TRANSPORT CHANNEL AND OPTICS

Introduction

SPring-8 is unique among third-generation X-ray synchrotron facilities in possessing two major features: (i) long beamline potentiality and (ii) straight sections for long undulators. Both improvements included in the supplemental budgets in FY 1998. Since these beamlines require several R&D's, they were constructed as RIKEN beamlines.

Construction of the first one-kilometer beamline was begun in November 1998 as an extension of an existing standard X-ray undulator beamline (BL29XU) [1-4]. It is from one of three beam ports to accommodate one-kilometer beamline. The other two are from a bending magnet (BL29B2) and a long undulator (BL31IS). The beamline was completed at the end of FY 1999. Commissioning is expected to take place by the end of the third quarter of FY 2000.

The first long undulator beamline started construction in June 1998, and will be completed in the second half of FY 2000. It is a hard X-ray beamline at BL19XU produced from a 25 m long undulator with a magnetic period of 32 mm. SPring-8 has 4 long straight sections for long insertion devices. Two of the beamlines (BL07IS and BL43IS) are of standard length (maximum 80 m), whereas BL19IS and BL31IS are beamlines of medium-length (up to 300 m) and long (up to 1000 m), respectively. The straight sections are currently occupied by focusing magnets of the storage ring. Rearrangement of the accelerator magnets for all four straight sections and installation of the first undulator at BL19IS will be done during the summer shutdown in 2000.

In addition to these extraordinary beamlines, a number of new public beamlines started commissioning in FY 1999. Among them are standard X-ray bending magnet beamlines (BL02B2, BL04B2, BL28B2 and BL40B2) [5], an infrared beamline (BL43IR) [6] and a high flux undulator beamline without any crystal monochromators (BL40XU) [7]. A meV-resolution inelastic scattering beamline (BL35XU) [7,8] started commissioning at the beginning of FY 2000. A 200 m beamline from an X-ray undulator for medical imaging (BL20XU) will be completed in October 2000. Construction of all these beamlines was included in the budget for FY 1998.

Construction of two new public beamlines was commenced in FY 1999, both of which are target for completion at the end of FY 2000 [9]. One is a standard X-ray undulator beamline (BL13XU) for surface/interface structure analysis. The other is a 110 m long bending magnet beamline (BL19B2) to promote industrial applications of synchrotron radiation. An extension building (Extension-W of the Storage Ring Building) to accommodate the bending magnet beamline is under construction and should be completed by the end of October 2000 [9].

Fig. 1. The Long Beamline Experimental Facility as of December 1999.

One kilometer beamline (BL29XUL)

The one-kilometer beamline was planned for (i) extending scientific applications for using wide-area coherent X-rays and (ii) developing far separated bi-crystal X-ray interferometers for accurate measurement of minute phase shift. The size of the central cone of the undulator radiation is estimated to be 18 mm in diameter at the one-kilometer point. An average flux density of 6×10^{10} photons/sec/mm^2 will be available even in the absence of focusing elements.

A new building for experimental stations, the "Long Beamline Experimental Facility" was designed and constructed for the beamline (Fig. 1). The building has an experimental hall (16.2 m (W) × 18.9 m (D) × 8.4 m (H)) where synchrotron X-rays are introduced. In addition, it has four side laboratories for preparation/data analysis and two office spaces for users and in-house staffs. The experimental hall in the building has the same temperature control capacity (25 °C ± 1°C all year round) as the storage ring building. An anti-vibration cut in the floor separates the station equipments from vibration sources. A radiation-shielding hutch (3 m (W) × 6 m (D) ×3.3 m (H)) is located on the anti-vibration floor. The basic structure of the hutch is the same as those in the storage ring building.

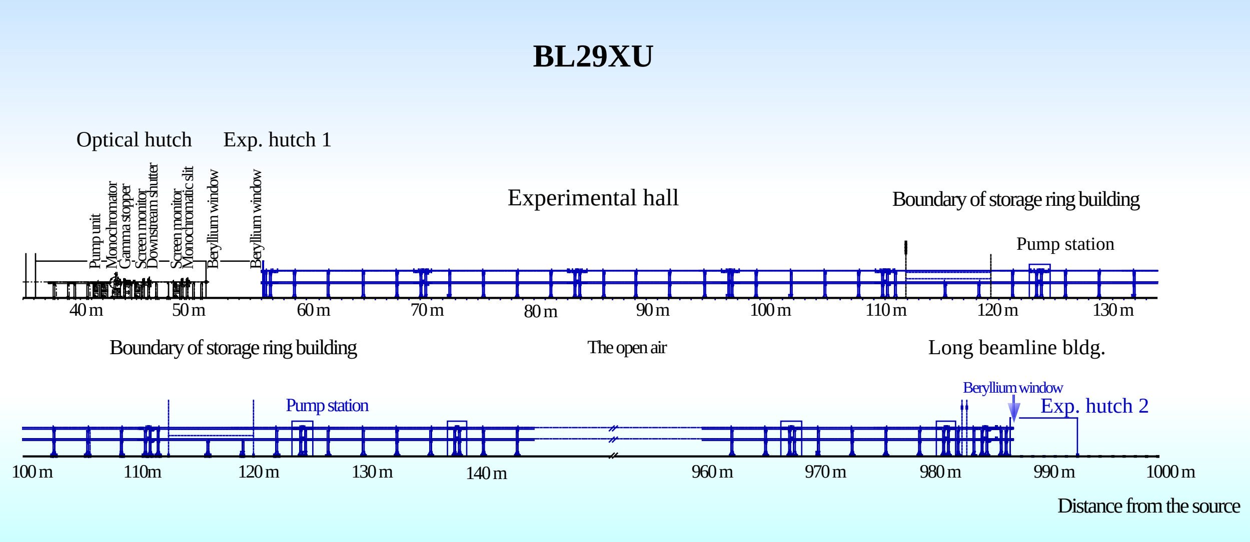

Fig. 2. Layout of the 1 km beamline (BL29XU). Newly-extended parts are printed in blue.

The newly-constructed part of the beamline includes the region from the existing experimental hutch in the storage ring building to the new experimental hutch in the new building (Fig. 2). Two-story vacuum ducts connect two experimental hutches. The lower duct guides the monochromatic X-ray beam directly from the beamline monochromator (1430 mm from the floor level of the storage ring building), while the higher duct is parallel to the lower one with a separation of 1000 mm between centers. Stainless steel ducts (100 mm inner diameter) with flanges for rubber gaskets in both sides are used for all the vacuum ducts for beam transport. Four mirror-polished Be windows with 250 µm thickness seal the vacuum of the two-story ducts at both ends. Between the two buildings, the beamline is composed of 64 quasi-equivalent modules with 13.6 m length. Each module consists of vacuum ducts, a vacuum pumping unit with rotary pump and gauge, bellows, supports and a hutch covering most of the components. A schematic drawing of the pumping units in a hutch is shown in Fig. 3. A photograph of the beamline is shown in Fig. 4. For beamline alignment, correction for the earth's curvature was taken into consideration.

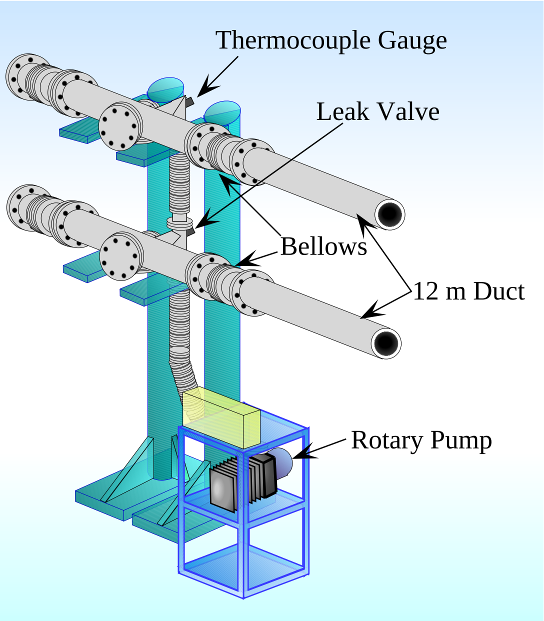

Fig. 3. Illustration of a vacuum pumping unit in the covering hutch outside of the buildings.

To conduct various experiments of wide-area coherent X-ray beam, a high precision diffractometer was equipped in the one-kilometer experimental station. The diffractometer is an upgraded version of that developed at the Photon Factory (PF) [10-12], consisting of several types of goniometers with position and angle alignment mechanisms assembled on a cast-iron surface plate, which is used as an experimental table. An improvement from the PF diffractometer type was the addition of another linear-translation guide with carriers for detectors and/or slits that are sometimes required to be spatially-fixed irrespective of the goniometers position. As X-ray detectors for intensity measurement, standard ionization chambers, NaI scintillation detectors, pure Ge solid-state detector, PIN photodiode detectors and APD detectors are available according to applications. An X-ray zooming tube (Hamamatsu) and a CCD monitor (Hamamatsu) were prepared for high spatial resolution image detectors. The zooming tube, used for observation of fine fringes of X-ray interference, has 0.6 mm field of view with 0.3 μm spatial resolution. On the other hand, the CCD monitor, used for diffraction imaging and radiography, has a 6 mm × 6 mm field of view with 12 μm spatial resolution. A VME-based system controls both mechanical positioning and data acquisition. All beamline equipments can be controlled from both consoles in the storage ring building and one-kilometer building.

Fig. 4. A section of transport channel of the 1 km beamline (BL29XU) in open air.

Long undulator beamline (BL19LXU)

The long undulator beamline was planned to develop the technologies to bridge 3rd and 4th generation synchrotron light sources. They will be useful for use with the upcoming self-amplified spontaneous emission (SASE)-based free electron lasers (FEL) [13]. As the first long undulator beamline at SPring-8, it should also play a role of feasibility testing stand of the long undulator in the storage ring.

Scientific applications of the beamline at the moment are (i) non-linear optics between femto-second laser and SR X-rays, (ii) higher order interferometry, (iii) coherent X-ray imaging, (iv) X-ray cavity development and (v) coherent magnetic scattering. However, the unique features of the long undulator source will allow wider applications for coherent X-rays.

The transport channel and optics are similar to those for standardized X-ray undulator beamlines. A standard double-crystal monochromator is used with a liquid nitrogen circulation system for cooling. There will be an optics hutch and four tandem experimental hutches. Most downstream experimental hutches will be located in the newly-constructed extension (Extension West) of the Storage Ring Building. The layout of the beamline is schematically shown in Fig. 5.

The first (most upstream) experimental hutch is equipped with a multiple-crystal precision diffractometer system similar to those in BL29XU. The second experimental hutch is used as a laser hutch. The third experimental hutch is an open hutch for user-equipments. The last hutch will be equipped with a diffractometer with a 15 T superconducting magnet.

Installation of the long undulator, front-end and transport channel and optics will be done during the summer shutdown of 2000. Hutches inside the experimental hall of the storage ring building will be completed by the end of May 2000. A photograph of the beamline hutches is shown in Fig. 6. Extension of the storage ring building will be completed by the end of October 2000. The last experimental hutch, together with the extension of the transport channel to the Extension-W will be completed by the end of March 2001.

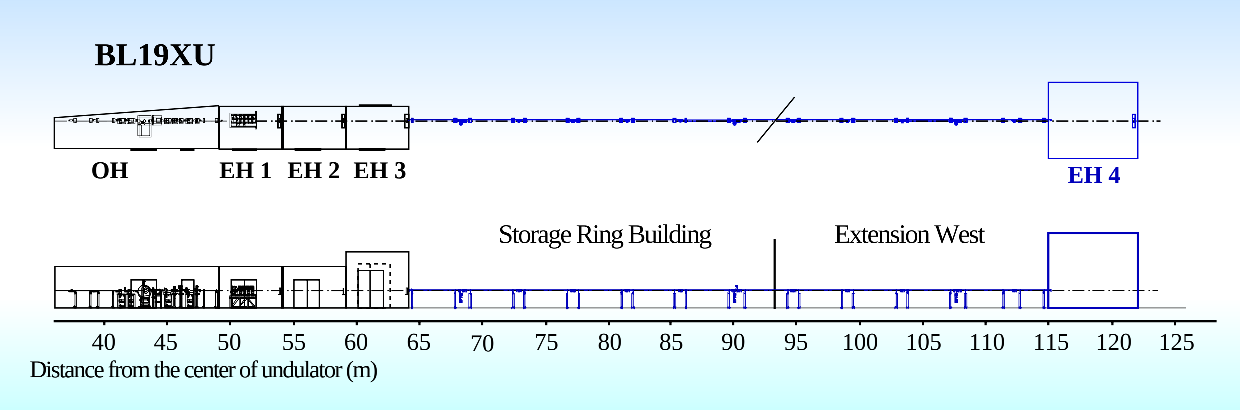

Fig. 5. Layout of the transport channel for the long undulator beamline (BL19XU): OH, optics hutch; EH1~EH4, experimental hutches.

Fig. 6. Recent view of the long undulator beamline (BL19XU).

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