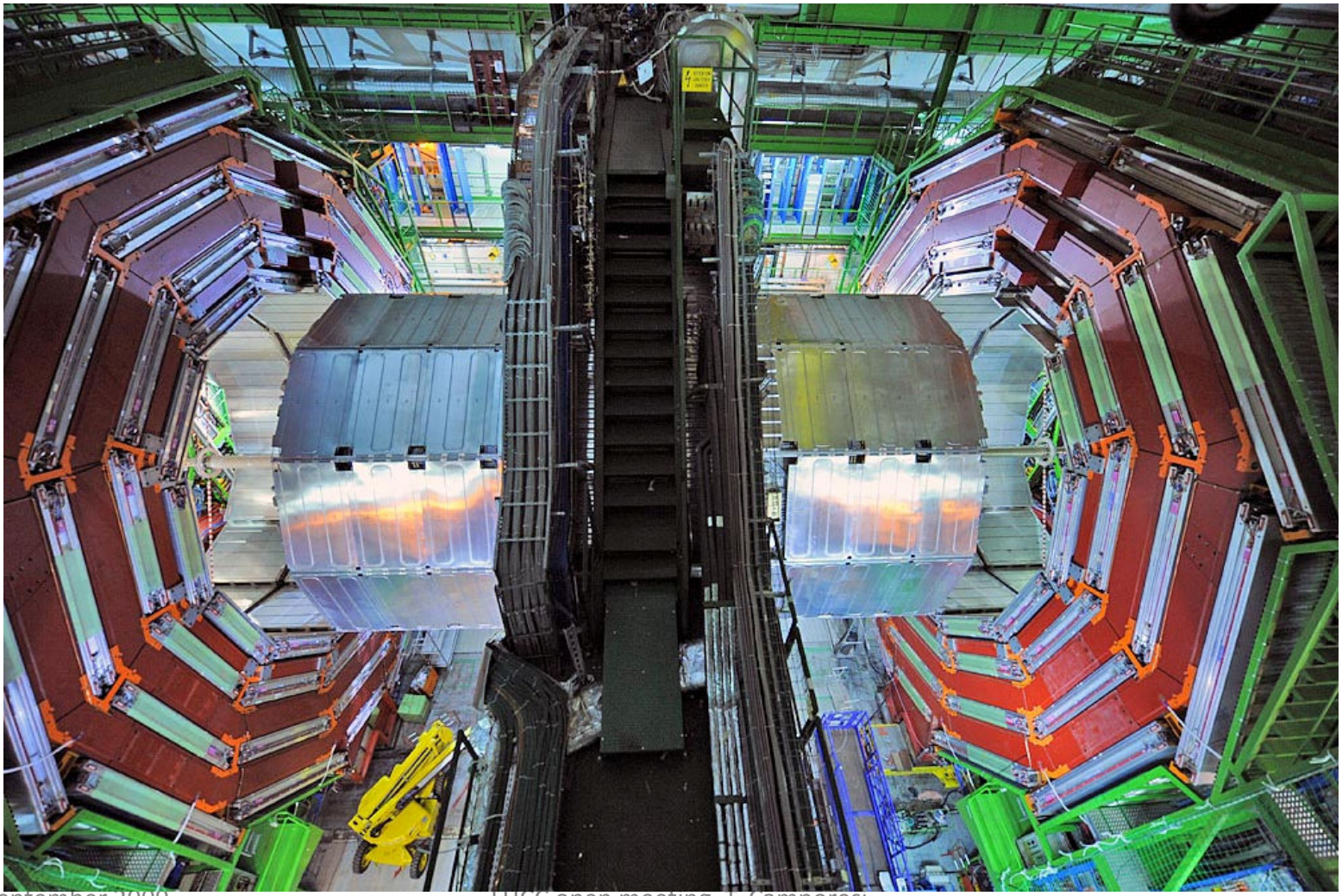
CMS status report

Activities in 2009

LHC operation readiness:

- Detector and trigger
- Offline
- Computing
- Physics

After the cosmics run ended (Nov '08), the detector was opened for **carefully selected maintenance, consolidation and repair activities**, as well as the **installation** of the preshower subdetector.



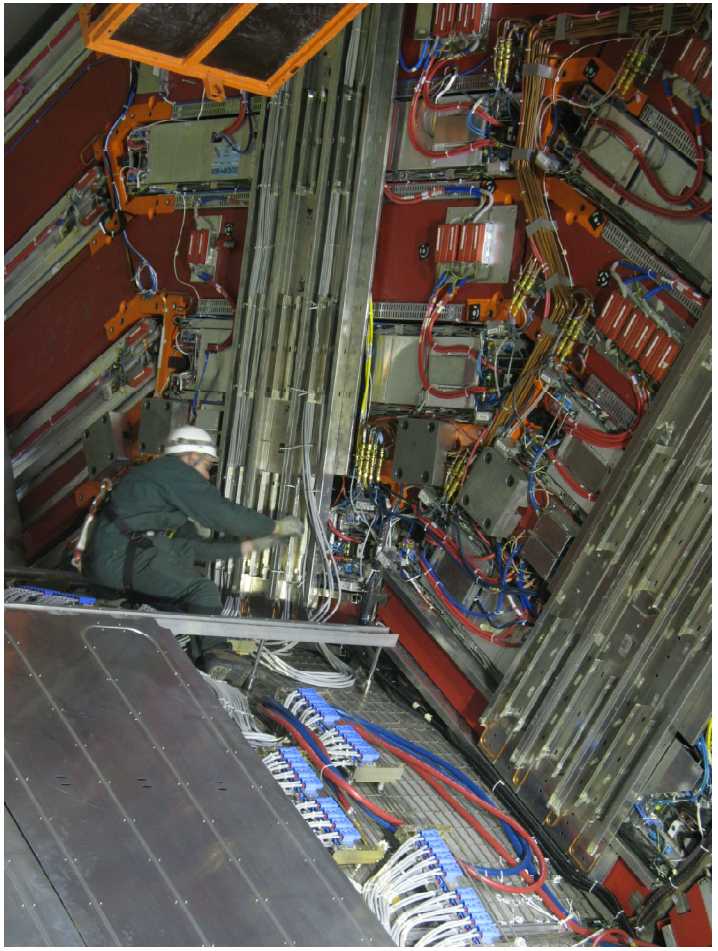
Shutdown activities

- **Work progressed according to the schedule** laid down in Nov. 2008.
- **Some highlights**:
- the installation and commissioning of the preshower (ES)
- the removal, repair, and re-insertion of the forward pixel system
- the maintenance and (small) repairs involving many sub-systems
- the revision of the tracker cooling plant
- Re-commissioning of CMS – Mid-Week Global Runs interspersed with final maintenance and consolidation activities.

- Continous operation Global cosmics run for 6 weeks since from Mid August

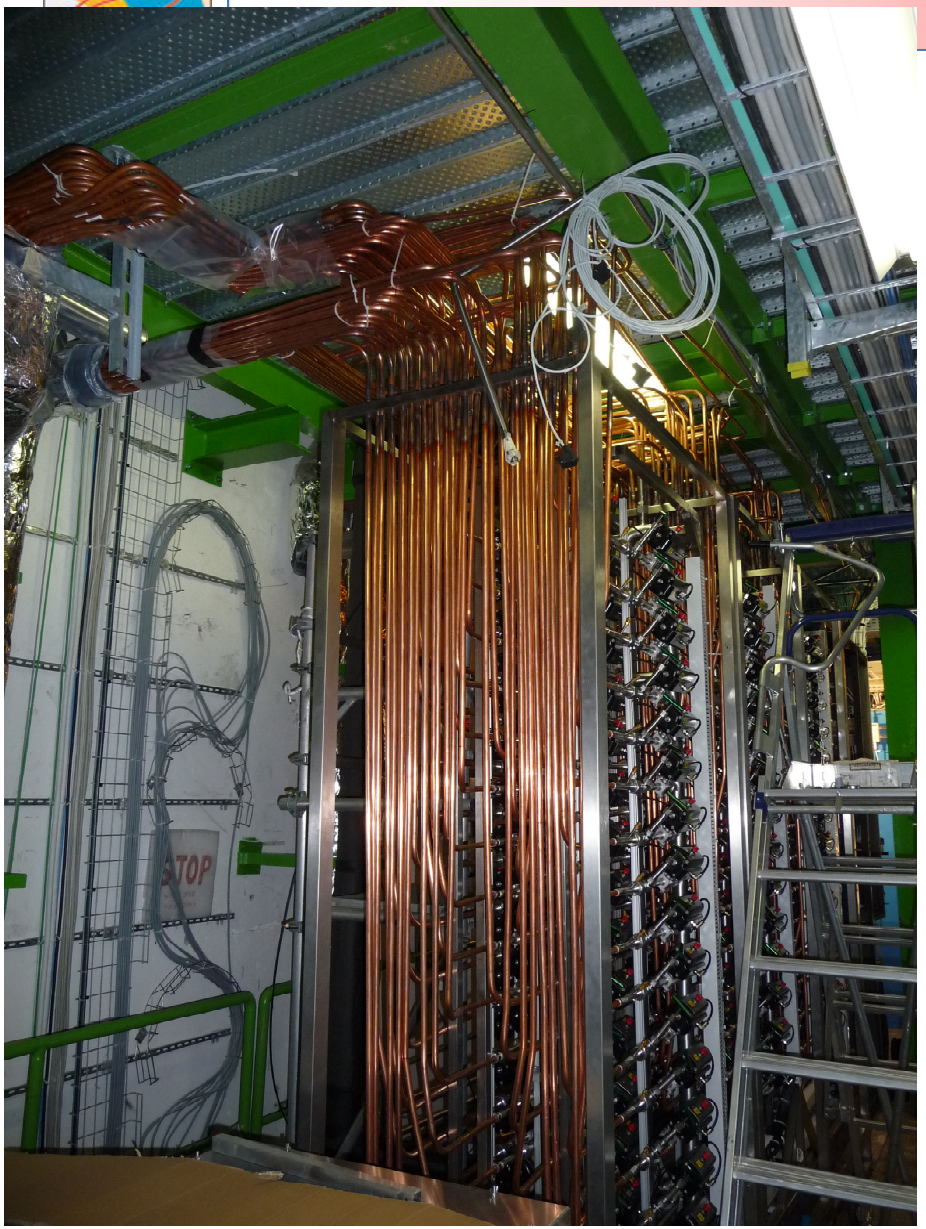
- Preparation of s/w for 2009 data taking, improving stability & reliability of computing infrastructure, large MC production and analysis at 10 and 7 TeV.

In Pictures



Reconnecting after repair of a barrel muon chamber

Tracker Cooling Plant Revision

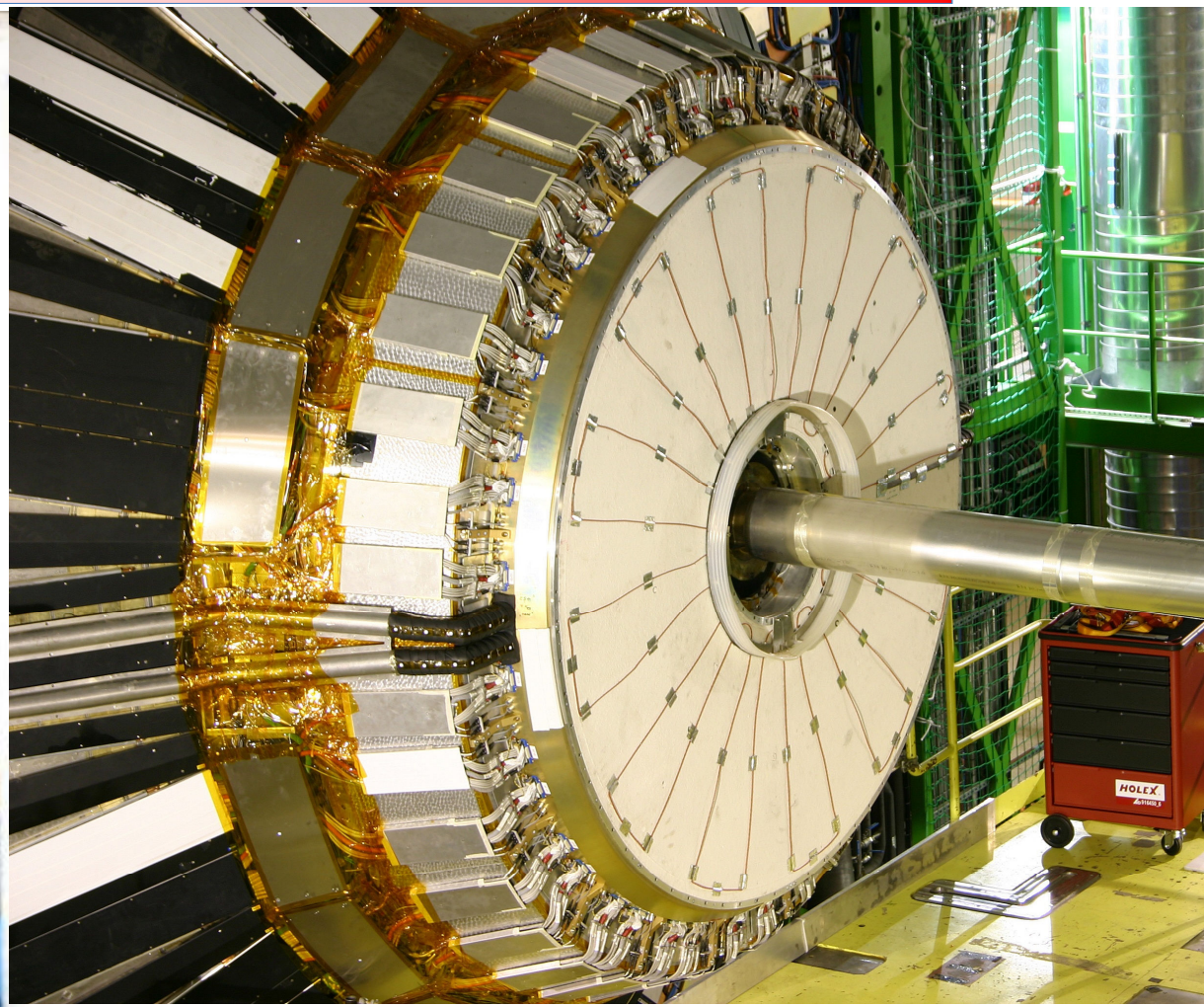


1. **To assure the long-term reliability:** complete replacement of the tanks, distribution lines, valves and manifolds on the SS1 and SS2 strip tracker (182 circuits) and pixels (36 circuits) cooling plants

1. The SS1, SS2 and Pixel cooling plants are in stable operation for several months. Leak rates are factor ~ 10 lower than last year.

2. Two out of the 182 lines closed. These are on SS2 and the leak rate of SS2 is limited (4-5 kg /day).

Preshower installation



The two separate ES Dees

Installation completed in Apr'09

Pixel intervention

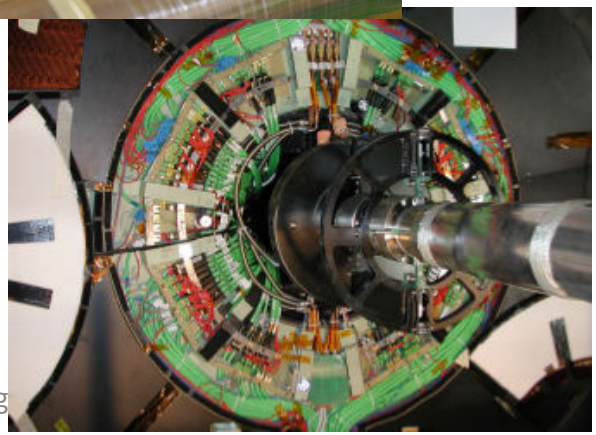
- **Fpix Low Voltage Problem (affecting 2% pixels) Now Fixed**

Some bad crimps that heated, melted the insulation and created shorts

The cable with short fixed. Resistance for all cables measured. The worst cables repaired by replacing connectors.

- **Fpix Cooling system upgraded**

To increase the safety margin
Silicone tubing inside the service cylinder replaced with tubing with higher pressure rating



- **Bpix & Fpix Detector**

running at 4^0C since mid May.

Magnet

- Operation of the magnet at full field in the cavern and the tracks from the cosmic run indicated that
  - The stray field in the forward region was higher than expected
  - The field map, while having an accuracy < 1‰ inside the solenoid was overestimated in the yoke

action

Mechanics of forward detectors (HF and Castor) consolidated during shutdown

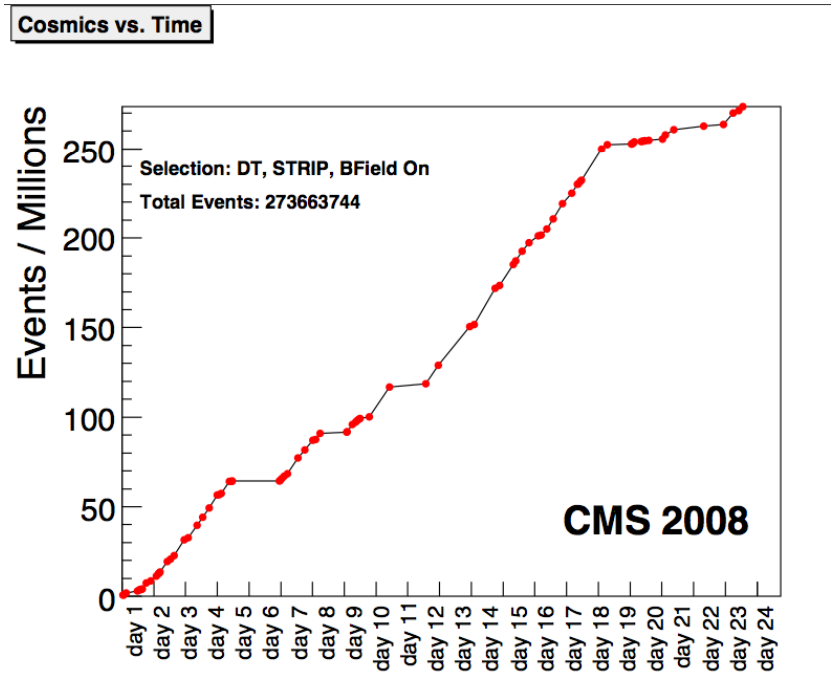
TOSCA model dependence from boundary volume size discovered. New model probed and tuned using cosmic tracks (CRAFT08 paper in preparation)

Cosmic data taking

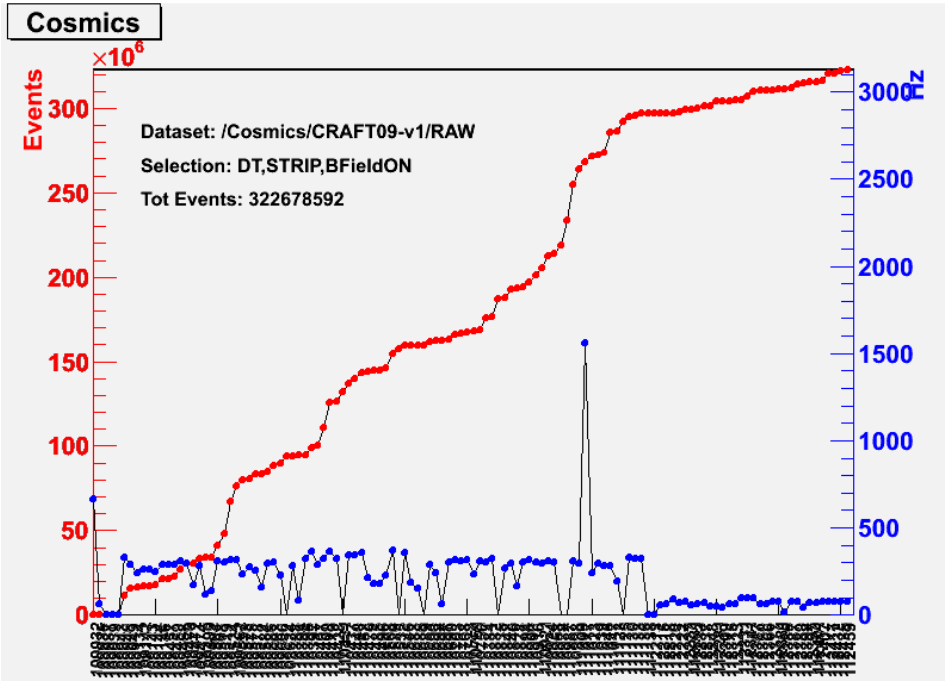
CRAFT = Cosmic Run At Four Tesla

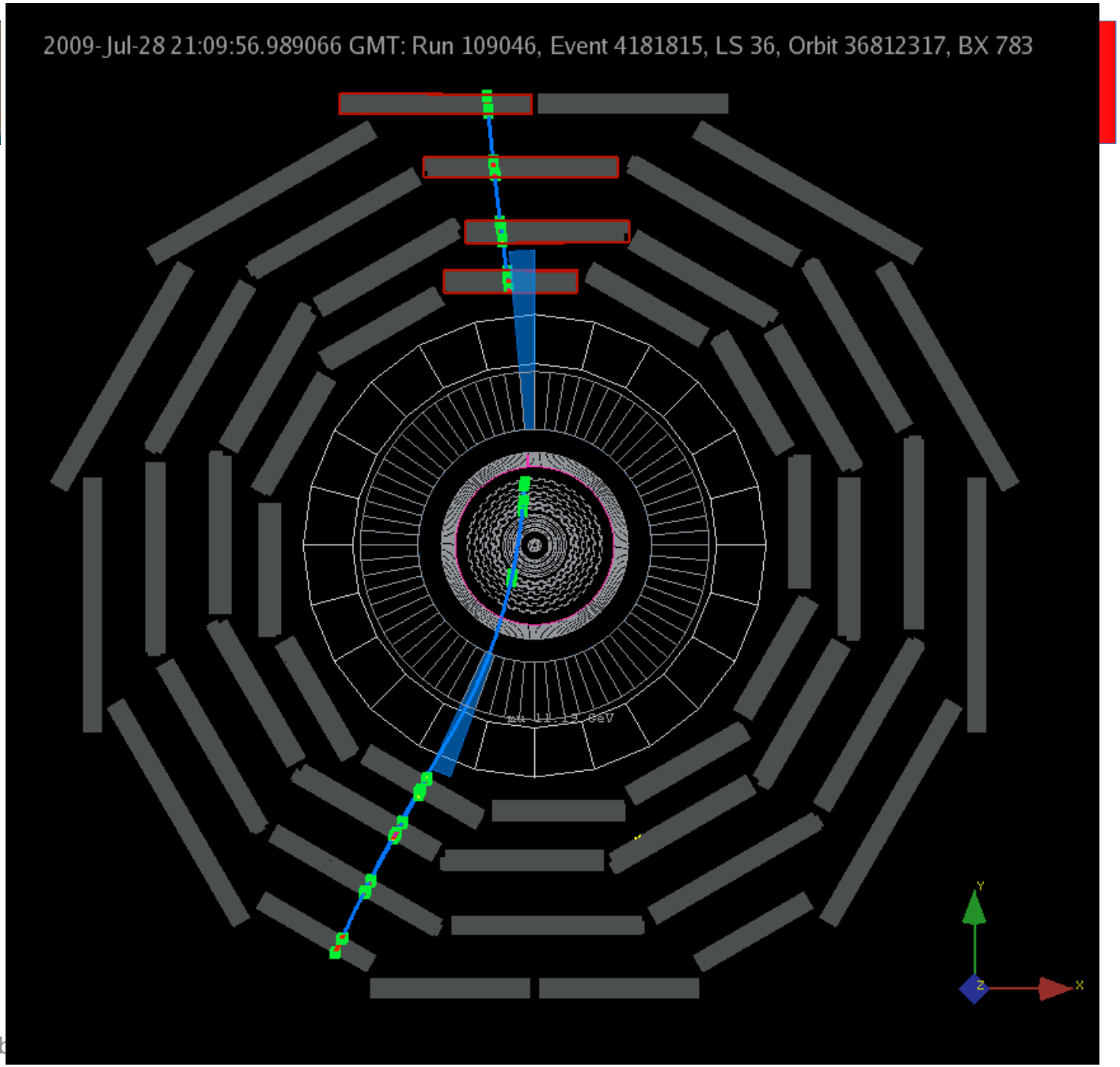
- > 1 Billion of cosmic trigger logged between 2008 and 2009

2008 CRAFT B@3.8T +Tracker

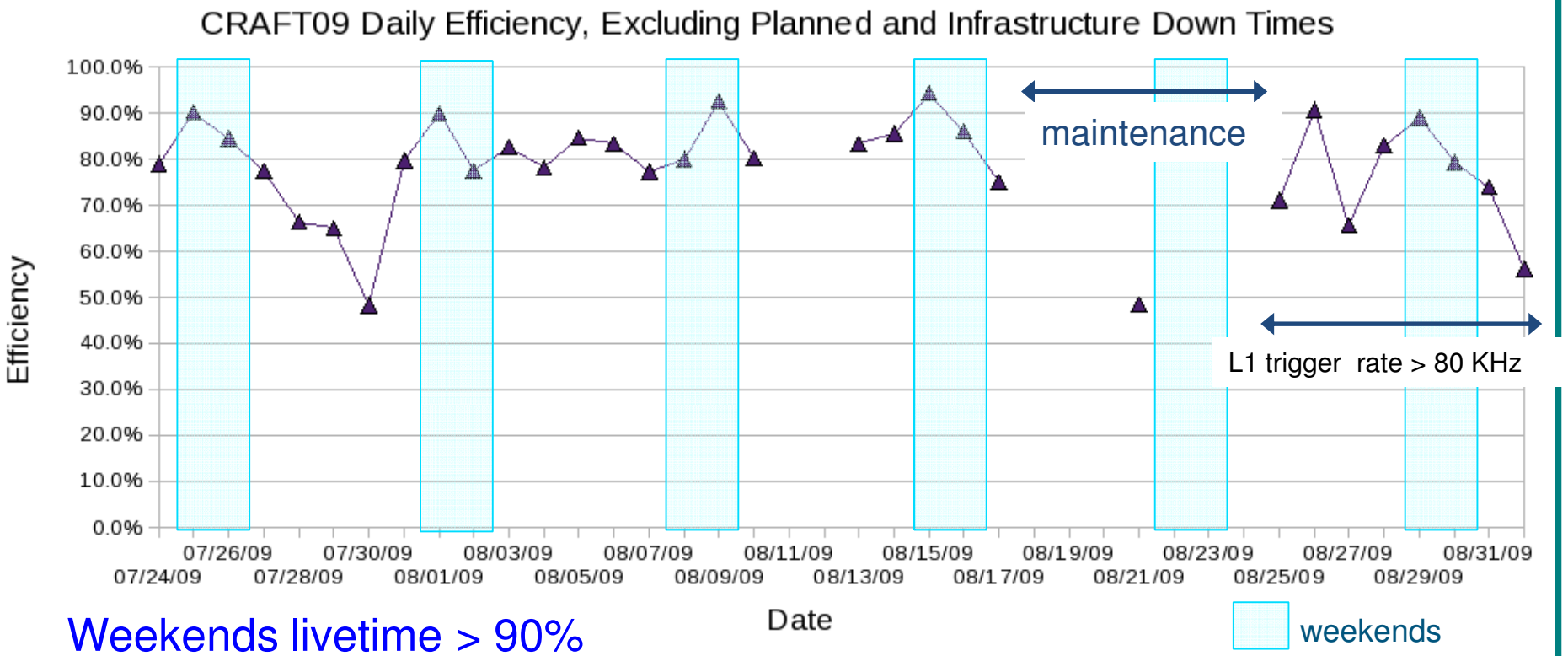


2009 CRAFT B@3.8T+Tracker




2009-Jul-28 21:09:56.989066 GMT: Run 109046, Event 4181815, LS 36, Orbit 36812317, BX 783
Y
Z
X

Operational efficiency



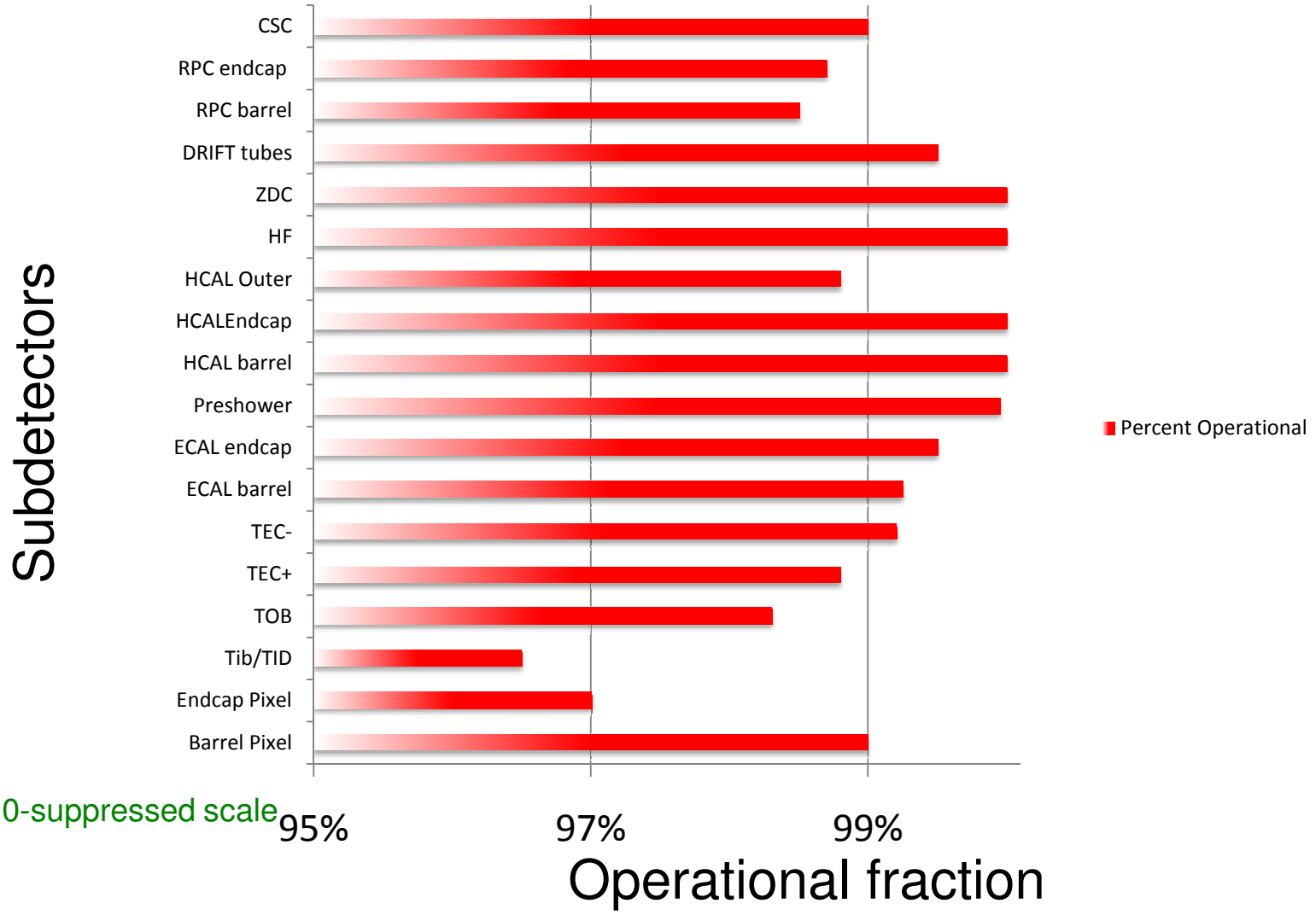
Weekends livetime > 90%

Average (24/7) overall efficiency 72%. Excluding service (cooling, power) failures the operational efficiency is >80%

Reasons for cooling service failures understood and corrective action implemented (in some case at CERN level)

Part of operational instabilities understood and we aim to fix before LHC beam in order to recover ~ 10% livetime

Detector status (end of August)

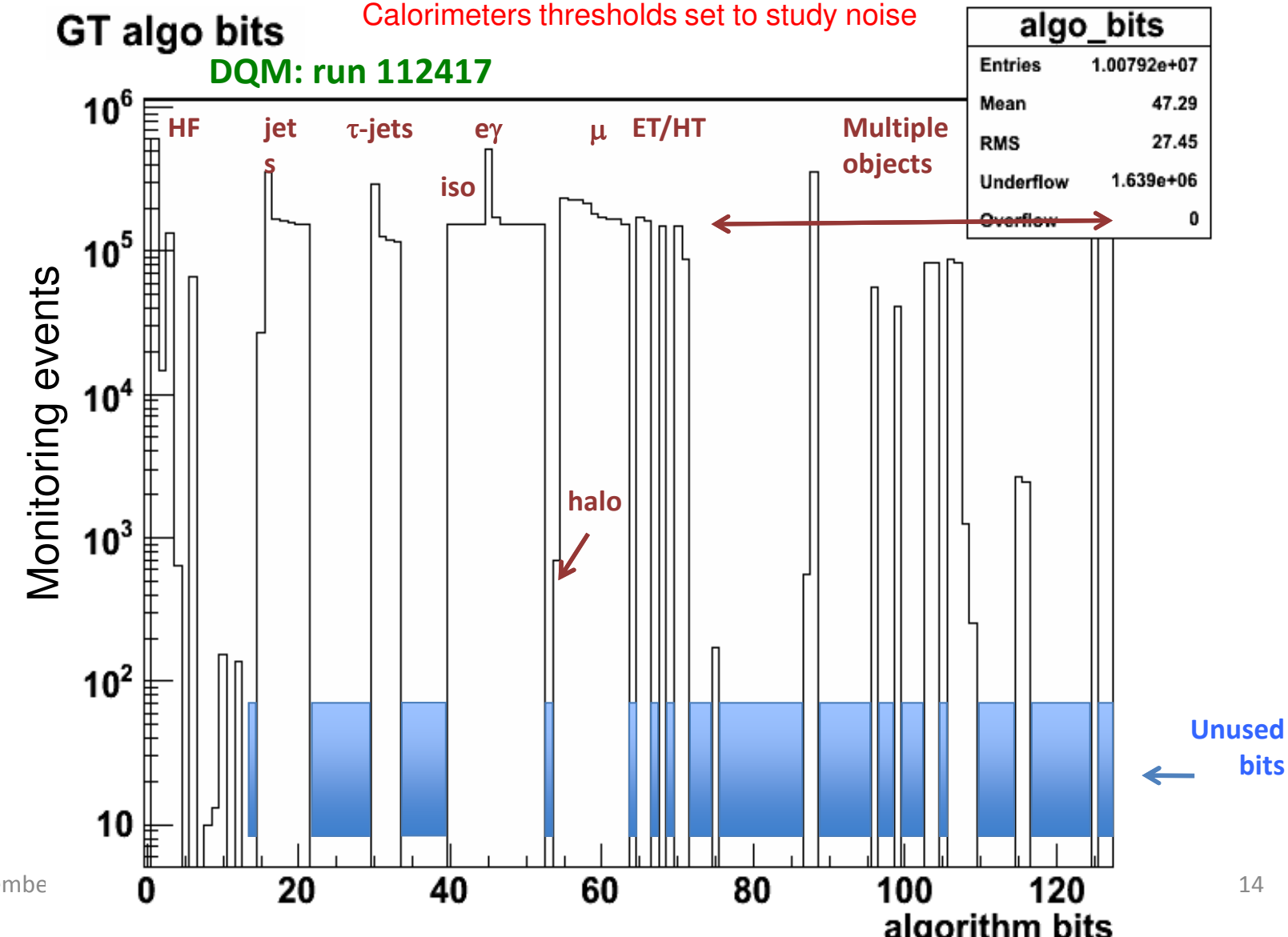


Note 0-suppressed scale

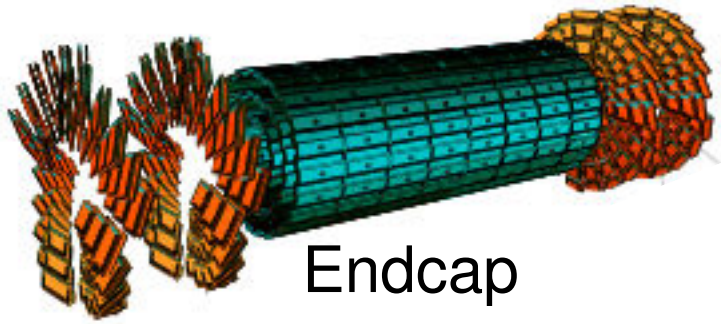
Detector readiness

23 papers in preparation to document performance measured in CRAFT08 (to be submitted to JINST on Nov 1)

L1 Triggers: all working

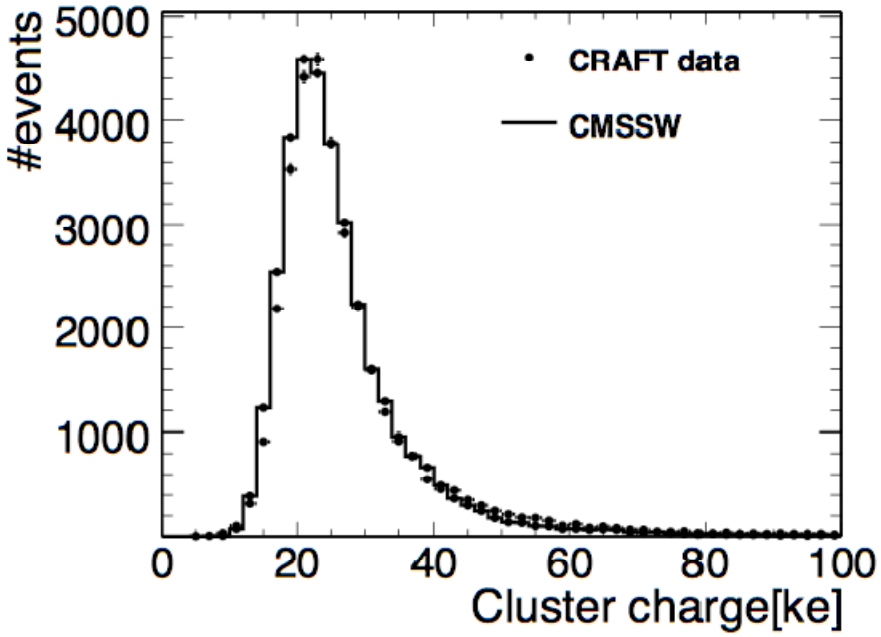


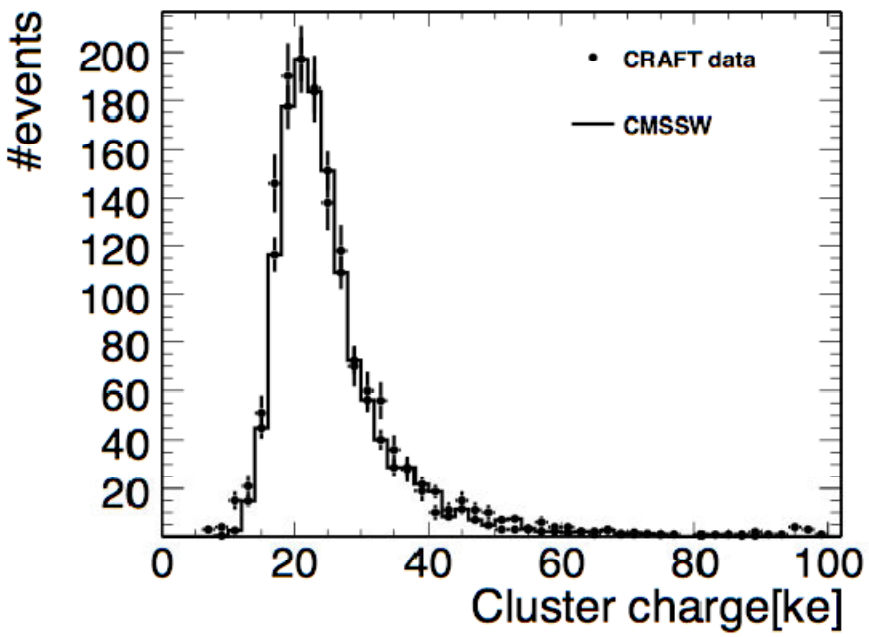
Pixel cluster charge



Barrel

Endcap



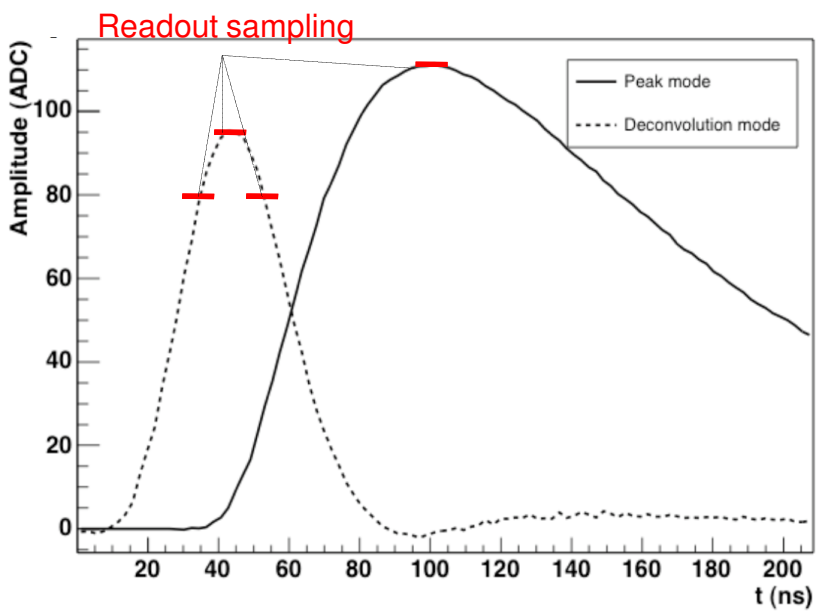


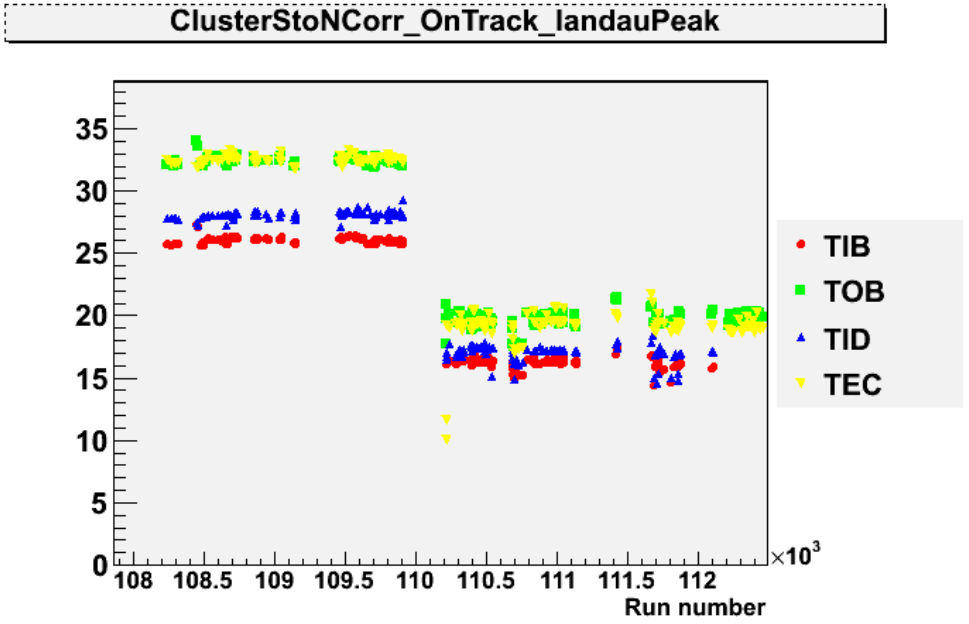
Noise ~ 140 e-

Tracker ready for LHC

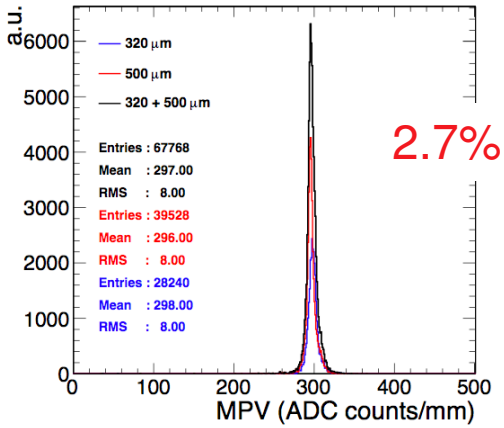
Deconvolution readout mode commissioned (tracker was read-out in peak mode in 2008)

The ratio Peak/Deconvolution is ~ 1.7 as expected (x1.5 noise and x0.9 signal)



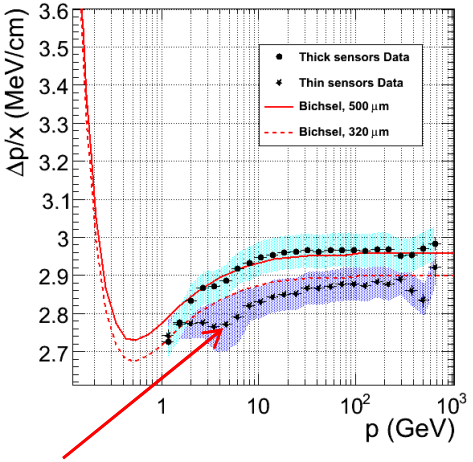


Silicon Tracker



2.7% rms

Relative calibration: Most Probable Value of signal adjusted to Mip signal at front-end



Contamination of off time muons in specific acceptance area

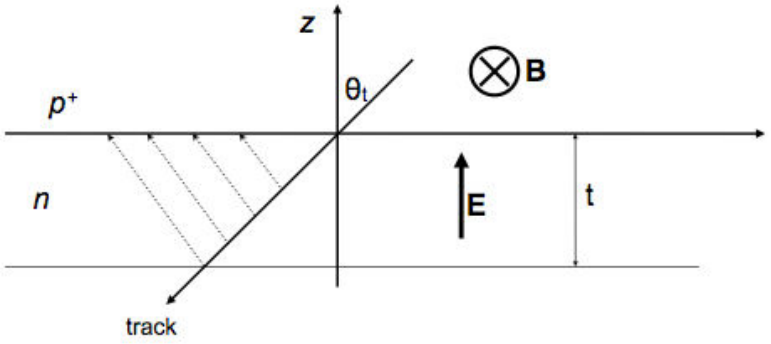
Absolute calibration from ionization curve adjusted to Bichsel function

262 +/- 3 e^-/ADC compared with 269 e^-/ADC from pulse injection

S/N (peak mode)

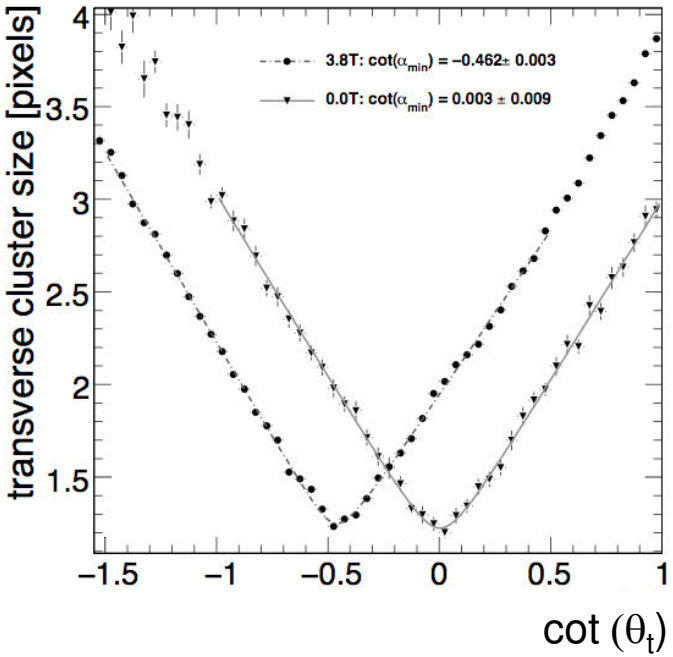
TIB	TID	TOB	TEC thin	TEC thick
25	28	32	27	32

Effect of B field: Lorentz Angle



Minimum of cluster width at Lorentz-angle

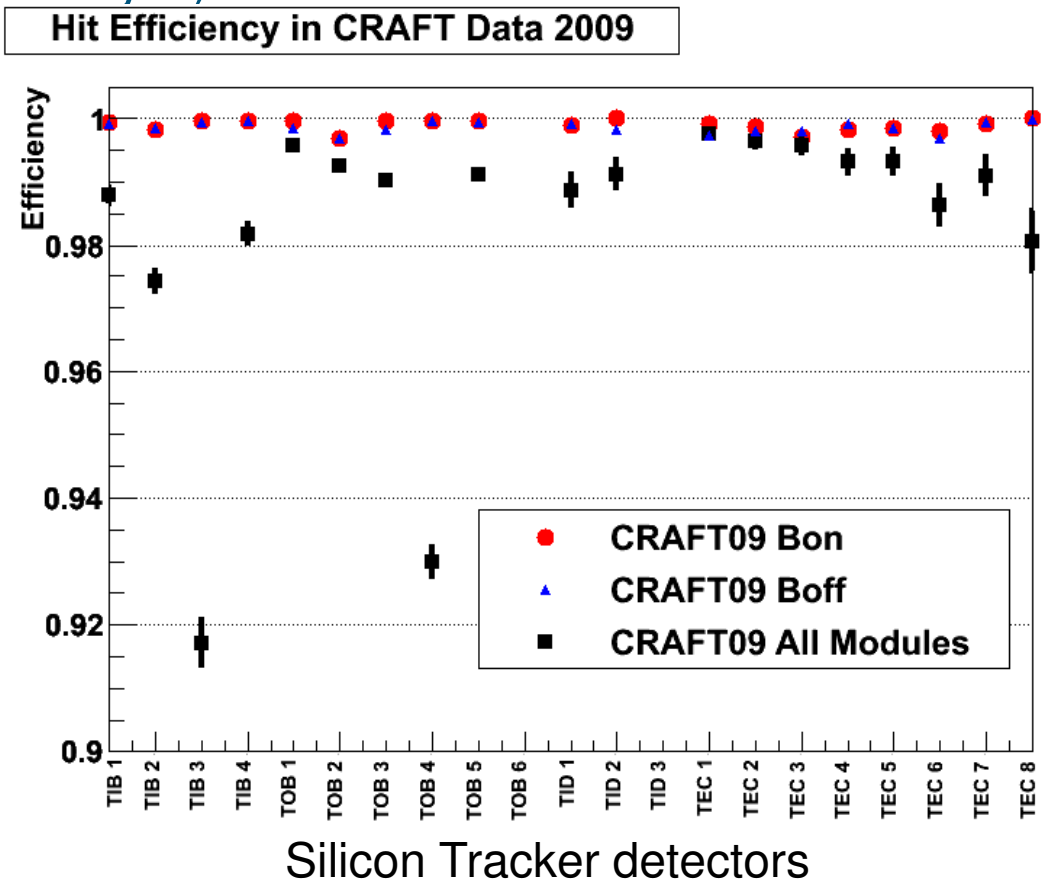
BPIX	FPIX	TIB	TOB
24.8°	4.2°	3.9°	5°



Correction to cluster position
~ 130μm BPIX, ~ 20μm FPIX, ~ 10μm TIB/TOB

Tracker efficiency

Hit efficiency is defined as total number of found hits divided by total number of expected hits from reconstructed tracks (removing hits from analyzed layer)



ε=99.8%

Excluding known faulty channels

Alignment

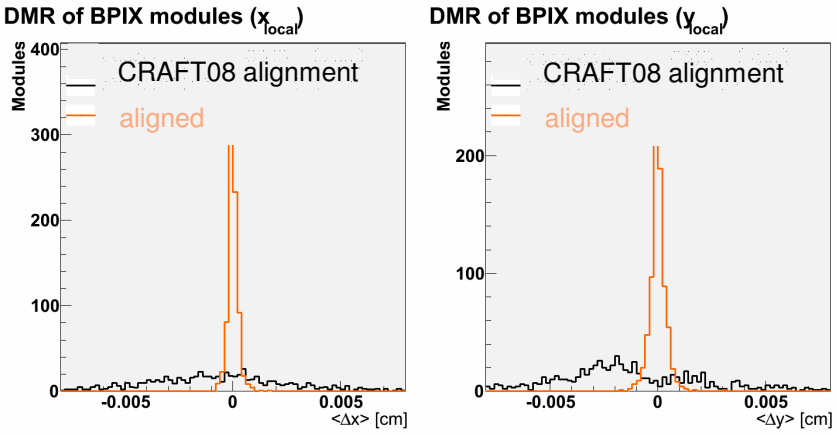
- Use RMS of distribution of Mean of residuals as ‘measure ‘ of alignment quality (insensitive to Multiple scattering)

CRAFT08

Pixel (reinstalled in shutdown) did indeed move..

DMR RMS (μm)	2009 prelim		MC alignment	Ideal alignment	Modules >30 Hits
BPIX (x)	2.6	2.5	2.1	2.1	757/768
BPIX (y)	4.0	4.0	2.5	2.4	757/768
FPIX (x)	13.1	13	12.0	9.4	391/672
FPIX (y)	13.9	13	11.6	9.3	391/672
TIB (x)	2.5	3	1.2	1.1	2623/2724
TOB (x)	2.6	3	1.4	1.1	5129/5208
TID (x)	3.3	4	2.4	1.6	807/816
TEC (x)	7.4	8	4.6	2.5	6318/6400

CRAFT09 data



Alignment quality Confirmed in 2009

Cosmic Track Finding Efficiency

Tag and Probe method

- Tag : Stand alone muons

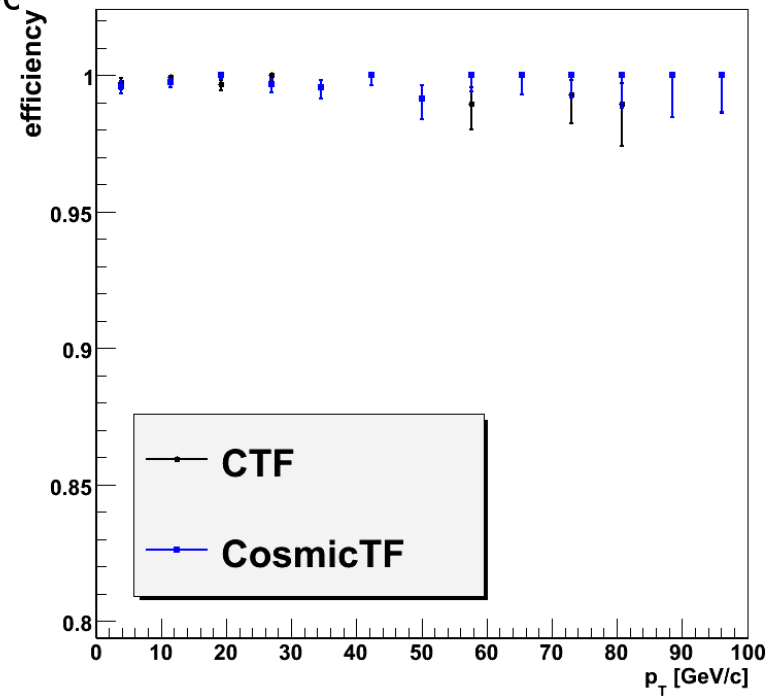
| dz | < 30cm, | dxy | < 30cm, | eta | < 1, 0.5 < | phi | < 2.5

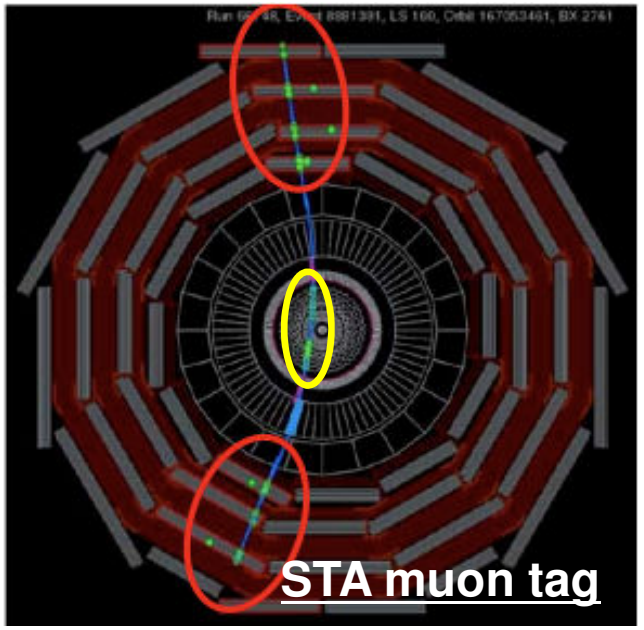
(at point of closest approach)

- Probe : Tracker reconstructed muons

Combinatorial Track Finder (collision algorithm with special outside-in seeding)

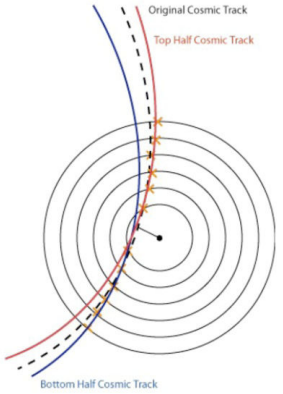
Cc





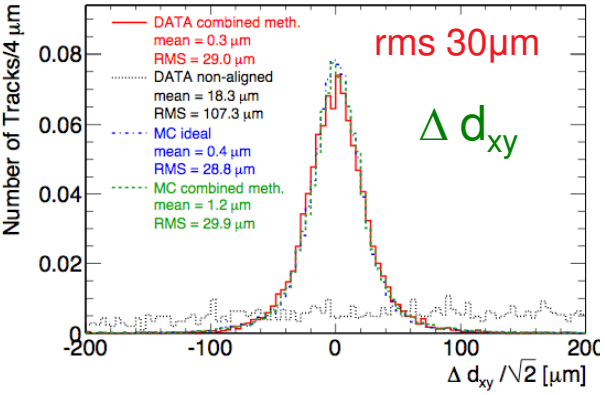
Efficiency (%)	CRAFT 09
CTF	99.8±0.1
CosmicTF	99.8±0.1

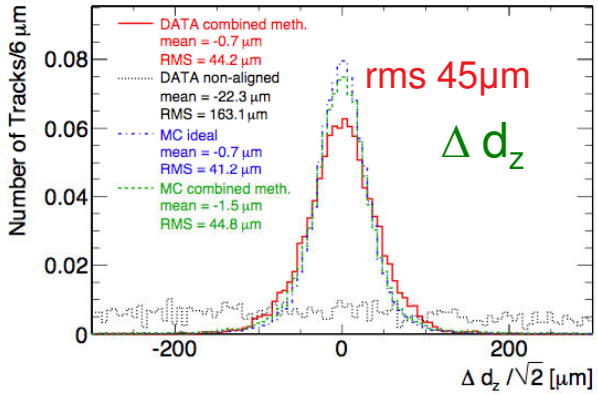
Track resolution

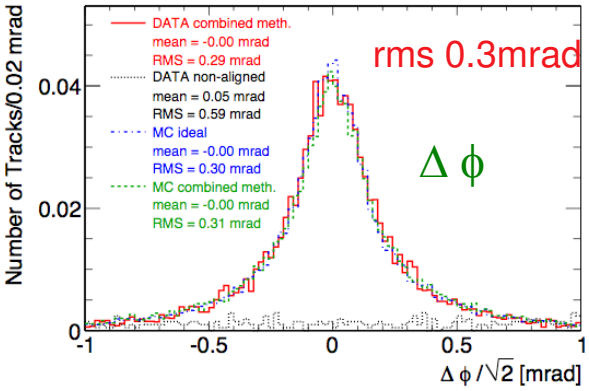


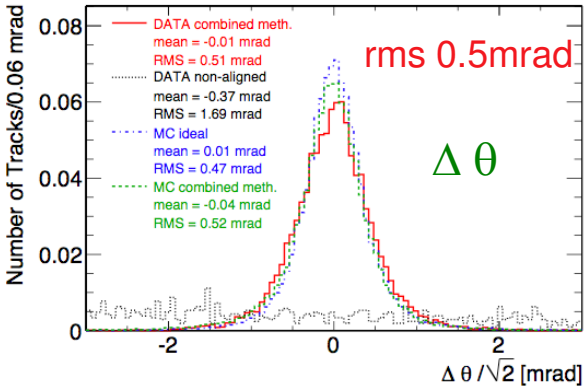
- Method: split cosmic track, reconstruct separately and compare at point of closest approach to beamline

CRAFT 08 result

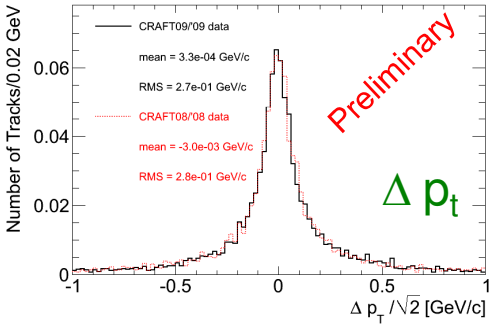


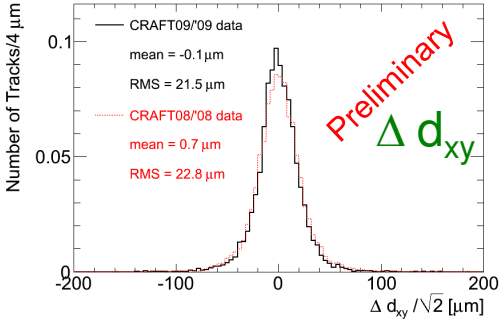






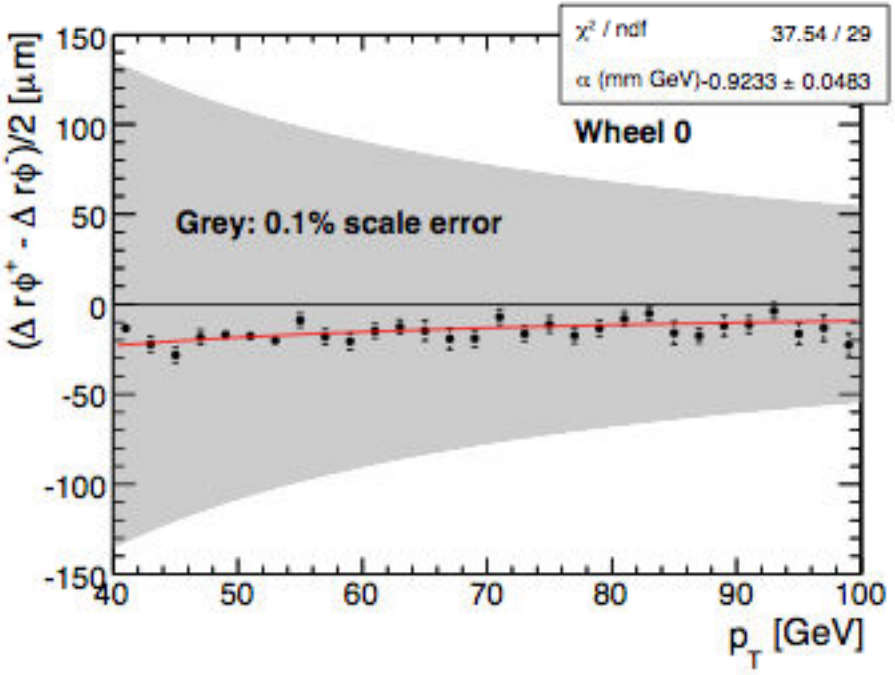
First look at CRAFT09 confirms it black=09 red=08

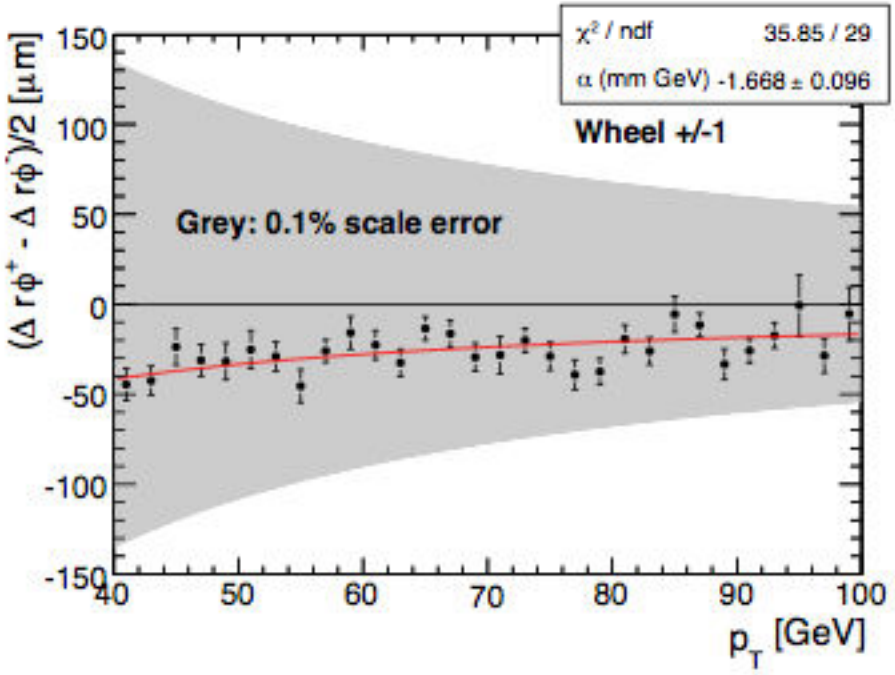




Magnetic field

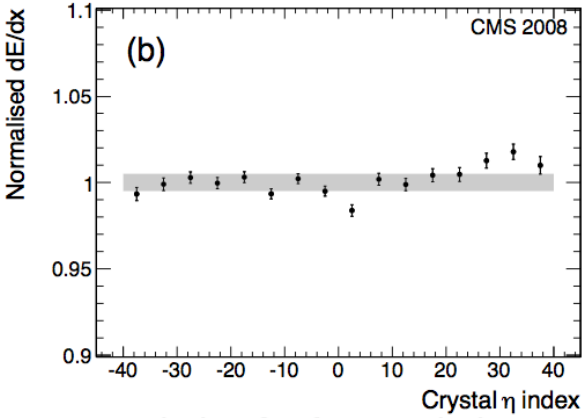
- CRAFT08 cosmic tracks allowed tuning of field in yoke to <3% in 3 inner wheel and <8% in two outermost wheel of the barrel
- Extrapolation of cosmic tracks reconstructed in tracker and extrapolated to first layer of barrel muon chambers verify that field inside solenoid is known to < 1‰



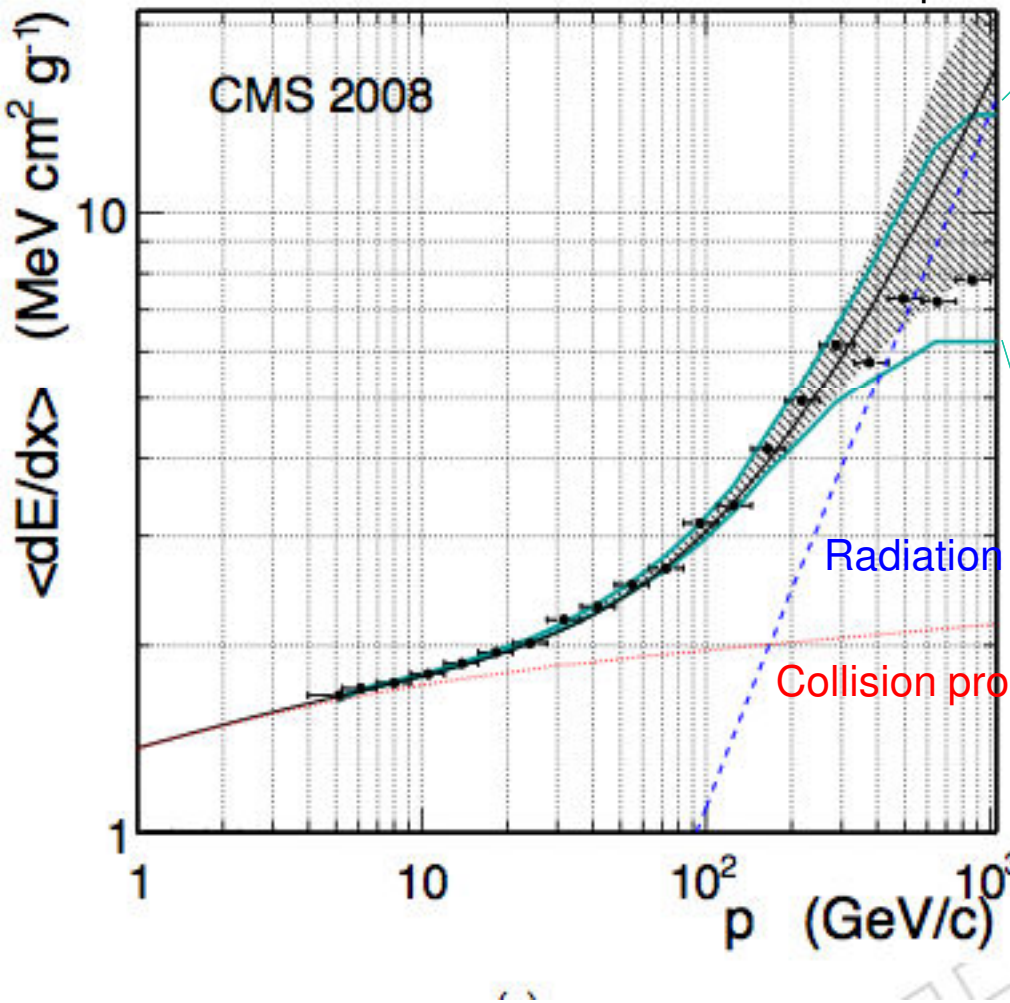


ECAL: μ stopping power

Validation of pre-calibration: rms 1.1%



Expected 68% prob interval

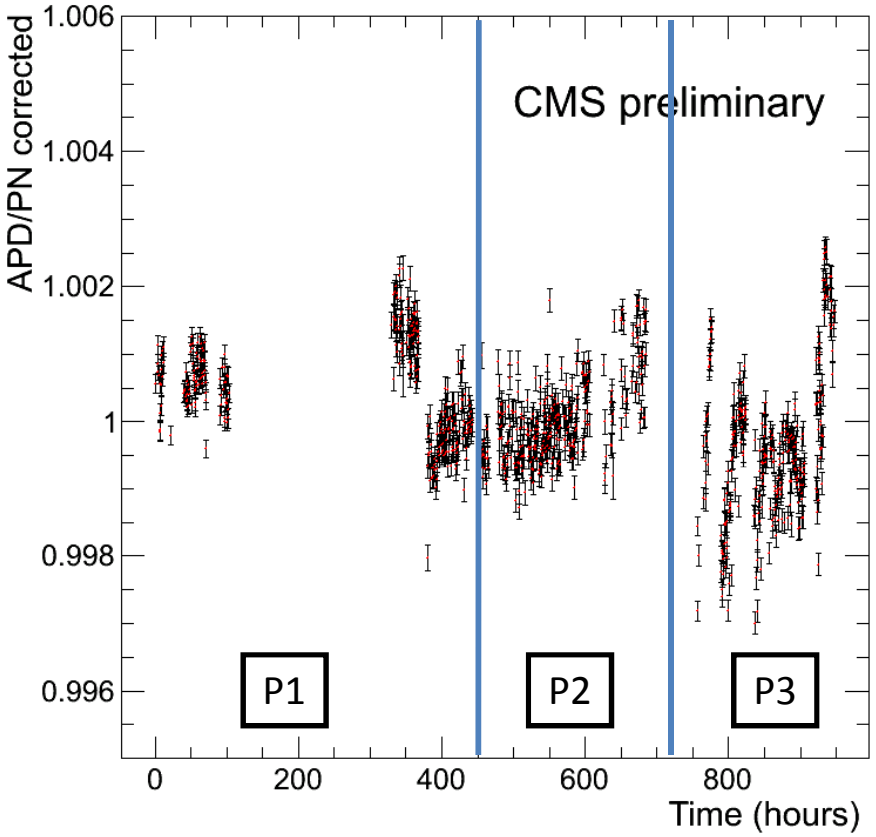


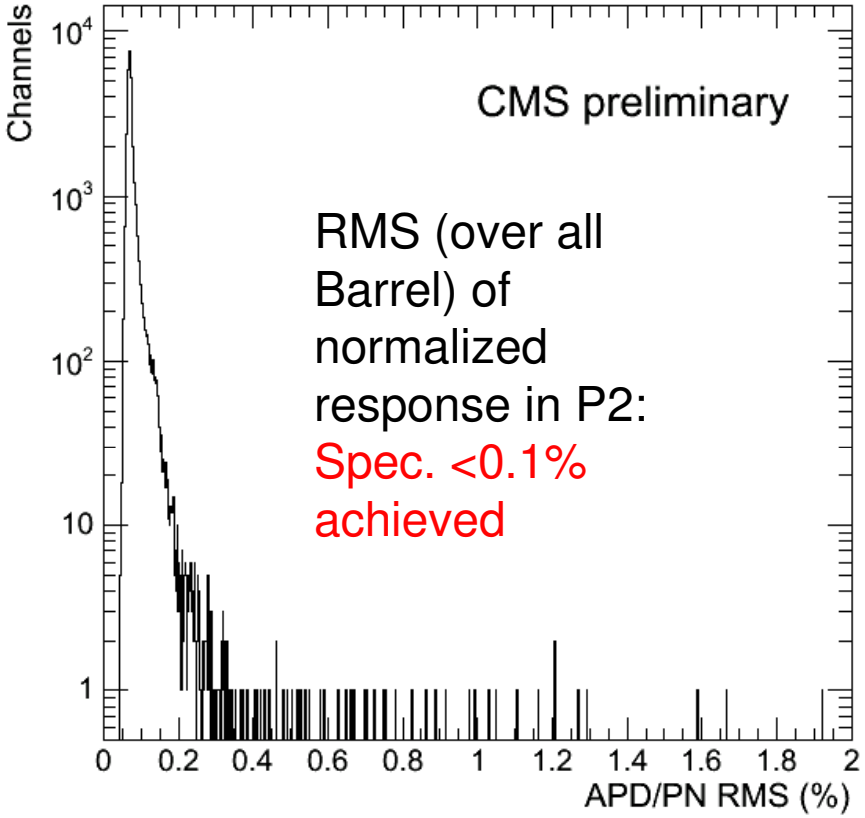
Minimal interval containing 68% of distribution (asymmetry in energy deposit distribution due to lack of containment of showers likely for high P μ)

Radiation processes

Collision processes

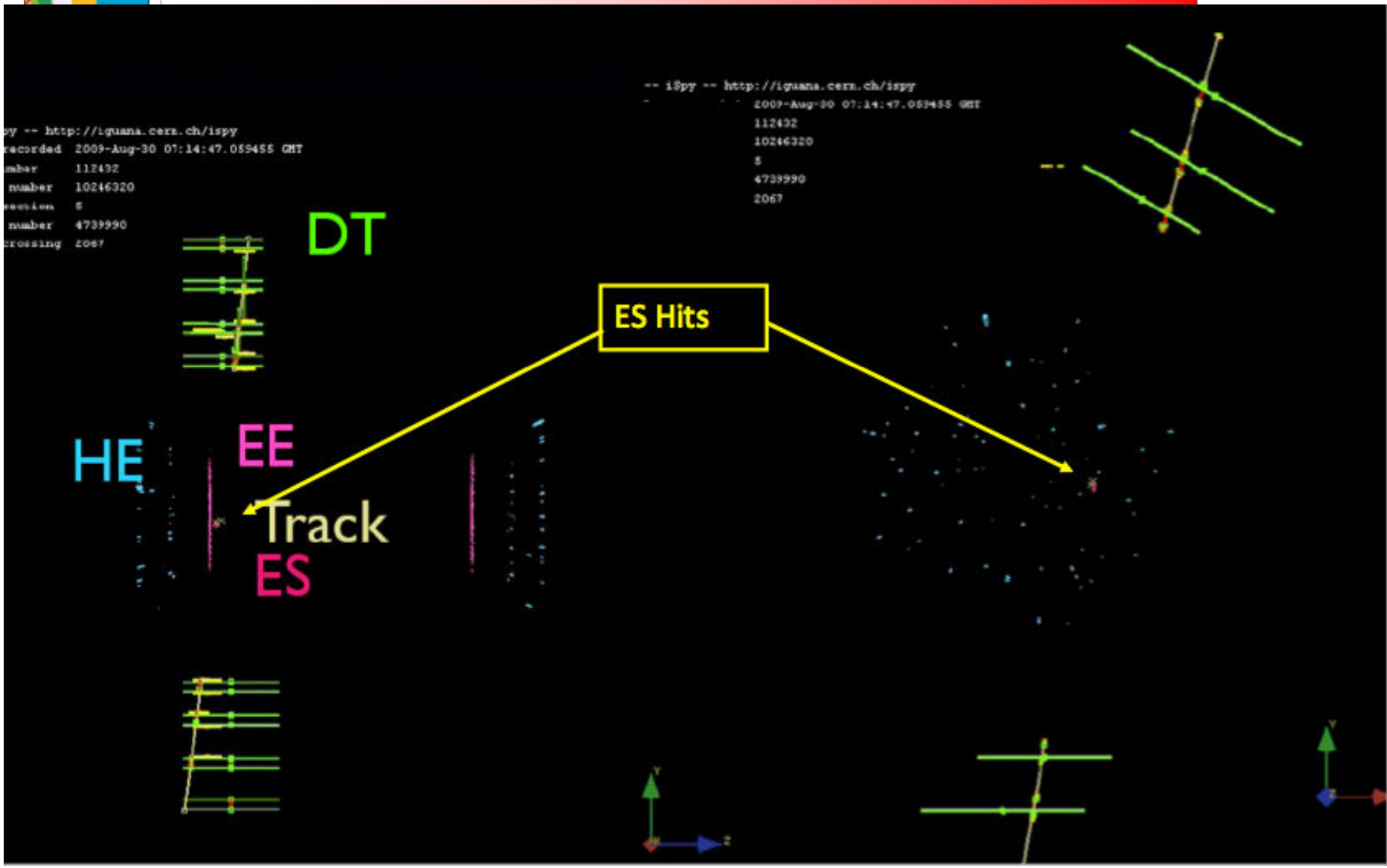
ECAL : laser calib commissioned





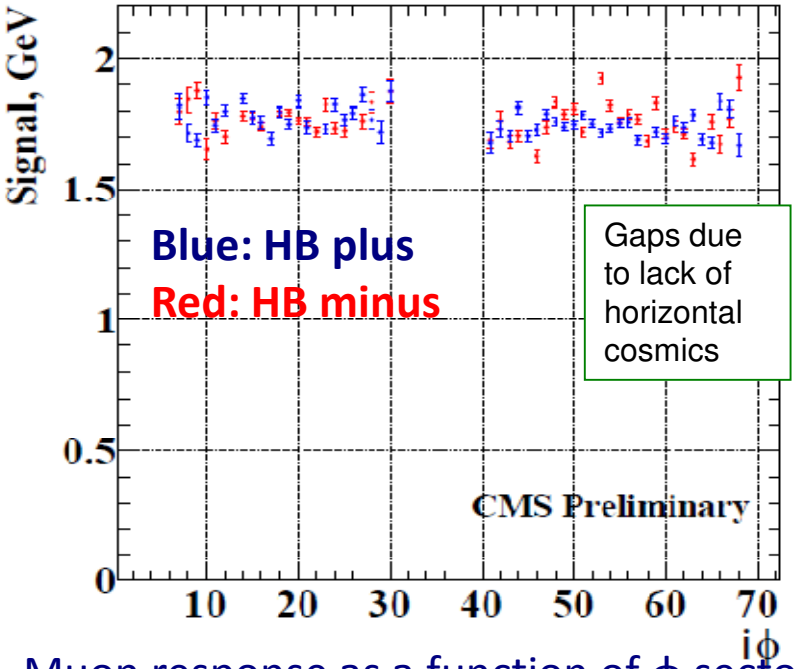
Normalized (to PN diode which monitors Laser light) response of typical channel

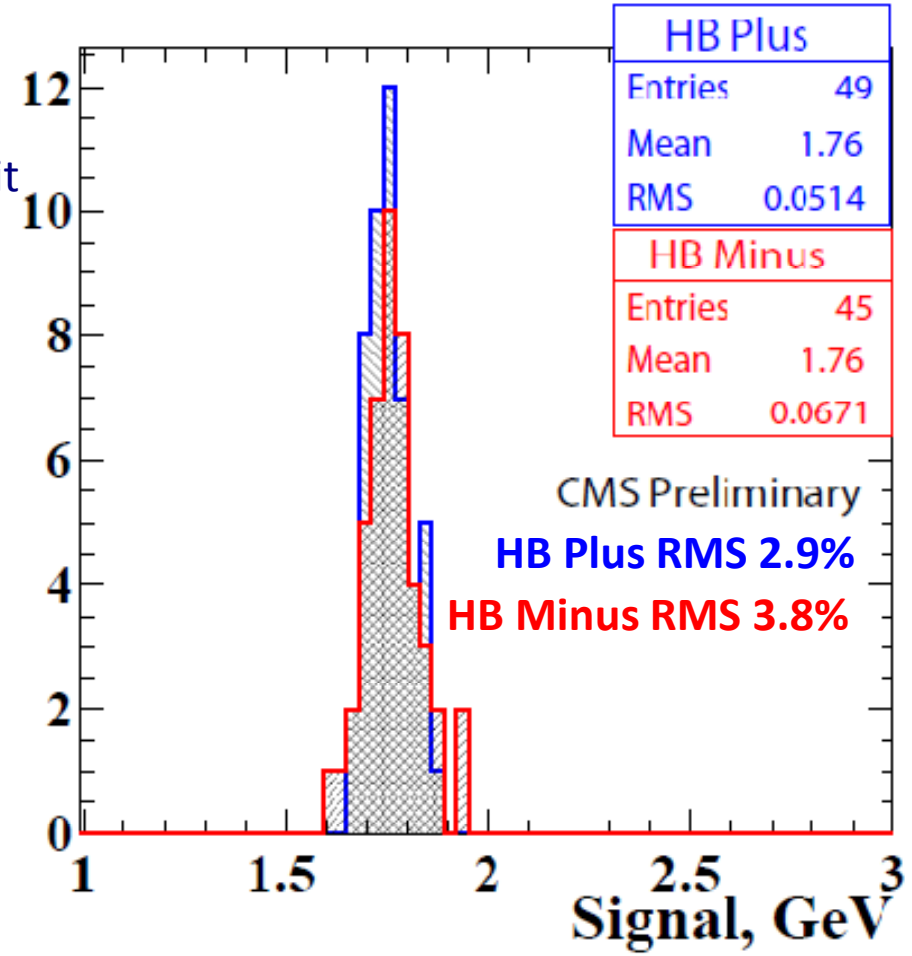
Cosmics in Preshower



HCAL

- Uses tracker tracks – propagation to the inner and outer radius of the HCAL barrel
- Pμ = 5-100 GeV/c
- Path length correction applied
- Signal is normalized to the response at one particular momentum value (25 GeV/c) using a fit to dE/dX vs. P_μ from data.

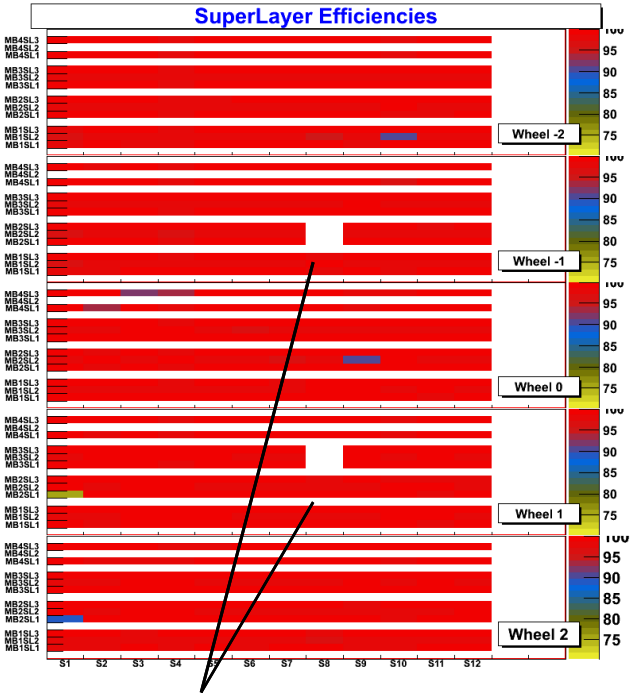




Muon response as a function of ϕ sectors

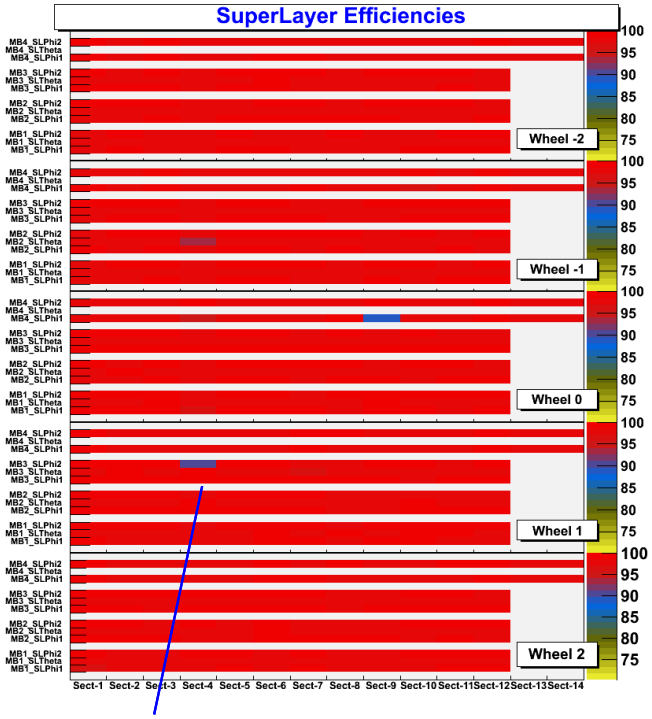
Muons: DT cell efficiencies

CRAFT08



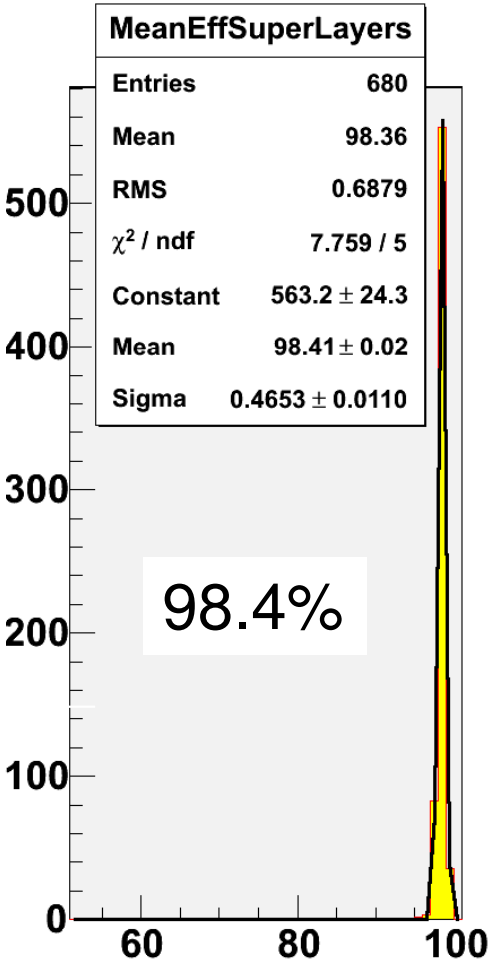
Chambers OFF
(fixed in shutdown)

CRAFT09

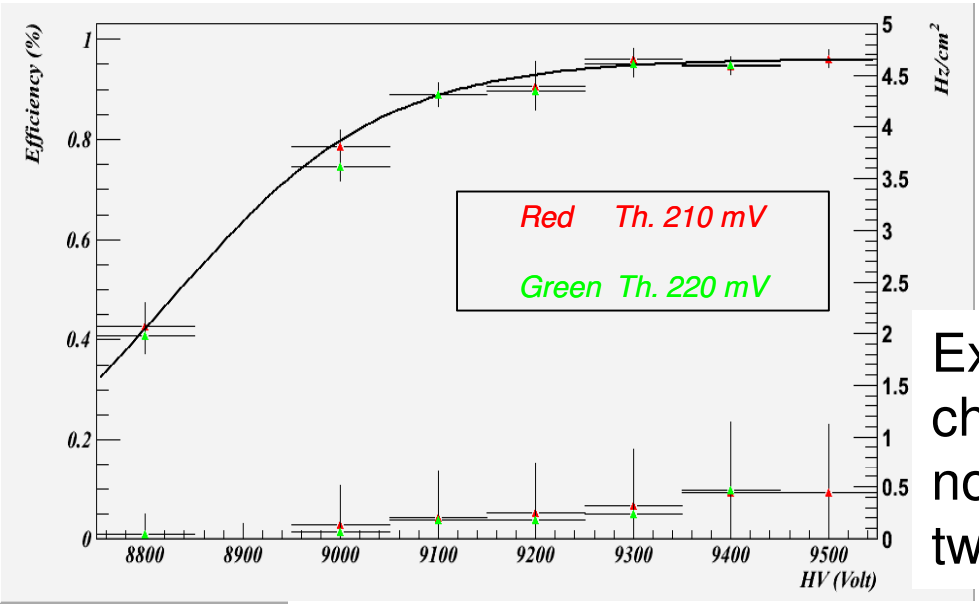


HV disconnected
(<0.3% channels)

CRAFT09

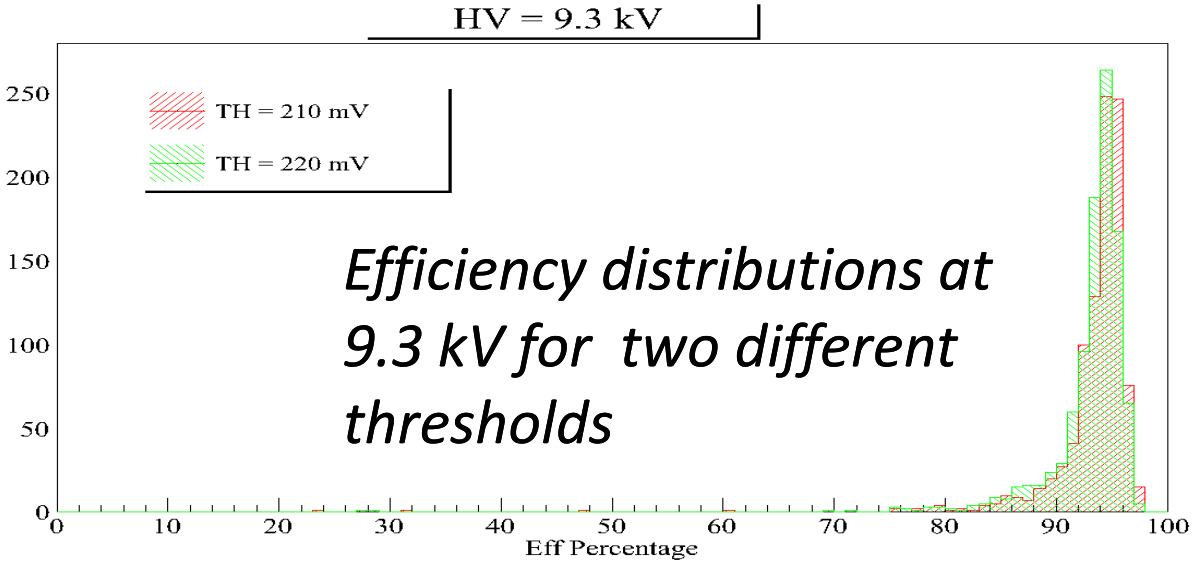


Muons: RPC



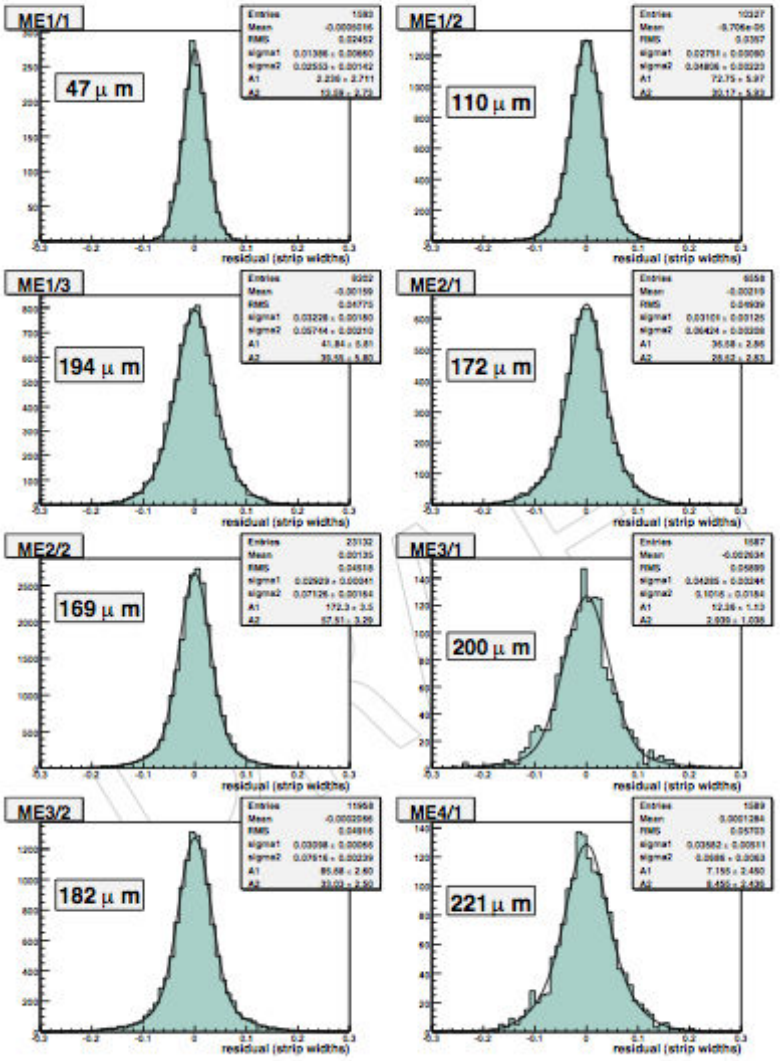
Barrel and Forward RPC fully functional during CRAFT09

Example of one barrel chamber HV scan for noise and efficiency at two different thresholds



Efficiency distributions at 9.3 kV for two different thresholds

Muons: CSC



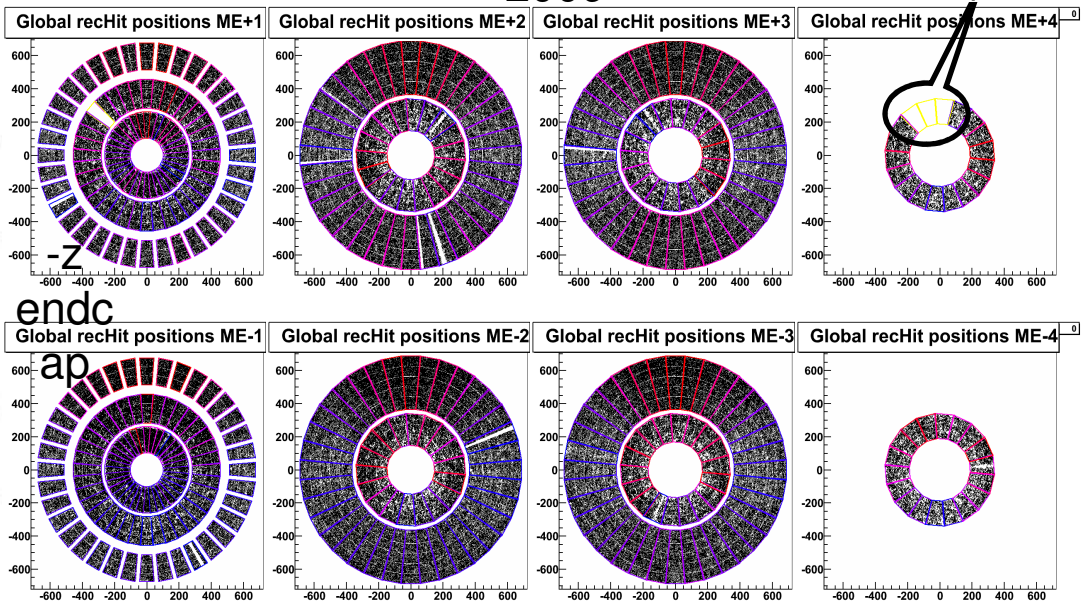
CRAFT08: residuals distributions

CRAFT09: 99% operational

Run 110508, 11 Aug 2009

+z endcap

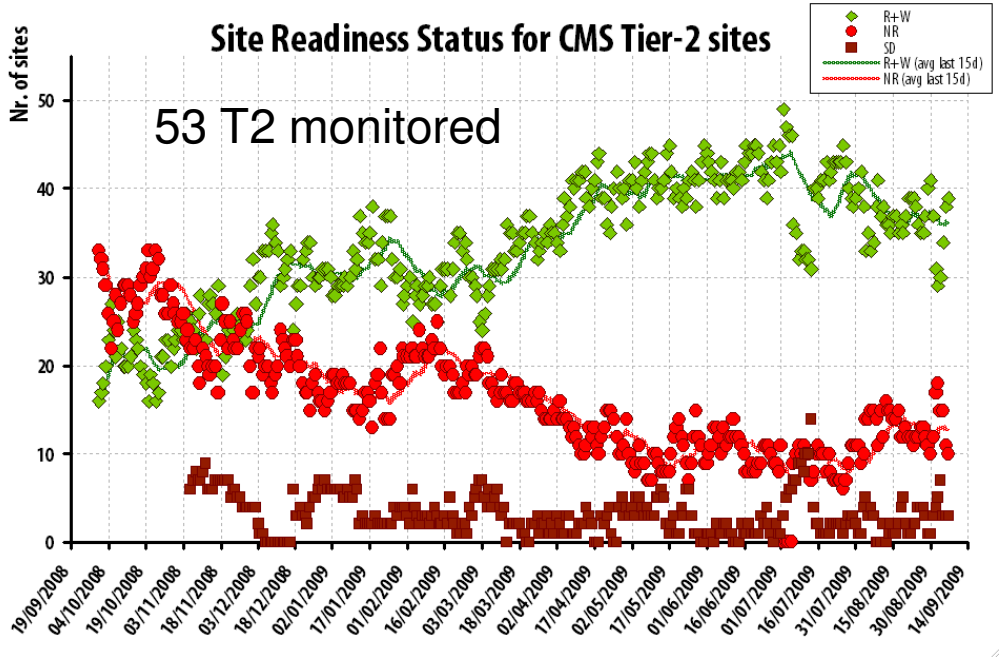
Low voltage off for development

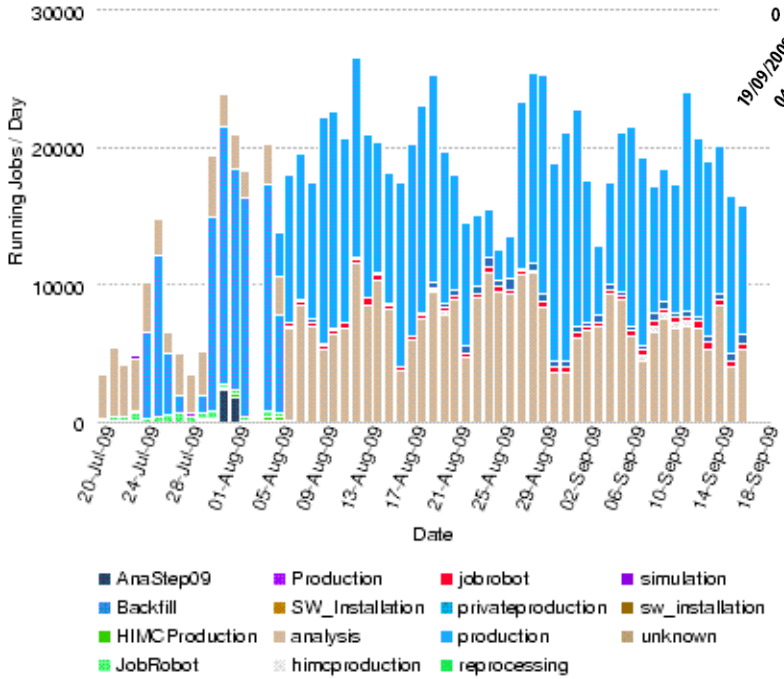


-z endcap

Tier2 readiness

Major progress in 2009 re Tier2s availability and readiness





During CRAFT, analysis job (brown) and MC production at 10 TeV (blue) made full use of Tier2s

Computing /offline

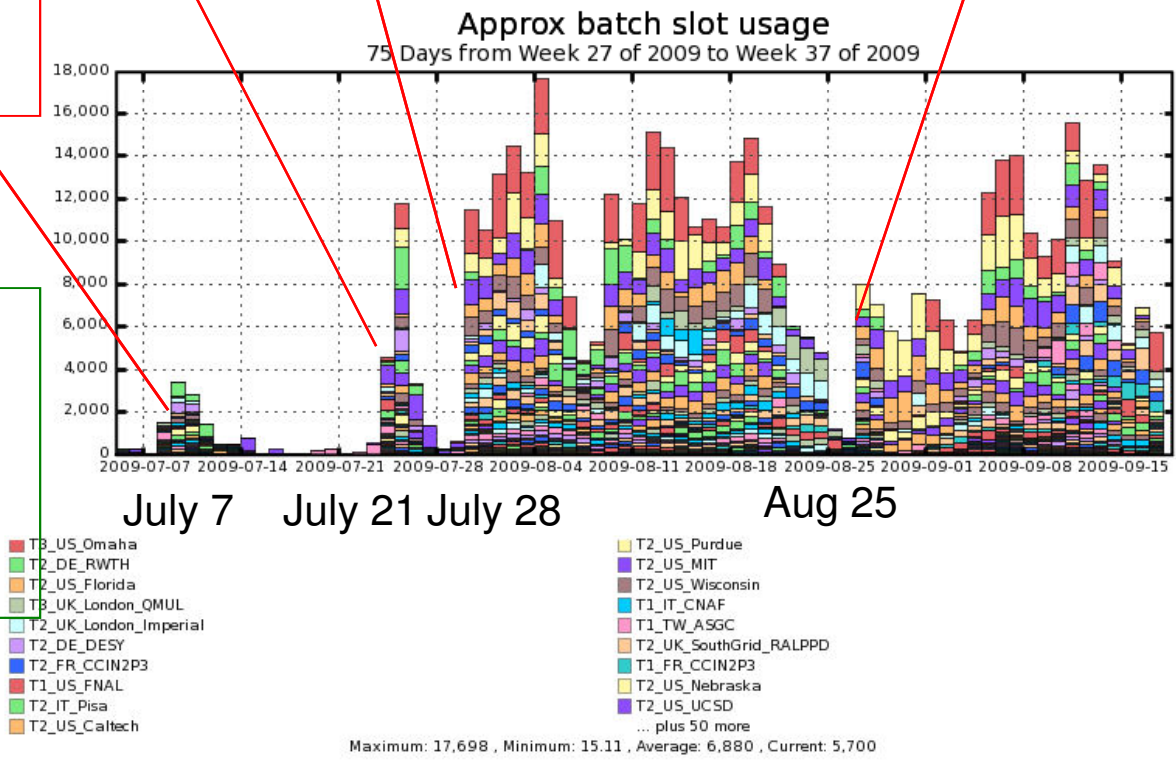
2nd iteration software released
Validation production started

MC production (7 TeV)
started (190 M produced)

CMSSW 3.1x (LHC reco SW)
software release
Pre-Validation production started

MC production (10 TeV)
started (300 M produced)

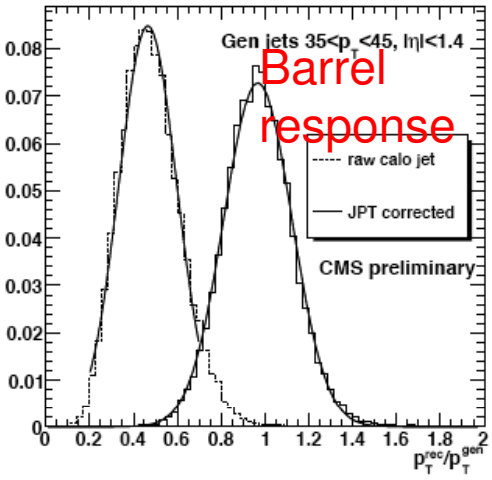
Patch releases for online + rapid offline release cycle (6 weeks) implemented



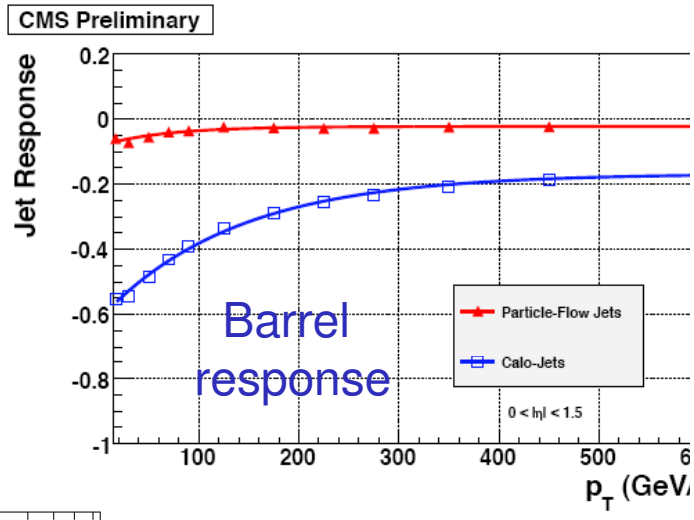
Physics: getting ready

Jets+Tracks

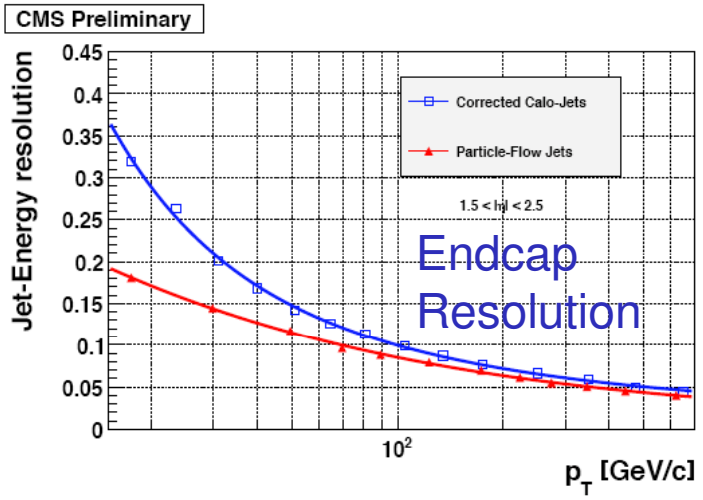
"Particle Flow"



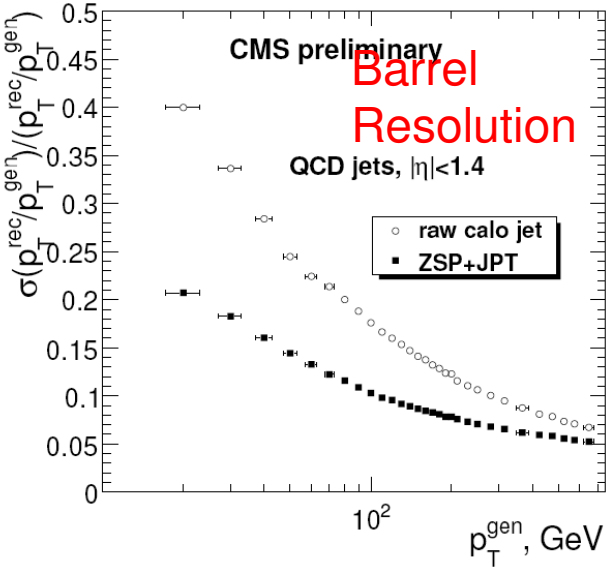
Barrel response



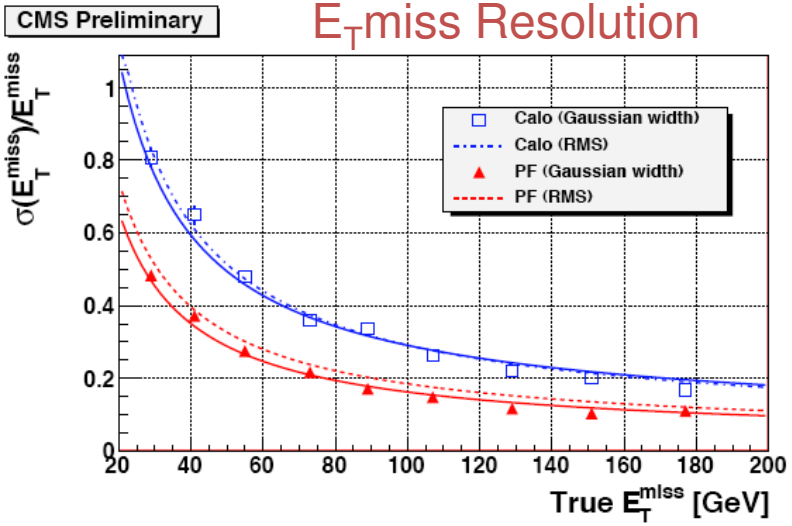
Barrel response



Endcap Resolution



Barrel Resolution



$E_T$miss Resolution

Physics: ready from Day 1

Charged Hadron Multiplicity in Minimum Bias pp Collisions at 900 GeV and 10 TeV
(5k events)

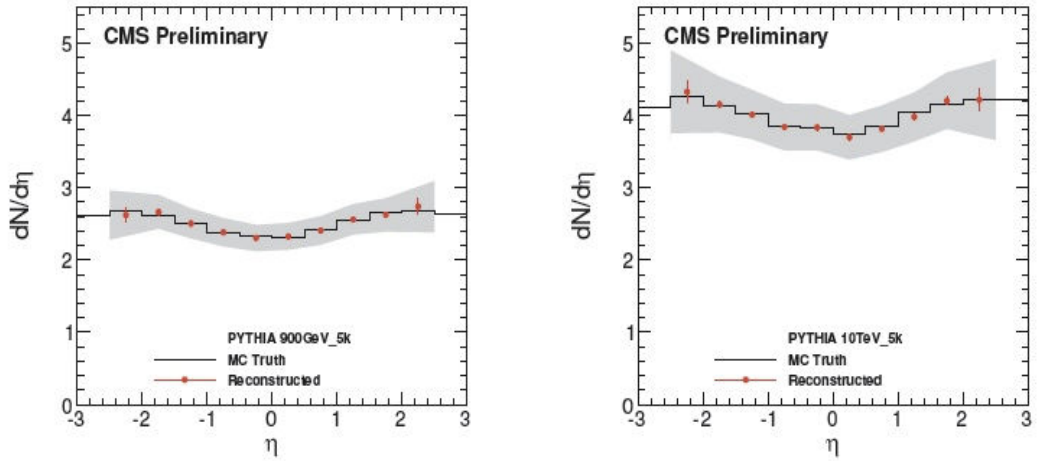
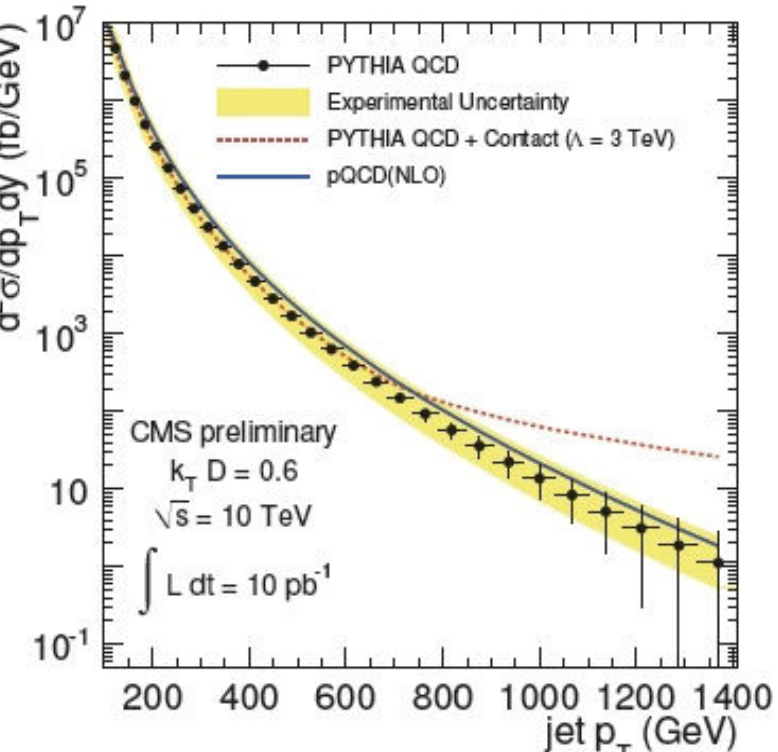


Figure 7: The measurement of $dN/d\eta$ in p+p at 900 GeV(left panel) and 10 TeV(right panel). Error bars show statistical errors using 5k events. The shaded area corresponds to 7.5 - 13.5% systematic error band.



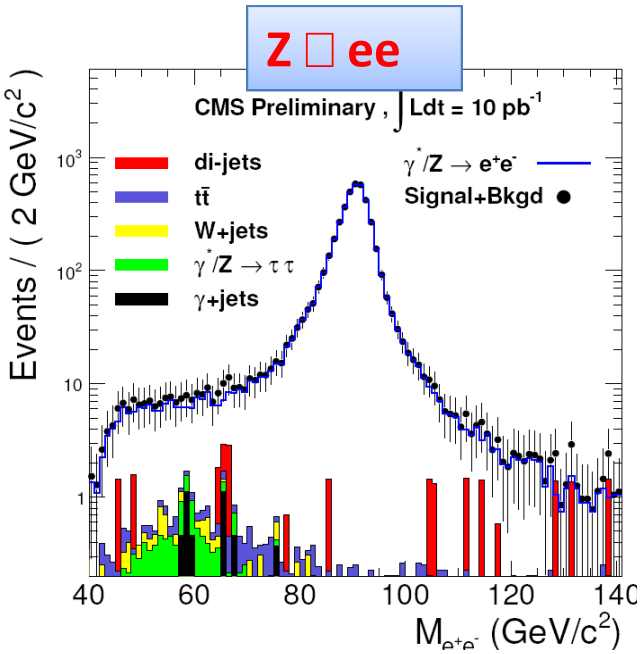
QCD studies : jet measurements , inclusive cross sections

And ready for more

- Z Selection
  $E_T > 20.0$ GeV
  both e isolated
  $70 < M_{e,e} < 110$ GeV

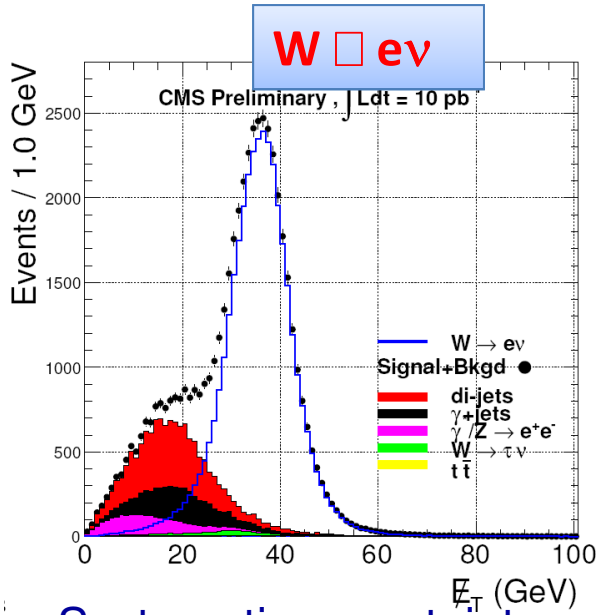
- W Selection
  $E_T > 30.0$ GeV
  Isolated e

σ x BR



Systematic uncertainty
2.4% + 10% for ∫Ldt

- Use data driven methods e.g. *tag and probe* method to work out efficiencies from "data"



Systematic uncertainty
4.0% + 10% for ∫Ldt;

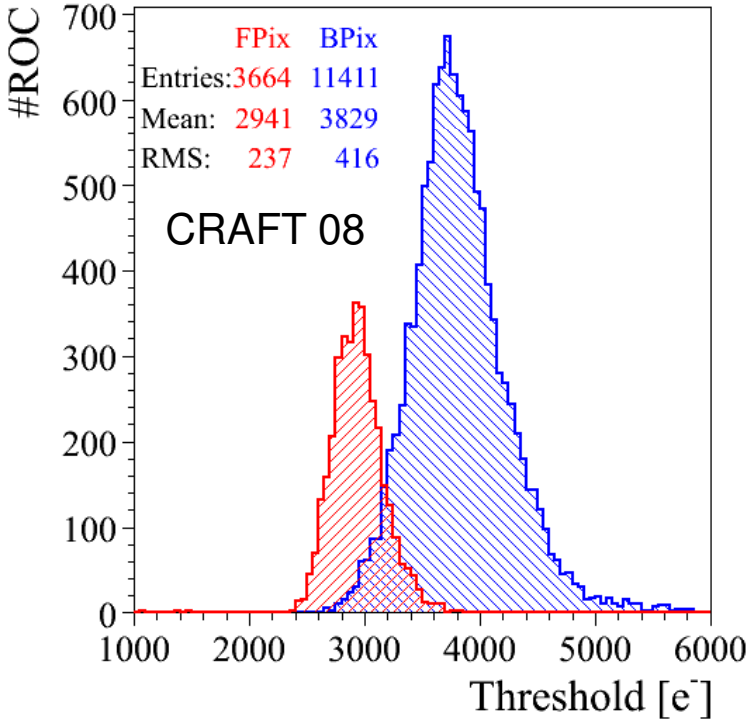
Summary

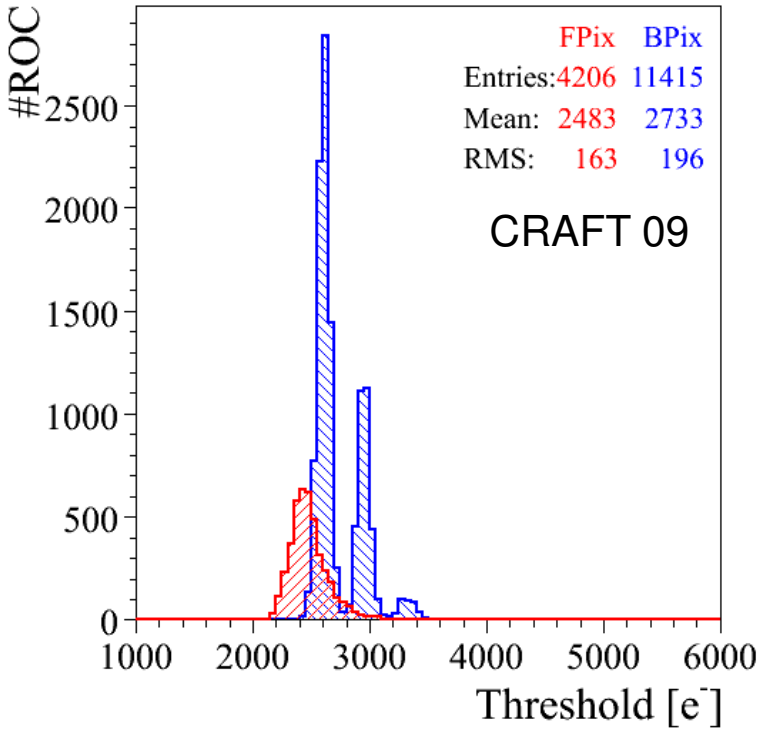
- No accelerator program in the past was as ambitious as the LHC for its first operation period
- We are ready
  - From DAQ to computing, from offline to Physics we believe CMS is well prepared for first beam
- Looking forward to beams (and collisions) before Christmas

Backup material

Pixel thresholds

Thresholds have been lowered in CRAFT09 with respect to CRAFT08
(thresholds are iteratively tuned using pulse injection to avoid cross talk between pixels)
In BPIX, ROC's failing the lower threshold tests were set to 2 higher thresholds

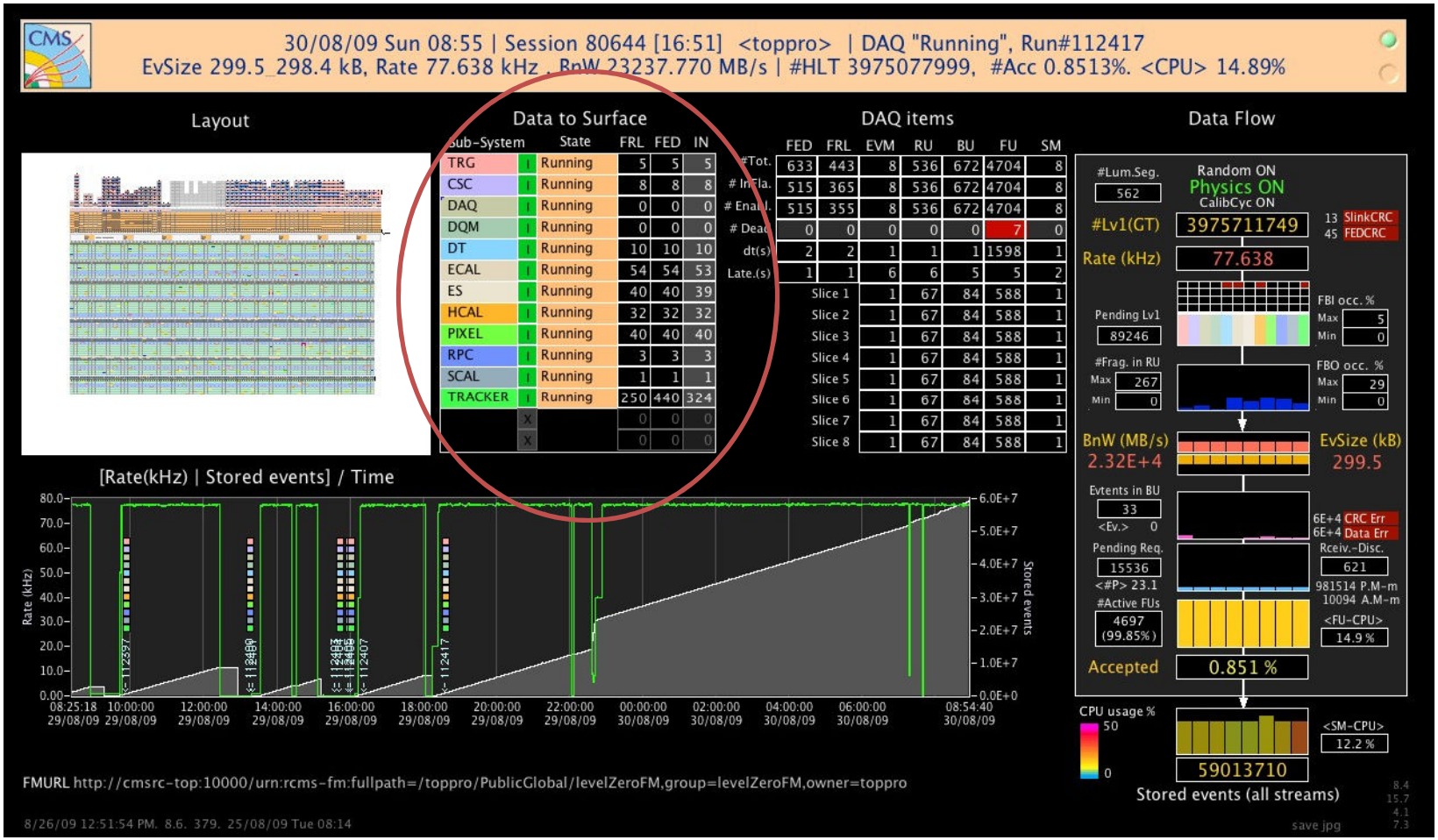




Preparing for LHC

- Work on infrastructure consolidation, understanding magnet operation, debug, repair and improve hardware reliability
- Detector readout and trigger understanding and calibration: weekly global data taking exercises + long periods of 24/7 cosmic data taking (CRAFT-08 4 weeks end 2008, CRAFT09 6 weeks summer 2009)
- Computing/offline challenges
- Training of physics production chain end-to-end

A typical day

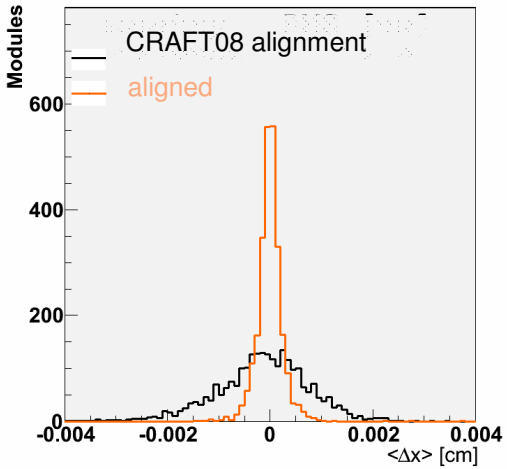


- ~1 kHz cosmics +100 Hz calibration + 80 kHz randoms

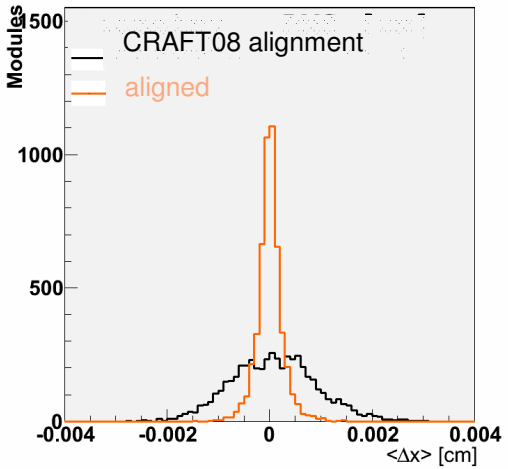
Alignment first look at 2009 data

Tracker moved very little
(operating temperature 7degees lower than in CRAFT08)

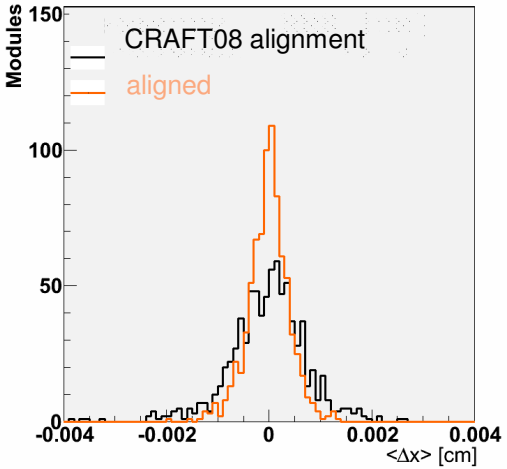
DMR of TIB modules



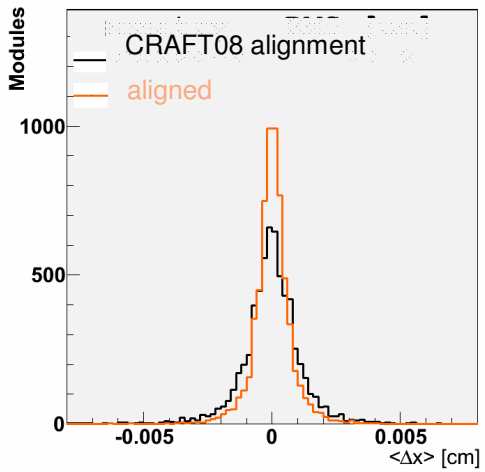
DMR of TOB modules



DMR of TID modules



DMR of TEC modules



CRAFT09: preliminary

RMS of DMR (μm)		# of aligned modules
BPIX (x)	2.5	761/768
BPIX (y)	4	
FPIX (x)	13	539/672
FPIX (y)	13	
TIB	3	2555/2724
TOB	3	5102/5208
TID	4	808/816
TEC	8	6346/6400

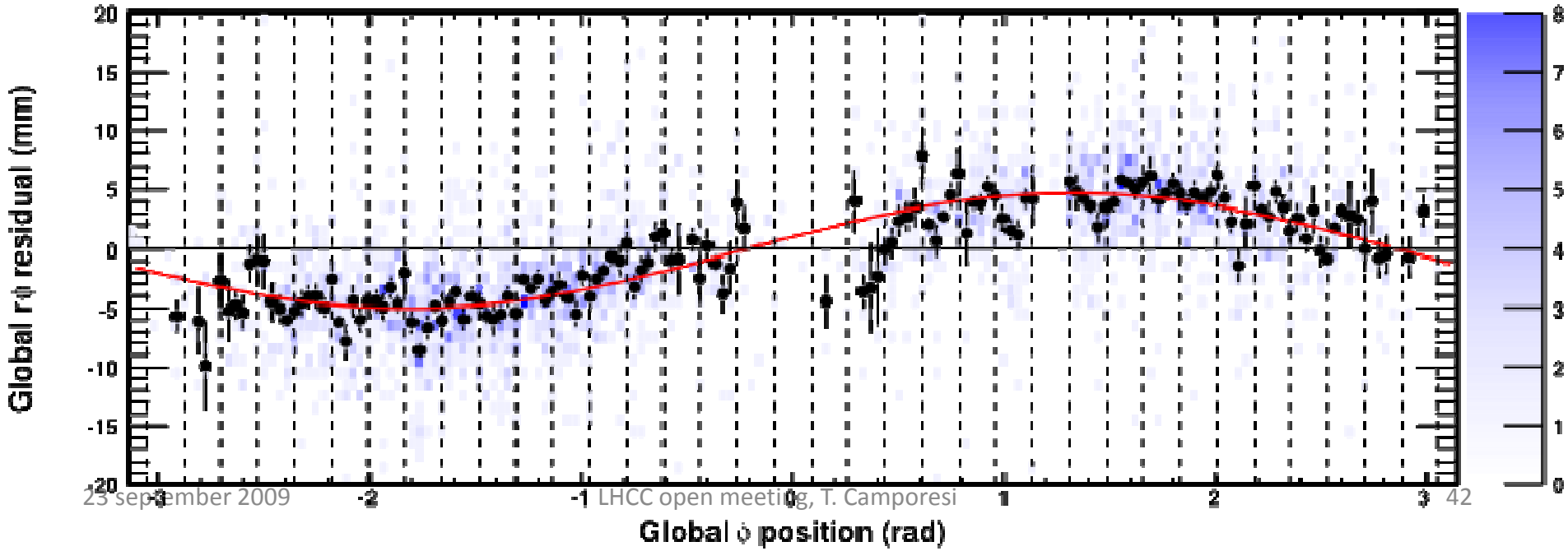
Alignment

Sufficient statistics has been accumulated in endcaps to allow alignment of endcap muon chambers

CSC ME+ 1/1 disk monitoring plot: show

$$\text{Fit } \delta_x \sin\phi + \delta_y \cos\phi + \delta_{\phi_z}$$

$$\delta_x = 4.7 \pm 0.1 \text{ mm},\ \delta_y = 1.2 \pm 0.1 \text{ mm},\ \delta_{\phi_z} = -0.11 \pm 0.04 \text{ mrad}$$



Computing/Offline readiness

CRAFT logging rates (500-700 Hz) similar in bandwidth to LHC.
Alignment and calibration workflows, express stream part of the exercise

Introduced 48 hour delay to wait for prompt calibration

Reconstruction latency