BeamCal Energy and Spatial Resolution for the ILC

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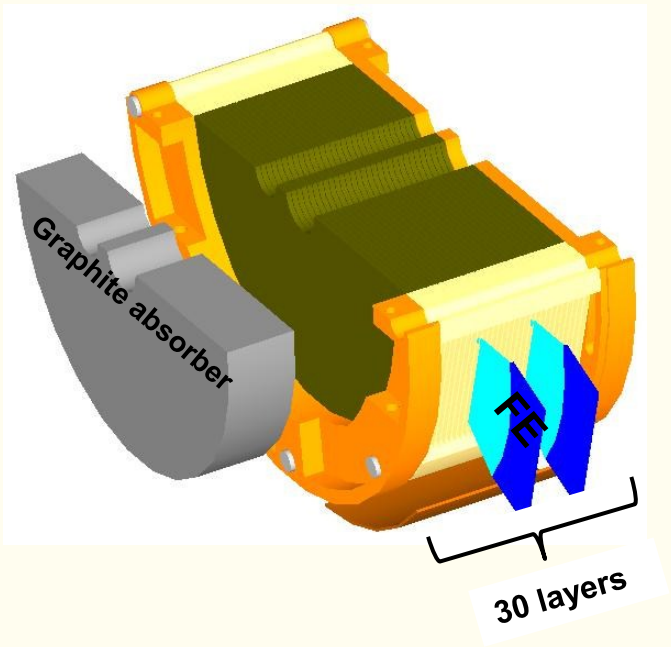
Beam Calorimeter for ILC

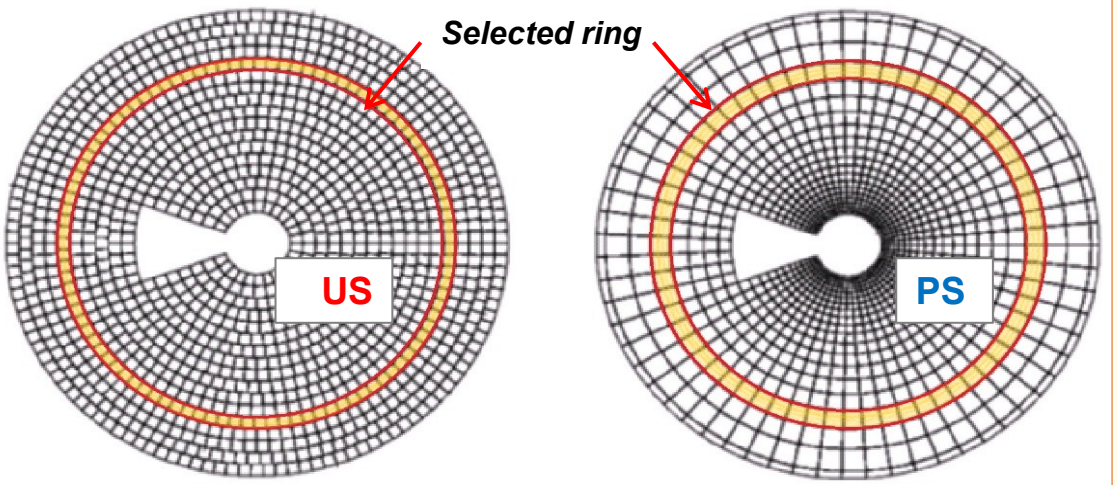


Size of pads:
- US - similar, ≈7.65x7.65 mm
- PS - ~R, min 2.2x2.2, max 14.4x14.4mm

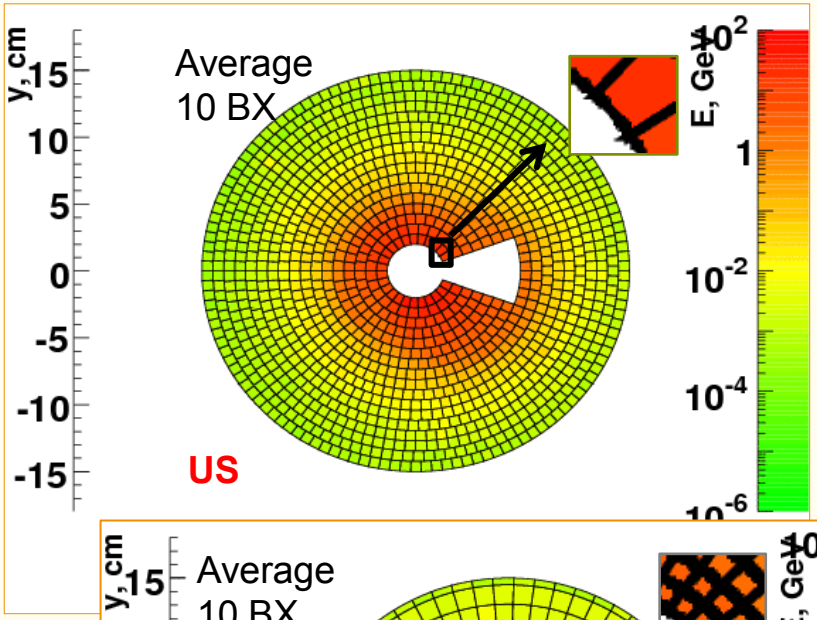
Number of pads:
- For US and PS similar

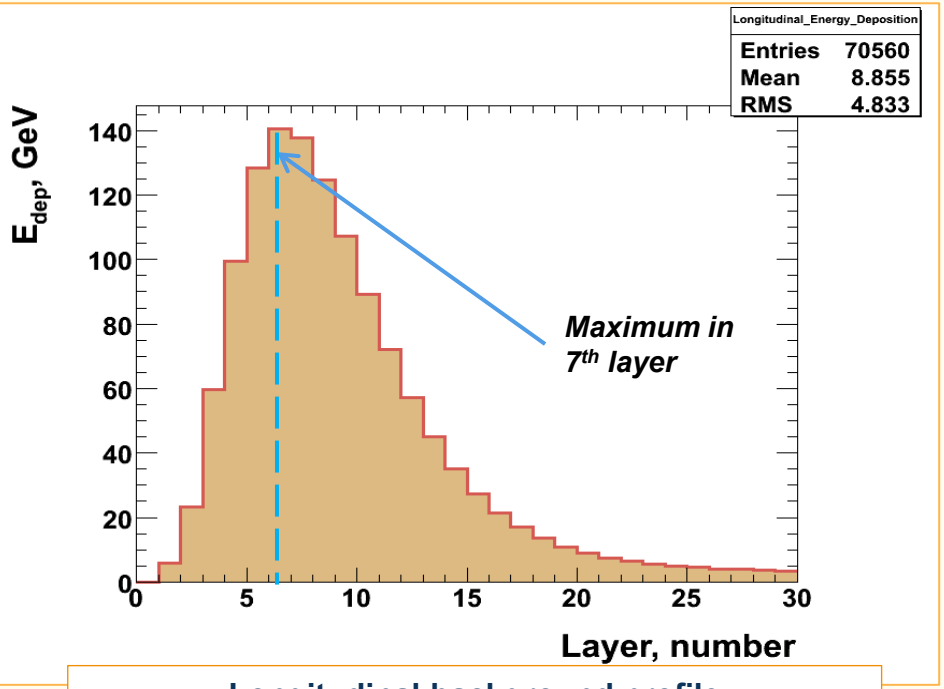
- **Tungsten absorber**
- **Diamond sensor**
- **Readout plane/air gap**

} **1 X_0**



Energy Deposition due to Beamstrahlung



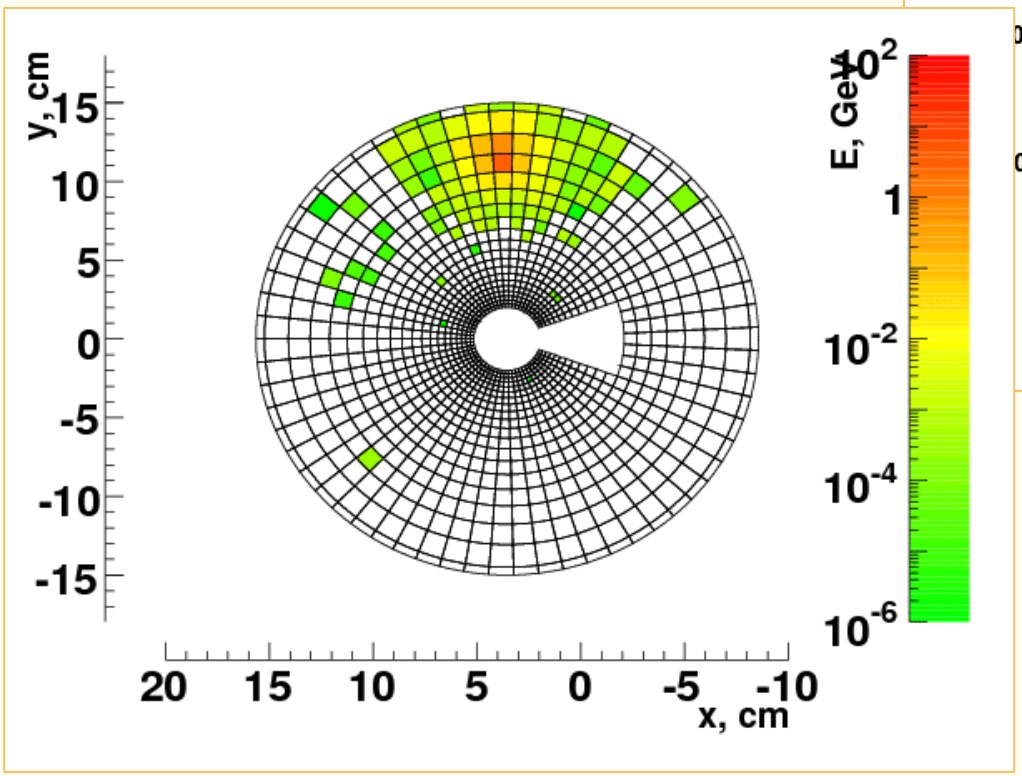


Longitudinal background profile

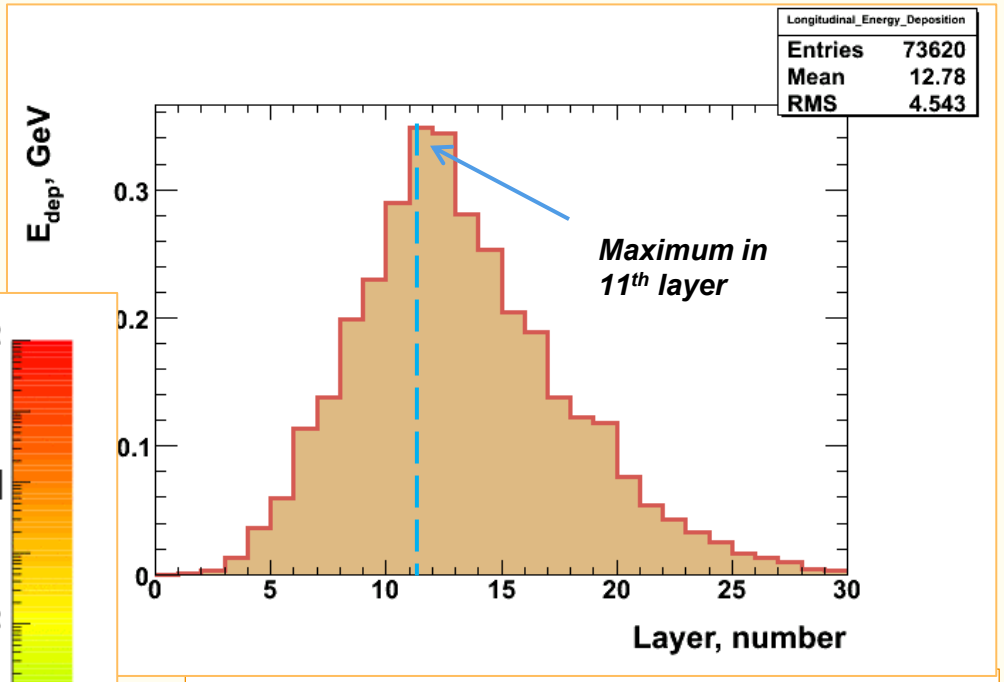
- Beamstrahlung (BS) pairs generated with Guinea Pig
- Energy deposition in sensors from BS simulated with BeCaS (Geant4) ⟶ *considered as background (BG)*

Shower from Single High Energy Electron

Example for 200 GeV electron:



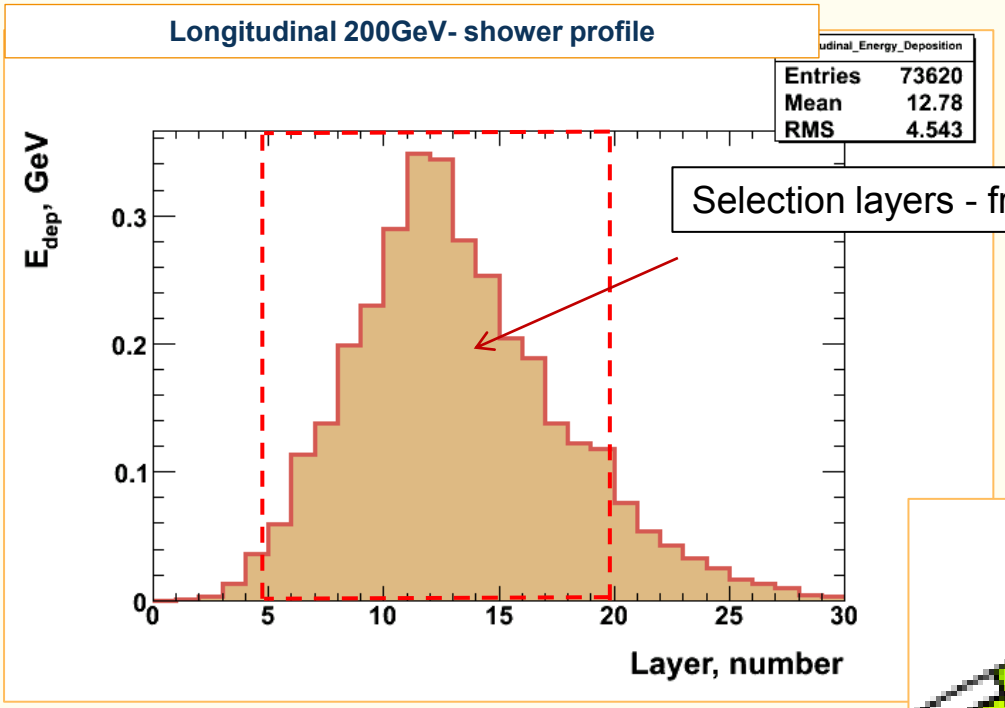
Shower from 200- GeV electron



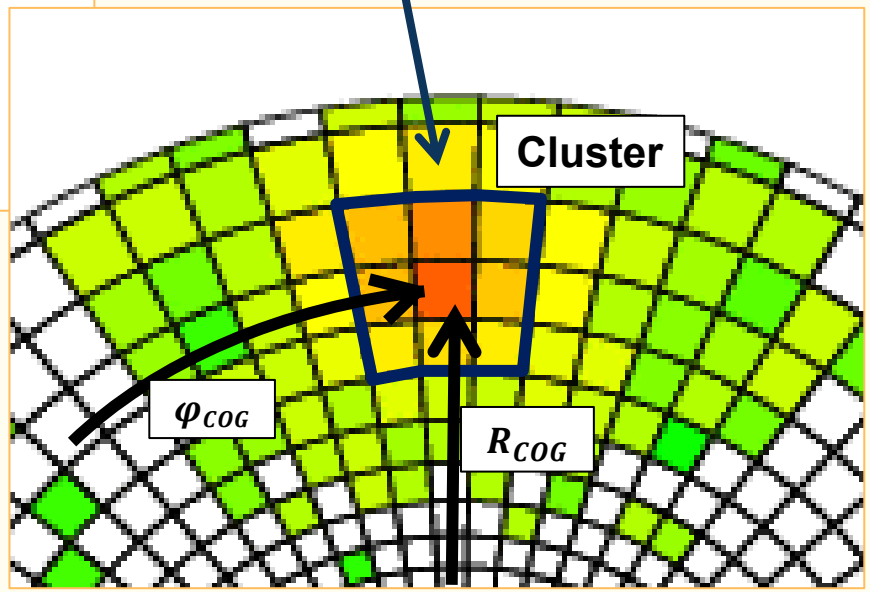
Longitudinal shower profile

Electron energy	Shower maximum
10 GeV	7 layer
20 GeV	8 layer
50 GeV	9 layer
100 GeV	10 layer

Reconstruction Algorithm



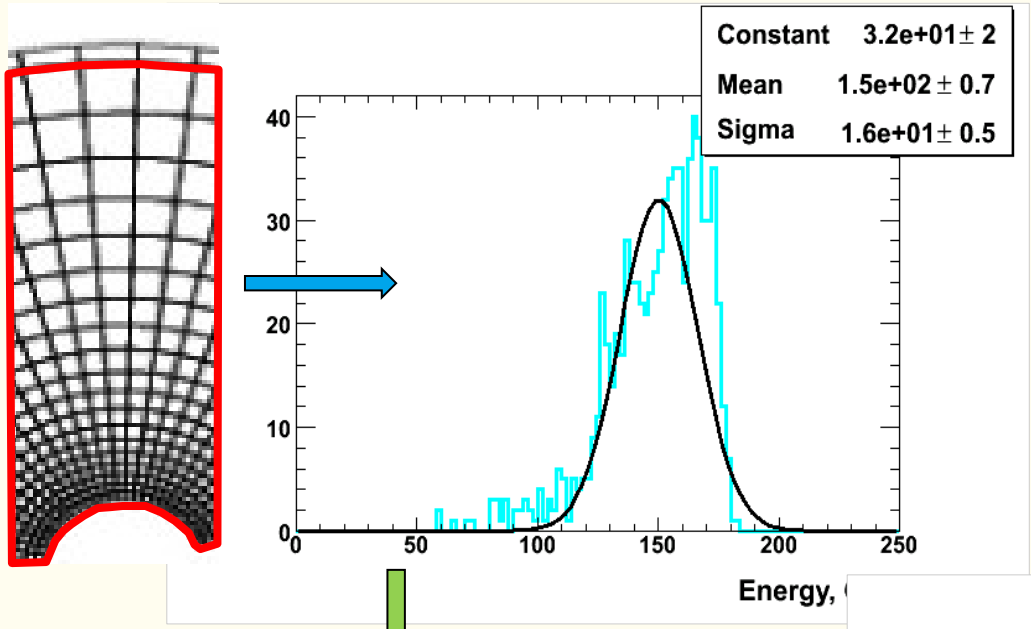
Selection pads – only first circle around the maximum

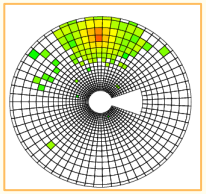


Reconsrtuction algorithm output:

$$R_{COG}, \varphi_{COG}, E_{clu}$$

Cluster Energy. PS. wo BG

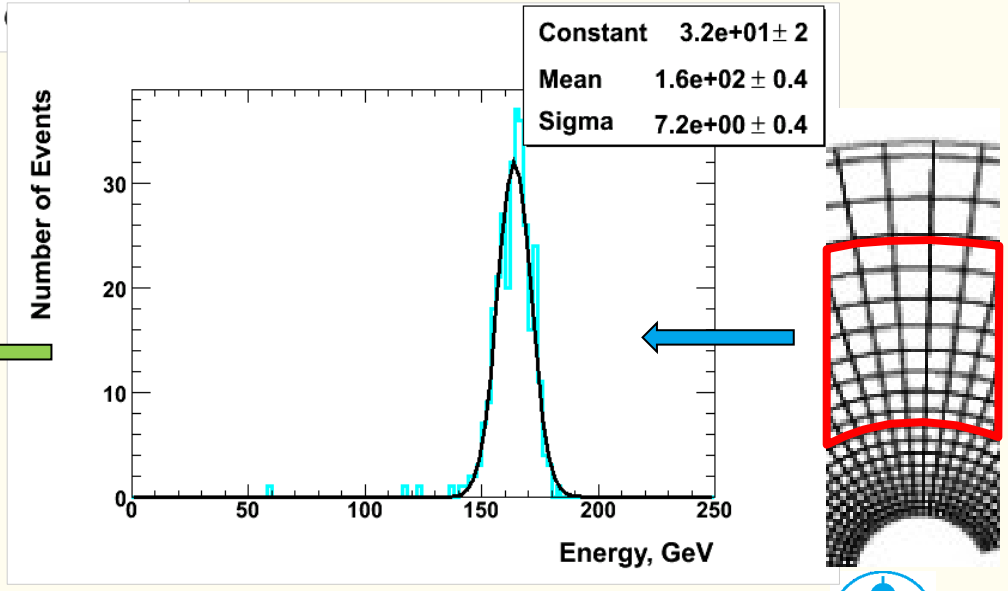




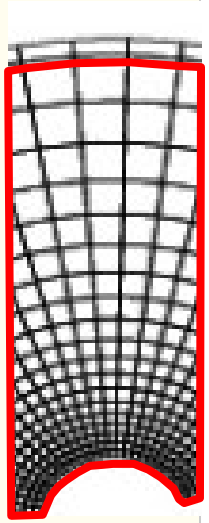
- Reconstructed only showers, without BG
- Energy of electron 200 GeV

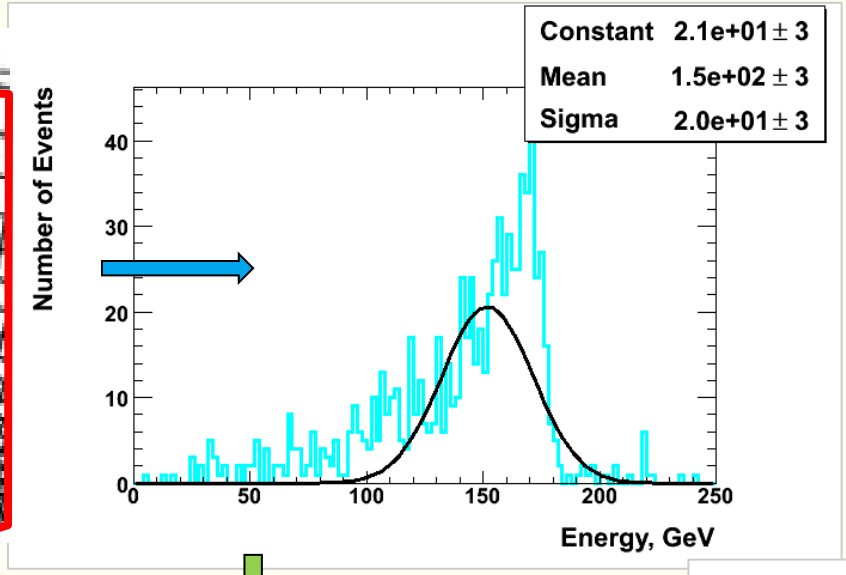
En_resolution ≈ 11%

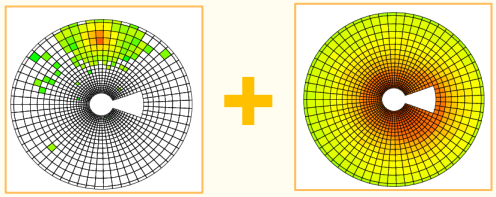
En_resolution ≈ 4.5%



Cluster Energy. PS. with BG



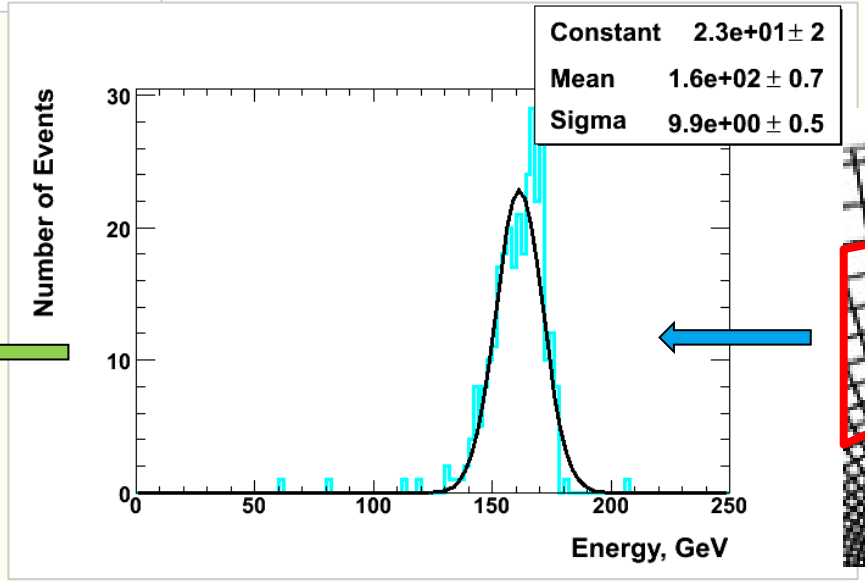


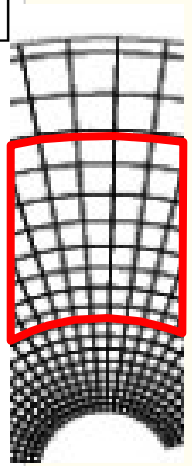


- Reconstructed showers, considering BG
- Energy of electron 200 GeV

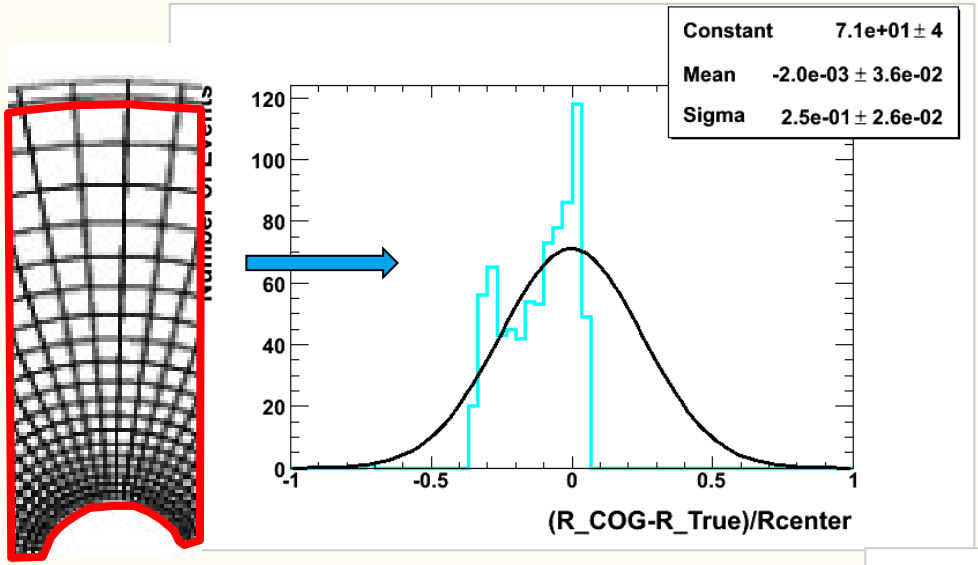
En_resolution ≈ 13%

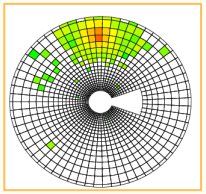
En_resolution ≈ 6%



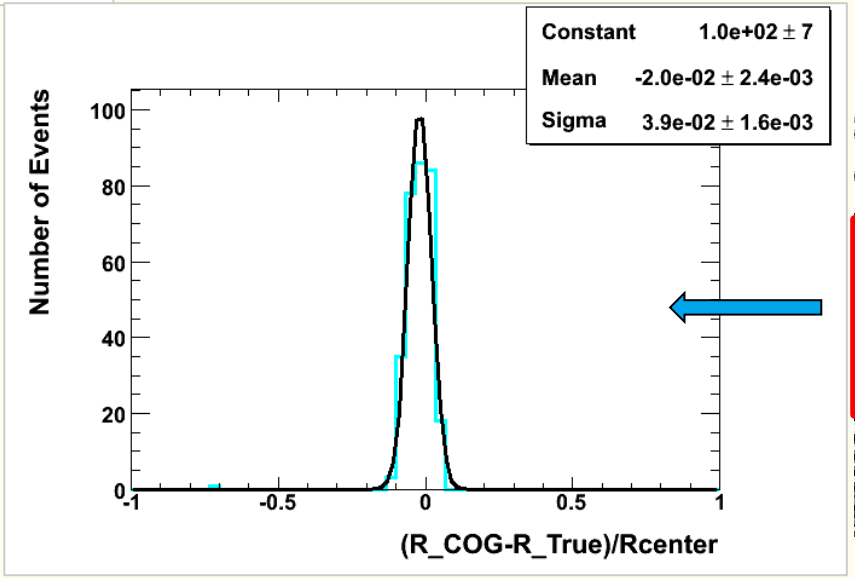


Residual Histo. PS. wo BG

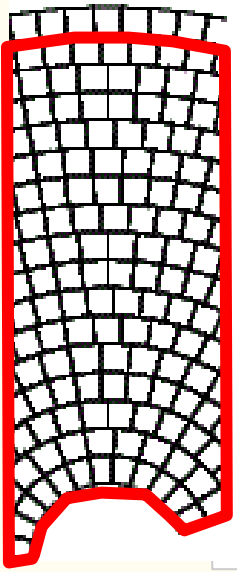


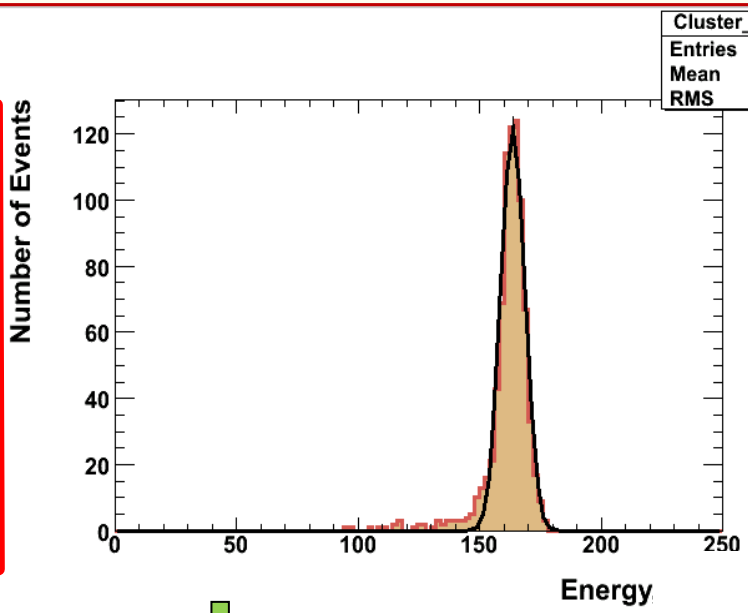


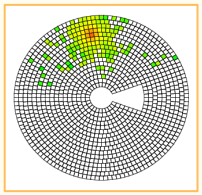
- Reconstructed only showers, without BG
- Energy of electron 200 GeV



Cluster Energy. US. wo BG



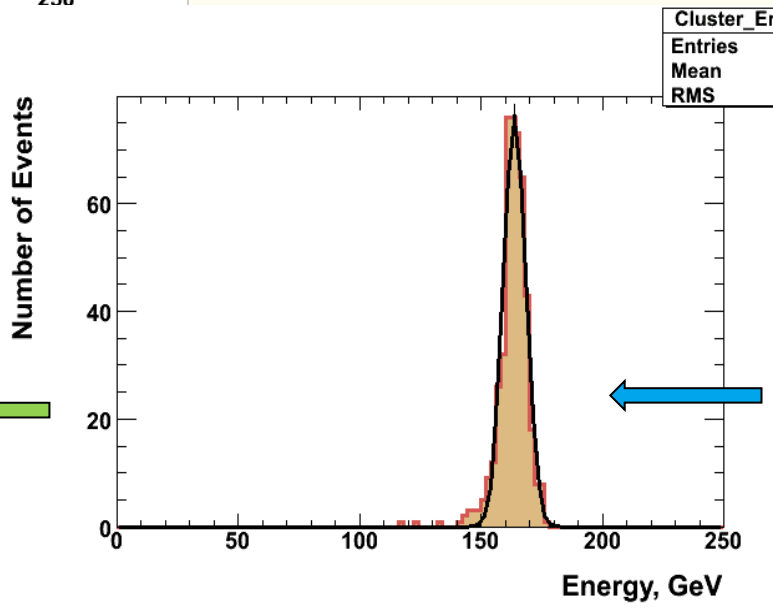


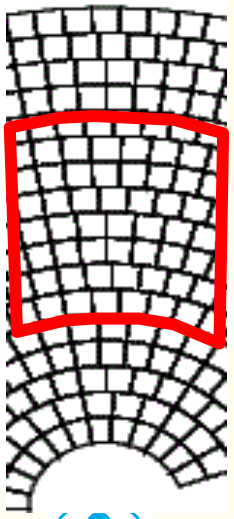


- Reconstructed only showers, without BG
- Energy of electron 200 GeV

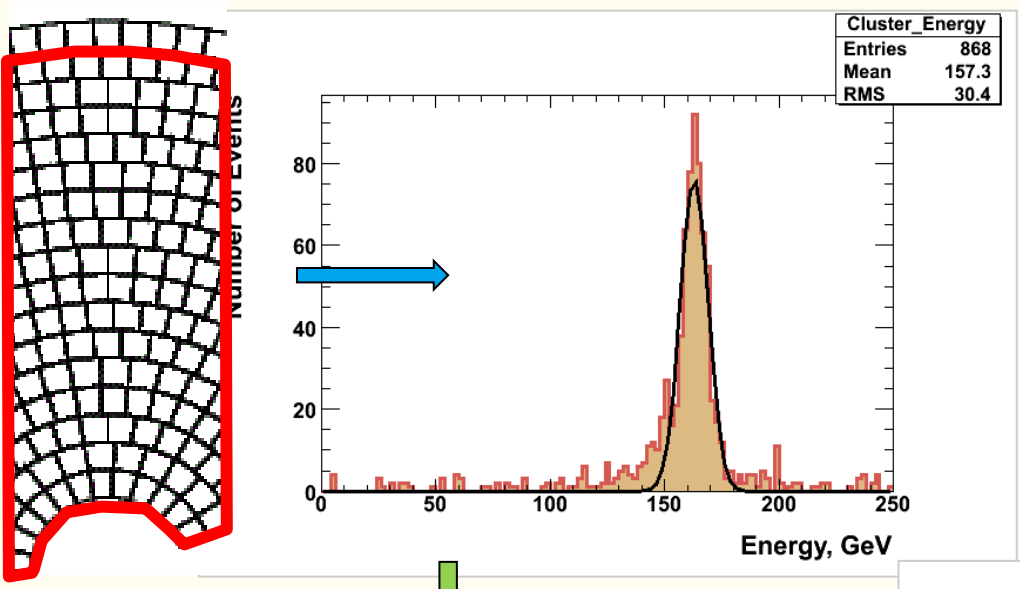
En_resolution ≈ 5.7%

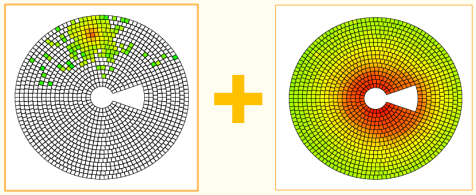
En_resolution ≈ 3.8%





Cluster Energy. US. with BG

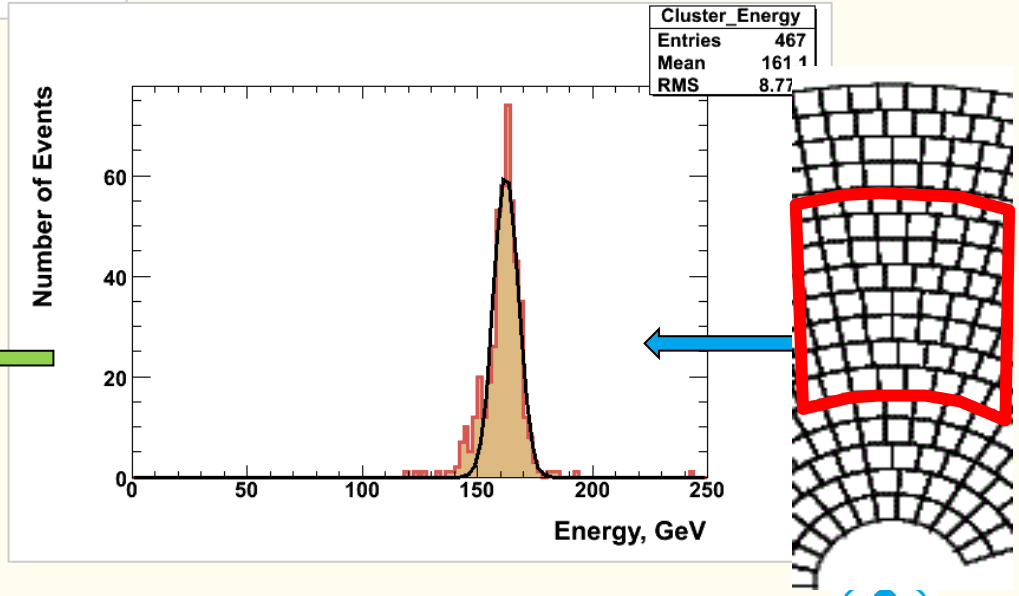




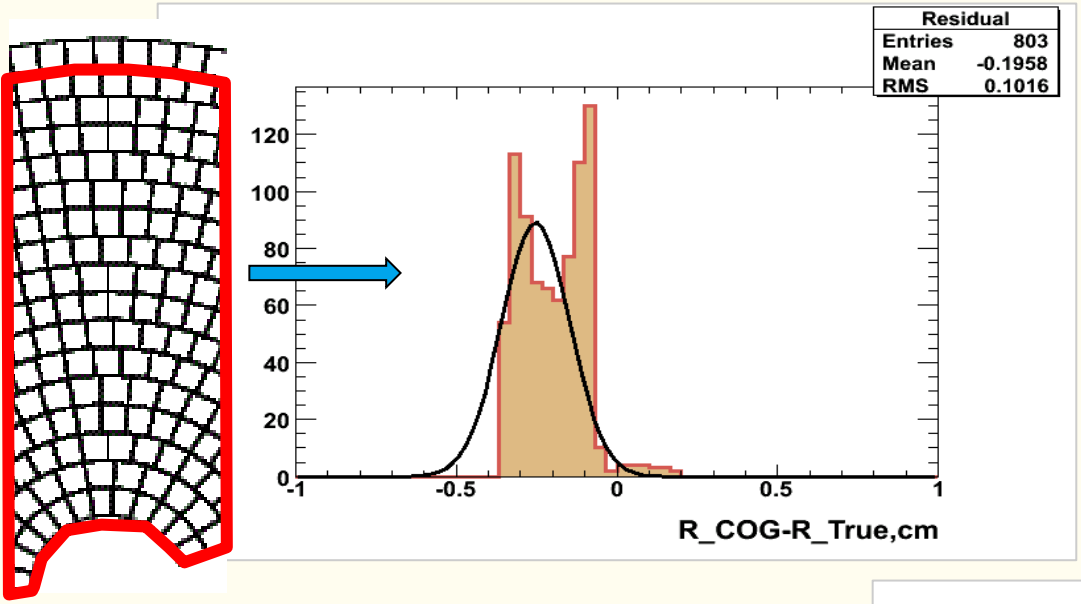
- Reconstructed showers, considering BG
- Energy of electron 200 GeV

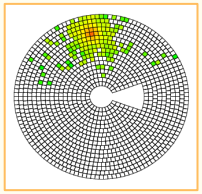
En_resolution ≈ 6 %

En_resolution ≈ 5.4%

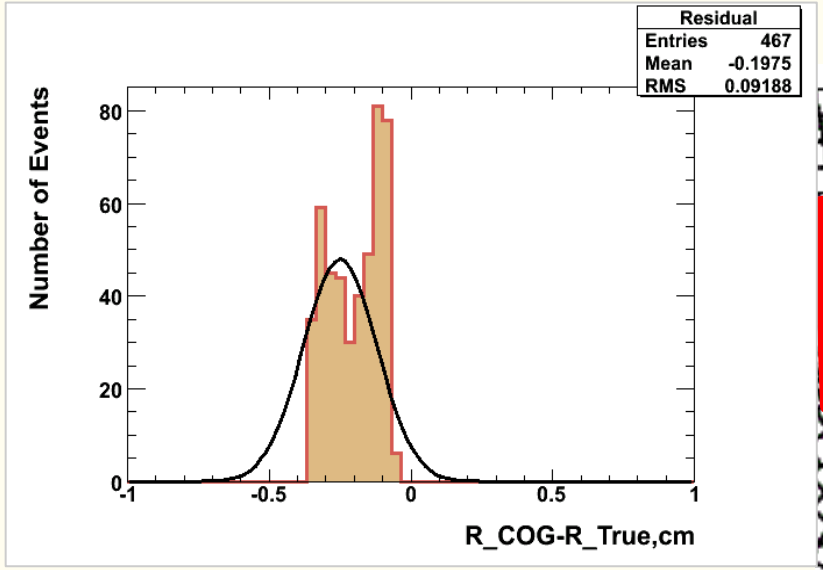


Residual Histo. US. wo BG

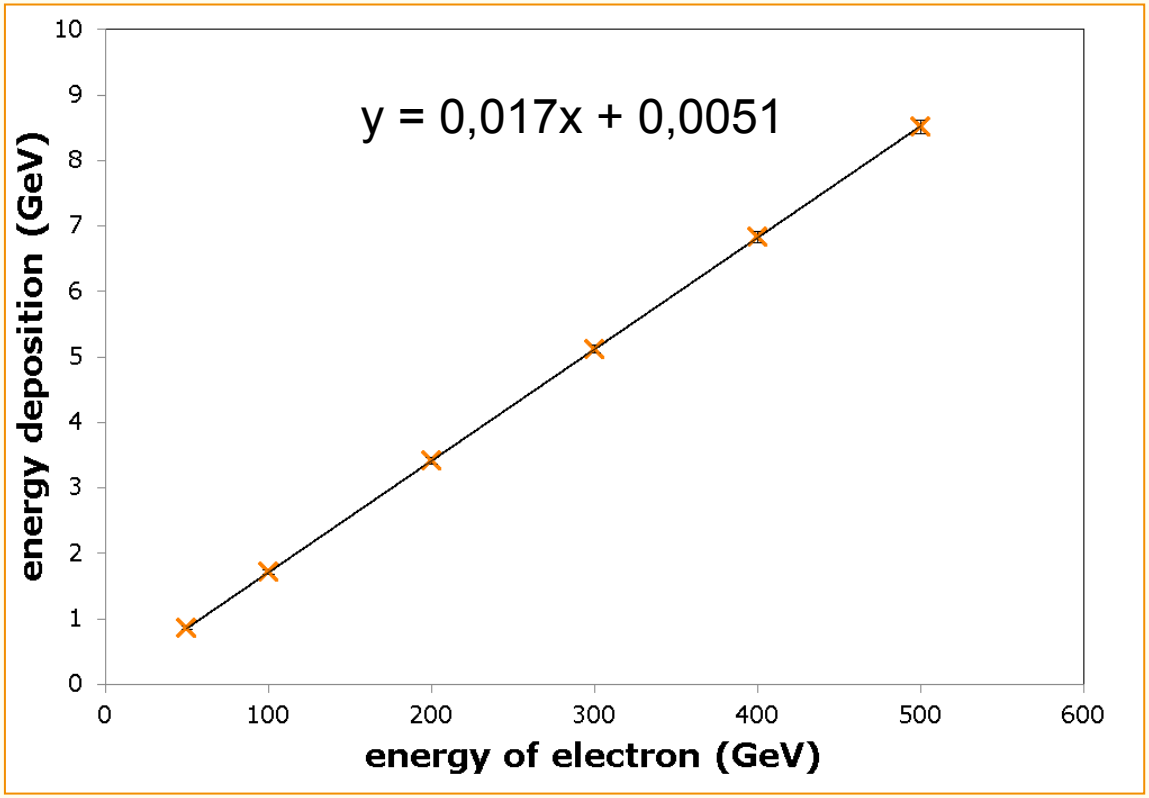




Reconstructed only showers, without BG
Energy of electron 200 GeV

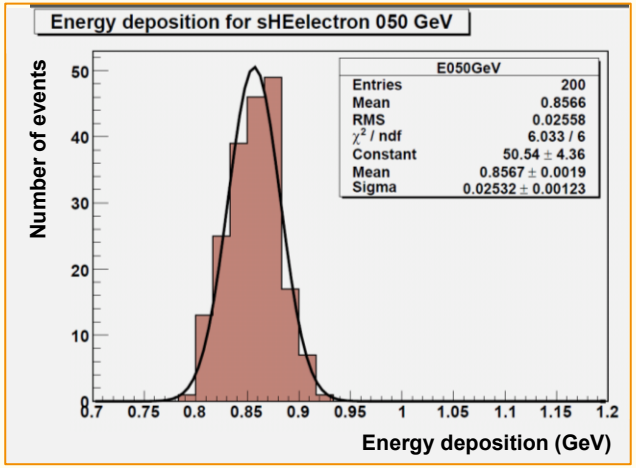


Deposited Energy vs Energy of Electron

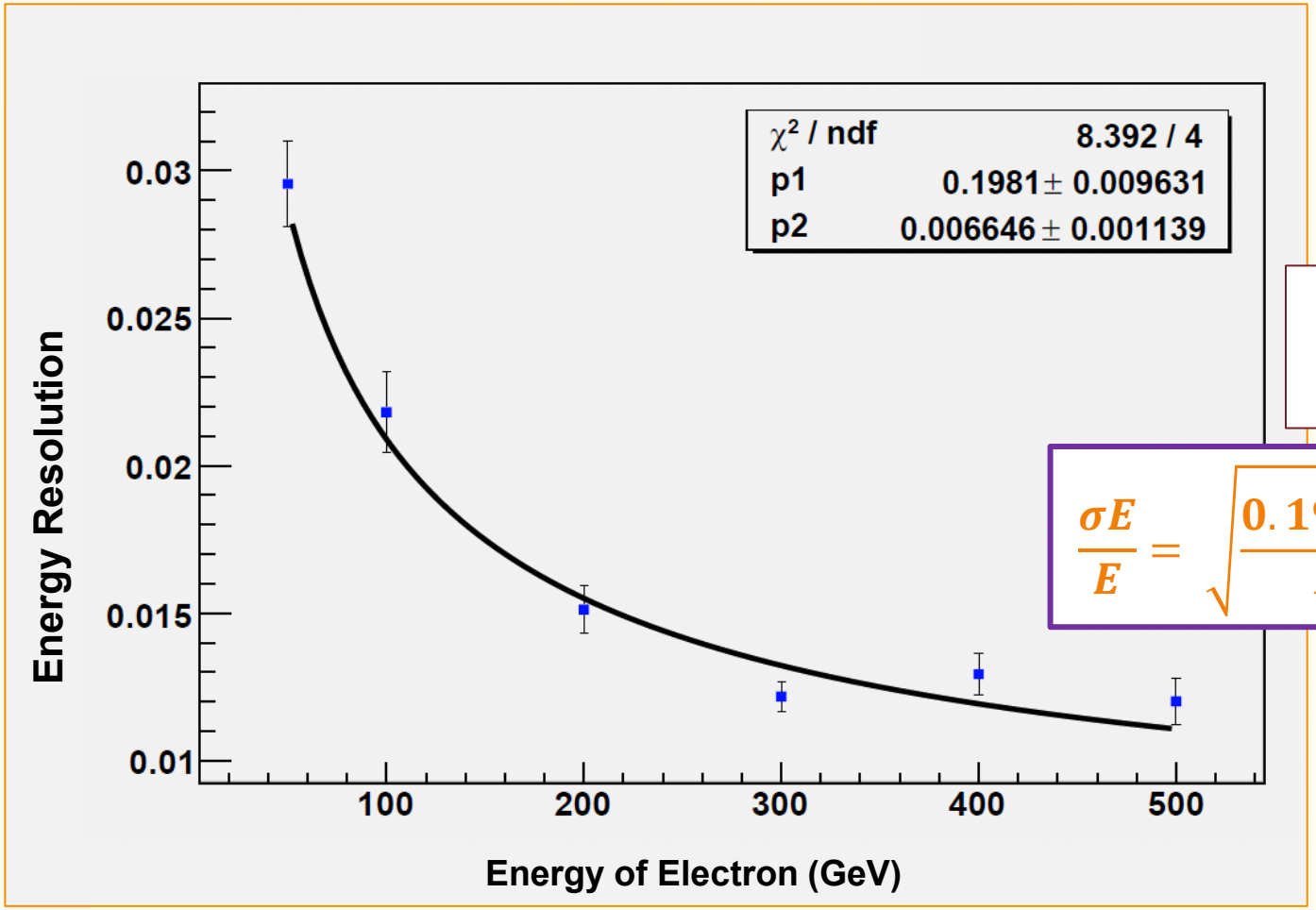


$$E_e = A * E_{dep} - B$$

$A = 58.66 \pm 0.03974; \quad B = -0.2972 \pm 0.1183$



Energy Resolution vs Energy of Electron



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

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

Conclusion and proposals

- The small software package was written, which
  - goes through reconstruction algorithm and calculate COG coordinates and energy of cluster
  - calculate true coordinate and center of corresponding pad coordinate
  - calculate residual and plot its histogram. Plot cluster energy histogram.

  This software made with options easily switching:
  - reconstruct with/without background
  - change number events
  - choose segmentation
- With this software were gotten cluster energy and residual histograms with different parameters: with/wo BG, whole/far-from-edges calorimeter area.
- For US energy resolution depends on selected calorimeter area a little and for PS – a lot.
- Energy resolution reconstructed (200GeV)showers (layer 5-20, 3x3 pads) wo BG, area far from edges:

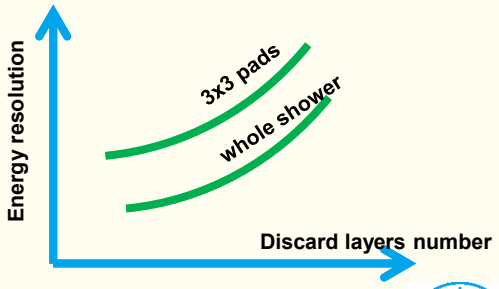
  PS: 4.5 %, US: 3.8 %

  Energy resolution of calorimeter for whole shower energy calculated:

  1.5 %

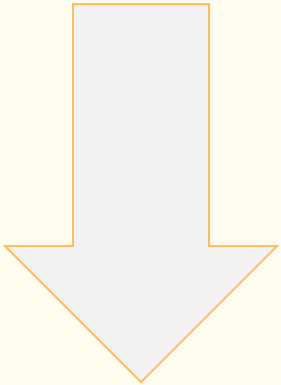
Proposals

- Change reconstruction algorithm: only for small radii of PS or for all cases for both segmentations?
- Look on the dependence energy resolution vs number discard layers
- What else can influence on resolution??...



Danke für Ihre Aufmerksamkeit!

Backup slides



Spatial Resolution (In Process)

US

PS

Estimation

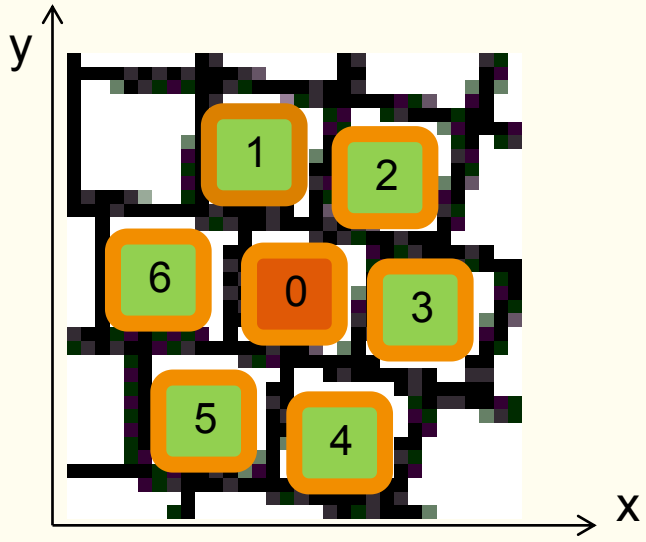
$\sigma d_R = \frac{\Delta d_R}{\sqrt{12}}$ = 2.21 mm

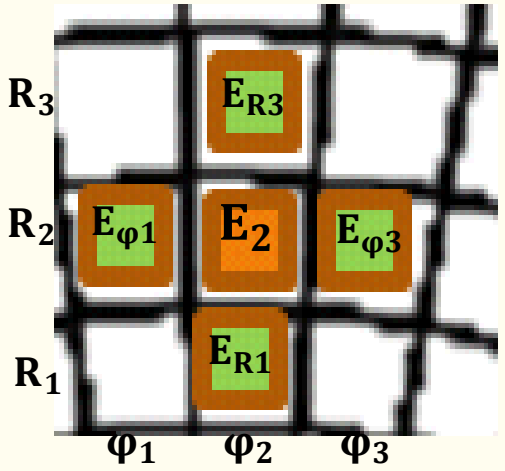
$\sigma d_C = \frac{\Delta d_C}{\sqrt{12}}$ = 2.16 mm → $\sigma\varphi_{in}$ = 5.14 deg, $\sigma\varphi_{out}$ = 0.848 deg

$\frac{\sigma R}{R} = \frac{\Delta R}{R\sqrt{12}}$ = 2.9% → σR_{in} = 0.609 mm, σR_{out} = 3.97 mm

$\sigma_\varphi = \frac{\Delta\varphi}{\sqrt{12}}$ = 1.65 degrees

COG

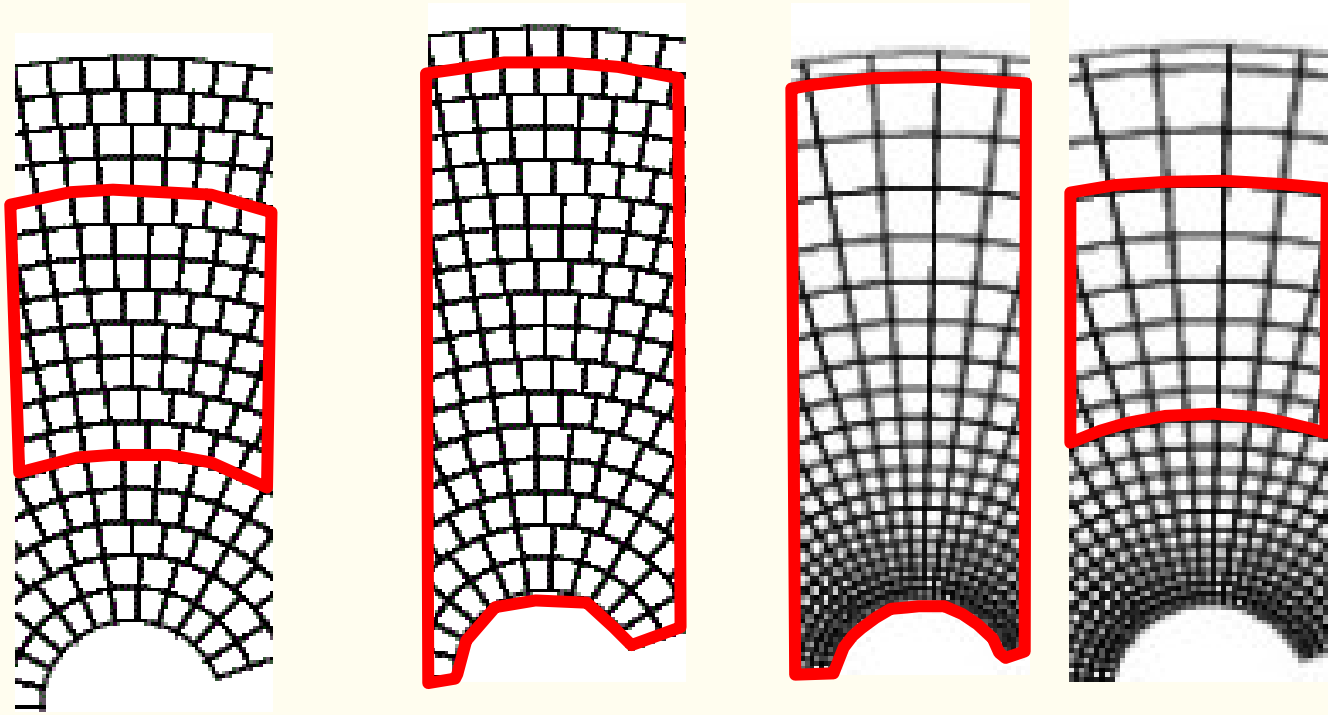




$$X_{COG} = \frac{\sum_{i=0}^{6} X_i E_i}{\sum_{i=0}^{6} E_i}$$

$$R_{COG} = \frac{R_1 E_{R1} + R_2 E_2 + R_3 E_{R3}}{E_{R1} + E_2 + E_{R3}}$$

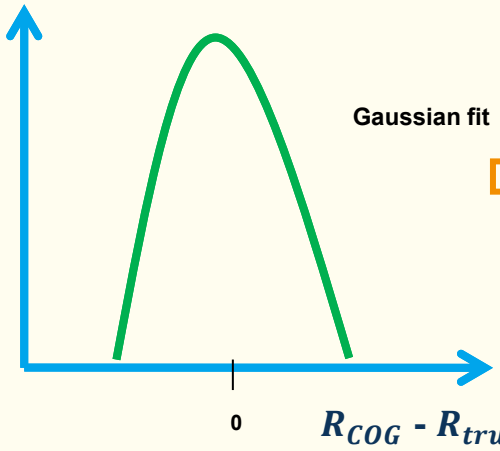
Shower from Single High Energy Electron



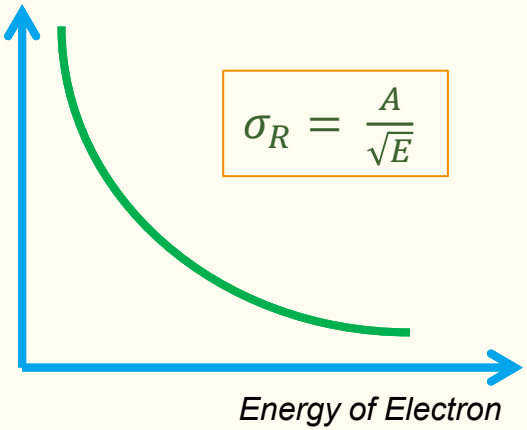
Spatial Resolution (In Process)

R_{COG}

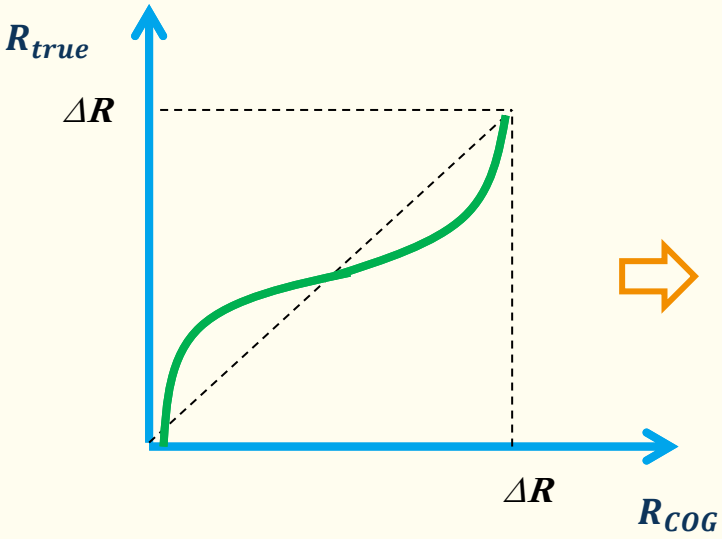
R_{true}



σ_R



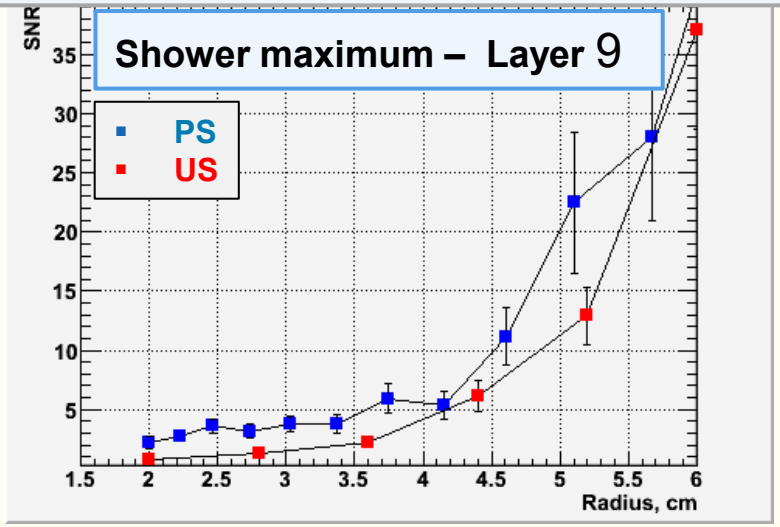
Corrected COG

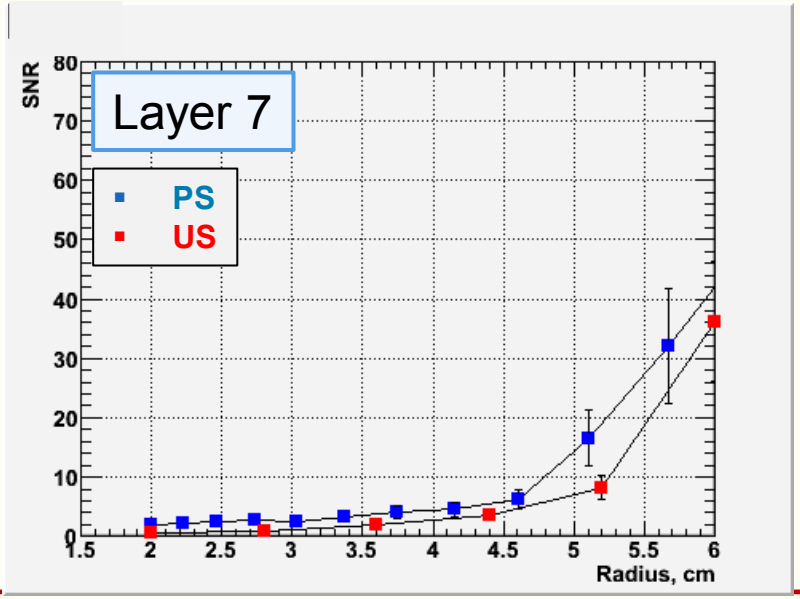


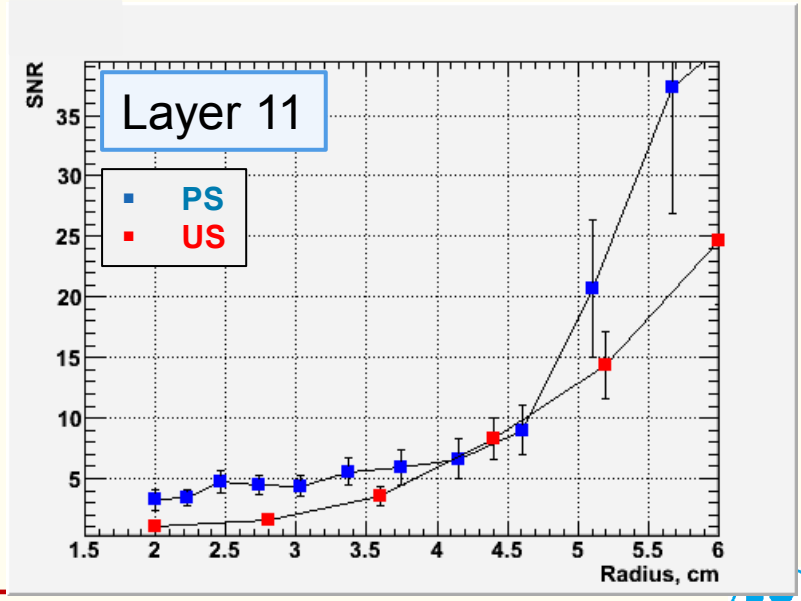
Parameters

SNR for 50 GeV Electron

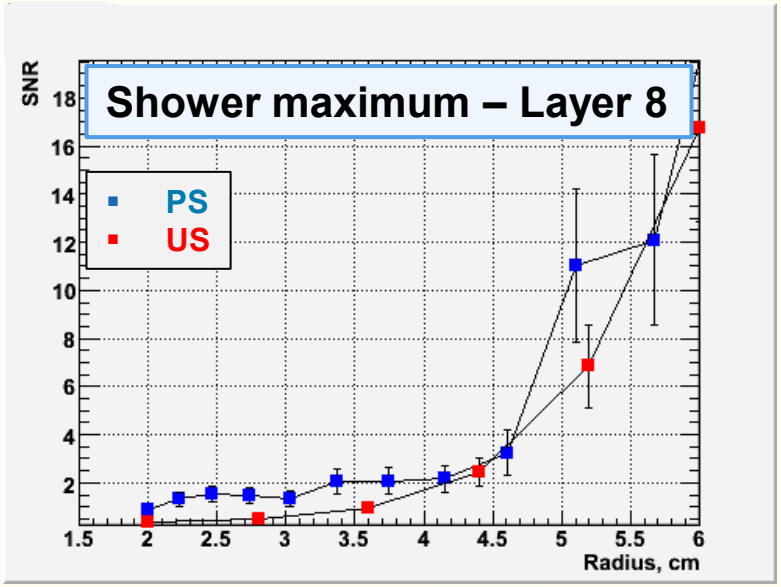
SNR in cell with maximum E_{dep}

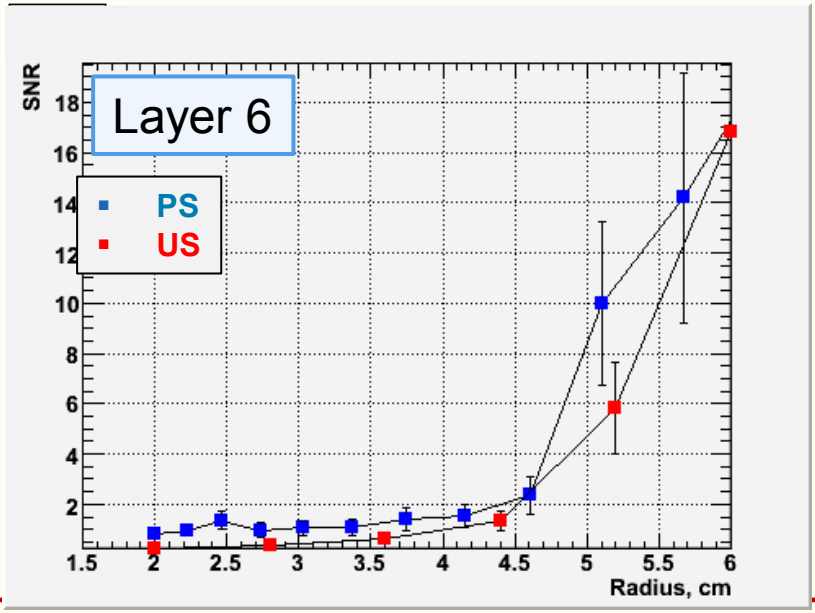


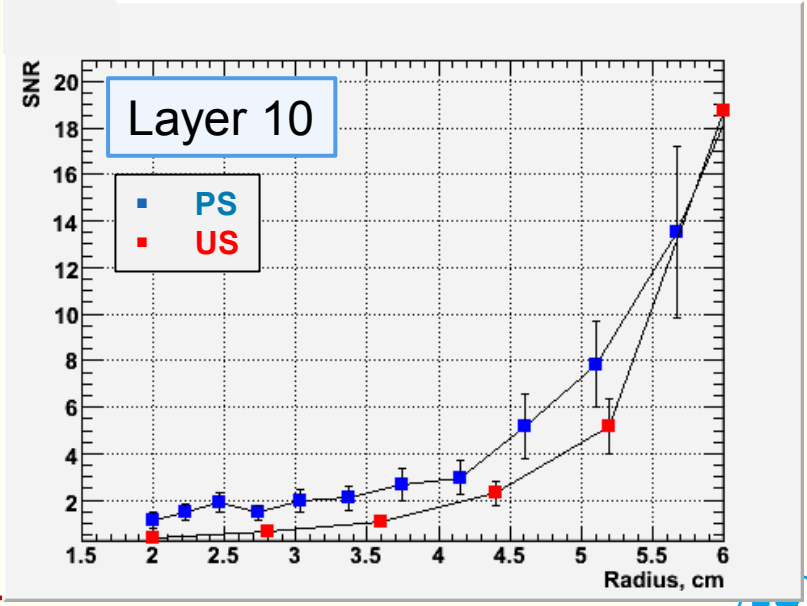




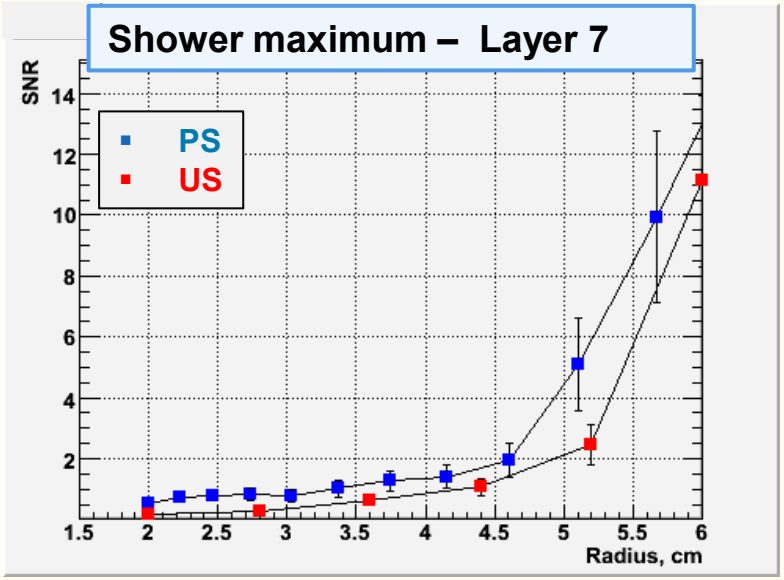
SNR for 20 GeV Electron

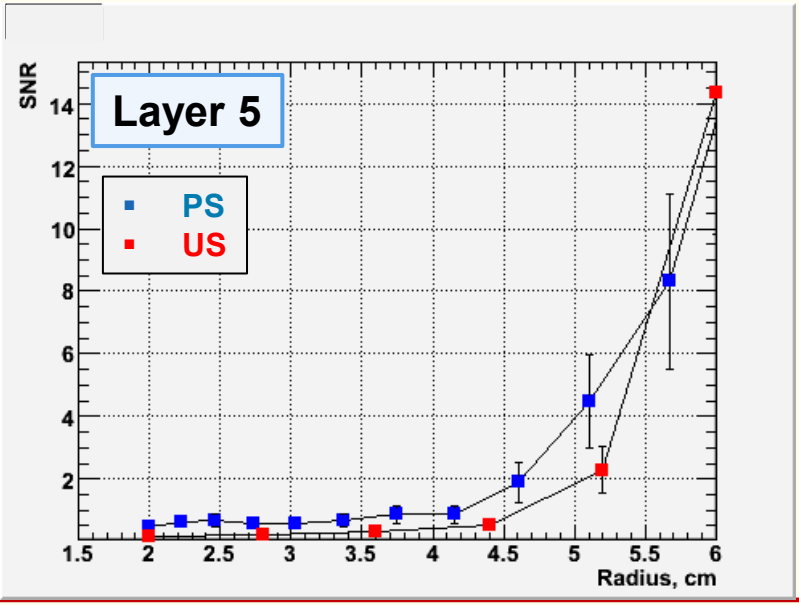


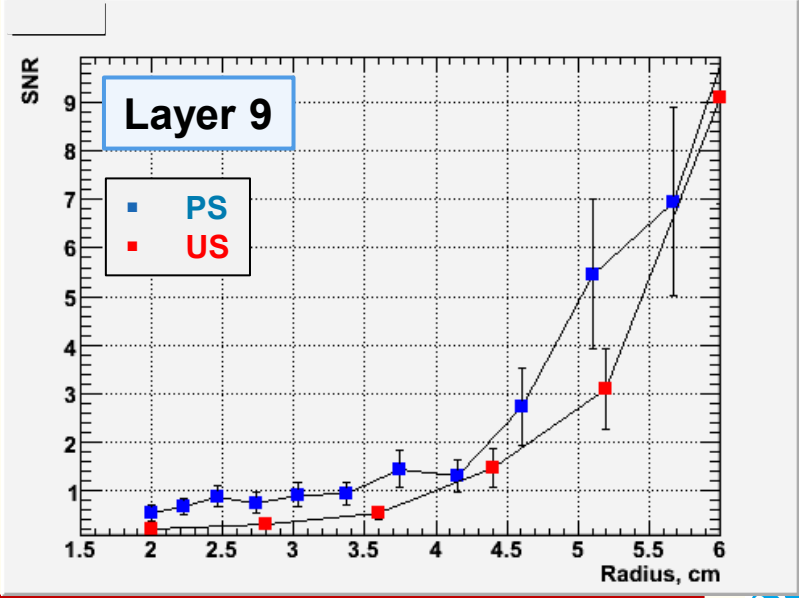




SNR for 10 GeV Electron

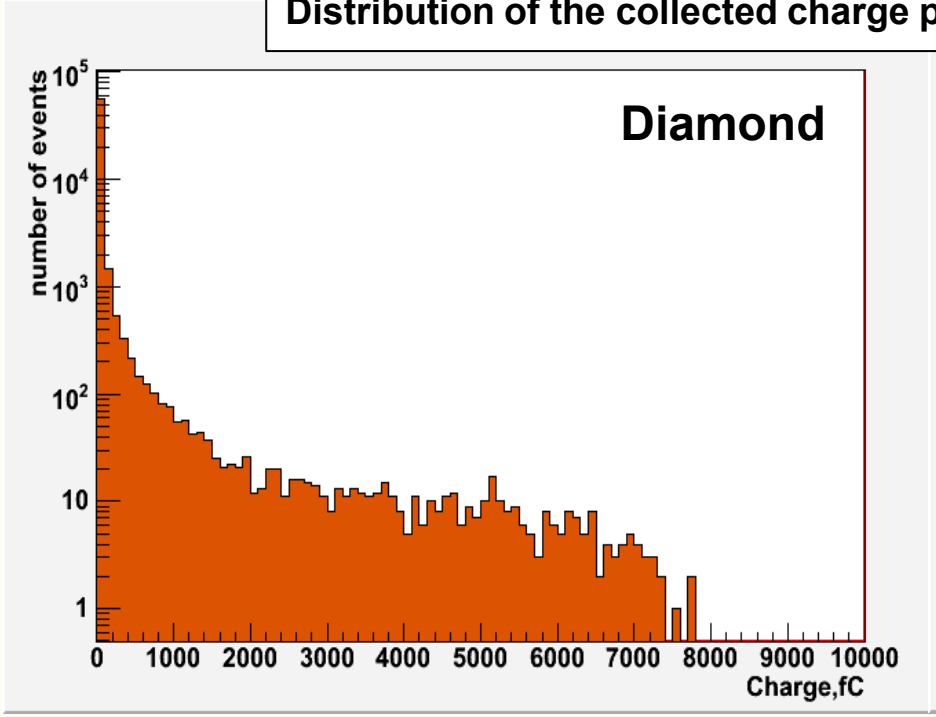


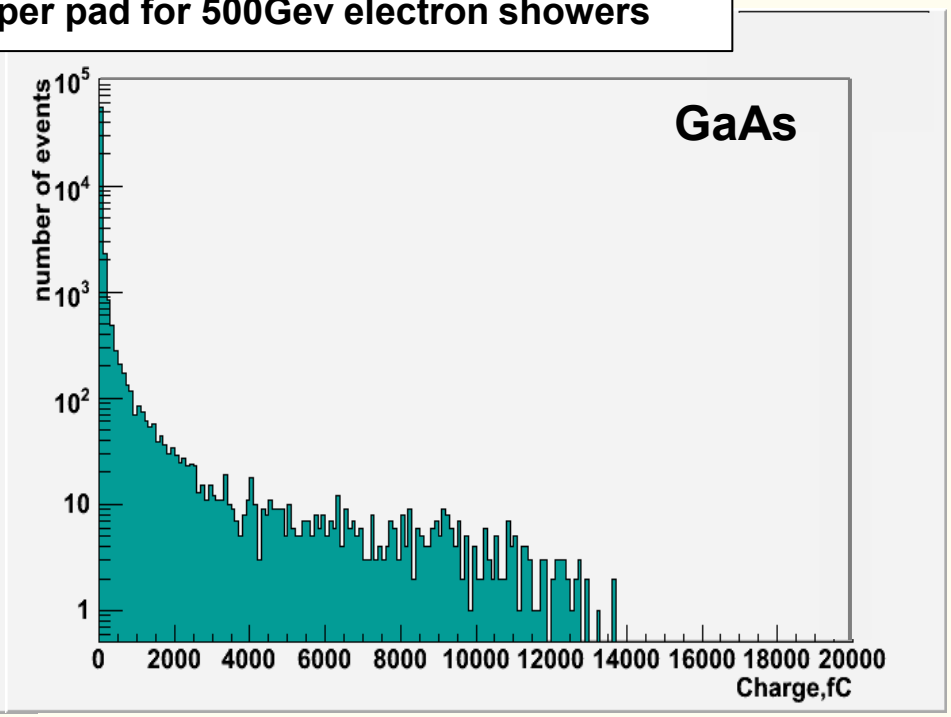




Charge range estimate

Distribution of the collected charge per pad for 500Gev electron showers

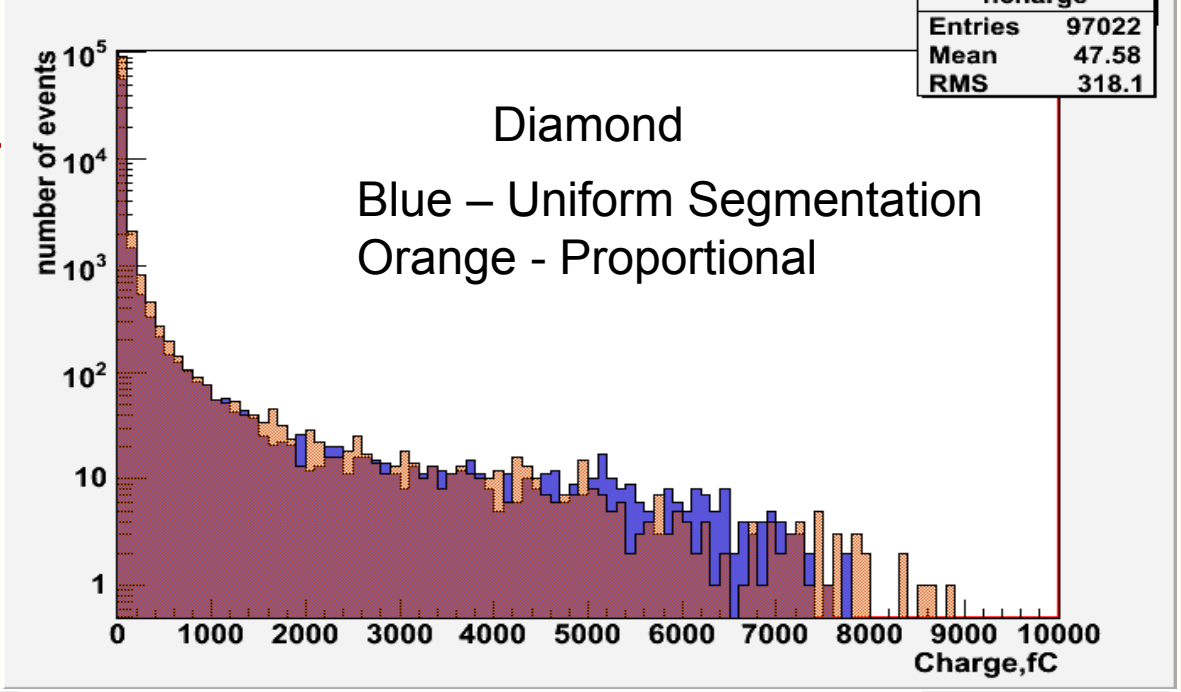


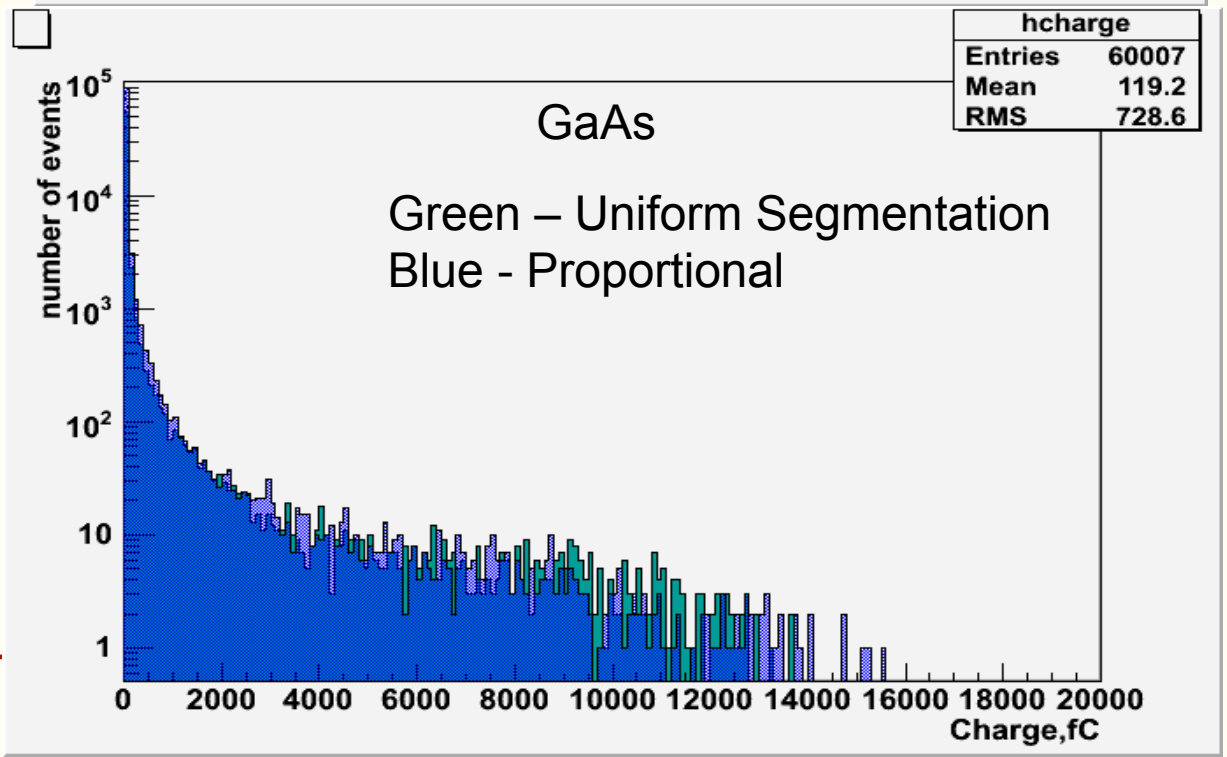


For Diamond sensor pad thickness 300 μm:

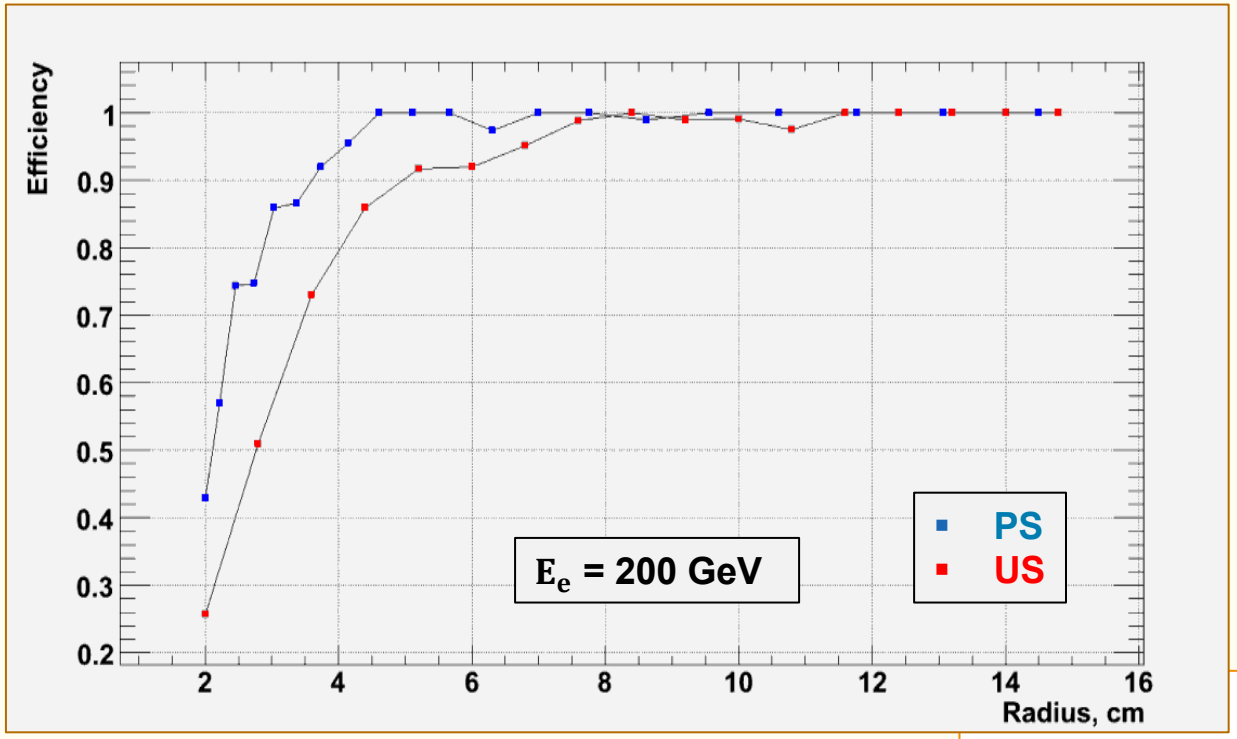
- Charge collected from MIP: 2.44 fC
- Maximum charge collected – for shower from 500 GeV electron: 12214 fC (correspond to about 5000 MIPs)

Distribution of the collected charge per pad for 500Gev electron showers





Efficiency of Showers Reconstruction

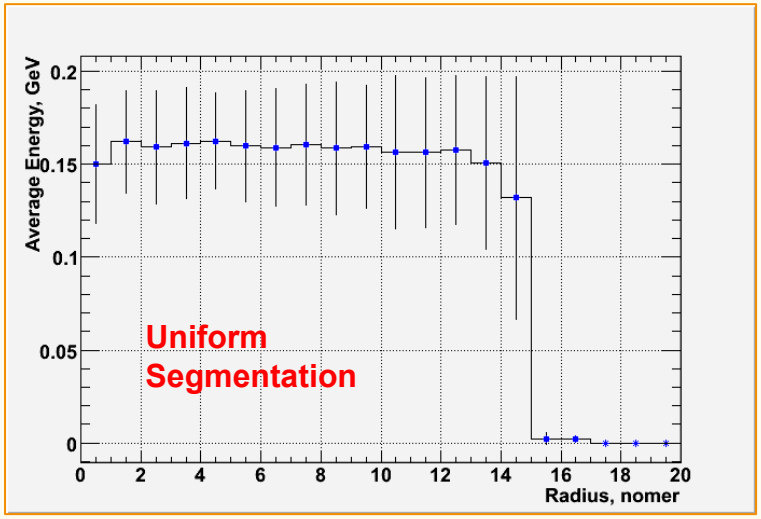


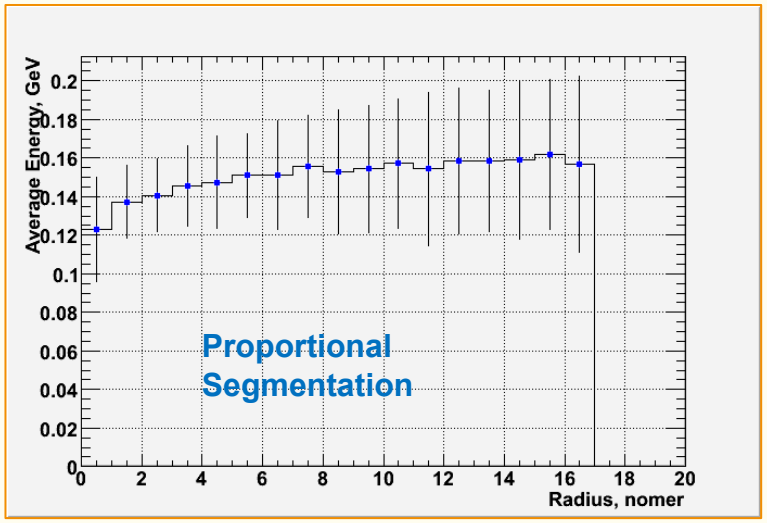
$$\text{Efficiency} = \frac{\text{Reconstructed SH considering BG}}{\text{Reconstructed SH without considering BG}}$$

Efficiency for 50 GeV

Signal and RMS for both Segmentations

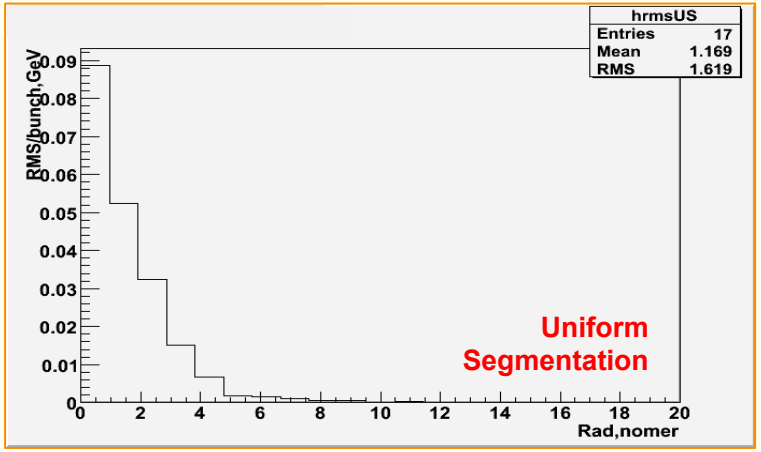
The average energy in the pad of the core of shower

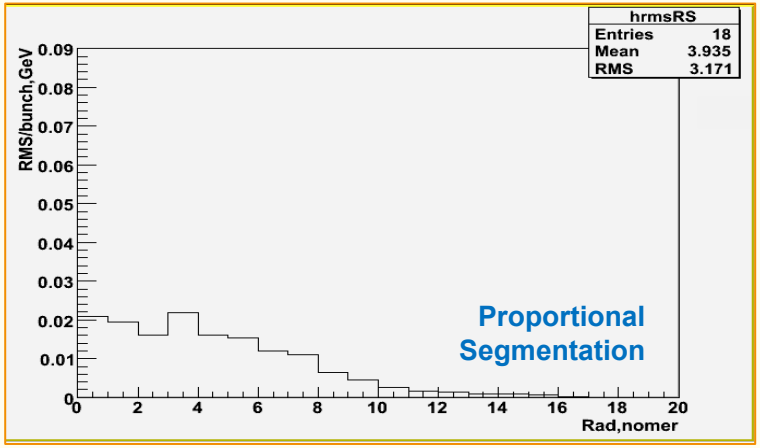




Signal nearly segmentation-independent!

RMS of the averaged Background





Different distributions!

20 bunch crossings were given