▪ The title of the item or system ▪ A description of the item ▪ WBS Number ▪ Type of design review ▪ Date of the review ▪ Names of the presenters ▪ Names, institutions and department of the reviewers ▪ Names of all the attendees (attach sign-in sheet) ▪ Completed Design Checklist (if utilized)	▪ Findings/List of Action Items – these are items that require formal action and closure in writing for the review to be approved. See Document LCLSII-1.1-QA-0009 for Design Review Requirements and Guidelines ▪ Concerns – these are comments that require action by the design/engineering team, but a response is not required to approve the review ▪ Observations – these are general comments and require no response

Type of Review:	Preliminary Design Review (PDR)		
Title of the Review:	LCLS-II Dressed Cavity Review		
WBS:			
Presented By:	T. Peterson, C. Grimm, Y. Pischalnikov / Fermilab		
Report Prepared By:	T. Nicol (Fermilab)		
Reviewers / Lab :	T. Khabiboulline, T. Nicol (chair), L. Ristori / Fermilab E. Daly, J. Preble / Jefferson Lab	**Date:**	April 15, 2014
Distribution:	S. Yakovlev, C. Grimm, J. Theilacker, R. Stanek, E. Borissov, Y. Pischalnikov, C. Ginsburg, T. Arkan, Y. Orlov, T. Peterson, M. Kaducak, N. Solyak, K. Premo, A. Rowe / Fermilab J. Galayda, D. Schultz, L. Plummer, D. Marsh, J. Healy, M. Ross / SLAC J. Mammosser, G. Ciovati, K. Wilson, J. Leung, N. Huque, J. Henry, K. Macha, G. Neil, J. Matalevich / SLAC A. Yamamoto / KEK		

Attachments:	☐ Review Slides	☐ Design Checklist	☐ Calculations	☐ Other

Purpose and Goal of the Review

Charge to the committee

1) Design overview -- what are the requirements (and do we know them, or what requirements are missing) and are we meeting them.
2) Any open design issues, concerns, risks. Do you see risks, technical issues that should have more attention?
3) Schedule. Are we on track to meet the schedule? Thus, design status, drawings status, and remaining work. The focus is on technical issues, status, and schedule.

In general, we would like an open discussion of our current design status, plans, and understanding of requirements, including any missing information or concerns that any of us may have.

Purpose and Goal of the Review

Agenda
Welcome and Logistics – Richard Stanek
Introduction to the LCLS-II cryomodule/cavity system - Tom Peterson
Cavity and Tuner requirements - Tom Peterson
Plans/schedule for first prototype cryomodules at FNAL/JLab - Tom Peterson
Helium Vessel and Magnetic Shielding - Chuck Grimm
Tuner design - Yuriy Pischalnikov
Remaining Tasks - Chuck Grimm
Reviewers meet to formulate comments

Review materials can be found at:
https://indico.fnal.gov/conferenceDisplay.py?confId=8398

Introduction and Outcome Summary of the Review

There was a great deal of discussion about various LCLS-II requirements documents available the review did not dwell on addressing requirements directly, at least not in a systematic way. Rather, discussions quickly focused on detailed design issues related to the cavity helium vessels, tuner design, magnetic shielding, various material-related topics, analyses, etc. As such it provided a useful forum for the open exchange of ideas, opinions, suggestions, and recommendations.

The conclusion is that a great deal has been done and a great deal is yet to be done to finalize the design of the LCLS-II dressed cavity. We recommend a graded approach to moving forward, that is, where few questions remain, moving forward now makes sense and where complex issues remain, it makes sense to take more time addressing those things. We feel that the designs for the prototype cavity, helium vessel, tuning bellows (with a couple caveats), Ti/SS steel transitions, etc. are sufficiently mature that long lead procurements can begin. The tuner and magnetic shield designs are less complete and require further work.

Schedule was only touched upon briefly and mostly through horizontal testing. We feel as though the cavity and helium vessel fabrication will likely be able to meet the scheduled completion date of mid-August 2014. That first dressed cavity with a tuner, maybe less so.

What follows are recommendations from the committee and comments from the committee and attendees wishing to contribute. We have made an attempt to separate the comments by their subject matter, but there is some overlap. Also, even though the focus was on the dressed cavity, a couple cryomodule-specific comments are included at the end to preserve the thoughts. There is no significance to the order of the comments in any section.

Findings and Action Items

Findings and Action Items

ID	Committee Action Items/Recommendations
1	Consider doing a mock-up to prove you can actually replace the piezos and motor through the access ports. Can the repair be made with the required precision.
2	Consider moving the tuner access port to the aisle side for in-situ access.
3	Compile the pros and cons for changes to the dressed cavity design for the production cryomodules and agree on choices.
4	Maintain a list of all differences between the prototype and prototype dressed cavity designs.
5	Complete and approve LCLS-II SCRF 1.3GHz cryomodule PRD.
6	Complete and approve LCLS-II SCRF 1.3GHz Cryomodule FRS. Ensure consistency with the PRD.
7	Perform magnetic measurements on entire tuner assembly.
8	Perform radiation hardness tests on piezo fast tuners.
9	Consider one tuner design for the prototype and production cavities.
10	Thermally sink the tuner piezo cartridges.
11	Formalize the agreement between all parties on the requirements for pressure vessel code compliance.
12	Document all the analysis that has been done, e.g. tuner structural analysis, magnetic shield magnetic analysis, pressure sensitivity, etc.

Concerns

General

1. In general, the cavity and helium vessel designs are mature enough that long lead procurements (bellows, Ti/SS transitions, etc.) can be released. The tuner and magnetic shield designs are less mature and require more attention prior to procurement.
2. From a manufacturing and certification point of view there are no major concerns. LCLS-II cavities will be very similar to ILC and XFEL cavities in this respect. Cavity suppliers, Fermilab, Jefferson Lab, and Cornell all have proven experience.
3. The strategy for parts procurement of the horizontal test and the prototype cryomodules might need to be reconsidered, weighing testing of prototypes and first articles against the production schedule.

Tuner and tuner access

4. Accelerated life testing is recommended for the tuner motor, gearbox or harmonic drive, and piezo assemblies.
5. There are no limit switches on the cavity tuner so these need to be added to the current design.
6. The tuning requirements that were presented and those reported in the requirement

Concerns

documents are inconsistent. Consensus should be reached at least on the most basic requirements such as coarse and fine tuning ranges.

7. The tuning system is too complex to be analyzed with a single finite element analysis as shown. If no additional analysis will be performed, a lower rigidity should be expected relative to what was shown. Also, add COMSOL to the list of tuner analysis tools (in addition to Ansys).
8. Both piezo stacks with their encapsulations and non-metallic components (epoxies, insulation, wire sleeves) will be subject to some level of radiation due to their positioning close to the beam axis. The piezos are closer to the beam in the lever tuner than the blade tuner. Degradation could be a concern.
9. Access to the piezo stacks from the access ports seems very difficult due to the presence of multiple barriers (e.g. magnetic shield, thermal shield, MLI, etc.) and their specific position and orientation.
10. In Chapter 5.8 of Cryomodule FRS (Tuning Requirements) one expects to find tuning requirements. Instead there is a list of figures of merit for the Saclay-1 tuner. One assumes that this tuner meets the requirements. It appeared that the very few actually had arguments against the Saclay tuner based on basic requirements.
11. Develop better concept of tuner access port and tooling for replacing tuner motor and piezos.
12. The piezo tuner operating and maximum allowed voltages were not well defined for the new design.
13. The voltage and pulse shape should be defined that coincide with the needed lifetime of 5x10-9 cycles.
14. The piezo blocking force is not well defined for the new tuner design.
15. Demonstrated cavity tuning accuracy is preliminary could be affected by chemistry. Consider that some small tuning adjustment might be needed after cavity dressing.
16. Ensure that tuner adjustments maintain force balance between piezos.
17. Check that the present tuning requirements quoted for the XFEL tuners are relevant to the new LCLS-II tuner, e.g. is the requirement of 1000 for the number of spindle turns adequate.
18. Ensure compatibility of the motor shaft, nut, and coatings. The use of dissimilar materials is highly encouraged.
19. Address the claim that the tuner motor won’t run during operation due to microphonics is a requirement. The experience form Jefferson Lab doesn’t support this claim.
20. For a couple reasons, it might be good to thermally sink the piezos, first to control the temperature and thus the performance, second to guard against overheating.
21. If possible, try to arrange radiation hardness studies of the materials in the tuner, especially the piezos. Review the work done at DESY concerning piezo radiation hardness (Simrock did some).

Concerns

22. Quantify the magnetic field from the motor to determine whether it will require additional magnetic shielding.
23. Verify that using the four piezo assemblies in the proposed configuration is best. It seems it would be better to use all four at some reduced capacity the use a reduced number only in the event of failures.
24. There appear to be are 8 tuners, but only 7 access flanges. If this is the case, presumably the 8th tuner motor is accessible through the end.
25. The plan to manually switch piezo leads and amplifier connections in an operating machine seems cumbersome. Entertain a more automated scheme.
26. Determine whether the tuner for the prototype cavities is viable for use on production cavities also.
27. Initiate a study of the magnetic properties of entire tuner assembly since it is within the magnetic shielding.
28. The tuner access ports are a good idea, but would be more practical if they could be on the aisle side of the tunnel.
29. If the prototype tuner meets the design requirements, consider keeping it for the production units as well.
30. Consider doing a mock-up to prove you can actually replace the piezos and motor through the access ports. Ensure the repair be made with the required precision.
31. Evaluate the performance history of the tuner parts running in vacuum at cryogenic temperatures and try to determine whether the design is consistent with a 20 year operating life.
32. Ensure that if one runs the drive motor the wrong way (accident case) the piezo unit won’t fall out.
33. Analysis should be performed to determine the yield limit of the tuner components.

Cavity mechanical (piping, welding, etc.)

34. The requirement on pressure sensitivity of cavity-vessel-tuner should be clearly defined before procurement of helium vessel components. If the requirement is not too ambitious, e.g. ~50 Hz/mbar, it may be possible to proceed with procurement on the base of the data presented at this review. Anything < 50 Hz/mbar will require additional analysis to demonstrate compliance with requirements. Without design changes at the cavity vessel level it appears improbable to achieve sensitivities of < 30 Hz/mbar.
35. Analysis should be performed to explore the mechanical eigen modes of the cavity/vessel/tuner system and cold mass as a whole. Values in the 50-100 Hz range may be problematic depending on the operating environment.
36. Helium vessel welding fixture should be updated to avoid bending of the cavity.

Concerns

37. The maximum operational and test pressures need to be determined. Simulation results summary should be presented including:
    a. Max allowed pressure.
    b. Stresses at 2 bar warm and 4 bar cold.
    c. Maximum allowed deformation of the cavity, bellow, and tuner.
    d. Stresses at maximum allowed deformation.
38. Analysis showed that the cavity stiffness is 4800 N/mm for 2.8 mm wall thickness whereas the measured value is 3000 N/mm. The discrepancy is significant and could be a result of less thickness in the real cavity. Cavity stiffness is important for choosing piezo dimensions and should be verified and better explained.
39. Consider joining the helium vessel cooldown lines on the bottom of the vessel before the transition to stainless steel. This would eliminate one Ti/SS transition joint.
40. Determine whether cavity Interchangeability due to using the XFEL tuner end blocks?
41. Explosion bonded Ti/SS transitions joints need to be qualified for this application. Testing at 2 K as early as possible would be good.
42. Formalize the agreement with SLAC about pressure vessel code compliance.
43. Much was made of the tuner design and planned modifications. It would be useful in future reviews to know what, if any, modifications are planned for the cold and warm input coupler sections.
44. Compile the pros and cons for changes to the dressed cavity design for the production cryomodules and agree on choices.
45. At future reviews, describe the differences between the prototype and production dressed cavity designs.

Magnetic shield

46. More effort is required to specify, analyze, and design the magnetic shielding.
47. More shielding should be added above the tuner support. A large area near the tuner is missing any magnetic shielding.
48. More shielding should be added on the last cavity in the cryomodule, near focusing magnet.
49. Add requirements for the spacers between magnetic shielding layers including material options and stress analysis.
50. Magnetic shield simulations were alluded to, but not presented. Ensure that the magnetic shield design is supported by analysis.
51. The magnetic shielding design accounts for 3.5 mm gap under the first layer of shielding and the helium vessel. Assuming the need to install 10 layers of MLI on the helium vessel, this might not be enough gap.
52. The number of PEM nuts and machine screws used to assemble the magnetic shielding halves

Concerns

should be minimized. Based on CM2 experience the two halves of the shielding never perfectly aligned during assembly. We ended using hose clamps to drive the two halves together so that the holes line up for the PEM nuts to be assembled. Using aluminum tape on the seams might be acceptable.

53. Details of the interconnect magnetic shielding weren't shown, but it is very important that there are cutouts on the edges of the shields, rather than holes, to give access to the RF cables and heat intercepts braids. From CM2 experience, this was very difficult to achieve through the holes on the interconnecting magnetic shielding.
54. The double shield concept seems reasonable for this CW operation requiring high-Q.
55. Carefully consider putting the first layer of magnetic shielding inside the helium vessel. It has several advantages including better coverage over the bore and better shielding of the end cells. Then the second layer can be outsider of the He vessel where it is still effective. There is some possibility of having two layers inside helium vessel without changing the vessel diameter.
56. When designing magnetic shielding it is important to avoid trapping flux inside the shield. One advantage of a two layer shield is the ability to segment the inner shield to eliminate a continuous cylinder. Continuous cylinders may be prone to trapping flux inside the shield surface.
57. It may be very much useful to review a report from the DESY TTC meeting and a report from KEK by K. Tsuchiya and M. Masuzawa.
58. Concerning the magnetic shield tests, it would helpful if those tests could be used to determine a recommended shield cutting direction. The optimum cutting direction could depend on the local magnetic field direction (natural, construction, and equipment) relative to cavity orientation.

Specifications

59. Continue to develop the specification for the HOM heat loads. Values in L3 CM16 (30 W) and L3 CM17 (15 W) seem high.
60. Finalize the physics requirements and the cryomodule FRS.
61. Need to create a technical specification for the tuner that flows down from the physics requirements and cryomodule FRS.
62. Complete and approve LCLS-II SCRF 1.3GHz cryomodule PRD.
63. Complete and approve LCLS-II SCRF 1.3GHz Cryomodule FRS. Ensure consistency with the PRD.

Cryomodule-specific

64. Quadrupole position at the axial end is convenient from a view point of the cavity string assembly. On the other hand, it should be understood how it affects deflection of the gas return pipe. It may not matter in LCLS, even though for the ILC cryomodule its position was

Concerns

more advantageous at the center.

65. Provide references or traceability to published heat load numbers.

Observations