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Memo

Date: *August 29, 2016*

To: *RSC*

From: *D. Beavis*

Subject: *Lateral Shielding for Photon Dose from Electron Losses*

The purpose of this memo is to provide some simple curves for estimating the lateral dose for photons outside light concrete shielding's. Tenth-Value-Layers (TVLs) will be extracted from the dose rates inside the light concrete. The lateral TVLs are lower than TVLs published for the forward direction and can be used to estimate transverse shielding for electron beams.

MCNPX was used to calculate the radiation generated from electrons striking a copper target. Beam energies spanning from 0.5 MeV to 500 MeV were used. The tunnel was approximated as a cylinder 200 in radius with walls 120 cm thick. The electron beam strikes the upstream face of a copper rod with a radius of 0.25 cm. The rod extends from z=0 to Z=10cm. The results are typical of radiation patterns at accelerators. Figure 1 displays the dose through the four feet of concrete as a function of Z in cm. The dose is evaluated 30 cm from the concrete.

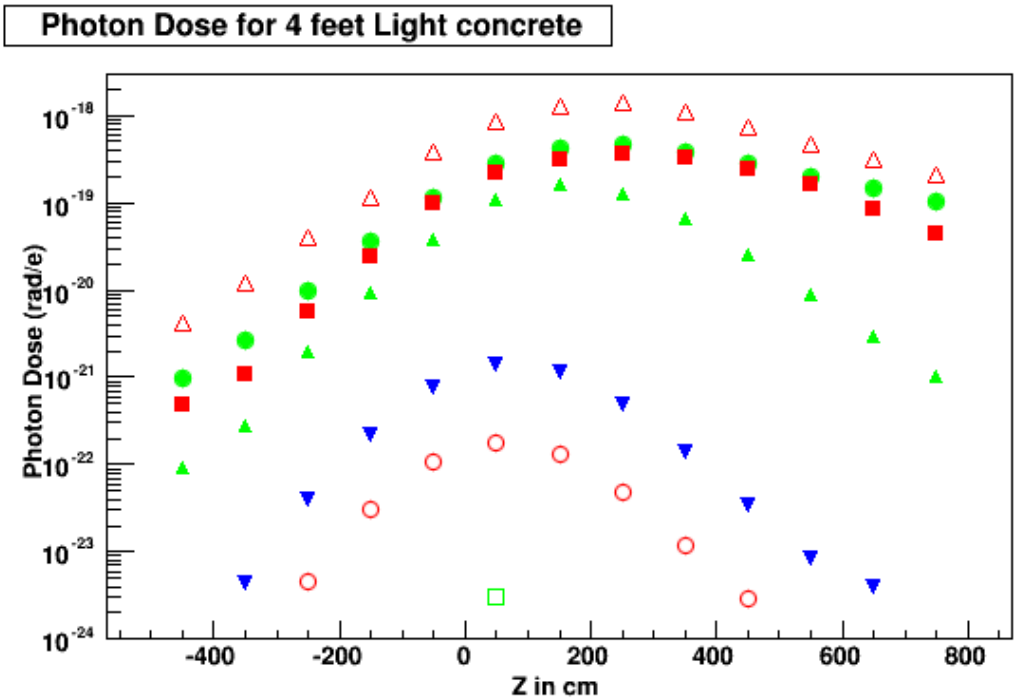

Figure 1: The photon dose per electron striking a copper rod 0.25 cm in radius and 10 cm long as a function of distance along the shield. The copper rod starts at z=0cm. The red-open triangles are for 500 MeV, green circles are for 160 MeV, the red squares for 80 MeV, green-solid triangles for 20 MeV, blue-solid triangles are for 5 MeV, red-open circles are 3.5 MeV, and the green-open square is for 1.0 MeV.

These dose rates can be scaled for thinner and thicker walls and changes in distances. The TVLs for photons were calculated from the MCNPX results typically at a depth of 3 to 4 feet. Table 1 provides the results extracted from the MCNPX results. The systematic differences between the transverse TVLs and the longitudinal TVLs as demonstrated in Table 1 are the results of geometry[1] and energy distribution of the photon spectrum striking the concrete. The target size used for this analysis does is not optimum[2] for some of the higher energies. The maximum dose could be higher. The curves along with the transverse TVL can aid in initial design of concrete shielding walls for electron machines.

Table 1: TVLs from MCNPX for Light Concrete

Beam Energy (MeV)	Transverse TVL (cm)	Longitudinal TVL[3] (cm)
500	37	51
160	34.7	50.2
80	35.4	48.1
20	32.5	44.7
5	26.3	31.5
3.5	22	25.5
1.0	13.5	16.9
0.5	11.3	11.9

[1] Longitudinal TVLs are defined for broad beams where the transverse TLVs defined here are for point sources.
[2] The results for 160 MeV were conducted for target radii of 0.1, 0.5, and 1.0 cm with a fixed length of 10 cm. The dose rate increased with the radius for 0.1 to 0.5 cm. Changing the target radius from 0.5 cm to 1.0 cm increased to dose rate 20%.
[3] These numbers were estimated from Figure 4.1 of NCRP Report 144 and NCRP 51 Figure E.12 for the 0.5 MeV results. Some error exists in reading the curves.