LCLS RESPONSES TO:

Department of Energy
Review Committee Report
on the
Technical, Cost, Schedule, and
Management Review
of the

May 2003

LINAC COHERENT
LIGHT SOURCE
(LCLS) PROJECT

July 2004

2. Long-Lead Technical Scope

2.3 Recommendations

1. Carry out previous DOE review recommendations regarding design trade-offs of the undulator and fabrication of the second prototype by CD-2b (April 2004).

a. From DOEApr2002 – Complete a thorough value engineering and production analysis of the undulator mechanical design. Trade offs on the choice of strongback materials, thermal compensation and phasing control, physical tolerances, and relationship between stringent tolerances and post assembly tuning must be completed. This is to be completed prior to submitting for bid any long-lead procurement.

Value engineering and production analysis of the 1st prototype have been continual since its design inception and throughout its history following its successful tuning on the measurement bench.

This 1st prototype was designed to permit construction by trained, but not necessarily highly skilled technicians. It was constructed at the APS by such a team of chosen technicians whose progress was monitored by APS engineers to evaluate the assembly process. Assembly of the 1st prototype progressed without any significant issues arising, and it was felt that this process could be easily transferred to industry. Following construction the magnet was placed on the magnet measurement bench, measured and tuned to the requirements of the LCLS. Without tuning it met the performance specifications in the horizontal plane and required very little tuning to bring it within tolerance in the vertical plane. It is expected that tuning of the production undulators should proceed rapidly once the initial learning curve is surmounted. Tuning should take no more than a couple of days per undulator. The schedule has allocated 5 days per undulator following the learning curve period.

A number of things were learnt in the course of testing the first undulator, and a number of innovative ideas have been developed since its first measurement. Value engineering of the design has been an ongoing process. The 1st prototype has repeatedly been modified and remeasured to test these ideas and modifications. The use of a canted pole concept has been successfully implemented to allow quick setting of the undulator K value and to allow for tapering in the future. This has also alleviated the need for phase tuning devices at the end of the undulator. A modification in the design of the poles has also been tested and found to be acceptable. This will simplify the construction and thus reduce the cost of the many poles that will be constructed. Other concepts have also been explored such as a back pole shunt for field control, but felt to be too complex and costly to implement successfully.

The stability and robustness of the design have also been tested. Following the first measurement of the prototype it sat undisturbed for over one and one half years. It was then place back on the measurement bench and remeasured. The trajectory walkoff values and rms phase errors were nearly identical to the previous measurements and within measurement errors. The over all field strength also remained unchanged within the known inherent error of the measurement. The undulator was next placed on a forklift and driven around the entire length of the APS to simulate transport during installation. Following this it was remeasured. No changes were detectable.

Two reviews of the undulator have also been conducted over the last year. One was held in October 2003 and was specific to the undulator magnet. A second review held in March 2004 encompassed the entire undulator system, but focus was also placed on the undulator magnet and the additional engineering enhancements that had occurred in the intervening period. The findings of these successful reviews were listened to and implemented where appropriate.

The issue of whether we should use titanium for the strongback material continues to be broached. We have continued to listen to the comments and have continued to explore possible uses of other materials such as brass, stainless steel, or cast aluminum, but have yet to find a material better suited to the task than titanium. We continue to present and defend this as our chosen strongback material and have since won endorsement of our selection by our undulator review committee.

The magnet material choice has at times also been called into question. This is due to its possible susceptibility to radiation damage. We feel that the alternative material does not have enough clear advantages to out weight the success we have had with our chosen material and feel that the risk of embarking on such a radical change in the magnet design is far greater than the radiation risk. We will mitigate this risk by producing additional undulator spares and will plan for regular swapping in and out undulators during maintenance periods to check for their magnetic qualities on the magnet measurement bench. Should a magnet be found to be damaged it will be fixed by methods similar to those used at the APS to fix radiation damaged magnets.

b. From DOEApr2002 – Focus the second undulator prototype on addressing mass production issues. The design and technical approaches are sufficiently advanced that production issues are the most urgent. If a second prototype is pursued, this recommendation must be completed prior to CD-3. If industrial production is selected, the second prototype should be produced in industry.

Due to financial reasons we have chosen not to produce a second prototype. Instead we pursued improvements of the first prototype as described above. It is our intentions, however, to pursue 1st article undulators from industry and to do this in a manner identical to how we will pursue the acquisition of the full production run. This will occur during the FY2005 period and will allow us to assess the industrial production process before starting the production run. The production run will occur during the FY2006 period.

c. From DOEApr2002 – Build and field a complete prototype subsystem consisting of an undulator (the existing prototype is adequate), vacuum chamber, a short diagnostic/focus section, and a long diagnostic/focus section. This should include the electron beam diagnostics and x-ray beam diagnostics. This is to be completed prior to CD-3.

Due to the very late arrival and limited quantity of FY2004 funding we have not been able to pursue this excellent idea; however, we should be able to complete this task during the FY2005 period.

2. Develop a prototype of the undulator beam position monitor, and test with beam to demonstrate resolution by September 2004.

Due to the limited quantity of FY2004 funding we have not been able to pursue this excellent idea; however, as part of the Next Linear Collider R&D, tests have been made at the Accelerator Test Facility in Japan. These tests have demonstrated the required resolution. We are fortunate to have access to the people who were essential to those tests and plan to capitalize on their experience.

3. Establish a dedicated team of experienced personnel at ANL for the manufacturing procurement activity, and develop a quality assurance plan for the procurement by CD-2b (April 2004).

A dedicated, experienced team of scientists and engineers has been assembled at ANL. The team has designed, constructed, and tested the prototype undulator, and has presented the results at several internal and external reviews. Team members also have recent large-project experience. Procurement activities are being integrated into the ANL procurement system, and a draft QA plan exists.

4. Establish a section of laser/optical physics within the project's organization. The section will serve the injector drive laser, beam transport, and optical diagnostics, but inevitable support will be needed for LCLS experimental efforts by CD-2b (April 2004)

It is planned to establish a laser/optical group within the LCLS project. An optical engineer has been hired to manage the injector drive laser. A laser physicist to head the laser/optical group will be hired once funds are made available in FY05.

5. Review approaches with adequate optical modeling for drive laser power amplifier and compressor components with vendors, and pursue in-house development if sufficient vendor interest cannot be established by CD-2b (April 2004).

Meetings with perspective laser vendors demonstrated strong interest by the vendors to build the injector drive laser. The drive laser requirements now allow the power amplifier to be fully diode pumped resulting in a more reliable and stable laser system. Three of the vendors propose to cryogenically cool the power amplifier TiS crystal to greatly reduce the thermal lensing introduced by the pump lasers. The compressor will not be a technical issue provided the beam is made large or if it is installed in vacuum. Because of the expense and complication, we will request a large beam to avoid non-linear effects in air. Therefore sufficient vendor interest has been established for the purchase of the laser power amplifier and compressor components.

6. Find space at SLAC or elsewhere (LLNL or LBNL) for early development of the laser capability. Such a crucial development of critical performance cannot wait until the last year for the first on-site test efforts. Also develop a plan so that long-lead procurement may be placed at the earliest possible time as soon as funds are made available. The facility must be available before delivery of the laser; the plan must be in place by CD-2b (April 2004).

Funding limits have prevented early development of on site laser capability. The principle technical issue for the drive laser is the temporal shaping of the beam into a square 10 ps long UV bunch. As part of our collaboration with INFN/Frascati, we have access to a Dazzler shaper with an extra long crystal. Tests done in Italy using a low power laser beam show this device is capable of producing the desired square pulses but with some additional oscillations during the flat top. Certainly this can be improved, however it is important to extend these tests to include a full laser system with a power amplifier and third harmonic generation. We have proposed performing these tests at the BNL DUVFEL which has not only the laser system and diagnostics, but also a photocathode gun for measuring the improvement in the electron beam. The plan calls for these tests to be performed during October and November, 2004.

The issue of third harmonic generation efficiency using a flat transverse profile is also being investigated using a laser system at the Argonne APS facility. SLAC has purchased the components for these tests.

7. Perform a successful conceptual design review of the superconducting wiggler to establish firm specifications for procurement by January 2004.

The superconducting wiggler has been removed from the LCLS baseline design. Its function has been replaced by the lower risk laser heater.

8. Review and update the schedule prior to CD-2b (April 2004) for injector development to optimize resource loading in FY 2005, and to demonstrate the required performance of critical components at earliest possible time.

A resource loaded schedule for the injector is complete and shows injector commissioning beginning in May 2006. This gives more than a year of testing of the injector since the first beam on main linac axis isn't required until June 2006 and injector system commissioning is scheduled to end Jan 2007.

9. Establish an engineering change control board by CD-2b (April 2004).

The LCLS team has established a Technical Change Control Board (CCB) for the project. The CCB is made up of the LCLS Project Director, Chief Engineer, Project Controls Head, System Managers, and representatives of SLAC Procurement, QA, ES&H. The CCB typically meets monthly and reviews all proposed changes to the LCLS project above $100K (or > than 1 month delay to any Level 2 milestone), and makes recommendations to the LCLS line management. Changes to the LCLS technical scope, project performance and/or interfaces between subsystems are also reviewed by the CCB. Further details on the roles and responsibilities of the CCB can be found in the LCLS Project Management Plan.

3. COST and FUNDING

3.3 Recommendations

1. Provide comparison cost tables (with contingency segregated) to show changes that have been made between DOE reviews. It will be important to have this comparison available for CD-2b (April 2004).

A cost comparison table has been prepared to show the CD-1 to CD-2a to CD-2b evolution of project scope with explicit contingency assumptions. This will be presented at the CD-2b review.

2. Review which participating laboratory should make major procurements with consideration of the laboratory's materials and services markup rates.

Responsibilities for all LCLS procurements were reviewed during the development of the LCLS baseline. These responsibilities have now been defined and are identified in the project baseline (P3/COBRA). At a high level, procurements are being managed by one of the three decentralized procurements departments, with the following primary focus:

ANL – Undulators (WBS 1.4, 2.4);
LLNL – X-Ray Transport, Optics and Diagnostics (WBS 1.5, 2.5)
SLAC – Remaining LCLS scope

The detailed list of procurement responsibilities can be found in the LCLS cost estimate which is derived from the project baseline. Going forward, changes to procurement responsibilities can be made (with appropriate change control) should it be in the best interest of the LCLS mission to do so. LCLS will continue to work to optimize the applied overhead rates at its three partner labs, however to reduce risk to the project, LCLS does not make procurement decisions solely on markup rates, but rather in consideration of reducing overall risk (technical, quality, cost, schedule and procurement) to the LCLS project.

3. Insure that initial spares ordered with the long-lead procurements portion of the project budget are necessary and do not impact other more critical equipment orders.

SM: Long-lead procurements for the undulator include the Titanium strongbacks, the magnet blocks and the vanadium permendur. Because of the high tolerances required for the completed undulators we fell it is prudent to purchase all the above materials including quantities required for spares at the same time. This will help better insure uniformity in quality and material. This plan will not impact any other equipment orders as it is the undulators that are on the critical path.

4. SCHEDULE

4.3 Recommendations

1. Development of a detailed critical path schedule must be completed prior to CD-2b (April 2004).

A detailed critical path schedule for the LCLS has been completed and will be presented in detail at the CD-2b/CD-3a DOE review in August 2004. At a high level, the critical path of the LCLS is seen to be driven by construction and assembly of the Linac-to-Undulator (LTU) transfer line and Electron Beam Dump, both of which are driven by available dates for beneficial occupancy. Currently the LCLS critical path estimates 140 days of total available float with respect to CD-4 (October 2008).

2. The schedule associated with the completion of the undulators, magnetic measurement, and installation must be examined to increase, or maximize schedule contingency prior to CD-2b (April 2004).

We have recently (June 2004) undergone an extensive review and revision of the undulator measurement and installation plan. This has resulted in a baseline change request. This new undulator measurement and installation plan is highly pipelined thus maximizing schedule contingency.

5. PROJECT MANAGEMENT

5.3 Recommendations

1. Expand the configuration management system and implement change control processes before CD-2b to minimize the risk of post-procurement changes to long-lead procurements

With a project baseline internally baselined in March 2004, the LCLS management implemented a configuration management system and formalized its change control processes. In detail, the following items are under configuration management:

- LCLS Project Management Plan (with Appendices)
- LCLS Advance Procurement Plan (w/ Critical Procurements Appendix)
- LCLS Quality Implementation Plan
- LCLS Risk Management Plan (with Risk Registry Appendix)
- Technical Specifications Documents (with GRD, PRDs, ESDs, ICDs)
- WBS Dictionary
- LCLS P3 Cost & Schedule Database (with Baseline Change Requests)
- LCLS L1-L2-L3 Milestones

These processes are documented in the LCLS Monthly Report using earned-value reporting (Cost Performance Report) and change control (Change Log).

2. Examine solidification of matrix agreements between various functional units within SLAC and the ANL Advanced Photon Source with the LCLS project. Some laboratories employ a formal matrix agreement that clearly establishes levels of support required, responsibilities and obligations of the project, and the functional organization. The project may wish to examine such agreements as a model.

The LCLS-ANL Project Manager and the Associate Director for the Advanced Photon Source arrived at an agreement on staffing availability for FY2004, which has been in place thru the FY. A formal agreement for personnel/staffing has not been standardized for the LCLS; more uniform implementation will be given serious consideration.

3. Begin detailed procurement planning of long-lead items by September 2003. This should include the formal trade study of the various procurement options mentioned during the review; the critical planning and scheduling of requirements, specifications, bid, and quality assurance packages; bid preparation by potential suppliers, and bid evaluation and award. Every effort should be made to permit the immediate award of procurements as soon as funds are provided rather than waiting to release requests for bids/proposals until after such authorization is in hand.

The first major procurement of FY2004 was the architect/engineering contract for LCLS conventional facilities. A request for expressions of interest was published in August of 2003, and nine vendors responded. After review of documentation and on-site presentations provided by all nine vendors in September 2003, four vendors were selected to submit bids. Bids were received in November of 2003. A vendor was selected in December. Procurement planning for other long-lead items have progressed significantly. In the case of the injector laser, a thorough market survey has led to a significantly improved acquisition strategy. Likewise, significant improvements to plans for long-lead procurement of undulator parts have been identified. The prototype undulator tests have given the LCLS team confidence that undulators meeting stringent uniformity requirements can be delivered by two vendors working in parallel. This reduces schedule risk.

At this time the most prudent means of acquiring an X-band klystron is to construct it at SLAC, making use of resident NLC expertise on site. Linac magnets identified for long-lead procurement will be discussed during the presentations.

Written acquisition plans are in various stages of development. LCLS concurs with the recommendation that these procurements be expedited to the extent possible, subject to spending authorization.

4. Conduct an internal project review of the complete undulator system procurement management, support, and logistics sufficiently in advance of the release of bid packages to provide assurance of the completeness of the approach.

An internal undulator system review that will focus on long-lead procurement readiness is planned to occur in September 2004. At present we are readying ourselves by planning for the long-lead procurements. This includes preparation of advanced procurement plans and draft of statements of work. We are also starting to assemble statements of work and have started in-depth discussions with the ANL procurement staff. The above mentioned review will look closely at our readiness and should provide us sufficient time to implement committee recommendations to the procurement packages.

5. The procurement, responsibility, and oversight of the long-lead magnetic measurement system should be clarified before CD-2b.

As presented at the April LCLS Facility Advisory Committee meeting the responsibility for the magnetic measurement facility (MMF) including long-lead procurement activities is clearly delineated. The magnet measurement facility is a SLAC responsibility with ANL acting in a consulting role. ANL will deliver magnets to the SLAC MMF and SLAC personnel will measure and tune these magnets. Upon successful tuning SLAC and ANL will sign that the magnet is tuned. At that point in time the magnet becomes the responsibility of SLAC.

6. Complete a comprehensive risk analysis and management plan of all systems and components before CD-2b. This risk analysis must include all sources of risks and should be controlled and maintained with a central risk registry for the project and each system.

A bottoms-up risk analysis has been carried out, the details of which are captured in the LCLS Risk Management Plan. The LCLS Risk Management Plan includes a Risk Registry which is a living document updated semiannually to ensure that identified risks are identified and actively managed. The risk analysis process and LCLS Risk Management Plan were reviewed during the OECM External Independent Review in May-June 2004.

7. Examine and establish a global quality assurance plan for the project prior to CD-2b. This plan must include roles and responsibilities associated with all systems and relationship to the LCLS Project Office.

A Quality Implementation Plan (QIP) has been developed for the LCLS project which defines roles and responsibilities for quality on the LCLS project. In addition, the LCLS QIP establishes and defines the necessary technical documentation for the LCLS to ensure that all specification and requirements are well-defined.

8. Resolve the discrepancy between the Undulator System staffing requirements and the funding profile, and balance workloads and expectations prior to FY 2004.

Funding limitations in 2004 forced the re-planning of the Undulator system effort. A significant amount of effort was expended earlier this year to develop a complete resource loaded schedule. This schedule was recently reviewed by an external independent committee and found to be acceptable. Funding for FY2004 as well as outlying years is and will be based on this baseline schedule. We will work this plan and provided the money arrives according to plan we should be able to afford the effort required to complete the project.

Biweekly discussions are held between the ANL project director and the APS director. Effort requirements and needs are discussed during these meetings and then relayed to the division directors. This method has proven successful over FY2004 at acquiring the required resources when needed and should continue to be successful in future years.

9. Establish a monthly reporting plan for the long-lead procurements to allow accurate reporting immediately after Critical Decision-2a is approved.

With the approval of LCLS Long-Lead Procurements (CD-2a) budgets for fiscal year 2005, LCLS established an earned-value system based upon a set of interim milestones for its Project Engineering and Design (PED) funds. This system did not track LLP funds as no LLP funds were authorized with CD-2a. The PED “earned-value” milestone reporting system provided performance, variances and indices data on LCLS until the full resource-loaded LCLS cost/schedule baseline was available in March 2004. With the implementation of the full baseline performance system, the “earned-value) milestone system was retired.

6. ENVIRONMENT, SAFETY AND HEALTH

6.3 Recommendations

1. Review the analyses and conclusions in the Environmental Assessment against the evolving designs of the LCLS, its components and Halls, and the results of the geotechnical study to be sure that it remains valid to support the project through design, construction, installation, and into operations.

The Environmental Assessment supports the evolving designs of the LCLS. We have not introduced new hazards, although there may be some changes with respect to volumetric removal of material during the excavation process.

2. Evaluate the level of ES&H staffing needed to support the continuing design process, as well as construction, installation of components, and operations. Determine that point in the future schedule when dedicated full time ES&H support may be needed.

We are at that point now. I believe a funded position is opening up soon.