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

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. 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 the entire length of the CXI experimental hutch.

The visible laser beam shall be introduced from an external (to the chamber) source through a chamber mounted viewport onto a retractable, in-vacuum mirror that reflects the laser beam to be collinear with the X-ray beam.

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, "Physics Requirements for the CXI Reference Laser System "
- SLAC ES&H Division document SLAC-I-720-0A24E-001-R002: "Seismic Design Specification for Buildings, Structures, Equipment, and Systems".
- SLAC ES&H Manual Chapter 14: Pressure, Vacuum and Cryogenic Systems
- SLAC Technical Specification No. FP-202-631-14, "Fabrication of U.H.V. Components"

2.2. Industry Specifications and Codes

- NEC, NFPA 70: "National Electric Code,
- NEC, NFPA 70E: "Electrical safety in the Workplace"
- CBC 2007: "California Building Code, 2007"

3. General Requirements

3.1. Location

The reference laser system will be installed at the upstream end of the CXI experimental hutch in the LCLS Far Experimental Hall and may be supported and aligned with a dedicated stand.

3.2. Stay clear requirements

In its intended location the reference laser system will be installed adjacent to the hutch 6 X-ray transport spool. The offset between the nominal CXI centerline and the hutch 6 nominal centerline at this location in hutch 5 is on the order of 540mm. There will be no interference between the hutch 6 transport spool and the reference laser.

A minimum stay clear radius of 10mm will be maintained when the reference laser deflecting mirror is retracted, i.e. "Out" position.

3.3. Environment

The temperature inside the experimental hutch will be controlled to within ±1°F to provide the good thermal stability required to maintain device alignment. Temperature gradients throughout the hutch may be encountered and are acceptable (for example warmer air near the ceiling) provided each is stable to within the ±1 degree Fahrenheit tolerance. No component specific temperature stabilizing system will be provided for the reference laser.

The CXI hutch will get somewhat dusty therefore the in-air optics system shall be contained within an enclosure. This enclosure will also serve to protect the in-air optics system from any accidental disruption of the alignment..

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.

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 the entire length of the CXI experimental hutch.

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 2.5 mm.

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 window to let the beam pass.

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.

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 20 meters upstream of the back wall of the CXI hutch (the very upstream end of the CXI experimental hutch), then in order for requirement to be met, the pointing of the reference line will need to be accurate and repeatable to within 5 μrad.

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 vacuum chamber will be linked to its vacuum environment as follows:

A 6" non-rotatable CF flange upstream

A 6" rotatable CF flange downstream

The upstream flange of the vacuum chamber shall be able to support a pneumatically actuated gate valve that will provide vacuum isolation of the device from the upstream vacuum section connecting the CXI experimental hutch to the XRT vacuum.

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.

Manufacturing, cleaning, handling, storage and leak testing operations shall be per all pertinent referenced documents.

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. Only materials and joining techniques that are universally acceptable for use in a high-vacuum environment will be used. Use of Teflon is specifically prohibited.

All applicable material safety data sheets (MSDS) shall be provided and stored in an accessible location.

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.

3.13. Stability

The reference line will 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.

3.14. Kinematics/Supports

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

3.15. Lifting Features

Clearly defined lifting features and instructions shall be provided to facilitate the assembly/installation of the device both on the workbench and in the beamline.

3.16. Alignment / Fiducialization

Fiducialization (likely using tooling balls) shall be performed on the reference laser assembly to locate the nominal centerline of the vacuum chamber. During installation, the chamber shall be coarse aligned such that the as-measured centerline shall lie along the nominal X-ray beam centerline. Vacuum chamber position (x, y, z, pitch, roll, yaw) shall be recorded. All fine adjustments will be accomplished with remotely operated stages.

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 set 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 will be located in radiologically controlled areas and there are no radiation physics issues.

6.2. Laser safety

The reference laser system shall be contained inside a protective enclosure 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.

6.3. Earthquake Safety

SLAC is situated in an active seismic zone. All hardware exceeding a weight of 400 Lbs. and / or mounted greater than 4 feet above the floor will be reviewed by a SLAC "citizen safety committee" for seismic loading resistance. Applicable loads and structural behavior will be evaluated for compliance to the 2007 version of the California Building Code (CBC) and SLAC ES&H Division document SLAC-I-720-0A24E-001-R002: "Seismic Design Specification for Buildings, Structures, Equipment, and Systems".

6.4. Electrical Safety

All electrical hardware and connections will be reviewed for compliance to national/local electrical code(s).

6.5. Pressure/Vacuum Vessel

The reference laser shall be designed for use in a High Vacuum environment with the appropriate safety factors.

Pressure relief safe guards will be provided, where appropriate, to ensure compliance with all applicable guidelines/regulations.