LUSI LCLS Ultrafast Science Instruments

ENGINEERING SPECIFICATION DOCUMENT (ESD)	Doc. No. SP-391-000-73 R0	LUSI SUB-SYSTEM CXI

CXI Reference Laser System

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Table of Contents

1. Overview

The ability to align the components of the beamline without the X-ray beam is necessary for the CXI instrument. A laser induced reference line visible to the naked eye collinear with the LCLS beam shall be provided for visual alignment of the beamline components. The reference line shall span at least the entire CXI experimental hutch.

The laser beam shall be in introduced in the X-ray beam path through a view port and reflected on a retractable in-vacuum mirror.

The coordinate system is defined in Mechanical Design Standards Supplement DS-391-000-36. See Applicable Documents, Specifications and Codes section below.

2. Applicable Documents, Specifications and Codes

2.1. Stanford Linear Accelerator Center (SLAC) Specifications

- SLAC drawing No. DS-391-000-36, "Mechanical Design Standards Supplement"
- SLAC drawing No. SC-700-866-47, "Specification; KLY & VAC Machining Fluids"
- PRD No. SP-391-000-21, "CXI Reference Laser System "

3. General Requirements

3.1. Location

The reference laser system will be installed roughly 1m upstream of the exit of the X-Ray Tunnel (XRT) and will be supported and aligned with a dedicated stand.

3.2. Stay clear requirements

The reference laser system will be installed between the spools transporting the X-ray beams for hutches 4 and 6. It will stay clear of these spools. The offset between the CXI beam line and the XCS beam line (hutch 4) is foreseen at 600mm minimum. The offset between the CXI beam line and the hutch 6 beam line at this location of the XTR is in the order of 550mm (TBD).

3.3. Environment

The temperature and relative humidity in the XRT area will not be controlled. However, they will likely settle (after about one month of full operation) at some equilibrium state of around 74°F +/-5°F (23.3°C +/-1.5°C), and 50% +/-15%, respectively. No component specific temperature stabilizing system will be provided for the reference laser.

The area will get somewhat dusty therefore the in-air optics system shall be shielded with an enclosure. This enclosure will also serve to protect the in-air optics system from tampering

3.4. Maintenance, Accessibility and Operations

Only the in-vacuum mirror mount assembly will need to be extracted from the beam path without the need to move the entire chamber. During normal operation removal of the reference laser system should only be necessary due to failure of an in-vacuum component. Due to this "off-normal" failure mode, no design effort is required to make the reference laser vacuum chamber removal/replacement fast, i.e. ConFlat® (CF) flanges are acceptable based on the very low frequency of flange disassembly. All in-air optics as well as the laser shall be easily accessible for maintenance.

Because the reference laser is installed in the XRT, accessibility will be limited to periods when beamlines are not in operation or during scheduled shutdown periods.

The reference laser components will all be remotely operated and controlled.

3.5. Lifetime

The expected service life of the apparatus is 10 years.

3.6. Optical Requirements

Optically opaque CXI components shall not prevent the use of the reference line.

The reference line shall span as much of the XRT as feasible while maintaining the size and positioning requirements of Sections 3.6 and 3.7

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.

The reference line shall propagate undisturbed from vacuum to air.

The reference line system will be functional with the entire beamline under vacuum or some specific parts of the beamline in air. For this reason all the gate valves downstream of the reference laser shall be equipped with a glass window to let the beam go through.

3.7. Performance Requirements

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. .(TBD)

Two operating settings shall exist for the reference beam: "In" or "Out".

A translational repeatability of 100 microns shall be maintained when the reference line is placed in the 'In' position.

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 to be met, the pointing of the reference line will need to be accurate and repeatable to within 2 μrad.(TBD)

3.8. Cyclic Requirements

The in-vacuum mirror mount will be moved in and out of the laser beam position 50 times daily, during 1 day monthly alignment periods.

The reference laser system shall have the ability to change state (in or out) in ~ 10 seconds.

3.9. Mechanical Interfaces

The reference laser chamber will be linked to its vacuum environment as follows:

A 6" non-rotatable CF flange upstream

A 6" rotatable CF flange downstream

The downstream flange will be able to support a gate valve that will isolate the chamber from downstream components.

The reference laser will be linked to components both downstream and upstream of itself by welded bellows assemblies.

3.10. Vacuum

The reference laser system will be compatible with a 10^{-7} Torr pressure environment, or better, under all operating conditions. The reference laser chamber will be equipped with its own ion pump, right angle valve and vacuum gauges. A portable pumping cart will be used for rough pumping. The chamber will have the necessary viewport to introduce the laser beam from atmosphere to vacuum.

3.11. Materials

All parts and materials for the device shall be new and compatible with the performance requirements of this specification. Mil source certifications, including heat number, chemical analysis for all materials used in the manufacturing of the device shall be furnished per Section XX of this specification. Use of Teflon is specifically prohibited.

3.12. Thermal Issues

Because of the precise angular reproducibility requirements on the mirrors, precaution should be taken to minimize motions induced by thermal drift. If necessary the reference laser shall be installed in either FEH H4 or H5 where the temperature is controlled. (TBD)

3.13. Stability

Because of the large lever arm of the laser beam when installed in the XRT, precautions should be taken to minimize vibrations. If necessary, the reference laser shall be installed closer to, or inside of, FEH H5 to reduce the distance from the laser optics to the instrument

3.14. Kinematics/Supports

The reference laser vacuum chamber will be mounted on an individual stand thru a set of struts in order to align it with the X-ray beam. All in-air optics and the laser will be mounted on a breadboard utilizing the same stand.

3.15. Alignment / Fiducialization

Tooling balls will be provided on the vacuum chamber to align it in a plane transverse, X and Y directions, to the X-ray beam.

4. Electrical Requirement

All necessary power supplies and control cables shall be provided by the Controls Group.

The interface from the control racks to the reference laser system (cable trays and routing, connector supports, etc.) will be determined jointly with the Controls Group

5. Controls

5.1. Optics controls

All functions related to steering or shaping of the laser beam, turning the power on and off, and inserting or retracting the in-vacuum mirror in the beam path shall be accessible remotely.

Limit switches shall be provided to control and indicate the “In” and “Out” positions of the in-vacuum mirror.

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.

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. These diagnostics will be able to view both the X-ray and the laser beams but not simultaneously. The alignment will be done sequentially and iteratively by looking at the position of one beam and then the other.

5.2. Vacuum controls

A vacuum gauge will control the vacuum level in the reference laser chamber. An interlock will trigger the closing of the upstream and downstream gate valve in the case of an abnormal pressure rise.

6. Environmental Safety and Health Requirements

6.1. Radiation Physics

The reference laser system is planned to be installed in the XRT therefore no radiation shielding for personnel protection is anticipated.

In the case the reference laser should be installed in hutch 4 (see 3.13) a personnel protective shield will be installed around the reference laser system to allow people to work in hutch 4 while beam is being delivered in hutch 5.

6.2. Laser safety

The reference laser system shall be contained inside a protective box to prevent accidental exposure to users.

The reference laser shall be low power (class IIIa or less) so that no possibility of eye injury exists.