Gaussian Energy Calibration of HPGe Count Rate Spectrums

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September 16, 2018

grammar

1 Introduction

The ability Accurate radiation energy spectrums are essential to further our understanding of nuclear physics. To achieve this it is essential to produce exact energy calibrations. This is especially true for High Purity Germanium Detectors (HPGe) that are able to achieve high-energy resolution beyond what other detectors, such as scintillators, are capable of. Due to the importance associated with the energy calibration, it is necessary to develop a fundamental understanding of the process of associating the bins with energy as well as the skills to develop the process used for performing energy calibrations. To this end, a count rate dataset of 5 known sources were provided to calibrate and subsequently verify the quality of the fit.

Energy calibration

Better described as pulse height spectra

2 Methods

2.1 Experimental Setup

A countrate energy spectrum dataset consisting of five sources wwas gathered with a coaxial high purity germanium detector (HPGE) by instructor Ross Barnowskifor. Out of the five sources ^{241}Am and ^{137}Cs were used to calibrate the energy spectrum and the peaks in ^{133}Ba was used to benchmark the accuracy of the calibration. The known energies of the calibration peaks are presented below in Table 1.

evaluate

Source	**Energy (keV)**
^{241}Am	59.5
^{137}Cs	661.6

Table 1: Source Isotopes and Corresponding Gamma-ray energies

Nice table... cite your source for nuclear data

2.2 Peak Selection

A program for peak selection was created using python 3.6, after inspection of the spectrum. The program iterated over the spectrum assuming a set number of gamma-ray energies were present because the spectrums consisted of only one source. With this knowledge, the max value was determined and the peak selected with a preset bin width. The peak information was recorded and then deleted to find the next max/peak.

You address this in the next section, but the centroid can be specified to sub-bin accuracy

Nice eqn, though in the future consider adding a description of the parameters

2.3 Gaussian and Linear Fit

The gamma-ray spectrum is approximated as being composed of a global non-linear background with guassian peaks due to the impingment of high branching ratio gamma-ray lines from radioactive decay.[1] The peaks are fitted by a Gaussian of the form:

$$G(x; A, \mu, \sigma) = A \exp\left(-\frac{(x-\mu)^2}{2\sigma^2} \right) \tag{1}$$

Additionally, the data was fit to a linear model and the two were summed together to achieve the final result.

Good, though the description here is a little decoupled from WHY this is done (you mention background above)

3 Results

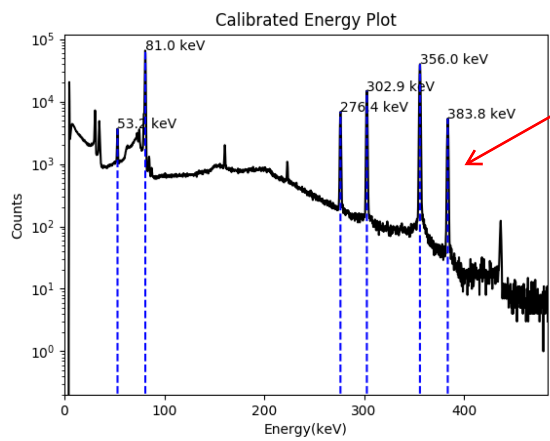
The peak selection and fitting procedure outlined in Section 2, resulted in a linear energy calibration of the form

$$E = .281 * Bin + 1.81 \tag{2}$$

Units?

The 133Ba spectrum presented in Figure 1. A comparison of the expected energy and the calibrated energies is provided in Table 2.

Figure 1 133Ba spectrum with calibration fit



Very nice, well labelled, though it is not clear whether the listed energies are the " known" values or the results of the calibration

Good. Consider plotting the residuals as well

Figure 1: 133Ba spectrum with calibration fit

Source	Energy (keV)	Calibration (keV)	abs(DeltaE) (keV)
^{133}Ba	53.1622	53.087	0.074
5	80.997	80.864	0.13
	276.398	276.437	0.0272
	302.853	302.805	0.0505
	356.017	356.101	0.0968
	383.851	383.871	0.0382

Table 2: Source Isotopes and Corresponding Gamma-ray energies

An astute observation... general peak finding algorithms tend to be quite complicated

4 Discussion

The code developed for the energy peak fitting has a number of limitations. Notably, the code relies on finding the max point in the spectrum inorder to locate the peaks. This was only possible because of visual inspection of the spectrums confirmed that this could be done. Additionally, the width size of the peaks are predetermined meaning that if one is not careful, it is possible to combine two peaks into one or even delete a peak. The method used for fitting the peaks also requires an extra step of fitting a linear model and adding it to the gaussian fit inorder to avoid incorrect curve fitting. However, the energy calibration does fit very well. The coefficient of determination for the linear fit is .99 showing a high degree of correlation.

Quantitative presentation here is good, though the quantity being presented may not be the most meaningful.

References

[1] Glenn Knoll. *Radiation Detection and Measurement*. John Wiley & Sons, Inc., 1999.