Response to the Comments and Recommendations of the 27 – 28 October 2005 Meeting of the LCLS Facility Advisory Committee*

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1.0 General

Introduction and Charge

The Linac Coherent Light Source (LCLS) Facility Advisory Committee (FAC) met with the LCLS project team on 27, 28 October 2005. The charge of the Facility Advisory Committee continues to advise SLAC, SSRL, and LCLS management on the continued execution of the LCLS Project and Facility development throughout its several phases and systems:

- Accelerator systems design and construction
- Undulator systems design and construction
- X-ray transport, optics and diagnostics design and construction
- Experiment station systems design and construction
- Conventional facilities design and construction
- Planning and execution of commissioning and early operations

The Committee was divided into four subgroups: the Electrons Subgroup that covered the accelerator and undulator systems design and construction, the X-Ray Subgroup that covered x-ray transport, optics, diagnostics and experiment station systems design and construction, the Controls Subgroup, and the Conventional Facilities Subgroup. The X-ray Subgroup was also briefed on the fast x-ray detector development plan and the MIE project that has been separately funded by Basic Energy Sciences Program (BES) within the Office of Science (SC) of the Department of Energy (DOE). Appendix A is a listing of the members of the Facilities Advisory Committee and their respective subgroup assignments. Appendix B is the Agenda of the 27, 28 October 2005 FAC meeting.

The following sections address the specific points of the charge through the summary reports of the subgroups. General comments and recommendations precede these summary reports in this section.

General Comments and Recommendations

Considerable progress in all areas was evidenced during the course of the FAC meeting as summarized in the project director's plenary presentation. The project demonstrated an understanding of the issues that confront it. The major issue confronting the project at the time of the FAC meeting is the conventional facilities cost growth, and this is discussed in the section on conventional facilities. The project has clearly engaged its "boost" phase and

* Meeting was held at SLAC on the 27-28 October 2005. This report contains the committee's final report. Additional text in red (bold) contains the responses from the LCLS management team.

LCLS has been addressing issues. Accommodations for the steep gradients in many areas of the project have occurred. Holes in the accommodation of the ramp up are present and some items are lagging with many more near-critical items in evidence. Delays or cost impacts (for example in conventional facilities) are very quickly amplified and become quite severe.

The FAC is pleased to see that SLAC clearly understands the importance of the project and considers the LCLS Project Director as part of the SLAC Directorate. The LCLS Project Director meets daily with the Laboratory Director and Deputy Directors, and top level institutional commitment and resources are in evidence. While some lower level integration and priorities associated with LCLS may still require some communication and emphasis by SLAC Directorate, over time, top-level attention should continue to diminish any such issues. Engineering and technical resource needs were mentioned by one subsystem as being slow in coming to LCLS from SLAC, but overall resource demands are being met. Although it is difficult during such a time of steep gradients, the FAC would like to encourage LCLS to involve students as much as feasible to provide an educational opportunity of working and developing an understanding of large scientific projects.

In the area of organization, the project is no longer *baroque,* and it is considerably cleaner and easier to understand. Key personnel have been added such as a new Electron Beam Systems Manager and a new Laser Group Leader. Some additional small *fixes* may, nonetheless, be in order. For example, while the FAC understands the logic behind having lasers in the photon beam systems area, at this stage of the project where a significant number of critical parameters are dependent upon the precise performance of laser systems the FAC would prefer to see it reporting into the Electron Beam Systems (c.f. Electron Subgroup Section). Visibility of the cross systems importance of controls should be emphasized if possible (c.f. Controls Subgroup Section). Also, explicit evidence of coordination across all instruments would be beneficial.

Response: Support of laser infrastructure and timing in the Experiment Halls is also part of the Laser Group mandate. LCLS Management judged that, in the long term, operations priorities would be better served by having the laser group report to the Photon Beam Systems Manager. The Laser Group Leader has been assigned Cost Account Management (CAM) responsibilities for the Injector Laser's Cost Accounts. This allows the Laser Group Leader cost and schedule responsibility into the Injector Laser commissioning (reporting to the E-beam System Manager) as well as overall reporting to the Photon Beam System Manager. This provides for the installation and commissioning control over the Injector Laser while maintaining a broad view of the overall laser needs for the entire LCLS project.

LCLS is making a measured response to the reduction of scope necessitated by cost growth in the conventional facilities. Two points of caution are worth highlighting. LCLS should be *very* careful before accepting irreversible changes. For example, a 20-meter shorter tunnel saving $500k may be in the end a very expensive savings (see more details in each of the subcommittee reports). Also, it is important to examine carefully what is actually required for contingency using a suite of approaches rather than just a global anticipated rule-of-thumb. These approaches can include rule-of-thumb at levels lower than total project, expert opinion at or below the subsystem level (sometimes called Delphi Method), and full risk and uncertainty based analysis. In all such analyses of contingency completeness is key. Without such a suite of complete contingency analyses there is no assurance as to whether a level of contingency is adequate, too large, or inadequate. Nonetheless, the approach LCLS is following to the reduction of scope seems appropriate

Response: The LCLS Project employs three methodologies to determine the adequacy of its contingency needs: (1) a bottoms-up assessment of contingency by the LCLS Cost Account Managers based upon guidance from the Project Office, (2) a Monte Carlo statistical determination for the LCLS project cost using recommendations on cost and escalation from the Architect/Engineer and (3) a risk-based cost contingency assessment as part of its monthly Risk Management meeting. All three assessments are in line with management estimates and are determined reasonable for this stage of the project. LCLS Management will have the opportunity to reverse many Value Engineering measures once risks are replaced by information in the form of Conventional Facilities bids.

In the area of project progress monitoring there is some concern that the tools available are not being fully exploited. While earned value is a valuable tool, care must be exercised to avoid judgments of progress based on opinions, rather than confirmed milestones. In particular, if the milestone density is examined, there is concern that it may not be sufficient at the lowest levels of the work breakdown structure (WBS). At WBS Level 1 there are, on average, ~0.9 milestones/year. At WBS Level 2 there are, on average, ~9.0 milestones/year. At WBS Level 3 there are, on average, ~33.0 milestones/year, and at WBS Level 4 there are, on average, ~51.5 milestones/year. During this period of rapid gradient the density of low level milestones should be significantly larger. Ideally, an increase in a factor of 10 from one level to the next would greatly facilitate monitoring progress. So the FAC recommends increasing the number of milestones at lowest control levels so that engineer (or worse, physicist) opinion estimates are not relied upon to monitor project progress. Lower level managers should use multiple aggressive milestones in their updates as a means of identifying areas of concern before they become critical. It is also important that cost managers throughout the project understand that contingency (budget and schedule), not costs, are centrally controlled, and so exceeding the baseline budget or schedule is extremely serious.

Response: As of February 2006, the project is tracking the following milestones: Level 1 Milestones – 7, Level 2 Milestones – 29, Level 3 Milestones – 135, Level 4 Milestones – 211. All CAM's and System Managers are aware of centrally-managed contingency. The process to request contingency allocation is through the LCLS Change Control Board (CCB3).

Additionally, in the area of project progress monitoring, the FAC suggests that LCLS needs to carefully track and identify all remaining risks, trades, uncertainties and unresolved aspects of the project.

Response: The project tracks and assesses risks and uncertainties to its project baseline on a monthly basis using the LCLS Risk Registry.

The project is rapidly moving towards the DOE Critical Decision 3b that authorizes complete construction. Consequently, the FAC suggests tracking all those items/subsystems that are in fabrication/construction, detailed design, preliminary design or conceptual design. The level of anxiety within the project should increase for the particular item/subsystem the further down this list appears and clearly the management team should understand and explicitly accept the justification for the location of an item/subsystem in this list, and the speed at which it is moving up this list.

A final point in the area of project management concerns the earned value management system (EVMS) certification that was mentioned during the FAC meeting. The FAC suggests that in view of the challenges the LCLS management team is facing and the critical juncture of the project, that the EVMS certification becomes an *institutional* certification and SLAC management should take primary responsibility for preparation and development of the materials, policy, descriptions, etc. for EVMS.

Response: It was determined that SLAC did not have adequate resources to support a full institutional certification. The chosen approach will be for LCLS to gain certification for its system, which will then be used as a model for a SLAC certification.

At other Department of Energy sites, successful EVMS certifications have been rather involved efforts and have consumed significant resources.

The general comments and suggestions are directed toward making the FAC meetings as effective as possible for the LCLS and SLAC. Lester J. Pourciau is quoted as saying, "*There is no monument dedicated to the memory of a committee."* The FAC is a tool to be used by LCLS for its benefit. As such, the FAC is not a *review* committee, but an *advisory* committee. The FAC does not require convincing of the value of the facility, nor does it require an extended exposé of accomplishments since the previous meetings. As FAC meetings are rather short, they should be focused on those issues that cause concern, or are lagging with respect to the bulk of the project. The best use of the FAC is to focus during the meeting on those areas where the FAC can advise or have influence. The FAC recommends that its Chair and the Project/Facility management discuss at least ~1 month prior to each future meeting to identify what areas and aspects are of most concern. Specific data can then be identified and made available to the FAC on the LCLS website prior to the actual meeting to allow all members to begin focusing on those items of most interest to the LCLS facility. Also, it is important to allow the FAC adequate time to interact with the project/facility team, in addition to straight presentations, to allow maximum benefit be realized. To this end, the FAC suggests that the LCLS Project Director, during the plenary session, and the LCLS Systems Managers in the breakout sessions, act as *proctors* in consultation with the chair and subcommittee leads to ensure adequate coverage of the issues of most concern.

Response: For the April 2006 FAC meeting, LCLS has modified its agenda accordingly, concentrating mostly on issues of concern and reducing the plenary discussion. In addition, a FAC website has been setup with all talks and documentation posted in advance to allow the committee adequate time to review the project's progress and issues. The members of the FAC who survive the LCLS

Construction Project will be invited to sign one of the LCLS undulators. The FAC Chair will be invited to sign an additional undulator.

It is important to stress that the recommendations and suggestions of the FAC are made with the desire to further improve the LCLS and that the FAC recognizes the substantial accomplishments and quality of work that is apparent in all areas.

2.0 Electron Systems Subgroup Summary

John Corlett, Max Cornacchia, Wim Leemans,
Joachim Pflüger, Jörg Rossbach

Management

The committee once again recognizes the excellent accelerator team supporting the LCLS. This is indeed a highly capable team that continually produces impressive work in accelerator physics and associated technology development.

The appointment of Bill White as Leader for the Laser Group and hire of an additional engineer are welcome developments. Continued growth of the group is essential, and the Committee would like to see further additions of "hands-on" expertise to the team in the near future. This will be particularly important as equipment is delivered and commissioning begins in the coming months – at this stage, practical expertise focused on making hardware work will be critical.

The Laser Group activities at this time are strongly directed toward work on the photocathode system. The committee recommends that the Laser Group should formally report to the Electron Beam Systems Manager rather than the Photon Beam Systems Manager as is currently depicted in the organization chart. We recognize that as the project evolves many more laser systems will be in need of the attention of this group, and that it is natural that priorities will shift towards the user community in time. In order to meet the demanding performance needs of the photocathode laser, a critical system defining the electron beam quality in the LCLS, the importance should be reflected in the team reporting to the systems manager with overall responsibility for the electron beam production, supporting the tight integration necessary for successful electron gun performance.

The Committee heard that access to engineering resources may be problematic. It appears that suitable resources exist within SLAC, however the LCLS line management is experiencing some difficulties in obtaining timely allocation of engineering effort needed to meet project milestones. The Committee recommends that the Project management team determine the details of the shortcomings, and find a solution with the SLAC Directorate.

Response: With regard to engineers to support the LCLS Controls effort, the LCLS Controls Manager has identified key personnel and has established an agreement with SLAC ESD. This is now working as planned. To address additional staffing shortages in the future, the LCLS Project Director and Deputy Project Director meet daily with SLAC management to address resource issues as they arise.

As the stewardship of SLAC moves from DOE High Energy Physics to DOE Basic Energy Sciences (BES), the future of the historically strong accelerator R&D activities at SLAC may be in question. The committee urges the LCLS management to foster support for accelerator R&D in support of LCLS in the era of BES operations of SLAC.

Response: The SLAC Laboratory Director's Office is committed to create a plan for accelerator R&D that spans the full range of SLAC's core competencies and strategic goals, including LCLS priorities. A notable example of this commitment is the Gun Test Facility Task Force, charged by SLAC Management to produce a white paper conceptual design for a SLAC Gun Test Facility.

Photoinjector

Laser systems

Bill White adds to the strength of the Laser Group in bringing broad experience with laser systems operations, in time for the photocathode laser system fabrication, R&D program development, and commissioning. Additional hands-on PhD level experimentalist staff is needed to perform the myriad of tasks needed for the photocathode laser and optical systems installation, commissioning, development, and operations. The integration of the laser systems with the accelerator systems is critical, and the gun work should be considered being performed by one team - laser and accelerator physicists work together.

The Committee has some concerns on the laser and optical systems ability to meet pointing stability requirements and uniformity on cathode. The beam spatial profiling system will be added by SLAC staff following delivery of the laser system by Thales. Integration of beam shaping system with Thales delivered systems should be closely coordinated with Thales engineers to ensure full operational capabilities of the integrated systems. The movement of the laser mode centroid had not been studied, and the Committee recommends that this be addressed as a potentially serious problem – the laser spot on the cathode may be expected to move and may cause beam degradation, as the laser mode changes from shot-to-shot. A consultancy agreement with Thales should be explored to guarantee access to Thales expertise in the future, as problems arise or as information is needed by the SLAC Laser Group.

Response: Regarding spatial shaper integration with the Thales laser: We have now tested spatial shapers from two vendors: Newport and MolTech. Both shapers take a gaussian input beam and convert it to a flat-top profile using a series of aspheric optics. Both shapers performed well in our test but we have decided to use the Newport device, for two primary reasons. Newport supplied all of the design specifications for their shaper so we were able to independently model the performance of the shaper. Secondly, the Newport shaper takes a larger input beam, making it less sensitive to input beam diameter and pointing requirments. As far as integrating the shaper into the Thales system: if the Thales temporal shaping and harmonics meet their design specifications, then the shaper will be inserted after the entire Thales system. In this case the shaper will be the first component in the beam delivery system and will interface with the Thales laser through a simple telescope. We have discussed this with Thales and they see no problems with this approach.

Regarding the centroid position on the cathode: The centroid position on the cathode will be monitored on the virtual cathode and will be under active control. Because of the importance of centroid position stability, we started development of this control loop first and testing is currently underway. The system as designed will employ two pointing stabilization loops. One will remove any pointing errors that result from the laser bay moving relative to the vault. The other will lock the centroid position on the cathode. We believe this should allow centroid position on the cathode to be held within spec. If the laser does not meet the Thales pointing specs, we will place another pointing lock loop in between the laser and the shaper. The parts for this third loop have been designed and procured in order to mitigate this risk.

Regarding spatial shape changes of the laser and the impact on the shaped beam: If the Thales specs for the spatial profile are met, this should not be a problem. If there asre problems with the shape, it will be a warranty issue and we will get the support of Thales engineers. We do have a more general consultancy agreement with Thales aim primarily at problems that could arise with respect to intefacing to their hardware and software. This agreement is general enough that it could be used if we needed help with optical issues.

A second laser system is recommended, in conjunction with a new gun test facility once the architecture of the first system has been verified to function properly. The second laser system should be a complete system, allowing development of performance as well as commissioning and characterization of components and spares for the operating laser system.

Response: This lies outside of the LCLS Project scope however the S20 laser facility has been sized to accommodate a second laser. Should cost performance on the LCLS deliverables be favorable, LCLS can consider adding a second laser later on in the project. The Project's approach to ensure a highly stable, high-reliability laser is to learn from the performance of the first laser before embarking on a second laser project. A second laser for the LCLS Injector could then act as a hot spare. There is an effort at the Lab to develop a Gun Test Facility which would need a second laser, this project is unfunded.

<u>RF gun</u>

In-house fabrication of the RF gun is to begin soon - this should retain a high priority in obtaining necessary resources. A new gun test facility is important for development of this critical technology. The Committee continues to urge the LCLS management to find a means to build a complete gun test facility replicating the full LCLS system - including laser, cathode cleaning, beam diagnostics, etc.

Response: See above.

The value of such a facility in developing the critical technology for producing highest quality electron beams is to be measured in the continued improvement of performance of the

LCLS, and the potential for opening of new opportunities as knowledge and experience of producing high-brightness electron beams increases.

The importance of a Gun Test Facility to the long range future of LCLS is acknowledged by LCLS Management. As mentioned above, SLAC Management is taking steps to plan this facility.

GTF
The Committee recognized in a previous meeting the need for LCLS management to discontinue activities at the GTF. Resources allocated to the GTF in FY06 may be better directed toward the LCLS injector test and commissioning phase.

Linac

FEL performance is very sensitive to phase and amplitude stability in the linac RF systems, and as a result the determination of electron bunch length following bunch compression and successful implementation of bunch length control through feedback systems are essential to successful operation of the facility. A progress report on development of techniques to measure bunch length by coherent synchrotron radiation analysis was presented. The level of conceptualization, planning and execution of this critical diagnostic are inadequate for this stage of the LCLS Project. The Committee strongly recommends that a remediation plan should be initiated immediately, and should include experience from other facilities in similar measurement of the coherent emission from short bunches.

Response: The design and fabrication of the CSR bunch length monitor has become a SLAC effort. In addition a simple microwave-based bunch length monitor, which has been used at SLAC before, has been added as a back-up measure for initial commissioning. Both these approaches will be discussed at the upcoming review.

Additional mechanical engineering resources are needed in several areas to meet the installation schedule. As noted above, the committee recommends that the Project management team determine the details of the shortcomings and find a solution with the SLAC Directorate.

Response: Currently, the LCLS has adequate engineering resources, with designer effort being the limiting resource for design progress. LCLS has recently secured three additional designers from outside sources to maintain progress on the RF design. To address additional staffing shortages in the future, the LCLS Project Director and Deputy Project Director meet daily with SLAC management to address resource issues as they arise.

The understanding of performance of the low-level RF systems (LLRF) has been developing since a recent review, and the committee recommends an additional LLRF systems review should be held before the end of the calendar year.

Response: Reviews of the LLRF system, and tests with prototypes, have continued.

FEL Physics

Following studies of tolerances to understand FEL output sensitivity, the temperature stability in the undulator hall is now relaxed to ±0.5°C. The physics analysis has thus allowed a de-scoping of the undulator hall HVAC, with consequent costs savings.

Undulator

The Committee recognized good progress with undulator systems, in general, however had some remaining concerns with the vacuum chamber fabrication. The Committee has not been presented with an alternative to the proposed design and fabrication technique. Concerns are; that the weld permeability be carefully tested to ensure that perturbation to the undulator field does not exceed specifications based on FEL performance; that the Al coating adhesion is robust and does not deteriorate during or after forming; that surface roughness impedance of the real vacuum chamber be determined and used in determining the impact of the wakefields.

The positioning and stability of the inter-undulator quadrupoles has a significant impact of FEL performance. The committee would also like to see details of quadrupole support developed before the next meeting.

Response: There has been progress with the design of quadrupole supports, and progress with the Single Undulator Test (SUT). This progress will be presented at the upcoming meeting.

The Committee would like to see proposals for fast beam loss monitoring systems for undulator protection.

Response: This will be presented at the next FAC meeting.

The various alignment proposals (beam-based alignment, stretched wire, scanning wire, hydrostatic level sensors, photon-beam based alignment) need to be re-examined in the context of an overall alignment strategy. The Committee would like to see a scheme for using these redundant systems in a coherent and logical manner.

Response: This will be presented at the next FAC meeting.

3.0 X-Ray Subgroup Summary

Josef Feldhaus, DESY, Paul Fuoss, ANL, Tom Rabedeau, SSRL

Presentations and Progress

The attention of the x-ray subgroup was primarily focused on evaluating the development of x-ray systems and conventional infrastructure to support the experimental program of the LCLS, both current and future. The current program consists of six distinct experiments:

1) AMO experiments in the soft x-ray region (AMO)

2) soft x-ray pump-probe measurements and coherent imaging (SXS)
3) hard x-ray pump-probe measurements (XPP)
4) hard x-ray photon correlation spectroscopy (PCS)
5) hard x-ray coherent imaging (CXI)
6) high energy density physics (HED)

The first of these experiments is included in the LCLS Project, experiments 2-5 are supported by the LCLS Ultrafast Science Instruments (LUSI) project and the final item will be separately funded.

Plenary Overview

There has been considerable activity and progress on the x-ray optics, transport and experimental stations since the last FAC meeting in April, 2005. The general overview was presented by John Arthur during the plenary session. There has been significant progress in optimizing optics and experimental layout in the Front End Enclosure (FEE), the Near Experimental Hall (NEH) and the Far Experimental Hall (FEH). The efforts of the experimental teams have become better defined and regular planning/design meetings have been held. These regular meetings have lead to a much better definition of the experimental requirements, a consensus on the hutch layout and initial utilization in both the NEH and FEH, and a general agreement on the use a periscope mirror system to suppress the background radiation from gas bremsstrahlung. The length of the FEE has been extended and the personnel access mode has been modified to make routine measurements in the FEE possible. The staff for both the x-ray transport, optics and diagnostics (XTOD) and x-ray end station systems (XES) efforts is expanding, and there are five open positions associated with LUSI to support the development of the experimental program. These are all very positive developments.

Building on the initial presentation of John Galayda, John Arthur also discussed the necessity to find cost savings in the LCLS program because of increases in the cost of conventional facilities. This directly impacts the x-ray program in two specific areas. First, it is proposed to move the FEH closer to the undulator by 20 meters with an estimated savings of $500K. The second is that the flipper mirror system, which switches the x-ray beam from the various FEH experiments, is being removed from the project until additional funding frees up, thus saving between $1M and $2M.

Breakout Session

<u>LUSI Status</u>

John Arthur presented an update on the LUSI project. The effort is now an official project, having received CDR approval in August. Initial hiring is underway including a project director, project manager, chief engineer, and three instrument scientists. LUSI will develop instruments in a phased approach with two instruments slated for completion in 2009 and two instruments in 2012. In order to achieve this ambitious schedule, an equally ambitious schedule for CDR approval including a draft CDR in February, 2006 and a Lehman review in June, 2006. Achieving this schedule will require a concerted effort of the LCLS staff and the LUSI external experimental teams.

<u>XTOD Overview</u>

Donn McMahon of LLNL provided an overview of their efforts and progress on the x-ray transport, optics and diagnostic systems. This system has a large number of components, mostly located in the FEE. They include two ion chambers, a gas attenuator, a diagnostics package, a solid attenuator and several collimators and mirrors. The XTOD system also includes the flipper mirror and vacuum transport to the FEH. Significant progress has been made on the conceptual design of all standard beamline optical and transport components (collimators, slits, beampipes, vacuum pumps, and controls). There was a significant discussion of the solid attenuator, particularly the availability of large blocks of suitable grade beryllium. LLNL has a stock of suitable material that can be used.

Gas Attenuator

Stewart Shen presented a status report on the gas attenuator. The gas attenuator is primarily designed to provide stable and reproducible (to within 1%) attenuation of the FEL beam at low energy (0.8 to 2 keV). In order to operate in a windowless mode, the system is differentially pumped and to achieve sufficient attenuation the design calls for an 8 m length. The preliminary design of the system is near complete and hardware procurement for a prototype has been started. There was a discussion of the length of the attenuator. There was speculation that the length could be reduced by using thin Be windows to allow higher gas pressures for higher photon energies. Those windows would have to be removable for use at the lowest photon energies.

Offset Mirror System

Michael Pivovaroff gave an excellent overview of the technical challenges associated with the beam offset mirrors for optics in the FEE. Since the beam divergence of the FEL radiation is roughly 1 microradian, the mirror must have slope error much less than that to not significantly increase the beam size. After much discussion, this does not appear possible with current technology. Fortunately, the suggestion that the beam size not be significantly increased is not a science based specification and no current experiment appears to need that level of performance. It is believed that current state-of-the-art mirror designs can deliver suitable performance, and it is conceivable that the off set mirrors could be removed and an experimental configuration made should it be required.

Detector Development

There are four detector efforts within the scope of LCLS and LUSI. Stefan Moeller described, in detail, the development of the 2D x-ray detector within the LCLS project. This detector is designed to the requirements of the single molecule scattering experiment. This experiment requires large dynamic range across the detector, but relatively small dynamic range in an individual pixel. The proposed detector satisfies this requirement since the electronics for each pixel can be independently tailored. The 2D x-ray detector project is on schedule with a prototype detector about to be sent out for fabrication. The prototype should be tested in CY05?. R&D with prototypes will continue through CY06. In CY07 a comprehensive review will be held and the decision made whether to proceed with full scale production. If successful, acceptance tests in early CY09 are expected. A separate pixel type detector using a different technology is being funded through LUSI. This detector was not extensively discussed in session, but is being designed to the specifications of the XPCS experiment. The final detector discussed is an x-ray streak camera. Negotiations are proceeding with LBL for its development and an MOU is expected shortly. A detector engineer hire is expected in early 2006.

Conventional X-Ray Experimental Systems

Stefan Moeller described the current plans for LCLS development of the end station systems. The level of detail of these plans is greatly expanded since the April FAC review and the design appears very good. There were minor discussions about some aspects of the design regarding safety showers and mechanical vibrations. There was agreement that the current design has adequate provisions for upgrade to "white" capability, if that is required by future experiments. There was significant concern about the decision to move the FEH towards the undulator by 20 meters (10%) and this resulted in a long discussion. John Arthur pointed out that there were advantages to this move beyond just the reduction in cost by $0.5M.

Observations of the Committee

- Given the revolutionary nature of the LCLS source it is difficult to predict, with certainty, the requirements that future experiments will place on the optics, detectors, and conventional facilities infrastructure. Thus, flexibility and adaptability are keys to a successful design.
- Cost saving measures that irreversibly close off opportunities should be avoided. While it is difficult to defend the full beam transport tunnel length, based on a specific scientific requirement, the savings of $500k does not justify the proposed tunnel length reduction and concomitant loss of future adaptability. Instead, the requisite savings should be realized through reversible savings measures such as not completely outfitting the NEH experimental floors with the full planned complement of lab facilities, etc.

  Response: LCLS project management has decided to accept the tunnel reduction, despite the irreversibility of the decision. This was a difficult decision, based upon a balanced set of priorities, and recognition that the original tunnel length was a 'soft' (longer is better) specification. This decision was made with the full knowledge and support of the LCLS Scientific Advisory Committee.

- The proposed elimination of the flipper mirrors employed to direct beams into the three FEH hutches severely limits the operational capability of the FEH. A stated assumption is that individual experiments would then be scheduled for extended, exclusive blocks of time. A probable outcome of this operating mode is a greatly reduced scientific productivity for the LCLS.
- An alternative to the flipper mirror system is translation of experiments in and out of the beam. Since the experiments are likely to be large and complex, such a simple sounding translation may be more expensive than the flipper mirrors.

- **Response: LCLS is coordinating with LUSI on a new design for beam splitting among the experimental stations, which will be optimized for the actual**

experiments that are planned. This new design can be added to the LCLS baseline plan at any time. At least some of the new design can be accommodated within the LCLS project.

- The present optics layout is predicated on the use of reflection optics for x-ray beam separation from bremsstrahlung as well as beam re-direction into multiple experimental stations. Full preservation of the x-ray beam brightness though the mirror system is a daunting task which appears beyond current mirror fabrication technology. Stated alternatively, realistic, affordable mirrors will have adverse effects on beam properties which must be managed. Consequently, careful consideration of the science driven beam characteristics should be reflected in the mirror specifications.
- The design, testing and acquisition of the mirror system is likely to be an extended process since the optic elements are near state of the art, unique alignment techniques will need to be developed for use with low repetition LCLS beams, and the lower operational stability (at least in the short term) may result in drift problems.

- **Response: The mirror design analysis is underway. It involves input from the experimental groups who will use LCLS radiation. Additional time and money have been added to the LCLS mirror effort.**

- Given the potential problems with reflection optic performance, the optics design must maintain compatibility with white beam transport for those experiments that cannot tolerate the mirror induced beam degradation. The beam transport system and the NEH/FEH hutch layouts preserve this option. During the detailed design phase of these systems, the potential for future, simple augmentation of the radiation shielding, if required, for white beam transport should not be compromised.

- **Response: The NEH and FEH designs incorporate massive shielding in the walls and floors, so white-beam modifications would be limited to the hutch walls and the PPS logic.**

- The link between science driven requirements and engineered product needs to be refined for improved cost effectiveness. In particular, two way communication needs to be improved and more rapid exchange of ideas encouraged. Neither over engineering nor under engineering is cost effective. Early and frequent exchange of ideas permits rapid evolution of requirements and concepts to enhance cost effectiveness without loss of necessary capability.

- **Response: This issue has been addressed by the recent hiring of a dedicated Physics Liaison scientist for the XTOD group, and more frequent meetings between SLAC and LLNL personnel.**

Endorsements of the Committee

- Significant progress is being made on staffing
- Regular meetings with the experimental teams are occurring and having a positive impact on the design effort.

- The beam transport system and NEH/FEH layouts have been significantly refined and improved. Among the positive developments are:
    - o Expanded space in the FEE for diagnostics and mirrors.
    - o A detailed functional layout of the NEH.
    - o A proposed side deflecting mirror to service the soft x-ray station in the NEH.
    - o An improved FEH hutch and tunnel layout.
    - o Preservation of white beam capability.
- Detector activities are working smoothly:
    - o Multiple detector development MOUs signed
    - o Detector Advisory Panel functioning.
    - o Detector efforts are coupled to specific experimental programs

Recommendations of the Committee

- Document the experimental design requirements and specifications in a central database that is available to both the experimental teams and engineering teams.

- **Response: This is being done through the LCLS document control system. LUSI is planning to use the same system.**
-
- The optics, and particularly mirror, design needs to:
    - o Investigate the impact long-term damage to mirrors and coherence preservation
    - o Include stability and alignment issues in design
    - o Simulate the performance of individual experiments with likely optics
    - o Generate holistic design that preserves future flexibility

    o **Response: This is being done. Beam simulation studies are underway which will evaluate mirror coherence issues. High-risk optical elements such as the attenuator system are being studied through prototypes. Damage studies are ongoing.**

    o
- Cost savings measures need refinement
    - o Don't move the FEH to save $500K (although there may be design considerations that lead to moving it).
    - o Include flipper mirrors in the project. They are crucial to the efficient operation of the experimental program and are long-lead time items.
    - o Improve the reliability and efficiency of the link between the science driven requirements and the engineering product.
    - o Engineer systems for cost effectiveness.
    - o **Response: LCLS management has decided to accept the risk associated with moving the FEH. Ways are being found to reinstate or mitigate the loss of other descopes in the x-ray area. The engineering process has been brought into much closer contact with the science requirements. As the experiment layout**

becomes more clear, opportunities for savings and improved functionality are being realized.

- Since the mirror design, testing and acquisition is likely to be challenging, and is crucial to the successful scientific operation of the facility, mirror system design should be made a priority.
- **Response: This has been done. Also, additional time has been added to the mirror development schedule, and additional funding has been added to the mirror budget plan.**

4.0 Controls Subgroup Summary

Tom Himel, Karen White,

The Controls team has made considerable progress since the last FAC meeting in April 2005. Many of the suggestions we made at the last meeting have been implemented. We appreciate the report with written responses to concerns raised at the last review.

Here are a few specific places where good progress was made along with comments about further work that is needed.

1. There is now a very strong technical team in place for the controls work, and they are making excellent progress towards most of the numerous milestones on their schedule.
2. In most cases, design choices have been made using the established standards for hardware and software. This will pay off not only during the construction phase of the LCLS, but will also reduce future maintenance and support loads.
3. The SLC aware IOC, identified early as a critical and risky element for controls has made considerable progress and demonstrated key functionality. This is a major accomplishment, achieved early enough in the project to alleviate any lingering concerns.

Concerns

1. ***Database*** - Due to the late hire of an experienced database expert, the central RDB is behind where one would hope for at this point in the project, and the controls team is currently planning to use the RDB for the online model, but not for other control system configuration needs. The online model will be needed for both the new XAL based applications and the old SLC applications, and it is important that both models are derived from the same source (RDB) rather than attempting to make updates in two or more places that will quickly become unsynchronized. It does appear that there are plans in place to store hardware configuration information in the RDB, but there is not yet a plan in place for how the database will be populated and maintained, or used during the construction and operations.
2. ***SLC Integration and High Level Applications*** – With the recent evaluation of the requirements for High Level Applications, plans to use a combination of existing SLC

applications and newer XAL based applications, it is apparent there will need to be the ability to send commands (such as writing set points) from XAL applications and/or EPICS IOCs to hardware controlled on the SLC side. This was not previously planned and will need to be addressed soon. We are also concerned about plans to share the PEP proxy server during LCLS testing while PEP continues to run. Such tests could introduce loads or other problems that would impact PEP operations and an isolated proxy server should be provided if possible.

3. ***PPS*** - The PPS system plan calls for a PLC based implementation. Since this implementation choice is new for PPS systems at SLAC, an internal review is required, and tentatively scheduled for November 2005. It is important that this review take place on schedule so work on the PPS system can proceed on schedule.

   Response: There has been excellent progress with the design of the PPS System, and with reviews of that system. This progress will be presented.

4. ***MPS*** - Work on the MPS system was recently started. This is a late start, and we are still concerned that it is a complex enough system that will be difficult to complete on time. We suggest that the functional requirements of the SLC "new MPS system" and the SNS MPS system be examined to help you determine the requirements for the LCLS MPS system. Also, to encourage prompt completion of the project, Himel made a high stakes bet (5 cents) with Dalesio. Dalesio wins if the MPS system is operational at the end of the November 2006 shut-down.

   Response: The MPS system remains a critical system. Progress will be presented.

5. ***Management*** - Organizationally, the distributed nature of Controls throughout the WBS structure still makes things a bit confusing. It would be helpful if the Controls manager was provided the same type of reports for all controls activities, as are available for higher level WBS elements. The controls activities appear to be well planned and running smoothly under the leadership of Bob Dalesio, however, it has long been recognized that a "local" and more permanent group leader is necessary. With this hire now imminent, it is important to plan for a smooth transition to ensure there is no disruption to the current activities which need to proceed on schedule to meet project milestones. We recommend a period of overlap for Bob and the new group leader to help keep progress on track.

   Response: Bob Dalesio and Hamid Shoaee overlapped by about three months. In addition, Bob has been retained by the project in another role providing long-term institutional memory and an excellent source of EPICS engineering.

6. ***Process*** - It appears that controls work is now being reviewed (internally in most cases) at appropriate stages, however, care should be taken to ensure these reviews are documented for future reference.

7. ***BPMs*** - Schedule is tight for BPM readout electronics.
8. ***Security***- For the next FAC meeting, we would like to see the overall network and cyber security plans.

5.0 Conventional Facilities Subgroup Summary

Summary

For the October 2005 Review, the Conventional Facilities Subcommittee of the Facility Advisory Committee was charged with follow-up on April 2005 recommendations, and with review of the Project approved scope reductions to save $11 Million in the Conventional Facilities construction scope.

The LCLS project staff did address the FAC Conventional Facility Sub-Committee concerns and recommendations from the April 2005 review. In the CF FAC April report, the Subcommittee had recommended the Project: write the Construction Safety Program, change the Undulator Tunnel Floor design criteria, promptly award the Construction Management contract, critically review Jacob's design staff continuity/qualifications for Title II design, and implement more stringent seismic design criteria than UBC 1997.

The Conventional Facilities Subcommittee agrees in principle with the approach to reducing CF costs and increasing CF contingency by reducing the CF Project construction scope. Some changes are not recommended.

This Subcommittee also recommends the root cause(s) of cost increases be fully characterized to determine all impacts and all necessary Project actions/corrective actions.

Follow-up on April Recommendations

Construction Safety Program
The Program document produced now requires a thorough edit and process review to correct errors in the text, and in the reference links within the document. Also, the responsibilities are not clearly stated in the overview hierarchy for all participants. Please consider the attached comments from subcommittee member Keith Schuh's review of the LCLS construction safety program document.

Response: The Construction Safety Program has been revised to reflect all the changes as suggested.

Undulator tunnel floor
The conventional facility design criteria for floor performance have been relaxed by taking credit for beam alignment methods available during operation. And, the floor configuration was simplified for constructability and to couple the rigid tunnel structure to the floor structure.

Construction Management Contract

The CM/GC contract was awarded to Turner after competitive bidding. The value of the contract awarded is $13.1 Million versus a reported budget of $6 Million for the CM and $5 Million for the GC in the DOE approved Title I baseline.

Jacob's Staff Turnover/Qualifications for Title II Design

In April 2005, the subcommittee expressed concern with Jacob's design staff turnover between Title I and Title II design, and asked the project staff to assure the best qualified personnel were being assigned to Title II design of the LCLS conventional facility. The project staff in October 2005 reported significant problems with the performance of Jacobs on Title II design construction cost management contributing to a 50% increase in Jacobs' own conventional facilities construction estimates from Title I. The project staff also reported overall coordination issues in Jacobs attributed to the Title II design being performed by Jacobs in more than one office. The LCLS project staff generated over 1000 comments on the Jacobs 30% Title II design submittals, and have identified several million dollars in Title II over-design that needs to be corrected. None the less, even with all recent project approved scope reductions in CF Title II design accounted, the estimated cost of construction of the conventional facility will still increase by ~ $13 Million in construction contracts and by ~ $2 Million in the CM/GC contract. Much of the $11 Million the project staff has proposed in LCLS scope reduction is not a result of correcting Jacobs' Title II over-designs. Some of the proposed changes, the FAC does not recommend unless reversible.

Seismic Design to UBC 1997

The Project has acknowledged that the 1997 UBC is not current for seismic design, but that it is policy to exceed that standard on the SLAC site, and will implement FEMA Standards that incorporate lessons learned from the structural failures during the Northridge Earthquake and will implement the later AISC standards that preclude the use of partial penetration welds on structures with moment welds subject to tensile loads. The Project did not respond to the Subcommittee concern on the out-of-date FONSI agreement with DOE, but the Subcommittee learned during the October 2005 review that DOE has taken steps to update the FONSI.

October 2005 Recommendations

Scope reduction on the LCLS project (to recover overruns now projected in the Conventional Facility budget)

The subcommittee commends the Project on the effort to find compensating scope to save budget. The FAC finds the approach constructive, but not in every case, advisable. Shortening the tunnel by 20 meters to save $600K is not reversible. The third floor of the CLOC cannot be left incomplete, but must be finished for a defined purpose within the project. The cost savings projected from scope reductions do not consider the costs of revising design documents, Jacobs has requested $400 K to revise design documents. Unless errors and omissions are demonstrated in each case, there will be redesign costs to the Project to offset some of the projected construction cost savings. The cost savings appear to be reasonable, but the subcommittee did no independent estimates and has not asked for independent estimates to validate the construction savings.

Project Cost Trends

The increases in Conventional Facility estimated construction costs from Title I to 30% Title II are excessive indicating either invalid Title I baseline cost estimates, over-design, or invalid Title II cost estimates. The expectation is that estimates based upon more detailed design, Title II 30%, are more accurate. But the Project does not at this time have a clear, crisp presentation demonstrating a full understanding of the root cause(s). The contention that Jacobs did not manage the Title II design to control construction costs, and that alone is the reason for cost increases, implies that Title II re-design could reduce costs back to the Title I estimates. That seems unlikely, and it also appears improbable that, at this point in the project, either the CM or an independent estimator will generate higher risk, lower estimates than the Jacob's 30% Title II estimates. Further, Sector 20 and the Magnetic Measurement Facility construction contracts now in progress were awarded at values of 70 to 100% more than the Jacobs' Title I & Title II construction cost estimates. The reasons construction bids are as much as double the AE's estimates may be site generic, not unique to CF construction. The Project should thoroughly analyze the causes of cost increases from Title I to Title II CF design to assure that the balance of total project cost estimates remain valid.

Response: An analysis has been performed of the Title I cost estimate as compared to the Title II cost estimates. The Title I cost estimate for the major scope did have some commonalities with the Sector 20 and MMF cost estimates. Example: estimates did not include some site specific requirements. Additionally the estimates were based on parametric format as opposed to detailed cost estimates identifying specific material, labor and equipment cost by activity. All items that were identified as weak components, or were not included in the previous cost estimate have been updated and included in the most recent cost estimates. A reconciliation of the cost estimates has been accomplished between the designer and the constructor: the report identifies a delta of 4% of the final estimated cost, which is considered satisfactory.

The Project is proceeding with scope reductions project-wide in parallel with obtaining additional Title II estimates from the CM and from an independent consultant. The FAC agrees with the interim strategy of reversible reductions to the project scope to increase contingency while this problem of excessive increases in CF fixed price construction costs is fully analyzed and understood.

The subcommittee learned that the CM/GC contract award increase was ~$2 Million over the combined Title I baseline budgets for the CM and the GC contractors. There may be creative ways of reducing the projected CM/GC costs by negotiating with Turner methods of accomplishment. Some methods to discuss are: the differences in issuing construction contracts by discipline versus by buildings or area, limiting the number of general contractors on site at any one time to minimize coordination problems, and negotiating unit price agreements for commodities in bulk to establish lower unit prices than would then be available to field contractors negotiating separately.

Timely Correction of Design

Design changes have increasingly greater impact as the Project progresses because of the increased number of design documents requiring change, and the increased number of contracts impacted by change. In addition, takeouts are generally of greater value before award of contract than after award. The subcommittee recommends prompt correction of all known design problems. Similarly, at the completion of any field contract, the subcommittee recommends the CM promptly resolve and closeout open contract issues/claims.

Response: Agreed. All known major design problems have been included in the design documents. During the construction activities, changes to the design will be incorporated in a timely fashion to avoid contract issues and claims.

Incentives for Early Occupancy

The subcommittee recommends that the Project take special care to define the acceptable conditions of transfer of completed construction to assure the new custodian receives a completed facility.

Response: Agreed, WBS Milestone Dictionary describes beneficial occupancy acceptability.

Multiple Transfers of Area Responsibility

There are as many as three CM organizations managing LCLS construction including the early CF construction (Sector 20 and MMF) now on-going, the future CF construction under Turner, and the future installation of accelerator equipment that will be independent of CF CM, Turner. There will be even more custodians than there are CM organizations who will be responsible for areas of the LCLS during the construction phase. The committee recommends special attention to formal passing of the baton, so there is no confusion on responsibilities and authorities for area management.

Response: A document has been developed that provides the approval and formal acceptance of site support groups, including the area manager and end user. In addition, on-going development of roles and responsibilities to clarify the expectations of individual staff members with responsibility and

Tunnel Access Shafts

Consider Value Engineering tunnel access to verify access shafts are the minimum length. The safety criteria for dead-ends may not be as stringent as now interpreted.

Response: The tunnel access length has been reviewed as a Value Engineering item and has been incorporated.

Building Siding

Consider Value Engineering the building siding for the type of significant cost savings identified on other DOE Lab projects.

Response: In process. A continued Value Engineering approach will be incorporated throughout the duration of the construction phase for items such as described above.

Survey Monuments

Consider early placement of monuments to allow early use and earlier monitoring.

Response: The survey monuments will be incorporated into the construction phase for early use and monitoring by the project.

Appendix A

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Appendix B

Stanford Linear Accelerator Center
Stanford Synchrotron Radiation Laboratory

Facility Advisory Committee (FAC) Meeting
Oct 27-28, 2005
Redwood Rooms, ROB, Bldg 48

AGENDA

Thursday, October 27th – Plenary

Location: Redwood Conference Rooms, Building 48

7:30	Executive Session	
8:00	Welcome	J. Dorfan
8:10	Opening Comments	K. Hodgson
8:20	Project Status Update, CF Updates and Charge to Committee	J. Galayda
9:00	Safety	M. Scharfenstein
9:30	Project Organization, Executive Status	M. Reichanadter
10:00	E-Beam Systems Update	D. Schultz
10:30	*Break*	
10:45	Update on Physics Issues	P. Emma
11:10	Undulator Update	S. Milton
11:35	Photon Systems Overview	J. Arthur
12:00	Conventional Facilities Update	D. Saenz
12:30	*Lunch*	

1:30 Breakout Sessions (see *Breakout Session Agenda*)
5:30 Executive Session (*Redwood C/D*)
7:00 Dinner – *TBD* Committee and Speakers

***Breakout Session 1:* Design & Construction: Accelerator & Undulator Systems**
Location: Redwood Conference Rooms, Building 48

1:30	Injector Design / Diagnostics / Gun & Linac RF Design E. Bong
2:00	Drive-Laser Update S. Gilevich
2:30	RF Gun Update H. Loos
3:00	Injector Physics and Design C. Limborg
3:30	*Break*
3:45	Undulator Physics Requirements and Alignment H-D. Nuhn
4:15	Undulator Metrology C. Lecocq
4:45	Undulator Cell Mock-up M. White
5:15	Executive Session *(Redwood C/D)*

***Breakout Session 2* -Design & Construction: XTOD & Experiment Station Systems**
Location: Redwood A/B, Building 48

1:30	LCLS/LUSI Experiments	J. Arthur
2:00	XTOD Beamline Configuration	D. McMahon
2:30	Attenuators	S. Shen
3:00	Mirrors	M. Pivovaroff
3:30	*Break*	
3:45	X-Ray Diagnostics	R. Bionta
4:10	X-Ray Detectors	S. Moeller
4:35	Experimental Area Conventional Facilities	S. Moeller
5:00	Discussion	
5:15	Executive Session *(Redwood C/D)*	

Breakout Session 3 **- Controls**
Location: Redwood Conference Room

1:30 Controls Overview	B. Dalesio
2:00 Integration with SLC	S. Allison
2:30 RDB	A. Chan
2:45 High Level Apps	D. Fairley
3:00 Controls plans for the 2006 installation	B. Dalesio
3:30 Break	
3:45 Laser Safety and Personnel Protection Systems P. Bong	
4:15 Laser Controls	S. Peng
4:30 BPM Control	T. Straumann
4:45 Undulator Controls	J. Stein
5:00 X-Ray Transport/Optics/Diagnostics Controls S. Lewis	
5:15 Executive Session *(Redwood C/D)*	

Breakout Session 4 **- Design and Construction: Conventional Facilities (Saenz)**
Location:

1:30	CF Readiness for CD-3b (Design, Cost and Schedule Maturity) D. Saenz
2:00	Construction Safety R. Hislop
2:45	Sector 20 Status P. Cutino
3:15	Magnet Measurement Facility Status J. Sevilla
3:45	Discussion
5:15	Executive Session *(Redwood C/D)*

Friday, October 28, 2005

Location: See Room Location listings below

Time 7:30 8:00 8:30- 10:00 10:00 *12:00* 1:30 4:00	***Topic*** Executive Session CSR-Based Bunch Length Monitor Breakout Sessions, continued Breakout 1: Breakout 2: Breakout 3: Breakout 4: Executive Session *Lunch* Executive Session Closeout - Plenary	***Speaker*** G. Travish