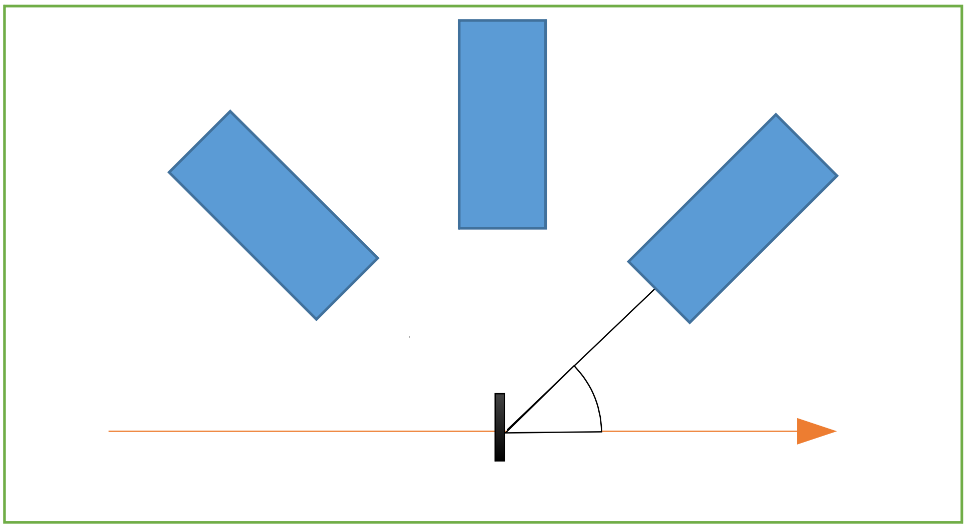
Data Analysis Tutorials - Session 4

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

Exercise 1 – Coincidences

As multiple hits may occur approximately simultaneously, such as in a cascade, it is advantageous to look not only at the singles spectrum (the 1D histogram of all gamma-rays) but also at coincident hits in multiple detectors.

Sort4.C includes a loop to produce a 2 dimensional histogram (sometimes refereed to as a matrix) of coincidence events.

Run Sort4.C on Run4.root and look at the resultant coincidence matix.

The matrix has been diagonalised, so $M_{ij} = M_{ji}$ so that all coincidences across the matrix can be viewed without bias due to data ordering.

Now by projecting along one axis of this histogram at a given energy, you can see all the gamma-rays that were coincident with a gamma-ray of that energy.

Use the TH2 functions: SetShowProjectionX (from the right-click menu) to look at different “slices” of the matrix in the GUI by moving the mouse.

A) Look at the coincidences of the largest peak. Which coincidence do you observe that is surprising?

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Sort4.C also produces a histogram of the time difference between gamma-rays hits.

B) Explain the features of the time spectrum?

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From the timing spectrum determine a suitable timing coincidence requirement (a time gate) and input this using *TgateLower* and *TgateUpper* at the top Sort4.C

C) Calculate the fraction of events selected by your requirement that are true coincidence events?

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By making the reasonable assumption that false coincidences are randomly distributed with time, one can determine a time-random contribution that can be subtracted can subtract.

Set your answer to question C as the *TrueCoincidenceFraction* at the top of Sort4.C and resort Run4.root.

Now the background is subtracted use SetShowProjectionX again and compare the coincidences observed with what you observed before. Only the true coincidences should remain.

D) What is the nucleus?

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(Hint: If you are struggling with question D : Set gBeta=0, TrueCoincidenceFraction=1, and Sort Run5.root)

EXTRA QUESTION) Using your efficiency curve, explain the features at ~2000 keV in the singles sum spectra?

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Exercise 7 – Lifetimes

TimeExp.root contains a histograms sorted from Run5.root. It is the time difference between gamma-rays populating and depopulating the 1600 keV state.

By fitting the isomeric tail of the timing distribution determine the lifetime of the state.

E) What is the lifetime of the 1600 keV state?

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Try fitting with the “L” binned likelihood fitting option rather than the chi-squared default. Do you notice a difference? At very low counts the Pearson’s chi squared test becomes unreliable and binned maximum likelihood method is preferable for an accurate result.

Modify Sort4.C to contain a new 1D histograms that will be filled with the time difference between any coincident 1600 keV and 439 keV gamma-rays. (Set gBeta=0, TrueCoincidenceFraction=1 if you have not done so already)

Sort Run5.root. There are too few counts for a reliable exponential fit.

Plot the same time spectra but in log(t) (with histograms bins uniformly spaced in log(t) instead of t) a peak should form with the maximum at the state lifetime. You can fit this with a Gaussian and see how it compares to the exponential method. This method (Often called the Schmidt method) is extremely useful in low statistics work where a reliable exponential fit is not viable.