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Attachment B

USI Screening Checklist

A) USI Screening Purpose:	**B) Description of Proposed Activity/Discovered Condition and Sponsor/Condition Owner:**
☒ **Proposed Activity** ☐ **Existing Condition**	Review of Ray Tracing Designs of SST (7-ID) Front-ends
C) USI Screening Outcome: ☒ **No potential USI** ☐ ***Potential USI***	**USI Screening Performed by/Date:** Steve Moss 10/03/17 Steve Moss / October 5, 2017 The following answers are based on compliance with: 1) RSC Memorandum dated October 4, 2017 with subject: Review of the Ray-Tracing Designs of the SST (7-ID) Front-Ends (copy attached).

Qualified Screener answers the following questions; if:

- Any question is answered yes (i.e., "Y"), check "Potential USI" box in Part C, above.
- If all questions are answered no (i.e., "N"), check "No potential USI" box in Part C, above.

Does the proposed change or discovered condition impact or potentially impact:

1) The personnel protection system (PPS)?
Examples: Access doors, fencing, hutches, accelerator enclosures, software change, hardware modifications that are not, "replacement-in-kind."

☐Y or ☒N

2) ODH Monitoring System?
Examples: Hutch ODH monitors, filling station ODH monitors.

☐Y or ☒N

3) Radiation Safety Component?
Examples: Shielding, earthen berms, hutches, concrete walls, beam shutters, scatter shields, burn-through devices, exclusion zones, labyrinths, beam stops, beam masks, collimators, hutch guillotine and beam transport pipes.

☐Y or ☒N

4) Area radiation monitoring system or components?
Examples: Changing instrument position or use of a new type of instrument used for area radiation monitoring, alarms and controls.

☐Y or ☒N

5) Radiological source terms identified in the SAD?
Examples: New insertion devices, change to the maximum synchrotron energy or accelerated charge values, accelerator modifications that are not "replacement-in-kind."

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Memo

Date: October 4, 2017
To: Christopher Amundsen, Mohamed Benmerrouche, and Sushil Sharma
From: Zhong Zhong (chair), Photon Science Radiation Safety Committee
Subject: Review of the ray-tracing designs of the SST (7-ID) front-ends

Dear Chris, Mo and Sushil,

The Photon Science Radiation Safety Committee (RSC)'s ray-tracing subcommittee concluded review of the front-end ray-tracing drawings of the SST (7-ID) On September 14.

Subjects reviewed include the synchrotron max-fan and Bremsstrahlung drawings. Since the max. fan drawings are sufficient for assuring the safety of the front-end against synchrotron radiation, the nominal synchrotron and interlocked ray-tracings, included in the drawing packages on sheets 2 and 3, were not reviewed by the RSC.

Documents Reviewed

The following documents were submitted to the RSC on September 7, 2017 for review:

1. SST front-end assembly drawing, SR-FE-IVU07-1001, Rev. C by D. Puleo.
2. SST front-end Bremsstrahlung ray-tracing, SR-FE-IVU07-1001, Rev. C, sheets 4 and 5 for horizontal and vertical projections, respectively.
3. SST front-end max. synchrotron ray-tracing, SR-FE-IVU07-1001, Rev. C sheets 6 and 7 for horizontal and vertical projections, respectively.
4. Rev. B of the above drawings.
5. Memo from Chris Amundsen to the RSC, dated September 6, 2017. The memo details changes made in Rev. C compared to prior version Rev. B.

Notes

The SST front-end Rev. B was reviewed by the RSC in 2016. The memo for that review is attached for completeness. The current version Rev. C contains minor updates from Rev. B., as detailed in Chris Amundsen's memo.

Conclusions

Based on our assessment of the ray-tracing drawings, the RSC finds the Bremsstrahlung and synchrotron shielding design for the SST front-end meeting the NSLS-II shielding policy.

Conclusions

Based on our assessment of the ray-tracing drawings, the RSC find the SST and BMM front-end Bremsstrahlung and synchrotron shielding design meets the NSLS-II shielding policy.

Attachment B

USI Screening Checklist

A) USI Screening Purpose: ☒ **Proposed Activity** ☐ **Existing Condition**	**B) Description of Proposed Activity/Discovered Condition and Sponsor/Condition Owner:** 7-ID (SST) Front End and Insertion Device / NIST
C) USI Screening Outcome: ☒ **No potential USI** ☐ ***Potential USI***	**USI Screening Performed by/Date:** Steve Moss 10/23/17 Steve Moss / October 23, 2017 (Answers to questions based on details contained in attached references including NSLS-II SAD Section 3.3.3.8 – Photon Sources and PS-C-XFDE-RSI-SST-BMM-001, Ver. 1, "RSI for the Sources and front Ends for the SST1&2 and BMM Beamlines (NIST)".)

Qualified Screener answers the following questions; if:

- Any question is answered yes (i.e., "Y"), check "Potential USI" box in Part C, above.
- If all questions are answered no (i.e., "N"), check "No potential USI" box in Part C, above.

Does the proposed change or discovered condition impact or potentially impact:

1) The personnel protection system (PPS)?
Examples: Access doors, fencing, hutches, accelerator enclosures, software change, hardware modifications that are not, "replacement-in-kind."

☐Y or ☒N

2) ODH Monitoring System?
Examples: Hutch ODH monitors, filling station ODH monitors.

☐Y or ☒N

3) Radiation Safety Component?
Examples: Shielding, earthen berms, hutches, concrete walls, beam shutters, scatter shields, burn-through devices, exclusion zones, labyrinths, beam stops, beam masks, collimators, hutch guillotine and beam transport pipes.

☐Y or ☒N

4) Area radiation monitoring system or components?
Examples: Changing instrument position or use of a new type of instrument used for area radiation monitoring, alarms and controls.

☐Y or ☒N

5) Radiological source terms identified in the SAD?
Examples: New insertion devices, change to the maximum synchrotron energy or accelerated charge values, accelerator modifications that are not "replacement-in-kind."

☐Y or ☒N

6) Critical devices
Examples: Safety shutters, dipole magnets, top-off apertures.

☐Y or ☒N

7) PS operating organization?
Examples: Control room operators, support staff responsible for PPS, radiation monitoring or shielding configuration management.

☐Y or ☒N

8) Operational safety limits described in the Authorization Basis Documents?
Examples: Maximum current, beam energy, pulse rate.

☐Y or ☒N

Forward the completed form to the Authorization Basis Manager

TABLE 3.7

3.7 LIST OF STORAGE RING MAGNETS

DESCRIPTION	REQUIRED IN STORAGE RING
100mm Corrector	90
100mm Corrector + Skew Quad	30
156mm Corrector	60
Fast Corrector	90
35mm Dipole	54
90mm Dipole	6
Single Coil Short Quad	30
Double Coil Long Quad	30
Long Double Kinked Quad	30
Double Coil Short Quad	90
Large Aperture Quad	60
Single Coil Short Wide Quad	30
Double Coil Wide Quad	30
Symmetric Sextupole	165
Wide Sextupole Magnet	75
Large Aperture Sext	30
TOTAL:	**900**

The injection straight section contains five pulsed magnets used during electron injection, four bump magnets and a pulsed septum. The bumps were designed and built at BNL with a titanium coated ceramic vacuum chamber and a ferrite yoke installed in air outside the chamber.

3.3.3.8 Photon Sources

The set of insertion devices included for the start of routine operations of NSLS–II consists of hard x–ray and soft x–ray undulators, x–ray damping wigglers and three–pole wigglers. Taken together, these IDs produce high–brightness radiation spanning a large photon energy range, from the soft x–ray (~200 eV) to the very hard x–ray (~300 keV).

TABLE 3.8

3.8 INSERTION DEVICES INCLUDED IN THE BASELINE CONFIGURATION OF NSLS–II

TYPE OF DEVICE	PURPOSE	QUANTITY
Damping Wiggler (DW90): 90 mm period, 1.85 T, 2 × 3.4–m long, 12.5mm pole gap	Broadband	3 (8)
In–Vacuum Undulators (IVU):	Hard X–ray	
IVU20: 20–mm period, 1.05 T (5.0 mm min. vertical aperture), 3–m long		2
IVU21: 21–mm period, 0.91 T (6.2 mm min. vertical aperture), 1.5–m long, canted		1
IVU22: 22–mm period, 0.76 T (7.2 mm min. vertical aperture), 2 × 3–m long		1
Elliptically–polarizing undulator (EPU49): 49–mm period, 0.94 T (11.5 mm min. magnet gap), 2 × 2–m long, optionally canted by ~0.16 mrad	Soft X–ray	1
Three–Pole Wiggler: 1.14 T peak field, 20–cm long*	Broadband	1

*Not installed in the baseline project scope

The complement of insertion devices included in the NSLS–II baseline configuration is listed in Table 3.8. This set is not meant to be complete for the built–out NSLS–II facility. Rather, these devices represent a set that initially seeks to optimize the performance of the Beamlines included in the NSLS–II

baseline configuration. These IDs have been chosen consistent with the philosophy of building Beamlines dedicated to a given technique, which requires that the source also be individually optimized for each application, as appropriate.

There will also be Beamlines in the future which utilize the NSLS–II bending magnets, which will have a relatively low critical energy: ~2.4 keV. It is expected that the available bend magnet ports will be allocated primarily to VUV and soft x–ray uses, as well as infrared uses. The NSLS–II bend magnets and three–pole wigglers will provide very stable beams. The relatively low emitted power from these sources simplifies the cooling requirements on the optics, although it does not eliminate the need to provide cooling. The brightness provided by the NSLS–II dipole sources will be two orders of magnitude higher than that of the present NSLS dipoles (extending up to ~12 keV) and their flux will also show some improvement (extending up to ~4 keV).

The basic parameters characterizing the IDs, bending magnet and three–pole wiggler sources are listed in Table 3.9.

TABLE 3.9

3.9 BASIC PARAMETERS OF NSLS–II RADIATION SOURCES FOR STORAGE RING OPERATION AT 3.0 GeV AND 500 mA

	U20	EPU49	DW90	SCW60	Bend Magnet	Three–Pole Wiggler
Type	IVU	EPU	PMW	SCW	Bend	PMW
Photon energy range [keV]	Hard x–ray (1.9 – 20)	Soft x–ray (0.18 – 7)	Broadband (<0.01–100)	Very hard x–ray (<0.01–200)	Soft and low–energy x–ray (<0.01 –12)	Hard x–ray (<0.01 –25)
Type of straight section	Low–β	Low–β	High–β	Low–β		
Period length, λ_0 [mm]	20	49	90	60		
Total device length [m]	3.0	4.0	7.0	1.0		0.25
Number of periods	148	2 x 39	75	17		0.5
Minimum magnetic gap [mm]	5.2**	11.5	12.5	15		28
Peak magnetic field in linear mode, B [T]	1.03	0.94	1.85	3.5 (6)	0.40	1.14
Max K_y* in linear mode	1.83	4.34	15.7	19.6 (33)		
Peak magnetic field in circular mode, B [T]		0.57				
Max K= $\sqrt{2}$ K_x =$\sqrt{2}$ K_y* in circular mode		3.69				
Minimum hν fundamental [keV]	1.6	0.17				
hν critical [keV]			11.1	21 (36)	2.39	6.8
Maximum total power [kW]	7.9	8.8	67	34 (101)		0.32
Horizontal angular power density [kW/mrad]			16	6.6 (11)	0.023	0.067
On–axis power density [kW/mrad²]	66	32.8	62	25 (44)	0.088	0.26

*K = 0.934 B[T] λ_u[cm]; effective K values listed

** Physical vertical aperture must be minimum 5.0mm

From the point of view of safety, an important parameter is the total power of the synchrotron radiation beam produced by the source. Table 3.9 gives the maximum total output power of the NSLS–II radiation sources. The total power radiated by the undulators at their maximum K settings is in the 8–10 kW range. The total power output from the NSLS–II wigglers is higher than that of the undulators, at nearly 70 kW for DW90, while that of the NSLS–II bend magnets and TPWs is very much less, at only ~23 W and ~67W per horizontal mrad.

Insertion devices in the NSLS–II Storage Ring generate radiation with high power density capable of damaging components of the vacuum system if incident on surfaces without adequate water cooling. Under normal operating conditions, the electron orbit is positioned in a manner assuring proper illumination of the user Beamlines and avoiding unwanted incident power on un–cooled surfaces. In the absence of faults, the electron orbit is highly stable exhibiting variations of only a

few microns. However, in the event of the failure of a magnet power supply or other hardware fault, the electron orbit can move by millimeters causing the insertion device radiation to be incident upon un-cooled surfaces. To prevent this from occurring, the equipment protection interlock system must kill the electron beam when the orbit variation exceeds predetermined limits. The definition of tolerable limits within which the beam positions and angles are allowed to vary depends on (list not necessarily complete):

- details of the geometrical constraints of the vacuum system
- the mechanical tolerances and the stability of the vacuum system
- the alignment tolerances and alignment stability
- the long term and short term stability of the detection systems which measure the beam positions and angles

To define the limitations we must understand

- the power distribution within the photon beam matters
- the maximum power which can be tolerated on components of the vacuum system
- the cooling capacity
- and special vulnerabilities such as vacuum seals, RF fingers, shielded bellows

The resulting constraints on the beam coordinates are further limited by necessary beam steering to launch the photon beam into the Beamlines which depends on Beamline alignment tolerances and stability as well as on mechanical tolerances in the Beamlines.

The resulting remaining free space for the beam positions and angles in the insertion devices must be compatible with robust and stable operating conditions which imply a certain tolerance against small anomalies, instabilities and minor hardware failures as they occur from time to time in a real accelerator. Thus the magnetic and mechanical design of insertion devices and the downstream system of absorbers and vacuum components are closely related to highly reliable operation of the facility.

3.3.3.9 Control System

The control system provides all the hardware and software necessary to monitor and control the Linac, Booster ring, transport lines, Storage Ring and Beamlines. All parameters essential for the operation of facility (e.g. magnet power supplies, RF systems, vacuum, cooling systems) are monitored and controlled by the control system.

The control system interfaces with the EPS. This system provides equipment protection for the Storage Ring front end components. Another branch of the EPS will provide protection and command/control on the experimental lines. The EPS protects equipment from the thermal effect of the synchrotron beam by monitoring the position of components, cooling supply and temperature. When a condition puts components in jeopardy of being damaged, the EPS will shut the RF systems down, causing the beam to dump or shut off power supplies to stop the flow of current in an overheating conductor.

These interlocks are not for personnel protection, but are important to prevent programmatic loses and are designed to be fail safe. A safe state is indicated by a closed contact sending a DC voltage. An unsafe state is indicated by an open contact that blocks the DC signal. On power failure, the system indicates an unsafe state. In case an interlock has been tripped, the system or subsystem is not operational, even if the cause of the interlock trip has been cleared, until the

Operator has reset the interlock. Control Room procedures provide guidance to the Operator for responding to equipment trips and systems alarm.

3.3.3.10 Top Off Operation

The traditional way of operating a storage ring based light source is in the "decay mode". In the "decay mode", beam is injected into the storage ring with frontend safety shutters closed. Neither x-rays nor injected beam can enter the user beamlines during injection. Once injection is completed, the stored beam current begins to decay due to beam loss from Touschek scattering, collision with residual gas, etc. The radiation flux and brightness are changing with stored beam current, as is the heat load on beamline optics which impacts the quality of experimental data.

Top–Off mode refers to injecting into the Storage Ring with the beamline photon and safety shutters open to maintain a near–constant stored beam current in the ring. The frequent injection of electron beam into the Storage Ring maintains the stored beam current at a near constant level. This provides for the stable operation of the accelerator and user beamlines without interrupting user experiments. Because stored beam intensity is maintained at a quasi-constant level and the shutters are continuously open, the x-ray flux to experiments and heat load on beamline optics are kept extremely stable, which is highly preferred by users. This mode of operations is supported by the design of the injection systems in most modern electron synchrotrons such as the Advanced Light Source, Advanced Photon Source, and Stanford Synchrotron Radiation Lightsource.

The NSLS-II large design beam current of 500 mA and the low emittances imply large Touschek scattering rates which limit beam lifetime to approximately 3 hours. This short lifetime requires electron injection of 8 nC every minute to maintain beam intensity within the specified limits. The injection system is designed to provide a maximum capability of delivering up to 15 nC per booster cycle.

Injection with open safety shutters introduces a special radiological risk caused by injected 3 GeV electrons which could enter the experimental floor via the open shutters during injection. This would cause unacceptably high radiation doses on the experimental floor, as discussed in Section 4.15.~~4~~10 – Radiological Hazards Associated with Top Off Operations. To guarantee the safety of Top-Off injection, one must assure that, for all possible fault conditions, all errant injected particles are lost before a safe point within the Storage Ring tunnel. At NSLS-II, each beamline will have a designated safe point beyond which no injected beam can be allowed to pass through all physical apertures and enter the First Optics Enclosure (FOE).

The safety of Top-Off injections has been extensively studied and reviewed by panels of experts from across the DOE community. Particle tracking analysis has been performed to assure that injected electrons cannot pass the safe point and several interlocks will be used to ensure that top off injections only occur when the stored beam is stable. These interlocks include stored beam current, dipole current and voltage, injected beam energy and injection current. A description of each of these interlocks is provided in Section 4.15.10.

Top–Off operation is now part of the scope of this document. During a fill of the Storage Ring from zero current, the Top Off Safety System (TOSS), would not permit electron injections to be made with front end safety shutters open at currents < 50 mA. Injection with the safety shutter open at currents < 50 mA will trigger the USI process and will require additional review and approval beyond

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

(Requirements, Specifications and list of Interfaces)

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

Approved by:

2/18/2015

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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

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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, $\Delta y = 1$ 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: $\Delta x, \Delta y = 1.5\ \mu m$ or better over any 8-hour period BMM: $\Delta x, \Delta y = 4\ \mu m$ 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).