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Focus study to measure phase effects of a bent Laue beam expander

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At the Canadian Light Source (CLS) in Canada, the BioMedical Imaging and Therapy (BMIT) bend magnet (BMIT-BM) beamlines and insertion device (BMIT-ID) have been very successful in their mission to image biological tissue and conduct live animal imaging studies. However, since their inception, they've been limited by the vertical beam size. This poses limitations for imaging modalities such as micro-computed tomography and dynamic phase imaging, techniques which are necessary to remain at the cutting edge of biomedical imaging research.

In order to observe edge-enhancement refraction effects, the source must be angularly small. When an X-ray beam is diffracted through a Bent Laue crystal, the apparent angular source size can be adversely affected if the single-ray focus does not coincide with the geometric focus. In order to preserve the beam's transverse coherence, these two focal points must coincide in what is referred as the "magic condition."

We previously reported results of a vertical beam expansion up to 7.7x. However, these attempts resulted in significant degradation of the beam's phase characteristics in the vertical direction (corresponding to horizontal edges in the object). We approached this problem from two angles. On the Physics side, we derived a better approximation for the polychromatic focal length and carefully merged it with the well-established geometric focus equation. On the Engineering side, we developed a bending frame that more carefully controls the bend radius of the crystal. The result of this effort is a great improvement in the coherence of the expanded beam, enabling techniques such as dynamic phase imaging at the BMIT beamlines.

In this work, results are presented of a focus study around the optimal Bragg angle for a (5,1,1)-type silicon wafer using a (3,1,1)-type reflection with asymmetry angle χ=3.33°. Images of tungsten carbide blocks (knife edge) and Lucite rods (phase object) were analysed to determine the width of the edge or phase fringe, measured in pixels, as a function of the Bragg angle. In summary, our findings were that the "magic condition" is somewhat soft and robust against deviations from the optimal energy, allowing some freedom in energy choice to suit other requirements from imaging experiments, such as specific K-edges of contrast agents or absorption characteristics of the sample.

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