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MEASUREMENTS OF PHOTO-NEUTRONS FROM THICK ALUMINUM TARGET BY 2 GeV ELECTRONS

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Abstract

Photoneutron spectra were measured using the TOF method when thick aluminum targets were bombarded by 2.04 GeV electrons at the injection Linac of the Pohang Accelerator Laboratory. Neutrons toward 90 degrees from the target were measured. The length of the flight path becomes longer than that in the previous work and neutrons up to 400 MeV were measured. Calculations of neutron energy spectra were also done using PICA3 and EGS4.

1 Introduction

There are only a few measurements of photoneutron energy spectra from thick targets of high-energy electrons above 0.3 GeV. In the previous measurements, neutrons toward 90 degrees from the targets were measured at the Accelerator Test Facility (ATF)[1] in KEK and the Linac of the Pohang Accelerator Laboratory (PAL) in POSTECH[2,3] using 1 and 2 GeV electrons.

Recently, the Time-of-Flight facility at the PAL was improved and the length of the flight path becomes longer. Neutrons up to 400 MeV were measured compared to the upper energy of 200 MeV in the previous work. The Photon track lengths in the target were calculated using EGS4. Photonuclear cross section was calculated using PICA3[4]. Measured neutron spectra were compared with these calculations.

2 Experiments and Calculations

The experimental setup is shown in Fig.1. The beam dump is placed at the 10 degrees beam line[3] in the Linac of PAL. The target was placed in front of the beam dump. In the previous measurements, the neutron detector was 5.6 m distant from the target[1,2,3]. To measure higher neutrons, the ceiling wall of the counting room was drilled and a steel frame was assembled on the ceiling. The neutron detector was set on the frame at 10.4 m distant from the target. The 1-m-long iron shadow bar is shown in Fig.1 and this was removed in the measurements. The detector was

surrounded by the collimator made of Pb. The size of the detector was 2"$\phi\times$2" and PILOT-U or NE-213 scintillator was used.

The results using the PILOT-U detector are shown in Fig.2 when 2.04 GeV electrons hit 5$\times$5cm-wide and 8.0cm-thick (0.9-radiation-length) Al targets. Neutrons between 10 and 400 MeV were measured using the KODAQ data-taking system[5]. The electron beam frequency was 10 Hz and the pulse width was about 1 ns. Thick Pb blocks, 15-30 cm, were placed in the middle of the flight path to suppress X-rays. These Pb blocks also reduced neutrons toward the detector, and this effect was evaluated using LAHET 2.7[6]. Calculations were also done using EGS4 and PICA3[4]. Transport of secondary neutron and pion etc. in the target was calculated by LAHET 2.7[6]. Results are also shown in Fig.2. Calculated ones tend to underestimate the measured ones.

To reduce the dead time of the counter after the pulsed X-rays[1], the discrimination level of the neutron scintillation detector was high and was 4.2 MeV electron-equivalent. The Pb collimator surrounding the detector affected the neutron detection efficiency. The detector was calibrated using quasi-monoenergetic neutron sources at TIARA in JAERI. It was found the efficiency was not affected by the collimator when the pulse height discrimination level of the detector was high[1,2]. But this was not confirmed for higher energy neutrons. Measurements were also done without the Pb collimator surrounding the detector.

The pulsed X-rays from the target do not contribute to these measurements. But there are still some secondary gamma-rays background. This effect was evaluated using NE213 organic liquid scintillator and neutron-gamma discrimination technique was used. This is difficult due to protons escaping through the scintillator wall[7] but secondary gamma-rays contribution were evaluated.

Preliminary results are shown in Fig.3, correcting these two effects, that is, the scattering in the Pb collimator and the secondary gamma-rays background. The measured results were more close to the calculated ones that those in Fig.2.

3 Summary

The neutron spectra up to 400 MeV were measured using the new experimental set up at PAL. Preliminary results were shown here. More experimental data were needed to show the Pb collimator effect at the higher energy above 200 MeV. Secondary gamma-rays contribution is also important for the higher energy. Neutron detection efficiency above 200 MeV needs to be confirmed again.

Acknowledgments

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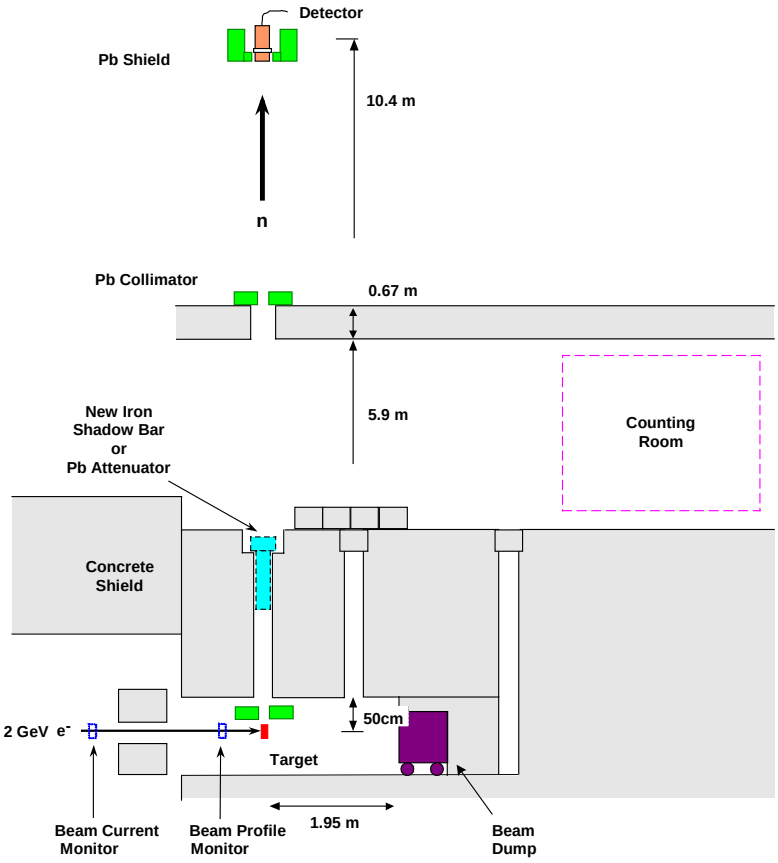

Figure 1: Experimental setup of the TOF measurements at PAL when 2.04 GeV electrons irradiated targets.

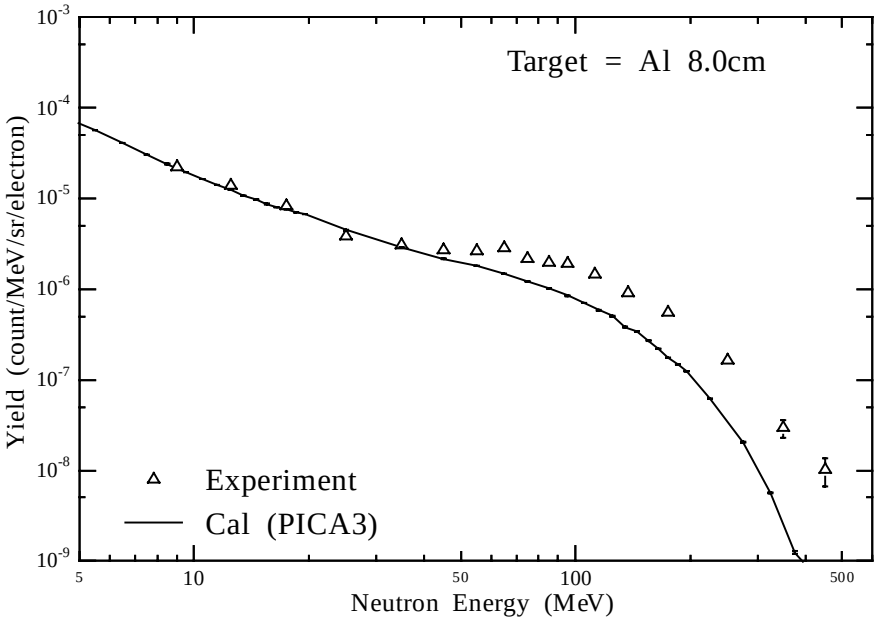

Figure 2: Preliminary neutron spectra toward 90 degrees from 8-cm-thick Al target irradiated by 2.04 GeV electrons. Triangle: Measured at PAL. Full line: Calculated using EGS4/PICA3[4]/LAHET2.7[6].

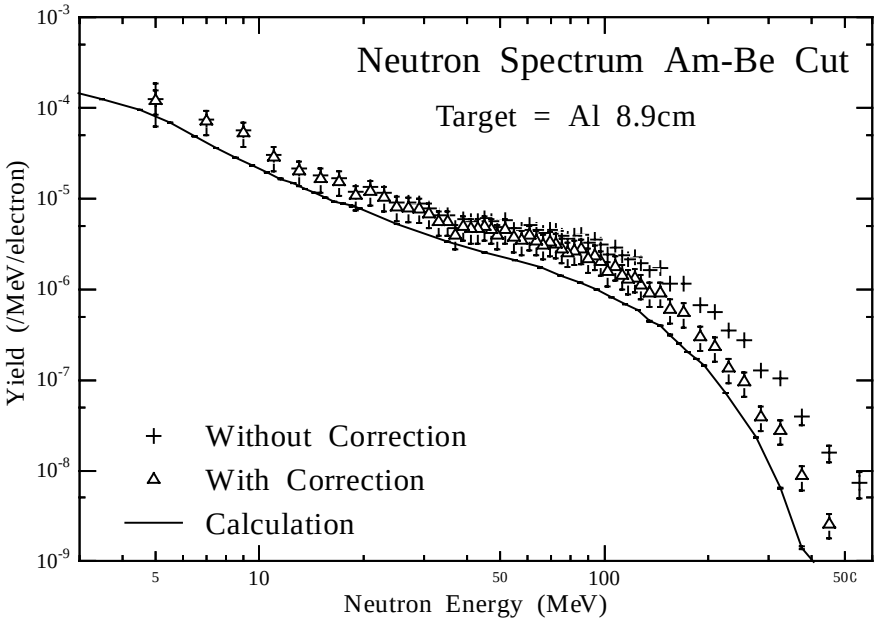

Figure 3: Preliminary results of neutron spectra toward 90 degrees from 8.9-cm-thick Al target irradiated by 2 GeV electrons. Pulus: Measured results without correction. Triangle: Measured results with correction (Pb collimator effect and secondary gamma-rays contribution). Full line: Calculated using EGS4/PICA3[4]/LAHET2.7[6].