The experimental setup of Test Beam

- A slice of the CMS calorimter was tested during summer of 2007 at the H2 test beam area at CERN with different beam energies ranging from 1 GeV to 300 GeV.

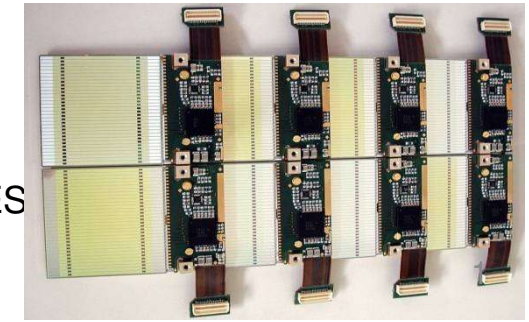
- The endcap calorimeters, namely the hadron endcap (HE), electromagnetic endcap (EE) and preshower (ES) were tested. ES was introduced for the first time in testbeam 2007.

- Data is taken for these protypes where every individual layers were readout separately.

- The HE is divided in a tower structure (eta, phi).

- The EE is readout crystal by crystal.

- The ES is readout as micromodules. The figure shows the structure of ES



The beam line of TB2007

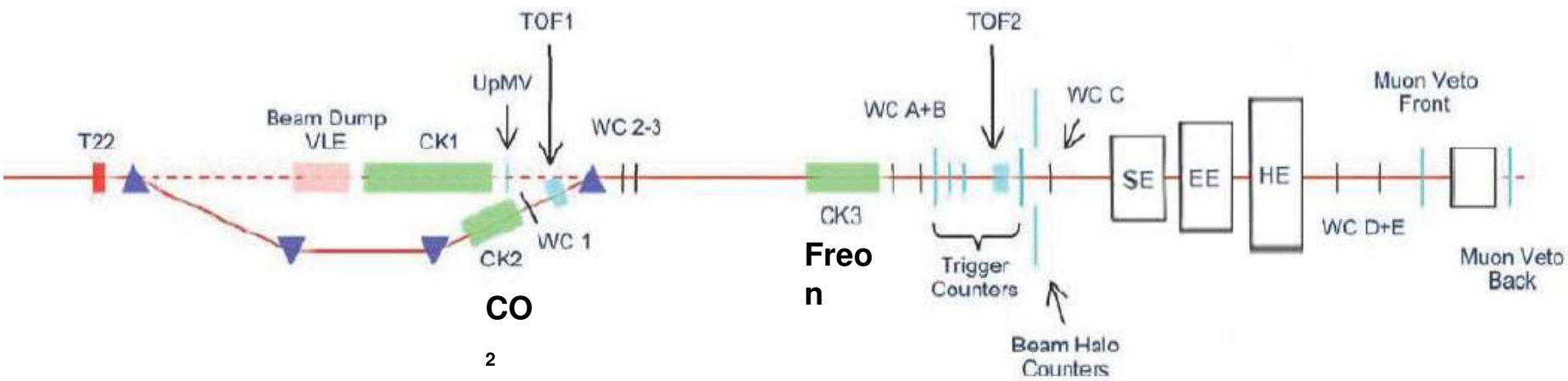
Very low energy (VLE) line provides 1 to 9 GeV of pions and electrons with good rate, a few hundred per spill using a tertiary target.

At lower end of the range, particles are mostly electrons.

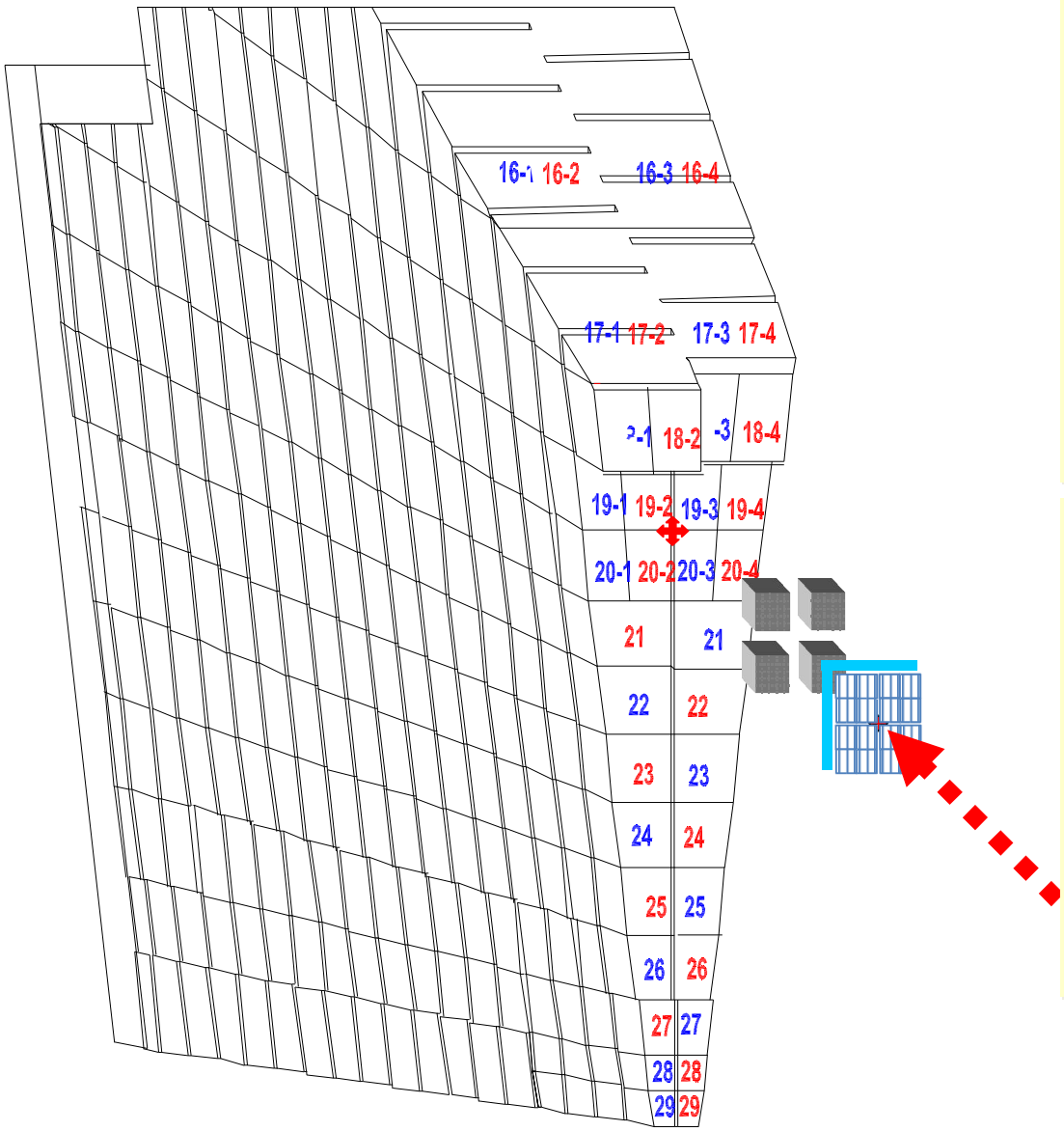
There is significant muon contamination as well. Particle ID is accomplished by time of flight counters (TOF), Cerenkov counters (CK) and muon veto counters (VM).

High energy (HE) line covered a momentum range from 10 to 300 GeV of hadrons through secondary particle production. For electrons/ positrons, the range was 10 to 150 Gev.

Cerenkov counters used CO2 and Freon as the gas medium. Wire chambers were put to align the beam precisely. The beam halo counters ensure no muon is there in hadron beam.



HE/EE/ES 2007 Beam Test



ES:

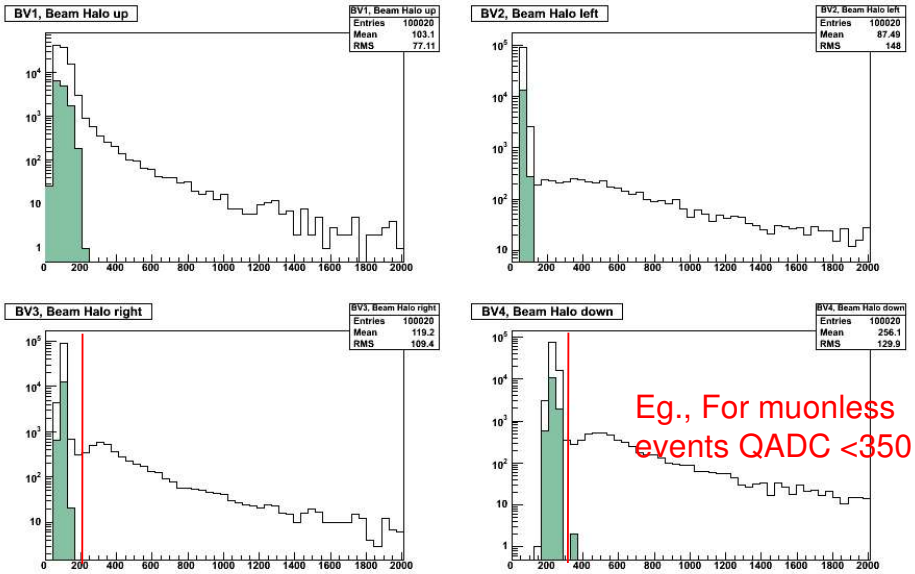
- Two X and Y layers
- each with 2 Ladders (2x4)
- total 32 Si-detectors
- real electronics 1024 channels
- separated DAQ, DCS, DQM

EE:

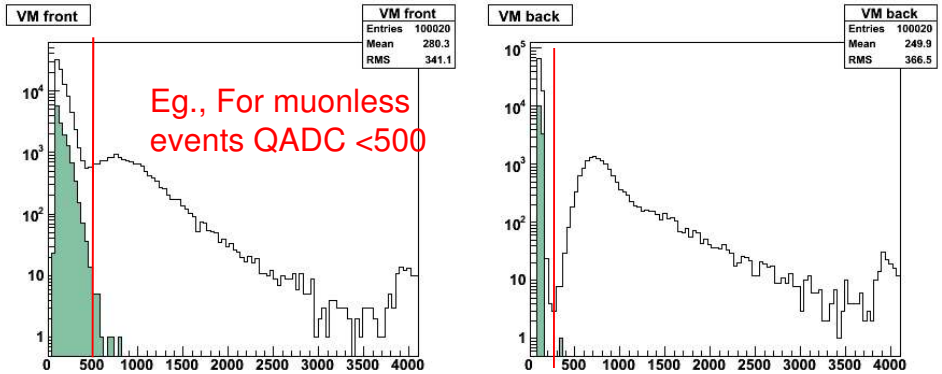
- Four SuperCrystals
- each with 5x5 crystals
- total 100 crystals
- real electronics
- separated DAQ, DCS, DQM

Beam cleaning – removing muon contamination

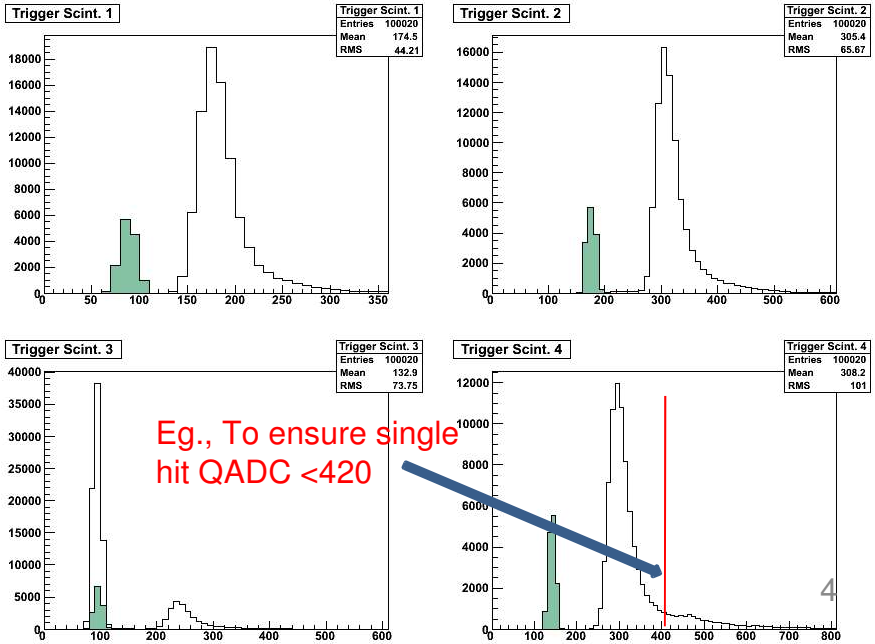
Beam Halo counters



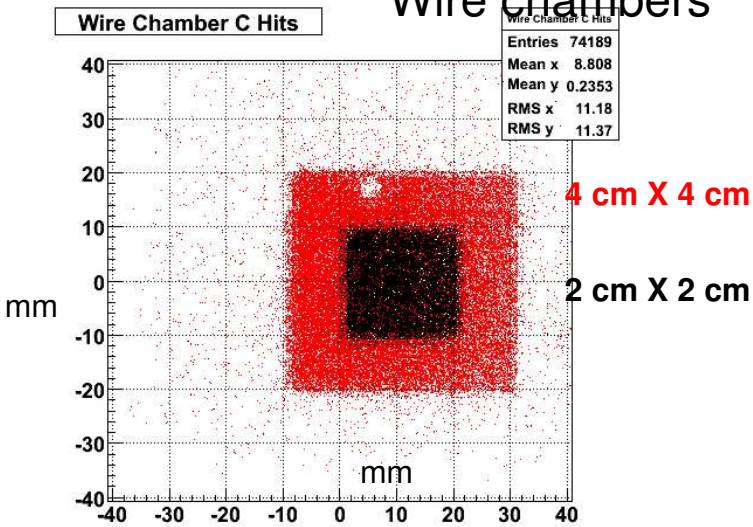
Muon Veto counters



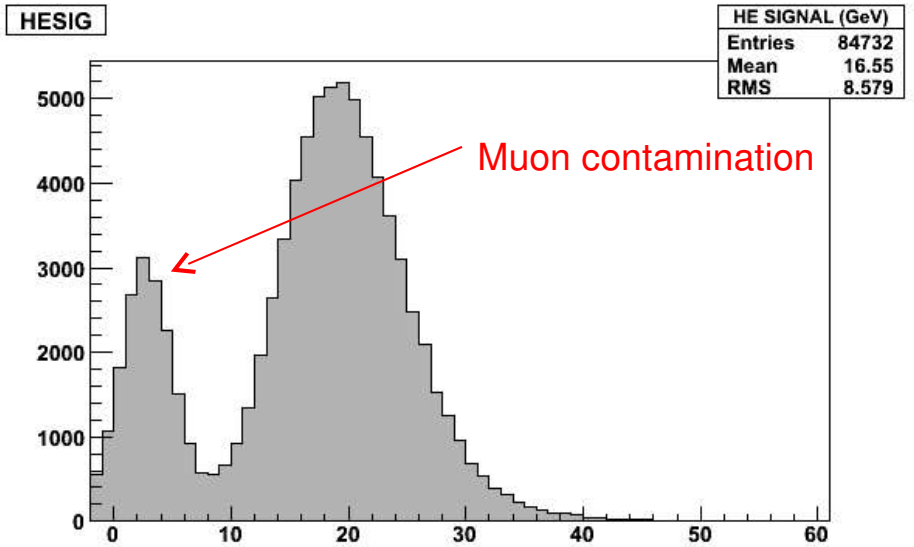
Trigger counters

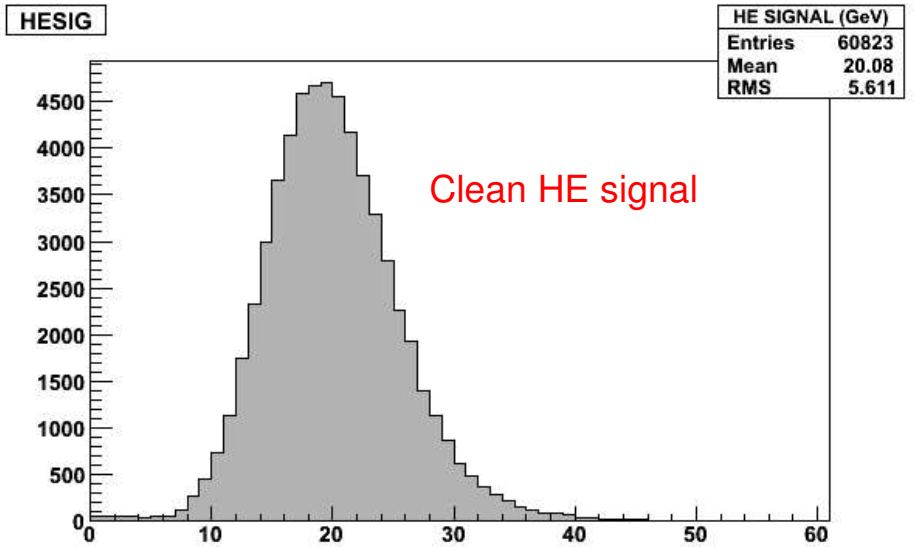


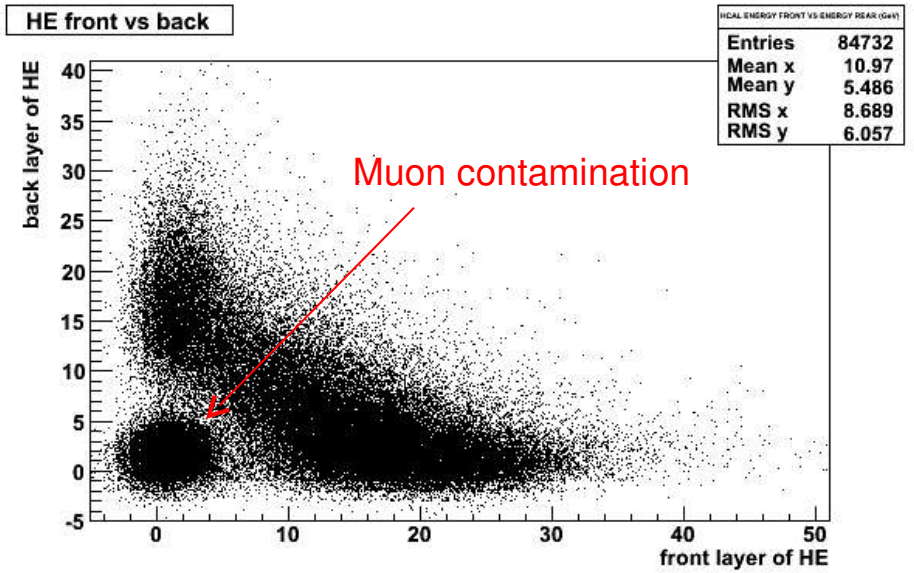
Wire chambers

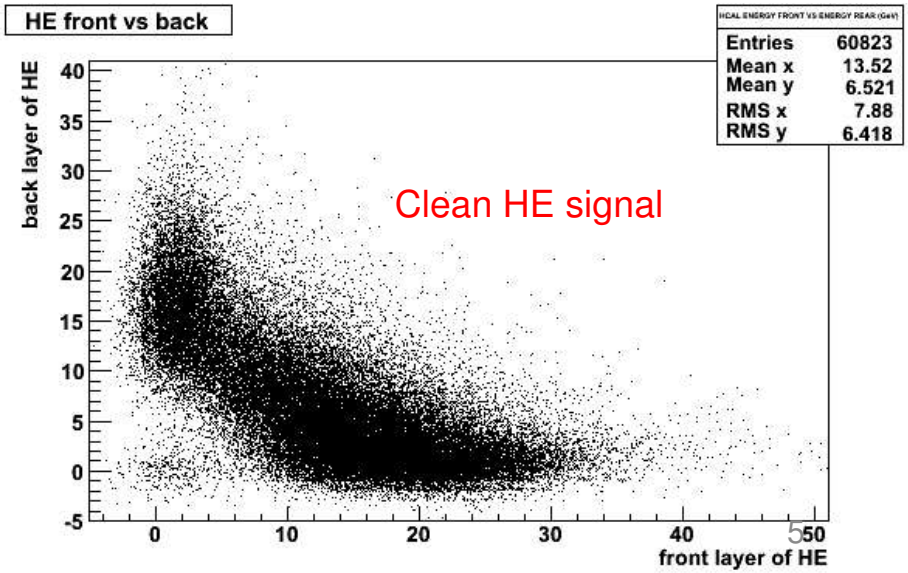


Effect of beam cleaning on the signal in hadron endcap calorimeter

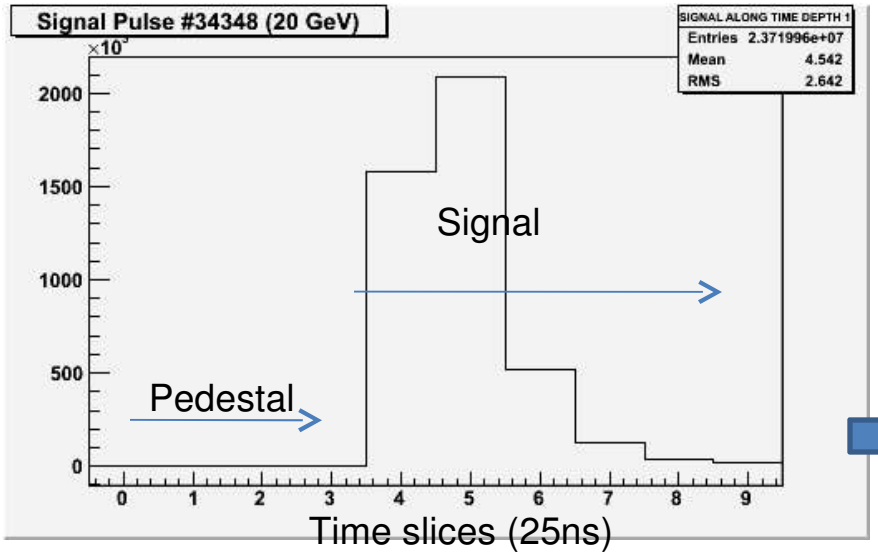


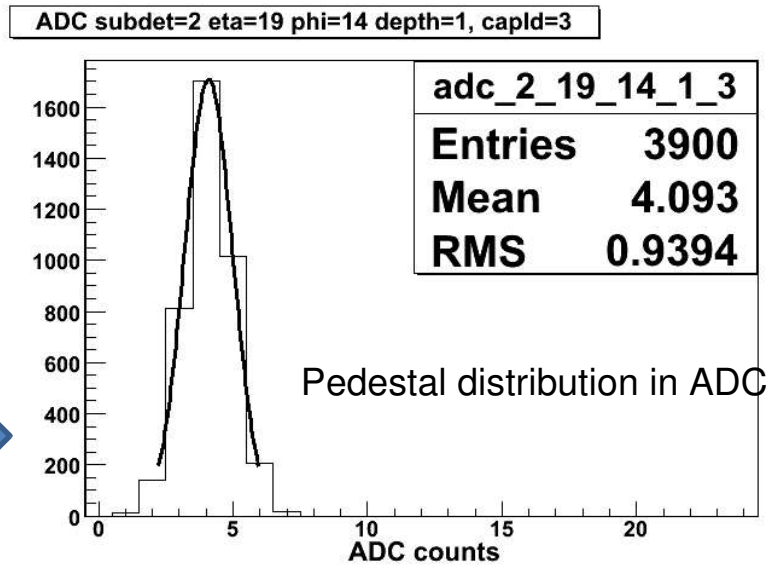






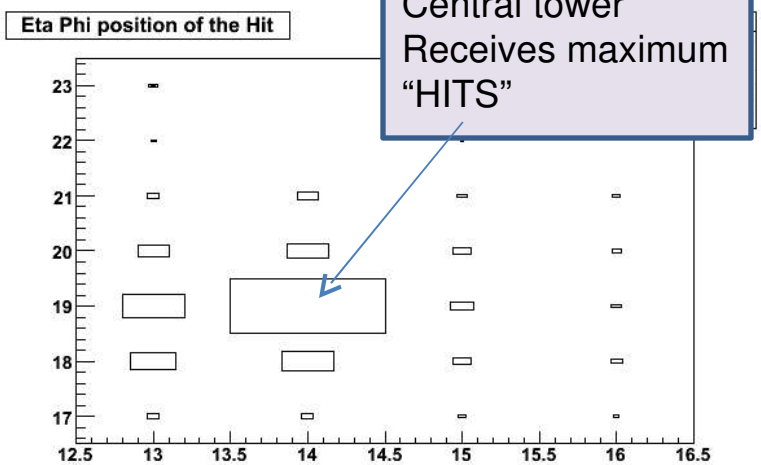
How energy is measured in the calorimeter



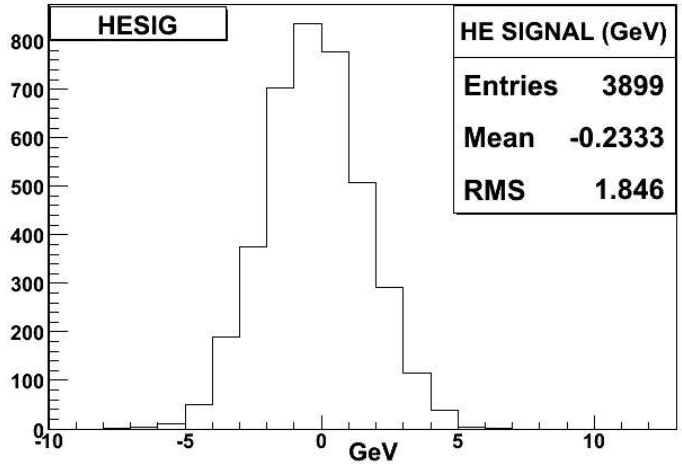


Pedestal distribution in ADC counts

Calibration is done with the muons.



Central tower Receives maximum "HITS"



Pedestal subtracted signal multiplied with conversion factors to bring the unit in GeV

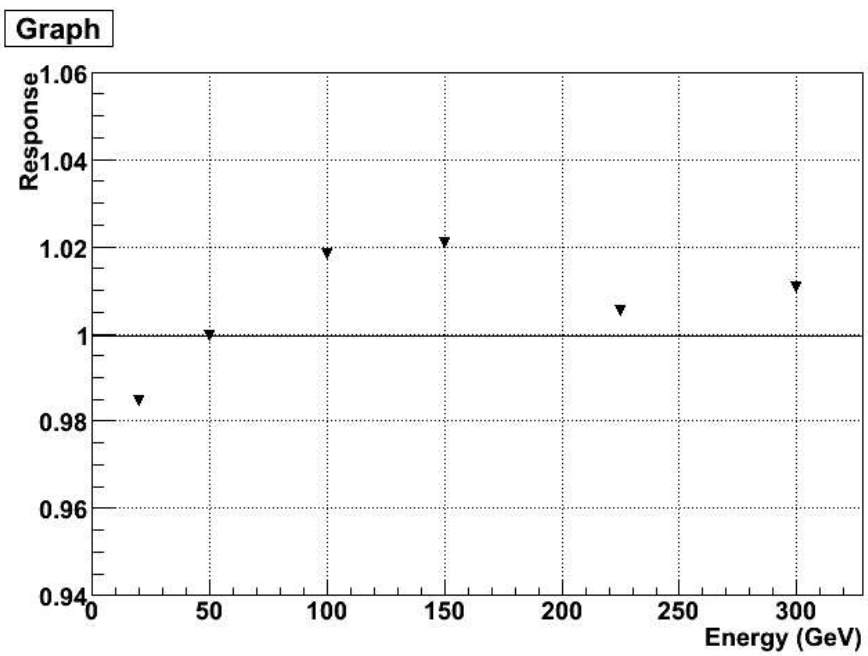
Response and resolution for Hadron endcap

Response of a detector is defined as the ratio of energy deposited to the nominal beam energy.

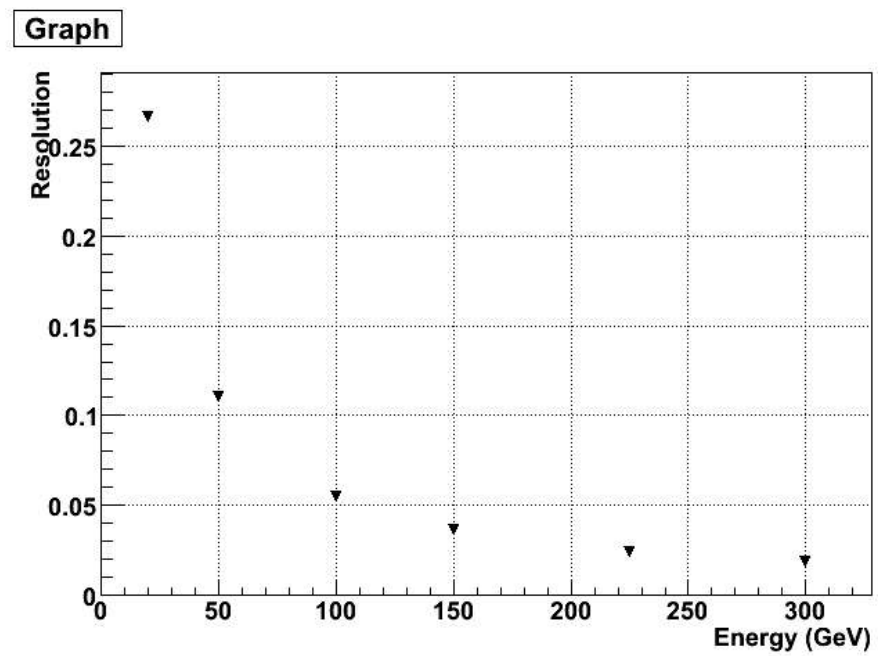
Resolution of a detector comes from statistical uncertainty, noise of the detector and fluctuations.

$$\left(\frac{\sigma_E}{E}\right)^2 = \left(\frac{A}{\sqrt{E}}\right)^2 + \left(\frac{B}{E}\right)^2 + C^2 +$$

A = due to sampling fluctuations which are Poisson in nature
B=contribution due to electronics (e.g. ADC resolution)
C=contribution due to calibration errors and other systematic effects

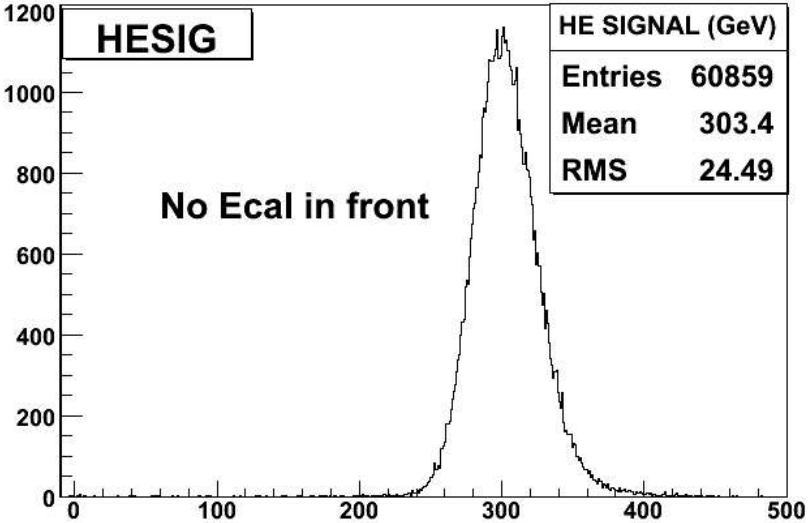


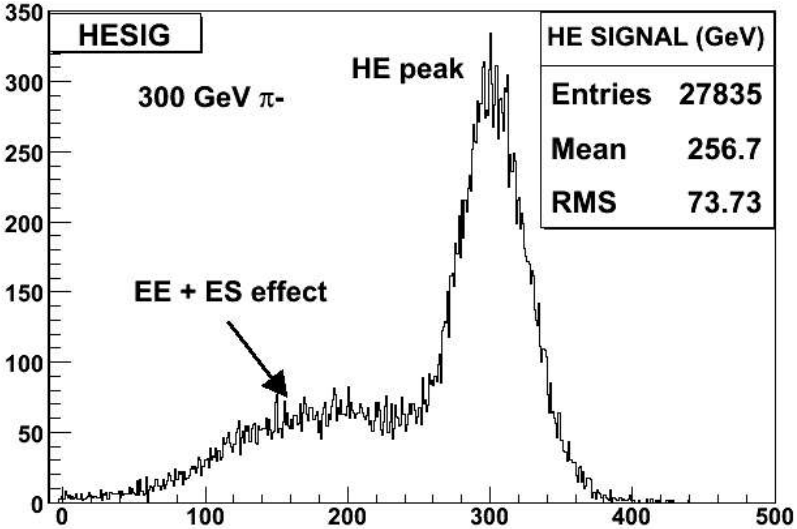
Response of HE varies within 4%



Resolution of HE – better with higher energy

Effect of having Ecal (EE+ES) infront of the Hadron endcap





When Ecal system stays infront of the HE system then one sees the lower bump
Which comes because of the early whoering that starts in the EE+ES system.