MiniBooNE Detector

Section III - Chapter 4

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Eric McHugh	Initial release of the MiniBooNE Detector chapter of the Fermilab Safety Assessment Document.	Revision 0 January 9, 2012

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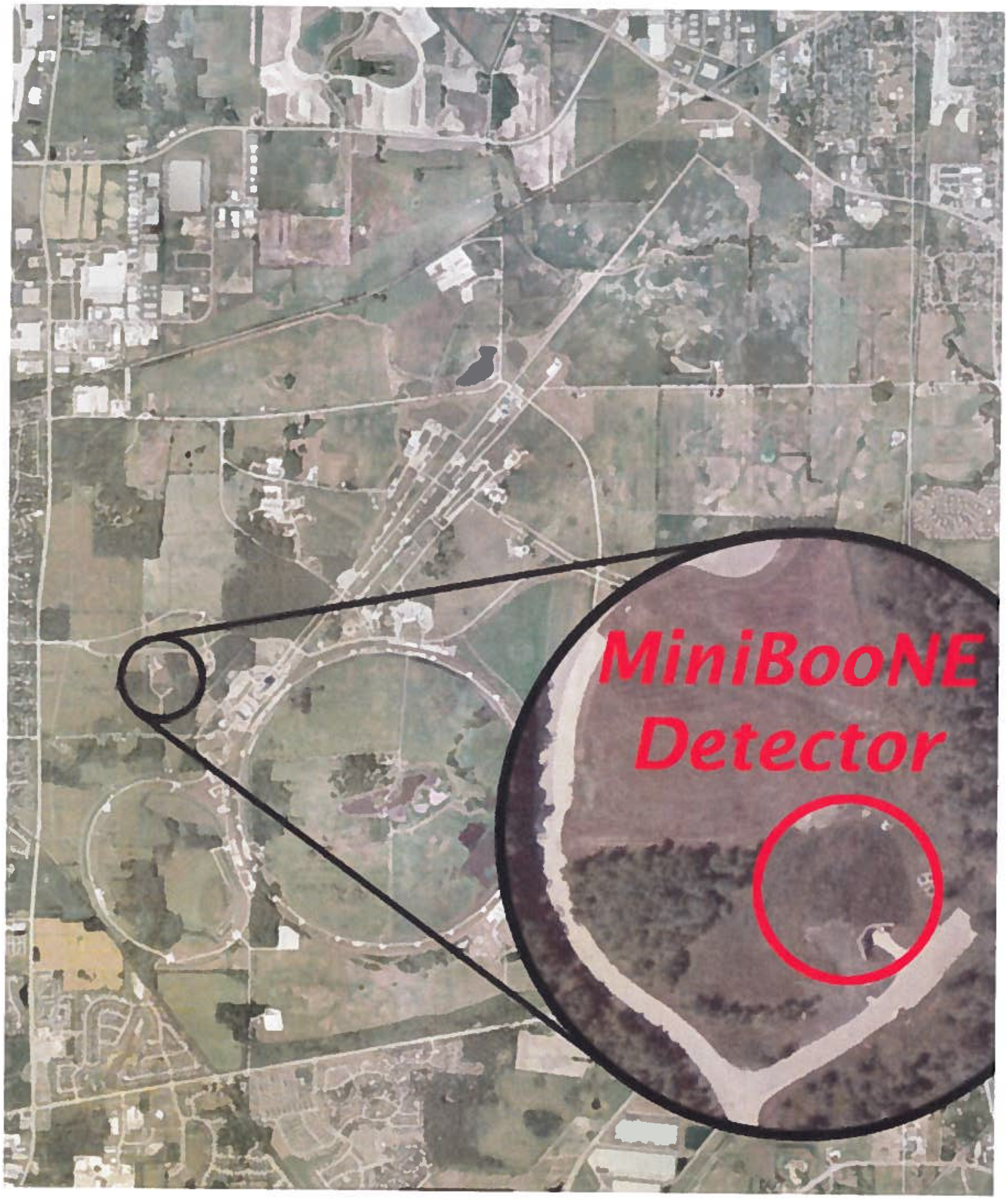
III - 4.1 MiniBooNE Detector Location on Fermilab Site



III - 4.2 Inventory of Hazards

The following table lists the identified hazards found in the MiniBooNE detector site. All hazards with an * have been discussed in Section I of the Fermilab Safety Assessment Document and are covered no further in this section.

Radiation Lasers	**Kinetic Energy** Power tools* Pumps and motors*
Toxic Materials	**Potential Energy** Crane operations*
Flammable & Combustible Materials Cables* Mineral oil	**Magnetic Fields**
Electrical Energy High voltage*	**Gaseous Hazards** Nitrogen
Thermal Energy Cryogens*	**Access / Egress** Life safety egress Confined space

III - 4.3 Introduction

This section of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) covers the MiniBooNE detector site.

III - 4.3.1 Purpose of the MiniBooNE detector

MiniBooNE is the first phase of the Booster Neutrino Experiment (BooNE); in this phase, neutrino oscillation measurements will be made with a single detector. If oscillations are observed, then MiniBooNE will be upgraded to the stage two BooNE that would have a two-detector configuration.

The BooNE experiment proposes to definitively explore the neutrino oscillation signal reported by the Los Alamos Liquid Scintillator Neutrino Detector (LSND) experiment. MiniBooNE represents the first phase for the BooNE collaboration and consists of a 1 GeV neutrino beam and a single, 800-ton mineral oil detector (the MiniBooNE detector). The MiniBooNE detector is located 500 meters downstream of the neutrino source, and is optimized to search for the LSND signal. This detector is designed to investigate the results of LSND.

III - 4.3.2 Description of MiniBooNE detector

The MiniBooNE detector is approximately 500 m north of the MiniBooNE Target Hall (designated MI-12) where the neutrino beam studied in the detector is generated. The nature of the beam requires minimal physical connection between the two sites. A conduit for trigger signal cabling is the only connection between the two sites.

The MiniBooNE detector site (figure 1) consists of:

- The MiniBooNE detector vault, a cylindrical, concrete-lined excavation, 50 ft in diameter and 45 ft deep. This vault houses the detector tank and is equipped with access hatches for personnel and equipment.
- The detector tank, a 40-ft-diameter spherical tank located in the detector vault, instrumented with a little over 1500 photomultiplier tubes, and filled with 250,000 gallons of Marcol 7 (Fermilab MSDS 16080) mineral oil. A cover gas of nitrogen, which is fed from 160 L liquid nitrogen dewars, is introduced in the empty space at the top of the tank to provide protection from oxidation. Oxidation degrades the desirable properties of the mineral oil that are important to the experiment[1].
- The detector support enclosure, a 50-ft-diameter circular room located (at surface level) above the detector vault which houses electronics and oil handling equipment. The support enclosure includes power, fire protection, and air handling equipment, as well as a 2-ton trolley hoist. The scope of the MiniBooNE detector is to search for muon-neutrino to electron-neutrino oscillations in the mixing parameter space region where the LSND experiment reported a signal. The MiniBooNE experiment uses a beam energy and baseline that is an order of magnitude larger than those of LSND so that the backgrounds and systematic errors are completely different.

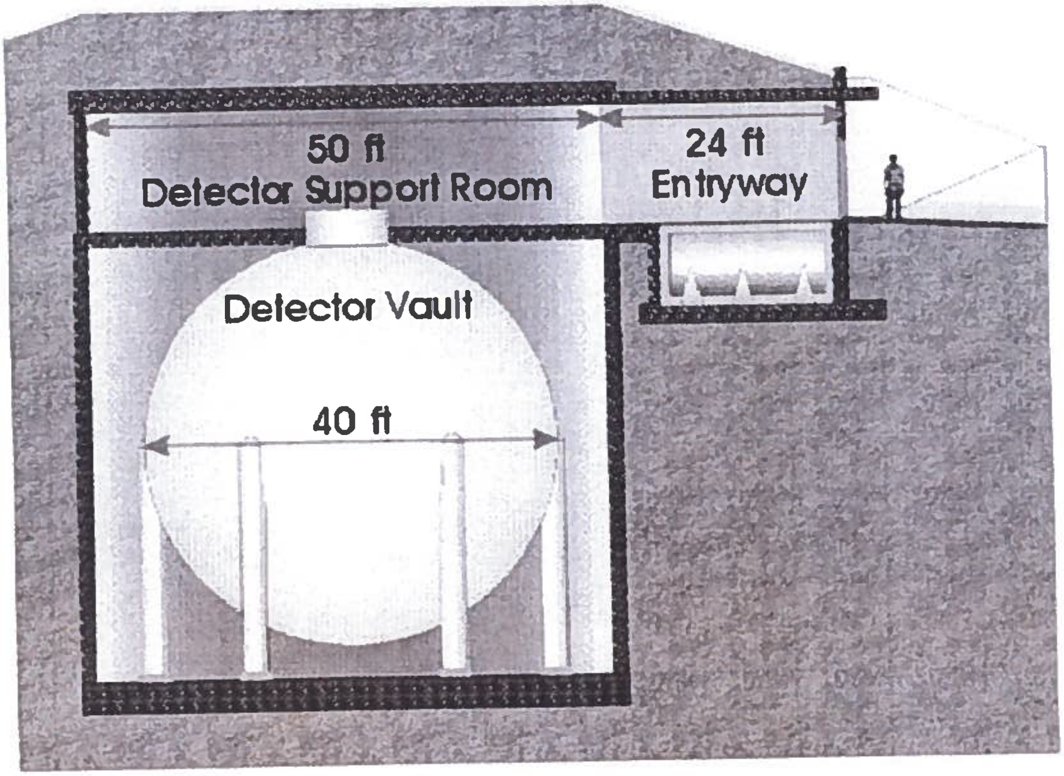


Figure 1: Layout of MiniBooNE detector vault and support room.

III - 4.3.3 Operating Modes

MiniBooNE operates as a neutrino detector in four basic modes, neutrino, anti-neutrino, beam on/horn off and beam off/horn off. None of the modes change the hazards associated with operation of the experiment.

III - 4.4 Safety Assessment

The unique accelerator-specific hazards of the MiniBooNE detector are analyzed in this section.

III - 4.4.1 Radiological Hazards

The MiniBooNE detector presents no hazards associated with prompt radiation, residual radiation, air activation, or groundwater contamination. An analysis[2] for the MiniBooNE Detector reveals that the expected absorbed dose is roughly 10 nanorads/year. Therefore, the neutrinos that travel to the detector (and beyond) do not present a radiological hazard.

III - 4.4.1.1 Lasers

A Class III B laser will be used in the MiniBooNE detector for calibration. The MiniBooNE laser calibration system consists of a pulsed diode laser (Pico-Quant GmBH PDL-800-B driver and LDH 375 laser head) and four dispersion flasks installed at various locations in the detector. Short pulses (<1 ns) of laser light with wavelengths peaked at 397 nm, are transmitted via optical fibers to each of the dispersion flasks. The primary purpose is to quantify and monitor individual photo multiplier tube performance parameters. The laser also allows for in-situ monitoring of the oil attenuation length over the lifetime of the experiment. All laser installations (class 3B or greater) will be reviewed and approved by the Fermilab Laser Safety Officer (LSO) prior to commencing operations in accordance with FESHM.

III - 4.4.2 Flammable and Combustible Materials

The MiniBooNE detector contains approximately 250,000 gallons of mineral oil. Mineral oil has a flash point of 420 degrees F. The interior of the tank is maintained in a nitrogen environment to protect the oil from oxidation, and to reduce the potential for fire. The exterior of the tank has a deluge spray system to maintain it at ambient temperature in the event of a fire. This system has been designed to provide a water spray to the top half and mid area of the tank at a rate of 0.25 GPM per square foot. This is in accordance with the Gage-Babcock & Associates analysis[3] and the National Fire Protection Association Pamphlet No. 15 entitled Water Spray Fixed Systems. MiniBooNE is also protected by a Very Early Smoke Detection and Alarm (VESDA) system that is connected to Fermilab's Fire and Utilities (FIRUS) emergency notification system.

The installation of electronics, power supplies, and all other electrical components of the experiments performed in this facility are in accordance with the guidelines of the Fermilab Environment Safety and Health Manual[4] (FESHM). This is to ensure that they do not constitute a fire hazard. All equipment has been reviewed under the Particle Physics Division's (PPD) ES&H review process as described in their procedure, "Operational Readiness Clearance: ES&H Review of Experiments[5]."

The MiniBooNE detector oil plumbing system was designed to enable filling, recirculation, filtering, temperature control, and removal of the mineral oil. All oil distribution pipes are stainless steel. Oil enters the detector tank during fill or recirculation via a 7.62 cm (3 inch) pipe that attaches to the inflow penetration at the bottom of the detector tank. During decommissioning of the detector, this line will be used, together with a pump located in the bottom of the detector vault, to remove the oil.

A 9,500-liter stainless steel oil overflow tank is located beneath the detector entrance hall and provides an overflow capacity of 1% of the detector tank volume. The thermal expansion coefficient of the mineral oil was measured to be 6.1×10^{-4} C^{-1}; therefore, the tank allows an oil temperature change of 16° C, well within any expected temperature variation. Data shows that during the year the temperature of the oil varies approximately 2° C. The level will be monitored for any deviation from nominal values. Any deviation outside nominal values would be remedied by increasing the flow of the circulation pumps through the heat exchanger and installing a 10kW chiller to reduce the thermal expansion if necessary[1].

III - 4.4.3 Access/Egress

III - 4.4.3.1 MiniBooNE Vault Access/Egress

The vault is classified as a permit-required confined space. FESHM defines a confined space as:

1. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
2. has limited or restricted means for entry or exit; and
3. is not designed for continuous employee occupancy.

The designation is determined by the presence of the oil, the space not meant for continuous occupancy, and the limited means of egress through hatches into the vault. The PPD/ES&H/Building Management Services (BMS) group maintains the space and provides equipment necessary for the permit-required entry. Entry into the vault must be approved by the PPD/ES&H/BMS group. The requirements contained in FESHM will be adhered to for all entries into the vault.

III - 4.5 Credited Controls

III - 4.5.1 Passive Controls

Passive controls are employed to ensure safe operations during all conditions at the MiniBooNE detector.

III - 4.5.1.1 Secondary Containment for Mineral Oil

The detector is housed in a concrete vault which also serves as the secondary containment for the full capacity of the detector. The drainage paths into the main sumps are physically isolated from the vault region so that no oil can get into the sump even in the event of a catastrophic leak or rupture of the detector itself. A secondary monitoring sump provides the ability to check for major oil leaks without entering the vault area. Both sump systems have been designed and built to be serviceable from outside of the concrete vault. In the event of a catastrophic leak during an access to the vault, procedures for the confined space entry would be followed and all entrants extracted immediately.

III - 4.5.2 Active Controls

As described in Chapters I-4 of the Fermilab SAD, active systems are designed to reduce the risk of accelerator operations hazards to an acceptable level. MiniBooNE does not require active controls due to the nature of the detector. The MiniBooNE detector site is geographically separated (approximately 500 m) from the accelerator components with the exception of a small signal cable chase that traverses through the earth.

III - 4.5.3 Administrative Controls

The administrative procedures and programs considered necessary to ensure safe operations at the MiniBooNE detector site are discussed below.

III - 4.5.3.1 Access to MiniBooNE vault during operations

The vault is classified as a permit required confined space. The PPD/ES&H/BMS group maintains the space and provides equipment necessary for the permit required confined space entry. Entry into the vault must be approved by the PPD/ES&H/BMS group.

III - 4.5.3.2 Description of detector operations

Commissioning, normal operations, and emergency management of the MiniBooNE detector site are all conducted under the auspices of the PPD Headquarters, the PPD/ESH/BMS Department, and the PPD Neutrino Department.

III - 4.6 Summary & Conclusion

Specific hazards associated with commissioning and operation of the MiniBooNE detector are identified and assessed in this chapter of the Fermilab Safety Assessment Document. The designs, controls, and procedures to mitigate MiniBooNE specific hazards are identified and described. In addition to these specific safety considerations, the MiniBooNE experiment is subject to the requirements, controls and procedures outlined in Section I of this Fermilab Safety Assessment Document.

Within the specific and generic considerations of this assessment, the MiniBooNE experiment can be constructed, commissioned, and operated with a level of safety that will protect people and property and is equal to or exceeding that currently prescribed by DOE orders and Fermilab regulations as put forth in the FESHM and the Fermilab Radiological Control Manual[6] (FRCM).

III - 4.7 Glossary, Acronyms

AD	Accelerator Division
BMS	Building Management Services
BooNE	Booster Neutrino Experiment
DOE	United States Department of Energy
ES&H	Environment, Safety and Health
FESHM	Fermilab Environment, Safety, and Health Manual
FIRUS	Fire and Utilities
FRCM	Fermilab Radiological Control Manual
GeV	Giga-electron volt
LSND	Liquid Scintillator Neutrino Detector
LSO	Laser Safety Officer
PPD	Particle Physics Division
SAD	Safety Assessment Document
VESDA	Very Early Smoke Detection and Alarm

III - 4.8 References

[1] The MiniBooNE Detector, A. A. Aguilar-Arevalo et.al., June 25, 2008. http://arxiv.org/pdf/0806.4201v1

[2] An Analysis of Dose from Neutrinos Arriving in the MiniBooNE Detector, P.S. Martin, MiniBooNE Technical Note 17, July 23, 1999.

[3] Gage-Babcock & Associates, Fire Protection/Life Safety Analysis for the Fermilab MiniBooNE Project, June 30, 1999.

[4] Fermilab Environment, Safety, and Health Manual. – The current web link is: http://esh.fnal.gov/xms/FESHM

[5] PPD ESH Procedure 006, Operational Readiness Clearance: ES&H Review of Experiments, Projects, and R&D Efforts. – The current web link is: http://www-ppd.fnal.gov/ESHBMGOffice-w/ESH%20Management/ESH_Manual/PPD_ESH_006.pdf

[6] Fermilab Radiological Control Manual. - The current web link is: http://esh.fnal.gov/xms/FRCM