Micro Booster Neutrino Experiment (MicroBooNE)

Section III – Chapter 7

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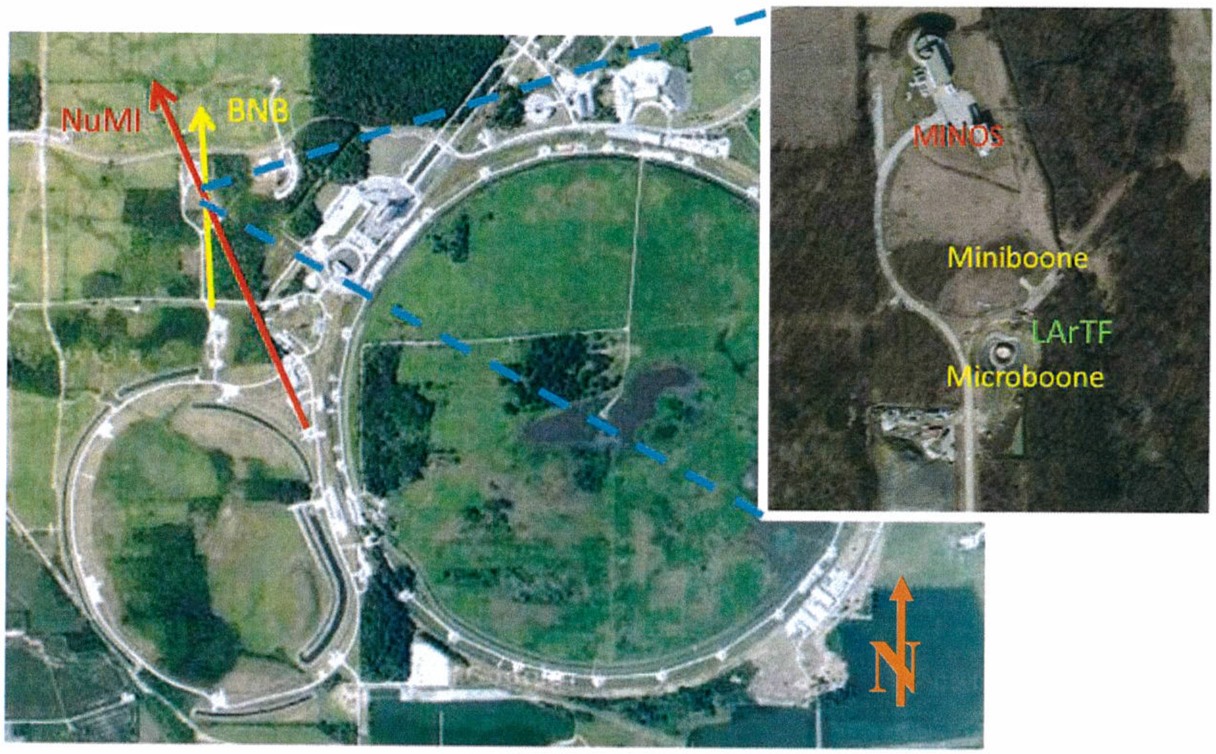
III - 7 Micro Booster Neutrino Experiment (MicroBooNE) Detector

III - 7.1 MicroBooNE Location on Fermi National Accelerator (Fermilab) Site

The MicroBooNE Detector, see the following photographs, is located just upstream of the Mini Booster Neutrino Experiment (MiniBooNE) detector hall in a new Fermilab enclosure, the Liquid Argon Test Facility (LArTF).



III - 7.2 Inventory of Hazards

The following table lists the identified hazards found in the MicroBooNE site. All hazards with an * have been discussed in Chapters 1-10 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) and are covered no further in this section.

Radiation Lasers Sealed source usage Other radiological hazards	**Kinetic Energy** Power tools* Pumps and motors*
Toxic Materials N/A	**Potential Energy** Crane operations* High pressure*
Flammable & Combustible Materials Cables*	**Magnetic Fields** N/A
Electrical Energy High voltage*	**Gaseous Hazards** Confined spaces * Cryogenics Oxygen Deficiency Hydrogen gas mixture
Thermal Energy Cryogenic Liquids *	**Access / Egress** Life safety egress

III - 7.3 Introduction

This Section III, Chapter 7 of the Fermilab SAD covers the MicroBooNE detector site. The MicroBooNE detector is not an accelerator and sits physically separate from accelerator facilities; nevertheless, MicroBooNE has specific hazards that warrant consideration in this Section.

III - 7.3.1 Purpose of the MicroBooNE Detector

The purpose of the MicroBooNE detector is to continue an investigation of effects observed by the MiniBooNE Experiment, while also developing the technology for a Liquid Argon Time Projection Chamber (LArTPC), a type of wire chamber which detects the ionization track left by passing particles. The LArTPC detector technology is the most promising for beam-based neutrino research, offering extraordinarily precise event reconstruction and particle identifications, as well as potential scalability to larger (>10 kiloton) detectors proposed for the future Long Baseline Neutrino Experiment (LBNE). Although the design of the MicroBooNE detector is not identical to the LBNE detectors, MicroBooNE will push the current limits on various hardware fronts (argon purity, high voltage, drift length, cold electronics) and make improvements in software (fully automated reconstruction of complex neutrino interactions).

III - 7.3.2 Description of the MicroBooNE Detector

The MicroBooNE Experiment will operate a liquid argon neutrino detector located along the Booster Neutrino Beam Line (BNB), just upstream of the MiniBooNE detector enclosure. The detector is housed within the LArTF. LArTF is a below grade vertical concrete cylinder structure, identical in size to the MiniBooNE cylinder, which is approximately 50 feet in diameter and 45 feet deep.

The Time Projection Chamber (TPC) is a 6-sided rectangular box, where one wall consists of a frame holding detection wire planes, and the other 5 walls comprise the high voltage cathode and electric field cage. The entire TPC is contained within a stainless steel cryostat approximately 13 feet in diameter and 40 feet long. A cryogenics plant located at LArTF provides the high-purity liquid argon which serves as both the neutrino target and the medium in which the particles produced by neutrino interactions leave their ionization trail. An array of photo multiplier tubes (PMT) are also installed inside the cryostat to provide precise timing information and measurements of the scintillation light produced during events. Cabling which provides power and carries out detection wire and PMT signals is routed from inside to outside through the wall of the cryostat. Detector signals are processed through analog and digital electronics and gathered by a data acquisition system, all of which are located at LArTF.

III - 7.3.3 Operating Mode

MicroBooNE operates as a neutrino detector placed in the path of the BNB. The Particle Physics Division (PPD) is responsible for the operation of the MicroBooNE Detector. The Remote Operations Center will be staffed around the clock during operations to monitor the detector and associated equipment.

III - 7.4 Safety Assessment

This section identifies the specific hazards of the MicroBooNE detector and discusses how the hazards are managed. These hazards include lasers, sealed radioactive sources, cryogenic liquids, oxygen deficiency, hydrogen gas, and enclosure access-egress.

III - 7.4.1 Radiological Hazards

III - 7.4.1.1 Lasers

A Class 4 laser is used in the MicroBooNE detector for calibration. Class 4 lasers can cause eye or skin injuries if a worker is exposed to the beam. To prevent injuries, the laser is enclosed with an interlock, and safety signage is posted on the enclosure. Any individual who operates/services the laser will have undergone laser safety training and a laser eye exam.

The laser installation has been reviewed and approved by the Fermilab Laser Safety Officer, thereby meeting all rules found in Fermilab Environment, Safety and Health Manual (FESHM) Chapter *Lasers*.

III - 7.4.1.2 Sealed Radioactive Sources

Calibrating the response of the detector with sealed radioactive sources may be necessary during the course of commissioning and operating the MicroBooNE Detector. These sources present potential radiation exposures to the worker if handled improperly, so all radioactive source usage will adhere to the provisions in the sealed radioactive source controls section contained within FRCM Chapter 4.

III - 7.4.1.3 Other Radiological Hazards

The MicroBooNE detector does not pose any other radiological hazards.

III - 7.4.2 Gaseous Hazards

III - 7.4.2.1 Cryogenics

The cryogenic system at LArTF uses liquid argon and liquid nitrogen. Liquid nitrogen in the system maintains the argon in a liquefied state. The system circulates and purifies the liquid argon, and condenses and purifies the argon boiling off the liquid surface inside the detector cryostat. The system consists of the detector cryostat, liquid nitrogen and liquid argon storage and distribution tanks, pumps, filter system, piping, and associated appurtenances. A 500-gallon liquid argon dewar, an 11,000-gallon liquid nitrogen dewar and an 11,000-gallon liquid argon buffer tank are located outside of LArTF. The detector cryostat, which contains approximately 32,000 gallons of liquid argon, is located in the pit of LArTF.

Cryogenic hazards at MicroBooNE include the potential for oxygen-deficient atmospheres due to catastrophic failure of the cryostat vessel or cryogenic systems, thermal (cold burn) hazards from cryogenic components and pressure hazards. An oxygen-deficient atmosphere could result from cryogenic systems failure/rupture of the vessel or piping, insulation failure, mechanical damage/failure, deficient maintenance, or improper procedures. The cryogenic system was designed and installed to comply with applicable American Society of Manufacturing Engineers (ASME) and American National Standards Institute (ANSI) standards, per FESHM Chapters *Pressure Vessels*, *Piping Systems*, *Inert Gas Trailer Connections and Onsite Filling Guidelines*, *Gas Regulators*, *Inspection and Testing of Relief Systems*, *Cryogenic System Review*, *Liquid Nitrogen Dewar Installation and Operation Rules*, and *Liquid Cryogenic Targets*. Special provisions have been included, such as the metal-grated floor raised 15 inches above the concrete floor of the pit to protect workers from exposure to physical contact with the cryogenic liquid in the event of a release. A one-inch layer of insulation was added to the concrete floor beneath the grating to delay the boil off any spilled liquid. The insulation creates a thermal barrier between the spilled cryogen and the concrete, delaying boil-off. This delay in boil-off in turn decreases the rate of gas conversion, and thus an ODH condition, which gives more escape time.

The LArTF cryogenic distribution system presents the potential for thermal burns, so the distribution system has been marked and insulation was installed to protect workers and visitors from inadvertent contact. All staff, visitors, and users of MicroBooNE and the LArTF must undergo building hazard awareness training that covers the potential hazards of cryogenic material.

III - 7.4.2.2 Oxygen Deficiency Hazard (ODH)

The cryostat vessel at LArTF contains 32,000 gallons of liquid argon, which necessitates that the LArTF be designated as an ODH area. The use of cryogenic liquids potentially can produce an oxygen-deficient atmosphere, which can result in death or injury from asphyxiation or from contact with the extremely cold fluids/gases. The failure of cryogenic systems can release gas and initiate an ODH event. FESHM Chapter Cryogenic *System Review* provides guidelines for designing and operating cryogenic vessels and systems to mitigate ODH hazards. See MicroBooNE DocDB #2322 and 2346 for the full ODH analyses.

The surface level and stairwells have been classified as ODH-0 areas, allowing for general access. The pit and platform levels of the detector enclosure are classified as ODH-1 areas with requirements for personnel accessing those areas to complete ODH training, a medical evaluation and use an oxygen monitor.

Hazard controls include ODH warning signals, oxygen sensors (interlocked with the Fermilab's Fire Incident Reporting and Utility System (FIRUS) alarm), ventilation fans and floor insulation (to slow the boil-off of any spilled cryogen). The MicroBooNE cryogenics controls system utilizes a parallel method of monitoring and reporting these alarms to the experiment personnel in the control room. The exit stairwells are over-pressurized to maintain an ODH Class-0 area for emergency egress.

Entry into the stairwells from the surface-level is controlled via a key-tree interlock system. Only personnel who have complete (and current) ODH training will be given access codes to the key-tree. The interlock system checks that the stairwells are at the appropriate positive pressure before allowing entry and maintains the positive pressure until the key has been returned to the key-tree. The interlock doors only require a key to go down the stairs. Keys are not required and the stairwell remains accessible for exiting.

A 150-kilowatt natural-gas-powered emergency generator has been installed to supply service to cryogenics monitoring and heating, ventilation, and air conditioning systems for ODH escape during power outages.

III - 7.4.2.3 Hydrogen Gas Mixture

A non-flammable argon/hydrogen gas mixture (2.5% hydrogen, balance argon) is used for filter regeneration. This gas mixture is supplied in a tube trailer located outside of the building. This tube trailer conforms to ASME and DOT standards per FESHM chapters *Pressure Piping Systems*, FESHM *Inert Gas Trailer Connections and Onsite Filling Guidelines*, and FESHM *Retesting Procedures for DOT Gas Storage Cylinders Including Tube Trailers*. Personnel utilizing the gas trailer will have completed Compressed Gas Cylinder Safety training.

The mixture does not pose unique hazards.

III - 7.4.3 Access/Egress

There are five entrances to the LArTF – a delivery area for truck access, an electronics room, a door to each of two stair columns, and an entry into the fire protection control room.

Entry into the building requires completion of building hazard awareness training. Only those persons having successfully completed the training will be able to access the building via the keycard entry system.

Entry into the stairwells from the surface-level is controlled by a key-tree interlock system, which ensures the stairwells are at the appropriate positive-pressure before allowing entry.

Employees or users who have successfully completed ODH training and the building hazard awareness training may receive key-tree access codes.

III - 7.5 Credited Controls

III - 7.5.1 Passive Controls

The MicroBooNE Detector does not have any accelerator components and thus does not require passive controls.

III - 7.5.2 Active Controls

The MicroBooNE Detector does not have any accelerator components and thus does not require active controls.

III - 7.5.3 Administrative Controls

Administrative procedures have been put in place to ensure safe operations at the MicroBooNE Detector site. Operational readiness of the experiment is governed by Particle Physics Division (PPD) ESH 006 - *ES&H Review of Experiments*. Subject matter experts review each aspect of the experiment prior to operations to ensure safe operations. The review includes procedure, hazard analysis and document reviews and walk-throughs of the experiment components. Division head(s) of the area(s) in which experimental components reside grant approval for operations.

III - 7.5.3.1 Detector Operations

Commissioning, normal operations, and emergency management of the MicroBooNE Detector site are all conducted under the auspices of the PPD Division Office, the PPD Environment Safety & Heath Group, and the PPD Intensity Frontier Department.

III - 7.6 Decommissioning

The LArTF will be utilized for future liquid argon experiments. Decommissioning of the MicroBooNE Experiment will follow the requirements of FESHM Chapter Facility *Decontamination and Decommissioning*. PPD ESH 014 - *ES&H Review of Expired Experiment Decommissioning and Dismantlement* is available to help employees identify and mitigate ES&H hazards during decommissioning.

III - 7.7 Summary & Conclusion

This chapter of the Fermilab SAD identifies and assesses specific hazards associated with commissioning and operation of the MicroBooNE Detector. The chapter identifies and describes designs, controls, and procedures to mitigate MicroBooNE Detector specific hazards. In addition to the specific safety considerations presented in this chapter, the MicroBooNE Experiment is subject to the global and more general safety requirements, controls, and procedures outlined in Section 1 of this Fermilab SAD.

The MicroBooNE Experiment has been constructed, commissioned, and will be operated within the specific and general considerations of this safety assessment. The preceding discussion of the hazards presented by the MicroBooNE Experiment operations and the credited controls established to mitigate those hazards demonstrate that the experiment can be operated in a manner that will produce minimal hazards to the health and safety of Fermilab workers, researchers, members of the public, as well as to the environment.

III - 7.8 Glossary, Acronyms

AD	Accelerator Division
ANSI	American National Standards Institute
ASME	American Society of Manufacturing Engineers
BNB	Booster Neutrino Beam
DocDB	Document Database
DOT	Department of Transportation
ES&H	Environment, Safety and Health
FESHM	Fermilab Environment, Safety, and Health Manual
FRCM	Fermilab Radiological Control Manual
FIRUS	Fire Incident Reporting and Utility System
Fermilab	Fermi National Accelerator Laboratory
FRCM	Fermilab Radiological Control Manual
LArTF	Liquid Argon Test Facility
LArTPC	Liquid Argon Time Projection Chamber
LBNE	Long Baseline Neutrino Experiment
MicroBooNE	Micro Booster Neutrino Experiment
MiniBooNE	Mini Booster Neutrino Experiment
MINOS	Main Injector Neutrino Oscillation Search
NuMI	Neutrinos at the Main Injector
ODH	Oxygen Deficiency Hazard
PMT	Photo Multiplier Tube
PPD	Particle Physics Division
SAD	Safety Assessment Document
TPC	Time Projection Chamber

III - 7.9 References

1. Fermilab Environment, Safety and Health Manual (FESHM) - The current link is: http://esh.fnal.gov/xms/ESHQ-Manuals/FESHM
2. Fermilab Radiological Control Manual (FRCM) – The current link is: http://esh.fnal.gov/xms/ESHQ-Manuals/FRCM
3. MicroBooNE Ground Floor ODH Analysis – The current link is: http://microboone-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=2346
4. MicroBooNE Hazard Analysis – The current link is: http://microboone-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=1612
5. MicroBooNE ODH Analysis – The current link is: http://microboone-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=2322
6. MicroBooNE Technical Design Report – The current link is: http://microboone-docdb.fnal.gov/cgi-bin/ShowDocument?docid=1821