BL35XU
High-Resolution Inelastic X-Ray Scattering

1. Introduction & Overview

During FY 2009 (April of 2009 - March of 2010) the BL35XU scientific staff included A. Baron, S. Tsutsui and H. Uchiyama, with additional support on specific issues from D. Ishikawa, H. Fukui and D. Ellis. Technical support, from SES, was mostly T. Oguchi with help from H. Yahata and then (after H. Yahata changed groups) from M. Hanada. The largest change at the beamline was the ID upgrade. We also continued a collaborative project with Brookhaven Lab investigating kinoform lenses for efficient micro-focusing and began to consider prism lenses as made by the Karlsruhe Institute of Technology. Great effort, mostly not discussed here, was devoted to design of a next-generation beamline for IXS using a long-undulator, in collaboration with other groups at SPring-8, of course.

Scientifically, work continued on both crystalline and disordered materials. Work on the new Fe-based superconductors began to slow, while new projects started in several areas. Work on samples in diamond anvil cells continued, as did investigations of liquid surfaces.

4. Unduator Upgrade

The undulator upgrade at BL35XU dramatically improved performance across the board. Considering the design BL43LXU made it clear that it should be possible to improve the flux at BL35XU by reducing the ID period – essentially trading the low-energy part of the spectra for a very strong fundamental tunable from 14.4 to 26 keV. Furthermore, the increase in flux would be without an increase in total power on the mono, as the increased number of magnetic periods lead to a narrower band-width undulator fundamental. The peak power density did increase, however, but this was deemed to be within the tolerances of the present front-end components. One should note that the new ID (figure 1) uses hybrid pole pieces on a new undulator frame design, in part as a test for future insertion devices. SPring-8 also now has a “spare” frame, which will allow other ID changes to be done with the magnets installed off-line, and the ID swapped in/out without a long (~several month) down-times.

The performance of the new ID was essentially as expected, with measured flux increases of between 2 and 3 times between 15.8-21.7 keV (see figure 2). All experiments saw the improvement immediately. In order to preserve the resolution in the face of higher flux from the mono, the band-width-reducing offset crystals had to be changed. These crystals, which reduce the heat-load on the

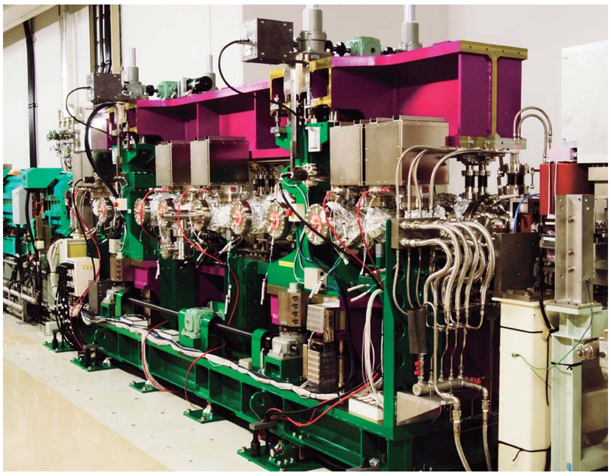

Fig.1 Photograph of the new ID installed at BL35XU. The magnetic period has been reduced to 20 mm to improve flux and the frame structure has been modified.

backscattering monochromator to prevent thermal distortion of the resolution function were switched, with, now, slightly asymmetric crystals used in each case: Si(400) at 21.75 keV (1.5 meV resolution), Si(220) at 17.8 keV (3 meV resolution) and Si(111) at 15.8 keV (6 meV resolution).

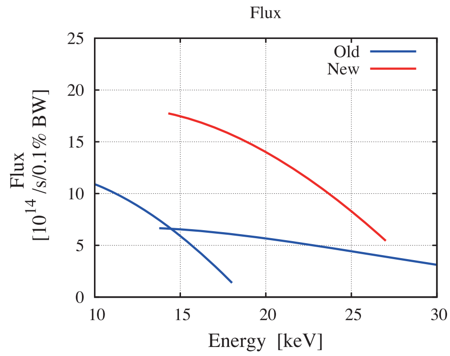

Fig.2 Calculated performance of the new 20 mm period ID compared to the 32 mm standard device.

2. Long Scan Range Monochromator

Following on earlier work, efforts continued to develop a long-scan-range backscattering monochromator, primarily aimed at investigations of electronic excitations. A three-crystal backscattering monochromator designed to provide ~40 meV resolution was installed and first tests made. Generally, the resolution was as expected (see figure 3) however the flux was a bit low (about triple the usual 6 meV setup, whereas about 5 to 6 times

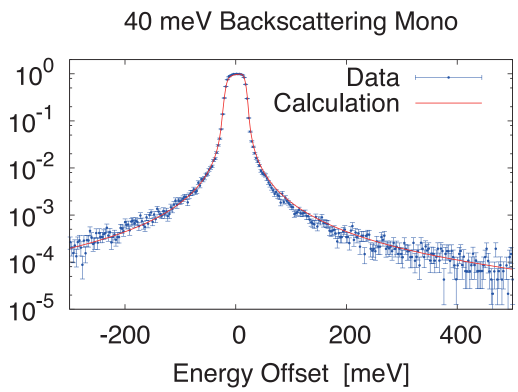

Fig.3 Response of the triple-crystal backscattering mono mono compared against a calculation using the dynamical theory of diffraction.

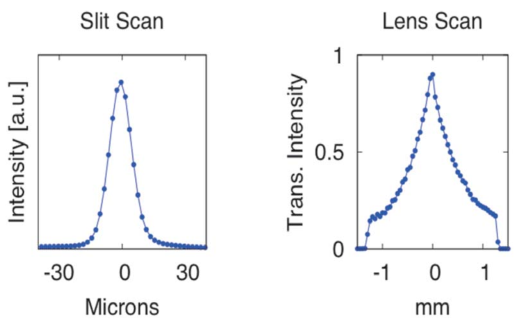

Fig.4 Response of Prism Lens (after[1]). Left panel shows a slit scan through the focused beam. Right panel shows the effect of scanning the lens through a small beam: acceptance (FWHM) is about 0.7 mm with a 0.7 m focal length.

had been desired) and the setup time was long. Work will continue to improve this.

3. Prism Lens

Achieving an efficient micro-focus (ie: ϕ~5 microns) of the full x-ray beam remains a significant challenge even at 3rd generation sources. While just achieving a micron focus is not so hard, to make such a focus *without losses* for the full beam is difficult, and becomes harder as the energy is increased beyond 10 keV. The main problem is the *horizontal* focus, as there is a severe source asymmetry: the horizontal x-ray emittance is ~20 nm-rad (FWHM: ~650 micron source size x ~30 micro-radian beam divergence) while the *vertical* is ~0.1 nm-rad. Thus the focusing in the horizontal is qualitatively a different problem than in the vertical. BL35XU presently uses a bent cylindrical mirror followed by a Kirkpartick-Baez (KB) mirror pair to get a ~16 micron focus of the full beam with ~40% throughput. However, both at BL35 and, eventually at BL43LXU, we would like to do better – with a spot size of more like 5 microns and efficiency ~80%.

Prism lenses function as a cross between a wave-guide and a refractive lens, using refraction in small (~10 micron) triangles of SU-8 polymer to guide the beam into a small spot. (SU-8 has a good radiation resistance, as compared to plexiglass, for example). While the spot size is limited by the ~10 micron triangle size, this is about the range of interest. First tests (figure 4) showed a focal spot size of about 13 microns of which the soruce contribution is about 10 microns and an acceptance of ~0.7 mm, FWHM. While this acceptance is actually quite good for a 0.7 m focal length, it would still lead to significant losses in real operation with a ~3 mm wide beam. We are considering how to proceed.

4. Next Generation Beamline

Great effort continued to focus on BL43LXU. Work in this period largely focused on pinning down details of the design of components, including the monochromator, mirrors, hutches, etc. This had great help from the SPring-8 Optics group.

5. Other

Other improvements, reports, and changes include:

- The granite base for the spectrometer did *not* require re-alignment in the summer of 2010.
- The problems with the liquid helium refrigerator (noted last year) were determined to be from a flaw in fabrication, this was corrected so it now is working well.
- Data processing software was upgraded to allow multiple bin sizes in data display.
- The temperature control of the analyzers still showed some instability (occasional jumps of ~3 to 10 mK) whose source (controller, or cabling) is still under investigation.
- Problems with a cut of the central cone from the ID, upstream of the mono at BL35XU, were resolved by a slight horizontal electron-beam orbit adjustment.
- Work was started (D. Ellis, D. Ishikawa) on a new temperature control system that may eventually replace the present commercial one.

[1] H. Fukui, V. Nazmov, M. Simon, J. Mohr, A. Baron, *et al* : work in progress.

Alfred Q. R. BARON
Satoshi TSUTSUI
Hiroshi UCHIYAMA
Daisuke ISHIKAWA
Hiroshi FUKUI
David ELLIS