



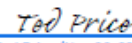
**Document Approval:**

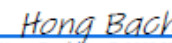
Originator: Diling Zhu, XPP Instrument Scientist	 <small>Diling Zhu (Nov 30, 2023 21:14 PST)</small>
• Content/Format • Content/ Format, Requirement ID's/Source ID's, Verification Planning, SME Input	

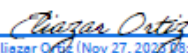
Reviewer: Ian Evans, ES&H Manager	<i>signature not required</i>
• ES&H Content, as appl	

Reviewer: Conny Hansson, LCLS Detector Department	<i>signature not required</i>
•Scope Alignment • Execution, as appl	

Approver: Angelo Dragone, Detector Engineer	 <small>Angelo Dragone (Nov 21, 2023 15:05 PST)</small>
•Complete/Accurate • SME Input • Meets Higher/Lower-Level Expectations	

Approver: Ted Price or designee – Systems Engineering Manager	 <small>Ted Price (Nov 26, 2023 11:01 PST)</small>
• Clarity • Format • Req ID's/Traceability • Change Control	

Approver: Hong Bach – Quality Assurance Manager	 <small>Hong Bach (Dec 7, 2023 09:34 PST)</small>
• General QA Provisions • Compliance • Req's Validation/Verification	

Approver: Eliazar Ortiz, Experimental Systems Manager	 <small>Eliazar Ortiz (Nov 27, 2023 09:55 PST)</small>
Articulation • Meets Higher-Level Expectations • Stakeholder/SME/Other System Manager(s) Engagement	

Approver: Scott DeBarger– Acting Project Chief Engineer	 <small>Scott DeBarger (Dec 14, 2023 00:15 PST)</small>
• Scope Alignment, Stakeholder/ SME Engagement	

See [Document Review/Approval Matrix of Responsibilities](#)

**Revision History**

Revision	Date Released	Description of Change
R1	11/21/2023	Adjusted LFAD noise and well depth requirements <ul style="list-style-type: none"> <li>• 4201: Updated range to 5 – 25 to be consistent with 4201, removed comment</li> <li>• 4104: changed 10keV to 8keV</li> <li>• 4105: changed max readout noise to 100 e-</li> <li>• 4108: removed length requirement and added comment referencing Detector IRD</li> <li>• 4109: added comment referencing Detector IRD</li> <li>• 4110: removed comment</li> <li>• 4112: changed diameter from 7 – 12 to 5 – 6 mm, added comment referencing Detector IRD</li> <li>• 4113: Added requirement</li> <li>• 4114: Added Requirement</li> <li>• 4101: Clarified requirement</li> </ul>
R0	5/3/2021	Original Release



# Table of Contents

<b>1</b>	<b>Purpose.....</b>	<b>3</b>
<b>2</b>	<b>Scope .....</b>	<b>3</b>
<b>3</b>	<b>Acronyms .....</b>	<b>3</b>
<b>4</b>	<b>References.....</b>	<b>3</b>
<b>5</b>	<b>Roles and Responsibilities .....</b>	<b>4</b>
<b>6</b>	<b>Requirements Definition .....</b>	<b>4</b>
6.1	Small Format Area Detector for Emission Spectroscopy .....	4
6.2	Large Format Area Detector for Scattering/Diffraction .....	5



## 1 Purpose

This Physics Requirements Document (PRD) identifies and outlines physics requirements that apply to the portion of the LCLS-II facility that is referenced in this document, and that must be addressed as part of the LCLS-II HE project. From this information, the engineering team will formulate engineering requirements that provide the basis for hardware and software design, development, and integration. Thus, the PRD primarily focuses on performance criteria that can be traced back to top-level system/facility performance parameters. However, PRD preparation and approval also ensure that requirements can be properly interpreted at lower levels of specification, for purposes of accurate system developmental definition.

## 2 Scope

This PRD details the requirements for the XPP high-rate X-ray area detectors. Two kinds of detectors are required in XPP: a large area detector for capturing scattering/diffraction patterns and a smaller format area detector for collecting dispersed emission spectra from x-ray analyzer crystal arrays. The listed parameters represent what is required at first light.

## 3 Acronyms

Acronym	Definition
IRD	Interface Requirements Document
LFAD	Large Format Area Detector
PRD	Physics Requirements Document
QE	Quantum Efficiency
SFAD	Small Format Area Detector
XPP	X-ray Pump Probe Instrument

## 4 References

LCLSII-HE-PP-0224	Requirements Specification Preparatory Instruction
LCLSII-HE-1.4-PRD-0212	LCLS-II-HE XPP Instrument PRD
LCLSII-HE-1.4-IC-0688	LCLS-II-HE Detectors ICD
LCLSII-HE-1.4-IR-0875	LCLS-II-HE XPP Detectors IRD



## 5 Roles and Responsibilities

Diling Zhu XPP Instrument Scientist	Defines requirements
Angelo Dragone Detector Engineer	Oversees the delivery of the requirements specified in this PRD
Conny Hansson LCLS Detector Department	Approves verification method

## 6 Requirements Definition

### 6.1 Small Format Area Detector for Emission Spectroscopy

Requirement #	Requirement	Comments	Verification Method	Parent Requirement
PRD0220.4201	The SFAD shall be designed for an energy sensitivity range of 5-25keV		Analysis Test	PRD0212.3320
PRD0220.4202	The SFAD QE shall be: >70% @ 12 keV and > 55% @ 25 keV	Goal: >70% @ 25 keV	Analysis	PRD0212.3320
PRD0220.4203	The SFAD frame-rate shall be > 5 kHz in full frame mode and 1 MHz under sparsified conditions (allowing up to 0.5% occupancy)	The goal is to achieve a frame rate $\geq$ 25 kHz in full frame mode for the SFAD	Test	PRD0212.3320
PRD0220.4204	The SFAD pixel full well shall be >10ph @ 10keV per pulse		Test	PRD0212.3320
PRD0220.4205	The SFAD read-out noise shall be < 75 e-		Test	PRD0212.3320
PRD0220.4206	The SFAD sensitive area shall be $\geq$ 140kPix, 40x40 mm <sup>2</sup>		Inspection	PRD0212.3320
PRD0220.4207	The SFAD pixel size shall be $\leq$ 50 $\mu$ m x 50 $\mu$ m		Inspection	PRD0212.3320



Requirement #	Requirement	Comments	Verification Method	Parent Requirement
PRD0220.4208	The SFAD cabling and cooling length shall be $\geq 2$ m.	Cabling and cooling provisions should minimize mechanical tension on detector mounting provisions.	Inspection	PRD0212.3320
PRD0220.4209	The SFAD physical package envelope (WxLxD) shall be $< 50\text{mm} \times 50\text{mm} \times 200\text{mm}$ (not including cables and cooling pipes etc) with W, L, D in the x, y, z directions respectively.		Inspection	PRD0212.3320

## 6.2 Large Format Area Detector for Scattering/Diffraction

Requirement #	Requirement	Comments	Verification Method	Parent Requirement
PRD0220.4101	The LFAD shall be designed for a minimum energy sensitivity of 4keV		Analysis Test	PRD0212.3320
PRD0220.4114	The LFAD maximum energy sensitivity shall be between 12 keV to 25 keV.	The goal is to achieve sensitivity range of 4 to 25keV	Analysis Test	PRD0212.3320
PRD0220.4102	The LFAD QE shall be: >70% @ 12 keV and > 55% @ 25 keV	The goal is to achieve QE >70% @ 25 keV on the LFAD	Analysis	PRD0212.3320
PRD0220.4103	The LFAD frame-rate shall be > 5 kHz in full frame mode	The goal is to achieve a frame-rate $\geq 25$ kHz in full frame mode.	Test	PRD0212.3320
PRD0220.4104	The LFAD pixel full well capacity shall be >10,000ph @ 8keV per pulse		Test	PRD0212.3320



Requirement #	Requirement	Comments	Verification Method	Parent Requirement
PRD0220.4105	The LFAD pixel read-out noise shall be < 100 e-		Test	PRD0212.3320
PRD0220.4106	The LFAD sensitive area shall be $\geq 2\text{MPix}$ , and cover > 160x160 mm <sup>2</sup>		Inspection	PRD0212.3320
PRD0220.4107	The LFAD pixel size shall be $\leq 100\ \mu\text{m} \times 100\ \mu\text{m}$		Inspection	PRD0212.3320
PRD0220.4108	The LFAD cabling and cooling length shall be compatible with the current XPP robotic detector positioner.	See Detector IRD for further detail.	Inspection	PRD0212.3320
PRD0220.4109	The LFAD shall be compatible with the mechanical mounting interface on XPP detector robot.	See Detector IRD for further detail.	Inspection	PRD0212.3320
PRD0220.4110	The LFAD mass shall be $\leq 25\ \text{kg}$ including the final 3 feet length of the cables and cooling lines.		Inspection	PRD0212.3320
PRD0220.4111	The LFAD assembly shall be light tight against environmental optical lighting and pump laser light.		Inspection	PRD0212.3320
PRD0220.4112	The LFAD central beam pass-through aperture shall be within 5-6 mm diameter.	See Detector IRD for further detail.	Inspection	PRD0212.3320
PRD0220.4113	Detector cables and cooling lines shall be sufficiently compact and flexible as to not interfere with robot motion reach and positioning performance.	See Detector IRD for further detail.	Inspection	PRD0220.4108 PRD0220.4110



**Physics Requirements Document**

**Document Title: XPP Detectors PRD**

**Document Number: LCLSII-HE-1.4-PR-0220-R1**

**Page 7 of 7**