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Measurement of angular correlations in gamma-gamma cascades using coincidence detection and Monte Carlo simulation

Coincidence counting techniques are widely used to determine correlated γ-ray emissions from nuclear decays. Measured singles and coincidence rates share common factors - i.e. absolute efficiency - that can be divided out in analysis. However, standard formulations often assume perfect isotropic correlation between emitted quanta, neglecting possible decay chain losses, and ignore angular correlations. In this work, we use coincidence-based absolute activity measurements to show that the angular correlation function, $W(\theta)$, modulates the detection probability of cascade pairs. Using 60Co and 22Na as benchmark sources with differing cascade and correlation properties, we demonstrate that the true coincidence rate reflects detector efficiencies and angular correlations, which can be extracted from the observed measurands.
A custom FLUKA Monte Carlo source routine was developed to implement angular distributions in $\gamma - \gamma$ correlations to support these observations. A Python proof-of-concept generated the normalised cumulative distribution functions of $W(\theta)$, which were incorporated into FLUKA for multi-detector simulations. The Monte Carlo results successfully reproduce the experimentally observed angular modulation, confirming that coincidence counting combined with a tailored simulation framework can probe angular correlations.
Our approach forms the groundwork for future studies of more complex decay schemes with non-trivial cascade probabilities and for developing multi-detector techniques for angular-correlation metrology.

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