News from the U.S. LHC Accelerator Research Program, LARP

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INTRODUCTION

LARP Magnet R&D strategy aims at Nb_3Sn magnets in the Theme-3/Phase-2 IR Upgrade. However, the magnet R&D plan also supports the Theme-2/Phase-1 IR Upgrade activities. Accelerator Systems topics may include Theme-1 Paper Studies, for example in support of the PS2 conceptual design. Always, LARP R&D should enable U.S. contributions to LHC accelerator components in a Construction Project, if and when the DOE decides to fund such a project. These contributions could include:

1. Cold masses
2. Rotatable collimators
3. Crab cavities
4. Electron lenses ...

Contributions could commence well before 2016.

POTENTIAL UPGRADE CONTRIBUTIONS

U.S. contributions to LHC IR Upgrades are being considered in the context of some basic assumptions:

1. The Phase-1 upgrade is expected to lead to "ultimate" luminosities well beyond "nominal", in the range 2×10^{34} to 3×10^{34} cm^{-2} sec^{-1}.
2. Any contributions, in Phase-1 or -2, would need additional funding to a construction project separate from LARP.
3. Launching a construction project is synonymous with achieving a "Critical Decision 0" (CD-0), which crucially requires a clear official "statement of mission need" from CERN.
4. Efforts towards CD-0 for a construction project should begin immediately, even though the challenge may need to be declined.
5. Not only magnets but also accelerator components such as Rotatable Collimators could be delivered for the Phase-1 upgrade.

Coldmasses

In Rossi's "hybrid proposal" the U.S. would provide 4 or 8 Nb_3Sn quads out of the 16 required for the Phase-1 upgrade, with the NbTi complement made at CERN. The hybrid proposal is an exciting challenge, but must receive careful evaluation and discussion (CERN, DOE, LARP) before any commitment can be made. Some LARP R&D re-programming would be necessary if the hybrid proposal is accepted, beyond current LARP budget guidance from the DOE.

LARP magnet R&D has a single strategic goal: making Nb_3Sn magnet technology fully mature for use in the Phase-2 upgrade. Any LARP magnet R&D for Phase-1 must enhance progress towards this goal, rather than compromising it. Nb_3Sn magnets provided in Phase-1 would have to perform at least as well as NbTi magnets, otherwise they would not be worth installing. While Phase-1 tin magnets would be state-of-the-art in 2012, they would be intermediate R&D prototypes on the path to Phase-2.

It is not clear that the U.S. can commit to delivering even just 4 Nb_3Sn quads, absolutely guaranteed to be ready and reliable, to begin installation on the December 2012 date, even in scenarios unconstrained by funding limits. Nonetheless, LARP will immediately begin to evaluate the delivery of (at least) 4 Nb_3Sn quadrupoles, or Nb_3Sn D1 dipoles. A clear U.S. response to the hybrid proposal challenge should be possible by June 2008.

Rotatable collimators

Second generation collimators will also be required to achieve "ultimate" luminosities. Parallel R&D paths are being pursued in LARP and at CERN, in preparation for the construction of as many as 30 such collimators, to be installed on the Phase-1 upgrade timescale. Rotatable Collimator prototype RC2 is scheduled for beam tests alongside CERN's design soon after delivery to CERN in January, 2009. The U.S. will consider delivering many such RCs as part of a Phase-1 construction project.

Crab cavities

A recent DOE review of LARP stated that:

"The crab cavity effort seems well matched to the LARP program, and should be given sufficient resources to move forward."

Crab cavities are required for one of the two Phase-2 schemes. They also increase luminosity in any stand-alone installation. LARP could be the basis for U.S. participation in this strategic emerging enabling technology. Current LARP funding prohibits significant R&D participation, beyond maintaining observer status in the nascent international collaboration, and despite strong and growing interest at CERN.

Much crab cavity R&D remains to be performed. Nonetheless, the U.S. should consider delivering crab cavities. LARP would like to take a significant role in crab cavity R&D, with explicit support from CERN, and additional funds from DOE.

A Small Business (SBIR) proposal has been submitted by Advanced Energy Systems (AES), to build a prototype LHC crab cavity (800 MHz). This could be installed in the LHC in about 2011, in order to perform beam dynamics tests that would definitively resolve the practicality of a crab cavity construction project.

Evaluation process

A final commitment to Phase-1 deliverables will only occur after a stringent independent cost and schedule review. Different potential formats for this review include LARPAC, Lehman, and a joint review with CERN. The LARP Magnet Systems group will perform most of the magnet cost and schedule analyses, with the goal of releasing a report at about the same time as the LIUWG report.

2007	
Nov 7-9	CARE-HHH-APD IR07, Frascati
Dec 5	DOE Mini-Review, Germantown
Dec 6	Executive Committee meeting, Fermilab
Dec 18	CERN-U.S. Meeting, CERN
2008	
April 23-25	LARP Collaboration Meeting 10
June	CERN LIUWG report
June	LAUC report release
June	DOE full-scale review
June	Phase-1 construction project review.

Table 1: Milestones in the preparation and evaluation of a U.S. funded LHC Accelerator Upgrade Construction project (LAUC).

"JOINT IR STUDIES" WORKING GROUP

The recent DOE review also stated:

"The importance of establishing closer relations between the magnet and accelerator sectors of LARP cannot be overstated, especially in view of the fact that it is not clear what should follow the completion of the LQ magnet."

In response, the "Joint IR Studies" (JIRS) working group has been created within LARP (see Fig. 1), merging Magnet and Accelerator Systems people and activities. Sasha Zlobin leads JIRS. Ranko Ostojic chairs CERN's "LHC Insertions Working Group", evaluating all aspects of the Phase-1 upgrade. JIRS and LIUWG will maintain broad and unrestricted communications, but will work independently.

One of the JIRS goals is to define and evaluate a short list of potential locations for early Nb_3Sn magnets. According to de Rijk:

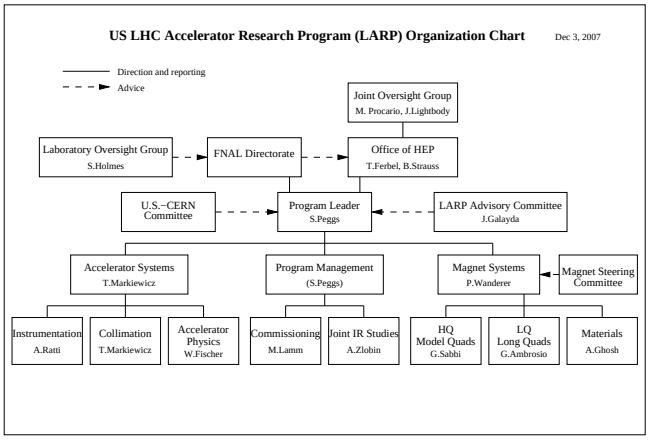

Figure 1: The organizational structure of LARP, the U.S. LHC Accelerator Research Program", in December 2007.

"New magnets are needed for the LHC phase 2 upgrade in about 10 years" [in the following potential locations:]

1. Quadrupoles for the low-beta insertions
2. Corrector magnets for the low-beta insertions
3. Dogleg dipoles for the cleaning insertions
4. Q6 for cleaning insertions
5. 10 m dipoles for the dispersion suppressors
6. Early separation dipole (D0)

Initial JIRS activities do not include crab cavity issues, although a crab task may be added to JIRS, eg in FY09

SUMMARY

LARP must move with "speed but not haste" to present to DOE possibilities for U.S. deliverables on the Phase-1 timescale. Rotatable collimators and crab cavity activities are gaining momentum. Potential Nb_3Sn cold mass locations include triplet quads and collimation quads. D1 dipoles are a significant alternative. CERN will definitively state upgrade parameters, on a timescale perhaps informed, but not driven, by LARP R&D. LARPs JIRS Working Group must work closely with LARP Magnet Liaison (Rossi), CERN-AB and AT divisions, and with the "LHC Insertions Upgrade Working Group" (Ostojic).

Mantra: LARP Magnet R&D strategy focuses on Nb_3Sn magnets for Phase-2, in collaboration with CERN/CARE.

What will beam say?