Report of the November 11 through 13th, 2008 Meeting of the LCLS Facility Advisory Committee

1.0 General

1.1 *Introduction and Charge*

The Linear Coherent Light Source (LCLS) Facility Advisory Committee (FAC) met with the LCLS project team and the LCLS Ultrafast Science Instruments (LUSI) project team on the 11th through the 13th of November 2008. For this meeting the FAC was divided into four subgroups: the Electron Systems Subgroup; the X-ray Subgroup; the Controls Subgroup; and the Conventional Facilities Subgroup.

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 November 11-13, 2008, FAC meeting.

The charge of the Facility Advisory Committee continues to advise SLAC, SSRL, and LCLS management on the continued execution of the LCLS and LUSI Projects and Facility development throughout its several phases and systems. For this meeting the FAC was specifically charged to look at the following:

- Electron Systems Subgroup:
  - Review and assess the commissioning strategy. Does the strategy provide the right balance of priorities and support the summer's scientific program?
  - Review and assess the preparation and readiness of the project for the Accelerator Readiness Review (ARR).
- Controls Subgroup:
  - Review and assess progress toward a complete suite of controls and applications to support operations.
- Civil Construction Subgroup:
  - Review and assess the closeout of the civil construction within LCLS and comment on the lessons learned discussion.
- Photon Beam Subgroup:
  - Review and assess the installation and commissioning strategy for the X-ray systems and the approach to achievement of early science with the AMO.
  - Review and assess the LUSI instruments, scope and schedule including;
    - Physics requirements,
    - Engineering design,
    - Plans to validate the design (e.g. reviews, prototypes)
    - Plans for acquisition (e.g. vendor selection and oversight)

The following sections address the aspects of the charge through individual reports of the subgroups. General comments and recommendations precede these individual reports and follow in the next subsection. 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 November 11-13, 2008, FAC meeting.

1.2 General Comments and Recommendations

The project has fully transitioned into a completing integration phase. All aspects of the project are coming together, but this also means that all areas are completely interlocked and connected and essentially all on the critical path. Installation and commissioning are fully underway and civil construction is approaching completion. There have been great results in commissioning. The installation is going smoothly and the FAC is anxiously looking towards first lasing. The project organization is stable and is well prepared for operations. The approach and focus of preparations for the accelerator readiness review is comprehensive and likewise the commissioning strategy well focused. There are no pronounced difficulties at this time.

One area of concern, however, is the lack of comprehensive diagnostics that may hamper the speed of commissioning with lasing action. In particular, the choice of fluorescent screens as the initial diagnostic set may be problematic. There is optimism that the FEL will turn on rapidly and things have been going relatively smoothly but, starting an FEL with a fluorescent screen and a fusible x-ray beam stop as the main diagnostics may prove quite limiting. The LCLS Project should be prepared that early science users, being users, will of course be quite grateful for all of the tremendous progress, but will naturally want all anticipated operating characteristics immediately.
We have made do with only a fluorescent flag. It was adequate for our purposes but we cannot propose this strategy as a “noteworthy practice”.

A paraphrased German proverb relates to projects: *A project has an end, and a sausage has two.* It is important to drive all portions of the project to an end. Final details in each of the major areas need to be doggedly pursued to complete conclusion. While Turner may be on its way out of the project there is still a substantial amount of conventional facilities work under in the X-ray area under the direction of SLAC. Further complicating the situation is the moving of SLI (a conventional facility project) within the responsibility of LCLS. It is important that LCLS and SLAC resist the temptation heap extraneous diverting responsibilities onto LCLS project resources at the same time as heaping accolades onto those same resources. It is essential to drive the project to an absolutely *complete* conclusion to secure a complete success with no caveats.
As predicted by the FAC, the workload on LCLS staff has ramped up as effort is diverted to operations. The risks of overload were considerable but (I believe) have been negotiated. The situation was mitigated by engaging the Accelerator Systems Division in LCLS operations.

The contingency levels are high and quite comfortable. LCLS may be in the position to *buy back* scope lost in previous budget exercises. It is advisable to examine and weigh the choices carefully. A complete list of candidate items must be established. Items that are

very appealing might be separately funded from DOE while those that are less appealing, but may not be funded separately by DOE, might be a better choice for this *buy back*. Nonetheless, in pursuing such scope items, LCLS must be prepared to answer the question that will inevitably be asked: *Why wasn't this done within the project in the first place?*

Recently LCLS has taken steps to procure a new building for Experimental Facilities Division personnel. This has been done after very careful scrutiny of options for scope addition by all stakeholders. "Buy-back" options will be addressed during the FAC review. This leaves adequate contingency for work to go; but there will be no further assignment of contingency to other enhancements until about December 2009.

There are several *lessons learned* that can be garnered from this and previous FAC meetings. Extracting lessons learned and identifying the root causes of issues that confronted the project are important activities. The following is an incomplete list quickly garnered from previous FAC meetings:

- Projects are nonlinear systems: Project never respond or start as quickly as anticipated and are even more difficult to slow or stop. Consequently, there is a natural tendency to over or under compensate.
- The integration of projects will not occur naturally: The integration phase of a project is more complicated than might be imagined and will only go smoothly with careful deliberate attention.
- In the integration phase all things are *near-critical path*: Conscious effort is required to avoid the tendency to relax because of float in a schedule. Unknown and unaccounted risks exist and are very real and can quickly consume whatever float there may have been. Squandered float cannot be used to address such *unknowns* if it is no longer available.
- Project sociology can be a real risk: Understanding a project team dynamics is critical to project success. An ill functioning team is every bit a tangible risk to the project as a more expensive bids. The tying of egos to technical solutions can create problems and delays that can threaten a project's cost and schedule.
- Institutional focus and relationships are critical: The institutions in a project can quickly jeopardize its success with a lack of focus, commitment, or conscious prioritization.
- Budgets and funding should not be confused with managing: Agency imperatives, or delays in funding such as continuing resolutions, pose challenges to a project, but regardless of the bureaucratic solution obtained, such as funding from different sources, the project *must* be managed as an integrated whole.
- Understand the role and function of advisory bodies: Advisory bodies, such as the FAC are not review committees. Their value exists solely in giving advice on a project and helping a project team with different perspectives and views of the issues the project is confronting. Spending too much time documenting successes, while essential for review committees, doesn't exploit the value of an advisory panel.
- Placing contracts always takes longer than originally scheduled: Placing a contract a specific phase of a project can be critical to the mitigation approach to risks on a project. Fully understanding the difficulty of placing a firm contract and appropriately scheduling resources and time is critical to successful risk management.

- *Fifty percent of the time a coin toss is tails:* Natural variability and uncertainty are inherent parts of project and physical systems. *Success-oriented* schedules (those requiring many risks, issues, and activities being resolved without deliberate attention) never are successful. Worse yet, the underlying distributions associated with project costs and schedules are not Gaussian.

It is important to continue to plan work aggressively until the complete end of the LCLS project. Details will continue to be a focus. Similarly, the FAC must evolve and should likely be transformed into a technical advisory committee (TAC) for the operations and upgrades of the LCLS facility and report to the Scientific Advisory Committee. While substantial successes have been realized, and more are anticipated, the focus of SLAC and the LCLS must remain until the LCLS Project is completely successful and finished.
LCLS has endeavored to fight for "float" time doggedly, particularly in the campaign to start experiment operations in Summer 2009. The one area where a late start has been tolerated is in disbursement of contingency, for understandable reasons.
As always, the FAC is very appreciative and would like to extend their sincere thanks to Helen O'Donnell, Siony Matni and the LCLS staff for all of their hard work and efforts in organizing the FAC meeting and making run so smoothly. Yes, LCLS has been fortunate to have such dedicated and competent administrative support.

2.0 Electron Systems and Undulator Systems Subgroups Summary

John Corlett, Max Cornacchia, John Lewellen, Joachim Pflüger, Kem Robinson

2.1 *Commissioning*

Commissioning of electron beam systems has continued to be successful and expeditious, and the committee commends the commissioning team for their efforts. Phase-II commissioning ended in August 2008, and operating with charge per bunch of 250 pC has been standard and has delivered good beam quality. Modeling of the FEL with measured beam parameters, and assuming *projected* emittance values (likely worse than the more relevant *slice* emittance), indicates that the beam is sufficiently bright to produce saturated lasing at 1.5 Å. Electron beam has been provided at 14 GeV, at 30 Hz repetition rate, under 24/7 operations with 90% uptime. Projected emittances at the end of the linac are measured to be 0.7 μm (vertical) and 1.6 μm (horizontal), and slice emittance at the injector of 0.6 μm (250 pC charge). Bunch compression has been demonstrated to 1–2 μm. At the design 120 Hz repetition rate, some feedback systems need to be developed to respond at the bunch rate. Agreement between measurements and ELEGANT predictions are very good, including coherent synchrotron radiation (CSR) effects. Phase-III commissioning began November 3rd, 2008.

2.1.1 Low charge operations

Initial experiments at significantly lower charge of 20 pC per bunch have shown very promising performance. Slice emittance of 0.14 μm has been measured at 135 MeV, and horizontal projected emittance of approximately 0.2 μm at 10 GeV. (Peak current is still limited to approximately 3 kA due to CSR effets.) Modeling of the FEL with bunch

parameters measured at the injector indicates lasing at 1.5 Å with approximately femtosecond x-ray pulses, close to the Fourier transform limit for the expected bunch length of order 1 μm at the end of the linac. The committee sees this mode of operation as very promising for providing ultrafast x-ray pulses, and encourages continued development along these lines, as commissioning and transitions to operations schedules allow. The new stripline BPMs and associated electronics work at this low charge per bunch, however the old BPM electronics do not work at such low bunch charges, and the committee supports the installation of new BPM electronics to resolve beam position under these conditions of low charge per bunch. All electron beam systems have been commissioned to full LCLS Project operating specifications, using the existing "old" BPM electronics in the linac. Upgrade of the BPMs is certainly an appropriate upgrade; however the upgrade will not be part of the LCLS Project.

2.2 *Photoinjector*

2.2.1 Cathode

A new cathode has been installed after degradation of quantum efficiency was observed following laser cleaning of the old cathode in July 2008. Analysis of the cathode removed from the gun has not shown unexpected surface chemistry, although this is difficult to state conclusively due to transport of the old cathode through air after its removal from the gun. Unusual ring-shaped features were observed apparently at the locations of the laser spots during the cleaning. It was noted that the diamond turning manufacturing process leaves structure of 10-15 nm depth (and longer transverse separation) on the cathode surface.

The new cathode also shows greatly improved thermal emittance over the original cathode, however, the reasons for this improvement are not known.

The committee comments that the science of photocathodes in these applications appears to be not well understood, and recommends that expertise in surface science be rebuilt for the LCLS project; the presence of SSRL should provide readily available expertise and analytical tools. We further recommend that an injector test facility be built to facilitate continued development of gun performance, and that a cathode quick-change capability be developed for high availability operations. A scoping study to choose the location of the Injector Test Facility (ITF) has begun. First funding for design of the ITF will be allocated in FY2010. However the ITF will not be part the LCLS Project.

2.3 *Coherent optical transition radiation*

Coherent optical transition radiation (COTR) effects have been causing significant difficulties with beam imaging diagnostics, particularly those following the bunch compressors. While this is an interesting physical phenomena in its own right, at the present time beam profile measurements are generally restricted to wire scanner measurements.

2.3.1 Laser Heater

Laser heater components apart from the undulator are ready, and the system is planned for installation in early December. The laser heater uses the IR "waste" beam from the photocathode laser system, after the harmonic conversion. While this beam is somewhat supergaussian, the ample power is expected to provide efficient operations. The laser beam optics allow adjustment of the waist size and corresponding overlap with the electron beam. A chicane introduces an electron beam offset of approximately 30mm to align with the laser, and the system can be turned off by turning off the chicane magnets. The committee encourages continued attention to installation of this important device for controlling the microbunching in the beam, and to its commissioning and applications at the earliest possible occasion. The Laser Heater installation was completed in January, and fulfilled its function within 30 minutes during the first attempt to operate it. Its beneficial effect on gain length has certainly justified the installation and test of this system.

2.3.2 Diagnostics

Designs for an IR–mm-wave spectrometer, developed for the FLASH FEL facility at DESY, and an x-band deflecting cavity for high resolution (~2.5 μm) bunch length measurements were presented. Both would be valuable tools in understanding the causes of COTR, and the committee recommends that they be installed and utilized at the earliest opportunity. LCLS welcomes this advice. Conceptual and preliminary designs have begun. Steps have been taken to implement thes suggestions. The x-band cavity design is underway.

2.4 *Plans for FEL Commissioning*

Preparations for the Accelerator Readiness Review scheduled for December 10th appear to be well progressed, although installation of final components will be "just in time".

A highly detailed checkout list and procedures for commissioning were presented, and preparations are being made for a variety of electron beam energies. Plans were presented to use beam loss monitors developed by ANL, and also salvaged components from the PEP-II B-factory. Thermoluminescent detectors will be used for quantitative measurements. A tune-up dump is located before the undulators, and the systems can be operated in single-shot mode for radiation tests. High-level applications for commissioning the FEL were described, and the committee commends the work that has gone into development of the procedures and software that will be essential to successful commissioning of the FEL. The committee recommends that the ANL team responsible for delivery of the undulator systems be kept "on hand" through beam commissioning, to assist the SLAC team with problems that may arise. LCLS-ANL personnel were active collaborators in the troubleshooting and commissioning tests leading up to lasing. They are still involved in assessing the performance of the cavity BPMs and Beam Loss Monitors.

There is an approximate 6-week delay in undulator installation expected, mostly due to financial repercussions from last year's continuing budget resolution. In the end, after budget

constraints were relaxed, the Commissioning team chose to delay installation of the undulators based on technical considerations. The undulator beam path was commissioned initially with no undulators installed, elminating the risk of damage to the undulators' field quality that could result from a mis-steered electron beam. In February a single undulator was installed, after lossless transmission of electrons to the beam dump was established. Synchrotron radiation from this single undulator was used to confirm alignment of the x-ray beam path to the diagnostic screen in the Beam Dump region. A total of 23 undulators were in place in April during the first attempts at lasing.

2.4.1 Temperature sensitivity of the undulators

It was demonstrated by Z. Wolfe, that there is a "thermal memory" of the undulator segments. If cooled down or heated up by as little as only a few degrees, irreversible changes in the peak fields were observed, when brought back to its nominal operating temperature. The suspected reason is bimetallic bending and subsequent slipping between the Al holders and Ti strongbacks. Observed changes are outside the tolerable range for the LCLS. The effects of a partial failure of the HVAC system must therefore be limited. In case of failure it must completely switch off so that the thermal inertia of the tunnel can keep temperature excursions as small as possible. Protocols for HVAC malfunctions have been established with SLAC Facilities and LCLS Operations. If the "K-monochromator" performs as expected, the risk of lost operations time duuring recovery from a HVAC failure are reasonably mitigated for present purposes.

3.0 X-ray Subgroup Summary

Tom Rabedeau, Thomas Tschentscher

3.1 *Overview*

The subgroup reviewed the status and progress of the LCLS X-ray systems including the efforts to construct one instrument as part of LCLS, three instruments within the LUSI project and two further instruments largely funded through collaborations outside the LCLS. The status of x-ray systems ranges widely. While most x-ray diagnostics instrumentation for the FEE have been constructed and await installation early 2009, components for the instruments in FEH still require technical design. The progress of all systems is good and it seems realistic to meet the current time schedule.

Finally, the FAC discussed the planning for the six instruments initially proposed for this facility. Budget constraints allowed the LCLS to maintain out of the originally proposed instruments only the AMO, while XPP, CXI and XCS have become the focus of the LUSI project. Now, with the SXR and MEE instruments, two more instruments return to the planning, in both cases realized by separate consortia involving SLAC and external partners. On Oct 22, 2008 CD-2 for the LUSI project was approved. This step presents a major advance for the three scientific instruments to be constructed within this project. A revised project schedule now foresees a common CD-3 in April 2010 and a common CD-4 in August 2012.

The new LCLS directorate organization includes LCLS and LUSI construction projects and prepares for the operation phase of the LCLS. The newly created LCLS experiments group can provide expertise and personnel required to operate the LCLS x-ray systems including the scientific instruments and to successfully carry through the user operation program of the LCLS instruments. The announced increase in staff of this group seemed appropriate.

3.2 *Highlighted Areas*

In the following, brief summaries of the reported areas and discussed topics are given.

3.2.1 XTOD Status & FEE installations

X-ray diagnostics will be a crucial element for commissioning the LCLS FEL operation. This commissioning is planned to start in April 2009 after installation of the undulators. Progress on diagnostics instrumentation is good and all components will be ready for installation before February 2009. Since the installation of cables and other infrastructure in the hutches will need to be completed beforehand, the commissioning of x-ray diagnostics elements with beam will commence in May ’09 and FEL optimization is scheduled for July ‘09. This apparent gap between start of FEL operation and availability of x-ray diagnostics of about three months is a consequence of delayed installation in the FEE. However, the current plan optimizes the time to take the x-ray diagnostics in the FEE hutch and the AMO instrumentation in hutch 1 of the NEH into operation. This is needed in order to start early user operation during August 2009.

The overall schedule for commissioning FEE components, for FEL optimization using x-ray diagnostics and for delivery of beam to NEH of less than three months is rather tight and ambitious. One possibility to reduce workload and gain commissioning time for soft x-ray components required during the remainder of 2009 might be deferring installation and commissioning of items for the hard x-ray beam transport, e.g. the HOMS mirrors. We have taken this approach.

3.2.2 AMO Instrument

The AMO instrument is now located in hutch 1 of the NEH, which is reasonable. This instrument will be the first available for scientific user experiments. The response to the first call for proposals in 2008 has been extremely strong indicating the high level and world-wide interest in this science. Start of early user operation is foreseen for August 2009.

Since funding only recently became available, procurement of AMO components was started during summer ’08 and several components will arrive only a few months before the scheduled start of operation. The installation and off-line commissioning plan for the AMO instrument components extends into July 2009.

The SXR beam transport though hutch 1 leads to a very close proximity of the SXR vacuum tube and the AMO experiments chamber. One consequence is that the AMO chamber has limited accessibility from this side. The SXR beam transport should be equipped with valves in order to enable venting and dismantling the corresponding SXR beam transport section thus facilitating access to the AMO chamber in urgent cases. This suggestion will be given serious consideration. It should be noted that a crane has been installed in Hutch 1 to facilitate work around the SXR line.

The first delivery of beam to hutch 1, required for commissioning of AMO, interleaves with FEL optimization in the FEE in order to optimize the overall time span to enable start of the user program in August 2009. The most critical component of the AMO instrument seems to be the KB mirror system. In order to reduce risk, an ALS design is used here and the construction and assembly will be performed by ALS. The full commissioning of these mirrors to reach focal spots on the order 1 micron will likely become part of the initial experimental program.
The overall schedule for commissioning the AMO instrument is unrealistically aggressive given the complexity of the instrumentation and potential source start up difficulties. The AMO instrument will be the only one operational during the year 2009. Therefore, until the spring of 2010, the entire user program of the LCLS will be based on this instrument. In order to allow the most efficient usage, it is crucial to make sufficient personnel with expertise in the related areas available. The hiring of a second scientist for this instrument must be a top priority since it is essential that this person participate in the installation and commissioning phases of the instrument. LCLS has hired a second scientist to support the AMO station. During initial operation of the AMO station, scheduling of FEL operation should allow for sufficient off-times for the instrument to enable further installations and improvements. LCLS welcomes this recommendation.

3.2.3 SXR Instrument

The SXR instrument in hutch 2 of the NEH provides the possibility to combine high spectral resolution with the tight focusing required for imaging and spectroscopy experiments on condensed and gaseous matter in this spectral regime. The SXR instrument has made big steps towards its start of operation in early 2010. The design of SXR x-ray optical components (monochromator and KB-optics) makes cost effective use of XTOD, AMO and proven designs from the ALS. Mirrors have been ordered and should become available in time. The time schedule with only 14 months until operation is very aggressive. The very tight space limitation for the AMO instrument in hutch 1 has been recognized and the teams interact closely to avoid collision of components.

3.2.4 XPP Instrument

The XPP in hutch 3 of the NEH is the first hard x-ray instrument to become operational and is part of the LUSI MIE project. Planning for this instrument has passed the CD-2 review and procurement approval is expected for July 2009 in order to obtain commissioning readiness by July 2010 and achieve early science by October 2010.
At the review, the strategy to achieve early procurement authorization for the detector mover was discussed. The process of defining requirements and comparing various suppliers for this system is complete, but not all details were discussed in depth. The overall strategy is highly appropriate.
The robot detector mover has been ordered and is expected in July.

Another aspect of this instrument came up later while discussing the XCS instrument. The scope of the LUSI project does not anticipate building a large-offset monochromator for the XPP instrument. Since in several experiments the definition of the spectral band will be important, the use of a less expensive double-crystal monochromator (DCM) was discussed. Such a DCM is now discussed as a temporary solution for the XPP and XCS

instruments. The availability of such a DCM at SSRL and the scheduling constraints (installation first at XPP, later at XCS) should be investigated thoroughly.
A Large Offset Monochromator is now included in the XPP Instrument – A temporary monochromator is not needed

3.2.5 XCS Instrument

The XCS instrument in hutch 4 of the FEH advances in the revised LUSI schedule considerably compared to the previous planning. The instrument should achieve early science by the time of CD-4. The instrument scope includes a large offset monochromator and a detector mover covering a large angular range.
At the review, aspects related to monochromatization for the XCS instrument were discussed. The proposal to move the large offset monochromator close to the experiments hutch seems justified. In modifying the design, care has to be taken to provide sufficient space for the optics components of the CXI instrument. Since the XCS requires monochromatization or sufficient longitudinal coherence, any experimental program prior to installation of the complex large offset monochromator will require another monochromator. The proposal to install a low cost DCM and to start this instrument's scientific program significantly earlier was discussed. This proposal is certainly justified, but the detailed planning to install and use this monochromator at the XPP, CXI and finally XCS instruments has to be thoroughly cross-checked with the needs for commissioning and operation of these instruments. The meaning of a 'low-cost' did not became fully clear and requires some clarification. In this context it is proposed to verify the availability of DCMs at SSRL. The relocated monochromator has been incorporated in the LUSI baseline.. This plan has been coordinated with the CXI instrument. The current plan for the post-monochromator is to use a modified monochromator that has been built for the APS.

3.2.6 CXI Instrument

The CXI instrument in hutch 5 of FEH should achieve commissioning readiness in April 2011 and early science in August 2011. The current status of planning seems appropriate to reach this goal. Several details of technical design were discussed during the review.
The design of the mirrors required for the strongly focusing KB-system had been one focus of activity during the last months. The proposal of a two strip design for the reflective coating provides a great deal of flexibility. Furthermore, initially using only one strip for depositing a conventional, low Z, high reflectivity material is a careful decision for this new regime of high performance mirrors. Once damage experiments (using LCLS) allow an improved understanding of the interaction of intense FEL radiation with heavier metal or even bi-layer coatings, a decision about coating the second strip will be based on much better grounds. Using the conventional coating SiC instead of the lighter B_4C will enable an increase in the energy of the CXI instrument towards harder x-rays (cut-off for given angle is ~11 keV). Although it is not clear how soon LCLS will be able to reach higher photon energies, in the long-term this strategy certainly will pay off. A question raised by the CXI team was the issue of the Cr underlayer argued for in the report from the last FAC meeting (Jun '08). The x-ray group felt not expert enough to deal with this question and proposes to verify the issue with

experts performing coatings of the class needed for LCLS mirrors. Issues like adhesion, island formation, wetting characteristics or increase of (interfacial) roughness of the coating layers need to be considered here. An additional aspect for the very thin coating layers might be energy transport following FEL impact. The underlayer must not create a conductivity barrier for the deposited energy from the pulse that shall diffuse to the bulk therefore minimizing heating of the coating. With respect to the issue of a 45˚ geometry for the KB-system (to obtain the focus in the horizontal plane) the committee was not convinced that the reward (a simpler detector geometry) was worth the cost of asking suppliers to develop instruments for this new geometry. Conventional geometry has been adoptted for the KB system.

A second issue was the focal plane design of the CXI instrument. The former requirements for the CXI instruments asked for a 1.0 and for a 0.1 micron focal spot diameter plus the possibility to provide unfocused beam. An initial design did plan to provide all these beams at one 'interaction' point with the sample volume. Since there exist a number of technical issues related to this solution the team proposed a new design with two interaction points, corresponding to two sample chambers. The committee members are of the opinion that this new design offers several advantages, for example it reduces the risk associated with early implementation of the short focal lengths optics. The issue of accessibility to the unfocused beam in the new design was not considered a severe problem. At the location of the 0.1 micron focus the distance of focused and unfocused beam is not large and access to both beam options should be possible if needed.

3.2.7 MEE Instrument

The MEE instrument in hutch 6 of the FEH responds to the need to combine tightly focused FEL radiation with high energy laser pulses in the study of matter under extreme conditions. Agreement with external partners has been reached and the current preliminary planning shall now in very short delay turn into feasible designs and a planning that enables to achieve commissioning readiness in 2010. The Office of Fusion Energy Sciences has approved CD-0 for an LCLS MEE (now "Matter under Extreme Conditions", or MEC) instrument. A budget of $19.4M is expected.

3.2.8 Other systems

The design of x-ray components for the LUSI instruments is considered as a separate task from the LCLS systems. Wherever possible, solutions from the existing LCLS designs shall be adapted or developed further. However, since the work is done by different people, some loss of know-how must be considered. Up until now, the project seems to have coped well with this. Nevertheless the committee had the impression that a lot of detailed design, in particular some of the more complicated instruments, is still ahead. Since time towards procurement and installation becomes pressing, there is no time to lose in this design work. Another issue of importance to the LUSI project is the situation with availability of lab space in the direct vicinity of the scientific instruments. In the NEH there exist very large rooms for experimental control on the instrument floor, but no laboratory space is foreseen. In this building, laser rooms are implemented and are located one floor above. In the FEH, the current design fills the floor with hutches 4 to 6 and with the rooms for experimental control. Thus, there is only very limited (if at all) space for laboratories and laser rooms. The committee recognized this situation and asks

the project to propose a solution for both halls. For the FEH, one possibility discussed at the meeting was to erect a steel frame inside the hall to build a mezzanine. Since the construction work of the FEH is nearing conclusion and installation of infrastructure and hutches is about to start, a decision on the construction of this mezzanine is urgent. Its design needs to consider issues like vibration and stability which require immediate solutions. A mezzanine will be constructed by the LCLS Project.

The committee was presented a new concept to measure the arrival time of the electron bunches considered for (post-)synchronization of the x-ray to optical laser delay. This phasing cavity system placed behind the undulators replaces the formerly considered Electro-Optical-System (EOS) since it is considered easier, as accurate and less expensive. The committee felt a lack of competence and asks the electron and/or controls groups to review the new concept and its performance.

The development of the DAQ system for LCLS/LUSI seems to make good progress. The proposed system responds to the need of treating large amount of data by the x-ray area detectors with a 120 Hz rate.

3.3 *Observations*

Following few general observations are made. In the final section we give recommendations with respect to specific issues.

- The proposed sequence of commissioning FEE and AMO instrument appears to be compressed into an unrealistically short time. This is necessitated by the objective of starting the early user experiments in August 2009. However, this commissioning schedule assumes that commissioning of the SASE FEL at photon energy of ~800 eV is possible almost without x-ray diagnostics. This judgment might be justified, seeing the results of the electron beam commissioning. But there is a risk that x-ray diagnostics will not be available in case of unforeseen problems with FEL commissioning. Despite the best efforts of the Project, it was necessary to accept this risk.
- The increase of staff for the scientific instruments is urgently required. The operation of these instruments will require experienced personnel that should be involved in the design, construction and commissioning of these instruments. While this seems still possible for the XPP, CXI and XCS instruments, the early operation of the AMO instrument might be constrained by late arrival of staff. As stated earlier, the most urgent need has been met by hiring an additional AMO scientist. LCLS has also identified an excellent candidate for the MEC instrument and intends to proceed with all due speed to a hire.
- There is now the possibility to use remaining contingency funds. The x-ray group has stated in previous reports its disappointment that the scope of x-ray systems and scientific instruments had been reduced in order to gain contingency. These systems now come very late and are only in stages added back into the project. The funds becoming available now should be allocated to x-ray systems and instruments by rescoping instrumentation and enable advanced procurements where needed. A monochromator and an “early science” detector for XCS have been added to the LUSI scope. Galayda response: The installation/integration of a donated soft x-ray spectroscopy/imaging instrument has been added to the LCLS scope. This $1.5M allocation of contingency was deemed the best way to exploit the scientific capabilities of the LCLS in the first years of operation, until the LUSI instruments are available.

3.4 *Recommendations*

The subgroup was in general terms asked to review/assess :

- **Installation and commissioning strategy.** The committee emphasizes making the FEE available for use of the x-ray instrumentation as early as possible. In view of the current constraint to achieve early science at the AMO instrument already in August 2009 the chosen strategy seems appropriate.
- **Approach to achievement of early science with AMO.** An extremely ambitious time schedule has been developed that will lead to success if implemented as planned. The schedule, however, includes little if any float to deal with set backs. It is essential, therefore, that the AMO project be allocated generous manpower resources for both commissioning and early operations support to ensure rapid and efficient problem resolution. Acquisition and installation of AMO has received very high priority. It is expected that the instrument will be ready to support first scientific experiments in September 2009.
- **LUSI instruments.** The schedule and scope are good now. The preparation seems to be on track, but a lot of detailed engineering design work is ahead and requires attention. The new designs for CXI and XCS are appropriate. Plans for design validation have not been discussed and plans for acquisition were considered appropriate in the case of the XPP detector mover.

The subgroup was specifically asked to comment on:

- **Procedure for procurement of detector mover for the XPP instrument.** The subgroup considers the overall strategy followed by the XPP team highly appropriate.
- **New concept of monochromator for the XCS instrument.** The proposal to move the large offset monochromator close to the experiments hutch is good. The new design has to consider needs for the CXI beam optics, but the teams work closely together, therefore this is not considered a problem. Enabling early science using a low cost DCM prior to availability of the large offset mono is certainly good. However, in addition to additional cost the teams need to provide a detailed schedule for installation and operation of this mono.
- **KB-mirror design of the CXI instrument.** The committee supports the two strip concept with initially one mirror surface deposited. The choice of SiC as reflective layer will provide the higher energy cut-off. The future operation of the LCLS will show if this advantage compensates for the slightly reduced reflectivity. With respect to a Cr underlayer experts in mirror coating should be consulted. The 45˚ geometry of the KB-system does not seem favorable with respect to the conventional geometry.
- **New concept of focal plane layout of the CXI instrument.** The concept of two separated sample interaction points for the two foci is supported by the committee. Access to the direct beam should not be a major design constraint.

4.0 Controls Subgroup Summary

J. Maclean, K. White

4.1 General Comments

The Controls Group continues to meet installation schedules and bring their systems on-line as needed to support commissioning activities. All major procurements have been completed and installation is nearly completed. As the construction activities wind down, the group is giving some much needed attention to operational issues such as configuration control, software testing and planning for future upgrades. They have established a good working relationship with the SLAC IT group to meet their needs for networking and cyber security support.

4.2 *Findings*

4.2.1 Machine Protection System

The LCLS MPS, which has routinely been noted as a schedule concern by the FAC, has been demonstrated to work, but the schedule remains tight with the ADC production hardware not yet in hand, the firmware not yet complete and a 12/8/2008 milestone to meet. The committee is pleased to see that the MPS is setup to get configuration information from a database. Although not the project Oracle database, plans call for future migration. This structure will pay future dividends in the form of reduced maintenance effort.The MPS was commissioned prior to installation of undulators in March 2009.

4.2.2 Personnel Protection System

The PPS has made enormous progress in the last six months. A well documented, rigorous configuration control process has been established and the corresponding culture change appears to have gained favor with the team. As it is usually extremely difficult to bring about culture changes in a short period of time, we are impressed with this accomplishment which is due in large part to the group's new deputy Enzo Carrone. This team has obviously made good use of the additional resources such as the documentation manager.

4.2.3 Configuration Control

The need for additional rigor in software configuration management has been recognized and new processes and tools are being developed. Recent improvements in how software is deployed, including emphasis on version control and test plans is appropriate as the project approaches the transition from commissioning to operations. A lightweight software installation and test plan process is in routine use and facilitates both planning and good communication between the Controls Group and Operations. Plans call for increased use of the RDB to capture software configuration information including plans to use IRMIS. Many other good ideas for improved software configuration control have been identified and this area will clearly need more work in the future. The group has also begun to designate a "Controls Program Deputy" as a single point of contact to help operations with controls issues. This is a rotating duty and not only serves to get operations the help they need, but also gives the controls engineers some useful exposure to the needs of their customers. The team also recognizes the need for hardware configuration management but this is not yet addressed. The committee welcomes the

attention paid to configuration control and encourages the team to continue their efforts to improve rigor in this area.

4.2.4 Relational Database

The Controls Group is increasing the use of the Oracle RDB for application configuration and has plans to use it for configuration control. The RDB is an essential element of the control system but the group lacks a dedicated DBA to extend and support this system. This is a critical skill and plans to hire someone for this role should proceed as quickly as possible, as was also noted in the first two FAC reports. Currently, not only does the Controls Group rely on a DBA outside the group, but the actual database and server are located outside of the LCLS controls network. This is not desirable from security, availability and performance standpoints. There are plans to move the RDB onto the LCLS network and identify and correct other operational dependencies on external elements.

4.2.5 High Level Applications

The availability of MATLAB applications has been critical for the success of LCLS machine commissioning. Plans are in place for the Controls Group to convert these applications to Java applications. The first Java applications have recently been delivered and converting all the MATLAB applications will be a great deal of work. We recommend investing in the infrastructure that all of the applications will use to ensure robustness and interoperability, then carefully identifying which applications would give operations the most benefit from the conversion and setting priorities accordingly. This should be done in close collaboration with the physics and operations groups to ensure the delivered products meet customer needs. The fast feedback is an application that does not currently exist and plans are in place to have a reviewed detailed design by spring 2009 and the first operations loop by January 2010. This project is a large effort that needs dedicated resources as it requires a dedicated network, additional hardware for the relevant IOCs and several new software applications. The use of commercial solutions for fast data passing will help alleviate schedule pressure MatLab applications have served commissioning well, and might well be the preferred long-term solution for applications.

4.2.6 Future Upgrades

The Controls Group presented a plan for improvements to enhance performance, reliability and maintainability of the control system. This plan includes some items that were deferred during construction and some based on experience gained with the control system during commissioning. A significant part of the upgrade plan addresses the lack of beam diagnostics and replacement of legacy hardware, which will both be important to operability of the LCLS. There are also plans to provide high level applications, including a fast feedback system, extend the use of the relational database and enhance the software development and deployment infrastructure. Planning is well underway for the Linac Controls Upgrade, which will use a phased approach to convert the linac as resources become available. It is good to see the group planning ahead, but clearly this is a huge amount of work, so attention should be paid to setting careful priorities.

4.2.7 Photon DAQ & Controls

The development work for the photon data acquisition and controls has made good progress. Setting standards for experimental equipment controls is a very good move that will help to limit the variety of systems that must be supported. The on-line work seems well thought out, but support for transfer of experimental data remains undefined and will need significant effort which should begin planning as soon as possible.

4.2.8 Recommendations

- Keep up the good work
- Proceed with plans to hire DBA
- Carefully prioritize the long list of planned upgrades to make the best use of available resources
- Continue with configuration control enhancements as this will become critical to continuing development work while supporting operations.
- Remove dependence on external RDB used for application configuration by moving it inside LCLS controls network. LCLS welcomes these recommendations

5.0 Conventional Facilities Subgroup Summary

H. Carter, T. Chargin, J. Cleary, A. Kugler, K. Schuh

5.1 *General*

At the time of this FAC meeting, the LCLS conventional facilities construction was reported as being 98% complete, LCLS was proceeding with close-out of Turner from the project, and lessons learned were being formalized.

The past recommendations in the area of conventional facilities were all satisfactorily addressed.

In the area of Safety, SLAC and LCLS are jointly addressing the critical issues previously identified by the FAC.

5.2 *Design, Construction, Installation and Commissioning*

- Designs are in progress for the remaining Conventional Facility equipment hutches.

- The post-award contract contingency usage continues at a low 7.2%. This 7.2% includes 2.5% of client-driven changes, leaving less than 5% as contractor requests.

- The LCLS project is still considering options for developing office space needed to support LCLS long-term operation. Office space development remains in the Conventional Facility project scope, but the funds now available are substantially less than originally budgeted.

- The initial equipment installation and alignment results indicate that excessive tunnel settlement will not be a problem.

5.3 *Safety*

All recommendations from the June 2008 FAC Review have been satisfactorily addressed by LCLS Project and SLAC management. LCLS and SLAC ES&H are now working together to identify and resolve the critical issues associated with work planning and control. In addition, SLAC ES&H is now addressing lab-wide problems which were identified by the FAC over the last two years.

The FAC commends the positive actions being taken by the Integrated Program Management team to improve safety trend analysis practices and encourages SLAC management's continued support of this effort. LCLS welcomes this recommendation.

The FAC believes the addition of Craig Ferguson as the Laboratory ES&H Director will benefit both the LCLS Project and SLAC safety performance.

5.4 *CF Turner Contract Closeout*

At the time of this FAC Review, the Turner Conventional Facility work on the LCLS project was expected to be completed by November 17, 2008. Turner had not yet provided the LCLS project a demobilization plan.

In order to facilitate the closeout process, LCLS project management has taken the following actions:

- A checklist for use in the close-out of the Turner contract has been prepared.

- The LCLS conventional facilities staff and the SLAC Facilities Group have developed a sign-off sheet for incremental custody transfers of project facilities.

5.5 *Lessons Learned*

In order to maximize the value of Lessons Learned from the LCLS Project, the following actions are being taken:

- A team of seven stewards will be addressing six major categories of the Lesson Learned on the LCLS project at SLAC.

- The SLAC ES&H Division is planning a root cause analysis class to be conducted at SLAC by Apollo Associates. The FAC encourages the LCLS appointed Lessons Learned stewards to attend this root cause analysis class. Darren Marsh is leading the collection of Lessons Learned.

- Formalization of the Lessons Learned process and development of root cause skills for those who participate is essential to identifying actual causes, thus avoiding miss-learning errors. Significant effort has been devoted to collection of Lessons Learned. The process will continue through CD-4 to Project Closeout.

Appendix A

LCLS Facility Advisory Committee Members

LCLS Facility Advisory Committee Members

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Appendix B

Facility Advisory Committee Meeting Agenda

LCLS Facility Advisory Committee Meeting Agenda

November 11-13, 2008

Tuesday, November 11th

Plenary Session

Location: *Redwood Conference Rooms, Building 48*

Time	Topic	Presenter
8:00	*Executive Session*	*Committee*
9:00	Welcome	P. Drell
9:15	Project Status Update, and Charge to Committee	J. Galayda
10:10	*Break*	
10:30	Project Management	M. Reichanadter
11:30	Safety	M. Scharfenstein
12:00	*Lunch (FAC Members only)*	
1:30	Breakout Sessions Begin (*See below*)	
4:30	*Tour of LCLS*	
6:00	Adjourn	
7:00	*Dinner – ?*	*Committee/Speakers*

Wednesday, November 12th

Breakout Sessions

Time	Topic	
7:30	*Executive Session*	Redwood A
8:00	*Breakout Sessions Begin*	(see below for listing)
3:30	*Executive Session*	Redwood A

Thursday, November 13th

Executive and Closeout Session

Location: *Redwood Conference Rooms, Building 48*

Time	Topic	Presenter
7:30	Executive Session	Redwood C/D
8:00	Executive Session, *or More Breakouts if Required*	Redwood C/D
9:30	Executive Session	Redwood C/D
11:00	Closeout – Plenary	Redwood Rooms

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Breakout Session Schedule

Breakout Session 1&2 – Accelerator and Undulator Systems

Location: *Redwood C, Bldg 48*

Tuesday, November 11th

Time	Topic	Presenter
1:30	Linac Commissioning Results and Plans for 2009	P. Emma
2:10	Experience with Cathode Replacement	A. Brachmann
2:50	Low-Charge Operating Point	J. Frisch
3:20	New High-Level Applications for 2009	H. Loos
4:30	*TOUR*	

Wednesday, November 12th

Time	Topic	Presenter
8:00	Undulator System Overview & Fabrication	G. Pile
8:40	LTU/UH /Dump Installation Status & Schedule	J. Chan
9:20	Undulator Tuning and Fiducialization Schedule	Z. Wolf
10:00	***Break***	
10:30	Undulator Controls Status	A. Alarcon
11:15	Undulator Checkout and Startup Plans	H.-D. Nuhn
12:00	***Lunch (FAC members only)***	
1:30	Accelerator Readiness	D. Schultz
2:00	Laser Heater Status	B. White
2:30	New Undulator Diagnostics	J. Frisch
3:00	Discussion	
3:30	Executive Session	

Breakout Session 3 – X-Ray Systems, Including LUSI

Location: *Redwood B, Bldg 48*

Tuesday, November 11th

Time	Topic	Presenter
1:30	X-Ray Overview	J. Arthur
2:15	FEE Installation & Commissioning Schedule	H. Tompkins
3:00	LUSI Project Budget & Schedule Status	T. Fornek
3:30	AMO: Installation & Commissioning Plan	J. Bozek
4:30	*TOUR*	

Wednesday, November 12th

Time	Topic	Presenter
8:00	SXR: Layout, Optics, Interface with AMO	M. Rowen
8:45	XPP: Critical Procurements	D. Fritz
9:15	XCS: Mono Location, Mono Crystals, Hutch Optics Layout	A. Robert
9:45	CXI: Mirror System, New Layout	S. Boutet
10:15	***Break***	
10:45	ME2: Beam Transport, Hutch, Phase 1	J. Hastings
11:15	Timing: Fiber Backbone, EO, X-Band	W. White, J. Frisch
12:00	***Lunch (FAC members only)***	
1:00	Diagnostics/Common Optics: Priorities, Engineering	E. Ortiz, etc.
2:00	Detectors: Cornell Detector Tests; BNL ASIC Tests	N. van Bakel
2:30	DAQ	A. Perazzo
3:00	Discussion	
3:30	*Executive Session*	

Breakout Session 4 – Controls

Location: *Redwood A, Bldg 48*

Tuesday, November 11th

Time	Topic	Presenter
2:00	Status of Controls Installation	E. Williams
2:30	PPS Configuration Control	M. Saleski
3:00	LCLS MPS	S. Norum., P. Krejcik
3:30	Application Software Status and Plans	P. Krejcik, D. Rogind
4:30	*TOUR*	

Wednesday, November 12th

Time	Topic	Presenter
8:00	Fast Feedback Plans	D. Fairley
8:30	Controls System Configuration Control	
9:00	Update on Security Issues	T. Lahey
9:30	Plans for future Control System enhancements	H. Shoaee
10:00	***Break***	
10:30	Photon Area Control & Data Acquisition	G. Haller
12:00	***Lunch (FAC members only)***	
1:30	Computing Resource Plans for DAQ & Data Analysis	G. Haller
3:00	Discussion	*all*
3:30	*Executive Session*	

Breakout Session 5 – Conventional Facilities

Location: *Redwood D, Bldg 48*

Tuesday, November 11th

Time	Topic	Presenter
1:30	Status of Construction	J. Albino
2:30	Far Experimental Hall Hutches	D. Saenz
3:00	Space Conversion to Offices	D. Saenz
4:30	*TOUR*	

Wednesday, November 12th

Time	Topic	Presenter
8:00	Construction Safety	M. Scharfenstein
8:30	Closeout of Turner Contract	J. Albino
9:00	Lessons Learned	J. Albino
9:30	Break	
10:00	Discussions	
