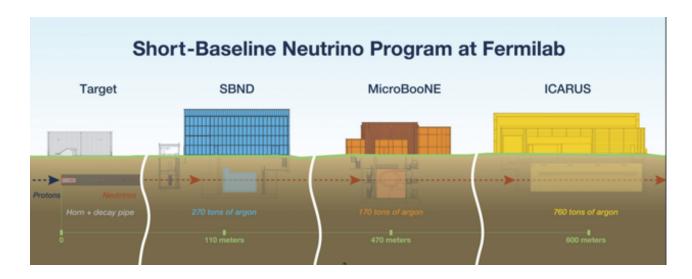




# WP1: NEUTRINO DETECTORS

## INTERIM REPORT DECEMBER 2, 2022

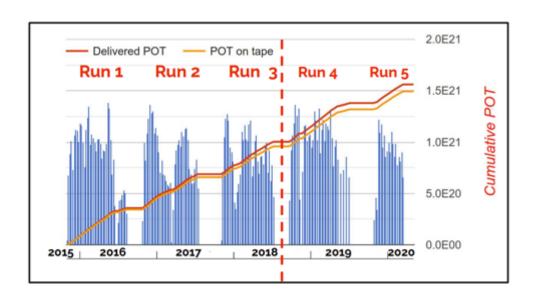






#### MicroBooNE operation

- Longest time operated LArTPC to date
- 24/7/365 operation
- 1-2 people on shift on-site, later also remote-only shifts,
   10-15 on-call experts on-site and off-site

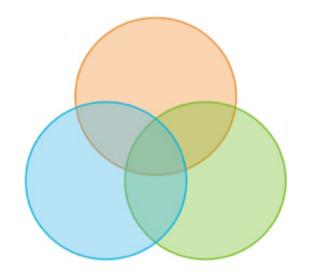


- "Intense" post-data taking phase with detector studies
  - Taking advantage of a well understood detector from operation since 2015
  - Noise and Light studies by varying HV, grounding studies
  - Reverse HV, rise HV —> 70 kV (stable) to 128 kV (small instabilities)
  - Purification study to understand impurities
  - Radon doping —> interesting results on Rn being filtered
  - Triggering





## Understand MiniBooNE LEE & other New Physics Searches



Precision
measurements of
ν – Ar crosssections

Pioneering R&D of LArTPC detector technology

2017 | 2018 | 2019 | 2020 | 2021 | 2022

learsh for an anomaious excess of inclusive charged-current v<sub>e</sub> interactions without pions in the final state with the MicroBooNE experiment learch for an anomatious excess of charged-current quasi-classic ve interactions with the MicroBooNE experiment using deep-learning-based reconstruction arch for an anomalous excess of inclusive charged-current v, interactions in the MicroBooNE experiment using Wire-Cell reconstructio arch for an excess of electron neutrino interactions in MicroBooNE using multiple final state topologies re-Cell 3D pattern recognition techniques for neutrino event reconstruction in large LArTPCs spretic shower reconstruction and energy validation with Michel electrons and  $\pi^0$  samples for the deep-learning-based analyses in MicroBooNi It for neutrino-induced NC & radiative decay in MicroBooNE and a first test of the MiniBooNE low-energy excess under a single-photon hypothesis arch for a Higgs Portal Scalar Decaying to Electron-Positron Pairs in the MicroBooNE Detector surement of the Longitudinal Diffusion of Ionization Electrons in the Detector mic Ray Background Rejection with Wire-Cell LAY TPC Event Reconstruction in the MicroBooNE Detector urement of the Flux Averaged Inclusive Charged Current Electron Neutrino and Antineutrino Cross Section on Argon using the NuAll Beam in MicroBooNE ntic Segmentation with a Sparse Convolutional Neural Network for Event Reconstruction in MicroBoo nance Generic Neutrino Detection in a LAr TPC near the Earth's Surface with the MicroBooNE Detector Event Selection in the MicroBooNE LAr TPC using Wire-Cell 3D Imaging, Clustering, and Charge-Light Matching ional Neural Network for Multiple Particle Identification in the MicroBookiE, Liquid Argon Time Projection Chamber ding and Reconstruction of Contained Two-track Neutrino Events in the MicroBooNE Detector was Readout Stream of the MicroBookE Liquid Agon Time Projection Chamber for Detection of Supernova Burst Neutrino of Differential Cross Sciences for Music Neutrino CC Intrapolation on Agon with Protons and Ne Plons in the Final State Space Charge Effects in the MicroBookE Liquid Agon Time Projection on Agon with Protons and Ne Plons in the Final State Space Charge Effects in the MicroBookE Liquid Agon Time Projection Mucro. inst Measurement of Inclusive Muon Neutrino Charged Current Differential Cross Sections on Argon at Enu -0.8 GeV with the MicroBooNE Detector Design and Construction of the MicroBoxNE Cosmic Ray Tagger System g Cosmic Background for Exclusive Neutrino Interaction Studies with Liquid Argon TPCs: A Case Study with the MicroBooNE Detector surement of Muon Neutrino Charged Current Neutral Plon Production on Argon with the MicroBooNE detector Network for Pixel-Level Electromagnetic Particle Identification in the MicroBooNE Liquid Argon Time Projection Chamber arison of Muon-Neutrino-Argon Multiplicity Distributions Observed by MicroBooNE to GENIE Model Predictions Ionization Electron Signal Processing in Single Phase LA/TPCs II: Data/Simulation Comparison and Performance in MicroBooNE Ionization Electron Signal Processing in Single Phase LA/TPCs II: 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 volutional Neural Networks Applied to Neutrino Events in a Liquid Argon Time Prosection Chamber

- More than 45 publications in the past 5 years <a href="https://microboone.fnal.gov/documents-publications/">https://microboone.fnal.gov/documents-publications/</a>
- More than 75 public notes sharing progress with community as we go <a href="https://microboone.fnal.gov/public-notes/">https://microboone.fnal.gov/public-notes/</a>

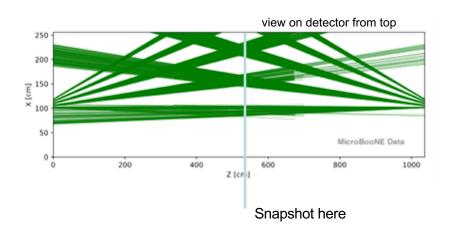
M. Weber, 28.11.2022

Design and Construction of the MicroBooNE Detector

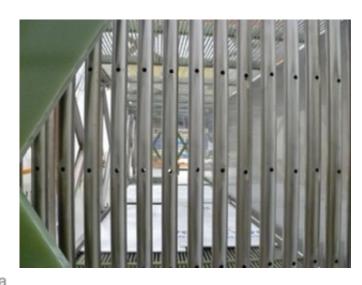


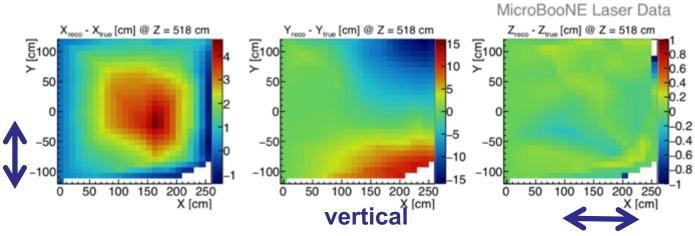


## **UV-laser** analysis



Laser tracks shot into MicroBooNE Laser light induces straight tracks





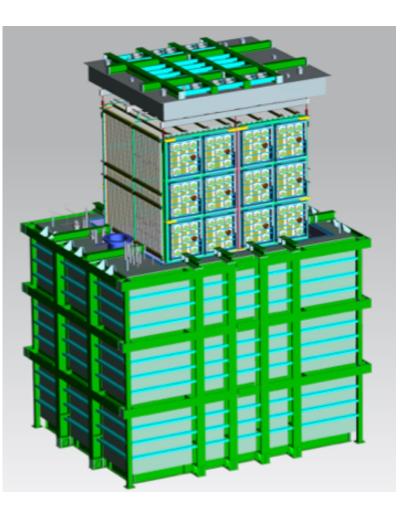
Measured Electric field

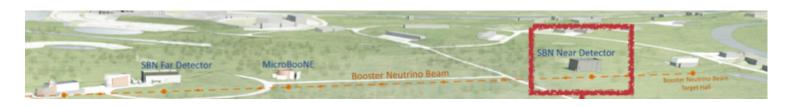
M. Weber, 28.11.2022



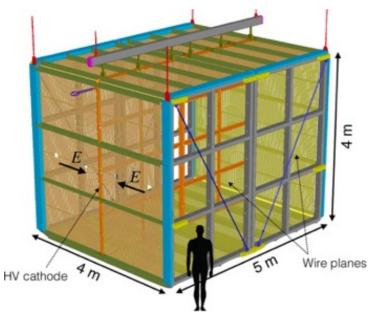


#### SBND





Short-Baseline Near Detector (SBND) is located 110 meters from the Booster Neutrino Beam target, and has 112 tons of liquid argon within the active

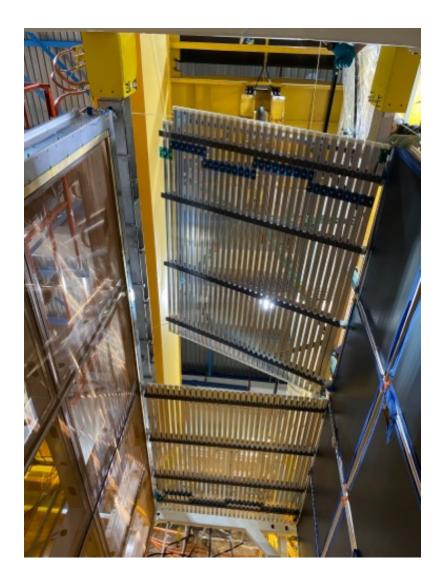


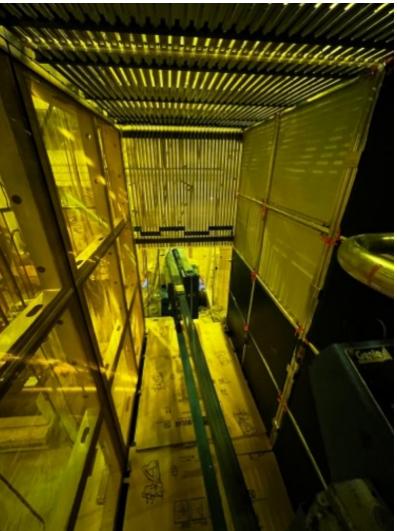


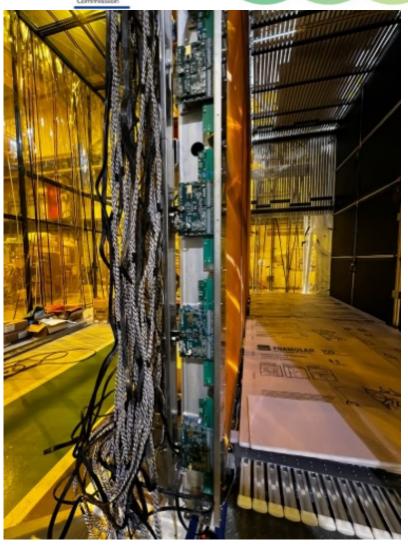
M. Weber, 28.11.2022











Field cage assembly

Cold electronics installation

#### SBND Cosmic Ray Tagger

- System delivered from UBERN
- Temporary beam muon telescope installed on the upstream and downstream walls of the SBND cryostat.
- This CRT enabled pre-LAr commissioning of the DAQ, CRT, Beam, Trigger and PMT electronics.
- Bottom modules installed before cryostat placed on top





Bottom CRT installation

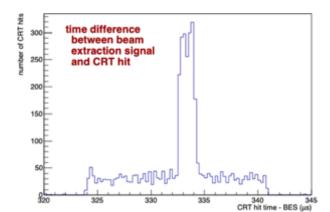








First "SBND data" before full detector installation

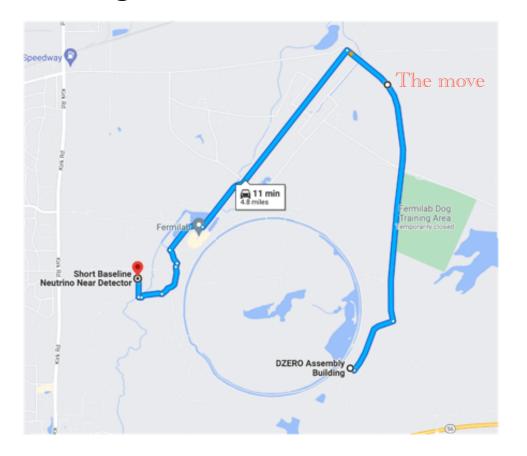


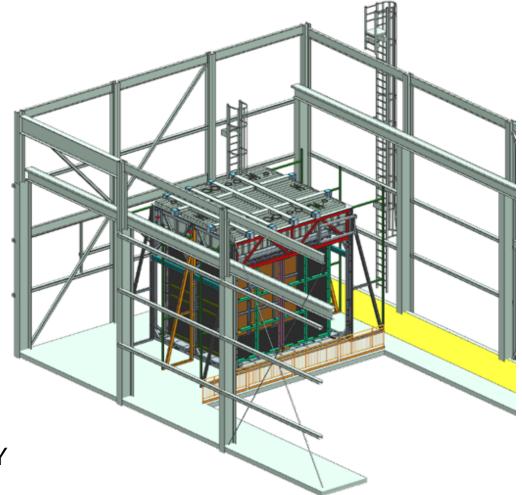
Beam spill duration is 1.6 us CRT timing resolution is 1-2 ns





#### Putting the detector into the cryostat





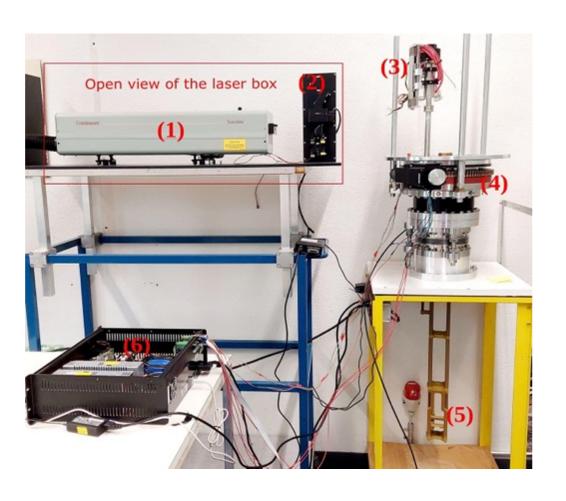
- Assembled Detector moved to the ND building YESTERDAY
- Detector insertion inside the cryostat is expected to take place in spring
- Expected to be ready for cryogenic operations at the beginning of next summer





## **SBND UV Laser**





Unit built at the University of Bern, see ESR report





#### ICARUS construction and commissioning

Aug. 28<sup>th</sup> 2020: start of TPC/PMT operation



Dec. 2021: completion of CRT installation



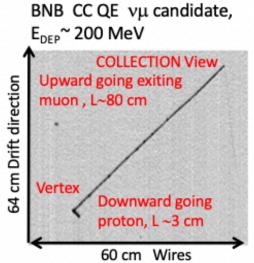
June 7<sup>th</sup> 2022: completion of overburden installation

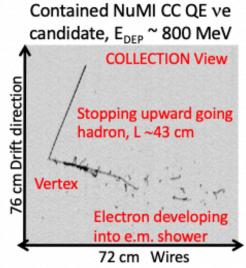


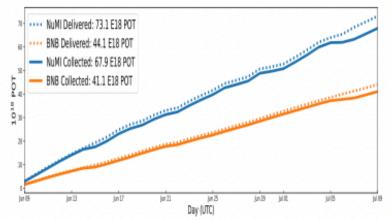
Steady data taking with BNB, NuMI beams since March 2021, in parallel with commissioning activities.

Cosmics,  $v_{\mu}$ , and  $v_e$  samples collected for trigger/calibration/event reconstruction studies.

#### Started data taking for physics with BNB, NuMI: June 9th 2022







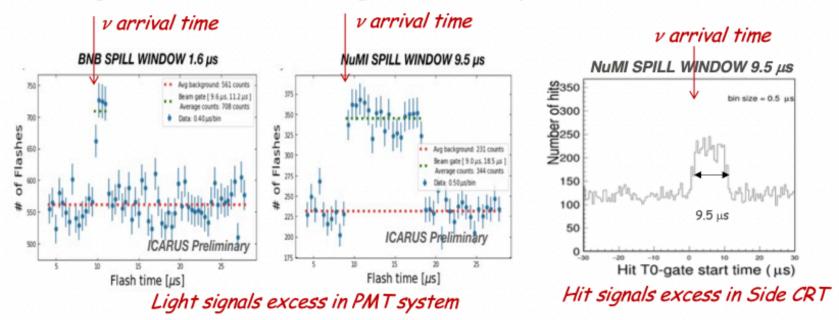
Collected event statistics (93% efficiency): 4.1x10<sup>19</sup> pot (BNB), 6.7x10<sup>19</sup> pot (NuMI)





#### ICARUS trigger system

- Trigger signal: scint. light from >5 fired PMT pairs in a 6 m longitudinal detector slice (30 left + 30 right PMTs per cryostat) in coincidence with the beam spill identified by an Early Warning signal of proton beam extraction.
- PMT and CRT signals are recorded 2 ms around the trigger to recognize/tag cosmics crossing the LAr-TPCs during the 1 ms e- drift time.
- The detector timing has been set by looking for excess of PMT light signals and of side CRT hit signals over the cosmic background in correspondence of the beam arrival.



Trigger efficiency initially evaluated on cosmic muons: > 97 % for E\_DEP > 250 MeV





#### Conclusions

- Excellent progress
- Recovering from COVID-time, travels and hardware activities resumed
- WP goal of publishing detector papers from MicroBooNE achieved
- WP goal of constructing ICARUS and commissioning achieved, first detector studies and publications underway
- WP goal of constructing SBND made good progress, underway