Development of an active deuteron target capable of neutron-gamma discrimination

M. Sasano,[a] A. Tamii,[b] Y. Maeda,[a] H. Suzuki,[a] and H. Sakai[a]

[a] *Department of Physics, University of Tokyo, Hongo, Tokyo 113-0033, Japan*
[b] *Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan*

Three-nucleon force (3NF) at intermidiate energies has been studied mainly from comparison between experiments in $p+d$ reactions and theoretical calculations in $n+d$ reactions. However, Coulomb force has substantial effects on differential cross sections [1]. Since precise treatment of the Coulomb interaction is not available in the theoritical calculations, we measured the angular distribution of the differential cross sections and analyzing powers for the $n+d$ scattering at 250 MeV to reveal the 3NF effect in Coulomb free system. The $n+d$ measurements at a forward angular region of $\theta_{\rm cm}$=10°–60° were performed at the neutron time-of-flight facility at RCNP [2]. The neutron beam produced by the ^{7}Li(p,n)^{7}Be(0°) reaction bombarded the deuteron target located 2 m downstream of the primary target. The scattered neutrons were detected by NPOL2 [3]. Although many collimators and blockers were used in the facility, there were a large number of background events such as the neutrons directly hit NPOL2. Therefore, we developed an active target.

The active target is made of deuterated liquid scintillator BC537. The schematic view of the target is shown in Fig. 1. The liquid scintillator is filled in a container with a window of Pylex glass. The container has a cylindrical shape with an inner diameter of 90 mm and a length of 60 mm. The container is made of 1 mm^t alumite and its inside is coated with fluorescent paint. A reservoir tube is connected to the container to keep the pressure constant even if the temperature varies. The glass window is attached to a photomultiplier tube (PMT) through a light guide. To prevent decrease of the gain on the condition of high counting rate, we have installed a booster circuit into the PMT. A charged particle veto scintillator was placed about 50 mm upstream from the active target. By selecting coincidence events of the active target and NPOL2, we could greatly reduce the backgroud events (See Fig. 2).

However, there were still background events in the active target due to gamma rays from the Faraday cup and the ^{7}Li target. To distinguish neutron events from gamma-ray events, we applied the pulse-shape-discrimination (PSD) method [4]. This method is based on the property of BC537 that the slow decay component of light pulse relative to the fast component is larger for neutron than gamma ray. To observe this difference of pulse shape, we put two ADC gates. One rises 8 nsec earlier than the light pulse and has a width of 100 nsec, containing the peak (peak ADC). The other rises 93 nsec later than the light pulse with a width of 350 nsec, corresponding to the tail compornent (tail ADC).

Figure 2 shows the correlation between the peak ADC and the tail ADC in the measurement at $\theta_{\rm lab}$=13° with a beam intensity of 50 nA and the ^{7}Li target with a thickness of 590 mg/cm^2. The counting rate of the active target was 250 kHz and that of the charged particle veto counter was 460 kHz. Neutron events were clearly separated from gamma-ray events. Fig. 3 shows the TOF spectra of single events of NPOL2, coincidence events with the active target, and neutron events selected by the PSD technique. The loss of the true events caused by the present PSD analysis is 88±10 percent. The error of the loss is a statistical error and can be reduced. The S/N ratio has been improved by a factor of 2. The active target was successfully used to obtain a good S/N ratio.

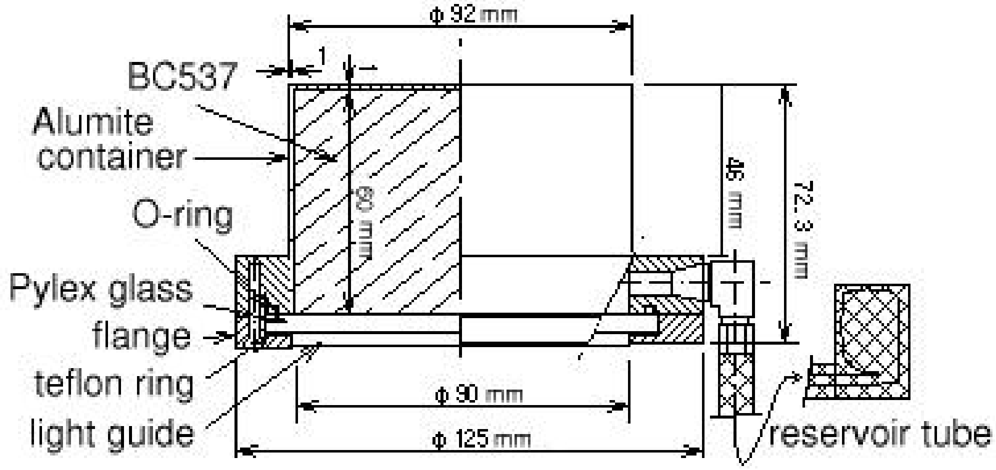

Figure 1: Schematic veiw of the active target.

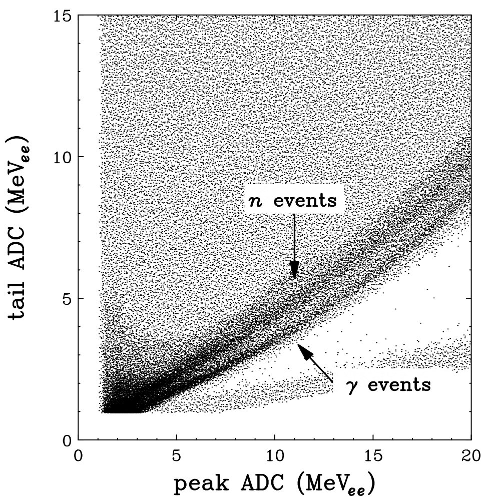

Figure 2: Correlation between peak ADC and tail ADC.

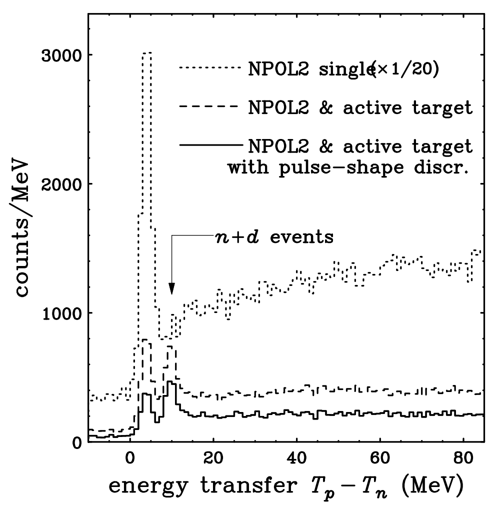

Figure 3: TOF spectra of NPOL2 single events, coincidence events and neutron events.

References

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