Gamma Ray Spectroscopy

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Instructor:	Asst Prof Aditya H. Kelkar

1 Objective

a. To obtain the gamma ray spectrum of the given radioactive sources ^{57}Co, ^{60}Co, ^{22}Na, ^{137}Cs and ^{133}Ba.

b. To find the relation between channel and energy from energy calibration curve using Photo-peak values.

c. To find the calibrated energy spectrum, resolution of detector and identification of unknown radioactive element from energy spectrum.

2 Theory

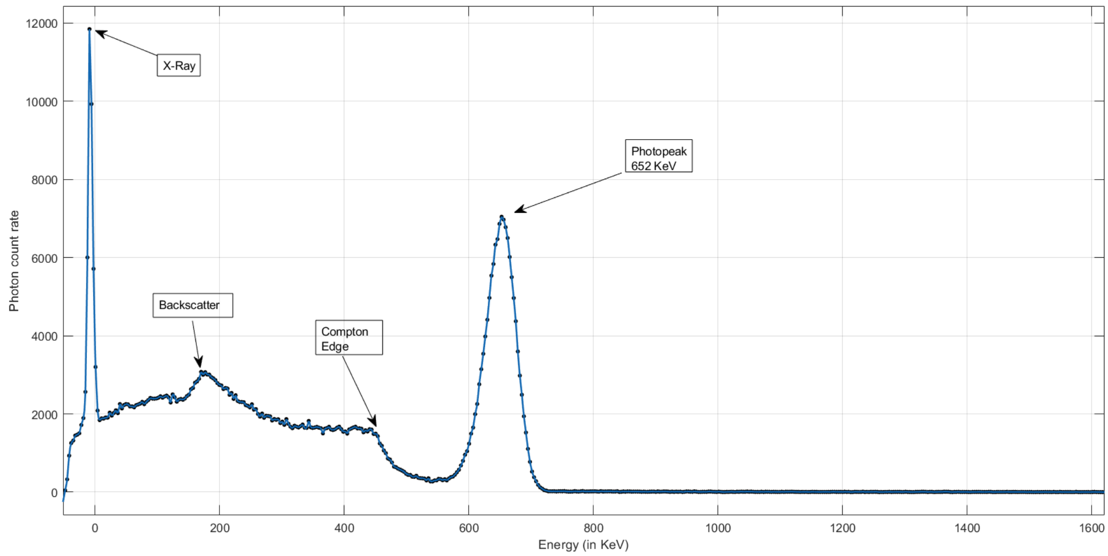
Gamma Rays are electromagnetic radiation produced by nuclear transitions. These high energy photons are more penetrating than alpha and beta particles. When gamma rays struck materials it can effect in Photoelectric effect, Compton effect and Pair production.

Photo electric effect occurs when gamma ray strikes the material and completely knocks off the orbital electron.

Compton effect occurs when a photon imparts only a part of energy to electron and gets deflected. Complete energy is transferred to electron when photon completely rebounds to it's original path which is known as compton edge.

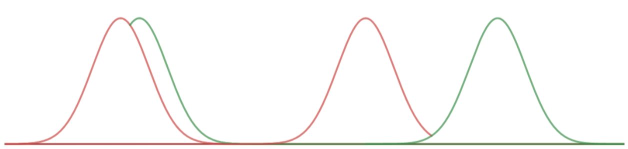
In pair production, gamma ray photon can spontaneously convert into an electron and positron when it is in the vicinity of coulombic force of nucleus. The excess energy formed is transformed into kinetic energy of nucleus.

Gamma Ray Spectroscopy is the technique to measure high energy photons produced in nuclear transitions. When a radioactive source is placed near detector, the detector produces pulse corresponding to activity of each nucleus. These pulses are analysed using multi channel analyser.



A typical Gamma Ray Spectrum.

The Resolution of detector is defined as ability to distinguish between two closely placed peaks. The peak shape is usually a Gaussian distribution. In most spectra the horizontal position of the peak is determined by the gamma ray's energy, and the area of the peak is determined by the intensity of the gamma ray and the efficiency of the detector. The most common way to find resolution is Full Width at Half Maximum (FWHM).



Poor resolved vs. good resolved

3 Data Collection

Gamma ray spectrum of ^{57}Co, ^{60}Co, ^{22}Na, ^{137}Cs and ^{133}Ba

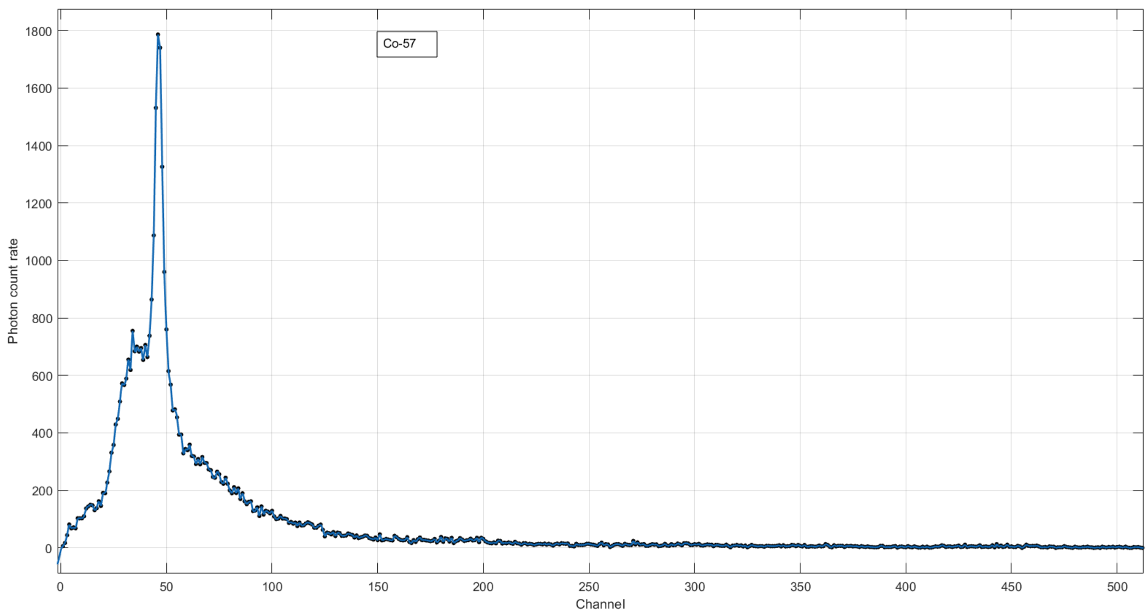


Figure 1: Channel vs.Photon Count Rate of Co-57

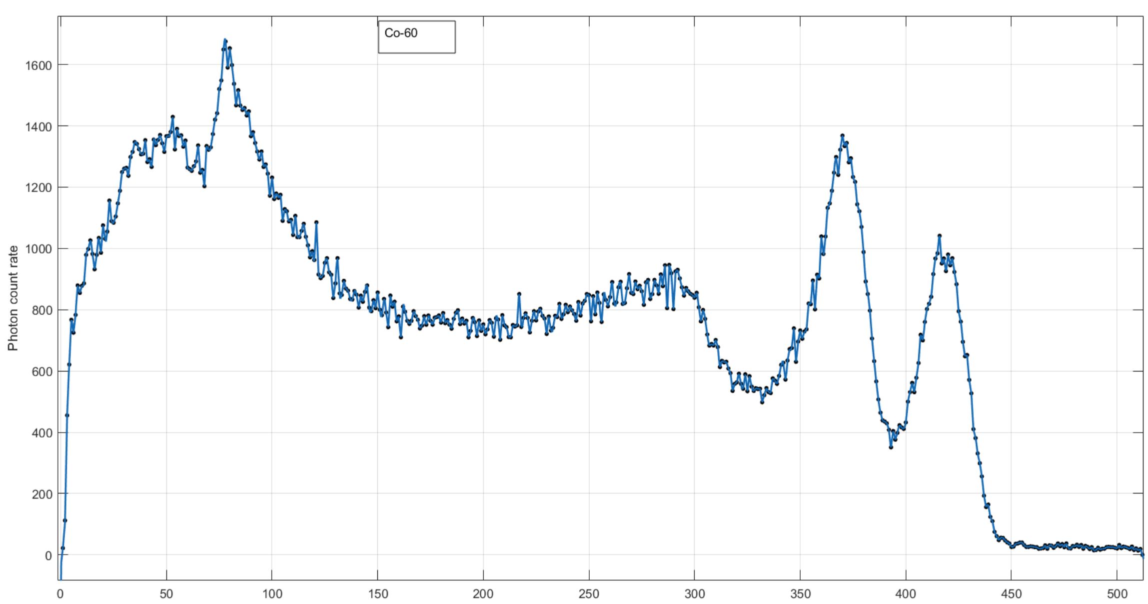


Figure 2: Channel vs. Photon Count Rate of Co-60

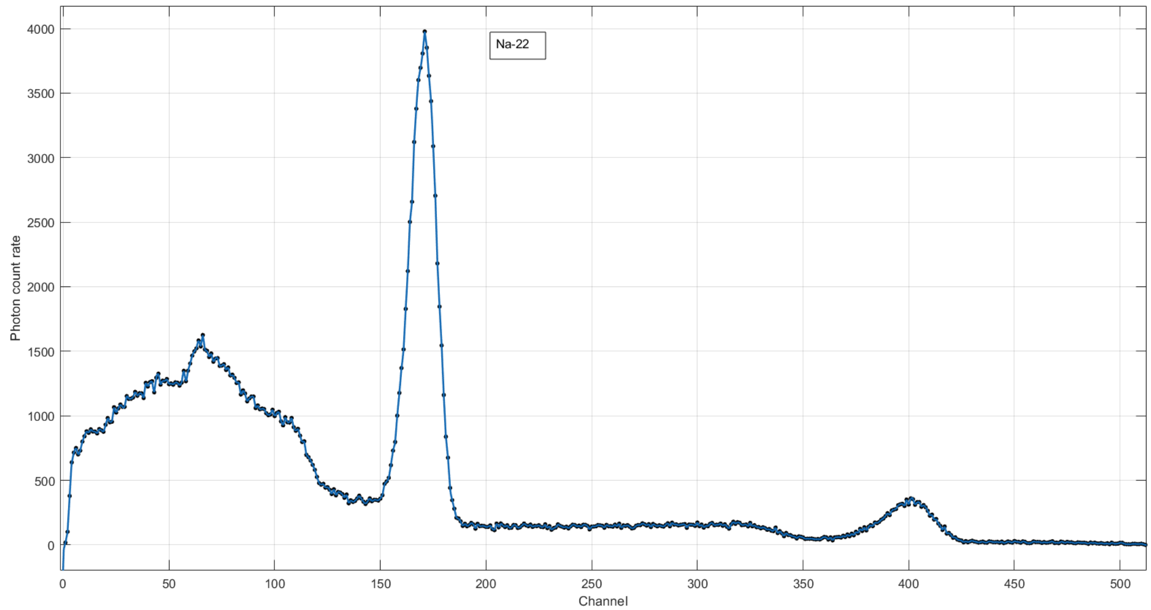


Figure 3: Channel vs. Photon Count Rate of Na-22

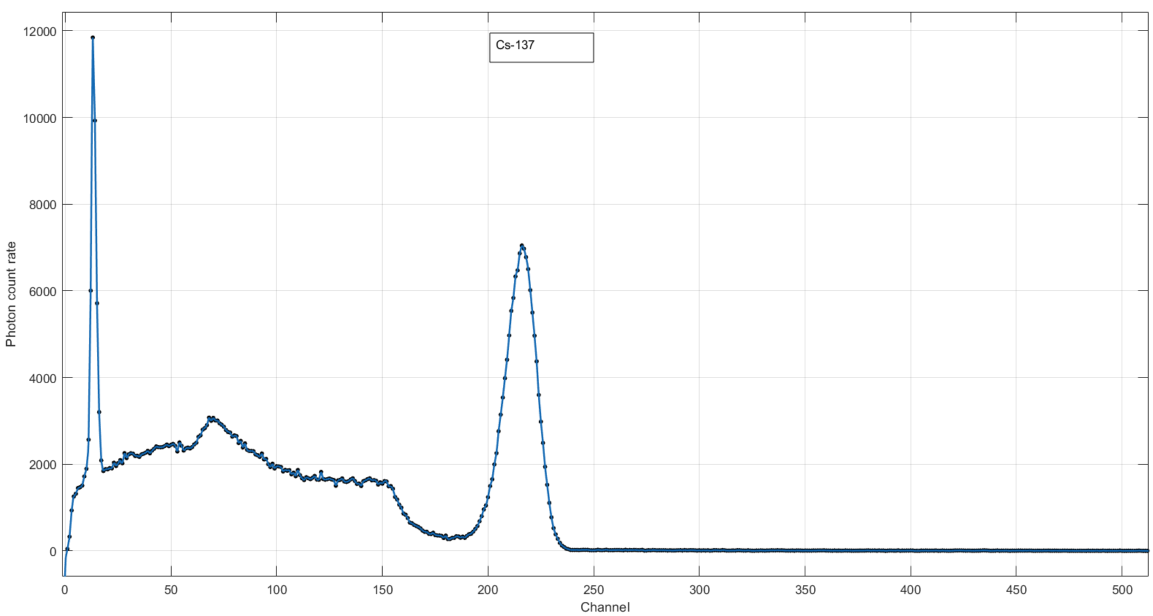


Figure 4: Channel vs. Photon Count Rate of Cs-137

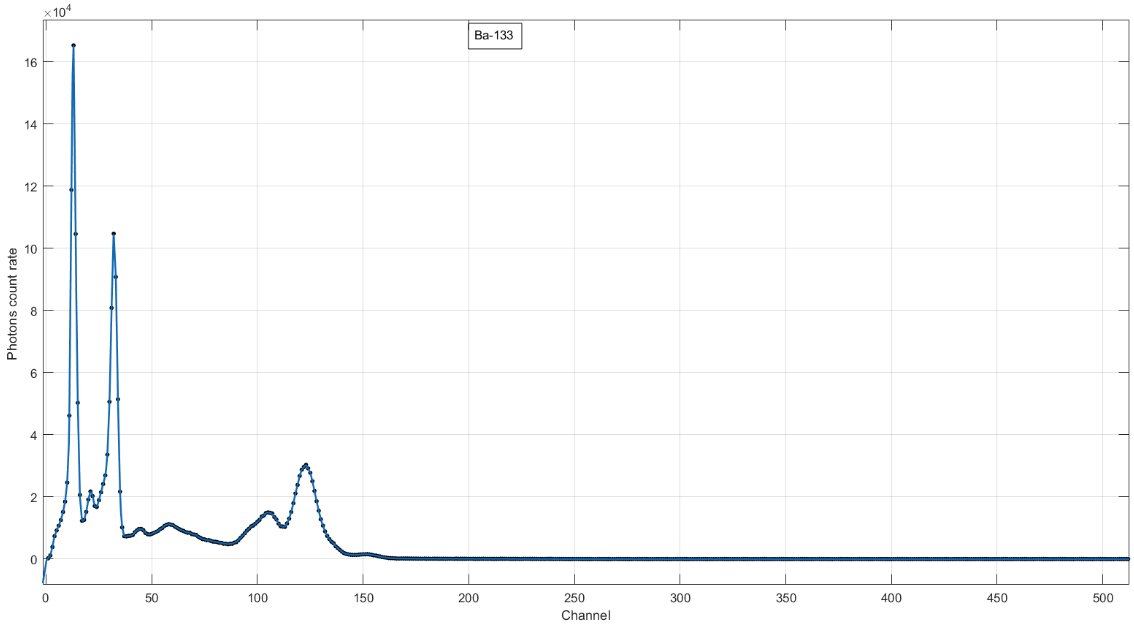


Figure 5: Channel vs. Photon Count Rate of Ba-133

4 Calculations

The energy vs channel obtained are as follows:

Radiation Source	Photo-peak energy (KeV)	Channel
Cs-137	650	215
Co-60	1148	369
Co-60	1303	415
Na-22	1256	401

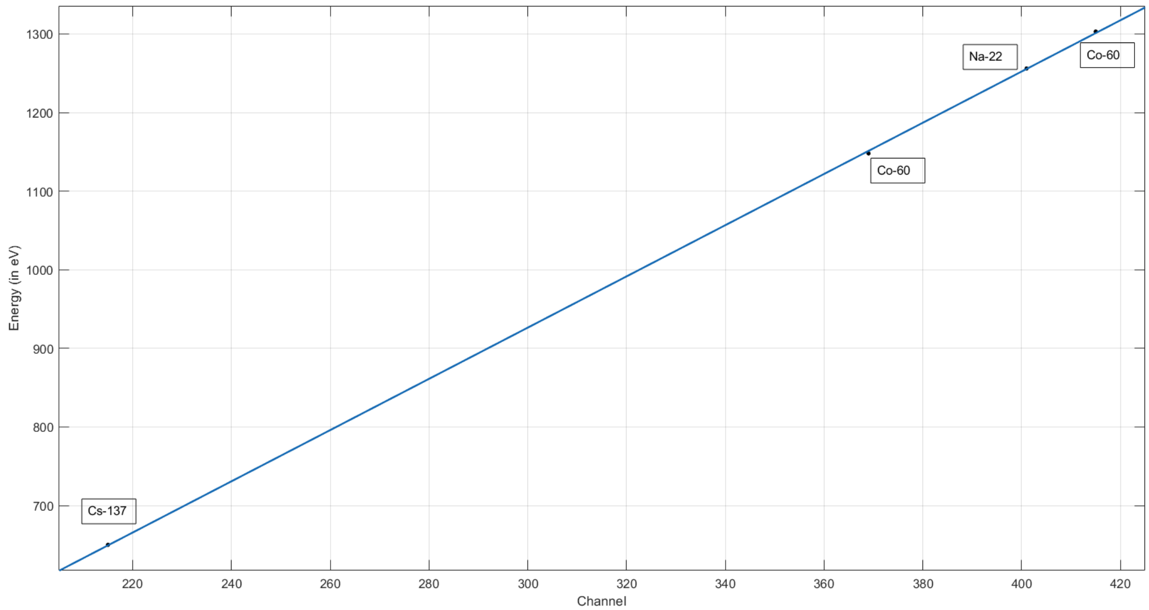


Figure 6: Channel vs. Photo-peak Energy

The equation of best fit curve is:

$$f(x) = p_1 x + p_2 \qquad i.e. \qquad Energy = p_1 * Channel + p_2$$

$$p_1 = 3.259$$

$$p_2 = -51.34$$

Radiation Source	Photo-peak energy calculated(KeV)	Theoretical value	Percentage Deviation
Cs-137	653	662	1.36
Co-60	1154	1173	1.61
Co-60	1304	1332	2.10
Na-22	1256	1274	1.41

Percentage Average deviation = 1.62

The calibrated energy vs photon count rate of sources are as follow:

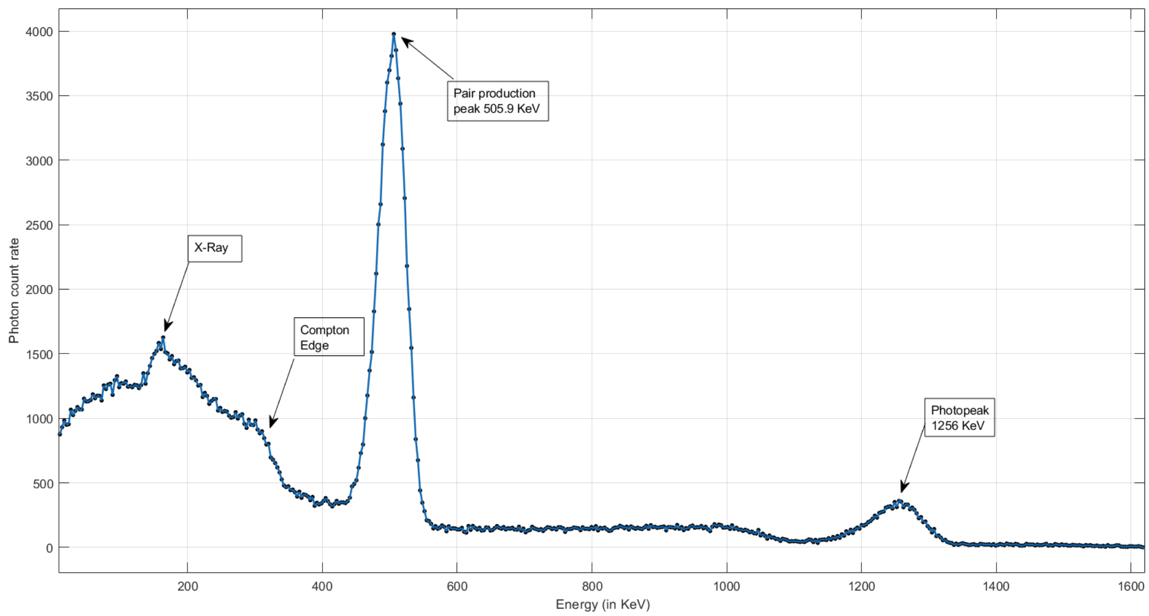


Figure 7: Energy vs Photon count rate for Na-22

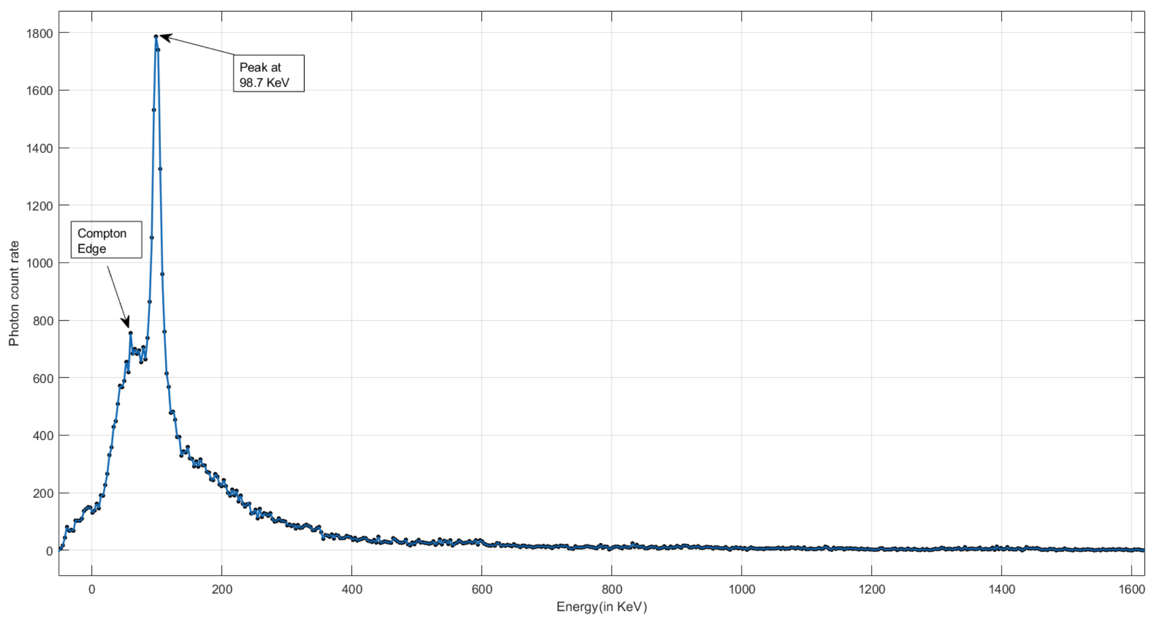


Figure 8: Energy vs Photon count rate for Co-57

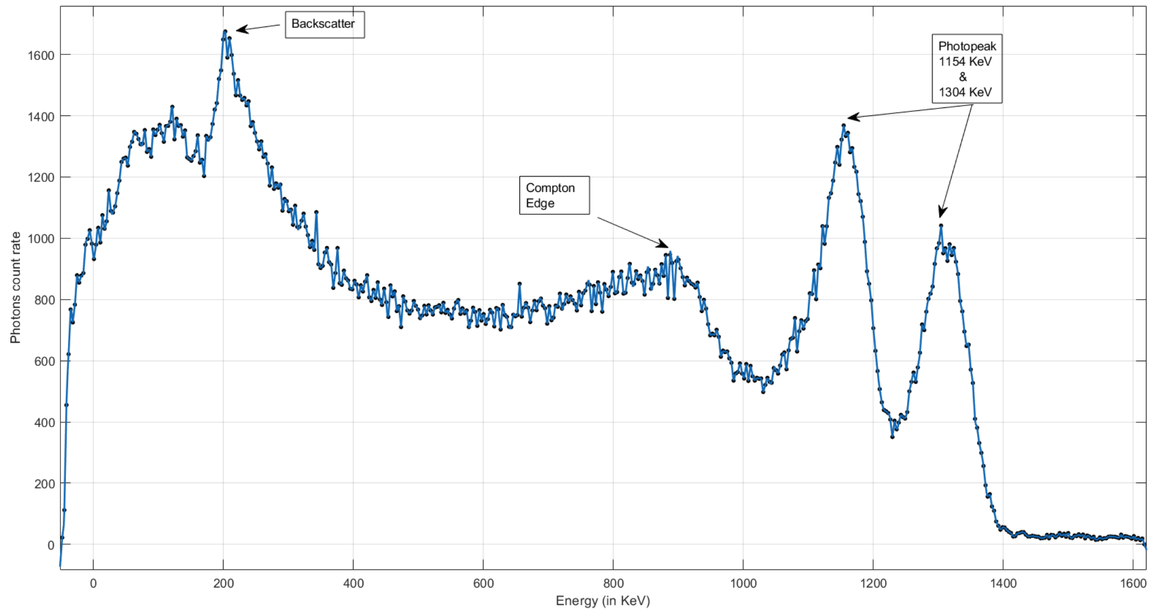


Figure 9: Energy vs Photon count rate for Co-60

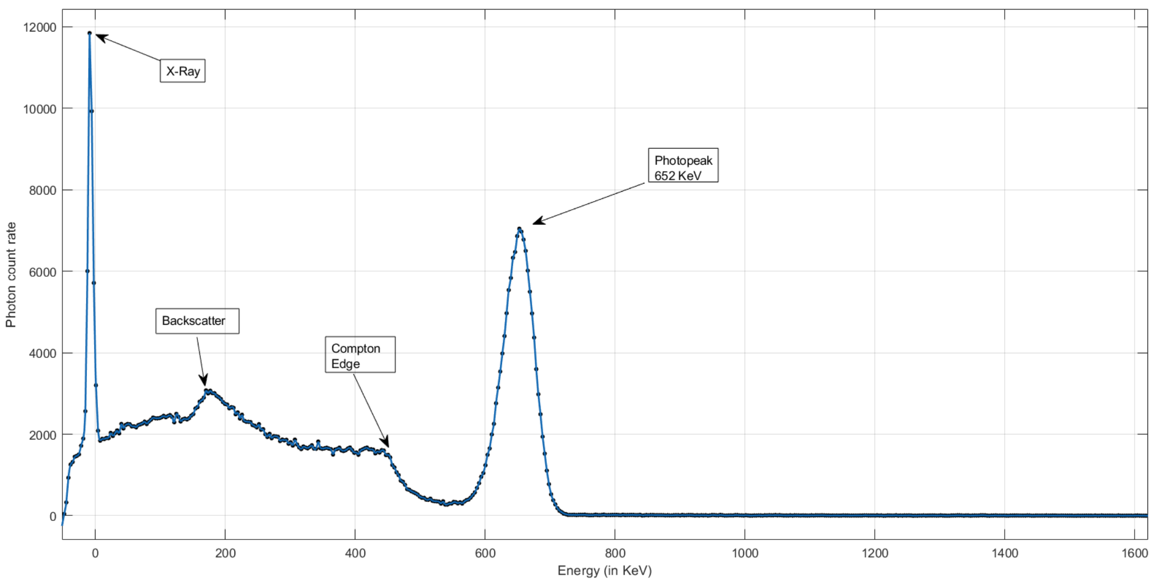
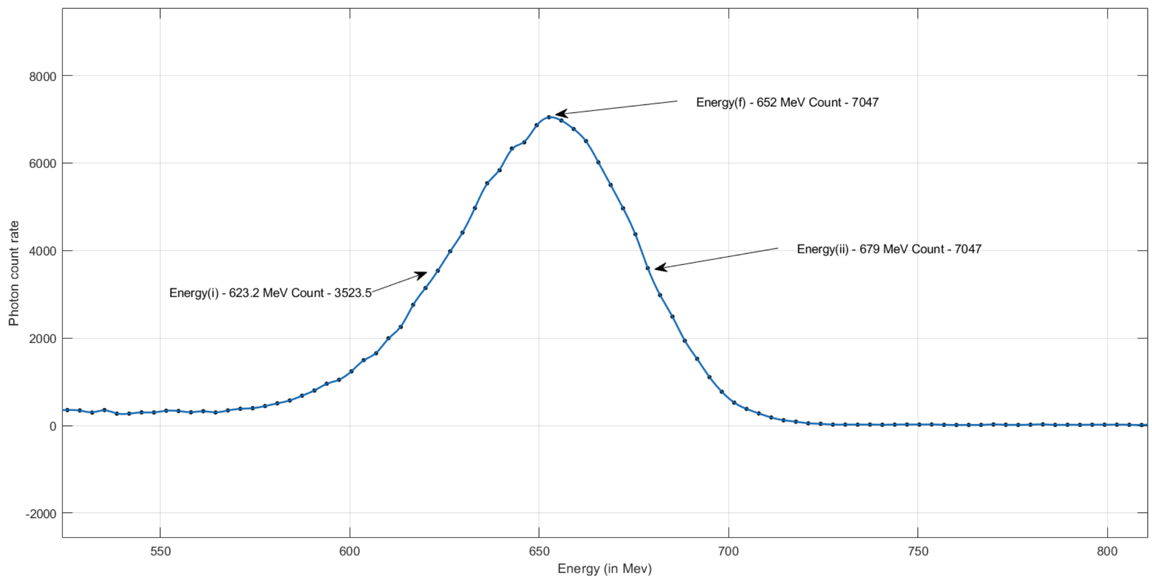


Figure 10: Energy vs Photon count rate for Cs-137



FWHM using photopeak of Cs-137

From the above graph:

Peak occurs at : Count = 7047 , Energy = 652 KeV
Half width: Count = 3523.5 , Energy = 679 - 623 = 56 KeV

$$\text{Resolution of detector} = \frac{56}{652} = 0.085 = 8.5\%$$

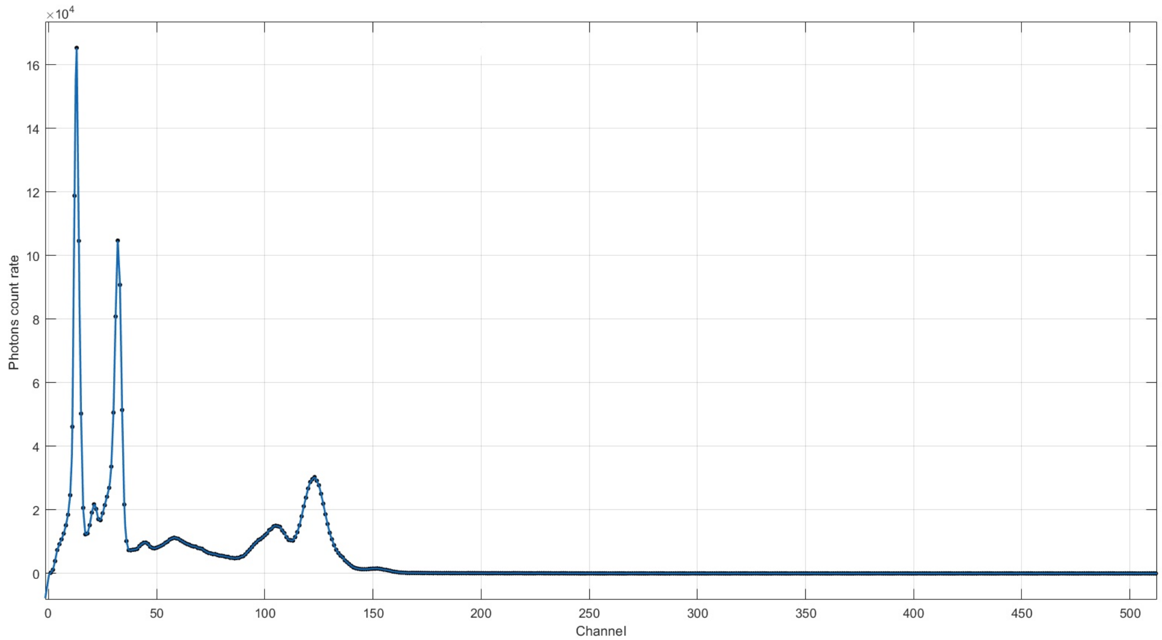


Figure 11: Unknown energy spectrum

Comparing the energy peaks with the data available in this site http://nucleardata.nuclear.lu.se/toi/ the radioactive source is found to be Ba-133.

5 Future Scope

When a Gamma Ray photon strikes the detector it gets scatter and leaving some part of it's energy. Usually to detect this energy detector is surrounded by escape suppression shield, this is a very inefficient method since it leaves much of the energy undetected.
A better way to detect and measure this energy is to use a technique called Gamma Ray Tracking. A closed array of highly segmented HPGe detectors is used to detect these energies. The gamma-rays are identified and separated by measuring their energy and position and then using tracking algorithms to reconstruct their path. A 3-D position can be constructed using 2-D segmented detectors.

References

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