Slow neutron detector WINDS for (p,n) reaction in inverse kinematics with SAMURAI

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In April 2014, we performed the SAMURAI17 experiment[1)] at RIKEN RIBF to study Gamow-Teller transition on ^{132}Sn by using (p,n) reaction with the Wide-angle Inverse-kinematics Neutron Detectors for SHARAQ (WINDS)[2)] and the SAMURAI spectrometer.

Figure 1 shows a schematic view of the experimental setup around the target. The secondary beam was transported to a 10 mm thick liquid hydrogen target, which was surrounded by the WINDS to detect recoil neutrons. From the measured neutron time-of-flight (TOF) and recoil angle, the excitation energy and center-of-mass scattering angle are determined.

The WINDS consists of 61 plastic scintillators with sizes of $600 \times 100 \times 30$ mm^3. In this experiment 12 scintillators of the ELENS[3)] with sizes of $1000 \times 45 \times 10$ mm^3 were also installed. The left and right walls with respect to the beam line covered the angular region from 20 to 122 degrees with 5 degree steps. Top and bottom walls covered the angular region from 16 to 74 degrees with 3.5 degree steps. Each detector is placed such that the 30-mm-wide (WINDS) or 10-mm-wide (ELENS) plane is oriented to the target direction and placed at a distance of 900 mm (1200 mm) from the target for left and right (top and bottom) walls.

The charge signal from each PMT is digitized by a CAEN V792 QDC. The timing signal is processed by a leading-edge discriminator (LeCroy 4413) and digitized by CAEN V1190 TDC. In order to maintain a low threshold of neutron detection, the PMT voltage is kept to be as high as possible, typically -2700V and -2500V for H7195 and H7415. The threshold for light output in the scintillator was set to be 70 keV proton energy.

The timing resolution of WINDS bar was estimated by using prompt γ ray from the liquid hydrogen target. The timing reference was taken from the plastic scintillators SBT1,2 whose timing resolution is typically 40 ps in FWHM. The observed peak width of the prompt γ ray was 800 ps in FWHM which is most due to the timing resolution of WINDS. This timing resolution corresponds to energy resolution of $\Delta E/E = 11\%$.

The neutron-detection efficiency depends on the energy of neutrons as well as the threshold on light output. The typical efficiency with a threshold of 60 keV$_{ee}$ was estimated by using the Monte Calro code of MCNP[4)], and it varied from 40% at 0.6 MeV neutron to 20% at 4 MeV neutron. The efficiency calibration was performed by locating a neutron source of ^{252}Cf at the target position with a NE213 liquid scintillator whose absolute efficiency as well as energy and threshold dependence are well known. The data analysis is currently in progress.

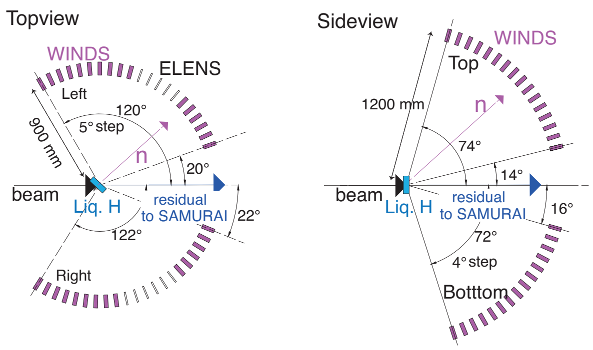

Fig. 1. A schematic view of the WINDS setup.

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References
1) M. Sasano *et al.*,: in this report.
2) K. Yako *et al.*, RIKEN Accel. Prog. Rep **45**, 137 (2012).
3) L. Stuhl *et al.*, Nucl. Instr. Meth. A 736, 1 (2014).
4) Monte Carlo NParticle Transport Code System, MCNP5-1.60 and MCNPX-2.7.0.