Design Studies for BeamCal using new Beam Parameters

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Goal and Motivation

Increase efficiency of reconstruction for showers produced by single high energy electrons (sHEe) in BeamCal

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The way to go: increase signal-to-noise ratio (SNR) in pads

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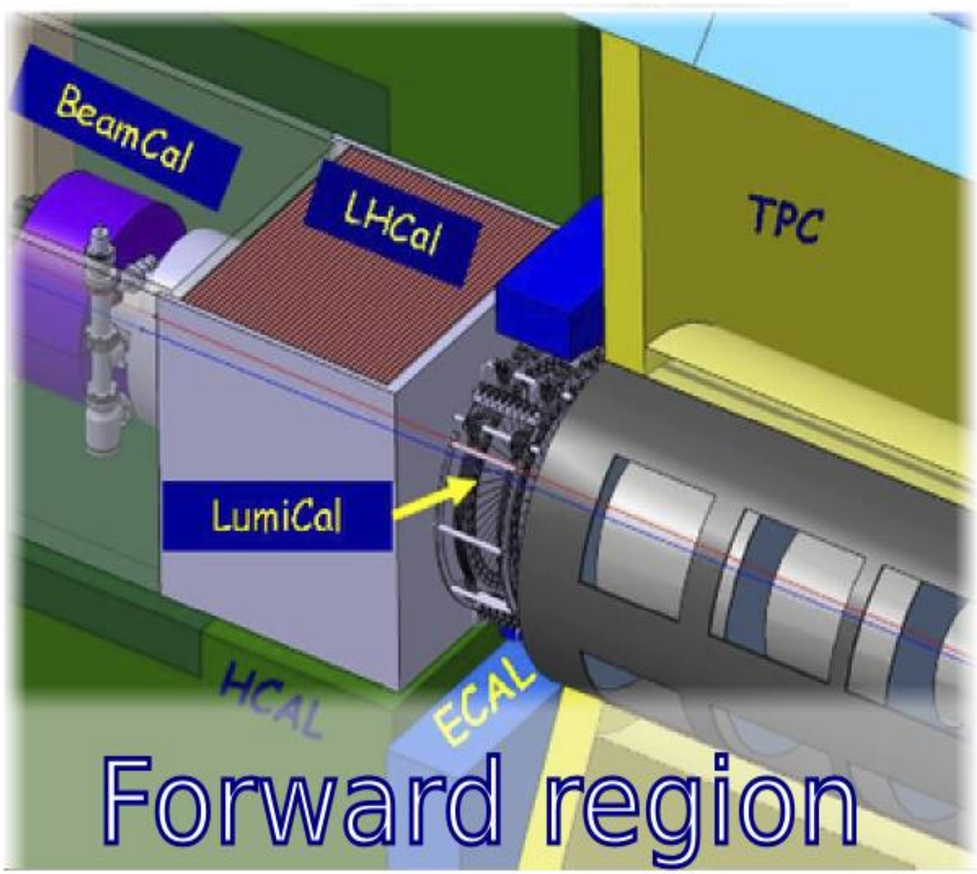
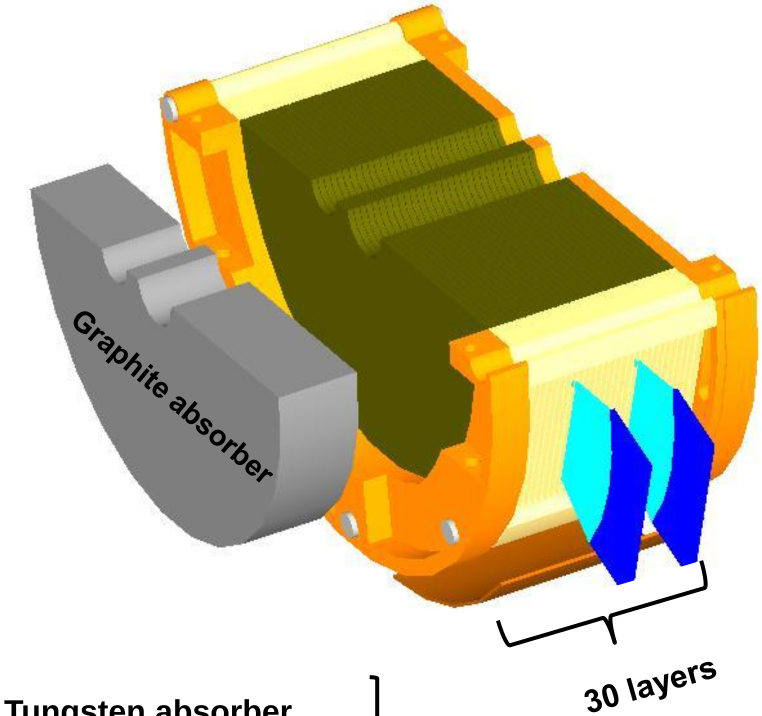
Change of design: new segmentation keeping the number of channels

Beam Calorimeter for ILC

Beam parameters from the ILC Technical Design Report (November 2012)
- Nominal parameter set
- Center-of-mass energy 1 TeV



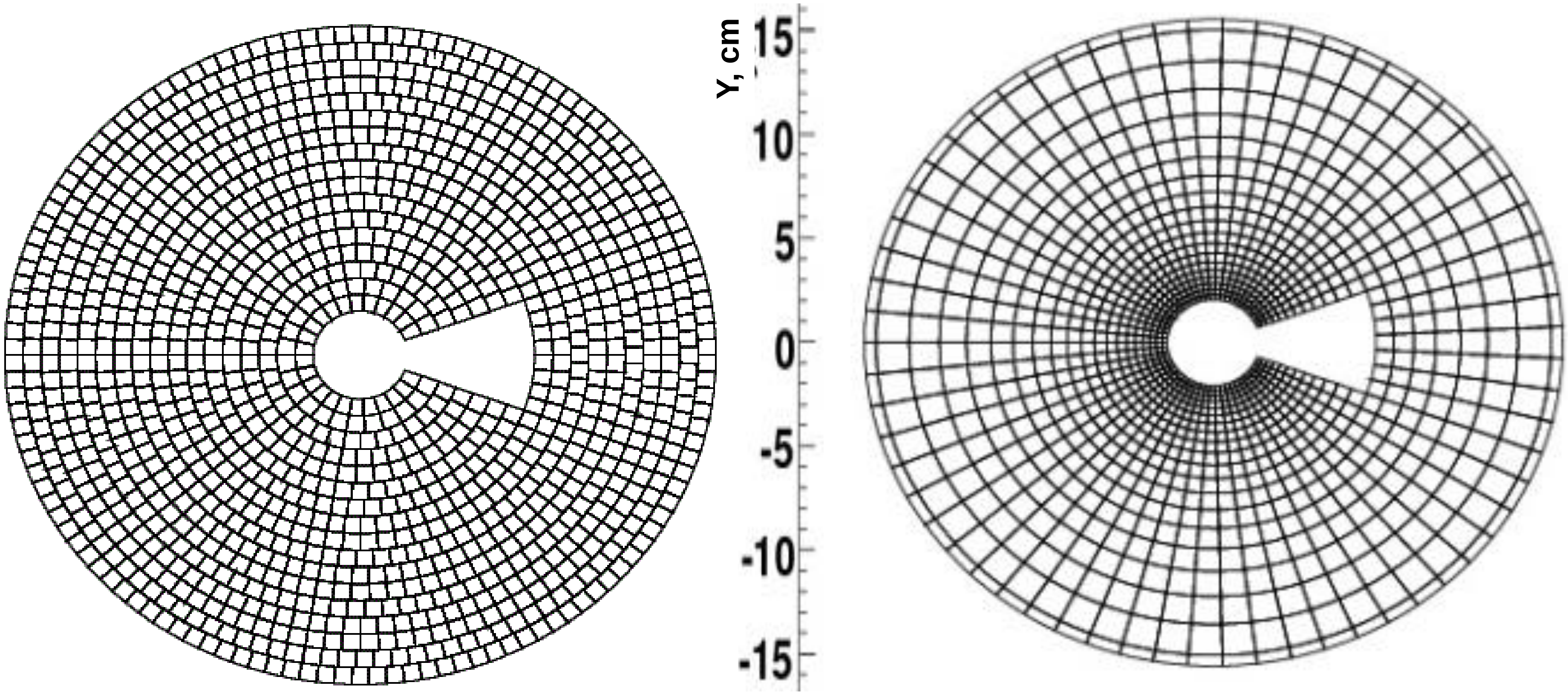
BeamCal:



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

} **1 X_0**

BeamCal Segmentation



Uniform Segmentation (US)

pad sizes are the same

Proportional Segmentation (PS)

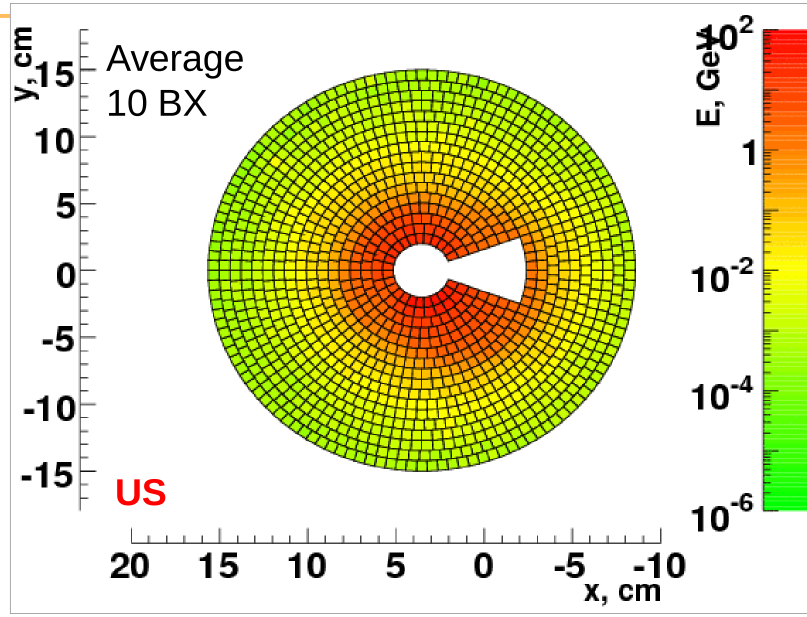
pads sizes are proportional to the radius

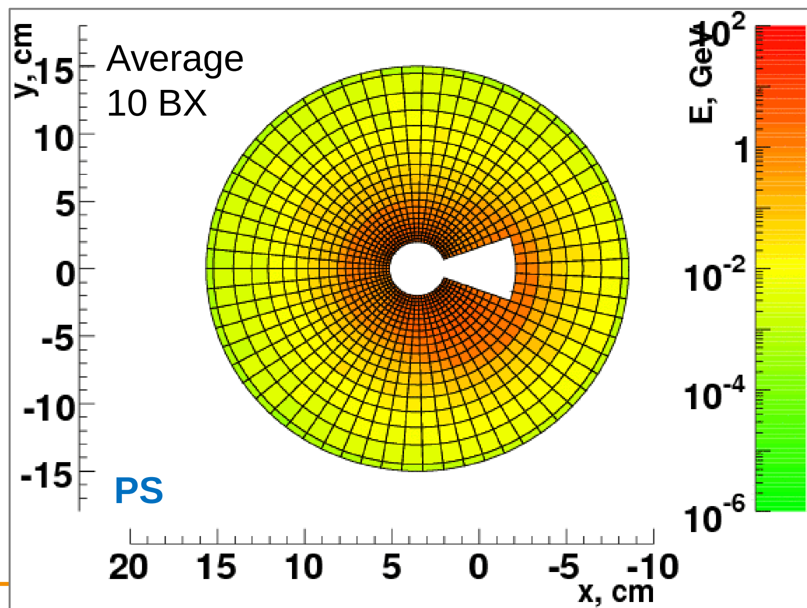
Similar number of channels

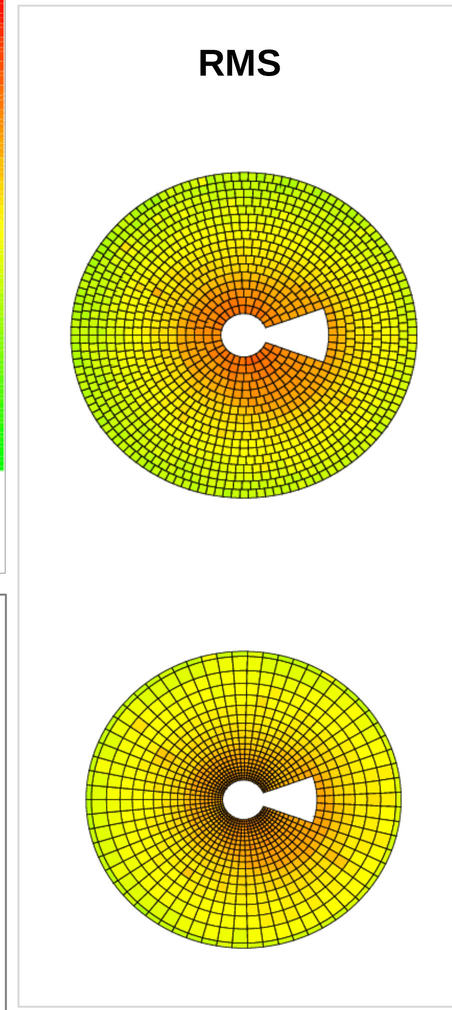
Energy Deposition due to Beamstrahlung

- **Beamstrahlung (BS) pairs generated with Guinea Pig**
- **Energy deposition in sensors from BS simulated with Geant4**
  $\longrightarrow$ ***considered as Background (BG)***
- **RMS of the averaged BG**
  $\longrightarrow$ ***considered as noise (for SNR)***

E_{dep} is the same, but E_{dep}/pad is different!







Figures show sum of all layers

Single High Energy Electrons

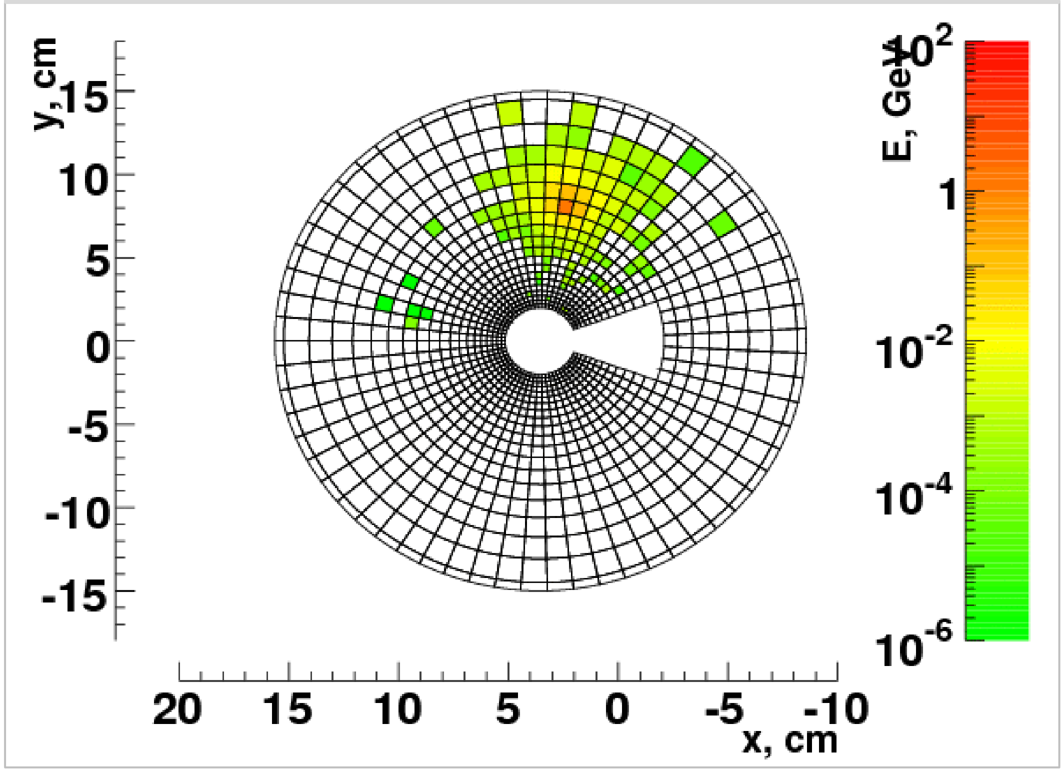
- sHEe of different energies (10, 20, 50, 100 GeV) are sent to each sensor ring

- Showers are simulated with Geant4

- Energy deposited in shower core

  → considered as signal

Example of shower from 100-GeV electron with core in ring at R = 8 cm

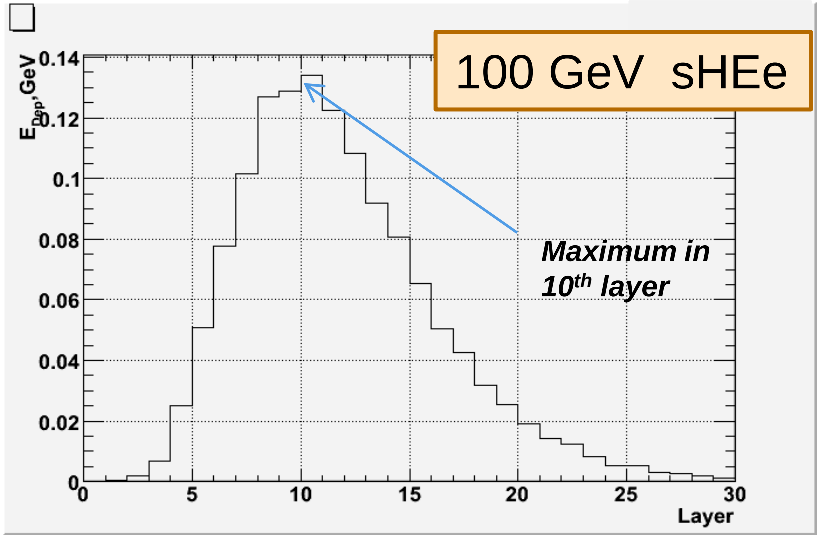


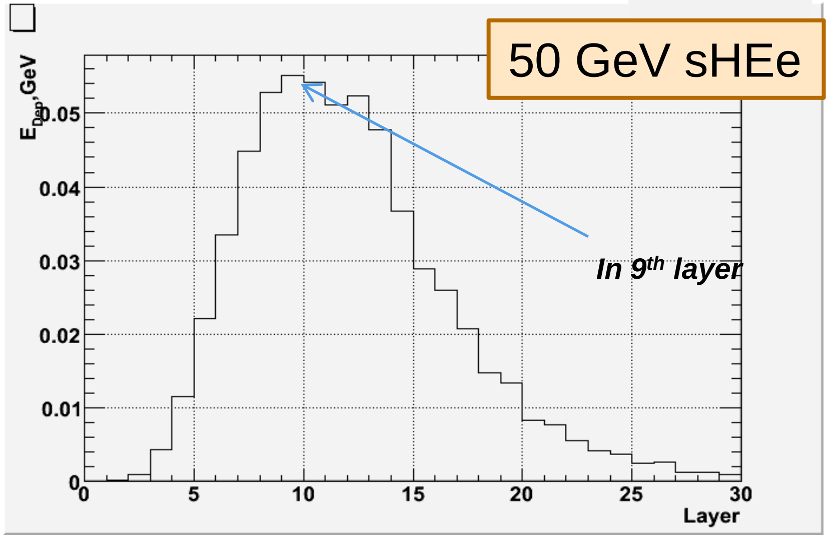
Signal-to-noise ratio:

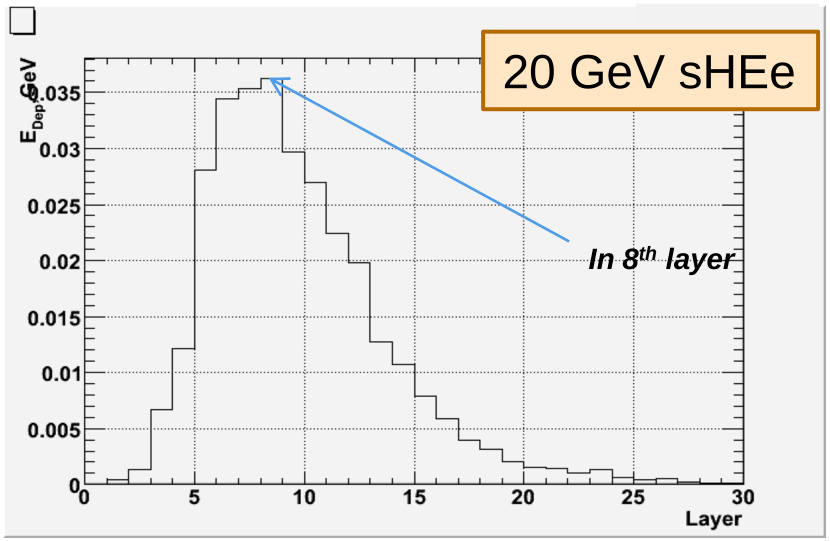
$$SNR = \frac{\text{signal from HE electron}}{\text{RMS from background}}$$

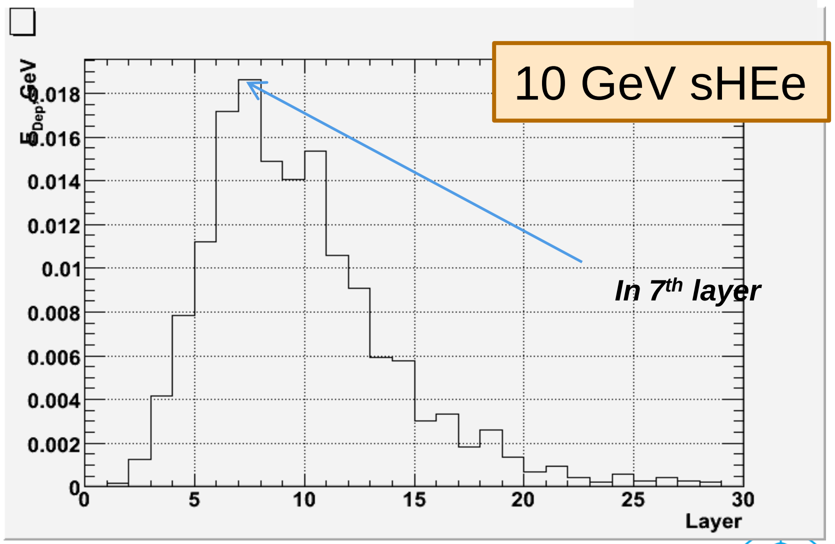
Evaluation around the Shower Maximum

Longitudinal shower profile (average over 10 showers):



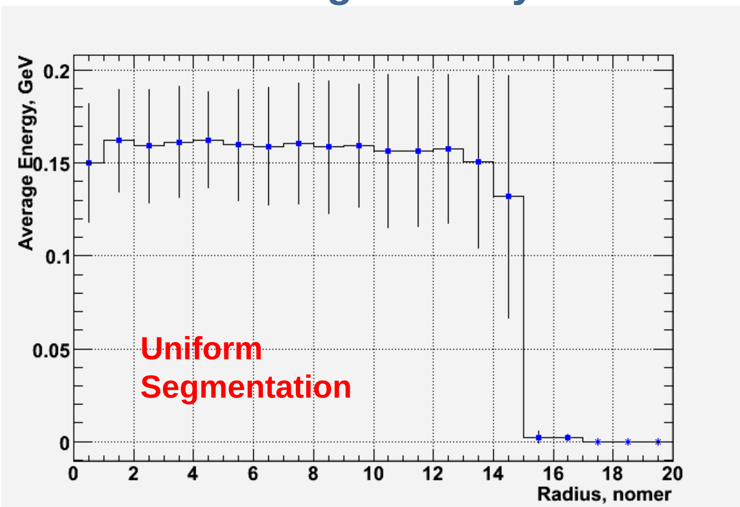


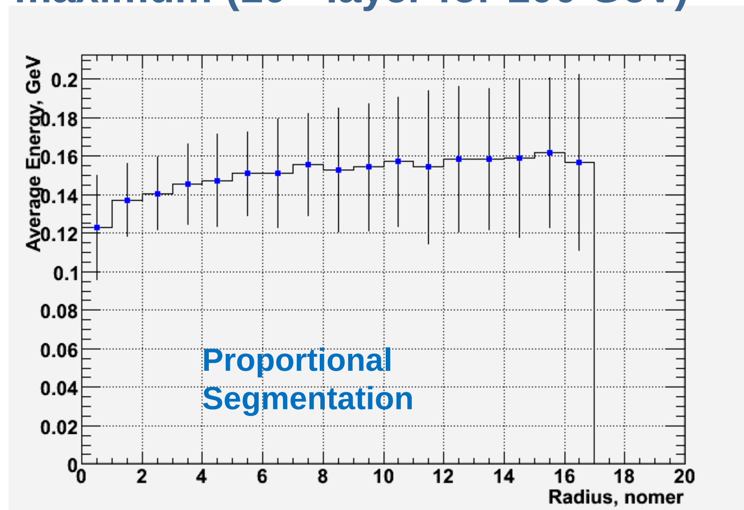




Signal and RMS for both Segmentations

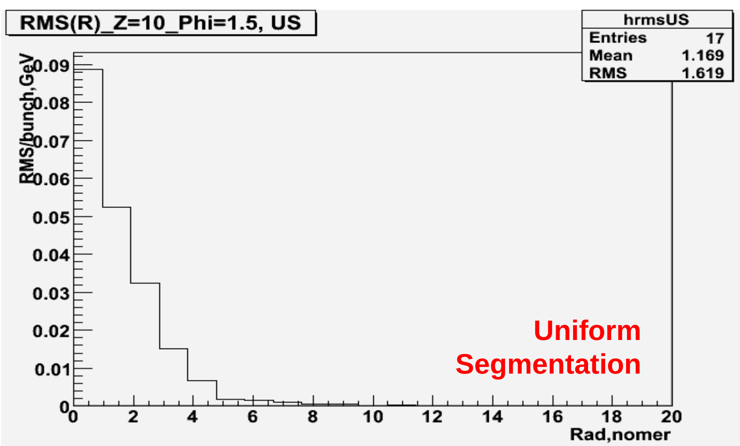
Core signal in layer of shower maximum (10th layer for 100 GeV)

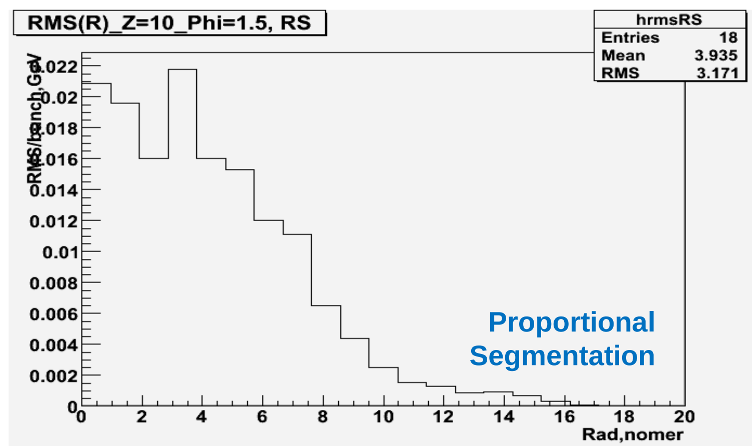




Signal nearly segmentation-independent!

RMS from Background (in 10th layer)

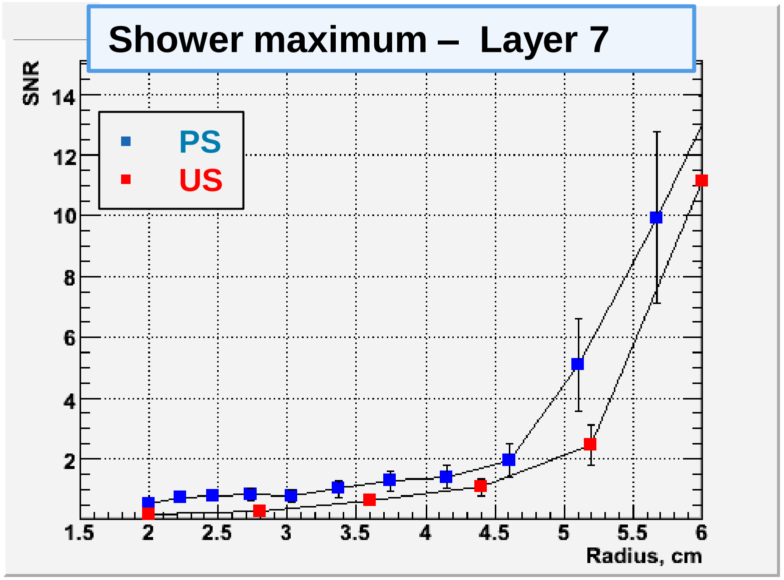


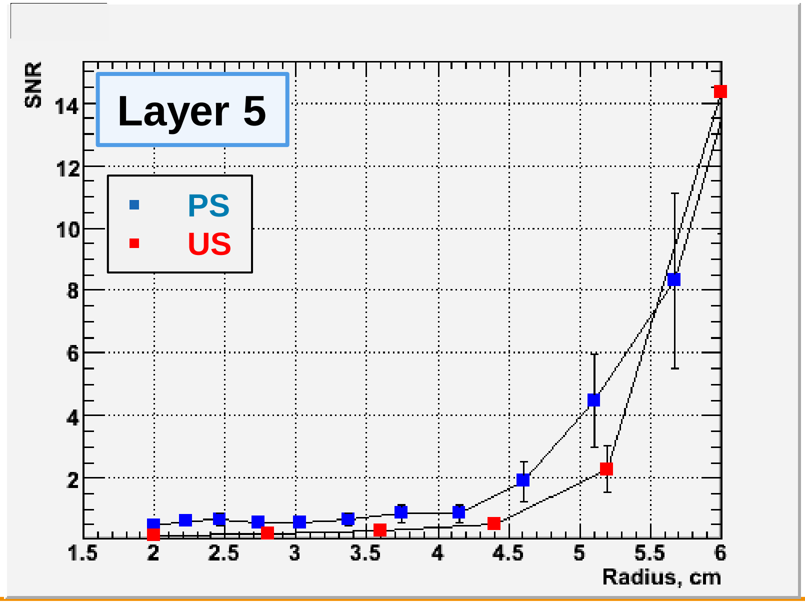


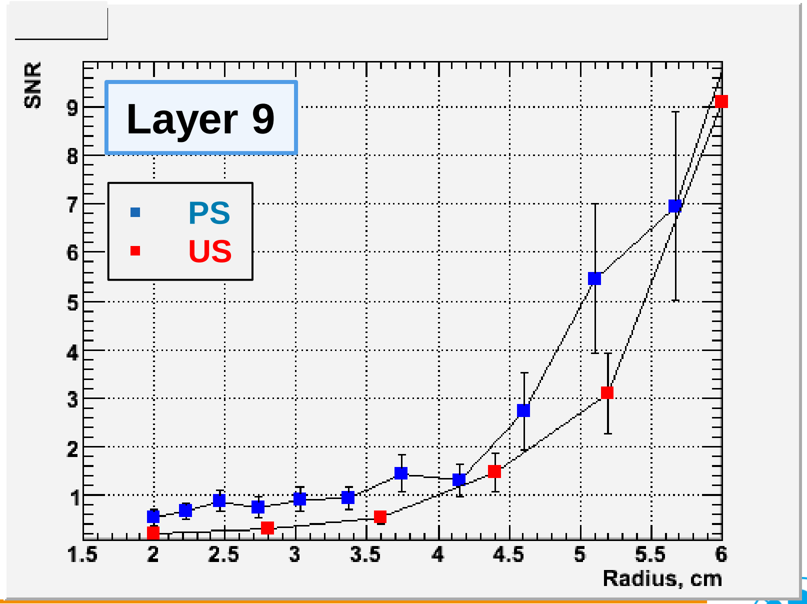
Different distributions!

20 bunch crossings were given

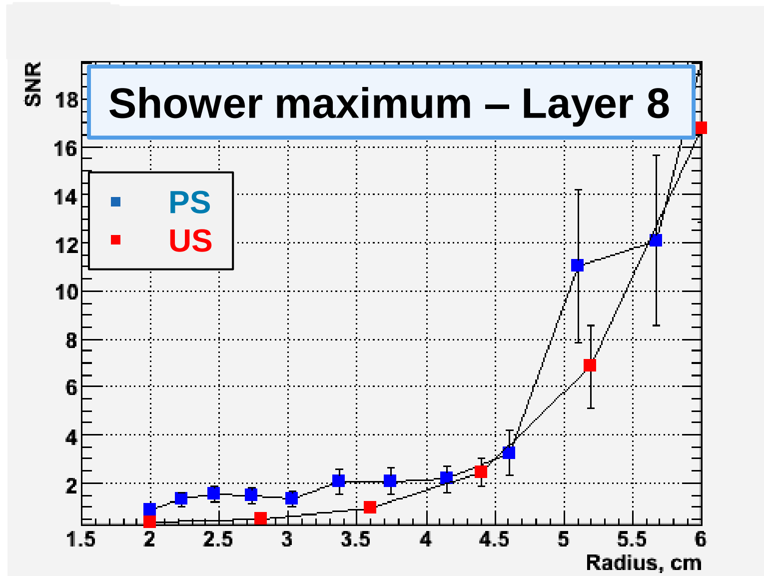
SNR for 10 GeV Electron

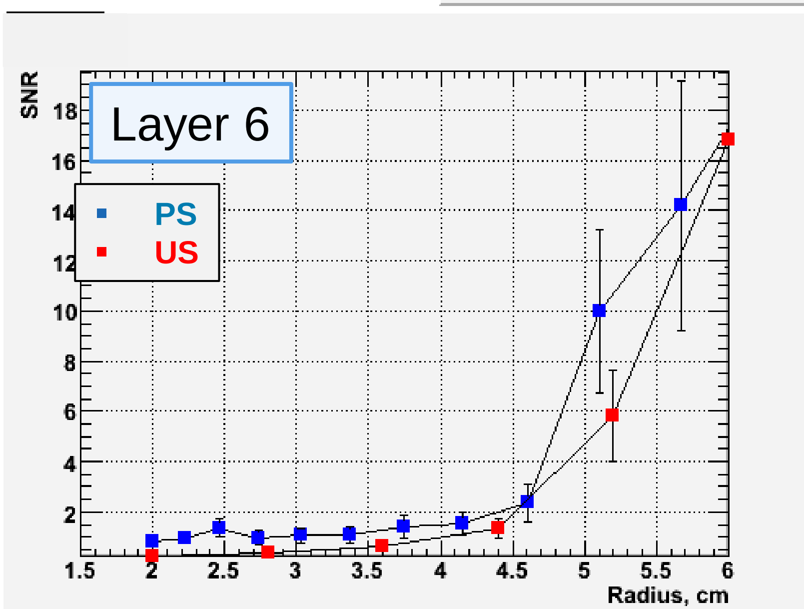


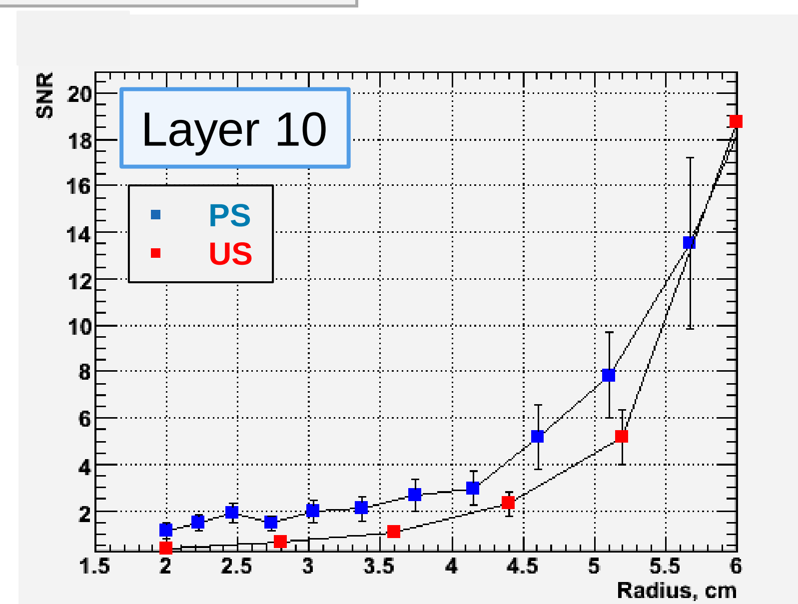




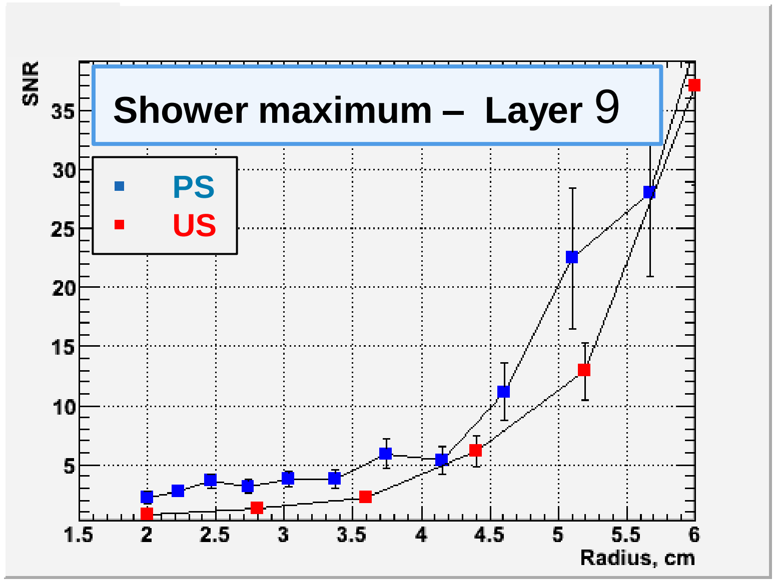
SNR for 20 GeV Electron

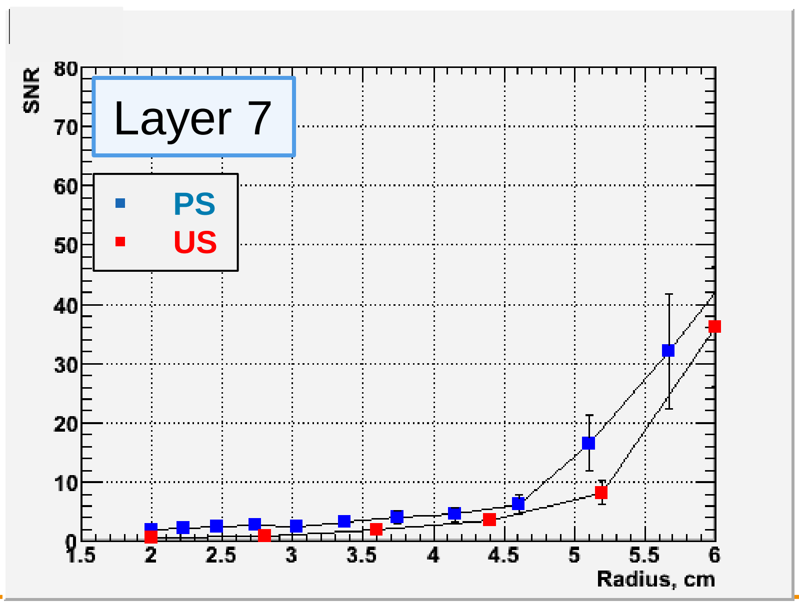


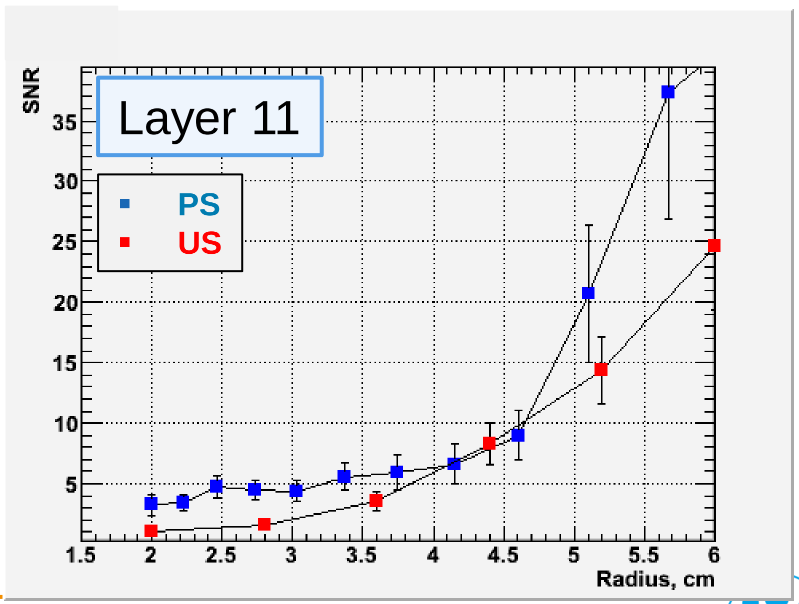




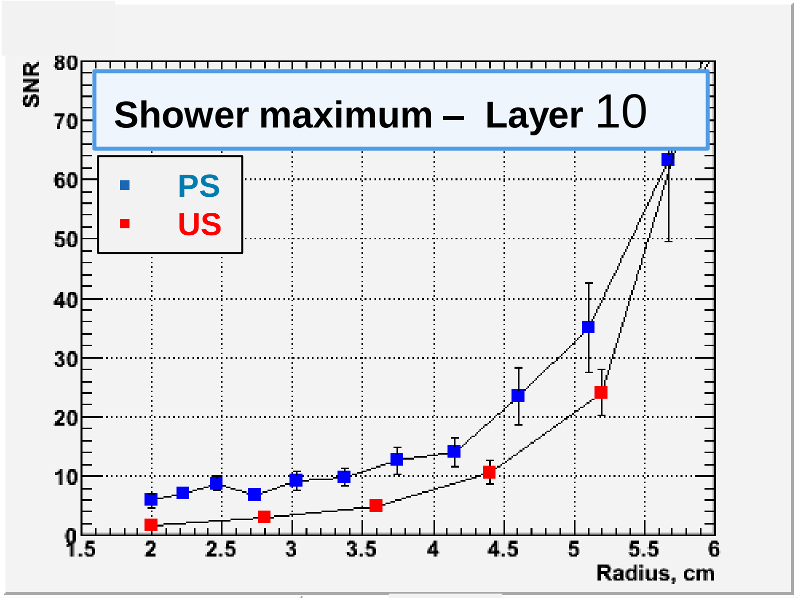
SNR for 50 GeV Electron

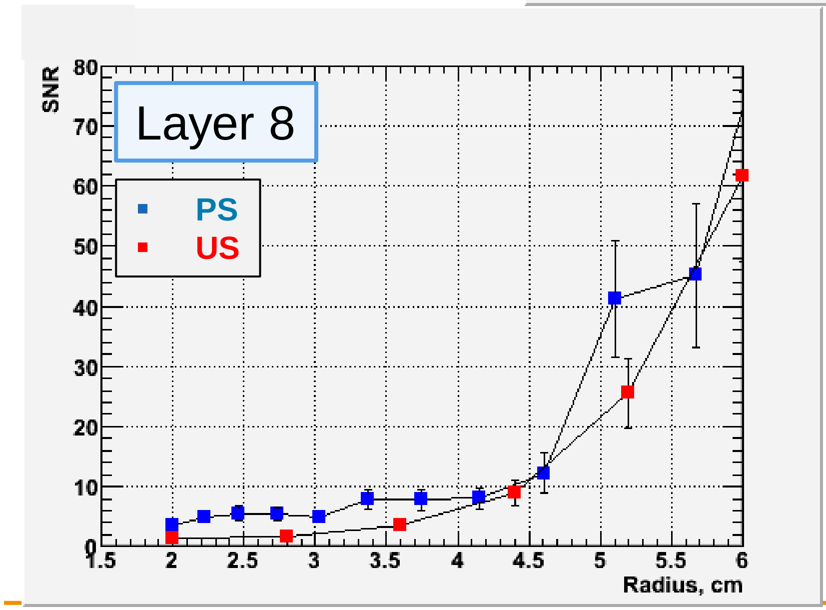


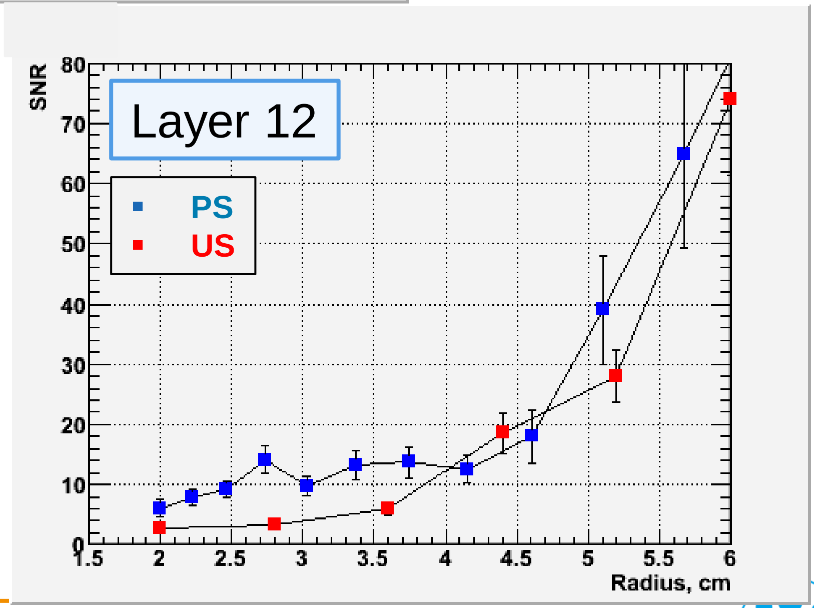




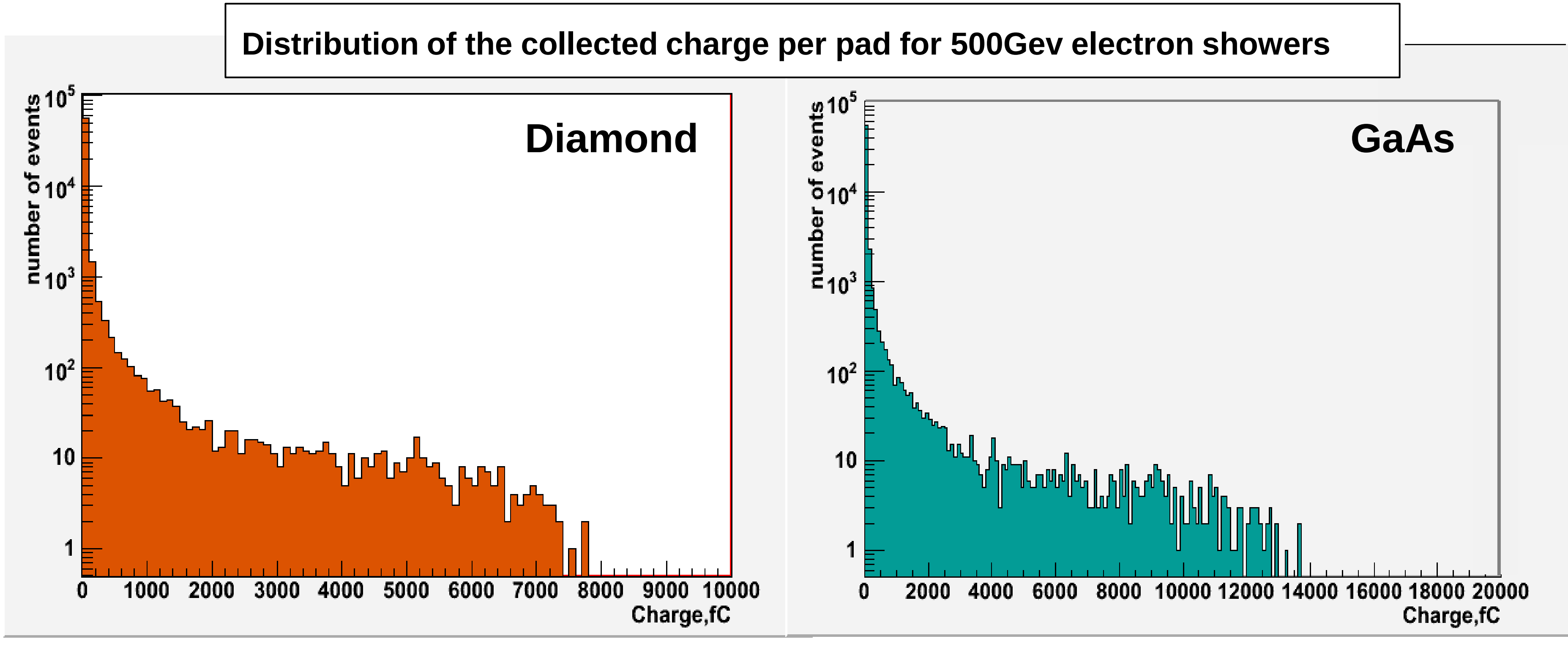
SNR for 100 GeV Electron







Charge range estimate



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)

Conclusion

- New beam parameters has been released in ILC TDR (November 2012)
- Performance of Beamcal for two different sensor segmentations was compared
  - Number of readout channels is kept similar
  - Signal from sHEe nearly independent of the segmentation
  - Energy deposition per pad from beamstrahlung differs significantly
  - Proportional segmentation improves the signal-to-noise ratio
  - We may expect better reconstruction efficiency
- The charge range has been estimated

Thank you for your attention

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