

DOI-based directional radiation monitoring system: Experimental verification of Septa for improving DOI estimation accuracy

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Rapid identification of radionuclide type and source location is essential for radiation accident response; however, conventional monitoring systems often suffer from a limited field of view and reduced capability for real-time monitoring of multiple sources [1]. A depth-of-interaction (DOI)-based directional radiation monitoring system was developed to provide real-time radionuclide identification and source localization over a 360° field of view. The system consists of a single cylindrical scintillator, dual-ended photomultiplier tubes (PMTs), and an eight-slot collimator that surrounds the scintillator. Each slot is configured to face a distinct direction as a function of axial height. Gamma rays incident from a given source direction preferentially interact at a specific height in the scintillator, and the interaction height is determined using a dual-ended DOI estimation method. Event data are then classified by interaction height, and source localization is performed by constructing slot-specific spectra and distribution images corresponding to the eight slots [2].

The fabricated system achieved an angular resolution of 48° and a sensitivity of 4.87 cps/MBq. A DOI resolution of 9.83 mm enables discretization of the interaction depth into eight DOI layers. Interactions occurring near the boundaries between DOI layers can introduce DOI-ratio estimation errors, which may cause misclassification into adjacent DOI regions and lead to increased counts in source-absent directions.

This study proposes adding septa between neighboring slots to improve DOI estimation accuracy and experimentally verify performance improvement. The septa are intended to shield gamma rays entering near slot boundaries and suppress misclassification into adjacent DOI regions. Two collimators were fabricated: a baseline multi-slot collimator and a modified collimator with 4 mm thick septa. Comparative measurements will be performed under the same scenario, followed by reconstruction into slot-specific spectra and distribution images to quantify count reduction in source-absent regions. Septa application is expected to reduce adjacent-DOI misclassification and improve the reliability of directional monitoring. In addition, the system can enhance operational utility for field response by providing real-time location and radionuclide information for multiple sources over a 360° field of view.

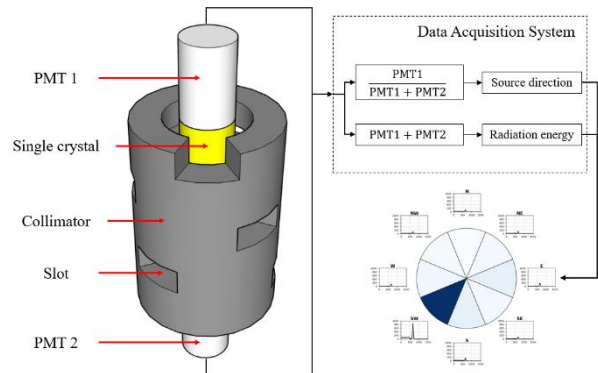


Figure 1. Configuration of DOI-based directional radiation monitoring system

1. L. Marques, A. Vale, and P. Vaz, "State-of-the-Art Mobile Radiation Detection Systems for Different Scenarios," *Sensors*, 21, 1051 (2021).
2. Y.S. Chung, M.K. Baek, S. Lee, J. Kang, and Y.H. Chung, "A novel directional radiation monitoring system for real-time nuclide identification and source localization using DOI method," *Nuclear Engineering and Technology*, 57, 103710 (2025).

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