Report on Recent FCAL Simulation Studies at SCIPP

Undergraduate Christopher Milke,
Professor Bruce Schumm,
Santa Cruz Institute for Particle Physics
University of California, Santa Cruz

Clustering WG Meeting, 22 September 2014

Topics

- Two seperate bug fixes:
  - Creating a SimCalorimeterHit wrapper
  - Removing extra background hits from studies
- Comparison of clustering results before and after bug fixes
- Signal Electron Angular Slice Study
- Comparison of our segmentation strategy to Lucia's strategies

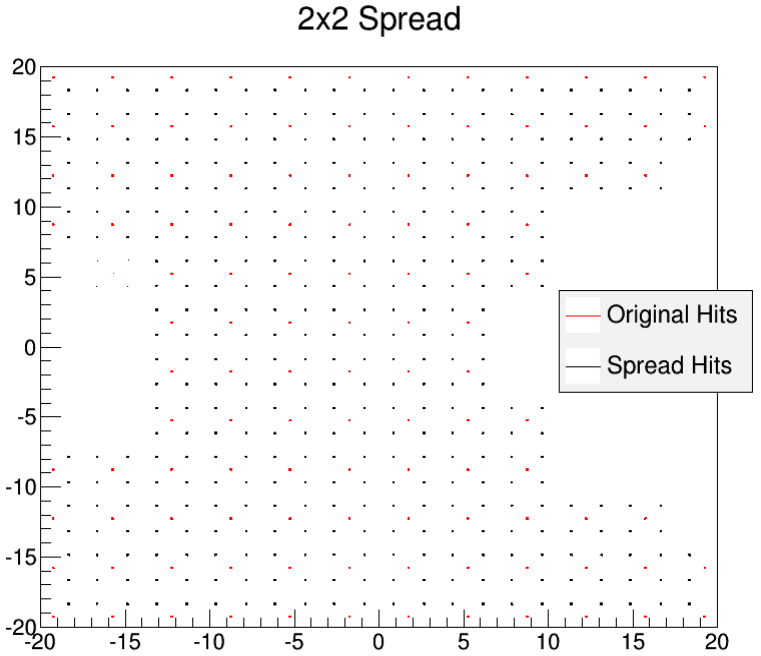
Bug Fixes

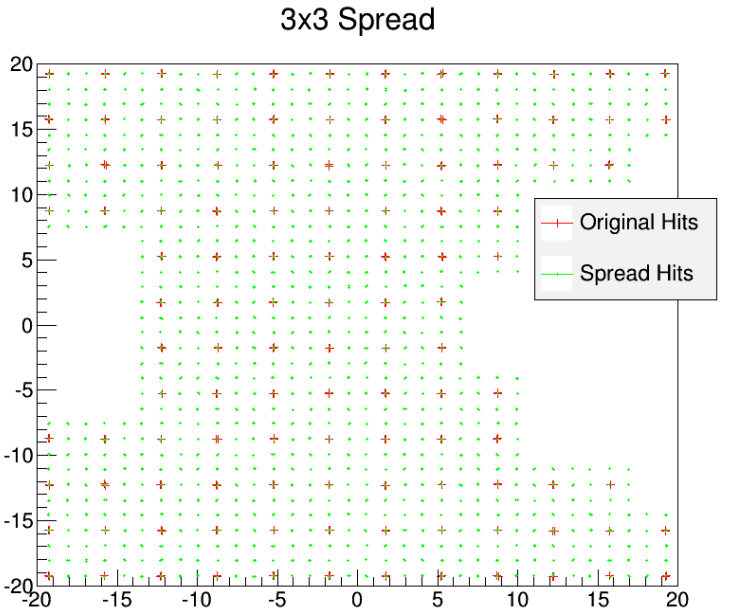
- We found that our simulation hits were not continuously distributed, but restricted to points on a grid. We implemented a wrapper to correct this.
- We found that we were using background hits from two seperate detectors (both the +z and -z BeamCal detectors) and combining them together. We have removed the hits of the -z detector to account for this.

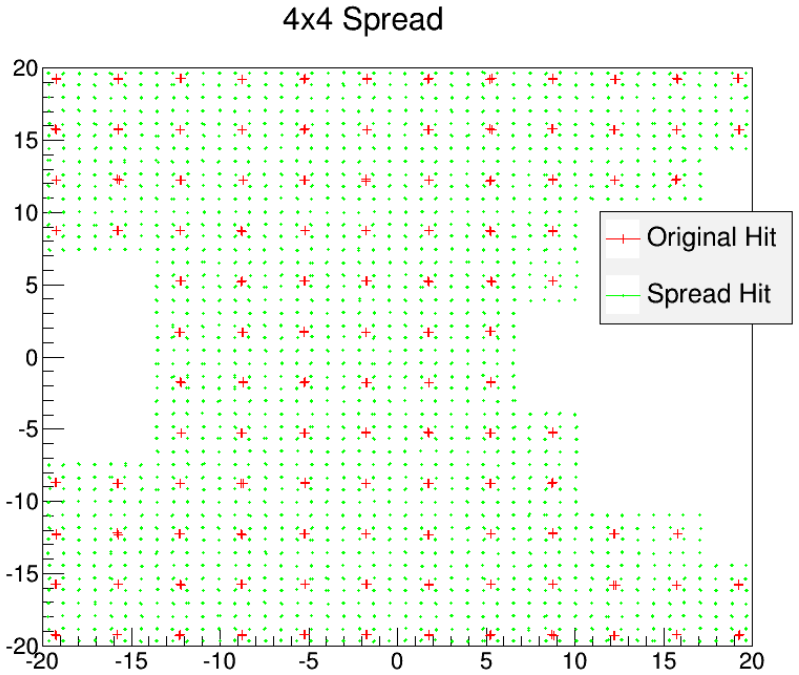
Hit Wrapper

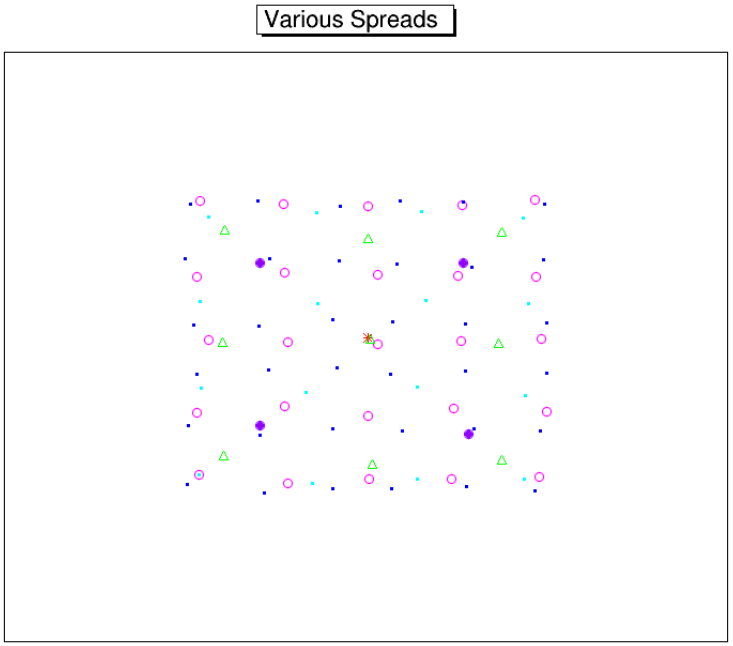
- We assumed our simulated hits were continuously distributed across the detector, allowing us to impose our own tiling geometry
- Instead, a 3.5x3.5 rectilinear grid tiling scheme had been assumed in the hit files, so all hits were clustered in a grid
- As a work around, we distribute the hits' energy across a finer grid pattern

Hit Distribution Before and After Wrapper





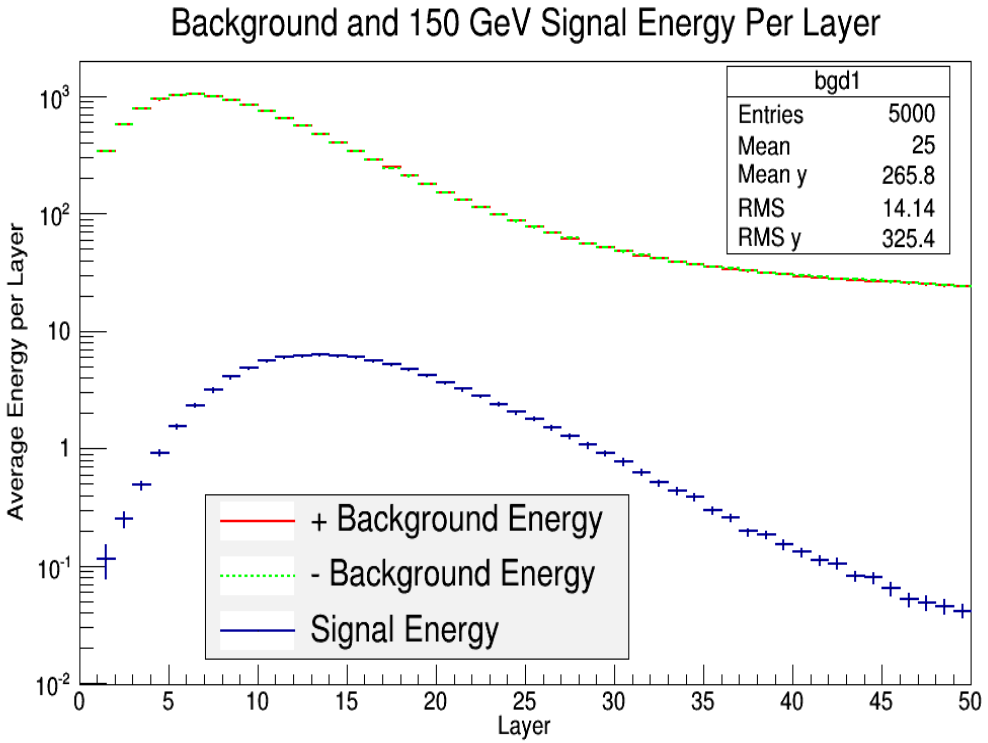


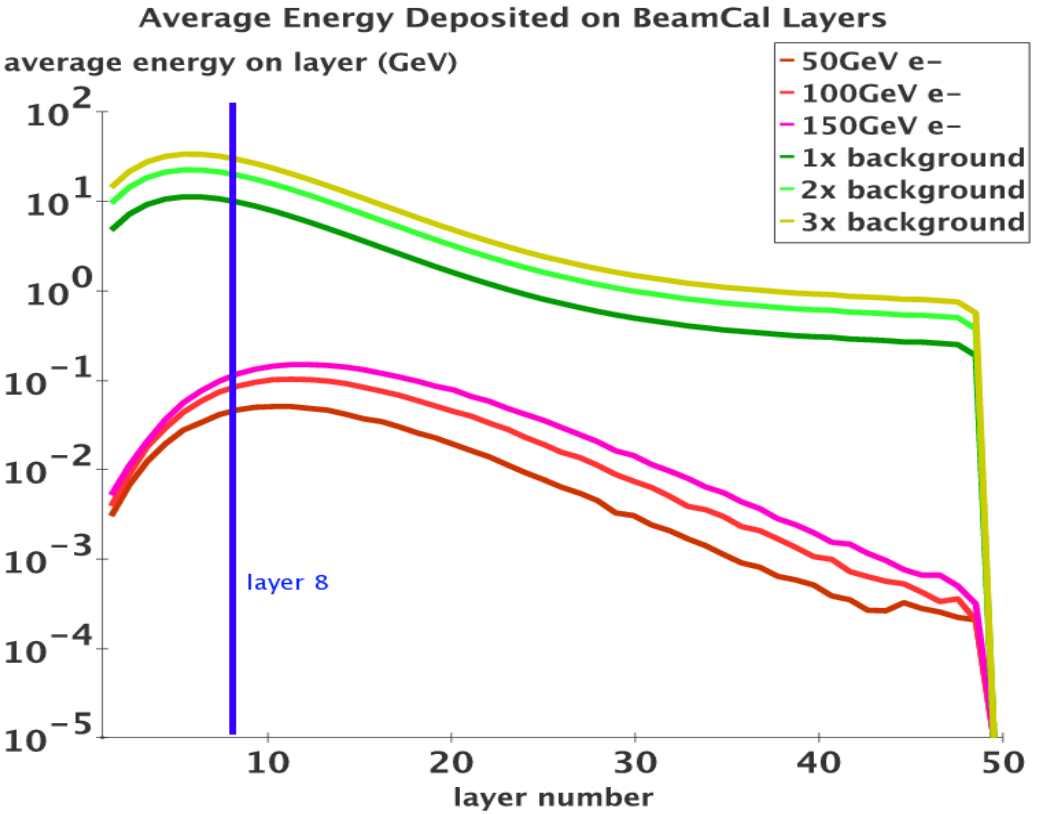


Negative z Background Hits

- We determined that our background simulation files contained information for two detectors, one at a positive z position, one at a negative z position
- However, we were applying both of these to the +z detector at the same time
- To correct this, we removed all hits with a negative z position
- Signal electron simulation files were not affected by this, as they are all in the +z direction

Positive Background Hit Energy vs Negative Background Hit Energy vs 150 GeV Signal Energy for SiD02



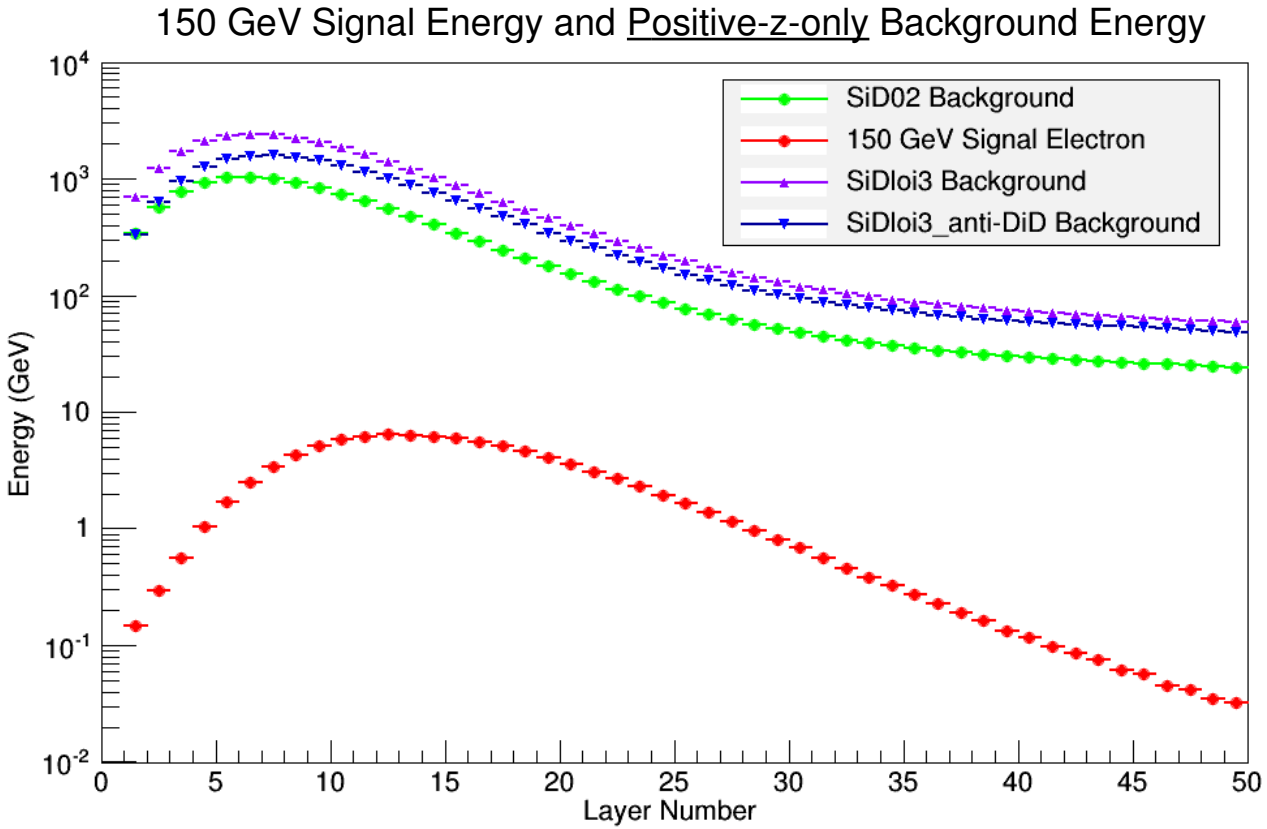


SCIPP: Mean background is x250 mean signal

(even with the '+' and '–' hits seperated)

Colorado: Mean background is x100 mean signal

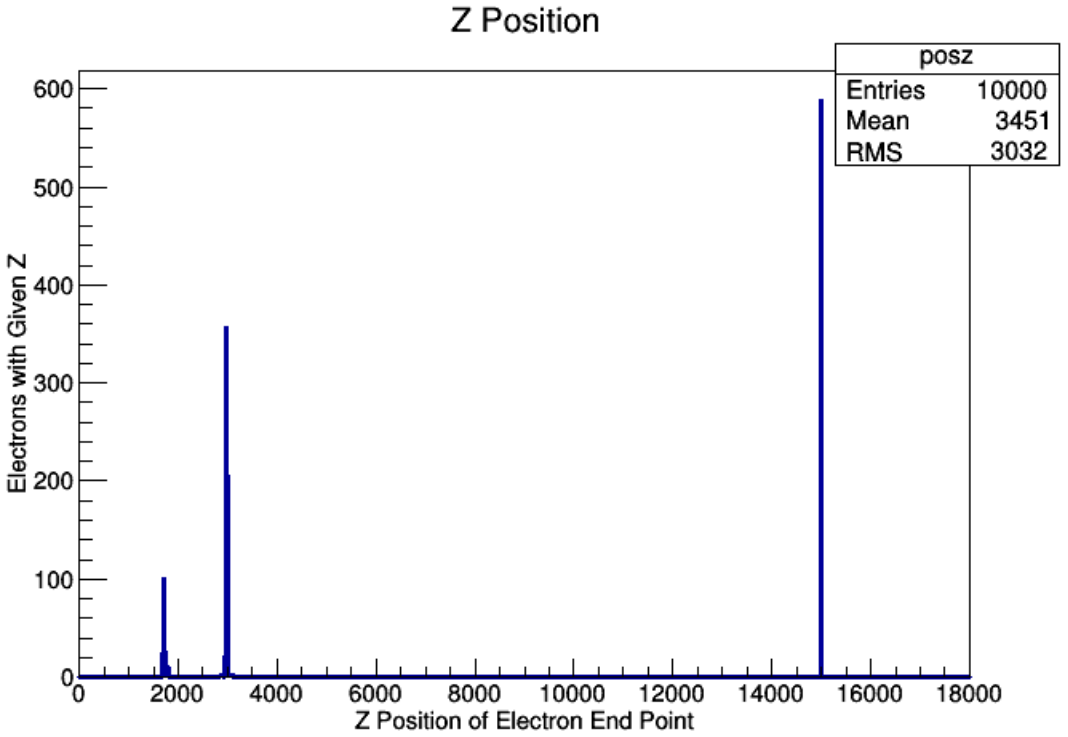
Positive Background Hit Energy and 150 GeV Signal Energy Comparison for Various Detector Models



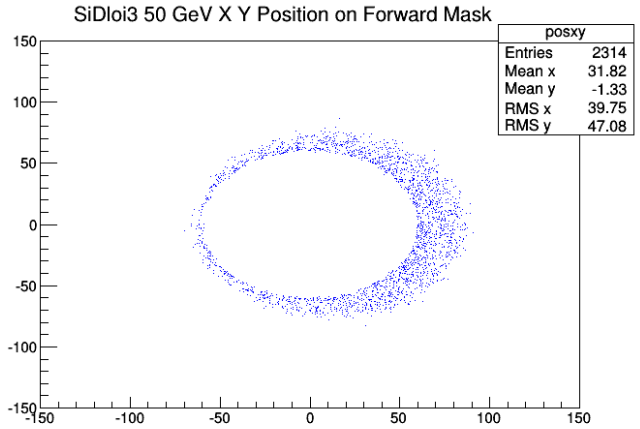
- As we still did not have an explanation for the increased background between SiD02 and SiDloi3, we thought to check the Lorentz angle
- We thought that in changing to a non-zero beam crossing angle the Lorentz angle may not have been properly implemented
- This led to the angular slice studies

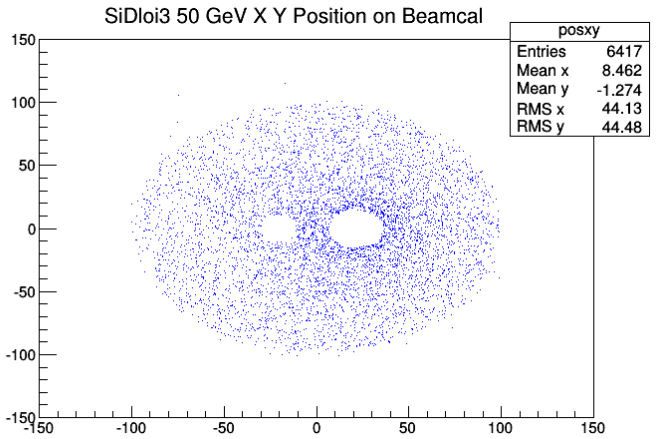
Signal Electron Angular Slice Study

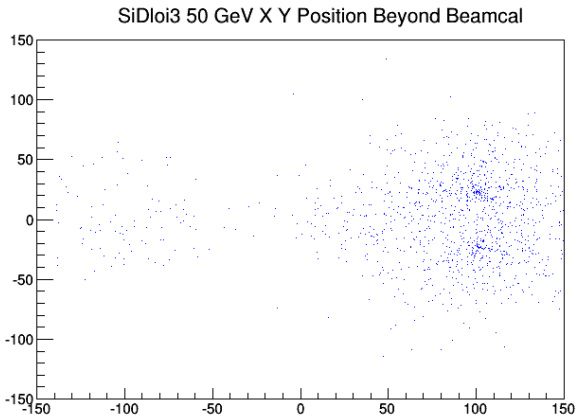
- Study intended to determine if Lorentz angle was correct
- There are three longitudinal locations the electrons can hit: A forward "mask" (which is almost certainly the LumiCal), the BeamCal itself, and an interaction point far behind the detector (which means the electrons went through the acceptance holes and missed the BeamCal).
- To simplify plots, they have bee
  interaction points

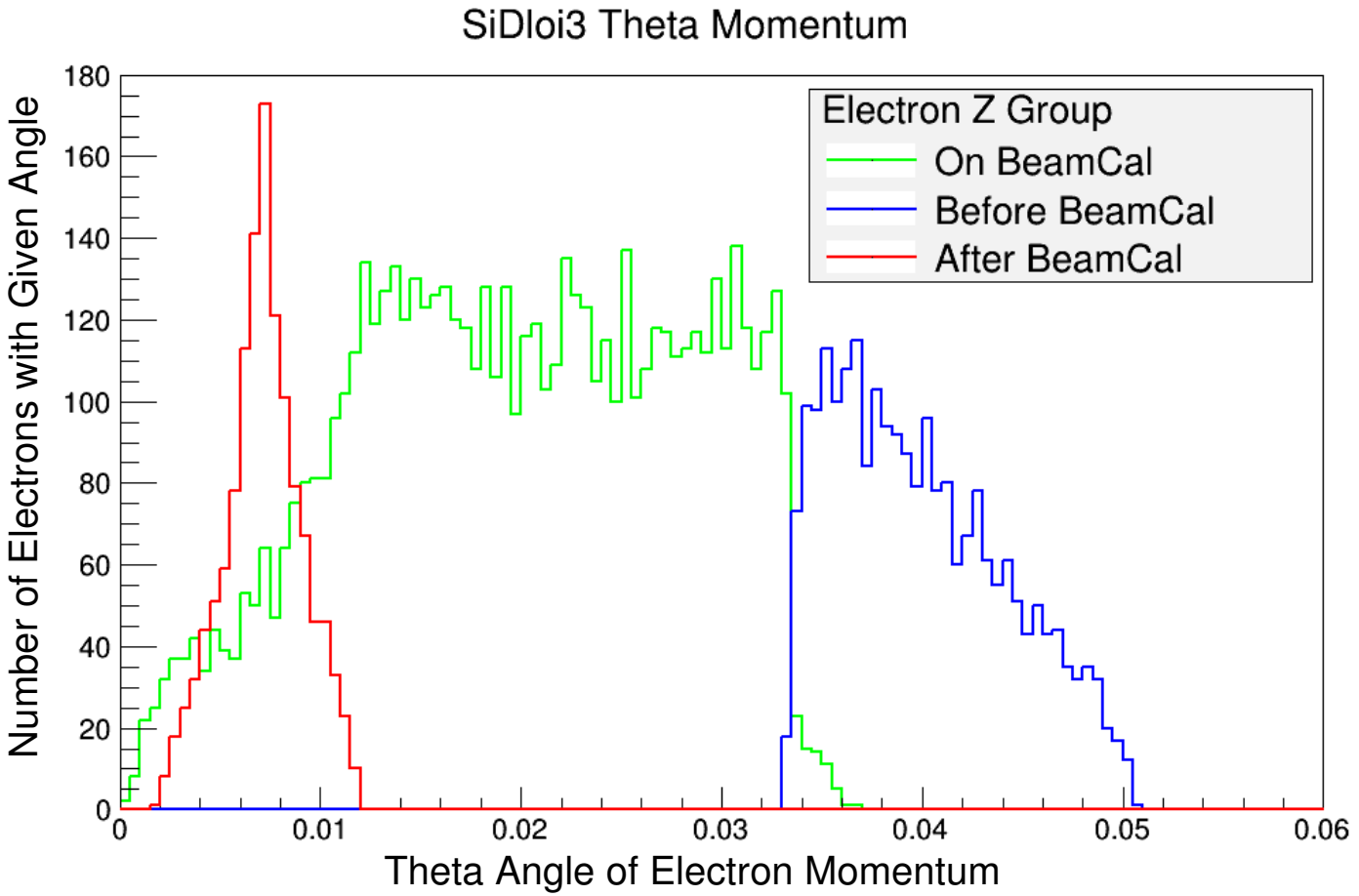


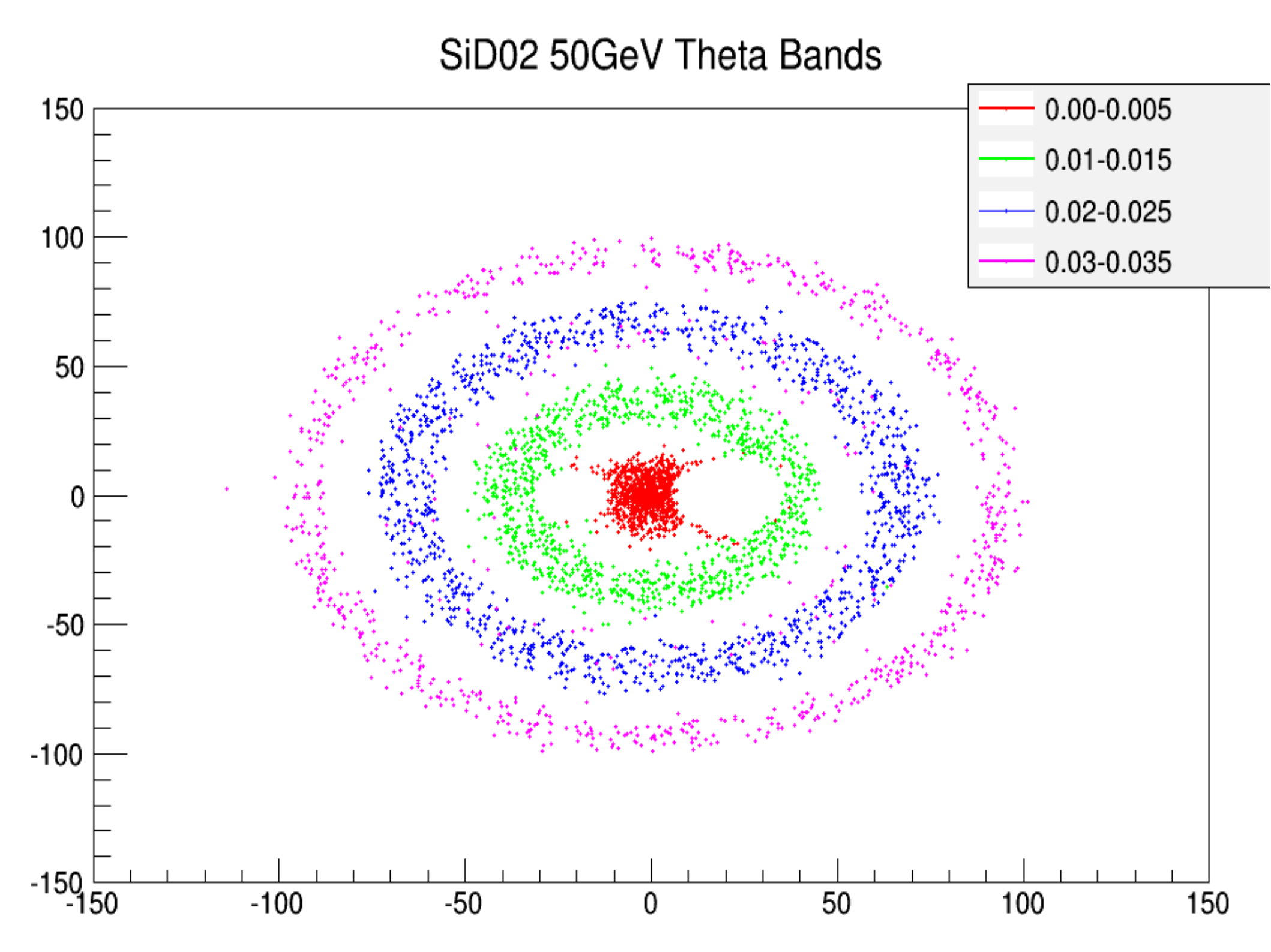
SiDloi3 50 GeV Signal Electrons Overview

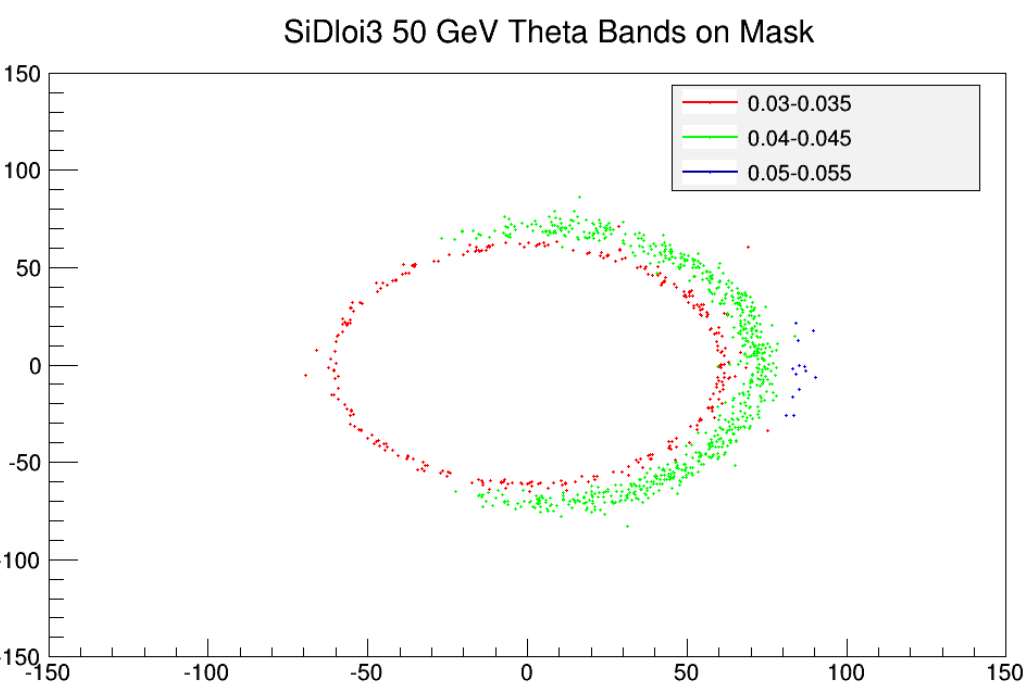


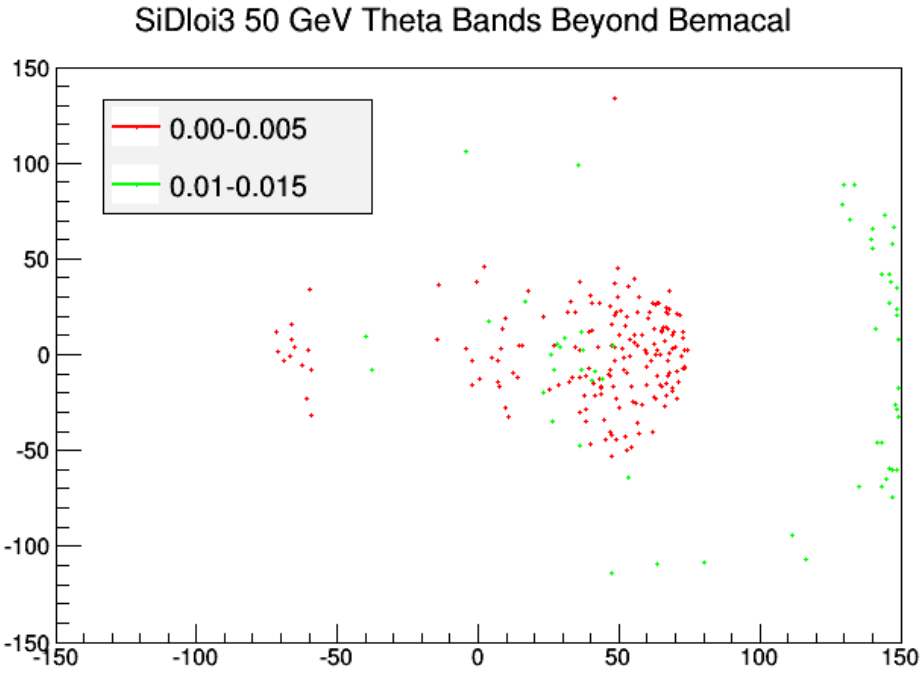


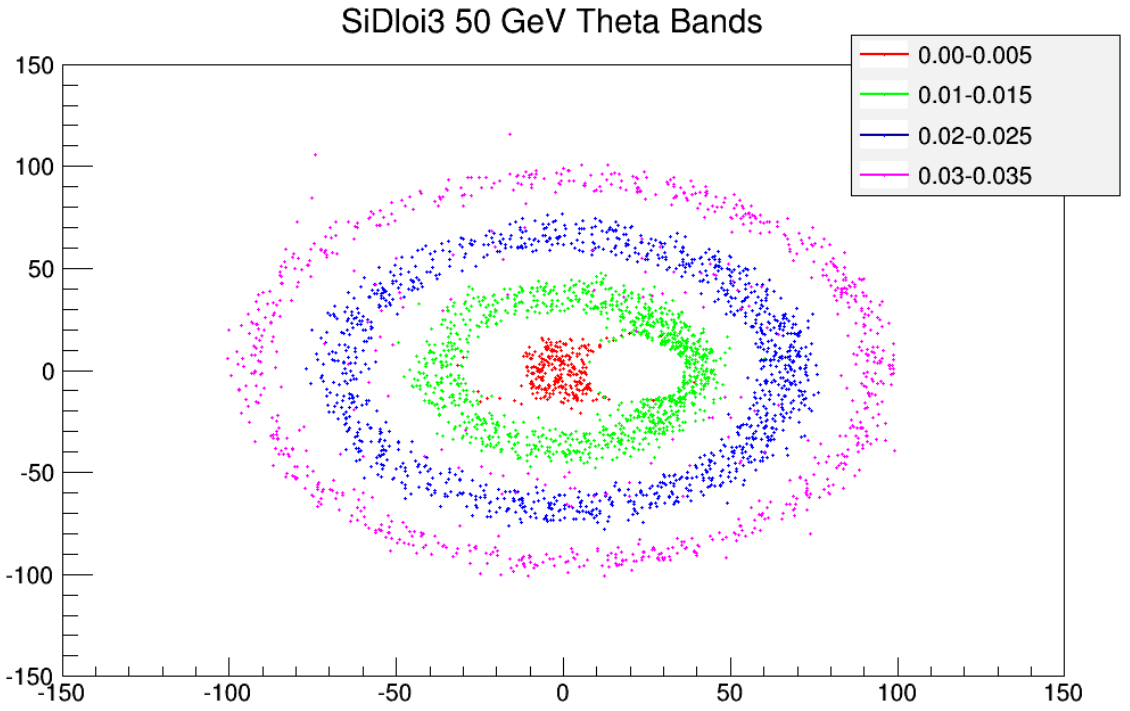





SiD02 50GeV Theta Bands
0.00-0.005
0.01-0.015
0.02-0.025
0.03-0.035
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150


SiDloi3 50 GeV Theta Bands on Mask
0.03-0.035
0.04-0.045
0.05-0.055
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150

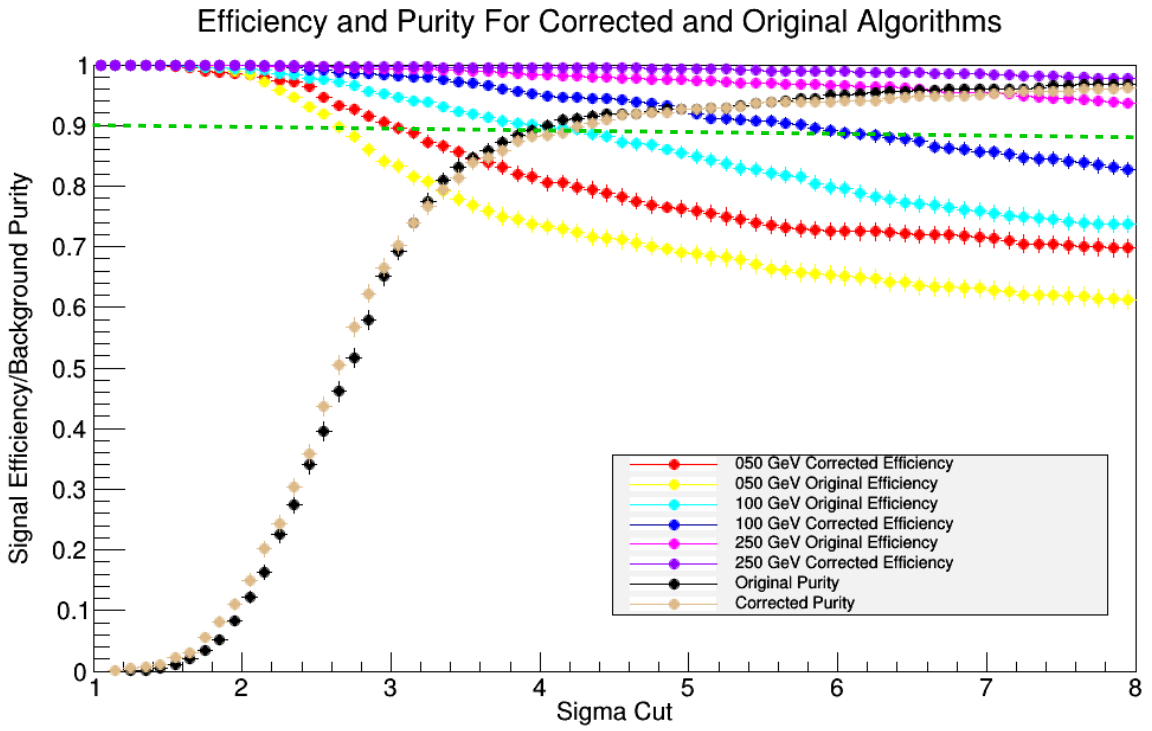

SiDloi3 50 GeV Theta Bands Beyond Bemacal
0.00-0.005
0.01-0.015
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150


SiDloi3 50 GeV Theta Bands
0.00-0.005
0.01-0.015
0.02-0.025
0.03-0.035
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150

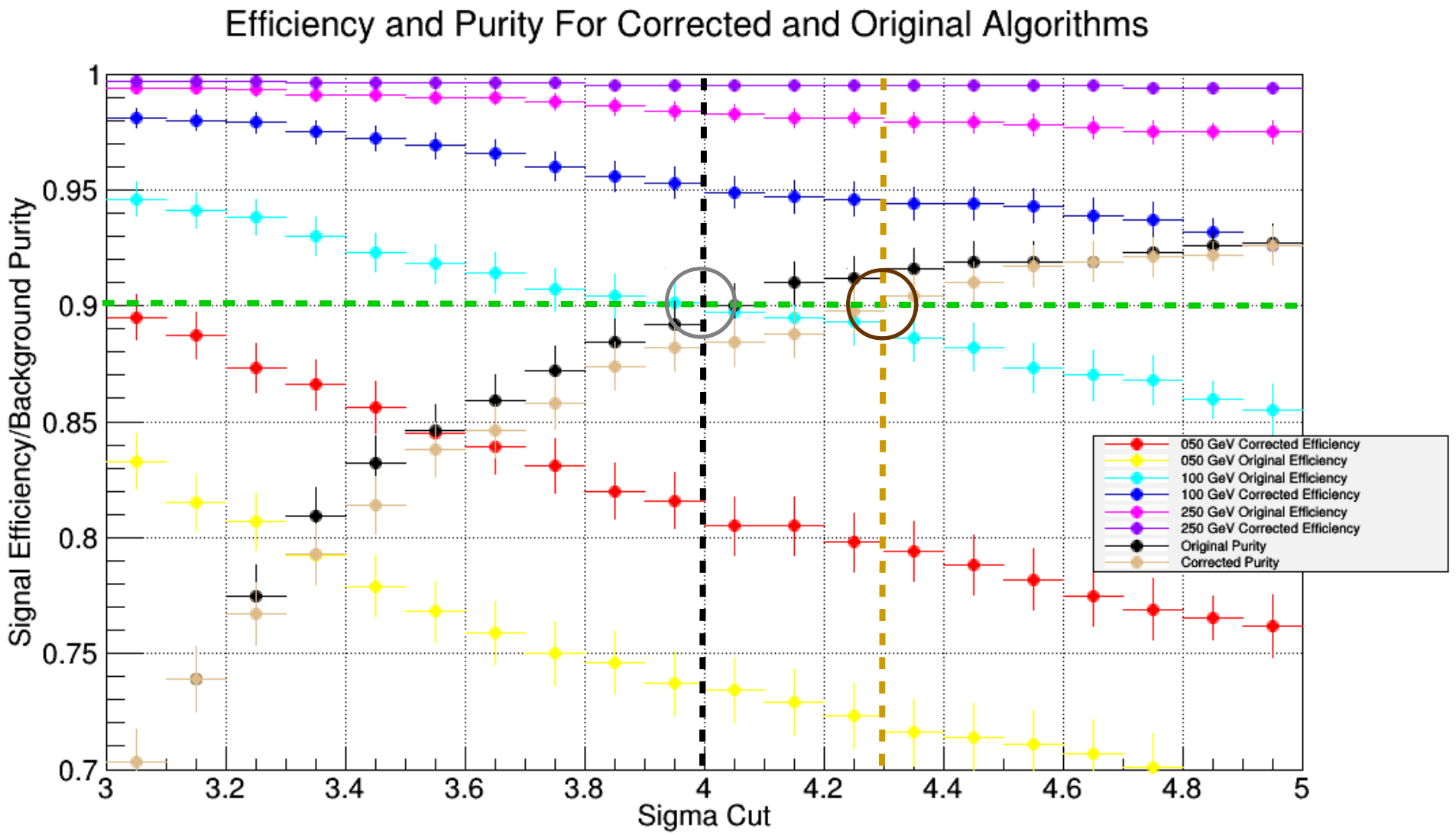
Efficiency Results Before and After Bug Fixes

- The intent of the algorithm is to reject events containing high energy “signal” electrons, as the SUSY events of interest do not contain these electrons
- We base rejection of an event on some number of standard deviations from the average energy
- The number of standard deviations (sigma cut) is set such that there is a 10% rejection rate for events with no “signal” electron in the BeamCal (translating to 90% background “purity” on the below plots)
- Thus, no more than 10% of these “background” events are rejected, as the background events are what may contain the SUSY events we are interested in

Note that the corrected algorithm performs better at all energies

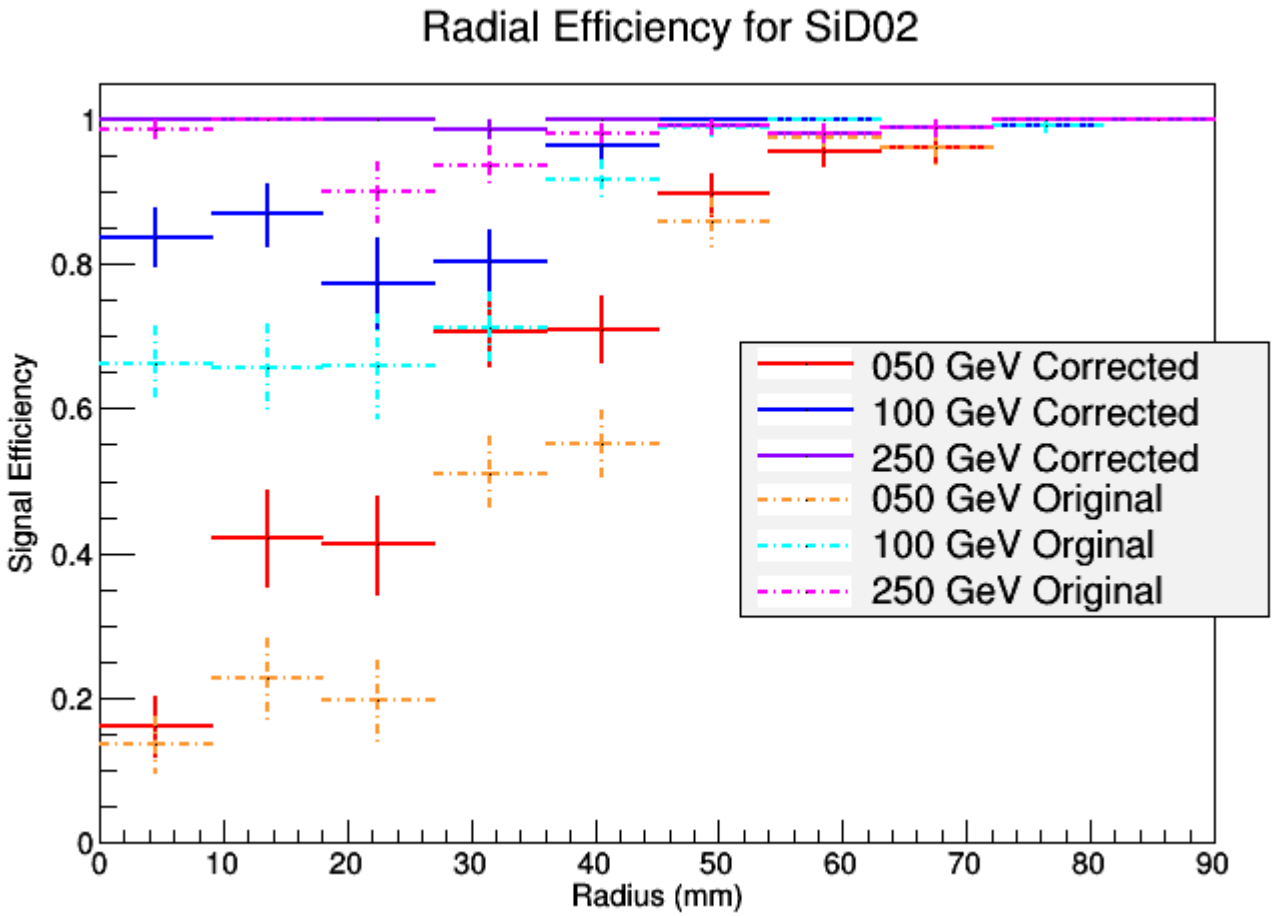


- The green horizontal line is the 90% background retaining rate.
- The black vertical line is the original sigma cut, at 4.0 standard deviations
- The tan vertical line is the new sigma cut, at 4.3 standard deviations



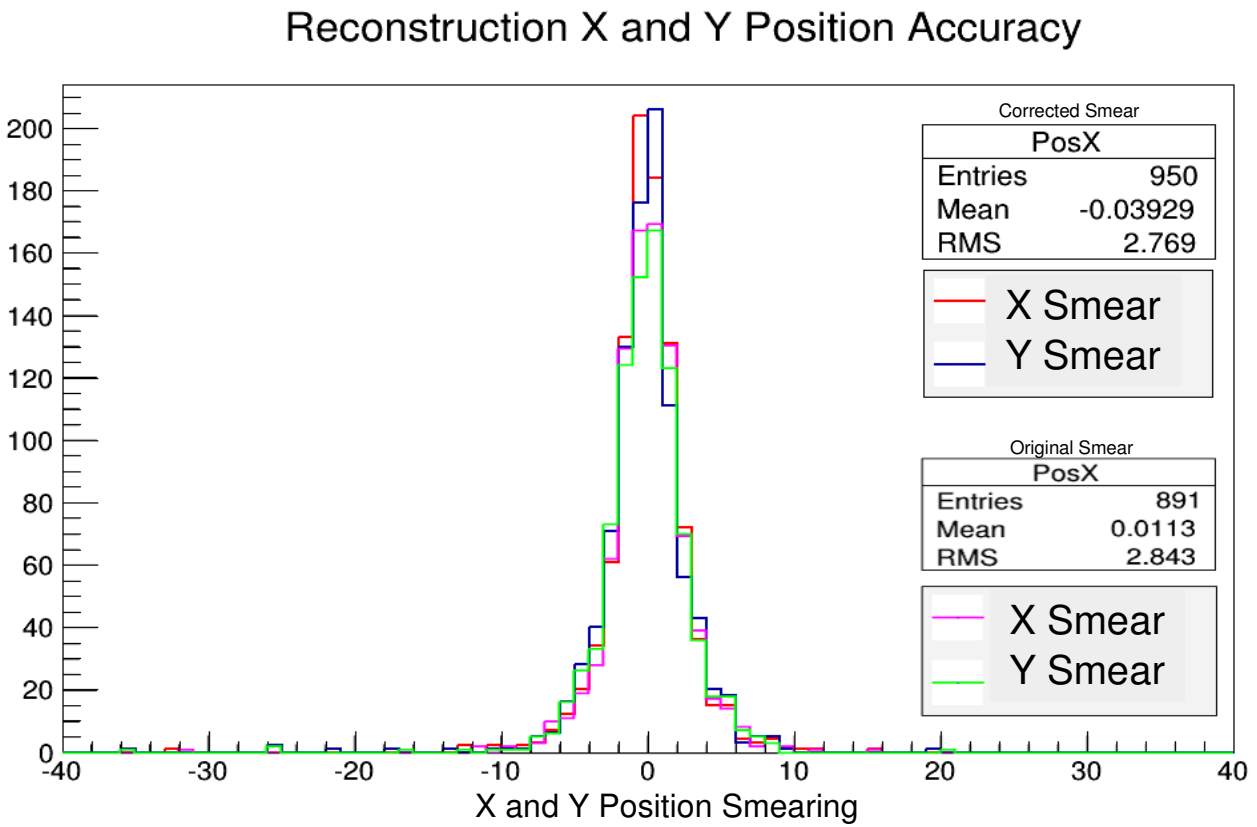
Radial Efficiency Results Before and After Bug Fixes

As with the plot of efficiency over various sigma, the corrected algorithm performs better at all radii.

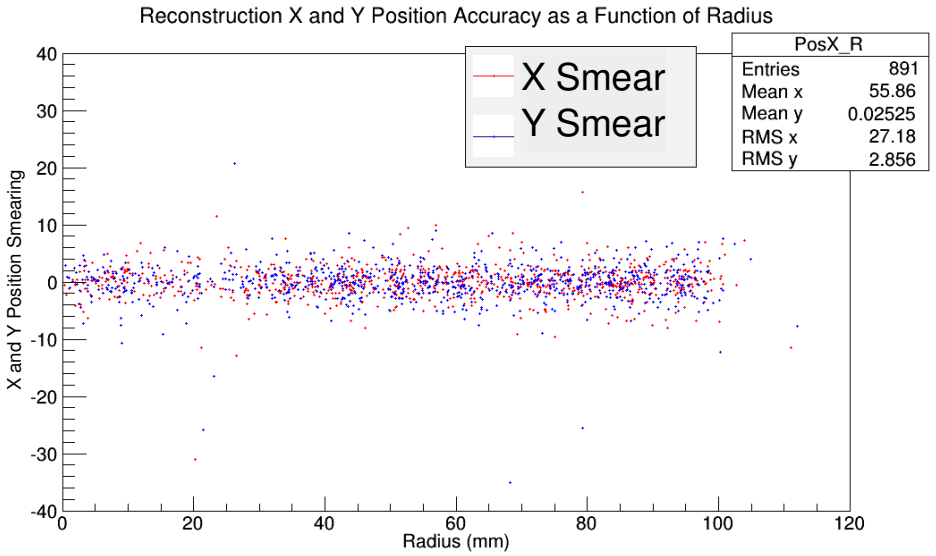


Comparison of the Reconstructed Electron Position Between Original and Corrected Algorithms

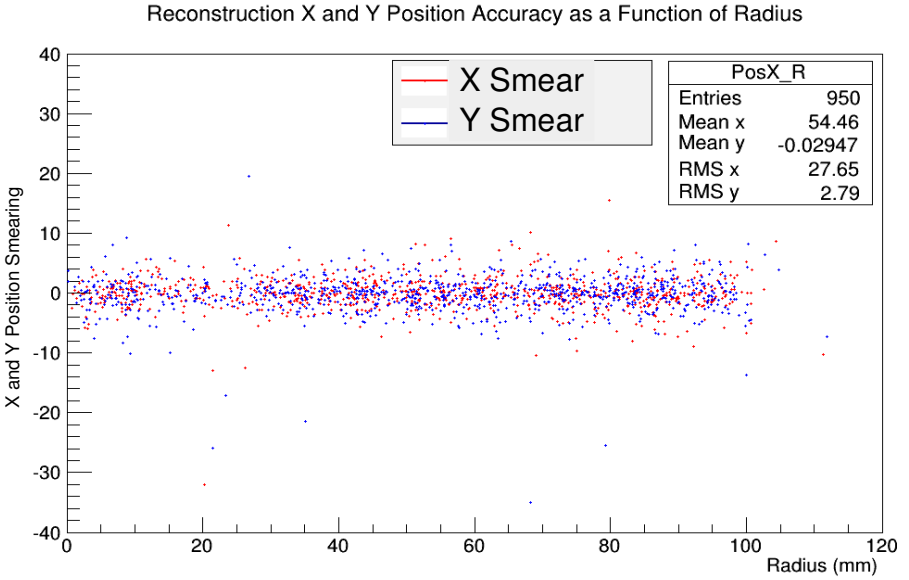
Both versions reconstruct the electron position equally well



Original Position Difference

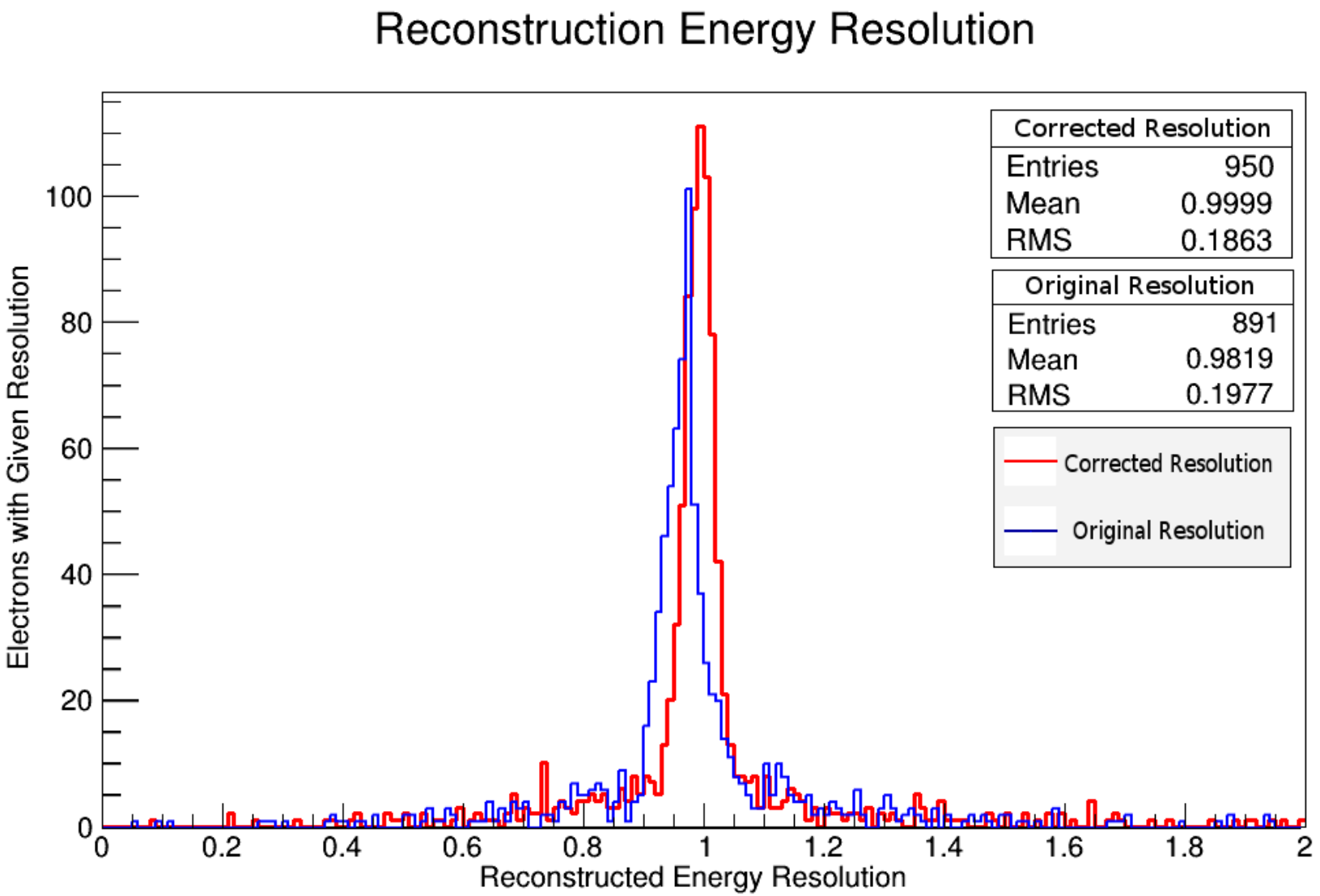


Corrected Position Difference



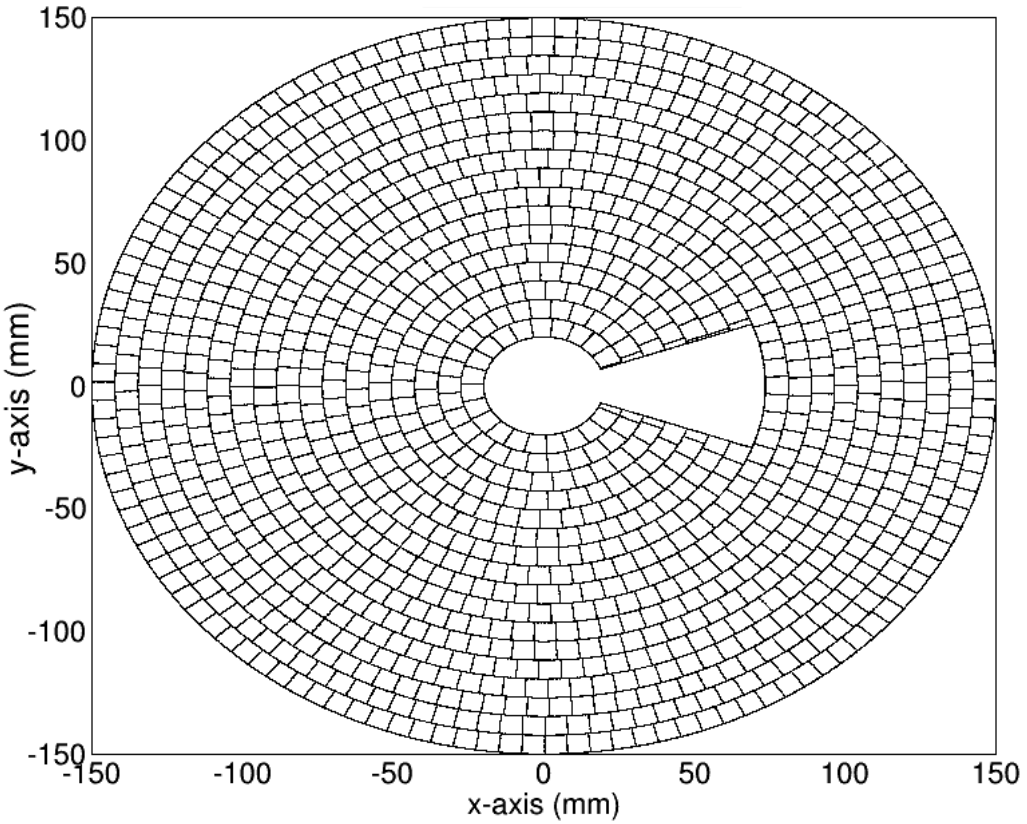
Energy Resolution Results Before and After Bug Fixes

- Energy Resolution is the energy of a given event divided by the average energy of all events.
- Both versions of the code perform almost equally well
- Original is slightly skewed

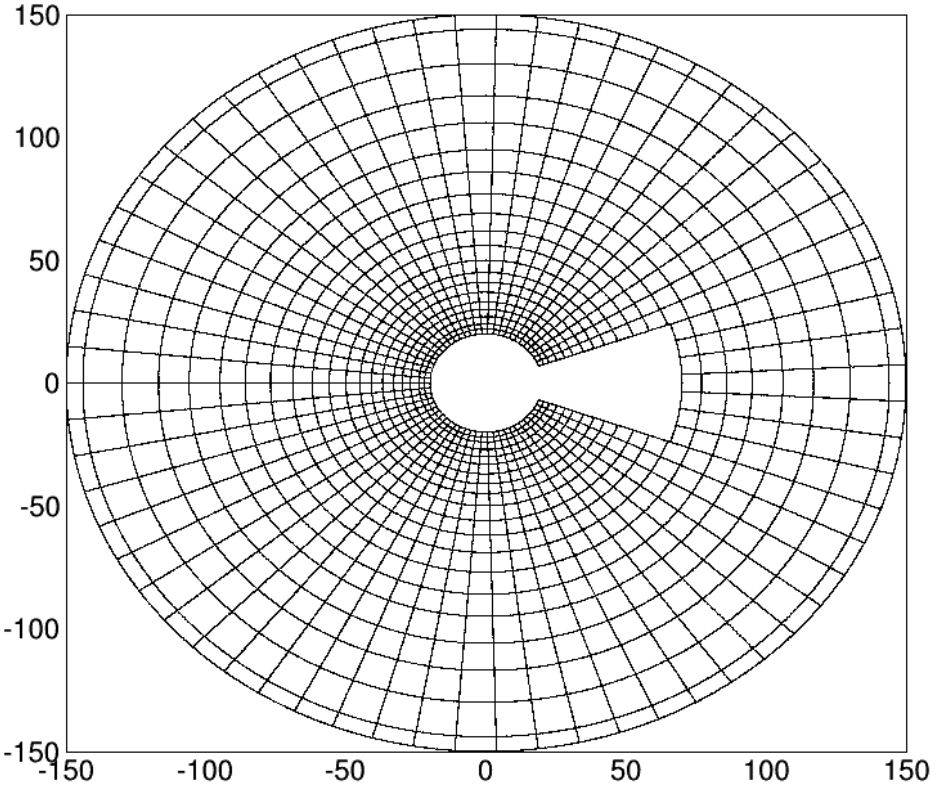


Comparison to Segmentation Strategies Provided by Lucia

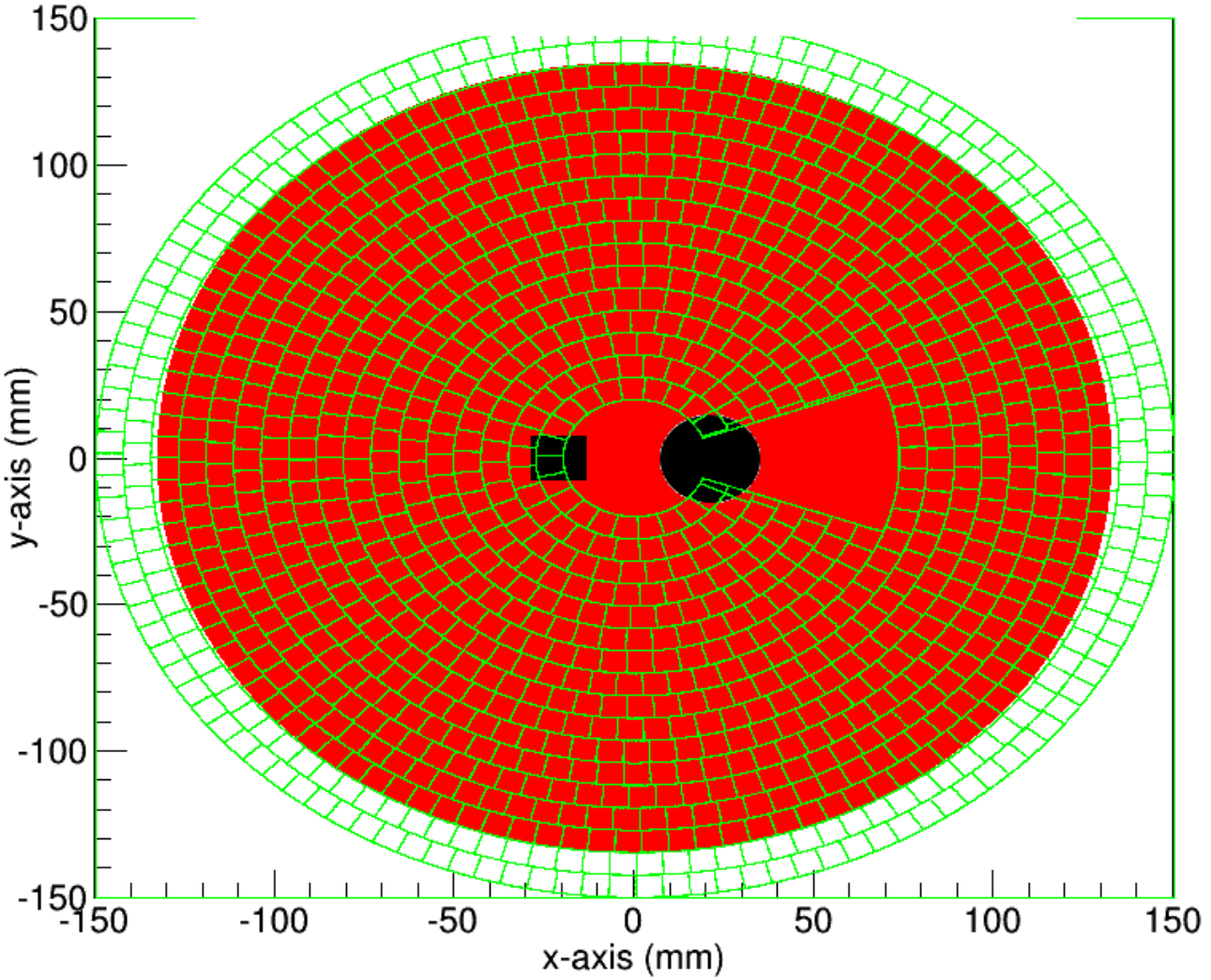
Lucia's Constant 7.647x7.647 mm Segmentation



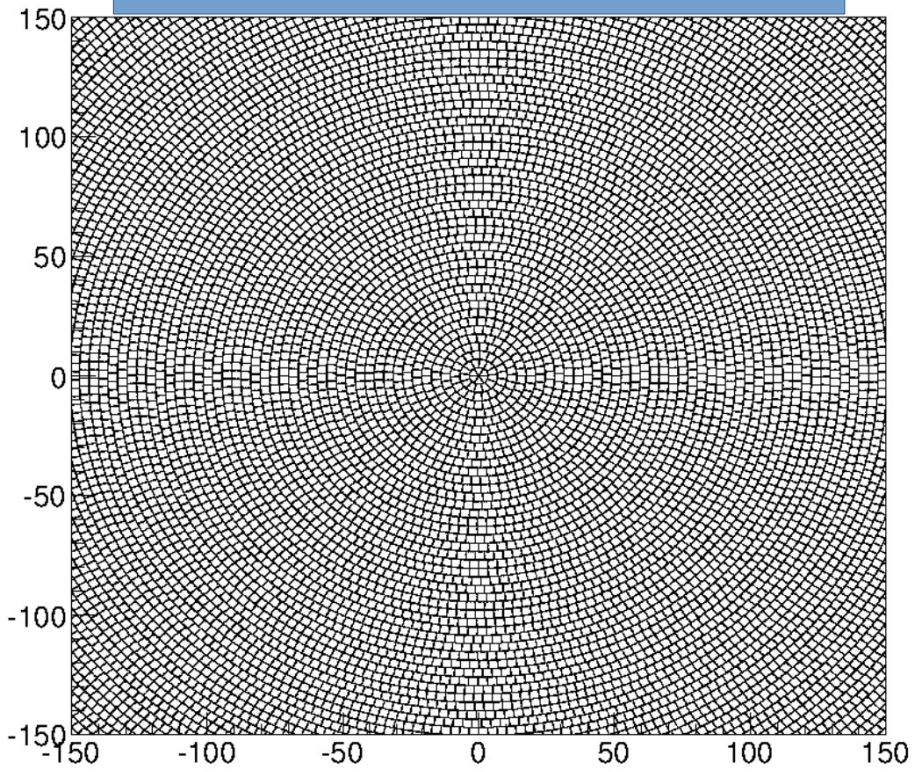
Lucia's Varied Segmentation



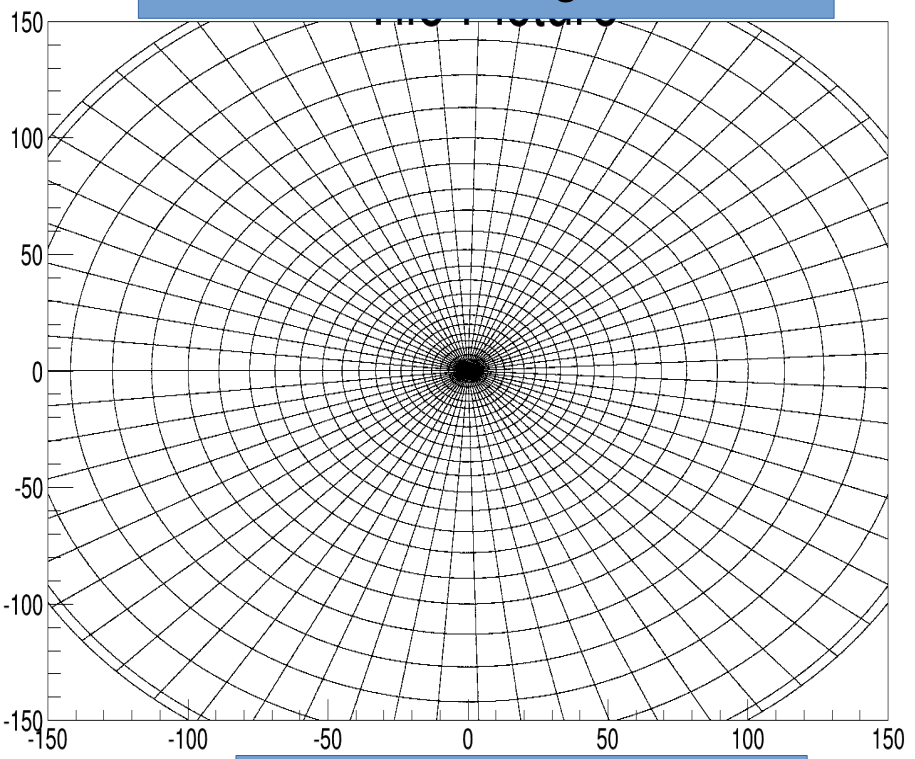
- Our current files use an older detector geometry in which the in-going and out-going beampipes are at either side of the center
- This causes some inconsistancies between our files and Lucia's segmentation, shown below where the beampipes (in black) overlap the segmentation (in green)
- Thus, the segmentation strategies have been contracted around the center, and the wedge shape removed



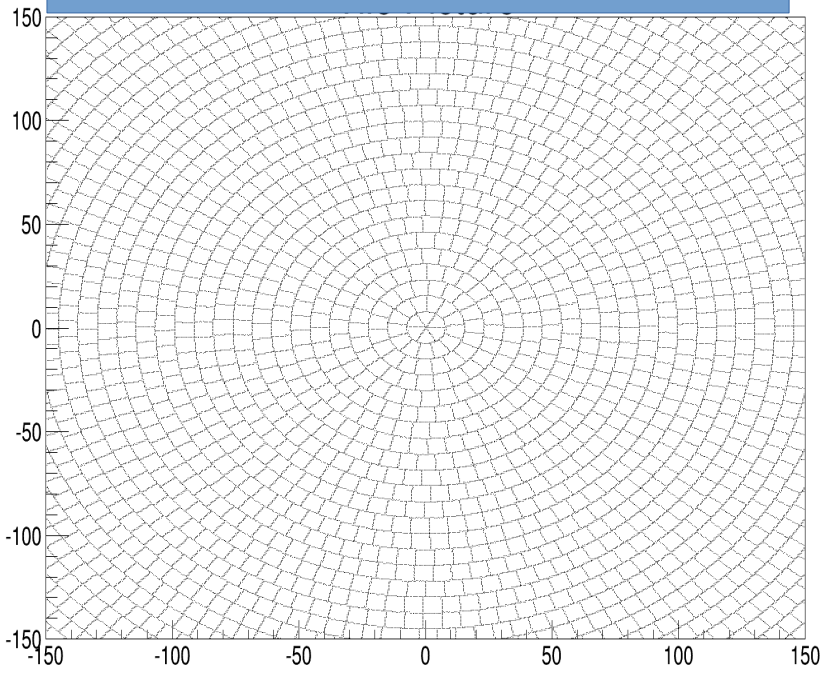
SCIPP's Constant 3.5x3.5 mm



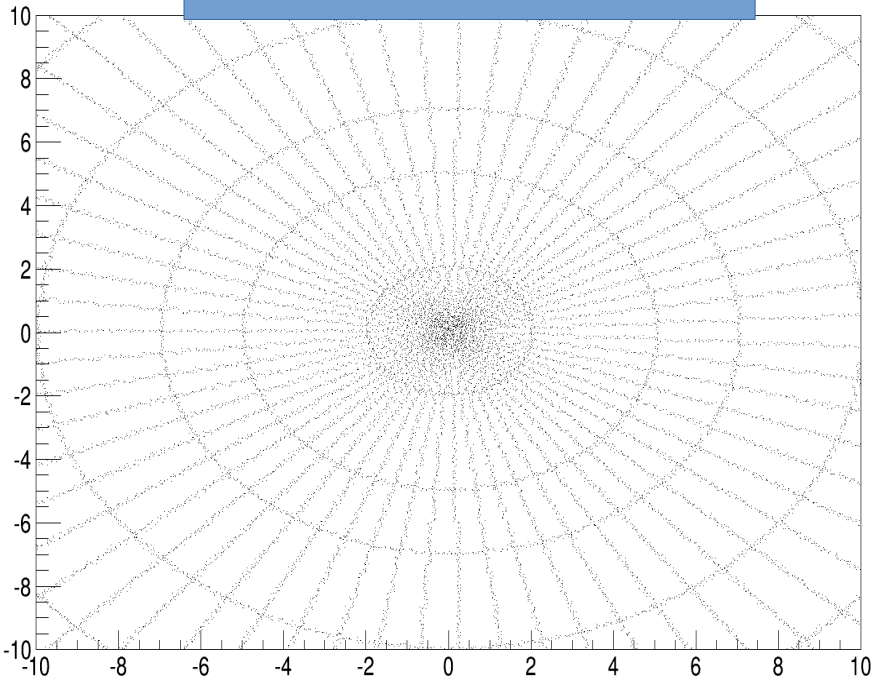
Lucia's Varied Segmentation



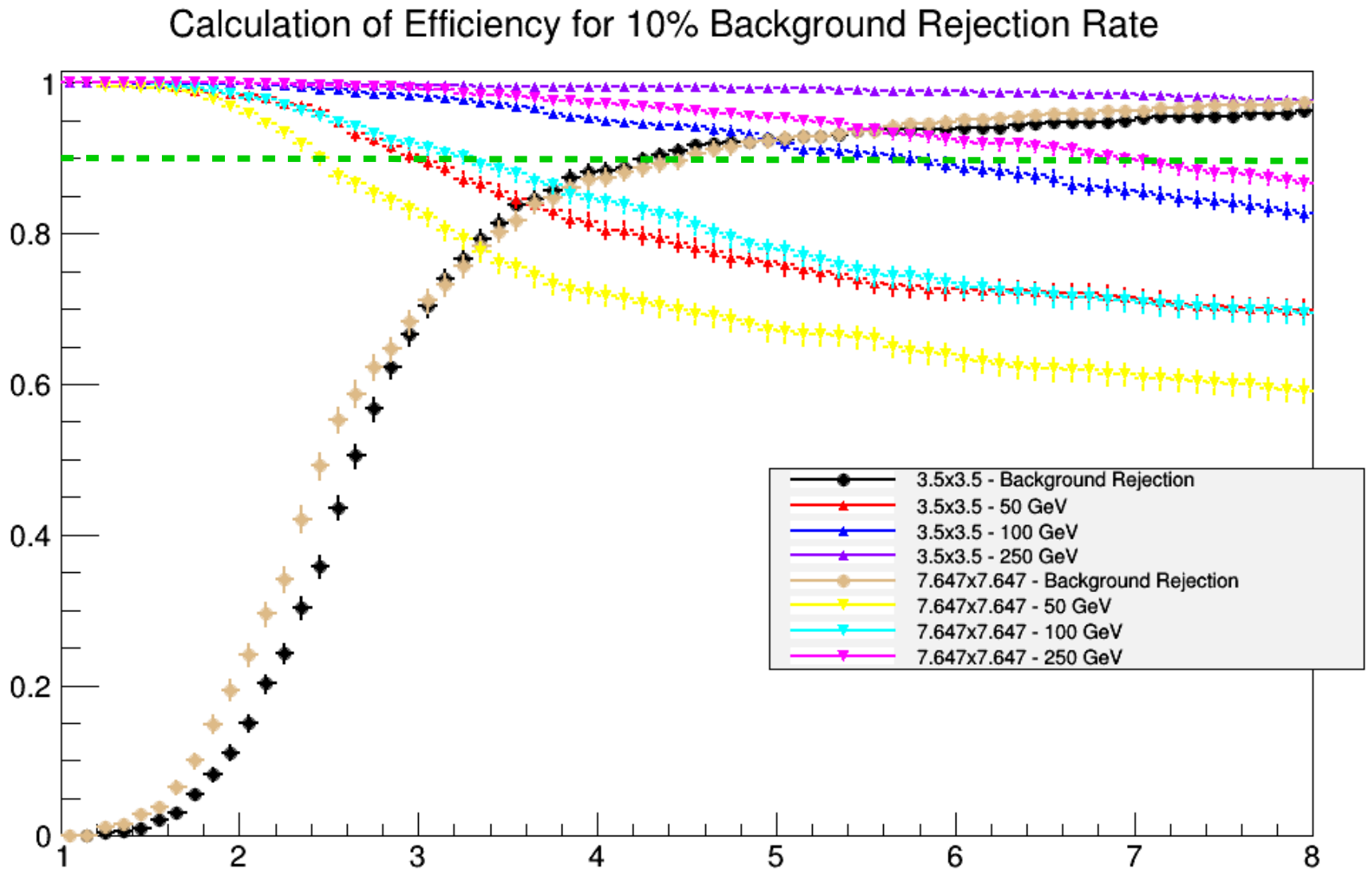
Lucia's Constant 7.647x7.647 mm



Lucia's Varied - Zoomed

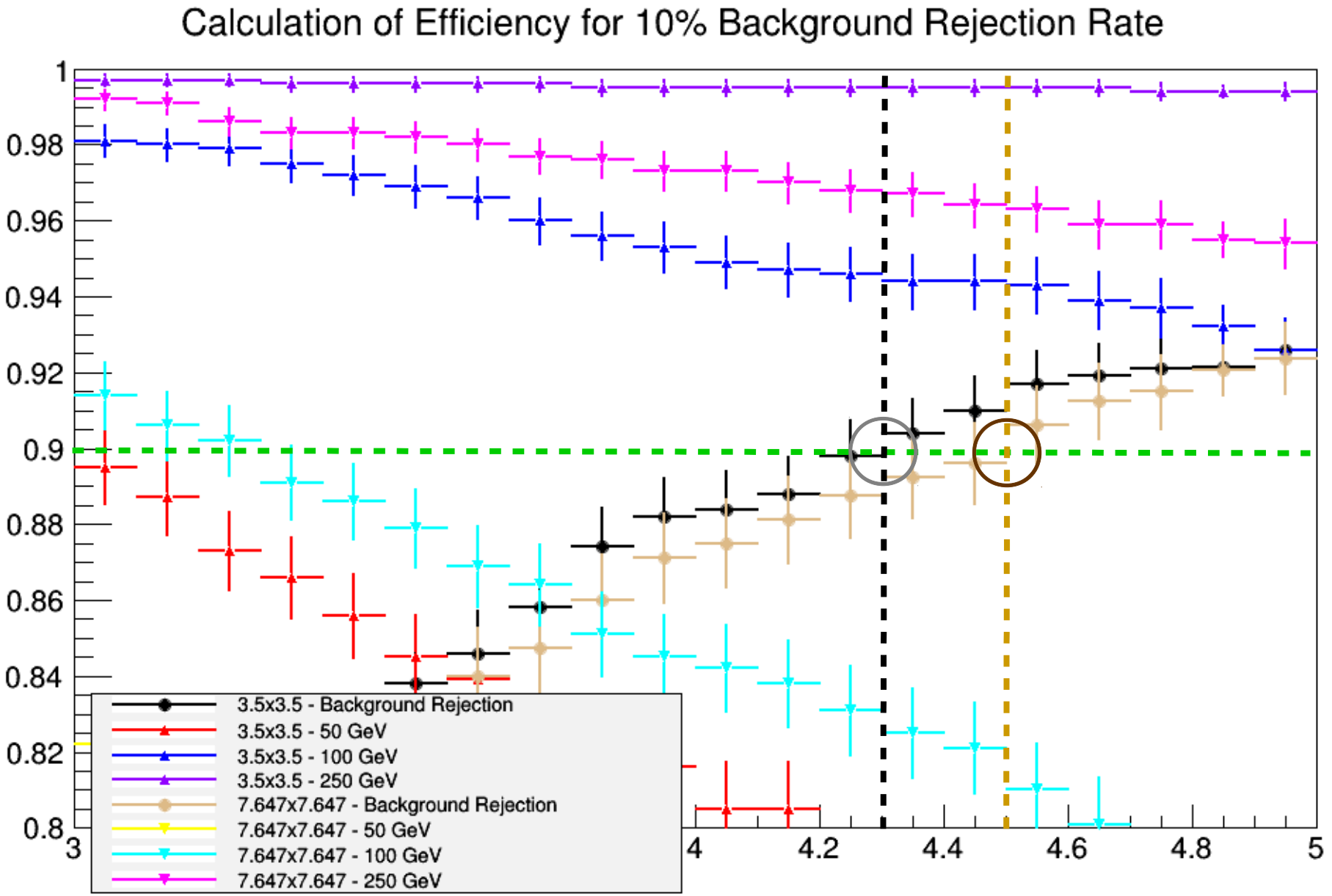


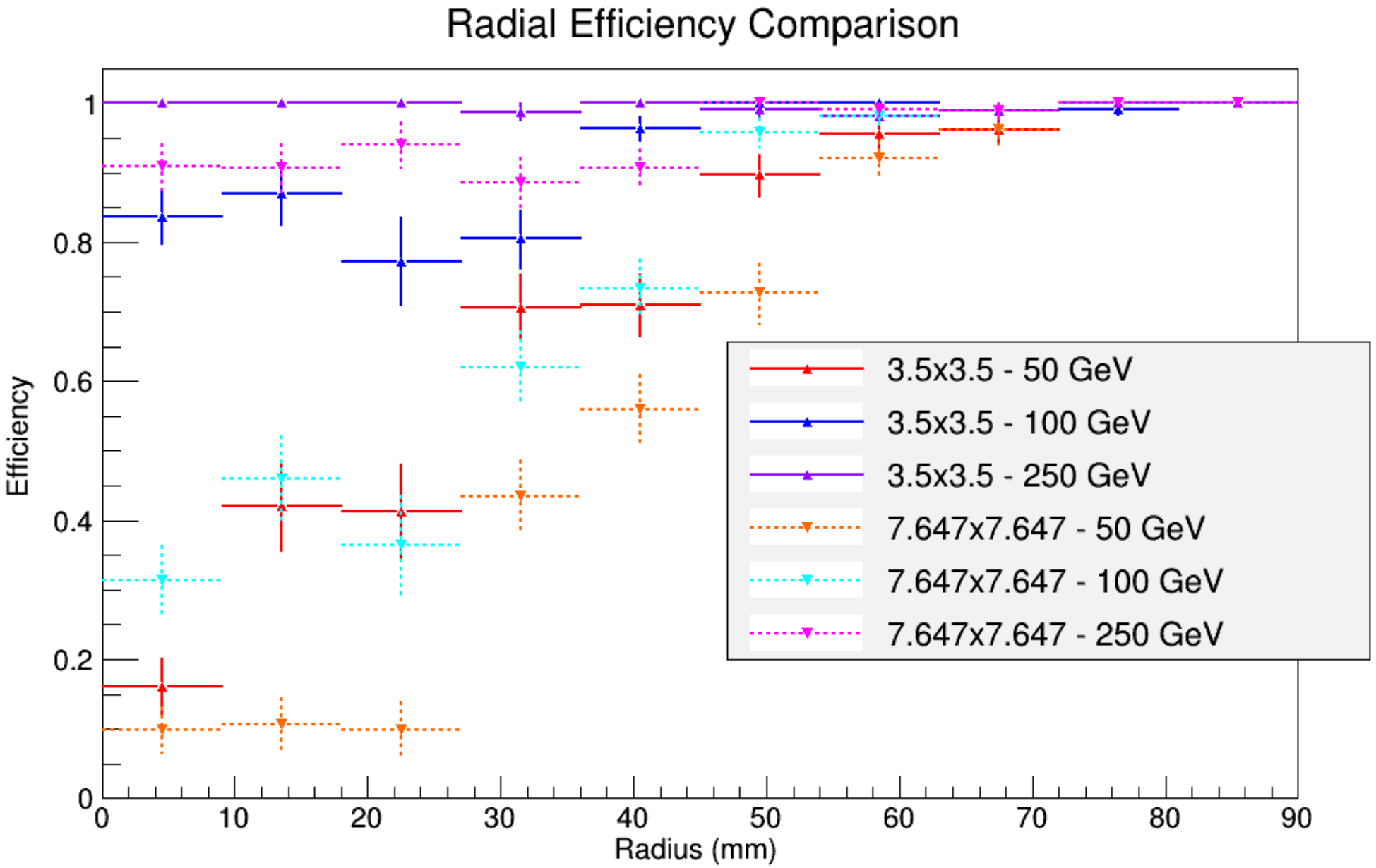
7.647x7.647 mm Efficiency Results Compared to our 3.5x3.5mm Results



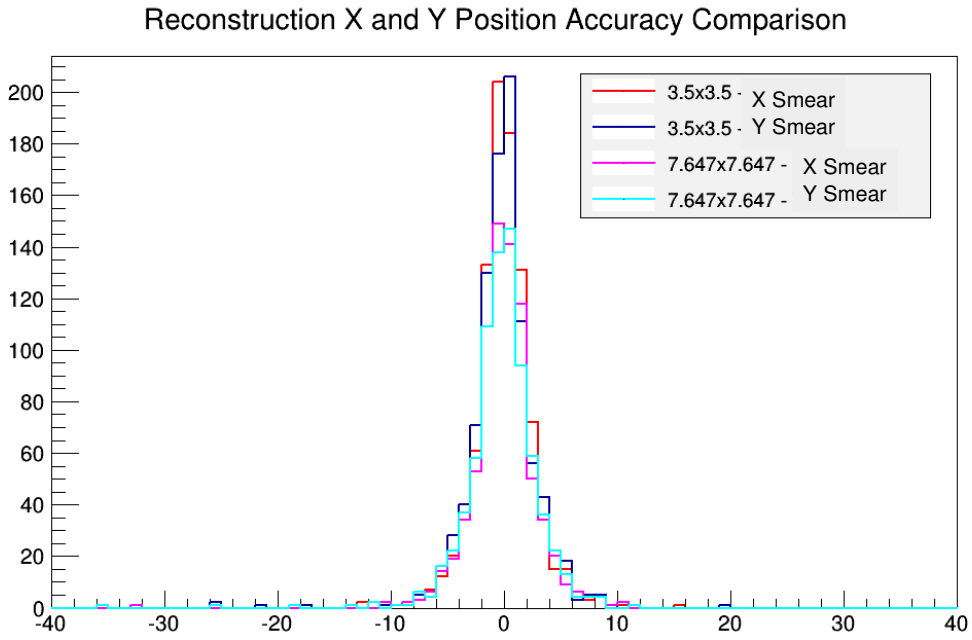
Sigma cutoff for our segmentation strategy is at 4.3

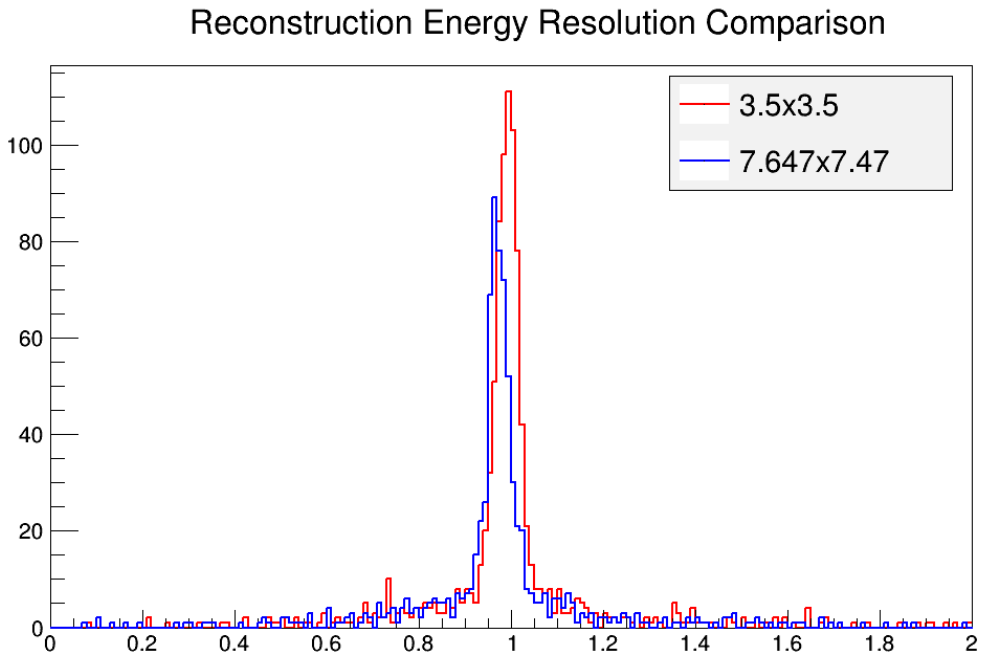
Sigma cutoff for Lucia's constant size segmentation strategy was set at 4.5

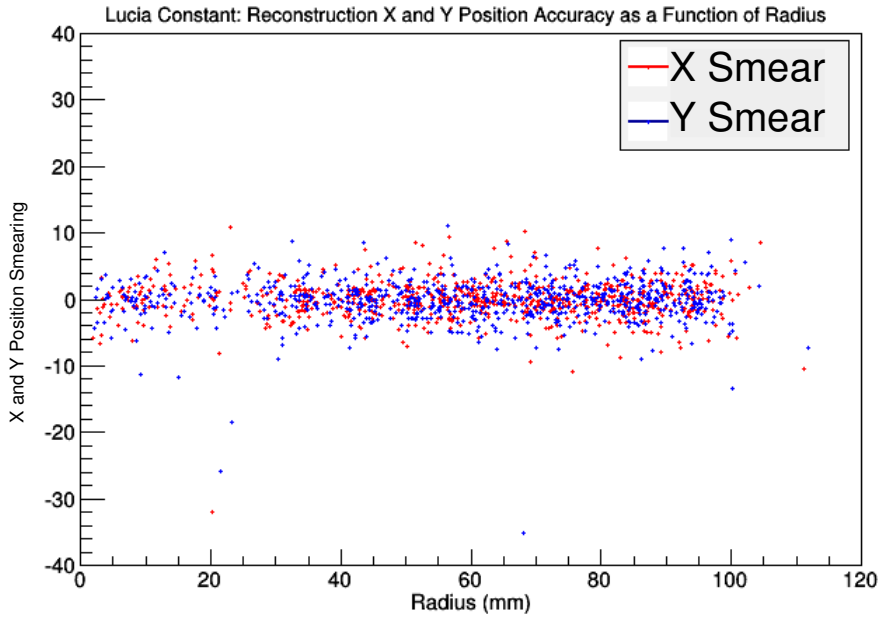


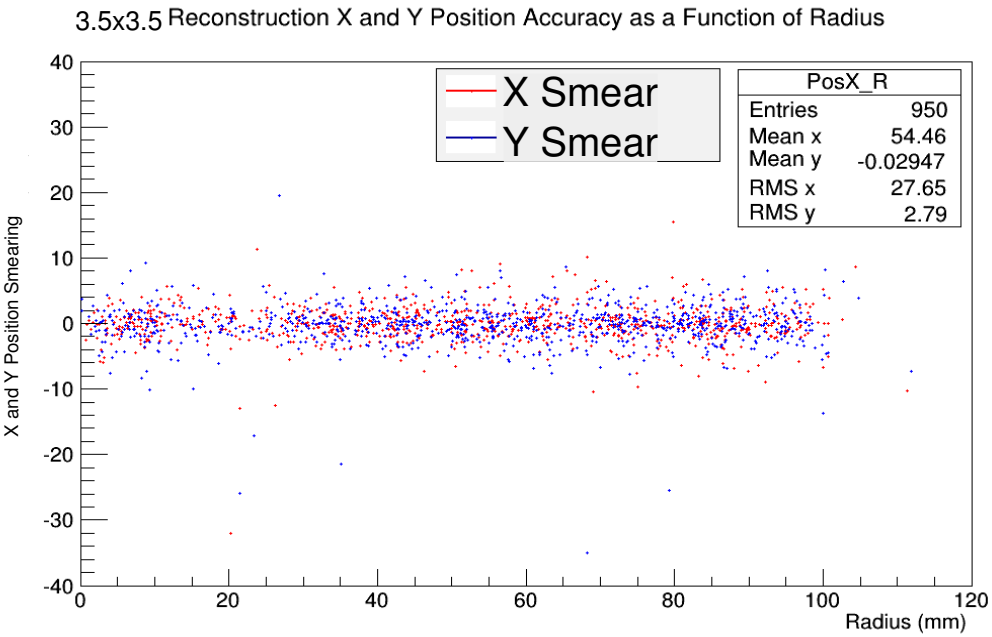

Radial Efficiency Comparison
Efficiency
Radius (mm)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
70
80
90
3.5x3.5 - 50 GeV
3.5x3.5 - 100 GeV
3.5x3.5 - 250 GeV
7.647x7.647 - 50 GeV
7.647x7.647 - 100 GeV
7.647x7.647 - 250 GeV

Recontruction Comparison

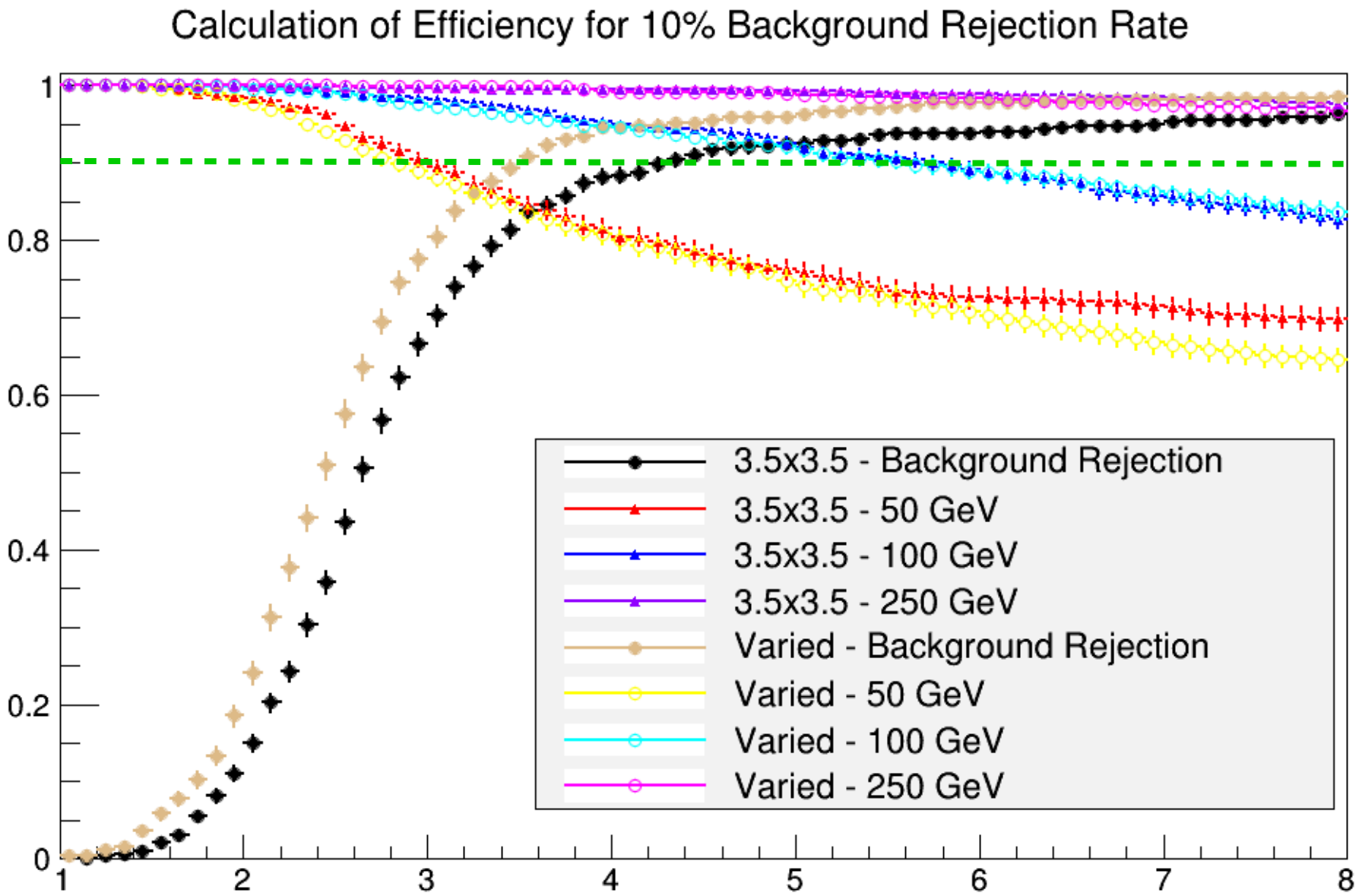






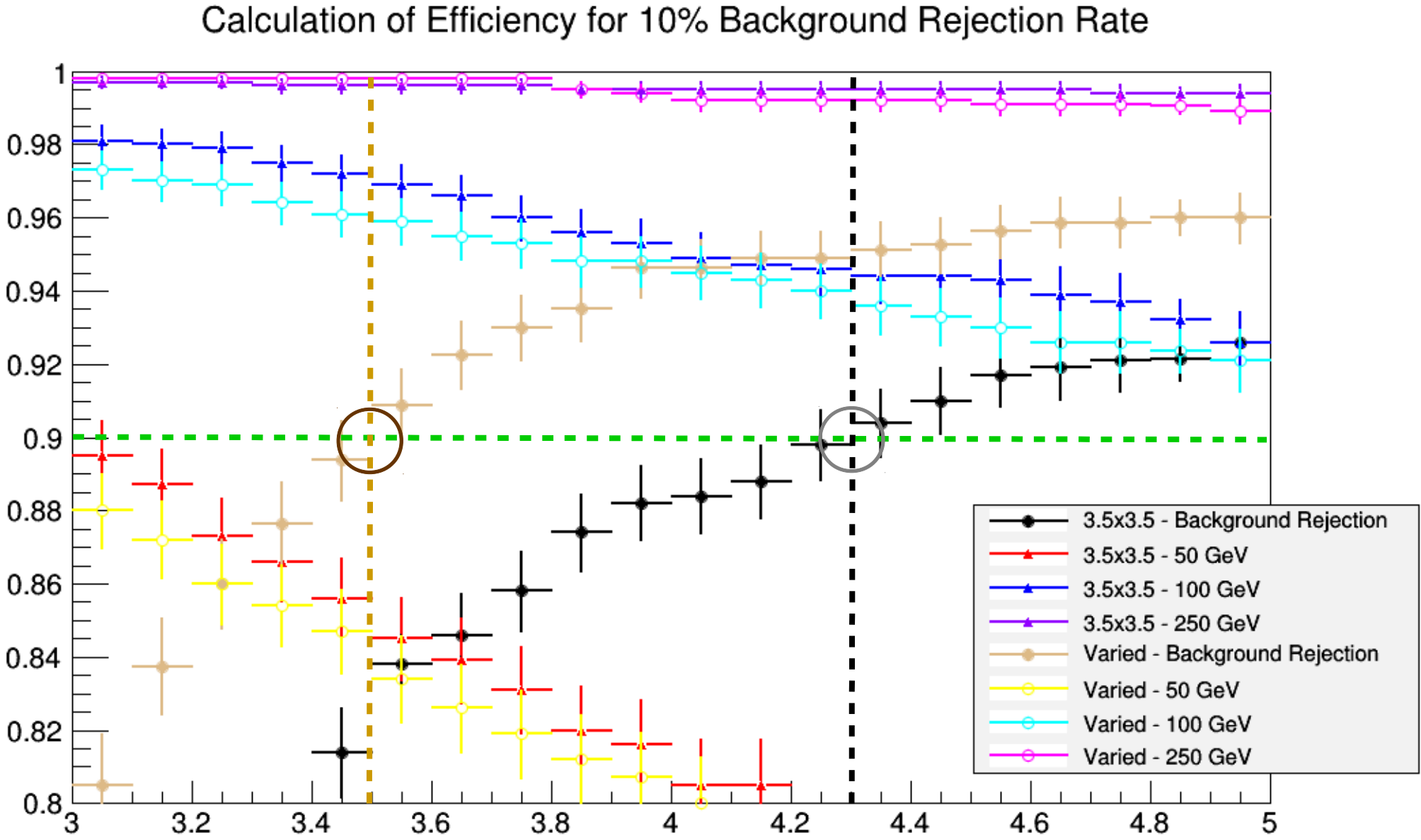


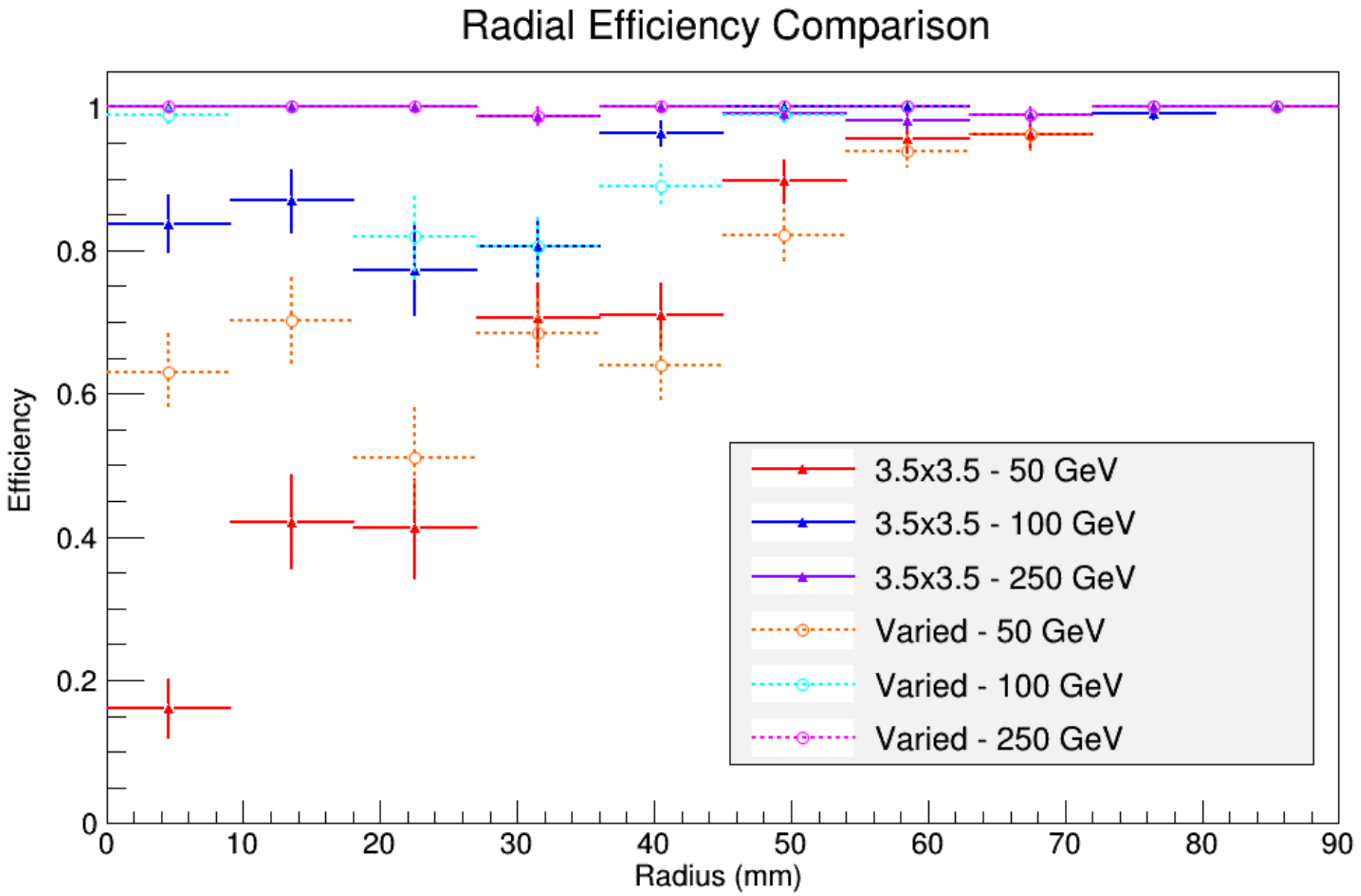
Varied Segmentation Efficiency Results Compared to our 3.5x3.5mm Results



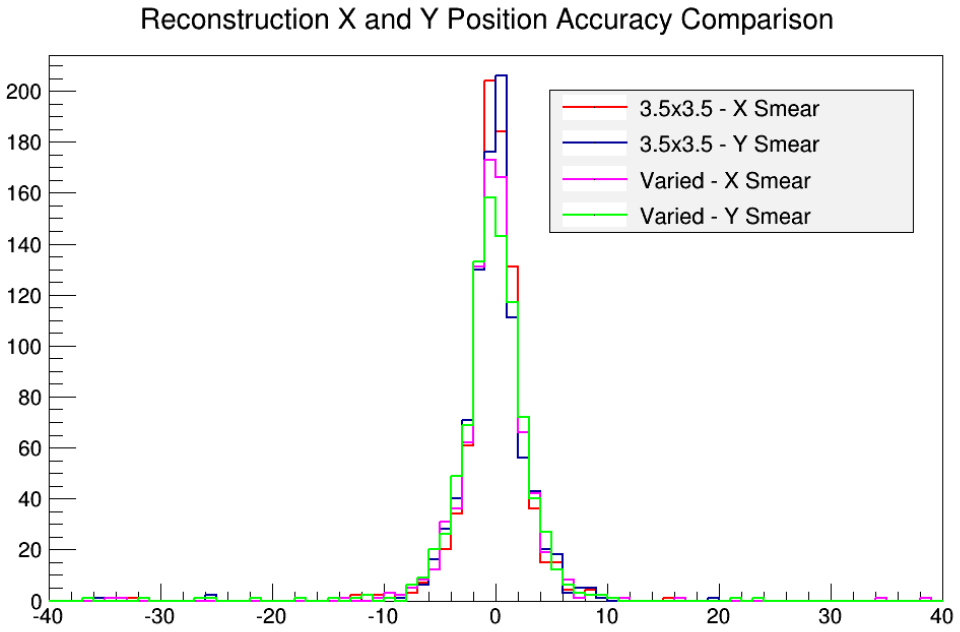
Sigma cutoff for our segmentation strategy is at 4.3

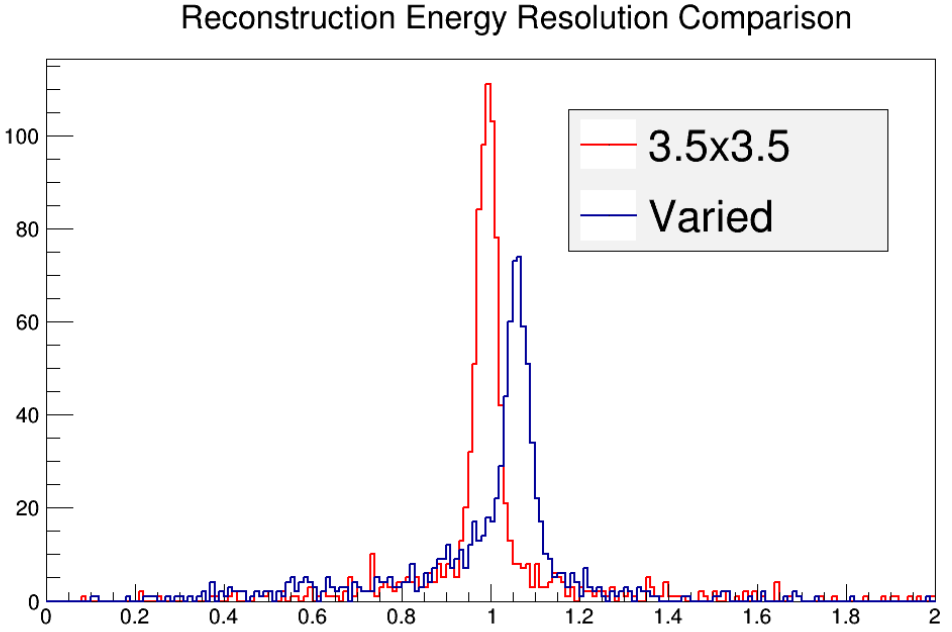
Sigma cutoff for Lucia's Varied size segmentation strategy was set at 3.5

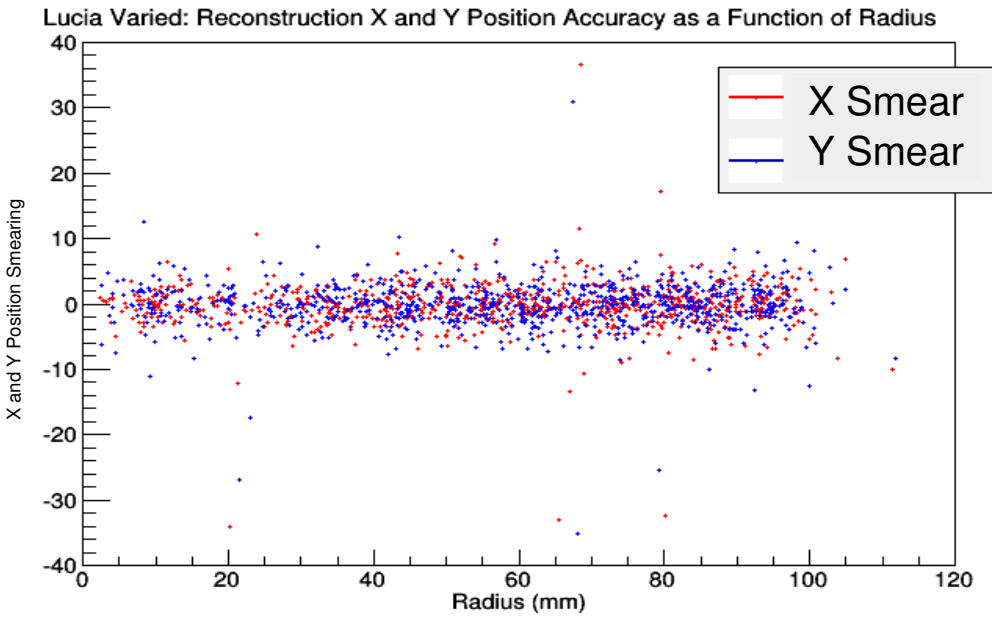


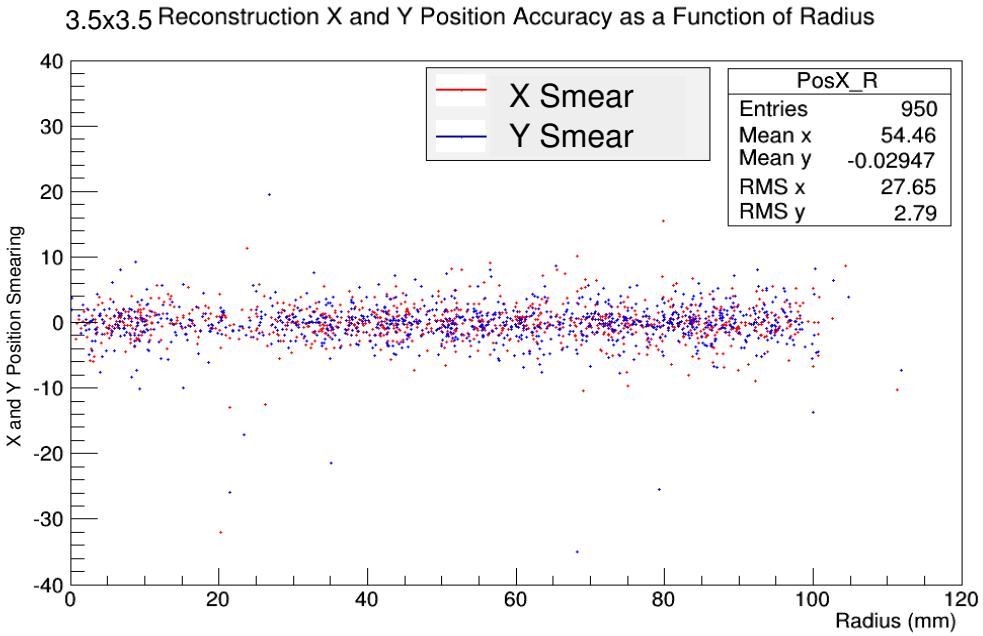

Radial Efficiency Comparison
Efficiency
Radius (mm)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
70
80
90
3.5x3.5 - 50 GeV
3.5x3.5 - 100 GeV
3.5x3.5 - 250 GeV
Varied - 50 GeV
Varied - 100 GeV
Varied - 250 GeV

Recontruction Comparison









Overview of Results

- We corrected two different bugs in our code, making it substantially more efficient
- We investigated the theta angle of the electrons, determining that the crossing angle for SiDloi3 had been properly implemented in our simulation files
- Lastly, we compared our segmentation strategy to those provided by Lucia:
  - The constant 7.647x7.647 segmentation performed worse on average than our segmentation strategy
  - The varied segmentation performed better on average than our segmentation strategy, except in the energy resolution study