Report of the October 29th through 31st, 2007 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 29th through the 31st of October 2007. 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

In addition to its general charge mentioned above, the FAC has been asked by LCLS management to specifically look at and comment on several items. In the area of undulator system integration, the FAC is asked to list and comment on risks with emphasis on girder set up and testing, vacuum system design *other than* extrusion (emphasis in original), SLAC/ANL coordination, diagnostics, and radiation protection. In the area of LUSI and photo system integration, the FAC is asked to list risks and comment on schedule pressure resulting from the impacts of the 2007 continuing resolution (CR) to LCLS and the 2008 CR on LUSI. In the area of controls, data acquisition and applications software, the FAC is asked to identify risks with emphasis and comment on high-speed data acquisition and the schedule for the development of data archiving. In the area of conventional facilities, the FAC is asked to look at the conditions at early occupancy, the safety on the construction site including the contingency burn rate, and the SLAC/Turner Construction Co. roles and responsibilities.

The FAC was divided into five subgroups: the Electron Systems Subgroup that covered the accelerator systems design and construction; the Undulator Subgroup that covered all parts of the undulator and its ancillary systems; the X-ray Subgroup that covered x-ray transport, optics, diagnostics and experiment station systems and the LUSI project design and construction; the Controls Subgroup; and the Conventional Facilities Subgroup. Additionally, this report also contains a separate section discussing Safety. 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 October 29–31, 2007, FAC meeting.

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.

1.2 *General Comments and Recommendations*

Progress across the entire project continues strong. Installations and integration have gone well so far. The interface and integration with the operations side of SLAC appears good. The LCLS Project is set to start early installation with co-occupancy in the new tunnels and linac to undulator (LTU) in December 2007. Linac installation is anticipated to be completed in January 2008, and early start of Near Hall Operations is scheduled for July 2009. With regard to commissioning, all performance goals of the LCLS injector have been met. The gun laser achieved 98% availability for over 3,000 hours of operation in support of commissioning. At the time of this FAC meeting some work remains on the first beam compressor (BC1) and the x-band cavity. The commissioning of the second beam compressor (BC2) is scheduled for January 2008, but a faulty magnet coil may delay the start of this activity. There should be adequate time for commissioning during 2008 and so the delay is deemed inconsequential. The undulator vacuum chamber, a FAC area of concern, has moved forward with an extruded aluminum chamber employing slurry pumping to meet technical requirements. Magnetic measurements are well under way with 39 undulators at SLAC and 15 have been measured and fiducialized. Importantly, LCLS has developed an integrated installation/commissioning plan that coordinates across all parts of the LCLS project and coordinates with other operational parts of SLAC as well. LUSI has received CD-1 from the DOE. Conventional facilities work continues to proceed well and in many areas is ahead of schedule. Consequently, installation activities in many areas should be able to start in January 2008.

As is incumbent upon an advisory committee, the FAC has some specific items that provide some concern. Those of a general nature follow in this subsection and others specific to subgroups can be found in corresponding sections of this report.

The LCLS Project has developed a baseline change request (BCR) as a result of the FY2007 continuing resolution (CR) that resulted in less than the full funding and budget authorization being provided to the LCLS project. To the extent that the LCLS FAC was able to examine the proposed BCR, it appears adequate. However, there may be some areas that may not fully mesh. For example, if all the requested schedule relief in the BCR is taken, are the resulting increased costs fully captured in the present BCR? Another area of concern is the natural tendency on the part of project management and staff to *oversteer* the project. That is, project momentum, contrary to linear and angular momentum is not a conserved quantity. It is also nonlinear in that there are significant delays with complex responses to external (and internal) pressures. Concerns over not overspending the reduced CR budget authorization could be too successful and cause some *stalling* of the project and result in increased costs not anticipated in the BCR. The aspect of integration and installation is a good example and the concerns over *co-occupancy* are one manifestation of this. Continued and strengthened emphasis on the integration of all the parts of the project is increasingly important.

The *imposed* schedule slip from the CR is a significant risk over and above what the project may have estimated. While schedule relief to compensate for the delay in adequate budget authorization is necessary and appropriate, extreme care should be taken on all subsystems. The LCLS project is in its full integrating phase. That is, many separate activities and tasks feed into the overall progress of the project. Consequently, many parallel subsystems, components or tasks will be *near critical*. The critical path can rapidly change and fluctuate. Also, when a project is in an integrating phase, resources are being *rolled off* of the project. This means that a delay of any task will inevitably be accompanied by an increase in cost for that task or series of tasks. In such a phase of the project the fact that a subsystem isn't presently on the *critical path* is nearly meaningless. During the integrating phase of a project, project management must only, most grudgingly, surrender any additional schedule slip to a subsystem as it will rarely, if ever, be without cost implications. The risk to LCLS is that areas not included in the cost impact analysis of the BCR may incur additional costs and place undue pressure on the project as a whole and specifically increase pressure on those areas that were, out of necessity, delayed to accommodate the revised budget authorization profile. Some items within the schedule appear to have consumed their entire available float and have now slipped forcing the schedule into a *crash* configuration where overtime and other more costly measures are needed to make the schedule *just in time.*

In spite of the concerns and risks of the BCR, installation and integration activities within the project and within SLAC appear to be doing very well. The next installation push may be both psychologically and physically more difficult based on the lack of a driving force from a scheduled B-Factory shutdown or from the very real challenges associated with attempting co-occupancy (see the Conventional Facilities section and Safety sections)**.**

The LCLS project organization continues to add depth as the complete integration of the LUSI project within the management structure of the LCLS project office is accomplished. It appears quite seamless at present. Additionally, the project management of LUSI is being strengthened. Specific support for the controls and data acquisition for LUSI has been added, and resources are being shifted from the accelerator area of the LCLS project to the x-ray activities.

The two and a half day format to conduct the FAC meeting is probably optimum. It allows adequate time for both the summary and overview discussions in addition to some detailed discussion time. As always, in order for the FAC to be of the most value to LCLS it needs to be able to have a *zoom* capability. That is, the FAC subgroups must be able to provide both a good summary judgment of the particular area, but also provide LCLS advice and counsel in detailed areas and issues. The LCLS has entered a phase where multiple chains of activities and tasks are critical or near critical. Seemingly insignificant details can end up exasperatingly delaying progress. As the project continues, it may be necessary for the FAC and LCLS to consider adding a specific subgroup tasked with reviewing integration, installation, and commissioning issues. The LCLS has made tremendous progress, but much remains to be done before complete success can be declared; the FAC is appreciative of the continued efforts of LCLS team and its many significant accomplishments.

The FAC is also very appreciative and would like to thank Helen O'Donnell and the LCLS staff who worked so hard to make this and all LCLS FAC meetings run so smoothly. If the FAC provides value to LCLS it is very much in part the result of the efficient and effective organization of its meetings.

2.0 Electron Systems Subgroup Summary

John Corlett, Max Cornacchia, Wim Leemans, Joerg Rossbach

2.1 *Injector Commissioning*

The commissioning of the LCLS injector has been highly successful, achieving essentially all of the commissioning performance goals through BC1. The committee congratulates the LCLS team on the excellent results already achieved as a result of careful and thorough planning for commissioning of the injector. The beam has been characterized in several aspects of energy, energy spread, trajectory, charge, beta functions, bunch length, and centroid coordinate stability. Characterization and tuning sensitivity measurements are continuing. Projected emittance (95% cut of particles) of 1.2 mm-mrad has been measured at 1 nC bunch charge and 0.8 mm-mrad at 700 pC. Bunch compression has been observed with edge radiation from the last dipole in BC1. In addition to meeting the injector commissioning goals, beam has been transported to the end of the linac and bunch length measurements made at 14 GeV.

Characterization of the beam has revealed some areas requiring further investigation and remediation of hardware problems and physics understanding. Two main areas of concern are that the projected beam emittance measured after BC1 is larger than anticipated at 1.7 mm-mrad at 1 nC bunch charge and the observation of coherent optical transition radiation.

2.1.1 BC1 magnets

Several factors were identified as possibly contributing to emittance growth, namely BC1 dipole field inhomogeneity exacerbated by increased bunch length at the cathode, and transverse wakes in the x-band linearizer cavity. The field quality of BC1 was known to be marginal at the time of installation. Beam-based measurements indicate that the poor field quality results in 1st and 2nd order dispersion, which may lead to the observed emittance growth in the bunch compressor. Modeling of the magnet design with wider pole pieces shows performance within specifications. The committee supports the plans presented to modify the magnets with the additional pole pieces. LCLS is urged to exercise caution in this approach as care must be taken to ensure good mechanical alignment and secure location of retrofitted components. The committee questions results that showed relatively large field variations over small horizontal position offsets for the original magnets and recommends careful magnetic measurements of the modified magnets.

2.1.2 Bunch length

During this initial commissioning phase, best performance was obtained with a smaller laser spot size on the cathode than the initial design value (1.3 mm rather than 2 mm radius was used). Simulations suggest that the increased longitudinal space charge from the smaller radius would lead to an increase in bunch length of approximately 30%. This bunch lengthening will exacerbate problems related to the BC1 dipole magnet field quality. The committee recommends studies to fully understand the observed preference for a smaller spot size.

2.1.3 Linearizer cavity wakefields

Minimum achievable emittance was experimentally found to be sensitive to the horizontal position of the beam in the x-band linearizer cavity. The minimum emittance was observed with a 0.6 mm displacement. The committee supports plans to re-align the cavity in the upcoming shutdown.

2.1.4 Ballistic compression

An alternate approach to bunch compression may be accomplished inducing an energy chirp along the bunch, introduced at low beam energy by controlled phase adjustments in the LOA accelerating section. While the committee encourages further study of this concept, it is not presently seen as a priority.

2.1.5 Coherent Optical Transition Radiation

The unexpected observation of coherent optical transition radiation (OTR), indicated by a quadratic dependence of signal in the optical spectrum as a function of bunch compression, is a strong indication of micro-structure in the beam on order of micron or shorter distance scales. With maximum compression in BC1, the optical OTR detector displays a “ring-like” distribution. These observations provide evidence of physics that may affect lasing and certainly impacts the ability of the diagnostic OTR screens to measure beam emittance. Plans were presented to install a bandpass filter on the OTR instruments to allow some degree of spectral resolution, and possibly provide a band in which measurements may be made outside of the coherent emission spectrum. The unique beam properties at the LCLS may lead to further surprises. The rapid development of understanding of the physics involved, together with appropriate diagnostics, is encouraged. The committee strongly supports plans for further investigation and particularly recommends:

- Development of high-resolution diagnostics allowing determination of sub-micron structure in the beam,
- Theoretical and experimental studies to understand the development of structure leading to coherent OTR under the LCLS conditions, and
- Use of the laser heater to control and diagnose conditions.

2.2 *Photoinjector*

2.2.1 Laser

The committee applauds the productive interaction between the laser group and the accelerator physicists in developing the design of complex systems to meet the performance needs of the facility, particularly as understanding rapidly evolves in the commissioning phase. The growth of the group to four staff plus a group leader is welcomed.

Laser systems beam quality and reliability has been very good, and 500 μJ pulses (twice the design specification) have been delivered to the cathode, with 1.5% rms stability. Position jitter has been significantly improved by modifications of the optics layout, and use of transport tubes to minimize convection currents in the optical path. New feedback systems provide stable alignment for the transverse shaping aperture mounted in the laser room. The vertical transfer tube from the laser room to injector vault has been cleaned, and cheaper windows will be used and replaced as needed before contamination causes deterioration in beam quality. An additional lens has been included to allow for tighter focusing on the cathode for cleaning of the metal surface.

Removal of the Lyot filter from the regenerative amplifier has eliminated modulation in the output spectrum and improved the temporal response. A pulse stacker has been added.

Aspheric optics will not now be used for transverse shaping, resulting in fewer transmissive optics. A selectable set of apertures, mounted in a wheel, will be used to change the spot size on the cathode.

A new oscillator has been delivered, overcoming problems with synchronization and mode-locking, and a sealed cavity protects the crystal from contamination.

Complete hot-swappable pump laser units are available, and the committee commends the group for obtaining spares of all long-lead items.

Recent improvements have not yet been tested with beam, and the committee encourages continued attention to optimize laser systems performance. In particular, early tests at 120 Hz are encouraged in order to illuminate potential problems with higher power operations.

2.2.2 RF gun

The performance of the gun has been excellent, and reflects the effort invested in detailed design studies.

Quantum efficiency of the cathode has been improved by laser cleaning of the surface and is now approximately a factor of two below specification. Measurements show significant variations across the cathode surface, with white-light images suggesting physical differences in the cathode give rise to quantum efficiency (QE) variations (high spots and surface roughness on the micron scale since it shows optically). The committee encourages continued detailed studies of the cathode, including the contribution of "thermal" emittance, which may lead to greater understanding and significant improvements in performance. The team is well positioned to make these improvements.

Field probes in the gun limit average power and will be replaced following RF tests scheduled for early in 2008 on the second gun. As with the laser systems, early tests of the RF gun at 120 Hz are encouraged in order to illuminate potential problems with higher power operations.

The committee encourages continued attention to build-up of the second gun, exploration of developments such as inclusion of a vacuum load-lock to facilitate analysis of operating cathodes and tests of cathode cleaning techniques. The committee recommends building of a gun test facility in which to perform such measurements.

2.3 *Instrumentation and Diagnostics*

2.3.1 Gun Faraday cup and toroid, wire-scanners

The gun Faraday cup and toroid were not working during the injector commissioning phase and vibration in wire-scanner units has compromised its usefulness. The committee encourages their repair before the next beam commissioning phase.

2.3.2 Timing system

Design of a fiber-optic based timing signal distribution system, to provide capability of synchronizing lasers and RF signals to the stability of tens of femtoseconds, has begun. The work is contracted to LBNL and will involve installation of fibers in the klystron gallery and linac tunnel to allow preliminary tests early in 2008. The committee supports this activity as an important development in instrumentation for the facility.

2.4 *Installation Schedule*

Excellent progress was made during the summer shutdown, and the committee applauds the planning and attention paid to maintaining the schedule. For the next phase, much of the schedule relies on co-occupancy of buildings, and this will require careful attention to details and monitoring the viability of installation operations during ongoing construction.

2.5 *Plans for Commissioning*

A larger accelerator physics group will be available for the next stage of beam commissioning. Resources seem reasonable with 14 physicists available along with plans for two physicists/shift for 10 shifts/week.

Plans for FEL commissioning are at an early stage and need to be developed with focus on:

- Instrumentation,
- Detailed simulations and modeling of commissioning procedures, and
- Techniques to identify the FEL signal at as low level as possible, e.g. the proposed modulation of the laser heater and using a lock-in detector to separate the coherent FEL output from the spontaneous emission.

Continued participation of photon scientists in instrumentation development, preparations for, and execution of FEL commissioning is strongly encouraged. The committee would like to hear a presentation at the next FAC meeting, jointly to e-beam, photon beam, and undulator groups, of photon beam diagnostics and plans for FEL commissioning.

3.0 Undulator Subgroup Summary

Joachim Pflüger, Kem Robinson

3.1 *General*

As compared to the spring review, the situation is somewhat relaxed. No further delays are expected to be accumulated to the already existing ones. However, the forthcoming installation in the tunnel needs to be well prepared in order to avoid further delays.

3.2 *Magnetic Measurements*

The Magnetic Measurements Facility (MMF) is now approaching its design capacity of one undulator per week. All 39 undulator segments are in-house, 15 out of the 39 are finished. There are plans in place on how to deal with segments needing substantial refurbishments. The risk of additional delays is small.

3.3 *Vacuum chamber*

Many concerns and recommendations of previous FACs in the vacuum chamber area have been finally addressed. Within the last half year, a convincing economic solution has been developed. It is based on the use of extruded aluminum profiles and fulfills specifications. Feasibility has been demonstrated. The schedule however is very tight, but is considered doable. All other vacuum chamber configurations at this point should be stopped.

3.4 *Beam Loss Monitors*

The beam loss monitors (BLM) finally have the priority they deserve. Protecting the undulator especially during commissioning must receive top priority. The schedule allows a system that is simple and reliable. Consequently, the project must accept whatever is available. Absolute dosimetry, although important, need not be integrated into the BLM system. It is a complication requiring a very high dynamic range. TLDs on the magnet structure, as close to the beam as possible, are sufficient to determine the damage level of the magnet material and they do not depend on any electronics. There is a good experience base at other labs that can serve as an example.

3.5 *Manufacturing, System Setup*

The production of the quadrupoles and cavity BPMs remains. While all problems seem to have been solved with the prototypes, the remaining issues are likely non-technical. Procurement is under an exceedingly tight time schedule. One should not underestimate the time required to prepare for installations such as training of personnel, building fixtures, handling aids and transportation tools in order to provide the proper infrastructure. As seen above, some items may come in very late, thus installation must be well prepared in order to avoid delays.

Integration of complete undulator systems remains completely untested. While the single undulator tests have given some confidence in the integration of the complete undulator, the actual assembly, integration, and installation of the production undulators remains quite nebulous. With the nearly *critical path* schedule of the quadrupole and RF-BPMs, there is precious little time for proving and adjusting the anticipated integration approaches.

Coordination between SLAC and ANL seems to have improved as a direct result of a conscious cooperative effort from both parties. Pressure on the relationship will continue to build as schedules (and tempers?) get shorter and rather insignificant issues begin to pose significant schedule risks. Continued conscious effort needs to continue to work towards improved coordination as frustrations as these inevitably arise.

4.0 X-ray Subgroup Summary

Paul Fuoss, Tom Rabedeau, Thomas Tschentscher

4.1 *Overview*

There continues to be significant changes to the scope and timeline of the x-ray instrumentation being developed for LCLS. A plenary session summary presented by John Arthur has x-rays delivered to the Near Experimental Hall (NEH) in FY09 and to the Far Experimental Hall (FEH) in FY10. The project is working towards having diagnostics ready for the beginning of commissioning in May of 2009 with the goal of performing the first AMO experiments late in the summer of 2009. The schedule is very tight since XTOD procurements have been delayed in FY07 because of the continuing resolution and AMO procurements are being delayed until FY09. With these changes, XTOD items are now appearing on the critical path towards first light.

Jerry Hastings discussed the status of the LUSI project during the plenary session. The coordination between the LUSI and LCLS projects has been strengthened, particularly by the staffing of all the instrument scientist positions and the SLAC reorganization described by John Galayda. Jerry described how the LUSI and LCLS scientific instruments require the same technical specifications from a large array of components (e.g. beam definition slits and focusing optics). Thus, development costs can be shared across the instruments and design improvements can be built into components for the instruments being completed later. Since all of the instruments will be negatively impacted, possibly severely, by inadequate performance of these common components, the LCLS/LUSI project should plan for an intensive testing and development effort of common experimental components during initial commissioning. Since there are a large number of technical challenges to overcome, the availability and timing of design and procurement funds is a large concern. In particular, the ramp up in spending anticipated in FY08 and FY09 is crucial to having instruments available for the start of LCLS operations in FY09.

4.2 *Summary of Highlighted Areas*

The following will discuss the areas that were highlighted during the breakout presentations.

4.2.1 XTOD Status

Richard Bionta updated the committee on the status of the X-ray Transport, Optics and Diagnostics (XTOD) systems. For the Front End Enclosure (FEE), the fixed mask, the attenuator and the gas detector have been ordered. The thermal sensor and direct imager are in the final design stage, although there are still significant difficulties with the thermal sensor. However, the K measurement system and the soft x-ray imager are being redesigned and are still at the system concept review (SCR) stage. The pop-in alignment cameras are still at the conceptual design stage and procurement has been delayed until FY09.

Tom McCarville presented a thorough review of the Low Energy (SOMS) and High Energy (HOMS) mirror systems. Tom's conclusion states there is significant technical risk associated the HOMS and moderate risk associated with the SOMS. The primary difference is the smaller divergences and longer distances associated with the HOMS result in tighter tolerances on pointing resolution and figure error. A finite element analysis has confirmed many of the design decisions associated with the mirror support and bending design. A primary conclusion is the figure errors required for the HOMS system are so small they cannot be reliably measured offline. Therefore, real-time correction will have to be included for the operation of the HOMS. Furthermore, the pointing requirement for the HOMS is difficult to achieve. Engineering towards this goal is following a four tier approach with a focus on eliminating thermal drivers of instability. It is believed an enclosure temperature controlled to ±0.1°C will result in adequate performance. If not, real time corrections are a last resort.

Two components in the XTOD effort have moved onto the LCLS critical path, the pop-in alignment cameras and the x-ray collimators.

4.2.2 AMO Instrument

John Bozek presented an overview of the scientific drivers for the atomic, molecular and optical (AMO) experimental station. This station is part of the baseline LCLS project and is scheduled to be ready for first light in July of 2009. The design of this instrument is advanced and John presented a reasoned justification for the various design decisions that have been made. We expect the preliminary design review scheduled for November 2007 will confirm the basic design. The committee encourages LCLS to examine the elimination of the hutch requirement for the AMO experiment since it adds significant cost, reduces flexibility and may not be necessary for radiation protection. The instrument described in the presentation is a very complex multi-chamber system having at least five time-of-flight spectrometers, a total energy spectrometer for the beam diagnostics, a pulsed gas jet system, differential pumping systems, and a beam imager. The schedule for the assembly and testing of this instrument is very aggressive since procurement starts in July 2008 and instrument assembly and testing is scheduled for February through June of 2009. Clearly there is little room for error or setback in this schedule.

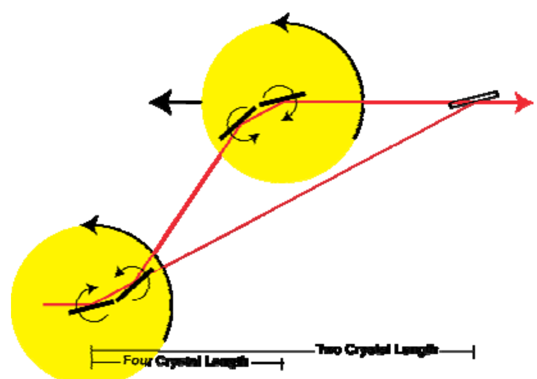
4.2.3 XPP Instrument

Dave Fritz described several scientific experiments that justify the laser pump, x-ray probe (XPP) instrument. The planned instrument will support x-ray spectroscopy and scattering with roughly 100 femtosecond time resolution. A detailed conceptual design of the instrument was presented and appears to be a solid basis for a more complete design. The goal of having the instrument ready for early science experiments in February 2010 appears possible given aggressive work on the design and availability of timely funding.

The committee had several comments on aspects of the proposed design.

1) The instrument includes a capability for femtosecond, time-resolved small-angle x-ray scattering (SAXS). By its nature, SAXS probes long-range correlations that often cannot respond to perturbations on that time scale. Interesting SAXS fluctuations will be much more likely to occur on the nanosecond and longer time scale. The scientific case for including SAXS capabilities should be carefully examined.

2) The project plans a high performance, scannable, large offset monochromator that will not be available for the first experiments. The committee felt that a monochromator is a crucial part of the instrument and that an interim but less capable monochromator should be made available. To achieve large offsets with single crystals, the monochromator needs to be very long. The long length impacts both cost and schedule and physically constrains the layout of experiments. The requirement for long motions might be reduced by using anti-parallel pairs in a constant offset configuration (see figure). While clearly unsuitable for a conventional synchrotron source, the extremely narrow horizontal divergence of the FEL beam might make this approach practical.



3) A second experimental station operating simultaneously on the third harmonic could be implemented using a thin second crystal for the monochromator. This possibility would suggest buying a second diffractometer for the instrument.

4) A simulation of a multi-crystal monochromator coupled with the chromatic Be lenses should be performed to see if they would provide adequate harmonic rejection.

4.2.4 CXI Instrument

Sébastien Boutet summarized the huge technological challenges facing the coherent x-ray imaging (CXI) instrument. The goal of this instrument is to image single molecules or particles with sub-nanometer resolution. To do this, a single particle is injected into a tightly focused (<1 μm) beam at the same time as the 300 μm long x-ray pulse arrives. Since the transit time of a large (50,000 Dalton) molecule across a 1 μm beam is of order 100 ns, achieving this coincidence is a challenging problem. This challenge is then multiplied by the need to measure an extremely weak x-ray signal from the individual particle. Calculations presented by Sébastien indicated that the background scattering from the x-ray beam had to be suppressed to better than 10^{-6} of the incident beam.

To address these technical challenges, a large and distributed development effort has been started. This effort has made impressive progress but much remains to be accomplished and there is still large uncertainty in the technical design of the instrument. Since the instrument relies on strongly focusing the LCLS x-ray beam, radiation damage may play a significant role in limiting the performance of the instrument. For example, the etched silicon apertures used to reduce background scattering fail rapidly at the FLASH so a mechanism for scanning an array of apertures into the beam has been included in the design. However, the failure of the apertures at FLASH was not expected and is not understood. Thus, it is impossible to predict whether the apertures will survive the LCLS beam long enough to allow this scheme to work. Similarly, little is known about the limits of radiation damage to the KB mirror systems required for the necessary strong focusing.

The committee believes that the CXI team should plan a series of experiments to be run as soon as LCLS generates hard x-ray photons to determine the stability and failure modes of optics under operating conditions approximating the actual CXI operating conditions.

4.2.5 XCS Instrument

Aymeric Robert described the progress on designing the x-ray correlation spectroscopy (XCS) instrument. The design of this instrument is relatively mature since it builds on existing successful programs at third-generation synchrotron facilities and is scheduled to be the last commissioned. The greatest uncertainties revolve around the split and delay x-ray monochromator and the x-ray detector. An MoU as been entered into with DESY to develop this system and a first instrument has been tested on the Troika beamline at ESRF. This instrument will need to be extended to operate at a variety of photon energies. The detector is anticipated to be a pixel array detector being developed at Brookhaven National Laboratory. The development of this detector appears to have appropriate progress.

The committee recommends that the XCS staff retain flexibility in their designs to facilitate change as opportunities and problems are discovered.

4.2.6 Data Acquisition

Gunther Haller described the development effort to provide common controls and data acquisition systems for LCLS and LUSI. The control portion of the project appears straightforward using readily available controllers and EPICS drivers. However, the data acquisition portion is challenging. When all of the instruments are operating, the data flow rates from the LCLS could reach 20 TB/day with peak data rates of 2 Gb/s. The collection, visualization and archiving of this data presents an enormous challenge.

To handle this challenge, LCLS has developed a plan based on three subsystems. First, a low-level detector control node will collect the data. Second, the data will be transmitted via a SLAC/LCLS DAQ controller to a local storage and visualization system for use during the experiment. Finally, the data will be archived in a central storage system. The overall architecture of the data acquisition system appears appropriate.

However, the committee has a number of concerns about the low-level data acquisition and the interface between the high-level system and the end-user. At the experiment level, much of the thinking appears strongly influenced by high-energy physics and astronomy applications. Both of those classes of experiments are driven by stable, long-term experiments. For HEP, the issue is primarily acquiring data over years to provide sufficient signal-to-noise to detect unusual events. In astronomy, stable observation of slowly changing (at least by condensed matter physics standards) objects is necessary to identify the interesting phenomena. The experiments performed using LCLS are likely to be very different with individual measurements lasting for days and requiring rapid reconfiguration and supplementing of the underlying hardware. For this to occur smoothly, there needs to be a reliance on well-defined software interface standards between the different subsystems. The current plan focuses on the development of custom hardware modules to interface with detectors. We are concerned that this approach risks obsolescence (e.g. it relies on PowerPC processors and specific operating systems) and will make addition of experimenter developed, high-performance equipment difficult.

Current operating practice in the synchrotron community is to develop complex data analysis packages on experimenter controlled computers and to bring those computers to the synchrotron during data collection. This approach is necessary because of the rapid turnaround of most experiments which precludes detailed testing on facility computers. Since we expect most experiments to be similarly short at the LCLS, it is important that the data acquisition and management architecture support this approach.

Finally, the budget and scope of the LCLS data acquisition and control program needs to be defined in more detail. There is a current lack of clear demarcation between the project’s and the experimenter’s responsibilities. Consequently, unless rectified, this subtask risks consuming all of its resources and not delivering a product that can be successfully used by the experimental community.

4.2.7 X-Ray Commissioning

Hal Tompkins presented a detailed timeline for the installation of XTOD components. This schedule appears to have been carefully worked out yet there are some inconsistencies between it and the overall experimental schedule we were presented. For example, it is not clear how the first AMO experiments can be performed in the summer of 2009 when the PPS certification is not scheduled until October, 2009. There are also worrisome comments such as "anticipate LUSI will handle vacuum transport in hutch 3". There should be clear responsibility for such items and any ambiguities should be rapidly resolved.

4.3 Summary

The LCLS and LUSI projects have plans to deal with the stress placed on the system by the changing experimental requirements, recent staffing of crucial positions, and by delayed funding. However, we note that items in this area are showing up on the critical path of the commissioning phase of the LCLS. While ultimately we expect that development of complex scientific instruments would be on the critical path of the LCLS as it moves towards full experimental operation, items from this area showing up on the commissioning critical path is worrisome. This means that these systems are lagging behind the rest of LCLS, a trend that will be difficult to reverse.

Given harsh budget realities (which have gotten worse since the review in October), it is very important to creatively look for scientific opportunities at incremental cost. We have constantly stressed that 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; these are even more important to maintain at this point of the project. We continue to urge LCLS and LUSI to develop "minimum equipment lists" for each experiment to guide design and data acquisition development. While the development of common components shared between the experiments is an excellent approach, it does accentuate the consequences (i.e. risk) if the design of a component is flawed. We encourage LCLS to use early machine time to validate designs and to examine material limits in these new regimes of peak x-ray intensity. Finally, this early testing will allow for phased improvement in the design and acquisition of cutting edge components such as optics.

5.0 Controls Subgroup Summary

T. Himel, K. White

There has been a lot of great progress made since the last FAC meeting in April 2007. The control system successfully supported commissioning of BC1 despite the just in time delivery of some components and a very tight schedule. The commissioning was aided by the use of numerous MATLAB applications developed by physicists and the use of SLC applications made possible by earlier work to allow information to be passed between the new EPICS based LCLS system and the old SLC system.

5.1 *Previous Concerns That Have Been Addressed or Are No Longer Relevant*

- The **DAQ for the X-ray experiments is a big deal and is very different than the types of things an accelerator controls group normally works on.** This scope is now in the capable hands of Gunther Haller's group. An architecture for the DAQ was presented; prototypes boards have been produced and test stands having been built. Great progress!

- **Controls should take advantage in more places of EPICS security features. DOE is very worried about computer security; it is advisable to make use of relatively easy to implement security features.** Some security features were implemented for the recent commissioning run however, the network used was an extension of the office network which is highly undesirable. The planned isolated network will be in place for the next run along with expanded channel access security.

- **The installation schedule for the Fall 2007 shut-down looks very tight. This is not strictly a controls problem; rather, the problem is all systems needing to install their equipment in a three-month downtime. Controls work will be forced to the end of the schedule and may not be completed or checked out. As mentioned in a previous section, this installation will need to be carefully planned with an integrated schedule.** The schedule remains tight, but improved coordination and planning appear to be helping.

5.2 *Previous Concerns That Have Not Been Fully Addressed*

- **There has been significant progress on the new MPS system including prototyping of boards, however, due to the slow start, the new MPS system remains a schedule concern**. The technical design now seems viable. New resources have been added which has helped the hardware development. The user interface has been specified but currently lacks a developer and is therefore stalled. This system has not had a PDR or FDR and these reviews should proceed as soon as possible to minimize the effect of any changes that may be needed.

- **Hamid still needs a deputy; this is even more evident now that he is head of the entire controls department. Effort has been made to hire someone, but without success so far. Keep on trying.**

- **There are many new types of diagnostics in the X-ray beamline that are not just repeats of what has been done for the e-beamline, these weren't covered in this review. Please inform the committee about the plans for implementing the new diagnostics at the next FAC meeting**. A list of needed diagnostics was presented, and implementing copies of existing devices should be straightforward. Plans still need to be made for unique devices and should be presented at the next FAC meeting. Both the hardware of the actual diagnostic and the controls interface should be addressed.

5.3 *New Concerns*

- Off-line storage and processing needs for experiments are quite unknown, probably expensive and assumed to be funded by operations. Be sure this is included in ops planning.

- Plans for data visualization and analysis software remain the great unknown. It is not clear who will do this and what needs to be done. Assign the responsibility for this and make at least some preliminary plans to present at the next FAC.

- Electronics in tunnel
    - We discussed the possibility of radiation in the tunnel having an effect on the electronics, for instance single event upsets; we suggest data be gathered.
    - Temperature stability of ±1 degree F is required around the undulators. Calculations have been made and indicate this will not be a problem. Equipment load estimates will be confirmed with measurements.

- The planned infrastructure for High Level Applications was presented along with the progress on the highest priority applications, most notably Save and Restore. The XAL framework from SNS has been adapted for modeling applications. The selection of the high level applications infrastructure and plans for specific applications is significant and developing the needed applications will involve many man years of effort. This should be reviewed soon by external software experts and internal customers (e.g. Physicists and Operations representatives).

6.0 Conventional Facilities Subgroup Summary

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

6.1 *General*

The conventional facilities subcommittee conducted a three-day review and presentation on the LCLS Conventional Facility addressing the areas of Design, Construction, Installation and Commissioning, and Safety. The charge specifically assigned to CF included the conditions at early occupancy, construction safety, and CF contingency burn rates.

The subcommittee recommendations from April 2007 were satisfactorily addressed with the exception of management of CF red line changes to drawings during construction. The Project addressed this concern as a records issue, instead of a real-time design interface problem that must be managed to avoid interferences with follow-on designs and installations not performed by CF contractors.

Most of the conventional facility construction was completed in the six months since the last FAC review in, April 2007. Construction completion in October 2007 was approaching 70% based on construction quantities, and the Turner scope of construction is projected to be completed two months ahead of schedule.

The subcommittee found the recent Turner performance on construction safety alarming and unacceptable because of two serious incidents involving high-energy sources that placed life and limb in peril. Turner's reticence to place responsibility for safety in line management and supervision requires immediate action by LCLS to justify continuing construction.

At the close of the October 2007 FAC review of LCLS, the CF subcommittee presented recommendations to the LCLS project on safety, construction status reporting, design interface management using red-line drawings, extending Jacob's Title III construction support, contingency, and possibly eliminating co-occupancy.

In response to the charge to the CF subcommittee, the subcommittee recommends an evaluation of eliminating co-occupancy, immediate assignment of CF staff to reinforce field safety implementation and the contingency for CF construction already contracted be further reduced based on field change-order performance trends.

6.2 *Design*

6.2.1 Findings

1. The CF field change-order rate continues to trend at less than 5% of contract awards indicating good quality design by Jacobs within the CF scope. In April 2007 the CF subcommittee found the change-order rate similarly low for early civil construction, but advised that performance of construction in all disciplines would be a better indication of CF performance on design quality in all disciplines and on the design interfaces between disciplines within the CF scope. The field change-order rate in CF scope indicates that the contingency held for CF field construction can be reduced further. See our discussion on Construction.

2. The quality of design integration between the CF and the accelerator components and utilities will be measured in the field by the accelerator component and utility installations. Field walks by downstream users have already defined the need to move CF overhead utilities in one or more hutches, one indication of a design coordination problem.

3. The Project interpreted the CF recommendation from the April 2007 FAC review on distributing redlines as a records issue. The subcommittee intended this concern be addressed as a real-time, design-interface management issue. The subcommittee learned that CF already has a scanner that can produce electronic copies of full-sized redlined CF construction drawings for distribution.

4. The LCLS project has delayed design in the CF scope, hutches and building modifications for offices because of cash flow limits. The cost of deferred design is on the order of $600,000. Failure to have designs completed for contract award precludes earlier completion of this delayed scope when cash flow changes on the Project present the opportunity.

5. The CF staff is very complimentary of Jacob's effectiveness on Title III design support to field construction.

6.2.2 Recommendations

1. Reduce the contingency held for CF field construction contracts awarded and in progress. Make funds available to complete design of at least the hutch(s).

2. Decide where contingency will be held to resolve design interface problems that become evident during the design and installation of accelerator components and utilities in the spaces designed and constructed by CF.

3. Distribute redline CF drawings to the designers and users of space provided by CF for accelerator components and utilities. The CF full-size drawing scanner on site may provide that capability.

4. Extend Jacob's Title III support as necessary to complete CF construction of Jacob's designs.

6.3 *Construction*

6.3.1 Findings:

1. Construction completion of the Conventional Facility has progressed to ~70% in the last six months. This progress estimate is based on construction quantities. The construction quantities are determined by joint CF and Turner walk-downs.

2. The contract negotiated with Turner has a duration of 28 months, started three months later than scheduled, but is trending to complete in 23 months, two months ahead of schedule.

3. Progress payments to construction contractors are at ~ 50% of contract and are based on the original progress payments negotiated with Turner.

4. Field contract change-order costs continue to trend at less than 5% of contracted work with ~$326,000 in identified field contract changes pending. The contingency held on contracted work remaining has been reduced from 14% in April 2007 to 10% in October 2007 but is still much greater than the 4% change-order rate.

5. The LCLS CF has a pragmatic method established and implemented for processing field change-orders. The process has been improved by obtaining

more thorough and critical reviews from Turner. Outstanding change-orders are logged, tracked, aged, and managed to closure.

6. Turner has submitted a claim for $4.5M on their $12M contract. The Turner claim is now with legal staff.

7. Site tour of construction areas after working hours show the site to be well-organized, material flow well structured, housekeeping very good, and the visible quality of CF craftwork is also very good.

8. The 50% increase in CF construction bids/awards over engineer's estimates is being applied to the budget estimates for similar work yet to be contracted by LCLS for construction of accelerator utilities and installations.

9. Early completion of CF construction (two months) and delay in the completion of the LCLS project (18 months) provides the opportunity to minimize overlap of CF construction contractors with follow-on construction activities.

6.3.2 Recommendations

1. Implement accrual system accounting to correct the CF CPR construction progress report (from 50% complete based on billings to 68% complete based on actual quantities constructed).

2. Evaluate reducing contingency for the remaining CF construction from 10% to 5% based on change-order trends, and separately budget the resolution of Turner's curiously large claim (40%) in the 2009 LCLS budget. Budgets for resolution of Turner's claim are not recommended here and should not be evident to the contractor.

3. CF construction delayed for budget reasons should be designed and ready for construction award when the ebb and flow of spending allows work to proceed. Collective experience on projects is that some scheduled work will slip providing the cash flow for an earlier completion if packages are on the shelf, ready for construction award.

6.4 *Installation and Commissioning*

6.4.1 Findings:

1. A period of co-occupancy is planned before Beneficial Occupancy so installation of accelerator components and utilities can begin before CF turns-over area control and while the CF field contractors are still constructing in space that would be co-occupied.

2. There is not a consistent understanding on the Project of the conditions for co-occupancy. For example, the conditions would not be suitable for installation of vacuum systems and sensitive accelerator equipment.

3. The CF staff is in the process of preparing a Memorandum of Understanding defining the conditions that would prevail if CF construction spaces were co-occupied before turnover and Beneficial Occupancy.

4. The projected co-occupancy period is only three months.

5. Turner would be responsible for safety and control in areas shared, but Turner's performance on safety management is not acceptable.

6. The Project also risks claims from CF field contractors for interference and for delays if co-occupancy is implemented. Co-occupancy would change contracted working conditions and responsibilities.

7. If co-occupancy is eliminated, there may be opportunity to compress accelerator installations unhindered by compromised environments, space, safety, and accountability.

6.4.2 Recommendations:

1. Perform a risk benefit analysis to determine if there is sufficient basis for proceeding with co-occupancy.

6.5 *Safety*

6.5.1 Findings:

1. Turner performance on safety management of CF field construction is unacceptable.

2. Turner safety management on LCLS places primary responsibility for construction safety on the Turner Safety personnel instead of in-line management.

3. Two safety incidents involved high-energy sources capable of causing loss of life or limb. A grounding rod was driven through a tunnel roof narrowly missing a 15KV bus. An elephant truck, unrestrained and suspended from the boom of a concrete pump truck, was whipped by unstable slugged flow of concrete and compressed air, and struck the operator inflicting serious injury to the shoulder.

4. Turner's safety performance on LCLS is better than the construction industry as a whole, but an order of magnitude worse than the average for construction on DOE projects.

5. Corrective actions implemented by Turner have not been effective, yet construction continues.

6. The risk of continued safety problems in CF field construction requires immediate action.

7. Co-occupancy would place greater reliance on Turner for personnel safety and that should not be acceptable.

8. After beneficial occupancy and commencement of operations, LCLS and SLAC safety responsibilities will require close coordination.

9. The LCLS safety program, including field construction, can be improved by utilizing methods and practices proven successful at other Labs and on other projects. A detailed description of this program is outlined in Section 7.0.

6.5.2 Recommendations:

1. Assign the best CF Staff personnel to support the implementation of Safety Programs by Turner in the field. Backfill their present roles on the Project as necessary but place their first priority on construction safety to assure construction can be completed without serious safety problems or directed work stoppage.

2. Evaluate the recommended methods in the Safety Section 7.0 to improve the LCLS safety program.

7.0 Report on LCLS Safety Performance

7.1 *Construction Safety Recommendations*

Turner's safety performance should not be accepted. Turner's lost time rate is 6 times higher than the rate experienced at other DOE construction projects. The corrective actions taken to this point have not resulted in improvement. Two safety incidents in Turner's scope, the concrete pumper injury and the grounding rod that penetrated a tunnel within a few inches of a live 15kv bus, clearly had potential for loss of life or limb. The risk of problems in the area of construction under Turner management requires immediate attention.

The LCLS- CF Panel recommends that the best CF staff be made available and reassigned to support Turner line managers in the field to direct safety activities.

7.2 *Roles and Responsibilities Recommendations*

If co-occupancy takes place, LCLS and Turner should formally create a document identifying who will have overall safety responsibilities for the spaces that have not been turned over to SLAC for beneficial occupancy.

A similar document should be developed between LCLS and other divisions at SLAC for future work. LCLS has written its own safety plan and the requirements may differ from those of other divisions. The document should clearly identify safety responsibilities when personnel from different divisions are working in common spaces.

The document should clearly define the following:

1. Which codes and standards will be enforced during this time period.

2. The work planning process and controls that will be followed. (It is suggested that a matrix be developed to identify who must review and approve a job safety analysis based on degree and nature of hazard.)
3. The names and contact information identifying all safety professionals that may be involved in determining safe work conditions.

7.3 *Safety Program Recommendations*

The following is a recommendation for safety oversight covering the period of time when there will be shared occupancy of the LCLS facilities. Turner construction, SLAC staff, collaborating university staff and sub contractors hired by LCLS may be working in common areas during the same period of time. This same recommendation would be applicable between LCLS and other divisions after beneficial occupancy.

A new hazard analysis should be developed to identify all hazards that can reasonably be expected to be encountered. There are hazards associated with construction to which many experimenters may not typically be exposed. Likewise, construction workers may not typically be exposed to hazards associated with operating a physics experiment. These hazards must be identified and incorporated during the Job Safety Analysis (JSA) and Job Hazard Analysis and Mitigation (JHAM) preparation process.

SLAC has a list published on its web page that describes typical hazards in their Hazard Analysis Process. A more extensive list can be found in Appendix C.

7.4 *Recommendations for Improving JSAs and JHAMs*

The FAC-CF panel recommends that a matrix be developed to facilitate the review and approval process for Work Plans/Hazard Analyses which exceed an agreed upon threshold. An example of such a matrix can be found in Appendix D.

The FAC-CF panel also recommends that a checklist be added to the JHAM Form such as found in Appendix E.

7.5 *Implementation of the Integrated Safety Management Program (ISM)*

The FAC-CF panel does not believe that the ISM program is being fully implemented. JHAMs are to describe routine hazards that a SLAC employee may encounter and are reviewed annually. Non-Routine JHAMs are to be written for tasks that are new or performed so infrequently they wouldn't qualify as routine.

The JHAM process needs improvement. In no case does the JHAM document address the ***specific scope of work.*** The JHAM process should emphasize the idea that everyone in line management is responsible for safety, including the employee. It should encourage all levels of line management to continuously evaluate the safety conditions of their work place.

An example of a routine JHAM might be testing emergency lights on a monthly schedule. During the completion of this task the safety conditions in the building can easily change from month to month. Changes could be caused by new construction or new processes. The employee's JHAM would not address these new hazards as presently implemented, and the LCLS CF- Panel has not found evidence that the existing JHAM process places appropriate emphasis on this point.

We recommend that additional training be made available. The LCLS- CF Panel was told that the UTR receive some training. The FAC-CF panel did not find any formal training available to the writers of JHAMs and JSAs other then being provided a few examples on the SLAC ES&H web page. That leaves many people in critical roles trying to interpret the web page on their own. It appears that the ISM documentation process is only being done for paper compliance rather than being used as a work planning tool. Below is a list of review criteria questions that the writers of the JHAMs and JSAs could use to make sure they are addressing the core functions of ISM, but even this additional guidance does not substitute for adequate training of line personnel.

7.5.1 Scope of Work Considerations:

Is work at the task level defined in sufficient detail that the workers, supervisors, planners, and appropriate ES&H personnel can reasonably identify the hazards and risks associated with both the work activity itself, and the environment/location in which the work is performed?

Do the documents and permits issued adequately describe the scope of work that is included in the work orders, procedures, and/or instructions?

Does the work process include a screening against mandatory safety standards agreed upon and permits issued?

Is the work adequately bounded by approved work packages, procedures, and permits?

Are work activities properly prioritized and scheduled to allow adequate allocation of resources based on the importance of the work, safety impact, and risk?

Have adequate personnel and equipment resources been identified for the performance of work, including operations, maintenance, and ES&H support?

Does the work-planning process provide for early involvement of workers and ES&H staff, in order to fully define the work and allow effective identification of hazards?

Are tasks for minimizing waste generation and controlling the release of effluents to the environment adequately defined during work planning?

Have higher-level work documents, such as project plans, been translated into discrete work packages and procedures with well-defined boundaries and interfaces?

7.5.2 Analyze the Hazards:

Do SLAC ES&H procedures address the hazards analysis process at the working level, and are the procedures properly implemented?

Are the Hazards Analysis responsibilities of ES&H subject matter experts and reviewers documented and understood?

Has a standardized hazards assessment process been developed and graded in its approach based on the complexity and risk of the activity/work, performance frequency, industry experience, and the initial hazard screenings?

Are thresholds identified within the hazards analysis process to trigger appropriate involvement of ES&H professionals?

Does the hazards analysis process address all types of work activities to be performed (e.g., project/construction, programmatic/R&D, experiments, manufacturing, D&D, testing, sampling, and facility operations and maintenance)?

Do formal procedures guide the development of hazards analyses and ensure that the hazards analyses are tailored to the specific work being performed?

Are the results of hazards assessment (i.e., identified controls) properly integrated into technical work documents and work procedures?

When work scope and technical work documents are changed, are hazard assessments reviewed for impact?

Do planners, workers, ES&H staff, and facility management personnel walk-down work sites to identify activity-related hazards based on the risk associated with the specific activity?

When conditions change, are new potential hazards analyzed?

Are hazards adequately communicated to all workers and subcontractors by way of work packages, procedures, instructions, permits, postings, training, and pre-job briefings?

Are current/controlled documents, drawings, surveys, and other data used in hazards analyses?

Are the hazards analysis documents reviewed for impacts when work scopes and work documents are changed?

Are environmental hazards associated with waste streams identified and analyzed?

Are hazards analysis documents in place for all operations and work activities?

Are hazards analyses sufficiently detailed to identify appropriate controls?

7.5.3 Develop and Implement Hazard Controls:

Are standardized hazard controls developed and used in a graded approach based on project/work complexity and risk, performance frequency, and initial hazard screenings?

Are the types of controls (engineering, administrative, and personal protection equipment) applied in the correct sequence?

Are the hazard controls comprehensive and adequate for maintaining planning efficiency while ensuring hazard mitigation?

Are training requirements incorporated into controls and hazards assessments?

Are thresholds identified for involvement of ES&H professionals in the tailoring of hazard controls?

Are the stop-work authority and responsibilities of workers/supervisors clearly defined for unexpected hazards or safety concerns?

Do procedures address interfaces between facility management, subcontractors, and SLAC personnel to ensure that conflicts and overlapping work activities are properly coordinated and resolved?

Are JSA’s analyzed to ensure they do not conflict or introduce additional hazards?

Do controls provide sufficient notification and afford protection to co-located workers who may either be present or traverse the areas potentially impacted?

Is independent safety review provided on the adequacy of controls for higher-hazard activities?

Are both workers and appropriate ES&H professionals included on planning teams and involved in hazard control development?

Do environmental, waste management, radiological, health, safety, and operations personnel have an adequate understanding of each other’s requirements and processes to minimize environmental impacts and meet regulatory requirements?

7.5.4 Perform Work Within Controls

Are work activities formally scheduled on the plan of the day or equivalent mechanisms to facilitate notification to affected personnel, resolution of scheduling conflicts, identification of resources and support required, prioritization with other work, and availability of required facilities and systems?

Are pre-job briefings effective in communicating to all workers work scope, prerequisites (including training), and permit requirements?

Are job-specific and area hazards adequately communicated to all workers before the start of work?

Is there an effective process that defines the safety requirements between the facility managers, operations, support organizations, and the maintenance organization to ensure that defined work does not overlap and cause conflicts?

Does the ISM work process define appropriate mechanisms to address how to handle changes in work scope or changes in method of completion after initial approval?

Have work activities and projects, including environmental protection activities, been properly planned, reviewed, and authorized?

Are methods for authorizing work and verifying the readiness to perform work, formal and documented?

7.5.5 Feedback and Improvement

Are formal, post-activity performance review processes (e.g. post-job reviews, operations reviews) established and effectively used?

Do facility representatives, subject matter experts, workers, supervisors, and line managers recognize, report, evaluate, and address accidents, incidents, near misses, injuries, illnesses, exposures and opportunities for improvement in a timely manner and in accordance with established procedures?

Is feedback from workers effectively solicited and used during work planning, execution, and closeout?

Is worker participation in safety programs (e.g. behavior based safety, safety committees), encouraged and effective?

Are lessons learned identified and incorporated into the work planning and authorization process?

Do assessment activities by line oversight (contractor and DOE) include observation of work activities by facility representatives, managers, supervisors, and subject matter experts?

Are identified deficiencies and weaknesses, and associated corrective actions, appropriately documented and managed in accordance with management processes for site issues?

Have findings related to work planning and control from previous Independent Oversight assessments been effectively corrected?

For issues identified by current inspection, what prevented the contractor or DOE line oversight activities from identifying and correcting the problems?

7.6 *Conclusion*

While the list of comments and recommendations that appear in this section may appear daunting, LCLS management is encouraged to carefully review these recommendations with SLAC management and find a joint course of action forward. Some of the comments and recommendations may cover topics/areas where the LCLS Project is in compliance with SLAC policy and procedures, but in these cases in particular, SLAC management should view this report as an opportunity to review, revise and improve present practice where applicable. This section was born out of the FAC desire and concern that LCLS and SLAC be successful in the fielding of a facility that advances and defines the state of the art of a next generation x-ray source. Aggressively pursuing risk mitigation where risks are real with substantive probabilities and severe impacts is a key requirement of project management. Both SLAC and LCLS have shown the ability to do this in the past and the FAC believes that both can continue to rise to the challenge.

Appendix A

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LCLS Facility Advisory Committee Members

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Appendix B

Facility Advisory Committee Meeting Agenda

LCLS Facility Advisory Committee Meeting Agenda

October 29-31, 2007

(v. 1.0)

Monday, October 29th

Plenary Session

Location: *Redwood Rooms, Building 48*

Time	Topic	Presenter
7:30	*Executive Session*	*Committee*
8:00	Welcome	K. Hodgson
8:15	Project Status Update, and Charge to Committee	J. Galayda
9:00	Project Management	M. Reichanadter
9:30	Installation and Planning	R.M. Boyce
10:00	***Break***	
10:15	E-Beam Systems Update	D. Schultz
10:45	Injector Commissioning Results	J. Welch
11:15	E-Beam Controls Systems	H. Shoaee
NOON	***Lunch (FAC members only)***	
1:15	Undulator Systems	G. Pile
1:45	Photon Systems Update	J. Arthur
2:15	Photon Controls	G. Haller
2:45	Lasers and Ultra-precise Timing	W. White
3:15	***Break***	
3:30	LUSI Update	J. Hastings
4:00	Conventional Facilities Update	J. Albino
5:00	*Executive Session*	*Committee*
7:00	*Dinner – Bucca de Beppo*	*Committee/Speakers*

Tuesday, October 30th

Location: *Redwood Rooms, Building 48*

Time	Topic	
7:30	*Executive Session*	Redwood D
8:00	*Breakout Sessions Begin*	(see below for listing)
3:30	*Construction Site Tour*	*all*
5:30	*Executive Session*	Redwood D

Breakout Session 1 – Accelerator Systems

Location: *Redwood C, Bldg 48*

Time	Topic	Presenter
8:00	Drive Laser Commissioning Results and Plans	P. Hering
8:30	RF Gun Commissioning Results	D. Dowell
9:15	Injector RF Results and Status for Next Phase	R. Akre
9:45	Installation Planning	R.M. Boyce
10:15	***Break***	
10:30	BC2/Linac Installation Status & Schedule	J. Chan
11:00	LTU Installation Coordination	K. Ratcliffe
11:30	Commissioning Plans for 2008	J. Frisch
12:00	***Lunch (FAC members only)***	
1:30	FEL Commissioning Plans	J. Welch
2:00	Discussion	*all*
3:30	*Construction Site Tour*	*all*

Breakout Session 2 – Undulator Systems

Location: *Red Slate, Bldg 280C, Room 112*

Time	Topic	Presenter
8:00	Undulator System Fabrication Schedule	G. Pile
8:30	Undulator Vacuum Chambers and System	G. Wiemerslage
9:00	Undulator Vacuum System	D. Walters
9:30	RF BPM Status and Testing	B. Lill
10:00	***Break***	
10:30	Quadrupole Magnet Results and Schedule	M. White (video)
11:00	Support/Movers Schedule	M. White (video)
11:30	BLM system design	B. Berg
12:00	***Lunch (FAC members only)***	
1:30	Undulator Tuning and Fiducialization Schedule	Z. Wolf
2:00	Undulator Physics Issues	H.-D. Nuhn
2:30	Undulator System Installation and Assembly Sched.	J. Chan
3:00	Undulator Commissioning Plans	H.-D. Nuhn
3:30	*Construction Site Tour*	*all*

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Breakout Session 3 – XTOD, XES, LUSI

Location: *Kavli Conference Room, 2nd Floor, Bldg 51*

Time	Topic	Presenter
8:00	XTOD Status	R. Bionta
8:30	Mirror Update	T. Mccarville
9:00	LUSI status	J. Hastings
9:30	Discussion	*all*
10:00	***Break***	
10:30	AMO instrument	J. Bozek
11:00	XPP instrument	D. Fritz
11:30	CXI instrument	S. Boutet
12:00	***Lunch (FAC members only)***	
1:30	DAQ/Controls	G. Haller
2:00	XCS instrument	A. Robert
2:30	X-ray commissioning	H. Tompkins
3:00	Discussion	*all*
3:30	*Construction Site Tour*	*all*

Breakout Session 4 – Controls

Location: *Redwood A/B, Bldg 48*

Time	Topic	Presenter
8:00	Controls Commissioning Results	E. Williams
8:30	LCLS MPS Status and Plans	P. Krejcik, S. Norum
9:00	Undulator BLM system	J. Stein; S. Norum
9:30	Undulator Motion Control	S. Shoaf
10:00	***Break***	
10:30	RF BPM Electronics and Controls	R. Johnson
11:00	Application Software Status and Plans	D. Rogind, G. White
11:30	Beam-Based Feedback Systems	D. Fairley
12:00	***Lunch (FAC members only)***	
1:30	BC2/Linac Controls Installation Status	A. Alarcon
2:00	LTU/Undulator Planning	H. Shoaee
2:30	DAQ/Controls	G. Haller
3:00	Discussion	*all*
3:30	*Construction Site Tour*	*all*

Breakout Session 5 – Conventional Facilities

Location: *Redwood D, Bldg 48*

Time	Topic	Presenter
8:00	Turner Contract Overview	J. Albino
8:30	Conventional Facilities Management	D. Saenz
9:00	Status of Construction	D. Saenz/J. Albino
9:30	Commissioning Plan	D. Saenz
10:00	***Break***	
10:30	Construction Safety	R. Hislop
11:00	Discussion	*all*
3:30	*Construction Site Tour*	*all*

Wednesday, October 31st

Closeout Session

Location: *Redwood Rooms, Building 48*

Time	Topic
7:30	Executive Session
8:00	Executive Session, *or More Breakouts if Required*
9:30	Executive Session
11:00	Closeout - Plenary

Appendix C

Representative Hazards List

Appendix C
Representative Hazards List

Asphyxiate Liquid leak Ventilation failure Sensor failure Confined space	**Leak and Spill Hazards** Materials listed on the TSCA inventory. Oil based material
Cryogenic Hazards	**Magnetic Field** Fringe fields
Electrical Energy Stored energy exposure High voltage exposure Low voltage, high current exposure Electrical faults Battery bank and UPS equipment	**Mechanical Hazards** Moving large awkward heavy equipment Handling large awkward heavy plastic components.
Environmental Hazards Materials listed on the TSCA inventory. Oil based material	**Oxygen Deficiency Hazard** Inert gas purge for detector containment
Fire Hazards Combustible Liquids Combustible Materials PVC	**Potential Energy** Crane operations Compressed gases Capacitor banks Vacuum/pressure vessels
Flammable Materials Wire insulation Cable insulation and Jackets Flammable liquids Combustible Liquids	**Radiation Hazards** Indirect from existing beamline
Hazards Atmosphere Adhesive Materials used for Detector assembly	**Thermal Energy** Cryogens High temperature equipment Vacuum pumps
Kinetic Energy Power tools and equipment Movement of large objects Overhead structures and equipment Motor generator equipment and Flywheels	**Toxic Material Hazards** Materials listed on the TSCA inventory.
Laser Hazards Calibration source exposure Creation of mixed waste	**Toxic Materials** Chemical agents Lead and other heavy metals

Appendix D

Example Matrix for Work Plans/Hazard Analyses Approvals

Appendix D

Example Matrix for Work Plans/Hazard Analyses Approvals

Hazard	Designated Approver threshold *(Who Approves)*	Department Head	ES&H Department	Division Head
Chemicals	Work with solvents, reactive or corrosive chemicals in large amounts or in a poorly ventilated area. *(Immediate Supervisors)*	Notify	Any work with poisonous, highly reactive, explosive, or carcinogenic chemicals. Work with new chemicals synthesized.	Notify
Computers in Systems that Protect People, Property, or the Environment			Notify	Notify
Confined Space Work			If known hazards require a Confined Space Permit	Notify
Crane, Hoist & Forklift Usage	Below-the-hook lifting devices require review. *(Engineering Approver)*		Notify	Approves unusual use (e.g. outside rated load limit)
Cryogenic Hazards	Any work with more than 200 liters of cryogenic material. *(Engineering Approver)*			Approves operation of any system with inventory exceeding 200 liters
Decommissioning & Dismantling		Approves all D&D work	Reviews all D&D work	Notify
Electrical Power	Work on AC electrical power distribution system requires an Electrical Work Permit. *(Electrical Coordinators)*	Notify		Notify Must approve all hot work.
Electronics	If "significant potential" for arcing, flash burns, electrical burns, or arc blast. *(Immediate Supervisors)*	Notify		
Environmental	Any work that will generate greater than 5 gallons of hazardous waste. Any work where a significant spill is possible and likely to get into the environment. *(Senior Safety Officer)*	Notify	Notify	
Excavation and Digging	Excavation permit for any earth removal. *(Task Manager or Construction Coordinator)*	--------- ---------	Notify Permit for any Bermline alteration.	-------- Notify
Fall Exposure	Any new scaffolding erection. *(Scaffold Competent Person)*	Notify	Notify	
"First time use" of new equipment	Machines designed or modified for use at SLAC require an approved procedure before production use. *(Engineering Approver)*	Notify		Notify
Flammable Gas Hazard		Approves work in Flammable Gas Class 1 or 2 areas.	Notify	Approves all Flammable Gas installations

Appendix D (Cont'd.)

Example Matrix for Work Plans/Hazard Analyses Approvals

Hazardous and Toxic Substances		Approves direct handling written procedure in advance of work	Approves all abatement work.	Notify for Direct Handling & Abatement.
Hydraulic Systems	SLAC designed or modified systems require review. *(Engineering Approver)*	Notify		
Lasers	Any work with a Class 3b or higher laser. *(Laser Safety Officer in ES&H)*	Notify	Notify	Notify
Machining and Grinding			Approves any work with hazardous mater.	Notify for work with hazardous materials.
Magnetic Field Hazards	Fringe fields over 1 kilogauss in air extending over 1 cubic foot. Potential mechanical movements due to magnetic fields. *(Engineering Approver)*	Notify	Any time average exposure of people to 300 or more Gauss	
Mechanical Equipment	Work with a mechanical system that has the potential to release stored energy in excess of 60,000 foot-pounds. Work with unguarded rotating machinery. *(Engineering Approver)*	Notify	Notify	Always notify. Must approve if potential energy release is above 500,000 ft-lbs.
Noise Hazards			Approves if more than 8 hrs work in an area above 85 dbA.	Notify
Other Work Environments	Continuous work in temperatures above 86 degrees F or below -25 degrees F. *(Immediate Supervisor)*	Notify		
Oxygen Deficiency Hazard	Work in ODH-1 areas. *(Immediate Supervisors)*	Approves work in any area classified as ODH-2 or >	Notify for ODH-2 work.	
Pressure or Vacuum Vessels and Systems	All pressure vessels and vacuum vessels require an engineering review. *(Engineering Approver)*	Notify	Notify	Following test, approves <u>operation</u> of all pressurized systems >200 SCFH & all vacuum systems > 35 cubic feet
Radiation	Work in a High Radiation Area, on Class 2-5 objects, with activated liquids, depleted U_2, or contaminated objects, requires a Rad Work Permit (RWP). *(Radiation Safety Officer)*	Notify	Notify ES&H Section and ES&H before moving a source to another building.	Notify -------
Repetitive Motion or Ergonomically Challenging Tasks	All repetitive assembly work taking more than 4 hours per day. *(Immediate Supervisor)*	Notify	Notify	
Welding, flame cutting, brazing, open flame work	All work requires a Burn Permit. *(Fire Department)*			
Work in space controlled by another division		Notify		Approves all such work.

Appendix E

Example Protective Equipment Checklist

Appendix E
Example Protective Equipment Checklist

PROTECTIVE EQUIPMENT CHECKLIST
(CHECK ALL PPE REQUIRED FOR THE JOB TASK)

EYE & FACE

- ☐ Safety Glasses w/ side shields
- ☐ Chemical/Splash Goggles
- ☐ Impact Goggles
- ☐ Full Face Shield (worn over 1, 2, or 3 only)
- ☐ Cutting Goggles
- ☐ Welding Hood
- ☐ Other___________________

HAND (Gloves)

- ☐ Cloth
- ☐ Leather
- ☐ Welding
- ☐ Metal Mesh
- ☐ Electrical Insulated
- ☐ Synthetic (Circle One)
  Rubber, Neoprene, Latex,
  Butyl, Vinyl, Nitrile
- ☐ Other

FOOT

- ☐ Hard Toe Shoes/Boots
- ☐ Dielectric
- ☐ Neoprene
- ☐ Rubber
- ☐ PVC / Urethane
- ☐ Metatarsal Guard
- ☐ Other ___________________

RESPIRATORY PROTECTION

- ☐ Dust Mask
- ☐ Fumes/Mist Mask
- ☐ Half Face Filter
- ☐ Full Face Filter
- ☐ Full Face Airline
- ☐ Full Face SCBA
- ☐ Emergency Escape Pack
- ☐ Emergency Escape Disposable

PROTECTIVE CLOTHING

- ☐ Nomex / FRC
- ☐ Tyvek Suit
- ☐ Rainsuit
- ☐ Acid Suit
- ☐ Encapsulating Suit
- ☐ Other_________________

HEARING

- ☐ Ear Plugs
- ☐ Canal Caps
- ☐ Ear Muffs
- ☐ Dual Protection
- ☐ Other ________________

HEAD

- ☐ Class A Hard Hat (limited voltage)
- ☐ Class B Hard Hat (High voltage)
- ☐ Chin Strap
- ☐ Other

List Any Other PPE Not Indicated Above:

Does the task present potential exposure to hazardous chemicals? YES NO

If yes, has the MSDS for each hazardous chemical been reviewed? YES NO