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Quantifying the Effect of Air on Uncertainty in the Particle Accelerator

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PIGE Count Rate Sensitivity to Air Gap

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Abstract

When measuring environmental PFAS contamination, precision is essential. We are quantifying systematic variation in measurements of liquid Sodium-Fluoride (NaF) standards undergoing particle induced γ emission (PIGE). These standards are measured in the atmosphere outside of the vacuum environment of the particle accelerator at Hope College. One source of systematic variation is the size of the air gap of the experimental setup. A variation in the air gap on the order of one millimeter will result in significant change in the PIGE γ -ray yield. We aim to model this effect with calculations from SRIM (Stopping Range in Material) software, simNRA (simulated Nuclear Reactions Analysis) software, and integrating γ peaks to determine counts per Coulomb.

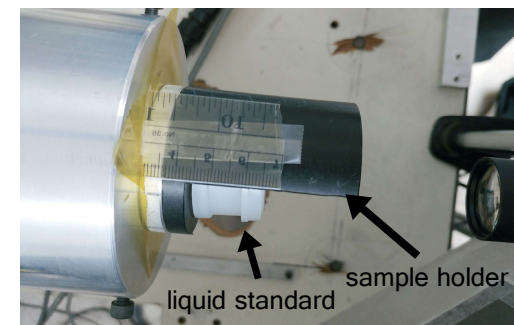


Figure 1: The end of the north line of the particle accelerator. The NaF standard was moved away from the vacuum chamber in small increments of 1-5 mm.

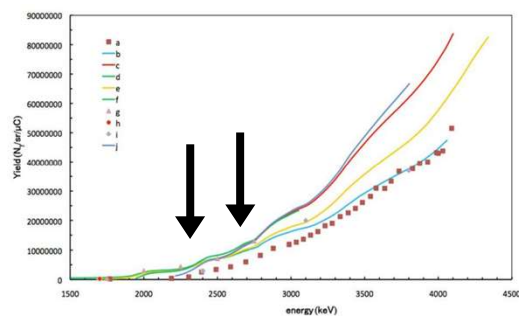


Figure 2: This graph shows the difference in γ yield between our highest and lowest beam energies due to air gap variation.

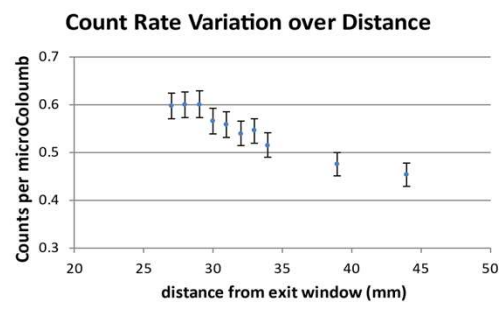


Figure 3: The observed reduction in counts per μ Coulomb at increased distances from the vacuum chamber.

Results

SRIM calculations indicated that an air gap between 27 mm and 44 mm varied the beam energy from 2699 keV to 2381 keV, causing up to a 25% reduction in γ yield (as shown in Figures 2 and 3).

Conclusions

A small air gap between the vacuum chamber and the NaF liquid standard was identified as the most significant source of decrease in the PIGE count rate. A new sample holder that minimizes the air gap was developed due to these findings. This research was done in preparation for this summer's work in identifying PFAS in groundwater.

Methods

- 2000 ppm liquid fluorine standard prepared
- Fluorine standard irradiated in the particle accelerator at 3400 keV with air gaps ranging from 27mm to 44mm
- γ peak at 197 keV from $^{19}\text{F}(p, p' \gamma)^{19}\text{F}$ reaction measured with a high purity germanium detector
- Counts normalized to amount of beam current with a gold coated mylar film
- Energy of beam when it hit the sample at varying distances calculated using SRIM

Citations

- IAEA. *Development of a reference database for particle induced gamma ray emission (PIGE) spectroscopy*. IAEA, 2017..
- J.F. Ziegler, M.D. Ziegler and J.P. Biersack, *SRIM2008*, [online] Available: <http://www.srim.org>.
- M. Mayer, "SIMNRA (Simulation program for the analysis of NRA RBS and ERDA)", *AIP Conf. Proc.*, vol. 475, no. 541, 1999.