COLLEGE OF SCIENCE
DEPARTMENT OF PHYSICS

TEXAS A&M UNIVERSITY

Dr. Dennis Kovar
Associate Director For High Energy Physics
Office of Science
US Department of Energy

Subject: Final report of the Magnet Review Panel for the 2009 LARP Review

Dear Dr. Kovar,

This the final report of the Magnet Review Subpanel of the 2009 LARP Program Review, held July 13-14, 2009. Members were Timothy Antaya, George Biallas, Peter McIntyre, and Akira Yamamoto. We structure our report as requested as findings, comments, recommendation, and action items.

Findings

- The 90 mm quadrupole program has been a remarkable success to date:
  - The TQ series has demonstrated that shell structure is a robust basis for assembly and preload.
  - The RRP conductor is industrialized and reproducible in both 54/61 and 108/127 configurations.
  - Conductor stability is now understood as it affects the working line of a magnet. The TQ series encountered stability limit in operation at reduced temperature, which is consistent with that understanding.
  - The shell structure and coil design have been evolved to optimize stress distribution, preload uniformity, and alignment issues.
  - The field quality and the reproducibility have been qualified to be approaching to the level of the LHC-IRQ Nb-Ti quadrupole, but the coil positioning stability is still a subject to be improved.
- The projected LQ magnet will be a valuable first test of the several issues that attend fabrication of long magnets for accelerator applications. It is of sufficient length to test issues of materials, structure, and coil strain in long-coil heat treatment, and to test quench protection strategies.
- The envisaged HQ program can be expected to establish the feasibility for extending the success of the TQ/LQ program to 120 mm bore.
- The MS team has demonstrated an excellent coordination of its resources, optimum use of the facilities and personnel of the several member teams, and ability to make tough decisions and work together toward a common goal.

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Comments

- The MS team responded well to the recommendations and action items from last year's review. They converged upon a structure and a conductor specification and built and tested a sequence of magnets to mature the understanding in a consistent way. The success to date of the TQ series is evidence that they made wise decisions.
- There is predicted to be a transition from magnet R&D within LARP to pre-construction R&D within a foreseen APUL2 construction project should Nb_3Sn quadrupoles be chosen for the Phase 2 luminosity upgrade. The DOE budget illustration suggested that such a transition could begin as soon as FY12. There is no discernable decision tree or criteria for decisions that would be required for a positive decision to proceed with Nb_3Sn quadrupoles at that time. Given the long time lines for tooling and conductor to pursue any given magnet development, such criteria should inform the choices and priorities in the MS program beginning now. *There is considerable risk that the orderly progression of model magnet R&D anticipated through FY14 may be too late for a Phase 2 technology decision.*
- The program as presented is success-oriented; i.e. it makes little provision for contingency should complications arise in the testing of LQ or HQ models.
- Many elements of the program rely upon efforts within the base programs of the participating labs. Is there explicit commitment by the labs for the roles that are stipulated within their base programs?
- To DOE: the timeliness of obtaining the above technical results in time for the Phase 2 decision should be a highest priority of the overall LARP program. Because the timing of the choice cannot be foreseen, additional budget during the coming two years may be important if the MS team's prioritized plan is paced its budget during those years.
- Much has been learned from the 90 mm program to date. Much more can be learned from the LQ program and by using the TQ series as a rapid-turnaround platform for addressing specific issues. Because it provides the potential for lower cost and shorter time per magnet, the 90 mm program should be utilized wherever it can yield information needed for the Phase 2 technology decision.

Recommendations

- Find a method to more assuredly match the LARP Magnet Program to CERN's needs. The method could be (1) another round of interaction with the CERN accelerator theory group(s), (2) assignment of visiting scientists from the Accelerator side to crack this problem while they are resident at CERN, or (3) establish a US interaction region theory group to work on the problem here and present it to CERN as a proposal. It should enable LARP to determine the major specification of the quadrupole required for the LHC Phase-2 upgrade, including requirement for the field gradient, aperture, length, field quality, and the reproducibility.
- Develop your best projection for a prioritized list of specific technical results that will be needed to form the basis of a Phase 2 technology decision and APUL2 transition. Re-analyze the technical plan for the coming years in light of that list of results needed. Optimize the technical program to produce the above technical results at the earliest possible date.

Identify constraints that pace your schedule for producing those results, and whether the constraint arises from personnel, facilities, or budget.

- Examine carefully which of the above results can be obtained using the 90 mm platform (TQ and LQ) now available. Use that platform to the greatest extent possible. Eliminate the distinction between HQ and QA. Choose an HQ length that is just long enough to provide adequate body field region for evaluation of field quality.
- Make a technical risk assessment to identify risks that may arise from test results, alternatives to mitigate the risks, and potential impacts on cost and schedule.

The timeline presented for R&D during FY10 shows completion and testing of the first two LQ quadrupoles and the first two HQ quadrupoles by Q3 of FY10. Also by that time the thinking on aperture for LHC Phase 2 should have matured considerably. The Panel considers that moment to be a critical decision point for the entire project.

After the results from the LQ and HQ tests are analyzed and understood, there should be a peer review to evaluate the results in terms of the suitability of Nb_3Sn quadrupoles for the luminosity upgrade of LHC. There should also be a workshop to bring all of the relevant parties together to develop a specification for a 6 m quadrupole suitable for use in the IP triplet for LHC upgrade. Given good planning, the review and the workshop could be accomplished by end of FY10.

Pending the outcome of the review and workshop, DOE should give highest priority to funding construction of two such full-length quadrupoles of the above design beginning FY11. Whether the construction were conducted within LARP or under APUL2 is a management decision. Demonstration of field-quality measurements, acceptable stability, quench protection, and testing with beam should be the goals of this project, to be completed by the end of FY13. In order to achieve such an aggressive schedule and limited budget, the Panel recommends that the development be conducted with a single institution carrying lead responsibility.

The development and demonstration of two full-length, full-aperture Nb_3Sn quadrupoles would provide a credible US technology for the Phase 2 upgrade on a meaningful time scale. That is the ultimate goal of the project and the Panel considers that this approach may be the only path to get there when it is likely to be needed.

Respectfully submitted:

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