An analysis of the separation between γ's hitting the Ecal barrel in ZZ and WW events that feature hadronic decays.

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Abstract

Discussed in this paper is a study of the actual distances between γ's as they hit the beginning of the LDC electromagnetic calorimeter. The γ's in question are those that are the product of π^0's that are created in the hadronic decay of a pair of Z^0's or W's, with center of mass energies of 500GeV and 1000GeV both analyzed. Presented within is data that should prove useful in future work that focuses on discriminating between a single photon hit and a pair of nearby photon hits on the ecal, and in looking for the signature of a π^0 decay. This data is comprised of plots that reveal the likelihood of a γ hit being within a given distance to another hit, and the energies of each γ in a pair of nearby hits.

In each case, the distances described are never between γ hits that originated from the same π^0; γ's created by the same π^0 are not compared to each other. This is done to paint a clearer picture of the expected background when searching for a π^0 decay.

1 Percentage of γ hits with a nearby hit within a given distance

1.1 Summary

The four plots below are concerned with the distances between e-cal hits and their nearest neighbors. In this case an e-cal hit refers to the actual (x,y,z) position of a γ just as it hits the inner edge of the e-cal barrel, and its nearest neighbor is the nearest e-cal hit that is created by a γ from a different π^0. Only γ's that are created at the origin are counted, and all γ's in this study are created by π^0's originating from a hadronic decay. This is done so that the data can be used to determine the likelihood that a pair of nearby γ hits result from a single π^0 decay, or from two different sources.

This data is useful because it shows the probability that a pair of γ's from different sources could produce a pair of cal hits that are sufficiently near to each other to be mistakenly identified as being products of the same π^0 decay.

On the y-axis of each plot is the percentage of e-cal hits with a nearest neighbor within the distance displayed on the x-axis.

1.2 Data

1.2.1 500 GeV events

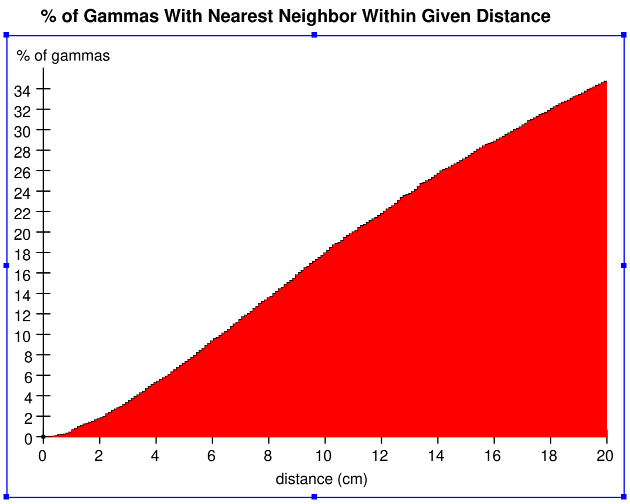

Figure 1: the percent of gammas whose nearest unrelated neighbor lies within the given distances: 500 GeV ZZ events

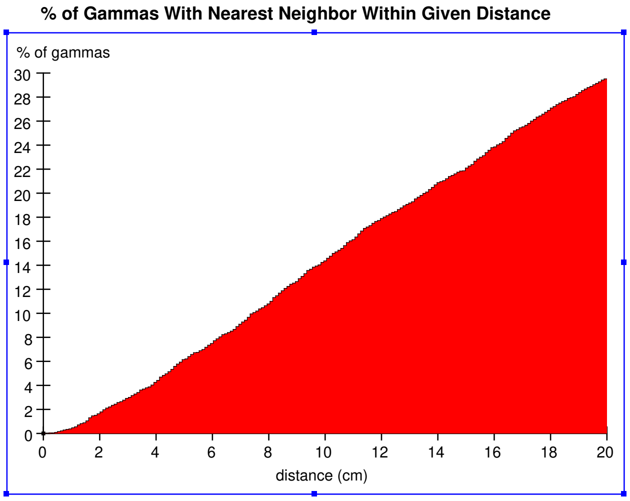

Figure 2: the percent of gammas whose nearest unrelated neighbor lies within the given distances: 500 GeV WW event

1.2.2 1000 GeV events

1.3 Generation of Data

Each of these plots was created by the same programs, with only the inputs differing. Each plot was created by generating a thousand events for both plots, and then discarding those events that did not feature hadronic decays (roughly four out of every nine).

The programs used were ISAJET, to simulate the particle decays in every event, SLIC, which is an implementation of GEANT4, to convert the ISAJET output into a easily workable format, and JAS3, a java analysis studio, to cut non-hadronic decays and to generate the actual plots.

The input for ISAJET consisted of four FFRead cards (one for each plot) that describe an e+e- beam with a center of mass energy of 500GeV and 1000GeV, and reaction products being either two Z^0's or two W's.

The input for SLIC was the output generated by ISAJET, and in this case the purpose of SLIC, which is to model the interactions between particles and the structure of the calorimeter, was actually ignored; SLIC merely served to convert the ISAJET ouput into .slcio files that could be analyzed in JAS3. For this reason, the calorimeter geometry file that was used while running

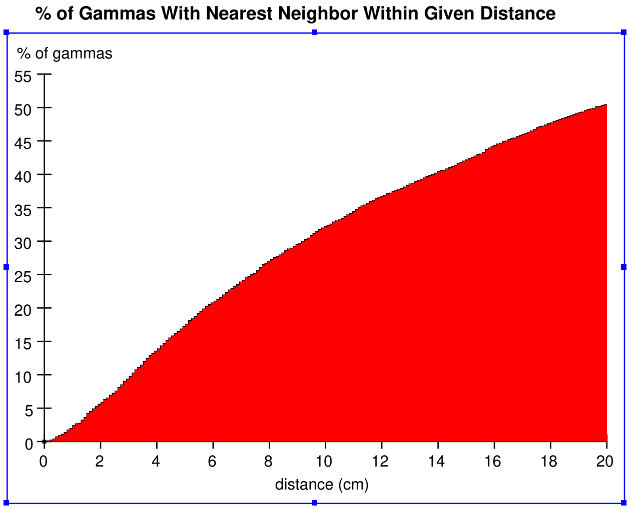

Figure 3: the percent of gammas whose nearest unrelated neighbor lies within the given distances: 1000 GeV ZZ event

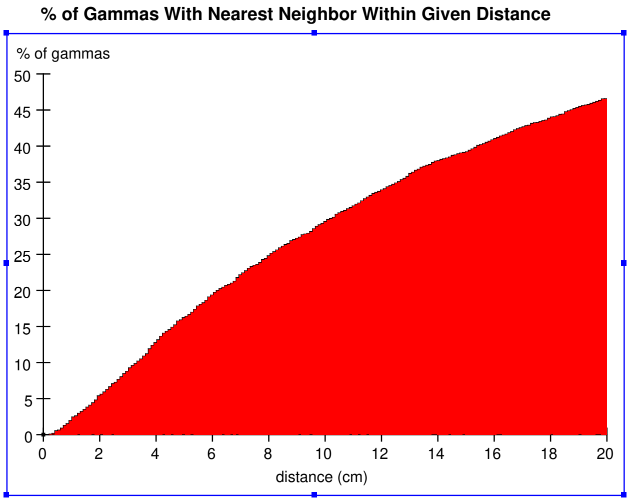

Figure 4: the percent of gammas whose nearest unrelated neighbor lies within the given distances: 1000 GeV WW event

SLIC is not of consequence, suffice it to say that the inner edge of the LCD electromagnetic calorimeter barrel in the file was defined as a cylinder with a radius of 175cm and a length of 565.6cm, and these were the dimensions used in the analysis program.

JAS3 was used to read the four .slcio files and to make several data cuts, and then to generate the actual plots.

1.3.1 Data Manipulation in JAS3

The first cut removed all events in which the Z^0's decay products included one or more leptons. Then, for every remaining event, a list of the π^0's in the event was created. Each π^0 that was not created at the origin (the very center of the barrel) was then removed from the list. Then, a list of every γ that was created by these π^0's was created. For each γ in the list, the actual momentum of the γ, as determined by ISAJET, was used to determine its position as it hit the e-cal barrel. Those γ's that avoided the barrel and hit the cap were discarded. Thus, for each γ that hit the barrel, a hit position was generated. It is important to reiterate that these positions refer to the actual, unknowable positions of the γ's; they are not dependant on the resolution of the calorimeter.

Each of these positions was collected into a list. Then, every element of the list was compared with every other element of the list, so long as the two elements were not created by γ's from the same π^0. In this way, for each hit position, a nearest neighbor was found, and the distance between each hit and its nearest neighbor was calculated.

A plot was then generated for all of the events, with the number of γ's on the y-axis, and the distance within which its nearest neighbor lay on the x-axis. Then, the y-values of each point on the plot was divided by the total number of γ's in all events, and this resulted in the percentage plots presented here.

2 Energies of γ's and their nearest neighbors on the e-cal barrel edge

2.1 Summary

The below six plots are concerned with the energies of γ's that create an e-cal hit and the energies of their nearest neighbors. As before, e-cal hits and nearest neighbor refer to the actual position of γ's as they hit the inner edge of the e-cal barrel, and e-cal hits that are closest to those positions, respectively. And also as before, only γ's created from different pions are compared, and only hadronic decay events are analyzed.

This data shows the energy distribution of nearby γ hits. Points that are far from the line y=x correspond to pairs of hits with greatly varying energies, and so can be precluded from being products of the same π^0 decay.

On the y-axis of each plot is the energy of every γ across all events (in GeV), and on the x-axis is the energy of it's nearest neighbor from the same event (in GeV).

2.2 Data

2.2.1 500 GeV e+e- to ZZ events

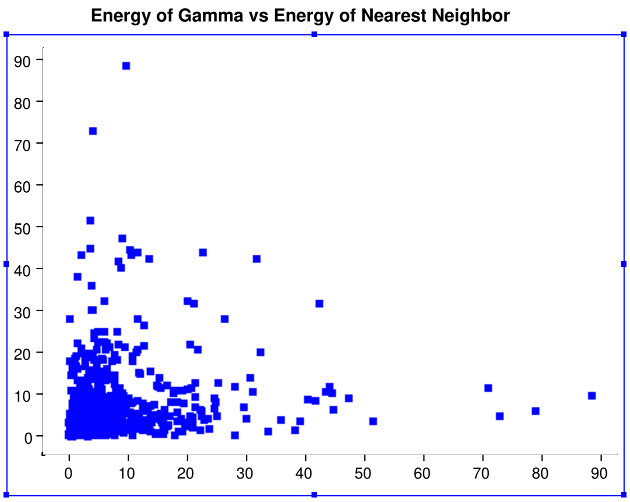

Figure 5: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor within 5cm

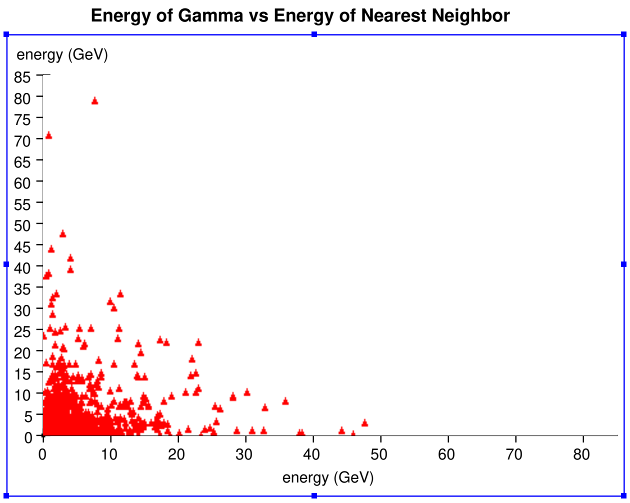

Figure 6: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 5cm and 10cm

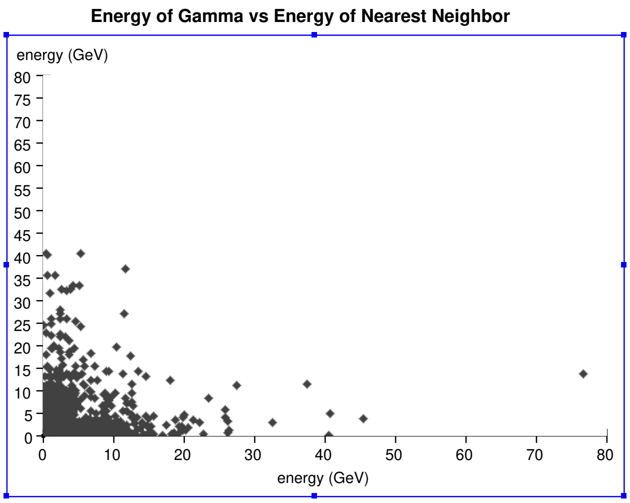

Figure 7: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 10cm and 20cm

2.2.2 500 GeV e+e- to WW events

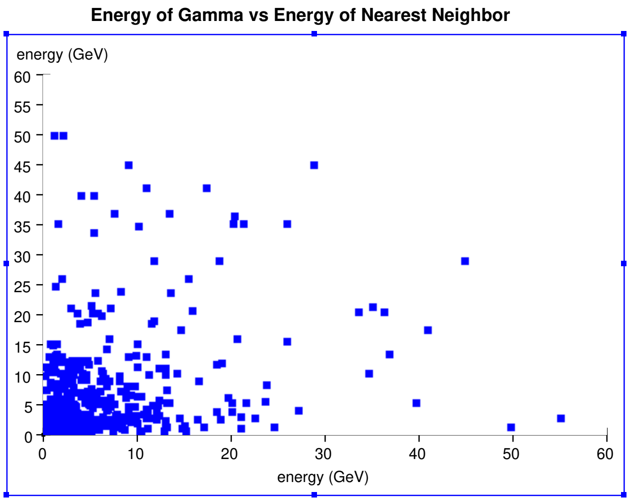

Figure 8: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor within 5cm

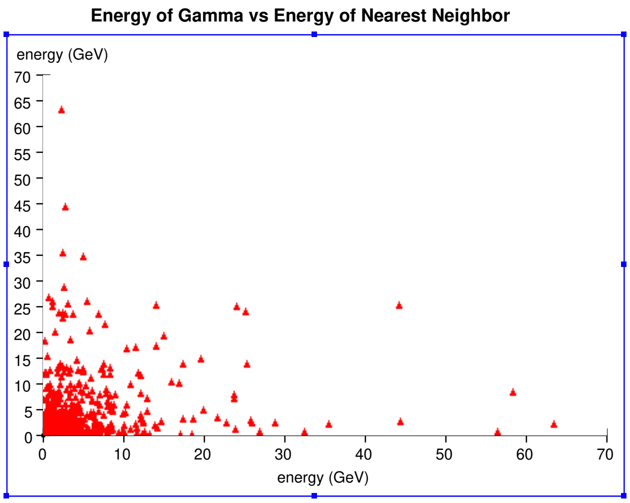

Figure 9: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 5cm and 10cm

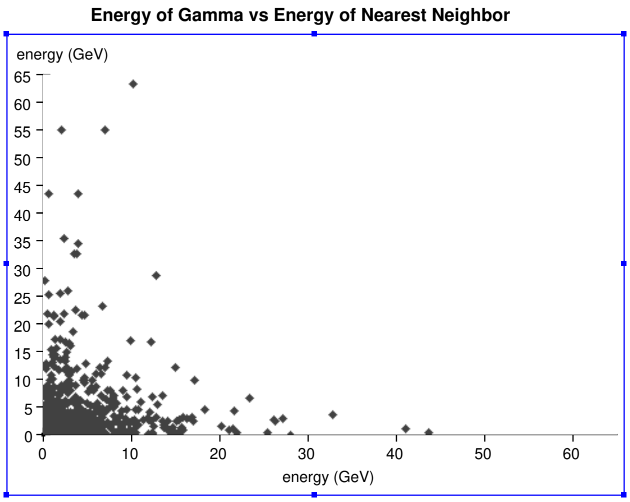

Figure 10: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 10cm and 20cm

2.2.3 1000 GeV e+e- to ZZ events

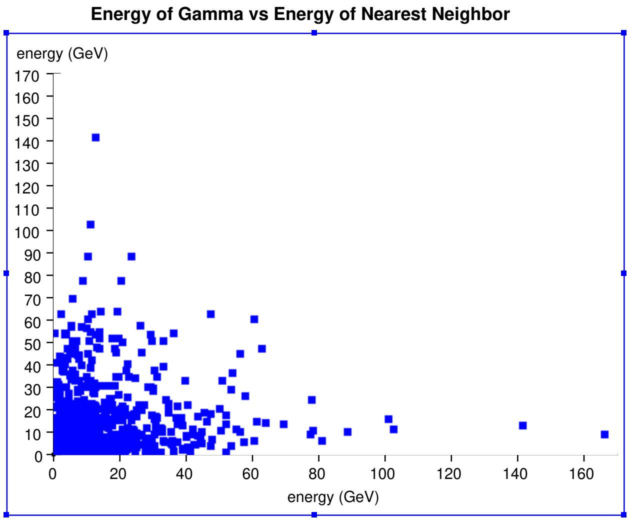

Figure 11: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor within 5cm

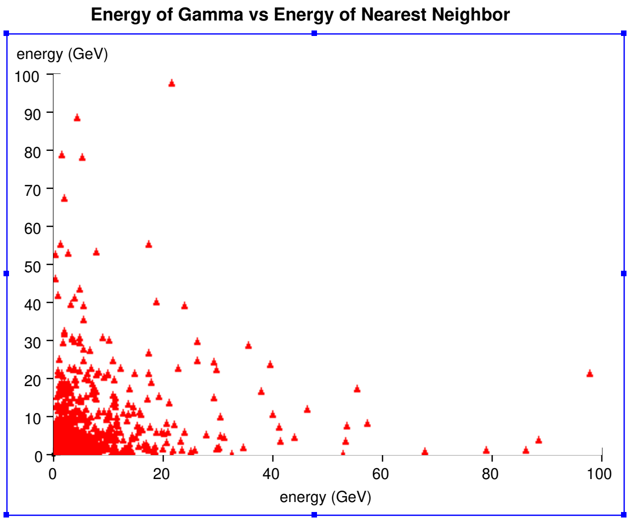

Figure 12: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 5cm and 10cm

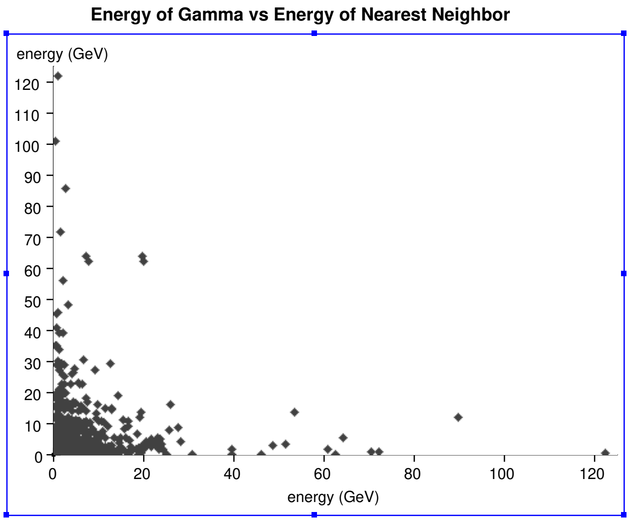

Figure 13: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 10cm and 20cm

2.2.4 1000 GeV e+e- to WW events

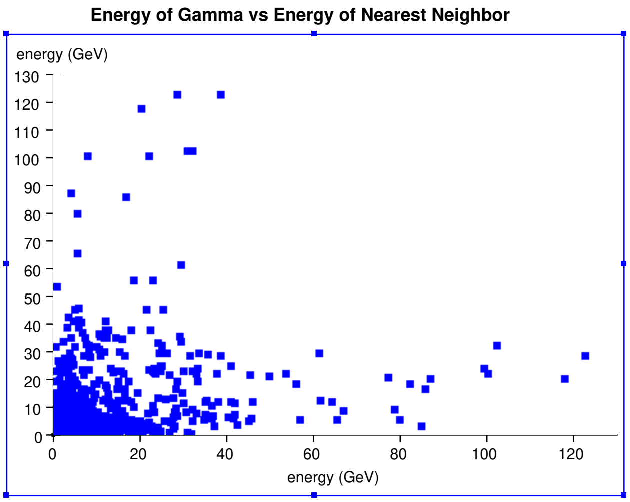

Figure 14: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor within 5cm

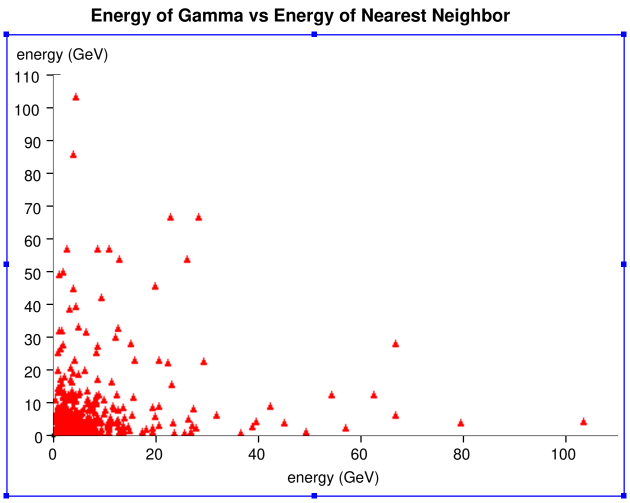

Figure 15: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 5cm and 10cm

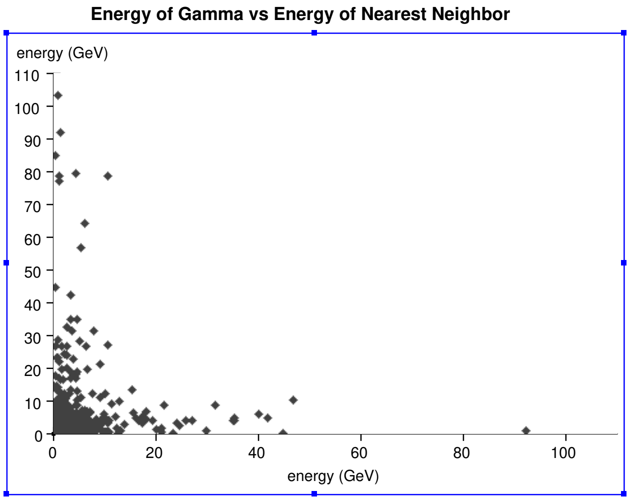

Figure 16: energy of gamma and energy of nearest unrelated neighbor: nearest neighbor between 10cm and 20cm

2.3 Generation of Data

The generation of this data, up to the point in which JAS3 was used, was identical to the process described in 1.3.

2.3.1 Data Manipulation in JAS3

The procedure for generating these plots in JAS3 was identical to that described in 1.3.1, up to the point where a nearest neighbor was found for every e-cal hit. When this was done, a new list of 2-dimensional data points was created; the x-coordinate of each point was the actual energy of the γ producing the e-cal hit, and the y-coordinate was the actual energy of the γ producing the nearest neighbor hit. The points of each list from all counted events were then plotted to generate the graphs in 2.2.

3 Conclusion

The six plots presented here should prove valuable in efforts to determine the likelihood of a pair of nearby cal hits being the result of a π^0 decay. When a π^0 decays, it creates a pair of γ's that must preserve the momentum of the π^0, and so have momentum vectors whose magnitude is dominated by components parallel to the π^0's momentum. This means that they should be fairly close to eachother when they hit the edge of the e-cal. The data in 1.2 reveals the likelihood that a pair of hits are from different γ's, and so quantifies the error to be expected when assuming that nearby hits are from a single π^0.

The data in 2.2 can be used to mitigate the error by noting the likelihood of dissimilar energies between nearby hits that are not from the same π^0. If two γ's hit nearly the same area of a calorimeter, but one is determined to be of much lower energy, this disqualifies the pair as being products of the same π^0 decay.

The data presented here is useful for an initial study of the problem of discerning γ background from π^0 decays, but a more detailed analysis is required if the problem is to be pursued further. Specifically, the data in 2.2 should be supplanted with a study of the probabilities of nearby γ hits from different sources sharing similar energies.