PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-04 R1	LUSI SUB-SYSTEM Diagnostics/Optics

Physics Requirements for LUSI Pop-in Profile Monitor

Yiping Feng LUSI Scientist, Author	Signature	Date
David Fritz LUSI Scientist	Signature	Date
Aymeric Robert LUSI Scientist	Signature	Date
Sébastien Boutet LUSI Scientist	Signature	Date
Niels van Bakel LUSI Scientist	Signature	Date
Eliazar Ortiz Diagnostics/Optics Lead Engineer	Signature	Date
Darren Marsh LCLS Quality Assurance Manager	Signature	Date
Nadine Kurita LUSI Chief Engineer	Signature	Date
Tom Fornek LUSI System Maneger	Signature	Date

Revision	Date	Description of Changes	Approved
R0	27Nov07	Initial release	
R1	1May08	Revision to update performance parameters	7/8/2008

DCR

1. Overview

The LCLS FEL beam exhibits intrinsic fluctuations in position and transverse intensity profile. A diagnostic is required to characterize the transverse intensity profile and position of the X-ray beam, as well as aide in the alignment of X-ray optics and diagnostics. This document describes the physics requirements of this monitor.

The coordinate system is defined in Design Standards Supplement DS31100036.

2. Requirements

2.1. Performance Requirements

2.1.1. The profile monitor shall be designed to capture 2-dimensional images of the X-ray beam in the XY plane to determine the X-ray beam spatial shape, centroid, and intensity.
2.1.2. The profile monitor shall be designed to work for X-ray energies from 2 keV up to 25 keV.
2.1.3. At high X-ray fluences, attenuation of the X-ray beam is acceptable to avoid saturation and potential permanent damage of the sensor.
2.1.4. At least one profile monitor per instrument shall be capable of capturing images on a pulse-by-pulse basis.
2.1.5. The profile monitor shall be designed to operate in variable field of view (FOV) with a maximum FOV of 25x25 mm^2 and a minimum FOV of 2x2 mm^2.
2.1.6. The profile monitor shall have a spatial resolution of 100 μm and 8 μm in the maximum and minimum FOV respectively.
2.1.7. The profile monitor shall also have the capability to achieve a spatial resolution of 4 μm in a FOV of no smaller than 1x1 mm^2.
2.1.8. The profile shall have at least 256 grey levels or 8 bits for intensity measurements with a design goal of 1024 or 10 bits.

2.2. Mechanical

2.2.1. Two operating positions are required for the profile monitor: 'In' and 'Out'.
2.2.2. The profile monitor state should have the ability to be changed in ~ 3 seconds.
2.2.3. When in the 'In' position, the nominal LCLS beam shall impinge at the center of the sensor to within 10% of the sensor size and the surface normal of each sensor shall be aligned to the z-axis of the LCLS coordinate system to within ±1°. This can be achieved manually.
2.2.4. A translational repeatability of 50 microns and a rotational repeatability (pitch and yaw) of 0.1° shall be maintained when the sensor is placed in the 'In' position.
2.2.5. A minimum stay clear radius of 0.5" will be maintained when the sensor is in the 'Out' position.
2.2.6. The sensor shall default to the 'Out' position in the event of a system fault if feasible.
2.2.7. The design of the profile monitor should be compatible with the overall design of all instruments (XPP, CXI and XCS).
2.2.8. The design of the profile monitor should permit replacement of the sensor in the field.

2.3. Vacuum

2.3.1. The profile monitor 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.

2.4. Controls and Data Systems

2.4.1. The profile monitor state, FOV operation mode and frame acquisition shall be controlled remotely.

2.4.2. There shall be the capability of displaying the profile image for visual inspection of single pulses at a rate of 30 frames/sec (retinal persistence).

2.4.3. There shall be the capability of capturing the profile images at a rate of 120 frames/sec for the per pulse operation.

2.4.4. There shall be rudimentary image processing of the captured frames to characterize the X-ray beam including, but not limited to: beam centroid, X and Y FWHM of the intensity profile, and estimating peak intensity. More complicated processing may involve averaging of multiple images, and calculating certain statistical quantities such as beam position jitters.

2.4.5. The profile monitor must allow the capability of saving images and/or image processing data described in 2.4.4.

2.4.6. The operation of the monitor shall be constrained by the status of other optical components to prevent potential damages.

Appendix A – Revision 1 Primary Changes Affected Sections

2.1. Performance Requirements

2.1.1. (no change)
2.1.2. (no change).
2.1.3. (no change)
2.1.4. (no change).
2.1.5. (R0) The profile monitor shall be designed to operate in two configurations: large field of view (FOV) (50x50 mm^2) and narrow FOV (10x10 mm^2).
2.1.6. (R0) The profile monitor shall have a spatial resolution of 50 μm and 10 μm in the large and narrow FOV respectively.
2.1.7. (added) The profile monitor shall also have the capability to achieve a spatial resolution of 4 μm in a FOV of no smaller than 1x1 mm^2.
2.1.8. (added) The profile shall have at least 256 grey levels or 8 bits for intensity measurements with a design goal of 1024 or 10 bits.

2.2. Mechanical

2.2.1. (no change).
2.2.2. (no change).
2.2.3. (no change).
2.2.4. (no change).
2.2.5. (no change).
2.2.6. (R0) The sensor shall default to the 'Out' position in the event of a system fault.
2.2.7. (no change).
2.2.8. (no change).