Vertex reconstruction

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Setup

Three-plane setup

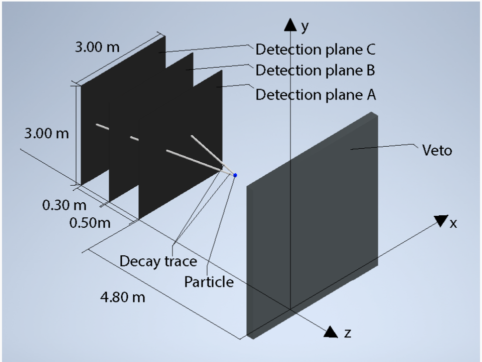

Figure 1: Three-plane setup.

Moving the first detection plane around does not change the simulation results significantly (assuming the decay occurs exactly at the center of the decay zone, between the veto and the first detection plane).

Scintillator overlapping

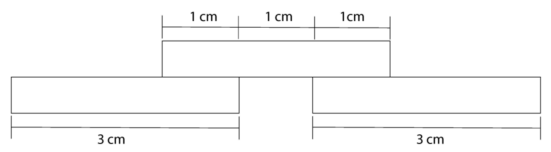

Figure 2: Scintillator overlapping as seen from their ends.

The detection planes are made of overlapping scintillator bars. Overlap is of 1 cm.

Effective detection grid

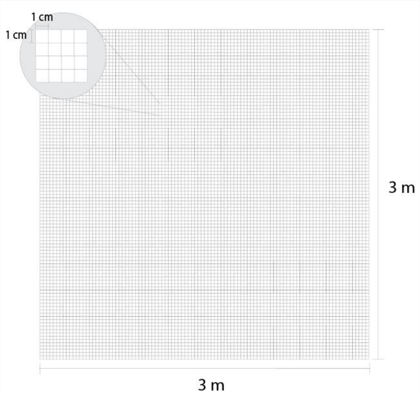

Figure 3: Effective detection grid on each detection plane as a result of scintillator bars overlapping.

Simulation

Simulation of real life detections

The blue dots simulate the real hits from the particles are each plane, with their respective blue tracks. The red dots simulate the observation of those hits in the laboratory. The red tracks are the reconstruction of the traces of the real hits based on the observation in the laboratory.

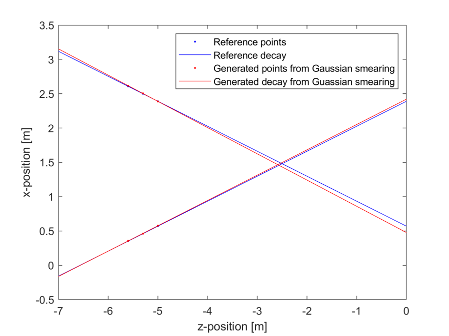

Figure 4: Detection simulation in 2 dimensions.

Simulation of real life detections (continued)

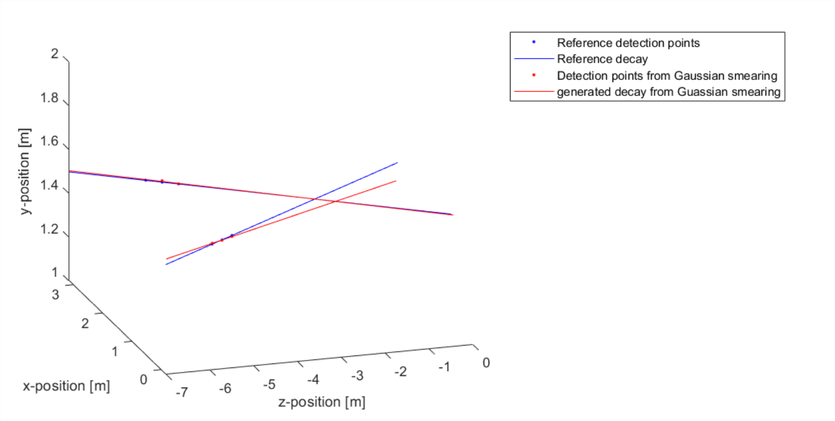

Figure 5: Detection simulation in 3 dimensions.

Vertex reconstruction resolution

Vertex-to-vertex distance

We look at the distance between the vertex were the real decay occurred and the vertex generated from a linear fit based on the observation in the laboratory. The analysis is done for different opening angles of the decay.

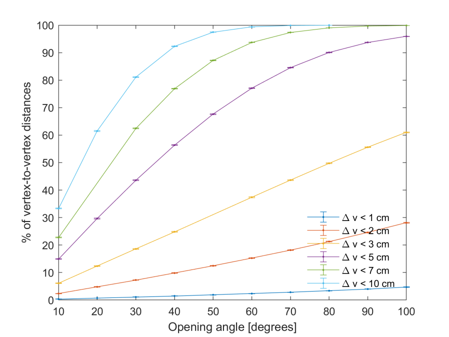

Figure 6: Vertex resolution.

Vertex-to-vertex distance by coordinate

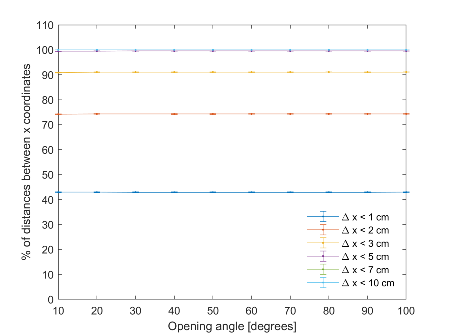

Figure 7: Vertex resolution in the x-coordiante.

Vertex-to-vertex distance by coordinate (continued)

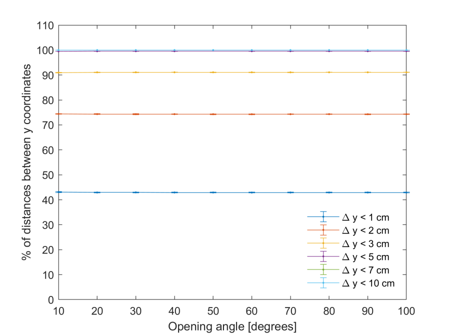

Figure 8: Vertex resolution in the y-coordiante.

Vertex-to-vertex distance by coordinate (continued)

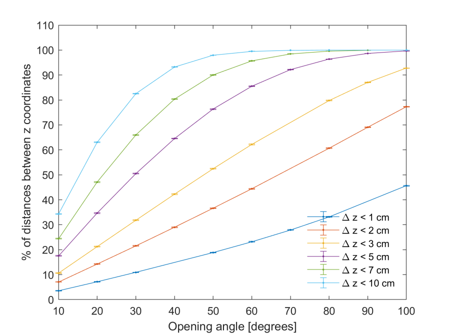

Figure 9: Vertex resolution in the z-coordiante.

Simulation with added noise

Simulation with added noise

As before, the blue dots simulate the real hits from the particles are each plane, with their respective blue tracks. The red dots simulate the observation of those hits in the laboratory. The red tracks are the reconstruction of the tracks of the real hits based on the observation in the laboratory without taking into account the added noise. The green dots are noise, and the green tracks are the reconstruction of the tracks of the real hits based on the observation in the laboratory taking into account the added noise.

Simulation with added noise (continued)

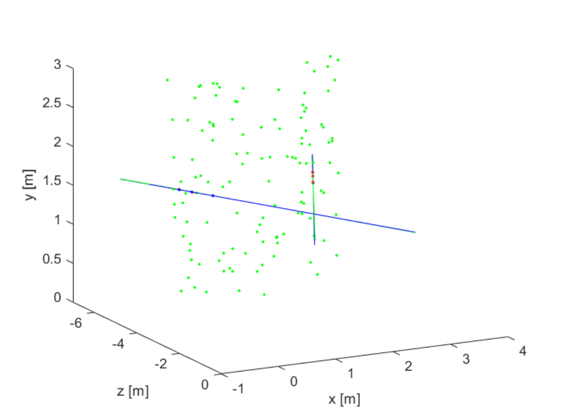

Figure 10: Simulation with added noise. 40 noise points per plane.

Simulation with added noise (continued)

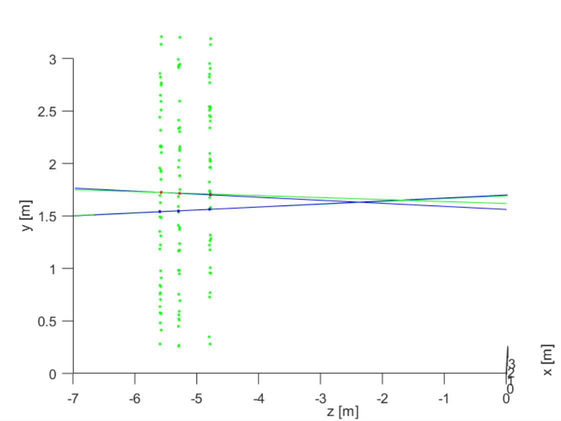

Figure 11: Simulation with added noise. 40 noise points per plane.

Noise cleaning

Method 1: procedure

The analysis is made for an opening angle of 40 degrees and a decay occurring in the xz-plane.

Step 1: noise cleaning is based on a (1) chi-squared analysis and (2) a look at the distance between the line generated by linear fit and the points used to generated that linear fit. This is for all the linear fits possible for the all the possible combinations of points in the detection planes. The results of the two methods are compared and their are matched. The best linear fits for each method that match the other's method are selected.

Step 2: the reconstructed tracks intersect each other in the xz-plane, but not in the yz-plane. Among the best linear fits, one looks at the tracks that intersect in the xz-plane inside the decay zone. Then one looks at the mismatch of the intersection in the y-axis and chooses the tracks that give the smallest mismatch value.

Method 1: results (preliminary)

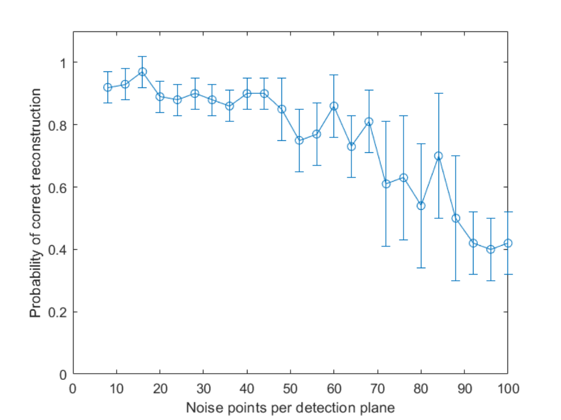

Figure 12: Results from noise cleaning, Method 1. Error bars are estimates only.

Method 2: procedure

This method looks at the y-axis mismatch of correct vertex reconstructions first (no noise present). The results give a range $\Delta y \approx [0, 0.14)$:

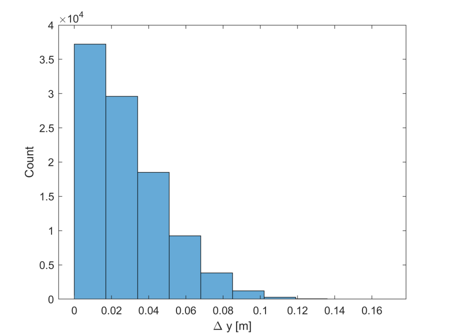

Figure 13: y-axis mismatch for a 40 degrees opening angle decay.

Method 2: next steps

The next steps to take is generated linear fits with noise included in the simulation. The linear fits that give a value of $\Delta y < 0.14$ [m] will be selected and the criteria of Method 1 with other criteria to be determined will be applied. This is expected to make the code run faster and improve the noise cleaning process.

Candidates:

- Opening angle filter (possible range: [35, 45])

ABORTED

Noise cleaning for various rotation angles (method 1)

Method 1: rotation angles of 45-135, 225-315 degrees

The noise cleaning is as in Method 1, and the analysis here is performed for rotation of the decay plane in angles of 45^o-135^o and 225^o-315^o. The angles of rotation are measured as follows: looking towards the planes of detection from the veto wall, one measures the angle of rotation of the decay plane from the y-axis (azimuth) in the counterclockwise sense. For the ranges of angles of rotation provided, the analysis works on linear fits that take as a basis/starting point the xz plane. For the missing ranges of angles, the linear fits take as a basis/starting point the yz plane. This detail was noticed when working on the 3 Section.

Results (preliminary)

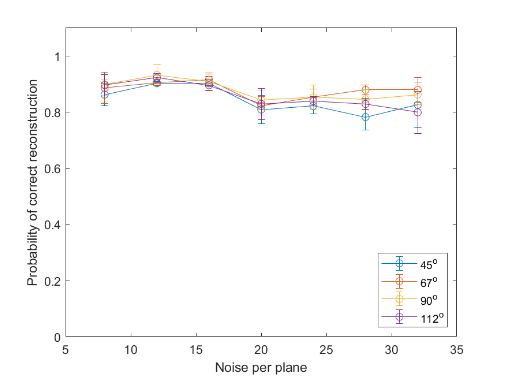

Figure 14: Preliminary results for variation of rotation angle, for an opening decay angle of 10^o.

Next steps

The next step to take is to have the computer generated linear fits that take as a basis/starting point bot the xz and yz planes, and then compare the best results of both paths after the noise is cleaned. The best result will then be chosen and compared to the correct reconstruction. I expect that this extra step will lower the noise cleaning capacity of the computer at rotation angles close to 0/360, 90, 180, and 270 degrees; this is because around those angles is where the two analysis paths just mentioned differ the most in their results. After this is achieved, the analysis will be extended to various opening angles, that is the angle between the tracks of the decay products of the original particle.

Method 1: rotation angle of 45 deg and analysis extended 3D case

Next step taken: the computer generates a linear fit in two dimensions and it subsequently adds a third dimension. The computer generated linear fits starting in two dimensions at both the xz and yz planes, and then it added the third dimension: y and x, respectively. The best result from both paths is then be chosen based on minimum distance of intersection and compared to the correct reconstruction.

Results: decay plane rotated 45 degrees

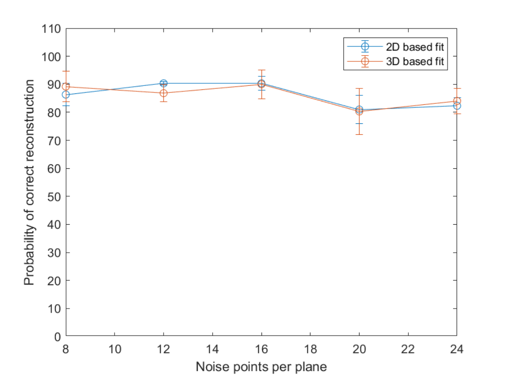

Figure 15: Preliminary results comparing the computer reconstruction capacity for the decay plane rotated 45 degrees and the cleaning noise method as described in the previous frame.

Results: decay plane rotated 90 degrees

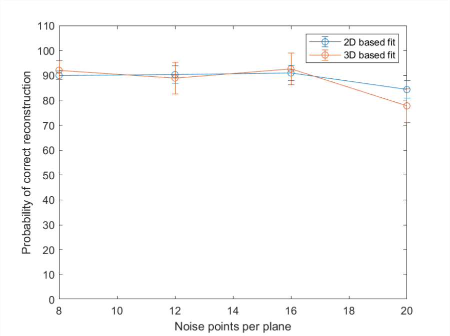

Figure 16: Preliminary results comparing the computer reconstruction capacity for the decay plane rotated 90 degrees and the cleaning noise method as described in the previous frame.

The results for the 3D based fit were expected to be significantly lower at this angle, but the computer seems to be doing a good job.

Noise cleaning (method 1) updated

Method 1: update

For this method I kept the technique of choosing the best linear fit from a chi-square analysis. The chi-squared analysis is performed by integrating the chi-squared density distribution. The result closest to 0.5 is taken to be the best result. (Previously, I was only calculating the reduced chi-squared and comparing it to 1.) The results have improved significantly, as can be seen in Figure 17.

cont.

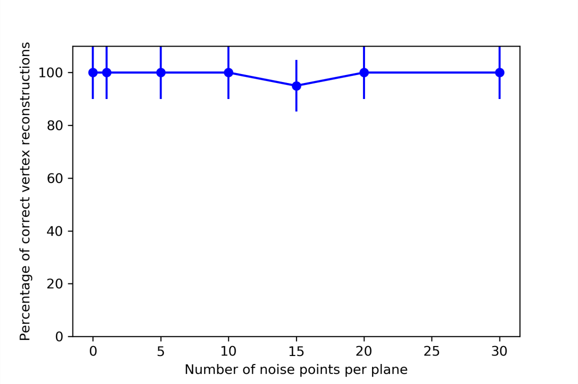

Figure 17: 15 nppp based on 20 runs, 20 nppp based on 7 runs, 30 nppp based on 3 runs. The uncertainties are only estimates, placed by hand. At this point, running the code a statistically significant number of times as to generate accurate error bars would be time wasted.

Further noise cleaning

I further cleaned the noise by eliminating data points that “occur” in the same (effective) bar (there are 300 effective bars in total). An analysis on how often two points land in the same bar is shown in Figure 18.

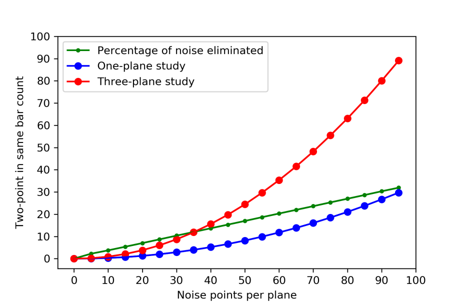

Figure 18: Expected number of times two signals will come to the PM from the same bar (horizontal and vertical counted together). Data generated from a 3mx3m plane with 3cmx3cm bars overlapped by 1cm, creating an effective 1cmx1cm gridded plane. The simulation for the noise points was run 100,000 times for statistically significant results. Vertical error bars included, but too small to see.

Results

- Faster code
- Improved percentage of correct reconstructions

The results are shown in Figure 19.

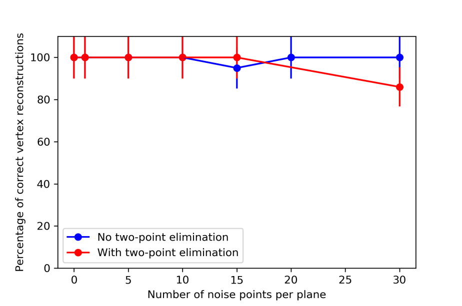

Figure 19: 20 nppp data missing (for saving time). The uncertainties are estimates only, and they have been put by hand. At this point, running the code a statistically significant number of times as to generate accurate error bars would be time wasted.

Results (Jan. 29 20201 update)

- Faster code
- Improved percentage of correct reconstructions

The results are shown in Figure 20.

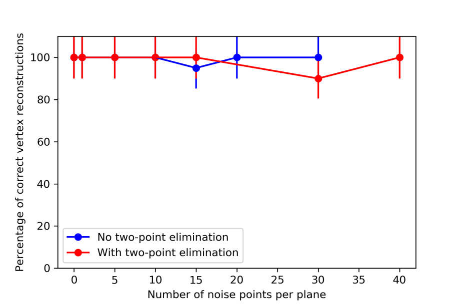

Figure 20: 20 nppp data missing (for saving time). The uncertainties are estimates only, and they have been put by hand. At this point, running the code a statistically significant number of times as to generate accurate error bars would be time wasted.

Probability of eliminating a real point with the two-point elimination technique

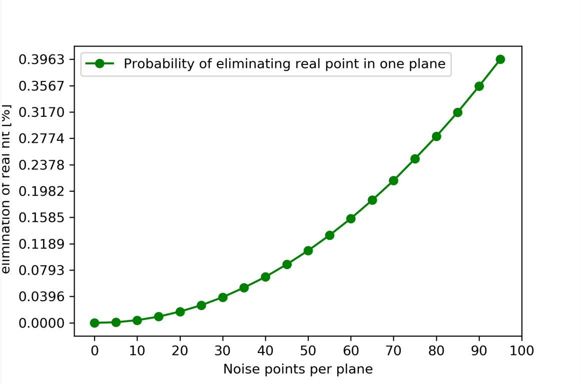

Figure 21: Probability of eliminating a real hit with using the two-point elimination technique.

Equipment

Changes in the experiment apparatus

- No longer overlapped scintillator bars. Instead, lines of waveshifting fiber in a single scintillating plane.
- The detection of light performed with SiPMs attached to the ends of the fiber.

Next: testing.