Critical Decision 2/3a
Approve Performance Baseline and
Approve Limited Construction
of the
Micro Booster Neutrino Project
at the
Fermi National Accelerator Laboratory
Office of High Energy Physics
Office of Science

A. Purpose

The purpose of this document is to record the review and approval by the Office of Science Energy Systems Acquisition Advisory Board-equivalent for Critical Decision (CD) 2 "Approve Performance Baseline" and CD-3a "Approve Limited Construction" for the Micro Booster Neutrino (MicroBooNE) Project at the Fermi National Accelerator Laboratory (Fermilab).

B. Mission Need

The Mission Need for the Project is contained in the CD-0 Approval for MicroBooNE Project that was approved on September 28, 2009.

The liquid-argon detector program is part of a larger DOE strategic program to understand neutrino flavor oscillations in detail, with possible implications for CP violation the matter-antimatter symmetry in the universe.

The new techniques for particle identification and high-resolution event reconstruction in liquid-argon time projection chambers that will be developed for MicroBooNE have direct application to the longer-term scientific plans of the high-energy physics neutrino community.

C. Project Performance Scope Baseline and Acquisition Strategy

The goal of the MicroBooNE experiment is to use Liquid Argon (LAr) Time Projection Chamber (TPC) detector technology to conduct a forefront neutrino measurement using a neutrino beam at Fermilab. The analysis of low energy neutrino interactions in the MiniBooNE experiment will provide the MicroBooNE experimental collaboration with a physics measurement goal for which to develop the capabilities of the LAr TPC detector. These low energy events are at the limits of most detector technologies, in particular the ability to distinguish between electrons and gammas. LAr TPC detectors have the potential for good particle identification, high spatial resolution and measurement of energy down to the MeV scale. These capabilities are needed to more precisely identify the events observed by MiniBooNE, and they will also be required of future, larger-scale detectors such as for Long Baseline Neutrino Experiment (LBNE).

The MicroBooNE Project will consist of the design and construction of:

- infrastructure needed to support the MicroBooNE operation, including HVAC, safety, and communications systems;

- a LAr TPC system for precise measurements of inclusive and exclusive neutrino cross sections to enable the low energy "excess" events observed by the MiniBooNE experiment to be identified and classified;
- photomultiplier detectors;
- a cryostat to house the LAr TPC and PMT systems;
- cryogenics system;
- readout and data acquisition systems for the detector; and
- detector assembly, installation, and integration.

Integration and commissioning of the detector components with liquid argon will be handled as operating R&D outside of the MicroBooNE Project; the R&D program will study the filling requirements for LAr TPC detectors and may choose to fill the MicroBooNE detector several times under varying conditions of cleanliness and argon purity. Filling and commissioning of MicroBooNE with liquid argon will begin after the project has completed acceptance testing for CD-4.

The project is defined to be completed when it has achieved the Key Performance Parameter (KPP). The Key Performance Parameter (KPP) for the project is:

> Liquid Argon Time Projection Chamber Detector positioned in the Booster Neutrino Beam with a total capacity for at least 100 tons of liquid argon after filling.

Completion of the KPP is demonstrated by accomplishment of the following items that enable readiness for initial filling with liquid argon:

1. Experiment infrastructure complete and operational;
2. Safety systems operational;
3. Detector installation complete;
4. Detector subsystem checkouts complete;
5. Cryo-plant tests complete;
6. Operational readiness clearance granted by the Laboratory.

An Acquisition Strategy (AS) was prepared and approved as a prerequisite for CD-1. Briefly, the AS describes why the DOE contractor of Fermilab has been chosen to lead the project, and how the acquisitions of the MicroBooNE Project will be managed.

D. Project Performance Cost Baseline and Planned Funding

The MicroBooNE Project is a Major Item of Equipment (MIE). The DOE total estimated cost (TEC) for the MicroBooNE Project is $14.76 million in then-year dollars. The DOE TPC is $19.90 million in then-year dollars.

In addition, the detector systems include fully-funded in-kind contributions of scope from NSF-funded university groups valued nominally at $1.89 million. This contribution from NSF is not part of the DOE scope or TPC.

The table below presents the DOE TEC, DOE R&D, and DOE TPC, by WBS. Baseline costs resulted from bottoms-up cost estimates, and contingency for the DOE scope is provided by DOE.

DOE Cost Estimate by WBS Element ($ in Millions)

WBS Element	Item	DOE OPC	DOE TEC	DOE TPC
1.1	Project Management	1.53	2.18	3.71
1.2	Cryogenics Systems	0.95	2.87	3.82
1.3	Cryostat	0.40	0.96	1.36
1.4	Time Projection Chamber*	0	0	0
1.5	Front-end Electronics	1.02	1.99	3.01
1.6	Experiment Infrastructure	0.28	0.17	0.45
1.7	Systems Installation	0.18	1.45	1.63
1.8	PMT System*	0	0	0
1.9	DAQ, Monitoring, and Control	0.07	0.85	0.92
1.10	Detector Assembly Integration	0.33	0.33	0.66
1.11	Electronics Readout*	0	0	0
	Subtotal of above	4.76	10.80	15.56
	DOE Contingency	0.38	3.96	4.34
	DOE Total‡	**5.14**	**14.76**	**19.90**
	Cost of Work Remaining at CD-2†	2.12	10.80	12.92
	Percent Contingency on Work Remaining†	18%	37%	34%

* WBS 1.4 TPC Chamber, WBS 1.8 PMTs, and WBS 1.11 Electronics Readout are funded by NSF.
† The work remaining was evaluated in August 2011 for the CD-2 baseline Independent Project Review.
‡ Estimated division between equipment cost (TEC) and operating expense (OPC) is shown in this table. The funding plan will be revised as needed to reflect the actual division between TEC and OPC during the MIE fabrication phase.

The planned DOE funding for the MicroBooNE Project is shown in the table below. Additionally, the National Science Foundation (NSF) is providing fully-funded in-kind contributions that are outside the scope of the DOE project. The NSF contributions nominally

estimated as $940,000 for WBS 1.4 at Yale University; $160,000 for WBS 1.8 at Yale/MIT; and $785,000 for WBS 1.11 at Columbia University.

Planned Funding ($ in Millions)

	FY2010	FY2011	FY2012	FY2013	Total
DOE OPC	2.043	6.000	0	0	8.043
DOE TEC	0	0	6.000	5.857	11.857
DOE TPC	**2.043**	**6.000**	**6.000**	**5.857**	**19.900**

E. Scheduled Baseline

The table below presents the Critical Decision milestones for the MicroBooNE Project. Schedule float has been added to each milestone based on the level of the milestone. Filling of the detector with liquid argon and subsequent commissioning of the detector are not part of the Project.

MicroBooNE Project – Critical Decision Milestones

Milestone	Description	Baseline Date
0.0	CD-0: Approve Mission Need	Sept 28, 2009 (A)
0.1	CD-1: Approve Alternative Selection and Cost Range	July 9, 2010 (A)
0.2	CD-2: Approve Performance Baseline	September 2011
0.3a	CD-3a: Approve Limited Construction	September 2011
0.3b	CD-3b: Approve Start of Full Construction	June 2012
0.4	CD-4: Approve Project Completion	September 2015

F. Independent Project Review

The Office of Project Assessment, at the request of the Acquisition Executive (AE), conducted a review to validate the MicroBooNE preliminary design and cost estimate for CD-2/3a on August 10-11, 2011. The MicroBooNE Project and documentation were reviewed and judged to be ready for CD-2/3a.

G. Environment, Safety and Health

The Categorical Exclusion (10CDF1021, Subpart B, Appendix B1.15 and B3.10) for the MicroBooNE Project was approved on March 18, 2011.

A MicroBooNE Hazard Analysis report has been updated for this project in preparation for CD-2 and 3. This analysis will be updated as needed for each subsequent CD. Liquid argon is the most significant safety hazard on the Project, and safety measures are being integrated in the designs. Fermilab has a history of performing similar work in a safe manner.

The MicroBooNE Project work at Fermilab will be conducted under the Integrated Safety Management (ISM) plan developed by Fermilab in consultation with DOE.

H. Risk Management

A detailed risk management plan and associated risk register have been developed and describe the Project's risk identification and mitigation actions. The identified risks will be monitored, assessed, and addressed throughout the life of the Project.

I. Summary of CD-2 Requirements

All prerequisites for CD-2 approval have been completed for the MicroBooNE Project, including:

- ✓ Preliminary Design—completed (Technical Design Report);
- ✓ Project Execution Plan—submitted for AE approval;
- ✓ Resource Loaded Schedule—completed;
- ✓ Performance Baseline—completed;
- ✓ Earned Value Mgmt System—completed;
- ✓ Environmental Documentation—completed;
- ✓ QA Program—in place;
- ✓ Hazard Analysis—completed (Hazard Analysis Document);
- ✓ Baseline Validation Review—completed (August 10-11, 2011 Review—project and documentation reviewed and judged to be ready for CD-2/3a.).

J. CD-3a Long Lead Procurements

The Project is requesting CD-3a approval for three long lead time cryogenics system procurements. Receiving CD-3a approval for these items will reduce the Project's schedule risk. The estimated costs for these procurements are presented in the table below.

Long Lead Procurements

	Estimated cost (in then year $k)
LAr Pumps	133
Cool Down Heat Exchanger	98
Cool Down Compressor	111
Total	**342**

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Submitted by:

Paul R. Philp — 9-15-11
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Fermi Site Office
Date

9/15/2011
Michael J. Weis
Manager
Fermi Site Office
Date

9/23/2011
Theodore L. Lavine
MicroBooNE Program Manager
Office of High Energy Physics
Date

Critical Decision 2/3a, Approve Performance Baseline and Approve Limited Construction of the MicoBooNE Project

Recommendations:
The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-2/3a, Approve Performance Baseline and Limited Construction, for the MicroBooNE Project at Fermilab as noted below.

9-23-11 Yes ✓ No ___
ESAAB Secretariat, Office of Project Assessment Date

David Goodwin 9/23/11 Yes ✓ No ___
Representative, Non-Proponent SC Program Office Date

9/23/11 Yes ✓ No ___
Representative, Office of Budget Date

9/26/2011 Yes ✓ No ___
Representative, Environmental, Safety and Health Division Date

David Goodwin 9/23/11 Yes ✓ No ___
Representative, Safeguards and Security Division Date

9/23/11 Yes ✓ No ___
Representative, Facilities and Infrastructure Division Date

Yes ___ No ___
Representative, Grants and Contracts Division Date

Approval of CD-2/3a

Based on the information presented above and at this review, Critical Decision-2 (CD-2), Approve Performance Baseline, and Critical Decision-3a (CD-3a), Approve Limited Construction, for the Micro Booster Neutrino (MicroBooNE) Project are approved.

9/27/2011
Michael P. Procario, Acquisition Executive Date
Acting Associate Director for High Energy Physics
Office of Science