LUSI
LCLS Ultrafast Science Instruments

ENGINEERING SPECIFICATION DOCUMENT (ESD)	Doc. No. SP-391-001-19 R0	LUSI COMMON INSTRUMENTS

Engineering Specifications for the LUSI Common Instruments Controls

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Revision	Date	Description of Changes	Approved
R0	29Jul08	Initial release	

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1. Applicable Documents

PRD# SP-391-000-03   LUSI Controls and Data System
PRD# SP-391-000-04   LUSI Pop-in Profile Monitor
PRD# SP-391-000-06   LUSI Data Processing
PRD# SP-391-000-08   LUSI Intensity-Position Monitor
PRD# SP-391-000-09   LUSI Pop-in Intensity Monitor
PRD# SP-391-000-10   LUSI Attenuator System
PRD# SP-391-000-11   LUSI X-ray Focusing Lens System
PRD# SP-391-000-14   LUSI Slit System
PRD# SP-391-000-15   LUSI Wavefront Monitor
PRD# SP-391-000-16   LUSI Offset Monochromator
PRD# SP-391-000-23   LUSI Pulse Picker
PRD# SP-391-000-34   LUSI Harmonic Rejection Mirror System

2. Overview

The LUSI project includes three instruments: XPP in NEH Hutch 3, CXI in FEH Hutch 5, and XCS in FEH Hutch 4. These instruments will use common X-ray beam shaping and diagnostics packages. These include:

> LUSI Pop-in Profile Monitor
> LUSI Wavefront Monitor
> LUSI Pop-in Intensity Monitor
> LUSI Position-Intensity Monitor
> LUSI X-Ray Focusing Lens
> LUSI X-Ray Slit System
> LUSI Attenuator
> LUSI Harmonic Rejection Mirrors
> LUSI Pulse Picker
> LUSI Offset Monochromator

This document contains the specifications for the control system for theses LUSI common instrument components.
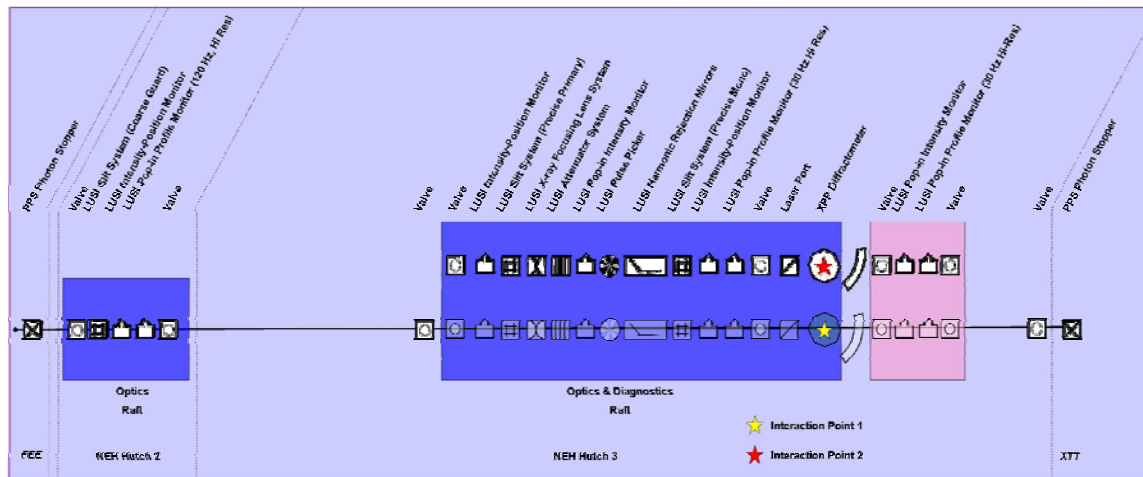
XPP Instrument Layout

CXI Instrument Layout
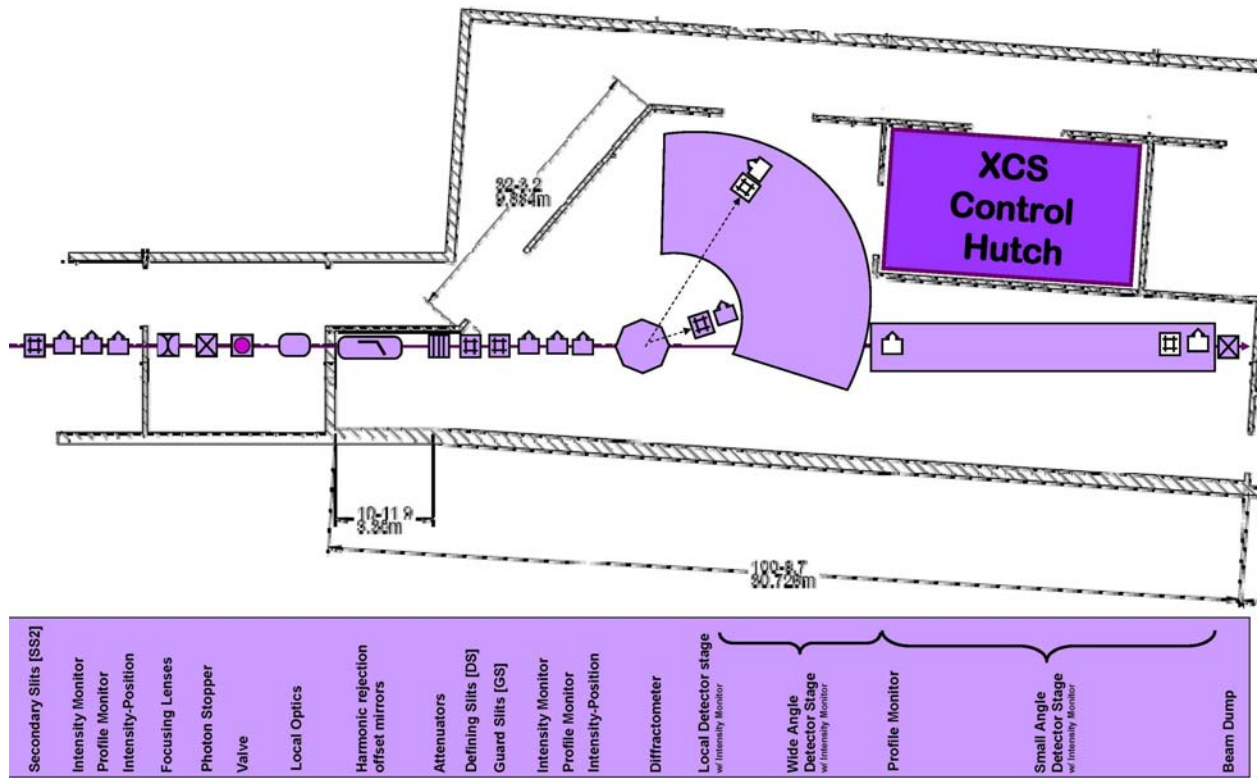
XCS Instrument Layout

3. LUSI Common Diagnostics Instrument Control

3.1. Instrument Components

LUSI had designed various photon beam-line components. Each component is detailed below. The LUSI experiment instrument packages incorporate these components to define and characterize the beam for those experiments.

EPICS control system will allow the user to select system to view summary status of components and to select individual components for detailed control.

3.1.1. LUSI Pop-in Profile Monitor *(SP-391-000-04)*
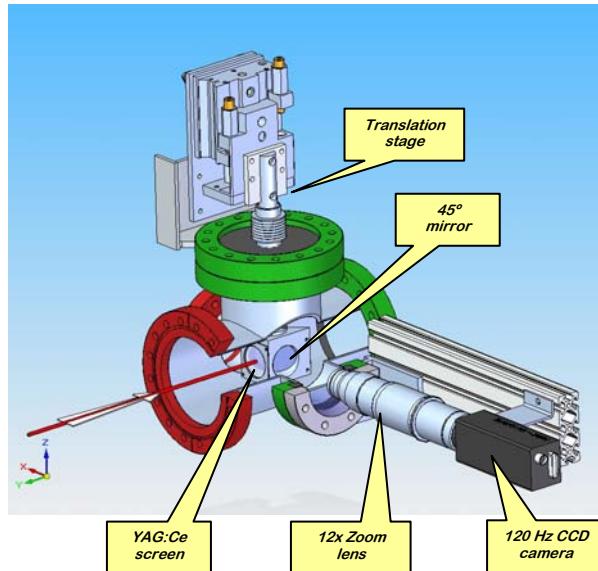
Pop-in profile monitor is inserted into beam via a motion stage. Camera is read out by EPICS at 30Hz synced with beam pulses. The zoom lens will be one of two options, motorized (Navitar) or fixed.

Range of motion for YAG screen is 100mm.

EPICS will control motion and zoom lens. EPICS will display image, with archive option.

A version of Pop-in profile monitor will be configured for high resolution, 120Hz operation. This modification, called the LUSI Pop-in High Resolution Profile Monitor or LUSI Wavefront Monitor, includes an additional motion stage to insert filters/attenuators in the FEL beam prior to the YAG screen, this additional stage has a range of motion of 100mm. The Wavefront monitor will not have a motorized lens.

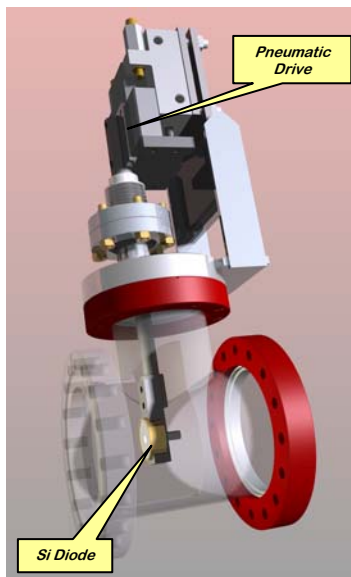Range of motion for the Filter/Attenuator stage is 100mm.

Note, where appropriate, the Pop-in Profile Monitor will be combined with the Pop-in Intensity Monitor. Range of motion shall accommodate the combined equipment. See Sec. 3.1.2 for additional functionality required for the combined instrument.

EPICS will control motion. Image acquisition and display will be handled by the DAQ system.

Component	Device	Model Number	Quantity	Interface Type
LUSI Pop-In Profile Monitor	Motion stage	Mdrive Plus (smart motor) TBD	1	Serial

	Encoder	TBD	1	Integrated into the motor controller
	Limit Switch	TBD	2	Integrated into motor controller
	Zoom lens (motorized option)	Navitar 1-62523	1	TBD (PC board, may be able to use smart motor driver)
	Camera	Pulnix TM-1402CL	1	CameraLink
Additional for LUSI Pop-in Wavefront Monitor	Motion stage for filters/attenuators	Mdrive Plus (smart motor) TBD	1	Serial
	Encoder	TBD	1	Integrated into the motor controller
	Limit Switch	TBD	2	Integrated into motor controller
	Camera with fixed zoom lens	Pulnix TM-6710CL or Imperx IPX-VGA210	1	CameraLink

## 3.1.2. LUSI Pop-in Intensity Monitor *(SP-391-000-09)*

Pop-in Intensity Monitor is inserted into beam via a motion stage. Front end electronics requires power, readout of ADC at 120Hz synced with beam.

Note, where appropriate, the Pop-in Profile Monitor will be combined with the Pop-in Intensity Monitor. Range of motion shall accommodate the combined equipment. See Sec. 3.1.1 for additional functionality required for the combined instrument.

EPICS will control and archive position information.

Component	Device	Model Number	Quantity	Interface Type
LUSI Pop-In Intensity Monitor	Motion stage	Mdrive Plus (smart motor) TBD	1	Serial
	Encoder	TBD	1	Integrated into the motor controller
	Limit switches	TBD	2	Integrated into the motor controller
	Power supply for SI diode	12 Volt supply	1	NA
	Front-end electronics and readout	SLAC developed board	1	Serial

### 3.1.3. LUSI Intensity-Position Monitor *(SP-391-000-08)*
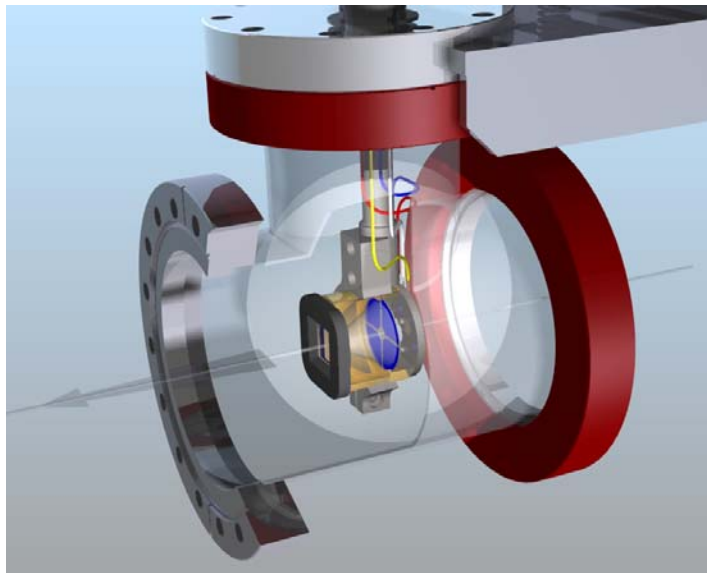
The Intensity-Position monitor is designed to remain in situ during operations, but can be fully retracted from beam. Requires X and Y motion control, 20 mm travel, 10 μm precision. Front end electronics will require power and DAQ read out of 4 ADC channels. System also includes a

movable target stage with 100 mm travel, 10 μm precision in Y and 20mm travel, 10 μm precision in X to position up to four different screens.

EPICS will control and archive position information.

Component	Device	Model Number	Quantity	Interface Type
LUSI Intensity-Position Monitor	Motion stages (2 axes, plus targe stage)	Mdrive Plus (smart motor) TBD	4	Serial
	Encoders	TBD	4	Integrated into smart motor
	limit switches	TBD	8	Integrated into smart motor
	Power supply	12 Volt Supply	up to 4 channels	NA
	Front-end Electronics and readout	SLAC developed board	1	Serial

3.1.4. LUSI Attenuator *(SP-391-000-10)*
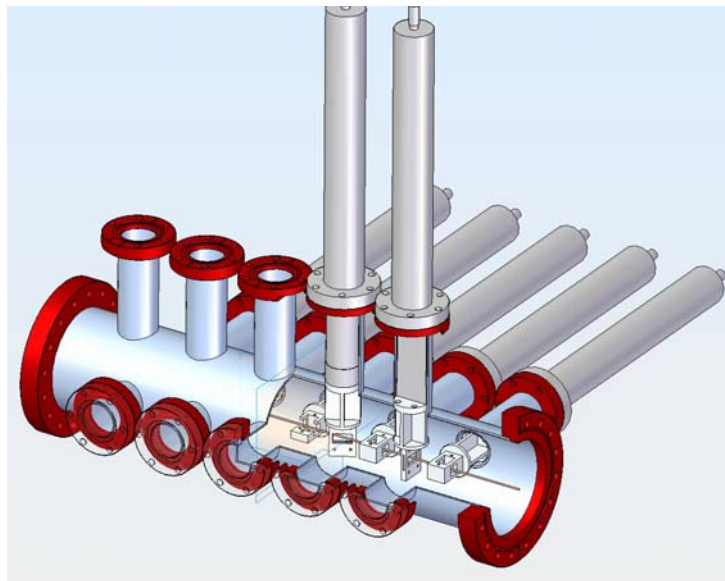

The LUSI attenuator consists of multiple filters that are pneumatically inserted into the beam.

EPICS will control and archive position information.

Component	Device	Model Number	Quantity	Interface Type

LUSI Attenuator	10 pneumatically driven filters.	SLAC Solenoid Controller SD-385-001	2	Digital IO to IP digital IO boards on VME cpu.

3.1.5. LUSI X-ray Slits *(SP-391-000-14)*
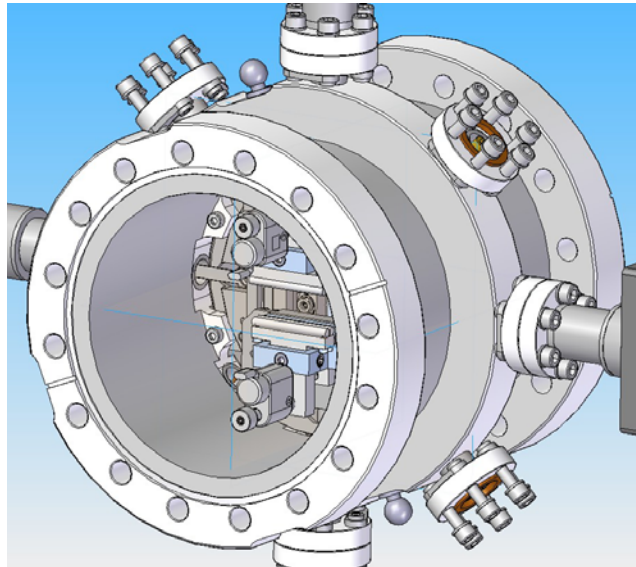
Composed of two pairs of movable slits, one pair in each direction. Each slit blade requires independent motion. Position information with respect to the beam and with respect to each other required.

Accuracy and repeatability of movement dependant on type of Slit set:

Name	Positioning Accuracy and Repeatability (μm)
Precise Primary	0.5
Precise Guard	0.5
Precise Monochromatic	0.5
Coarse Primary	5
Coarse Guard	5
Coarse Monochromatic	5

EPICS will control and archive position information.

Component	Device	Model Number	Quantity	Interface Type
LUSI X-Ray Slits	Motion stages, 4	Mdrive Plus (smart motor) TBD	4	Serial
	Encoders	TBD	4	Integrated into motor controller
	Limit switches	TBD	8	Integrated into motor controller

3.1.6. LUSI X-ray Focusing Lenses *(SP-391-000-11)*


Be Lens stack

Be Lens stack holder
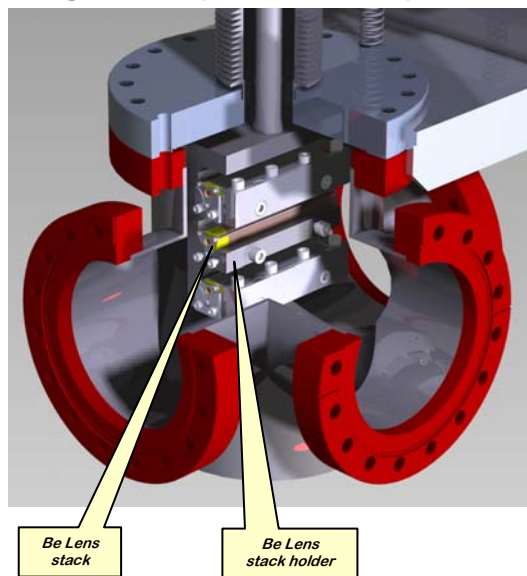
The X-ray Focusing Lens system consists of a movable lens assembly with motions in X, Y. Vertical motion shall accommodate removal of the lens assembly from the beam requiring travel of 60 mm. Horizontal motion shall accommodate a range of ± 10 mm. Both vertical and horizontal motion shall have an accuracy of 2 μm.

EPICS will control and archive position information.

Component	Device	Model Number	Quantity	Interface Type
LUSI X-Ray Focusing Lens	Three motion stages	Mdrive Plus (smart motor) TBD	2	Serial
	Encoders	TBD	2	Integrated into motor controller
	Limit Switches	TBD	4	Integrated into motor controller

### 3.1.7. **LUSI Harmonic Rejection Mirror** *(SP-391-000-34)*
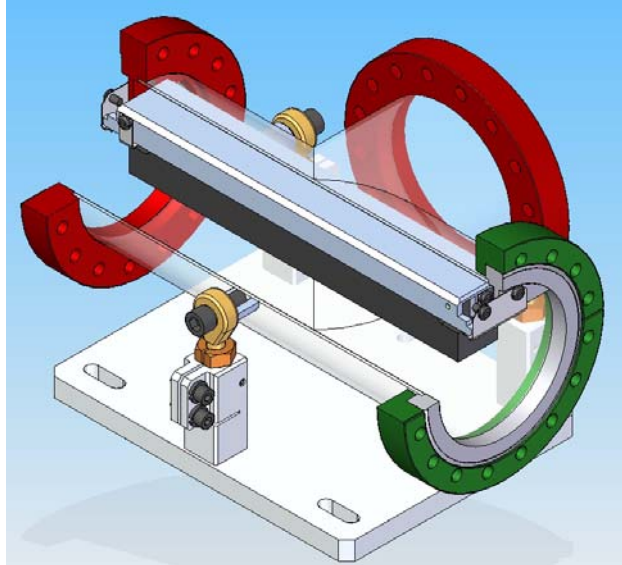
The Harmonic Rejection Mirrow system consists of two x-ray mirrors in grazing incidence geometry. Each mirror needs to be moved in X and Y, and tilted with respect to the beam. Mirrors shall be fully retractable out of beam. Vertical motion shall accommodate a range of 60 mm with accuracy of 2 μm, horizontal motion shall accommodate a range of ± 10 mm with accuracy of 2 μm, and tilt of each mirror shall accommodate a range of ± 2 degrees with accuracy of 5 millidegrees.

EPICS will control and archive all positions.

Component	Device	Model Number	Quantity	Interface Type
LUSI Harmonic Rejection Mirror	Motion stages for both mirrors	Mdrive Plus (smart motor) TBD	6	Serial
	Encoders	TBD	6	Integrated into motor controller
	Limit Switches	TBD	12	Integrated into motor controller

### 3.1.8. **LUSI Pulse Picker** *(SP-391-000-23)*
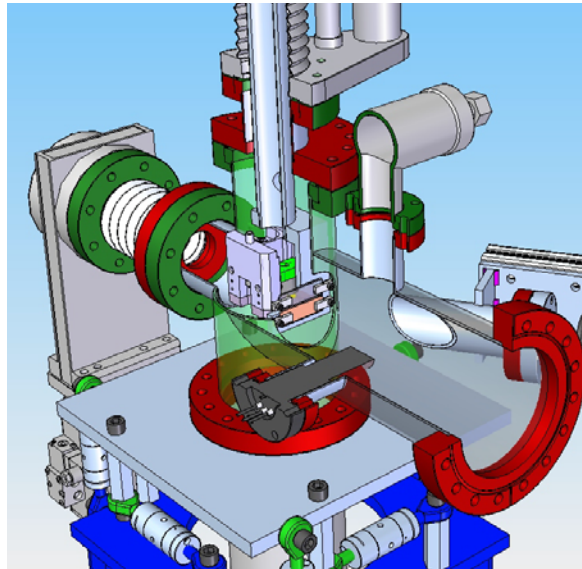
The Pulse Picker will be used to reduce the pulse rate of the photon beam. Pulse Picker assembly will be centered on the beam position. Motion in the vertical direction should allow for removal of the pulse picker assembly. Vertical motion shall accommodate a range of 60 mm with accuracy of 2 μm, horizontal motion shall accommodate a range of ± 10 mm with accuracy of 2 μm.

EPICS will control the position and the setting of the pulse picking pattern. EPICS will archive all parameters.

Component	Device	Model Number	Quantity	Interface Type
LUSI Pulse Picker	Motion stages	Mdrive Plus (smart motor) TBD	2	Serial
	Encoders	TBD	2	Integrated into motor controller
	Limit Switches	TBD	4	Integrated into motor controller
	TTL Trigger	SLAC Trigger module	1	VME

3.1.9. LUSI Offset Monochromator *(SP-391-000-16)*
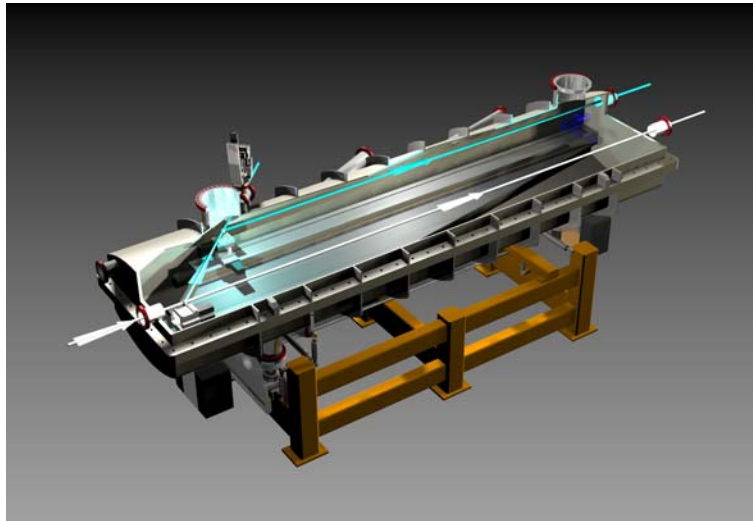
The LUSI Monochromator will separate off a monochromatic beam from the main LCLS beam and offset this beam from the main LCLS beam. Bragg crystals will be used to create the offset beam. The Monochromator will require motion control of each crystal with the following parameters:

- First crystal:
    - X motorized stage $\pm$ 50mm - precision $\pm5\mu$ - repeatability $\pm1\mu$
        - Ability to interchange crystals (stack of 3)
    - Y motorized stage $\pm$ 10mm - precision $\pm5\mu$ - repeatability $\pm1\mu$
    - Rotation motorized stage χ - range $\pm$ 5° - precision .002° - repeatability ±0.01°
    - Rotation motorized stage Θ - range -5° + 30° (beam diffraction angle= 9° to 45°) precision ±0.2 arcsec (5.5 10^{-6} °) - repeatability ±0.1arcsec
- Second crystal:
    - Z motorized stage – 2400mm stroke - precision $\pm5\mu$ - repeatability $\pm1\mu$
    - X motorized stage $\pm$ 50mm - precision $\pm5\mu$ - repeatability $\pm1\mu$
    - Y motorized stage $\pm$ 10mm - precision $\pm5\mu$ - repeatability $\pm1\mu$
    - Rotation motorized stage χ - range $\pm$ 5° - precision .002° - repeatability ±0.01°
    - Rotation motorized stage Θ - range -5° + 30° (beam diffraction angle= 9° to 45°) precision ±0.2 arcsec (5.5 10^{-6} °) - repeatability ±0.1arcsec

In addition, the large volume of the Monochromator chamber will require a dedicated vacuum system to maintain vacuum on the order of 10^{-8} torr.

The Monochromator will also be instrumented with LUSI Pop-in Profile and Intensity monitors on the secondary beam. These instruments are described in other sections of this document.

EPICS will control the position archive the settings of all parameters. Vacuum system will be integrated with the LUSI instrument Vacuum System utilizing that instrument's Vacuum PLC.

Component	Device	Model Number	Quantity	Interface Type
LUSI Offset Monochromator	10 Motion stages	TBD (Anticipate use of MDrivePlus smart motors or	10	Serial (if MDrive)

		MDrive Controllers for in-vacuum motors)		
	Encoders	TBD	10	Integrated into motor controller (if MDrive)
	Limit Switches	TBD	20	Integrated into motor controller (if MDrive)
Vacuum	Ion Pumps (3)	Gamma MPC • MKS 937 • Cold Cathode board • Pirani Board DIGI TS 16 MEI	2	Serial for EPICS, digital IO to Vacuum PLC system
	Vacuum Gauges	MKS 937 with Cold Cathode board and Pirani Board	1	Serial for EPICS, analog and digital IO to Vacuum PLC system
	Turbo Pump	Turbo Pump Controller	1	Digital IO to Vacuum PLC