

PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-21 R0	LUSI SUB-SYSTEM CXI
Physics Requirements for the CXI Reference Laser System		
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1. Overview

The ability to align the components of the beamline without the X-ray beam is necessary for the CXI instrument. This document describes the requirements of a system to perform this task.

The coordinate system is defined in Mechanical Design Standards Supplement DS-391-000-36.

2. Performance Requirements

- 2.1.** A reference line visible to the naked eye collinear with the LCLS beam shall be provided for visual alignment of the beamline components.
- 2.2.** The reference line shall span at least the entire length of the CXI experimental hutch.
- 2.3.** The reference line shall span as much of the X-ray Transport Tunnel as feasible while maintaining the size and positioning requirements of Sections 3 and 4.
- 2.4.** Optically opaque CXI components shall not prevent the use of the reference line.
- 2.5.** The LCLS beam is not required to propagate through the beamline while the reference line is in use. The use of the reference line and the x-ray beam are not required to be concurrent. The spatial overlap of the two beams can be verified serially by looking at one beam and then the other.
- 2.6.** The position and pointing of the reference line shall have a short term stability (over a period of a few days so that the position of the beam does not vary by more than 5% of the laser beam FWHM at any point on the reference line. The FWHM of the laser beam will depend on the location of the reference laser system as will need to satisfy Requirement 3.1.
- 2.7.** The reference line shall be stable over the scale of a few months to within 15% of the laser beam FWHM at any point along the line so that realignment of the reference laser only needs to occur 6 times or less per year. The FWHM of the laser beam will depend on the location of the reference laser system as will need to satisfy Requirement 3.1.

3. Size Requirement

- 3.1.** The reference line shall be as collimated as possible, with minimal divergence and a maximum Full Width at Half Maximum (FWHM) at any point inside the CXI hutch of 5.5

mm. The divergence of the beam will depend on the position of the reference laser and the source size required to meet the size requirement stated above.

4. Positioning Requirements

- 4.1. Two operating settings shall exist for the reference beam: “In” or “Out”.
- 4.2. The reference laser system state shall have the ability to be changed in ~ 10 seconds.
- 4.3. A minimum stay clear radius of 10 mm will be maintained when the reference laser is in the ‘Out’ position.
- 4.4. The reference line shall be deflected by the X-ray optical components in the same manner as the X-ray beam.
- 4.5. It shall be possible to align the centroid of the reference beam with the centroid of the LCLS beam within 0.1 mm over the entire length of the reference line.
- 4.6. A translational repeatability of 100 microns shall be maintained when the reference line is placed in the ‘In’ position.
- 4.7. A rotational repeatability (pitch and yaw) consistent with the translational repeatability and total length of the reference line shall be maintained when the reference line is placed in the ‘In’ position. As an example, if the laser source is located 52 meters upstream of the back wall of the CXI hutch (the very end of the X-ray Transport Tunnel), then in order for requirement 4.5 to be met, the pointing of the reference line will need to be accurate and repeatable to within $2 \mu\text{rad}$.

5. Vacuum Requirements

- 5.1. The reference laser system shall reside and propagate in a 10^{-7} Torr pressure environment and the appropriate vacuum practice for the design, manufacturing, and installation of the system components shall be implemented.
- 5.2. The reference line shall be useable in high vacuum (down to 10^{-7} Torr) and at atmospheric pressure.
- 5.3. The reference line shall propagate undisturbed from vacuum to air.
- 5.4. The reference line system shall be functional with the entire beamline under vacuum or some specific parts of the beamline in air. These specific parts are the CXI Sample Chamber (PRD 391-000-20), the CXI 0.1 micron KB system (PRD 391-000-24) and the CXI Detector Stage and the reference line shall be useable with any single one of these components vented to air.

6. Controls Requirements

- 6.1. The reference laser system is required to change state remotely via the instrument control system.
- 6.2. The alignment of the reference laser with the x-ray beam shall be performed remotely via the instrument control system.
- 6.3. A single diagnostic at a particular location shall be used to align the reference line to the LCLS beam. That is a screen that allows both the X-ray beam and the visible laser beam to

be seen shall be used to verify the spatial overlap at a given point. The LUSI Pop-in Profile Monitor (PRD SP-391-000-04) could be used for this purpose.

- 6.4.** Multiple diagnostics along the CXI beamline shall be used to verify the spatial overlap at multiple points and therefore verify the collinearity of the reference laser and the LCLS beam. The collinearity can only be verified if a monitor is present at more than one point. The type of screen described in Requirement 6.4 will shall placed at multiple locations to verify the alignment of the beams.
- 6.5.** An interlock between the reference laser and a PPS photon stopper located upstream shall be present to insure the LCLS beam does not hit the reference laser mechanism when it is in the “In” position to prevent damage.
- 6.6.** There shall be an indicator of the status of the reference laser in the instrument control system.
- 6.7.** It shall be possible to set up scans of a selected axis of motion and monitor the effect on the reference laser beam position using a user selected monitor from the list of all available CXI monitors, which include the CXI 2D X-ray Detector (LCLS PRD # 1.6.002), all the CXI Pop-in Profile Monitors (PRD SP 391-000-04), CXI Pop-in Intensity Monitors (PRD SP 391-000-09), CXI Intensity-Position Monitors (PRD SP 391-000-08) and a photodiode located within the CXI Detector Stage (PRD SP 391-000-28).

7. Safety Requirements

- 7.1.** The reference laser system shall be contained inside a protective box to prevent accidental disruption of the alignment.
- 7.2.** The reference laser shall be low power (class IIIa or less) so that no possibility of eye injury exists.