

LDC Calorimeter Calibration

Viktor Hangartner

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Outline

Introduction

LDC

Calibration Method

Calculation of new Calibration Coefficients

Determining the 'upper edge'

Implementation as Marlin Processor

Improvement on determining the edge

Fitting gaussian to the edge

Study error on mean

Summary

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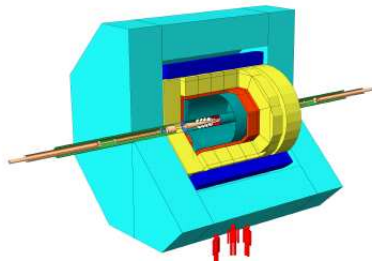
Summary

Large Detector Concept

LDC detector:

- ▶ Efficient vertexing
- ▶ Highly efficient tracking system
- ▶ High granular calorimetry

⇒ needed for PFlow concept



- ▶ ECAL consists of two sampling fractions:
inner section: thin absorber
outer section: thick absorber
- ▶ HCAL consists of one sampling fraction

⇒ Automated procedure needed to calibrate the calorimeters

Calibration Method

- ▶ As Described by V. Morgunov in Calorimeter energy calibration using the energy conservation law ("absolute calibration")
- ▶ E_{CM} is known with high accuracy
- ▶ Measure energy in Calorimeters
E: Energy sum in ECAL of event (in plots Eecal, [GeV])
H: Energy sum in HCAL of event (in plots Ehcal, [GeV])
- ▶ For each Event in Detector

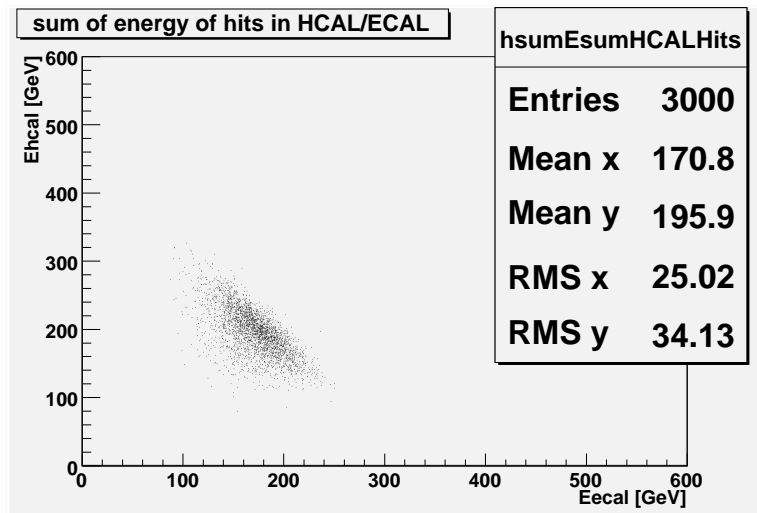
$$E_{CM} = H + E(+E_{\text{missing}})$$

$$E_{CM} = c_1 * E_{1,\text{vis}} + c_2 * E_{2,\text{vis}} + c_3 * H_{\text{vis}}$$

- ▶ Create 2d Histogram, display H vs E of each event

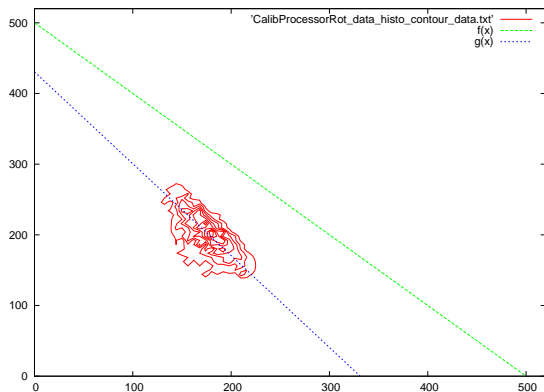
Scatter Plot

- ▶ $E_{CM} = 500 \text{ GeV}$, $t\bar{t} \rightarrow 6\text{jets}$, LDC01



Contour Map

- ▶ $t\bar{t} \rightarrow 6\text{jets}$, LDC01, $E_{CM} = 500$ GeV
- ▶ red: data
- ▶ blue: line describing orientation of the cloud
- ▶ green: expectation if energy is conserved (calibrated data sample)



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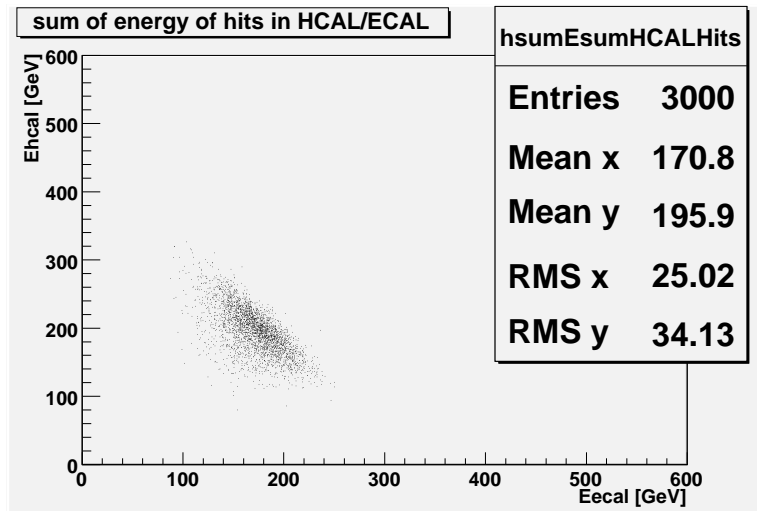
Summary

Calculation of new Calibration Coefficients

- ▶ previous calibration coefficients given c_1, c_2, c_3 . Calculate corrected ones as function of c_1, c_2, c_3 (as described by V. Morgunov).
- ▶ $c_{1, \text{new}} = f * a * c_1,$
 $c_{2, \text{new}} = f * a * c_2,$
 $c_{3, \text{new}} = f * c_3$
- ▶ $f = \frac{E_{\text{CM}}}{E_0}$
- ▶ E_0 and a from simple line fit describing the orientation of the cloud $H(x) = a * E + E_0$ on plot E vs H

Calculation of new Calibration Coefficients

- ▶ Due to energy loss (ν, μ , acceptance) need of a fit on 'upper edge'



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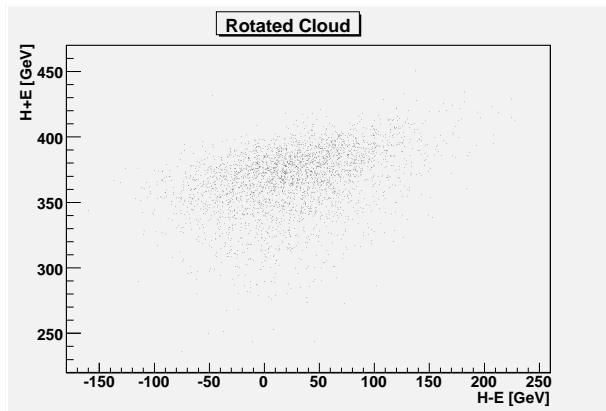
Fitting gaussian to the edge

Study error on mean

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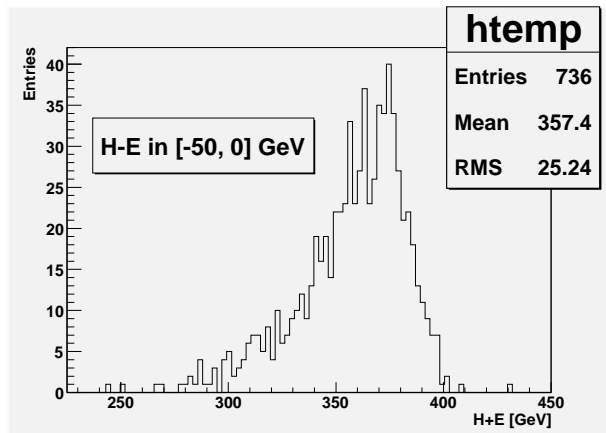
How to find the edge in an easy way I

- ▶ Rotate the cloud by plotting $E + H$, $H - E$
- ▶ Divide the rotated cloud in slices (intervals in $H-E$), e.g select Events $H - E$ in $[-50,0]$ GeV
- ▶ Create Histogram to look at $H + E$ distribution in slice



How to find the edge in an easy way II

- ▶ Edge described by Position of the maximum $H+E_{\max}$
- ▶ Determine $H+E_{\max}$:
 - Method 1: select max bin
 - Method 2: fit function to histogram

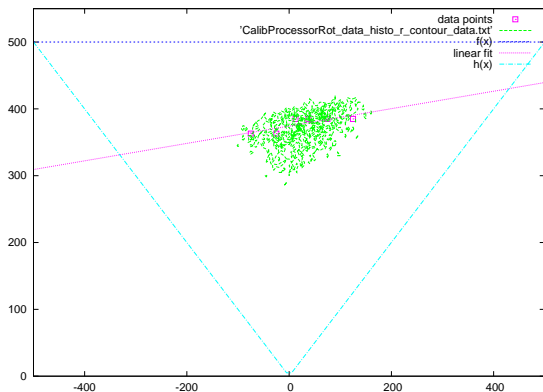


How to find the edge in an easy way III

- ▶ Determine for each slice the $(H+E)_{\max}$
- ▶ Fit line $y(x) = a * x + y_0$ to data points $(H-E, (H+E)_{\max})$

The edge

- ▶ green: $t\bar{t} \rightarrow 6\text{jets}$, LDC01, $E_{CM} = 500$ GeV
- ▶ dark blue: Expectation, energy conservation
- ▶ light blue: $E=0$ or $H=0$
- ▶ pink: fit describing the edge (methode 1, 6 slices)
- ▶ New calibration coefficients calculated using parameters parameters of the fit.



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CalibProcessor

- ▶ Processor reading slcio files
- ▶ Calibration after first Digitisation/Calibration easily applicable for non calibrated Calorimeter Hits (SimCalorimeter Hit) after minor changes
- ▶ GSL used for linear regression and edge finding (Methode 1 implemented)
- ▶ Output (new calibration coefficients) written to ASCII file

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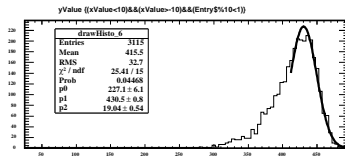
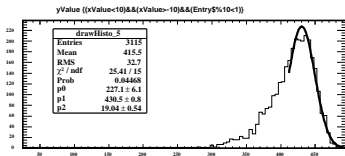
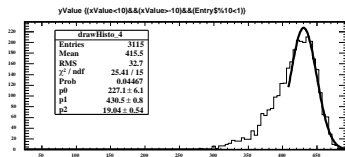
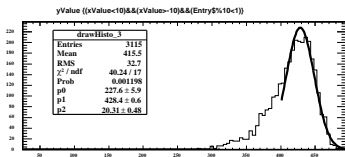
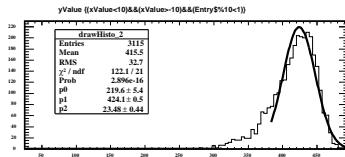
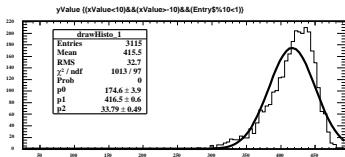
Current implementation - Methode 1

- ▶ Edge defined by H+E-Value of bin having maximal number of entries
- ▶ Many possible difficulties:
binning, stat. fluctuations, ...

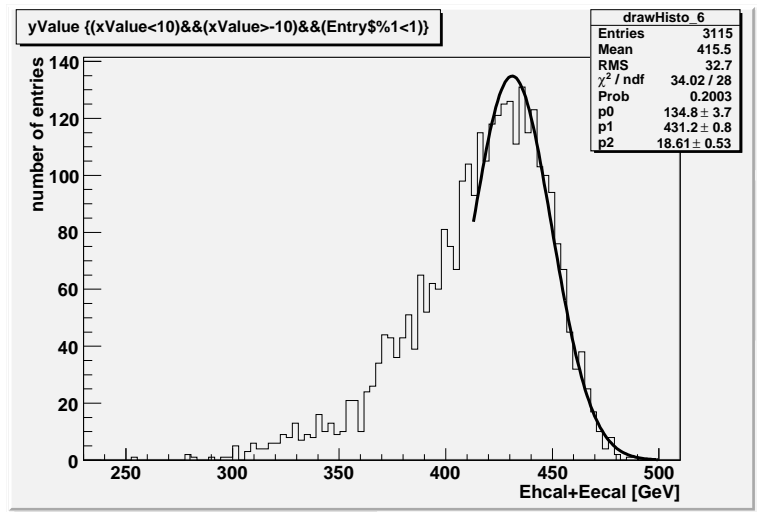
⇒ Fit gaussian on the 'upper edge' of the histogram and take mean

⇒ Iterate fit to improve the result

Fitting gaussian to the edge



Fitting gaussian to the edge



Iterated fitting

- ▶ Binned Maximum likelihood fit is used
- ▶ Fit range $[a,b]$ is set to $[\text{mean}-\text{sigma},b]$ for the next fit
- ▶ More studies needed concerning parameters of initial fit
- ▶ Mean is the position of the edge. Error of mean effects on result of the line fitted to the cloud.
⇒ Question of statistics?

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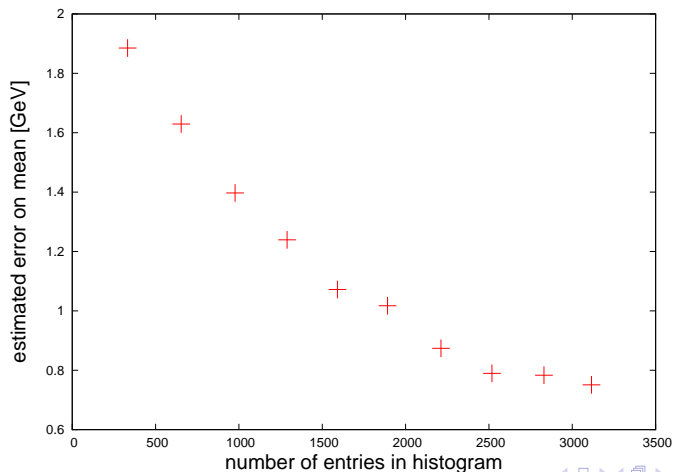
Fitting gaussian to the edge

Study error on mean

Summary

Study error on mean

- ▶ Error of mean as function of Entries in slice
- ▶ first data point : 5000 events
- ▶ last data point : 50000events



Study error on mean

- ▶ Number of entries in slice > 2500 (= 40'000 events in data sample)
- ▶ Improvements:
Study independent subsamples to get better estimation of error on mean and use this to improve the line fit (number of slices vs. number of entries in slice)

Summary

- ▶ Approach to calibrate the LDC calorimeter simulation exists
- ▶ Still a lot to do:
 - ▶ Extend studies of error on mean
 - ▶ Implement fit of rhs gaussian using GSL (methode 2)
 - ▶ Make CalibProcessor user-friendly
 - ▶ Testing of the Processor
 - ▶ Adapt processor for SimCaloHit level
 - ▶ Documentation

Thanks to:

- ▶ Oliver and Jorge

