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Memo

Date: October 4, 2017
To: Wah-Keat Lee, Julian Adams, and Paul Zschack
From: Zhong Zhong (chair), Photon Science Radiation Safety Committee
Subject: Review of the radiation safety design of the 18-ID (FXI) beamline

Dear Wah-Keat, Julian and Paul,

The Photon Science Radiation Safety Committee (RSC) conducted review of the design of the FXI beamline, 18-ID, on Thursday September 28, 2017. 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. FXI assembly drawing, PD-FXI-RAYT-0001 rev. A, by C. Longo, sheet 1, "Ray Tracing, FXI Beamline, 18-ID".
2. FXI Bremsstrahlung ray-tracing drawings, PD-FXI-RAYT-0001 rev. A, sheets 2 and 3 for horizontal and vertical projections, respectively. Details for Bremsstrahlung collimator and Bremsstrahlung stop are included on sheet 6.
3. FXI max. synchrotron ray-tracing drawings, PD-FXI-RAYT-0001 rev. A, sheets 4 and 5 for vertical and horizontal projections, respectively.
4. Powerpoint presentation "Radiation Safety Committee Meeting 18-ID" presented by Wah-Keat Lee.
5. "FXI Beamline Lead Bricks Thermal Analysis Report", PD-FXI-CO-CALC-0107 Rev. A by Mary Carlucci-Dayton and Yi Zhu dated February 23, 2017.
6. "Fixed Mask Thermal Calculations" showing the fixed mask will perform safely within the requirements of LT-C-XFD-SPC-COM-001.
7. NSLS-II technical note, #257 by Wah-Keat Lee, "FXI 18-ID front-end ray-trace updates".
8. NSLS-II technical note, #265 by Wah-Keat Lee, "FXI mis-steered Pink Beam".
9. NSLS-II technical note, #266, dated 09/21/2017 "Radiation shielding analysis of the 18-ID-FXI beamline" by S. Chitra and M. Benmerrouche.
10. NSLS-II technical note entitled "18-ID-FXI Top-off Radiation Safety Analysis", by S. Chitra, M. Benmerrouche and Y. Li, dated 08/08/2017.

Presentation

Wah-Keat Lee gave the presentation entitled "Radiation Safety Committee Meeting: FXI". Following the guideline from the memo by Paul Zschack to the RSC on May 29, 2014, the following were discussed:

1. FXI serves a transmission x-ray microcope using a damping wiggler as x-ray source. The beamline optics consists of a collimating mirror (bounce vertically), a double-crystal monochromator and a toroidal focusing mirror, all located in the First Optical Enclosure (FOE); secondary source aperture, condenser and objective lens are located in the endstation (enclosure B).
2. The energy range of the monochromator is from 4 to 12 keV using Si 111 reflection. The upper end of the energy range is dictated by the collimating mirror (Rh stripe) reflectivity.
3. The preliminary FXI ray-tracing drawings were reviewed by the ray-tracing sub-committee in March. The recommendations were addressed by the FXI team. The approved ray-tracing drawings were reviewed in early August. The report from the March review is attached for completeness. There were no concerns at the early August review.
4. The white beam is stopped in the FOE. The white beam and the pink beam on the monochromator are controlled by the front-end shutter. The monochromatic beam is controlled by shutter at the downstream end of the FOE.
5. The beamline is designed to accommodate a future addition of a separate beamline using the inboard part of the damping wiggler fan. The FOE fixed mask is designed to accommodate only the current FXI beamline using the center part of the wiggler fan.
6. Shielding for the primary Bremsstrahlung x-rays is designed using ray-tracing method. A collimator (Bremsstrahlung Collimator at 27.71 m in FOE) and beam-stop (Primary Bremsstrahlung Stop at 32.79 m in FOE)combination, with a vertically deflecting collimating mirror in-between, stops the primary Bremsstrahlung in the FOE. The Primary Bremsstrahlung Stop has an aperture to allow the synchrotron pink beam through.
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 Benmerrouche. The FLUKA analysis results were documented in the technical note "Radiation shielding analysis of the 18-ID-FXI beamline" by S. Chitra and M. Benmerrouche.
8. A shielded beam pipe transports the monochromatic synchrotron beam from the FOE to the SOE.
9. The top-off safety analysis shows that in the case of top-off fault at FXI, the dose rates on the FOE exterior is less than 10 mrem/hr, lower than the 100 mrem/hr required by NSLS-II shielding policy for fault conditions.
10. 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 focusing and collimating mirrors alignment errors. Wah-Keat described a "Monte-Carlo" ray-tracing program that simulates all possible mis-steering scenarios for the collimating mirror. The simulations show that taking into account worst case tolerances, the extremal mis-steered pink beam would be 2.52 mm from the edge of the pink beam stop. Although

this is less than the recommended 3 mm, the committee considers this to be acceptable."

11. Access to the FXI endstation B and FOE (station A) is controlled by standard door interlock and search-and-secure mechanism. The PPS logic diagram for the FXI beamline was reviewed separately by the RSC PPS subcommittee.
12. Configuration control of the radiation safety component was discussed.

Lest the traditions fail, Peet's coffee was served.

Recommendations

The RSC has no recommendations for action.

Conclusions

1. Based on our assessment of the ray-tracing drawings and radiation simulation results, the RSC find that the FXI 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 FXI masks, collimators, white- and pink- beam-stops are adequately designed to protect against thermal failure of shielding components.
3. Based on our review of the beamline layout, the RSC finds that all Radiation Safety Components meet NSLS-II design requirements.

Report from the preliminary review of ray-tracing in March 2017

Date: April 18, 2017
To: Wah-Keat Lee, Julian Adams, and Paul Zschack
From: Zhong Zhong (chair), Photon Science Radiation Safety Committee
Subject: Preliminary review of the FXI ray-tracing

Dear Wah-Keat, Steve, and Paul

I would like to thank you for requesting a preliminary review of the FXI beamline ray-tracing, and for inviting members of the ray-tracing subcommittee of the Photon Science Radiation Safety Committee (RSC) to discuss the ray-tracing.

The following documents and drawings, submitted on March 13, 2017, were reviewed:
1. FXI front-end ray-tracing, SR-FE-DW18-1001, Rev. C, by J. Fabijanic, sheets 1-7.
2. FXI front-end ray-tracing, SR-FE-DW18-1001, Rev. B, by J. Fabijanic, sheets 1-7.
3. FXI beamline Bremsstrahlung ray-tracing, AA-00054 for horizontal and AA-00055 for vertical, by Watanabe of Toyama

4. FXI beamline maximum synchrotron ray-tracing, AA-00062 for horizontal and AA-00057 for vertical, by Watanabe of Toyama
5. Memo from Wah-Keat Lee dated March 8, 2017. The memo documents that the very small changes of front-end ray-tracing revision (rev C) have a negligible effect on the beamline ray traces that were previously drawn according to rev B. The analysis shows that there is no need to re-do the beamline ray traces.

Wah-Keat met with the RSC ray-tracing subcommittee on March 24 to discuss his simulation and analysis of the FXI mirror mis-steering.

Recommendations

1. Sheet 1 of the drawing package should be the beamline layout drawings.
2. Add the primary bremsstrahlung envelope on the downstream cross-section drawing for the primary bremsstrahlung stop (currently they only show the envelope on the upstream cross-section).
3. We recommend that the FXI team update the drawings and then submit the ray-tracing to the vault for approval, and to the RSC for final review.

Conclusions

1. Front-end ray trace changes from rev B to rev C have negligible impact on beam line ray traces completed under rev B. Thus here is no need to re-do the beamline ray traces.
2. Mis-steered pink beam simulations are acceptable to show that the pink beam is safely captured (instead of ‘mis-steered beam ray traces’).

Radiation Safety Committee

Name	*Expertise*	*Directorate*
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Dana Beavis	Experimental Nuclear Particle Physics	NPP
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
Lutz Wiegart	Beam Line Physicist	PS
Zhong Zhong	Beam Line Physicist	PS
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Ray-tracing sub-committee

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Lutz Wiegart	Beam Line Physicist	PS
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RSC checklist sub-committee

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Ray Fliller	Accelerator Physicist	PS