Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

Monte Carlo Simulation of the Time-Of-Flight Technique for the Measurement of Neutron Cross-section in the Pohang Neutron Facility

So Hyun AN[a*], Young Seok LEE[b], Young-Ouk LEE[a], Cheol Woo LEE[a]

[*a]*Nuclear Data Evaluation Lab. Korea Atomic Energy Research Institute,*
105 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea, sohyun2@kaeri.re.kr
[b]*Materials Research Team, R&D Division, National Fusion Research Institute, Daejeon, 305-333, Korea*

1. Introduction

It is essential that neutron cross sections are measured precisely for many areas of research and technique. In Korea, these experiments have been performed in the Pohang Neutron Facility (PNF) with the pulsed neutron facility based on the 100 MeV electron linear accelerator [1]. In PNF, the neutron energy spectra have been measured for different water levels inside the moderator and compared with the results of the MCNPX calculation. The optimum size of the water moderator has been determined on the base of these results. In this study, Monte Carlo simulations for the TOF technique were performed and neutron spectra of neutrons were calculated to predict the measurements.

2. Simulations

2.1 Methods

Pulsed neutrons based on an electron linear accelerator are used to measure the energy dependent cross-sections with high resolution by TOF technique. Pulsed neutrons are generated in PNF with the help of the 100 MeV electron linear accelerator and the tantalum target system [2]. Figure 1 gives the configuration of the Ta-target system.

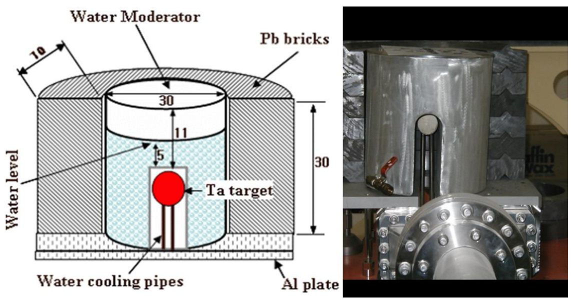

Figure 1. Ta-target system

The system is composed of ten sheets of Ta plates, and there is a 0.15 cm water gap between them in order to cool the target effectively. The housing of the target is made of 0.5 mm thick titanium. The moderator vessel is filled with water for obtaining thermal neutrons for cross section measurement. A model of the 600 cm long flight path was added to the target model. The MCNPX model used in this study is shown in figure 2.

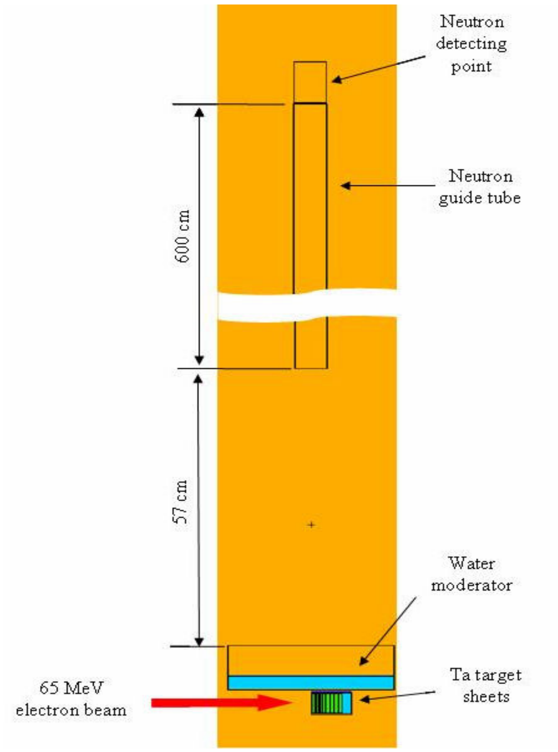

Figure 2. Geometrical model for the target system and neutron guide tube used in the MCNPX simulation

In the PNF, photoneutrons are produced in the Ta-target by (γ,n) and (γ,x) reactions induced by bremsstrahlung with a 65 MeV electron beam. To obtain the neutron spectra and the resolution function, point detector tally (F5) was used with tally time card (Tn) at the end of neutron guide tube.

2.2 Neutron flux distributions

The simulated neutron yield per kW beam power for the electron energy 65 MeV was calculated about 1.912 $\times 10^{12}$ n/s. In other words, only 2 neutrons are produced in the target for 100 electrons incident on the target. Because of these low-probability events, point detector tally was considered to gain a neutron flux at a distance of 700 cm from the Ta-target. Figure 3 compares neutron spectra at surfaces of the Ta-target and the water moderator. These peaked at 1 MeV and drop by two and one order of magnitude at 1 eV, respectively. For the moderated spectrum, a peak was suppressed by more than one order of magnitude at the Ta-target while the number of thermal neutrons was increased.

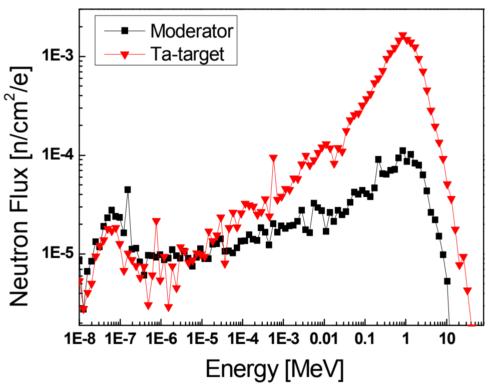

Figure 3. The neutron spectra at surfaces of the Ta-target and the water moderator

Figure 4 gives a neutron spectrum at the end of 90° TOF path. The shape of this angle corresponded to the moderated spectrum. The maximum flux was 1 $\times$ 10^{-10} $n/cm^2/e$ at the energy of 1 MeV.

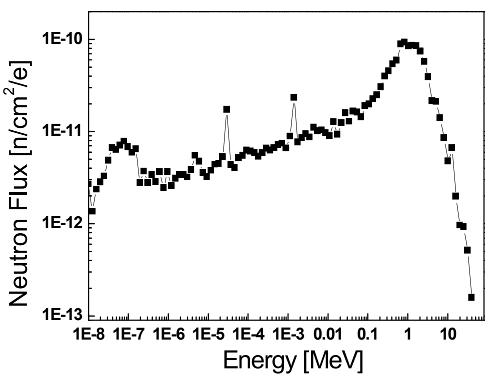

Figure 4. The neutron spectrum at the detecting point in figure 2

2.3 Neutron resolution function

To obtain the resolution function, a representative energy range was determined from 420 to 520 keV. The resolution function is the distribution of arrival times t for neutrons of a given energy E. To collapse the resolution functions for neutron energies, the arrival times are multiplied with the velocities v of the neutrons at the measurement point. To render the result independent of the distance from the center of the target to the measurement point, this length 700 cm is subtracted. The resulting quantity d is the delay distance is given by following equation [3].

$$d = vt - 700 \qquad (1)$$

Thus, the resolution function presented here is probability density function (PDF) in delay distance that is normalized to have an integral of one [4].

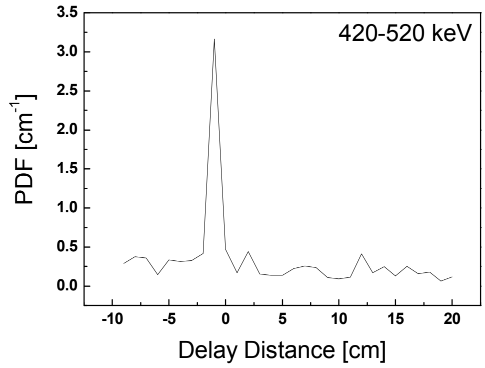

Figure 5. The resolution function for the energy range from 420 to 520 keV

In this simulation, neutron flux was calculated with a time interval of 0.01 shake (1 shake = 10^{-8} sec). The result for the resolution function is presented in figure 5. The sharp peak was observed at delay distances between -1.0 cm and 0.0 cm with a PDF of about 3.162 cm^{-1} and a FWHM of about 0.973 cm.

3. Conclusion

Monte Carlo simulations were performed with the MCNPX code to obtain neutron spectra of neutrons for time-of-flight path at PNF. Neutron spectra peaked at 1 MeV and drop by two and one order of magnitude at 1 eV. The water moderator suppressed a peak and increased thermal neutrons. The resolution function was obtained in PDF in delay distance. Further study would be performed to estimate overall characterization of photoneutrons at PNF.

REFERENCES

[1] K. Devan, Young Seok Lee, Monte Carlo Simulation of Pohang Neutron Facility by Using MCNPX Code, J. Korean Phys. Soc. 49, 1(R), 2006, pp. 89-96
[2] V. Kovalchuk, G. N. Kim, Measurement of Photoneutron Spectrum at Pohang Neutron Facility, Elsevier, 2002, pp. 93-108
[3] D. Ene, C. Borcea, Global characterization of the GELINA facility for high-resolution neutron time-of-flight measurements by Monte Carlo simulations, Elsevier, pp. 1-26, 2007
[4] M. Flaska, A. Borella, Modeling of the GELINA neutron target using coupled electron-photon-neutron transport with the MCNP4C3 code, Nucl. Instr. and Meth. A 531 (2004) 392-406