Measurement of neutron production from 7 MeV/nucleon α incidence on a Bi target

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RIKEN has a plan of installing a new beam line for producing ^{211}At by α particle incidence on a ^{209}Bi target. It is assumed that an α beam should have an energy of 7.16 MeV/nucleon to reduce undesired byproducts. Validation of Monte Carlo simulation codes on radiation shielding is required for the design of a beam line. The neutron energy spectrum of the ^{209}Bi$(\alpha, 2n)^{211}$At reaction has not been measured. Experimental data of double-differential neutron thick target yields (TTY) are desired as a neutron source term in the radiation shielding design. We measured the neutron energy spectra by the time-of-flight (TOF) method.

The experiment was carried out at the E7B course of AVF cyclotron. The experimental arrangement is illustrated in Fig. 1.

The 7.16 MeV/nucleon α beam irradiated a ^{209}Bi target. The repetition rate of the beam was about 16 MHz. The integrated beam current was obtained from the counts of a neutron survey meter set near the target chamber. The thickness of the target was 2 mm, which was longer than the range of the α particle.

Neutrons from the target were measured with EJ301 liquid organic scintillators that were 2 inch in diameter and thickness. A 2 mm thick plastic scintillator was set as a veto detector. The neutron kinetic energy was determined by the TOF method in which the start and stop signals came from the neutron scintillator and the RF signal of the AVF cyclotron, respectively. The flight path lengths from the target to the detectors were from 1 to 1.2 m as shown in Fig. 1. The background neutrons were estimated from the measurement data with an iron shadow bar of 60 cm thickness between the target and each neutron detector.

Figure 2 shows the TOF spectrum at 0°. The horizontal axis represents the time difference between the RF signal and the neutron detector. The TDC resolution was about 0.012 ns/ch. The peak at 3650 ch was the prompt γ-ray from the α incident reactions. Low-energy neutrons from the preceding beam bunch were overlapped in the TOF spectrum. These events were excluded because their small signals were lower than the threshold level of the electronics. The neutron events were extracted by using the difference in the decay part of the signal between neutrons and γ-rays.[1)]

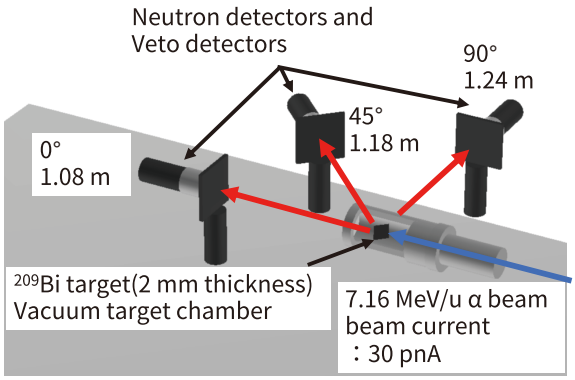

Fig. 1. Experimental arrangement.

The measured neutron TTY and the calculation results by INCL[2)] and JQMD[3)] models in PHITS[4)] code are shown in Fig. 3. The results of INCL show better agreement with the experimental results than those of JQMD.

The measured data will be applied to the shielding design of the new beam line.

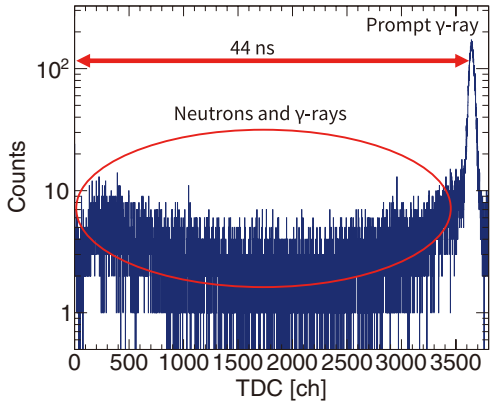

Fig. 2. TOF spectrum at 0°.

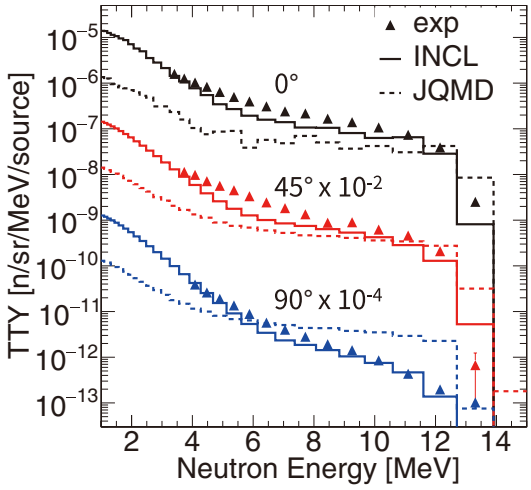

Fig. 3. Neutron TTY and the calculation results by INCL and JQMD implemented in PHITS.

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References

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