LUSI — LCLS Ultrafast Science Instruments

PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-03 R0	LUSI SUB-SYSTEM Controls and Data System

Physics Requirements for the LUSI Controls and Data System

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Revision	Date	Description of Changes	Approved
R0	20Aug07	Initial release	

1. Overview

The need for per-pulse data collection at 120 Hz, high data rate, large data volume, and precise timing control of the experimental measurements to be carried out at LCLS require a certain degree of sophistication in the controls and data system in design, implementation, and integration.

This document describes the physics specifications for the controls and data infrastructure that will provide standard motion, vacuum controls, timing measurement, data acquisition capabilities, online data storage and management capabilities, and certain common data analysis capabilities to the LUSI instruments. For specific specifications pertaining to an individual instrument, a separate document will be written to provide precise requirements on the scope, capabilities, and performance based on the design of the particular instrument.

For data archiving, retrieval, and offline data processing, the physics specifications are described in a separate document "Physics Requirements for the LUSI Data Management System". The interface between the front end data acquisition system described in this document and the data management system will be covered by an interface control document, where specific interface specifications are defined.

The nomenclatures used in this document are defined in "Controls-Data-Systems-Dictionary".

2. Requirements

2.1. Controls Requirements

2.1.1. The controls and data system shall provide motion controls, vacuum controls, laser system controls, and controls of all diagnostic devices for all LUSI instruments described in sp39100033, sp39100019, and the PRD's for the individual components referenced therein, where details of the specific performance requirements pertaining to controls are provided.

2.1.2. The controls and data system shall provide the same capabilities for the XCS instrument using controls and data hardware and software developed for the XPP and CXI instruments as in 2.1.1.

2.1.3. The controls and data system shall provide common user interfaces for all LUSI instruments specified in 2.1.1 and 2.1.2.

2.1.4. The controls and data system shall provide the user interface to operate the LCLS Personnel Protection System (PPS) for endstation operation of all LUSI instruments.

2.1.5. The controls and data system shall provide the user interface to operate the LCLS Machine Protection System (MPS) for the safe operation of beamline components of all LUSI instruments.

2.1.6. The controls and data system shall provide trigger signal to all endstations with configurable shapes and delays. The jitter in the trigger signal shall be better than 10 ps, and the delay shall have a dynamic range of 8.3 ms.

2.1.7. The controls and data system shall permit the use of the sub-picosecond timing system being developed by the Lawrence Berkeley Laboratory team with the LUSI ultra-fast timing

measurement system described in sp39100002.

2.1.8. The controls and data system shall be compatible with the LCLS controls system to readily allow exchange of information between the control systems of the electron beam and the X-ray beam at a maximum rate of 120 Hz, and at a bandwidth to be specified in the future.

2.2. Data Acquisition Requirements

2.2.1. The controls and data system shall provide data acquisition capability to all LUSI instruments described in sp39100033, sp39100019, and the PRD's for the individual components referenced therein, where details of the specific performance requirements pertaining to data acquisition are provided.

2.2.2. The controls and data system shall provide the same data acquisition capabilities for the XCS instrument using controls and data hardware and software developed for the XPP and CXI instruments as in 2.2.1.

2.2.3. The controls and data system shall provide common user interfaces for data acquisition for all LUSI instruments specified in 2.2.1 and 2.2.2, including but not limited to the 2-dimensional detectors described in sp39100097 and sp31900098, and the detector to be provided to the CXI instrument by the LCLS, namely the Cornell 2-dimensional detector described in LCLS PRD #1.6-002.

2.2.4. The controls and data system shall be capable of acquiring science data at a rate greater than 2 Gbit/s, and scalable to 32 Gbit/s as needs increase.

2.2.5. The controls and data system shall have the ability to display the science data at a rate of 5 frames/s for 2-dimensional detectors of about 1 Mpixels, and scalable to 16 Mpixels.

2.2.6. The controls and data system shall provide a total capacity of 20TB of local storage per each instruments specified in 2.2.1, with the possibility of expanding to 320TB when needs increase.

2.2.7. The controls and data system shall be capable of acquiring metadata at a rate that is the same as that for the science data for proper processing.

2.2.8. The metadata and the associated science data shall be merged/linked before processing the science data.

2.2.9. The controls and data system shall allow the operators in the instrument control room to browse the directory structure and the file contents of the local storage. The specifications for file organization and data format are provided in sp391000006.

2.2.10. The controls and data system shall be capable of transferring data from the local storage to the long term storage system described in sp391000006 to perform data archiving and data retrieval in a manner that will not disrupt the on-going experimental measurements and will allow for network (local-to-long term) downtime for up to one week.