MLF Experimental Report

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課題番号 Project No. 2014A0262 実験課題名 Title of experiment Development of neutron scintillation detectors 実験責任者名 Name of principal investigator Masaki Katagiri 所属 Affiliation Ibaraki University, Frontier Research Center for Applied Atomic Sciences	装置責任者 Name of responsible person Dr. Oikawa 装置名 Name of Instrument/（BL No.） NOBORU /(BL10) 実施日 Date of Experiment Apr 21-24, 2014, May 13-15, 2014 May 20-21, 2014, June 16-18, 2014

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.

In this allocated experimental time, the detection characteristics of (i) new ZnS/^{6}LiF neutron scintillators, and (ii) low-background 2D neutron detector using a position-sensitive PMT (PSPMT) were evaluated.

(i) New ZnS/^{6}LiF neutron scintillators

We have developed new ZnS/^{6}LiF neutron scintillators for iBIX-type detectors, Senju-type detectors, Takumi-type detectors, PSPMT detectors, and neutron imaging detectors (CCD camera) that are used in J-PARC. The most important object for the development of these scintillators is to obtain good detection efficiency for neutrons with wide neutron wavelength range, for example, from 1Å to 12Å. By results obtained by TOF experiments of 2013A, it is confirmed that a ZnS/^{6}LiF neutron scintillator using a polymer-type binder shows a best detection efficiency characteristics for neutrons with wide neutron wavelength range. Therefore, it is very important to obtain the best amount of the binder that is used for adhesion of ZnS phosphor and ^{6}LiF because the amount gives large effect to the detection efficiency characteristics. We measured the detection efficiency of the scintillators using a polymer-type binder as a function of time-of-flight at the distance of 12.5 m from the mercury target after scintillator was attached on the front of crossed WLS fiber bundles of iBIX detector. Figure 1 shows the dependency of the detection efficiency curves normalized by the efficiency of

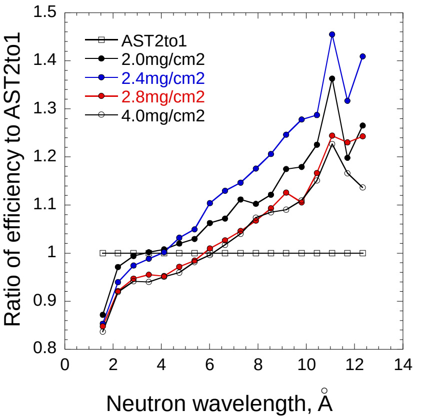

Figure 1 Dependency of the detection efficiency curves normalized by the efficiency of AST2to1 scintillator on the amount of the polymer-type binder

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

AST2to1 scintillator (world standard) on the amount of the polymer-type binder. It is clear from these results that the efficiency is improved at neutron wavelength more than 4 Å and the amount from 2 to 2.4mg/cm^2 is best for our object.

Next, we inquired the reason of the detection efficiency improvement by measuring pulse height distribution of output signals from PSPMT that the scintillator was attached on. Figure 2 shows both pulse height distributions of AST2to1 scintillator and the scintillator with polymer-type binder of 2mg/cm^2 at neutron wavelength of 2.8Å and 10.1Å. It is clear that the pulse height distribution of AST2to1 scintillator shifts to lower pulse height at wavelength of 10.1Å. Namely, the reason is transparency of the scintillator.

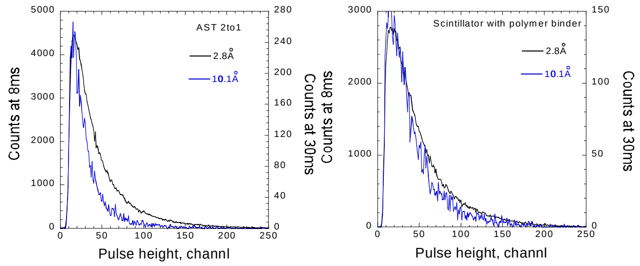

Figure2 Comparison results of pulse height distribution of AST2to1 scintillator (world standard) and new developed scintillator using polymer-type binder

(ii) Low-background 2D neutron detector using a position-sensitive PMT

A low-background 2D neutron detector using a PSMPT was developed for refractometer and SANS. Figure 3 shows a schematic diagram of the 2D neutron detector. The largest merit in this detector is a LBO ($Li_2B_4O_7$) crystal plate that is inserted between a scintillator and a PSPMT. Back-scattered neutrons from the PSPMT can be captured by this plate. The effect of this plate for neutrons from 1.3 to 12.6 Å was evaluated by TOF experiments. Figure 4 shows dependency of 1mmϕ neutron beam profile on thickness of the LBO at neutron wavelength of 2.5-3.8 Å. As experimental results, it is confirmed that 2mmt LBO is best. Next, figure 5 shows comparison of 1mmϕ neutron beam profiles in case of non LBO and 2mmt LBO with four neutron wavelength ranges. It is confirmed that the low-background 2D neutron detector with a 2mmt LBO plate reduces back-scattered neutrons and its amount is about half for neutrons from 1.3 to 6.3 Å. But, the effect is few in 6.3 to 12.6 Å because the neutron scintillator absorbs almost the neutrons. And, the effect becomes larger if the base background that is produced by a ^{6}LiF 1mmϕ collimator decreases.

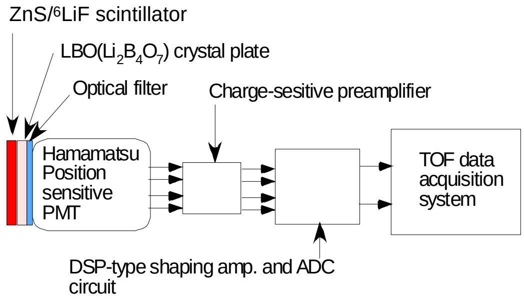

Figure 3 Schematic diagram of low-background 2D neutron detector using a PSPMT

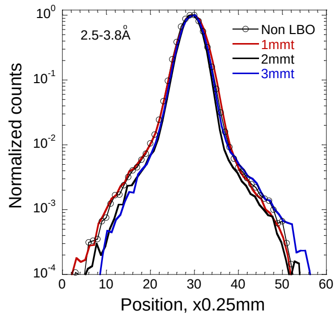

Figure 4 Dependency of 1mmϕ neutron beam profile on thickness of LBO plate at neutron wavelength of 2.5-3.8 Å

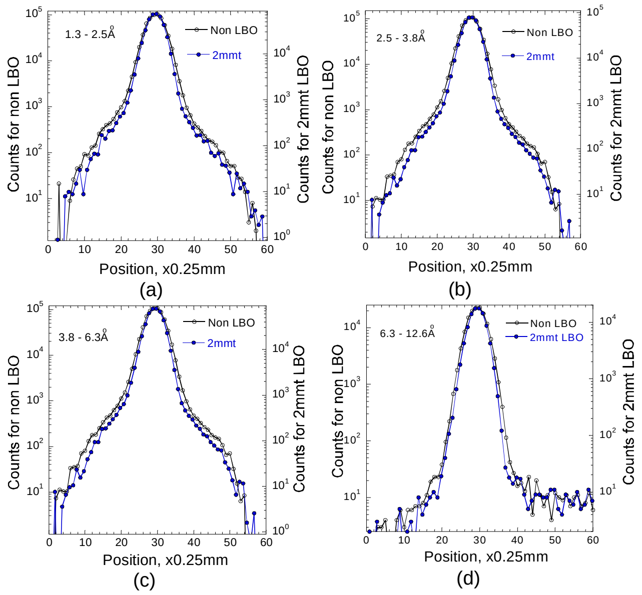

Figure 5 Comparison of 1mmϕ neutron beam profile in case of non LBO and 2mmt LBO for four neutron wavelength ranges.