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Test Experiments of Disk Chopper with Supermirror Converging System

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Abstract

We measured transportation property of neutron pulsed by disk chopper with three kinds of setting of supermirror guide at JRR-3M, JAERI. We confirmed a gain of supermirror converging system to narrow straight supermirror system. The gain is approximately same as the ratio of entrance width of converging guide to width of narrow straight guide. On the other hand, we did not get a gain of supermirror converging system to wide straight supermirror system which has a same width to entrance width of converging guide and we will plan more precisely experiment.

Introduction

The neutron transportation technique is very important on spallation neutron scattering method and the development of neutron converging technique is indispensable. There are several simulations about converging supermirror system [1], [2], but there are no systematic experiments of converging supermirror system.

Our purposes are to apply supermirror converging system to high-resolution inelastic spectrometer, TOF radiography and TOF prompt γ-ray activation analysis and so on. These instruments needs longer flight-path length or smaller sample area. So we performed test experiments to confirm a gain of converging system and validity. We briefly report preliminary results in this article.

Experimental

Experiments were performed at C2-3 cold-neutron guide port in JRR-3M, JAERI. Figure 1 shows top cross sectional view of the experimental setting. There are three kinds of settings. The first one is narrow straight setting which consists of guide tubes of 6 $mm^w \times 3\ cm^H$ cross section both forward and backward of a disk chopper. The length of both guides is 1 m. Supermirror sheets ($3Q_c$, 80 % reflectivity) were attached on both right and left side and Ni mirror sheets were attached on top and bottom side in guide tubes. Alignment accuracy of sheets was less than 1 μm. The second one is wide straight setting which consists of guide tubes of 12 $mm^w \times 3\ cm^H$ cross section both forward and backward of a disk chopper. The third one is wide straight and converging setting which consists of a first guide tube with 12 $mm^w \times 3\ cm^H$ cross section and a second guide tube with entrance cross section of 12 $mm^w \times 3\ cm^H$ and exit cross section of 6 $mm^w \times 3\ cm^H$. All of these guide tubes were not evacuated in this preliminary study for simplicity.

Continuous neutrons come through $5mm^w \times 5mm^H$ aperture which is made of Li tile, then enter guide tube. Emitted neutrons from a first guide tube are pulsed by a disk chopper. Pulsed neutrons enter a second guide tube. Emitted neutrons from a second guide tube are detected by ^3He detector with 2 mm^w slit. The disk chopper produced by DaimlerCrysler Aerospace Dornier company has a maximum chopper speed of 12000 rpm and we used 1000 rpm in these experiments. The ^3He detector is movable to detect i(λ) as a function of detector position and covered range of detector translation is between -12.5 mm and 12.5 mm from nominal zero position.

Results

Figure 2 shows measured i(λ) as a function of detector position for narrow straight setting. The scale for main part of beam profile, which means the intense part of beam spot, is about 5 mm and approximately the same as guide width in experimental accuracy. Figure 3 shows wavelength dependence of fraction of i(λ) at individual detector position to total i(λ) which was obtained by summing i(λ) at all detector position. In the case of outer detector position, the fraction of longer wavelength neuron increases as increasing distance from actual beam center. On the other hand, shorter wavelength neutron concentrated to central position of beam spot. This effect is a nature of supermirror guide. Because longer wavelength neutron is transported being reflected to higher angle.

Figure 4 shows measured i(λ) as a function of detector position for wide straight setting. The scale for main part of beam profile is about 12.5mm and approximately the same as guide width. This is similar to narrow straight setting. Figure 5 shows wavelength dependence of fraction of i(λ) at individual detector position to total i(λ) of wide straight setting. Wavelength dependence is somewhat weak above 0.5 nm compared with narrow straight setting. This effect corresponds to the fact that the average number of reflections of neutron in wide straight setting is smaller than that of narrow straight setting.

Figure 6 shows i(λ) dependence of detector position for converging setting. In this case, broad beam profile is observed. This means that the beam divergence is bigger than that of straight setting and this corresponds to the fact that the average number of reflections of neutron in converging setting is bigger than that of straight setting. Figure 7 shows wavelength dependence of fraction of i(λ) at individual detector position to total i(λ) of converging setting. Wavelength dependence above 0.5 nm is very weak in this case. This effect is due to bigger beam divergence.

Figure 8 shows the gain as a function of wavelength by converging setting to narrow straight setting in range from 0.4 nm to 2.0 nm. In the case of total region, the gain from 0.4 nm to 1.0 nm is approximately 2 and this is consistent with the ratio of entrance width of converging guide to width of narrow straight guide. The gain gradually decrease as increasing wavelength above 1.0 nm. This seems to the influence of absorption of neutron by supermirror and air. In the case of focusing region, the gain is less than 2 but still higher than 1. This means that converging setting has the advantage to narrow straight setting.

Figure 9 shows the gain as a function of wavelength by converging setting to wide straight setting in range from 0.4 nm to 2.0 nm. The gain is less than 1 both total and focusing region. One possible explanation is the absorption of neutron due to big average number of reflections of converging setting.

Conclusion

We confirmed the gain of supermirror converging system to narrow straight supermirror system. We did not get a gain of supermirror converging system to wide straight supermirror system. We will plan more precisely experiment to use high reflectivity supermirror with evacuated condition.

References

[1] F. Mezei and M. Russina, Physica B 283 (2000) 318

[2] B. W. Wehring, J. Y. Kim and K.Ünlü, Nucl. Instr. and Meth. A 353 (1994) 137

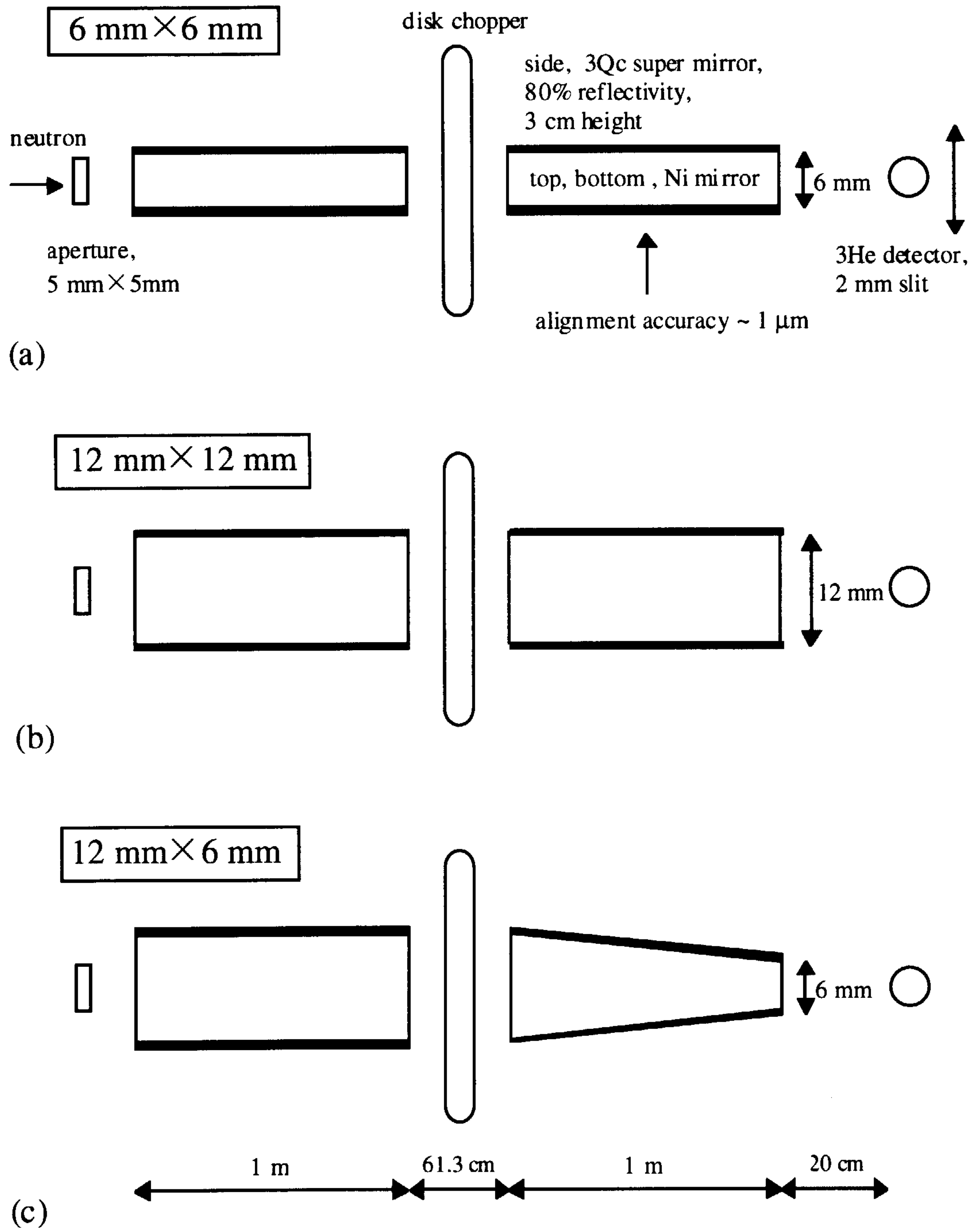

Fig. 1. Top cross sectional view of the experimental setting. (a) narrow straight setting. (b) wide straight setting. (c) converging setting.

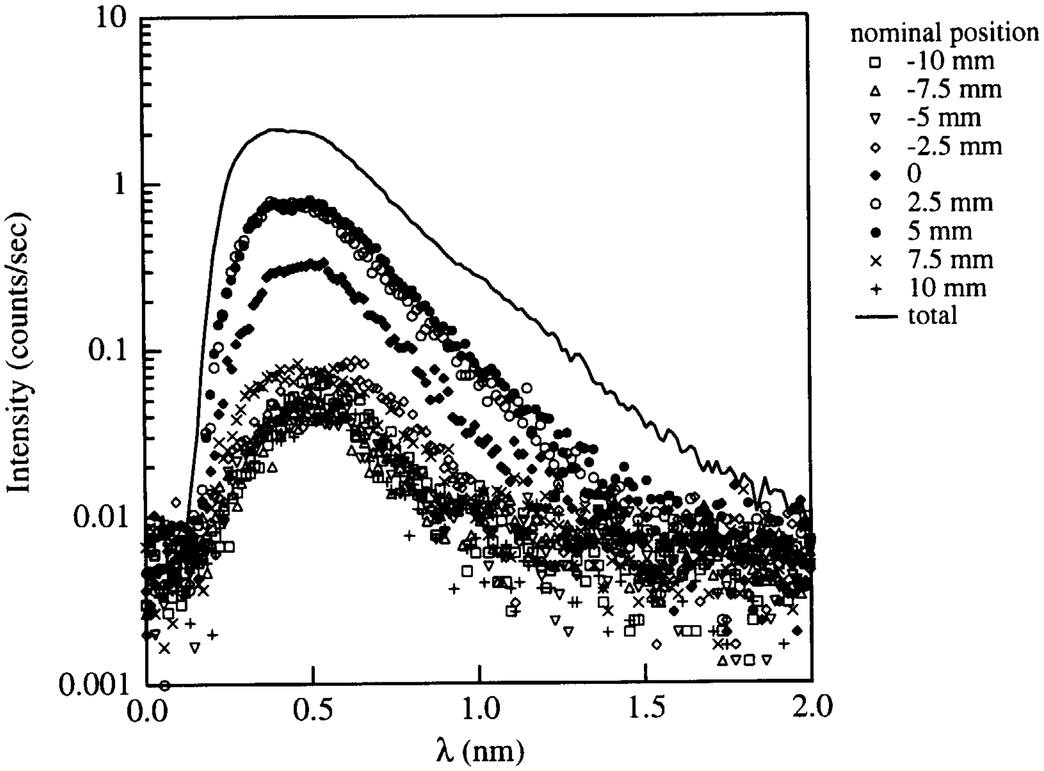

Fig. 2. i(λ) dependence for detector position with 6 mm × 6 mm setting (narrow straight setting).

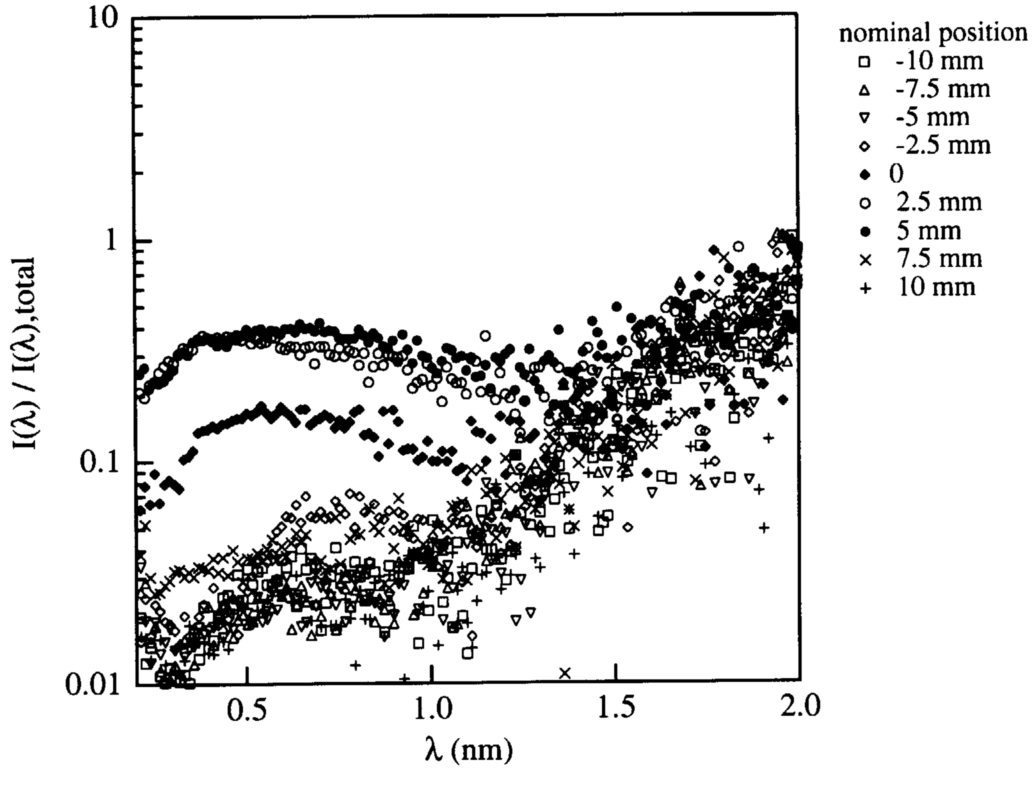

Fig. 3. Fraction of i(λ) for detector position to total neutron flux with 6 mm × 6 mm setting (narrow straight setting).

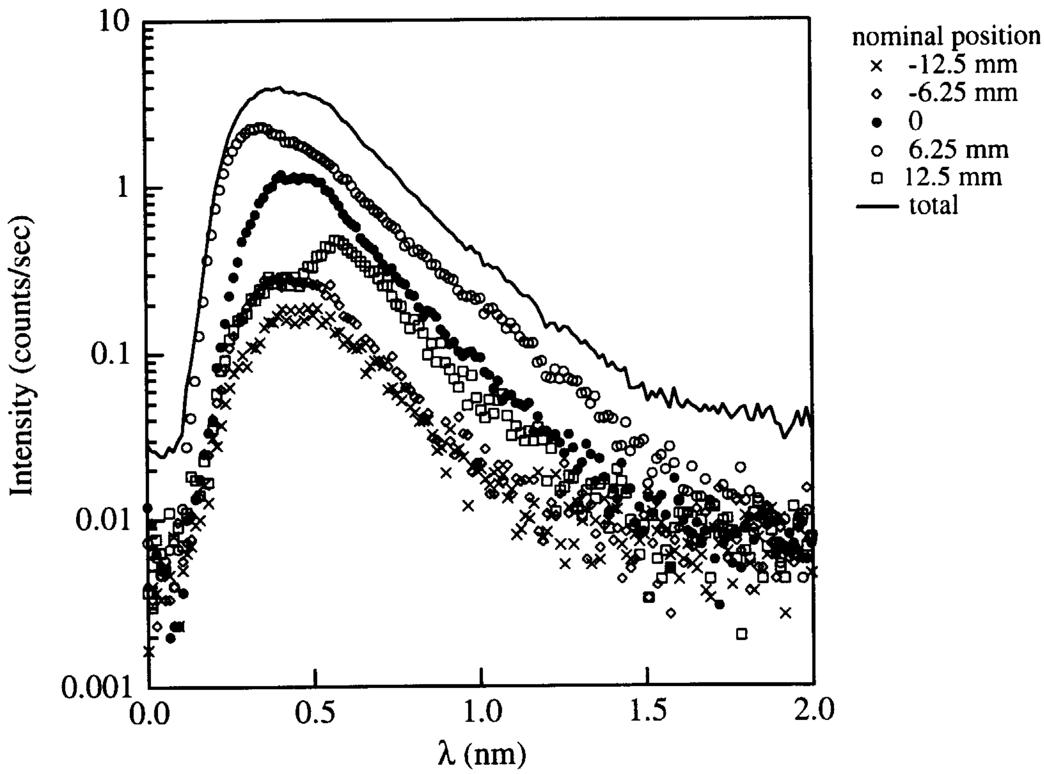

Fig. 4. i(λ) dependence for detector position with 12 mm × 12 mm setting (wide straight setting).

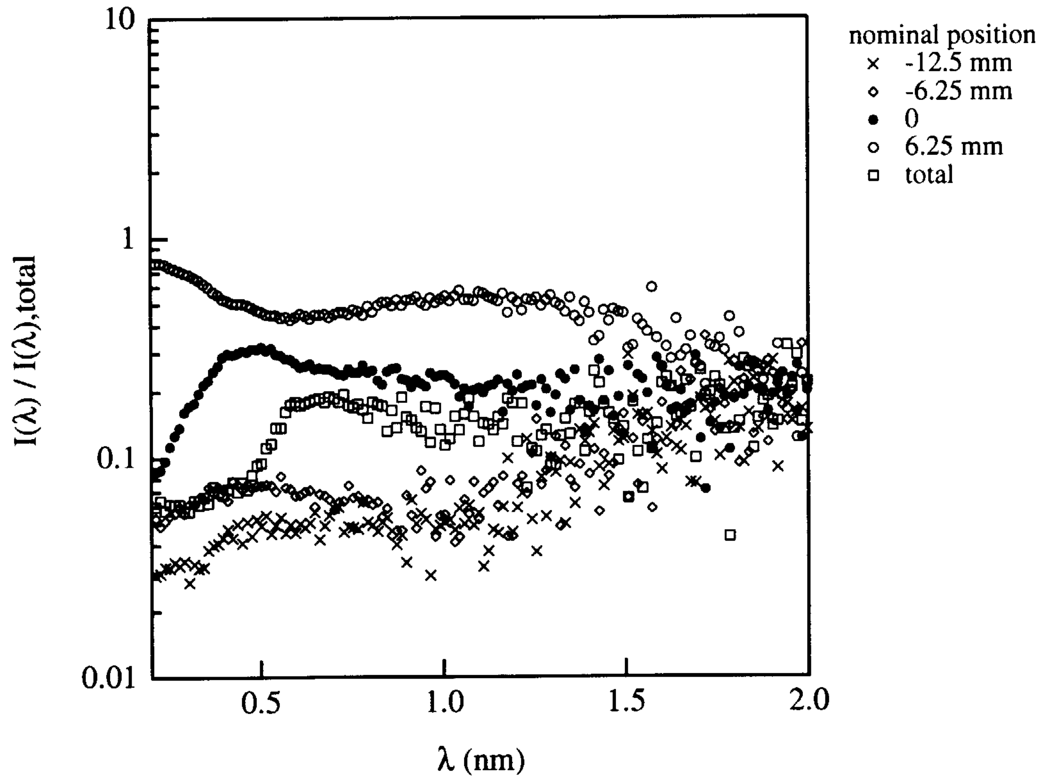

Fig. 5. Fraction of i(λ) for detector position to total neutron flux with 12 mm × 12 mm setting (wide straight setting).

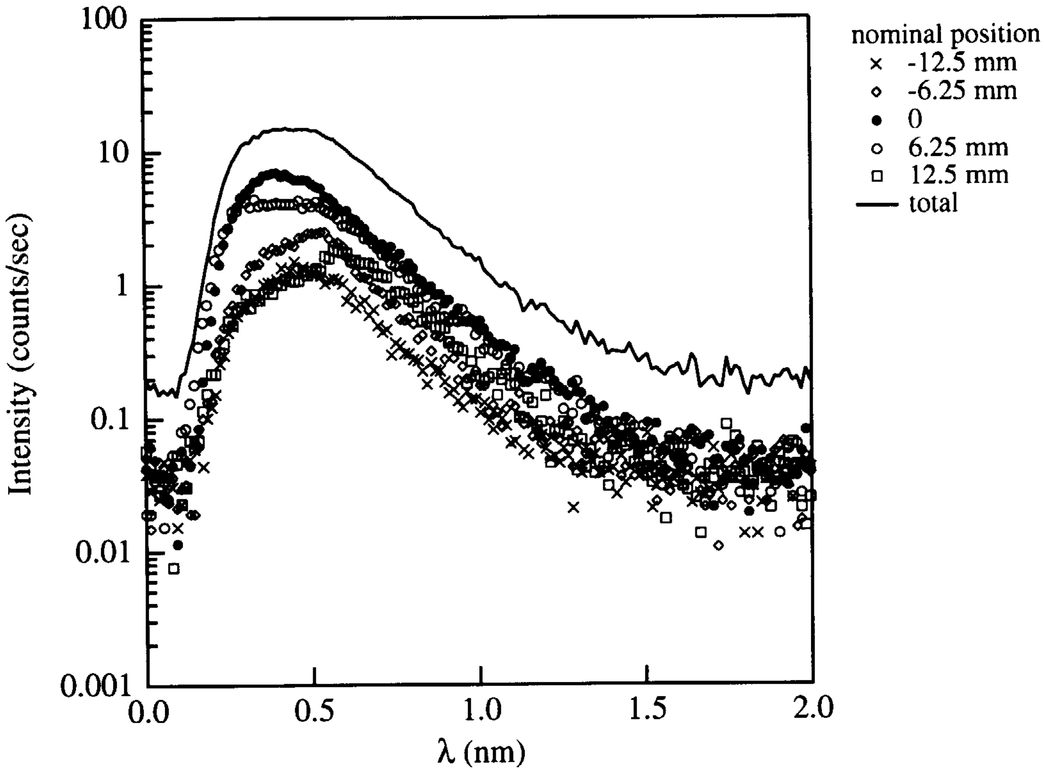

Fig. 6. i(λ) dependence for detector position with 12 mm × 12 mm setting (converging setting).

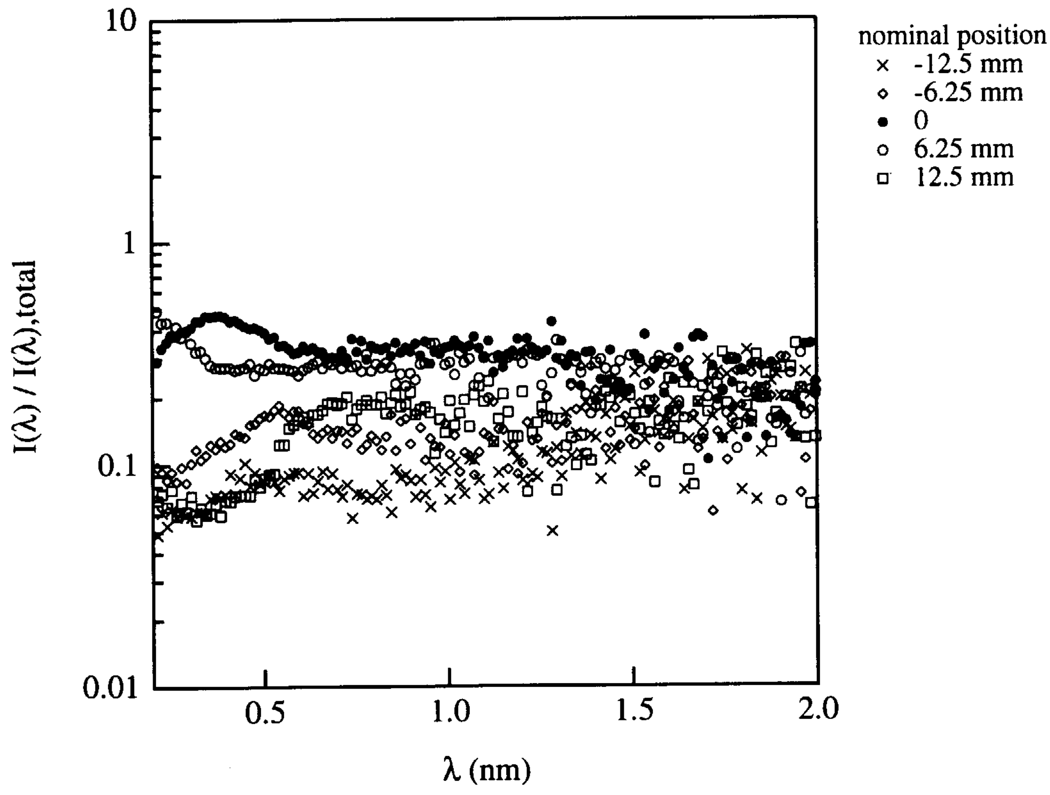

Fig. 7. Fraction of i(λ) for detector position to total neutron flux with 12 mm × 12 mm setting (converging setting).

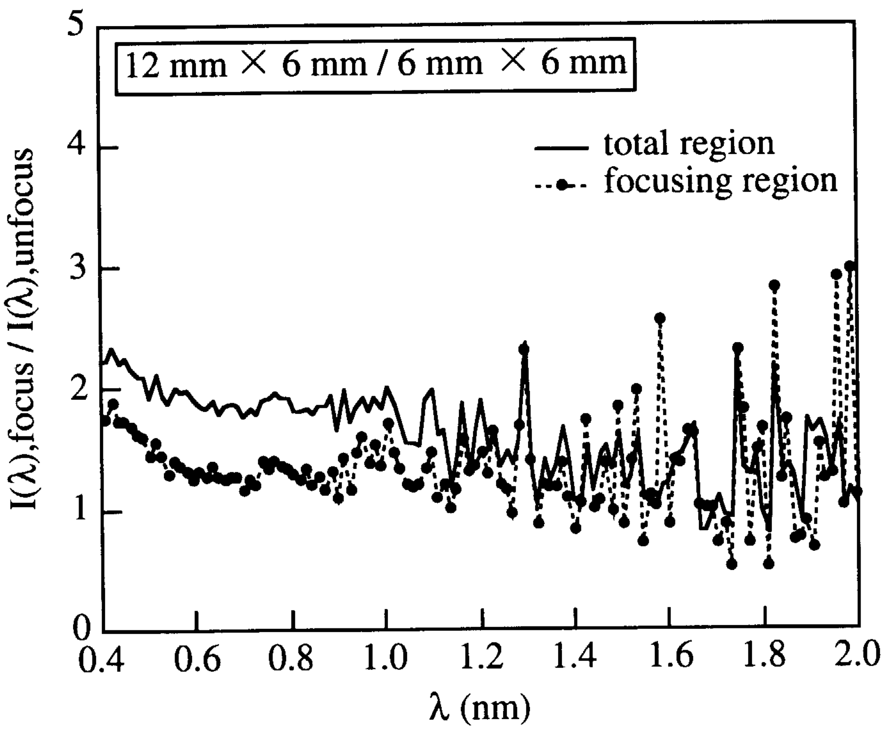

Fig. 8. Gain as a function of wavelength by converging setting to narrow straight setting.

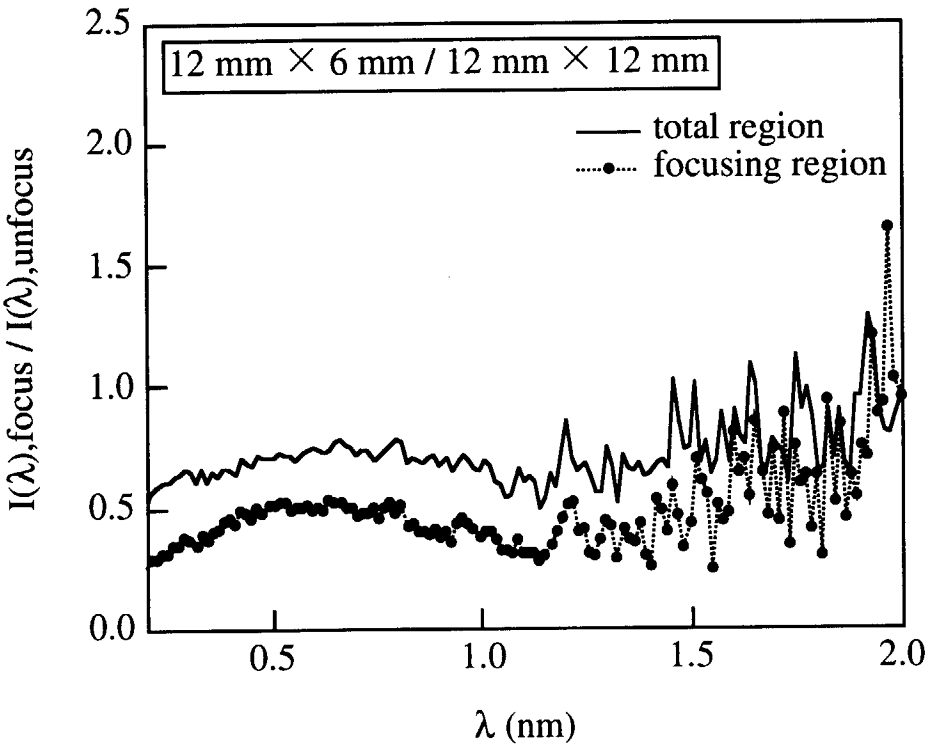

Fig. 9. Gain as a function of wavelength by converging setting to narrow straight setting.