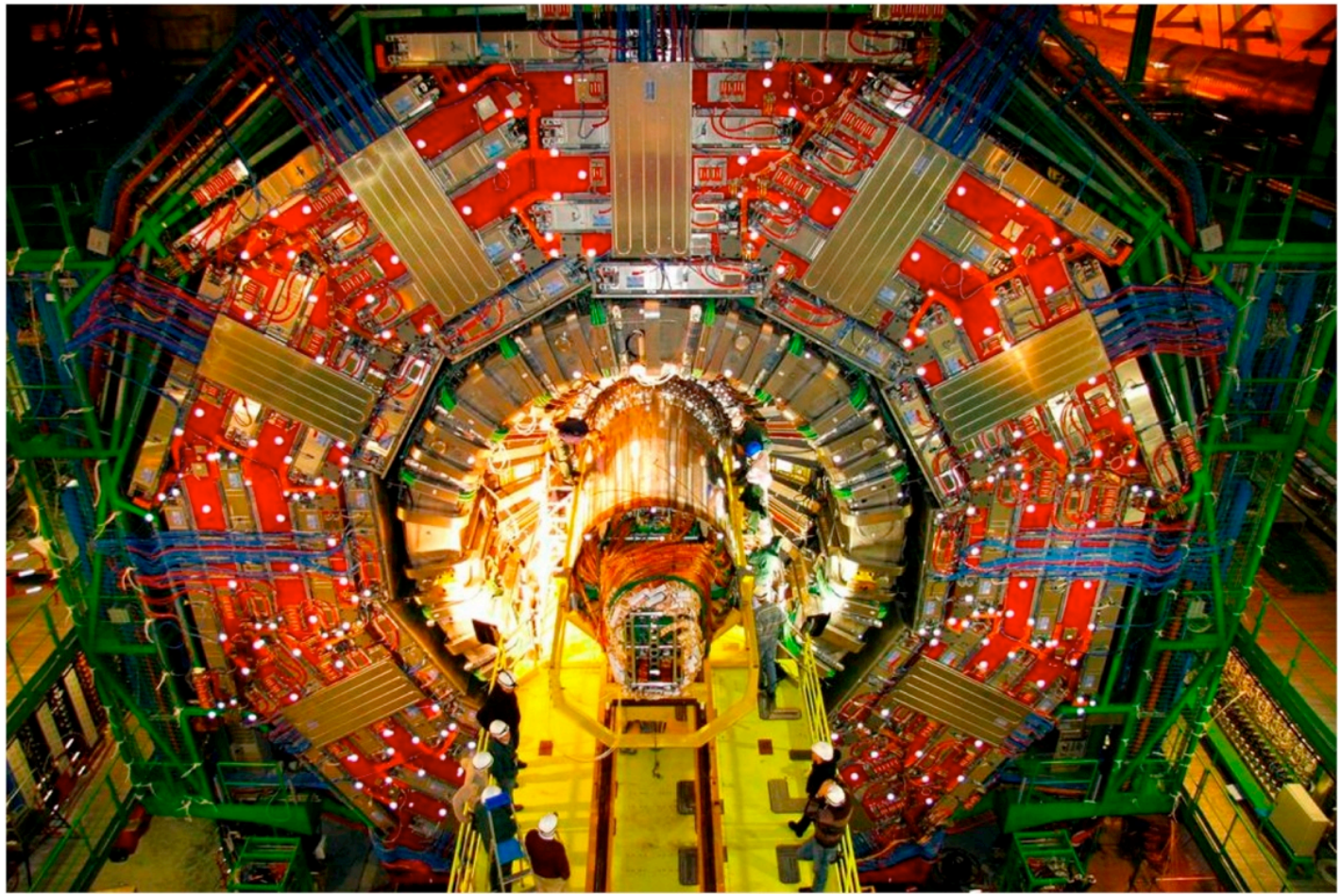
CMS commissioning status



L. Malgeri - CERN - *on behalf of the CMS coll.*

30/5/08 - HCP08 - Galena (IL-US)

A special thank to: D. Acosta, T. Camporesi and the commissioning teams

Outline

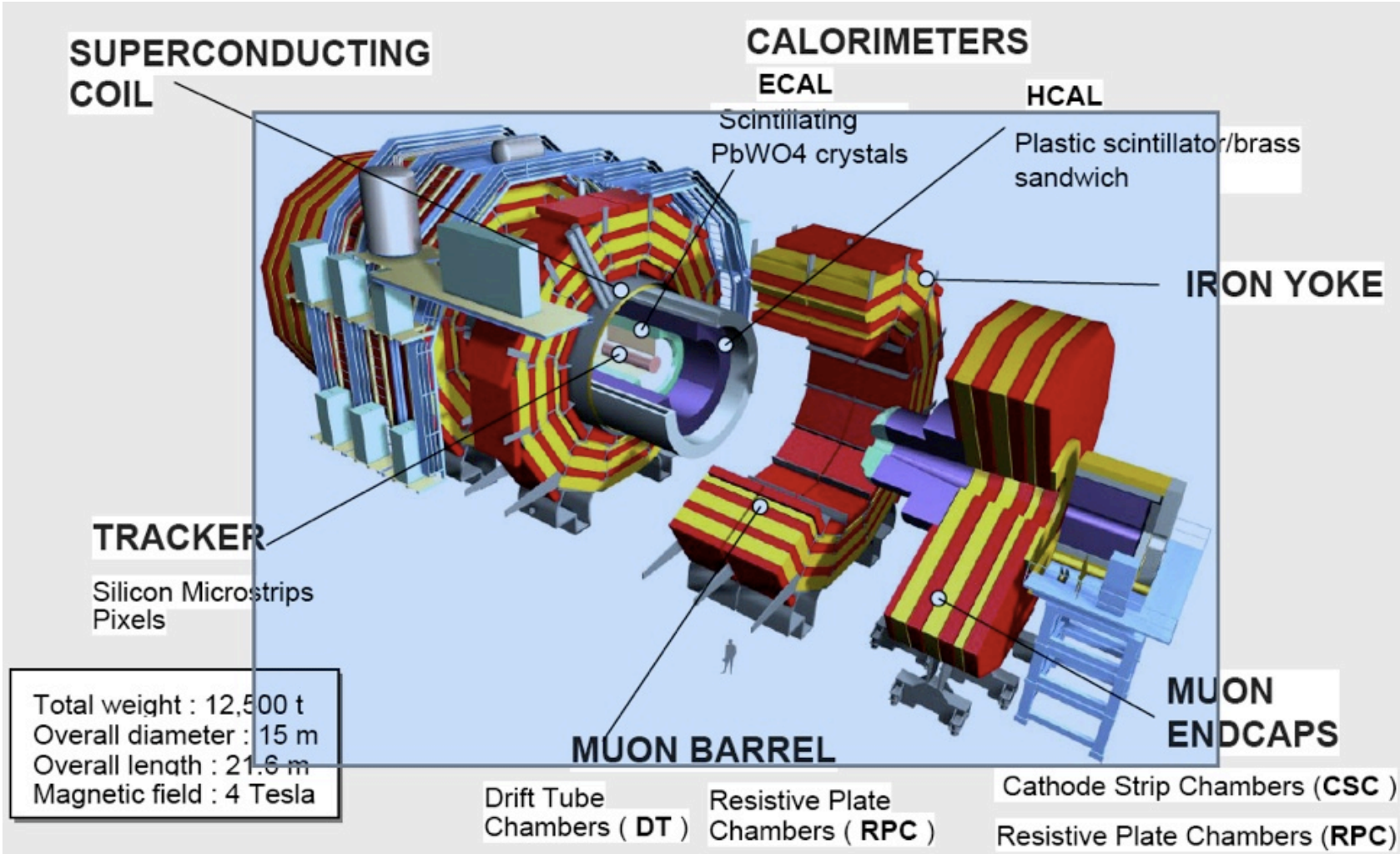
CMS and its status

- muons(DT+CSC+RPC)
- calorimeters (ECAL+HCAL)
- tracker(Pixels+Sistrip)
- data acquisition + trigger
- lowering campaigns

Commissioning activities

- Magnet Test, Cosmic Challenges
- Test beams
- Computing and Software challenges
- Local and Global runs

CMS



1. Robust and Redundant Muon system
2. Best e/γ calorimeter consistent with 1.
3. Efficient Tracker consistent with 1. and 2.
4. Hermetic calorimeter
5. Affordable

Magnet

CMS Magnet

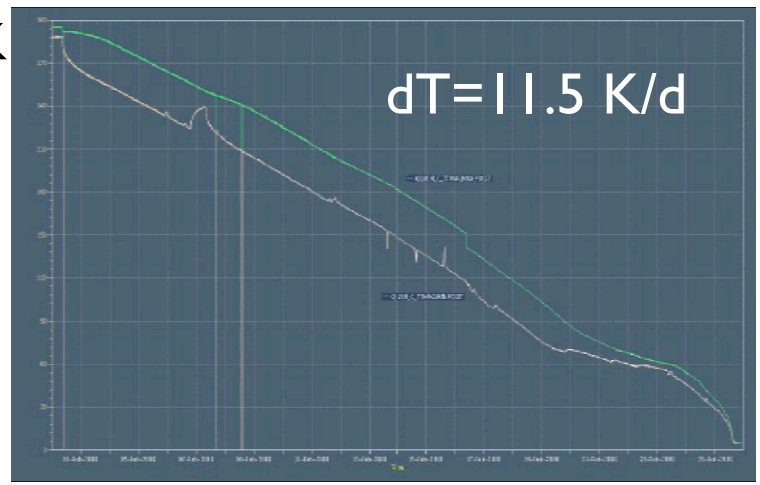
4 Tesla

Length 13m Radius 3m

Energy 2.7 GJ

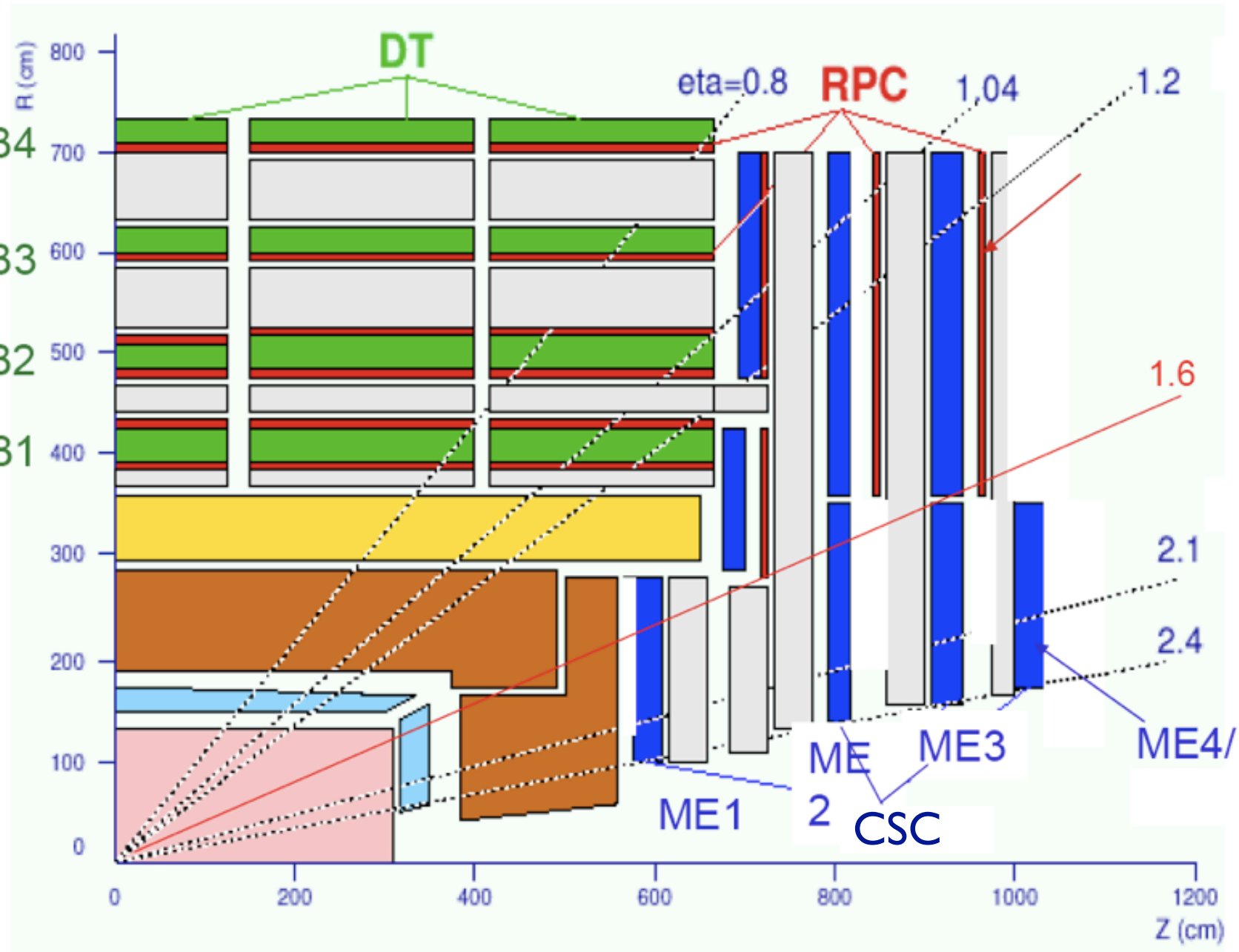
Current 20kA

64 Atm Radial Mag Pressure



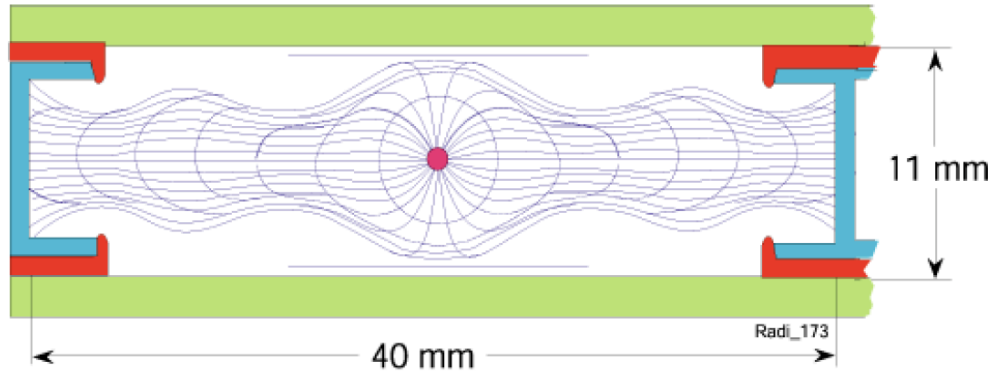
More on magnet test later...

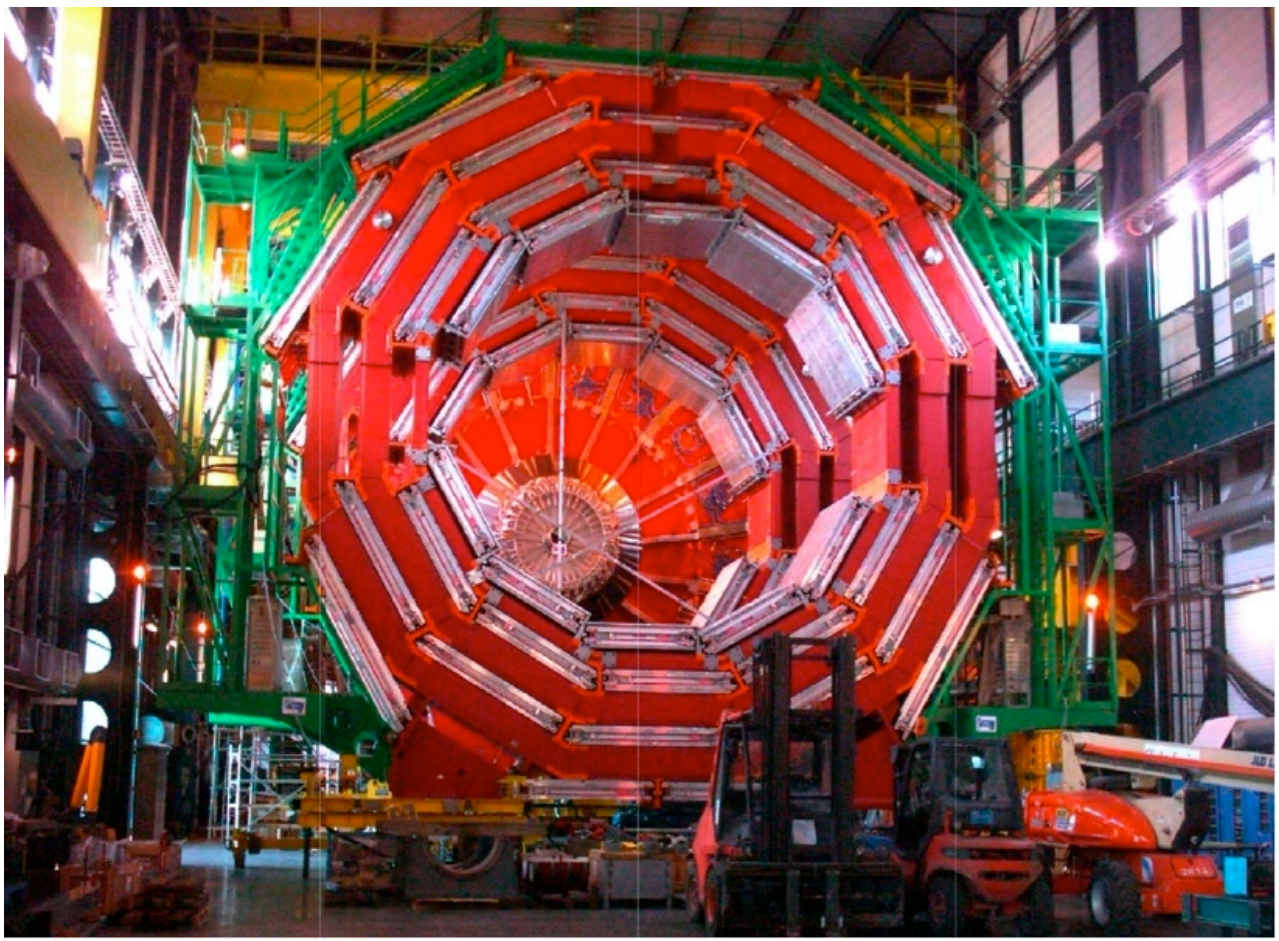
Muon System


DT
RPC
eta=0.8
1.04
1.2
1.6
2.1
2.4
MB4
MB3
MB2
MB1
R (cm)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
Z (cm)
ME1
ME 2
ME3
CSC
ME4/1

Drift Tubes

DT
250 Chambers
200K Channels TDC
250µm Resolution



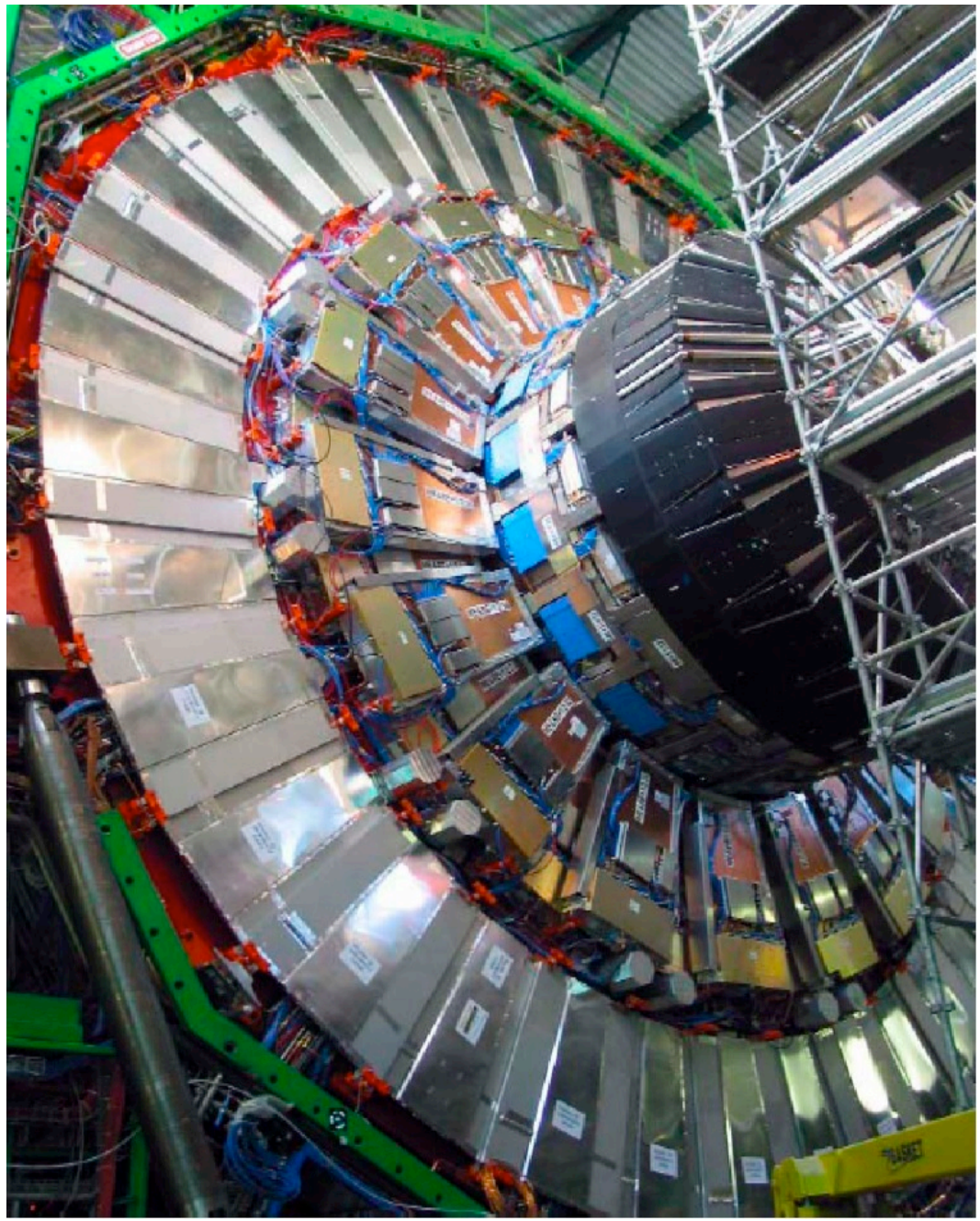


Installation complete

Resistive Plate Chambers

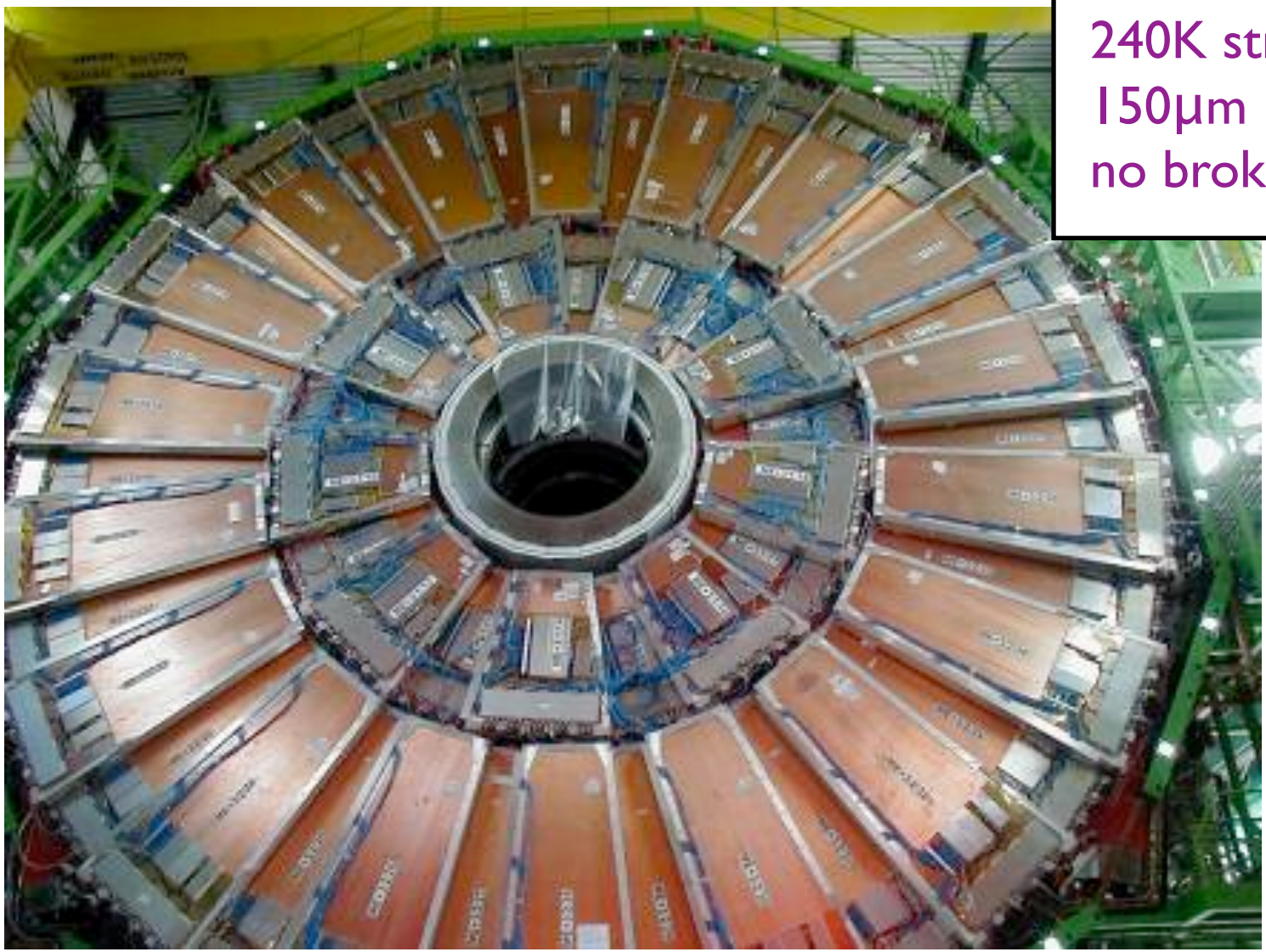
RPC (Independent Trigger)
Course position, fine timing
Barrel 80K channels
Endcap 92K channels

Installation complete



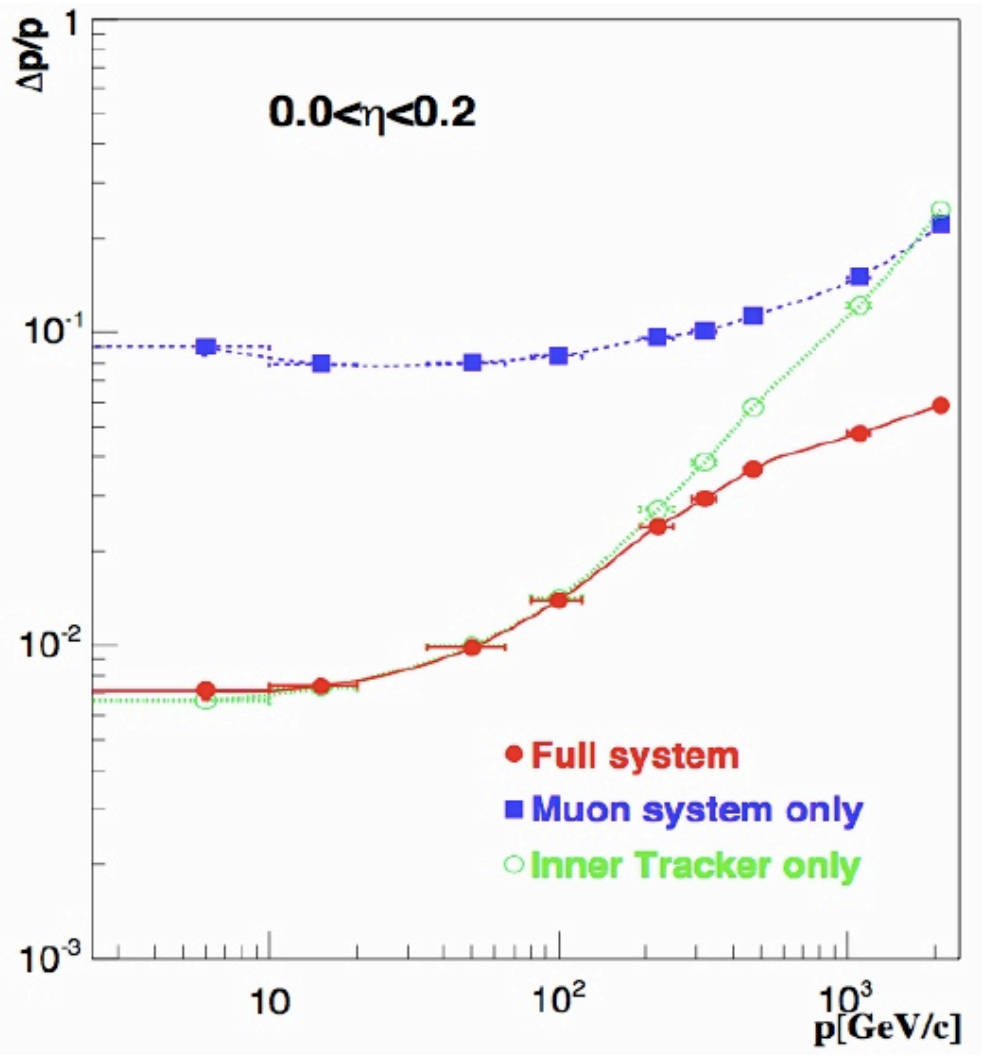
Cathode Strip Chambers

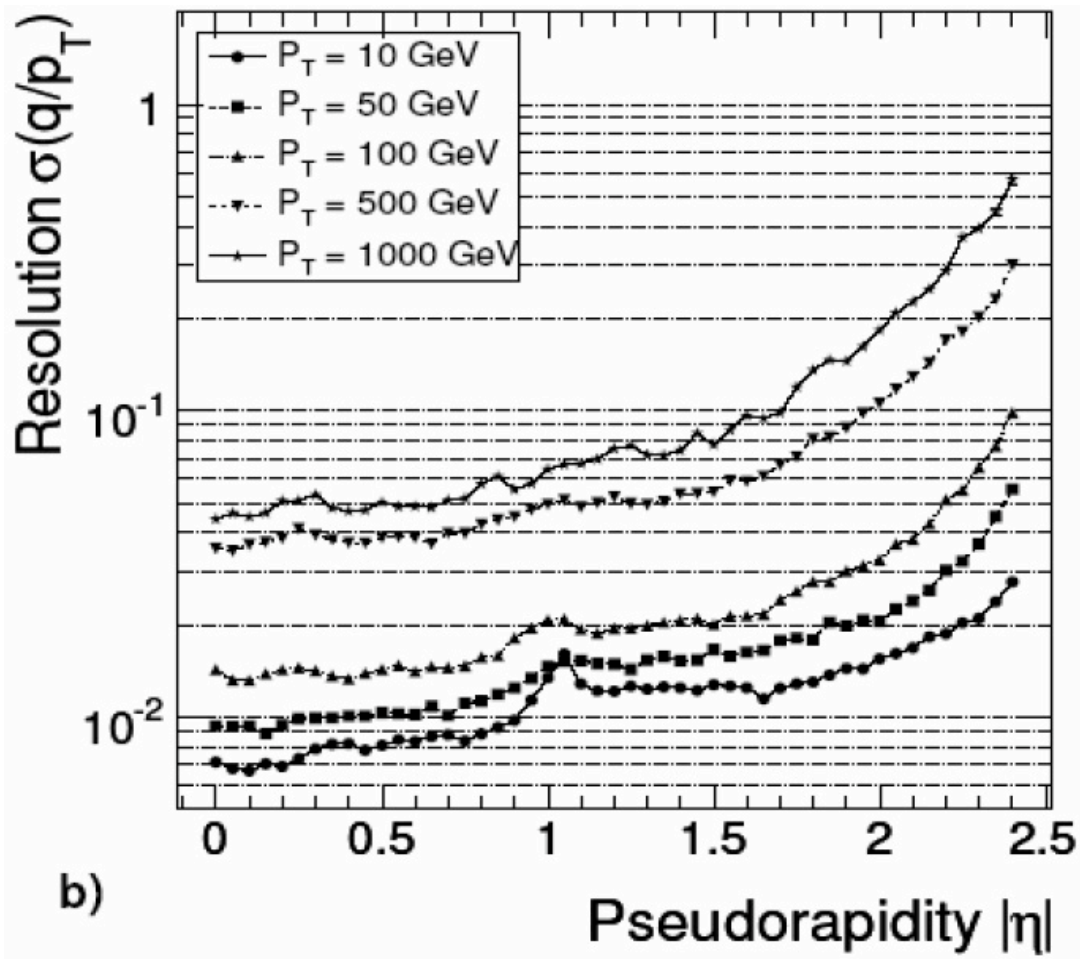
CSC
468 Chambers
240K strips
150µm Resolution
no broken wire out of 2M



Installation complete

Muon momentum resolutions

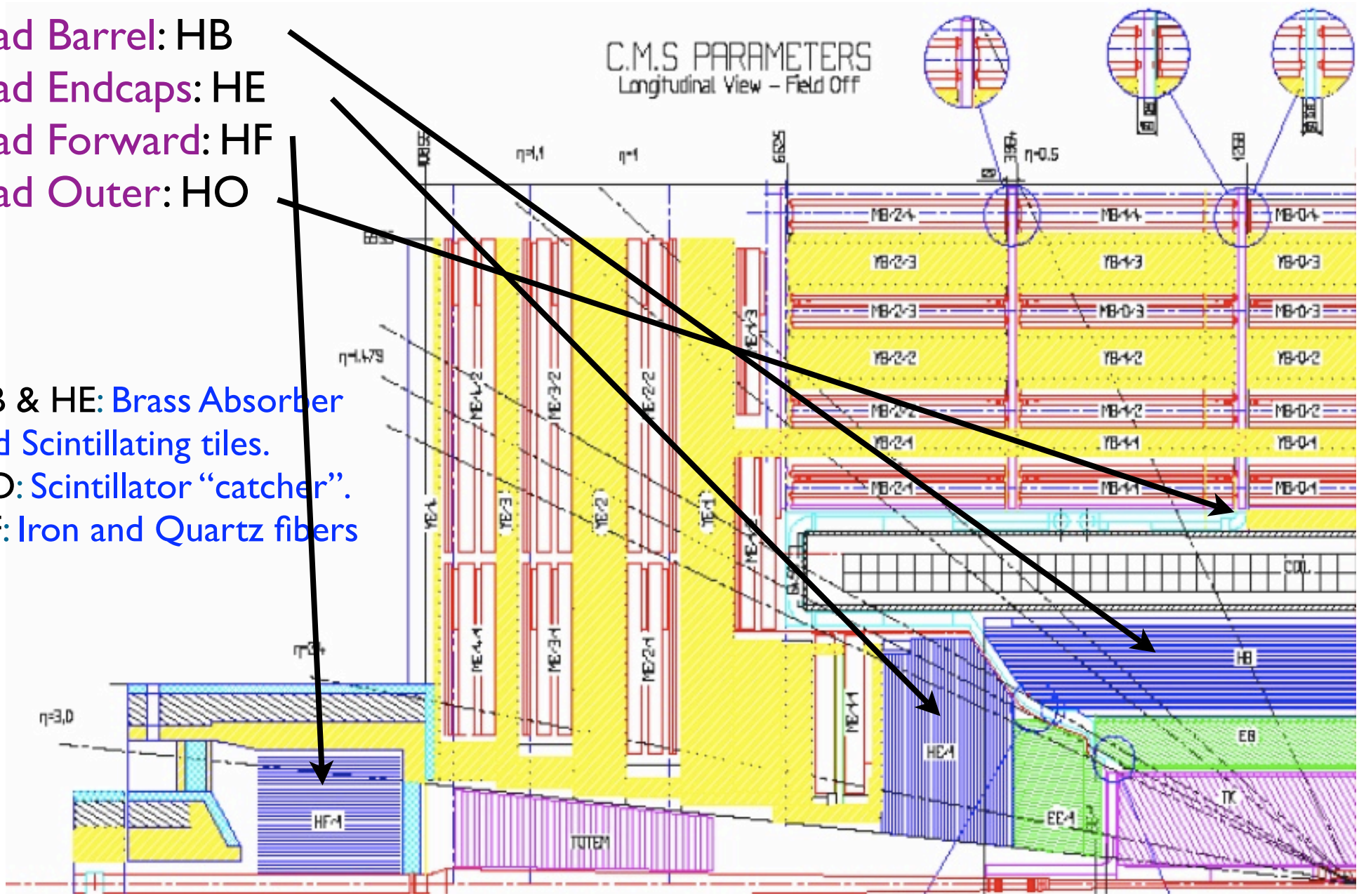




Hadronic calorimeter

Had Barrel: HB
Had Endcaps: HE
Had Forward: HF
Had Outer: HO

HB & HE: Brass Absorber and Scintillating tiles.
HO: Scintillator "catcher".
HF: Iron and Quartz fibers



HCAL system

HB: |η|<1.3
HE: 1.3<|η|<3
HF: 3<|η|<5
Very Fine Granularity:
Δφ x Δη = 0.087x0.087
for |η|<1.7

HF: 3<|η|<5
Δφ x Δη =
0.174 x13η towers

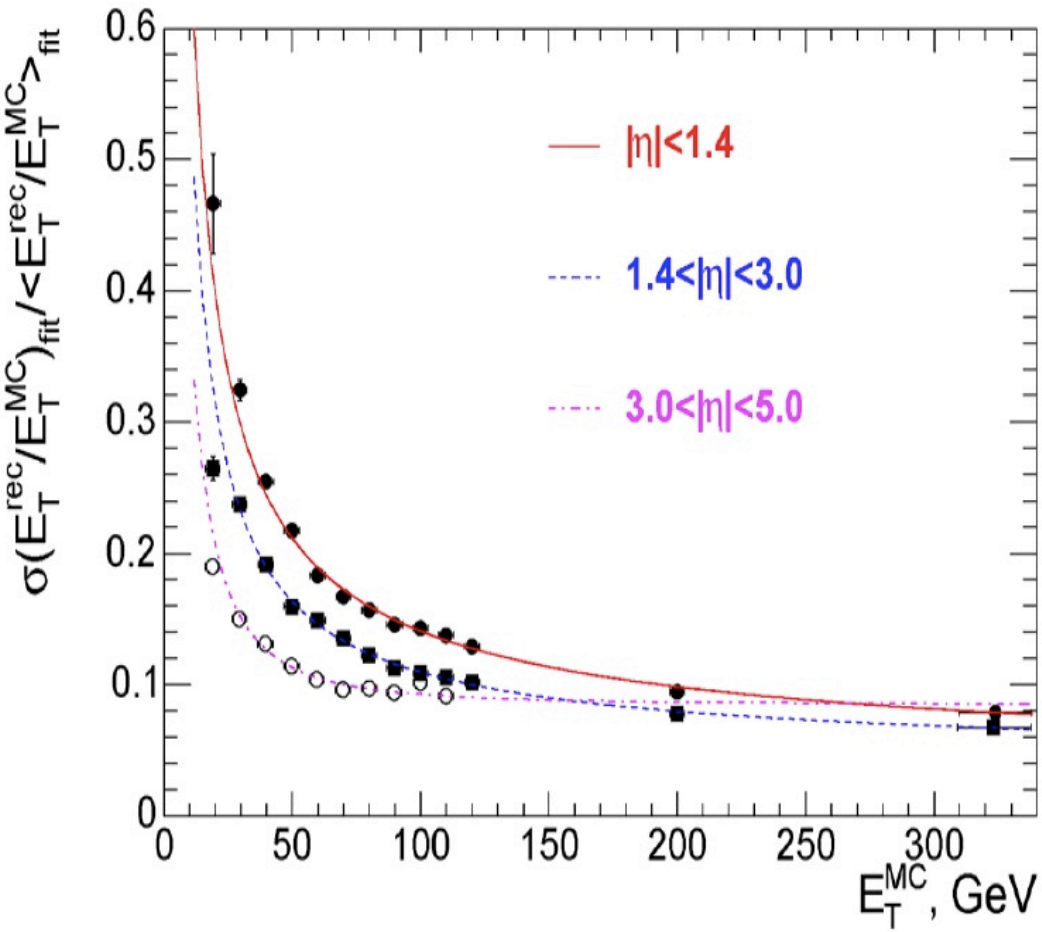
All source calibrated to < 5%

Installation complete

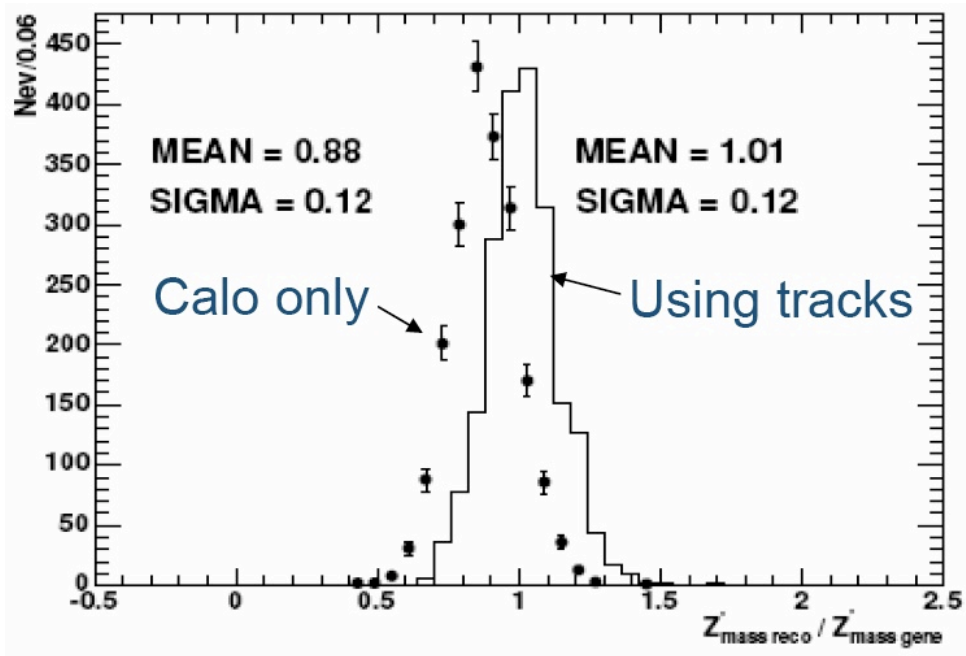
HB insertion

HCAL performance

Jet E_T resolution



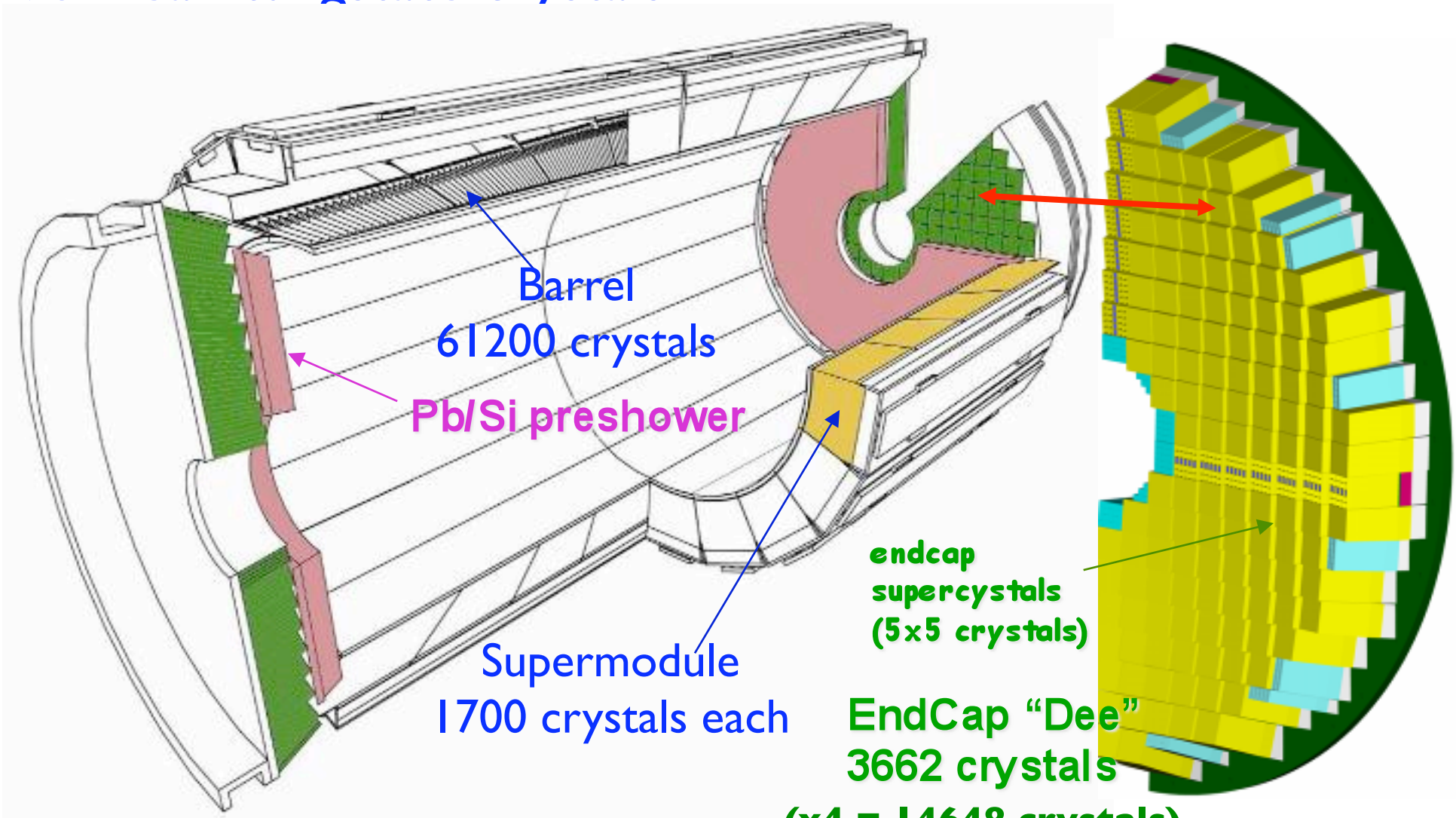
Mjj resolution at 120 GeV



Mjj resolution ≤ 15%

Electromagnetic calorimeter

>75k lead tungstate crystals

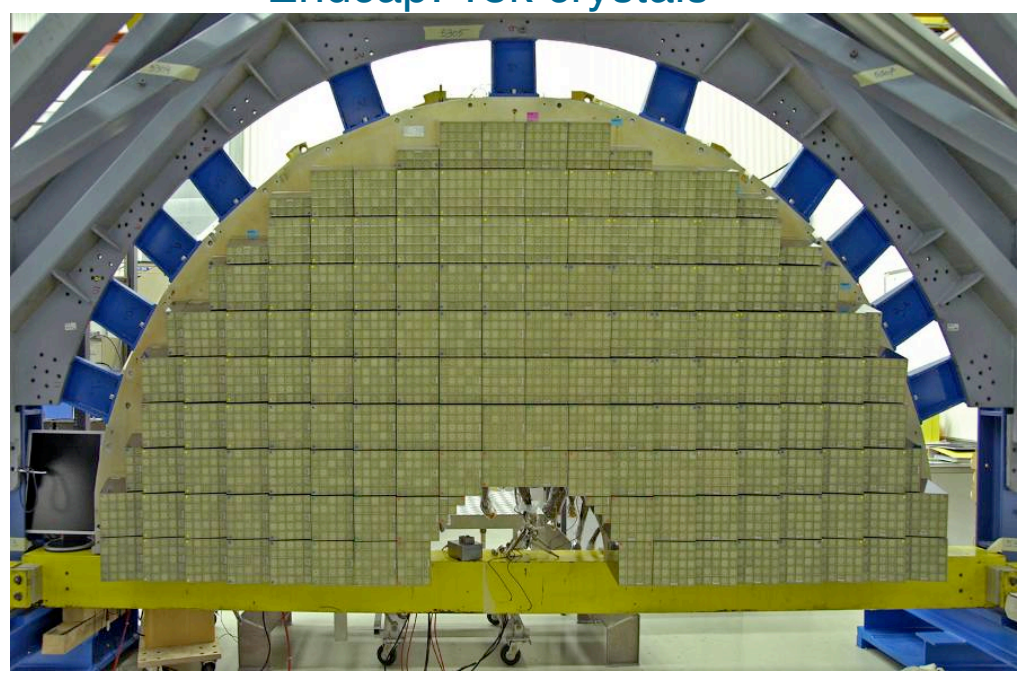


ECAL: status

Barrel installed
First endcap ready by mid June
Second endcap ready by mid July

Barrel: 36 Supermodules (1700 crytals each)

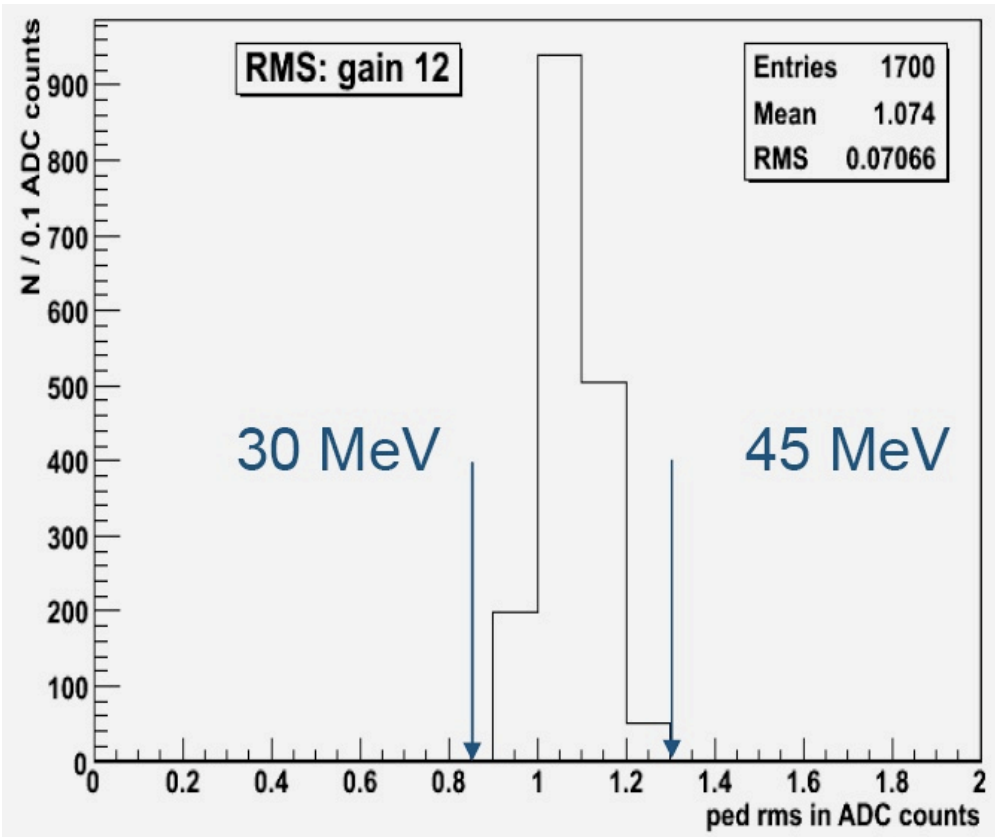
Endcap: 15k crystals



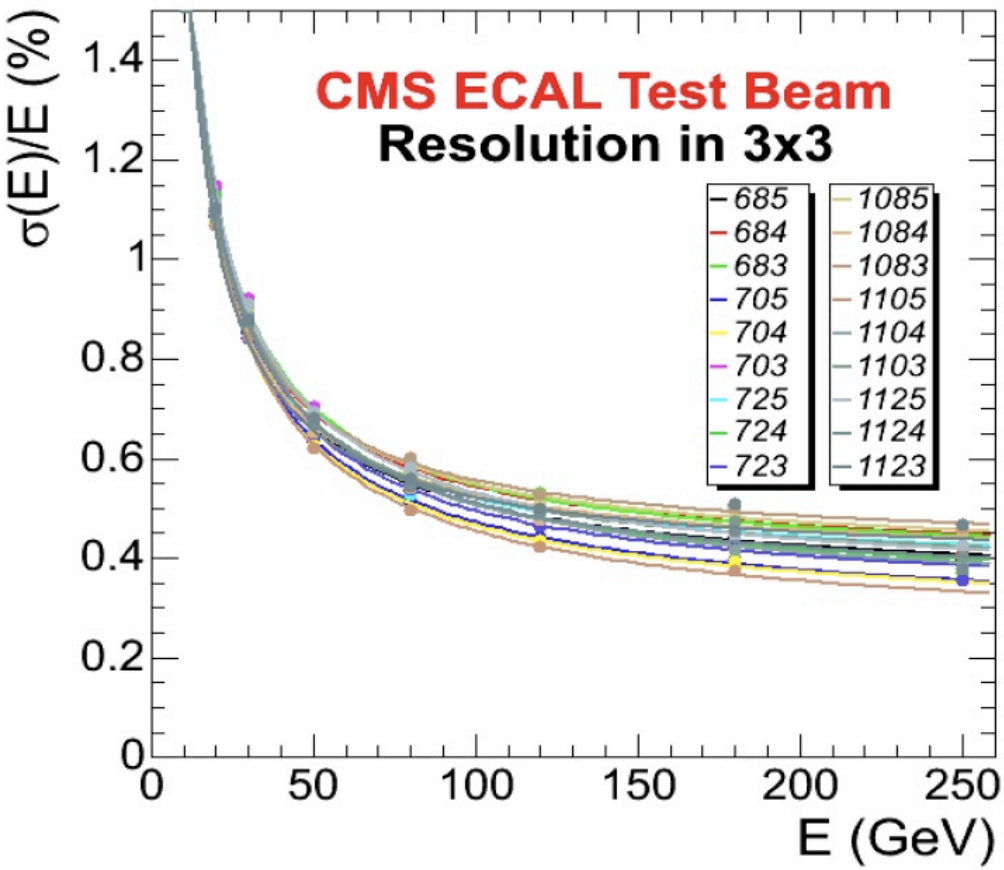
Every integrated Supermodule (barrel) is precalibrated with cosmic rays for ~ 1 week
< 2% accuracy on pre-calibration achieved

ECAL performance

Noise distribution

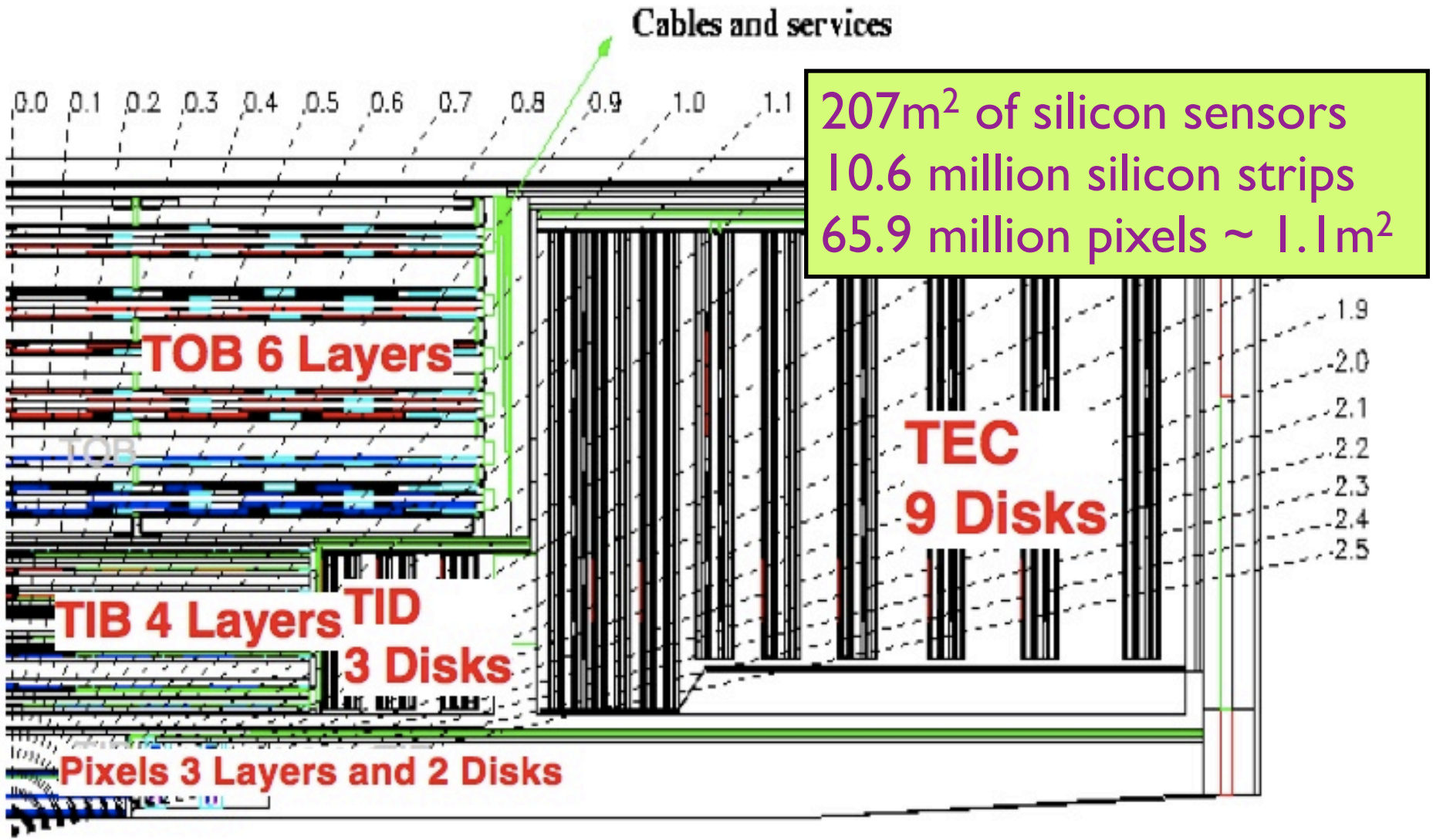


Energy resolution after calib.



From test beam analyses

Tracker status



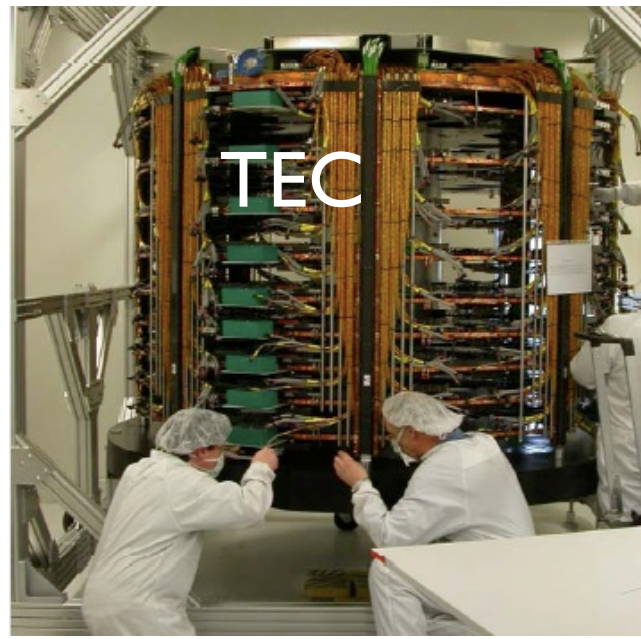
207m^2 of silicon sensors
10.6 million silicon strips
65.9 million pixels ~ 1.1m^2

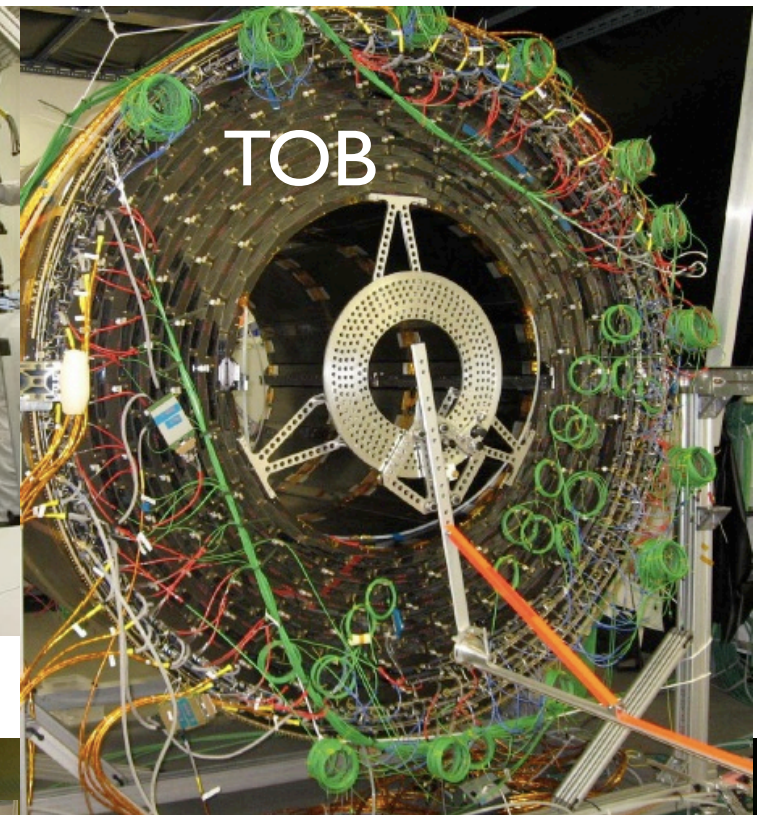
Pixels:
100 µm x 150µm
rφ and z resolution: ~15 µm

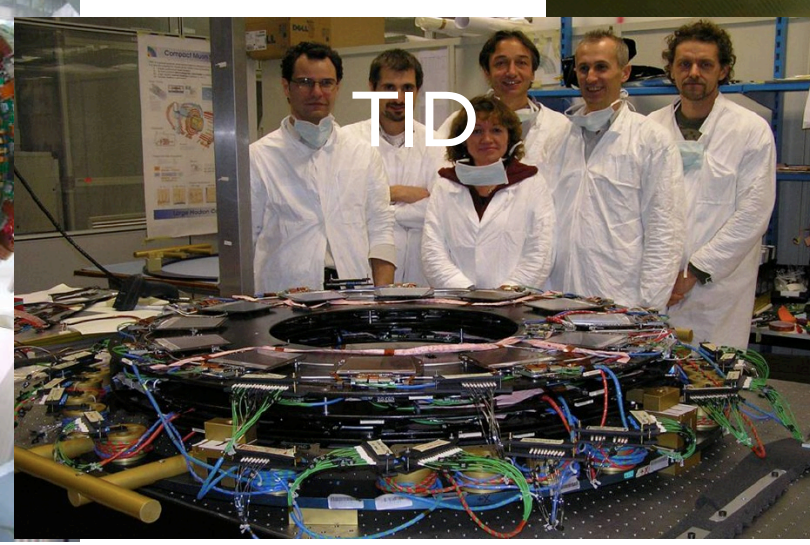
Strips:
Pitch: 80 µm to 180µm
Hit Resolution: 20 µm to 50µm

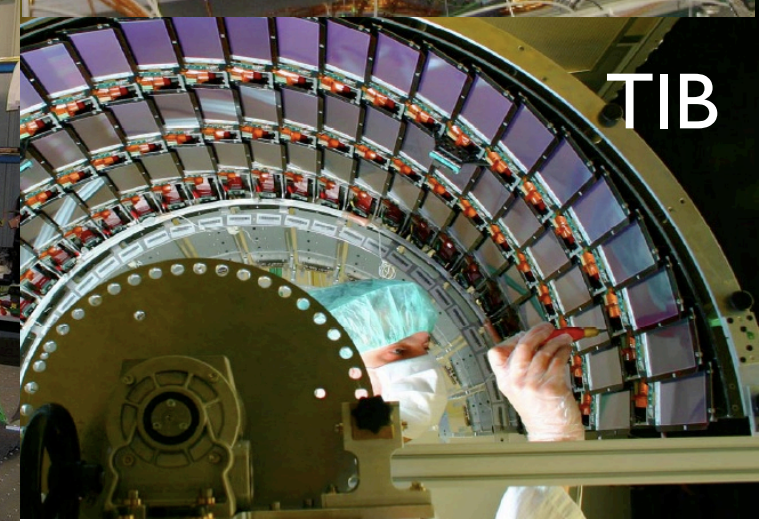
Tracker status

- Sistrip complete (inserted Dec. 2007)
- Forward pixel complete
- Barrel pixel ready end-May

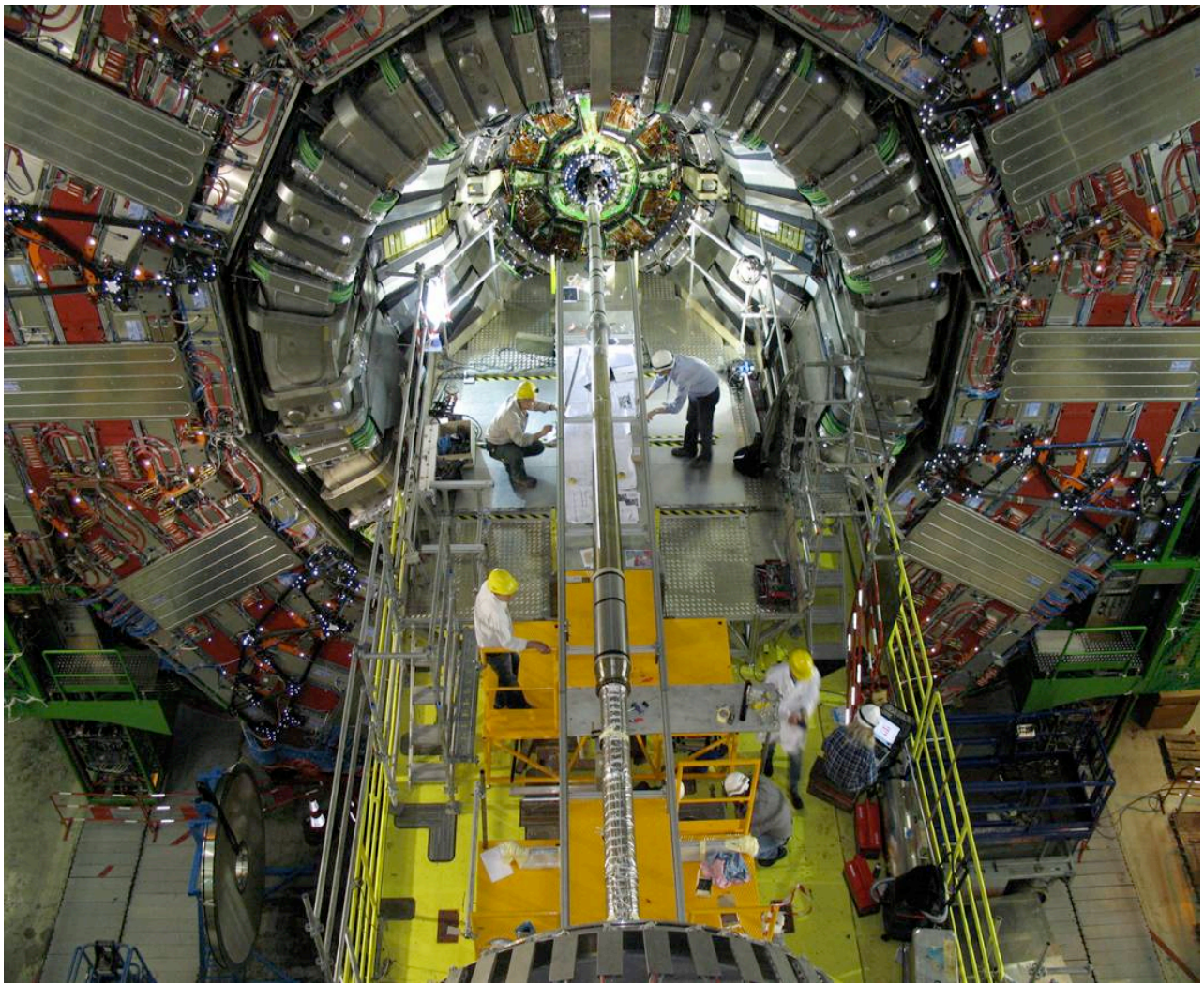






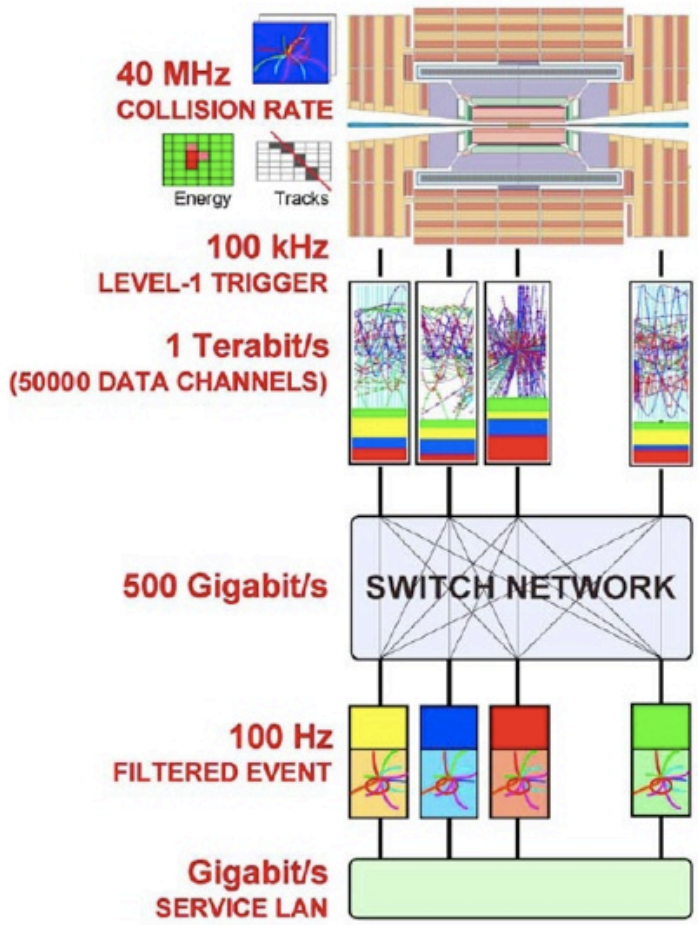


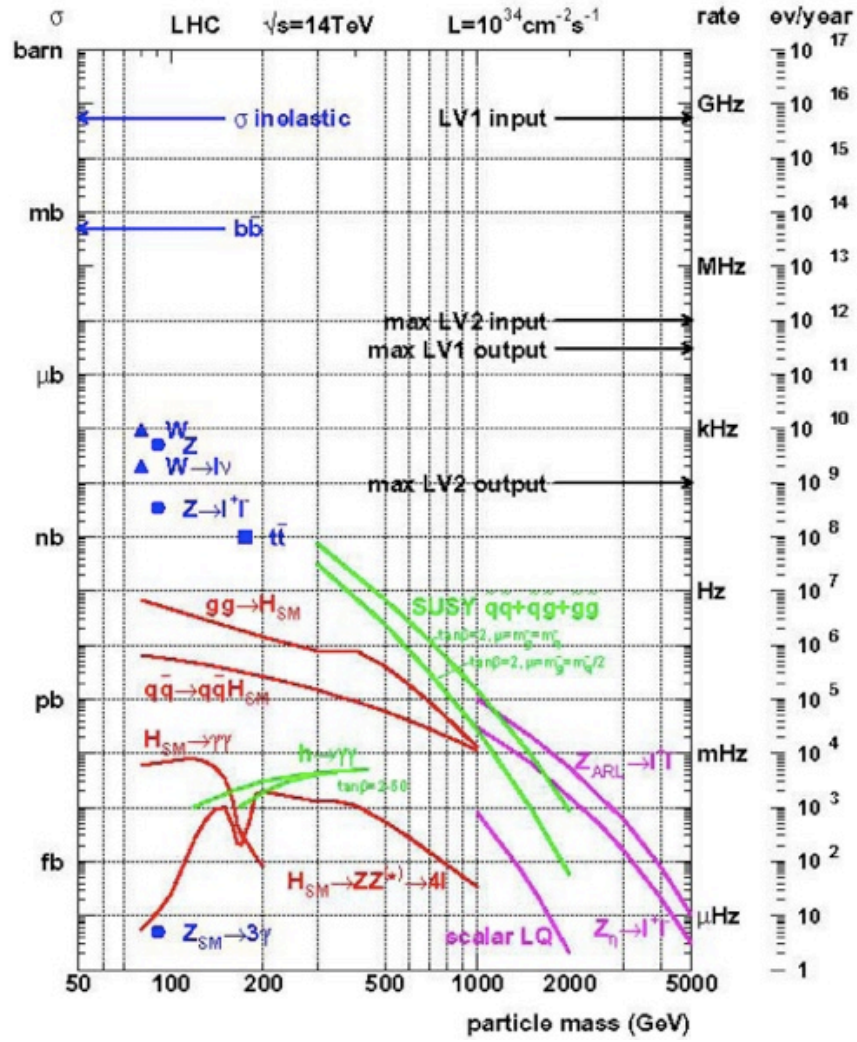
Beam pipe



- Beam pipe bake-out complete by mid-June
- Pixel will be installed just after
- One ECAL endcap to be installed after pixels
- Pixel mock-up insertion tried successfully

DAQ and Trigger





LV1 Trigger (3.2μsec Latency)

All hardware installed

Jet trigger being commissioned

HLT Trigger Farm

Data links completed

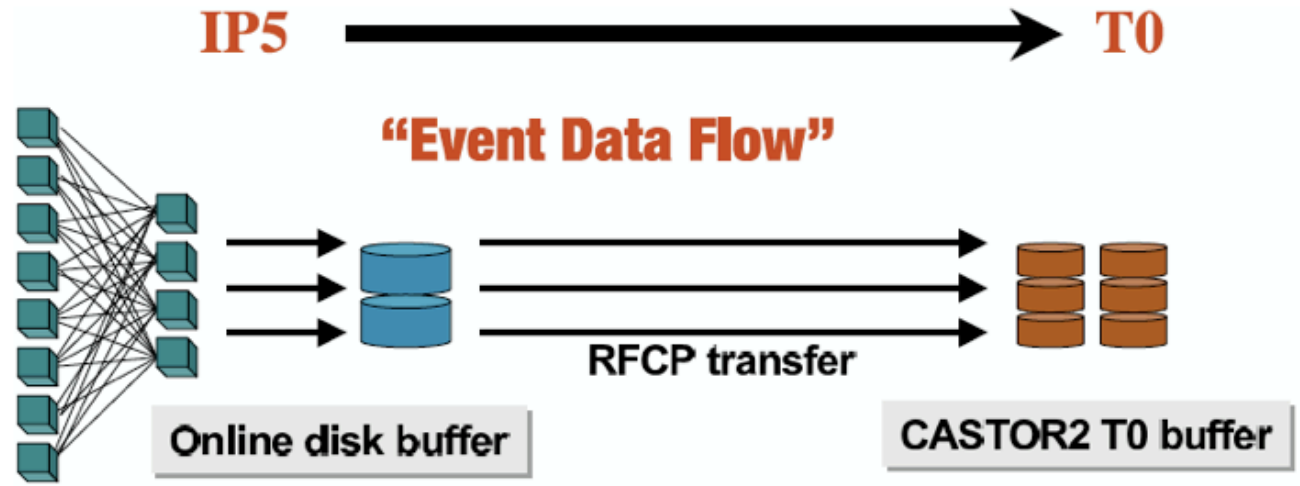
Storage managers commissioned

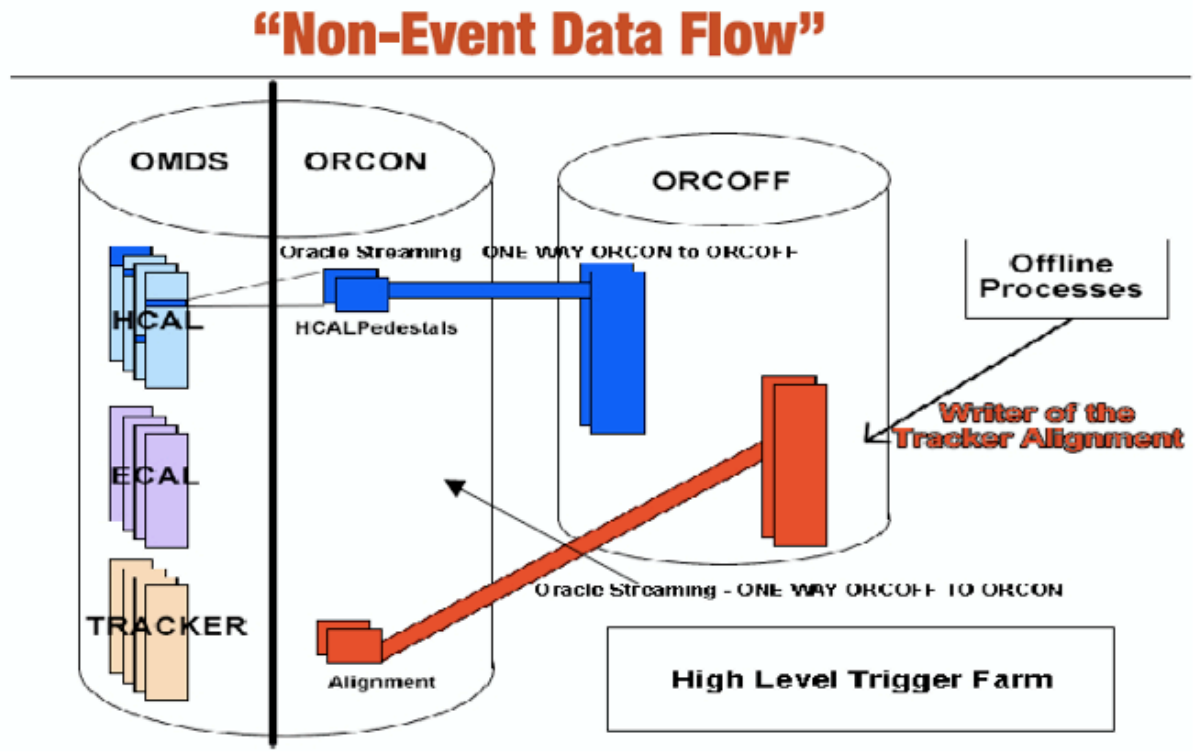
2008 target: 50kHz input

Dataflow design

Design proposed beginning '06 and tested during all software challenges and global runs:

- Magnet test
- Computing, Software and Analyses challenges '06, '07, '08
- Global and local runs since June '06





Lowering campaigns

From surface to pit: first HF's in Nov. '06

2 Nov

HF+ en route for UXC

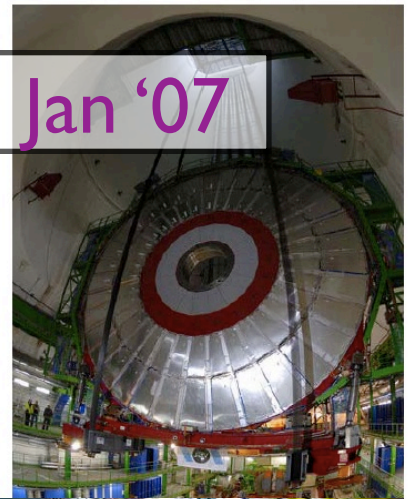
9 Nov

both HF in UXC

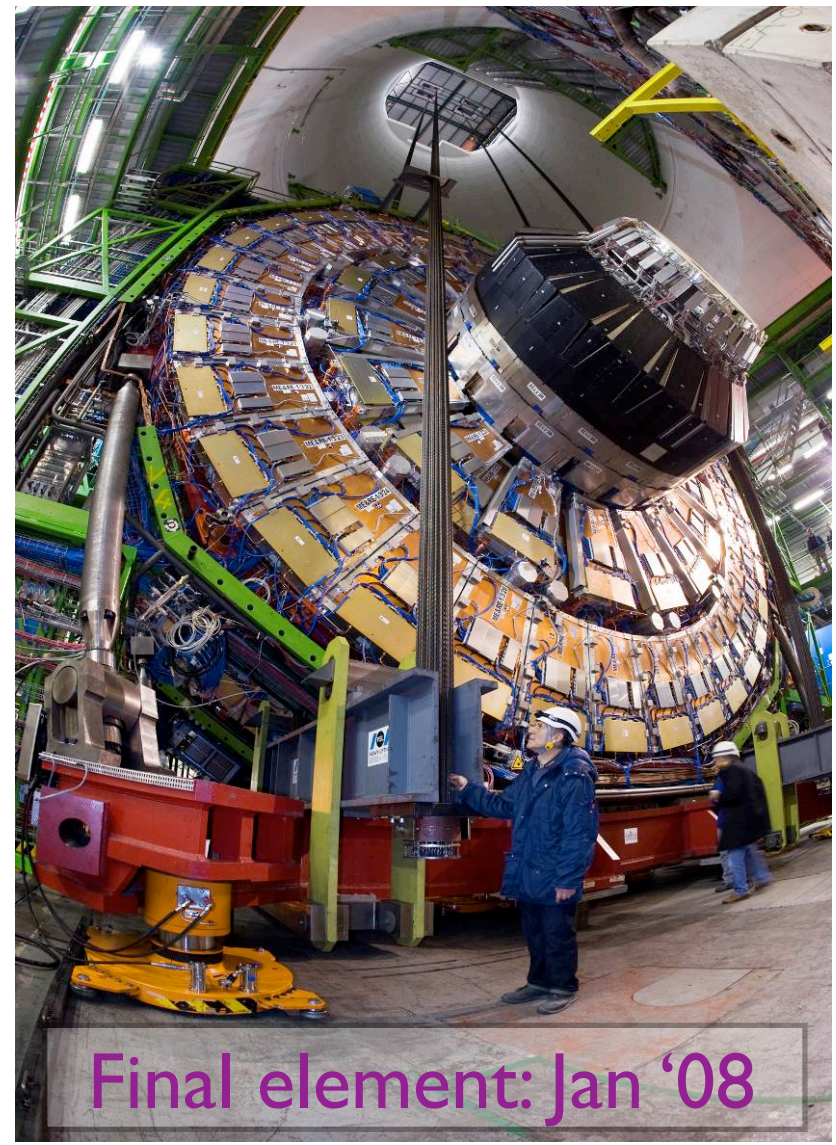
Lowering campaigns

Then all other 15 pieces, one by one....

Endcap disks: Jan '07



Central yoke: 2000 tons
Feb '07



Final element: Jan '08

Achievements

An intermediate reminder from the outline (what's next?)

Magnet Test and Cosmic Challenge

Tracker Integration Facility and Test beams

Computing and Software Challenge

"Local" and "Global" Runs

MTCC campaigns

MTCC = Magnet Test and Cosmic Challenge

Original aim:

closure of the yoke

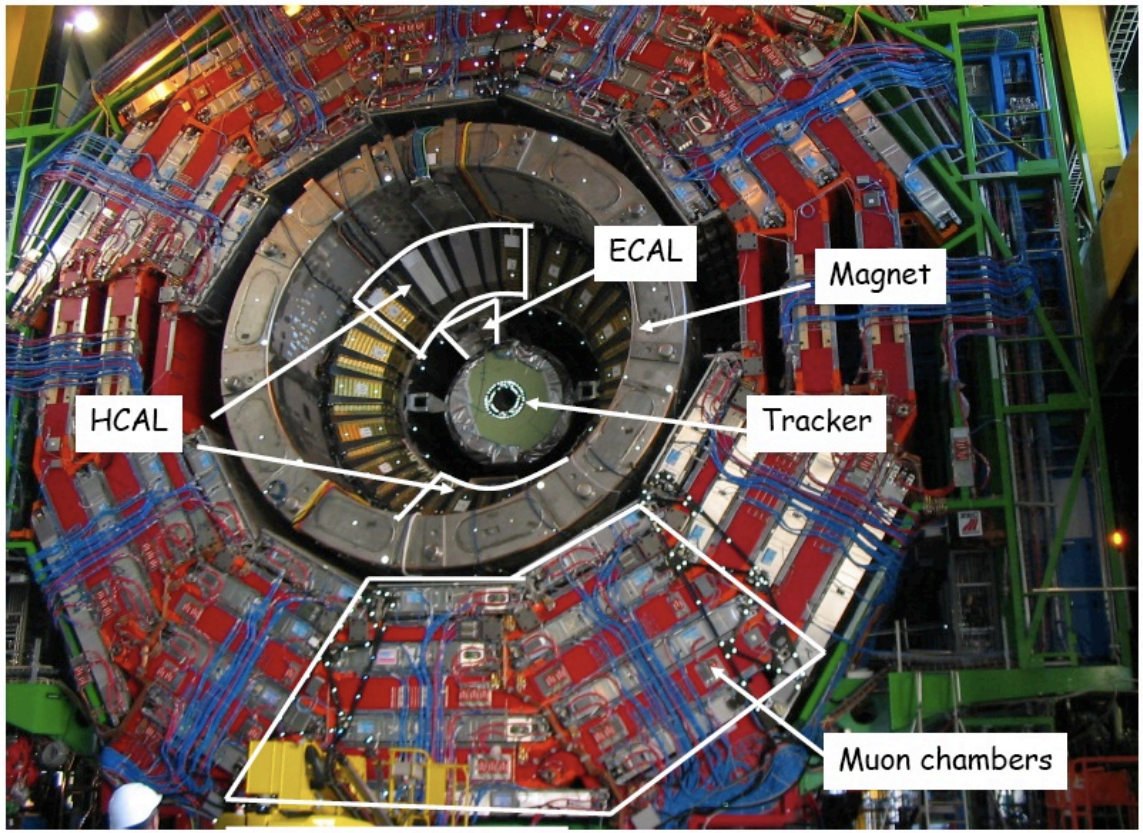
coil commissioning and mapping of the magnetic field

Scope extended to run 1/20 of CMS with all detectors (except tracker pixels) participating, with central controls, trigger and readout systems

MTCC was split in two phases due to incompatibility of field mapper with ECAL and Tracker

Phase I accomplished in August and phase II in November 2006

MTCC participation

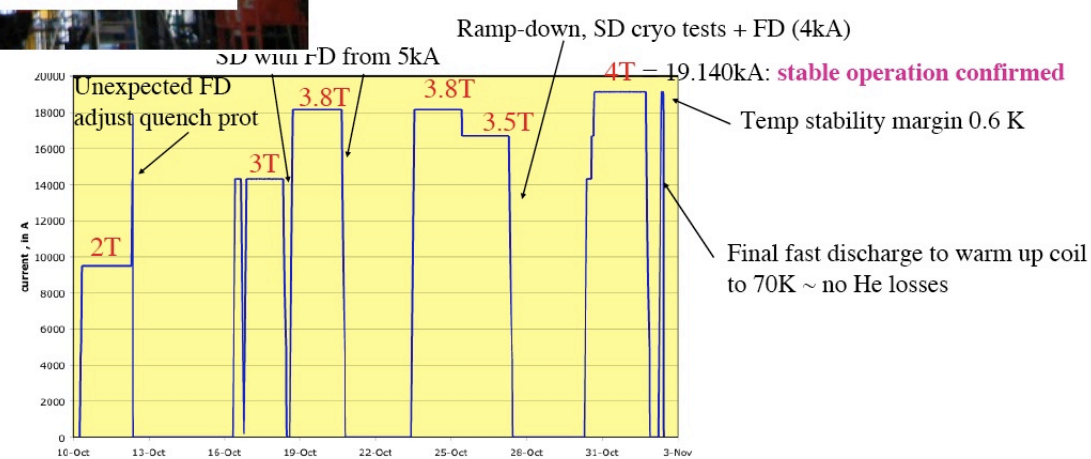


Subdetectors:
Tracker, ECAL, HCAL, muon (DT, CSC, RPC)

SX5 services:
gas, power, water, insertion

Central Systems
Magnet, Infrastructure (racks,closing and positioning systems), Low Voltage, Alignment, Trigger, DCS, DSS
DAQ (pre-series), DQM, databases, network, data storage & transfer, offline

Main objective (achieved):
➔Field-map (10^{-4})
Data sample: 250M events
Trigger rate: up to 200Hz in stable running

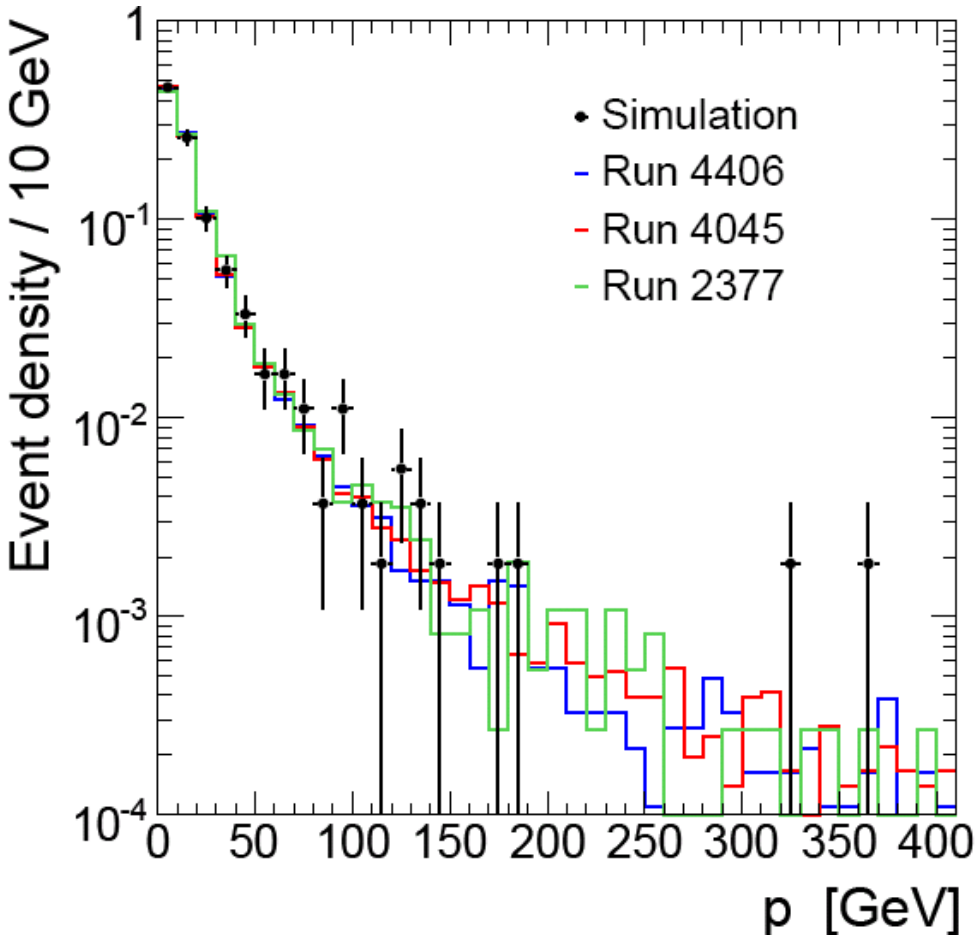


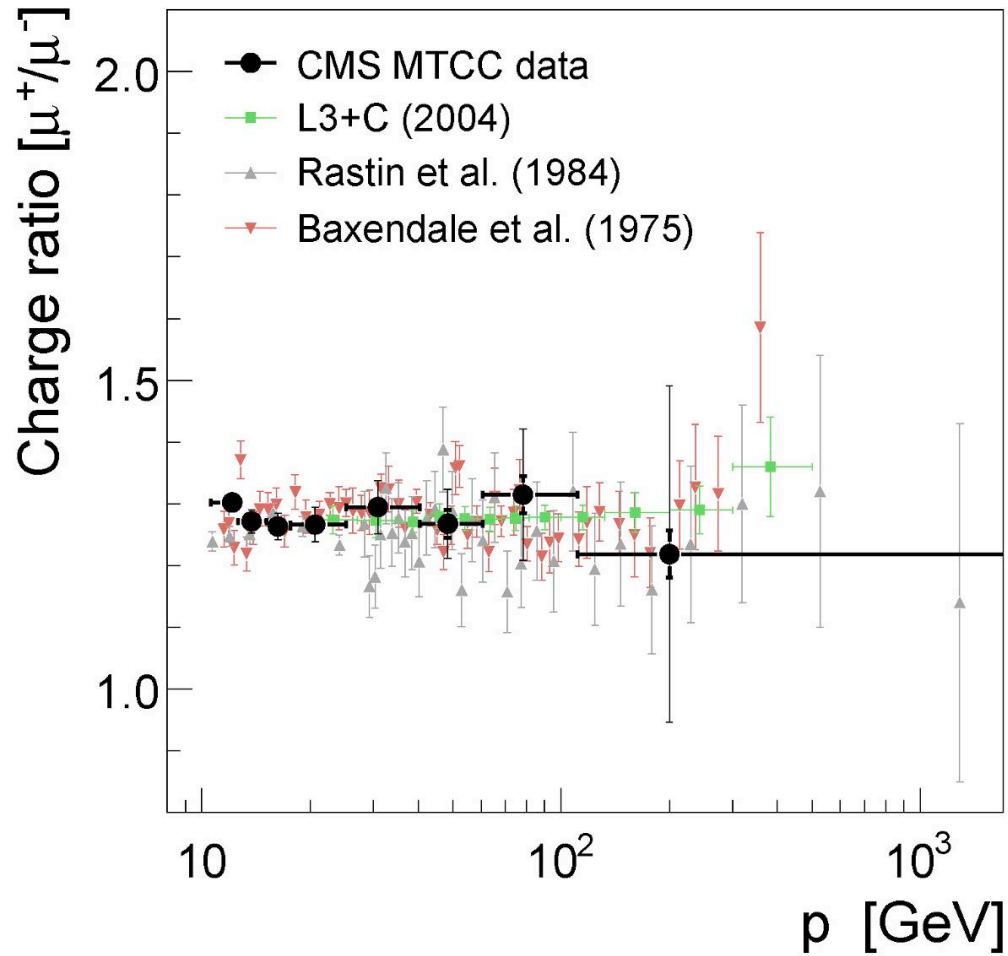
Field mapped at:

2.0, 3.0, 3.5, 3.8(twice) & 4.0 T with 0T references before and after

MTCC physics results

Cosmic charge ratio measurement



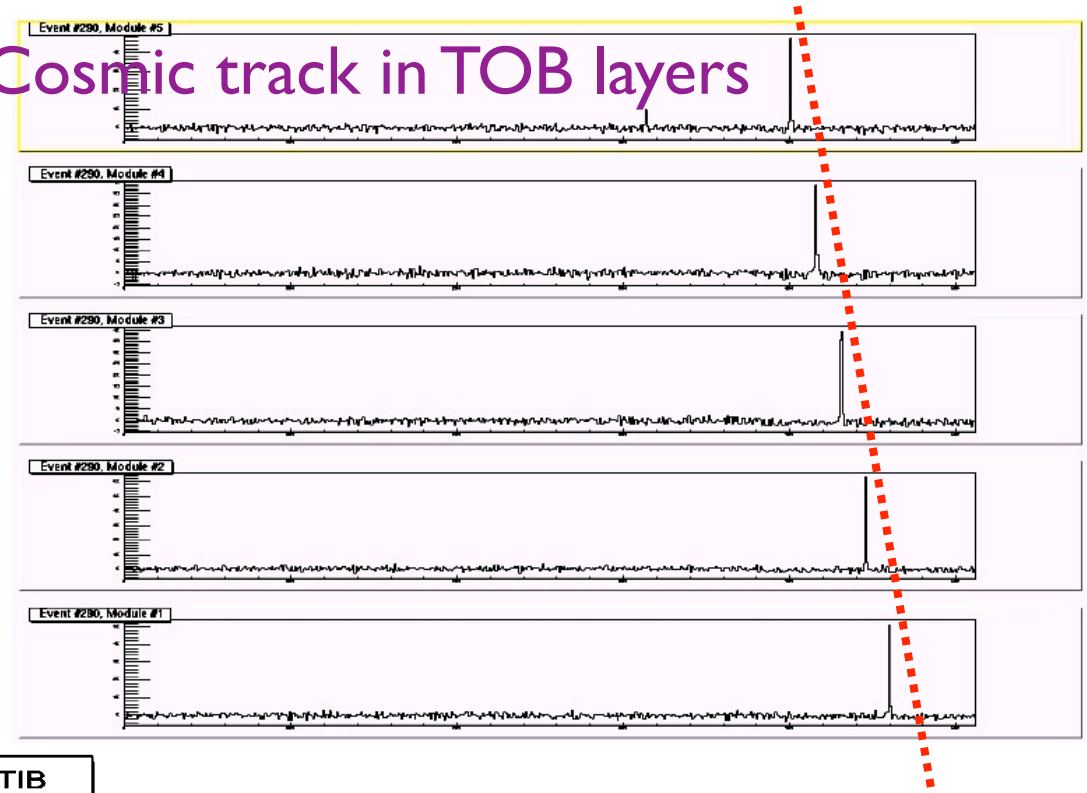


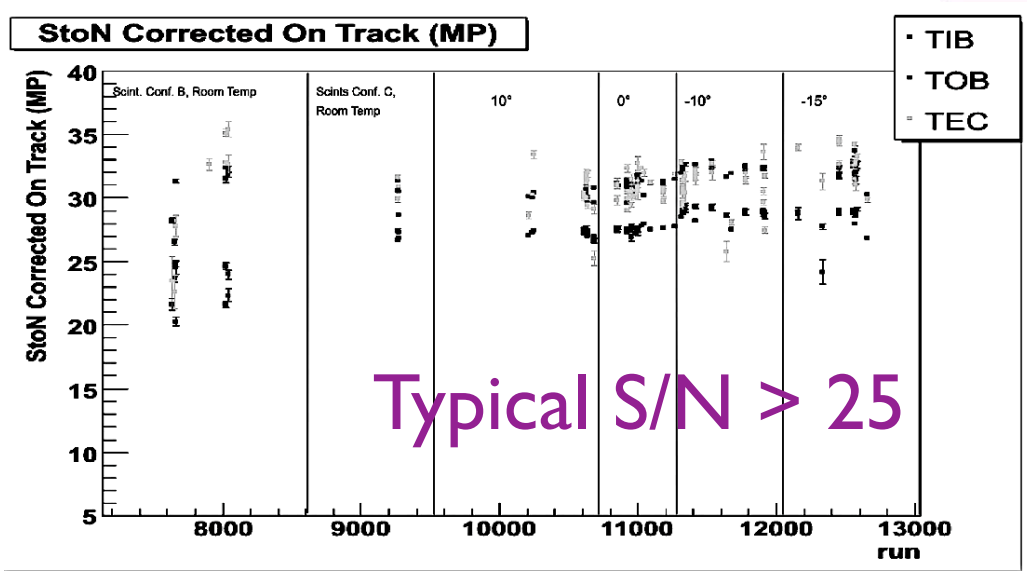
➔ *CMS Note 2008/016*

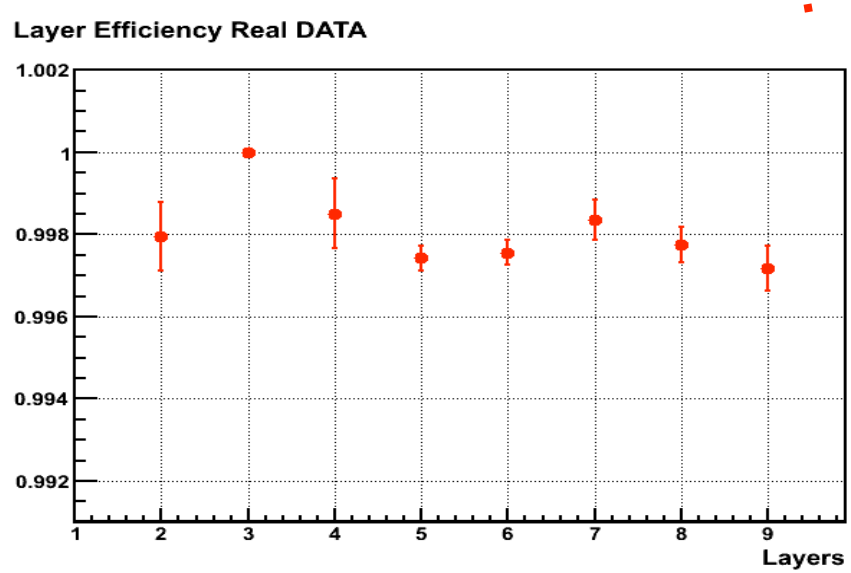
Tracker Integration Facility

From surface Tracker Integration Facility:

- 15% of full tracker integrated
- 5 million cosmics collected from Jan to Jul '07
- efficiency for single cosmic track > 99.7%



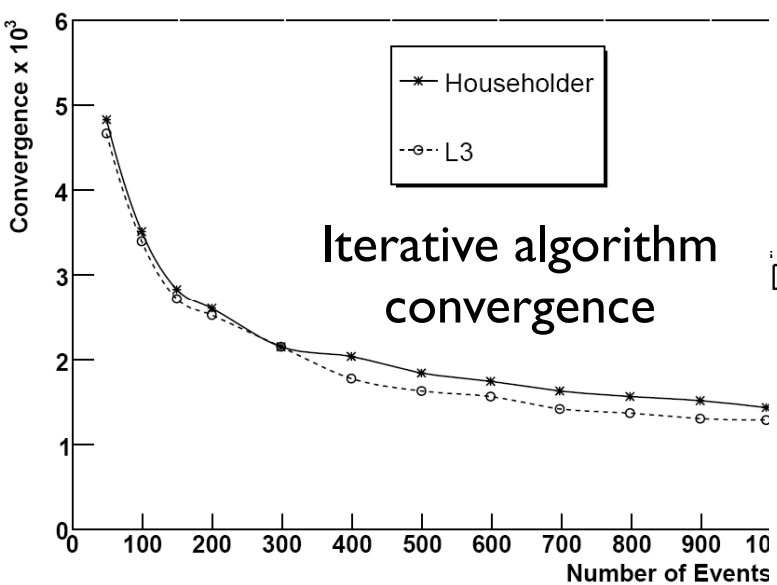


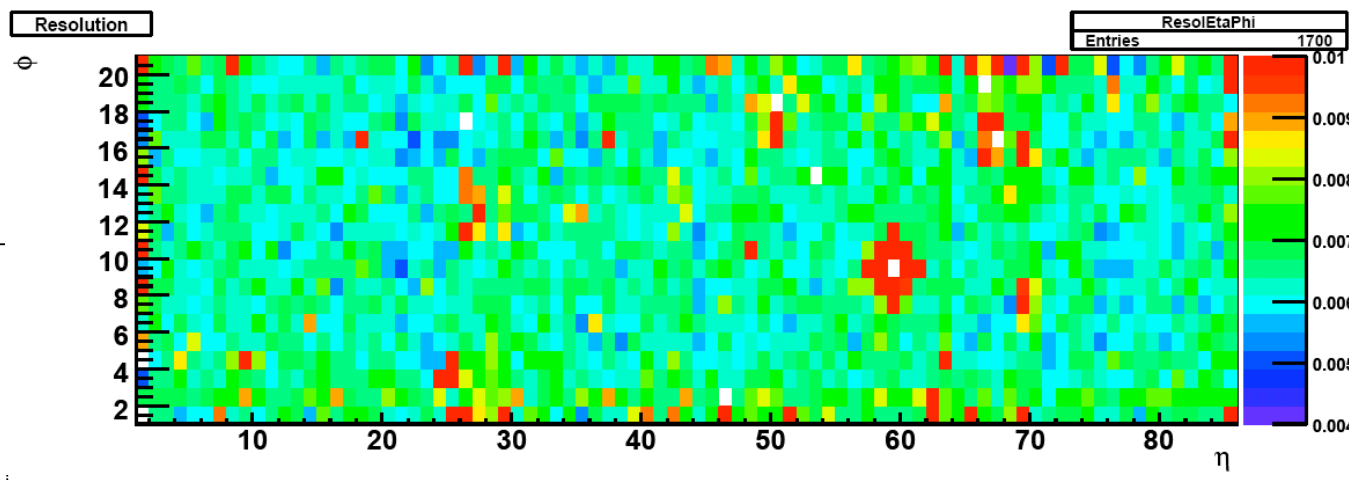


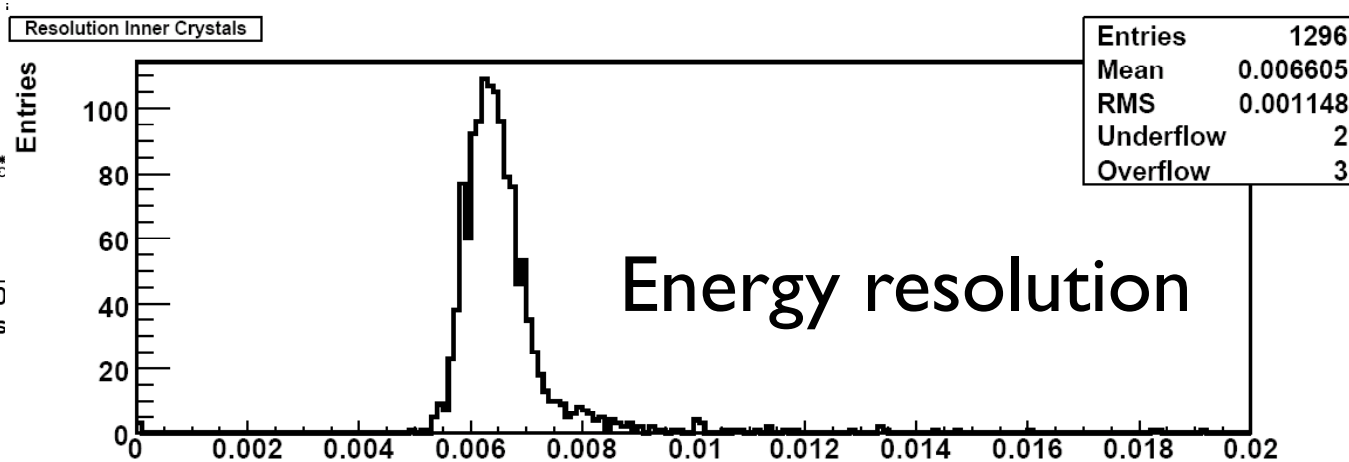
Test beams for calibration/commissioning

ECAL test-beam 2006: >15000 ECAL crystals calibrated

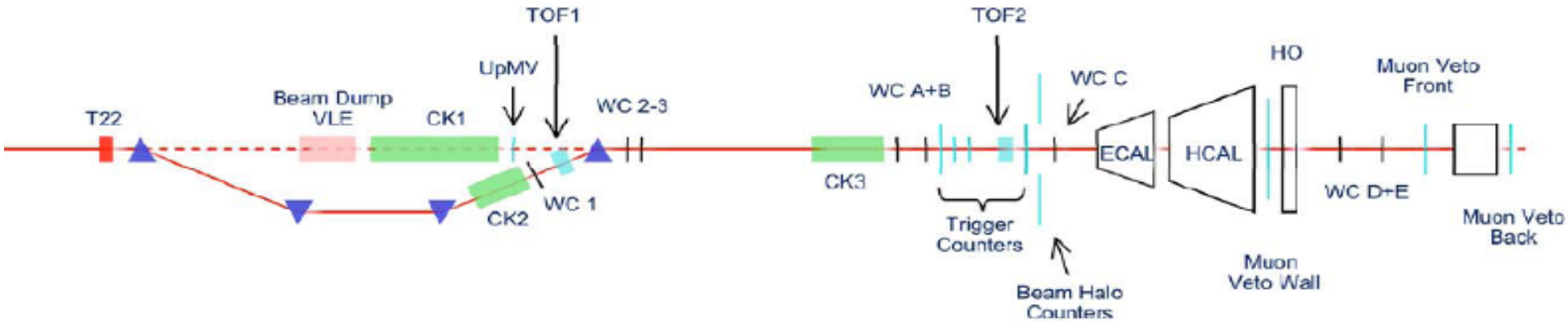
- Electrons of 120 GeV used to calibrated 25% of the entire ECAL (calibration at the startup).
- Maximum performance (0.6% resolution) reached.
- Same algorithms (code) as for "in-situ" calibration have been used.





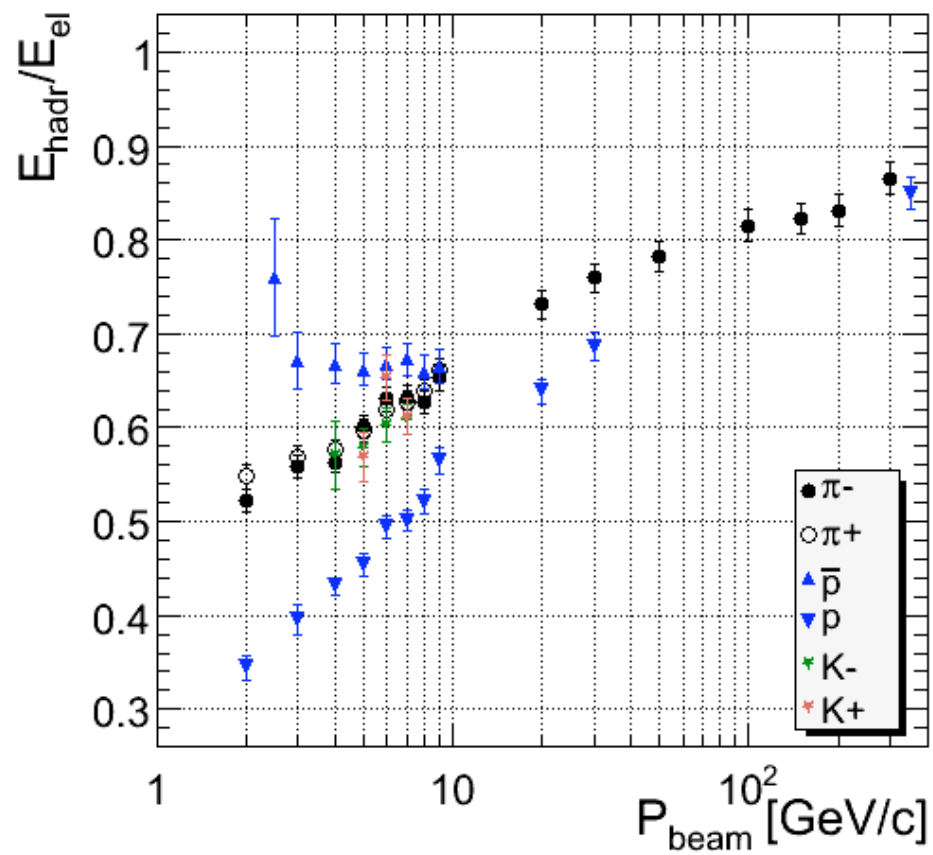


Test beams for calibration/commissioning



Combined ECAL/HCAL test beams in 2006 and 2007

- low energy: up to 2 GeV thanks do a dedicated target
- TOF and Cherenkov for particle ID
- Essential input for simulation tuning



Computing and Software Challenges

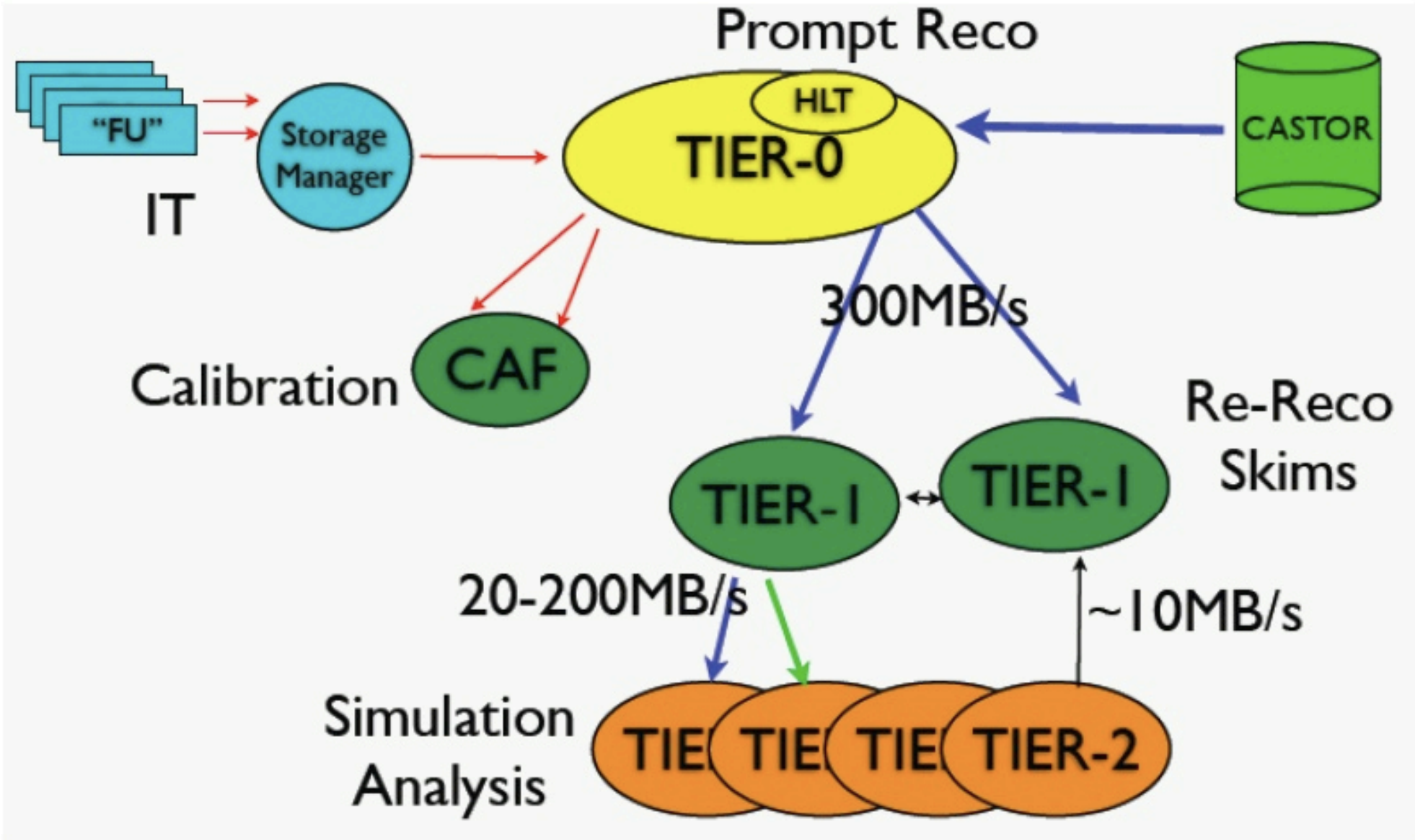
What they are:

- A several tens of million event exercises to test the workflow and dataflow associated with the data handling model of CMS
- Three major exercices: CSA06, CSA07, CSA08(ongoing)

Major components:

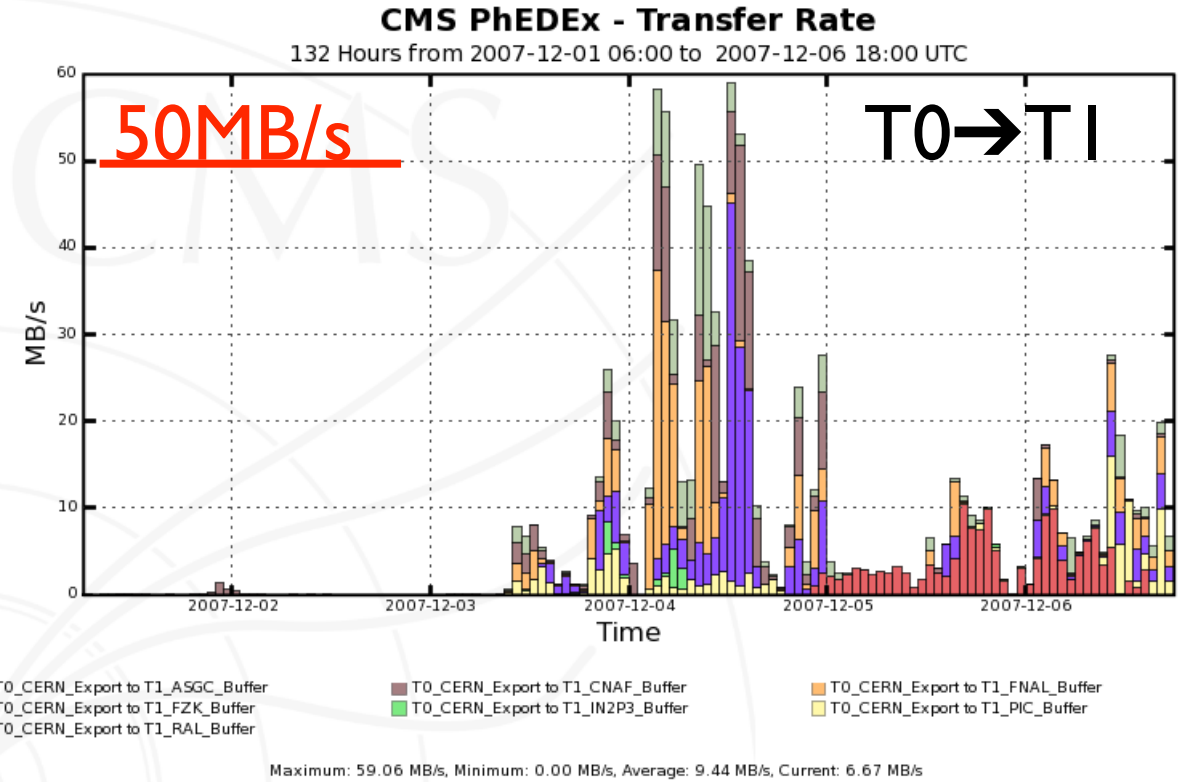
- Preparation of large simulated datasets (some with HLT-tags)
- Prompt reconstruction at T0:
  - Reconstruction at 40 Hz using "final" code
  - Derivation and application of calibration constants from offline Database
  - Generation of datasets
  - Splitting of an HLT-tagged sample into streams
- Distribution of datasets to all participating T1s
- Calibration jobs on AlCaReco datasets at some T1s and CAF
- Re-reconstruction performed at a T1
- Skim jobs at some T1s with data propagated to T2s
- Physics jobs at T2s and T1s on AOD and Reco

CMS data flow during CSA's

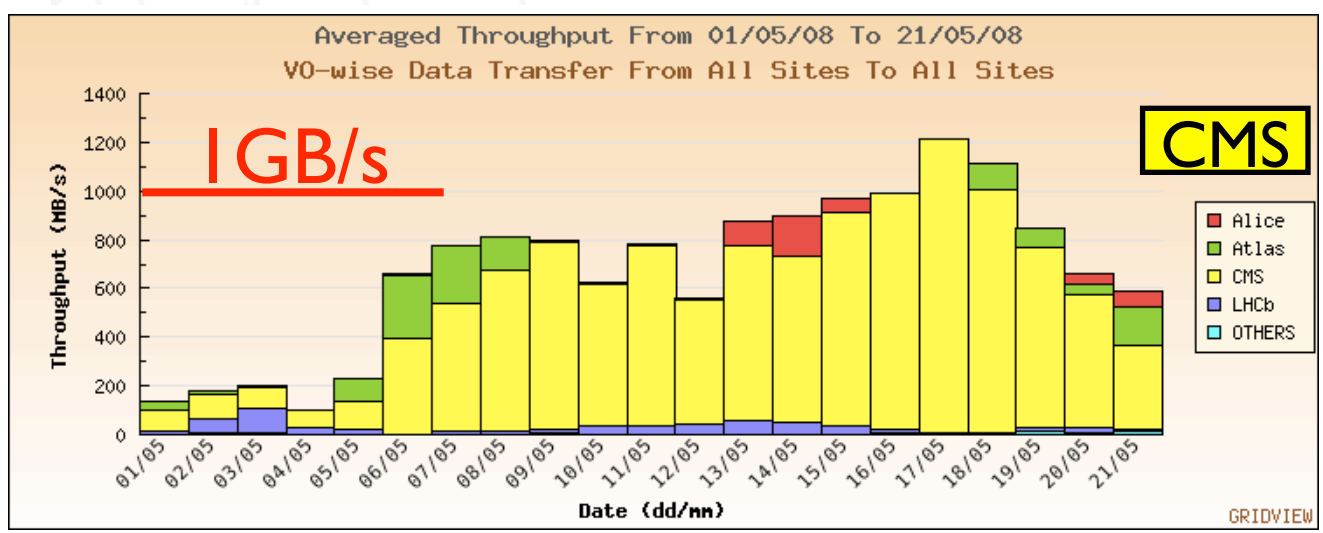


Data flow during computing challenges

Global commissioning runs



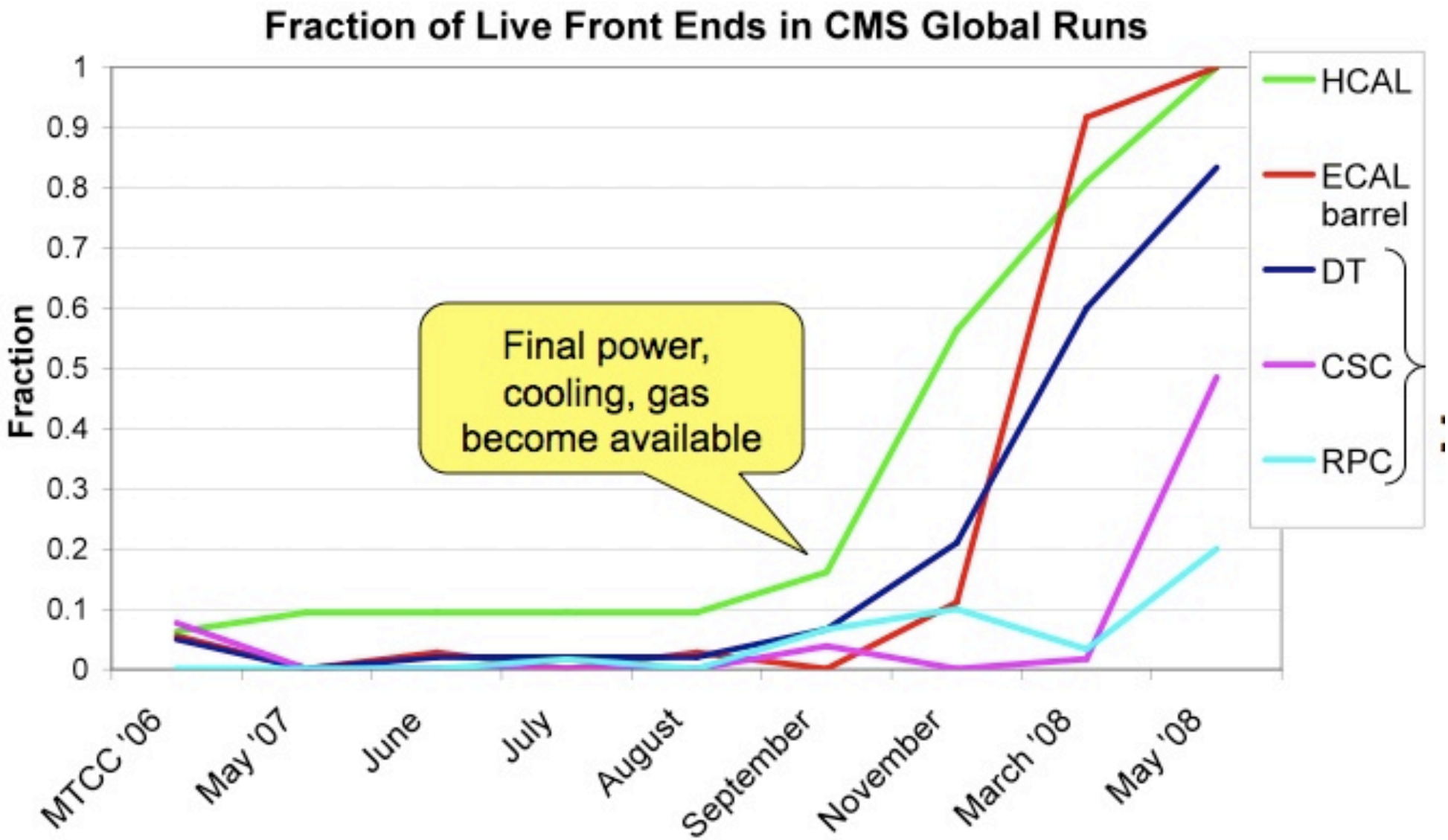
CERN combined computing challenge (this month)



"Local" and "Global" runs

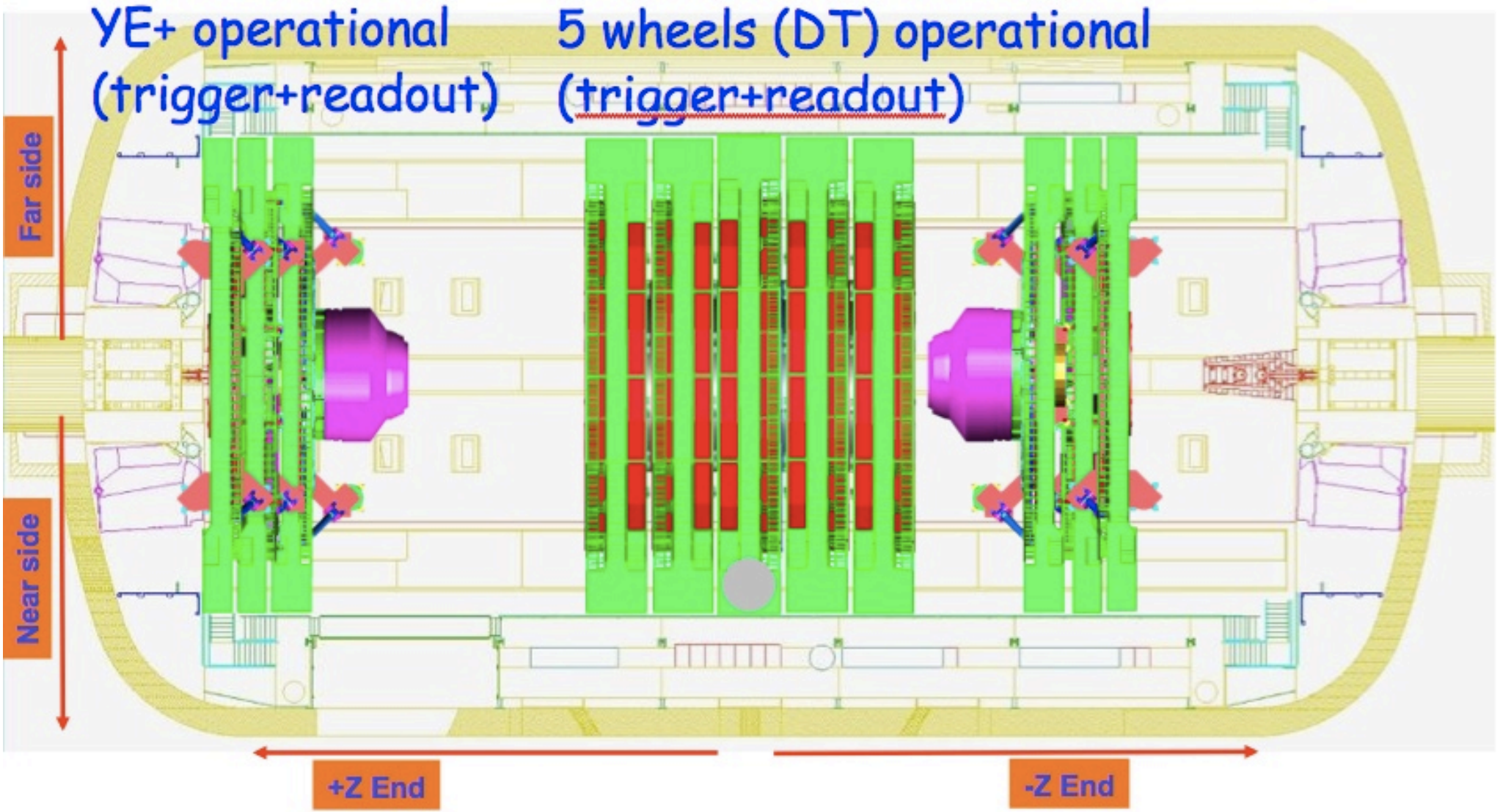
- Since May 2007, single detector commissioning activities ("local" runs) are alternating with major integration activities ("global" runs) lasting for ~10 days per month.
- Several millions of cosmic events are collected using the central DAQ system with increasing scale and goals.
- Run meetings are help regularly and shifts are scheduled both locally and remotely (pit, CERN, remote centres)
- Services, workflows and dataflows are kept as close as possible to collision physics mode

“Global” runs participation vs time



“Local” and “Global” runs

Geometrical configuration



Latest Global Run: CRUZET

CRUZET: Cosmic RUn at ZEro Tesla, 5-9 May 2008

Components:

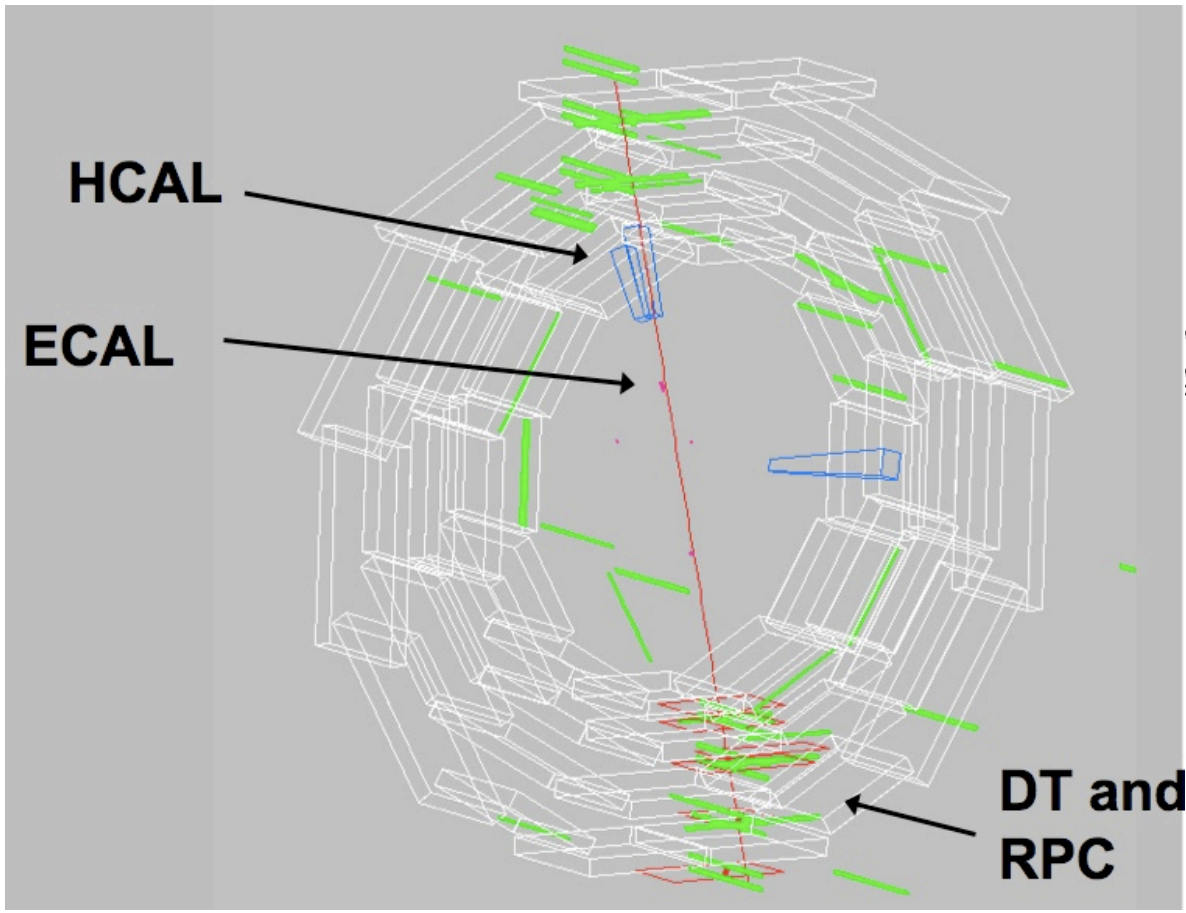
- ECAL 100%, HCAL 100%, DT 85%, CSC 50%,RPC 20%
- "Pixel in a box" (to exercise operation
- L1 triggers: muons, ECAL and HCAL mips plus abort gap triggers used for calibration streams
- HLT: several trigger menus, including the physics startup menu

Achieved goals:

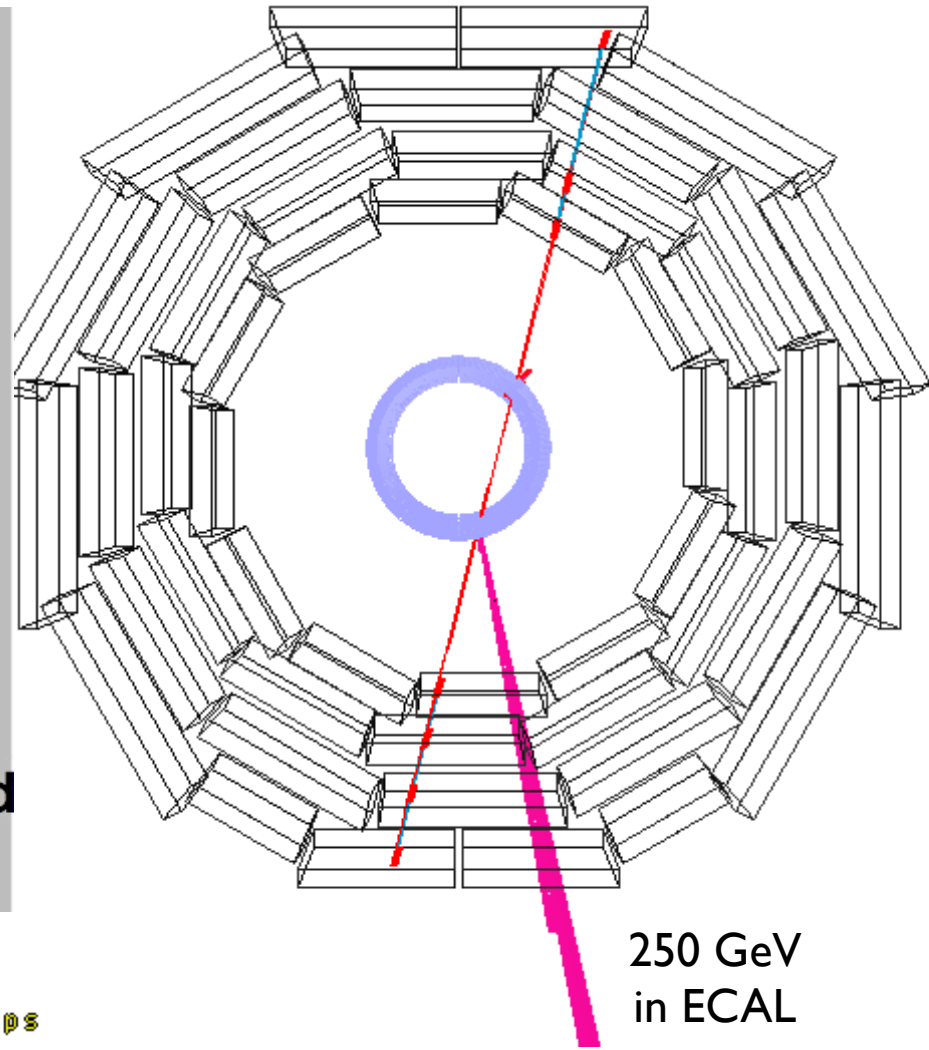
- Sustained runs (several hours) @ 240 Hz for a total of >30M events
- Online Data Quality Monitoring for shifters
- Prompt T0 reconstruction and monitoring (<1h delay)
- Prompt data transfer at CAF (Central Analysis Facility) for fast turnaround analyses
- Prompt calibration and reprocessing

Event displays from CRUZET

A muon coincidence

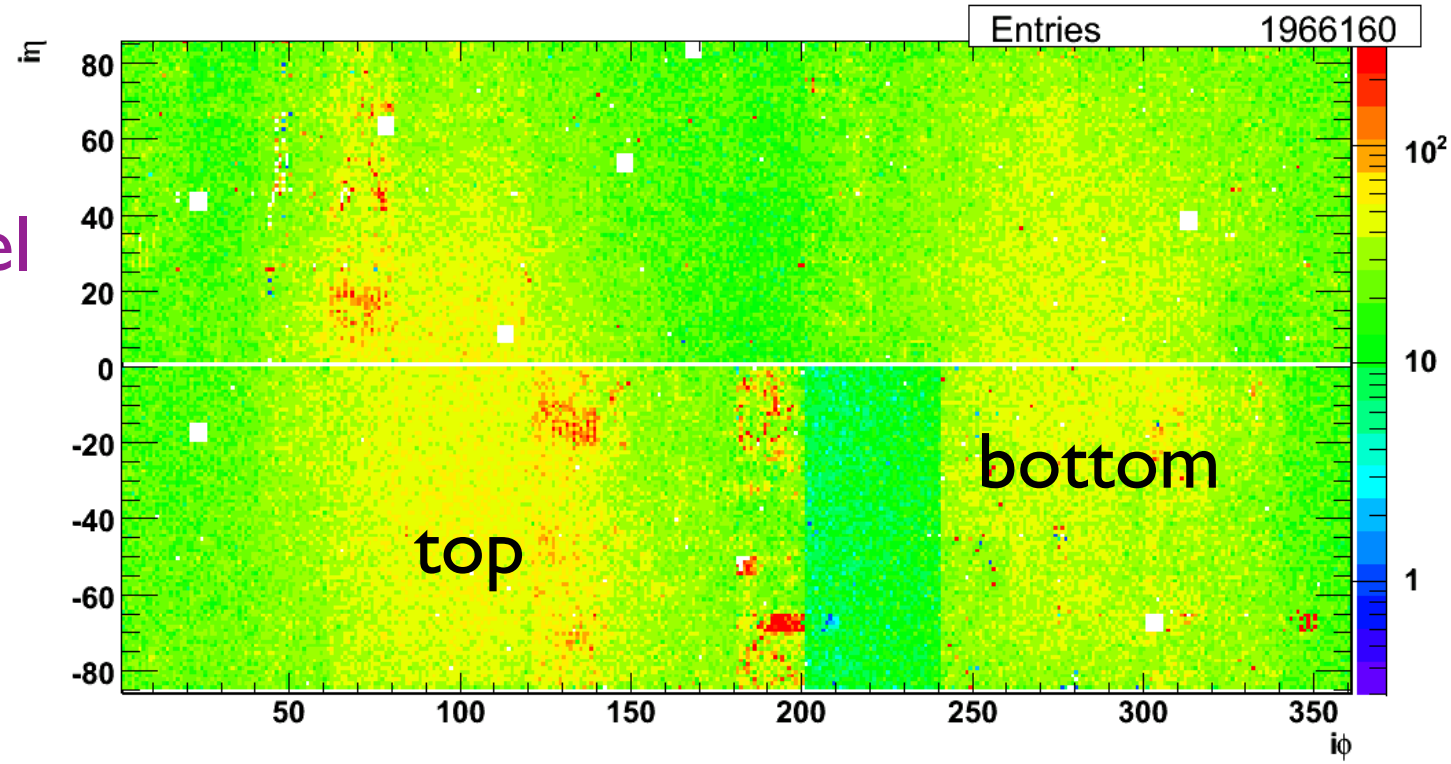


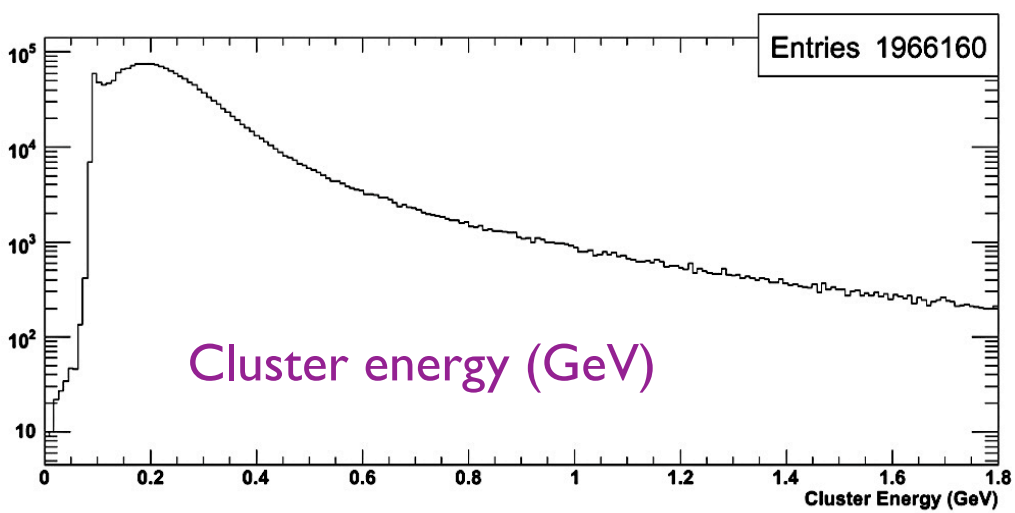
A showering muon

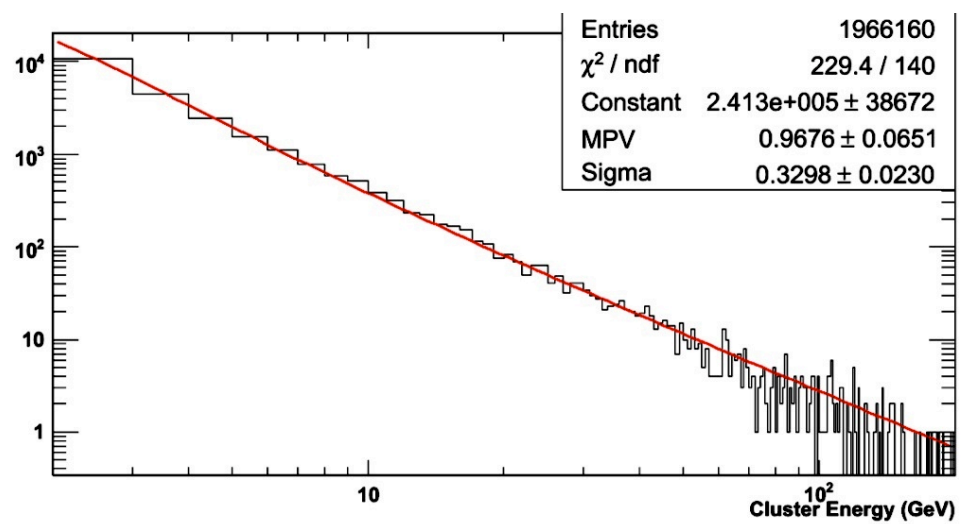


Few ECAL results from CRUZET

- Total ECAL barrel occupancy
- Empty spots are masked trigger towers

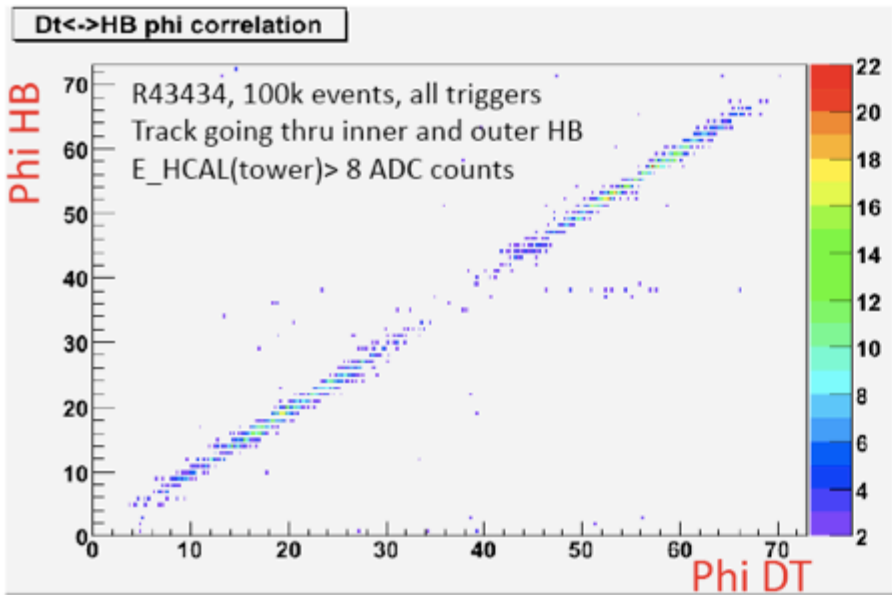


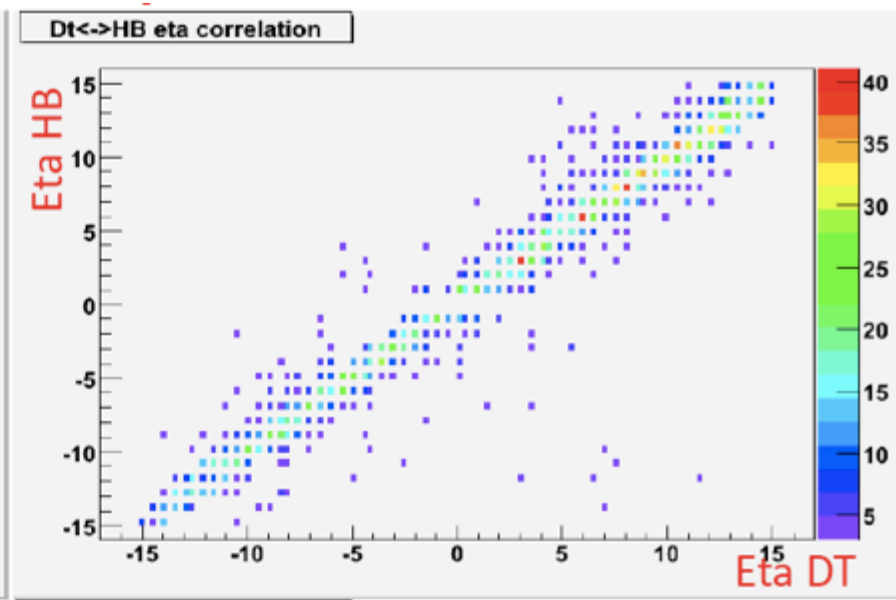


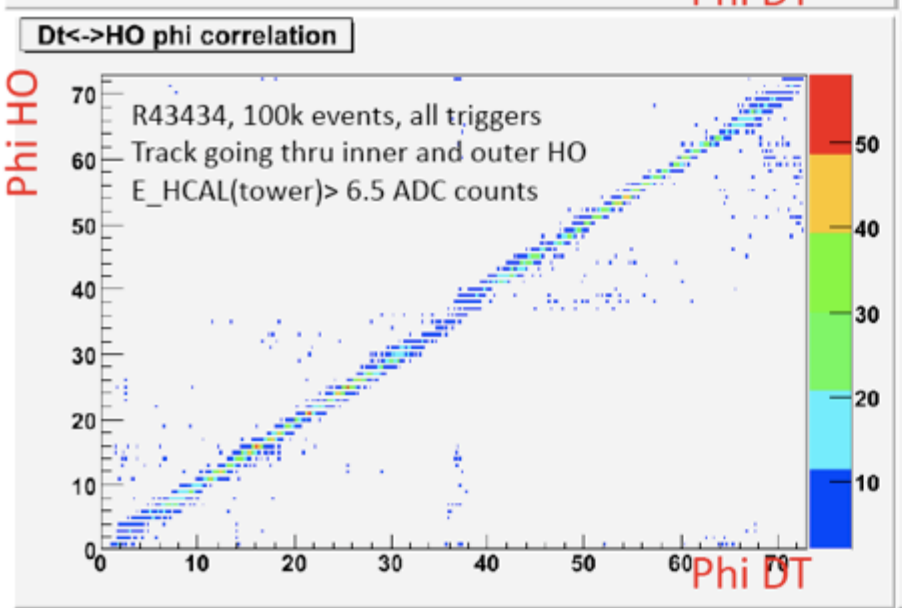


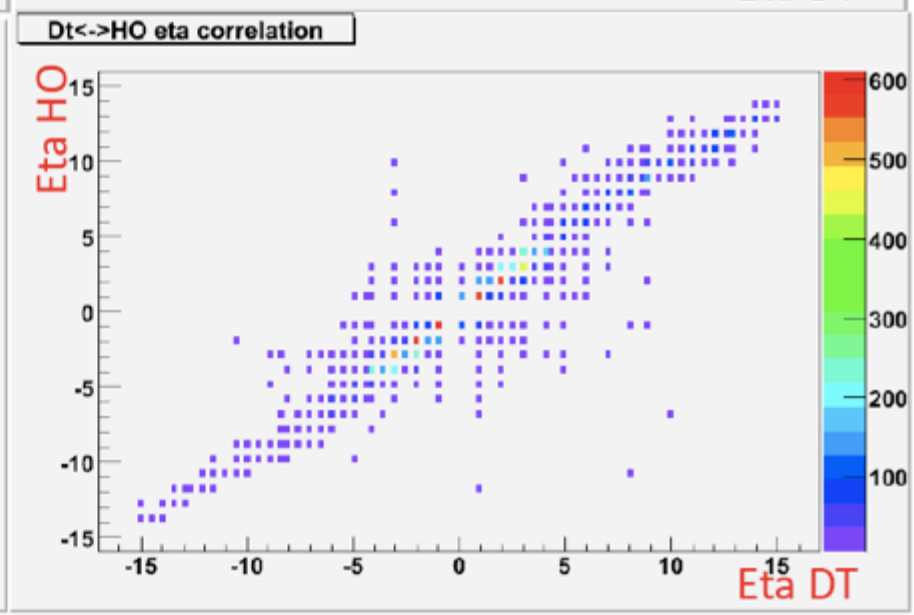
Few HCAL results from CRUZET

DT vs HB/HO correlations (muon tracks)



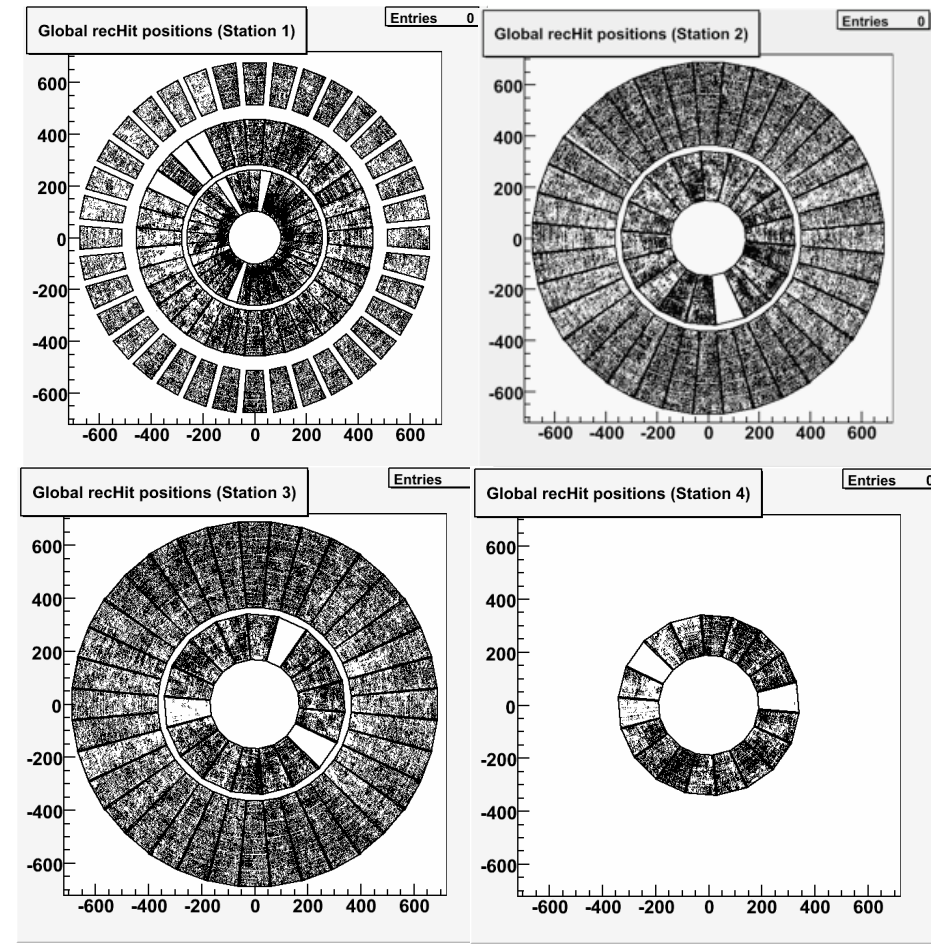




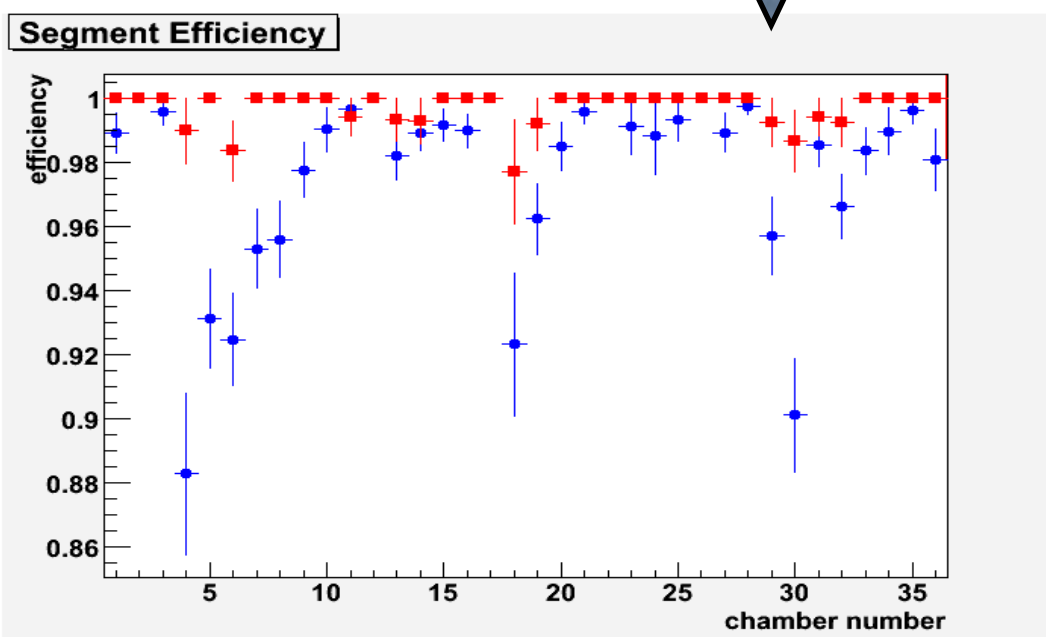


Few CSC results from CRUZET

- Occupancy in four stations



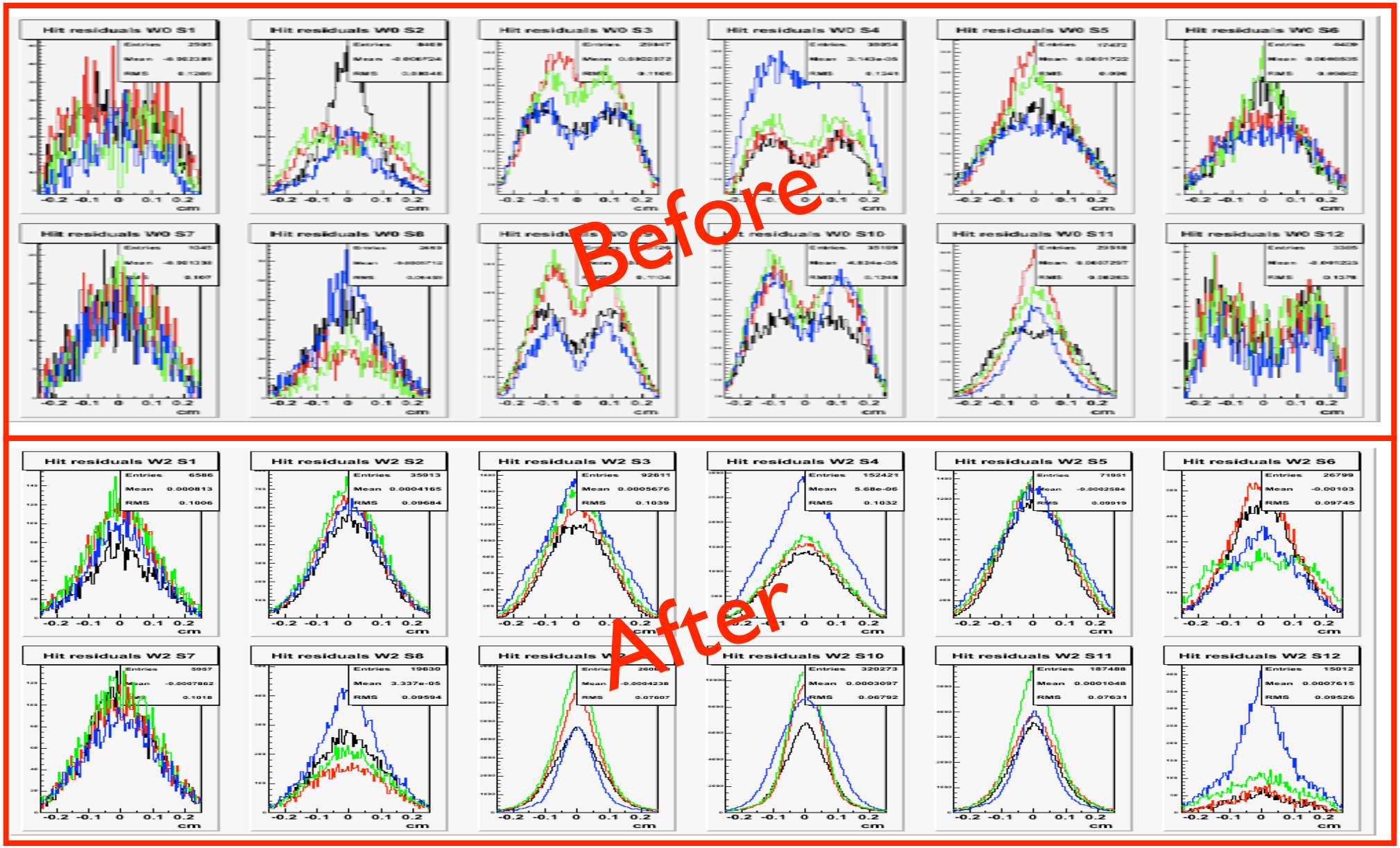
- Segment efficiency before and after CRUZET



Commissioning of CSC is half complete

Few DT results from CRUZET

DT hit residuals before and after time calibration



Summary

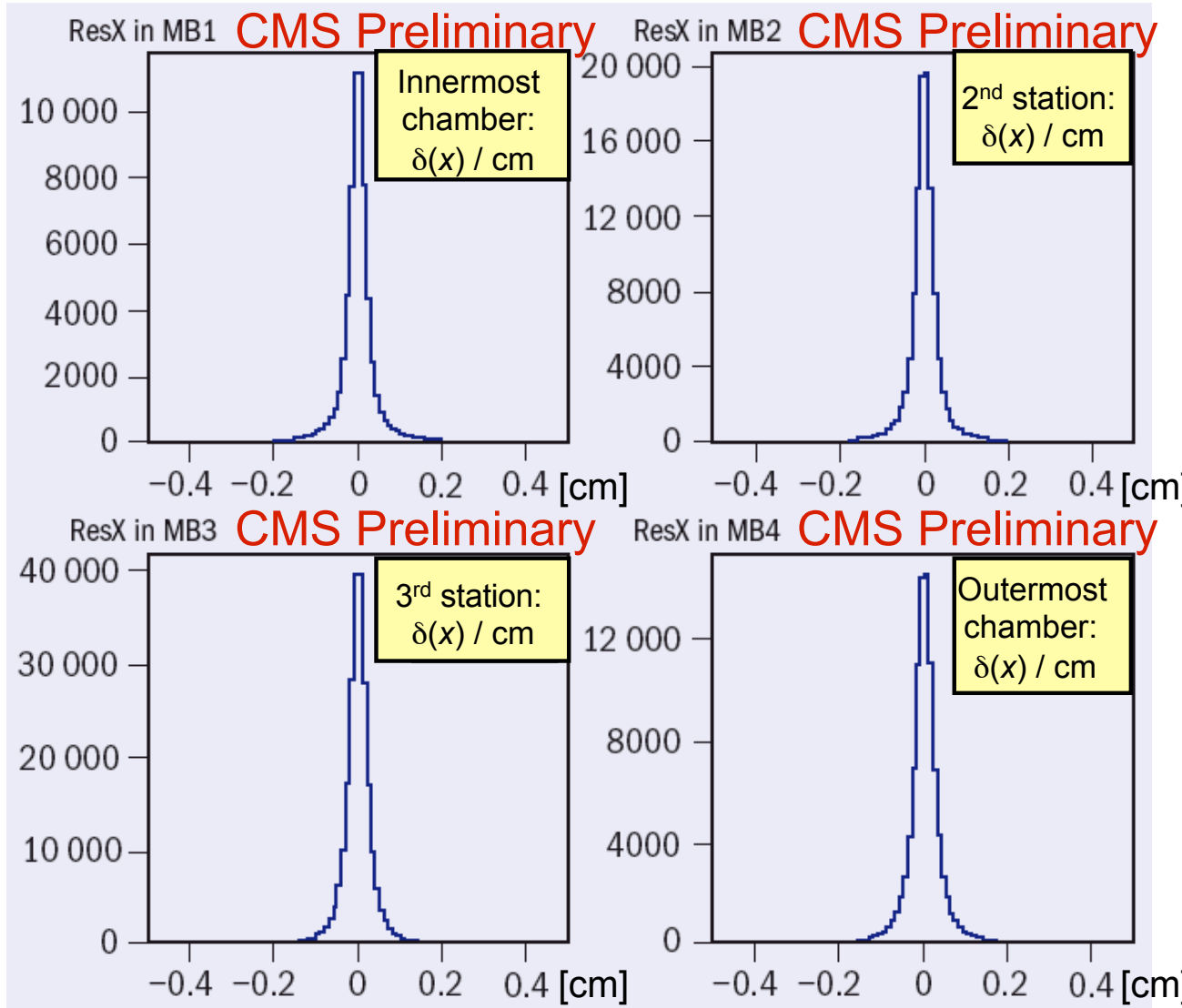
- CMS commissioning is going full speed
- No major obstacles foreseen on the road
- Major milestone in front of us: integration of tracker
- MTCC, software challenges and global runs have proven that:
  - CMS sub-detectors work as a single detector
  - The DAQ and software is ready for prime-time
- Next steps:
  - Tracker switch-on
  - CMS closed mid-July with Pixel and at least one ECAL endcap installed
  - Waiting for collisions with continuous full magnet cosmic runs

BACKUP

"Local" and "Global" runs

First results from cosmic data:

single-hit resolution of barrel drift tubes (DT): < 280 μm

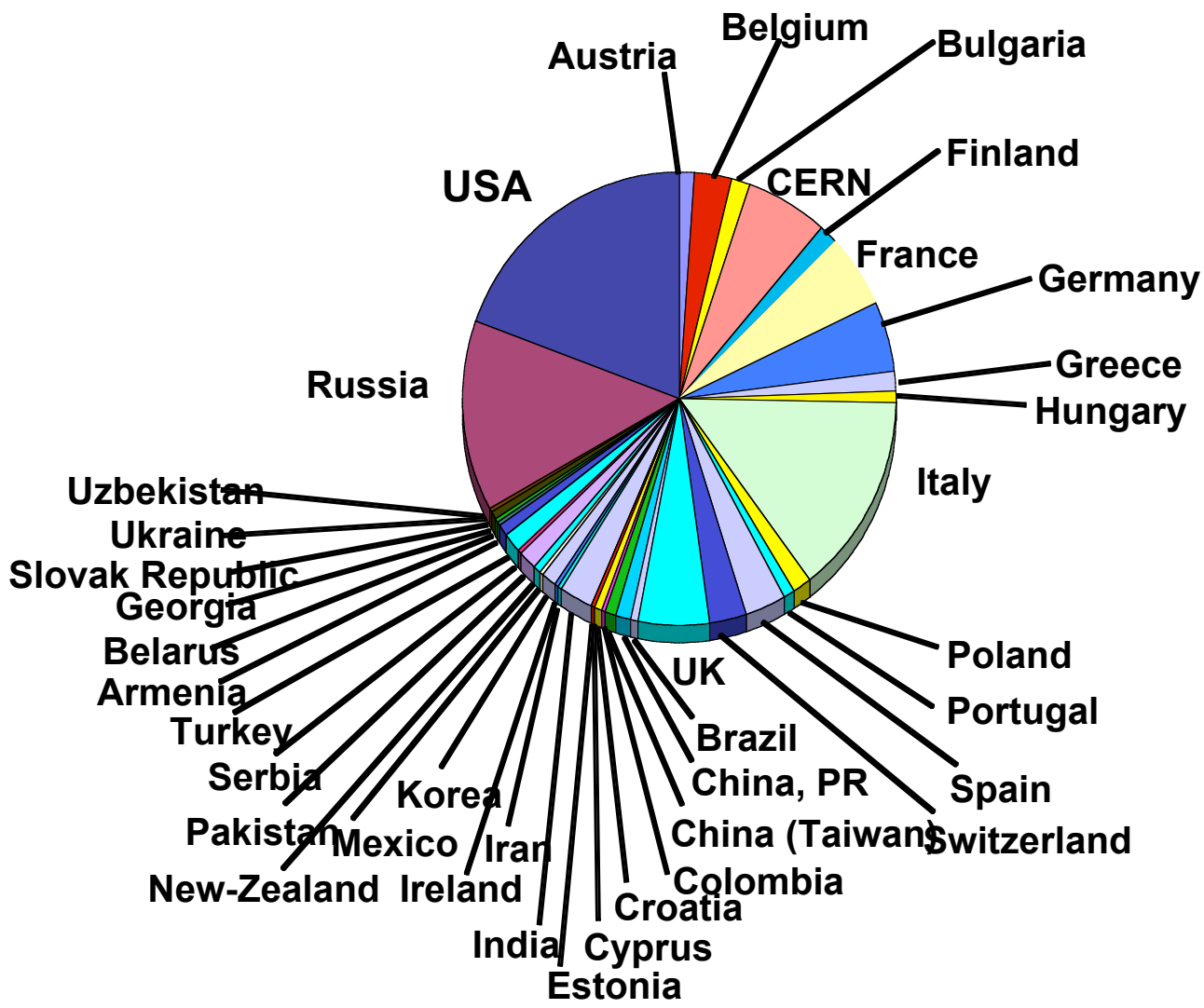


The CMS collaboration

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

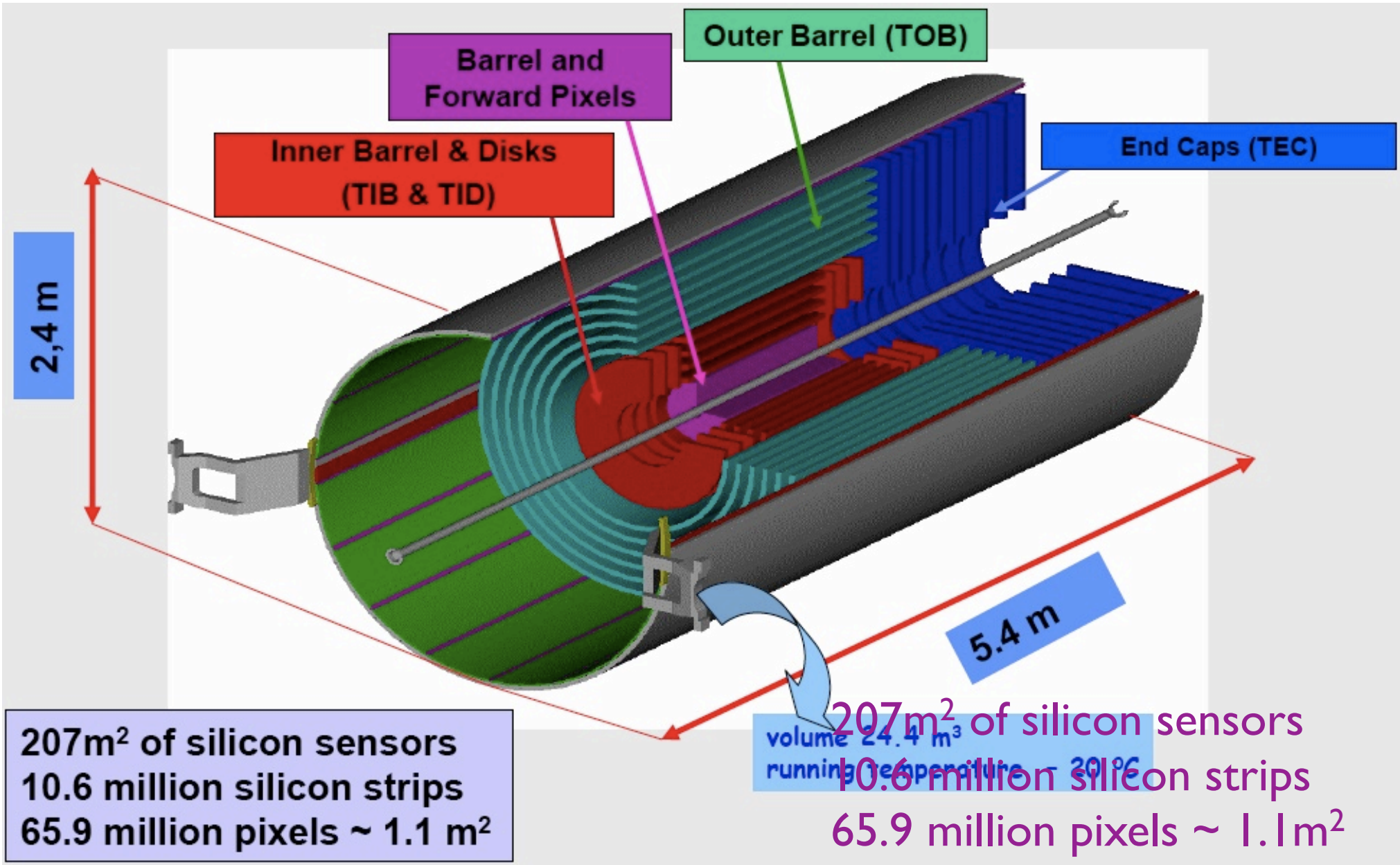
	Scientists
Member States	1055
Non-Mem. States	428
USA	547
Total	2030

Associated Institutes	
Number of Scientists	46
Number of Laboratories	8



2030 Scientific Authors, 38 Countries, 174 Institutions

Tracker status



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

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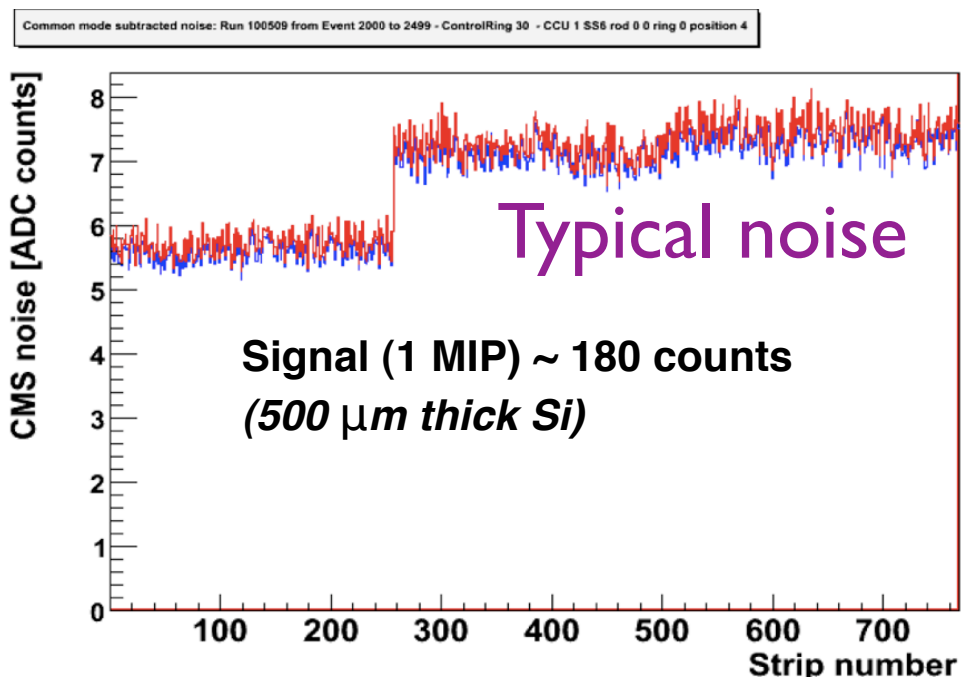
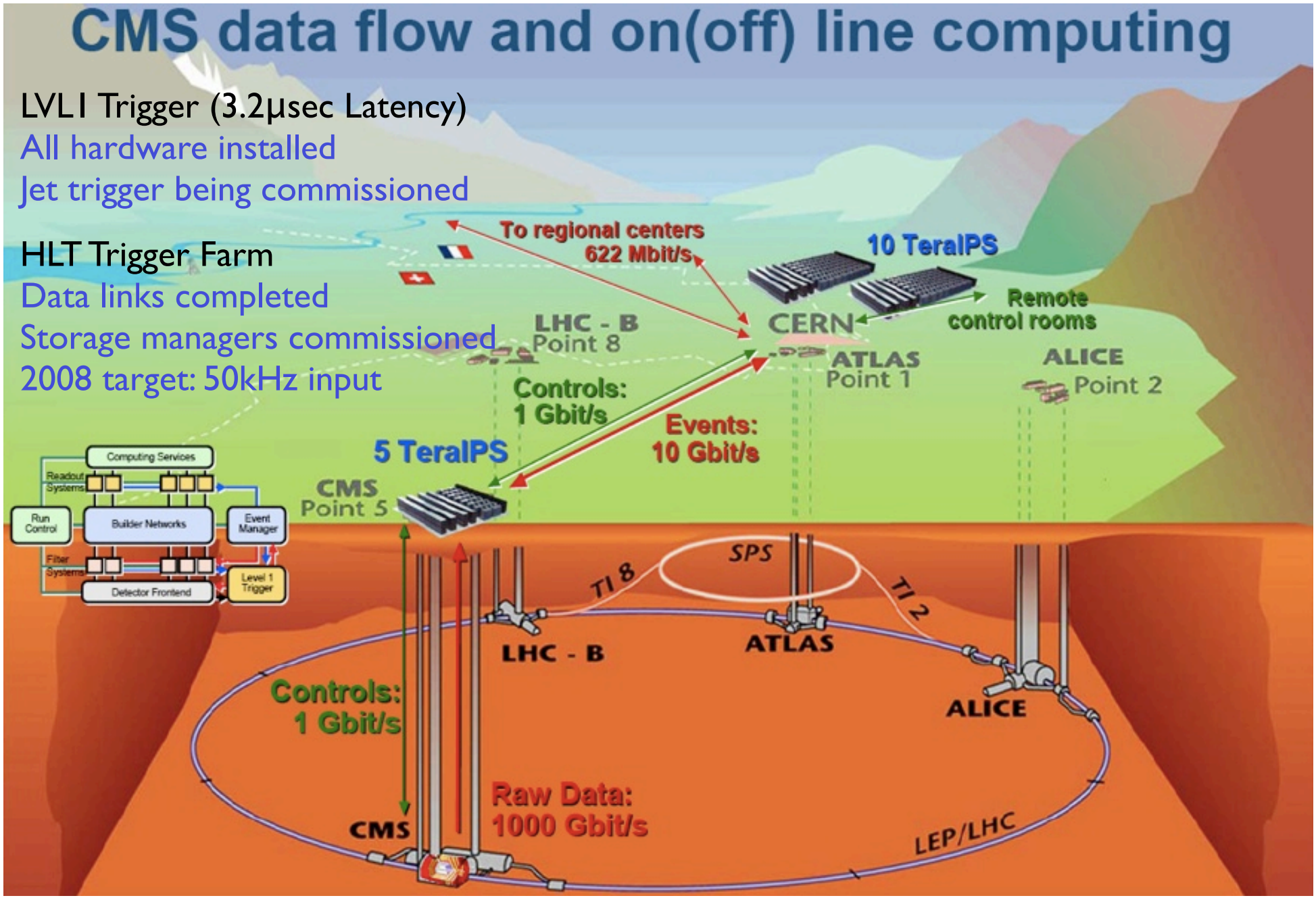
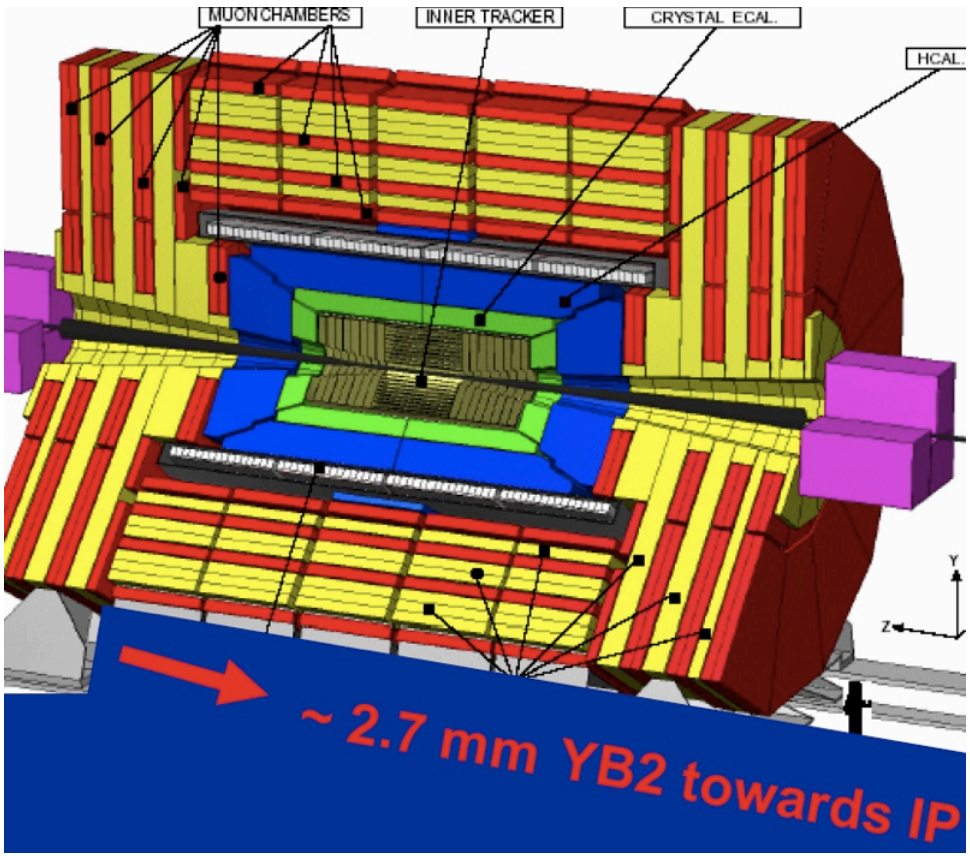

Common mode subtracted noise: Run 100509 from Event 2000 to 2499 - ControlRing 30 - CCU 1 SS6 rod 0 0 ring 0 position 4
CMS noise [ADC counts]
0
1
2
3
4
5
6
7
8
100
200
300
400
500
600
700
Strip number
Typical noise
Signal (1 MIP) ~ 180 counts
(500 μm thick Si)

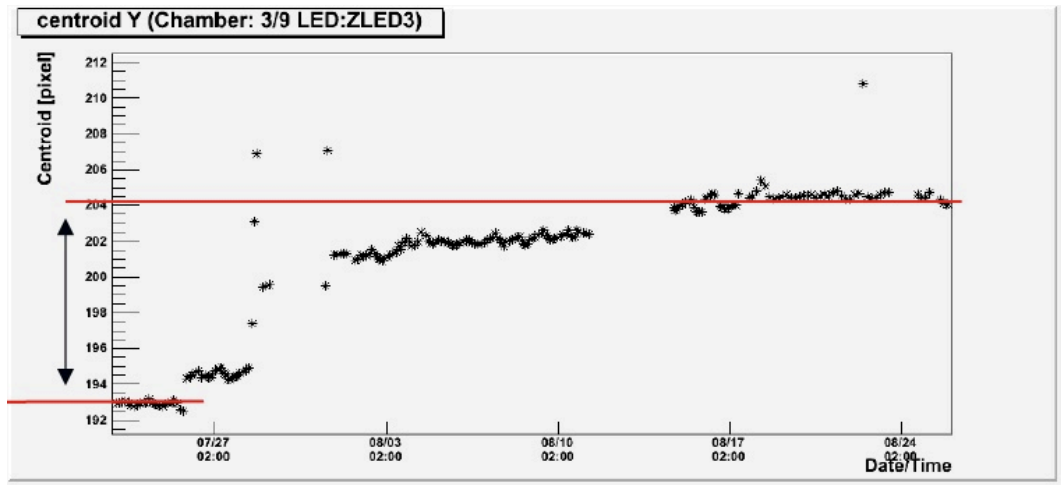
DAQ and Trigger status

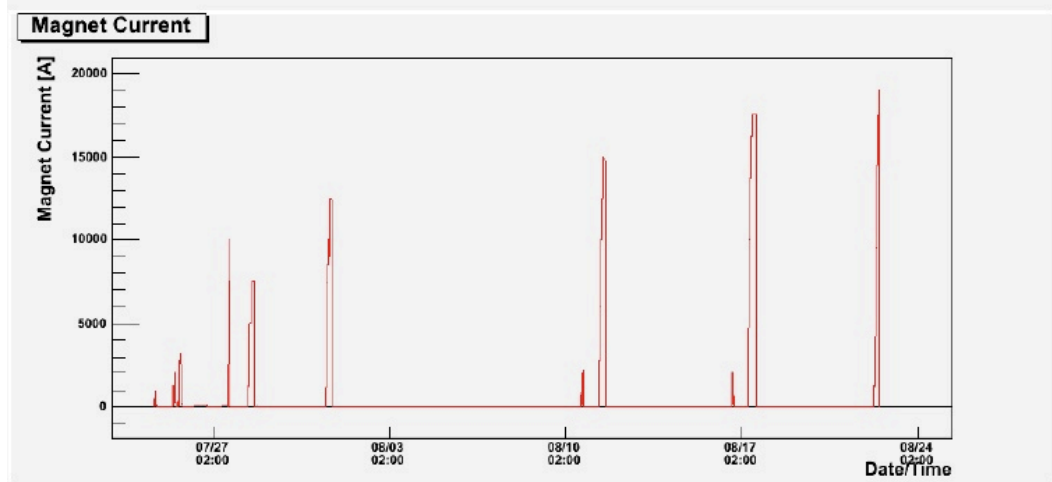


Yoke Distorsion with Field

Magnetic attraction force ~ 10000 tons





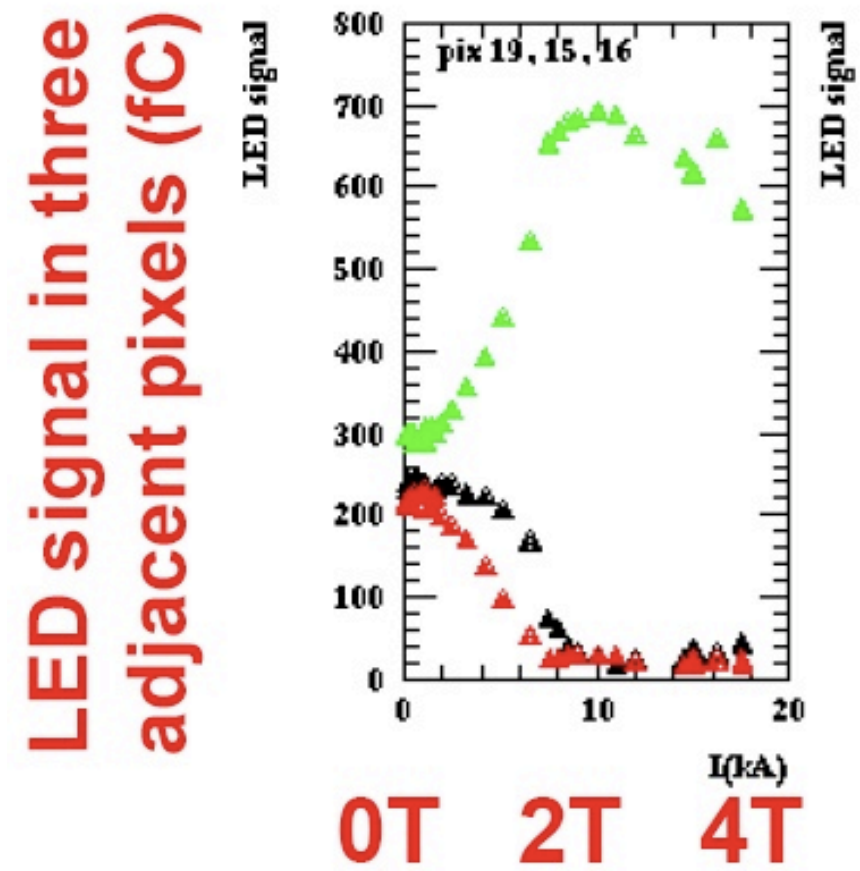


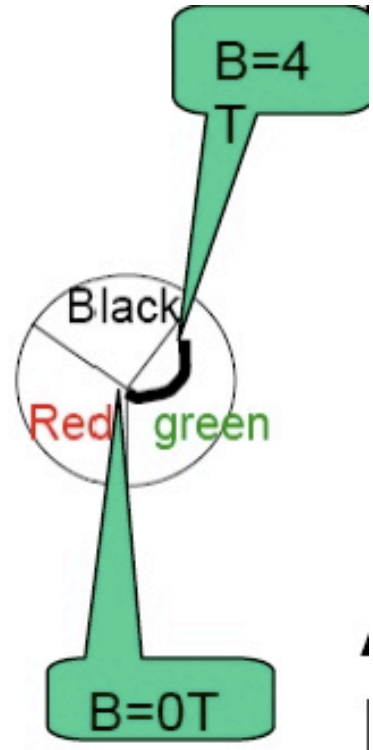
MTCC phase 1: selected topics

Increased cross-talk between HCAL readout pixels

HCAL:
angle of field to HO HPD axis found to be 25 degrees different from simulation.

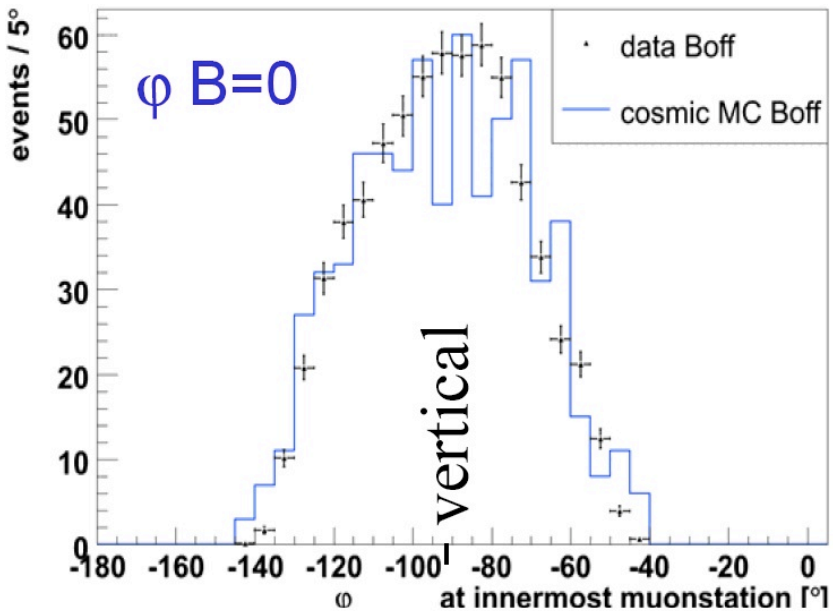
Solution (tested succesfully in MTCC II):
Displace HPD box:
limit effect to ≤10%

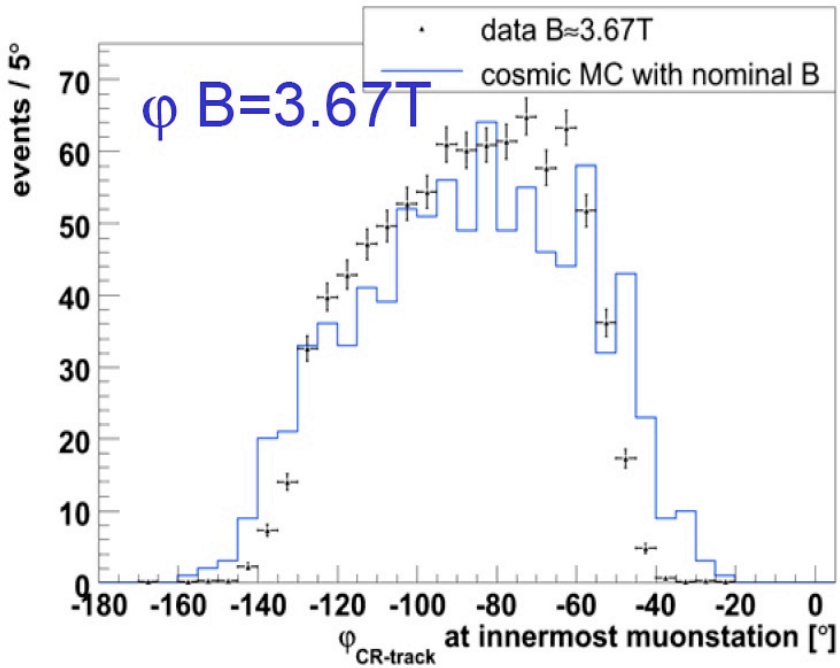


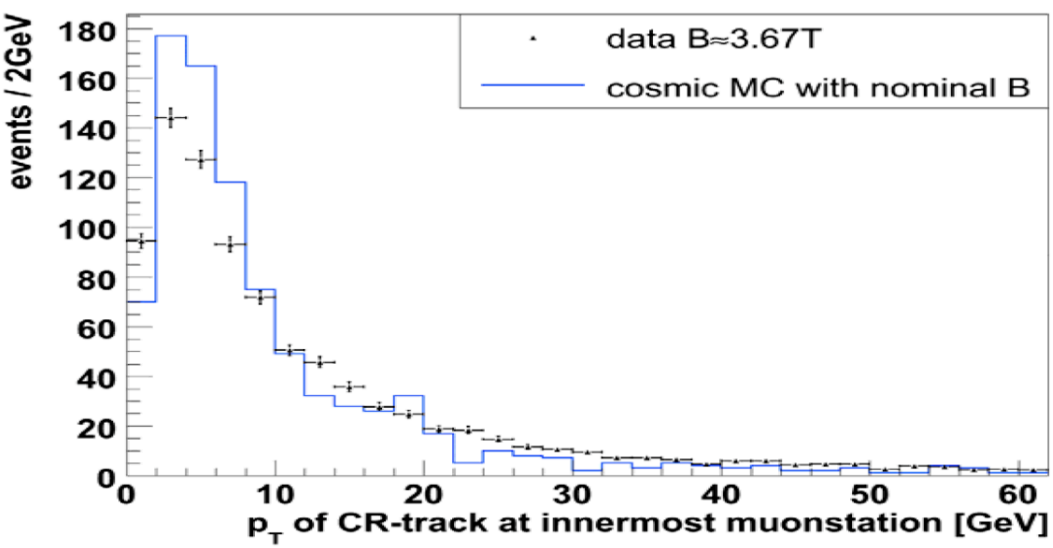


MTCC phase 1: selected topics

First physics results with cosmics



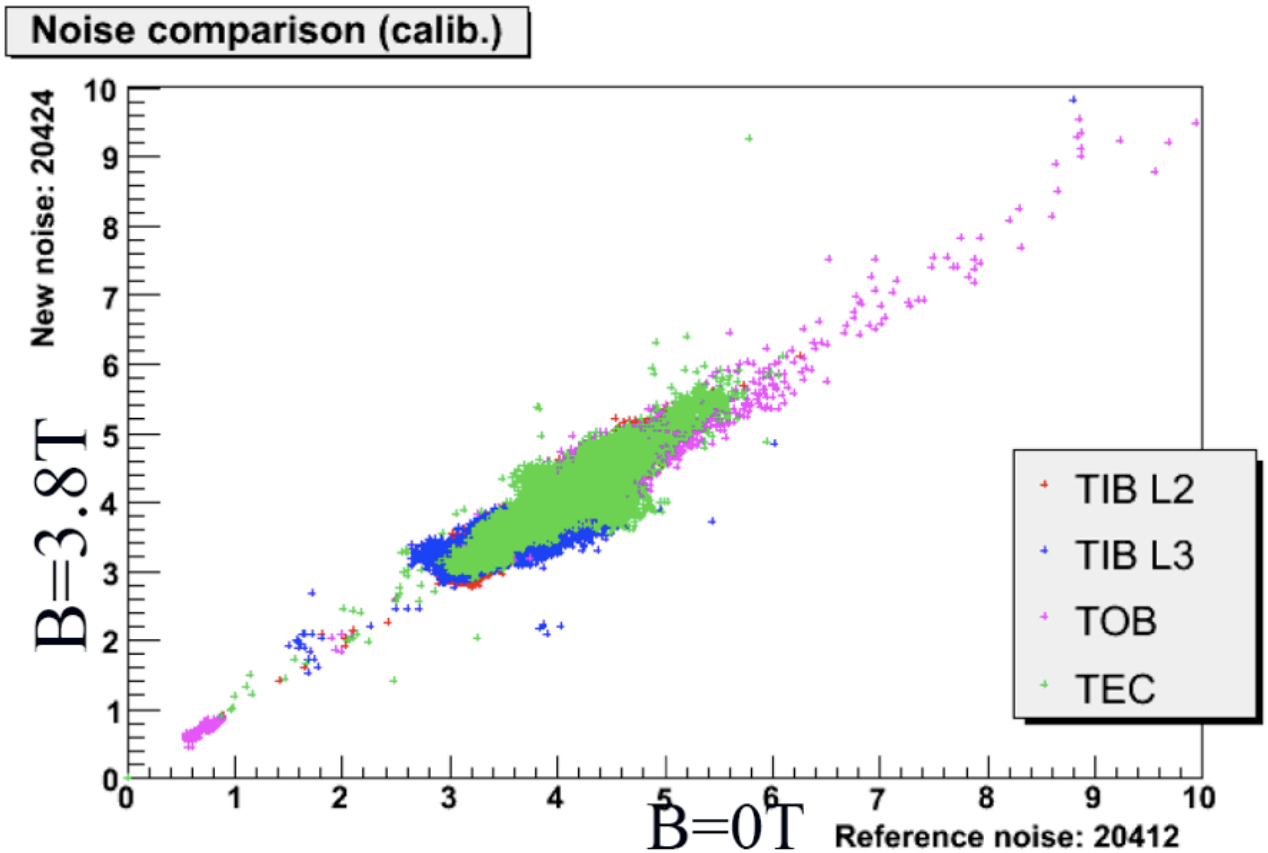


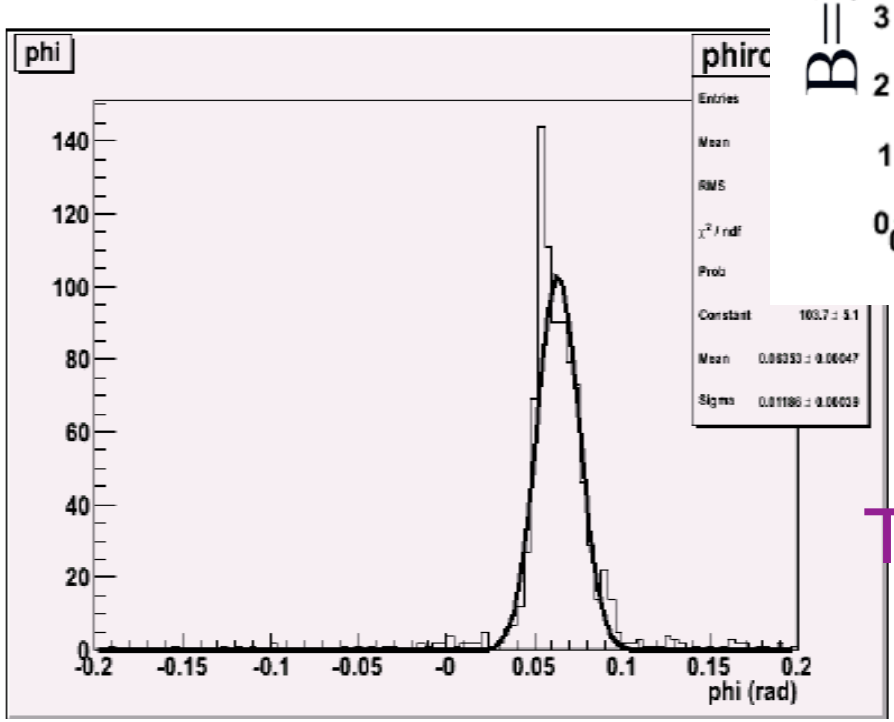


Reasonable agreement MC-data
Complete test of DAQ/offline reconstruction!

MTCC phase 1: selected topics

Noise and pedestals values unchaged in magnetic field

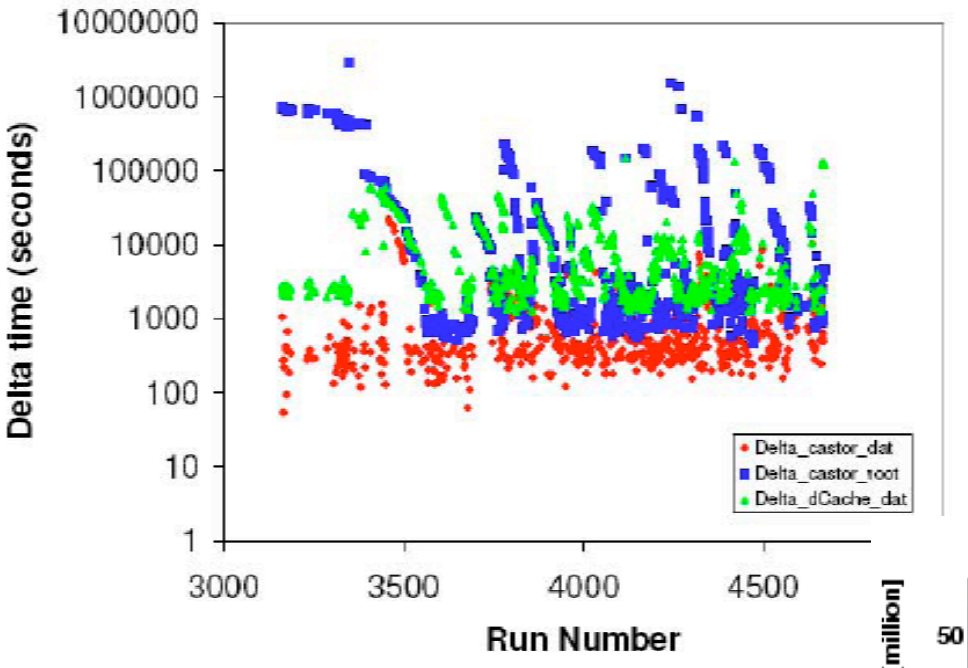




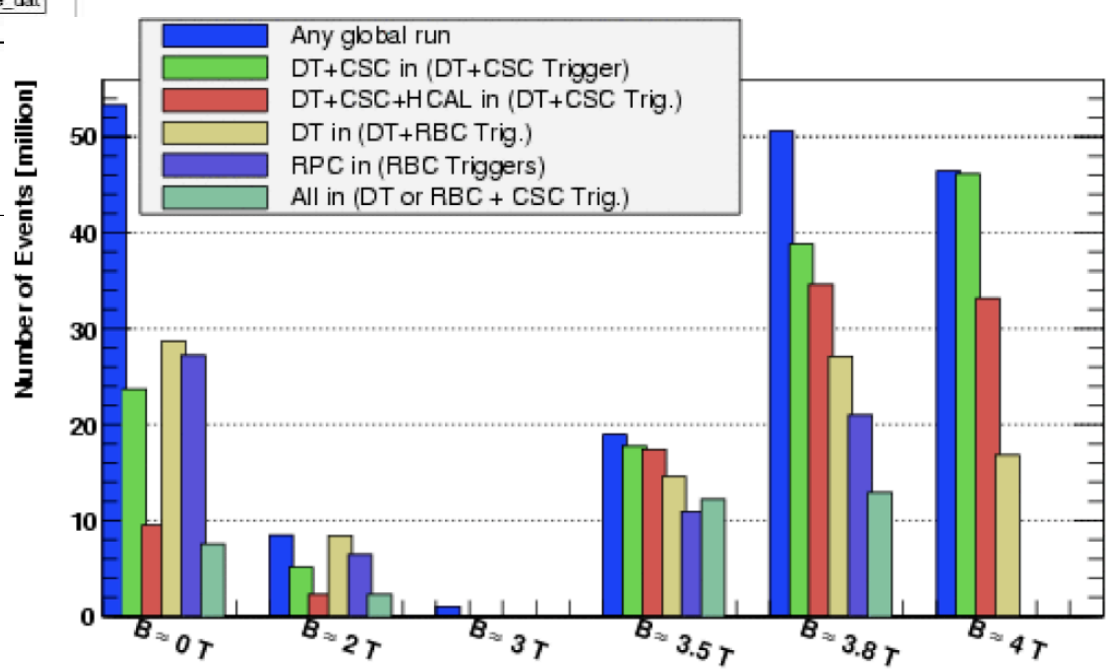
TIB-TOB relative rotation

MTCC phase II

As a data recording capability test

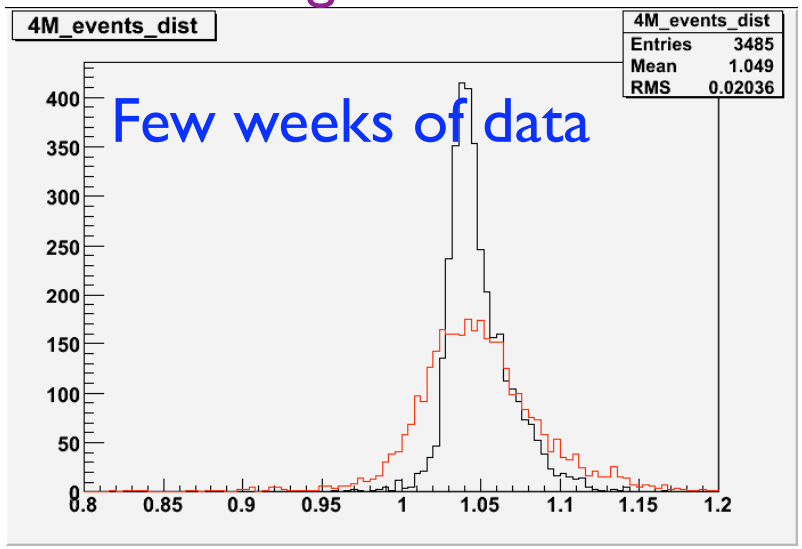


More than 160M events recorded and transferred to CASTOR (archiving system)

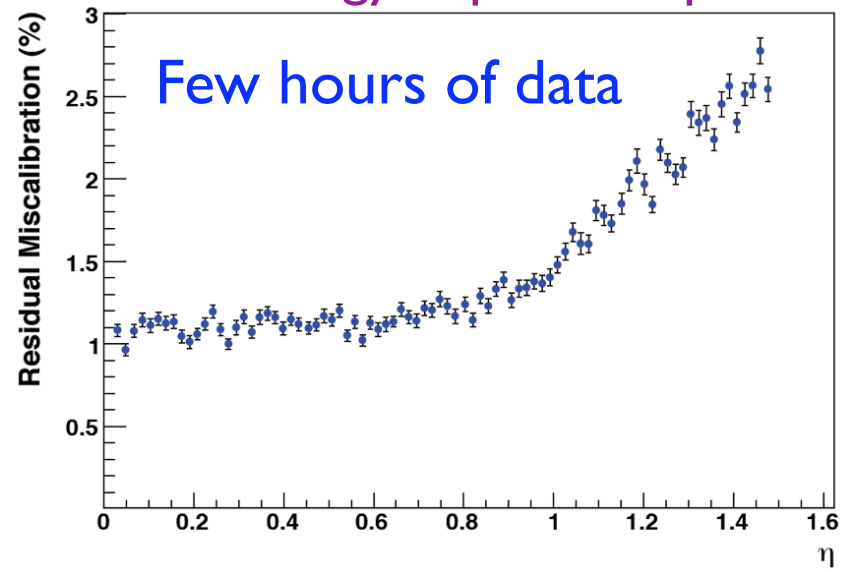


CSA06: calibration exercises

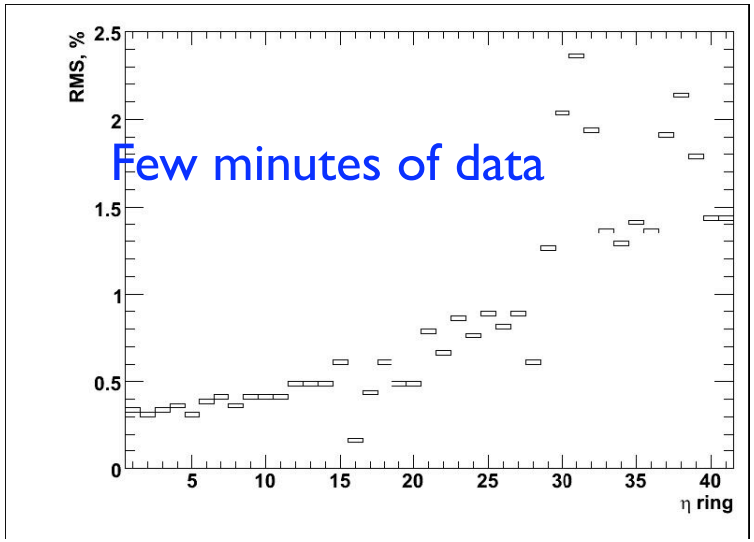
ECAL calibration using E/P = 1 convergence with time



ECAL calibration using symmetry of energy deposits in phi



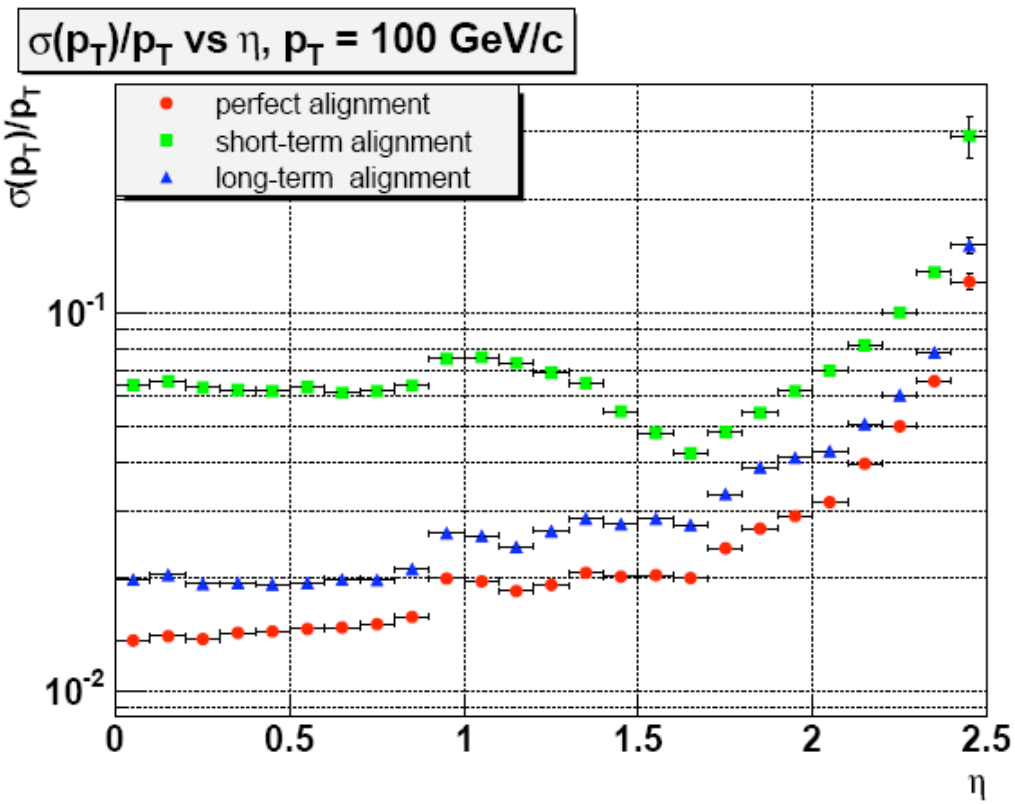
HCAL phi-symmetry



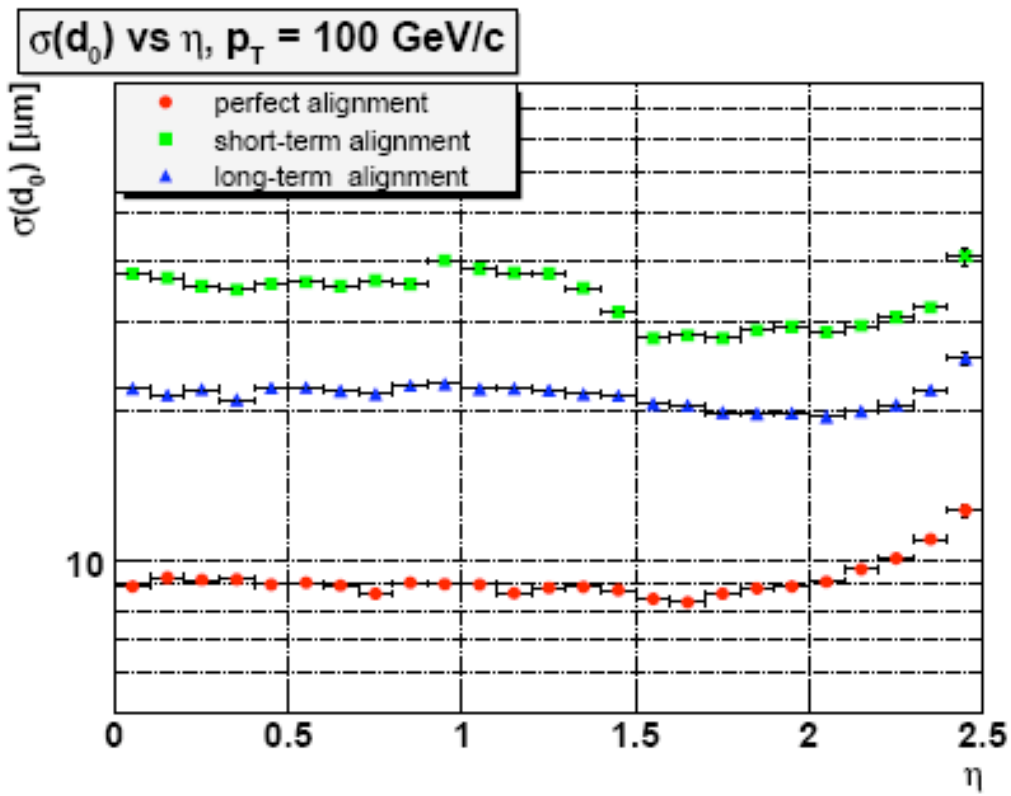
All exercises were successful in reproducing older analysis (in a "almost-real, almost-online" environment)

Impact of misalignment

Transverse Momentum Resolution



Transverse Impact Parameter resolution



Alignment strategy

2007 before collisions: alignment with cosmics and beam halo muons

2007 Calibration Run: use high pT tracks (if possible)

2008 alignment with muons from Z,W

- Standalone alignment of pixel detector
- Alignment of strip tracker (pixel as reference)

ECAL calibration

Before data taking:

Pre-calibration using test beam, light yield meas., cosmics: ~3%

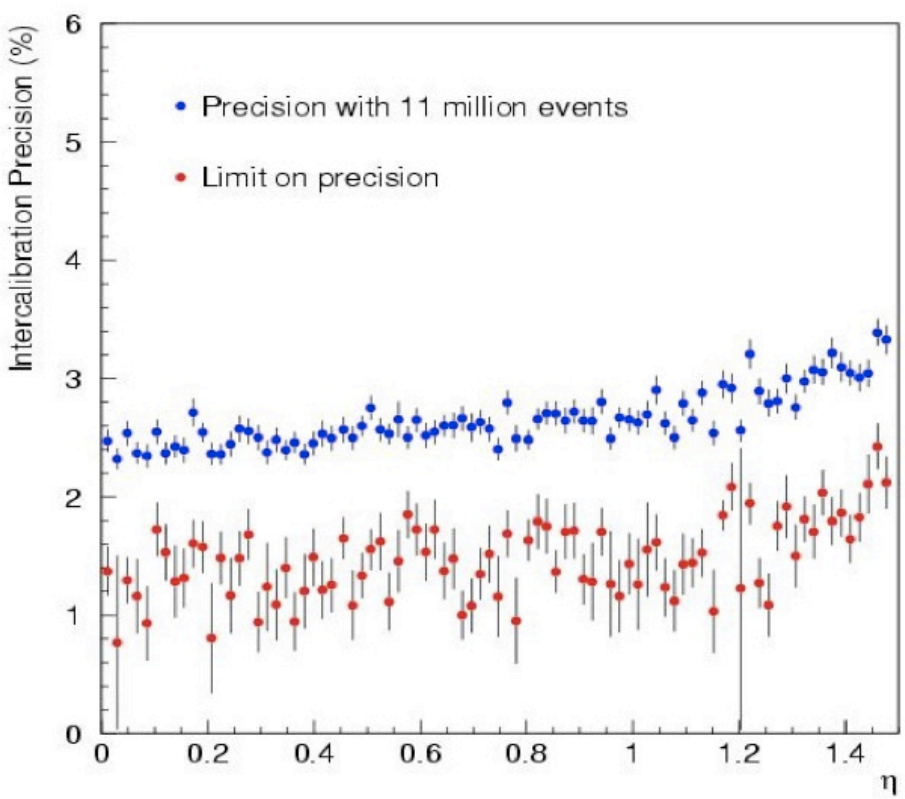
Calibration run 2007:

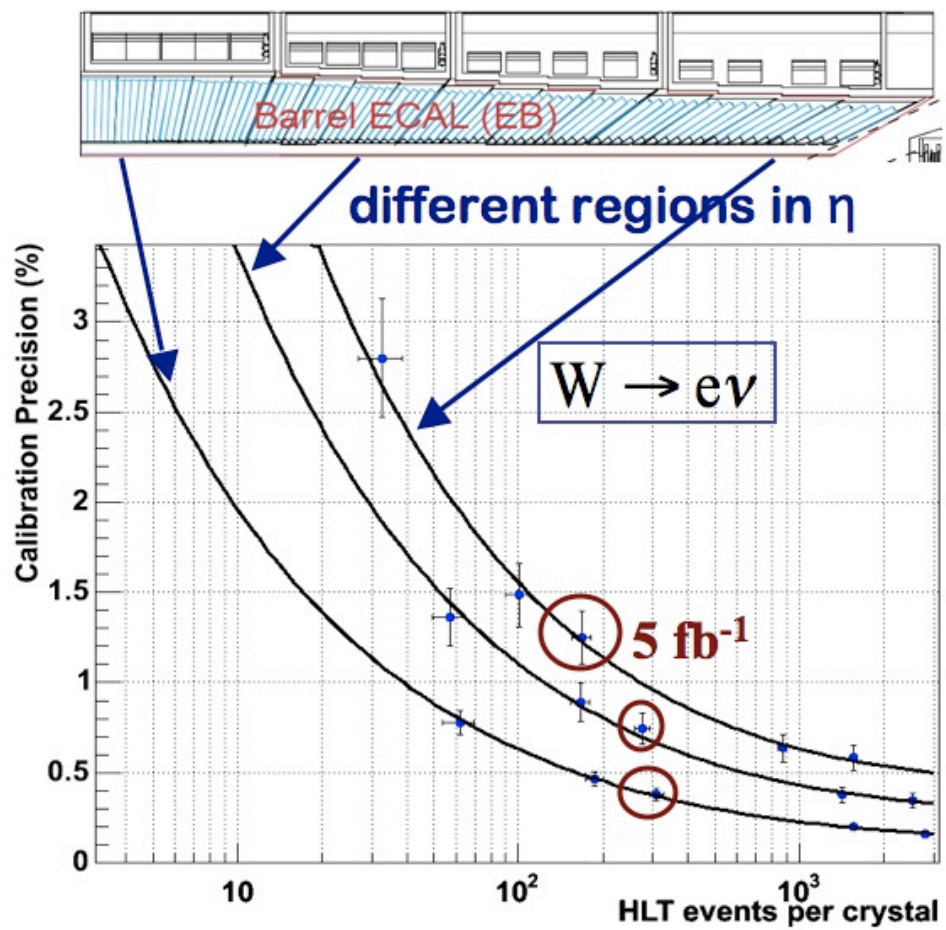
Few hours of min. bias events (1kHz calib. Stream): 1..2%

Phi symmetry, pi0

From 2008 Pilot run onwards:

Isolated electrons from W,Z using E/p ~ 0.5%

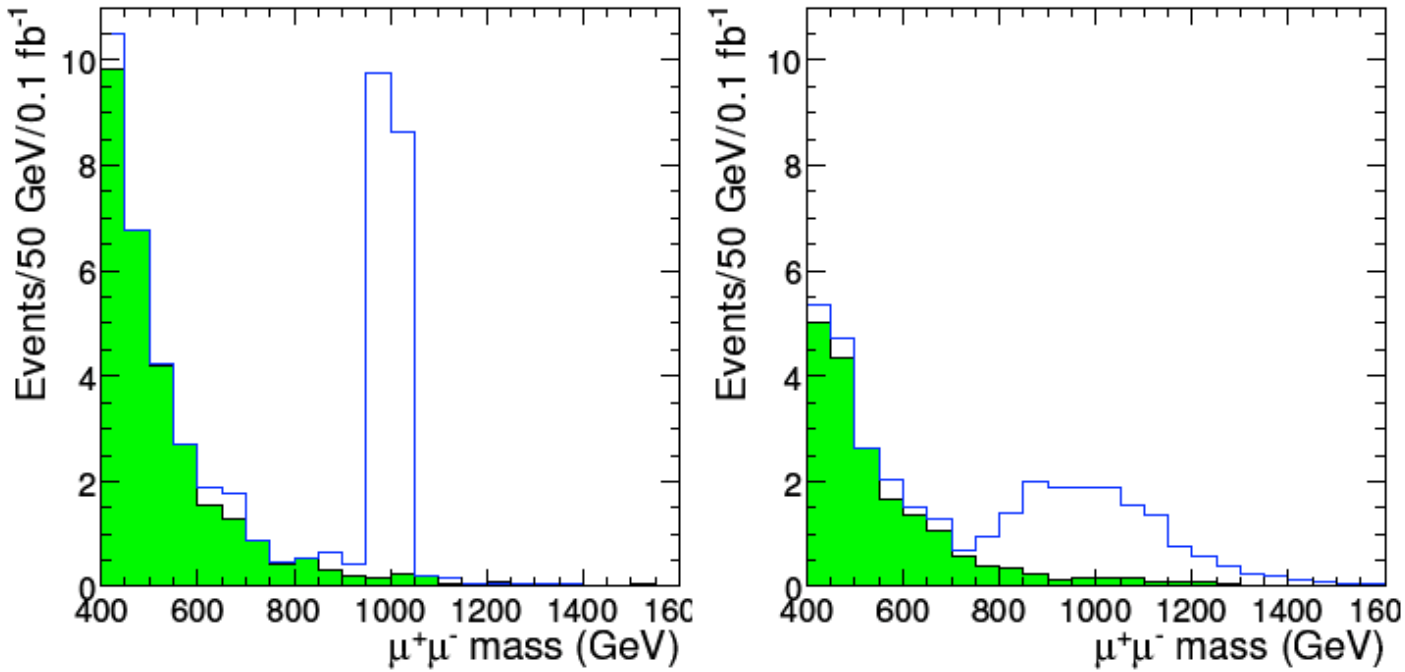


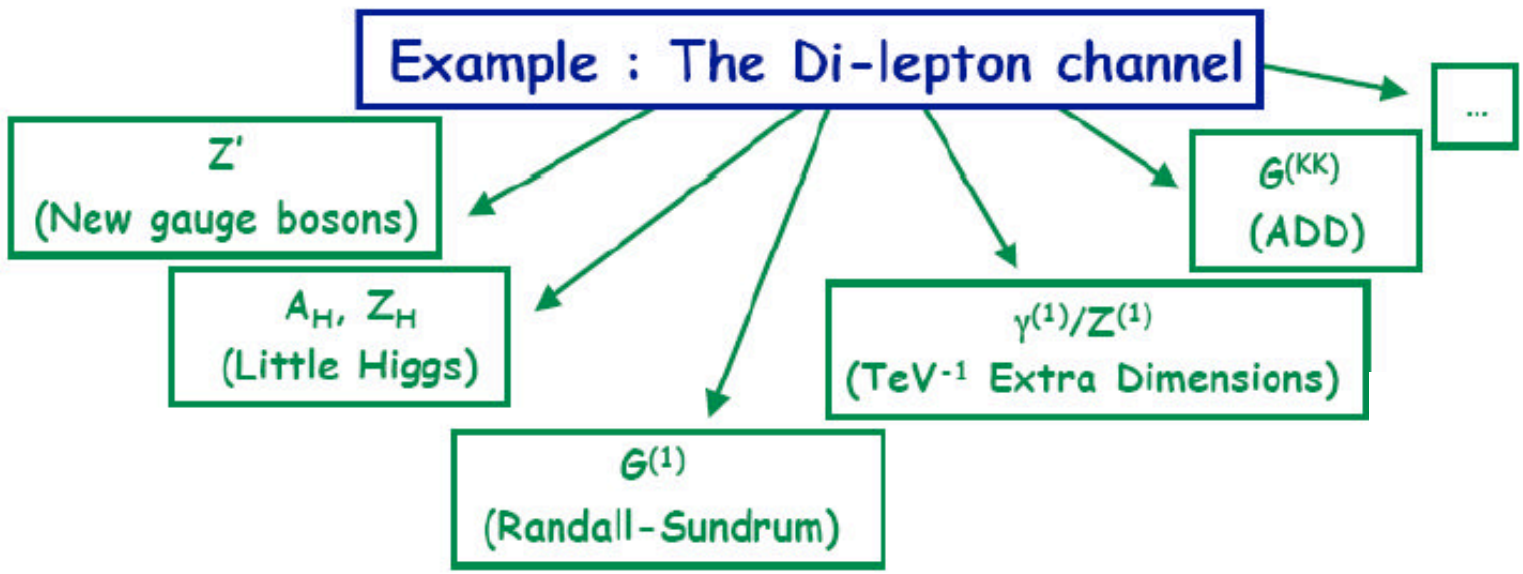


Early physics: di-lepton resonances

Z'→μμ (0.1fb^{-1})

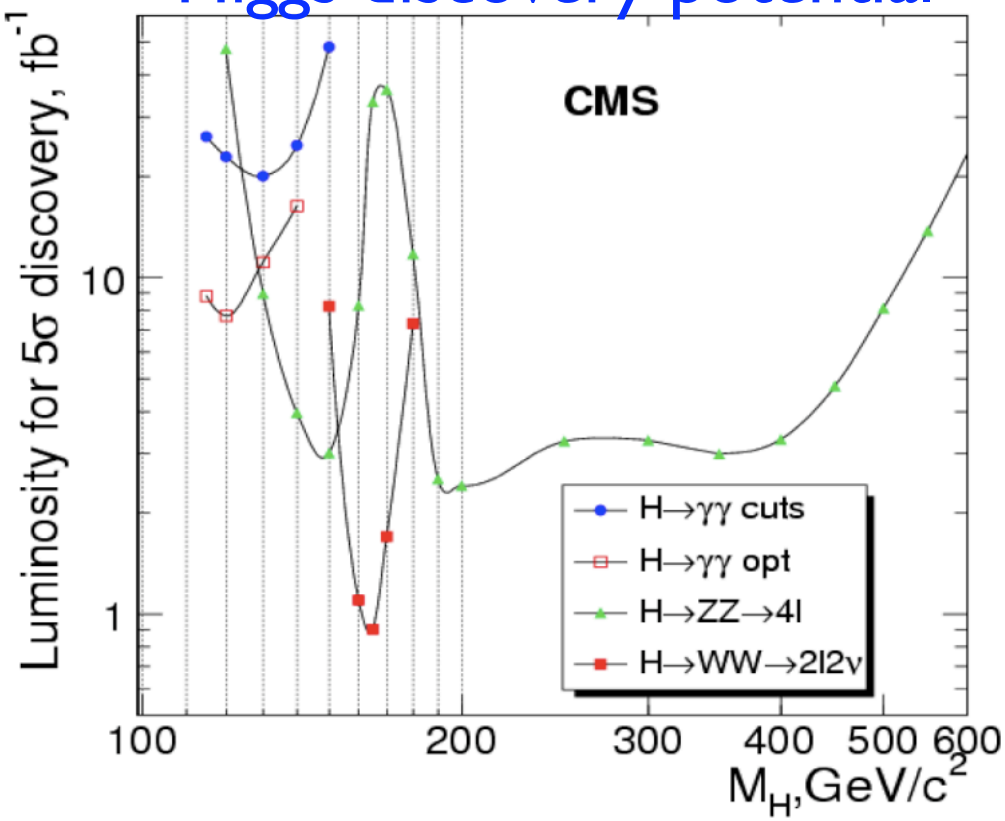
May be seen very early: first weeks





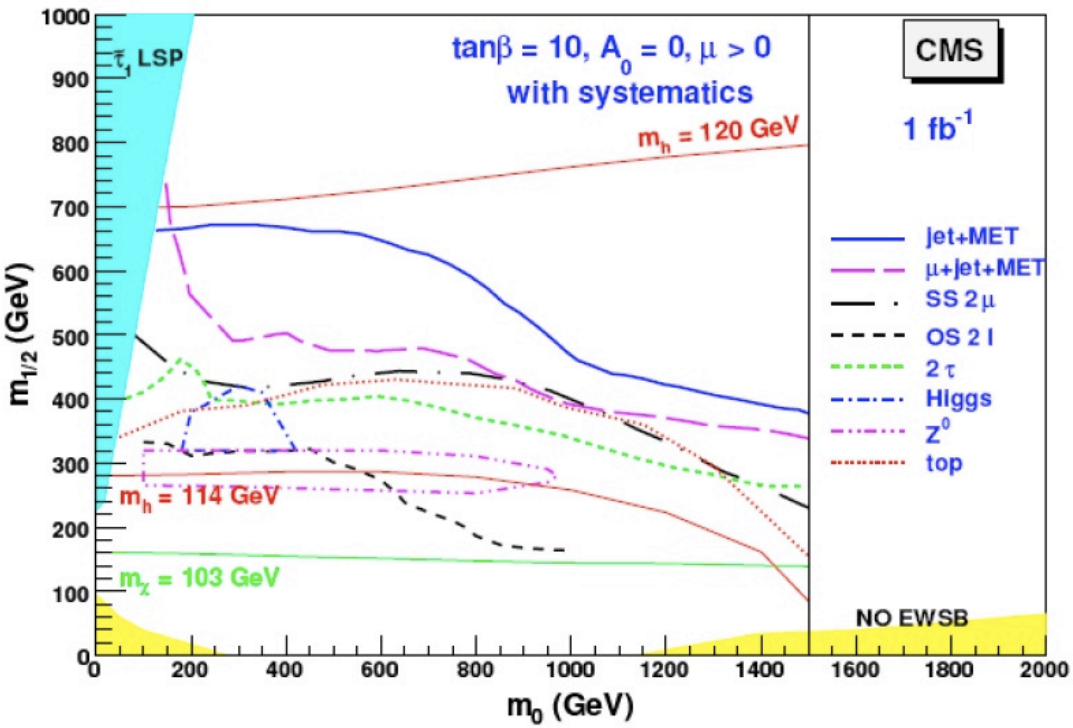
Higgs and Susy discovery potential

Higgs discovery potential



Some phase-space available below 1fb^{-1}

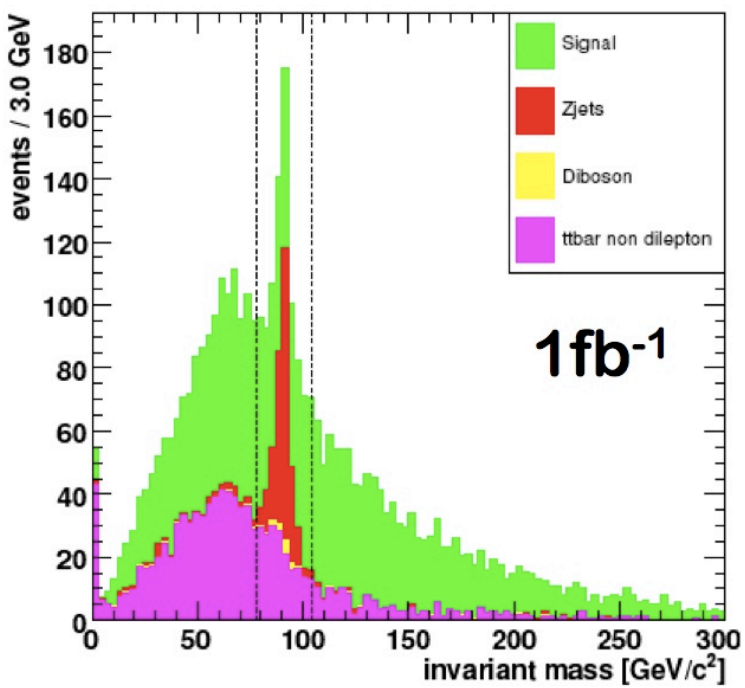
SUSY 5σ discovery reach with L=1fb^{-1} including systematics



Low-mass SUSY might be in reach

Early Physics: Top Quarks

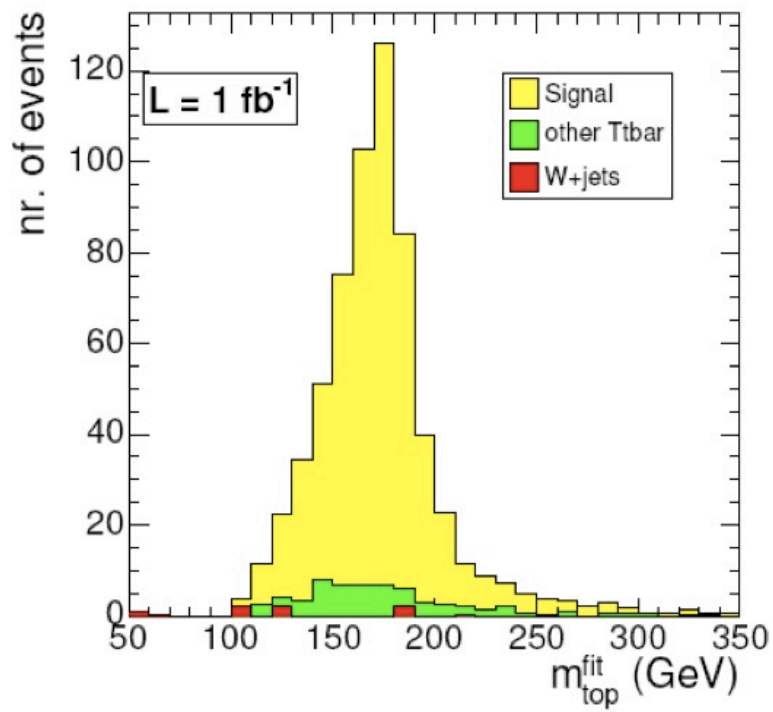
Top pair-production ~ 830 pb
Cross section and mass measurements in all 3 channels (dilepton, semileptonic, hadronic)



Dilepton channel

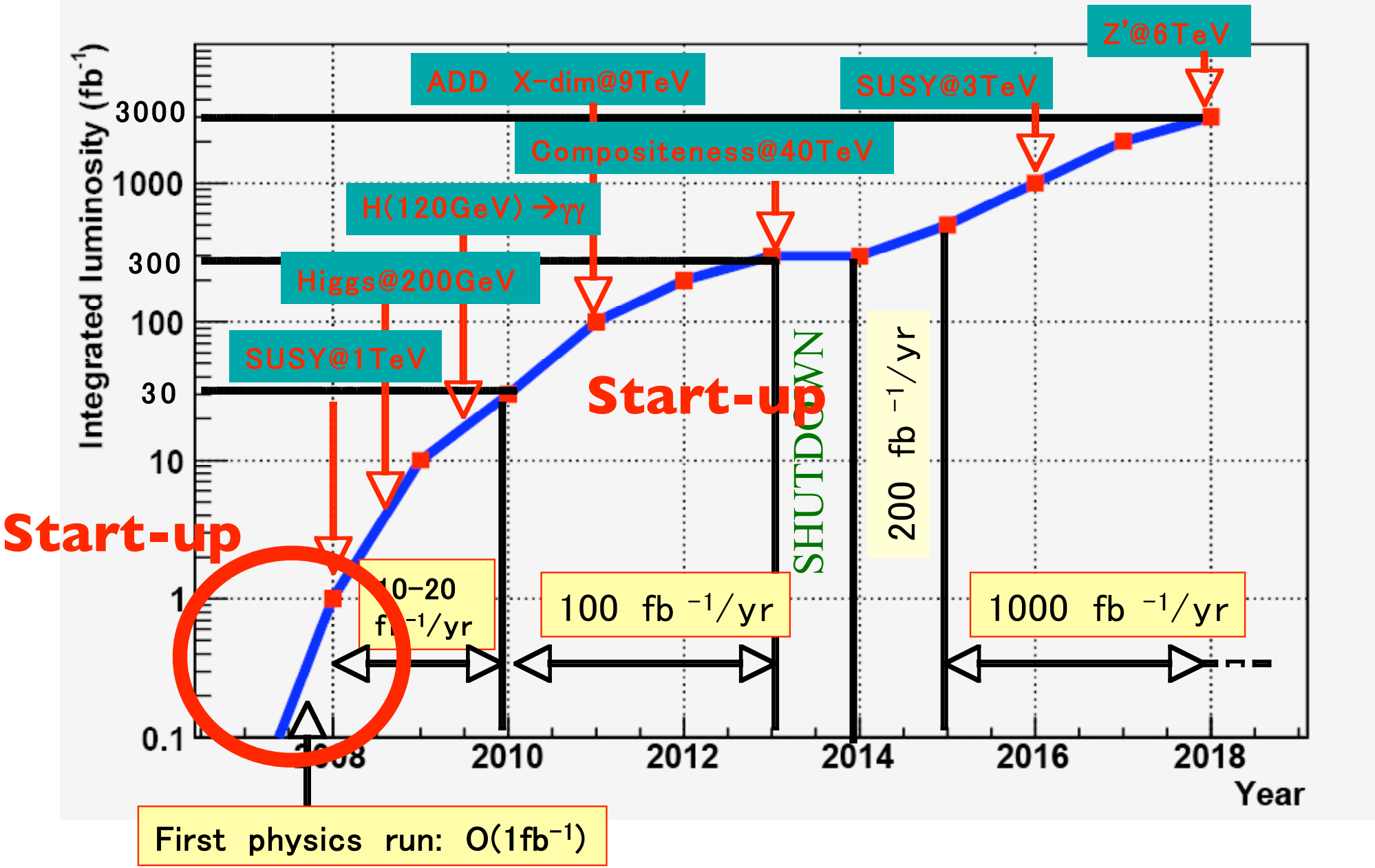
1fb^{-1}: 700 events in dilepton channel (large S/B~12)
Δm_t~4.2 GeV (1fb^{-1}): b-jet energy scale 15%
x-section measurement at ~10% possible

Mass measurement in semileptonic channel:



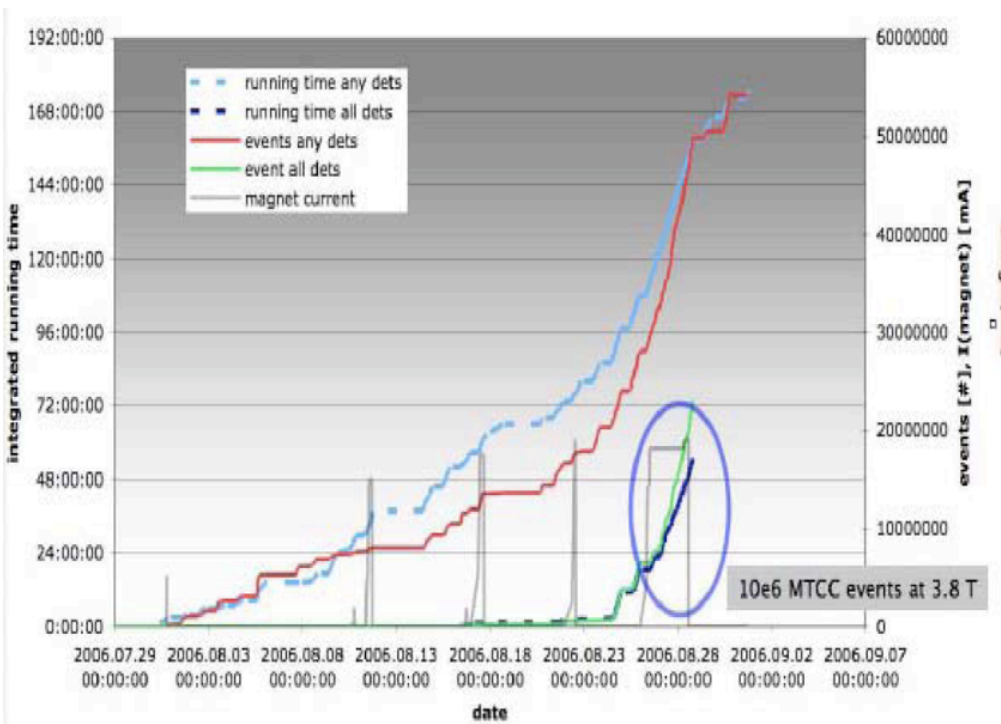
Potential for Δm_t~1.2 GeV (10 fb^{-1})
Requires b-jet energy scale known to 1.5%

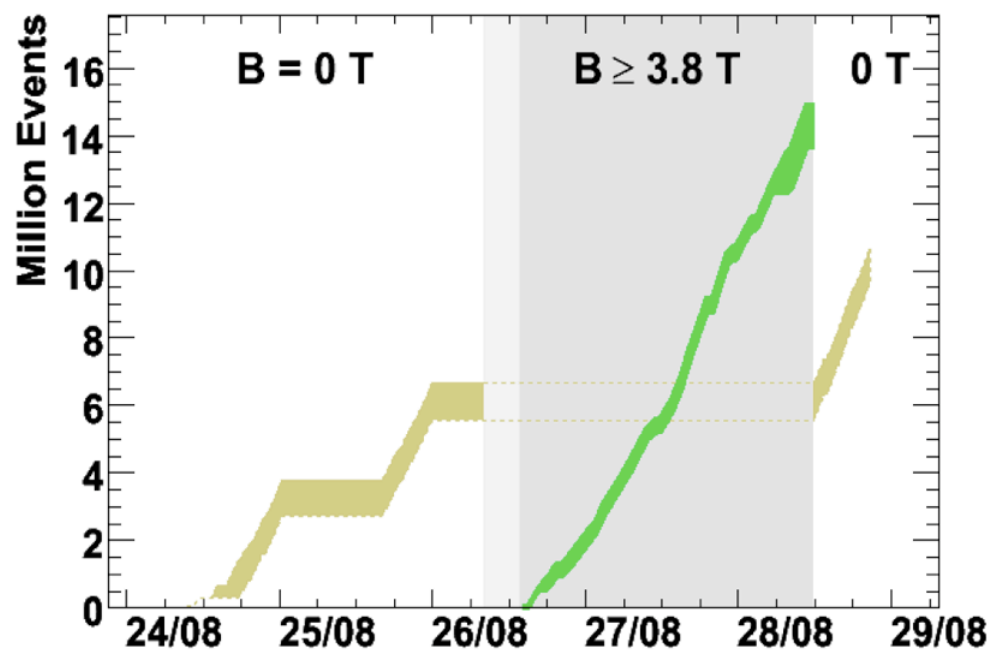
CMS physics road-map



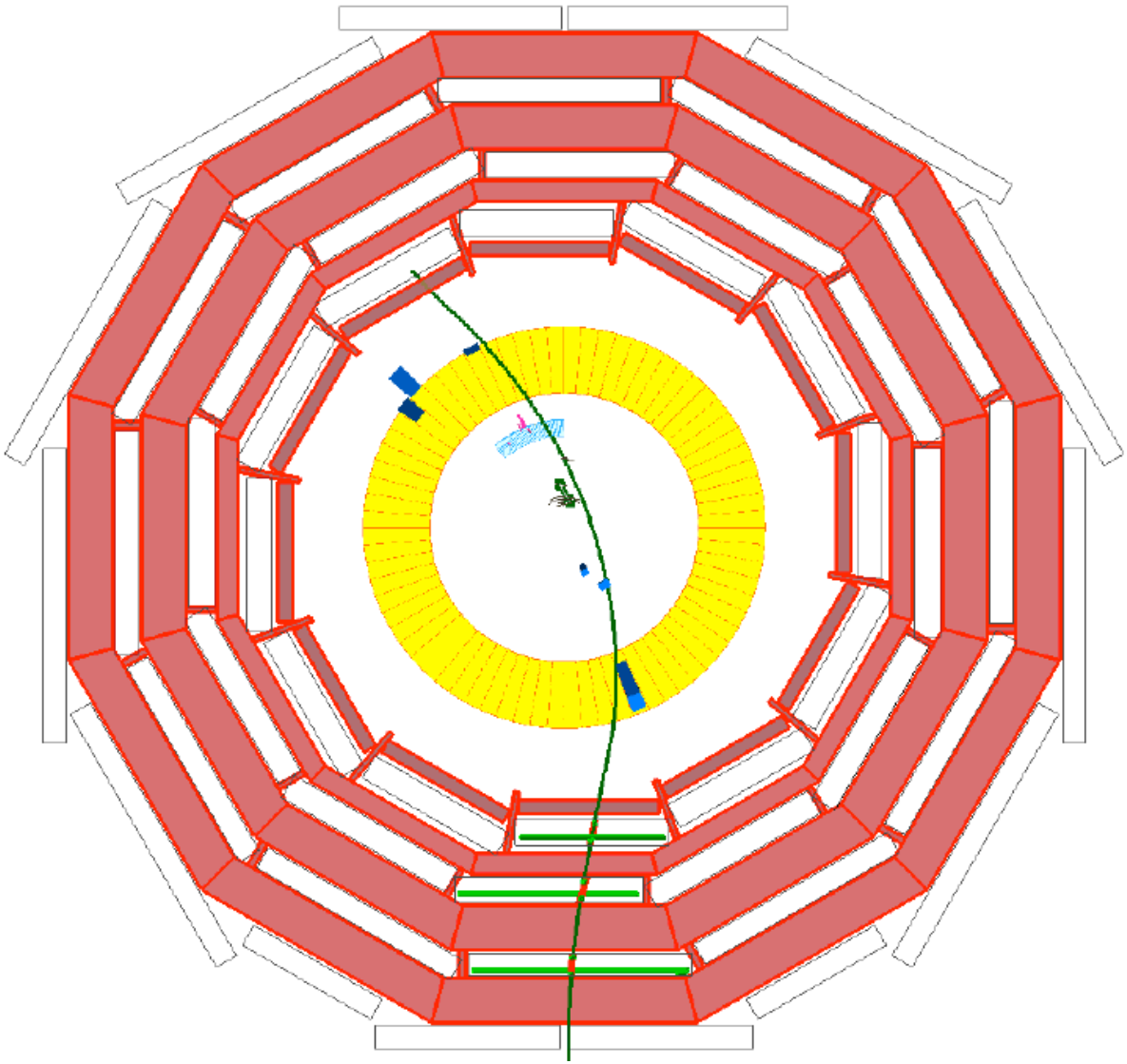
MTCC phase 1

- ~170 h data taking sessions, 50M events taken, 25M good events (with at least DT, ECAL and Tracker data), 10K events with good tracks reconstructed in Tracker
- 90% Data taking efficiency
- Event size ~170Kb
- Max Trigger rate~200Hz
- Shift crew ~ 20 people at the time





MTCC phase I: a typical event



Hits tracker modules, in ECAL and HCAL, track segments in the Muon system

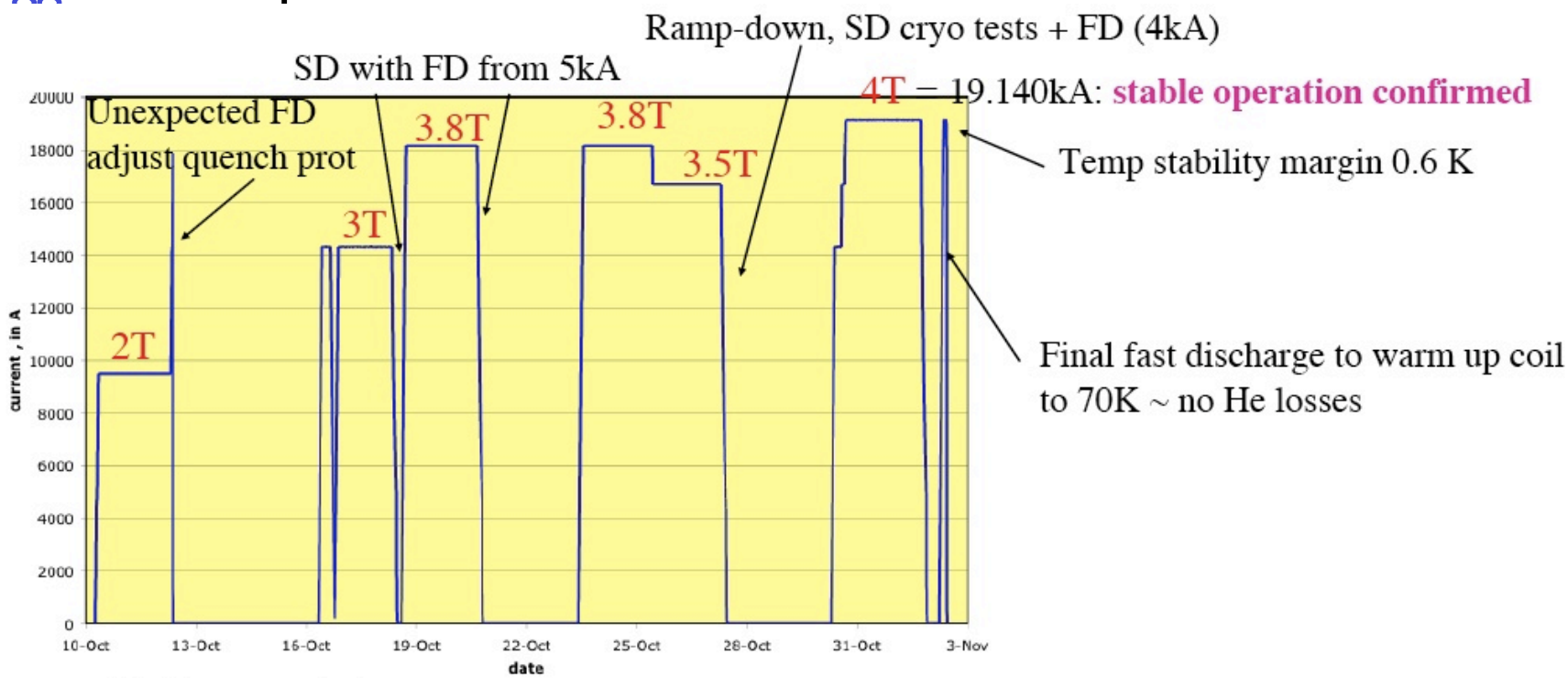
Standalone muon track reconstruction working

Propagation in magnetic field to tracker working

Event display, DQM, fast data access tested

MTCC phase II

Improvements: fringe field shielding, cooling system monitoring etc.
Setup: As MTCC-I but ECAL & Tracker
Main objective (achieved): Field-map (10^{-4})
Data sample: 200M events
Trigger rate: up to 200Hz



Field mapped at:

2.0, 3.0, 3.5, 3.8(twice) & 4.0 T with 0T references before and after

“Global” runs participation vs time