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PROJECT TITLE

Construction of Mono-energetic Fast Neutron Standards Facility

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Summary
KIGAM is under the construction of a neutron standards facility with the neutron energies of 144 keV, 250 keV, and 565 keV. The long counter, which was made by KIGAM, is used as a neutron monitor. Its efficiency for KIGAM neutron standards should be known to compare the neutron fluences of KIGAM with those of JAEA. So its efficiency was measured by both JAEA neutron standards and KIGAM neutron facility. The agreements within 15% for three kinds of energies were obtained in the efficiency. Current the absolute neutron fluences for KIGAM standards are estimated by an unfolding process for the spectra of the proton proportional counter, which were measured by neutron standards and obtained by MCNP code.

key words: Neutron standard, Efficiency, Long-counter, Proton proportional counter

1. Objectives

The objective of this project is to measure the efficiencies of the long-counter and the proton proportional counter at three kinds of neutron energies such as 144 keV, 250 keV, and 565 keV to use them as a neutron monitor and a neutron fluence detector.

2. Methods

The neutrons with the energies of 144 keV, 250 keV and 565 keV were obtained by the $^{7}Li(p,n)^{7}Be$ reaction at JAEA. Their neutron fluences were ones from 7000 neutrons/cm^2 to 15000 neutrons/cm^2. In this case a few micro-ampere proton current and a neutron target thickness of about 100 ug/cm^2 were used. In the measurements of their efficiency the long-counter and the proton proportional detector were positioned to be 297.73 cm and 60 cm from neutron target and 0^o to the proton beam direction, respectively. Table 1 shows the experimental property for the efficiency measurement at JAEA. The efficiencies of long-counter at JAEA were obtained by using the counts of long-counts and the irradiation neutron number.
KIGAM made a neutron thin film target of LiF with the thickness of 96 ug/cm^2 by the electron-sputtering evaporation. The thickness of LiF was estimated by techniques of measuring its weight on a microgram-balance, measuring the resonance of 483 keV at $^{19}F(p,\alpha\gamma)$ reaction[1] and measuring time width by the n-TOF method, respectively. The characteristics of n-TOF system such as the time constant and the flight time were confirmed by measuring the resonances of neutron total cross sections on Fe at neutron energies from 130 keV to 160 keV. The spectra of long-counter were measured with and without a shadow bar to remove the scattered neutrons. The counts of thermal neutron peak were extracted from their spectra and the dead time correction was also performed. The accumulated proton charge was also measured for the proton bombardment on LiF thin film. The irradiated neutrons for the long-counter were calculated by the target thickness of LiF, the accumulated proton charge and the differential cross section on $^{7}Li(p,n)$ reaction at 0^o degree to the beam direction and the long-counter efficiencies for three kinds of energies were obtained by using the counts of long-counts and the irradiation neutron number.

The biased intrinsic efficiencies above 90 keV for a proton proportional counter were obtained by KIGAM facility and compared with the results to have been measured at JAEA facility. The energy calibration of the spectra was performed by selecting the middle points of their end-slopes for 144 keV, 250 keV, and 565 keV

experimental spectra. The spectra of the proton proportional counter were normalized by the neutron yields, which were obtained by the neutron target thickness, the proton accumulated charge, the differential cross section of ^{7}Li(p,n) reaction and the solid angle of the detector.
However, the unfolding process should be done to know the accurate neutron fluences. The unfolding process needs the spectra for several neutron energies, which were simulated by MCNP code[2]. Now the simulation spectra for a proton proportional counter is being calculated. The shape of this counter is spherical and its diameter is 5 cm.

Table 1 Experimental property for the efficiency measurement at JAEA.

Average neutron energy (keV)	Shadow bar	Proton charge (μC)	Measuring time (sec)	Neutron flux (n/cm^2)
144	No	1484	1000	9.05E3
	Yes	1373	1000	8.36E3
250	No	2274	1000	8.77E3
	Yes	2012	1000	7.71E3
565	No	680	1000	1.54E4
	Yes	736	1000	1.42E4

3. Results and Discussion

Figure 1 shows the spectra of long-counter obtained at KIGAM and JAEA for the neutron average energies of 144 keV. X axis at the figure 1 denotes channel number and Y axis means counts per μC. In this case the average energy of KIGAM neutron standard was confirmed to be 144 keV by n-TOF system. The neutron width of this standard was also obtained to be 5.9%.The comparison of two data shows a considerable agreement in spite of the difference with 4 % for the target thickness.

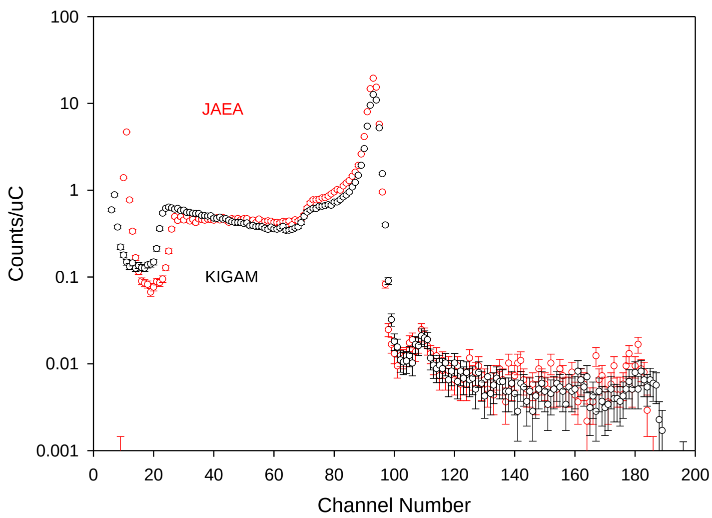

Fig. 1. Comparison of the spectra of long-counter obtained at KIGAM with that of JAEA for the neutron average energy of 144 keV.

Table 2 shows the efficiencies calculated for the long-counter. An agreement within 15 % for two efficiencies is obtained. This table shows that the efficiencies of long-counter are constant for neutron energy, which has a good agreement to the simulation result with MCNP code.

Table 2. Efficiencies of long-counter obtained at KIGAM and JAEA.

Average neutron energy(keV)	Efficiency of Long-counter at JAEA	Efficiency of Long-counter at KIGAM
144	0.047±0.001	0.045±0.001
250	0.041±0.001	0.047±0.001
565	0.041±0.002	0.045±0.001

Figure 2 shows the comparison of the two measured efficiencies at the average energy of 565 keV. Red data are the efficiencies at JAEA, black data are the efficiencies at KIGAM. Blue solid line means the intrinsic efficiency obtained by MCNP code. The comparison of efficiencies for the neutron energies above 90 keV, which were obtained at JAEA and KIGAM, shows the agreement within the difference of 14%. The efficiencies at other energies such as 144 keV and 250 keV have agreements within the differences of 17%.

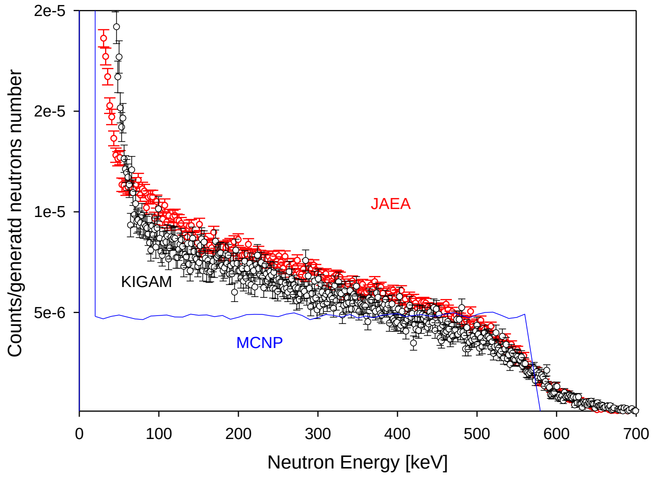

Fig. 2. Comparison of the intrinsic efficiency at KIGAM facility facility for proton proportional counter with that at JAEA. Red data are the efficiencies at JAEA, black data are the efficiencies at KIGAM and solid line means the intrinsic efficiency by MCNP code.

Intrinsic efficiency of the detector will be obtained by MCNP code. Intrinsic efficiencies of the proton proportional counter for several neutron energies were calculated by MCNP code. When neglecting the wall effect and the applied high voltage effect in the experimental spectra of figure 2, Comparison of the experimental data with the simulation data gives a fair agreement. In the future, the absolute value of the produced neutron yield for neutron energies of 144 keV, 250 keV, and 565 keV will be calculated by the unfolding process.

4. References

[1] S.O.F. Dababneh, K. Toukan, and I. Khubeis, “Excitation Function of the Nuclear Reaction $^{19}F(p,\alpha\gamma)^{16}O$ in the Proton Energy Range 0.3-3.0 MeV”, Nuclear Instruments and Methods in Physics Research B 83 (1993) 319-324.

[2] Bernd R.L. Siebert, Hein Jurgen Brede and Heinrich Lesiecki, " Corrections and Uncertainties for Neutron Fluence Measurements with Proton Recoil Telescopes in Anisotropic Fields", Nuclear Instruments and Methods in Physics Research A235 (1985) 542-552.