Neutron Background Measurements at Kuo-Sheng Reactor Neutrino Laboratory with Neutron Detector

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Introduction

Taiwan EXperiment On NeutrinO (TEXONO) Collaboration is pursuing experimental investigation of neutrino physics, WIMP dark matter search and other physics searches beyond the standard model at the Kuo-Sheng Reactor Neutrino Laboratory (KSNL)[1]. In this article we will report on the measurement of the fast and thermal neutron backgrounds at the KSNL under the identical shielding configuration used in various physics data taknig [1, 2]. The Hybrid Neutron Detector (HND) is a novel detector concept and was custom-built for this study consists of Bicron BC501A, which is sensitive for fast neutrons and BC702 organic scintillator detector, which is sensitive to thermal neutrons [3].

Hybrid Neutron Detector

A schematic drawing of the HND is shown in Fig. 1. The HND was installed at the same location as the various HPGe detectors inside the well of an NaI(Tl) anti-Compton detector and kept under the same shielding configurations and data-taking conditions as depicted in Fig. 3 of Ref. [2]. Therefore the measured ambient neutron flux is same as for the HPGe detectors [1]. Different particles produce different pulse shapes with the HND [3]. The normalized reference pulses of α, n_{fast}, $n_{thermal}$ and γ are shown in Fig. 2 [2]. In Ref. [3], two independent PSD techniques were developed, after standard filtering of events due to electronic noise and other spurious non-physical triggers, the physical events are identified as γ, n_{fast}, and $n_{thermal}$ from the reference pulse shape information as in Fig. 3 [2].

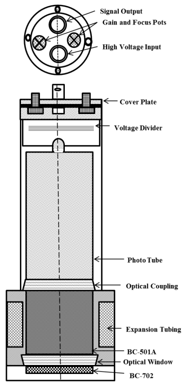

FIG. 1: Schematic diagram of the HND

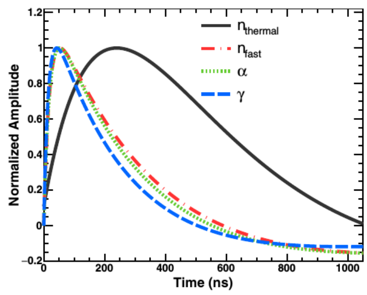

FIG. 2: Reference pulse shapes for α, n_{fast}, $n_{thermal}$ and γ [3].

Results and discussion

To determine the ambient neutron background it is essential to measure the intrinsic radiopurity of the HND. Nuclear α decays

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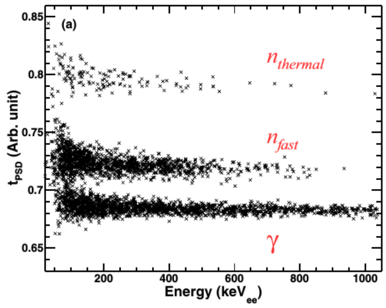

FIG. 3: Energy Distribution of the PSD variable [2].

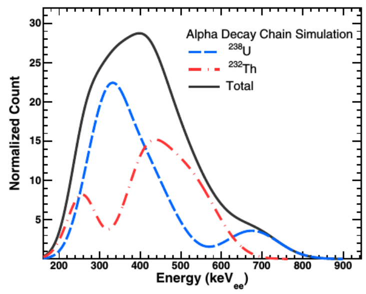

FIG. 4: Simulated -energy spectra of ^{232}Th and ^{238}U decay chains including detector resolution and quenching effects [3].

from the ^{238}U and ^{232}Th series can mimic neutron-induced nuclear recoil signatures and hence it is important to determine their contributions [2]. The PSD characteristics of events as well as the unique time correlations of two decay sequences (DS) provide powerful means to measure contamination of the ^{238}U and ^{232}Th series well described in Ref. [2]. The simulated α-energy spectra of the ^{238}U and ^{232}Th series, convoluted with detector resolution and quenching effects, are shown in Fig. 4 [2].

The complete neutron background spectrum at the KSNL is displayed in Fig. 5. The capture rates of ^{70}Ge(n, 3n)^{68}Ge and ^{70}Ge(n, γ)^{71}Ge due to the thermal, epithermal and fast neutron components evaluated by full GEANT simulations [2] are listed in Table II of Ref. [2], the sum of which is in

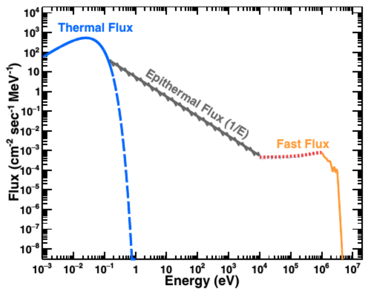

FIG. 5: Neutron spectrum model at the target region of the KSNL. The total thermal and fast neutron components are based on measurements and analysis reported in this article. The epithermal component is from interpolation [3].

excellent agreement with the measured rates. The derived neutron spectrum provides excellent agreement with the cosmic-ray neutron-induced Ge-recoil spectra and thereby providing strong support to the validity of the results as well as the experimental approaches and analysis procedures [2]. Therefore HND detector are useful to characterizing neutron background in other rare-event search experiments, in both surface as well as underground laboratories [2].

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