SnT 2021

CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

CTBTO PREPARATORY COMMISSION

Quality Control source analysis using a rotating frame of reference

Matthew Cooper, James Ely, Warren Harper, Charlie Hubbard, Michael Mayer, Ryan Wilson
Pacific Northwest National Laboratory

P3.5-278

POSTER

BATTELLE

Pacific Northwest NATIONAL LABORATORY

NNSA National Nuclear Security Administration

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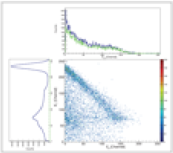
Abstract: Development of methods to track beta-gamma detector gains is important to the accuracy of radioxenon system measurements. Typical gain monitoring and correction is done using a mixed $^{137}Cs/^{154}Eu$ source, which results in several gamma-ray lines that can be fit by Gaussian distributions, and gain adjustments made to bring the peaks into the expected channel. The beta detector on the other hand does not produce clear peaks, so peaks are made by taking slices from the 2-D Compton scatter line and then analyzed. The method developed at PNNL takes a different approach; it uses the 2-D Compton scatter line and rotates the frame of reference until the projection of the Compton scatter line forms a peak. This method optimizes the use of counting statistics available from the Compton scatter and gives reliable results even with relatively short measurement times.

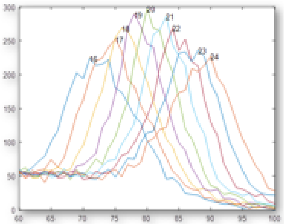
Introduction

- Radioxenon system gain stability is critical to accurate activity and activity concentration measurements.
- The challenge is maintaining confidence in radioxenon system results
  - Energy drift is one critical area to monitor
    - An energy shift impacts many different areas of the nuclear measurement, including the isotopic identification, detection efficiency, interference ratios for beta-gamma analysis
  - Useful to monitor other areas like energy resolution and detection efficiency



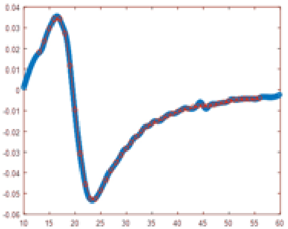
Quality Control Rotational Method

- Rotational method maximizes the use of counting statistics
- Cs-137 data is acquired over 15 minutes
- By using a rotating frame of reference and projecting the coincidence data onto the rotated x'-axis one gets peaks for each angle of rotation.



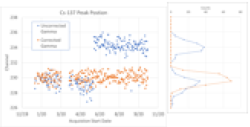
Quality Control Rotational Method: Fitting

- Savitsky-Golay (SG) is used to get the smoothed first derivative.
- Red points are the SG first derivative.
- Blue is interpolated data.
- High density interpolated data used to find the zero crossing of 19.55 degrees.
- Peak centroid, area, and width are used to determine the best fit of the Compton scatter line.



Gamma Gain Correction Results

- Corrects for the gain shifts exceeding a parameter setting (this example uses 1%) to channel 230
  - 1% is based on research presented at INGE 2019, suggesting shifts of <2% have negligible impact to final activity concentration results
- Corrects for slight downwards drift seen January-March
- Corrects the gain shift seen in June



	Uncorrected Gamma Position	Gain Corrected Gamma Position
Mean	232.9	230.1
Standard Deviation	2.48 ± 0.16	0.64 ± 0.04

Beta Gain Correction Results

- Corrects for the gain shifts exceeding a parameter setting (this example uses 1%) to channel 200
  - 1% is based on research presented at INGE 2019, suggesting shifts of <2% have negligeable impact to final activity concentration results
- Corrects for slight downwards drift seen after April

	Uncorrected Beta Intercept	Gain Corrected Beta Intercept
Mean	203.0	200.3
Standard Deviation	1.46 ± 0.09	0.85 ± 0.05

Conclusions

- A ^{137}Cs is used on Xenon International to verify the beta-gamma nuclear detector stability.
- The Compton scatter beta intercept is tracked by using a rotational frame of reference
- This rotational method projects the Compton scatter line onto the x-axis of the rotated frame to maximize the available counting statistics
  - Allows the determination of the Compton scatter line slope, intercepts, and width
- The method corrects for observed gain shifts on a case-by-case basis

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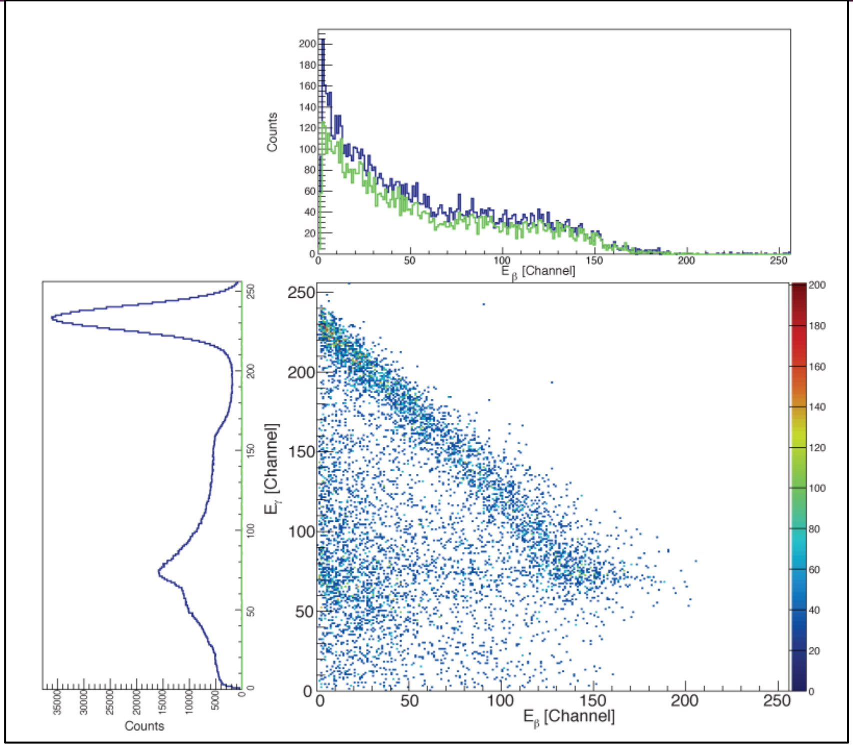

Cs-137 spectral data showing the beta-singles and beta projection beta-gamma in the top plot, gamma-singles and gamma projected beta-gamma in the left side plot, and beta-gamma spectrum in the central figure.

Quality Control source analysis using a rotating frame of reference
Quality Control Rotational Method

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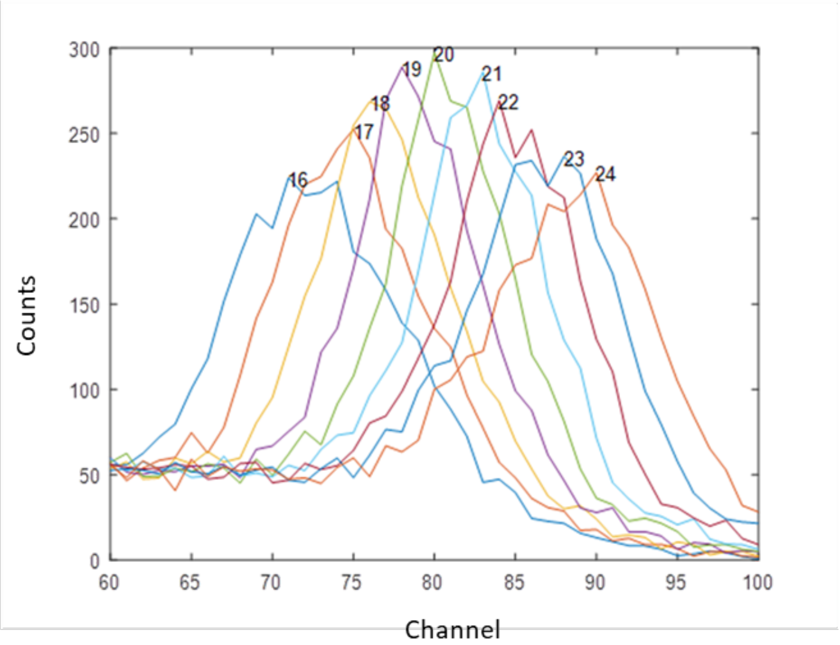

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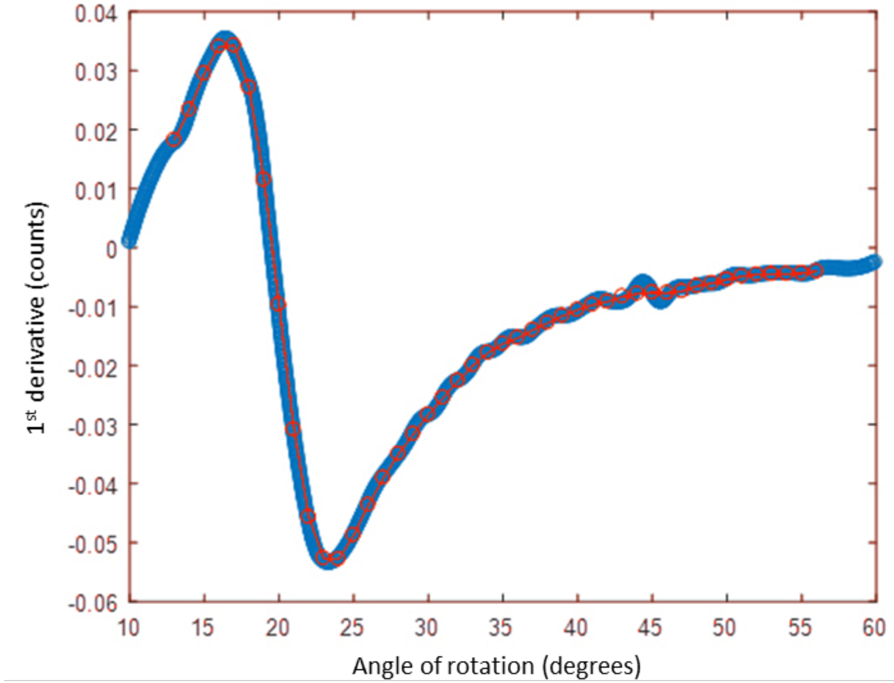

Quality Control source analysis using a rotating frame of reference
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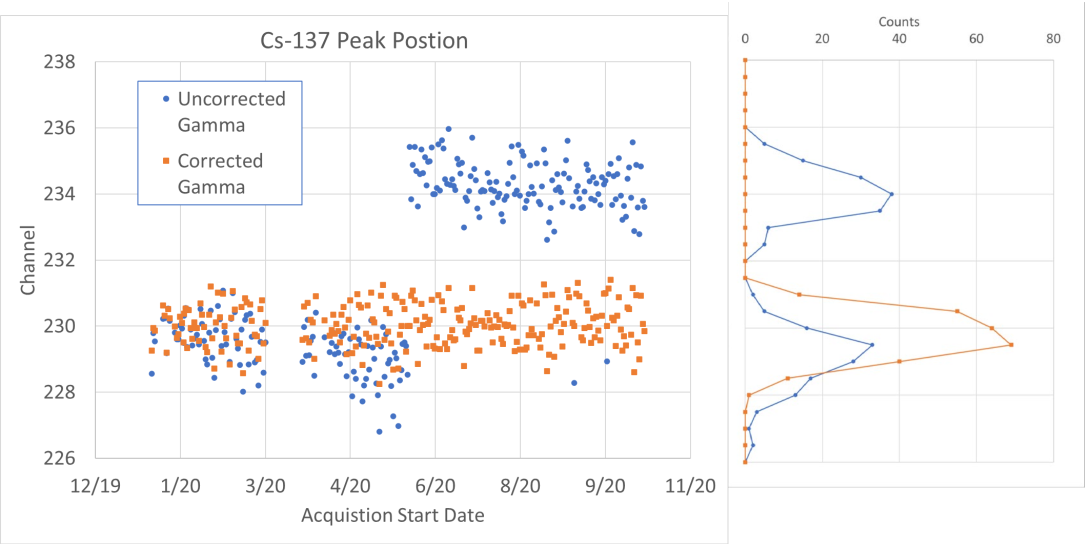

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Quality Control source analysis using a rotating frame of reference
Beta Gain Correction Results

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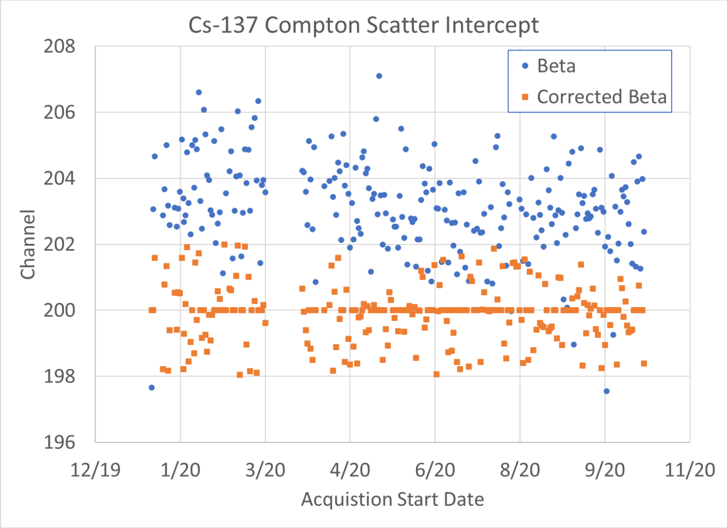

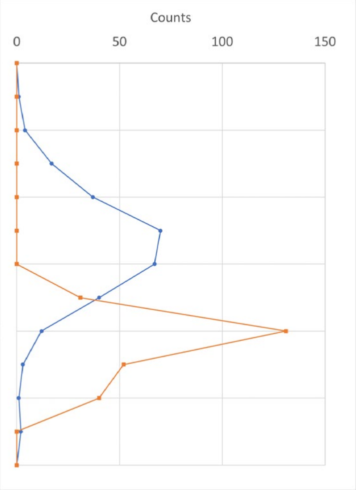

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

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