Report of the April 16th and 17th, 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 on the 16th and 17th of April 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

The FAC was also asked to additionally concentrate on the systems integration/installation planning strategy and the XRTOD diagnostics.

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 design and construction; 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 April 16th and 17th, 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*

The LCLS Project has continued to make very strong progress since the previous FAC meeting of October 2006. Notable accomplishments include achieving a 250 MeV beam and the first use of beam compressor 1 (BC1) immediately prior to this FAC meeting. Tunneling has begun, and civil construction is making strong progress. Coordination and the *position* of the project within SLAC are strengthened at all levels at SLAC. Integration and installation preparedness is increasing and the integrating phase of the project is clearly in full swing. While there have been many very remarkable accomplishments and much progress, some issues still exist in various areas that give pause. Specific issues, within the areas of the subgroups, are covered in the respective subgroup reports.

The LCLS Project organization has matured, but continues to be tweaked. The project has added an Associate Project Director for Engineering and Chief Instrument Scientist. The addition of the Chief Instrument Scientist is part of the incorporation of the LUSI MIE Project within the aegis of the LCLS project management structure. The LUSI MIE Project now appears as one of the top-level systems joining Conventional Facilities, Electron Beam Systems, and Photon Beam Systems.

There are specific staffing issues that continue to plague us, such as the continued lack of a deputy within the controls area and the recent change of the Undulator System Manager. While these do present challenges, they do not appear to be central issues for the project.

There is a change in the focus of the project organization reflecting the evolution of the project into one of integration. These integrating aspects are beginning to take hold. The time necessary to completely benefit from these integrating aspects places them squarely on the critical path of the project. The timeliness of the complete integration and installation planning has created concern within SLAC management. This concern extends to the point of delaying the scheduled shutdown of the B-Factory.

The detailed shutdown and installation scheduling is only starting and the *first cut* at the detailed planning isn't anticipated until mid May. A complete *bulletproof* schedule is anticipated by August 1, 2007. While it may be premature to consider slipping the shutdown timing at the time of this FAC meeting (April 2007) such consideration cannot wait until the 1st of August. The LCLS Project and SLAC Management must establish a *gate point* date for shutdown scheduling and criteria for making the decision at that *gate point*. In the detailed planning for the installation, integration of the linac access, the tunnel access, and even locations within the tunnel, must be viewed as explicit resources to be scheduled and loaded appropriately. This clearly needs to be established *prior* to the upcoming Lehman review.

While LUSI presently appears on the project organization chart, it is not clear how fully the controls and management of LUSI have been integrated into LCLS. While it is true that funding and statements of work must not be co-mingled, previous DOE review reports have made it clear that the two projects must be closely correlated. LUSI is contributing to the overall facility of the LCLS, and therefore must be integrated into the decisions that may affect either the operations or the infrastructure of the LCLS facility. This need for close integration covers all three dependent variables of a project- scope, schedule and cost. Care must be taken that the division of scope is carefully delineated between the two projects, but that interfaces and integration between the two are centrally controlled. Likewise, on schedule, integration and installation between the two projects must also be centrally controlled. These two projects, both from DOE fiat and from sheer necessity, must be fully integrated and centrally controlled and the relationship of LUSI with respect to the FAC must be considered in no different a light from that of any other major system within the LCLS.

The continuing resolution (CR) created a major disruption for the LCLS project as it did in many parts of the scientific research community. There were many explicit impacts on schedule and costs, and the LCLS Project has accommodated the uncertainty and delay in funding as well as could be expected. The FAC appreciates the frustration and disruption that such uncertainty and changes in funding profiles can create in a project. It is important to remember that the impact of these uncertainties on the project are certainly far reaching and may not initially be completely quantifiable. Consequently, the development of a revised project baseline must reflect this uncertainty and the need for schedule and cost contingency in order to ensure a successful completion of the project. Care must be taken that the revised baseline does not compromise the project's success by inadvertent acceptance of a baseline where relative schedule or cost contingencies of the LCLS Project are less than required.

While the CR provides an opportunity to re-baseline the LCLS Project, this must not be viewed as an opportunity to reduce vigilance over the project. Neither the DOE, nor the scientific community, will accept any loosening of the reins at this point. Everything that the FAC stated in its previous report with respect to schedule is at least as critical as it was in October 2006. In most cases the situation is even more serious. The schedule has only gotten tighter. Delays have accumulated in some areas at a rate to cause serious concern. For example, in the area of magnetic measurements, in October 2006 the FAC learned there were six months of float for the scheduled completion of the measurements. In the intervening six months, three months – a day of slip for every two days of elapsed time – has been consumed. As previously mentioned, the installation schedule remains to be controlled and so continues to be a major area of concern. *Buoyancy* of the project has been decreasing (loss of float) as the number of *just in time* items and subsystems increase. This geometrically raises the potential for unrecoverable schedule loss. A day of float must only grudgingly be surrendered or the project, even with a revised baseline, could suffer significantly.

The use of the risk registry has improved, but in the movement to convert it into an active *punch-list*, care should be taken not to lose sight of those risks that may be less tactical in nature, but nonetheless strategic in scope and impact. This extends to risks that may require a more passive mitigation strategy.

Finally, there appears to have been some *backsliding* in the quality of the interaction between the LCLS Project (including LUSI) and the FAC. The FAC is a body that is *owned* and reports to the LCLS Project Director. The FAC should be viewed as a project *personal trainer* rather than merely an entity that brings people of the scientific community together and provides cover for the project from external entities. The present format of 1½ days for the FAC meeting is simply too short to delve into issues. Because the FAC is an entity of the LCLS project itself, the FAC meeting should not be approached in the same manner as the project would approach a DOE review. Concentrating on accomplishments within presentations, rather than issues, reduces the value that the FAC can provide to LCLS. The FAC should be viewed both as a *tactical* and *strategic* instrument of LCLS. This is particularly important as the timing and structure of the next FAC meeting is contemplated. It may be advisable to have subsets of the FAC meeting prior to the full, formal FAC meeting. This could most likely be the case in the areas of magnetic measurements, conventional facilities, and installation and integration. The FAC remains committed to the LCLS Project and so would welcome additional reasonable efforts to maximize its value.

2.0 Electron Systems Subgroup Summary

John Corlett, Max Cornacchia, Wim Leemans, John Lewellen

2.1 *Initial Injector Commissioning*

The Committee congratulates the LCLS team on the excellent results already achieved in the first stages of commissioning the photo-injector. Injecting the beam into the main linac is a major milestone for the project, and has been accomplished within the short time frame of four days between generating the first beam from the cathode, and measuring the beam at the furthest downstream point accessible at this stage. A charge of 300 pC has been accelerated to 250 MeV through the first bunch compressor, and some evidence of compression has already been observed. About half of the commissioning goals have already been achieved in a short time. This encouraging start of the initial injector commissioning testifies to the high quality of its design and fabrication, and bodes well for the more detailed studies to come.

The next stage of commissioning will involve detailed characterization of the beam, and the LCLS physics team has planned well for this. The availability of diagnostics, however, is a concern. Several beamline components were reported to not be fully installed as yet, to have failed, or taken out of the scope of the construction project. These concerns will be addressed in more detail later.

2.2 *Photoinjector*

2.2.1 Laser

The laser group has done a good job in shaking down issues with the photocathode laser system, and the committee commends their efforts in getting first electron beams from the state-of-the-art LCLS gun. This has been a strong team effort, and the integration of laser scientists and engineers, as well as the accelerator physics group, has been very productive.

There are some areas in which the laser beam performance is not meeting design goals, in particular, neither temporal nor spatial pulse shaping is fully operational. There is a significant and irregular distortion from a “flat-top” in both the time-profile of the pulse, and the spatial profile.

The system design includes a Dazzler to provide longitudinal shaping of the laser pulse. Optimal operation of the Dazzler appears to be compromised by harmonic content in the pulse, introduced by a birefringent filter in the regenerative amplifier cavity located upstream. The laser manufacturer is planning to return during the September shutdown to replace the identified filter. In the meantime, the impact on commissioning may not be severe. The problems encountered with the longitudinal pulse-shaping system are not unusual. Unfortunately, almost every group that has attempted to provide a flat-topped pulse has encountered problems. As an alternate approach, stacking of Gaussian pulses was proposed by the laser group.

It was unclear whether the problems encountered with the transverse profile transform were a result of the specific aspheric optical device used, or a general characteristic of this transform mechanism. The impact on electron beam emittance is not yet clear. Solutions are becoming more practical as the team gains experience with the systems. For example, the mode shaper has been replaced by simple iris imaged to the cathode. The laser team will need to develop means, such as the use of deformable mirrors as suggested by the group, to improve beam homogeneity if the impact of the existing spatial beam modulation on emittance turns out to be significant.

The committee recommends that alternate optical techniques (e.g. pulse stacking, deformable mirrors) be pursued for both the transverse and longitudinal shaping, along with continued cathode-to-beam-dump modeling of the LCLS as a whole, using initial beam distributions derived from measured laser performance. The results of tracking studies will help guide the laser group in pursuing solutions.

The laser oscillator lock-to-clock hardware has failed, and a home-made system has been implemented to allow remote resetting of the mode-lock. New mirror mounts are expected to fix the locking to the external RF clock. Contamination of the crystal surfaces is a concern, as experience of other groups has shown that this design of oscillator requires cleaning service every 100 hours (with at least 1-2 hours downtime and continuous degrading of performance of oscillator), which is not commensurate with operations as a user facility. The committee strongly urges the procurement of a different oscillator to eliminate the issue of contamination.

The committee recommends procurement of a complete duplicate laser system, with a hot-swapping beam system. In addition, a good cache of long-lead-time spares should be made available, since repairs will need to be made on the down laser. Spare parts procurement should be fast-tracked, as without the drive laser, literally nothing can be accomplished in terms of LCLS operation. Tests of the active steering stabilization system are under way.

2.2.2 RF gun

The gun performance appears to be good, with the measurements indicating excellent agreement with the design data. Overheating of the cavity probes has resulted in administrative limits to the operation of 30 Hz RF pulse repetition rate, and a maximum gradient of 115 MV/m. Although this problem does not represent a serious limitation at the moment, and will be corrected in the second gun, the committee recommends that modified probes be retrofitted in the present photo-injector at an appropriate time. Even though the gun's functionality is somewhat limited by the presently installed field probes, it should serve for commissioning purposes. The gun should not be vented to replace the probes unless, and until, they become limiting factors in obtaining the required beam properties as it would potentially entail significant recovery time. At such time, however, the entire Gun 1 installation should probably be replaced by Gun 2, as the second gun and solenoid incorporate additional features (e.g. thin-film quad field correctors inside the solenoid) that may also be required for ultimate performance.

The displacement of the gun from its proper position is a somewhat troubling mistake. Since correcting it will potentially be a large job and will require venting much of the injector, as well as re-optimizing the laser transport, the committee recommends investigating the potential impact of this on LCLS performance. If a change is required to achieve the design performance, the change should be made as soon as possible. This might also represent an opportunity to install Gun 2, if it is ready.

The quantum efficiency appears to be lower than expected, and the early measurements need to be confirmed after verifying the calibration of the diagnostics. The commissioning team is encouraged to perform cathode quantum efficiency mapping as soon as possible. This is not only needed for feedback into the beam dynamics simulation, but will also help to set up for laser-based cathode cleaning. On a positive note, the measured dark current from the gun is very low.

2.3 *Diagnostics*

The electron beam diagnostics are not yet fully installed, or are not yet working properly. The full complement of injector diagnostics is critical to ensure adequate characterization of the LCLS injector performance and detailed tune-up. This includes charge and profile measurements at all planned locations along the injector accelerator. The committee recommends a high priority be given to completing the installation up to the end of BC1.

The charge calibrations of the toroids, beam position monitors and Faraday cups should be cross-checked to determine the source of the discrepancies noted in the review.

The removal of the four wire-scanner systems immediately upstream of L2 is of significant concern. This was to be the primary tool for measuring the beam properties and transverse wakefield corrections at the entrance to BC2. The four-station package makes the measurement fast and easily repeatable, as it would not require changes to the linac lattice to perform the measurement. The committee notes that the decision to remove the wire scanners in linac L2 may introduce a limitation in the accuracy of characterizing the beam in the critical region before BC2, and introduces risk in characterizing the beam. We did not receive enough information to make specific recommendations, other than to place a very high priority upon verifying the usefulness of the OTR screen as a replacement measurement.

2.4 *RF Systems Controls*

A presentation of the LCLS LLRF network, which is gradually being implemented to replace the existing linac RF controls, indicates a solid design and a sound plan.

2.5 *Installation Schedule*

The Committee applauds the plan to develop an integrated installation schedule, under the competent and proven ability of Richard M. Boyce. Nonetheless, the three months scheduled for the BC2 installation, with little or no slack due to the PEP-II start of its last operational run, and the possibility of an extended PEP-II run delaying the onset of installation, appear tight. Despite reassurance from the LCLS management that it can be done, it was apparent to the committee that the integrated schedule still has to show how it will be done. The integrated schedule is planned to be completed in June 2007.

3.0 Undulator Subgroup Summary

Kem Robinson, Joachim Pflüger

The Undulator System within the LCLS Project continues to make good progress. A major management change has occurred since the previous FAC Meeting (October 2006) with Geoff Pile replacing Steve Milton. The subcommittee could see no deleterious effects from this management change and strong progress continues. The Argonne National Laboratory (ANL) LCLS team has focused on deliverables and quality assurance (QA) of the complete undulator system. At SLAC the focus in the undulator systems continues to be in the area of magnetic measurements and integration. The ASK system is about be deployed at ANL and this should facilitate stronger integration, QA, and communication. A comprehensive time tracking and planning system has been in active use at ANL for some time and has demonstrated its effectiveness.

The continuing resolution has caused major difficulties in the undulator system arena from both a cash flow and matrix resource allocation. These issues have been fully addressed and progress again appears to be *on track*. As the LCLS Project moves towards its re-baseline in July 2007 as a result of the continuing resolution, the project team must exercise care in the undulator system in particular to fully understand, appreciate, and account for unrecoverable cost and schedule losses.

3.1 *Undulator Magnetic Structures*

Three undulator magnetic structures have been completely tuned and are *finished*. One additional magnetic structure is in rough tuning and another is in fine tuning at the time of this FAC meeting (April 2007). The final undulator magnetic structures are expected to be delivered to SLAC in June 2007.

The Magnetic Measurement Facility (MMF) is fully operational with both the fiducialisation and testing plans in place. Significant time, however, has been spent in the last six months *commissioning* the MMF and identifying and addressing many unexpected *features* that have slowed progress considerably in production measurements. Among the *features* that have appeared and been addressed are excessive noise in a hall probe from a manufacturer that previously had probe elements with superior noise characteristics. The magnetic measurement bench drive system generated more electrical noise than anticipated. Planar and tensor Hall-effect issues and hall probe calibration problems also contributed to a lengthened commissioning phase and a delay of fully getting into production measurements.

In addition to the *features* surrounding the commissioning of the MMF, other, more characteristic of the types of oversights that can torment progress in a project at this phase, also contributed to a delay in the deployment of full production magnetic measurements and fiducialisation. In the area of general plant commissioning for example, the MMF air conditioner and air compressor failures have slowed progress. In the area of general planning and oversight, the MMF ran out of the magnetic shims necessary for tuning and the MMF was also short a mechanical designer. In the area of QA implications and communication, a set of magnetic structures with oversize strongbacks were accepted by ANL, but not communicated to SLAC. Consequently, these particular magnetic structures would not fit on the magnetic measurement benches nor accept the magnetic Mumetal shields for kinematic mountings. Finally, in the area of unknown uncontrolled variables, the S/N-06 magnetic structure had very anomalous end field configurations that did not permit it to be tuned. Both SLAC and ANL are investigating this particular magnetic structure.

The result of these issues is that the magnetic measurements of undulator magnetic structures are three months behind the schedule presented to the FAC six months previously (October 2006). To the credit of the Undulator Systems Team, they have acknowledged and accounted for the schedule slippage as shown in the following table (taken from a presentation given by Z. Wolfe to the subgroup).

Lost time from problems encountered for magnetic measurements	**Cumulative**
Lost three months due to noise problems with the Kugler bench.	12 weeks
Lost at least two weeks due to air conditioner failures.	14 weeks
Lost at least two weeks due to air compressor failures.	16 weeks
Lost two weeks understanding the Hall probe *y*-dependence.	18 weeks
Lost one week understanding our Hall probe calibration problem.	19 weeks
Lost one week when shield did not fit oversize strongback.	20 weeks
Lost one week when we ran out of shims.	21 weeks
Lost one week when the undulator feet did not fit in the slots.	24 weeks
Lost three weeks understanding SN 06.	27 weeks
Lost many weeks due to loss of mechanical designer	27+? Weeks

As seen in the table above, the estimate shows that more than six months have been lost. The schedule presented to the FAC in October 2006 indicated six months of float from the scheduled completion of the magnetic measurements of the last section to when magnetic measurements would impact the overall project schedule. Learning curves and commissioning issues, however, were anticipated in the original schedule and so only ~3 months of schedule slippage has actually occurred.

Nonetheless, several of the issues underlying the causes of some of the schedule slippages still remain and so the subgroup remains concerned about maintaining the schedule. An area of specific concern that should be addressed includes development of tuning approaches for end-fields. There is no indication whether the anomalous end-fields present on S/N-06 are unique in the production series or merely the first of many such structures to be encountered during production measurements. End-fields in insertion devices have a notorious reputation for uncontrolled variability and so such tuning approaches are essential, as several devices will most likely require specific end-field tuning.

With the identification of significant planar/tensor Hall-effect considerations with the hall probes, an effort should be made to understand and document the sensitivity of the magnetic centerline to these effects. At present, the magnetic centerline is not measured directly and consequently this could contribute to uncertainties and errors between the measurements and the actual tuning and performance of a magnetic structure with the electron beam.

An additional risk to schedule float is that the full production processing is not fully integrated or streamlined. This indicates that the learning curve gains in throughput have not yet been fully realized. It is unlikely that the magnetic measurements will recover the schedule slippage accumulated to date, as telescoping the measurement time and increasing the throughput of undulator magnetic structures to greater than 1 per week is unlikely. The LCLS Project may wish to conduct a short informal review of progress in the magnetic measurements area prior to the DOE Lehman review (July 2007) or the next FAC Meeting.

3.2 *The Undulator Vacuum Chamber*

At the October 2006 FAC meeting the undulator vacuum chamber was an area of major concern for both the project and the FAC. Two design approaches were carried forward to a prototype stage: the baseline four-weld aluminum coated stainless steel chamber and an aluminum alternative. At a review conducted by the project in February 2007 the stainless chamber was selected to remain the baseline.

Two full-length prototypes have been completed since the previous FAC meeting (Prototypes A and B). Prototype A was fabricated with a 20Cb-3 stainless steel strongback and end cap and 316LN stainless steel top and bottom strips. Prototype B was fabricated with a 316LN strongback and 20Cb-3 stainless steel end cap and top and bottom strips. Both had vacuum leaks. The leaks in one chamber were repaired by brazing with Ag and Sn-Ag-Cu. Prototype B was repaired using laser welding. Both prototypes were aluminum coated. Both prototypes were used in the string tests, and both were reported as having met vacuum performance specifications. It was reported that Prototype A was installed in the single undulator test (SUT) to measure flatness. Prototype B was cut into pieces to examine the surface finish. With these development and design verification test results, the technologies necessary for the successful production of these chambers appear to be in hand.

Unrecoverable schedule slip associated with the vacuum chambers has put the first production parts arriving at SLAC for integration into the complete undulator system in November 2007, with the last production vacuum chambers slated to arrive in April 2008. This means that the vacuum chambers are on or very near the critical path. An area of concern is that at the time of this FAC meeting, suppliers for the strongback machining and the final machining of the vacuum chamber have not yet been identified. The Undulator System Team (UST) is strongly urged not to allow any further slips in the production schedule of the vacuum chambers.

Additionally, permeability tests were being planned for only a small section cut from Prototype A. In many respects, the permeability of a single small section is of only modest interest, as variability of permeability over one or more vacuum chambers is of much greater concern, and remains an uncontrolled variable with respect to ultimate undulator magnetic fields, and consequently electron beam trajectory. The FAC recommends that a greater number of samples be examined for magnetic permeability variations and effects on undulator magnetic fields. Those parts of Prototype A that have been split to allow examination of the surface can still be used for this purpose.

3.3 *Undulator Systems Diagnostics*

The beam finder wire (BFW) is in a combination of final design (the wire card) while other parts are presently with APS Procurement. Fixture designs are 90% complete and alignment and assembly procedures are only ~50% complete. BFW is apparently using the same members of the UST engineering staff as the vacuum chamber. The BFW is scheduled for final shipment to SLAC in

December 2007, completely overlapping the vacuum chamber. Careful monitoring by the Project is warranted to ensure that neither subsystem adversely affects the other.

Another area of concern has been the undulator rf-cavity beam position monitors. Considerable progress has been made since October 2007. A 3 RF-BPM test is scheduled to be installed and run on the Low Energy Undulator Test Line (LEUTL) in May 2007. The UST must ensure that these prototype tests match the layout configurations, including the long rather spindly rf-waveguides, as it is very possible that such mechanical or configuration aspects could degrade performance of the RF-BPMs and may require reworking. Delivery of the final production series of the RF-BPM is scheduled for delivery in January 2008 and therefore has only 3 months of float with respect to the vacuum chamber production schedule.

Beam loss monitors (BLM) appear to remain somewhat neglected, or at least unresolved at this point. The BLM are only at a conceptual level which is much too undefined for the state of the project. Because of the give and take that has occurred on the specifications and requirements levied on the BLM, the FAC feels it unlikely that they will survive cost and schedule pressures. Consequently, the Project is encouraged to establish gate points when further work on these devices will be abandoned and a minimal protection system would be defined and fielded. While such a minimal beam loss monitor may not be sufficient to ensure the ultimate level of desired protection, it could very likely be better than no system whatsoever.

3.4 *Other Details*

At this stage of the project the UST must focus on timely shipment of deliverables and quickly getting *all* components out of design and into production. Many details remain unresolved and with the undulator system getting closer and closer to the critical path, resolving these details is becoming more and more important. These details have already begun to, and will likely continue to, impact the overall project. Every process needs procedures to be quickly reduced to a *loosely-supervised* technician level. The completeness of the documentation and the aspects of quality assurance need to be carefully examined and any shortcomings remedied. It has come to the FAC's attention that the aberrant end-field issues associated with S/N-06 may actually be nothing more than an improperly demagnetized end magnet. If such is the case, the UST must re-examine its initial pre-shipment peak field scan, used for release from the supplier, and as such, it should have been caught at that point. The ASK deployment must quickly go forward or its full deployment could in itself begin to hinder integration and assurance associated with the Undulator System. No procurement, traveler, inconsistent drawing, or specification can be allowed to languish at this point or the Undulator System will very quickly become the pacing system of the LCLS Project - a situation that only a short time ago was not considered at all possible. Integration and installation details have made great strides, but much remains to be finished. The UST has shown great dedication and good performance to date, but it must not stumble as it closes in on the finish line.

4.0 X-Ray Subgroup Summary

Paul Fuoss, Tom Rabedeau, Thomas Tschentscher

4.1 *Presentations and Progress*

There have been significant changes to the scope and more prominently, the timeline of the x-ray instrumentation development for LCLS. These changes impact both the instrument being directly developed through the LCLS project, the AMO experiments in the soft x-ray region (AMOP) and the efforts of the LUSI project to develop x-ray pump-probe and coherent imaging for soft x-rays (SXP), hard x-ray pump-probe (XPP), hard x-ray coherent imaging (XCI), and hard x-ray correlation spectroscopy (XCS). We will briefly review and evaluate the material presented to us at the committee meeting. The XCS and SXP programs were not explicitly discussed during this meeting.

4.1.1 LCLS Efforts

Overview: The LCLS project response to schedule and funding difficulties has been to split the CD4 dates into two goals. In March of 2009 operation will begin in the near experimental hall (NEH). Operation in the far experimental hall (FEH) will begin a year later. In response to these changes in the program goals, LCLS and LUSI have modified their development plans. The SXP, XCI and XPP experiments will initially be operated in the NEH. After operations in the FEH commence, the XCI experiment will be relocated to the middle FEH hutch. The XCS experiment will be constructed in the FEH but since it wasn't originally scheduled for completion before 2010, the LUSI and not the LCLS schedule drives its operational date. The experimental infrastructure for the SXP experiment will primarily come from use of existing surface science chambers at SSRL. The committee felt that this was a reasonable response to the schedule and funding changes.

X-Ray Transport, Optics and Diagnostics: Most of the x-ray transport and diagnostics are on schedule. The committee is concerned that the lack of a final radiation shielding design may complicate some of these efforts and encourages a higher priority for this effort. There has been progress on the design of non-destructive x-ray monitoring detectors which the committee feels are crucial to the successful experimental use of the LCLS.

Mirrors remain a topic of great concern. The physics requirements on the soft x-ray mirrors have been completed. Five companies were asked to provide engineering feasibility information. Two companies declined to participate. Substrate samples were obtained from the remaining three companies. Samples from two companies have been tested and have failed to meet all of the physics requirements although each substrate was close to the desired performance. Substrates from the third company are currently being tested. The decision has been made to coat the mirrors at LLNL with B_4C because of its high optical density. The mirror movers, benders and vacuum systems are still at an early stage of design. The committee feels that baking of the vacuum chambers should not be necessary and should be avoided for the hard x-ray mirrors since it can potentially damage long mirrors. The physics requirements documents for the hard x-ray mirrors have not been completed. The committee is very concerned about the status of the mirror systems and urges LCLS to purchase an interim set of hard x-ray mirrors for the initial commissioning.

X-Ray End-Station Systems: Steady progress has been made on the x-ray end-station systems despite the adjustments of schedule and scope driven by the LCLS funding difficulties. The physics requirements for the AMO experiment were finalized in December. A preliminary design review will be held in May. The AMO experimental effort appears to be well organized and on schedule. A scheduled review for the Cornell 2D detector project has been delayed until September to coincide with the delivery of a prototype detector. Finally, in conjunction with the controls group, serious design work has started on a computing and data acquisition infrastructure for LSLS.

Controls and Data Acquisition: R. Sass and Y. Feng discussed the effort to develop requirements and preliminary architecture for the data acquisition system. There are a large number of slow control systems (e.g. motor movers), a number of high bandwidth detectors, and a data stream of FEL performance information that need to be correlated, preprocessed, visualized, archived and eventually transmitted to users for analysis. This is a daunting task because of the magnitude of data that will be generated. The upper estimate on data that must be stored during a day is 118 TB. While the committee feels that this limit will not be reached for years, the system must be designed to handle tens of terabytes of data per day. The initial configuration calls for using hardware components developed for the Large Synoptic Survey Telescope as building blocks for the network. This is a major undertaking - one of the largest data handling systems ever built, and will require a significant effort. While applauding the efforts to leverage high energy physics and astronomy technology, the committee is concerned that there is a significant difference between the short run experiments at LCLS and the many year data averaging of high energy physics experiments. These differences need to be clearly communicated to software designers transitioning from high energy physics projects.

4.1.2 LUSI Efforts

Overview: Jerry Hastings discussed the new plan for the LUSI project. At CD-4a in February of 2010, capabilities for x-ray pump-probe and coherent imaging will be provided on a shared instrument in the NEH. These will be significantly reduced instruments in terms of optics and laser capabilities from the original specifications. At the end of the project, CD-4b in March of 2012, the capabilities of the XPP and XCI instruments will be upgraded to the original specifications. There will be no support for the XCS experiment until CD-4b and then there will be delivery of an x-ray beam to the hutch in the FEH along with the Brookhaven detector array.

The concept for a non-destructive beam monitor of position and photon flux based on Compton backscattering was presented. Further, the idea to use a Hartman wave front analyzer to measure location and size of the sub-micron focal spot in the CXI experiment was introduced. These are important first steps in providing the necessary monitoring tools that will be crucial for successful experiments.

X-Ray Pump-Probe: Dave Fritz gave an overview of plans for the x-ray pump-probe experimental facilities. There was a discussion regarding the use of a robot versus a conventional diffractometer to move the x-ray detector. The robot would allow for greater flexibility but at significant programming cost. The committee didn't feel that the benefits provided by the robot solution were sufficient to justify its additional cost and complexity. Also, the committee suggested that the diffractometer include multiple detector circles (at least two) so that simultaneous features could be monitored during time-resolved experiments. In particular, this would allow for the use of a well defined simple process as a time base for a more complex interaction and thus, would partially compensate for timing jitter in the incident x-ray beam. Another capability that could be usefully included is x-ray imaging systems (e.g. using zone plates) to more easily and rapidly visualize structure in the x-ray signal.

X-Ray Coherent Imaging: Jerry Hastings talked about the plans for the coherent imaging experiment. The committee was asked if adjusting the spot size by working past the focus would be detrimental to image reconstruction because of the curved wave front. Recent work reported by Keith Nugent and coworkers suggests that not only is it not detrimental, it actually improves the convergence of the reconstruction (Williams, G.J., et al. PRB, **75**, 104102-1-7, 2007).

4.2 *Highlighted Observations of the Committee*

Note: Some of these observations (*in italics*) are repeated from earlier reports for emphasis.

- 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. This is particularly true in designing the data acquisition system.
- *The definition of the physics requirements for the various components is a crucial process. While much progress is being made on this issue, it is not clear that sufficient staff is available for this important activity to be completed in a timely manner that doesn't delay design and procurement.*
- *Communications within the project and with the experimental teams continue to improve. Yet there still seems to be inadequate attention paid to critical path items. In particular, there seems to be no appreciation that the critical path to commissioning may be significantly different than the critical path to successful experiments. Both should be optimized.*
- *The SPPS experience demonstrates that incorporation of shot-by-shot diagnostic and performance information from the RF, the electrons and the photons will be important to the success of the LCLS experimental program. Development of suitable diagnostics is still at an uncomfortably immature stage.*
- *Real-time x-ray performance information will be important for developing suitable metrics for accelerator performance. The lack of such metrics greatly hindered the SPPS program.*
- *The basic XTOD systems appear on track for initial LCLS commissioning. However, more sophisticated systems like the x-ray mirrors risk being late.*
- *The proposed staffing levels for the operational phase appear too low. Basing them on the much different operating environment of a storage-ring based synchrotron source is inappropriate since a much broader skill set will be required to effectively use an FEL.*
- The design, testing and acquisition of the mirror system is likely to be an extended process. This results from the optic elements that are near state of the art. Unique alignment techniques will need to be developed for use with low repetition LCLS beams, and the lower operational stability (at least in the short term) may result in drift problems. The design of these systems needs to be rapidly advanced.

- *The budget is continually being squeezed and items descoped. Many of the descoped items are still critical for the experimental programs and their costs are being shifted to either LUSI or future operational budgets.*
- *The interface between the LCLS and LUSI projects is now formally defined and greatly improved.*
- Detailed specifications for radiation shielding are critical for optimization of experimental design. It is worrisome that the radiation design has not been finalized even though the NEH is being constructed.
- The data rates from a successful LCLS project will be very high but the computer plan seems to overestimate them. In particular, a relatively small fraction of the data will need to be permanently archived (relative to high energy physics or astronomy experiments) because of significant setup and alignment times.

4.3 *Principal Recommendations of the Committee*

- Mirrors are crucial in the current concept
    - Mechanical and optical design concept efforts can and should move ahead semi-independently.
    - A commissioning set of hard x-ray mirrors should be purchased by the end of May even if they do not meet the ultimate performance specifications.
- LUSI should obtain expert advice on design and fabrication of thin monochromator crystals since they appear critical to the future operation of the facility.
- LCLS and LUSI should define critical paths for commissioning and for each experimental program. In particular, “strawman” experiments should be proposed and examined for missing capabilities.
- Develop a “minimum equipment list” for each experiment to guide control and data acquisition development.
- Don’t let the “best be the enemy of the good” by including phased improvement in the design and acquisition of cutting edge components such as optics and data acquisition systems.

5.0 Controls Subgroup Summary

T. Himel, K. White

There has been a lot of progress made since the last FAC meeting in October 2006. First of all, there is beam and a control system to run it. Congratulations to the team for getting it all together in the short time they had. There were some complaints from users about various aspects of the project which did not meet their expectations. Examples given seemed relatively minor but the controls group will address them. We will not go over them in this summary but would like to offer our congratulations on a successful commissioning.

Of particular note is that the PLC based PPS system was approved and works. This is a major milestone not only for LCLS, but for SLAC as it is the first PLC based PPS system implemented here.
In addition to the above sign of success, many of the suggestions we made at the last meeting have been implemented.

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

- **Schedule:** The schedule was very tight for the 2006 installation with commissioning following in January 2007. The project admitted this and delayed the commissioning. This was a good ecision given the circumstances. The 2007 installation is shaping up to have the same type of problem. There is too much to install in the limited time available.
- **Integration:** At the last FAC we expressed concern that the emittance and bunch length measurements done in MATLAB on the LCLS side would not be available to the Correlation Plots on the SLC side as was currently planned. This lack of functionality has not turned out to be a problem.
- **Coordinators:** There was a shortage of Coordinators which could possibly slow down installation. Two more coordinators have been hired, fixing this problem.
- **Revision Control:** We commented that while the MATLAB applications developed by the Controls Group were under revision control, the ones developed by the physicists were not. Revision control is also now available for use by the physicists.
- **BCS:** The schedule was very tight. A simplified version was implemented and completed in time.

5.2 *Previous Concerns That Have Not Been Fully Addressed*

The new MPS system remains a concern. The technical design now seems viable. There are many pieces to the MPS system. The backbone has been getting all the work. It is not a one person job to implement both the backbone as well as the conditioning and connection of all the inputs to the system. More resources are needed here. Due to the schedule delays on the new system, the 1553 MPS system is being temporarily used for more of the LCLS. This is the correct decision given the circumstances.

Hamid still needs a deputy. This is even more of a priority now that he is head of the full controls department. Effort has been made to hire someone, but so far, without success.

5.3 *New Concerns*

As mentioned above, the MPS system remains a schedule concern. We have a couple of other concerns about the MPS system.

Care must be taken in the software interface to protect against unwanted logic changes and bypassing of inputs. While it is stated that this is planned, the full implementation of such an interface can be a large job and needs to be addressed as soon as possible.

The MPS system needs a name. - “newest MPS” is clearly inadequate. We suggest MPS 2006. This follows the Microsoft naming convention of naming something for the year it was supposed to be released. Much as we love to hate Bill Gates, in this case he has a good system. The “new MPS system” can be retroactively named MPS 1994.

There are many new types of diagnostics in the X-ray beam line that are not just repeats of what has been done for the e- beam line. They have not been covered in this review. We would like to know what the plans are for implementing these at the next FAC meeting.

The DAQ for the X-ray experiments is considerably different from the usual scope an accelerators controls group normally works on. The estimate of 60 TB/day of data is daunting even if that rate will not occur for half a dozen years. We have not looked at the budget and schedule, but both should be checked after the project is clearly defined. We suggest recruiting people with DAQ and analysis experience from large HEP detectors (this has started). We also need to get X-ray users to consider how data can be triggered and/or compressed. Note that in spite of these concerns, it sounds like the first phase of AMOS has been adequately planned except the analysis, which remains largely undefined.

Controls should take advantage in more places of EPICS security features. DOE is very worried about computer security so it is best to make use of relatively easy to implement features.

The installation schedule for the fall 2007 shut-down appears very tight. This is not strictly a controls problem. The problem, however, is that all systems need to install their equipment in a three month downtime. Controls work will be forced to the end and may not get completed or checked out. As mentioned in a previous section, this installation will need to be carefully planned with an integrated schedule.

6.0 Conventional Facilities Subgroup Summary

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

6.1 *Conventional Facilities Findings*

6.1.1 General

- Overall, we are pleased to see that good progress has been made in preparation for Conventional Facility (CF) construction ramp-up.
- CF contracts at 98% of the total are awarded.
- CF percent complete is 31% vs. 46% for the total project.
- CF change order rate is 6.5% to date for total work completed vs. 14% contingency held by the project office.
- The Central Laboratory and Office Complex (CLOC) elimination has been implemented in the project plan but as yet is not approved by the DOE.

There is a pending claim from the CM/GC in the amount of $4.5M. The realistic project exposure is ~$1.1M. The final number is under negotiation.

6.1.2 Organization

- CF staff additions within the past year are making a positive difference to subsystem progress.
- Management of the CM/GC contact continues to be a challenge, but the LCLS staff is handling it.
- CF staff continues to perform special inspections on construction and has an inspection agency under contract to supplement their staff.
- Five new CF personnel are in the process of being requested to support the construction ramp-up. This appears appropriate.

6.1.3 CF Documentation and Tracking

- The CF staff has implemented a formal tracking process of Requests For Information (RFI). Approximately 10% of the RFI end up as Field Change Orders (FCO).
- An FCO system is in place. Forty FCOs have been written and twenty eight have been approved and fully released.
- The risk registry is improved and supports the contingency analysis.
- The "red lined" drawing issue from the October 2006 FAC review still needs to be addressed. A defined process is required.

6.1.4 Schedule

- CF Schedule is very aggressive with inherent risk.
- The project plans to use co-occupancy as a means of saving schedule.

6.1.5 Safety

- Turner has effective control of the work process and safety planning at the job site.
- LCLS safety personnel are effectively providing safety oversight of the construction site.

6.1.6 October 2006 FAC Recommendations

– All subcommittee recommendations from October have been addressed, with the exception of the recommendation to address the distribution of red-line changes.

6.2 *Conventional Facility Comments*

6.2.1 Organization

– The CF has continued to develop and strengthen staff.
– The cohesiveness of the CF staff is an excellent reflection on management.
– The CF is well positioned for successful outcomes with experienced field contractors performing well in the field; a clean, organized, and structured construction site.

6.2.2 Management of CM/GC

The LCLS management chose to contract CF activities through two separate contracts Architect/Engineer (A/E) and Construction Management/General Contractor (CM/GC). Jacobs is the A/E and Turner is CM/GC. This arrangement required LCLS management to strengthen its CF group. This strengthening was accomplished and the group is functioning well. There are five new people in CF with plans for a few more. Some initial difficulties with the design and the A/E were solved. As the facility design is being implemented in the field it appears to have been done adequately well.

Similarly there were initial difficulties with the CM/GC contractor Turner. The LCLS management team, all the way up through to the SLAC Director was engaged in reaching a resolution with Turner's San Jose office. The key personnel from Turner, all the way from the Project Manger down, were replaced with people that have more capability functioning in a national lab environment. While this may have been a very trying and difficult experience for LCLS and SLAC management, it nevertheless showed that the management team is capable of reacting and dealing with difficult situations in the CF area.

The FAC CF subcommittee probed in this area extensively and found that many suggestions that we may have had for dealing with Turner were already implemented by the LCLS team. One initiative taken was to meet with Turner Corporate to obtain Corporate Office support in the best interest of Turner and SLAC. Turner needs a successful outcome on LCLS for their future with Stanford University, as well as SLAC. That is the fundamental lever that LCLS has.

As noted in the previous CF FAC report, the construction bids have come in up to 50% over the estimated price. While the resulting total price may look like an increase in scope in the accounting sense, it is certainly not an increase in technical scope. In fact the technical scope may have been decreased in some areas (such as removing the CLOC). There may have been some changes in the management cost to Turner due the need to make up schedule. The FAC, nevertheless, encourages the LCLS team to keep up the pressure on Turner to perform to the originally agreed upon scope of work, and at least somewhat close to the originally agreed upon fee.

The early indications are that the work in the field is of good quality. The FAC did a tour of the site where this was evident but more importantly, up until this time, the field changes have been approximately half of what has been budgeted in the contingency. There are issues remaining on meeting the required schedule. Some of the problems are due to the late start because of the budget CR. It is very important to implement essentially all the schedule saving methods that the CF team can think of. The longer the LCLS team waits to implement schedule savings the harder it will be to make any time gains.

6.2.3 Quality

- There is evidence of good quality in field construction, and we see no reason this cannot be positively stated in status presentations. On one of the early concrete placements, the contractor accepted and placed 10 cubic yards of concrete from the batch plant that was not the correct mix design. The contractor was required to jack hammer and remove the noncompliant concrete.
- The current field change order rate of 4.5% implies a good quality design. When the interfaces between mechanical, electrical, and civil design are tested by field construction, the project will know more about the quality of the Jacob's design issued for bid.

6.2.4 Safety

- The CF Subcommittee commends the continuing excellent CF safety performance on field construction.
- Recent changes in Turner on-site personnel have improved the working relationship with LCLS project safety personnel.

6.2.5 Continuing Resolution

- The project office placed the correct priority on CF construction. The CF already has an aggressive construction schedule that cannot be delayed further.
- Bundling the CLOC de-scope with the baseline change due to continuing resolution in seeking DOE approval could delay the DOE de-scope approval significantly. LCLS management is exposed to the risk of executing a project scope that is not formally DOE approved for several months. Despite informal approvals and understandings, independent government auditors can cite LCLS for failure to obtain prior (formal) approvals on scope changes.

6.2.6 Learning Curves

- The project office and CF staff demonstrate a healthy respect for the impacts of the often overlooked project learning curve.
- Recognition that each new contractor to the LCLS construction project requires particular attention at the beginning of their participation will pay dividends on safety, quality, cost, and schedule.

- Further, CF management is keenly aware of the impacts of learning curves in evaluation and assessment of construction acceleration and workarounds. Less experienced construction
- managers frequently fail to consider the risks and inefficiencies inherent in staffing and de-staffing versus seeking increases in productivity using proven resources already on the project.

6.2.7 Schedule Reliance on Co-Occupancy

- The project has committed and relies upon schedules that are contingent upon productive use of co-occupancy well before Beneficial Occupancy.
- This work around has inherent risks. Environmental conditions may be more difficult than envisioned, and the working space limitations may delay CF contractors. These risks need to be assessed and managed.

One of the methods of dealing with this issue is to have good internal documentation among the interested parties within the project. Each section of the facility that is planned for co-occupancy should have a detailed agreement negotiated among the project principals that is documented and signed. Then, upon the planned delivery of the co-occupied space, a walkthrough by the project principals should confirm the negotiated environment within the facility. The project principal who is responsible for the facility during a specific time period before its final completion needs to be spelled out, since this responsibility may slide from one person to another. In addition to lights and HVAC, the dust condition needs to be understood before critical machine components are brought into the facility.

6.3 *CF Subgroup Recommendations*

Recommendation #1: LCLS Project Management should continue in its efforts to improve the interface with Turner.

Recommendation #2: Project performance on field construction quality should be a part of status presentations.

Recommendation #3: Schedule reliance on co-occupancy has inherent risks that need to be assessed and managed.

Recommendation #4: CF is implementing an impressive list of DOE safety standards. These should be included in safety status presentations.

Recommendation #5: Implement the proposed tunnel boring schedule as soon as possible**.**

Recommendation #6: Consider adding temporary safety personnel during the next shutdown.

Recommendation #7: Prepare and implement a written process for distributing CF redline changes that originate in the field during construction.

Recommendation #8: Schedule the next CF subcommittee review of construction before completion of the next critical activities required from CF in the next four months, assuming that FAC advice could be relevant in those areas.

Appendix A

LCLS Facility Advisory Committee Members

LCLS Facility Advisory Committee Members

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Appendix B

Facility Advisory Committee Meeting Agenda

Facility Advisory Committee Meeting Agenda

April 16-17, 2007

Monday, April 16th

Plenary Session

Location: Redwood Rooms, Building 48

Time	*Topic*	*Presenter*
7:30	Executive Session	Committee
8:00	Welcome	J. Dorfan
8:05	Opening Comments	K. Hodgson
8:15	Project Status Update, and Charge to Committee	J. Galayda
8:45	Project Management	M. Reichanadter
9:15	Installation and Planning Update	R. M. Boyce
9:35	E-Beam System Update	D. Schultz
10:00	First Commissioning Experience	P. Emma
10:20	***Break***	
10:40	Undulator Systems Update	G. Pile
11:00	Photon Systems Update	J. Arthur
11:20	Controls Systems Update	H. Shoaee
11:40	Conventional Facilities Update	J. Albino
12:00	***Lunch (FAC members only)***	
1:30	Breakout Sessions (*see below for listing*)	
4:30	Construction Site Tour	
5:30	Executive Session (Redwood Rooms)	Committee
7:00	Dinner – Chef Chu's, Los Altos, CA (map/menu)	Committee/Speakers

Breakout Session 1 – Accelerator Systems

Location: Redwood C, Bldg 48

Time	*Topic*	*Presenter*
1:30pm	BC2/Linac Installation Status & Schedule	J. Chan
2:00pm	BC2/Linac Installation Coordination	K. Ratcliffe
2:30pm	LTU/Dump Installation Planning	T. Montagne
3:00pm	***Break***	
3:30pm	Drive Laser Commissioning Experience	B. White
4:00pm	RF Gun Commissioning Experience	D. Dowell
4:30pm	Discussion	all

Breakout Session 2 – Undulator Systems

Location: Red Slate, Bldg 280C, Room 112

Time	*Topic*	*Presenter*
1:30pm	Undulator System Fabrication Schedule	G. Pile
2:00pm	Undulator Vacuum Chambers and System	D. Walters
2:30pm	RF BPM Status and Schedule	B. Lill
3:00pm	***Break***	
3:30pm	Undulator Tuning and Fiducialization Schedule	Z. Wolf
4:00pm	Undulator System Installation and Assembly Plans	R. Pope
4:30pm	Undulator Physics Issues	H-D. Nuhn
5:00pm	Discussion	all

Monday, April 16th, *continued*

Breakout Session 3 – XTOD, XES, LUSI

Location: Redwood B, Bldg 48

Time	***Topic***	***Presenter***
1:30pm	XTOD status	R. Bionta
2:00	Mirror update	P. Stefan, M. Pivovaroff
2:30	XES status	S. Moeller
3:00	***Break***	
3:30	LUSI status	J. Hastings
4:00	XPP experiment	D. Fritz
4:30	Discussion	all

Breakout Session 4 – Controls

Location: Redwood A, Bldg 48

Time	***Topic***	***Presenter***
1:30pm	Controls Commissioning Experience	P. Krejcik
2:00pm	LCLS MPS	S. Norum
2:30pm	BPM and Toroid Update	S. Smith
3:00pm	***Break***	
3:30pm	X-ray End Station (XES) Controls	R. Sass
4:00pm	Timing Systems Update	S. Allison
4:30pm	BC2/Linac Controls Installation Planning	H. Shoaee
5:00pm	Discussion	all

Breakout Session 5 – Conventional Facilities

Location: Redwood D, Bldg 48

Time	***Topic***	***Presenter***
1:30pm	Readiness for Construction	D. Saenz
2:00pm	Construction Organization	B. Law
2:30pm	Interface and Configuration Management	J. Sevilla
3:00pm	***Break***	
3:30pm	Construction Procurement Management	D. McGiven
4:00pm	Construction Safety	R. Hislop
4:30pm	Discussion	all

Tuesday, April 17th

Location: See Room Location listings below

Time	***Topic***	***Location***
7:30am	Executive Session	Redwood D
8:00am	Breakout Sessions, *continued*	

Breakout Session 1– Accelerator Systems

Location: Redwood C, Bldg 48

Time	***Topic***	***Presenter***
8:00 am	New RF System Commissioning Experience	R. Akre

Breakout 2: TBD

Breakout Session 3 – LUSI, Experiment Controls

Location: Redwood B, Bldg 48

Time	***Topic***	***Presenter***
8:00am	CXI experiment	J. Hastings
9:00 am	Experiment controls, data acquisition	R. Sass, Y. Feng

Breakout Session 4 – Controls

Location: Redwood A, Bldg 48

Time	***Topic***	***Presenter***
8:00am	MATLAB Applications Software	M. Zelazny

Breakout 5: TBD

Breakout Session 6 – Safety

Location: Bldg 280A, Pacific Crest; Construction Site

11:00 K. Schuh, R. Hislop, M Scharfenstein

9:15	TOUR: Klyston Area; Laser Area; Injector Vault	
10:30am	Executive Session	Redwood C/D
12:00	***Lunch (FAC members only)***	
1:30pm	Executive Session	Redwood C/D
3:30pm	Closeout - Plenary	Redwood Rooms