Front End

1. Introduction

At the end of FY 1999, we completed the installation of the beamline front ends consisting of 13 bending magnet (BM) and 19 insertion devices (ID). Among these, 31 beamline front ends are under successful operation at the maximum beam current of 100 mA, which was put into operation mode in June. We made efforts to cope with the construction of the first long straight section beamline (BL19LXU), namely by (1) designing the front end for the incomparable intensive heat load light source and (2) constructing the front end exclusive cooling water system.

We are also developing a photon beam monitoring system using the X-ray beam position monitors (XBPMs).

2. Construction

2.1 New Front Ends

The front ends for BL12B2, BL15XU, BL35XU, BL40XU, and BL43IR were constructed during the summer shutdown period.

Two front ends for BL12B2 and BL35XU are our standard types for the bending magnet and the standard in-vacuum undulator, respectively.

As the light source of the BL15XU is a revolver type undulator, equipped with a planar undulator and a helical soft X-ray undulator, the layout of the front end components was arranged to correspond to both sources. Because the spatial power distributions for both sources are different, the fixed mask for the helical undulator was installed just upstream of the standard fixed mask for the planner undulator.

As for BL40XU, the light source for which is a helical X-ray undulator, the specific layout of the front end components was applied. As the optics group decided that only 1st harmonic radiation just near on-axis should be used without a monochromator, they required the front end to feed the X-ray beam which has a fixed size of about 10 μrad at the beginning. However, this means that the final exit size of the photon beam would be about 0.4 mm in diameter at the end of the front end. Because it is assumed that such a small beam size would cause unnecessary complications to our commissioning work, we established a design concept whereby the photon beam size should be restricted within about 50 μrad by masks and afterwards users would have the option to change it using the XY slit by users as occasion demanded. Accordingly, as the masks are handling what amounts to almost the total power, we prepared two masks, namely the 1st mask (fixed) and the 2nd mask (movable). The 1st mask, located at about 22 m from the light source point, has an exit aperture size of 7 mm in diameter (312.5μrad). The 2nd mask, the exit aperture size for which is fixed at 1 mm in diameter (42.7μrad), is mounted on the precise XZ-stage in order to be aligned with the light axis precisely. Because the power passing through the masks was reduced to a very small level, the pre slit is unnecessary and the XY slit can be miniaturized as compared with the standard type.

As BL43IR is an Infrared beamline, a fundamentally different design from the standard was applied to its front end [1].

2.2 Front End Exclusive Cooling Water System

A front end cooling system was constructed for A (BL01B1~BL12IN) and D (BL37IN~BL48IN) blocks within the summer shutdown period. The new system supplies the cooling water to not only the front end components but also to the insertion device absorbers and the chiller systems which cool the insertion device magnets for all beamlines except those controlled by the accelerator division. Therefore, we had to separate the existing front end cooling systems from the "L1 cooling system" and connect them to the front end cooling system for 17 beamlines in the A and D blocks by the end of this summer shutdown period. The most important feature of the front end cooling system is to be able to maintain a pressure loss between the inlet and the outlet valves at the interface of greater than 5 kgf/cm^2 even at the maximum flow rate. In order to achieve this specification, the size of the valves at the interface was changed to 65A as compared with 25A in the previous cooling system. We also increased the main pipe size of the front end cooling system for a new beamline from 25A to 32A, because the pressure loss between the valves at the interface and each component should be made as smaller as possible. For the existing front end cooling systems, we prepared an exclusive manifold in each beamline for the masks and the absorber, which require a large quantity of cooling water. This is the reason why it would be very difficult and expensive to replace the existing main pipe of 25A by a new one of 32A. We also take care of the quality of the circulating water. The specific resistance is maintained at about 16 MΩcm as against the specification of 4 MΩcm. The remaining part, B (BL12B2~BL24IN) and C (BL25IN~BL36IN) blocks, will be completed by the end of the 2000 summer shutdown period.

3. Design of BL19LXU Front End

The beamline for the very long in-vacuum X-ray undulator will be constructed at BL19LXU within FY2000 [2]. At a beam current of 100 mA, the front end will be subjected to a total power of 33kW with a power density of 1.92kW/mm^2 at the entrance of the front end. As compared with the standard undulator, these values are about 3 and 1.5 times larger, respectively. To handle such an intense heat load within the restricted space, we introduce a new configuration for the high heat load components, as shown in Fig. 1.

3.1 Design Concept

The basic design concept is for the equipment to deal with most of the power upstream of the absorber. Thereby it allows for the to utilization of the standard components downstream from the absorber. As a result, it is decided that the absorber should be moved as far downstream as possible, and only the masks were newly designed.

3.2 Each Component

3.2.1 Masks

A series of four masks, two fixed and two movable, was newly designed, as shown in Fig. 1. The movable masks are mounted on the precise XZ-stage, so that their position relative to the photon beam axis can be changed easily. The 1st movable mask has a horizontal exit aperture of 1.5 mm, and the 2nd one has a shape rotated in a 90-degree arc of the 1st one. The inclined angle of the slit is 6.7 mrad, compared to the standard fixed mask of 10 mrad. We made the thermal and thermo-mechanical analysis using ANSYS for the 1st movable mask. In this calculation, assuming that the electron orbit fluctuates to the maximum allowable value, the total inlet power to the 1st movable mask is about 20 kW. If the electron orbit fluctuates beyond the allowable value, the electron beam would be aborted. Accordingly, it is necessary for the 1st movable mask to be capable of handling this huge power. In spite of this severe condition, we confirmed that both the maximum temperature and the maximum equivalent stress are within the allowable level.

3.2.2 Beryllium Window

As shown in Fig. 1, a graphite filter assembly is installed to reduce the heat loads on the beryllium foils. According to the results of the ANSYS analysis, if the aperture size of the XY slit set at 1mm square, it is necessary to insert a graphite foil of 0.9 mm to suppress the maximum stress of the 1st beryllium foil to less than 280 MPa of the general yield strength. Because the real strength of such a thin foil is influenced severely by its purity, the degree of rolling and heat treatment caused by brazing or diffusion bonding, we are preparing to measure the yield strength, the elongation and the ultimate tensile strength for the real beryllium foil. As for the absorption rate in 0.9 mm graphite foil, the flux would be decreased about 37 % at the fundamental of 7.7 keV at the maximum K value of 1.7. But, when 10 keV is selected as the 1st harmonic energy, the absorption in the 0.9 mm foil would be lowered to about 20 %.

3.2.3 Other Components

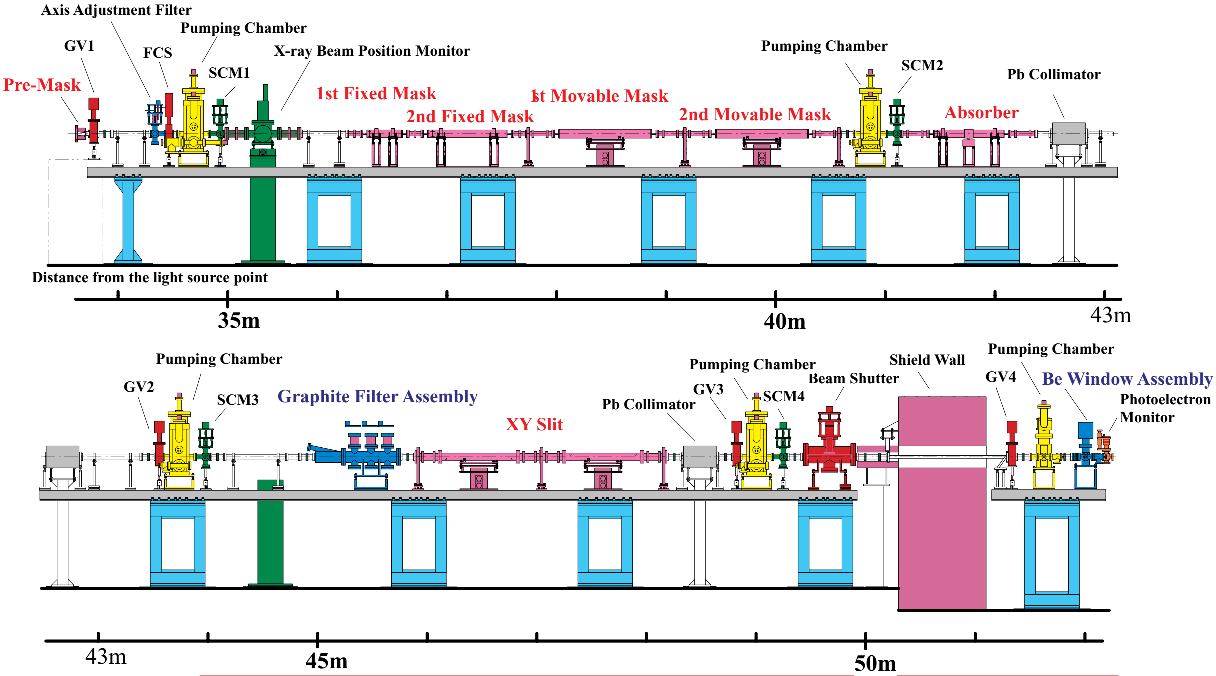
As for the other high heat load components, considering the fact that the total power passing through the masks is only about 3 kW, there should be a possibility of miniaturizing the absorber and the XY slit. But, because the power density is about 1.4 times larger than that of the standard type at the absorber position and because of the maintenance work, we decided that a design which was exactly the same as the standard one should be adapted.

4. Monitoring the Photon Beam

Photon beam diagnostics have been carried out using XBPMs [3]. The XBPMs for the ID beamlines are able to measure photon beam positions in both the horizontal and vertical directions, the typical resolutions of which are about 1.0 μm and 0.5 μm, respectively. During user time, the data from the XBPMs are logged every six seconds, and routine measurements are performed immediately after every injection with all ID gaps closed. For special purposes, such as observation of the beam oscillation, the system is set up to match the high frequency and the synchronous measurement [4]. In this system, cellular telephones are used to carry the trigger signal.

References

[1] H. Kimura *et al.*, in this volume.
[2] H. Kitamura *et al.*, in this volume.
[3] H. Aoyagi *et al.*, in this volume.
[4] T. Kudo *et al.*, in this volume.



	Location(m)	Opening(mm)	Outer Size(μrad)	Power In (kW)	Power Abs (kW)
Pre-Mask :	33.7	18×18	534.12×534.12	33.07	0.29
1st Fixed Mask :	33.6	ϕ13	ϕ177.673	32.78	0.7
2nd Fixed Mask :	37.5	ϕ6	ϕ79.917	32.08	10.96
1st Movable Mask :	38.9	H1.5	38.601	21.12	18.54
2nd Movable Mask :	40.3	V1.5	37.231		
Absorber :	41.8			2.58	2.58
XY Slit :	47.0	Adjustable			

Fig. 1. Layout of the front end for the very long in-vacuum undulator beamline (BL19LXU). The components shown by the biggest and red letters are high heat load components.