ESH&Q DIVISION
RADIATION CONTROL DEPARTMENT

LERF Shielding Requirements for LCLS-II Cryomodule Commissioning

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The LERF vault will be used to commission the LCLS-II cryomodules (CM). In order to bring the CMs into the vault, the truck entrance concrete shielding (shown in Figure 1) has been removed. The purpose of this note is to assess potential radiological conditions at and around the unshielded truck ramp; and, to determine the shielding and posting requirements.

Figure 1: LERF truck entrance with concrete shielding in place

As shown in Figure 2, the CMs will be installed in the LERF vault two at a time. They may be tested at full accelerating gradients of up to 130 MeV each.

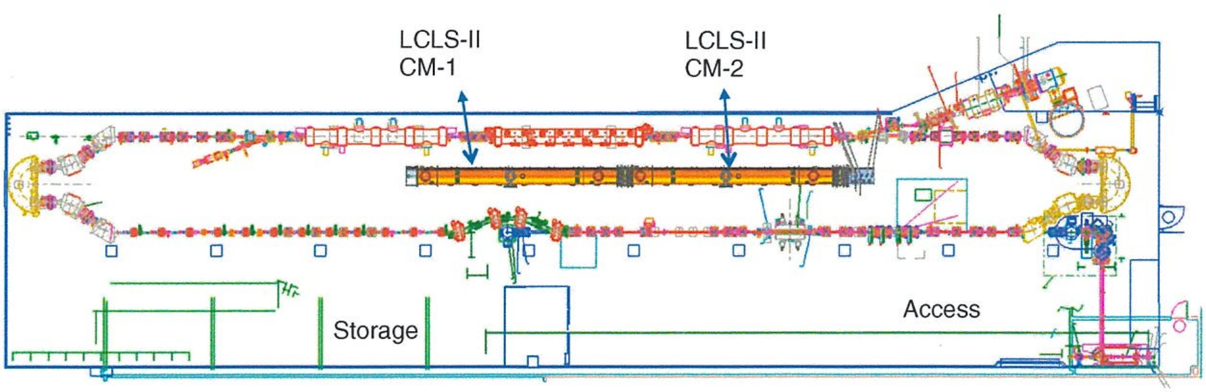

Figure 2: Layout of LERF vault for LCLS-II CM testing

In the absence of any beam injection capabilities, the only source of ionizing radiation from the CM testing is the electron field emission. Estimating the related radiation source term is difficult, especially for new devices like the LCLS-II CMs, which typically come with limited, or no, experimental data regarding the field emissions.

Each end of the two-CM assembly is covered with a stainless steel stopper during the CM commissioning. The stoppers act as effective beam dumps for the field-emitted dark current. For the worst-case scenario shielding calculations, it is assumed that the field emission site is located at the far end of the two-CM assembly and a portion of the dark current gets accelerated to 260 MeV – the energy equal to the combined accelerating energy of two CMs. While Santana Leitner and Ge[1] assume such capture current to be of the order of 10 nA, order of 100 nA dark current estimates were made by extrapolating the C100 CM data.[2] In the absence of experimental measurements of the dark current, a 100 nA value is assumed in line with the conservative nature of shielding calculations.

FLUKA[3] was used to model the interaction of a 100 nA, 260 MeV electron beam with a thick stainless steel target (R=2cm, L=20cm) located at the west end of the two-CM assembly. The FLUKA model of the LERF truck entrance is shown as Figure 3.

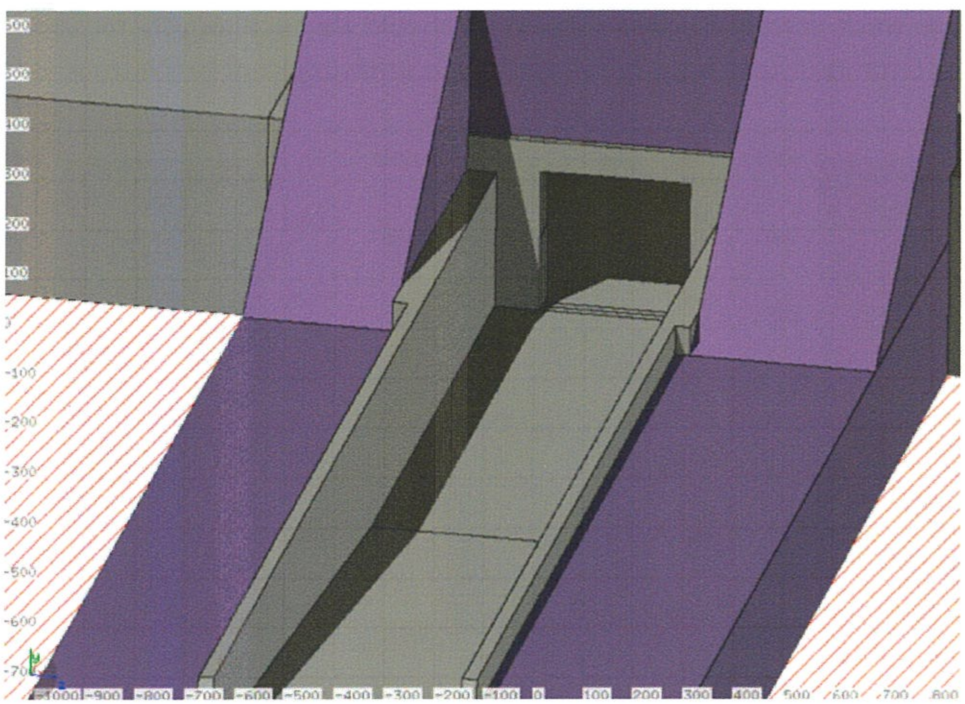

Figure 3: LERF truck entrance model

Three cases of CM operation were considered: a) no shielding installed; b) install 3-foot thick concrete shielding inside the rollup door with 1-foot overlaps with the walls on each side; and, c) 4-foot thick concrete shadow shield is installed at 1 m from the end of the CM and 1/8 inch thick lead shielding is installed at the rollup door.

The expected ambient dose equivalent rates at 1 m above the bottom of the truck ramp are presented in Figure 4. The unshielded case (a) will result in dose rates well above 1000 mrem/h per 100 nA. However, both the local shielding (b – 4 ft local concrete shield and 1/8 inch lead at the door) and the door shielding (c – 3 foot concrete) will reduce the dose rates to below 100 mrem/h, allowing the truck entrance area to be posted as a radiation area during the CM commissioning runs.

The expected ambient equivalent dose rates at 1 m above ground level are presented in Figure 5. With no shielding in place (scenario a above) the whole body dose rates in the occupiable areas around the truck entrance will be of the order of 100s of mrem/h per 100 nA. The introduction of a 4-foot thick local shielding in combination with the 1/8 inch thick lead shielding at the rollup door (scenario b) will reduce the expected maximum dose rates to just below the 5 mrem/h threshold of a radiation area. A 3-foot thick concrete shielding fully covering the rollup door (scenario c) will be even more effective, reducing the expected maximum dose rates to approximately 1 mrem/h per 100 nA dark current.

Considering that the 100 nA assumption has not been experimentally verified, radiation dose rates near the truck entrance door in the vault should be continuously monitored to avoid exceeding the 5 mrem/h dose rates in the occupiable areas adjacent to the truck entrance.

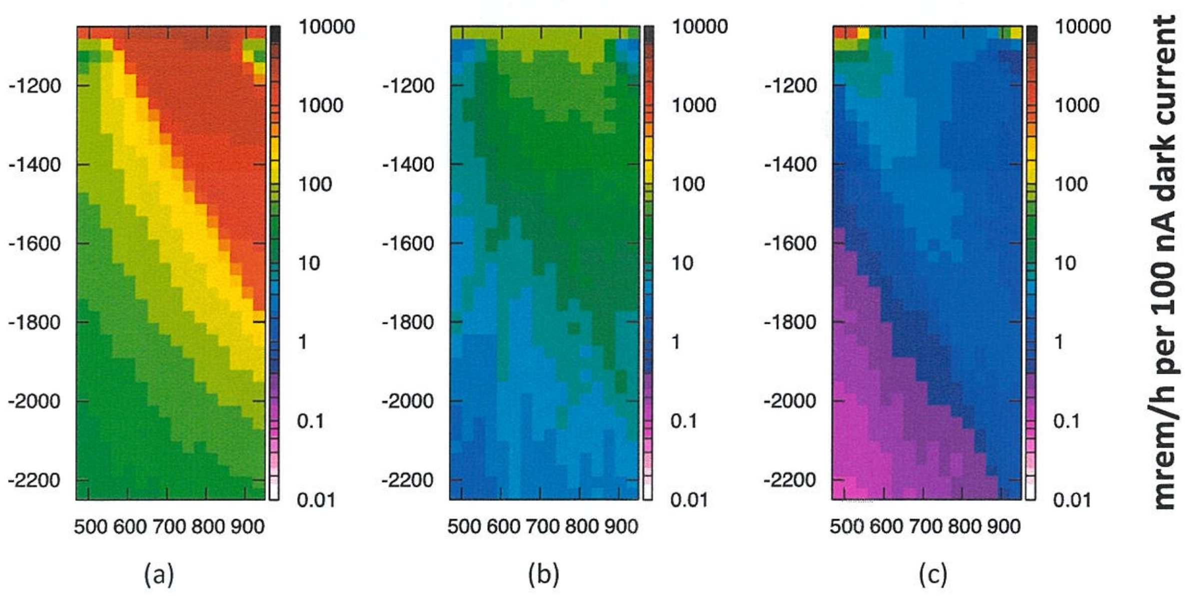

Figure 4: Expected ambient dose equivalent rates per 100 nA dark current at 1 m above the bottom of the truck entrance for a) unshielded, b) local concrete shielding and lead shielding at the door, and c) 3-foot concrete shielding at the door

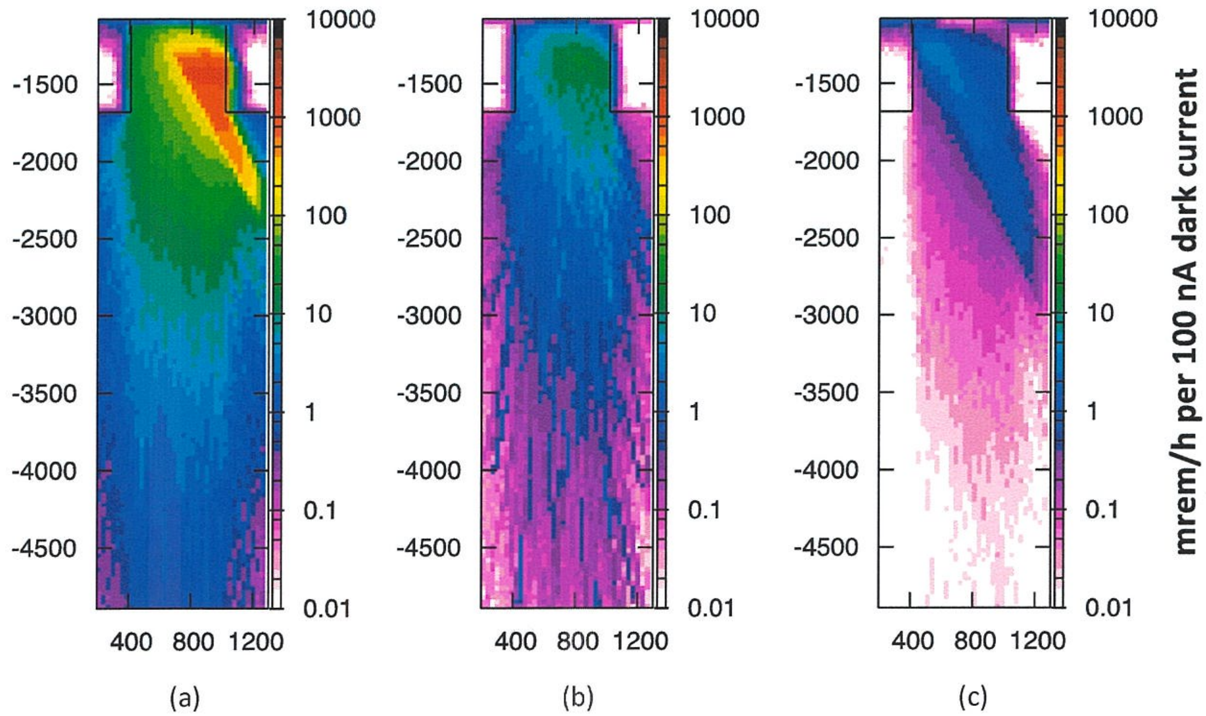

Figure 5: Expected ambient dose equivalent rates per 100 nA dark current at 1 m above the ground level around the LERF truck entrance: a) unshielded, b) local concrete shielding and lead shielding at the door, and c) 3-foot concrete shielding at the door

References

[1] M. Santana Leitner, Lixin Ge, *Radiation Fields from Field Emission at the SCRF cavities of LCLS-II*, SLAC RADIATION PHYSICS NOTE RP-15-13, July 2015.

[2] G. Kharashvili, *Shielding Basis of the Cryomodule Test Facility Upgrade*, JLAB-TN-16-009, 2016.

[3] A. Ferrari, P.R. Sala, A. Fassò, and J. Ranft (2005), "FLUKA: a multi-particle transport code", CERN-2005-10, INFN/TC_05/11, SLAC-R-773.