

Helium-4-based scintillation detector technology is emerging as a strong alternative to pulse-shape discrimination-capable organic scintillators for fast neutron detection and spectroscopy, particularly in extreme gamma-ray environments. ^4He is intrinsically insensitive to gamma radiation, as it has a low cross-section for gamma-ray interactions, and the stopping power of electrons is low compared to that of ^4He recoil nuclei. Consequently, gamma rays can be discriminated in these detectors by energy deposition thresholding rather than pulse shape analysis. While ^4He is promising as a scintillation medium, its energy resolution has not yet been well-characterized over a broad range of energy depositions such that the response of these detectors to known source spectra cannot be fully simulated. In this work, an experiment was performed to characterize the response of an Arktis S670 ^4He detector to ^4He nuclear recoils up to 9 MeV. The ^4He detector was positioned in the center of a semicircular array of organic scintillation detectors at various angles such that when the ^4He detector is operated in coincidence with any one of the organic scintillators, the events recorded by the ^4He detector correspond to a specific neutron scattering angle. This leads to a consistent nuclear recoil energy if a monoenergetic neutron source is used. Deuterium-deuterium and deuterium-tritium neutron generators at Sandia National Laboratories produced monoenergetic neutrons of 2.45 and 14.1 MeV, respectively, which yielded nuclear recoils ranging from 0.102 to 8.90 MeV upon collision with ^4He nuclei. The measured spectral responses to these monoenergetic recoil energies were used to quantify the energy resolution of the ^4He detector so that the detector can be simulated with sufficient fidelity in Monte Carlo frameworks such as Geant4 and MCNP. The simulation will allow a better understanding of the signatures observable with ^4He detectors when used in diverse applications, including nuclear security, safeguards, and arms control.