Collimator Design for Hybrid Gamma Imaging Devices

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Introduction

Gamma imaging collimators are crucial instruments in nuclear medicine and radiology, enabling precise control over emitted gamma rays' directionality and focus. They are renowned for their ability to yield improved resolution images, fundamental for accurate diagnostics and the study of physiological processes. However, the evolving landscape of medical imaging is increasingly embracing hybrid techniques, seamlessly integrating multiple modalities. Our group has been working on such an intraoperative device, SAIGC-Torch, that incorporates hybrid imaging [1]. In this paradigm, the primary challenge encountered pertained to achieving precise Field of View alignment between the two distinct imaging systems. Mismatched fields of view mainly results in loss of data. To address these issues, this article introduces an innovative compact gamma imaging collimator made of tungsten specifically designed for our detector module that houses 8x8 pixelated crystal of size 50 mm x 50 mm and its integration into hybrid imaging systems [2].

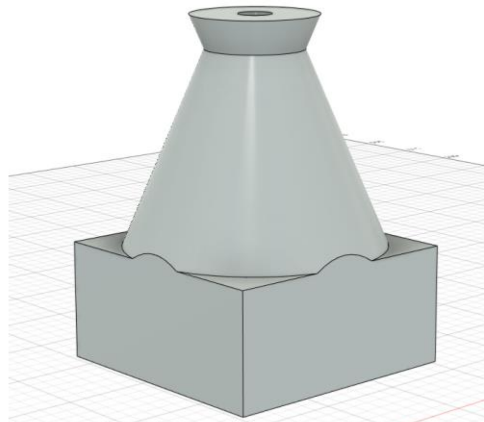

Fig. 1 Isometric view of the collimator

Design and Geometry

Pinhole collimators often provides a superior resolution-sensitivity tradeoff for radionuclide imaging compared to SPECT with parallel-hole collimator. The collimator is designed to have a half-angle of 23 degrees to maximize the effective detecting area of the detector of size 50 mm x 50 mm and to have a minimum working distance of 6 mm from the collimator to match the field of views of other imaging modalities. The aperture diameter is 1.5 mm. Its unibody structure ensures complete shielding for the detector module from the most probable operating directions.

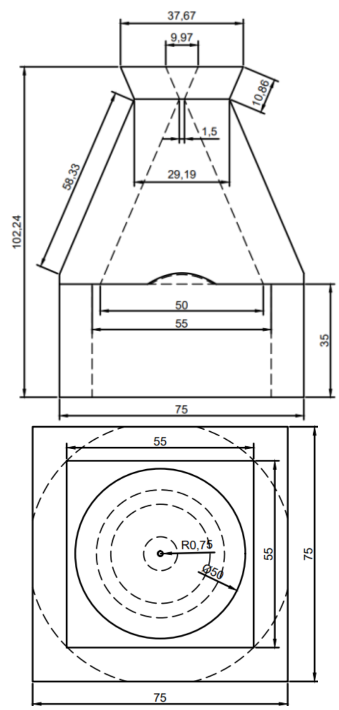

Fig. 2 (Above) Side View of the collimator (Below) Bottom view of the collimator.

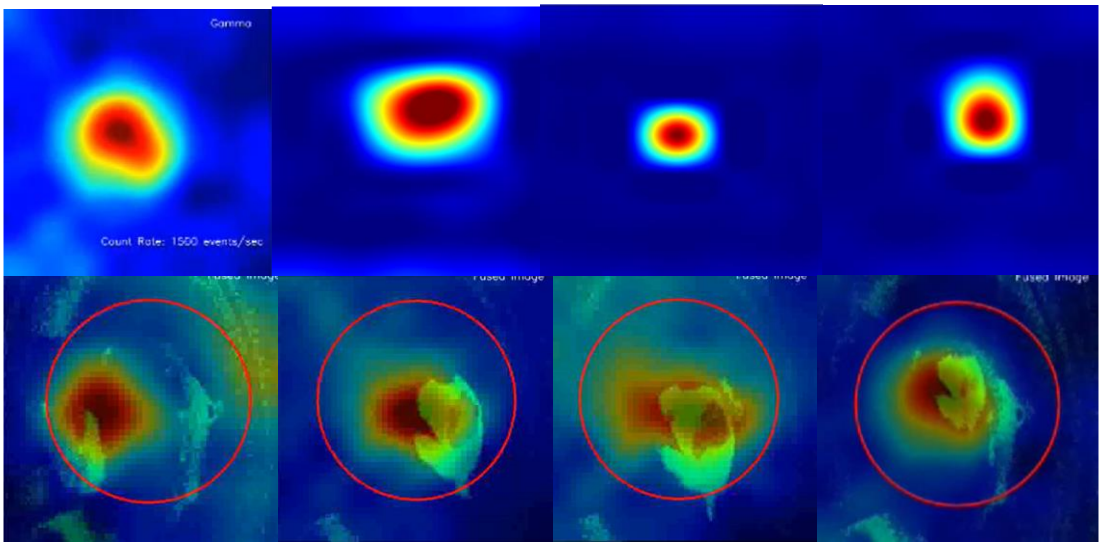

Fig. 3 (Top row) Gamma Images of a radionuclide I^{131} and Tc^{99m}; (Bottom row) Fused Images of Radionuclide with fluorophore.

Performance Characteristics

The design parameters that govern the pinhole collimator include the factors like spatial resolution R_{coll}, and efficiency, g. For pinhole collimators, these are given by the equations (1) and (2).

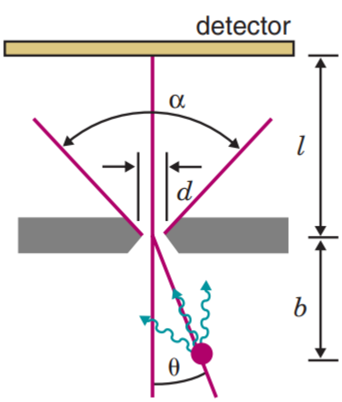

Fig. 3 Generic Pinhole collimator with the parameters labelled

$$R_{\text{coll}} \sim d_{eff,\text{R}}(l+b)/l \qquad (1)$$

The Spatial Resolution is found to be 6.2 mm at a working distance of 8 mm from the collimator.

Observations and Results

The collimator is mounted on the 8x8 pixelated scintillator crystal and the detector module. Additionally, the FOV matching is done by mounting the Near Infrared sensitive CMOS camera in front of the collimator. Since the FOV of both the IR camera and the collimator are same, no additional processing is carried out for the IR frames.

For hybrid imaging purposes, an IR camera is integrated along with the Gamma imaging module. A phantom containing the radionuclide I^{131} and a fluorophore was used for imaging purposes. The results are shown in ***Fig. 3***.

Acknowledgements

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References

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[2] M. Ravi and S. S. S. Sanagapati, "A Practical Design and Implementation of a Low-Cost platform for Real-Time Diagnostic Imaging," in IEEE Access, vol. 5, pp. 24952-24958, 2017