FRONT END CONSTRUCTION FOR THE POHANG LIGHT SOURCE[1]

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Abstract

We describe the general layout as well as the particular designs and specifications for the new constructed front ends at the PLS. Each front end plays an important role for the protection of ring vacuum, radiation safety and the photon beam monitoring, and it bridges the possible vacuum differences between the storage ring and beamlines. All the components of the front end are designed to withstand a power density of 3 kW/mrad^2 at 2.0 GeV and 300 mA. To construct three beamlines every year, the front end section is modularized and standardized as much as possible. According to this design principle, we have constructed five front ends for SAXS, KJIST X-ray scattering, the protein crystallography, the slitless, and the high resolution spectroscopy beamlines in 1997.

1 INTRODUCTION

The PLS storage ring has a twelve-fold symmetry structure. Each superperiod of the ring consists of one straight section and three bending magnets. Excluding two straight sections installed the injection system and rf cavities, there are totally 32 beam ports, 22 for bending magnets and 10 for insertion devices. Each beam port can accommodate at least two branch beamlines. Therefore, more than forty beamlines can be installed. At present, eight beamlines are operational. They are the photo-emission (VUV), X-ray scattering, NIM for gas phase, EXAFS, the microprobe, LG-lithography, SAXS, and KJIST X-ray scattering. The protein crystallography, the slitless and the high resolution spectroscopy beamlines will be commissioned in this September. And four beamlines are under construction. They will be used for magnetic spectroscopy, electro-chemistry, materials science, and deep etch X-ray applications [1]. Table 1 summarizes the source parameters at the PLS.

Table 1 : Source parameters at 2.0 GeV and 300 mA current.

Parameter	**Planar Undulator**	**Polarized Undulator**	**Bending Magnet**
Period Length(cm)	7.0	6.0	NA
Number of Periods	59	25	NA
Max. Magnetic Field(T)	0.98	0.69	1.06
First Harmonics at K_{max}(eV)	24	80	NA
Max. Deflection, K_y	6.6	3.86	NA
Total Power(kW)	3.2	0.54	$3.22 \times 10^{-2*}$
Peak Power Density(kW/mrad^2)	3.1	1.90	0.03

* In case of 3 mrad horizontal acceptance.

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2 FRONT END LAYOUT

According to the photon beam exit port, we classify front ends as follow: A type for insertion devices, B type for a single branch for bending magnets, and C type for double branches from bending magnets.

2.1 Front end for insertion devices

The A-type front end has a 6-meter long single branch for insertion device beam. The photon beam with 4 mrad radiation fan is extracted from A-port of the storage ring vacuum chamber. Figure 1 shows the front end layout of U7 undulator [2][3] beamline. The major components as shown in Figure 1 are (1) all metal manual gate valve (MGV), (2) fixed mask, (3) photon shutter, (4) all metal pneumatic gate valve (PGV), (5) fast closing shutter, (6) lead collimator, and (7) safety shutter. The two fixed masks confine the photon beam and protect the downstream components from a mis-steered beam.

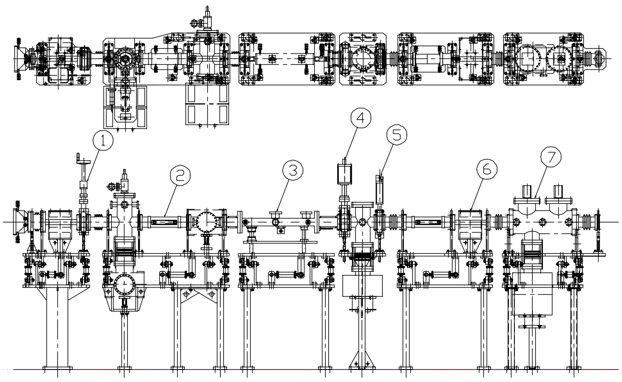

Figure 1: Layout of the insertion device front end.

2.2 Front end for bending magnets

The B-type is designed to deliver 3 mrad total horizontal radiation fan to the users about 32W total photon beam power at 2.0 GeV and 300 mA. Figure 2 shows the layout of the BM 6B-port front end. As shown in Figure 2, this front end has a single long branch. The components are (1) flat mask, (2) all metal MGV, (3) photon shutter, (4) all metal PGV, (5) Be-window, (6) beam position monitor, (7) movable aperture, (8) vertical collimating mirror, and (9) safety shutter. The usable length in the tunnel is about 8.3 m. Enough space is possible to put the collimating or focussing mirror system. Especially, the in-line ion pump with a double-ended flange is used to enhance the pumping speed. The chamber size is determined as small as possible within the limits of maximum beam mis-steering. All components are supported by adjustable 6 strut assemblies functioning as a highly precise alignment tool.

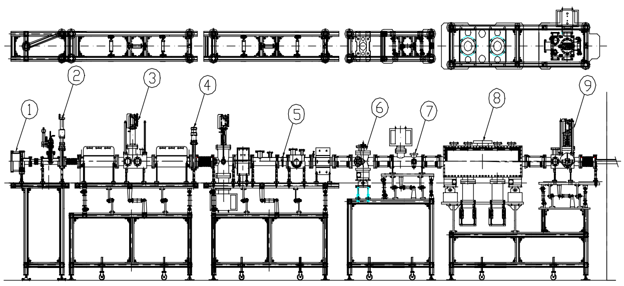

Figure 2: Layout of the bending magnet front end.

The C-type front end has two 5 m branches. The extracted beam is splitted by the dividing aperture located in photon shutter chamber. Each branch receives 5 mrad total horizontal radiation fan. The layout is almost the same as the B-type. Each component is arranged sequentially as follows; (1) water cooled copper diaphragm, (2) all metal MGV, (3) photon shutter, (4) dividing aperture, (5) all metal PGV, (6) fast closing shutter, (7) acoustic delay line (ADL), and (8) safety shutter. The ADL loaded with an array of six conical diaphragms is a stainless steel tube of 16 cm in diameter and 160 cm in length.

3 FRONT END COMPONENTS

3.1 Mask

The water cooled flat mask is the first component to interact with beam in the bending magnet front end. For the A-type front end, this one has a function to eliminate the parasitic beam radiated from the edges of the adjacent bending magnets. For the B and C type front ends, this consists of OFHC copper plate with beam defining aperture. The flat mask has a cooling channel to avoid the direct vacuum-water joint. Two con-shaped masks are inserted in the insertion device beamline. These masks consist of an OFHC copper body with a precision electro-discharge machined aperture and stainless steel transition pieces. By using sloped surfaces, the dilution of power density can be effectively achieved. For a glancing 3^{o} geometry, the fixed mask receives about 2 W/mm^2 of heat flux. To monitor the bulk temperature rise, a thermocouple is embedded at 5 mm apart from the inner surface.

3.2 Photon shutter

The peak power density on the A-type front end is about 30 W/mm^2 at normal incidence beam. This power level is defended by the design of the grazing geometry and the enhanced heat transfer techniques. At an A-type front end, the photon shutter is designed to be installed 11.9 m from the U7 undulator source. Figure 3 shows the fast acting photon shutter assembly. In order to minimize the closing time, the shutter itself is designed to serve as a rotating mask unlike the conventional shutter constituted inside a cylindrical chamber. The total closing time is less than 10 msec. The soft landing during final closing is realized by a hydraulic shock absorber. The shutter can interrupt the photon beam by tilting the entire absorber by 3^{o} rotation. At closing position, the photon beam transmitted out of the right blade is absorbed by the left blade or the stopper. Most of the incident power is absorbed by the lower plate. The small angle scattered beam is interrupted by the stopper plate.

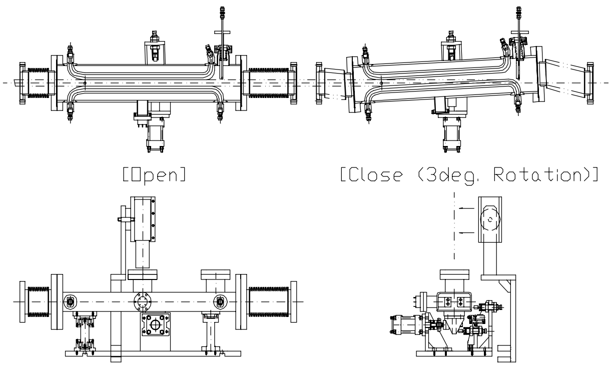

Figure 3: Fast acting photon shutter.

The rotational movement is driven by a solenoid and a double-acting pneumatic cylinder. Two welded bellows with suffiecient lateral displacement are connected at both ends of the absorber body. In order to eliminate the direct contact between water and vacuum, 70 cm long OFHC copper blades which are properly bended, are brazed to the rectangular shape stainless steel tube. An infrared camera will be installed to monitor the magnitude and the distribution of surface temperature on the heating area.

3.3 Bremsstrahlung shutter

The shutter is essentially constituted by a cylindrical chamber inside which two tungsten blocks are placed. These blocks are moved in the vertical direction by means of a pneumatic actuator. The W-block size is decided to 92 mm wide $\times$ 50 mm high $\times$ 110 mm thick by considering the transverse overlap with lead collimators. The shutter is connected with bellows on both sides to isolate the vibration propagation from the quick motion of heavy loads. Two W-blocks must be operated independently but simultaneously. The air actuators have a magnetic strip on the position of the air cylinder. Reed switches mounted on the tie rods of the air cylinder produce the signal for the open and closed position, and the double actuating cylinder for soft landing. In order to protect the safety shutter from exposing to the photon beam directly, the photon shutter is interlocked to close before the closing of the safety shutter.

3.4 Vacuum Components

All front ends are evacuated with some noble gas oriented ion pumps and a turbomolecular rough pumping system. Remotely driven components such as the valves and shutters have a high degree of reliability because they are located inside the tunnel where it is impossible to access under the normal operation. The vacuum is ordinarily monitored with ionization vacuum gauges. The fast closing shutter (FCS) is developed by ourselves. Figure 4 shows the assembly drawing of fast closing shutter with 70 mm×30 mm opening aperture. It is an all metal shutter which closes in less than 10 msec providing a high impedance to the gas flow. The fast closing shutter is closed by releasing a loaded spring and opened by compressed air. The shutter structure is designed to realize easy fabrication and assembly. The Kalrez seal is used to tolerate high bake-out temperature in actuating mechanism. Now the development of FCS controller is under way. The pneumatic gate valve is an all-metal type, and its closing time is usually 1 ~ 2 sec. This valve must be interlocked to close only the beam off status or photon shutter close status. This valve is sequenced to close after the FCS is closed.

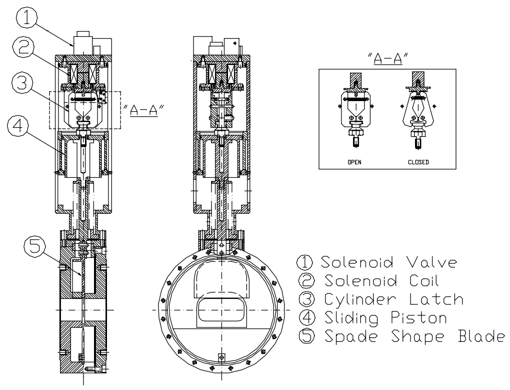

Figure 4: Fast closing shutter

3.5 *Be-window*

The Be-window is a key element for the vacuum isolation in an X-ray beamline, and is used as both a vacuum seal and a synchrotron radiation filter to provide hard X-ray. The hot-pressed and then cross-rolled beryllium foil (IF-1 class) is manufactured by Brush Wellman. The Be foil with a thickness of 250 µm is brazed to an aperture of a copper disk, which is sandwiched with stainless steel half nipples. For photons with energies above 4 keV, this window has the transmission of 70%. The aperture is 16 mm high and 50 mm wide with tapered corners. Two water channel of 6.35 mm in diameter are drilled along the aperture. Thermometers made of Pt resistor are attached to the inlet and outlet of the channels to measure temperature difference of the cooling water along with its flow rate. Sapphire-made viewing ports are located at the downstream end of the beryllium window to inspect the surface temperature of the Be foil. In addition, two cold cathode gauges are continuously monitored the vacuum change at the both ends of Be-window.

3.6 *Photon beam diagnostic system*

The B-type front end has an X-ray beam position monitor. It is used to accurately measure the horizontal/vertical position of the beam and to allow precise positioning of beamline optics. It is an area type monitor positioned 9 m from the source point. It consists of two triangular photoemitting electrodes, vacuum chamber, electric feedthroughs, and XY moving mechanism. We use the 70% transmissive molybdenum wire grids. The grids are mechanically supported and electrically isolated from each other by a Macor frame. Electrical signals are extracted from the UHV enclosure via BNC feedthroughs. The differential voltage between the grids is proportional to the beam displacement at a given current. The monitor is mounted on the XY stepping motor driver stage with a 0.6 µm stepping size and 0.1 µm linear encoder resolution.

The front end includes fluorescent screens and photodiode probes for the beam diagnostic purpose. The water cooled fluorescent screen is for the white beam, and the non-water cooled one is for the monochromatic beam. The silver-activated zinc-sulfide-emitting blue light (P22 blue) is used as a phosphor powder. Its peak-emitted wavelength is 450 nm, and the maximum allowable input power density is 0.25 W/mm^2. The screen is moved on the stepper-motor-driver linear stage with a 50 µm stepper size and 5 µm linear encoder resolution.

4 SUMMARY

We have presented a general overview of the design for the PLS front ends. In principle, the standardization and the modularization were pursued to meet the tight construction schedule. The standardization results in the reduction of engineering effort and the high reliability in maintenances and operations. The modularization is possible to install the front end components in the storage ring tunnel quickly and efficiently. The latter is more emphasized because the assembly and vacuum test, installation and bakeout, and all wiring and piping work should be completed during machine maintenance periods. Both the vacuum control and the interlock system will be centralized. These basic concepts will be steadily applied to the photon transfer line construction in 1998.

5 REFERENCES

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[3] K. H. Park, D. E. Kim, W. W. Lee, J. S. Bak and B. K. Kang, “Magnetic Measurement of PLS U7 Undulator,” 15th International Conference on Magnet Technology (Beijing, China, Oct. 20-24, 1994).