

# Linac Coherent Light Source Monthly Report March 2008



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## Project Overview and Assessment

### Highlights:

- Cover Page (Undulator Hall looking west) – The Undulator Hall (UH) is nearing the completion of civil construction. Tunneling activities are complete and the installation of MEP (mechanical, electrical and plumbing) is underway. Beneficial Occupancy, the formal transfer of the facility from Turner Construction to SLAC, is scheduled for late May 2008.
- Phase-II of LCLS commissioning was completed at the end of March roughly five months ahead of schedule. The Phase-II commissioning was based upon a set of technical performance goals which included the RF gun through first bunch compressor chicane, but concentrated mostly on the new BC2 compressor and the bulk of the SLAC linac up to the start of the beam switchyard. Although the initial commissioning goals have been met, there is still considerable work to be done in reliability improvement, operations training, and controls software development which will continue through August 2008.
- The design of the Atomic, Molecular and Optics (AMO) instrument is in the detailing phase. Progress for this month included completion of the designs for the stand assemblies and vacuum chambers for the high field physics end-station and diagnostics chamber, gas jet, magnetic shielding and electron time-of-flight spectrometers.
- Civil construction (Turner-managed) is approximately 88% complete. About \$2,747K in Field Change Orders have been negotiated and approved, which is 4% of construction progress to date.

### Assessment and Issues:

- The March 2008 Cost Performance Report is the 49<sup>th</sup> month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$305,968K. Cost and schedule indices are 1.00 and 1.00, respectively. Civil construction is on track for its Beneficial Occupancy dates.

## Project Office and Support

### WBS 1.1, 2.1 Project Planning, Management and Administration

#### Highlights:

- LCLS Environmental, Safety & Health Status –
  - LCLS worked 299 days without a lost time injury and 26 days without an injury involving days of restricted work or job transfer. Total project hours are 1.73 M comprised of 1.27 M collaboration hours and 456 K subcontracted work hours.
  - The LCLS project DART rate for construction is currently 3.5<sup>1</sup>, as compared to the general industry rate of 3.2 and the Department of Energy rate of 0.6. The total project DART rate is 1.2; this includes construction and laboratory hours.
  - Safety Training Metrics –
    - Mandatory safety training = 95% (goal = 93%)
    - Supervisor required safety training = 94% (goal = 93%)
    - Compliance for training assessments = 98% (goal = 92%)
    - Medical exams for affected employees = 100% (goal = 90%)
  - Turner Construction –
    - Recordable Injury – A worker was in the process of installing sheet metal siding on the interior of the Near Experimental Hall roof elevator housing. The worker tripped and fell against sheet metal and cut his forearm requiring stitches. The worker was released to full duty without lost time, restriction, or transfer.
    - Water Pipe Leak – On March 20<sup>th</sup> an 8-inch domestic water line began leaking below ground near the trailer city parking lot. Once isolated the leak was abated by installing valves on either side of the suspected broken pipe. Water service was returned to ‘normal’ on March 22<sup>nd</sup>. The exact nature of the broken pipe will not be determined until after April 7<sup>th</sup> when excavation operations can proceed safely.
  
- LCLS Procurements Status –
  - The LCLS Procurement Department experienced moderate level of activity in March 2008, including new and on-going issues with the Turner subcontract, as well as issuing and negotiating several Field Change Orders (FCOs) and Change Order Requests (CORs).
  - A/E Design (Jacobs) – Agreement was reached to extend the current contract at no additional cost through March 2009 to allow sufficient time for complete of the Title 3 scope (completion of record drawings).

<sup>1</sup> The number of injuries sustained by an average work crew of 100 individuals over a year.

- Construction Procurements –
  - Field Change Orders and Change Order Requests (FCOs/CORs)–
    - A total of 272 FCOs and CORs have been settled through negotiation or agreement.
    - 117 FCOs and CORs are open in technical review, fact finding, or negotiation.
  - The PG&E gas valve lock was removed in late March and turned over to SLAC. All gas line systems were functioning normally and accepted.
  - Linac Electric Upgrade – Effort complete. Punch list items still to be completed.
  - Electrical S522 Substation Construction – SLAC continues to resolve issues concerning temporary and permanent battery power; negotiation of proposed change order requests continues.
- Technical Procurements –
  - Cable Plant Install (Phase 3) – Complete in March.
  - Cable Plant Install (Phase 4) – Notice to Proceed was issued on March 24, 2008 with a completion date of Oct. 31, 2008.
  - Cable Plant Installation (Phase 5) – Issue for Bid (IFB) was sent out in March with an award pending in April.
  - AC Power INC/PS racks IFB was sent out in March with bid due in late April.
  - LTU magnet Assembly Installation was sent out for bid in March with an award pending in April.

**Assessment and Issues:**

- None.

## Electron Beam Systems

### WBS 1.1, 1.x.2 Controls System

#### Highlights:

- Management and Safety –
  - There are no significant variances for schedule and cost.
  - The EPICS Collaboration Meeting was held in Shanghai, China last week. Sheng Peng is representing SLAC and presenting talks on LCLS Controls. The EPICS meeting is a very useful and beneficial exchange with experts in the field of accelerator control systems.
  - The Control systems database team formed to begin working on a device-oriented relational database.
  
- Preparation for BTH – NEH Installation –
  - Cable Plant Installations (Phase 4/5) are on cost and schedule. Rack loading in building 24 is ongoing. The start of long-haul cable activity is planned for the first week of April.
  - The design of the UCPS is 90% complete, however the front panel layout still needs to be addressed.
  - The test procedure for the translation stage interlocks is complete and awaiting approval.
  - Work continues on a handover plan for how SLAC (Operations) wants to receive components.
  - Production electronics and communication chassis designs are in progress with no problem for cost and schedule expected.
  - The network project plan was updated with details for each building and the rack power details were added.
  - The SOW for the fiber termination contract was submitted to SLAC Computing (SCCS).

#### Assessment and Issues:

- None.

## **WBS 1.2, 1.3, 2.2, 2.3 Injector and Linac Systems**

### **Highlights:**

- Linac-To-Undulator (LTU) Design and Procurement Progress –
  - Drilling holes for support stands in the LTU floor was completed, and 90% of the stands were installed and aligned.
  - The major magnet sub-assemblies are complete. There are still a few BPMs which remain in process.
  - All mechanical supports were pre-assembled to check for problems. All design problems are being corrected prior to installation.
  - Metrology has started the GPS observations for the vertical penetration.
  - Detail drawings were started for the heater undulator. The heater procurement and installation is being held until FY09 for funding availability. Should adequate budget become available the heater will be advanced as soon as possible.

### **Assessment and Issues:**

- 1.3 Linac SPI = 0.96 – The SPI for WBS 1.3 is 0.96. This variance is due to a delay in award of contracts for installation in the LTU area. Those contracts are now placed and the schedules are set so that this variance should correct in the coming months.

## **WBS 1.4, 2.4 Undulator System**

### **Highlights:**

- Undulator Components & System Integration –
  - The first 17 of 40 production vacuum chambers have been delivered to SLAC. The travelers, documentation and QA records of the remaining devices will be processed to allow final shipment to SLAC.
  - The first 29 of 40 production quads have now been delivered to SLAC.
  - The Beam Finder Wire units at ANL are under assembly. The wire card will be fitted at SLAC.
  - The first 20 of 40 BPM support stands have been delivered to SLAC.
- Undulator Assembly & Measurement (SLAC) –
  - CF started grinding the undulator floor to bring the high spots to the nominal height.
  - Tuned and fiducialized undulators are now being stored in a temperature controlled room.
  - Five undulator chambers were aligned and assembled onto girders without much difficulty.
  - The major undulator mechanical sub-assemblies are being completed and staged in end station “A” for installation.

### **Assessments and Issues:**

- The BPM production schedule for leak-tight housings has experienced a problem with window cracking during final brazing. Recently however, good progress was made on the window to transition braze joint leading to 13 of 13 successful tests of the windows without cracks or leaks. Eleven bodies and 55 transitions were delivered to ANL from M1. A plan and process for completing the BPM production is due next month. The delay in BPM production is responsible for the SPI of 0.99 in WBS 1.4. Now that BPM production is underway, this schedule variance will be recovered in the course of assembling complete undulator girders.
- The CPI of 0.98 for WBS 1.4, along with the CPI of 1.13 for WBS 2.4 will be largely corrected after costs of special process spares are changed to their correct accounts.



## Photon Beam Systems

### WBS 1.5, 2.5 X-ray Transport, Optics & Diagnostics (XTOD)

#### Highlights:

- Management and Safety – There are no significant variances for schedule and cost.
- XTOD Design & Production Status –
  - Mechanical & Vacuum – The seismic anchor locations in the FEE are being checked to estimate the amount of rebar that must be cut.
  - Slit – The bonded slit blocks have been mounted at LLNL. One of the blocks is suspect, since it was brazed early before a robust brazing technique was devised. Additional B<sub>4</sub>C plates have been received and more tungsten alloy ordered, so that the suspect block can soon be replaced with a properly brazed block.
  - Gas Detector - The first of the two Gas Detector assemblies has been received. The magnet coils were fit to the chambers. The chambers were electro-polished and welded after the magnets were installed. The B<sub>4</sub>C plates for the apertures have also arrived and are ready to be machined.
  - Direct Imager - The EPICS software for the Cascade 512B cameras was demonstrated at SLAC with an external trigger at 10Hz. The camera and EPICS software have been moved to LLNL.
  - Soft X-ray Offset Mirror System (SOMS) – Metrology inspection and surface verification were performed on the two SOMS mirrors delivered to LLNL at the end of February. One of the two mirrors was significantly out of specification for High and Mid Spatial Frequency Roughness. Although the X-ray optical performance at LCLS will be determined primarily by the figure, the roughness could have some effect on the adhesion quality of the B<sub>4</sub>C layer that will be applied. Therefore, after discussion with the vendor (and because the schedule will allow this extra time), both SOMS mirrors were shipped back for further work.
  - Hard X-ray Offset Mirror System (HOMS) - The Purchase Order for the HOMS mirrors has been placed. The purchase includes 2 mirrors, 1 spare mirror, 3 polished coupons, a surrogate mirror for fixturing, and metrology data.
  - Controls – All EPICS modules were successfully rebuilt and restarted at LLNL using the latest tagged versions of EPICS for photon systems which are consistent with the rest of LCLS controls.

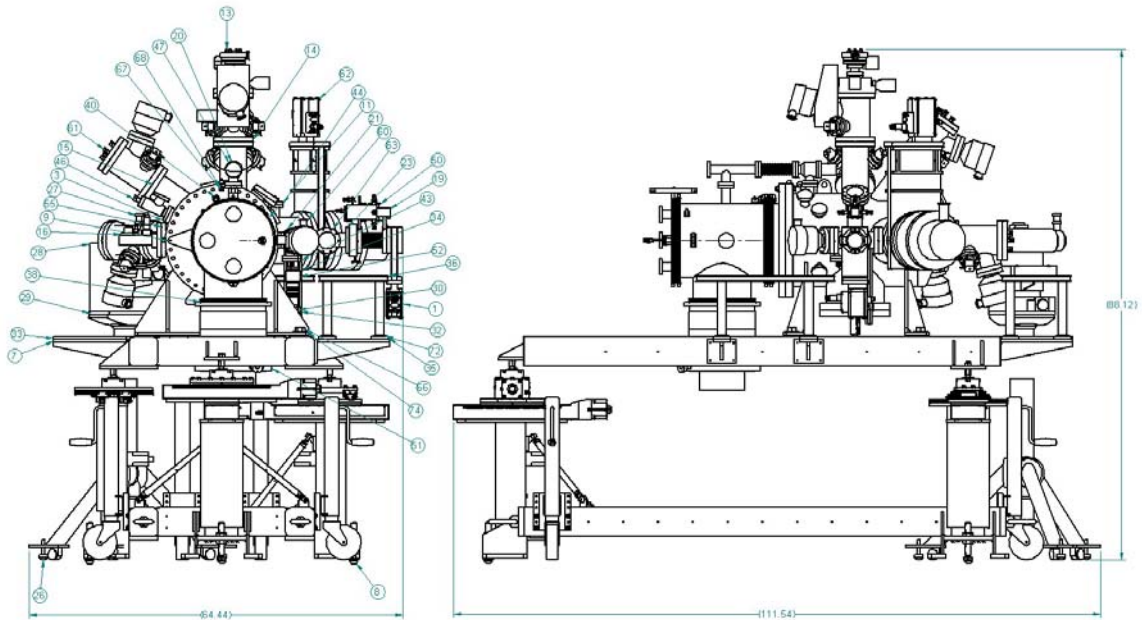
#### Assessment and Issues:

- None.

## WBS 1.6, 2.6 X-Ray Endstation Systems (XES)

### Highlights:

- Management and Safety – There are no significant variances for schedule and cost.
- Mechanical Systems –
  - Hutch stopper parts fabrication continued through March according to schedule. Commercial parts were ordered for the stoppers.
  - Hutch door parts fabrication continued through March. The lead thickness in the door plywood-lead-plywood laminated skin is 1/16 in., following Radiation Physics requirements.
- Detector Project at Cornell –
  - Testing of the bump-bonded chips is continuing. Preliminary test results have been made available for review by the LCLS Detector Advisory Committee members on a secured website. Single X-ray sensitivity of the detector was confirmed. Tests on the pixel array detector have been performed under varying conditions including flat-field illumination, pinhole array illumination, knife edge measurements, and radiation tests. Several modifications to the FPGA implementation were made to eliminate errors. Work continued on the 2x1 module packaging design.
- Atomic, Molecular and Optics (AMO) Instrument –
  - The design of the AMO instrumentation is in the detailing phase. Progress for this month included completion of the designs for the stand assemblies and vacuum chambers for the high field physics end-station and diagnostics chamber, gas jet, magnetic shielding and electron time-of-flight spectrometers. An example of the assembly drawing for the high field physics chamber is shown on the next page.



- Discussions with the controls engineers over specifications for the control system and data acquisition system continued over March and are nearing completion.
- LCLS together with the AMO team leaders have scheduled the first Proposal Preparation Workshop for AMO for June 2-3 at SLAC.
- XES Controls and Data Systems –
  - The Photon System Controls group participated in the DESY XFEL Data Acquisition Workshop. The LCLS Photon Area Controls and DAQ system were presented. XFEL liked the system and is sending several engineers to SLAC in May to learn more.
  - The PDR for the Personal Protection System Controls was held. The report is available.
  - A draft of the network security plan was created and is circulating.

#### Assessment and Issues:

- None.

## Conventional Facilities (CF)

### WBS 1.9, 2.9 Conventional Facilities (CF)



**NEH with final grading**



**FEH final liner installation of rebar**

#### Highlights:

- Construction Progress –
  - Construction is approximately 88% complete. To date, \$2,747K Field Change Orders have been negotiated and approved, which is ~4% of construction progress to date.
  - Central Utility Plant – Continued progress on seismic bracing, underground CTW piping, and interior housekeeping pads. Commencement of MEP installations, setting of switchgear and compaction and testing at exterior perimeter.
  - Beam Transport Hall - Continued progress on epoxy flooring, misc ductwork set-up of Air Handling Units for Service Buildings #2.1 and #2.2, ductwork supports, and misc mechanical connections are complete. Prep and clean sub-grade areas in RSY for final installation of grading and asphalt.
  - Near Experimental Hall - Continued progress on MEP, drywall, insulation, seismic installation, underground storm drain and domestic water in the parking lot area. Preparation of loading dock stairs, and vertical tubes for the elevator shaft. See Issues and Assessments.
  - 12 KV Substation - Energization to Substation from manhole (MH) 49 has been completed safely and as planned. Additional work in MH 55 has been completed. See Issues and Assessments.
  - Far Experimental Hall - Continued progress on underground storm sewer at manhole 9K. Install reinforcing steel FEH. Cellular concrete injection installation and cylinder testing at Access Tunnel and FEH transition. Installation of rebar for final liner continues to make good progress.

- X-Ray Tunnel - Installation of the final shotcrete liner and mud slab has been completed. Installation of rebar and concrete slab at mid section (approx 100') of tunnel has been completed. Commenced backfilling of the Adit tunnel.
- Undulator Hall Tunnel - Continued progress on fire alarm systems are nearly complete. Lighting and final grounding applications are nearly complete.

### **Issues and Assessments**

- Non-TCCo subcontractor (Palmer Electric) has commenced installation of cable plant inside of the BTH and related Service Buildings (#2.1, #2.2). This non-TCCo activity is being performed in “co-occupancy” with existing TCCo subcontractors and has progressed safely as planned.
- As previously reported the NEH roof continues to leak into the facility. A 48 hour water test has been performed per specifications and contract drawings. LCLS CF has issued a Non-Compliance Notification for corrective action/s to be provided by TCCo. TCCo will provide a response during the next reporting month. Currently this does not have any impact to the completion of the project.
- An existing Domestic Water (DW) line was ruptured. At the end of this reporting period, it was not determined what the root cause of the break in the line. The line is approximately 15' below grade and out of the immediate area where construction activity was being performed. The DW line caused minimal to very little disruption to the lab. Approximately 15,000 gallons was discharged as a result of this water break. Majority of the water was diverted into the sanitary sewer.
- The Natural Gas Line project is 100% complete and was completed safely without any injuries or incidents. This project was managed directly by the LCLS CF group. The completion of this installation allows for the start-up of the boiler unit to commence commissioning on schedule.
- 12KV Substation - Bus #1 switchgear was energized. Bus #2 of substation switchgear failed to be energized due to a problem of the Control Power Transformer in Bus #2. The Project will pursue the manufacturer to correct the device. Permanent DC Battery System to be installed at a future date.



## LCLS Cost and Schedule Performance – March 2008

LCLS Cost/Schedule Status Report									31-Mar-08	
WBS	Cumulative to Date (\$K)							Budget At Complete (\$K)	% Complete	
	Budgeted Cost		Actual Cost Work Performed	Variance		Performance Indices				
	Work Scheduled	Work Performed		Schedule	Cost	SPI	CPI			
1.1 Project Management	18,943	18,943	18,983	0	-39	1.00	1.00	22,822	83%	
1.2 Injector	20,239	20,239	20,237	0	2	1.00	1.00	20,239	100%	
1.3 Linac	24,174	23,203	23,134	-971	68	0.96	1.00	28,257	82%	
1.4 Undulator	40,116	39,610	40,258	-505	-648	0.99	0.98	45,355	87%	
1.5 X-ray Transport	20,820	20,552	21,083	-268	-531	0.99	0.97	27,494	75%	
1.6 X-ray Endstations	2,580	2,567	2,605	-13	-38	0.99	0.99	9,115	28%	
1.9 Conventional Facilities	111,763	111,444	111,196	-319	248	1.00	1.00	135,888	82%	
1.X LCLS Controls	27,023	27,668	27,543	645	126	1.02	1.00	41,369	67%	
<b>1 LCLS Total Base Cost</b>	<b>265,658</b>	<b>264,227</b>	<b>265,039</b>	<b>-1,431</b>	<b>-811</b>	<b>0.99</b>	<b>1.00</b>	<b>330,539</b>	<b>80%</b>	
							<b>LCLS Total Estimated Cost</b>		<b>352,000</b>	
							<b>Contingency</b>		<b>21,461</b>	
							<b>% Contingency on ETC</b>		<b>32.4%</b>	
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	14,616	14,616	14,609	0	7	1.00	1.00	24,246	60%	
2.2 Injector (OPC)	5,209	5,262	5,335	53	-73	1.01	0.99	5,802	91%	
2.3 Linac (OPC)	1,047	1,047	1,030	0	18	1.00	1.02	2,027	52%	
2.4 Undulator (OPC)	3,972	4,130	3,640	157	489	1.04	1.13	9,772	42%	
2.5 X-ray Transport (OPC)	1,978	1,960	1,810	-18	150	0.99	1.08	3,861	51%	
2.6 X-ray Endstations (OPC)	1,691	1,691	1,745	0	-54	1.00	0.97	8,089	21%	
2.9 Conventional Facilities (OPC)	330	325	204	-5	121	0.98	1.59	1,865	17%	
2.X LCLS Controls (OPC)	810	781	691	-30	89	0.96	1.13	2,817	28%	
<b>2 LCLS Total Other Project Cost</b>	<b>29,653</b>	<b>29,811</b>	<b>29,064</b>	<b>157</b>	<b>747</b>	<b>1.01</b>	<b>1.03</b>	<b>58,480</b>	<b>51%</b>	
							<b>LCLS Other Project Cost</b>		<b>68,000</b>	
							<b>Management Reserve</b>		<b>9,520</b>	
							<b>% Management Reserve on ETC</b>		<b>33.2%</b>	
<b>LCLS Total Project Cost</b>	<b>295,311</b>	<b>294,038</b>	<b>294,103</b>	<b>-1,273</b>	<b>-64</b>	<b>1.00</b>	<b>1.00</b>	<b>420,000</b>	<b>76%</b>	

## Cost and Schedule Performance (con't)

### Overall Cost and Schedule Assessment

<b><u>March 2008 Project Performance</u></b>	<b>AYK\$</b>
<b>Total Project Cost (TPC)</b>	<b>\$420,000</b>
% Planned (Cumulative)	75.9%
% Complete (Cumulative)	75.6%
<b>Total Estimated Cost (TEC)</b>	<b>\$352,000</b>
Cost and Commitments to Date	\$275,629
Estimate at Complete (EAC)	\$332,799
Work Remaining	\$68,571
Outstanding Phase-Funded Awards	\$21,472
Remaining Contingency Based on EAC	\$19,201
	38.2%

The LCLS cost and schedule are consistent with the approved baseline with a Total Estimated Cost (TEC) of \$352M and a Total Project Cost (TPC) of \$420M. The CD-4 milestone is July 2010. All costs are in actual-year dollars and out-year costs are escalated.

The March 2008 Cost Performance Report is the 49<sup>th</sup> month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$305,968K. Cost and schedule indices are 1.00 and 1.00, respectively. Civil construction is on track for its Beneficial Occupancy dates.

The project critical path runs through the production of FEE photon diagnostics and has 108 working days (~5 months) of float to CD-4. Near critical path activities are the SOMS Vacuum Hardware (and the assembly of the Undulator girders).

Civil construction activities are currently on its baseline schedule for Beneficial Occupancy of the BTH – NEH facilities. Early installation of technical equipment is being installed by SLAC prior to beneficial occupancy of the facilities to maintain schedule.

Overall contingency (32% on cost to go) and management reserve (33% on cost to go) are considered adequate for this stage of the project. An aggressive schedule is planned through the remainder of FY08. Contingency through FY08 remains tight and is being actively managed.

## DOE (Level 2) Milestones

Milestone	Baseline	Projected	Variance	2004		2005		2006		2007		2008		2009		2010	
				Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr
<b>Level 2 DOE (SSO) Milestones</b>	<b>Fri 8/29/08</b>	<b>Fri 2/26/10</b>	<b>368 days</b>														
Prelim Safety Assessment (PSAD) Doc Complete	Fri 4/30/04	Fri 4/30/04	0 days	●													
DOE External Independent Review (EIR) Complete	Tue 6/15/04	Tue 6/15/04	0 days	●													
Fire Hazard Analysis Approved	Thu 6/30/05	Mon 8/15/05	32 days			●	●										
Prelim Safety Assessment (PSAD) Doc Approved	Tue 2/28/06	Tue 2/28/06	0 days					●									
Delivery of Undulator 1st Articles to MMF	Mon 7/3/06	Thu 6/15/06	-12 days					●	●								
Sector 20/Alcove Beneficial Occupancy	Fri 7/21/06	Fri 4/14/06	-70 days					●	●								
MMF Qualified & Ready to Measure Prod Undulator:	Mon 8/28/06	Mon 8/28/06	0 days						●								
Research Yards Mods Beneficial Occupancy	Fri 10/20/06	Wed 8/30/06	-37 days						●	●							
Start Injector Commissioning (Drive Laser)	Mon 1/29/07	Fri 12/15/06	-22 days							●	●						
Injector Laser Commissioning Review Complete	Wed 1/31/07	Fri 12/1/06	-34 days							●	●						
Injector Accelerator Readiness Review (ARR) Comp	Wed 1/31/07	Fri 3/30/07	42 days								●						
Start Injector Commissioning(UV Beam to Cathode)	Mon 4/9/07	Thu 4/5/07	-2 days								●	●					
Linac Water/Power Available	Wed 7/11/07	Thu 3/29/07	-74 days									●	●				
Linac (Li20-Li30) Ready for Commissioning	Sat 12/1/07	Sat 12/1/07	0 days										●				
Start Installation of Undulator Facility	Fri 5/16/08	Fri 5/16/08	0 days											●			
XT Start FEE Installation	Mon 7/21/08	Mon 7/21/08	0 days											●			
BTH - UN - FEE - NEH - CUP Beneficial Occupancy	Mon 7/21/08	Mon 7/21/08	0 days											●			
Safety Analysis Document (SAD) Approved	Fri 8/29/08	Fri 8/29/08	0 days											●			
XT - FEH Beneficial Occupancy	Wed 10/22/08	Wed 10/22/08	0 days											●			
Beam Path Project Close Out	Fri 12/12/08	Fri 12/12/08	0 days											●			
LCLS ARR Complete (BTH thru FEH)	Fri 4/17/09	Fri 4/17/09	0 days											●			
Start Linac-to-Undulator (LTU) Commissioning	Mon 4/20/09	Mon 4/20/09	0 days											●			
XT Start Tunnel Installation	Wed 5/27/09	Wed 5/27/09	0 days											●			
XE Start Installation in NEH	Thu 6/4/09	Thu 6/4/09	0 days											●			
Start Undulator Commissioning (1st Light)	Mon 7/6/09	Mon 7/6/09	0 days											●			
2-D Detector Shipped to SLAC	Thu 7/30/09	Thu 7/30/09	0 days											●			
Start FEE Commissioning with Beam	Thu 8/6/09	Thu 8/6/09	0 days											●			
First X-Rays into NEH - Initiate Early Ops	Thu 9/10/09	Thu 9/10/09	0 days											●			
XE Start Installation in FEH	Thu 9/17/09	Thu 9/17/09	0 days											●			
First X-Rays into FEH	Fri 2/26/10	Fri 2/26/10	0 days												●		

Baseline (Blue Circle), Projected (Red Diamond), Actual (Green Circle Diamond)



## Glossary

**Actual Cost of Work Performed (ACWP)** – Actual cost reported through the LCLS cost accounting systems, plus any accruals, for a specific WBS#, subproject, or project.

**Budget Authority (BA)** – Cumulative funds currently allocated and authorized by the Department of Energy that may be committed and spent by LCLS for project-related activities.

**Budget at Completion (BAC)** – The total budgeted cost at completion for a given WBS, subproject, or project. BAC is the budgeted cost of the project excluding contingency.

**Budgeted Cost of Work Performed (BCWP)** – Budgeted value of planned work for a WBS#, subproject, or project physically accomplished.

**Budgeted Cost of Work Scheduled (BCWS)** – Budgeted value of planned work time-phased to the schedule for a specific WBS#, subproject, or project.

**Commitments** – Funds allocated to subcontractors where work has been authorized but not yet expensed.

**Cost Performance Index (CPI)** – The ratio of the value of the work performed to actual cost;  $CPI = BCWP/ACWP$ . Values less than 1.0 represent “cost overrun” condition, and values greater than 1.0 represent “cost underrun” condition.

**Cost Variance (CV)** – Difference between the estimated value of the physical work performed and the actual cost expended for a specific WBS#, subproject, or project.  $CV = BCWP - ACWP$ . A negative result is unfavorable and indicates the potential for a cost overrun.

**Estimate at Completion** – Forecast of the final cost for a specific WBS#, subproject, or project based on the current ACWP plus a management assessment of the cost to complete the remaining scope of work.

**Estimate to Complete (ETC)** – A realistic appraisal of the cost to complete the remaining scope of work.

**Other Project Cost (OPC)** – LCLS “supporting” costs not directly contributing to the construction project. OPC costs generally include research and development and pre-operation (start-up) activities.

**Percent Complete** – The ratio of the work accomplished (earned-value) to the Budget at Completion for any WBS#, subproject, or project.  $\% \text{ Complete} = BCWP/BAC$ .

**Percent Contingency Remaining** – The ratio of remaining contingency dollars to remaining line item (TEC) work calculated as follows: the numerator is equal to the contingency available (after consideration of the EAC) less 5% of outstanding technical phase-funded awards and less 10% of outstanding conventional facilities phase-funded awards. The denominator is the EAC less ACWP less outstanding phase-funded awards.

**Percent Planned** – The ratio of the current plan to the Budget at Completion.  $\% \text{ Planned} = BCWS/BAC$ .

**Project Engineering and Design (PED)** – Funding used to support the engineering and design effort for the LCLS.

**Schedule Performance Index (SPI)** – The ratio of the value of work performed to work scheduled,  $SPI = BCWP/BCWS$ . Values less than 1.0 represent a “behind schedule” condition, and values greater than 1.0 represent “ahead of schedule” condition.

**Schedule Variance (SV)** – Difference between the value of the physical work performed and the value of the work planned (scheduled).  $SV = BCWP - BCWS$ . A negative result is unfavorable and indicates a behind schedule condition.

**Total Estimated Cost (TEC)** – The total capital budget authorized for the LCLS project for the construction phase of the project. TEC includes contingency but does not include OPC.

**Total Project Cost (TPC)** – The total capital budget authorized for the LCLS project, including TEC and OPC.

**WBS (Work Breakdown Structure)** – A method of hierarchically numbering tasks in a traditional outline numbering format. The WBS provides a basis for the LCLS work plan which is used to track all resources, schedules, and cost