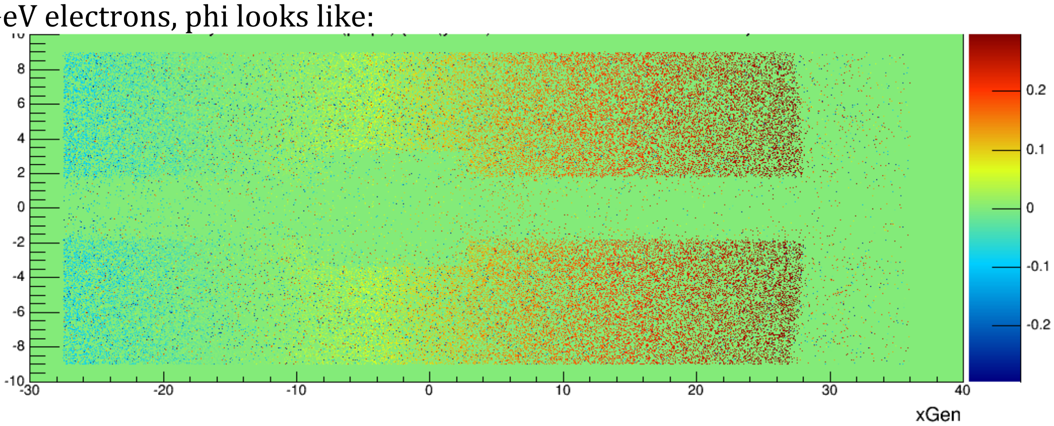
Brief Summary of the Opening Angle and the ECal

There is a known relationship between the opening angle of a particle at the target and it's final position at the ECal. To trace back to the opening angle at the target, it's necessary to know the position, energy, and particle charge (electron or positron). This can be used to construct the invariant mass of a pair of particles using ECal information only.

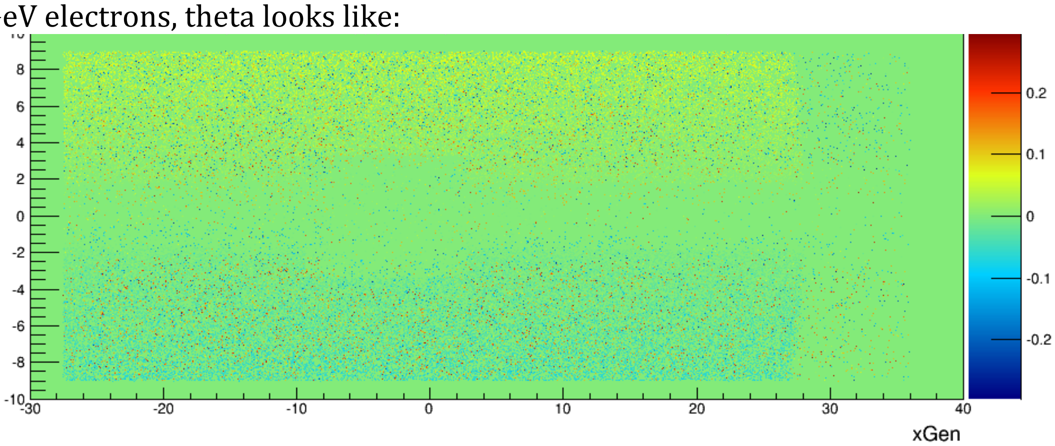
Method

Using the same simulations from the HPS Note 2014-001 (electrons and positrons fired from the target at discrete energies toward the ECal), I was able to support characterize the relationship of the angle at the target, specifically. This was done preliminarily in the HPS Note, but a formal calculation is necessary if one wants to apply the calculation to triggered pairs. Since I was interested in studying this first with single particles, I chose to use the HPS coordinate system. I defined phi as the angle in the x-z plane, arctan(px/pz), and theta as the angle in the y-z plane, arctan(py/pz).

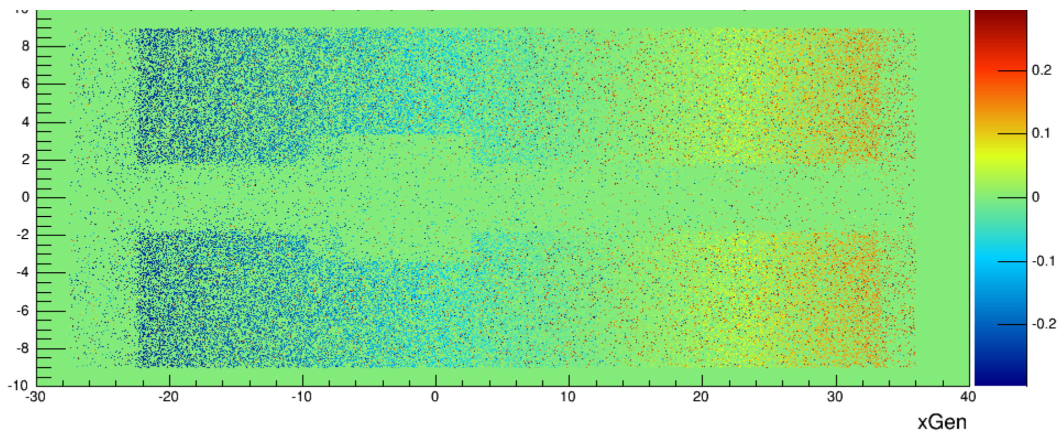
For 1 GeV electrons, phi looks like:



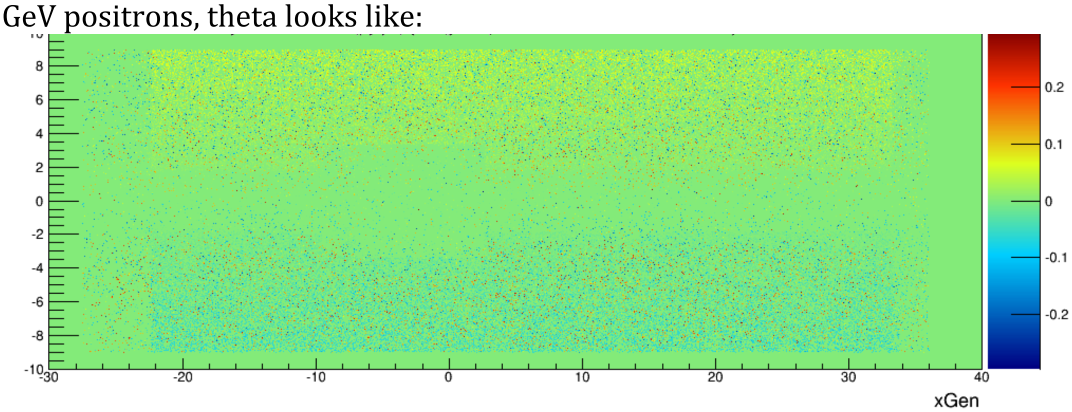
For 1 GeV electrons, theta looks like:



For 1 GeV positrons, phi looks like:

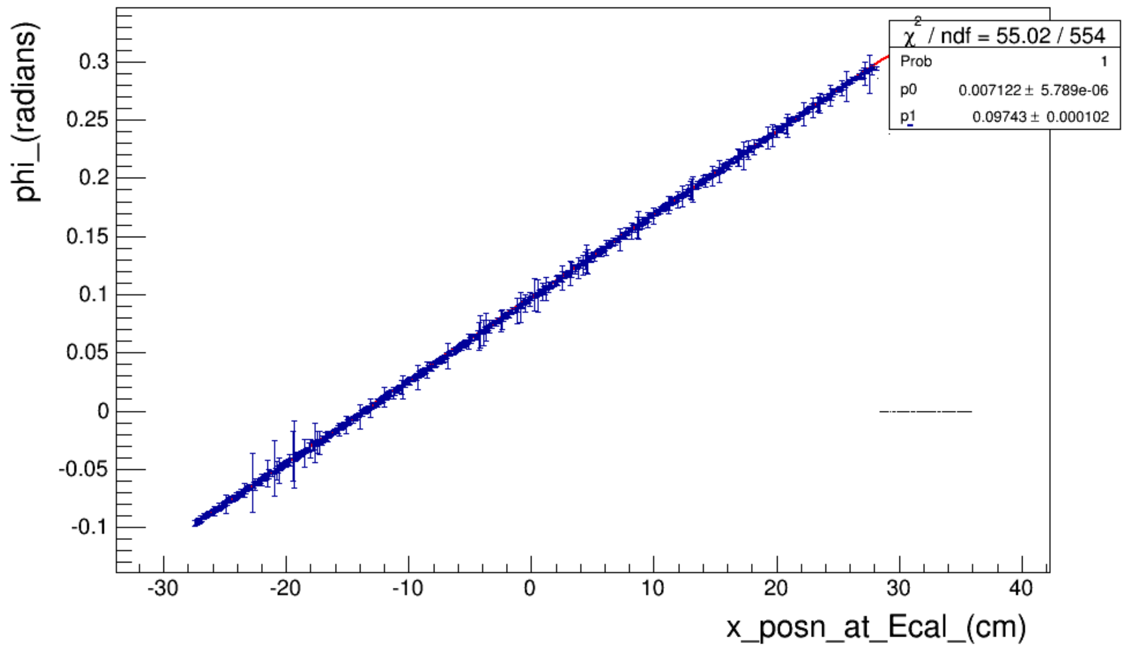


For 1 GeV positrons, theta looks like:

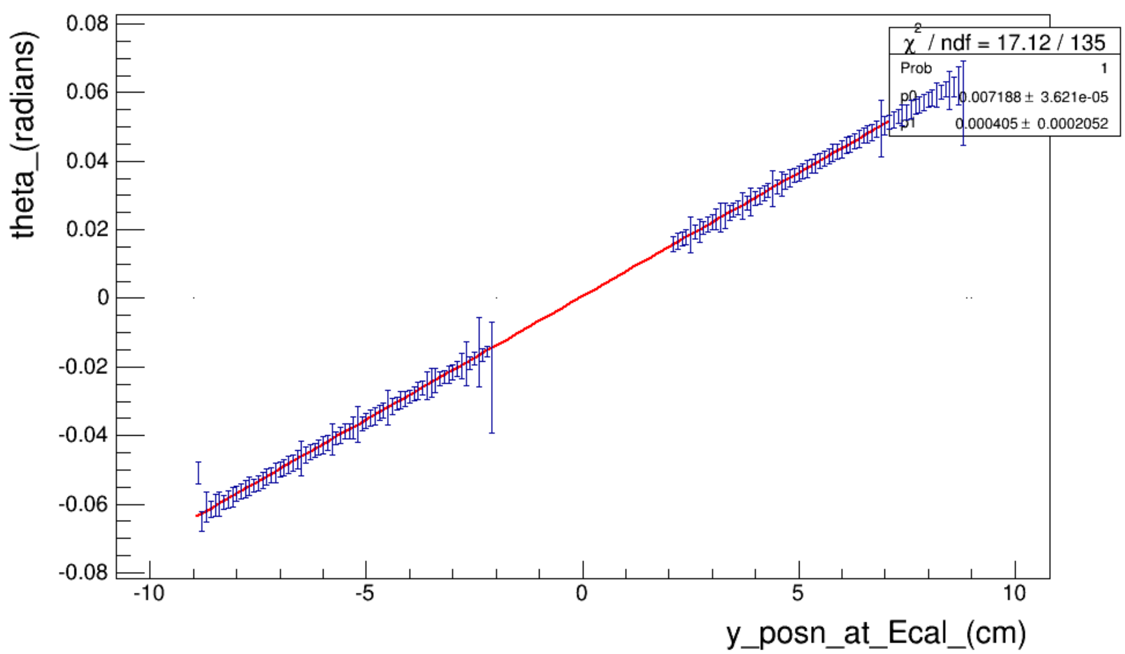


Phi can be uniquely determined by knowing the x-position of the particle on the ECal and the energy and particle type (+/-). Theta can be determined by knowing the y-position of the particle on the ECal and the energy and particle type. I divided the face of the ECal into a grid, finding the angles associated between every 1mm segment in x and then in y (this is smaller than our position resolution so should not be susceptible to resolution effects). The results of this led to straight line fits in both theta and phi versus y and x, respectively.

An example of the straight line for 1 GeV electrons is shown for phi:



And then for theta:



Next, an energy dependence was explored for these fits (Ax+B). All A,B parameters were plotted versus the energy to look for trends. While there was not a discernible energy dependence found for theta, the relationships found were as follows (x and y are in cm):

Electrons:

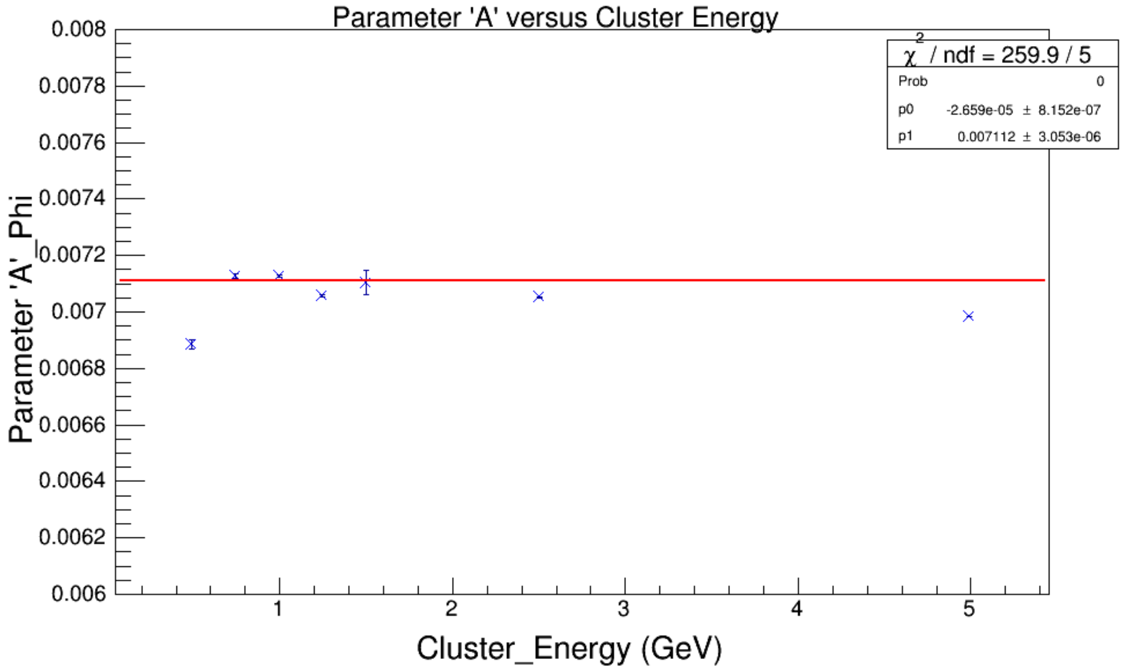
Phi: 0.007x + B

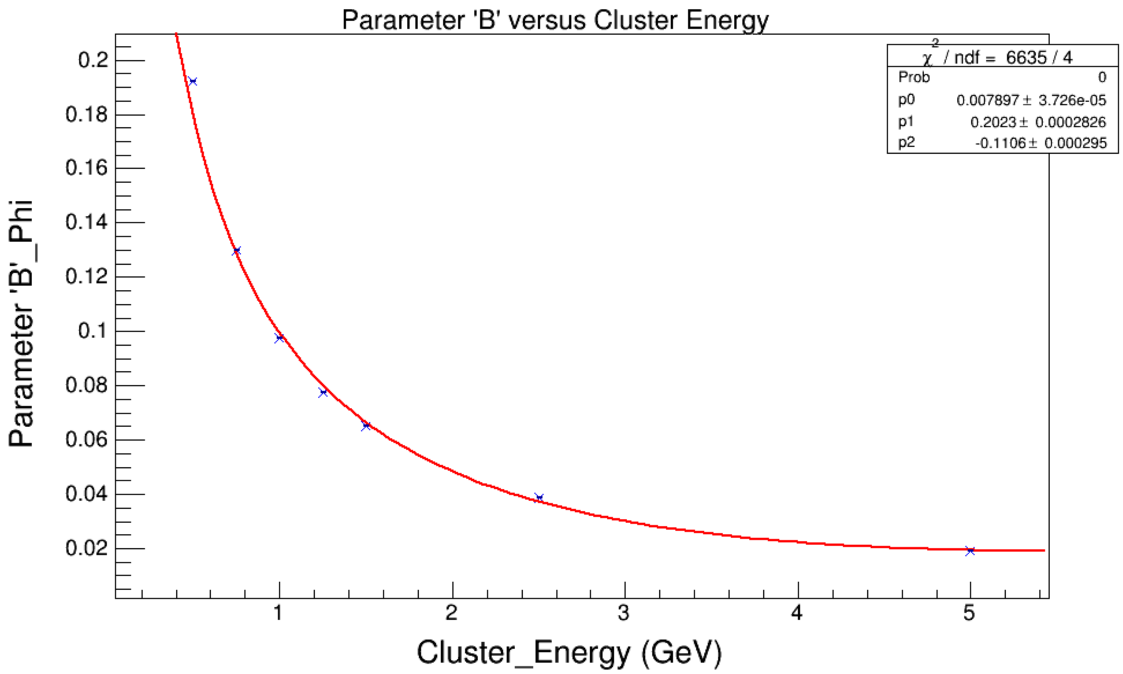
Where B = 0.007897E+0.2023/sqrt(E)-0.1106

Theta: 0.0071y

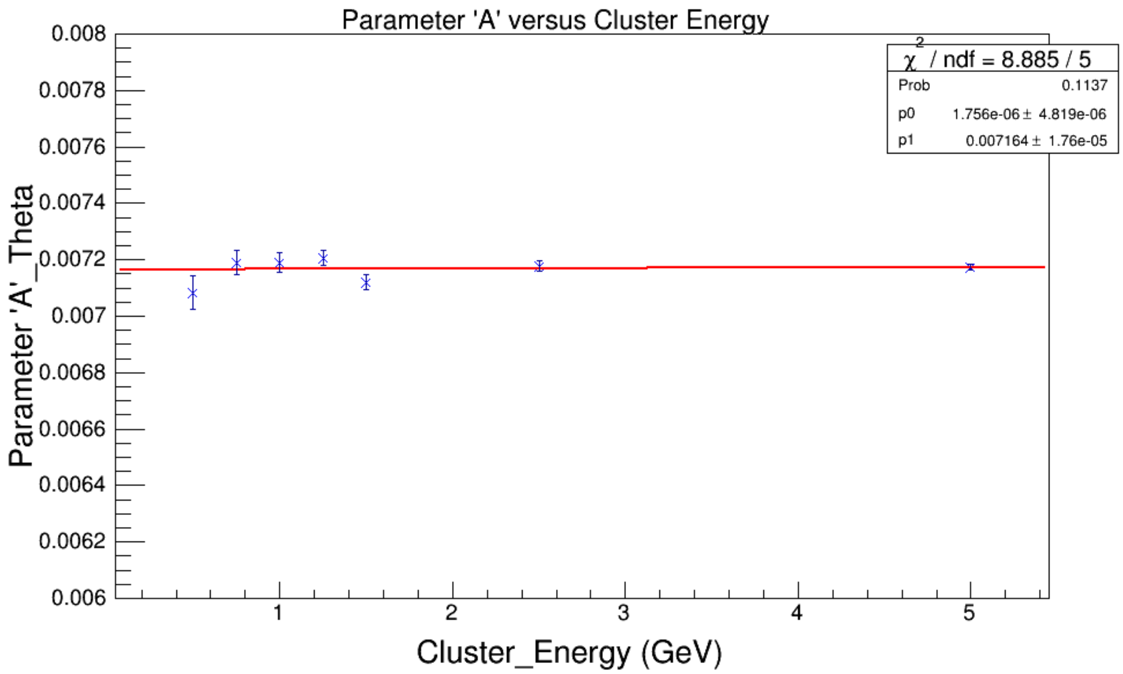
Positrons:
Phi: 0.007x + B
Where B = -0.00999E-0.2146/sqrt(E)+0.1255
Theta: 0.0071y

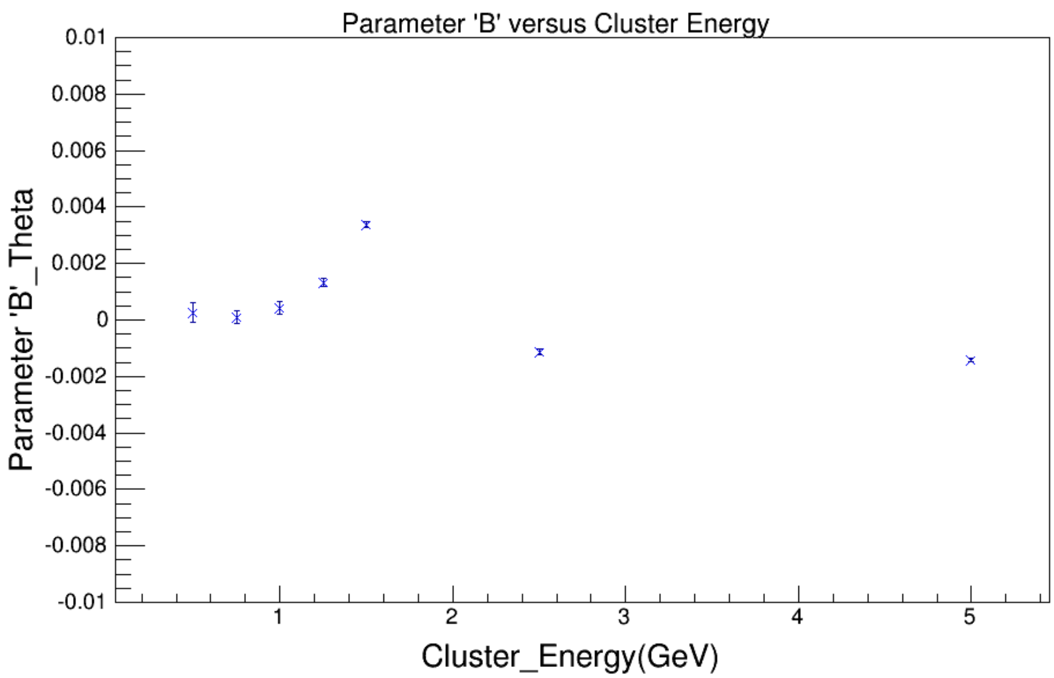
The fits used for the electrons in phi is shown:





The fit for the electrons in theta is shown:


Parameter 'A' versus Cluster Energy
χ^2 / ndf = 8.885 / 5
Prob 0.1137
p0 1.756e-06 ± 4.819e-06
p1 0.007164 ± 1.76e-05
Parameter 'A'_Theta
Cluster_Energy (GeV)
0.006
0.0062
0.0064
0.0066
0.0068
0.007
0.0072
0.0074
0.0076
0.0078
0.008
1
2
3
4
5


Parameter 'B' versus Cluster Energy
Parameter 'B'_Theta
Cluster_Energy(GeV)
-0.01
-0.008
-0.006
-0.004
-0.002
0
0.002
0.004
0.006
0.008
0.01
1
2
3
4
5