Experiment – 4

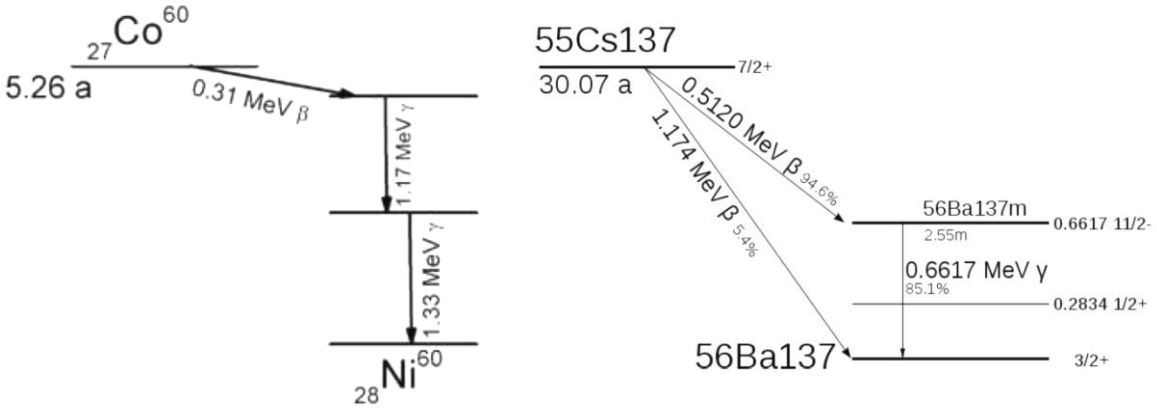
Objective : Analysis of gamma energy spectra with Multi-Channel Analyzer (MCA).

Sources : γ-ray source = $\mathbf{Co}^{60}$, $\mathbf{Cs}^{137}$

Scope of Expt :

i) Set PMT voltage dial to around 470 V [Check the detector setting for voltages i.e HV=670, Gain=8, LLD=1 etc.]. It depends upon which detector you are using for your experiments.
ii) In MCA program, open new file. Set display size to 1024.
iii) Put radioactive source ($\mathbf{Co}^{60}$) in front of PMT. Start data taking. Set discriminator level to cut noise part of spectrum.
iv) Record spectrum for 10 minutes or so.
v) Save spectrum. Calibrate energy of the spectrum by using two points. Channel No & energy to be given.
vi) Check calibration by using another source ($\mathbf{Cs}^{137}$) to find energy of some other peak.
vii) Find FWHM of peaks and hence resolution of detector for $\mathbf{Co}^{60}$ peaks.
viii) Check how the resolution of a peak varies as a function of PMT voltage, by changing PMT dial reading from 420 (470 - 50) to 520 (470 + 50) in steps of 10. (± 50 volts from step (i) voltage)
ix) Find relative photo-peak efficiency for $\mathbf{Co}^{60}$ peak by using the ratio of total area of the spectrum to photo-peak area.

Theory : Write necessary theory for γ-ray interaction with matter. Decay of γ-ray sources like $\mathbf{Co}^{60}$, $\mathbf{Cs}^{137}$



Experiment

A. Calibration and Determination of Cs^{137} peak

Chose the two photo peak of **Co**^{60} in order to perform this calibration. The first and second photo peaks of **Co**^{60} comes at certain channels which corresponded to the energies of 1.17 MeV and 1.33 MeV respectively. Find the channel numbers of the peaks by calculating the position of the centroid of the peaks. Then calibrate by using the following formula. The Energy of any unknown peak can be found by :

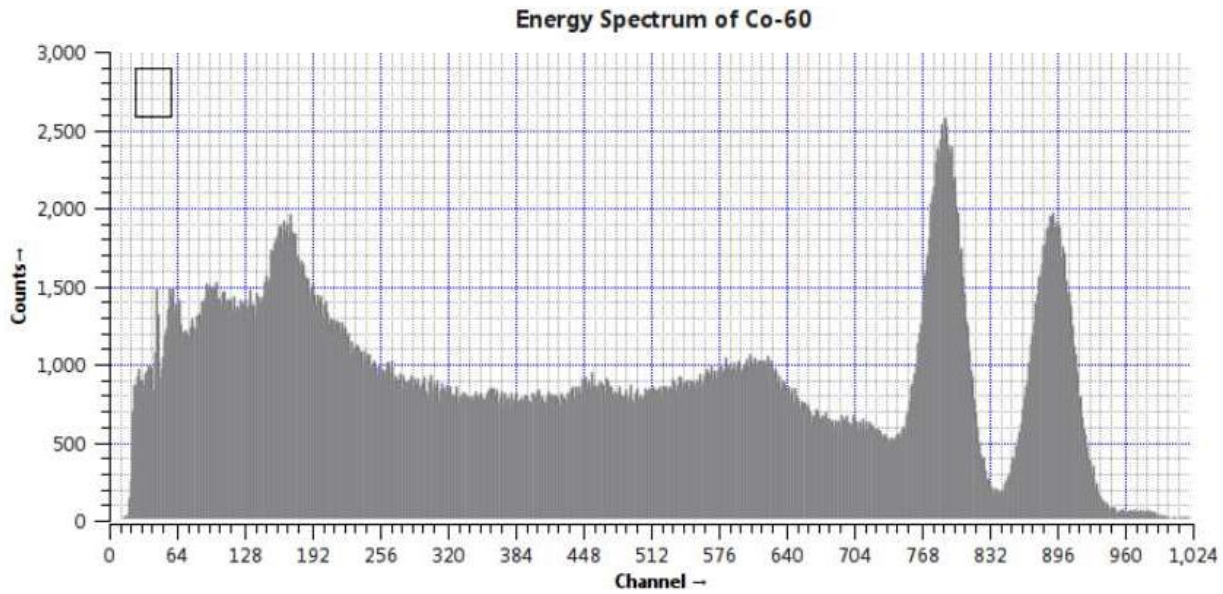
$$Energy = \frac{E_A - E_B}{A - B} \times Channel\ Number$$

where E_A is the energy (1.17 MeV) of the first point used for calibration at channel no. A. E_B is the energy (1.33 MeV) of the second point used for calibration at channel no. B.

Use the same calibration to find the energy peak of **Cs**^{137}.

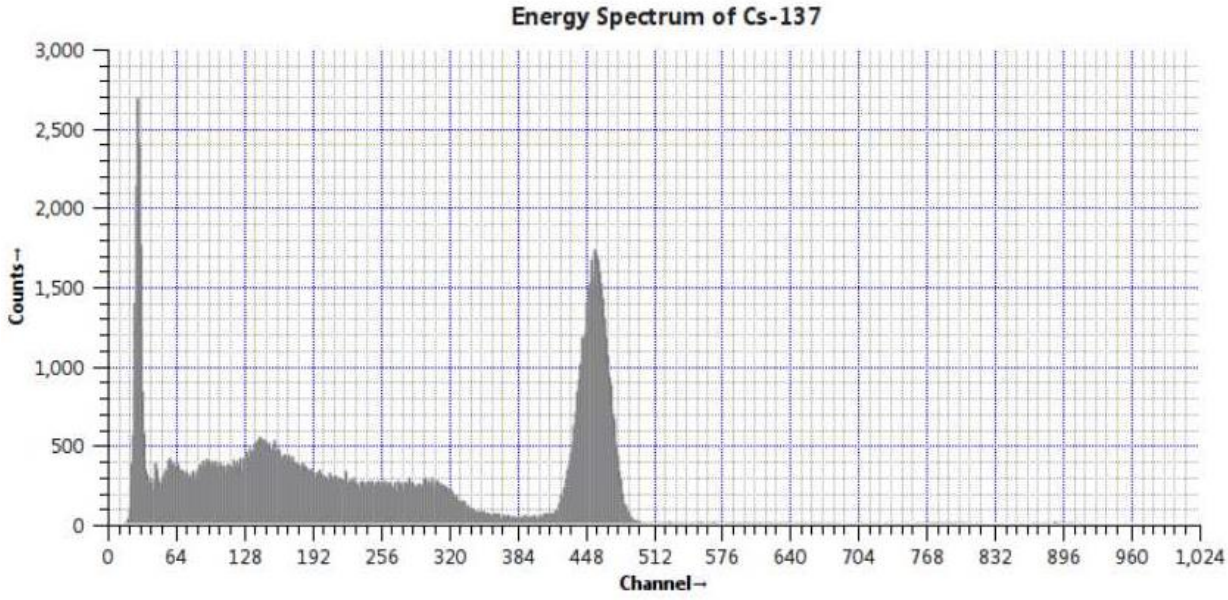
Energy = Energy of unknown peak of **Cs**^{137} ,
Channel number = Channel number of unknown peak of **Cs**^{137}

The Cobalt spectrum



The following two reference points from the spectrum of **Co**^{60} are used for calibration. Fit the spectra by a Gaussian fit to get the centroid as channel number.
1st peak = Ch. No. 790 = 1.17 MeV , 2nd peak = Ch. No. 890 = 1.33 MeV

The Cesium spectrum



Fit the spectra by a Gaussian fit to get the centroid as channel number. Then use the above calibration to find the energy of **Cs^{137}** peak.

B. Photo peak efficiency

Photo-peak efficiency is defined as the ratio of the area under the peak to that of the area of the whole spectrum.

$$Photopeak\ efficiency = \frac{Area\ under\ peak}{Area\ under\ the\ whole\ spectrum}$$

Area	**1.17 MeV peak**	**1.33 MeV peak**	**the whole spectrum**
Counts	66080	62156	901383
Efficiency	0.0733	0.0690	-

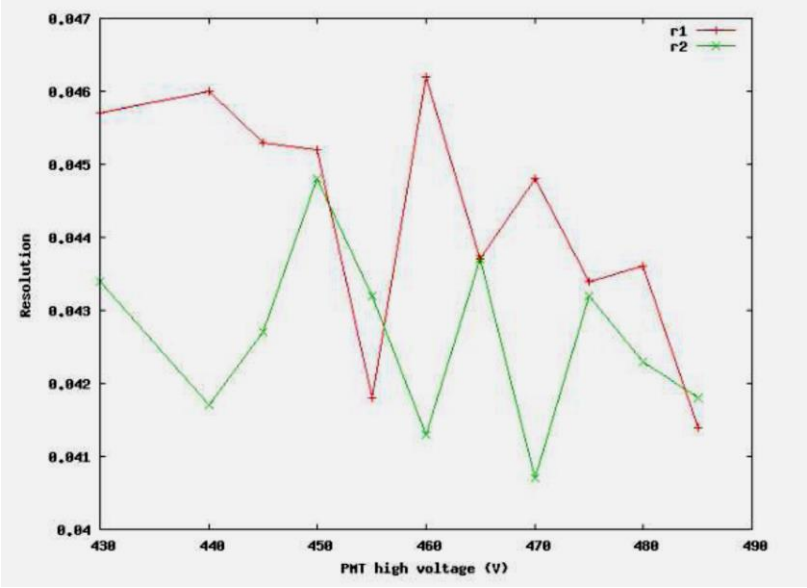
C. Variation of resolution with PMT voltage

$$Resolution = \frac{\Delta E}{E} = \frac{FWHM\ of\ peak}{Centroid\ of\ peak}$$

The following data were obtained for the variation of resolution with voltage.
E_1, ΔE_1 and R_1 are for the first Cobalt peak.
E_2, ΔE_2 and R_2 are for the second Cobalt peak.

High voltage (V)	E_1 (MeV)	ΔE_1 (MeV)	Resolution (r_1)	E_2 (MeV)	ΔE_2 (MeV)	Resolution (r_2)
380	1.1700	0.0535	0.0457	1.3240	0.0575	0.0434
390	1.1700	0.0538	0.0460	1.3240	0.0552	0.0417
400	1.1700	0.0530	0.0453	1.3230	0.0565	0.0427
410	1.1700	0.0529	0.0452	1.3240	0.0593	0.0448
420	1.1700	0.0489	0.0418	1.3230	0.0572	0.0432
430	1.1700	0.0541	0.0462	1.3230	0.0547	0.0413
440	1.1700	0.0511	0.0437	1.3230	0.0578	0.0437
450	1.1700	0.0524	0.0448	1.3230	0.0538	0.0407
460	1.1700	0.0508	0.0434	1.3230	0.0571	0.0432
470	1.1700	0.0510	0.0436	1.3230	0.0560	0.0423
480	1.1700	0.0484	0.0414	1.3220	0.0552	0.0418
490						

The plot of resolution *vs* voltage.



Conclusion : Write your conclusion on the above observations.