LCLS Interface Control Document # 1.6-	X-ray Endstation Systems	Revision 0

Interface between the 2D-PAD and CXI Instrument

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Brief Summary:

This document presents the mechanical interface between the Cornell 2D Pixel Array Detector in LCLS WBS 2.06.05.02 & 2.06.02.08 and the CXI Instrument in LUSI described by WBS section 1.03.

Change History Log

Rev Number	Revision Date	Sections Affected	Description of Change
0	Nov 17, 2008	All	Initial Version

Supporting Documents

LCLS PRD 1.6-002 r1: Physics Requirements for the 2D X-Ray Detector.

LCLS ICD 1.1-514 r0: PCD (Photon Controls & Data) systems.

LUSI PRD SP-391-000-28 r0: Physics Requirements for the CXI Detector Stage.

LUSI PRD SP-391-001-42 r0: Physics Requirements for the CXI 1 μm Precision Instrument Stand.

LUSI ESD SP-391-001-18 r0: Data Acquisition Specification for the CXI Experiment.

LUSI DS-391-000-36 r0: Mechanical Design Standards Supplement.

1. Introduction

The LCLS X-ray Endstation System group will develop a prototype x-ray detector (2D-PAD) in collaboration with Cornell to be used in the LUSI Coherent X-ray Imaging (CXI) experiment. The detector consists of a sensor diode bump-bonded to two pixelated readout ASICs. The CXI experiment requires a tiled detector to cover a larger area and a variable hole size in the center to accommodate the diverging beam when moving the detector along the LCLS beam.

This document describes the interfaces between the CXI detector assembly, holding multiple 2D-PAD detectors, and the CXI Instrument.

1.1. Acronyms

2D-PAD: two dimensional pixel array detector

1.2. Coordinate System

See document LUSI DS-391-000-36 r0.

2. CXI Detector Assembly

Here is a list of the major components and sub-assemblies which make-up the CXI Detector:

- Analog PCB: provides power, grounding, high voltage, and data & controls interface to 2D-PAD.
- Digital PCB: provides interface between analog PCB and LCLS Photon Controls & Data systems.
- Strong-back: aluminum structure that holds 2 carrier boards and has 4 thermal feet mounted to a quadrant raft to cool the readout ASICs.
- 2x1 Detector module: 2 ASICs bump-bonded to one sensor diode.
- Carrier board: this rigid-flex PCB holds a wire-bonded 2x1 detector module. A flexible circuit cable connects to the analog PCB.
- 2x2 Detector module: 2 carrier boards glued to a so-called metal strong-back, this module contains 2x2 ASICs.
- Quadrant raft: holds up to 4 2x2 detector modules and one analog and one digital PCB. Connected via cold straps to a water cooled mounting plate.

Cornell develops and tests the 2x1 detector modules and ships them to SLAC. SLAC loads the strong-backs with calibrated 2x1 detector modules to produce the 2x2 detector modules. The strong-back and the assembly tools will be developed by SLAC. The assembled 2x2 modules will be used to build the tiled CXI detector. SLAC will develop the carrier board and the analog PCB. The CXI detector stage and precision instrument stand are part of LUSI and designed at SLAC.

The CXI detector assembly accommodates 4 moveable quadrant rafts, readout electronics, motors and cooling. The quadrant rafts move with respect to each other to resize the square aooerture in the center of the detector. The current CXI detector can hold up to 16 2x2 detector modules.

2.1. Diagram showing detector with its major sub-assemblies, showing all internal and external interfaces (structural, electrical, conductive, convective/radiation).

3. Interface Definition

The interfaces between the LUSI CXI instrument and the LCLS x-ray detector described in this document are mainly mechanical. For details about the interface between the x-ray detector and the LCLS Photon Controls & Data systems we refer to document LCLS ICD 1.1-514.

3.1. Mechanical Requirements

The not-to-exceed (NTE) weight of the entire detector assembly shall be 11 kg (25 pounds).

The center of gravity along the Z-axis shall not exceed 2.5" (63.5 mm) from the interface plane on the back of the detector package. The center of gravity of the detector assembly must be within 0.25" (6.4 mm), radially, of the center.

The stayclear volume is 11.25" (286 mm) diameter by 5" (127 mm) long envelope. All cables, cooling, and other services must exit the detector assembly off the back flange. An additional 3" (76 mm) in Z is available off the back end of the detector to allow for connectors and cable routing to either route the services in Z or radially. The diameter of the sample chamber flange should be 11.75" or larger.

The detector motion along beam direction is 700 mm. Cables, cooling, and any other services leaving the detector need to be flexible (flex or regular cable with service loop) to accommodate this movement along the beam direction.

Detectors must be contained in a light shield with a fixed center hole of 10 mm to accommodate the LCLS beam. The thickness of this Beryllium window needs to be 100 μm or less to achieve a transmission better than 0.98 for 8 keV photons. The Beryllium window should be replaceable (e.g. for different thickness or different aperture).

The detector shall be designed to be removable.

3.1.1. Aperture Sizing and Tiling of the quadrants.

The aperture size in the center can be changed from 1 mm square to 10 mm square with an accuracy of 100 microns. A repeatability of aperture sizing of 10 microns is desirable. Aperture re-sizing must be done remotely without breaking the vacuum.

All detectors in the focal plane shall be co-planar within 200 microns.

3.1.2. Detector Stability

Detector positioning is re-calibrated whenever the detector is moved or the aperture re-sized, so all stability requirements apply only during one calibration cycle. The pixel position stability is absolute with respect to the interface mount, see fig. 1. This position stability of the detector pixels has to be 10 microns or less over a duration of 12 hours.

The Detector Stage and Precision Instrument Stand will contribute to the overall stability of the detector w.r.t. the sample or beam. These stability numbers are assumed to be uncorrelated and added in quadrature, see the specific PRD/ESD.

3.2. Thermal Requirements

The detector shall be cooled and operated between 20 - 40 °C with a temperature stability of ±1 °C per 2x1 module.

The temperature uniformity within a single 2x1 detector module is 2 °C or less. Thermal equilibrium will be reached in 1 hour.

Power allocation: 4 W max/carrier board. Derived from 300mA at 3.3V = 1W for each ASIC, plus 1 W allocation for support circuitry on the support PCB, plus 1 W margin. This gives 32 W for the complete CXI detector assembly, without power cycling.

3.3. Fluid Requirements

Water cooling requires air-guards to prevent water to vacuum interfaces. The nominal water temperature in the Far Experimental Hall is 20 °C.

3.4. Vacuum Requirements

The x-ray detector operates in a 10^{-7} Torr vacuum of the CXI sample chamber. To minimize the total outgassing rate of the detector assembly, lubricants for mechanisms, and all materials used in the packaging shall be materials from the NASA list in Table 1. Pumping at the back side of the detector should be arranged.

Contamination control during assembly and maintenance is largely procedural and deals with the preparation, processing and handling of components at Cornell, SLAC and sub-contractors. All materials, components, and assemblies shall be processed and cleaned according to standard UHV handling practices. After cleaning, all materials, components, and assemblies used in the detector assembly or fixturing shall be stored, handled, and used in accordance with standard UHV practices. Special care should be

3.5. Electrical Requirements

The electrical and optical signal cables shall be connected to the LCLS PCD systems via vacuum feedthrus.

3.6. Power Requirements

All moving parts, and actuators shall be fail-safe from sudden loss of power.

High voltage cable (120-200 V) to bias the sensor. Low voltage power for the readout electronics.

3.7. Signal Requirements

All the detector motions need to be remote controlled. After moving the detector or changing the hole size one first has to align with a reference visible laser beam and then with an attenuated LCLS beam. Only after alignment verification the full LCLS beam is allowed. Software locks on these motions are needed so the motors cannot be actuated at all when the full beam is on. We possibly also need to interlock this to the MPS system so that if someone someone bypasses the software lockouts and moves the motors, the MPS system is tripped. So administrative and software protection is envisioned for this.

3.8. Other Requirements