1. Introduction:

The NSLS-II BEAMLINE RADIATION SHIELDING POLICY has been stated as follows in reference 1: Radiation exposure to staff and users resulting from National Synchrotron Light Source II (NSLS-II) operations must comply with Brookhaven National Laboratory (BNL) and Department of Energy (DOE) radiation requirements and must be maintained as low as reasonably achievable (ALARA). Per the Photon Science Shielding Policy (PS-C-ASD-POL-005), in continuously occupied areas during normal operation the dose rate is ALARA, and shall be < 0.5 mrem/h (based on occupancy of 2000 hours/year) or less than 1 rem in a year.

For a fault event, the dose shall be < 20 mrem in a non-radiation controlled area and < 100 mrem in a radiation controlled area. Although the experimental floor is initially designated as a radiation controlled area, it is hoped that in the future, it can be declared a non-radiation controlled area. As such, beamlines should be shielded such that in the event of a fault, the total dose, integrated over the duration of the fault, is < 20 mrem.

Beamlines are required to shield against the two primary sources of radiation, the primary gas bremsstrahlung (GB) and the synchrotron beam, as well as the secondary radiation resulting from the scattering of these two primary beams by the beamline components and/or air. The shielding requirements for the First Optical Enclosure (FOE) are dominated by the scattering of the primary bremsstrahlung and not the synchrotron beam. Guidelines for the NSLS-II Beamline Radiation Shielding Design are also provided in reference 1. These guidelines were used to determine the thickness of the first optical enclosure (FOE) walls as well as dimensions of the supplementary shielding required to reduce the dose on the downstream FOE walls. The shielding recommended for the lateral and roof panels is generally sufficient for most white beam component configurations. However, the recommended as-built shielding for the downstream FOE wall may not be sufficient to protect against secondary gas bremsstrahlung (SGB) and additional shielding is usually necessary.

The radiation shielding analysis for the Inner Shell Spectroscopy (ISS) beamlines (8ID-ISS) is documented in this technical note. The goal of the simulations documented here was to estimate the radiation dose levels generated inside and outside the FOE during normal operations and some fault conditions, thus evaluating the efficiency of the as-designed SGB shielding.

The layout of the 8ID-ISS beamlines is presented in figure 1. These drawings were extracted from the Beamline Ray Trace Layout [PD-ISS-RAYT-0001]. The ray trace drawings list the major components in the beamline and provide the position of each component. The
positions, dimensions and materials of the main components are included in Appendix 1. The beam travels from right to left in the Ray Trace drawings.

Figure 1. Layout of 8ID-ISS showing FOE, hutch B1, B2 and major beamline components

The NSLS-II primary gas bremsstrahlung (GB) source parameters are listed in Table 1.

Table 1. NSLS-II primary bremsstrahlung source parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron energy</td>
<td>3 GeV</td>
</tr>
<tr>
<td>Stored current</td>
<td>500 mA</td>
</tr>
<tr>
<td>Length of ID straight section</td>
<td>15.5 m</td>
</tr>
<tr>
<td>Pressure in straight section</td>
<td>1 ntorr</td>
</tr>
</tbody>
</table>

The beam is normalized at 17μW incident power, for the long (15.5m) straight. This value corresponds to the estimated bremsstrahlung power generated by a 500mA electron beam of 3GeV, assuming that the vacuum in the straight sections is better than 10^-9 Torr. The bremsstrahlung source file is attached as Appendix 2.

The Fluka model is described in section 2 and a sample Fluka input file is included in Appendix 3. The following simulations were performed to confirm the adequacy of the radiation safety components.

1. GB on mask CM-MA0 or simply MA0
2. GB on mask CM-MA-01
3. GB on mirror CM1
4. GB on mask CM-MA-02
5. Gb on mirror CM2
6. GB on mask CM-MA-03
7. GB on Mono-beam mask HH-MA-02 or MA-4
8. GB on High Heat monochromator crystal 1
9. GB on pink beam stop: PBS
10. GB on Bremsstrahlung stop or BS
11. GB on CM-MA0: no BS02, BS03
12. GB on CM1: no BS02, BS03
13. GB on CM2: no BS02, BS03
14. GB on CM1: no BS02, BS03, SGB1, SGB2, SGB3
15. GB on HHM crystal 1: no BS02, BS03, SGB1, SGB2, SGB3
The results of the GB simulations are presented in section 3.

The results of the synchrotron radiation simulations are presented in section 4.

A summary of all simulation results is presented in Section 5. The results of the GB simulations are summarized in table 2. This table lists the maximum dose rate (in mrem/h) on the roof, sidewall and the downstream FOE wall for each simulation.

All shielding simulations should be validated by comparisons with measurements of the dose rates near the walls of the FOE, the beam transport pipe and the end station enclosure during commissioning.

2. Description of the Fluka model

At NSLS-II the white beam or First Optical Enclosure (FOE) shielding requirements are dominated by the scattering of the primary gas bremsstrahlung and not the synchrotron beam. The white beam components disperse the primary bremsstrahlung without significant energy loss; thereby greatly increasing the angular range of very high-energy bremsstrahlung photons. It is necessary to intercept this secondary bremsstrahlung before it hits the downstream FOE wall. The design of the ISS beamline includes additional shielding in order to reduce the dose on the downstream wall.

As recommended by reference 1 Appendix A we use the “custom GB generator based on an analytic representation of the source’s energy spectrum which was scaled in intensity in accordance with the experimental estimates of total GB power. This custom source assumes a 1/E energy spectrum dependency, with a maximum energy of 3GeV, and generates internally the corresponding probability density function from analytical descriptions”. The beam is normalized at 17$\mu$W incident power, for the long (15.5m) straight. This value corresponds to the estimated bremsstrahlung power generated by a 500mA electron beam of 3GeV, assuming that the vacuum in the straight sections is better than $10^{-9}$Torr.

The 8ID-ISS Fluka model includes the FOE roof, sidewall, the downstream wall as well as the ratchet wall and long wall of the storage ring (SR). The FOE outboard lateral panel is made of 18 mm Pb (157 cm distance from beam), roof 10 mm Pb (200 cm above beam) and downstream FOE wall 50 mm Pb (~1300 cm from the ratchet wall).

The FLUKA model (vertical view) of the ISS beamline is shown in figure 2. All components are placed symmetrically with respect to the beam centerline in the transverse direction. For the Fluka models the Z axis represents the beam centerline, the X axis the horizontal axis normal to the beam direction and the Y axis is the vertical axis. For the Ray Trace drawings the zero of the co-ordinate system is the center of the short straight. However, for the Fluka input files the downstream end of the ratchet wall is set as the zero of the Z axis. The beam travels from right to left in the Ray Trace drawings. For the Fluka model the beam travels from left to right.
Figure 2. Vertical view of the ISS FLUKA geometry at the beam centerline.

The positions, dimensions, materials and drawings of the main components are included in Appendix 1. The bremsstrahlung source file is attached as Appendix 2. A sample Fluka input file is included in Appendix 3.
3. Results for primary gas Bremsstrahlung (GB) simulations

3.1 GB incident on the aperture of the fixed mask CM-MA0

The Fluka model of the fixed mask is shown in figure 3(a). The aperture is tapered in both the vertical and horizontal planes. In this simulation the GB was started just upstream of the selected point of contact at x = 1.6, y = 0, z = 91.0 and impinges on the outboard tapered plane close to the neck of the aperture. The width of the downstream aperture is ±1.52 cm. The total dose distributions in mrem/h (on contact) on the roof, the sidewall and the downstream wall of the FOE are shown in figure 3(b), 3(c) and 3(d). All shields were included in the simulation.

![Figure 3](image)

Figure 3. (a) Mask CM-MA0. The total dose distributions in mrem/h (on contact) on (b) the roof, (c) the sidewall and (d) the downstream wall of the FOE.

To understand the contribution of the various beamline components on the dose distribution it is useful to look the vertical and horizontal profiles of the dose distribution in the FOE (figure 4). When the GB hits the metal it is scattered largely in the forward direction. The radiation that passes through mask MA-01 and the collimator CM-BS-01 impinges on the mirror CM1 which becomes a scattering target. Figure 4 shows clearly the impact of the various shields in blocking the secondary GB. The dose on contact with the roof, side wall and downstream FOE wall are shown in figure 3(a), (b) and (c) and all doses are less than 0.05 mrem/h.
3.2 GB incident on the aperture of the fixed mask CM-MA-01
In this simulation the GB was started at x=0, y= -0.32, z=160.0 and impinges on the bottom tapered plane close to the neck of the aperture. The height of the aperture is ±0.15 cm. All shields were included in the simulation. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 5.
mirror CM1. The beam is scattered upwards. The tungsten shield BS-02 attenuates the radiation as do the other downstream shields. The dose distribution on the downstream wall of the FOE is shown in figure 6.

![Figure 6. The total dose distributions in mrem/h on the downstream FOE wall.](image)

The dose distribution shows the ‘image’ of the SGB1 shield as well as the image of the guillotine. The maximum dose rate is well within acceptable limit. The dose rate on the side wall and the roof was also found to be lower than 0.05 mrem/h.

### 3.3 GB incident on the white beam mirror CM1

The white beam mirror CM1 is centered at z=275.0 and the top surface of the mirror is at y=0 or at the beam centerline. The mirror is rotated at 2.2 mrad with respect to the x axis so the reflected beam exits at 4.4 mrad to the original beam centerline. The GB is stared at x=0, y=0, z=274 so that the GB passes through half the mirror and is scattered upwards. The fraction of GB that is transmitted through the apertures of the tungsten shield CM-BS-02 and mask CM-MA-02 impinges on the bottom surface of the mirror CM2 and is scattered downwards. The dose distribution in the FOE is shown in figure 7.
Figure 7. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose distribution on the downstream FOE wall is shown in figure 8. The yellow spot on the FOE wall is due to the dose coming through the aperture in the guillotine and the wall. The maximum dose is just below the guillotine and is much smaller than 0.01 mrem/h. The dose rate on the side wall and the roof was also found to be lower than 0.05 mrem/h.

Figure 8. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

3.4 GB incident on the aperture of the fixed mask CM-MA-02

In this simulation the GB was started at x=0, y= 0.0, z=370.0 and impinges on the bottom tapered plane close to the neck of the aperture. The vertical offset of the aperture is 0.51 cm. All shields were included in the simulation. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 9.
Figure 9. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The radiation that is transmitted through the aperture of the mask impinges on mirror CM2 and it is scattered predominantly downwards. The lead shield stops most of the forward-directed radiation. The dose distribution on the DS FOE wall is shown in figure 10.

Figure 10. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

The maximum dose is below and on the sides of the shadow of the shield SGB1. This maximum dose rate is well below 0.01 mrem/h.

3.5 GB incident on the White Beam Mirror CM2

This simulation assumes that the GB is lost on the upstream edge of mirror CM2 at x=0, y=0.88, z=400.0. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 11.
The dose distribution on the downstream FOE (shown in figure 12) is very similar to the dose distribution when the GB is lost on mask CM-MA02.

The maximum dose on the Foe wall is approximately 0.02 mrem/h.

### 3.6 GB incident on the aperture of the fixed mask CM-MA-03

In this simulation the GB was started at x=0, y= 0.66, z=570.0 and impinges on the bottom tapered plane close to the neck of the aperture. The vertical offset of the aperture is 0.88 cm. All shields were included in the simulation. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 13.
All beamline components downstream of the SGB1 shield including the moonbeam mask MA-04, the HHM crystals and the PBS become sources of secondary GB. The lead shield SGB2 stops the more intense part of the forward directed radiation. The dose rate distribution on the DS FOE wall is shown in figure 14.

Figure 14. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

The maximum dose on the Foe wall is less than 0.05 mrem/h.

3.7 GB incident on the aperture of the mono-beam mask MA-4
In this simulation the GB was started at x=0, y= 0.53, z=643.0 and impinges on the bottom tapered plane close to the neck of the aperture. The vertical offset of the aperture is 0.88 cm. All shields were included in the simulation. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 15.
Figure 15. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

All beamline components downstream of the mask including the HHM crystals and the PBS become sources of secondary GB. The lead shield SGB2 stops the more intense part of the forward directed radiation. The dose rate distribution on the DS FOE wall (shown in figure 16(a)) was found to be larger than 0.05 mrem/h. However, the dose was below 0.05 at 30 cm from the FOE wall (figure 16(b)).

(a) (b)

Figure 16. The total dose distributions in mrem/h (a) on contact on the downstream wall of the FOE and (b) at 30 cm.

3.8 GB incident on the DCM crystal 1

The high heat monochromator has two crystals. The bottom crystal 1 is centered at z=700 and the top surface of the crystal is at y=0.88. The crystal is modeled as a cylinder of diameter 12.50 cm and height 6.25 cm. The crystal is rotated to select the energy of the mono-beam. The angle of the top crystal is adjusted to move the mon-beam to y=2.88 cm. In this simulation the GB impinges on crystal 1 which has been rotated at 45°. The crystal will
reflect only the mono-beam and the GB will be transmitted to impinge on the PBS and Brem stop. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 17.

![Image](image17)

Figure 17. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 18. The on-contact dose rate was found to be smaller than 0.01 mrem/h.

![Image](image18)

Figure 18. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

3.9 GB incident on the Pink Beam Stop
In this simulation it is assumed that the entire GB beam loss occurs at the PBS. The GB is started at x=0, y=0.88, z=760.0 and impinges on the top tapered surface of the PBS. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 19.
Figure 19. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 20. The on-contact dose rate was found to be smaller than 0.01 mrem/h.

Figure 20. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

3.10 GB incident on the Bremmstrahlung Stop

According to the Ray Trace Drawings it is possible for the GB to bypass the PBS and directly impinge on the Bremmstrahlung stop. This scenario is modelled in this simulation. The GB is started at \( x=4.32, y=0, z=800.0 \). The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 21.
Figure 21. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 22. The on-contact dose rate was found to be smaller than 0.01 mrem/h.

Figure 22. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

3.11 GB incident on the aperture of the fixed mask CM-MA0: no BS-02 and BS-03

The tungsten shields BS-02 and BS-03 were designed to intercept the radiation scattered off the white beam mirrors CM1 and CM2. Since the lead shield SGB1 performs the same function they may not be needed. There is some concern that the integrity of these shields will be compromised due to the radiation scattered off of the mirrors CM1 and CM2.

The simulation described in this section is identical to the one described in Section 3.1 except that BS-02 and BS-03 are effectively removed. The GB was started just upstream of the
selected point of contact at \( x = 1.6, y = 0, z = 91.0 \) and impinges on the outboard tapered plane close to the neck of the aperture of MA0. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 23.

![Figure 23](image_url)

**Figure 23.** The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 24. The results show that the dose rate outside the FOE walls is below the acceptable limit even when the tungsten shields BS-02 and BS-03 are removed.

![Figure 24](image_url)

**Figure 24.** The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

### 3.12 GB incident on the aperture of the fixed mask CM1: no BS-02 and BS-03
The simulation is identical to the one described in Section 3.2 except that BS-02 and BS-03 are effectively removed. The white beam mirror CM1 is centered at \( z = 275.0 \) and the top surface of the mirror is at \( y = 0 \) or at the beam centerline. The mirror is rotated at 2.2 mrad with respect to the x axis so the reflected beam exits at 4.4 mrad to the original beam.
centerline. The GB is stared at x=0, y=0, z=274 so that the GB passes through half the mirror and is scattered upwards. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 25.

![Diagram of dose distribution](image)

Figure 25. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 26. The results show that the dose rate outside the FOE walls is still below the acceptable limit even when the tungsten shields BS-02 and BS-03 are removed.

![Diagram of dose rate distribution](image)

Figure 26. The total dose distributions in mrem/h (on contact) on the downstream wall of the FOE.

### 3.13 GB incident on mirror CM2: no BS-02 and BS-03

The simulation is identical to the one described in Section 3.5 except that BS-02 and BS-03 are effectively removed. The GB is lost on the upstream edge of mirror CM2 at x=0, y=0.88, z=400.0. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 27.
The dose rate distribution on the DS FOE wall is presented in figure 28. The results show that the dose rate on the downstream FOE wall on contact is ~0.5 and at 30 cm is ~0.1 mrem/h. If the tungsten shields BS-02 and BS-03 are damaged the dose rate at 30 cm will be higher than the acceptable dose rate of 0.05 mrem/h.

3.14 GB incident on mirror CM1: no BS-02, BS-03, SGB1, SGB2 and SGB3
The next two simulations were performed to confirm that the lead shields SGB1, SGB2 and SGB3 are required to reduce the dose rates on the downstream wall to acceptable values. The mirror CM1 is at its nominal orientation and the beam hits the center of the mirror as is the simulations described in Section 3.2 and section 3.11. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 29.
Figure 29. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the DS FOE wall is presented in figure 30. The results show that the dose rate outside the FOE walls is <0.08 on contact and less than 0.05 at 30 cm.

Figure 30. The total dose distributions in mrem/h (a) on contact on the downstream wall of the FOE, (b) at 30 cm from the FOE wall.

3.15 GB incident on DCM crystal 1: no BS-02, BS-03, SGB1, SGB2 and SGB3
This simulation is similar to the scenario described in section 3.8. The GB impinges on HHM crystal 1. The crystal will reflect only the mono-beam and the GB will be transmitted to impinge on the PBS and Brem stop. The shields SGB2 and SGB3 are no longer effective and will not attenuate the forward-directed dose. The vertical (bottom) and horizontal (top) profiles of the dose distribution in the FOE are shown in figure 31.
Figure 29. The total dose distributions (mrem/h) in the FOE. The top figure shows the horizontal view and the bottom the vertical view at the beam centerline.

The dose rate distribution on the FOE roof and walls is presented in figure 32. The dose rate distribution on the roof (figure 32(c)) shows that the maximum dose rate is within acceptable limits. The dose rate on the sidewall may be close to 0.05.

Figure 32. The total dose distributions in mrem/h (a) on contact on the downstream wall of the FOE, (b) at 30 cm from the FOE wall.

The maximum dose rate on the downstream FOE wall is 0.3-0.4 outside the guillotine. The dose at 30 cm is above 0.1 mrem/h. These simulation shows that shields SGB2 and SGB3 are necessary to lower the dose rate on the downstream FOE wall.
4. Synchrotron Radiation Calculation

The ID08 (ISS) beamline is a Damping Wiggler (DW100) source with its parameters given in Table 2 [2]. The horizontal opening angle for the 17ID source fan entering the first optics enclosure (FOE) is given in column 2. In addition, the NSLS-II stored electron beam parameters of 3 GeV and 500 mA (See Table 1) have been assumed to calculate the critical energy (column 6) and total integrated power (column 7).

<table>
<thead>
<tr>
<th>Source</th>
<th>Max. source opening</th>
<th>No. Of periods</th>
<th>Max. ( B_{\text{eff}} ) (T)</th>
<th>Period (mm)</th>
<th>( E_c ) (keV)</th>
<th>STAC 8 Total Power (kW) @ 500mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW100</td>
<td>1.0 mrad-H</td>
<td>70</td>
<td>1.8</td>
<td>100</td>
<td>10.8</td>
<td>10</td>
</tr>
</tbody>
</table>

The analytic code STAC8 [3] was used to calculate the ambient dose equivalent rates in the occupied areas outside beamline enclosures and transport pipes. The build-up factor in shield was included in the calculation. However, the effect of SR polarization was not considered leading to the same shielding requirements for the lateral wall and roof provided the distance from the scatter target to dose point is the same. The shielding calculations for the monochromatic beam pipe and experimental enclosures (08ID-B1 and 08ID-B2) assumes that bremsstrahlung has been completely stopped in the FOE (08ID-A).

4.1 First Optics Enclosure (FOE)

The scattering target is assumed to be a silicon disk of 10 cm radius and 2 cm thick tilted at 0.155 degree with the respect to the incident beam [4]. The position of the scatter target is assumed to be located at ISS High Resolution Monochromator approximately 430 cm from the FOE downstream wall, 150 cm from the lateral wall and 200 cm from the roof. The minimum required shielding for the SR source (no credit has been given to the SGB shielding or Guillotine) and the corresponding ambient dose rates are given in Table 3. The dose rate from SR is negligible on downstream wall, lateral wall, and roof with existing FOE shielding. The existing shielding thicknesses of the FOE walls and roof as given in Appendix 1 is more than adequate to meet the design requirement of 0.05 mrem/h.

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>Required Shielding</th>
<th>Ambient Dose rate (mrem/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral wall</td>
<td>150</td>
<td>9 mm Pb</td>
</tr>
<tr>
<td>Roof</td>
<td>200</td>
<td>9 mm Pb</td>
</tr>
<tr>
<td>Downstream Wall (&gt; 1°)</td>
<td>430</td>
<td>13 mm Pb</td>
</tr>
</tbody>
</table>

4.2 Monochromatic Beam Transport Pipe

In the following we assume the worse-case scenario for miss-steered monochromatic beam hitting the beam transport pipe. Using five higher harmonic reflections (111, 333, 444, 555, and 777) of the fundamental mode of 29 keV with corresponding bandwidths [2, 4, 5], the dose is calculated by assuming the monochromatic beam striking the beam pipe normal incidence using the “NICK” card in STAC8. In addition for the monochromatic beam to
enter the beam pipe a series of reflecting mirrors must be inserted to bring the monochromatic beam into the beam pipe toward the experimental enclosures. We assumed 2 platinum coated mirror at 2.2 mrad to the incident beam [2]. The calculated dose rate for 6 mm lead shielded pipe is 2.2E-03 mrem/hr which is below the design criteria of 0.05 mrem/hr.

4.3 End Station Enclosures (08ID-B1 and 08ID-B2)

The side and downstream panels of ISS enclosures are made of 4 mm Lead while the roof is made of 3 mm of Pb. Monochromatic beam stops have been installed on the downstream wall of the 08ID-B1 and 08ID-B2 enclosures to intercept a direct monochromatic and consist of 39 cm × 44 cm × 10 mm thick Pb. The minimum distance between the scattering targets and the walls is given in Table 4. The scattering target is assumed to be a 10 cm radius, 2 cm thick silicon disk, tilted at 0.155 degree to the incident beam located at 100 cm from the downstream wall. The calculation was carried out in STAC8 code using the same beam harmonic energies and bandwidths described above and the two Pt-Coated reflecting mirrors (see section 4.2).

The dose rates on the lateral wall and roof are listed in Table 4. The maximum dose rates for the downstream wall is 1.9E-04 mrem/hr for scattering angles greater than 1° without taking into account the monochromatic beam stop which cover scattering angles less than 11° for scattering target location of 100 cm.

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>Shielding</th>
<th>Dose rate (mrem/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral Wall</td>
<td>150</td>
<td>4 mm Pb</td>
</tr>
<tr>
<td>Roof</td>
<td>208</td>
<td>3 mm Pb</td>
</tr>
</tbody>
</table>

Table 4 Maximum dose rate on lateral wall and roof
5. Summary and Conclusions

At NSLS-II the white beam or First Optical Enclosure (FOE) shielding requirements are dominated by the scattering of the primary bremsstrahlung and not the synchrotron beam. For the simulations the GB beam is normalized at 17μW incident power. This value corresponds to the estimated bremsstrahlung power generated by a 500mA electron beam of 3GeV, assuming that the vacuum in the 15.5 m long straight sections is better than 10^-9Torr. Beamline components that intercept the primary GB beam were selected as scattering targets in the simulations. A summary of the simulation results is presented in table 2.

Table 2. Maximum total dose rates (mrem/hr) on the roof, sidewall and downstream FOE wall on contact. The numbers in parentheses are the dose rates at 30 cm downstream of the FOE wall. Simulations 1-10 performed with all shields

<table>
<thead>
<tr>
<th>#</th>
<th>Simulation</th>
<th>Maximum dose (mrem/hr)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Roof</td>
<td>Sidewall</td>
<td>DS FOE wall on contact</td>
</tr>
<tr>
<td>1</td>
<td>GB on CM-MA0</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>2</td>
<td>GB n CM-MA-01</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>3</td>
<td>GB on CM1</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>4</td>
<td>GB on CM-MA-02</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>5</td>
<td>GB on CM2</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>6</td>
<td>GB on CM-MA-03</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>7</td>
<td>GB on HH-MA -02 or MA-04</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>~0.05 (&lt;0.05)</td>
</tr>
<tr>
<td>8</td>
<td>GB on HHM crystal 1</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>9</td>
<td>GB on PBS</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>10</td>
<td>GB on Bremsmstrahlung Stop</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>11</td>
<td>GB on MA0: no BS02, BS03</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>12</td>
<td>GB on CM1: no BS02, BS03</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>13</td>
<td>GB on CM2: no BS02, BS03</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>~0.6 (~0.1)</td>
</tr>
<tr>
<td>14</td>
<td>GB on CM1: no BS02, BS03, SGB1, SGB2, SGB3</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>~0.07 (&lt;0.05)</td>
</tr>
<tr>
<td>15</td>
<td>GB on HHM crystal1: no BS02, BS03, SGB1, SGB2, SGB3</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>&lt;0.4 (0.2)</td>
</tr>
</tbody>
</table>

For the first 10 cases when all shields were included in the simulations the dose rates on the roof, side wall and the downstream FOE wall were below 0.05 mrem/h. The shielding as designed by the beamline scientists is more than adequate.

Simulations 11 (GB on CM1: no BS02, BS03) and 12 (GB on CM2: no BS02, BS03) show that even when the tungsten shields CM-BS-02 and CM-BS-03 are removed the dose rate outside the FOE walls is still below the acceptable limit. However, simulation 13 (GB on CM2: no BS02, BS03) shows that the dose rate on the downstream FOE wall in ~0.6 rem/h on contact and ~0.1 mrem/h at 30 cm from the wall. This value is higher than the acceptable upper limit of 0.05 mrem/h so shield BS03 is necessary to reduce the dose rates on the DS FOE wall.
The results of simulation 14 (GB on CM1: no BS02, BS03, SGB1, SGB2, SGB3) show that the removal of shields SGB1, SGB2 results in an increase in the dose on the downstream FOE wall to 0.07 mrem/h on contact. The dose at 30 cm from the FOE wall however, is below the acceptable dose rate 0.05 mrem/h. If the total beam is lost at the HHM crystal 1 and shield SGB2 and SGB3 (simulation 15) were removed then the dose on the downstream FOE wall would be 0.4 mrem/h on contact and 0.2 mrem/h at 30 cm from the wall. The design goal of shields SGB1, SGB2, and SGB3 is to block the scattered radiation from the white beam mirrors, the HHM crystals and the focusing mirror. Removing all three shields increases dose rates on the downstream wall above acceptable levels. It was not checked if shield SGB3 is really needed.

Based on the STAC8 calculation, the dose rates outside of the beam transport pipe and beamline enclosures are less than 0.05 mrem/hr on contact with the walls, roof and transport pipes.

All shielding simulations should be validated by comparisons with measurements of the dose rates near the walls of the FOE, the beam transport pipe and the end station enclosure during commissioning.

### 6. References:

[2] Email from K. Attenkofer to M. Benmerrouche (February 03, 2016).

### 7. Acknowledgements:

We would like to thank Alex Price and Cynthia Longo for providing all the beamline geometry information listed in Appendix 1. We would like to thank Klaus Attenkofer and Eli Stavitski for multiple discussions.
### Appendix 1

**Table 1.1 Beamline Enclosures**

<table>
<thead>
<tr>
<th>Wall</th>
<th>Position</th>
<th>Thickness</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/S End of 8-ID-A Ratchet Wall</td>
<td>2671.7 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D/S End of FOE (8-ID-A) Backwall</td>
<td>3971.7 cm</td>
<td>5.0 cm</td>
<td>Lead</td>
</tr>
<tr>
<td>Distance of FOE Sidewall from LS CENTERLINE</td>
<td>1494.2 cm</td>
<td>1.8 cm</td>
<td>Lead</td>
</tr>
<tr>
<td>Distance of FOE Roof from LS CENTERLINE</td>
<td>200.0 cm</td>
<td>1.0 cm</td>
<td>Lead</td>
</tr>
<tr>
<td>Distance of FOE Floor from LS CENTERLINE</td>
<td>140.0 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of FOE</td>
<td>1300.0 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U/S End of experimental hutch (8-ID-B) Wall (note: aperture 22.90 cm in diameter, for beam pipe at 6.5 cm above orbit height)</td>
<td>5600.0 cm (US)</td>
<td>4 mm</td>
<td>Lead</td>
</tr>
<tr>
<td>D/S End of experimental hutch (8-ID-B) Wall</td>
<td>6800.0 cm (DS)</td>
<td>4 mm</td>
<td>Lead</td>
</tr>
<tr>
<td>Monochromatic Beam Stop at D/S end of 8-ID-B (note: 39.0 cm wide x 44.0 cm tall, centered 6.4 cm above LS CL)</td>
<td>6798.5 cm (US)</td>
<td>10 mm</td>
<td>Lead</td>
</tr>
<tr>
<td>Height of roof above LS CL</td>
<td>208.4 cm</td>
<td>Roof 3 mm</td>
<td>Lead</td>
</tr>
<tr>
<td>Distance of B hutch floor from LS CL (note: beam height varies, nominally between 0.88 cm and 12.26 cm above the LS CL at the focus point at Z=6010 cm)</td>
<td>140.0 cm</td>
<td>(+/- about 1 cm floor manufacturing tolerance)</td>
<td></td>
</tr>
<tr>
<td>Distance of outboard Sidewall from beam CENTERLINE</td>
<td>149.5 cm to inner lead surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance of inboard Sidewall from beam CENTERLINE</td>
<td>149.5 cm to inner lead surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>12.0 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partition panels between hutches B1 and B2 (note: oval aperture 11.50 cm wide x 22.54 cm tall behind removable monochromatic beam stop, centered 6.5 cm above LS CL)</td>
<td>6246.7 cm (US)</td>
<td>4 mm</td>
<td>Lead</td>
</tr>
<tr>
<td>Monochromatic Beam Stop at partition (note: 39.5 cm wide x 44.0 cm tall, centered 6.5 cm above LS CL and 0.75 cm outboard)</td>
<td>6238.6 cm (US)</td>
<td>10 mm</td>
<td>Lead</td>
</tr>
</tbody>
</table>
## Table 1.2 Beamline Transport Pipes:

| Transport Pipes between FOE & SOE (AKA B hutch, AKA experimental hutch) for the ISS beamline | ID=14.64cm OD= 15.24cm Material: Stainless Steel | Shielding Thickness 6 mm Lead OD=16.74cm with SS cover. Lead shielding starts DS of interface box | Pipe center 6.51 cm above source height (same as guillotine). |

## Co-ordinate system

For 8ID-PD-ISS the Long Straight centerline was used as the z or beamline axis for the Fluka models. Y is the vertical axis and x the horizontal axis orthogonal to the y and z axes. The Fluka model uses the nominal values of the various beamline components. The dimensions in the Ray Trace drawings use the smallest possible values taking tolerances into account. There may therefore be minor discrepancies in the two values.

## Table 1.3 ISS Beamline Components and SGB shields.

<table>
<thead>
<tr>
<th>Components</th>
<th>Z = Distance from LS centerline U,D or C</th>
<th>Dimensions (specify units)</th>
<th>vertical/ horizontal Offset &amp; Rotation w.r.t LS CENTERLINE</th>
<th>Material</th>
<th>Associated Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Outer dimensions (W)x(H)x(L)</td>
<td>Aperture (W)x(H) or (R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed mask FM0</td>
<td>2770.9 cm</td>
<td>15.0(x)11.0(y) z1=25, z2=3.0</td>
<td>US: 5.45(x)2.04(y) DS: 3.04(x)0.29(y)</td>
<td>Glidcop</td>
<td>PD-ISS-PCM-2000_mask0.p df</td>
</tr>
<tr>
<td></td>
<td>(D)</td>
<td></td>
<td></td>
<td>Cu</td>
<td></td>
</tr>
<tr>
<td>Fixed mask CM-MA0</td>
<td>2849.05 (D)</td>
<td>11.7(x)7.5(y) z=20.0</td>
<td>US: 4.53(x)1.47(y) DS: 2.99(x)0.29(y)</td>
<td>Glidcop</td>
<td>PD-ISS-PCM-2100_mask1.p df</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cu</td>
<td></td>
</tr>
<tr>
<td>CM Collimator CM-BS01</td>
<td>2849.05 (U)</td>
<td>11.7(x)7.5(y) z=20.5</td>
<td>3.25(x)0.70(y)</td>
<td>Tungsten</td>
<td>PD-ISS-PCM-2100_mask1.p df</td>
</tr>
<tr>
<td></td>
<td>2869.55 (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirror CM1</td>
<td>2947.50(C)</td>
<td>145(z)</td>
<td>rotated -2.2mrad wrt x axis so beam up 4.4mrad Yoffset = -3.0cm</td>
<td>Si</td>
<td>PD-ISS-PCM-3100.pdf &amp; P13-118 ICD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.0(x)6.0(y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM-BS2</td>
<td>3023.9 (U)</td>
<td>40.0(x)44.7(y) 2.5cm (z)</td>
<td>0.51cm at ap. center (level)</td>
<td>Tungsten</td>
<td>PD-ISS-PCM-2200_mask2.p df</td>
</tr>
<tr>
<td></td>
<td>3026.4 (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Components</td>
<td>Z = Distance from LS centerline U, D or C</td>
<td>Dimensions (specify units)</td>
<td>vertical/horizontal Offset &amp; Rotation w.r.t LS CENTERLINE</td>
<td>Material</td>
<td>Associated Drawings</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------</td>
<td>----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Fixed mask CM-MA2</td>
<td>3066.4 (D) 3063.40 at aperture</td>
<td>Outer dimensions (W)x(H)x(L)</td>
<td>Aperture center at y=0.51 cm at z=3063.4 cm</td>
<td>Glidcop</td>
<td>PD-ISS-PCM-2200_mask2.p df</td>
</tr>
<tr>
<td>CM-MA2 support</td>
<td></td>
<td></td>
<td>Top of support -8.0/2.0+0.5 cm</td>
<td>SS</td>
<td>PD-ISS-PCM-2200_mask2.p df</td>
</tr>
<tr>
<td>Mirror CM2</td>
<td>3147.50 (c)</td>
<td>Aperture (W)x(H) or (R)</td>
<td>rotated 2.2mrad wrt x axis so beam out level</td>
<td>Si</td>
<td>PD-ISS-PCM-3200.pdf &amp; 3D model</td>
</tr>
<tr>
<td>CM-BS3</td>
<td>3246.33 (U)</td>
<td></td>
<td>Offset:0.88+2.5 cm</td>
<td>8.8mm</td>
<td>PD-ISS-PCM-2300_mask3.p df</td>
</tr>
<tr>
<td>Fixed mask CM-MA3</td>
<td>3266.05 (D)</td>
<td>Outer dimensions (W)x(H)x(L)</td>
<td>8.8 mm</td>
<td>Glidcop</td>
<td>PD-ISS-PCM-2300_mask3.p df</td>
</tr>
<tr>
<td>CM-BS4</td>
<td>3266.05 (D)</td>
<td></td>
<td></td>
<td>8.8 mm</td>
<td>PD-ISS-PCM-2300_mask3.p df</td>
</tr>
<tr>
<td>SGB1 Outside CM-BS4 (AKA CM-BS-05)</td>
<td>3266.05 (U)</td>
<td></td>
<td></td>
<td>8.8mm</td>
<td>Lead IJJ00060_LeadShelter_brem-coll. pdf</td>
</tr>
<tr>
<td>Monobeam Mask MM (AKA HH-MA-02)</td>
<td>3329.3 (D)</td>
<td>Aperture center at y=0.51 cm at z=3063.4 cm</td>
<td>Top center fixed at 8.8mm. Rotate crystal</td>
<td>Si</td>
<td>3D model in Inventor</td>
</tr>
<tr>
<td>1st. Mono (HHM = high heat mono) crystal</td>
<td>3381.0 (C) Nom.Rotation 11.4° at 10keV with a 111 crystal Full range 3° to 45°.</td>
<td></td>
<td>Cylinder, basically 12.50cm diameter and 6.25cm tall, but with lots of cuts in it.</td>
<td>8.8 mm at center of aperture</td>
<td>PD-ISS-HHM-2100_mask4.p df</td>
</tr>
<tr>
<td>Components</td>
<td>Z = Distance from LS centerline U,D or C</td>
<td>Dimensions (specify units)</td>
<td>vertical/ horizontal Offset &amp; Rotation w.r.t LS CENTERLINE</td>
<td>Material</td>
<td>Associated Drawings</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------------</td>
<td>---------------------------</td>
<td>-------------------------------------------------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>2nd Mono crystal</strong></td>
<td>Crystal posn depends on energy to keep offset at 20mm.</td>
<td>Rectangle 21.0cm long, 4.4cm wide, 1.5cm thick.</td>
<td>Nominal (11.4°) 41.4mm (C). Full range 24.8mm-100.1mm (C) NOT rotated</td>
<td>Si</td>
<td>3D model in Inventor</td>
</tr>
<tr>
<td>Pink Beam Stop PBS (AKA HH-MA-01)</td>
<td>3427.5 (U) 3450.5 (D)</td>
<td>7.2(x)23.0(z) 1.82(y1)* 3.03(y2) * changed to 1.75 to match survey data</td>
<td>Top downstream edge Y=13.98mm Top upstream edge Y= 1.14mm</td>
<td>Glidcop</td>
<td>3JB_04128_pink beam stop.pdf &amp; survey data</td>
</tr>
<tr>
<td>SGB2 (AKA BS)</td>
<td>3493.77 cm (D) = average of survey data</td>
<td>61.06(x)56.05(y)33.02(z) lead bottom at Y=-250.0</td>
<td>Aperture center 2.88cm, 279mm up from lead bottom (at Y=-250.2)</td>
<td>Lead</td>
<td>2JJ00711-LeadShelter_brem_stop.pdf &amp; survey data</td>
</tr>
<tr>
<td>Hi Res Mono Not included in fluka model because GB cannot hit it.</td>
<td>3545.25 (C)</td>
<td>Channel-cut single crystal.</td>
<td>Beam out at 16.8mm minimum, 20mm maximum, depending on wavelength. Or can be bypassed.</td>
<td>Si</td>
<td></td>
</tr>
<tr>
<td>Focusing Mirrors FM Only one mirror added in model</td>
<td>3695.40 (C)</td>
<td>145(z) 10.0(x)5.0(y) centered on beam</td>
<td>2.2 mrad, to reflect beam up at 4.4 mrad. Mirror center at beam height: 28.8mm</td>
<td>Si</td>
<td>3D model (PD-ISS-PFM-3100.pdf is obsolete)</td>
</tr>
<tr>
<td>SGB3 (AKA BT-BC-01)</td>
<td>3823.0 (U) 65.0(x)23.6(y) 10.16(z)</td>
<td>No aperture – lead only above beam.</td>
<td>Bottom surface at Y = 42.3mm</td>
<td>Lead</td>
<td>2AB-000451</td>
</tr>
<tr>
<td>Photon Shutter simplified model</td>
<td>3873.37 cm (U) 12.5 cm (x) 15 cm (y) 3.8 cm (z)</td>
<td>40 mm × 25 mm Centered wrt block</td>
<td>Offset 27.3 mm</td>
<td>Tungsten</td>
<td>PD-COM-PSH-1000 (unreleased)</td>
</tr>
<tr>
<td>Components</td>
<td>Z - Distance from LS centerline U, D or C</td>
<td>Dimensions (specify units)</td>
<td>vertical/ horizontal Offset &amp; Rotation w.r.t LS CENTERLINE</td>
<td>Material</td>
<td>Associated Drawings</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer dimensions (W)x(H)x(L)</td>
<td>Aperture (W)x(H) or (R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guillotine</td>
<td>3956.7 (U)</td>
<td>84 cm (x) 80 cm(y) 10 cm(z)</td>
<td>Aperture 15.24cm (same as beam pipe OD)</td>
<td>Guillotine/Aperture Offset 6.51cm</td>
<td>Lead</td>
</tr>
<tr>
<td>A Hutch downstream wall</td>
<td>3971.7 (D)</td>
<td>5cm thick</td>
<td>Aperture 22.9cm</td>
<td>Aperture offset 6.51cm as above.</td>
<td>Lead</td>
</tr>
<tr>
<td>Pipe collar</td>
<td>4066.9 (D)</td>
<td>33.2 cm OD, 5cm thick</td>
<td>Aperture 15.24cm (on bare pipe)</td>
<td>Centered on pipe (at Y=6.51cm)</td>
<td>Lead</td>
</tr>
<tr>
<td>A Hutch interface box</td>
<td>4073.3 (D)</td>
<td></td>
<td>Aperture 17.2cm (on shielded pipe)</td>
<td>Centered on pipe (at Y=6.51cm)</td>
<td>Lead with steel covers</td>
</tr>
</tbody>
</table>
Appendix 2: Gas Bremmstrahlung Source File: src_bl2.f

* $ CREATE SOURCE.FOR
* COPY SOURCE
* 
* === source ===============================*
* SUBROUTINE SOURCE ( NOMORE )

INCLUDE '(DBLPRC)'
INCLUDE '(DIMPAR)'
INCLUDE '(IOUNIT)'

------------------------------------------------------------------------*
* Copyright (C) 1990-2010 by Alfredo Ferrari & Paola Sala *
* All Rights Reserved. *
*
* New source for FLUKA9x-FLUKA20xy: *
*
* Created on 07 January 1990 by Alfredo Ferrari & Paola Sala *
* Infn - Milan *
*
* Last change on 17-Oct-10 by Alfredo Ferrari *
*
* This is just an example of a possible user written source routine. *
* note that the beam card still has some meaning - in the scoring the *
* maximum momentum used in deciding the binning is taken from the *
* beam momentum. Other beam card parameters are obsolete. *
*
* Output variables: *
* *
* Nomore = if > 0 the run will be terminated *
*
------------------------------------------------------------------------*
* INCLUDE '(BEAMCM)'
INCLUDE '(FHEAVY)'
INCLUDE '(FLKSTK)'

INCLUDE '(IOIOCM)'  
INCLUDE '(LTCLCM)'  
INCLUDE '(PAPROP)'  
INCLUDE '(SOURCM)'  
INCLUDE '(SUMCOU)'  

* LOGICAL LFIRST  
*  
SAVE LFIRST  
DATA LFIRST / .TRUE. /  
*
*======================================================================*  
*                                                                      *  
*                 BASIC VERSION                                        *  
*                                                                      *  
*======================================================================*  

NOMORE = 0  
+

* First call initializations:  
 IF ( LFIRST ) THEN  
*  
*** The following 3 cards are mandatory ***  
TKESUM = ZERZER  
LFIRST = .FALSE.  
LUSSRC = .TRUE.  

*** User initialization ***  
GB_LO = WHASOU (1)  
GB_HI = WHASOU (2)  

IF(WHASOU(2).LE.WHASOU(1))STOP 'Emax <= Emin'  
WRITE(LUNOUT,*)  
WRITE(LUNOUT,'(A,132A)') ('*',I=1,132)  
WRITE(LUNOUT,*)  
WRITE(LUNOUT,*)"GB Low and high energy limits: GB_LO,GB_HI"  
WRITE(LUNOUT,*)GB_LO,GB_HI  
WRITE(LUNOUT,*)  
END IF  
END IF  
+

Push one source particle to the stack. Note that you could as well  
push many but this way we reserve a maximum amount of space in the  
stack for the secondaries to be generated
* Npflka is the stack counter: of course any time source is called it
* must be =0
    NPFLKA = NPFLKA + 1
* Wt is the weight of the particle
    TKEFLK (NPFLKA) = GB_LO + (GB_HI -GB_LO) * FLRNDM(XDUMMY)
    WTFLK (NPFLKA) = 1/TKEFLK(NPFLKA)
    WEIPRI = WEIPRI + WTFLK(NPFLKA)
* Particle type (1=proton.....). Ijbeam is the type set by the BEAM
* card
* +---------------------------------------------------------------*
* | (Radioactive) isotope:
    IF ( IJBEAM .EQ. -2 .AND. LRDBEA ) THEN
        IARES = IPROA
        IZRES = IPROZ
        IISRES = IPROM
        CALL STISBM ( IARES, IZRES, IISRES )
        IJHION = IPROZ * 1000 + IPROA
        IJHION = IJHION * 100 + KXHEAV
        IONID = IJHION
        CALL DCDION ( IONID )
        CALL SETION ( IONID )
    ELSE IF ( IJBEAM .EQ. -2 ) THEN
        IJHION = IPROZ * 1000 + IPROA
        IJHION = IJHION * 100 + KXHEAV
        IONID = IJHION
        CALL DCDION ( IONID )
        CALL SETION ( IONID )
        ILOFLK (NPFLKA) = IJHION
        LRADDC (NPFLKA) = .FALSE.
    ELSE
    * | Flag this is prompt radiation
        IGROUP (NPFLKA) = 0
    ELSE
    * | Group number for "low" energy neutrons, set to 0 anyway
    * +---------------------------------------------------------------*
* | Normal hadron:
    ELSE
IONID = IJBEAM
ILOFLK (NPFLKA) = IJBEAM
* | Flag this is prompt radiation
LRADDC (NPFLKA) = .FALSE.
| Group number for "low" energy neutrons, set to 0 anyway
IGROUP (NPFLKA) = 0
END IF
|
+-------------------------------------------------------------------*
| From this point ..... *
| Particle generation (1 for primaries)
LOFLK (NPFLKA) = 1
|
* User dependent flag:
LOUSE (NPFLKA) = 0
|
* No channeling:
LCHFLK (NPFLKA) = .FALSE.
DCHFLK (NPFLKA) = ZERZER
|
* User dependent spare variables:
DO 100 ISPR = 1, MKBMX1
SPAREK (ISPR,NPFLKA) = ZERZER
100  CONTINUE
|
* User dependent spare flags:
DO 200 ISPR = 1, MKBMX2
ISPARK (ISPR,NPFLKA) = 0
200  CONTINUE
|
* Save the track number of the stack particle:
ISPARK (MKBMX2,NPFLKA) = NPFLKA
NPARMA = NPARMA + 1
NUMPAR (NPFLKA) = NPARMA
NEVENT (NPFLKA) = 0
DFNEAR (NPFLKA) = +ZERZER
|
* ... to this point: don't change anything
* Particle age (s)
AGESTK (NPFLKA) = +ZERZER
AKNSHR (NPFLKA) = -TWOTWO
* Kinetic energy of the particle (GeV)
* TKEFLK (NPFLKA) = SQRT ( PBEAM**2 + AM (IONID)**2 ) - AM (IONID)
* Particle momentum
* PMOFLK (NPFLKA) = PBEAM
PMOFLK (NPFLKA) = SQRT ( TKEFLK (NPFLKA) * ( TKEFLK (NPFLKA) + TWOTWO * AM (IONID) ) )

* Cosines (tx,ty,tz)
TXFLK (NPFLKA) = UBEAM
TYFLK (NPFLKA) = VBEAM
TZFLK (NPFLKA) = WBEAM

* T2FLK (NPFLKA) = SQRT ( ONEONE - TXFLK (NPFLKA)**2
* & - TYFLK (NPFLKA)**2 

* Polarization cosines:
TXPOL (NPFLKA) = -TWOTWO
TYPOL (NPFLKA) = +ZERZER
TZPOL (NPFLKA) = +ZERZER

* Particle coordinates
XFLK (NPFLKA) = XBEAM
YFLK (NPFLKA) = YBEAM
ZFLK (NPFLKA) = ZBEAM

* Calculate the total kinetic energy of the primaries: don't change
IF ( ILOFLK (NPFLKA) .EQ. -2 .OR. ILOFLK (NPFLKA) .GT. 100000 )
& THEN
  TKESUM = TKESUM + TKEFLK (NPFLKA) * WTFLK (NPFLKA)
ELSE IF ( ILOFLK (NPFLKA) .NE. 0 ) THEN
  TKESUM = TKESUM + ( TKEFLK (NPFLKA) + AMDISC (ILOFLK(NPFLKA)) )
ELSE
  TKESUM = TKESUM + TKEFLK (NPFLKA) * WTFLK (NPFLKA)
END IF
RADDLY (NPFLKA) = ZERZER

* Here we ask for the region number of the hitting point.
* NREG (NPFLKA) = ...
* The following line makes the starting region search much more
* robust if particles are starting very close to a boundary:
CALL GEOCRS ( TXFLK (NPFLKA), TYFLK (NPFLKA), TZFLK (NPFLKA) )
CALL GEOREG ( XFLK (NPFLKA), YFLK (NPFLKA), ZFLK (NPFLKA),
& NRGFLK(NPFLKA), IDISC )

* Do not change these cards:
CALL GEOHSM ( NHPRT (NPFLKA), 1, -11, MLATTC )
NLATTC (NPFLKA) = MLATTC
CMPATH (NPFLKA) = ZERZER
CALL SOEVSV
RETURN

*** End of subroutine Source ==============================**
END
Appendix 3: Sample input file: 17ID-d5-FMXppsm.inp

* 8ID-ISS
TITLE
GB on BS
* Version History
* 01/04/2016: version d1 (Vinita Ghosh)
* 01/15/2016: version d2 (VJG) includes DCM crystals, PBS, IB and transport pipe
*
DEFAULTS
* Define the beam characteristics
BEAM            -3.0                 -.4                              PHOTON
* Define the beam position for Bremsstrahlung Stop
BEAMPOS          4.32                 0.0              800.0       0.0       0.0
* Define the beam position for Pink Beam Stop
*BEAMPOS          0.0      0.88     760.0       0.0       0.0
* Define the beam position for MonoBeam Mask -Pos A.
*BEAMPOS          0.0      0.53     643.0       0.0       0.0
* Define the beam position for MonoBeam Mask -Pos B
*BEAMPOS          0.0       -0.65     643.0       0.0       0.0
* Define the beam position for MA3
*BEAMPOS          0.0      0.66     570.0       0.0       0.0
* Define the beam position for MA2
*BEAMPOS          0.0       0.0     370.0       0.0       0.0
* Define the beam position for CM1
*BEAMPOS          0.0       0.0     274.0       0.0       0.0
* Define the beam position for Fixed Mask Ma0
*BEAMPOS          1.6       0.0      91.0       0.0       0.0
SOURCE          1E-5       3.0   0.00017
!@what.3=3.5*mrad
*ROT-DEFI        200.       0.0     0.035       0.0       0.0
*ROT-DEFI        200.       0.0     0.0       0.0       0.0
*ROT-DEFI        100.      -12.5       -12.5       -12.5
#define bl 4500.
#define zro 2671.7
#define ma2OS 0.5
#define ma3OS 0.88
#define sgb2OS 2.88
#define sgb3OS 4.23
#define fmOS 2.88
#define pshOS 2.73
#define gioOS 6.51

GEOBEGIN
  
  0 0
  * Black body
  SPH blkbody  0.0 0.0 0.0 4000.0
  * Void sphere
  SPH air      0.0 0.0 0.0 3000.0
  * Ratchet Wall simplified for ID beamlines
  XYP rwxxA_i -140.0
  XYP rwxxA_o  0.0
  Y2P rwxxA_s  185.0
  * Sidewall simplified for ID beamlines
  PLA swxxA_o  0.99782149649341 0.0 0.06597166918965 -50.0 0.0 0.0
  PLA swxxA_i  0.99788010596582 0.0 0.0650791373456 -130.0 0.0 0.0
  PLA swxxA_s  -0.0407823695143 0.0 0.99916805310057 -5.0 0.0 1525.0
  * SR Roof
  X2P rfxxA_t  250.0
  * Experimental floor
  X2P flxxA_b  -150.0
  X2P flxxA_t  -140.0
  * Beamline enclosure sidewall, roof and backwall
  !@what.1=b(bswxxA_i,1)+1.8
  Y2P bswxxA_o  151.00000000000002
  * FOE Sidewall
  Y2P bswxxA_i  149.4
  * FOE BackWall downstream face
  !@what.1=b(bbwxxA_i,1)+5.0
  X2P bbwxxA_o  1300.
  * FOE BackWall Upstream face
  !@what.1=3971.7-zro-5.0
  X2P bbwxxA_i  1295.
  * Top of FOE Roof = 201cm
  !@what.1=b(brfxxA_b,1)+1.0
  X2P brfxxA_t  201.
  * FOE Roof
  X2P brfxxA_b  200.0
  * Hutch B upstream wall
!what.1=(5600.0-zro)
XYP bfwxxB_o  2928.3000000000002
#if 0
* Front End beam pipe outer/outer shell, 2 mm thick beam SS pipe
!what.3=-zro
!what.6=zro
!what.7=4.*inch/2.
RCC fep_o  0.0 0.0 -2671.6999999999998 0.0 0.0 2671.6999999999998
      5.0800000000000001
#endif
#if 0
!what.3=-zro
!what.6=zro
!what.7=3.87*inch/2.
RCC fep_i  0.0 0.0 -2671.6999999999998 0.0 0.0 2671.6999999999998
      4.9149000000000003
#endif
* Fixed Mask 0
!what.1=-15.0/2.
!what.2=-w(1)
!what.3=-11.0/2.
!what.4=-w(3)
!what.5=2770.0-zro -28.0
!what.6=w(5)+28.0
RPP fm0_ -7.5 7.5 -5.5 5.5 70.30000000000182 98.30000000000182
* Box size of DS aperture
!what.1=-3.04/2.
!what.2=-w(1)
!what.3=-0.29/2.
!what.4=-w(3)
!what.5=b(fm0_,5)-1.0
!what.6=b(fm0_,6)+1.0
RPP fm0_in -1.52 1.52 -0.14499999999999999 0.14499999999999999
      69.30000000000182 99.30000000000182
* Box size of US aperture
!what.1=-5.45/2.
!what.2=-w(1)
!what.3=-2.04/2.
!what.4=-w(3)
!@what.5=b(fm0_,5)-1.0
!@what.6=b(fm0_,6)+1.0
RPP fm0_ou -2.7250000000000001 2.7250000000000001 -1.02 1.02
  69.300000000000182 99.300000000000182
* Position of neck
!@what.1=b(fm0_,6)-3.0
XYP fm0_zc 95.300000000000182
* Outboard tapered plane
!@what.4=3.0/2.
!@what.6=b(fm0_zc,1)
PLA fm0_xo 99.8840400 0.0 4.8144107 1.52 0.0 95.300000000000182
* Inboard tapered plane
!@what.1=b(fm0_xo,1)
!@what.2=b(fm0_xo,2)
!@what.3=-b(fm0_xo,3)
!@what.4=-b(fm0_xo,4)
!@what.5=b(fm0_xo,5)
!@what.6=b(fm0_xo,6)
PLA fm0_xi 99.884039999999999 0.0 -4.8144106999999998 -1.52 0.0 95.300000000000182
* Top tapered plane
!@what.5=0.29/2.0
!@what.6=b(fm0_zc,1)
PLA fm0_yt 0.0 99.9381055 3.5178213 0.0 0.14499999999999999 95.300000000000182
* Bottom tapered plane
!@what.1=b(fm0_yt,1)
!@what.2=b(fm0_yt,2)
!@what.3=-b(fm0_yt,3)
!@what.4=b(fm0_yt,4)
!@what.5=-b(fm0_yt,5)
!@what.6=b(fm0_yt,6)
PLA fm0_yb 0.0 99.938105500000006 -3.5178213 0.0 -0.14499999999999999 95.300000000000182
* Fixed Mask 1
!@what.1=-11.7/2.
!@what.2=-w(1)
!@what.3=-7.5/2.
!@what.4=-w(3)
!@what.5=2849.05 - zro -20.0
!@what.6=w(5)+20.0
RPP fm1_ -5.8499999999999996 5.8499999999999996 -3.75 3.75
  157.35000000000036 177.35000000000036
* Box size of DS aperture
!@what.1=-2.99/2.
!@what.2=-w(1)
!@what.3=-0.29/2.
!@what.4=-w(3)
!@what.5=b(fm1_,5)-1.0
!@what.6=b(fm1_,6)
RPP fm1_in -1.4950000000000001 1.4950000000000001 -0.14499999999999999 0.14499999999999999
  0.14499999999999999 156.35000000000036 177.35000000000036
* Box size of US aperture
!@what.1=-4.53/2.
!@what.2=-w(1)
!@what.3=-1.47/2.
!@what.4=-w(3)
!@what.5=b(fm1_,5)-1.0
!@what.6=b(fm1_,6)
RPP fm1_ou -2.2650000000000001 2.2650000000000001 -0.73499999999999999 0.73499999999999999
  0.73499999999999999 156.35000000000036 177.35000000000036
* Position of neck
!@what.1=b(fm1_,6)
XYP fm1_zc 177.35000000000036
* Outboard tapered plane
!@what.4=2.99/2.
!@what.6=b(fm1_zc,1)
PLA fm1_xo 99.9259698 0.0 3.8471498 1.4950000000000001 0.0
  177.35000000000036
* Inboard tapered plane
!@what.1=b(fm1_xo,1)
!@what.2=b(fm1_xo,2)
!@what.3=-b(fm1_xo,3)
!@what.4=-b(fm1_xo,4)
!@what.5=b(fm1_xo,5)
!@what.6=b(fm1_xo,6)
PLA fm1_xi 99.925969800000004 0.0 -3.8471498 -1.4950000000000001 0.0
  177.35000000000036
* Top tapered plane
!@what.5=0.29/2.0
!@what.6=b(fm1_zc,1)
PLA fm1_yt  0.0 99.9565159 2.9487172 0.0 0.14499999999999999 177.35000000000036
* Bottom tapered plane
!@what.1=b(fm1_yt,1)
!@what.2=b(fm1_yt,2)
!@what.3=-b(fm1_yt,3)
!@what.4=b(fm1_yt,4)
!@what.5=-b(fm1_yt,5)
!@what.6=b(fm1_yt,6)
PLA fm1_yb  0.0 99.956515899999999 -2.9487171999999999 0.0 -0.14499999999999999 177.35000000000036
* CM Collimator
!@what.1=-11.7/2.
!@what.2=-w(1)
!@what.3=-7.5/2.
!@what.4=-w(3)
!@what.5=b(fm1_,5)+20.0
!@what.6=w(5)+20.5
RPP cmcol1 -5.8499999999999996 5.8499999999999996 -3.75 3.75 177.35000000000036 197.85000000000036
* CM Collimator aperture
!@what.1=-3.25/2.
!@what.2=-w(1)
!@what.3=-0.70/2.
!@what.4=-w(3)
!@what.5=b(cmcol,5)
!@what.6=b(cmcol,6)
RPP cmcolap -1.625 1.625 -0.3499999999999998 0.3499999999999998 177.35000000000036 197.85000000000036
# if 0
* White beam mirror CM1 - unrotated
!@what.1=-14.0/2.
!@what.2=-w(1)
!@what.3=-6.0
!@what.5=2947.50-zro-145.0/2.
!@what.6=w(5)+145.0
RPP cml -7.7 -6.0 0.0 203.30000000000018 348.30000000000018
#endif
* White beam mirror CM1 - rotated 2.2 mrad, translated 275.8 cm
BOX cml -7.0 -6.159485332456 203.31337543768 14.0 0.0 0.0
  5.99998548000093 -.0131999877887 0.0 .31899970489281
  144.99964910022
* Sec. Brem Shield CM-BS2
!@what.1=-40.0/2.
!@what.2=-w(1)
!@what.3=-44.7/2.+ma2OS
!@what.4=-w(3)+2.*ma2OS
!@what.5=3026.4-zro -2.5
!@what.6=w(5)+2.5
RPP cmbs2 -20.20 -21.850000000001 22.85000000000001
  352.20000000000027 354.70000000000027
* Sec. Brem Shield CM-BS2 aperture
!@what.1=-8.3/2.
!@what.2=-w(1)
!@what.3=-3.0/2.+ma2OS
!@what.4=-w(3)+ma2OS*2.
!@what.5=b(cmbs2,5)
!@what.6=b(cmbs2,6)
RPP cmbs2ap -4.15000000000004 4.15000000000004 -1.2 352.20000000000027
  354.70000000000027
* Fixed Mask 2
!@what.1=-20.0/2.
!@what.2=-w(1)
!@what.3=-8.0/2.+ma2OS
!@what.4=-w(3)+ma2OS*2.
!@what.5=b(cmbs2,5)+2.5
!@what.6=w(5)+40.0
RPP fm2_ -10.10 -3.5 4.5 354.7000000000027 394.7000000000027
* Box size of DS aperture
!@what.1=-2.99/2.
!@what.2=-w(1)
!@what.3=-0.29/2.+ma2OS
!@what.4=-w(3)+2.*ma2OS
!@what.5=b(fm2_,5)-1.0
!@what.6=b(fm2_,6)+1.0
RPP fm2_in  -1.4950000000000001 1.4950000000000001 0.35499999999999998
            0.64500000000000002 353.70000000000027 395.70000000000027
* Box size of US aperture
!@what.1=-8.16/2.
!@what.2=-w(1)
!@what.3=-2.87/2.+ma2OS
!@what.4=-w(3)+ma2OS*2.
!@what.5=b(fm2_,5)-1.0
!@what.6=b(fm2_,6)+1.0
RPP fm2_ou     -4.0800000000000001 4.0800000000000001 -0.93500000000000005
            1.93500000000000001 353.70000000000027 395.70000000000027
* Position of neck
!@what.1=b(fm2_,6)-3.0
XYP fm2_zc     391.70000000000027
* Outboard tapered plane
!@what.4=b(fm2_in,2)
!@what.6=b(fm2_zc,1)
PLA fm2_xo     99.7416103 0.0 7.1840917 1.4950000000000001 0.0
            391.70000000000027
* Inboard tapered plane
!@what.1=b(fm2_xo,1)
!@what.2=b(fm2_xo,2)
!@what.3=-b(fm2_xo,3)
!@what.4=b(fm2_in,1)
!@what.5=b(fm2_xo,5)
!@what.6=b(fm2_xo,6)
PLA fm2_xi     99.741610300000005 0.0 -7.1840916999999997 -1.4950000000000001
            0.0 391.7000000000000027
* Top tapered plane
!@what.5=b(fm2_in,4)
!@what.6=b(fm2_zc,1)
PLA fm2_yt     0.0 99.9392774 3.4843694 0.0 0.64500000000000002
            391.70000000000027
* Bottom tapered plane
!@what.1=b(fm2_yt,1)
!@what.2=b(fm2_yt,2)
!@what.3=-b(fm2_yt,3)
!@what.4=b(fm2_yt,4)
!@what.5=b(fm2_in,3)
!@what.6=b(fm2_yt,6)
PLA fm2_yb  0.0 99.939277399999995 -3.4843693999999998 0.0 0.35499999999999998 391.70000000000027
* Fixed Mask 2 support
!@what.1=-40.0/2.
!@what.2=w(1)
!@what.3=b(fm2_.3)-2.5
!@what.4=b(fm2_.3)
!@what.5=b(cmbs2,5) +2.5
!@what.6=w(5)+40.0
RPP fm2sup -20. 20. -6. -3.5 354.70000000000027 394.70000000000027
* White beam mirror CM2 - rotated 2.2 mrad translated z=475.8 y=0.88cm
BOX cm2   -6.0 .7205001475536 403.30017544989 12.0 0.0 0.0 0.0 4.9999879000077 -.0109999898239 0.0 .31899970489281 144.99964910022
#if 0
* White beam mirror CM2 - unrotated
!@what.1=-12/2.
!@what.2=-w(1)
!@what.3=ma2OS
!@what.4=w(3)+5.0
!@what.5=3147.50-zro-145.0/2.
!@what.6=w(5)+145.0
RPP cm2   -6. 6. 0.5 5.5 403.30000000000018 548.30000000000018
#endif
* Shield CM-BS-03
!@what.1=-45.0/2.
!@what.2=-w(1)
!@what.3=-35.6/2.+ma3OS
!@what.4=-w(3)+2.*ma3OS
!@what.5=3246.33 -zro
!@what.6=w(5)+2.5
RPP cmbs3 -22.5 22.5 -16.920000000000002 18.680000000000003 574.63000000000011 577.13000000000011
* Shield CM-BS-03 aperture
!@what.1=-11.00/2.
!@what.2=-w(1)
!@what.3=-12.0/2.+ma3OS
!@what.4=-w(3)+2.*ma3OS
!@what.5=b(cmbs3,5)  
!@what.6=w(5)+2.5  
RPP cmbs3ap  -5.5 5.5 -5.1200000000000001 6.8799999999999999  
574.630000000000000 577.130000000000000  
* Fixed Mask 3  
!@what.1=-11.0/2.  
!@what.2=-w(1)  
!@what.3=-12.0/2.+ma3OS  
!@what.4=-w(3)+ma3OS*2.  
!@what.5=3266.05 -zro -24.5  
!@what.6=w(5)+24.5  
RPP fm3_  -5.5 5.5 -5.1200000000000001 6.8799999999999999  
569.85000000000036 594.35000000000036  
* Box size of DS aperture  
!@what.1=-2.99/2.  
!@what.2=-w(1)  
!@what.3=-0.29/2.+ma3OS  
!@what.4=-w(3)+2.*ma3OS  
!@what.5=b(fm3_5)-1.0  
!@what.6=b(fm3_6)+1.0  
RPP fm3_in  -1.4950000000000001 1.4950000000000001 0.73499999999999999  
1.0249999999999999 568.85000000000036 595.35000000000036  
* Box size of US aperture  
!@what.1=-6.35/2.  
!@what.2=-w(1)  
!@what.3=-1.96/2.+ma3OS  
!@what.4=-w(3)+ma3OS*2.  
!@what.5=b(fm3_5)-1.0  
!@what.6=b(fm3_6)+1.0  
RPP fm3_ou  -3.1749999999999998 3.1749999999999998 -0.0999999999999978  
1.8599999999999999 568.85000000000036 595.35000000000036  
* Position of neck  
!@what.1=b(fm3_,6)  
XYP fm3_zc  594.350000000000000  
* Outboard tapered plane  
!@what.4=b(fm3_in,2)  
!@what.6=b(fm3_zc,1)  
PLA fm3_xo  99.7657238 0.0 6.8410782 1.4950000000000001 0.0  
594.350000000000000
* Inboard tapered plane
!@what.1=b(fm3_xo,1)
!@what.2=b(fm3_xo,2)
!@what.3=-b(fm3_xo,3)
!@what.4=b(fm3_in,1)
!@what.5=b(fm3_xo,5)
!@what.6=b(fm3_xo,6)
PLA fm3_xi  99.765723800000004 0.0 -6.8410782000000001 -1.4950000000000001 0.0 594.35000000000036

* Top tapered plane
!@what.5=b(fm3_in,4)
!@what.6=b(fm3_zc,1)
PLA fm3_yt 0.0 99.9419727 3.4061856 0.0 1.0249999999999999 594.35000000000036

* Bottom tapered plane
!@what.1=b(fm3_yt,1)
!@what.2=b(fm3_yt,2)
!@what.3=-b(fm3_yt,3)
!@what.4=b(fm3_yt,4)
!@what.5=b(fm3_in,3)
!@what.6=b(fm3_yt,6)
PLA fm3_yb 0.0 99.941972699999994 -3.4061856000000001 0.0 0.73499999999999999 594.35000000000036

* Shield CM-BS-04
!@what.1=-11.7/2.
!@what.2=-w(1)
!@what.3=-7.5/2.+ma3OS
!@what.4=-w(3)+2.*ma3OS
!@what.5=b(fm3_yt,6)
!@what.6=w(5)+11.3
RPP cmbs4  -5.84999999999996 5.84999999999996 -2.8700000000000001 4.6299999999999999 594.35000000000036 605.65000000000032

* Shield CM-BS-04 aperture
!@what.1=-3.25/2.
!@what.2=-w(1)
!@what.3=-0.70/2.+ma3OS
!@what.4=-w(3)+2.*ma3OS
!@what.5=b(fm3_yt,6)
!@what.6=w(5)+11.3
RPP cmbs4ap 
-1.625 1.625 0.5300000000000003 1.23 594.35000000000036
605.65000000000032
* Shield SGB1
!/what.1=-101.6/2.
!/what.2=-w(1)
!/what.3=-111.76/2.+ma3OS
!/what.4=-w(3)+2.*ma3OS
!/what.5=b(fm3_,6)
!/what.6=w(5)+10.16
RPP sgb1 
-50.799999999999997 50.799999999999997 -55. 56.759999999999998
594.35000000000036 604.51000000000033
* Shield SGB1 aperture
!/what.1=-40.64/2.
!/what.2=-w(1)
!/what.3=-30.48/2.+ma3OS
!/what.4=-w(3)+2.*ma3OS
!/what.5=b(fm3_,6)
!/what.6=w(5)+10.16
RPP sgb1ap 
-20.32 20.32 -14.359999999999999 16.120000000000001
594.35000000000036 604.51000000000033
* Mask Pink Beam entrance
!/what.1=-9.0/2.
!/what.2=-w(1)
!/what.3=-7.8/2.+ma3OS
!/what.4=-w(3)+ma3OS*2.
!/what.5=3329.3 -zro -14.1
!/what.6=w(5)+14.1
RPP fmm_ 
-4.5 4.5 -3.02 4.7800000000000002 643.50000000000034
657.60000000000036
* Box size of DS aperture
!/what.1=-2.99/2.
!/what.2=-w(1)
!/what.3=-0.29/2.+ma3OS
!/what.4=-w(3)+2.*ma3OS
!/what.5=b(fmm_,5)-1.0
!/what.6=b(fmm_,6)+1.0
RPP fmm_in 
-1.4950000000000001 1.4950000000000001 0.7349999999999999
1.0249999999999999 642.500000000000034 658.600000000000036
* Box size of US aperture
!what.1=-4.1/2.
!what.2=-w(1)
!what.3=-1.2/2.+ma3OS
!what.4=-w(3)+ma3OS*2.
!what.5=b(fmm_,5)-1.0
!what.6=b(fmm_,6)+1.0

RPP fmm_ou -2.0499999999999998 2.0499999999999998 0.28000000000000003 1.48
642.50000000000034 658.60000000000036

* Position of neck
!what.1=b(fmm_,6)
XYP fmm_zc 657.60000000000036

* Outboard tapered plane
!what.4=b(fmm_in,2)
!what.6=b(fmm_zc,1)
PLA fmm_xo 99.9226227 0.0 3.9331245 1.4950000000000001 0.0
657.60000000000036

* Inboard tapered plane
!what.1=b(fmm_xo,1)
!what.2=b(fmm_xo,2)
!what.3=b(fmm_xo,3)
!what.4=b(fmm_in,1)
!what.5=b(fmm_xo,5)
!what.6=b(fmm_xo,6)
PLA fmm_xi 99.922622700000005 0.0 -3.9331244999999999 -1.4950000000000001
0.0 657.60000000000036

* Top tapered plane
!what.5=b(fmm_in,4)
!what.6=b(fmm_zc,1)
PLA fmm_yt 0.0 99.9508033 3.1363873 0.0 1.0249999999999999
657.60000000000036

* Bottom tapered plane
!what.1=b(fmm_yt,1)
!what.2=b(fmm_yt,2)
!what.3=b(fmm_yt,3)
!what.4=b(fmm_yt,4)
!what.5=b(fmm_in,3)
!what.6=b(fmm_yt,6)
PLA fmm_yb 0.0 99.9508033000000004 -3.1363873 0.0 0.7349999999999999
657.60000000000036
* 1st crystal of HHM rotated 45 degrees, translated =3381.0-zro =709.3
@what.7=12.5/2.
RCC monol 0.0 -3.797163414972 713.09716341497 0.0 4.4194173824159
        -4.419417382416 6.25
#if 0
* 1st crystal of HHM unrotated
@what.2=-6.25 +ma3OS
@what.3=3381.0-zro
@what.7=12.5/2.
RCC monol 0.0 -5.3700000000000001 709.30000000000018 0.0 6.25 0.0 6.25
#endif
@what.1=-4.4/2.
@what.2=-w(1)
@what.3=sgb2OS
@what.4=w(3)+1.5
@what.5=3390.1 -zro
@what.6=w(5)+21.0
RPP mono2 -2.2000000000000002 2.2000000000000002 2.8799999999999999
        4.3799999999999999 718.40000000000009 739.40000000000009
* PBS outboard plane
@what.1=7.2/2.
YZP pbsxo 3.6000000000000001
* PBS inboard plane
@what.1=-7.2/2.
YZP pbsxi -3.6000000000000001
* PBS upstream plane
@what.1=3450.5-zro-23.0
XYP pbszu 755.80000000000018
* PBS downstream plane
@what.1=b(pbszu,1) +23.0
XYP pbsd  778.80000000000018
* PBS bottom plane
@what.1=0.114-1.75
XZP pbsyb -1.6359999999999999
@what.6=b(pbszu,1)
PLA pbsyt 0.0 99.8455005 -5.5566211 0.0 0.114 755.80000000000018
#if 0
* PBS top plane
@what.1=b(pbsyb,1)+3.03
XZP pbsyt1 1.3939999999999999
#endif
* Shield SGB2
!@what.1=-61.06/2.
!@what.2=-w(1)
!@what.3=-25.02
!@what.4=w(3)+56.05
!@what.5=3493.77 -zro
!@what.6=w(5)+33.02
RPP sgb2   -30.530000000000001 30.530000000000001 -25.02 31.029999999999998
            822.07000000000016 855.09000000000015
* Shield SGB2 aperture
!@what.1=-4.37/2.
!@what.2=-w(1)
!@what.3=-1.2/2.+sgb2OS
!@what.4=-w(3)+2.*sgb2OS
!@what.5=b(sgb2,5)
!@what.6=b(sgb2,6)
RPP sgb2ap  -2.1850000000000001 2.1850000000000001 2.2799999999999998 3.48
            822.07000000000016 855.09000000000015
* Focussing mirror FM - unrotated
!@what.1=-10.0/2.
!@what.2=-w(1)
!@what.3=-5.0/2.+fmOS
!@what.4=-w(3)+fmOS*2.
!@what.5=3695.4-zro-145.0/2.
!@what.6=w(5)+145.0
RPP focmir  -5.5 0.3799999999999989 5.3799999999999999 951.20000000000027
            1096.20000000000003
* Shield SGB3
!@what.1=-65.0/2.
!@what.2=-w(1)
!@what.3=sgb3OS
!@what.4=-w(3)+23.6
!@what.5=3823.0 -zro
!@what.6=w(5)+10.16
RPP sgb3   -32.5 32.5 4.2300000000000004 19.3700000000000001
            1151.30000000000002 1161.46000000000003
* Shutter
@what.1=-12.5/2.
@what.2=-w(1)
@what.3=-15./2.+pshOS
@what.4=-w(3)+2.*pshOS
@what.5=3873.37-zro -3.8/2.
@what.6=w(5)+3.8
RPP psh    -6.25 6.25 -4.7699999999999996 10.23 1199.77 1203.5699999999999
  * Shutter aperture
@what.1=-4./2.
@what.2=-w(1)
@what.3=-2.5/2.+pshOS
@what.4=-w(3)+2.*pshOS
@what.5=b(psh,5)
@what.6=b(psh,6)
RPP psh_ap   -2. 2. 1.48 3.98 1199.77 1203.5699999999999
  @what.1=-84./2.
  @what.2=-w(1)
  @what.3=-80./2.+gioOS
  @what.4=-w(3)+2.*gioOS
  @what.5=3956.7-zro
  @what.6=w(5)+10.
RPP giotn    -42. 42. -33.490000000000002 46.510000000000005 1285. 1295.
  * Guillotine aperture
  @what.2=gioOS
  @what.3=b(giotn,5)
  @what.7=15.24/2.
RCC giotn_ap 0.0 6.5099999999999998 1285. 0.0 0.0 10.0 7.6200000000000001
  * Beamline transport pipe
  @what.2=gioOS
  @what.3=4066.9-zro
  @what.6=(4955.436-3986.698)+5.0+1.0
  @what.7=14.64/2.
RCC blp_i    0.0 6.5099999999999998 1395.20000000000003 0.0 0.0 974.7379999999983 7.3200000000000003
  * Beamline transport pipe, SS shell
  @what.2=b(blp_i,2)
  @what.3=b(blp_i,3)
  @what.6=b(blp_i,6)
  @what.7=15.2472.
RCC blp_o 0.0 6.5099999999999998 1395.2000000000003 0.0 0.0 974.737999999999983 7.6200000000000001
* Lead shielding 6mm
!@what.2=b(blp_i,2) !@what.3=b(blp_i,3) !@what.6=b(blp_i,6) !@what.7=b(blp_o,7)+0.6
RCC blp_shd 0.0 6.5099999999999998 1395.2000000000003 0.0 0.0 974.73799999999983 8.2200000000000006
* Outer SS layer
!@what.2=b(blp_i,2) !@what.3=b(blp_i,3) !@what.6=b(blp_i,6) !@what.7=b(blp_o,7)+0.75
RCC blp_shdl 0.0 6.5099999999999998 1395.2000000000003 0.0 0.0 974.737999999999983 8.3700000000000001
* A Hutch DS aperture
!@what.2=b(blp_i,2) !@what.3=b(bbwxxA_i,1) !@what.7=22.9/2.
RCC hutA_ap 0.0 6.5099999999999998 1295.0 0.0 0.0 5.0 11.449999999999999
* pipe collar
!@what.2=gicOS !@what.3=4066.9-5.0-zro !@what.7=33.2/2.
RCC collar 0.0 6.5099999999999998 1390.2000000000003 0.0 0.0 5.10 16.600000000000001
* pipe collar aperture
!@what.2=gicOS !@what.3=4066.9-5.0-zro !@what.7=15.24/2.
RCC collrap 0.0 6.5099999999999998 1390.2000000000003 0.0 0.0 5.0 7.6200000000000001
* Pipe collar DS edge
!@what.1=4066.9-zro
XYP collrds 1395.2000000000003
* Interface Box DS walls
!@what.1=4073.3-zro -5.8
XYP ibds1 1395.8000000000004
* Interface Box DS walls
   !@what.1=4073.3 -zro -5.4
   XYP ibds2  1396.2000000000003
* Interface Box DS walls
   !@what.1=4073.3 -zro -0.4
   XYP ibds3  1401.2000000000003
* Interface Box DS walls
   !@what.1=4073.3 -zro
   XYP ibds4  1401.6000000000004
* Interface box outboard wall
   !@what.1=55.8/2. -2.8
   YZP ibxo1  25.09999999999998
* Interface box outboard wall
   !@what.1=55.8/2. -2.4
   YZP ibxo2  25.5
* Interface box outboard wall
   !@what.1=55.8/2. -0.4
   YZP ibxo3  27.5
* Interface box outboard wall
   !@what.1=55.8/2.
   YZP ibxo4  27.89999999999999
* Interface box inboard wall
   !@what.1=-b(ibxo1,1)
   YZP ibxi1  -25.09999999999998
* Interface box inboard wall
   !@what.1=-b(ibxo2,1)
   YZP ibxi2  -25.5
* Interface box inboard wall
   !@what.1=-b(ibxo3,1)
   YZP ibxi3  -27.5
* Interface box inboard wall
   !@what.1=-b(ibxo4,1)
   YZP ibxi4  -27.89999999999999
* Interface box top wall
   !@what.1=55.8/2.0 +gioOS -2.8
   XZP ibyt1  31.609999999999996
* Interface box top wall
   !@what.1=55.8/2.0 +gioOS -2.4
   XZP ibyt2  32.00999999999998
* Interface box top wall
!@what.1=55.8/2.0 +gioOS -0.4
XZP ibyt3 34.009999999999998
* Interface box top wall
!@what.1=55.8/2.0 +gioOS
XZP ibyt4 34.409999999999997
* Interface box bottom wall
!@what.1=-55.8/2.0 +gioOS +2.8
XZP ibyb1 -18.59
* Interface box bottom wall
!@what.1=-55.8/2.0 +gioOS +2.4
XZP ibyb2 -18.990000000000002
* Interface box bottom wall
!@what.1=-55.8/2.0 +gioOS +0.4
XZP ibyb3 -20.990000000000002
* Interface box bottom wall
!@what.1=-55.8/2.0 +gioOS
XZP ibyb4 -21.390000000000001
END
* Black hole
BLKBODY 5 +blkbody -air
* Void around
AIR 5 +air +rwxxA_i +rwxxA_s +swxxA_s -swxxA_i
    | +air +rwxxA_i +swxxA_s -rwxxA_s -swxxA_i
    | +air +rwxxA_i +swxxA_i +swxxA_s
    | +air +swxxA_s -rwxxA_i -rwxxA_s -swxxA_i
    | +air +rwxxA_s +swxxA_i +swxxA_s -rwxxA_i
    | +air -rwxxA_i -rwxxA_s -swxxA_i -swxxA_s
    | +air +rwxxA_s +bfwxxB_o -rwxxA_i -swxxA_i -swxxA_s -blp_shdl
    | +air +rwxxA_s +swxxA_i -rwxxA_i -swxxA_s
    | +air +rwxxA_s +swxxA_s -rwxxA_i -swxxA_i -rfxxA_t
    | +air +rwxxA_s +swxxA_i +flxxA_b -rwxxA_i -swxxA_i
    | +rwxxA_s +rfxxA_t +bbwxxA_o -rwxxA_o -flxxA_t -bswxxA_o
    | +rwxxA_s +swxxA_s +rfxxA_t -swxxA_o -flxxA_t -bbwxxA_o -blp_shdl~(-bbwxxA_o +ibds4 +ibxo4 -ibxi4
    | +ibyt4 -ibyb4)
    | +rfxxA_t +bswxxA_o +bbwxxA_o -rwxxA_o -swxxA_o -brfxxA_t
    | +air -bfwxxB_o

* Fixed mask MA0
FM0_XX 5 +fm0_ -fm0_in -fm0_zc
* Fixed mask MA3

FM3_XX 5 +fm3_ -fm3_in -fm3_zc
  | +fm3_ +fm3_zc -fm3_yt
  | +fm3_ +fm3_yb +fm3_zc
  | +fm3_ +fm3_yt +fm3_zc -fm3_xo -fm3_yb
  | +fm3_ +fm3_xi +fm3_yt +fm3_zc -fm3_yb

* Fixed mask MA3 aperture

FM3_XXA 5 +fm3_ +fm3_in -fm3_zc
  | +fm3_ +fm3_zc +fm3_xo +fm3_yt +fm3_zc -fm3_xi -fm3_yb

* Shield CM-BS3

CMBS3 5 +cmbs3 -cmbs3ap

* CM-BS3 aperture

CMBS3AP 5 +cmbs3ap -fm3_

* Shield CM-BS4

CMBS4 5 +cmbs4 -cmbs4ap

* CM-BS4 aperture

CMBS4AP 5 +cmbs4ap

* Shield SGB1

SGB1 5 +sgb1 -sgb1ap

* Shield SGB1 aperture

SGB1AP 5 +sgb1ap -cmbs4

* Mono-beam mask MM

FMM_XX 5 +fmm_ -fmm_in -fmm_zc
  | +fmm_ +fmm_zc -fmm_yt
  | +fmm_ +fmm_yb +fmm_zc
  | +fmm_ +fmm_yt +fmm_zc -fmm_xo -fmm_yb
  | +fmm_ +fmm_xi +fmm_yt +fmm_zc -fmm_yb

* Mono-beam mask MM aperture

FMM_XXA 5 +fmm_ +fmm_in -fmm_zc
  | +fmm_ +fmm_xo +fmm_yt +fmm_zc -fmm_xi -fmm_yb

* 1st crystal of HHM

MONO1 5 +mono1

* 2nd crystal of HHM

MONO2 5 +mono2

PBS 5 +pbsxo -pbsxi -pbszu +pbszd -pbsyb +pbsyt

* Shield SGB2

SGB2 5 +sgb2 -sgb2ap

* Shield SGB2 aperture

SGB2AP 5 +sgb2ap
* Focussing Mirror
FOCMIR 5 +focmir
* Shield SGB3
SGB3 5 +sgb3
* Photon Shutter
SHUTTER 5 +psh -psh_ap
* Shutter APERTURE
SHUTERAP 5 +psh_ap
* Guillotine APERTURE
GILOAP 5 +giotn_ap
* Guillotine
GILOTN 5 +giotn -giotn_ap
* Hutch A APERTURE
HUTA_AP 5 +hutA_ap
* Storage ring outer shielding
SOW_SHLD 5 +rwxxA_o +rwxxA_s +rfxxA_t -rwxxA_i -swxxA_i -flxxA_t
| +swxxA_o +swxxA_s +rfxxA_t -rwxxA_o -swxxA_i -flxxA_t |
| +rwxxA_s +swxxA_s +flxxA_t -rwxxA_i -swxxA_i -flxxA_b |
ARF_SHD 5 +bswxxA_o +bbwxxA_o +brfxxA_t -rwxxA_o -swxxA_o -brfxxA_b
ENC_A 5 +bswxxA_i +bbwxxA_i +brfxxA_b -rwxxA_o -swxxA_o -flxxA_t -cmco1 -cml
-giotn -fm0 -fm1 -cmbs2 -fm2 -fm2sup -cm2 -fm3 -cmbs3 -cmbs4 -sgb1 -fmm
-sgb2 -focmir -sgb3 -psh -mono1 -mono2 -( +pbsxo -pbsxi -pbszu +pbszd -pbsyb +pbsyt )
ASW_SHD 5 +bswxxA_o +bbwxxA_i +brfxxA_b -rwxxA_o -flxxA_t -bswxxA_i
ABW_SHD 5 +bswxxA_o +bbwxxA_o +brfxxA_b -swxxA_o -flxxA_t -bbwxxA_i -hutA_ap
* Transport pipe starting at IB downstream edge
tbp_va 5 +bfwxxB_o +blp_o +blp_i -ibds1
tbp_ss 5 +bfwxxB_o +blp_o -blp_i -ibds1
tbp_sh 5 +bfwxxB_o +blp_shd -blp_o -ibds1
tbp_sh1 5 +bfwxxB_o +blp_shd1 -blp_shd -ibds1
* Pipe collar inside Interface box
COLLAR 5 +collar -collrap
* Pipe collar aperture
COLLRAP 5 +collrap
* Interface Box Cavity
IB 5 -bbwxxA_o +ibds1 +ibxo1 -ibxil +ibyt1 -ibyb1 -collar
* Interface Box inside SS layer
IB1 5 -bbwxxA_o +ibds2 +ibxo2 -ibxil2 +ibyt2 -ibyb2 -(-bbwxxA_o +ibds1 +ibxo1 -ibxil1 +ibyt1 -ibyb1)
- blp_shd1
* Interface Box Pb layer
IB2          5 -bbwxxA_o +ibds3 +ibxo3 -ibxi3 +ibyt3 -ibyb3 -(-bbwxxA_o +ibds2 +ibxo2 -ibxi2 +ibyt2 -ibyb2)
           -blp_shd1
* Interface Box outside SS layer
IB3          5 -bbwxxA_o +ibds4 +ibxo4 -ibxi4 +ibyt4 -ibyb4 -(-bbwxxA_o +ibds3 +ibxo3 -ibxi3 +ibyt3 -ibyb3)
           -blp_shd1
END
GEOEND
MATERIAL  2.35  26. CONCRETE
COMPONENT -0.01 HYDROGEN -.54 OXYGEN -0.02 SODIUM CONCRETE
COMPONENT -.04 ALUMINUM -.34 SILICON -.05 CALCIUM CONCRETE
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
ASSIGNMA BLCKHOLE BLKBODY
ASSIGNMA AIR AIR
ASSIGNMA VACUUM ENC_A
ASSIGNMA CONCRETE SOW_SHLD
ASSIGNMA LEAD ARF_SHD
ASSIGNMA LEAD ASW_SHD
ASSIGNMA LEAD ABW_SHD
ASSIGNMA COPPER FM0_XX
ASSIGNMA VACUUM FM0_XXA
ASSIGNMA COPPER FM1_XX
ASSIGNMA VACUUM FM1_XXA
ASSIGNMA TUNGSTEN CMCO1
ASSIGNMA VACUUM CMCO1AP
ASSIGNMA SILICON CM1
ASSIGNMA TUNGSTEN CMBS2
ASSIGNMA VACUUM CMBS2AP
ASSIGNMA COPPER FM2_XX
ASSIGNMA VACUUM FM2_XXA
ASSIGNMA IRON FM2SUP
ASSIGNMA SILICON CM2
ASSIGNMA COPPER FM3_XX
ASSIGNMA VACUUM FM3_XXA
ASSIGNMA TUNGSTEN CMBS3
ASSIGNMA VACUUM CMBS3AP
ASSIGNMA TUNGSTEN CMBS4
ASSIGNMA VACUUM CMBS4AP
ASSIGNMA COPPER FM4_XX
ASSIGNMA VACUUM FM4_XXA
ASSIGNMA SILICON MONO1
ASSIGNMA SILICON MONO2
ASSIGNMA COPPER PBS
ASSIGNMA LEAD SGB1
ASSIGNMA VACUUM SGB1AP
ASSIGNMA LEAD SGB2
ASSIGNMA VACUUM SGB2AP
ASSIGNMA SILICON FOCMIR
ASSIGNMA LEAD SGB3
ASSIGNMA TUNGSTEN SHUTTER
ASSIGNMA VACUUM SHUTERAP
ASSIGNMA VACUUM GILOAP
ASSIGNMA LEAD GILOTN
ASSIGNMA VACUUM tbp_va
ASSIGNMA IRON tbp_ss
ASSIGNMA LEAD tbp_sh
ASSIGNMA VACUUM HUTA_AP
ASSIGNMA LEAD COLLAR
ASSIGNMA VACUUM COLLRAP
ASSIGNMA VACUUM IB
ASSIGNMA IRON IB1
ASSIGNMA LEAD IB2
ASSIGNMA IRON IB3
ASSIGNMA IRON tbp_sh1

PHOTONUC 1.0 HYDROGEN @LASTMAT
LAM-BIAS 0.0 0.02 COPPER PHOTON
LAM-BIAS 0.0 0.02 LEAD PHOTON
LAM-BIAS 0.0 0.02 IRON PHOTON
LAM-BIAS 0.0 0.02 TUNGSTEN PHOTON
LAM-BIAS 0.0 0.02 CONCRETE PHOTON
LAM-BIAS 0.0 0.02 SILICON PHOTON
USRBIN 10.0 DOSE-EQ -30.0 150.0 200.0 2000.0 FOE_T
USRBIN -150.0 -100.0 0.0 60.0 60.0 200.0 &
AUXSCORE USRBIN ALL-PART FOE_T AMB74
USRBIN 10.0 DOSE-EQ -30.0 150.0 200.0 2000.0 FOE_P
USRBIN -150.0 -100.0 0.0 60.0 60.0 200.0 &
AUXSCORE USRBIN PHOTON FOE_P AMB74
USRBIN 10.0 DOSE-EQ -30.0 150.0 200.0 2000.0 FOE_N
USRBIN -150.0 -100.0 0.0 60.0 60.0 200.0 &
AUXSCORE USRBIN NEUTRON POE_N AMB74
USRBIN 10. DOSE-EQ -31. 200. 211.0 1450.0RF_T
USRBIN -200. 201.0 0. 200. 10. 290. &
AUXSCORE USRBIN ALL-PART RF_T AMB74
USRBIN 10. DOSE-EQ -31. 200. 211.0 1450.0RF_N
USRBIN -200. 201.0 0. 200. 10. 290. &
AUXSCORE USRBIN NEUTRON RF_N AMB74
USRBIN 10. DOSE-EQ -31. 161.2 100. 1450.0SW_T
USRBIN 151.2 -100. 0. 10. 100. 290. &
AUXSCORE USRBIN ALL-PART SW_T AMB74
USRBIN 10. DOSE-EQ -32. 161.2 100. 1450.0SW_N
USRBIN 151.2 -100. 0. 10. 100. 290. &
AUXSCORE USRBIN NEUTRON SW_N AMB74
USRBIN 10. DOSE-EQ -32. 160.0 200.0 1450.0BW_T
USRBIN -160.0 -140.0 1300.0 64.0 68.0 75.0 &
AUXSCORE USRBIN ALL-PART BW_T AMB74
USRBIN 10. DOSE-EQ -32. 160.0 200.0 1450.0BW_N
USRBIN -160.0 -140.0 1300.0 64.0 68.0 75.0 &
AUXSCORE USRBIN NEUTRON BW_N AMB74
USRBIN 10. DOSE-EQ -33. 100. 100. 1500.0MoreT
USRBIN -100. -100. 0.0 100. 100. 750.0 &
AUXSCORE USRBIN ALL-PART MoreT AMB74
USRBIN 10. DOSE-EQ -33. 100. 100. 1500.0MoreN
USRBIN -100. -100. 0.0 100. 100. 750.0 &
AUXSCORE USRBIN NEUTRON MoreN AMB74
USRBIN 10. DOSE-EQ -35. 20.0 20. 2300.0TP_T
USRBIN -20. -4. 1300.0 40. 24. 500.0 &
AUXSCORE USRBIN ALL-PART TP_T AMB74
USRBIN 10. DOSE-EQ -35. 20.0 20. 2300.0TP_N
USRBIN -20. -4. 1300.0 40. 24. 500.0 &
AUXSCORE USRBIN NEUTRON TP_N AMB74
* Beam position and direction
!@what.1=C(BEAMPOS,0,1)
!@what.2=C(BEAMPOS,0,2)
!@what.3=C(BEAMPOS,0,3)
!@what.4=b1*C(BEAMPOS,0,4)
!@what.5=b1*C(BEAMPOS,0,5)
!@what.9=b1*sqrt(1.0-C(BEAMPOS,0,4)**2-C(BEAMPOS,0,5)**2)
!arrow 4.32 0.0 800. 500. 220.beam
!arrow 0.0 0.0 4500.
* Beam position and direction
!*arrow 1.5 0.0 590.0 500. 220.beam &
!*arrow 0.3 0.0 100.0 &
* Beam position and direction
!*arrow -140.0 1.0778 -530.0 500. 220.beam &
!*arrow 0.0 0.0 4500.0 &
!@what.2=b(brmcolap,2)
!@what.3=b(brmcolap,5)
!@what.7=b(brms,2)-b(brmcolap,2)-4.613
!@what.9=b(brms_ap,5)-b(brmcolap,5)
!*arrow 0.0 ? ? 0.0 0.0 0.0UMaxRayH
!*arrow ? 0.0 ? &
!@what.2=b(brmcolap,4)
!@what.3=b(brmcolap,5)
!@what.8=b(brms_ap,3)-b(brmcolap,4)-2.828
!@what.9=b(brms_ap,5)-b(brmcolap,5)
!*arrow 0.0 ? ? 0.0 0.0 0.0UMaxRayV
!*arrow 0.0 ? ? &
* Set the random number seed
RANDOMIZ 1.0574998238.
* Set the number of primary histories to be simulated in the run
START 1.E8 54000.0
STOP