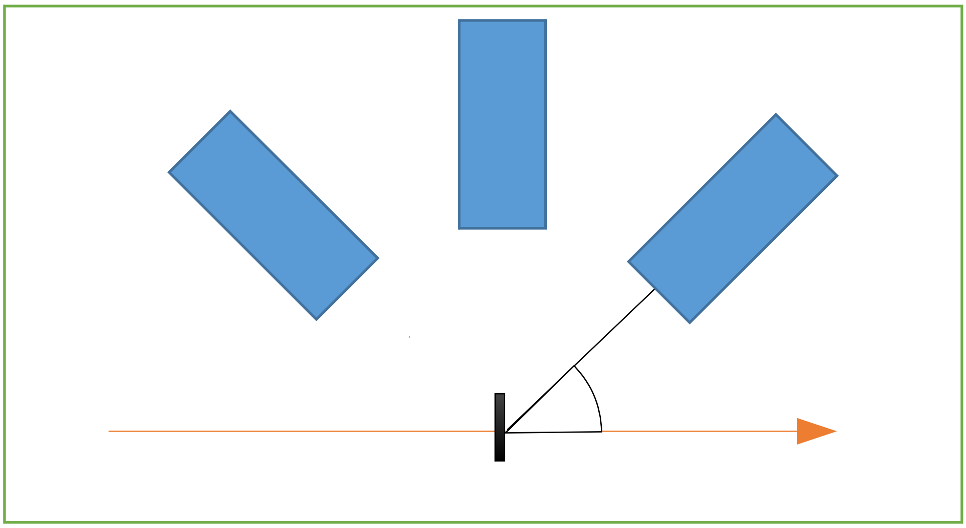
Data Analysis Tutorials

The Experiment

Data are taken with an array consisting of 3 gamma-ray detectors positioned around a target position on an accelerator beam line. The 3 detectors are positioned, with respect to the target and beam, at angles of 45,90,135 degrees.



Data are stored in root “trees”, effectively long lists of individual events; an event being a single moment in time, in which the data acquisition computer detected an input and recorded all data from detectors during a short time window.

A series of .root data files are provided from the experiment:

Run1 – A source of ^{60}Co at the target position
Run2 – A source of ^{152}Eu at the target position
Run3 – A source of ^{133}Ba at the target position
Run4 – An A=36 beam with an energy of 250 MeV impinging on a thin A=40 target.
Run5 – A decaying source feeding the nucleus observed in Run4

Important note :
Before attempting to open the run files in a root session, run the command “.L Det.h” to load the data format library for the experiment. This is achieved with an include statement in the example scripts.

Exercise 1 – Determine Array Efficiency: Peak Areas

If you did not yet determine an energy efficiency calibration use the lines from Calib.txt to set calibration parameters before sorting data.

Sort a single histograms, comprising data from all detectors, of energy in keV for all detectors from Run2. (You may use Sort2.C)

Using your ^{152}Eu sum spectra determine we will determine the <u>relative</u> photo-peak efficiency of the array as a function of energy.

To do this we must determine the areas of specific known peaks in the ^{152}Eu spectrum N_i and produce a a graph of energy vs relative efficiency Eff_i

$$Eff_i = (N_i / I_i) * C$$

Where I_i is the expected intensity from the known nuclear decay date of ^{152}Eu given in 152Eu.csv and C is an arbitrary scaling constant. The scaling constant is best set to the inverse of maximum value you have measure for (N_i / I_i) resulting a in graph with a maximum at 1.

In order to determine the values of N_i one can either use peak fitting or integration, in both cases we must take account of the background as we wish only to measure the peak counts, and determine an appropriate statistical uncertainty.

One useful way to deal with a background is to calculate and subtract it from the histogram before fitting or integrating. **Use the functions available in the class TSpectrum to determine a background by iterative smoothing:**

TH1 *Returned=TSpectrum::StaticBackground(histogram,N);

Where Returned is a pointer to a histogram the function creates containing the calculated background, histogram a pointer to your spectrum histogram and N the integer number of iterations. (This is demonstrated in lines of Sort2.C you can uncomment).

Compare the spectrum and background, experiment with changing N until you have a good background i.e. smooth under peaks but not undercutting the continuum background

We can then subtract the background using:

histogram->Add(Returned,-1);

Where -1 is a scaling factor changing the addition to subtraction.

A) What is the area and uncertainty of the 344 keV peak?

………………………………………………………………………………………

Is your uncertainty what you expect?

Repeat the above steps BUT call the function histogram->Sumw2() before doing the subtraction?

B) What is the uncertainty of the 344 keV now?

………………………………………………………………………………………

Construct a graph Eff_i vs energy for the major peaks of ^{152}Eu

It is recommended you make use of the TGraphErrors root class:
https://root.cern.ch/doc/master/classTGraph.html
https://root.cern.ch/doc/master/classTGraphErrors.html

Exercise 2 – Determine Array Efficiency: Curve Fitting

There are many possible functions to describe the efficiency curve of a gamma-ray detector (the shape of which is dominated by gamma-ray attenuation coefficients) the following is an example you can use which converges easily (some functions such as those used by radware and sigma require extra effort to ensure a successful fit). Start with N=2

$$y = e^{\left(\sum_{n=0}^{n=N} P_n log(x)^n\right)}$$

Whether determining peak areas by integration or by fitting, be sure to determine appropriate errors.

C) What is the efficiency ratio between 300 and 1200 keV?

...