

# Linac Coherent Light Source Monthly Report October 2008



# CONTENTS

---

PROJECT OVERVIEW AND ASSESSMENT	3
TECHNICAL AND PROGRAMMATIC PROGRESS	
<u>LCLS Project Office &amp; Support</u>	
WBS 1.1, 2.1	Project Management and Administration 4
<u>Electron Beam Systems</u>	
WBS 1.1.3, 1.x.2	Global Controls 5
WBS 1.2, 2.2, 1.3, 2.3	Injector and Linac 6
WBS 1.4, 2.4	Undulator 7
<u>Photon Beam Systems</u>	
WBS 1.5, 2.5	X-Ray Transport & Diagnostics 8
WBS 1.6, 2.6	X-Ray Endstations 9
<u>Conventional Facilities</u>	
WBS 1.9, 2.9	Conventional Facilities 11
COST PERFORMANCE REPORT	
-Cost/Schedule Performance	12
-Cost/Schedule Assessment	
-Milestone Performance	
GLOSSARY	15

---

## Project Overview and Assessment

### Highlights:

- Cover Page (LCLS Undulator Hall) – The photo shows an undulator magnet (labelled “30-06”) installed on its girder in the Undulator Hall as a test of the overall integration of the undulator system. Installation of the magnet required two hours and no interferences, gaps or conflicts were identified. The magnet will be removed from its girder and transported to the Magnetic Measurement Facility to determine if there were any changes to the overall calibration of the magnet.
- LCLS technical equipment installation in the Linac-To-Undulator (LTU), Undulator Hall, and Electron Beam Dump continues to make steady progress. 95% of the drift tubes have been installed in the Beam Transport Hall (BTH), aligned and pumped down. E-dump pit steel and magnet installation are complete and awaiting checkout and testing. An Accelerator Readiness Review (ARR) is scheduled for December 2-4, 2008 in preparation for start of LTU to E-Beam Dump commissioning in early January.
- Civil Construction (Turner) Status –
  - Approximately 97% complete.
  - \$3,971K Field Change Orders have been negotiated and approved, <5% of construction cost to date.
  - A “Certificate of Substantial Completion” was achieved for the Beam Transport Hall, Undulator Hall, Electron Beam Dump, Front End Enclosure, and all Service Buildings.
  - “Certificate of Substantial Completion” for Near Experimental Hall, X-Ray Transport Tunnel and Far Experimental Hall is due in November.

### Assessment and Issues:

- The October 2008 Cost Performance Report is the 56<sup>th</sup> month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$344,317K. Cost and schedule indices are 1.00 and 0.98, respectively.
- Civil construction activities continue to lag behind the target schedule for Beneficial Occupancy of the FEH facilities. SLAC continues to install technical equipment, so as to maintain the overall schedule float to CD-4.

## Project Office and Support

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

#### Highlights:

- LCLS Environmental, Safety & Health Status –
  - LCLS has worked 146 days without a lost time injury (days away) and 60 days without a recordable injury. Total project hours are 2.045M comprised of 1.446M collaboration hours and 579K subcontracted hours. Over the past six months, LCLS safety performance has improved by nearly 70%. This was accomplished by improved work planning/control processes and an increased field presence by SLAC and DOE-SSO personnel.
  - The LCLS project DART rate for construction is currently 3.1<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; this includes construction and laboratory hours.
  - Conventional Facilities / Technical Installations / Turner Construction - Construction work associated with Conventional Facilities, Technical Systems Installations and Turner Construction is progressing adequately. Work planning and control improvements have resulted in a reduction of safety related incidents and worker injuries.
  
- LCLS Procurements Status –
  - Construction Procurements (Turner) –
    - Three modifications were issued during October (Modifications 067 for one COR for Hatch Mott MacDonald, 068 for 11 Trades in seven FCOs, and 069 additional FCO funding).
    - A total of 359 FCOs and CORs have been settled, through negotiation or agreement, with issuance of a Modification.
  - Technical Procurements –
    - XES Optical Laser Tables order placed – due mid March.
    - FEH Hutches design was awarded with a Dec, 10, 2008 completion date.
    - Grouting/Packing of beam pipe penetrations awarded in October.
    - Phase 5 Fiber Optic Termination Project complete pending final test results.

#### Assessment and Issues:

- None.

---

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

## Electron Beam Systems

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

#### Highlights:

- Management and Safety – There are no significant variances for schedule and cost.
- BTH – NEH Installation –
  - The cabling, network, and timing installation is complete.
  - The Magnet power supplies, VME crates and I/O hardware is installed. The PLC is installed and programmed. All polarity checks are complete. The connections of the Undulator magnets and 12 magnets in the LTU to power supplies are complete.
  - The Undulator motion controls and cabling are complete.
  - The Stripline BPM installation and checkout for 37 of 40 devices is complete. The Cavity BPM installation is complete for 33 of 36 devices.
  - All vacuum ion pumps and gauges are installed and operational in the LTU. All pneumatic and manual vacuum valves are connected.
  - The PPS safety PLC and the BTM interface prototypes are tested. The light contactor panels are installed and terminated. Door Switches and Magnalocks are installed. The PPS cameras are installed and configured. The BSOIC panels and the BTM stands are also installed. The hot checkout and Undulator Complex Initial Acceptance Test of the PPS was executed successfully.
  - The MPS is ready and tested for laser protection. The EPICS Database and configuration GUI is completed. The Database Documentation is also complete.
  - The Toroid software/database/screen configuration is complete. The chassis, patch panels, and short interconnect cables are installed in B911.

#### Assessment and Issues:

- None.

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

### **Highlights:**

- Linac-To-Undulator (LTU) Design, Procurement and Installation Progress –
  - The LTU installation is complete except for the Single Beam Dump and TDUND shielding which will be installed in November.
  - The permanent magnets were installed and checked out. The installation of the BYD and vacuum chambers is complete. The covers for the BYD magnets are in fabrication and will be installed in November.

### **Assessment and Issues:**

- None.

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

### **Highlights:**

- Management and Safety – The ANL management team has been focused on reorganizing the ANL effort required for completion of the LCLS Undulator project. Cost codes have been closed and staff moved from the project as activities are completed. In some areas such as controls APS needed to renegotiate terms to bring back staff to complete unfinished work (that was stopped in September due to funding issues). Documentation is being finalized by completing drawings, QA records and ASK System updates. The Technical Addendum to the Memorandum of Understanding for FY09 was completed and signed off by both ANL and SLAC.
- Undulator Components and System Integration –
  - The additional six quad spools were received at SLAC in the beginning of October.
  - The girder extension support for the first RFBPM was shipped to SLAC in early October.
  - 7 extension bellows were completed and shipped to SLAC. This completes this portion of bellows fabrication.
  - Two RFBPM spares were shipped to SLAC along with two additional RFBPM bodies. The ANL RFBPM production is now complete. Four sets of RFBPM electronics is now expected to ship in early November.
  - The 5 production BLM units are expected to be delivered to SLAC approximately November 18. This will still meet installation schedule requirements.
- Undulator Assembly and Measurement (SLAC) –
  - All girders are installed and vacuum connections made up. The checkout process will continue through November.
  - The installation of Hydrostatic Level System and the Wire Position Monitor has commenced.
  - The installation of the ANL Undulator Motion Controls continues.

### **Assessments and Issues:**

- None.

## Photon Beam Systems

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

#### Highlights:

- Management and Safety – The cumulative SPI and CPI for XTOD construction activities are 0.92 and 0.92, respectively. The significant drop in SPI from last month is due to the delay in initial installation. A plan has been formed to recoup the schedule over the next 3 months, so that the installation completion dates should not be affected.
- Mechanical and Vacuum –
  - It was found that ~14 of the 18 serial IO cards in the MKS 137 gauge controllers did not function properly. Cards were hand-carried to the MKS field office in San Jose where it was confirmed that the cards were indeed at fault. New cards were shipped to LLNL, and found to work properly. The controllers are now in their production configuration.
  - The Wall 1 Shielding design drawings were released and sent to SLAC for manufacturing. SLAC has ordered the plates, and will oversee the fabrication and install the shielding.
- XTOD Design & Production Status –
  - *K*-monochromator – Diodes by both IRD and Canberra are being considered for detection of the monochromatic X-ray signal. With proper electronics, each should be able to give intensity measurements of ~1%, as required for determining the undulator *K* with the required precision.
  - SOMS mirror #3 was measured in the metrology lab. The critical figure error (long-period roughness) and the short-period roughness meet specifications. The mid-period roughness is slightly out of spec, but this should not significantly degrade the mirror performance.
  - Hard x-ray Offset Mirror System (HOMS) – The figure error of the 4 HOMS mirrors was measured. Three meet the spec (one mirror significantly beats the spec, and two just meet it), whereas the fourth mirror does not meet the spec. This last mirror will be treated as a spare and possibly re-polished.
  - Gas/Solid/Attenuator/Detector – All pumps and valves were installed on both differential pumping sections. The triple bay vacuum rack was connected and both sections were pumped down, reaching  $8 \times 10^{-8}$  Torr after a few hours. All scroll, turbo and twin screw pumps were started and gas flow was established in the gas attenuator.

#### Assessment and Issues:

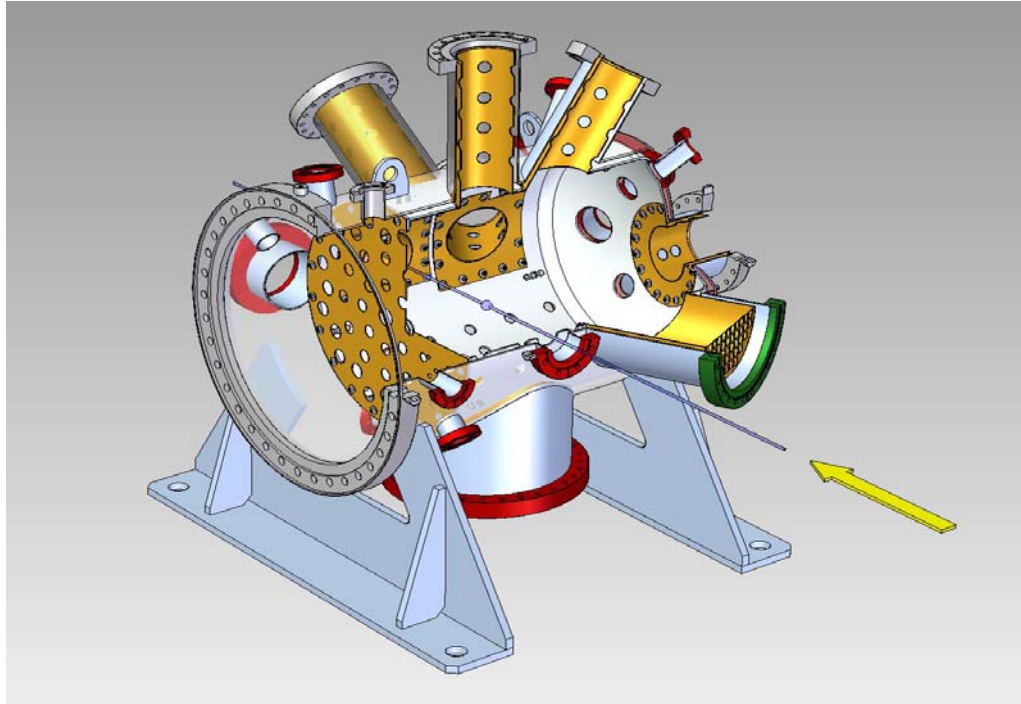
- None.



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

### Highlights:

- Management and Safety – Cost and schedule performance shows lower values than last's month: 0.85 for SPI and 0.95 for CPI. The higher variance is mainly due to the delayed completion of the AMO instrument design driven by changes to the AMO specifications resulting in additional engineering time. Milestones are not impacted but this work is being managed actively and the organization has been strengthened to manage this phase more efficiently. Variances exist also in the WBS of Controls, Laser System and Installation which are expected to be resolved over the next few months.
- Mechanical Systems –
  - The fabrication of the electron dump stoppers ST1 and ST2 was completed and both stoppers are being tested with controls. The collimator in the same area is ready for installation as well.
  - The hutch stopper actuator mechanism was corrected and design drawings have been revised to reflect this modification. Assembly is progressing with a target date for controls check out in late November and a finish date in early December.
- Detector Project at Cornell –
  - The first carrier boards have been fabricated at SLAC and shipped to Cornell University. The analog board is in fabrication.
  - Detector testing is continuing with emphasis on low flux measurements, determining the effective pixel size and edge distortions and investigation charge sharing.
  - The Cornell detector group is preparing to use the 2D-PAD in a small angle x-ray scattering experiment in December at the CHESS synchrotron source.
- XES Laser System – The purchase order contracts for the laser master oscillator and its pump laser were awarded. The kilohertz regenerative amplifier contract should be awarded in early November.
- Atomic, Molecular and Optics (AMO) Instrument – A very informative presentation on magnetic shielding principles and design was given by Larry Matlin of Amuneal Corporation. The presentation and discussion helped to finalize the design of the magnetic shielding that will be used in the AMO chambers to prevent distortion of the trajectories of charged particles due to ambient magnetic fields. A cut-away view of the magnetic shield designed for the AMO High Field Physics chamber is shown in the figure below as gold-colored material.



- XES Controls and Data Systems –
  - The MPS rack was installed in the NEH hall and DIN rail cross-connects were added. The network switch was installed in the racks and the fibers connected via the NEH server room to the Main Control Center (MCC).
  - The PPS final design review was held.

#### **Assessment and Issues:**

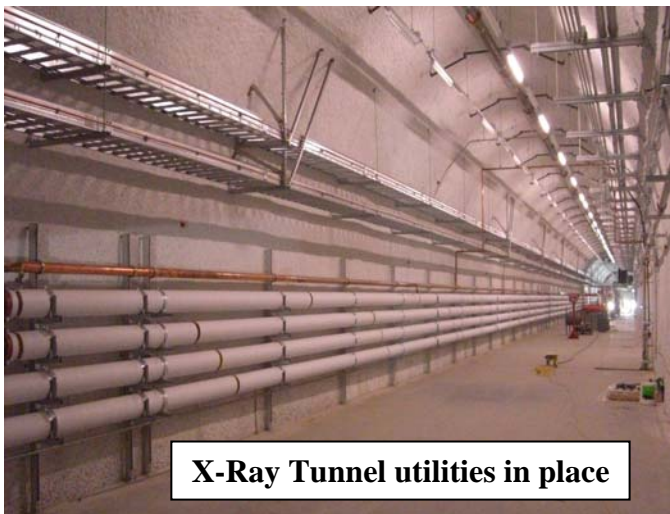
- None.

## Conventional Facilities (CF)

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



**Far Hall nearing completion**



**X-Ray Tunnel utilities in place**

#### Highlights:

- Construction Progress –
  - Construction (Turner) is >97% complete. To date, \$3,971K Field Change Orders have been negotiated and approved, <5% of construction progress to date.
  - A “Certificate of Substantial Completion” was issued to Turner Construction for the Beam Transport Hall, Undulator Hall, Electron Beam Dump, Front End Enclosure, and all Service Buildings.
  - Central Utility Plant – Final commissioning in process for preparation of transfer of ownership to SLAC Facilities.
  - Beam Transport Hall – The remaining 5% of punch-list items are in process for final completion.
  - Near Experimental Hall – The remaining 5% of punch list items are in process for final completion. Preparations are in place for upcoming elevator inspection.
  - Far Experimental Hall – Continued progress on installation of ductwork, domestic water, sanitary sewer, chilled water, compressed air, electrical feeders and branch circuits, conduits, light fixtures, HVAC controls, and Make-Up Air Unit (MAU) startup.
  - X-Ray Tunnel – Final phase for installations of fire alarm, wiring terminations and epoxy flooring.

#### Issues and Assessments

- LCLS performed an advance elevator inspection by the local State office in preparation for the upcoming final inspection. The inspector was able to identify issues that required changes to be corrected in advance of the upcoming final inspection. This elevator inspection is scheduled to be completed next month.



## LCLS Cost and Schedule Performance – October 2008

LCLS Cost/Schedule Status Report									31-Oct-08		
WBS	Cumulative to Date (\$K)								Budget At Complete (\$K)	Estimate At Complete (\$K)	Variance At Complete (\$K)
	Budgeted Cost		Actual Cost Work Performed	Variance		Performance Indices					
	Work Scheduled	Work Performed		Schedule	Cost	SPI	CPI				
1.1 Project Management	20,414	20,410	20,082	-4	327	1.00	1.02	22,897	22,324	572	
1.2 Injector	20,239	20,239	20,240	0	0	1.00	1.00	20,239	20,240	0	
1.3 Linac	27,708	27,665	27,326	-43	340	1.00	1.01	28,257	27,903	354	
1.4 Undulator	45,194	45,234	45,156	40	78	1.00	1.00	46,065	45,762	303	
1.5 X-ray Transport	24,966	22,755	24,496	-2,211	-1,741	0.91	0.93	28,134	30,214	-2,080	
1.6 X-ray Endstations	4,150	3,607	4,105	-544	-499	0.87	0.88	9,482	12,573	-3,092	
1.9 Conventional Facilities	125,588	122,848	122,564	-2,740	284	0.98	1.00	138,290	139,732	-1,442	
1.X LCLS Controls	34,466	33,859	33,633	-607	226	0.98	1.01	41,362	41,135	226	
<b>1 LCLS Total Base Cost</b>	<b>302,726</b>	<b>296,618</b>	<b>297,603</b>	<b>-6,109</b>	<b>-985</b>	<b>0.98</b>	<b>1.00</b>	<b>334,726</b>	<b>339,885</b>	<b>-5,159</b>	
<b>LCLS Total Estimated Cost</b>								<b>352,000</b>			
<b>Contingency</b>								<b>17,274</b>			
<b>% Contingency on ETC</b>								<b>45.3%</b>			
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	17,815	17,689	17,313	-126	376	0.99	1.02	24,246	24,141	105	
2.2 Injector (OPC)	5,738	5,673	6,045	-65	-372	0.99	0.94	5,789	6,269	-480	
2.3 Linac (OPC)	1,973	2,027	2,175	54	-148	1.03	0.93	2,027	2,176	-149	
2.4 Undulator (OPC)	6,613	6,100	5,903	-514	196	0.92	1.03	9,904	9,993	-89	
2.5 X-ray Transport (OPC)	2,903	2,807	3,050	-96	-243	0.97	0.92	4,039	4,476	-437	
2.6 X-ray Endstations (OPC)	3,018	2,540	2,394	-478	146	0.84	1.06	8,314	10,194	-1,880	
2.9 Conventional Facilities (OPC)	921	904	835	-17	70	0.98	1.08	1,865	2,239	-373	
2.X LCLS Controls (OPC)	2,042	1,755	1,644	-287	110	0.86	1.07	2,940	2,830	110	
<b>2 LCLS Total Other Project Cost</b>	<b>41,023</b>	<b>39,495</b>	<b>39,359</b>	<b>-1,529</b>	<b>136</b>	<b>0.96</b>	<b>1.00</b>	<b>59,123</b>	<b>62,316</b>	<b>-3,193</b>	
<b>LCLS Other Project Cost</b>								<b>68,000</b>			
<b>Management Reserve</b>								<b>8,877</b>			
<b>% Management Reserve on ETC</b>								<b>45.2%</b>			
<b>LCLS Total Project Cost</b>	<b>343,749</b>	<b>336,112</b>	<b>336,962</b>	<b>-7,637</b>	<b>-849</b>	<b>0.98</b>	<b>1.00</b>	<b>420,000</b>	<b>85%</b>		

## Cost and Schedule Performance (con't)

### Overall Cost and Schedule Assessment

<u>October 2008 Project Performance</u>	<b>AYK\$</b>
<b>Total Project Cost (TPC)</b>	<b>\$420,000</b>
Planned % Complete	87.3%
Actual % Complete	85.3%
<b>Total Estimated Cost (TEC)</b>	<b>\$352,000</b>
Cost and Commitments to Date	\$302,837
Estimate at Complete	\$339,885
Work Remaining	\$42,282
Outstanding Phase-Funded Awards	\$5,150
Remaining Contingency (Based on EAC)	\$12,115
% Contingency on uncommitted work remaining	31.6%

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 October 2008 Cost Performance Report is the 56<sup>th</sup> month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$344,317K. Cost and schedule indices are 1.00 and 0.98, respectively.

The critical path to meet CD-4 technical performance runs through the Soft X-ray Offset Mirrors and has 108 working days (~5 months) of float. Near critical path activities are the XES PPS and XTOD Pop-Up Cameras. The critical path to meet CD-4 overall performance runs through the LCLS space renovation has 83 working days.

Civil construction activities remain behind schedule although colocation of technical equipment will continue to be installed by SLAC to maintain the overall schedule float to CD-4.

The projected Estimate at Complete (EAC) provides the most current estimate of the TEC final cost. Contingency on EAC is considered adequate for this stage of the project. LCLS is evaluating possible enhanced capabilities to the approved baseline. Any added capabilities will be presented to the LCLS Change Control Board for approval prior to being added to the baseline.

### DOE (Level 2) Milestones

Milestone	Baseline	Projected	Variance	2006			2007			2008			2009			2010		
				Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	
<b>Level 2 DOE (SSO) Milestones</b>	<b>Fri 8/29/08</b>	<b>Fri 2/26/10</b>	<b>368 days</b>															
DOE External Independent Review (EIR) Complete	Tue 6/15/04	Tue 6/15/04	0 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 Undulators	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						●	●								
Start Installation of Undulator Facility	Fri 5/16/08	Thu 8/14/08	64 days								●	●						
BTH-UN-FEE-NEH-CUP Beneficial Occupancy	Mon 7/21/08	Thu 8/14/08	18 days								●	●						
Linac (Li20-Li30) Commissioning Complete	Wed 7/30/08	Tue 4/1/08	-86 days								●	●						
Safety Analysis Document (SAD) Approved	Fri 8/29/08	Tue 9/23/08	17 days									●	●					
Start Installation of Beam Transport Hall	Fri 9/26/08	Thu 7/31/08	-41 days									●	●					
XT-FEH Beneficial Occupancy	Wed 10/22/08	Mon 11/17/08	18 days										●	●				
XT Start FEE Installation	Tue 1/13/09	Tue 1/13/09	0 days											●	●			
Beam Path Project Close Out	Thu 2/12/09	Thu 2/12/09	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															●
Start Undulator Commissioning (1st Light)	Mon 7/6/09	Mon 7/6/09	0 days															●
XE Start Installation in NEH	Fri 7/24/09	Fri 7/24/09	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 Operations	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