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# Memo

Date: June 25, 2016
To: Christie Nelson, Steven Hulbert, and Paul Zschack
From: Zhong Zhong (chair), Photon Science Radiation Safety Committee
Subject: Review of the radiation safety configuration design of the 4-ID, ISR, beamline

Dear Christie, Steve, and Paul

The Photon Science Radiation Safety Committee (RSC) conducted review of the design of the ISR (In-situ and Resonant X-ray Studies) beamline, 4-ID, on Friday June 3, 2016. Subjects reviewed include synchrotron max-fan and Bremsstrahlung drawings, Secondary Bremsstrahlung and synchrotron radiation shielding analysis, and aspects of thermal management that relate to radiation safety.

**Written documents**

The following documents and drawings were reviewed:

1. ISR assembly drawing, PD-ISR-RAYT-0001 rev. A, by C. Longo, sheet 1, "ISR Beamline Ray Tracing Layout".
2. ISR Bremsstrahlung ray-tracing drawings, PD-ISR-RAYT-0001 rev. A, sheets 4 and 5 for horizontal and vertical projections, respectively, sheet 6 for collimator and stop details looking downstream.
3. ISR max. synchrotron ray-tracing drawings, PD-ISR-RAYT-0001 rev. A, sheets 2 and 3 for horizontal and vertical projections, respectively, and sheet 7 for synchrotron beamstop details.
4. Vendor report "NSLS2 ISR Thermo-structural analysis Fixed Aperture Mask (1.5 mm lower part)" by Tsubota, dated 2015/2/5.
5. Vendor report "NSLS2 ISR Thermo-structural analysis 2$^{nd}$ Fixed Aperture Mask" by Tsubota, dated 2015/2/5.
6. Vendor report "NSLS2 ISR Thermo-structural Analysis White Beam Stop" by Tsubota, dated 2015/2/5.
7. Vendor report "NSLS2 ISR Thermo-structural Analysis Pink Beam Stop" by Tsubota, dated 2015/2/24.
8. Vendor report "NSLS2 ISR Thermo-structural Analysis Pink Beam Stop (13.4 mm upper side irradiation" by Tsubota, dated 2015/2/6.
9. Report "Finite Element Analyses of a Beampipe Flange on the ISR Beamline" by Steven W. O'Hara, dated January 15, 2016.
10. FEA stress analysis report "ISR Beamline PPS Aperture" by D. Bacescu, dated November 4, 2015.

11. Power point presentation “Radiation Safety Committee Meeting: 4-ID Overview ” by Christie Nelson dated June 3, 2016.

**Oral Presentation**

Attendance: Andrew Ackerman, Mo Benmerrouche, Mary Carlucci-Dayton, Vinita Ghosh, Wah-Keat Lee, Michael Lucas, Christie Nelson, Steven Hulbert, Kristen Rubino, Chuck Schaefer, Chris Stelmach, Ashley Showmaker-Skokov, and Zhong Zhong

Christie Nelson gave the presentation entitled “Radiation Safety Committee Meeting: 4-ID Overview”. Following the guideline from the memo by Paul Zschack to the RSC on May 29, 2014, the following were discussed:

1. ISR is an x-ray scattering beamline that operates from 2.4 to 23 keV with $2x10^{-4}$ (dE/E) energy resolution. The focused beam at the sample is expected to be 40 (V) by 100 (H) microns with primary focusing, and more than an order of magnitude smaller in both dimensions with secondary focusing.
2. The source is 2.8 m long IVU23 with 6.1 mm minimum gap. This source, slightly upstream of the ID center, is canted at 0.6731 mrad outboard to allow for a future canted undulator downstream of the ID center. A unique asymmetric canting arrangement was noted.
3. The high-heat-load optics consist of a horizontal focusing mirror (HFM) receiving 460 W white beam, followed by a double-crystal monochromator (DCM) receiving 340 W pink beam. The Dual Plate Assembly and Vertical Focusing Mirror (VFM) are in the monochromatic beam. These optics are located in the FOE.
4. A shielded beampipe transports the monochromatic beam to the Second Optical Enclosure, 4-ID-B. A Dual Harmonic Rejection Mirror (DHRM) and Secondary Source Aperture are located in 4-ID-B. The DHRM has a horizontal offset of 4 mm and can be bypassed for operations above 6 keV.
5. A shielded beampipe then transports the beam through an experimental enclosure for the future canted beamline. Three ESM endstations are located in two experimental enclosures, 4-ID-C and 4-ID-D. The C and D enclosures are separated by a movable beamstop that is interlocked by the PPS (Personnel Protection System), allowing access to D for setup with C receiving beam, when the beamstop is in place.
6. Shielding for the primary Bremsstrahlung x-rays is designed using ray-tracing method. A daul-collimator and beamstop combination, with a vertically deflecting monochromator and horizontally and vertically deflecting mirrors in between, stops the primary Bremsstrahlung in the FOE. Each of the Lead collimators, at 30.073 and 33.110 m, is downstream of and in close proximity to a fixed mask. The Bremsstrahlung beam-stop, at 39.442 m, intercepts all possible primary Bremsstrahlung radiation while allowing the synchrotron beam through an aperture of 15.5 mm (V) by 26.5 mm (H).
7. 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 Ghosh and Benmerrouche. Simulations show localized dose rate of about 0.2 mrem/hr on contact at the downstream wall of FOE, an unoccupied area. Due to the intrinsic conservatism of the simulation, the experimental data will likely show dose rate below 0.05 mrem/hr at 30 cm from the downstream wall.

8. Shielding of synchrotron x-ray in the transport pipes and experimental enclosures is supported by STAC8 simulations taking into account the output of the x-ray source and throughput of the optics.
9. 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. The vendor supplying the VFM and DCM provided detailed FEA simulation of water-cooled synchrotron masks and beamstops.
10. The PPS logic diagram for the ISR beamline was reviewed separately by the RSC PPS subcommittee.
11. The ISR front-end ray-tracing was previously reviewed by the RSC ray-tracing subcommittee.
12. Configuration control of the radiation safety component was discussed.

The tidbit on coffee can be dug out of the ESM report.

**Notes**

The following comments are noted for completeness:

1. We concur that the white beam stop blocks the mis-steered beam by the HFM. Thus configuration control of the HFM is not necessary.
2. Due to the small distance between the white-beam stop and the fixed mask, we believe that the 2.35 mm horizontal clearance between the max. synchrotron beam and the edge of white-beam stop is sufficient.
3. Secondary shielding simulation shows dose rate of around 0.2 mrem/hr on contact in localized areas at the downstream wall of FOE, an unoccupied area. This is justified by recent ALARA analysis by Robert Lee.

**Recommendations**

Radiation measurements are needed at the downstream wall of the FOE to assess levels and determine if additional posting or area access control is needed.

**Conclusions**

1. Based on our assessment of the ray-tracing drawings, thermal analysis, and simulation results, the RSC find that the ISR 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 and max. synchrotron ray-tracing drawings, the RSC believes that the ISR masks, mirror, white- and pink- beam-stops are adequately designed to protect against thermal failure of shielding components.

**Radiation Safety Committee**

| *Name* | *Expertise* | *Directorate* |
|---|---|---|
| Andrew Ackerman | Deputy ESH Manager | PS |
| Dana Beavis | Experimental Nuclear Particle Physics | NPP |
| 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 |
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| Ashley Shoemaker-Skokov | Administrative Support | PS |

*Ray-tracing sub-committee*

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| Andrew Ackerman | Deputy ESH Manager | PS |
| Mary Carlucci-Dayton | Mechanical Engineer | 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*

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| Mohamed Benmerrouche | Nuclear and Radiation Physics | PS |
| Scott Buda | Personnel Protective Systems | PS |
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| Zhong Zhong | Beam Line Physicist | PS |