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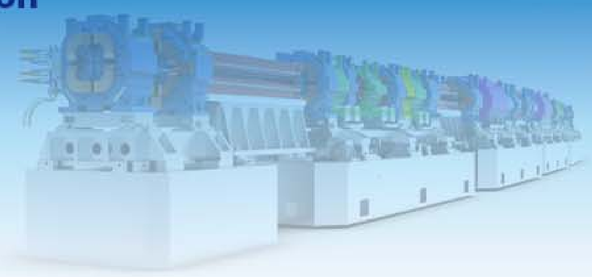

Progress of Front Ends at HEPS

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Abstract

High Energy Photon Source (HEPS) is a 6GeV synchrotron radiation facility building in Huairou, with a storage ring perimeter of 1390.6m and 41 straight sections. In phase I, 15 front ends will be installed, including 14 insertion device front ends and 1 bending magnet front end. These front ends are divided into three types: the **U**ndulator front end, the **W**iggler front end, and the **B**ending Magnet front end. The U-type front end will receive 766W/mrad^2 of peak power density and 25kW of the total power. The design of the W-type front end is based on compatibility with various insertion devices, including undulators and wigglers. In this paper, the designs and the progress of HEPS front ends are presented.

INTRODUCTION

HEPS storage ring has 48 straight sections, and 41 of them that are 6m long can extract user beams, as 7 are required for injection and RF straights. 15 beamlines are being built in Phase I of HEPS project. One of them is BM beamline, others use ID as light source. These front ends are divided into three types: the **U**ndulator front end (UFE), the **W**iggler front end (WFE), and the **B**M front end (BFE). The UFE will receive 766W/mrad^2 of peak power density and 25kW of the total power. The design of the WFE is based on compatibility with various insertion devices, including undulators and wigglers.

GENERAL LAYOUT

Front ends at HEPS are divided into three types: Undulator Front End (UFE), Wiggler Front End (WFE), and Bending Magnet Front End (BFE). There are 12 UFEs, 2 WFEs, and 1 BFE. Due to the implementation of a unified standardized design, the layout of the three types of front ends is similar. The main components of front ends are: (1)Pre-Mask, (2)Low Power Photon Shutter, (3)All-metal Fast Valve, (4)1st Fixed Mask, (5)XBPM, (6)Photon Shutter, (7)Slits, (8)Filters, (9)Safety Shutter, (10)Ratchet Wall, (11)2nd Fixed Mask, (12)Be Window. Figure 1 shows the layout of UFE. Table 1 summarizes the front end parameters.

Table 1: the Parameters of Front Ends line at HEPS

FE Type	UFE	WFE	BFE
Length [m]	18.9	18.9	22.2
Beam Size at Entrance [mrad]	3.1×1.3	3.1×1.3@ID19, 3.2×1.5@ID42	3.3×1.5
Beam Size at Exit [mrad]	0.2×0.2	1.0×0.9@ID19, 2.0×0.3@ID42	2.0×0.4
Power Density [kW/mrad^2]	766	414	0.18kW/mrad
Total Power [kW]	25	9	

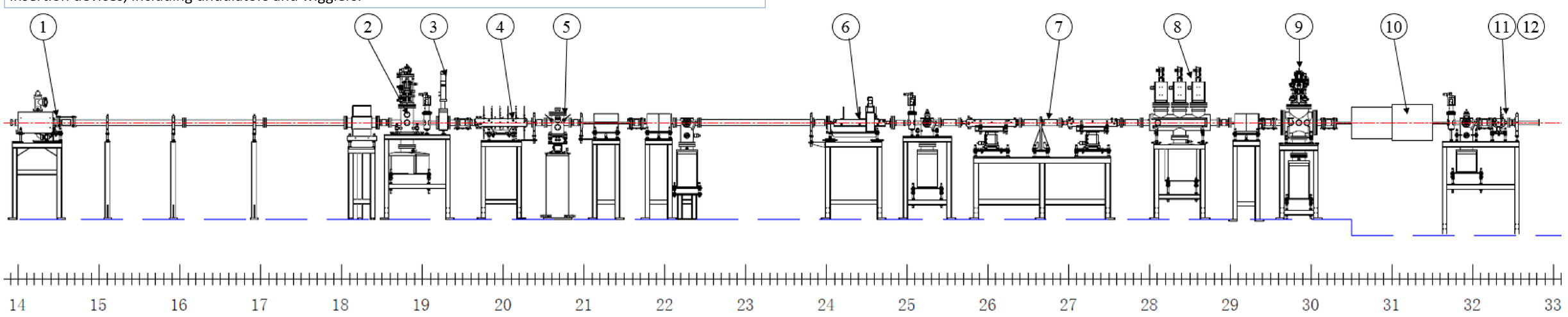


Figure 1: the Layout of Front End

COMPONENTS

Pre-Mask

The isolation valve on the crotch leg of the storage ring is followed by the Pre-Mask which is to reduce dipole radiation to downstream 1st Fixed Mask. The absorber of the Pre-Mask is made of OFHC and cooled by water.

Fixed Mask

The Fixed Mask defines the angle of departure of the beam which pass into the front end, and prevents down-stream components from irradiated by misteered beam. The form of aperture presents an hourglass, which provide grazing incidence to the beam in order to reduce the power density on the footprint. The grazing incidence is 0.68˚.

Photon Shutter

Low Power Photon Shutter (LPPS) which is subject to the heat load from upstream and downstream bending magnet of an insertion device. The LPPS absorber is made of OFHC and cooled by water. Photon Shutter (PS) which can close the synchrotron radiation to downstream components. Due to suffering from the peak power density up to 1.3kW/mm^2, it has a grazing incidence surface with 1.3˚ that will intercept the beam.

Safety Shutter

The function of the Safety Shutter is to block bremsstrahlung radiation. The absorber made of Tungsten is divided into two parts, movable block and fixed block. And the total thickness of the absorber is 200mm.

Slits

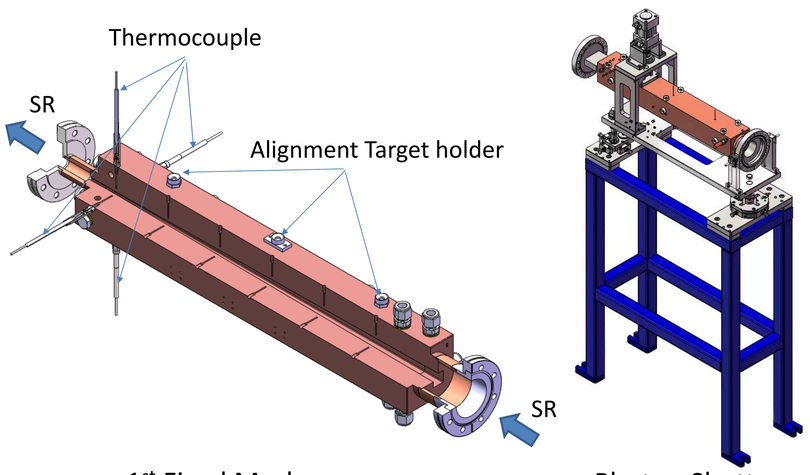
A set of Slits is to define the beam size exiting the front end, the upstream and downstream absorber both are L-shaped components can independently move in the vertical and horizontal directions. The stages below the absorbers have an accuracy of 1μm with an equivalent angular accuracy of approximately 0.04μrad.

Filters

A set of Filters is used to reduce the heat load on the downstream components in the First Optical Enclosure. It is composed of three sets of 3-position carbon foils which have different thicknesses installed according to various requirements. A water-cooled copper frame is used to clamp the graphite foils.

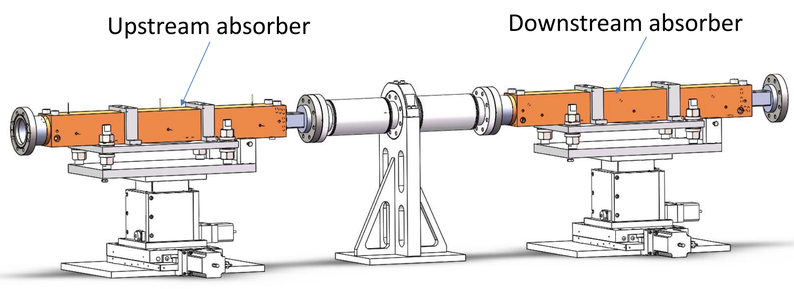
Fast Valve

An all metal Fast Valve is installed downstream of LPPS, with a maximum aperture of 60(H) × 20(V)mm and can be closed within 8ms. The leakage rate is less than 0.4Torr · L/s, and the service life is greater than 1000 times.



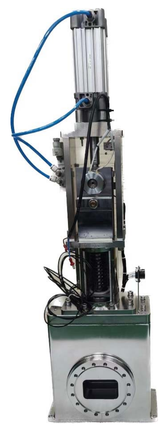
1st Fixed Mask

Photon Shutter



Slits

Filters



All Metal Fast Valve

PROJECT CHALLENGES

Fatigue Life

The design of the HEPS front end absorber is based on a strain based low cycle fatigue life analysis method. The length of the absorber for UFE 1st Fixed Mask can be restricted within 700mm, and its service life can meet the 30 year usage requirement with a safety factor of two.

Mechanical Manufacturing

The length of the absorber of the UFE components is nearly 700mm. The processing technology is to use a medium wire-cut machine to process the optical aperture and cut out the hourglass shape of the grazing incidence surface, finally manually polish the inner surface through customized tooling. After testing, the internal surfaces and apertures of the 12 UFE 1st Fixed Masks meet the requirements of geometric tolerances, and the surface roughness is less than Ra0.8.

CONCLUSION AND DISCUSSIONS

The 15 front ends constructed in the phase I of HEPS adopt standardized design, and most of the materials of the absorber are made of dispersed copper alloy. The challenge of High heat loads are well solved by using grazing incidence and enhanced heat transfer, and the design criteria are based on the strain based low cycle fatigue life analysis method. At present, 13 of the 15 front ends have completed factory acceptance, and some of the 12 front ends are installed in the tunnel of the storage ring, which is expected to be formally installed in January 2024.

Acknowledgements

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