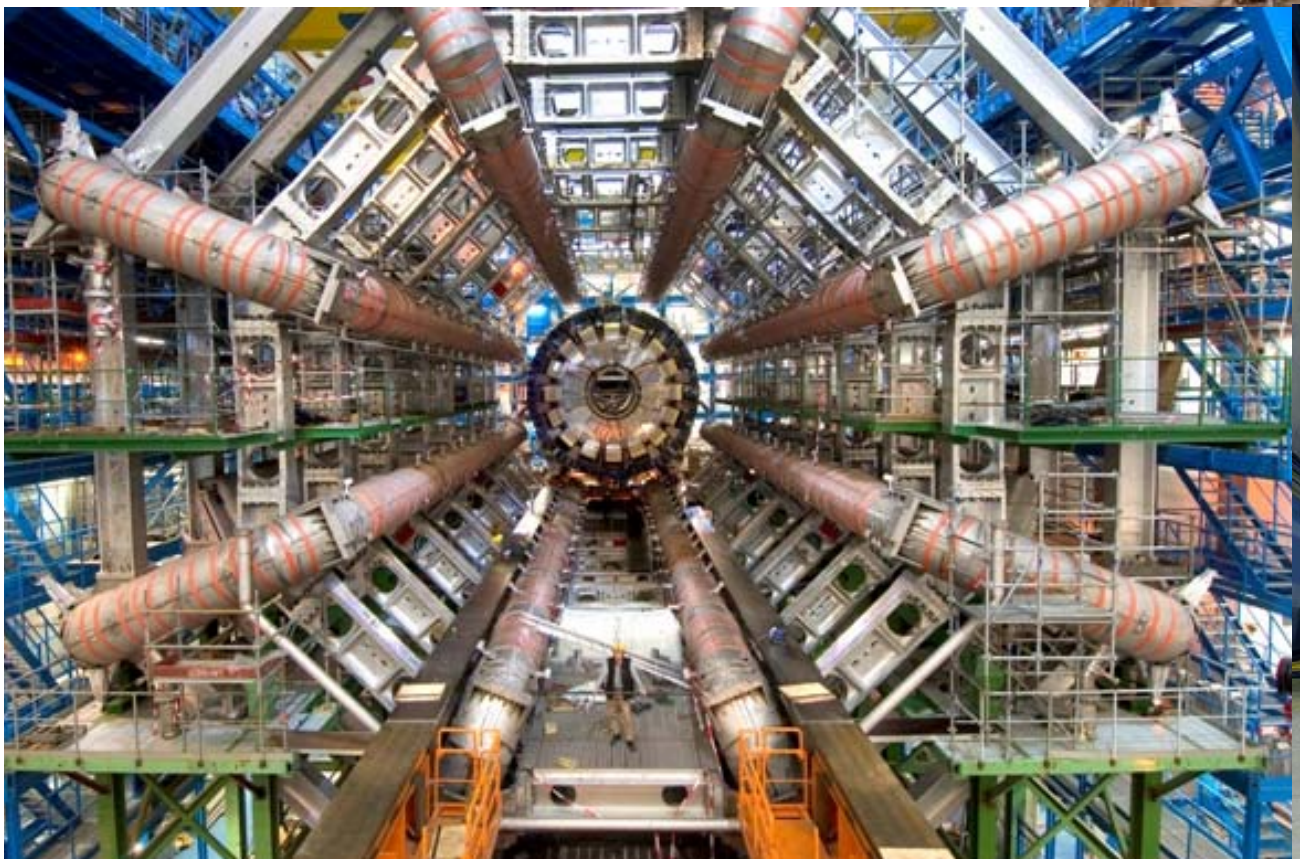


# ATLAS Magnet

Solenoid (integrated design with LAr)
Feb.04: Inserted into LAr cryostat
Jun.04: Tested at full current

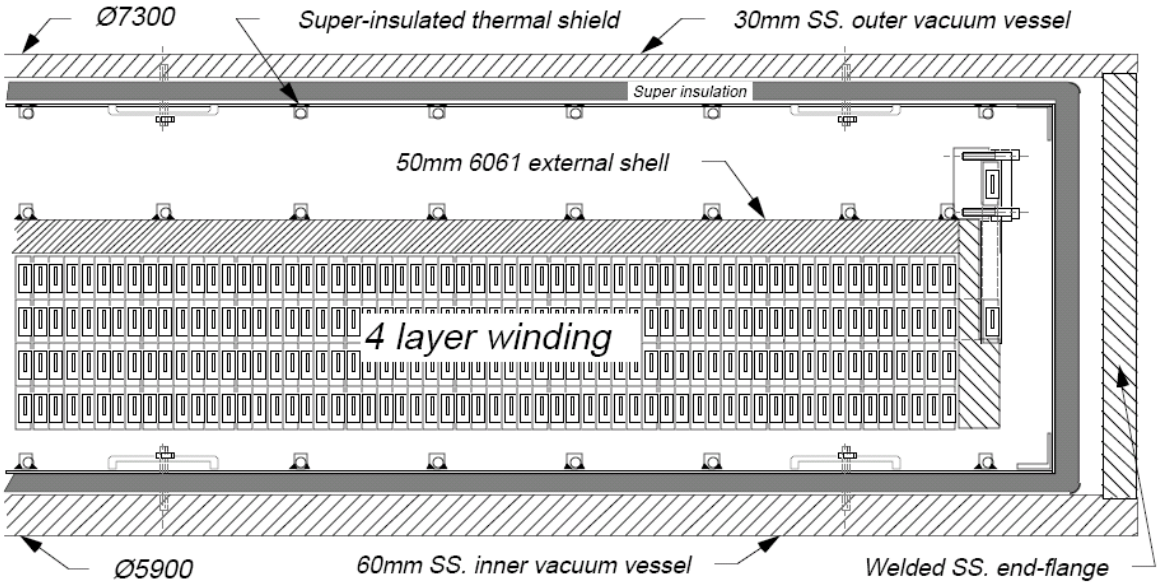
Barrel Toroid
Jun.04: Surface test at full current
Aug.05: Installation at P1 complete



Endcap Toroid
Move to P1
May06/Sept.06

# CMS Magnet

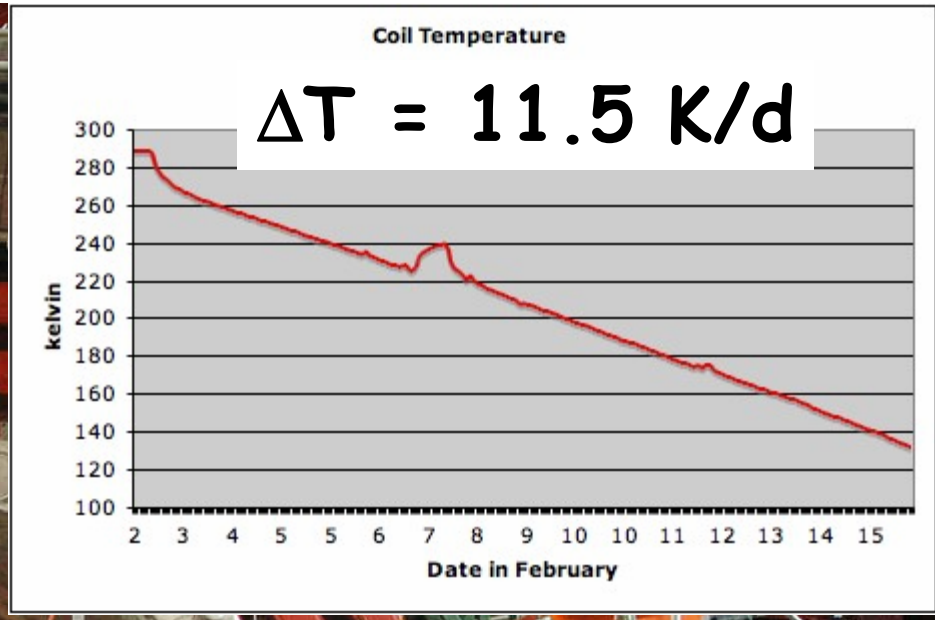
## Assembly and testing at surface




## Sept.05: coil insertion

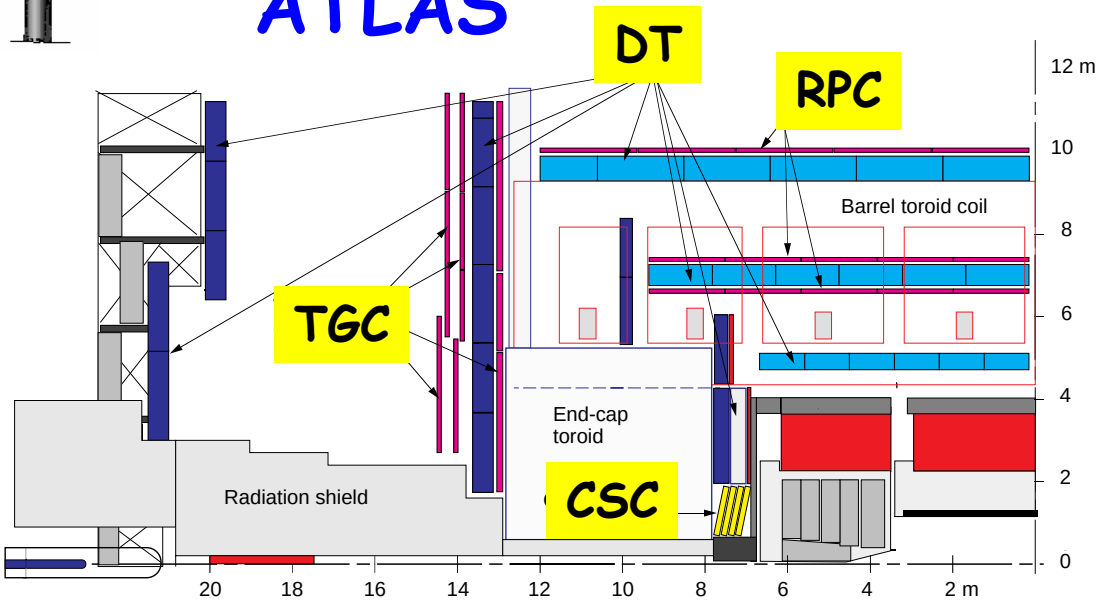
## Nov.05: inner vacuum

# CMS magnet cool down (Feb. 2006)

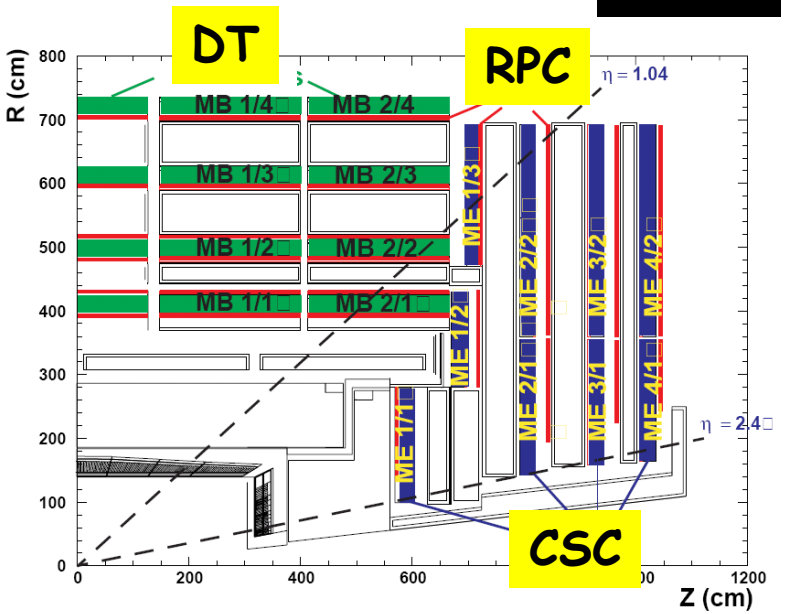


# Muons

## ATLAS




## CMS




**Res. at 100 GeV**

$\frac{\Delta p_T}{p_T} = 0.2 - 1\%$

**"stand alone"**

**DT = drift tube**
**RPC = resistive plate chamber**
**CSC = cathode strip chamber**
**TGC = thin gap chamber**

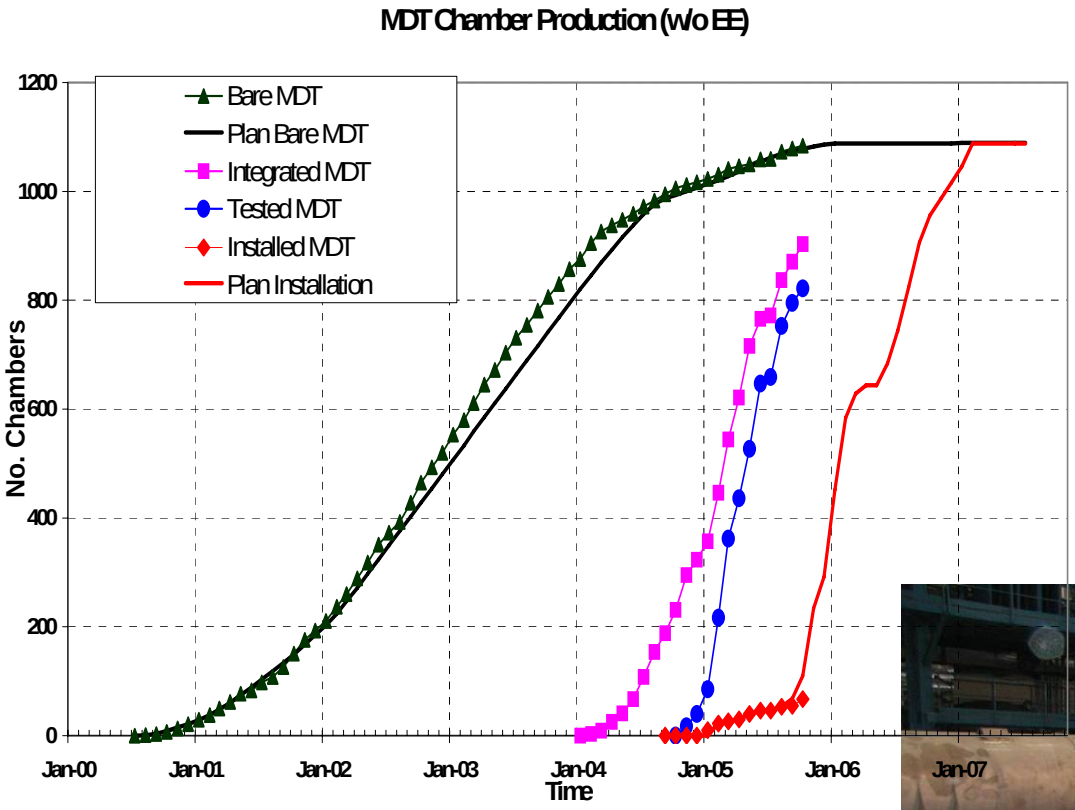
**Res. at 100 GeV**

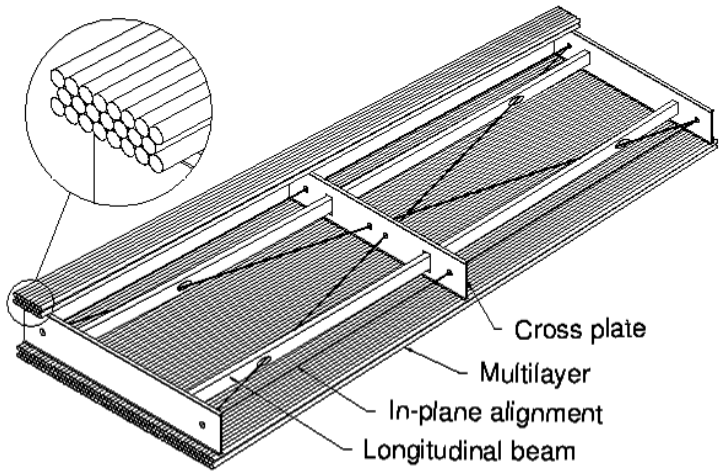
$\frac{\Delta p_T}{p_T} = 0.6 - 1.7\%$

**(2-4% "stand alone")**

| | *rapidity* | *stations* | *trigger* |
|---|---|---|---|
| **ATLAS** barrel | $\eta < 1.0$ | 3, 50 $\mu$m | 3 RPC |
| endcap | $1 < \lvert\eta\rvert < 2.7$ | 3, 60 $\mu$m | 3 TGC |
| **CMS** barrel | $\eta < 1.3$ | 4, 100 $\mu$m | 4 DT+6 RPC |
| endcap | $1 < \lvert\eta\rvert < 2.4$ | 4, 100 $\mu$m | 4 RPC |

# ATLAS Barrel DT



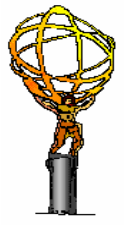

Installation of barrel muon station

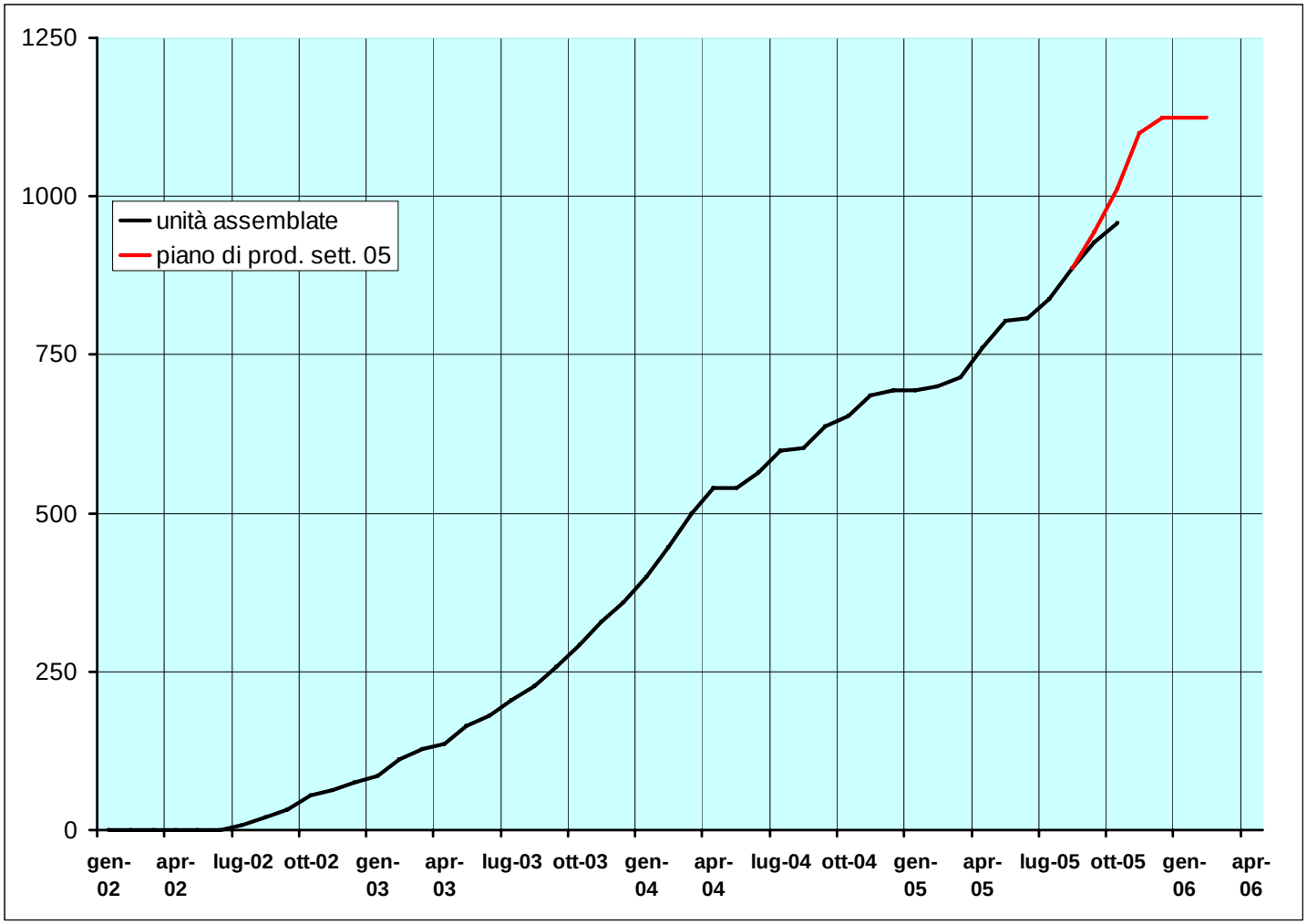
A major effort is spent in the preparation and testing of the barrel muon stations (MDTs and RPCs for the middle and outer stations) before their installation in-situ

The electronics and alignment system fabrications for all MDTs are on schedule

# ATLAS
# RPC

**RPC production essentially completed**






| Type | BML | BMS | BOS | BOL | Special |
|---|---|---|---|---|---|
| Layout | 298 | 280 | 202 | 192 | 144 |
| Done | 298 | 280 | 202 | 98 | 84 |
| % | 100 | 100 | 100 | 51.0 | 58.3 |

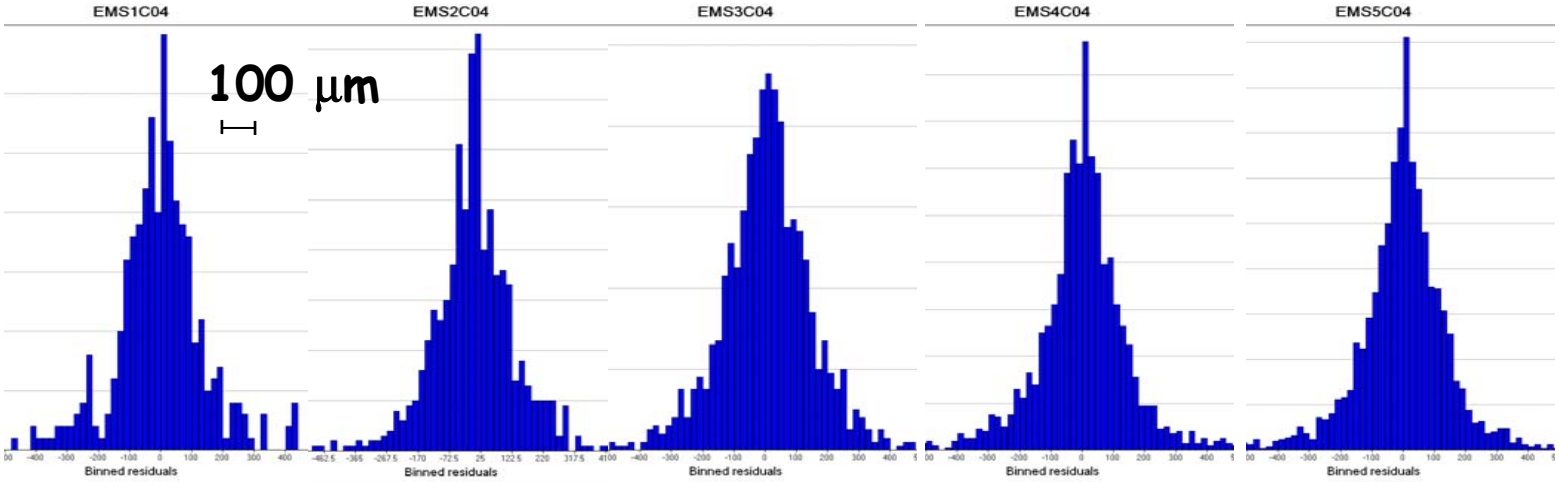
# ATLAS Endcap

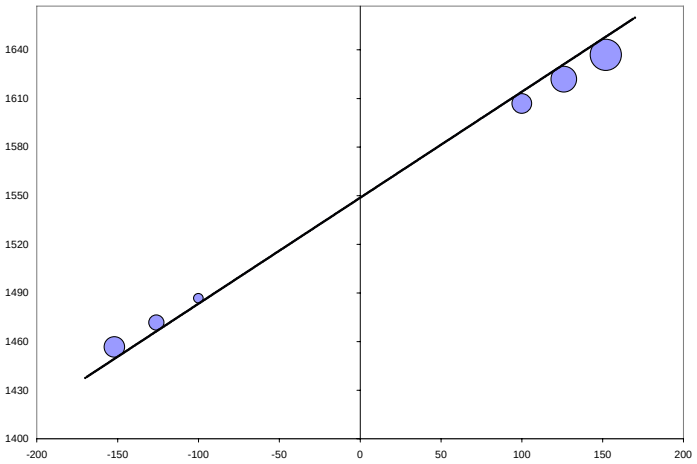
**72 TGC and 32 MDT "Big Wheel" sectors have to be assembled. This work is now in full swing in the Hall where previously the Barrel Toroid and the LAr integration and tests were done.**

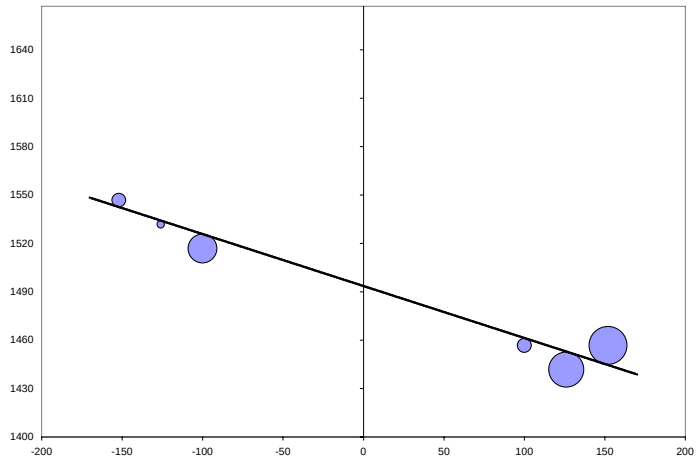

"Big Wheel" endcap muon MDT sector assembled in Hall 180

"Big Wheel" end-cap muon TGS sector assembled in Hall 180

# ATLAS Endcap
## Cosmic Ray Residuals for Small Wheel Sector C04

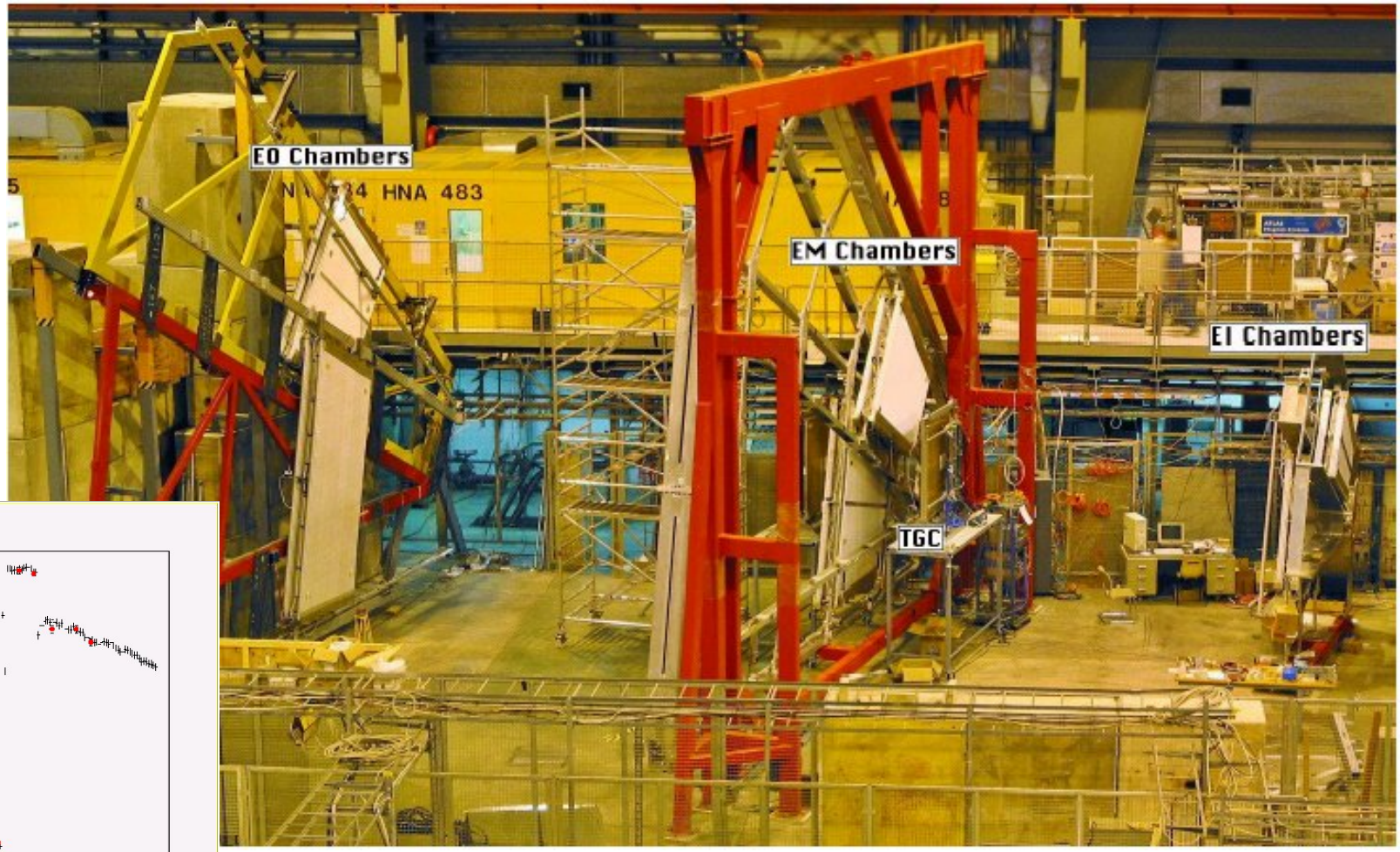


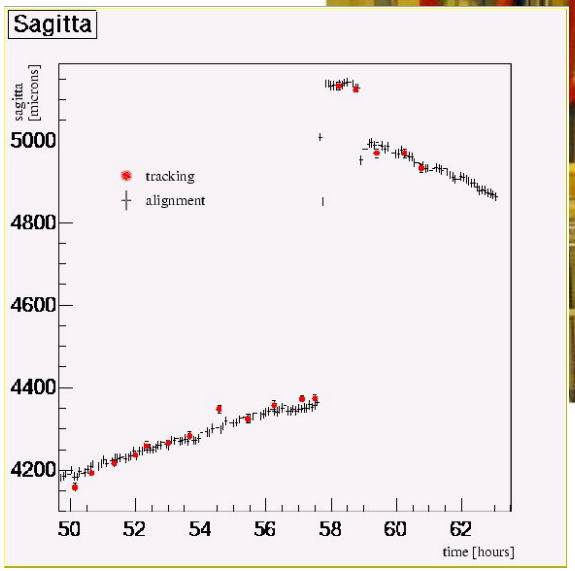



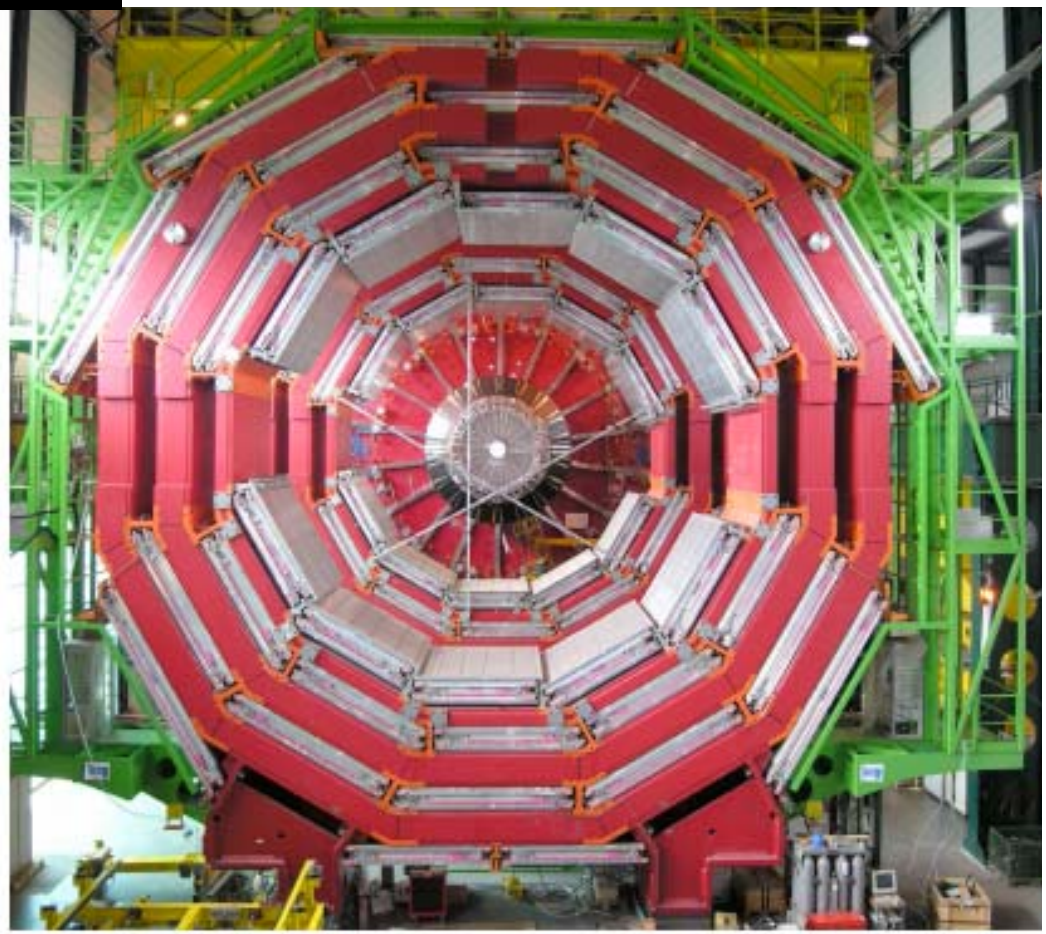
# ATLAS Muon Test Beam

Large-scale facility for alignment, mechanical, and system tests, with chamber stations in the SPS H8 beam



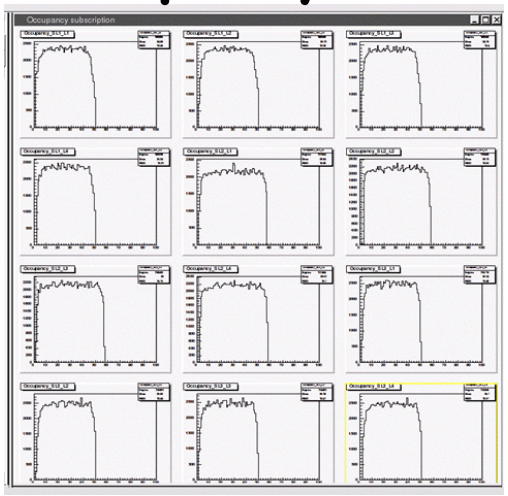
# CMS Barrel DT



Shown here YB+2 and YB+1 essentially complete,
42 chambers installed and commisioned Dec.05
To do: 54 chambers before magnet test,
64 after magnet test, and 40 underground

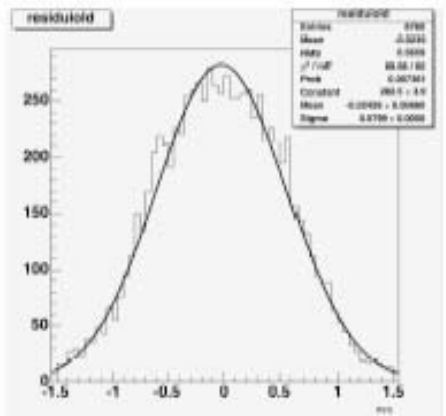
# CMS DT Commisioning with Cosmic Rays

## Occupancy dist.



Autotriggering has random time distribution

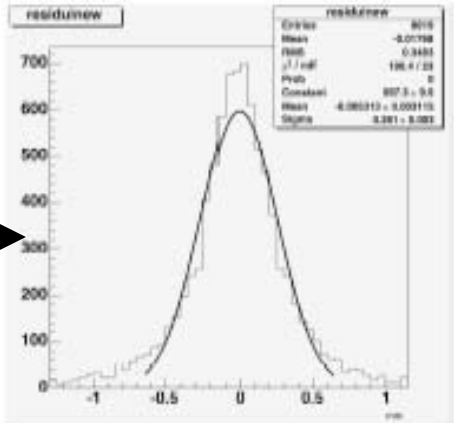
## No time corr.




| layer | mean [$\mu m$] | sigma [$\mu m$] |
|---|---|---|
| 1 | -8±15 | 518±7 |
| 2 | -12±7 | 546±6 |
| 3 | -14±7 | 552±5 |
| 4 | 14±7 | 537±6 |
| 5 | -14±6 | 547±5 |
| 6 | 28±7 | 559±6 |
| 7 | -22±7 | 556±5 |
| 8 | 15±6 | 526±5 |

$\sigma_{media_{old}}$ = 543+- 2 mu

## Drift time corr.




| layer | mean [$\mu m$] | sigma [$\mu m$] |
|---|---|---|
| 1 | -2±3 | 221±3 |
| 2 | -16±3 | 220±3 |
| 3 | 7±3 | 227±3 |
| 4 | 9±3 | 239±3 |
| 5 | -9±3 | 247±3 |
| 6 | 25±3 | 235±3 |
| 7 | -18±3 | 222±3 |
| 8 | 3±3 | 244±3 |

$\sigma_{media_{new}}$ = 232+-2 mu

## Sector commissioning

autotriggering

## Sector test

Read with local DAQ

## Sector test-regional

Triggering with TTC

## 3-Sector test

Cosmic trigger 3 sectors

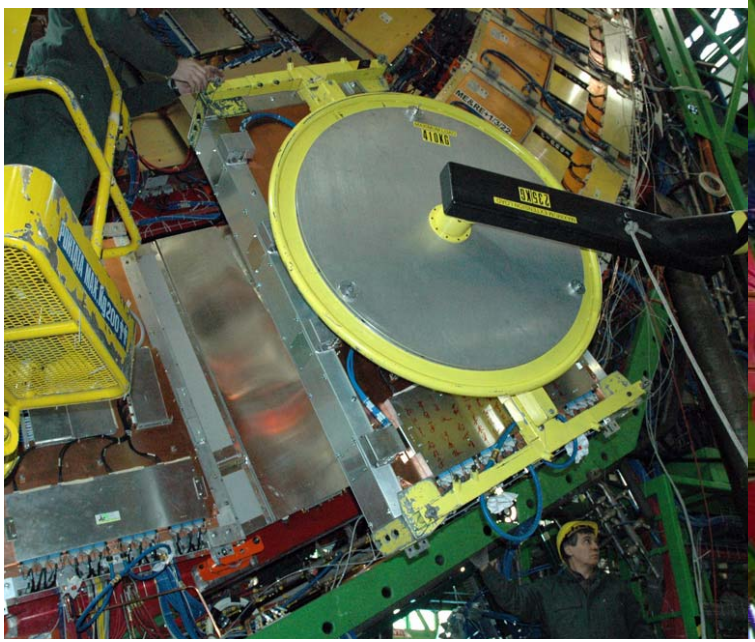
## FED intgration

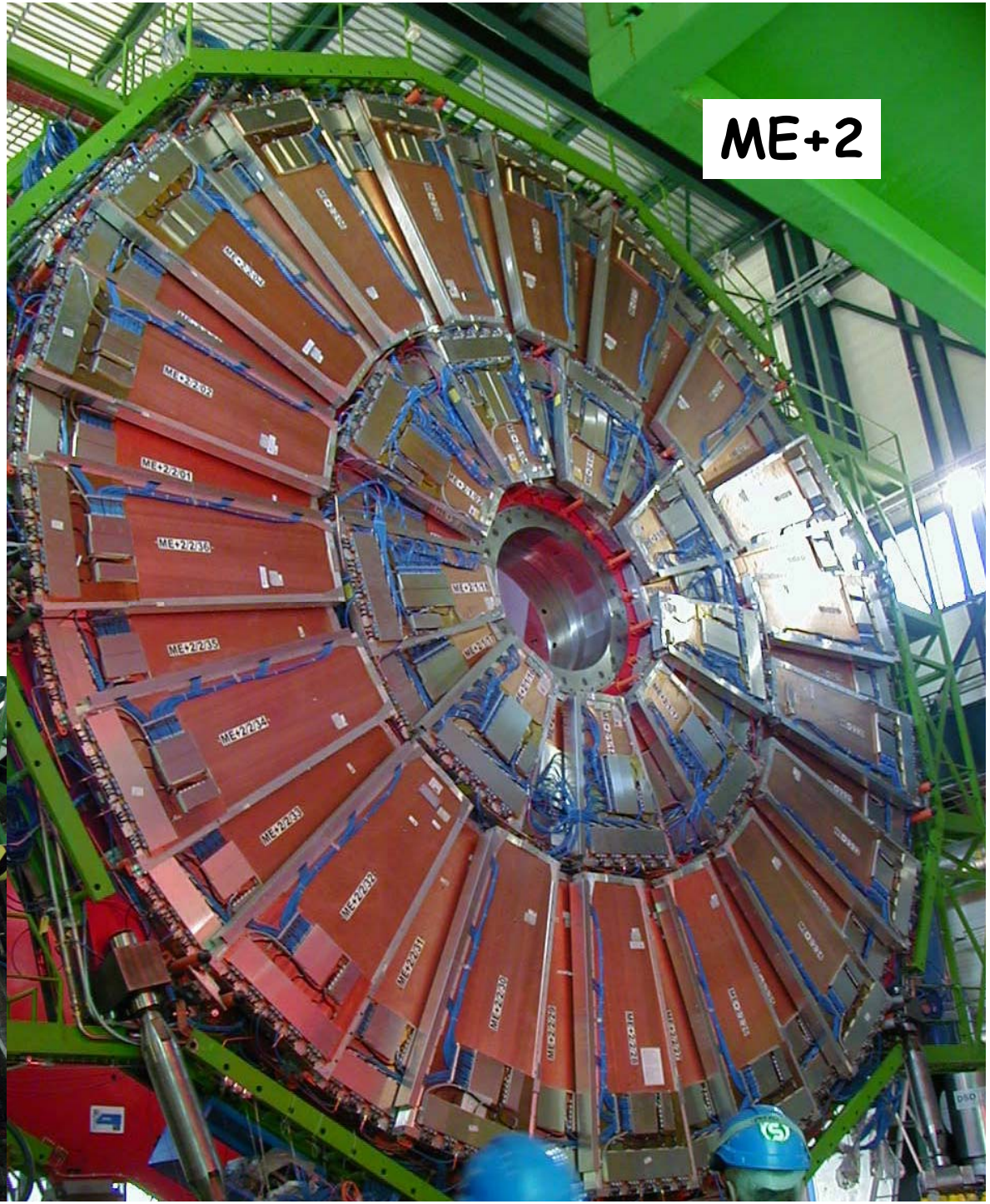
Compete readout chain

# CMS
# Muon Endcap

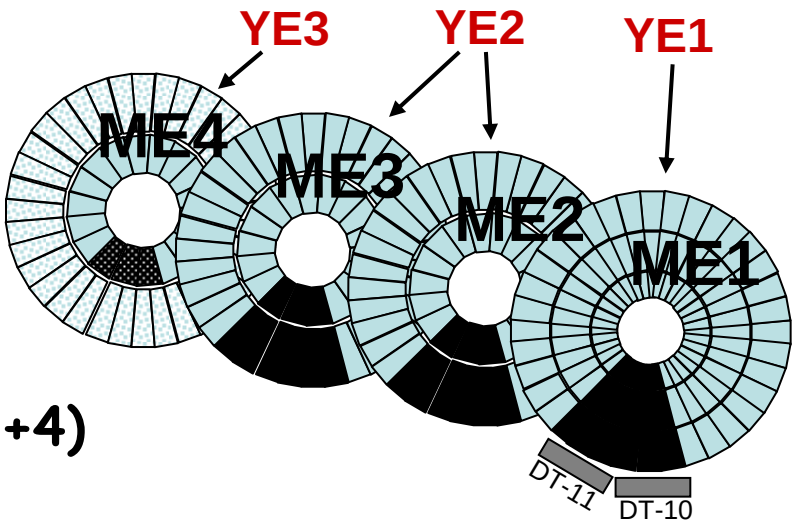
cathode-strip chambers

All chambers (468)
and electronics
are produced,
>3/4 are installed
and commissioned





# CMS CSC Slice Test: overview



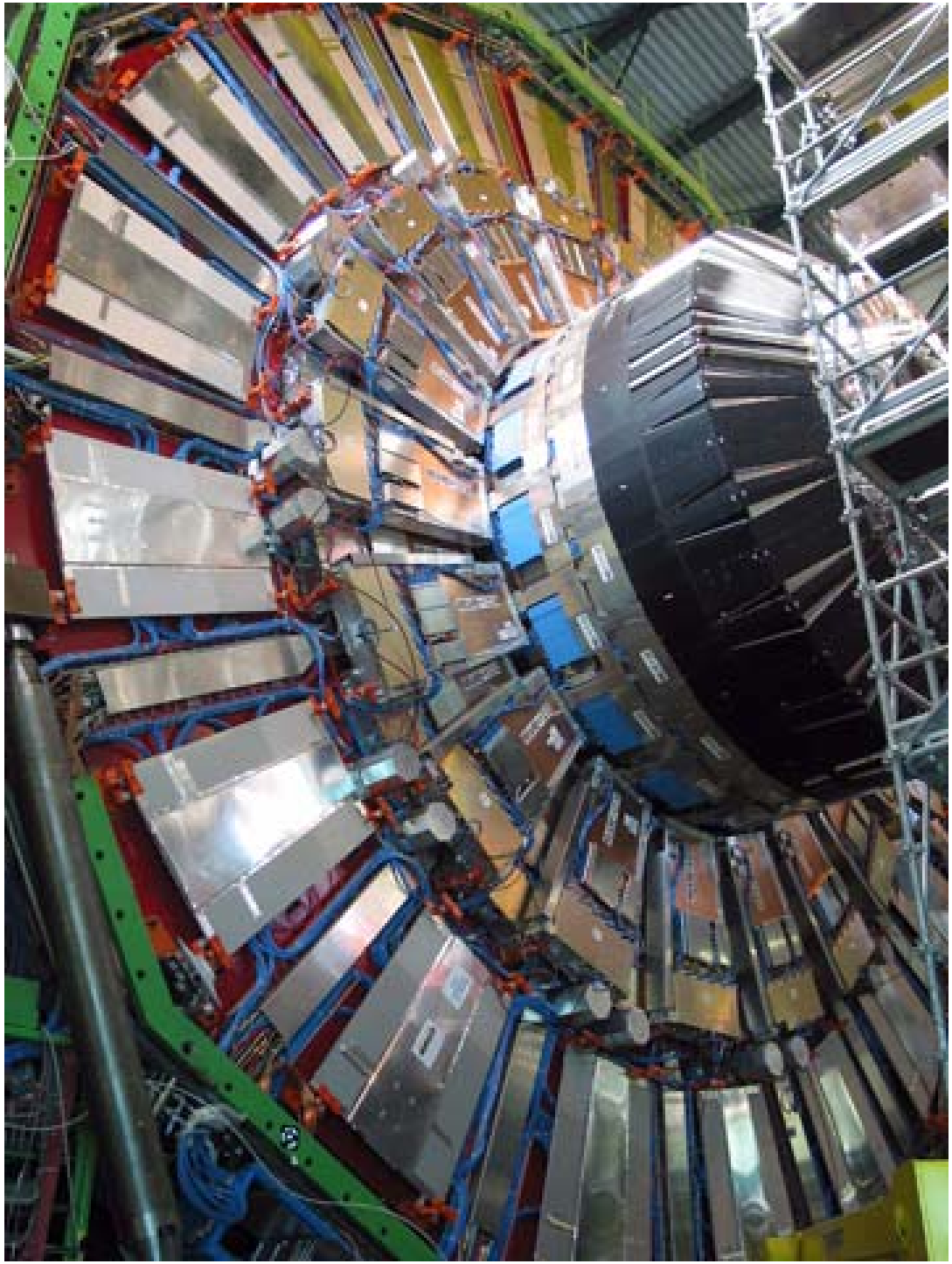

- Goal: One 60° Trigger Sector:
  - overlap with DT sectors 10-11
  - Multiple stations
    - YE+1, YE+2 (and YE+3)
    - ME+1, ME+2, ME+3 (and ME+4)
    - Total of up to 39 chambers
- Trigger options:
  - Self-trigger on cosmics: TrackFinder/SectorProcessor
  - Externally provided, scintillator in front of ME+2
- DAQ options:
  - Local DAQ (DDU-spy channel): DQM and calibration
  - Global DAQ (DCC S-Link): CMS-DQM, EvF, off-line analyses

**Recent milestone: CSC trigger and readout with global DAQ up to the online event filter unit**

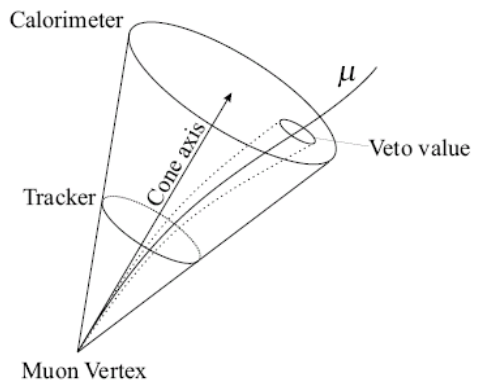
# CMS
# Muon RPC
## resistive plate chambers

Ring +1/+2 mostly installed

YE -1/+1 installed

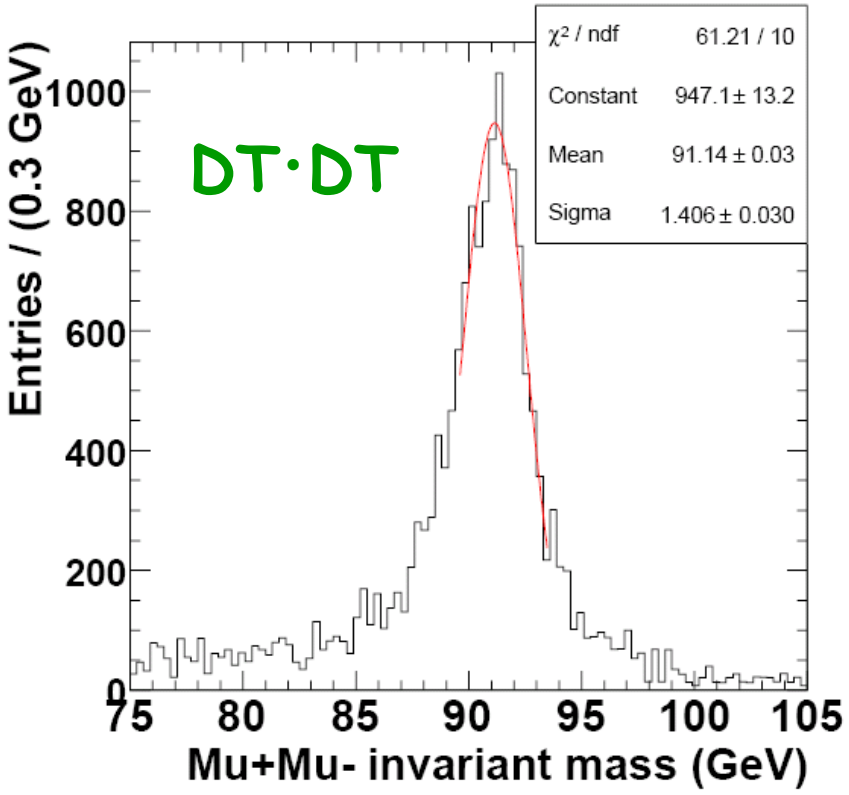


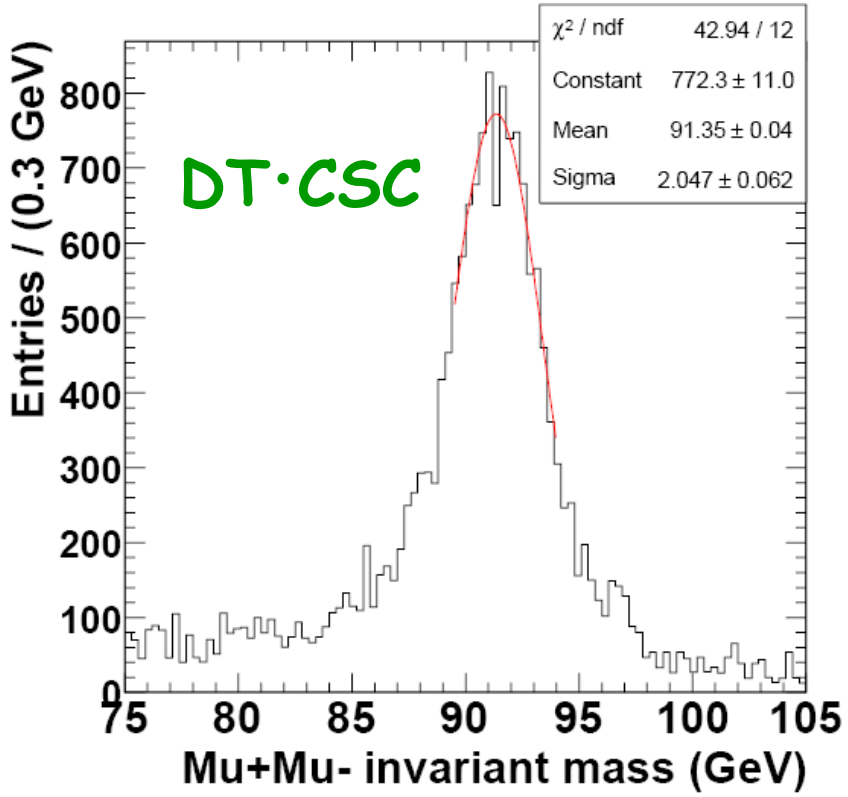
# CMS $\mu^+\mu^-$ mass resolution: 1 day at $2 \times 10^{33}$ cm$^{-2}$s$^{-1}$




**2 isolated muons with**

$p_T > 20$ GeV/c, 10 GeV/c




CERN/LHCC 2006-001, CMS TDR 8.1, 02 Feb. 2006

# Calorimetry

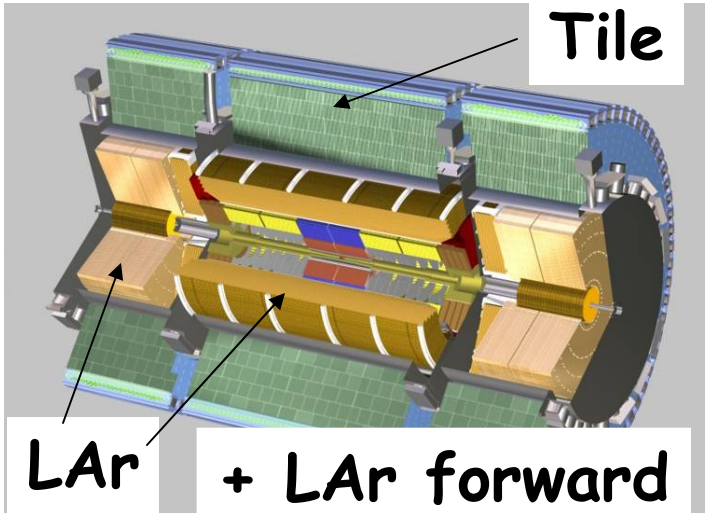
## ECAL

| | *res. @ 50 GeV* | *material in front* | *thickness* | $\Delta\eta \times \Delta\phi$ |
|---|---|---|---|---|
| **ATLAS** | 1.3% | 2-4 $\chi_0$ | 21-36 $\chi_0$ | front 0.003 × 0.1<br>middle 0.025 × 0.025<br>back 0.05 × 0.025 |
| **CMS** | 0.8% | 0.4-1.3 $\chi_0$ | 25-27 $\chi_0$ | 0.0174 × 0.0174 |

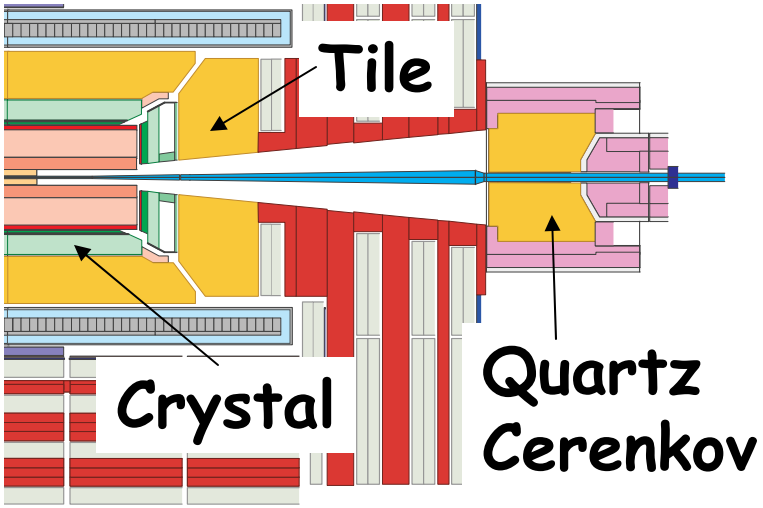
## HCAL

| | *coverage* | *res. @ 100 GeV* | *thickness* | $\Delta\eta \times \Delta\phi$ |
|---|---|---|---|---|
| **ATLAS** barrel | $\lvert\eta\rvert < 1.0$ | 8% | 8-10 $\lambda$ | front 0.1 × 0.1 |
| extended barrel | $0.8 < \lvert\eta\rvert < 1.7$ | | | back 0.2 × 0.1 |
| endcap | $1.5 < \lvert\eta\rvert < 3.2$ | | | 0.1-0.2 × 0.1 |
| forward | $3.1 < \lvert\eta\rvert < 4.9$ | | | 0.2 × 0.2 |
| **CMS** barrel | $\lvert\eta\rvert < 1.4$ | 10% | 11-15 $\lambda$ | 0.087 × 0.087 |
| endcap | $1.4 < \lvert\eta\rvert < 3.0$ | | | 0.087 × 0.087-0.17 |
| forward | $3.0 < \lvert\eta\rvert < 5.0$ | 20% | | 0.17 × 0.17 |

## ATLAS



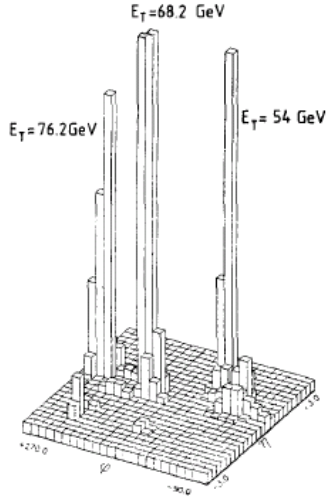

## CMS



# Jets at the LHC

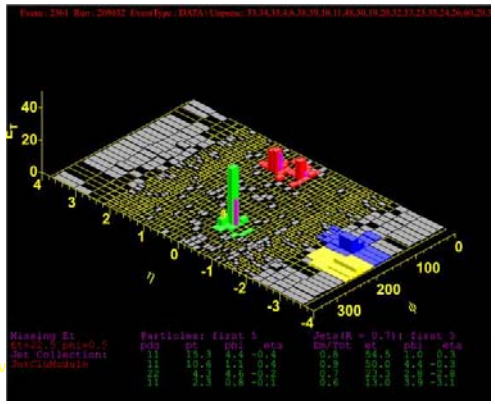
## CERN $\bar{p}p$

$\sqrt{s} = 0.540$ TeV



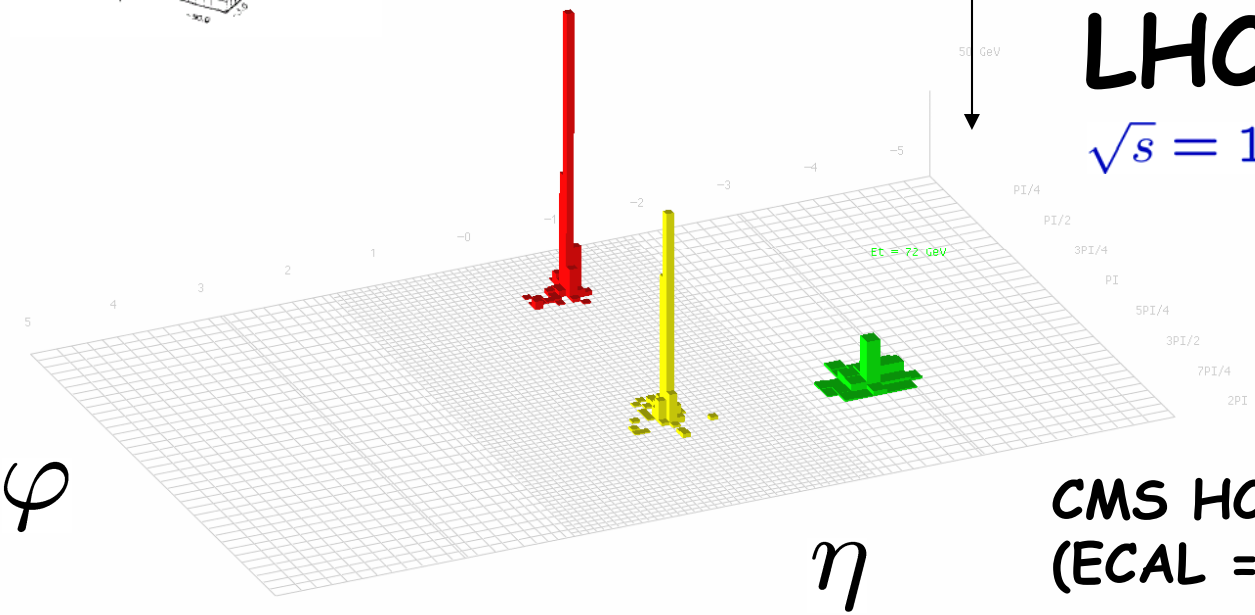

## Tevatron $\bar{p}p$

$\sqrt{s} = 2$ TeV



## LHC pp

$\sqrt{s} = 14$ TeV



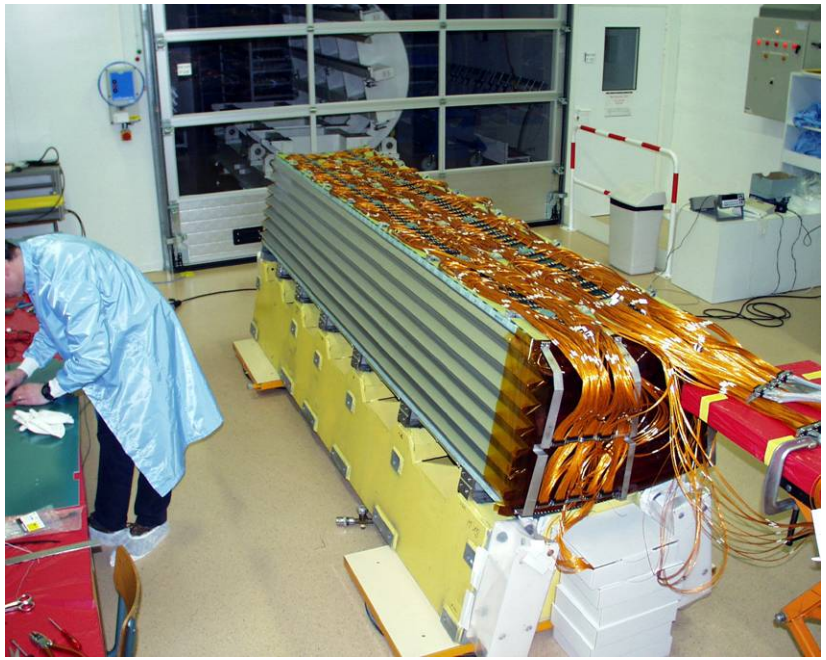

$\varphi$

$\eta$

CMS HCAL towers
(ECAL = x5 granularity)

# ATLAS ECAL (LAr) Barrel

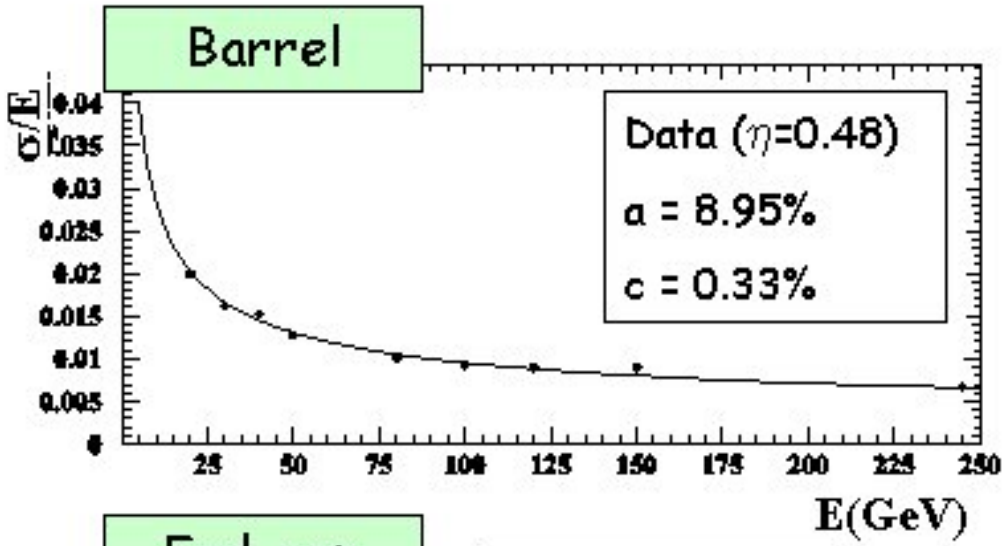
Commisioning on surface: complete cold test (with LAr) during summer 2004 at CERN (dead channels much below 1%)

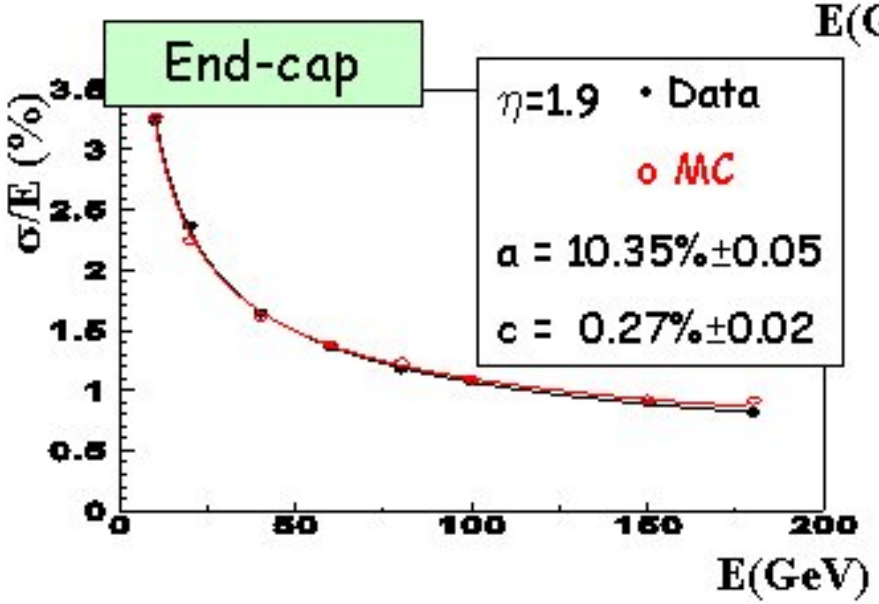


LAr barrel EM calorimeter module at one of the assembly labs

LAr barrel EM calorimeter after insertion into the cryostat

# EM beam test results:
# Energy resolution




$$\sigma_E/E = a/\sqrt{E} \oplus c \oplus n/E$$

For every tested points:

| Barrel | End-cap |
|---|---|
| a < 10% | a < 12.5% |
| c < 0.4% | c < 0.5% |

- Within specifications
- Good agreement with MC

# Impact on Higgs mass resolution

Simulations, $m_H$=130 GeV

✓ $H \rightarrow \gamma\gamma$

Resolution: 1% (low lum)

1.2% (high lum)

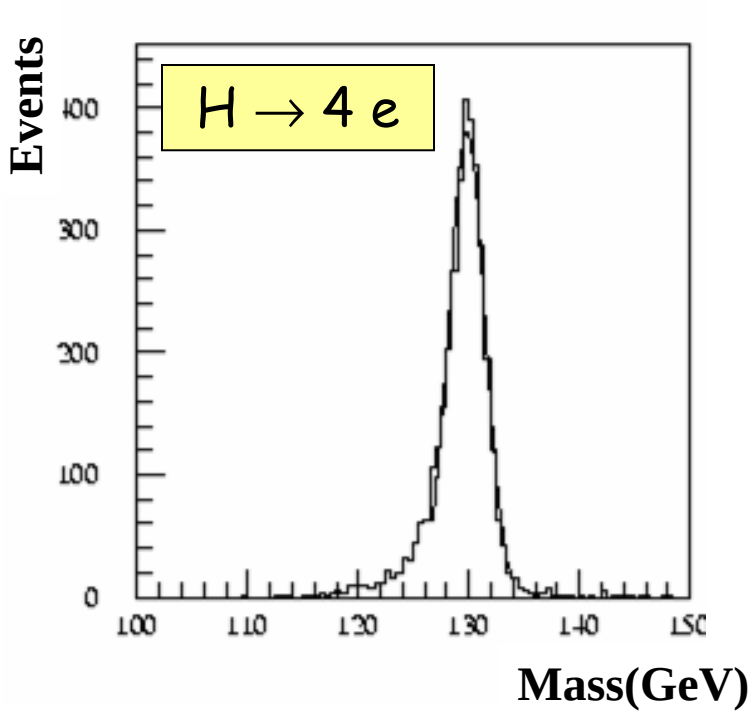
Acceptance: 80% within $\pm 1.4\ \sigma$

✓ $H \rightarrow 4e$

Resolution: 1.2% (low lum)

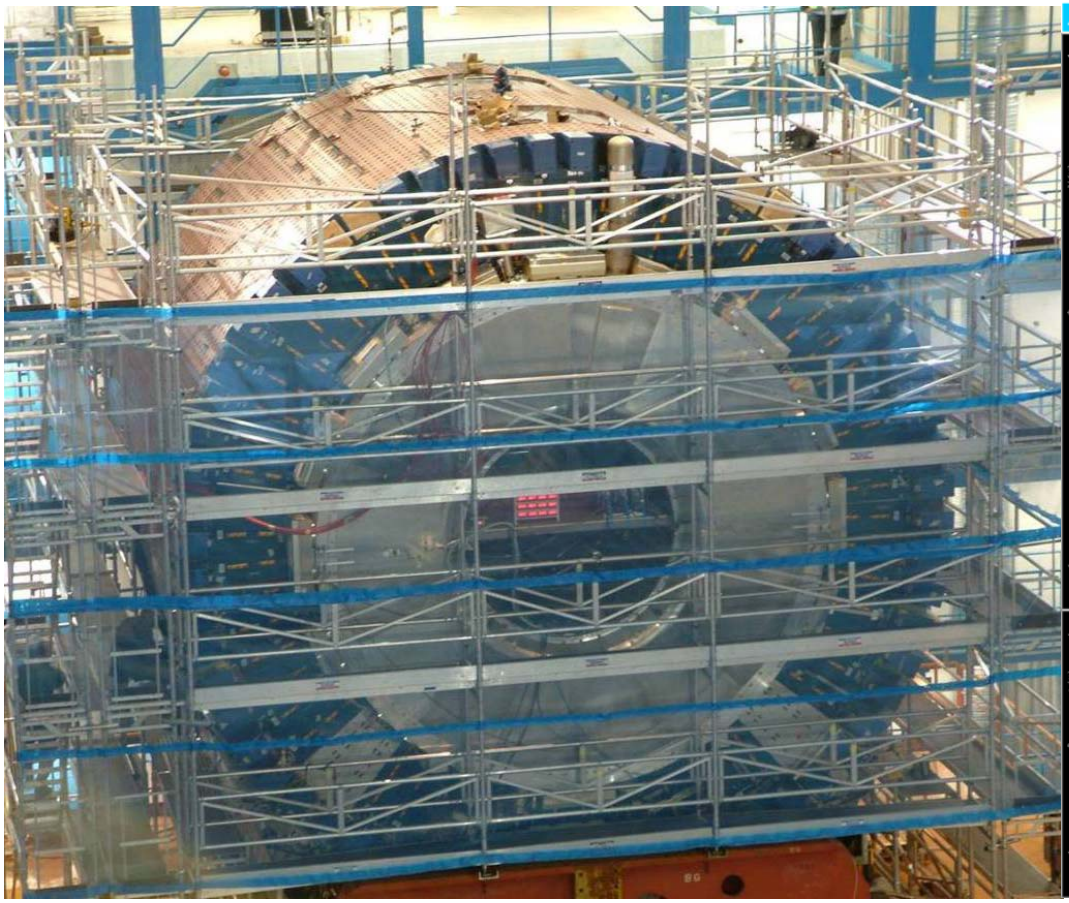
1.4% (high lum)

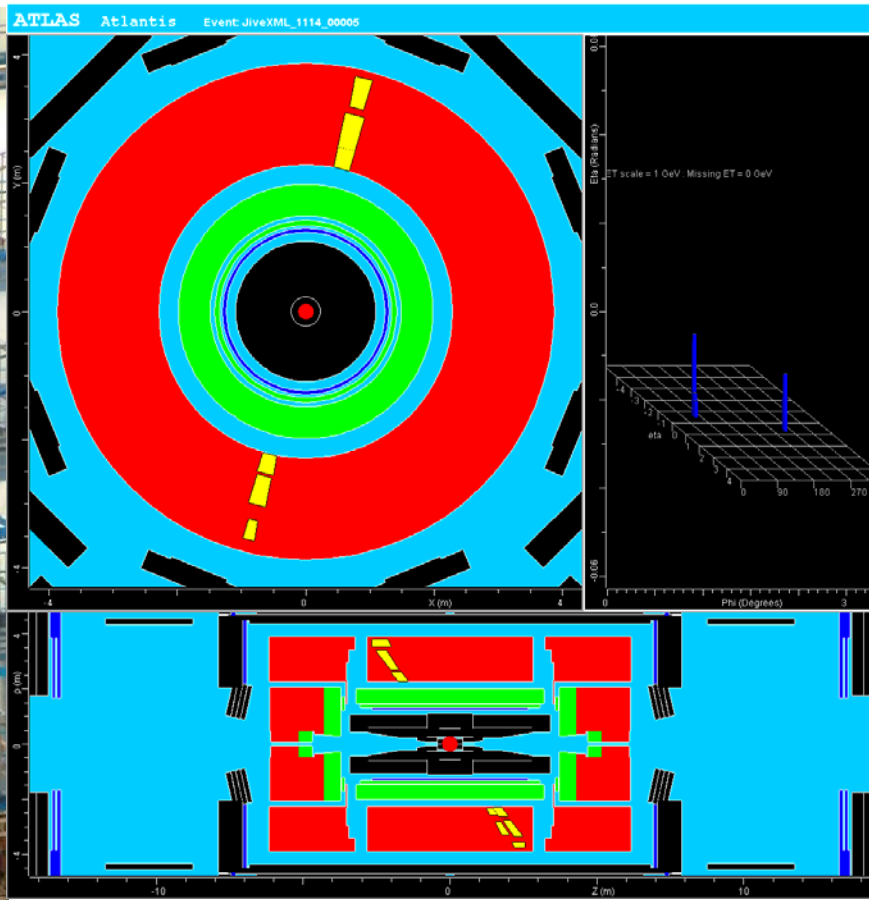
Acceptance: 84% within $\pm 2\ \sigma$



# ATLAS HCAL (Tile) + ECAL (LAr) Barrel

In garage in collision hall…



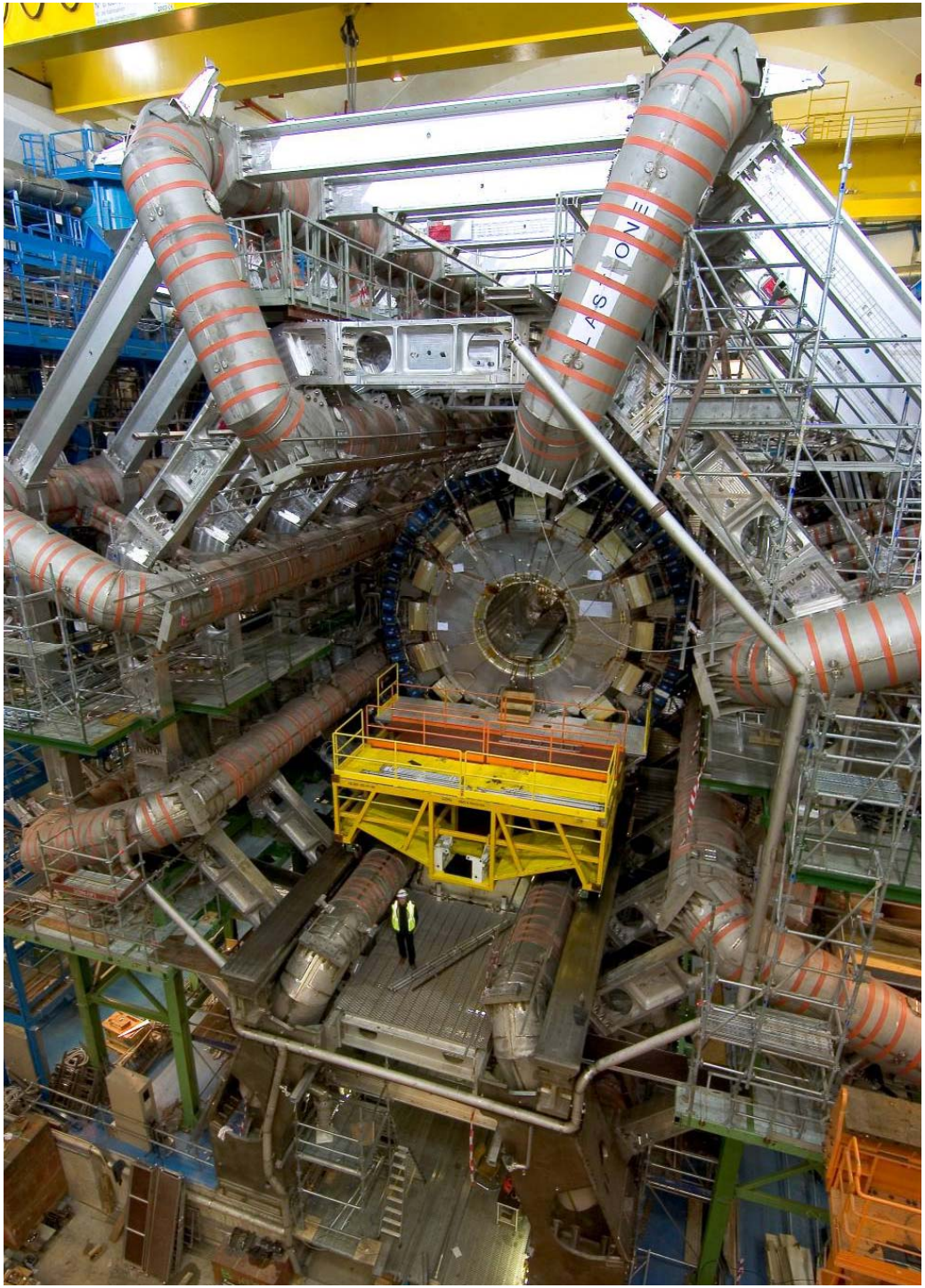



Cosmic ray in the tiles

# ATLAS ECAL+HCAL Barrel

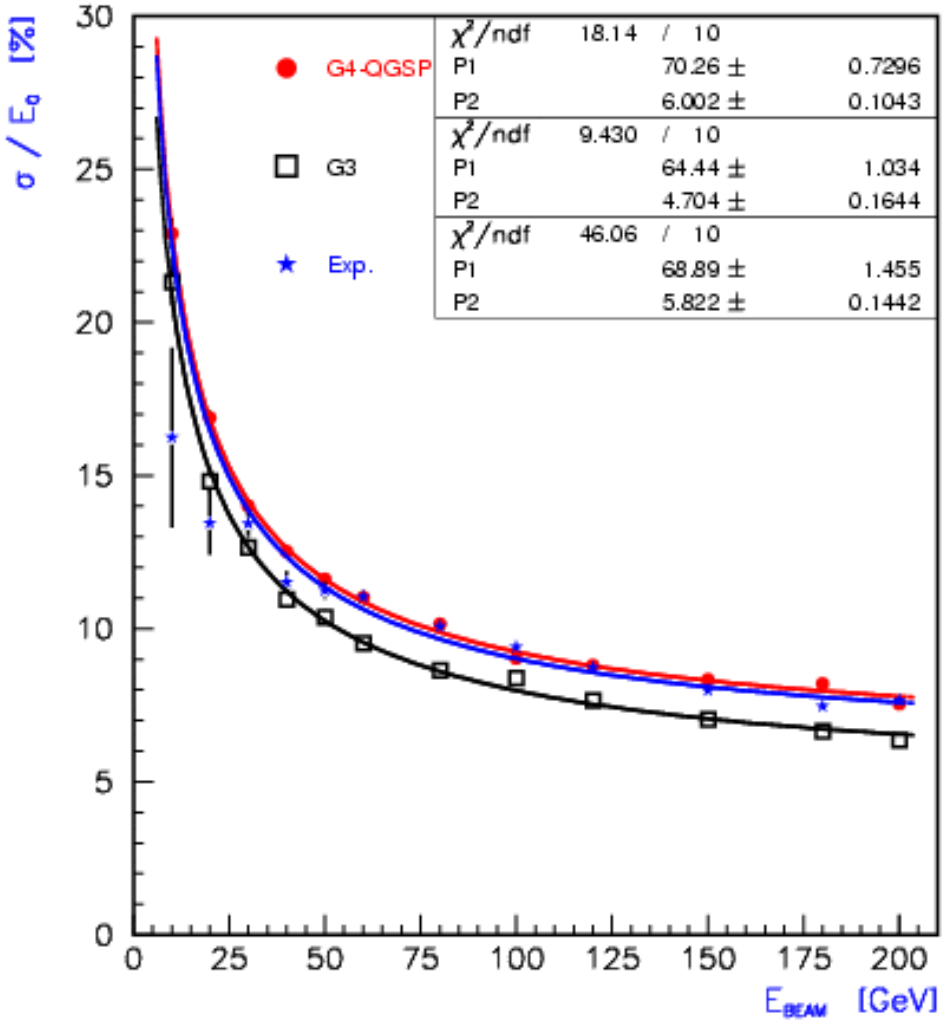
# ATLAS

another view




# ATLAS pion resolution (HCAL)

$\pi^{\pm}$ E-resolution from ATLAS had. calorimeter test beam data: ~ 70%/√E

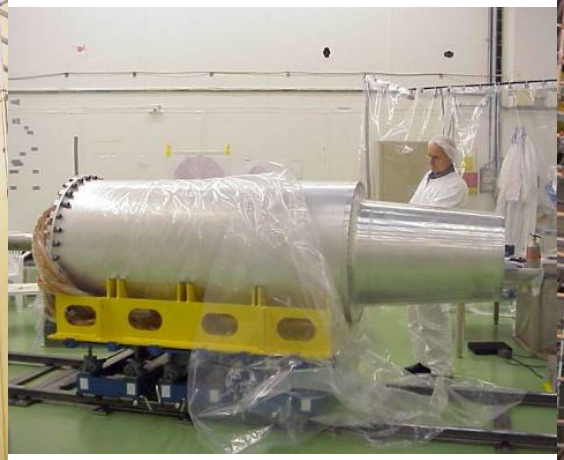


# ATLAS ECAL (LAr) Endcaps

End-Cap C: Surface cold tests with LAr are finished, with very good results (dead channels well below 1%)

End-Cap A: Surface cold test measurements are finished, and it will be ready for transport end of January 2006

Endcap cryostat A before insertion of the FCAL

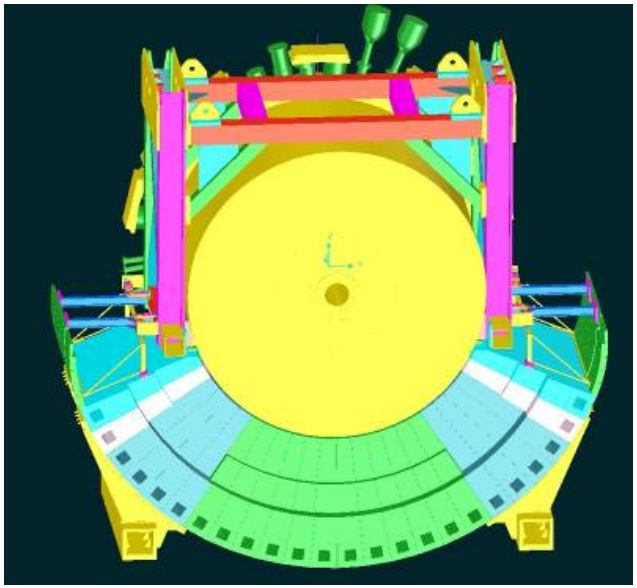


FCAL

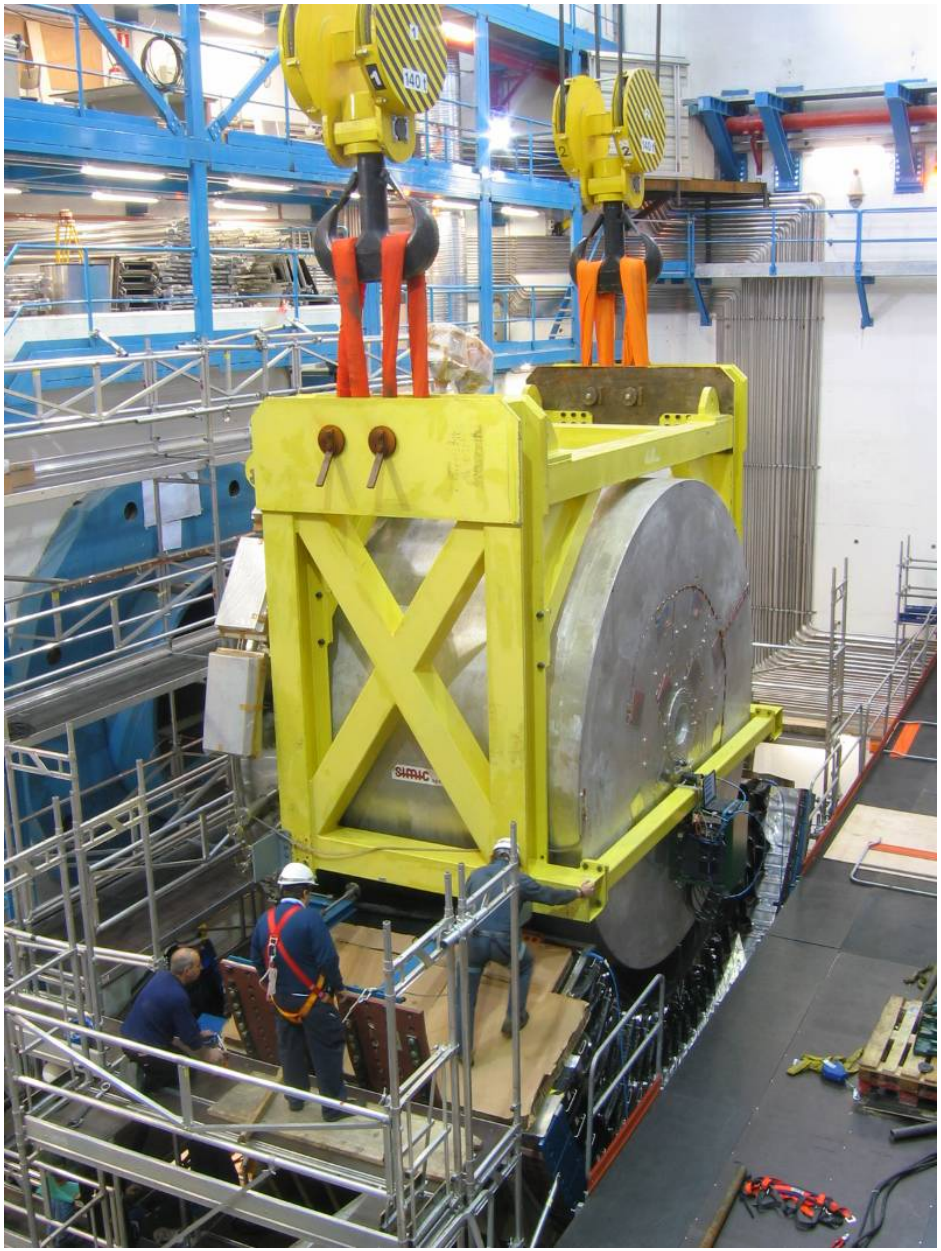

End-Cap A during the surface cold tests

# ATLAS Endcaps

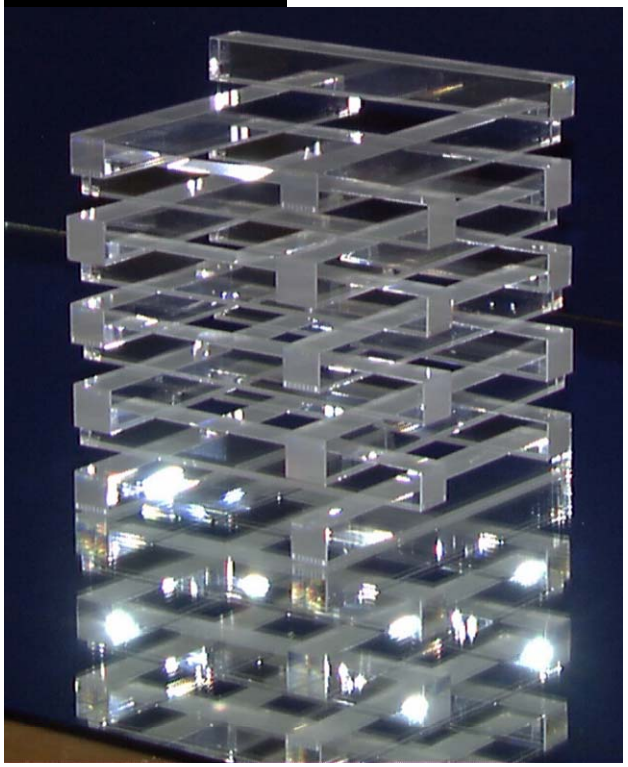
Next major activity:
Endcap A installation
from Jan 06 → Mar 06

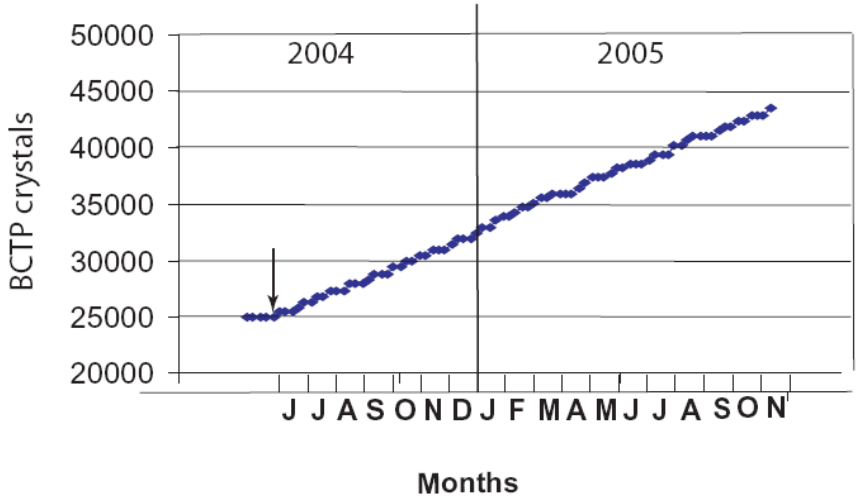


First LAr End-Cap arriving on the Tile Calorimeter in the cavern through the shaft on the C-side



# CMS ECAL (crystals)

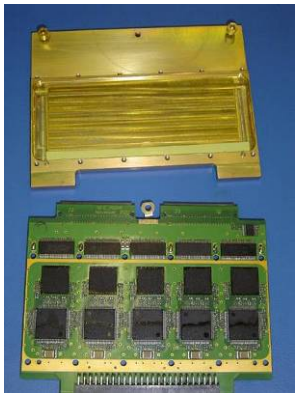





**44k crystals received (71% of barrel)**

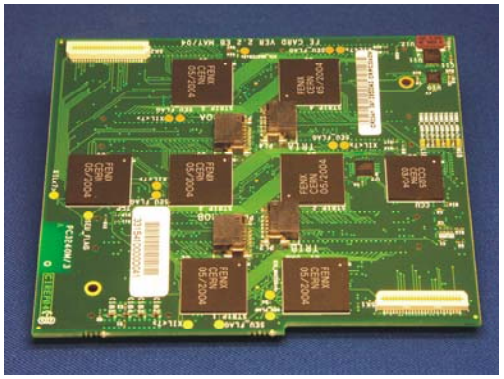
# CMS ECAL electronics

VFE



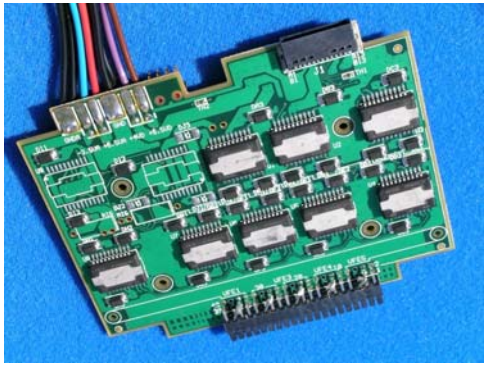
100%

FE



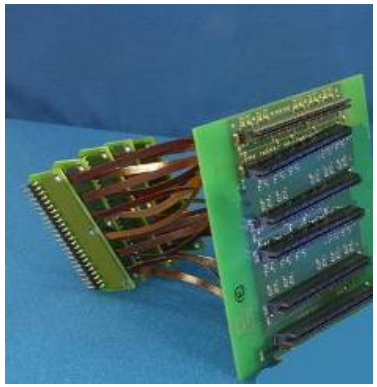
100%

LVRB



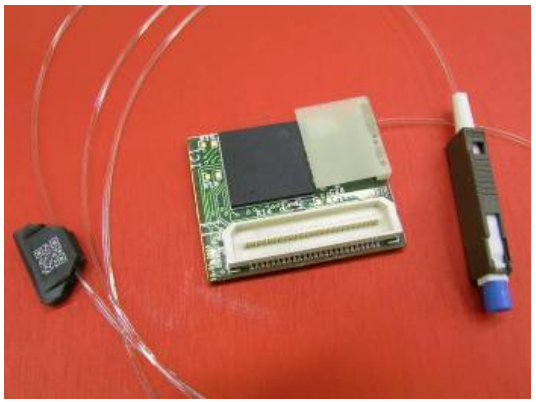
65%

Motherboard



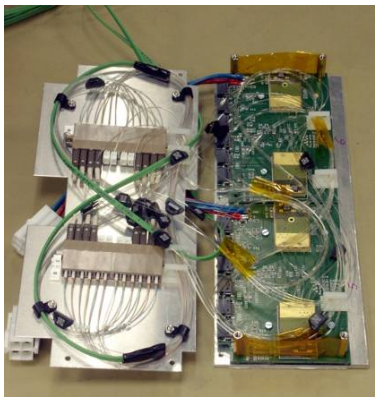
34%

GOH

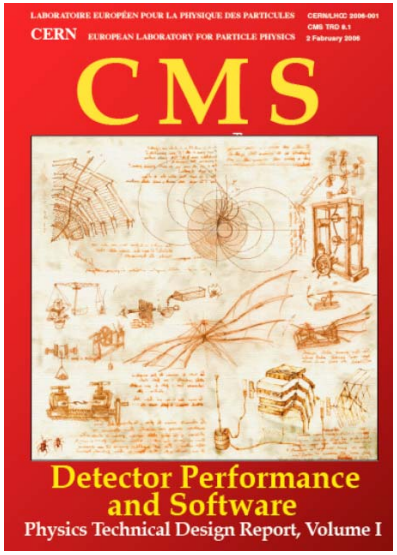


70%

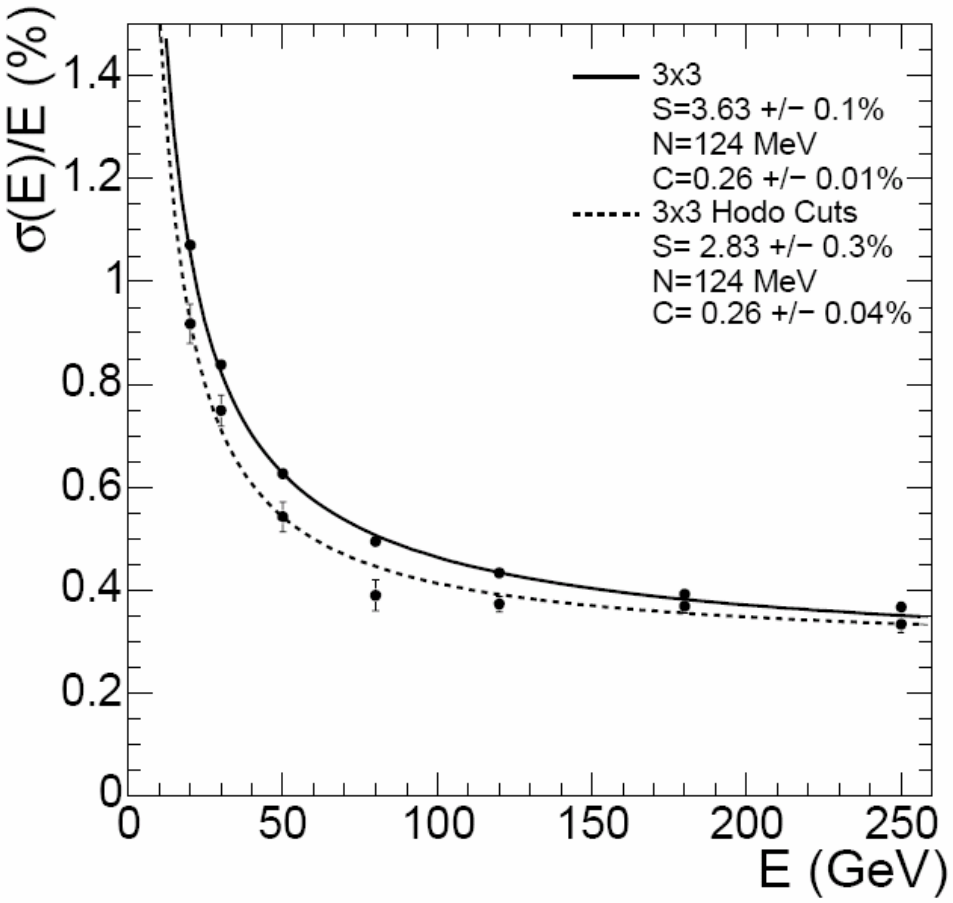
TRLB



70 %




# CMS ECAL Energy Resolution

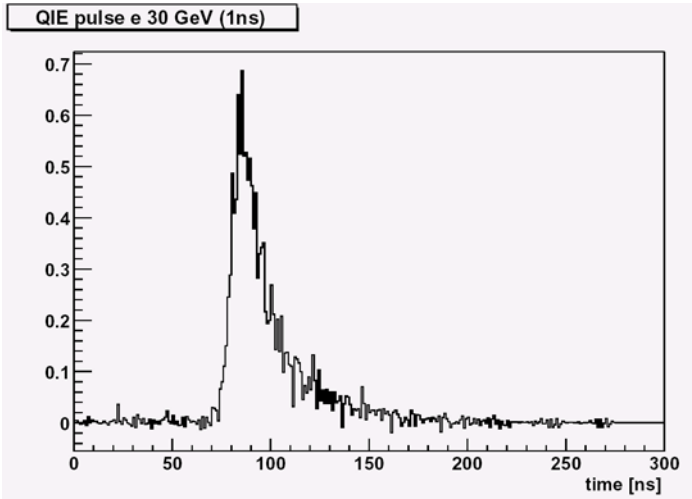


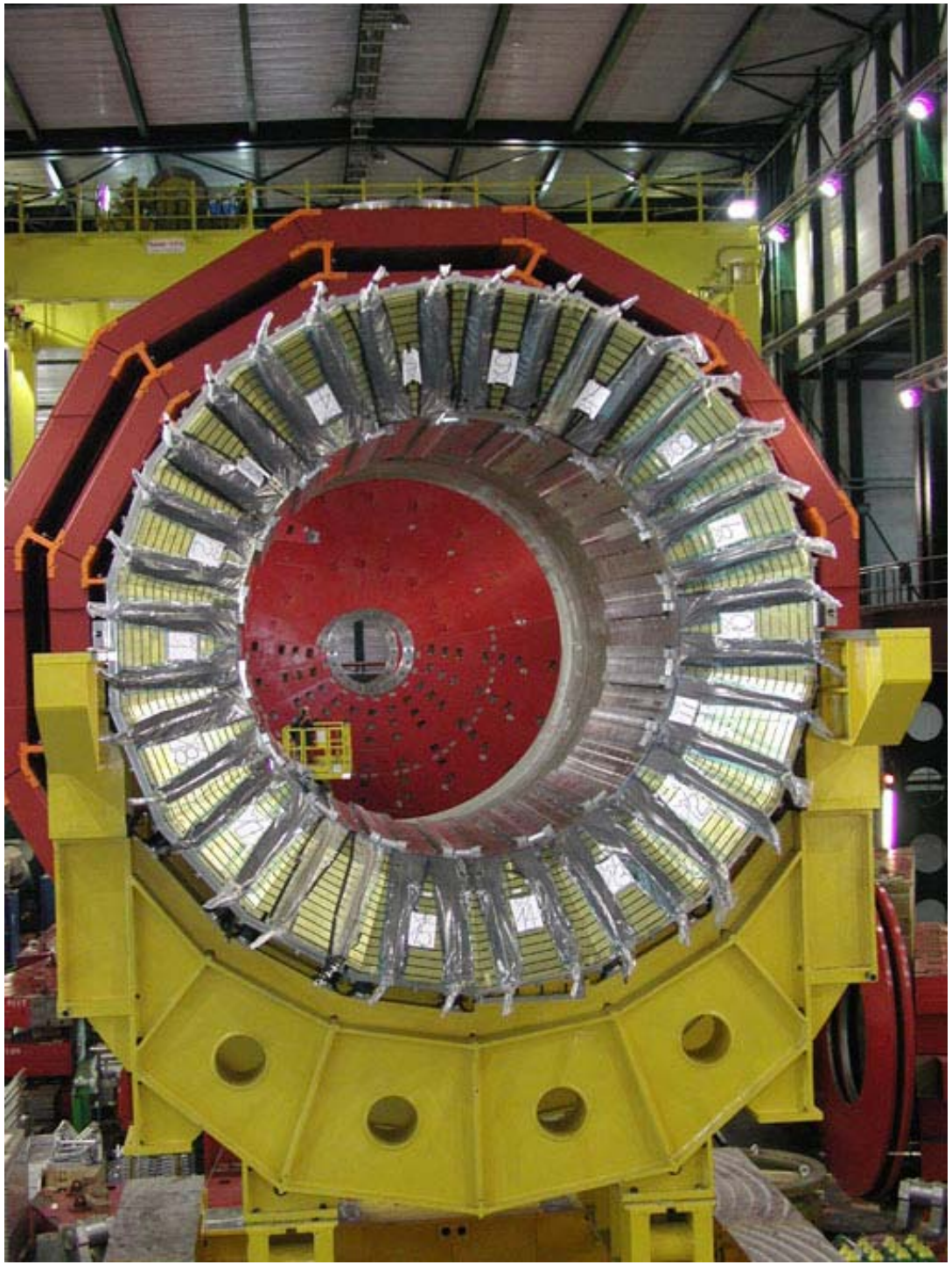

## Electron test beam

CERN/LHCC 2006-001, CMS TDR 8.1, 02 Feb. 2006

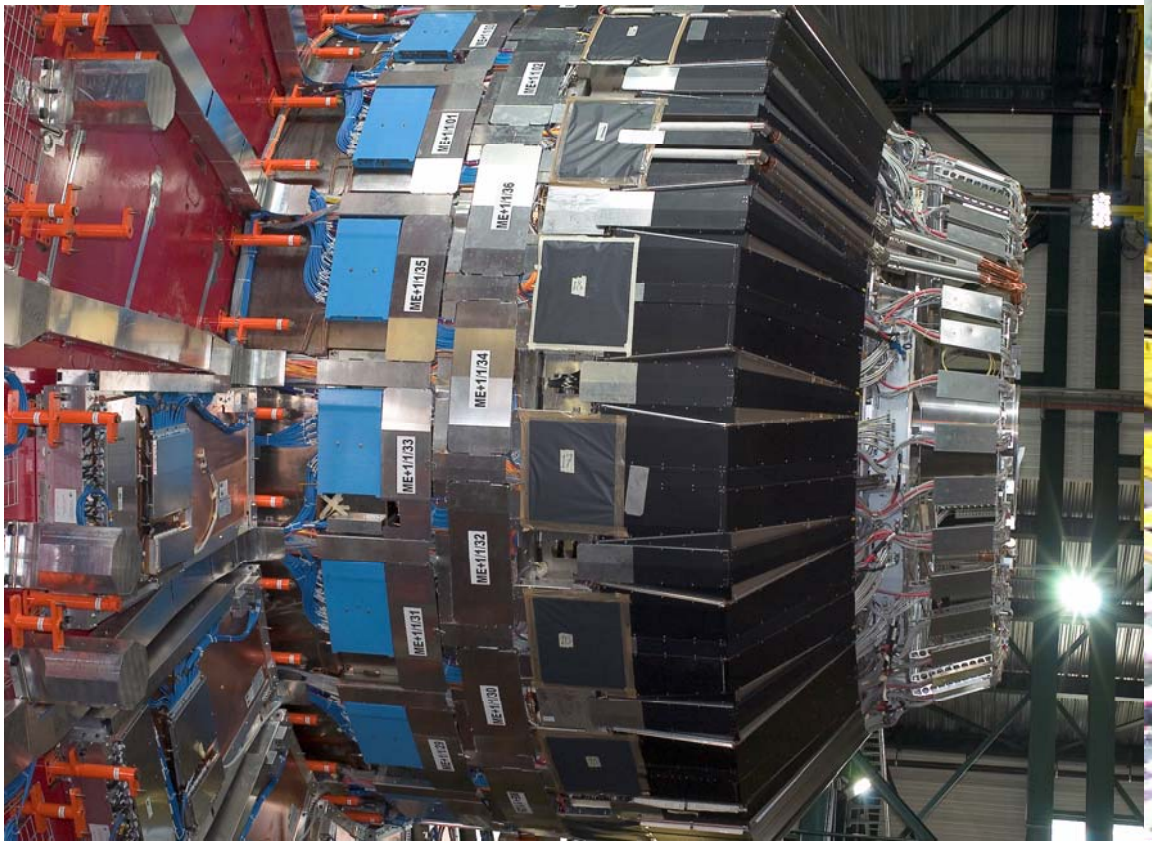
# CMS
# HCAL Barrel

All components of HCAL have been extensively tested in test beam and surface hall SX5

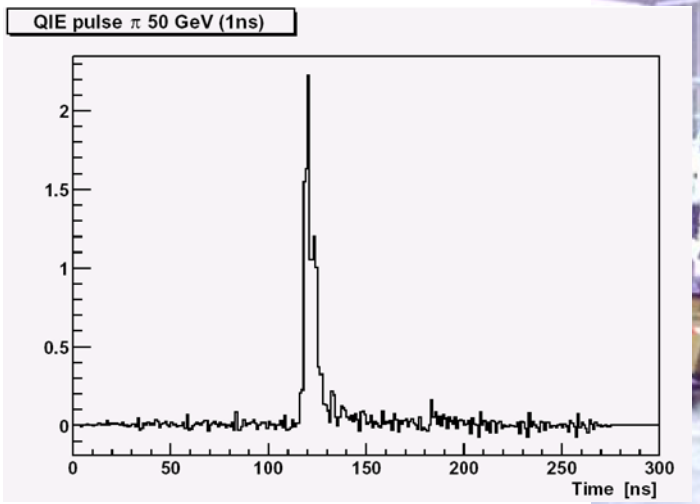


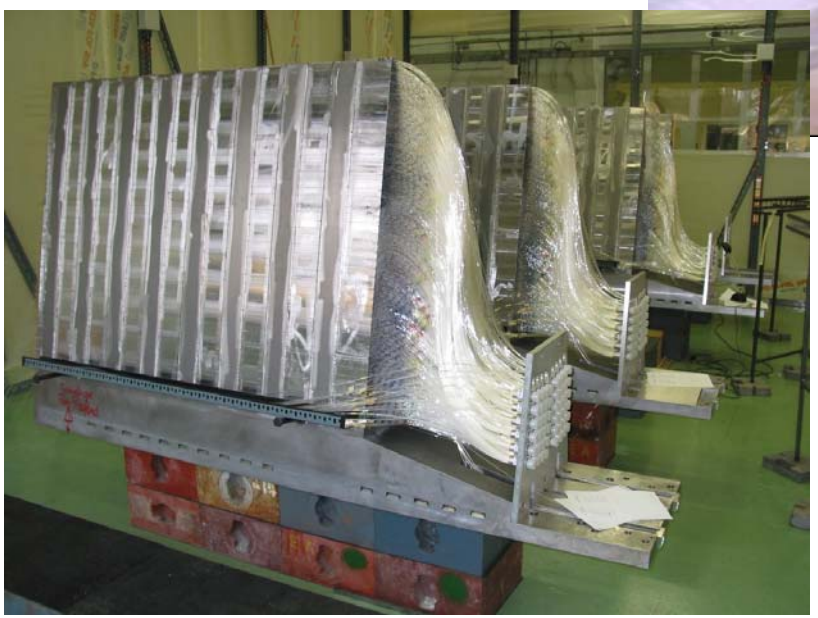



# CMS
# HCAL Endcap



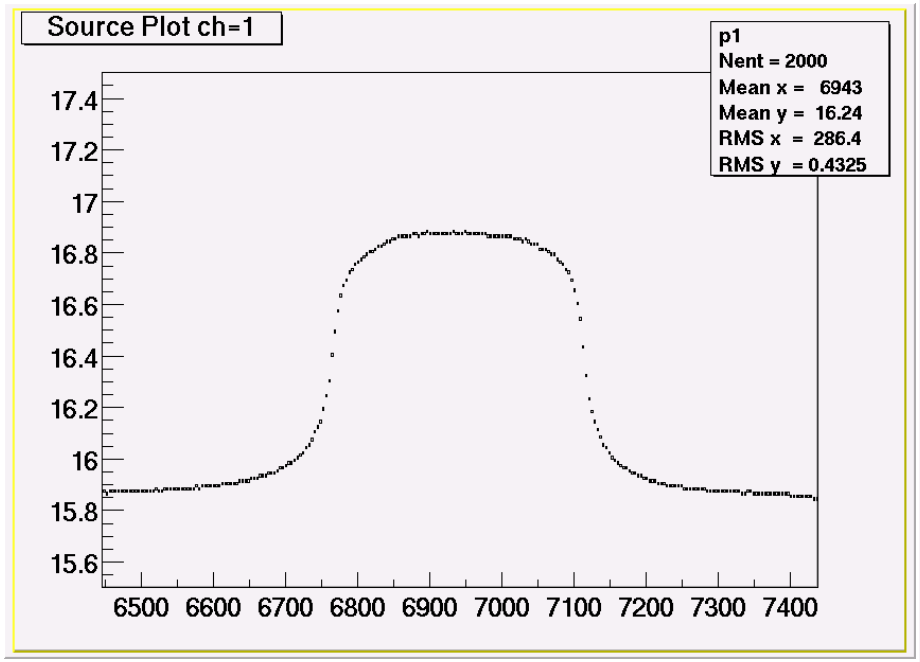

# CMS HCAL Forward

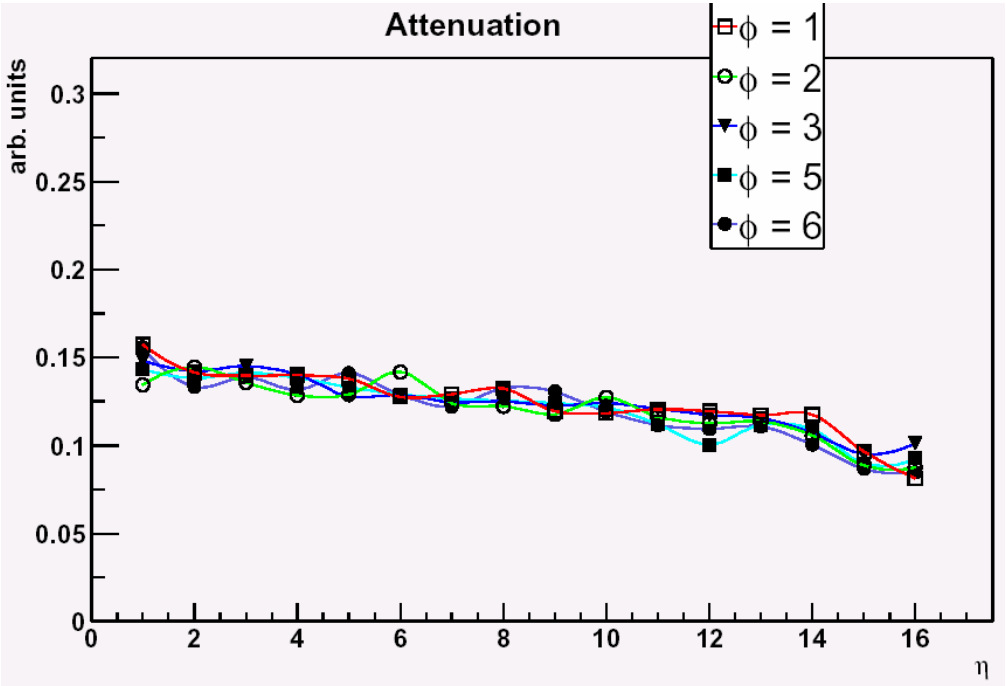


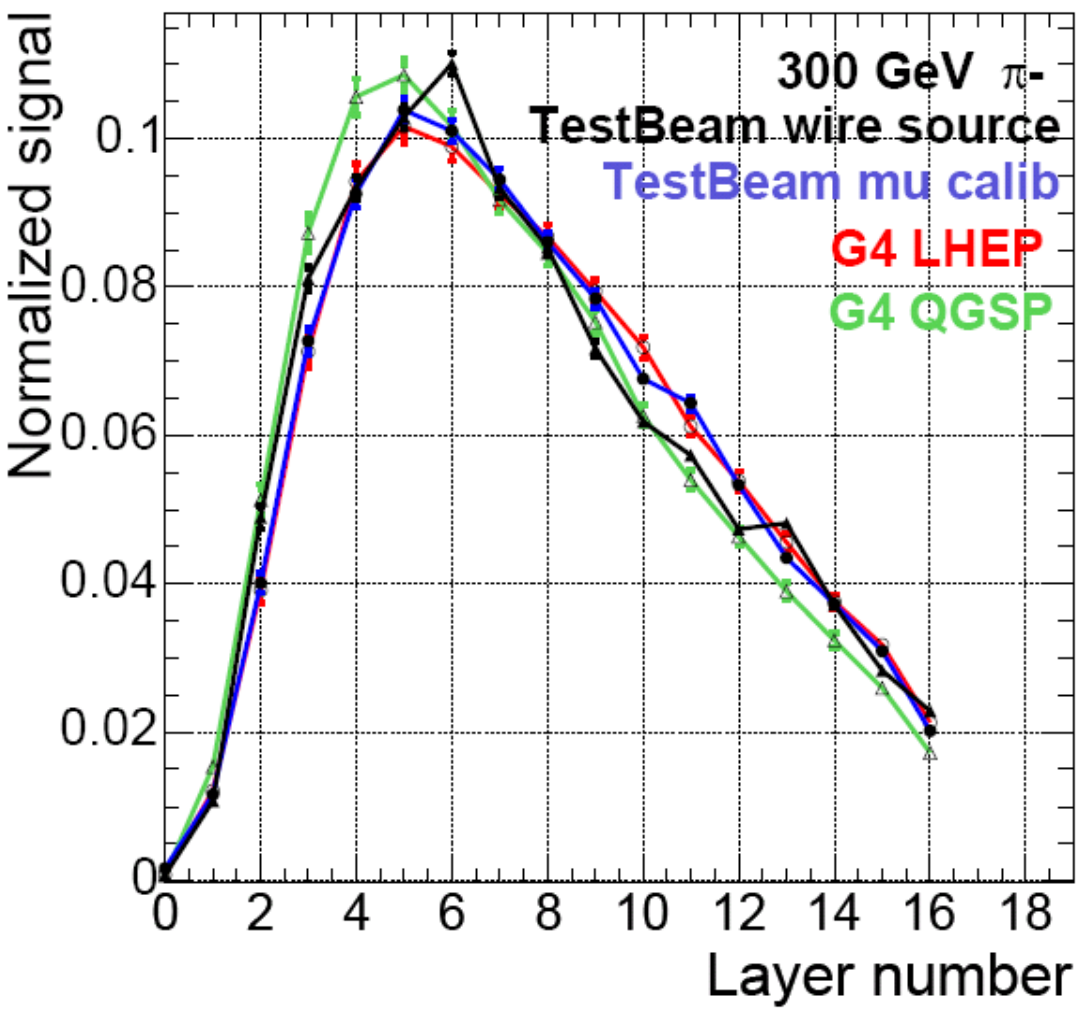
First subdetector to be lowered into pit (May 06)

# CMS HCAL: radioactive source calibration



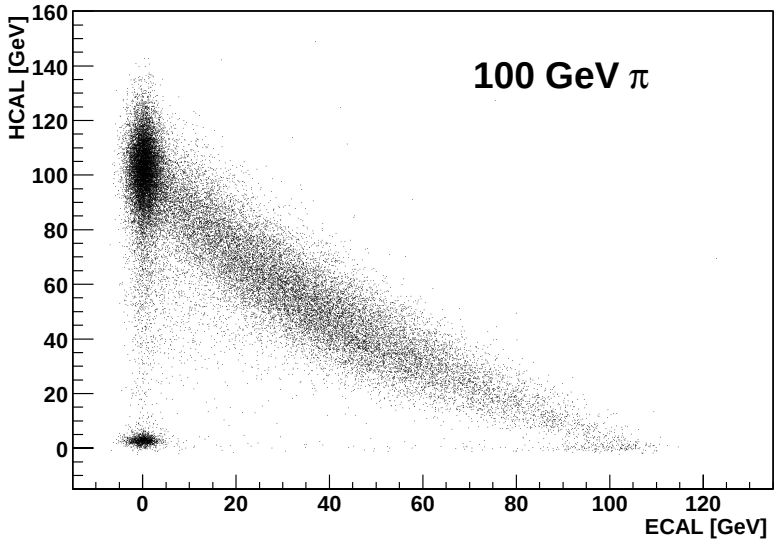



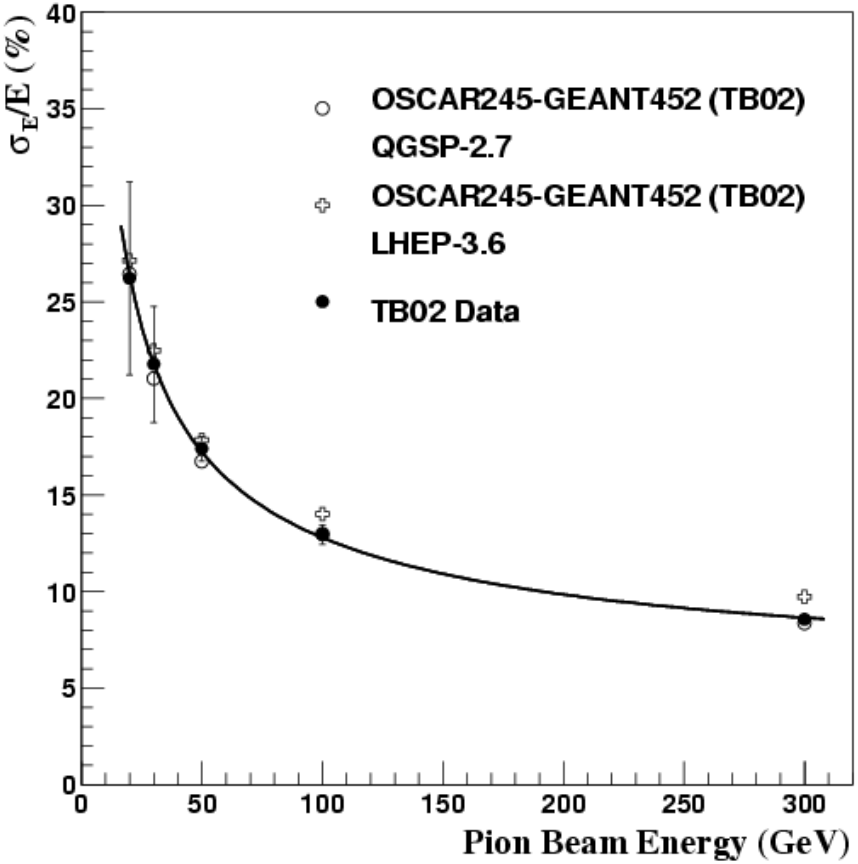
# CMS HCAL longitudinal shower profile




CERN/LHCC 2006-001, CMS TDR 8.1, 02 Feb. 2006

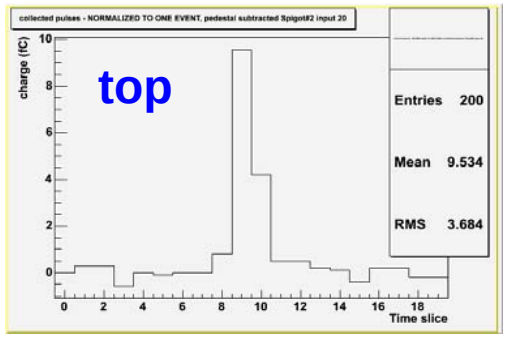
# CMS ECAL+HCAL Energy Resolution



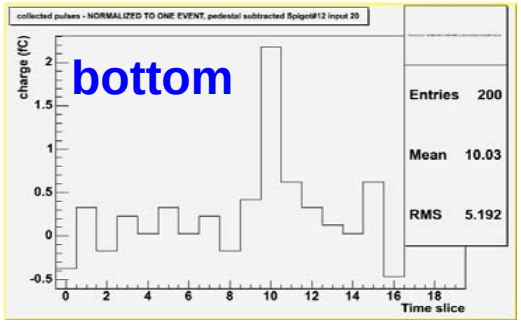



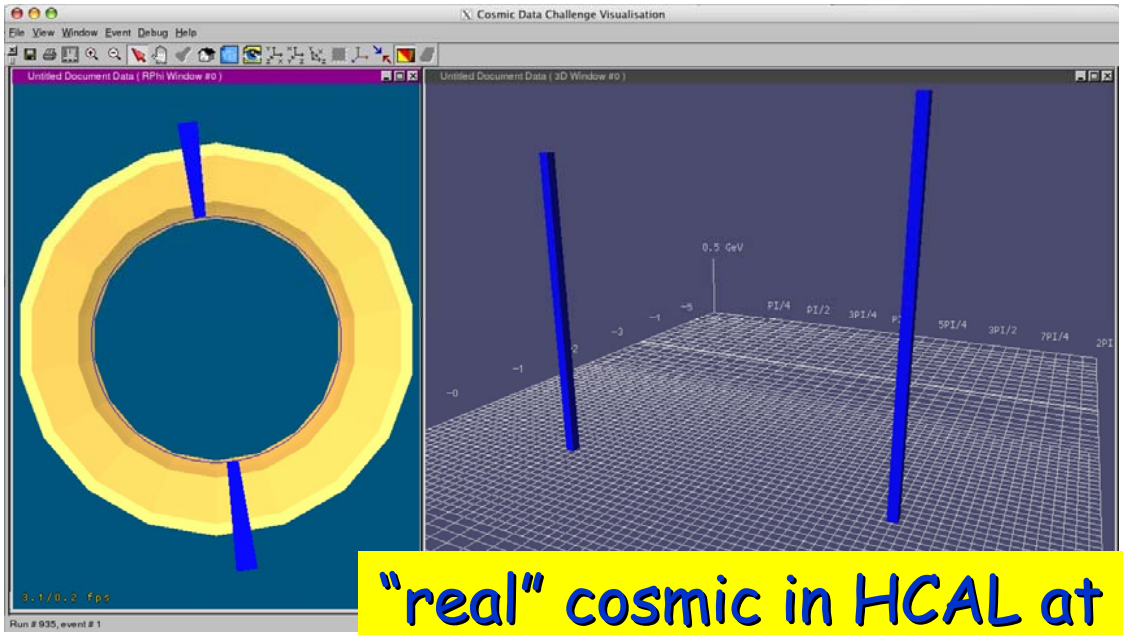
# CMS HCAL: Cosmic Rays at SX5

Q (fC)




Time (25 ns)



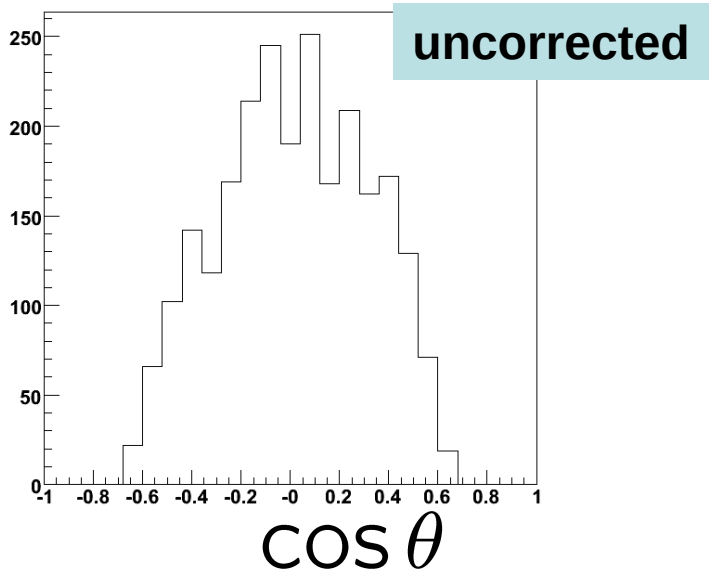

"real" cosmic in HCAL at SX5

**Note:**

1) time shift of ½ bin due to transit time of cosmic ray.
2) Energy loss.

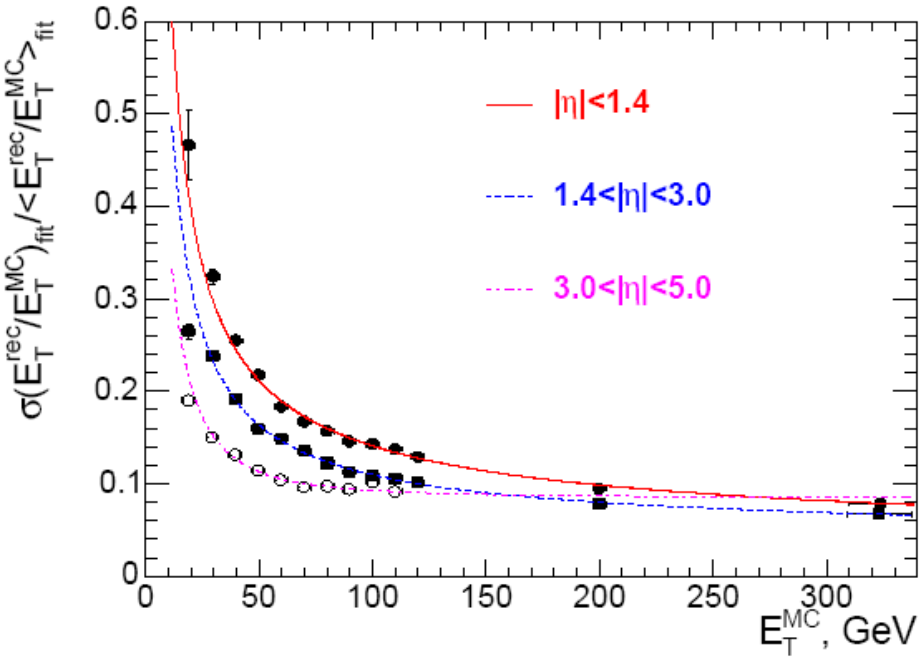
Real-time data access:
http://cmsmoe3.cern.ch:40000

$$\frac{dN}{d\cos\theta}$$

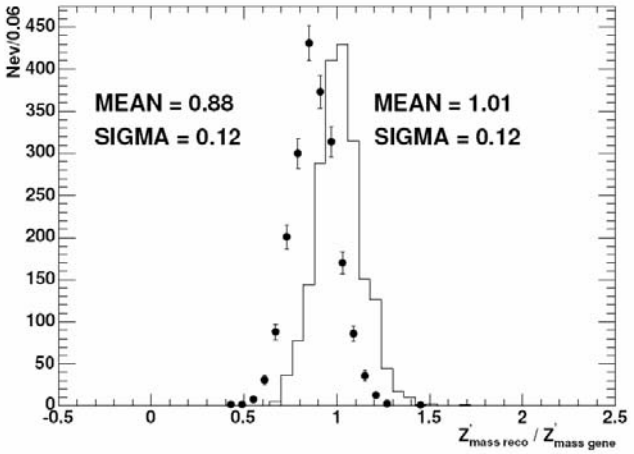


# Jet resolution

## QCD, with pileup $\mathcal{L} = 2 \times 10^{33} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

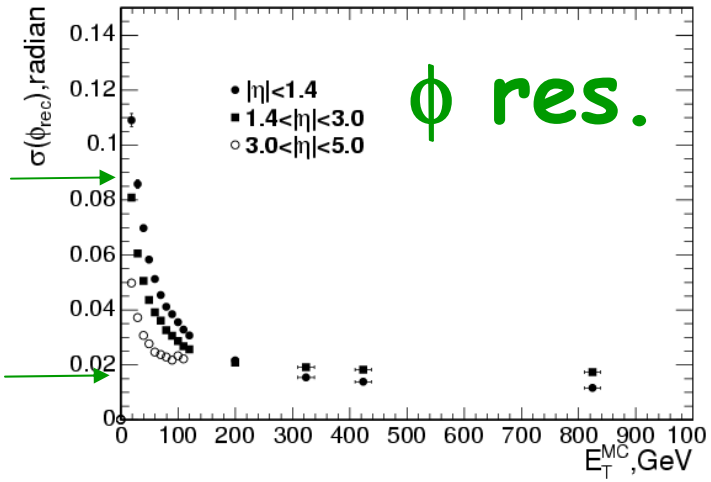



$m_{jj}$ res. at 120 GeV/$c^2$

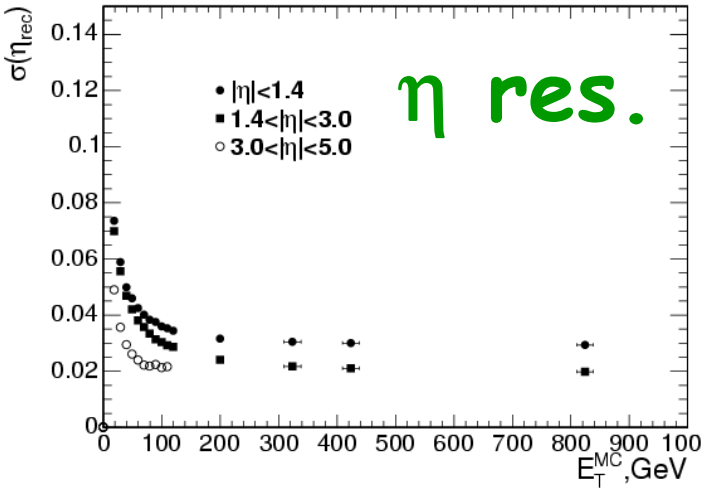



HCAL tile

crystal



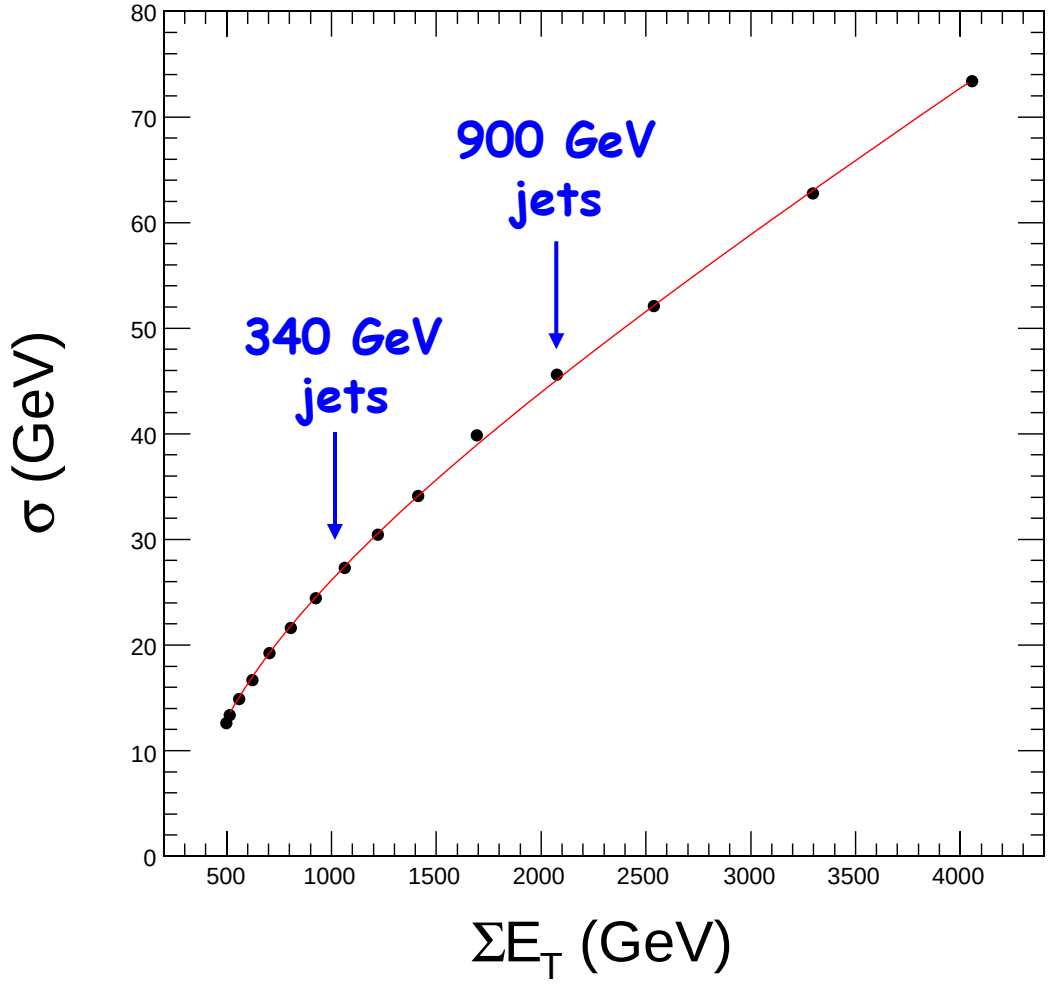

ϕ res.




η res.

# $E_T^{miss}$ resolution

**QCD, with pileup** $\mathcal{L} = 2 \times 10^{33} \mathrm{cm}^{-2}\mathrm{s}^{-1}$




**Fit:** $\sigma = [(3.8\ \mathrm{GeV})^2 + (0.97\ \mathrm{GeV}^{1/2}\sqrt{\Sigma E_T - 350\ \mathrm{GeV}})^2 + [0.012(\Sigma E_T - 350\ \mathrm{GeV})]^2]^{1/2}$

# Jet Rate

$\mathcal{L} = 2 \times 10^{24} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

**$\phi$ calibration**

$\mathcal{L} = 2 \times 10^{25} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

**$\sigma$ measurement**

$\mathcal{L} = 2 \times 10^{26} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

**$\eta$ calib., MET studies**

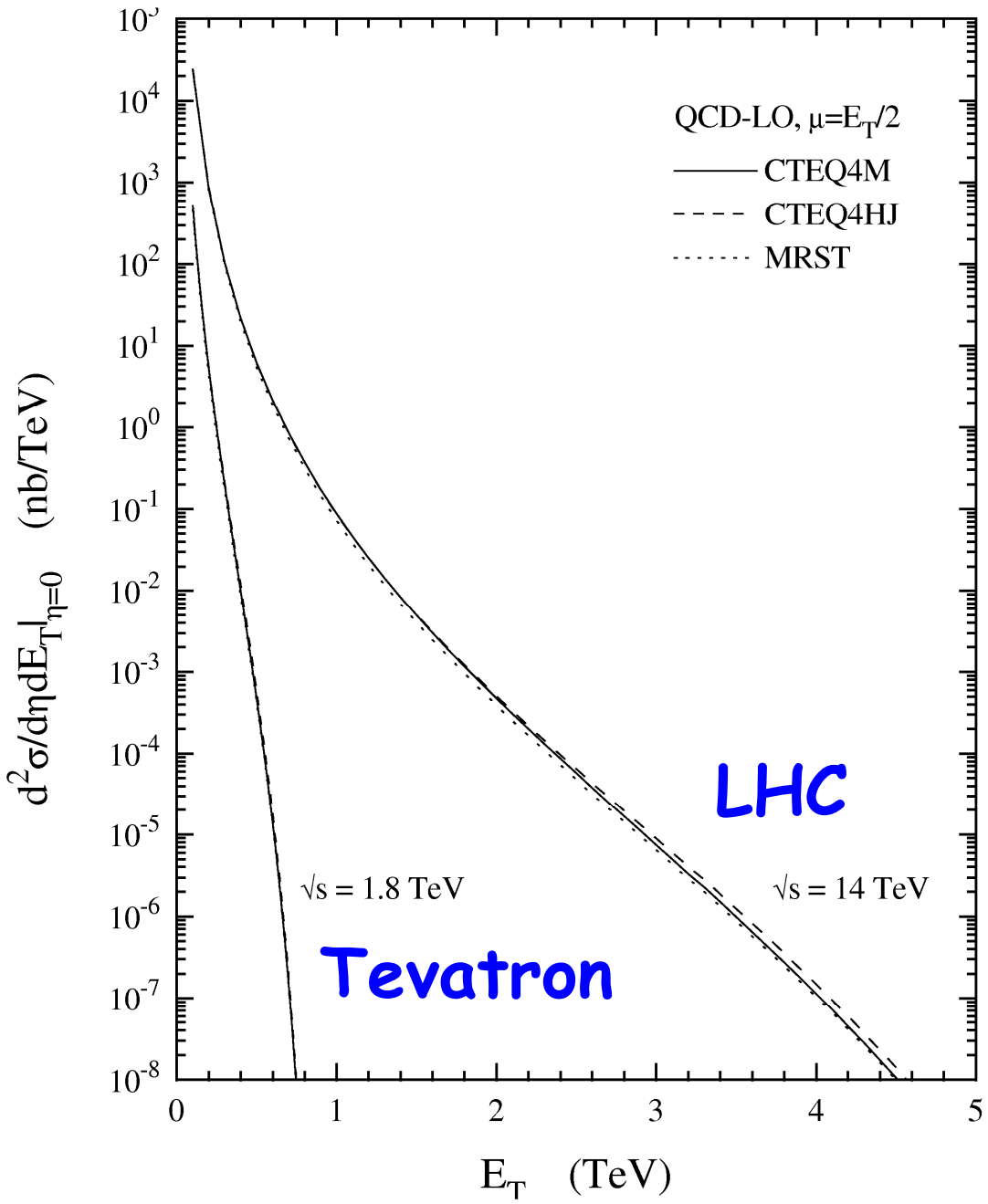
$\mathcal{L} = 2 \times 10^{27} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

**$m_{jj}$ > 2 TeV**

**Design luminosity**

$\mathcal{L} = 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

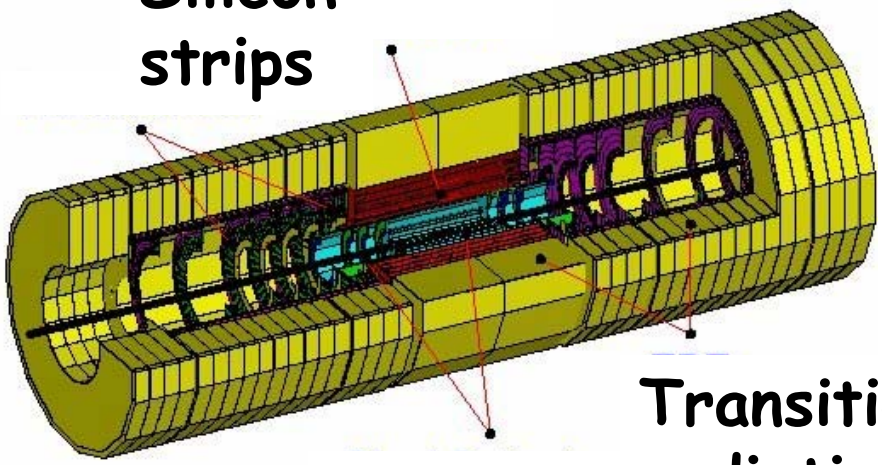
**top at 10 Hz,**
**W at 1 kHz**



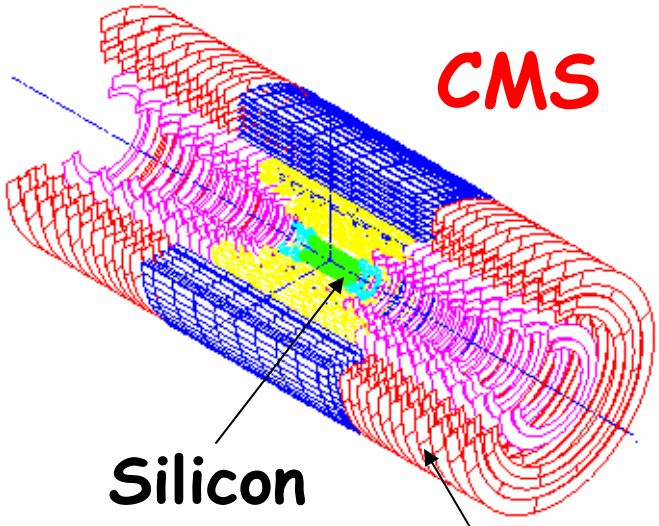
# Tracking

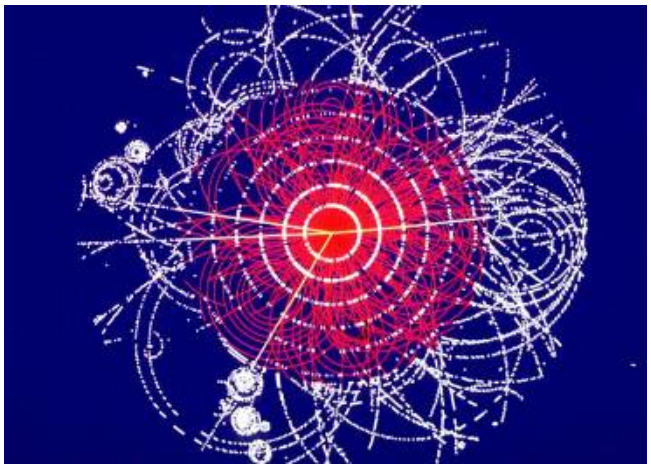
| | *Si pixels* | *Si strips* | *TR straws* |
|---|---|---|---|
| ATLAS | 80M ch, 2 $m^2$ | 6M ch, 60 $m^2$ | 420k ch. |
| CMS | 66M ch, 1 $m^2$ | 10M ch, 220 $m^2$ | |

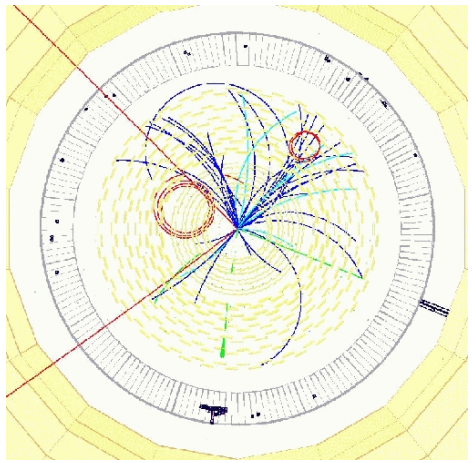
## ATLAS




## CMS





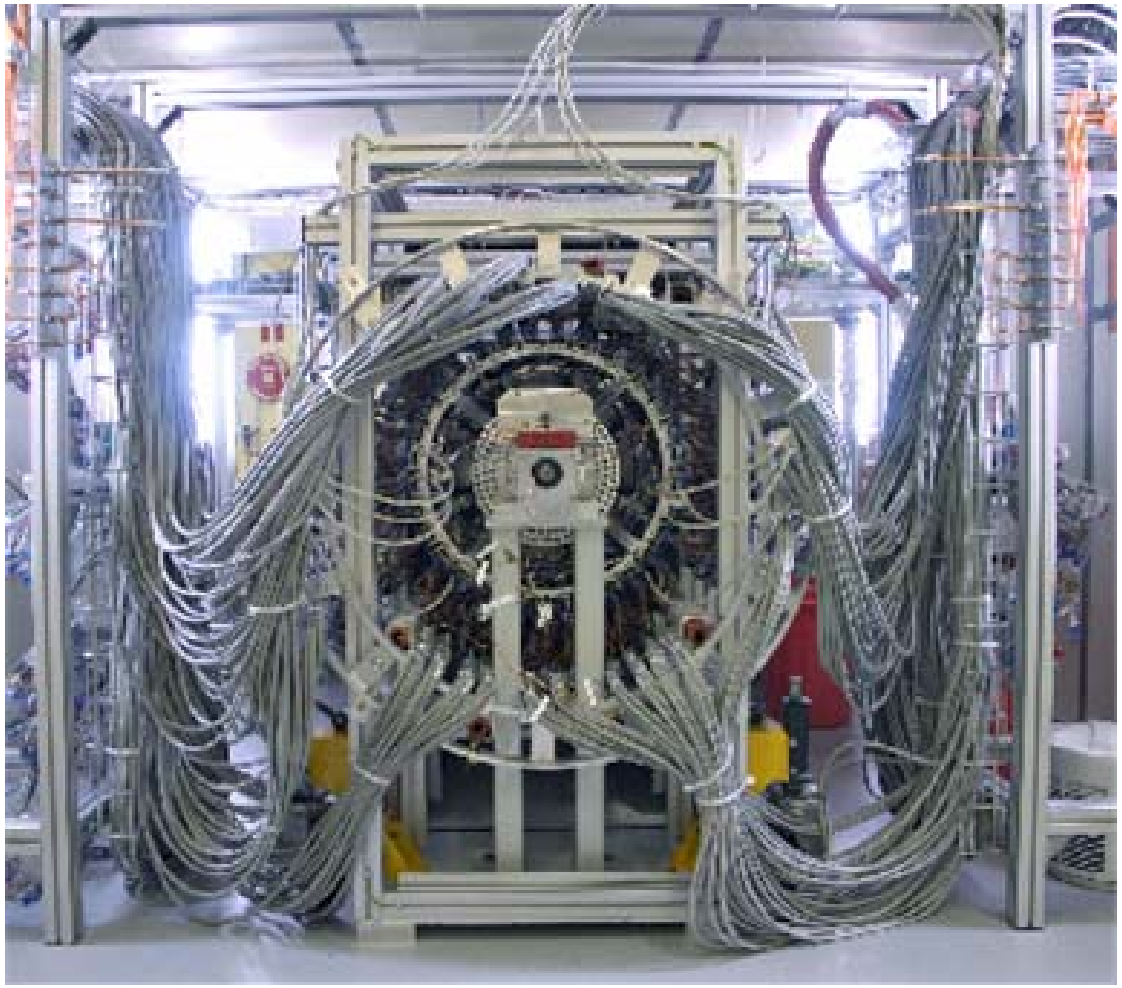
# ATLAS Silicon Tracker (SCT) Barrel

All four cylinders are complete and at CERN.
The SCT is being integrated with the TRT.

SCT acceptance tests
(each barrel fully tested)

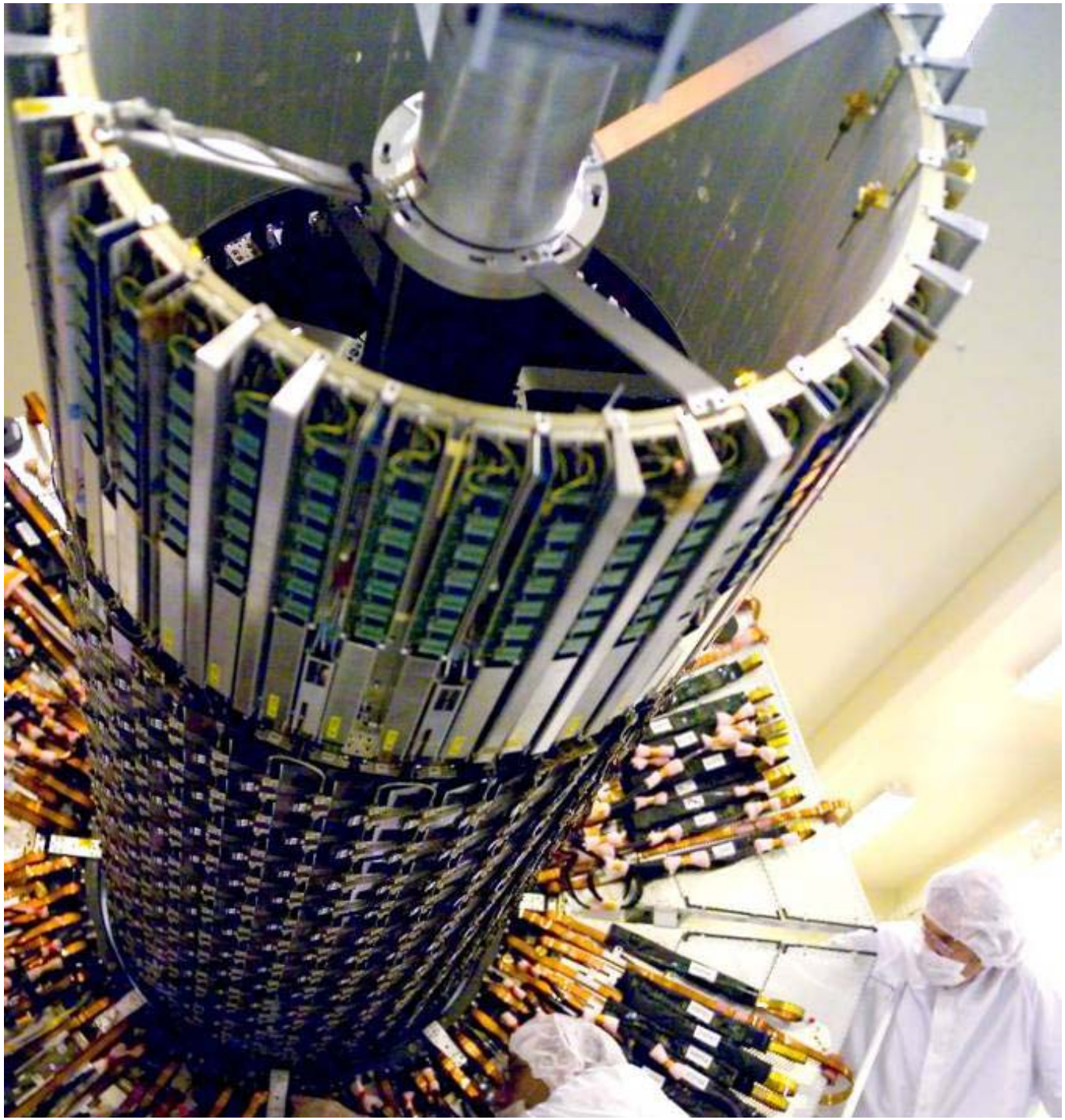
| Barrel | Total Channels | Total Defects |
|---|---|---|
| **3** | 589824 | 1483 |
| **4** | 737280 | 841 |
| **5** | 884736 | 1818 |
| **6** | 1032192 | 5720 |
| **Total** | **3244032** | **9862** |

99.7% of ch. fully functional



Commissioning at the surface

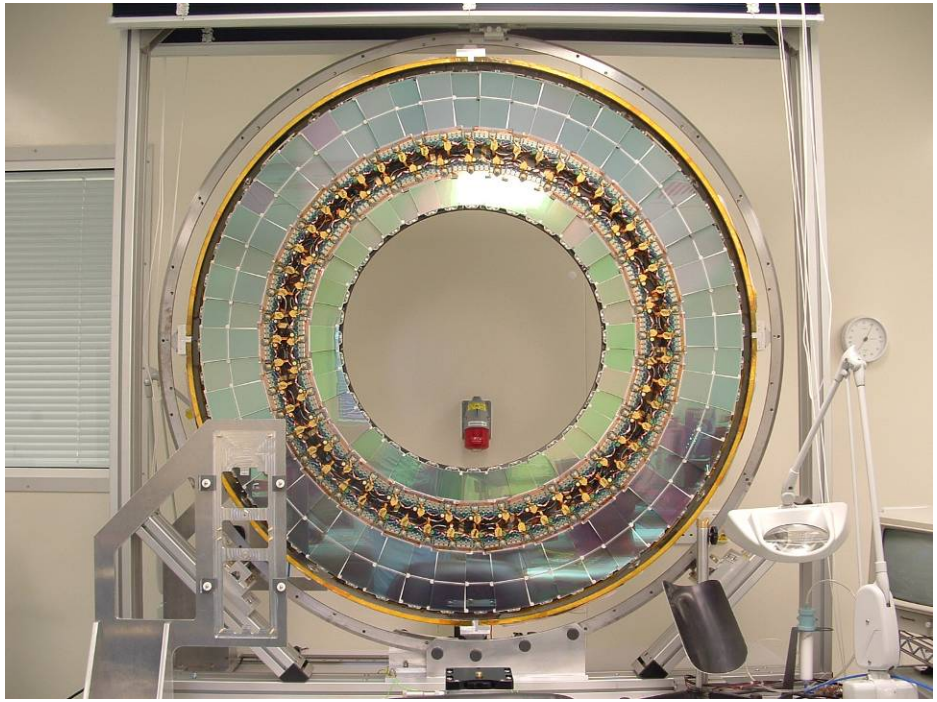
# ATLAS
# Barrel STC



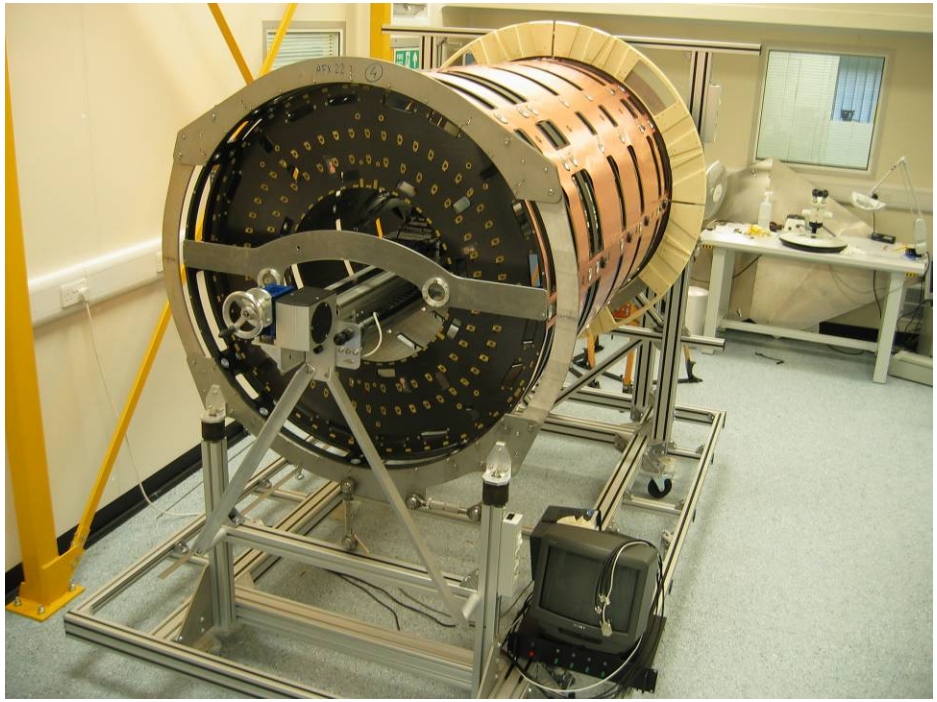
# ATLAS SCT Endcap

All disks for the first end-cap are finished, and they are very well advanced for the second one

The recovery of a failure in the end-cap LMTs (low mass tapes for electrical services) is proceeding according to plan (requiring fabrication of new LMTs)

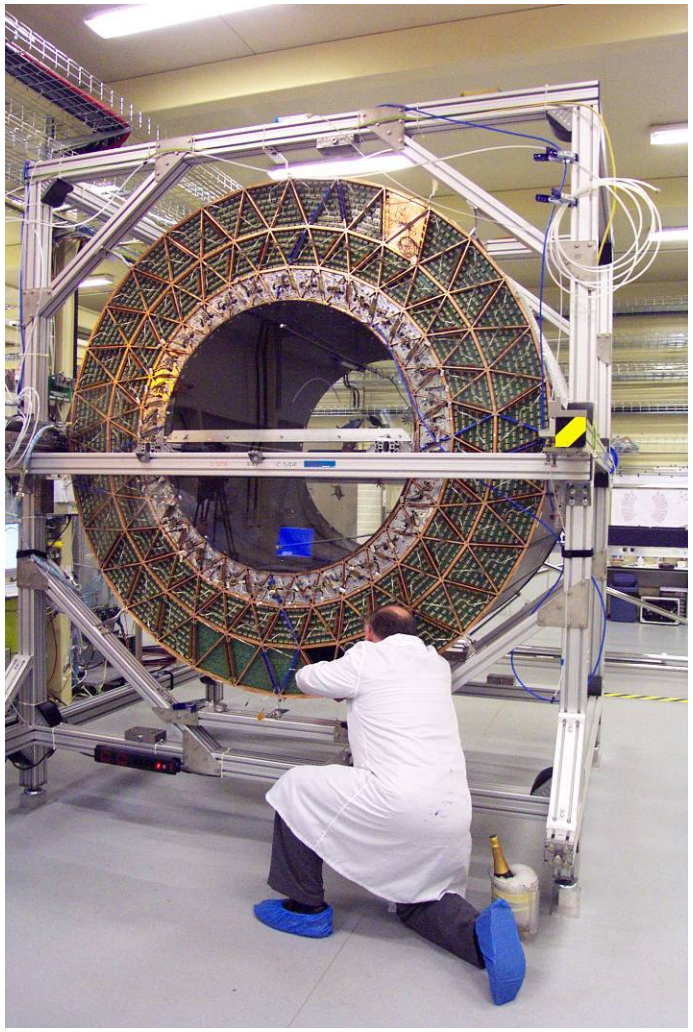


Completed SCT endcap disk



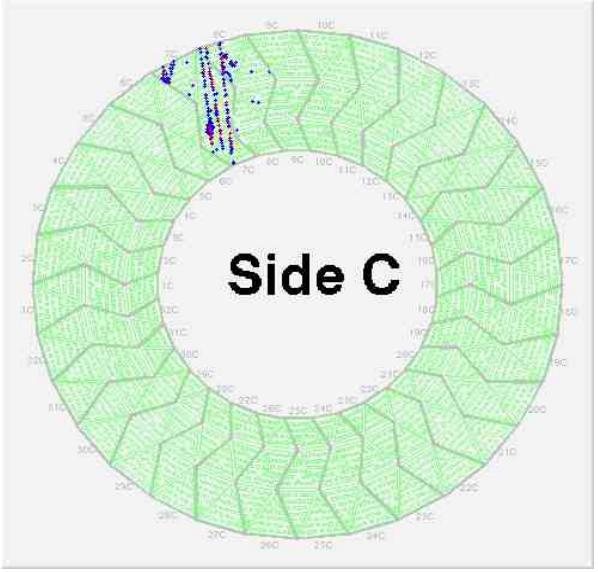
STC endcap Support cylinder

# ATLAS Transition Radiation Tracker (TRT)



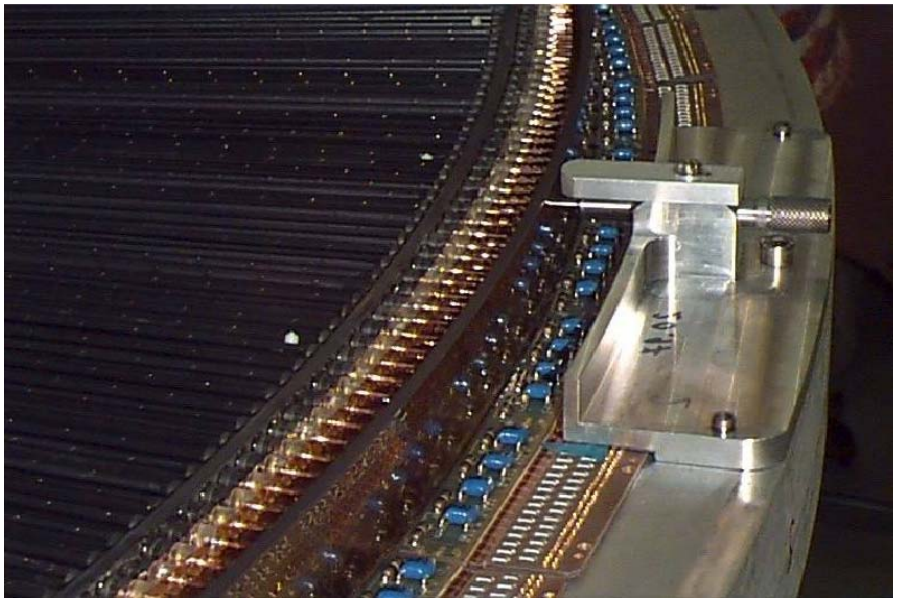
Barrel TRT during insertion of the last modules (February 2005)

## Cosmic rays on the surface

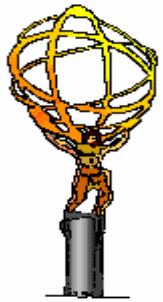


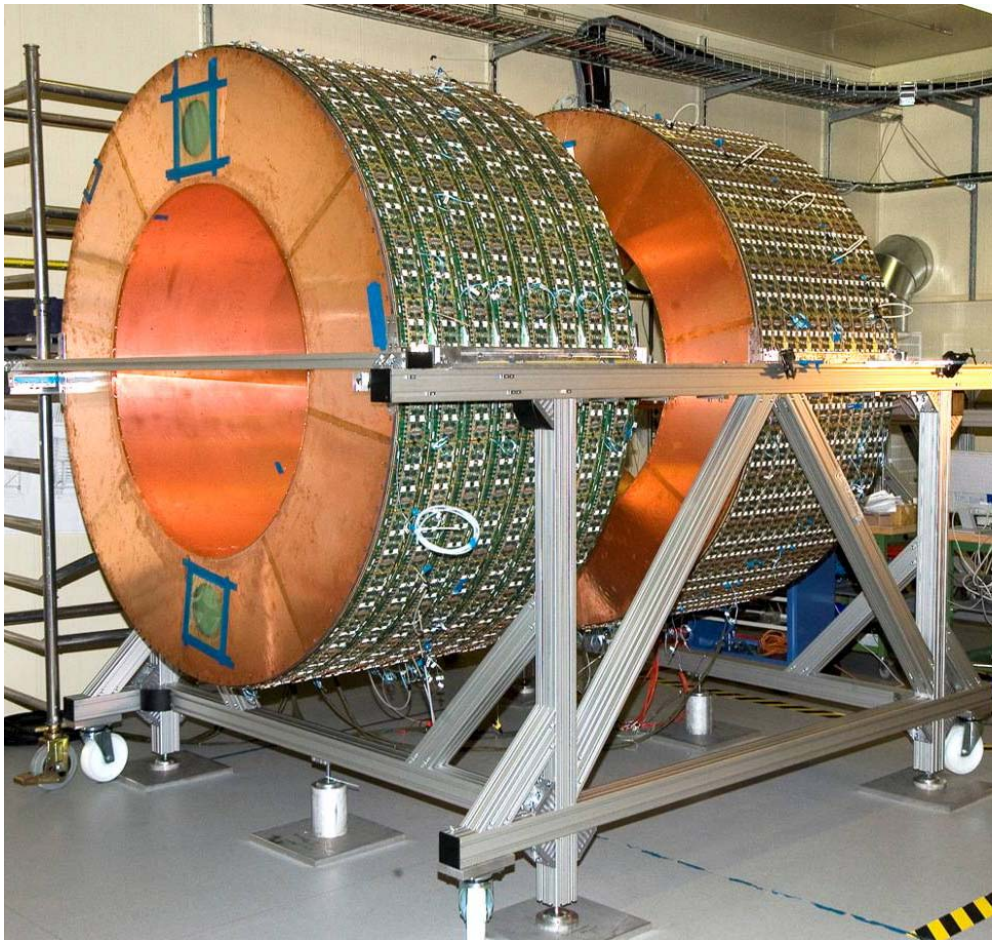

# ATLAS TRT Endcap

The module construction for the TRT is complete, and the first end-cap side (A and B wheels) has been assembled and integrated.



TRT assembly detail

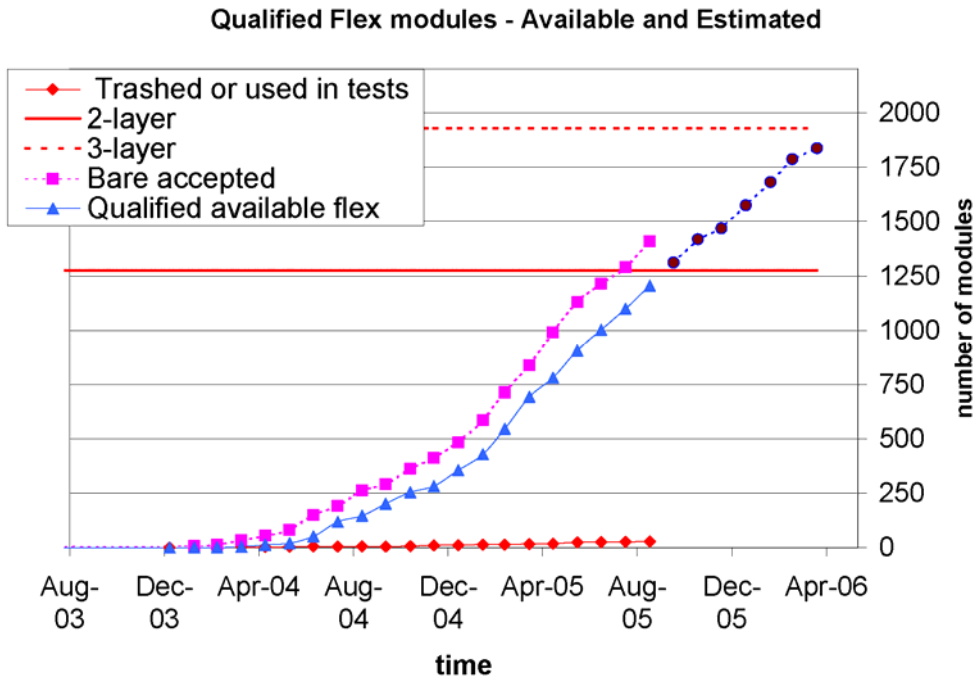


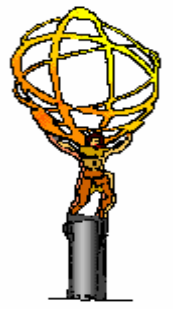


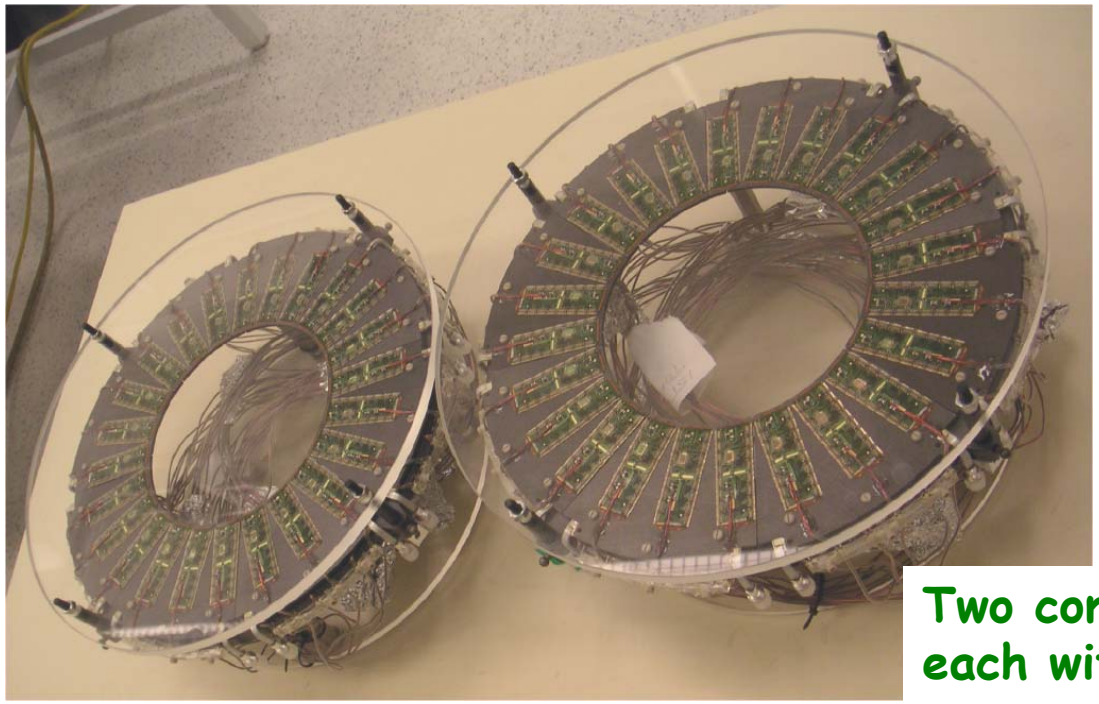
First of 2 endcap TRT fully assembled

# ATLAS Pixels

The rate for assembled and fully qualified modules meets the needs for a 3-hit system in time (1766 modules needed)

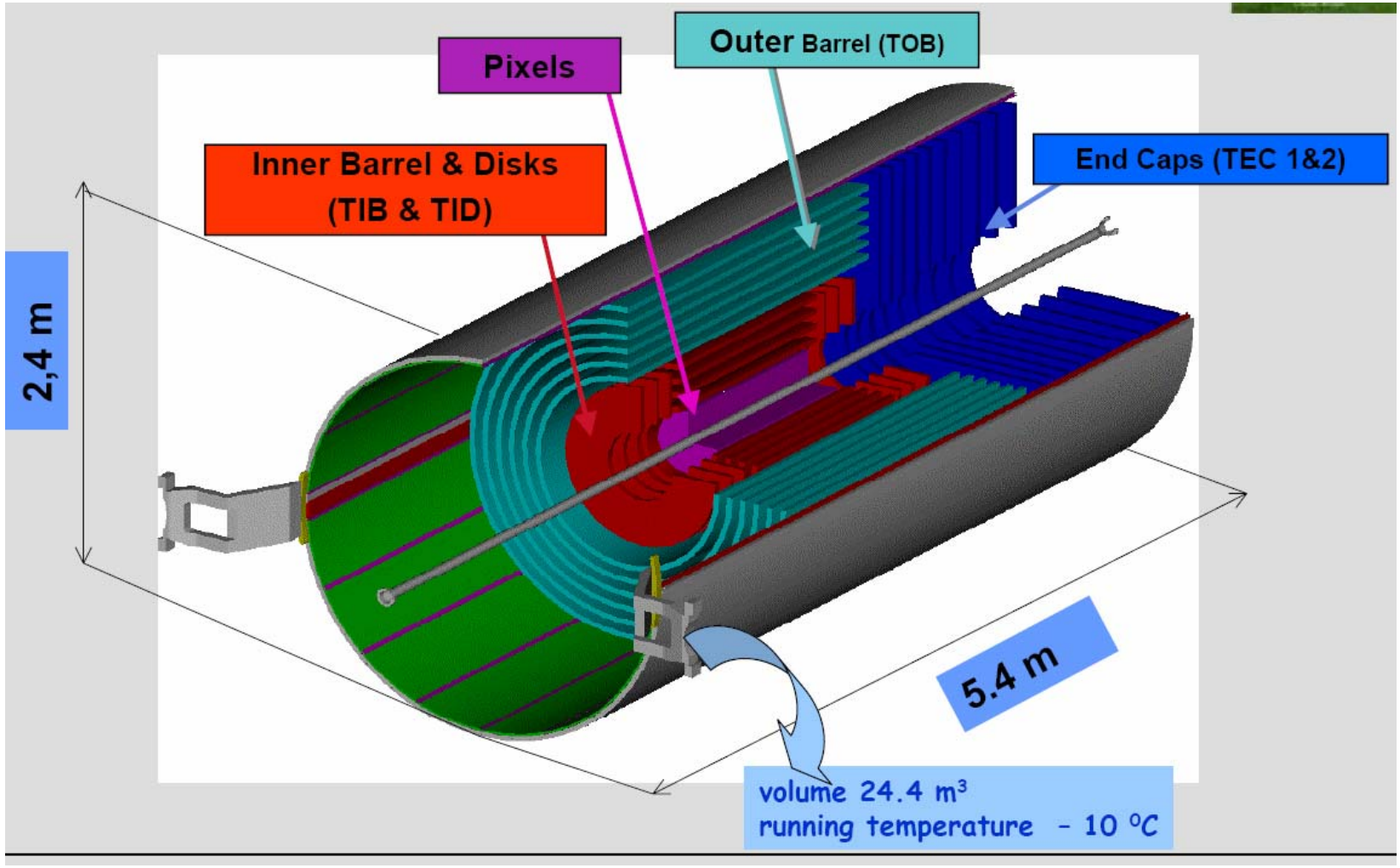




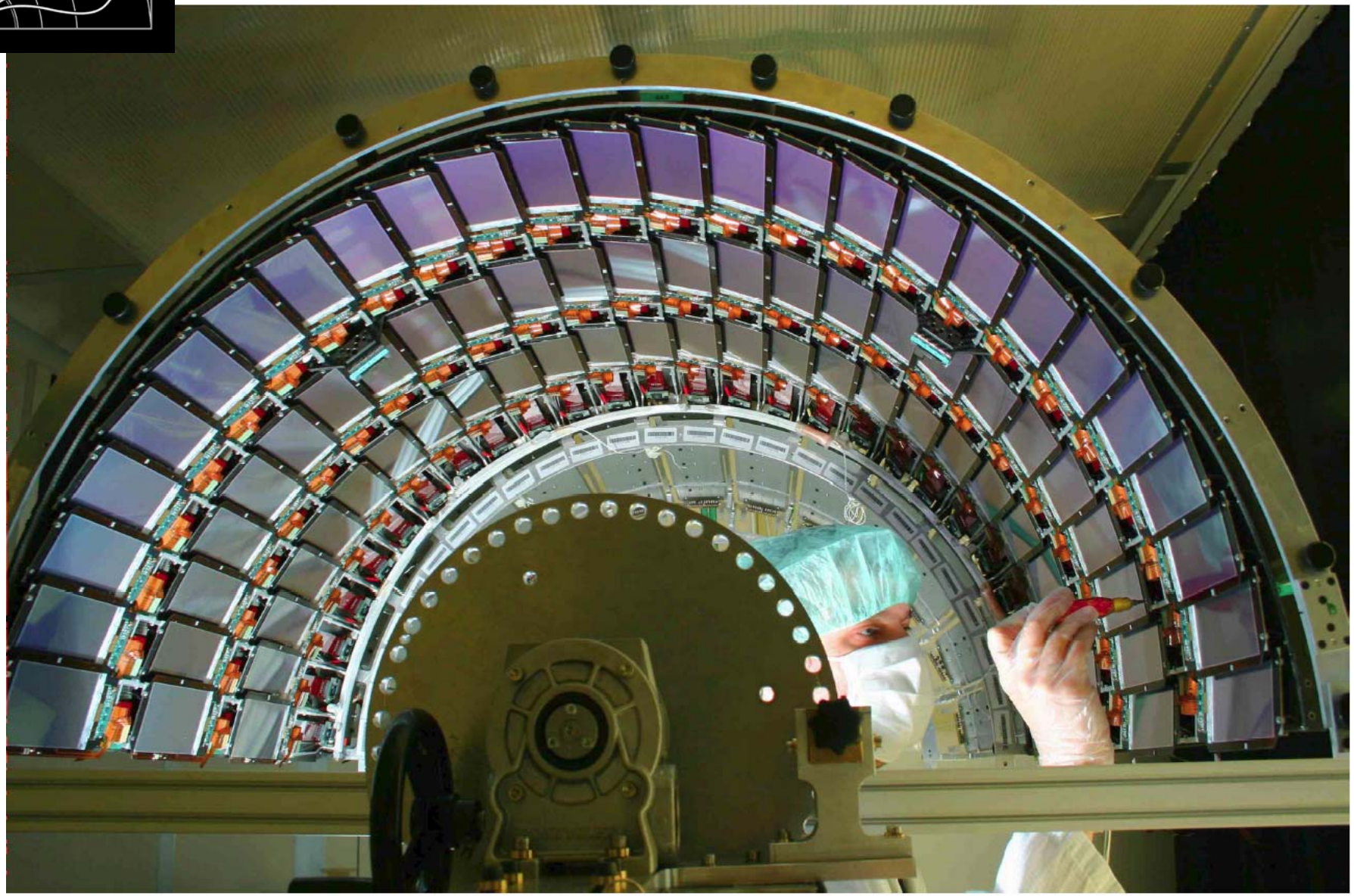
Two completed Pixel disks, each with 2.2 M channels

# CMS Silicon Tracker

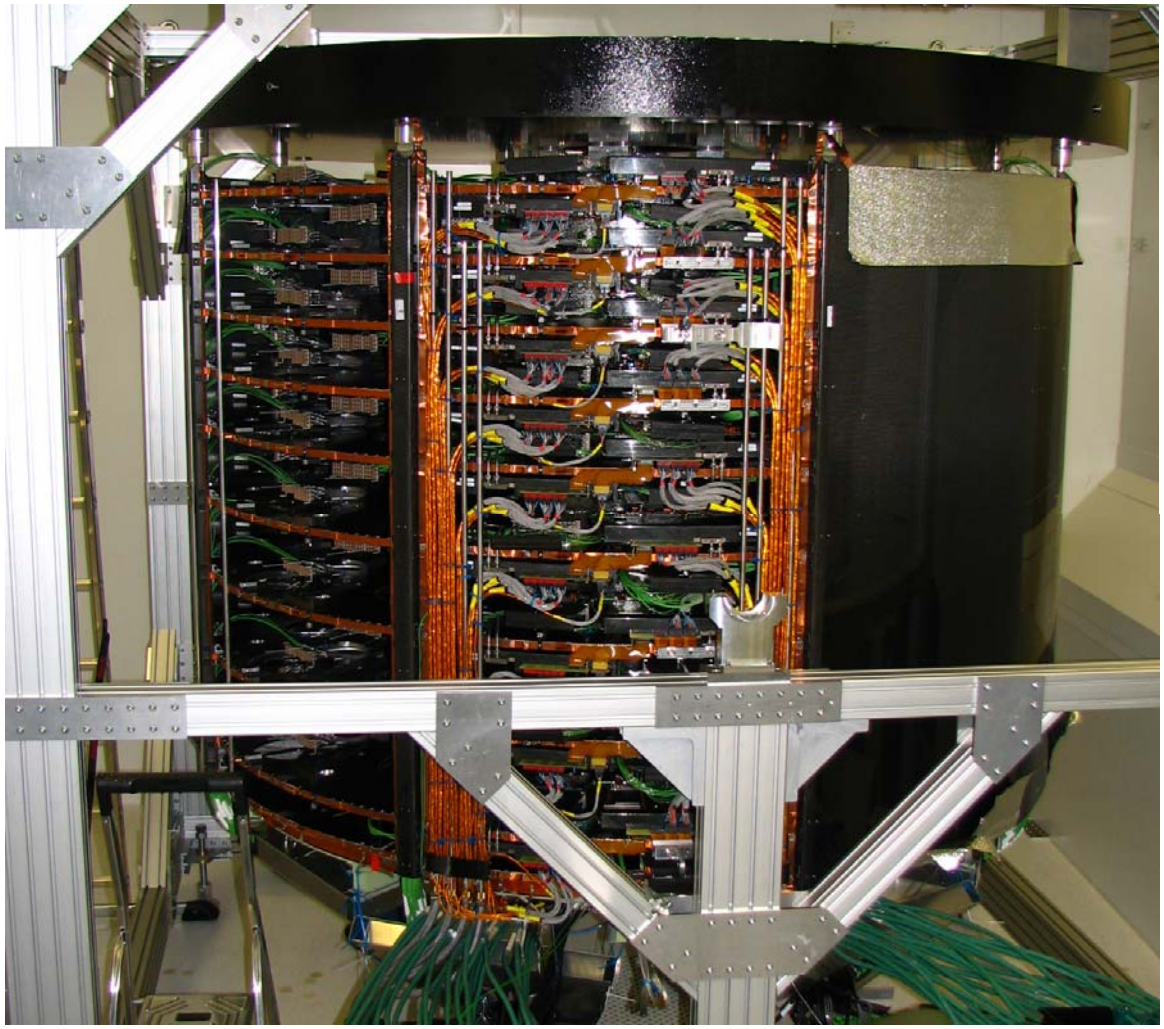


# CMS Si Tracker Barrel

## L4+ Pisa



# CMS Si Tracker Endcap (TEC+)

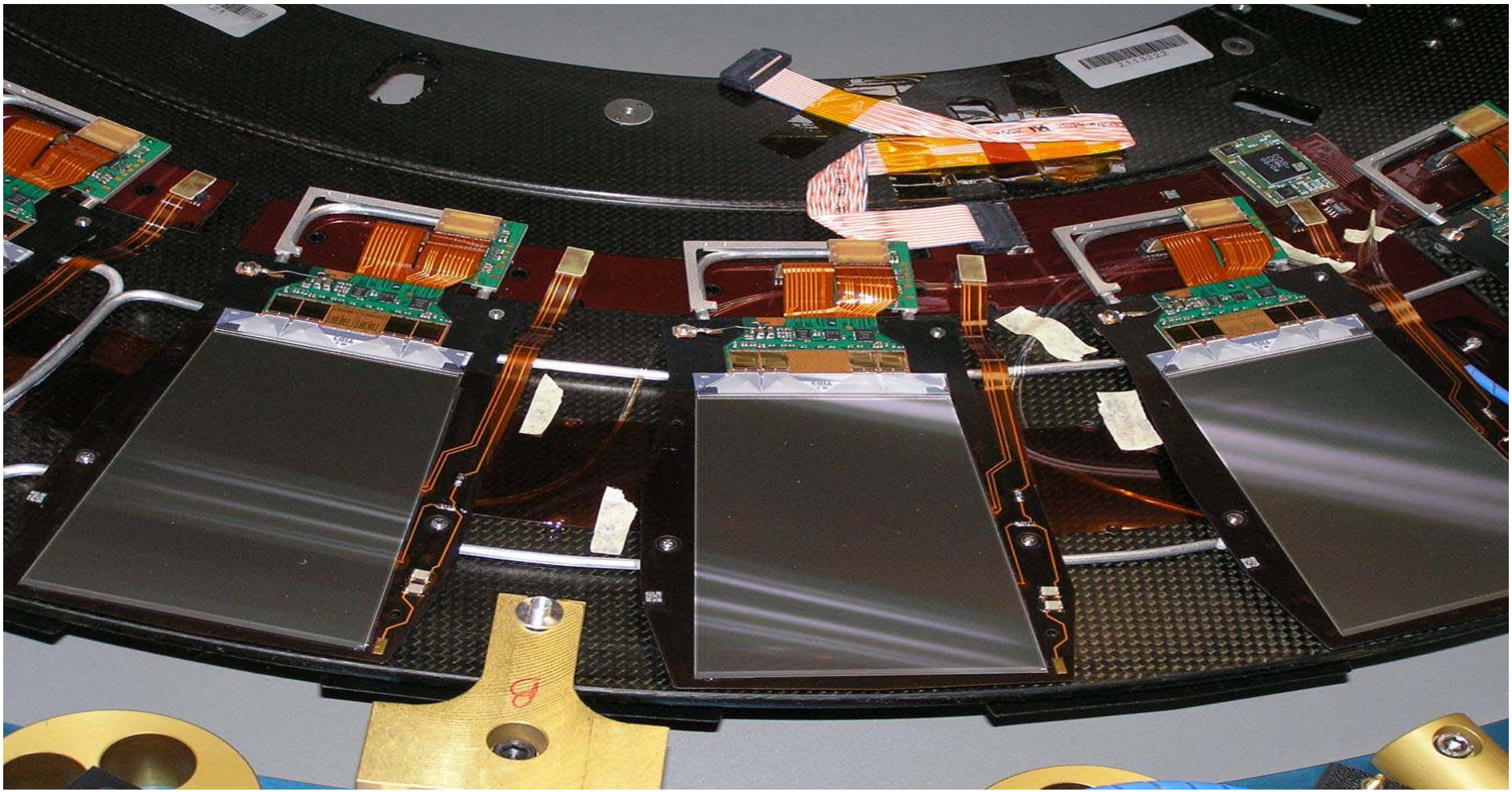


Aachen, Jan. 2006

Being read out and debugged

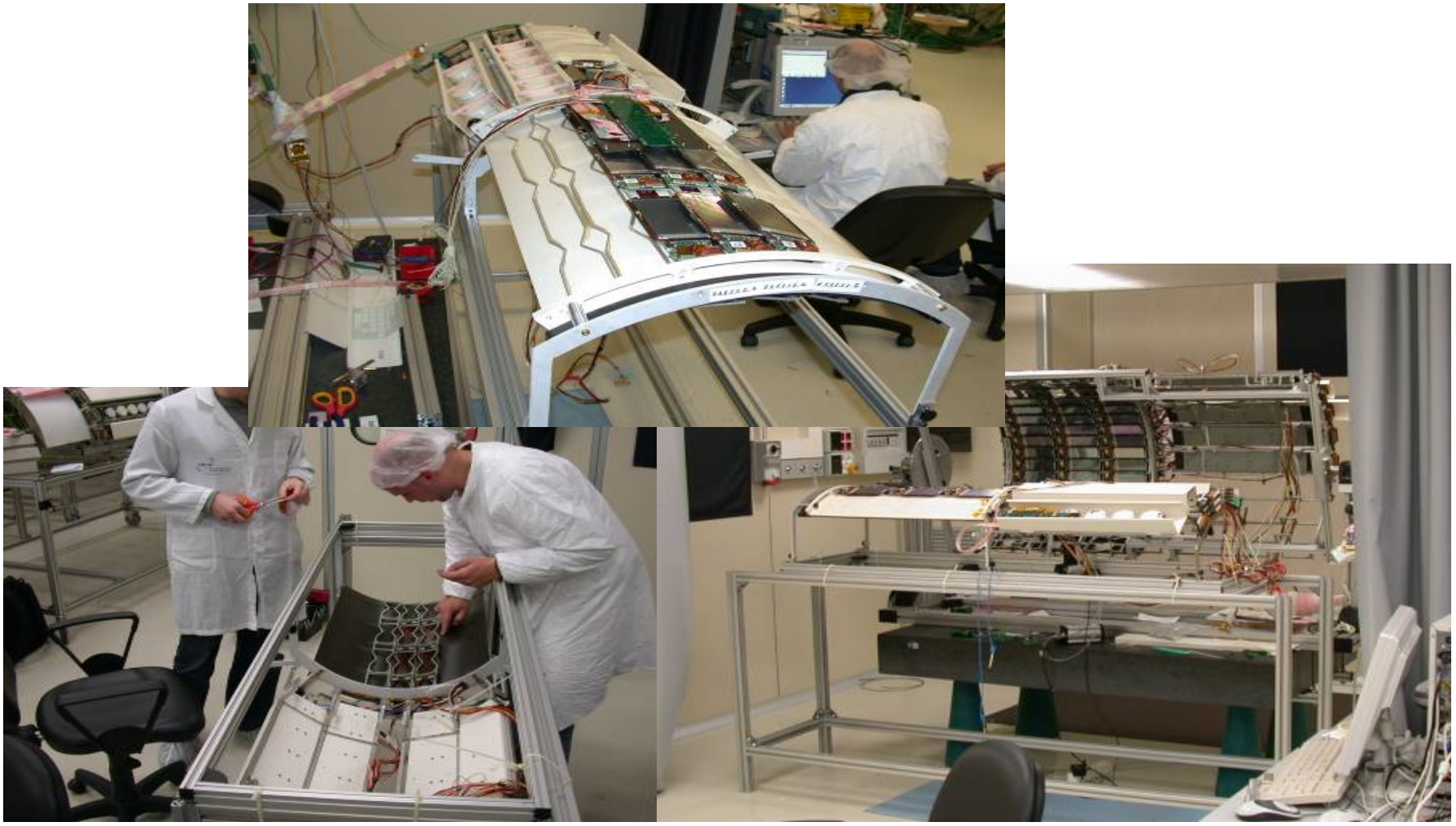
# CMS Si Tracker Inner Disk

## integration at Torino



# CMS Si Tracker Inner Barrel

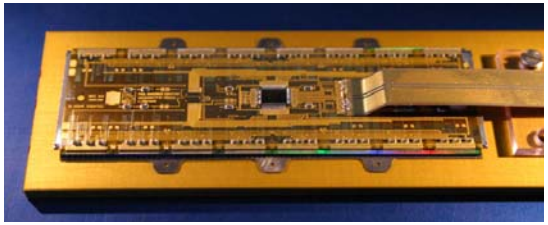
## Completed integration of sectors L2 and L3 for the magnet test



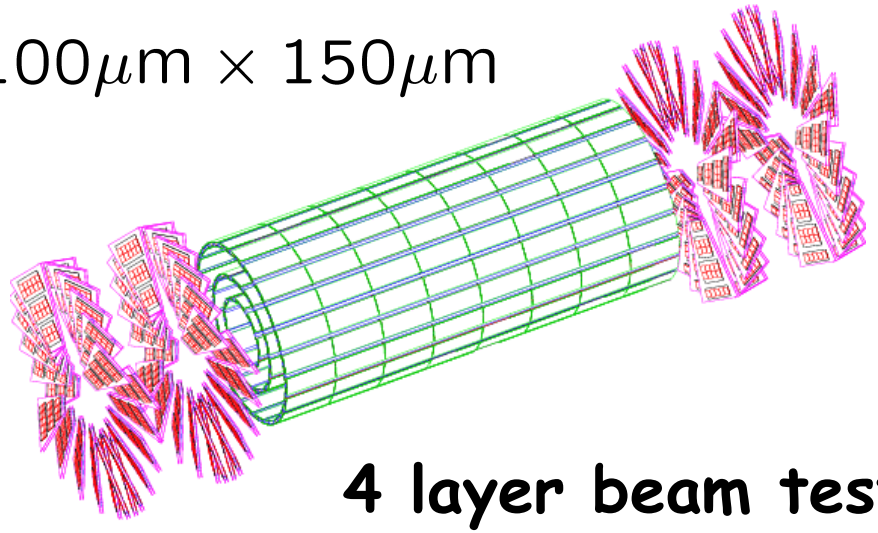
# CMS Si Tracker Integration and Commissioning

- The TIB + and TIB – will be integrated in Italy and inserted into TOB+/- at CERN.
- TOB+/– will be integrated at CERN.
- TEC + will be integrated in Aachen.
- TEC – will be integrated at CERN.
- Initial commissioning of Electronics, DCS and DAQ will take place CERN in B 904. It should be fully commissioned by March 2006.
- After Transport to Point 5, and installation of the Tracker into CMS, the cabling and systematic checks of the System, the Commissioning process can continue in CMS.Depending on the assumptions you make about LHC, there should be ~ 6 months to continue the commissioning in CMS.

# CMS Pixels



$100\mu\text{m} \times 150\mu\text{m}$

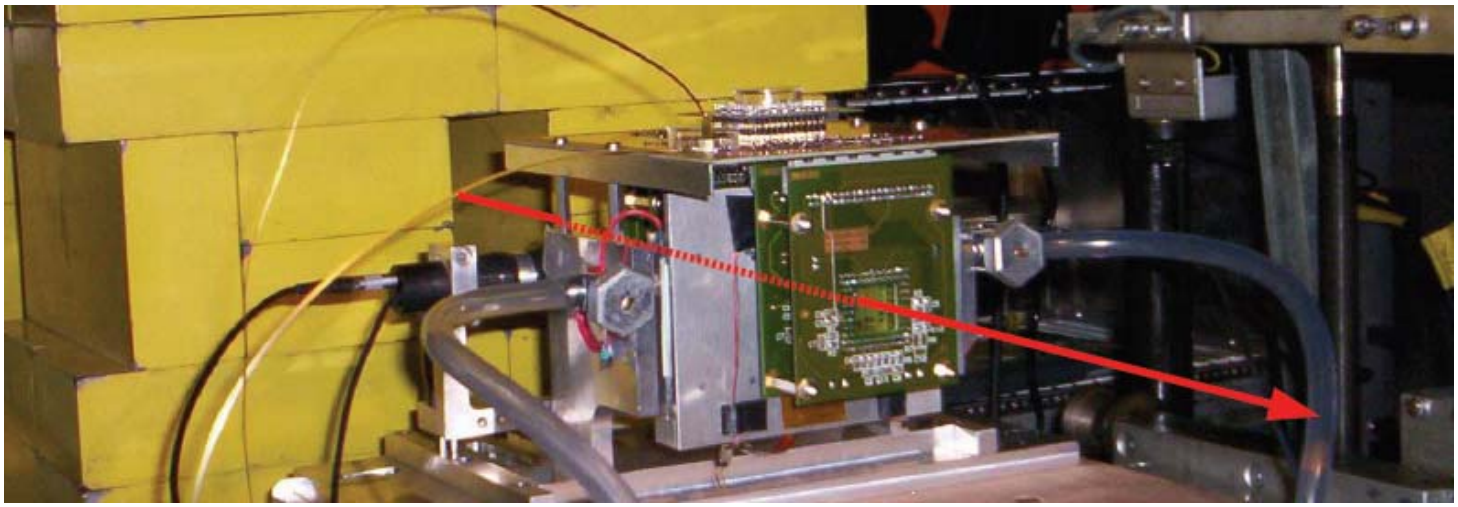


**720 barrel modules**
**672 endcap modules**

**Exected vertex res.:**

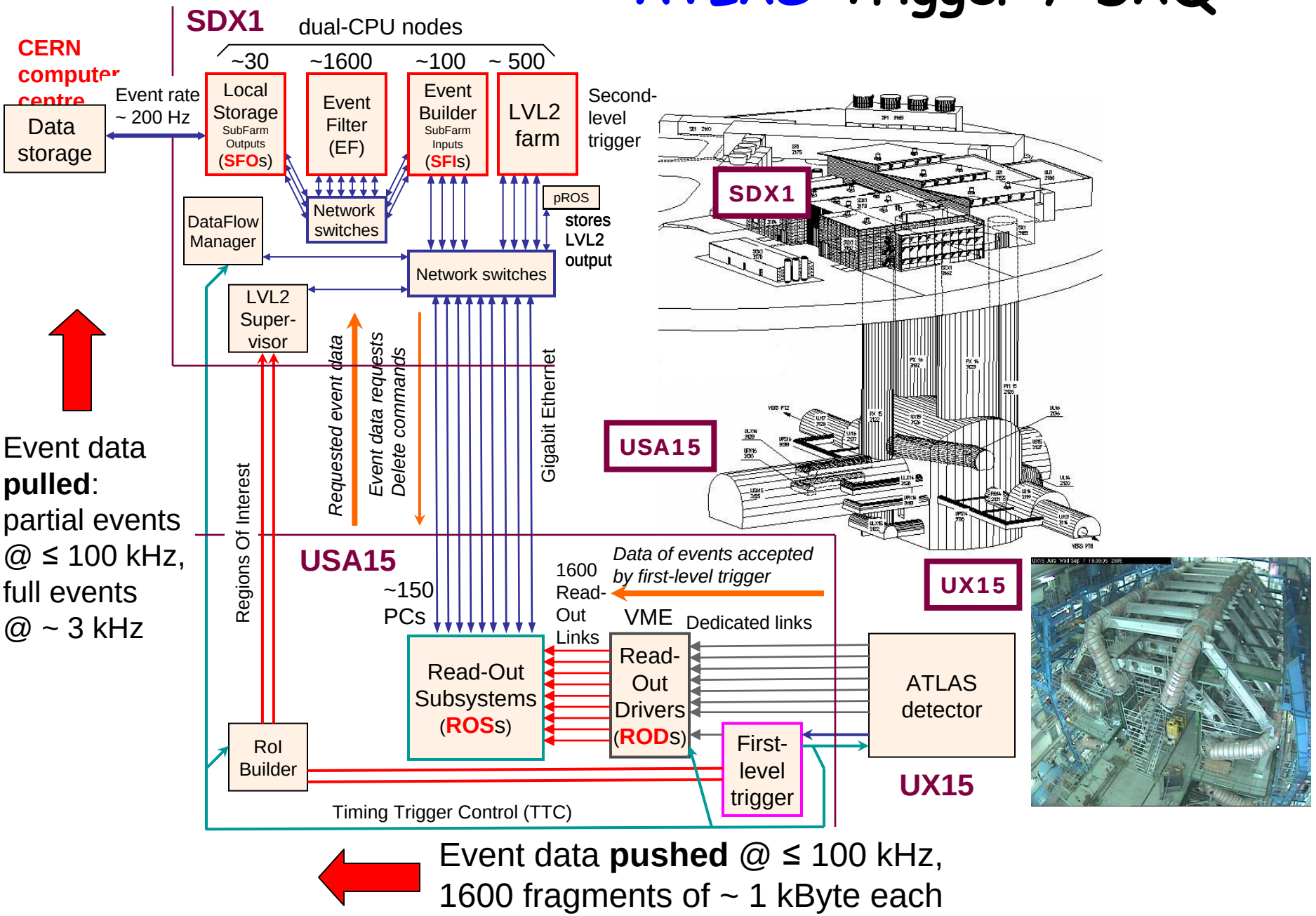
$$\sigma_{r,\phi} = 10\mu\text{m}$$
$$\sigma_z = 20\mu\text{m}$$

**4 layer beam test in Dec. 05**



**The Pixel Systems will use the Tracker Integration Facility in B 186 from Q4 2006**

# ATLAS Trigger / DAQ



# ATLAS Level-1 Trigger

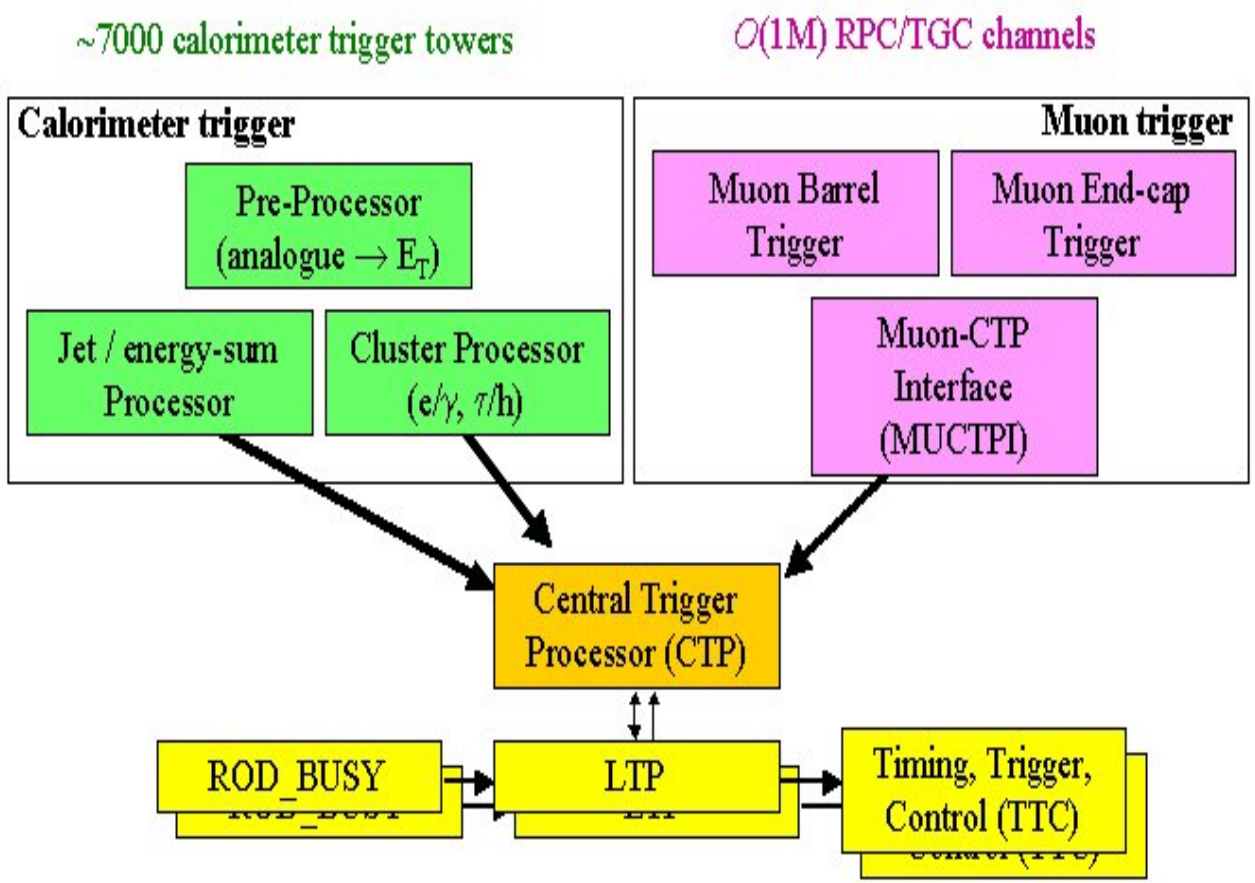
**The level-1 system (calorimeter, muon and central trigger logics) completed the final ASICs developments and testing of full-functionality prototype modules; series production has started**

**The calorimeter level-1 trigger worked successfully at the combined test beam in 2004**

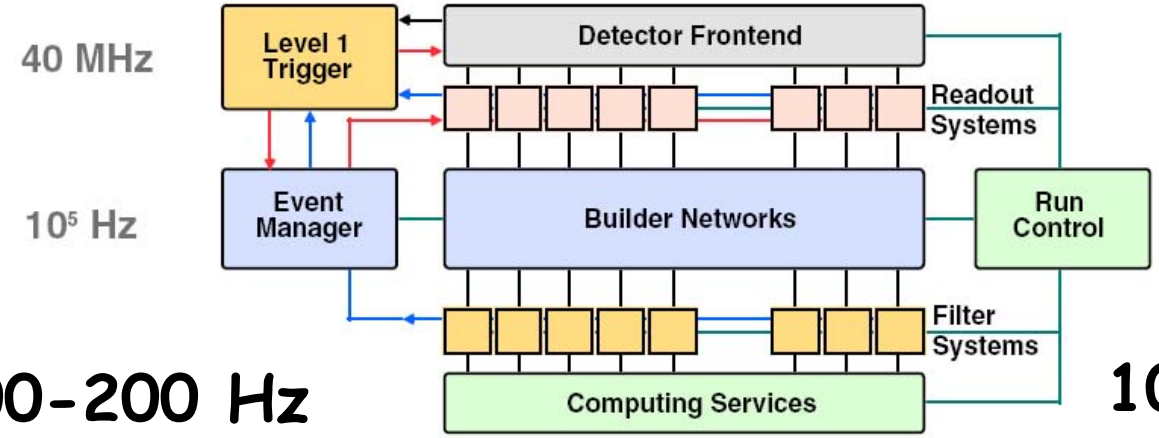
**The series production of the various modules is now starting**

**The muon level-1 trigger has been tested with 25 ns bunched test beams, final improvements were implemented in a last iteration**

**The Central Trigger Processor progresses on schedule**



# CMS Trigger / DAQ




100-200 Hz

100-200 MByte/s

| | | | |
|---|---|---|---|
| Level-1 Maximum trigger rate | 100 kHz | No. Readout Units | ≈512 |
| System efficiency | 98% | No. Builder Units | ≈512 |
| Event Flow Control | ≈$10^6$ Mssg/s | No. Filter Unit | ≈n x 512 |
| Builder network (512x512 port) | ≥500-1000 Gb/s | No. (C&D) Network ports | ≈10000 |
| Event filter computing power | ≈5 $10^6$ MIPS | No. programmable units | ≈10000 |

# CMS Level-1 Trigger Integration

HCAL/regional calorimeter trigger (RCT)
- done

ECAL/RGT
- done

RCT/global calorimeter trigger (GCT)/global trigger
- in progress

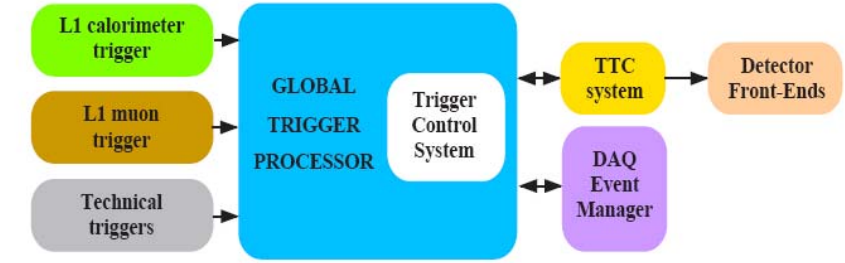
GT/trigger timing and control
- starting

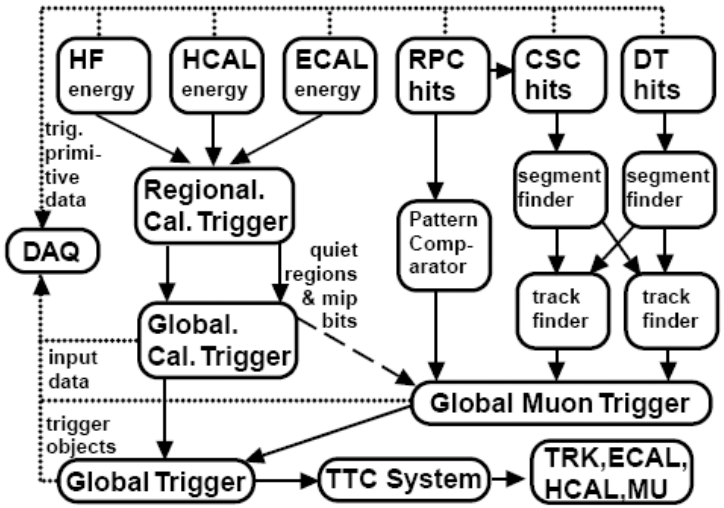
DT/global muon trigger (GMT)
- starting

CSC/GMT
- starting

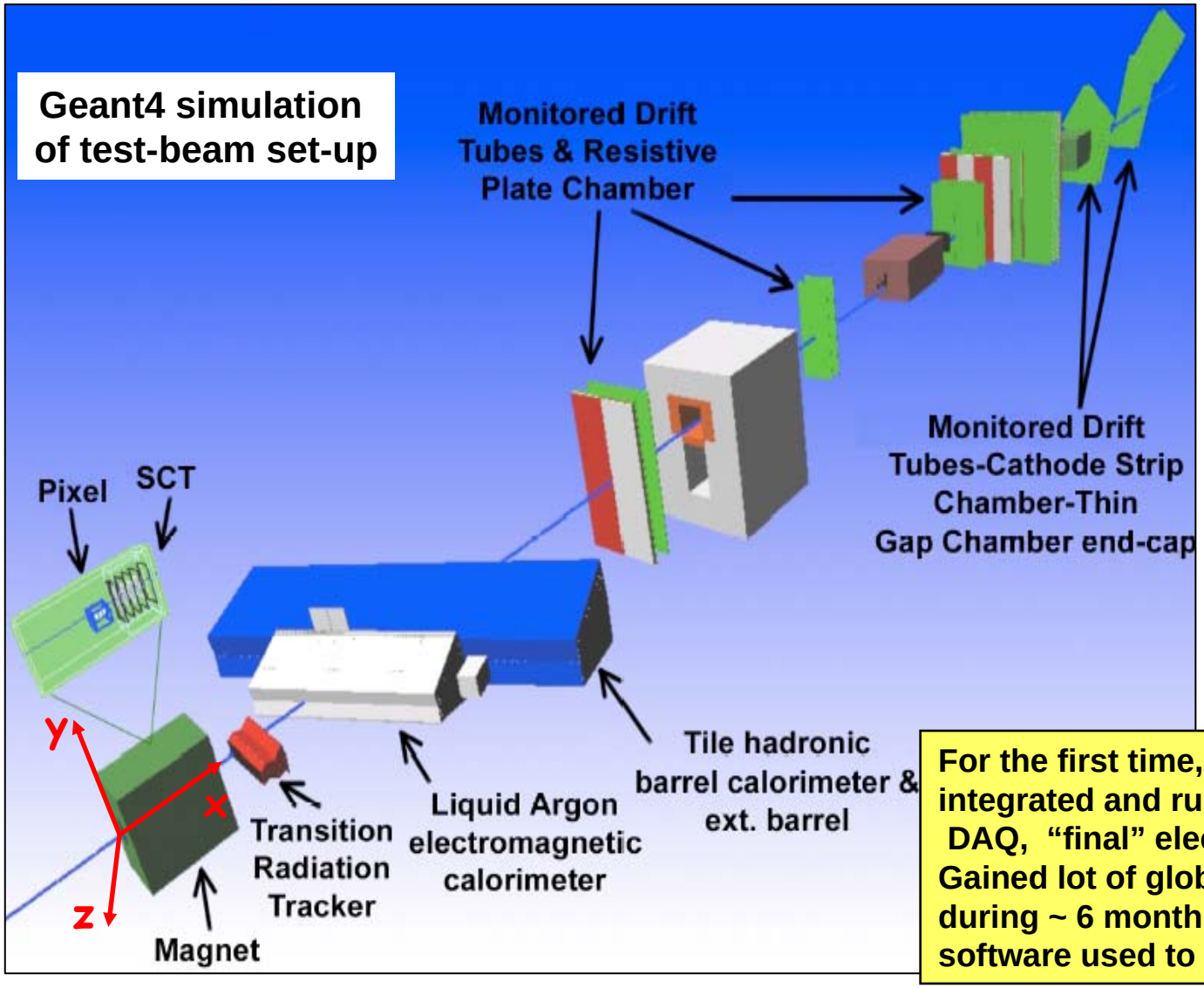
RPC/GMT
-starting

CSC/DT
- starting



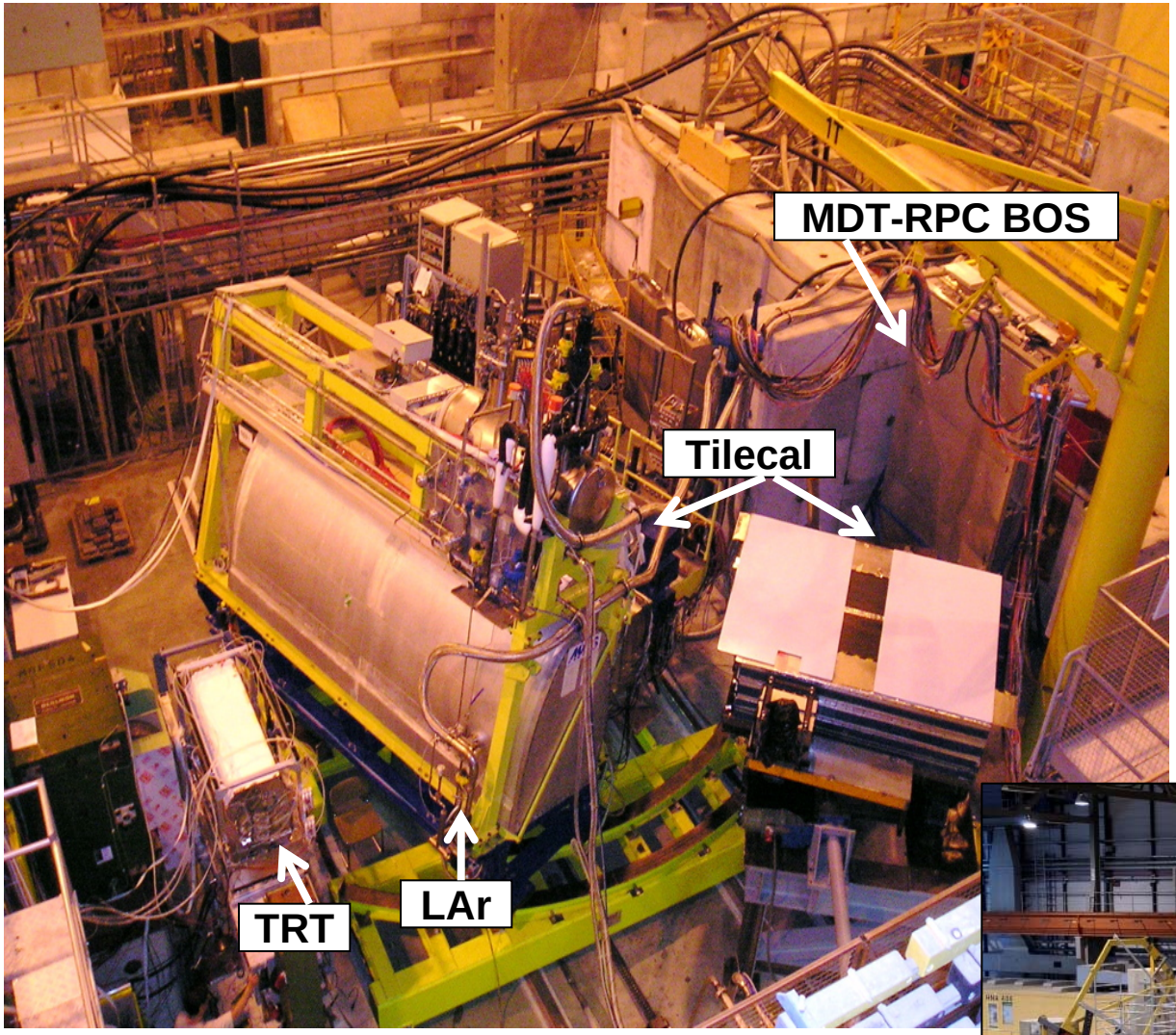



# ATLAS vertical slice integration with test beam




2004

For the first time, all ATLAS sub-detectors integrated and run together with common DAQ, "final" electronics, slow-control, etc. Gained lot of global operation experience during ~ 6 month run. Common ATLAS software used to analyze the data



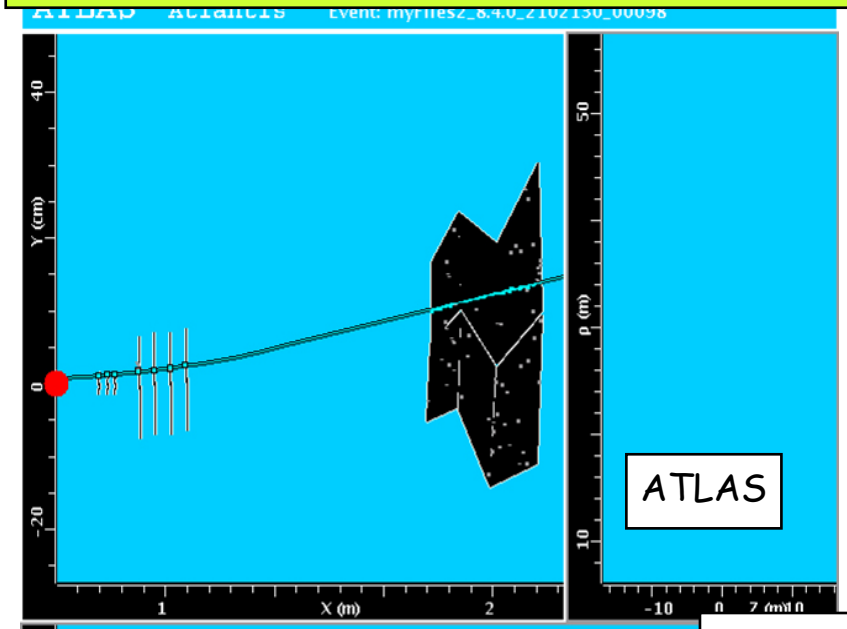

~ 90 million events collected
~ 4.5 TB of data:

| | |
|---|---|
| $e^{\pm}$, $\pi^{\pm}$ | $1 \rightarrow 250$ GeV |
| $\mu^{\pm}$, $\pi^{\pm}$, p | up to 350 GeV |
| $\gamma$ | ~ 30 GeV |

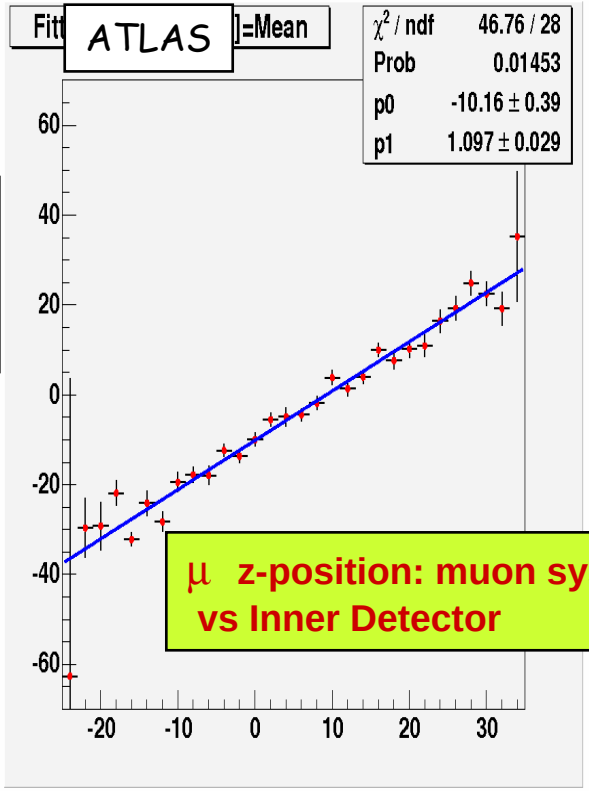
B-field = $0 \rightarrow 1.4$ T

End-cap muon chambers

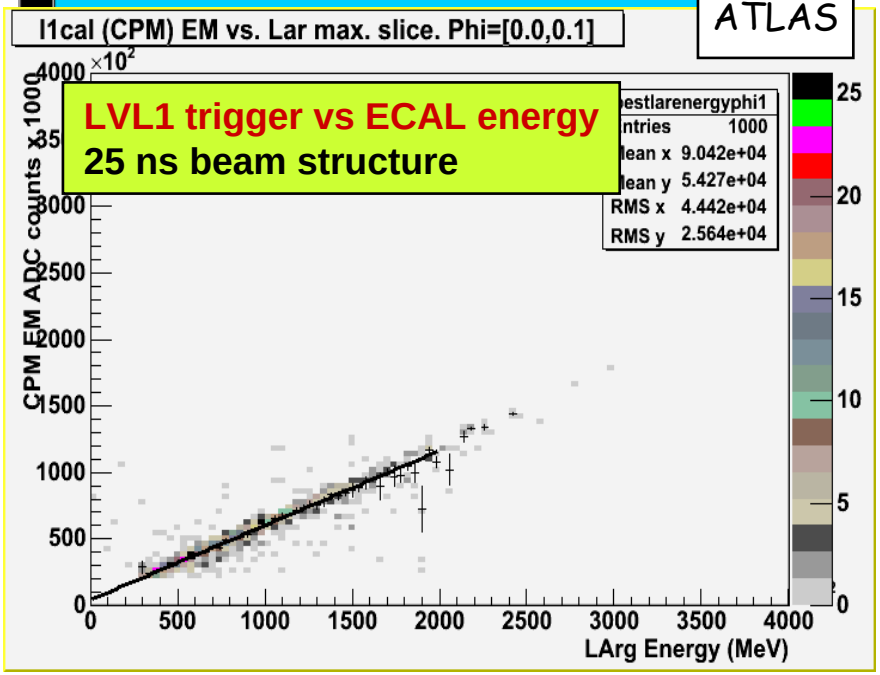
**9 GeV pion track in Pixels, SCT, TRT (B=1.4 T)**



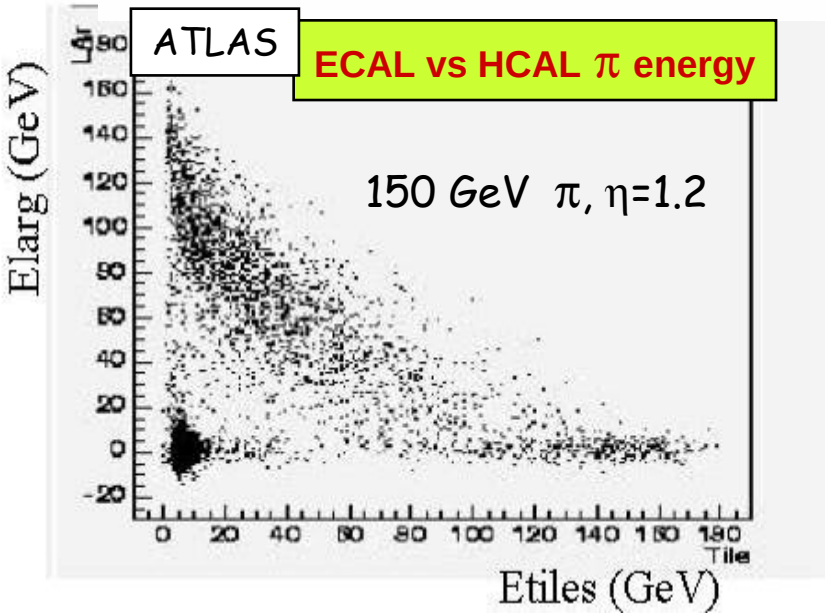

**A few very preliminary results**




**μ z-position: muon system vs Inner Detector**

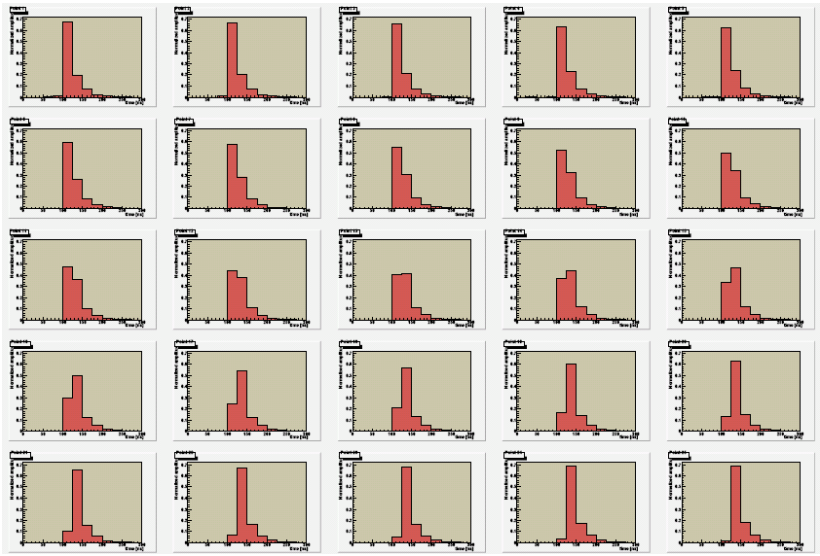



**LVL1 trigger vs ECAL energy**
**25 ns beam structure**

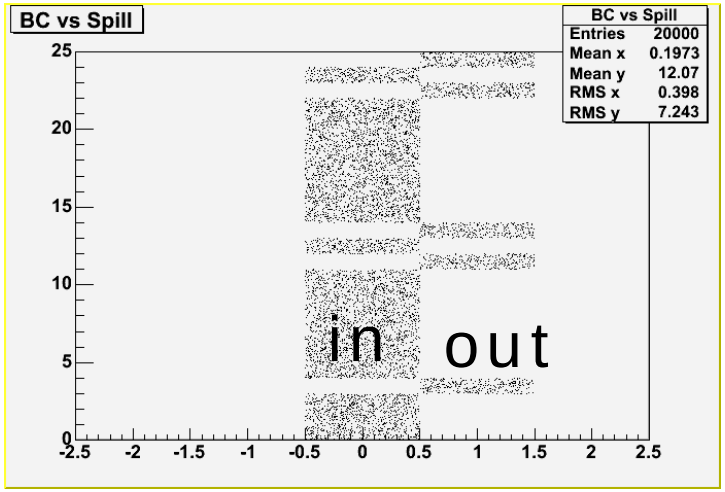


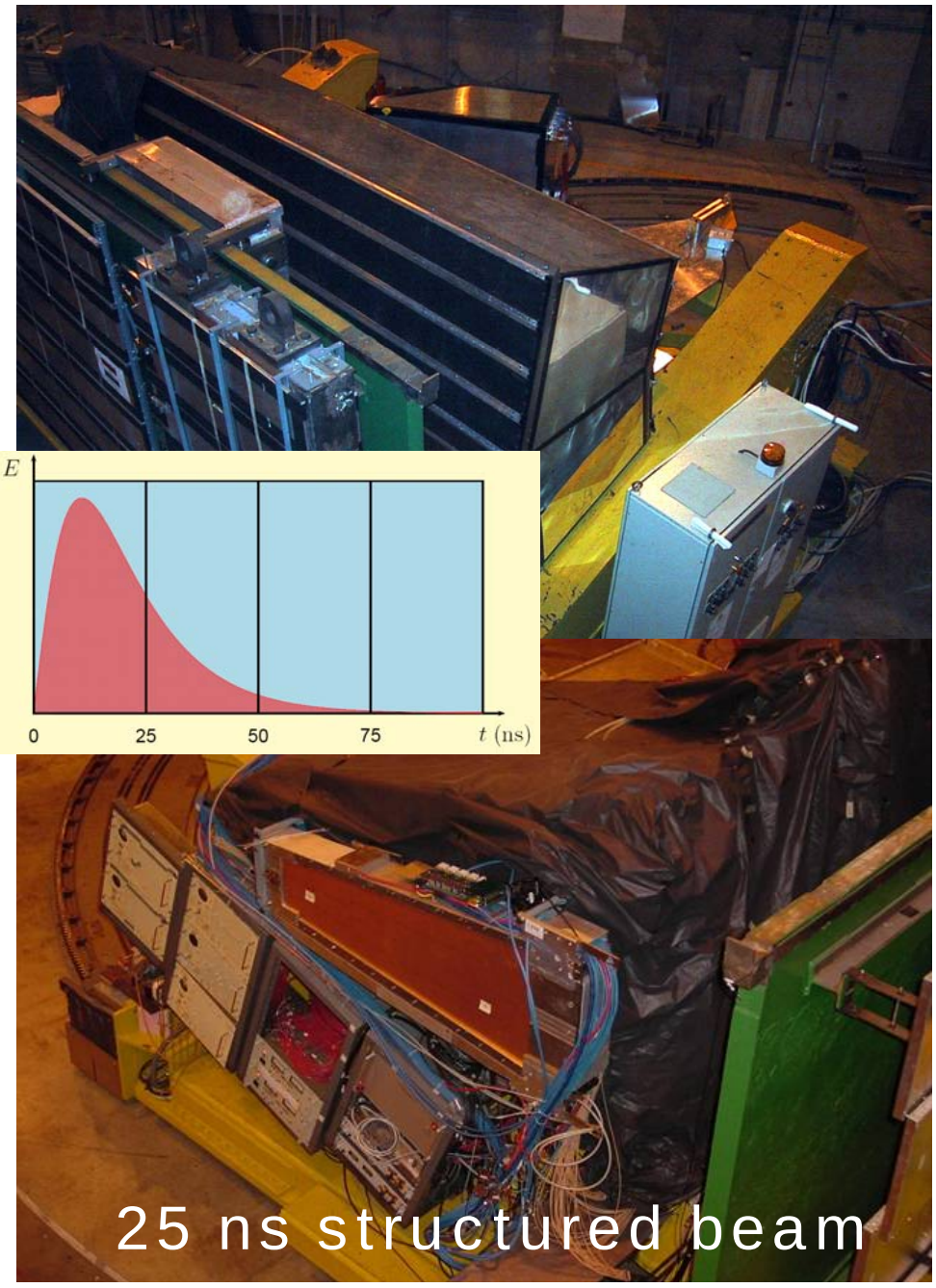
# CMS slice integration with test beam (2004)

## Phase control (HCAL Sync.)



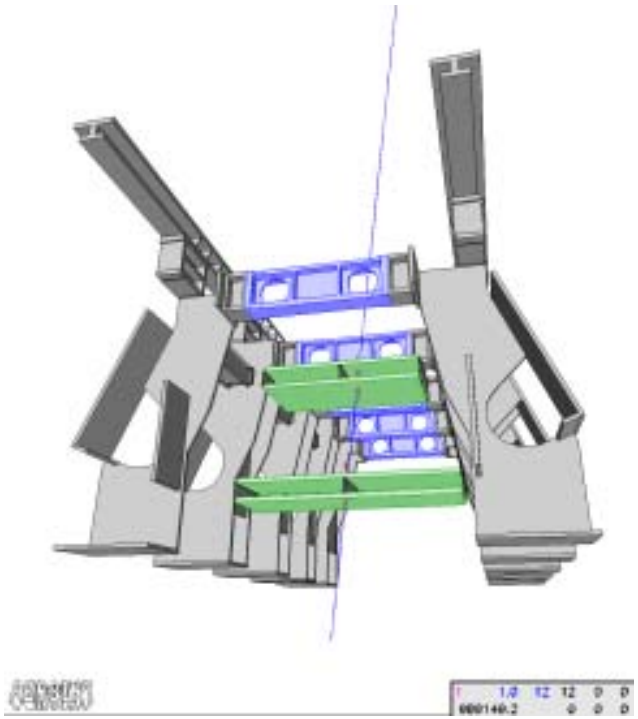
## Muon-HCAL Sync.

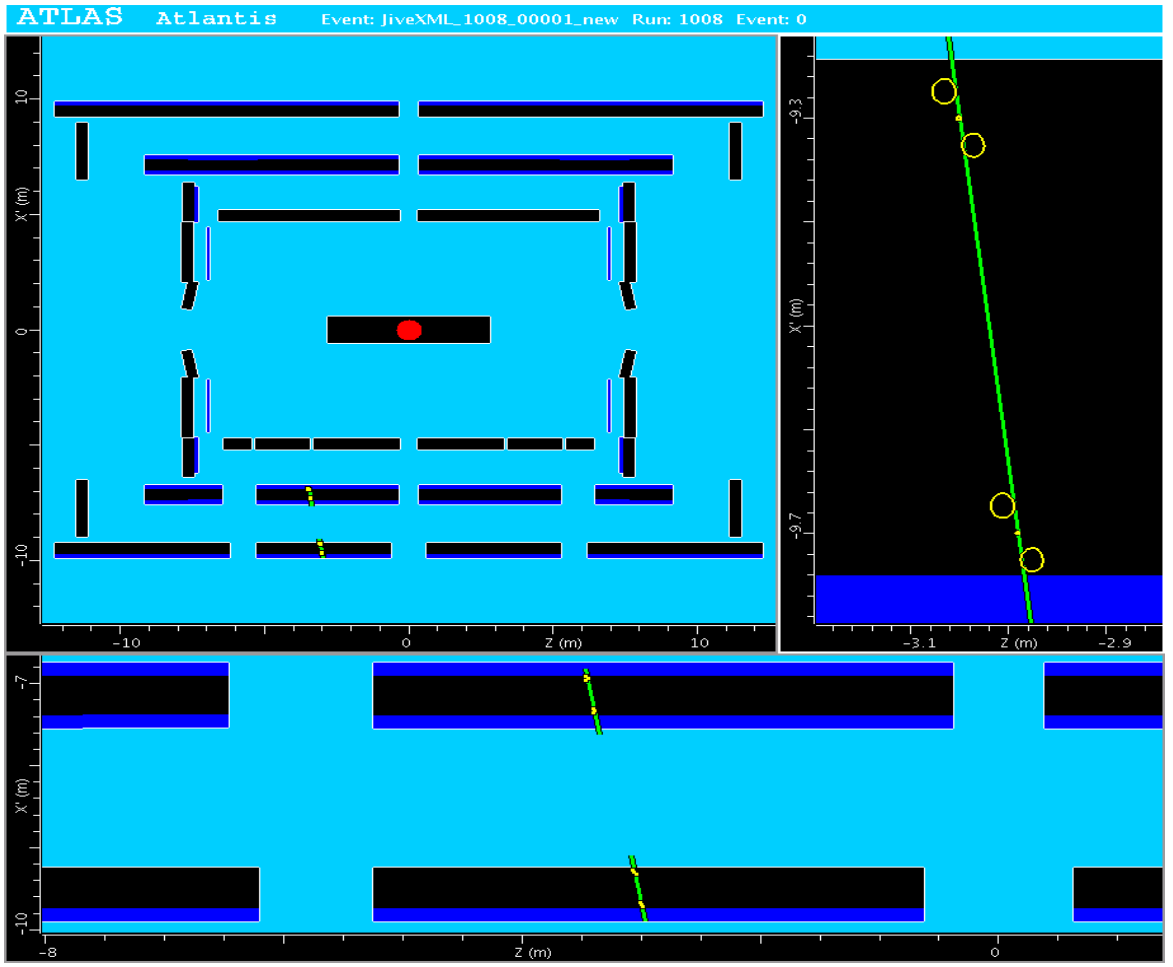


# Cosmic Rays in ATLAS

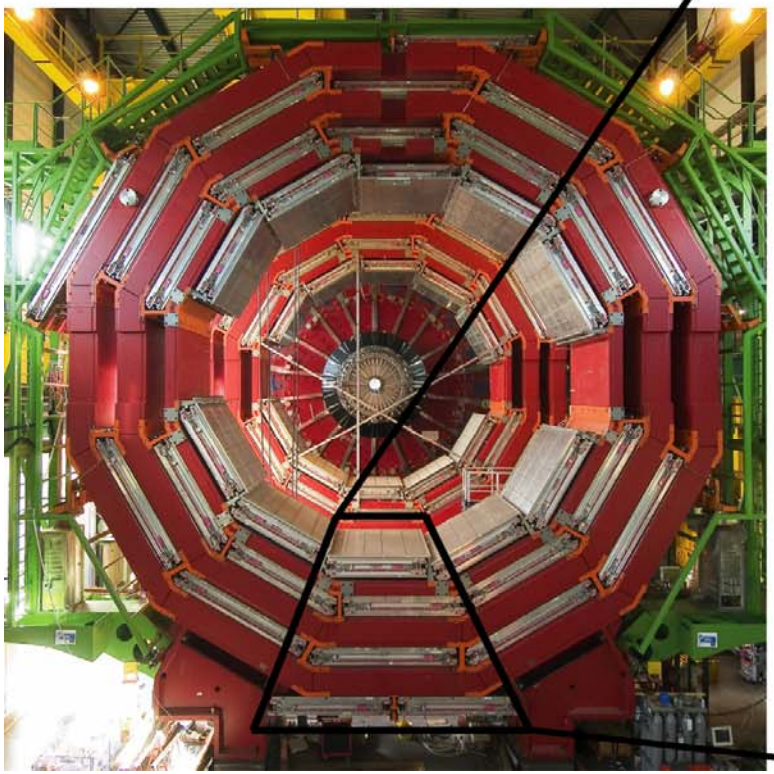
Dec. 05: First cosmics muons registered in the stations installed in the bottom sector of the spectrometer

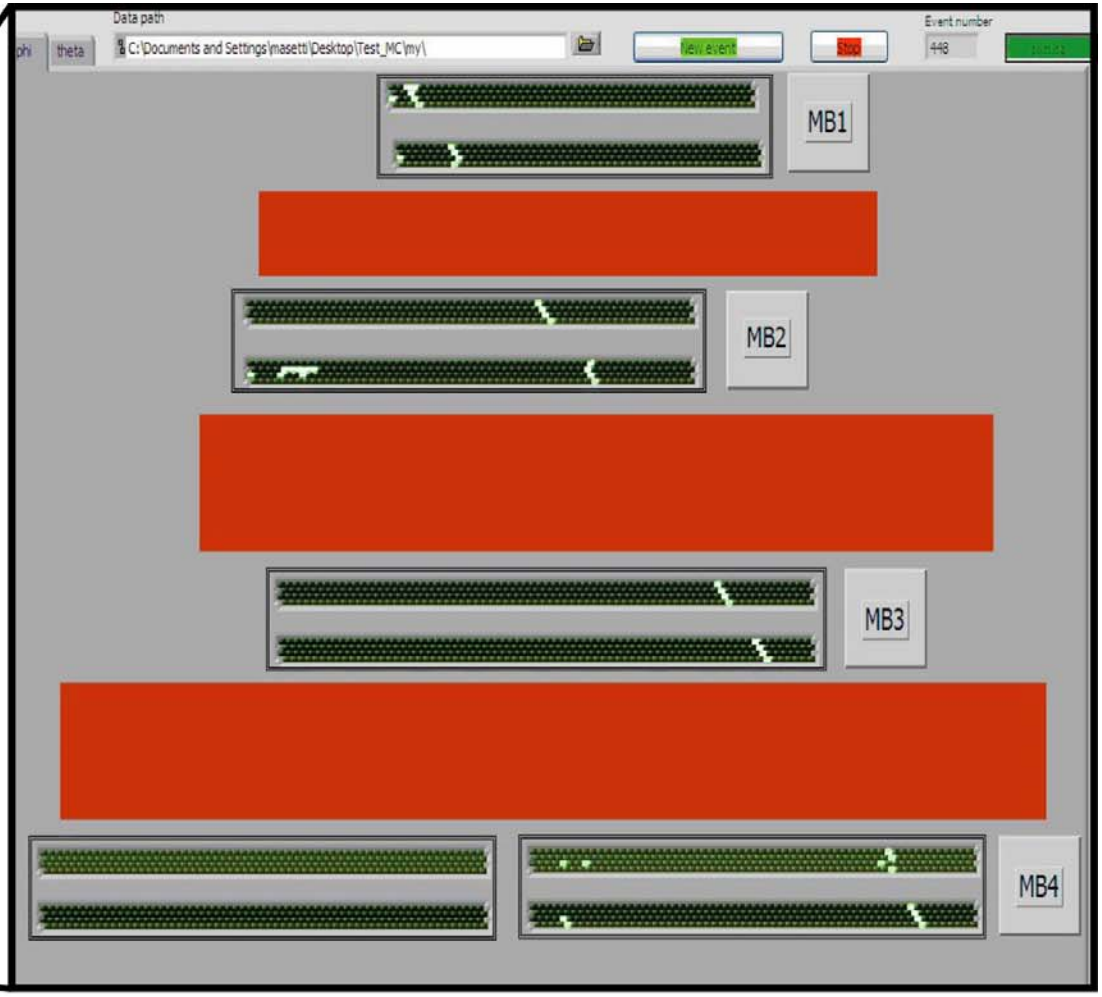




# Cosmic Rays in CMS

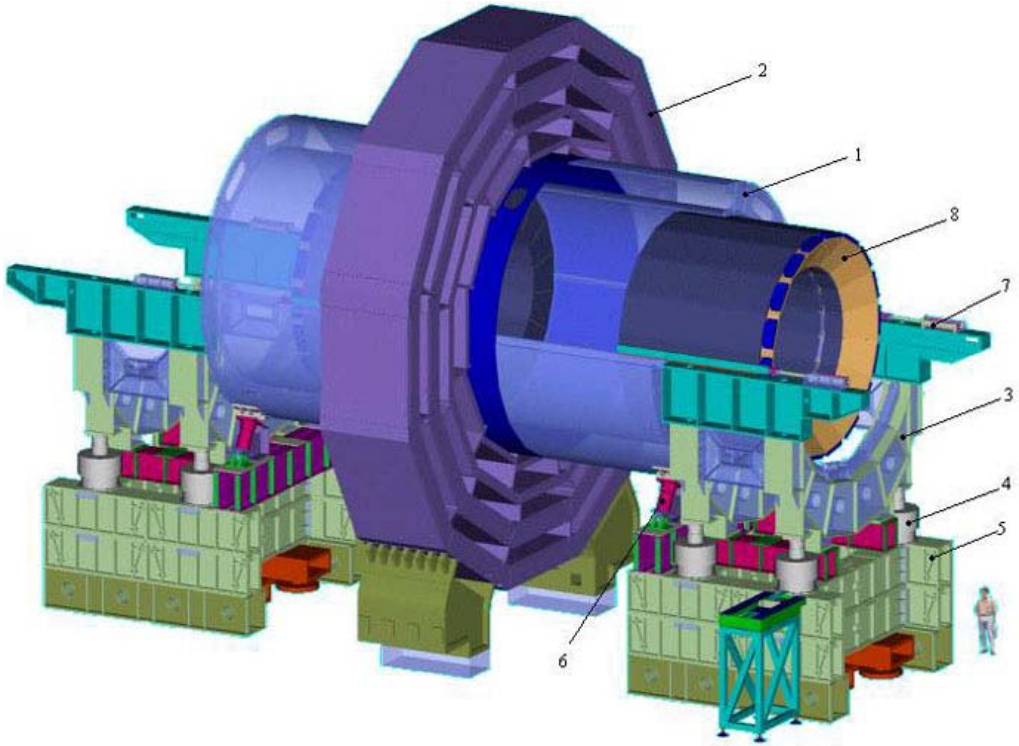
## Assembled Muon Barrel in SX5






(Dec. 15, 2005) Dan Green: "Wow - we may have an experiment..."

# CMS HCAL insertion into solenoid planned for this month…



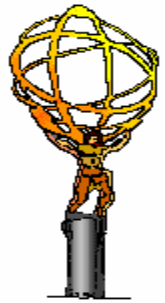

to be followed by slices of tracker & ECAL for integration with muon/magnet/DAQ/trigger using cosmic rays in situ

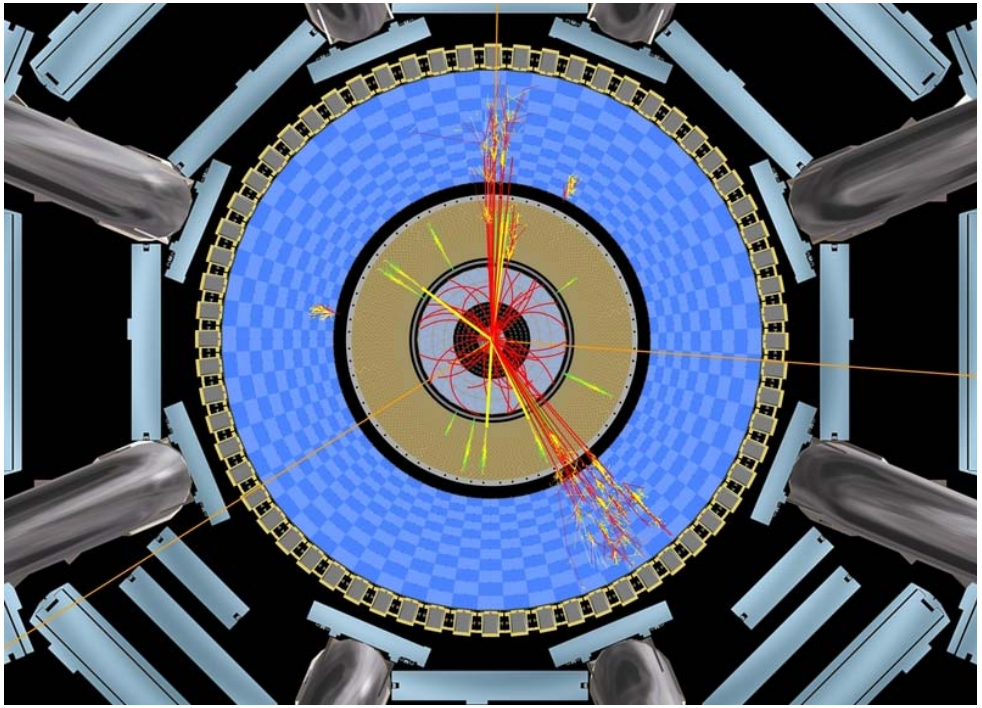
# Summary

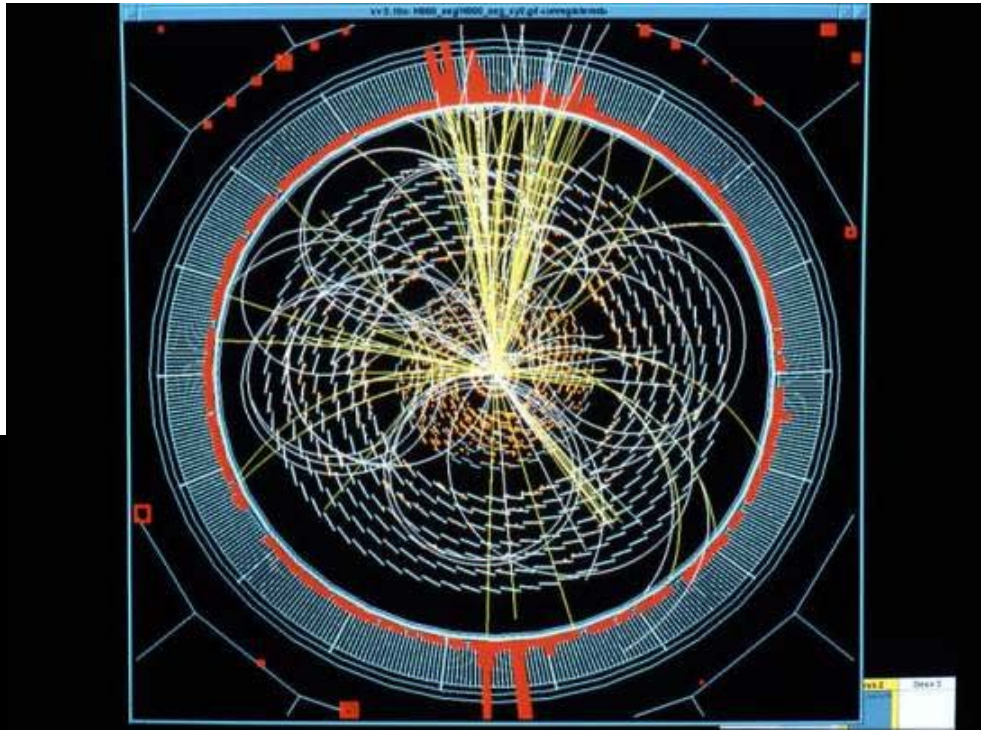
ATLAS

and

CMS








will be ready for first pp collisions!