BL35XU

High-Resolution Inelastic X-Ray Scattering

1. Introduction

During FY 2006 (April of 2006 - March of 2007) most experiments at the beamline were supported by S. Tsutsui, A. Baron, as J. Sutter had moved to Diamond Light Source and D. Ishikawa was primarily doing work away from the beamline. In December of 2006, H. Uchiyama arrived at SPring-8 as JASRI staff. Beamline improvement proceeded on several fronts, including installation of a KB setup for (beam size < 20 m) and a plan to upgrading the BL35 undulator.

2. KB Setup

For many experiments, a small beam spot is desirable. The optimized beam spot at BL35 using the bent cylindrical mirror, about 50 m x 70 m (VxH, full-width at half-maximum (FWHM)), is good, given that the focusing setup accepts the full beam from the undulator and that the beam divergence remains 0.1x0.3 mrad, FWHM, after focusing. However, for some experiments, a smaller size would be highly desirable. This includes experiments with very small samples (e.g. high pressure work with samples in a diamond anvil cell (DAC)) and also measurements at extreme grazing incidence, though, in both cases, one needs to be careful about the increase in divergence with focusing.

We have been pursuing a compound optical scheme with a the goal of achieving a focus of < 20 m diameter, while retaining good throughput. The upper limit on the size is set by typical sample sizes for DAC experiments, and noting that most experiments are count-rate limited, making thick samples highly desirable. The final system was then a reasonable compromise between performance, flexibility and cost. The main issues were preserving space near the sample (for diffractometer motion) and, of course, achieving the desired focal spot size without large losses (throughput >50%). The essential optical scheme is shown in figure 1. The large (1m) main cylindrical mirror is used to over-focus the beam and then followed by smaller (15 and 20 cm) mirrors generating the final focus. The short mirrors, especially the horizontal focusing, mirror require elliptical shapes (cylindrical is not sufficient). Fixed curvature mirrors (SESO, JTEC) were considered, and also bent flat mirrors from Xradia. However, as the final mirror had to be 20 cm (too long for JTEC) and as the bender setup took too much space near the sample, we chose fixed elliptical mirrors from SESO. Some flexibility for

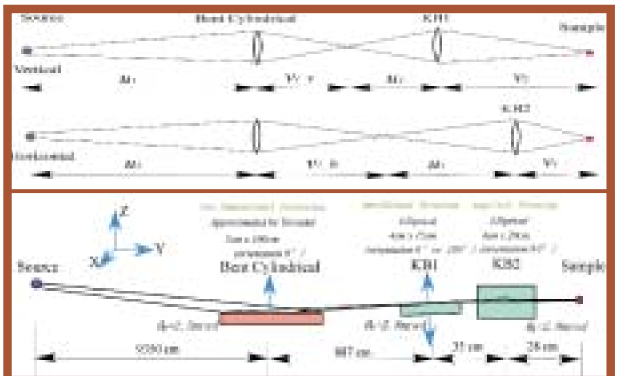

Figure 1. Optical setup for compound focusing. The top panel shows this schematically while the lower one gives the setup at BL35. Note drawings are not to scale.

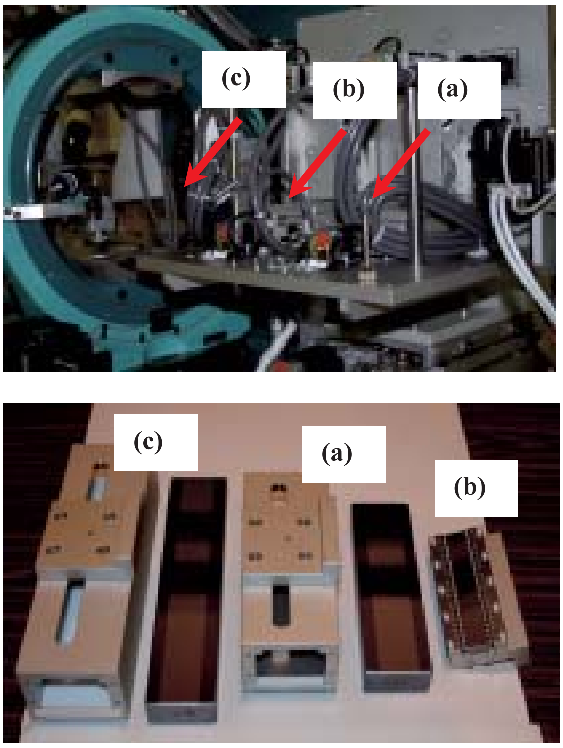

Figure 2. KB Mechanics and Mirrors
The top panel shows the mounting scheme (see text) with arrows showing mirror locations. The lower panel shows the mirrors and holders. Letters (a-c) correspond to the vertical focusing, vertical deflecting and horizontal focusing mirrors and mounts.

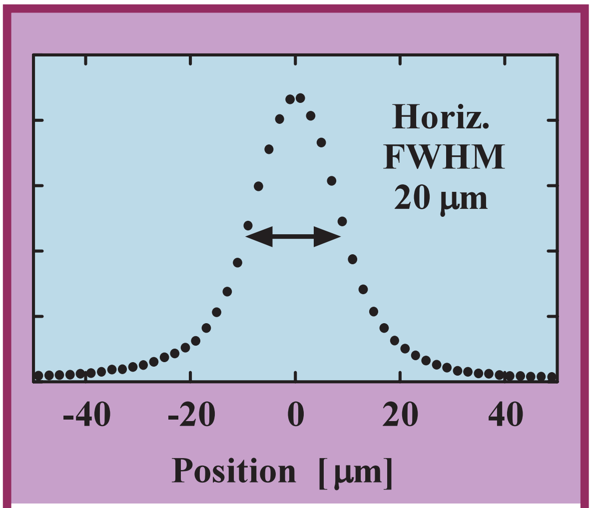

Figure 3: Measured horizontal beam size.

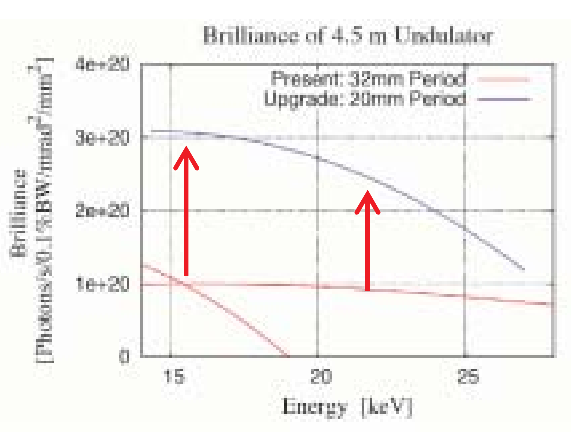

Figure 4. Brilliance improvement with a short period undulator at BL35

optimization is then insured by the varying focal length of the bent cylindrical mirror, One notes that under-focusing with the cylindrical mirror was also considered, however, companies did not have experience with the required hyperbolic figure, so over-focusing was the more conservative choice.

The mirrors (and holders) are shown in the lower panel of figure 2, with the longest (20 cm) mirror for the horizontal focus and the 15 cm for the vertical focus, and also a short (10 cm) mirror designed to allow the beam to be deflected, e.g., to allow grazing incidence onto a liquid surface. The mechanical setup is shown in the upper panel of figure 2, with the mounting for the first two mirrors (vertical focusing, and vertical deflecting) visible in the figure. The mount for the final, horizontal focusing, mirror is not installed in the photo. It fact, the removal of the last mirror and mount was an important design parameter of the system: the end of the horizontal mirror is only 18 cm from the sample, so it limits the motion of the diffractometer omega circle in one direction. It is therefore only installed when used. The other mirrors can be left in place and simply moved slightly our of the beam path.

The final mirrors were delivered late by SESO, so testing tool place in stages. Figure 3 shows a 20 micron measured horizontal spot size, using a slit scan, so the real size is a bit better (˜15 m). In the vertical, our tests showed a similar size, <20 m , but we must improve our measurement system to determine the final value (the vertical slit scan for that test was not stable). The expected size from ray-tracing (including the slope error of the large mirror) is 5 x 12 m2. (VxH, FWHM) The main setup time is now the re-alignment of the upstream optical components to allow installation of the KB mirrors while keeping the sample position fixed in the center of the spectrometer. Presumably this will improve with experience.

3. Toward Flux Improvement at BL35

Many experiments at BL35 remain flux limited. Considerations last year (see the 2005 annual report) of an optimized long-undulator beamline showed that a short-period small-gap undulator could be chosen to improve the flux/unit heat load by working only in the fundamental. This reduces the tuning range of the beamline, but, given that most experiments at BL35 occur between 14 and 22 keV, this is a feasible. Notable enabling points at SPring-8 are the high, 8 GeV electron beam energy, the expertise with in-vacuum undulator technology and the very good emmittance, which combine to make it possible to consider such an insertion device, with a minimum gap of 6.5 mm. For a long, 22m, undulator, gains of a factor of 20 were calculated. An immediate corollary is then that even a short 4.5m device can yield improved performance compared to the present beamline, as seen in figure 4. An upgrade is now (FY2007) in progress with the very strong support of JASRI and RIKEN.

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