

SLAC MEMORANDUM

RP-RPG-080929 -MEM-01

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TO: Hal Tompkins 

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Via: Sayed Rokni, (RSO) 

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SUBJECT: Shielding Requirements for the LCLS hard-X ray beam pipe

1. Introduction:

The PPS requirements described in Ref. [1] imply that several hutches may be in “access” while hard x-ray beam passes through them to be delivered to experiments downstream. Specifically, the first and second hutch are possibly in access while the XPP experiment is running in the third hutch (“XPP in” mode), the third hutch may be accessed (in “XPP out” mode) when the XPP experiment is withdrawn and beam is delivered to areas downstream (including the X ray tunnel and the Far Experimental Hall FEH), and the fourth hutch can be accessed when its experiment (XCS) is retracted and beam is delivered to the fifth hutch. To allow for such access, the vacuum chamber must provide sufficient shielding wherever it contains a component (“target”) that can potentially be hit by the beam.

The shielding requirements described in this memo are applicable to potential targets enclosed in:

- 1) The hard x-ray pipe through the first and second hutch,
- 2) The hard x-ray pipe through the third hutch and fourth hutch in the “XPP out” or “XCS out” modes, and
- 3) The hard x-ray pipe in the upstream part of the X-Ray Tunnel (XRT) between the Hutch 3 XRT separation wall and the SH2 stopper (see Ref. [1]).

2. Shielding requirements:

For the proposed vacuum pipe with a **4” diameter** [2], an analysis using the codes FLUKA and STAC8 has been performed to determine the minimum thickness required to reduce the dose rate to 0.05 mrem/h on contact with the pipe when the beam hits a target (an inclined Si mirror) enclosed inside the pipe (see Ref. [3]). The synchrotron radiation source term (spontaneous and FEL) used for the analysis is described in Ref. [4]. It takes into account the reduction in beam intensity due to aperturing by the C1 collimator (5 mm diameter) and filtering by the two hard X-ray mirrors (SiC) located in the Front End Enclosure. The same source term was used for the FEH hutch wall recommendations addressed in Ref. [5].

The shielding options for potential targets include:

- 1) A **6.2-mm-thick steel pipe** (or 0.95 mm of lead),

- 2) A **0.6-mm-thick layer of lead wrap** around the proposed **2.1-mm-thick (0.083") SS vacuum pipe**, or
- 3) A **0.7-mm-thick layer of lead wrap** around a **1.65-mm-thick SS vacuum pipe**, or
- 4) An exclusion zone (a cylindrical volume with a 30-cm radius centered on the beam pipe axis) around the 2.1-mm-thick SS beam pipe.

The shielding or exclusion zone shall extend along the entire (Z) length of the target, as well as **8" upstream and 8" downstream** of the target.

It should be noted that the latter three options increase the complexity of the necessary configuration control.

All bellows and viewports require shielding. Bellows and viewports in the vicinity of a target must be shielded as described above, except that for viewports shielded with lead the necessary lead thickness is 1.2 mm. For bellows and viewports not in the vicinity of a target, shielding equivalent to 2.1 mm steel is sufficient.

For beam pipe sections that do not have any potential targets, the beampipe thickness of 2.1-mm SS (Ref. [2]), provides sufficient shielding.

3. Target identification:

Potential targets to which this shielding requirement applies shall be identified by a detailed beamline ray trace study. The ray trace shall depict all items which could potentially be struck by the beam (all "targets") including, *e.g.*, mirrors, monochromator crystals/gratings, apertures, slits, valves, shutters, insertable diagnostics, *etc.*, as well as vacuum chambers or other components serving as shielding or personnel exclusion barriers. Locations of viewports and bellows should also be indicated.

A configuration control program needs to be developed to ensure the integrity of the vacuum chamber as well as of the additional shielding, which will be considered as radiations safety items.

References

1. M. Saleski, X-ray systems Operational Modes Safety Analysis, LCLS PRD#1.6-009.
2. P. Stefan, Overview of the LCLS Near Experimental Hall (NEH), LCLS ESD#1.5-128 draft version 3.
3. J. Vollaire and A. Prinz, Comparison of FLUKA and STAC8 for shielding calculations of the hard X-ray lines of the LCLS, RP-Note-08-11.
4. P. Stefan, "Estimation of the XTOD Beam Line Photon Spectra", LCLS ESD 1.5-127, April 1, 2008.
5. J. Vollaire and A. Prinz, Shielding recommendations for the walls of the FEH hutches, RP-RPG-080606-MEM-01.

c.c.: RP file

Attachment(s): none