National Synchrotron Light Source

Building 743, National Synchrotron Light Source
Brookhaven National Laboratory
Upton, NY 11973-5000
Phone 631 344-2117
Fax 631 344-3238
zhong@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: February 1, 2018
To: Daniel Fischer, Joseph Woicik, Cherno Jaye, Conan Weiland, Howard Robinson, Andrew Broadbent, and Paul Zschack
From: Zhong Zhong (chair), Photon Science Radiation Safety Committee
Subject: Review of the radiation safety design of the 7-ID (SST) beamline

Dear Dan, Joe, Cherno, Conan, Howard, Andy and Paul,

The Photon Science Radiation Safety Committee (RSC) conducted review of the design of the SST beamline, 7-ID, on January 12, 2018. Subjects reviewed include synchrotron max-fan and Bremsstrahlung drawings, Secondary Bremsstrahlung and synchrotron radiation shielding analysis, top-off safety analysis, and aspects of thermal management that relate to radiation safety.

Written documents

The following documents and drawings were reviewed:

1. SST assembly drawing, PD-SST-RAYT-0001 rev. A, by J. Fabijanic, sheets1 to 3, "SST Beamline Raytrace" showing plan and elevation view of both the tender and the soft branches, and how the soft branch monochromatic beam can feed into the tender experimental endstation via a transfer line.
2. SST Bremsstrahlung ray-tracing drawings, PD-SST-RAYT-0001 rev. A, sheets 7 and 8 for horizontal and vertical projections, respectively. Details for Bremsstrahlung lead and tungsten stops are included on sheet 8.
3. SST max. synchrotron ray-tracing drawings, PD-SST-RAYT-0001 rev. A, sheets 4 for horizontal projection, sheet 5 for vertical projections of M branch, and sheet 6 for vertical projections of L branch. Additional details for the beam mis-steering considerations and beam stop are shown on sheet 9 for M branch, and sheet 10 for L branch.
4. Powerpoint presentation "Radiation Shielding Overview SST 7-ID Beamlines" presented by Cherno Jaye and Conan Weiland, January 12, 2018.
5. NSLS-II technical note number 275 by S. Chitra and M. Benmerrouche entitled "07-ID (SST) Beamline Radiation Shielding Analysis" dated January 31, 2018. The document presents analysis results of Gas Bremsstrahlung (GB) as well as Synchrotron Radiation (SR) at 500 mA.
6. NSLS-II technical note #NSLSII-TOS-RPT-016, "07ID (SST) Top-off Radiation Safety Analysis" by S. Chitra and M. Benmerrouche, dated 12/20/1017.

Oral Presentation

Attendance: Andrew Ackerman, Andi Barbour, Mo Benmerrouche, Andy Broadbent, Sunil Chitra, John Fabijanic, Daniel Fischer, Cherno Jaye, Robert Lee, Boris Podobedov, Conan Weiland, Lutz Wiegart, Joseph Woicik, Emil Zitvogel, and Zhong Zhong

Cherno Jaye and Conan Weiland gave the presentation entitled "Radiation Shielding Overview SST 7-ID Beamlines". Following the guideline from the memo by Paul Zschack to the RSC on May 29, 2014, the following were discussed:

1. SST, located at 7-ID, is a suite of soft- and tender- x-ray spectroscopy beamlines using an elliptically polarized undulator (EPU)60 for the soft (M) branch, and planar U42 undulator for the tender(L) branch, as x-ray source.
2. The beamline optics consists of mirrors located in the FOE and two monochromators, one for each branch, on the experimental floor. Two shielded beam pipes transport the pink beams for the two branches from the FOE to the monochromators on the experimental floor. The M branch monochromator is a variable line spacing (VLS) planar grating monochromator (PGM) manufactured by FMB-Berlin. The output energy is 100-2200 eV. The L branch monochromator is a standard double-crystal monochromator (DCM) made by FMB-Oxford using 111, 220 or 333 reflections of Silicon crystal. The output energy range is 2 to 7.5 keV. The beam stop for each monochromator is located outside of, and separate from, the monochromator vacuum chamber.
3. The preliminary SST ray-tracing drawings were reviewed by the ray-tracing sub-committee before in March and May 2016, and in November last year. The comments from the three prior reviews, adequately addressed in the current ray-tracing, are attached for completeness.
4. The white beams for both branches on the mirrors located in the FOE are controlled by the front-end shutter. The pink beams are controlled by water-cooled shutters, one for each branch, at the downstream end of the FOE. The monochromatic beam(s) feeding into each endstation is/are controlled by shutter(s) immediately upstream of the endstation. Each endstation is interlocked by its own vacuum safety switch to prevent beam into the vacuum chamber when it is vented for access.
5. Shielding for the primary Bremsstrahlung x-rays is designed using ray-tracing method. A collimator (frontend collimator 2 and downstream RCO collimator) and beam-stop (U/S BRS at 35.66 m) combination, with horizontally deflecting mirrors L1 and M1 in between, stops the primary Bremsstrahlung in the FOE. The Tungsten Bremsstrahlung beam-stop, at 35.66 m, intercepts all possible primary Bremsstrahlung radiation. It was noted that the Tungsten stop is in air, but lead is not used as beam stop due to its larger size protruding into the beam-pipes on the inboard and outboard sides.
6. Shielding and control of secondary Bremsstrahlung radiation is designed by ray-tracing from possible secondary scattering sources in FOE, and verified by FLUKA analysis performed by Chitra and Benmerrouche. 5 cm of lead was recently installed at the downstream wall of the FOE as a result of the FLUKA analysis.
7. The transport pipe between the FOE and monochromators on the experimental floor is shielded with 8 mm lead, exceeding the amount recommended for pink-beam transport by NSLS-II shielding guideline. Sections of un-shielded pink-beam transport pipe and bellows were shielded with additional stainless steel wrapping as

recommendations by Chitra and Benmerrouche and documented in the synchrotron shielding report (item 5).

8. The monochromatic beam, when mis-steered by the mirrors, could strike the stainless steel monochromatic beam transport pipe. Preliminary analysis by Amy Xia in 2015 (shown on the power point presentation), and further detailed analysis shown in item 5 by Chitra and Benmerrouche, all show that this condition is safe.
9. For the endstation chamber, simulations show that scattering of the monochromatic beam from worst-case target in the chamber is safe for personnel outside of the stainless steel chamber as well as outside of the glass viewports.
10. The top-off safety analysis shows that in the case of top-off fault at SST, the dose rates outside of the FOE downstream walls (at 100-150 mrem/hr when taking credit for existing secondary shielding) slightly exceeds the 100 mrem/hr required by NSLS-II shielding policy for fault conditions. Thus an Area Radiation Monitor (ARM) located on the sidewall of the FOE is required.
11. The peak power density is 6.7 kW/mr^2 and 13.8 kW/mr^2 for EPU60 and U40, respectively. These are much less than that of typical IDs at the NSLS-II. FEA analysis for white-beam mask and beam-stops, some performed assuming typical NSLS-II ID powerload, were presented to show that they are adequately designed to handle the modest power load. Thermal protection of the beamline shielding components is designed using ray-tracing method. The design is supported by synchrotron ray-tracing drawings assuming maximum possible synchrotron fan and mirror alignment errors.
12. Access to the SST FOE is controlled by standard door interlock and search-and-secure mechanism. Similar to other soft x-ray beamlines such as CSX and SIX, access to the monochromators (PGM and DCM) and the 6 experimental endstations on the experimental floor is controlled by vacuum-safety switches. The PPS logic diagram for the SST beamline was reviewed separately by the RSC PPS subcommittee.
13. The SST front-end ray-tracing was previously reviewed by the RSC ray-tracing subcommittee.
14. Configuration control of the radiation safety component was discussed.

Peet's coffee was served. The chair of the RSC had to leave the meeting briefly and dash to LOB3 to retrieve missing equipment for making the coffee. All ended well.

Recommendations

The team added dimensions of extremal max. synchrotron rays to the edge of tapered white-beam stops (WBS) for the M and L branches as suggested by item 5 of November 2017 preliminary ray-tracing review report (attached). For the M branch white-beam stop, edge of WBS to white beam distance including tolerance is 1.75 mm top/1.34 mm bottom, less than the 3.0 mm suggested. We recommend granting exception for the M branch white-beam stop clearance for the following reasons:
a) The toleranced clearances include 0.64 mm on the WBS (0.2 mm manufacturing tolerance+ 0.44 mm positional tolerance) and 0.64 mm (on both the top- and bottom- sides) tolerance on the white-beam mask. Both the white-beam mask and the WBS were machined with high precision and were recently surveyed in 2017. Thus, subject to verification using the survey results, the actual clearances are expected to be 3.03 (1.75+0.64+0.64) mm top/ 2.62 (1.34+0.64+0.64) mm bottom. These are close the recommended clearance of 3 mm.

b) The small distance (2.49m) between the WBS (at 29.142m) and the fixed mask (at 26.652m) means that it is unlikely for the relative heights of the WBS and fixed mask to change by 3 mm in the future.
c) The small peak power of EPU60, at 6.7 kW/mr^2, results in the un-tapered part of the beam stop on the bottom being adequate for less than 1 mm of worst-case white-beam exposure.

To summarize, our recommendations are

1. We recommend granting exception for the M branch white-beam stop clearance.
2. We further recommend that the team analyze the survey results to confirm that the actual clearances on the M branch white-beam stop are about 1.2 mm larger than the toleranced clearance shown on the ray-tracing drawings. This should be carried out before commissioning of the beamline.

Conclusions

1. Based on our assessment of the ray-tracing drawings and radiation simulation results, the RSC finds that the SST beamline shielding design meets the NSLS-II shielding policy. Subject to experimental verification by radiation survey, we believe the installed shielding will provide adequate personnel protection for normal operation and against failures of synchrotron orbit.
2. Based on our review of the max. synchrotron ray-tracing drawings, the RSC believes that the SST masks, mirror, white- and pink- beam-stops are adequately designed to protect against thermal failure of shielding components.

Comments from preliminary review of ray-tracing in March 2016.

Sheet 1 should be beamline assembly drawing, with a table of specifications. Please see sheet 1 of the attached ISS ray-tracing drawing for an example.

Sheet 1: Not needed, but OK to keep. Please do not spend time on this drawing, simply move it to the back of the drawing package.

Sheet 2: Not needed. Move to the back of drawing package.

Sheet 3: Please propagate pink beams for both branches down to pink beam stop. After the monochromator, it is OK to use the nominal beam.

Please include the additional masks to contain the mis-steered pink beam.

Please add white and pink beam stops, and pink beam masks to the tolerance table.

Sheet 4: Please call out the dimension from top of the white beam stop to the extremal ray. Please do the same for the pink beam stop.

Please add white and pink beam stops to the tolerance table.

Sheet 5: Please call out the dimension from top of the white beam stop to the extremal ray. Please do the same for the pink beam stop.

Please add white and pink beam stops to the tolerance table.

Sheet 6: Good.

Sheet 7: Good.

Sheet 8: Not needed. Move to the back of drawing package.

Sheet 9: Good.

Sheet 10: Not needed. Please keep it at the back of drawing package.

Summary:

1. Please work only on improving sheets 3, 4, and 5. Scanned mark-ups for sheets 3-5 are attached,
2. Add a sheet for assembly drawing using the attached example.
3. All the other sheets are OK. The “not needed” sheets should be moved to the back of package.

Comments from preliminary review of ray-tracing in May 2016

General comments: The drawing package is great except for the max. synchrotron ray-tracings, sheets 2, 3, 4 and 5. I believe Andrew is better equipped than the NSLS-II designer to incorporate the suggested improvements below.

Sheet 2:

a. For the pink beams, please draw green rays crossing each-other, for both M and L branches, as illustrated in the mark up.
b. Please use the specified mirror adjustment angle to trace the worst-case rays originating from the mirror to the water-cooled masks.
c. Please label each branch, M and L.
d. Please remove the monochromatic beam going to the precision slit in branch M. This should result in the pink beam terminating at the pink-beam stop.

Sheet 3:

a. Please remove the nominal ray-tracings – those originating from z=+-1250 mm.
b. Take credit for the cooled aperture upstream of the shielded pink-beam transport pipe.
c. Please make an effort to increase distance from the extremal ray to the edge of the pink-beam stop to preferably > 3 mm. Hopefully step b will help in this respect.
d. If you do take credit for the cooled aperture, please add it to the tolerance table.

Sheet 4:

a. Please remove nominal ray-tracing.
b. Add max. ray similar to sheet 3.
c. Please take credit for cooled aperture.
d. Let's discuss whether or not to take credit for CVD FL screen. If we take credit for it, we can not move it freely.
e. Please make an effort to increase distance from the extremal ray to the edge of the pink-beam stop to preferably > 3 mm. Hopefully steps c and d will help.

Sheet 5:

My understanding is that sheet 5 is made obsolete by sheets 3 and 4. If true, please remove sheet 5.

Comments from preliminary review of ray-tracing in November 2017.

The following updates to the SST ray-tracing are suggested:

1- Sheets 1-3, Show angles of branches on layouts, locate photon shutters, locate beam stops on end stations.
2- Sheets 1-3, show “X” dimensions of all major optical components
3- Sheets 1-3, Show all centerlines for all branches
4- Shielded beam pipe not shown on “L branch”
5- Show footprint of white beam on WBS L&M branches
6- Show all centerlines on Horizontal max
7- Add U/S apertures for FM to tables, horizontal and vertical Sync tracing
8- Add all PSH to horizontal and vertical sync ray trace
9- Add stops on both branches to horizontal and vertical sync
10- Add all component labels to missteer sheets

Radiation Safety Committee

Name	*Expertise*	*Directorate*
Andrew Ackerman	Deputy ESH Manager	PS
Andi Barbour	Beam Line Physicist	PS
Mohamed Benmerrouche	Nuclear and Radiation Physics	PS
Scott Buda	Personnel Protective Systems	PS
Ray Fliller	Accelerator Physicist	PS
Wah-Keat Lee	Beam Line Physicist	PS
Boris Podobedov	Accelerator Physics	PS
Chuck Schaefer	Accelerator SME	ESH
Om Singh	Accelerator Controls	PS
Lutz Wiegart	Beam Line Physicist	PS
Zhong Zhong	Beam Line Physicist	PS
Emil Zitvogel	Accelerator Operations	PS
Ashley Shoemaker-Skokov	Administrative Support	PS

Ray-tracing sub-committee

Andrew Ackerman	Deputy ESH Manager	PS
Wah-Keat Lee	Beam Line Physicist	PS
Chuck Schaefer	Accelerator SME	ESH
Christopher Stelmach	Designer	PS
Lutz Wiegart	Beam Line Physicist	PS
Zhong Zhong	Beam Line Physicist	PS

PPS sub-committee

Dana Beavis	Experimental Nuclear Particle Physics	NPP
Mohamed Benmerrouche	Nuclear and Radiation Physics	PS
Scott Buda	Personnel Protective Systems	PS
Robert Lee	ESH manager	PS
Zhong Zhong	Beam Line Physicist	PS

RSC checklist sub-committee

Andi Barbour	Beam Line Physicist	PS
Mohamed Benmerrouche	Nuclear and Radiation Physics	PS
Ray Fliller	Accelerator Physicist	PS