High Flux (BL40XU)

1. Introduction

The basic design concept of BL40XU is to use the fundamental undulator radiation as a quasi-monochromatic X-ray beam. This eliminates need for a crystal monochromator with a band-pass on the order of 10^{-4}, which is unnecessarily narrow in many experiments. The fundamental undulator radiation has an energy peak width of 2 %, and thus the flux is more than 100 times higher than that obtained with a crystal monochromator.

2. Undulator

The X-ray source of BL40XU is a helical undulator. The core of its radiation has an energy spectrum with a very sharp fundamental peak and smaller peaks of higher harmonics (Fig. 1). In fact, most of the power of higher harmonics is emitted off-axis. On the other hand, the energy of the fundamental radiation is concentrated in the core; even when only the central 15 μrad (horizontal) $\times$ 5 μrad (vertical) radiation is used, the flux is as high as 1.5×10^{15} photons/sec.

The undulator gap can be varied so that the fundamental radiation is altered between 10 and 15 keV.

3. Front End

The elimination of higher harmonics helps reduce the heat load on the optics. The first optical component, which is a horizontally focusing mirror, receives only 7 watts of power. The rest of the power is absorbed by the water cooled fixed slits in the front end. They are fixed at the center of radiation but can be moved to scan the radiation when the center of radiation is searched during commissioning. The front end slits are located behind these fixed slits. They will be used with an aperture of less than 15 $\times$ 5 μrad in most experiments. However, the aperture can be opened up to 50 $\times$ 50 μrad for experiments that require quasi-white radiation. Such a large aperture has to be used with caution because the heat load on the optics may cause instability of the X-ray beam.

4. Optics

The focusing optics consist of horizontally and vertically focusing mirrors made of silicon and coated with rhodium. Both mirrors are water-cooled. The glancing angle is set to 3–4 mrad to eliminate higher harmonics. The 700 mm long horizontal mirror is placed first because the beam is larger in width than height; at a fixed glancing angle, the footprint of the beam is larger on a horizontally focusing mirror giving lower heat density.

5. Experimental Hutch

The mirrors are located at a about 4:1 position between the undulator source and the focus of the beam. Thus the beam size at the focus is about 1/4 of the source, although the surface unevenness of the mirrors may affect the beam size. From experience in other beamlines with focusing optics, the beam size is expected to be 300–600 μm horizontally, 100–200 μm vertically.

The experimental hutch has two tables. The first table has fast shutters: one is driven by a galvanometer-like motor and opens and closes within 1.5 msec after a trigger pulse. The other is a rotating-aperture type shutter. By synchronizing the two shutters, a 10 μsec opening can be achieved. This table also has final slits.

The second table, with a size of 2.7 $\times$ 1.0 m, will be used in various experiments. Thus, nothing is fixed on it. A vacuum pipe of 2 m can be set up for small-angle experiments. A fast CCD camera with a framing rate of 250 per sec (640 $\times$ 480 pixels, 10 bits) will be installed with an X-ray image intensifier that has a short decay phosphor. By reducing the size of the frame, a framing rate of up to 5,000 per sec can be achieved.

Plans call for a YAG laser to be installed in the hutch for experiments that requires a quick trigger of events.

6. Conclusion

This beamline will be commissioned in the 1999B period (October-December 1999) of beam operation. It will be open to users from the 2000A period (January-June 2000). Initially, it will mainly be used in experiments that require high flux, such as time-resolved small angle diffraction and scattering experiments in biology and material sciences, X-ray speckle experiments, and time-resolved protein crystallography.

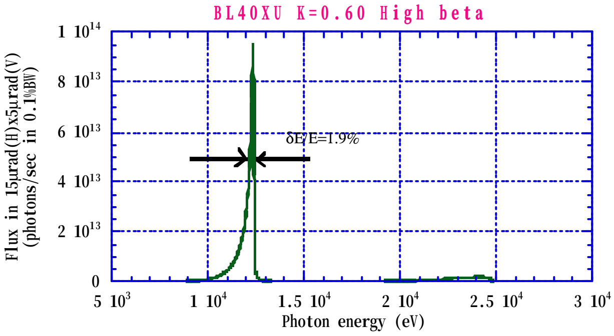

Fig. 1. Flux spectrum of the helical undulator.