Development of a high resolution neutron detector HIME

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A high-granularity neutron detector array HIME is newly designed for multiple-neutron detection with good timing and position resolution as well as high efficiency. The high granularity enables us to perform the tracking of recoiled protons produced by (n, p) elastic scattering and knockout reactions such as $^{12}C(n, np)$, cleanly eliminating neutron crosstalk background by using the kinematics and causality of (n, p) elastic scattering. In this report, we show the result of a commissioning experiment aiming at the establishment of a proton tracking method and the evaluation for two-neutron detection with a very low decay energy by simulation.

Figure 1 shows a schematic view of HIME, composed of 48 bars of plastic scintillator modules, each of which has a size of 2 cm(T)×4 cm(V)×100 cm(H). HIME has five layers, and three pieces of thin plastic scintillator modules are equipped to veto charged-particle backgrounds.

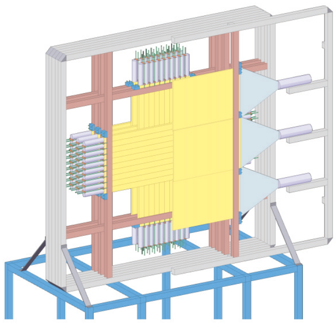

Fig. 1. Schematic view of HIME. Each module of HIME is coupled to two phototubes at both ends to obtain the light-output and timing information. A half of VETO modules is drawn.[1)]

The commissioning experiment was carried out as a parasitic run of SAMURAI 20, 27, and 36. Details are described in Ref. 2). Figure 2 shows examples of tracks obtained by the recoil proton tracking analysis. We could successfully establish a proton tracking technique for the first time.

The performance of the proton tracking analysis for eliminating neutron crosstalk background was evaluated by GEANT4 simulation for two-neutron detection in the decay of ^{26}O into $^{24}O + 2n$ ($E_{rel} = 18$ keV[3)]). This is one of the most difficult cases because the two neutrons are emitted in a small angle. Figure 3 shows the relative energy spectrum after eliminating neutron crosstalk background by a conventional method described in Ref. 4) (blue) and by the proton tracking analysis (red). The proton tracking method yields a detection efficiency that is 1.5 times higher than that with the conventional method. The simulated relative energy resolution is 30 keV (FWHM), which is much better than that in a previous experiment (ΔE_{rel} = 110 keV[3)]). These results show that the proton tracking analysis of HIME is a powerful method for two-neutron detection, and the proton tracking method can be applied to the detection of more than two neutrons in the future.

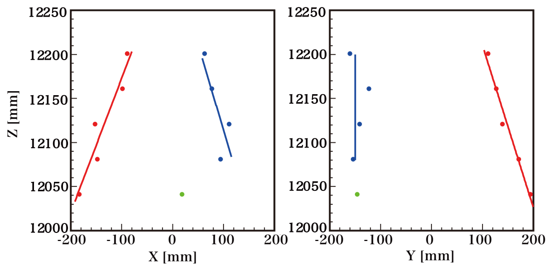

Fig. 2. Examples of recoil proton tracks in which two tracks by two neutrons are observed. The beam is along the Z direction, and X and Y correspond to the hit position in the horizontal and vertical directions, respectively. Each dot corresponds to a hit position. The red and blues dots show each track. The green dot is a hit regarded as background.

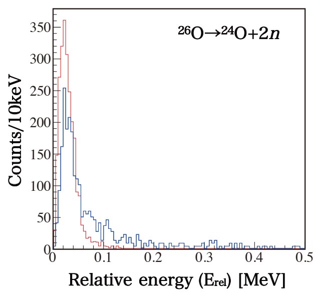

Fig. 3. Relative energy spectrum of ^{26}O. The high-energy tail in the blue histogram originates from the remaining crosstalk, which is not removed by conventional crosstalk analysis.

References

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