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塑料闪烁体反应堆中微子探测器

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Nuclear reactor safeguard, based on detection of electron antineutrino flux and energy spectrum, is of great interests to both administrative agencies such as International Atomic Energy Agency (IAEA) and neutrino community. A dominant reaction channel of such detection is inverse beta decay (IBD), for which discrimination of gamma against neutron is critical. In this study, pulse shape discrimination (PSD) is used over plastic scintillator, for its ease of detector assembly, no risk of leakage, and high chemical stability. Using 22Na and 137Cs radioactive sources to calibrate the energy response of the whole system (data acquisition and materials), EJ200 and EJ426 scintillator combination is used as the discrimination setup. The figure of merit (FOM) can reach 9.13 ± 0.01, and could be adopted to build a reactor neutrino safeguard detector. In addition, the PSD of two kinds of plastic scintillators were compared. The FOM of the EJ276 plastic scintillator can reach 1.35 ± 0.01 at the energy threshold of 1 MeV gamma equivalent in comparison to 0.96 ± 0.01 of UPS-113NG at the same energy threshold.

Summary

In this study, a detector system composed of EJ200 and EJ426 plastic scintillators coupled with an XP3232 PMT was tested for thermal neutron and gamma discrimination. Gamma sources were used to perform energy calibration by fitting the Compton edges. The FOM value was calculated to be 6.61 ± 0.01 in the whole range of channels. Compared with the EJ276 or UPS-113NG plastic scintillator systems with fast neutron and gamma discriminating capability, the former has better discrimination power. Under the threshold of 1 MeV, the FOM of the EJ276 was 1.35 ± 0.01, and the UPS-113NG was 0.96 ± 0.01. Although the PSD power of EJ276 and UPS-113NG scintillator systems are weaker than that of EJ200 and EJ426 coupled, they have the advantage of compactness and less light loss. Therefore, all of them could be viable candidates for small safeguard detectors.

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