RSI for the Sources and Front-Ends for the SST1&2 and BMM Beamlines (NIST)

(Requirements, Specifications and list of Interfaces)

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VERSION CONTROL LOG

VERSION	DESCRIPTION	DATE	AUTHOR	APPROVED BY
1	First Issue. 2/18: Controls group leader's signature is added. ID requirement documents are added in section 3.1. Ranishaw encoder as standard NSLS-II linear absolute encoder replaced Heidenhein.	12 Feb 2015	A. Broadbent	See cover page

Contents

1 DOCUMENT CONTROL

1.1 Identification

This document, *RSI for the Sources and Front Ends for the SST 1 & 2 and BMM Beamlines,* is part of the Requirement Specification and Interface (RSI) documentation system, mapping to the NSLS-II Work Breakdown Structure (WBS) and Cost Estimate Database (CED). It captures and summarizes all requirements and specifications for the *Sources and Front-Ends* and lists all related technical interfaces with other parts of the project.

1.2 Scope

This document covers Insertion Devices and Front Ends for the two NIST beamlines, SST and BMM to be located at 7-ID and 6-BM at NSLS-II, respectively.

2 ACRONYMS

BC	Bremsstrahlung Collimator
BM	Bending Magnet
BMM	Beamline for Materials Measurement
BMPS	Bending Magnet Photon Shutter
CED	Cost Estimate Database
EPICS	Experimental Physics and Industrial Control System
EPS	Environmental Protection System
EPU	Elliptically Polarized Undulator
FE	Front End
FM	Fixed Mask
FV	Fast Gate Valve
ID	Insertion Device
NIST	National Institute of Standards and Technology
NSLS-II	National Synchrotron Light Source II
PLC	Programmable Logic Controller
RSI	Requirements, Specifications, and list of Interfaces
SGV	Slow Gate Valve
SST	Spectroscopy Soft and Tender
TPW	Three Pole Wiggler
WBS	Work Breakdown Structure
XPBM	X-ray Beam Position Monitor

3 SOURCES FOR THE NIST BEAMLINES

The insertion devices for the NIST beamlines are tabulated below:

Beamline	BMM 6-BM	SST1&2 7-ID	
Branch		SST1	SST2
Type	TPW	EPU	U42
Source	To be fabricated by NSLS-II	SRC Wisconsin	Loan from ESRF
Device envelope length	Standard	0.89 m	1.6 m
Magnetic Length	Standard	0.84 m (14 periods)	1.6 m
Canted	N/A	Y	
Cant angle	N/A	2.0 mrad	
Period		60 mm	42 mm
Nominal (minimum) gap *		20.5mm (14mm)	12 (11.5) mm
Peak field: nominal (maximum)	1.2 T nominal	V: ~0.79 (~1.02) T H: ~0.45 (~0.73) T	0.79 (0.82) T
Keff: nominal (maximum)		V: 4.1 (5.7) H: 2.5 (4.1) Circ: 3.0 (4.7)	3.15 (3.27)
Energy Range: nominal (minimum)		LH: 150 (80) eV – ~3 keV LV: 340 (150) eV - ~3 keV C: 250 (115) eV - ~1 keV	345 (325) eV - ~10 keV
Power total: nominal (maximum)	250W (TPW) + 69W (BM)	LH: 1.4 (2.7) kW LV: 0.51 (1.36) kW C: 0.74 (1.8) kW	2.9 (3.2) kW
Max.power per unit solid angle: nominal (maximum)	365 W/mr^2	LH: 4.8 (6.7) kW/mr^2 LV: 2.8 (4.7) kW/mr^2 C: 1.35 (2.0) kW/mr^2	13.3 (13.8) kW/mr^2
Straight	N/A	Low beta	
Device center *2	366mm U/S of 6-BM-B	D/S +1.25 m	U/S -1.25 m
Fan angle *1 (mrad H) : nominal (maximum)		LH: 1.60 / 2.16 (2.14 / 2.67) LV: 0.85 / 1.35 (0.87 / 1.41) C: 1.52 / 2.03 1.96 / 2.49)	1.29 / 1.87 (1.34 / 1.90)
Fan angle *1 (mrad V) : nominal (maximum)		LH: 0.86 / 1.40 (0.87 / 1.43) LV: 1.06 / 1.66 (1.59 / 2.16) C: 1.51 / 2.02 (1.95 / 2.47)	0.85 / 1.38
Gap scanning and other requirements		Require energy scanning at fixed polarizations.	Required for NEXAFS experiments (specs as SRX).

* Chambers should be sized for the minimum gap.

The above data is courtesy of Oleg Chubar, checked and correct on 28-Nov-2014.

Note 1: 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 and (for SST) the canting; the worst case fan size is taken (linear horizontal mode gives the worst case horizontal fan, but helical mode requires the largest vertical fan aperture). 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 XBPM and fixed mask entrance shall take into account these fringe power loads.

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

3.1 Insertion Device Controls

The Insertion Devices planned for the SST beamline are both non-standard devices with motors and controls that need to be connected and adapted (where required) to the standard NSLS-II motion control solution. The motion controls shall be developed in-house using the standard EPICS interface/Delta-Tau controller/Power amplifiers, as required. All the devices must follow the requirement described by LT-C-ASD-ENG-RSI-001 (Requirements for Design and Electrical Wiring of Insertion Devices for NSLS-II) and LT-C-ASD-ENG-RSI-002 (Motion Control Requirements for Insertion Devices for NSLS-II).

The devices have the following interfaces:

Insertion Device	Number of Axes	Motor	Encoder
EPU60	6	Pacific Scientific T23NRLH-LDF-NS	Ranishaw RESOLUTE LSLA-80mm
U42	TBA	TBA	TBA

4 FRONT END COMPONENTS FOR THE NIST PARTNER BEAMLINES

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.

	BMM	SST	
Photon shutter (BMPS)	Y	Y	
Slow Gate Valve (SGV)	Y	Y	
Beam Position Monitor 1 (XBPM1)	N	Y	
Beam Position Monitor 2 (XBPM2)	N	Y	
Fixed Mask (FM)	Y	Y	
Type	Single	Dual	
Source	3PW	EPU	IVU
Vertical aperture (mrad)	0.3+/-0.05 *Note1	0.3+/-0.05	0.3+/-0.05
Horizontal aperture (mrad)	2.0+/-0.05 *Note1	0.5+/-0.05	0.5+/-0.05

Shape	Corner Radius	Corner Radius	Corner Radius
Bremsstrahlung Collimator BC1	Y	Y	
Water Cooled Beryllium Window	N	N	
Fast Gate Valve (FGV)	Y	Y	
Number of X-Y Slit sets. *Note2	1	2 *Note3	
X-ray flag	N	Y (required for both IDs)	
Mirror System / design	Y by FMB-O see following table	N	
Fixed Mask 2	Y	N	
Gate Valve	Y	N	
Diagnostics Cross	Y	N	
Photon Shutter (PSH)	Y	Y	
Bremsstrahlung Collimator BC2	Y	Y	
Safety Shutter (SS) (x2)	Y	Y	
Cycles per year required	50,000	50,000	
Ratchet Wall Collimator	Y	Y	
Ratchet Wall Modification	If required.	N	
Gate valve outside Ratchet Wall.	Y	Y	

Note 1: The BMM aperture may be made 0.4 x 2.5 mrad if this is a more appropriate standard size.

Note 2: The X/Y slits are to be under beamline control except when disabled by the machine control room.

Note 3: The slits for the SST beamline shall comprise two separate sets, one for each of the canted beamlines.

Note 4: The slit resolution is discussed further in Section 5.3.

5 BMM BEAMLINE FE MIRROR SPECIFICATIONS

Mirror system length, between flanges	1190 mm
Length of mirror substrate	1000 mm
Orientation	Bounce up
Material	Silicon
Mirror figure	Paraboloidal
Beam incidence angle	3.5mrad
Mirror acceptance (H/V)	2.1 mrad (H) x 0.24 mrad (V)
Mirror system center position	13m from source
Mirror operating limits (max incidence angle *).	5 mrad
Water flow rate for the mirror	Ideally 1.5 gpm (6 l/min). First component in any cooling chain; followed by slits, mask, PSH.

***** Assume hard stops set for the max height at D/S end of mirror and the min height at the U/S end of the mirror.

6 COMPONENT DESCRIPTIONS

6.1 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 insertion device and a complete front end.

6.2 Slow Gate Valve (SGV)

The Slow Gate valve is included to isolate the machine and FE, but will not withstand white beam from IDs, TPW 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 Beam Position Monitor 1 (XBPM1)

The XBPMs shall be designed to work with the insertion devices specified:

Material	Water-cooled mountings and Tungsten blades
Power protection	A pre-mask may be included if design considerations dictate
Motorized	Yes to allow centering of the device around the beam.

The XBPMs shall be mounted on X/Y stages with the following specifications:

Position stability	SST: Δx, Δy = 1 μm or better over any 8-hour period
Speed	No requirement
Position resolution	x and y = 0.1 μm (expected value from calculations); <<1micron (guaranteed).

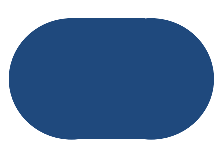
The X/Y stage for the XBPM and the X/Y slits are expected to be the same design, including the stand, where possible.

6.4 Beam Position Monitor 2 (XBPM2)

This device and X/Y stages shall be identical to XBPM1, however the blades shall be relocated to avoid masking effects.

6.5 Fixed Mask (FM)

The fixed aperture mask shall provide radiation fans to the First Optical enclosure (FOE) as defined in the table above.
It is permissible for the mask aperture to have corner radii equivalent to half the aperture height, as shown below.



6.6 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.

6.7 X-Y Slits

The X-Y slits shall be of the dual "L" type design, connected with bellows to allow full adjustment of all four "blades" via two X-Y stages. The specifications are as follows:

Material	Water-cooled copper alloy with Tungsten blocks
Power protection	A pre-mask may be included if design considerations dictate
maximum opening angle	Sufficient to allow full FAPM fan to continue to the FOE without clipping.
Motorized	Yes to allow selection of any part of the FAPM fan. The same X/Y stage shall be used for the XBPMs.
Aperture position stability	SST: Δx, Δy = 1.5 μm or better over any 8-hour period BMM: Δx, Δy = 4 μm or better over any 8-hour period
Aperture size stability	SST: 0.15 μm or better over any 8-hour period BMM: 0.4 μm or better over any 8-hour period

6.8 X-Ray Flag

The X-ray flag is used for low power beam alignment (ID Beamlines only) while the ID photon shutter and safety shutters remain closed. This device is specifically used after configuration changes and during beamline commissioning. It will be mounted to the pumping cross downstream of the slits within the frontend. This device shall only be used at low power (<2mA) so it will not require water cooling.

6.9 Photon Shutter

The photon shutter is required to stop full white beam, for IDs this is expected to be water cooled copper alloy at a grazing incidence angle.

6.10 Fast Gate Valve (FV)

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

6.11 Bremsstrahlung Collimator (BC2)

Bremsstrahlung collimators 1 and 2, and ratchet wall collimator should 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.

6.12 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.

6.13 Ratchet Wall Collimator

See note above for BC2. This will use standard tube sizes.

6.14 Gate valve downstream of Ratchet Wall.

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

Note 1: This valve cannot be removed after commissioning.

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

6.15 Motion Controls

The front end components requiring motion control include the XBPMs (2 units, X/Y axes for each) and the slits (4 axes).

6.16 Vacuum controls

The FE vacuum control is part of storage ring vacuum control through EPICS and storage ring vacuum PLC. EPICS provides the menu driven on-line control and logging of all vacuum devices, while 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 document 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 (and $10E^{-8}$ mB where a mirror is included).