Report on Installing Sagittal Focus Bender in Bending Magnet Beamline

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1. Introduction

Horizontal focussing of a synchrotron beam with the second crystal in a double crystal monochromator especially high energy region is of great importance to the bending magnet beamline of SPring-8, because the spectrum of flux of SPring-8 shifts toward higher energy compared to the second generation SR spectrum.

Main optical elements of the bending magnet beamlines are a monochromator and a pair of mirrors. One mirror installed downstream of the monochromator is vertical focusing type. The mirrors are actually effective until X-ray energy of ∼20 keV, and in high energy region (30 keV∼), the sagittal focus bender of the monochromator work well to increase flux density.

In this report, we tested the sagittal focusing bender at bending magnet beamline with the standard monochromator.

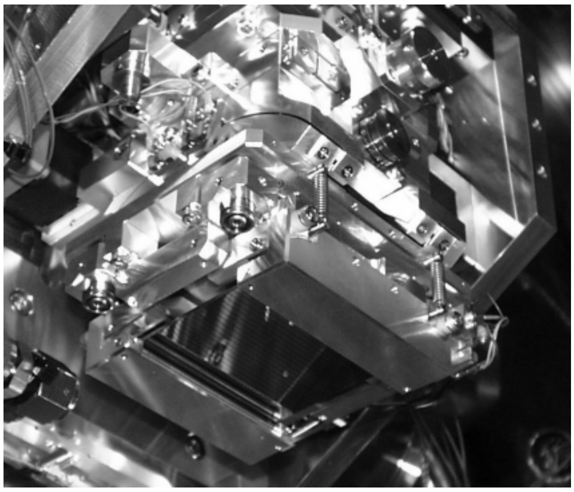

Fig. 1: Sagittal Focus bender with ribbed crystal installed in standard monochromator as second crystal.

2. Experimental Results

The prototype bender for standard monochromator of bending beamline was designed by Furukawa [1] and improved by optics group. This bender works as a curved second crystal of the monochromator as shown in Fig. 1. A Si(311) ribbed crystal was used to avoid the anticlassical bending. The ribbed crystal demension is 90 mm(along the direction of the beam) × 100 mm × 2 mm-thick, and cramped by four cylinders of the bender.

The sagittal focus bender was tested at BL14B1 with the beam current around 70 mA. Incident X-ray beam was limited to the area of 40 mm width × 5mm height by TCSLIT1(water cooled 4-jaw slits for white X-rays) installed on upstream of the monochromator. The monochromator is located at 37.5 m from the source and the horizontal beam size at the monochromator is 50 mm. Figure 2 shows Beam profiles photographed on the 3:1 sagittal focus point at 40 keV. In the case of unbent, the horizontal beam size was 65 mm. It was focused as decreasing the bent radius R. Changing the radius of curvature does not generate any signficant twist which causes loss of phton flux.

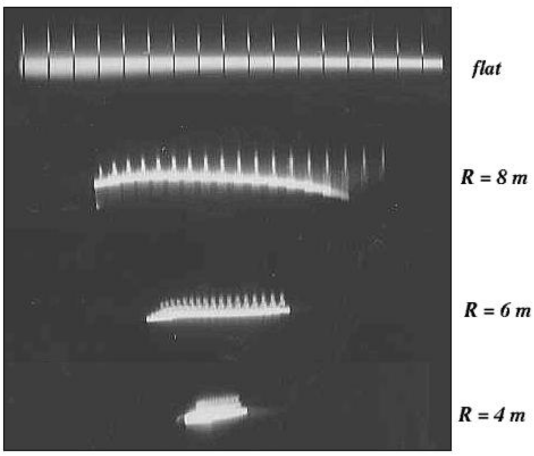

Fig. 2: Beam profiles with the sagittally focussing crystal monochromator at 40 keV. Period of ribbed crystal is 3 mm. X-ray beam was focused as decreasing bent radius R.

The horizontal X-ray beam size at the monochromator is 50 mm and the period of the ribbed crystal is 3 mm, that is, the flux density shuold be increased by 17 times. Figure 3 shows horizontal scans at the 3:1 focus position in cases the crystal was flattened and bent ($R = 4\ m$) at 40 keV. These profiles were obtained by using 0.5-mm-width tungsten carbide slit. The flux density at the fine focus increased 15 times larger than that when the crystal was flattened.

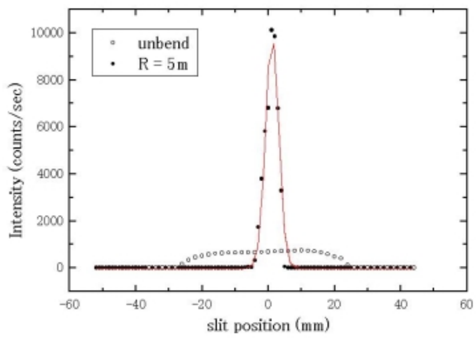

Fig. 3: Horizontal scan through the focus with the second crystal

Although it is required very tight controll to obtain the fine focussing as Fig. 2 and 3, we achieved the sagittal focus in high energy region with Si(311) crystal as we had expected.

When the X-ray energy is changed, the bent radius R also should be changed to obtain the fine focus. It is also required that the exit position of X-ray beam is fixed in use of sagittal focus bender. Figure 3 shows the energy dependence of the X-ray beam height from 40 keV to 60 keV. The beam position was measured in the experimental hutch after tuning the bent radius and the parallelity between the first and the second crystals. The deviation of the beam height from 40 keV to 60 keV was ± 0.15 mm. The horizontal beam size at each energy was focused within 3.5 mm.

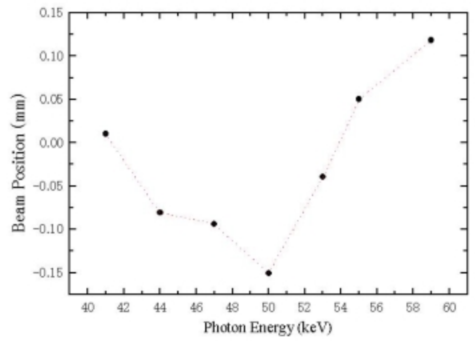

Fig. 4: Beam height in the experimental hutch measured from 40 keV to 60 keV

3. Conclusion and Improvements

We have demonstrated that the sagittal focus bender in the second crystal of a Si(311) double crystal monochromator can be used up to 60 keV with ribbed crystal at the BL14B1 beamline. Changing the radius of curvature from 2m (60 keV) to 4m (40 keV) does not cause any significant change to the beam position. Although the fixed height exit is achieved in wide band energy, tighter control on bender should be required for XAFS measurement.

One of the most serious problem of this sagittal focus bender is heatload. The bender was heated up to 70 °C by radiation from the first crystal. Altough the bender installed as a second crystal of monochromator of bending magnet beamline, water cooled plate shuld be needed.

This sagittal focus bender is designed for inclined double crystal monochromator. The property of sagittal focussing of inclined geometry with Si(111) plane will be checked soon.

References

[1] Y. Furukawa *et al*, SPring-8 Annual Report 1995, 191 (1995).