

Calibration Lab report

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Introduction

Energy calibration of a HPGe detector is an ubiquitous task in radiation detection laboratories, in this experiment, the main purpose is to practice generating lab reports using the reproducible workflow required for this course.

Methods

This is not a real lab in the sense that we don't need to collect data by ourselves. The data is given by the instructor and can be downloaded by students. Because this experiment is actually used to practice writing lab reports, so what we have to do is doing energy calibration using the data given us.

The data file consists of pulse height spectra taken with a coaxial HPGe detector using 5 different radionuclide calibration sources: ^{241}Am , ^{133}Ba , ^{137}Cs , ^{60}Co , and ^{152}Eu . The MCA with which the data was collected had 13-bit resolution, yielding 8192 channels. As the characteristic energy of the full energy peaks of these 5 radionuclides is already known, which is to say you can find their spectrum in textbook or nuclear data website, we only need to find out the centroid of each peak and correlate it with its energy using least square method.

$$\text{Energy} = \text{slope} \cdot \text{Channel Number} + \text{intercept}$$

As for each full energy peak, we use gauss curve to simulate and get the centroid (B) of each peak:

$$f(x) = A \cdot e^{-\frac{(x-B)^2}{2 \cdot C^2}}$$

and this is achieved by function *curve_fit*.

Now, the centroid of each peak and its corresponding energy are known, we can make linear regression using least square method to find the relationship between the channel number and its corresponding energy value.

Results

Totally, we found 17 peaks and their corresponding energy, listed as the table below:

Table 1: Peaks with Corresponding Energy.

Peak #	Channel #	Energy(keV)
1	207.72934164066072	59.5409
2	2353.969595281511	661.657
3	4177.6835240821465	1173.228
4	4745.511220436352	1332.492
5	429.56728236065885	121.7817
6	867.77043054316	244.6974
7	1222.6117121691966	344.2785
8	1460.7650922753362	411.1165
9	2772.003206539464	778.9045
10	3432.077389155436	964.072
11	5014.927456550307	1408.013
12	3959.8315489345346	1112.076
13	284.28923089774975	80.9979
14	980.9088851006587	276.3989
15	1075.1587761476976	302.8508
16	1264.6138573728588	356.0129
17	1363.8190002015974	383.8485

Making a linear regression of the table above, we have

$$Energy[keV] = 0.280521278253 \cdot Channel\ Number + 1.27621057811 \quad (1)$$

with the coefficient of determination R^2 :

$$R^2 = 0.999999997516$$

which is very close to 1. so the calibration result is very good.

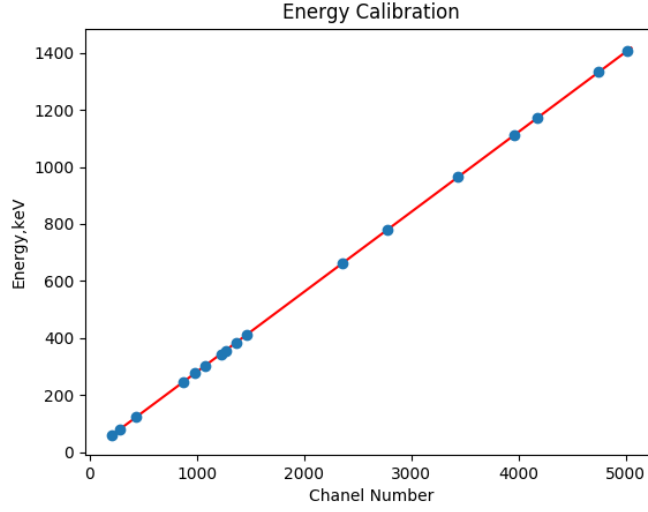


Figure 1: Energy Calibration.

Discussion

If only using the peak of Am-241(59.5409 keV) and the peak of Cs-137 (661.657 keV), an approximation result is got as:

$$Energy^* = 0.2805446 \cdot Channel\ Number + 1.263557 \quad (2)$$

Compare Equation (1) with Equation (2), it is found they are still very close, especially with respect to the slope.

References