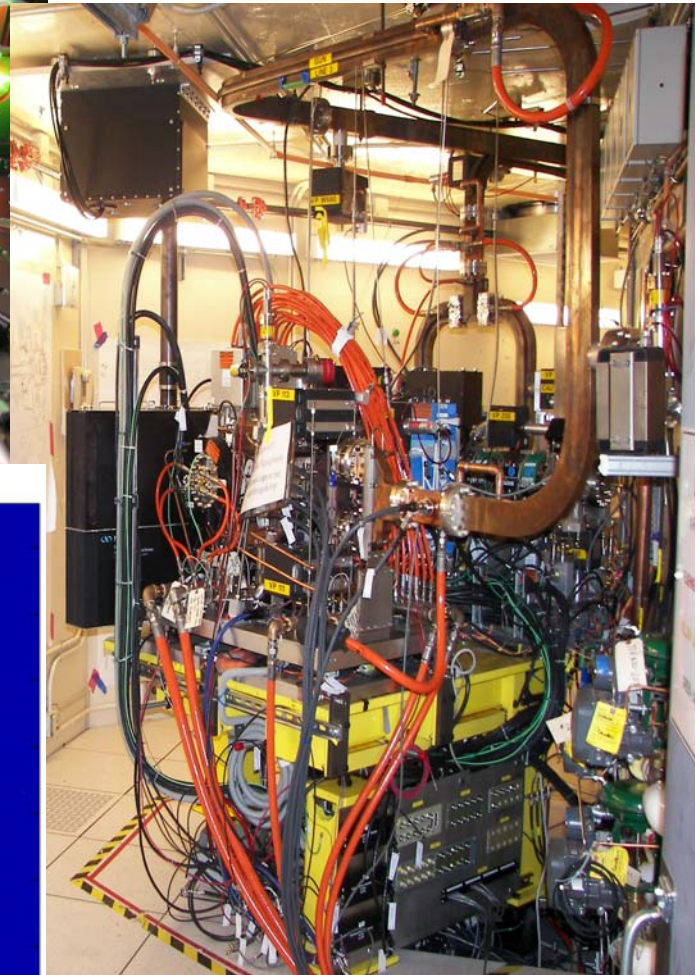
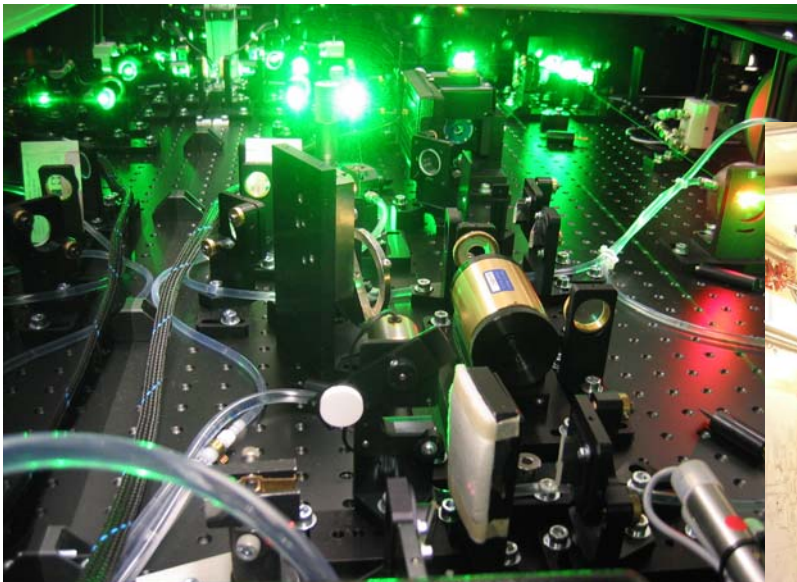
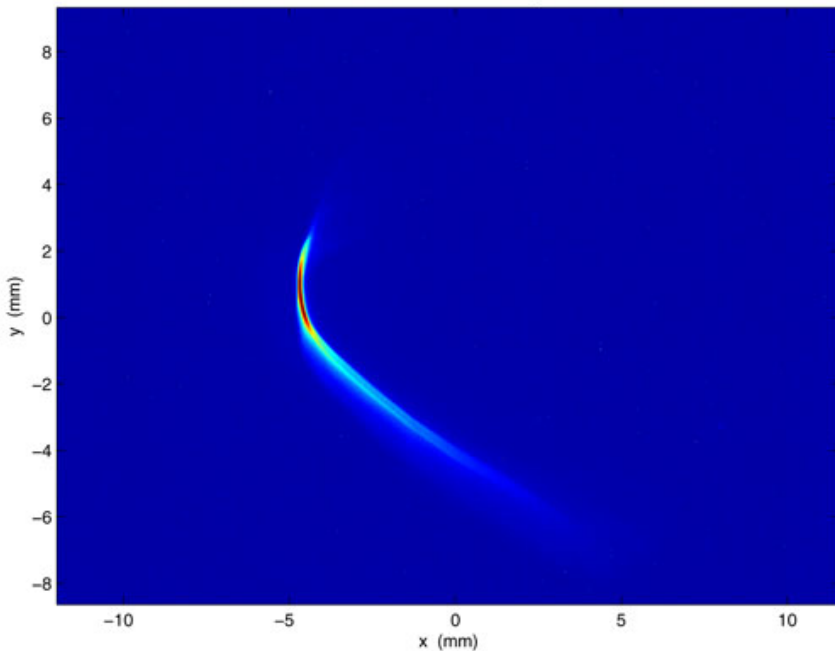


# Linac Coherent Light Source Monthly Report August 2007



Profile Monitor YAGS:IN20:995 16-May-2007 19:32:22



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## Project Overview and Assessment

### Highlights:

- Cover Page – The LCLS Injector successfully met all its commissioning goals in August. Shown clockwise from the top – The LCLS Drive Laser, which transports a  $>0.25$  mJ of energy in a 10-ps pulse length at a repetition rate of 10Hz – The RF Gun which operates with a peak cathode field of  $>110$  MV/m with  $>200$ pC of charge at a repetition rate of  $>10$  Hz, – ‘Streaked’ electron beam image indicates the LCLS Injector is capable of delivering horizontal and vertical normalized emittance values below one micron at 135 MeV, below the 1.2-micron goal for a 1nC bunch charge, and if preserved through the linac is expected to be adequate to drive the 1.5-Angstrom LCLS SASE Free-Electron Laser. Further documentation on the LCLS Injector performance is available in the LCLS Project Office.
- The construction phase for the LCLS major civil activities is being managed by the Turner Construction (TCCo). Overall construction is ~44% complete. To date, \$1,122K Field Change Orders have been negotiated and approved, which is under 4% of construction progress to date.
- Based upon recommendations from the DOE Office of Science (Lehman) Review conducted on July 10-12, 2007, LCLS is revising its proposed BCR to reflect current costs estimates on all remaining work. The Committee found that the project provided sufficient justification on the impacts of the 2007 Continuing Resolution, but had not yet adequately developed the revised baseline to ensure sufficient confidence in completing the project at the new cost and schedule. It is estimated this revision will be complete in early September and a mini-review of the LCLS BCR is scheduled for September 18, 2007.

### Assessment and Issues:

- The August 2007 Cost Performance Report is the 42<sup>nd</sup> month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$255,474K. The LCLS cost and schedule indices are 0.93 and 0.85, respectively. The SPI (‘yellow’ on the PARS threshold) is primarily driven by CR impacts (which are unrecoverable and require replanning) and delays in civil construction. The civil construction effort continues to show a schedule delay but is projected to recover to near its original schedule over the next few months.

## Project Office and Support

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

#### Highlights:

- LCLS Environmental, Safety & Health Status –
  - LCLS worked 8 days without a lost time injury at SLAC [8/22 DART]. Total project hours are 1.3 M comprised of 1.05 M collaboration hours and 256 K subcontracted work hours.
  - The LCLS project lost time injury rate is currently 3.10<sup>1</sup>, which compares favorably to the general industry rate of 6.0 for similar work. The total project lost time injury rate is 0.9; this includes construction and laboratory hours.
  - Safety Training Metrics –
    - Mandatory safety training = 97% (goal = 93%)
    - Supervisor required safety training = 97% (goal = 93%)
    - Compliance for training assessments = 97% (goal = 92%).
    - Medical exams for affected employees = 100% (goal = 90%)
  - DOE SSO/Oakridge Construction Safety Review – The SSO invited the DOE ORO Integrated Support Center (ORO) to assist it in a review of the LCLS construction project safety management process. The review is in part a result of 3 DARTs that occurred in April (1) and June (2); and in part due to the increase in surveillance by the SSO of project construction activity. The review began on 31 July and ended on 3 August.
    - The review found good work practices were in place; identified observations associated with electrical cord management and application of hot work (torch cutting); identified one finding associated with fall protection – all observations and findings were corrected in the field.
  - SSO Requested Injury Analysis Corrective Action Plan – In late June SSO wrote the Project stating concern regarding incidents on the TCCo construction site. At the same time the project had initiated an internal assessment the results of which were corrective actions. The SSO and the Project agreed to formalize the assessment. From the assessment LCLS Corrective Actions were initiated in the July/August time frame. On 27 August the project wrote the SSO to give an update on the status of the corrective actions and to advise them that a formal close-out letter for the actions, with supporting documentation, will be submitted on or about 17 September. The corrective actions and supporting documentation have been discussed with the SSO contact for the LCLS project and the SLAC Office of Assurance for concurrence.

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

- LCLS Procurements in August 2007 –
  - A/E Design (Jacobs) – Subcontract Modification 26 was issued to incorporate three minor design change requirements identified by Jacobs as Design Change Notices and settled in July. Subcontract Modification 27 for Design Change Notices T-3-15 & T3-16 were executed in August.
  - Construction Procurements –
    - SLAC and Turner attorneys/staff continued to meet in an effort to settle claims disputes outside of arbitration. SLAC/Turner team building meetings continue to resolve various contractual issues. Additionally, separate weekly change order meetings with Turner and Conventional Facilities have been scheduled to catch up on outstanding FCOs and CORs.
    - Subcontract modifications 36 and 37 were issued by SLAC in August. Modification 36 incorporated 2 fully negotiated FCOs into the Subcontract and settled 3 CORs while Modification 37 was issued to de-scope Trade Subcontractor allowances that are expected to remain unused.
    - Electrical S522 Substation – A successful award was made in July with completion expected on 11-30-07.
    - Alpine Road/Gate Natural Gas Line – Responsibility for the installation of the gas meter to the SLAC property line was transferred to the DOE SSO per the terms and conditions of the lease. LCLS has prepared a specification to bid the installation of the new gas line from the gas meter to the CUP. All required gas metering installation information has been provided to the SSO for implementation and establishment of contract with P G & E.
  - Technical Procurements –
    - Injector Laser Heater Dipoles – Subcontract awarded.
    - BC2 Chicane Dipole Magnets – One magnet arrived on July 3 and testing went well. The balance was shipped in late July and arrived in early August.
    - LTU Quadrupole Magnets – June delivery slipped due to material delays. Two units arrived in August but required rework. The balance of the order is planned for receipt in mid September.
    - Controls (VME CPUs, Power Modules & Crates) – All items to meet the 2007 shutdown were received in late June.
    - Intermediate Power Supplies – Awarded with split delivery of the end of July and the end of September, 2007. The July deliveries have been delayed to late September and LCLS has been expediting the supplier for in attempt to bring the items in earlier.

### Assessment and Issues:

- None

## Electron Beam Systems

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

#### Highlights:

- Injector Controls Commissioning – Complete. All goals met.
- 2007 Shutdown Installation Progress –
  - The BC2 cable plant installation contract was awarded. The RWT1 training was completed and a notice to proceed was issued. Five power supply racks were installed at sector 24. All sector 24, 30, and MCC cable tray installation and grounding was completed
  - BC2 vacuum hardware was received. The chasses are loaded in the racks and the PLC crates have been tested and installed. All MPS M&S for BC2 has been received and installed. The LION High Voltage Power Supply Chassis, PIC Integrating Detector Card Chassis, PIC Detector Tester Chassis, Bypass & Summary Chassis have been delivered and installed.
  - The latest versions of the LLRF and the Bunch Length Monitor software with beam-synchronous data acquisition capability have been released. The Injector launch and longitudinal feedback systems were put in production and are working reliably.

#### Assessment and Issues:

- None

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

### **Highlights:**

- Injector Commissioning – Complete. All goals met.
- 2007 Shutdown Installation Progress –
  - Installation components and hardware are being kitted in preparation for the 2007 downtime. Earthquake supports have been ordered and are planned to be installed in November while the controls group is checking out the BC2 center table. MFD has hired temporary technicians to provide assembly support for the 2007 down.
  - Two out of four dipoles for BC2 have been measured and met all the specifications
- LTU Design and Procurement Progress –
  - Orders for LTU stands and Quad stages have been placed and deliveries are expected in October.
  - 90% of e-Dump components and supports have been submitted to the MFD shop for fabrication. The remaining 10% is being designed, and all parts and installation drawings are expected to be complete in November 2007.

### **Assessment and Issues:**

- The 2007 Continuing Resolution led to delays in final design and procurement of the Linac system, which is reflected in poor schedule performance against the baseline. These variances will persist until the new plan becomes official.
- Considerable effort is being applied to the revision of the P3 resource-loaded schedule and budget, particularly in updating the Linac cost estimates and schedule revisions due to the effects of the FY07 CR. It is expected that this effort will be complete in September 2007.

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

### **Highlights:**

- Management & Safety –
  - ANL – The ANL Integration Engineering position has been selected and will be starting in early September. This is an important step in improving the quality of components delivered to SLAC.
  - SLAC – With the completion of the Injector System, management resources are being shifted to Undulator management at SLAC. This will allow better support for system integration during the main installation phase of the undulator.
  - With new staff joining the Undulator team, SLAC and ANL are working on improving their communications and coordination. An “Undulator Week” meeting has been scheduled for late September at ANL to work through any remaining system engineering and integration issues.
  
- Undulator Components & System Integration –
  - Support Movers – Parts for the series production of the Support and Motion Systems are to be machined and assembled at Hi-Tech, with the girders subcontracted to Metalex. ANL staff will provide training for Hi-Tech staff in the proper use of the camshaft mover testing apparatus. First-article pedestals, interface plates and girder arrived at Argonne. The next three sets are to be delivered to SLAC.
  - Quadrupoles – The first two article quadrupoles from Everson-TESLA were received and measured to be slightly low in field. The problem was found and corrected, and production is proceeding.
  - Beam Position Monitors – The 3-BPM test is nearly complete. Early results show the resolution of the BPM is better than the specification of 1 micron. The end cap of the RF BPM cavity assembly has completed redesign. Parts have been made and tests have been conducted validating the design. Cavity drawings are out for quotation.
  - Vacuum Chamber – The work on the three different vacuum chambers designs is complete. The prototype extrusion and copper chambers were completed. The drawings for the chamber support were updated and sent to the vendor. The material has been changed to aluminum and the support plates have been lengthened to better support the aluminum extrusion chamber.
  
- Undulator Assembly & Measurement –
  - SLAC’s Building 750 continues to be prepared for assembly activities (clean-up, safety barrier, pedestal anchor layout, quotation for epoxy painting). Preparations for the transportation of Undulators between MMF and 750 are being made. The portable clean room was completed and bridge crane was load tested.



- Production tuning of undulators continues (14/40 are tuned). The fiducialization of Undulator Magnets continues (13/40 are fiducialized).

**Assessments and Issues:**

- The LCLS undulator vacuum chamber and BPM designs are still of concern and significant R&D is still required. The development and production of both of these components remain the highest priority of the ANL management.
- Considerable effort is being applied to the revision of the P3 resource-loaded schedule and budget, particularly in updating the Undulator cost estimates and schedule revisions due to the effects of the FY07 CR. It is expected that this effort will be complete in September 2007.

## Photon Beam Systems

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

#### Highlights:

- Management and Safety –
  - Significant effort was devoted to the revision of the P3 resource-loaded schedule and budget. In addition the revised XTOD controls plan is now in P3. A prioritized list of XTOD procurements was prepared for planning purposes. A draft MOU for FY08 was completed except for the detailed spending plan which will be taken from the new P3 plan.
  - The LLNL safety document for the Gas Attenuator was revised and a pre-start review was held to reflect the switch to actually building the real attenuator. IWS 14018, which documents the safety aspects of designing and building the FEL Offset Mirror Systems, has been approved by the LLNL Safety Team and is ready for a pre-start review.
  
- XTOD Design Status and Progress –
  - Solid Attenuator – The modified actuators that insert and remove the solid attenuator blocks have been ordered. These actuators include a spring mechanism that causes them to retract out of the beam in the event of loss of power or air pressure.
  - Direct Imager - Work on the camera control software continues. A draft of the Direct Imager ESD is complete and has been forwarded to SLAC for comment. Final design of the Direct Imager tank has begun.
  - X-ray Mirrors – A draft ESD covering the HOMS mirror is complete and a HOMS PDR is scheduled for September.
  - Damage Measurements - Multi shot damage tests were conducted at the excimer laser facility at Kovia, Inc. on a Si wafer and other samples. The results found damage to the Si at twice the melt fluence. Reflectivity measurements showed the Si melted at the melt fluence but epitaxially solidified, leaving no visible damage up to twice the melt fluence.
  - Controls – The first prototype FEE short racks were received and are being built up to verify all mechanical/electrical features. The bulk of the electronic hardware is at LLNL, or on order, or in fabrication, for all of the FEE subsystems. This includes the basic VME and PCI chassis and motion controls, vacuum, HV, digitizers, and CCD cameras.

#### Assessment and Issues:

- CPR metrics – Variances for cost and schedule continue to be accrued mainly due the effects of the Continuing Resolution and aligning the tasks more along the new baseline schedule. Delays are seen in all areas. It is expected that the variances will disappear once the new baseline schedule takes effect.

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

### **Highlights:**

- Management and Safety – The XES group has responded to guidelines given by the LCLS Project Office and modified the XES schedule and budget profile accordingly. The new schedule proposes a delay of the AMO procurements into FY09 and readiness for experiments near the end of FY09.
- XES Design Status and Progress –
  - Personal Protection Systems – Thermal stress analysis of the ST 1 - 3 stoppers was performed using heat deposition simulations from Radiation Physics. Results indicate that the stoppers can survive a 5kW beam strike from a 40 micron round beam. 5kW power delivery to ST1 is not actually achievable in the LCLS baseline design.
  - LCLS Detector Development (Cornell) – Testing of the full-lot ASIC continued. Basic functionality of the digital components of the pixel was verified, demonstrating functionality of the logical control and addressing of the array. Preliminary tests of the digitization were successful. Further testing is required to quantify the results. One of the circuit boards has been modified to more easily accommodate FPGA interfacing and to fix some small problems that were discovered during testing. The bump-bonding vendor is working on processing of the ASIC wafers.
  - Atomic Molecular and Optics (AMO) Instrument – The design of the AMO high field physics chamber was significantly modified to accommodate a longer flight path for sample atoms/molecules/clusters from the source nozzle to the interaction region, in order to achieve single particle densities in the interaction region. This design modification required rearranging the positions of the electron and ion time-of-flight spectrometers to accommodate the gas source in the plane of the floor. The PDR for the AMO instrument is planned for late October.
  - XES Controls and Data Systems – Some controllers are being received and incorporated into the XES prototype rack in the lab. Fiber routing options for network, 120-Hz beam-data, and MPS are being investigated. Options are to use radiation hard fibers or to dig a short trench from an existing cable box to the Near Experimental Hall.

### **Assessment and Issues:**

- CPR metrics – Variances for cost and schedule continue to be accrued mainly due the effects of the Continuing Resolution and aligning the tasks more along the new baseline schedule. Delays are seen in all areas. It is expected that the variances will disappear once the new baseline schedule takes effect.

## Conventional Facilities (CF)

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



E-Beam Dump and Front-End Enclosure Re-bar Install



Beam Transport Hall with Service Building 2.1 and 2.2

#### Highlights:

- Construction Progress –
  - Construction is ~44% complete. To date, \$1,122K Field Change Orders have been negotiated and approved, which is <4% of construction progress to date.
  - Near Experimental Hall (NEH) – The NEH is 100% erected: all concrete floors, walls and ceiling decks are installed. Final utility installation is in process and work is on schedule.
  - Undulator Hall (UH) – The full excavation (top and lower bench) including the installation of the initial liner is complete.
  - Electron Beam Dump/Front End Enclosure – The sitework has been completed. Rebar layout and installation is 50% complete during this reporting period.
  - FEH Cavern – Over 50% complete of the top heading excavation and initial liner is complete. Ground conditions have proven to be favorable thus far.

#### Issues and Assessments

- Overall, civil construction lags behind its baseline schedule by 3-4 weeks. The most critical area is the Central Utility Plant which could impact the commissioning (not the initial installation activities). Opportunities exist for recovery during concrete and metal building stages and re-sequencing of MEP installations.



## LCLS Cost and Schedule Performance – August 2007

LCLS Cost/Schedule Status Report								31-Aug-07	
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	16,203	16,203	17,264	0	-1,061	1.00	0.94	18,013	90%
1.2 Injector	16,722	16,615	20,083	-106	-3,467	0.99	0.83	16,760	99%
1.3 Linac	15,032	13,335	17,076	-1,698	-3,742	0.89	0.78	19,940	67%
1.4 Undulator	31,219	26,324	31,057	-4,895	-4,733	0.84	0.85	37,398	70%
1.5 X-ray Transport	19,231	13,125	15,579	-6,106	-2,454	0.68	0.84	22,803	58%
1.6 X-ray Endstations	3,380	2,043	1,960	-1,337	83	0.60	1.04	8,735	23%
1.9 Conventional Facilities	79,453	70,328	68,607	-9,124	1,721	0.89	1.03	127,438	55%
1.X LCLS Controls	26,148	18,142	20,083	-8,006	-1,941	0.69	0.90	32,366	56%
<b>1 LCLS Total Base Cost</b>	<b>207,387</b>	<b>176,114</b>	<b>191,709</b>	<b>-31,273</b>	<b>-15,594</b>	<b>0.85</b>	<b>0.92</b>	<b>283,453</b>	<b>62%</b>
<b>LCLS Total Estimated Cost</b>								<b>315,000</b>	
<b>Contingency</b>								<b>31,547</b>	
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	11,730	12,145	11,476	415	669	1.04	1.06	30,195	40%
2.2 Injector (OPC)	3,984	2,314	3,781	-1,670	-1,467	0.58	0.61	5,317	44%
2.3 Linac (OPC)	742	318	488	-424	-170	0.43	0.65	3,232	10%
2.4 Undulator (OPC)	3,204	2,901	749	-303	2,152	0.91	3.87	6,852	42%
2.5 X-ray Transport (OPC)	1,156	1,099	1,010	-57	88	0.95	1.09	4,544	24%
2.6 X-ray Endstations (OPC)	1,971	1,698	1,009	-273	689	0.86	1.68	5,559	31%
2.9 Conventional Facilities (OPC)	292	0	0	-292	0	0	0	683	0%
2.X LCLS Controls (OPC)	650	68	114	-582	-46	0.10	0.60	1,129	6%
<b>2 LCLS Total Other Project Cost</b>	<b>23,728</b>	<b>20,543</b>	<b>18,627</b>	<b>-3,185</b>	<b>1,917</b>	<b>0.87</b>	<b>1.10</b>	<b>57,511</b>	<b>36%</b>
<b>LCLS Other Project Cost</b>								<b>64,000</b>	
<b>Management Reserve</b>								<b>6,489</b>	
<b>LCLS Total Project Cost</b>	<b>231,115</b>	<b>196,658</b>	<b>210,335</b>	<b>-34,458</b>	<b>-13,678</b>	<b>0.85</b>	<b>0.93</b>	<b>379,000</b>	<b>58%</b>

## Cost and Schedule Performance (con't)

### Overall Cost and Schedule Assessment

<u>August 2007 Project Performance</u>	AYK\$
<b>Total Project Cost (TPC)</b>	<b>\$379,000</b>
% Planned (Cumulative)	67.8%
% Complete (Cumulative)	57.7%
<b>Total Estimated Cost (TEC)</b>	<b>\$315,000</b>
Cost and Commitments to Date	\$233,543
Estimate at Complete (EAC)	\$303,903
Work Remaining	\$112,194
Outstanding Phase-Funded Awards	\$56,129
Remaining Contingency Based on EAC	\$11,097
	10.9%

The LCLS cost and schedule are consistent with a CD-4 milestone of March 31, 2009, a Total Estimated Cost (TEC) of \$315M and a Total Project Cost (TPC) of \$379M. All costs are in actual-year dollars and out-year costs are escalated.

The August 2007 Cost Performance Report is the 42<sup>nd</sup> month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$255,474K. The LCLS cost and schedule indices are 0.93 and 0.85, respectively. The SPI ('yellow' on the PARS threshold) is primarily driven by CR impacts (which are unrecoverable and require replanning) and delays in civil construction. The civil construction effort continues to show a schedule delay but is projected to recover to near its original schedule over the next few months.

The project critical path runs through the Undulator Facility Co-(early) Occupancy followed by installation of undulators followed by FEL beam commissioning and finally photons in the FEH. The rebaseline exercise will also require a replanning of the project critical path.

The LCLS EAC incorporates all overruns and potential BCR's into the performance baseline to provide a realistic assessment of the project's final cost. To date, remaining contingency on EAC is less than ideal for this phase of the project. Contingency reserves on civil construction are 10% on committed but uncosted work, comparing favorably with <4% actual contingency usage. Early assessments on the tunneling ground conditions are near optimal.

### DOE (Level 2) Milestones

System	Level	Milestone	Baseline	Projected	Variance	2005		2006		2007		2008		2009
						Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	
		<input type="checkbox"/> <b>Level 2 DOE (SSO) Milestones</b>	<b>8/29/08</b>	<b>10/8/08</b>	<b>28 days</b>									
PM	ML2	Prelim Safety Assessment (PSAD) Doc Complete	4/30/04	4/30/04	0 days									
PM	ML2	DOE External Independent Review (EIR) Complete	6/15/04	6/15/04	0 days									
PM	ML2	Fire Hazard Analysis Approved	6/30/05	8/15/05	32 days	●	●							
PM	ML2	Prelim Safety Assessment (PSAD) Doc Approved	2/28/06	2/28/06	0 days			●						
UN	ML2	Delivery of Undulator 1st Articles to MMF	7/3/06	6/15/06	-12 days				●					
CF	ML2	Sector 20/Alcove Beneficial Occupancy	7/21/06	4/14/06	-70 days				●					
CF	ML2	Research Yards Mods Beneficial Occupancy	10/20/06	8/30/06	-37 days					●				
UN	ML2	MMF Qualified & Ready to Measure Prod Undulators	11/27/06	8/28/06	-65 days					●				
IJ	ML2	Start Injector Commissioning (Drive Laser)	1/29/07	1/16/07	-9 days						●			
IJ	ML2	Injector Laser Commissioning Review Complete	1/31/07	12/1/06	-34 days						●			
IJ	ML2	Injector Accelerator Readiness Review (ARR) Comp	1/31/07	3/30/07	42 days						●			
IJ	ML2	Start Injector Commissioning(UV Beam to Cathode)	4/9/07	4/5/07	-2 days						●			
CF	ML2	Linac Water/Power Available	7/11/07	3/29/07	-74 days						●			
XE	ML2	2-D Pixel Detector Production Start	12/5/07	12/5/07	0 days							●		
LN	ML2	Linac ARR (Li20-Li30) Complete	1/31/08	1/31/08	0 days								●	
LN	ML2	Start Linac (Li20-Li30) Commissioning	3/3/08	3/3/08	0 days								●	
PM	ML2	Final Safety Analysis Document (FSAD) Approved	3/31/08	3/31/08	0 days								●	
CF	ML2	Start Installation of Front End Enclosure	5/20/08	5/20/08	0 days								●	
CF	ML2	Start Installation of Undulator Facility	5/20/08	5/20/08	0 days								●	
CF	ML2	Start Installation of Beam Transport Hall	5/20/08	5/20/08	0 days								●	
CF	ML2	Start Installation of Near Experimental Hall	5/20/08	5/20/08	0 days								●	
PM	ML2	LCLS ARR Complete (BTH thru FEH)	7/11/08	7/11/08	0 days								●	
LN	ML2	Start Linac-to-Undulator (LTU) Commissioning	7/31/08	7/31/08	0 days								●	
UN	ML2	Start Undulator Commissioning (1st Light)	8/18/08	8/18/08	0 days								●	
CF	ML2	Start Installation of X-Ray Transport	8/20/08	8/20/08	0 days								●	
CF	ML2	Start Installation of Far Experimental Hall	8/20/08	8/20/08	0 days								●	
XE	ML2	Start XES Commissioning	10/2/08	10/2/08	0 days								●	
XTOD	ML2	Start XTOD Commissioning	10/8/08	10/8/08	0 days								●	

## 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