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TECHNICAL ADVISORY COMMITTEE (TAC) REPORT 3

May 19-20, 2000

TAC Committee Members:

Bill Colson (Chair, NPS)
Dave Attwood (LBL)
Jerry Hastings (BNL)
Pat O'Shea (UMD)
Ross Schlueter (LBL)
Ron Ruth (SLAC)

The purpose of the Technical Advisory Committee (TAC) is to provide expert advice with regard to the R&D program of the Linac Coherent Light Source (LCLS). The report contains (A) general comments and sections on (B) the injector, (C) the accelerator and compressor, (D) the undulator, (E) FEL simulations, (F) x-ray optics, and (G) the LCLS experiments.

A. GENERAL COMMENTS

The collaboration has provided a very tight and focused technical realization of present LCLS design. The TAC sees a tighter team effort, and there needs to be a continued effort to develop innovative communication methods to keep the team effort focused and "on the same page". It is good to see the beginnings of a global system study of LCLS stability analysis. The excellent progress on LCLS subsystems must now be complimented by extensive communication in order to achieve "buy-in" of the complete LCLS system CDR. While the CDR provides a focal point for the LCLS design now, some design choices can still be made in the future.

B. INJECTOR (Pat O'Shea, University Of Maryland)

We were given four presentations on the injector during this review: Injector Overview, Gun, Drive Laser, and Beamline and Diagnostics. These presentations demonstrated that the LCLS injector team is now focused on developing workable technologies for CDR.

A firm decision has been made to choose a Cu photocathode with a load-lock. The decision to use a load-lock is a good one. The primary reason for this choice is to allow the cathode to be prepared outside the gun environment. There is an added advantage in that improvements in cathode technology can be readily incorporated later. The experience at CLIC with a similar load-lock indicates that the concept is workable at the 100 MV/m field level. It should be noted that load-locks have been used in several laboratories at the 30 MV/m level for over a decade without any problems.

Preliminary mechanical design work is underway to upgrade the gun design for 120 Hz operation. The average RF power deposited in the gun walls will be about 2kW. As long as the power density at all points on the wall are below the generally accepted cooling limit of $0.2 kW/cm^2$, there should be no major difficulties with the thermal design of the gun. The location of the emittance compensation solenoid still needs to be finalized, however it seems that there is no major obstacle here.

The design of the drive laser, while complex, appears to be well conceived. Laser technology is advancing rapidly, and the LCLS is well positioned to take advantage of the latest technology.

Many of the details of the location of the beamline components between the gun and the main linac have been worked out. At present, the planned injection energy is 150 MeV. There is still some uncertainty concerning space-charge induced emittance growth up to 150 MeV. Further simulations or experimental results may require the design to be modified. While space is tight in the injector vault, it seems likely that any design changes can be accommodated. If a third accelerating section is deemed necessary, it may be possible to accommodate it by inserting it partly into the shielding end-plug. It is fortunate that the shielding design allows the injector vault to be occupied while the main SLAC linac is operating.

While no new experimental results were presented at this review, we look forward to hearing results from the planned experiments. The plan for GTF emittance measurements is well conceived. Careful measurements with spatially and temporally shaped pulses will be of great significance. The results will contribute not just to the LCLS, but to photoinjector physics in general. We were quite happy with the progress on the injector design since the last review. The team is well on its way toward developing a complete design for CDR.

C. ACCELERATOR AND COMPRESSOR (Ron Ruth, SLAC)

Overall the progress on the linac and compressor system is excellent, but we caution the group to keep the CDR clearly in focus over the next several months. We were given a good summary of work to date; the collaboration seems to be working well, and the short bunch scenarios may be important to the scientific case.

The start-to-end simulations have made lots of progress. The focus on the dynamics of the slices is important because of the decoupling of different parts of the bunch. The bunch length measurement using deflector structures looks very interesting. In a pulse-grabbing mode, it could be critical to tuning and stability.

The stability and sensitivity studies have made lots of progress. Elegant seems to be a great tool and up to the task. It is important now to integrate the injector region to the extent possible. It is also important to pay attention to possible drifts in parameters as well as jitter. Feedback will not solve all problems, and the focus should be on elimination of the variation at the source. This points to the need for technical support for the tolerance studies. The stability studies will benefit from collaboration with selected engineers that are expert on hardware throughout the system. It is important to identify critical items for the CDR to tackle early, for example the laser system design and the variation of centroid and timing.

It would be useful to have a mini-review of the system design with local experts to examine the choices made to minimize the effects of parameter variation and jitter.

D. UNDULATOR (Ross Schlueter, LBL)

At the time of the last TAC meeting (Feb. 2000), the Argonne team had agreed with their SLAC colleagues to concentrate efforts on a hybrid-based undulator technology producing linear polarized light on-axis. Effort had begun to tackle the difficult job of alignment of undulator/quadrupole sections. Certain lattice modifications (specifically, employing a triplet) were being evaluated for beam focusing to address the difficulty of 1-micron quad positioning. The TAC committee suggested that at the next TAC meeting, it would be appropriate to hear about (1) alignment plan progress, and (2) magnetic measurement plans. Accordingly, the Argonne group put much effort during the past 3 months on the focusing issue (including alignment) and on developing a diagnostics plan (including magnetic measurements).

Moreover, in the undulator camp, as in other LCLS areas, the team has appropriately focused on a workable set of technologies in preparation for a CDR. Specifically:

* Magnetic and mechanical details of a linear hybrid undulator design have been worked out.

* Optimization of section lengths (3420 mm) breaks lengths (187 & 421 mm), *etc*. in a FODO focusing array is complete. Verification of the beam breakup alignment technique for this lattice (including optimized breaks) has been simulated confirming its suitability and effectiveness, and giving sensitivity to perturbations of the planned LCLS lattice/layout.

* Planned use of supplemental horizontal and vertical correctors will ensure ability to position to within 1 micron.

* Tolerances for alignment and for field quality within undulator sections have been established, along with schemes for maintaining and monitoring the appropriate phase relationship and magnitude of fields in undulator sections. In particular:

    # Plans for a full array of x-ray diagnostics instrumentation along the undulator line, as in LEUTL) is envisioned for and has been worked out in preliminary form for the LCLS undulator line. This strategy will yield useful R&D info as well as insure alignment success. The TAC affirms this “belt and suspenders” approach to attain the most information possible on alignment

and output radiation characteristics. Continued effort on developing the details of techniques to monitor the effects of misalignment on radiation output and schemes to make required adjustments in a reasonable period of time is needed.

Remote (from the control room) in-situ alignment and adjustment of phase between sections coupled with the x-ray diagnostics instrumentation is a prudent plan of attack for LCLSs state-of-the-art alignment requirement.

End details of the undulator, and implementation thereof, were not presented; this work remains to be done.

* A magnetics measurement plan and shimming procedures for meeting field requirements are in place.

In addition to formal preparation for the CDR, several undulator issues need continued attention by the LCLS team:

* One possible area of difficulty is the temperature stability requirement, given in February as 0.13 degrees. The current plan is to maintain temperature stability in the tunnel to 1 degrees C. Argonne plans to compensate by adjusting magnetic gap via thermal expansion of backing beams, with several undulators attached to each titanium low-expansion girder. Girders must move in sync. Another technique planned is to simply tweak beam energy, whenever field perturbations throughout all undulator sections are identical. Continued thought on this most critical alignment and stability issue is called for. It is not clear if the present plan for maintaining field stability is adequate.

* The TAC affirms LCLS plans to perform experiments confirming effects of radiation dose and rate for the appropriate LCLS proximity, field conditions, and materials.

* Details for undulator end phase adjustment remain to be worked out. Remote adjustment from the control room is an essential capability for this tuning.

The TAC committee looks forward to hearing details about stability and alignment in the presence of temporal and spatial thermal variations. Plans or results from experiments quantifying magnet degradation due to radiation and details of undulator end phase adjustment are also appropriate topics for continued work and discussion at the next TAC review meeting.

E. X-RAY OPTICS (Dave Attwood, LBL)

Experimental solutions have been identified for time slicing, pulse compression, and focusing. Thermal modeling of transient thermal loading continues to provide an improved understanding, which will be very valuable in the selection and design of experiments.

To prepare for the CDR, x-ray optical requirements should be identified for each of the (six) highlighted experiments. From among the creative solutions presented, realistic proposals should be selected which are likely to be realized in the first years of facility use. Also, realistic program plans need to be developed for pursuing the most promising techniques in the pre-construction years.

Space constraints on the experimental hall require further attention from the larger LCLS community.

F. SIMULATIONS (Bill Colson, NPS)

It was reported that a comparison of the GINGER and GENESIS computer codes showed adequate agreement from the beginning of the undulator to saturation. The TAC suggests that the codes be further compared at increased amounts of electron beam emittance to test their sensitivity to beam distributions. Agreement on trends is more important that for specific numbers. The simulation upgrade plan looks good. There has been excellent progress and results on the start-to-end simulations.

The concept of slice emittance appears to be solid as expressed in theory and simulations, but experimental confirmation is needed and appears to be far in the future. Similarly, injector and compressor simulations could benefit from experimental comparisons.

G. EXPERIMENTS (Jerry Hastings, BNL)

The collaboration must develop tools, for example LASNEX the modeling of crystals, dynamic scattering theory for time dilation etc, for understanding crystals for the x-ray optics job. Radiation of 1.5 Angstrom wavelength is not efficiently manipulated with grating optics and LCLS is supposed to be an x-ray FEL. I agree that perhaps 15 Angstrom will be startup, but the object is 1.5 Angstroms, and the bulk of the effort is needed to manipulate photon beams at this wavelength. The multilayer work by Roman Tatchyn is starting to address these issues, but Si crystals will in all likelihood be the critical component and little appears to have been done.

The layout of the experimental areas is still rather primitive and seems to be progressing in a vacuum. There seems to be little overlap with the proposed experimental program. This should change after the middle of July when there will be concrete experimental programs written up.