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Energy-Sensitive Photon and Neutron Bimodal Imaging System: Design and Performance Validation

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Conventional photon and neutron bimodal imaging systems suffer from inherent limitations such as different imaging beam geometry, leading to challenges in direct fusion of transmission image and system complexity. While the single-source-single-detector configuration based on a compact electron linear accelerator proposed by Tsinghua University addresses imaging beam geometry issue, it remains susceptible to beam-hardening effects that correlate material properties with sample mass-thickness, thereby compromising material identification accuracy. To resolve this problem, this study introduces a quasi-monoenergetic bimodal imaging system utilizing a gamma converter and an event-based detector instead of frame-based detector. The gamma converter ensures monoenergetic photon generation, while Time-of-Flight (TOF) spectrum filtering via the event-based detector achieves quasi-monoenergetic neutron imaging. This paper elaborates on three critical aspects of the system design: energy-sensitive target station optimization, event-based imaging detector configuration, and energy-resolved bimodal reconstruction methods. Experimental results on pure elemental material demonstrate that the proposed system effectively corrects beam-hardening effects, significantly enhancing the reliability of material identification. The performance highlights the system's potential to establish a robust framework for optimizing the accuracy of bimodal material discrimination.

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