Medical and Imaging I (BL20B2)

1. Introduction

The medium length bending-magnet beamline BL20B2 is dedicated mainly to basic medical science using biological specimens and small animals [1]. The construction of the beamline was completed in June 1999. BL20B2 has been operational for users since October 1999. The areas of research in medical applications are micro-tomography, refraction-contrast imaging and micro-angiography.

BL20B2 is a multipurpose beamline used for various imaging techniques in the energy range 5-100 keV as well as medical imaging. Research in imaging techniques involves the diffraction imaging of crystalline materials, micro-tomography of primitive meteorites, ultra-small-angle scattering, X-ray phase contrast microscopy and so on.

The full length of the beamline is 215 meters from the X-ray source to the end station. In Fig. 1, the X-ray beam produced by the bending magnet passes out of the experimental hall surrounding the storage ring and enters a satellite laboratory, biomedical imaging center. Different experiments are performed in the experimental hall and the biomedical imaging center.

A fan-shaped beam with a cross-section size of 75 mm width by 5 mm height is produced in the experimental hall. On the contrary, a 300 mm × 20 mm beam is obtained 200 meters from the source in the biomedical imaging center. In the future, two other medium length beamlines (BL20XU and BL21IN) using insertion devices will be available in the biomedical imaging center.

2. Beamline Design

The beamline comprises an optics hutch and three experimental hutches. The main optics is the standard SPring-8 bending magnet system that contains a fixed-exit double crystal monochromator. The monochromator is located in the optics hutch that is attached to the shield wall of the storage ring.

The first experimental hutch (4 m long and 2.8 m wide) is located in the experimental hall, 42 meters from the source point. The second and third experimental hutches are located 200 and 206 meters from the source, respectively, in the biomedical imaging center. The second and third hutches are 3 meters wide and 6 and 9 meters long, respectively.

The monochromatized X-ray is emitted from a vacuum tube into the air in the first hutch by passing through a beryllium window. A 150-m long beam-transport pipe connects the first experimental hutch to the second hutch. Both ends of the tube are beryllium windows that maintain the vacuum in the pipe.

3. Medical Applications

Areas of research are micro-tomography and micro-radiography (refraction-contrast imaging and micro-angiography) using high-spatial-resolution image detectors. The setups for radiography and tomography are displayed in Fig. 2.

The three-dimensional visualization of human tissue specimens with and without lesion has been performed by 3-D micro-tomography with image pixel sizes of 6-24 μm [2]. Micro-tomography can be used on biopsy specimens in order to obtain accurate diagnoses. Tomography experiments are performed in the first experimental hutch.

Refraction-contrast technique using a long object-to-detector distance has been applied to high-contrast imaging of the respiratory system. Images of the lung are expected to have high refraction contrast because of the marked difference in density between lung tissue and the air. Experiments are performed in the first and third experimental hutches.

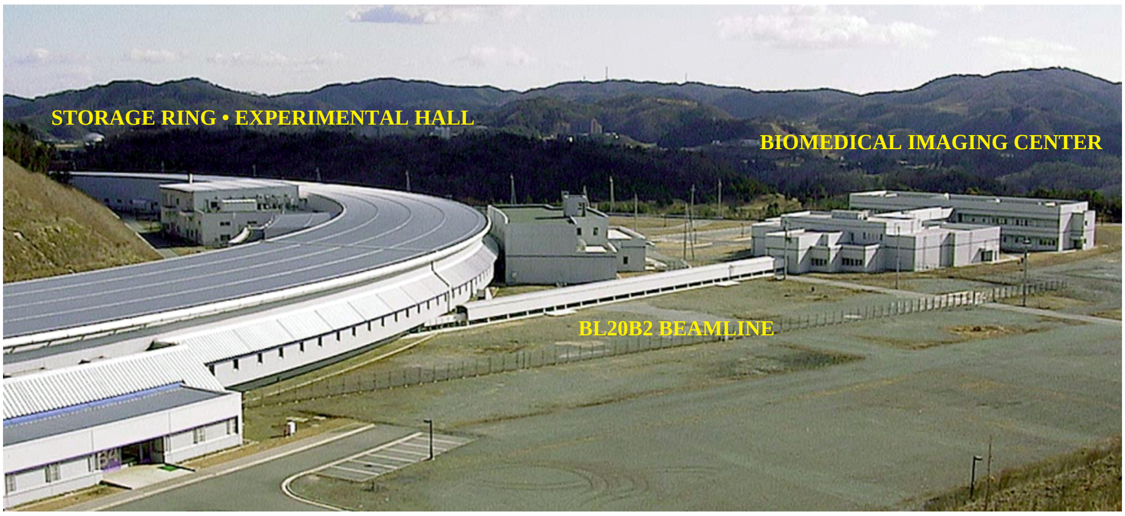

Fig. 1. View of beamline and facilities.

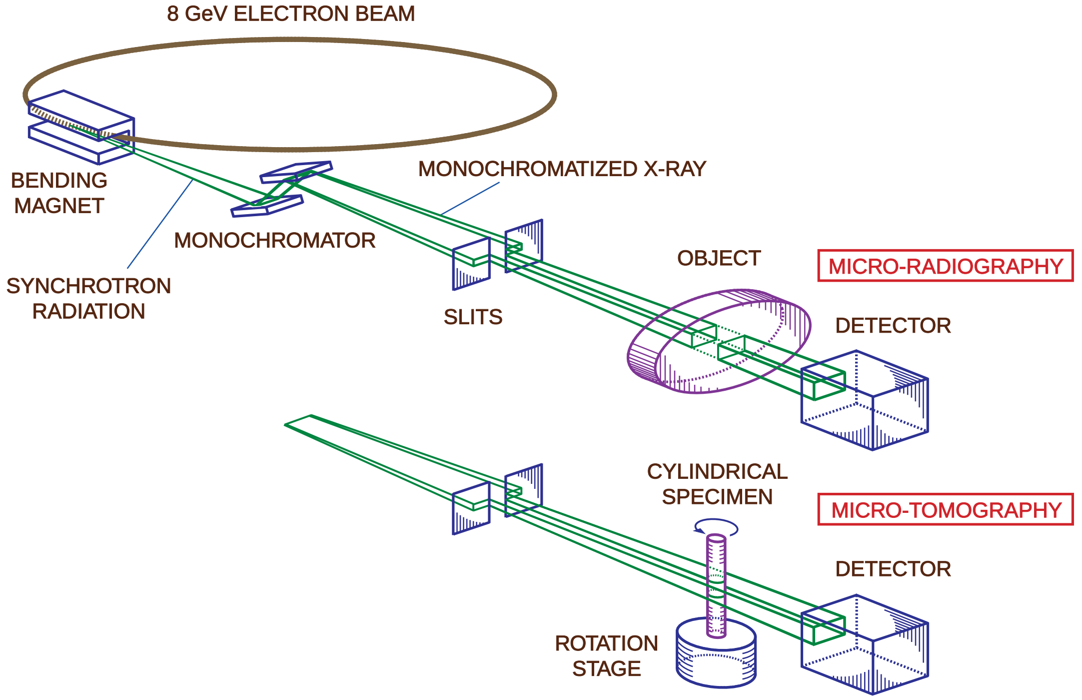

Fig. 2. Configurations of micro-radiography and micro-tomography.

Micro-angiography will be used for visualization of tumor-induced small blood vessels. A tumor stimulates the growth of small blood vessels in order to receive adequate nutrients. It has been proposed that tumor-induced small vessels are an intrinsic part of tumor development and progression.

4. Imaging Techniques

The following are research areas in other fields using the medium length beamline.

Topography using high energy, plain wave and wide beam. Combining four goniometers in the second experimental hutch, multi-crystals diffraction topography experiments can be performed for studies on the lattice perfection of large single crystals.

Micro-tomography of primitive meteorites [3]. Chondrules are one of the characteristic constituents in primitive meteorites that have information on the early stage of the solar nebula. Three-dimensional structures of chondrules are investigated with an X-ray tomographic microscope.

Ultra-small-angle scattering. The first and second hutches are separated by about 150 meters. From this design, it is expected that this beamline is potentially suitable for recording small-angle scattering and diffraction. A specimen is placed in the first hutch and the X-ray scattering and diffraction patterns are recorded in the second hutch.

X-ray Zernike phase contrast microscopy with X-ray refractive lenses. An object and the lens are placed in the first hutch and a maginified image is obtained in the second hutch.

Other research areas are X-ray microbeam with a grazing incidence mirror, X-ray fluorescence analysis of large materials and so on.

References

[1] K. Umetani *et al.*, Proc. SPIE **3977** (2000) 522.
[2] K. Shimizu *et al.*, Proc. SPIE **3977** (2000) 196.
[3] K. Uesugi *et al.*, Proc. SPIE **3772** (1999) 214.

Light Source
The standard SPring-8 bending magnet system that contains a fixed-exit double crystal monochromator.

X-rays at Sample
75 mm width×5 mm height in the experimental hall and 300 mm×20 mm in the biomedical imaging center.

Facilities in Experimental Station
· Three-dimensional micro-tomography system with image pixel sizes of 6-24 µm. · Fluorescent-screen lens-coupling CCD-camera detectors for taking static images. · High-resolution and high-speed imaging system is under development.