



MicroBooNE Decommissioning

Matt Toups

ND All-hands Meeting

Tues Feb 21 2023

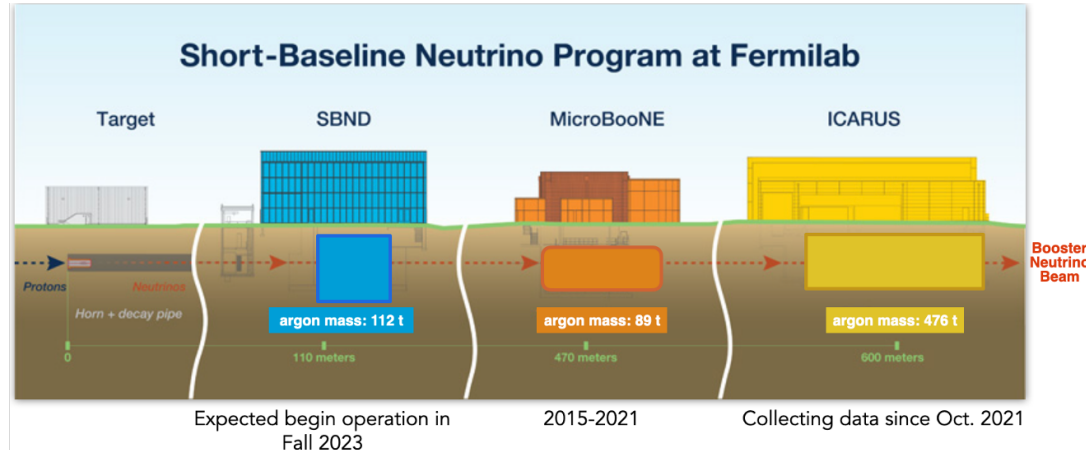
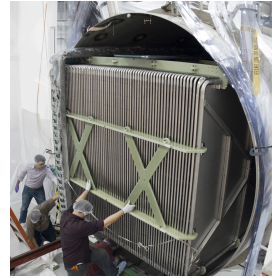
MicroBooNE

Operated from 2015-2021

- Detector electronics turned off Oct. 2021
- Recirculation pumps switched off Dec. 2022
- Cryogenics operational (cryostat still full of LAr)

Longest running LArTPC in the world!

First of three detectors deployed in the Short Baseline Neutrino (SBN) program



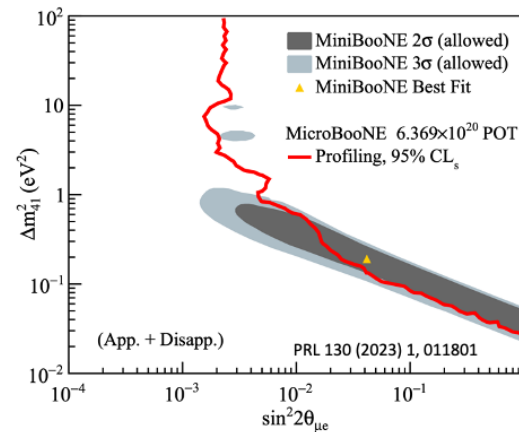
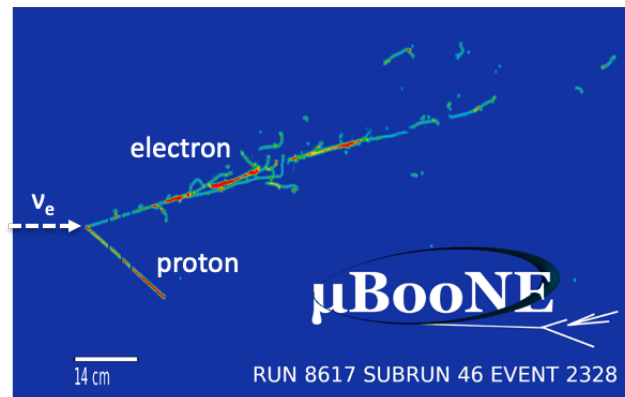
MicroBooNE Science Highlights

Released first MicroBooNE analyses searching for an excess of low-energy electromagnetic events in 2021

- No hints of an electromagnetic event excess, but results do not rule out existence of sterile neutrinos

With groundbreaking sterile neutrino results in 2022, demonstrated the versatility and power of liquid argon
→ SBN, DUNE

Pioneers of an expanded and ongoing physics scope for short-baseline accelerator-based LArTPC experiments, beyond just sterile neutrino oscillations



MicroBooNE Science Output

2017 ↓ 2018 ↓ 2019 ↓ 2020 ↓ 2021 ↓ 2022 ↓ 2023

World's most scientifically prolific LArTPC experiment

55 papers to date

– Many more publications in the pipeline—paper factory!

Multi-Differential Cross Section Measurements of Muon-Neutrino-Argon Quasielastic-like Reactions with the MicroBooNE Detector
First double-differential measurement of kinematic imbalance in neutrino interactions with the MicroBooNE detector
First measurement of quasi-elastic Λ baryon production in muon anti-neutrino interactions in the MicroBooNE detector
First Measurement of Differential Cross Sections for Muon Neutrino Charged Current Interactions on Argon with a Two-proton Final State in the MicroBooNE Detector
First constraints on light sterile neutrino oscillations from combined appearances and disappearance searches with the MicroBooNE detector
Differential cross section measurements of charged current ν_e interactions without final-state pions in MicroBooNE
Search for long-lived heavy neutral leptons and Higgs portal scalars decaying in the MicroBooNE detector
Measurement of neutral current single π^0 production on argon with the MicroBooNE detector
Observation of radon mitigation in MicroBooNE by a liquid argon filtration system
Cosmic ray muon clustering for the MicroBooNE liquid argon time projection chamber using sMask-RCNN
Novel approach for evaluating detector-related uncertainties in a LArTPC using MicroBooNE data
First measurement of energy-dependent inclusive muon neutrino charged-current cross sections on argon with the MicroBooNE detector
Search for an anomalous excess of inclusive charged-current ν_e interactions without pions in the final state with the MicroBooNE experiment
Search for an anomalous excess of charged-current quasi-elastic ν_e interactions with the MicroBooNE experiment using deep-learning-based reconstruction
New theory-driven GENIE tune for MicroBooNE
Search for an anomalous excess of inclusive charged-current ν_e interactions in the MicroBooNE experiment using Wire-Cell reconstruction
Search for an excess of electron neutrino interactions in MicroBooNE using multiple final state topologies
Wire-Cell 3D pattern recognition techniques for neutrino event reconstruction in large LArTPCs
Electromagnetic shower reconstruction and energy validation with Michel electrons and π^0 samples for the deep-learning-based analyses in MicroBooNE
Search for neutrino-induced NC Δ radiative decay in MicroBooNE and a first test of the MiniBooNE low-energy excess under a single-photon hypothesis
First measurement of inclusive electron-neutrino and antineutrino charged current differential cross sections in charged lepton energy on argon in MicroBooNE
Calorimetric classification of track-like signatures in liquid argon TPCs using MicroBooNE data
Search for a Higgs Portal Scalar Decaying to Electron-Positron Pairs in the MicroBooNE Detector
Measurement of the Longitudinal Diffusion of Ionization Electrons in the Detector
Cosmic Ray Background Rejection with Wire-Cell LAr TPC Event Reconstruction in the MicroBooNE Detector
Measurement of the Flux-Averaged Inclusive Charged Current Electron Neutrino and Antineutrino Cross Section on Argon using the NuMI Beam in MicroBooNE
Measurement of the Atmospheric Muon Rate with the MicroBooNE Liquid Argon TPC
Semantic Segmentation with a Sparse Convolutional Neural Network for Event Reconstruction in MicroBooNE
High-performance Generic Neutrino Detection in a LAr TPC near the Earth's Surface with the MicroBooNE Detector
Neutrino Event Selection in the MicroBooNE LAr TPC using Wire-Cell 3D Imaging, Clustering, and Charge-Light Matching
A Convolutional Neural Network for Multiple Particle Identification in the MicroBooNE Liquid Argon Time Projection Chamber
Vertex-Finding and Reconstruction of Contained Two-track Neutrino Events in the MicroBooNE Detector
The Continuous Readout Stream of the MicroBooNE Liquid Argon Time Projection Chamber for Detection of Supernova Burst Neutrinos
Measurement of Differential Cross Sections for Muon Neutrino CC Interactions on Argon with Protons and No Pions in the Final State
Measurement of Space Charge Effects in the MicroBooNE LAr TPC Using Cosmic Muons
First Measurement of Differential Charged Current Quasi-Elastic-Like Muon Neutrino Argon Scattering Cross Sections with the MicroBooNE Detector
Search for heavy neutral leptons decaying into muon-pion pairs in the MicroBooNE detector
Reconstruction and Measurement of O(100) MeV Electromagnetic Activity from Neutral Pion to Gamma Gamma Decays in the MicroBooNE LArTPC
A Method to Determine the Electric Field of Liquid Argon Time Projection Chambers Using a UV Laser System and its Application in MicroBooNE
Calibration of the Charge and Energy Response of the MicroBooNE Liquid Argon Time Projection Chamber Using Muons and Protons
First Measurement of Inclusive Muon Neutrino Charged Current Differential Cross Sections on Argon at Enu \sim 0.8 GeV with the MicroBooNE Detector
Design and Construction of the MicroBooNE Cosmic Ray Tagger System
Rejecting Cosmic Background for Exclusive Neutrino Interaction Studies with Liquid Argon TPCs: A Case Study with the MicroBooNE Detector
First Measurement of Muon Neutrino Charged Current Neutral Pion Production on Argon with the MicroBooNE detector
A Deep Neural Network for Pixel-Level Electromagnetic Particle Identification in the MicroBooNE Liquid Argon Time Projection Chamber
Comparison of Muon-Neutrino-Argon Multiplicity Distributions Observed by MicroBooNE to GENIE Model Predictions
Ionization Electron Signal Processing in Single Phase LArTPCs II: Data/Simulation Comparison and Performance in MicroBooNE
Ionization Electron Signal Processing in Single Phase LArTPCs I: Algorithm Description and Quantitative Evaluation with MicroBooNE Simulation
The Pandora Multi-Algorithm Approach to Automated Pattern Recognition of Cosmic Ray Muon and Neutrino Events in the MicroBooNE Detector
Measurement of Cosmic Ray Reconstruction Efficiencies in the MicroBooNE LAr TPC Using a Small External Cosmic Ray Counter
Noise Characterization and Filtering in the MicroBooNE Liquid Argon TPC
Michel Electron Reconstruction Using Cosmic Ray Data from the MicroBooNE LAr TPC
Determination of Muon Momentum in the MicroBooNE LAr TPC Using an Improved Model of Multiple Coulomb Scattering
Convolutional Neural Networks Applied to Neutrino Events in a Liquid Argon Time Projection Chamber
Design and Construction of the MicroBooNE Detector

MicroBooNE Decommissioning Measurements

Opportunity to understand operational characteristics and perform measurements on the world's best understood LArTPC detector

- Interest already expressed from the broader liquid argon neutrino community, e.g. DUNE
 - Origin of many unexpected observations made with the MicroBooNE detector remain unexplained and relevant for DUNE, e.g. light yield degradation, high single PE rate, cross-connected TPC channels, etc.
- If there are other groups (e.g. cryo engineering, ES&H) that also want to make decommissioning measurements, please get in touch!

MicroBooNE Decommissioning Measurement Leadership Team


- **Avinay Bhat** (University of Chicago) and **Joseph Zennaro** serve as MicroBooNE Decommissioning Measurement Coordinators
 - They lead the planning and implementation of all MicroBooNE's decommissioning activities
- **Cindy Joe** joins the decommissioning leadership team in a continuation of her role as our Experiment Liaison Officer
 - She leads our interface with Fermilab

Decommissioning
MicroBooNE

Avinay Bhat and Joseph Zennaro,
(University of Chicago) (Fermilab)

On behalf of the MicroBooNE Collaboration

DUNE Collaboration Meeting
January 25th, 2023

 Fermilab

MicroBooNE Decommissioning Measurement Charge

Work with the collaboration to **define a program of measurements** that is useful to the broader liquid argon community in characterizing the evolution of a LArTPC over six years of running, informed by proposals

Recruit collaborators and laboratory staff necessary to make the measurements and analyze the results

Develop a plan for the execution of the measurements and make the scientific case to the Neutrino Division for the requisite allocation of lab resources

Interface with Neutrino Division and collaboration leadership to execute this plan in the context of the lab's decommissioning work

Inform the collaboration on the progress of the measurements and decommissioning work on a regular basis

Ensure that our decommissioning measurements are **published** and presented publicly

MicroBooNE Decommissioning Measurement Status

Prioritizing effort on measurements that must be made before or during the venting of the MicroBooNE cryostat

- Sampling the liquid argon
 - Contaminants in the liquid argon could potentially explain both the light yield degradation (nitrogen) and the high single PE rate (TPB wavelength shifter)
 - Studies performed last year provide evidence, though inconclusive, of a potential contamination of N_2
 - Now acquiring final components for sample cylinder assembly with a goal of extracting sample by the end of Feb., assuming recirculation pump can be restarted
- Monitoring the resistance between adjacent wire planes
 - Measure of the number of cross-connected channels as wires are agitated during cryostat venting/boil-off
 - Change in the resistance would be an indication that connection between channels is mechanical, e.g. touching wires

Additionally, collecting collaboration proposals for measurements and observations to be made after the cryostat is vented, such as viewing inside the cryostat



Returning and Repurposing Detector Components/Equipment

There are no plans for the future use of the MicroBooNE detector or of LArTF beyond the decommissioning phase

Scope of MicroBooNE/LArTF decommissioning is therefore to return detector equipment owned by universities or other labs, strip the detector and LArTF for parts, and then mothball the entire detector in its current location

MicroBooNE Co-Spokespersons will coordinate the return of non FNAL-owned equipment to MicroBooNE collaborators

- UV laser system, warm electronics, trigger electronics, etc.

Cindy and Matt will coordinate the process of stripping MicroBooNE/LArTF for parts with the collaboration

Currently organized into four main scopes of work with different point people identified

- **Cryogenics**
- **Electronics and infrastructure**
- **Computing equipment**
- **Cosmic Ray Tagger**



MicroBooNE Cryogenics

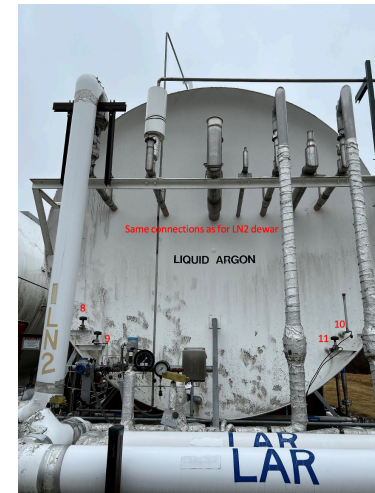
Dave P., Mike Z., Michael G. will coordinate the repurposing of cryogenic equipment and infrastructure from MicroBooNE to other projects and facilities

Scope of cryogenics:

- Any equipment related to the operation of the cryogenic equipment at LArTF

First three big-ticket items:

- External LN₂ and LAr dewars → Helen Edwards Building (DUNE cold lab)
 - Planning well underway
 - Preparatory work for move estimated to start mid-2023, at which point it becomes impractical to keep MicroBooNE cold
- Gas analyzers, rack, and manifold → 2x2 Demonstrator
 - Plans underway
- Filter skids (one full-sized and one with 1/3 of the filter material)
 - Three candidates so far under discussion: ICARUS far detector, LNTF, Helen Edwards building (DUNE cold lab)



Many other pieces of equipment potentially reusable: condenser (x2), LN₂ phase separator, PLCs, purity monitors, etc.

MicroBooNE Electronics and Infrastructure

Linda Bagby will coordinate the repurposing of electronics and infrastructure from MicroBooNE to other projects

- Linda will ensure that the request actually meets the needs of the project and has a broad view of the neutrino program at Fermilab to ensure an efficient allocation

Scope of electronics and infrastructure:

- Rack infrastructure: smoke sensors, power distribution units, A/C switch boxes, etc.
- Custom and commercial electronics, LV and HV power supplies, etc.
- Custom electronics

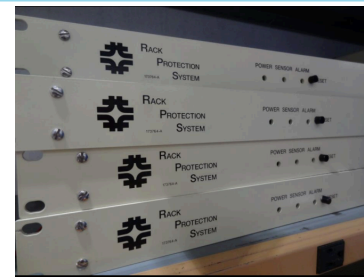
Currently tracking electronics equipment that have been sent to other experiments

- https://docs.google.com/spreadsheets/d/1Nj0361Fg_RTO8orR4QQloFWedXHNU-XgXCzeRx8xT1s/edit#gid=0

In the process of identifying which electronics belong to Fermilab and which need to be returned to collaborating institutions so that an inventory of available hardware can be made

Proposed points of contact with other experiments/facilities:

- ICARUS: Donatella
- LNTF/R&D: Flor
- Helen Edwards: Flor/Monica
- SBND, 2x2: Linda is currently serving in this role herself



MicroBooNE Computing Equipment

Geoff Savage will coordinate the repurposing of computing equipment from MicroBooNE to other projects

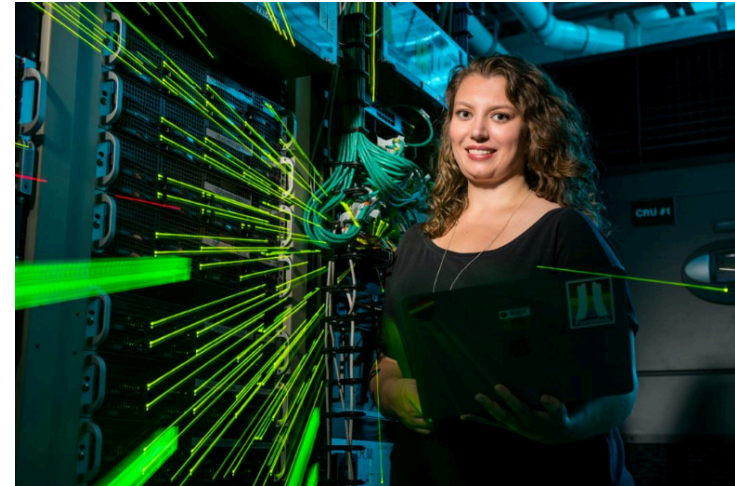
- Geoff will ensure that the request actually meets the needs of the project

Scope of computing equipment

- LArTF DAQ room servers (not including UPSes): DAQ machines, file servers, gateway nodes, etc.
- Does not include CRT rack servers

Immediate needs from the 2x2 demonstrator and ICARUS have already been identified and are being evaluated

Geoff will make an inventory of MicroBooNE computing hardware available for repurposing



MicroBooNE Cosmic Ray Tagger (CRT)

Anne Schukraft will coordinate the repurposing of the MicroBooNE cosmic ray tagger to SBND (exact number of modules TBD)

Scope of cosmic ray tagger:

- CRT panels and unistrut supports (may be taken apart later if not needed for SBND supports)
- CRT rack power supply and possibly other rack equipment (DAQ servers, etc.)

Status:

- Modules needed in fall (not before, due to space limitations)
- Support for CRT modules in SBND has not yet been designed and the layout is not yet finalized
- Plan to use Tom Wick's crew
 - Estimated to be a ~2 week job



Conclusion

MicroBooNE has ended detector operations and is now churning out science results

The decommissioning of the MicroBooNE detector presents a unique opportunity to perform measurements that will add to our understanding of the operational characteristics of the world's best understood LArTPC before the detector is mothballed

Work to decommission various MicroBooNE detector components and LArTF equipment is well underway

Cindy and Matt will coordinate these decommissioning efforts with the collaboration

- Please loop us in as you plan and execute your work

Thank you for your attention

Discussion/feedback