MLF Experimental Report

課題番号 Project No. 2014B0246 実験課題名 Title of experiment Development of neutron scintillators and detectors with them 実験責任者名 Name of principal investigator Masaki Katagiri 所属 Affiliation Ibaraki University, Frontier Research Center for Applied Atomic Sciences	提出日 Date of Report June 8, 2017 装置責任者 Name of responsible person Dr. K. Oikawa 装置名 Name of Instrument/（BL No.） NOBORU /(BL10) 実施日 Date of Experiment Dec 17-20, 2014, Apr 16-18, 2015 Apr 15-16, 2016, Apr 22-23, 2016 May 16-17, 2016

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

No sample was used in the experiment. The detector performances were purely evaluated using a collimated pulsed neutron beam only.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

Two research themes were evaluated in this term. One is new ZnS/^{6}LiF scintillators of a two-dimensional scintillator detector for "*iBIX*" instrument and the other is a scintillator-type neutron monitor.

(i) Evaluation of new ZnS/^{6}LiF neutron scintillators

We have developed new ZnS/^{6}LiF neutron scintillators for iBIX-type detectors using wavelength shifting fiber readout method. Two kinds of scintillators, namely, a front-side scintillator and a rear-side scintillator are used for these detectors. The former is set on front of a crossed WLS fiber bundles and the latter on the rear. The front-side scintillator requires a good detection efficiency for wide-wavelength neutrons. The rear-side scintillator requires a high detection efficiency for short wavelength neutrons to detect effectively neutrons passed from the front-side scintillator. In this scintillator, neutrons are irradiated to surface of the scintillator. Therefore, we evaluated the front-side and rear-side scintillators fabricated with a new polymer-type adhesive material under several conditions.

We measured counting-rate characteristics of the scintillators as a function of time-of-flight at the distance of 12.5 m from the mercury target after a scintillator sample was attached on the front or the rear of the crossed WLS fiber bundles of an iBIX-type detector. Figure 1 and 2 show dependency of counting-rate curves for the front-side scintillator and the rear-side

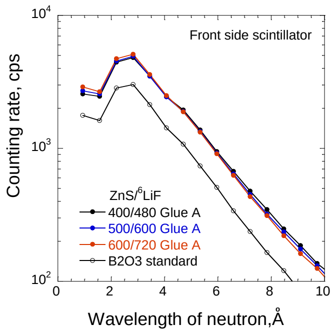

Fig.1 Dependency of counting-rate curves for the front-side scintillator on the amount of mixture

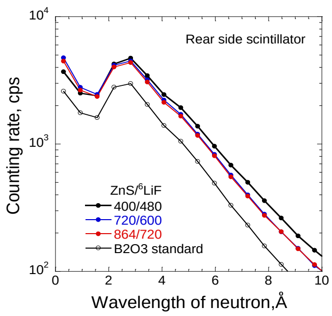

Fig.2 Dependency of counting-rate curves for the rear-side scintillator on the amount of mixture

2. 実験方法及び結果（つづき） Experimental method and results (continued)

scintillator on amount of the mixture. The detection characteristics of the front-side scintillators are nearly unchanged with increasing the amount of mixture and the detection characteristics of the rear-side scintillators improves in short wavelength region with increasing the amount of mixture. By these results, a thin scintillator was selected as the front-side scintillator and a thick scintillator as the rear-side scintillator. Figure 3 and 4 show dependency of counting-rate curves for the front-side and the rear-side scintillator on amount of the adhesive material. It is confirmed that the amount of 2 mg/cm^2 is best for a thin scintillator and the amount of 4mg/cm^2 is best for a thick scintillator. By using these results, we can improve the detection efficiency depending on the thickness of scintillator by optimizing the amount of the adhesive material.

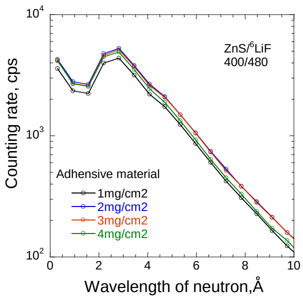

Fig.3 Dependency of counting-rate curves for the front-side scintillator on the amount of adhesive material

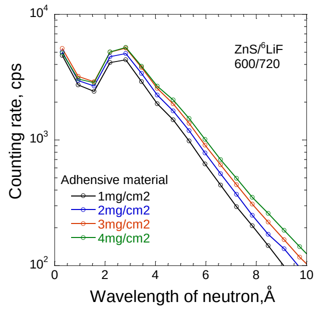

Fig.4 Dependency of counting-rate curves for the rear-side scintillator on the amount of adhesive material

(ii) Evaluation of a scintillator-type neutron beam monitor

A neutron beam monitor is very important to measure accurately incident pulsed neutrons in neutron instruments. Especially, a scintillator-type neutron monitor should be used for high intensity neutron beams when the power of J-PARC will reach 1MW.

Therefore, we developed a low-sensitive scintillator-type neutron monitor correspond to a high-counting-rate neutron beam. Figure 5 shows a photograph of a developed neutron monitor. A neutron-sensitive area has a size of 50 x 50 mm^2 with a scintillation layer thickness of about 0.1 mm on a quartz glass plate. Fluorescence signals emitted from the scintillator are detected by two photomultipliers and are converted to two electric pulse signals. With coincidence counting of both signals, a neutron monitor signal is produced. We prepared three kinds of scintillators: only ZnS:Ag(4mg/cm^2), ZnS:Ag(4mg/cm^2)/^{nat}LiF(2mg/cm^2) and ZnS:Ag(4mg/cm^2)/ ^{nat}LiF(4mg/cm^2). Sensitivities of these scintillator were measured as a function of time-of-flight. TOF characteristics of sensitivities for three scintillators are shown in Fig. 6. Sensitivities of three scintillators at neutron wavelength of 2.2 Å at BL10 are 1.1x10^{-4}, 2.0x10^{-4} and 3.7x10^{-4}, respectively. These sensitivities are better able to deal with 1MW pulsed beam intensity because the maximum counting rate of scintillators is several ten times more than the counting rate of gas-type neutron monitors. Figure 7 shows pulse height distributions of developed neutron monitors. It was confirmed that almost every signal in three scintillators can be counted by a low discrimination level. By these results, we can easily change the sensitivity by adjusting thickness of the scintillator and amount of the added ^{nat}LiF.

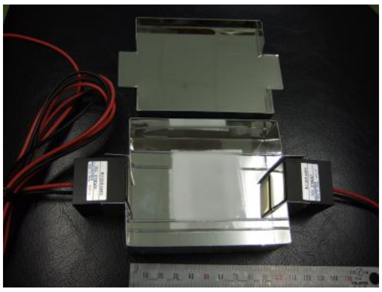

Fig. 5 A developed neutron monitor.

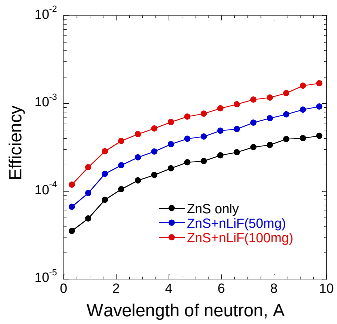

Fig.6 TOF characteristics of sensitivities for three scintillators

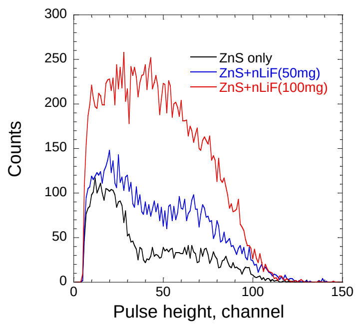

Fig.7 Pulse height distribution for three scintillators