| PHYSICS REQUIREMENT DOCUMENT (PRD) | Doc. No. SP-391-00-16 R0 | LUSI SUB-SYSTEM **XCS** |
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# Physics Requirements for the LUSI Large Offset Monochromator

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# 1. Overview

The LUSI monochromator is an important component of both the XCS and XPP Instruments. The design of both monochromator should be to the extent possible similar.

To select a desired wavelength from the incident polychromatic x-ray beam (thus providing also a control of the longitudinal coherence length of the beam) or eventually to split beamlines to double research capacity, a large offset double crystal monochromator (LODCM) will be installed on the XCS and XPP Instruments. The monochromatic beam provided by the LODCM (the monochromator) will be reflected to the north-side with a horizontal offset of 600 mm as shown in Fig. 1.

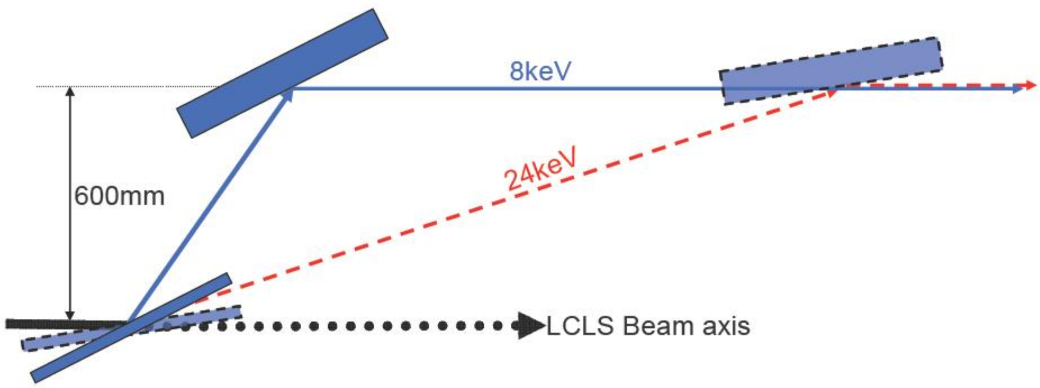


**Figure 1 Schematic of a 600mm Large Offset Double Crystal Monochromator**

The first crystal of the monochromator actually provides the monochromatizing action, while the second crystal simply redirects the monochromatized beam parallel to the incoming beam with an in-plane horizontal offset of 600 mm, while preserving the nominal LCLS beam height of 1.4 m.

The coordinate system is defined in Design Standards Supplement DS31100036.

# 2. LUSI Monochromator System Performance Requirements

2.1. The monochromator shall be operated with a fixed horizontal large offset of 600 mm as well as an independent rotation of the two parallel crystals.

2.2. The monochromator shall provide a monochromatic beam in the range from 4kev up to 25keV.

2.3. The overall length of the monochromator should be as small as possible

2.4. The monochromator should accommodate Silicon and/or Diamond single crystals in (111) and (220) orientations over the full range of energy described in 2.2.

2.5. The possibility of having permanently 2 different crystals should be investigated

2.6. The rotational stages for adjusting the Bragg angles has to be in the range of [0° ; 90°] for alignment purposes.

2.7. The vacuum chamber and its in-vacuum motion stages assembly must be as small as possible in order to ease its integration to both instruments.

2.8. The vacuum chamber assembly may consist of three modular chambers such as a 1st crystal vacuum chamber, a 2nd crystal vacuum chamber, and a transition vacuum chamber for the horizontal offset of 600 mm. The vacuum chamber could also consist of a single vacuum chamber containing both crystals.

2.9. Each crystal motion should include multi-axis motorized motion stages that provide independent rotations and translations. It should in any case ensure that both crystals can be adjusted parallel when operated at a specific Bragg angle and keeping the large offset of 600mm constant.

2.10. The monochromator should ensure to provide sufficient stability to deliver the offset monochromatic beam to the sample.

2.11. The monochromator will reside in a better than $10^{-7}$ Torr pressure environment and the appropriate vacuum practice for the design, manufacturing, and installation of the system components shall be implemented.

# 3. LUSI Monochromator coordinates and motions definitions

3.1. The motions (rotations, translations) for each crystal are required to realize the full functionality of the monochromator as shown in Fig 1.:

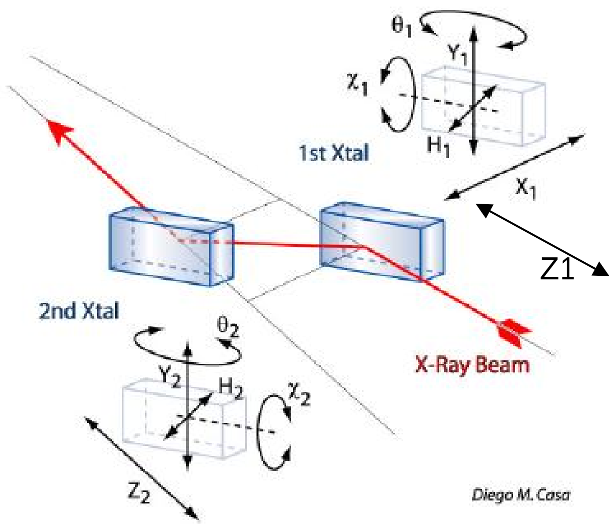


Fig.1 : Definition of the motion system for the two crystals.

## Description of the 1st crystal motion

3.2. Horizontal translation X1 is perpendicular to the incident beam. This motion is used to bring the vertical axis of rotation of the first crystal into alignment with the incident beam.

3.3. Vertical translation Y1 is perpendicular to the incident beam and horizontal translation X1. This motion is used to adjust the height of the first crystal. In the case of mounting two crystals or more on a holder vertically (i.e multi-crystal monochromator concept), this stage has to be positioned at the top of rotation stage for $\chi$1 to bring the different crystals into the beam.

3.4. Rotation $\theta$1 is around the vertical axis of Y1 through the center of the diffracting surface of the first crystal. This motion is used to select the angle of the first crystal with the incident beam and thereby selects the energy of the monochromatic exit beam.

3.5. Rotation $\chi$1 is around horizontal axis parallel to the surface of the first crystal. This motion is used to adjust the pointing of the exit beam from the first crystal towards the center of the second crystal.

3.6. Horizontal translation H1 is perpendicular to the diffracting surface of the first crystal: This motion is used to bring the diffracting surface of the first crystal into alignment with the axis of rotation and the incident beam.

3.7. Horizontal translation Z1 is parallel to the incident beam and is under any of the previously described motion. This motion is used to adjust the horizontal position of the first crystal in the beam if the solution with two crystals translating in opposite directions is used.

**Description of the 2nd crystal motion**

3.8. Horizontal translation Z2 is parallel to the exit beam from the second crystal. This motion is used to adjust the horizontal position of the second crystal in the beam from the first crystal.

3.9. Vertical translation Y2 is perpendicular to the exit beam from the second crystal and to the horizontal offset plane. This motion is used to adjust the height of the second crystal. In the case of mounting two crystals or more on a holder vertically (i.e multi-crystal monochromator concept), this stage has to be positioned at the top of rotation stage of $\chi2$ to bring the different crystals into the beam.

3.10. Rotation $\theta2$ is around the vertical axis of Y2 through the center of the diffracting surface of the second crystal. This motion is used to match the incident angle of the second crystal with the incident angle of the first crystal.

3.11. Horizontal translation H2 is perpendicular to the diffracting surface of the second crystal. This motion is used to bring the diffracting surface of the second crystal into alignment with the axis of rotation and the incident beam.

3.12. Rotation $\chi2$ is around the horizontal axis parallel to the surface of the second crystal. This motion is used to adjust the pointing of the exit beam from the second crystal towards the experimental enclosure.

# 4. LUSI Monochromator special requirements

## Bragg angle motion requirements

4.1. The Bragg rotations $\theta1$, $\theta2$ should consist of two different adjustment levels : a coarse and a fine one, thus allowing to scan the rocking curve of any single crystal installed in the monochromator, as described in 2.4.

4.2. The fine adjustment level of each Bragg rotation can be operated by piezo-actuators.

4.3. Each Bragg rotation should be equipped with incremental encoders

## Tilt angle motion requirements

4.4. The tilting mechanism of each crystal $\chi1$, $\chi2$ should consist of two different adjustment levels : a coarse and a fine one.

4.5. The fine adjustment of each tilting mechanism can be operated by piezo-actuators.

## Monochromator internal diagnostics requirements

4.6. The monochromator itself should be equipped with the necessary dedicated diagnostics to perform its alignment (i.e each crystal orientation) if the diagnostics located upstream/downstream are not sufficient/appropriate.

4.7. The diagnostics should be compatible with the existing diagnostics used at LUSI

# 5. Controls Requirements

5.1. All motions (translation, rotations) must be performed remotely.

5.2. All adjustable electronic limits that will be provided for the large offset monochromator must be incorporated into the instrument control system.

5.3. Every diagnostic used to aid the alignment of each crystal should be performed remotely and must be incorporated into the instrument control system