Conclusions from the

"*Working Meeting to Discuss the Geotechnical Characterization of LBNE at the Sanford Underground Research Facility 4850L and Impacts on LAr Detector Design – October 8-10, 2014*"

prepared for the LBNF interim International Executive Board

Dario Autiero, Elaine McCluskey, Guido Nuijten, André Rubbia, Jim Strait, Bob Wilson

Introduction

Four members of the Long-Baseline Neutrino Facility iIEB[1] participated in the *Working Meeting to Discuss the Geotechnical Characterization of LBNE at the Sanford Underground Research Facility (SURF) 4850L and Impacts on LAr Detector Design* held at the Sanford Underground Research Facility, Lead, South Dakota October 8-1, 2014, which also included surface and underground tours of the facility. Participants in the meeting included representatives from the scientific and technical leadership of LBNO and LBNE, technical consultants, and members of SURF staff.

The web site for the meeting can be found at:

https://sharepoint.fnal.gov/project/lbne/reviews/Geotechnical%20Characterization%20of%20LBNE/SitePages/Home.aspx.

and the agenda with links to the presentations is here:
https://sharepoint.fnal.gov/project/lbne/reviews/Geotechnical%20Characterization%20of%20LBNE/SitePages/Agenda.aspx.
The agenda and participant list also appear in the appendices.

The primary technical objectives of the working meeting were:

- To discuss rock mass behavior at the 4850L of the Sanford Underground Research Facility (SURF) and the Pyhäsalmi Mine and the impact of rock mass behavior on the design of the LBNE and LBNO cryostats.
- Address how an LBNO-style cryostat could be accommodated in the 4850L rock mass at SURF, including whether direct support against the rock is reasonable.
- Review relevant risks and examine costs and cost assumptions/methodologies at a summary level.

In this note we summarize the post-meeting impressions and general conclusions of the participating iIEB members as to the feasibility of SURF as the location for a massive far detector of either the current LBNE or LBNO LAr detector designs. LBNE Project Manager Elaine McCluskey and co-chair of the LAGUNA-LBNO Technical Board Guido Nuijten participated in the preparation of this note.

Impressions, Action Items and Conclusions

The impressions, action items and conclusions presented here are drawn primarily from a three-hour concluding session during which each participant was asked to comment, where appropriate, in three general areas: Existing Facility (SURF), Geotechnical Evaluation and Excavation Issues,

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and the Cryostat (free-standing or rock wall support). Many topics were discussed, including, for example, the different approaches to cryostat design between LBNE and LBNO, the choice of rock mass in which to site the detectors, different detector installation methods, and many design details. In this brief report, we concentrate just on the main points relevant to evaluating the feasibility of SURF as the location for the LBNF far detector. A photograph of the whiteboard on which all key points were recorded and annotated at the conclusion of the meeting appears in the appendix. A set of action items and a work plan resulting from the full range of issues raised is under preparation.

Key Point: Science requirements are the foundation that will drive all decisions.

The essential science goals will be outlined in the Letter of Intent (LOI) under preparation. A comprehensive set of science requirements and timescale for achieving them for the long-baseline facility and detector complex must be prepared before a detailed conceptual design report can be prepared.

Existing Facility Impressions:

- The layout has two access shafts for personnel, equipment, and rock removal that are connected by two independent horizontal paths at the 4850 level.
- The local staff was found to be very motivated, well organized, highly knowledgeable about the SURF site, and very welcoming.
- The infrastructure is not sized for a project of the scale of LBNF. LBNE and SURF have developed conceptual designs for the expansion of the infrastructure to support this experiment.
- At present the Yates shaft provides access to the various underground activities.
- The rehabilitation of the Ross shaft is a mandatory requirement in view of excavation and construction of LBNF. The refurbishing, which is under way and currently more than 33% complete, must be completed before further work is started. Reactivation of the Ross shaft is foreseen for 2017.
- Further investigations are necessary to develop the most efficient, affordable and timely extension of the infrastructure needed for the construction and operation of LBNF (overall underground layout, enlarged drifts, new underground space, feasibility of caverns of very large volumes, ancillary underground space for logistics and safety, optimal location of new caverns).
- The refurbished Ross shaft will provide cage inside dimensions of 1.42m x 2.13m x 3.77m, a maximum load of 5,450 kg and a 3.25 minute travel time. Larger loads, up to 1.42 m x 2.13 m x 9.10 m can be slung under the cage. The material presented did not allow assessing the impact on the LBNF construction and operation of an underground access limited to this shaft, nor the overall risks for the project. Information regarding construction and operations that has been developed by LBNE and SURF, but which was not presented at this meeting, will be made available to LBNF collaborators to aid in such an assessment.

Geotechnical Evaluation/Excavation:

- The geotechnical evaluation, including the results from a local site investigation, has been presented. The rock presents in general good quality. Both the underground visit and the thorough geotechnical investigation of the proposed LBNE cavern site

have evidenced foliated rock. Ninety-nine percent of the rock core had an RQD value ≥90%, which classifies it as excellent.

- A better analysis of potential long-term rock movements (creep) is needed to support the LBNE concept of the tank embedded in the rock. This needs to include evaluation of the stability of existing excavated structures at or near the 4850L in the Poorman formation.
- The cavern optimal shape and maximum size need to be further studied with three-dimensional rock analyses. A quantitative comparison of shapes is recommended: mailbox vs. cylindrical, and as a function of the span.
- It might be advantageous to consider siting a large diameter, cylindrical cavern in the stronger Yates formation, where the LBNE water Cherenkov detector had been proposed. Such a siting can be addressed by a proper design of the access drift and would likely require construction of a dedicated ventilation drift to the 4 Winze Wye.
- No obvious impediments related to rock engineering were uncovered, but there are many details to be understood.

Cryostat Considerations:

- Both the LBNE and LBNO concepts are advanced and are the result of fully integrated studies considering the underground construction, detector installation, and operation – addressing cost optimization.
- LBNE selected a membrane cryostat following an engineering evaluation, which also considered more conventional designs as well as an evacuable cryostat design. LBNO selected a membrane tank over a 9% Ni-steel tank after a full design of both solutions. There is an agreement on membrane cryostat as cost effective/practical solution to be fully demonstrated by specific tests foreseen at FNAL and CERN.
- The LBNE cryostat is supported by the rock, on the basis that this maximizes the use of the excavated volume for the detector. LBNO finds that a free-standing tank, decoupled from the cavern, globally offers advantages during all phases of the project (construction, detector assembly, operation) and mitigates some risks. There is a need to develop a process and schedule for deciding between free-standing vs. rock-supported cryostat designs.
- At this stage, both LBNE and LBNO designs seem applicable at SURF but more detailed studies are needed.

Conclusions

Based on the working meeting presentations, discussions and facility tours and subsequent phone meetings and email exchanges, we could not find any indications that LAr detectors of either LBNE or LBNO styles (or a combination of the two) could not be constructed at SURF with a sufficiently large investment. However, further studies are required to support this statement, in particular in view of a timely and affordable realization of LBNF. For LBNO-type, the feasibility and cost of larger-span caverns must be assessed. For the LBNE-type, the concept of a cryostat embedded in the rock must be further developed and the associated risks at SURF must be better understood. Construction, detector assembly and operation plans must be presented taking into account the constrained access of the Ross shaft. We recommend that the new collaboration focuses efforts at quickly resolving these pending issues.

APPENDICES

Agenda

Wednesday, October 08, 2014

07:30	Welcome and Introductions	Tracy Lundin
07:40	Presentation of Laguna Industrial Partners Invited Rhyal Engineering Introduction	Collins, Nuijten, Judd
08:10	Overview of LBNE Facillities at SURF	Josh Willhite
08:40	Geology of the SURF Site	David Vardiman
09:10	LBNE Geotechnical Characterization / Cavern Study	Seth Pollak
10:40	**Break**	
10:55	LBNE Far Detector Including Risks	Jim Stewart
11:55	**Lunch and Safety Training**	
12:35	Obtain PPE and Tag in For 13:00 Cage	
13:00	Tour of Davis Campus and 4850L Geology	
16:00	Discussion	Tracy Lundin
16:30	Adjourn	

Thursday, October 09, 2014

08:00	LBNE Cryostat Risks And QA	Barry Norris
08:30	LBNE Membrane Cryostat Design	John Powell
09:00	LBNE CF Design Plan and Risks	Tracy Lundin
09:30	CF Cost Assumptions/Methodology & Cost Summary	Josh Willhite
09:45	Cryostat Cost Assumptions/Methodology & Cost Summary	Barry Norris
10:00	**Break**	
10:15	Discussion	Tracy Lundin
10:45	LBNO Geology / Geotechnical Characterization	Guido Nuijten
11:45	**Lunch**	
12:15	LBNO Cryostat and Containment Structure Design	Roger Collins
13:15	LBNO Cryostat and Detector Installation	Mike Haworth
14:15	LBNO Risks / QA Driven Design	Guido Nuijten
14:45	**Break**	
15:00	LBNO Cost Assumptions/Methodology & Cost Summary	Simon Judd
15:30	Discussion of Impact of Rock Mass on Cryostat Design and Other Related Topics	
16:30	Facility Tour - Surface	
18:00	Adjourn	

Friday, October 10, 2014

08:00	SURF Operations	Mike Headley
08:30	Further Discussion, Conclusions and Next Steps	Jim Strait, Andre Rubbia
11:00	Adjourn	

Participants

LBNO	Andre Rubbia, ETH, Coordinator of the international FP7 LAGUNA Design Study
	Dario Autiero, IPNL
	Guido Nuijten, Rockplan, co---chair of the FP7 LAGUNA Technical Board
	Roger Collins, Technodyne Ltd
	Mike Haworth, Technodyne Ltd
	Simon Judd, Rhyal Engr. Ltd
LBNE	Jim Strait, Project Director
	Elaine McCluskey, Project Manager
	Mike Andrews, LBNE Safety Manager
	Jim Stewart, L2 Far Detector Manager
	Barry Norris, FD L3 Cryogenics and Cryostat Manager
	Russ Rucinski, FD Project Engineer
	Tracy Lundin, L2 Conventional Facilities Manager
	Derek Martin, Chairman, Neutrino Cavern Advisory Board (NCAB)
	Jeff Dolph, LBNE Systems Engineer
	Bob Wilson, Collaboration Co---spokesperson
SURF	Mike Headley, Laboratory Director and SDSTA Executive Director
	Gil Gilchriese, SURF Deputy Head of Operations
	Josh Willhite, LBNE L3 CF Far Site Manager
	David Vardiman, LBNE Lead Geotechnical Engineer
	Syd DeVries, LBNE Lead Infrastructure Engineer
	Jon Hurt, Arup, Excavation Design Project Manager
	Seth Pollak, Arup, Rock Mechanics
	John Powell, Arup, Cryostat Design

Concluding session "Impressions" whiteboard