Shielding related to the Beryllium window in BLIP

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I. Introduction and Setup

The areas near the Beryllium window of the BLIP beamline have experienced high radiations. Previously, MCNPX (2.7.0) simulation has been used to estimate the doses at various locations. In this note, similar simulation has been performed to investigate the effects of some shielding near the Beryllium window in the BLIP beam line. Only that this time some shielding materials have been added. Figure 1 shows the geometry around the Beryllium window and the relevant shieldings. In the simulation, protons of kinetic energy of 200 MeV are hitted at the center of the Beryllium window and the proton beams have Gaussian σ's (horizontally and vertically) of 0.55 cm.

Cylindrical shielding blocks of 30 cm in length (in the beam direction) are placed inside and outside the beampipe. The detection volumes are the cylindrical shells denoted by 120 (inside) and 121 (outside) in Figure 1 and this is supposedly where the WCM (Wall Current Monitor) will be. { By drawing straight lines from the Beryllium window to the detection volumes, one may see that the portion of the shielding blocks closer to the window, especially the one outside the beampipe are not really effective in intercepting particles bounced off from the Beryllium window. The shielding shown here is just a first attempt and not of an optimal shape. }

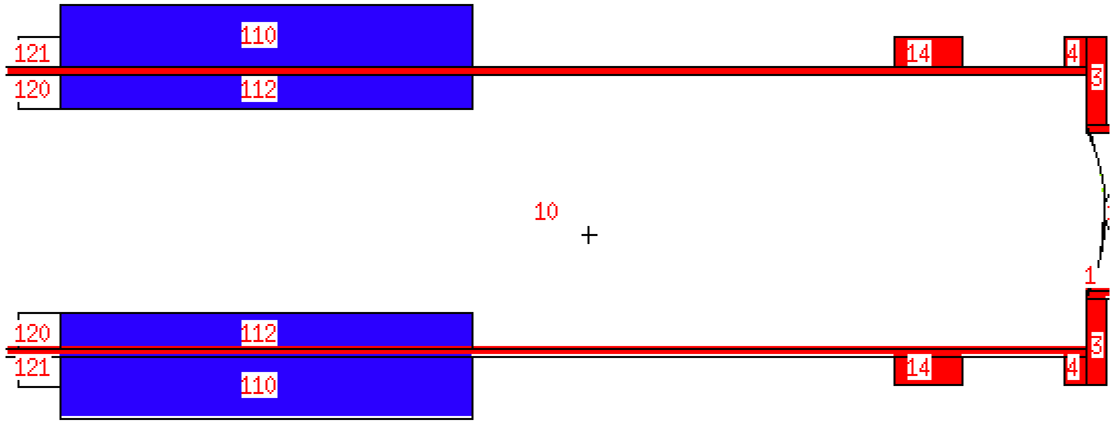

Figure 1: The above is a 2-dimensional view (side view or plan view) of a portion of the geometry in my MCNPX simulation. The volumes of 110 and 112 in blue are the cylindrical shielding blocks. The concave shape on the right is the Beryllium window. The proton beam runs from the left to the right.

II. Results and Conclusions

Simulation was first done with no shielding to measure the doses at the detection volumes. After that, various shielding configurations have been tried, which include borated polyethylene (11.6 H, 61.2% C, 5% B and 22.2% O[1] by weight, with density of 0.93 g/cm^3) added only outside the beampipe (i.e., only the block 110 in Figure 1), then added for both inside and outside the beampipe (ie. both blocks 110 and 112 in Figure 1), aluminium (density of 2.699 g/cm^3, both inside and outside) as well as graphite (density of 2.21 g/cm^3, both inside and outside). The latter two configurations have the same shape and size as before and only the materials are different.

The results in terms of the ratios of the doses with various shielding configurations and the dose without any shielding are shown in Table 1. All errors are statistical (from simulation). Just a note of caution: I have used equivalent doses (in rem) only for convenience (because one just needs to measure the fluxes of various particles of different energies crossing the detection volumes in simulation and one can use the flux-to-dose conversion functions to obtain the equivalent doses). But in principle, the equivalent doses

[1] This composition with 5% boron was found by google search in the Fermi note: FERMILAB-FN-697 (August 2000), "A Cross-comparsion of MARS and FLUKA Simulation Codes" by M. Huhtinen and N. V. Mokhov.

are appropriate only for human beings and they do not really apply to the doses received by various detectors (in rad).

	Position 120 (inside)	Position 121 (outside)
Borated Polyethylene (only outside)	$(105.1 \pm 1.4)\%$	$(64.7 \pm 0.8)\%$
Borated Polyethylene (both)	$(39.6 \pm 0.6)\%$	$(25.1 \pm 0.3)\%$
Aluminium (both)	$(38.1 \pm 0.5)\%$	$(20.5 \pm 0.4)\ \%$
Graphite (both)	$(32.1 \pm 0.5)\%$	$(16.9 \pm 0.3)\ \%$

Table 1: Results of shielding comparisons as ratios (in %) of the dose after the respective shielding configuration has been added. For the 1st row, only the block outside the beampipe (110 in Figure 1) has been added; whereas for the other three rows of shielding configurations, both blocks inside and outside (110 and 112 in Figure 1) have been added.

Apparently, the areas near the beampipe are difficult to shield. This may be understood if one draws straight lines between the Beryllium window and the detection volumes 120 and 121 in Figure 1. Without putting some materials in the beampipe, the particles bounced off from the window may reach the detection volumes with little or no obstruction. This is why shielding inside the beampipe has been attempted and it is said that this can be done in principle. By the same token, for areas adjacent to the beampipe, the closer to the Beryllium window, the more difficult it is to shield. Graphite seems to be the most effective material among the three materials that we have tried.