SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
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Long-term Radioxenon Efficiency Calibration Study of Beta-Gamma Detectors

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INTRODUCTION AND MAIN RESULTS

This study investigates the long-term variations in radioxenon efficiency calibrations by conducting calibrations over a year on a single system. Results show that efficiencies remain consistent in the absence of contamination. Preliminary results show that even small variances in efficiencies have large effects on activity concentrations.

This Ground-based Nuclear Detonation Detection (GNDD) research was funded by the National Nuclear Security Administration, Defense Nuclear Nonproliferation Research and Development (NNSA DNN R&D).

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Background:

Radioxenon systems used for nuclear explosion monitoring are calibrated infrequently, usually only once during setup and any time a physical change is made. The practice of rarely calibrating a system stems from the idea that paired beta and gamma detectors do not change, the background changes minimally, and thus the efficiencies should vary little. To determine the variation in detector efficiencies, a series of calibrations were completed on a stationary radioxenon system at the Pacific Northwest National Laboratory over the course of a year. Each calibration set consisted of isotopically pure ^{135}Xe, ^{133}Xe, ^{133m}Xe, and ^{131m}Xe produced by Idaho National Laboratory. The efficiency analysis was completed using the traditional 7 Region-of-Interest (7ROI) method.

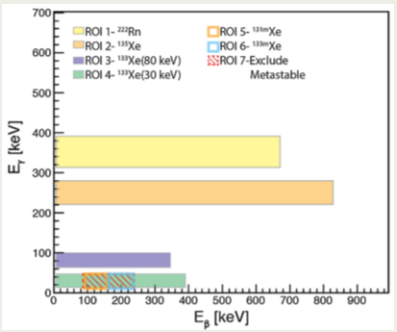

Fig. 1: Traditional 7ROI defined ROIs

Calibrations Over a Year:

Each calibration set was periodically injected into a radioxenon system. Figures 2-6 show the beta-gamma efficiency for one detector pair for each region of interest (ROI). Efficiencies were calculated using the traditional 7 Region-of-Interest (7ROI) approach, as detailed in reference [1].

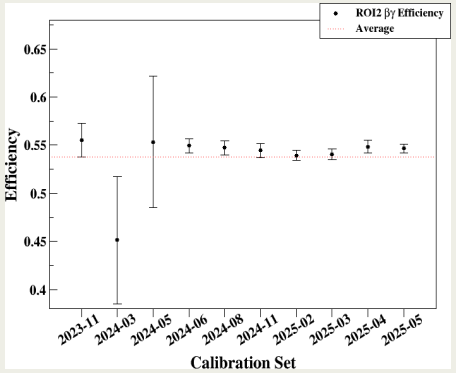

Fig. 2: ROI2 β-γ Efficiencies

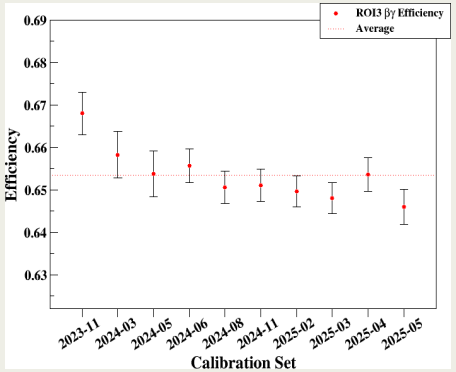

Fig. 3: ROI3 β-γ Efficiencies

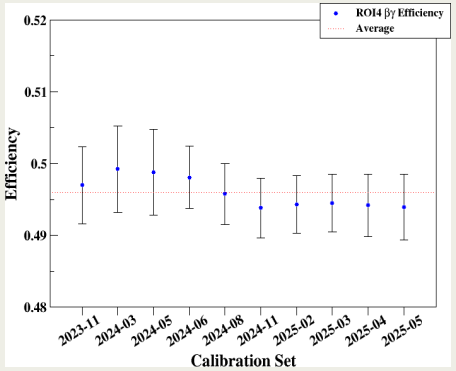

Fig. 4: ROI4 β-γ Efficiencies

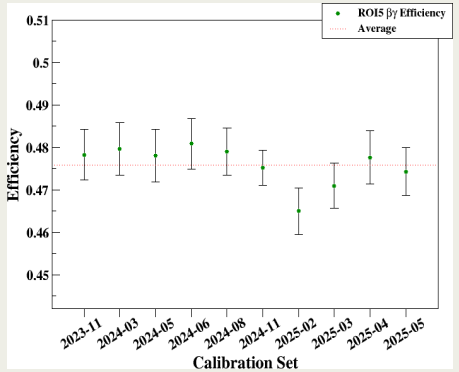

Fig. 5: ROI5 β-γ Efficiencies

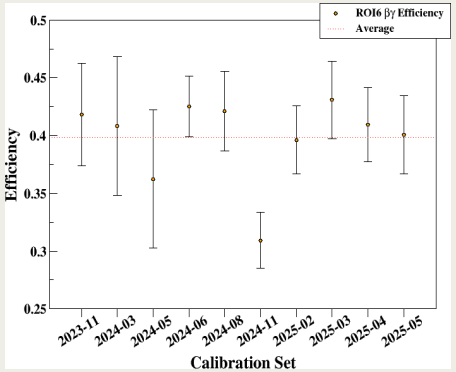

Fig. 6: ROI6 β-γ Efficiencies

Results:

The large error bars on the first three calibration sets are due to the presence of ^{133m}Xe and ^{133}Xe contamination in ^{135}Xe, which was accounted for in the efficiency calculations. Overall, the efficiencies for each ROI remained consistent throughout the year, with the exception of ^{133m}Xe.

The calibrations were then used to calculate activity concentrations for each of the calibration spikes to determine if any change in efficiency would result in a change in the activity concentration. Figure 7 shows the ^{133}Xe results.

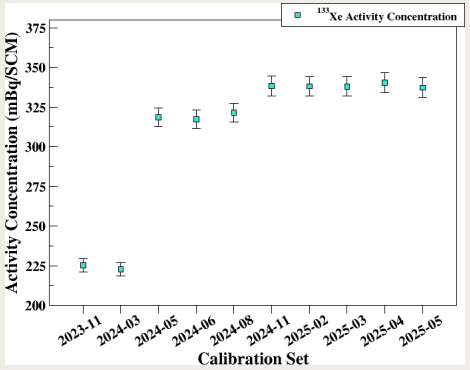

Fig. 7: ^{133}Xe activity concentrations calculated using new efficiencies.

Future Work:

The results indicate that contamination during efficiency calibration significantly impacts activity concentrations. Small efficiency variations also affect measurements. Further investigation into the effects of potential contamination, changing backgrounds, and other factors (including better improved interference ratios) are ongoing to understand how often the radioxenon systems should be calibrated to produce reliable results.

[1] Cooper, M.W. et al., IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 60, No. 2, April 2013.

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