BL19LXU
RIKEN SR Physics

1. Introduction

BL19LXU is a hard X-ray beamline equipped with a 27-m in-vacuum undulator in one of the four long straight sections of the SPring-8 storage ring. Experimental hutches (EHs) 1, 2, and 3 have been in operation since FY2000, and EH4 was constructed in FY2001.

The beamline has been continuously updated as follows. Major updates in the optics hutch include the installation of a transport-channel (TC) mirror to reject higher harmonic radiation (FY2004), the installation of precision four-jaw slits (FY2010), the renewal of the stages (FY2013), the installation of the cooling pipes in the double-crystal monochromator for enhanced stability (FY2015), the installation of an in-line beam monitor made of a diamond thin film (FY2015), and the replacement of the vacuum system from turbomolecular pumps to an ion pump (FY2017) to keep the surfaces of the monochromator crystals and the mirrors clean. In FY2017, the minimum photon energy was lowered from 7.270 keV to 7.092 keV, which is below the iron K edge at 7.112 keV, by changing the minimum gap size of the undulator.

For micro- and nano-focusing, Kirkpatrick–Baez (KB) mirror systems were permanently installed in EH 3 (FY2014) and EH4 (FY2010). The outdated Ti:sapphire laser system was updated (FY2016), and the repetition rate was increased from 1 kHz to 10 kHz, which improved efficiency in time-resolved experiments. In accordance with the 10-kHz system, the X-ray chopper was also upgraded to select a single bunch at 9.49 kHz (FY2016). To improve the experimental environment, the lighting in the hutches was changed from fluorescent tubes to LEDs (FY2015), the precision air-conditioning systems in EH1 and EH3 were upgraded (FY2016), and the doors of EH1 and EH3 were motorized (FY2017). The PLC system was upgraded to allow users to select the active hutch and to operate in a remote mode at all times for users' convenience (FY2018). The regles of the doors of EH1 and EH3 were backfilled to seamlessly join the floors inside and outside the hutch, which makes it much easier for users to carry heavy apparatuses into the hutch (FY2019). A heavy-load Z stage was installed in EH2. The Z stage mounts the X-ray chopper, a four-jaw slit, and the diamond thin-film beam monitor, and these components can be easily adjusted to the beam axis.

2. Recent activities

For many years, the TC mirror was used in many experiments to reduce higher harmonics. Then, drift of the beam position emerged as a problem in using the TC mirror. To stabilize the mirror system, a cooling system of the mirror substrates was installed and later modified to improve the performance. However, the problem is still unsolved.

Drift became more problematic when the KB mirror was used together with the TC mirror. Drift of the TC mirror resulted in the degradation of the focus size. Figure 1 shows a series of vertical knife-edge scans over 24 hours. The photon energy was 18 keV, and Pt-coated surfaces of the TC mirror were used at a glancing angle of 3 mrad. The edge indicates the focus position, and the steepness is related to the focus size. The focus size, which was initially 2.2 μm (FWHM), became 3.9 μm after 24 hours (Fig. 2). It was highly desirable to develop a simple method to determine the change in the focus size without measuring it and to recover the focus size, because it is difficult to monitor the focus size during user experiments.

Since the degradation of the focus size was caused by the drift of the TC mirror, it could be recovered by correcting the mirror angle. In the present R&D, the TC mirror angle was corrected by maximizing the beam flux after the entrance slits of the KB mirror. As shown in Fig. 2, the focus size almost recovered after the correction of the mirror angle. Now, users can indirectly sense the drift from the decrease in the flux and recover the focus size by scanning the mirror angle.

Various user experiments that require brilliant X-rays and R&D programs for X-ray free-electron laser experiments are performed at each experimental hutch. In FY2022, experiments performed in EH1 included a fundamental study on X-ray parametric down-conversion, and nuclear resonance vibrational spectroscopy to study hydrogenase. Most of the experiments were performed in EH3, such as those on the X-ray pumping of the thorium-229m isomeric state, high-energy X-ray diffraction for the stress–strain analysis of iron materials, linear dichroism in HAXPES, and time-resolved diffraction experiments with the synchronized Ti:sapphire laser system. X-ray magnetic scattering was performed in EH4 using superconducting magnets.

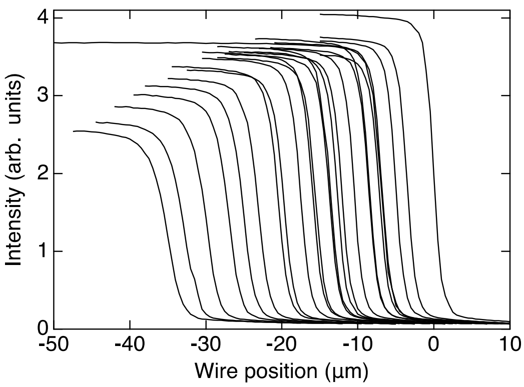

Fig. 1. Vertical knife-edge scans to measure the focus position and size of the KB mirror. The measurement was done every 1 hour over 24 hours.

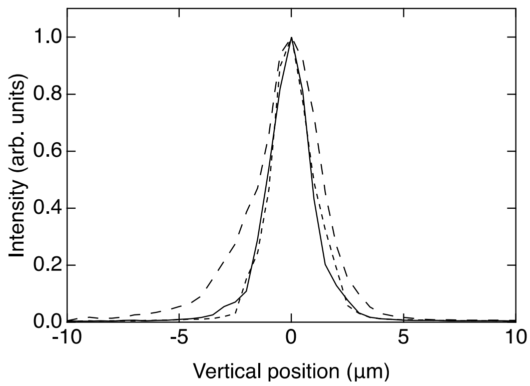

Fig. 2. Vertical beam profiles at the focus. Solid and dashed lines represent the initial profile and the profile after 24 hours, respectively. The profile after the mirror-angle correction (dotted line) was almost the same as the initial one.

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