Exercise set 6 (for 18-22 October, week 43)

46) When measuring γ radiation one usually use a spectrometer. A spectrometer is an apparatus which will sort the measured data into an histogram sorted according to γ-ray energies. Thus, a picture of the intensity distribution of the absorbed energy in the detector is obtained. In such a picture, peaks from the photo electric absorption of the various γ rays emitted from the source can easily be spotted and analysed. The area of each peak will be proportional to the intensity of the corresponding γ-ray. Such a spectrometer is usually referred to as a Multi Channel Analyser (MCA).

Before an MCA can be used to measure γ rays of unknown energies (i.e. unknown samples) it must be calibrated. Your task in this exercise is to perform such an calibration and identify the two unknown samples.

Energy calibration of the MCA: From the exercise web-page you can download a PDF file with spectra measured on a NaI detector. In this file you will find 6 calibration spectra obtained from measurements of ^{137}Cs, ^{88}Y, ^{60}Co, ^{241}Am, ^{54}Mn, and ^{133}Ba. The MCA associate the amount of light measured from the NaI crystal with channel numbers. The channel numbers is simply the numbering of the bars in the spectrum histogram. We use measurements of known nuclei to calculate the relationship between channel numbers and energy. Each of the calibration spectra has peaks corresponding to the distinct γ-rays emitted from the given source. The spectra has been labelled with the peak positions (centroids).

a) Use the table of γ-energy standards on page 15 in the booklet to the nuclear chart and the 6 calibration spectra to plot the relationship between the measured peak positions (centroids) in the spectra and the tabulated γ-ray energies.
b) Fit a straight line through the data points from a) (the best way to do this is by linear regression fitting, but you can also do it manually using plotting paper and a ruler). What is the slope and y-intercept of the straight line?
c) How good is the data represented by the straight line fitted in b)? Plot the deviation between the values calculated from the coefficients of the straight line and the actual values from the Nuclear Chart Table (page 15). Is the deviations random? If not, suggest a better fitting function!
d) Identify the sources used for the two spectra with unknown samples. The sources are two of the nuclei listed in the page 15 table. (To do this you must use your calibration function from b) to calculate the energies of the peaks in the spectra. Then you can search for corresponding γ lines in the table. Remember that there is some uncertainty in the measurements, so the energies will not match 100%!).
e) (if you have time to spare) Fit a second order polynomial to the data from a) and calculate the deviation between your calibration and the tabulated γ-ray energies. How much did this improve your energy calibration, if at all?