The Kirkpatrick-Baez Mirror Configuration at the Complex Materials Consortium Collaborative Access Team (CMC-CAT) Beamline 9-ID

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Introduction

The 9-ID beamline managed by the CMC-CAT at APS is a multipurpose monochromatic diffraction and spectroscopy beamline with experimental hutches located between 60 and 80 m from the source. In its current configuration, a six-circle diffractometer is located 64 m, a liquid surface spectrometer is located 69 m, and a small-angle scattering camera (with 7-m rail) is located 72 m from the source. In order to deliver a focused beam over this distance range, a Kirkpatrick-Baez mirror configuration has been implemented, with the horizontal focusing mirror (HFM) and vertical focusing mirror (VFM) located in the first optical enclosure, after the monochromator, at 33.3 and 34.4 m from the source, respectively. The purpose of the above mirror configuration is to provide a 1:1 image of the undulator source at the experiment with optimal beam size and divergence conditions.

Methods and Materials

The VFM and HFM are three-stripe (Rh, Ni, and Au) mirrors on polished ultralow-expansion (ULE) substrates with benders; they are manufactured by SESO. The reflecting surface of the HFM is 800 × 120 mm and that of the VFM is 600 × 90 mm. Both can accept a maximum incident angle of 4 mrad. The bending radius of each mirror can be varied from ∞ to 1.5 km, thereby changing the position of the focus or even set to yield a perfectly collimated beam.

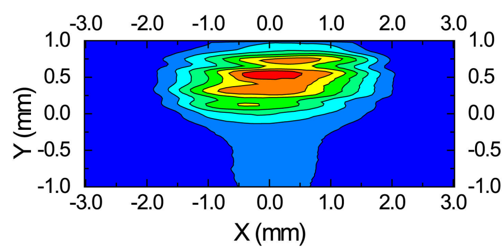
Results and Discussion

Mirror Performance

The focusing capability of the mirrors was measured by using a 45-μm pinhole (in 300-μm-thick Pt) mounted in the secondary optical enclosure, 60 m from the source. The pinhole was mounted on an X-Y translation stage with a resolution of 1.5 μm in the vertical Y direction and 3 μm in the horizontal X direction. A pin-diode detector was used to measure the direct beam flux.

The beam was aligned to reflect off the Rh coating on both mirrors with the vertical angle of incidence set to 2.32 mrad and the horizontal angle of incidence set to 1.57 mrad. X-Y mesh scans were taken with the HFM and VFM benders set to produce unfocused and focused beams. For the purpose of this characterization, the beam size was limited to 0.8 mm (vertical) × 2.1 mm (horizontal) by the white beam slit, with the mirrors accepting the total vertical beam width and 1.2 mm of the horizontal beam width.

The profiles of the unfocused beam and beam focused at 60 m are shown in Fig. 1. Deconvoluting the pinhole size from the total widths yields a focused full width at half-maximum (FWHM) beam size of 89 μm (vertical) × 700 μm (horizontal). The significant structure in the unfocused beam appears to result from the inhomogeneous reflectivity of the VFM; however, the structure disappears when the beam is focused. The theoretical FWHM source size is 50 × 844 μm. In the horizontal direction, the measured FWHM is smaller because of the shallow incident angle of the mirror, resulting in only a fraction of the total beam being accepted. In the vertical direction, one contribution to the larger measured beam size is from the transmission of the harmonics through the tapered pinhole, which increases the apparent beam size. A final characterization remains to be performed with the mirrors at their maximum



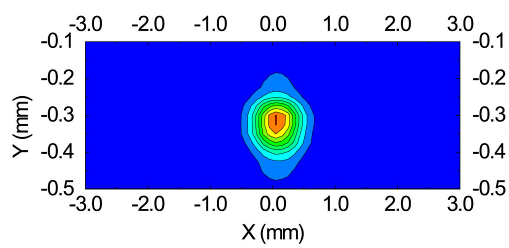


FIG. 1. Unfocused beam (top) and horizontally and vertically focused beam at 60 m from the source on beamline 9-ID.

incident angle, allowing acceptance of the full beam and maximum harmonic rejection.

Beam-pipe Articulation

When the incident angle of the x-rays on either the horizontal or vertical focusing mirror is changed, a maximum beam excursion at the entrance of the experimental station of about 360 mm is incurred. To accommodate this beam motion, a beam pipe articulation mechanism has been installed in the downstream section of the beam transport system. In this design, a 6-m-long section of beam pipe is attached to a gimbal mount, which allows free horizontal and vertical rotation around its upstream end. On the downstream end, the beam pipe reaches into the experimental station; the shielding integrity at this transition is maintained by a compliantly moving guillotine. Motion of this beam-pipe section is facilitated by a bridge equipped with actuators and air pads, which allows for horizontal and vertical motion of this structure.

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