Test beam data analysis for the CMS CASTOR calorimeter at the LHC

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DESY

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The CMS experiment at the LHC

- CMS $\hat{=}$ Compact Muon Solenoid
- onion shell structure
- length: 21 m
  radius: 7.5 m
- weight: 12500 t
- high magnetic field (4 T solenoid)

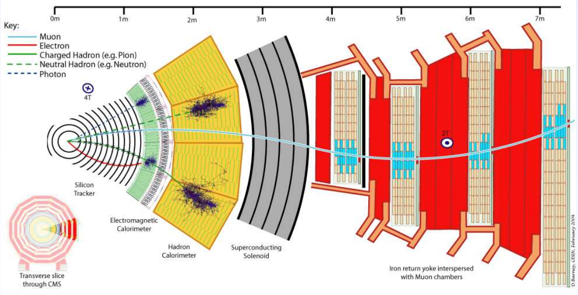


Figure: Slice of the CMS experiment

The CASTOR forward calorimeter

- CASTOR $\hat{=}$ ”Centauro And STrange Object Reasearch”
- detector based on the Cherenkov effect
- used for pp and heavy ion collisions (Pb-Pb)
- η coverage: $5.2 < |\eta| < 6.6$
- installed 14.4 m from CMS interaction point

Why do we need CASTOR?

We need it...

- to measure the PDFs at low momentum fractions x
- to improve the understanding of the strong interaction
- to support the Higgs measurements
  (higher acceptance of the CMS detector)
- to watch the shower development and investigate the nature of exotic objects like ”Centauros”
- and many further applications

Centauros are rare cosmic events with a very high hadronic fraction.

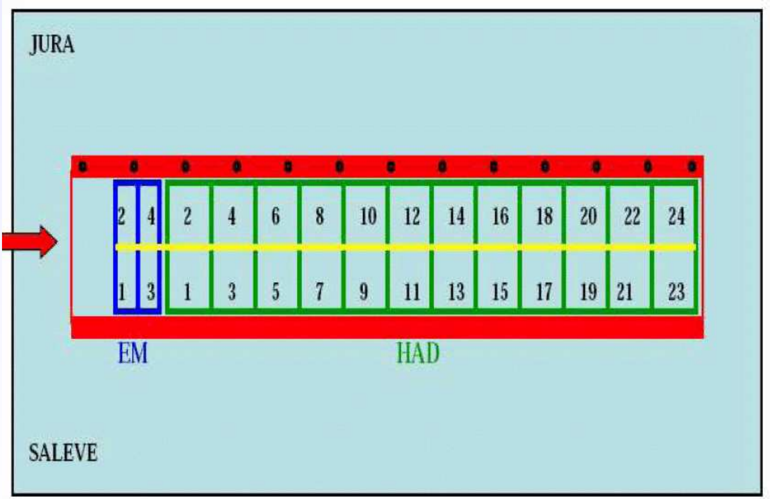
What is CASTOR made of?

- sampling calorimeter:
  - active material: quartz plates (Q)
  - absorber material: tungsten plates (W)
- 16 semi-octants around the beam pipe
- each semi-octant:
  2 em and 12 hadronic channels (Readout Units (RU))
- each RU has several Sampling Units (SU)
- SUs are made out of Q and W plates

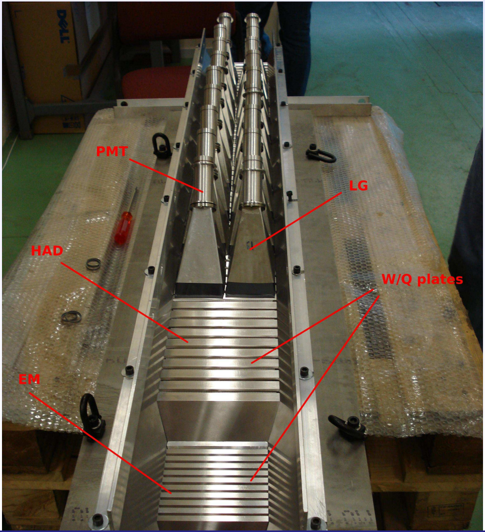
How can we measure the particles with CASTOR?

- relativistic particles hit the detector
- they cause a cone of light (due to the Cherenkov effect)
- light is collected and transported via light guides
- the signal is amplified with photomultipliers

The CASTOR forward calorimeter prototype



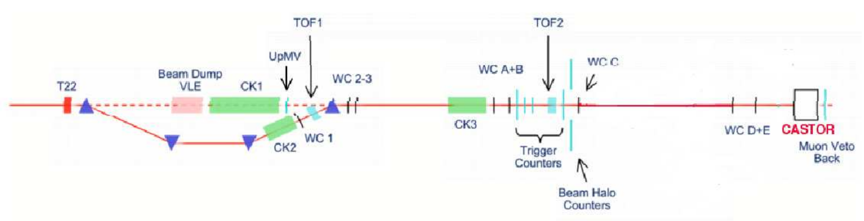
The CASTOR forward calorimeter prototype



The test beam setup

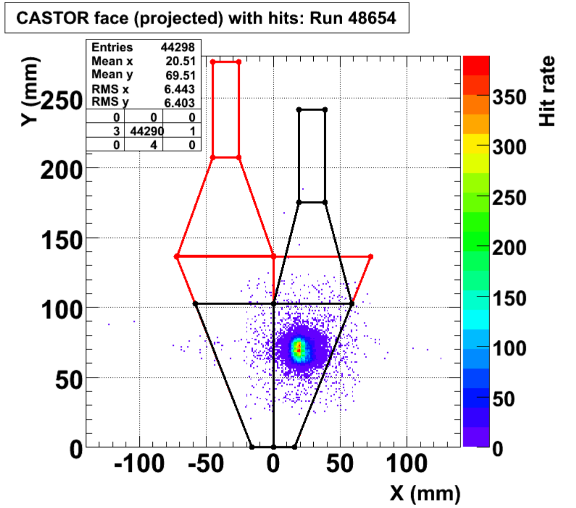
- protons are accelerated with the SPS
- protons hit a target $\Rightarrow$ secondary particles
- magnets and collimators select particle mass and energy
- readout is triggered by coincidence of signals from scintillators
- wire chambers measure position of beam particles
- large scintillator behind CASTOR can veto muon particles

The test beam setup II



- prototype for the test beam consists of two semi octants
- semi octants are called ”Saleve” and ”Jura”
- particles enter the detector on Saleve side

Beam profile



Pedestal amplitudes

- electronic noise: each signal as a certain offset $\Rightarrow$ Pedestal
- get the "‘real signal"’: subtract this offset
- check first: Is the pedestal stable in each channel?

$\Rightarrow$ Plot the mean pedestal of one channel for each electron run.

Pedestal amplitudes

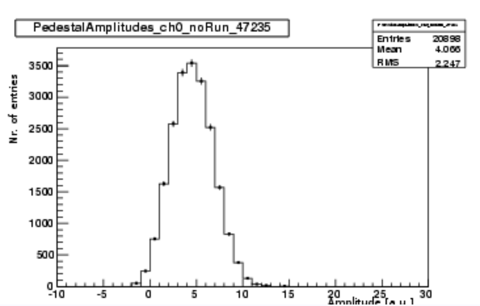
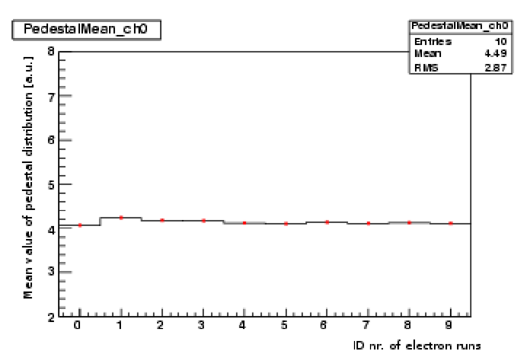


Figure: Pedestal pulse shape

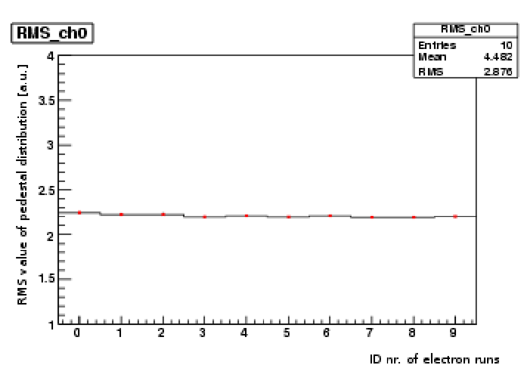
- pedestal $\longrightarrow$ offset
- width of pedestal: noise of electronics
- amplitudes are shown in the histogram

Pedestal mean stability



- errors of means are very small
- mean of the pedestal is stable

Pedestal RMS stability

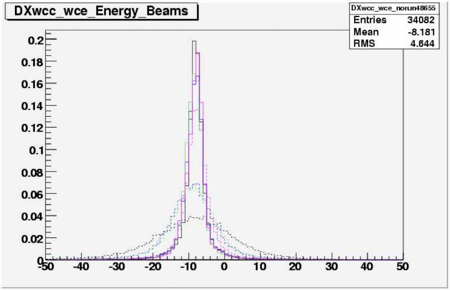


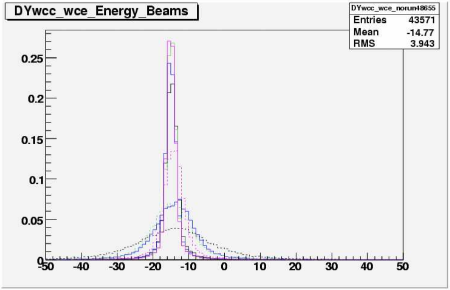
- RMS values are stable as well
- electronics is ok

Further cross checks

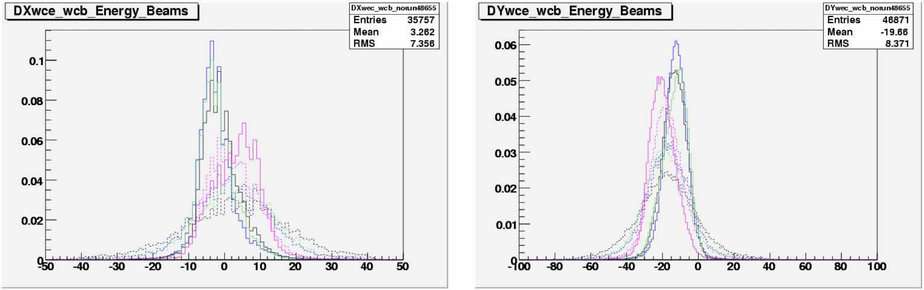
- Electron energy scans: Check if the beam changes its profile
  - require a single wire chamber hits in x and y direction
  - calculate difference between the position of different wire chambers
- Scintillator counters checked: worked as expected
- Check the stability of the LED runs

Difference of wire chamber C and E





Difference of wire chamber E and B



The LED run

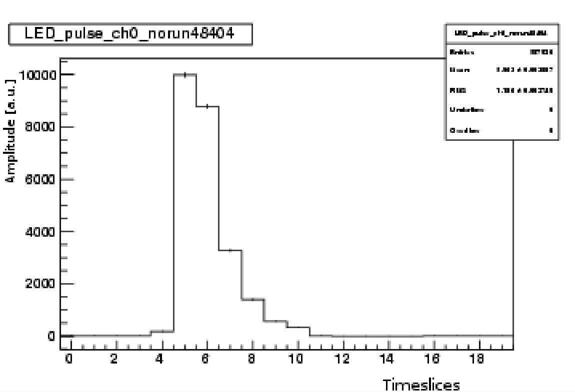


Figure: LED pulse

The LED run

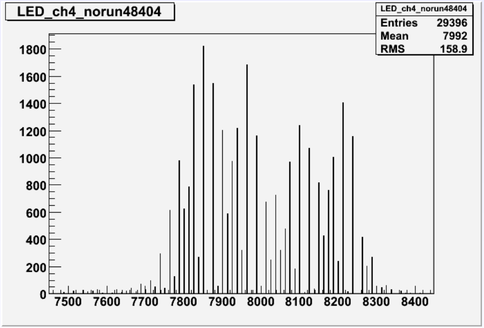


Figure: LED amplitudes

LED runs: mean value and rms

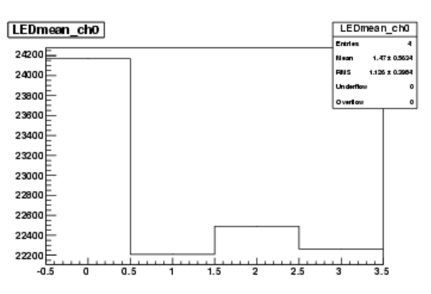


Figure: Mean stability of LEDs

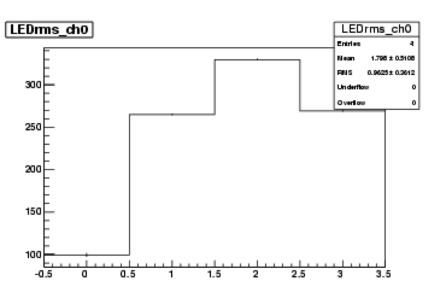


Figure: RMS stability of LEDs

Intercalibration factors

- each channel has another response to particles with the same energy

  $\Rightarrow$ We have to find the relation between the channels.

- Muons can fly through all channels without being absorbed.

  $\Rightarrow$ Use muons with a certain energy to gauge the channels.

Intercalibration with muons

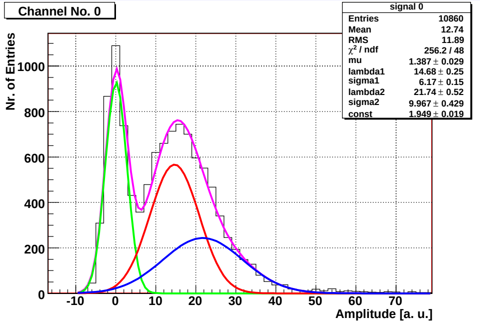


Figure: Channel 0 (em)

- fit function: sum of three Gaussians
- fit the pedestal peak first
- fix mean and rms of the pedestal peak
- fit distribution

How do we get the signal?

- signal for each channel: sum of time bins 3-6 without pedestal
- in this run: electrons are used

  $\Rightarrow$ we expect most of the signal in the two em channels and the first hadronic channel (ch 0-2)
- sum of channel 0-2 while using the intercalibration factors

Signal without cuts

Require only beam trigger and single hit in wire chamber E

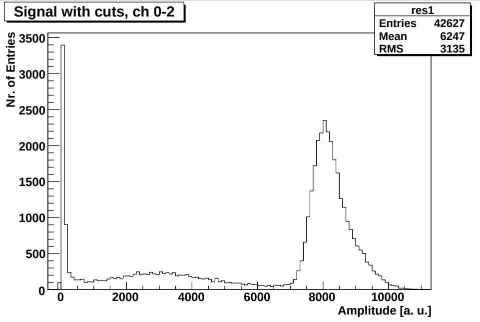


Figure: Electrons with E = 180 GeV

Comparison of different cuts

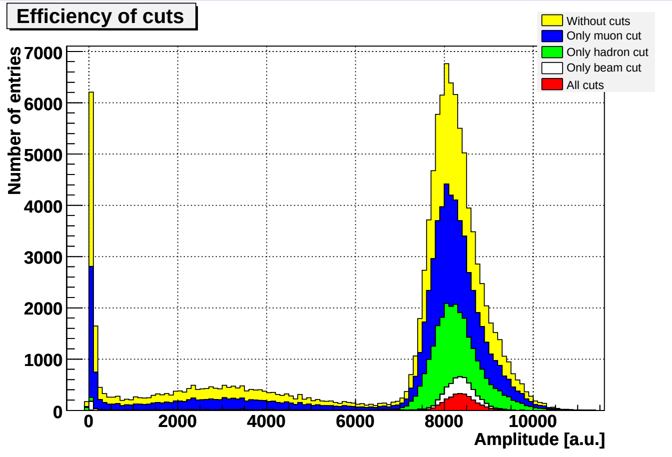


Figure: Result of different cuts

Resulting signal after cuts

Applied cuts

- hadron cut
- muon cut
- beam cut: accept only events which hit the wire chambers in a circle of 2 mm around the beam center

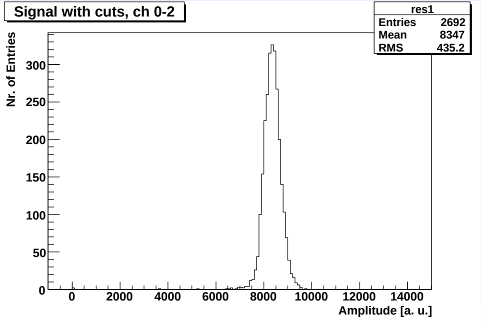


Figure: Result after 3 different cuts

Linearity of detector response

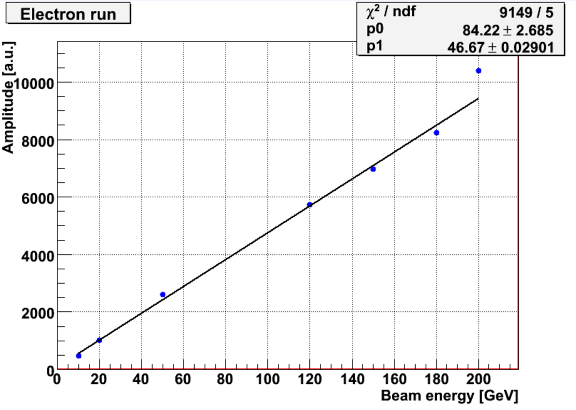


Figure: Linearity

Resolution of the detector

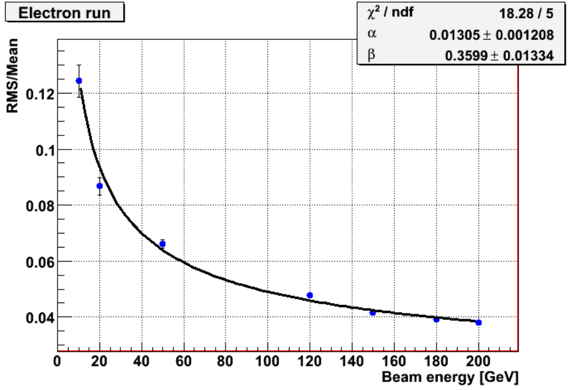


Figure: Resolution

Conclusion and outlook

Conclusion

- Pedestal mean and RMS are stable and can be used
- long term stability of the LED amplitude at a level of 10 %
- LED intensity should be decreased for other studies
- Linearity of the detector is not satisfactory (beam stability)
- Resolution as expected

Outlook

- one has to check the sensitivity of the intercalibration factors
- further studies of the linearity are necessary

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