Joint Institute for Nuclear Research

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Radiation Protection and the Safety of the Radiation Sources – INTEREST Wave 7

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Wave 7

Introduction:

The project covers radiation protection and the different types of detectors used in measuring the energy levels as released by different radiation sources.

The scope of the project includes using the software ROOT to analyse data measured using the BGO and NaI detector and finding the attenuation coefficients of different sources as well as determining unknown energy sources using the measure of their energy after the calibration of the applicable detector.

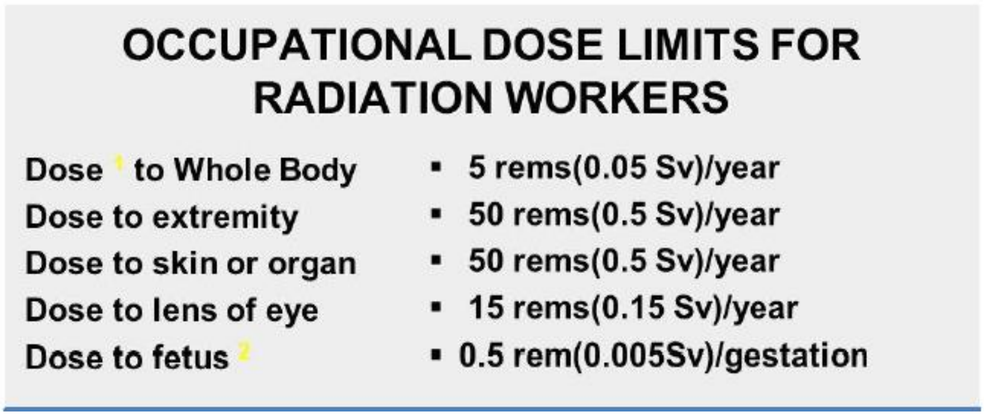
The detectors measure can be tuned by calculating their resolution at their given mean and sigma values thus allowing one to use several peaks detected in the readings to find the linear relation of the data and using the derived function and the unknown sources mean to find the energy released by the source.

Radiation Protection and Dosimetry:

There are different types of radiation such as non-Ionizing radiation and Ionizing, where the former is a classification of low energy release that thus doesn't remove electrons from their atomic orbitals and the latter does.

Depending on the type of radiation exposure and the source of the radiation, dose assessments are conducted once an individual has been exposed to radiation which takes into account the biological sensitivity of the exposed region and accompanying exposure parameters such as duration and distance.

The below imagine shows the dose limits applicable at different safety considerations.



OCCUPATIONAL DOSE LIMITS FOR RADIATION WORKERS

Dose [1] to Whole Body	5 rems(0.05 Sv)/year
Dose to extremity	50 rems(0.5 Sv)/year
Dose to skin or organ	50 rems(0.5 Sv)/year
Dose to lens of eye	15 rems(0.15 Sv)/year
Dose to fetus [2]	0.5 rem(0.005Sv)/gestation

Figure 1: Occupational Dose Limits, Source – Said M. Shakour Radiation Protection Notes

Task 1: Relation of Resolution Against Applied Voltage for BGO Detector

Where Resolution R = (Sigma/Mean)*2.35

File	Sigma	Mean	Resolution %	Applied Voltage V
12	0.475348	1.59103	70.21	1200
13	0.309162	1.40843	51.58	1300
14	0.293898	1.92381	35.90	1400
15	0.461516	2.98533	36.33	1500
16	0.664837	4.401	35.50	1600
17	0.848851	6.0835	32.79	1700
19	1.23262	10.6876	27.10	1900
20	1.58148	13.586	27.36	2000

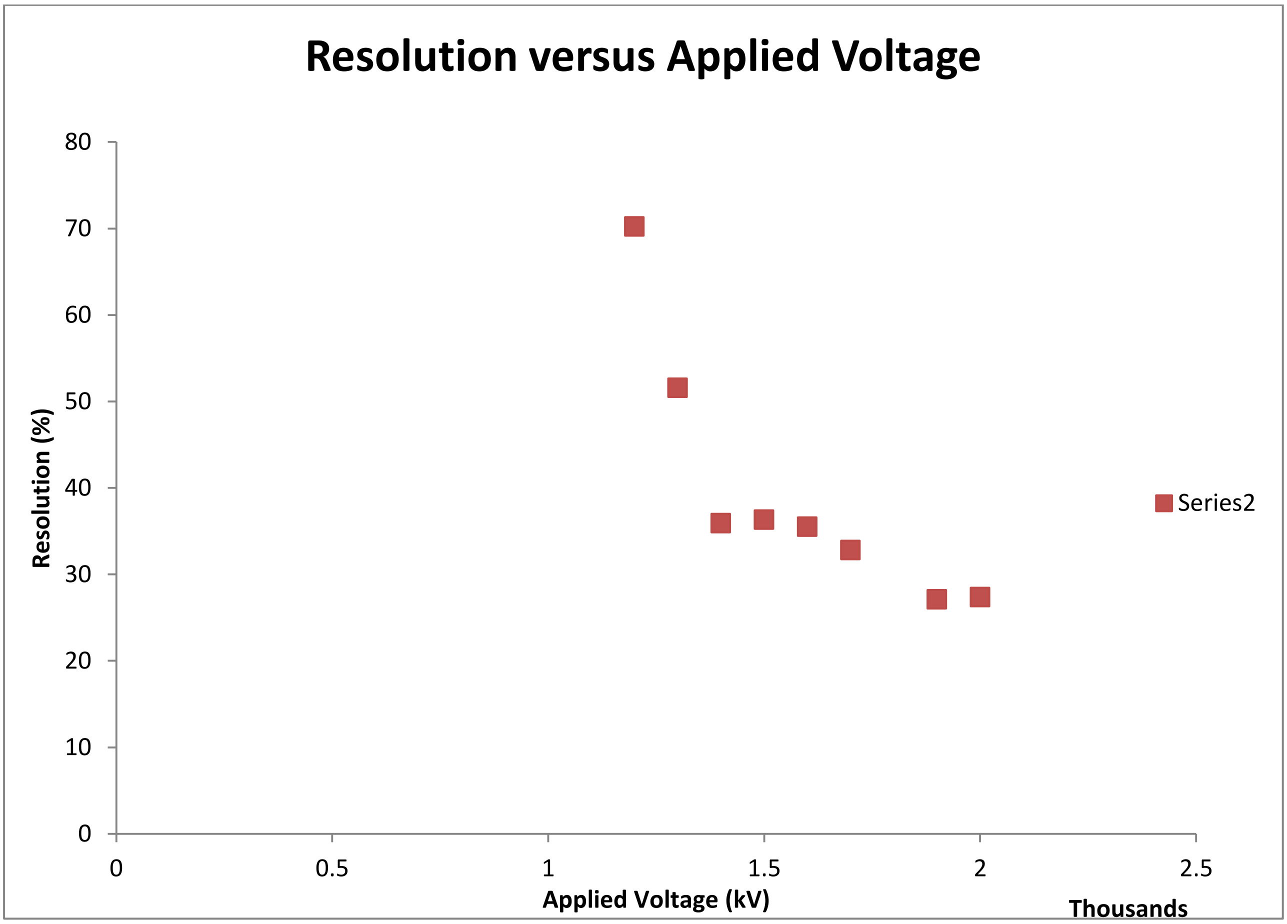
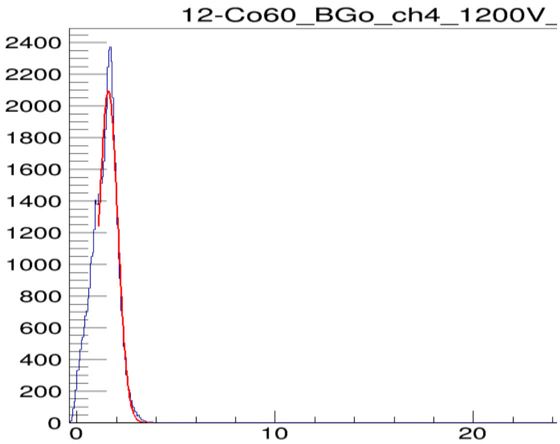
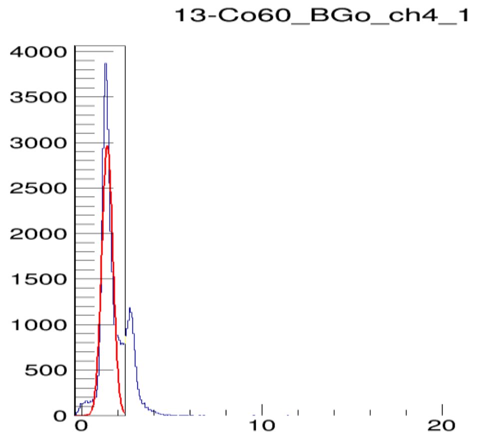
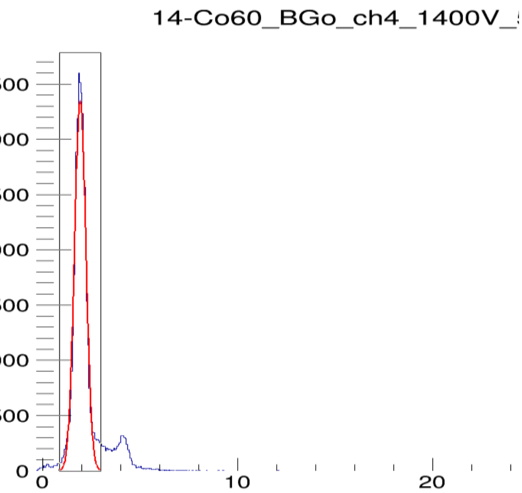
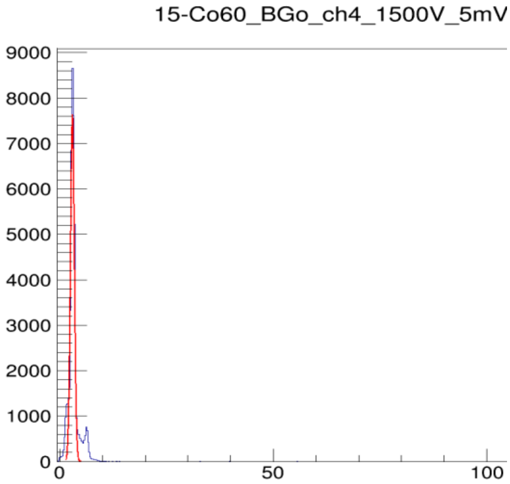


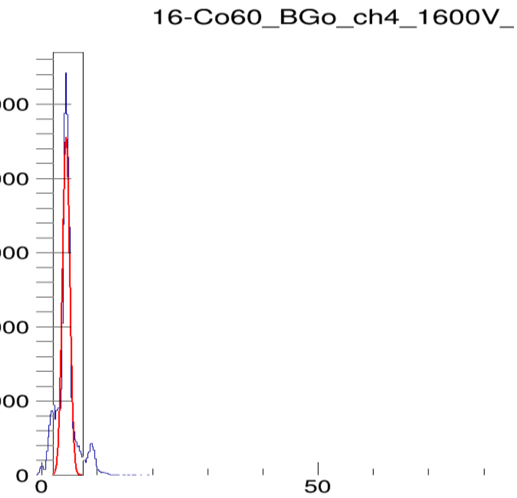
Chart 1 : Relation between the resolution and applied voltage of a BGO detector

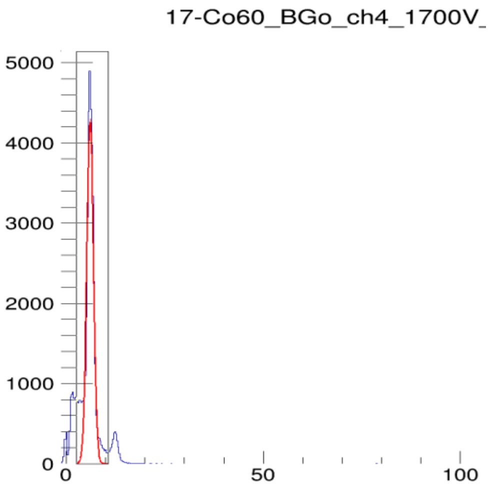

12-Co60_BGo_ch4_1200V_

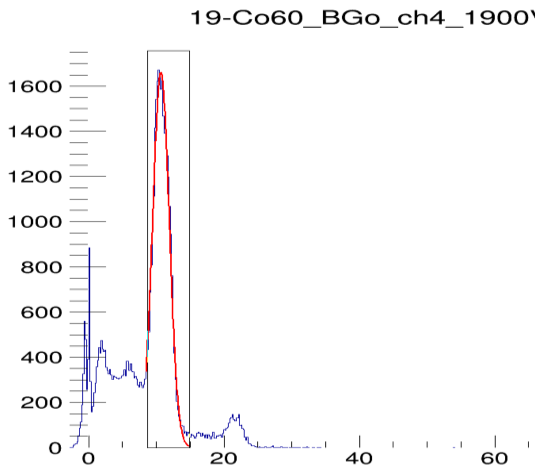

13-Co60_BGo_ch4_1

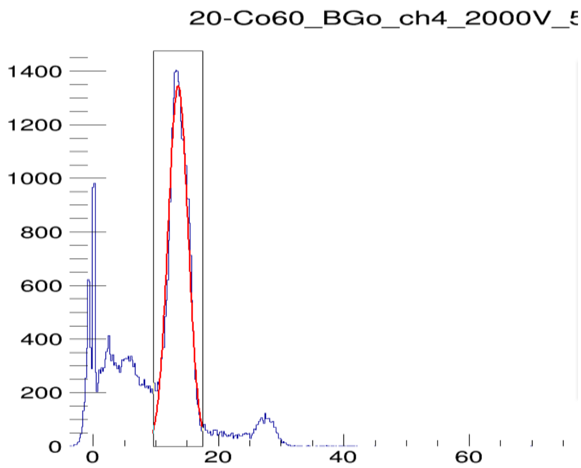

14-Co60_BGo_ch4_1400V_


15-Co60_BGo_ch4_1500V_5mV


16-Co60_BGo_ch4_1600V_

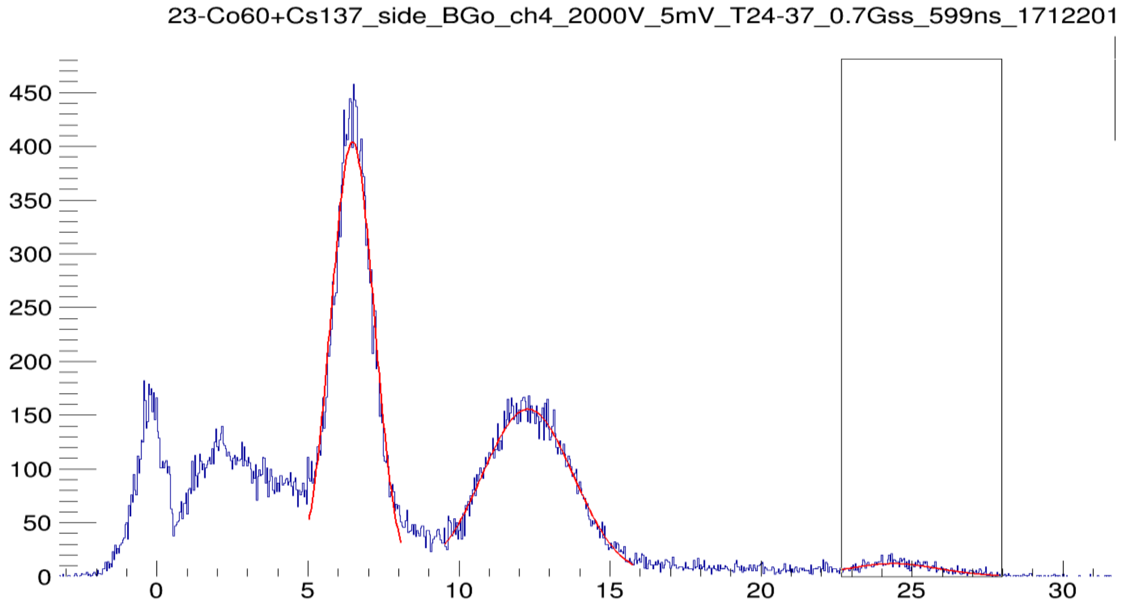

17-Co60_BGo_ch4_1700V_


19-Co60_BGo_ch4_1900V_


20-Co60_BGo_ch4_2000V_

Energy Calibration of BGO Detector

Where the energy calibration function is determined to be **y = 0.09833x + 11.879054,** using a gauss fit and determining the linear relation**.**



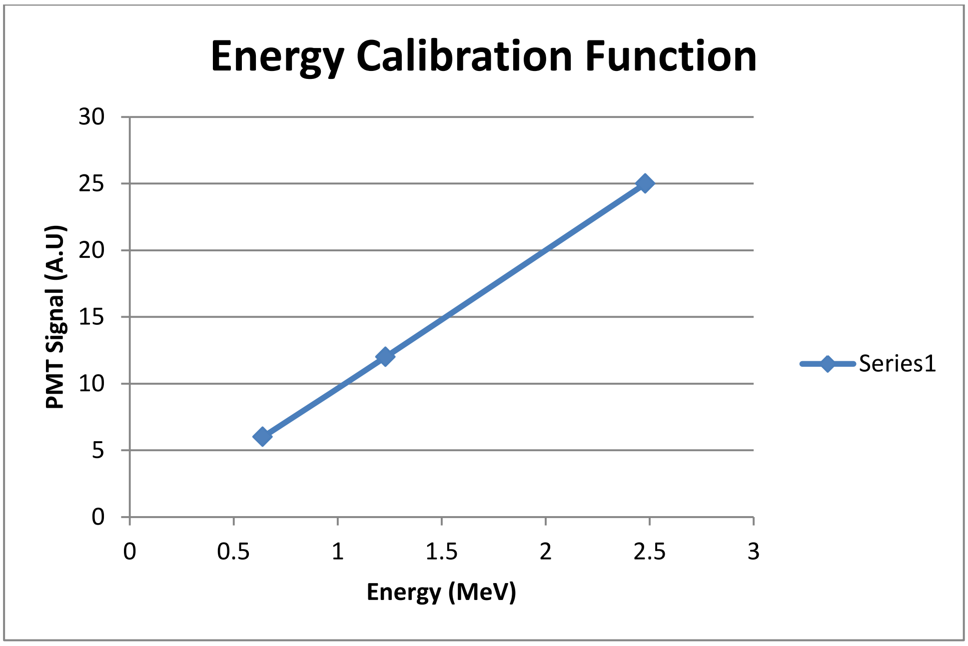


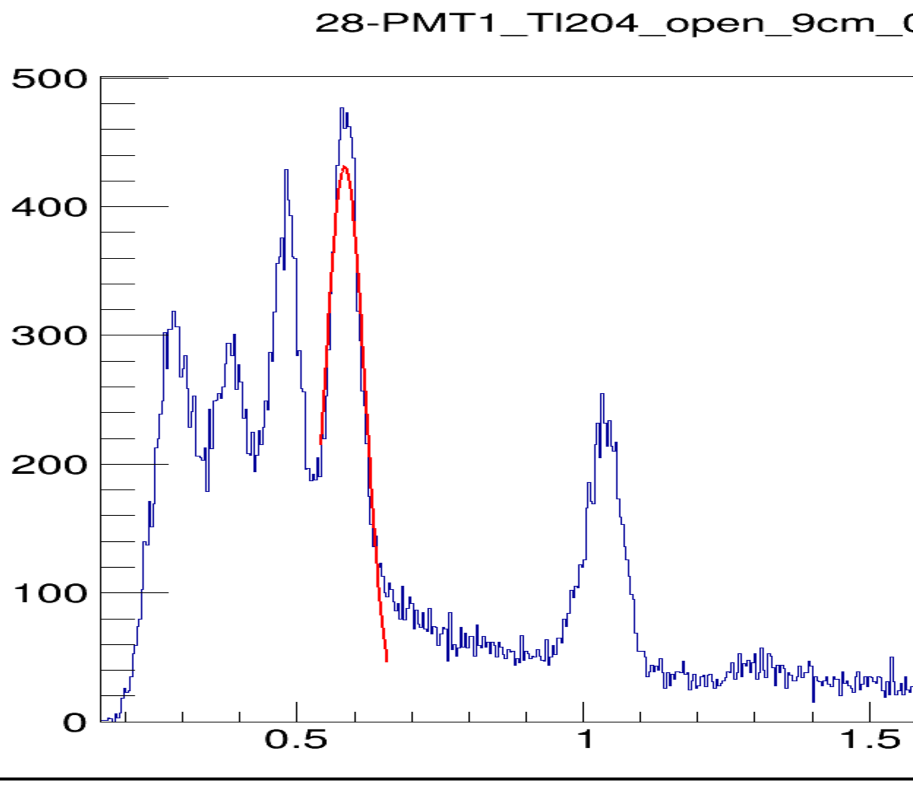
Chart 2: Energy Calibration Function

Where the variable y is the PMT signal A.U and the variable x is the energy of the unknown source.

Thus for the unknown source given:

Mean = y = 0.583767

Thus x = 0.881Mev and the unknown source is Kr84.



Task 2: Relation of Resolution Against Applied Voltage for NaI Detector

Where Resolution R = (Sigma/Mean)*2.35

File	Sigma	Mean	Resolution %	Applied Voltage V
2	0.625963	23.663	5.81	900
3	0.938983	40.6874	5.42	1000
4	1.45739	65.8242	5.20	1100
5	1.96799	98.7501	4.68	1200
6	2.52685	137.387	4.32	1300

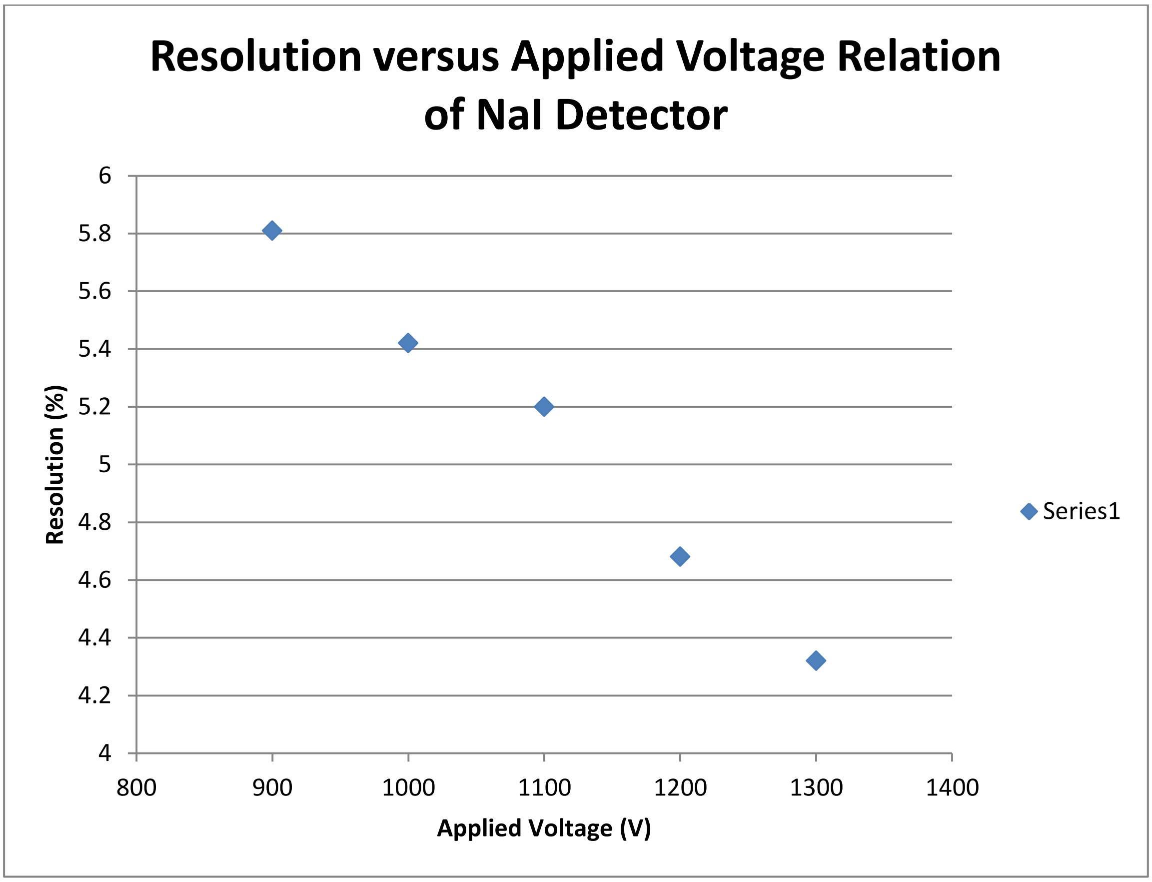
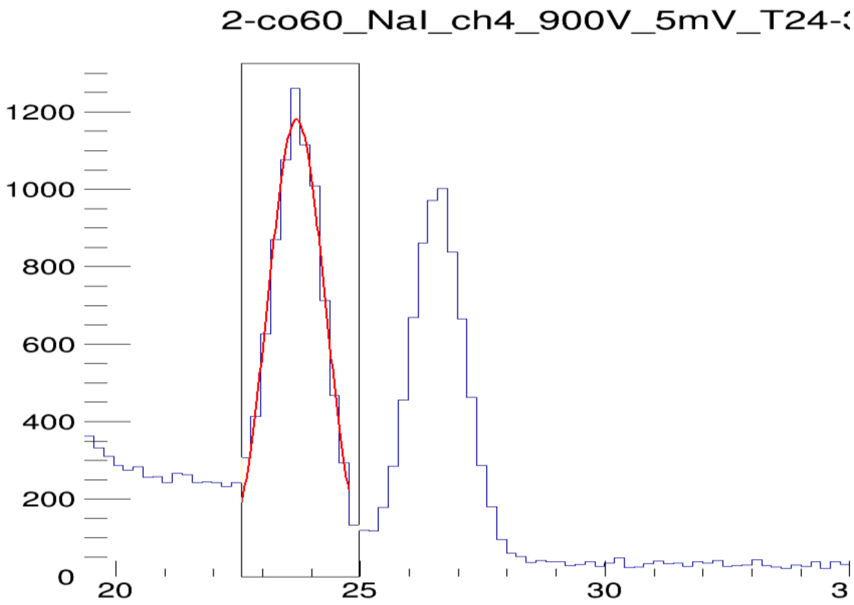
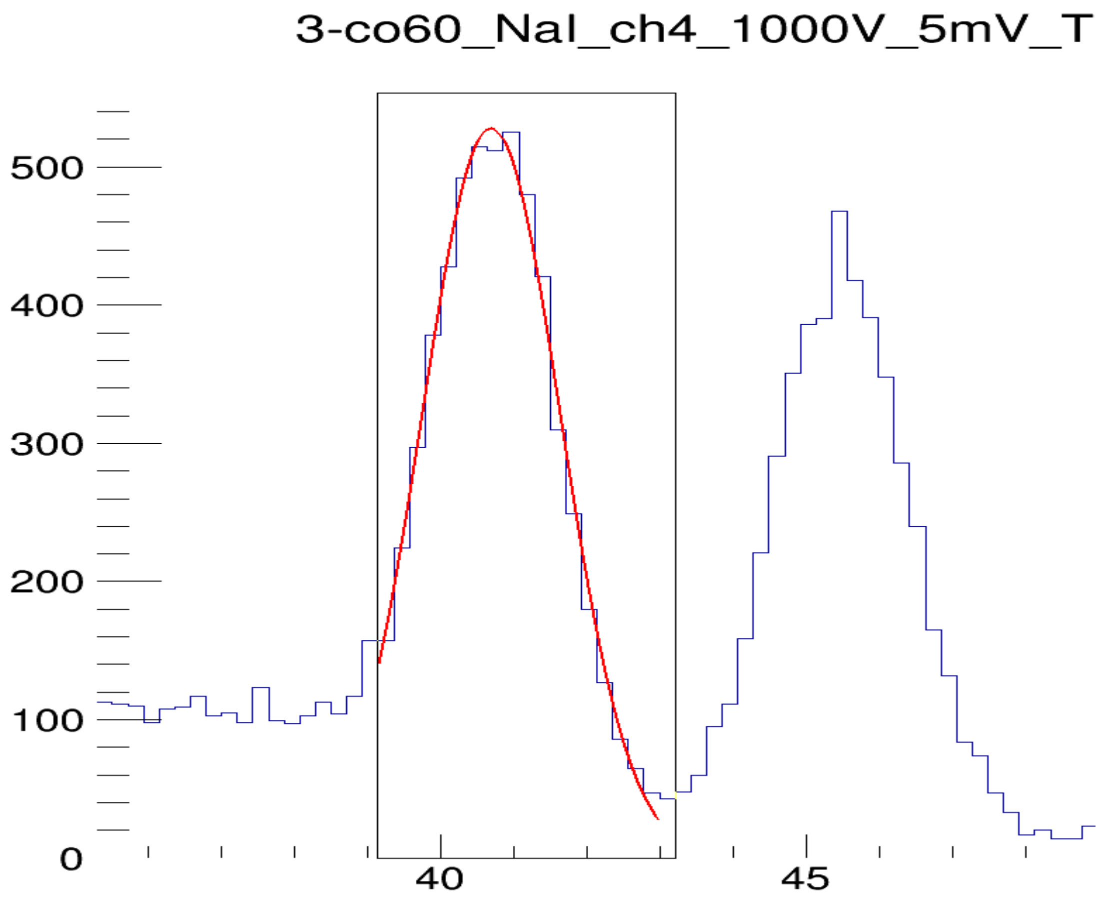
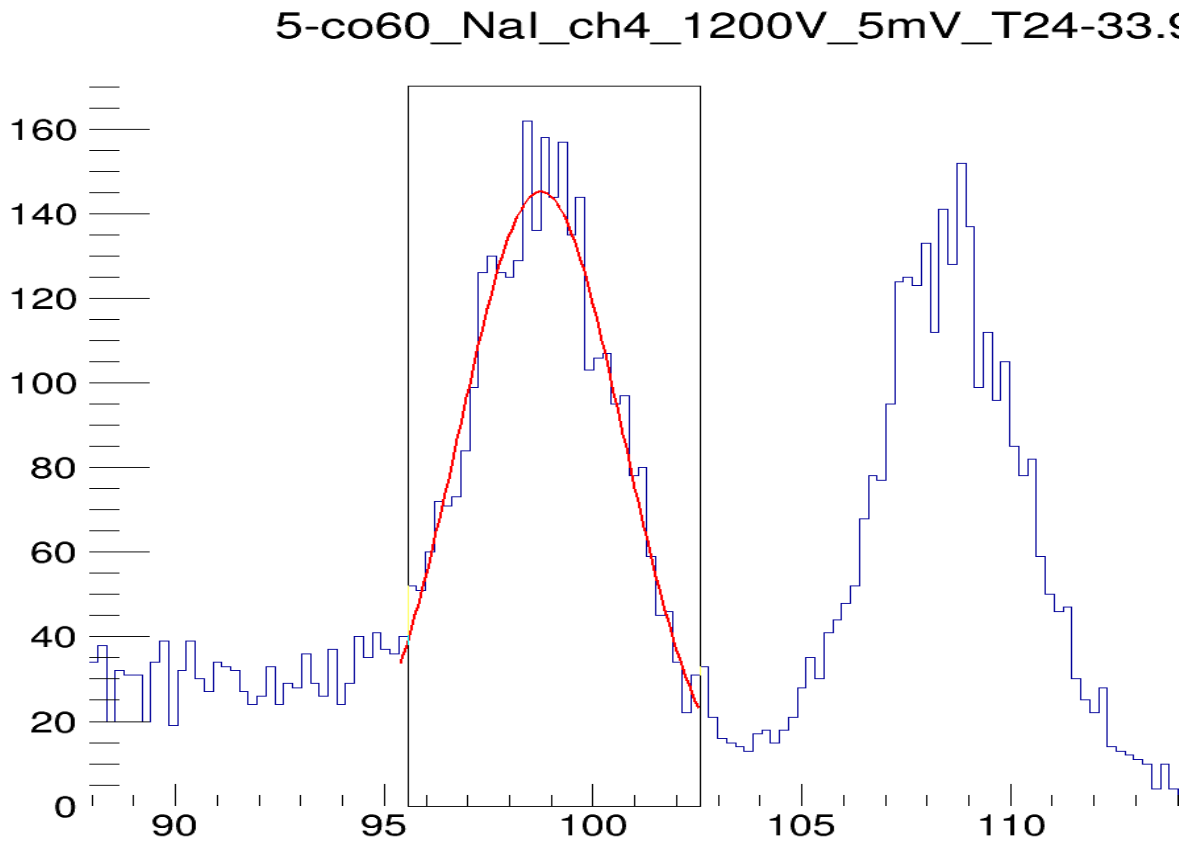
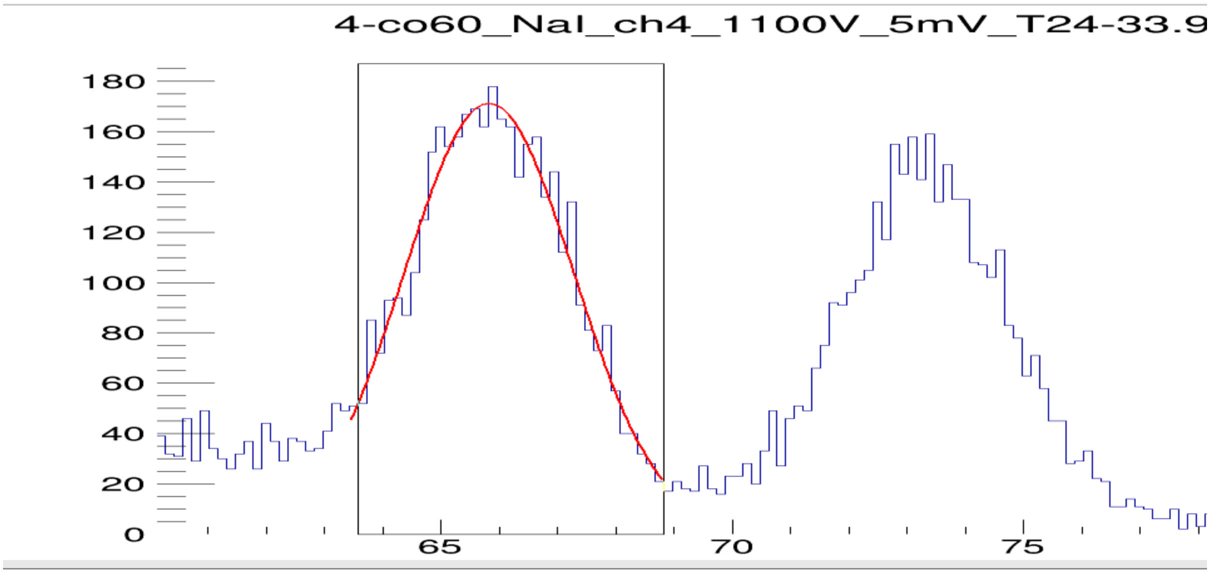


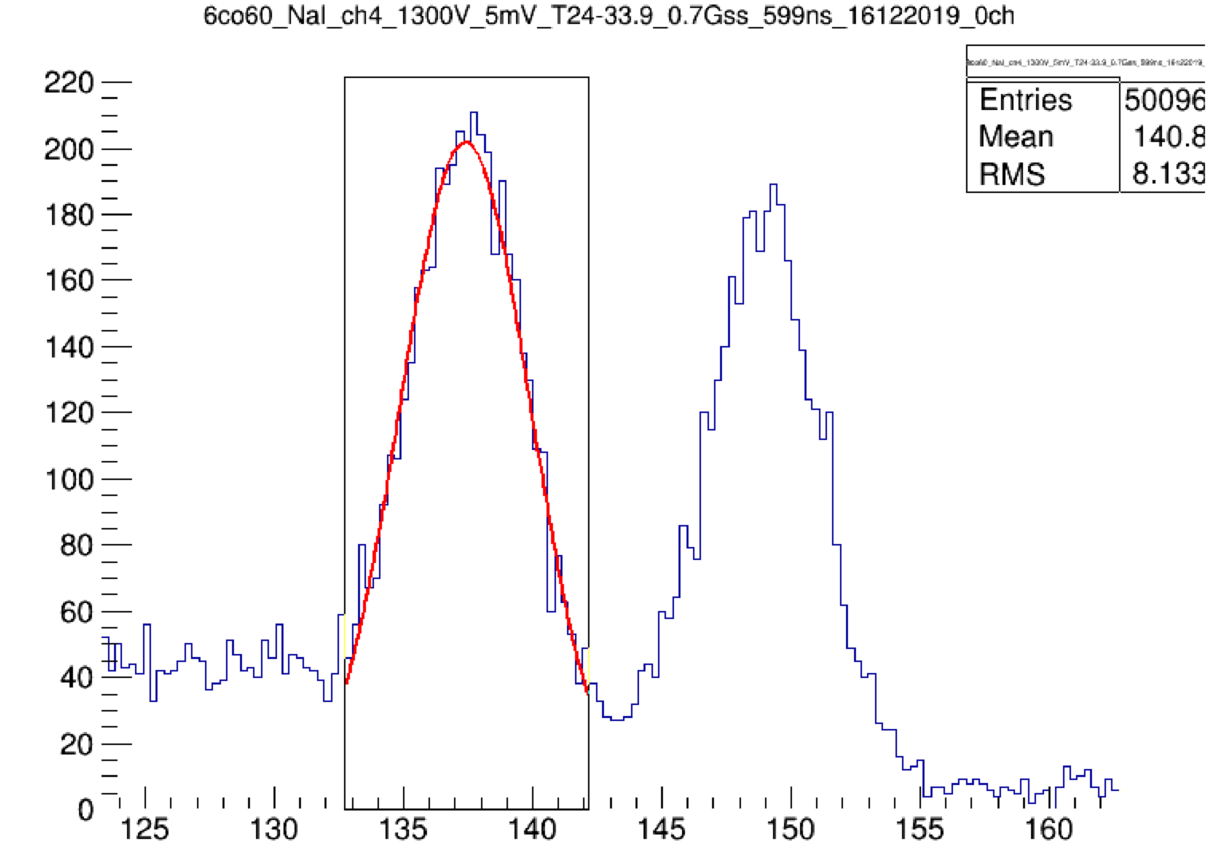
Chart 3: NaI Detector Resolution and Applied Voltage Relation




3-co60_NaI_ch4_1000V_5mV_T
500
400
300
200
100
0
40
45

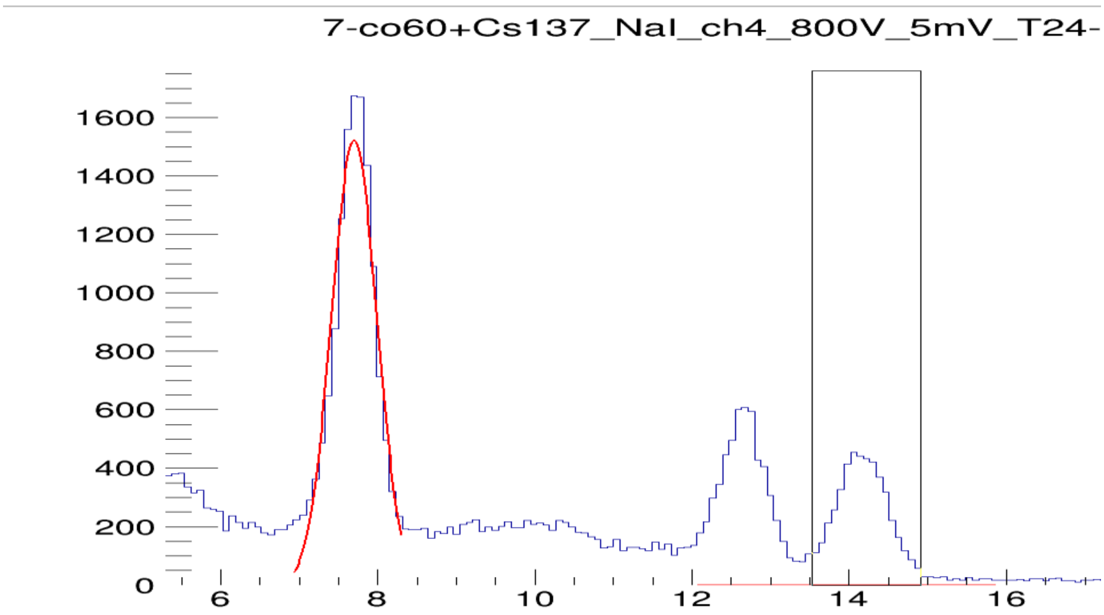

5-co60_NaI_ch4_1200V_5mV_T24-33.
160
140
120
100
80
60
40
20
0
90
95
100
105
110





Energy Calibration of BGO Detector

Where the energy calibration function is determined to be **y = 1.076x – 1.2293,** using a gauss fit and determining the linear relation**.**



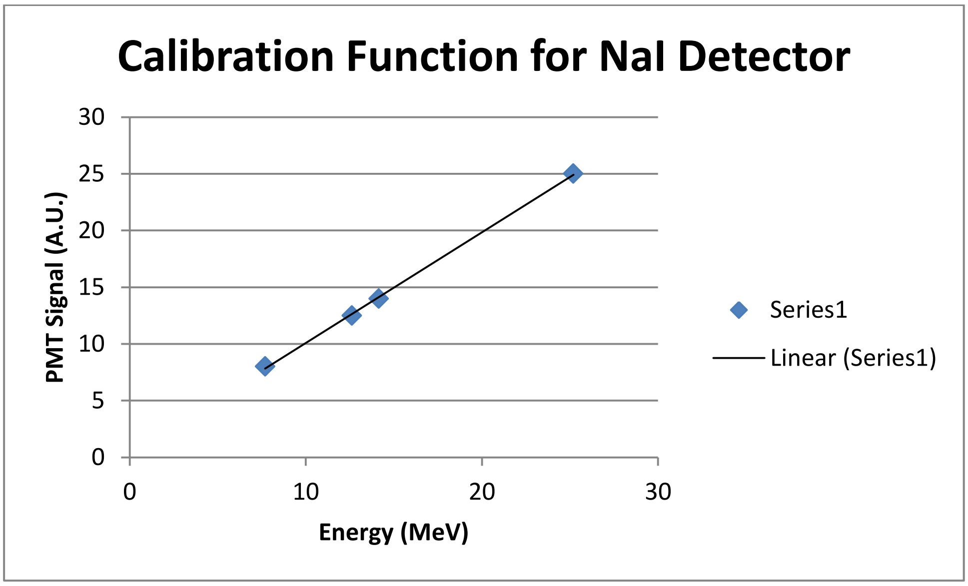


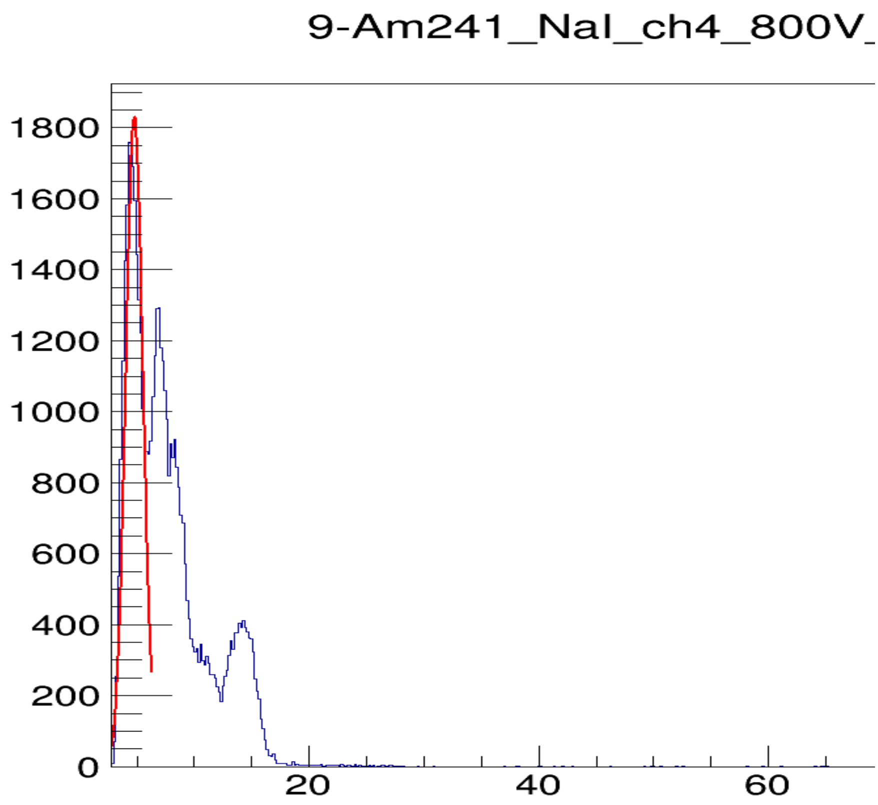
Chart 4 : Calibration Function for the NaI Detector

Where the variable y is the PMT signal A.U and the variable x is the energy of the unknown source.

Thus for the unknown source given:

Mean = y = 4.80524

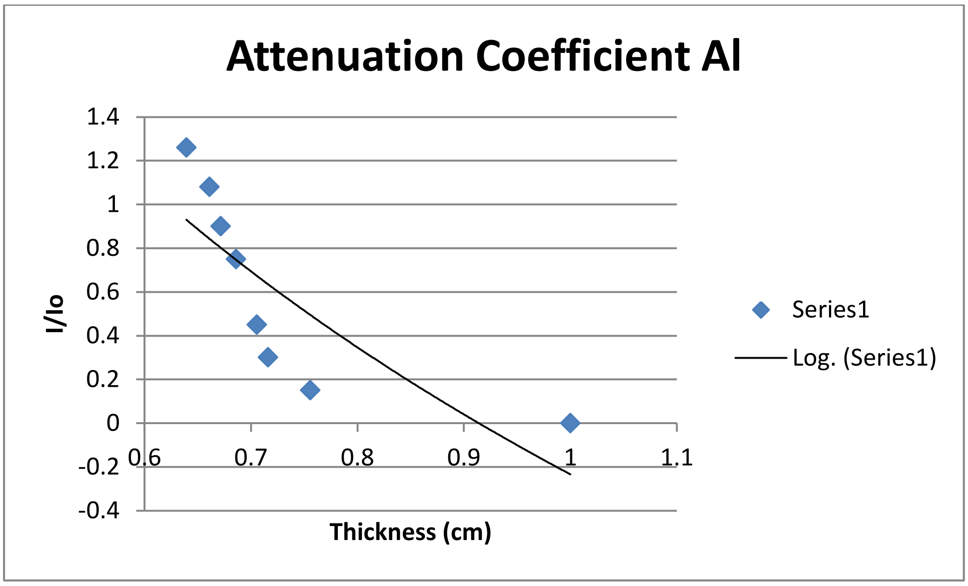
Thus x = 5.608Mev and the unknown source is F18 .



Task 3: Attenuation Coefficient

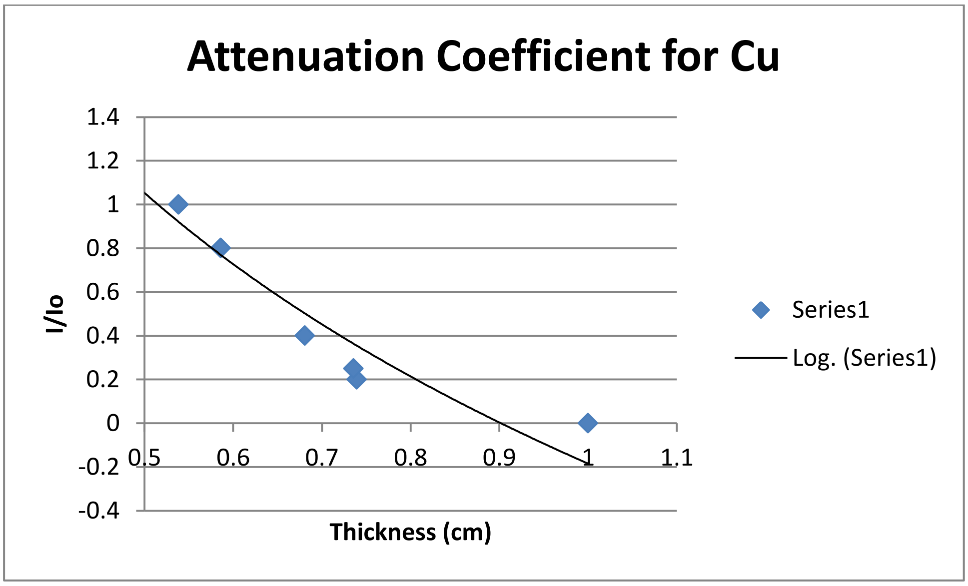
Where $I = I_0 e^{-\mu x}$

I/Io	Thickness in cm
1	0
0.75573	0.15
0.71623	0.3
0.70569	0.45
0.68596	0.75
0.67155	0.9
0.66103	1.08
0.63939	1.26



Thus **μ = 0.24 cm^{-1}** where **y = 0.8416e$^{-0.249x}$** for Al.

I/Io	Thickness (cm)
1	0
0.73931	0.2
0.7357	0.25
0.68065	0.4
0.58611	0.8
0.53827	1
0.48042	1.2



Thus **μ = 0.52 cm^{-1}** where **y = 0.8806e$^{-0.517x}$** for Cu.

Conclusion:

Thus knowledge regarding the basics of radiation protection and safety was acquired along with assessing doses after exposure. Furthermore, practical tools were learned in detecting radiation energy, their experimental setup and software functions as well as calibration thereof.