Key Assumptions:
Physics Research Goals of the LBNE Project

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Revision History

Revision	Date	Section No.	Revision Description
0.1	23 Sep 10	All	Initial draft for discussion.
0.2	29 Sep 10	II	Draft discussed with LBNE Executive Committee 13 Oct 2010
0.3	13 Oct 10	II.1	Promote supernova burst detection to a primary objective.
		II.2	Delete details under objective 2.1.
		II.3	Clarify the explanation of what this group of objectives is.
		II.4	Simplify and renumber the list of near detector objectives.
		II.5	Add an explanation of use of the additional objectives in project planning and reformat.
0.4	28 Oct 10	II.3	Specify that these are “Additional *secondary* objectives”
1.0	18 Nov 10	Title page	Update table of signatures to be obtained.

TABLE OF CONTENTS

I. Introduction

The Long Baseline Neutrino Experiment (LBNE) Project will provide facilities for a world-class program in neutrino physics, proton decay, and other non-accelerator-based physics. It will enable the program envisioned by the Particle Physics Project Prioritization Panel (P5) in its 2008 report[1], which made the following recommendations:

> The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.
>
> The panel recommends an R&D program in the immediate future to design a multi-megawatt proton source at Fermilab and a neutrino beamline to DUSEL and recommends carrying out R&D on the technologies for a large multi-purpose neutrino and proton decay detector.

Following the P5 report, the United States Department of Energy (DOE) has issued a Mission Need Statement for a Long Baseline Neutrino Experiment (LBNE)[2], which states:

> The Office of High Energy Physics proposes construction of an experiment comprised of a large detector illuminated by a distant, intense neutrino source and a much smaller detector located close to the source.
> . . .
> The increased research capabilities afforded by a long baseline (distance between the detector and the neutrino source) neutrino experiment will enable a world-class program in neutrino physics that can measure fundamental physical parameters, explore physics beyond the Standard Model, and better elucidate the nature of matter and antimatter.
> . . .
> The large detector, if located underground, and thus shielded from cosmic backgrounds, could also be sensitive to proton decay, predicted by grand unified theories which are natural extensions of the Standard Model. … Furthermore, an underground detector could serve as an observatory for neutrinos generated by supernovae since the beginning of time and for neutrinos generated more recently by supernovae in our galactic neighborhood, yielding new information on the collapse mechanisms of stars.

This Mission Need Statement supported DOE Critical Decision (CD-0) for LBNE, which was approved in January 2010.

The National Science Foundation (NSF) proposes to build the Deep Underground Science and Engineering Laboratory in the former Homestake Mine in Lead, South Dakota. DUSEL is currently the preferred site for the LBNE far detector complex. LBNE is considered to be one of the key physics experiments to be conducted in DUSEL.

The DOE and the NSF have agreed that DOE will be the "steward" of the LBNE Project, and that NSF will contribute financially to its construction as part of the DUSEL Project.

II. Physics Research Goals of LBNE

Following from the P5 recommendations, the DOE Mission Need Statement, discussions with the funding agencies (DOE Office of High Energy Physics and NSF Physics Division), Fermilab management, and the LBNE Science Collaboration, it is been determined that the priorities for the scientific research to be enabled by the LBNE Project are the following:

1. The primary objectives of the LBNE Project are the following experiments:

1.1 Search for, and precision measurements of, the parameters that govern $\nu_\mu \rightarrow \nu_e$ oscillations. This include measurement of the third mixing angle θ_{13}, for whose value only an upper bound is currently known, and if θ_{13} is large enough, measurement of the CP violating phase δ and determining of the mass ordering (sign of Δm^2_{32}).

1.2 Precision measurements of θ_{23} and $|\Delta m^2_{32}|$ in the ν_μ disappearance channel.

1.3 Search for proton decay, yielding a significant improvement in current limits on the partial lifetime of the proton (τ/BR) in one or more important candidate decay modes, e.g. $p \rightarrow e^+\pi^\circ$ or $p \rightarrow K^+\nu$.

1.4) Detection and measurement of the neutrino flux from a core collapse supernova within our galaxy, should one occur during the lifetime of LBNE.

2. Secondary objectives, which may be enabled by the facility that is designed to achieve the primary objectives include:

2.1 Other accelerator-based neutrino oscillation measurements.

2.2) Measurements of neutrino oscillation phenomena using atmospheric neutrinos.

2.3) Measurement of other astrophysical phenomena using medium energy neutrinos.

3. Additional secondary objectives, the achievement of which may require future upgrades to the facility that is designed to achieve the primary objectives, include:

3.1) Detection and measurement of the diffuse supernova neutrino flux.

3.2) Measurements of neutrino oscillation phenomena and of solar physics using solar neutrinos.

3.3) Measurements of astrophysical and geophysical neutrinos of low energy.

4. Purposes of the Near Detector

4.1) **The primary objective of the near detector** is to make measurements necessary to achieve the primary physics research objectives listed above.

4.2) **Secondary objectives of the near detector** are studies of neutrino interactions, which may be enabled by the facility that is designed to achieve the primary objectives or by future upgrades to the facility and detectors. These include:

4.2.1) Studies of the Weak Interaction.
4.2.2) Studies of nuclear and nucleon structure.
4.2.3) Searches for New Physics.

5. These priorities will be considered in planning the configuration of the facilities constructed by the Project.

5.1) Configurations will be chosen which maximize the effectiveness of the facility to achieve the *primary objectives*.

5.2) The ability to achieve the *secondary objectives* will be considered in cases in which a modest investment will enable or enhance one or more of them, thereby broadening the LBNE physics program, without significantly compromising the ability to achieve the primary objectives.

5.3) The *additional objectives* are expected to require substantial investment, beyond that required to achieve the primary objectives, to be able to be achieved. These will be considered if a modest initial investment, that does not significantly compromise the ability to achieve the primary objectives, can leave open the option of future upgrade(s) that would enable one or more of them.

III. References

[1] US Particle Physics: Scientific Opportunities, A Strategic Plan for the Next Ten Years, Report of the Particle Physics Project Prioritization Panel, 29 May 2008, http://www.er.doe.gov/hep/files/pdfs/P5_Report 06022008.pdf

[2] Redacted Mission Need Statement for a Long Baseline Neutrino Experiment (LBNE), January 2010, unpublished.