STUDYING THE CHARACTERISTICS OF THE FORWARD CALORIMETER

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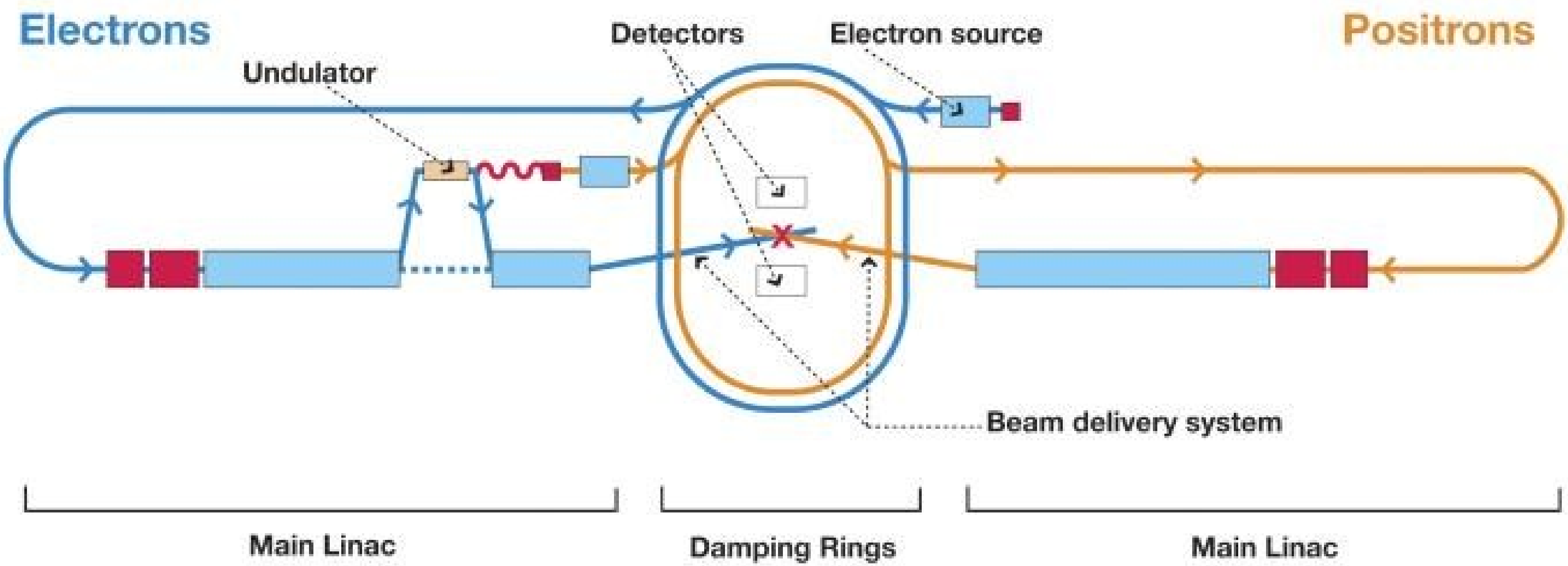
Goal

- Find energy resolution of BeamCal
- Find spatial resolution of BeamCal

Content

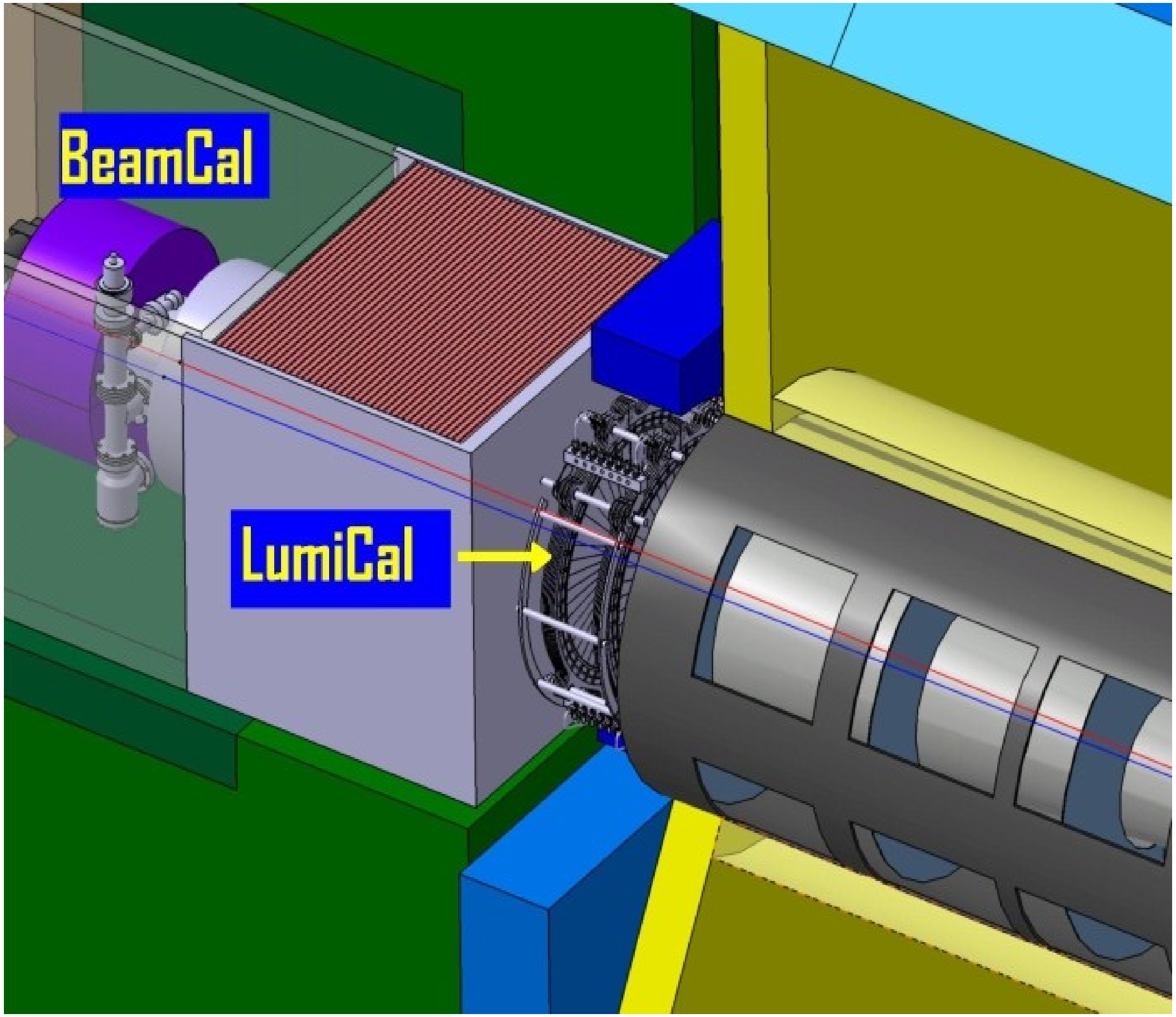
- Introduction
    - Part I Energy Resolution
    - Part II Spatial Resolution
- Conclusion

ILC



www.desy.de

Forward Calorimeter

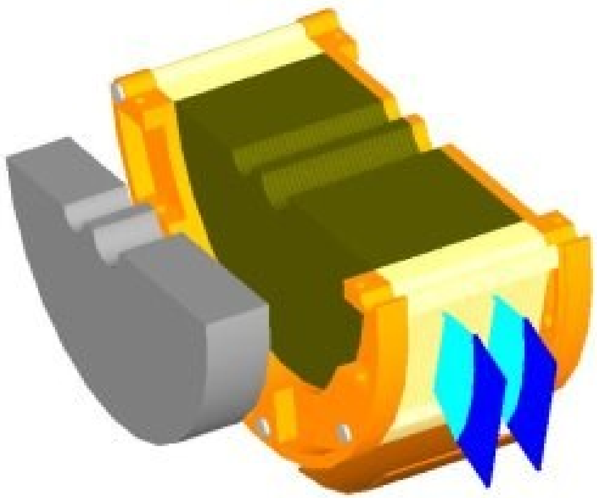


- BeamCal
- LumiCal
- Pair monitor

http://fcal.desy.de/

BeamCal

- Measure energy deposition from single high energy electron on top of background
- Assist beam tuning
- Protect inner part of detector



http://fcal.desy.de

Plan for Energy Resolution

Find deposited energy from single high energy electron

Standard Deviation and average deposited energy

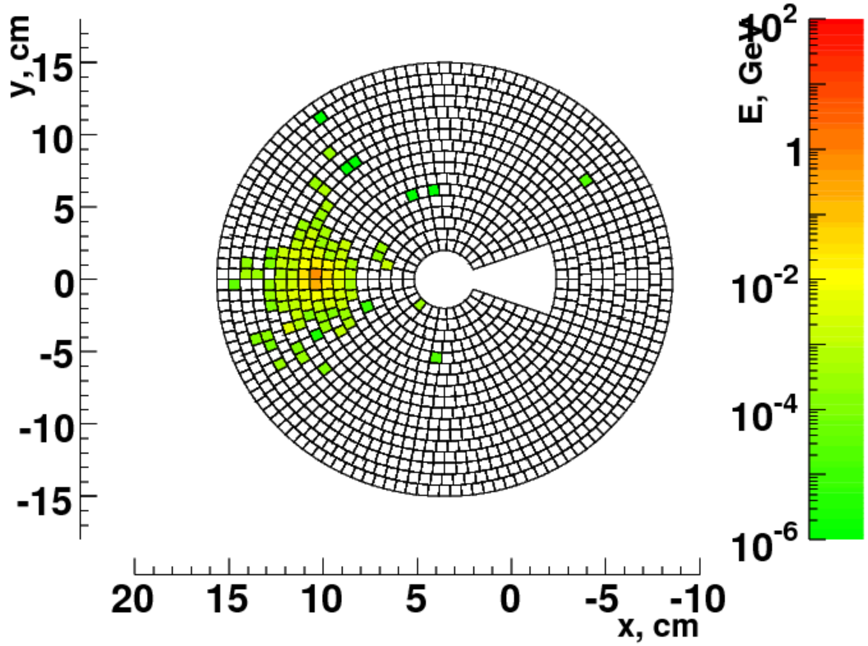
Energy Resolution

Simulation

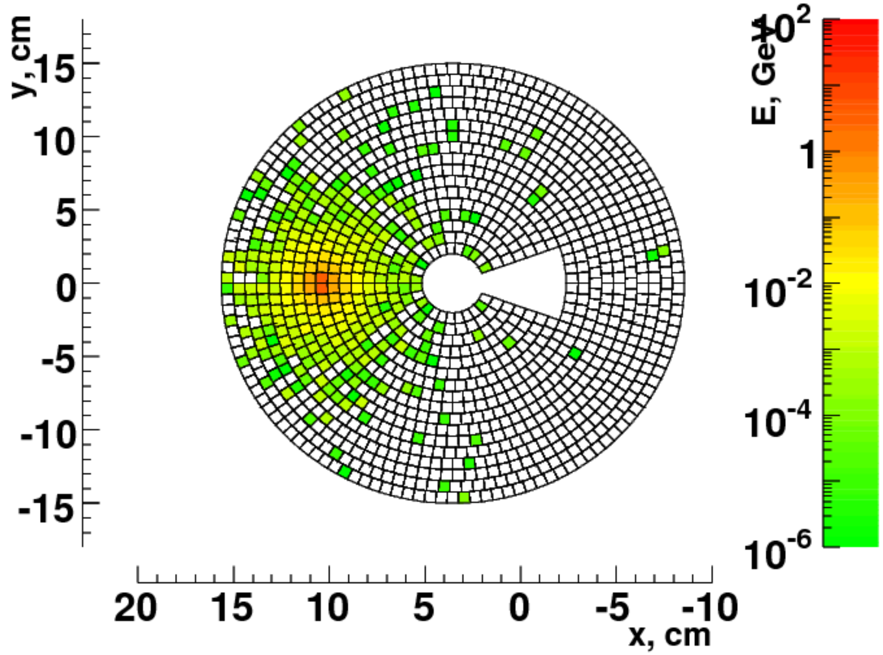
- Simulated energy deposition
  - Sent 200 times electron with energy 50 GeV
  - 100 GeV
  - 200 GeV
  - 300 GeV
  - 400 GeV
  - and 500 GeV to calorimeter

Examples of Energy deposition by simulation

50GeV



500GeV

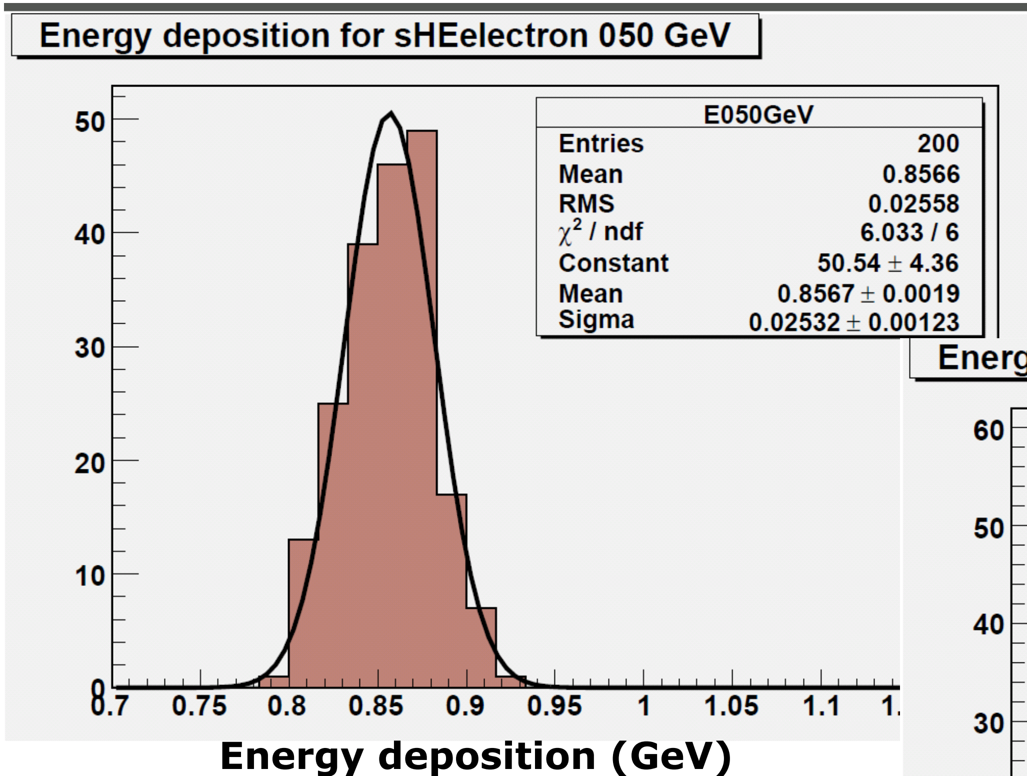


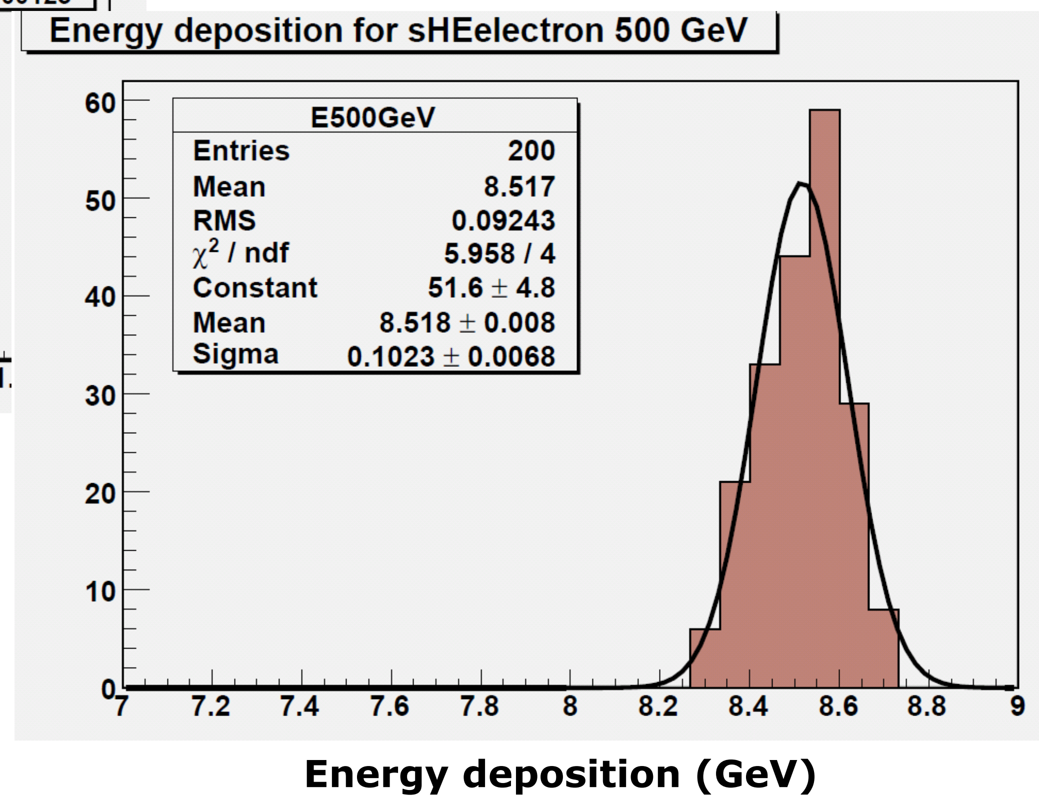
Processing

- Created energy deposition histograms from simulation data
- Fitted these histograms with gauss function
- Found average deposited energy
- Found standard deviation
- Calculated energy resolution
- Plotted energy resolution vs energy of electron
- Fitted the plot and got parameters

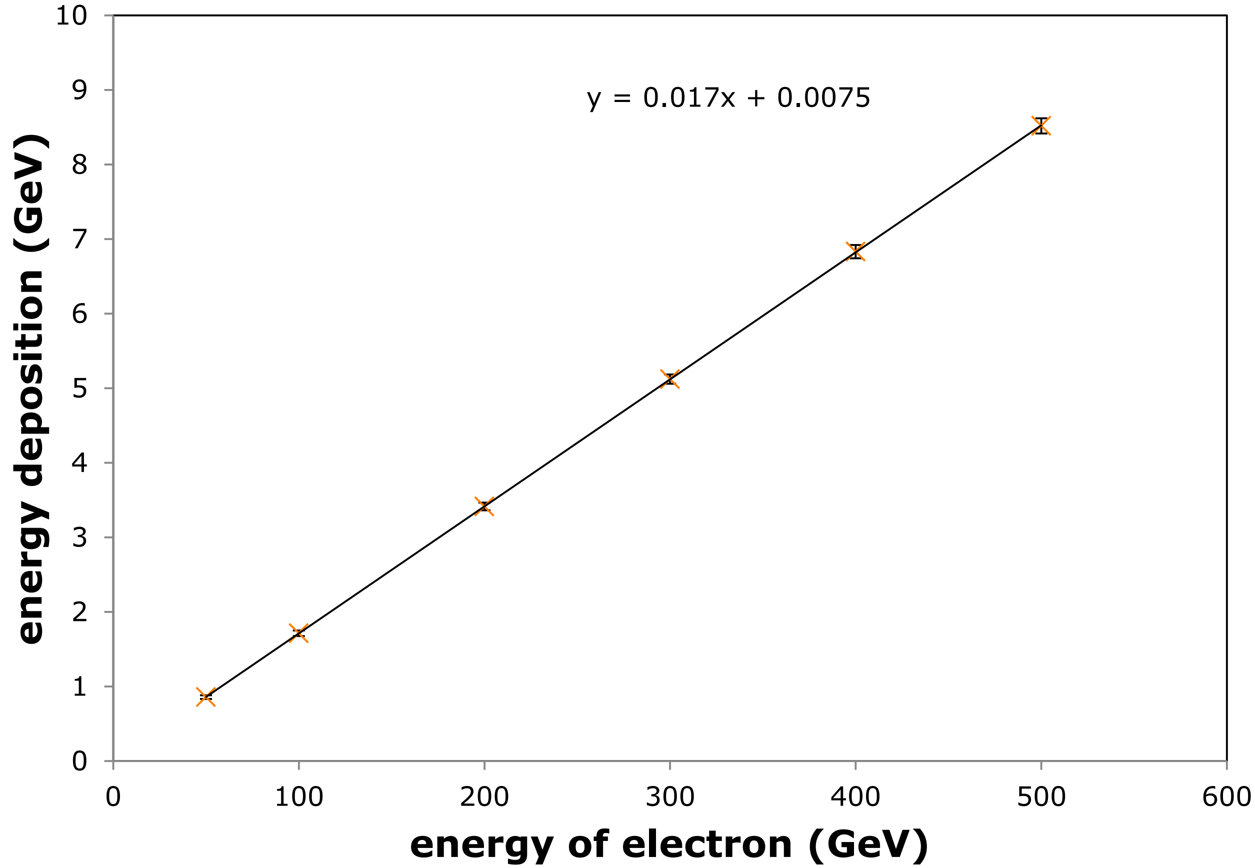
Examples of Histograms

energy deposition from simulation





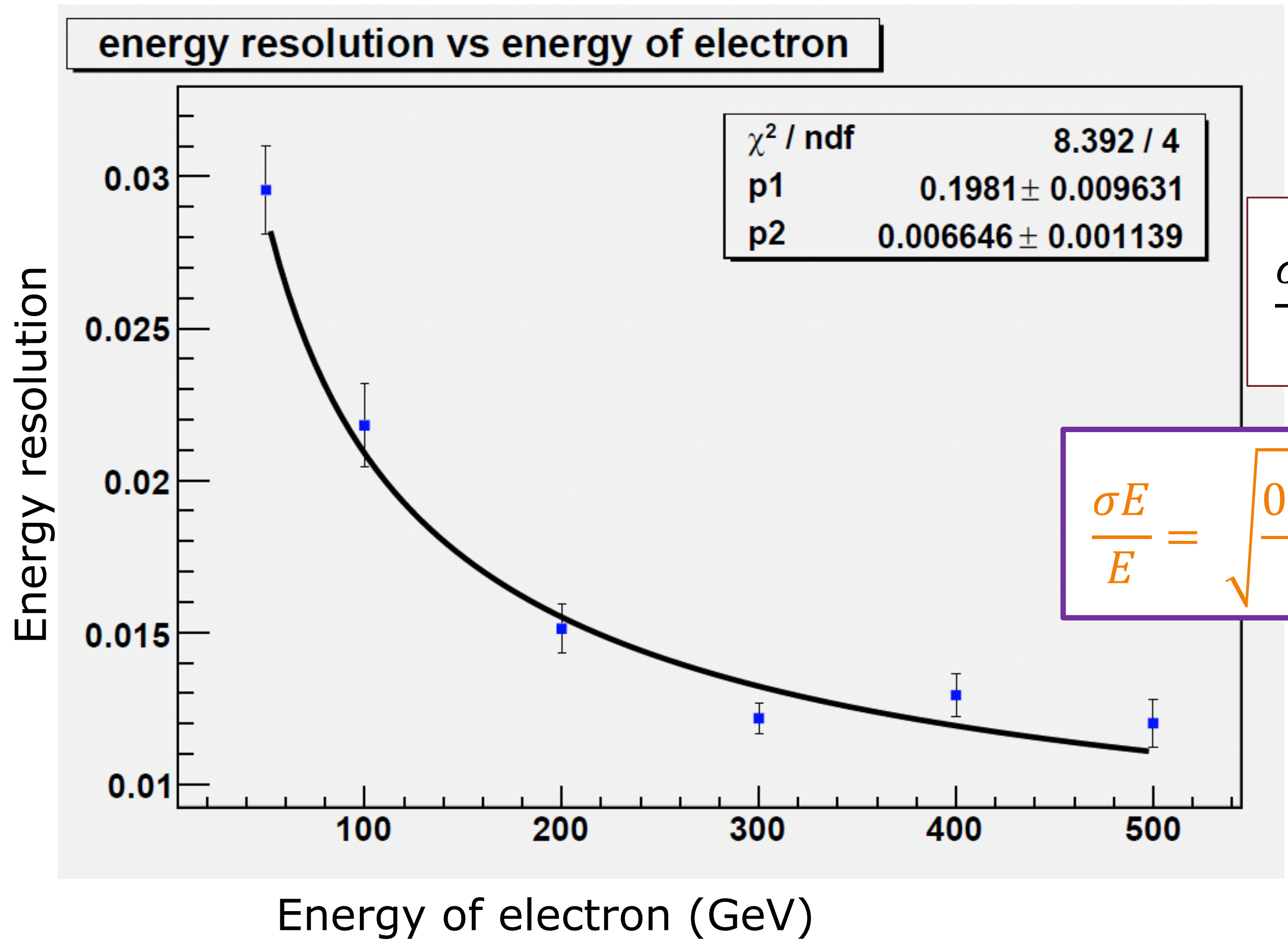
Deposited energy versus energy of electron



$$E = A * E_{dep} - B$$

$A = 58.66 \pm 0.03979$; $B = -0.2972 \pm 0.1183$

Plot energy resolution versus energy of electron



$$\frac{\sigma E}{E} = \sqrt{\frac{{p_1}^2}{E} + {p_2}^2}$$

$$\frac{\sigma E}{E} = \sqrt{\frac{0.1981^2}{E} + 0.006646^2}$$

Plan for Spatial Resolution

Find estimated resolution

↓

Find Center Of Gravity (COG)

↓

Create histogram of the difference between center of gravity and true coordinate of particle

↓

Find standard deviation

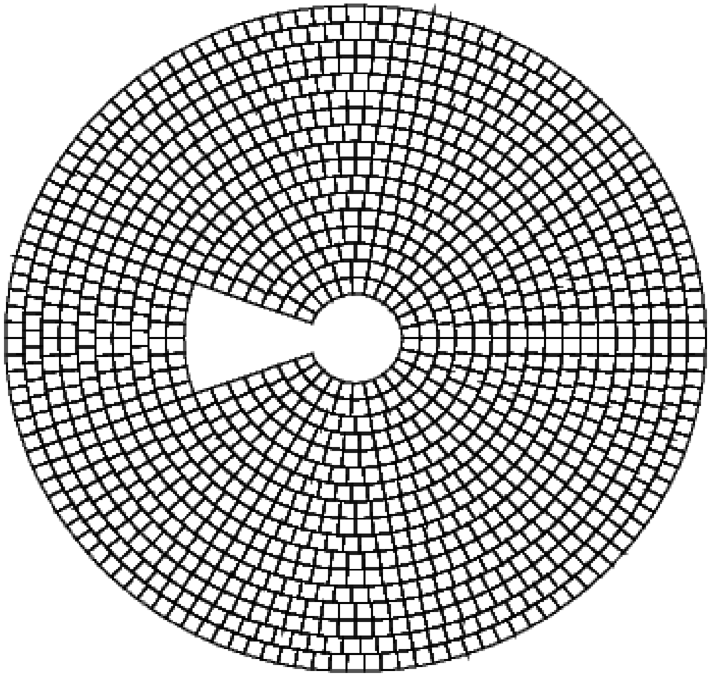
↓

Create graph σ vs Energy of electron

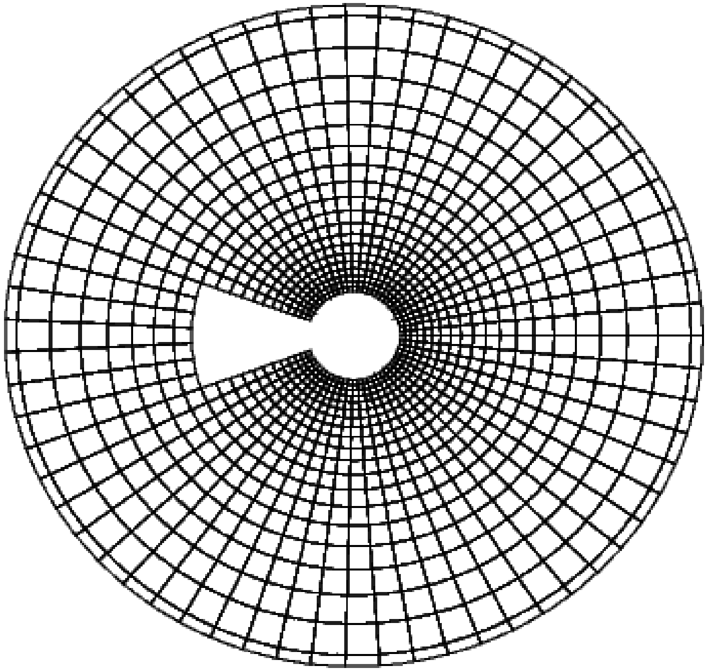
↓

Find Parameters

Segmentation



Uniform Segmentation



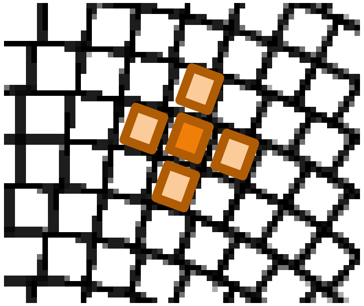
Radial Segmentation

How to find spatial resolution for Uniform Segmentation

Estimated resolution

$$\sigma_x = \frac{a}{\sqrt{12}} = 2.2075\,mm$$

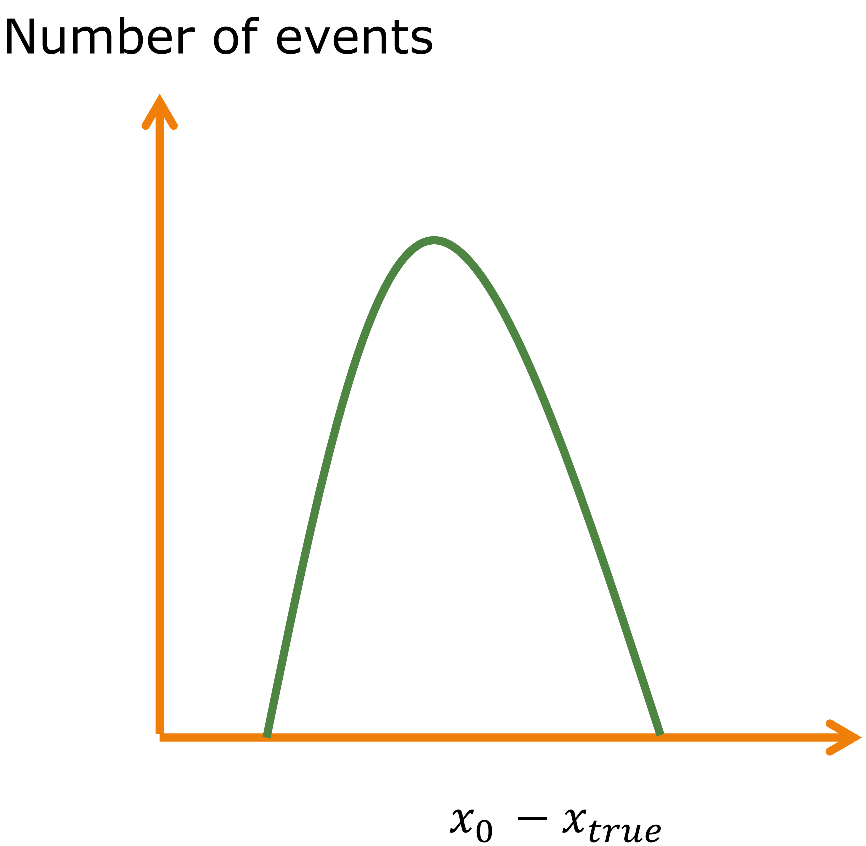
$$\sigma_y = \frac{b}{\sqrt{12}} = 2.1592\,mm$$

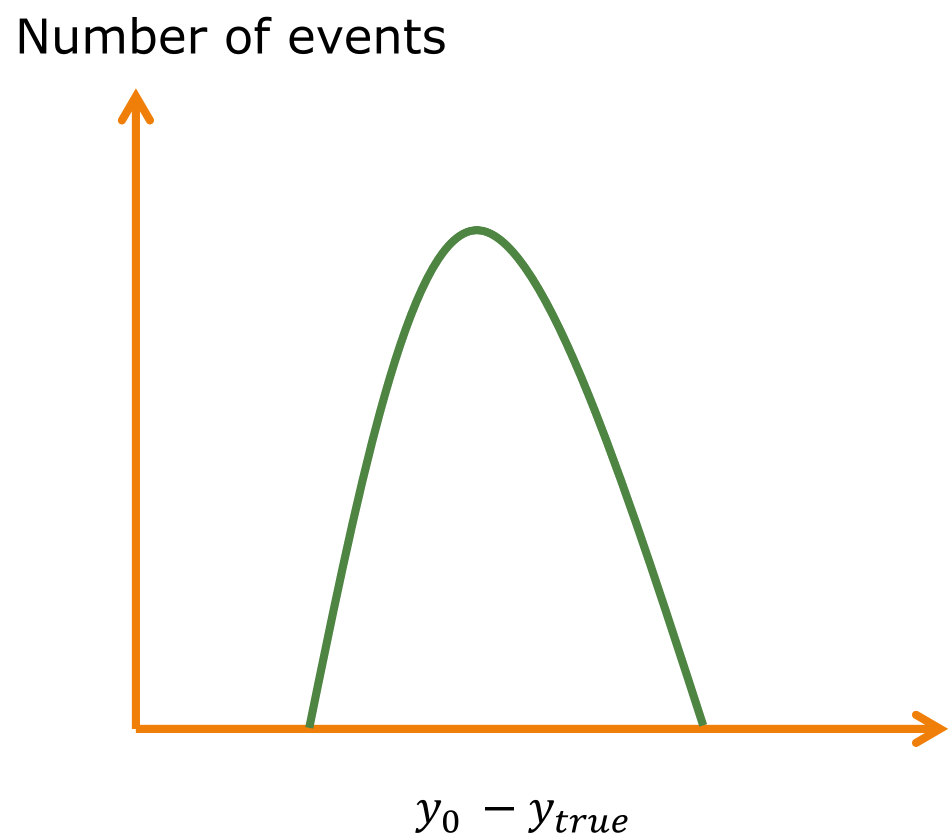


Center of gravity

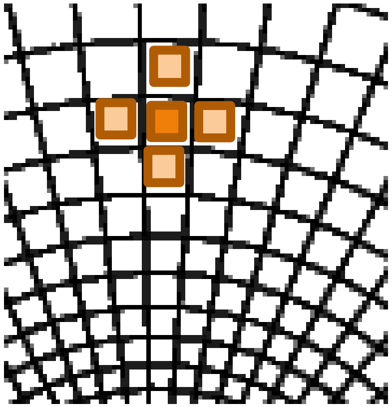
$$x_0 = \frac{x_1E_1 + x_2E_2 + x_3E_3}{E_1 + E_2 + E_3} \qquad y_0 = \frac{y_1E_1 + y_2E_2 + y_3E_3}{E_1 + E_2 + E_3}$$

Difference between center of gravity and true coordinate of particle (US)





How to find spatial resolution for Radial Segmentation



Estimated resolution

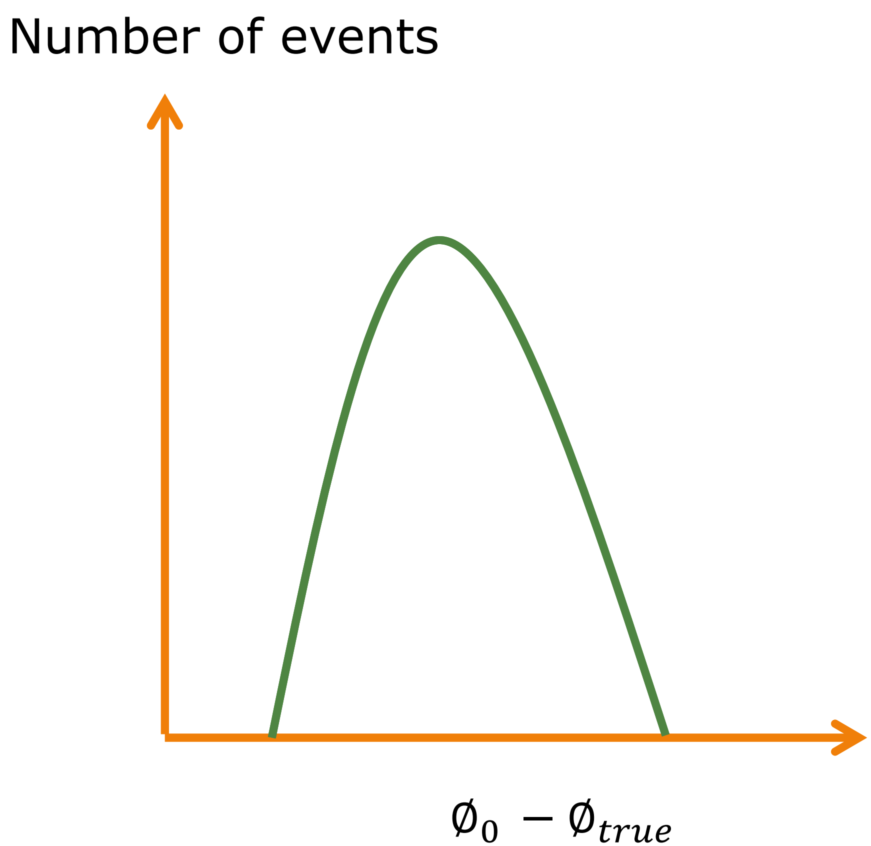
$$\frac{\sigma R}{R} = \frac{\Delta R}{R\sqrt{12}} = 0.02858$$

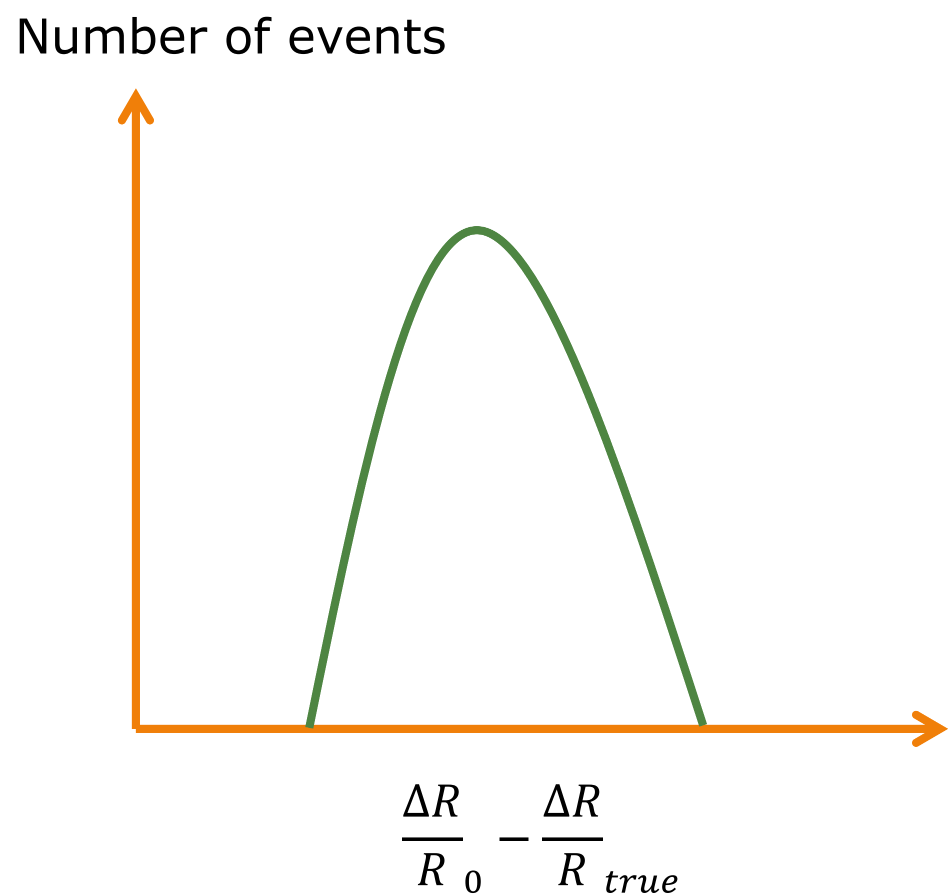
and $\sigma_\varphi = \frac{\Delta\varphi}{\sqrt{12}} = 1.6496$ degrees

Center of gravity

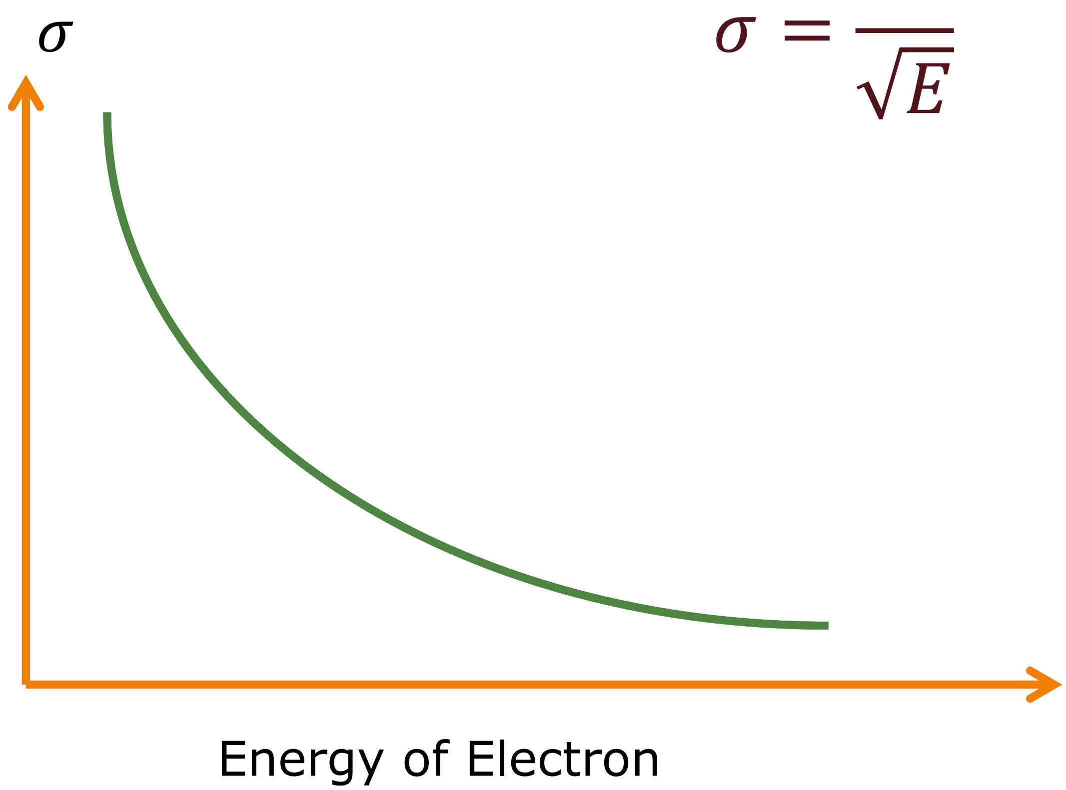
$$R_0 = \frac{R_1 E_1 + R_2 E_2 + R_3 E_3}{E_1 + E_2 + E_3} \qquad \varphi_0 = \frac{\varphi_1 E_1 + \varphi_2 E_2 + \varphi_3 E_3}{E_1 + E_2 + E_3}$$

Difference between center of gravity and true coordinate of particle (RS)





Resolution vs energy of electron



$$\sigma = \frac{A}{\sqrt{E}}$$

Conclusion

Have done

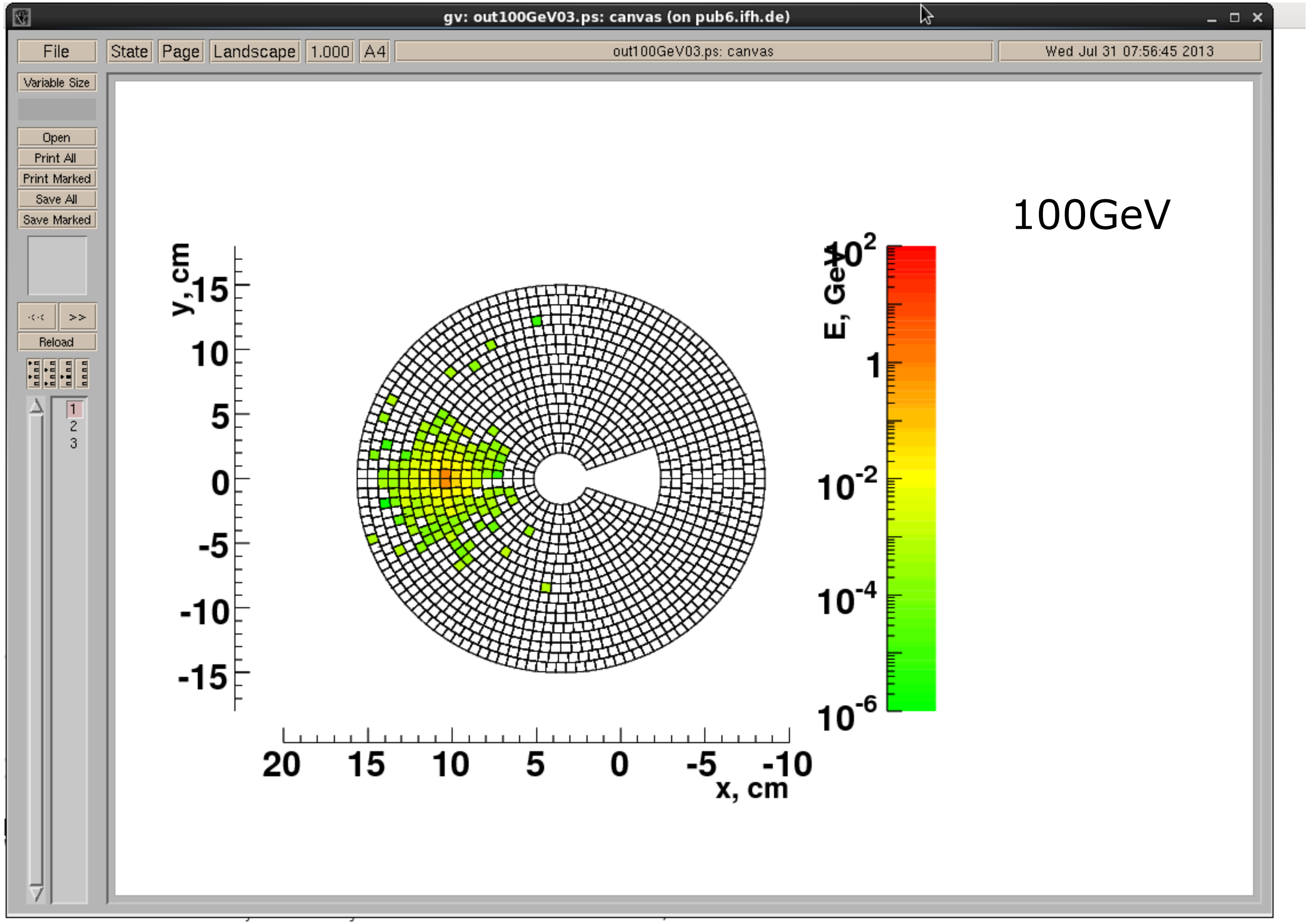
- Studied Linux
- Reviewed FCAL
- Studied data from supervisor
- Planed to get result
- Learned how to write shell script
- Simulated single high energy electron
- Found standard deviation
- Plotted energy resolution versus energy of electron
- Fitted this plot and found parameters p_1 and p_2
- Learned how to find spatial resolution(Logic and program)
- Found estimated resolution
- Started writing report

To do

- Find spatial resolution

Thank you

Energy deposition by simulation



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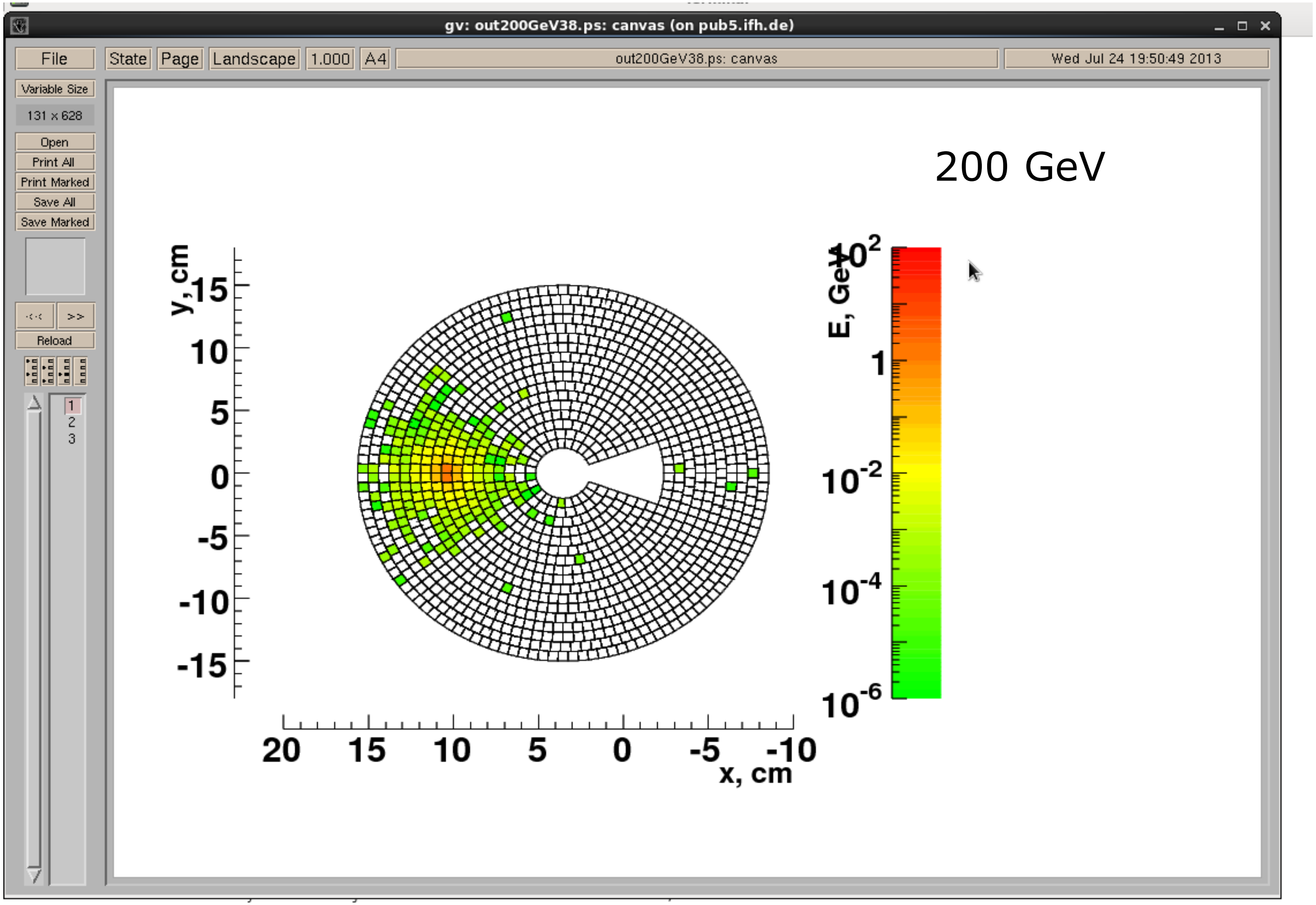

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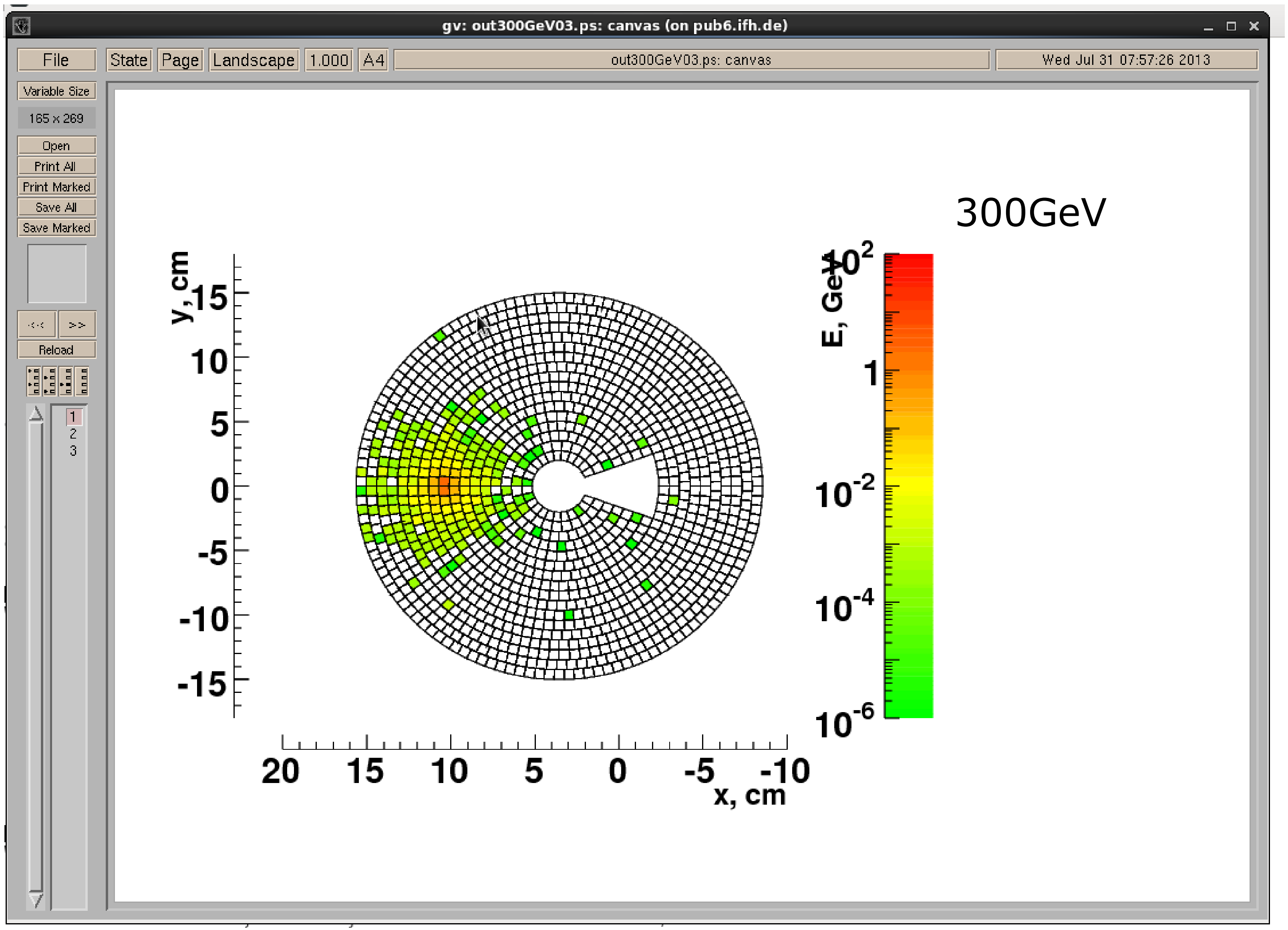
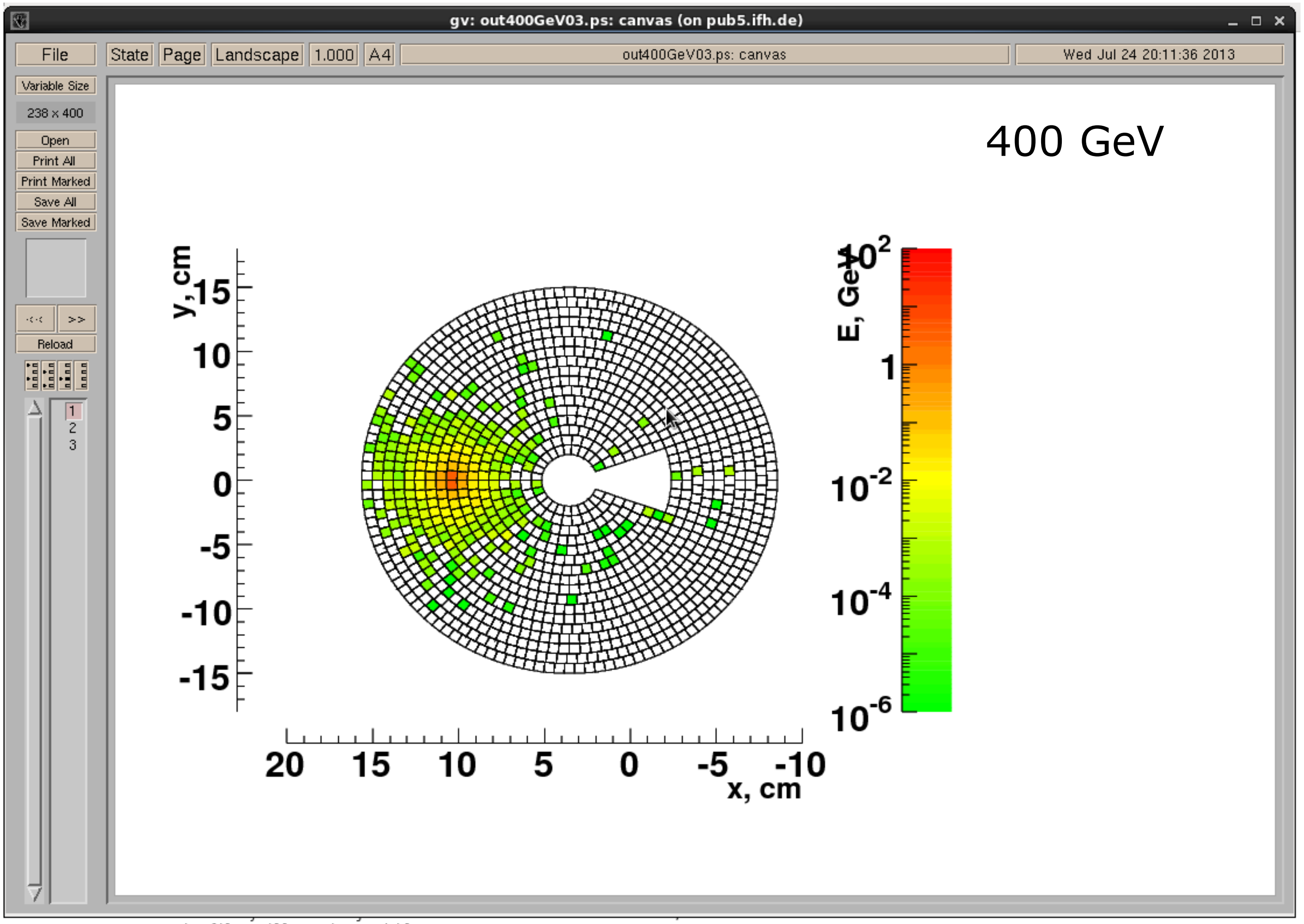
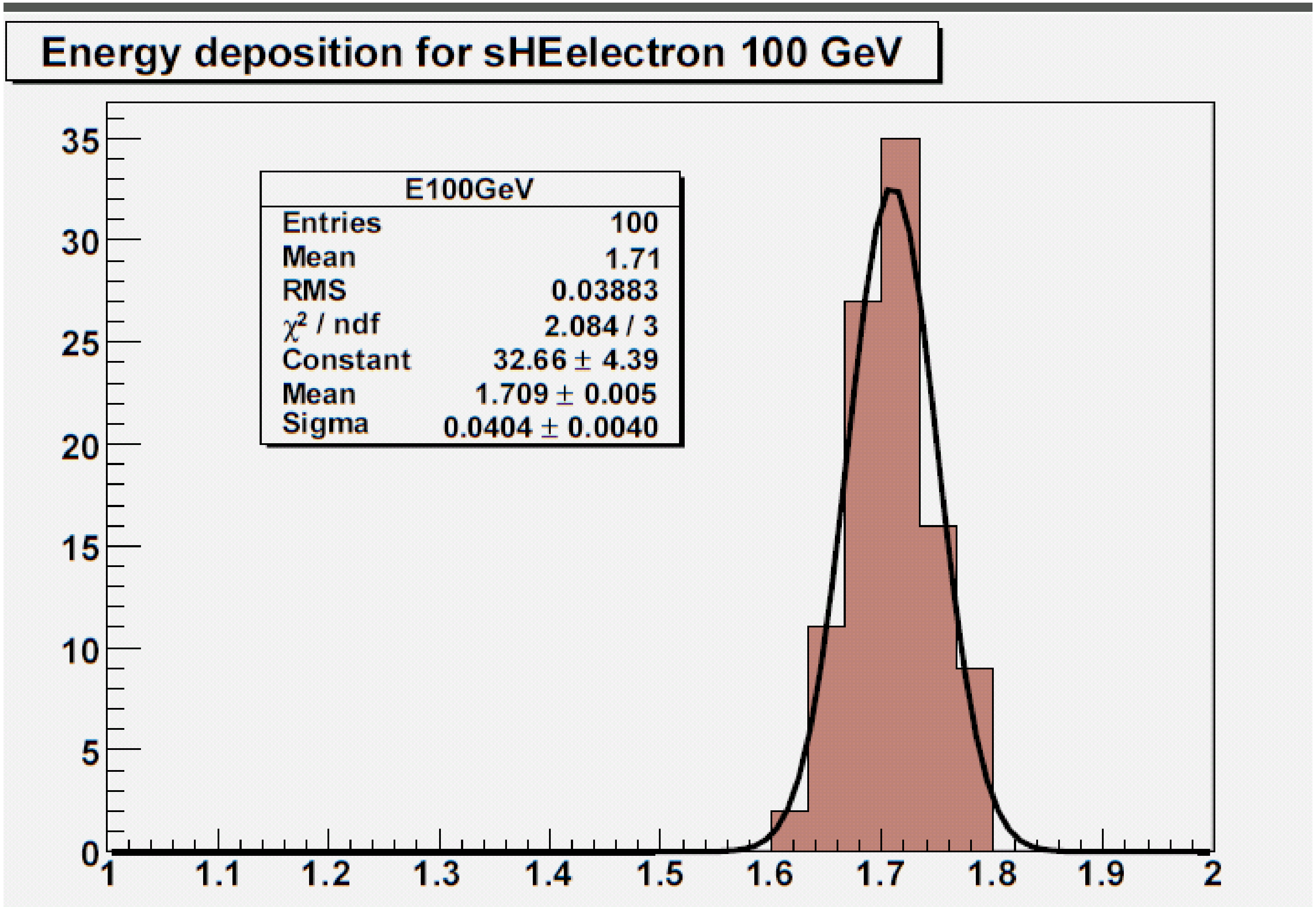


Energy deposition by simulation

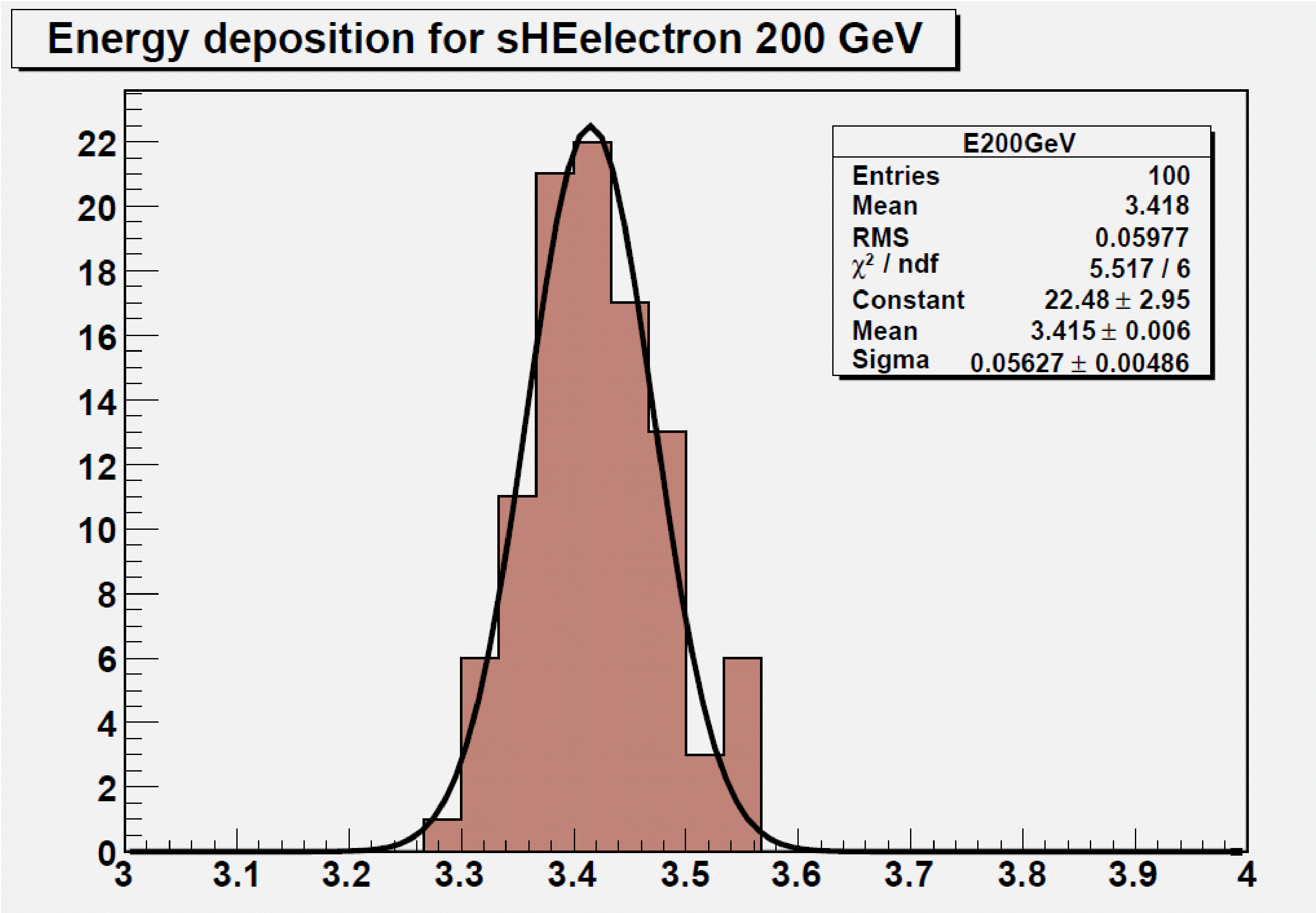


Histogram : energy deposition from simulation



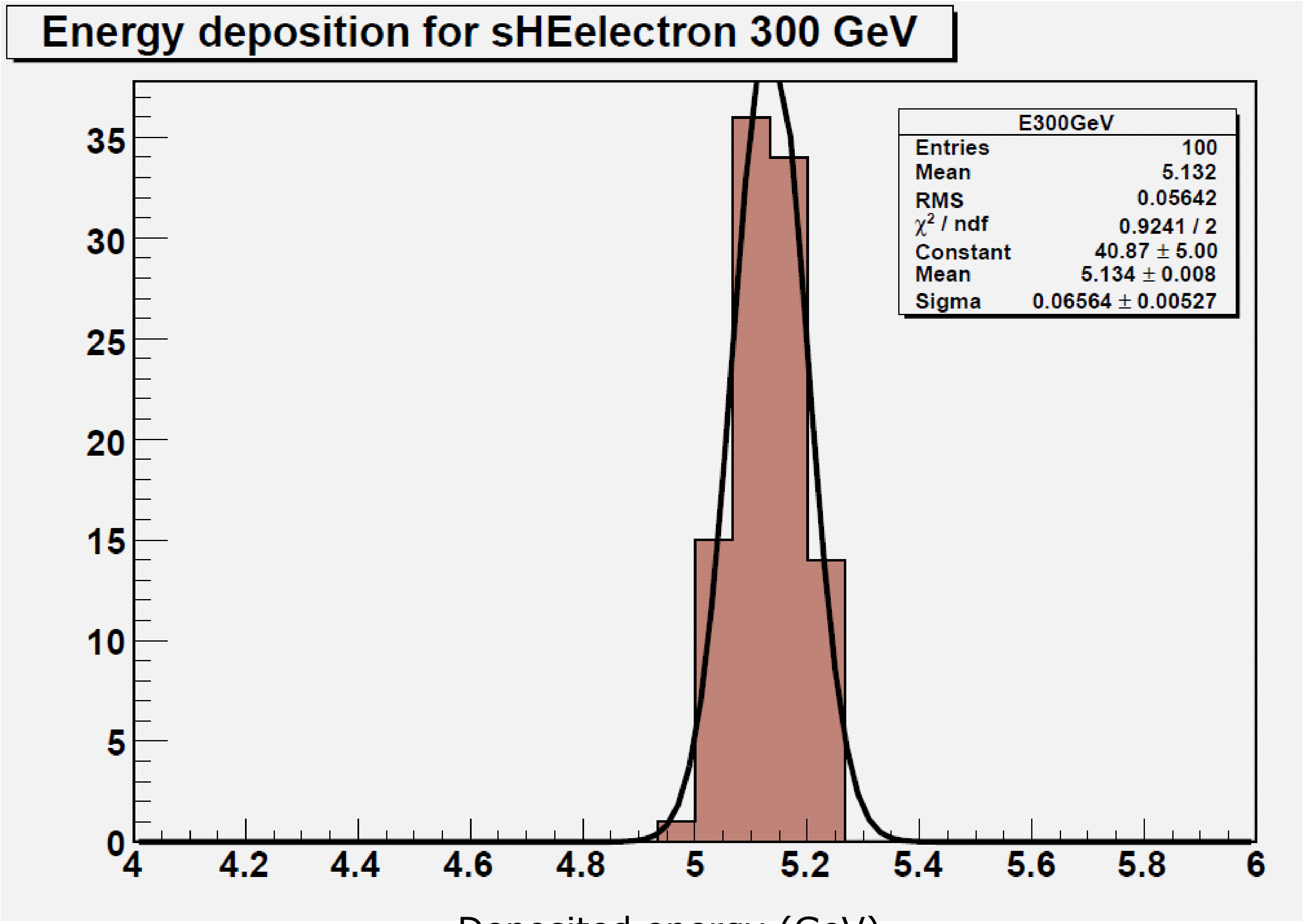
Deposited energy (GeV)

Histogram : energy deposition from simulation



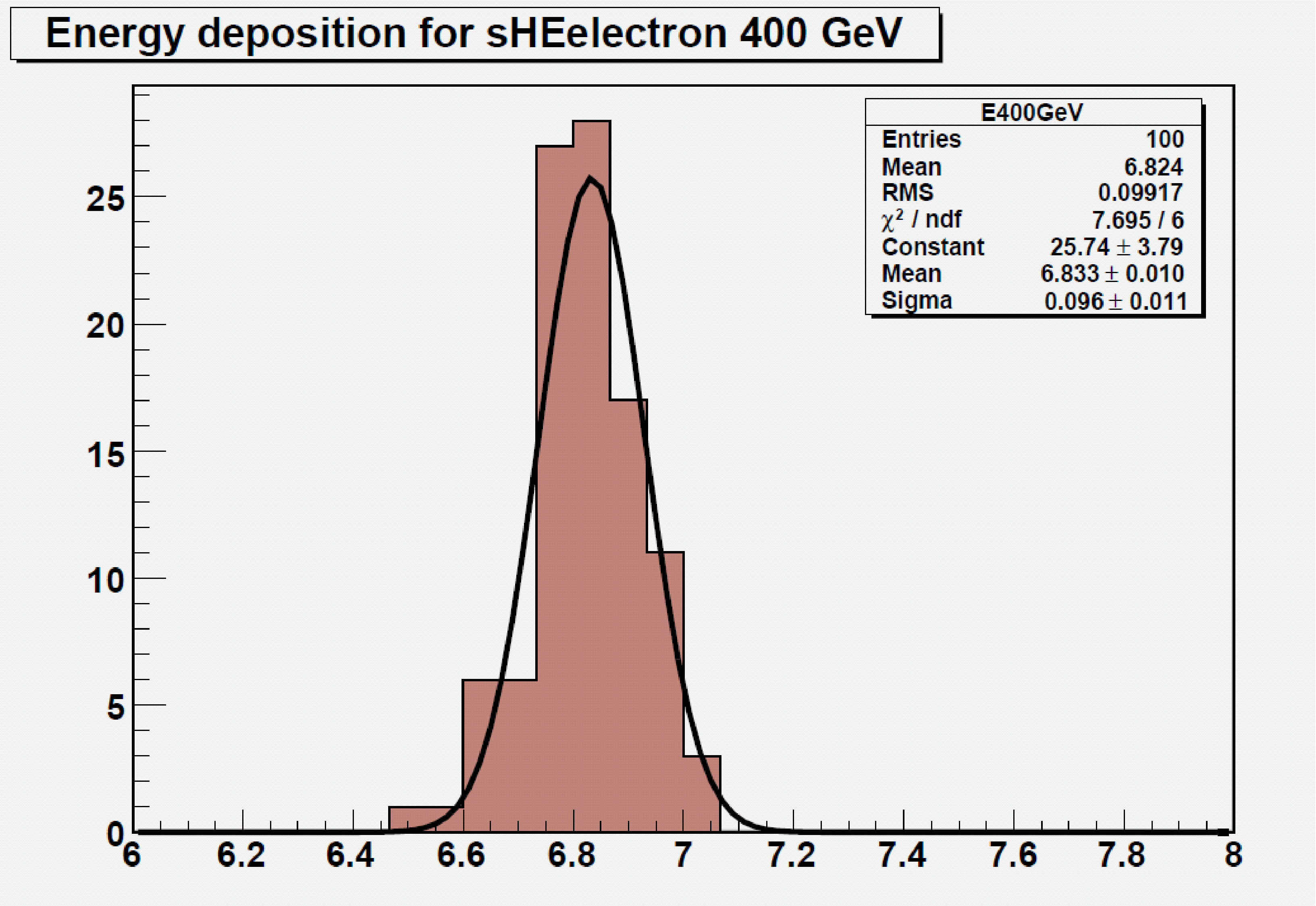
Deposited energy (GeV)

Histogram : energy deposition from simulation

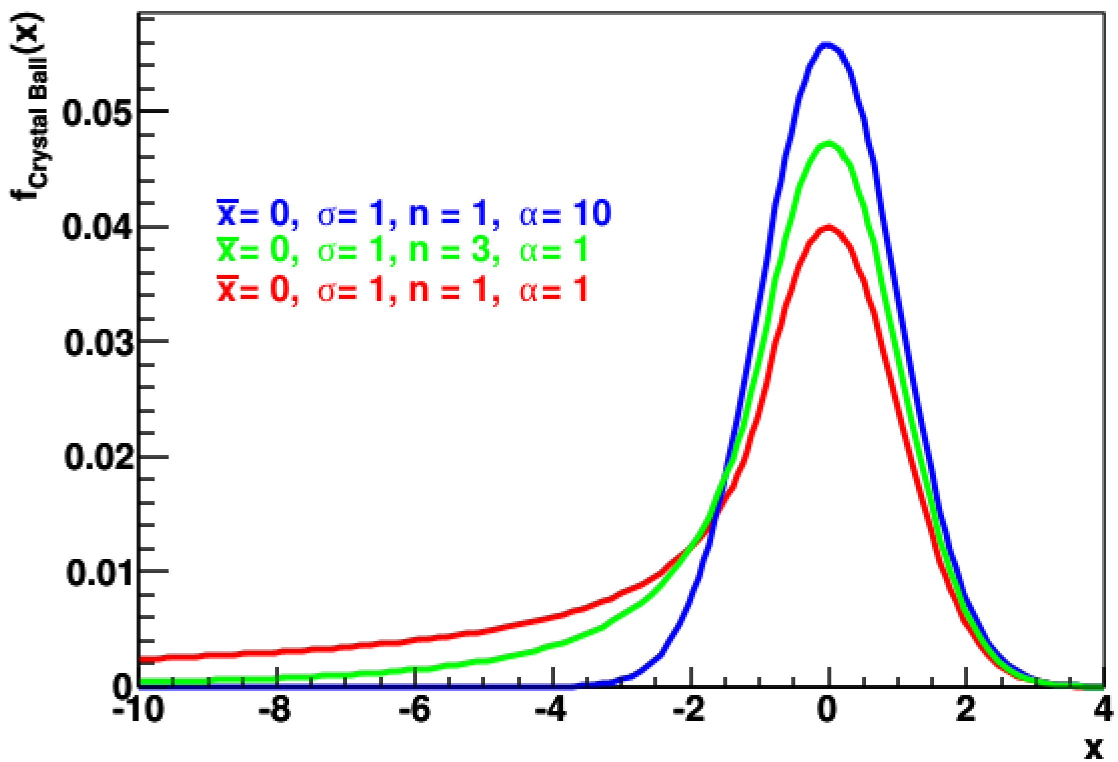


Deposited energy (GeV)

Histogram : energy deposition from simulation



Deposited energy (GeV)



http://en.wikipedia.org/wiki/File:CrystalBallFunction.svg

The **Crystal Ball function**, named after the Crystal Ball Collaboration (hence the capitalized initial letters), is a probability density function commonly used to model various lossy processes in high-energy physics. It consists of a Gaussian core portion and a power-law low-end tail, below a certain threshold. The function itself and its first derivative are both continuous.

The Crystal Ball function is given by:

$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant -\alpha \end{cases}$$

where

$$A = \left(\frac{n}{|\alpha|}\right)^n \cdot \exp\left(-\frac{|\alpha|^2}{2}\right),$$

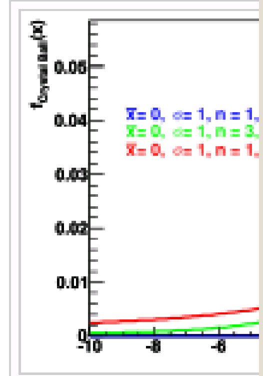
$$B = \frac{n}{|\alpha|} - |\alpha|,$$

$$N = \frac{1}{\sigma(C+D)}$$

$$C = \frac{n}{|\alpha|} \cdot \frac{1}{n-1} \cdot \exp\left(-\frac{|\alpha|^2}{2}\right)$$

$$D = \sqrt{\frac{\pi}{2}}\left(1 + \operatorname{erf}\left(\frac{|\alpha|}{\sqrt{2}}\right)\right)$$

N (Skwarnicki 1986) is a normalization factor and α, n, $\bar{x}$ and σ are parameters which are fitted with the data. erf is the error function.



Examples of the Cr

BeamCal is an electromagnetic sandwich calorimeter that uses Tungsten as absorber. It serves three major purposes:

- Improving the hermeticity of the ILC detector by providing electron and photon identification down to polar angles of a few mrad. This is a specially challenging task due to the vast amount of deposited energy from the electron-positron pairs originating from beamstrahlung.
- Reducing the backscattering from pairs into the inner ILC detector part and protecting the final magnet of the beam delivery system.
- Assisting beam diagnostics. A fast luminosity signal will be provided by BeamCal. The detailed analysis of the shape of the energy deposition from pairs hitting the BeamCal grants access to parameters of the colliding beams.