Electron Detection in the SiD BeamCal

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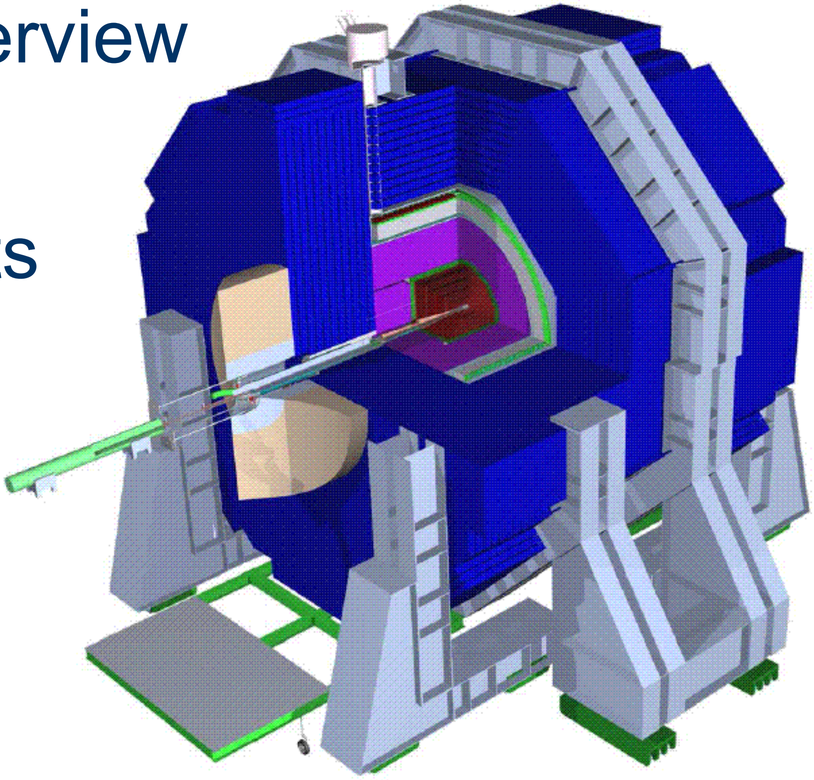
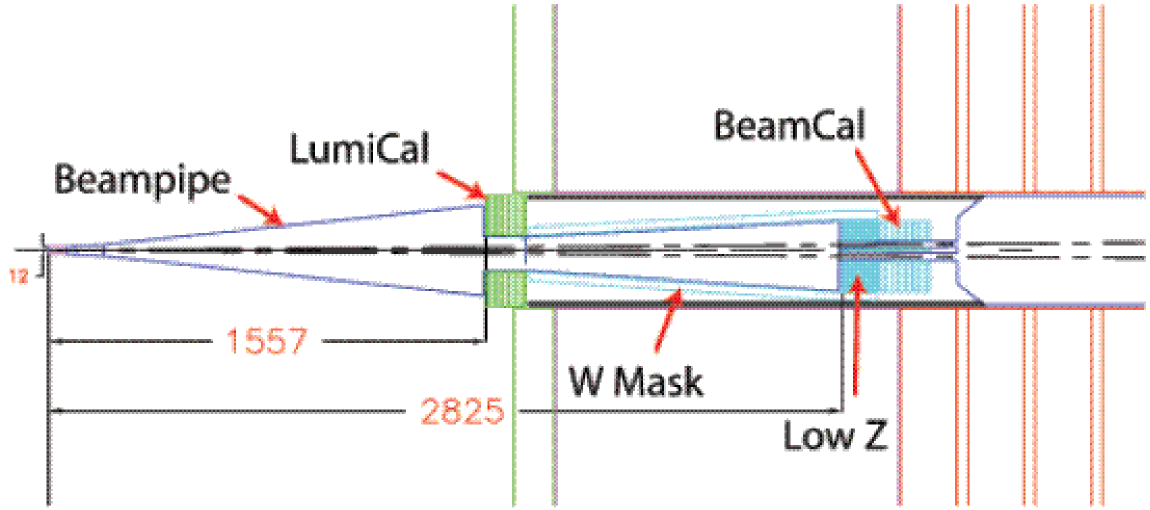
Outline

1. SiD & BeamCal overview
2. Software
3. Generating Datasets
4. Analysis
5. Conclusion



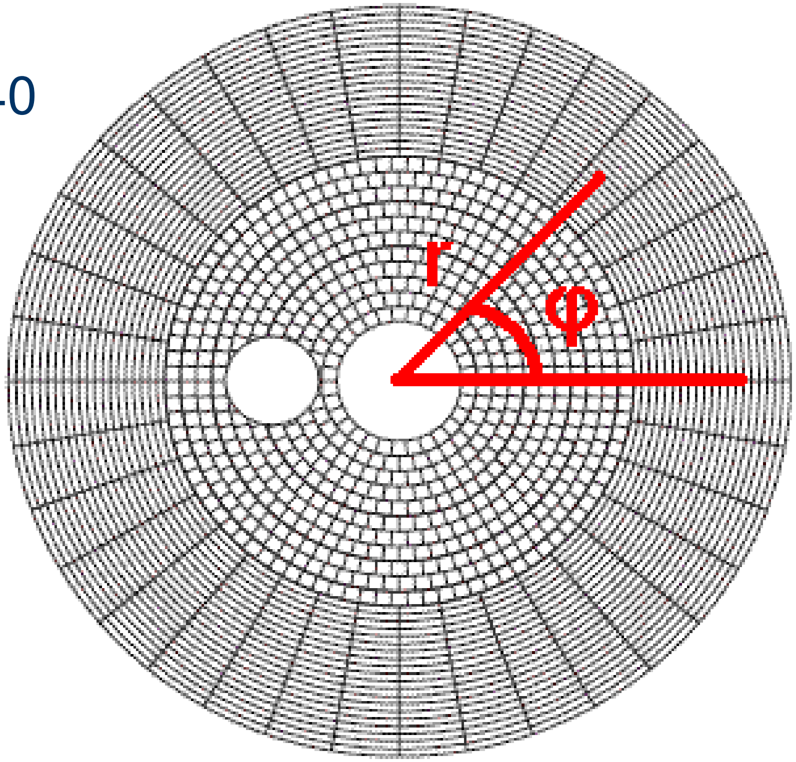
1. SiD Overview

- SiD is currently at version 2 (Febuary 2009)
- 5T solenoid based on CMS design
- Anti-DiD field reduces pair deposition from 20 TeV to 10 TeV



1. BeamCal Overview

- BeamCal at z_{in}= 295cm, z_{out}= 320cm
- Covers polar angles 3 mrad to 40 mrad, with r_{in}= 1.5cm (exit beampipe), r_{out}= 14.5cm
- Inner tiles ~ 3.5mm x 3.5mm
- 50 layers tungsten + silicon



BeamCal sensor and segmentation.

2. Software

- GUINEAPIG used to generate the beamstrahlung background. ILC nominal 500 GeV beam parameters were used
- SLIC, an implementation of Geant4, was used to generate high-energy electron events, and to shower the background and the electrons
- Analysis was done with the org.lcsim package, a java-based reconstruction framework

3. Generating Data Sets

1. Develop detector model
2. Generate high-energy e- events and shower them
3. Generate beamstrahlung bunches and shower them
4. Overlay the high-energy e- events with beams. showers

3. Generating Data Sets - Detector Sim

- Used SiD02 compact.xml available on SiD confluence site with SLIC
- Features all sub detectors with proper segmentation and composition
- 5T solenoid field (we replaced the simple solenoid field with a field-map description that is also available on the confluence site)
- Anti-DiD field calibrated to maximize pair deflection into exit beampipe (10TeV still reaches the BeamCal)

3. Generating Data Sets - Electrons

- Shot electrons at the BeamCal with the GEANT4 General Particle Source (GPS)
- r = [0,150mm] (at z=2950mm, isotropic distribution)
- φ = 0°, 90°, 180°
- E=50GeV, 100GeV, 150GeV
- For each energy and φ, we generated 2000 e- events
- Showered with SLIC

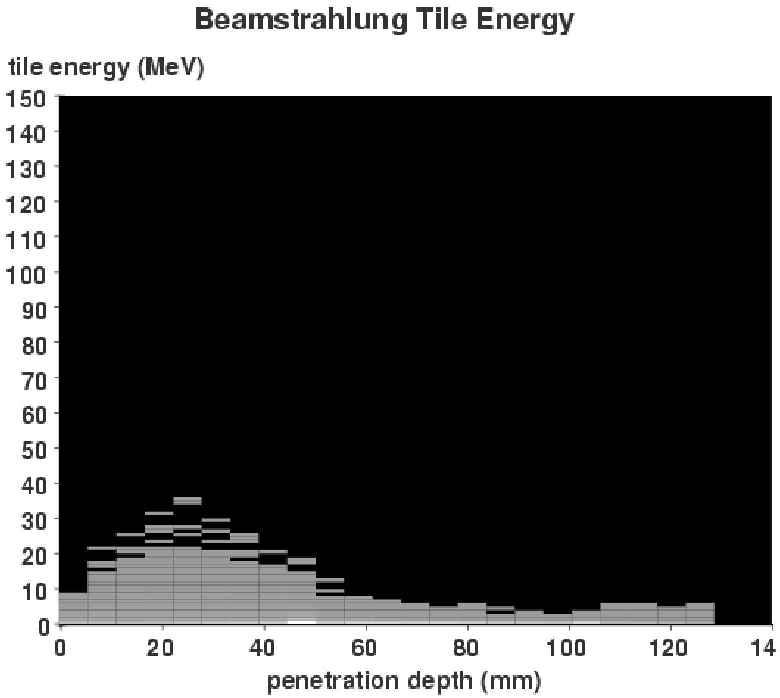
3. Generating Data Sets - Beamstrahlung

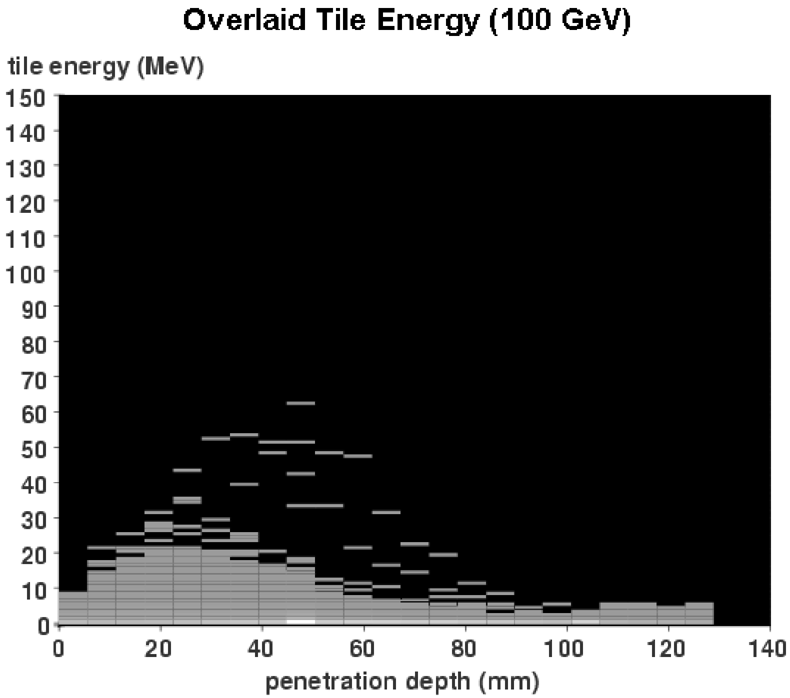
- 10k bunch crossings simulated with GUINEAPIG
- Acc.dat available on:

  http://hep-www.colorado.edu/~oleinik/acc.dat
- Showered with SLIC

3. Generating Data Sets - Overlaying

- For each e- shower, pick a random bunch crossing shower & simply sum the tile energies





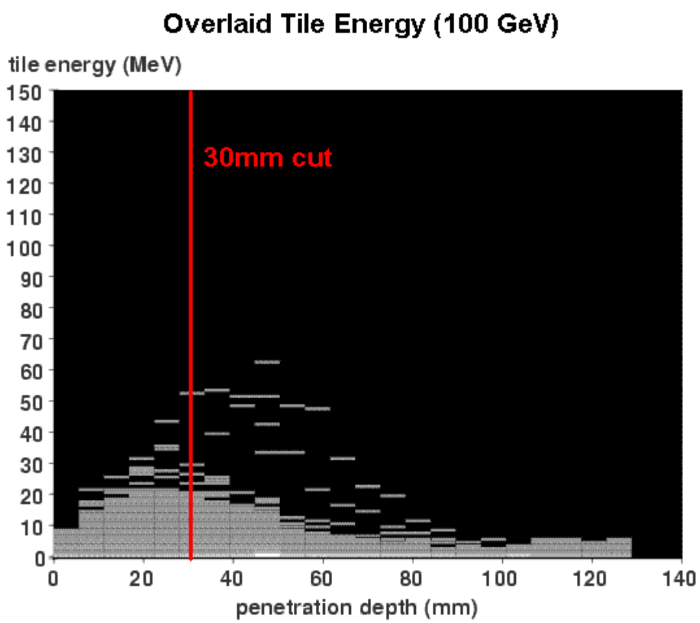
4. Analysis - Overview

- Strategy: tag high-energy electron events by comparing output of clustering algorithm to average beamstrahlung measurements. Beamstrahlung is big challenge.
- Clustering:
  1. Determine probable shower axis - (r, φ)
  2. Apply geometric cuts around the axis
  3. Subtract expected beamstrahlung deposition from the remaining shower

4. Analysis - Geometric Cuts

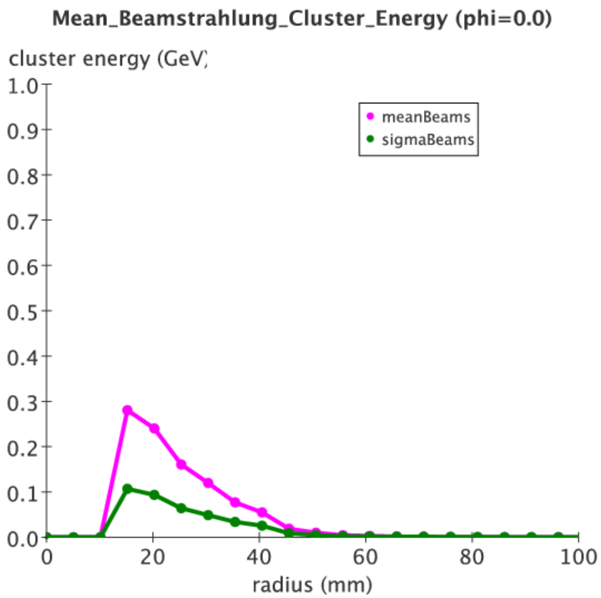
- Given an (r, φ), keep hits that are:
  1. Within 2 tile-widths of the axis; in other words, inside of a cylinder with r=5.5mm (cylinder 3 tiles wide, roughly Moliere radius)
  2. Deeper than 30mm

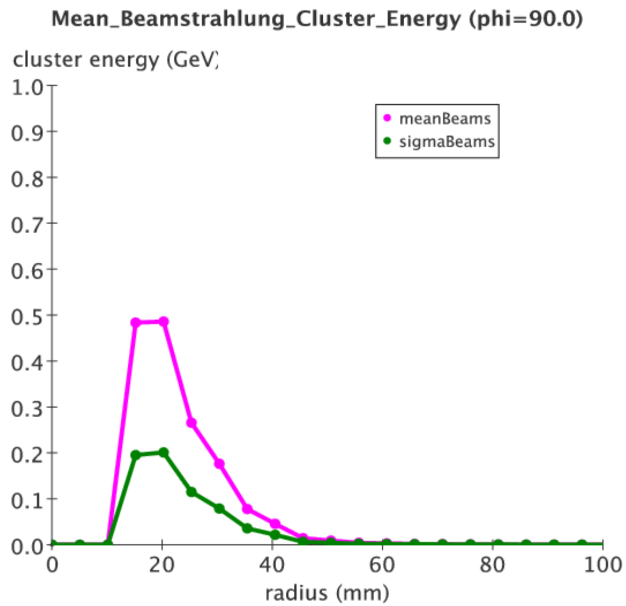
(majority of beamstrahlung deposition is from low energy pairs; shallow deposition)

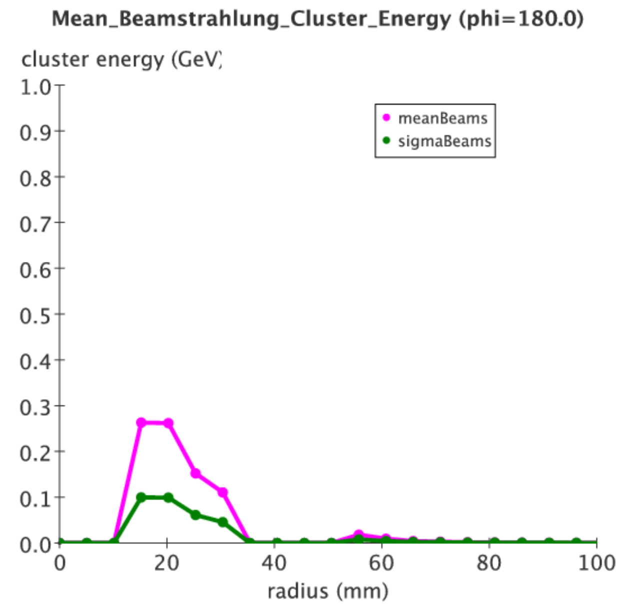


4. Analysis - Beamstrahlung Subtraction

- Table that associated each (r, φ) path through the BeamCal to a beams. mean and sigma







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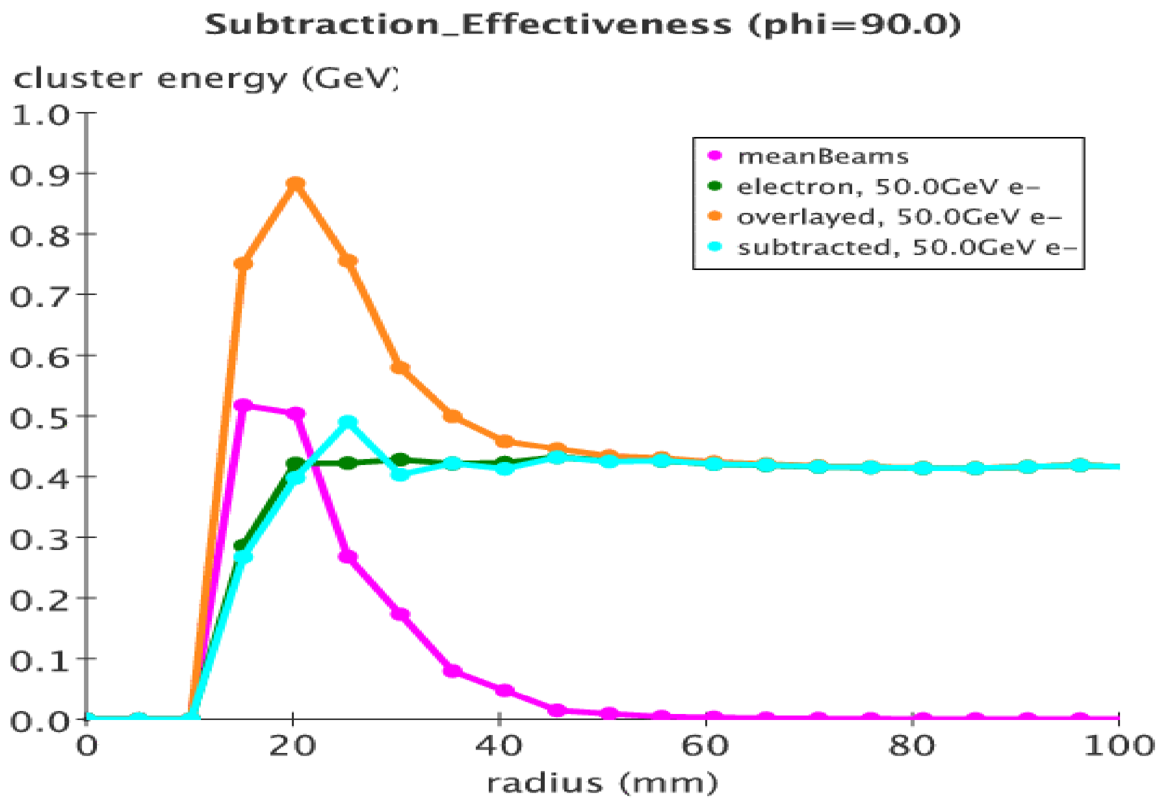

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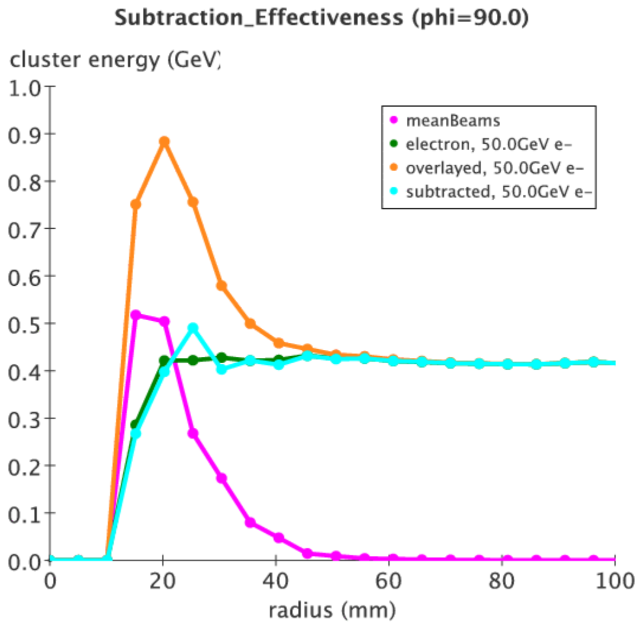
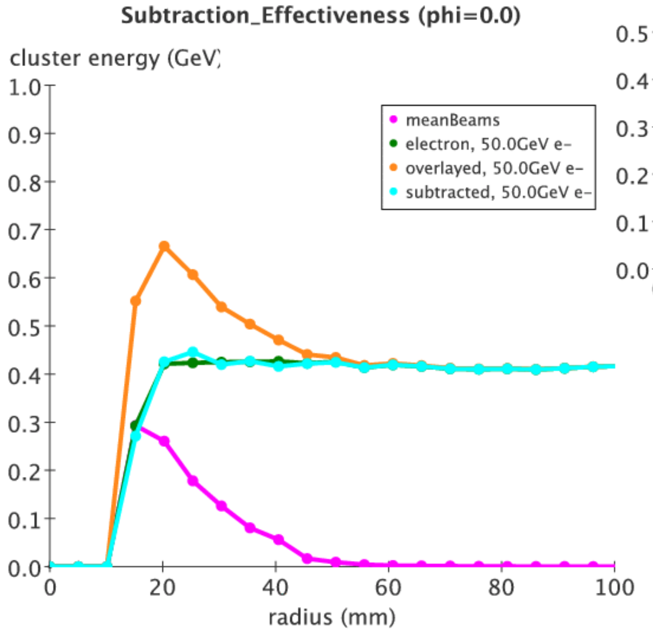
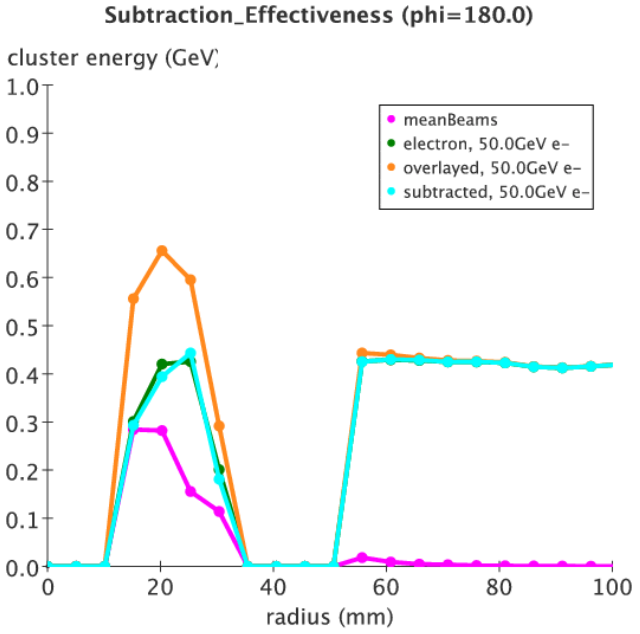


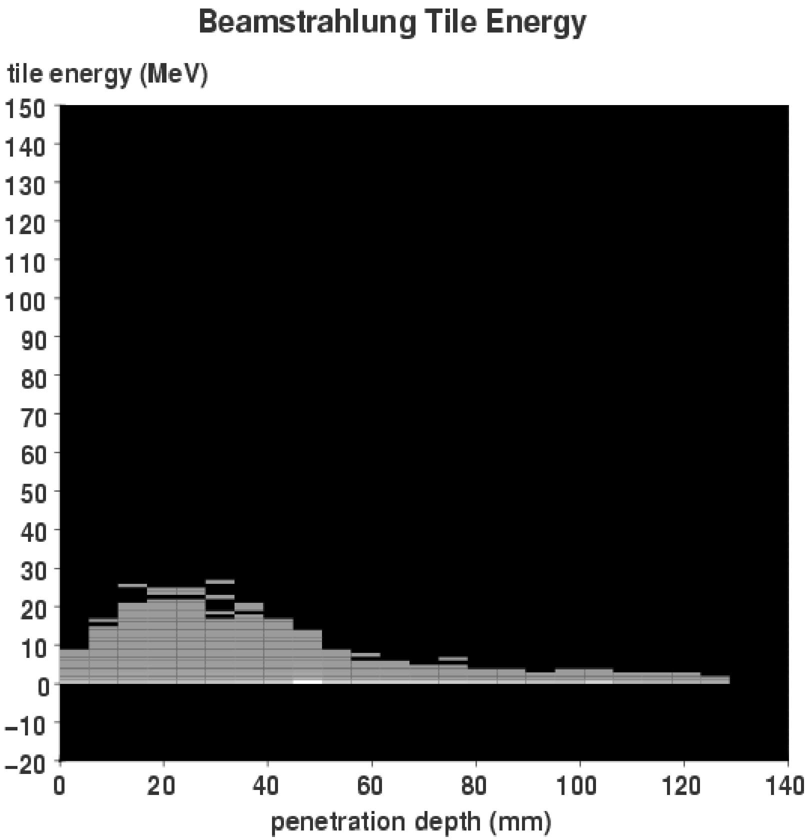


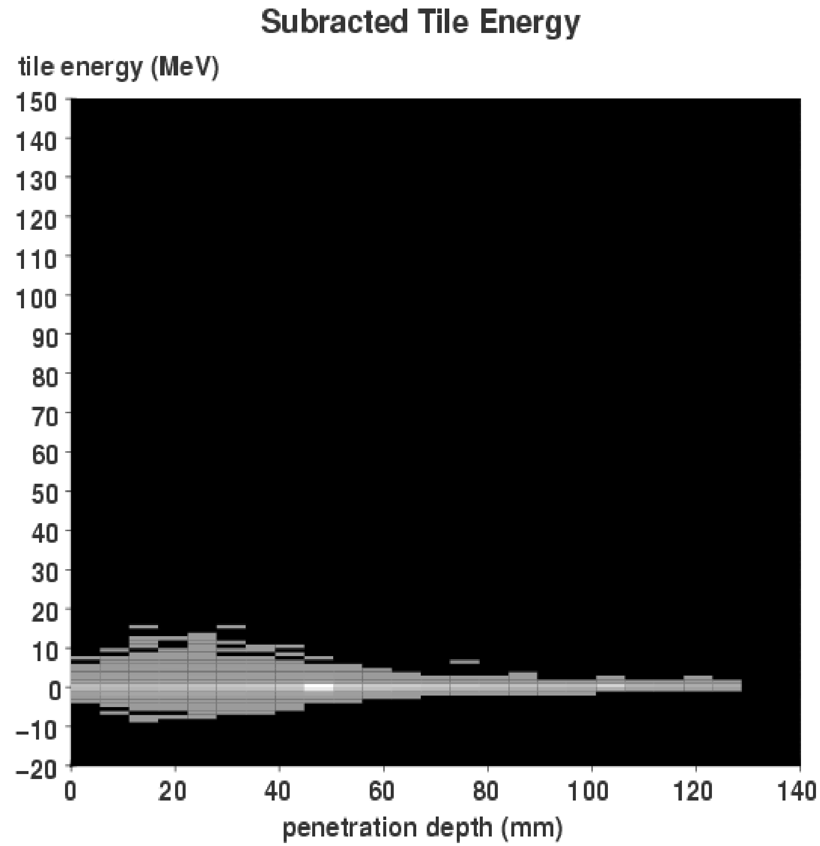


4. Analysis - Finding Shower Axis

1. Generated a *different* table of mean beamstrahlung deposition that correlated each **tile** in the BeamCal to an expected beams. deposition
2. For each overlaid event, we subtracted the average from each tile in the shower
3. We then found the tile with the highest remaining energy, and made the assumption that the high-energy e- passed through this tile in a straight line from the IP. Determine (r, φ) of e- trajectory.

4. Analysis - Finding Shower Axis





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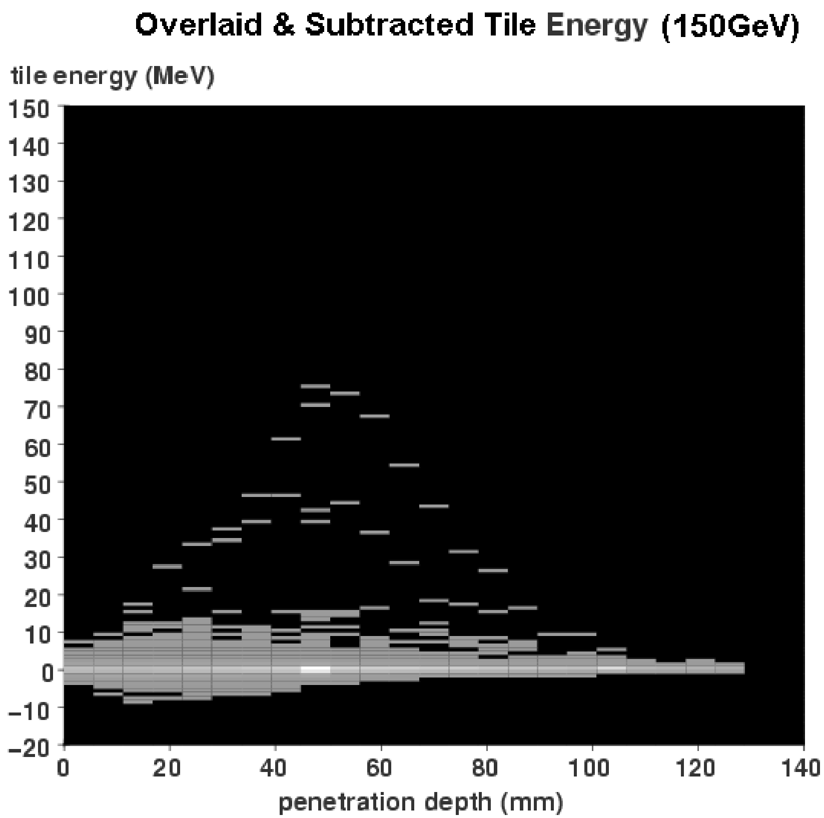


4. Analysis - Finding Shower Axis

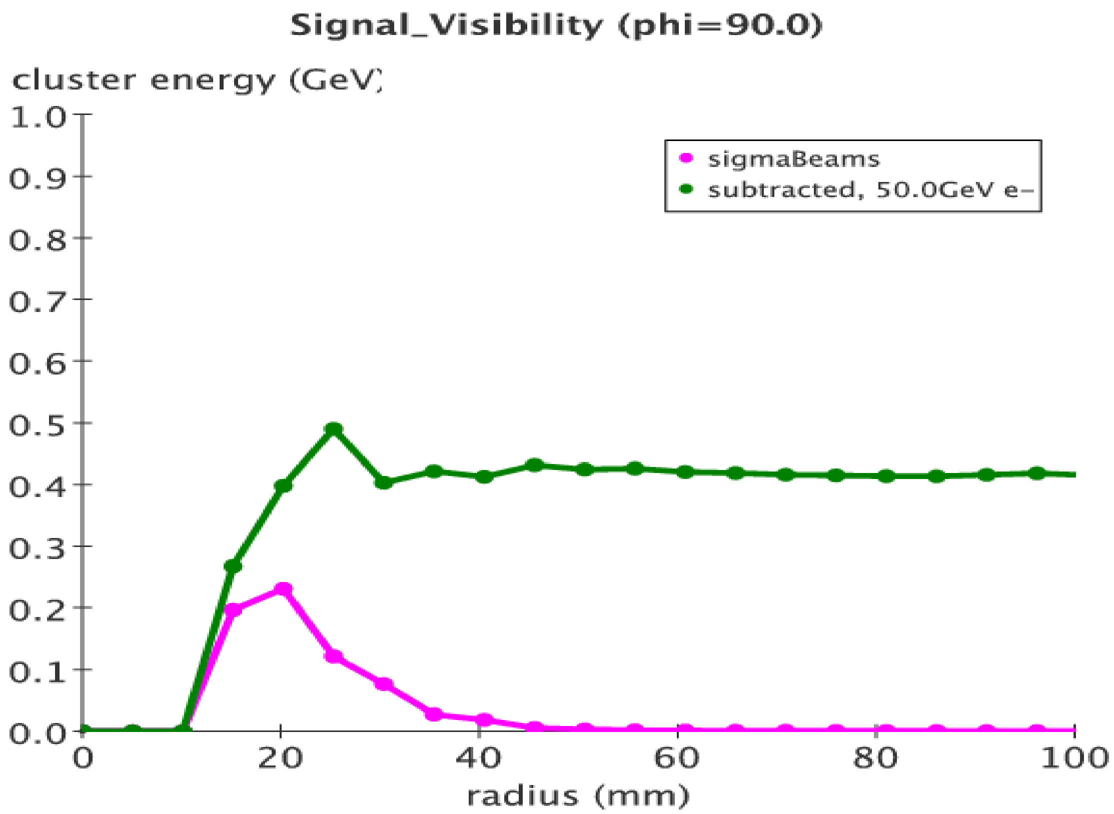
- Not the most sophisticated approach, but initial inspection revealed that it tended to produce good axis determination (to within 1 or 2 tile widths) for most events
- Ultimately, we are not studying how well we can determine the true axis, but how well we can guess that the e- is present; the suitability of this method is reflected in our efficiency results

4. Analysis - Cluster Energy

- We thus obtain a subtracted cluster energy for each event, and compare it to the sigma of the mean beamstrahlung energy for that axis
- If the subtracted energy is more than 3 x sigma, we tag the event as containing a high-energy e-

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

4. Analysis - Cluster Energy



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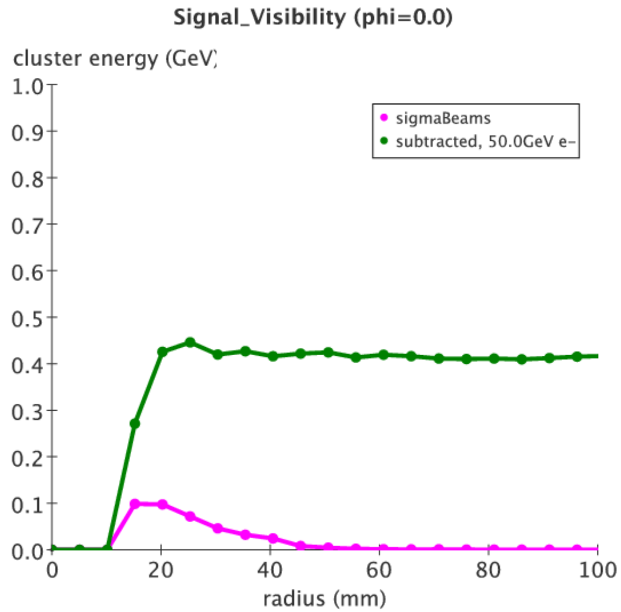
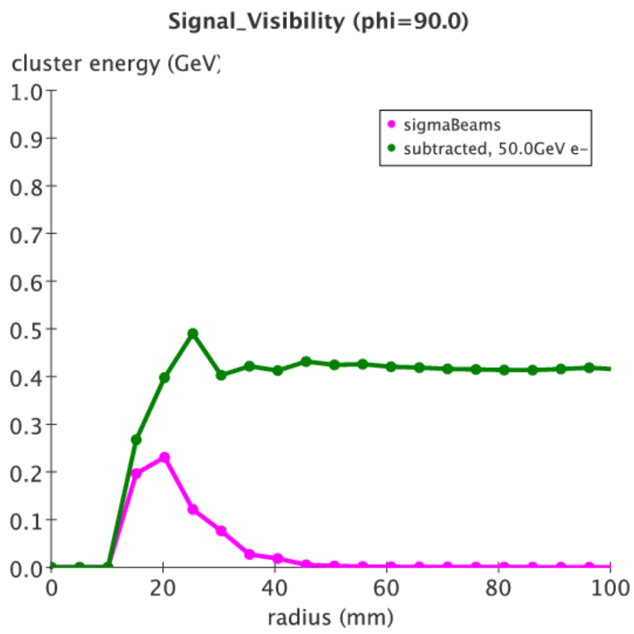
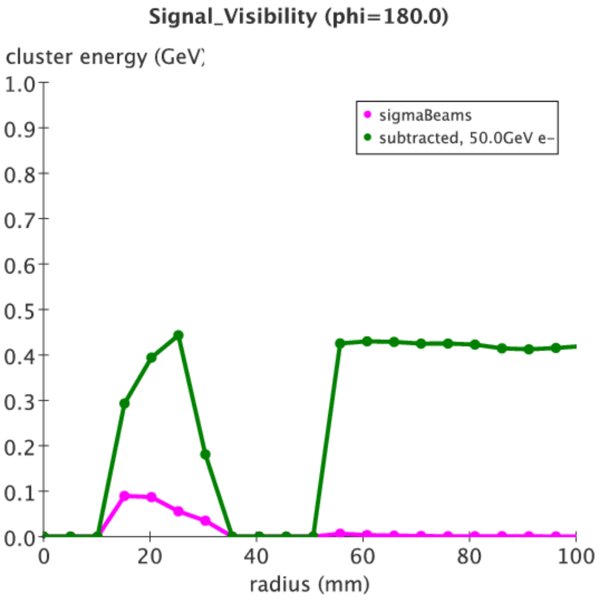
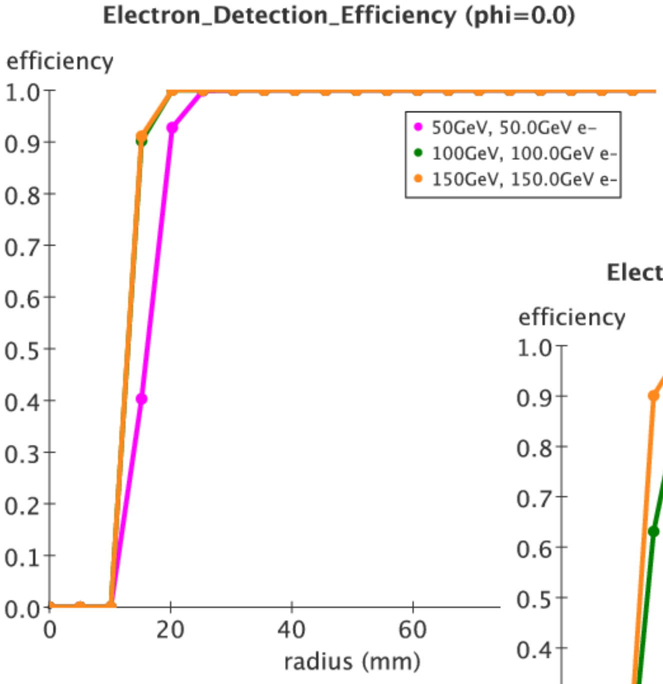
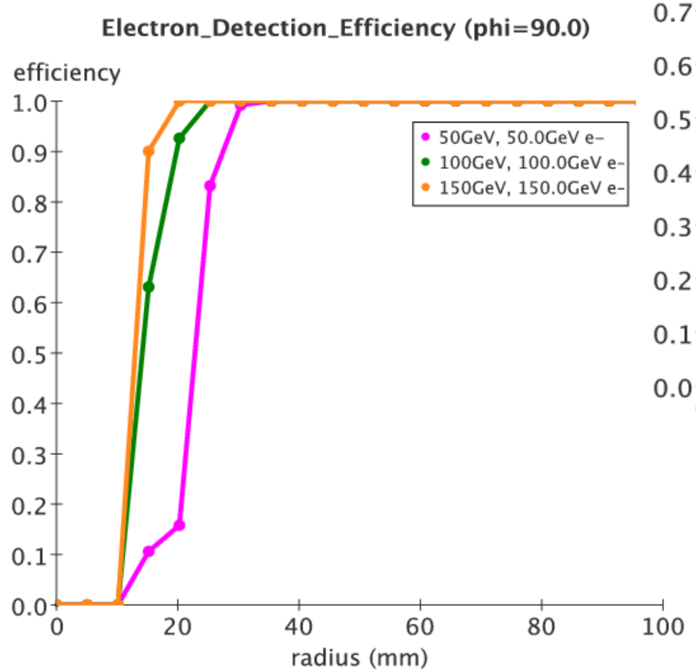


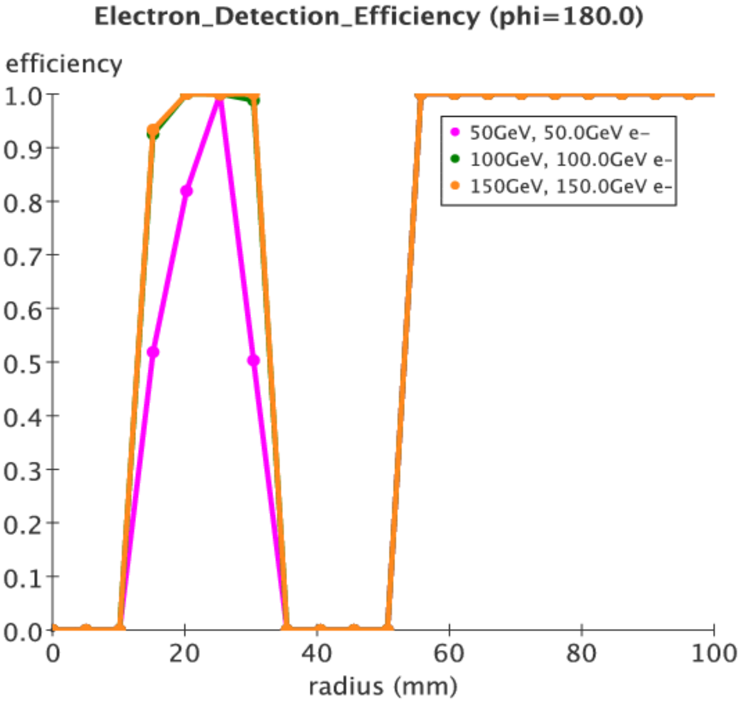




4. Analysis - Efficiency Results







4. Analysis - Purity

- Run *just the beamstrahlung* events through the algorithm (let it find a shower axis, a subtracted cluster energy, and compare to the beams. sigma as just described)
- 972 false positives out of 10,000 events
- Purity = ~90%

5. Conclusion

- Except for within 10mm (2-3 tiles) of the exit beampipe at 90°, we can almost always see even 50GeV e- (despite 10TeV background!)
- Next step is to investigate momentum resolution with these datasets
- With momentum resolution results, we can determine how well the two-photon background can be suppressed