07-ID (SST) TOP-OFF RADIATION SAFETY ANALYSIS

APPROVALS

12/20/2017

X Ray Fliller

Ray Fliller
Coordination Group for Top Off Safety Leader
Signed by: Fliller, Raymond

12/22/2017

X Timur Shaftan

Timur Shaftan
Accelerator Division Director
Signed by: Shaftan, Timur

1/22/2018

X paul zschack

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

12/20/2017

X

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

12/21/2017

X

Robert Lee
ESH Manager
Signed by: Lee, Robert J

1/9/2018

X Cherno Jaye

Cherno Jaye
SST-1 Lead Beamline Scientist
Signed by: Jaye, Cherno

1/10/2018

X Conan Weiland

Conan Weiland
SST-2 Lead Beamline Scientist
Signed by: Weiland, Conan

NSLS-II TECHNICAL NOTE BROOKHAVEN NATIONAL LABORATORY	NUMBER: **NSLSII-TOS-RPT-016**
AUTHORS: S. Chitra & M. Benmerrouche	DATE: 12/20/2107
07ID (SST) Top-Off Radiation Safety Analysis	

1. Introduction

The primary radiological safety concern for Top-Off injection, with the Front End (FE) safety shutters open, is the scenario where injected electrons are transported down to the beamline through the FE due to an erroneous combination of lattice magnetic field settings and beam energy. These primary electrons will interact with the FE components resulting in secondary radiation, which will further interact with the components in the First Optics Enclosure (FOE), thereby leading to potentially high dose rates outside the FOE walls. The radiological consequences of this fault condition for the 07ID-SST beamline are analyzed and discussed in this report.

The Spectroscopy Soft and Tender (SST) beamline is powered by 2 undulators (U42 and EPU60) and the front end has 2 sets of slits that in combination can let the synchrotron radiation from either or both into the FOE. The FE components downstream of the fixed mask and the ratchet wall collimators all lie along the long straight centerline. Inside the FOE, the beamline splits horizontally into two branches (soft and tender) with the components arranged accordingly.

The layout of the 07ID-SST FE components is shown in Figure 1. Figure 2 shows the layout of the FOE and the components inside it.

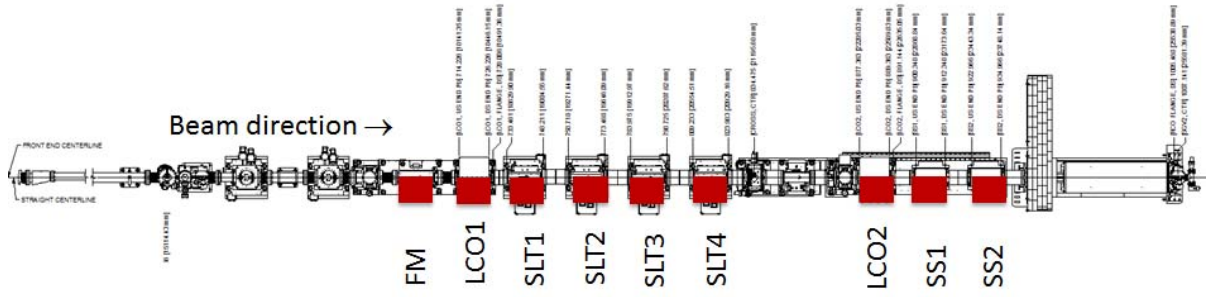


Figure 1: Layout of 07ID-SST front end showing major components. The beam travels from left to right in this figure.

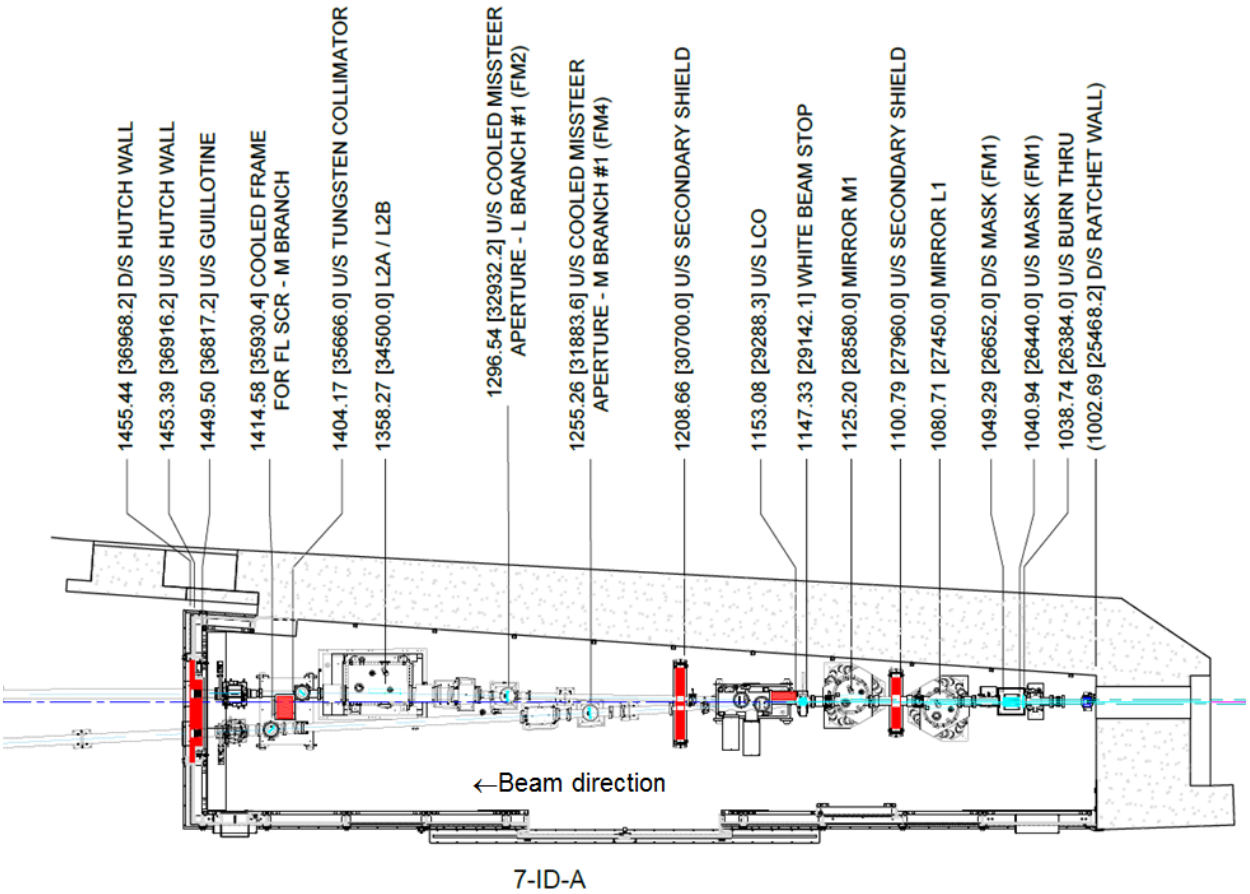


Figure 2: The layout of the 07ID-A (FOE) enclosure and the components inside it. Beam travels from right to left in this figure.

The Top-Off backward particle tracking analysis applicable for 07ID-SST is discussed in Section 2, the FLUKA model is described in Section 3, results in section 4, and the summary and conclusions are given in Section 5.

2. Top-Off Particle Tracking Analysis

At NSLS-II, the Top-Off Safety System guarantees that the injected electron beam does not channel down the FE and into the beamline FOE. The SST FE is identical to that of the 17ID-AMX/FMX, but the apertures are slightly smaller. The 17ID-AMX/FMX apertures in turn are identical to that of 05ID-SRX. Since particle tracking for the SRX beamline has shown it to be safe for top-off, no particle tracking is required for the front end of the 7-ID-SST (Appendix 1). The top-off credited apertures with their alignment tolerances are [3]:

- Fixed Mask, ±2 mm horizontally
- LCO2: ±2 mm horizontally
- Synchrotron Radiation Absorber: ±5 mm horizontally

- S4 vacuum chamber: ±5 mm horizontally

To ensure the radiological safety of the 07ID-SST, FLUKA Monte Carlo radiation transport simulations are carried out with the electron beam directions configured accordingly.

3. Description of the FLUKA Model

The horizontal and elevation views of the FLUKA geometry used for the Top-Off simulations of the 07ID-SST beamline are shown in Figures 3 and 4. The geometry is shown as two separate figures for clarity with Figure 3 showing the FE components and Figure 4 showing the FOE and the components inside. The data input used to generate the FLUKA model is listed in Appendix 2.

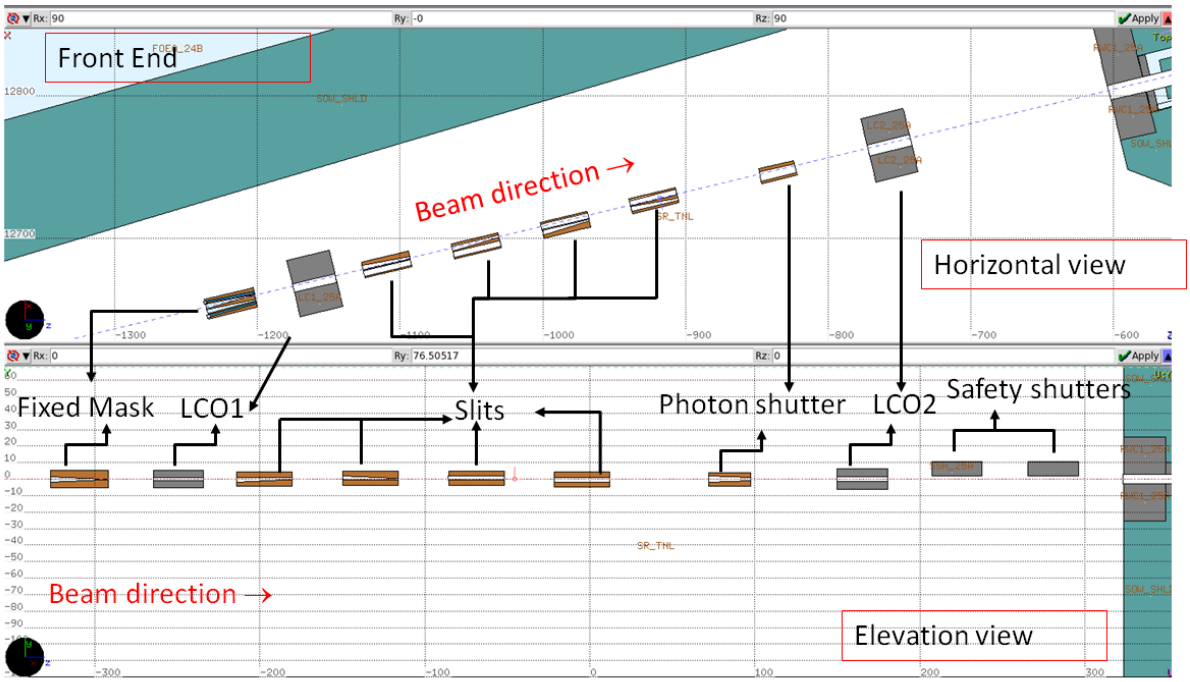


Figure 3: Horizontal (at Y=0) and elevation view (in line with the ratchet wall collimator aperture) of the front end FLUKA geometry used in Top-Off simulation of the 07ID-SST beamline. The beam travels from left to right.

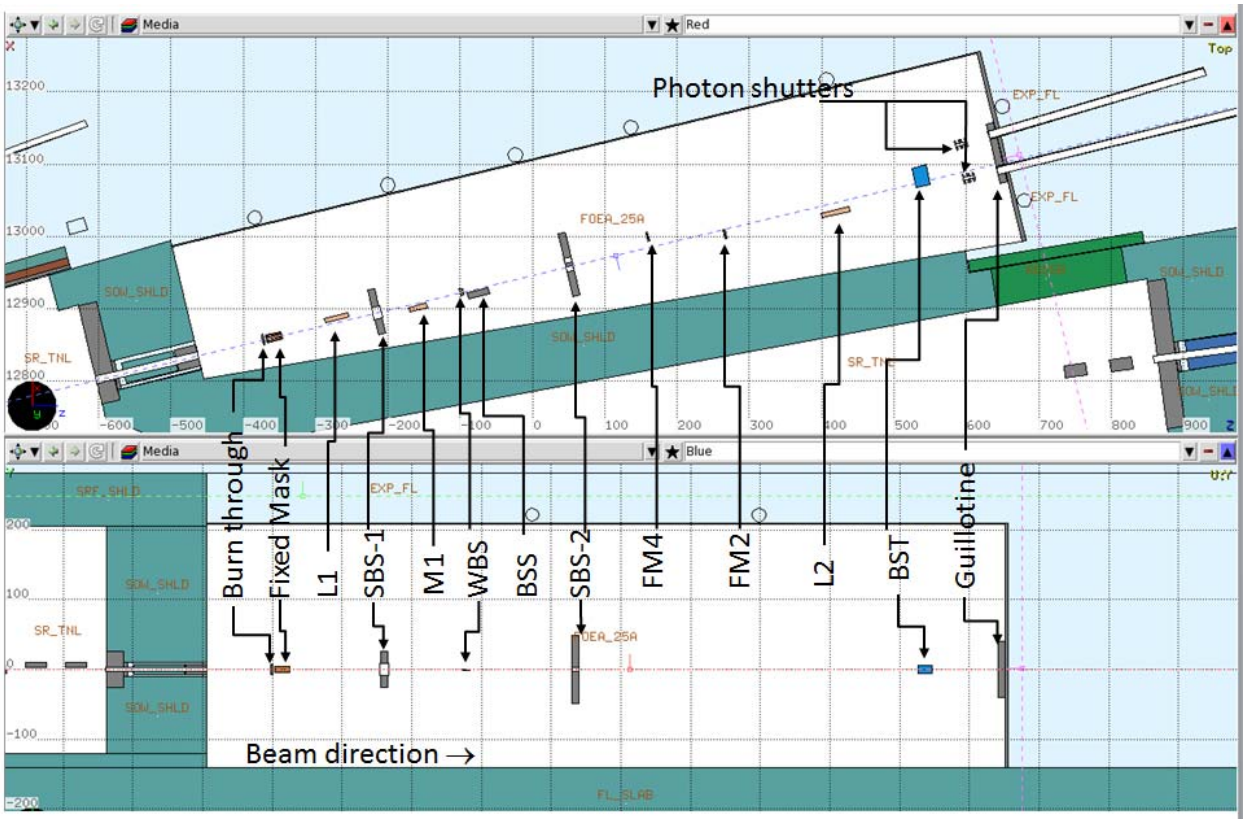


Figure 4: The horizontal (at Y=0, top figure) and the elevation view (bottom figure) of the FOE part of the geometry used in Top-Off simulation of the 07ID-SST beamline. The beam travels from left to right.

Based on the discussion in section 2, the beam is assumed lost at the safe endpoints (2 mm from the upstream aperture edge of LCO2). In all the FLUKA simulations, a pencil beam of 3 GeV electrons is assumed for the injected beam. The results are normalized to a booster to storage ring injection charge rate of 45 nC/min and the total ambient dose equivalent rates are reported in units of mrem/h.

4. Results for Top-Off FLUKA Simulations

Simulations were carried out without the lead (Pb) that makes up the secondary bremsstrahlung shields (SBS-1, BSS and SBS-2) in the FOE. The radiation environments were estimated with three configurations of the slits. They are (a) all slits open (b) slits 1 and 2 open while slits 3 and 4 closed and (c) slits 1 and 2 closed while slits 3 and 4 open. The following four scenarios of electron beam directions were considered in the FLUKA simulation analysis for the above three configurations.

1. Injected beam starting at the inboard side of the downstream aperture of FM and directed toward the front face of LCO2 at 2 mm from the inboard side of the aperture (Case 1: inboard-inboard).

2. Injected beam starting at the inboard side of the downstream aperture of FM and directed toward the front face of LCO2 at 2 mm from the outboard side of the aperture (Case 2: inboard-outboard).
3. Injected beam starting at the outboard side of the downstream aperture of FM and directed toward the front face of LCO2 at 2 mm from the inboard side of the aperture (Case 3: outboard-inboard).
4. Injected beam starting at the outboard side of the downstream aperture of FM and directed toward the front face of LCO2 at 2 mm from the outboard side of the aperture (Case 4: outboard-outboard).

In addition, a few more cases were also studied by removing the mirrors and by inserting all three lead secondary bremsstrahlung shielding (SBS-1, BSS and SBS-2) sequentially. In total, 18 sets of simulations were carried out. The aperture of the FE collimator (LCO2) and the ratchet wall collimator primarily determines the amount of radiation transmitted into the FOE. The results in Figures 5-18 are shown without SBS-1, BSS and SBS-2 inside the geometry.

4.1 Case 1: Inboard- inboard

In this simulation, the injected electron beam originates from the downstream of the horizontal aperture on the inboard side of the FM and is directed toward the front face of LCO2 at 2 mm from the inboard side of the horizontal aperture. The total ambient dose equivalent rates in and around the FOE are shown in Figures 5-7 with (a) all slits completely open, (b) slits 1 & 2 closed and 3 & 4 open and (c) slits 1 & 2 open and 3 & 4 closed. In all these cases, the mirrors inside the FOE are included in the simulations.

For all the three slit positions, the dose rates outside the FOE are estimated to be less than 100 mrem/h. The maximum dose rate outside the storage ring door is expected to be 700 mrem/h when all the slits are open and about 600 mrem/h for the other two scenarios.

An additional simulation was carried out for this beam condition with all the slits open and with the mirrors L1 and M1 removed from the FOE geometry. This simulates a case when the mirrors are retracted. Figure 8 shows the results of this simulation. The dose rates outside the FOE remain approximately the same as that observed with the mirrors in place.

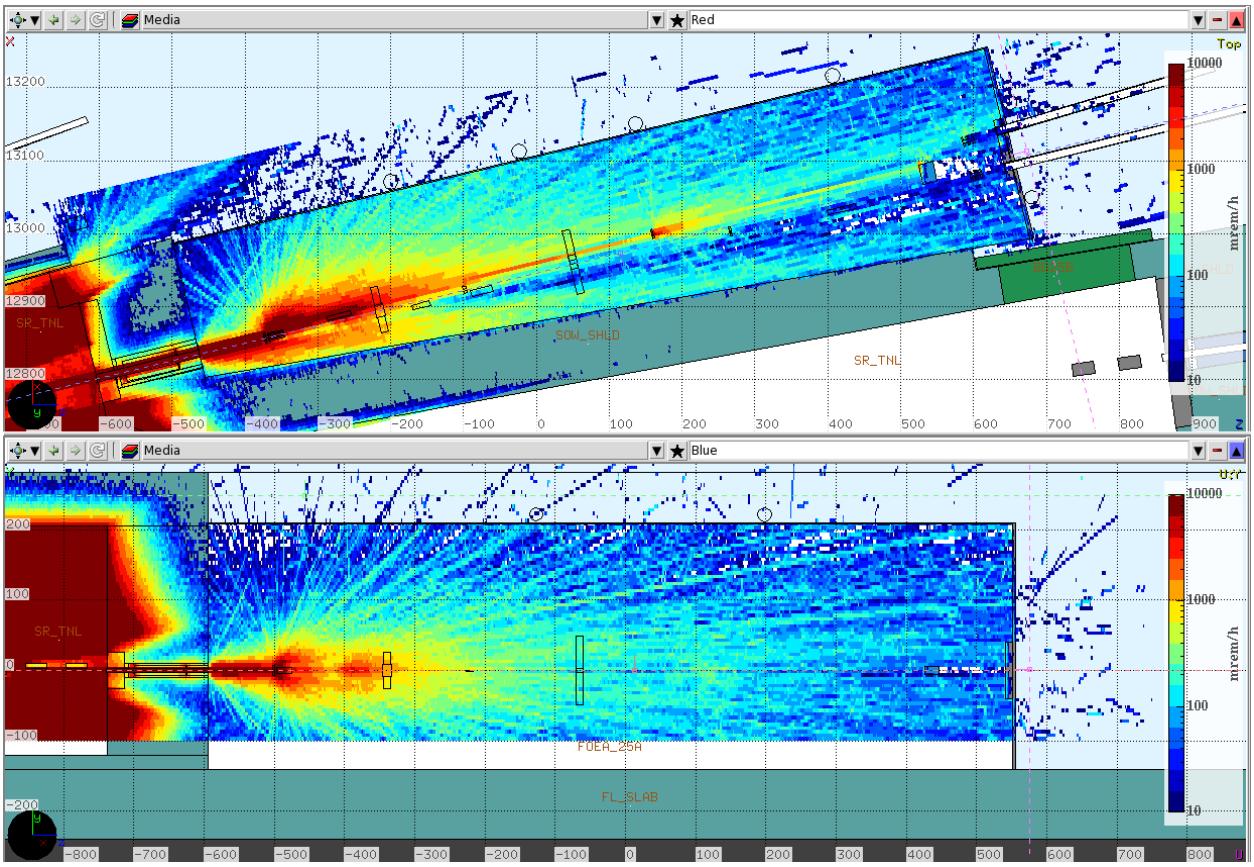


Figure 5: Total ambient dose equivalent rate distributions (mrem/h) with all slits open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

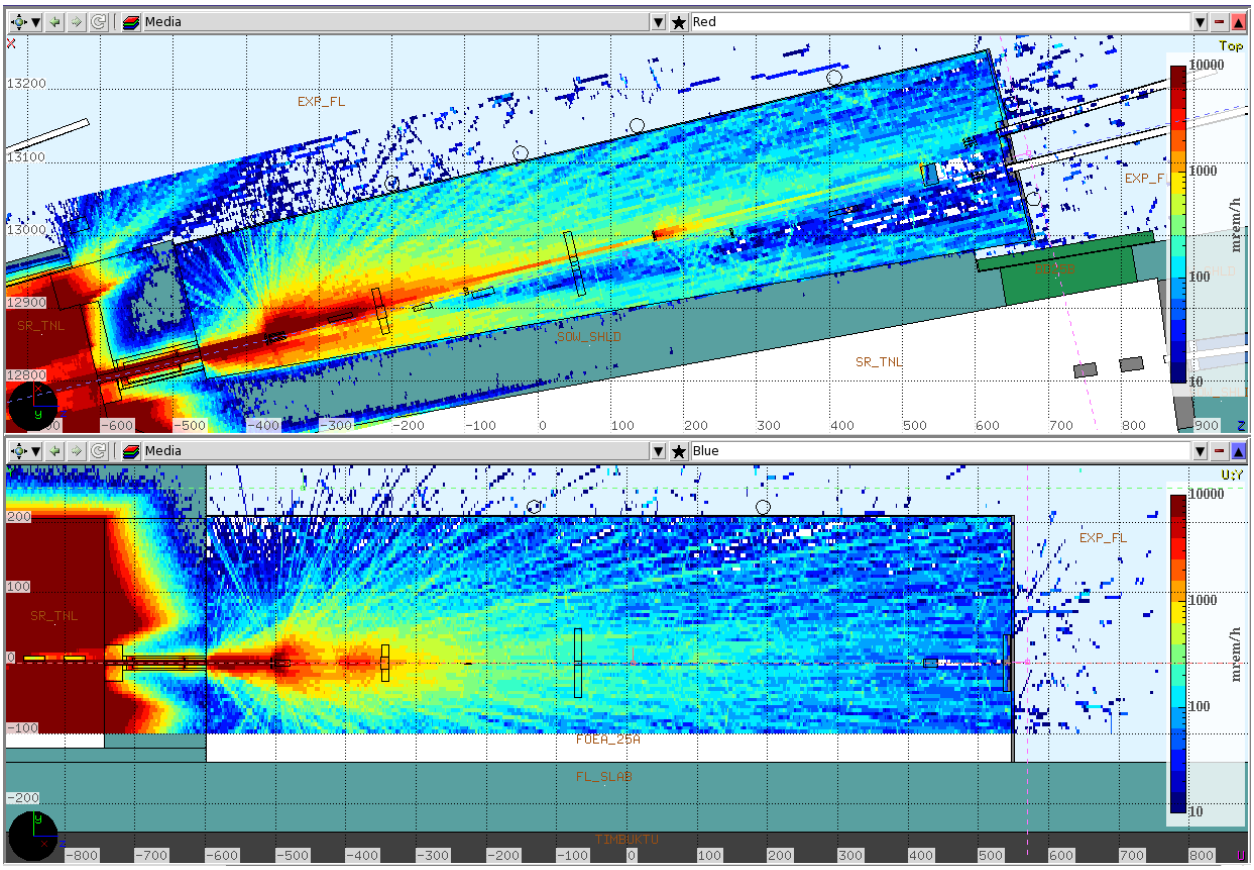


Figure 6: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 closed and slits 3 & 4 open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

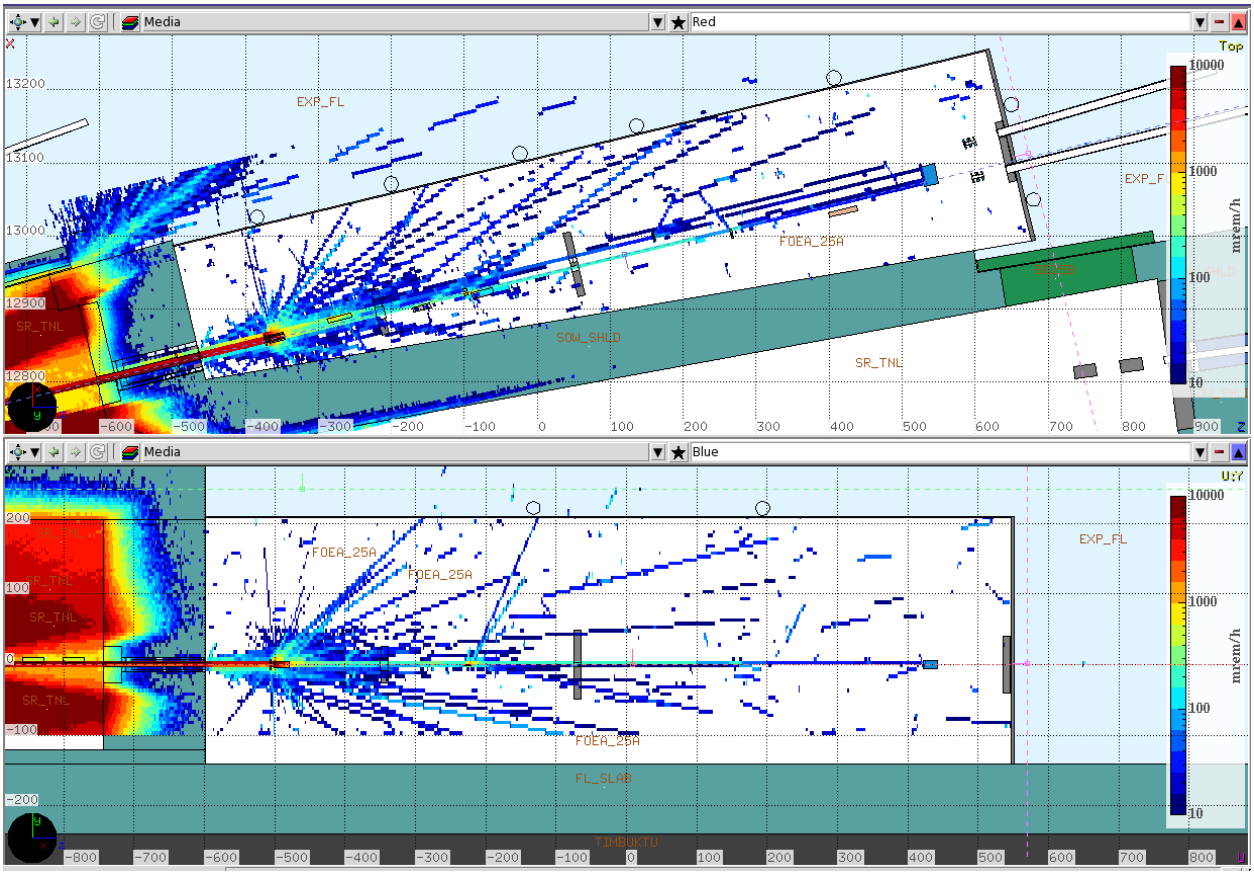


Figure 7: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

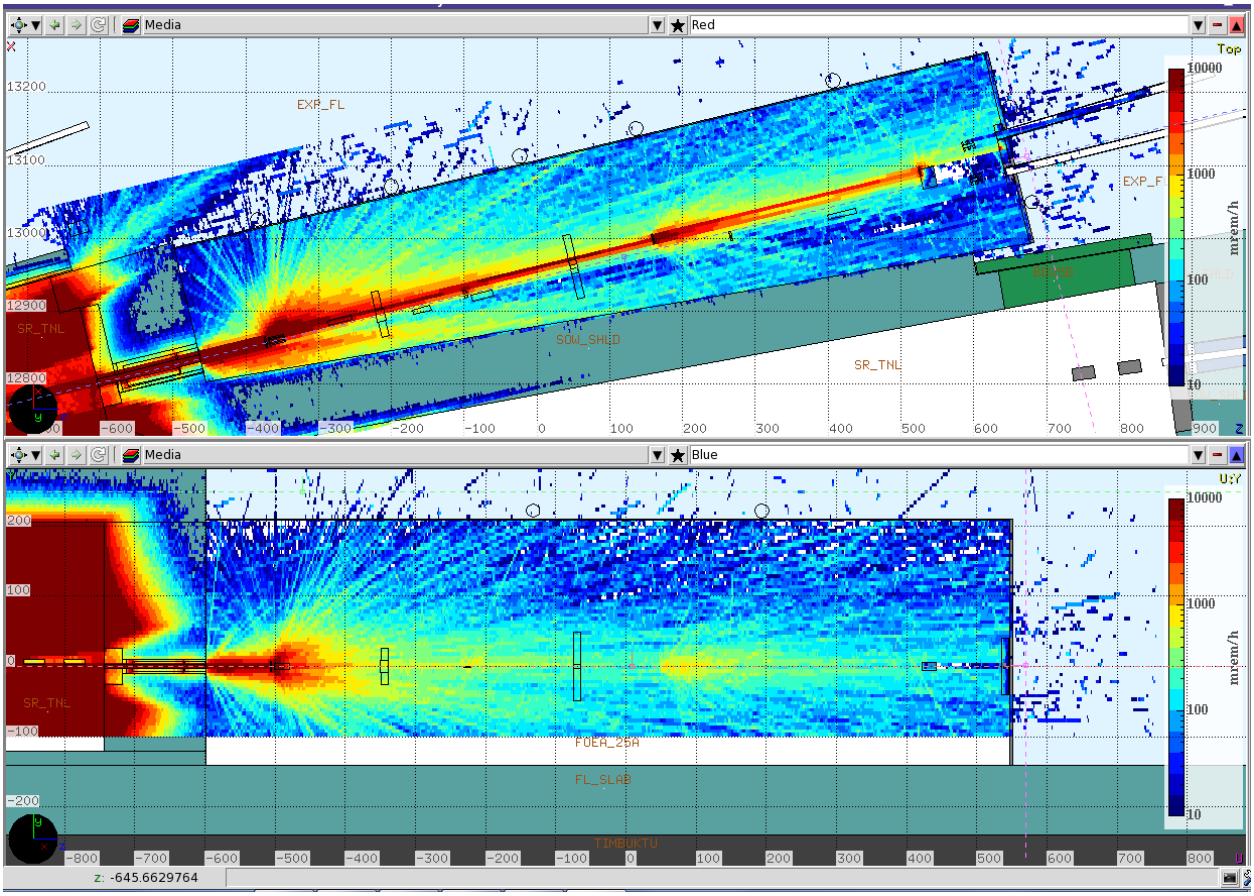


Figure 8: Total ambient dose equivalent rate distributions (mrem/h) with all slits open and mirrors L1 and M1 retracted. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

4.2 Case 2: Inboard- outboard

Here, the injected electron beam was started downstream of the horizontal aperture, on the inboard side of the FM, and directed toward the front face of LCO2, at 2 mm from the outboard side of the horizontal aperture. The total ambient dose equivalent rates in and around the FOE are shown in Figures 9-11 with the (a) slits completely open, (b) slits 1 & 2 closed and 3 & 4 open and (c) slits 1&2 open and 3&4 closed.

The dose rates outside the FOE are less than 100 mrem/h for all three scenarios of slits considered for the simulations here. The maximum dose rate outside the storage ring door is estimated to be ~200 mrem/h.

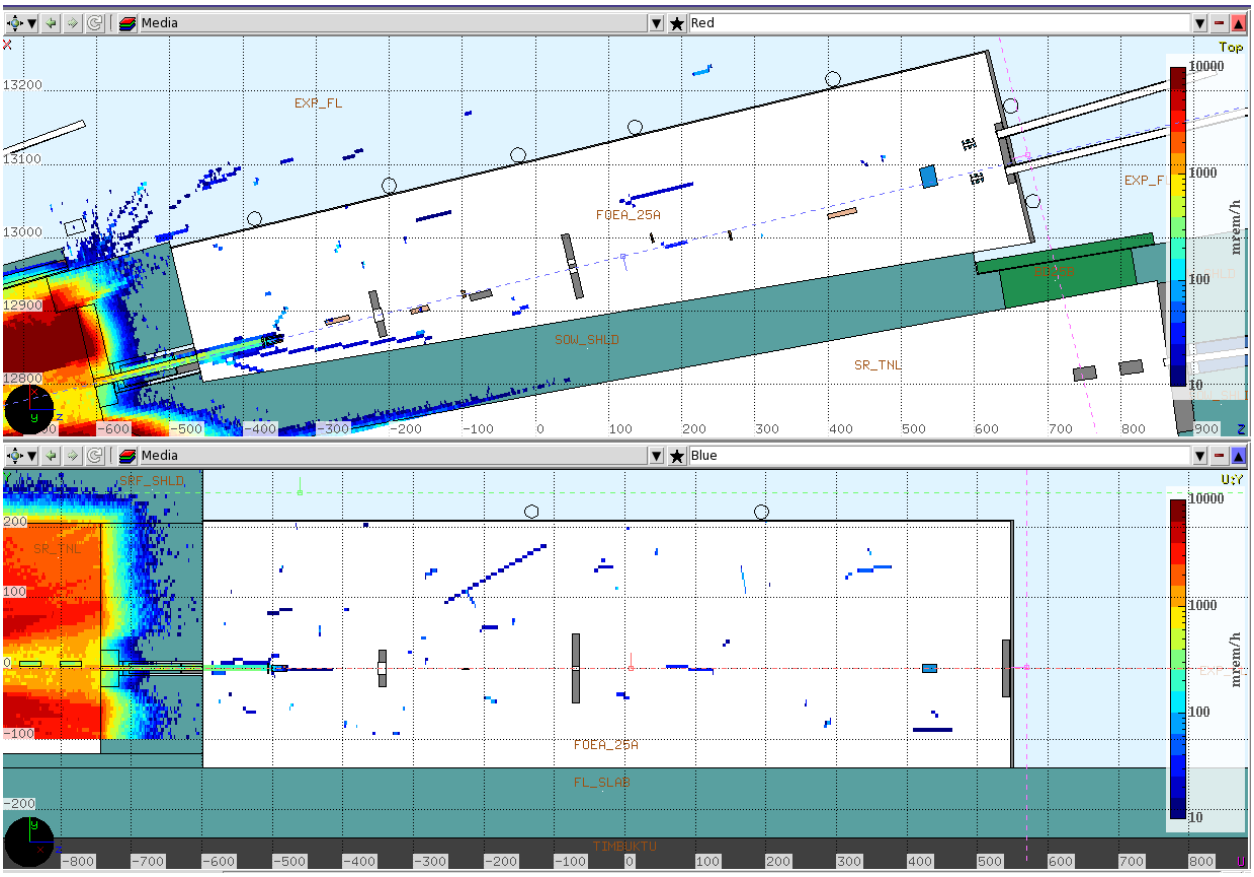


Figure 9: Total ambient dose equivalent rate distributions (mrem/h) with all slits open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

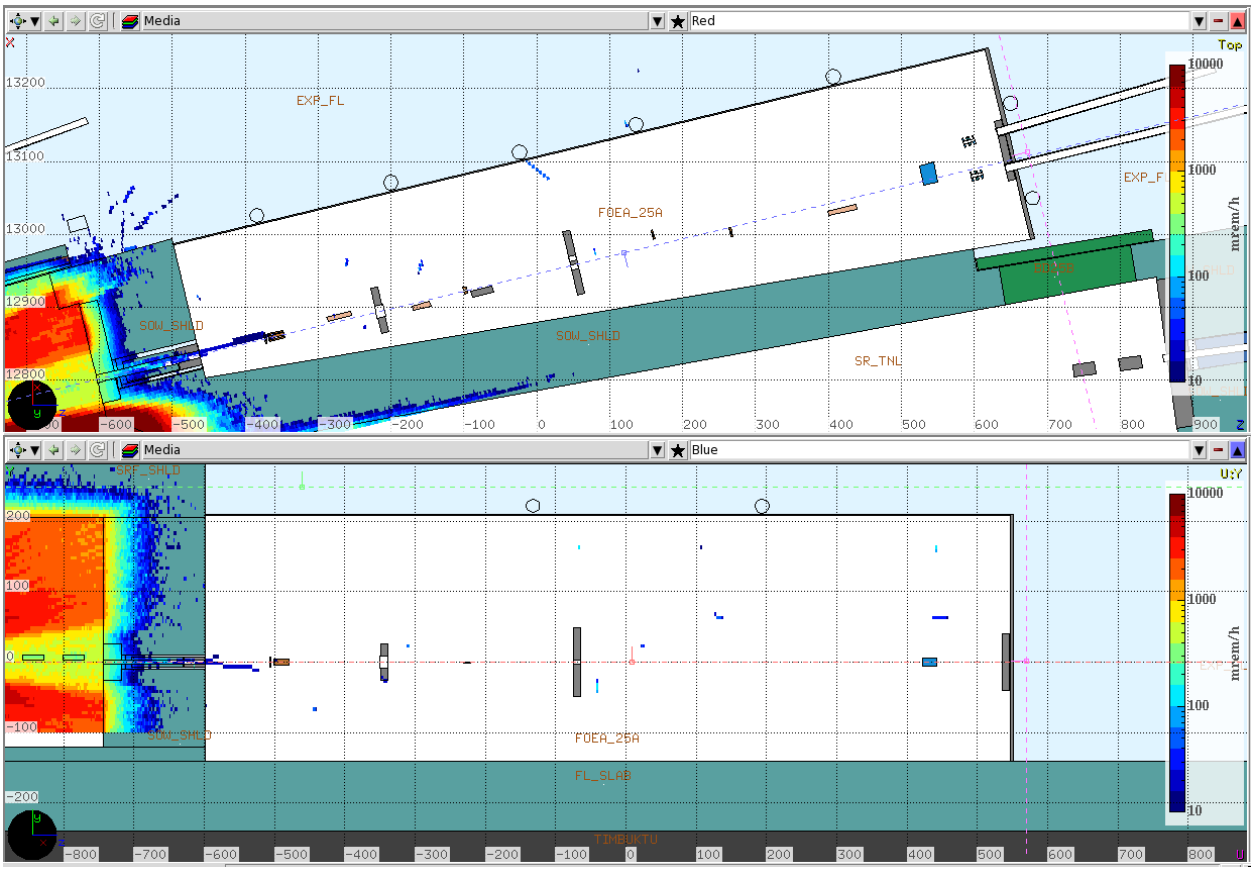


Figure 10: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 closed while slits 3 & 4 open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

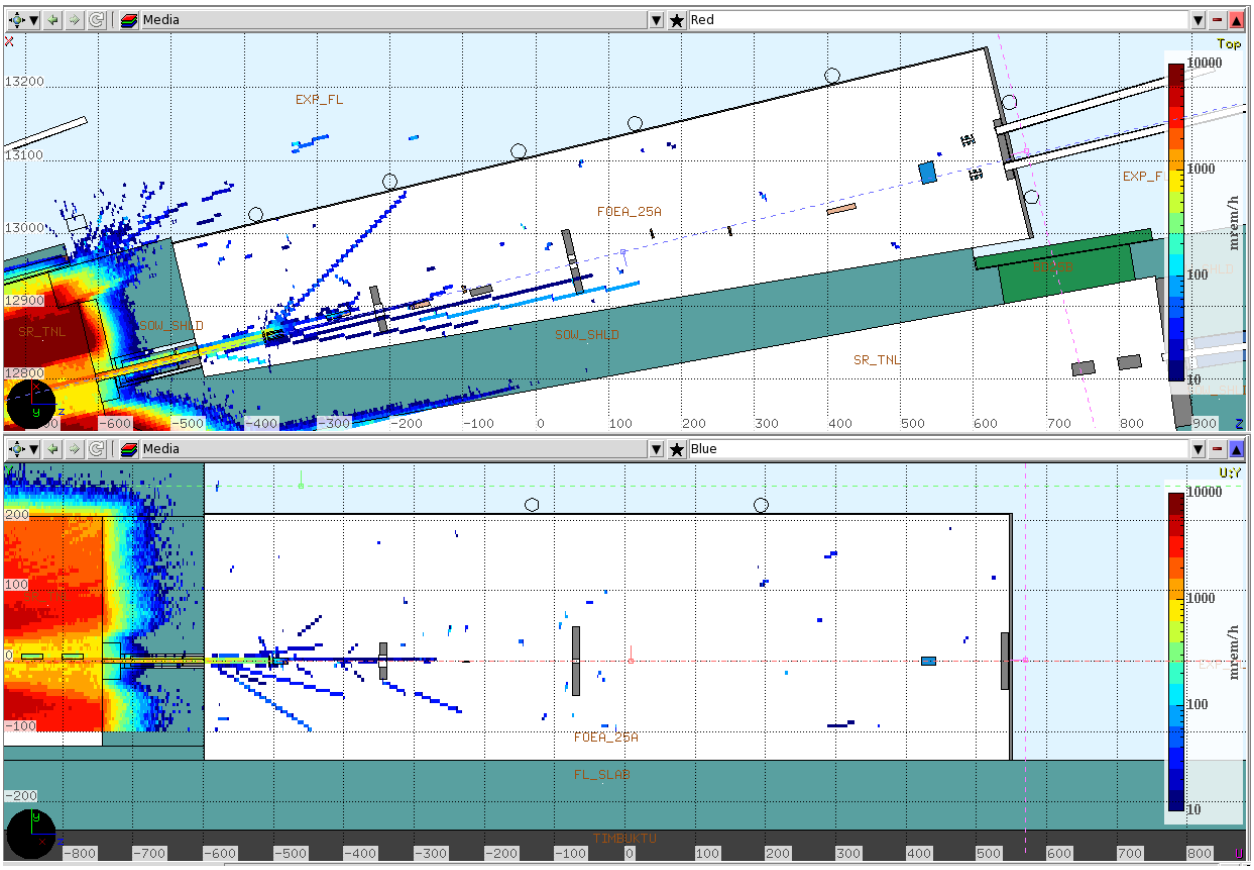


Figure 11: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

4.3 Case 3: Outboard - inboard

In this case, the injected electron beam was started downstream of the horizontal aperture on the outboard side of the FM and directed toward the front face of LCO2 at 2 mm from the inboard side of the horizontal aperture. The total ambient dose equivalent rates in and around the FOE are shown in Figures 12-14 with the (a) slits completely open, (b) slits 1 & 2 closed, with 3 & 4 open, and (c) slits 1 & 2 open, with 3 & 4 closed.

The dose rates outside the FOE are estimated to be less than 100 mrem/h for all the three scenarios, as seen in the figures. The maximum dose rate outside the storage ring door is expected to be about 150 mrem/h.

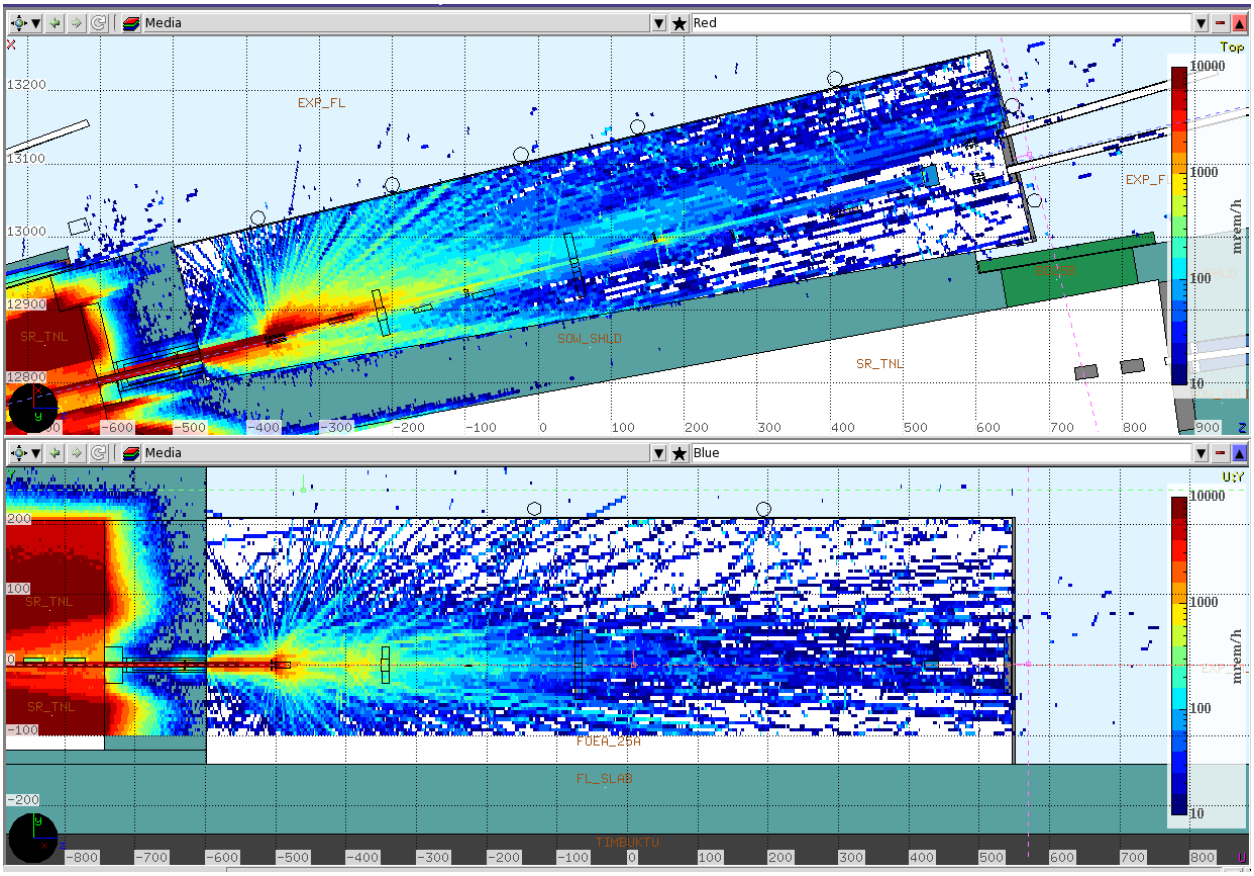


Figure 12: Total ambient dose equivalent rate distributions (mrem/h) with all the slits open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

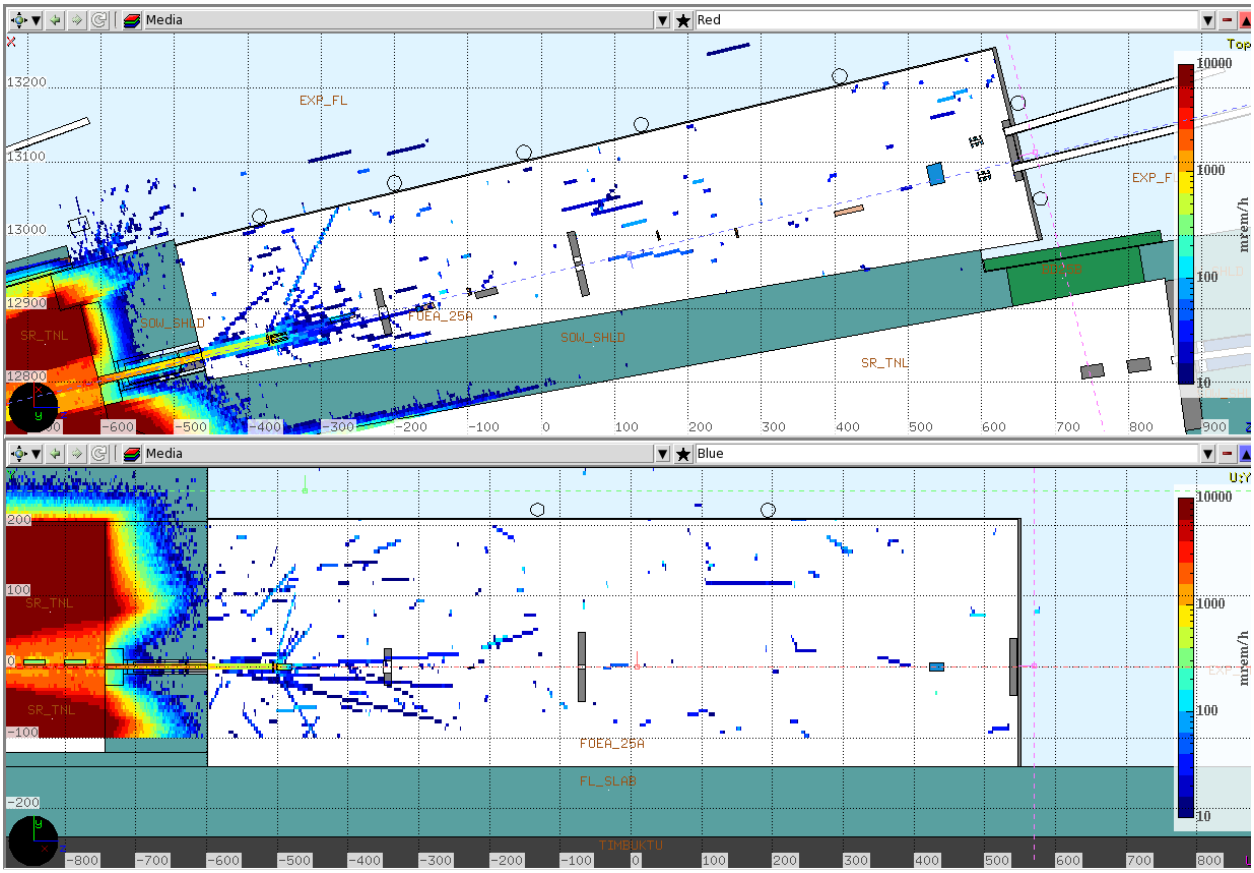


Figure 13: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 closed snd slits 3 & 4 open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

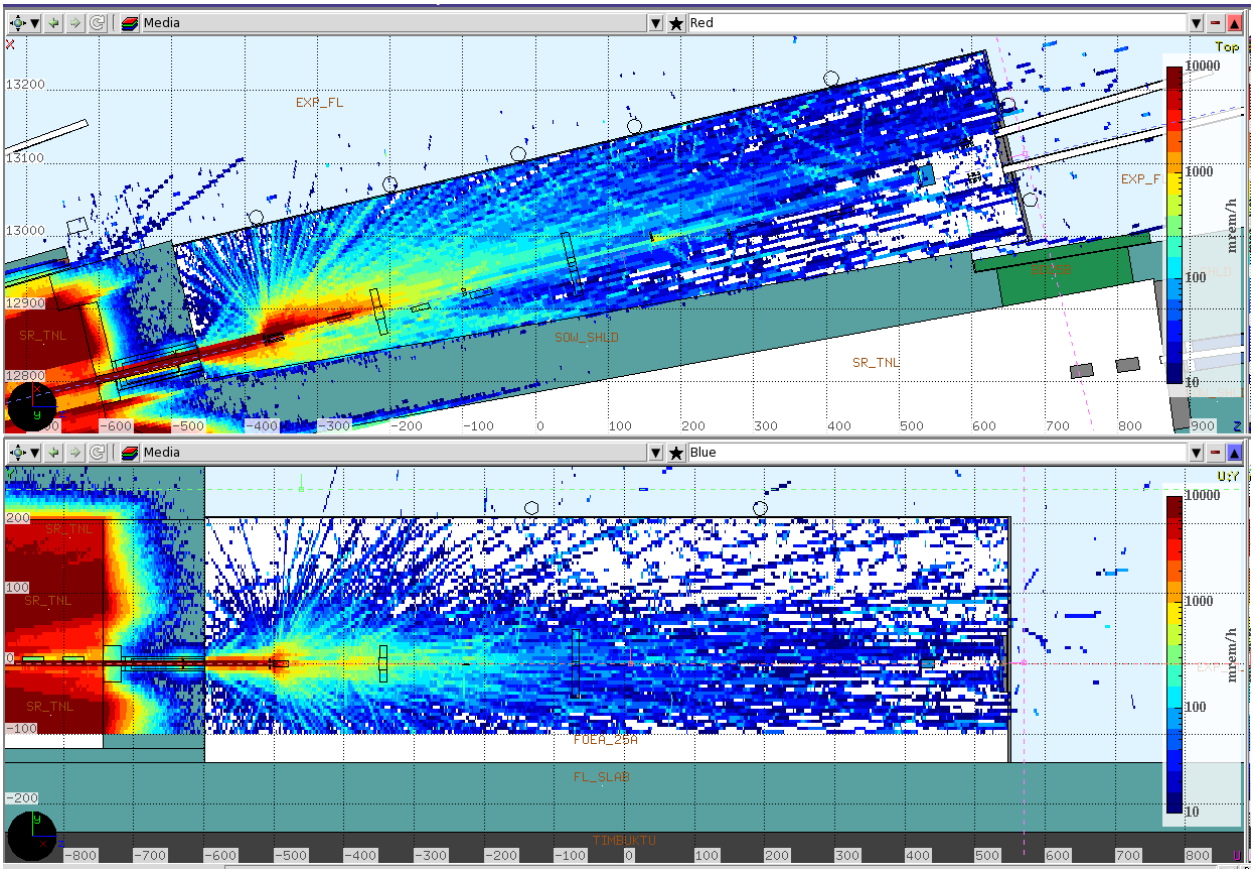


Figure 14: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

4.4 Case 4: Outboard - outboard

In this case, the injected electron beam was started downstream of the horizontal aperture on the outboard side of the FM, and directed toward the front face of LCO2, at 2 mm from the outboard side of the horizontal aperture. The total ambient dose equivalent rates in and around the FOE are shown in Figures 15-17 with the (a) slits completely open, (b) slits 1 & 2 closed, with 3 & 4 open and (c) slits 1 & 2 open, with 3 & 4 closed.

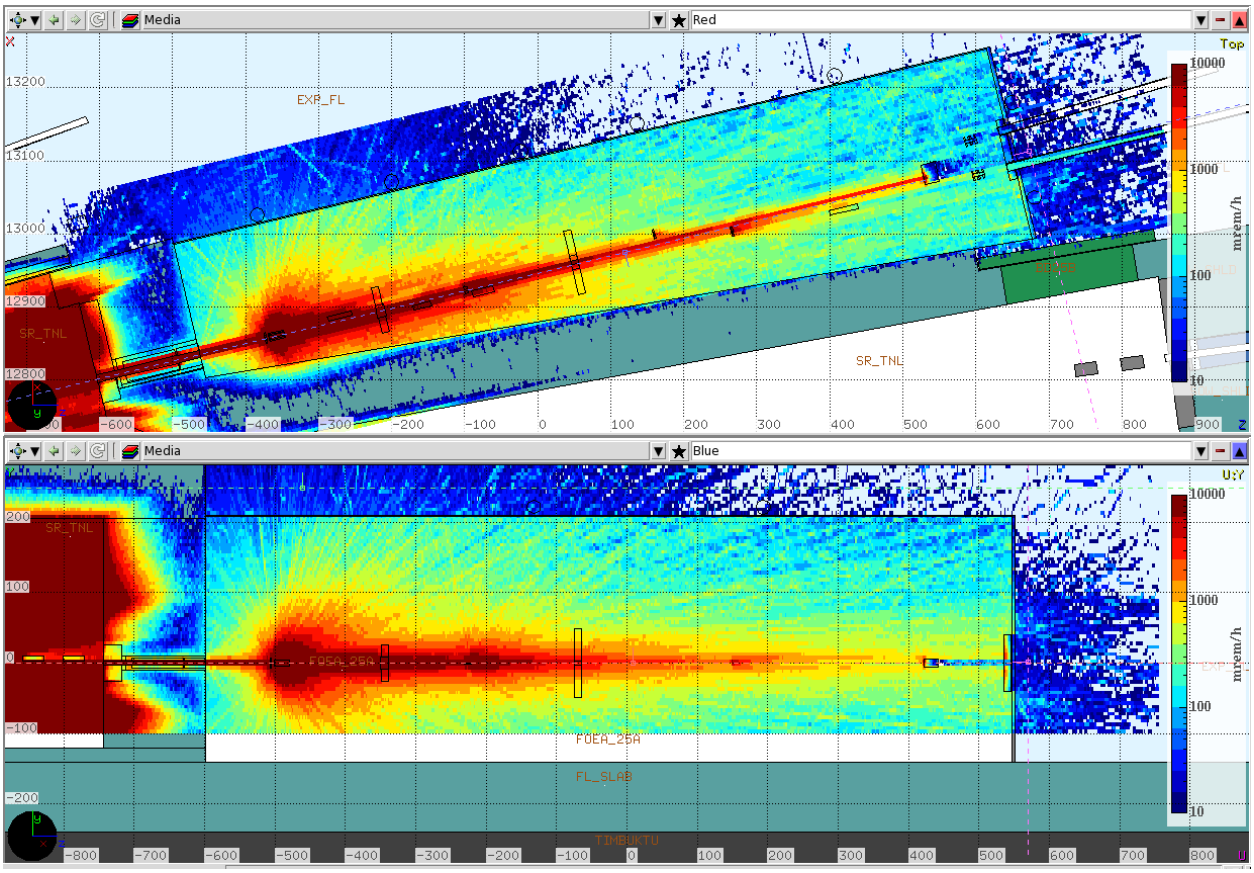


Figure 15: Total ambient dose equivalent rate distributions (mrem/h) with all slits open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

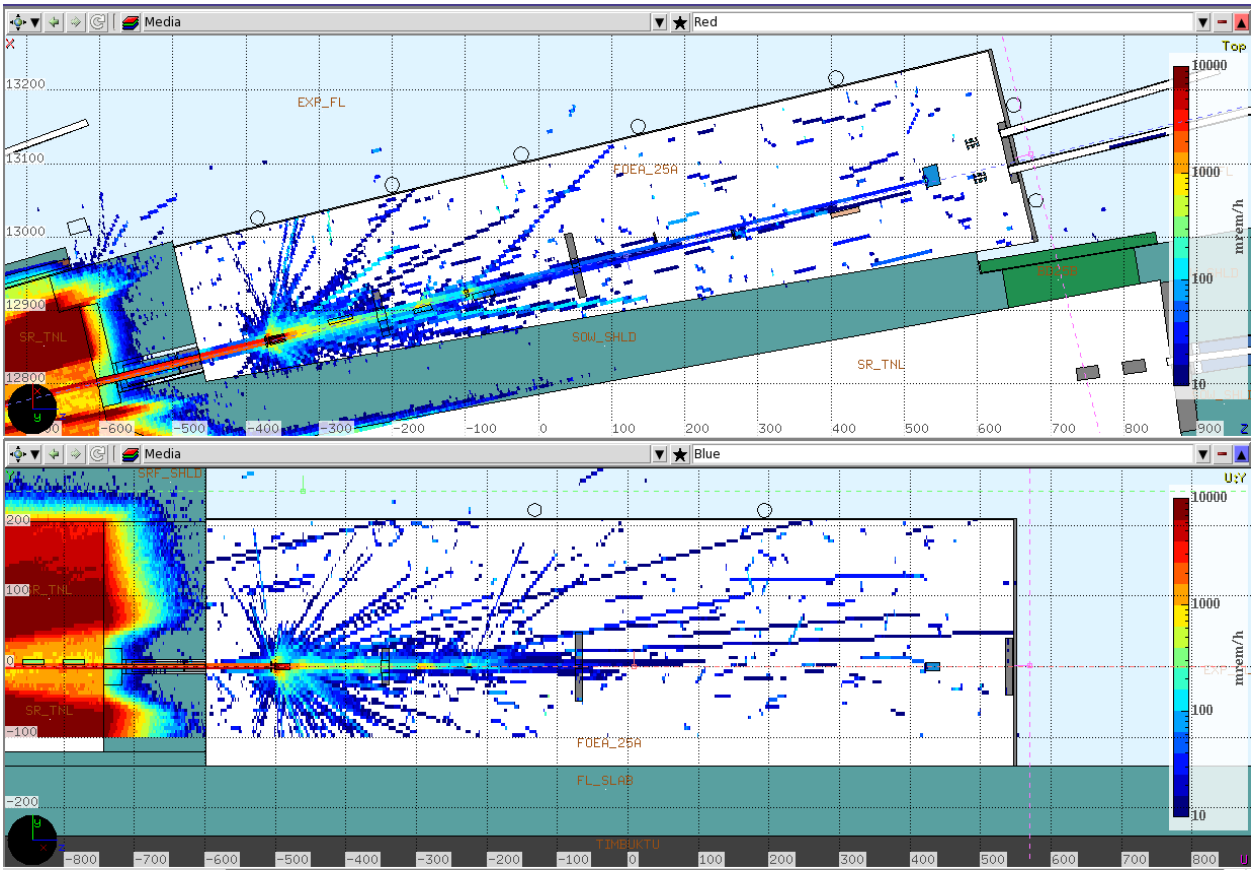


Figure 16: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 closed and slits 3 & 4 open. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

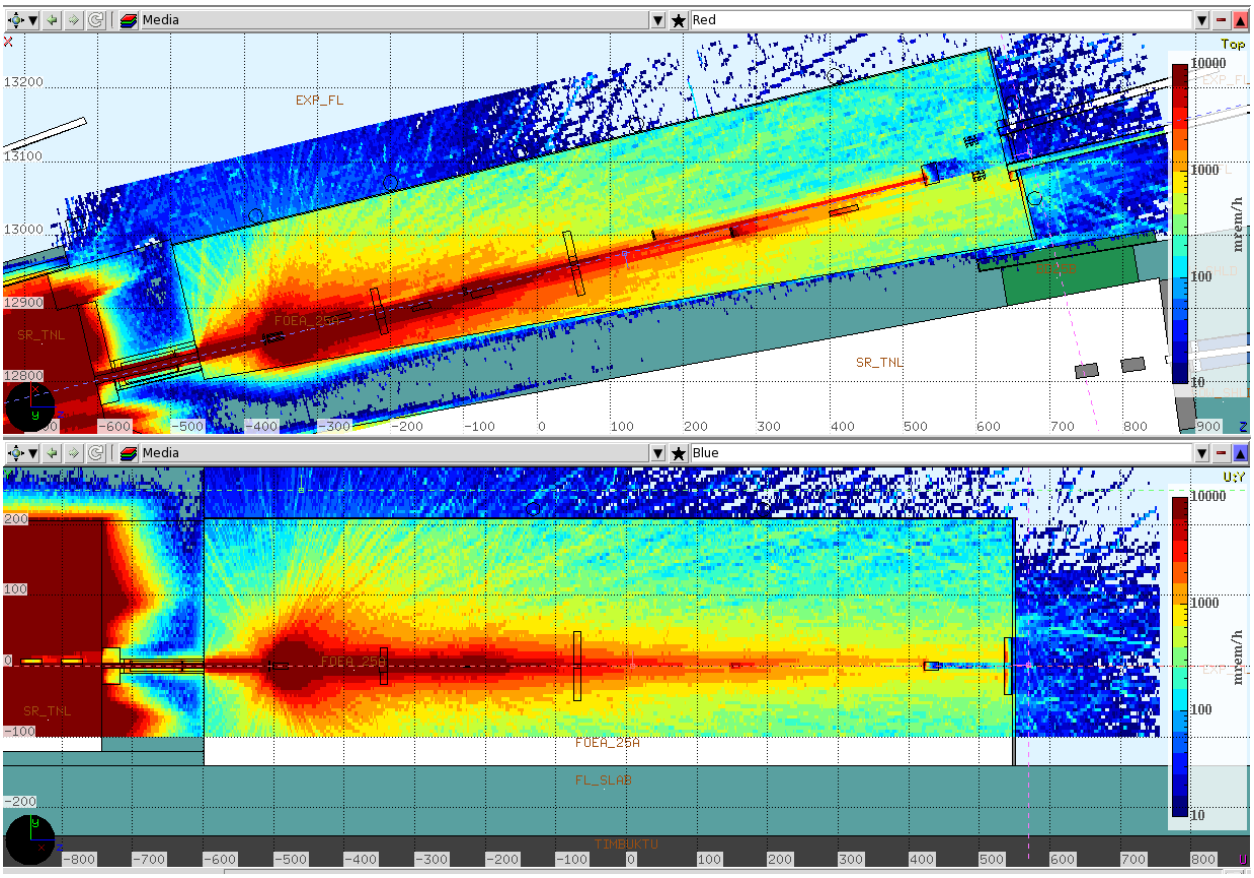


Figure 17: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

For the two scenarios where the slits are fully open. and when slits 1 & 2 are open (Figures 15 and 17), the maximum dose rates observed outside the downstream wall of the FOE is 300-400 mrem/h, while it is 100-150 mrem/h outside the sidewall and the roof. The maximum dose rate outside the storage ring door, for these two cases, is estimated to be about 100 mrem/h. For the case when slits 1 & 2 are closed and 3 & 4 are open, the dose rates outside the FOE are approximately 70-80 mrem/h and the dose rate outside the storage ring door is estimated to be approximately 200 mrem/h. In all these simulations, the lead shield components were excluded, but the mirrors were included in the geometry.

In Figure 18, another case is considered where the mirrors are also removed (simulating a condition where the mirrors are retracted) from the geometry. This was done with slits 1 & 2 open and slits 3 & 4 closed. The results indicate that the mirrors do not majorly affect the dose rates outside the FOE.

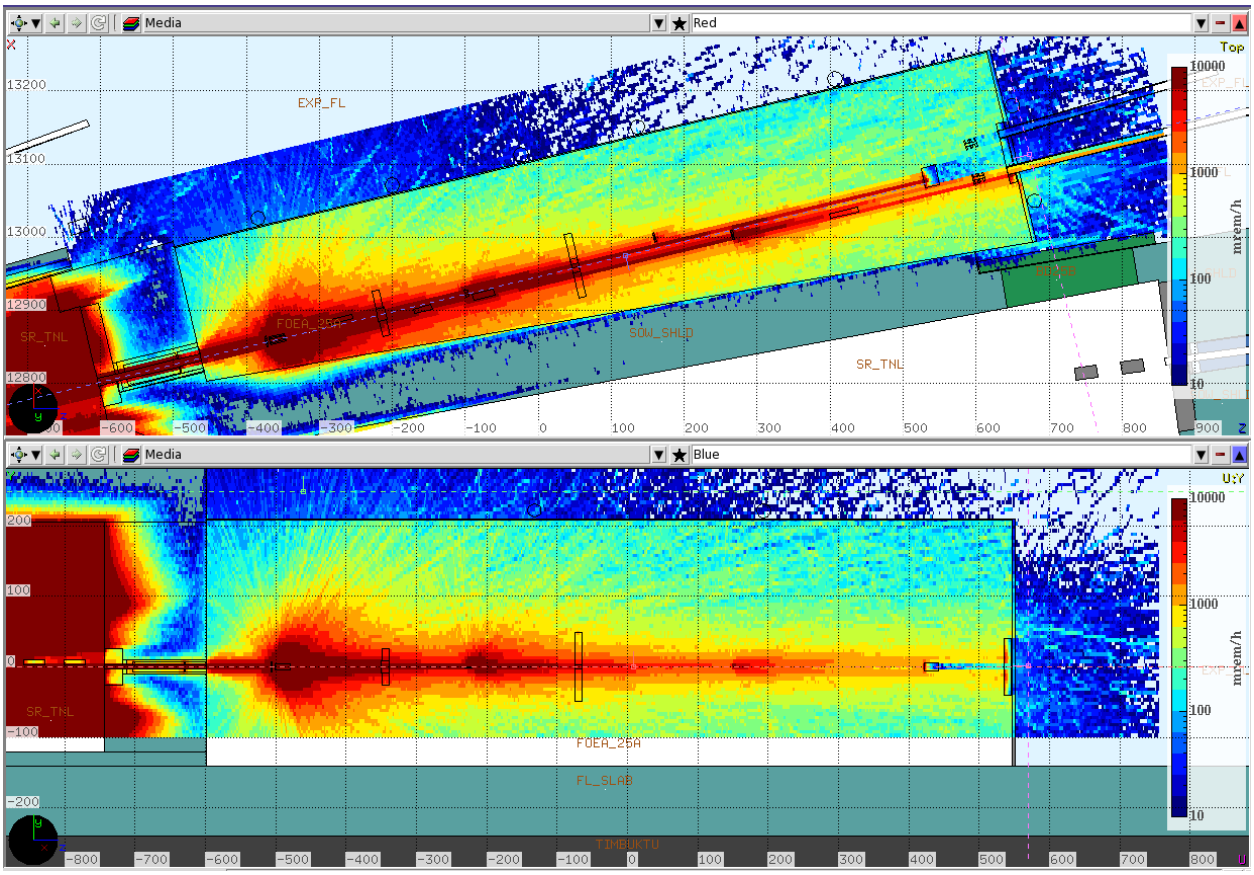


Figure 18. Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed and by removing the mirrors from the geometry. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

In the next set of simulations, the lead shield components were added sequentially starting with the BSS followed by SBS-1 and SBS-2 to estimate the dose rates outside the FOE. Figures 19-21 show the dose rates from these calculations.

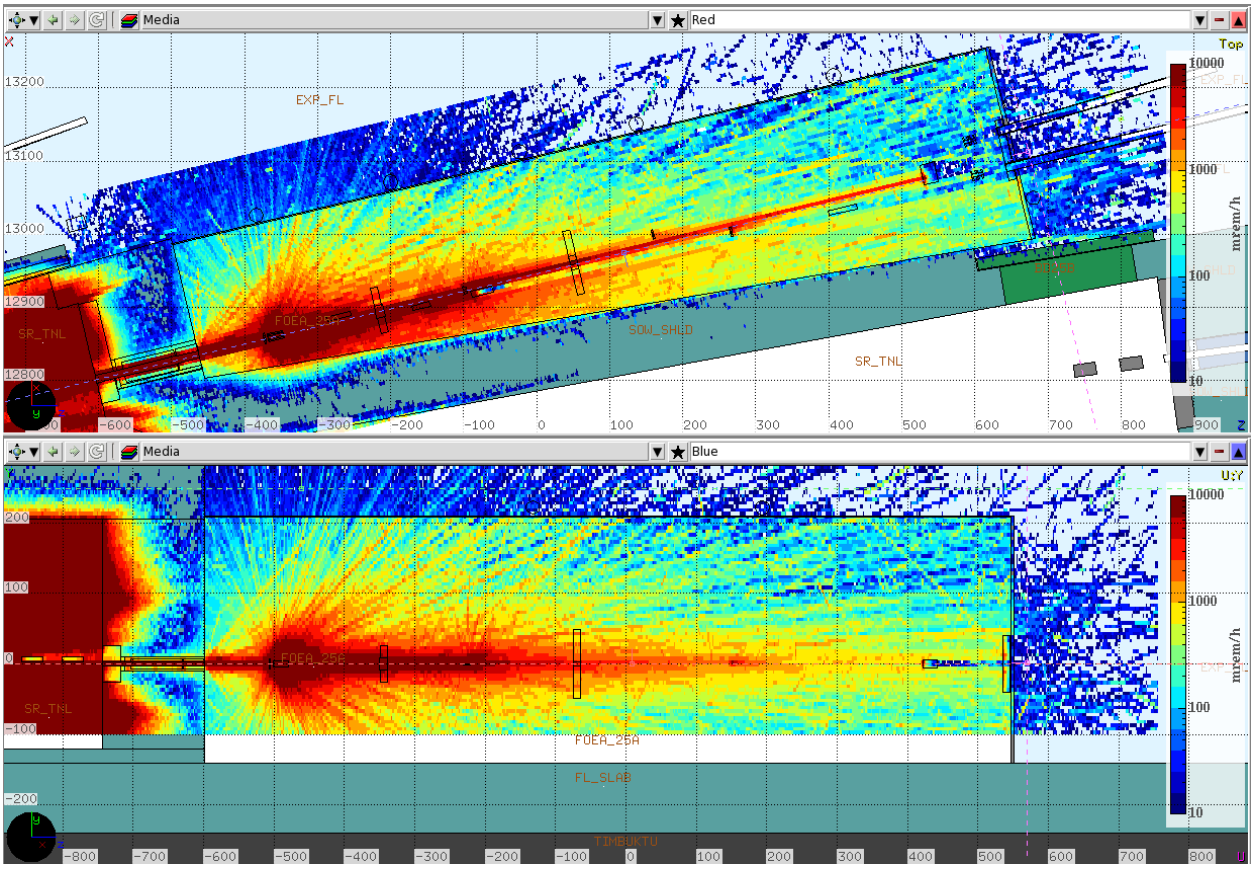


Figure 19: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed, with the mirrors and BSS included in the geometry. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

While the BSS does alter the shower propagation, the dose rates outside the FOE are about 100-200 mrem/h outside the downstream wall and 100-150 mrem/h outside the sidewall and roof.

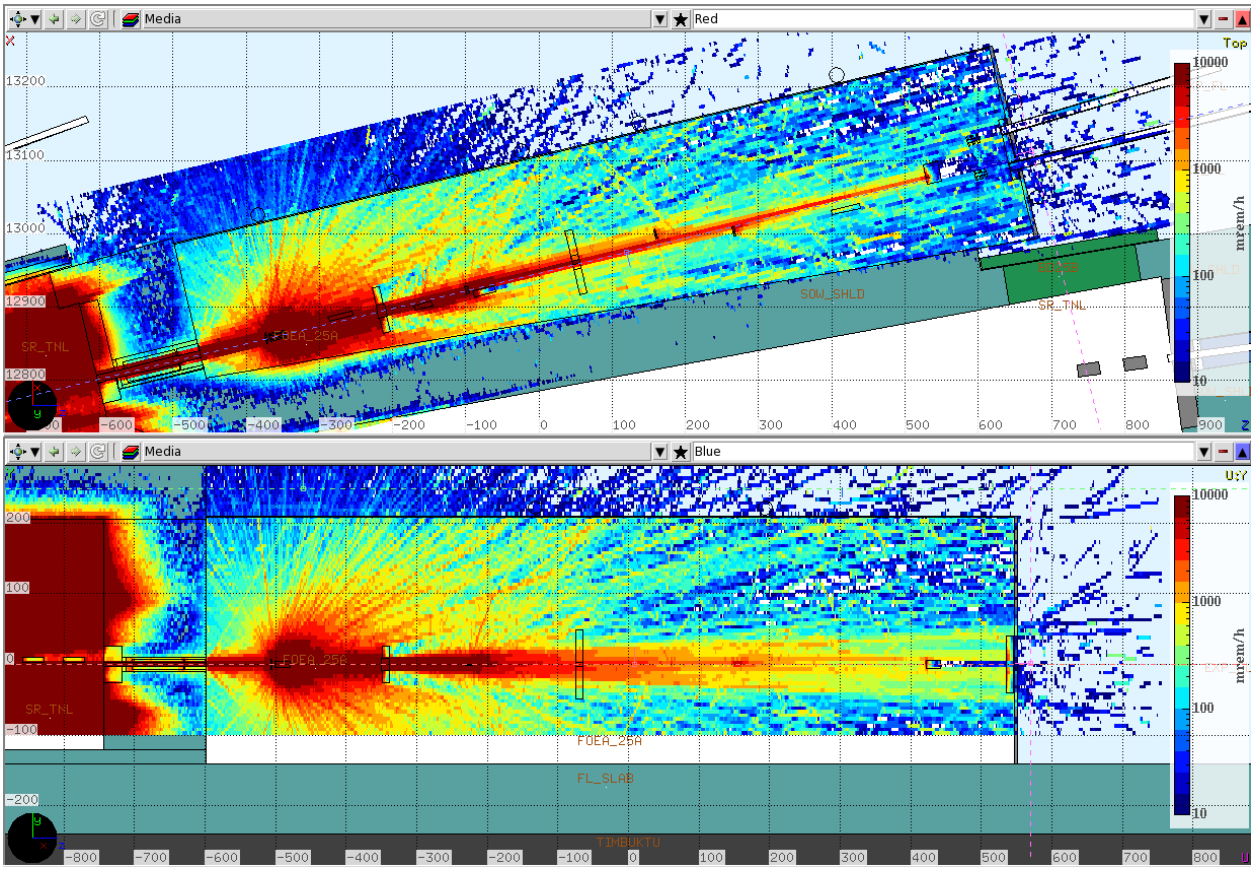


Figure 20: Total ambient dose equivalent rate distributions (mrem/h) with the slits 1&2 open and slits 3&4 closed, with the mirrors, BSS and the SBS-1 included in the geometry. The horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

When the SBS-1 is introduced in addition to the BSS, the dose rates (Figure 20) outside the downstream wall of the FOE has substantially reduced as the shields intercepts the shower that is directed towards the inboard side of the FOE. The dose rates outside the downstream wall, sidewall and roof are estimated to be 100-150 mrem/h. In the next simulation, all the three lead components (BSS, SBS-1 and SBS-2) were introduced in the geometry. The results shown in Figure 21 indicate that the dose rates are now less than 100 mrem/h outside the downstream wall, while on the sidewall and the roof, it is expected to be approximately 100 mrem/h. The introduction of the secondary shields, while reducing the dose rates in the downstream direction, does not reduce it appreciably in the lateral direction, as the shower development occurs in the first two solid components, i.e. the burn-through device and the fixed mask that are situated before the lead shields.

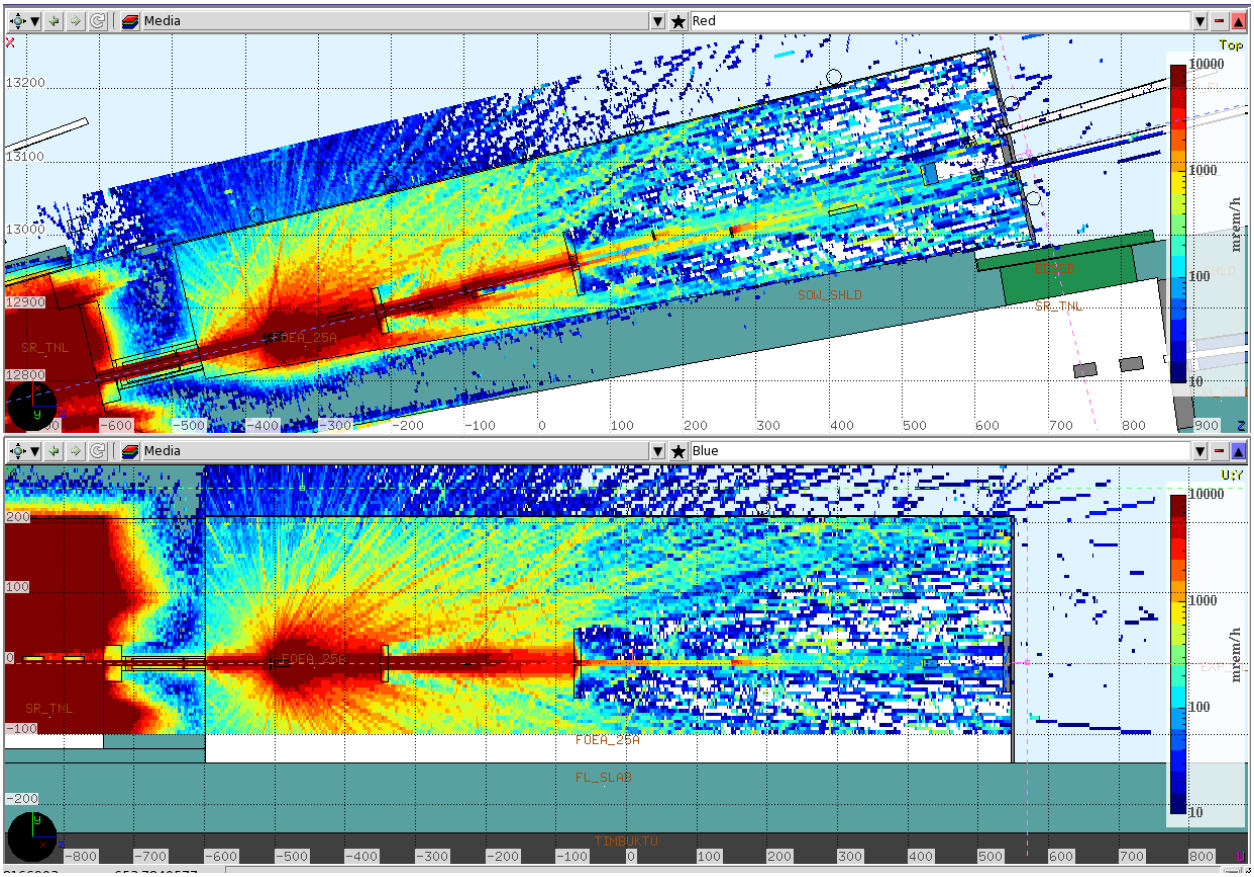


Figure 21: Total ambient dose equivalent rate distributions (mrem/h) with slits 1 & 2 open and slits 3 & 4 closed, with the mirrors, BSS, SBS-1 and SBS-2 are included in the geometry. The Horizontal view (at Y=0) is shown in the top figure and the elevation view (in line with the ratchet wall collimator aperture) in the bottom figure.

4.5 Area Radiation Monitor

An area radiation monitor (ARM) is located next to the door of the storage ring and is also modeled in the simulations here. The dose rates as estimated by the detectors in the simulation are shown in Table 1, for all the scenarios with the slits. The uncertainties reported are statistical in nature. The introduction of the secondary shields in the FOE does not affect the dose rates estimated by this ARM. For the maximum dose rates observed for the beam condition described in section 4.4, the ARM is expected to read about 12-18 mrem/h (case number 4 for all slits open and slits 1&2 open 3&4 closed) due to its location away from the door. In case of a Top-Off accident, the ARM will turn off the electron beam at 5 mrem/h, consistent with the NSLS-II Shielding Policy. The results from this simulation show that the ARM readings could be about a factor of two higher than this level. A corresponding reduction in the dose rates will result in approximately 150-200 mrem/h outside the downstream wall.

Table 1: The total ambient dose equivalent rates estimated at the storage ring ARM.

Case Number	Slits	Beam Direction	Dose rates (mrem/h)
1	All slits open	In-In	44.5±4.5
2		In-Out	4±0.6
3		Out-In	3±0.3
4		Out-Out	**15.7±1.8**
1	Slits 1&2 closed, 3&4 open	In-In	4±0.4
2		In-Out	3±0.8
3		Out-In	4.4±0.4
4		Out-Out	2.7±0.8
1	Slits 1&2 open, 3&4 closed	In-In	19±2.1
2		In-Out	5±0.9
3		Out-In	5±1.1
4		Out-Out	**12.6±1.2**

The ARM for the beamline when positioned on the sidewall can detect the streaming in the lateral direction, which is still significant with the shields present. Positioning an ARM on the sidewall of the FOE is also suitable to detect the dose rates outside the FOE arising out of the interaction of the gas bremsstrahlung with beamline components, the results of which are discussed in a separate Tech Note. The practical location for placing this ARM is identified to be at about 170 cm from the downstream end of the ratchet wall. Figure 22 shows the dose rate outside the sidewall with slits 1 & 2 open, slits 3 & 4 closed and the beam direction as described in section 4.4 (outboard to outboard). The location of the ARM is marked on this plot as a red box. When the maximum dose rates outside the downstream wall is estimated to be 400 mrem/h, the corresponding dose rates outside the sidewall where the ARM is located is expected to be near 55±4 mrem/h.

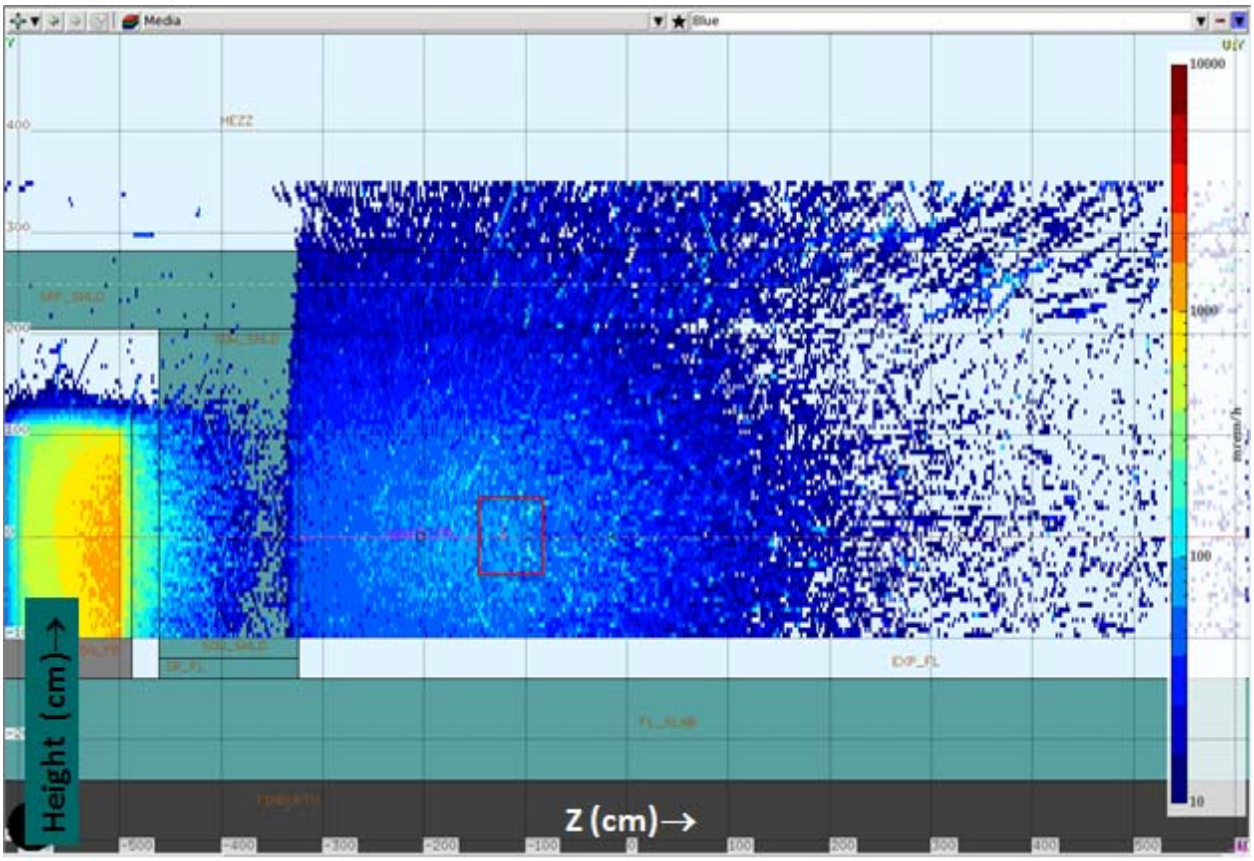


Figure 221: Elevation view of the total ambient dose equivalent rate (mrem/h) outside the sidewall when slits 1&2 are open, slits 3&4 closed, without the BSS, SBS-1 and SBS-2 in the geometry. In the figure, the downstream end of the FOE is towards the right hand side.

5. Summary and Conclusions

The Top-Off radiation safety analysis of the 07ID-SST beamline has been carried out using the FLUKA Monte Carlo radiation transport code. Based on the results obtained, the maximum radiation dose rate estimated at the exterior of the FOE is estimated at about 400 mrem/h outside the downstream wall and 100-150 mrem/h on the sidewall when the lead shield components are not taken into account. The introduction of the secondary shields inside the FOE reduces the dose rate outside the downstream wall to less than 100 mrem/h, but does not appreciably reduce the dose rates outside the sidewall and roof. The beamline ARM, when located on the sidewall of the FOE, will be an effective control point for the top-off radiation safety as it shuts off the beam at 5 mrem/h, and will keep the dose rates outside the FOE less than 100 mrem/h.

The results of the calculations indicate that the FOE shielding of 07ID-SST falls within the NSLS-II Shielding Policy [1], with the beamline ARM on the sidewall identified as the credited controls for the case when the dose potential exceeds 100 mrem/h.

ACRONYMS:

ALARA	As Low as Reasonably Achievable	L2	Second Mirror On L Branch.
ARM	Area Radiation Monitor	LCO	Lead Collimator
BSS	Bremsstrahlung Stop	M1	First Optic On M Branch.
BST	Bremsstrahlung Stop	NSLS-II	National Synchrotron Light Source II
C	Center	PBS	Pink Beam Stop
DCM	Double Crystal Monochromator	PGM	Plane Grating Monochromator
DS	Downstream	PSH	Photon Shutter
EPU	Elliptically polarized Undulator	RCO	Ratchet Wall Collimator
FE	Front End	SBS	Secondary Bremsstrahlung Shield
FM	Fixed Mask	SLT	XY Slit
FOE	First Optical Enclosure	SS	Safety Shutter
FS	Fluorescent Screen	SST	Spectroscopy Soft and Tender
GeV	Giga Electron Volts	U	Undulator
H	Horizontal	US	Upstream
ID	Insertion Device	V	Vertical
L1	First Mirror On L Branch.	WBS	White Beam Stop

2 References

[1] Photon Sciences Shielding Policy, PS-C-ASD-POL-005, March 26, 2014.

[2] Guidelines for NSLS-II Beamline Front End Design for Top Off Safety, NSLS-II Technical Note 153, Y. Li and R. Fliller, Jan 21, 2015. Email from Fliller, Raymond, July 28, 2017

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

Appendix 1

Chitra, Sunil

From: Fliller, Raymond
Sent: Monday, October 30, 2017 2:33 PM
To: Chitra, Sunil
Cc: Benmerrouche, Mohamed
Subject: FW: SST

Sunil,

SST's front end's apertures are slightly smaller than AMX/FMX which is identical to SRX's front end. SRX's front end was one of the two initial beamlines analyzed for top off safety. No tracking is needed for this beamline.

Ray

Raymond Fliller
Brookhaven National Laboratory
National Synchrotron Light Source II
Building 744
P.O. Box 5000
Upton, NY 11973-5000
Phone: 631-344-2356
Fax:631-344-3029

From: Fliller, Raymond
Sent: Thursday, December 15, 2016 9:49 AM
To: Amundsen, Christopher
Cc: Benmerrouche, Mohamed; Li, Yongjun
Subject: SST

Thanks Chris. This is exactly what I need.

Mo, Looks like SST's front end is identical to ID 17. Since 17 is safe for top off, ID7 is too. No tracking needed for this one.

Ray

Raymond Fliller
Brookhaven National Laboratory
National Synchrotron Light Source II
Building 744
P.O. Box 5000
Upton, NY 11973-5000
Phone: 631-344-2356
Fax:631-344-3029

Appendix 2

07ID / SST Front End Mask, Collimator and Shielding Data for FLUKA Calculations

Front End Components for FLUKA Calculations

Front End Component	Z location, m (Distance from Source Point) (U), (D) or center (C)	Dimensions		Offset (vertical or horizontal) w.r.t 07 ID white beam CL	Material	Associated Drawings
		Outer dimensions (W)x(H)x(L)	Lead CO or Mask Aperture, mm (W)x(H) or (Dia)			
Crotch Absorber (at beam CL)	9821.1 (US)	45.0 W x 42.0 H x 254.0 L	75.0(W) x 18.0(H)	-	AL-15 GlidCop	SR-VA-ABS-1080
Exit Absorber	10121.0 (US)	139.7 W x 50.8 H x 187.0 L	85.7(W) x 25.0(H) (US) 48.0(W) x 25.0(H) (DS)	-	AL-15 GlidCop	SR-FE-ABS-2025
FE Flange Absorber1 (MSK2)	17045.2 (DS)	171.5 W x 151.6 H x 20.0 L	71.5 (W) x 44.5 (H) Thru	+2.4 Horiz Offset	AL-15 GlidCop	SR-FE-ABS-3800
FE Fixed Mask (MSK1)	17518.1(US)	139.7 W x 102.2 H x 350.0 L	77.9(W) x 51.9 (H) (US) Inboard 9.6(W) x 5.4(H) (DS) Outboard 8.3(W) x 5.4(H) (DS)	+2.4 Horiz Offset	Copper Chromium Zirconium	SR-FE-MSK-3801
FE LCO1 (BC1)	18142.9 (US)	406.0 W x 102.0 H x 305.0 L	61.0 (W) x 21.5 (H) Thru	+2.4 Horiz Offset	Lead	SR-FE-CO-3820
FE Slit 1 (Closed)	18817.2 (C)	112.7 W x 88.9 H x	Outboard aperture 33.8(W) x 25.7 (H) (US)	Trimming edge +21.4 (W) x	AL-15 GlidCop	SR-FE-SLT-3801

		336.6 L	30.1(W) x 11.4(H) (DS) Inboard aperture 38.1(W) x 25.7 (H) Thru	0.0 (H)		
FE Slit 1 (Open)	18817.2 (C)	112.7 W x 88.9 H x 336.6 L	Outboard aperture 33.8(W) x 25.7 (H) (US) 30.1(W) x 11.4(H) (DS) Inboard aperture 38.1(W) x 25.7 (H) Thru	Trimming edge +28.3 (W) x -5.1 (H)	AL-15 GlidCop	SR-FE-SLT-3801
FE Slit 2 (Closed)	19458.8 (C)	111.1 W x 88.9 H x 336.6 L	Outboard aperture 33.8(W) x 25.4 (H) (US) 15.4(W) x 11.4(H) (DS) Inboard aperture 37.5(W) x 25.4 (H) Thru	Trimming edge +22.0 (W) x 0.0 (H)	AL-15 GlidCop	SR-FE-SLT-3821
FE Slit 2 (Open)	19458.8 (C)	111.1 W x 88.9 H x 336.6 L	Outboard aperture 33.8(W) x 25.4 (H) (US) 15.4(W) x 11.4(H) (DS) Inboard aperture 37.5(W) x 25.4 (H) Thru	Trimming edge +15.0 (W) x +5.1 (H)	AL-15 GlidCop	SR-FE-SLT-3821
FE Slit 3 (Closed)	20100.3 (C)	112.7 W x 88.9 H x 336.6 L	Inboard aperture 33.8(W) x 25.7 (H) (US) 30.1(W) x 11.4(H) (DS) Outboard aperture 38.1(W) x 25.7 (H) Thru	Trimming edge -18.0 (W) x 0.0 (H)	AL-15 GlidCop	SR-FE-SLT-3841
FE Slit 3 (Open)	20100.3 (C)	112.7 W x 88.9 H x 336.6 L	Inboard aperture 33.8(W) x 25.7 (H) (US) 30.1(W) x 11.4(H) (DS) Outboard aperture 38.1(W) x 25.7 (H) Thru	Trimming edge -24.7 (W) x +5.1 (H)	AL-15 GlidCop	SR-FE-SLT-3841
FE Slit 4	20741.8 (C)	111.1 W x	Inboard aperture	Trimming edge	AL-15	SR-FE-SLT-3861

(Closed)		88.9 H x 336.6 L	33.8(W) x 25.4 (H) (US) 15.4(W) x 11.4(H) (DS) Outboard aperture 37.5(W) x 25.4 (H) Thru	-18.6 (W) x 0.0 (H)	GlidCop	
FE Slit 4 (Open)	20741.8 (C)	111.1 W x 88.9 H x 336.6 L	Inboard aperture 33.8(W) x 25.4 (H) (US) 15.4(W) x 11.4(H) (DS) Outboard aperture 37.5(W) x 25.4 (H) Thru	Trimming edge -25.5 (W) x -5.1 (H)	AL-15 GlidCop	SR-FE-SLT-3861
FE Photon Shutter	21506.0 (US)	108.0 W x 82.5 H x 254.0 L	66.7(W) x 37.5 (H) (US) 66.7(W) x 22.7 (H) (DS)	0.0 (open) -19.0 (closed) +2.4 Horiz Offset	AL-15 GlidCop	SR-FE-PSH-2701
FE LCO2 (BC2)	22285.0 (US)	457.2 W x 127.0 H x 305.0 L	77.2 (W) x 26.9 (H) Thru	+2.4 Horiz Offset	Lead	SR-FE-CO-3800
FE Safety Shutter 1	22860.3 (US)	177.8 W x 165.1 H x 305.0 L	Lead raised above beam in open position. Lead dropped to block beam when closed.	+21.9 (open) -61.1 (closed) +2.4 Horiz Offset	Lead	SR-FE-3PW-SS-4000
FE Safety Shutter 2	23441.2 (US)	177.8 W x 165.1 H x 305.0 L	Lead raised above beam in open position. Lead dropped to block beam when closed.	+21.9 (open) -61.1 (closed) +2.4 Horiz Offset	Lead	SR-FE-3PW-SS-4100
Shield Wall Lead	24020.4 (US)	1380.0 W x 498.5 H x 254.0 L	106.4 (W) x 56.4 (H) Thru	+2.4 Horiz Offset	Lead	SR-FE-RCO-0700
Upstream Penetration Lead	24274.4 (US)	403.2 W x 200.0 H x	106.4 (W) x 56.4 (H) Thru	+2.4 Horiz Offset	Lead	SR-FE-RCO-0700

		50.8 L				
Concrete Filler	24414.1 (US)	288.1 W x 136.5 H x 730.3 L	104.0 (W) x 56.8 (H) Thru	+2.4 Horiz Offset	Concrete	SR-FE-RCO-3800
RCO	25468.2 (DS)	289.6 W x 139.7 H x 304.8 L	101.0 (W) x 52.0 (H) Thru	+2.4 Horiz Offset	Lead	SR-FE-RCO-3800

Note: All dimensions are in Millimeters. Offset dimensions are from the straight center line in X & Y and center of straight section for Z.

7-ID-SST / Beamline Mask, Collimator and Shielding Data for FLUKA Calculations

First Optical Enclosure

Shielding Information (dimensions in mm) *	Distance/Position	Thickness (mm)	Material
	Z =		Concrete / Lead
DS face of ratchet wall (inside FOE)	Z = 25468.2mm	1447.8mm	Concrete / Lead
OB wall distance from 7-SST photon beam centerline	X= 1539.6	18.0	Lead
Minimum distance from beam centerline to roof Pb shielding	Y= 2085.8	10.0	Lead
Min distance: white beam (US) Z-axis to SR wall outer face	Z= -3673.9	-	Concrete / Lead
Min distance: white beam (US) Z-axis to hutch wall inside Pb face	Z= 7775.1	50.0	Lead
Angle betw SR wall & white photon beam Z-axis: 4 degrees	-	-	-
DS End of 7-SST FOE Back wall (inside face of lead)	36916.2	50.0	Lead

Z locations from the source point.
FOE dimensions, distances (to the lateral walls etc.)

Notes

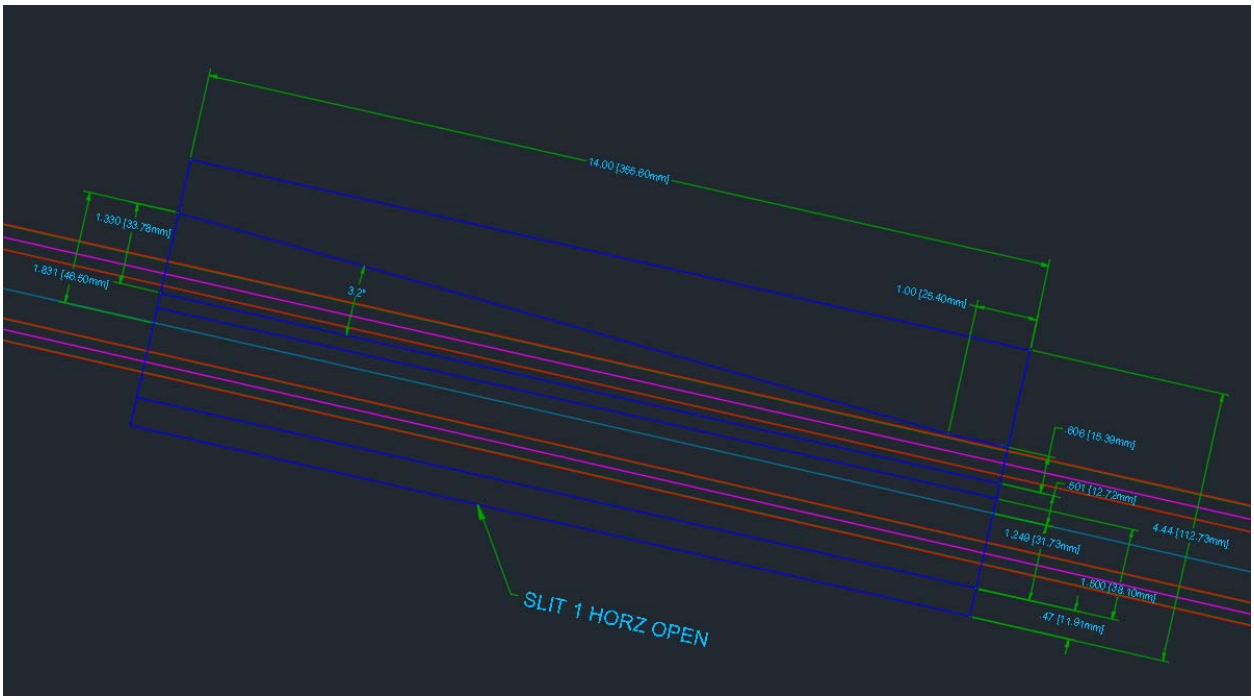
Beamline Components for FLUKA Calculations
Dimensions in mm.
Aperture dimensions include all tolerances

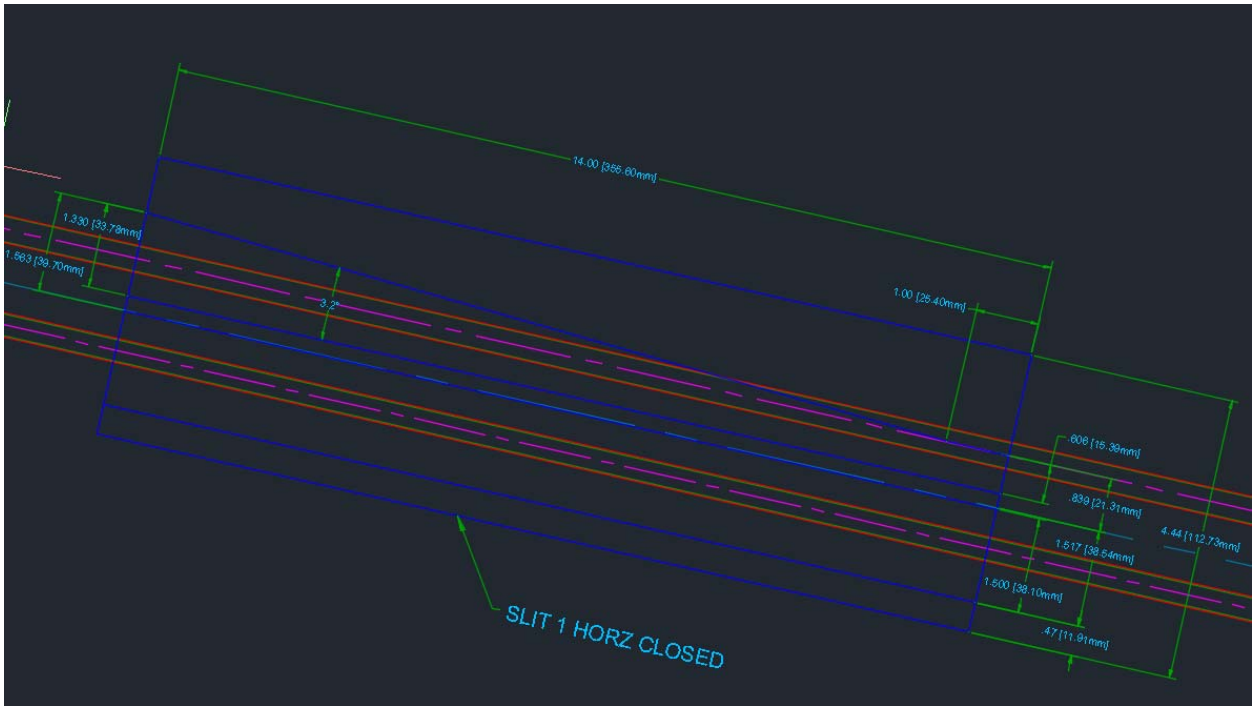
Beamline Component	Z location, (Distance from Source Point) (US), (DS) or center (C)	Dimensions		Offset (vertical or horizontal) w.r.t SST white beam center line	Material	Associated Drawings
		Outer dimensions (W)x(H)x(L)	Lead CO or Mask Aperture, mm (W)x(H) or (Dia)			
FOE						
Burn through device	26384.0 (US)	&151.6 x 20.1	Inboard Aperture "M" Branch: 27.88 x 22.70 Outboard Aperture "L" Branch : 27.88 x 20.20	(H) Inboard "M" Branch: -24.16 (C) (H) Outboard "L" Branch : 28.70 (C)	NIColoy E	PD-COM-APERT-0090
Fixed mask 1	26440.0 (US) 26652.0 (DS)	108 x85 x 212	Inboard "M" Branch: 29.82 x 24.7 (US) Inboard "M" Branch: 7.78 x 7.78 (DS) Outboard Aperture "L" Branch :22.2 x22.2 (US) Outboard Aperture "L" Branch : 7.78 x 5.4 (DS)	(H) Inboard "M" Branch: -24.16 (H) Outboard "M" Branch: 28.70	Glidcop AL-15	FMB Dwg No: AAC0226 Rev 1

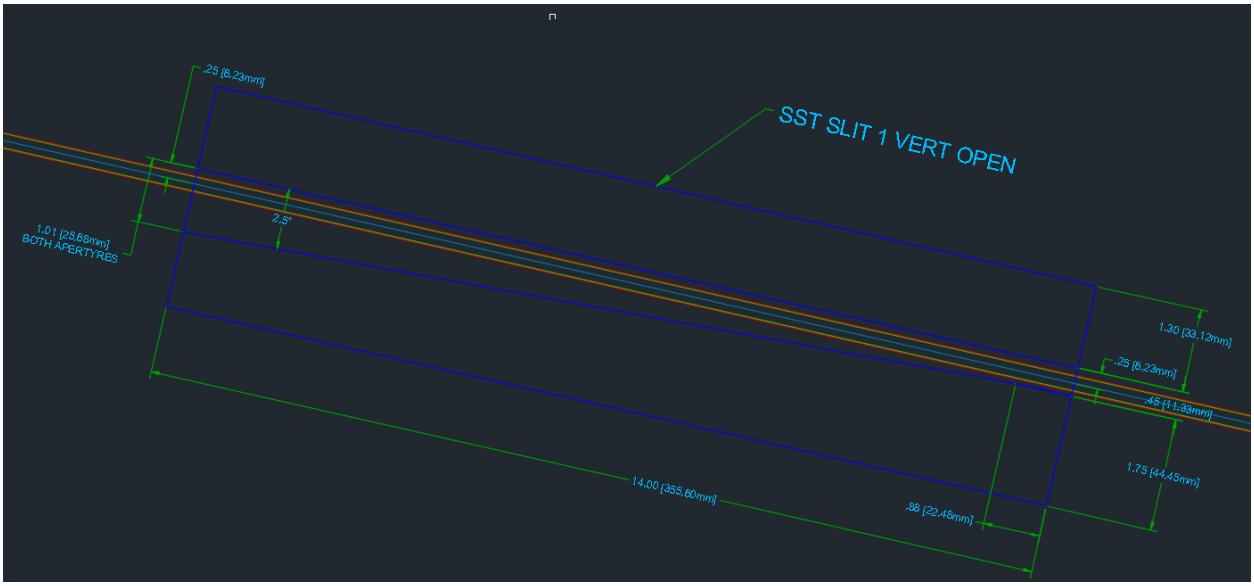
Mirror L1	27450.0 (C)	60 x 60 x 335	N/A	(H) Inboard "M" Branch: 29.72	Single Crystal Silicon	FMB Dwg No:
Secondary shield #1 (SBS-1)	27960.01 (US)	630 x 522 x 100	& 165.0	7.2 (H) 0.0 (V)	Lead	FMB Dwg No:
Mirror M1	28580.0 (C)	70 x 60 x 250	N/A	-28.8 (H) 0.0 (V)	Single Crystal Silicon	FMB Dwg No:
White beam stop	29142.1 (US)	See Fmb Dwg	31.64 x 11.9	1.0 (H) 0.0 (V)	OFHC Copper	FMB Dwg No:
BSS	29288.3 (US)	88.39 x 149.22 x 300	N/A	-25.4 (H) 0.0 (V)	Lead	FMB Dwg No:
Secondary shield #2 (SBS-2)	30699.99	890 x 968 x 100	Inboard: &72.0 Outboard: &72.0	(H) Inboard: -36.0 (H) Outboard: 85.2	Lead	FMB Dwg No:
FM2 L Branch	32932.2 (US)	&130.0	&105.36 (US) 13.05 x 13.05 (DS)	(H) -72.77	OFHC Copper	FMB Dwg No:
Mirror L2A/L2B	34500 (C)	60x 60 x 400	N/A	(H) -104.75	Single Crystal Silicon	FMB Dwg No:
Bremsstrahlung stop	35666.0 (US)	278 x 120 x 200	N/A	(H) Inboard: -67.4 (Edge)	Tungsten	FMB Dwg No:

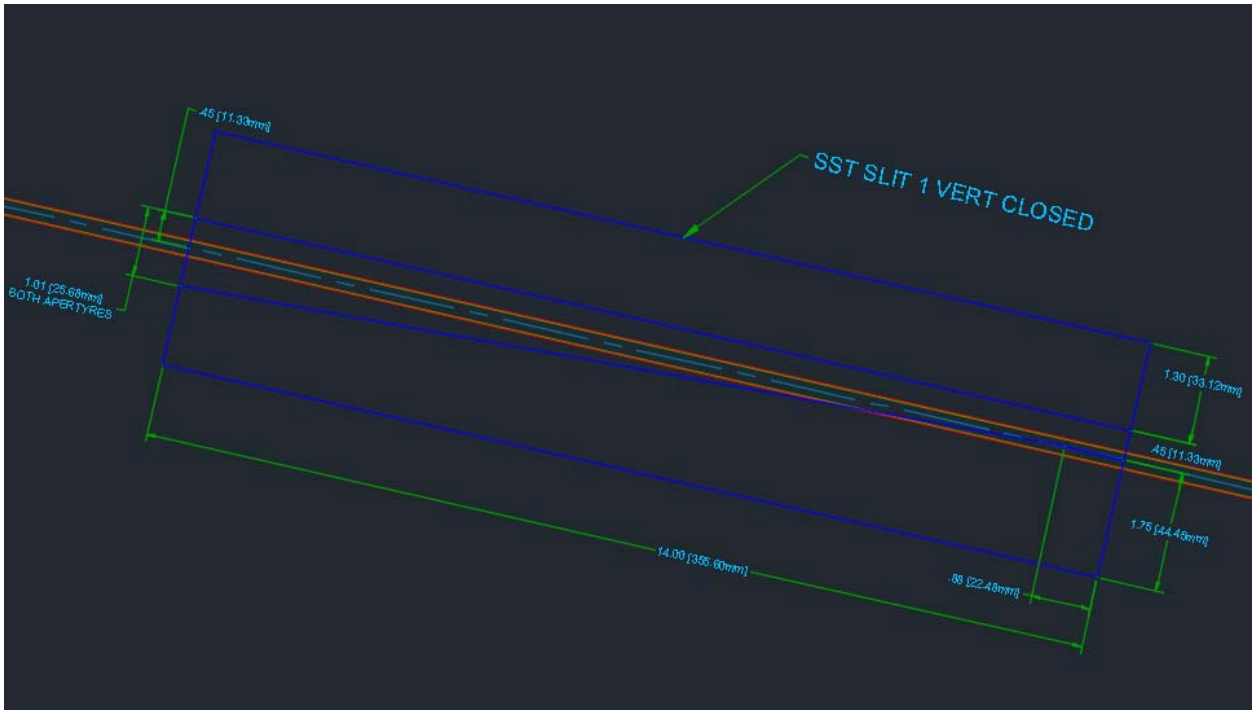
				(H) Outboard: 210.6 (Edge)		
Cooled Frame – FS- L Branch #1	35666.0 (US)	80 x 58 x 12	14.14 x 11.24 (US) 9.54 x 11.24 (DS)	(H) -102.01	OFHC Copper	FMB Dwg No:
Cooled Frame – FS- M Branch	35930.4 (US)	100 x –x 12	17.58 x 11.24 (US) 13.55 x 11.24 (DS)	(H) 352.44	OFHC Copper	FMB Dwg No:
FM4	31883.6 (US)	&130.0	&107.19 (US) 20.64 x 20.64 (DS)	(H) 143.51	OFHC Copper	FMB Dwg No:
Guillotine	36817.2 (US)	840 x 800 x 100	Inboard: &121.76 Outboard: &121.76	(H) Inboard: -99.31 (H) Outboard: 404.76 (DS)	Lead	Dwg No:
Collar						

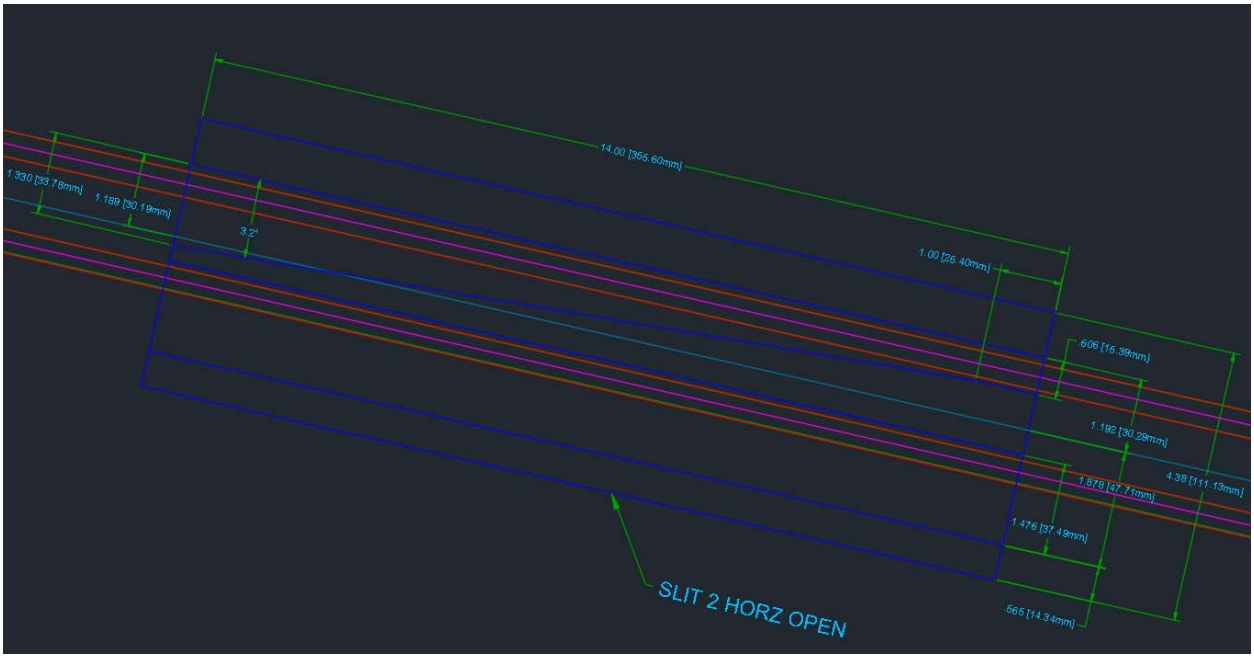
The FE slits shown in open and closed conditions with dimensions with respect to the straight center line

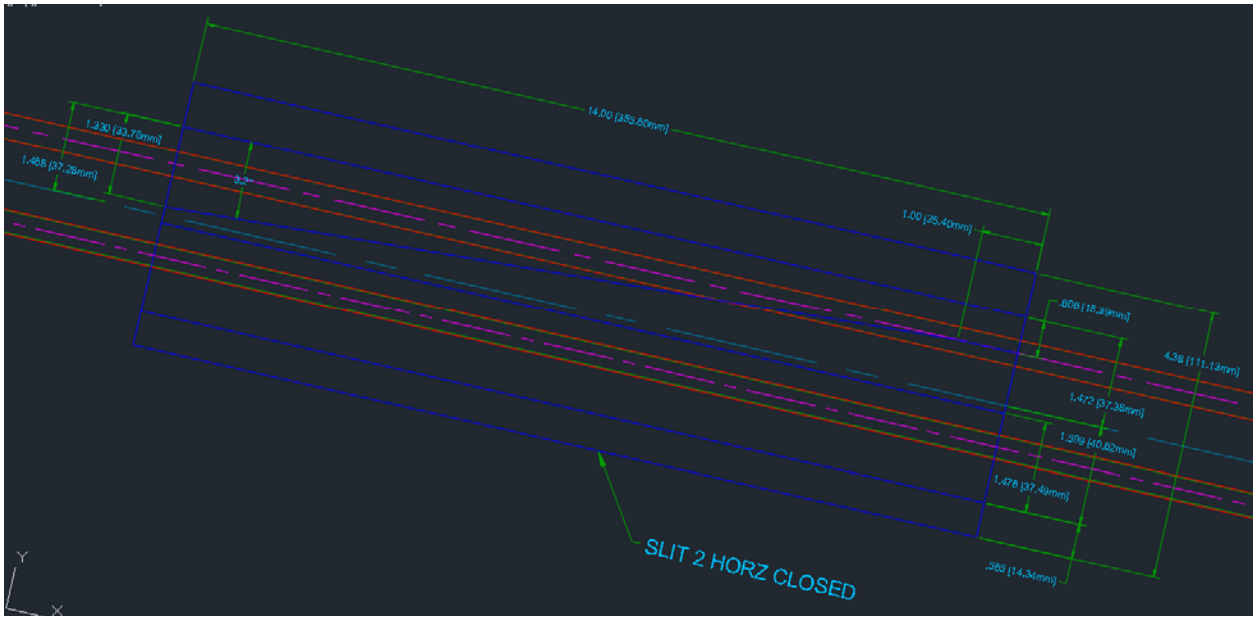


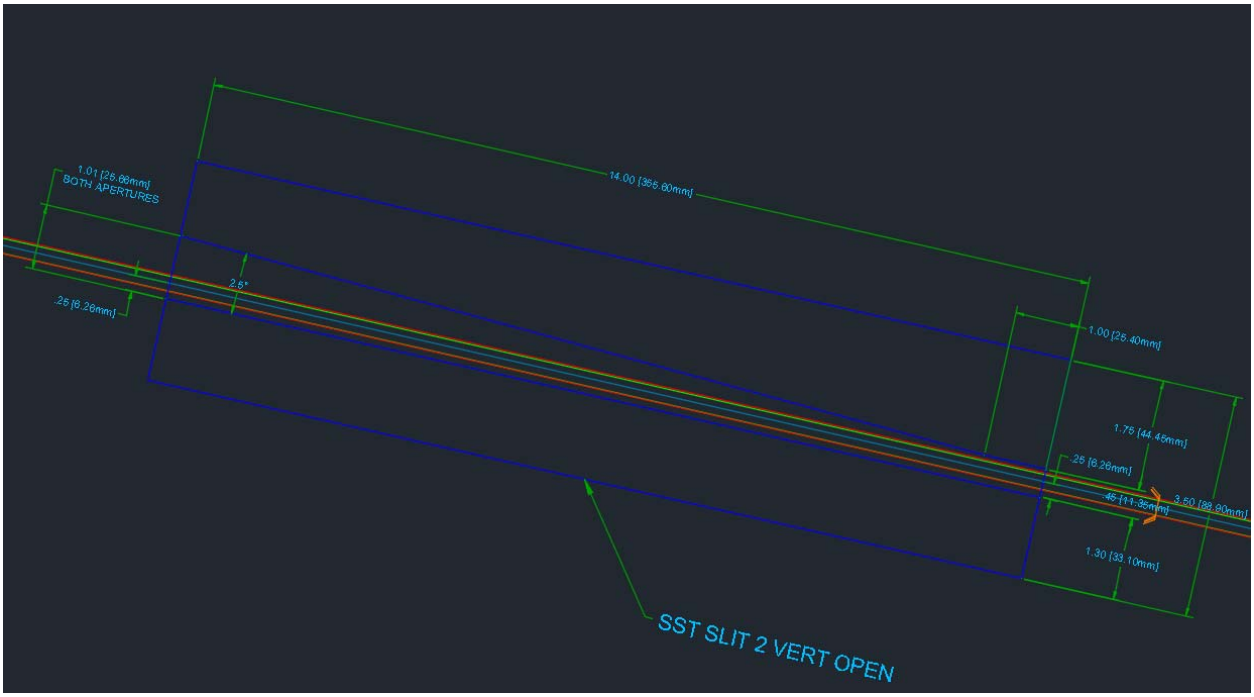


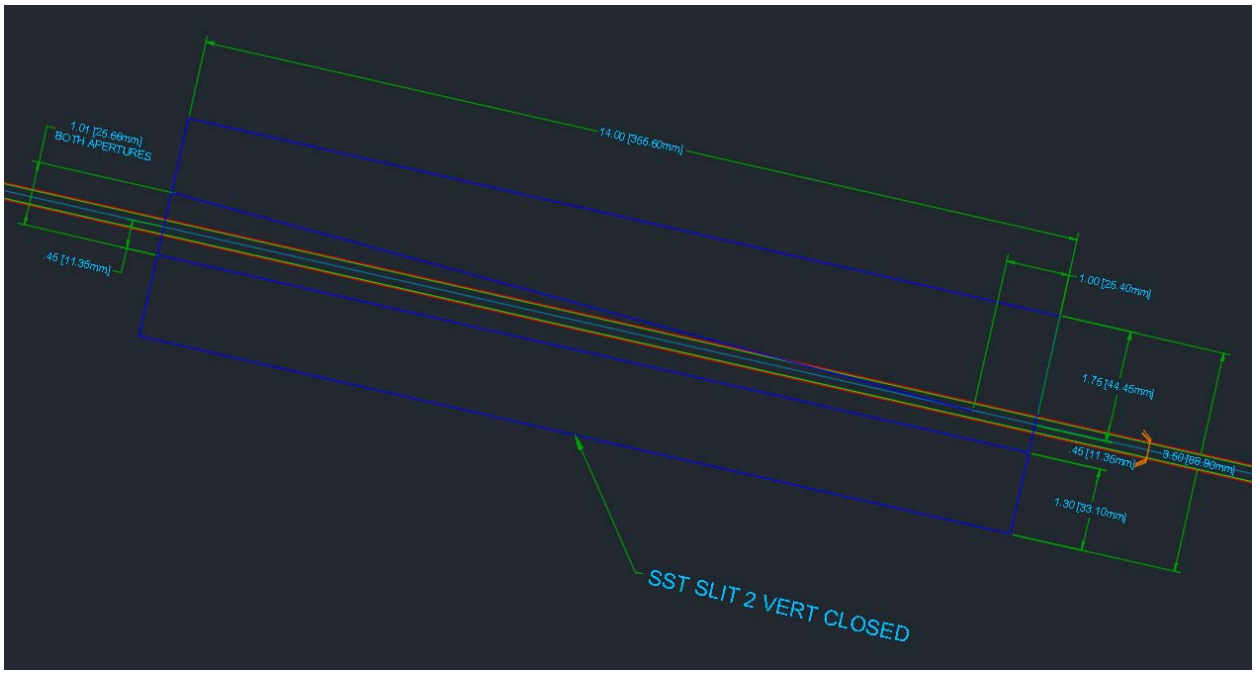

.25 [6.23mm]
SST SLIT 1 VERT OPEN
1.01 [25.68mm]
BOTH APERTYRES
2.5°
1.30 [33.12mm]
.25 [6.23mm]
.45 [11.33mm]
1.75 [44.45mm]
14.00 [355.60mm]
.88 [22.48mm]

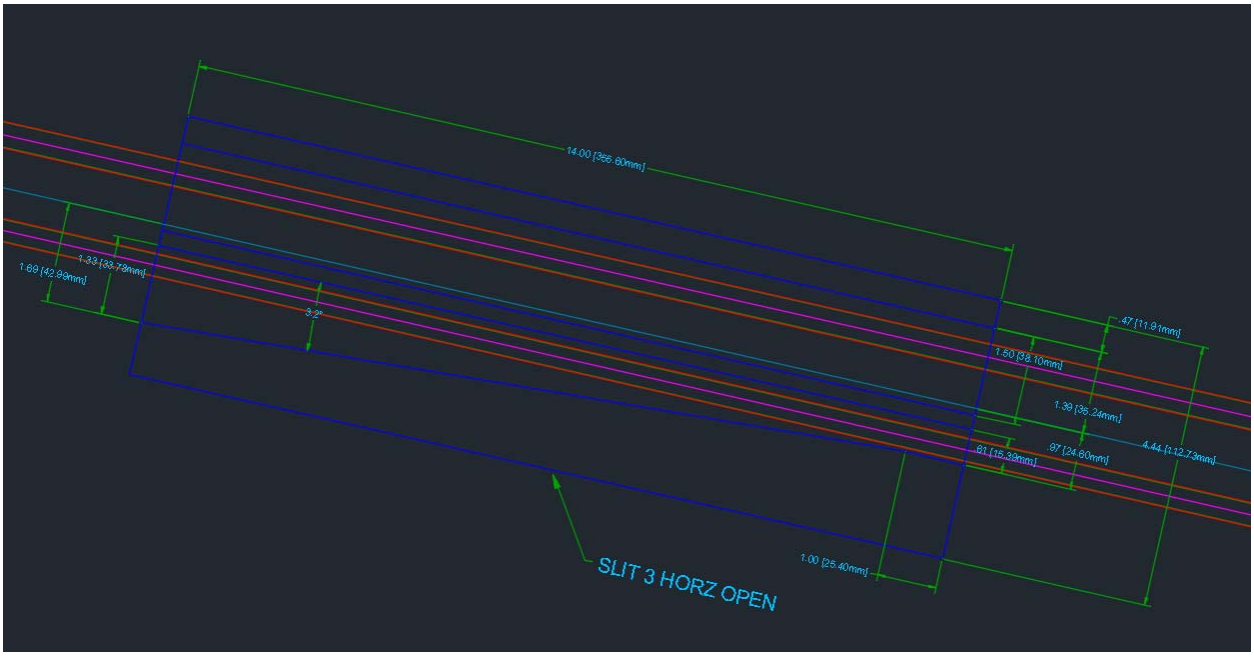

.45 [11.33mm]
SST SLIT 1 VERT CLOSED
1.01 [25.68mm]
BOTH APERTYRES
1.30 [33.12mm]
.45 [11.33mm]
1.75 [44.45mm]
14.00 [355.60mm]
.88 [22.48mm]

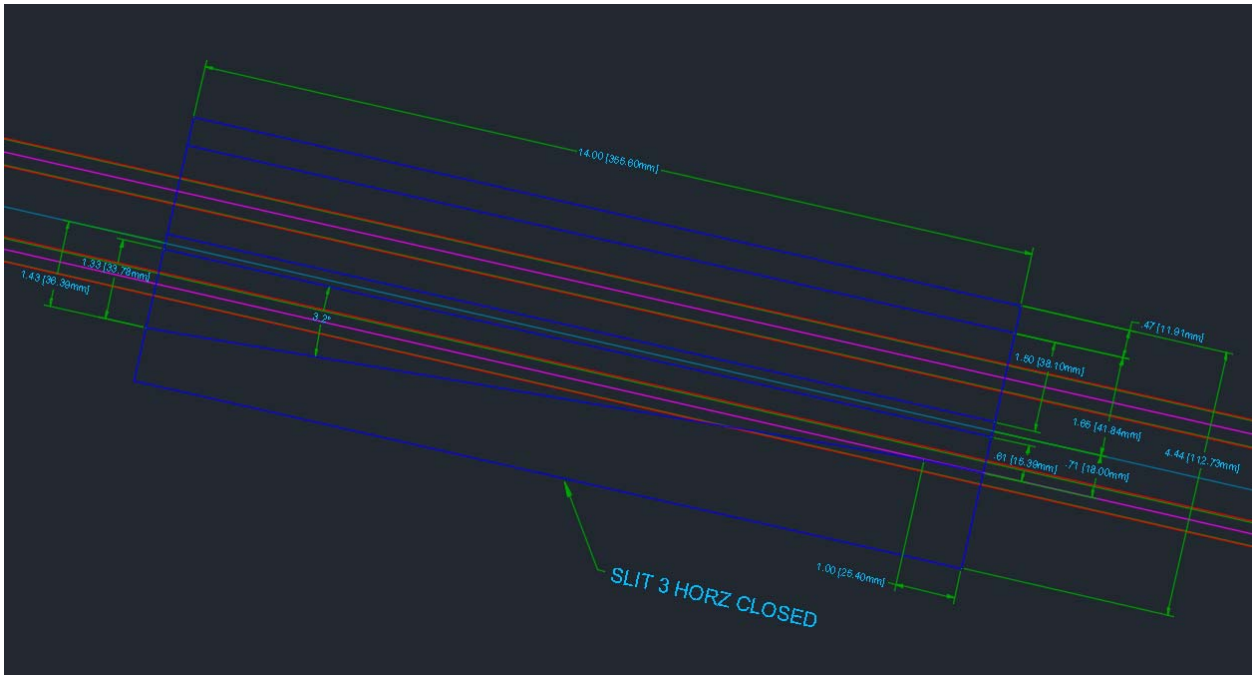

14.00 [355.60mm]
1.330 [33.78mm]
1.189 [30.19mm]
3.2°
1.00 [25.40mm]
.606 [15.39mm]
1.192 [30.28mm]
4.38 [111.13mm]
1.476 [37.49mm]
.565 [14.34mm]
SLIT 2 HORZ OPEN

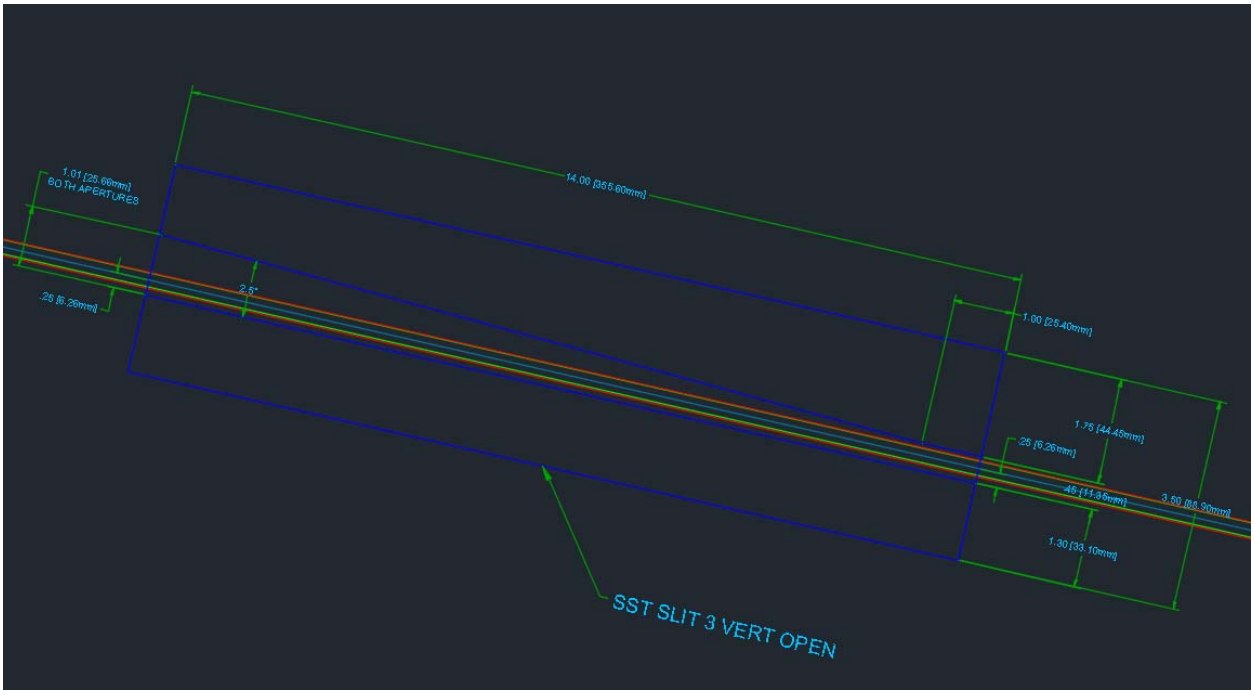

14.00 [355.60mm]
1.330 [33.78mm]
1.466 [37.28mm]
3.2°
1.00 [25.40mm]
.606 [15.39mm]
4.38 [111.13mm]
1.472 [37.39mm]
1.476 [37.49mm]
.565 [14.34mm]
SLIT 2 HORZ CLOSED
Y
X

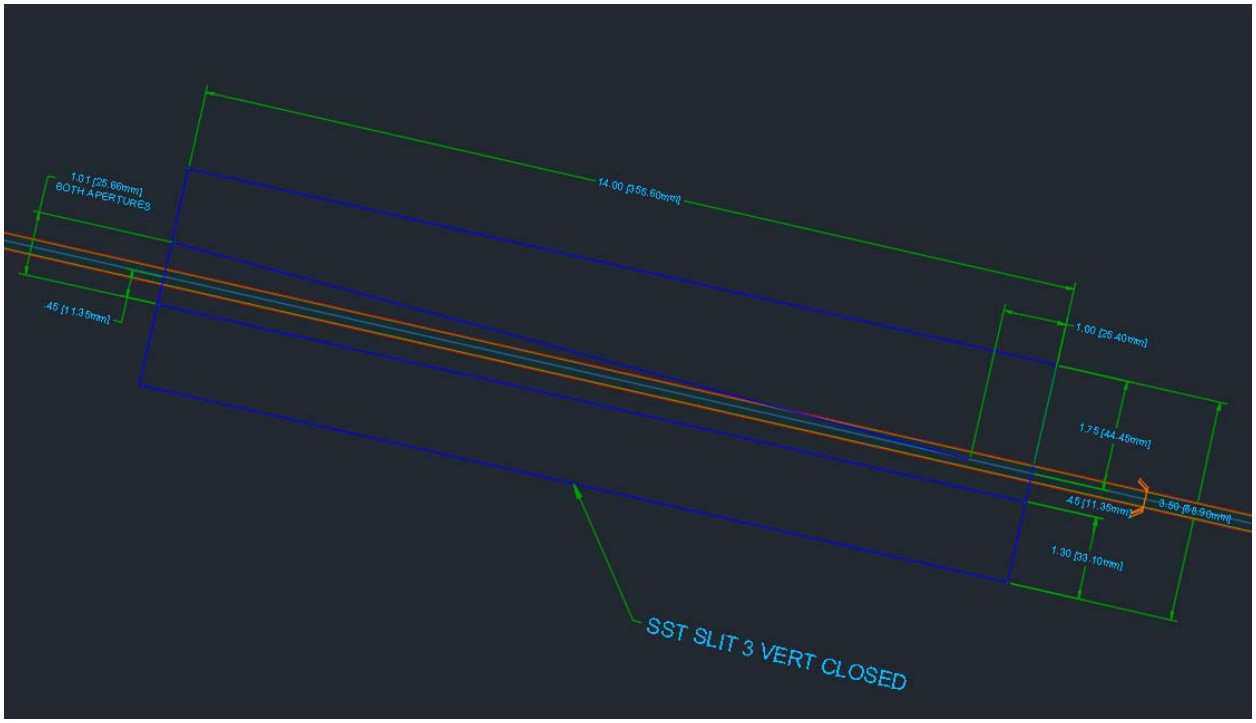

1.01 [25.68mm]
BOTH APERTURES
14.00 [355.60mm]
.25 [6.26mm]
2.5°
1.00 [25.40mm]
1.75 [44.45mm]
.25 [6.26mm]
.45 [11.35mm]
3.50 [88.90mm]
1.30 [33.10mm]
SST SLIT 2 VERT OPEN

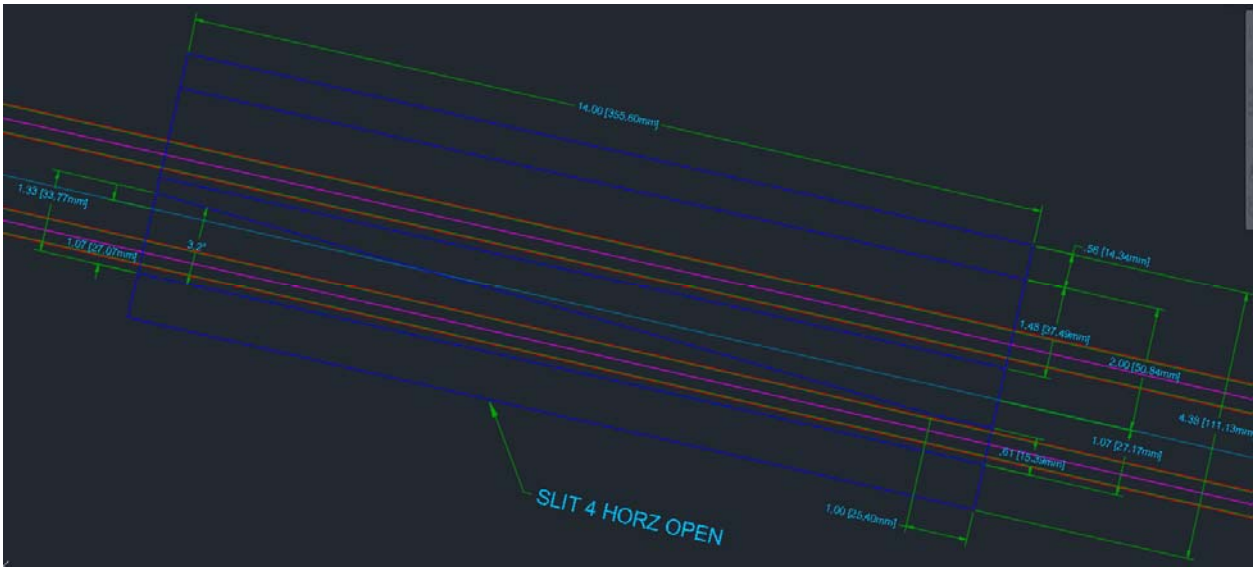

1.01 [25.68mm]
BOTH APERTURES
14.00 [355.60mm]
.45 [11.35mm]
1.00 [25.40mm]
1.75 [44.45mm]
.45 [11.35mm]
3.50 [88.90mm]
1.30 [33.10mm]
SST SLIT 2 VERT CLOSED

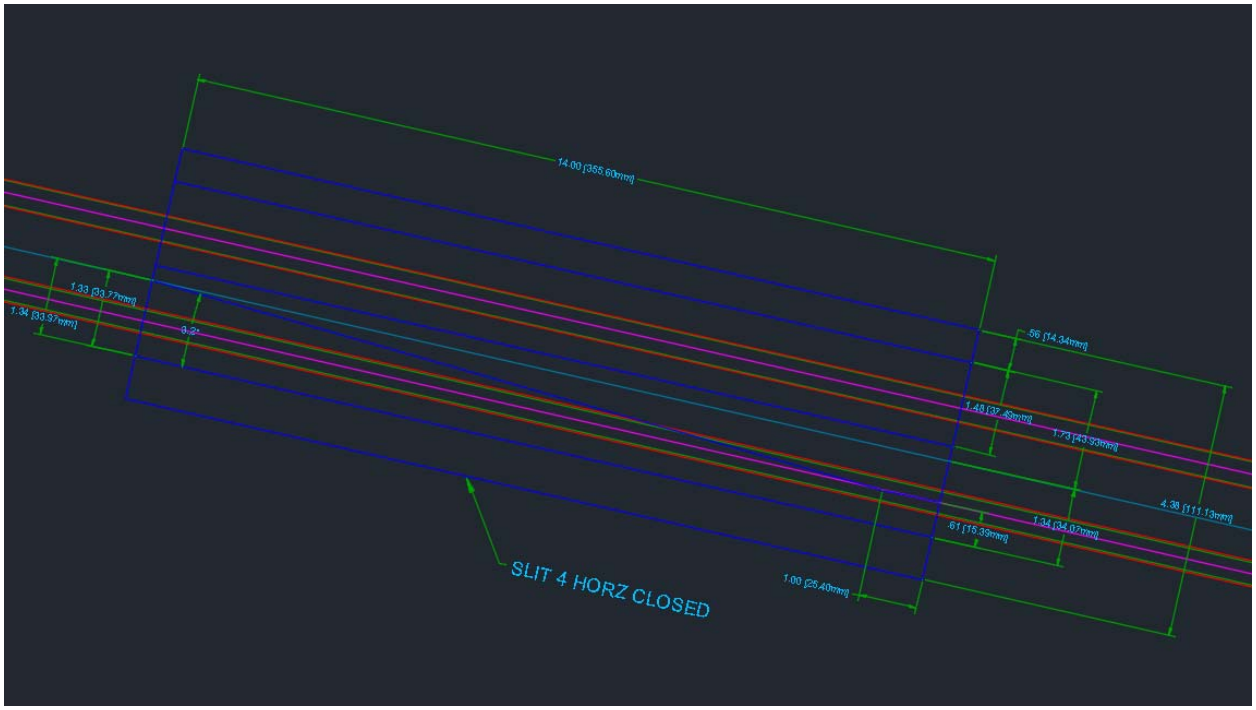

14.00 [355.60mm]
1.69 [42.93mm]
1.33 [33.78mm]
3.2°
.47 [11.91mm]
1.50 [38.10mm]
1.38 [35.24mm]
.97 [24.60mm]
.61 [15.39mm]
4.44 [112.73mm]
1.00 [25.40mm]
SLIT 3 HORZ OPEN

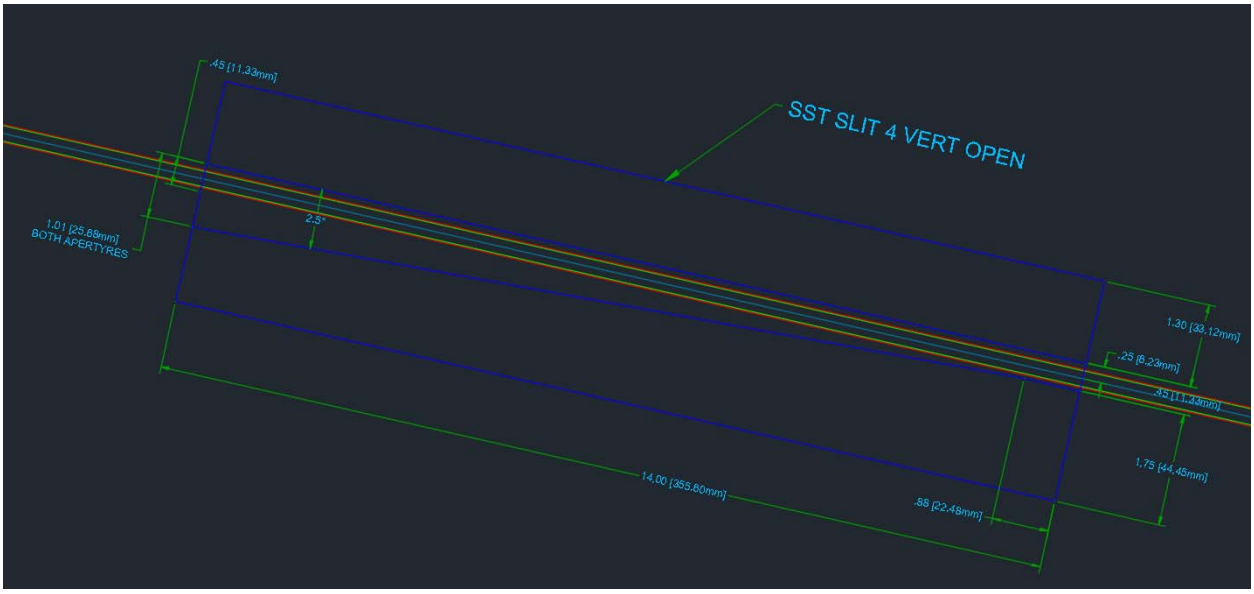

14.00 [355.60mm]
1.43 [36.39mm]
1.33 [33.78mm]
3.2°
.47 [11.91mm]
1.50 [38.10mm]
1.66 [41.84mm]
.61 [15.39mm]
.71 [18.00mm]
4.44 [112.73mm]
1.00 [25.40mm]
SLIT 3 HORZ CLOSED

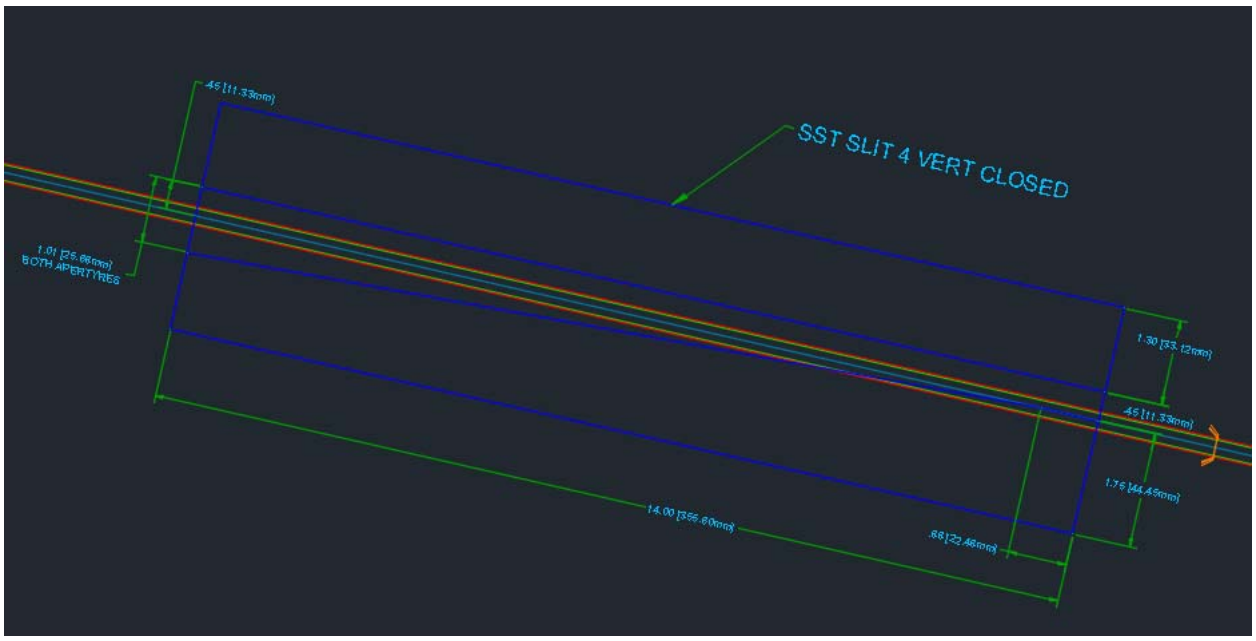

1.01 [25.66mm]
BOTH APERTURES
14.00 [355.60mm]
.25 [6.26mm]
2.5°
1.00 [25.40mm]
1.75 [44.45mm]
.26 [6.26mm]
.45 [11.35mm]
3.50 [88.90mm]
1.30 [33.10mm]
SST SLIT 3 VERT OPEN


1.01 [25.66mm]
BOTH APERTURES
14.00 [355.60mm]
.45 [11.35mm]
1.00 [25.40mm]
1.75 [44.45mm]
.45 [11.35mm]
3.50 [88.90mm]
1.30 [33.10mm]
SST SLIT 3 VERT CLOSED


14.00 [355.60mm]
1.33 [33.77mm]
1.07 [27.07mm]
3.2°
.56 [14.34mm]
1.45 [37.49mm]
2.00 [50.84mm]
4.38 [111.13mm]
1.07 [27.17mm]
.61 [15.39mm]
1.00 [25.40mm]
SLIT 4 HORZ OPEN


14.00 [355.60mm]
1.33 [33.77mm]
1.34 [33.97mm]
3.2°
.56 [14.34mm]
1.48 [37.42mm]
1.73 [43.93mm]
4.38 [111.13mm]
1.34 [34.07mm]
.61 [15.39mm]
1.00 [25.40mm]
SLIT 4 HORZ CLOSED


.45 [11.33mm]
SST SLIT 4 VERT OPEN
1.01 [25.66mm]
BOTH APERTYRES
2.5°
1.30 [33.12mm]
.25 [6.23mm]
.45 [11.33mm]
1.75 [44.45mm]
14.00 [355.60mm]
.88 [22.48mm]


.45 [11.33mm]
SST SLIT 4 VERT CLOSED
1.01 [25.66mm]
BOTH APERTYRES
1.30 [33.12mm]
.45 [11.33mm]
1.75 [44.45mm]
14.00 [355.60mm]
.88 [22.48mm]