RSI for the Superconducting Wiggler Source and Front End for the HEX Beamline

(Requirements, Specifications and List of Interfaces)

Compiled by Andy Broadbent and Zhong Zhong, with special thanks to Oleg Chubar.

Version 2

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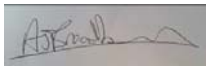
X 

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REVISION HISTORY

VERSION	DESCRIPTION	DATE	AUTHOR	APPROVED BY
1	First Issue. .	30SEPT2017	Z. Zhong and A. Broadbent	See page ii
2	Updated the FE slit description and the tabulated slit openings.	26MARCH2018	Z. Zhong and A. Broadbent	See page ii

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Contents

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1 DOCUMENT CONTROL

1.1 Identification

This document, *RSI for the Sources and Front Ends for the HEX Beamline*, is part of the Requirement Specification and Interface (RSI) documentation system, mapping to the NSLS-II Work Breakdown Structure (WBS). It captures and summarizes all requirements and specifications for the *Source and Front End* and lists all related technical interfaces with other parts of the project.

1.2 Scope

This document covers the Insertion Device and Front End for the HEX beamline, to be located at sector 27-ID of the NSLS-II, respectively.

2 ACRONYMS

3PW	Three Pole Wiggler
BC	Bremsstrahlung Collimator
BMPS	Bending Magnet Photon Shutter
CED	Cost Estimate Database
EPICS	Experimental Physics and Industrial Control System
EPS	Environmental Protection System
FE	Front End
FM	Fixed Mask
FOE	First Optical Enclosure
FV	Fast Gate Valve
HEX	High Energy Engineering X-ray Scattering (beamline)
ID	Insertion Device
NSLS-II	National Synchrotron Light Source II
PLC	Programmable Logic Controller
RSI	Requirements, Specifications, and list of Interfaces
SCW	Superconducting Wiggler
SGV	Slow Gate Valve
WBS	Work Breakdown Structure
XPBM	X-ray Beam Position Monitor

3 SOURCES FOR THE HEX BEAMLINE.

3.1 Insertion Device Specifications

The insertion device for the HEX beamline is specified below:

Beamline	HEX
Type	SCW
Device envelope length	~1.8 m
Magnetic Length	1.2m nominal (29 main and 4 partial poles)
Canted	No
Period: nominal	70 mm
Nominal (minimum) gap of vacuum bore tube *	10 mm TBC
Peak field nominal	4.3 T
Keff: nominal	28.1[*1]
Energy Range:	8 keV –200 keV
Power total: nominal	55.7 kW[*1]
Max.power per unit solid angle: nominal	28.4 kW/mr^2 [*1]
Straight	Low beta
Device center[*2]	May be offset in the straight to the downstream end.
Fan angle [*3] (mrad H) : nominal (maximum)	9.87 (10.15)
Fan angle [*3] (mrad V) : nominal (maximum)	0.88 (1.47)
Magnetic field variation range	Current adjustment 0 – 100%

Note 1: In assumption of sinusoidal magnetic field distribution in central part of wiggler.

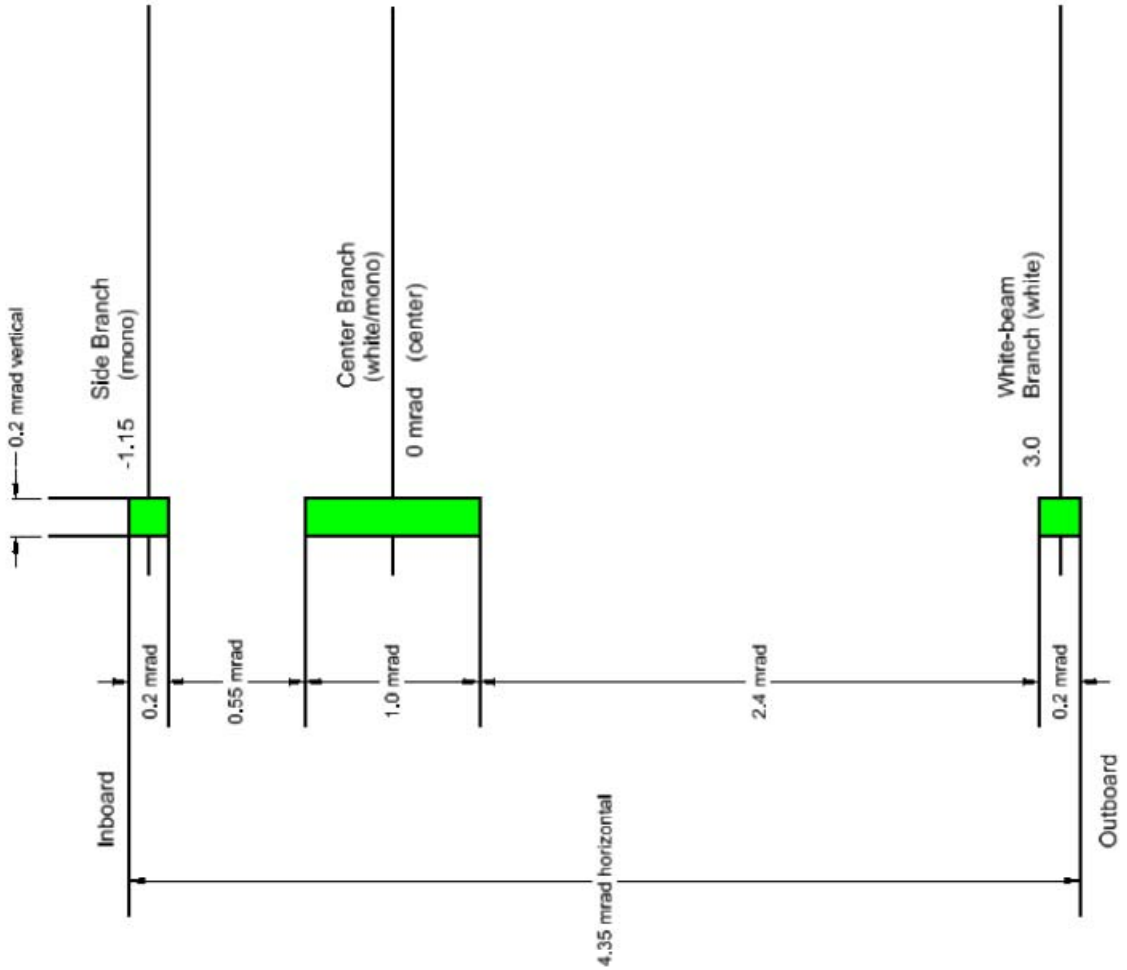
Note 2: The ray tracing should accommodate axial movements of the IDs by +/-5mm, which might be required in the design of the straight.

Note 3: The fan angles of the radiation quoted here are as seen at 16m from the source, and take into account the effects of source length; the worst case fan size is taken. The two values quoted are for the points where the power density falls to values that are 1% and 0.1% of the central value. Designs of the fixed mask entrance shall take into account these fringe power loads.

3.2 Insertion Device Controls

The ID planned for the HEX beamline has no motors. The SCW will require control of the magnet current (for ramp up and ramp down) and monitoring of the cryogenic condition. All of the devices shall follow the requirement in LT-C-ASD-ENG-RSI-001, *Requirements for Design and Electrical Wiring of Insertion Devices for NSLS-II*. The SCW controls interfaces will be in a separate document (Technical Specification for the Superconducting Wiggler).

3.3 Required Fans from the HEX Insertion Device



4 SUPERCONDUCTING WIGGLER STRAIGHT SECTION

The straight section shall include all necessary parts required for integration of the superconducting wiggler to the storage ring, as well as all required utilities. The following items are included in the scope for the Straight Section:

Vacuum transitions from the outer vacuum case of the wiggler, to the vacuum chamber at the ends of the straight	Y
Button type BPMs integrated into the straight vacuum chambers (standard stability type)	Y
Canting magnets	N
Vacuum pumps and pressure monitors	Y
DI water for cooling the vacuum chambers, as required	Y
Straight gate valves	Y
Installation of all cables to support the Insertion Device (SCW), to include 2 x ~400A / 10V main power cables, 4 x controls cables for LHe and LN2 level sensors, thermal sensors, etc. Low current trim coil cables	Y
Chilled water on tunnel roof for cooling cryogenic re-liquifying compressor	Y
Installation of GHe and GN2 exhaust pipes	TBC
ODH Monitoring System	TBC

5 FRONT END COMPONENTS FOR THE HEX BEAMLINE

The components listed below shall be included as a part of the Front End.

Specifications based on the scientific requirements are included in the indented rows.

	HEX
Photon shutter (BMPS)	Y
Slow Gate Valve (SGV)	Y
Beam Position Monitor 1 (XBPM1)	N
Beam Position Monitor 2 (XBPM2)	N
Fixed Mask (FM)	Y (Mk2 design)
Type	Triple aperture
Source	SCW
Beam apertures (mrad)	
In-board	At 1.15 mrad, 0.2mrad H x 0.2mrad V
Center	At 0 mrad,1.0mrad H x 0.2mrad V
Outboard	At 3.0 mrad, 0.2mrad H x 0.2mrad V
Tolerance on apertures	+/-0.01mrad
Shape	Corner Radius
Bremsstrahlung Collimator BC1	Y
Water Cooled Beryllium Window	N
Fast Gate Valve (FGV)	Y
Number of X-Y Slit sets *Note 1	3
X-ray flag	N
Fixed Mask 2	Y
Gate Valve	Y
Diagnostics Cross	Y
Photon Shutter (PSH)	Y
Bremsstrahlung Collimator BC2	Y
Safety Shutter (SS) (x2)	Y
Cycles per year required	50,000
Ratchet Wall Collimator	Y
Gate valve outside Ratchet Wall	N
FOE Fixed Mask 1	Y
Water Cooled Diamond Window	Y
FOE Bremsstrahlung Collimator 1	Y

Note 1: The three independent branches will ideally have independent control of the beam power entering each branch. Slits are considered to be a better means to control this than by using independent shutters.

Note 2: The slits for the HEX beamline shall comprise three independent sets, one for each of the branches. If it is not acceptable, then please consider not having slits for the small inboard beam. The V-slit design may also be considered to control the vertical beam size.

Note 3: The slit resolution is discussed further in Section 5.3.

6 COMPONENT DESCRIPTIONS

6.1 Bending Magnet Photon Shutter (BMPS)

The BMPS is designed to protect the SGV (see below) from BM/3PW radiation before the upstream straight is fitted with an ID and a complete Front End.

6.2 Slow Gate Valve (SGV)

The SGV is included to isolate the machine and Front End, but will not withstand white beam from ID, 3PW or BM radiation. The SGV is controlled and monitored by storage ring vacuum PLC, using a voting scheme with inputs from vacuum sensors at both sides of the valves and position of BMPS; the BPMS acts to protect the SGV when closed.

6.3 Fixed Mask (FM)

The fixed aperture mask shall provide radiation fans to the First Optical enclosure (FOE) as defined in the table above.

6.4 Bremsstrahlung Collimator (BC1)

The Bremsstrahlung collimator restricts the Bremsstrahlung radiation fan exiting the shield wall. This should be as tight to the beam as is reasonable, preferably using standard tube sizes, and without undue mechanical tolerances or alignment difficulty. Consideration will be given to amending these specifications to suit standard tubes sizes, if sensible.

6.5 X-Y Slits

The X-Y slits for the three branches shall comprise a beam stop, actuated in the vertical direction to switch between apertures of varying sizes to control power; the aperture sizes are tabulated in the following tables.

The specifications for the slits are as follows:

Material	Water-cooled copper alloy with Tungsten (or equivalent) blocks Thickness 6mm.
Power Protection	A pre-mask may be included if design considerations dictate
Maximum Opening angle	Sufficient to allow full fan to continue to the FOE without clipping.
Motorized	Yes to allow selection of any part of the fan.
Aperture Position Stability	$\Delta x, \Delta y = 4$ μm or better over any 8-hour period
Aperture Size Stability	0.4 μm or better over any 8-hour period

Slit Apertures		
Outboard Branch	Center Branch	Inboard Branch
0.2mrad H x 0.2mrad V	1.0mrad H x 0.2mrad V	0.2mrad H x 0.2mrad V
0.2mrad H x 0.1mrad V	0.4mrad H x 0.2mrad V	0.1mrad H x 0.2mrad V
0.2mrad H x 0.05mrad V	0.2mrad H x 0.2mrad V	0.05mrad H x 0.2mrad V
0.05mrad H x 0.05mrad V	0.05mrad H x 0.05mrad V	0.05mrad H x 0.05mrad V
0mrad H x 0mrad V	0mrad H x 0mrad V	0mrad H x 0mrad V

6.6 X-Ray Flag

An x-ray diagnostic flag should be included in the scope. This is required for visual and unambiguous checking of the alignment for radiation safety reasons.

Since this will only operate at a low current, it does not need to be cooled.

6.7 Photon Shutter

The photon shutter is required to stop the full white beam from the FM (one shutter for all branches). This is expected to be water cooled, copper alloy, at a grazing incidence angle and is fitted with a single actuator.

6.8 Fast Gate Valve (FV)

The fast valve is to shut within 15 milliseconds, once triggered by FV sensors located in the Front End and beamline whenever there is a sudden increase of pressure of a few decades. The stored beam has to be dumped prior to the FV closing, and the cause then investigated and mitigated

6.9 Bremsstrahlung Collimator (BC2)

Bremsstrahlung collimators 1 and 2, and the ratchet wall collimator shsll be made as tight as possible using out-of-vacuum lead designs, preferably with standard size stainless steel tubes, or in-vacuum tungsten if needed.

6.10 Safety Shutter

The safety shutter is actually a pair of shutters, required for redundancy, air actuated with independent redundant and diverse position sensing. A life of >50,000 cycles is required.

6.11 Ratchet Wall Collimator

See section 5.9, BC2 above. This will use standard tube sizes wherever possible.

6.12 Gate valve downstream of Ratchet Wall.

This slow gate valve, pneumatically actuated with position sensing switches, will be monitored and controlled by the storage ring vacuum PLC using vacuum sensors in the FE and beamlines.

Note 1: This valve cannot be removed after commissioning.

Note 2: This gate valve shall be protected from any exposure to (white) beam.

6.13 Motion Controls

The front end components requiring motion control include the slits for each branch, as well as the diagnostic flag (in/out).

6.14 Vacuum Controls

The Front End vacuum control is part of the storage ring vacuum control through EPICS and the storage ring vacuum PLC. EPICS provides the menu driven on-line control and logging of all vacuum devices, while the PLC provides the control logics for various vacuum devices and interface to EPS PLC for machine protection.

The vacuum system shall be compatible with the LT-ENG-RSI-SR-VA-002, *Requirements for the Design and Fabrication of Components for NSLS-II UHV Systems,* and obtain a vacuum level of $10E^{-9}$ mB.

7 REFERENCES

1. LT-C-ASD-ENG-RSI-001, *Requirements for Design and Electrical Wiring of Insertion Devices*

2. .LT-ENG-RSI-SR-VA-002, *Requirements for the Design and Fabrication of Components for NSLS-II UHV System*