

PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-63 R1	LUSI SUB-SYSTEM Coherent X-Ray Imaging
Physics Requirements for the CXI 0.1 micron Precision Instrument Stand		
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1. Applicable Documents

PRD# SP-391-000-03	LUSI Controls and Data System
PRD# SP-391-000-06	LUSI Data Management System
PRD# SP-391-000-19	CXI Instrument
PRD# SP-391-000-20	CXI 0.1 micron Sample Chamber
PRD# SP-391-000-24	CXI 0.1 micron KB System
PRD# SP-391-000-25	CXI 1 micron KB System
PRD# SP-391-000-28	CXI Detector Stage

2. Overview

The CXI 0.1 micron Sample Chamber (PRD SP-391-000-20), the CXI Detector Stage (PRD SP-391-000-28) as well as the CXI 0.1 micron KB System (PRD SP-391-000-24) will all interface directly with each other in a small area. Furthermore, the 0.1 micron Sample Chamber and the Detector Stage will be required to move together as a solid unit and therefore require a unique stand to support both. The 0.1 micron KB system does not need to move with the other 2 components but its close proximity to the 0.1 micron Sample Chamber makes it so that it may be necessary to support it using the same stand.

This document describes the requirements for a 0.1 micron Precision Instrument Stand that can support the 0.1 micron Sample Chamber, the Detector Stage and the 0.1 micron KB System. This stand can consist of a single support structure supporting all 3 devices or a structure supporting the chamber and detector stage with a separate structure supporting the 0.1 micron KB system. The decision on which option works best is expected to be made during the design phase.

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

3. Size Requirements

3.1. The 0.1 micron Precision Instrument Stand shall be large enough to support the CXI 0.1 micron Sample Chamber and the CXI Detector Stage (with all the necessary expansion vacuum spools as described in PRD SP-391-000-28).

3.2. The instrument stand shall also support the CXI 0.1 micron KB System either on the same structure which supports the sample chamber and the detector stage or as separate structure.

4. Positioning Requirements

4.1. The instrument stand shall be surveyed into a position where, with all the motion stages listed in Table 5-1 located at their nominal positions, the on-beam axis of the instrument stand is oriented along the nominal unfocused LCLS beam to within $\pm 1^\circ$ in pitch, roll and yaw.

4.2. The instrument stand shall allow the interaction region of the chamber to be placed at a height of 1.4m from the ground with all the stages at their nominal positions.

4.3. The Z location of the Precision Instrument Stand shall be determined by the positioning requirements of the CXI 0.1 micron Sample Chamber described in documents PRD SP 391-000-19 and PRD SP 391-000-20.

5. Motion Requirements

5.1. The instrument stand shall translate the CXI 0.1 micron Sample Chamber and the CXI Detector Stage in the x and y directions to allow centering of the interaction point of the CXI 0.1 micron Sample Chamber on the focal spot of the LCLS beam to within 50 μm for any of the focusing optics, described in PRD SP-391-000-24 and PRD SP-391-000-25, as well as for the unfocused beam.

5.2. The instrument stand shall translate the sample chamber in the z direction to allow centering of the interaction point on the beam waist to within 50 μm .

5.3. The combination of motions of the instrument stand allow the yaw angle of the sample chamber and detector stage to be aligned with the X-ray beam for all focusing optics (the 0.1 micron KB system and the 1 micron KB system) and the unfocused beam.

5.4. The 0.1 micron sample chamber and detector stage shall be positioned using the instrument stand according to the motions listed in Table 5-1. The stability requirement in Table 5-1 is meant to represent stability with respect to the incident LCLS beam over a period of a few minutes.

Motion	Range	Nominal Position	Resolution	Repeatability	Stability
x position	$0 \text{ mm} < x < 120 \text{ mm}$	0 mm	50 μm	50 μm	0.1 μm
y position	$-10 \text{ mm} < x < 10 \text{ mm}$	0 mm	50 μm	50 μm	0.1 μm
z position	$-10 \text{ mm} < x < 10 \text{ mm}$	0 mm	50 μm	50 μm	0.1 μm
Yaw	$-0.1^\circ < \text{yaw} < 0.8^\circ$	0°	30 μrad	30 μrad	5 μrad

Table 5-1: Positioning requirements for the precision instrument stand as referenced to the nominal unfocused LCLS beam.

5.5. All the motions of the instrument stand shall not cause the mirrors of the 0.1 micron KB system to move. The mirrors shall remain fixed while the vacuum enclosure of the mirrors can be allowed to move. This requirement may force the engineering solution to require 2 separate support structures.

6. Interface Requirements

6.1. The instrument stand shall allow for an interface between the 0.1 micron sample chamber and the 0.1 micron KB system that allows the 0.1 micron sample chamber to rotate without causing the KB mirrors to move.

6.2. The Precision Instrument Stand shall allow for the Detector Stage to be mounted in place of the 0.1 micron KB System, upstream of the 0.1 micron Sample Chamber. This requirement applies only if the engineering solution for the 0.1 micron KB System involves a vacuum enclosure separate from the 0.1 micron Sample Chamber. If not, then the 2D X-ray Detector shall be mounted inside the Sample Chamber as described in PRD SP-391-000-20, *Physics Requirements for the CXI 0.1 micron Sample Chamber*.

7. Stay Clear Areas

7.1. It shall be possible to bring a laser beam through the 0.1 micron Precision Instrument Stand below the CXI 0.1 micron Sample Chamber. This beam would then be introduced travelling vertically into the chamber through the bottom of the chamber. This means the structure of the instrument stand cannot be a solid block which would prevent access some parts of the sample chamber.

7.2. The structure of the instrument stand shall all be kept below the bottom level of the 0.1 micron chamber door so that access to the door and all other viewports is unimpeded.

8. Controls Requirements

The controls and data acquisition associated with the Precision Instrument Stand shall be consistent with the requirements outlined in the documents PRD SP-391-000-03, *Physics Requirements for the LUSI Controls and Data System* and PRD SP-391-000-06, *Physics Requirements for the LUSI Data Management*. Requirements specific to the sample chamber are described below.

- 8.1.** Remote operation of all instrument stand components shall be implemented via the instrument control system.
- 8.2.** It shall be possible to scan every motion at a constant speed or constant time between steps during data collection.
- 8.3.** It shall be possible to synchronize the scanning steps with the LCLS pulses.
- 8.4.** The position of the stages shall not be lost when they are powered off. The positions shall be recorded in software and recovered upon reinitialization.
- 8.5.** Software limits on the motions shall be implemented.
- 8.6.** There shall be two sets of software limits. The first one will allow only fine motions to fine tune the position of the stand relative to the LCLS beam. The second shall allow large motions when the configuration of the instrument is changed between the 2 KB systems.
- 8.7.** It shall be possible, with password control, to modify the software limits at any time from the control console.
- 8.8.** It shall be possible to lock, with password control, the position of the stages of the instrument stand once a proper alignment has been achieved.
- 8.9.** The position of every positioner shall be recorded on every pulse for which experimental data is measured and these positions shall be embedded in the experimental metadata.
- 8.10.** The position of all stages shall be displayed at the control console and refreshed after every move.