PEDESTAL STABILITY OF CMS HADRON CALORIMETER AND CASTOR TEST BEAM 2008

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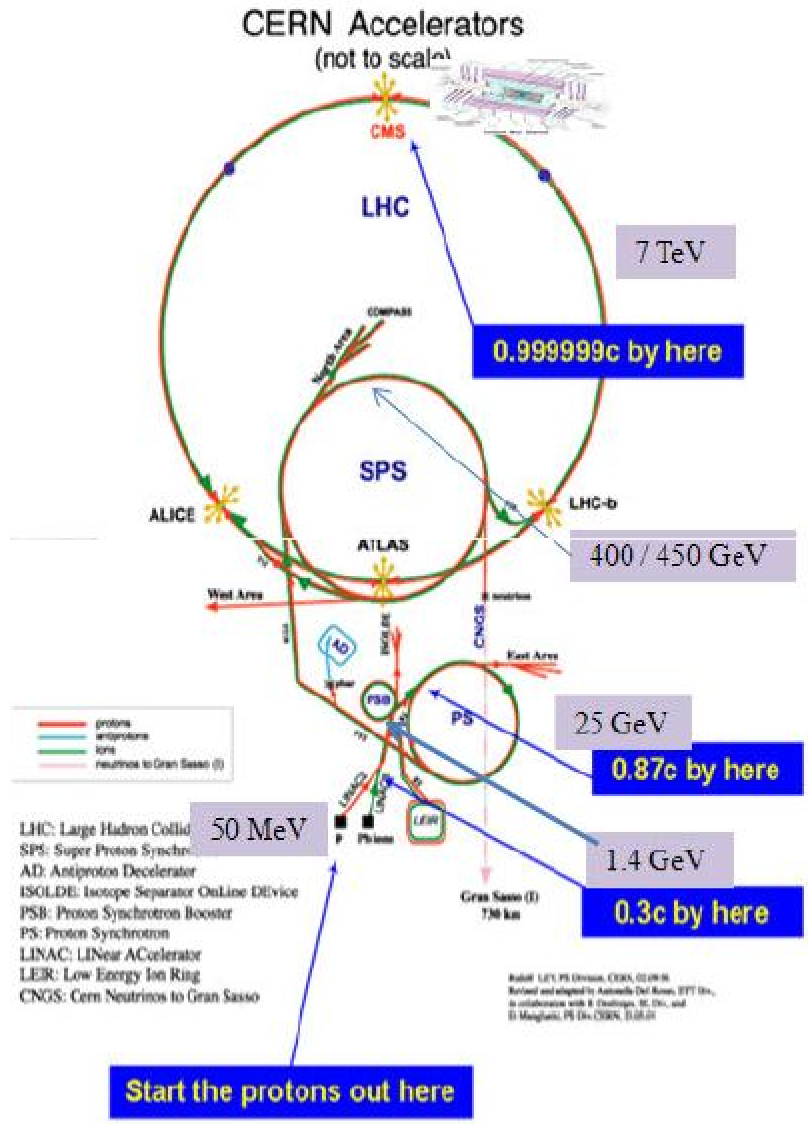
CERN / Large Hadron Collider (LHC)

➢ LHC is a large proton-proton collider located at CERN.
➢ The main goal of LHC is to provide collisions of protons at a center of mass energy of 14 TeV. Initially LHC will be operated at lower center of mass energies (7/10 TeV)
➢ Physics program : study of Electroweak Symmetry Breaking and exploration of new physics beyond Standard Model
➢ CMS (Compact Muon Solenoid) is one of the four detectors at LHC



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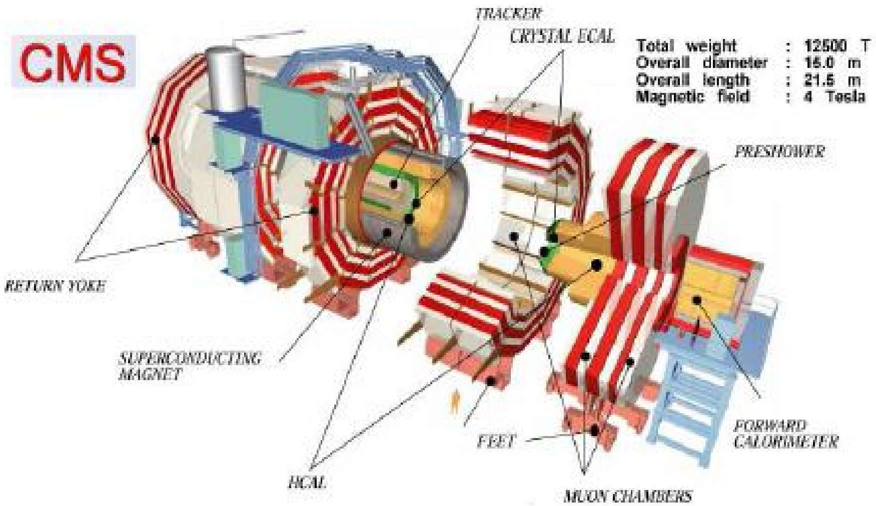
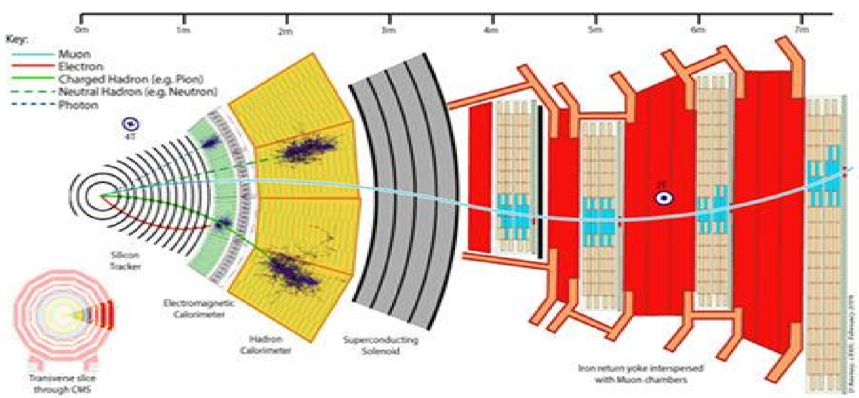
The CMS experiment

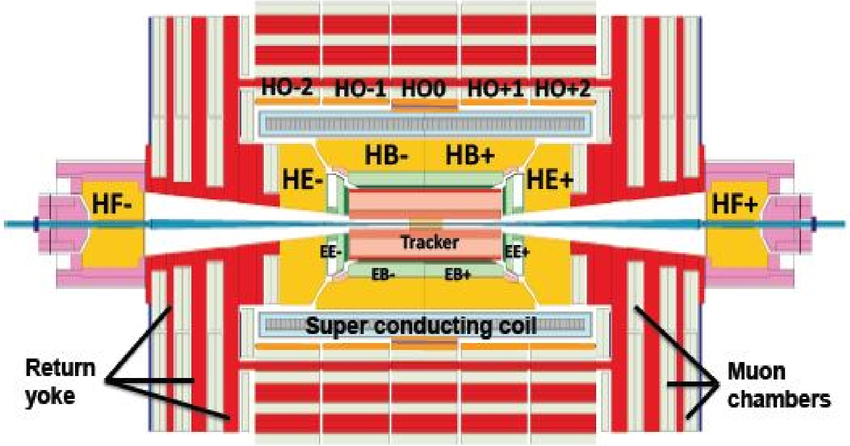


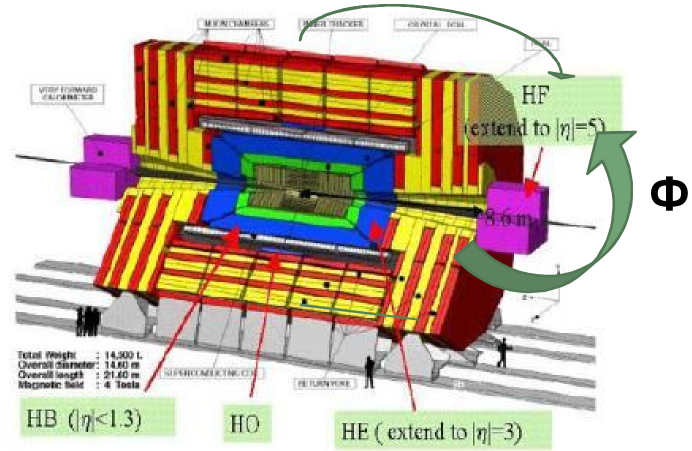


- CMS is multi-purpose detector designed to measure both single particles (electrons, photons, muons) and particle jets (e.g. hadronic jets or tau-jets)
- CMS features following subsystems
  1) Tracker measures momentum of charged particles
  2) ECAL detects electrons and photons and measures their energy
  3) HCAL detects hadrons and along with ECAL measures hadronic jets
  4) Muon system is designed to identify muons and along with tracker measures muon momentum
- Tracker, ECAL and HCAL are surrounded by a solenoid which generates magnetic field of 4 T.

CMS HADRON CALORIMETER

$\eta = -\ln[\tan(\theta/2)]$

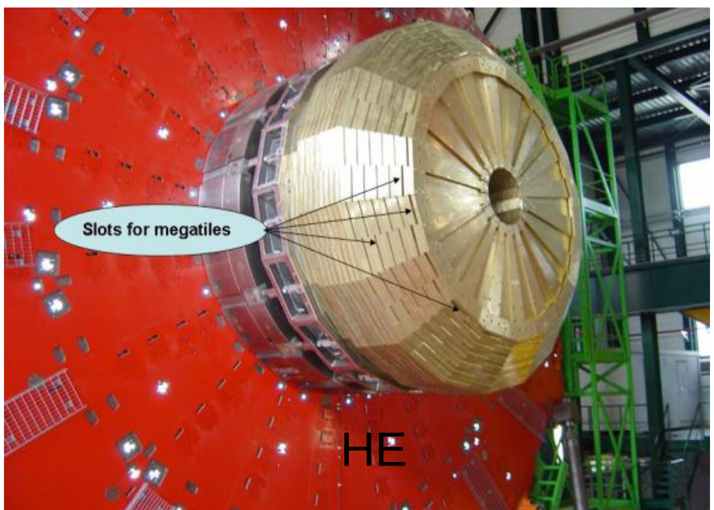




- HCAL is designed to detect hadrons
- Together with ECAL it measures energy and direction of single hadrons and jets.
- HCAL consists of four sub-detectors : Hadron Barrel (HB), Hadron Endcap (HE), Hadron Outer (HO) and Hadron Forward (HF). HB covers η range $-1.3< \eta <1.3$ and HE covers the $1.3< |\eta| <3.0$. HO covers the region $-1.26< \eta <1.26$.
- The HF calorimeter is placed ±11 m away from the interaction point. The HF calorimeter covers $3.0< |\eta| <5.0$.
- In addition, the CASTOR calorimeter will be placed 14 m from the IP which covers $5.2 < \eta < 6.4$
- In the following I will describe only HB, HE and omit HF and HO

Hadron Barrel and Endcap (HB and HE)

- HB is sampling calorimeter, consisting of two half-barrels (HB+ and HB−).
- Each half-barrel has fine segmentation $(\Delta\eta,\Delta\varphi) = (0.087, 0.087)$
- Most of segments (called tower) have 16 layers, consisting of brass plates interleaved with plastic scinitillators
- Depth at $\eta=0$ is 5.8 λ
- Scintillating light is read out with pixelated hybrid photodiodes (HPDs).



- HE has similar structure
- 17 layers of brass plates interleaved with scintillators
- 14 segments in η ($\Delta\eta=0.12$)
- 72 sectors in φ ($\Delta\varphi=0.087$) at $\eta<1.9$
- 36 sectors in φ ($\Delta\varphi=0.174$) at $\eta >1.9$

HCAL PEDESTAL STABILITY

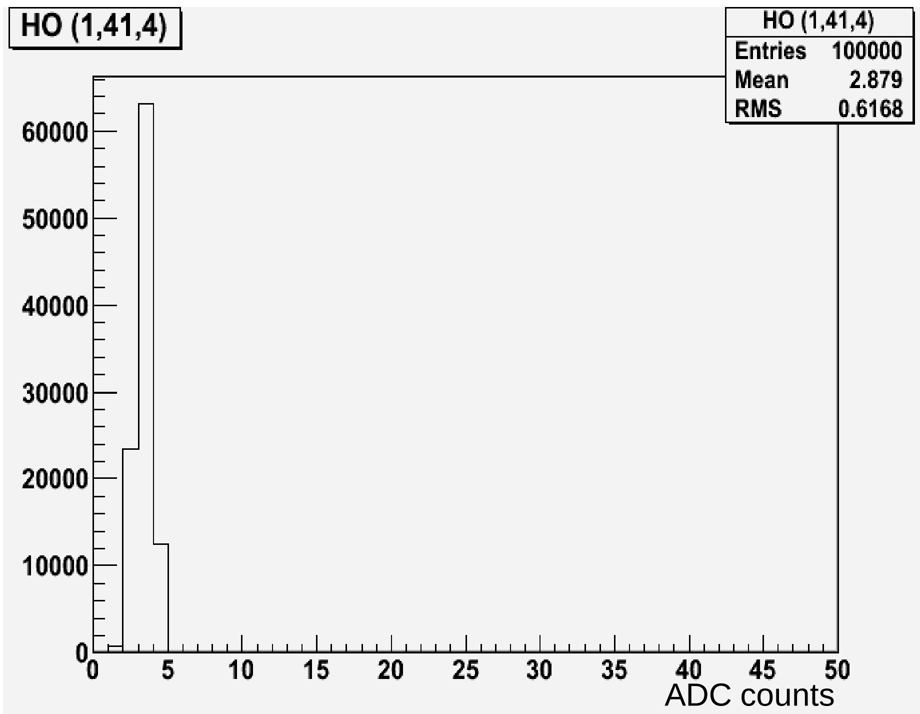
Overview

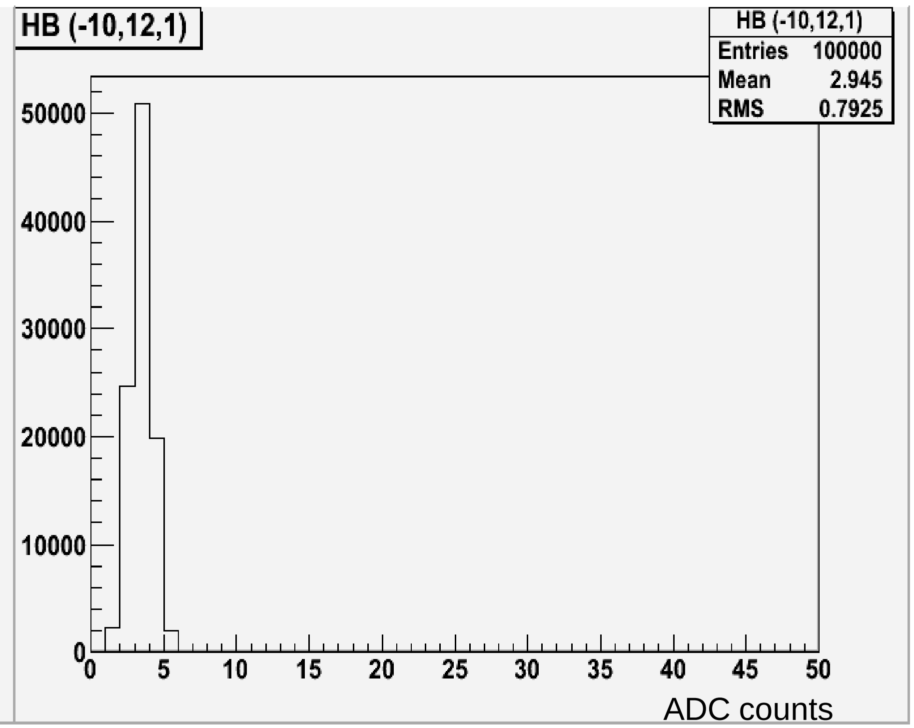
1. In HCAL, pedestal (response of device in absence of signal) subtraction is important for accurate determination of the real signal. Precision of pedestal determination has also direct impact on the quality of HCAL calibration.
2. We analyzed stability of HCAL hardware pedestals in all channels in the period from August 31 to December 16, 2009: ~ 300 global runs.

period	dates	run range
Beam09 @ 3.8T (wk50-wk..)	December 7 – December 16	123726 - 124301
Beam09 @ 3.8T (wk49)	November 30 – December 6	123151 - 123614
Beam09 @ 0T (wk48)	November 20-November 30	121942 -123149
InterSplash09 @ 0T(wk 46 - wk47)	November 9- November 20	118326 – 119950
SPLASH09a	November 6- November 8	119959 - 120042
CRAFTb (wk44 - wk45)	October 26 - November 6	118326 - 119807
MWGR41	October 8 - October 9	116629 - 116675
MWGR40	October 1 - October 2	115911 - 116136
CRAFT2_2009@B=0T	August 31 - September 1	112541 - 115871

3. We have used pedestal events collected during abort-gap (global runs).
4. We considered threshold of 0.2 ADC counts over time slice (TS) of 25ns to define unstable channels.
5. We categorized unstable channels as
   - channels with pedestal shift in a single run
   - channels with shifting/drifting pedestals over several runs

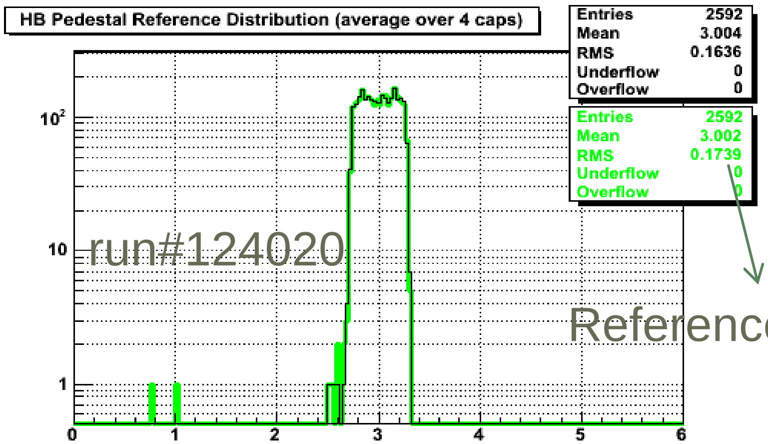
ADC counts distribution for local pedestal run 124041 (for 100k events)

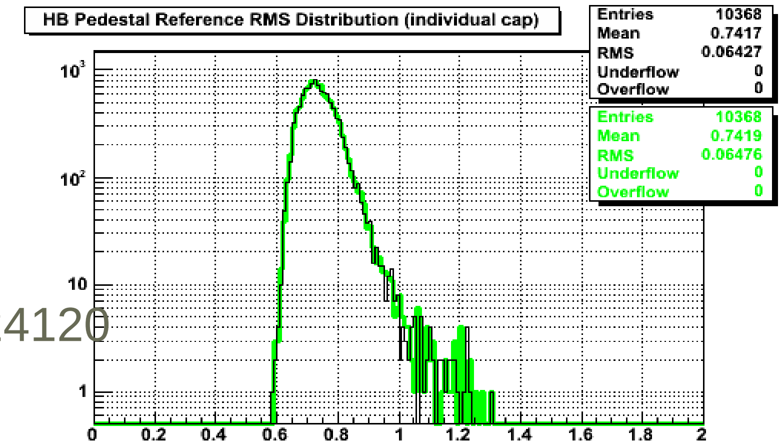


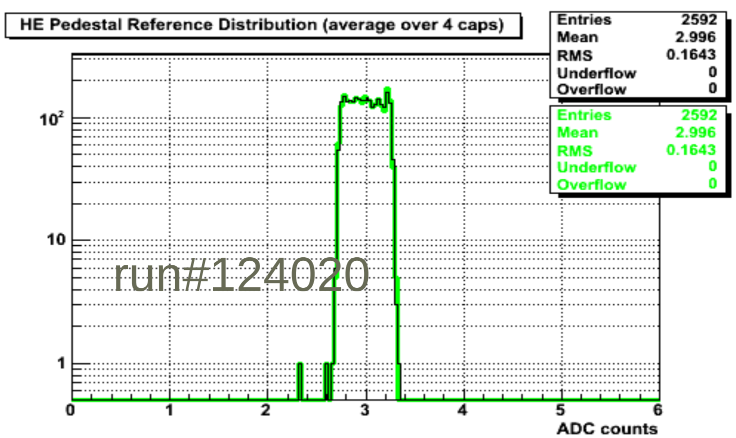


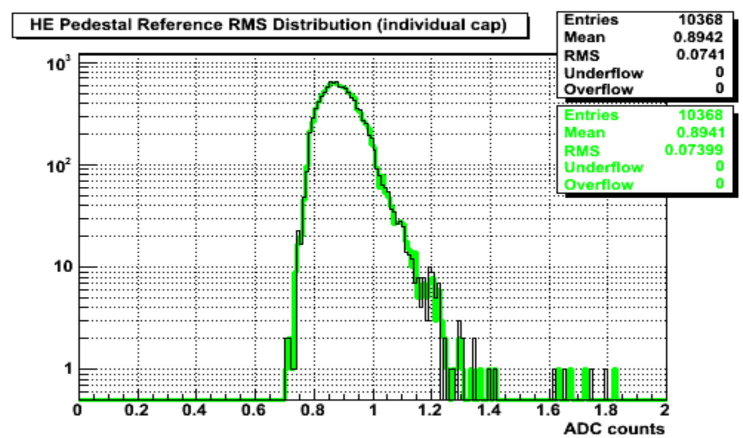
A typical pedestal signal in ADC counts

Pedestal and rms distributions for HB and HE for global run 124020



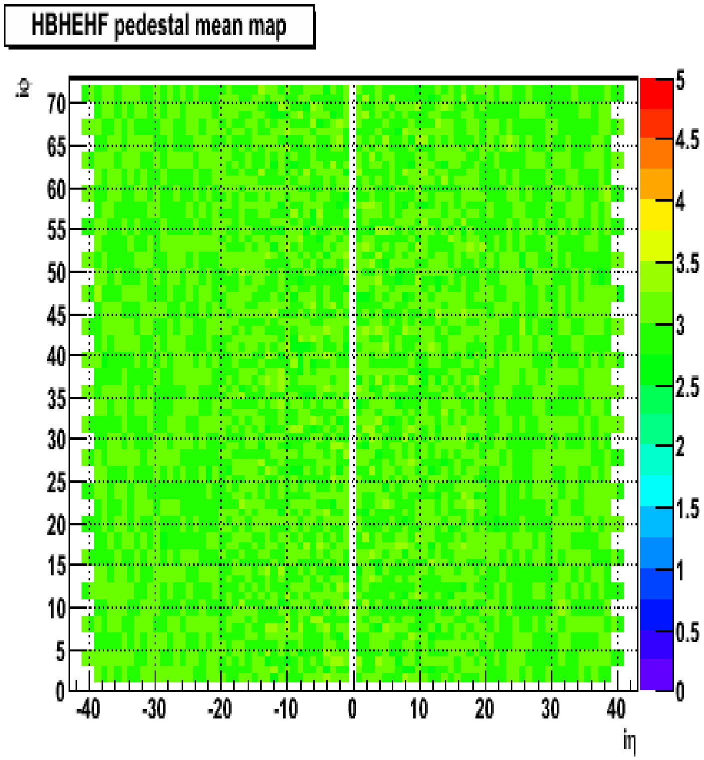


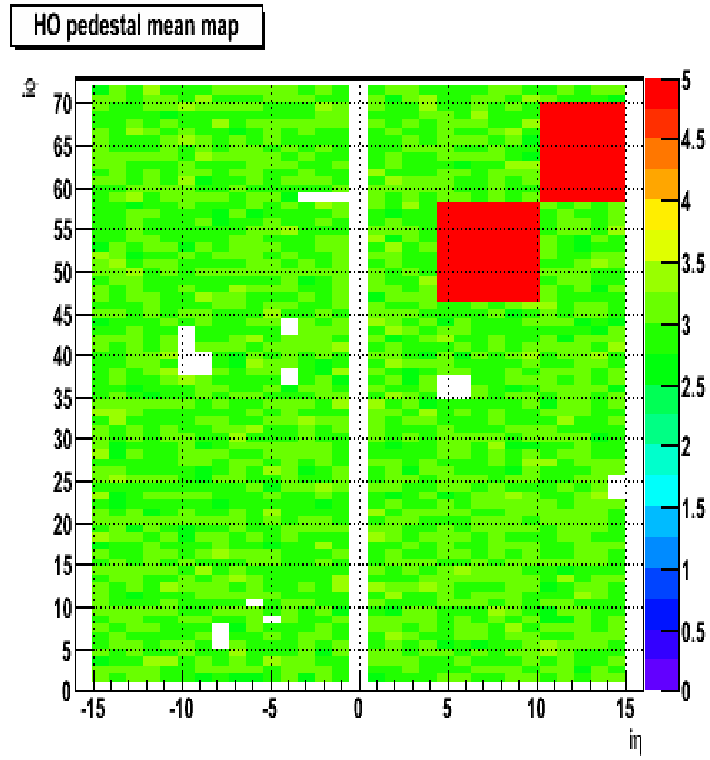




Pedestal value~ 3 ADC/TS and event to event RMS of pedestal ~ 0.7 ADC/TS

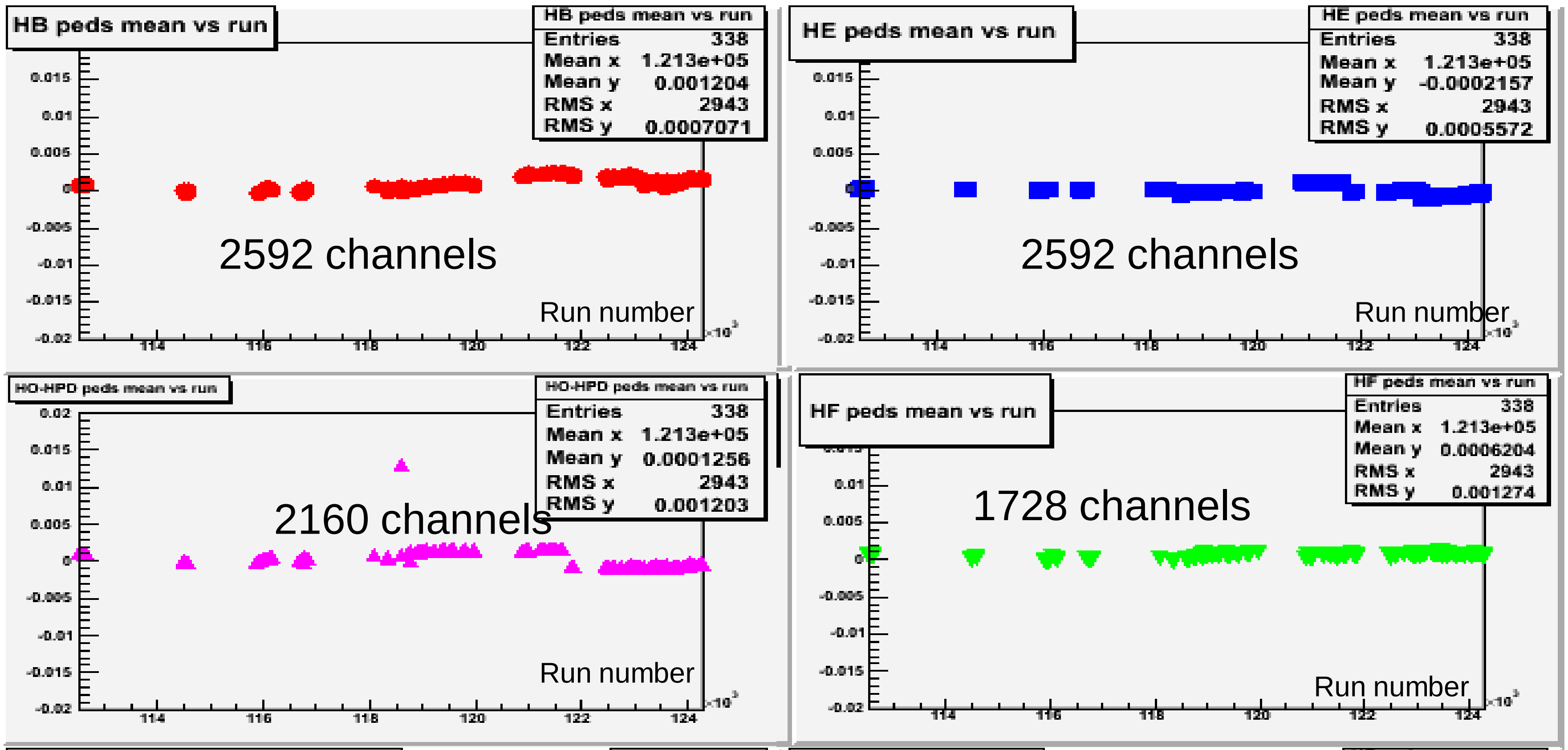
Status of pedestal :HB,HE,HF,HO For global run 124120





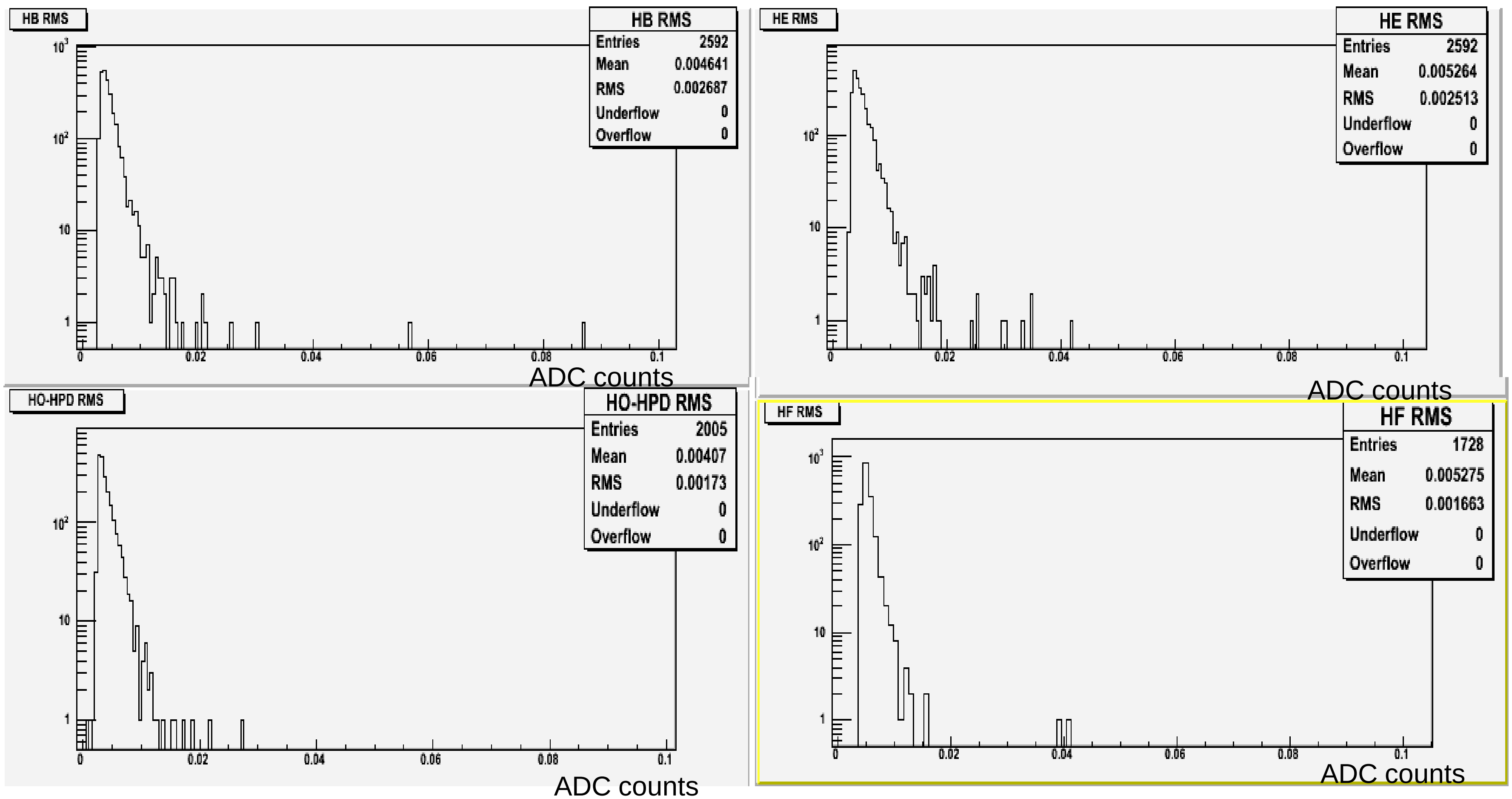
- Most of channels have pedestal mean ~2.7-3.3 ADC/Time Slice
- Generally there are 29 missing channels in HO
- Red areas in HO pedestal mean map correspond to channels with SiPM readout (instead of HPD)

HCAL pedestal stability with respect to reference run 124120



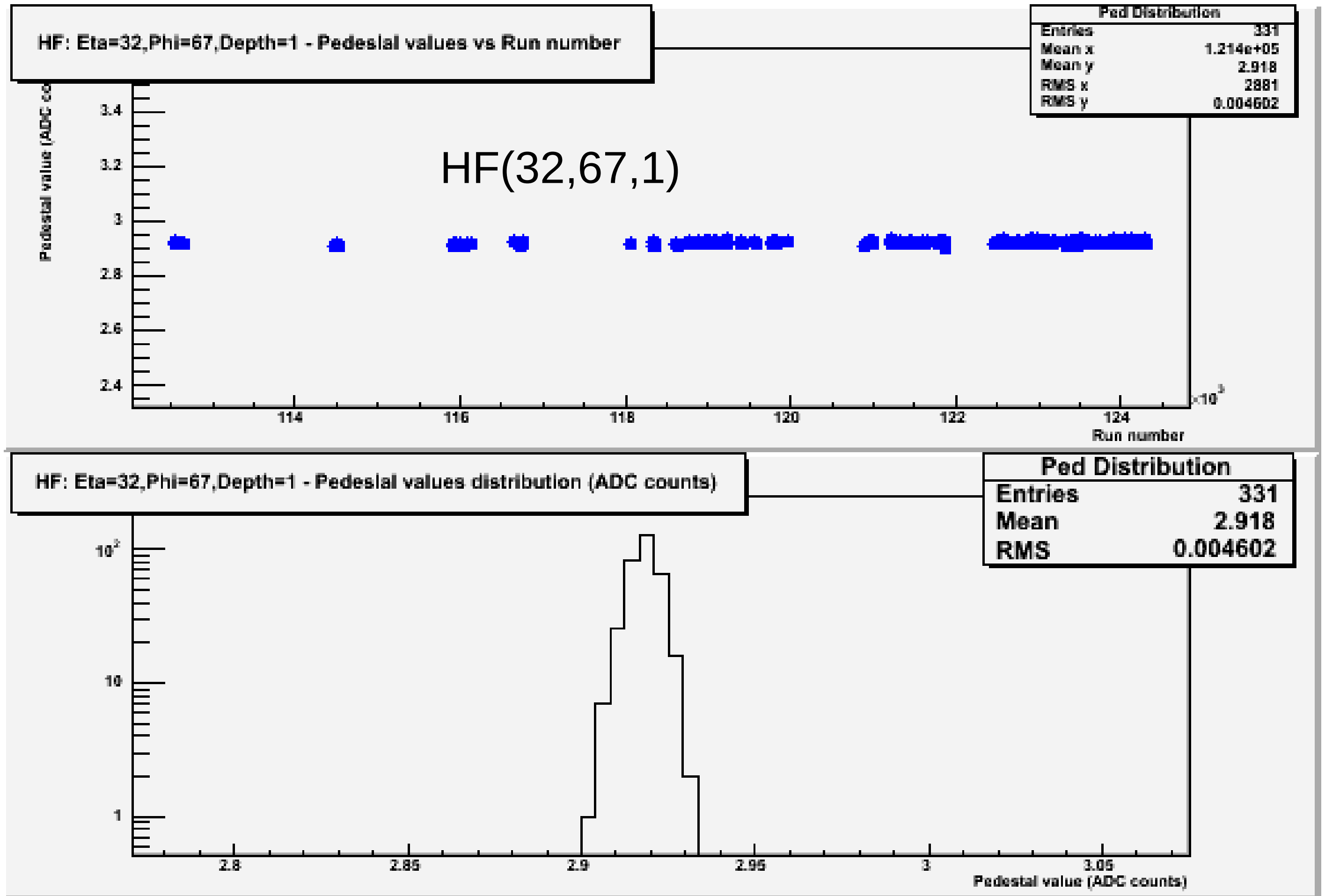
Each point shows the difference between pedestal mean value averaged over all channels for a given run and the value in reference run

Run to Run Pedestal RMS per subsystem



Average run-to-run RMS per subsystem ~ 0.004 ADC/TS

Example of pedestal stability of individual channel. Average pedestal in one channel versus run number



List Of Unstable Channels

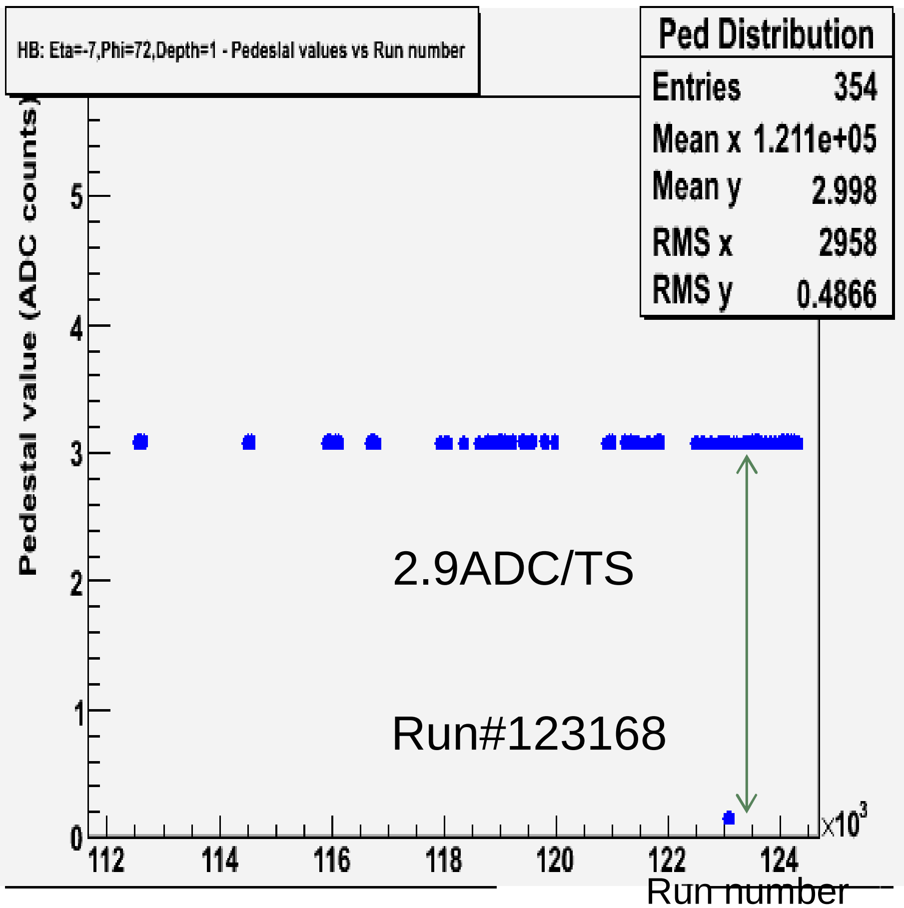
Channels	comment
HB(-7,72,1)	Single Shift Run#123168
HB(-11,72,1)	Single Shift Run#123168
HE(16,28,3)	Single Shift Run#119024
HE(17,28,1)	Single Shift Run#119024
HE(24,51,2)	Single Shift Run#117924
HE(28,51,2)	Single Shift Run#117924
HE(-18,22,1)	Single Shift Run#129024
HE(-18,22,2)	Single Shift Run#129024
HF(41,67,1)	Single Shift Run#119017
HO(4,41,4)	Single Shift Run#116815

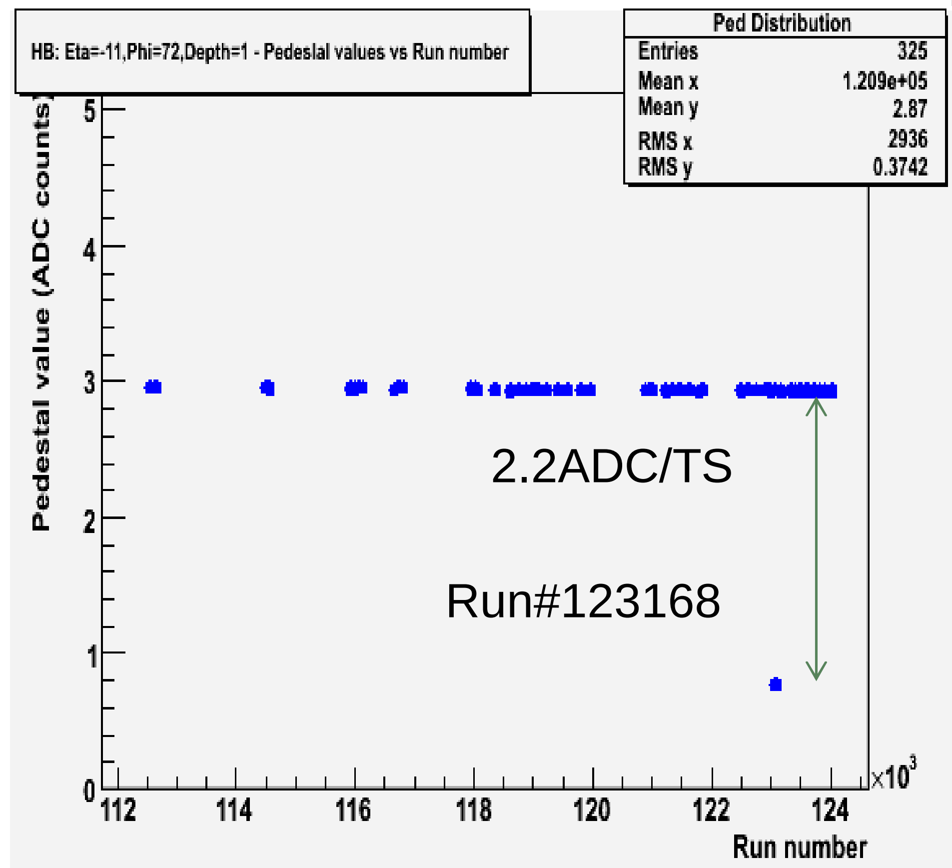
Channels with Single Shift in Pedestal

Channels	Comment
HB(4,36,1)	Shift/Drift in Pedestal
HB(14,31,1)	Shift/Drift in Pedestal
HF(29,71,1)	Shift/Drift in Pedestal
HF(32,53,1)	Shift/Drift in Pedestal
HF(40,67,1)	Shift/Drift in Pedestal
HF(33,61,1)	Shift/Drift in Pedestal

Channels with Shifting/Drifting Pedestal

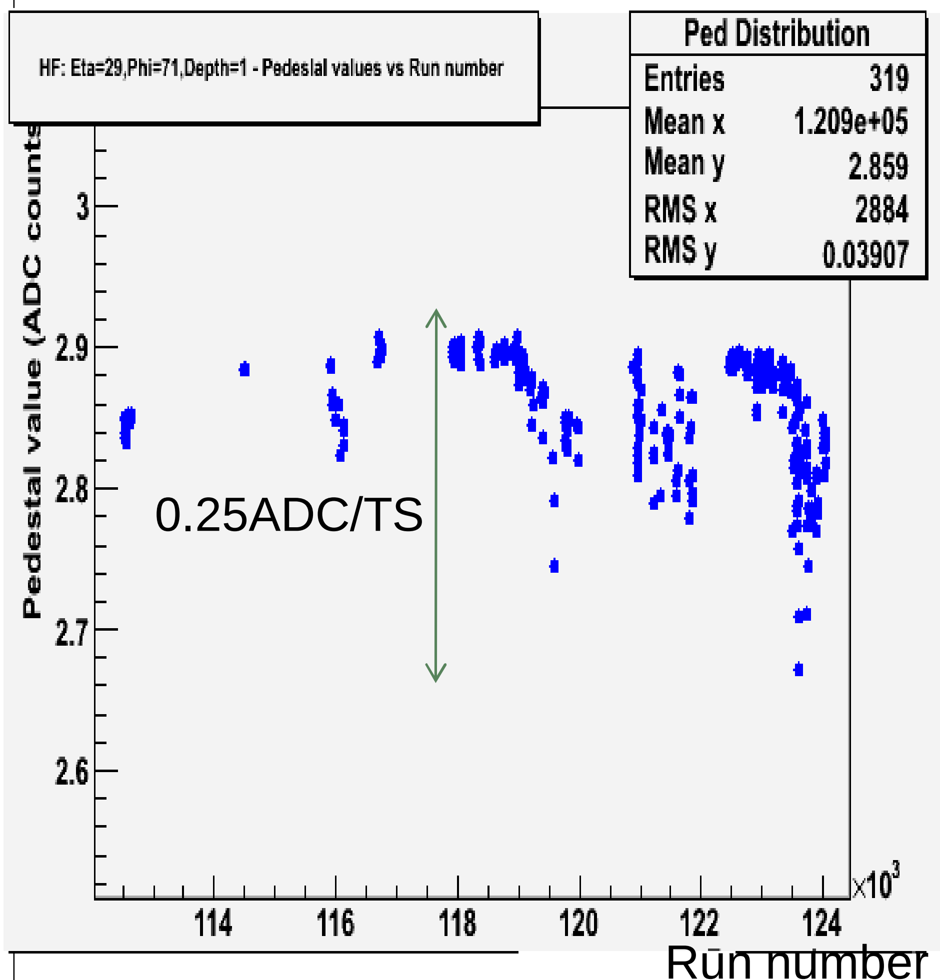
Example of Single Shift in Pedestal:
HB(-7,72,1) HB(-11,72,1)

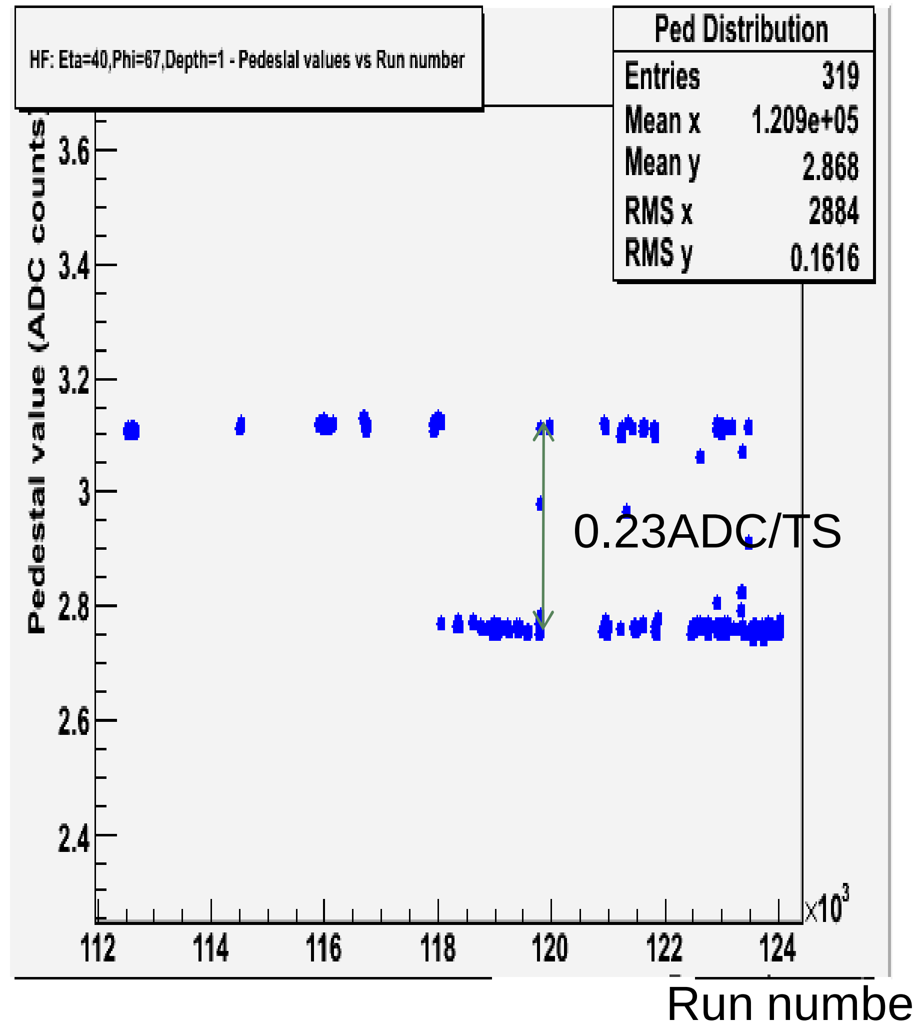




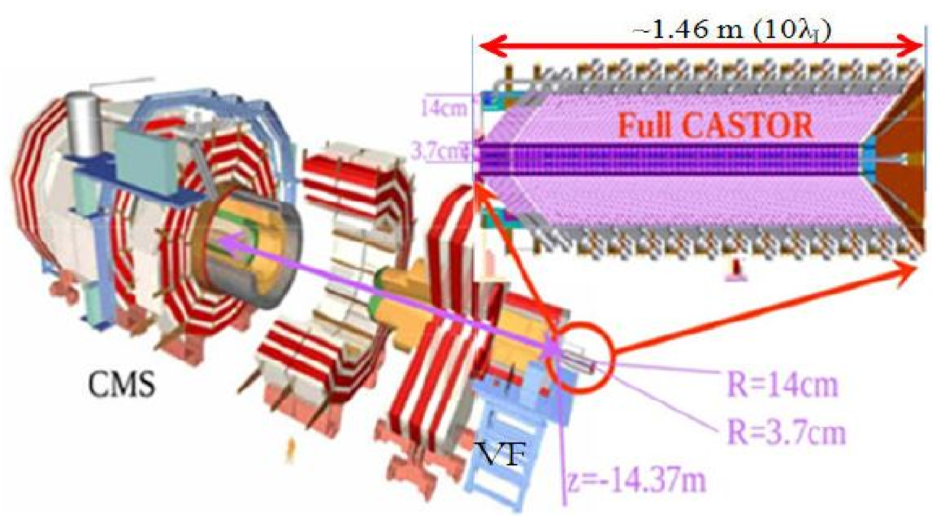
Example of Shift/Drift in Pedestal:

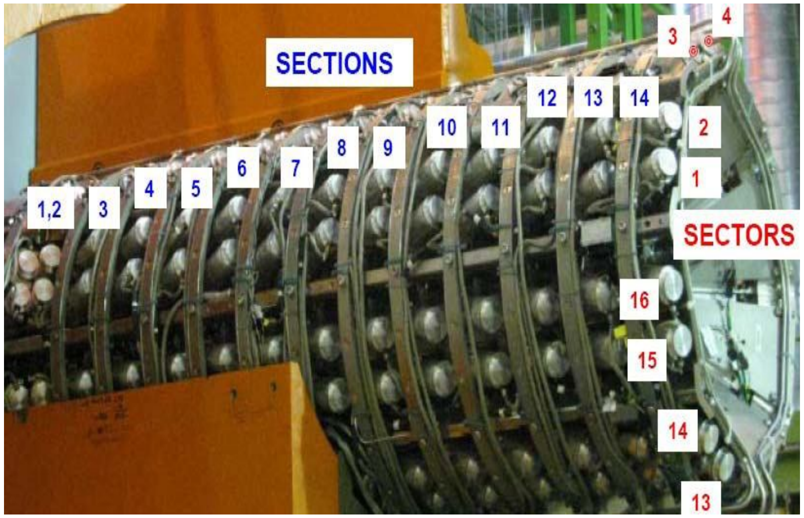
HF(29,71,1), HF(40,67,1)





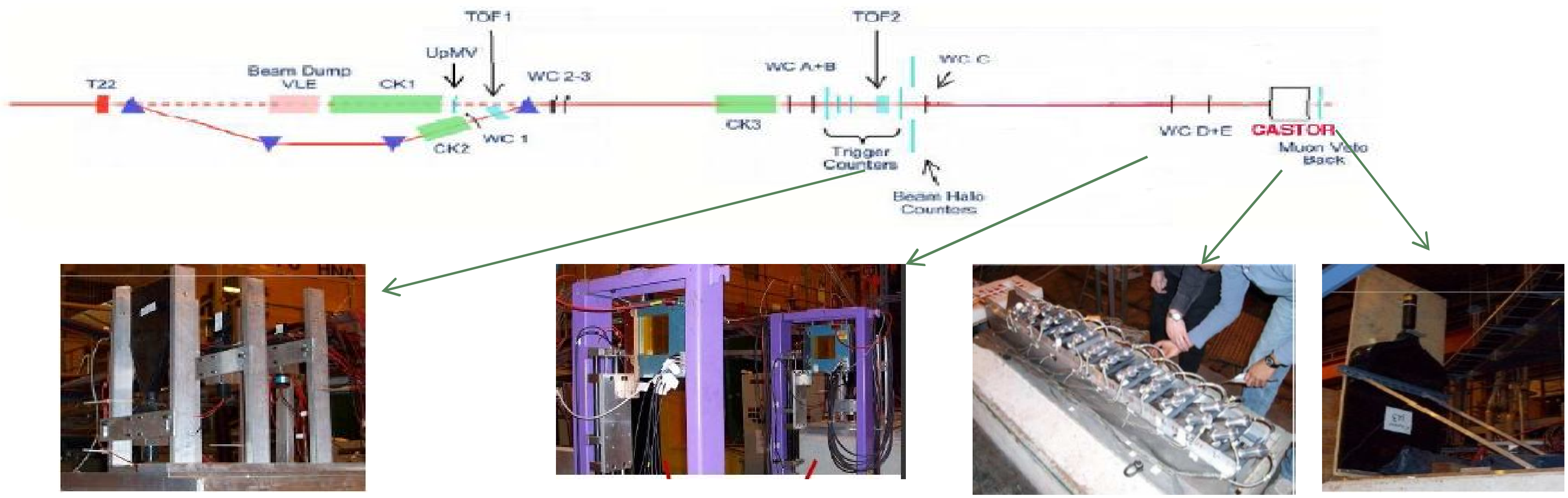
Centauro And Strange Object Research (CASTOR) Calorimeter





- The Centauro and Strange Object Research (CASTOR) calorimeter is one of the forward detectors of CMS.
- CASTOR will search Centauro-type events in heavy-ion collisions.
- CASTOR is a tungsten/quartz Cerenkov electromagnetic and hadronic calorimeter.
- It consists of successive layers of tungsten plates (W) as absorber and quartz (Q) plates as active medium
- It is divided into 16 sectors in azimuth, 14 sections in depth.

CASTOR TEST BEAM 2008



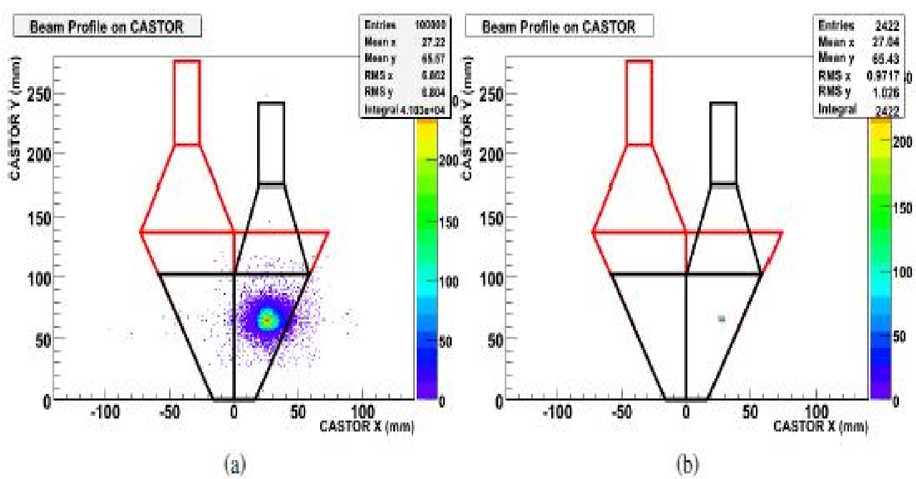
- The beam test of prototype IV was performed in the H2 line at CERN Super Proton Synchrotron (SPS).
- The CASTOR Test Beam 2008 (TB08) was scheduled from 12 June to 26 June 2008.
- The fourth prototype of CASTOR contains a full-length octant, containing the electromagnetic and hadronic sections, with a total of 28 readout-units.
- Light is produced by the passage of relativistic particles via Q medium and collected by 5 W/Q layers. Then it is focused by air-core light guides onto the PMTs.

X-surface scan with electron beams @100GeV

Surface scans (position scans) of *x* positions make it possible to acquire information on the transverse distribution for both electron and pion showers. In order to study the surface scans, we have several criteria such as requiring single hit, rejecting unwanted particles (muon, hadron or electron) which contaminate the beam.

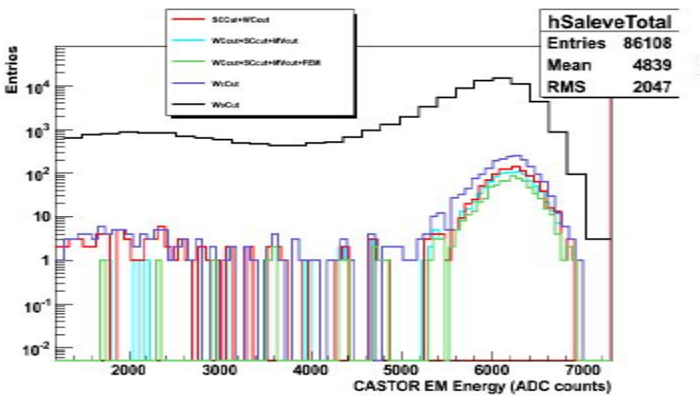
RunNo	X Position	Y Position	WC	(# events)
47599	16.82	65.28	E	100k
47600	22.04	65.32	E	100k
47601	26.97	65.32	E	100k
47602	31.99	65.36	E	100k
47605	12.1	65.78	E	100k
47614	11.84	65.65	E	100k
47626	7.3	65.7	E	100k
47636	2.5	65.58	E	100k
47650	-3.14	65.62	E	100k
47658	-8.02	65.64	E	100k
47663	-12.65	65.66	E	100k
47684	-23.27	65.59	E	100k
47700	-27.89	65.37	E	100k
47711	-32.99	65.24	E	100k
47722	-38.31	65.33	E	100k
47728	-42.89	65.05	E	100k
47746	-47.93	64.94	E	100k

Beam Profile with and w/o WC cut

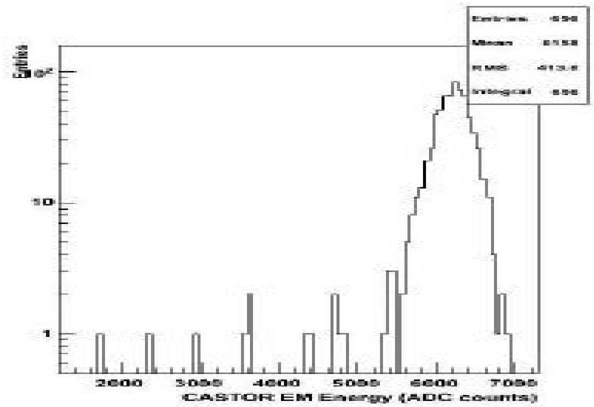


1. Beam Profiles of 100 GeV electrons impinging on center of the Saleve side.(Run 47601)
2. Around each point a circle cut of 1mm radius selected

X-surface scan with electrons @ 100GeV

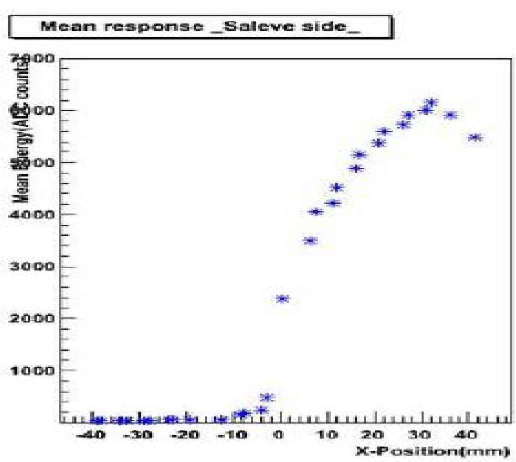


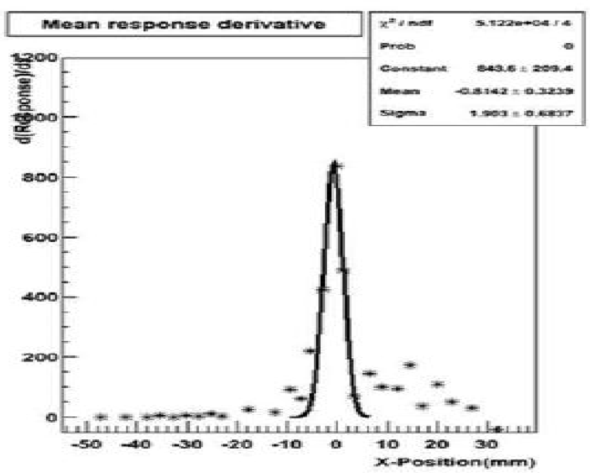
(a)



(b)

a)Energy spectrum for an electron beam of *E=100 GeV, before and after applying all cuts*
b)Signal distribution of the sum of the signals in EM1, EM3 and HAD1 channels





EM shower width is found 1.9mm (Saleve)

Conclusions

- My work contains two major studies.

1. The first one is the beam test of the CASTOR prototype IV.
   - the X-scan analysis with 100 GeV electrons
     - EM shower width is found 1.9mm (Saleve)
     - Consistent with EPJC paper (1.68mm @100GeV e)
     - Consistent with MC results in EPJC paper (1.56 mm)
2. In the second study, I present my analysis of stability of HCAL pedestal by using global data.
   - Most (99.9%) of individual channels are stable with RMS of 0.001-0.002 ADC/TS.
   - Some channels showed pedestal variation above the level of 0.2 ADC/TS.
   - We categorized unstable channels as
     - Single shift for few channels in a single run

HB(-7,72,1) HB(-11,72,1) HE(16,28,3) HE(17,28,1) HE(24,51,2) HE(28,51,2) HE(-18,22,1) HE(-18,22,2) HF(41,67,1) HO(4,41,4)

- Shifting/drifting channels in several runs.

HB(4,36,1)HB(14,31,1)HF(29,71,1)HF(32,53,1)HF(40,67,1)HF(33,61,1)

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