Critical Decision 1
Approve Alternative Selection and Cost Range
of the
Large Liquid Argon Detector for Neutrino Physics
(MicroBooNE) Project
at the
Fermi National Accelerator Laboratory
Office of High Energy Physics
Office of Science

Purpose

The purpose of this paper is to document the review and approval by the Office of Science Energy Systems Acquisition Advisory Board-equivalent for Critical Decision 1 (CD-1) "Approve Alternative Selection and Cost Range" for the Large Liquid Argon Detector for Neutrino Physics (MicroBooNE) Project at the Fermi National Accelerator Laboratory (Fermilab).

Project Overview

The MicroBooNE Project is a neutrino detector being planned for fabrication by Fermilab as a Major Item of Equipment (MIE) for a high-energy physics experiment. It will utilize a Liquid Argon (LAr) Time Projection Chamber (TPC) as a combined target medium and tracker for events coming from neutrinos in the Fermilab Booster Neutrino Beam. The MicroBooNE Project will advance the state of LAr detectors at the 100 ton scale for neutrino physics.

The MicroBooNE Detector will be fabricated as a DOE MIE project at Fermilab by a team from DOE National Laboratories and university groups, headed by Fermilab. Part of the fabrication will be funded in-kind by the National Science Foundation (NSF) and executed through NSF grants to Yale University, Columbia University and the Massachusetts Institute of Technology.

The MicroBooNE scientific collaboration is planning to use the MicroBooNE Detector to resolve an anomalous excess of apparent low-energy neutrino events in the Fermilab Booster neutrino beam observed by an earlier, mineral-oil Cerenkov-light experiment, MiniBooNE, that could not discriminate well between electrons and photons.

MicroBooNE has three major objectives that combine immediate scientific interests with technological innovations for the long-term. The scientific goals are (1) to resolve the source of the low-energy neutrino events observed by the MiniBooNE detector and (2) to measure exclusive neutrino-argon cross sections. The third major objective is to gain technical experience in the construction of a moderate-size LAr TPC detector at the 100 ton scale via the execution of the MicroBooNE Project, which will be directly applicable to the design of a future multi-kiloton LAr TPC detector. The design of the MicroBooNE experiment balances the detector development objectives against timely and precise physics results to assure success on both the scientific and technological fronts. These are the primary design-drivers of the experiment.

The scientific goals of MicroBooNE (as well as those of the future long-baseline neutrino oscillation experiments being planned) rely on the superior capabilities of a LAr TPC detector for reconstructing neutrino interactions and discriminating between electrons, photons and

pions. These capabilities are needed to identify the low energy events observed by MiniBooNE and also will be required for a larger-scale detector such as for Long Baseline Neutrino Experiment (LBNE).

The MicroBooNE experiment will utilize the Fermilab Booster Neutrino Beam. The new MicroBooNE detector will be installed in the MiniBooNE experiment's enclosure, or in an enclosure adjacent to the MiniBooNE enclosure. The MicroBooNE detector will be constructed of modular pieces built at Fermilab or at other collaborating institutions, and then assembled and installed at the MicroBooNE experiment site.

Filling the detector with cryogens is not included in the project scope; the R&D program will study the filling requirements for future LAr TPC detectors and may require filling the MicroBooNE detector several times under varying conditions of cleanliness and argon purity.

Alternative Selection

The alternatives are limited by the nature of the project. Three alternatives were presented in the Mission Need Statement (MNS).

MNS Alternative 2, the MicroBooNE proposal, was selected because it will enable the development of LAr TPC detector technology at the 100 ton scale that can be used for future neutrino research with multi-kiloton detectors at long baselines. .The developmental MicroBooNE detector will be large enough to study the excess of low energy events observed in the MiniBooNE experiment. Several facility options are being considered on the Fermilab site, each at or near the existing MiniBooNE detector site.

In 2007, the Neutrino Scientific Assessment Group (NuSAG) recommended to the High Energy Physics Advisory Panel (HEPAP) a phased R&D program for developing the LAr Time Projection Chamber detector option at the 20,000 to 100,000 ton scale as a cost-effective candidate technology for a long-baseline neutrino oscillation experiment being conceptualized as part of the future U.S. High Energy Physics program.

The superior capability of a LAr TPC for imaging neutrino interactions and discriminating between pions, photons and electrons down to tens of MeV of energy was recently demonstrated by a 0.3-ton LAr test chamber called ArgoNeuT at Fermilab. MicroBooNE, at the 100-ton scale, is the next phase of development and is being designed in a manner such that its costs can be accurately scaled-up to the much larger fiducial mass and volume recommended by NuSAG for the long-baseline neutrino oscillation experiment.

MNS Alternative 1, to do nothing, was not selected because it would not enable the United States development of detectors that the review panels have recommended as a possible option for large neutrino experiments and a capability gap would develop.

MNS Alternative 3, to collaborate with other liquid argon TPC development efforts, was not selected because the other liquid argon TPC development, ICARUS at the Gan Sasso underground laboratory in Italy, does not appear to be well suited for large scale liquid argon TPCs.

Critical Decision 1 Requirements

All prerequisites for CD-1 approval have been completed for the MicroBooNE Project:
- Acquisition Strategy—submitted;
- Conceptual Design Report—completed;
- Preliminary Project Execution Plan—submitted;
- Integrated Project Team—chartered and functioning (included in PPEP);
- One-for-one Replacement for Building sq. footage—addressed;
- Preliminary Hazard Analysis—completed;
- ISM implementation—Fermilab work included in Fermilab's DOE-approved ISM Program
- Environmental Documentation—Categorical Exclusion expected;
- High Performance Sustainable Building—applying DOE Guiding Principles as applicable
- QA Program—outlined in PPEP and in MicroBooNE Quality Management Plan;

Preliminary Cost Range

The DOE Total Project Cost (TPC) for the MicroBooNE Project is estimated to be in the range $18.8 million to $20 million in then-year dollars. In addition, the Project expects to receive in-kind contributions of scope estimated at $1.6 million from the National Science Foundation.

The DOE Office of Science Office of Project Assessment at the request of the Acquisition Executive conducted a review to validate the MicroBoone conceptual design and cost range for CD-1 on March 2-3, 2010. The project and documentation were reviewed and judged to be ready for CD-1. Subsequent to the review, the cost range and preliminary funding profile were updated in the Preliminary Project Execution Plan and Acquisition Plan with the information presented in the tables below.

DOE Cost Range ($ in Millions)	
DOE TPC range	18.8 - 20

Preliminary Funding Profile ($ in Millions)					
	FY 2010	FY 2011	FY 2012	FY 2013	Total
DOE TPC	2.0	8.0	6.0	4.0	20

Key Milestones and Events

The following table shows the preliminary key milestones. The CD-0 milestone date is an actual date, and the future dates are the estimates from the Integrated Project Team (IPT) of the desired schedule.

Critical Decision Milestone	Date
CD-0 Approve Mission Need	9/28/09 (actual)
CD-1 Approve Alternative Selection and Cost Range	3rd Qtr. FY 2010
CD-2 Approve Performance Baseline	1st Qtr. FY 2011
CD-3 Approve Start of Construction	4th Qtr. FY 2011
CD-4 Approve Project Closeout	3rd Qtr. FY 2014

DOE Review

The Office of Project Assessment, at the request of the Acquisition Executive (AE), conducted a review on March 2-3, 2010 to assess the MicroBooNE Project's readiness for CD-1 approval. The review committee found the Project to be ready to seek CD-1 approval. The committee had four near-term recommendations. These recommendations and the status of the responses are presented below.

- Consider increasing the funding range to a ceiling of $20 million.

  The Office of High Energy Physics has increased the planned DOE funding to $20 million and the cost range has been changed to $18.8-20 million.

- A comprehensive schedule to CD-2 requires development

  A comprehensive schedule to CD-2 has been prepared and will be refined as needed with time. Progress against this schedule will be presented at Project meetings including the MicroBooNE Integrated Project Team (IPT) Meetings.

- Produce a detailed plan/milestones for all deliverables/actions required for CD-2 and communicate this plan to the L2 managers and Collaboration by the end of March.

  This plan was developed and was presented by the Project Manager to the WBS Level 2 managers and the Collaboration at the MicroBooNE Collaboration meeting on April 2, 2010.

- Develop a coherent strategy (and the critical milestones) with FNAL management for the D&D of MiniBooNE and the subsequent conversion of the enclosure for MicroBooNE by the end of April.

  This strategy was developed by the end of April 2010. The strategy requires an engineering study of the means and methods and associated cost and schedule to D&D the MiniBooNE detector enclosure, including the removal of the enclosure roof; electrical and mechanical systems; and the MiniBooNE detector. A list of eight critical milestones was developed to track progress with respect to the strategy. The MiniBooNE D&D costs will be factored into the decision of whether to reuse the MiniBooNE enclosure or construct a new enclosure.

Acquisition Strategy

An Acquisition Strategy has been submitted for approval as a prerequisite for CD-1. Briefly, the Acquisition Strategy describes why Fermi Research Alliance (FRA) has been selected to lead the project based on its existing scientific and engineering expertise, the need to involve the collaborating physicists in the design and construction, and to simplify the interfaces among the collaboration, the project, and the rest of the lab.

FRA will serve as the prime contractor for work involving DOE funds for the fabrication of the MicroBooNE. Thus, Fermilab will have primary responsibility for oversight of all contracts required to execute this part of the Project involving DOE MIE and R&D funds. These contracts are expected to include the purchase of components from vendors as well as contracts with university groups to fabricate some of the subsystems. The IPT reviewed and evaluated the feasible acquisition alternatives, taking into account Fermilab's extensive in-house capabilities and the capabilities of institutions participating in the scientific research collaboration. The primary source of materials for these projects will be commercial vendors vying for purchase orders under competitive conditions. Several components will be provided by universities or foreign institutions. It is anticipated that Fermilab will issue fixed-price contracts.

Environmental Strategy

The NEPA action for the MicroBooNE Project is likely to be Categorical Exclusion. This will be approved prior to CD-2.

Risk Management

Risks identification has begun. The Project will manage risk according to its formal Risk Management Plan. Risks are identified by WBS Level 2 managers and ranked within their subprojects based on probability of occurrence and impact/consequence. MicroBooNE Project management reviews the results and classifies the risks as high, medium, or low based on a Risk Classification Matrix. Included in this process are high level risks and risks that might be shared among several subprojects that may be identified and "owned" by the MicroBooNE Project Manager.

The Level 2 managers then develop Risk Mitigation/Abatement Plans for all risks rated as either high or moderate. The MicroBooNE Project Manager will establish and maintain a watch-list of risk issues and events that need special attention or on which action is imminent. The development of risk abatement strategies and plans and their execution is monitored by a Risk Management Board (RMB) that consists of the MicroBooNE Project Manager, Deputy Project Managers, and Level 2 managers. The MicroBooNE Project Manager will decide whether a documented risk would benefit from additional review by the RMB. Risk Management issues will be regularly addressed at the MicroBooNE management meetings, the Integrated Project Team meetings, and will be included in monthly reports.

Technical risk has been minimized by limiting advanced technologies to those subsystems that reap the largest benefit. Other systems are designed with well tested technologies that have been used in other high energy physics projects. The building construction/conversion contract is

anticipated to be the largest single procurement, and the cryostat vessel procurement is anticipated to be the largest component procurement. Most of the other procurements are either for commercially available items or are for items that include commercially available items. To reduce risks, orders may be split between multiple vendors to ensure adequate source of supply.

Use of fixed-price subcontracts and competition will be maximized to reduce cost risk. The primary risk of cost increase comes from the uncertainty in the cryogenics plant. This cost risk has been mitigated by including cost contingency.

Schedule risk will be minimized by performing aggressive R&D; realistic planning; close surveillance of vendor performance; and advance expediting.

Critical Decision 1, Approve Alternate Selection and Cost Range of the MicroBooNE Project

Submitted by:

Paul R. Philp
Federal Project Director
Fermi Site Office

6-24-10
Date

Mark E. Bollinger
(Acting) Site Manager
Fermi Site Office

6-24-10
Date

Theodore L. Lavine
Program Manager
Office of High Energy Physics

6/24/10
Date

Critical Decision 1, Approve Alternate Selection and Cost Range of the MicroBooNE Project

Recommendations:
The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-1, Approve Alternate Selection and Cost Range, for the MicroBooNE Project at Fermilab as noted below.

6/28/10 Yes ✓ No ___
ESAAB Secretariat, Office of Project Assessment Date

David Goodwin 6/28/10 Yes ✓ No ___
Representative, Non-Proponent SC Program Office Date

6/28/10 Yes ✓ No ___
Representative, Office of Budget Date

Sat Paul Jul 6/28/10 Yes ✓ No ___
Representative, Environmental, Safety and Health Division Date

David Goodwin 6/28/10 Yes ✓ No ___
Representative, Safeguards and Security Division Date

6-28-10 Yes ✓ No ___
Representative, Facilities and Infrastructure Division Date

___ Yes ___ No ___
Representative, Grants and Contracts Division Date

Approval of CD-1

JUL 9 2010
Dennis G. Kovar, Acquisition Executive Date
Associate Director for High Energy Physics
Office of Science