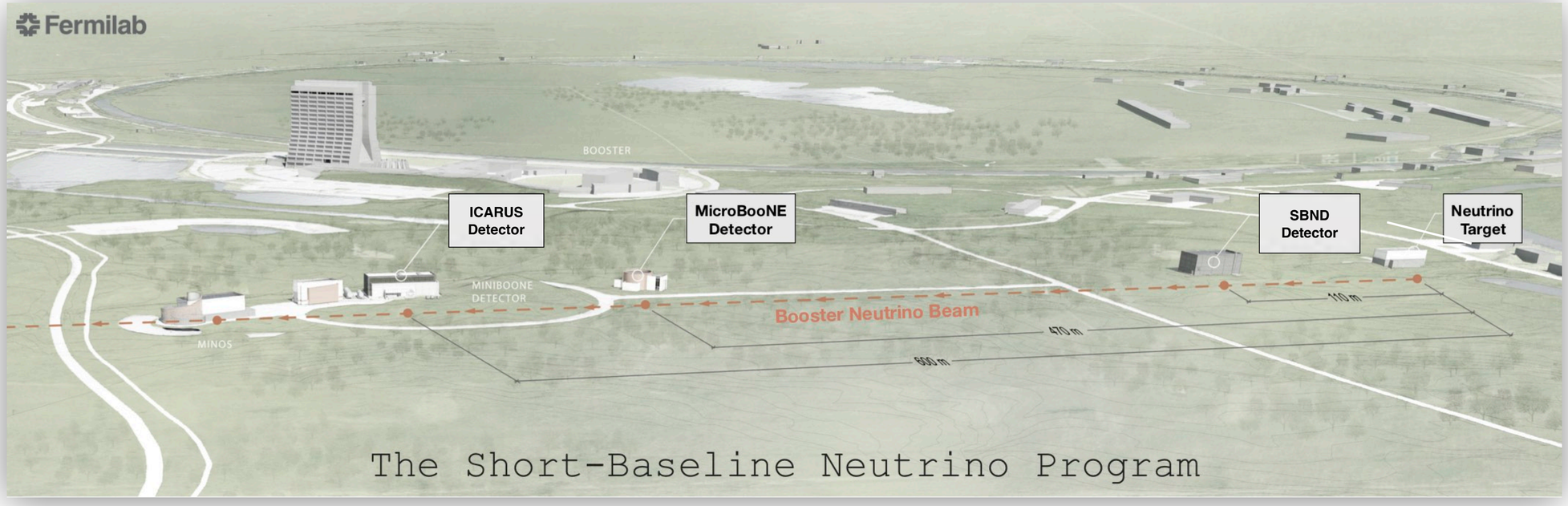


SHORT-BASELINE NEUTRINO PROGRAM

P5 TOWN HALL

FERMILAB, MARCH 21ST, 2023

ORNELLA PALAMARA
FERMILAB

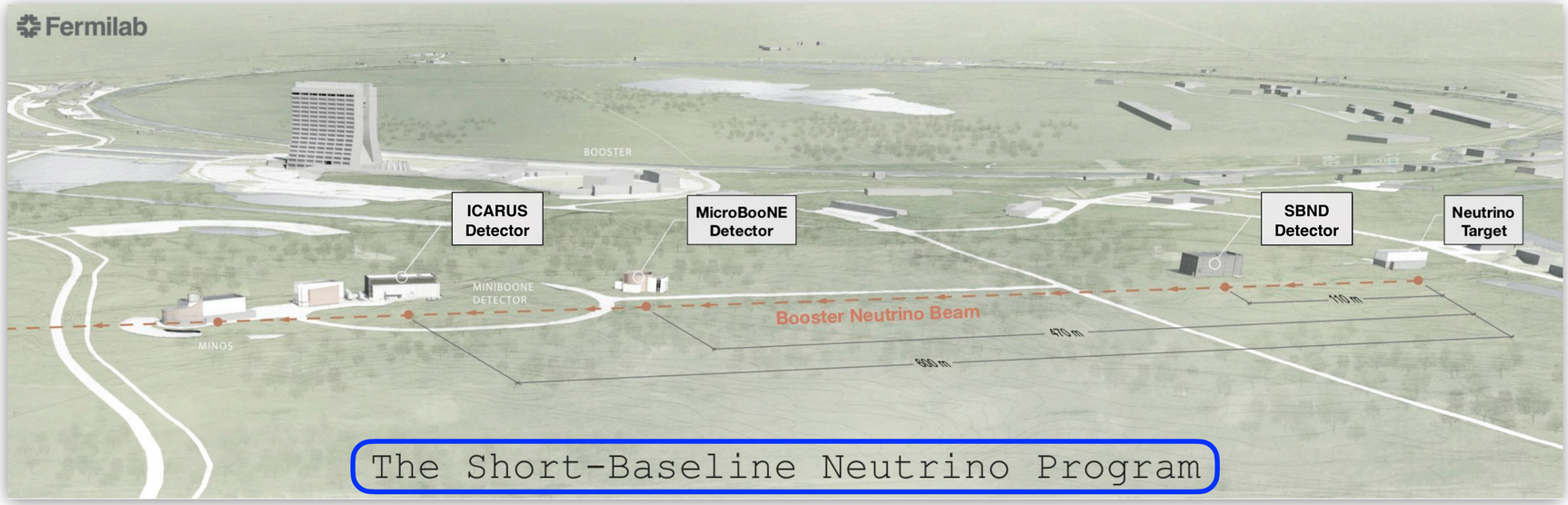
P5-2014 and the Short-Baseline Neutrino Program

One of the recommendations of the **2014 P5** report "Building for Discovery" was to realize a **world leading short-baseline experimental neutrino program*** with **strong participation by the domestic and international neutrino physics communities working toward LBNF [DUNE]**:

- **Recommendation 12**: In collaboration with international partners, develop a **coherent short- and long-baseline neutrino program hosted at Fermilab**.
- **Recommendation 15**: Select and perform in the short term a set of small-scale **short-baseline experiments** that can **conclusively address experimental hints of physics beyond the three-neutrino paradigm**. Some of these experiments should use **liquid argon** to advance the technology and build the international community for LBNF at Fermilab.

P5 Report, May 2014

The **Short-Baseline Neutrino (SBN)** program at Fermilab is well matched to these recommendations



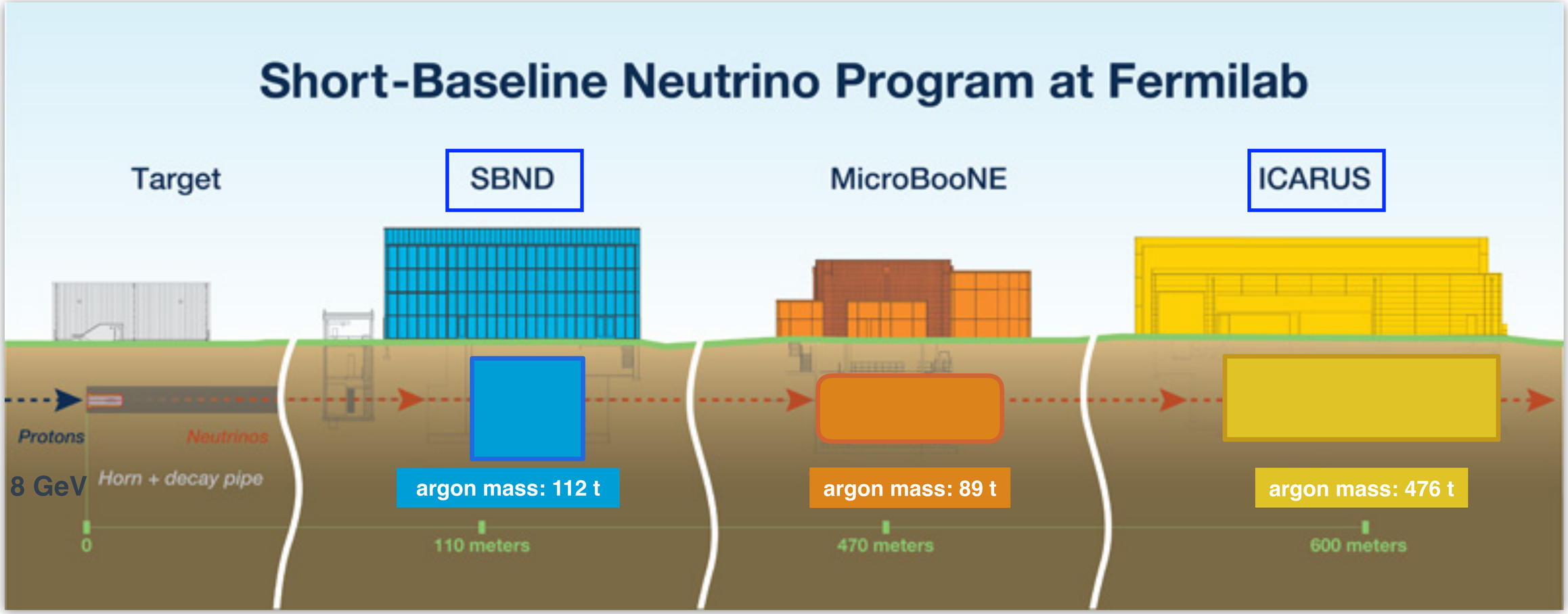
SBN Proposal, January 2015
arXiv:1503.01520

SBN detectors design/ construction/installation, 2016-2023

Physics in the forthcoming P5 cycle

* Short-Baseline: L~100-1000 m, $\Delta m^2 \sim 1 eV^2$
cfr.: Long-Baseline: L~100-1000 km, $\Delta m^2 \sim 10^{-3} eV^2$

SHORT-BASELINE NEUTRINO PROGRAM



Booster Neutrino Beam (BNB)

2015-2021
Large production of scientific results

Beam composition:
ν_μ (93.6%)
$\bar{\nu}_\mu$ (5.9%)
ν_e+$\bar{\nu}_e$ (0.5%)

Mean ν_μ energy: ~0.8 GeV

BNB + LAr Enables A Rich Science Program

MicroBooNE Papers

MicroBooNE has published 55 papers so far

2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

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 appearance 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 ve 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 ~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

FAR DETECTOR - ICARUS

From **Gran Sasso Laboratory** to **Fermilab** via **CERN**

July 2017

Transport from CERN to Fermilab

August 2018

Installation of ICARUS cryostats

August 2020

Start of ICARUS detector operation

Four Time Projection Chambers in two modules
Each module dimension:
3m x 4m x 18m

Steady **data taking since March 2021**, in parallel with commissioning activities

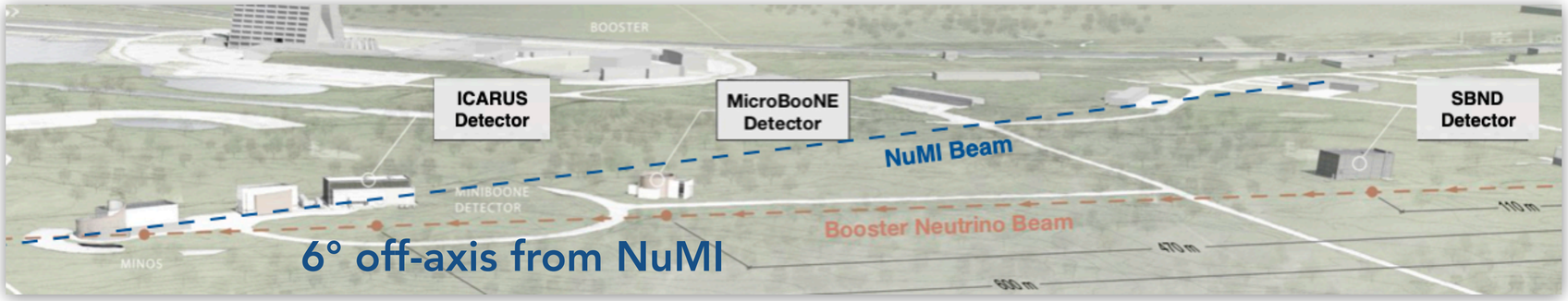
FAR DETECTOR - ICARUS

Completion of Cosmic Ray tagger

Completion of concrete overburden

Collecting data in final configuration since **June 2022**

ICARUS receives two neutrino beams: it also sits 6° off-axis from the NuMI beam



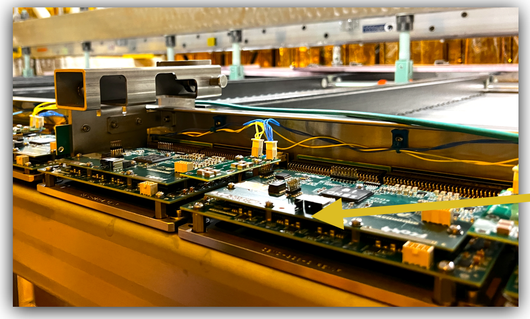
Detector components: INFN (Italy)
Side/bottom CRT: FNAL (DOE) and US institutions
Detector refurbishment infrastructure and shipping: CERN
Cryostat and Cryogenics: CERN and FNAL (DOE)
Building and Infrastructures: FNAL (DOE)
Assembly and Installation: FNAL (DOE) and Collaboration Institutions

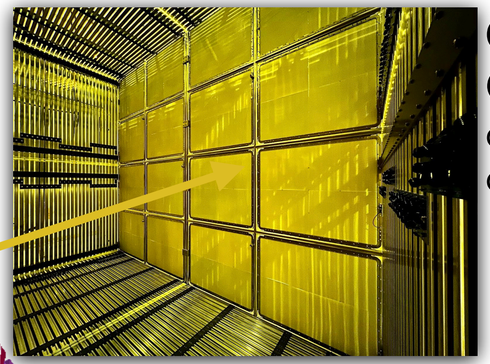
NEAR DETECTOR - SBND OVERVIEW

The design of the SBND TPC is largely based on the design of the TPC for the DUNE Far Detector 1 (FD1)

Two Time Projection Chambers
Total dimension: 4m x 4m x 5m

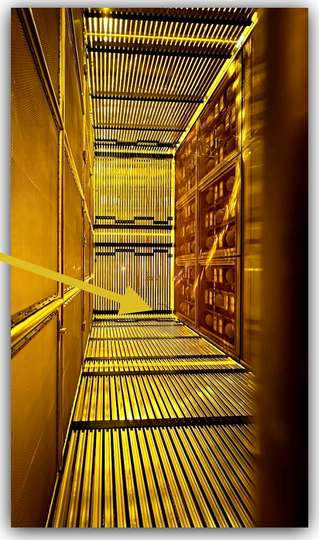
TPC Cold electronics

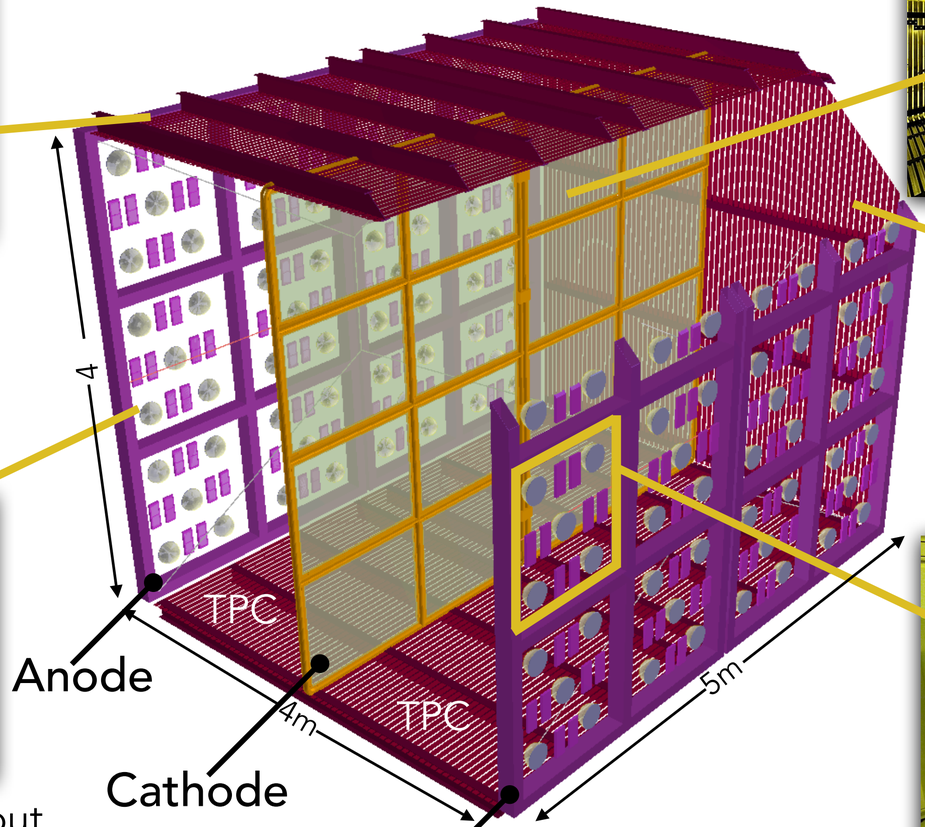


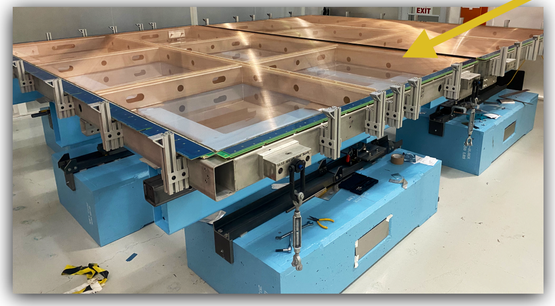


CPA - Cathode covered with TPB coated reflectors

Field Cage





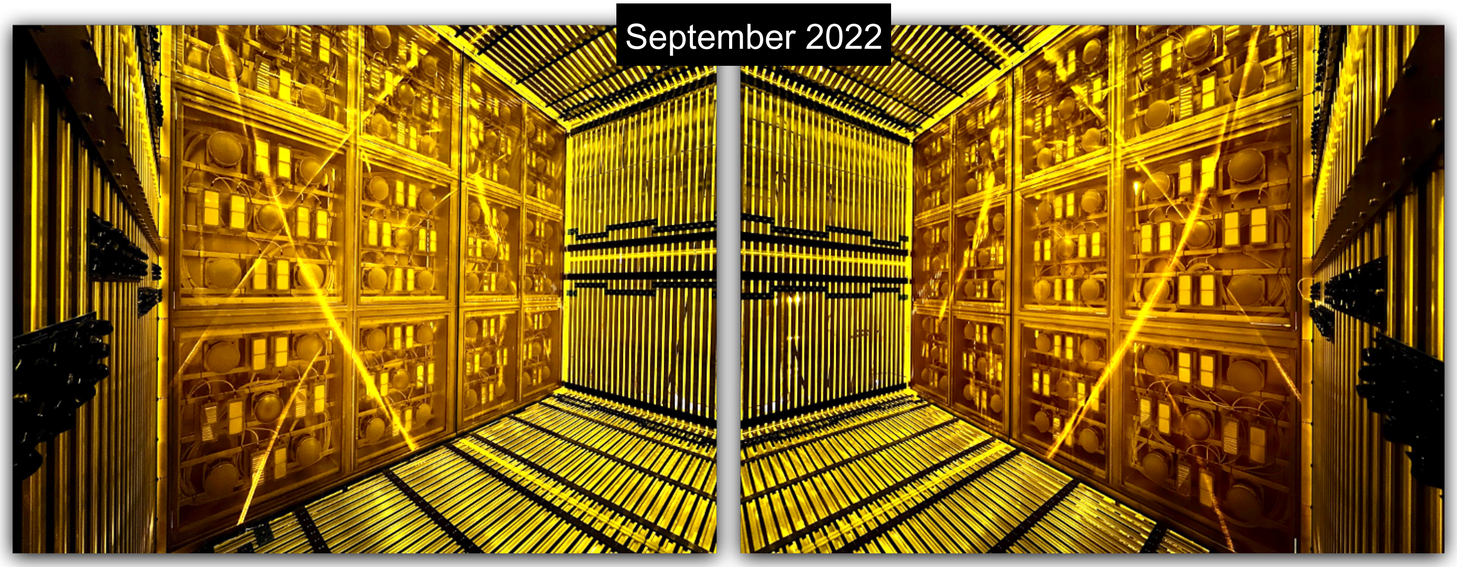


APA - wire planes - 3 readout planes, ~11000 wires

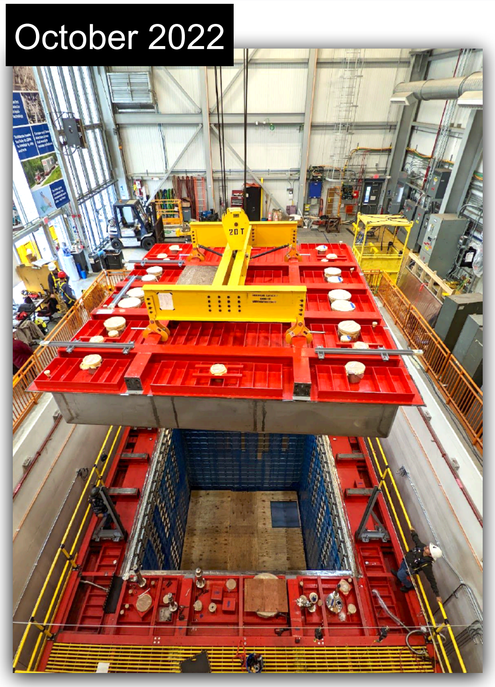
Photon Detection Systems: 120 PMTs, 192 X-Arapucas

Detector components: Brazil, UK, Switzerland and US (NSF and DOE) Institutions
Cryostat and Cryogenics: CERN and FNAL (DOE)
Building and Infrastructures: FNAL (DOE)
Assembly and Installation: FNAL (DOE) and Collaboration Institutions

SBND Status



SBND detector completed



Membrane cryostat as in DUNE FD1 and FD2

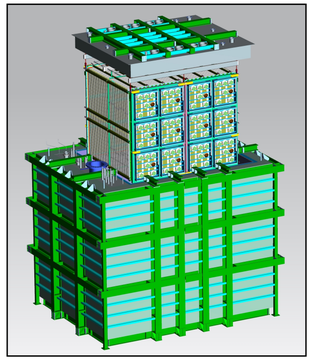
SBND cryostat completed

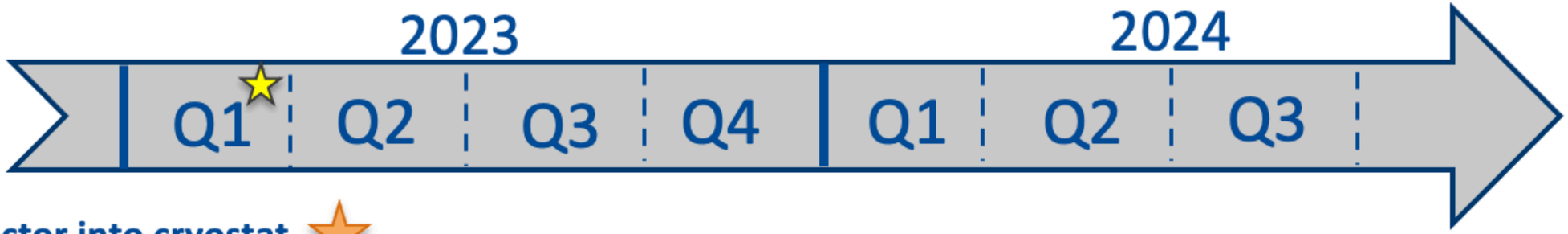
On **December 1, 2022** the assembled SBND TPC + photon detector systems was successfully moved across the Fermilab site from DAB to the SBND Detector hall

A newsworthy day

SBND detector move

SBND - Timeline to Operations





Rigging detector into cryostat *April, 2023*

Ready for Cryogenic Commissioning

Purge, Cooldown, Fill

Filled & ready for Physics Commissioning *November, 2023*

Detector commissioning

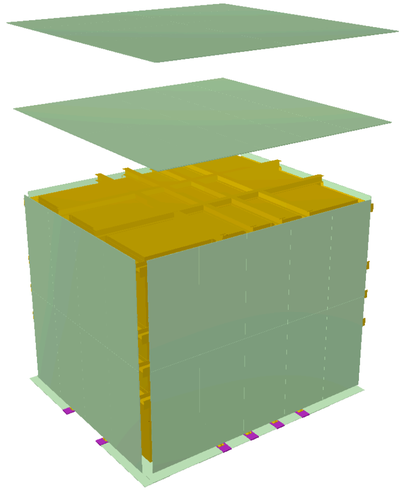
Initial Physics Run

Complete CRT Installation

CRT is operational

summer shutdown 2024

Cryostat surrounded by a Cosmic Ray Tagger system. Panels made of scintillator strips



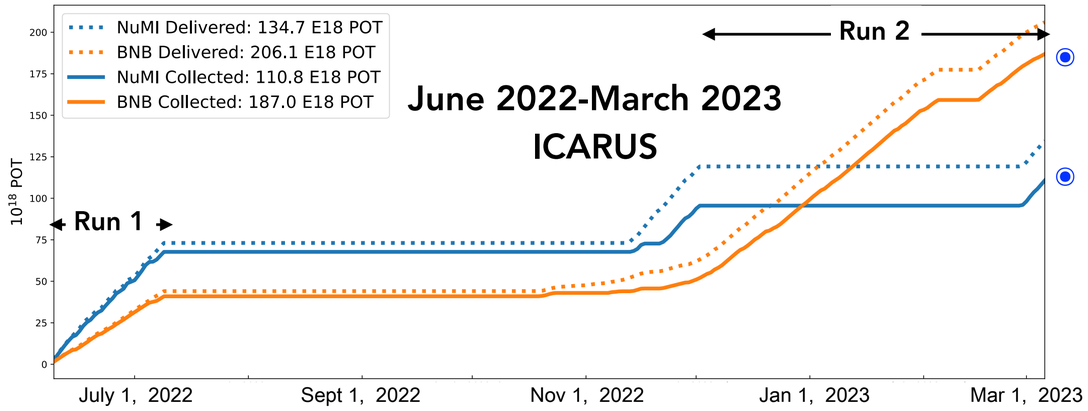
SBN Run Plan

- ICARUS is collecting physics data since June 2022:

Run 1, first ICARUS physics run:
June 9th – July 10th, 2022
(average collection efficiency ~93% for both BNB and NuMI)

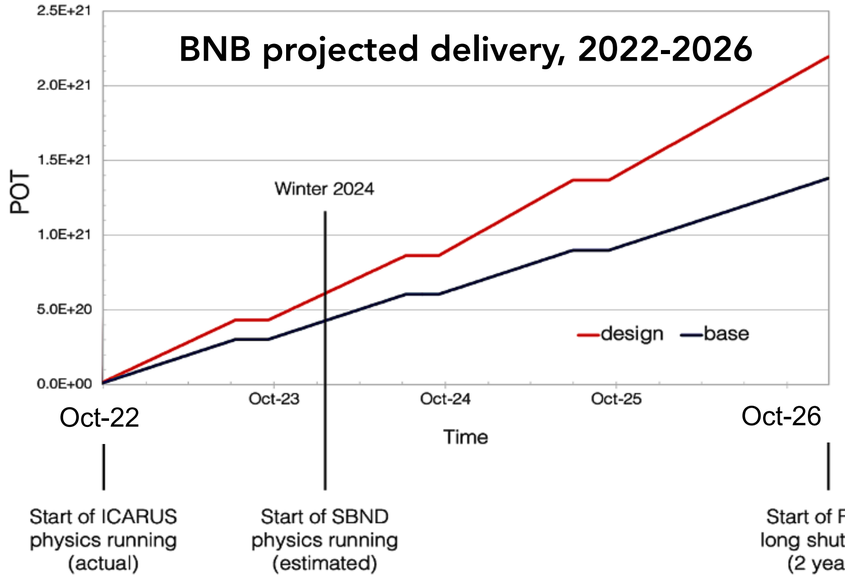
Run 2:

December 5th, 2022 –
(average collection efficiency ~95%)



- **1.9 × 10^{20} protons on target (POT)** collected from BNB
- **1.1 × 10^{20} POT** collected from NuMI

- Running **until** the Fermilab **accelerator long-shutdown** in 2027:
  - ICARUS is expected to collect **15-22 × 10^{20} POT** from BNB
  - SBND is expected to collect **10-13 × 10^{20} POT** from BNB
    - This is x2 the assumed exposure in the SBN proposal (6.6 × 10^{20} POT)

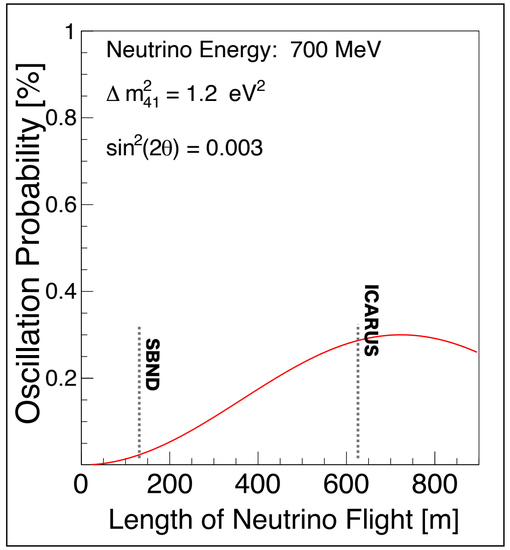


- We have started considering the **physics potential of extending the run after the long-shutdown** (2029+). Possible scenarios:
  - Continue to run in neutrino mode
  - Run in anti-neutrino mode
  - Run in beam-dump mode

What makes the SBN Program Unique?

LAr Technology

Event imaging
Fine granularity calorimetry and particle identification
Electron-γ separation
Good timing resolution
Low energy threshold



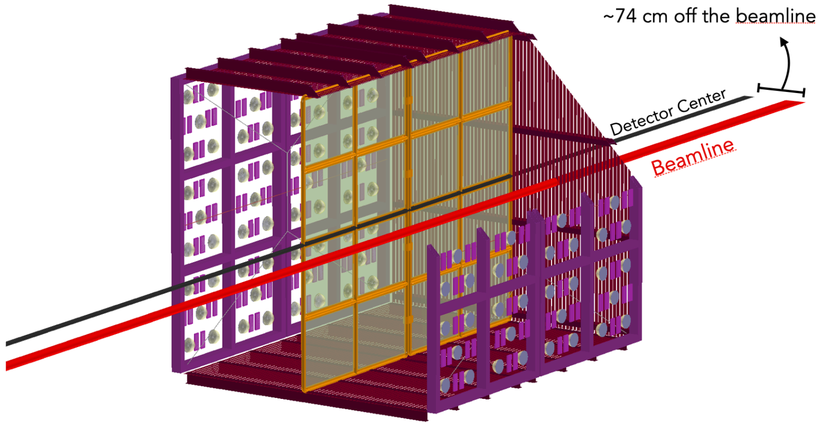
Near detector SBND

Crucial for oscillation searches.
Sitting close to the neutrino source, SBND plays a **unique role.**
It sits before oscillations turn on @eV-scale → it characterizes the beam and **addresses the dominant systematic uncertainties**

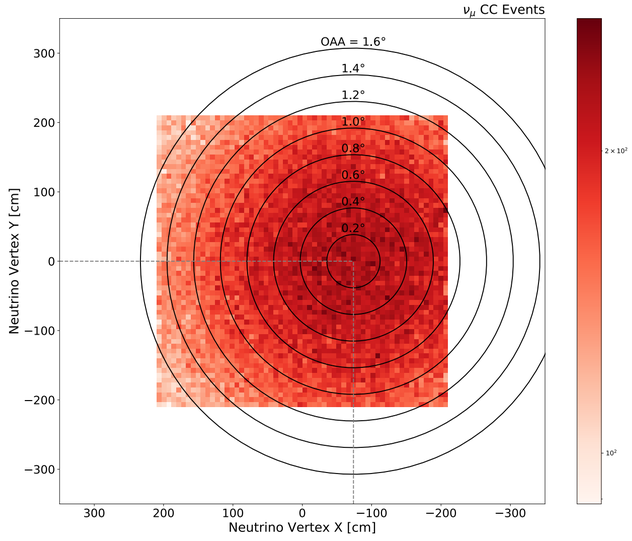
Far detector ICARUS

Given its far location and large mass provides big exposure to oscillated neutrinos, allowing for a **high sensitivity oscillation search**

SBND is close (110 m) to the neutrino source and intentionally positioned offset relative to the beam center.



SBND-PRISM



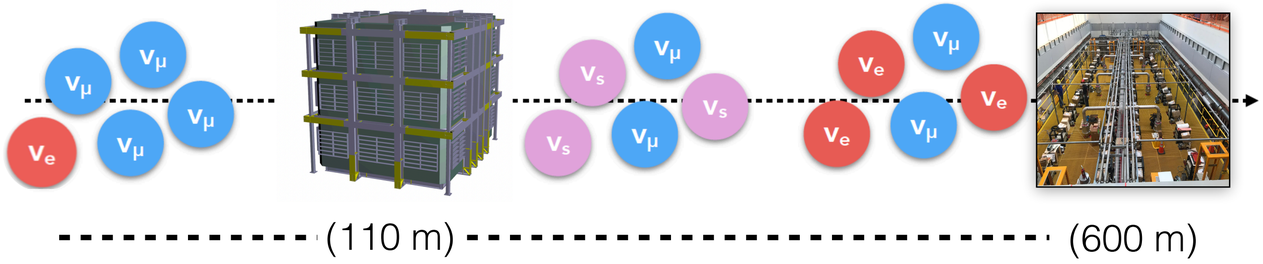
This "PRISM"* feature of SBND allows **sampling multiple neutrino fluxes in the detector**

SBND-PRISM provides unique constraints of systematic uncertainties, helps mitigate backgrounds and expands the SBN(D) physics potentials

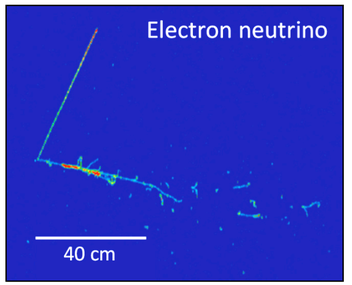
*Similar to the nu-PRISM and DUNE-PRISM concepts, but with a fixed detector.

SBN - A Broad Physics Program

eV-scale sterile neutrinos: searches for physics beyond the three-neutrino mixing with **multiple-detectors at different baselines.**



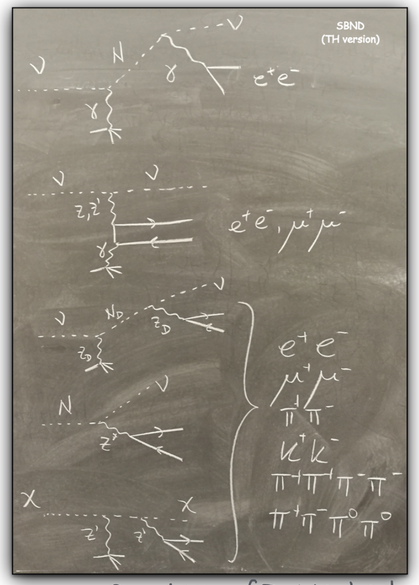
Neutrino-argon interactions: with **an order of magnitude more data** than is currently available.



We have expanded the physics program!

New physics scenarios: study alternative explanations of the short-baseline anomalies and other Beyond Standard Model scenarios.

Many ideas for new searches emerging from collaboration with theory colleagues.



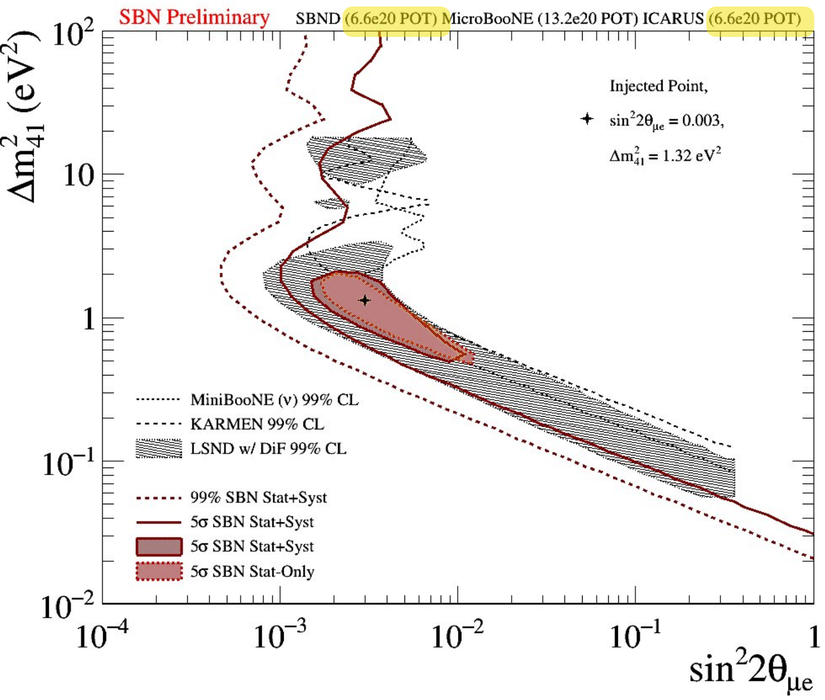
Courtesy of P. Machado

P.Machado, O.P., D. Schmitz,
Annu. Rev. Nucl. Part. Sci. 69 363-387 (2019)

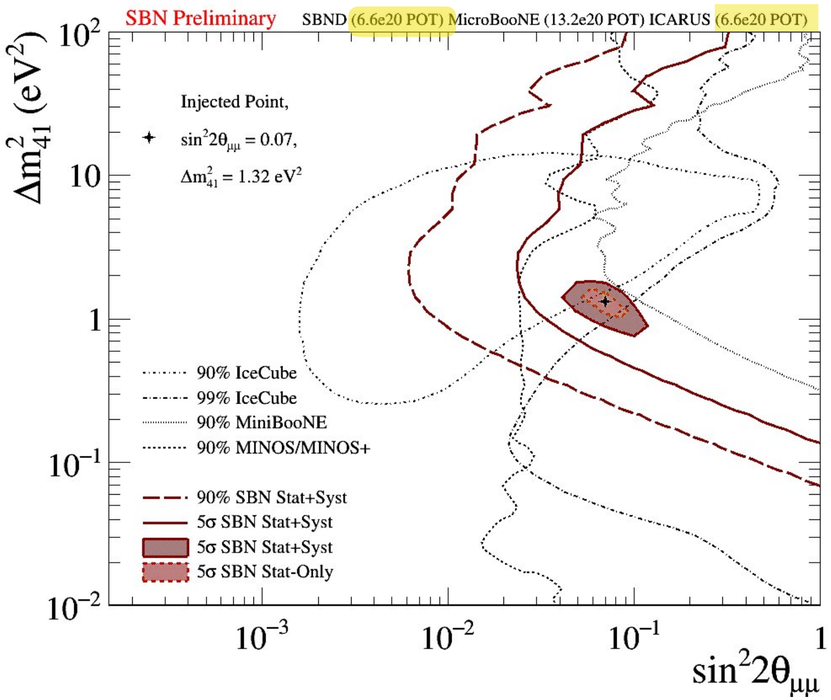
Large volumes of LAr data will enable further developments of powerful reconstruction and analysis techniques.

SBN Sterile Neutrino Sensitivities

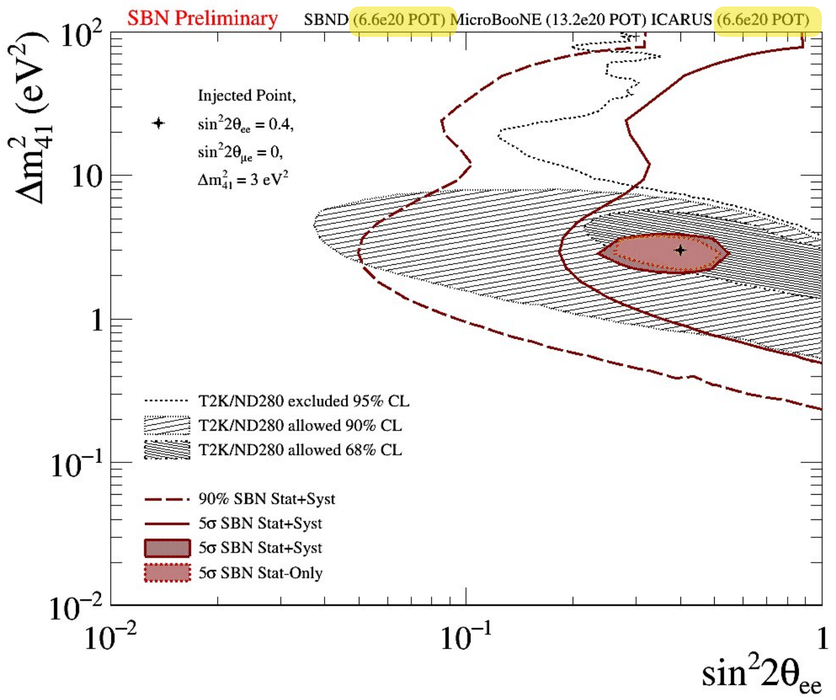
ν_e Appearance



ν_μ Disappearance



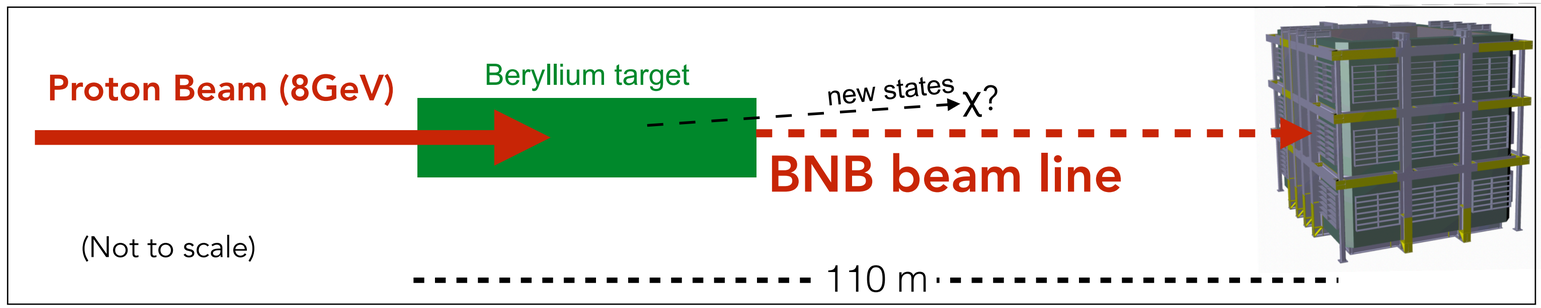
ν_e Disappearance



The SBN program tests the sterile neutrino hypothesis by covering the parameter regions allowed by past anomalies at **5σ significance**.

Complementary measurements in different modes:
important for interpretation in terms of **sterile neutrino oscillation**.

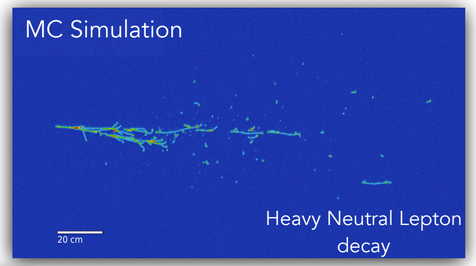
SIGNATURES FOR NEW PHYSICS IN SBN

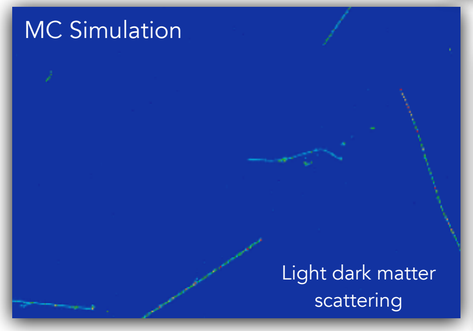


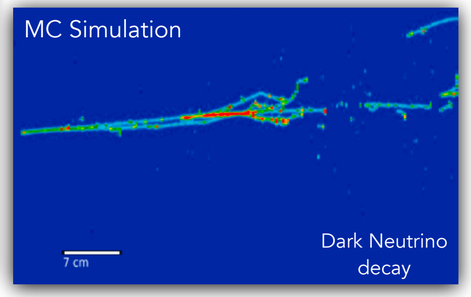
SBND
on-axis

ICARUS
6° off-axis

Large mass LAr detectors close to the beam target







Final state signatures: single photon, single electron, "trident" with di-leptons and different levels of hadronic activity

High-intensity proton beams (high-intensity neutrino beams)

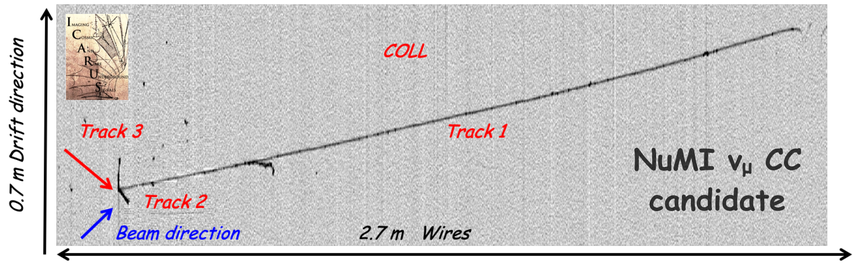
Opportunities to **probe signatures** for **new physics scenarios** in the **neutrino sector** and **beyond**

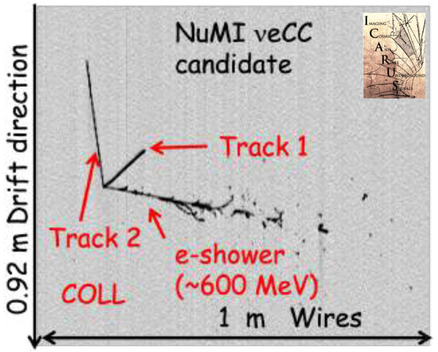
Ability of LAr experiments to perform BSM searches have been demonstrated by recent measurements from ArgoNeuT and MicroBooNE.

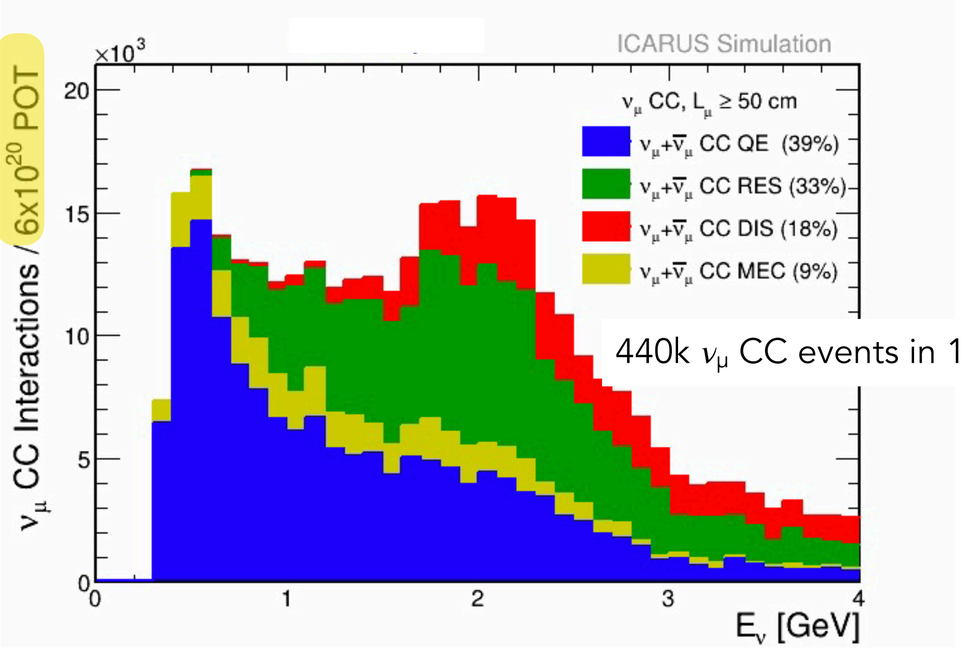
PRECISION STUDIES OF NEUTRINO-ARGON INTERACTIONS IN SBN

Neutrino cross sections measurements are crucial for understanding neutrino interaction with matter and informing oscillation measurements. Also, neutrinos are background for BSM searches!

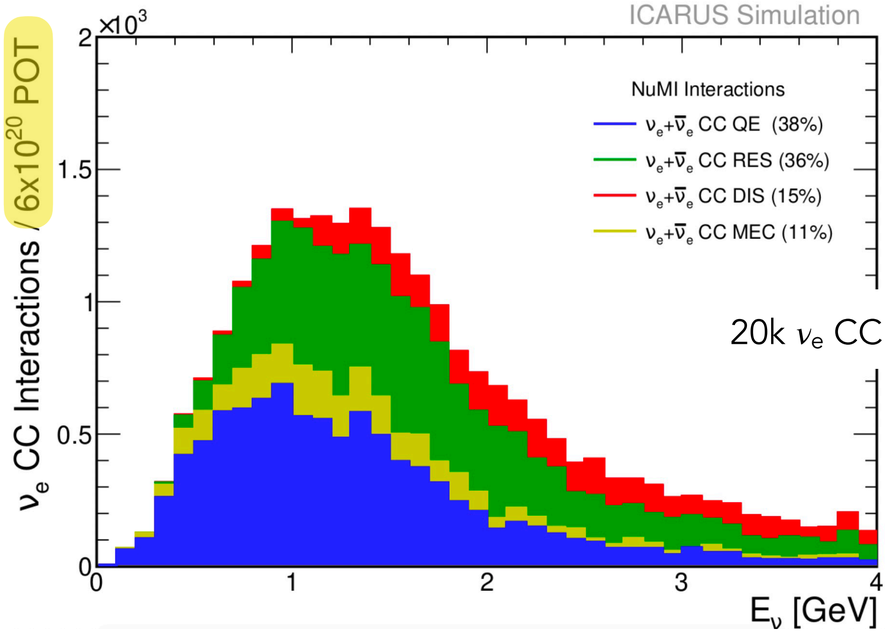
ICARUS collects high statistics of neutrino-argon interactions in its off-axis location on NuMI.







440k ν_μ CC events in 1 year



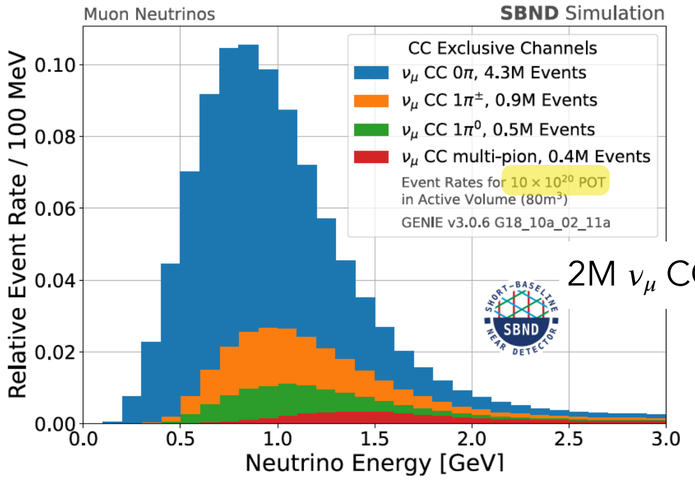
20k ν_e CC events in 1 year

Electron and muon neutrino spectra from NuMI at ICARUS includes a substantial event rate at the DUNE first oscillation peak

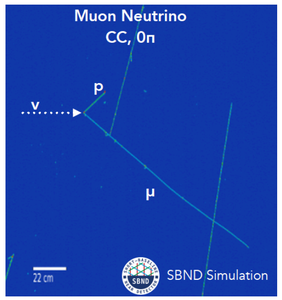
Precision Studies of Neutrino-Argon Interactions in SBN

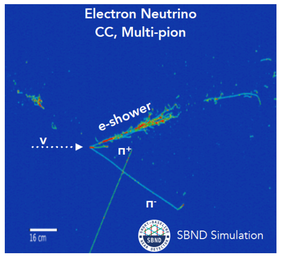
With its proximity to the neutrino source, **SBND** will compile neutrino data with unprecedented high event rate and will enable a generational advance in the study of neutrino-argon interactions in the GeV energy range.

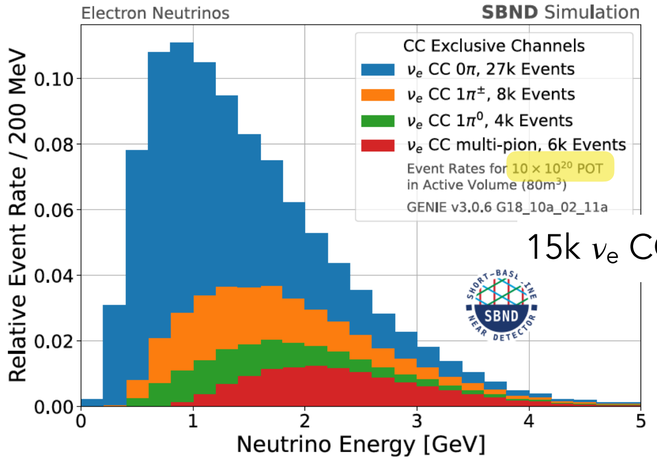
Up to 7000 ν events/per day in SBND!



2M ν_μ CC events in 1 year

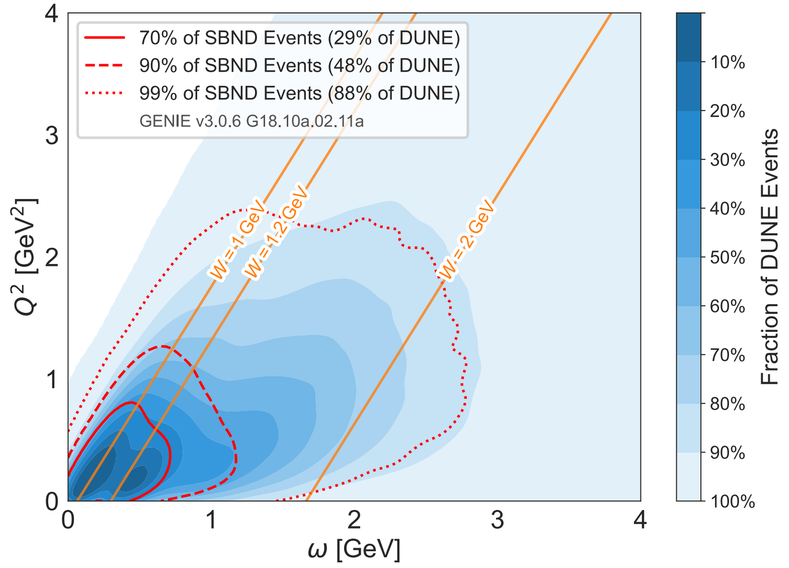






15k ν_e CC events in 1 year

SBND has a **significant phase space overlap with DUNE** → SBND measurements can be used to constrain the same physics DUNE needs to know.



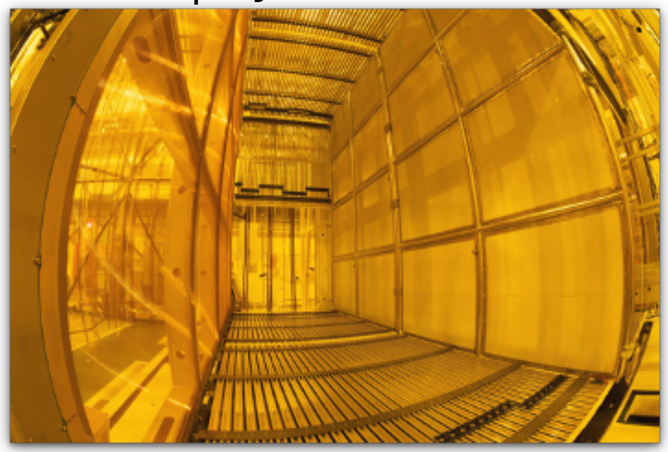
DUNE kinematic coverage is represented with the blue 2D histogram. SBND kinematic coverage is shown with 3 contours, representing 70%, 90%, and 99% of all SBND data.

SBND will record **20-30x more neutrino-argon interactions** than is currently available

(10 million total events (CC+NC), including around 50,000 ν_μ CC events above 2 GeV, and 50,000 ν_e CC events).

SBN in Numbers

A **large, International team** to produce the SBN physics!



178 Total Collaborators

150 Scientific Collaborators
(faculty/scientists, postdocs, PhD students)

25 Institutions

12 INFN Sections (Italy)
CERN
1 Indian Laboratory
1 Mexico University
7 US Universities, 3 National Laboratories

253 Total Collaborators

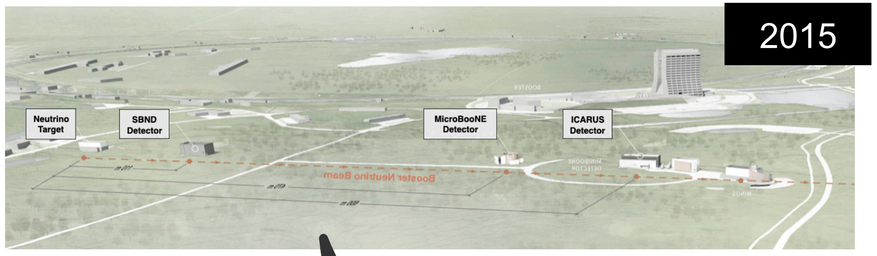
206 Scientific Collaborators
(faculty/scientists, postdocs, PhD students)

39 Institutions

5 Brazilian Universities
CERN
1 Spanish University, 1 National Laboratory
1 Swiss University
7 UK Universities, 1 National Laboratory
18 US Universities, 4 National Laboratories

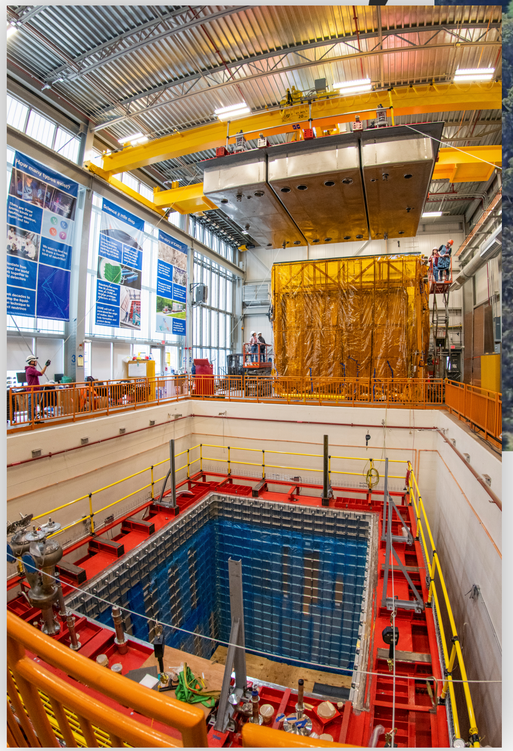
P5-2014 - Recommendation 15: Select and perform in the short term a set of small-scale **short-baseline experiments** that can conclusively address experimental hints of physics beyond the three-neutrino paradigm. Some of these experiments should use **liquid argon to advance the technology and build the international community for LBNF [DUNE] at Fermilab.**

SBN in Pictures



Short-Baseline Neutrino program

SBN in Pictures



SBN in Summary

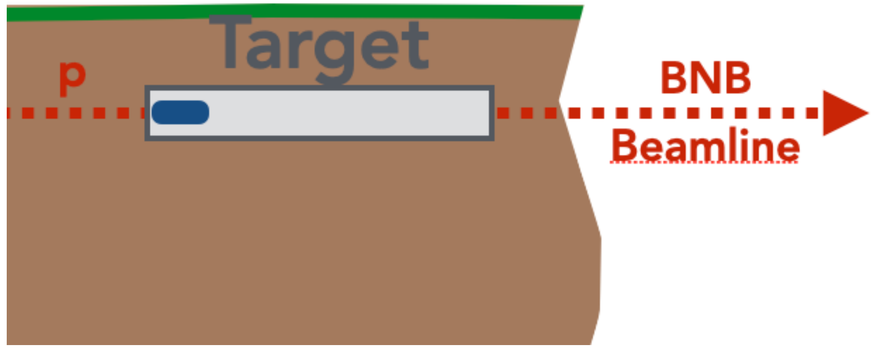
Construction of the SBN program realized several recommendations from the last P5.
SBN operations and physics program will be mostly realized in the forthcoming P5 period.

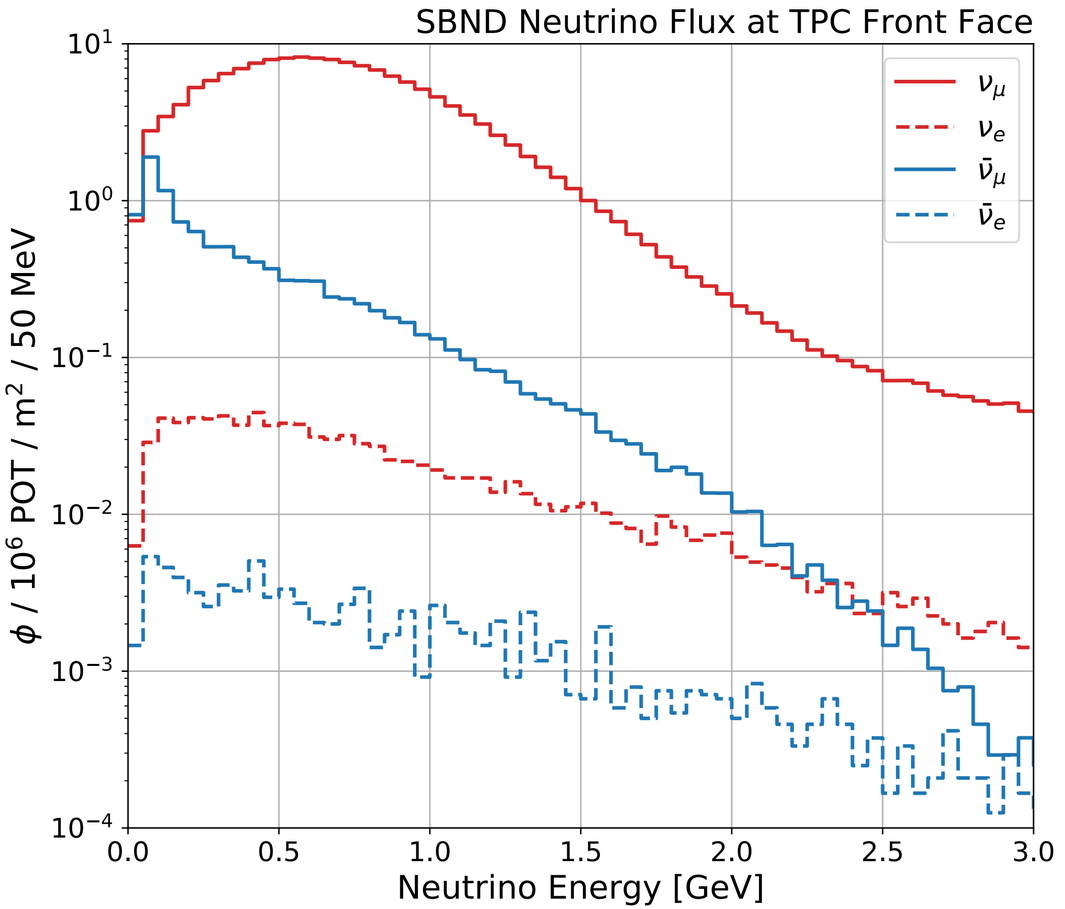
Exciting times are ahead for the
Short-Baseline Neutrino Program!

EXTRAS

Booster Neutrino Beam

High-intensity neutrino beam from 8 GeV proton beam.





Neutrino flux at the SBND front face.

Mean muon-neutrino energy: ~0.8 GeV

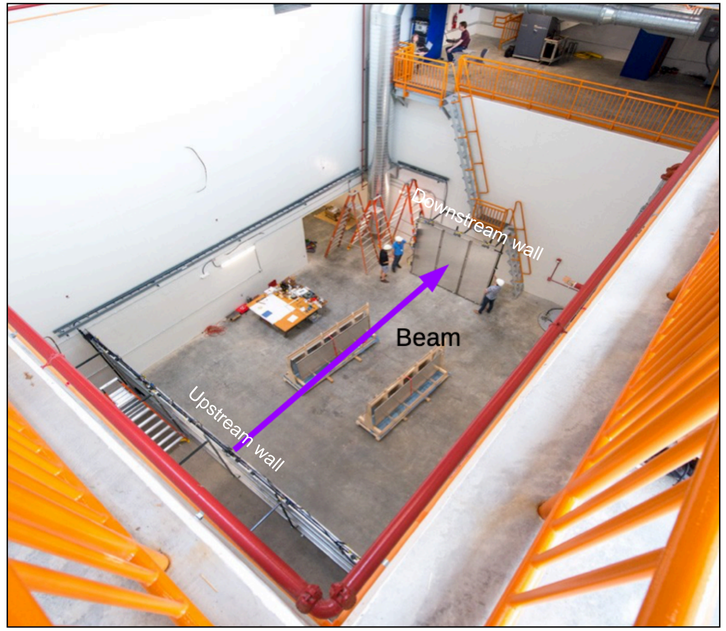
Beam composition:

ν_μ (93.6%)

$\bar{\nu}_\mu$ (5.9%)

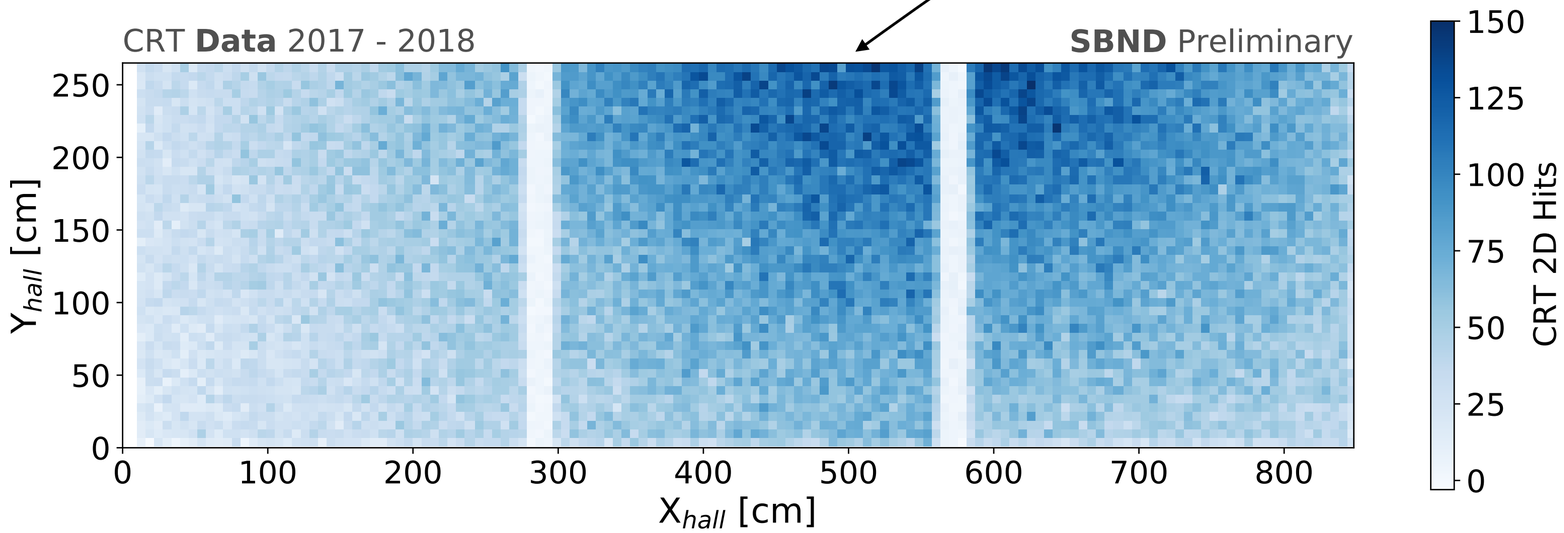
ν_e+$\bar{\nu}_e$ (0.5%)

Cosmic Ray Tagger (CRT) Data



Part of the SBND CRT system was temporary installed in the detector hall and took BNB data in 2017-2018

CRT data: **muons from neutrinos** that interacted in the material upstream of the SBND detector hall. The beam intensity decreases moving away from the beam center.



SBND-PRISM - Neutrino Fluxes

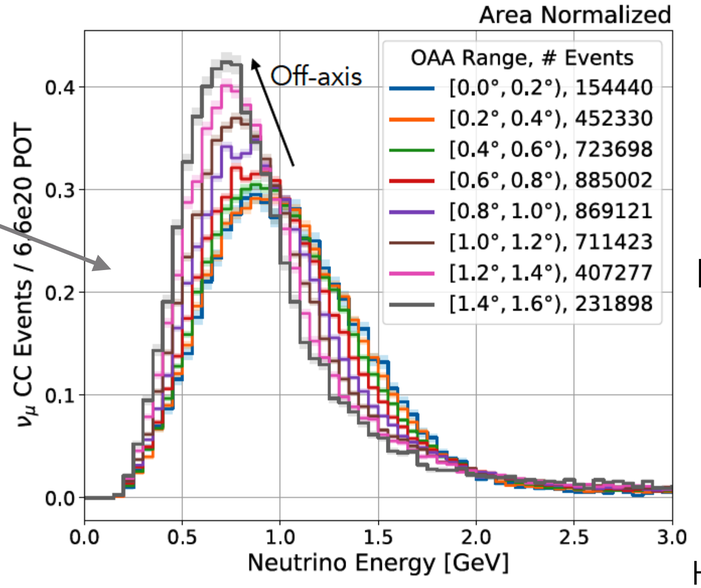
The **Muon** neutrino energy distributions are affected by the off-axis position
[ν_μ come predominantly from two-body decay].
Larger off-axis angle ⇾ lower mean energy.

The **Electron** neutrino energy distributions also change, but they are less affected by off-axis position
[ν_e come from three-body decay].

Muon and electron neutrino spectra change in a different way!

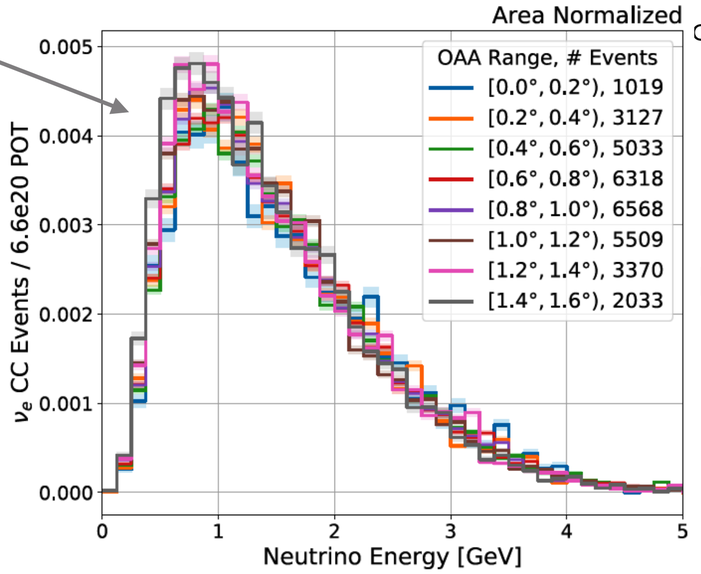
Leveraging the different behavior of muon and electron neutrinos in the OAA regions, we can improve sensitivity for sterile neutrino searches.

Neutrino Fluxes in Off-Axis Angle (OAA) regions



Muon neutrino

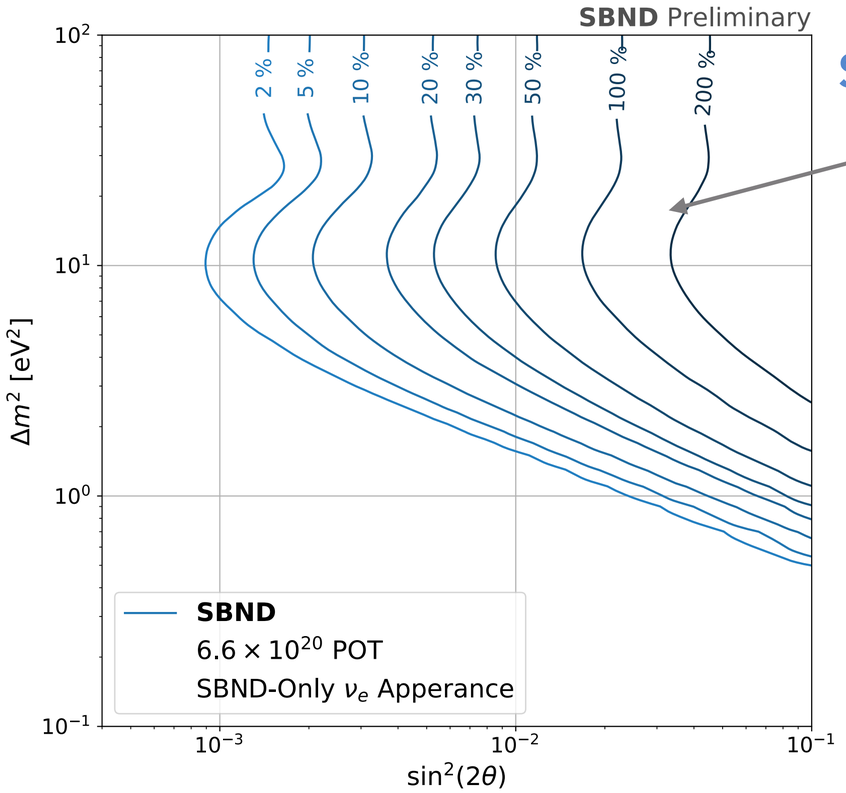
High event statistics in all off-axis regions.



Electron neutrino

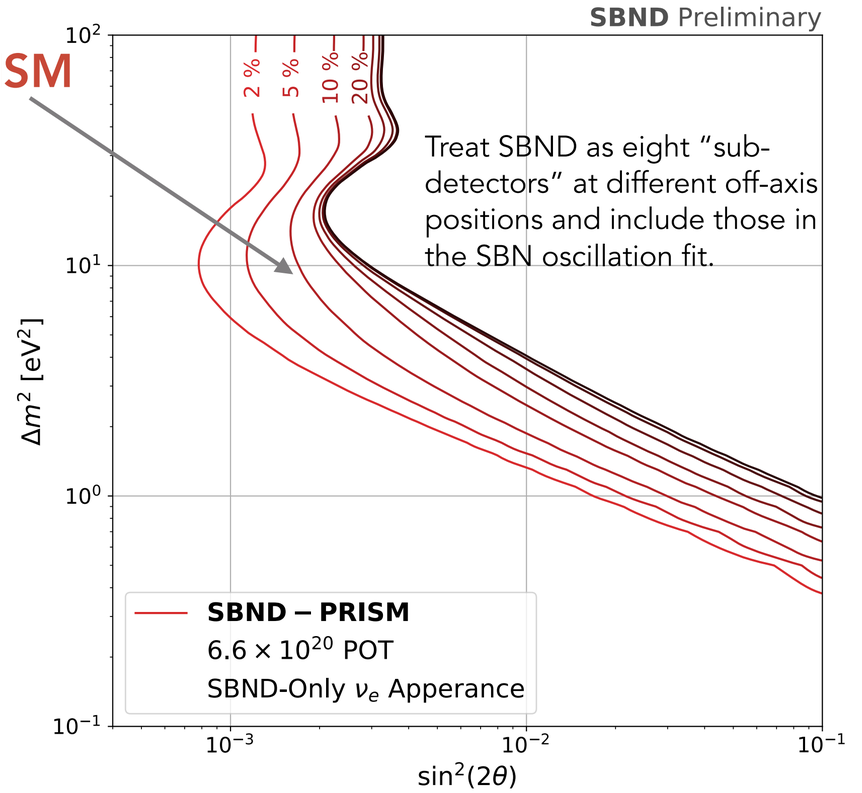
EFFECT OF SBND-PRISM ON OSCILLATION ANALYSES

SBND-only - simplified Oscillation Analysis (ν_e Appearance)



SBND as a single detector vs **SBND-PRISM**

Curves include neutrino flux plus 2-to-200% systematics on total cross section.



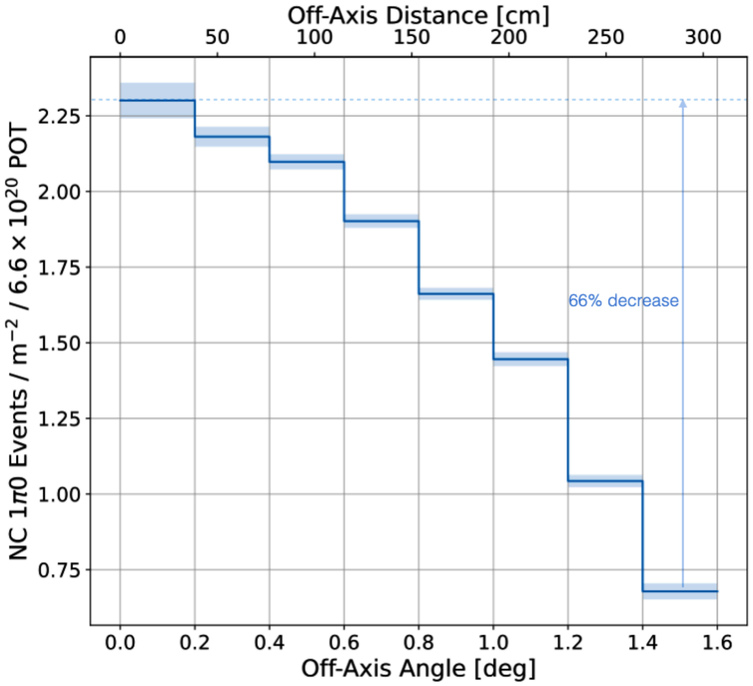
- Improvement in sensitivity by exploiting SBND-PRISM.
- Using the PRISM technique the neutrino interaction model is over-constrained, becoming ~ insensitive to cross section model uncertainties above 20%. Robust against large cross-section uncertainties.

Study of the effect of SBND-PRISM on SBN Sterile neutrino oscillation sensitivities is ongoing.

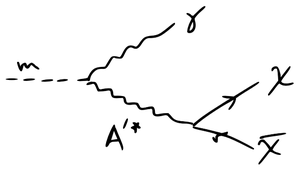
SBND-PRISM to mitigate Backgrounds

An example: electron neutrino measurements

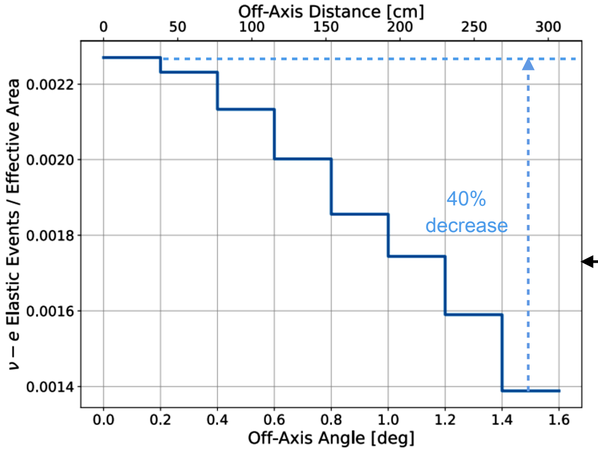
Main background for electron neutrino: NC 1 π^0 events.



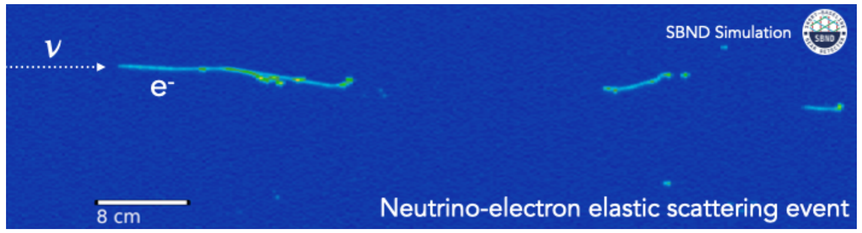
Another example: search for Light (sub-GeV) Dark Matter



Dark photons, produced by the decay of neutral meson (pions, etas) in the target and decay into dark matter.
The dark matter, through the dark photon, **scatter off electrons in the detector**.



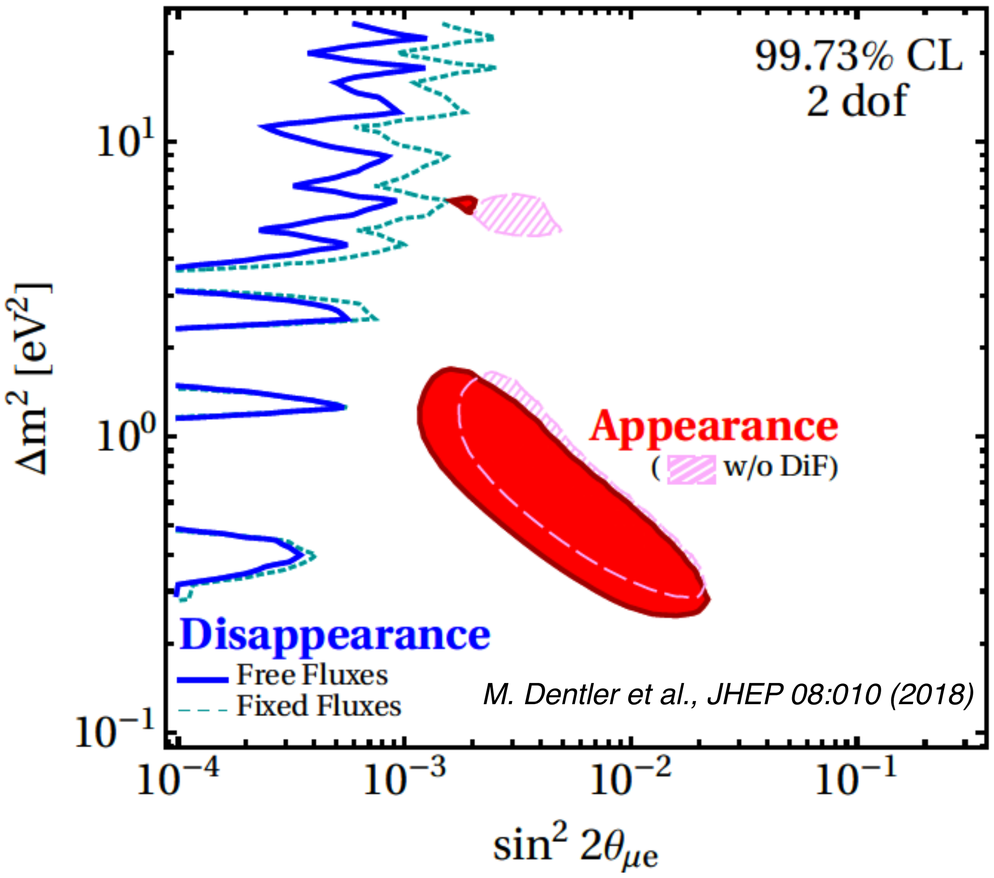
- **Signal**: DM elastic scattering electron events. DM comes from neutral (unfocused) mesons.
- **Background**: neutrino-electron elastic scattering. Neutrinos come from two-body decays of charged (focused) mesons.



SBND-PRISM provides a natural way to **reduce backgrounds by looking off-axis**.

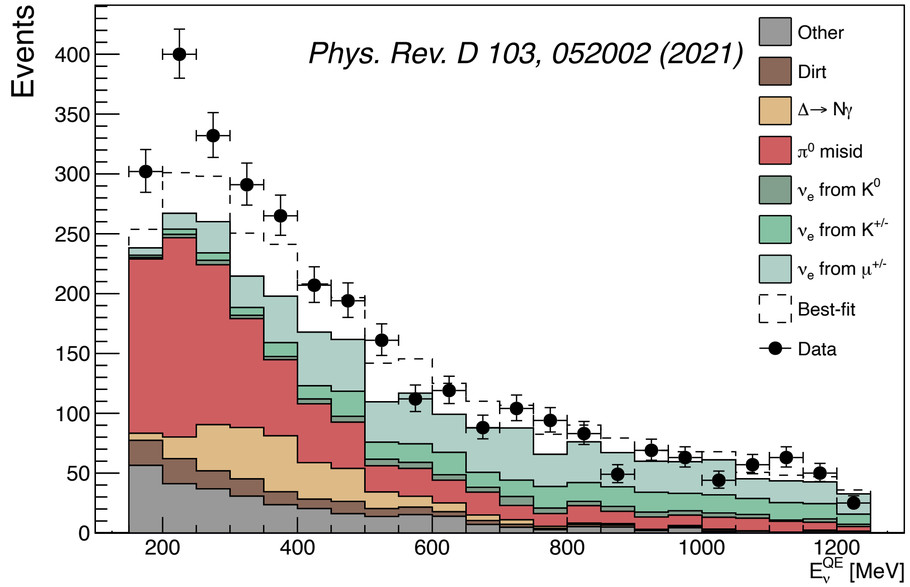
LIGHT STERILE NEUTRINO - EXPERIMENTAL LANDSCAPE

A 4.7 σ tension arises when combining ν_e appearance and ν_μ disappearance data sets.



Limits from disappearance and appearance allowed region

MiniBooNE electron-like excess

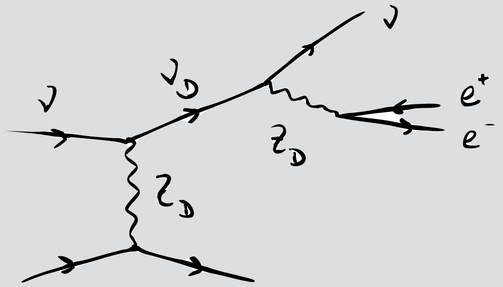


Alternative (Beyond Standard Model) explanations exist that could explain the MiniBooNE (and LSND) anomalies.

Evolving Landscape…

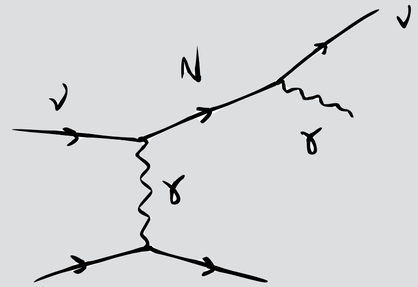
Alternative explanations of the MiniBooNE excess and other Beyond Standard Model scenarios.

Dark Neutrinos



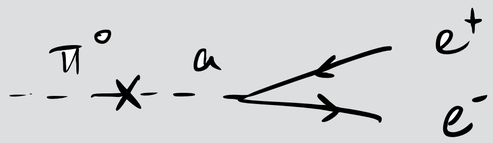
Bertuzzo Jana Machado Zukanovich PRL 2018, PLB 2019
Arguelles Hostert Tsai PRL 2019
Ballett Pascoli Ross-Lonergan PRD 2019
Ballett Hostert Pascoli PRD 2020

Transition Magnetic Moment



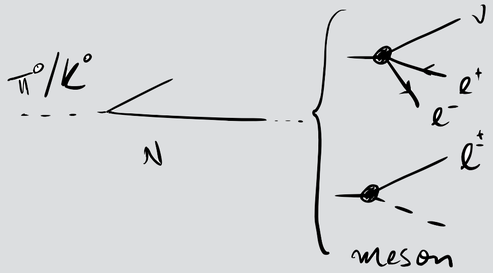
Gninenko PRL 2009
Coloma Machado Soler Shoemaker PRL 2017
Atkinson et al 2021 Vergani et al 2021

Axion-like Particles



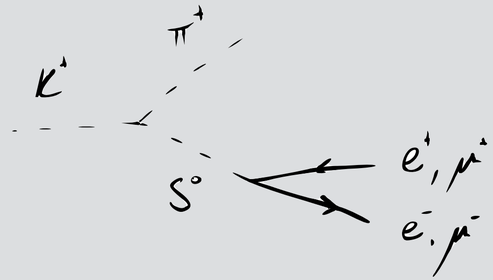
Kelly Kumar Liu PRD 2021
Brdar et al PRL 2021

Heavy Neutral Leptons



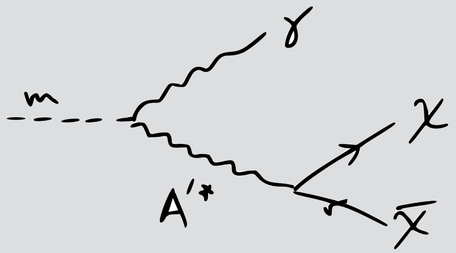
Ballett Pascoli Ross-Lonergan JHEP 2017
Kelly Machado PRD 2021

Higgs Portal Scalar



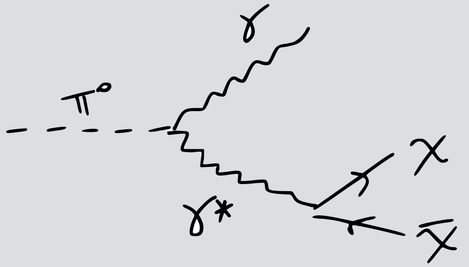
Pat Wilczek 2006
Batell Berger Ismail PRD 2019
MicroBooNE 2021

Light Dark Matter



Romeri Kelly Machado PRD 2019

Millicharged Particles



Magill, Plestid, Pospelov, Tsai, PRL 2019
Harnik Liu Palamara, JHEP 2019

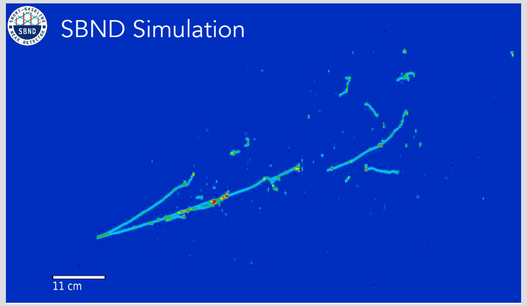
Note: not an exhaustive list!

Image credit P. Machado and M. Del Tutto

Signatures for New Physics in SBN

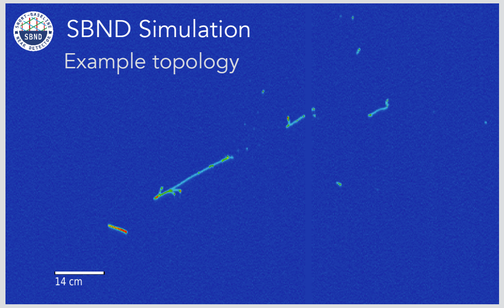
Collaboration between experimentalists and theorists is crucial for these searches.

Dark Neutrinos



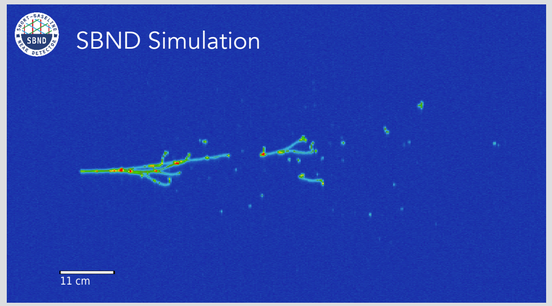
e+e- pair w/ or w/o hadronic activity

Transition Magnetic Moment



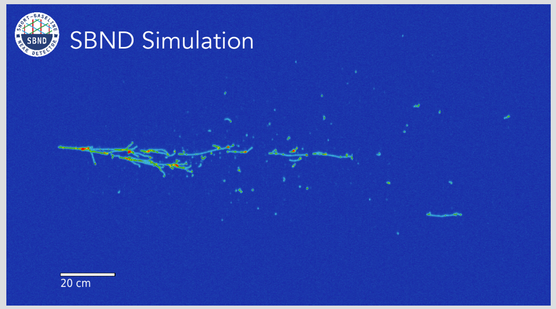
photon shower and hadronic activity

Axion-like Particles



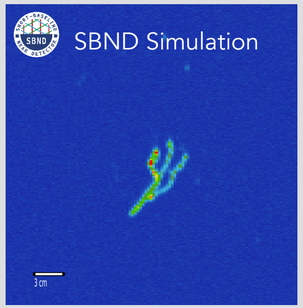
high-energy e^+e^-, $\mu^+\mu^-$

Heavy Neutral Leptons



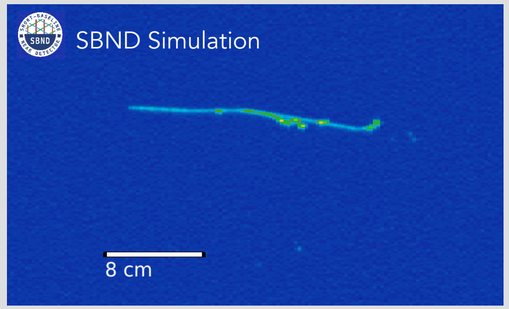
e^+e^-, $\mu^+\mu^-$, $\mu\pi$

Higgs Portal Scalar



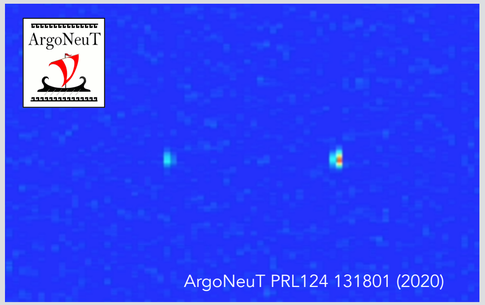
e^+e^-, $\mu^+\mu^-$, no hadronic activity

Light Dark Matter



electron scattering

Millicharged Particles



blips/faint tracks

Search for Millicharged Particles in SBND

Millicharged particles would appear in SBND as **blips** or **faint tracks** pointing back to the target.
Projected SBND threshold: 50 keV

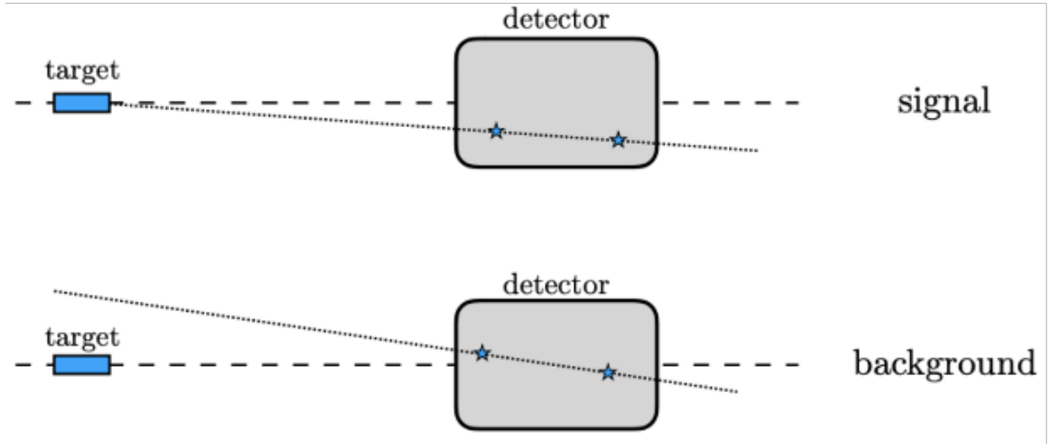
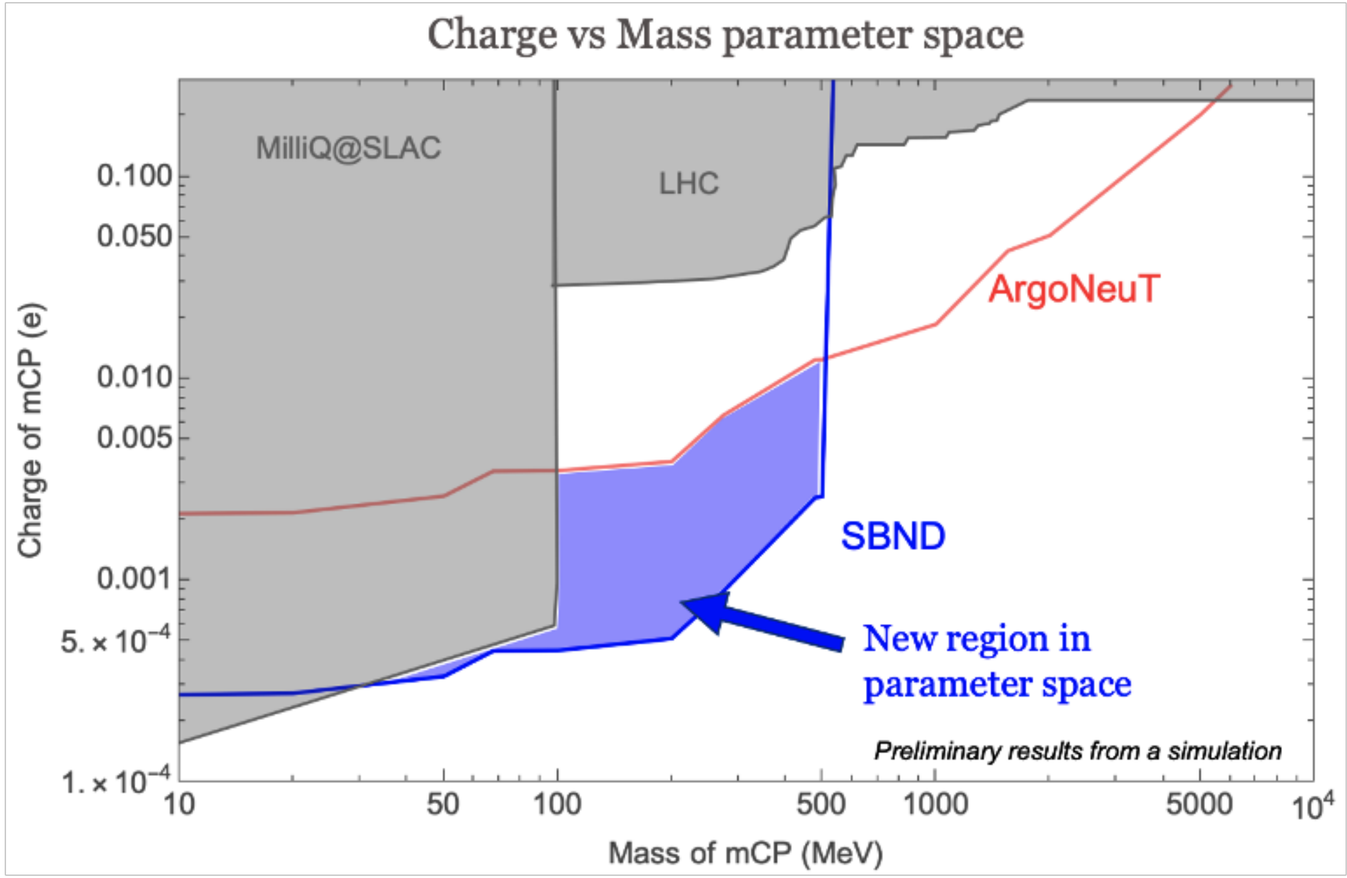
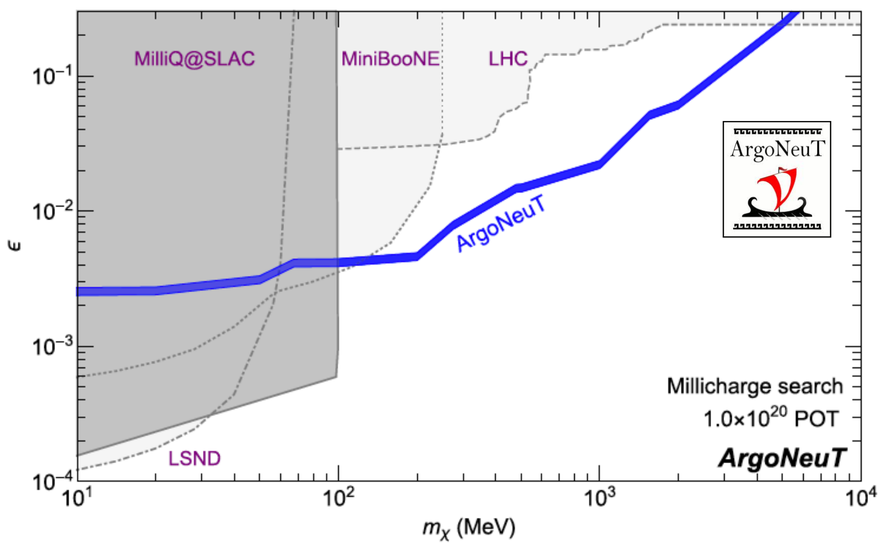


Image credit: ArgoNeuT, PRL124 131801 (2020)



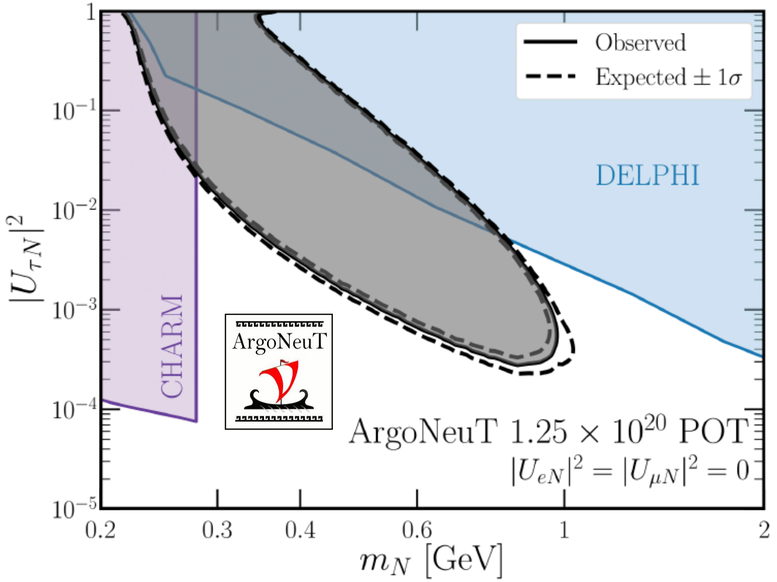
Search for New Physics in LAr Detectors

Millicharged Particles



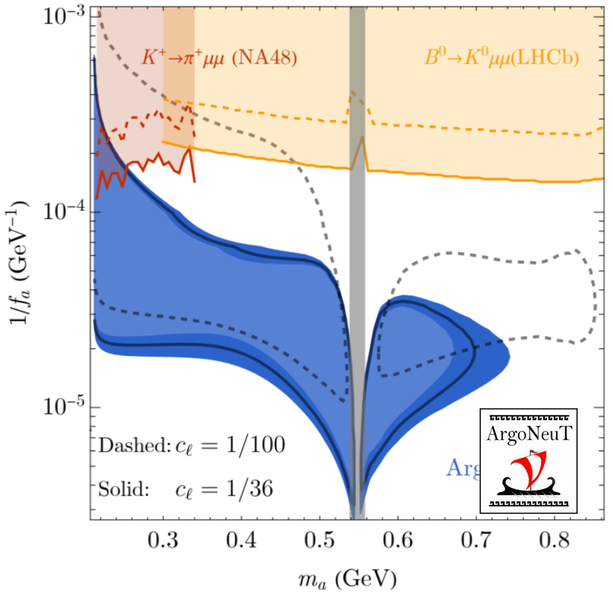
R. Acciarri et al., PRL124 131801 (2020)

Heavy Neutral Leptons N→$\nu\mu^+\mu^-$



R. Acciarri et al., PRL 127 121801 (2021)

Heavy QCD Axions



R. Acciarri et al., https://arxiv.org/abs/2207.08448

ArgoNeuT: small LAr TPC - 0.24 t - exposed to the NuMI beam at Fermilab for 5 months.

MicroBooNE:

- **Heavy Neutral leptons** (N→$\mu^\pm\pi^\mp$ decay channel in a delayed time window)

  P. Abratenko et al., PRD 101 052001 (2020)

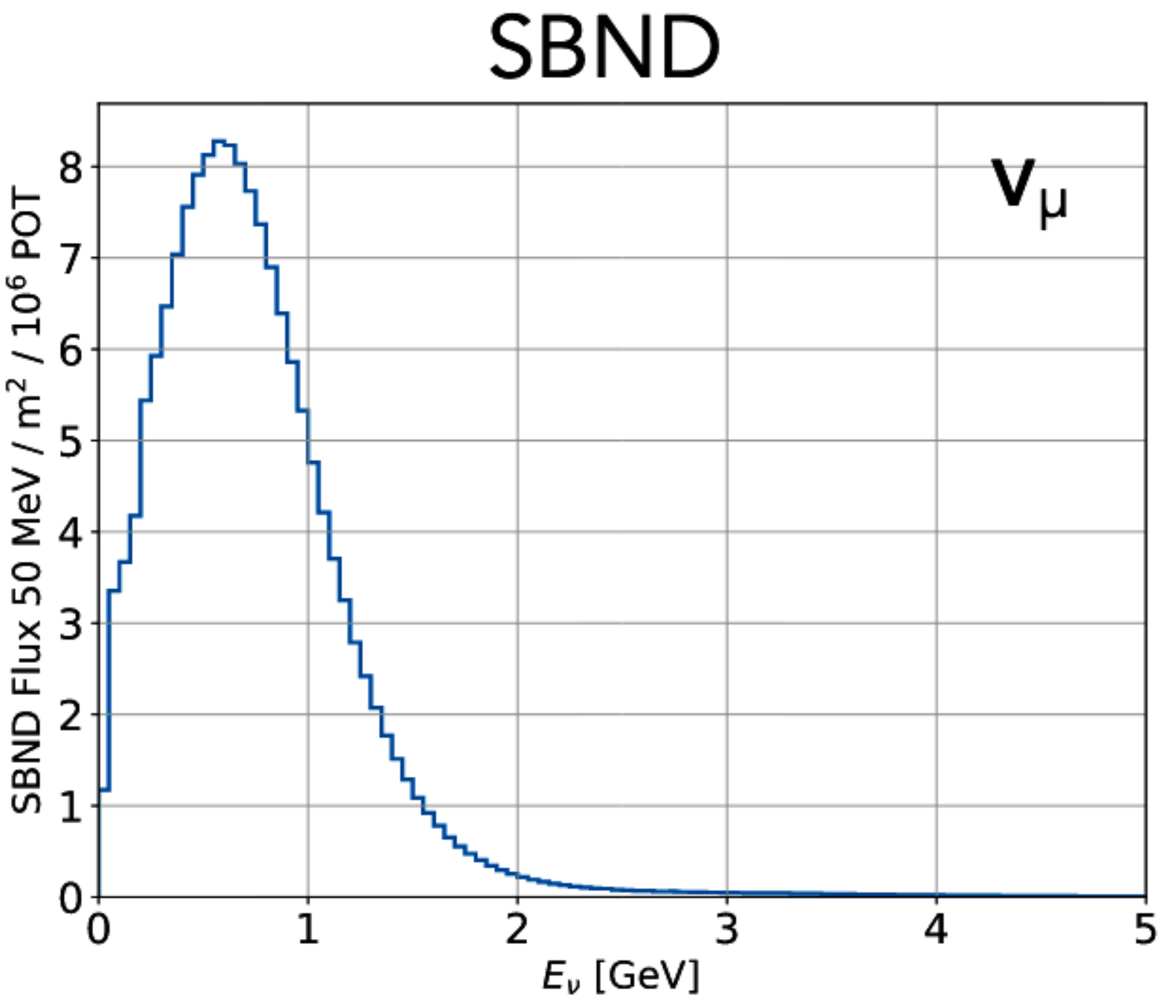
- **Higgs scalar portal** (e^+e^- final state from NuMi off-axis events)

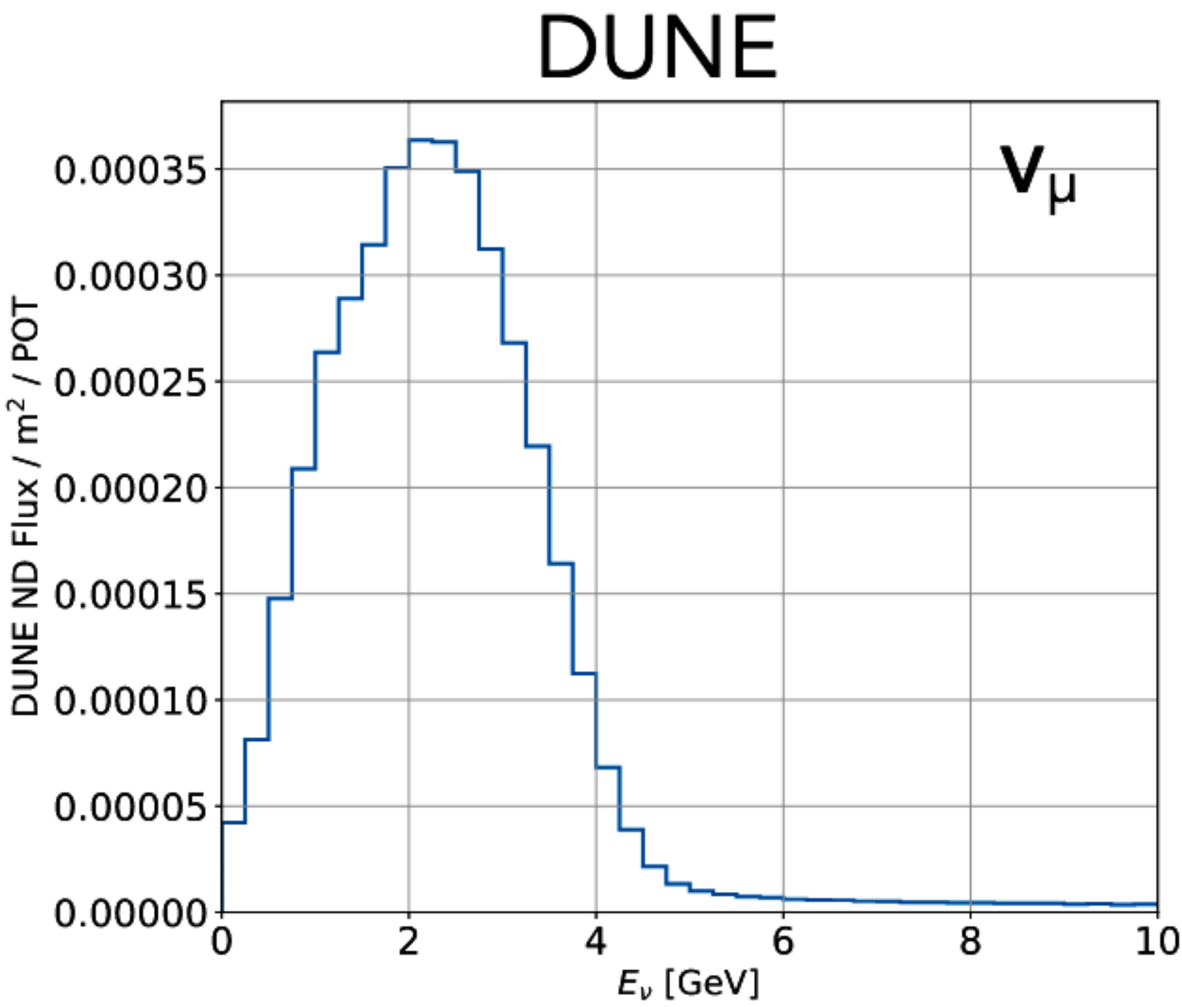
  P. Abratenko et al., PRL 127 151803 (2021)

  Results recasted to constraint **Heavy Neutral Leptons**

  K. Kelly and P. Machado, arXiv:2106.06548

SBND/DUNE Energy Spectra

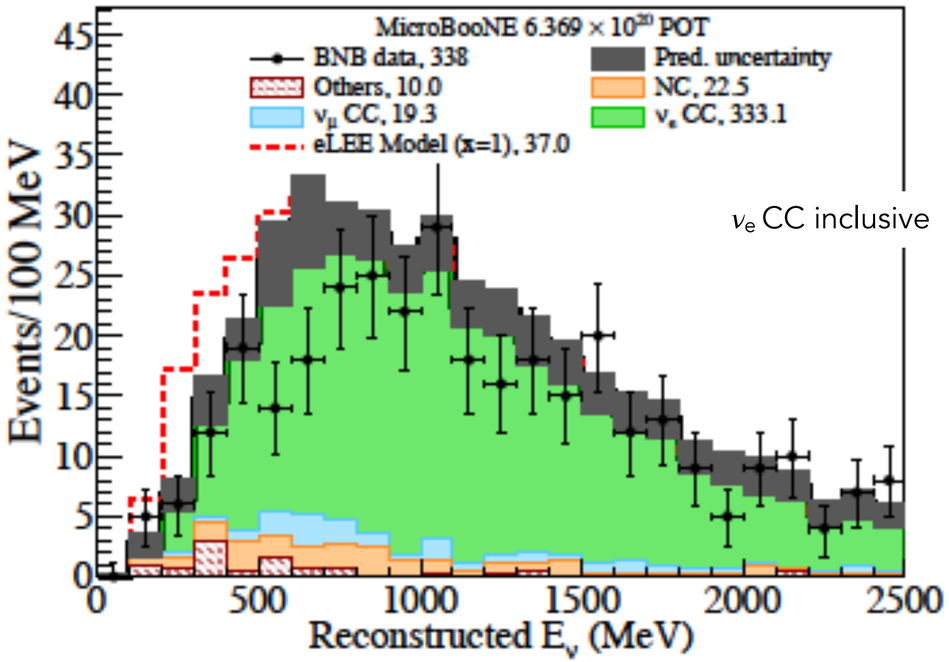




STERILE NEUTRINO SEARCHES BEYOND MICROBOONE

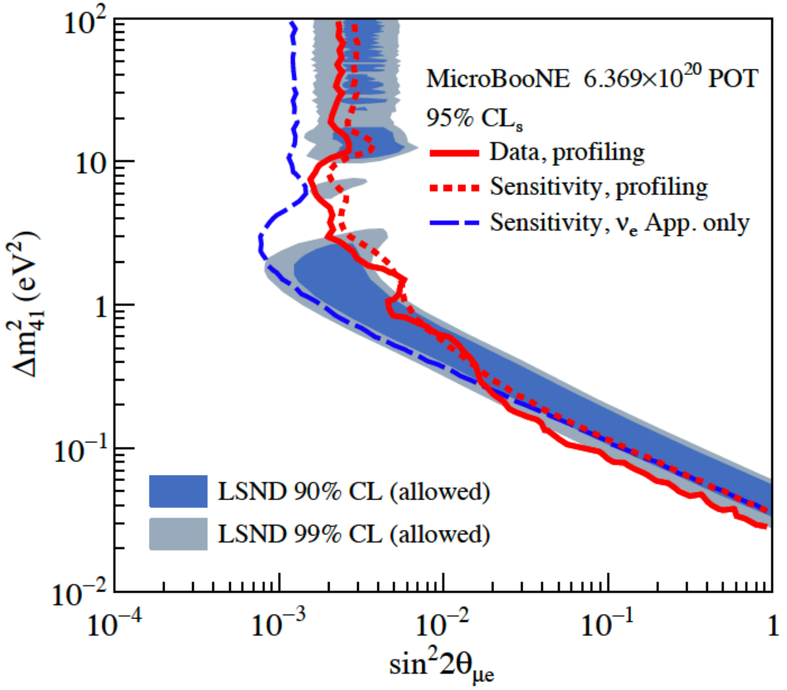
The MicroBooNE experiment presented very interesting results of first analyses searching for an excess of low-energy electromagnetic events:
no hints of an electromagnetic event excess, but results **do not rule out existence of sterile neutrinos**.

P. Abratenko et al., Phys. Rev. Lett. 128, 241801



ν_e CC inclusive

P. Abratenko et al., https://arxiv.org/abs/2210.10216



Entering the **next phase** now, with a **Near detector** and a **larger Far detector**.