

LUSI Project
WBS Dictionary PM-391-001-12

WBS	Definition
1	<p>LUSI PROJECT MAJOR ITEM OF EQUIPMENT This summary WBS covers the Total Estimated Cost (TEC) Estimate for the LUSI Project being designed, fabricated, assembled and installed at SLAC. The LUSI TEC is supported by the U.S. Department of Energy.</p>
1.1	<p>PROJECT MANAGEMENT This summary cell of the WBS identifies the technical and administrative management of the project, establishment and operation of the Project Management Control System (PMCS), generation of financial and technical reports, and organization of technical support and reviews. Effort and supplies related to management of project-wide ES&H issues are included.</p>
1.1.01	<p>ES&H This summary WBS cell describes the ES&H support for the LUSI project at SLAC.</p>
1.1.01.01	<p>ES&H This WBS element captures efforts of the safety coordinator and other effort and associated supplies needed to manage safety related issues in the design and construction phases of the Project.</p>
1.1.02	<p>Project Management This summary WBS cell describes the Project Management support for the LUSI project at SLAC.</p>
1.1.02.01	<p>Management Office This element captures efforts of the Project Director, the Chief Engineer, and the Project Manager. Also includes related supplies and travel.</p>
1.1.02.02	<p>Project Support This element captures efforts of the Project PMCS, Office Manager Computer support, and PMCS contractors, System management and Cost Accounting. Also includes related supplies and travel.</p>
1.1.03	<p>Technical Support This summary WBS cell describes the effort associated with technical support, review activities, and general collaboration not identified with a specific instrument.</p>
1.1.03.01	<p>Technical Support This element captures all technical support, review activities, and general collaboration not identified with a specific instrument.</p>
1.1.03.02	<p>Reviews This element captures the effort, travel and supplies to support all project level reviews.</p>
1.1.03.03	<p>Collaboration This element includes effort, travel and supplies to support technical collaborations.</p>

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- 1.2 X-RAY PUMP PROBE (XPP)**
This WBS element summarizes the engineering, design, procurement administration, fabrication, assembly, testing, and installation efforts associated with the XPP instrument. The XPP will predominantly use a fast optical laser to generate transient states of matter and utilize the ultra-bright, ultra-short X-ray pulses from LCLS, to probe the structural dynamics initiated by the laser excitation. The laser pump will have the ability to conduct precise optical manipulations, in order to create the desired excited states.
- 1.2.01 XPP System Integration & Design**
This WBS element primarily captures physics, engineering and design support associated with the integration of the XPP instrument. Also included are procurement preparation, fabrication, assembly and installation coordination, vendor site inspections and laboratory facility supply for the XPP instrument. It does not include any component or assembly detail analysis or design, which is captured in subsequent WBS elements. This element includes effort to develop the baseline budget and schedule, to manage the budget and schedule and to track and document the earn value.
- 1.2.02 XPP X-ray Optics & Support Table**
This WBS element summarizes the engineering, design, fabrication, assembly and testing of the support structures for all x-ray beamline optical and diagnostic elements associated specifically to XPP. (excluded is any component specific precision alignment assembly, captured in other LUSI WBS elements)
- 1.2.02.01 XPP Support Table, Supports & Shielding**
This WBS element is the engineering, design, fabrication, assembly and testing of the support structures for all x-ray beamline optical and diagnostic elements required to translate between position 1 (white beam line) and position 2 (monochromatic beamline) associated specifically to XPP. It includes all hardware required to span the distance from the hutch floor to immediately below the component specific precision alignment assemblies. (excluded are any component specific precision alignment assemblies, captured in other LUSI WBS elements)
- 1.2.02.02 XPP Optics Support Table & Supports**
This WBS element is the engineering, design, fabrication, assembly and testing of the support structures for all x-ray beamline optical and diagnostic elements NOT required to translate between position 1 (white beam line) and position 2 (monochromatic beamline) associated specifically to XPP. It includes all hardware required to span the distance from the hutch floor to immediately below the component specific precision alignment assemblies. (excluded are any component specific precision alignment assemblies, captured in other LUSI WBS elements) hardware will be located in hutch 3 AND hutch 2
- 1.2.02.03 reserved**

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1.2.03	XPP Laser System This WBS element summarizes the engineering, design, fabrication, assembly, and testing of the XPP laser system.
1.2.03.01	XPP Ti:Sapphire Laser This WBS element summarizes the fabrication and testing of the XPP ultrafast laser. These components will add to the capability of the LCLS AMO laser system and will provide the excitation pulse (pump) to initiate time resolved phenomena for the XPP instrument. This element consists of a Ti:Sapphire power amplifier, optical parametric amplifier (OPA) and temporal pulse shaper. This configuration permits flexibility of the wavelength, excitation level and temporal profile of the laser pulses used to photo-excite various materials.
1.2.03.01.01	<i>reserved</i>
1.2.03.01.02	Ti:Sapphire Amplifier(s) System/Pumps This WBS element includes the fabrication, assembly and testing of the Ti:Sapphire Amplifier System. This 2nd stage multi-pass power amplifier, operating at 120 Hz, will increase the pulse energy to 20 mJ with a pulse-to-pulse energy stability < 1.5% rms. This level of pulse energy and stability is achieved through use of the high energy diode-pumped solid state lasers implemented in the LCLS gun laser.
1.2.03.01.03	Temporal Pulse Shaper This WBS element includes the fabrication and testing of the Temporal Pulse Shaper. This device will be inserted between the Ti:Sapphire oscillator and regenerative amplifier when pulse shaping is required.
1.2.03.01.04	Optical Parametric Amplifier This WBS element includes the fabrication and testing of the optical parametric amplifier.
1.2.03.01.05	<i>reserved</i>
1.2.03.02	XPP Optics, Optomechanics & Diagnostics This WBS element includes the engineering, design, fabrication, assembly, and testing of the XPP laser system optics, optomechanics and diagnostics.
1.2.03.02.01	Optics & Optomechanics This WBS element includes the fabrication of the optics and optomechanical components associated with the XPP laser system.
1.2.03.02.02	Laser Diagnostics This WBS element includes the fabrication of the laser system diagnostics. These diagnostics will be used to characterize the temporal profile, pulse energy, spatial profile and timing of the XPP laser system.
1.2.03.02.03	Hutch Optical Table System

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	This WBS element includes the engineering, design, fabrication, assembly, and testing of the optical tables to support the XPP laser system elements located exclusively in hutch 3.
1.2.03.02.04	Optical Experiments This WBS element includes the fabrication of the components used to probe a sample that is excited via the FEL using optical techniques.
1.2.03.02.05	Laser Containment System This WBS element includes the engineering, design, fabrication, assembly, and testing of the optical laser containment system (IE: safety covers) for XPP specific components in hutch 3. It includes the hardware attached to the covers, doors or optical tables required to locate or support the safety interlock hardware (it does not include design, procurement, switches, wiring, or wire management elements of the interlock system).
1.2.03.02.06	Laser Hall Optical Table System This WBS element includes the engineering, design, fabrication, assembly, and testing of the optical tables to support the XPP laser system elements located exclusively in the laser hall.
1.2.04	XPP Detector System (BNL) This WBS element is managed and executed at BNL. This WBS element summarizes the engineering, design, fabrication, assembly, and testing of the XPP detector system.
1.2.04.01	Detector Support and Integration This WBS element is managed and executed at BNL. This WBS element includes the Physics and Engineering support associated with the execution of the design, fabrication, and installation efforts for the XPP 2-D detector system. Efforts related to design reviews and vendor visits will be captured in this WBS element.
1.2.04.02	Detector Sensor This WBS element is managed and executed at BNL. This WS element includes the engineering, design, fabrication, assembly and testing of the XPP detector sensor sub-system.
1.2.04.03	Detector Application Specific Integrated Circuits (ASIC) This WBS element is managed and executed at BNL. This WBS element includes the engineering, design, fabrication, assembly and testing of the XPP detector application specific integrated circuit sub-system.
1.2.04.04	Detector Controls, Electronics and DAQ This WBS element is managed and executed at BNL. This WBS element includes the engineering, design, fabrication, assembly and testing of the XPP detector controls, electronics data acquisition sub-systems.
1.2.05	XPP Sample Environment & Diffractometer System

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This WBS element summarizes the engineering, design, fabrication, assembly, and testing of the XPP diffractometer system (& sample environments).

1.2.05.01 XPP Diffractometer System

This WBS cell includes the engineering, design, fabrication, assembly, and testing of the XPP Diffractometer System. components include: sample goniometer (kappa and Tilt configuratoins), detector mover, mounting bases for goniometer and detector mover, alignment fixtures, sample mount heads, detector array protection beam stop and cable management.

1.2.06 XPP Facilities

This WBS element summarizes the engineering, design, fabrication and testing of components required to complete the outfitting of hutch 3 to support XPP experiements. Items included are not directly associated with experimental operations (IE: not x-ray beam, optic laser related hardware)

1.2.06.01 XPP Hutch Specification

This WBS element includes the specification of requirements and engineering, design and documentation of the general hutch support hardware layout. It includes placement of special access hardware (raised floor, general safety barriers), support hardware (control racks, cable trays) and personnel accommodation items (supply cabinets, desks, benches, etc).

1.2.06.02 XPP Utilities & Hutch Equipment

This WBS element includes the engineering, design and fabrication of hardware to outfit hutch 3 for XPP operations, including raised floor, specialized cable trays (components with special functional requirements not addressed in other LUSI WBS elements), cabinets and personnel accommodation hardware. Items included are not directly associated with experimental operations (IE: not x-ray beam, optic laser related hardware)

1.2.07 XPP Vacuum System

This WBS element summarizes the engineering, design, fabrication and testing of the XPP vacuum system. Included are all pumping, pressure diagnostics, line replaceable bellows, drift spools, and drift spool supports. Not included are x-ray beam diagnostic and optic vacuum enclosure elements or supports

1.2.07.01 XPP Vacuum Equipment

This WBS element includes the engineering, design, fabrication and testing of the XPP vacuum system pumping, pressure diagnostics, valves and related equipment.

1.2.07.02 XPP Vacuum Hardware

This WBS element summarizes the fabrication and testing of the XPP vacuum system line replaceable bellows, drift spools, and drift spool supports. Not included are any engineering, design or any x-ray beam diagnostic and optic vacuum enclosure elements or supports

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1.2.07.02.01	<p>XPP Spools and Bellows This WBS element includes the fabrication and testing of the XPP vacuum system line replaceable bellows and drift spools. Not included are any engineering, design or any x-ray beam diagnostic and optic vacuum enclosure elements</p>
1.2.07.02.02	<p>XPP Vacuum Supports This WBS element summarizes the fabrication and testing of the XPP vacuum system drift spool supports. Not included are any engineering, design or any x-ray beam diagnostic and optic vacuum supports</p>
1.2.08	<p>XPP Installation This WBS element summarizes all labor and material required for approval to install and installation of the LUSI XPP hardware</p>
1.2.08.01	<p>XPP Installation This WBS element includes all tasks exclusively related to installation of XPP instrument hardware in hutch 3. included are engineering technical planning (safety approvals, statement of work generation), and engineering oversight of the of the installation. Included are efforts related to preparing the installation location, moving and installing all necessary hardware, connecting all wires and cables, aligning the instrument, and performing to vacuum leak check to meet LUSI CD-4a deliverables.</p>
1.3	<p>COHERENT X-RAY IMAGING (CXI) This cell of the WBS identifies all required design, procurement, fabrication, assembly, testing and installation efforts associated with this instrument, which takes advantage of the extremely bright, ultra-short LCLS pulses of hard x-rays to allow imaging of non-periodic nano-scale objects, including single biomolecules or small clusters, at or near atomic resolution. The main components are the pulse picker, 2 Kirkpatrick-Baez (KB) mirror systems, upstream x-ray diagnostics, a sample chamber including a particle injector and an ion time-of-flight, a detector stage and x-ray diagnostics downstream of the sample chamber.</p>
1.3.01	<p>CXI System Integration & Design This cell of the WBS identifies all the Physics and Engineering support associated with the execution of the design, procurement and fabrication efforts for this instrument. Costs related to sustaining design support, instrument design reviews, radiation physics support, vendor visits and lab supplies will also be captured in this WBS element</p>
1.3.02	<p>CXI X-ray Optics This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the x-ray optics that are specific to the CXI instrument, namely two Kirkpatrick-Baez (KB) mirror pairs.</p>
1.3.02.01	<p>CXI KB System (0.1 micron)</p>

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	This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with a KB mirror system capable of producing a 0.1 micron x-ray focal spot at the sample location. The mirror system consists of 2 mirrors and their associated 3-axis of rotation mounting system, a translation system to position the mirrors into the x-ray beam and a vacuum vessel to hold the entire system under ultra high vacuum.
1.3.02.02	<p>CXI KB System (1 micron)</p> <p>This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with a KB mirror system capable of producing a 1 micron x-ray focal spot at the sample location. The mirror system consists of 2 mirrors and their associated 3-axis of rotation mounting system, a translation system to position the mirrors into the x-ray beam and a vacuum vessel to hold the entire system under ultra high vacuum.</p>
1.3.03	<p>CXI Lasers</p> <p>This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the lasers and laser transport systems that will be used with the CXI instrument.</p>
1.3.03.01	<p>CXI Reference Laser</p> <p>This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the CXI Reference Laser. This laser will be introduced into vacuum and the x-ray beam path using remotely moveable mirrors and will provide a visible reference line which is collinear with the LCLS beam. This laser will allow for alignment of the experiment without the use of the x-ray beam.</p>
1.3.03.02	<i>reserved</i>
1.3.04	<p>CXI Coherent Imaging Injector</p> <p>This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with a particle injector system that will be used to deliver support-free particles into high vacuum to be intercepted by the LCLS beam.</p>
1.3.04.01	<p>Coherent Imaging Particle Injector System</p> <p>This cell of the WBS identifies all required Physics support, engineering, design, documentation procurement, fabrication, assembly and testing efforts associated with the CXI Coherent Imaging Particle Injector.</p>
1.3.05	<p>CXI Sample Environment</p> <p>This cell includes all efforts to design, procure, and fabricate all required parts to complete the room temperature Sample Chambers (0.1 micron & 1.0 micron), the Ion ToF, and the Precision Instrument Stands (0.1 micron & 1.0 micron).</p>

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1.3.05.01	<p>CXI Room Temperature Environment This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with a room temperature sample chamber, an Ion time-of-flight detector, a precision instrument stand and a detector stage.</p>
1.3.05.01.01	<p>CXI Sample Chambers and Ion TOF This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the CXI Sample Chambers (0.1 micron and 0.1 micron) and the ion time-of-flight mass spectrometer. Each CXI Sample Chamber will include an interface to the Coherent Imaging Injector, aperture raster stages and a sample raster stage with 2-axis rotation, as well as vacuum equipment to maintain and monitor the high vacuum of each chamber. The ion TOF will sample ions created at the interaction region and be mounted on the sample chamber. A single high resolution sample viewing system is also captured in this WBS.</p>
1.3.05.01.02	<p>CXI Precision Instrument Stands This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with two Precision Instrument Stands (0.1 micron and 1.0 micron) for the CXI instrument. Each stand will support, position and orient its respective Sample Chamber, the Coherent Imaging Injector and the Detector Stage. The Coherent Imaging Injector and the Detector Stage may be used with only one Sample Chamber/Precision Instrument Stand pair at any given time.</p>
1.3.05.01.03	<p>CXI Detector Stage This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the Detector Stage which will support, position and orient the detector inside a vacuum vessel. The vacuum vessel and the necessary vacuum equipment to produce the high vacuum are also captured in this WBS element.</p>
1.3.05.02	<i>reserved</i>
1.3.06	<p>CXI Hutch Facilities This WBS element summarizes the engineering, design, fabrication and testing of components required to complete the outfitting of hutch 5 to support CXI experiments. Items included are not directly associated with experimental operations (i.e., not x-ray beam, optic laser related hardware)</p>
1.3.06.01	CXI Hutch Specification

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	<p>This WBS element includes the specification of requirements and engineering, design and documentation of the general hutch support hardware layout. It includes placement of special access hardware (raised floor, general safety barriers), support hardware (control racks, cable trays) and personnel accommodation items (supply cabinets, desks, benches, etc).</p>
1.3.06.02	<p>CXI Utilities & Hutch Equipment This WBS element includes the engineering, design and fabrication of hardware to outfit hutch 5 for CXI operations, including raised floor, specialized cable trays (components with special functional requirements not addressed in other LUSI WBS elements), cabinets and personnel accommodation hardware. Items included are not directly associated with experimental operations (i.e., not x-ray beam, optic laser related hardware)</p>
1.3.07	<p>CXI Vacuum System This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with creating an high vacuum along the entire CXI beam line. This WBS element includes all hardware, bellows, spools, and vacuum supports.</p>
1.3.07.01	<p>CXI Vacuum Equipment This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with of the vacuum equipment. This includes all pumps, valves, vacuum diagnostics and miscellany vacuum equipment for the entire CXI instrument, except for those of the Sample Chamber, the Detector Stage and the Coherent Imaging Injector.</p>
1.3.07.02	<p>CXI Vacuum Hardware This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the CXI vacuum hardware such as bellows, spools and all the supports vacuum vessels.</p>
1.3.07.02.01	<p>CXI Bellows & Spools This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the vacuum bellows and spools for the CXI instrument. Included in the vacuum spools are the vacuum tees or crosses necessary for connecting vacuum equipment.</p>
1.3.07.02.02	<p>CXI Vacuum Supports This cell of the WBS identifies all required engineering, design, documentation, procurement, fabrication, assembly and testing efforts associated with the supports stands of the vacuum spools, the support stands of all common optics and diagnostics, the support stands of the reference laser and the 1 micron KB system. The only support stand of the CXI instrument not captured in this WBS element is the Precision Instrument Stand.</p>

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1.3.08	<p>CXI Installation</p> <p>This element summarizes all labor and material required for the assembly and installation of the LUSI CXI Instrument.</p>
1.3.08.01	<p>CXI Installation Phase</p> <p>This element captures the efforts by engineers to provide technical planning, design of installation equipment and oversight of the installation. This element captures the efforts of preparing the installation location, moving and installing all necessary hardware, diagnostics/common optics and the CXI Instrument (including the 1.0 micron KB system and 1.0 micron Sample Chamber/Precision Instrument Stand), connecting all wires and cables, aligning the instrument, and performing a vacuum leak check to meet LUSI CD-4b deliverables. Additionally, this element captures the efforts of preparing the installation location, moving and installing all necessary hardware, diagnostics, 0.1 micron KB system, 0.1 micron Sample Chamber/Precision Instrument stand, Coherent Imaging Injector, IToF, connecting all wires and cables, aligning the instrument, and performing vacuum leak to meet LUSI CD-4c deliverables.</p>
1.4	<p>X-RAY CORRELATION SPECTROSCOPY (XCS)</p> <p>This cell of the WBS identifies all required design, procurement, and fabrication efforts associated with this instrument, which will take advantage of the unique opportunity provided by the unprecedented brilliance and narrow pulse duration of the LCLS to observe dynamical changes of large groups of atoms in condensed matter systems over a wide range of time scales using X-ray Photon Correlation Spectroscopy (XCS). The proposed instrument will include a beam multiplexing fixed-exit monochromator, coherence preserving optics, a diffractometer and detector stages, and a fast 2D detector. The XCS instrument will be complemented by x-ray optics elements, sample environment and experimental instrumentation provided by the collaborative teams.</p>
1.4.01	<p>XCS System Integration & Design</p> <p>This WBS element includes all of the Physics support associated with the execution of the design, procurement and fabrication efforts for the XCS instrument. Engineering and design effort required to support integration of the XCS instrument within LUSI and also into the LCLS project are included here. Effort and supplies to support instrument level reviews, design management/standardization, vendor visits, work related training, project meetings and general procurement and fabrication coordination (not covered elsewhere) are also included here.</p>
1.4.02	<p>XCS X-ray Optics and Support Table</p> <p>This WBS element summarizes the engineering, design, fabrication, assembly and testing of the support structures for all x-ray beamline optical and diagnostic elements associated specifically to XCP. (excluded is any component specific precision alignment assembly, captured in other LUSI WBS elements)</p>
1.4.02.01	<p><i>reserved</i></p>

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1.4.02.02	XCS Hutch Supports, Tables and Shielding This WBS element includes all required engineering, design, procurement, fabrication, assembly and testing of optics and diagnostics support structures for the XCS beamline in Hutch 4 upstream of the diffractometer. It includes all hardware required to mount components to the floor below the component specific precision alignment assemblies. (Excluded are any component specific precision alignment assemblies, captured in other LUSI WBS elements.)
1.4.02.03	XCS Stoppers This WBS element includes all required engineering, design, procurement, fabrication, assembly and testing of a single module diagnostic stopper; a modification of the SSRL dual module PPS stopper.
1.4.02.04	<i>reserved</i>
1.4.03	XCS Detector System (BNL) This summary WBS describes the efforts and costs associated with the XCS 2D X-Ray Detector.
1.4.03.01	Detector Support and Integration This WBS element is managed and executed at BNL. This WBS element includes the Physics and Engineering support associated with the execution of the design, fabrication, and installation efforts for the XCS 2-D detector system. Efforts related to design reviews and vendor visits will be captured in this WBS element.
1.4.03.02	Detector Sensor This WBS element is managed and executed at BNL. This WS element includes the engineering, design, fabrication, assembly and testing of the XCS detector sensor sub-system.
1.4.03.03	Detector Application Specific Integrated Circuits (ASIC) This WBS element is managed and executed at BNL. This WBS element includes the engineering, design, fabrication, assembly and testing of the XCS detector application specific integrated circuit sub-system.
1.4.03.04	Detector Controls, Electronics and DAQ This WBS element is managed and executed at BNL. This WBS element includes the engineering, design, fabrication, assembly and testing of the XCS detector controls, electronics data acquisition sub-systems.
1.4.04	XCS Sample Environment & Diffractometer System This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of the XCS sample environment and diffractometer system including the diffractometer, sample environment and the large angle detector mover.

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1.4.04.01	<p>XCS Diffractometer System</p> <p>This WBS element includes all required engineering, design, procurement, fabrication, assembly and testing of the XCS diffractometer. The diffractometer provides a mounting surface for the sample chamber, the near field detector and anchors to the floor. Also included is the capability to move the diffractometer off of the XCS beamline toward the South wall.</p>
1.4.04.02	<i>reserved</i>
1.4.04.03	<p>XCS Large Angle Mover & Chamber</p> <p>This WBS element includes all required engineering, design, procurement, fabrication, assembly and testing of the large angle detector mover translation stage, vacuum chamber, vacuum window and detector mounting interface of the large angle diffractometer system.</p>
1.4.05	<p>XCS Hutch Facilities</p> <p>This WBS element summarizes the engineering, design, fabrication and testing of components required to complete the outfitting of hutch 4 to support XCS experiments. Items included are not directly associated with experimental operations (IE: not x-ray beam, optic laser related hardware)</p>
1.4.05.01	<p>XCS Hutch Specification</p> <p>This WBS element includes the specification of requirements and engineering, design and documentation of the general hutch support hardware layout. It includes placement of special access hardware (raised floor, general safety barriers), support hardware (control racks, cable trays) and personnel accommodation items (supply cabinets, desks, benches, etc).</p>
1.4.05.02	<p>XCS Utilities & Hutch Equipment</p> <p>This WBS element includes the engineering, design and fabrication of hardware to outfit hutch 3 for XPP operations, including raised floor, specialized cable trays (components with special functional requirements not addressed in other LUSI WBS elements), cabinets and personnel accommodation hardware. Items included are not directly associated with experimental operations (IE: not x-ray beam, optic laser related hardware)</p>
1.4.06	<p>XCS Vacuum System</p> <p>This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of the XCS X-Ray Transport Tunnel and Hutch vacuum systems including all hardware, bellows, spools, and vacuum supports.</p>
1.4.06.01	<p>XCS XRT Vacuum System</p> <p>This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of the XCS X-Ray Transport Tunnel vacuum system including all hardware, bellows, spools, and vacuum supports.</p>

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1.4.06.01.01	XCS XRT Vacuum Equipment This WBS element summarizes all required engineering support, procurement, processing and testing of the vacuum equipment for the XCS X-Ray Transport Tunnel vacuum system including pumps, gauges and valves.
1.4.06.01.02	XCS XRT Vacuum Spools & Bellows This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of drift spools and bellows for the XCS X-Ray Transport Tunnel vacuum system.
1.4.06.01.03	XCS XRT Vacuum Supports This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of XCS X-Ray Tunnel vacuum system component supports including pump, gauge, valve and drift tube supports.
1.4.06.02	XCS Hutch Vacuum System This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of the XCS Hutch vacuum system including all hardware, bellows, spools, and vacuum supports. Excluded is the large angle mover vacuum chamber covered elsewhere in the WBS.
1.4.06.02.01	XCS Hutch Vacuum Equipment This WBS element summarizes all required engineering support, procurement, processing and testing of the vacuum equipment for the XCS Hutch 4 vacuum system including pumps, gauges and valves.
1.4.06.02.02	XCS Hutch Vacuum Spools & Bellows This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of drift spools and bellows for the XCS Hutch 4 vacuum system.
1.4.06.02.03	XCS Hutch Vacuum Supports This WBS element summarizes all required engineering, design, procurement, fabrication, assembly and testing of XCS Hutch 4 vacuum system component supports including pump, gauge, valve and drift tube supports. Excluded are supports for the large angle mover vacuum chamber supports.
1.4.07	XCS Installation This element summarizes all labor, material and engineering support required for the assembly and installation of the XCS instrument components.
1.4.07.01	XCS XRT Installation

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	<p>This element captures the efforts by engineers to provide technical planning, design of installation equipment and oversight of the installation of the X-Ray Transport Tunnel beamline segment of the XCS instrument. This element also captures the efforts of preparing the installation location, moving and installing all necessary components and hardware , alignment of the components, vacuum interconnection and vacuum leak check of the X-Ray Transport Tunnel beamline segment of the XCS instrument to meet LCLS CD-4 deliverables.</p>
1.4.07.02	<p>XCS Hutch 4 Installation</p> <p>This element captures the efforts by engineers to provide technical planning, design of installation equipment and oversight of the installation of the XCS instrument components located in Hutch 4. This element also captures the efforts of preparing the installation location, moving and installing all necessary components and hardware, alignment of the components, vacuum interconnection and vacuum leak check of the CS instrument components located in Hutch 4 to meet LCLS CD-4 deliverables.</p>
1.5	<p>DIAGNOSTICS & COMMON OPTICS</p> <p>This element of the WBS rolls up all the materials and effort required to manage, design, procure, fabricate, assemble, integrate and test the Diagnostics and Common Optics deliverables.</p>
1.5.01	<p>Diagnostics & Common Optics System Integration & Design</p> <p>This element covers the physics, engineering and design support associated with the execution of the design, procurement, and fabrication efforts for the Diagnostics and Common Optics systems. It also includes integration engineering between its deliverables and the instruments to which these deliverables shall be installed. Effort and materials related to the coordination of design reviews, design management/standardization, vendor visits, work related training, project meetings, supplies and procurement and fabrication coordination effort is also included.</p>
1.5.02	<p>Diagnostics</p> <p>This element rolls up all the materials and effort required to manage, design, procure, fabricate, assemble, integrate and test the following deliverables:</p> <ol style="list-style-type: none">1) Pop-In Profile Monitor: 3 for XPP, 4 for CXI and 5 for XCS2) Pop-In Intensity Monitor: 2 for XPP, 2 for CXI, and 5 for XCS3) Wavefront Monitor: 1 for CXI4) Intensity-Position Monitor: 3 for XPP, 3 for CXI and 5 for XCS
1.5.02.01	<p>Pop-in Profile/Wavefront Monitor</p> <p>This element covers the design, procurement, fabrication and assembly of the Pop-In Profile Monitors for XPP, CXI and XCS (Pop-In Profile Monitor: 3 for XPP, 4 for CXI and 4 for XCS & Wavefront Monitor: 1 for CXI). This element does not cover the installation of the devices. The deliverables for this device are a stand alone vacuum chamber with a 40 mm YAG screen and visible mirror mounted on a pneumatic actuator, an optical imaging system, a six degree of freedom support system that can be mounted to a table and design documentation of the hardware.</p>

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- 1.5.02.02 Pop-In Intensity Monitor**
This element covers the design, procurement, fabrication and assembly of the Pop-In Intensity Monitors for XPP, CXI and XCS (2 for XPP, 2 for CXI, and 7 for XCS). This element does not cover the installation of the devices. The deliverables for this device are a stand alone vacuum chamber with a pips diode mounted to a pneumatic actuator, a six degree of freedom support system that can be mounted to a table and design documentation of the hardware.
- 1.5.02.03 Intensity-Position Monitor**
This element covers the design, procurement, fabrication and assembly of the Pop-In Intensity Monitors for XPP, CXI and XCS (3 for XPP, 3 for CXI and 5 for XCS). This element does not cover the installation of the devices. The deliverables for this device are a stand alone vacuum chamber with a quadrant diode mounted to a pneumatic actuator, a filter assembly mounted to a slide and driven by a stepper motor, a six degree of freedom support system that can be mounted to a table design documentation of the hardware.
- 1.5.03 Common Optics**
This element rolls up all the effort and deliverables required to manage, design, procure, fabricate, assemble, integrate and test the following deliverables:
- 1) Slits:
 - a. 1 dual blade primary slit device and 2 single blade slit devices for XPP
 - b. 4 single blade slit devices for CXI
 - c. 1 dual blade primary slit device and 5 single blade slit devices for XCS
 - 2) Attenuators: 1 for XPP, 1 for CXI, 1 for XCS
 - 3) Pulse Picker - one system per Instrument
 - 4) Be Lens System: 1 for XPP, 1 for XCS
 - 5) Harmonic Rejection Mirror: 1 for XPP, 1 for XCS
 - 6) Monochromator System: 1 for XCS
- 1.5.03.01 Large Offset Monochromator**
This WBS element captures physics, engineering and design support associated with the procurement of two "large offset thin crystal monochromators" as a complete systems. These monochromators are destined for the XCS and XPP experiments. Included are the procurement preparation, vendor selection, and award efforts. It also includes fabrication oversight, assembly inspection, vendor site inspections, verification of deliverable monochromators, and installation coordination. It does not include any component or assembly detail analysis or design, as it should be captured as a deliverable on the vendor's Statement of Work, SOW. This element includes effort to manage the budget and schedule, and to track and document the earn value associated with the procurement of the monochromator. This element includes the effort to identify physics requirements, define SOW, and specification on the types and quantities of tests needed to validate the monochromator integration, workmanship and performance. It does not include the design or procurement of controls and controls related equipment, which is covered in element 1.6.

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1.5.03.02	X-ray Focusing Lenses This element of the WBS identifies all required engineering, design, procurement, and fabrication efforts associated with the analyses and technical trades to go from the initial concept to a mature design. It also includes the effort to develop and document engineering specifications, generating manufacturing drawings, manufacturing, assembly, and verification to deliver one Be lens system to XPP and one to XCS. Performance requirements for each system shall be described in their respective PRD's.
1.5.03.03	Slit System This cell of the WBS identifies all required engineering, design, analyses, technical trades, procurement, and fabrication efforts to go from the initial concept to a mature design of the slit system for XPP, CXI and XCS. This element also includes generating manufacturing drawings, manufacturing, assembly, and verification of deliverable slit systems for XPP, CXI, and XCS. Performance requirements for each assembly shall be identified in their respective PRD's. Slits: <ul style="list-style-type: none">a. 1 dual blade primary slit device and 2 single blade slit devices for XPPb. 4 single blade slit devices for CXIc. 1 dual blade primary slit device and 5 single blade slit devices for XCS
1.5.03.04	Attenuators / Filters This cell of the WBS identifies all required engineering, design, procurement, and fabrication efforts required to go from the initial concept to a mature design. This element also involves generating manufacturing drawings, manufacturing, assembly, and verification of working one working attenuator system for each of the LUSI experiment, XCS, XPP, and XCI. Performance requirements for each assembly shall be identified in their respective PRD's.
1.5.03.05	Pulse Pickers This cell of the WBS identifies all required engineering, design, analyses, technical trades, procurement, and fabrication efforts needed to go from the initial concept to a mature design of a pulse picker system that would be shared amongst all LUSI experiments (XPP, XCI, XCS). This element includes generating an engineering specification document (ESD), manufacturing drawings, manufacturing, assembly, and verification. Performance requirements for this assembly shall be documented the PRD.
1.5.03.06	Harmonic Rejection Mirrors This cell of the WBS identifies all required engineering, design, the analyses, and technical trades, to go from the initial concept to a mature design of one harmonic rejection mirror system for XCS and one fo XPP. This element includes generating an ESD, manufacturing drawings, procurement, fabrication, manufacturing, assembly, and verification efforts associated with the delivery each system. Performance requirements for each assembly shall be delineated in it respective PRD.
1.5.03.07	Channel Cut Monochromator

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This WBS element captures physics, engineering and design support associated with the procurement of one "channel-cut thin crystal monochromators" as a complete system. This monochromator is destined for the XCS experiment. Included are the procurement preparation, vendor selection, and award efforts. It also includes fabrication oversight, assembly inspection, vendor site inspections, verification of deliverable monochromators, and installation coordination. It does not include any component or assembly detail analysis or design, as it should be captured as a deliverable on the vendor's Statement of Work, SOW. This element includes effort to manage the budget and schedule, and to track and document the earn value associated with the procurement of the monochromator. This element includes the effort to identify physics requirements, define SOW, and specification on the types and quantities of tests needed to validate the monochromator integration, workmanship and performance. It does not include the design or procurement of controls and controls related equipment. which is covered in element 1.6.

1.6 CONTROLS AND DATA ACQUISITION

This cell of the WBS identifies all required engineering, design, procurement, and fabrication efforts associated with the control systems for the three instruments. It consists of 2 major areas, the control subsystems and the data subsystems. The control subsystem will control the basic operations of all experimental endstations in the two experimental halls, the Near Hall and the Far Hall. The data subsystems will acquire, store, analyze, and archive all experimental data.

1.6.01 Controls and Data Acquisition System Integration & Design

This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with system management and system engineering.

1.6.02 LUSI Common Controls

This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the LUSI Common Controls. Common controls includes areas which are common to all experiments as detailed in WBS level 4.

1.6.02.01 Photon Beam Feedback

This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the 120 Hz information flow between LUSI instruments as well as from/to the electro-optics instrument. Information is acquired and processed in station IO controllers, and multi or broad cast to other controllers where it is attached to the event data of that particular beam event.

1.6.02.02 Electron Beam Feedback

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WBS	Definition
	<p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the infrastructure for the 120 Hz information flow between photon beam-line and the accelerator electron beam line. Information is acquired and processed in station IO controllers, and exchanged with the emachine control system e.g. to provide feedback in order to improve the beam quality. Data from the ebeam section is attached to photon beam line data to enable event processing as well as reduction of event data stored in cache.</p>
1.6.02.03	<p>Hutch Environmental Controls</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the environmental monitoring and control of the hutches. Examples are temperature and humidity measurements, display, and recording.</p>
1.6.02.04	<p>FEH DAQ Data Storage</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the local data storage in the far hall. Data is to be stored for at least 4 days in case of service interruption to the SLAC computing facilities.</p>
1.6.02.05	<p>DAQ Data Processing</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the common acquisition and online processing of instrument data before storage in the cache.</p>
1.6.02.06	<p>Racks & Cabling (Common)</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the common racks and associated cabling for the far hall. Includes installation of all racks and cables.</p>
1.6.03	<p>X-ray Pump Probe Hutch 3 (NEH)</p> <p>This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the XPP Hutch 3 (NEH).</p>
1.6.03.01	<p>XPP H3 Requirements, Design, Setup</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with deriving and documenting requirements for the XPP controls and data systems. Includes preparation for and holding the preliminary design review. Test setups to explore potential controller types are assembled and tested. Test software is developed.</p>
1.6.03.01.01	<p>XPP H3 Requirements, Design</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the deriving and documenting requirements for the XPP controls and data systems. Includes preparation for and holding the preliminary design review.</p>

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WBS	Definition
1.6.03.01.02	<p>XPP H3 Development Test Setup This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the test setups to explore potential controller types are their assembly and testing. Test software is developed.</p>
1.6.03.02	<p>XPP H3 Standard Hutch Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with experiment specific workstation, beam line processor, the channel access gateway, and the machine protection system.</p>
1.6.03.02.01	<p>XPP H3 Cables & Racks This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the instruments specific racks and cabling. Essentially the hutch racks and cables. Includes installation of racks and cables.</p>
1.6.03.02.02	<p>XPP H3 Workstation This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the workstations for the instrument control and monitoring.</p>
1.6.03.02.03	<p>XPP H3 Beam Line Processor This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the exchange of 120-Hz beam line data. Includes VME crate and its IO controller CPU plus a timing system interface board.</p>
1.6.03.02.04	<p>XPP H3 Channel Access Gateway This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the EPICS channel access gateway. Includes work-station to run channel access gateway software.</p>
1.6.03.02.05	<p>XPP H3 MPS This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the interface to the XES common machine protection system. Includes purchase and installation of LCLS common link-nodes and switches.</p>
1.6.03.03	<p>XPP H3 Specific Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the individual section of the instrument to be controlled and read out.</p>
1.6.03.03.01	<p>XPP H3 Data Acquisition (DAQ)</p>

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the acquisition of data from the instrument. Included is the detector pixel read out specific to this instrument.
1.6.03.03.02	XPP H3 DAQ Hutch Data Management This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the transport and management of the control and event data in the hutch.
1.6.03.03.03	XPP H3 Experiment Configuration Control This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the configuration control of the instrument. Included are VME crates, switches, and terminal servers. Selected EPICS screens to interface to the users.
1.6.03.03.04	XPP H3 Valve Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the valves. Solenoid drivers and VME interface hardware and software.
1.6.03.03.05	XPP H3 Vacuum Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control and measurement of the vacuum for the instrument. Included are pump controllers, gauge controllers, and VME interface hardware and software
1.6.03.03.06	XPP H3 Pop-In Profile Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in profile monitors for the instrument. Included are CPU's, camera control and readout hardware and software, and pneumatic actuator controllers.
1.6.03.03.07	XPP H3 Pop-In Intensity Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in intensity monitors for the instrument. Included are CPU's, analog signal digitization and readout hardware and software, and pneumatic actuator controllers.
1.6.03.03.08	XPP H3 Intensity-Position Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the intensity position monitor. Included are stepper motor control, linear encoder readout, and analog-to-digital converter hardware and software.
1.6.03.03.09	XPP H3 X-Ray Focusing Lens Controls

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the focusing lens control. Included are stepper motor control, encoder readout, and VME hardware and software.
1.6.03.03.10	XPP H3 Slit Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the slit control. Included are stepper motor control, encoder readout, and VME hardware and software.
1.6.03.03.11	XPP H3 Attenuator Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the attenuators. Included are pneumatic actuator control, status readout, and VME hardware and software.
1.6.03.03.12	XPP H3 Pulse Picker Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pulse picker. Included are hardware and software. Basically needs timing signal synchronized with the machine and stepper motor control, limit switch readback and vision camera control and readout.
1.6.03.03.13	XPP H3 Harmonic Rejection Mirrors Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the harmonic rejection mirrors. Included are stepper motor control and encoder readout plus associated VME hardware and software.
1.6.03.03.14	<i>reserved</i>
1.6.03.03.15	XPP H3 Vision Camera Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the vision cameras via webcam controllers.
1.6.03.03.16	XPP H3 Diffractometer/Wide Angle Detector Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation and installation efforts associated with the wide angle detector control. Included are stepper motor control, limit switch readback and position readback and associated VME hardware and software.
1.6.03.03.17	<i>reserved</i>
1.6.03.03.18	XPP H3 Laser System Controls

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the system control of the laser system. Software only development for provided laser control hardware.
1.6.03.03.19	<i>reserved</i>
1.6.03.03.20	XPP H3 Laser Optics Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the laser optics. stepper motor control, limit switch readback and cameras control and readout are included with associated VME hardware and software.
1.6.03.03.21	XPP H3 Laser Diagnostics This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the diagnostics of the laser. Identical to the LCLS gun laser. Interface is Ethernet or RS232. Also uses some analog-to-digital acquisition channels, spare channels of already present ADC modules are used.
1.6.03.03.22	<i>reserved</i>
1.6.03.03.23	<i>reserved</i>
1.6.03.03.24	<i>reserved</i>
1.6.03.03.25	<i>reserved</i>
1.6.03.03.26	<i>reserved</i>
1.6.03.03.27	<i>reserved</i>
1.6.03.03.28	<i>reserved</i>
1.6.03.03.29	<i>reserved</i>
1.6.03.03.30	<i>reserved</i>
1.6.03.03.31	<i>reserved</i>
1.6.03.03.32	<i>reserved</i>
1.6.03.03.33	<i>reserved</i>
1.6.03.03.34	XPP Controls System Integration Test

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	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the system integration effort and associated testing.
1.6.04	Coherent X-ray Imaging (CXI) Hutch 5 (FEH) This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the CXI Hutch 5 (FEH).
1.6.04.01	CXI H5 Requirements, Design, Setup This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with deriving and documenting requirements for the CXI controls and data systems. Includes preparation for and holding the preliminary design review. Test setups to explore potential controller types are assembled and tested. Test software is developed.
1.6.04.01.01	CXI H5 Controls Requirements, Design This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the deriving and documenting requirements for the CXI controls and data systems. Includes preparation for and holding the preliminary design review.
1.6.04.01.02	CXI H5 Development Test Setup This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the test setups to explore potential controller types are their assembly and testing. Test software is developed.
1.6.04.02	CXI H5 CXI Standard Hutch Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with experiment specific workstation, beam line processor, the channel access gateway, and the machine protection system.
1.6.04.02.01	CXI H5 Cables & Racks This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the instruments specific racks and cabling. Essentially the hutch racks and cables. Includes installation of racks and cables.
1.6.04.02.02	CXI H5 Workstation This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the workstations for the instrument control and monitoring.
1.6.04.02.03	CXI H5 Beam Line Processor

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	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the exchange of 120-Hz beam line data. Includes VME crate and its IO controller CPU plus a timing system interface board.
1.6.04.02.04	CXI H5 Channel Access Gateway This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the EPICS channel access gateway. Includes work-station to run channel access gateway software.
1.6.04.02.05	CXI H5 MPS This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the interface to the XES common machine protection system. Includes purchase and installation of LCLS common link-nodes and switches.
1.6.04.03	CXI H5 Specific Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the individual section of the instrument to be controlled and read out.
1.6.04.03.01	CXI H5 Data Acquisition (DAQ) This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the acquisition of data from the instrument. Included is the detector pixel read out specific to this instrument.
1.6.04.03.02	CXI H5 DAQ Hutch Data Management This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the transport and management of the control and event data in the hutch.
1.6.04.03.03	CXI H5 Experiment Configuration Control This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the configuration control of the instrument. Included are VME crates, switches, and terminal servers. Selected EPICS screens to interface to the users.
1.6.04.03.04	CXI H5 Valve Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the valves. Solenoid drivers and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.05	CXI H5 Vacuum Controls

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control and measurement of the vacuum for the instrument. Included are pump controllers, gauge controllers, and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.06	CXI H5 Pop-In Profile Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in profile monitors for the instrument. Included are CPU's, camera control and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.07	CXI H5 Pop-In Intensity Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in intensity monitors for the instrument. Included are CPU's, analog signal digitization and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.08	CXI H5 Intensity-Position Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the intensity position monitor. Included are stepper motor control, linear encoder readout, and analog-to-digital converter hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.09	<i>reserved</i>
1.6.04.03.10	CXI H5 Slit Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the slit control. Included are stepper motor control, encoder readout, and VME hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.11	CXI H5 Attenuator Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the attenuators. Included are pneumatic actuator control, status readout, and VME hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.04.03.12	CXI H5 Pulse Picker Controls

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pulse picker. Included are hardware and software. Basically needs timing signal synchronized with the machine and stepper motor control, limit switch readback and vision camera control and readout.
1.6.04.03.13	CXI H5 KB Mirror Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the mirrors. Included are stepper motor control, status readout, and associated VME hardware and software.
1.6.04.03.14	CXI H5 Sample Environment Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the sampling environment. Essentially vacuum and non-vacuum motor control, limit switch readback, and position readback plus several vision camera controllers. Hardware and software effort is included.
1.6.04.03.15	CXI H5 Particle Injector Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of particle injector. Motor control, limit switch readback, and position readback plus high-speed waveform sampling modules. Hardware and software effort is included.
1.6.04.03.16	CXI H5 Ion TOF Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the ion time-of-flight control and readout. Provided is hardware and software to set and readback bias voltages, pulsed high-voltages, and analog waveform sampling. VME and cPCI hardware is included.
1.6.04.03.17	<i>reserved</i>
1.6.04.03.18	CXI H5 Vision Camera Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the viewing via vision cameras. Commercial camera controller interfaces are provided, hardware and software.
1.6.04.03.19	CXI H5 Detector Stage Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the motion control of the detector stage. Stepper motor control, limit-switch readback, and encoder readback as well as photo-diode signal digitization is provided.

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1.6.04.03.20	<i>reserved</i>
1.6.04.03.21	<i>reserved</i>
1.6.04.03.22	<i>reserved</i>
1.6.04.03.23	<i>reserved</i>
1.6.04.03.24	<p>CXI H5 Reference Laser Controls</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the reference laser. Pico motor control and readback is provided.</p>
1.6.04.03.25	<i>reserved</i>
1.6.04.03.26	<p>CXI Controls System Integration Test</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the system integration effort and associated testing.</p>
1.6.05	<p>X-ray Correlation Spectroscopy (XCS) Hutch 4 (FEH)</p> <p>This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the XCS Spectroscopy Hutch 4 (FEH).</p>
1.6.05.01	<p>XCS H4 Requirements, Design, Setup</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with deriving and documenting requirements for the XCS controls and data systems. Includes preparation for and holding the preliminary design review. Test setups to explore potential controller types are assembled and tested. Test software is developed.</p>
1.6.05.01.01	<p>XCS H4 Requirements, Design</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the deriving and documenting requirements for the XCS controls and data systems. Includes preparation for and holding the preliminary design review.</p>
1.6.05.01.02	<p>XCS H4 Development Test Setup</p> <p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the test setups to explore potential controller types are their assembly and testing. Test software is developed.</p>
1.6.05.02	<p>XCS H4 Standard Hutch Controls</p>

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with experiment specific workstation, beam line processor, the channel access gateway, and the machine protection system.
1.6.05.02.01	XCS H4 Cables & Racks This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the instruments specific racks and cabling. Essentially the hutch racks and cables. Includes installation of racks and cables.
1.6.05.02.02	XCS H4 Workstation This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the workstations for the instrument control and monitoring.
1.6.05.02.03	XCS H4 Beam Line Processor This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the exchange of 120-Hz beam line data. Includes VME crate and its IO controller CPU plus a timing system interface board.
1.6.05.02.04	XCS H4 Channel Access Gateway This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the EPICS channel access gateway. Includes work-station to run channel access gateway software.
1.6.05.02.05	XCS H4 MPS This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the interface to the XES common machine protection system. Includes purchase and installation of LCLS common link-nodes and switches.
1.6.05.03	XCS H4 Specific Controls This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the XCS Specific Controls.
1.6.05.03.01	XCS H4 Data Acquisition (DAQ) This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the acquisition of data from the instrument. Included is the detector pixel read out specific to this instrument.
1.6.05.03.02	XCS H4 DAQ Hutch Data Management

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the transport and management of the control and event data in the hutch.
1.6.05.03.03	XCS H4 Experiment Configuration Control This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the configuration control of the instrument. Included are VME crates, switches, and terminal servers. Selected EPICS screens to interface to the users.
1.6.05.03.04	XCS H4 Valve Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the valves. Solenoid drivers and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.05	XCS H4 Vacuum Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control and measurement of the vacuum for the instrument. Included are pump controllers, gauge controllers, and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.06	XCS H4 Pop-In Profile Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in profile monitors for the instrument. Included are CPU's, camera control and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.07	XCS H4 Pop-In Intensity Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in intensity monitors for the instrument. Included are CPU's, analog signal digitization and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.08	XCS H4 Intensity-Position Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the intensity position monitor. Included are stepper motor control, linear encoder readout, and analog-to-digital converter hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.09	XCS H4 Slit Controls

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WBS	Definition
	This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the slit control. Included are stepper motor control, encoder readout, and VME hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.10	XCS H4 Attenuator Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the attenuators. Included are pneumatic actuator control, status readout, and VME hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.03.11	XCS H4 Harmonic Rejection Mirrors Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the harmonic rejection mirrors. Included are stepper motor control and encoder readout plus associated VME hardware and software.
1.6.05.03.12	XCS H4 2D Detector Motion Camera Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the movement of the @D detector cameras. Vacuum motor control and readback as well as vision cameras are included here. Note that the detector configuration and readout itself is under Data-acquisition 1.6.5.1.
1.6.05.03.13	XCS H4 Diffractometer Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the diffractometer. Motion control and position readback is provided.
1.6.05.03.14	XCS H4 Large Angle Detector Stage Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the detector stage. Included are vacuum stepper motor control and encoder readout plus associated VME hardware and software.
1.6.05.03.15	<i>reserved</i>
1.6.05.03.16	XCS H4 Controls System Integration Test This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the system integration effort and associated testing.
1.6.05.04	XCS Beam Transport to FEH

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WBS	Definition
	This cell of the WBS is a summary of the engineering, design, procurement, and fabrication and component installation efforts associated with the Beam Transport to FEH.
1.6.05.04.01	XCS BT to FEH Valve Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control of the valves. Solenoid drivers and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.04.02	XCS BT to FEH Vacuum Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the control and measurement of the vacuum for the instrument. Included are pump controllers, gauge controllers, and VME interface hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.04.03	XCS BT to FEH Pop-In Profile Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in profile monitors for the instrument. Included are CPU's, camera control and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.04.04	XCS BT to FEH Pop-In Intensity Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the pop-in intensity monitors for the instrument. Included are CPU's, analog signal digitization and readout hardware and software, and pneumatic actuator controllers. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.04.05	XCS BT to FEH Intensity-Position Monitor Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the intensity position monitor. Included are stepper motor control, linear encoder readout, and analog-to-digital converter hardware and software. Main development effort is under XPP and only incremental effort is included under this WBS. Main development effort is under XPP and only incremental effort is included under this WBS.
1.6.05.04.06	XCS BT to FEH Monochromator Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the monochromator.
1.6.05.04.07	XCS BT to FEH X-Ray Focusing Lens Controls

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WBS	Definition
	<p>This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the focusing lens control. Vacuum motion controllers and readback modules including limit switch readback is provided.</p>
1.6.05.04.08	<p>XCS BT to FEH Split and Delay Controls This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the split-and-delay unit. Assumption is that controller is part of the instrument deliverable and only integration into LCLS system is provided under this WBS. Ethernet or serial connection.</p>
1.6.05.04.09	<p>XCS Beam Transport to FEH System Integration Test This cell of the WBS identifies all required engineering, design, procurement, and fabrication and component installation efforts associated with the system integration effort and associated testing.</p>
1.6.06	<p>Offline Data Management This cell of the WBS is a summary of the engineering, design, procurement, and fabrication efforts associated with the Offline Data Management.</p>
1.6.06.01	<p>Data Format and API This cell of the WBS identifies all required engineering, design efforts to arrive at the appropriate data formats and application program interfaces for the LUSI instruments.</p>
1.6.06.02	<p>Data Catalog / Metadata Management This cell of the WBS identifies all required engineering, design effort to arrive at the appropriate data catalog for LUSI data and how to manage the meta data.</p>
1.6.06.03	<p>Processing Framework / Workflow / Pipeline This cell of the WBS identifies all required engineering, design effort to arrive at the appropriate framework to process LUSI data and how the workflow and data pipeline is constructed.</p>