Development of CCD-based High Resolution Imaging Detectors

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The beam monitor is an X-ray area detector designed to observe an X-ray beam directly [1]. Although it was originally designed for diagnosis of an X-ray beam in beamline commissioning, it is now widely used in various kinds of imaging experiments as well.

The beam monitor comprises of a window (either beryllium or aluminum depending on the required energy range), and a phosphor, a tandem lens system, and a camera. The phosphor used so far is P43 ($Gd_2O_2S:Tb^{3+}$, about 10 μm thickness). The choice of CCD camera depends on the purpose of the experiment. The most widely used camera to obtain high quality images is a cooled-CCD camera with 1,000 × 1,018 pixels (C4880-17, Hamamatsu Photonics). For time-resolved recordings, a fast CCD camera, which can record up to 28 frames per second (C4880-82, Hamamatsu Photonics, 656 × 494 pixels), is used. If a recording over a long span of time is required, a video CCD camera (XC-55, Sony) may be useful. Alteration of the camera was made possible by the use of Philips mount which connects the beam monitor to the camera.

In the original design [1], there was a pair of plates of lead glass (5 mm thick) behind the phosphor to protect the optical system from X-ray radiation, and a mirror was placed between two lenses of the tandem lens system. However, this design was found unsatisfactory because (1) extremely intense X-rays of high energy such as a white radiation from a bending magnet can pass through lead glass plates and cause browning of the lens, (2) the separation of the two lenses is not ideal for the function of the tandem lens system, (3) lead glass seems to worsen spatial resolution.

A new version (beam monitor 2, Fig. 1) has a mirror between the phosphor and the lens (Fig. 1). The mirror was found to be quite resistant to X-ray radiation. The lens is f = 24 mm, so that in combination with the f = 50 mm lens of the CCD, a magnification of about 2 is obtained. With C4880-17, each pixel of CCD corresponds to a size of 6 × 6 μm on the phosphor. The spatial resolution (FWHM), measured using a 1,500 lines/inch gold mesh, was about 12 μm (Fig. 2).

The beam monitor 2 has a remote-controlled mechanism for focus adjustment. This is especially useful because the detector is often used in combination with different types of cameras. To obtain best images, it is necessary to adjust focusing when the camera is altered.

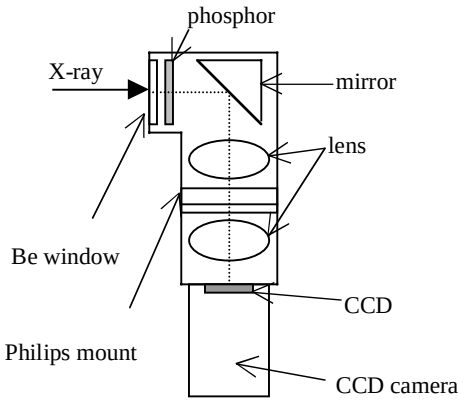

Fig. 1. Schematic diagram of beam monitor 2.

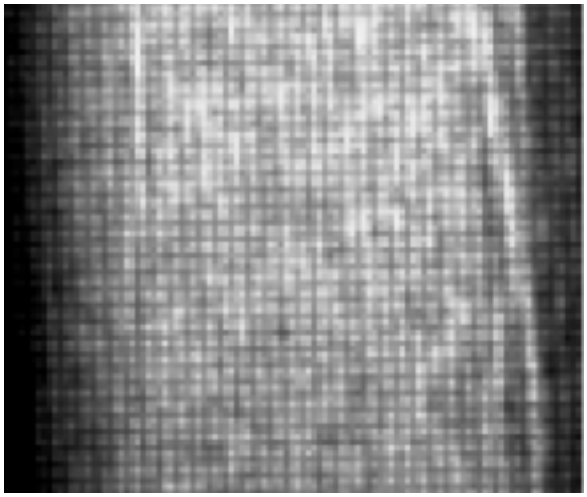

Fig. 2. View of 150 lines/inch gold mesh recorded with beam monitor 2. The experiment was done at BL47XU with an 18.7 keV undulator X-rays.

References

[1] N. Yagi and T. Endo, SPring-8 Annual Report 1997, 230 (1997)