FERMILAB-SLIDES-25-0120-PPD

Fermilab

FERMI NATIONAL ACCELERATOR LABORATORY

Status of the Short-Baseline Near Detector at Fermilab

Josephine Paton

On behalf of the SBND Collaboration

Weak Interactions and Neutrinos 2025

10th June 2025

U.S. DEPARTMENT of ENERGY

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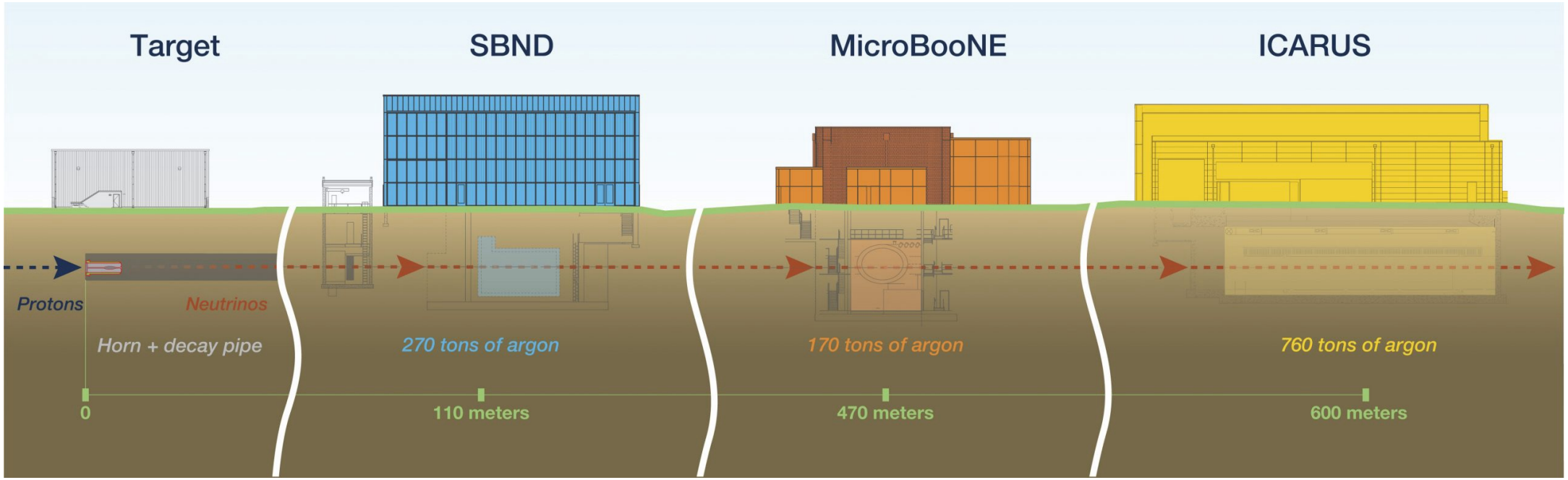
The SBN Program at Fermilab

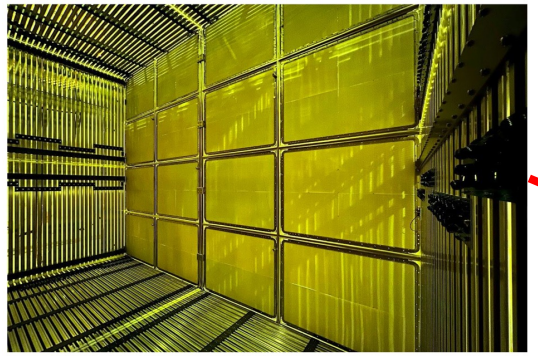


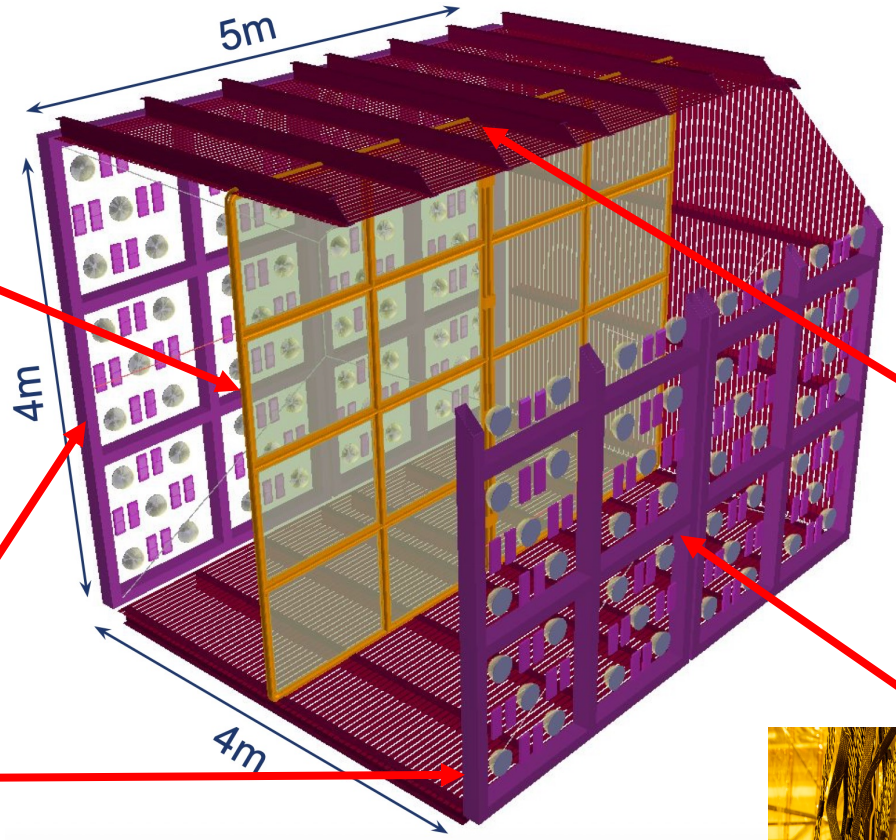
- The **S**hort **B**aseline **N**eutrino program comprises of two LArTPCs, SBND and ICARUS, along the Booster Neutrino Beam (BNB) at Fermilab on either side of MicroBooNE
- The program aims to resolve the anomalous Low Energy Excess seen at MiniBooNE but not observed by MicroBooNE
- By using the same detector technology, target nucleus, and beamline, the SBN program can constrain systematic uncertainties to the %-level

SBND – The LArTPC

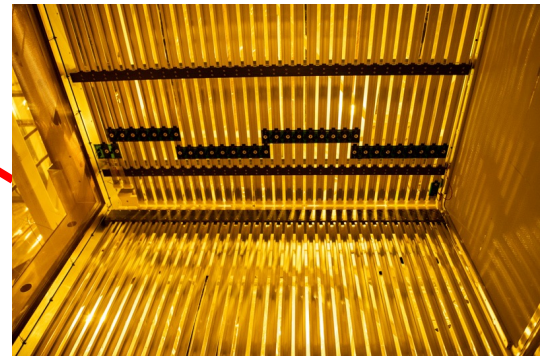
Two drift volumes
Active volume of 112t

Central Cathode Plane



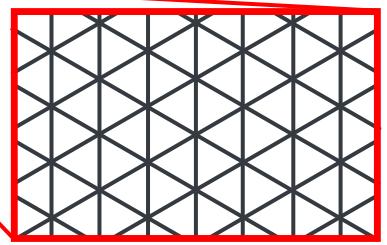


Field Cage

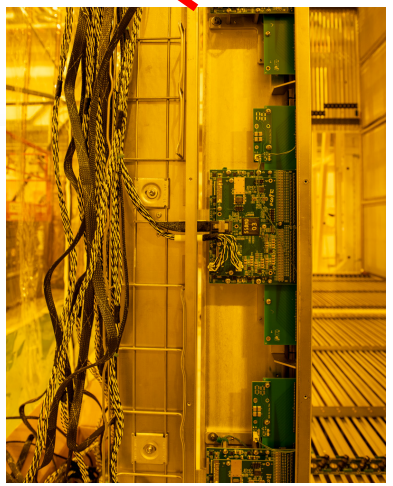


500 V/cm field across TPC

Anode Planes



Three wire planes
$\theta = 0^\circ$, $\pm 60^\circ$
Spacing 3mm
11,264 total wires
JINST 15, P06033 (2020)

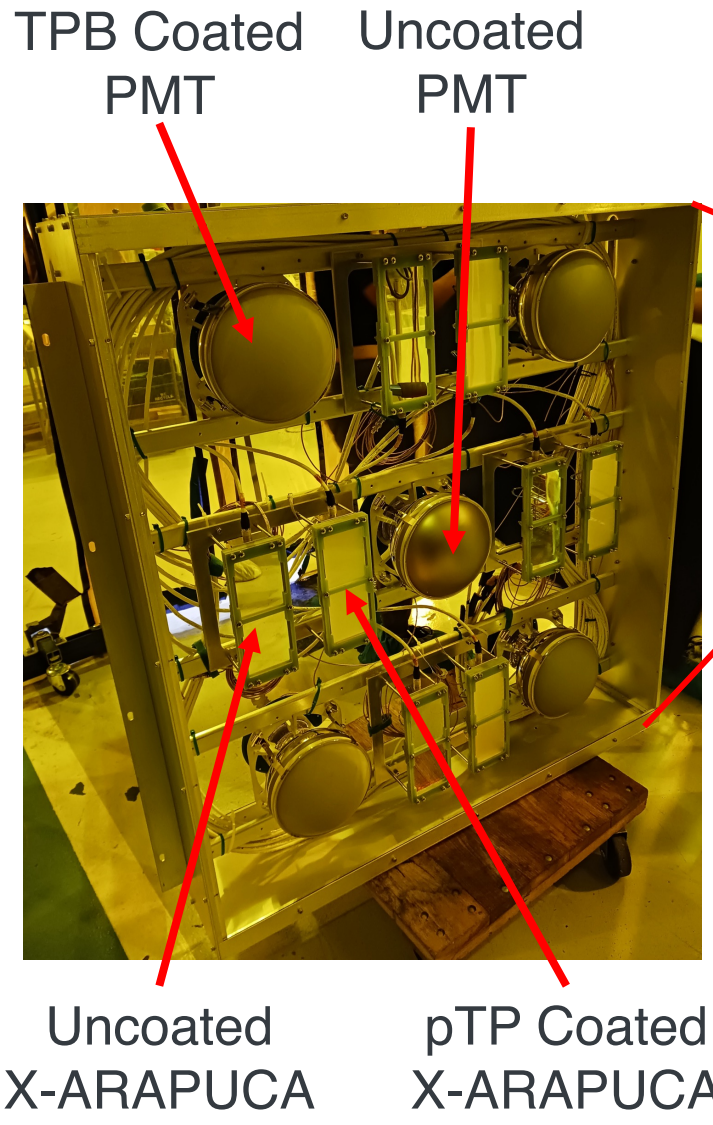


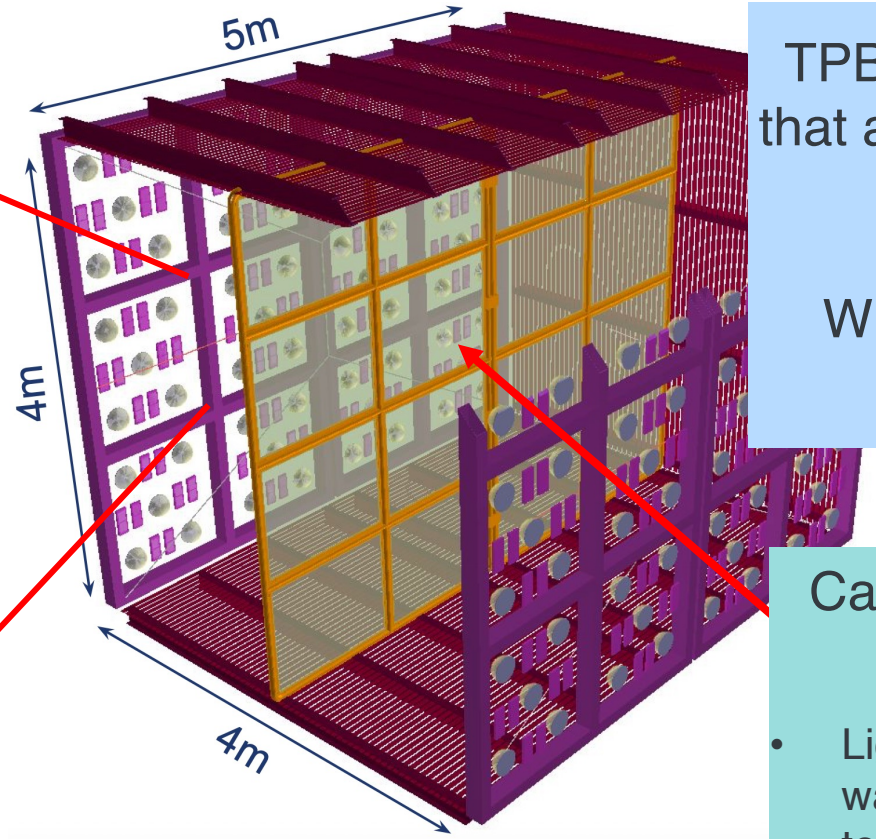
Cold electronics

Operation at 89K for LAr

Low noise preamplification and digitisation

SBND – Photon Detection System





24 PDS modules

5 PMTs per module
8 X-ARAPUCAs per module

TPB and pTP are wavelength shifters that allow the detection of VUV photons from LAr scintillation

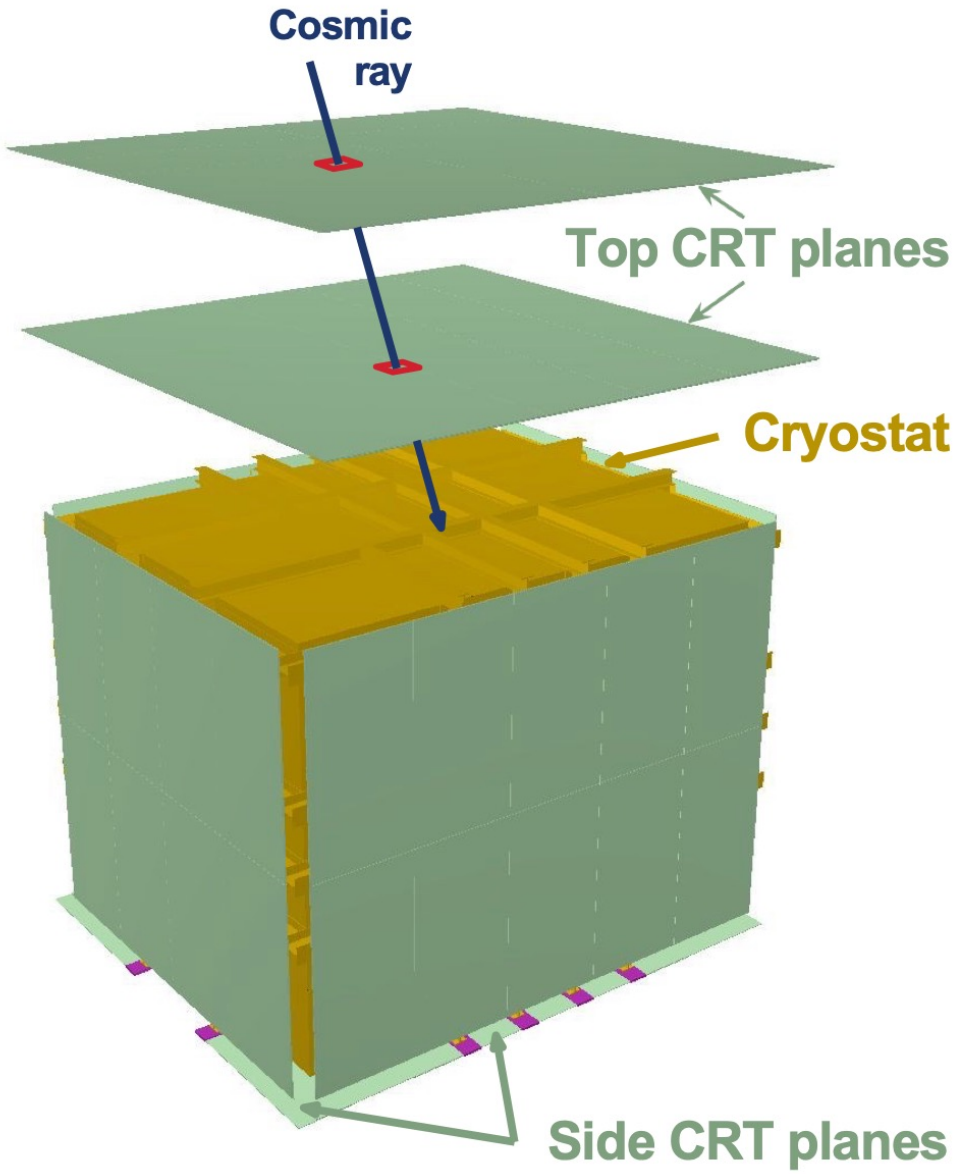
Why leave some photon detectors uncoated?

Cathode plane is covered with TPB coated reflective foils

- Light emitted towards the cathode plane is wavelength shifted and reflected back towards the photon detectors
- This is detected by all photon detectors, including uncoated ones!
- Not only able to collect reflected light, but have ability to distinguish for the purposes of reconstruction

Eur. Phys. J. C 84, 1046 (2024)

SBND – Cosmic Ray Tagger



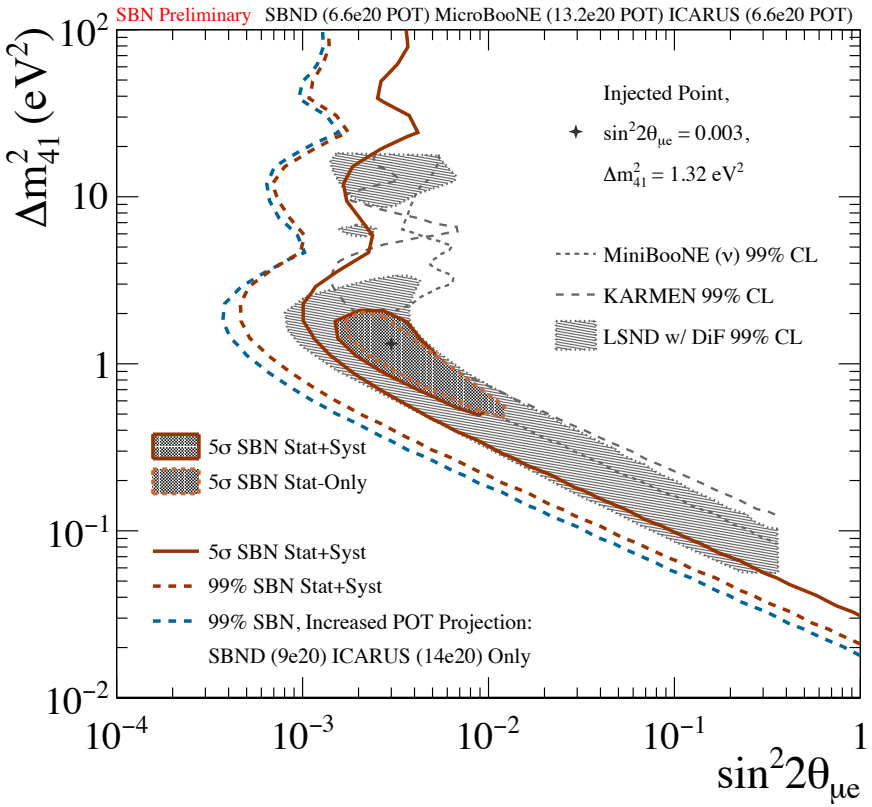
SBND is surrounded by 7 CRT walls for 4π coverage

- As a surface detector, SBND has a high cosmic rate
- Accurate tagging is necessary for background reduction
- 2 top CRT planes allow telescopic detection
- Each CRT plane is comprised of orthogonal scintillator strips for position reconstruction

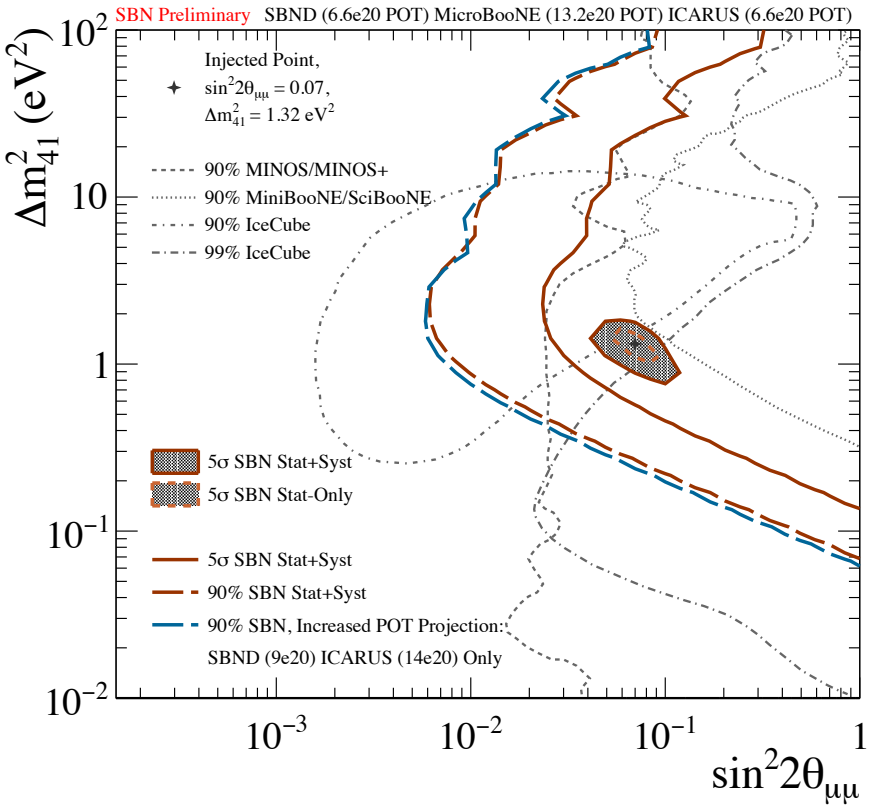
SBND Physics Program

SBN Neutrino Oscillations

ν_e appearance



ν_μ disappearance



External contours from:
JHEP 08, 010 (2018)
Phys. Rev. D 85, 032007 (2012)
Phys. Rev. Lett. 122, 091803 (2019)
Phys. Rev. D 102, 052009 (2020)

arXiv:2504.00245

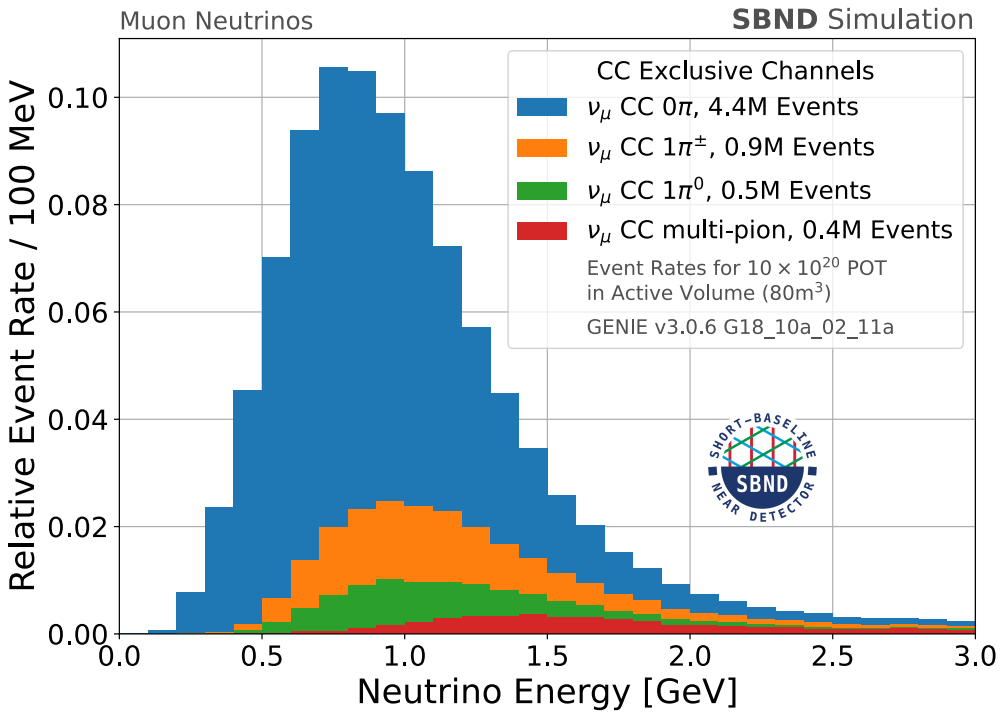
- SBND will be the near detector for the SBN oscillation measurement, tightly constraining beam and cross section systematic uncertainties
- Must include both ν_e appearance and ν_μ disappearance to conclusively address the sterile neutrino solution to the short baseline anomaly

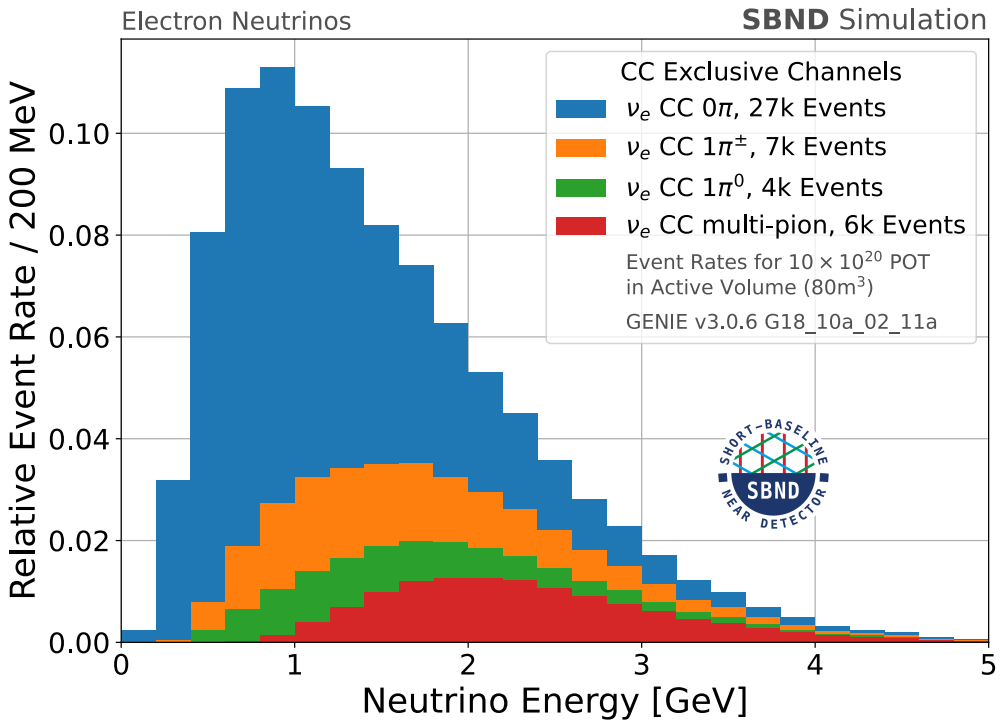
Neutrino Interactions

- Since December, SBND has collected the world's largest ν-Ar interaction dataset
  - Rate of ~7000 events per day
  - Total dataset predicted to be ~10 million events (CC + NC)
- Large statistics means highly precise, multi-dimensional cross section measurements can be made

Talk by Amy Filkins

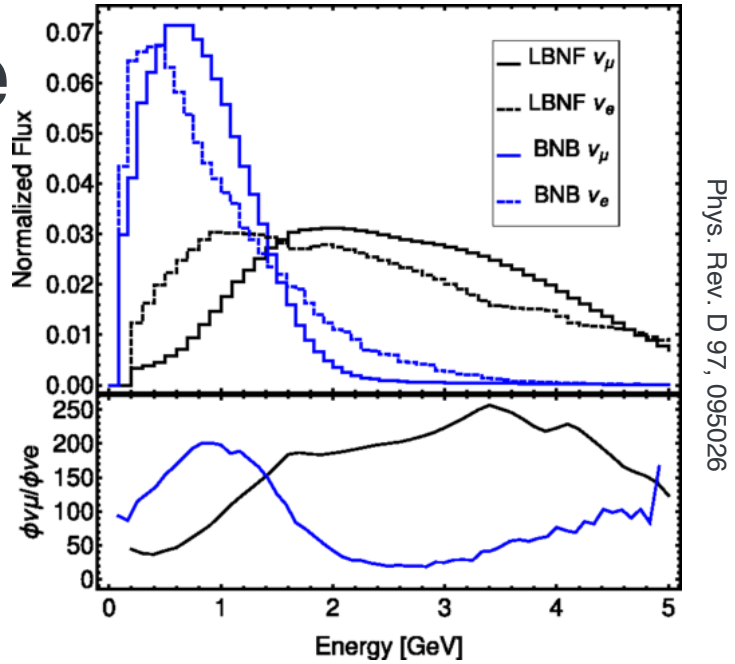
Wed 11/6 11:45am



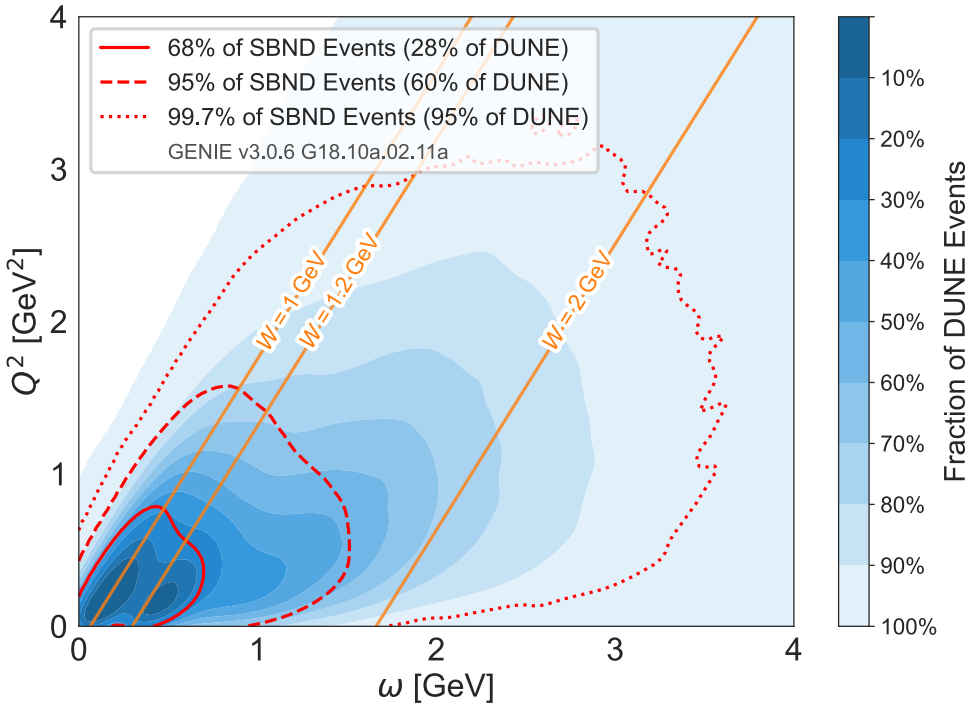


DUNE Phase Space Coverage

- Despite the expected neutrino energies for LBNF being higher than for BNB, SBND has significant kinematic phase space overlap with DUNE
- Additionally, the flux for BNB peaks near the second oscillation maximum for DUNE (~0.8GeV)
- Measurements at SBND can be used to crucially constrain cross section uncertainties at DUNE

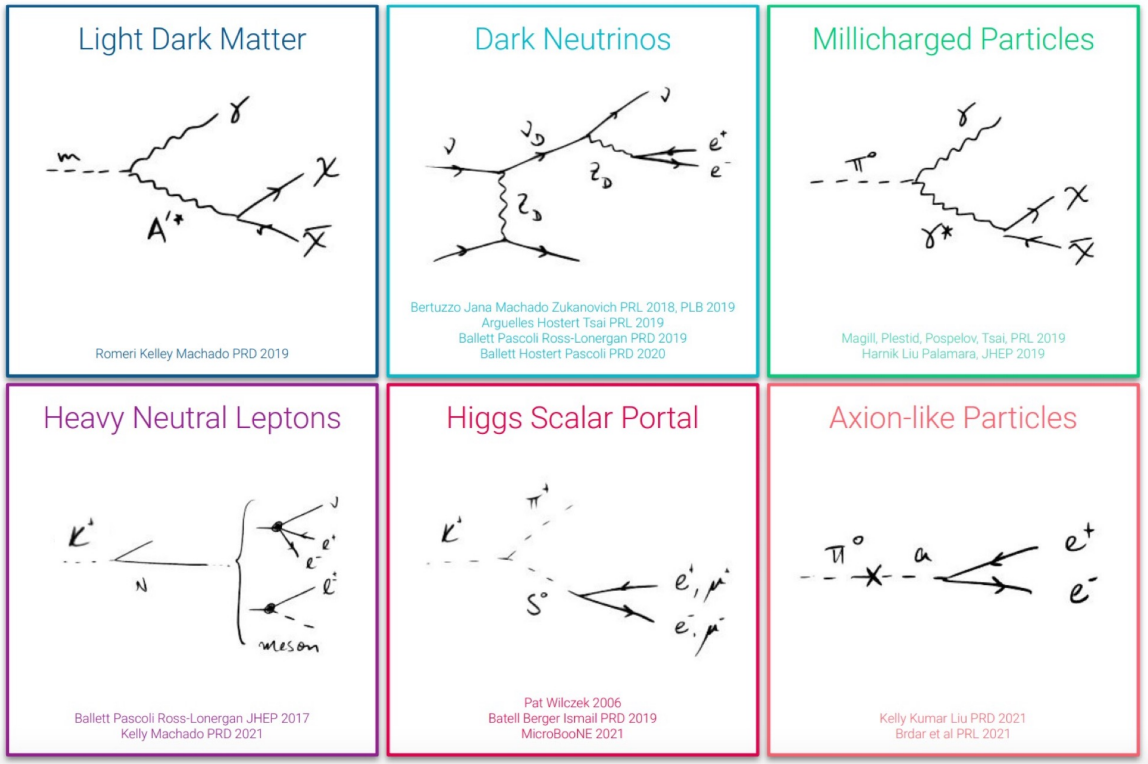


Phys. Rev. D 97, 095026



Beyond the Standard Model

- SBND's proximity to the beam and high statistics create an opportunity to search for low-mass, low-coupling BSM particles
- Developing advanced timing reconstruction based on scintillation light will help separate massive long-lived particles from neutrinos based on time of flight



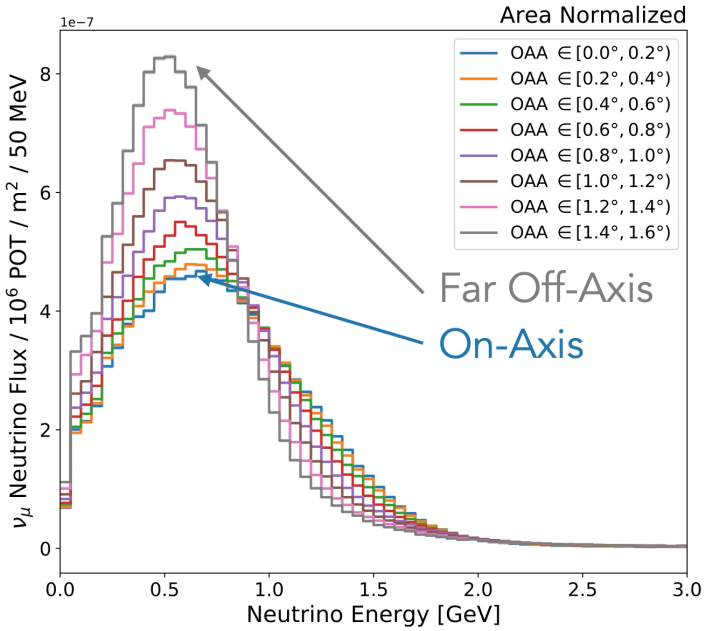
- Competitive sensitivities to many dark-sector particles
- Ongoing efforts to carry out searches using more model-independent approaches
- Working closely with theorists to realise these searches

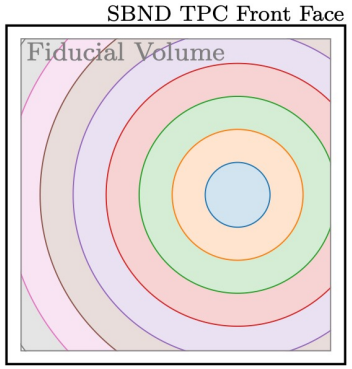
Image credit: Pedro Machado, Marco Del Tutto

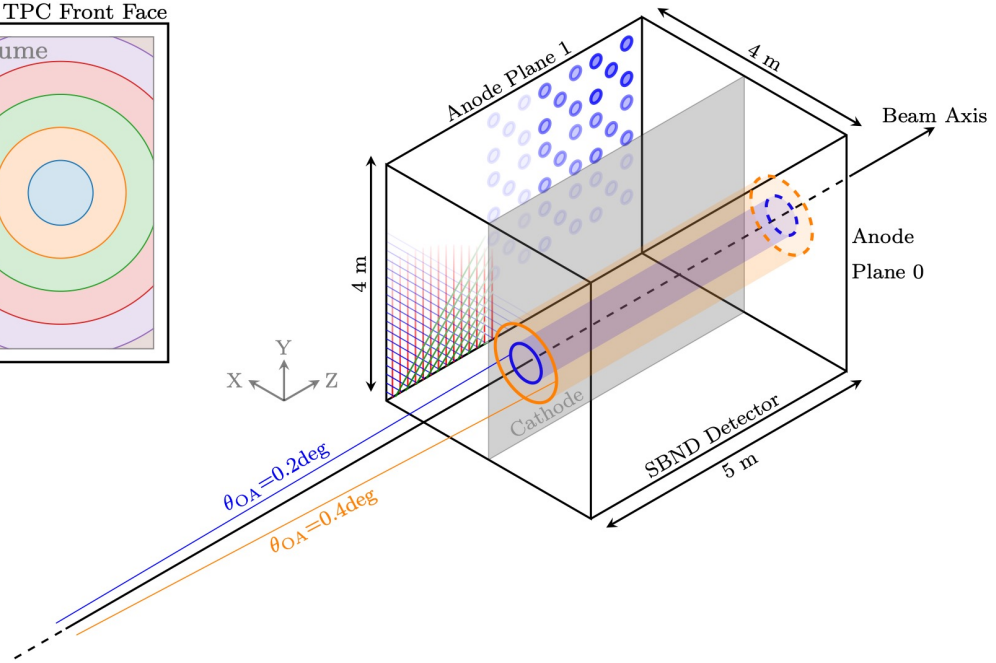
SBND PRISM

Talk by Vincent Basque
Tues 10/6 4pm

- **P**recision **R**eaction **I**ndependent **S**pectrum **M**easurement
- SBND's proximity to the beam and 74cm offset mean that it covers an angular range of [0°,1.6°]
- The detector can be divided into 0.2° slices from the beam axis to explore the changing ν_μ energy spectrum







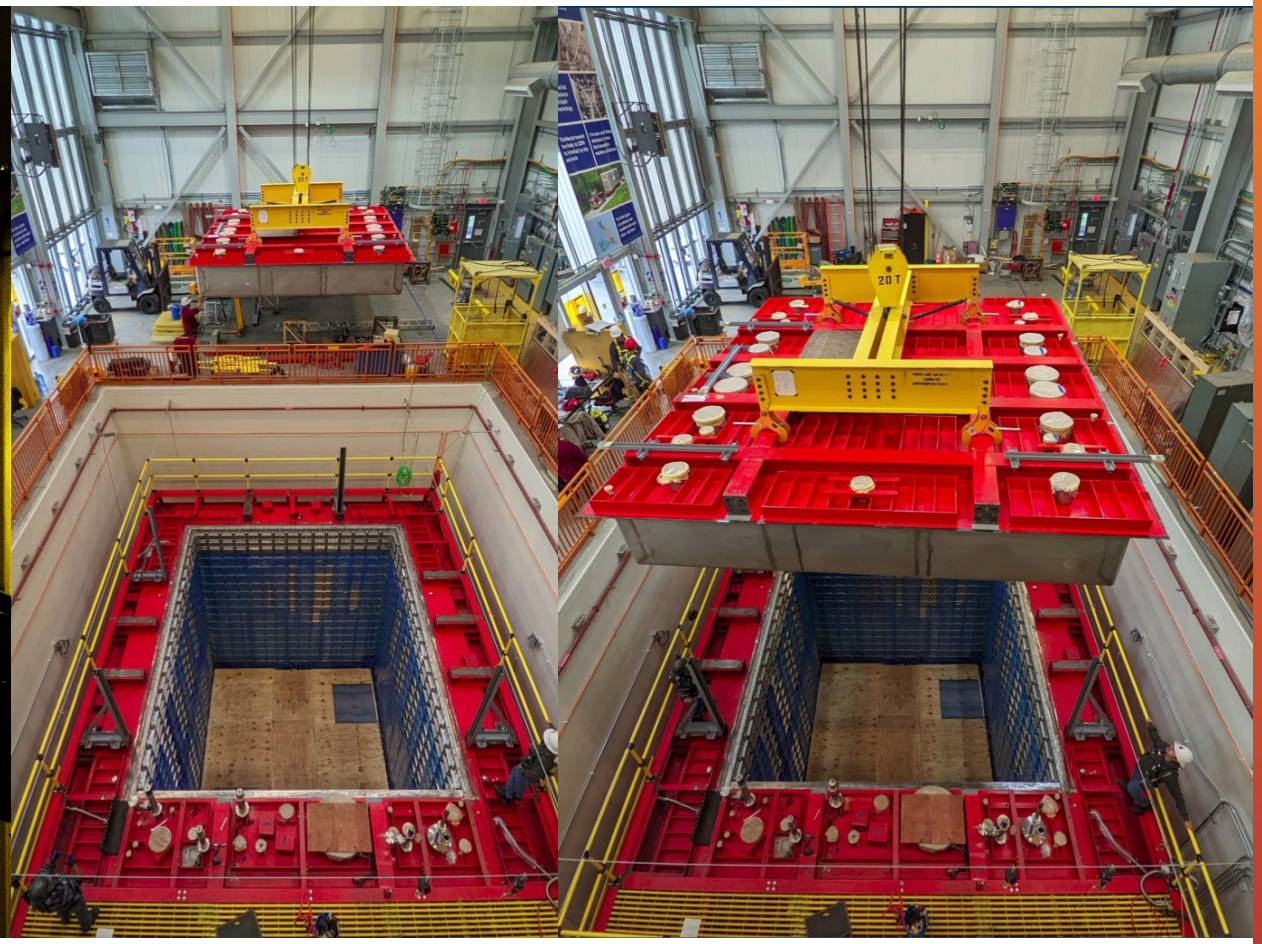
Status of SBND

SBND Timeline

September 2022

TPC and PDS Completed

October 2022



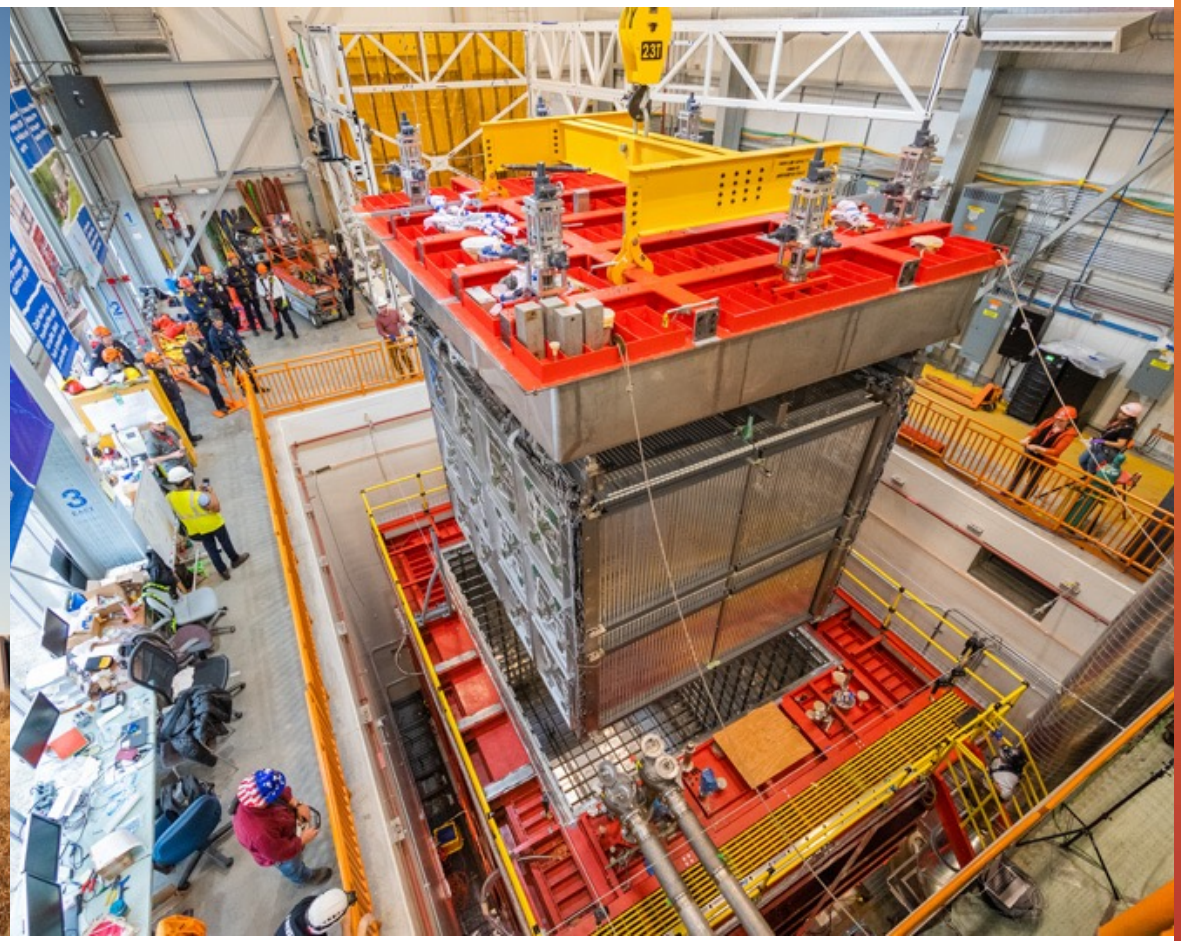
Cryostat Completed at ND Building

SBND Timeline

December 2022

TPC Transported to ND Building

April 2023



TPC Lowered into Cryostat

SBND Timeline

March 2024

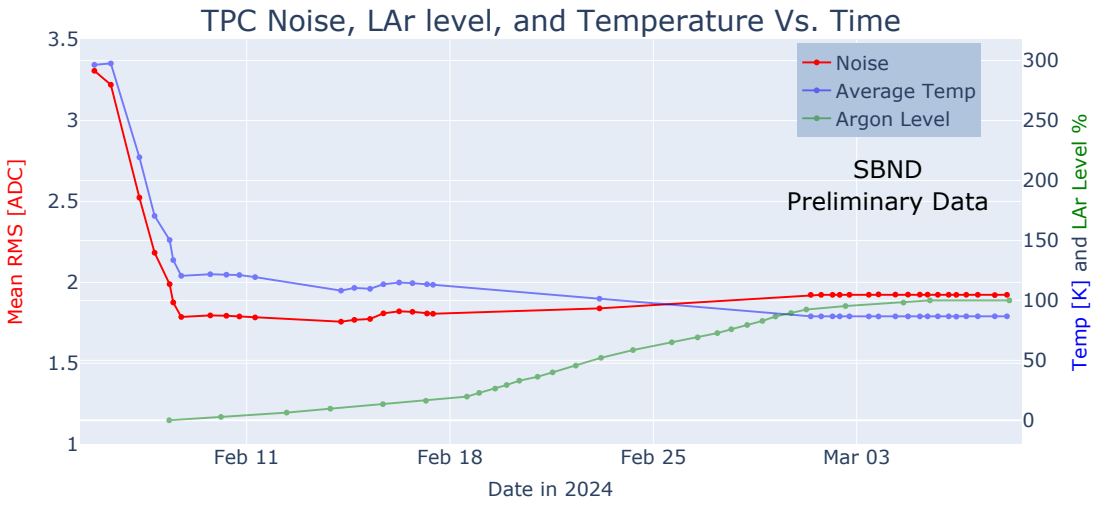
Detector Filled with LAr

July 2024

Successfully Ramped to 500V/cm

SBND Current Status

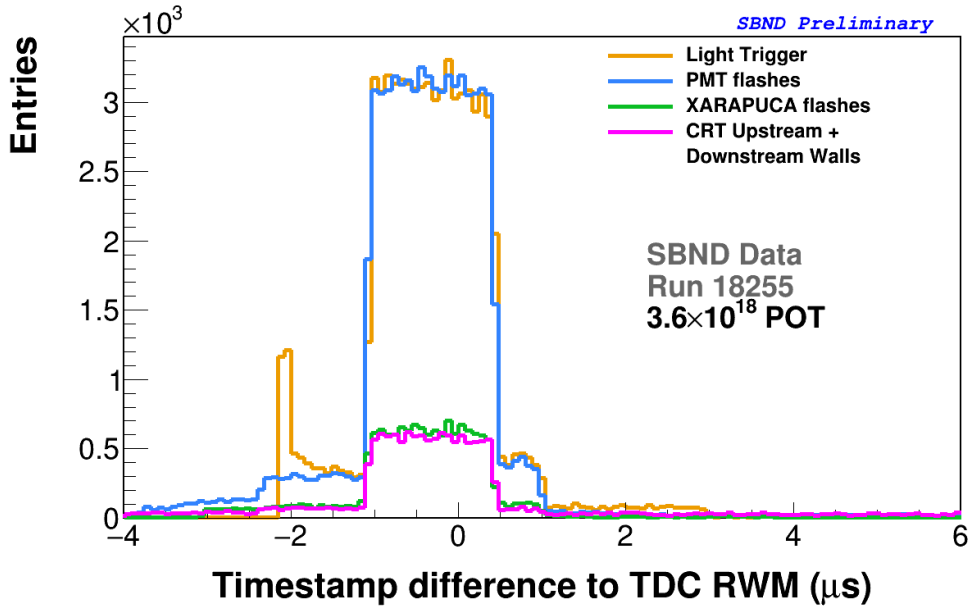
Demonstrating very low noise



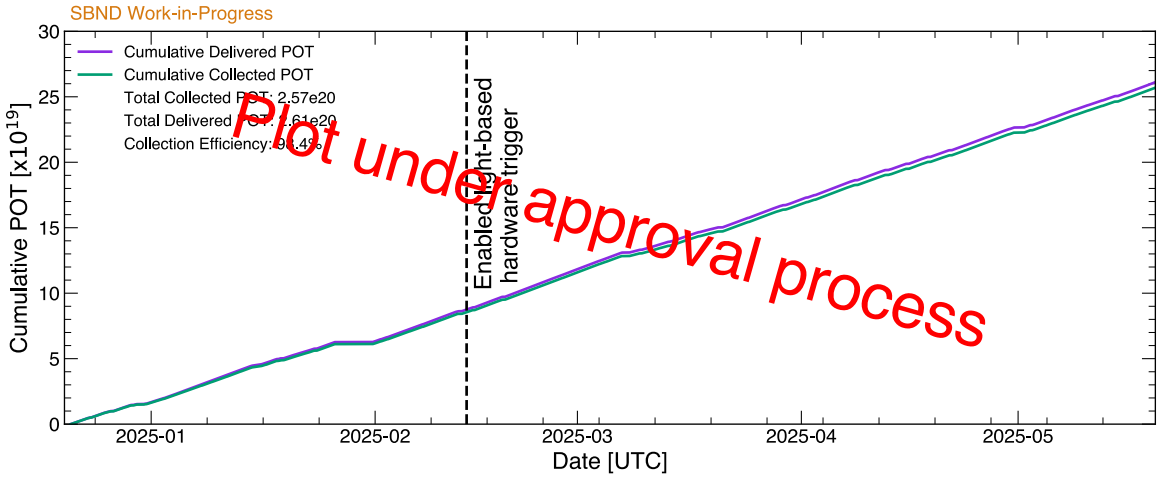
Talk by Lauren Yates
Thurs 12/6 11:30am

Talk by Lynn Tung
Tues 10/6 11:15am

Visible beam pulses in multiple subsystems



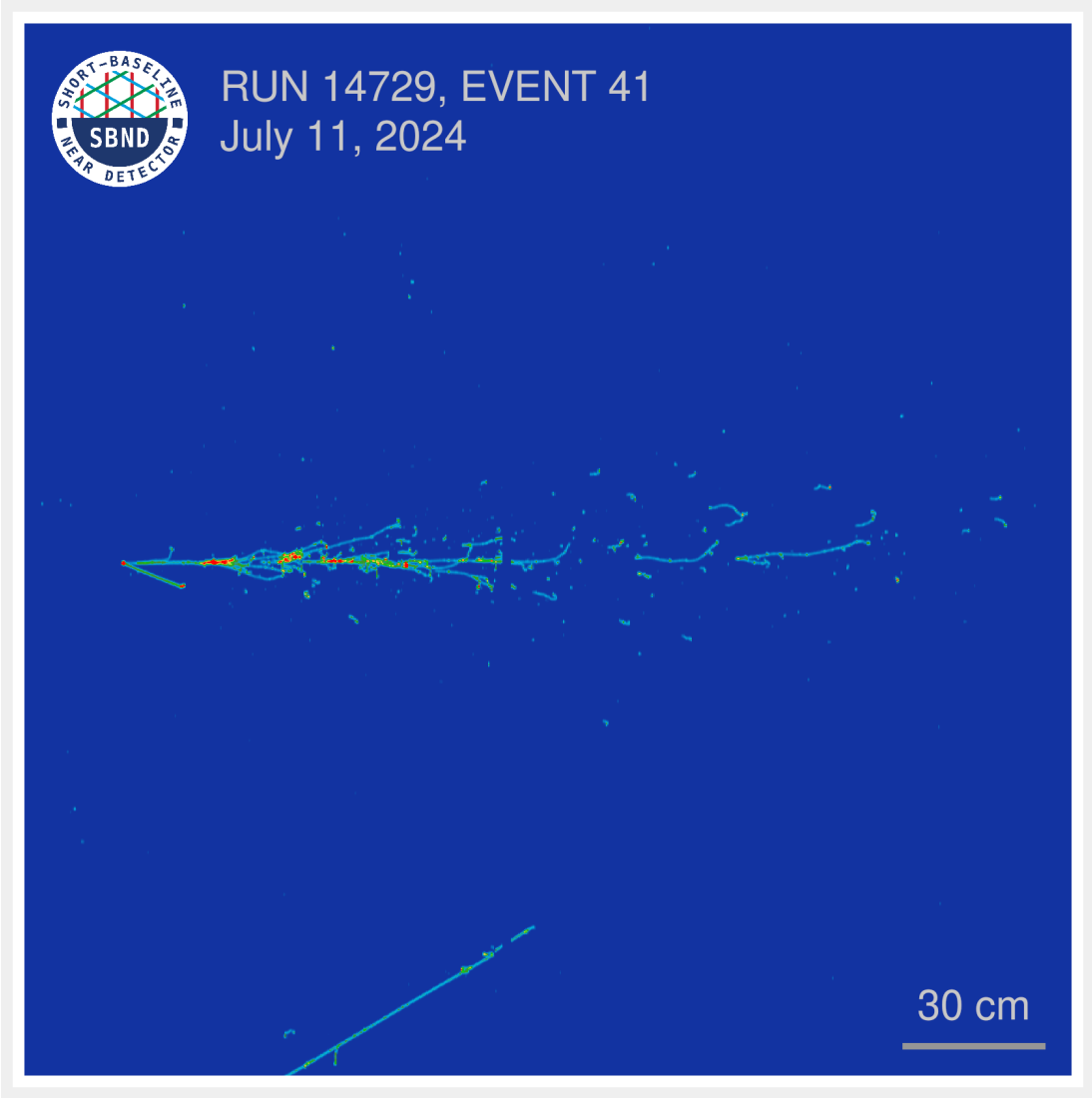
SBND Cumulative POT through May 20, 2025



Collecting lots of data with high efficiency!

SBND Current Status – Neutrinos!

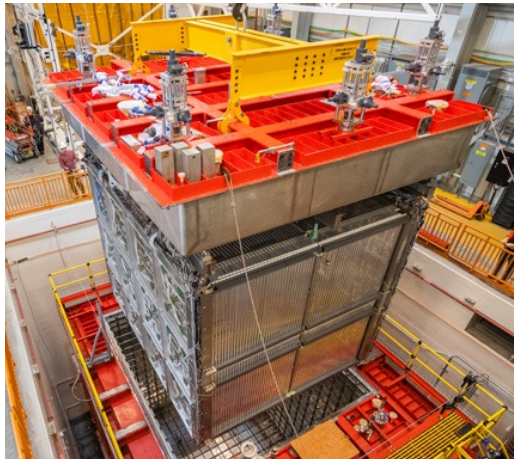
ν_μ CC candidate

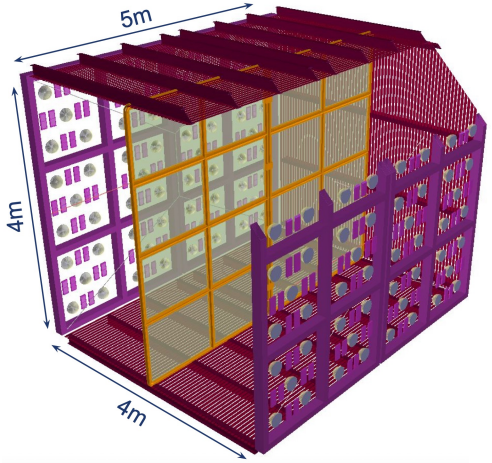


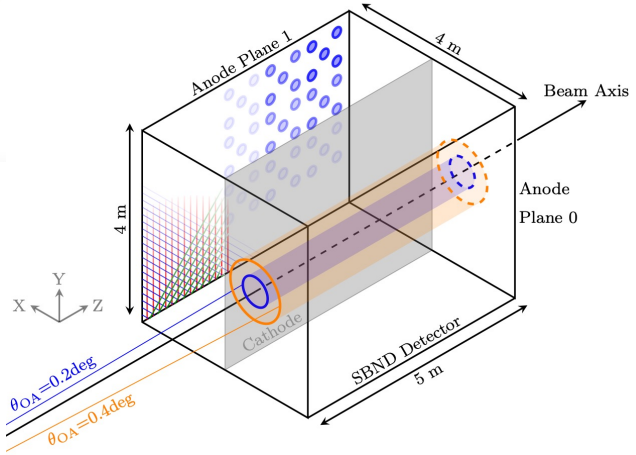
ν_e CC candidate

Summary

- SBND will collect an unprecedented ν-Ar interaction dataset
- This can be used for a broad program of neutrino physics topics
- The detector is now operating, detecting ~7000 neutrino interactions per day
- Looking forward to first physics results!







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SBND Talks

SBND Calibrations – Lynn Tung, 10/6 11:15am

SBND PRISM – Vincent Basque, 10/6 4pm

SBND Cross Sections – Amy Filkins, 11/6 11:45am

SBND Commissioning – Lauren Yates, 12/6 11:30am

Watch This Space!

Josephine Paton – jpaton@fnal.gov

10th June 2025

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