DOE/NSF U.S. LHC Program Office
February 28, 2006

Report on the Joint DOE/NSF Review of the U.S. LHC Accelerator Research Program (LARP)

Held at Santa Rosa, California, November 2-4, 2006

Report to the U.S. Department of Energy and the National Science Foundation

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Executive Summary

The Large Hadron Collider (LHC) will be a unique facility for basic research, providing the world's highest energies for probing the structure of matter and the underlying forces. This machine, presently under construction at the European Laboratory for Particle Physics (CERN) near Geneva, Switzerland, is being housed in the same 27-km tunnel that contained the Large Electron Positron (LEP) collider. The United States has contributed to the construction of the LHC with in-kind contributions of industrial products manufactured domestically and, most importantly, in providing the magnet systems for the final focus for five interaction regions around the ring, as well as intellectual support for accelerator physics and beam diagnostics.

In order to exploit this U.S. investment in the technology and science of particle accelerators, the U.S. LHC Accelerator Research Program (LARP) was developed with the aim of empowering U.S. scientists with the means and tools needed to maintain and improve their skills in superconducting magnet design as well as in accelerator physics, commissioning, and instrumentation. The scope of the proposed LARP projects includes the R&D for an upgraded set of magnets for interaction regions for handling an eventual improvement in luminosity, as well as instrumentation, simulation and commissioning of the LHC.

A Department of Energy/National Science Foundation (DOE/NSF) review of LARP was held on November 2-4, 2005, at Santa Rosa, California. The charge for this review was given by Dr. Robin Staffin in a letter to Dr. Stephen Peggs, dated October 19, 2005 (attached as Appendix A). The review covered management of the program, commissioning of components of the LHC hardware and beam, proposed additional instrumentation for the accelerator, and detailed aspects of the development of Nb_3Sn superconducting magnets (agenda attached as Appendix B). The expert reviewers (see Appendix C) and the proponents were instructed to address the progress in LARP since the previous review, and to assess the needs and plans for FY2007 and beyond. Presentations were made by LARP management, including lower-level managers. The reviewers asked questions during the presentations, and provided both oral and written comments to LARP management. The panel members also discussed their observations and recommendations in executive sessions in the presence of representatives from the DOE and NSF funding agencies, and then presented their preliminary findings. A previous report (November 24, 2005) captured the brief observations and recommendations provided by the review committee at the close-out session, and this report folds in the final written conclusions of the committee.

One of the main goals of this review was to examine the path chosen for the development of the Nb_3Sn magnets. The panel was pleased with the progress and detailed planning and design efforts to date, and especially about the agreement reached for using a common superconductor strand and cable. Nevertheless, there remained lingering concern regarding the protocol for selecting the final approach to achieving high-performance quadrupole magnets.

Plans for commissioning of LHC hardware are already being implemented, with the first U.S. staff member (Peter Limon) now stationed at CERN. It was reported by management that U.S. laboratories will provide staffing for this effort, and, in fact, FNAL has committed seven persons to this task. LARP and CERN will cover costs of travel and of additional living expenses in the Geneva area.

The review committee was very pleased with the presentations on beam instrumentation and accelerator physics. In addition, they found the idea of participation in the development of a remote control room a very interesting possibility for enhancing interactions with CERN from afar via the Fermilab project "LHC@FNAL."

Finally, the committee still felt uncomfortable with the lack of formality in the dealings of LARP, and strongly recommended a more effective bookkeeping system for managing expenses and progress on all active tasks, and the addition to the management team of a person who would be responsible for implementing such a system.

The discussion below, based on LARP presentations (http://uslarp.lbl.gov/workshops/051102/), provides greater detail of the views and recommendations proffered by the review committee

Introduction

During the June Review of the LARP Program held at the Fermi National Accelerator Laboratory (Fermilab), an action item was formulated to "hold a detailed technical review of LARP magnet systems in the first quarter of FY06." Although this specified only the magnet portion of the program, the entire technical content of LARP was presented at Santa Rosa. This proved useful, in that it provided an opportunity to review progress in the accelerator-physics and the technology branches of the program.

It is worth emphasizing that it is especially important for the more project-like aspects of the LARP program to be reviewed at the level of detail presented at Santa Rosa. In general, the preparation by the LARP group was much better than was the case at the previous general review at Fermilab. Presentations were clear and usually highly responsive to questions raised by the committee. The program is maturing rapidly, which is very gratifying. Nevertheless, it would be helpful in the future if the responses to previous reviews were made available more promptly. For this review, they were not ready until essentially the start of the review, and that was too late to be fully useful. At the very latest, such documents should be offered to reviewers 1–2 weeks prior to any review.

In general terms, the areas to which LARP funding is directed can be summarized as R&D related to the improvement of performance and upgrade of luminosity of the LHC, hardware commissioning (particularly of that supplied by the U.S. LHC Accelerator Construction Project), accelerator physics, beam commissioning and beam instrumentation.

LARP activities can be divided effectively into two parts: (i) commissioning of beam and hardware, accelerator physics, and development of specific beam instrumentation, and (ii) the development of the materials and the technology required for the construction of high-field superconducting magnets for an upgrade of the low-beta insertion regions of the LHC. To succeed, the magnet program may need more budgetary support than has been allocated to it thus far, and it is therefore vital for LARP management to continue to balance the two components of the program in order to optimize overall benefit to the LHC. We discuss these two components in turn here below.

Accelerator Physics and Commissioning

Instrumentation

The list of proposed instrumentation tasks appears to be reasonable, and all of the items have the potential for helping ensure the success of the LHC. The committee continues to believe that the bunch-by-bunch luminosity monitor and the tune monitor are critical to successful LHC operation and development. In fact, experience at the Tevatron confirms the critical role of luminosity detectors, the control of the tunes during the energy ramp, and the need for bunch-by-bunch diagnostics. The collimators may be less important at the outset, but they will be essential if LHC is to make rapid progress at increasing the luminosity without damaging key machine or detector components. Thus, for the success of the LARP mission, these devices must be viewed as essentially true "deliverables." At this review, it was made clear that LARP management recognizes this fact. In this regard, there was concern over possible stretch-out in funding the luminometers, which comprise the largest part of the funding of the instrumentation tasks.

Not all mechanisms for ensuring that these deliverables appear on time are presently in place, but there is a heightened awareness on the part of LARP management that such mechanisms are needed, which corresponds to an important first step. The instrumentation work to date appears to be of high quality, and led by competent individuals. Given adequate resources, they should be able to deliver what has been promised. There are other devices that the LARP team would like to promote as instruments for LHC that have not yet been accepted by CERN. These include a longitudinal bunch-density monitor based on detection of synchrotron radiation, and a zero-degree calorimeter. As implied above, the first of these seems very worthwhile, and there should be an ongoing effort to convince CERN of its merits. The second device seems to be motivated more by aims of nuclear rather than high-energy physics. It is not clear that this effort should be supported by LARP, unless there is an identified customer willing to fund this activity.

The instrumentation items comprise a small part of the overall program, but they are well-chosen and are adequately supported at present. The possible request from CERN for four additional luminosity monitors needs to be treated cautiously. Insofar as what is requested is merely an augmentation of the present fabrication order, and is funded fully by CERN, there is no reason not to accommodate the request. However, there were "hints" that this might require significant changes in the electronics, and thus a major increase in scope. Even if CERN is willing to pay for the additional effort, there is some risk of distracting those responsible for delivering the presently agreed-upon instrumentation. LARP management should not commit to building the additional devices unless they can verify that this would not over-commit resources. This is not simply an issue of funding, but rather of limited intellectual resources involved in the activity. There is also general concern that the interface to the LHC controls system, and in particular the delays in completion of the DAB-IV board and firmware needed for all diagnostic instruments, may put LARP instrumentation efforts at risk.

One very positive result of the work in this entire area is the good use made of existing U.S. accelerators (Tevatron, RHIC, and ALS) in developing and testing prototypes. This has been a great success, and such collaboration should be encouraged in the future.

Hardware Commissioning

The "hardware commissioning" activities are now better understood than was the case this past June. Two topics are to be covered under this heading. First is commissioning of the hardware items provided by the U.S. as part of the LHC construction project? This is a straightforward LARP activity, and is well planned. The second topic, helping in the general hardware commissioning of the entire LHC, was a new request at the last review, and thus not formally part of LARP. Since then, CERN has formalized its request for assistance, and the DOE and Lab Directors have agreed to participate. The Labs have begun making commitments for assigning personnel to hardware commissioning. LARP has also become officially involved. The agreement worked out, wherein the Labs cover the salaries, LARP covers the travel and relocation costs, and CERN covers the incremental costs of living in Europe, seem appropriate, and involves sharing of costs with all interested parties. LARP management should be commended for arriving at an equitable solution to this problem without sacrificing other important activities.

A proposal was made to place both the IR Commissioning and Hardware Commissioning tasks under the management of a single person, Mike Lamm. That is, the two tasks will remain separate, but under joint management. Given the overlap in personnel and activities, this approach seems reasonable. The IR Commissioning is already under way, with a task list being created, installation and oversight procedures being developed, and preparations for sending people to CERN well along. One point brought up at the review was whether travelers for the work in the tunnel should be written only in English or in both English and French. The senior managers are usually fluent in English, but it is unlikely that this holds true for the technical staff and hired contractors. An ounce of prevention may be a very good investment here. Mike Lamm should investigate this issue and make a recommendation.

Beam Commissioning

Participation in beam commissioning of the LHC is an important aspect of LARP, not only in terms of maintaining U.S. accelerator skill, but also in terms of training new U.S. accelerator staff and helping commission the LHC rapidly and effectively. The accelerator skills that need honing are those of the accelerator physicists as well as those of the supporting accelerator engineers. The committee felt that LARP management understood these needs, and is acting accordingly. The Commissioning Task Force has issued a report advising LARP management how to proceed. Subsequently, a Commissioning Oversight Team (COT) was formed to serve as liaison between the individual Lab bureaucracies and LARP. Its first task is to get the inter-laboratory agreements between CERN and the various U.S. Labs into a form that each Lab finds acceptable. This is appropriate, as it is impractical for CERN (or LARP, for that matter) to deal with the U.S. Labs with a "one size fits all" approach.

An encouraging recent development was the selection of the first Toohig Fellow. However, this process should proceed in a timelier way in future years if LARP is to have a good selection of candidates from which to choose. By the time the decision was made this year, many of the top candidates had already accepted positions elsewhere. Next year, the process will hopefully go more smoothly.

An important organizational change since the last review was the appointment of Vladimir Shiltsev as head of accelerator systems. Filling this vacant slot was a strong recommendation at the last review, and Shiltsev is an excellent choice for the task. One result of the change in management was the separation of accelerator physics and beam commissioning. The committee felt that that it would have been useful to provide more elucidation for this decision. Clearly, there are differences between the two sets of tasks, but many of the accelerator physics tasks (and hopefully personnel) have relevance to beam commissioning. It would be useful to understand the rationale for this change, and this should be provided at the next DOE review.

Specific beam commissioning tasks have started to crystallize. It appears that the choices were prioritized mainly on the basis of interests of individual scientists. For the overall benefit of U.S. HEP, it will be worthwhile to revisit the priorities in terms of needs of U.S. Labs. We wish to contribute to success at CERN, but also wish to benefit the U.S. program. Rapid commissioning of the LHC is one justification for our effort, but developing and enhancing our domestic skill set should also be kept in mind. A list of names for beam commissioning has been developed, but is not as yet public. Timelines for the tasks must also be developed. Both should be available at the time of the next review. Once decided from a U.S. perspective, the beam commissioning tasks should be agreed upon with CERN. This agreement should also be in place no later than the time of the next DOE review. The development of timelines is clearly hindered by the frequent changes in the CERN schedule. The budget for commissioning in FY06 is probably fine, but needs more justification than found in the present task sheets.

A possibility was offered for LARP to consider using the Response Matrix Fit technique, demonstrated to good effect for improving luminosity in the Tevatron, in commissioning the LHC. The U.S. team might be able to play a key role in this through the LHC@FNAL link, which is discussed below.

The idea of a remote monitoring system "LHC@FNAL" appears to have a lot of merit. It will be invaluable to the beam commissioning task by getting U.S. participants up to speed on the LHC control system and hardware nomenclature before they show up at CERN. It is possible that even hardware commissioning could benefit from LHC@FNAL. Although this system is being implemented independently of LARP, the committee strongly encourages LARP staff to take advantage of the LHC@FNAL infrastructure and to help to test and debug it during the early stages of LHC commissioning.

Management

The committee remains uncomfortable with the level of contingency maintained by LARP management, which is only $200K out of a budget of $11M. Granting that much of the work is

R&D, a contingency of order 5–10% would be more prudent, and should be adopted by the program. Any unallocated funds at the end of the fiscal year could be used to bridge budgetary delays that might otherwise halt key activities. This should become part of the planning for LARP management.

The committee still remains unconvinced that LARP tasks can be monitored and managed purely from the information in the task sheets, which in some cases is quite meager. The committee suspects that the tasks are not really managed in this way, but rather through other review mechanisms that keep tasks well on track, but without management taking credit for this. Each year, the task sheets project budgets and tasks into future years, but, unfortunately, are not revised as plans change. A mechanism for reconciling task sheets from year to year (what was stopped and what changed in cost or scope) is essential, and would help LARP management, and certainly help LARP reviewers understand progress. As it now stands, the process is essentially discontinuous across fiscal-year boundaries.

It appears to the committee that the number of oversight committees and groups that LARP management must deal with is somewhat excessive. For a program that has two DOE technical reviews per year, the need for an advisory committee and an oversight group seems excessive. It is recommended that DOE and LARP management review the structure to see if all that "help" is truly needed.

The lack of signed and monitored agreements also remains a concern. In principle, the CERN EDMS web-based system is used for this purpose, but the committee was unable to find any examples where this system was being utilized. While a letter pointing to agreement from CERN on this year's tasks was provided to the committee, there was no paperwork describing what was, in fact, promised. It appears that what was agreed to be simply a Power Point presentation that was not even posted publicly. This seems below the minimum standards for management, and requires improvement. There is a change-control procedure in place, although it was unclear whether it has been exercised very much. It appeared that changes could be proposed from the outside without going through the L4 and L2 managers. It is recommended that at least the L2 manager be asked to sign off on any proposed changes before they are raised as an option for discussion. Bypassing these managers is risky and unwise, if that is indeed what takes place.

Some of the accounting practices seem unusual and somewhat misleading. For example, if funds for the Toohig Fellowship are not assigned, they should be carried as LARP reserve, and not assigned 25% to each of the four participating Labs. Similarly, management expenses should be written off against the Lab that incurs the expense, and not distributed more or less uniformly. These sorts of issues would be easily resolved if there were a Project Engineer on the management team to take care of budgets, schedules, and change-control matters. We encourage LARP management and DOE to identify a suitable person for this task as soon as possible.

Magnet Development

Introduction

It must be stated at the very outset that in the six-month interval between the general review conducted in June, 2005 and the present review, there has been very visible and highly commendable progress. In particular, relationships between the various test and development efforts have been clarified and their interdependence demonstrated. It has also become clear that the participants have bought into the program with great enthusiasm and vigor, and, given the assembled talent, the program is undoubtedly headed for success in a technologically demanding area of endeavor.

Management

The main goal of the LARP magnet program is to demonstrate by 2009 whether it is feasible to build a high-gradient Nb_3Sn quadrupole of accelerator quality. In particular, the LARP program will try to construct two prototype quadrupole magnets with 90 mm aperture, lengths of 3.6 m and gradients of 200 T/m. It must be emphasized that failure to build a magnet with the desired parameters could still be a successful R&D outcome, as long as the limitations and reasons for the lack of success are well understood. The approach to this very challenging goal will have four stages, starting with (i) model short coils (SQ), followed by (ii) model magnets of 1 m in length (TQ), then (iii) long model coils (LR), and finally (iv) the long prototypes of 3.6 m in length (LQ). Each stage will address or validate a series of issues related to conductor and insulation, two-dimensional and three-dimensional magnet designs, as well as tooling and manufacturing procedures. The number and difficulty of the tasks to be carried out require a strongly integrated effort from BNL, Fermilab, LBNL and SLAC to achieve success. The involvement of the four laboratories also provides a sharing of risks and back-up solutions in case of technical problems.

A management structure has been put in place to enforce this integration and facilitate transverse exchange of information at all levels, from technicians to managers. This organization is now operating in a manner that offers confidence that the three laboratories are learning how to work together so as to foster synergies between the collaborators.

Materials

The development of the materials needed to construct high field magnets of the type required for the LHC upgrade is based on a fundamental change in the technology that was used to produce magnets for the LHC. LARP recognizes that the new superconducting material is the bedrock on which the entire program will rest. Conductor development, manufacture and measurement have

now become the first priorities of LARP. The skills and facilities of the collaboration have been integrated in the materials program, which has resolved many previous questions. In particular, the detailed technical report presented on materials gave the reviewers great confidence in LARP's ability to handle issues of conductor stability against flux jumps.

The questions pertaining to use of MJR, RRP and PIT material for cable has also seen closure. The MJR material available to LARP will be used for small test coils to learn more about idiosyncrasies of niobium-tin, while the very expensive PIT material will not remain a contender for LARP. RRP, and in particular the 54/61 conductor manufactured by OST, is the material of choice for the program. OST is learning rapidly how to manufacture the RRP conductor with consistently reproducible characteristics. Given the exigencies of the program, LARP's plan to order only about 1000 kg of the material appears to be marginal, because "borrowing" more from the Conductor Development Program, should there be a shortfall, may be a good idea to solve an unexpected problem, but should not be a strategy. LARP must make sure that an adequate supply of conductor is on hand, or on order for rapid delivery.

Conductor deliveries are stated as being 5 to 9 months A.R.O., with the vendor planning production 12 to 13 months in advance. This is an area of concern, as many conductor procurements are being planned, and OST must know well in advance the size and timing of any order. Procurement is time consuming, with possibly detrimental consequences for the program if problems should arise. It may therefore be prudent for LARP to discuss with OST whether base material can be pre-stocked to shorten procurement time. To re-emphasize, LARP must ensure that an adequate supply of conductor is always on hand.

OST has only real experience in fabricating strands of 54/61 design, which is considered a "production" strand with other commercial applications. It has a reproducible J_c, comes in long lengths with good sub-element bonding, and has an RRR value greater than 150. However, the strands have filaments of large diameter, and are therefore intrinsically unstable to flux jumps at low fields. In order to reduce the filament diameter, OST is experimenting with different stacking arrangements, currently regarded as R&D products by the manufacturer. The entire superconducting material and magnet portion of LARP must therefore be based on 54/61 conductor strand, and its specific properties. As the presentations showed, this issue is well in hand and developing satisfactorily. Under no circumstances should the perceived promise of some "new and improved" material derail this more conservative and sensible approach of the program.

Specifics of the Four-Phase Program

The SQ program, about which there was concern that it could divert resources from the TQ program, has demonstrated its value. SQ02 with MJR conductor, led to a good understanding of the flux-jump instability, and the collaboration has now learned how to address this problem. The upcoming TQ tests should put this matter to definitive rest, and demonstrate that LARP has overcome the problems that plagued other laboratories in the past. Likewise, the careful and

impressive SQ analyses presented at the review showed that SQ magnets can provide a useful R&D vehicle to foster magnet development.

The TQS and TQC designs were presented as tests of two different 2D coil-support structures. In fact, they also differed in an equally significant manner in the longitudinal support of the coils. A more comprehensive comparison of longitudinal support in the TQS and TQC designs should be developed, and, to further that goal, FNAL should be encouraged to develop its 3D mechanical-design capabilities.

The Long Racetrack (LR) R&D is intended to address most of the issues associated with long niobium-tin coils. The program envisions the fabrication and testing of four long coils using a segmented aluminum shell-based support structure in which the coils will be pre-stressed with the LBNL bladder-and-key technique. In the present plan, the support structure will scale up the existing support structure for the LBNL SM coils, which unfortunately cannot be used for the LQ configuration. If the LR is to be a good model for a long quadrupole, then its longitudinal features must address differential thermal contraction, in particular a 3D model of the LR coil support structure must be established and carefully evaluated with respect to the implications of a 3-piece aluminum shell. Alternatives to this structure should also be investigated.

Because the LQ program is clearly the goal of LARP, it would seem prudent to address the high-gradient (HQ) program only after the LQ program has become established and is in good shape. Under no circumstances should the former be delayed or impacted by any parallel effort, as long as the field and geometrical requirements of an LQ quadrupole remain undefined. More specifically, there could be advantages in providing a larger aperture with lower gradient, both from the perspective of the accelerator and from any difficulties in constructing an LQ magnet.

Two other items were briefly mentioned in the review, but did not receive the attention commensurate with their importance: (i) that stability studies be extended to 1.9 K, as this is the likely operating temperature of the upgraded IR magnets, and (ii) the low priority given to the present studies of radiation damage. Operation at 1.9 K will result in higher values of low-field critical currents, thereby yielding a lower stability current in the magnets. Both items should be revisited and reconsidered for inclusion in the program

Programmatic and Management Issues

An overall magnet R&D plan has been established, and is characterized by its small incremental steps. It is conservative, relying on multiple overlapping activities and resource developments. These overlapping activities represent a redundancy, which was not adequately justified on the basis of the presented schedules and defining task sheets.

It is evident that historical perspectives on magnet development for large-scale accelerator production, small-scale advanced-performance testing, and a demonstrated expertise at each institution are the major inputs that provide significant strength to the plan. It may also well be

true that this plan reflects a compromise over complex and difficult choices, and that, as a consequence, it may result in more elements than are needed or worse efficiency than desired.

It is our view that two major programmatic issues should be addressed as soon as possible. First is that there is no explicit contingency and little schedule float in this R&D effort. The only recourse to funding shortfalls or technical delays is to descope or shift needed results to later years (which may compromise key objectives), or transfer funds from the other part of the program (and thereby reduce its scope). The second issue has to do with the fact that, although the operational plans for each key test or development were presented with care, there was only sparse discussion of the quantitative criteria for judging their success, or the relationship between these criteria and overall programmatic goals and priorities.

Clearly, the primary goals of the program are tied to the multi-year, multi-million dollar effort to demonstrate a complex proof-of-principle of a single magnet based on an advanced A15-type conductor, a demonstration recognized internationally as critical for guiding future high-luminosity upgrade scenarios at LHC. Developing methods for large-scale fabrication of such magnets is not part of the LARP mission. Consequently, LARP must prepare, without delay, a realistic schedule that takes account of available resources and personnel, keeping in mind any programmatic uncertainties and technical risks, in order to identify explicitly the key "must have" priorities in this complex effort. Furthermore, LARP leadership should articulate both the plan and the key priorities to the DOE and to participants in its program.

Once the resources and their disposition are identified, the balance between the testing, which is currently a large fraction of the entire effort, and advanced analysis, which is currently relatively limited, should be re-evaluated to take advantage of 3D analyses for optimizing the number of steps and step sizes in the R&D effort. Clearly, this should be done only if the obtained results warrant such direction. There is substantial historical precedent for the value of this approach in magnet design.

Finally, explicit, transparent, quantitative success criteria must be established for each key test or developmental milestone. These quantitative success criteria must be tied to the overall goals of the mission, and made available to program participants, the DOE and subsequent review committees. They should also form the basis for the evaluation of milestones at the end of each campaign.

Concluding Remarks

Since the last review, there has been evolution at CERN on the possibility of using Nb_3Sn for the upgrade of LHC IR magnets, emphasizing the importance and criticality of the LARP program in providing a timely, clear-cut demonstration that Nb_3Sn technology is a viable option for the IR upgrade. Should the long quadrupole development prove successful, it will substantially improve LHC luminosity. This will be especially true if LHC beam currents are limited by beam losses or instabilities, since stronger quadrupoles offer the opportunity of getting higher luminosity for a given (limited) beam current. Clearly, LARP management must be encouraged

to keep working hard on developing and maintaining the ongoing synergies that are so crucial to the success of the program.

Judging by the astonishing progress made in the past six months, LARP is headed for success, provided that the necessary resources can be made available. There is a threshold of support below which no progress is possible, and the marginal efficiency of investment high. This is especially true in the range of funding that is now being considered. The goal of determining whether this approach can provide the needed magnets is ambitious, and has very far-reaching consequences for the scientific community, and it deserves strongest support.

Glossary

SQ: Short quadrupole

TQ: Technology quadrupole

LR: Long racetrack

LQ: Long quadrupole

MJR: Modified Jelly Role. A method used in the initial fabrication of Nb_3Sn

RRP: Rod Restack Process. A method used in the fabrication of Nb_3Sn

PIT: Powder in Tube. A method of fabricating Nb_3Sn starting with fine powders in niobium tubes.

OST: Oxford Superconductor Technology. A manufacturer of Nb_3Sn strands.

SM: Small magnet.

HQ: High-gradient quadrupole

RRR: Residual resistivity ratio, or resistivity at room temperature divided by that at nominal liquid-helium temperature. For copper, it reflects the level of purity of the material.

Appendix A

Text of Charge Letter

October 19, 2005

Dr. Steven Peggs
Brookhaven National Laboratory
P. O. Box 5000
Upton, NY 11973

Dear Dr. Peggs:

The previously proposed follow-up review of technical aspects of magnet development by the U. S. LHC Accelerator Research Program (LARP), and your clarification of the benefits of the accelerator-physics and instrumentation components of LARP, is now scheduled for November 2-4, 2005 at the Hilton Hotel in Santa Rosa, California. We look forward to your preliminary agenda for the presentations, which we will combine with the needs for executive and writing sessions by our review committee.

The review committee will be asked to examine the research plans you are submitting for the development of superconducting magnets, and you should therefore be prepared to address details in the immediate evolution of your magnet development, such as your key objectives, including how you plan to overcome present technical limits, anticipated gains, key facilities and personnel you will need, and schedules and the milestones you plan to follow.

In light of the findings of the general review of this past June, the upcoming review should also address the elements in the proposed management plan that was of concern to the review committee. In particular, the committee asked about the apparent lack of documented understandings, especially between LARP and CERN, but also among the U.S. laboratories. This should be resolved to satisfaction. In addition, because it is crucial for LARP to work closely with CERN, it is important to assess the arrangements being made with CERN to integrate the U.S. efforts for commissioning of U.S. supplied components, the commissioning of the beam and associated instrumentation, and any potential upgrades of the LHC accelerator.

We will ask our consultants to provide distinct evaluations of: (i) goals for magnet R&D for next year, and (ii) the long-term plans based on the current funding guidance. We also expect a brief discussion by LARP management of the overall balance and priorities of the research program, as well as a clarification of the anticipated impact of the proposed accelerator-instrumentation efforts on the performance of the LHC.

Bruce Strauss will chair and serve as our contact on all aspects of the review. A tentative list of members of the review committee is enclosed for your information. To acquaint the committee with activities of LARP, we ask that you make available, well in advance of the review, background material as well as the latest information on the status of the program.

The committee will be expected to present closeout statements following the review, and provide a more formal jointly-written report by December 16, 2005. We thank you for organizing this technical review, and look forward to an update of the status and direction of the program.

Sincerely,

Robin Staffin
Associate Director
Office of High Energy Physics

Enclosure

Appendix B

Review Agenda

Oct 11, 05 **Santa Rosa agenda v3**

Tuesday Nov 1

830 All day	Dry Run at LBNL (building 71 conference room)	

Wednesday Nov 2

900 30	Executive session	
930 60 + 15	Program & management overview	S. Peggs
1045	BREAK	
1100 60 + 15	Accelerator Systems R&D Plan overview	V. Shiltsev
1215	LUNCH	
1330 45 + 15	Commissioning: Beam, IR & Hardware	M. Syphers
1430 45 + 15	Luminosity Monitor & Tune Feedback	A. Ratti
1530	BREAK	
1545 60 + 15	Magnet R&D Plan overview	S. Gourlay
1700 60	Open / discussion / executive session	
1800	ADJOURN	

Thursday Nov 3

830 75 + 15	Materials	A. Ghosh
1000 45 + 15	Sub-scale Quad series (SQ)	P. Ferracin
1100	BREAK	
1115 45 + 15	Technology Quadrupole series (TQ)	G. Sabbi
1215	LUNCH	
1330 45 + 15	TQ Shell – details	S. Caspi
1430 45 + 15	TQ Collar – details	R. Bossert
1530	BREAK	
1545 45 + 15	Long Racetrack coils	G. Ambrosio
1645 45 + 15	High Gradient (HQ) & Long Quad (LQ) series	A. Zlobin
1745 45	Open / discussion / executive session	
1830	ADJOURN	

Friday Nov 4

830 90	Supplementary talks, task details, etc.
1000	BREAK
1015 105	Open/discussion/executive session
1200	LUNCH
1300 120	Report writing
1500	BREAK
1515	Close out

Appendix C

Review Committee

Tom Taylor	CERN
Tim Antaya	MIT
Steve St.Lorant	SLAC (retired)
Alex Lumpkin	ANL
Mike Zisman	LBNL
Stan Schriber	MSU

CARE/NED Observer

Arnaud Devred	CEA-Saclay/CERN

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