Dose Rates Around the Gallium Target After Irradiation

This document continues the study of exposure rates around the target after irradiation. Results include the contribution from the target and other activated components in and around the target assembly.

Previous estimates showed that for a 24 hour 5 kW run with 48 hour decay, the result is a dose rate of about 250 mR/h at 30 cm *from the target only*, as seen below.

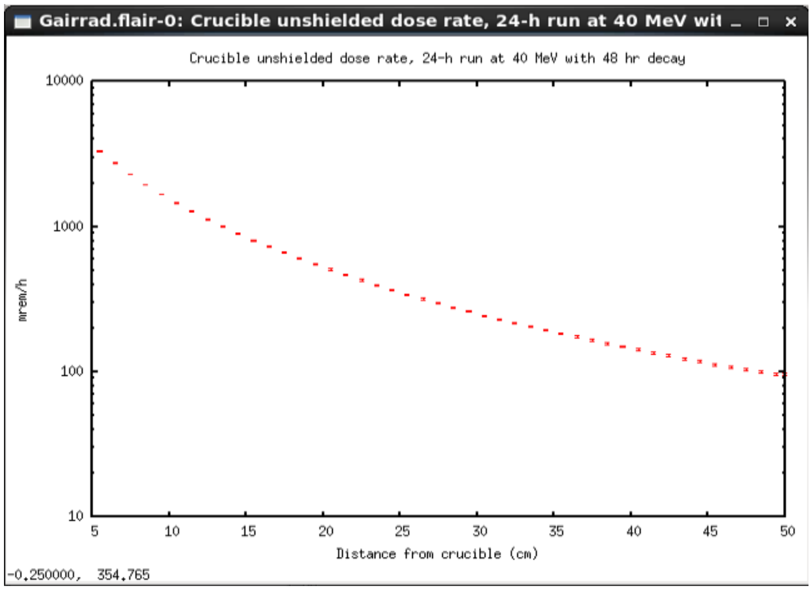

Figure 1: 5 kW power for 24 hours at 40 MeV (48-h decay)

For the same run with a 24 hour decay period, the dose rate from the target is about 400 mR/h at 30 cm. Contact dose rate may be a few 10s of R/h. Below is a graphic depiction of the dose rate with distance up to about 30 cm away from the target.

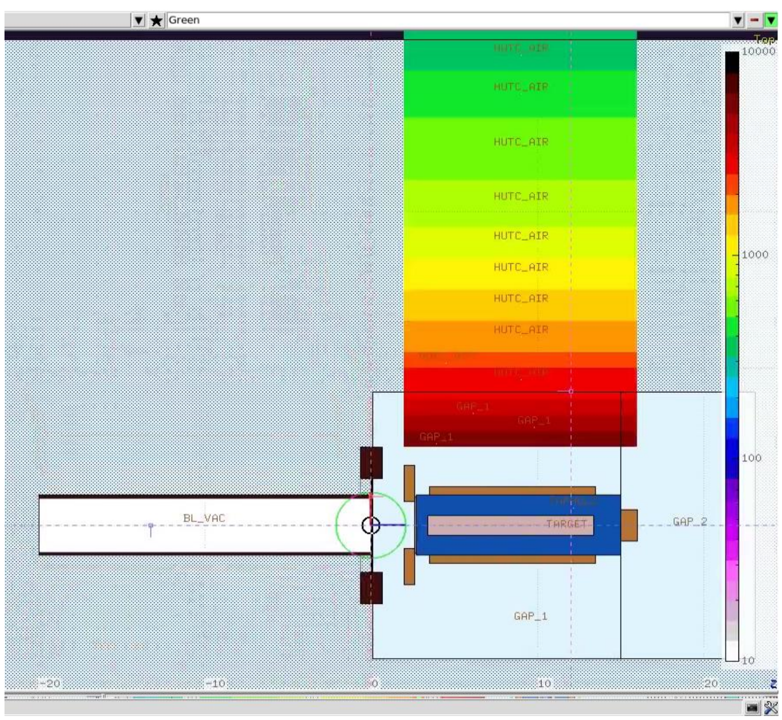

Figure 2: Dose rate from the target

The estimates above are useful for purposes of planning the target packaging and shipping activities, where the concern is directly handling the target crucible. But this does not address the radiation fields present around the target during work to remove it from the shield hutch. In addition to activation in the target material, there will be an additional radiation field produced by the target support structure and other internals within the shield hutch, such as the shielding itself.

To estimate this contribution, we created a simplified hutch and hardware model that includes the shielding and support hardware for the target. We ran simulations with FLUKA to estimate the total dose rate in the area. This result ignores the contribution from the radiator, as it will be partially shielded and at a larger distance from the workers when the hutch is opened for target extraction. We also ran the simulation with the gallium target itself (in addition to the radiator) removed from the contribution in order to see how much of the radiation field is attributable to the surrounding materials. The technique used also removed the effect of the side and top iron shielding, with respect to shielding the radiation from the residual radionuclides. This allows the model to simulate the operation of opening the hutch via pulling the end shield plug out, along with the target assembly. The figure below depicts the hutch with target inside.

Figure 3: Cutaway of geometry for irradiation of the target within the hutch

Results show that a significant fraction of the dose rate is caused by the activation in the target support base and target positioning hardware. The total dose rate at 30 cm from the assembled hardware after a 5kW run and 24 hours decay is estimated at about 740 mrem/h. About half of this radiation field is caused by the hardware associated with supporting the target. This includes a copper plate and positioning system which holds the target, and an aluminum base on which the target system rests. The exposure rate on contact with the crucible and positioning system may approach 100 R/h.

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The figures below show the dose rates produced around the target.

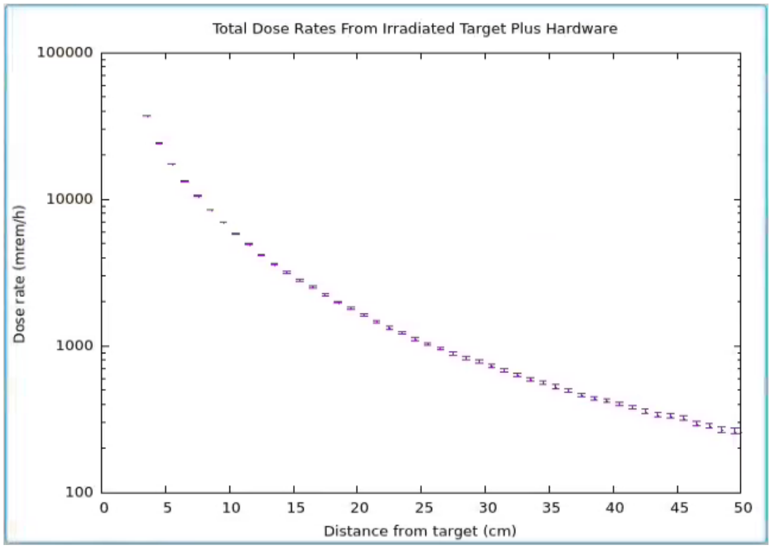

Figure 4: Total dose rate from target and support hardware

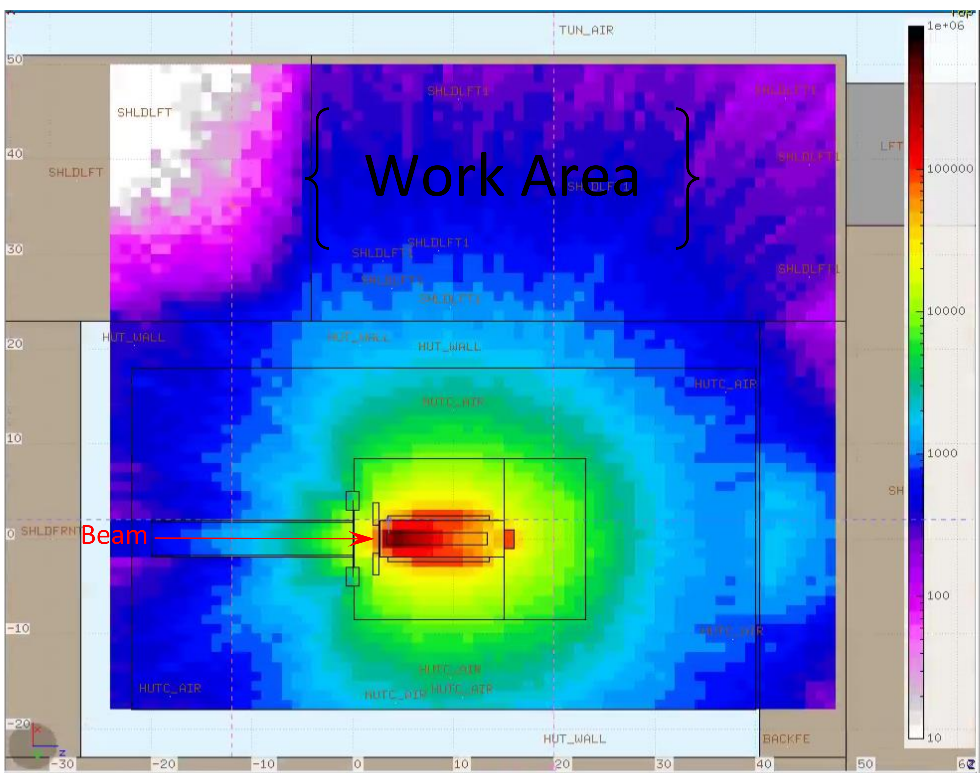

Figure 5: Top view of radiation field around the target (24 hr decay after 24 hr, 5 kW run)

The figures below show the radiation fields produced by the hardware only, without contribution from the gallium target or the radiator. The dose rate from the hardware contributes on order 400 mrem/h to the radiation field at 30 cm.

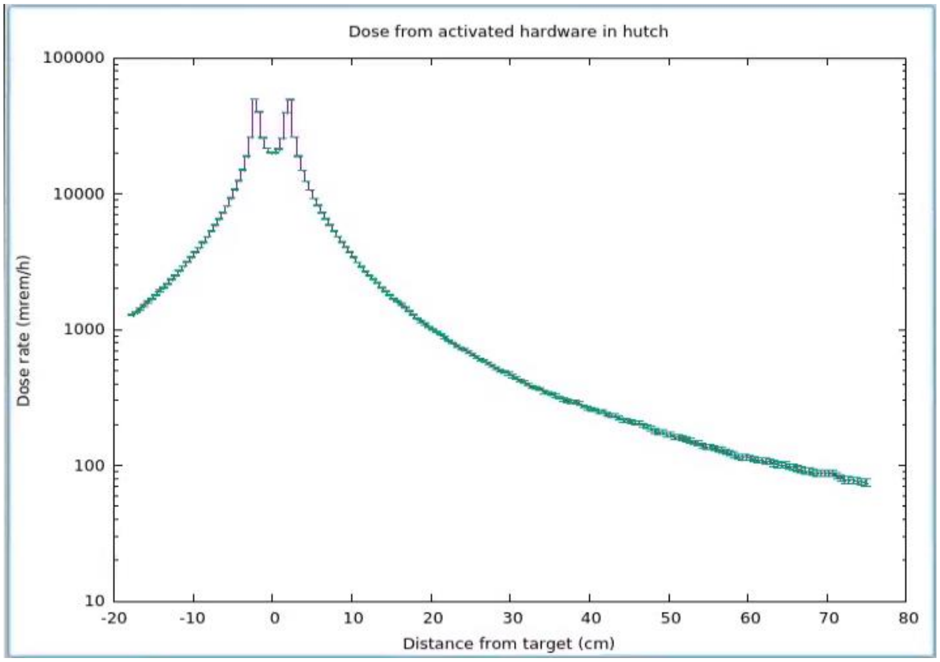

Figure 6: Dose rate contribution from the target support hardware

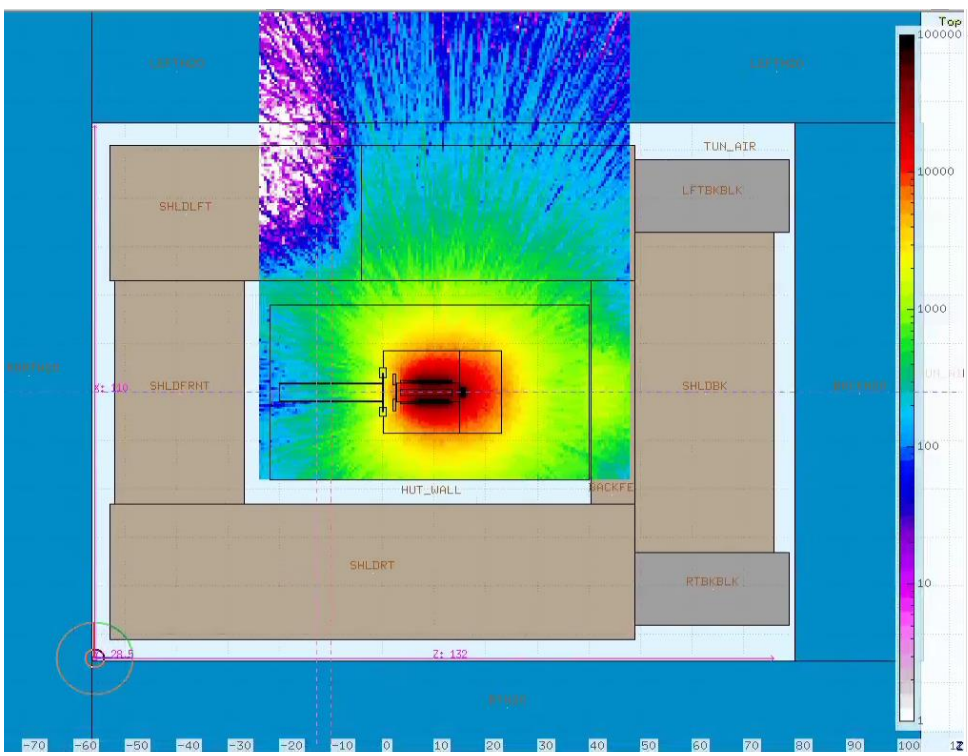

Figure 7: Radiation field in the vicinity of the target support hardware (top view)

For 1 kW runs, if everything is held constant except beam current, the dose rate would scale lower by a factor of five, giving a whole body dose rate on order 150 mrem/h. However, present plans call for a somewhat longer run time and a shorter decay time for the 1 kW run(s).

To address these differences, additional FLUKA runs were performed with 1 kW 40 MeV beam for 34 hours of irradiation and 10 hours of decay. The results show a total whole body dose rate of about 400 mrem/h in this case. The difference is primarily a function of the shorter decay time.

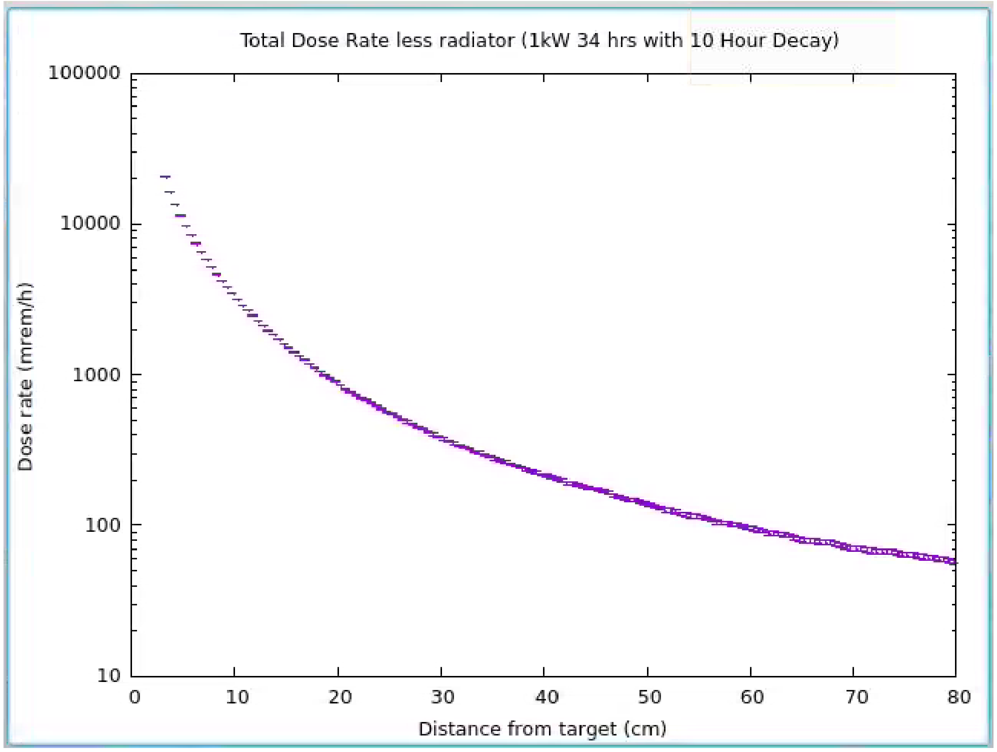

Figure 8: Total dose rate from target and support hardware for 1kW run

Summary

This study indicates residual *in situ* whole body dose rate around the irradiated target after a 5 kW run could approach 1 rem/h at the time planned for extraction of the target (24 hours decay). Target removal following the 1 kW run will be done with less decay time. Estimated dose rate in this case is about 400 mrem/h. Advanced planning, to include rehearsals of the target extraction, temporary shielding, and other dose reduction techniques are critical to ensuring doses for the experiment are ALARA.