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# 15.2
# Development of detector based on neutron scintillator with wavelength shifting fiber

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## Abstract

We have been developing neutron optical devices based on neutron refractive optics, such as a neutron lens and a prism. For the purpose to evaluate performance of these optical devices, we have been developing a 2-dimensional position sensitive neutron detector based on a scintillator with wavelength shifting (WLS) fibers. Three layered structure, fibers-scintillator-fibers, was formed. The luminescence shifted by the WLS fibers is detected by multi-channel photomultiplier. Preliminary experiments were performed using $ZnS(Ag)+^6Li$ scintillator plate (Bicron BC-704), 20mm x 20mm x 0.4mm thick, and 1mm WLS fibers (Kuralay Y-11(200)). A spatial resolution of 1 mm in FWHM with detection efficiency of 55 % for 10 Å neutrons has been experimentally confirmed. Gamma sensitivity is about $10^{-3}$ to a neutron. A spatial resolution of 0.5 mm in FWHM with area of 100 mm x 100 mm will be soon available.

## 1. Introduction

Neutron optical devices had been developed and made practicable. However, it was reflective devices like mirror. For more than five years, we have been developing neutron optical devices [1-3] and succeeded in substantiating a focusing action of magnetic lens [4]. Recently we are also developing a material lens. These refractive devices have a function of 2-dimentional focusing. In order to make sure this function, 2-dimentional survey must be required after a exit of these devices. We had performed 2-dimentional scan by the $^3He$ proportional gas counter with a pinhole. The scan is inefficient method. To make experiment progress efficiently, 2-dimensional neutron detector has been highly required to develop the neutron optical devices.

Scintillator has extensively used to detect various radiations. Our neutron detector was modeled on X-ray detector based on a scintillator with wavelength sifting (WLS) fiber. It could work as neutron detector in exchanging a scintillator for that adulterated with neutron converter. We made a prototype and obtained preliminary experimental results.

## 2. Experiment

The detector was composed of a $ZnS(Ag)+^6Li$ scintillator plate (Bicron BC-704), 20mm x

20mm x 0.4mm thick, two groups of 16 pieces of 1mm WLS fibers (Kuralay Y-11(200)), and two pieces of 16 channels multi anode photo multiplier tubes (16ch. MAPMT). Neuron beam experiments were performed at the C3-2 beam line of the JRR-3M research reactor of Japan Atomic Energy Research Institute. Experimental setup is shown in Fig. 1.

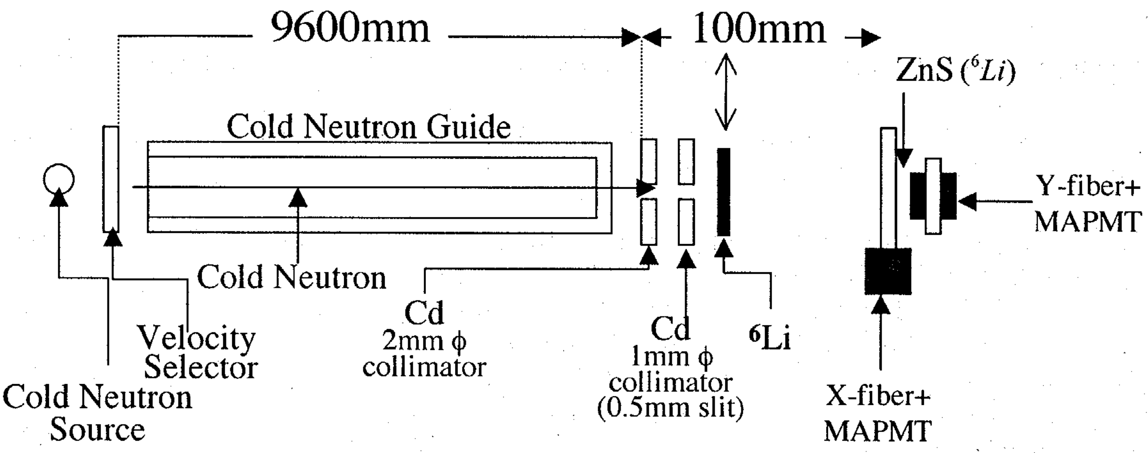


Fig. 1. Experimental setup to measure a neutron beam.

## 3. Results

Using 10 Å neutron, a beam profile with cadmium collimator of 1mm in diameter was obtained and shown in Fig. 2. FWHM of the observed peak for collimated beam was 1 mm when the Gauss function fitted to the data. Figure 3 shows a profile with cadmium slit of 15 mm x 0.5 mm window.

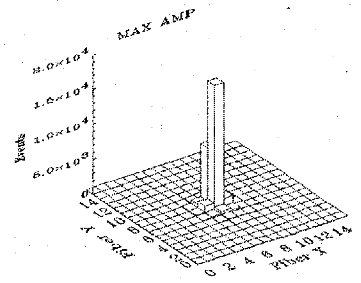

Fig. 2. Profile of collimated neutron beam, 1 mm in diameter.

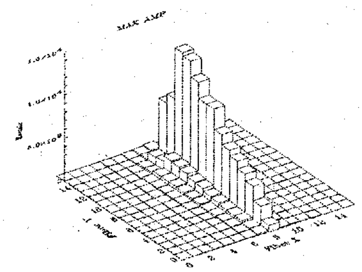

Fig. 3. Profile of neutron beam after slit, 15 mm x 0.5 mm.

Gamma ray background was measured in the configuration of shutter opened but neutron stopped by a $^6$Li plate. The profiles of signals from gamma ray are shown in Fig. 4. The signals concentrate a region of small ADC channels, i.e., small photon count.

## 4. Discussion

The experimental result of neutron detecting efficiency was 0.55. This is explained with transmission of WLS fiber and absorption coefficient of scintillator at 10 Å. The transmission of fiber, 0.62, times the absorption coefficient of scintillator, 0.89, becomes 0.55. A scintillator is generally sensitive to gamma ray compared with $^3$He proportional gas counter because of its nature. However, a hundred or a thousand of gamma ray are needed to generate the same number of photons for one neutron. We could discriminate most of gamma rays from all signals by ignoring the signals small number of photons. Using this method, a gamma/neutron ratio was improved from 1/50 to 1/300 but the detecting efficiency decreased from 0.55 to 0.45.

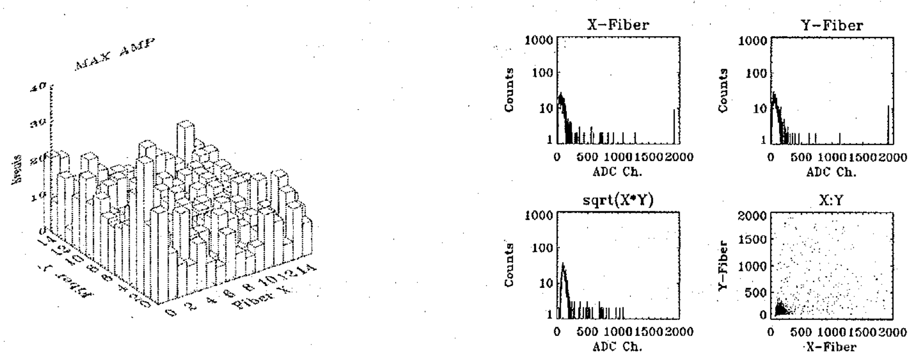


Fig. 4. Background profile of gamma ray. The left one is a map of gamma intensity and the right four are signals after MAPMT.

We are developing improved detector which has larger sensitive area and better spatial resolution. Possibilities improving detection efficiency and spatial resolution are investigated by selection of the scintillator, fiber size and structure.

## References

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