ENGINEERING SPECIFICATION DOCUMENT (ESD)	Doc. No. SP-391-000-57 R0	LUSI SUB-SYSTEM XPP DIFFRACTOMETER

LUSI XPP Sample Goniometer Engineering Specification

DRAFT

Prepared by: J B Langton XPP System Manager	Signature	Date
Reviewed by: Jim Delor – XPP Design Engineer	Signature	Date
Approved: David Fritz XPP Instrument Scientist	Signature	Date
Approved: Darren Marsh LCLS-LUSI QA Manager	Signature	Date
Approved: Nadine Kurita LUSI Chief Engineer	Signature	Date
Approved: Tom Fornek LUSI System Manager	Signature	Date

Revision	Date	Description of Changes	Approved
R0		Initial release	

Table of Contents

1. Scope:

This document describes and defines the engineering requirements for a system to precisely support, translate and rotate experimental samples in the LUSI X-ray Pump Probe (XPP) instrument. This device will subsequently be known as the “sample goniometer”.

2. Sample Goniometer Summary:

The LCLS-LUSI XPP sample goniometer will be used to precisely control the physical location and orientation of a sample. The nature of the LCLS-LUSI machine requires an extraordinary level of flexibility and accuracy from the diffractometer system. The diffractometer consists of two major components, the sample goniometer (subject of this document) and the detector mover. The sample goniometer must have the ability to position the sample within two widely separated interaction point regions. Two different goniometer configurations (“Tilt” and “Kappa”) are required to accommodate a wide range of experimental objectives. The system must incorporate features to enable the use of future sample vacuum environments, cryostat or cyrostream. Features to accommodate alignment fixtures for sample goniometer and detector mover must be integral to the overall design to achieve desired levels of accuracy. Goniometer design must enable rapid reconfiguration to maximize science output.

3. Glossary / Definitions:

Accuracy: Defines the ability to establish location or angle to a predetermined value, with respect to a fixed coordinate system.
Detector: Transduction Hardware
Detector Mover: Hardware designed to position and translate a detector
Diffractometer system: Hardware system employed to position and translate both sample and detector
Experiment Sphere of Confusion: Uncertainty in absolute location of the intersection of x-ray beam, pump laser and sample feature
FEH: Far Experimental Hall
FEL: Free Electron Laser
Goniometer foundation: Surface providing attachment for goniometer mount base.
IP: Interaction point, the intersection of x-ray, pump laser and sample
Kappa goniometer: Hardware employed to position and rotate a sample feature
LCLS: Linac Coherent Light Source
LUSI: LCLS Ultrafast Science Instruments
Mechanical Sphere of Confusion: Uncertainty in absolute position of sample goniometer center of rotation.
NEH: Near Experimental Hall
Pitch: Rotation about the X-axis
Range: The total available limit(s) of motion with respect to a fixed coordinate system origin or axis
Repeatability: Defines the ability to successively reestablish a desired location or angle, with respect to a fixed coordinate system.

Resolution: Defines the uncertainty of a measurement of location or angle with respect to a fixed coordinate system. Also defines the minimum measurable difference between two dissimilar values.
Roll: Rotation about the Z-Axis
SLAC: Stanford Linear Accelerator Center
Stability: Defines accuracy for a specified time
Tilt platform goniometer: Hardware employed to position and rotate a sample
XPP: X-ray Pump Probe
Yaw: Rotation about the Y-axis

4. Applicable Documents, Specifications and Codes:

4.1. SLAC Documents and Specifications:

SP-391-000-84:	"LUSI XPP Instrument Engineering Specification"
AP-391-000-59:	"Engineering Review Guidelines"
DS-391-000-36:	"Design Standards Supplement"
GP-391-300-00:	"Hutch 3 - XPP Arrangement"
ID-391-300-10:	"XPP- Sample Goniometer Installation"
ID-391-320-07:	"Mounting Base Installation"
GP-391-750-14:	"Hutch 3 - XPP Sub-system Stay Clear Definitive Lay-out"
SLAC-I-720-0A24E-002:	"Specification for Seismic Design of......at the Stanford Linear Accelerator"

4.2. Industry Specifications and Codes:

NEC, NFPA 70; "National Electric Code,
NEC, NFPA 70E; "Electrical safety in the Workplace"
CBC 2007: " California Building Code, 2007"

5. General Area / Adjacent Equipment Description:

5.1. LCLS / LUSI overview:

The Linac Coherent Light Source (LCLS) is a machine for the production of coherent hard x-rays (IE: x-ray laser light). The overall length of the LCLS machine is approximately 1.8 km.

The LCLS Ultra-fast Science Instruments (LUSI) program consists of a suite of x-ray instruments for exploiting the scientific capability of the LCLS. These instruments will be housed in experimental hutches located down-beam of the LCLS in a Near Experimental Hall (NEH) and a Far Experimental Hall (FEH).

The linear architecture of the LCLS complex (as compared to previous storage ring light sources), and the stringent requirements necessary to maintain the coherent x-ray beam properties, coupled with the need to maximize user scientific productivity, determine unique requirements for the LUSI instruments.

5.2. XPP Instrument Overview:

The X-ray Pump Probe (XPP) instrument is one of the experimental configurations for the LUSI program. XPP combines an optical “pump” laser, to excite the atomic structure of a sample, and the X-ray beam to “probe” the properties of that structure. The major XPP subsystems and locations are shown in GP-391-300-00.

XPP is located in Hutch 3 of the NEH.

Due to the linear architecture of LCLS, the XPP instrument hardware must have the capability of reconfiguring to enable beam sharing with other experiments.

XPP configured for data taking at “Position 1” blocks X-ray beam from propagating to the FEH.

XPP configured for data taking at “Position 2” permits X-ray beam to propogate through to the FEH.

To maximize scientific output, all XPP systems will be designed, constructed and installed to support hardware reconfiguration, realignment and recalibration in 8 hours or less. This includes hardware repositioning from position 1 to position 2, or visa-versa.

All Hardware for XPP will be specified, designed, fabricated and installed in such a way as to provide for function at both x-ray beam sample positions (position 1 and position 2).

5.3. Hutch 3 / XPP Hardware Layout:

The XPP hutch 3 floor plan consists of a main experimenter area and a down-beam alcove.

Overall **hutch 3 dimensions are shown in figure 1**.

A master coordinate system, to define locations of hardware in hutch 3, is also defined in this figure. The master coordinate system is right handed Cartesian with its origin nominally 1.4 meters above the floor and the Z+ axis in the nominal direction of X-ray beam propagation, parallel to the floor. The X+ axis is in the horizontal plane and Y+ axis is vertically up.

An interaction point is defined as the location where the x-ray beam and optical pump laser intersect the sample. XPP will have two nominal interaction point locations (IP1 and IP2), also shown in **figure 1**. IP1 is actively defined when XPP is in “straight ahead” mode, blocking x-ray propagation to the FEH. IP2 is actively defined when XPP is using monochromatic offset x-ray beam. The nominal separation between IP1 and IP2 is 0.60 meter.

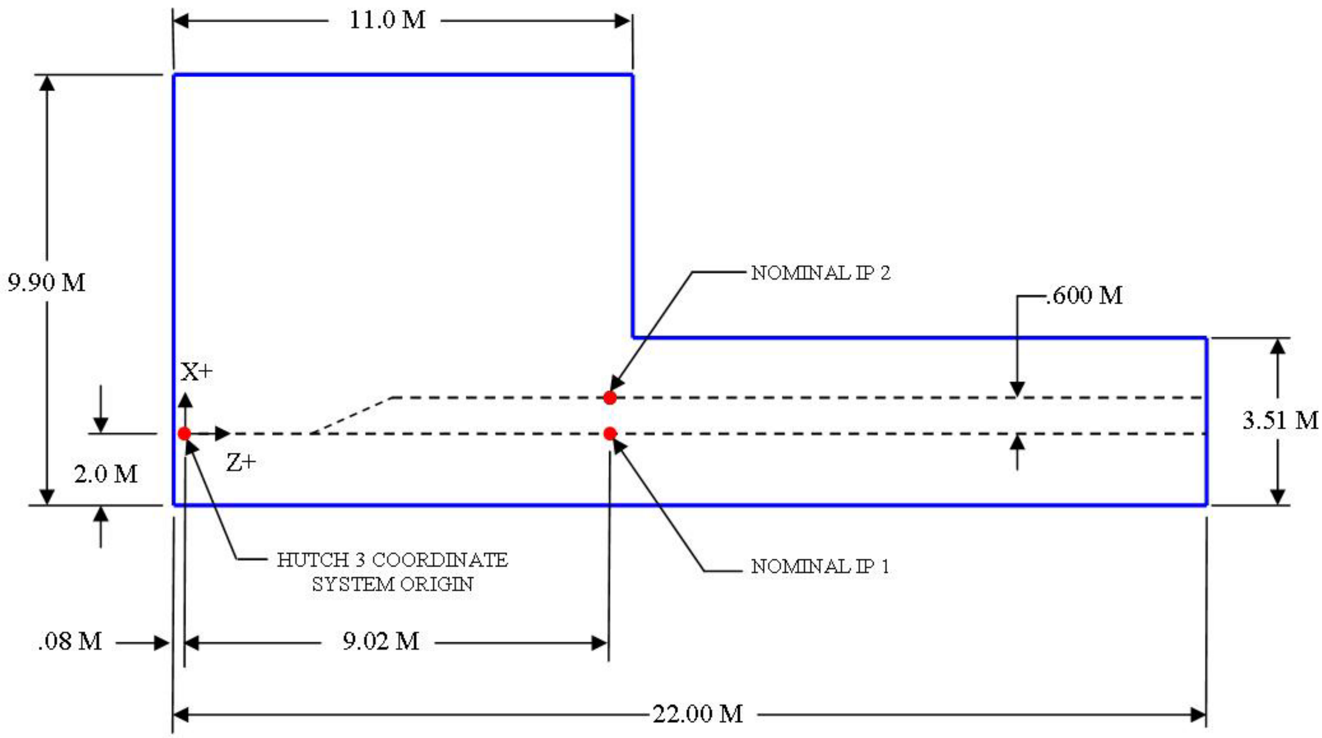


Figure 1
Hutch 3 – XPP Floor Plan

5.4. Coherent X-ray beam:

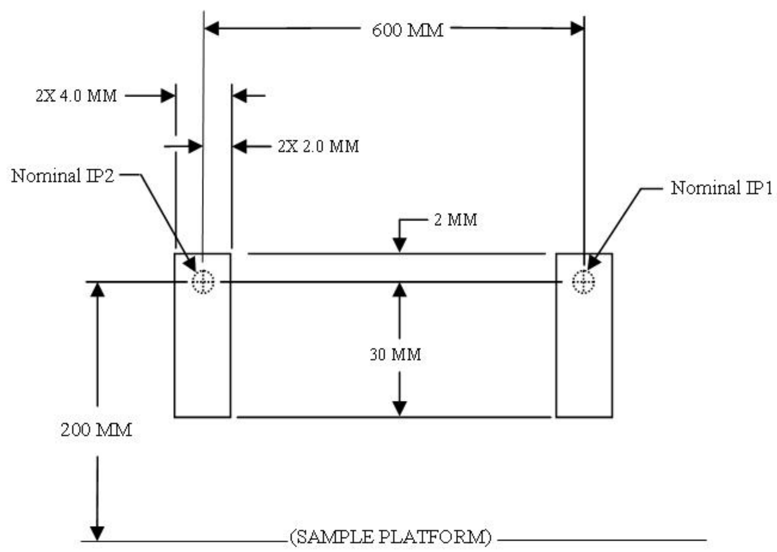
Up-beam optical transport elements can have a significant effect on the position of the x-ray beam entering hutch 3.

The active interaction point and subsequently **the true, aligned, location of the diffractometer system rotation center will vary by up to 4 mm (+/- 2 mm tol) from nominal**.

Some classes of XPP experiments will require the x-ray beam to have a down angle at the sample surface interface (IE: active interaction point) . Elements in the optics-diagnostic section will be employed to steer the x-ray beam to the desired down angle. This down angle translates to a vertical offset of the active interaction point.

The maximum vertical offset of the active interaction point, and subsequently **the true, aligned, vertical location of the diffractometer system rotation center will vary by up to 30 mm**.

The horizontal and vertical extents of possible diffractometer rotation center locations, with respect to the two nominal locations, is shown in **figure 2**. The view is shown with the X-ray beam into the page. **Sample goniometer hardware will be constructed to allow the rotation center to be aligned within these two zones**.



<u>Figure 2</u>
Diffractometer Rotation Center Zones

5.5. Detector Mover System:

The Detector Mover is used to position a custom, large area detector (1024 x 1024 pixels, approx. 200mm square) about a pre-defined diffractometer rotation center, coincident with the sample goniometer coordinate system origin. The detector will be moved over spherical surfaces with radii ranging from 10–100 centimeter. To insure maximum accuracy and stability of the diffractometer system, the detector mover system will be physically (structurally) isolated from the sample goniometer.

6. Sample Goniometer Coordinate System:

The sample goniometer will have a coordinate system defined to establish relative position and angle with respect to the x-ray beam (i.e.: active interaction point), adjacent equipment and hutch. This coordinate system will exist independent of the configuration of the sample goniometer.

The goniometer coordinate system will, by definition, be a right handed Cartesian system with its origin located at the center of axis rotation of the active hardware configuration. The Z+ axis is the nominal direction of X-ray beam propagation, parallel to the floor. The X+ axis is in the horizontal plane and Y+ axis is vertically up.

All subsequent coordinate directions indicated in this document are reference per this coordinate system.

7. Goniometer Basic Performance Requirements:

7.1. Overall dimensions:

The complete sample goniometer system shall be designed to accommodate an X-ray beam nominally located 1.40 meters above the goniometer foundation (floor).

7.2. Sphere of Confusion:

The minimum diameter spherical volume that is required to include x-ray beam, pump laser and sample feature is the “experimental sphere of confusion”. The coincidence (overlap) of these elements cannot be guaranteed for a volume smaller than this defined region. This diameter value defines the lower limit on the certainty of the absolute location of the interaction point.

The final achievable value for experimental sphere of confusion is effected by aspects of the x-ray beam, pump laser and sample goniometer. Determination of the specifications for the sample goniometer hardware are directly related to, and determined by, the desire to minimize the experiment sphere of confusion.

The “mechanical sphere of confusion” is defined as the uncertainty of location of the sample goniometer center of rotation. The mechanical sphere of confusion is determined by the variation of the measured location of the goniometer center of rotation as all rotation axis are translated through their full range of travel. The measured location is with respect to a fixed coordinate system attached to the goniometer foundation (IE: the floor)

The LUSI-XPP sample goniometer will have a mechanical sphere of confusion less than 30 microns. This value applies independent of goniometer configuration and with loading as defined in section 7.3.

7.3. Load Capacity:

7.3.1. Tilt Platform:

The tilt platform configuration shall maintain the specified mechanical sphere of confusion, per section 7.2, with a 225 Lb (~100 kg) payload mounted with center of mass up to 1.97 inches (~50 mm), in any direction, from the goniometer rotation center. (ref: ID-391-300-10, sheet 2, section A-A)

7.3.2. Kappa Goniometer:

The kappa goniometer configuration will maintain the specified mechanical sphere of confusion, per section 7.2, with a 2.2 Lb (~1.0 kg) payload mounted with center of mass up to 0.24 inches (~6.0 mm), in any direction, from the goniometer rotation center. (ref: ID-391-300-10, sheet 3, section B-B)

7.4. Goniometer Element Interface Requirements:

The goniometer elements described in sections 8 through 12 are each consider individual, unique, elements of the complete goniometer. Under no circumstance will the elements, as defined in sections 8 through 12, be subdivided further than as described in those sections.

XPP system requires maximum operational flexibility and reconfigurability from the goniometer.

To achieve this end, **it is a distinct advantage to have a single interface configuration compatible between as many elements as possible**.

Elements sharing a compatible interface configuration shall be capable of assembly without other modification.

All interfaces require mate-demate rigidity and durability. Any element mating interface shall have the rigidity required to simultaneously achieve the sphere of confusion (section 7.2) and load capacity (section 7.3) requirements.

Each interface must achieve a minimum five hundred (500) mate-demate cycles without requiring overhaul or component replacement.

Due to the nature of the XPP experiment, repeatability between mate-demate cycles is not a stringent requirement.

Mate–demate element interface alignment repeatability shall be 50 microns (maximum).

Detailed definition of all mating surface parameters: flatness, bolt pattern, bolt size, alignment interface, bolt torque, etc, are defined in **SC-391-XXX-XX**.

8. Mounting Base Requirements:

The sample goniometer translation elements are attached to, and statically aligned via, the mounting base assembly and its interface with the goniometer foundation.

The mounting base will not be repositioned, or otherwise adjusted, on an experiment by experiment basis.

The mounting base shall have the ability for realignment under extreme circumstances (eq: significant seismic ground displacement). Therefore the mounting base will not be grouted in place or otherwise permanently restricted from being repositioned with respect to the goniometer foundation.

Static alignment accuracy of the mounting base defines the absolute orientation of the common rotations vertical axis with respect to the hutch master coordinate system.

The mounting base provides the surface upon which the sample goniometer translation and rotation components (ref: sections 9 through 12) are placed.

The top surface of the mounting base element shall be mateable to the lower surface of the interaction point translation element described in section 9, as specified in section 7.4.

Mount Base Alignment Specification

Direction	Range	Accuracy	Repeatability
Y	12 mm (+/-6)	50 micron (+/-25)	N/A
X, Z	12 mm (+/-6)	150 micron (+/-75)	
Roll, Pitch	N/A	<0.10 mRad (<+/-0.25)	
Yaw	N/A	<0.26 mRad (<+/-0.13)	

The mounting base shall be designed to:

1) Have the top mounting surface located 1182 mm, +/-0.5mm, below nominal x-ray beam
2) Have a top mating surface minimum length (“X” coordinate) of 750 mm.
3) Have a top mating surface minimum width (“Z” coordinate) of 450 mm.
4) Have a top mating surface flatness of 25 micron.
5) Have mating surface attachment features as shown in SC-391-XXX-XX
6) Accommodate a goniometer foundation elevation variation of 45 mm (+/-22 mm).This variation is distinct from the alignment specification. This variation can be address by in situ spacers adjustments, machine to as measured thickness, or other means.

SLAC is situated in an active seismic zone. All hardware exceeding a weight of 300 Lbs. and / or mounted greater than 4 feet above the floor will be reviewed by a SLAC “citizen safety committee” for seismic loading resistance. Applicable loads and structural behavior will be evaluated for compliance to the 2007 version of the California building code and SLAC publication SLAC-I-720-0A24E-002: “Specification for Seismic Design of Buildings, Structures, Equipment, and Systems at the Stanford Linear Accelerator”.

9. Interaction Point Translation Requirements:

The interaction point translation element’s purpose is to position the sample goniometer center of rotation at the intersection of the x-ray beam and the optical pump laser.

This positioning defines the absolute location of the active interaction point.

The sample goniometer rotation center will, by definition, be located within either of two zones as defined in section 5.4, figure 2.
It is desirable to have total X travel range beyond the explicitly defined 604 mm to allow for base mounting alignment tolerances.

Fine X adjustment is required at both nominal interaction point locations.

The lower mating surface of the interaction translation point element shall be located 1182 mm, +/-0.5 mm, below the nominal goniometer rotation center (IE: 218 mm, +/-0.5mm, above the goniometer foundation). This dimension is based on, and includes, the asymmetric “Y” range specification.

Interaction Point Translation Specification

Direction	**Range (mm)**	**Accuracy (micron)**	**Repeatability (micron)**	**Resolution (micron)**	**Stability (micron / hour)**
X coarse	604 min	1000 (+/-500)	<10 (+/-5)	<10 (+/-5)	N/A
X fine (Note 1)	4 .0 (+/-2.0)	5.0 (+/-2.5)	1.0 (+/-0.5)	<1.0 (+/-0.5)	<1.0
Y (Note 2)	32 min (+2.0 / -30.0)	5.0 (+/-2.5)	1.0 (+/-0.5)	<1.0 (+/-0.5)	<1.0

Note 1: “X fine” values are applied two times, singularly centered at each nominal interaction point

Note 2: “Y” range tolerance applied asymmetrically to accommodate active interaction point zones (figure 2).

All translations shall be motor driven and encoded per section 16. Cable management shall be per section 17.

The lower surface of the interaction point translation element shall be mateable to the upper surface of the mounting base element (ref: section 8), as specified in section 7.4.

The upper surface of the interaction point translation element shall be mateable to the lower surfaces of the common rotations, sample translation and kappa goniometer elements (ref: sections 10 through 12), as specified in section 7.4.

Interaction point translation nominal acceptable configuration geometry is defined in SLAC document number **SC-391-XXX-09**.

10.Goniometer Common Rotations Requirement:

The common rotations element is the primary element of the sample goniometer. It establishes and defines the rotations of the sample when the goniometer is configured as a tilt platform. The common rotations element supports the kappa element when so configured. The accuracy of the rotation axis intersections establishes the lower limit achievable for the mechanical sphere of confusion. When the sample goniometer is in the kappa configuration the common rotations vertical axis may be used to establish incremental rotations.

The common rotations element shall have the center of rotation located 460.0 mm, +/-1.0 mm above the upper mating surface.

Goniometer Common Rotations Specification

Direction	Symbol	Range (degree)	Accuracy (arc-sec)	Repeatability (arc-sec)	Resolution (arc-sec)	Stability (arc-sec / hour)
Roll	χ	10 (+/-5)	30 (+/-15)	6 (+/-3)	<3 (+/-3)	<6
Pitch	ω	10 (+/-5)	30 (+/-15)	6 (+/-3)	<3 (+/-3)	<6
Yaw	μ	360 (continuous)	30 (+/-15)	6 (+/-3)	<3 (+/-3)	<6

All rotation axis shall be motor driven and encoded per section 16. Cable management shall be per section 17.

The upper surface of the interaction point translation element shall be mateable to the lower surfaces of the sample translation and kappa goniometer elements (ref: sections 11 and 12), as specified in section 7.4.

The lower surface of the common rotations element shall be mateable to the upper surface of the interaction point translation element (ref: section 9), as specified in section 7.4.

Goniometer common rotations nominal acceptable configuration geometry is defined in SLAC document number **SC-391-XXX-10**.

11.Sample Translation Requirements:

The sample translation element will provide the mounting platform for samples and special sample environments. It will also serve as the mounting platform for sample goniometer and detector alignment fixtures (ref: section 15). The sample translation element will typically be mounted atop the common rotations assembly.

The sample translation element shall provide motion in the X, Y and Z directions for accurate centering of mounted components to the goniometer rotation center.

Sample Translation Specification

Direction	range (mm)	accuracy (micron)	repeatability (micron)	resolution (micron)	Stability (micron / hour)
X, Z	50 min	5.0 (+/2.5)	1.0 (+/-0.5)	<1.0 (+/-0.5)	<1.0
Y	20 min	5.0 (+/-2.5)	1.0 (+/-0.5)	<1.0 (+/-0.5)	<1.0

All translations shall be motor driven and encoded per section 16. Cable management shall be per section 17.

The sample translation element upper mounting surface shall:

1) Have transverse (X,Z) dimension of 0.39 meter on a side minimum (0.15 M^2).
2) Have the upper mounting surface 200 millimeter, +/-0.5 millimeter, below the goniometer rotation center (ref; ID-391-300-10) when "Y" translation range is at its median value.

The lower surface of the sample translation element shall be mateable to the upper surface of the common rotations element (ref: section 10), as specified in section 7.4.

The lower surface of the sample translation element shall have identical mating features as the kappa goniometer element mounting interface (ref: section 12).

The upper surface of the interaction point translation element shall be configured as specified in section 7.4.

Sample translation element nominal acceptable configuration geometry is defined in SLAC document number **SC-391-XXX-11**.

12.Kappa Goniometer Requirements:

The kappa goniometer element establishes and defines rotations of the sample distinct from those provided by the tilt platform element. The accuracy of the kappa rotation axis intersections establishes the achievable lower limit for the mechanical sphere of confusion when so configured.

The kappa goniometer element shall:

1) Have "eta" axis nominally oriented in the diffractometer coordinate system X-Z plane.
2) Have "kappa" axis oriented at 50 to 60 degrees (54.5 degree preferred) with respect to the eta axis.
3) Have "phi" axis parallel to "eta" axis when "kappa" value nominally zero.
5) Have lower mating surface 460 mm, +/-0.5 mm below rotation center.
6) Have lower mounting surface parallel, +/-0.2 degrees, with respect to "eta" axis.
7) Provide 70 millimeter minimum radial clearance, rotation center to "phi' rotation mounting surface.

Kappa Rotation Specification

Rotation Direction	Symbol	range (degree)	accuracy (arc-sec)	repeatability (arc-sec)	resolution (arc-sec)	Stability (arc-sec / hour)
Eta	η	360 (continuous)	30 (+/-15)	6.0 (+/-3.0)	<3 (+/-1.5)	<6.0
Kappa	κ	360 (continuous)	2.0 (+/-1.0)	1.0 (+/-0.5)	<1 (+/-0.5)	<6.0
Phi	φ	360 (continuous)	2.0 (+/-1.0)	1.0 (+/-0.5)	<1 (+/-0.5)	<6.0

All rotation axis shall be motor driven and encoded per section 16. **Counting motor steps is an acceptable method of maintaining axis position information.** Cable management shall be per section 17.

Kappa element encoding may take the form of "step counting" as an acceptable method of maintaining rotation axis values.

Fine adjustment of the kappa element rotation axis orientation, with respect to the hutch master coordinate system, shall be accomplished using the common rotation element's pitch and roll translations.

The lower surface of the kappa goniometer element shall be mateable to the upper surface of the common rotations element (ref: section 10), as specified in section 7.4.

The kappa element lower mounting interface shall be identical to the sample translation element mounting interface (ref: section 11).

Kappa goniometer element nominal acceptable configuration geometry is defined in SLAC document number **SC-391-XXX-12**.

13. Sample Mount Interface Requirements:

13.1. Tilt Platform:

All sample mount hardware for the tilt platform configuration shall:

1) Have lower interface configuration identical to that employed to mate the sample translation element (ref: section 11) to the common rotations element (ref: section 10).
2) Have 200 mm dimension from lower mount interface to goniometer rotation center.
3) All mounts, including special environment (IE: vacuum, cryostat, cyrostream) shall use identical lower interface configurations.

Additionally a specialized rotation element, required for some tilt platform sample mounting, shall:

A) Provide continuous rotation in the X-Z plane (IE: rotation in the horizontal plane)
B) Have 200 mm dimension from lower mount interface to rotation center.
C) Rotation shall be motor driven, encoded (step counts permissible) and cable management per section 16.
D) Provide for kappa style sample mount stage assembly per section 13.2.

Specific sample mounting methods and hardware details will be confirmed on an experiment by experiment basis.

13.2. Kappa Goniometer:

Attachment of samples to the kappa goniometer configuration shall be accomplished via a translation / rotation stage assembly. The sample mount positioning stage will accurately locate the sample feature at the rotation center of the kappa goniometer.

The stage assembly will have a minimum of five degrees of freedom ("sample X", "sample Y", "sample Z", "sample tip" and "sample tilt").

Kappa Sample Mount Translation Specification

Direction	range	accuracy	repeatability	resolution	Stability
"Sample X" "Sample Z"	5 mm, min	5.0 micron (+/-2.5)	1.0 micron (+/-0.5)	<1.0 micron	<1.0 (micron / hour)
"Sample Z"	10 mm, min	5.0 micron (+/-2.5)	1.0 micron (+/-0.5)	<1.0 micron	<1.0 (micron / hour)
"Sample Tip" "Sample Tilt"	3 degree, min	30 arc-sec (+/-15)	0.6 arc-sec (+/-0.3)	<0.6 arc-sec	<0.6 (micron / hour)

All translation-rotation axis shall be motor driven and encoded per section 16. Counting motor steps is an acceptable method of maintaining axis position information. Cable management shall be per section 17.

For kappa sample mount, encoding may take the form of "step counting" as an acceptable method of maintaining rotation axis values

The sample mount positioning stage will mount to the kappa "phi" rotation axis element. Mounting configuration details are defined in SLAC document number **SC-391-xxx-yy**

In addition to sample support, the stage assembly will serve to control alignment indicators to accurately position the kappa goniometer rotation center at the intersection of the x-ray beam and optical pump laser, thereby defining the location of the active interaction point

14. X-ray Beam Stop Requirements:

The array detector may on occasions be moved directly behind the sample goniometer to collect small angle scattering data. In order to protect the array detector from high intensity radiation damage when located in such a position, an x-ray beam stop will be positioned directly behind the sample.

The x-ray beam stop shall:

1) Have transverse (X,Y) dimensions of 2 millimeter, +/-0.2 millimeter.
2) Have a total thickness (Z) dimension of 5 millimeter, +/-0.5 millimeter.
3) Be located 175 millimeter, +/-10 millimeter minimum behind the goniometer rotation center.
4) Be made of boron carbide over a tungsten substrate.

Beam Stop Translation Specification

Direction	range (mm)	accuracy (micron)	repeatability (micron)	resolution (micron)	Stability (micron / hour)
X, Y	25 min	5.0 (+/2.5)	1.0 (+/-0.5)	<1.0 (+/-0.5)	<1.0

All translations shall be motor driven and encoded per section 16. **Counting motor steps is an acceptable method of maintaining translation position information.** Cable management shall be per section 17.

For x-ray beam stop translation, encoding may take the form of "step counting" as an acceptable method of maintaining rotation axis values

The x-ray beam stop assembly shall be mounted such that interaction point translations (Ref: section 9) do not effect to location of the beam stop relative to the goniometer rotation center.

15. Alignment Fixture Interface:

Due to the nature of the sample goniometer, the fabrication accuracy of alignment fixtures is not critical. The diffractometer alignment procedures will address, via the numerous translation degrees of freedom, any inaccuracies inherent in the alignment hardware.

15.1. Tilt Platform:

All fixtures intended for positioning of the tilt platform rotation center shall have a mating interface configuration identical to that used for sample mounts (ref: section 13.1). The sample translation element (ref: section 11) shall provide the positioning of the alignment fiducials with respect to the rotation center. The nominal distance from mating interface to alignment fiducials shall be 200 mm, +/-0.5mm.

15.2. Kappa Goniometer:

Hardware intended for alignment of the kappa goniometer rotation center shall mount directly to the sample mount stage assembly (ref: section 13.2).

Additionally the sample mount stage assembly translations shall provide positioning of the rotation center alignment fiducials when so configured.

16.Motor and Encoder Requirement:

Motor power and data (control) interface shall be in accordance with accepted and approved industry standards for environmental safety and health.

Total sample goniometer motor – encoder count is:
Gross total motor quantity is 19. Net total motor quantity is 16, tilt platform and kappa element configuration motors will not be installed simultaneously.

Sample Goniometer Motor Count

Element	Axis	Motor-Encoder Qty	ESD Ref.	Comments
IP Translation	beamline "X" & "Y"	2	sec. 9	
Common Rotations	Roll, Pitch, Yaw	3	sec. 10	
Sample Trans	X, Y, Z	3	sec. 11	Not req'd with kappa config
Kappa	Eta, Kappa, Phi	3 (note 3)	sec. 12	Not req'd in Tilt Config.
Tilt Sample Mount	sample pitch	1 (note 3)	sec 13.1	Only req'd with special rotation element.
Kappa Sample mount	Sample X, Y, Z, tip, tilt	5 (note 3)	sec 13.2	May be req'd with tilt special rot element.
Beam Stop	Bm Stp X & Y	2 (note 3)	sec 14	

Note 3: Step counting acceptable for noted element encoding.

XXXXXXXXXX

17.Power and Data Interface / Cable Management:

17.1. Power Requirement / Interface

TBD:

17.2. Controls Requirement / Interface

TBD:

17.3. Cable Management Requirements

All motor connectors shall be located, configured and labeled to provide rapid and intuitive reconfiguration of the sample goniometer.

All power and data cabling shall be routed and strain relieved in a manner such that:

1) All translation directions and rotation axis can achieve full range capability, plus 10% of full range, without load on cable, connector or diffractometer hardware.

2) Rotation axis with a range specification of "360 degree continuous" shall be capable of plus/minus ~200 degree of rotation, from nominal "zero" without load on cable, connector or diffractometer hardware.

XXXXXXXXXXXXXX

18.Lifting Features:

All components with a mass greater than 15 Kg (~33 Lb weight) shall have clearly defined lifting features and instructions.

19.Materials

All parts and materials for the device shall be new and compatible with the performance requirements of this specification.

No system, sub-system or part shall be reconditioned or remanufactured.

All applicable material safety data sheets (MSDS) shall be provided and stored in an accessible location.

20.Environmental Safety and Health Requirements

20.1. Reviews

All systems hardware will be subject to SLAC review and approval. Reviews will be conducted in accordance with SLAC document number AP-391-000-59: "Engineering Review Guidelines". SLAC reserves to right to employ an internal (SLAC direct), external independent, or mixed source review panel.

Particular review attention will be devoted to:

- Personnel access restriction methodology
- Emergency stop methodology / mechanisms
- Power failure provision – fault modes
- Electrical subsystem Lock-Out / Tag-Out:
- Training mode functionality
- Maintenance mode functionality

As previously stated, all hardware exceeding a weight of 300 Lbs. and / or mounted greater than 4 feet above the floor will be reviewed by a SLAC "citizen safety committee" for seismic loading resistance.

All electrical hardware and connections will be reviewed for compliance to local electrical code(s).

20.2. Applicable Standards

All hardware designs and installation will be reviewed for compliance one or more of the following codes – specifications for personal safety criteria:

21. Supplemental System Requirements:

Requirements, including the following topics, will be addressed in detail in subsequent procurement specifications and contracts.

i. Inspection, testing and acceptance
ii. Installation support services
iii. Training support services
iv. Maintenance procedures, schedules and assistance
v. Repair and overhaul services