Closeout Report

on the

Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

May 12, 2005

memorandum

DATE: April 1, 2005

REPLY TO
ATTN OF: SC-12

SUBJECT: CD INDEPENDENT PROJECT REVIEW FOR THE LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

TO: Daniel R. Lehman, Director, SC-81

I would like to request that you organize and lead an Office of Science (SC) semi-annual status review of the Linac Coherent Light Source (LCLS) project at the Stanford Linear Accelerator Center (SLAC) during May 10-12, 2005. The purpose of this review is to evaluate progress in all aspects of the project: technical, conventional facilities, cost, schedule, management, and environment, safety and health (ES&H).

The LCLS project is in the process of starting Tktle II design activities and placing long-lead procurements. These long-lead items include the 135 MeV injector linac, undulator modules and their associated magnetic measurement system, and main linac magnets and RF systems. Actual construction start is scheduled for March 2006.

In addition to the LCLS construction project, SLAC is preparing to initiate a Major Item of Equipment (MIE) project called the Photon Instrumentation for X-ray Experiments at LCLS (PIXEL). It will provide the LCLS facility with additional experimental instrumentation once the LCLS is completed. The committee should also evaluate SLAC's preparations to start conceptual design of this MIE project later in FY 2005.

In carrying out its charge, the review committee should respond to the following questions:

1. Are the project's cost, schedule, and technical baselines consistent with those in the FY 2006 LCLS Construction Project Data Sheet and the current DOE-approved LCLS Project Execution Plan (e.g., Total Project Cost of $379 million and CD-4 in march 2009), and is there adequate progress to meet the baseline objectives? Is the information in the DOE Project Assessment Reporting System consistent with physical progress?

2. Are the designs of the technical systems sufficiently mature to support the long-lead procurements planned in FY2005? Will the procurement plans support the project schedule requirements?

3. Is there adequate contingency (cost and schedule) to address the risks inherent in the remaining work and is it being properly managed? Is the contingency supported by and consistent with an appropriate project-wide risk analysis?

4. Is the project being managed (i.e., properly organized, adequately staffed) as needed to proceed with construction? Is there adequate support from SLAC in all necessary areas (e.g., procurement, human resources, etc.)?

5. Is SLAC adequately prepared (e.g., organized and staffed) to start conceptual design of the PIXEL MIE project?

6. Are ES&H aspects being aggressively addressed and are future plans sufficient given the project's current stage of development?

7. Has the project responded appropriately to recommendations from prior DOE/SC reviews?

Jeff Hoy, the LCLS Program Manager, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your Committee's report within 60 days of the review's conclusion.

[signed]

Patricia M. Dehmer
Associate Director of Science
for the Office of Basic Energy Sciences

cc:
H. Lee, SSO
N. Sanchez, SSO
K. Hodgson, SLAC
J. Galayda, SLAC
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E. Rohlfing, SC-13
P. Debenham, SC-22
S. Tkaczyk, SC-81
K. Hodgson, SLAC

Department of Energy Review of the Linac Coherent Light Source (LCLS) Project
May 10-12, 2005

Stephen E. Tkaczyk, DOE/SC, Chairperson

SC1	SC2	SC3	SC4	SC5
Accelerator Physics	**Injector/Linac**	**Undulator**	**Photon Beam Handling Systems**	**Control Systems**
* Sam Krinsky, BNL	* George Neil, TJNAF	* Kem Robinson, LBNL	* Al Macrander, ANL	* Dave Gurd, ORNL
	Zenghu Chang, KSU	Erik Johnson, BNL	Robert Schoenlein, LBNL	Michael Thuot, Consultant
		David Robin, LBNL		

SC6	SC7	SC8	SC9	SC10
Conventional Facilities	**Cost and Schedule**	**Project Management Procurement/Pre-Ops**	**ES&H**	**Endstations**
* Dixon Bogert, Fermilab	* Bob Simmons, PPPL	* Robert Wunderlich, DOE/CH	* Arnold Clobes, LLNL	* John Haines, ORNL
Jerry Hands, SNL		Jeff Atherton, LLNL/NIF		
Dale Knutson, ANL		Bruce Warner, LLNL/NIF		
		Les Price, ORO/SNS		

Observers

Pat Dehmer, DOE/SC	Hanley Lee, DOE/SSO
Jeff Hoy, DOE/SC	Nancy Sanchez, DOE/SSO
Pedro Montano, DOE/SC	Jim Krupnick, LBNL
Michael Casassa, DOE/SC	

LEGEND

SC Subcommittee

* Chairperson

Count: 21
(excluding observers)

Department of Energy Review of the
Linac Coherent Light Source (LCLS) Project

REPORT OUTLINE/WRITING ASSIGNMENTS

Executive Summary ..... Tkaczyk

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Action Items
DOE Review of LCLS
May 10-12, 2005

ITEM DESCRIPTION	DUE DATE	RESPONSIBILITY
1. Resolve all comments and issue the Request for Proposal for Construction Manager/General Contractor activities.	June 13, 2005	LCLS / SC / SSO
2. The Laboratory Director will conduct an assessment and report to the Director, Office of Basic Energy Sciences, the necessary resource commitments from SLAC to ensure the readiness of the project to proceed with construction as a primary element of SLAC.	~~June 13~~ 23, 2005	SLAC Director
3. Conduct the next DOE Review	November 2005	LCLS / SC

John Galayda 12 MAY 2005
John N. Galayda
LCLS Project Director
SLAC

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Samuel Krinsky

2.1 Accelerator Physics

Findings

- The analysis and modeling of the accelerator physics has reached a mature state. The emphasis of current work is on optimization of the accelerator configuration for commissioning and early operation.

- The proposed low charge operation (0.2 nC rather than 1 nC) provides a way to ease the requirements on the accelerator systems. We strongly endorse this low charge mode of operation.

- The management of the accelerator physics effort has been effective and the appointment of Paul Emma as Accelerator Team Leader will strengthen the management of the accelerator physics at this critical time.

- At the review, it became apparent that there is a need for a comprehensive listing of the hardware and environmental tolerances needed to achieve required system performance. This information is needed to facilitate proper cost-benefit trade-offs.

- The development of high-level software to be used during commissioning is of the highest importance. It is necessary to provide intelligent interface to diagnostics, to facilitate comparison of observations to modeling codes, and to implement tuning algorithms to optimize performance.

Recommendations

- Carry out a comprehensive study of the required hardware and environmental tolerances. Clearly indicate when feedback and feed-forward can be used to ease tolerances if passive solutions cannot be found. (November 2005)

- Develop the high-level software needed for commissioning . Programmers should be assigned to this task by November 2005.

Injector/Linac Subcommittee

George Neil (chair), *TJNAF*

Zenghu Chang, *KSU*

Injector/Linac Subcommittee

Findings

- Mature design and appropriate long lead procurements. Critical decision on the driving laser.
- Adequate and properly managed contingency.
- Adequate support exception of Mechanical Engineering.

Injector/Linac Subcommittee

Findings

- Excellent hiring of Laser Group Leader for LCLS.
- Potential misunderstandings between SLAC divisions on ES&H.

Injector/Linac Subcommittee

Recommendations

- Resolve schedule conflicts on October waveguide installation (August, 2005).
- Continue laser staff hires (June, 2006).

2.3 Undulator

SC3

Erik Johnson, David Robin, and
Kem Robinson (Chair)

DOE Review of the LCLS
Committee Closeout

12 May 2005

2.3.1 Findings

- Undulator Systems Organization evidences good management
  - Significant personnel additions in the last six months in several areas
    - Overall Undulator System Chief Engineer
    - SLAC Undulator Integration Engineer for SLAC activities
    - Mechanical engineer for undulator fixed supports
    - Survey and alignment liaison
    - Dedicated procurement officer.
  - Placement of significant long-lead procurements
    - 2 for the titanium strongbacks
    - Fabrication of the vanadium permendur poles
    - NdFeB Magnets for undulator
    - Soon: undulator assembly
  - Evidence of integration of ANL and SLAC activities
  - Response to changes dictated for numerous reasons
    - EM quadrupoles
    - Responsibility for the undulator fixed supports
    - Vacuum chamber
    - Surface equipment halls.

2.3.1 Findings (cont.)

- Operational configuration anticipates regular exchange of undulators
  - Swap out the cradle with undulator section and all of the subsystems
  - Requires breaking the vacuum and exchanging the BPM and quadrupole at the same time
  - Must not disrupt the 140-meter stretched wire or the hydrostatic leveling systems
  - The center of the vacuum chamber within an undulator section requires ~24 hours of pumping to achieve a vacuum of 10^{-6} torr

2.3.1 Findings (cont.)

- The undulator system RF BPM
  - Scheduled to be installed on FFTB October 2005
  - FFTB is scheduled for shut down March 2006 (no later than June 2006)
  - Installing prototype RF-BPM on LEUTL at ANL could be done at any time
  - Desire to field a complete diagnostic suite and controls for testing at FFTB.
- A complete integrated error tolerance budget has not been completed.
  - Many independent sets
  - Not systematically integrated
  - Often without normal operational assumptions or approaches
- The project team presented an initial commissioning approach
  - Pre-beam checkout
  - Electron beam commissioning
  - FEL gain optimization

2.3.2 Comments (cont.)

- No PED Funding in 2006:
  Carefully watch ancillary parts of the undulator system
  - Some Not very far in design development
  - Could degrade system performance
  - Could jeopardize schedule contingency and float
  - Examples
    - RF beam position monitors (BPM)
    - Undulator cradle
    - Vacuum chamber
    - Fixed supports
- Lack of a completely integrated error tolerance budget analysis
  - May adversely impact design choices
  - Present analyses are conservative
  - Often do not include operational context
- Undulator system physics issues cannot justify extraordinary measures for either the undulator hall floor or spatial temperature uniformity requirement
- The dual location of the multi-undulator section integration testing seems redundant

2.3.2 Comments (cont.)

- Full integration testing setup using three undulator sections preferred
- The project should plan on explicit learning curve benefits in the development and actual execution of BBA during commissioning and operation
- The undulator system organization appears to be a well developed and run project team.
  - Integration of ANL and SLAC activities
  - Good technical progress
  - Good response to AC conductivity issue
  - Moving responsibility of undulator fixed supports (WBS 1.4.8.3) to ANL
- The ES&H aspects are being aggressively addressed and in evidence

2.3.3 Recommendations

1. Define clear roles and responsibilities for the LCLS Physics Liaison Support group in order to ensure adequate global integration and consideration of physics requirements and implications by 1 June 2005. The Accelerator Team Leader should be formally given the authority and responsibility to preside over this group and ensure integration across major systems.
2. Examine the opportunity to kinematically mount the undulator magnet onto the transverse slides of the cradle to allow a greatly simplified exchange during operations by 1 September 2005.
3. Assess the feasibility and eliminate, if possible, the duplication of the multi-undulator section integration tests by 1 October 2005

2.3.3 Recommendations (cont.)

4. Accelerate the development of a design verification test of a prototype RF-BPM system for deployment on LEUTL at ANL by 15 August 2005.
5. Develop a complete integrated physics error tolerance budget that factors in civil construction constraints taking into account the various optimization modes and tolerance zones that will likely be employed during commissioning and operations by 1 October 2005.
6. Develop a complete undulator systems engineering plan including decision trees to optimize integration, installation, alignment, commissioning and operation planning by 1 October 2005.

2.4 & 2.6 Photon Beam Handling Systems/ Endstations
A. Macrander, Robert Schoenlein, John Haines

Comment: The committee was encouraged by the plans for damage testing at DESY/TTF and looks forward to hearing about the results.

Comment: The committee was also happy to see the degree of planning for the 2D detector to be built at Cornell.

1) Finding: There have been several significant recommended changes to the baseline design:

- Offset mirrors in FEE
- Steel hutches instead of concrete
- Possible move of monochromator and diagnostics to FEE
- Possibly shorter gas attenuator

Recommendation: These change requests along with the redesign of the FEH need to be processed with high priority.

2) Finding: The changes in the offing affect the work to be done at LLNL.

Recommendation: The work to be done by LLNL needs to be prioritized and sequenced to reduce risk. Changes need to be detailed to LLNL so that the work done will eventually be productive and cost effective. Accommodating changes will require flexibility. LLNL will have to approach the WBS 1.5 items with a flexible approach, and SLAC should support that flexibility.

3) Finding: Engineering designs are incomplete.

Recommendation: Engineering designs need to be completed with scrutiny by and support from radiation physicists at SLAC. The personal protection system (PPS) at hard x-ray light sources (e.g., the APS) need to be studied and considered.

Control Systems

SC05: Dave Gurd, Mike Thuot

Findings:

- The controls group is responsible for a far larger scope than is traditional for accelerator control systems – it includes diagnostics, LLRF and power supplies (even some lead shielding!)

- There has been excellent success in recruiting software engineers – both full-time LCLS employees and matrixed from ESD and SSRL. The result is excellent progress on the critical SLC-aware IOC and timing interface software – ahead of required schedules.

- We are pleased to note that COTS or designs from other labs are being used where possible. Care must be taken to assure that these designs meet all LCLS requirements.

- Predictably, the cost basis improves as the design proceeds, and we are pleased to note that the controls group intends to update their cost estimate after prototyping is complete.

Comments:

- The controls group is faced with very challenging work and tight schedules in both diagnostics and LLRF – forces need to be mustered to complete this work in a timely fashion.

- The team is falling behind in the acquisition of hardware (EE) personnel for design and this will affect delivery schedule unless rectified soon.

- With the addition of a new level of management, controls has lost some project-wide visibility. Because controls is now explicitly on the linac side, the important integrating link to the photonic side is now less direct. It will take effort to make this rather arcane reporting structure work.

Recommendations:

- The project should resolve the issue of electronic design engineering (and support infrastructure) for the controls team, using either the matrix model already successful in the software area, or by hiring dedicated electronics engineers (and designers and technicians) directly into the group. The project needs to be made appealing to engineers who might be concerned about their long-term future.

- The project requires a full-time resident controls group leader, and a plan should be developed to expedite this transition. If possible, this plan should include retention of the current group leader to direct the EPICS integration activities.

LCLS Review May 12, 2005
SC 6 – Conventional Facilities
Closeout Summary
Dixon Bogert, Jerome Hands, Dale Knutson

Selected Findings and/or Comments
Resultant Recommendations

Finding and/or comment:

1. If the physics specifications are now "frozen", then the CF team has adequate technical, cost, and schedule contingency to accomplish the scope of work defined for the LCLS project. The challenge of accomplishing this work on the project schedule will require a substantially increased level of integration and support from the Laboratory, the project and the DOE.

   Recommendation: (The project should) Review the management and support staffing at all levels to ensure the level of competence, experience and availability reflects the integrated schedule requirements.

Finding and/or comment:

2. The value of a CM/GC approach is dependent upon early awareness of the technical approach and design outcomes by the CM/GC contractor. This process is now behind the desired schedule. The introduction of a 3rd party CM (or an "interim" solution) has a strong potential to introduce loss of accountability and will substantially reduce the "steeping time" that the ultimate CM/GC must have to develop and "own" the designs and work packaging of the LCLS project. The committee concurs in the project approach to introduce constructability reviews as an integrated element of the design process.

   Recommendation: Immediately resolve the process of implementing the procurement for the CM/GC contract. Use the existing A/E to deliver an integrated design at the 30% point of Title II design that includes a constructability review.

Finding and/or comment:

3. The technical specifications for tunnel design and environmental control are very conservative. However, the money spent in achieving the environmental specifications of the undulator hall may not be addressing the greatest contributors to RMS variation. A global "value engineering approach" (this means technical plus CF designs) is needed to clearly quantify the greatest return in technical performance for the dollars spent in design.

   Recommendation: Conduct a thorough review of all design parameters that affect the environmental and physical dimensioning of the tunnel structures and reflect the least conservative physics values that can be addressed through other technical means.

Finding and/or comment:

4. The committee finds that the facts and data surrounding the CF cost estimate reflects a current variance of no less than 50% based on two competitive procurement results. We also find that this level of impact has not been addressed in the project's risk registry at a level necessary for mitigation.

   Recommendation: Update the risk registry and project planning approach to reflect an adequate mitigation strategy.

Finding and/or comment:

5. The CF schedule risk is highly influenced by the timely delivery of CM/GC technical services and the integration of this service with design. Risk elements are not adequately addressed in the project mitigation planning

   Recommendation: Quantify the plan for schedule recovery in the CF activities based on the current understanding of schedule loss created by the delayed CM/GC contract award.

4.0 Cost, Schedule, and Funding
Bob Simmons, PPPL

Findings:

- Current Baseline (CD-2b) - TPC $379M - $315M TEC, $73.6M Contingency (33.3%), & $64M OPC
  - Increased project office staffing
  - Increasing CF construction management & tunneling costs
  - Extending overall schedule by 6 months
  - Increasing contingency & management reserves
- November 2004 SC Mini-Review & this review confirmed that all cost and schedule recommendations have been satisfactorily resolved.
  - Updated cost estimate, contingency, and project schedule
  - Updating Risk Registry on a monthly basis
  - Updating procurement plans to reflect more realistic start dates and durations
  - Updating construction contract durations to accommodate potential complexity of work
- Project schedules and cost estimates reasonably detailed. CD-4 is now March 2009 and the critical path appears to be well understood.

Comments:

- Cost estimate and project schedule adequate to enhancing likelihood of success.
- Increasing frequency of updating Risk Registry to monthly will provide a better visibility of issues and potential contingency usage.
- Quantity and intervals of control milestones appear to be reasonable for providing regular progress reporting.
- Reliance on contractors for all of Project Control functions - no evidence that this has created issues.

- The Configuration Control System appears to be working adequately. Baseline Change Requests (BCRs) are only processed once a month. As Title II activities wind down and construction activities commence, the need for having BCRs being processed at CCBs more frequently will become very evident. Level 4 BCRs do not necessarily include impact assessments by other technical areas.

Recommendations:

1. Benchmark current durations of CM/CG SOW to award against the very similar Molecular Foundry CM/CG contract experience to ensure that the current plan is realistic by June 1st.
2. Conduct CCB's as frequently as needed vs. only once a month.

Section 5.0 Project Management, Procurement, and Pre-Operations
(R.Wunderlich, B. Warner, L. Price, J. Atherton)

Findings and Comments:

The LCLS Project was baselined in April 2005 with the approval of CD #2. The baseline was responsive to the recommendations of the August 2004 DOE Review Committee. The LCLS Project baseline establishes a TEC of $315M and a TPC of $379M. The Project schedule calls for project completion in March 2009. The overall contingency is 33% of the work to go and schedule float is about 26% (216 days).

The LCLS Project is about 8% complete. Project cost and schedule variances are small. Overall cost estimates are considered reasonable. Overall contingency and schedule float are believed to be adequate. Notable progress continues to be made on the project in all areas.

SLAC is an organization in transition from a high energy physics laboratory to a multi-program laboratory with a primary photon science focus. The LCLS will become the most important facility at SLAC when it is completed in 2009.

The three partner organizations (SLAC, ANL, and LLNL) are working well together.

The LCLS presented their preliminary start-up and commissioning plans for the facility. LCLS also presented the proposed Major Item of Equipment for instrumentation. Both of these plans will continue to be developed.

Required Project documents and systems are in place, although not all are working as needed. The Review Committee noted the need for an integrated change control system that includes appropriate evaluations on technical, cost, and schedule changes. There is also a need for developing a technical requirements list and interface management process.

The Review Committee has some reservations concerning the project's ability to effectively start construction. In particular, the hiring of a GC/CM is needed as soon as possible so that they can contribute to the acceptance of the design. In addition, there is a need to define and commit SLAC resources (people, infrastructure, systems) for initiation of construction. For example, the Committee identified project needs for electrical engineers, laser optics technical support, and construction management.

Recommendations:

1. Award the GC/CM contract as soon as possible. The LCLS Project needs to work through the procurement reviews and comments on the GC/CM contract and issue the RFP for this contract by June 13, 2005. SLAC Management, DOE Site Office, and SC HQ support will be provided, as needed.

2. Identify the specific needs for the LCLS Project to ensure that adequate SLAC resources are provided to fully support the LCLS construction as a primary element of SLAC. This includes the management needs of the CM/GC contract including managing the interface between the AE and the CM/GC contracts. (July 15, 2005)

3. Clear roles and responsibilities need to be identified and communicated for the SLAC organization units. Ensure SLAC organizations understand how they support the accomplishment of the LCLS Project (July 15, 2005)

4. Integrate the LCLS change control boards into a single board that evaluates technical, cost, and schedule risks and changes. The LCLS Project should ensure that ANL and LLNL input are adequately linked to the change control process. (July 1, 2005)

5. Ensure that interface and requirements management is effective. Specific major project decisions on technical changes need to be scheduled to ensure that the decisions are timely. The project parameters list (PRD 1.9-001 rev1) needs to be updated, reviewed, approved, and maintained by the integrated change control board. (July 15, 2005)

6. Environmental, Safety and Health.
(Arnold R. Clobes)

Findings and Comments

LCLS has taken steps since the last review to establish a comprehensive construction safety program (CSP). This includes adding key safety staff.

The CSP model being used by LCLS has been proven to work at other sites and meets industry standards and Integrated Safety Management (ISM) principles.

SLAC has recognized they also need to develop a more effective contractor management process. To rectify this, SLAC has assembled a working group that includes LCLS staff.

The contract safety specifications in the statement of work for the CM/GC have been reviewed and appropriate safety requirements included.

The authority of the Citizens Committees involved in LCLS is unclear with some committees having "approval" authority while others limit their involvement to offering observations.

The LCLS Project Director has charged his safety staff to define safety criteria for the technical systems.

Various safety procedures are in use across SLAC divisions. Installation, activation and operation of LCLS shared equipment with various procedures and staff could compromise the safe work environment.

Project documentation (PHA, EA, PSAD, FHA) is complete or on schedule to support the construction schedule.

Recommendations

1. Clarify the role and responsibilities of the Citizens Committees.	June 30, 2005
2. Develop a plan, including delivery dates for the completion of the ES&H program elements and a staffing plan that supports it.	July 31, 2005
3. Compile technical specifications and safety criteria for equipment that is being developed by LCLS and its collaborating laboratories and adopt the "best practices" to be uniformly used.	August, 31 2005
4. Review LCLS systems that are used by other SLAC organizations and develop a common safety program for shared use.	By next DOE LCLS Review

7. Instrument MIE

SC10: John Haines

- Charge Item No. 5: Is SLAC adequately prepared (e.g. organized and staffed) to start conceptual design of the instrument MIE project?

7.1 Findings

- Organization needed to execute the MIE project is defined well enough for the CD-0 stage
  - Key positions identified (although many still need to be filled)
  - Technical interfaces defined at an appropriate level
- Plan for staffing ramp-up is reasonable and necessary to support an aggressive Phase 1 schedule
  - Requires making some key hires over the next six months (e.g. lead engineer, 3 instrument scientists)
  - Ability to make key hires requires FY06 funding
- Science thrust areas and instruments have been selected and project is engaged with the science teams
  - Four instruments cover three science thrust areas

7.2 Comments

- Plans for integrating the MIE science and technical teams with LCLS (especially with the AMO instrument) in a practical way regardless of organization are encouraged
- Integration of administrative and support efforts (e.g. ES&H, project controls, finance) with LCLS should be done to ensure efficient use of resources
- Need to clearly define the roles and responsibilities of the science thrust area leaders/teams relative to the interface with the MIE for all phases of project execution and into operation of the experiments
  - Required soon for the project execution phase (e.g. Preliminary PEP for CD-1), but addressing this early will avoid confusion

7.3 Recommendations

1. Create an “Implementation Plan” that formalizes a mutual agreement to coordinate the division of resources between the instrument MIE and LCLS projects
2. Include a member of the MIE management team on the LCLS Change Control Board