Beta-delayed neutron measurement with new detector NiGIRI

V.H. Phong,[*1,*2] S. Nishimura,[*1] J. Liu,[*3] T. Lokotko,[*3] Z. Li,[*4] and J. Lee[*3]

A new scintillation detector system NiGIRI[1)] (Neutron, ion and gamma ray identification for Radioactive Isotope beam) is under development to measure the energies of neutrons for decay and reaction studies using the time-of-flight technique[2)]. The design of the NiGIRI detector is based on a novel plastic scintillation material EJ-299-33, which has a superior pulse shape discrimination (PSD) capability[3)]. Each scintillator bar (30x55x127 mm^3) is coupled by two PMTs (Hamamatsu H11265-200 and R8520-20-12) allowing to locate the interaction position along the scintillator bar from the time difference between two PMT signals.

A feasibility study of the NiGIRI has been conducted in conjunction with the newly developed plastic scintillator strip detector (MaCi) coupled with the multianode PMT (Hamamatsu H8500B) as a start detector. An array of 26 NiGIRI detectors were arranged in a half-barrel configuration surrounding the start detector and attached into the EURICA support frame with a flight path of approximately 50 cm. The waveform output from each detector was recorded by four flash ADC modules (CAEN V1730B) with a sampling rate of 2 ns synchronized with the RIBF DAQ and EURICA DAQ by sharing the clock with LUPO modules. A customized DAQ for the flash ADC with the capability of processing high data throughput has been developed.

Offline digital pulse processing was performed to extract useful information such as timing and pulse height to reconstruct the implantation and decay position in the start detector as well as time-of-flight between the start detector and NiGIRI detectors in the sub-nano second resolution. By applying a charge integration method with the optimized parameters, a clear separation between neutrons and gamma rays was obtained as shown in Fig. 1 while the time-of-fight was obtained by using the pulse fitting method.

The test experiment has been carried out in the parasitic mode with the SEASTAR campaign. Figure 1 shows the experimental setup. The RI beam after reaction target at F8 focal plane and the Zero Degree Spectrometer (ZDS) tuned for selecting isotopes around ^{95}Kr was implanted into the MaCi detector at the F11 focal plane while beta delayed neutrons and gamma rays were measured by the NiGIRI and the EURICA array.

Figure 2 shows the time-of-flight spectrum combining all NiGIRI detectors with the decay curve reconstructed in the MaCi detector for the beta-correlated gamma and neutron events identified with NiGIRI detectors. The delayed neutron events were selected by gating on a 200 ms window after the RI implantation in MaCi. Possible high energy neutrons have been detected from this spectrum.

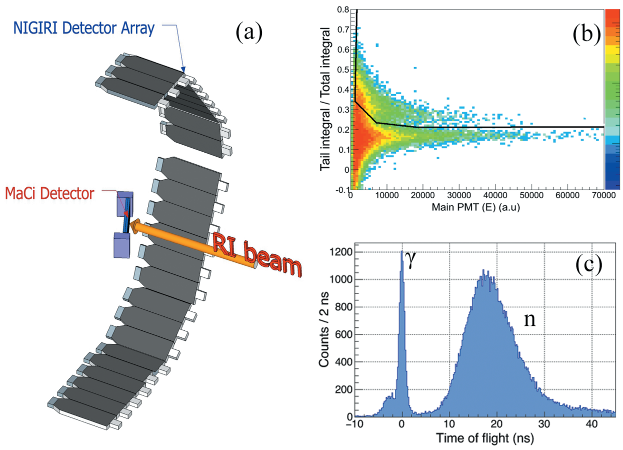

Fig.1. A schematic view of the experimental setup employing the NiGIRI and MaCi detectors (a). ^{252}Cf source test: PSD versus total integral. PSD cut (black lines) has been applied to select neutron events (b). The time-of-flight spectrum from all NiGIRI detectors after applying PSD cut (c) (small tail prior to gamma ray peak appeared due to backscattering).

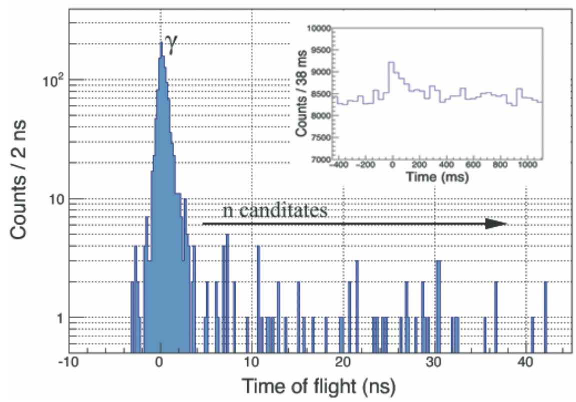

Fig.2. Combined neutron time-of-flight spectrum associated with the implantation of the RI beam in the MaCi detector. The inserted figure shows the time correlation between decay events and implantation events from the MaCi detector.

Further analysis with the available spectroscopic information of delayed gamma rays from EURICA is undergoing. The result from this test experiment is expected to provide useful information for the upcoming BRIKEN project to measure the beta-delayed neutron emission probability.

*1 RIKEN Nishina Center
*2 Faculty of Physics, VNU University of Science, Hanoi.
*3 Department of Physics, The University of Hong Kong
*4 School of Physics, Peking University

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