Use Cases for Halo Collimators *

J. Welch and Y. Ding

April 13, 2020

1 Introduction

A system of Halo Collimators is included in the LCLS-II upgrade to collimate beam halo so that it does not get lost in the Undulator Hall where it could cause radiation damage to the undulator magnets. This note addresses other possible applications of the Halo Collimators.

No flow interlocks or other changes are needed for most of the off-project applications. One application, Horn Cutting, would require redesign and replacing the jaws and interlocked flow control to be able to work over the full range of beam current.

2 Use Cases

The applications or 'Use Cases' discussed are using the Halo Collimators:

1. as tune-up dumps,
2. to block gun dark current,
3. to block Cryomodule dark current,
4. for wakefield studies, and
5. for Horn Cutting.

2.1 as tune-up dumps

The COL0 collimators are a set of four collimators at the 100 MeV point of the SC beamline. CEHTR is a single collimator that is in the dispersive region of the laser heater chicane and is also at the 100 MeV point just upstream of the COL0 collimators. As tune-up dumps all Halo Collimators would be limited at all times to less than 100 W average power by the MPS. This amounts to a limit on the intercepted average current of 100 W / 100 MeV = 1 microamp. Since 1 microamp is 100 pC x 10 kHz, it seems that there would be many useful beam patterns that could be stopped by the COL0 or CEHTR collimators. They could be used in 'burst mode' as long as the average power was low.

Shielding for the CEHTR collimator was designed for to 32 W of beam with a 'Use Factor' of 57% [1]. The COL0 collimators are shielded for up to about 15 W of beam. The Use Factor is time the device is used divided by the time the linac is operating, averaged over a year. Shielding around the CEHTR and COL0 collimators is provided to keep the accumulation of tritium in the nearby soil to extremely low levels.

Commissioning plans are to run with no more than 100 Hz, possibly for several months using the CEHTR and COL0 collimators as tune-up dumps. If the average charge is no more than 250 pC, the average beam power at these collimators would be no more than 2.5 W — much less than the shielding design value of 32 W. Typically during commissioning the charge and beam power would be even lower. So it should be possible to use the CEHTR and COL0 collimators as tune-up dumps during commissioning with even a 100% Use Factor.

*Work supported in part by the DOE Contract DE-AC02-76SF00515. This work was performed in support of the LCLS-II project at SLAC.

2.2 to block dark gun dark current

It may be desirable to completely block the dark current from the gun without turning off the gun RF. This would be useful if we wanted to see how much of the observed current or radiation was dependent on the gun dark current. This can be done by using any of the CEHTR or COL0 collimators.

The gun dark current at the CEHTR location is supposed to be below 40 nA for operation [2]. The shielding was designed for this case. The dark current is likely to be orders of magnitude less. If it is as high as 40 nA it would amount to only 4 W on the Halo Collimators. This is well below the 100 W MPS threshold. So these collimators should work well for this application.

2.3 to block Cryomodule dark current

Cryomodules can emit dark current in both up-beam and down-beam directions, and some of it may be captured by adjacent cryomodules and be further accelerated. It may be desirable to block this dark current beam using the CEHTR, COL0, CE11B, or COL1 collimators and observe changes in measured current or radiation. The power levels expected are even lower than for the gun dark current. So these collimators would also perform well in this application.

2.4 for wake-field studies

Wakefields can affect the ability of the electron bunches to generate FEL pulses. We know that the x-ray pulse energy degrades when the beam is brought too close to a collimator jaw. Wakefield generated in the de-chirper also are used to change the longitudinal energy profile for a number of special effects. It may be desirable for MD studies to be performed to see if the jaws are having a deleterious effect, or for more obscure reasons.

These tests would probably be done with low power beams where very little beam hits the jaws. In any event all the collimators are protected against accidental beam strikes of more than 100 W. They should work for this application.

2.5 for Horn Cutting

Horn cutting refers to the continuous trimming of the energy spectrum using collimators in a dispersive region. It has been employed at LCLS in the Cu linac and results in a better defined energy profile which can be tuned in a variety of ways.

This technique could become useful for the SC linac as well. However, it would require intercepting a good fraction of the beam current, perhaps 40%, by the CEHTR collimator. If that collimator is limited to 40 W by the shielding, this technique would could only be applied to beams with a 4 GeV final beam power of 4000 W, which is low compared with the capability of the linac, but plenty for studies. If we wanted to implement a version of CEHTR that could handle 40% of the design current for the full capability of the SC linac (250 kW), it amounts to the jaws absorbing 2.5 kW and would require a redesign of the jaws and inclusion of interlocked flow switches.

References

[1] M. Santana-Leitner, "Radiation protection requirements for the halo collimators," Physics Requirements Document LCLSII-1.2-PR-0259-R1, SLAC, November 2016.

[2] J. Welch, "LCLS-II Electron Beam Loss and Maximum Credible Beam," Physics Requirements Document LCLSII-2.7-PR-0079-R1, SLAC, October 2015.