ENGINEERING SPECIFICATION DOCUMENT (ESD)	Doc. No. SP-391-000-80 R0	LUSI SUB-SYSTEM Diagnostics

Intensity-Position Monitor Mechanical Requirements

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1. Overview

The LCLS X-ray FEL pulses will exhibit intrinsic intensity, position, and pointing fluctuations on a pulse-by-pulse basis. A diagnostic is required to measure the intensity, position, and to the extent possible the pointing of the X-ray beam (when two monitors are used in tandem with sufficient separation in the beam direction), aiding in normalization of intensity measurements, as well as characterizing positional and pointing jitters of the X-ray pulses. This document describes the mechanical requirements of this monitor.

The coordinate system is defined in Design Standards Supplement DS31100036.

2. Applicable Documents, Specifications and Codes

2.1. Stanford Linear Accelerator Center (SLAC) Specifications

- SLAC drawing No. DS-311-000-36, "Design Standards Supplement"
- SLAC drawing No. SC-700-866-47, "Specification; Machining Lubricants"

3. General Requirements

3.1. Location

A total of 11 Intensity-Position Monitors shall be installed, with distribution as follows:

	Shared	XPP	CXI	XCS	Totals
Intensity-Position Monitor		3	3	5	11

3.2. Environment

The sensor assembly will operate in vacuum and does not have environmental concerns. The pneumatic actuator or stepper drive, if applicable, will be in ambient air.

Devices installed in the tunnel will generally operate in a hot, dusty environment and must be designed to operate without service for at minimum one year.

The tunnel environment has the characteristics listed in the table below.

Parameter/Condition	Value
Location	Tunnel
Temperature	0°-40° C
Humidity	80% relative
Radiation	10 rad/year

Cleanliness	Airborne dust
Lifetime	20 year

Devices installed in the hutches will operate in a relatively cool, clean environment. It is expected that the devices will operate for several years prior to requiring non-routine maintenance.

Modify above chart for Hutch environment – what are Hutch characteristics?

3.3. Maintenance, Accessibility and Operations

The finished device shall be designed for straightforward installation, alignment, and removal. The sensor may require yearly servicing or replacement. Replacing the sensor shall not require removing the vacuum chamber; it shall be serviceable by unbolting the flange(s) to which it is attached.

3.4. Lifetime

The expected service life of the device is 20 years.

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4. Optical and Physics Requirements

Physics requirements (including optical requirements) are set forth in SP-391-000-08 "Physics Requirements for LUSI Intensity-Position Monitor". The requirements relevant to the mechanical specifications are as follows:

5. Mechanical Requirements

5.1. Physical Requirements

- No spare devices shall be built. 11 devices will be built and installed.
- The intensity-position monitor shall be designed to work for X-ray energies from 6 keV up to 25 keV.
- The operational range of the intensity-position monitor shall be greater than 2x2 mm^2.
- The intensity-position monitor shall be designed to measure the position of the X-ray beam in the XY plane to better than 10 µm in both X and Y directions.
- The intensity-position monitor must withstand the full LCLS flux when focused to an X-ray Gaussian spot size of 20 µm FWHM with a 1 mJ pulse energy across the 6-25 keV spectral range without degradation to the monitor due to radiation damage. (is this the number we want to use for what the shielding should be designed to withstand?)

- The design shall incorporate UHV standards and practices for all chambers and all components to be in a vacuum environment. UHV treatment of parts and assemblies shall be observed during cleaning, brazing/welding, handling, and assembly.

- The device shall be designed to mount to standard Conflat knife-edge type flanges with "clearance" type bolt holes.

- The chamber into which this device is installed shall have a 6" non-rotatable flange on the upstream end of the chamber, and a 6" rotatable flange on the downstream end of the chamber.

- Standard flange-to-flange chamber length of 10.62" for off-the-shelf 4, 5, or 6-way crosses shall be considered acceptable. Shorter than this length shall also be considered acceptable.

- Envelope size:

    - -Y distance (center of chamber to top of table) shall be fixed at 16".

    - +Y dimension shall be 16" or less (soft requirement).

    - –X dimension shall be 13.75" or less.

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    - +X dimension shall be 20.75" or less.

      Deleted: 13

    - Z (flange-to-flange) shall be 10.62" or less.

- Design must allow for all bolts to be loaded from inboard of the chamber. Studs and nut plates shall also be acceptable.

5.1.1. Sensor Assembly Requirements

- The design of the intensity-position monitor shall permit replacement of the both the target medium and the detection elements in the field.

- Three operating positions are required for the target media (foils): 'Unobstructed' meaning no foil is in position, '1' meaning foil 1 is in position, and '2' meaning foil 2 is in position.

- The detector itself does not transition in and out of the beamline; it remains permanently in place with the beam passing through its unobstructed center section.

- The intensity-position monitor state should have the ability to change target media states within ~5 seconds. A high precision motorized drive shall be utilized to perform this function.
- During target medium transitions, the incident X-ray beam shall be proactively turned off to avoid damage to materials surrounding the foils.
- An electrical feedthrough with 9 pins shall be utilized to connect necessary wiring from the non-vacuum to vacuum side. An Electronics Engineering Specification Document will detail the wiring, circuitry, and connections of the electrical and electronic components.
- Beam power spec (Yiping)– what does the shielding need to be capable of withstanding? A protective plate capable of sustaining the incident X-ray beam shall be used to cover all materials other than the sensor which could potentially be irradiated by the beam during a mis-steer and shall have a window exposing the clear aperture of the sensor.
- The intensity-position monitor shall have the ability to be translated in the X and Y direction with a 5 μm accuracy and repeatability.
- The nominal LCLS beam shall impinge at the center of the target medium to within 10% of the monitor working range (0.2 mm) and the surface normal of the sensor shall be aligned the z-axis of the LCLS coordinate system to within ±2°. This can be achieved manually.
- The size of the target media shall be greater than 10mm x 10mm, permitting an active area of 10x10 mm^2 for full range of monitor operation.
- The device shall be designed to have at minimum a clear aperture of 10mm x 10mm for the target medium.
- A holder for the detection elements for the measured signal shall be designed to allow a stay clear area of at least 2x2 mm^2 in order to not obstruct the beam from the target medium.
- Positioning the target media: a translational repeatability of 200 μm and stability of 5 μm, and a rotational repeatability (pitch and yaw) of 1.0° and stability (pitch and yaw) of 0.1° shall be maintained when either target medium is moved into position.
- The sensor and its housing shall be electrically insulated from the vacuum can of the monitor. (what is Gunter's position on this? Just the sensor isolated?)
- The sensor may be mounted on a metal fixture, which is then attached to the shaft fixing the device to a flange. The shaft shall be stiff enough that motions resulting

from mechanical resonances will be less than 50% of the specified spatial resolution of 5 μm.

- A minimum beam stay clear radius of 12.7mm (0.5 inches) shall be maintained when the sensor is in the 'Out' position. The beam shall be assumed to lie down the design centerline of the chamber into which this device is installed.

- There is no sensor "fail safe" consideration.

5.2. Cyclic Requirements

Bellows for sensor assembly to be designed for 10,000 cycles under vacuum load at 60º C. Stroke will be approximately 1.5 inches and will be specified in the final design. The sensor assembly must be able to structurally withstand 1,000 sensor in/out cycles. Pneumatic actuator or motorized drive shall be capable of 1,000 in/out cycles within mechanical specifications.

5.3. Mechanical Interfaces

The chamber in which this device sits shall be supported from the underlying table by rod ends. The rod ends shall allow adjustability in the x, y, and z directions, and shall allow for roll, pitch, and yaw adjustment.

In every case and in all three instruments (XPP, CXI, XCS), alignment of adjacent chambers shall be driven by the alignment of the Intensity-Position Monitor. That is, the upbeam/dowmbeam flanges of the Intensity-Position Monitor shall be adjusted to optimize the perpendicularity of the sensor to the beam. The designs of adjacent chambers shall take into account to the limits of the tolerances on the Intensity-Position Monitor beamline flanges, and shall have adjustability or permitted misalignment large enough to account for these tolerance limits.

Where the PRD does not specify a location or orientation, this specification shall be considered non-critical. Whereas pitch, yaw, X, and Y of the sensor (and by extension the chamber into which it is mounted) are dictated by requirements of the PRD, roll and Z are not present in the PRD and as such shall be allowed to be variable. This variability will allow for adjacent devices to be optimized. Therefore, if an adjacent device has a roll requirement, the Intensity-Position Monitor shall be rolled to meet the spec of the adjacent device.

5.4. Vacuum

This device will be used in an Ultra-High Vacuum (UHV) of 10^{-7} Torr. The device's vacuum sealing surfaces shall be leak tested as specified in section xxx (Nadine – where is the standard spec?).

All lubricants, cutting fluids, etc., used in manufacturing shall be "sulfur-free". SLAC document No. SC-700-866-47 is a compendium of SLAC approved lubricants. The use of sanding discs, abrasive paper or grinding wheels is typically prohibited. In special circumstances good vacuum practices should be followed when grinding and polishing is required. This process shall be reviewed and approved by the engineer for its vacuum compatibility.

All parts and subassemblies shall be cleaned for UHV. Once parts are cleaned for vacuum, handle only with clean latex or nitrile gloves in/on a clean room/surface. This includes all subassemblies. For storage or transportation, place in clean sealed vacuum grade plastic bag that has been back-filled with nitrogen.

5.5. 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. The device will be used in a radiation environment with a maximum rate of about XX kilorad per year, and a total integrated dose of xx rad. Use of Teflon is specifically prohibited. (Nadine – need your input for these standards)

5.6. Thermal Issues

Sensor: Beam does not strike the sensor. Heating of the sensor is not expected to be a problem.

Thermal loads on the remainder of the device are not expected to be appreciable in normal operation. Adjacent devices and chambers shall not expect significant heat sourcing or sinking from this device.

5.7. Structural Issues

Rapid cycling or start/stop of pneumatic actuator could cause damage to the sensor. Soft start/stop shall be a design consideration, and testing will be done to ensure appropriate controls are in place to protect the sensor from damage.

Supports for the sensor/actuator assembly and camera/lens assembly shall be sufficiently robust to handle loads applied (vacuum, actuator, torque, cycling, etc). Static and dynamic deflection shall be less than .050”. The sensor support shaft shall not resonate when the pneumatic actuator or stepper drive is operating.

5.8. Precision motion

Reserved.

5.9. Alignment/Fiducialization

During installation, the chamber shall be aligned such that the as-measured centerline shall lie along the nominal beam centerline. Chamber position (x, y, z, pitch, roll, yaw) shall be recorded. Fiducialization (likely using tooling balls) shall be performed to ensure compliance with alignment requirements.

5.10. Stability

The stability of the chamber is expected to be less than a micron. Small stability changes may occur during state transitions while the actuator is working (any transient issues are expected to die out within a few seconds).

Thermal issues could impact stability. Anything that may cause significant heating (especially cyclic heating) of the device or chamber should be investigated full to determine its impact on device operation.

5.11. Kinematics/Supports

The device shall be designed to meet or exceed the mechanical requirements as assembled. Tolerances shall be adjusted to ensure that the device as bolted together is within specified requirements. Applicable experimental verification, fiducialization, and QC shall be performed to verify compliance. No in-the-field adjustment will be necessary.

The support shall be a 6 degree of freedom strut system utilizing rod ends. Each rod end should have at minimum 0.25 inches of adjustability (plus and minus) from nominal. The distance from the center of the chamber to the table to which the device is mounted shall be designed to be a nominal 16 inches. Mounting system from the rod ends to the table shall also be part of the design of this device.

There shall be 3 rod ends at each end of the chamber. One end of the chamber shall have two Y supports and one X support. The other end of the chamber shall have one each of X, Y, and Z supports. This system allows adjustability of the chamber in all six degrees of freedom (X, Y, Z, roll, pitch, yaw).