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Calibration Software for Beta-Gamma Coincidence Detectors

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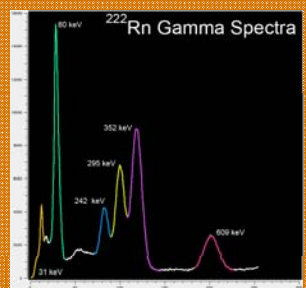
Abstract

In order to be able to read absolute activity from a beta-gamma coincidence detector, it must be well characterized and calibrated. Current procedures are labor intensive and require experts well versed in calibration techniques to perform the process accurately. It is desirable to capture this capability within an automated software package that allows experts to perform their task more efficiently and non experts to do rudimentary calibration with minimal error. The objectives of the software include using sample spectra to produce a channel to energy conversion , determine detector characteristics such as efficiency and resolution, and assist in high voltage selection. Because all of these objectives require each of the spectral peaks to be found and matched to a known energy, the automation of peak identification is an important step towards fully automating the entire calibration process. Four methods were evaluated for automating the peak finding process and three methods for determining peak endpoints. All were selected based on existing procedures, robustness, and ease of use. Evaluation criteria includes required user interaction and effectiveness in finding a solution. While the final version of a fully automated calibration system has not yet been attained, the combination of methods selected provide an effective algorithm requiring minimal user input that fits current needs.

Introduction

In order to find detector settings, sample data from detector files containing ^{137}Cs, ^{133}Xe, ^{131m}Xe, and ^{222}Rn were used.

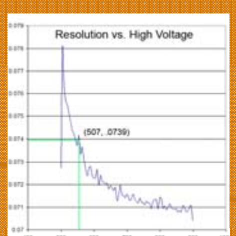


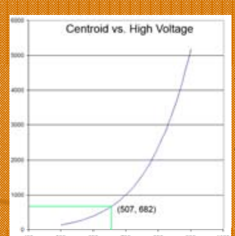
Channel To Energy Conversion

The process used to obtain a channel to energy conversion involves matching peaks present in experimental spectra with energies where there is a high probability of an emission.

High Voltage Adjustment and Energy Resolution

By running a sample of ^{137}Cs through the detector at various high voltages, the 662 keV peak can be fit and used to calculate resolution and gain at each voltage. Using that information, it can be determined whether or not the voltage which gives the desired gain yields an acceptable resolution.





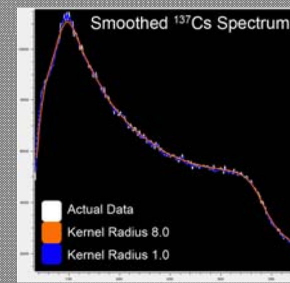
Methods

Determination of Peak Endpoints

Searching for Minimums:
- Endpoints occur where data has increased N successive times
- N difficult to determine due to variable noise

Using Endpoints at Half Maximum:
- Endpoints occur where data is approximately one half of peak height
- Possibility of an inaccurate fit on the data below half maximum

Estimating a Standard Deviation:
- Approximated half maximum used to approximate standard deviation
- Endpoints occur at a certain number of standard deviations from centroid
- Number of standard deviations is hard coded and varies with peak and isotope

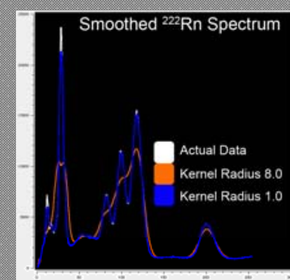


Automating Peak Finding on Various Isotopes

Manual Peak Finding:
- User clicks each peak individually
- Inconvenient and time consuming

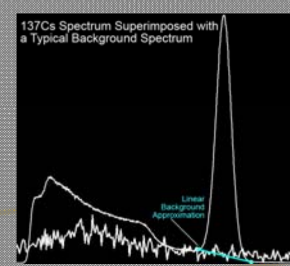
Curve Smoothing:
- Reduction in noise to facilitate the process of taking derivatives
- Possibility of augmenting or modifying data in undesirable way

Detecting and Subtracting
- Repeating a process of finding highest peak and removing from consideration
- Isotope or spectral attributes expected due to variable peak width



Approximation of Background Spectra

- Background Spectra for voltage test files not available
- Approximated background by fitting spectra to Gaussian function plus linear function



Results

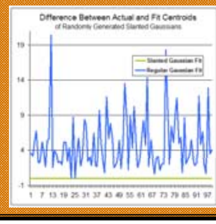
Factors that were most challenging to overcome were noise from low count statistics and understanding the mapping of isotope decay products to energy lines seen by the detector.

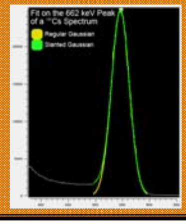
Realistic Level of Automation

- Amount of time and effort that would have to be put into an isotope identification is not realistic for the needs of this program.
- Routine using standard deviations for endpoint determination and "Detecting and Subtracting" was chosen as the most convenient and functional

Slanted Gaussians for Background Approximation

- Average error of slanted Gaussians was comparable to regular Gaussians
- Difference in centroid error increased, but did not cause significant change in resolution error
- The slanted Gaussians offered a visibly tighter fit around endpoints





Conclusion

The methods implemented in this software have been shown to be both accurate and robust; however, there are areas for improvement. One future goal that will enable completely automated calibration is better isotope identification. The main difficulty involved with this is the dependence on detector efficiencies required in order to perform a spectral fit. The efficiencies are calculated using data from Gaussian fits, which are automated based on an isotope expectation. Research into efficiency calculating techniques paired with a better understanding of what to expect from the detector could help to identify isotopes without the use of efficiencies. Continued testing of this application will help determine added functionality that could increase the utility of the software.

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