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§28. Study on Benchmark Experiment for Backward-Angle Scattering Reaction Cross Section at 14 MeV

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To test nuclear data for fusion reactor, a lot of integral experiments were carried out with DT neutrons so far. Inside experimental assemblies used in such benchmark experiments, neutron scattering reactions are dominantly induced. Especially contribution of forward scattering is much more dominant than backward angle scattering, because the forward scattering reaction cross section is quite large compared to that of backward angle scattering. However, it was reported that in deeper places contribution of the backward angle scattering could increase and affect the final result like dose estimation outside radiation shields.[1)]

We thus started examining how to carry out integral experiments in order to validate large angle scattering cross sections. The objectives of the present study are to design and carry out new integral benchmark experiments with activation foils to see back ward angle contribution. The key point is how to decrease the contribution of forward scattering neutrons to activation as low as possible, in order to emphasize that of backward scattering neutrons. For this purpose, we proposed a new shadow-bar experiment.[2)] The conceptual geometry is shown in Fig. 1. By using this arrangement, neutrons scattering backward in the target plate can enter a detector foil, preventing the DT source neutrons from entering the foil directly.

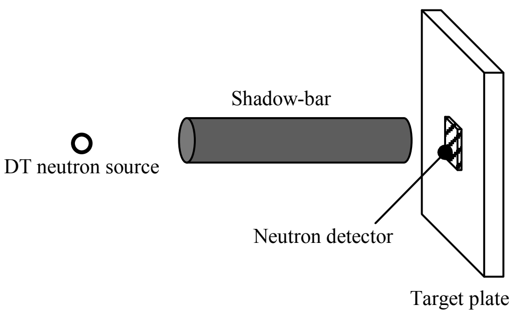

Fig. 1 Conceptual arrangement of experiment.

From preliminary investigation for experimental assembly, basic dimensions of the target plate and shadow-bar were determined. Then MCNP5 calculations were conducted to record the whole neutron tracks and events by PTRAC option to analyze more precisely. Reaction rates of ^{93}Nb(n,2n)^{92m}Nb reaction were also estimated. As a result, it was confirmed that in case of C22.5 configuration in Fig. 2 large-angle scattering could be enhanced most effectively. And as shown in the scattering-angle contribution distribution of tallied neutrons in Fig. 3 the backward peak can shift to the forward direction with increase of the target plate angle θ shown in Fig. 2. By the C22.5 configuration, the ratio of backward scattering neutron contribution to that of forward direction for the niobium sample activation could be improved to be 1:3.

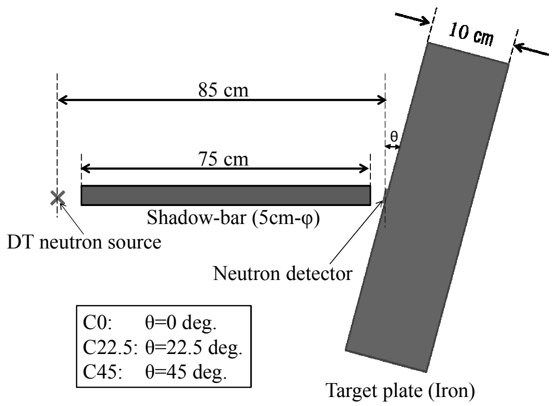

Fig. 2 Centered configuration.

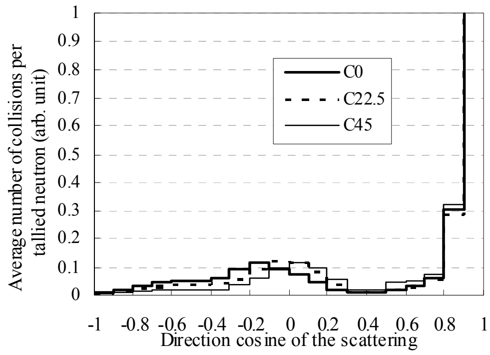

Fig. 3 Scattering-angle contribution distribution.

After the numerical analysis, preliminary experiments were carried out with the configuration in Fig. 2 at the Intense 14 MeV Neutron Source Facility, OKTAVIAN, of Osaka University. According to an analysis carried out in advance, after one-day irradiation, 24-hour measurement could give a result of more than several-hundred counts for gamma-rays emitted from the niobium foil. However, it was actually not possible to complete the measurement accurately, because the S/N ratio was critically deteriorated since the amount of activation was really small. We are now planning to perform new experiments, in which the accuracy of measurement would be suppressed within several % by improved experiments in the next fiscal year.

1) S. Ohnishi, K. Kondo, T. Azuma, S. Sato, K. Ochiai, K. Takakura, I. Murata, C. Konno, “New integral experiments for large angle scattering cross section data benchmarking with DT neutron beam at JAEA/FNS,” *Fusion Engineering and Design*, **87** (2012) 695-699.
2) S. Ohnishi, I. Murata, “Design of A New Integral Benchmark Experiment for Large Angle Scattering Using Shadow Bar and DT Neutron Source, “ Progress in Nucl. Sci. and Technol. (2014). in press