WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04				UNDULATOR SYSTEM	The LCLS Undulator System Project Costs, including undulator magnets and supports, undulator diagnostics, vacuum systems, and controls for the undulator equipment are included herein. Integration and installation are also included within this area. Total cost for the LCLS undulator system planning, project management, design, construction, and installation are summed at this level.
1	04	01			Undulator System Management & Integration	All project management and engineering integration oversight is covered by this element. Total cost of all project management and project integration tasks required to design, construct, test and install an operationally complete undulator system for the LCLS: Undulator System Management; ANL Project Support; Undulator System M&S – General; Undulator System Reviews and Workshops.
1	04	01	01		Undulator System Management	Oversee project management details and delivery of a completely operational undulator system for the LCLS. This section includes all project management and project integration tasks required to design, construct, test and install an operationally complete undulator system for the LCLS: Undulator System Management-Technical; ANL Project Support-General.
1	04	01	01	01	Undulator System Management - Technical	Oversee the technical project management details and delivery of a completely operational undulator system for the LCLS. Technical management and oversight cost of all project management and project integration tasks required to design, construct, test and install an operationally complete undulator system for the LCLS.
1	04	01	01	02	ANL Project Support	Provide all necessary administrative, PMCS, budget, schedule, and contract monitoring, website and other basic sundry support required for the delivery of a completely operational undulator system for the LCLS. This section includes direct and indirect ANL LCLS project support costs required to design, construct, test, and install an operationally complete undulator system for the LCLS.
1	04	01	02		Undulator System Materials & Supplies	This section covers the total M&S cost of the ANL LCLS project office required during the design, construction, testing and installation of an operationally complete undulator system for the LCLS.
1	04	01	02	01	Undulator System M&S - General	Basic M&S cost excluding travel of the ANL LCLS project office required during the design, construction, testing and installation of an operationally complete undulator system for the LCLS: Office supplies and miscellaneous materials; Tele/video conferencing; CPUs and Software; Shipping and Storage.
1	04	01	02	02	Undulator System Travel	Basic M&S cost of travel for the ANL LCLS project required during the design, construction, testing and installation of an operationally complete undulator system for the LCLS.
1	04	01	03		Undulator System Reviews and Workshops	This section provides the necessary support for all reviews of the undulator system or required workshops. It includes all costs required to cover all semiannual reviews and occasional workshops focused on the needs of the LCLS undulator system: Organization and management of all LCLS undulator system reviews and related workshops; Travel for reviewers or necessary workshop attendees; Miscellaneous items required during the reviews and workshops.
1	04	02			Controls	Overall undulator controls task covers all controls issues involved with the LCLS undulator. This includes the costs involved with the entire controls section of the LCLS undulator. It also consists of the specification, design, procurement, assembly and testing of all controls components of the LCLS undulator.
1	04	02	01		Controls Management & Integration	Cost tracking for management issues within the undulator controls section, including controls management and integration with SLAC. Specifically the subsystems which must communicate with the SLAC control system.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	02	01	03	Software Interface with SLAC	This is the Cost Center for the software design effort required for high-level control applications which will interface with the SLAC control system. Includes commercial software required for design and implementation of these applications. The high level software is that which the operators and scientists in charge of the LCLS use to interact with the undulators. By necessity, this software must function in a dual control system environment (LCLS and SLAC).
1	04	02	01	04	General Rack and Cable Layout Plan	This is the Cost Center for the design effort required to generate a plan for the equipment location, layout and distribution within the undulator hall. All components connected via cable to equipment located in racks must be accounted for, and estimates on cable lengths and locations will be made.
1	04	02	02		Motion	This element tracks any controls effort and materials for motion within the LCLS undulator hall. This consists of all controls effort and materials required to control motion based component within the LCLS undulator.
1	04	02	02	01	Fine Motion	This element covers effort and materials for the multiple motion platforms that require accurate (with feedback) positioning.
1	04	02	02	02	Motion Test Stand	In order to test certain controls aspect of the undulator motion, a test stand will be assembled to evaluate a variety of motion parameters. This cost center will cover the design and procurement of these components.
1	04	02	02	06	Scanning WIre Motion	The motion of the scanning wire element is contained within this element. This covers the controls effort and costs involved in the motion of the scanning wire transducer.
1	04	02	02	07	Macroscopic Motion	This section is the total center for macroscopic motion controls effort and equipment. Macroscopic motion is defined as any motion requirement that does not need positional feedback for operation. Currently it includes the diagnostic "elevator" and OTR camera controls.
1	04	02	03		Signal Analysis	This element includes all signal analysis done for data acquisition and beam analysis within the LCLS undulator. All signal acquisition hardware and software for signal analysis is included in this element. Effort for data analysis and control is also included.
1	04	02	03	01	RFBPM	This element consists of the hardware and software required to interface the RFBPM units to the control system. All hardware and software required for interfacing the RFBPM units to the control system is included within this element. This includes the timing interface, signal acquisition and control software.
1	04	02	03	02	Charge Monitor (CM)	This element consists of effort involved in interfacing the charge monitors into the undulator control system. All effort involved in the interfacing of the charge monitor into the undulator control system will be tracked in this element.
1	04	02	03	03	Scanning Wire	This covers the integration of the scanning wire transducer into the undulator control system. All effort involved in interfacing the scanning wire transducer into the undulator control system will be tracked in this element.
1	04	02	04		Video	All video requirements for the undulator control system. Any effort or materials required for video signal acquisition, routing and analysis are tracked within this element.
1	04	02	04	01	OTR Monitor	All video requirements needed for the OTR Monitor. Any video requirements for use of the OTR diagnostic within the LCLS undulator will be tracked in this element. The OTR diagnostic uses image capture (via video cameras) and data analysis to characterize the beam (size, position, shape) in real time.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	02	04	03	Observation Station Video	This element consists of all controls responsibilities for the observation stations. All control effort for the observation video stations will be tracked in this element. Also, the video multiplexing system will be tracked here.
1	04	02	05		Data Acquisition & Control	This element covers the various I/O that is not covered in previous elements but is a part of the control system. In general the costs underneath this section are effort only. If hardware is required, it is typically for reading of discrete signals. This consists of the specification and integration of general signals into the control system.
1	04	02	05	01	Strongback Temperature Monitoring	Consists of the software required to communicate to the strongback temperature probes. The costs cover the effort involved in interfacing the strongback temperature monitoring equipment to the undulator control system. This consists mainly of effort involved in creating software to talk to the temperature equipment.
1	04	02	06		Vacuum	This is the overall element covering any controls tasks involved in interfacing the vacuum equipment. This is a parent to the other (specific) vacuum controls tasks. It consists of software effort to interface commercial vacuum components.
1	04	02	06	01	Ion Pump Controller	Integration of the ion pump controllers into the undulator control system (UCS). The costs cover the software design and effort for integrating the ion pump controllers to be used within the undulator hall. Readback and control of the ion pump controllers via dedicated communications cables.
1	04	02	06	02	RGA	Integration of the residual gas analyzer controllers into the undulator control system. The costs cover the software design and effort for integrating the residual gas analyzers to be used within the undulator hall.
1	04	02	07		Machine Protection	All MPS components and effort will fall under this category. The MPS system is responsible for protecting the undulator hall from equipment damage. It must interface to the SLAC injector to cause a beam abort in event of a failure.
1	04	02	07	01	Undulator Global MPS	This element covers the design of necessary components and the interface effort for commercial products into the machine protection system. This includes any custom hardware required and the interface effort for equipment.
1	04	02	07	02	Cherenkov Detector	All effort and materials devoted to the MPS portion of the Cerenkov detector will be tracked within this element. The Cerenkov detector generates a signal which must be processed to interface to the machine protection system.
1	04	02	07	03	Gamma Ray Detector	All effort and materials devoted to the MPS portion of the gamma-ray detector will be tracked within this element. The gamma-ray detector generates a signal which must be processed to interface to the machine protection system.
1	04	02	08		Power Supply Controls	This element covers design of the power supply controls software, documentation, construction of the computer interface, and integration.
1	04	03			Undulator Magnet & Support	The LCLS undulator magnets and supports, including integration and installation are included within this area.
1	04	03	01		Undulator Magnet & Support-Mgmt & Integration	Management and integration of the undulator design, construction, installation, and commissioning efforts.
1	04	03	02		First Prototype Undulator & Mfg Plan	This section covers the design, construction, testing, and modification of a full-scale prototype undulator magnetic structure. Reviews and reporting efforts are included within this area. A plan for acquiring the LCLS production undulators is to be developed.
1	04	03	03		1st Article Undulators & Long Lead Procurements	Procurement of the long lead items, Titanium Strongbacks, Magnet Blocks, and Magnet Poles is in this area. The first articles from each vendor of the production undulators are also contained herein.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	03	03	01	Ti Strongback (LLP)	Procurement of Long Lead Items: Titanium Strongbacks. This covers the labor and materials for 33 production devices. Additionally, there are 7 operational spares, located in WBS 2.4.3.3.1. This cost includes effort for design, procurement, testing and receiving of these units.
1	04	03	03	02	Magnet Blocks (LLP)	Magnet blocks for the 33 installed undulators, plus 5% extra construction/assembly spares. Blocks for the 7 operational spare undulators are located in WBS 2.4.3.3.2. This covers the labor and materials for enough magnet blocks to fabricate 33 production undulators, and includes 5% spares to cover those that are likely to be broken during assembly. Additionally, there are enough blocks for 7 operational spare undulators, without the 5% spare count, located in WBS 2.4.3.3.2. This cost includes effort for design, procurement, testing and receiving of these units.
1	04	03	03	03	Magnet Poles (LLP)	Magnet poles for the 33 installed undulators, plus 5% extra construction/assembly spares. Poles for the 7 operational spare undulators are located in WBS 2.4.3.3.3
1	04	03	03	04	Magnet Assembly & Supports - 1st Articles	Assembly of the first article undulators from each vendor is included within this WBS area.
1	04	03	03	05	Magnetic Measurement (ANL or SLAC)	Magnet Assembly and Supports – Assembly of 31 Production Undulators and Supports (Assembly of the 7 operational Spare Units is listed under WBS 2.4.3.4.1).
1	04	03	03	06	Integrated Single Und Module Test	This WBS includes preparation for and execution of a single-undulator module test at ANL.
1	04	03	04		Production Undulator Mag Assy & Supports	Procurement, magnetic measurement, and tuning are included in this area.
1	04	03	04	01	Prod Undulator Assy - Vendor A	Magnet Assembly and Supports – Assembly of 31 Production Undulators and Supports (Assembly of the 7 operational Spare Units is listed under WBS 2.4.3.4.1).
1	04	03	04	02	Prod Undulator Assy - Vendor B	Assembly by Vendor B of 19 production undulators is included in this WBS.
1	04	03	04	03	Prod Support/Mover Fab/Assy	This WBS area contains the fabrication and assembly of 38 support/mover systems.
1	04	03	05		Quadrupole Focusing Magnets	Focusing Magnets – 34 quadrupole magnets and supports; 4 spares are in 2.4.3.5.
1	04	03	05	01	Quadrupole Magnets	Focusing magnets – 34 quadrupole magnets and supports; 4 spares are in 2.4.3.5.1
1	04	03	05	03	Quadrupole Stages & Stands	Design and fabrication of the stages and stands that support the quadrupole magnet on the cradle and allow it to be mechanically positioned for initial alignment are included herein.
1	04	03	05	04	Quadrupole Cables	All power and controls cables for the installed quadrupole magnets are included herein.
1	04	03	06		Undulator Magnetic Measurement Facility (SLAC)	This element covers setup of the MMF at SLAC, magnetic measurements and fiducialization of the undulator system components, and monitoring of the installed undulator system.
1	04	03	06	01	Undulator MMF Setup	This element covers design and construction of the undulator test stand and test stand prototype, fiducialization method for all magnetic devices, calibration system for magnetic instruments, and undulator handling.
1	04	03	06	02	Fiducialization and Magnetic Measurements	The magnetic properties of all beam-steering components are measured using the LCLS Magnetic Measurements Facility. Additionally, the magnetic axes of these components are referenced to mechanical fiducials used for alignment.
1	04	03	06	03	Undulator Monitoring	This element covers design and construction of the stretched wire monitoring system, the hydrostatic leveling system, and measurement of the BPMs.
1	04	03	08		Fixed Supports	This system provides an ultra-stable non-adjustable support platform for the majority of the undulator system components.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	03	08	01	Project Management	This section covers the effort to organize the design, fabrication/procurement and installation and test of the system, and report to the undulator system manager.
1	04	03	08	02	Fixed Support Design	All design work for this system is put in this WBS category.
1	04	03	08	03	Stabilized Girder Assemblies	Long insulated granite beams, joined together in the tunnel. This is the primary piece of fixed support system.
1	04	03	08	04	Thermal Intercept System	This section covers the costs of the system that surrounds the girder insulation and intercepts heat from the environment and sends it to chilled water.
1	04	03	08	05	Thermometry	This category refers to thermometry monitoring the temperature of parts of the girder. It does not cover the costs for the system used for the control of the thermal intercept water.
1	04	03	08	06	Kinematic Girder Support	This element covers the cost of a rolling support for the girder that is kinematic and low friction.
1	04	03	08	07	Earthquake Bracing	Welded assemblies bolted or built into the floor that limit the motion of the girder in the event of an earthquake, but do not touch the girder otherwise.
1	04	03	08	08	Controls & Software	The cost of controls to read the temperature, and valve position data and present the data to the SLC control system. This software calculates the changes in girder positions and implied changes in bpm, quad, and undulator positions, by taking data from the HLS and WAS systems.
1	04	04			Vacuum System	This is the Total Center for Vacuum System in the Undulator System to deliver a functional vacuum system for the Undulator System within LCLS. The Vacuum System and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing. This center includes all vacuum components from the upstream treaty valve to the downstream treaty valve.
1	04	04	02		Undulator Vacuum Chamber Assembly	Total Center for Undulator Chamber Assembly in the Vacuum System in the Undulator System. The Undulator Vacuum Chamber is an assembly that resides within the Undulator Magnet. It is designed to contain the electron beam and the produced x-ray beam under vacuum within its walls with little interaction to the beam. Undulator Vacuum Chamber Assembly and related equipment includes the effort required for procuring the technical equipment, including specification review, design, oversight of the bid process, issue of purchase requests, and billing.
1	04	04	02	01	Prototype Chamber Weldment	Total cost of (2) Prototype Undulator Vacuum Chambers that includes: design, procurement, quality assurance, and testing. This element includes material and labor charges. Prototype Chamber Weldment and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing. The (2) prototypes will be used to qualify both the design and the materials selection for the Production Vacuum Chamber.
1	04	04	02	02	Production Chamber Weldment	Total cost of (34) Production Undulator Vacuum Chambers including: design, procurement, quality assurance, and testing. This element includes material and labor charges. Production Chamber Weldment and related equipment includes the effort required for procuring the technical equipment, including specification review, design, oversight of the bid process, issue of purchase requests, and billing. The chambers will be in a state ready for installation when they are shipped from ANL to SLAC.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	04	02	03	Prototype Aluminum Chamber	Total cost of (2) Prototype Aluminum Chambers that includes: design, procurement, quality assurance, and testing. This element includes material and labor charges. Prototype Aluminum Chamber and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing. The (2) prototypes will be used to qualify both the design and the materials selection for the Production Vacuum Chamber.
1	04	04	03		Beam-line Bellows Module Assembly	Total Center for Bellows Assembly in the Vacuum System in the Undulator System. The Beam-line Bellows are placed in the spaces between the undulators. The Bellows assembly contains both a barrier for vacuum and a liner (channel) for the beam to follow. Beam-line Bellows Module Assembly and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing.
1	04	04	03	01	Prototype Bellows Module	Total cost of (3) Prototype Bellows Modules including: design, procurement, quality assurance, and testing. This element includes material and labor charges. The (3) prototypes will be used to qualify both the design and the materials selection for the Production Bellows Module.
1	04	04	03	02	Production Bellows Module	Total cost of (47) Production Bellows Modules including: design, procurement, quality assurance, and testing. This element includes material and labor charges. The (47) Production Bellows Modules will be used in the Short and Long Diagnostics Breaks along with the Entrance and Exit Sections.
1	04	04	05		Short Diagnostic Break (SDB) Assembly	Total Center for (23) Short Diagnostic Break Assembly in the Vacuum System in the Undulator System. This center includes: design, procurement, quality assurance, and testing. This element includes material and labor charges. The Short Diagnostics Break is that set of vacuum components that reside within the smaller breaks between the undulator magnets. This is also the assembly that includes both diagnostics devices and vacuum components, although the costing of these items will be found in other places in the WBS.
1	04	04	06		Long Diagnostic Break (LDB) Assembly	Total Center for (11) Long Diagnostic Break Assembly in the Vacuum System in the Undulator System. The Long Diagnostics Break is that set of vacuum components that reside within the larger breaks between the undulator magnets.
1	04	04	07		Entrance Section Assembly	Total Center for (1) Entrance Section Assembly in the Vacuum System in the Undulator System. The Entrance Section Assembly is composed of diagnostic devices and vacuum components that reside in the area that starts at the upstream treaty valve and ends at the first undulator.
1	04	04	08		Exit Section Assembly	Total Center for (1) Exit Section Assembly in the Vacuum System in the Undulator System. The Exit Section Assembly is composed of diagnostic devices and vacuum components that reside in the area that starts at the end of the undulator to the downstream treaty valve.
1	04	04	09		Baking System	Total Center for Baking System in the Vacuum System in the Undulator System. This element covers the labor and materials for the baking system for vacuum components going into the undulator vacuum system. This includes effort for design, procurement, and receiving of these units. Baking System and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing.
1	04	05			Diagnostics	Deliver a functional Diagnostics for the Undulator System within LCLS. This center includes all diagnostics devices from the upstream treaty valve to the downstream treaty valve.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	05	02		E-Beam and X-Ray Profile Diagnostics	Total Center for the E-Beam and X-Ray Diagnostics for the Undulator System. This element covers the labor and materials for this center. This includes effort for design, procurement, testing and receiving of the units. This center contains the intra-undulator diagnostics that reside within the diagnostics station that are placed in the (11) Long Diagnostics Breaks.
1	04	05	02	01	EBXPD Test Station	This element covers the labor and materials for making the (1) EBXPD Test Station. This includes effort for design, procurement, testing and receiving of this unit. The Test Station will be used along with the prototypes of the scanning wire, OTR, x-ray imaging, x-ray intensity, and monochromator to test the sub-systems in a beam line.
1	04	05	02	02	EBXPD Vacuum Chamber	This element covers the labor and materials for the group of (11) production vacuum chambers. This includes effort for design, procurement, testing and receiving of the units. The EBXPD Vacuum Chamber is the housing where the production type EBXPD Diagnostics are contained.
1	04	05	02	03	Positioning Mechanism	The Positioning Mechanism is a device for moving from one diagnostic device to another within the EBXPD Diagnostics Station. This cost element covers the labor and materials for prototype related work and the group of (11) production devices. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	02	04	Scanning wire assembly (EBXPD-SWA)	The Scanning Wire, also called wire scanner, will be used to measure the overlap of the electron beam and the x-ray beam.
1	04	05	02	05	Optical transition radiation imaging assembly	The OTR is used to produce an image of the electron beam to characterize its size and shape, this is needed for beam tuning purposes. This element covers the labor and materials for prototype related work and the group of (11) production devices. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	02	09	ULD Design & Integration	This element represents the integration of the subsystems, like OTR and scanning wire, into the EBXPD station. There will be (11) EBXPD Stations produced for the LCLS Undulator System and this unit cover the integration of the sub-systems into the station. The element includes design, procurement, quality assurance, lab testing, and shipment to SLAC.
1	04	05	04		End-of-Undulator(EOU) X-ray and Profile diagnost	The End of Undulator Diagnostics is an important area where studies and simulations are being conducted to best utilize the area. Total Center for the End-of-Undulator Diagnostics for the Undulator System. There will be just a single suite of EOU diagnostics.
1	04	05	04	01	Prototype Construction and Testing	This element covers the labor and materials for the fixtures related to testing the (1) EOU prototype. This includes effort for design, procurement, testing and receiving of the fixtures and test pieces for the EOU prototype test.
1	04	05	04	02	Bunch Length Monitor-Streak Camera (BLM)	The Bunch Length Monitor will take the form of a streak camera that will measure the length of the generated x-ray pulse. This element covers the labor and materials for prototype related work and a single (1) production device. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	04	03	Upstream corrector / separator	These are magnets used to separate the electron beam from the x-ray beam by a small magnetic bump. This element covers the labor and materials for prototype related work and a single (1) production device. This includes effort for design, procurement, testing and receiving of the units.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	05	04	04	Optical Diffraction radiation imaging assembly (	Similar to OTR, ODR is used to produce an image the electron beam to understand its size and shape, this is needed for beam tuning purposes. ODR is different from OTR in that ODR produces an image from the fringe of the beam rather than a direct beam strike onto a screen. ODR is used in higher power application than OTR. This element covers the labor and materials for prototype related work and a single (1) production device. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	04	05	X-ray High Resolution monochromator assembly (EO	The monochromator will be used to measure the x-ray strength over a narrow range of wavelengths. This element covers the labor and materials for prototype related work and a single (1) production device. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	04	06	X-ray Imaging High Resolution detector assembly	This device will be used to form an image of the generated x-ray beam to understand if there are shape changes occurring down the undulator beam line. This element covers the labor and materials for prototype related work and a single (1) production device. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	04	07	EOU Design and Integration	This element represents the integration of the subsystems, like ODR and bunch length monitor, into the EOU station. There will be (1) unit produced for the LCLS Undulator System. The element includes design, procurement, quality assurance, lab testing, and shipment to SLAC.
1	04	05	05		RFBPM	The RFBPM will be used to precisely measure the position of the electron beam in all the breaks between the undulators. Total Center for RFBPM Diagnostics for the Undulator System. This element covers the labor and materials for (3) prototypes and a group of (35) production devices. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	07		Charge Monitor (CM)	The charge monitor that is located at the end of the undulator system is used to measure the amount of charge that is in each electron beam bunch. Total Center for Charge Monitor Diagnostics for the Undulator System. This element covers the labor and materials for a group of (2) production devices. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	08		Cherenkov Detector	The Cerenkov Detector is used to measure Cerenkov radiation that is generated when the electron beam unintentionally strikes something. This is part of the machine protection system. Total Center for Cerenkov Detector Diagnostics for the Undulator System. This element covers the labor and materials for a group of (35) production devices. This includes effort for design, procurement, testing and receiving of the units.
1	04	05	09		Radiation Detection Monitor (RDM)	Radiation Detection Monitor is a gamma ray detector and is part of the machine protection system. RDM and related equipment includes the effort required for procuring the technical equipment, including specification review, oversight of the bid process, issue of purchase requests, and billing. This element covers the labor and materials for a single (1) production device. This includes effort for design, procurement, testing and receiving of this unit.
1	04	05	11		Supplemental Shielding	Total Center for the Diagnostics Supplemental Shielding for the Undulator System. This element covers the labor and materials for a group of supplemental shielding for diagnostics devices and electronics stationed in the undulator tunnel. This includes effort for design, procurement, and receiving of these units.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	04	06			Undulator System Installation and Alignment	Following beneficial occupancy of the LCLS undulator hall all technical equipment, fixed supports, undulators and quadrupole magnets, diagnostics, vacuum systems, and controls system, will be moved into the undulator hall, installed, basic checkout performed, and if required aligned to the stated position and accuracy. Total cost center for all M&S and effort, management oversight, technical and other labor, required for the LCLS undulator system installation, basic checkout, and alignment tasks.
1	04	06	01		Undulator System Installation and Alignment Inte	This WBS element covers all installation and alignment oversight and integration tasks along with their required M&S needed to support the overall installation and alignment of the LCLS undulator system at SLAC. Total cost center covering the oversight and integration oversight of all installation and alignment tasks of the LCLS undulator system; in particular, the entrance section, the exit section, and ancillary needs of the various other components are covered by this cost center.
1	04	06	01	01	Undulator System	To oversee the installation and integration of the LCLS undulator beam line system and related equipment. This includes the effort for all integration and oversight of the installation for the system from the end of the LCLS undulator entrance section to the entrance of the LCLS undulator exit section. Total cost center for the integration and installation oversight of the LCLS undulator system at SLAC. This element covers the labor for installation oversight and system integration of components in the undulator beam-line system. This includes effort from both ANL and SLAC.
1	04	06	02		Control System Installation and Alignment	The control system installation will be done as the pieces to be controlled are installed - in a phased approach. Checkout will be done when specific modules are in place and testing will be productive. All costs involved in the installation and checkout of the undulator control system will be tracked within this element.
1	04	06	04		Vacuum System Installation and Alignment	This element contains the individual effort for transporting the vacuum system into the LCLS undulator tunnel and installing the different vacuum components in the Undulator System. Installation, integration, and checkout of bellows, pumps, vacuum gauges, residual gas analyzers, pump-out valves, and gate valves will be worked on in this element. Total Center for the installation of the Vacuum System in the Undulator System at SLAC. This element covers the labor for vacuum components going into the undulator vacuum system.
1	04	06	05		Diagnostics System Installation and Alignment	This element contains the individual effort for transporting to the LCLS undulator hall installing and doing the operational checkout of the different diagnostics devices in the Undulator System. Installation, integration, and checkout of Charge Monitors, RF BPM's, EBXPD stations, Radiation Detectors, and Cerenkov Detectors will be worked on in this element. Total Center for the installation of the Undulator System Diagnostics at SLAC. This element covers the labor for the System Diagnostics for the different devices, like EBXPD station and RFBPB, going into the undulator system. This includes effort from both ANL and SLAC.
2	04				UNDULATOR SYSTEM (OPC)	The LCLS Undulator System OPC area for spares plus any R&D and commissioning for all elements including undulator magnets and supports, undulator diagnostics, vacuum systems, and controls for the undulator equipment are included herein. Total cost for the LCLS undulator system Other Project Costs (OPC) including R&D, spares, and commissioning.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
2	04	01			Undulator System Management & Integration	All LCLS Undulator Systems project management and commissioning oversight for Other Project Costs (OPC) items is covered by this element. Total cost of all project management and commissioning oversight tasks required to perform R&D, commissioning or oversight of the acquisition of spares is included in this element.
2	04	01	01		Undulator System Management & Integration	All LCLS Undulator Systems project management and commissioning oversight for Other Project Costs (OPC) items is covered by this element. Total cost of all project management and commissioning oversight tasks required to perform R&D, commissioning or oversight of the acquisition of spares is included in this element.
2	04	02			Controls	All controls related spares and OPC. Any spares purchased for controls are tracked underneath this element.
2	04	02	01		Controls Management and Integration	Management and integration tasks associated with spares and OPC. Any management effort associated with control spares and OPC will be tracked within this element.
2	04	02	07		Machine Protection	Controls spares to support the machine protection system of the LCLS undulator. Any spares required for the machine protection system of the undulator will be tracked in this element. This consists of 10% spares for all components.
2	04	03			Undulator Magnet & Support	Other Project Costs [OPC] are collected in this WBS area. This WBS area includes some management, integration, as well as the construction and assembly of spare undulators.
2	04	03	02		First Prototype Undulator & Mfg Plan	Other Project Costs [OPC] related to the undulators are collected in this WBS. Specifically, this area contains elements related to construction of the first prototype undulator and development of a manufacturing plan. Specifically, this area contains elements related to construction of the first prototype undulator and development of a manufacturing plan.
2	04	03	04		Production Undulator	This area contains elements related to construction of the Production Undulators.
2	04	03	05		Focusing Magnets	This area contains elements related to construction of the 4 spare Focusing Magnets with precision movers.
2	04	03	06		Undulator Magnetic Measurement Facility (SLAC)	This area contains elements related to construction of the Undulator Magnetic Measurement Facility [SLAC].
2	04	03	08		Fixed Supports	This area contains elements related to construction of the Fixed Supports.
2	04	04			Vacuum System	Total Center for the OPC Spares of the Undulator Vacuum System. This center includes all vacuum components from the upstream treaty valve to the downstream treaty valve.
2	04	04	02		Undulator Vacuum Chamber Assembly	Total Center for the spare Undulator Vacuum Chamber and supports for the Undulator System. This element covers the labor and materials for (7) spare chambers and (4) spare supports. This includes effort for procurement and receiving of the unit.
2	04	04	02	01	Surface Roughness Minimization	Total Center for the development of techniques for chamber fabrication. In this section there are efforts for developing the surface finish of the chamber, welding and surface finish measurement techniques These are all required before a prototype chamber can be constructed.
2	04	04	03		Beam-line Bellows Module Assembly	This element covers the labor and materials for (7) spares. This includes effort for procurement and receiving of the unit. The (7) spare Bellows Modules will be used in the Short and Long Diagnostics Breaks along with the Entrance and Exit Sections.
2	04	04	05		Short Diagnostic Break (SDB) Assembly	The SDB Assembly is composed of diagnostic devices and vacuum components that reside in the area of the short breaks between the undulators. SDB Assembly and related equipment includes the effort required for procuring the technical equipment including issuing of purchase requests and billing.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
2	04	04	06		Long Diagnostic Break (LDB) Assembly	The LDB Assembly is composed of diagnostic devices and vacuum components that reside in the area of the long breaks between the undulators. LDB Assembly and related equipment includes the effort required for procuring the technical equipment including issuing of purchase requests and billing.
2	04	04	07		Entrance Section Assembly	The Entrance Section Assembly is composed of diagnostic devices and vacuum components that reside in the area that starts at the upstream treaty valve and ends at the first undulator. Entrance Section Assembly and related equipment includes the effort required for procuring the technical equipment including issuing of purchase requests and billing.
2	04	04	08		Exit Section Assembly	The Exit Section Assembly is composed of diagnostic devices and vacuum components that reside in the area that starts at the end of the undulator to the downstream treaty valve. Exit Section Assembly and related equipment includes the effort required for procuring the technical equipment, including issuing of purchase requests and billing.
2	04	05			Diagnostics	Total Center for the OPC Spares of the Undulator System
2	04	05	02		Undulator Line Diagnostics	Total Center for spares and R&D effort in the E-Beam and X-Ray Diagnostics for the Undulator System. This center contains the intra-undulator diagnostics that reside within the diagnostics station that are placed in the Long Diagnostics Breaks.
2	04	05	03		High-Power X-Ray and Profile Diagnostics (HPD)	This contains the prototype assemblies for optical diffraction radiation diagnostics and a laser wire device for measurement of high power x-ray properties. The HPPD consist of elements that will be determined after a group study is completed in mid 2005. The HPPD at this time is made up of a number of projected types of x-ray diagnostics. The laser wire and the optical diffraction radiation are two very promising types of x-ray instrumentation. These tasks will be performed as an R&D task. Total Center for High Power Diagnostics for the Undulator System. This collection of diagnostics devices will be worked on as an R&D activity. This area provides for one prototype of each type to be built and tested.
2	04	05	04		End-of-Undulator(EOU) X-ray and Profile diagnost	This effort contains the study and a workshop to help decide what will be the best course of action to pursue for the design of x-ray instrumentation. Total Center for the R&D effort in the End-of-Undulator Diagnostics for the Undulator System. This element covers the labor for this center. This includes effort for design, procurement, testing and receiving of the units.
2	04	05	05		RFBPM	The RFBPM will be used to precisely measure the position of the electron beam in all the breaks between the undulators. Total Center for RFBPM Spares for the Undulator System. This element covers the labor and materials for (4) spares of the production devices. This includes effort for procurement and receiving of the units.
2	04	05	07		Charge Monitor (CM)	The charge monitor that is located at the end of the undulator system is used to measure the amount of charge that is in each electron beam bunch. Total Center for the spare Charge Monitor for the Undulator System. This element covers the labor and materials for (1) spare. This includes effort for procurement and receiving of the unit.
2	04	05	08		Cherenkov Detector	The Cerenkov Detector is used to measure Cerenkov radiation that is generated when the electron beam unintentionally strikes something. This is part of the machine protection system. Total Center for Cerenkov Detector Spares for the Undulator System. This element covers the labor and materials for (4) spares of the production devices. This includes effort for procurement and receiving of the units.
2	04	05	09		Radiation Detection Monitor (RDM)	This element covers the labor and materials for (1) spare. This includes effort for procurement and receiving of the unit. Total Center for the spare Radiation Detection Monitor for the Undulator System.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
2	04	06			Undulator System Commissioning	Effort support for the commissioning of the LCLS undulator system. This includes support from commissioning of the controls system, the mechanical systems, and basic beam physics support during the initial turn on and commissioning of the overall LCLS system.
2	04	06	01		Undulator System Commissioning	Effort support for the commissioning of the LCLS undulator system. This includes support from commissioning of the controls system, the mechanical systems, and basic beam physics support during the initial turn on and commissioning of the overall LCLS system.