U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Review Committee

for the

Linac Coherent Light Source (LCLS)

at the

Stanford Linear Accelerator Center

May 13-15, 2009

Daniel R. Lehman

Review Committee Chair

Office of Science, U.S. Department of Energy

http://www.science.doe.gov/opa/

Charge Memorandum Charge Questions

1. Are the project's remaining cost, schedule, and technical baselines realistic, reasonable, and consistent with the current approved Project Execution Plan? Is the information in the DOE Project Assessment Reporting System consistent with physical progress?
2. Are the designs, procurement, and commissioning plans of the scientific and technical systems sufficiently mature to support the project schedule? Has LCLS properly addressed instrument scope issues identified by the Instrument Development Teams?
3. Has the renovation of office space (Buildings 28 and 751) been integrated into the appropriate project planning and execution documents, and is progress appropriate to complete this renovation as scheduled?
4. Are risks properly managed and is there adequate contingency (cost and schedule) to address the risks inherent in the remaining work?
5. Is the project properly managed (organization, adequate staffing) to complete construction and technical equipment installation and commissioning? Does the project have the 'end game' properly planned and are they capable of completing the project as defined in the Project Execution Plan? Is transition-to-operations planning adequate?
6. Are ES&H aspects being properly addressed?
7. Has the project responded appropriately to recommendations from prior DOE and other reviews?

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Review Committee Participants

OFFICE OF SCIENCE

Daniel R. Lehman, DOE/SC, Chairperson

SC1
Accelerator Physics

* George Neil, TJNAF
Michael Borland, ANL

SC2
Injector/Linac

* Richard Sheffield, LANL

SC3
Undulator

* Erik Johnson, BNL
Steve Marks, LBNL
Toshiya Tanabe, BNL

SC4
Photon Beam Handing Systems

* Dennis Mills, ANL
Mark Beno, ANL
Zahid Hussain, LBNL

SC5
Control Systems

* Larry Hoff, BNL
Elder Mathias, CLS

SC6
Conventional Facilities

* Dixon Bogert, Retired FNAL
Mike Schaeffer, BNL

SC7
Cost and Schedule

* Cathy Lavelle, BNL
Angus Bampton, PNNL
Ray Won, DOE/SC

SC8
Project Management

* Brenna Flaugher, Fermi
Chad Henderson, DOE/PNSO

SC9
ES&H

* Arnold Clobes, LLNL

Observers

Pedro Montano, DOE/SC
Tom Brown, DOE/SC
Hanley Lee, DOE/SSO
Hannibal Joma, DOE/SSO
Brian Huizenga, DOE/OECM
Bob Raines, DOE/OECM

LEGEND

* Chairperson

Count: 20 (excluding observers)

Report Outline/ Writing Assignments

Executive Summary……Won

1. Introduction……Brown

2. Technical Systems Evaluations

   2.1 Accelerator Physics (Charge Question #1,2,4,7)……Neil/Subcommittee 1

      2.1.1 Findings

      2.1.2 Comments

      2.1.3 Recommendations

   2.2 Injector/Linac (CQ#1,2,4,7)……Sheffield/Subcommittee 2

   2.3 Undulator (CQ#1,2,4,7)……Johnson/Subcommittee 3

   2.4 Photon Beam Handling Systems (CQ#1,2,4,7)…Mills/Subcommittee 4

   2.5 Control Systems (CQ#1,2,4,7)……Hoff/Subcommittee 5

3. Conventional Facilities (CQ#1,3,7)……Bogert/Subcommittee 6

4. Environment, Safety and Health (CQ#6,7)……..Clobes/Subcommittee 9

5. Cost and Schedule (CQ# 1-4,7)……Lavelle/Subcommittee 7

6. Project Management (CQ#1-5,7)……Flaugher/Subcommittee 8

2.1 Accelerator Physics

Michael Borland, ANL
George Neil, TJNAF

2.1.1 Findings

- Commissioning of the injector, linac and bunch compressors has been outstanding. Beam quality at the end of the linac meets/exceeds requirements for operations.
- Safety is integrated into all planning for the accelerator systems
- The MatLab-based controls have made it possible to write powerful applications which have greatly facilitated commissioning.
- Transitioning to operator control is a work in progress and is at the appropriate stage of development.

- **This area has met the CD-4 requirements for wavelength and flux early and on budget**

- **Congratulations on this spectacular achievement!**

2.1.1 Findings (continued)

- It appears that beam availability and MTFB (Mean Time Between Failure) will not be at the level that storage ring x-ray users generally expect.
  - It is unclear what impact this might have on experiments.
  - There seems to be insufficient dialog with the user community about such issues.

2.1.2 Comments

- Should proceed quickly to replace (& improve resolution) of the old beam position monitors in the linac. The present BPM performance is an impediment to optimization and operations

- Replacement of legacy controls is important to meet availability and control for users. For example, the ability to perform trajectory feedback is limited in some sections of the accelerator.

- **It is incumbent on the team to understand the details of the performance** so that others in the DOE and international community can apply the lessons. Experimental comparisons to models needs to be completed for reduction of design contingency in future LCLS upgrades and for benefit of other machines.
  - Need to carry out extensive beam studies as planned
  - Implement start-to-end modeling for support of this activity

2.1.3 Recommendations

- None

2.2 - Injector/Linac

Richard Sheffield
Los Alamos National Laboratory

2.2.1 Findings

- Accelerator is operating at the design point and is consistent with the particle beam simulations.
- The FEL performance is consistent with the measured electron beam properties.
- Based on present results, all beam-dependent CD4 milestones are well in hand.

An exceptional accomplishment. These results demonstrate the practicality of 4th generation FEL x-ray light sources!

2.2.2 Comments (general)

- Response to last reviews recommendations:
  - Establish schedule for early implementation of wire scanners in sector 24: successful operation has lowered the priority for the wire scanners.
  - A plan for implementing higher resolution BPMs in the remaining linac: the components have been ordered, plan to be installed in July, and operated in August. The installation of the higher resolution BPMs should enable more repeatable and faster energy change for x-ray wavelength variations.

2.2.2 Comments (general)

- The following two comments are not part of project construction scope:
  - One significant hardware concern that still needs to be addressed is the upgrade of the RF legacy computer components and power supplies to modern systems.
  - Operations at 120Hz were last performed in 1997, operating at this duty factor again could produce component failures and result in un-anticipated down-time.

2.2.2 Comments (general)

- Extraordinary and world-class results are:
  - Production, bunch compression, and propagation to an undulator at 14 GeV of sub-micron emittance beams at a substantial fraction of a nanocoulomb,
  - Generation of 10 GW of 1.5 Å laser light,
  - And, perhaps most impressive, that the FEL was brought up to full power in weeks. This implies a very robust system and bodes well for users and for future 4th generation machines world-wide.

2.2.2 Comments (schedule & cost)

- N/A - injector/linac systems commissioned

2.2.3 Recommendations

- None

2.3 LCLS Undulator

13-14 May 2009

Erik Johnson (BNL),
Steve Marks (LBNL),
Toshiya Tanabe (BNL)

2.3.1 Findings (I)

Undulator team has overcome significant challenges

- At project conception
  - undulators required for this project ~ installed inventory world wide
  - tolerances and specifications beyond state of the art for FEL undulators and diagnostics
- During construction
  - developed mass production and value engineering methods
  - develop/refine technologies for component manufacture (RF BPM, chamber roughness)
  - constructed production scale MMF
- During commissioning
  - capabilities of installed undulator contributed to flexibility in FEL commissioning (canted poles, alignment tools)

2.3.1 Findings (II)

- Cost, Schedule & Contingency on track
  - Substantially complete
  - WBS 1.4 TEC 45,720 K$ 99.33% complete as of March 2009
  - Baseline objectives met or exceeded
- Designs, procurement & commissioning plans mature?
  - 28 of 33 undulator modules installed
  - FEL Saturation achieved at 1.5 Å with 18 installed (less needed to saturate)
- Undulator functionality clearly established
  - Remaining risk registry entry for mechanical failure of undulator
  - Monitoring undulators for damage (radiation/thermal/ ...) during commissioning
  - Have plan for rotating undulators through MMF to monitor
- Team has been responsive to the recommendations from the May 2008 Independent Project Review

2.3.2 Comments

- Undulator team started capturing lessons learned
  - need to roll these up (with more detail) into the project lessons learned
- Mechanism for radiation damage of under investigation
  - As mitigation strategy against possible damage :
    - Periodically remove and measure undulators
    - Tune and/or repair as necessary
    - Rotate back into service
  - Subcommittee encourages continued (expanded) study of radiation damage issues
  - Until detailed understanding of damage mechanism is understood, subcommittee endorses rotation strategy

2.3.3 Recommendations

1. Incorporate the valuable knowledge gained by the team during the development and construction of the undulator systems into the project lessons learned. Include sufficient detail that this knowledge can be utilized by the SLAC/LCLS staff to guide future work, as well as being shared in a meaningful way across the complex (Complete by CD-4)

2. Maintain measurement facility and develop repair capabilities as continuing risk mitigation strategy against possible radiation damage of undulators (continue to CD-4 and beyond).

2.4 Photon Beam Handling Systems

1.5/2.5 X-ray Transport, Optics, and Diagnostics (XTOD)
1.6/2.6 X-ray End Stations (XES)

Mark Beno (ANL), Zahid Hussain (LBNL)
and Dennis Mills (ANL)

2.4 Findings

New things in XTOD and XES since the last review:

- Geoff Pile is now responsible for Photon Beam Systems Installation and Engineering (effective Mar 09) and seems to be doing a good job keeping the front end, beam transport, and end station installation on track.

- X-ray beam transport scope has been removed from LLNL hands and is now the responsibility of SLAC.

- Far Experiment Hall now includes 3 hutches and equip mezzanine.

- Since the last review a Soft X-Ray (SRX) instrument has been added to the scope of the XES
  - consortium formed between Stanford University, the University of Hamburg, CFEL (at DESY), LBNL, and the LCLS.
  - $1500K from LCLS contingency allocated to this, which will leverage an additional $2927K from consortium members

2.4 Findings (continued)

General Findings:

- All soft X-ray mirrors have arrived (including a spare) and are at LLNL.
- All except one of the hard x-ray mirrors have arrived. They still need to be coated by LLNL.
- Vacuum chambers for the mirrors have not yet arrived (but should be here any day now) and installation schedule for the mirrors is very tight.
- Nonetheless, there seem to be no showstoppers to reach the CD-4 milestones.
- Although the suite of the early science experiments is very impressive, their success could be at risk because of the tight installation and short commissioning schedule.

2.4 Comments

- The commissioning schedule of many of the novel/unique components in the FEE is very ambitious and challenging.

- The AMO schedule is also ambitious but do-able.
  - Complete mechanical instrument installations by June 30th
  - Can start AMO commissioning in July (w/o Refocus System & Magnetic Bottle)
  - Install Refocus Optics by the end of July
  - Users in September

- SXR schedule is even more ambitious, particularly considering the SXR instrument had slow start due to funding issues.
  - Very ambitious schedule but do-able
  - Critical paths are monochromator and the K-B mirrors.
  - SXR should be ready for beam by the end of February 2010.

- Close collaboration will be required between the controls group and experimenters to assure successful early science.

2.4 Recommendations

- Continue the close coordination between LCLS and LLNL by monitoring delivery and installation schedules for remaining FEE components.

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2.5 LCLS Controls

Larry Hoff (BNL)

Elder Matias (Canadian Light Source)

2.5 Findings

- Electron beam controls efforts are essentially complete
  - New MPS system successfully deployed
  - Impressive suite of MATLAB-based physics applications
  - Sufficient for producing “first light” (and therefore CD-4)
  - Further enhancements AIP, operations funded
- Remaining controls activities involve photon beamlines and end-stations
  - “Slow” controls, data acquisition (DAQ), MPS, PPS
- There was a $1.14M cost variance in January
  - Related to excess XTOD installation labor charges

2.5 Comments

- Cost and schedule seem adequate for remaining work
- No significant remaining technical issues
- Electron beam controls lack ability for “rapid” energy changes
  - Affects beam-based alignment
- 120Hz electron beam feedback systems not fully developed
- Smooth integration of user-supplied detectors benefits from clear interface definitions and timely review
- As well as adequate “staging area” prior to installation

2.5 Recommendations

- None

3.0 LCLS Conventional Facilities
DOE Review 5/13-14/09

Dixon Bogert - Fermilab
Mike Schaeffer - BNL

Findings and/or Comments

The underground and surface facilities necessary to produce x-ray light have been completed, equipment installed, and x-rays produced. A very impressive facility was shown to the reviewers on tour.

The Turner contract is complete but not closed. Negotiations over claims and retention continue.

The remaining conventional facilities work consists of two areas of activity:

1) The construction of three hutches in the Far Experimental Hall.
2) The creation of some office space.

The design work for the hutches is complete; bids on construction are due May 19th. The structural steel required has already been procured and is being fabricated.

Findings and/or Comments

The design for rehabbing/refurbishment of two existing SLAC locations (parts of Building 28 and Building 751) is almost complete (due June 1) and the project is prepared to bid this work in June, 2009.

The project has prepared an alternate option in lieu of the refurbishment of Buildings 28 and 751. The alternate is to construct a new "LCLS Office Building" under a "guaranteed maximum" design/build contract. In order to have a firm basis of choice, proposals have been solicited and are being evaluated.

The execution of this "guaranteed maximum" contract will exceed the current cost baseline for this work. The project must evaluate carefully the available contingency for the entire project before committing to proceed. The work can be completed within the schedule float to CD-4.

Findings and/or Comments

The project has the information and methodology to make an informed decision on whether it is possible to proceed with the more expensive "guaranteed maximum" construction.

Safety performance during the final work of the Turner contract improved. The safety record on work outside the Turner contract continues to be good.

The closeout of retention and settlement of the Turner contract claims has been slow. The project could consider a counter-claim to Turner to offset management expenses associated with the time connected with closing the contract.

The project should be congratulated on the facilities construction accomplishments to date.

Recommendations

1. **Carefully review the contingency available across the project before any commitment to proceed with the "guaranteed maximum" procurement of the LCLS Office Building option in lieu of the baselined building renovation projects.**

2. **Continue to examine and implement proactively all possible factors necessary to achieve an exemplary safety record on the remaining work.**

3. **Close out the Turner contract.**

4.0 ES&H SUBCOMMITTEE

Arnold Clobes
LLNL/NIF

Findings

- Recommendations from the May, 2008 Review have been adequately addressed
- The safety record since the last review demonstrates an effective application of ISM
  - Total Project DART = 1.02 (2.16 M work hours)
  - LCLS Collaborators DART = 0.26 (1,566 K work hours)
  - LCLS CF subcontractors, Technical Systems Installation and Commissioning is well managed with an exceptional safety record. (zero recordables in 120k work hours)
  - 280 days w/o DART and 180 days w/o a recordable.

Findings

- The Turner Contract experience has been effectively captured and documented in two Lessons Learned.
  - ES&H specific addresses the CMGC experience
  - ES&H combined with project management experience
- Based on these Lessons Learned, future CMGC contracts will include significantly improved ES&H requirements
  - ES&H will be an integral part of the Technical Evaluation
  - Subcontractor qualification form included in the Technical Evaluation
  - Experience Modification Rate more stringent (0.81 from 1.0 to 1.25), subcontractor 3 year OSHA record reviewed as part of evaluation,
- Remaining conventional facilities construction needs to ‘keep the eye on the ball’
  - Incorporate LL’s from previous experience
  - Execute Lab program for subcontractor selection and oversight

More Findings

- Lesson Learned
  - Project LL are developed and placed in a SLAC database
  - Improvements are needed in dissemination and use within LCLS, SLAC and DOE.
- LCLS ES&H processes have been adopted by and improved by SLAC, are now being used in LCLS as an institution wide process.
  - Demonstrates an effective Continuous Improvement process
  - Includes WP&C, Safety Observations and Construction safety

More Findings

- Project safety documentation (e.g. Fire Hazard Analysis, Hazard Analysis Report, Safety Assessment Document, etc) is reviewed periodically throughout the project life cycle, and is current.
- Readiness Reviews are conducted and consistent with the Project status
  - Accelerator Readiness Reviews – LCLS process in place to review phased turn over from Commissioning to Operations
    - Includes update and SSO Approval of Accelerator Safety Envelope
  - Instrument Readiness Reviews – similar to ARR
- Transition to Operations is well underway including the User program
  - Dedicated ES&H Personnel in place addressing both Operations and User safety issues.
  - SOP's indentified and in development
  - Based on SLAC experience and bench marked against other National Lab's

Comments

- The Feb ’09 Risk Registry states regular Safety Audits will be conducted at the completion of major activities as steps for handling ES&H risk.
  - Safety Audits have been done but dropped off in the last year and should be resumed.
- The LCLS ES&H support staff is capable and has an effective working relationship with line management.
  - the number of staff is may not be consistent with the workload associated with the many concurrent LCLS activities.
- The Lab’s ES&H Division support to the LCLS Project, appears adequate
- The interactions with SSO are collaborative and effective.

Recommendation

- Evaluate the ES&H staffing level required for Operations prior to start of User Program and adjust as necessary. (Sept 2009)

5.0 Cost and Schedule

Review of the Linac Coherent Light Source

13-15 May 2009

Cathy Lavelle, BNL

Angus Bampton, PNNL

Raymond Won, DOE/SC

5.1.1 Findings

- Project cost/schedule and technical baseline is realistic and consistent with current PEP and data reported in PARS.

March 09	$M		
	TEC	OPC	TPC
Actual Cost of Work Performed	$315.6	$45.3	$360.9
Estimate to Complete	$29.4	$16.7	$46.1
Estimate At Complete	$345.0	$62.0	$407.0
Budget at Completion	$352.0	$68.0	$420.0
Total Available Contingency	$7.0	$6.0	
Percent Complete	91%	70%	89%
Cost Performance Index	0.99	1.06	1.00
Schedule Performance Index	0.98	0.97	0.97

5.1.1 Findings

- Planned funding was received in FY09, and enables early science and acceleration of the procurement schedule.
- There are several scope enhancements totaling $4.5M since the last review:
  - XSR Instrument Installation and Integration - $1.5M
  - Far Hall Hutch 6 and Mezzanine – $800K
  - Building 28 Office area increase – $2.15M

5.1.1 Findings

- A risk assessment was completed by the project in March 09 validated the $7.0M remaining contingency based on EAC.
- LCLS Office Space:
  - Renovation cost is close to recent new construction cost at other sites.
  - The new office construction alternative has a guaranteed maximum cost.
- The project responded appropriately to the project cost and schedule recommendations from the May 08 review.

5.1.2 Comments

- Estimates to Complete are developed and appear reasonable.
  - WBS 1.5 & 1.6 - Reasonable recovery plans have been developed and are reflected in EAC. Photon System schedules are aggressive.
  - WBS 1.9 – A contract claim estimate is included in project baseline.
    - Supported by external independent assessment.

5.1.3 Recommendations

- Consider the new office construction alternative if:
  - Upcoming bids for Hutches are within plan
  - The project schedule recovery plan is successful per April/May performance.
- The November 2007 PEP should be updated if significant changes occur on the project (e.g. Tilt-up Building).
- Add cost/schedule EVMS to Lessons learned document.

6.0 Management

Brenna Flaugher, FNAL

Chad Henderson, DOE,PNSO

Findings

- The project team responded well to the recommendations from the May 2008 review.
- DOE recently raised the procurement authority for SLAC to $1M.
- The project has developed an end-game plan and DOE and SLAC are supporting it.
- An LCLS directorate has been put in place and is engaged in the transition from a construction project to operations as a user facility.
- Staffing of the new organizational structure of the LCLS directorate is in progress with a number of key positions still to be filled.
- The LCLS Project has a letter indicating that the AMO design meets the requirements of the AMO Design Team

Comments

- LCLS is on track for successful achievement of it's technical, cost and schedule goals.
- There are good channels of communication between the project and DOE.
- Plans for contingency usage and use of American Recovery and Re-investment Act (ARRA) funds will continue to place high demands on the LCLS procurement office for at least another year.
- As pieces of the project are finished, they should be incorporated into a draft close-out report.
- It is unlikely that another on-site progress review will be needed.

Recommendations

- Continue close and frequent communication between the project and DOE on progress towards completing the CD-4 deliverables by July 2010.
- Monitor work load and staffing of the LCLS procurement office through the end of the project.
- Start preparation of the Close-out report now so that a nearly complete draft is available at CD-4.