May 6, 2004

# Response to: Report of the Review Committee for the LCLS Linac Technical Design Review

## Response Overview:

The response to the committee is presented as a compilation of statements by the review presenters; **Project Management,** Eric Bong; **Accelerator Design,** Paul Emma; **LSC/CSR Instabilities,** Zhirong Huang; **Diagnostics & Controls,** Patrick Krejcik; **Component Specifications,** Carl Rago; **Linac Engineering,** Leif Eriksson; **LTU & Dumpline ,** Tim Montagne; **RF Systems,** Peter McIntosh; **RF Waveguide & Structures,** Carl Rago.

**Review date:**

December 12, 2003

**Committee members:**

Scott DeBarger, Bob Hettel, Rusty Humphrey, John Seeman (Chair)

**Review Scope:**

The review discussed many aspects of the design of the Linac portion of the LCLS covering the area from the injection point of the beam into the linac downstream of the gun, through the two bunch compressors, the Beam Switch Yard, transport lines and, finally, the dump line. The undulator and x-ray beam regions were not covered.

The presented materials covered in the review were well planned and presently in a coherent manner. The committee appreciated the large amount of time put into making the strong presentations and the technical efforts on the LCLS design.

The charge to the committee is contained in Appendix A.

The agenda of the review is included in Appendix B.

Comments from the committee on specific linac areas are found below.

**Linac Accelerator Design:**

A summary of requirements for the operation of a 1.5 Å SASE FEL was presented. These requirements include a 14.1 GeV electron linac with bunch compressing chicanes and X-band linac structure to reduce the length of a ~1 nC bunch to the order of 200 fs rms in order to reach 3.4 kA peak bunch current. The micron slice emittance of the beam must be preserved over the length of the linac and FEL, which should not add more than 20% to the initial normalized emittance, and the slice energy spread must be kept to

0.01%. Successful FEL operation will only be achieved if the jitter in charge, accelerating voltage and rf phase is maintained below stringent (and challenging) limits.

The RF phase and amplitude tolerances are recognized as the one of the most important performance goals in the LCLS Linac

The optics and physical layout of the accelerator system and FEL have been meticulously analyzed and optimized using a suite of simulation codes, including “Parmela” for the low energy injector beam (accounting for space charge effects), “Elegant” for the linac (accounting for bunch compression effects, wake fields, and coherent synchrotron radiation) and “Genesis” for the FEL (accounting for SASE and wake fields). The results of these simulations have been cross-checked with other codes and by other researchers. The technical challenges include restricting the potential for emittance growth from coherent synchrotron radiation in bunch compressor dipoles, the micro-bunching instability, transverse wake fields, and misalignments and chromaticity, and reducing gun and rf system jitter to tolerable levels. The LCLS designers plan to mitigate these problems with a laser heating system in the injector to reduce CSR and micro-bunching, maintaining tight (but reachable) component alignment tolerances, implementing low-jitter controls for the RF and gun system, using feedback to control “slow” changes in beam energy and bunch length, and using beam monitors and a beam-based alignment technique to achieve and maintain a precise beam trajectory through the whole facility. The facility is being designed to operate over an electron energy range of 3-15 GeV, and future upgrade plans include the possibility of multi-bunch operation.

The review committee was impressed with the thoroughness and quality of the accelerator design and the quantification of design issues. All apparent issues seem to have been identified and the committee members made the following comments regarding the design of the accelerator and transport systems:

The number of bunches that can be accelerated in a future multi-bunch mode might be limited by several design parameters, for example the X-band macro-pulse length. It is easier to include more bunches in the design now rather than later.

Multi-bunch operation modes will be investigated during the project design phase.

RF stability requirements for LCLS are already demanding for single-bunch mode of operation. The longitudinal wakefield interaction in multi-bunch mode will significantly deteriorate phase stability margins and would require extensive evaluation should this mode of operation for LCLS become a formal requirement. The X-Band system is not expected to be the limiting factor in determining if a second bunch is feasible.

While linac sections L2 and L3 have in-situ standby klystrons that can be switched in very quickly after the failure of a working klystron, L1 does not have standby klystrons. The recovery from an L1 klystron failure will therefore be more time-consuming. Steps might be taken to minimize this recovery time.

Currently the L1 LINAC section for LCLS does not include redundant operational klystrons. In the LINAC gallery it typically takes 4-5 hours to replace a failed klystron and resume normal operations. This mode of operation was deemed to be the most efficient and cost effective when compared to providing a ‘hot’ spare klystron and PSU with its associated waveguide switching network. There are currently 9 critical klystrons on the SLAC main linac of which if any one fails, operation is at least partially shut down.

> The electron beam diagnostics at the end of the undulator are presently minimal and do not include a device for measuring beam size or emittance. The committee recommends that such a device (or devices) be included, if possible, to enable evaluation of the effects of the undulator structure on beam emittance. If the beam entering the undulator is of good quality but the undulator does not make laser light, then knowing the properties of the exiting electrons will be very important.

While it as agreed emittance diagnostics might be helpful downbeam of the undulator, the capability is not in the present Linac budget. However, space has been made available to incorporate emittance diagnostics in the future if it becomes necessary. We, in fact, think this added diagnostic capability is fairly low on the priority list since thorough projected-emittance and slice-emittance diagnostics already exist in the design just 130 meters upbeam of this point (at the undulator entrance) and it is unlikely that the emittance will be significantly diluted during the passage of the undulator.

> Linac quadrupoles must operate over a wide range of beam energies. The last third of the linac is to be shared between the LCLS and high energy beams. The quadrupoles in the last third of the linac have special steel to allow low remnant fields at low excitations. Laboratory measurements should be done to determine the proper hysteresis curves and standardization cycles to arrive at the best low field situation for the LCLS quadrupoles. The new magnets build for the linac should use the same steel as the existing quadrupoles to make standardization easier.

The committee suggested bench measuring the QE-type quadrupole magnets to ensure adequate performance for the low current settings needed for the LCLS. Although it was forgotten during the meeting, these measurements were already made in 1996/97 based on LCLS needs and show adequate performance at current settings in the ˜20 to +20 ampere levels, as (in some cases) needed in the LCLS linac.

> Trim windings are being provided for the chicane dipoles so that their remnant fields can be zeroed out when straight-ahead beam operation is needed.
>
> The component specifications were alluded to but only one example was shown. If a future committee is to comment if the designs are reasonable, then many more examples, if not all, need to be shown.

The committee suggested making available all of the component specifications lists, whereas only one magnet specifications sheet was shown as an example at the meeting. In fact, all LCLS magnet specifications sheets (30 bends and 69 quads) are now available in EXCEL format on the web at:
http://www-ssrl.slac.stanford.edu/lcls/linac/specs/
In addition, other component specifications sheets, such as diagnostocs, are rapidly becoming more available.

> A computer simulation of cascaded beam-based feedbacks along the LCLS for position, angle, energy, energy spread, and bunch length from the front to the end should be done. The review team believes that this simulation would help the operation of the feedback systems across the two chicanes interact with one another.

An effort is underway at present (J. Wu and P. Emma) to do a thorough simulation of the bunch length and energy feedback systems for the full LCLS linac, including all bend systems (DL1, BC1, BC2, and LTU) and separating linac stages. The code is running and includes a fast and accurate model of all system sensitivities to 2nd order (e.g., bunch length and beam energy change at each bend system with respect to each upstream linac phase and amplitude, charge, timing, etc). The code is presently at a simple level but is fairly easily broadened to simulate the full LCLS longitudinal stabilization against a broad spectrum of parameter variations and will be used to verify system performance prior to construction.

> If and when the LCLS project changes the power supplies for the quadrupoles in the regions Sector 20 to 30, care must be taken to allow quadrupole strengths for both low and high energy beams. A plan needs to be worked out with the Technical Division.

Dual switched power supplies are presently planned for.

> The LCLS linac will need feedback magnets that operate at 60 Hz or so. Where will these magnets be located and what do the associated vacuum chambers look like?

Feedback requirements and solutions in the linac are being investigated.

**Overall LCLS:**

> A “Vacuum Czar” should be identified for the LCLS project to standardize the vacuum requirements and establish mechanical quality of the project to assure that components are carefully constructed and that vacuum processing is done properly.

It is agreed that the LCLS project needs a Vacuum Czar. The project office has appointed Leif Eriksson.

> A project wide nomenclature list for installed components should be made. The SLAC/SSRL maintenance crews will have a much easier time if the Linac components in Sectors 20-30 have a nomenclature which is the same as is in use now. There are sufficient label numbers available to name all new LCLS components added to the existing linac scheme.

In the design phase for LCLS component names track the MAD deck convention. Since multiple manes for components are unavoidable at SLAC, room will be left to add an operational name. Every attempt will be made to fit within the existing Linac name/numbering system at that time. If this is not possible, LCLS will revise existing Linac schematic documentation that will identify LCLS added components to the Linac.

**Linac Project Management:**

The person in the "Head Controls" position in the linac organization needs to be identified soon.

Bob Dalesio has been assigned as temporary Head of LCLS Controls.

There should be a "Head RF" person identified to coordinate RF activities and specifications.

Peter McIntosh is the CAM for LCLS Linac RF.

The number of components including "overage" and "spares" of the various manufactured items should be determined relatively soon.

Overage is not explicitly addressed. Spares are identified clearly in the RLS through P3.

The persons in the organization who have budget authorization should be clarified.

Cost account managers have been identified. Their budget authority will be addressed.

The WBS spread sheet shown was an out-of-date one but indicated a problem that should be fixed in the new one. There were large fluctuation in the total money spent each quarter, e.g. ranging from 160 k$ to 2400k$ and then back down for one group. These numbers should be spread more evenly during the various quarters, while, of course, taking into account single large purchases. It is hard to move manpower in and out of a group that quickly.

The Work Breakdown Structure has been finalized. Resource loading has been smoothed by fiscal year. Resource smoothing by month in underway.

Many of the FFTB magnets belong to BINP in Novosibirsk. Has the project arranged to have the magnets that will be used by the LCLS linac transferred to the LCLS project?

There is a note of approval of use issued by the SLAC Technical Division. The LCLS project office will seek BINP approval.

There were two schedule issues in the review. 1) The present FFTB is to be removed according to the LCLS linac group in October 2005 but the SLAC Technical Division believes the FFTB is taken apart in January 2006 or later. 2) The LCLS Linac schedule shows installing BSY components in Spring 2006 but the PEP-II program runs beam through there until August 2006. These schedule conflicts and the overall downtime dates should be resolved between the Technical Division and the LCLS project.

Demolition and construction schedules will be arranged to coincide with TD Linac programs and downtimes.

Access to the Linac housing during LCLS commissioning will be restricted and must the controlled in coordination with the PEP-II program. Nominally, beams will be running constantly during that time.

It is understood that the PEP-II program is a primary SLAC mission and that LCLS access to the Linac must be coordinated effort. Delays in commissioning due to lack of access to the Linac beam housing are anticipated.

> The present component layout for the LCLS linac should take future LCLS upgrade plans into account so as to not force major movements of newly installed LCLS components during the upgrades.

Upgrade scenarios are being considered in the design of the phase 1 LCLS implementation.

> The overall design effort for the LCLS Linac calls for two engineers and two designers. The committee feels that there is significantly more work to do than these four people can perform in the time allowed.

Additional resources will be added as indicated by the Linac resource loaded schedule.

**Linac Safety System:**

> A Safety Officer should be assigned to the LCLS Linac System.

An interim safety officer has been working with the LCLS project. A dedicated LCLS safety officer will be added to the project in FY05

> The LCLS proposal for the PPS system redefines the geography of the present LINAC PPS in the LCLS region. In addition, the team proposes to go to a PLC (Programmable Logic Controller) design approach. The review committee believes that it will require a full-time effort on the part of the LCLS PPS system manager to shepherd such a redesign through the necessary reviews and manage a design and construction team. Please do not forget that the SLAC linac can deliver a 660 KW electron beam to the LCLS beam line.

Design effort for the modification of the existing SLAC Linac PPS system and design of the PPS system in the new beamlines will begin in FY05. It is understood that a significant effort will be involved in realizing this design concept. The 660 KW beam delivery will be considered as an accident scenario.

**Linac LSC/CSR Instabilities:**

> The committee suggests that the complete specifications of the laser beam and electron beam (position, energy, area overlap, time overlap, etc.) in the devise for the "emittance increase" at the 100-MeV location be completed in the near future.

A complete set of specifications be written for the laser-heater system. A note specifying the system has been completed by J. Wu and is being reviewed by P. Bolton at this time. This should be complete in early May 2004.

**Linac Controls:**

> The LCLS Control System will integrate two existing control system technologies – the SLAC SLC Control System and EPICS. Such integration has been done at PEP-II, but the LCLS will take this another step further in the LINAC. Careful planning must be done.
>
> An important control item will be the integration of a common LINAC timing system across both the control systems. The LCLS team proposed using the present timing system. This proposal should be looked at in more detail. The number of beam codes available may not be sufficient for LCLS operation. The present timing system uses obsolete components and the maintenance for this system over the 30 year lifetime of the LCLS will certainly be problematic. The review team believes that for this reason alone, a new LCLS timing system should be developed. Technology (fiber optics) which has been successfully tested at the proof of principle level for the NLC could be applied here. The design of a new timing system will have to meet the requirement that the LCLS timing system operates with the timing system for the PEP injection lines.

It is now envisaged that we will design and build an "SLC aware" IOC that will bridge the gap between the present SLC control system and the EPICS controls for new LCLS devices. In this way new components can be integrated into the control system with instrumentation crate data bus systems such as VME with user interfaces programmable in EPICs. A communication link from the new IOC to the SLC control system will mimic the microprocessor used in the SLC control system and transmit hardware values to the SLC system with existing protocols. This method gives us a road map for upgrading the entire SLAC control system. Initially, the well-developed application software of the SLC will be available for commissioning of the LCLS. However, over time the application packages can be ported to the new EPICs based system and take over more of the control support of the accelerator.

The SLC-aware IOC will have an event receiver (EVR) that will take the low level RF fiducial signal and process it together with the binary data from the master pattern generator (MPG) transmitted on the SLC PNET system. This module will be able to interpret the SLC beam codes and generate a whole new subsystem of timing signals with a new event generator (EVG) module. Whether the new timing signals are broadcast over a fiber network or a high-bandwidth ethernet link awaits further R&D effort.

> The fact that the timing and machine protection systems work in such a way that there is a three pulse pipeline before any MPS required shutoff can occur was brought up in this meeting. This could mean that the undulator would have to take three LINAC pulses in the case of an MPS fault. The LCLS team will have to investigate this issue.

The 3 pulse latency of the SLC MPS system is inadequate for the undulator MPS. A new programmable logic controller (PLC) will therefore be developed to process the MPS inputs from the undulator system and control the single bunch beam dumper that aborts beam pulses ahead of the undulator.

> The control system functional requirements for software and system integration have yet to be developed at the necessary levels of detail. The LCLS team is adding staff to work in this area. One point raised in this review is that the nomenclature for the two control systems differs significantly. The LCLS needs to have some mechanism to name devices in a consistent fashion across the two systems.

A new naming system is being developed that will be interpretable by both the old and new control systems.

**Linac Diagnostics:**

The LCLS diagnostics involves a large number of different systems. The review did not cover all these systems in detail. In the area of conventional beam diagnostics and their upgrades, the review team can make the following observations:

Requirements for each of the conventional diagnostics system have now been detailed.

BPMs: According to Table 7.26 of the CDR, there are only 19 new BPMs required for the LINAC. However, we do know that new modules are required for the LCLS stripline BPMS in general. As pointed out in this review, no resources (manpower, dollars) are presently assigned to work on a new electronics design, which will require two calendar years; this includes the electromagnetic field analysis effort. We also note that the cavity BPMs (eight of which are required for the LINAC) also require a new module design (as well as a mechanical design); this is an ANL responsibility, but there is not yet a design effort for the module although there is a mechanical engineer assigned at ANL.

Requirements for the BPMS have been detailed. Further progress on the hardware design of a VME based module for both the linac stripline BPMs and the undulator cavity BPMs is awaiting resource allocation and may start as early as 2005.

The connection between BPMs readout by the SLAC linac controls and the BPMs readout by the new EPIC control systems should be determined.

The connection between the EPICs control system BPMs and the SLC control system will be via the new SLC-aware IOC.

Both CAMAC and VME circuits need to be designed. A time and effort plan to do this work should be made.

Only a VME based BPM module will be developed.

Toroids: The LCLS requires toroid accuracy at the 1-3 % level. An accuracy better than 10 % for toroids is controversial. There is a component of the user community which does not believe that the present technology can meet this requirement. The LCLS team needs to find out if the present technology meets the LCLS needs or if a better design approach is necessary.

In fact this is simply a misunderstanding. There is no 1-3% accuracy specification. The LCLS specification for *relative charge stability* from pulse to pulse is 2% rms. However, there is not a need for measurement accuracy at the "1-3%" level. Toroid accuracy should be at the 5-% level, since system tune-up (compression setup, etc) will fully compensate for a 5-% charge uncertainty. Once atained, however, the charge needs to be maintained at the 2% rms level over long term. This is not an accuracy requirement, but a precision and stability requirement.

Toroids and processor modules from commercial vendors (Bergoz) will be procured, as funding allows, and evaluated in comparison with existing SLAC devices.

> Profile Monitors: As the LCLS team states, careful optical and system engineering is needed. This effort cannot wait until late in the project schedule.

Commercial digital cameras have been selected and will be evaluated as soon as funding allows.

> LLRF: The LCLS team proposes that the low level RF system be housed in a temperature controlled room to meet the LCLS requirements for temperature induced drifts. In order to maintain the temperature stability in transporting the signals to the klystron systems, LCLS proposes that the signal cables be routed down through a penetration into the LINAC tunnel, and then up through the appropriate penetrations to the klystron systems. The review team believes this is a poor idea, since anything in the LINAC tunnel has an access problem for maintenance. The LCLS team responded to this criticism by noting that cables are passive, and therefore require minimal maintenance. The review team wonders why not just use temperature controlled cable, which has a successful history here at SLAC.

The RF amplitude and phase stability requirements for LCLS dictate that the temperature stability of ALL RF components require attention. The RF distribution from the temperature controlled source into the tunnel was chosen as the tunnel temperature variations are considerably less than that experienced in the gallery. Routing then up through the penetration to the appropriate klystron minimizes the cable lengths exposed to large temperature and therefore phase fluctuations. Access is not an issue for these cables as there are no associated active components located in the tunnel. Many of the high power connectors which these cables connect to are on high power components located in the tunnel.

> The LCLS team discussed research efforts for a number of new and exciting diagnostic tools which will be necessary to achieve LCLS performance specifications. As the team noted, "[The] LINAC relies heavily on several new and complex bunch length and timing diagnostics. Development work on these has started at SPPS." There is a significant schedule risk associated with carrying these research efforts through a development phase to produce operational and maintainable diagnostics for the LCLS. The LCLS needs to manage that schedule risk at an acceptably low level by supporting the research and development efforts with the necessary resources (manpower, money, and time).

Several new bunch length and timing R&D efforts have been planned for the SPPS involving electro optic crystal detection and analysis of CSR signals. These await funding.

> The number, location, and detailed specifications for all the instrumentation needed in the LCLS Linac should be tabulated.

Physics requirements documents for diagnostic systems now tabulate this information.

**Power Conversion:**

The LCLS LINAC Power Supply Status Report (Linebarger, December 7, 2003) was reviewed. The list of power supplies looks in reasonable shape. This reviewer discussed the tables of power supplies with the PSOG Deputy (Craft) with responsibility for LINAC power supplies. In the footnotes to the list on page 7, which lists power supplies for the LINAC up to the undulator, it is pointed out that the list does not contain power supplies for corrector magnets (XCORs and YCORs). The LCLS team notes that this reflects a deliberate choice not to replace the present LINAC SCORs because they have been measured to meet the LCLS stability and accuracy requirements. However, the committee believes that these power supplies should be replaced with the newer MCORs because the SCORs are of a very old water cooled design which has become unreliable and a significant maintenance problem over the years. They are inadequate from the maintenance standpoint for the LCLS. We also note, as does the LCLS team, that the list of power supplies for the line from the undulator to the dump, on page 8, is incomplete.

The committee suggested replacing the aging "SCOR" corrector power supplies in the linac (sectors 21-30) with the newer MCOR supplies. These correctors and their power supplies were recently measured in order to confirm LCLS regulation requirements, especially at the low-energy end of the machine. The measuremnts show that the SCORs can attain the necessary regulation, except for a current variation that occurs at 60 Hz, which might generate a border-line tolerable trajectory jitter. Since the 60-Hz component can be compensated with feedback systems, the motivation for MCOR replacement rests mostly on a maintenance issue. For the time being, no clear decision has been made concerning the MCOR replacement, mostly in consideration of present budget limitations.

The power supply list is now complete.

**Linac Component Specification:**

The concept of a project database to collect, record, organize, and publish information was presented. Discussion was centered on the integration of component design requirements and CAD documentation, both released, and in progress. Sample input and reporting forms were presented.

The component database was presented as an interim tool until an LCLS project-wide database could be established. While use of the Linac component database *could* be extended to the entire project, this was not necessarily assumed to be the specific tool that the project would select.

Experience of the review team leads us to caution that the details of the implementation of this plan will be critical if the LCLS Linac project is to realize the potential benefits that such a database offers. Similar databases have been attempted at other projects at SLAC and elsewhere with varying results. Failure of individuals to comply with data entry requirements, or failure to complete component documentation in even a small number of instances, reduces the usefulness, and thus the acceptance, of the database. Also, appropriate resources must be assigned to the development and maintenance of the database and its associated tools.

The LCLS Linac group recognizes the importance of constructing and maintaining a documentation and specifications database. The LCLS project office must convince the rest of the LCLS project of it's importance.

> Special attention must be given to the selection and documentation of nomenclature. The LCLS Linac group presented a plan that allows for multiple aliases for a single component. Their ideas concerning the naming conventions have covered Beam Modeling and Mechanical Design in some detail, but are less advanced in the area of Control Systems. There will need to be attention paid to the handling of SCP and EPICS naming, as these systems follow differing naming conventions.

The naming conventions will be addressed as the LCLS controls team integrate into the project.

> As the LCLS Linac project involves the modification of beamlines within an existing facility, naming standards should be selected to follow the existing nomenclature as much as is possible. This should help with the integration of the LCLS into the existing operations and support efforts.

Special consideration will be given to naming standards especially where new systems are incorporated into existing beamlines. Existing SLAC departments with experience in SLAC naming standards will be consulted.

**LI20 – LI30 Accelerator:**

Conceptual plans for the Bunch Compressor 1 and Bunch Compressor 2 were presented. Specific descriptions of the work to be performed were discussed. The current design calls for a four dipole chicane at each location, complete with correcting quadrupoles and diagnostic devices. Two of the dipoles, and the diagnostic devices, will translate in the X-Z plane to permit straight ahead operation for (non-LCLS) programs where the bunch compression is not needed. To achieve success with the translating dipoles, attention to backlash/repeatability issues is crucial. The needed tolerances have been identified, but engineering effort will be needed to meet these tolerances.

Detailed specifications have been generated for the BC1 Bunch Compressor. Engineering and design of the BC1 bunch compressor is underway.

> **LTU & Electron Beam Dump:**
>
> The current Linac To Undulator (LTU) design was presented. The design has evolved since CD1 to allow for up to 5 beamlines, although the initial phase of the project will include only one beamline. The beam optics for this area have been determined and preliminary layouts have been passed to Radiation Physics for comment. The initial device lists have been prepared.
>
> Plans to dump the beam upstream of the undulator will need to involve Radiation Physics involvement. The suggested tunnel shielding of 70 inches of concrete will probably not be sufficient, by itself, to permit 120 Hz dumping of the beam in the tunnel. Local shielding at the dump, and any other points of continuous beam loss, will be needed.
>
> The vacuum system has not had its components identified yet, although money has been budgeted to purchase vacuum components. The LCLS performance will be negatively

impacted if pressure in this area rises above 1 x $10^{-7}$ torr. To achieve this pressure, attention to vacuum standards and procedures is needed. A “Vacuum Czar” should be designated; this person’s expertise could be used to good effect in the other LCLS areas outside of the LTU.

The vacuum components are now identified. The LTU area vacuum design assumes a base pressure of high 10E-8 Torr. LCLS vacuum design will follow SLAC Technical Specification TN - 86 - 6. Leif Eriksson will act as the LCLS Vacuum Czar.

The alignment technology to be used in this area has not yet been selected. The LTU group has suggested that the initial device alignment should be good to the 50 m level. Meeting this goal will require appropriate alignment technology and procedures.

Alignment procedures using laser tracking systems should be adequate for the majority of the LTU. Special attention will be made in the undulator matching section to identify whether more exotic methods are required.

**Linac RF Systems:**

The main drive-line will be used for the LCLS and for the high energy beam in the last third of the linac. A plan combining the two uses should be made.

The Main Drive Line will not be modified in such a way that the operation of the linac will be inhibited. The only planned modification to the MDL is to add a coupler in sector 20.

The current plan is to NOT combine these two modes of operation. The X-band accelerating structure and particularly its mounting hardware is being designed so that when intense high energy beams are required for end-station useage, the X-band structure can be withdrawn. This is because the transverse dimensions of the X-band structure will become the limiting aperture in the LINAC and severe damage to the structure could result from combined operation with high intensity and high energy beams.

**Linac RF Waveguide and Structures:**

The x-band RF accelerating section should be specified soon and ordered from the NLC group. These structures are long lead time items and these structures have to get “into the pipeline” in the NLC manufacturing chain.

The accelerating gradient, dissipated power and the corresponding phase and amplitude stability requirements for the X-band structure are known. NLCTA has a number of structures which meet these requirements, whilst not achieving some of the increased requirements for NLCTA. Although verbal agreement has been made, no formal approval has yet been given by the NLC Group as to which structure we can employ for LCLS. Based on these communications, the costs for a 60 cm X-band structure has been withdrawn from the LCLS project schedule.