Diagnostic Beam Absorber in $\mu 2e$ Beam Line*

Igor Rakhno

Fermilab, P.O. Box 500, Batavia, Illinois 60510

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Abstract

Star density, hadron flux, and residual dose distributions are calculated around the $\mu 2e$ diagnostic beam absorber. Corresponding surface and ground water activation, and air activation are presented as well.

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A computer model of the diagnostic beam absorber in the tunnel is shown in Figs. 1 and 2.

Fig. 1. Plan (top) and elevation (bottom) view of the model of diagnostic beam absorber in $\mu 2e$ beam line.

Fig. 2. Cross section of the model of diagnostic beam absorber in $\mu 2e$ beam line.

In this design, longitudinal structure of the diagnostic absorber is similar to that of $\mu 2e$ beam absorber [1] while its transverse dimension is limited by the tunnel. Another difference is in the estimated amount of protons the diagnostic absorber should take – only about 3.3×10^{19} proton/year in contrast to 4×10^{20} proton/year in [1]. As a consequence, one can expect that while the surface and groundwater activation will be within acceptable limits, the residual dose might be a problem. Therefore, the left tunnel wall and the isle side of the absorber were covered with 10-cm layers of marble that is known to reduce significantly the residual dose. The distributions of star density and hadron flux, calculated with the MARS15 code [2] at hadron threshold of 30 MeV, are shown in Figs. 3 and 4. One can see that the maximum star density in the soil is $3.1 \times 10^5 \text{ cm}^{-3} \text{ s}^{-1}$, while the maximum hadron flux in the tunnel is $9.1 \times 10^7 \text{ cm}^{-2} \text{ s}^{-1}$.

The surface and groundwater activation can be estimated using the Concentration Model [3]. It follows that six years of continuous operation of the diagnostic absorber will result in the contamination of the ground water at 0.015% of the allowed regulatory limits. For the surface water, if the sump pumps that pump the under-drain operate once a week, the contamination levels will be less than 1%. For the air activation at the estimated 1000 cfm flow rate, the annual amount of the activated air released will be about 0.43 Ci in a year [4]. The operation of the diagnostic absorber will constitute a small fraction of the total air and water contamination releases due to the $\mu 2e$ beam losses.

Calculated distributions of residual dose are shown in Figs. 5 and 6.

Fig. 3. Plan (top) and elevation (bottom) view of the calculated [3] star density distribution around the diagnostic beam absorber in μe beam line. Hadron energy threshold is 30 MeV. Normalization is for 2×10^{13} 8-GeV proton/s.

Fig. 4. Plan (top) and elevation (bottom) view of the calculated [3] star hadron flux around the diagnostic beam absorber in μ 2e beam line. Hadron energy threshold is 30 MeV. Normalization is for 2×10^{13} 8-GeV proton/s.

Fig. 5. Plan (top) and elevation (bottom) view of the calculated [3] residual dose around the diagnostic beam absorber in $\mu 2e$ beam line after a 1-hr irradiation and 1-hr cooling. Normalization is the same as in previous Figures.

Fig. 6. Calculated distribution [3] of residual dose around the diagnostic beam absorber in $\mu 2e$ beam line after a 1-hr irradiation and 1-hr cooling. The cross section is taken through the midpoint of the absorber core. Normalization is the same as in previous Figures.

The marble layers reduce residual dose significantly, so that the highest residual dose is observed at the concrete ceiling (about 560 mrem/hr), which means that a marble layer should cover the ceiling as well, or one should extend the cooling time beyond one hour. Besides that hottest spot, there is a spot with the dose of about 210 mrem/hr on the left concrete wall (Fig. 5, top), and a spot on the floor with the dose of about 110 mrem/hr. Spatial attenuation in the air at a distance of 30 cm will provide an attenuation factor of about 0.5.

References

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