ESRF	Experiment title: Studies of the reflection properties of bent Laue and Bragg crystals and their use in focusing fixed-exit monochromator	Experiment number: Mi-68
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Report: ESRF wiggler and bending magnets provide for the first time high energy photons from a low emittance source. The weak interaction of high energy X-rays with matter results in a small angle of total reflection, small Bragg angles, narrow rocking curves and low absorption. Classical optical components (mirrors, sagittal focusing, flat perfect crystals) become inefficient and require extreme mechanical precision. Mosaic crystals provide an increased inte- ~grated reflectivity but do not preserve the emittance. On the other hand, bent crystals can be adapted to the opening divergence of wiggler and bending magnet radiation, providing focusing and enhanced flux.

In the present experiment a bent Laue crystal in inverse Cauchois geometry was combined with a Bragg crystal in Johann geometry to give an energy tunable, focusing fixed-exit monochromator (60-100 keV) [1, 2]. The Laue crystal produces a virtual source which is then imaged by the Bragg crystal. The bending of the crystals widens the rocking curves and eliminates the contribution of the beam divergence to the total energy band pass. The 551 reflection of silicon was used for both crystals with the asymmetry angles being 76.90 and 3.00 respectively. The crystal thickness was 0.92 mm. The critical energy of the wiggler was 33.4 keV and 1 mm of Cu was added to the 4 mm of Al to prevent thermal damage of the uncooled crystals.

A vertically diffracting high order analyser crystal was used to study the beams reflected by the individual as well as the combined crystals. Both, the Laue and the Bragg crystal were characterized with respect to the parameters rocking curve width and polychromatic focus length. The resubs agreed well with theory. The analyser crystal was used to adjust the Laue crystal bending radius to match the Rowland condition by measuring the peak position of the rocking curve when a narrow slit was scanned across the crystal. Afterwards the Bragg crystal was ins tailed and its bending radius was adjusted by maximizing the peak reflectivity while minimizing the rocking curve width at maximal horizontal slit opening (48 mm).

Figure 1 shows the signal measured when the offset of a narrow horizontal beam was scanned across the incident beam. With the exception of the tip region the beam reflected by the Laue crystal is fully accepted by the Bragg crystal. The focused beam was characterized by slit (12 µm) scans for different secondary slit openings. Figure 2 indicates that aberrations were not observable and that slope errors were negligible. Note that the intensity distribution across the focus corresponds to the profile of the rocking of the Bragg crystal.
The flux was determined in a Compton scatter experiment. At 73.1 keV photon energy 2.15.1010 photons/sec/57.6mA/O.6mrad/0.016%bw were measured in the 1 mm wide focus in good agreement with theoretical calculations predicting 3.10^{10} photons. No explanation can be given presently for the stronger discrepancy found at 90 keV 1.02”1010 vs. 3.3”1010 photons/see.
The energy distribution in the focus was measured using the vertically diffracting analyser crystal. The energy is a linear function of the horizontal focus position. Further analysis showed that the monochromatic focus size corresponds to the source dimension when the source is imaged through a pinhole, i.e. the Laue-Bragg monochromator preserves the source emittance when bending errors can be eliminated.

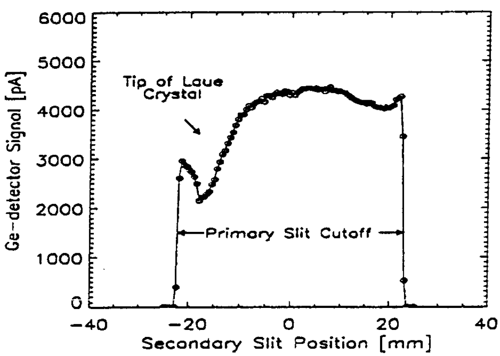

Figure 1: Intensity distribution measured in the focus position by scanning the horizontal offset of the secondary slits across the beam.

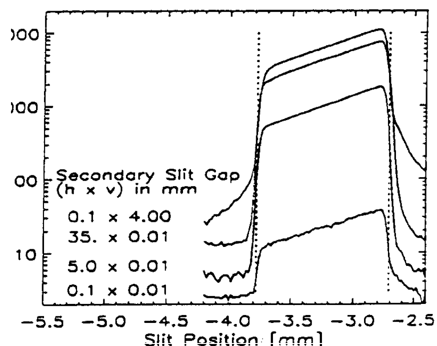

Figure 2: Comparison of the focal intensity distribution for different secondary slit openings.

The successfully tested prototype setup can be further improved by making use of lower order reflections, by adding a cooling mechanism to the Laue crystal and by better bending techniques. With an improved version of the Laue-Bragg monochromator 10^{12} Pht/sec will be obtained up to 100 keV photon energy.

[1] CJ. Sparks, BNL report 26740, (unpublished)
[2] P. Suortti and C. Schulze, J. Synchrotrons Rad., 2, (1995), 7