Electron Identification Efficiency of the BeamCal (modified SiD02)

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3 March 2009

Overview

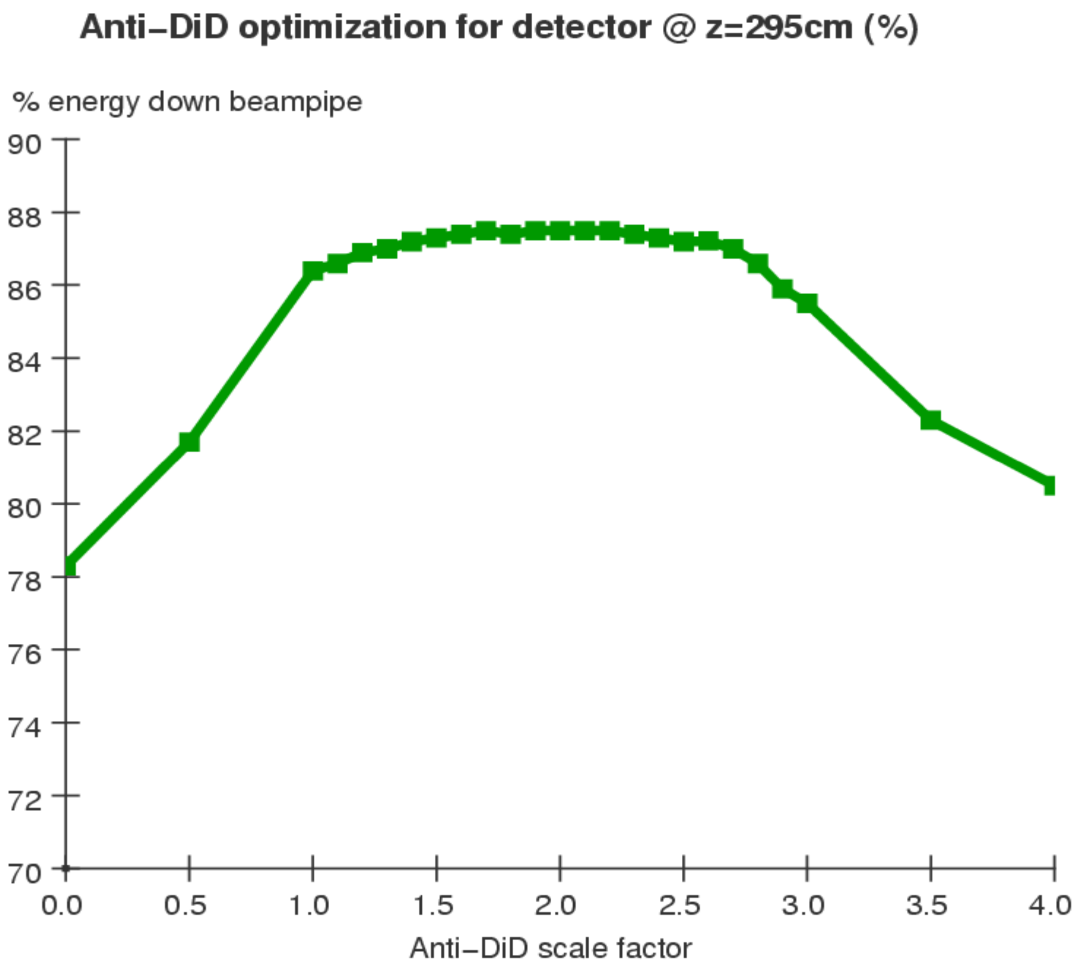
- Measure our ability to pick up high energy electrons (50GeV, 100GeV, 150GeV) on the BeamCal
- Study conducted with SLiC (GEANT4) simulation using modified SiD01 geometry (results should be same for SiD02)

Our Modified SiD01

- Inserted 14mrad crossing angle
- Created BeamCal subdetector matching SiD02 specifications

- Inserted antiDiD and calibrated to maximize beamstrahlung deflected into outgoing beampipe
- Using fieldmap description for 5T solenoid

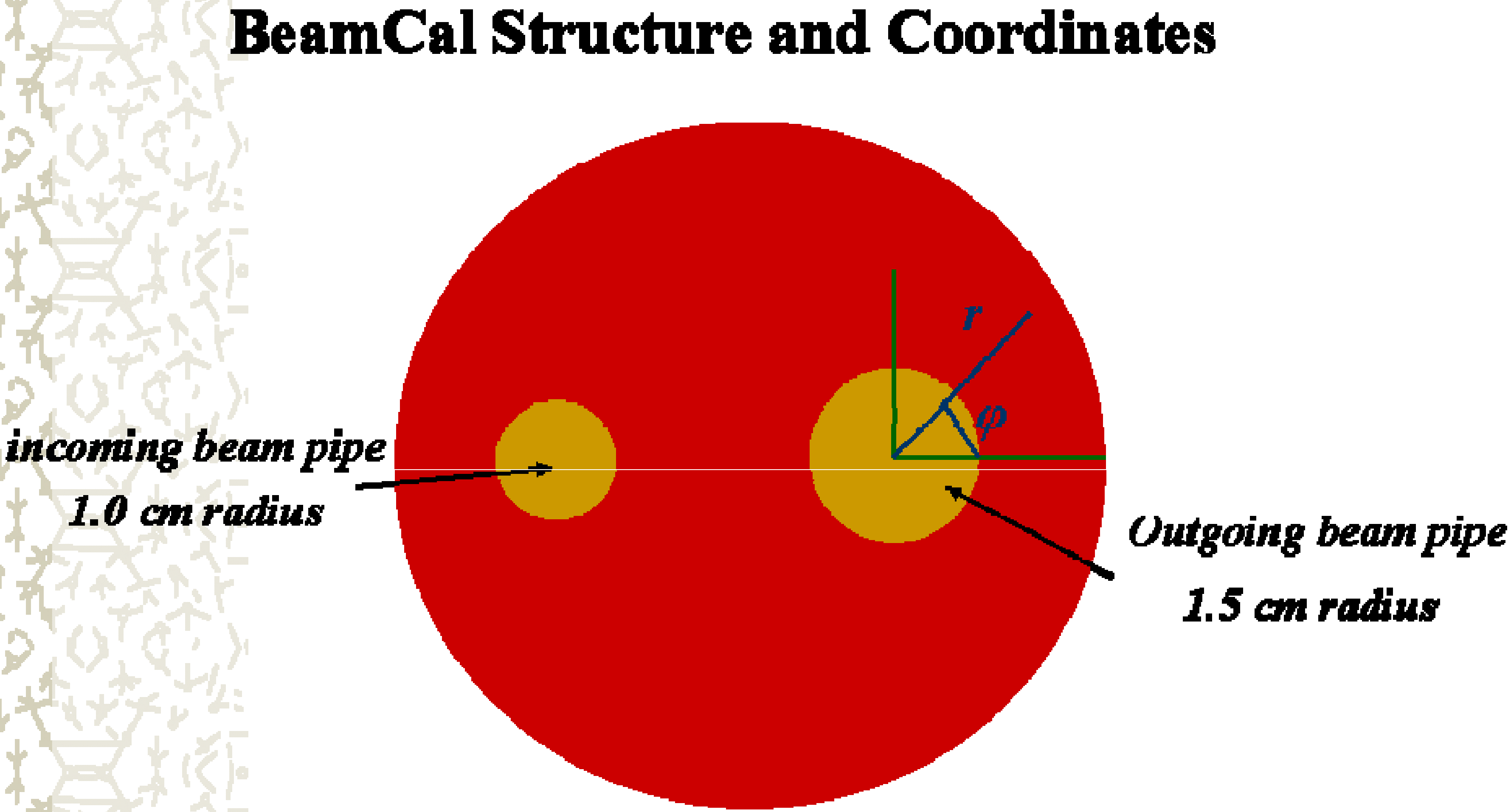
Anti-DID calibration



BeamCal Overview

- We require a detector in the far forward region to veto two-photon events
- This study pertains to the two-photon events with a 4-lepton final state, where the two primary leptons go into the BeamCal
- Analysis is difficult in this region due to very large beamstrahlung deposition

BeamCal Overview



Simulation Overview

- Scan across the BeamCal with e- of various energies
- Simulate beamstrahlung depositions
- Overlay each high energy e- shower with random beamstrahlung deposition
- Subtract average beamstrahlung deposition from each overlayed shower

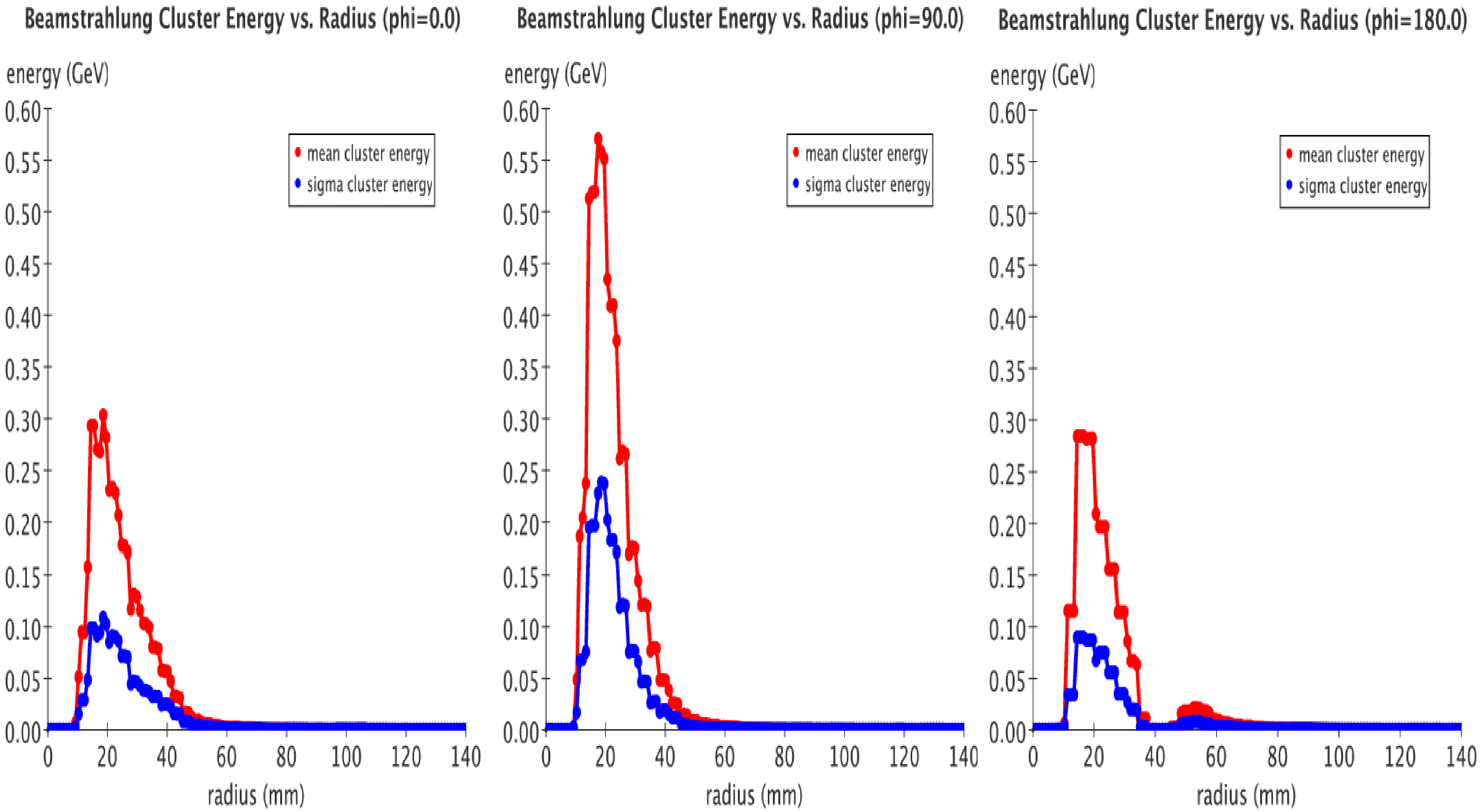
Beamstrahlung

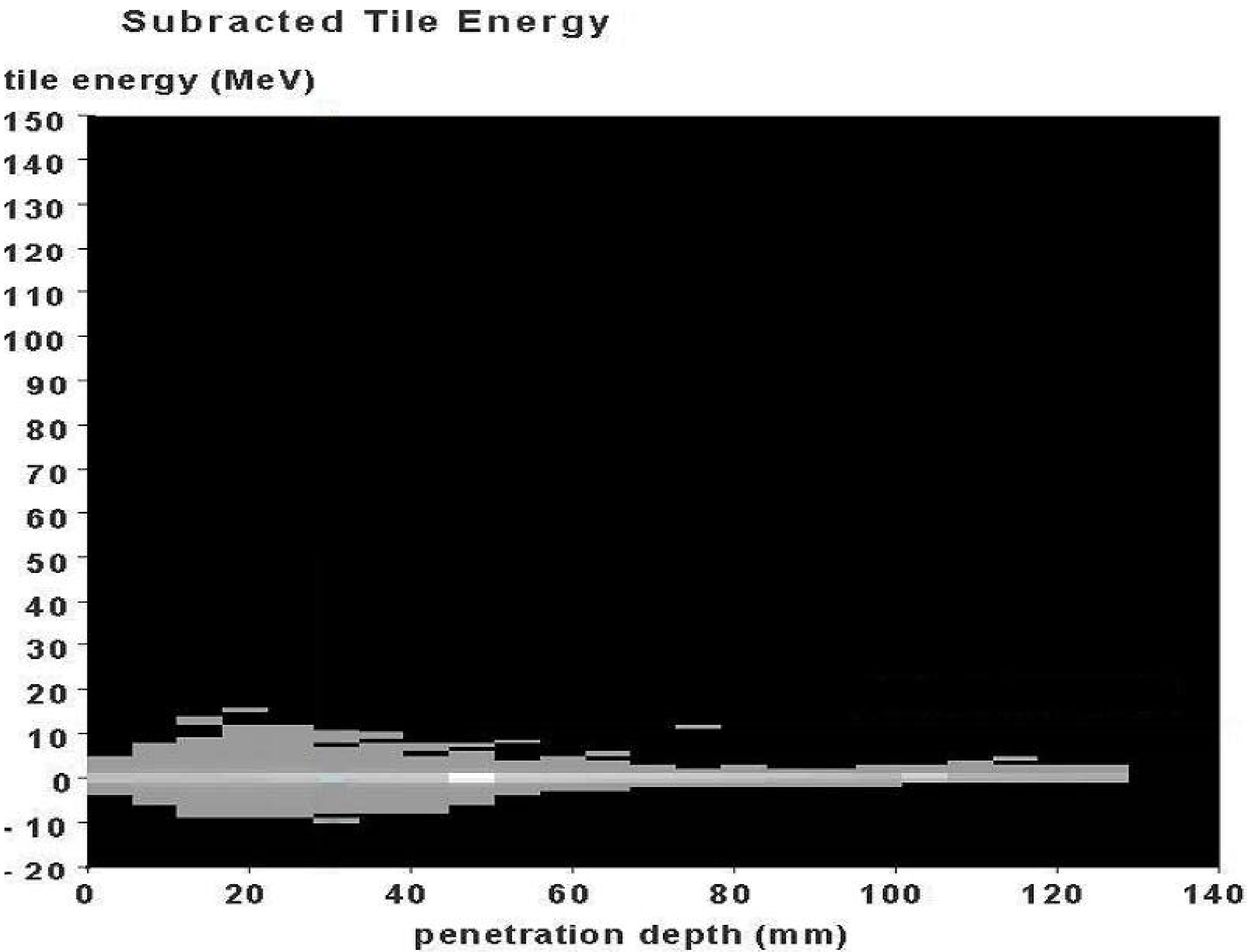
- 10k crossings created with GuineaPig event generator
- Each crossing corresponds to 500GeV c.m. energy
- Lorentz boost in +x direction to account for crossing angle

Table of Mean Beams.

- Two tables: one has averages for each tile, one has averages for each (r, φ)
- Use the entire sample of 10k bunch crossings
- For each tile in the BeamCal, calculate the mean and sigma energy deposition due to beamstrahlung
- When analyzing high energy e- shower, subtract this mean from each tile in the overlayed shower

Table of Mean Beams.




Subracted Tile Energy
tile energy (MeV)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
penetration depth (mm)

High Energy Electrons

- Events created with the GEANT4 General Particle Source (GPS)
- E= {50GeV, 100GeV, 150GeV}
- r = [0,150mm] (at z=2950mm)
- φ = 90°
- Overlay each e- shower with the shower from a randomly chosen beamstrahlung crossing

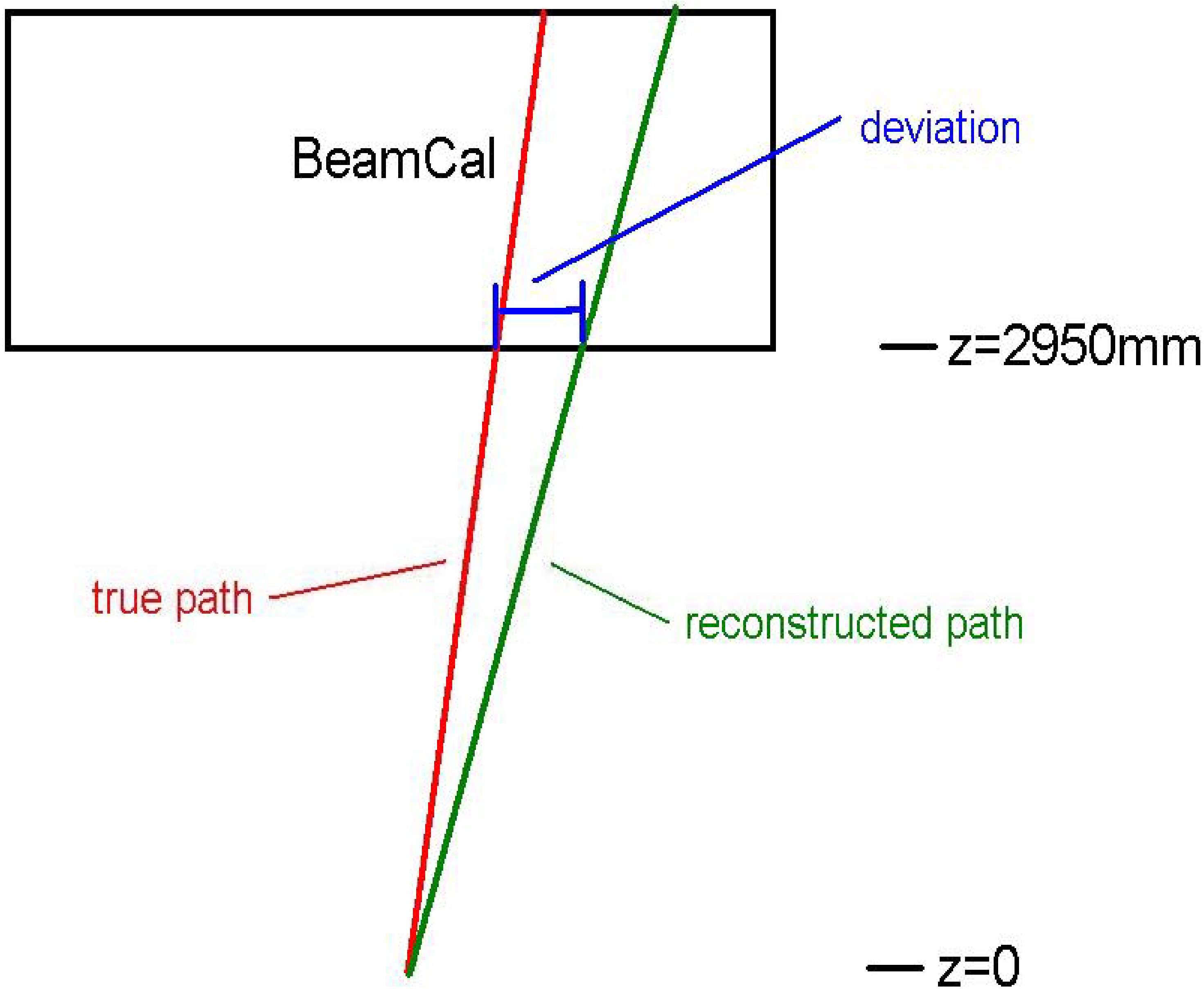
Identification Efficiency

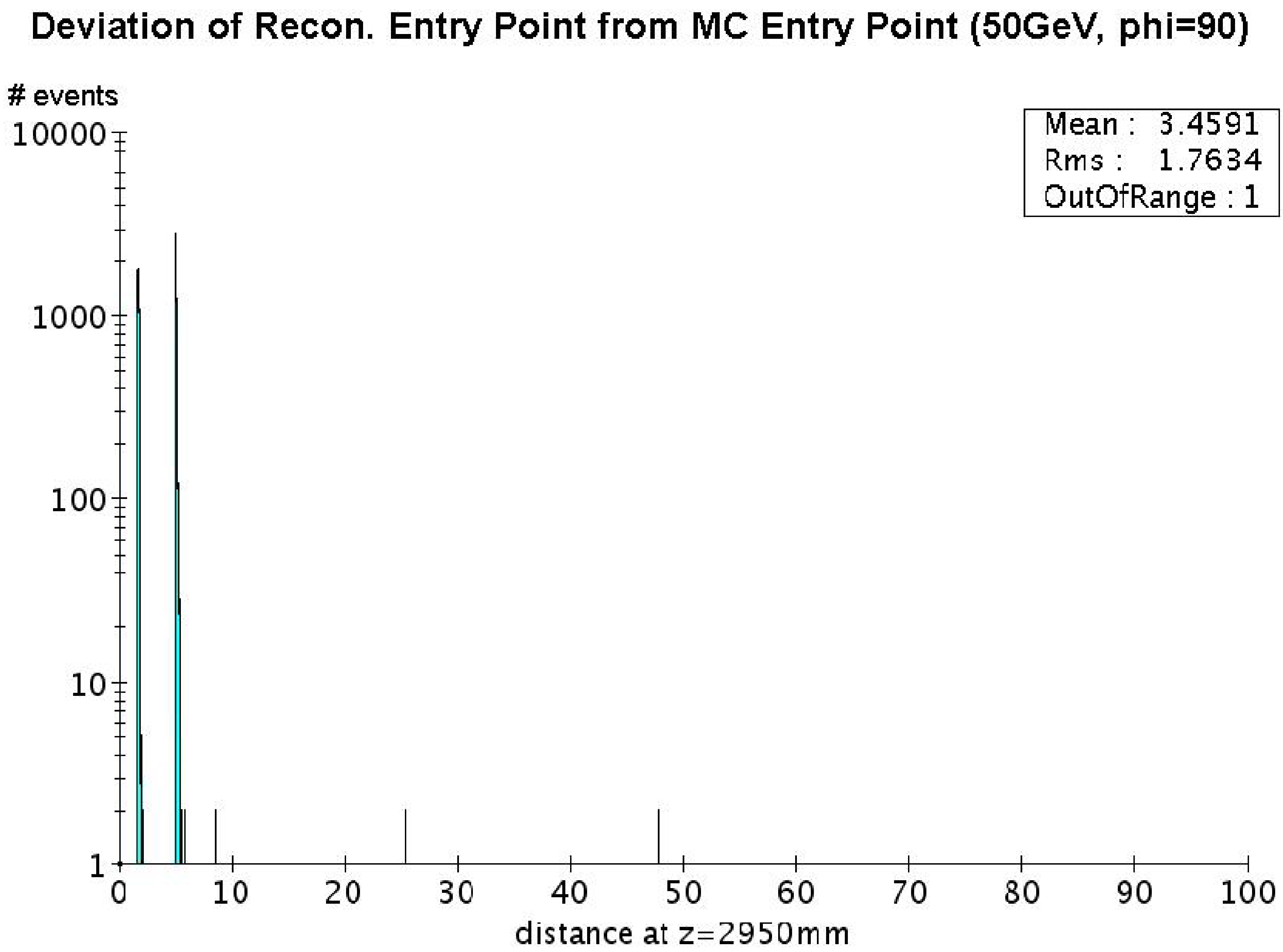
If a high energy e- showers on the BeamCal, how often will we see this with absolute certainty?

1. Find probable shower axis
2. Measure energy deposition about the axis

1. Finding the shower axis

1. Find tile with the highest energy (after the mean beams. deposition has been subtracted from each tile)
2. Assume electron passed directly through this tile
3. Draw line from IP through the tile, take this line as the path of the electron through the detector

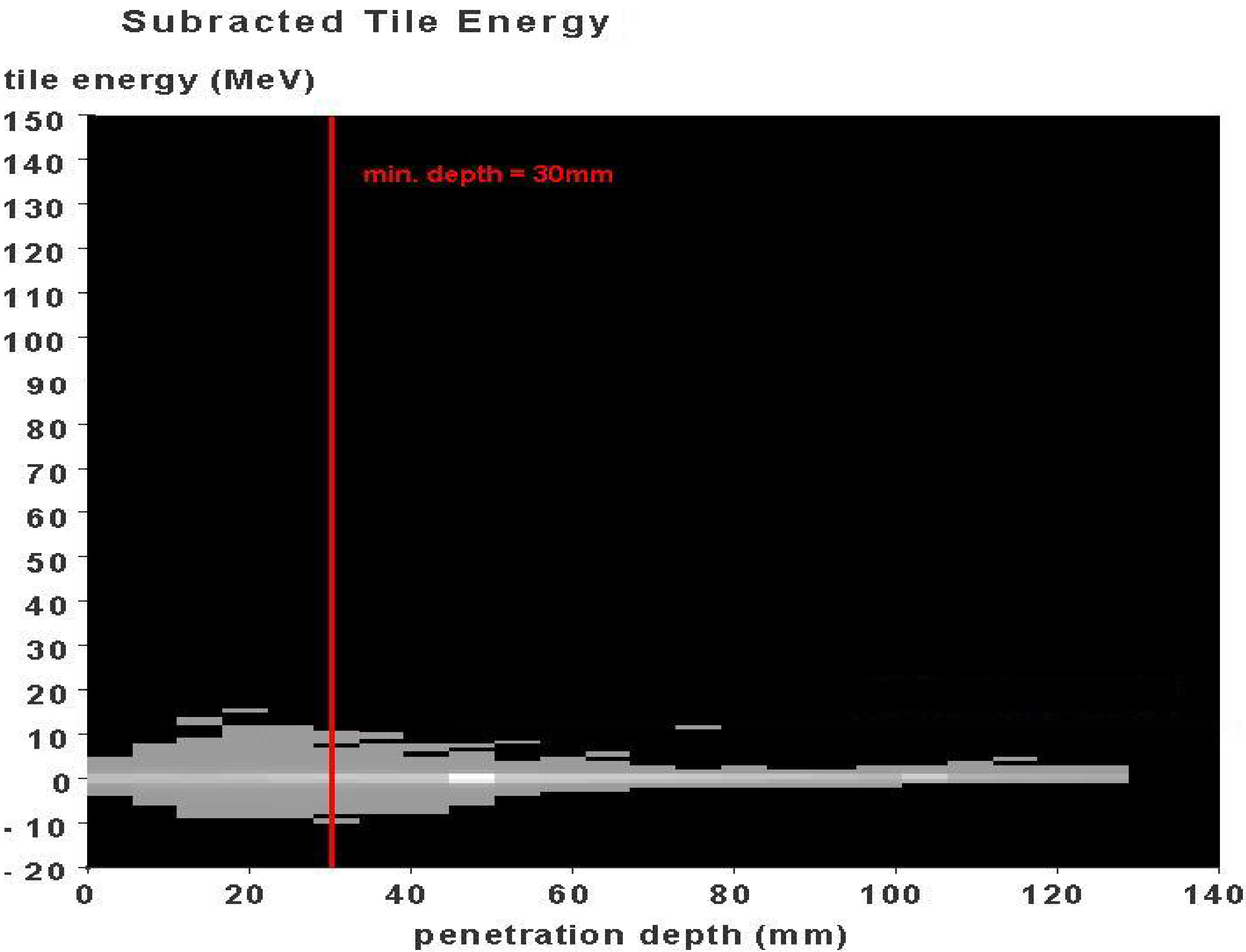

BeamCal
deviation
z=2950mm
true path
reconstructed path
z=0


Deviation of Recon. Entry Point from MC Entry Point (50GeV, phi=90)
events
Mean : 3.4591
Rms : 1.7634
OutOfRange : 1
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
distance at z=2950mm

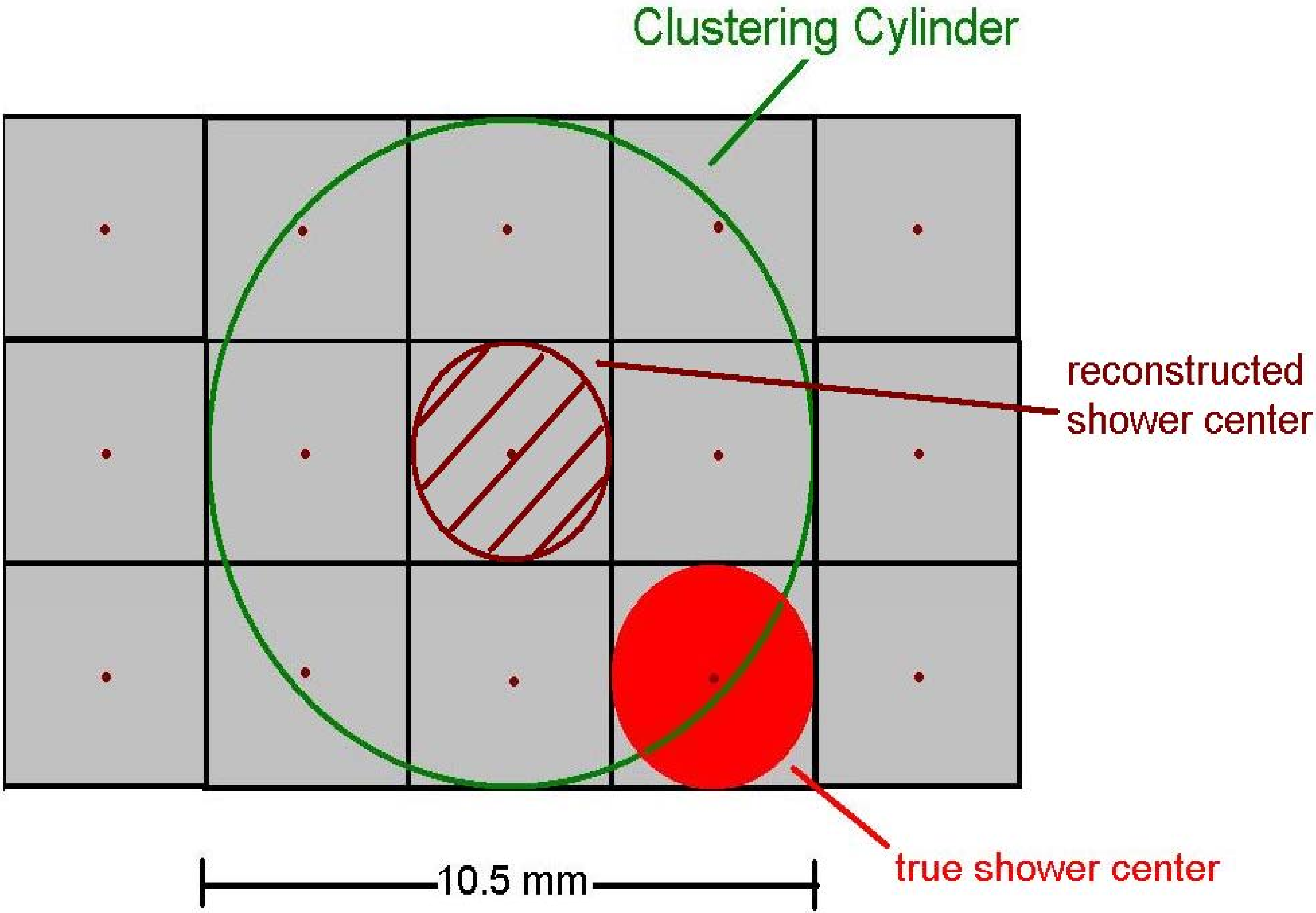
2. Measure shower energy

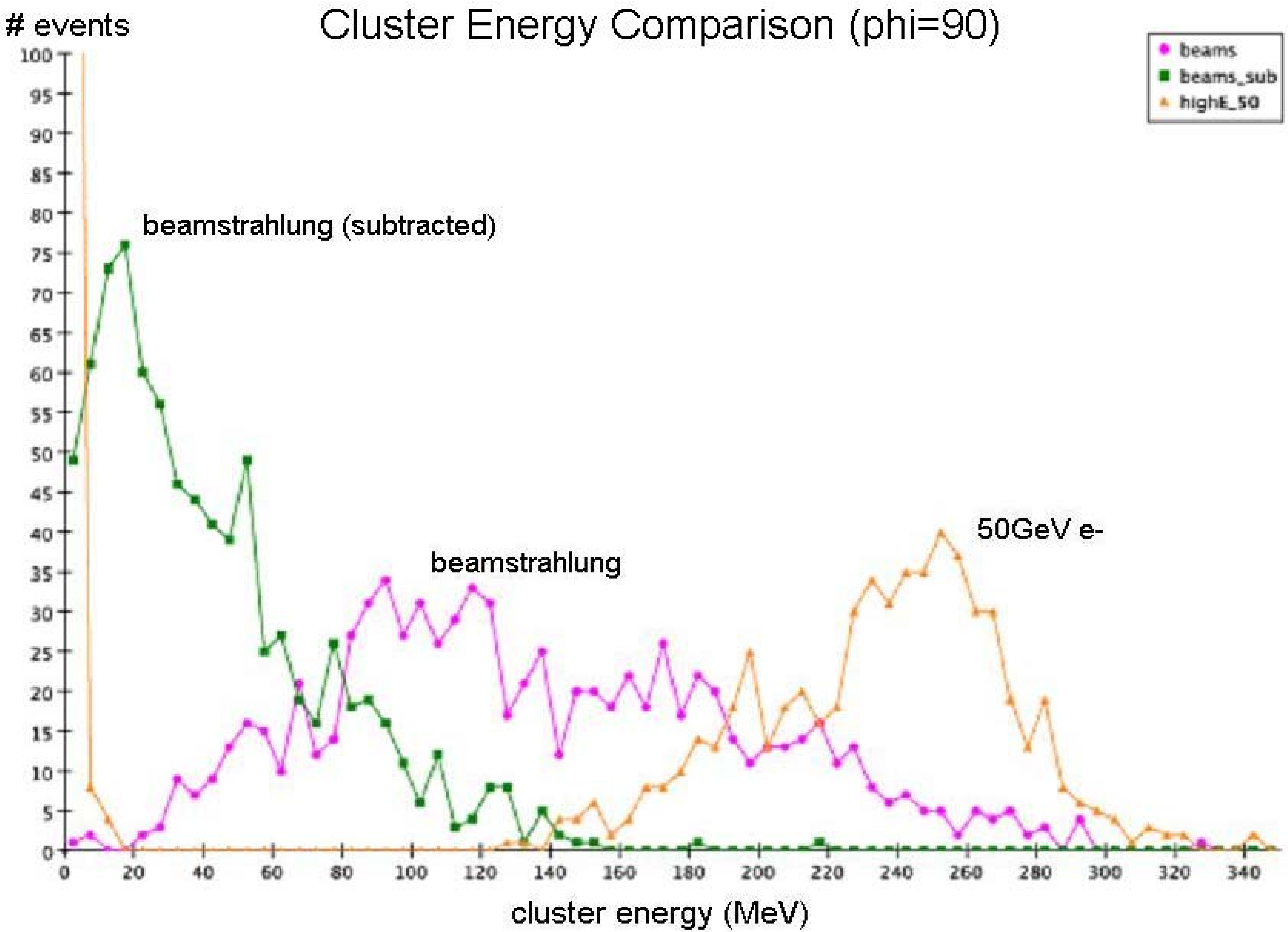
- Apply 10.5mm cylindrical clustering about shower axis (cylinder is 3 tiles wide, so for majority of cases we're guaranteed to have the center of the shower within the cylinder)
- Apply 30mm depth cut (majority of beamstrahlung deposition is from low energy pairs, shallow deposition)
- If the resulting shower energy is 3x greater than the sigma of the expected beamstrahlung for the cluster, we say that we have positively identified a high energy electron shower:

$$E_{\text{overlayed signal}} - \bar{E}_{\text{beams}} > 3^{*}\sigma_{\text{beams}}$$

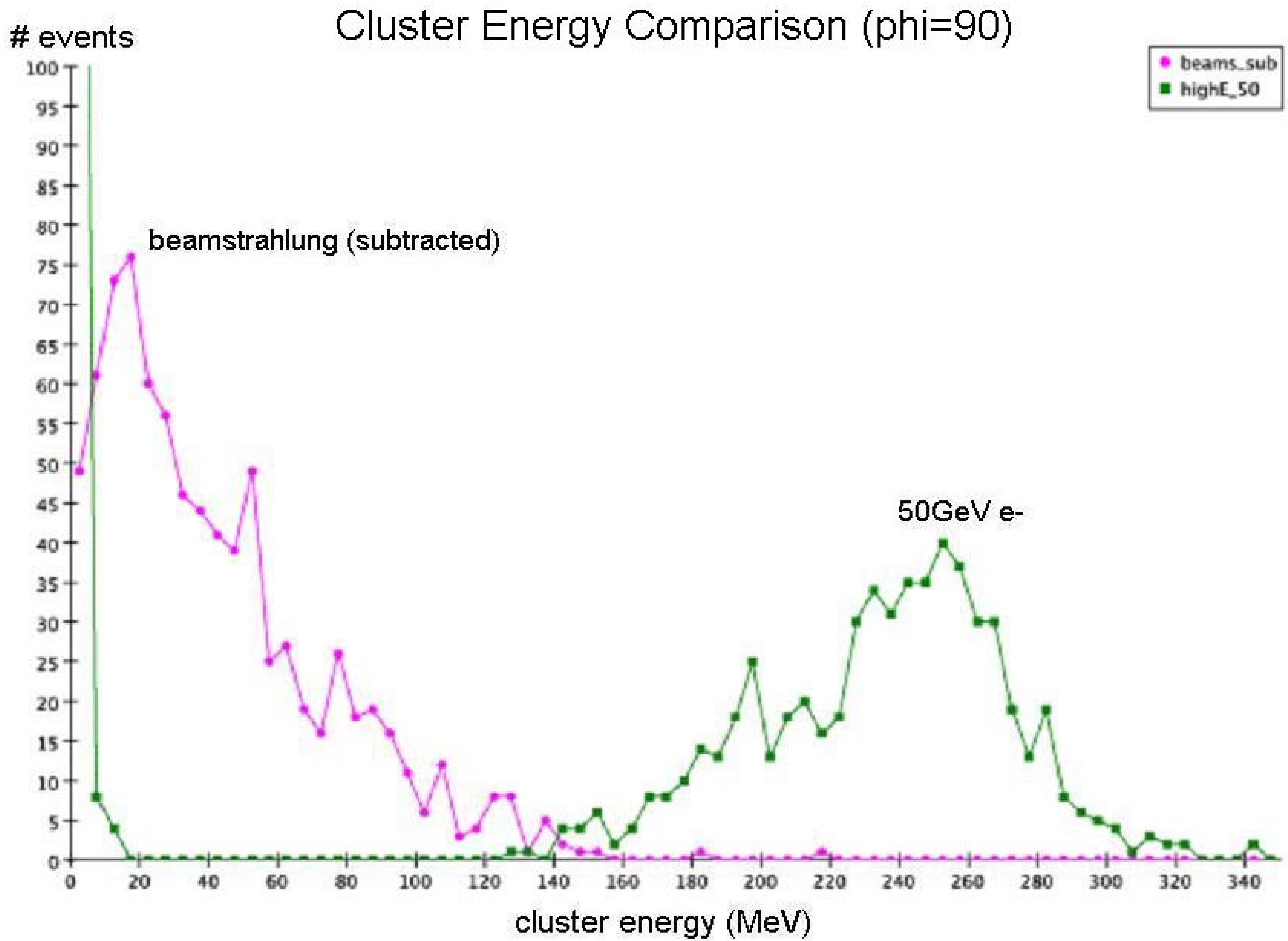


Subracted Tile Energy
tile energy (MeV)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
min. depth = 30mm
0
20
40
60
80
100
120
140
penetration depth (mm)


Clustering Cylinder
reconstructed shower center
10.5 mm
true shower center



Cluster Energy Comparison (phi=90)
events
beams
beams_sub
highE_50
beamstrahlung (subtracted)
beamstrahlung
50GeV e-
cluster energy (MeV)

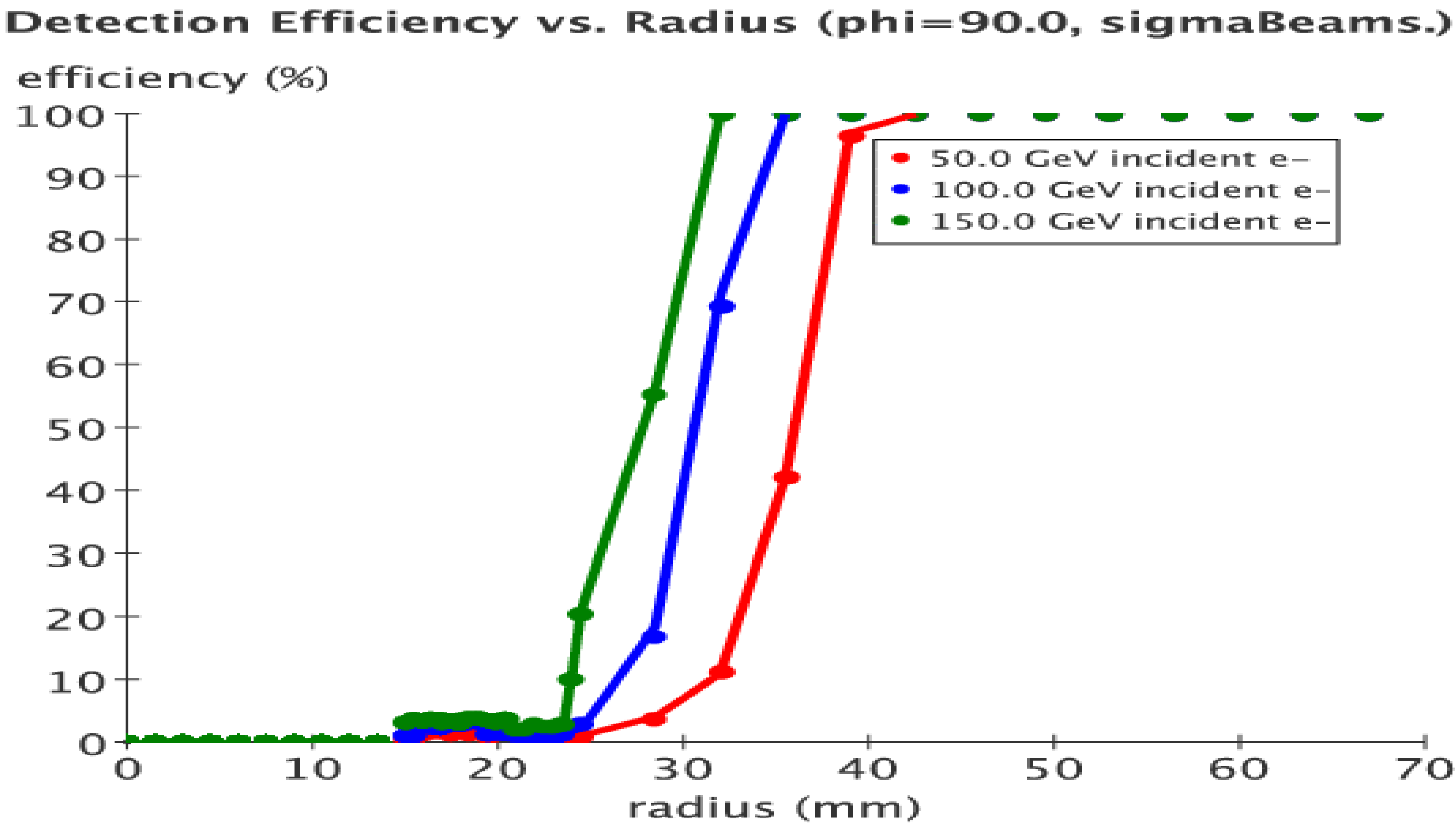


Cluster Energy Comparison (phi=90)
events
beams_sub
highE_50
beamstrahlung (subtracted)
50GeV e-
cluster energy (MeV)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340

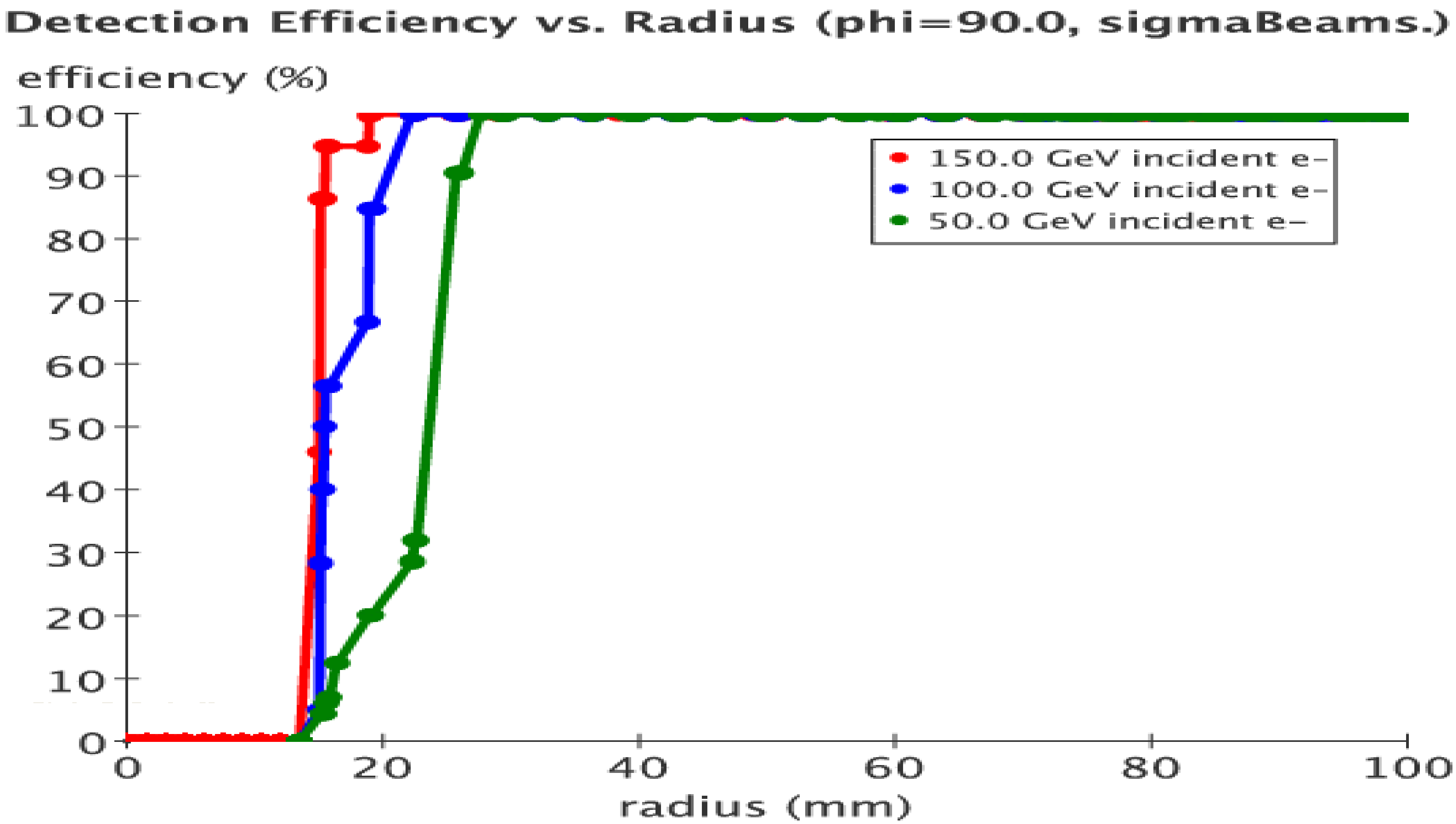
3. Overall Detection Efficiency

- The probability of seeing an event should roughly be the product of the probability of reconstructing it's path **and** of seeing the required three sigma deposition
- We obtain the overall efficiency in the following way:
  - Reconstruct path (1)
  - Check for three sigma cluster energy (2)
  - Average over 250 high energy e- events for every measured (r, φ) to get the efficiency at that point
- **Purity = ~90%** (972 false positives out of 10,000 events)

Old Result


Detection Efficiency vs. Radius (phi=90.0, sigmaBeams.)
efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
radius (mm)
50.0 GeV incident e−
100.0 GeV incident e−
150.0 GeV incident e−

New Result

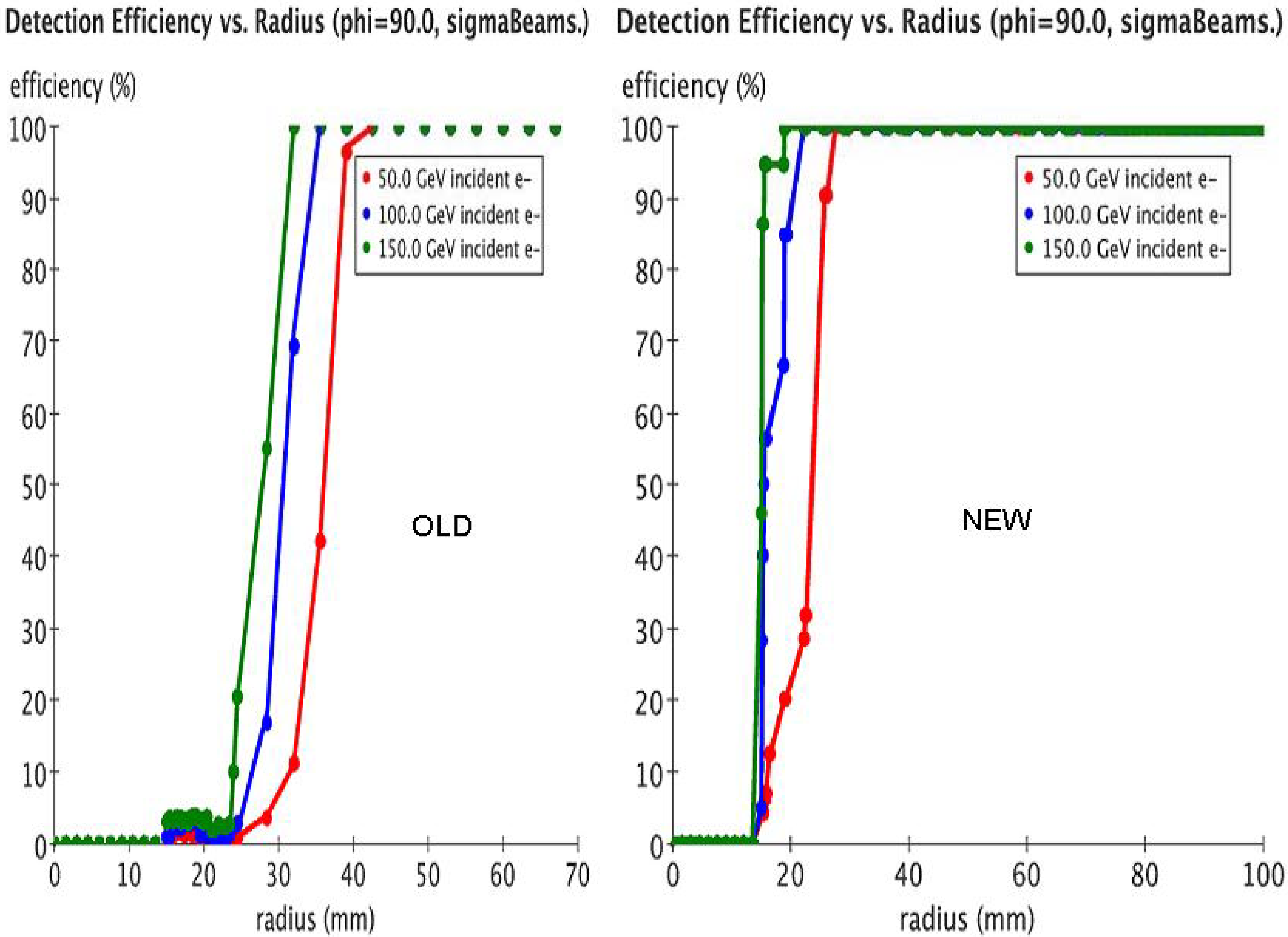

Detection Efficiency vs. Radius (phi=90.0, sigmaBeams.)
efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
radius (mm)
150.0 GeV incident e-
100.0 GeV incident e-
50.0 GeV incident e-

Old Result

- Results generated with the same method as I just described for the new results
- Only difference between new and old method is the parameters of the clustering algorithm:

  -20mm cylinder width

  -no depth cut
- These are the efficiencies currently in the LOI



Detection Efficiency vs. Radius (phi=90.0, sigmaBeams.)
efficiency (%)
50.0 GeV incident e-
100.0 GeV incident e-
150.0 GeV incident e-
OLD
radius (mm)
Detection Efficiency vs. Radius (phi=90.0, sigmaBeams.)
efficiency (%)
50.0 GeV incident e-
100.0 GeV incident e-
150.0 GeV incident e-
NEW
radius (mm)

To Do

- Get data for various φ
- Insert fieldmap & antiDiD into SiD02
- Redo everything with new modified SiD02
- Measure efficiencies for lower energy (25GeV) e-