Response to the March 3,4 2004 Undulator System Review

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On March 3rd and 4th the LCLS undulator system was reviewed. The members of the review team were:

Kem Robinson, LBNL (Chair)
Dieter Walz, SLAC
Eric Johnson, BNL

This document is a summary of responses to recommendations provided to us by the committee in their closeout report dated March 4th 2004.

Section 1: This section addresses the direct responses to the questions given to the committee in their charge.

Question to the Committee: *Review and evaluate the complete system design. Is the maturity of the design known to the level of detail to justify setting the cost and schedule performance baseline at this time?*

Response from the Committee: Not at this time. Many of the subsystems are well prepared to be baselined, but the integrated system has many holes and gaps where uncertainties are quite large and approaches are not even at a concept design level.

Response from LCLS: This is addressed in follow-up to the second question and response, below.

Request to the Committee: *Identify any open design issues that should be addressed prior to setting the baseline.*

Response from the Committee: The integration of rf BPM, quadrupole, vacuum chamber, the cradle (and its design) are of concern. Additional thought and direction on logistics, installation and handling are necessary as well (see specific section comments).

Response from LCLS: The Committee's *to the Committee:* *Is the management team adequately structured for completing the LCLS design?*

Response from the Committee: Yes, with one possible absence. Clear responsibility for total system integration, interfaces and engineering was not identified. A strong project engineering/manager would be very useful.

Response from LCLS: The ANL/APS Team concurs with this advice and is seeking a qualified project engineering/manager.

Question to the Committee: *Are there adequate resources and of the correct skill type to meet the needs of the project?*

Response from the Committee: The present team shows very evident technical and project management strength. However, the dramatic increases in effort required in FY05 are a cause for concern. When resources are augmented so quickly an inevitable transitional period results with decreased productivity and a slowing of progress. It is not clear that this has been adequately anticipated.

Response from the LCLS: This response is addressed in the recommendations below.

Question to the Committee: *Is the project progressing adequately?*

Response from the Committee: Yes, with the resources and funding that are available considerable progress has been made. Progress since the November review is particularly noteworthy.

Additional Comment from the Committee

A specific aspect of the charge requires comment as this review is directed towards achieving the Department of Energy (DOE) Critical Decision 2 (CD-2), Preliminary Design Complete and Approval of the Performance Baseline. The charge states: "Note that this is a pre-baseline (conceptual) design review." However the DOE Manual 413.3 state concerning CD-2:

> *Approval of the Performance Baseline marks the beginning of performance tracking. It also authorizes submission of the total project budget request. Key activities that take place leading up to the approval include preliminary design; development of key performance, scope and schedule parameters; risk assessment; establishment of a performance measurement system; identification of project interfaces; and development of the Project Execution Plan.* (Section 2.2.1, page 2-5, emphasis added)

The DOE Manual 413.3 also states Concerning Preliminary Design

> …*Preliminary design initiates the process of converting concepts to a design appropriate for procurement or construction. This stage of the design is complete when it provides sufficient information to support development of the Performance Baseline. The appropriate completion percentage is dependent upon the project. … For complex projects, the percentage of design may not be definitive because these projects may have many subsystems undergoing concurrent designs that may be at various stages of completion. Scientific systems, such as accelerators and detectors, production and manufacturing facilities, spacecraft and other systems, do not follow a linear process in which all subsystems reach the same maturity at the same time. Concurrency in these types of projects increases the risk because each subsystem design is dependent upon the design maturity of other subsystems.* (Section 6.2, page

6-1, emphasis added)

Consequently, in view of the desire of the project, and the undulator system in particular, to achieve DOE CD-2 in such a short time, the Committee felt obligated to assess the undulator system in that context which is more rigorous than would be required of a conceptual design review.

Section 2: Direct responses to recommendations made by the committee

Recommendation: A Risk Registry and Issues Log should be developed and implemented for the entire undulator system.

Response: The LCLS project has started a project-wide risk registry that we will contribute to. We will further expand upon this to other items that fall outside of the scope of the LCLS Risk Registry definition, but that we feel would be of benefit for us to monitor. An Issues Log will be developed and implemented prior to entry into FY05.

Recommendation: When producing a cost/budget estimate provide a technology maturity and risk (technical, cost, schedule) assessment at the same time as providing a *contingent-free* (50%) number.

Response: The contingent-free cost estimates, estimated contingencies based on design maturity and engineering judgment, and risk assessments have been provided to the project office for all WBS elements.

Recommendation: The integration of rf BPM, quadrupole, vacuum chamber, the cradle (and its design) are of concern. Additional thought and direction on logistics, installation and handling are necessary as well.

Response: We agree that we are further along on individual design than on complete system integration and will start devoting effort to this as soon as additional engineering and design support is available. We believe that, although due care must be taken to successfully integrate the RFBPM/quadrupole/vacuum chamber/cradle, there are no high technical risks associated with this aspect of the design.

Recommendation: Clear responsibility for total system integration, interfaces and engineering was not identified. A strong project engineering/manager would be very useful.

Response: This is planned and we expect to have someone onboard in this role by late summer 04

Recommendation: The dramatic increases in effort required in FY05 are a cause for concern.

Response: We recognize this and have biweekly discussions with the APS Director. He is aware of our needs and continues to make the LCLS a top-priority project of the APS and within ANL.

Recommendation: The Committee recommends that while producing the cost budget estimate, that the undulator system project team also provide a technology maturity, a risk (technical, cost, schedule), and an uncertainty assessment at the same time as providing a *contingent-free* (50% probability percentile) estimate of the WBS element.

Response: Contingency numbers, based on LCLS project guidance, have been included in all estimates.

Recommendation: Unfortunately the delay in addressing recommendations from previous reviews concerning the choice of NdFeB vs. Sm_2Co_{17} has not resulted in a situation that now precludes any action in this area. Consequently, in this present review, the Committee is not ready to endorse the NdFeB material choice, but understands that the Undulator Systems Team must move forward with NdFeB at this time.

Response: Risk mitigation involving upstream collimators, radiation detectors between undulators, roll-away undulators, a clearly defined commissioning plan, 7 additional spare undulators, high-coercivity NdFeB magnet material, low demagnetization fields in the magnet blocks, and monitoring of measurements underway the APS have reduced the risk to the undulators to an acceptable level.

Recommendation: The Committee recommends that the strongbacks, magnets, and poles each be procured from single sources for delivery directly to the undulator magnet assemblers.

Response: We concur and it is part of our acquisition strategy

Recommendation: The Committee notes that the procurement approach being pursued, unfortunately, transfers no risk responsibility to any of the suppliers or assemblers and therefore the Undulator Team must exercise extreme diligence or schedule and cost budgets may be exceeded, or technical performance compromised.

Response: Experience with the prototype undulator indicate that we have mitigated the technical risks of the design. As a result, we expect that bids for assembly of undulator modules will be very favorable. BA favors our decision to follow this path, but we will continue to investigate other procurement strategies where we can transfer additional risk to the vendors

Recommendation: In the same vein the granite for support bases should also be procured from a single source, and in fact, from the same quarry face from that source to minimize variation.

Response: We concur. Alternatives to granite are also under consideration.

Recommendation: The Committee suggests that the team examine the possibility of employing a dithering capability on the quadrupoles for ease of implementation of beam based alignment and the possible use for synchronous detection excitation during startup commissioning.

Response: We recognize the value of this and resurrect our early work on using a EM quad. This may now be possible due to the reduced strength of the quadrupoles and the additional space allocated to the undulator system.

Recommendation: The Undulator Magnet Subsystems group should concentrate on resolving design issues and prototyping a complete system even at the expense of delay in delivery of undulator magnet first article as many particular issues may be uncovered that are simply not known at this time.

Response: We have already begun investigating pursuit of this; however, BA may preclude our following this route.

Recommendation: While the individual techniques well established and evolved, the effort to fully reduce the approaches to production may need to be revisited as it may not be sufficient. Likewise, the logistics and workflow within the SLAC Magnet Measurement Facility (MMF) need to be carefully studied.

Response: The committee saw a preliminary plan for the layout of the MMF. Revised layouts will take into account the committee's concern on workflow.

Recommendation: Given the scarce resources, funding limitations, and lack of a complete systems engineering consideration of the environmental and support issues, the Committee suggests that prototype of the granite support could be deferred.

Response: This will be deferred and we will make use of industry and trade information.

Recommendation: A careful examination of support of granite benches, the size requirements and function should be examined. Access and installation flow must be factored into the design. The Committee is concerned about air flow and induced thermal gradients noting that titanium has thermal characteristics similar to stainless steel and can therefore maintain large thermal gradients for significant periods of time. The total integrated system performance should be modeled to fully understand all of the driving factors and concerns.

Response: We are presently looking to supplement the CAM manager who is focusing on this area with an additional engineer who has extensive background in supports requiring high precision. We will also reexamine the thermal control issue in a more system holistic fashion.

Recommendation: These tradeoffs of various different vacuum chamber designs should be followed up with prototypes to fully understand and address fabricability and finish, vacuum performance (voids/leaks), and mechanical performance (alignment stability). Beam physicists should evaluate the transition pieces with respect to impacts on the beam. In particular with regards to shape changes. A careful mechanical engineering evaluation should be performed of the bellows motions. The electrical conductivity/continuity through transitions must also be fully considered. The projected system performance during commissioning needs to be studied and examined, e.g., pumping, gas loading, recovery time.

Response: We will begin prototyping soon and we will continue to design in such a fashion that minimizes the overall wakefield effects. The wakefields generated by the inevitable variations will also be checked for their impact on the beam performance.

Recommendation: BPM prototype development should be given very high priority. Developing a prototype system would be valuable for proving out system integration approach. Significant effort should be devoted to this in FY 04.

Response: We continue to be bound by funding and it may need to wait until FY05. However, we do understand the risk in this and we will try to redirect some resources to get this crucial task moving forward at a proper pace.

Recommendation: The Committee had only a few areas of potential concern in the area of controls. Among them is the integration with SLAC controls. This needs early attention as the controls are dispersed throughout the WBS and will therefore require particular care in integration. Another area of concern is the rapid jump in staffing in required in FY05.

Response: Indeed controls integration is an area of risk; however, we have a very good experienced team LCLS wide that is focused on achieving clean integration of the controls system throughout the LCLS. As for staffing, see the above comments.