Physics Specifications for the Injector Cherenkov Radiators (CR01 & CRG1)

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Brief Summary:
This document describes the physics specifications for the injector radiator screens used for measuring the electron bunch length in the gun to linac section of the beamline.

Change History Log:

<table>
<thead>
<tr>
<th>Rev Number</th>
<th>Revision Date</th>
<th>Sections Affected</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>Dec 12, 2005</td>
<td>All</td>
<td>Initial Version</td>
</tr>
<tr>
<td>001</td>
<td>January 18, 2006</td>
<td>Figure 1 and Table 1</td>
<td>Cross references and formatting</td>
</tr>
</tbody>
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PHYSICS SPECIFICATIONS FOR THE INJECTOR CHERENKOV RADIATORS

Justification
It is necessary to measure the electron bunch length and its time-energy correlation after the gun in order to fully characterize the beam before entering L0-a. This will be done at two locations: immediately before the beam enters the L0-a linac at CR01, and in the focal plane of the gun energy spectrometer at CRG1 as shown in Figure 1. Measurements at CR01 will give the bunch length before the beam enters L0-a, and CRG1 measurements provide the time-energy correlation. As described in ESD 1.2-134, a streak camera located in the drive laser room will measure the bunch length using the light from these prompt radiators when placed in the beam.

Figure 1. Engineering drawing of the LCLS Injector Gun-to-Linac region showing the locations of the radiator screens, CR01 and CRG1.

CR01 and CRG1 Radiator and Mirror/Faraday Cup Specifications
The specifications for the radiators and mirrors are listed in Table I. The CR01 and CRG1 radiators themselves need to be 100 microns thick Fused Silica to achieve 0.37-ps (full width) resolution and have transverse dimensions equal to their nearby YAG screens: YAG02 and YAGG1. The exit surface needs to be frosted or roughened with randomly distributed micron sized pits to scatter the light out of the radiator. Cherenkov radiator details can be found in ref [1].

The mirror material is proposed to be polished, or diamond turned stainless steel since the beam will be intercepting the mirror. Uncoated, the mirror reflectivity at visible wavelengths will be
75%, which is acceptable. Coating the mirror will increase the reflectivity, but it could delaminate from the substrate with the electron beam striking it. Therefore the mirror should be uncoated.

Table I. Radiator and Mirror Specifications.

<table>
<thead>
<tr>
<th>Radiator</th>
<th>Material</th>
<th>Thickness</th>
<th>Entrance/Exit Surfaces</th>
<th>Radiator Dimensions</th>
<th>Nominal rms Beam Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \sigma_x \times \sigma_y ) (mm)</td>
</tr>
<tr>
<td>CR01</td>
<td>Fused Silica</td>
<td>100 microns</td>
<td>Polished/Frosted</td>
<td>2.0 cm, dia</td>
<td>0.457 \times 0.457</td>
</tr>
<tr>
<td>CRG1</td>
<td>Fused Silica</td>
<td>100 microns</td>
<td>Polished/Frosted</td>
<td>5 cm \times 1 cm, horiz. x vert.</td>
<td>3.339 \times 1.50 [45.00 \times 8.00]</td>
</tr>
<tr>
<td>45 degree mirrors/FC</td>
<td>Stainless Steel</td>
<td>NA</td>
<td>( \lambda/10, 60-40) scratch-dig</td>
<td>NA</td>
<td>NA</td>
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</table>

Proposed Optical Layout for the CR01 and CRG1 Cherenkov Radiators

Since the frosted surface will scatter the Cherenkov light into large angles, it is important to have the first lens immediately outside the vacuum window to collect the light as shown in Figures 2 and 3 for the two radiators. Moving the lens closer to the radiator does increase the angular spread of the light collected, but this light is lost later due to the limited angular acceptance of the long optical tubes between the injector vault and the laser room.

![Collimating Lens Diagram](image)

**Figure 2.** The layout for the radiator and optics at the CR01 radiator. The drawing on the left shows the current design for the CR01 and YAG02 diagnostics box. The drawing on the right gives details of the location of the collimating lens with respect to the radiator and the 45-degree mirror.

As Figure 3 shows, the CRG1 should be located behind YAGG1 in order to reduce its distance from the collimating lens. The camera for YAGG1 and the optics for the streak camera share the same optical path up to a shuttle mirror which diverts the light either to the YAGG1 camera or the
streak camera. The challenge of the optical design is to image the large viewing area of $5 \times 1$ cm onto the streak camera slit without significant vignetting of the image. The optical design should determine these details.

Figure 3. The proposed geometry for the diagnostics after the gun spectrometer includes a collimating lens placed close to the vacuum window to improve the light collection for the streak camera measurements.

References