



**International Linear Collider Physics and Detector Workshop**  
**Snowmass, Colorado, August 14-27, 2005**



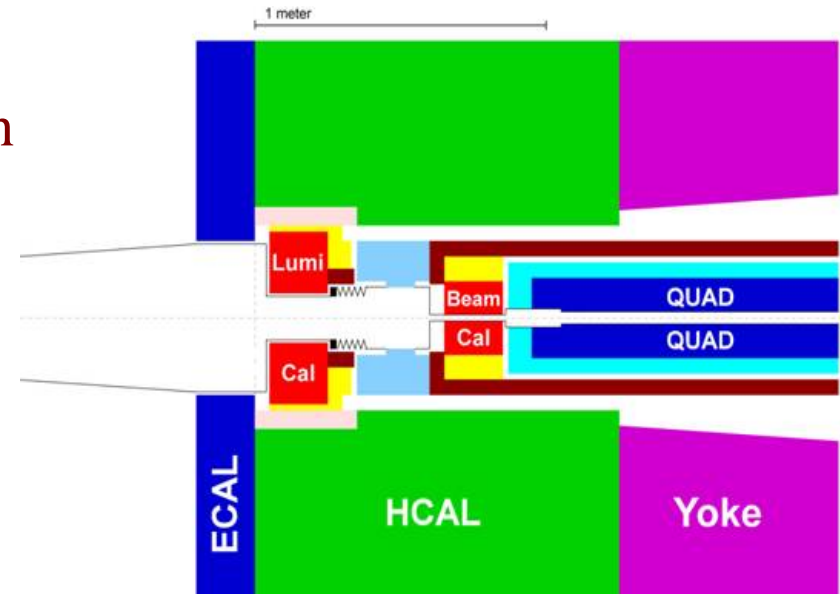
# **The Optimized Sensor Segmentation for the Very Forward Calorimeter**

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**JINR Dubna**

# Beam Calorimeter main parameters

- ✓ beam diagnostic
- ✓ identification and measurement of the high energy particles

<u><i>Diamond-tungsten</i></u>	
Distance from the IP, cm	370
$\theta_{\min} - \theta_{\max}$ , mrad	4 – 28
$R_{\min} - R_{\max}$ , cm	1.5 – 10
Sensor thickness, mm	0.5
Absorber thickness, mm	3.5
Number of layers	30
$X_0$ , mm	4
$R_{\text{molier}}$ , mm	10



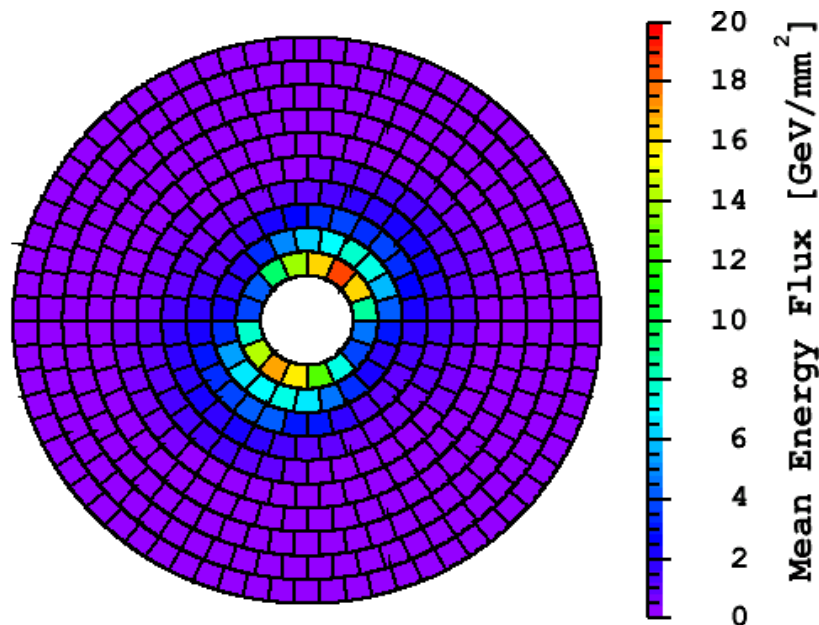
## Technologies for the BeamCal:

- 1) Silicon-tungsten or diamond-tungsten sandwich calorimeter
- 2) PbWO<sub>4</sub> crystal

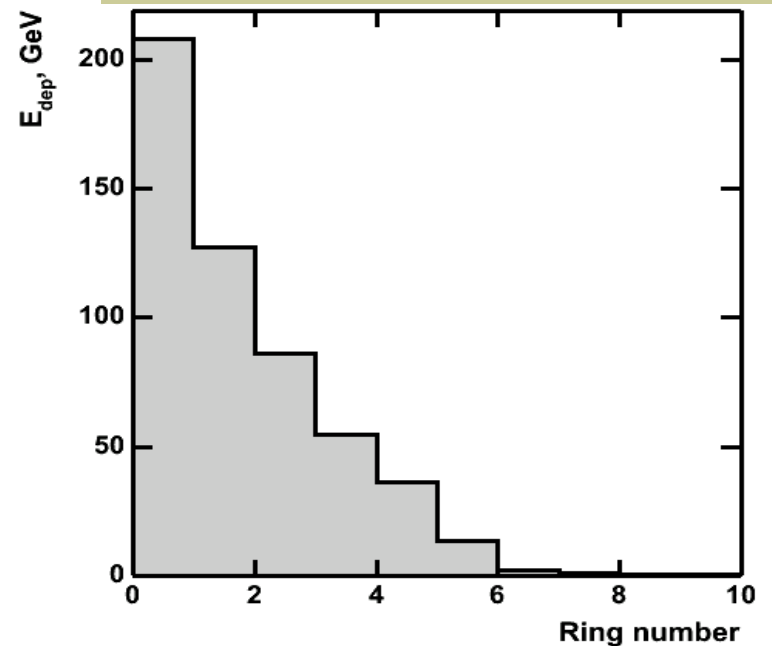
## Background from the beamstrahlung

BeamCal will be hit by beamstrahlung remnants carrying about 20 TeV of energy per bunch crossing.

r- $\phi$  distribution per one bunch



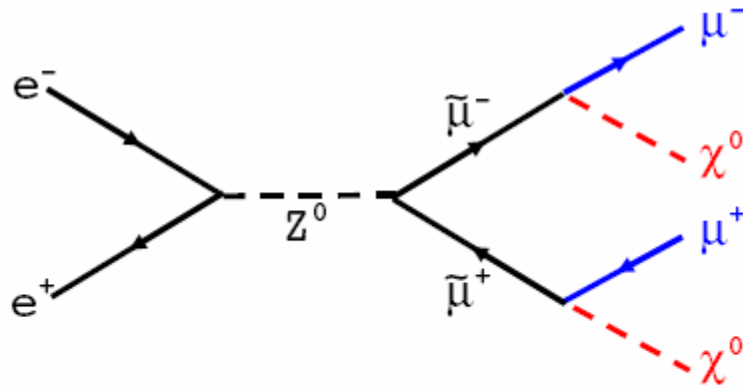
Energy deposition in diamond rings per one bunch



Severe background for electron identification

# Particle identification in the BeamCal

## Motivation

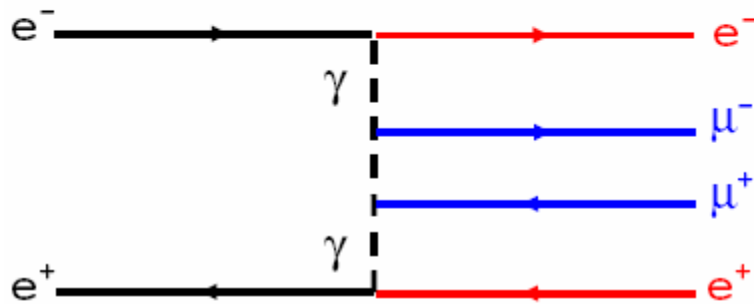


### The Physics:

SUSY particles production  $\sigma \sim 10^2 \text{ fb}$

### Signature:

$\mu^+ \mu^- + \text{missing energy}$



### The Background:

two photons event  $\sigma \sim 10^6 \text{ fb}$

### Signature:

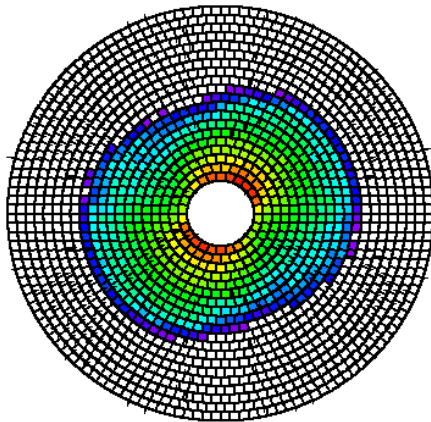
$\mu^+ \mu^- + \text{missing energy}$   
(if electrons are not tagged)

**Excellent electron identification is needed down to as small angle as possible**

# Segmentation Optimization Study

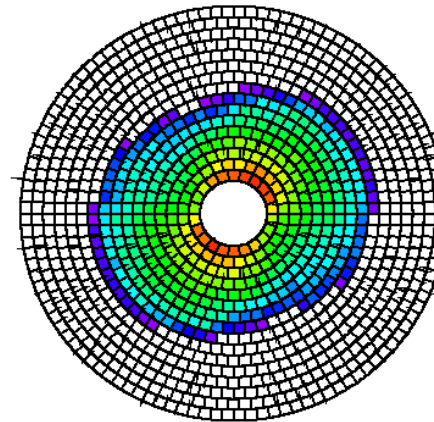
## motivation

4 mm



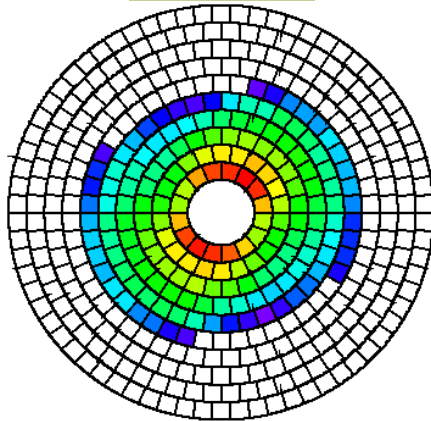
$N_{\text{rings}}$	20
$N_{\text{cells}}$	1660
$N_{\text{channels}}$	<b>49 800</b>

5 mm



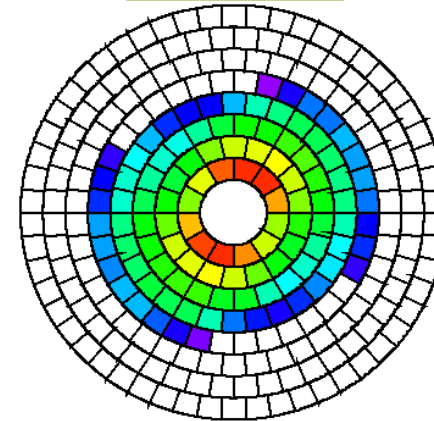
$N_{\text{rings}}$	16
$N_{\text{cells}}$	1072
$N_{\text{channels}}$	<b>32 160</b>

8 mm



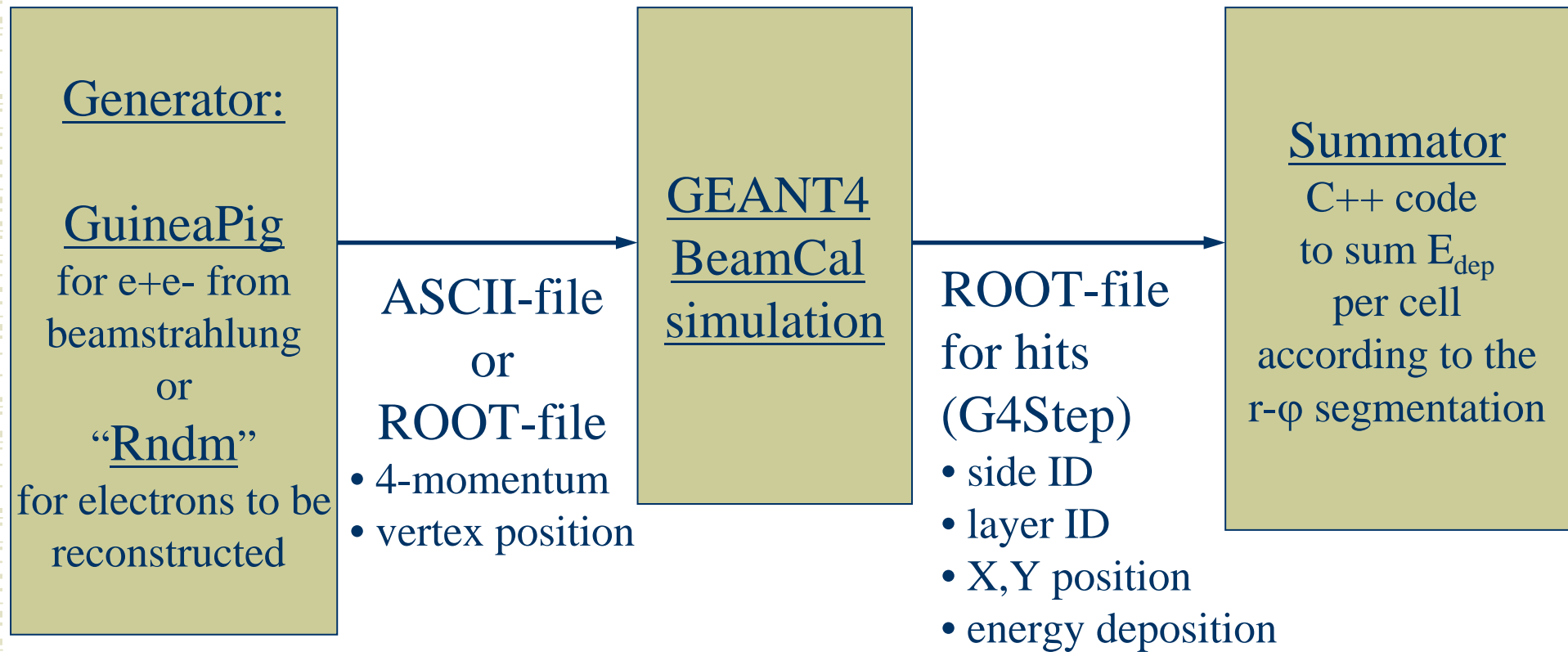
$N_{\text{rings}}$	10
$N_{\text{cells}}$	430
$N_{\text{channels}}$	<b>12 900</b>

10 mm

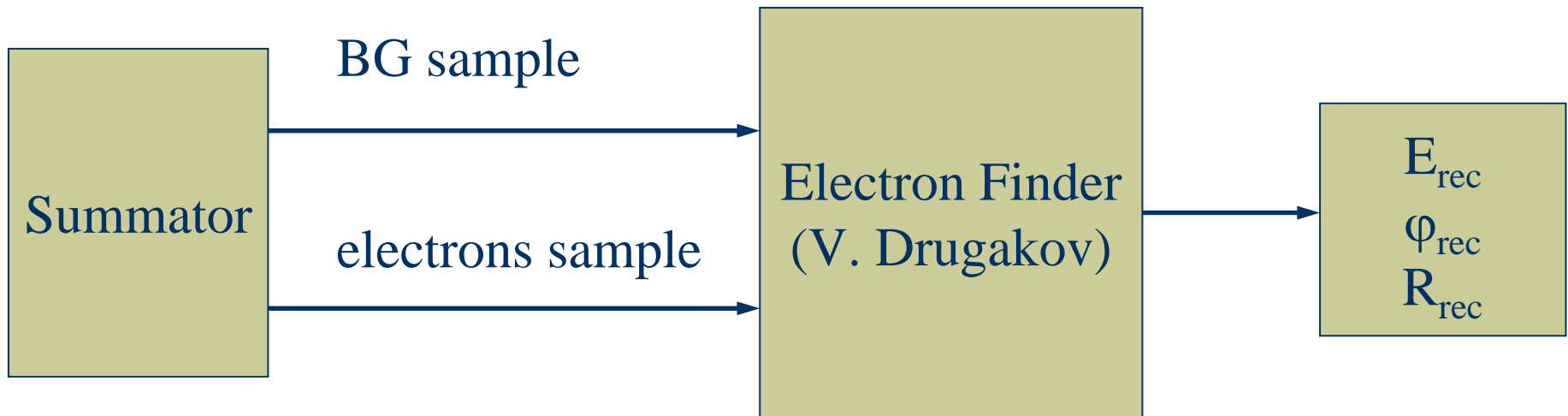


$N_{\text{rings}}$	8
$N_{\text{cells}}$	264
$N_{\text{channels}}$	<b>7 920</b>

# Particle identification in the BeamCal simulation chain



## Particle identification in the BeamCal simulation chain



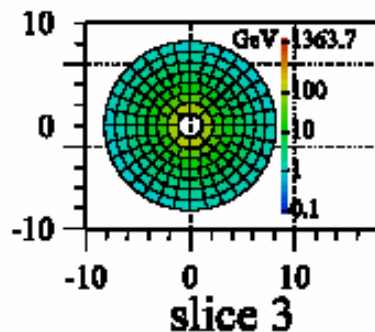
Since actual parameters ( $E_{\text{sim}}$ ,  $\varphi_{\text{sim}}$ ,  $R_{\text{sim}}$ ) of the electrons are known from the simulation one can extract efficiency of the electron identification from the **eFiner** output.

# Particle identification in the BeamCal

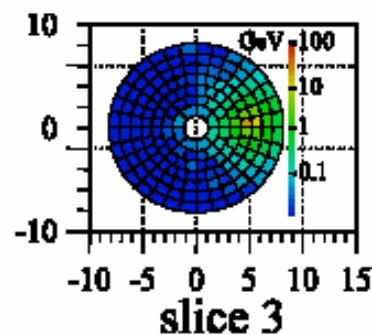
Electron Finder from V. Drugakov

1. Use 10 events to define  $\langle E_{bg} \rangle$  and  $RMS_{E_{bg}}$  for each pad.
2. For signal event subtract  $\langle E_{bg} \rangle$  from  $E_{dep}$  for each pad.
3. Keep pads with remaining  $E_{dep}$  larger than  $5 \cdot RMS_{E_{bg}}$ .
4. Search along each segment:  
cluster is found if there are more than 7 pads in the segment and more than 4 pads within at least one neighbor segment.

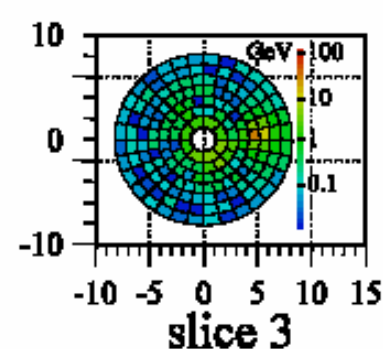
BG



particle



“event”

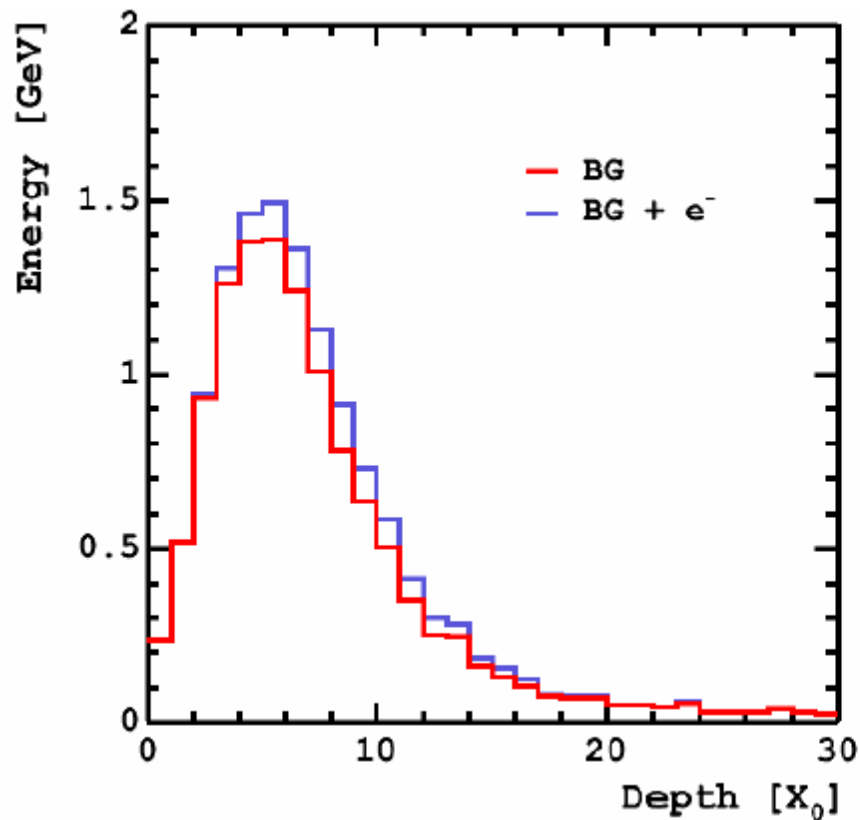




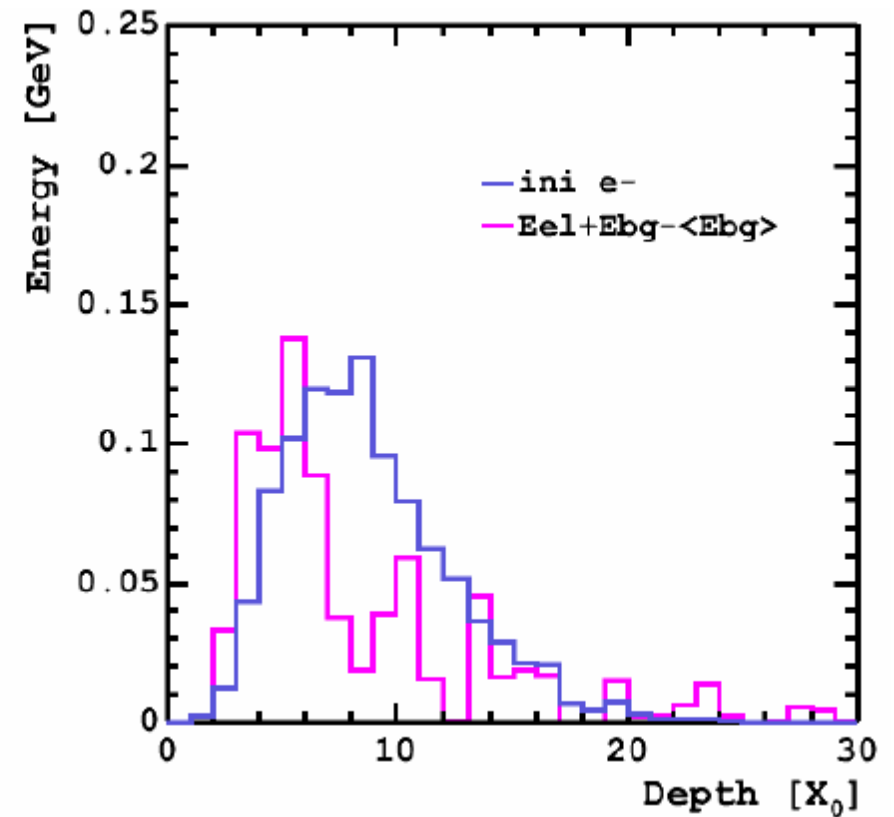
# Particle identification in the BeamCal

Electron Finder from V. Drugakov

100 GeV electron on top of the  
beamstrahlung



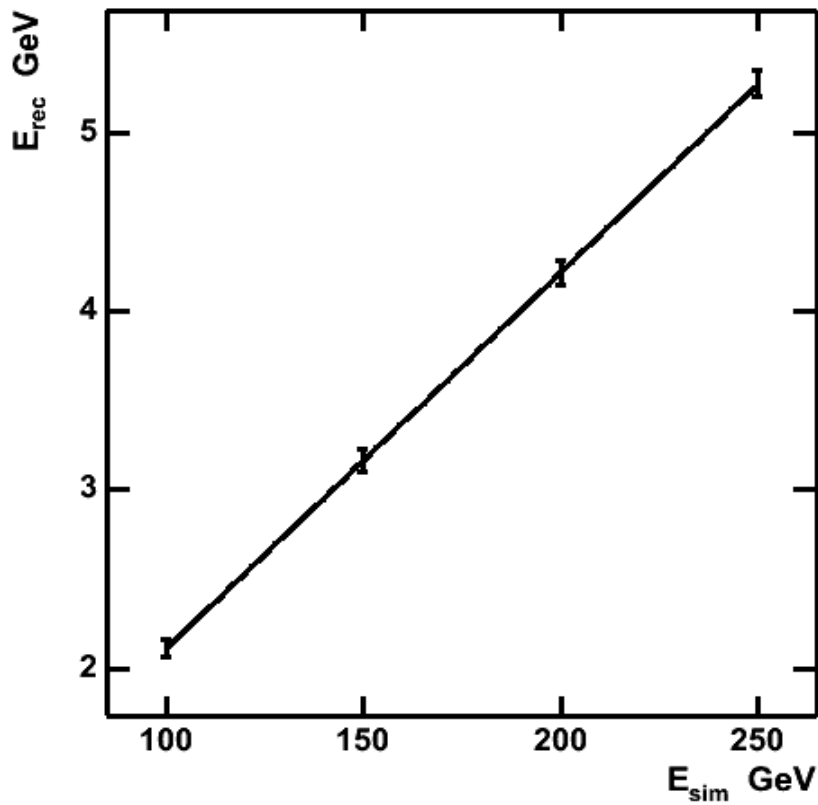
Subtraction of average background



# Energy reconstruction

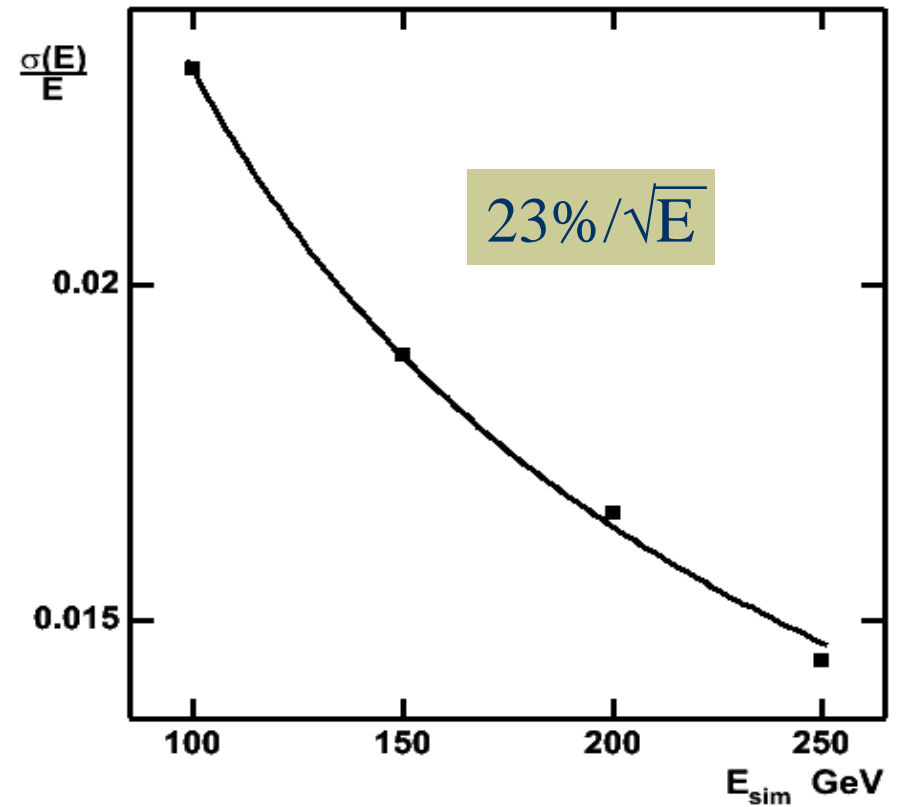
No background

calibration



5 mm

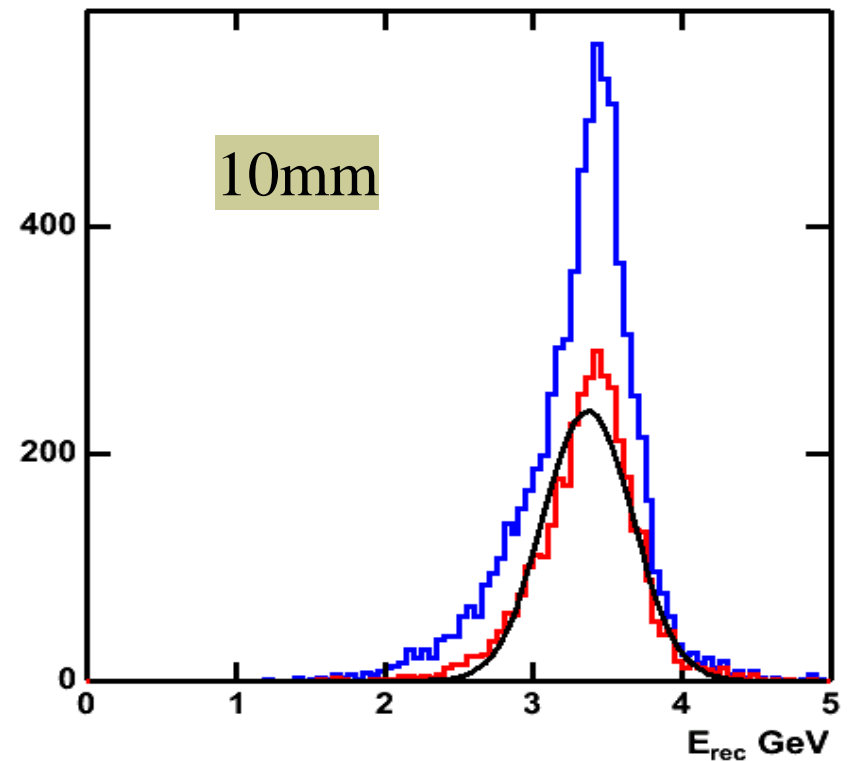
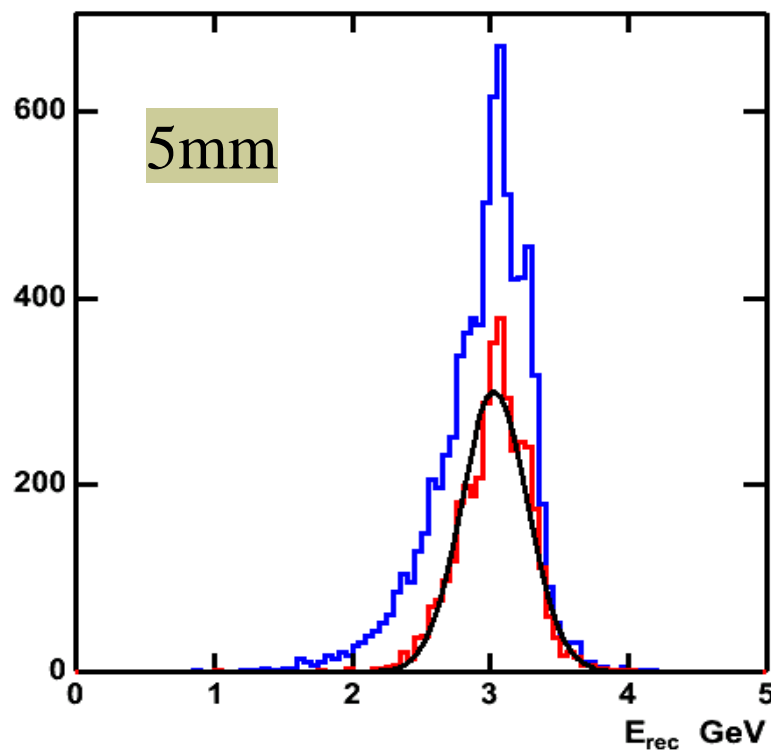
intrinsic resolution



# Energy reconstruction

## electrons on top of the background

Energy deposited in diamond for 200 GeV electrons  
low BG region ( $\varphi \sim 0^\circ$ )



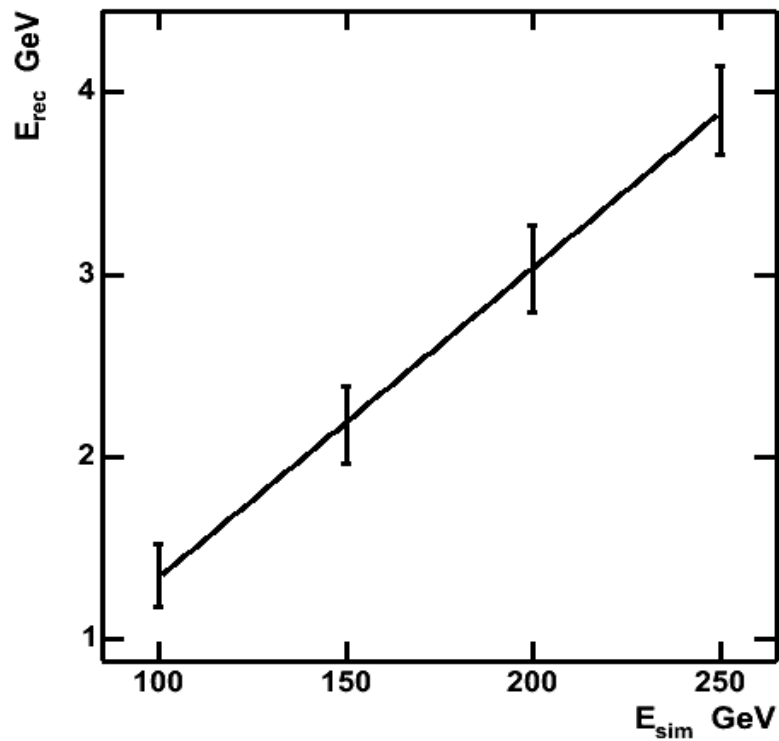
Blue – all events, red –  $2 \cdot R_{\text{molier}}$  from edges

# Energy reconstruction

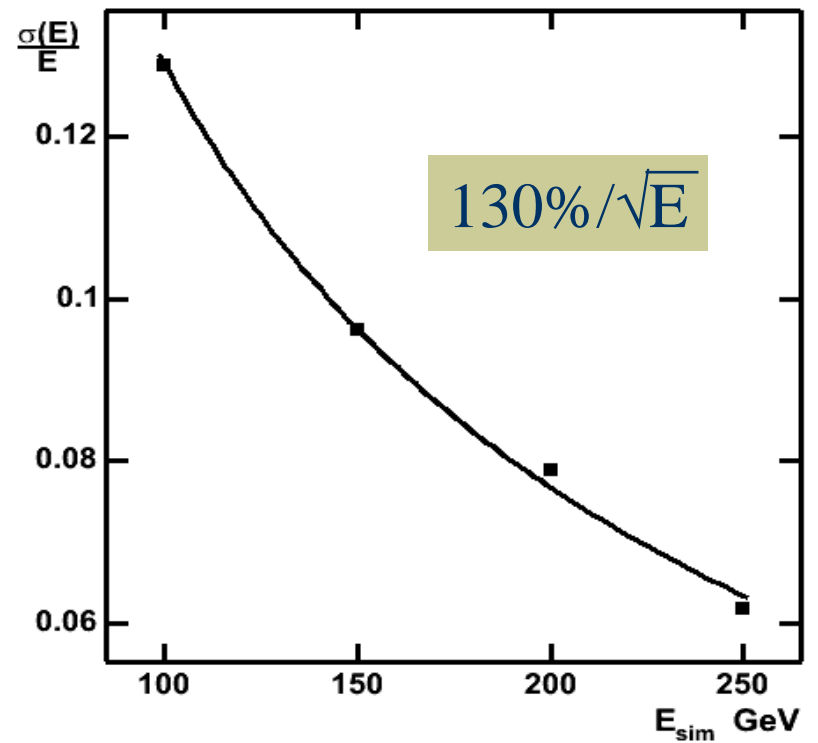
electrons on top of the background

Low BG region ( $\varphi \sim 0^\circ$ )  
5 mm

calibration



resolution



## Cuts for reconstructed particles

Electrons are considered as reconstructed if:

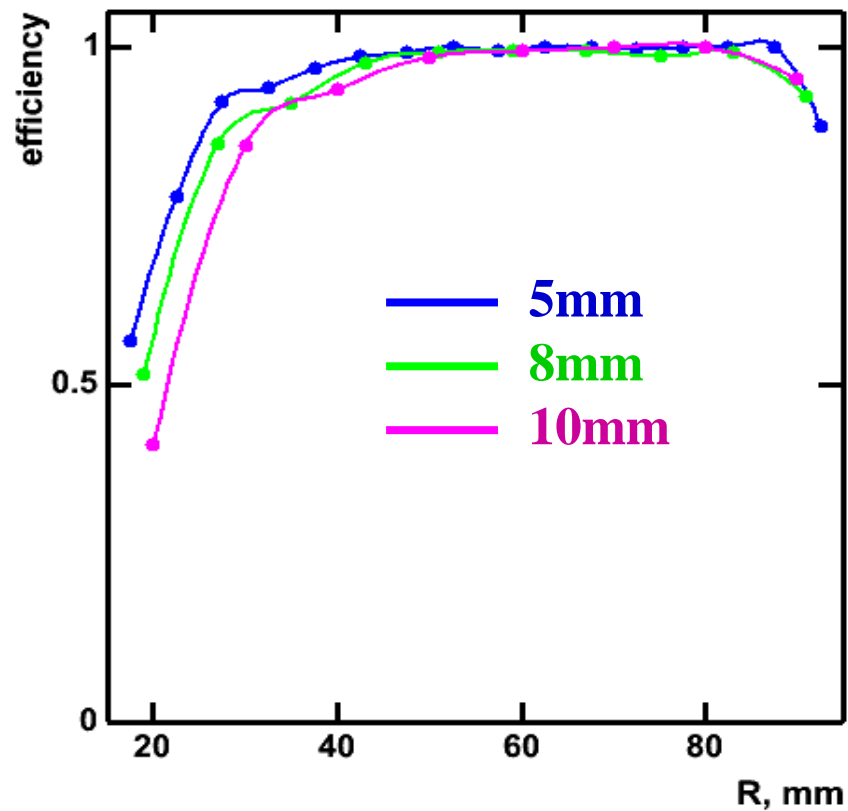
1.  $E_{\text{fit}} - 3\sigma_{\text{fit}} < \mathbf{E}_{\text{rec}} < E_{\text{fit}} + 3\sigma_{\text{fit}}$
2.  $\mathbf{R}_{\text{sim}} - \text{CellSize}/2 < \mathbf{R}_{\text{rec}} < \mathbf{R}_{\text{sim}} + \text{CellSize}/2$
3.  $\varphi_{\text{sim}} \cdot \mathbf{R}_{\text{sim}} - \text{CellSize}/2 < \varphi_{\text{rec}} \cdot \mathbf{R}_{\text{rec}} < \varphi_{\text{sim}} \cdot \mathbf{R}_{\text{sim}} + \text{CellSize}/2$

$E_{\text{fit}}$  and  $\sigma_{\text{fit}}$  are defined from the distribution of the reconstructed energy for events in the middle of the BeamCal

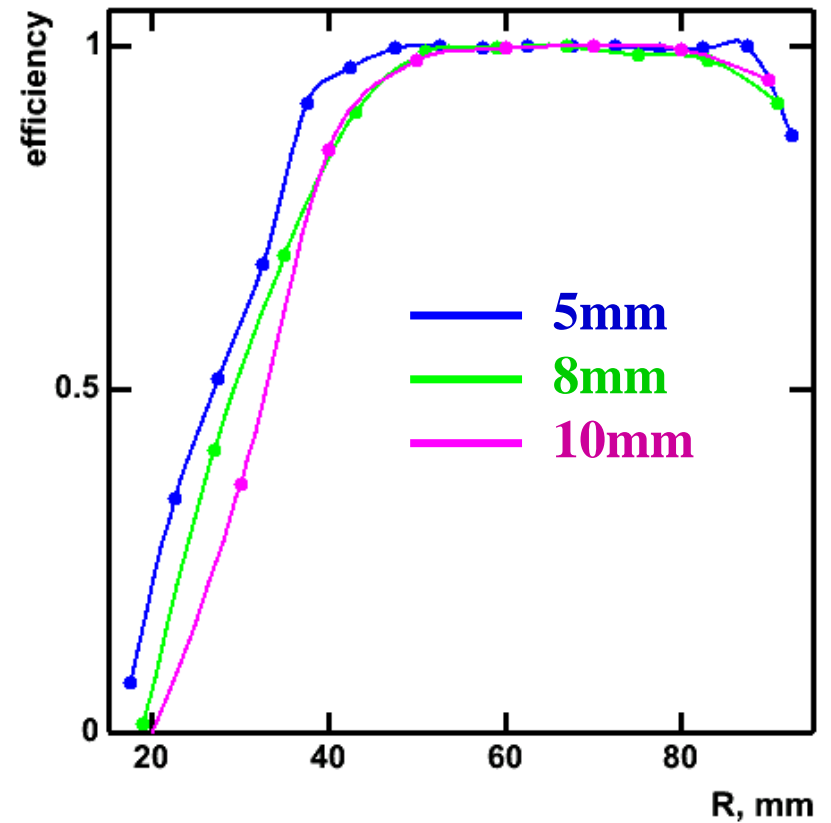
# Particle identification efficiency

electrons 200 GeV

Low BG ( $\varphi \sim 0^\circ$ )



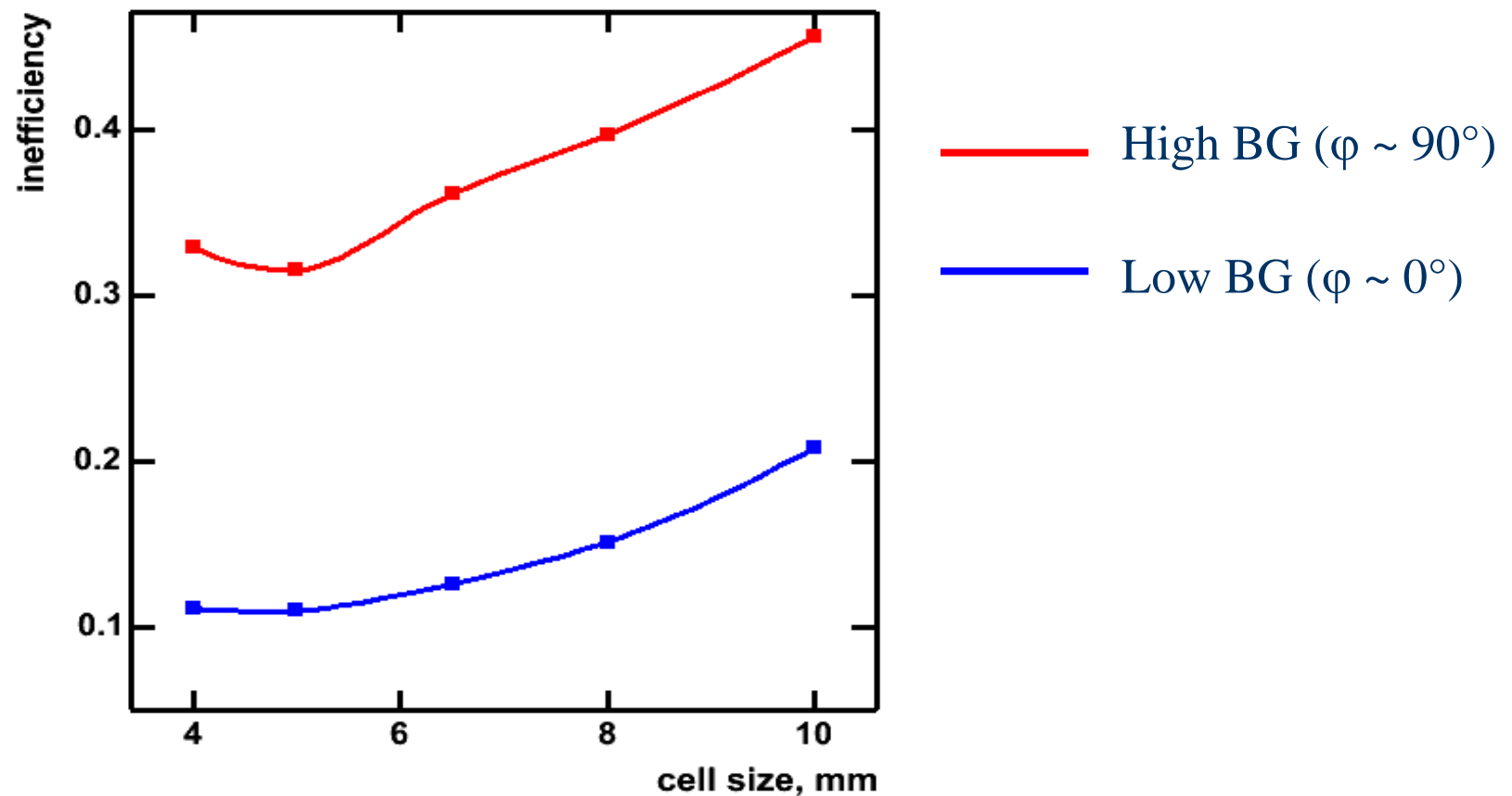
High BG ( $\varphi \sim 90^\circ$ )



# Inefficiency in particle identification

Lost particles for  $R < 55$  mm

Inefficiency to identify  
200 GeV electrons



## Summary

- Complete simulation chain for BeamCal exist:
  - GEANT4 based simulation (A. Elagin)  
(crossing angle options are available, implemented by V. Drugakov)
  - eFinder for electron identification (V. Drugakov)
- **5 mm** segmentation is the best for electron identification at small radii
- **8 mm** – is not too bad
- **10 mm** segmentation gives 100% efficiency for  $R > 55$  mm