Top-Off Safety Analysis
for
ISR, ISS and SMI Beamlines

PS-C-ASD-TOS-RPT-003

Z. Xia & Y. Li

August 17, 2015

TOP-OFF SAFETY ANALYSIS FOR ISR, ISS AND SMI BEAMLINES

APPROVALS

8/17/2015

X Ray Fliller

Ray Fliller
Top Off Safety System Coordinator
Signed by: Fliller, Raymond

8/31/2015

X T. Shaftan for F. Willeke

Ferdinand Willeke
Accelerator Division Director
Signed by: Shaftan, Timur

9/3/2015

X Sean McSweeney for P. Zs...

Paul Zschack
Photon Science Division Director
Signed by: McSweeney, Sean

8/17/2015

X

Steve Moss
Authorization Basis Manager
Signed by: Moss, Steven H

8/17/2015

X

Robert Lee
ESH Manager
Signed by: Lee, Robert J

8/18/2015

X Christie Nelson

Christie Nelson
ISR Lead Beamline Scientist
Signed by: Nelson, Christie

8/27/2015

X Klaus Attenkofer

Kaus Attenkofer
ISS Lead Beamline Scientist
Signed by: Attenkofer, Klaus

8/21/2015

X Elaine DiMasi

Elaine DiMasi
SMI Lead Beamline Scientist
Signed by: Dimasi, Elaine

NSLS II TECHNICAL NOTE BROOKHAVEN NATIONAL LABORATORY	NUMBER PS-C-ASD-TOS-RPT-003
AUTHORS: **Z. Xia and Y. Li**	DATE **8/17/2015**
Top-off Safety Analysis for ISR, ISS and SMI Beamlines	

1. Summary

The purpose of this report is to provide the results from the top-off safety analysis for the following NEXT beamlines: 4-ID (ISR), 8-ID (ISS) and 12-ID (SMI), which were not included in the top-off design report issued in 2014[1]. Note that this report is only to be used as the basis for approving top-off operation at these three specific NEXT beamlines. The top-off operation of future beamlines shall follow the same safety requirements as the originally analyzed beamlines in [1]; the approval process is guarded by procedure PS-C-ASD-PRC-183[2].

The primary radiological safety concern for top-off injection, (i.e., injection with the beam line front end safety shutters open) is the scenario where injected electrons are conveyed down the beam line through the front end and into the first optics enclosure (FOE). This report shows that the radiological effect of the mis-steering cases during 4, 8 and 12-ID beamline top-off operation is acceptable.

2. Top-off safety tracking study

Based on the ray trace review, the top-off operation of 8-ID is represented by the analysis for 28-ID (XPD) which is reported in [1]; both are damping wiggler beamlines. The top-off safety analysis of 4-ID and 12-ID have been implemented respectively. Since their front end credited aperture longitudinal locations are same, though 12-ID has larger apertures in fixed mask and COL #2, 4-ID can be covered by 12-ID.

Figure 1 and Figure 2 show the particle tracking simulations for 12-ID, which has a larger photon shutter collimator 2 (C2) apertures (83.88 cm × 27.24 mm). The TOSS interlock specifications were used for the analysis [4].

Note: For 4-ID and 12-ID beamline particle tracking simulation, the ring side aperture tolerance was reduced from 5 mm to 2 mm in order to eliminate a scenario in which any bright e-beam could strike on the edge of COL #2.

The cone on C2 was increased from 2 to 7 mm to make sure no beam strike C2's edge (at least 5 mm distance between worst ray and edge of the C2 aperture).

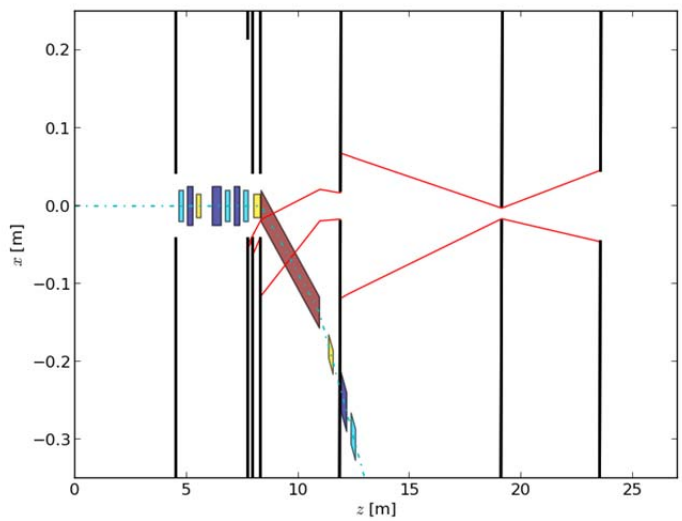

Figure 1: Envelop of backward tracking trajectories for the SMI beam-line: 7 mm inboard hole tracking (2 mm tolerance considered)

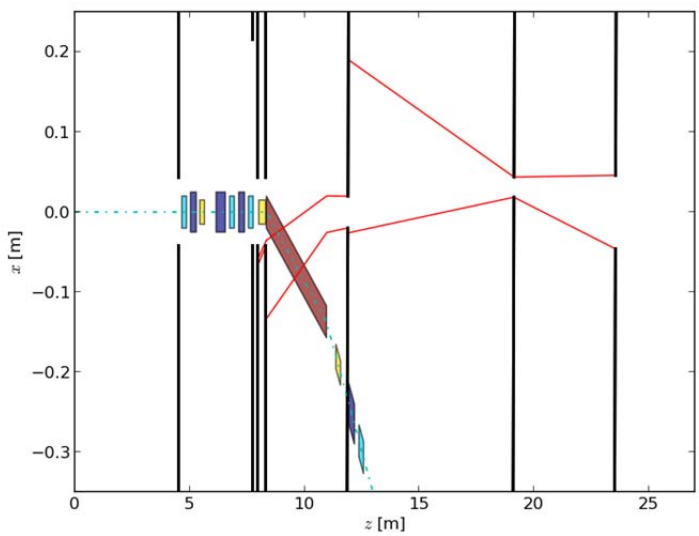

Figure 2: Envelop of backward tracking trajectories for the SMI beam-line: 7 mm outboard hole tracking (2 mm tolerance considered)

Based on the particle tracking simulation above and as reported in [1] and the communication between Z. Xia and Y. Li, the electron beam will have at least a 5 mm distance away from the LCO2 aperture edge for 4, 8 and 12-ID beamlines (i.e. electron beam cannot go through LCO2 aperture to reach first optical enclosure-FOE).

3. Top-off radiological effect analysis

The radiological effect for top-off operation is mainly based on C2 and ratchet wall collimator (RWC) aperture sizes. These two apertures decide the level of radiation leakage through the front end (FE) and into the FOE, which may cause high radiation dose outside the FOE. The aperture sizes of C2 and RWC of these three beamlines are listed in Table 1 and SRX beamline is included for comparison.

Table 1: C2 and RWC dimensions [5]

	LCO2 Dimensions X (mm)	LCO2 Dimensions Y (mm)	RWC Dimensions X (mm)	RWC Dimensions Y (mm)
8-ID, ISS	**79.2**	**28.4**	**44.74**	**17.03**
4-ID, ISR	**79.33**	**28.22**	**88.16**	**30.56**
ID12-SMI	**83.88**	**27.24**	**95.29**	**31.09**
ID5-SRX	*79.2*	*28.4*	*78.44*	*21.80*

Note: The 4-ID and 8-ID radiological hazard is much less than the 12-ID beamline, therefore only the 12-ID FLUKA calculation was performed.

FLUKA calculation was performed for the12-ID SMI beamline, which has the largest apertures among this group of beamlines. Figure 3 and Figure 4 shows the dose rate distribution for the worst scenario discussed in [1]; electrons scraping the pipe next to C2 aperture. Note the dose rates in Figure 3 and 4 are normalized to 3 GeV beam at 45 nC/min injection rate.

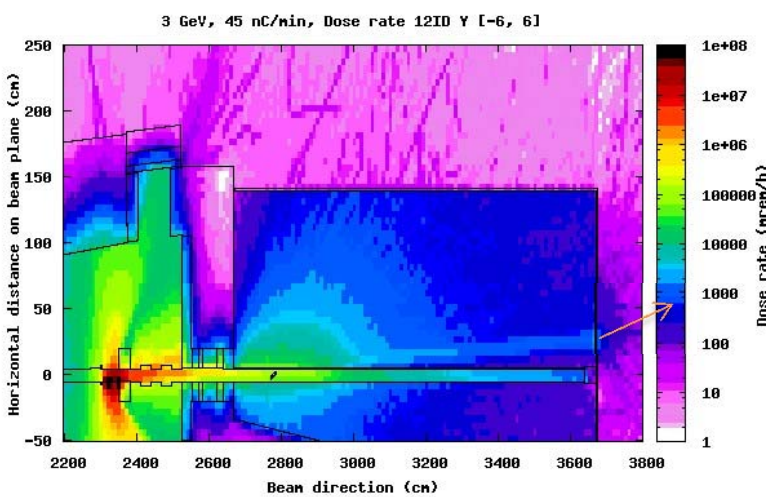

Figure 3: Dose rate distribution on 12-ID beam plane: 3 GeV, 45 nC/min electron beam scraping iron pipe 40 cm upstream of C2 at 5 mrad angle

As shown Figure 3, the highest dose rate appears on the FOE downstream wall, so the 1-D dose rate on FOE downstream wall is plotted on Figure 4. Note only minimum shields in FOE are considered for this FLUKA simulation: 2 mm thick Fe pipe and a standard beam stop (13 cm × 9 cm Pb) at the end of FOE hutch. In reality the SGB shields, upstream collimators and guillotine in FOE will drop down the downstream wall dose rate substantially.

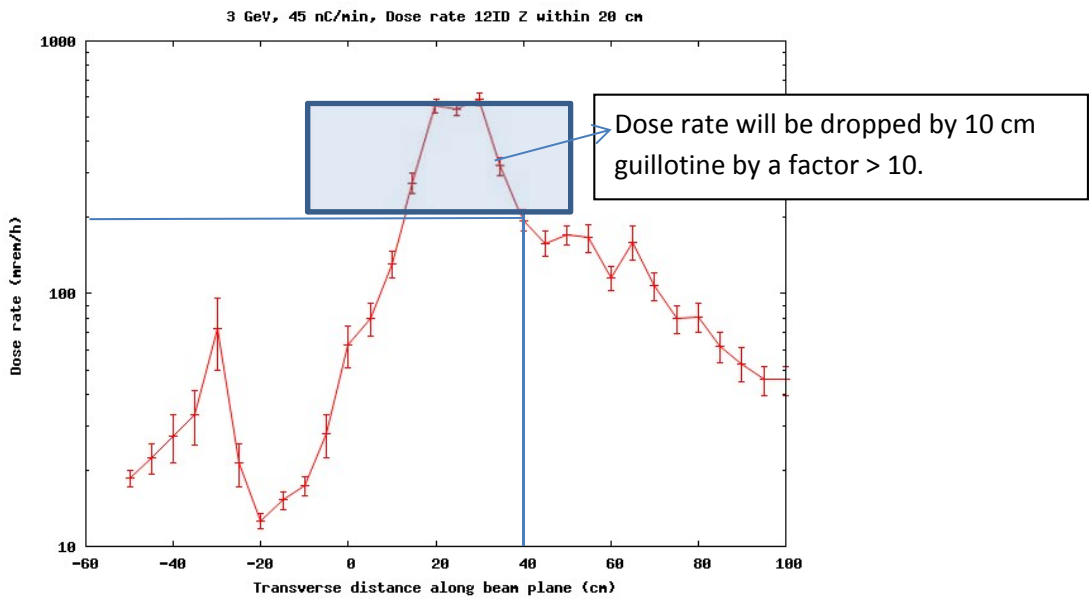

Figure 4: The dose rate along FOE downstream wall: 3 GeV, 45 nC/min electron beam scraping iron pipe 40 cm upstream of C2 at 5 mrad angle. 12-ID (SMI) has an 80 cm × 80 cm × 10 cm guillotine attached to the downstream wall of FOE. The Guillotine will drop the dose rate by a factor of > 10

As shown in Figure 3 and Figure 4, ***<u>the maximum dose rate on FOE downstream wall will be < 200 mrem/h and the lateral wall dose rate is < 20 mrem/h</u>***. Note that the dose rate on the FOE downstream wall is still over-estimated in this note because of collimators and SGB shields in reality for these beamlines. There is an area radiation monitor (ARM) around the ratchet door area to catch this fault condition. An additional ARM is planned to be placed outside of the FOE enclosure to detect the fault scenarios too.

4. Conclusions

Based on the safety analysis in this note and as reported in [1], the radiological effect of ISR (4-ID), ISS (8-ID) and SMI (12-ID) beamlines top-off operation is acceptable and complies with the NSLS-II Shielding Policy.

References:

[1] Top-Off Safety Analysis and Requirement of Hazard Mitigation for NSLS-II Facility, PS-R-ASD-RPT-DRV-001, 2014

[2] PS-C-ASD-PRC-183, Approval of New and Modified NSLS-II Beamline Front Ends for Top Off Safety, Jan 14, 2015.

[3] Private discussion between Y. Li and R. Fliller.

[4] Email from Y. Li to R. Fliller on 6/25/2015.

[5] Email from M. Loftus, Re: Next set of beamlines for Top Off Analysis, May 20, 2015.

[6] ISS, SR-FE-DW08-1001, Revision B.

[7] ISR, SR-FE-IVU04-1001, Revision B.

[8] SMI, SR-FE-IVU12-1001, Revision B.