# Sagittal Focusing of the Adjustable Inclined Monochromators for Bending Magnet Beamlines

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## 1. Introduction

For the bending magnet beamlines of the SPring-8, adjustable inclined double crystal monochromators are proposed [1] to cover wide energy range of x-ray. In this report, focusing properties of inclined double crystal monochromator with curved second crystal and conceptual design of its bender are discussed.

## 2. Sagittal focusing with inclined geometry

There are no investigation on the sagittal focusing properties for inclined geometry, therefore using a ray-tracing code, RTW [2] which has been developed for the MS-Windows with full GUI, the spot sizes and relative throughput for the various configuration of the optics have been studied.

For simplicity, the ray-tracing was made for model beamline having only the double crystal monochromator located at the 35.74m from the source. The real bending magnet beamline designed for XAFS and the structural phase transition has a collimating and a refocusing mirrors, which do not effect significantly the horizontal beam properties. Focal plane (the sample position of the real beam line) is placed at the 47.65m point from the source, which is located at the 1.38m from a final Be-window in an experimental hutch. The focal plane is just on the 3:1 sagittal focus point. The other parameters used for simulations are standard beam ones of the SPring-8.

The bent radius R of the curved crystal for optimal focal properties is given by

$$R = 2 \sin \theta_B / ( (p^{-1} + q^{-1}) \cos \phi ), \quad (1)$$

where $\theta_B$ is the Bragg angle, p and q are the distance from the source to the bent crystal and the crystal to the focal plane, respectively, and $\phi$ is the inclined angle of the crystal [3]. For the SPring-8 bending beamlines $\phi$ =29.4962, 0 and 9.4462 degrees for Si(111), Si(311) and Si(511), respectively.

Horizontal beam profiles at the focal plane shown in Fig.1 for various reflections of Si at 20keV are the gaussian of profile, which means the sagittal focusing works well for inclined double crystal monochromator. The calculated horizontal spot width (FWHM) and transport efficiencies for the monochromatic x-ray beam are shown in Fig. 2 as functions of the x-ray energy. The energy region higher than 60keV has not been calculated because anticlastic bending effect degrades the beam intensity on the focal plane. The flat crystal should be used for this energy region [3]. This result shows that the sagittal focusing with inclined crystal has enough potential for the SPring-8 bending magnet source beamlines.

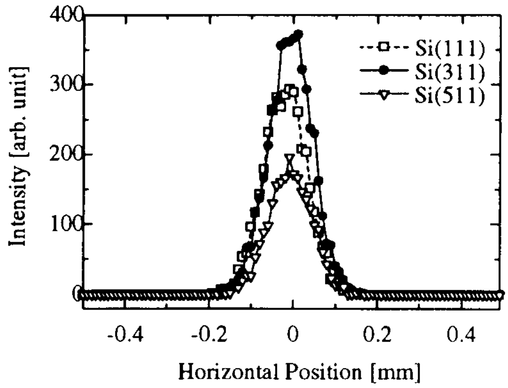


Fig.1. Horizontal beam profile on the focal plane at 20keV.

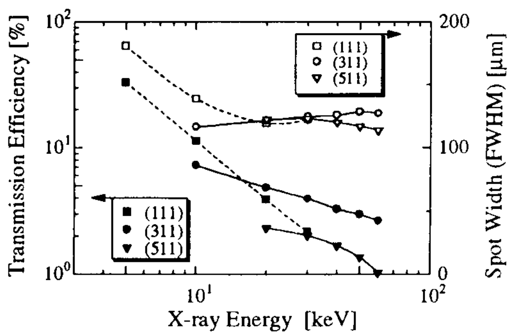


Fig.2. Transmission efficiency and horizontal spot width of the sagittal focusing of the adjustable inclined monochromator.

## 3. Conceptual design of crystal bender for the sagittal focusing

To change the x-ray energy maintaining the optimal focus properties at the focal plane, the bent radius R should be changed to saticefy the eq. (1) as the Bragg angle $\theta_B$ axis of monochromator revolves. It is required that the exit x-ray from the monochro mator keeps constant height in changing the x-ray energy, especially for XAFS measurements. However the center of the bent crystals of conventional crystal benders deviate as the bent radii are changed. The fixed exit height may be achieved by a vertical translational stage, but this introduces pitching or yawing of the monochromator crystal, which degrades quality of x-ray.

Using a simple theorem in geometry, we have proposed a fixed center height bender as shown in Fig. 3. The two circles A and B in Fig.3 are always across at the right angle to the circles C and D of which centers $O_C$ and $O_D$ are on the perpendicular bisector L of the centers of circle A and B. This shows that the crystal, which corresponds to the cirucle C or D in Fig. 3, is bent cylindrically without changing the height of middle point of the arc of the circle C or D, if pure torque applied at the cross points E and F.

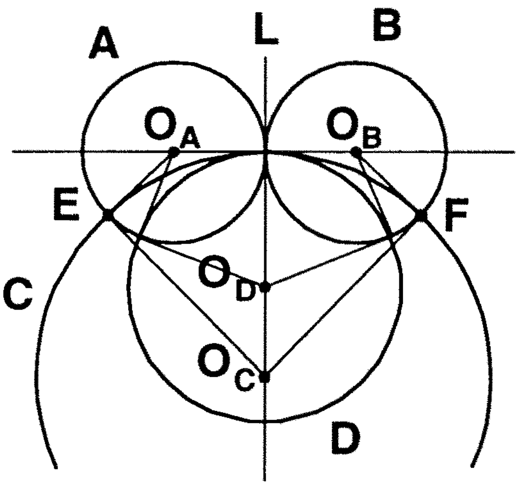


Fig.3. Geometrical condition of the fixed height crystal bender.

This can be realized by using a bender shown in Fig.4. The apparatus consists of the crystal, two arms with rollers to apply torque to the crystal and pushing mechanism which apply foces F in Fig. 4 to the arms . In principle, this is similar to the conventional four point bender [4]. The arms revolve around the middle point of the crystal center and rollers, which correspond to the $O_A$ and $O_B$ of the Fig. 2. To avoid the bending mechanism disturbing the x-ray path, finite offset between the center of crystal and rotation axis is introduced, while top of the circle C and D are on the line $\overline{O_AO_B}$, however there are no essential difference between the mechanism and the theorem in Fig.3.

An acryl model was made for checking the idea described above, and shown to work well.

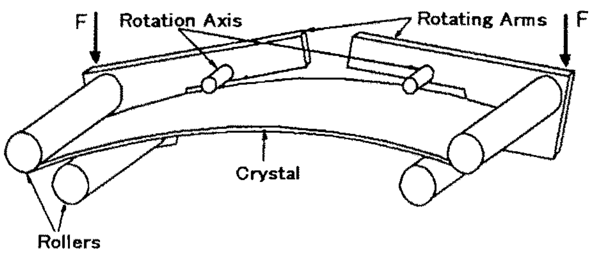


Fig. 4. Schematic view of the fixed height bender.

## 4. Summary


Sagittal focusing properties of an inclined double crystal monochromator with curved second crystal were studied using a ray-tracing code RTW and it is shown that this monochromator has enough focusing capability for the bending beamlines of the SPring-8. A basic design of fixed beam height crystal bender was also discussed. A test bender of Si crystal will be manufactured and tested soon.



References

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