

Study of NuMI Critical Devices using MARS

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The critical devices for the NuMI primary beam are the Lambertsons and the HV101 dipole string in the MI Extraction Enclosure (NuMI stub). The purpose of this study was to verify the function of the NuMI primary critical devices (Lambertsons and HV101) for the upgraded NuMI beam optics. Two failure scenarios were simulated with MARS using the existing NuMI beamline model:

1. Lambertsons are OFF (all 3 magnets) and all other magnets at normal field.
2. HV101 dipole string is OFF (all 6 magnets) and all other magnets - including Lambertsons - at normal field.

In both cases, the prompt dose rate was calculated in the tunnel just downstream of the carrier tunnel interlock gate. This is at the downstream end of the 6-foot diameter concrete pipe, and just upstream of Q113. In addition, dose rates were calculated 17 and 37 meters upstream of this gate to measure the dose attenuation.

In the first scenario the Lambertsons are off, and the beam hits the wall of the Main Injector tunnel as shown in Figures 1 and 2. The relative positions of the beam loss point and interlock gate are shown in Figure 3. Dose rate distributions are shown in Figures 4 through 6. Results are presented in the NuMI beamline coordinate system (points with $x = 0$, $y = 0$ on the figures coincide with coordinates of the beam closed orbit). It is seen that at the first surface (about 40 meters upstream of the interlock gate, Fig.4) there are two spots - in the primary beam direction and inside or near the tunnel. Radiation reaches the second surface (about 20 meters upstream from the gate, Fig.5) mostly from inside the tunnel. The dose in the primary beam direction is very small. The dose distribution at the interlock gate is presented in Figure 6. The average dose inside the tunnel is 0.45 mSv/hr at the gate. Note that the existing model does not include elements of the Main Injector beam line.

If there is no magnetic field in the HV101 dipole string, scenario 2, the beam is lost on the first HV101 magnet (Fig.7). The beam loss point is shifted away from the gate in both horizontal and vertical directions compared with scenario 1. Dose rates are calculated at three surfaces - interlock gates (Fig.10), 37 meters (Fig.8) and 17 meters (Fig.9) upstream. The average dose rate inside the tunnel at the interlock gate is 3.2×10^{-3} mSv/hr.

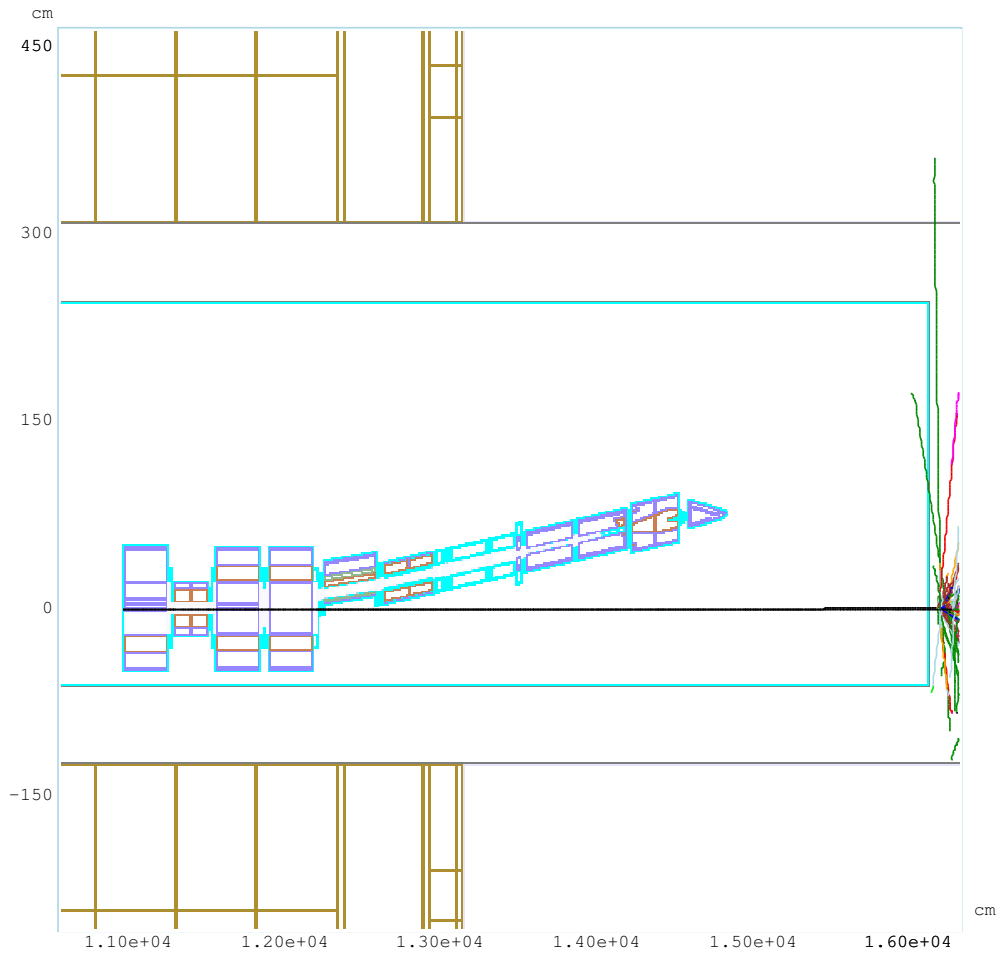


Figure 1: Beam loss scenario 1: the Lambertsons are OFF. Plan view of the NuMI stub region.

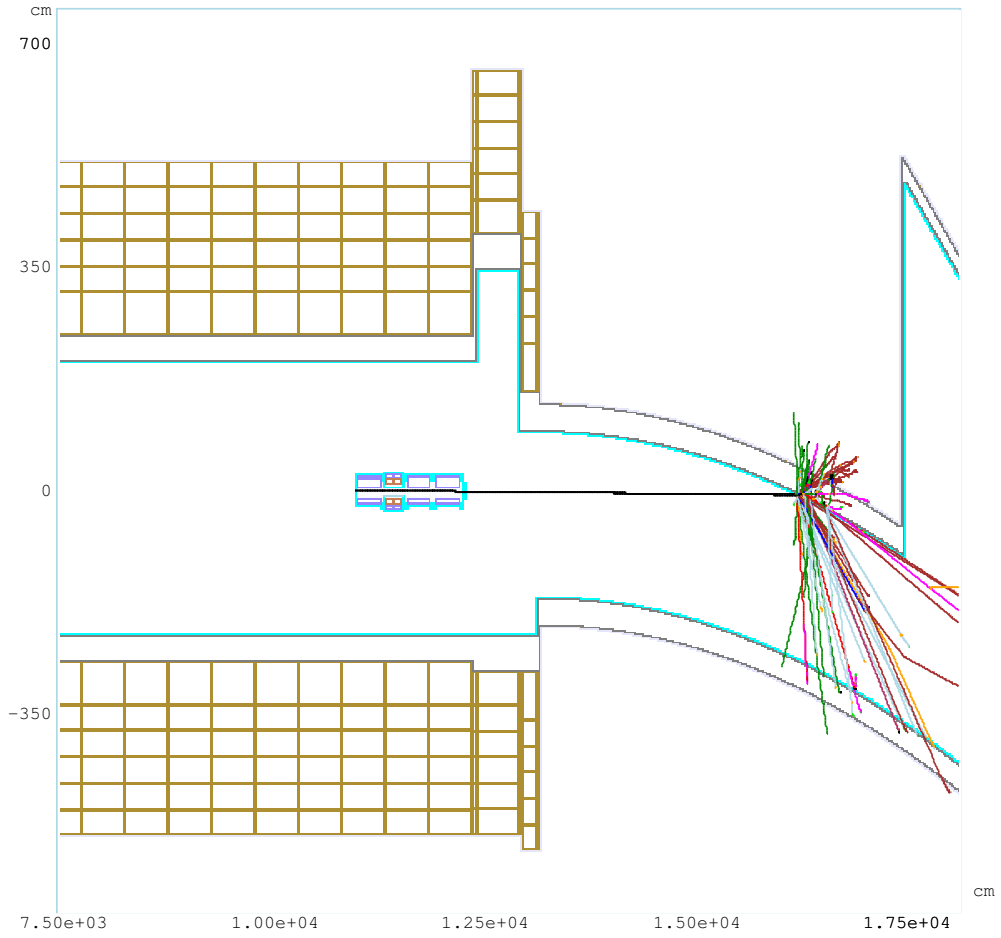


Figure 2: Beam loss scenario 1: the Lambertsons are OFF. Elevation view of the NuMI stub region.

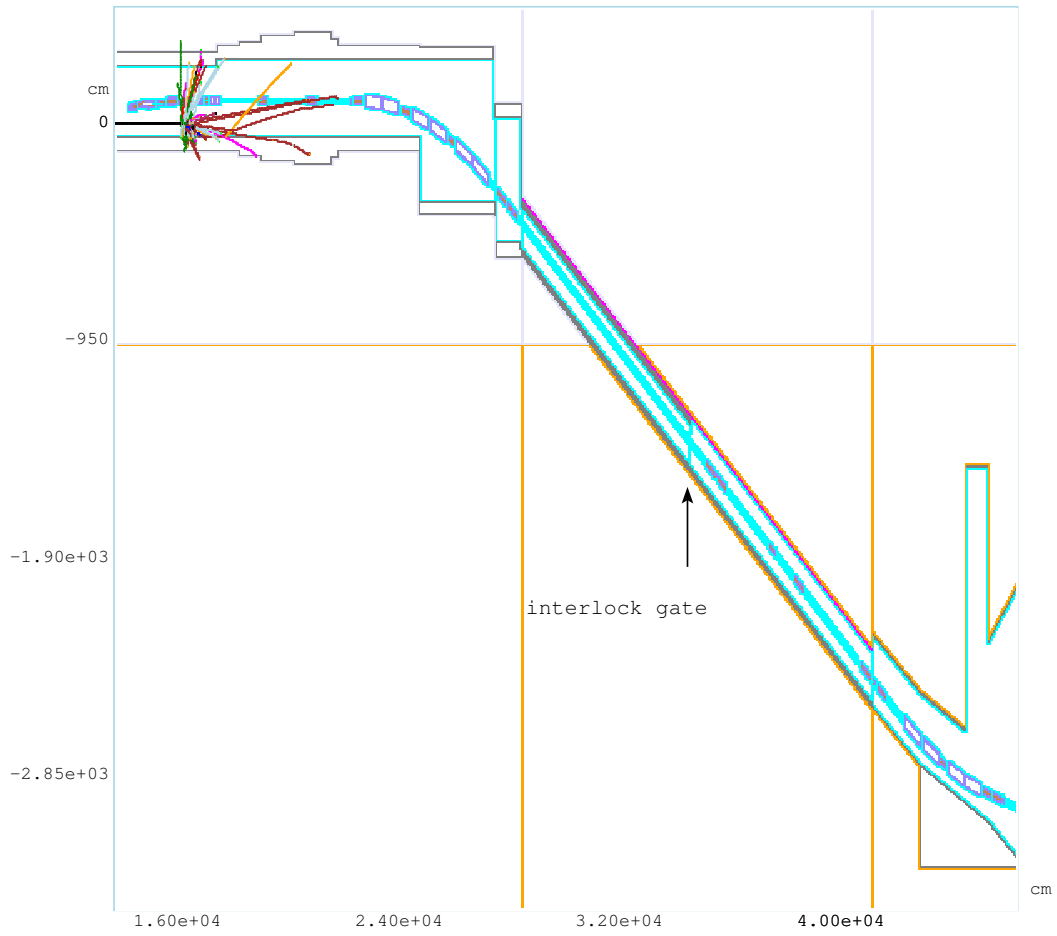


Figure 3: Beam loss scenario 1: Lambertsons are OFF. Elevation view of NuMI stub and carrier pipe enclosure.

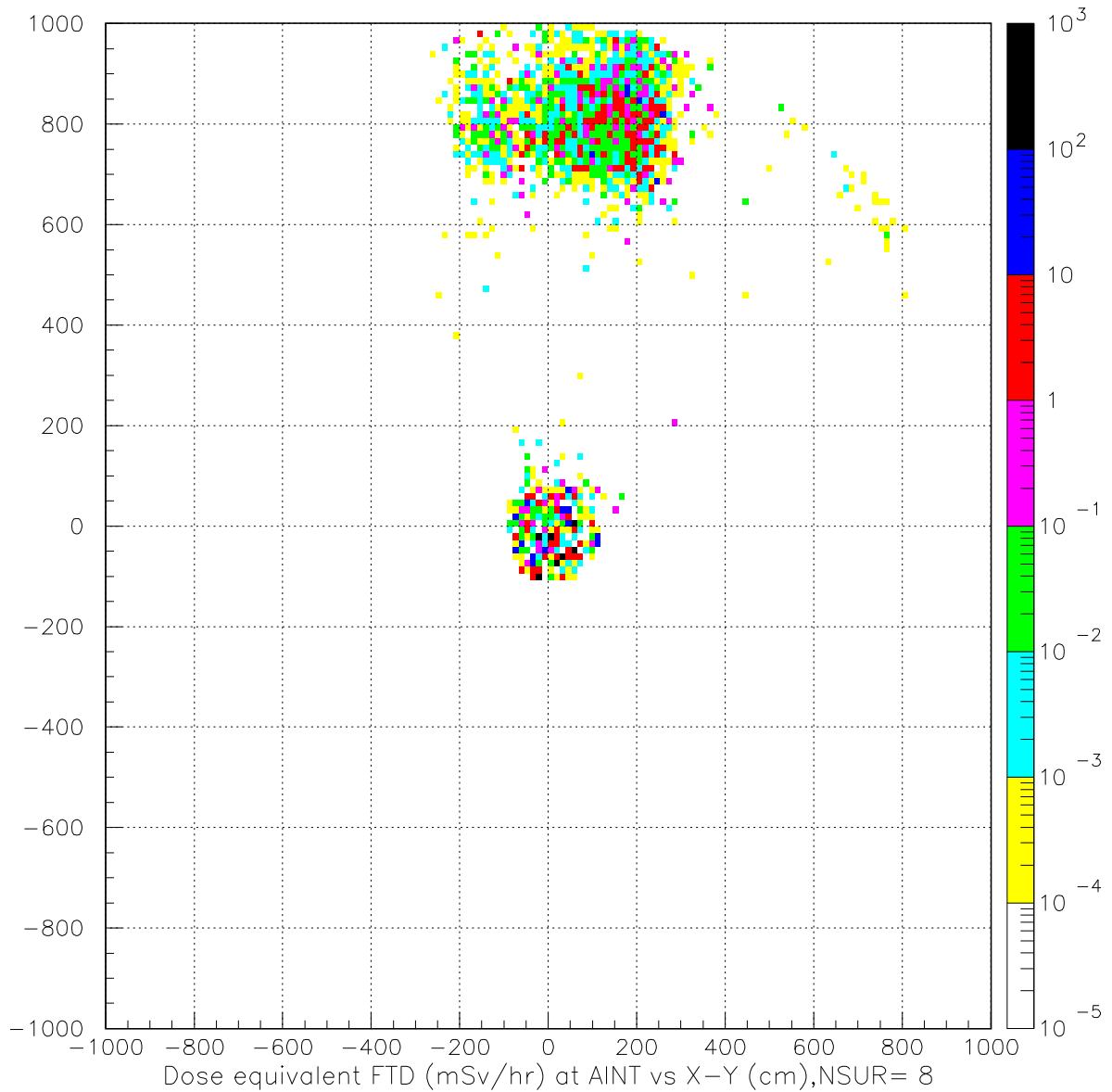


Figure 4: Beam loss scenario 1: Lambertsons are OFF. Prompt dose rate at 37 meters upstream of the interlock gate. The vertical direction (up) is to the right.

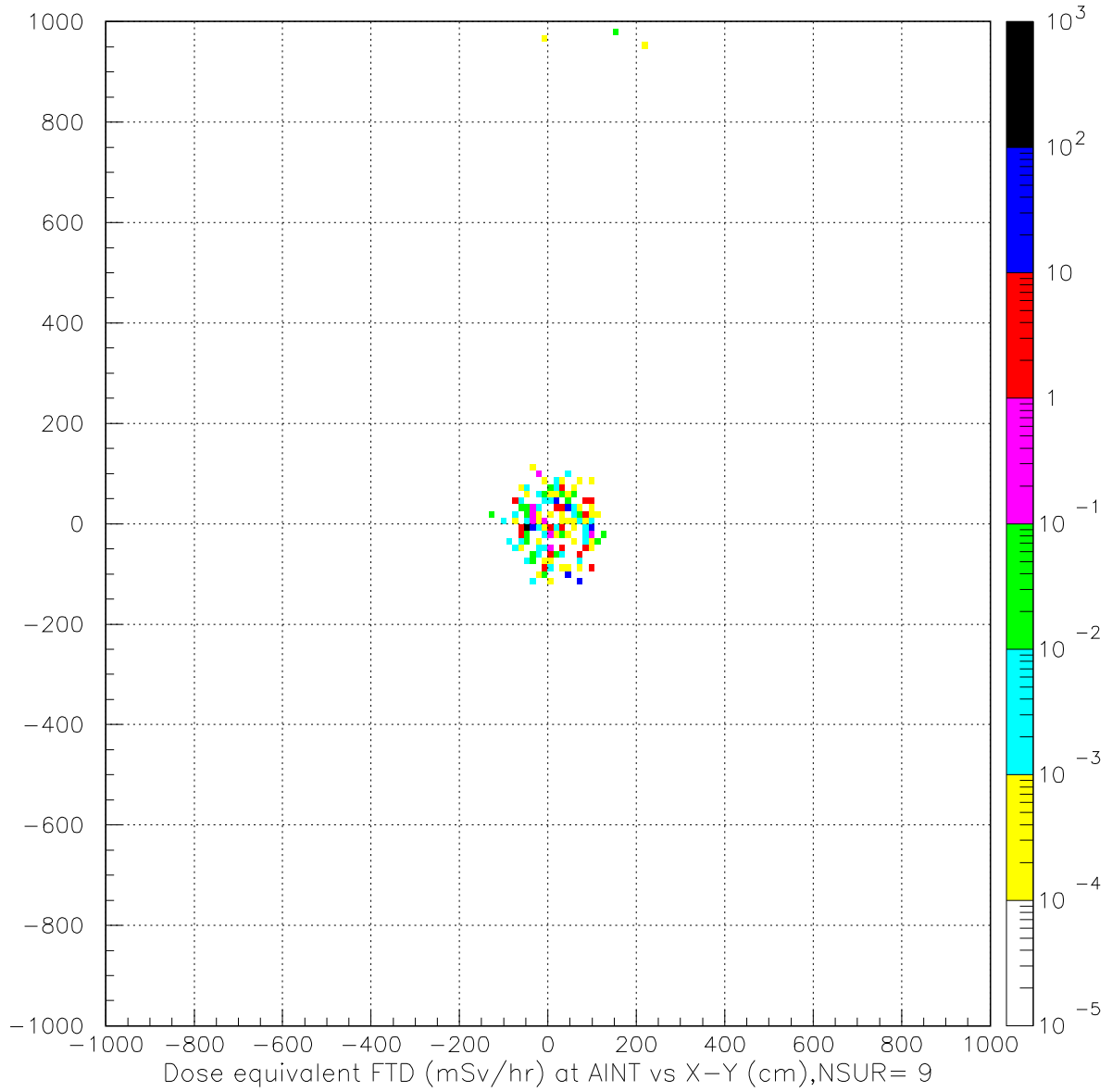


Figure 5: Beam loss scenario 1: Lambertsons are OFF. Prompt dose rate at 17 meters upstream of the interlock gate. The vertical direction (up) is to the right.

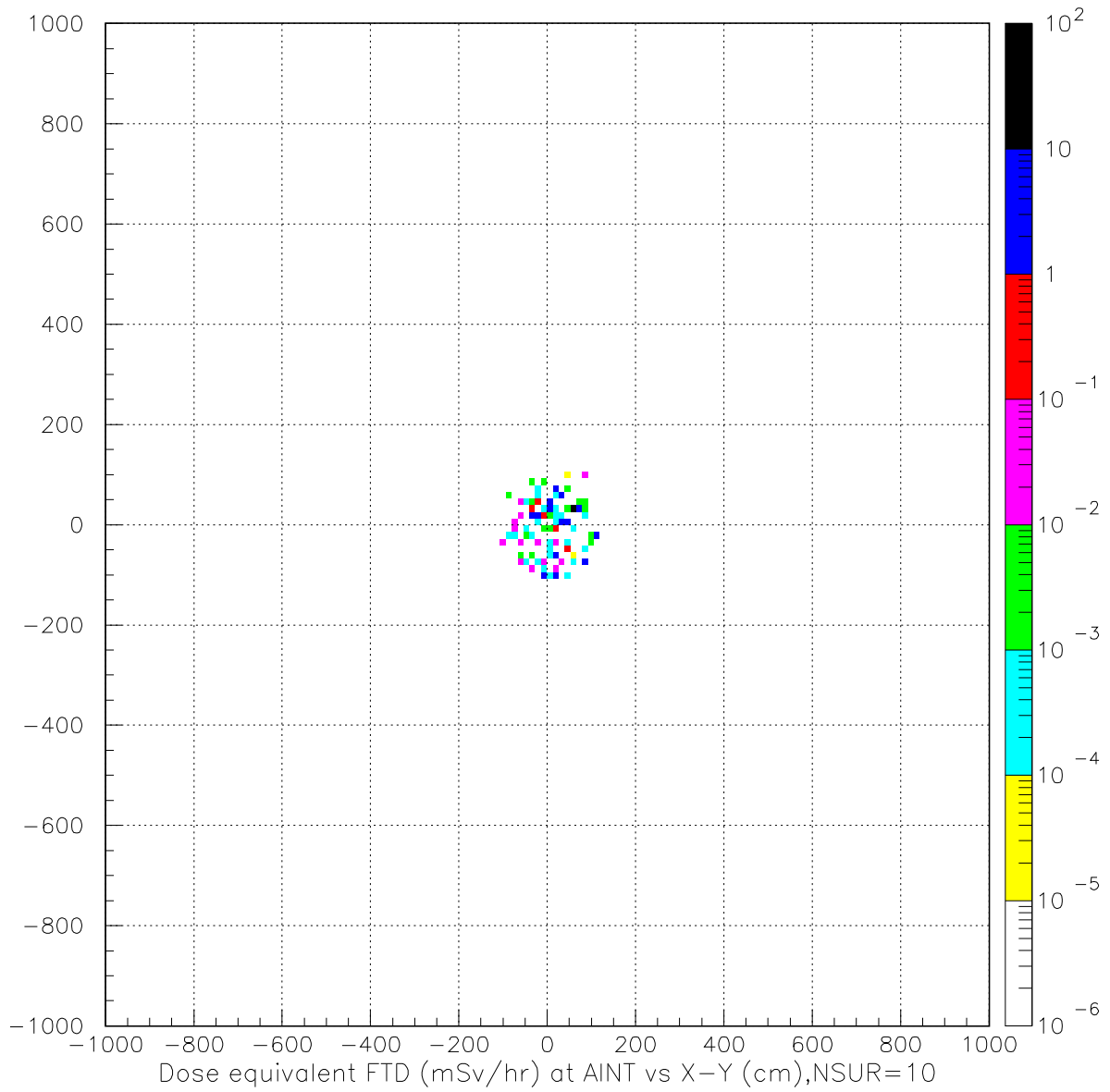


Figure 6: Beam loss scenario 1: Lambertsons are OFF. Prompt dose rate at the interlock gate. The vertical direction (up) is to the right.

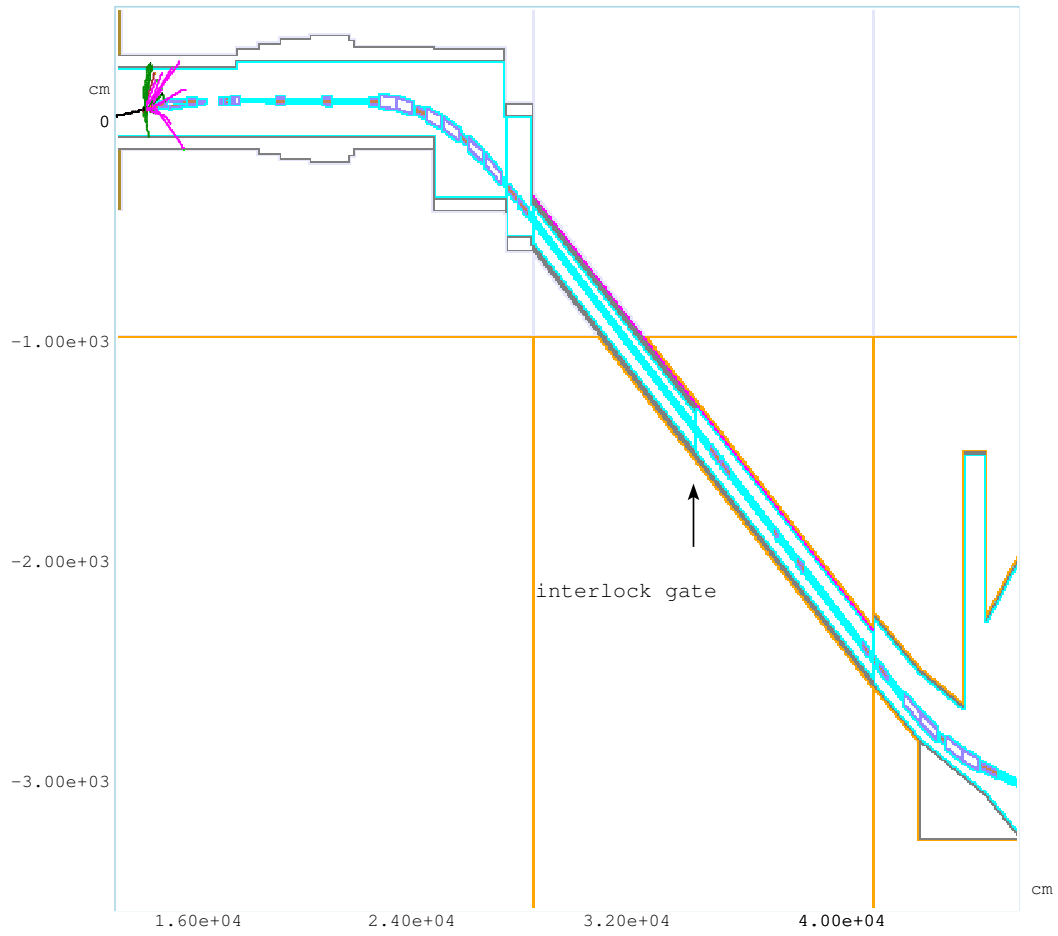


Figure 7: Beam loss scenario 2: HV101 string is OFF. Elevation view of NuMI stub and carrier pipe enclosure.

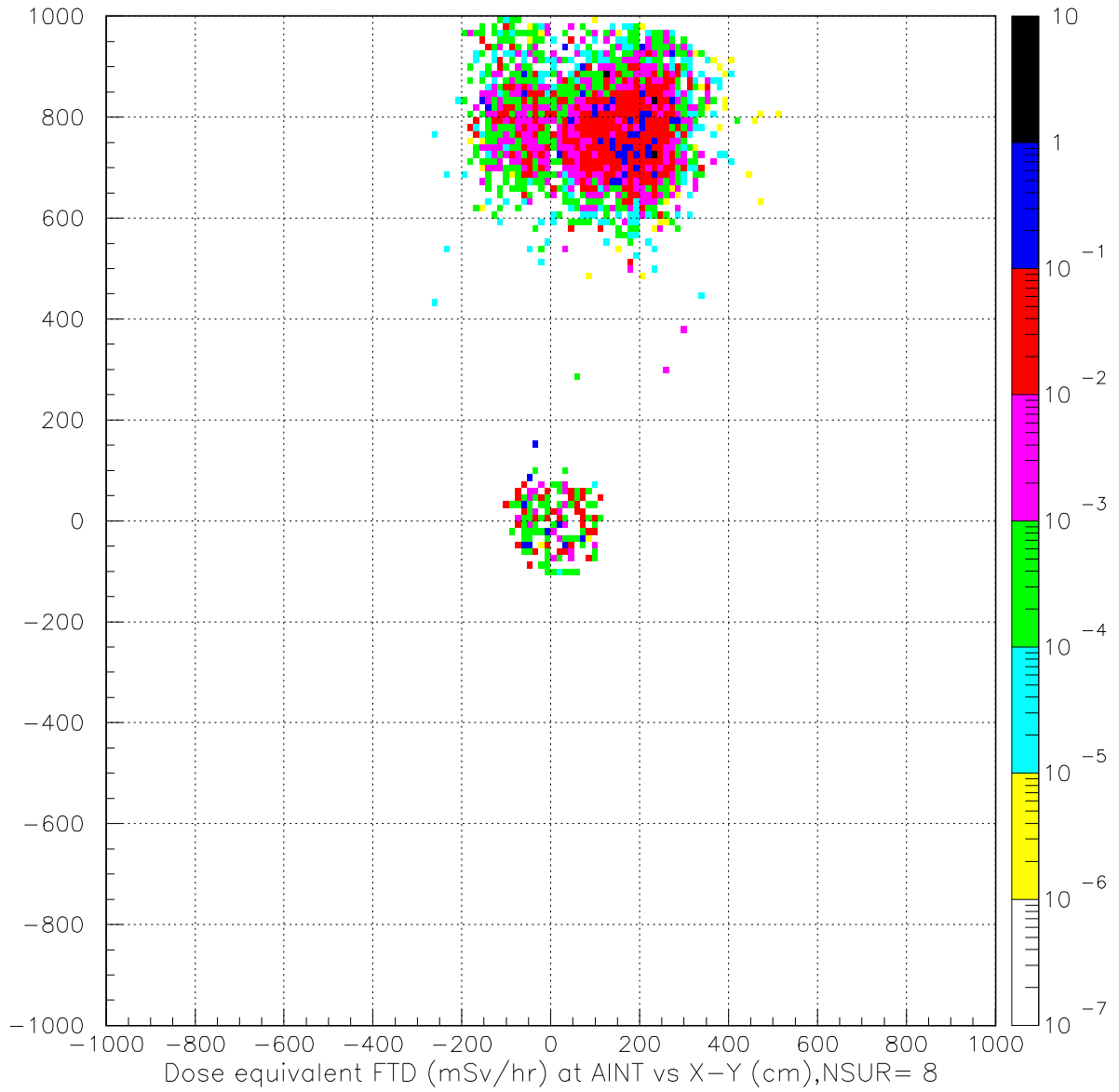


Figure 8: Beam loss scenario 2: HV101 string is OFF. Prompt dose rate at 37 meters upstream of the interlock gate. The vertical direction (up) is to the right.

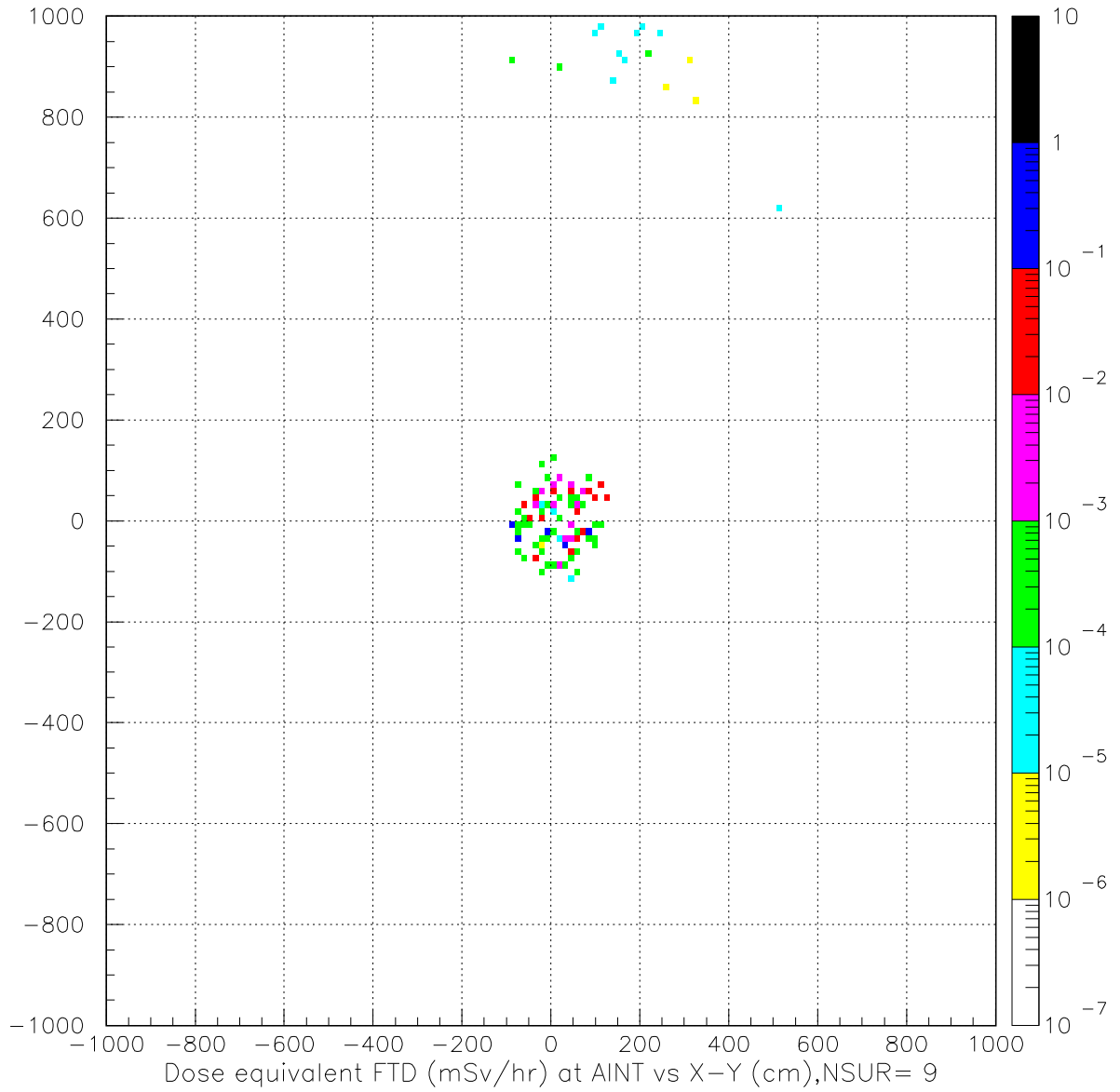


Figure 9: Beam loss scenario 2:HV101 string is OFF. Prompt dose rate at 17 meters upstream of the interlock gate. The vertical direction (up) is to the right.

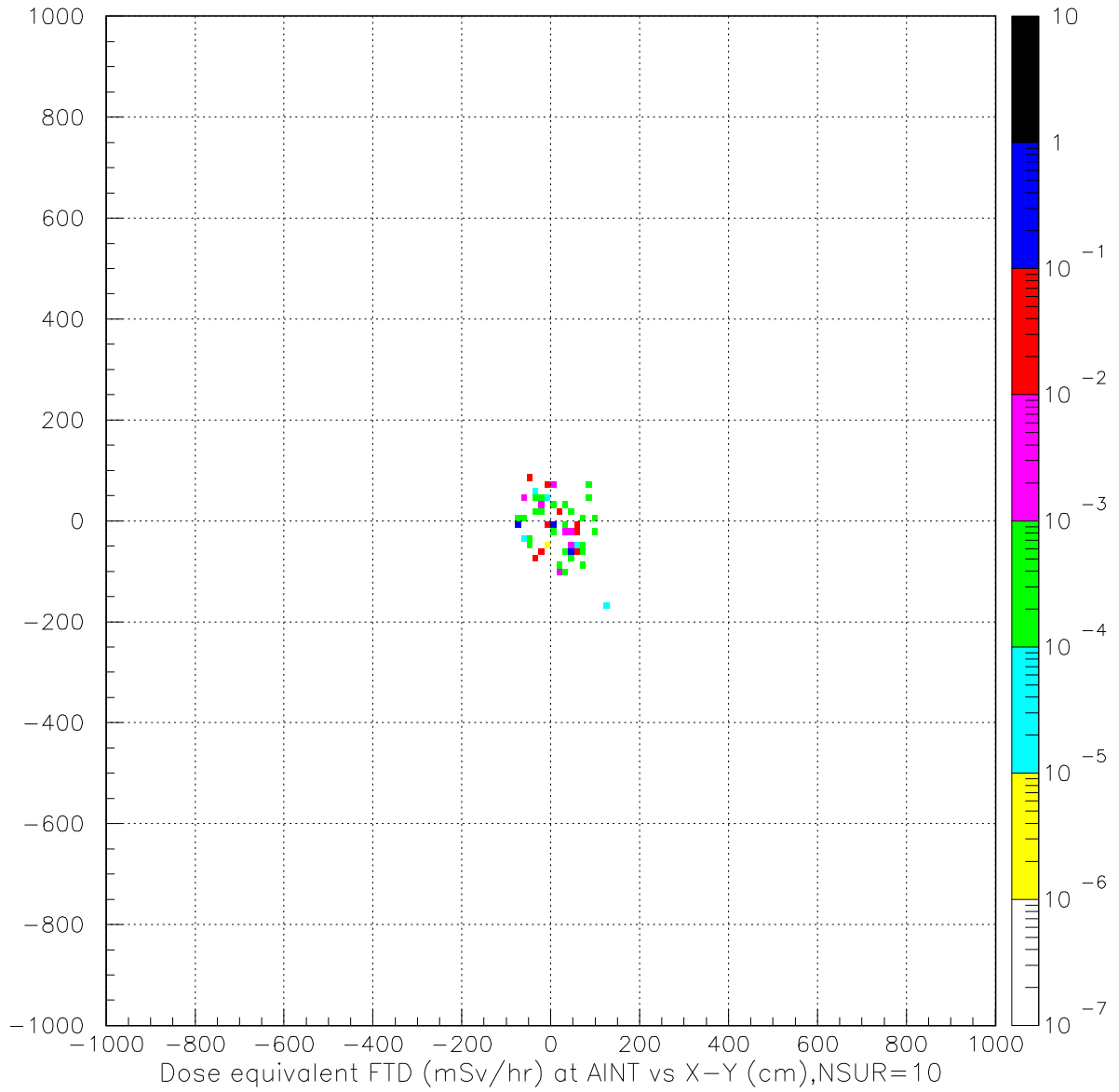


Figure 10: Beam loss scenario 2: HV101 string is OFF. Prompt dose rate at the interlock gate. The vertical direction (up) is to the right.