MLF Experimental Report

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課題番号 Project No.
2016A0323

実験課題名 Title of experiment
Optimization of scintillators and neutron imaging detectors using them

実験責任者名 Name of principal investigator
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装置名 Name of Instrument/(BL No.)
NOBORU /(BL10)

実施日 Date of Experiment
May 17-18, 2016, June 14-16, 2016
June 23-24, 2016, Nov 14-16, 2016
Dec 2- 3, 2016, Jan 23-24, 2017

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, optimization of an iBIX-type neutron detector and development of a high-resolution and high-counting-rate 2D neutron detector using a PSPMT were carried out.

(i) Optimization of an iBIX-type neutron detector

We developed new $ZnS/^{6}LiF$ neutron scintillators for iBIX detectors in the project of 2014B. In this project, we optimized an iBIX-type neutron detector by combining a thin front-side scintillator with a thick rear-side scintillator. After several combinations with a front-side and a rear-side scintillator were evaluated, we selected an iBIX-type detector that has good detection characteristics. An absolute detection efficiency of this detector in a function of neutron wavelength was determined by a special method using a ^{3}He proportional counter. Figure 1 shows outline of calibration experiments. Count of the ^{3}He counter, count of iBIX-type detector after absorption by the ^{3}He counter and count of iBIX-type detector after deinstallation of the counter were obtained in the experiments. By using these counts, absolute detection efficiencies of the iBIX-type detector and the ^{3}He counter were obtained as a function of neutron wavelength. These results are shown in Fig.2. Also, efficiencies of the ^{3}He counter calculated by using a neutron absorption cross-section of ^{3}He and an absorption length

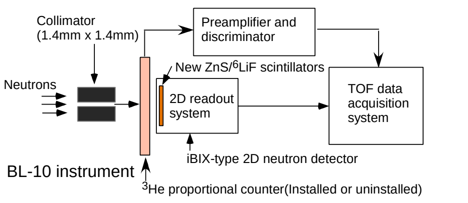

Fig. 1 Outline of calibration experiments

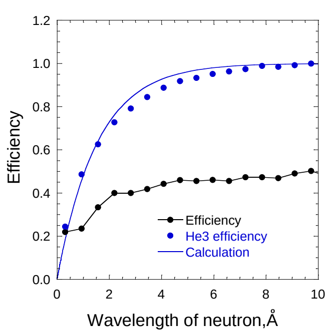

Fig.2 Detection efficiencies as a function of neutron wavelength

of the ^{3}He counter are shown in same figure. It is confirmed that the measured efficiency is in agreement with the calculated efficiency. After that, efficiency in case of both scintillators and efficiency in case of only front-side scintillator or only rear-side scintillator were measured and compared in Fig. 3. It is found out that the rear-side scintillator increases the efficiency especially in short wavelength of neutrons.

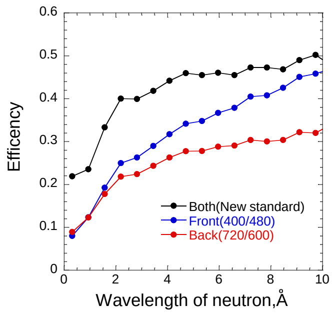

Fig.3 Three kinds of efficiencies as a function of neutron wavelength

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

A high-resolution and high-counting-rate 2D neutron detector using a PSPMT(Position-Sensitive Photomultiplier) was developed for a refractometer and a SANS. Figure 4 shows a schematic diagram of the 2D neutron detector. The largest merit in this detector is a DSP-type shaping amplifier and high-speed ADC circuit that processes signals from a PSPMT(Position-Sensitive Photomultiplier). This DSP has a remarkable ability for high-counting signal processing with more than 100kcps. High-resolution and high-counting-rate characteristics of the 2D neutron detector was evaluated by TOF experiments. The experiments were carried out by combining a collimated beam for position resolusion with an added beam for increase of counting rate. A sample of measured 3D neutron image at 8ms is shown in Fig. 5. Figure 6 shows a proportional relation of counting rate between a collimated beam and a total beam(collimated beam + added beam). It is confirmed that a linearity of counting rate for the total beam is good to 40kcps and becomes worse after that because of dead time. The effect of the added beam on counting rate of the collimated beam is shown in Fig. 7. Proportion of counting rate for collimated beam to that with the added beam is almost 1 to 40kcps and increases a little at more 52kcps. Also, a collimated beam was only measured under low counting rate to inquire pure position resolutions. Figure 8 shows FWHM position resolutions in a function of total counting rate. The resolution of 0.4mm remains unchanged to 40kcps. Consequently, it is found out that the developed 2D detector has excellent performances to the position resolution and the counting rate.

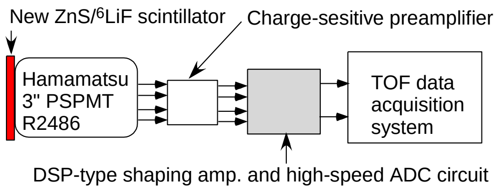

Fig.4 Schematic diagram of the 2D neutron detector

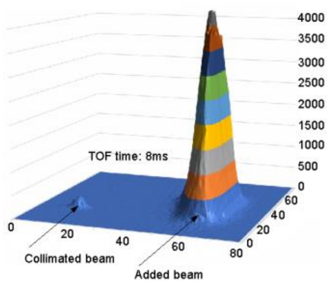

Fig.5 Measured 3D neutron image at 8ms

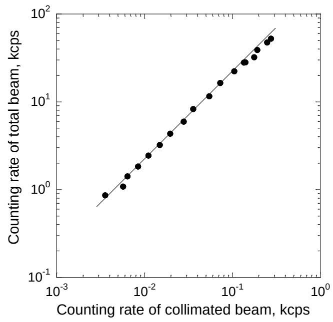

Fig.6 Proportional relation of counting rate between a collimated beam and a total beam

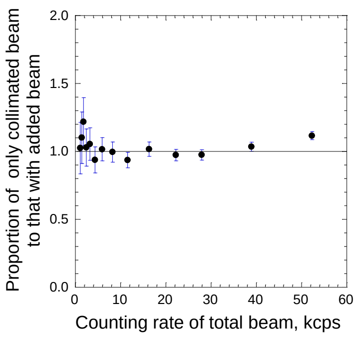

Fig.7 Effect of of added beam on counting rate of the collimated beam

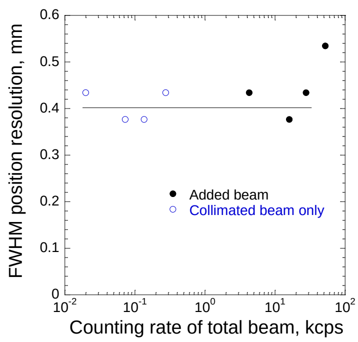

Fig.8 FWHM position resolutions in a function of total counting rate