PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-11 R1	LUSI SUB-SYSTEM CXI, XCS, XPP

Physics Requirements for the LUSI X-ray Focusing Lens System

Aymeric Robert LUSI Scientist, Author	Signature	Date
David Fritz LUSI Scientist	Signature	Date
Sébastien Boutet LUSI Scientist	Signature	Date
Marc Messerschmidt LUSI Scientist	Signature	Date
Yiping Feng LUSI Scientist	Signature	Date
Eliazar Ortiz Diagnostics/Optics Lead Engineer	Signature	Date
Darren Marsh LCLS QA Manager	Signature	Date
Nadine Kurita LUSI Chief Engineer	Signature	Date
Tom Fornek LUSI System Manager	Signature	Date

DCR

Revision	Date	Description of Changes	Approved
R0	28NOV07	Initial release	
R1	9June08	Revision in maximum lens number	7/8/2008

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1. Overview

The purpose of the X-ray Focusing Lens System (XFLS) is to provide a selection of lens configurations having different focusing capabilities. This will provide the capability to reduce the spot-size of the x-ray beam while maximizing the x-ray flux at the sample.
It is based on the use of commercially available hard x-ray compound refractive lenses. Each identical lens has the same focal length (i.e focusing capability) which depends on the energy of the x-ray beam. By stacking several of these lenses, one can obtain a focal length of interest for a given experimental use.

The coordinate system is defined in Design Standards Supplement DS31100036.

2. Specifications

The XFLS should be based on a common design for all instruments (XPP, CXI and XCS) with the specifications described in 2.1. Instrument specific requirements are described in 2.2.

2.1. **Common specifications for all LUSI instruments**

2.1.1 The XFLS is based on the use of commercially available hard x-ray compound refractive lenses.

2.1.2 The XFLS should operate in vacuum.

2.1.3 The XFLS system should allow the possibility to transmit the x-ray beam without any lenses configuration on its path by providing a stay clear of at least 0.5".

2.1.4 The XFLS should accommodate 3 different lens configurations.

2.1.5 The change from one lens configuration to another one should be easy and be reflected in the proposed design.

2.1.6 The XFLS must operate both in white and monochromatic beam.

2.1.7 The XFLS must withstand the full LCLS flux in the NEH Hutch 3, where the x-ray spot size is 220mm FWHM, across the 2-25 keV spectral range without degradation to the lenses nor any component of the system itself due to radiation damage**.** The LCLS flux can be calculated from parameters listed in LCLS PRD# 1.1-014.

2.2. **Instrument dependent specifications**

2.2.1 The XFLS should be included in the overall design of each instrument (XPP, CXI and XCS). Namely the position of the XFLS will differ for each instrument and the system should be properly integrated within the others surrounding systems.

2.2.2 The details of the required number of hard x-ray focusing lenses for each of the three lens configurations will be defined by each instrument scientist (i.e instrument dependent) and should not influence the design of the XFLS.

3. Description of a lens configuration

3.0.1 As described in 2, the XFLS should accommodate 3 different lens configurations.

3.0.2 A lenses configuration consists of a stack of commercially available hard x-ray compound refractive lenses and spacers. The spacers do not interact with the x-ray beam. All lenses in a given stack are identical.

3.0.3 The maximum number of lenses (per lenses configuration) is 10.

3.0.4 The detail of the each lens configuration is instrument dependent and will be defined by the Instrument scientist.

3.0.5 The design should accommodate possible changes of the details of a given lens configuration (i.e number of compound refractive lenses) but in any case the number of lenses involved will not be more than 10.

4. Positioning Requirements

Position requirements common to all LUSI instruments are described in 4.1. An additional requirement for the XPP instrument is described in 4.2.

4.1. **Common requirements for all LUSI instruments**

4.1.1 The XFLS should be provided with motorized (X,Y) translations for the fine alignment of each lenses configuration. Both translations should allow translating each lens configuration with a Resolution and Repeatability better than 2μm and Stability better than 0.2μm over a stroke equivalent to the refractive lens size.

4.1.2 The pitch and yaw of the lens assembly must be less than 0.1° relative to the LCLS coordinate system. A motorized adjustment of these degrees of freedom is not necessary. An easily accessible manual adjustment of these degrees of freedom should be provided, allowing the metrology group to align the system during its installation on the beam path.

4.1.3 There is no roll requirement since the lens assembly is not sensitive to this degree of freedom.

4.1.4 The relative axial positioning of the lens centers for an individual stack should not deviate by more than 10 μm.

4.1.5 A mechanism for removing the lens assembly from the x-ray beam path is required. A stay clear radius of 0.5" will be maintained when the refractive lens is not used.

4.1.6 Switching between lens configurations and/or stay clear position should be motorized and accessible remotely.

4.2. **Additional requirement for the XPP instrument**

4.2.1 In addition to the motorized (X,Y) translations, the XPP instrument requires a motorized translation of the XFLS along the LCLS beam axis direction (i.e Z) with a Stroke of ±200 mm, a Resolution and Repeatability better than 1mm and Stability better than 10μm.

5. Vacuum Requirements

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

6. Controls Requirements

6.0.1 All motorized degrees of freedom of the XFLS dedicated to each instrument is required to be controlled remotely via the corresponding instrument control system (i.e except for tilt and yaw as described in 4.2.1).

Appendix A – Revision 1 Primary Changes Affected Sections

2.1 *Common specifications for all LUSI instruments*

2.1.1 (no change).
2.1.2 (no change).
2.1.3 (no change).
2.1.4 (no change).
2.1.5 (no change).
2.1.6 (no change).
2.1.7 (was) The XFLS must withstand the full LCLS flux in the NEH Hutch 3, where the x-ray spot size is 220mm FWHM and energy per pulse is 1 mJ, across the 2-25 keV spectral range without degradation to the lenses nor any component of the system itself due to radiation damage.

3. Description of a lens configuration

3.0.1 (no change).
3.0.2 (no change).
3.0.3 (was) The maximum number of lenses (per lenses configuration) is 50.
3.0.4 (no change).
3.0.5 (was) The design should accommodate possible changes of the details of a given lens configuration (i.e number of compound refractive lenses) but in any case the number of lenses involved will not be more than 50.