BL43LXU
RIKEN Quantum NanoDynamics

1. Introduction

The bulk of the beamtime at BL43LXU [1] in 2022/2023 was for user experiments, but also included some testing, installation and commissioning of new equipment (see below). The present report will, as usual, emphasize both the changes and the problems at the beamline to provide a record of progress and to provide useful information to others working to develop SR instrumentation. The impact of the COVID-19 outbreak on travel had largely dissipated by the end of FY2022 though it still hampered things in the early part of the year.

Work at the experimental stations has largely been done by members of the Materials Dynamics Laboratory, with assistance on some projects by members of JASRI, and RIKEN. K. Taguchi also provided part-time help. BL43 also had occasional help from full-time members of the engineering team on specific tasks including standard start-up of the LN_2 cooling for the mirror and mono, and, sometimes, setup of sample refrigerators.

2. Upstream of the Optics Hutch

The upstream components (electron orbit, IDs, mirrors, HHL mono) were stable during this period. The orbit-correction protocol operated smoothly, and there were no issues with the IDs.

3. High Heat Load Mono

Several changes were made to the monochromator that affected its performance under high power. This will be detailed in a future report. However, it is worth noting that as of the present time, very good conditions were obtained for either very high power running (18 and 22 keV) or for high energy (25 and 30 keV) running but not yet both. This is under investigation as it impacts the extremely high resolution setup discussed below. It may in fact be due to issues with optics downstream of the HHL mono.

4. Medium-resolution Spectrometer

Most work during the year used the high-resolution spectrometer.

5. High-resolution Spectrometer

This operated reasonably over most of the year. There was one period when meV-scale energy shifts appeared on some analyzers. This was finally traced to an incorrect setting in the software. The granite base remained stable.

6. Extreme Resolution.

We are now working to achieve higher resolution, continuing our work from previous years. During the present reporting period, we tried new silicon crystals, new detectors, and a modified geometry, as will be discussed. Building on these changes, we were finally able to successfully collect data from a sample with 0.38 meV resolution.

7. Silicon Crystal Perfection

We tested two crystals made from extremely high resistivity silicon (>30 kOhm-cm) from SUMCO. This company is willing to provide extremely high resistivity undoped silicon ingot material on a case-by case basis. We found that the crystal perfection was surprisingly non-uniform: two pieces cut from neighboring locations in one ingot yielded different resolution, with one piece having an area of good response and the other being significantly poorer. In both cases the crystal were prepared in the same way, with the reflecting surface etched and not polished. The positions -dependent resolution can be seen in figure 1.

8. Lambda Flex Detector

We began working with a Lambda Flex detector from X-Spectrum. This detector consists of 4 low-profile boards, each with a 14x14mm² detection area on a board of size of 14 mm x ~100 mm x ~5 mm, with the main electronics separated from these boards by 1 m long cables. We designed a module case holding 2 boards that allowed and active area of 14x28 mm² to be placed very close to the x-ray beam.

The new detector has some advantages and disadvantages compared to the previously used DECTRIS detectors. The biggest improvement is the geometry, as the Flex low profile design, with separated electronics, allowed straightforward integration into our setup with redesign of only a few components. However, the Flex readout time is ~1 ms, as compared to the deadtime free readout of the recent DECTRIS detectors. The 1 ms dead time then limits the practical frame rate to ~10 Hz to keep losses below 1%, which significantly limits the dynamic range and complicates the data processing when the required noise reduction is applied (see [2]). Another issue is that while the 55 um pixel size (from the medipix chip) of the Lambda detectors allows, in principle, good position resolution, this resolution is in fact, better than is needed for the IXS work (~0.1 or

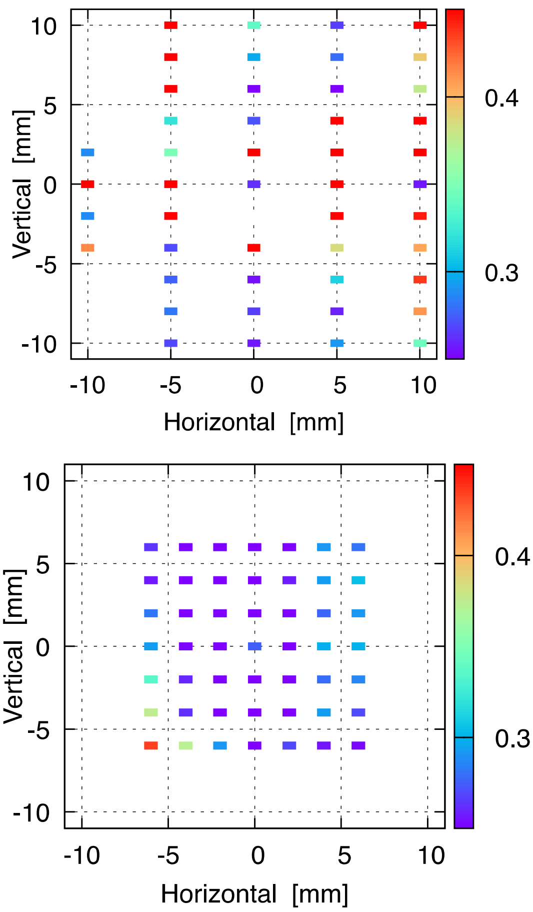

Fig. 1. Resolution at different locations for two silicon crystals from the same very high resistivity ingot. The color scale is the measured full width at half maximum (FWHM) in meV at the Si(15 15 15) reflection at 29.66 keV,

even ~0.15 mm would be sufficient). The small pixel size makes charge sharing more problematic, reducing the detector efficiency. This is under investigation. Also, we note that the initial calibration of the detector was not uniform, with one of the 4 chips having a calibration that was off by several keV at 20 keV, and this had to be changed by SP8 staff. In fact, this chip finally failed entirely and was replaced.

The final performance of the detectors was acceptable, with a real background rate <~0.004/s/cm^2. This, however, requires both extensive data processing and also shielding around the detector [2]. It is interesting to note that in fact the first attempt at carefully shielding the detector used Pb parts provided by an external company (Asahi) according to SPring-8 design were used. However, the Pb material used by Asahi was slightly radioactive and lead to backgrounds >0.02/s/cm^2. This required some time to understand and was finally corrected by fabricating the shielding from 5mmthick Pb plates supplied by SPring-8. Those plates had been tested and seen to have low backgrounds. This issue, lightly contaminated Pb, is apparently not extremely rare, with Pb material contaminated by heavy radioactive elements (e.g., Th). This does not pose a health hazard, but should be avoided in very sensitive experiments.

9. Laser Hutch

We installed a small (~2m x2m square) hutch on the experimental floor that for testing the IR lasers used for heating high pressure samples (see figure 2). This allows testing of the laser operation and indeed the DAC heating before IXS beamtime.

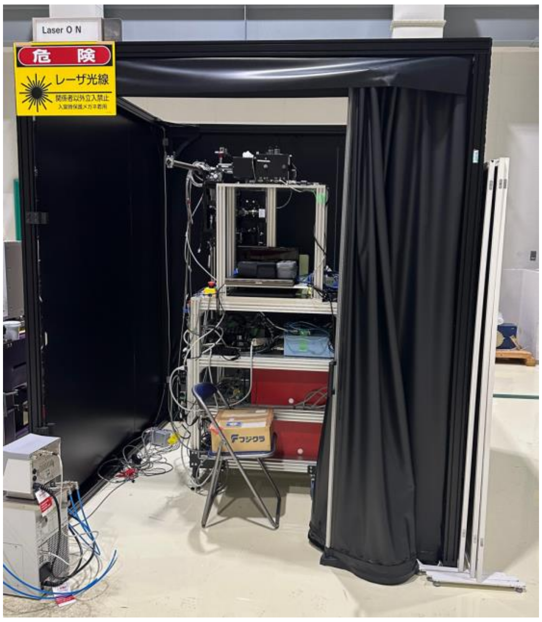

Fig. 2. Small hutch for testing/using the IR laser heating and operation off-line.

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References:

[1] A. Q. R. Baron, SPring-8 Inf. Newsl. **15**, 14 (2010) http://user.spring8.or.jp/sp8info/?p=3138 and A. Q. R. Baron, in *Synchrotron Light Sources Free. Lasers Accel. Physics, Instrum. Sci.*, edited by E. Jaeschke, et al. (Springer, Cham, 2016), p. 1643–1757. See also http://arxiv.org/abs/1504.01098

[2] A. Q. R. Baron and D. Ishikawa, Nucl. Inst. Meth. Phys. Res. A **1049**, 168101 (2023) https://www.sciencedirect.com/science/article/pii/S0168900223000918