Electron Detection in the SiD BeamCal

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Outline

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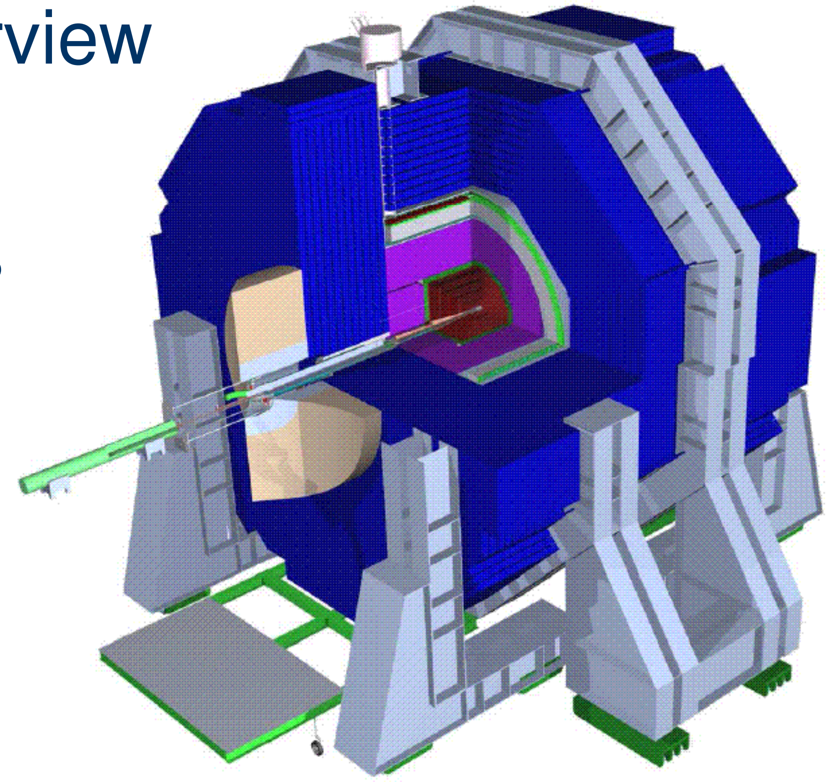
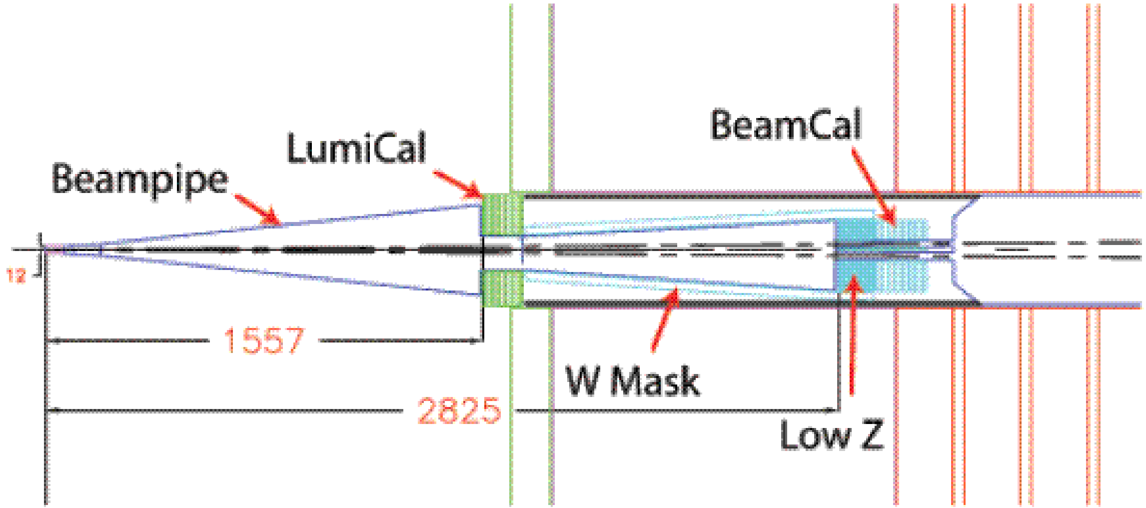
2. Software
3. Generating Datasets
4. Analysis
5. Two Photon Results
6. Conclusion



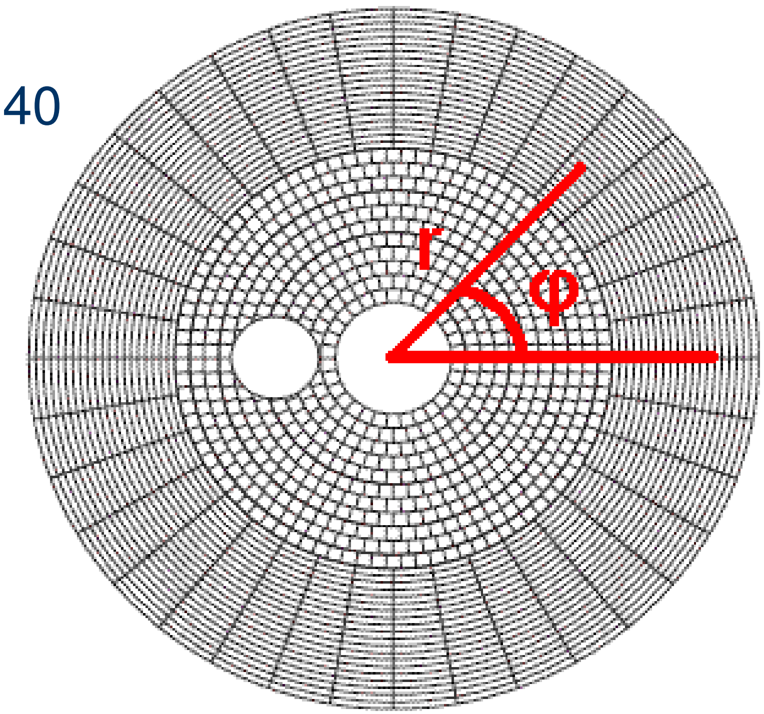
1. SiD Overview

- Using SiD 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

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)
- $\varphi = 0°, 90°, 180°$
- E=50GeV, 100GeV, 150GeV
- For each energy and φ, we generated 2000 e- events
- Showered with SLIC

3. Generating Data Sets - Beamstrahlung

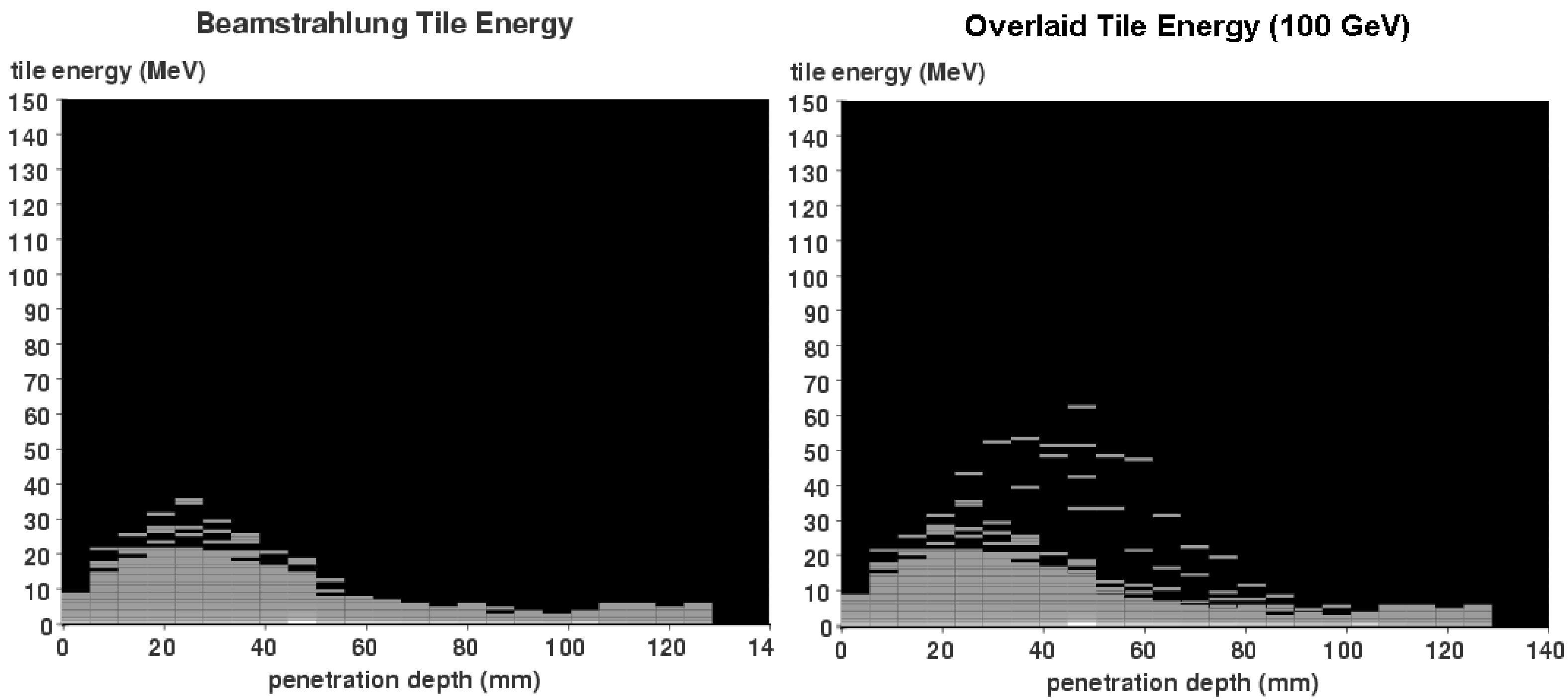
- 10k bunch crossings simulated with GUINEAPIG
- Acc.dat available on:

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



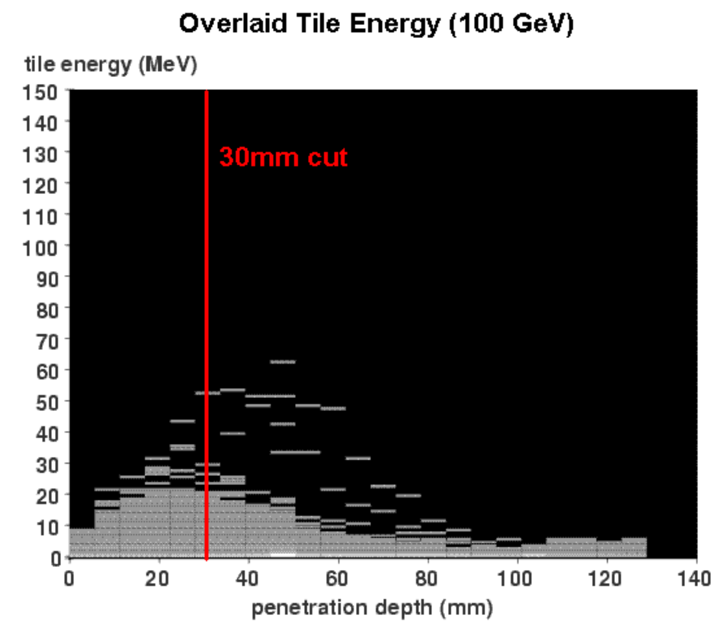
4. Analysis - Overview

- 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

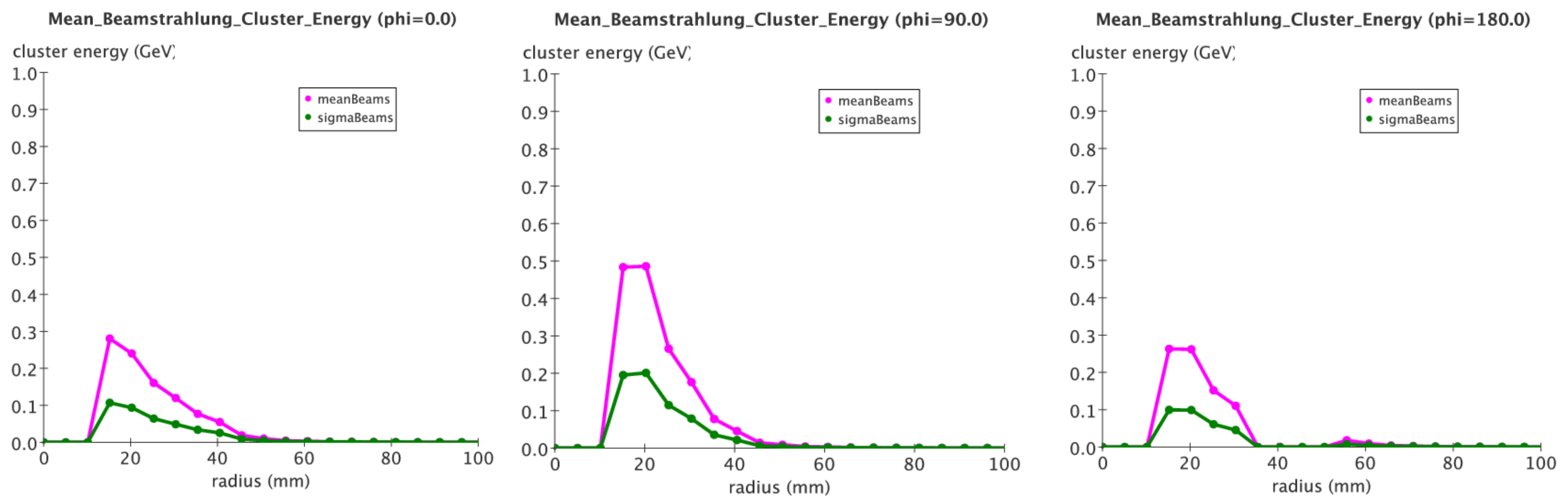
- Given an (r, φ), keep hits that are:
    1. Within 2 tile-widths of the axis; in other words, inside of a cylinder with r=5.5mm (cylinder 3 tiles wide, roughly Moliere radius)
    2. Deeper than 30mm

(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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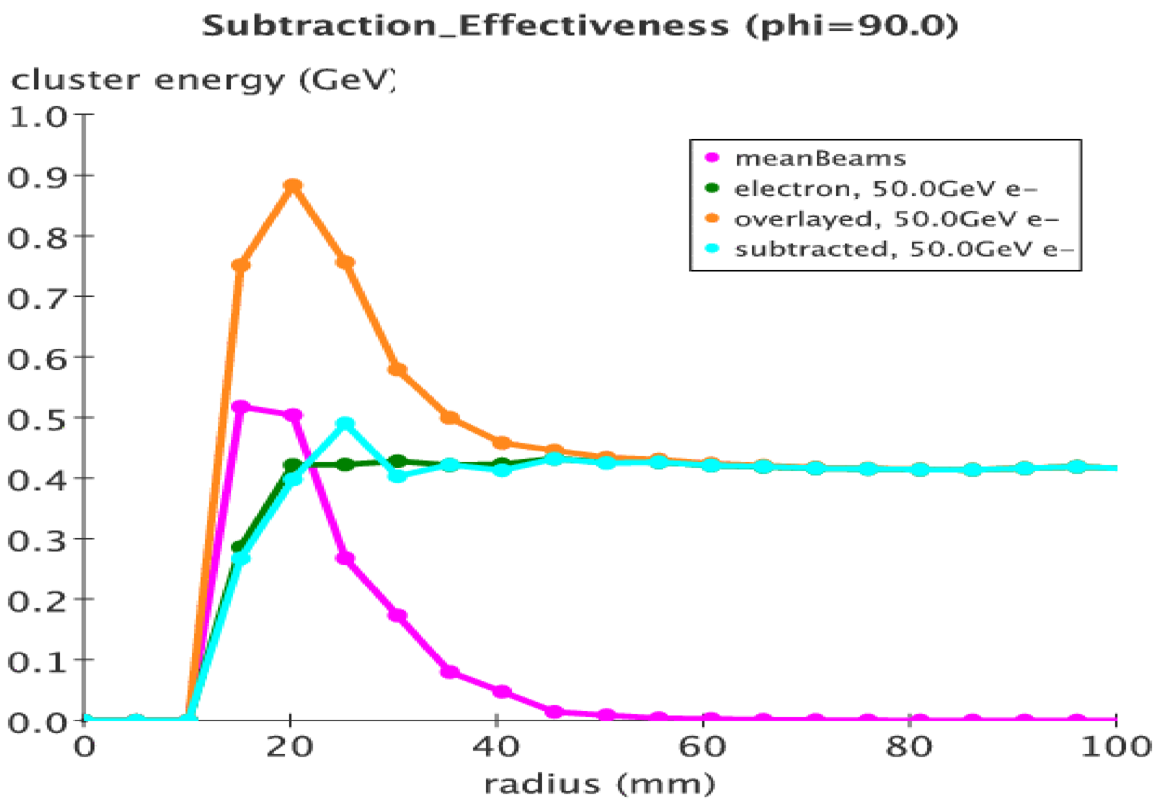

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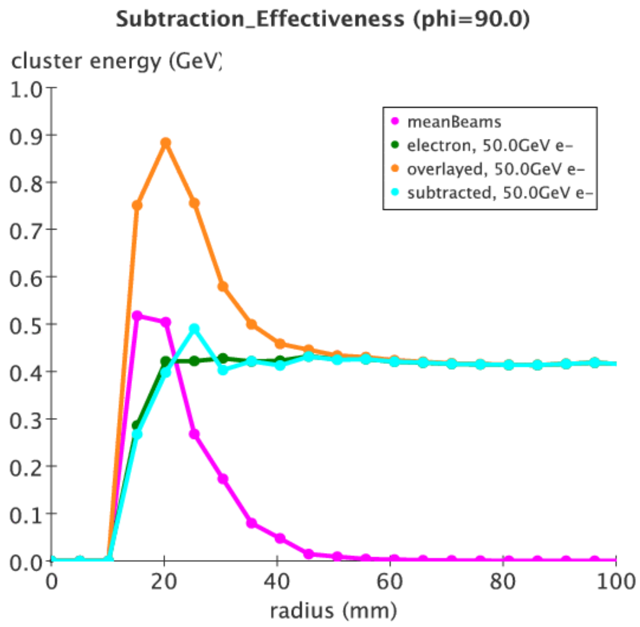
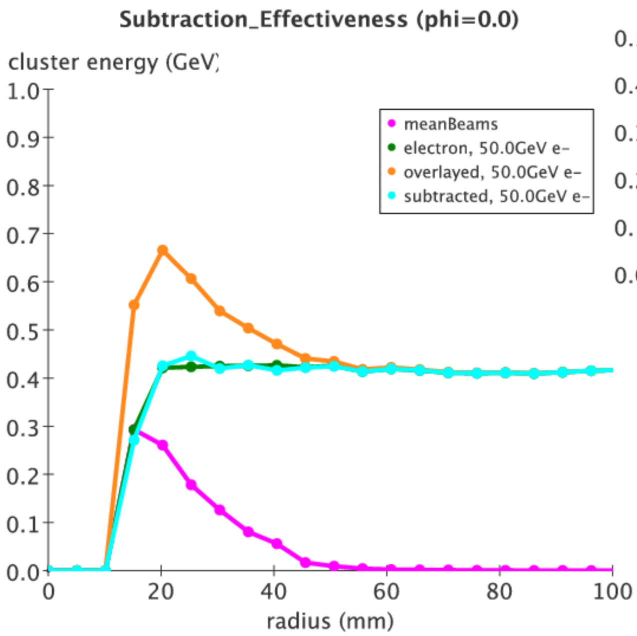
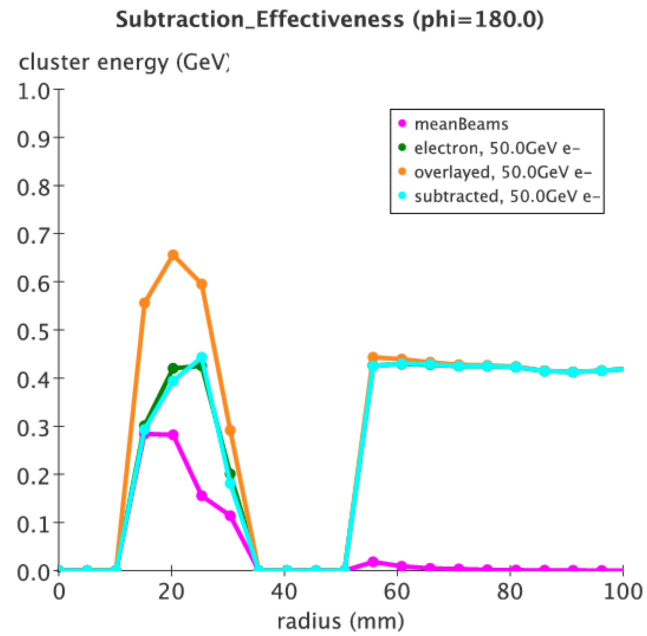






4. Analysis - Finding Shower Axis

1. For each overlaid event, scan through every (r, φ) trajectory and apply clustering cuts & mean beams. subtraction

1. Find the (r, φ) trajectory that has the highest ratio of cluster energy to sigma beams.

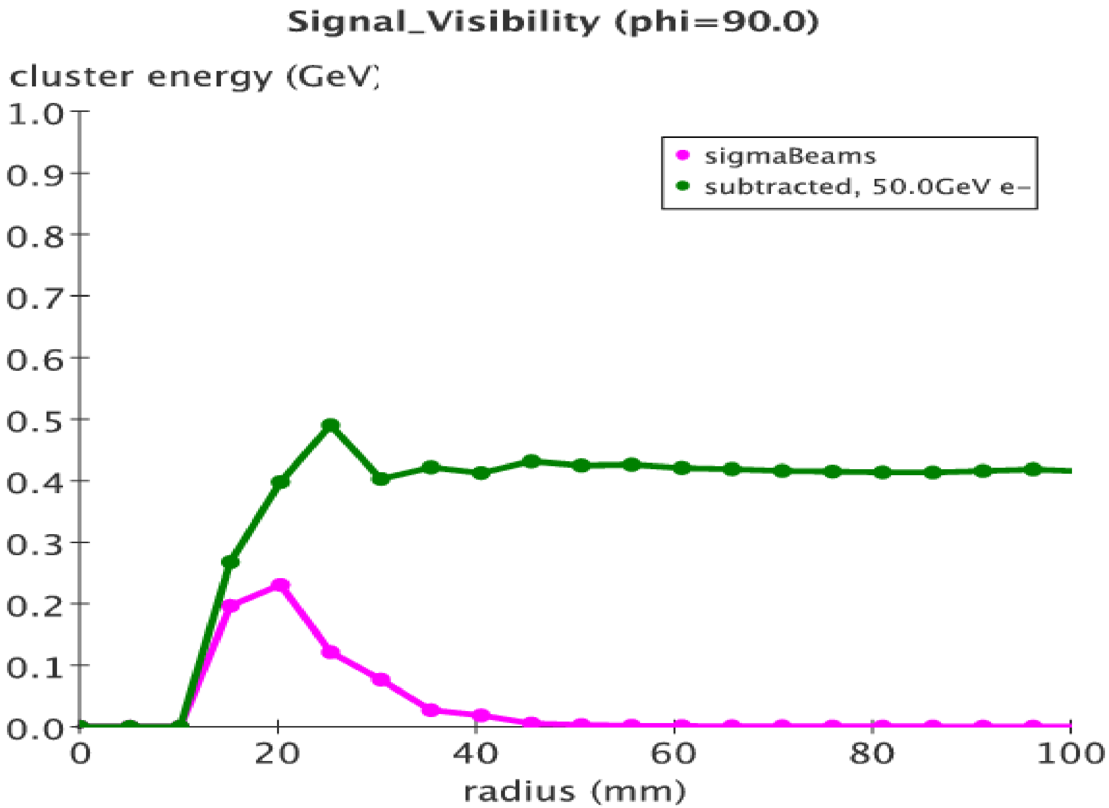
1. In majority of cases (over 90%), the resulting (r, φ) corresponds to within 2-tile widths of the BeamCal entry point of the e- (from MC data)

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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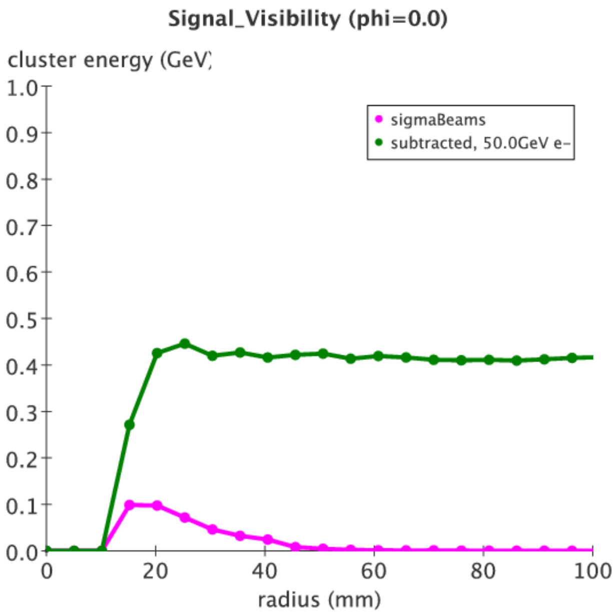
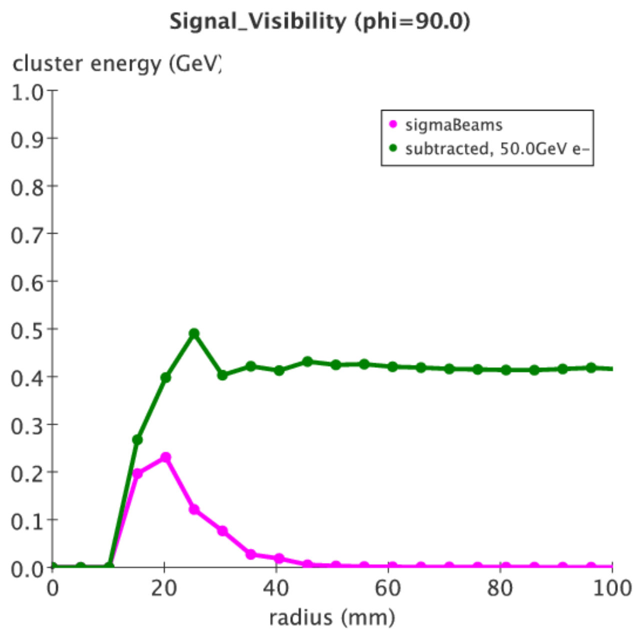
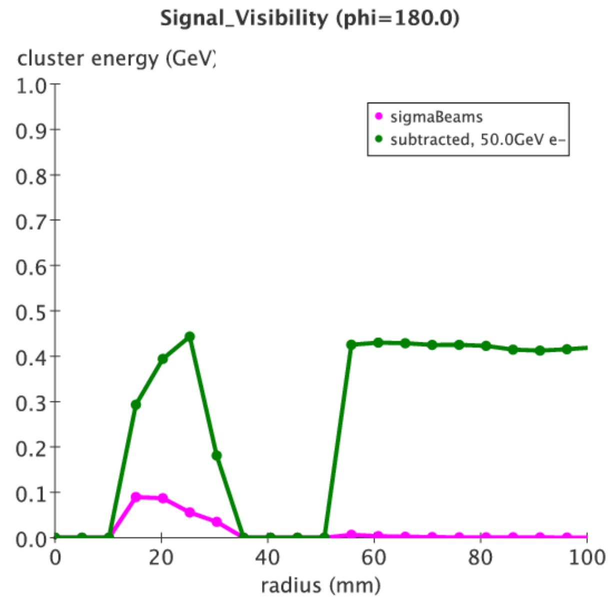
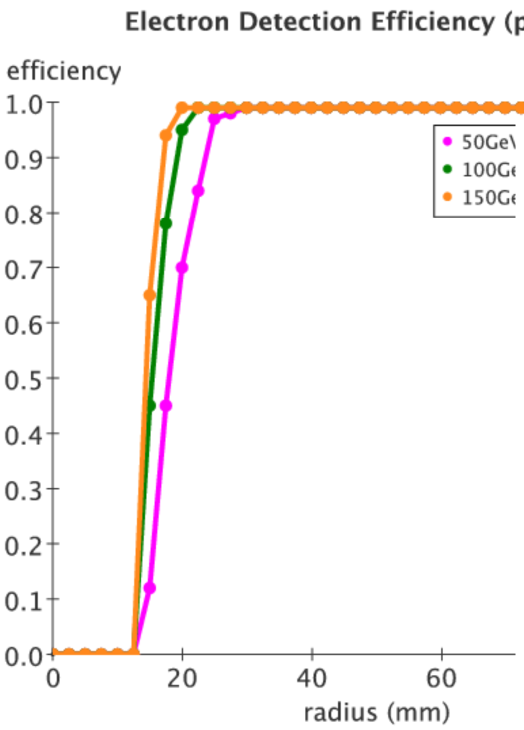
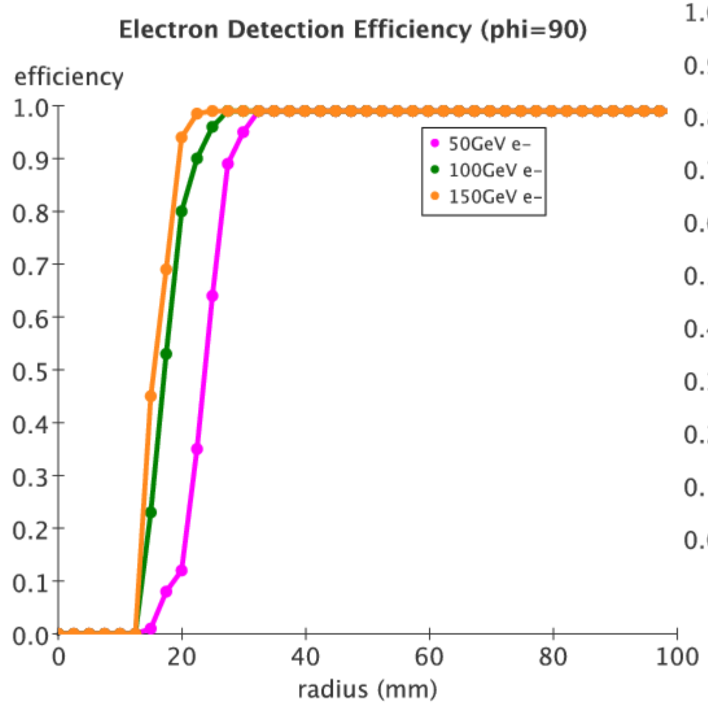


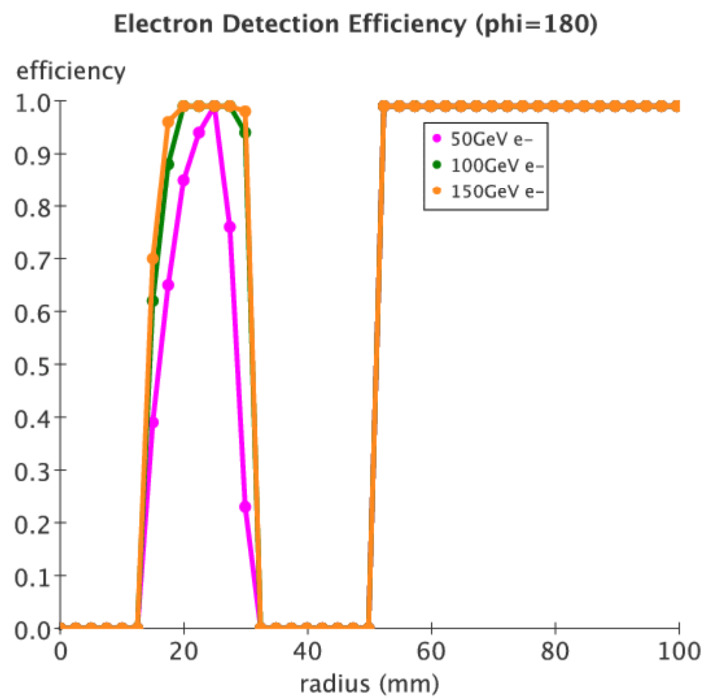




4. Analysis - Efficiency Results





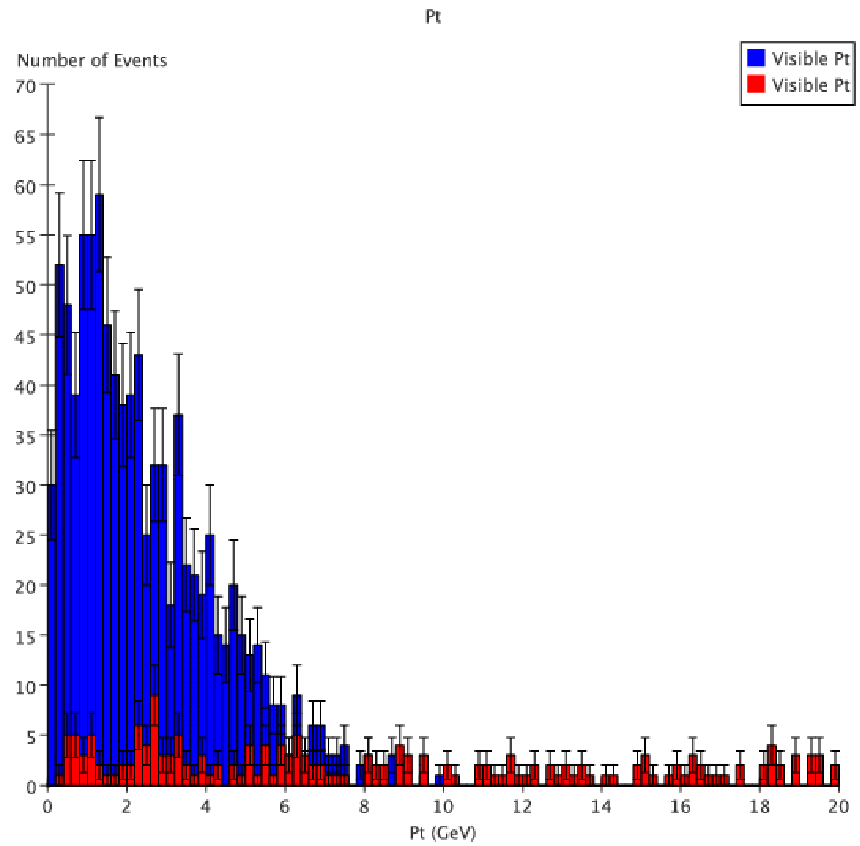


4. Analysis - Purity

- 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)
- 1331 false positives out of 10,000 events
- **Purity = ~87%**

5. Initial Results for $\gamma\gamma$ Veto

- Blue shows P_t spectrum of stau decay leptons
- Red shows two photon events
- selected events with 2 lepton final states
- Used our BeamCal efficiencies, assume other detectors 100%
- |cos(theta)| < .99 for both visible leptons
- Very good result for D'



6. Conclusion

- Except for within 10mm (2-3 tiles) of the exit beampipe at 90°, we can almost always see even 50GeV e-
- Preliminary results with these efficiencies indicate that the two-photon background can be suppressed at D’
- Currently working on replicating $\gamma\gamma$ suppression using MCFast (modify MCFast to use our lookup table)