Radiation doses around the 12 o'clock IP due to various faults

April 20, 2013

Kin Yip

Experimental Support & Facilities Division, Collider-Accelerator Department

I. Introduction

This note is to report on the simulation done to estimate the radiation doses at the 12 o'clock area. The z-coordinate is along the beam direction, with z=0 (close to the leading edge of DX, around the junction where the Experimental Hall meets the tunnel and the +ve z direction is the direction pointing from the Interaction Point {IP} to the DX in the east side of the IP), y-coordinate points vertically towards the sky and the remaining x-coordinate is fixed by the right-hand-rule.

Though the author has started from an earlier geometry of PHENIX, things surrounding the IP of 12 o'clock is very different from that of 8 o'clock and the author has used substantial time to add a lot of details in the 12 o'clock area (including the support building and the parking) up to the fence.

From [1], the full and maximum beam after the upgrades will be 5×10^{13} protons per ring. The (kinetic) energy of proton beam used in all simulation described is 250 GeV.

When protons hit DX, they are at an angle about 3.67 mrad which has been an angle recommended (by the machine physicists) and used in background simulation several years ago.

All the dose results shown below are due to neutrons (eg. photons typically contribute around 1 to 2% of the neutron doses in the simulation and are ignored).

II. MCNPX Simulation

This simulation considers only the "Ring Center Side" of the 12 o'clock structure, where people normally get access to the service building and park their cars. The "Side Opposite Ring Center" is heavily shielded by thick layers of concrete blocks that the "Ring Center Side" does not have and thus the radiation risk at the "Side Opposite Ring Center" should be considerably smaller. Figure 1 shows the geometry as seen at beam height (y=0) implemented in the MCNPX simulation (version 2.7.0) and those structures not touching y=0 are not shown. There is a steel door (blue in Figure 1) near the exit of the labyrinth at the lower corner of the figure on the right and the door has a thickness of 4 cm in the simulation (which is a conservative setting as the real thickness can be thicker).

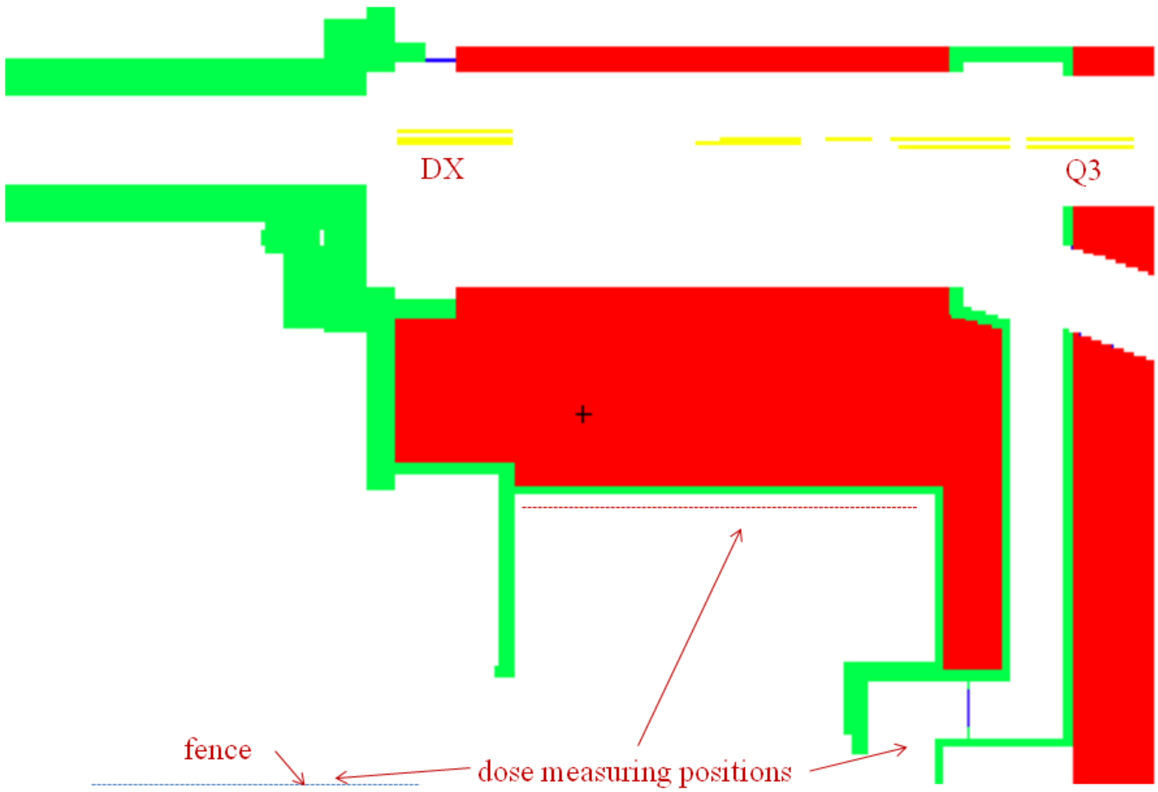

Figure 1: The above diagram shows a plan/top view of a part of the geometry of the 12 o'clock complex seen at vertical coordinate y=0 used in simulation (and structures not touching the plane y=0 are not visible in this diagram). The z-coordinates run from the left to the right whereas the x-coordinates run from the bottom to the top. It also indicates where the doses have been measured in the simulation. The positions of the magnets DX and Q3 (yellow) are as indicated.

From [2] and [3], the largest threat of radiation comes from faults by protons hitting DX or Q3. In the MCNPX simulations, the protons are made to hit the inner aperture of the DX and Q3 magnets at beam height (y=0) and the locations are uniformly distributed across the length of the magnets.

Since now, we have a fence and many spots that people worried about in 1998 as in [3] are no longer the most relevant any more. In this set of simulations, the locations that we measure the doses in the simulation are indicated in Figure 1. They are at the fence, inside the service building and at the exit of the labyrinth in the service building. These are very different locations from what have been used in [3]. Even the fence line is almost ~2 m further away from the IP than what was assumed in [3]. The actual shielding due to the soil and concretes are also different from what they were thought to be in 1998.

III. Results

As in [3], we present the results in the following tables. We assume the loss at DX to be half of the total proton beams (ie. 2.5×10^{13}) and full beam loss at Q3 (ie. 5×10^{13}). We show the maximum dose in each location as found in the MCNPX simulations in 2 significant figures.

Table 1: Maximum doses due to beam faults at Q3 when the beam hit Q3 towards the –z direction.

Locations	Doses due to fault at Q3 (hitting towards –z)
Fence	1.9 mrem
Service building	5.3 mrem
Labyrinth exit	140 mrem

Table 2: Maximum doses due to beam faults at DX when the beam hit DX towards the –z direction.

Locations	Doses due to fault at DX (hitting towards –z)
Fence	7.2 mrem
Service building	0.013 mrem
Labyrinth exit	0.15 mrem

Table 3: Maximum doses due to beam faults at DX when the beam hit DX towards the +z direction.

Locations	Doses due to fault at DX (hitting towards +z)
Fence	0.46 mrem
Service building	0.045 mrem
Labyrinth exit	0.57 mrem

IV. References

[1] Dana Beavis's Radiation Safety Committee memo on Apr. 20, 2012.

[2] RSC Minutes of Meetings held on Sept. 10, 1996 and Oct. 20, 1997 as indicated from D. Beavis memo on Feb. 5, 2010.

[3] AD/RHIC/RD-121, "Dose Equivalent Estimates at the 12 O'Clock IR", July 17, 1998.