MLF Experimental Report	提出日 Date of Report Oct 31, 2013
課題番号 Project No. 2012A0131 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 26-28, 2012, May 10-12, 2012 May 22-25, 2012

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 detector performances of (i) neutron monitor detectors using ZnS scintillator, and (ii) a new developed iBIX detector were evaluated.

(i) Scintillator monitor detector

We have developed already some kinds of ZnS monitor detectors with neutron converter materials that are ^{nat}LiF, $^{11}B_2O_3$ and $CaCl_2$. But, the detector efficiency was tuned around 10^{-2} to 10^{-3} which was still rather “high” as monitor detector. Therefore, we developed a new scintillator monitor detector that has the efficiency of around 10^{-4} like a comercial ^{3}He neutron monitor. The developed monitor detector used only ZnS phosphor that has $^{32}S(n,\alpha)^{28}Si$ and $^{33}S(n,\alpha)^{29}Si$ reaction for neutron. The cross sections are around 10^{-2} burn with natural abundance. Figure 1 shows photograph of the new neutron monitor detector composed of a reflected body, a scintillator and two photomultipliers. The neutron-sensitive area of the detector had a size of 50 x 50 mm^2 with a layer thickness of 0.05 mm, just enough to cover the beam at BL-10. Figure 1 shows the photograph of the prototype detector.

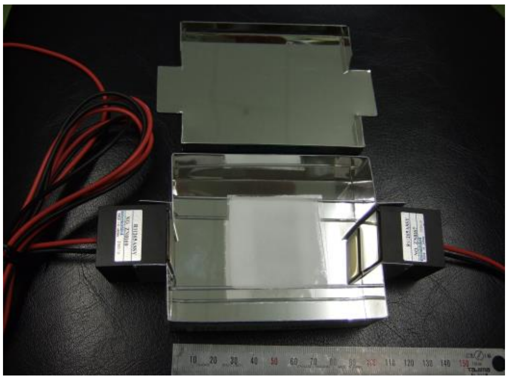

Figure 1 Photograph of a new ZnS monitor detector

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

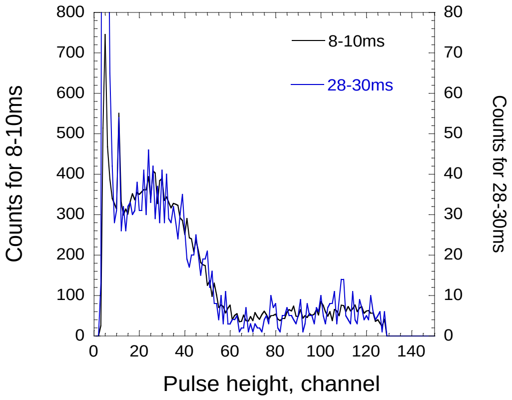

Figure 2 Pulse height spectrum measured the ZnS monitor

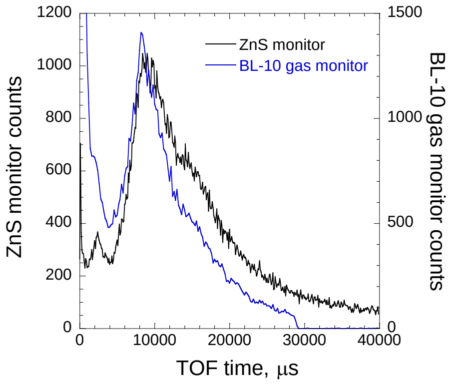

Figure 3 Time-of-flight spectra measured the ZnS monitor

At first, pulse height spectrums of ZnS phosphor shown in Fig.2 were measured. The alpha rays, ^{28}Si and ^{29}Si based on (n, α) reactions were measured. Discrimination level was set at channel 10 to reject electronics noise. Figure 3 shows time-of flight (TOF) spectra measured at the distance of 12.5 m from the mercury target. The λ(Å) is obtained by TOF(µs)/3160. The detector efficiency was evaluated as 3x 10^{-4}. The result demonstrated the feasibility of the detector. Gamma-ray sensitivity is less than 10^{-6} because the sensitivity of ZnS phosphor is very low. The detector efficiency can be easily adjusted by the amount of ZnS phosphor.

(ii) Evaluation of a new position-sensitive scintillator detector developed for iBIX

Position-sensitive scintillator detectors with a high spatial resolution were newly developed for the iBIX 16 detectors fabricated based on a proto-type detector and installed in the BL-03 by the end of FY2012. The detector performances of the proto-type position-sensitive scintillator detector were evaluated by using the BL-10 beam line. Figure 4 shows photograph of the developed proto-type iBIX detector.

Figure 4 Photograph of a new iBIX detector

The present detector has a neutron-sensitive area of 132 x 132 mm^2 with a pixel size of 0.5 x 0.5 mm^2. The detector technology using WLS fibre readout has been greatly improved after three years since the first iBIX detector was developed. This would include the detector efficiency, multi-count characteristics and counting rate characteristics thanks to the increased light yield collection efficiency and to the newly developed ZnS/$^{10}B_2O_3$ scintillators. The detector structure, fiber arrays sandwiched with the two scintillator screens, remained the same as in the first original iBIX detector. In the experiments of detector performances such as detector efficiency, special resolution, counting rate characteristics were evaluated as a function of time-of-flight. One of the most important performances for the iBIX is position resolution. Figure 5 shows the performance of position resolution which is 1.1mm FWHM in case of irradiation of 1.0mmϕ collimated beam. The intrinsic position resolution is about 0.6mm FWHM.

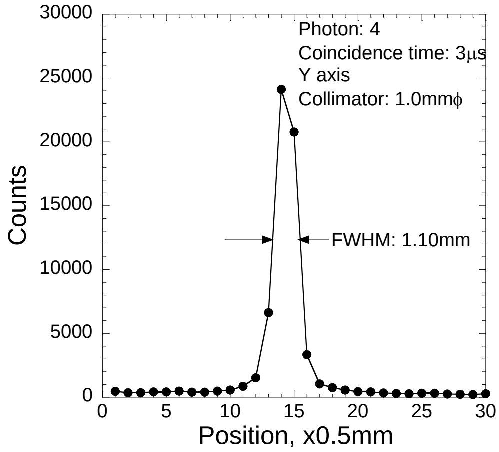

Figure 5 A spatial response of the detector with a 1-mm diameter beam