Development of a Traceable ^{241}Am on ZnS Phantom for Quantitative Alpha-Particle Imaging

Likhitha Polepalli, MS[1], Sean Jollota, Ph.D.[1], Denis Bergeron Ph.D.[2], R. Michael Verkouteren Ph.D.[2], Brian W. Miller Ph.D. [3], and Larry DeWerd Ph.D.[1]

University of Wisconsin-Madison[1], National Institute of Standards and Technology[2], University of Arizona[3]

Introduction

- Accurate sub-organ dosimetry is a critical need as Targeted Alpha Therapy (TAT) research advances
- Standardization of TAT is bottlenecked by challenges in accurately verifying imaging resolution and quantifying activity
- This study evaluates a digital autoradiography system paired with a custom-printed, traceable 2D reference standard to simultaneously validate activity quantification and verify imaging resolution

Methods

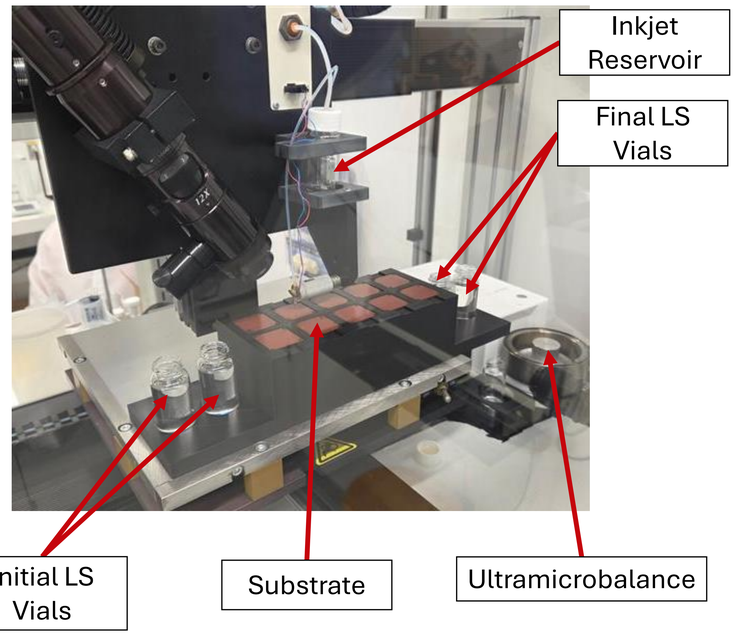

Figure 1. Jetlab-4 benchtop dispenser utilized for fabricating the ZnS phantom

- ^{241}Am with 0.1 mol/L HCl solution, with activity traceable to NIST was deposited onto a ZnS phosphor screen utilizing a Jetlab-4 drop-on-demand printer (Figure 1)
- Deposition was in a Derenzo phantom pattern consisting of 3,338 droplets (approximately 60 pL each) and 50 drop line pattern with seven lines
- Total phantom activity was established via precise ultramicrobalance gravimetry and the initial and final LS vials
- The phantoms were imaged using an ionizing-radiation Quantum Imaging Detector (iQID) with optimized settings [1], yielding the images shown in Figure 2

Conclusions

- A traceable, 2D reference standard was successfully printed utilizing an inkjet printer, demonstrating accurate activity measurements across all regions of interest and sub-millimeter spatial resolution (Figure 3)
- The iQID system accurately quantified activity to within <0.5% of known traceable values, demonstrating the high accuracy of the fabrication method and iQID calibration (Table 1)

References

- [1] S. P. Jollota et al., *"Gravimetric drop-on-demand inkjet deposition for imaging phantoms with traceable activity,"* Applied Radiation and Isotopes, vol. 218, p. 111683, Jan. 2025, doi: https://doi.org/10.1016/j.apradiso.2025.111683.

Contact Information

Please contact Likhitha Polepalli at polepalli@wisc.edu with any questions

Results

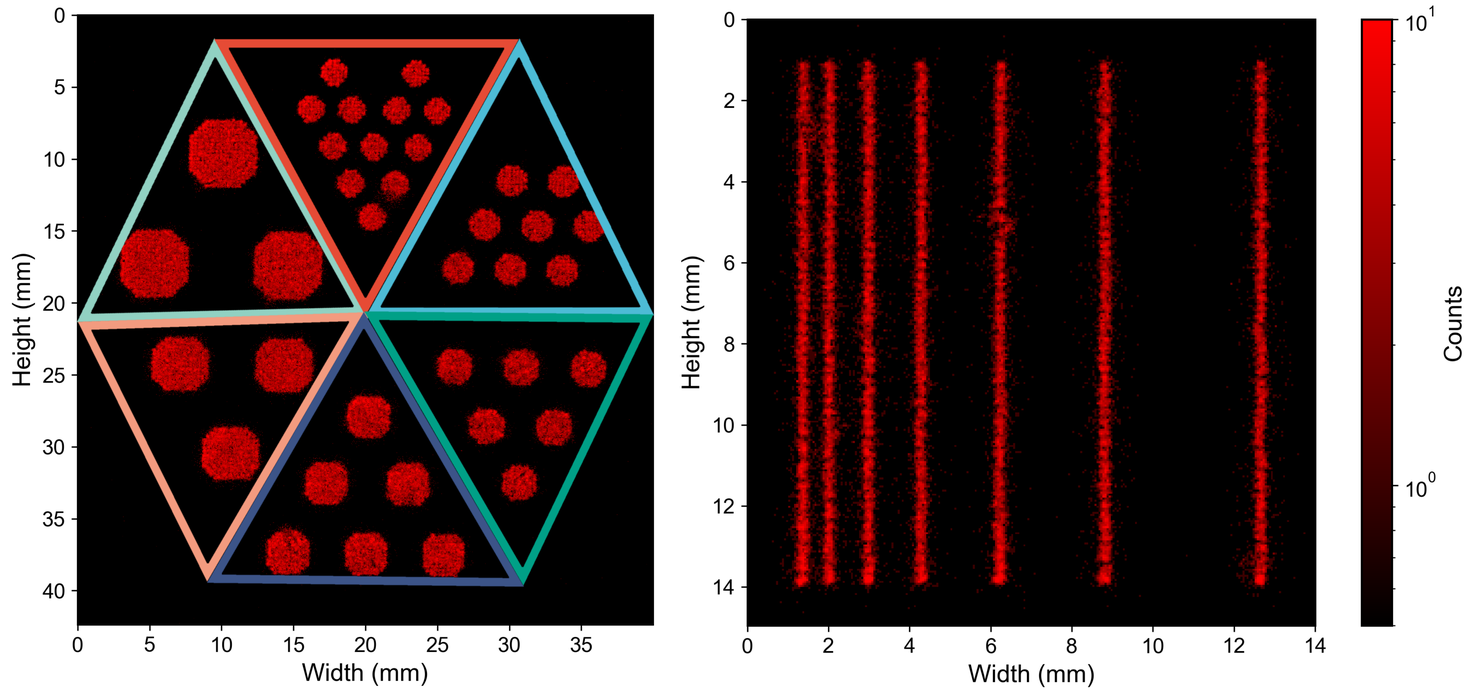

Figure 2. iQID images of (**Left**) Derenzo printed phantom with regions of interest (ROI 1 – 6) labeled and (**Right**) 50 drop line pattern for imaging resolution characterization

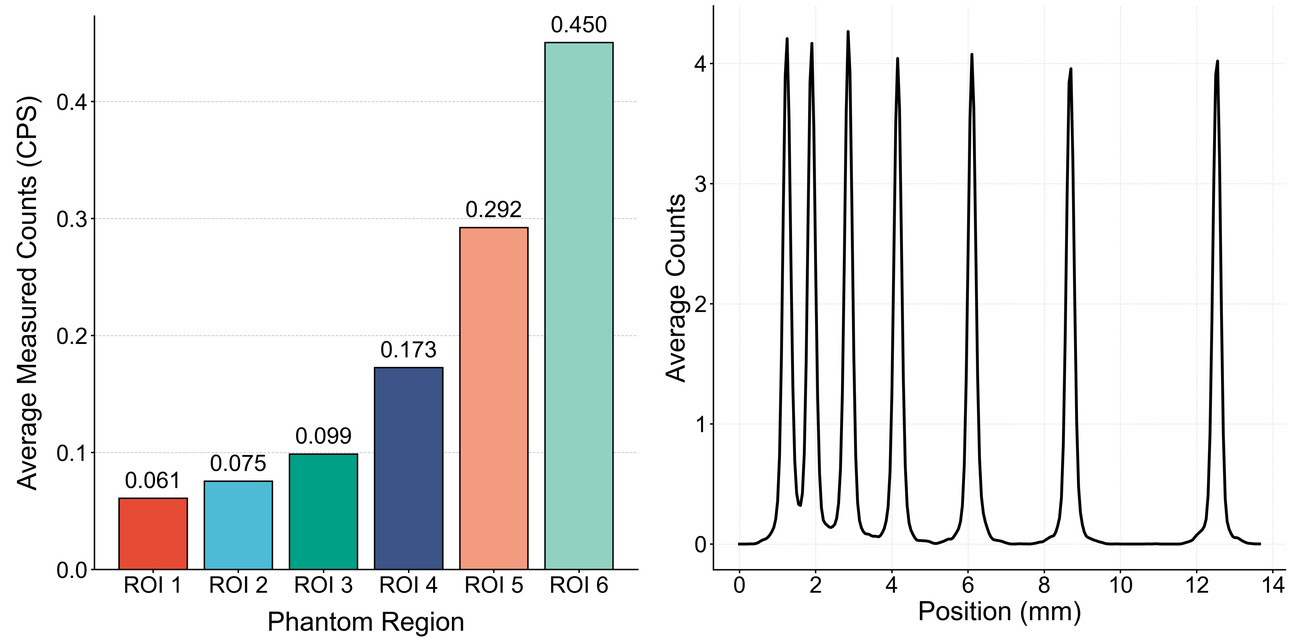

Figure 3. **(Left)** Average measured count rates (CPS) by ROI, showing the expected step-wise increase correlating with deposited spot size. **(Right)** Vertical profile analysis of the line source pattern. The sharp peaks demonstrate an average line thickness (FWHM) of 0.235 ± 0.007 mm.

Table 1. Comparison of traceable known count rates (R_{known}) and measured count rates (R_{meas}) showcasing high agreement validating the accuracy of the activity quantification

Source	R_{meas} (CPS)	R_{known} (CPS)	% Difference	Absolute Difference
Derenzo	5.265	5.288	0.4%	0.023
50 Drop Lines	0.552	0.555	0.5%	0.003

Acknowledgements

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