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Regional analysis of neutron/gamma figure-of-merit in scintillator volumes using a multi-anode photomultiplier tube

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Accurate neutron detection can be important for nuclear forensics, safeguards, and nuclear security applications. Organic scintillation detectors are used widely due to their resilience, rapid timing characteristics, and their dual sensitivity to both gamma and fast neutron events. Pulse-shape discrimination (PSD) is often used to separate gamma and neutron events as part of the analysis of data obtained with these systems, but challenges can arise at lower energies approaching 500 keV where the gamma and fast neutron plumes tend to overlap. The associated figure-of-merit (FoM) quantifies the separation possible by dividing the distance between the neutron and gamma event plumes by the sum of their respective widths but this parameter is prone to artificial augmentation via energy cut-offs, which can exclude the low-energy overlap zone somewhat selectively, inherently reducing the overall detection efficiency. Moreover, FoM is only representative of the specific field within which it was measured: for example, high-energy fields such as that derived from americium-beryllium sources often yield a degree of separation that is superior to that achievable with californium-252, highlighting that the neutron/gamma discrimination performance may not be directly transferable to realistic neutron fields encountered in nuclear safeguarding or SNM monitoring scenarios. This study reports on a novel approach to the assessment and improvement of FoM via simultaneous location and analysis of event pulses within a continuous scintillator by employing a 16 × 16 multi-anode photomultiplier tube (MAPMT). Real-time measurement of centre-of-interaction coordinates showing anisotropy in full-volume event data is demonstrated that enables a regional quantification of FoM across a scintillator volume. This allows for the selection or rejection of events based on pulse quality metrics, eliminating the need for arbitrary and rigid energy thresholds. On this basis it is anticipated that FoM might instead be optimised in-field according to situational needs, allowing more accurate measurements across the full spectrum capabilities of the detector and amplifying the efficacy of established nuclear safeguarding and SNM forensic monitoring methods.

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