Lab 0 - Linear Calibration of a High Purity Germanium Detector

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Abstract

This report details the importance and process of generating a two-point energy calibration using ^{137}Cs and ^{241}Am to produce a calibrated ^{133}Ba.

1 Introduction

The purpose of Lab 0 was to perform a two-point linear calibration between two gamma-ray photopeaks. In gamma-ray spectroscopy, determining which gamma-rays are present is an important aspect of radiation detection, and relying solely on the raw channel output makes it difficult to determine the gamma-ray energies present. By performing an energy calibration, the identification and discernment of of gamma-ray photopeaks from noise or spurious results becomes more effective, and this serves importance for non-proliferation reasons. Thus, having a properly calibrated spectrum is an essential component of gamma-ray spectroscopy. The following report details the process and results of a two-point linear calibration using ^{137}Cs and ^{241}Am as calibration sources.

2 Methods

The data for this lab came from a HPGe detector collected by Dr. Ross Barnowski. The sources used to generate the spectrum are shown in Table 1.

Source
^{241}Am
^{133}Ba
^{60}Co
^{137}Cs
^{152}Eu

Table 1: Gamma-ray lines used in the calibration

The energy calibration was performed using a two-point linear fit between ^{137}Cs and ^{241}Am. To perform the calibration, a python program searched the raw spectrum data of ^{137}Cs and ^{241}Am looking for the largest peaks within the spectrum. The program iterated over the spectrum for the number of gamma-ray energies present since there should only be peaks corresponding to the number of gamma-ray energies present. Before the program iterated over the raw spectrum, the data needed to be "cleaned". Noise from the detector could obscure some of the peaks found from iterating peak heights. With a peak found, the centroid of the peak was recorded, and subsequently, utilizing a pre-defined width that incapsulates the whole peak, the program fit a Gaussian and a linear model to this portion of the data.

After modeling the data with the Gaussian and linear model, the peak was set to zero so during the next iteration the same peak is not found again. The width of the peak was determined from first analyzing the spectrum and establishing the average width of each peak.

Once all of the peaks were discovered, polyfit within python was used to plot a linear line. The inputs for polyfit were the position of the peak and the actual gamma-ray energies. The slope-intercept from polyfit was applied to the channel numbers within the ^{133}Ba spectrum. Finally, to plot the data I did the newly calibrated channel numbers vs the original ^{133}Ba spectrum.

3 Results

The raw spectrum of ^{133}Ba is depicted in Figure 1.

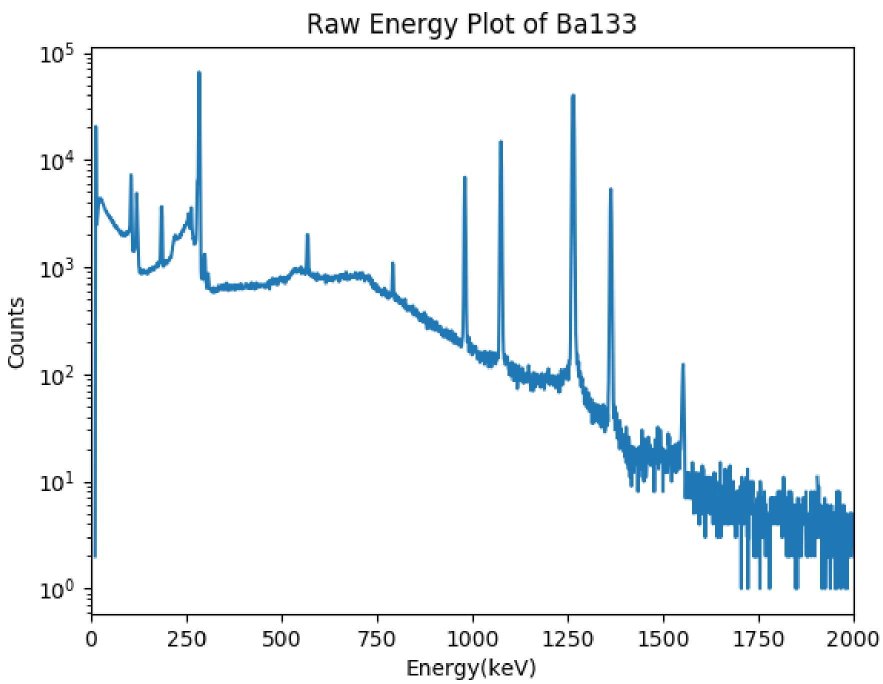

Figure 1: Raw data of ^{133}Ba produced from a HPGe detector.

Inspection of Figure 1 shows that the data has not been calibrated yet. ^{133}Ba has seven gamma-ray energies, but for this analysis, I used six peaks from ^{133}Ba detailed in 2 [1].

Table 2: ^{133}Ba Gamma-ray Energies

Source	**Energy (keV)**
^{133}Ba	53.1622
	80.9979
	276.3989
	302.8508
	356.0129
	383.8485

I excluded 79.6142 keV from the energy list because it blurs together with

80.99 keV into one photopeak due to the energy resolution of the HPGe. A better resolution detector would be needed to distinguish these two peaks. For this reason, I removed it so the iterator in the program will not search for a peak that is not present.

After performing the linear calibration with ^{137}Cs and ^{241}Am, a slope-intercept was found.

$$E = 0.28057 * x + 1.18109 \tag{1}$$

The slope and intercept was applied to the channel number of the raw Ba133 data. Figure 2 depicts the two-point calibration.

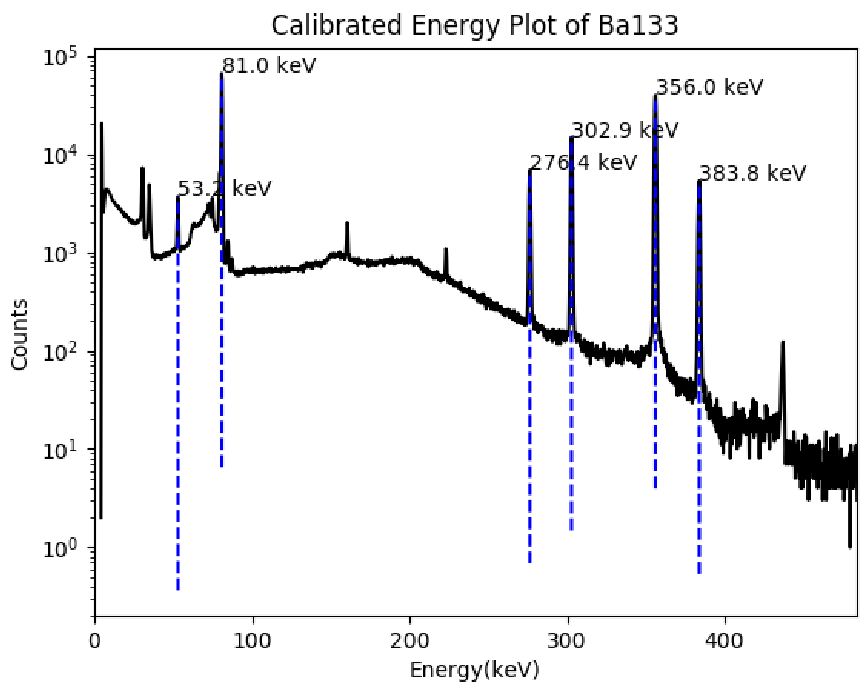

Figure 2: Calibrated ^{133}Ba data with their corresponding gamma-ray energies depicted by dashed blue lines

4 Discussion

The two-point energy calibration proved to be an effective method to calibrate a spectrum. After cleaning the raw data to remove electronic noise and excluding the 79 keV line for ^{133}Ba, the calibrated data corresponded well with the actual gamma-ray energies. There was a small amount of error between the gamma energies and the photopeaks, but this is expected because I only used a two-point energy calibration. Once more sources are added in to the calibration, the photopeaks should correspond better with their corresponding energies.

References

[1] Recommended gamma-ray energies and emission probabilities ordered by radionuclide. $www - nds.iaea.org/xgamma_standards/genergies1.htm$. (Accessed on 02/01/2018).