

Linac Coherent Light Source – Baseline Change Request Description

This document provides an overview of Baseline Change Request (BCR) PM-38 for the LCLS Project. The BCR proposes a revised cost and schedule baseline, primarily in response to the effects of six months' funding uncertainties followed by a reduction in funding due to the FY07 continuing resolution (CR) appropriation. In addition to the CR effects, and in response to recommendations of the 2007 DOE Office of Science Integrated Project Review (IPR), this BCR includes updated cost and schedule estimates and increased contingency allowance to provide a high probability that the project's remaining commitments can be delivered on cost and on schedule. There is no change to the project's scope, capability or performance criteria.

SUMMARY DESCRIPTION: The LCLS is designed to provide laser-like radiation in the x-ray region of the spectrum that is 10 billion times greater in peak brightness than any existing coherent x-ray light source. This advance in brightness is similar to that of a synchrotron over a 1960's laboratory x-ray tube. Synchrotrons revolutionized science across disciplines ranging from atomic physics to structural biology. Advances from the LCLS are expected to be equally dramatic. The LCLS Project will provide the first demonstration of an X-FEL in the 1.5 - 15 Angstrom range and will apply these extraordinary, high-brightness x-rays to scientific problems. The LCLS experimental program will commence with: measurements of the x-ray beam characteristics and tests of the capabilities of x-ray optics; instrumentation; and techniques required for full exploitation of the scientific potential of the facility. This will be the world's first such facility.

CURRENT PROJECT STATUS:

- | | | |
|---|--------------------|---------------------|
| • CD-0 (Approve Mission Need) | Planned: June '01 | Actual: June '01 |
| • CD-1 (Approve Preliminary Range) | Planned: Oct. '02 | Actual: Oct. '02 |
| • CD-2a (Approve LLP Budget) | Planned: May '03 | Actual: July '03 |
| • CD-2b (Approve Performance Baseline) | Planned: April '05 | Actual: April '05 |
| • CD-3a (Approve Start of LLP) | Planned: Dec. '04 | Actual: Dec. '04 |
| • CD-3b (Approve Start of Construction) | Planned: Feb. '06 | Actual: March '06 |
| • CD-4 (Approve Start of Operations) | Planned: March '09 | Forecast: March '09 |
| • Total Estimated Cost (TEC): | \$ 315.0M | |
| • Other Project Cost (OPC): | \$ 64.0M | |
| • Total Project Cost (TPC) : | \$ 379.0M | |
| • TPC Percent Complete (June '07): | Planned: 60.1% | Actual 51.5% |

APPROVED CD-2b FUNDING PROFILE*:

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	Total
PED		5,925	7,456	19,914	2,518	161			35,974
Construction				29,760	82,170	105,740	51,356	10,000	279,026
OPC	1,500		2,000	4,000	3,500	16,000	15,500	21,500	64,000
Annual Total	1,500	5,925	9,456	53,674	88,188	121,901	66,856	31,500	379,000

* April 2005 CD-2b approved funding profile. Due to the FY07 CR, the Project's FY07 funding has been reduced to \$101.0M Construction and \$13.0M in OPC. LCLS has been directed by DOE to provide a revised baseline of the project's costs and schedule in order to deliver its commitments to DOE. This revised baseline has been presented for review to DOE SC IPR in July 2007.

BRIEF DESCRIPTION OF PROJECT SCOPE: The LCLS Project is constructed on the grounds of Stanford University at the Stanford Linear Accelerator Center (SLAC). LCLS has been designed such that future expansion on the existing site is possible. The LCLS project scope includes the following major systems:

1. Technical Systems:

- a. A 135 MeV injector built at Sector 20 of the 30-sector SLAC linac to create the electron beam required for the X-FEL.
- b. Modifications to the last one-third of the linac, including the addition of two magnetic bunch compressors. Most of the linac and its infrastructure remain unchanged.
- c. The existing components in the Final Focus Test Beam tunnel have been removed and replaced by a Beam Transfer Hall (BTH).
- d. An Undulator system, installed in a below-grade tunnel with associated equipment.
- e. A Beam Dump where electron beam is separated from photons
- f. Photon Systems including x-ray diagnostics, optics, and transport from Front End Enclosure (FEE) to Near Experimental Hall (NEH) and Far Experiment Hall (FEH).

2. Capital Facilities:

- BTH above grade structure connecting the existing Linac to Undulator Hall
- Undulator Hall underground tunnel
- Electron Beam-Dump and Front End Enclosure underground facilities
- The NEH facility constructed near the PEP Ring Road
- X-Ray Transport underground tunnel from NEH to FEH
- The FEH facility, an underground cavern, being constructed east of NEH
- Renovation of two existing SLAC buildings to provide office space for operations staff when LCLS becomes operational.

3. Atomic, Molecular and Optical (AMO) Instrument:

The LCLS project will fabricate the Atomic, Molecular and Optical (AMO) physics instrument.

OVERVIEW OF THE REVISED BASELINE:

Due to the U.S. Congress FY07 Continuing Resolution (CR), DOE-Basic Energy Sciences (BES) informed LCLS Project management that FY07 funding has been reduced by \$8M and that the funds will not be restored until FY09. BES directed LCLS management to prepare a revised schedule and cost baseline, and funding profile that delivers the Project technical baseline. The results, described below, are based on a comprehensive re-evaluation of the Project's cost, schedule, contingency and risks to the mission.

At the summary level, the key features of the proposed baseline change for the LCLS project can be summarized as follows:

- Changes to the Project Scope: There are no changes to the scope, capability or performance of the LCLS. The key performance parameters in the Project Execution Plan will be achieved.
- Funding Profile – A revised TEC funding profile for the LCLS Project is shown in Figure 1 below, with TEC cost and commitment profile in Figure 2. Adequate contingency is available on a year-by-year basis to address unplanned issues. The FY08 funding is fixed at the original baseline level therefore restoration of FY07 funding shortfall will not occur until FY09.
- Changes to Project Cost: The LCLS Project’s Total Estimated Cost has been revised to \$352.0M and Other Project Cost revised to \$68M with a Total Project Cost of \$420.0M. Figure 3 depicts the project budget at Work Breakdown Structure (WBS) Level 2.
- Changes to Project Schedule: Figures 4 and 5 list the revised level 1 and 2 milestones. For completion of the LCLS Project a revised date for achievement of the CD-4 milestone is proposed:
 - CD-4 (July 2010) – All capital facilities installed and commissioned as necessary to demonstrate detection of X-rays in the Near and Far Experimental Halls (NEH and FEH), and demonstrate a single-pulse x-ray with minimum spectral flux density of 10^6 photons/(mm² • 0.1% BW).

Figure 1 – LCLS Proposed TEC and OPC Funding Profiles

Linac Coherent Light Source Proposed Funding Profile (AYM\$)						
	Costs to Date	FY07	FY08	FY09	FY10	Total
TEC Funding		101.16	51.36	36.50	15.24	352.00
Cum TEC Funding	147.74	248.90	300.26	336.76	352.00	
OPC Funding		13.00	15.50	17.00	11.50	68.00
Cum OPC Funding	11.00	24.00	39.50	56.50	68.00	
Total Funding		114.16	66.86	53.50	26.74	420.00
Cum Total Funding	158.74	272.90	339.76	393.26	420.00	

Figure 2 – LCLS Proposed TEC Funding, Commitment and Cost Profiles

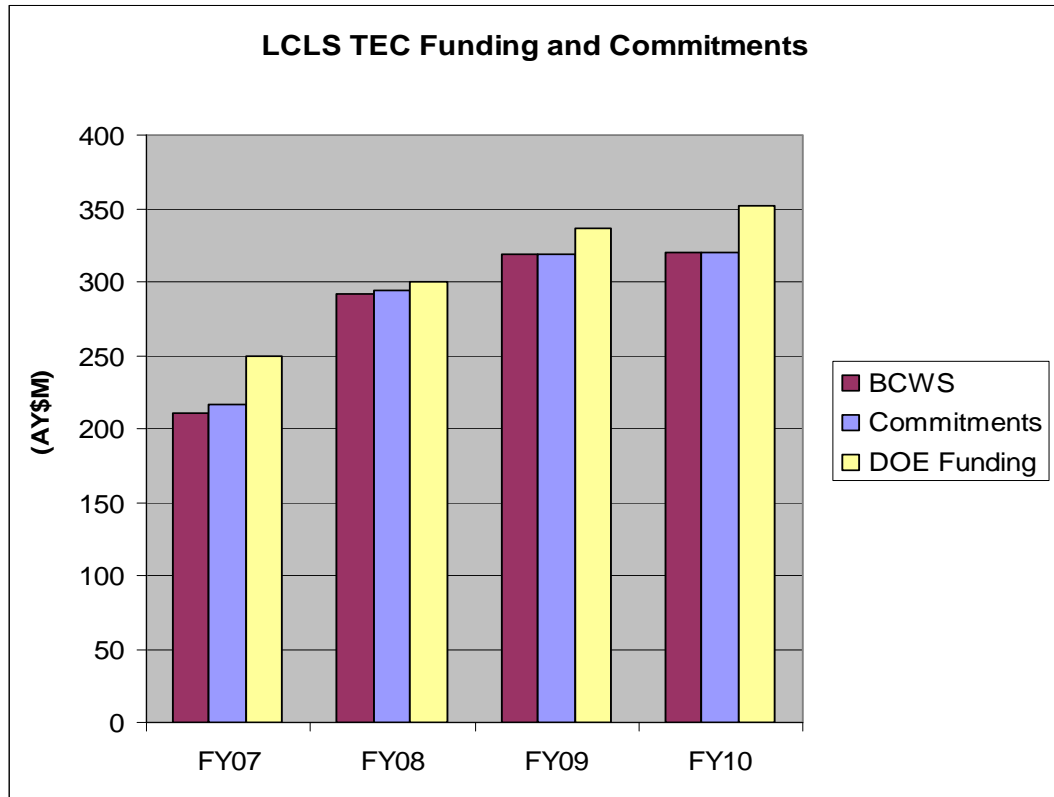


Figure 3 – LCLS Level 2 Cost Table

WBS	System	Budget (\$M)
TEC		
1.1	Project Management	31.46
1.2	Injector System	23.87
1.3	Linac System	39.26
1.4	Undulator System	47.97
1.5	X-Ray Transport and Diagnostics	27.77
1.6	X-Ray Endstations	17.16
1.9	Conventional Facilities	132.38
	Total Base Budget	319.86
	Contingency	32.14
	TEC	352.00
OPC		
2.1	Project Management	25.44
2.2	Injector System	5.34
2.3	Linac System	3.43
2.4	Undulator System	10.60
2.5	X-Ray Transport and Diagnostics	3.52
2.6	X-Ray Endstations	10.15
2.9	Conventional Facilities	1.52
	Total Base Budget	60.00
	Management Reserve	8.00
	OPC	68.00
	Total Project Cost (TEC + OPC)	420.00

Figure 4 – LCLS Level 1 Milestones

Level 1 Milestones	Scheduled Date	Completion Date*
CD-0 Approve Mission Need	June 2001	June 2001(A)
CD-1 Approve Preliminary Baseline Range	October 2002	October 2002(A)
CD-2a Approve Long-Lead Procurement Budget	May 2003	July 2003(A)
CD-2b Approve Performance Baseline	April 2005	April 2005(A)
CD-3a Approve Start of Long-Lead Procurement	December 2004	December 2004(A)
CD-3b Approve Start of Construction	February 2006	March 2006(A)
CD-4 LCLS Project Complete – Start Full Ops	July 2010	

* (A) indicates actual milestone completion date

Figure 5 – LCLS Level 2 Milestones

Level 2 Milestones	Scheduled Date*	Completion Date**
Prelim Safety Assessment (PSAD) Doc Complete	April 2004	April 2004(A)
DOE External Independent Review (EIR) Comp		June 2004(A)
Fire Hazard Analysis Approved	June 2005	August 2005(A)
Prelim Safety Assess (PSAD) Doc Approved	February 2006	February 2006(A)
Delivery of Undulator 1st Articles to MMF	July 2006	June 2006(A)
Sector 20/Alcove Beneficial Occupancy	July 2006	April 2006(A)
Research Yards Mods Beneficial Occupancy	October 2006	August 2006(A)
MMF Qual & Ready to Measure Prod Undulators	August 2006	August 2006(A)
Injector Laser Commissioning Review Complete	January 2007	December 2006(A)
Start Injector Commissioning (Drive Laser)	January 2007	January 2007(A)
Injector Accel Readiness Review (ARR) Comp	January 2007	March 2007(A)
Start Injector Commissioning (Beam on Cathode)	April 2007	April 2007(A)
Linac Water/Power Available	July 2007	March 2007(A)
Start Installation of Beam Transport Hall	February 2008	
Start Installation of Undulator Hall Facility	February 2008	
Linac (Li20 – Li30) Ready for Commissioning	February 2008	
Beam Transport Hall Beneficial Occupancy	April 2008	
Undulator Facility Beneficial Occupancy	April 2008	
Front End Enclosure Beneficial Occupancy	April 2008	
Near Experimental Hall Beneficial Occupancy	April 2008	
Central Utility Plant Beneficial Occupancy	April 2008	
X-Ray Transport Beneficial Occupancy	July 2008	
Far Experimental Hall Beneficial Occupancy	July 2008	
XT Start FEE Installation	August 2008	
Safety Analysis Document (SAD) Approved	August 2008	
Linac (Li20 – Li30) Commissioning Complete	September 2008	
Beam Path Project Close Out	September 2008	
XE Start Installation in NEH	February 2009	
LCLS ARR Complete (BTH thru FEH)	April 2009	
Start Linac-To-Undulator (LTU) Commissioning	April 2009	
2-D Detector Shipped to SLAC	May 2009	
XT Start Tunnel Installation	May 2009	
Start Undulator Commissioning (1 st Light)	July 2009	
Start FEE Commissioning with Beam	July 2009	
Initiate Early Experimental Operations ¹	September 2009	
First X – Rays into NEH	September 2009	
XE Start Installation in FEH	September 2009	
First X – Rays into FEH	March 2010	

*Level 2 scheduled date includes ~2months float to the early finish milestones

** (A) indicates actual milestone completion date

¹ This level 2 milestone is approved by Director of the Office of Basic Energy Sciences.

DEVELOPMENT OF REVISED BASELINE: To identify the root causes for the changes to the LCLS cost and schedule baseline, the project team adopted a methodical process in developing a revised baseline, as follows:

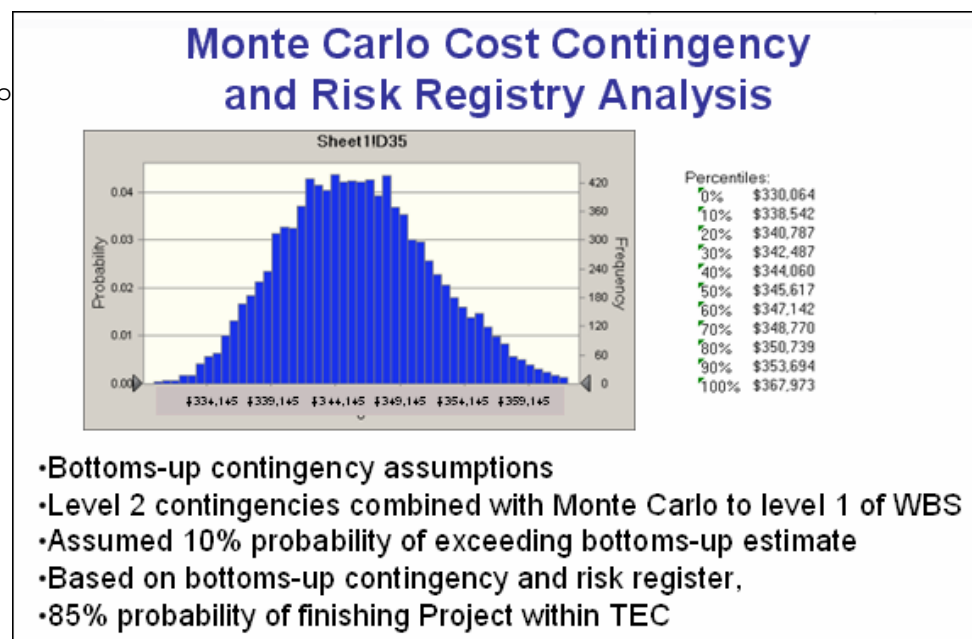
STEP 1 (Document Status against Baseline): Assess the current status of the project's earned value as of month-end June 2007. Actual costs to date (ACWP) and remaining work (ETC) for the approved baseline were documented.

STEP 2 (Revise baseline to address CR): Develop a Performance Measurement Baseline (PMB) for the remainder of the project, taking into consideration reduced FY07 funding and no changes to FY08 funding. TPC funding in FY09 and beyond was revised to deliver LCLS commitments to DOE in the earliest possible timeframe. The cost difference (STEP 2 – STEP 1) is related to the direct effect of the FY07 CR and FY09 funding restoration on the work to go after 6/30/2007.

STEP 3 (Update estimates): Update all cost and schedule estimates for work after 6/30/2007, based upon current best estimates. Update resource rates, escalation and indirect (G&A) rates. Optimize the transition to the LCLS operations phase based upon the current programmatic guidance from DOE-HEP and DOE-BES. The cost differences (STEP 3 – STEP 2) are due to re-estimating future work and optimizing the transition to LCLS operations.

STEP 4 (Reassess contingencies and risks on revised ETC): With the revised Performance Measurement Baseline (PMB) known, the project reassessed its contingency needs to address future uncertainties and known risks. Figure 6 shows the results of a Monte Carlo analysis of TEC contingency needs and a probabilistic determination of the known risks to the project. The results of the analysis provide an 85% confidence level that the project can be completed within TEC.

Figure 6 – LCLS Monte Carlo Cost Contingency and Risk Analysis



Summarizing the primary impact drivers to the BCR are shown below in Figure 7.

Figure 7 – Summary of BCR PM-38

Impact Cause		\$AYK	Comments
CR-Related	Cost associated with extending schedule to address FY07 funding reduction	\$21,277	This describes the cost to go (ETC) due to rescheduling work and captures the future effects of the FY07 CR.
	Unplanned (Actualized) Cost Due to CR and re-planning	\$7,001	Recovery of drawn contingency to support unplanned activities related to the FY07 CR (replanning scenarios, revised cost and schedule baseline preparation and review, inefficiencies due to procurement delays and accelerations, standing army costs).
Reestimate cost and schedule for all remaining work		\$2,067	This summarizes the reestimate of all remaining work (ETC). Updating the cost estimates, escalation rates, indirects, etc.
Increased Contingency Allowance		\$10,655	This includes \$10,615K contingency (TEC) and \$40K management reserve (OPC). This allowance is necessary to provide a high confidence that the project can be delivered on schedule and within the TPC.
Total Impact		\$41,000	Total TPC increase to the LCLS Project

Summary of BCR Impacts

- CR Effects – The cost and schedule impacts due to the CR can be summarized as unplanned (actualized) costs (\$7.00M) and the extended schedule costs (\$21.28M) to address the FY07 funding reduction. The total effect is ~\$28.28M. Unplanned costs include delayed activities due to six months of funding uncertainty, procurement delays, reassessment of several mitigation actions/impacts and preparation/review of the revised baseline. Extended schedule costs are primarily driven by re-sequencing future activities to fit within the revised funding profile. This impacted the overall project schedule by sixteen months. Appendix 1 (Category “A”) provides the basis of estimate @ Level 3 to support the extended schedule costs. Appendix 2 provides the detailed basis to justify the unplanned (actualized) costs
- Updated Cost and Schedule Estimate – Effects unrelated to the CR include updating the cost and schedule estimates for all remaining work, updates to the project’s escalation rates and indirect costs (G&A). The total cost impact of updating the cost and schedule estimate is ~2.07M. Appendix 1 (Category “B”) provides the basis of estimate at Level 3 to support the updated cost estimate. The effects of escalation and indirect charges are small but can be summarized as follows:
 - Escalation – Labor escalation rates at SLAC and LLNL were increased from 2.6% per year to 4.0% per year, and the ANL rate increased from 2.6% per year to 4.5% per year. This is based upon accurate projections for near-term salary increases at the three partner laboratories. The total cost impact for the escalation increase is \$1.003K.
 - Indirect costs (G&A) – SLAC’s indirect charges were increased from 38% to 40% and TEC non-labor changed from 4.8% to 4.32% and OPC non-labor changed from 5.52% to

5.04%. These changes were based upon accurate reflection of SLAC indirect support of the LCLS Project. The total cost impact for the change in indirects is \$151,407.

- Contingency (Management Reserve) – Contingency and management reserve allowances were reassessed on the project’s remaining work. The basis for determining the TEC contingency was a bottoms-up contingency assessment and a probabilistic evaluation of the project’s remaining risks. To provide an 85% probability for successful completion of the project, the contingency was found to be \$32.14M. The approved project baseline has \$14.52M contingency remaining. After restoring \$7.0M contingency due to the unplanned costs of the CR unplanned costs, an additional \$10.61M contingency is required to provide a high probability of successfully completing the project on this proposed baseline cost and schedule. \$40K of management reserve was added to the project OPC. Summarizing, this baseline change request provides \$32.14M of contingency or ~22.1% on remaining TEC work, and \$8.00M or ~18.7% on remaining OPC work.

ADDITIONAL INFORMATION & ASSUMPTIONS CONTAINED IN THIS BCR:

- DOE O413.3A – The revised LCLS PMB is compliant with DOE O413.3A, *Project and Program Management for the Acquisition of Capital Assets*, and strives to incorporate ‘best practices’ from other large-scale first of a kind large scale science projects from the DOE complex.
- Project Execution Plan – The LCLS Project Execution Plan (PEP) was approved by DOE’s Under Secretary for Science in April 2005. The PEP has been modified to reflect the proposed revision to the LCLS approved baseline. DOE Federal Project Director and LCLS Project Office will manage and control work at SLAC in accordance with the revised PEP. The revised PEP will be approved as part of approving the revised cost and schedule baseline.
- Work Breakdown Structure (WBS) – The Work Breakdown Structure has not been changed as a result of this BCR. There has been no change in technical baseline or the key performance parameters from this revised baseline.
- Cost, schedule, technical and programmatic assumptions used in preparing the revised baseline –
 - All revisions are compared to Actual Cost of Work Performed plus the original approved Estimate to Complete as of month-end June 2007.
 - Funding – Per guidance from DOE-BES, any changes to LCLS funding profile will not occur until FY09.
 - Cost and Schedule
 - All escalation and resource rate calculations are consistent with PMD 1.1-015 (Project Management Control System Description). Future labor costs will use the most likely escalation on prevailing salaries.
 - Schedule estimating, cost estimating and contingency assessment calculations are consistent with PMD 1.1-020 (Project Schedule Procedure) and PMD 1.1-021 (Cost Estimating Procedure).
 - LCLS utilizes a hierarchy of milestones to monitor project progress.
 - Level 4 (L4) milestones are defined, monitored and managed by the System Managers. These are ‘early finish’ milestones without float.
 - Level 3 (L3) milestones are defined, monitored and managed by the LCLS Project Office. These are assigned fixed dates with 1 month float to the L4 milestone. Float between L4 and L3 is monitored monthly.
 - Level 2 (L2) milestones are defined, monitored and managed by the DOE Federal Project Director. These are assigned fixed dates with 2 months of float to the L4 milestone. Float between L4 and L2 is monitored monthly.

finishing the project with the TEC, which is considered adequate for the remainder of the project.

- Risk Management
 - LCLS risk management policies and procedures have not been affected by the Continuing Resolution. LCLS Risk Management Plan (RMP) assesses and quantifies potential cost and schedule impacts to the Project which are not explicitly budgeted or otherwise acknowledged in the Project cost and schedule baseline. The LCLS RMP addresses risks over the entire scope and life cycle of the project. The possible financial impacts of these risks are estimated quantitatively and compared to available contingency in a statistical “Monte Carlo” analysis.
- Project Interface Assumptions
 - Fund type Definitions
 - TEC (Total Estimated Cost) – The TEC portion of the project scope is reserved for construction resources and activities. This includes planning, design, construction, installation and checkout. The logical end of most TEC activities is the installation phase.
 - OPC (Other Project Cost) – The OPC portion of the project scope is reserved for non-construction activities such as R&D, spares and commissioning, or first pre-operational tests of the performance of major (WBS level 2) LCLS systems such as the Injector, Linac, Undulator, etc. Installation is budgeted in the TEC. When installation is complete, commissioning begins. Commissioning activities are budgeted in OPC. OPC is assumed to cover all costs associated with commissioning newly installed LCLS equipment. Commissioning activities are fully complete at CD-4.
 - Transition to Operations – LCLS is a state of the art facility that will enable discovery-class experiments. This requires a transition to operations not typically used for a conventional facility. LCLS plans a phased transition into operations as each major subsystem achieves its commissioning goals. The first major subsystem is the Laser and Injector facilities which met their commissioning goals in August 2007 and are now supported by Linac Operations funding. Once a major subsystem is turned over to Linac Operations, no additional project funds, either TEC or OPC will be applied to these subsystems. Experiment operation activities in the LCLS Near Experimental Hall will be supported by a separate funding source, LCLS Experimental Operations funding, in FY2009.