| Engineering specification Document (ESD) | Doc. No. SP-391-000-70 R0 | LUSI SUB-SYSTEM CXI instrument |
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# CXI Detector stage

| | Signature | Date |
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| Revision | Date | Description of Changes | Approved |
|---|---|---|---|
| R0 | 13March2008 | Initial release | |
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# 1. Overview

The 2D X-ray Detector used by the CXI instrument is described in document LCLS PRD # 1.6-002, Physics Requirements for the 2-D X-Ray Detector. The detector is required to be accurately placed so that the incident X-ray beam passes through the hole in the middle of the detector at various distances from the sample. The detector will be mounted in vacuum. The detector stage comprises the vacuum enclosure in which the detector is placed, the supports and motions of this vacuum enclosure and the in-vacuum mount and motion stages that hold the detector. This document describes the technical specifications of the detector stage system.

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

# 2. Applicable documents

| | |
|---|---|
| PRD# SP-391-000-20 | CXI sample chamber |
| PRD SP-391-000-28 | CXI detector stage |
| ESD# SP-391-000-69 | CXI Precision instrument stand |
| ESD# SP-391-000-67 | CXI sample chamber |

# 3. Performance Requirements

3.1. It shall be possible to set the detector distance from the interaction region to values between 50 and 2600 mm.

3.2. It shall be possible to continuously and remotely vary the detector distance from the interaction region over a range of at least 600 mm.

3.3. It shall be a design goal to make it possible to mount the detector stage downstream and upstream of the sample chamber. When the detector is installed in the sample chamber in the time delay upstream position no XYZ motorized motion will be available. If necessary the 0.1 micron KB system (PRD SP-391-000-24) shall be removed to allow the detector stage to be mounted in the upstream position. If the engineering solution for the sample chamber and the 0.1 micron KB system is to have the 0.1 micron KB system located inside a larger sample chamber, then this requirement no longer applies.

# 4. Size Requirement

The detector will be provided to the CXI instrument housed in a 10" diameter cylinder that is 5" deep. This is a maximum envelope which will drive many of the design decisions.

4.1. The vacuum enclosure of the detector shall be large enough to enclose the detector, its mount and the Z motion in-vacuum stage .Room will be provided for a cables and cooling lines carrier to follow the Z motion of the detector.

4.2. The flange of the vacuum spool attached to the sample chamber shall be large enough to allow the detector to protrude into the sample chamber.

# 5. Positioning Requirements

Two focusing optics will be used for the CXI instrument and they will each have a different focal spot location in the xy interaction plane. Furthermore, the unfocused beam will also be located at a third point in the x-y plane. The KB1 and KB0.1 systems (PRD SP-391-000-24, *Physics Requirements for the CXI 1 micron KB System* and PRD SP-391-000-25, *Physics Requirements for the CXI 0.1 micron KB System*) will deflect the beam in the horizontal plane by 6.8 to 12 mrad. This exact angle is still to be determined. While the deflection angle will be the same for both KB systems, the upstream location of the KB1 system causes a large displacement in the x direction at the detector location. The following requirements are designed to account for these beam displacements to be able to align the detector on any of the 3 beam directions. Some of these requirements can be accommodated by the CXI Precision Instrument Stand (PRD SP-391-000-69) on which the detector stage shall be mounted.

2 types of positioning will be provided for the detector

# 6. Detector chamber assembly positioning

6.1. The detector chamber assembly shall be attached to the same precision stand as the sample chamber described in ESD# SP-391-000-69

6.2. The Z axis of the chamber assembly shall be aligned by construction to the Z axis of the sample chamber. Both the sample chamber and the detector chamber assembly will be positioned thru the precision stand to align their Z axis to the LCLS beam with the focusing optic in use.

6.3. The detector chamber assembly will follow all the motions of the sample chamber in x,y,z and yaw as described in ESD# SP-391-000-69 table 5-1

6.4. Alternate positions of the detector chamber assembly on the precision stand shall be provided to cover the full range of motion of the detector. These positions will be obtained by manually moving the whole detector chamber assembly on the precision stand and inserting extension spools between the detector stage and the sample chamber.

See figure 1

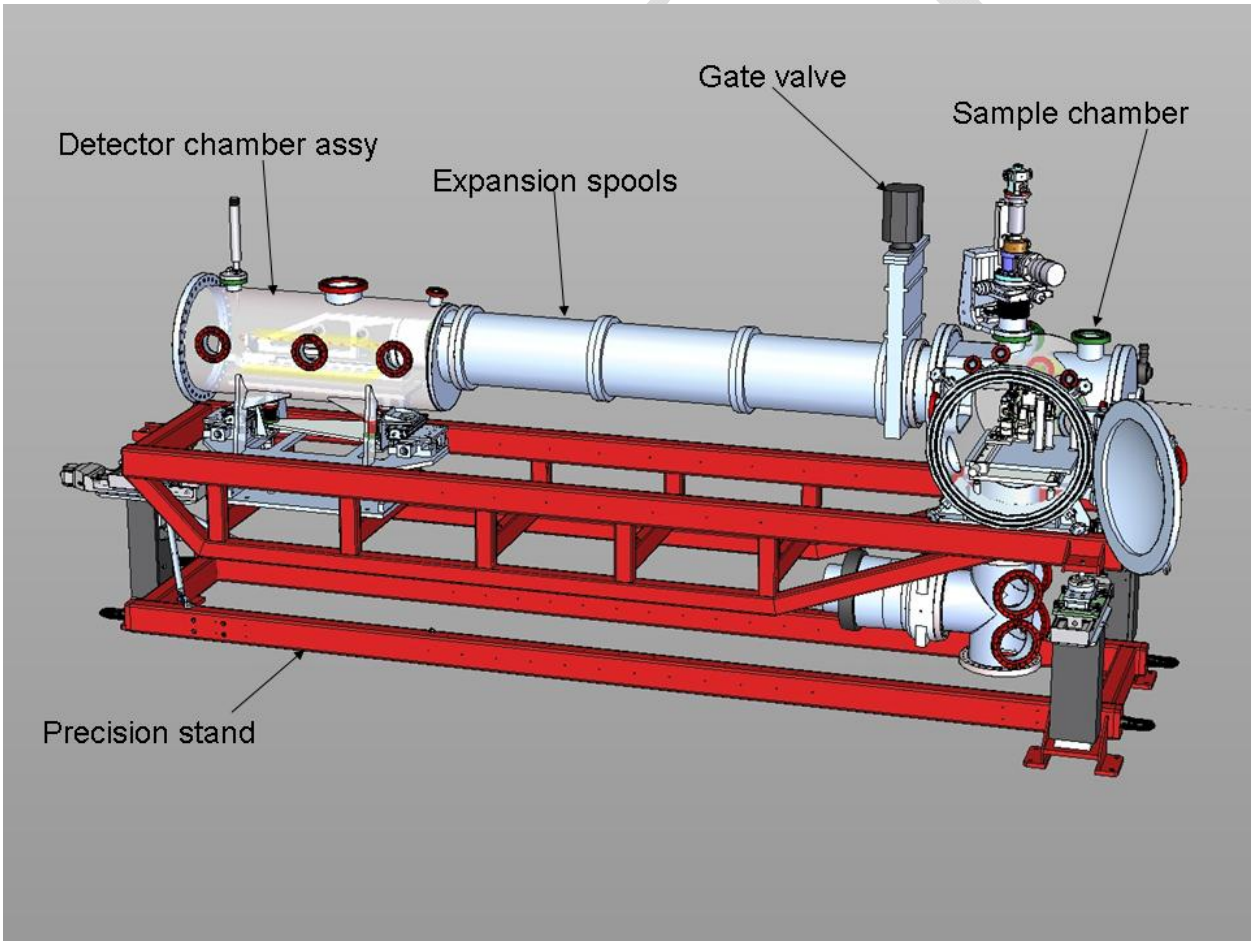


**Figure 1**

# 7. Detector Z stage axis positioning

7.1. A Z motion stage will be provided inside the detector chamber to obtain a 600mm continuous range of the detector on top of the alternate positions described in 6.4

7.2. The Z detector stage assembly will come as one unit that can be assembled outside of vacuum and installed in the vacuum chamber assembly. It consists of the Z linear stage, the detector with its support and cooling lines and the cable carrier. See figure 2

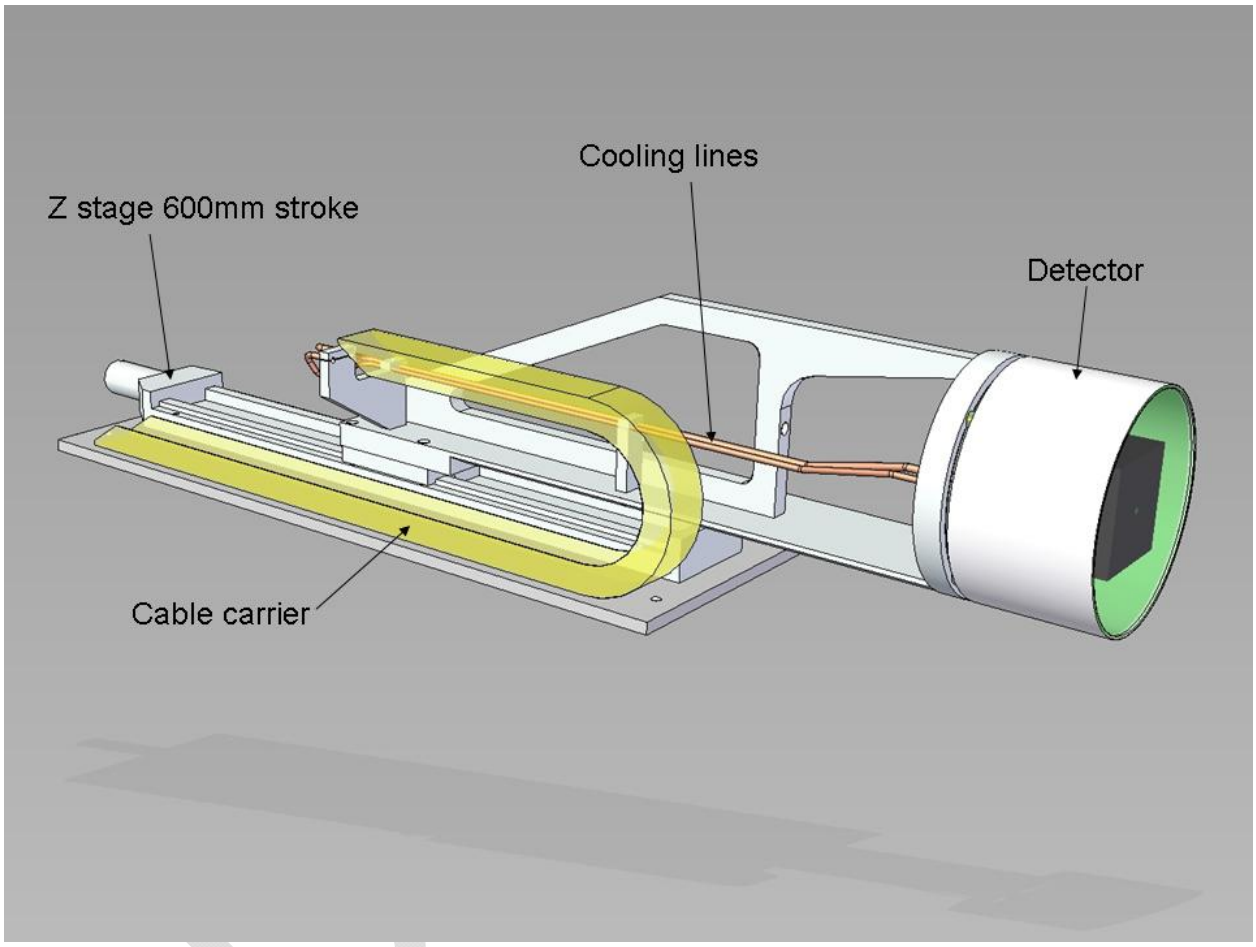


Figure 2

7.3. 2 pairs of additional XY stages included in the detector chamber assembly will be provided to align the detector Z motion axis relatively to the sample chamber Z axis. The X and Y motion of the detector will be driven by linear stages outside of vacuum. The combination of movements of the XY stages will provide a pitch and yaw alignment of the Z stage of the detector. See figure 3

7.4. The XY stages will allow the centering of the LCLS beam to within 10 μm of the center of the hole in the detector for any of the focusing optics (KB0.1, KB1 and Focusing Lenses). They will also provide for any necessary realignment of the Z stage motion axis to the LCLS beam.

7.5. The Z detector stage shall have the motorized motions listed in **Error! Reference source not found.**.

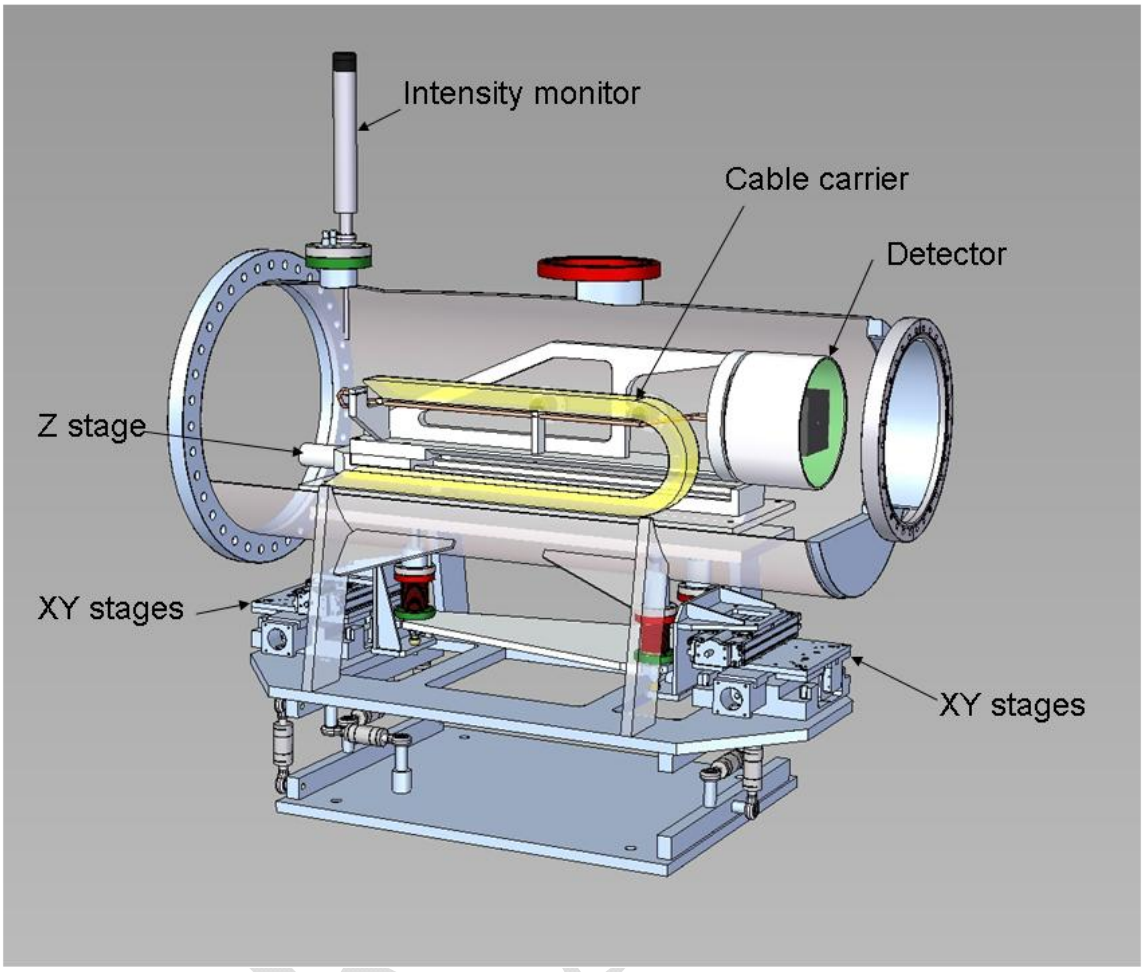


Figure 3

7.6. The detector shall be able to protrude out of its own chamber into the sample chamber at a 50mm distance from the sample. See figure 4

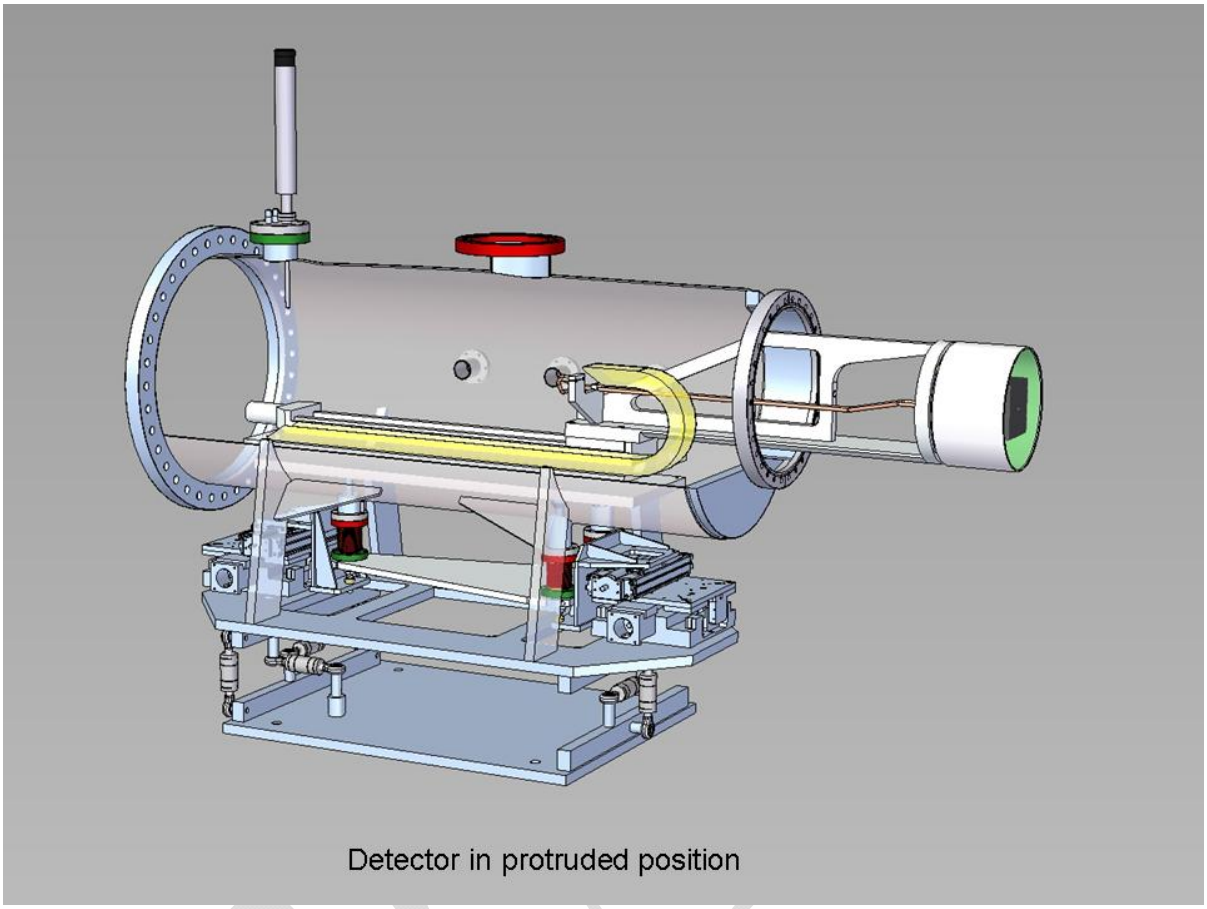


Figure 4

| Motion | Nominal Position | Range | Resolution | Repeatability | Stability |
|---|---|---|---|---|---|
| Out of vacuum y1 | 0 | -5 mm < y < 5 mm | 10 µm | 10 µm | 1 µm |
| Out of vacuum x1 | 0 | -5 mm < x < 5 mm | 10 µm | 10 µm | 1 µm |
| Out of vacuum y1 | 0 | -5 mm < y < 5 mm | 10 µm | 10 µm | 1 µm |
| In-vacuum z | 50 mm | 50 < z < 2600 mm in steps of 600mm | 50 µm | 50 µm | 1 µm |
| Yaw (x combination) | 0º | ±20 mrad | 100 µrad | 100 µrad | 10 µrad |
| Pitch (Y combination) | 0º | ±20 mrad | 100 µrad | 100 µrad | 10 µrad |

## 8. Cooling requirements

8.1. The detector will need water or gas cooling lines to remove the heat produced by the ASIC and circuit board.

8.2. These cooling lines will need to follow all the motions of the detector and be easily disconnected and reconnected when installing the detector in the time delay configuration.
See figure 2

## 9. Vacuum Requirements

9.1. The detector shall be mounted in a $10^{-7}$ Torr pressure environment or better and the appropriate vacuum practice for the design, manufacturing, and installation of the system components shall be implemented.

9.2. It shall be possible to isolate the vacuum of the detector stage from the vacuum of the sample chamber with a gate valve. See figure 1

9.3. The isolation gate valve shall be equipped with a view port to let the HeNe reference laser pass through when the valve is closed.

9.4. A port for visual inspection of the detector shall be provided.

9.5. The feedthrough(s) for the detector signals and power shall be located near the downstream end of the vacuum enclosure.

9.6. There shall be a feedthrough flange near the downstream end of the chamber for cooling lines.

9.7. The 2D X-ray detector housing will have an open back end. The pumping on the vacuum enclosure of the detector stage shall be designed to make any outgasing from the detector flow away from the interaction region. A suitable size turbo pump will provide the pumping of the detector enclosure.

9.8. The downstream end of the vacuum enclosure of the detector shall allow more vacuum sections to be attached to let the beam propagate further to diagnostics devices.

9.9. 6 extra ports will be provided on the chamber for vacuum accessories and control.

## 10. Alignment laser intensity monitor

10.1. The detector and its Z motion axis shall be aligned to the FEL beam by using a HeNe reference laser collinear to the FEL beam.

10.2. A HeNe detector diode will be installed in the vacuum enclosure, down stream of the detector, to monitor the alignment of the detector along its full Z motion. The diode will measure the alignment laser intensity passing through the detector aperture and will allow the user to center the detector on the laser path.

10.3. The diode will be attached to a retractable mount to move it out of the way of the FEL beam after the alignment process is done. See figure 3

10.4. Another optional configuration is to put the diode outside of vacuum and install a mirror on the feedthrough to reflect the laser to the diode via a view port.

## 11. Controls Requirements

The controls and data acquisition associated with the detector stage 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 detector stage are described below.

11.1. Remote operation of all the positioners shall be implemented via the instrument control system.

11.2. Password protection shall be implemented for all the positioners of the detector stage to protect the detector from damage due to the LCLS beam in the event of an accidental move.

11.3. Interlocks shall be implemented to prevent the gate valve separating the sample chamber from the detector vacuum spool from closing while the detector is protruding through the valve.

11.4. Vacuum interlocks shall prevent the valve separating the sample chamber from the detector vacuum spool from opening while the pressure is above $10^{-5}$ Torr.

11.5. 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.

11.6. Limit switches shall be used to prevent the detector from colliding with the walls of the vacuum enclosure or the components inside the sample chamber.

11.7. Temperature monitoring will be provided on the detector.