Status of the Short-Baseline Near Detector

Fermilab PAC

January 19, 2023

Ornella Palamara (Fermilab) & David Schmitz (U. of Chicago)

OUTLINE

Sterile Neutrino Searches beyond MicroBooNE

Overview of the SBND Experiment

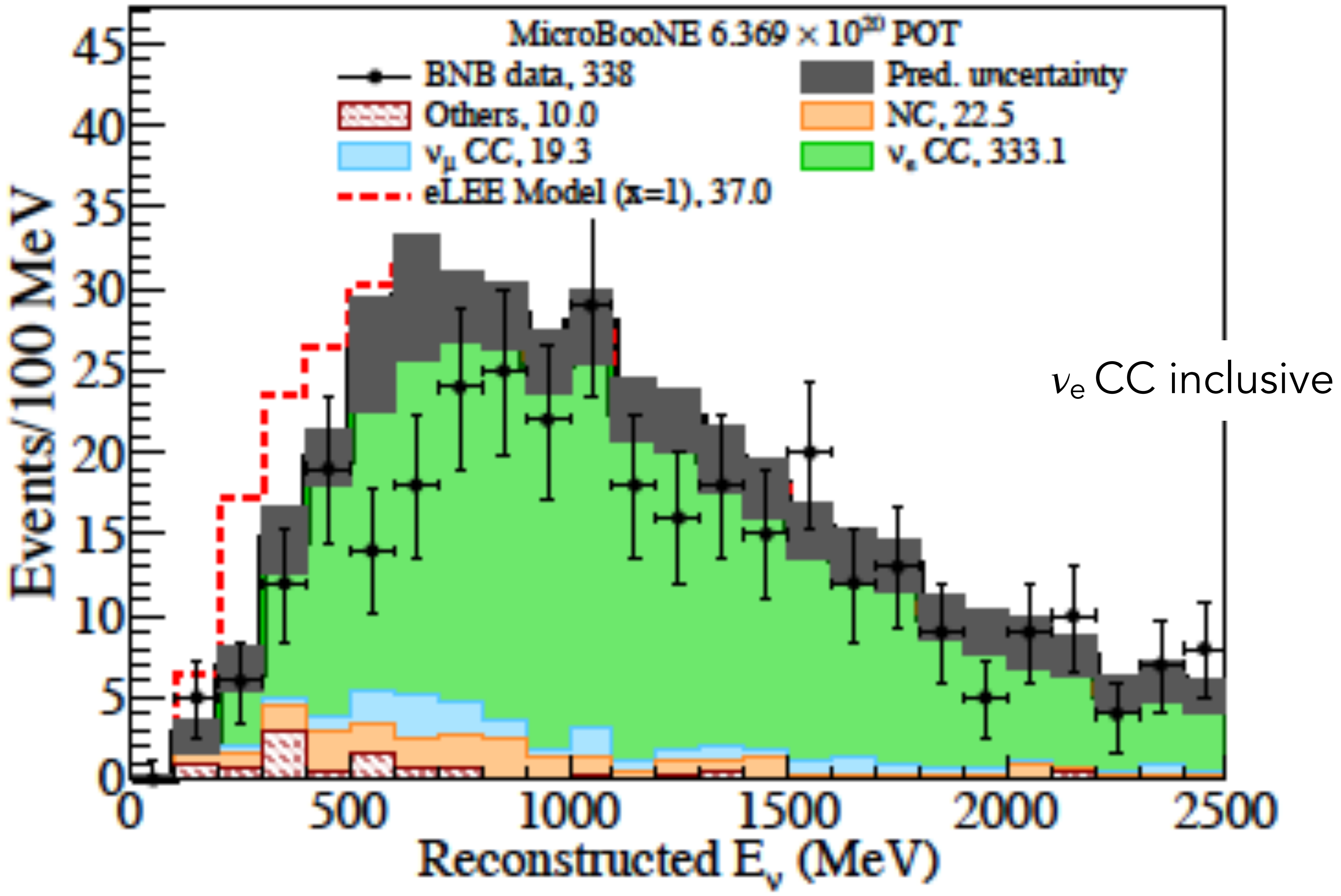
SBND Status & Timeline to Operation

SBND Physics Program

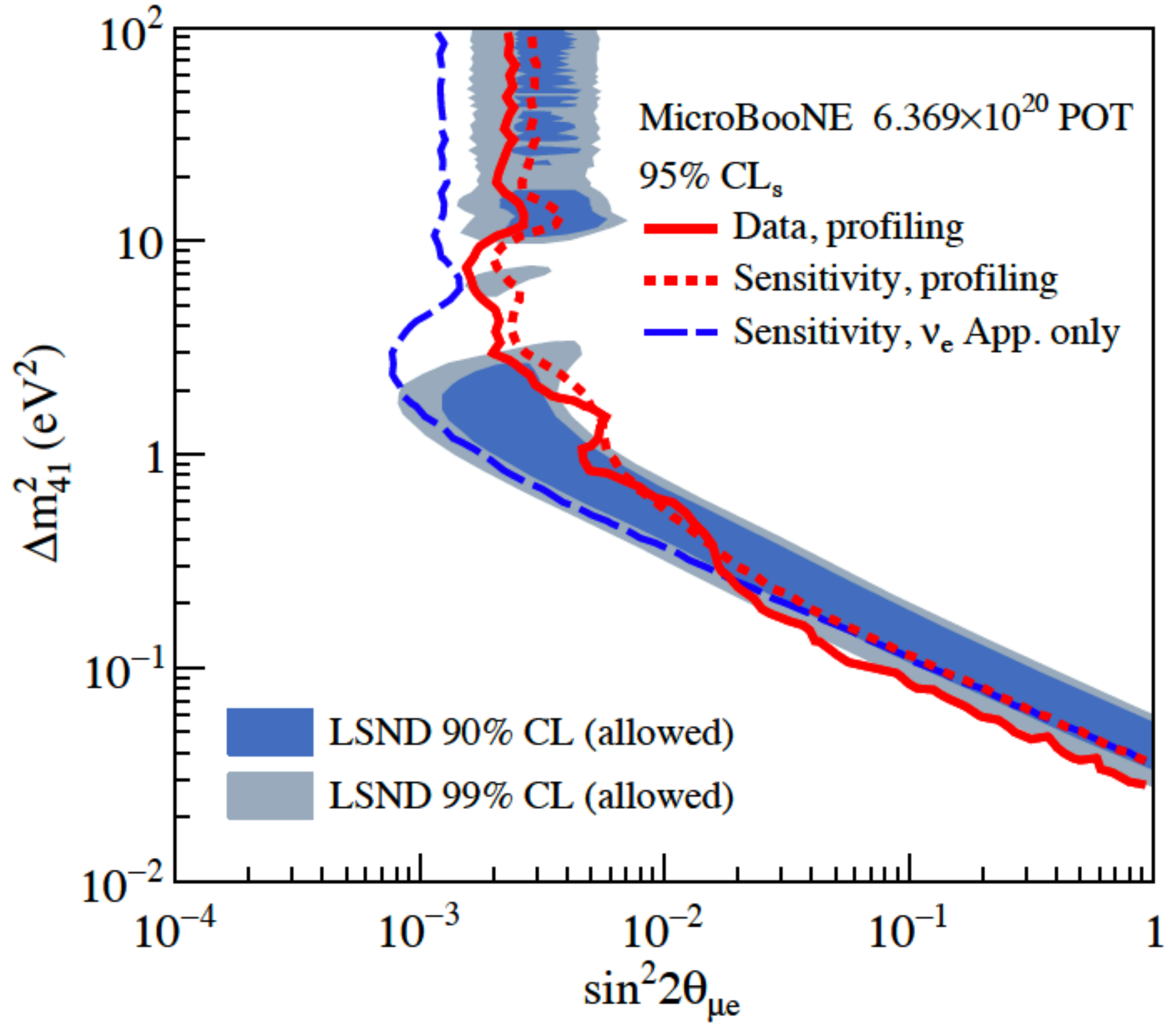
STERILE NEUTRINO SEARCHES BEYOND MICROBOONE

The MicroBooNE experiment presented the 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. Abratenco et al., Phys. Rev. Lett. 128, 241801

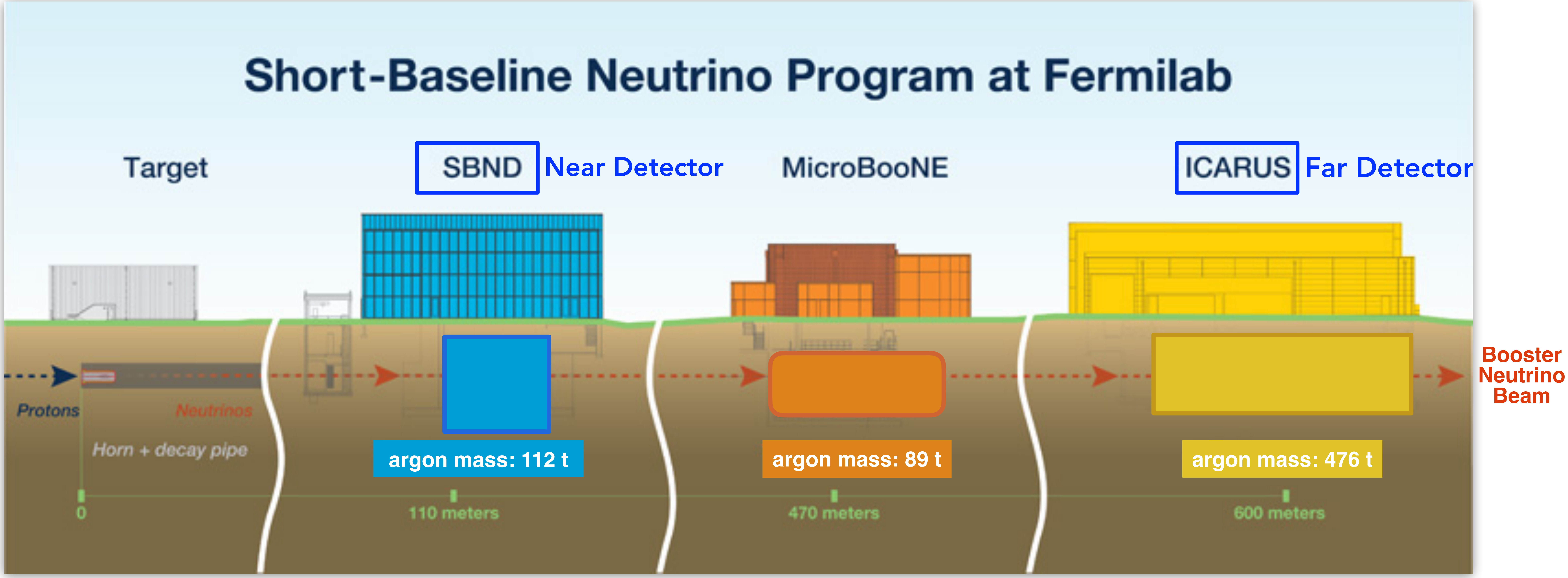


P. Abratenco et al., https://arxiv.org/abs/2210.10216



Entering the **next phase** of accelerator-based short baseline oscillation searches requires:
increased exposure through a larger **far detector** and
a **near detector** for systematics constraints.

The SBN Program



Expected begin operation in Fall 2023

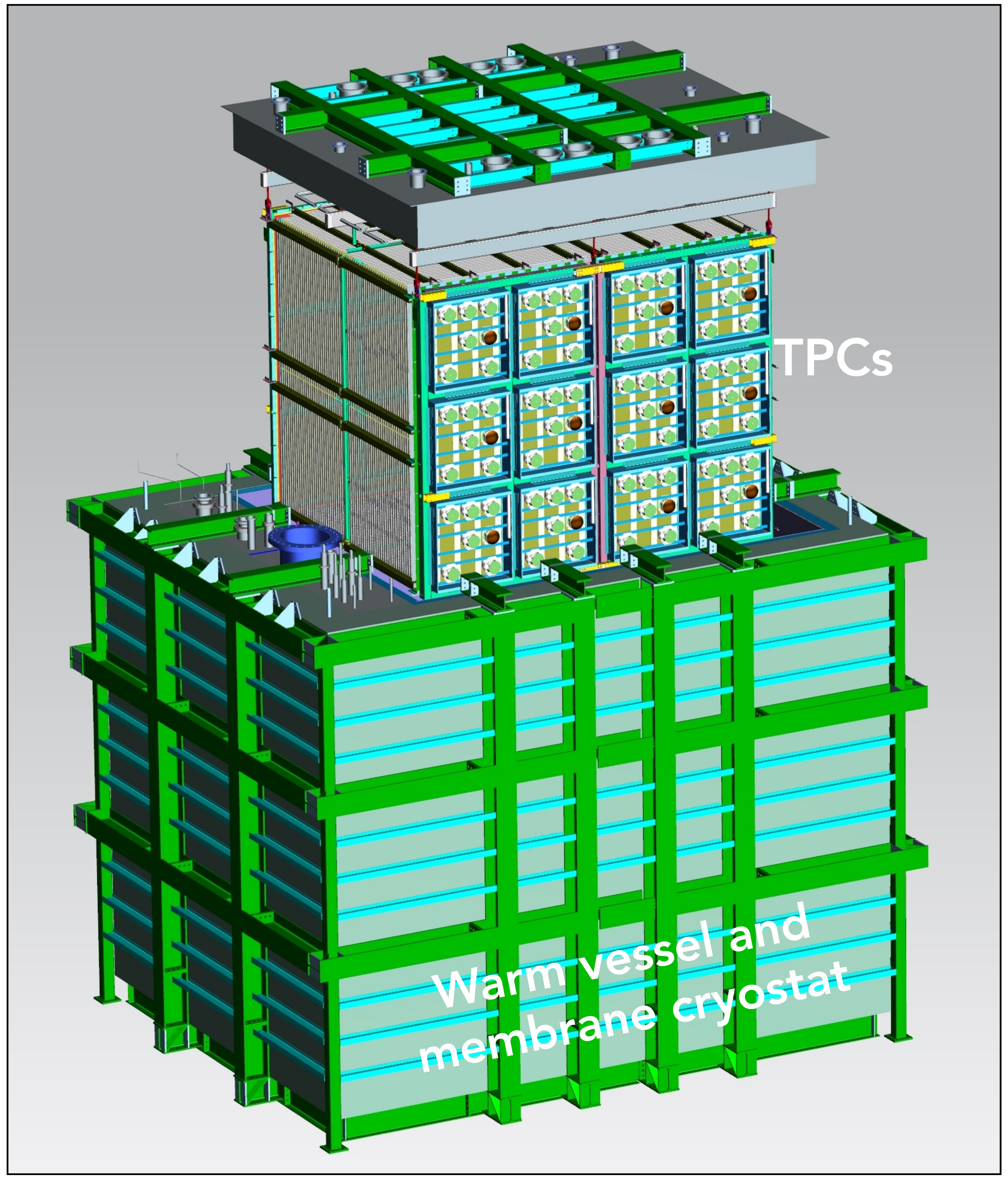
2015-2021

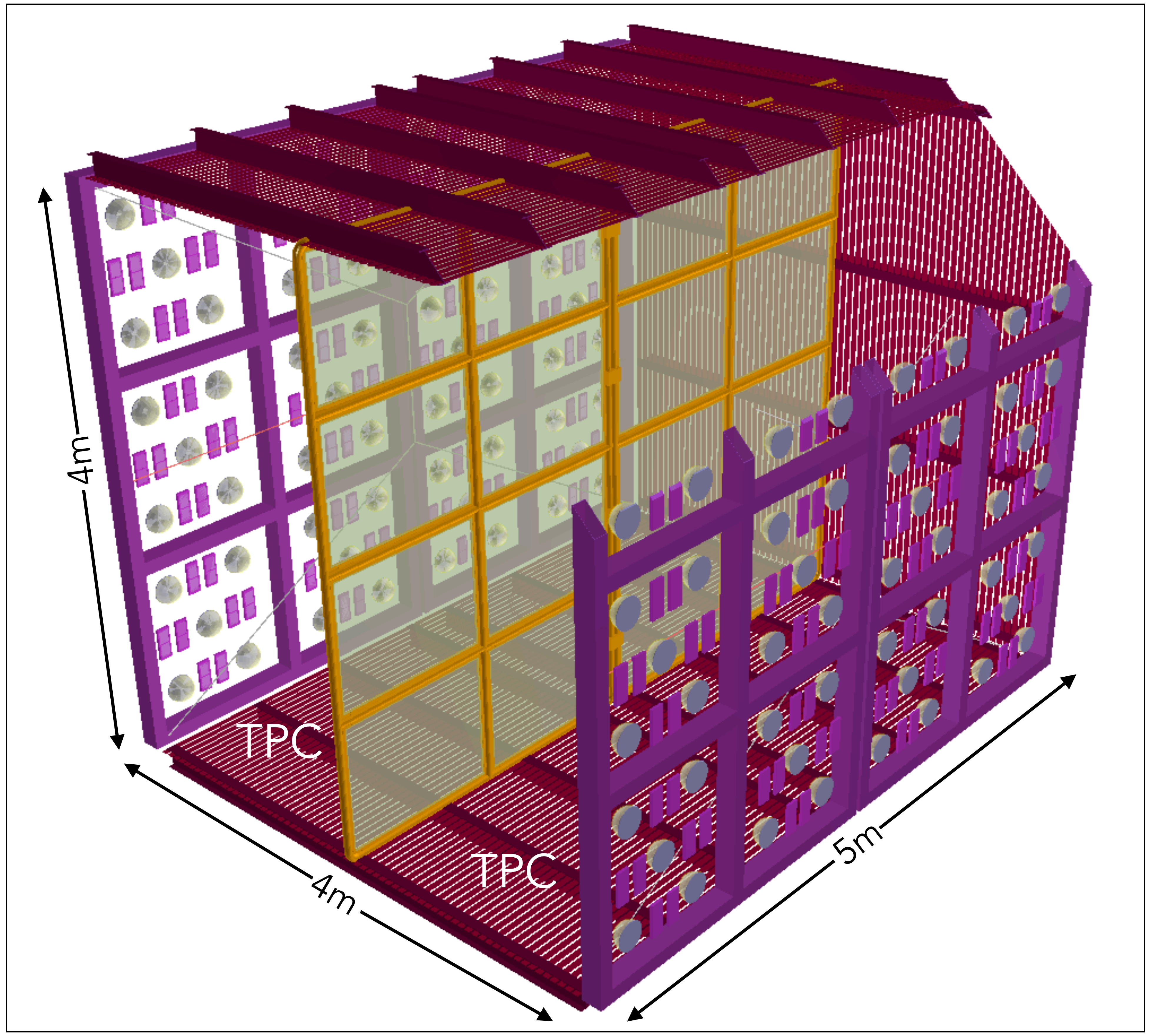
Collecting data since Oct. 2021

A program designed for **Sterile Neutrino** searches: same neutrino beam, nuclear target and detector technology to reduce systematic uncertainties to the % level.

But large LAr TPC detector masses and proximity to intense beams enables a **broad physics program**.

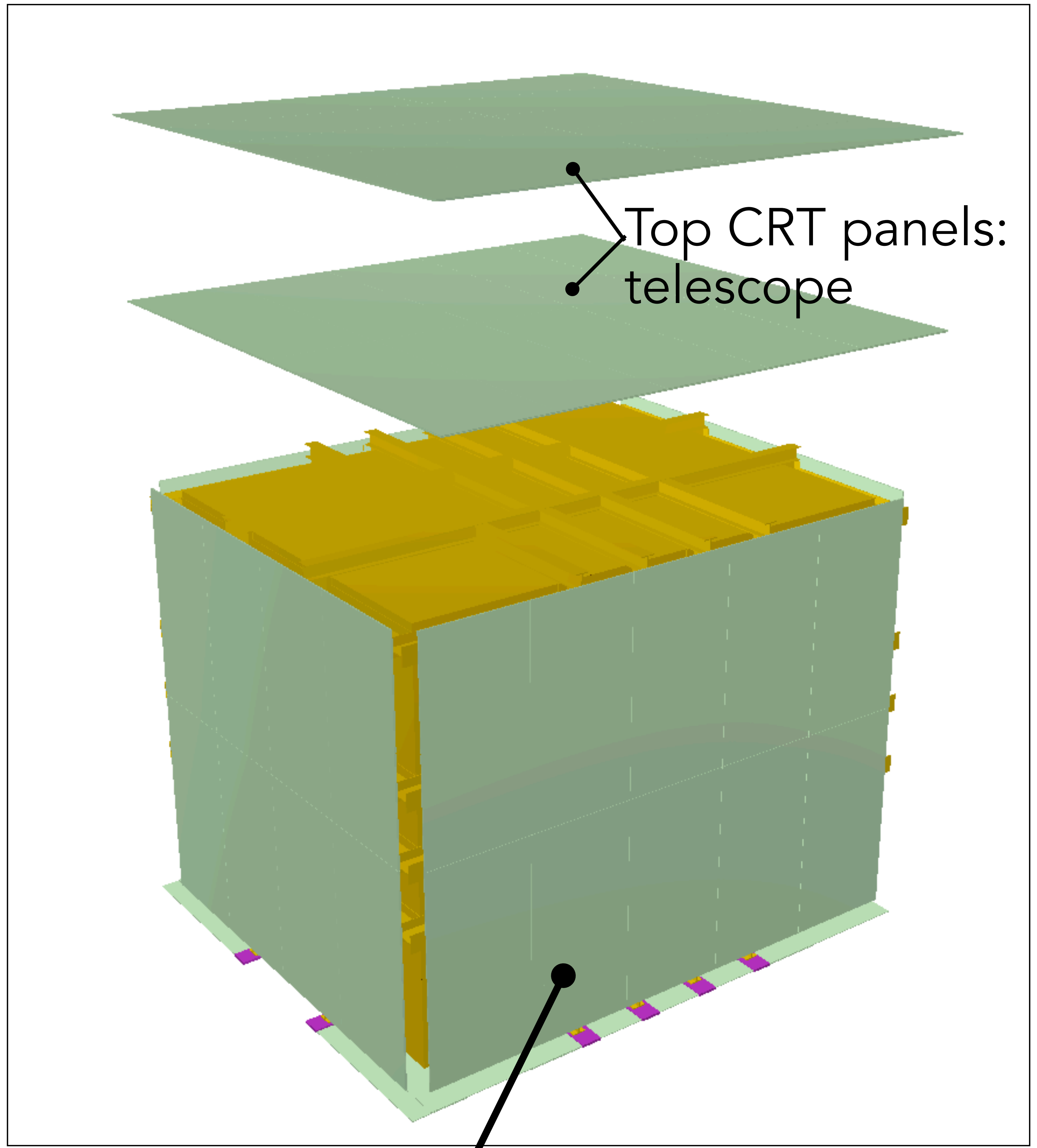
SBND Design Overview





Two Time Projection Chambers

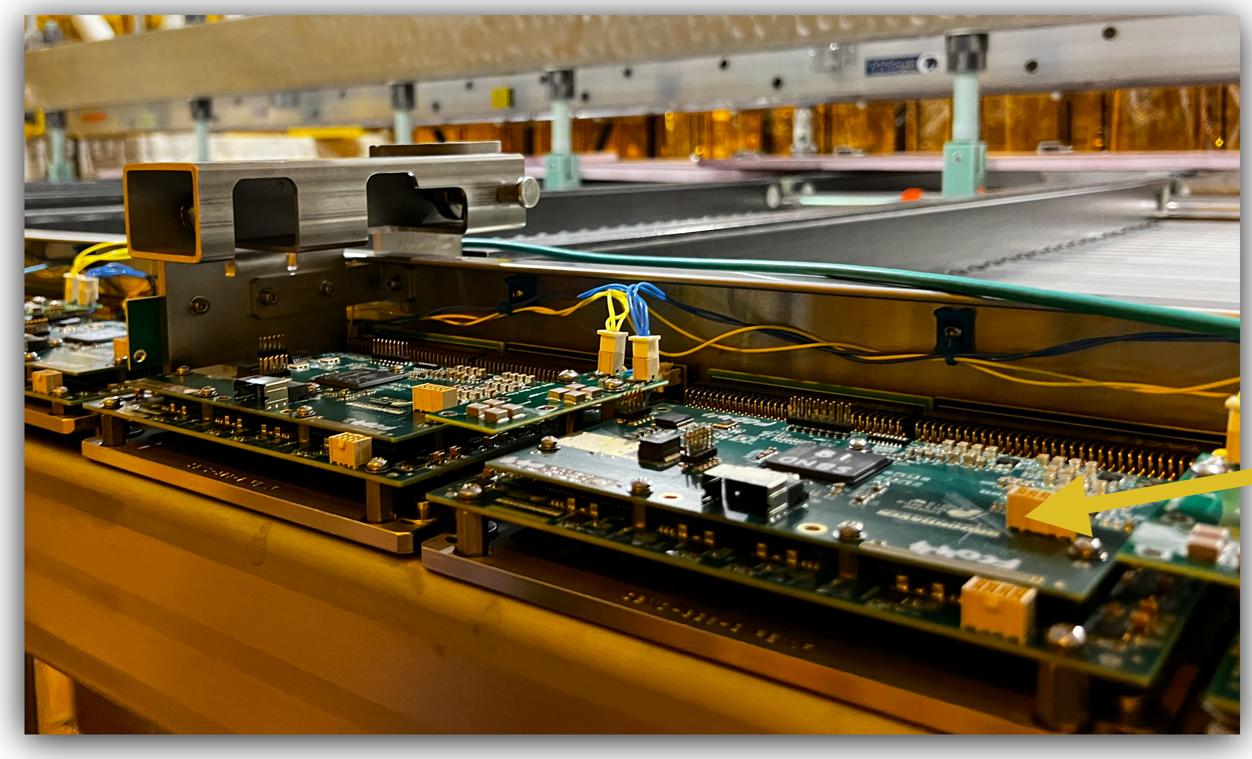
Cryostat surrounded by a Cosmic Ray Tagger system



Panels made of scintillator strips

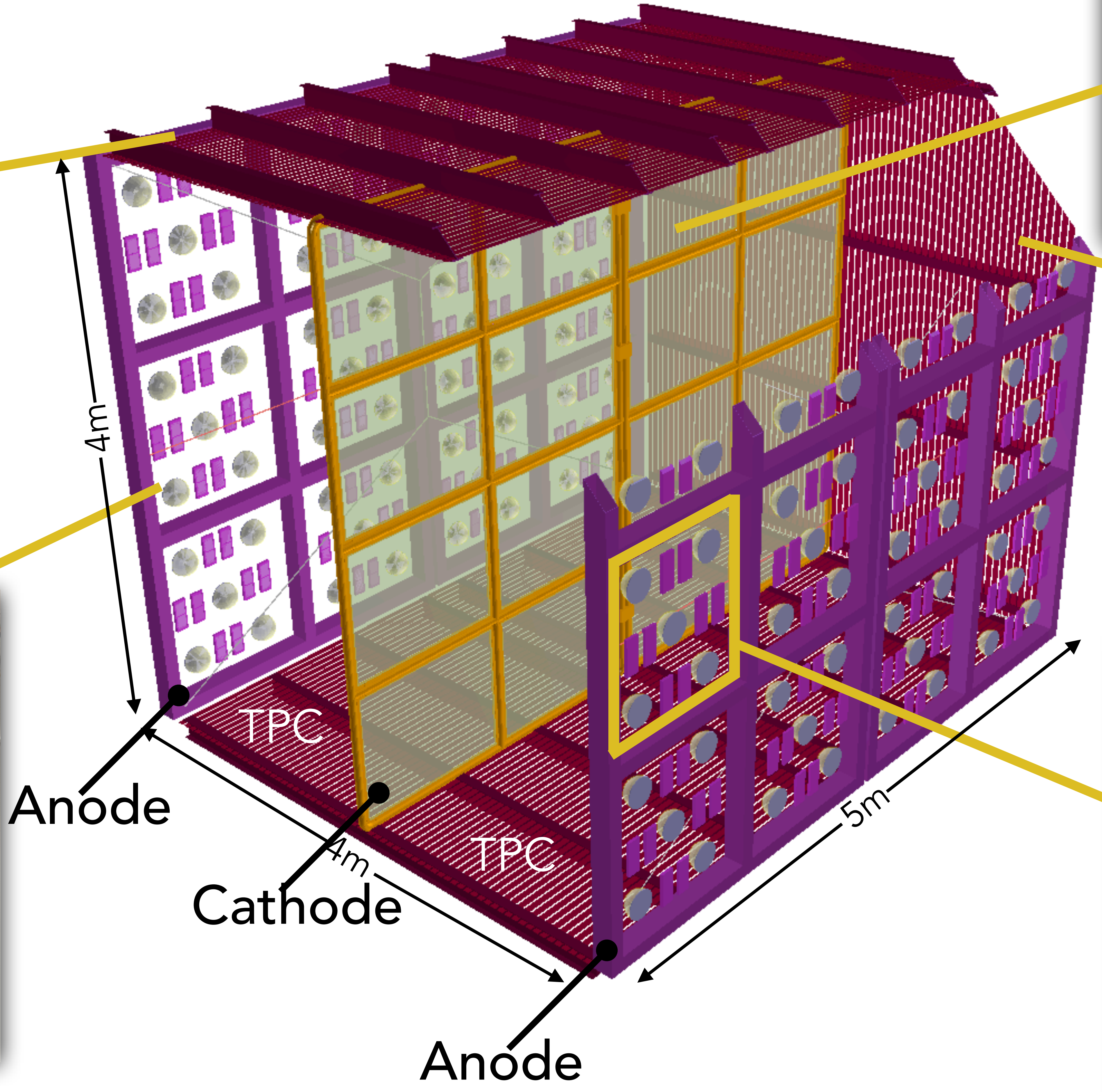
SBND Design Overview

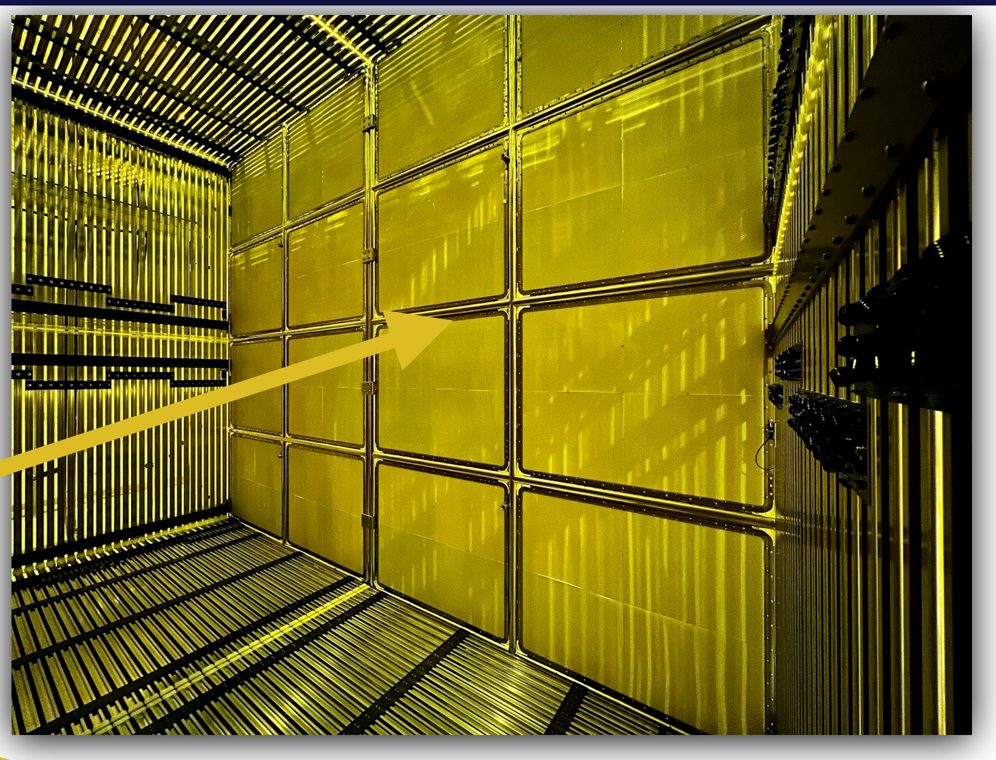
TPC Cold electronics



Two Time Projection Chambers

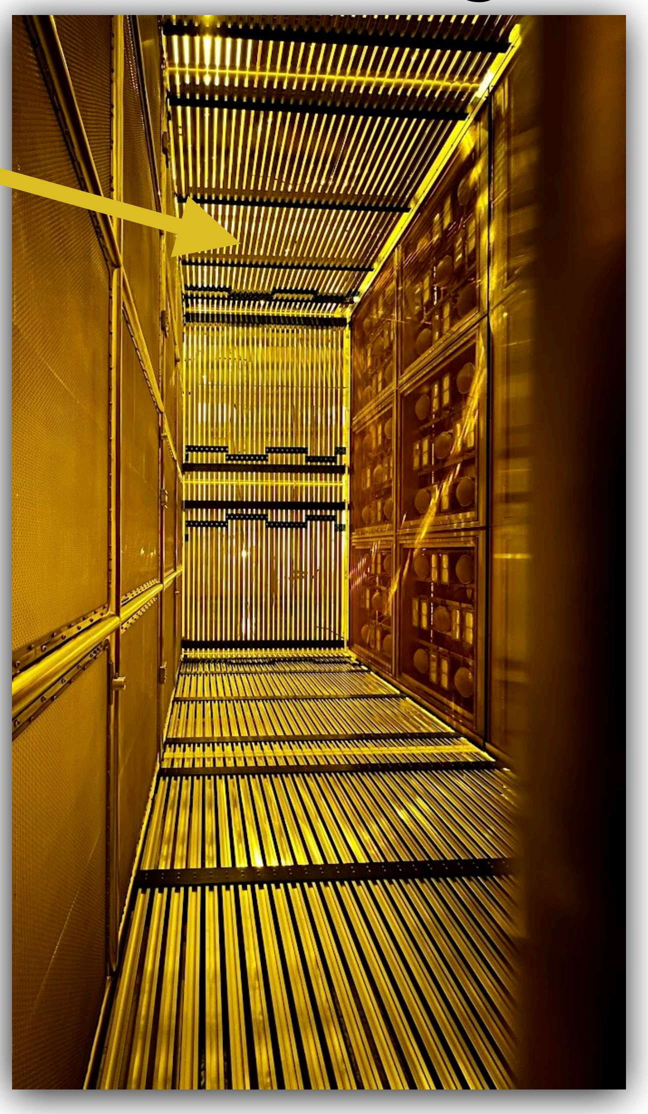
Total dimension: 4m x 4m x 5m

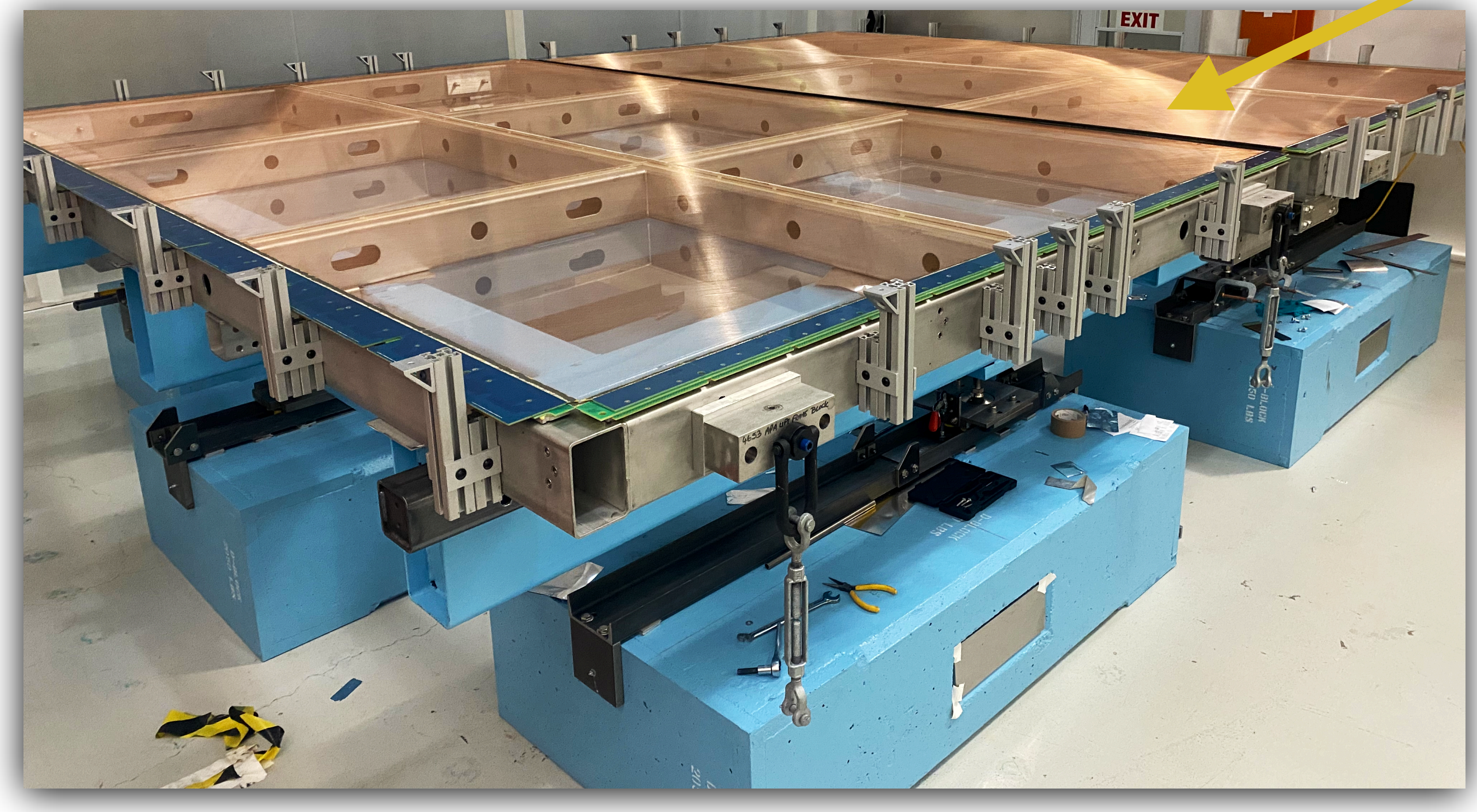




Cathode covered with TPB coated reflectors

Field Cage





Wire Plane - 3 readout planes, ~11000 wires

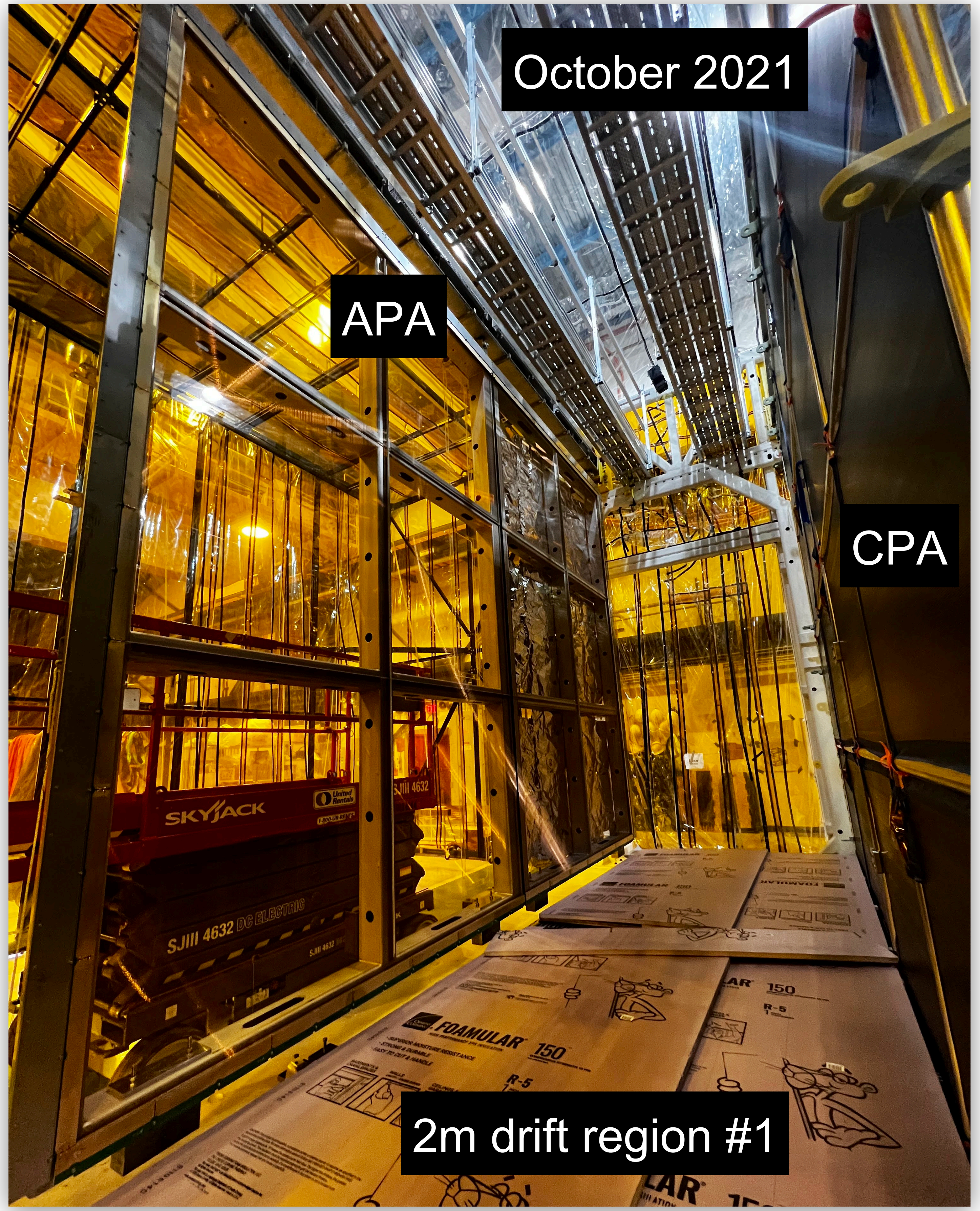
Photo Detection System: 120 PMTs, 192 X-Arapucas

TPC + PDS System Assembly

- Components of the TPC and PDS (photon detection system) subsystems were built at collaborating institutions and delivered to Fermillab for assembly and integration.
- The TPC was assembled outside of the cryostat at DAB (D0 Assembly Building) into the **atf (assembly and transportation fixture)** and transported across site to the SBND Hall when the cryostat was ready.
- Assembly was a joint effort by Fermilab engineers, SBND assembly team and experts from collaborating institutions.

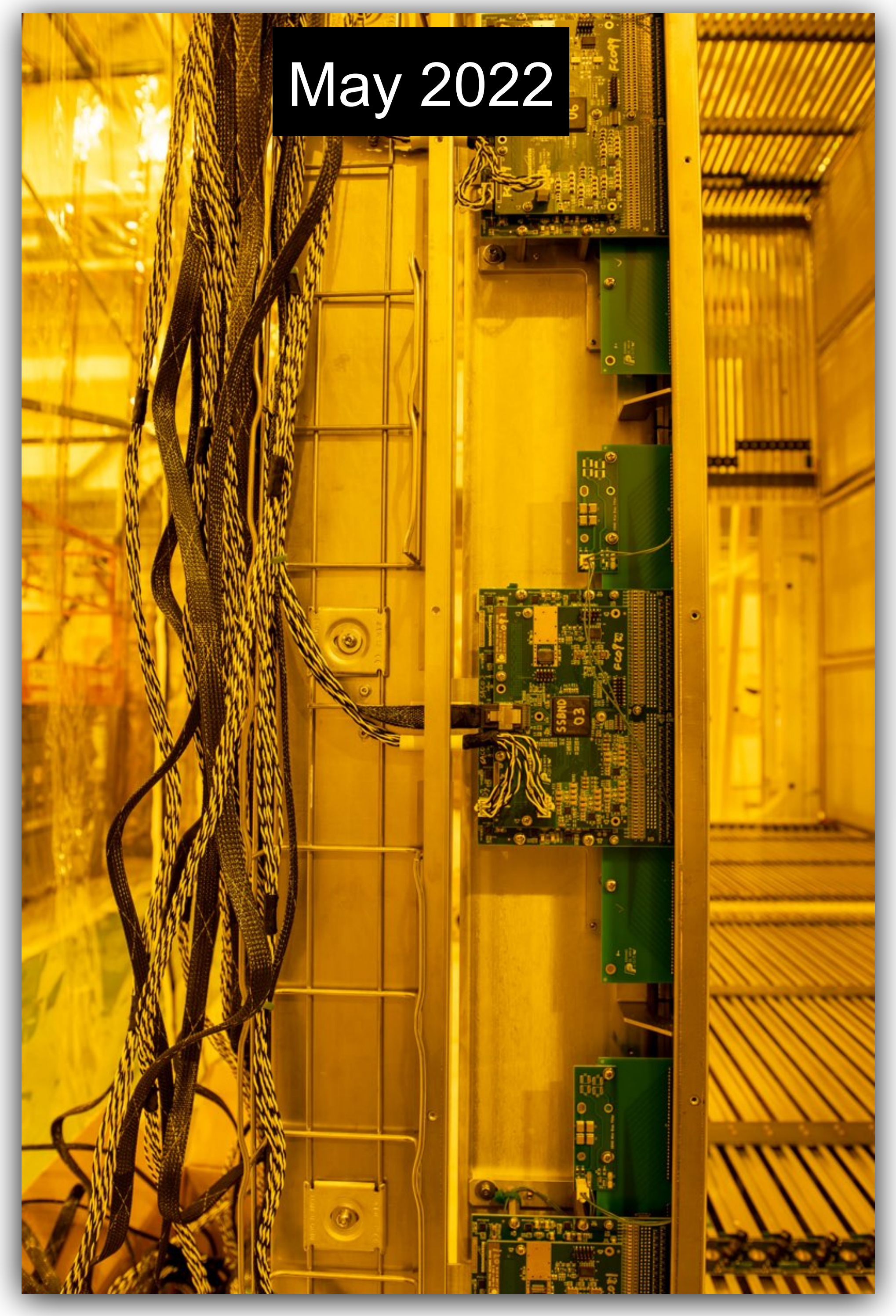
atf completed

First Anode plane (WEST) installed



TPC + PDS System Assembly - Highlights of last year

Installation of the EAST Anode plane



TPC Cold Electronics
Installed and tested

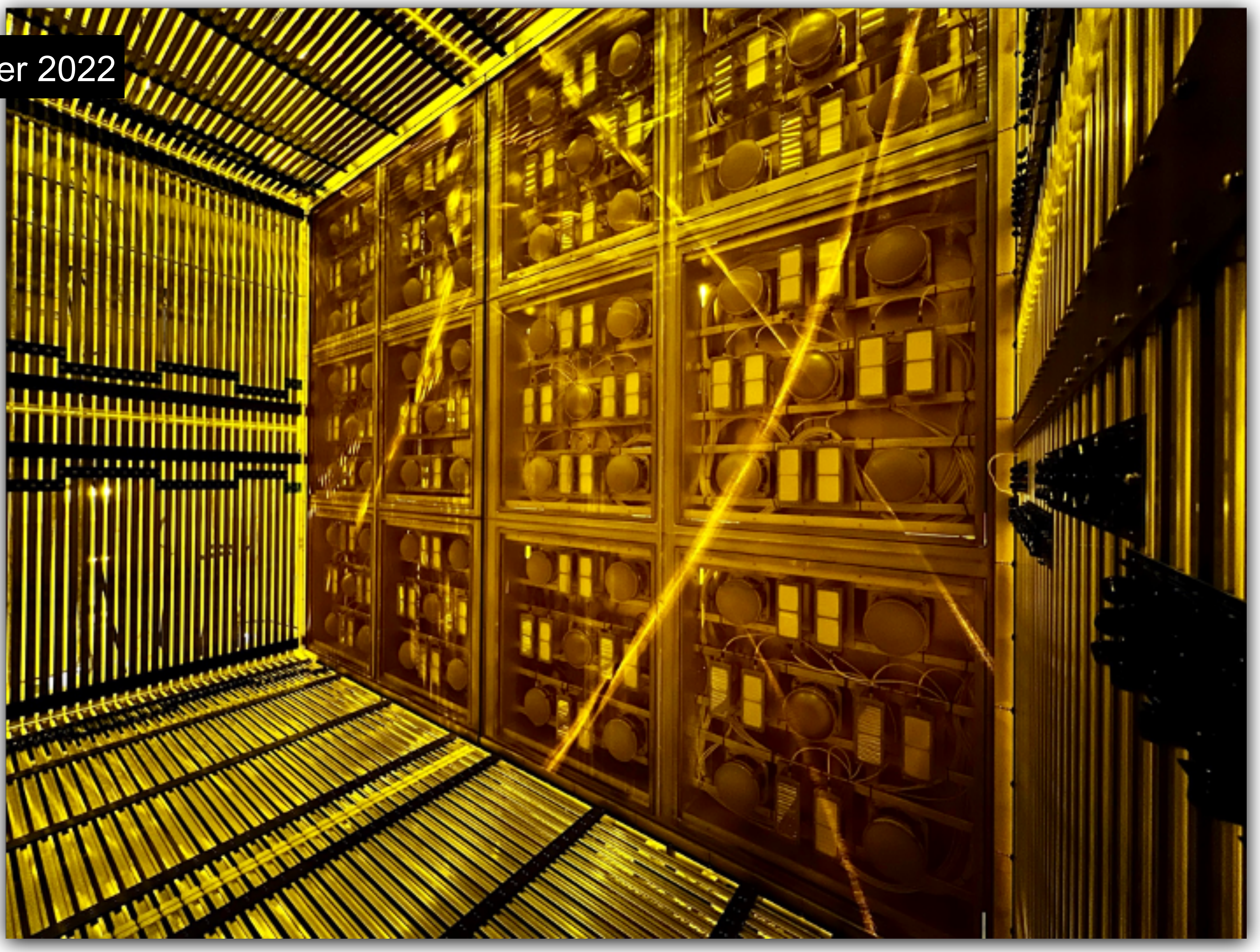
Installation of field cage completed

PDS boxes completed,
PMT and X-Arapuca tested

TPC + PDS System Assembly - Highlights of last year

Installation of the PDS boxes completed.

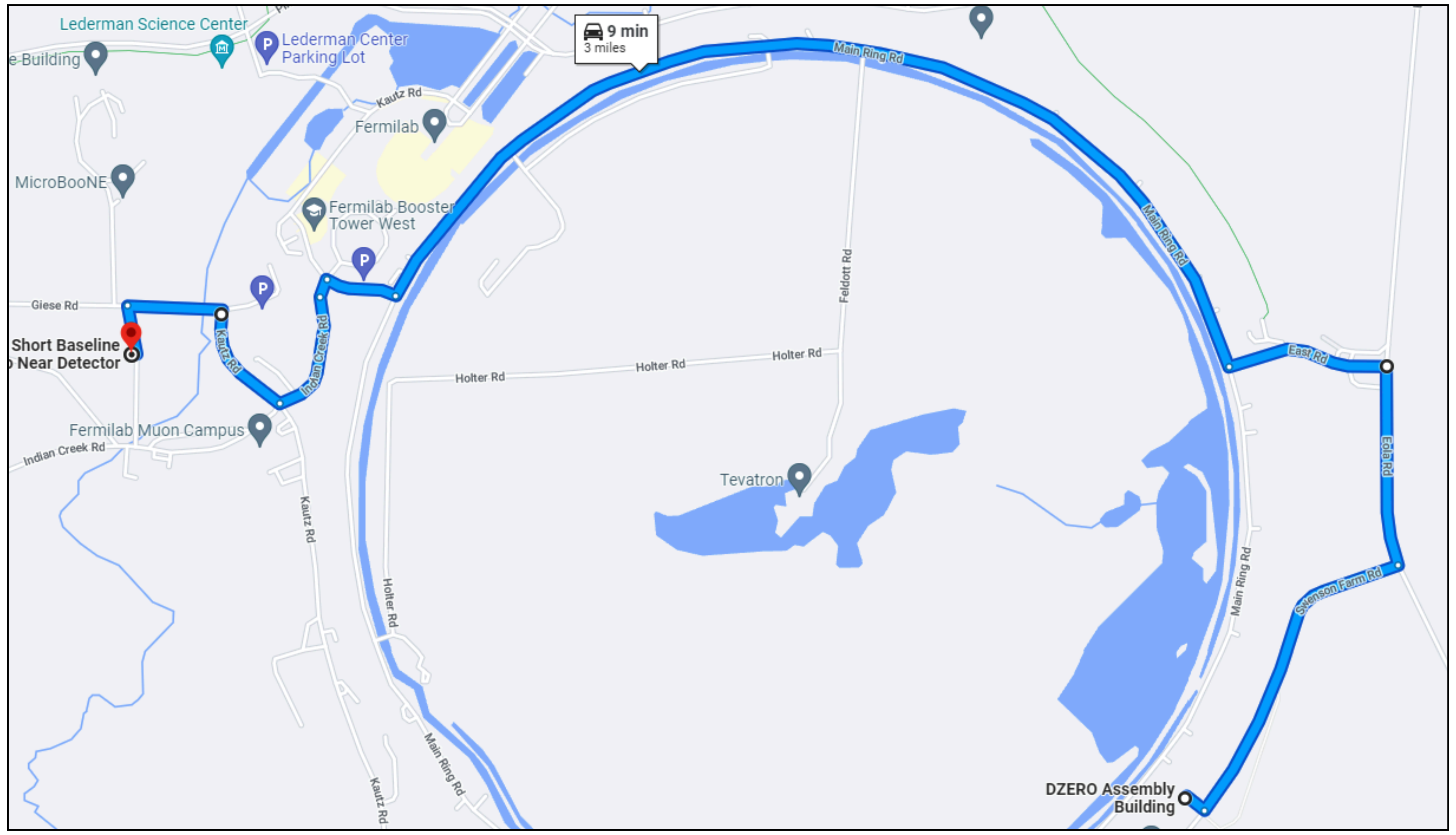
September 2022



SBND detector completed!

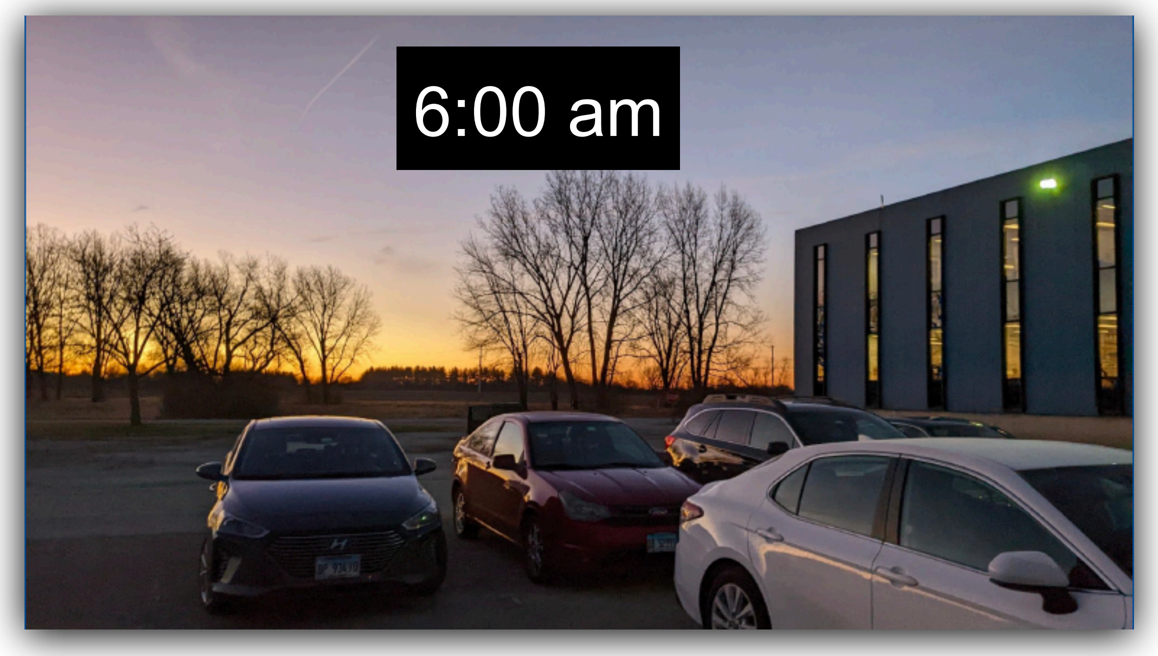
SBND Detector Move

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



Video - Fermilab creative service

SBND Detector Move



Happy collaborators escorted the detector across the site [from 6:00 am to 4:40 pm!].

And Fermilab supporters came out to watch us pass by the High Rise just after noon.

SBND Detector Move

An incredible team of engineers, technicians and physicists, with support from the Fermilab Infrastructure and Service Division (ISD), worked for years in preparation for the move and were on hand for a very long (and very cold) day to make the operation a huge success.

SBND Detector Move

A newsworthy day…

News

Neutrino detector on the move

December 1, 2022 | Emily Ayshford

Share Tweet Email

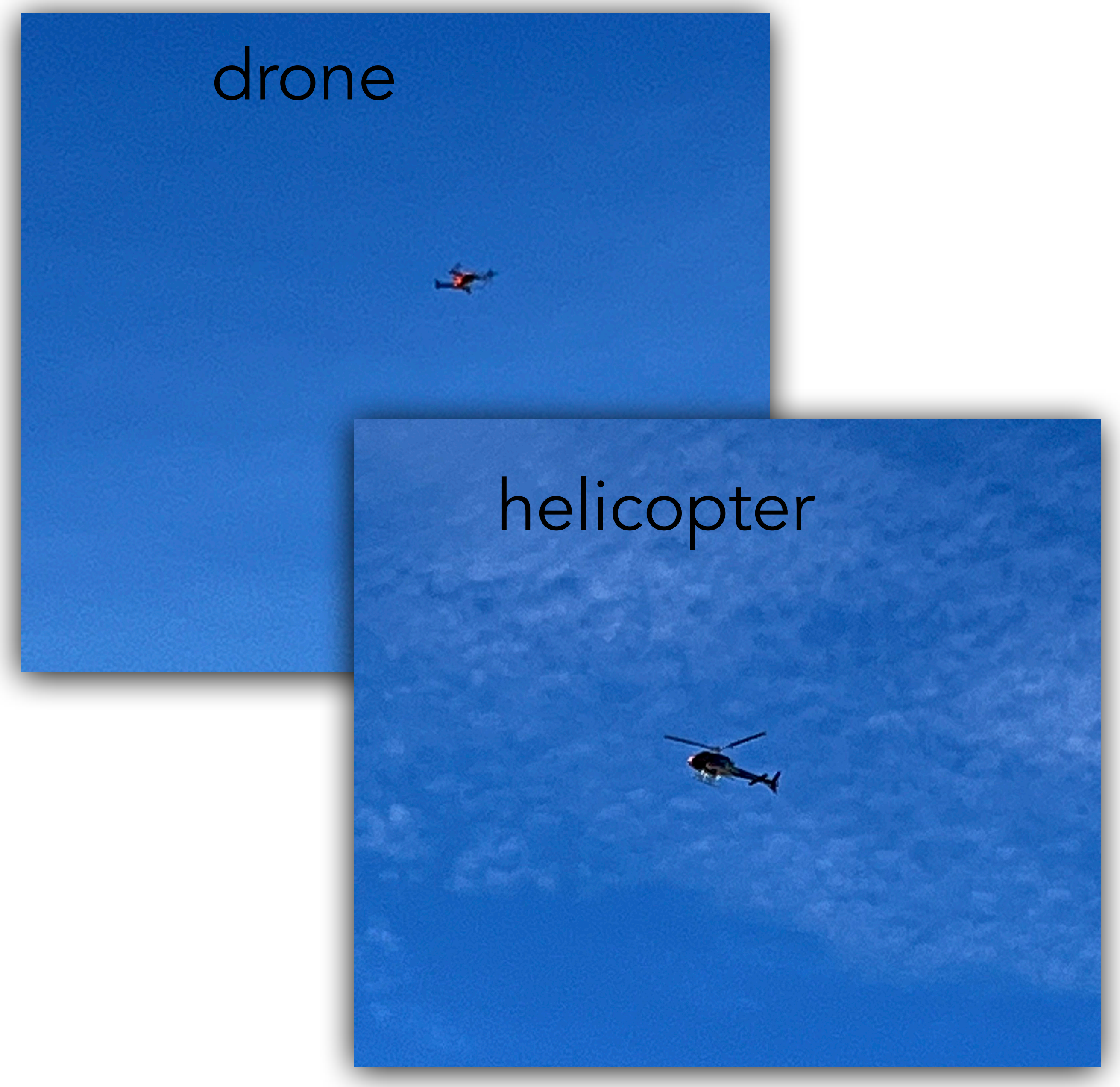
Editor's note: At 4:40 p.m. today, the neutrino detection system was placed inside the SBND detector hall after a successful move.

After years of construction, testing and planning, an exciting move is currently underway at the U.S. Department of Energy's Fermi National Accelerator Laboratory.

A neutrino detection system built for the Short-Baseline Near Detector will travel 3 miles today, Dec. 1, from the warehouse-like building in which it was constructed to its final home in the SBND detector hall. There scientists will use a beam of particles called neutrinos to examine the collisions of these particles with atoms. Their goal is to learn more about the mysterious properties of neutrinos.

Moving the system is no easy feat. As a nearly 20-foot cube, it's the size of a small house. It weighs 20,000 pounds and contains delicate sensors and wiring that, if rattled too much, could compromise the integrity of the system.

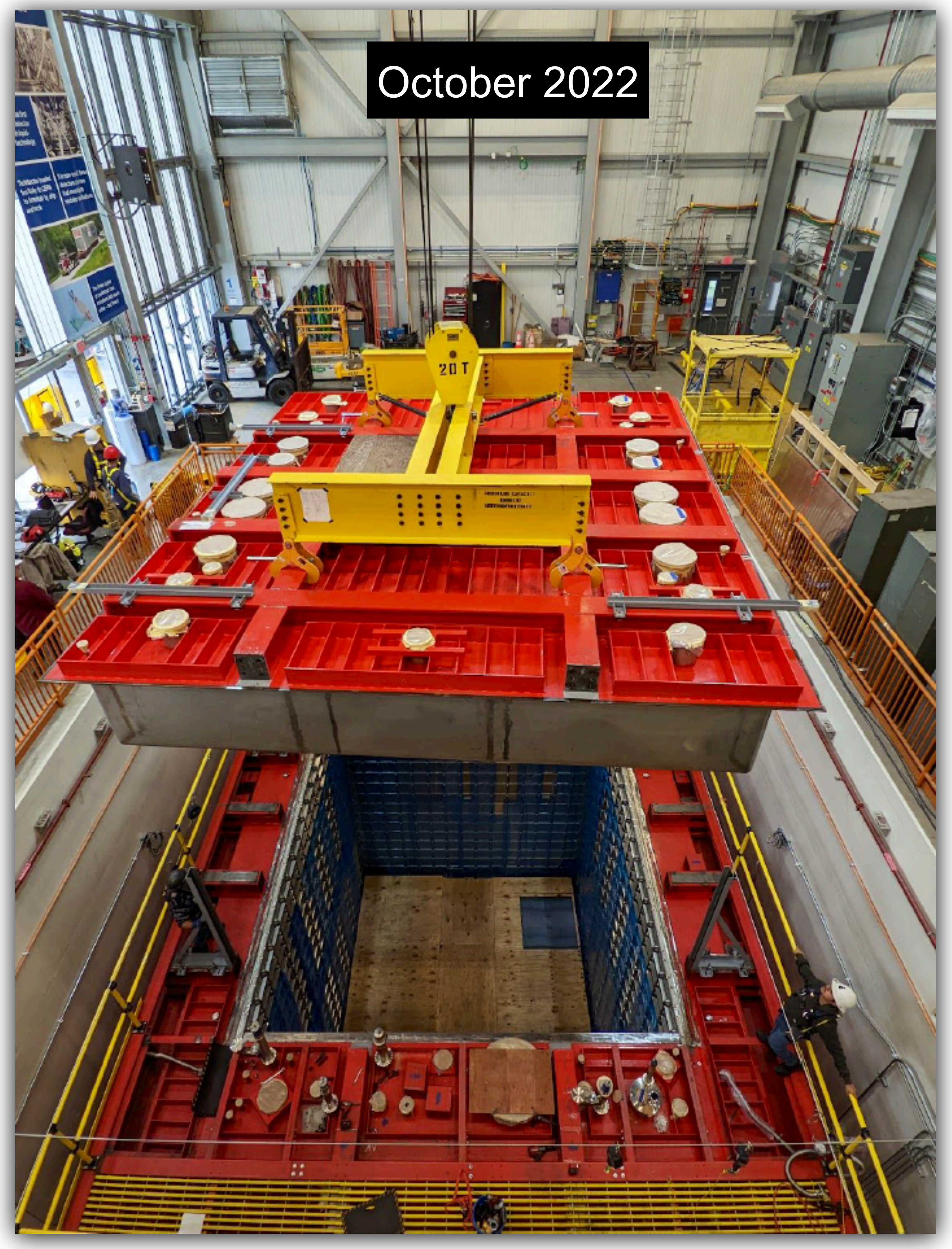
Fermilab office of communication



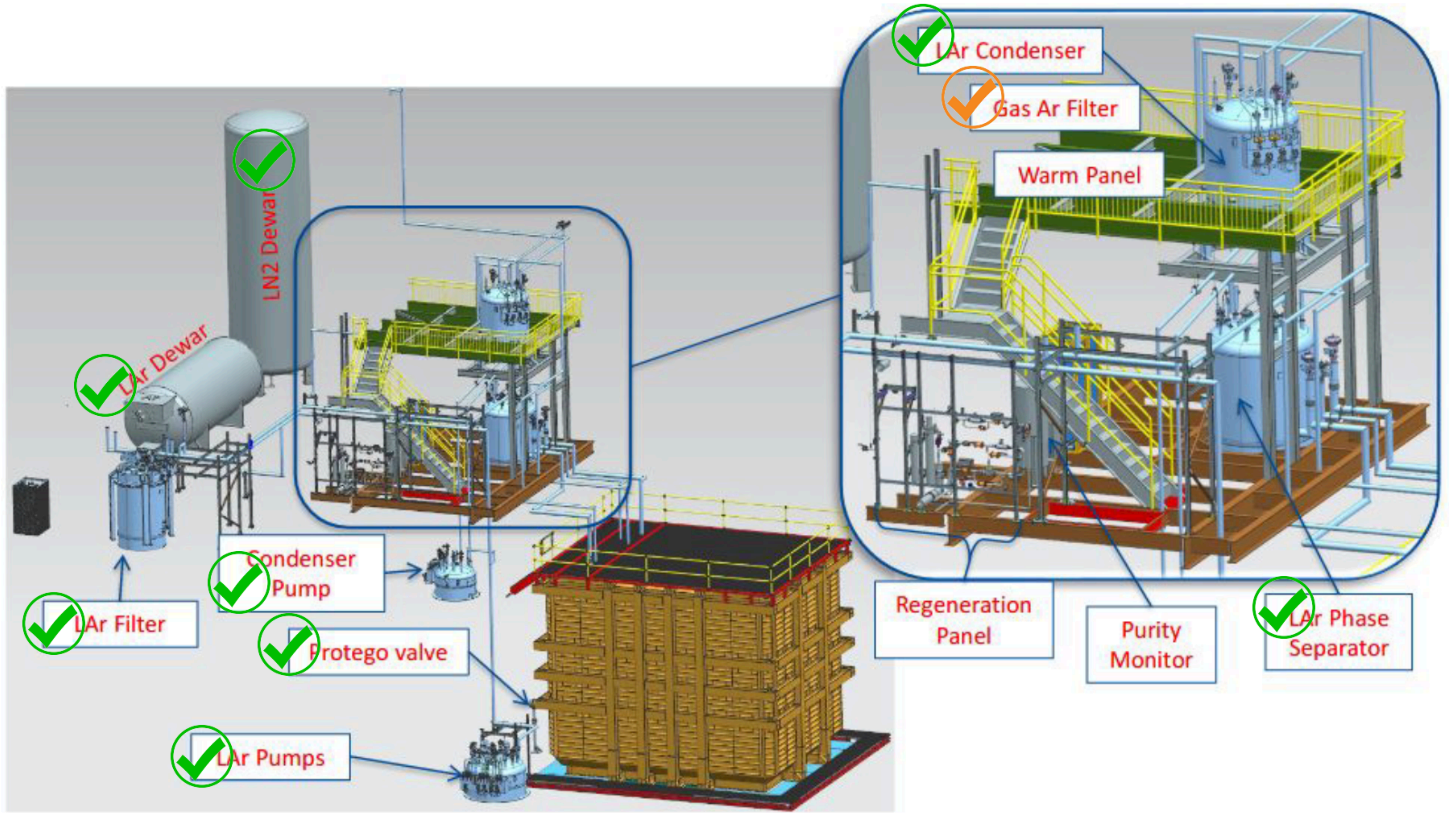
Cryostat and Cryogenics

Membrane cryostat construction (Gabadi, GTT, Cern and Fermilab)

Membrane cryostat completed - (August 2022) and leak checked.



SBND Cryogenic System



External cryogenics installation progressing well.

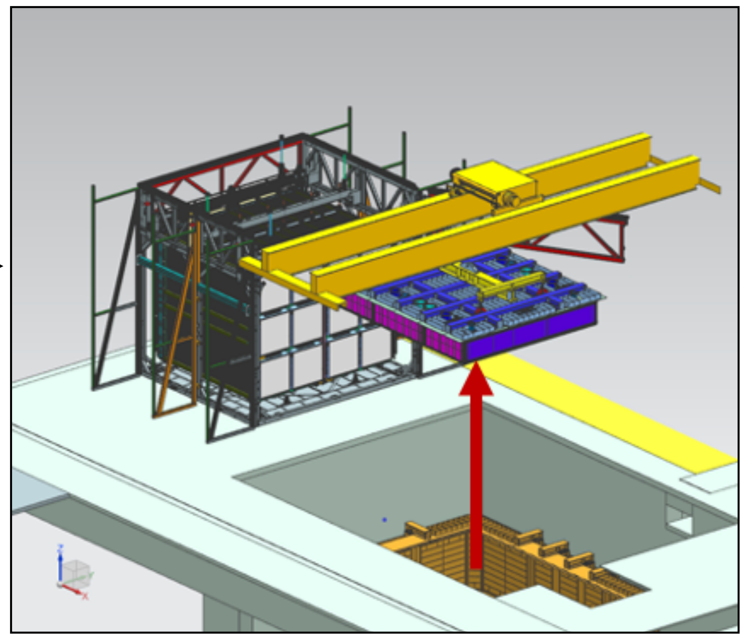
Installation of internal cryogenics completed (October 2022).

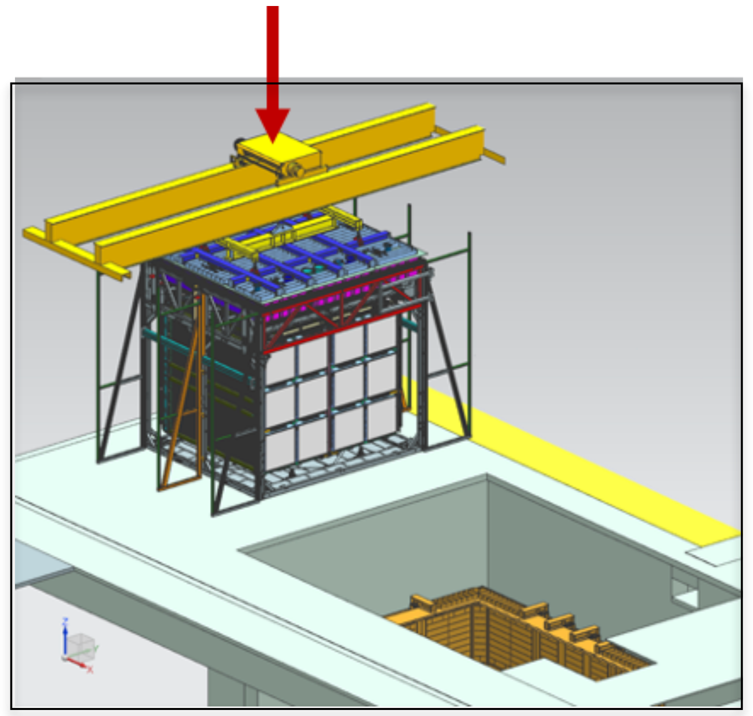
Schedule to Filling

CY 2023

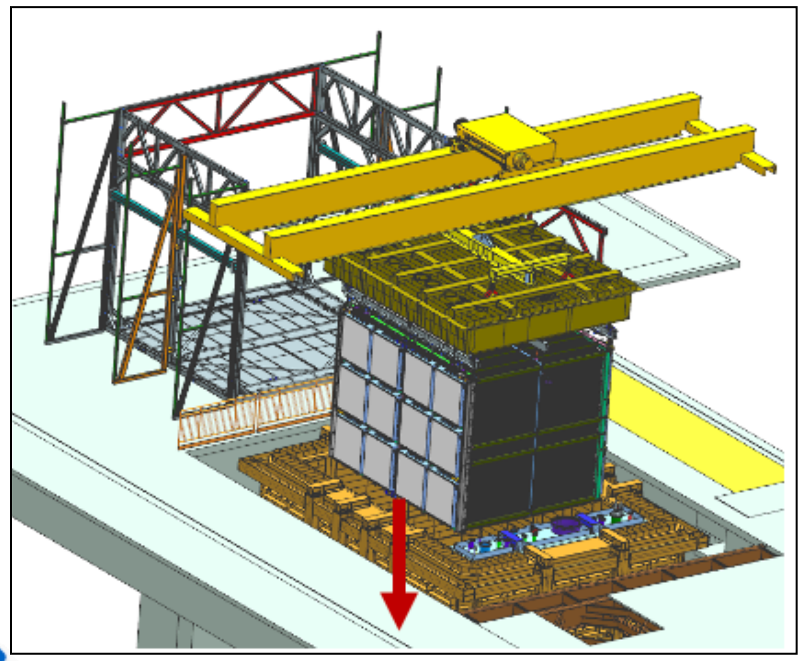
Jan | Feb | Mar | Apr | May | Jun | Jul

- QC of detector subsystems (almost completed)
- Install instrumentation on detector & cryostat walls
- Install detector top on the atf





- Cryo Installation
- Top cap cabling & subsystem QC
- Detector rigged into cryostat



- Cryo Transfer Line Installation
- Readout Cabling
- CRT North Wall Installation
- Cryostat top welded
- HV FT, TPC Laser, Purity Monitor Installation
- Finalize cryo piping
- S2: Ready for Cryogenic Operation

Quality Control tests will also be performed:

- After top cap installation
- After detector insertion in the cryostat
- After top cap welded in place
- After warm cables connected
- During cooldown → "Chilly detector Checkout"
- During and after LAr fill

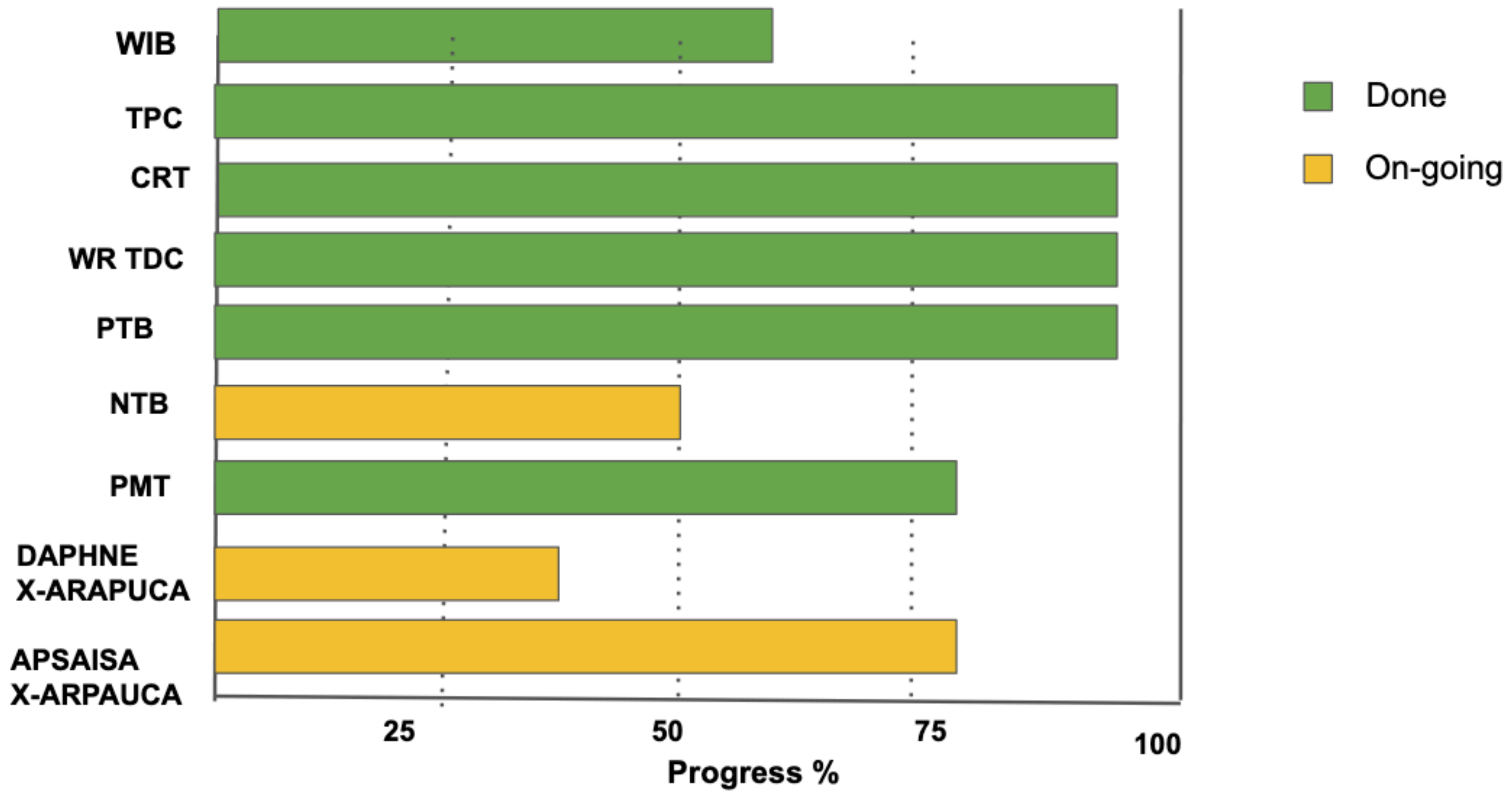
DAQ, Readout Electronics Installation

- The readout & server rack installation on the mezzanine level is progressing well
  - Readout racks and DAQ servers are already in active use
- We started installing ground floor racks, i.e. HV, Laser, CRT, Purity Monitor
- Integration and commissioning have already begun for the DAQ and the trigger.

Online server racks

TPC readout racks

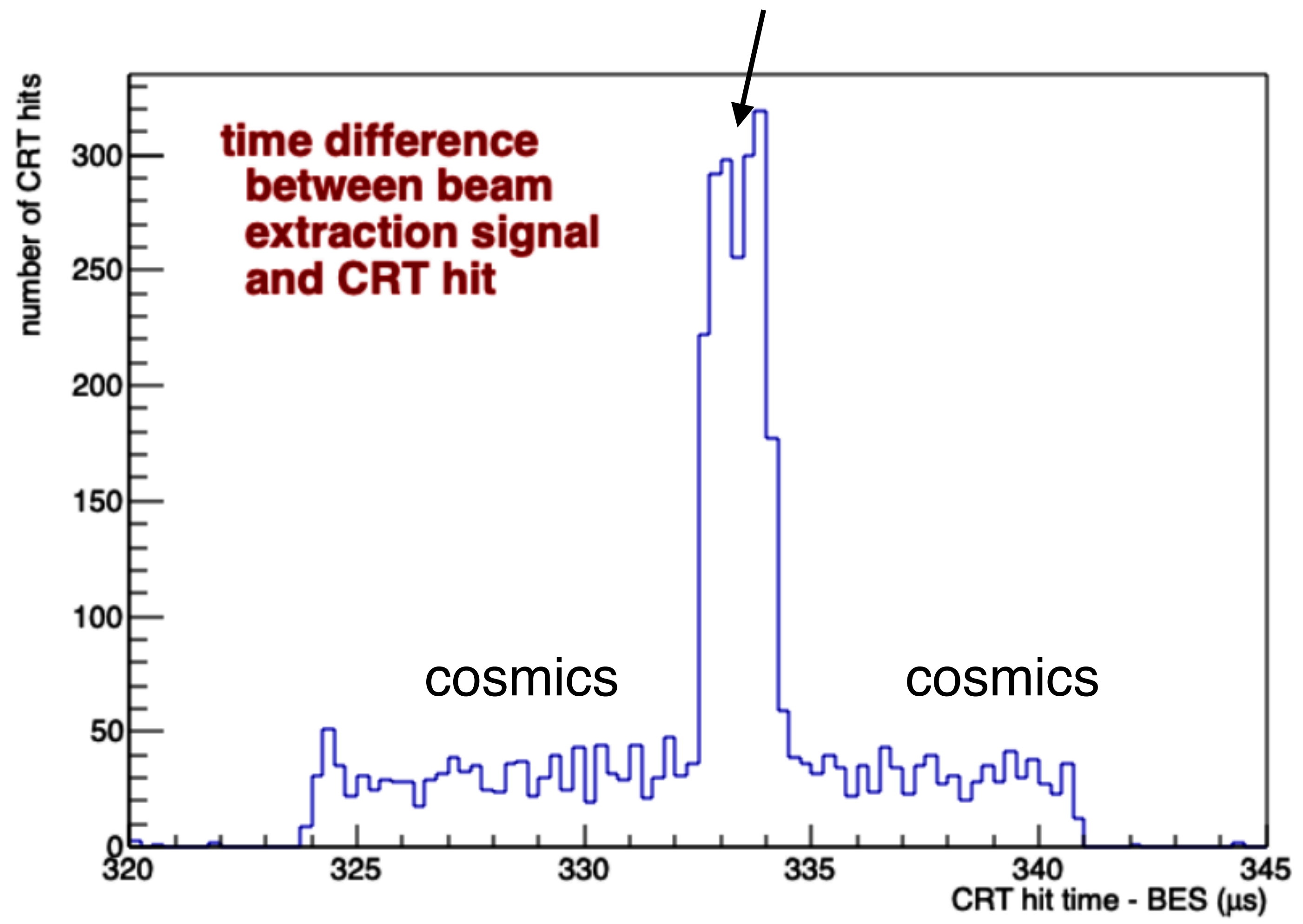
SBND-DAQ System Status



DIRECTORS REVIEW AND PLANNING FOR OPERATION

- The next Directors Review will be held Feb 28 - Mar 2, 2023.
- The focus of the review will shift from Installation to **Commissioning & Transition to Operations** [getting from S2 -ready for cryogenics operation- to S4 -ready for physics data].
  - We are developing cryogenics & detector commissioning plans [pre-LAr and post-LAr filling] and work is ongoing to complete as much of the DAQ and trigger commissioning as possible in the months before we fill with argon and to prepare analysis tools for commissioning.
- We aim to **start taking physics quality data in Fall 2023**.

muons from neutrino interactions (1.6 μs) in the material upstream of the SBND detector hall



The "CRT## commissioning project" is front-loading a lot work for the CRT and the timing, trigger/DAQ

SBND Physics Program and Exposure

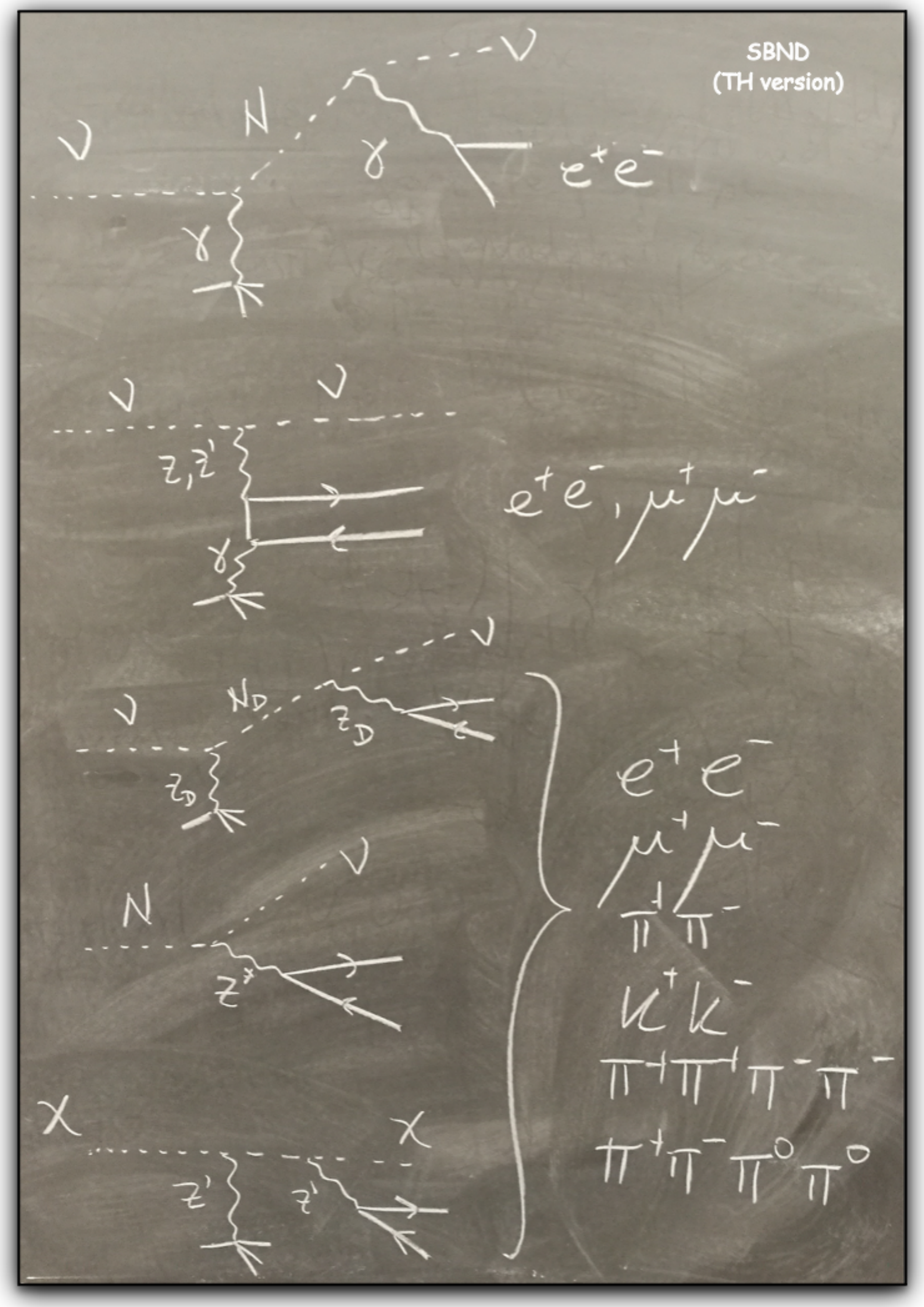
Physics Program:

eV-scale sterile neutrinos: searches with **multiple-detectors at different baselines.**

—> see the next presentation by G. Karagiorgi on SBN Analysis working group

New physics scenarios: with **many ideas for new searches** emerging from collaboration with theory colleagues.

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



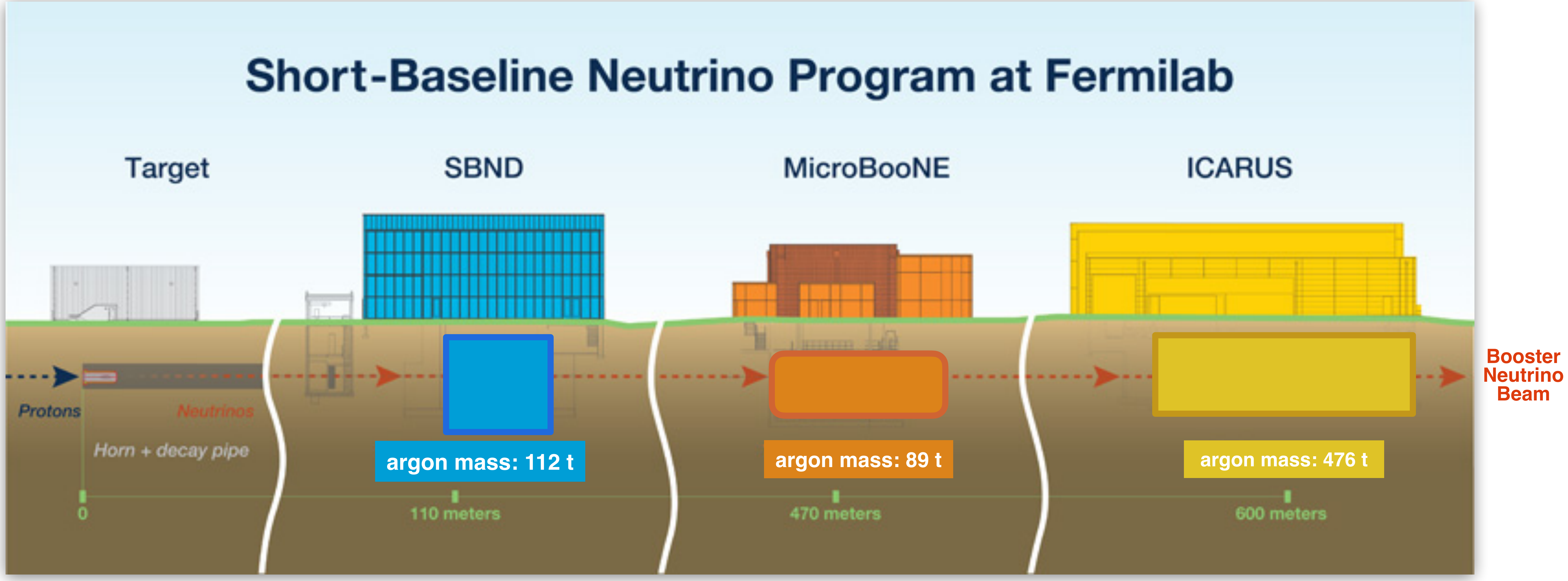
Courtesy of P. Machado

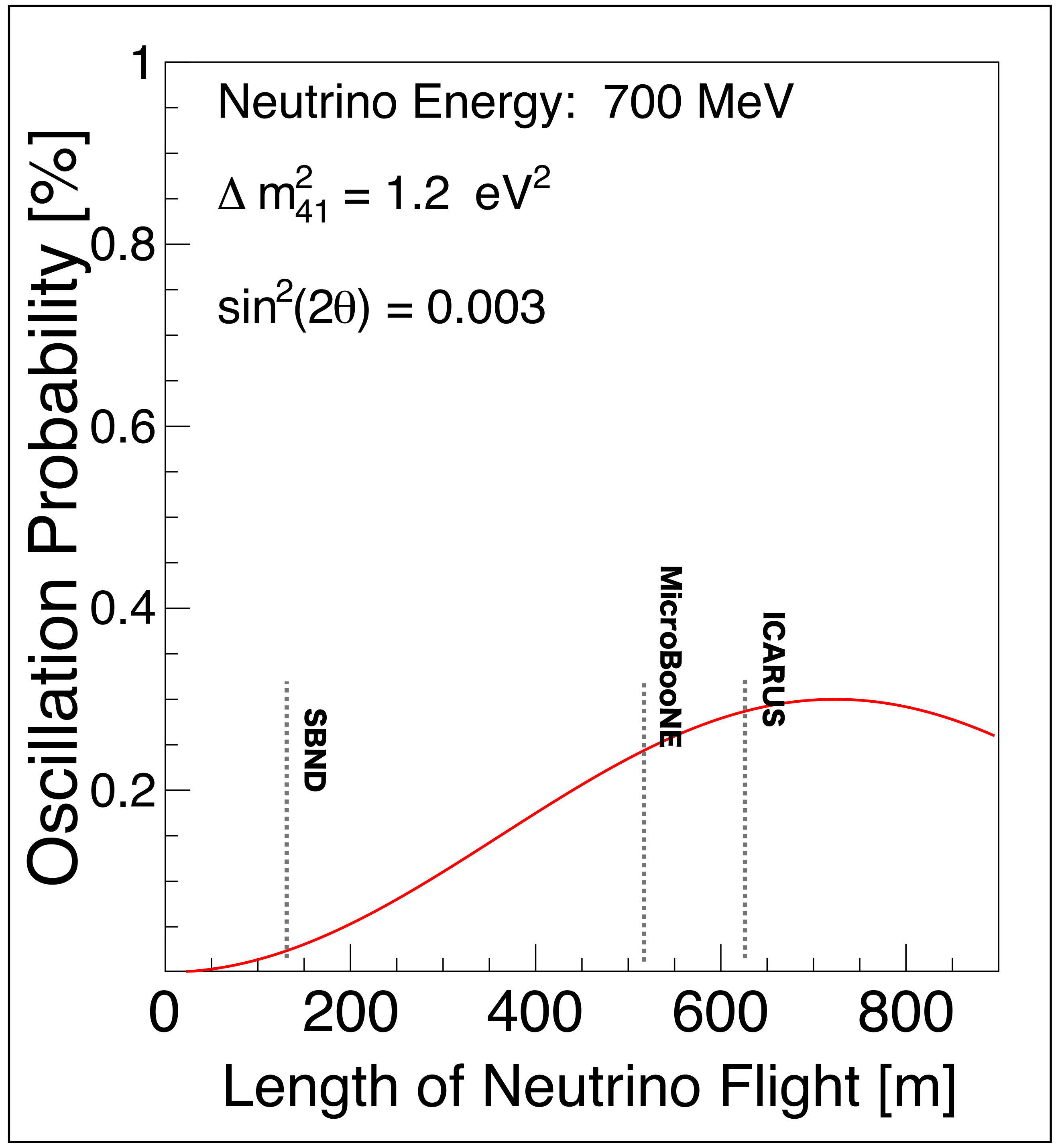
Exposure:

Assuming a start in Fall 2023 and running until the Fermilab accelerator long-shutdown in 2027, SBND is expected to collect **10-13 × 10^{20} POT**.

The SBND Collaboration has started considering the physics potential of **extending the run** after the **long-shutdown**.

SBND Role in Oscillation Searches





The near detector is crucial for oscillation searches.

Sitting close to the neutrino source, SBND plays a **unique role** in the chain of detectors.

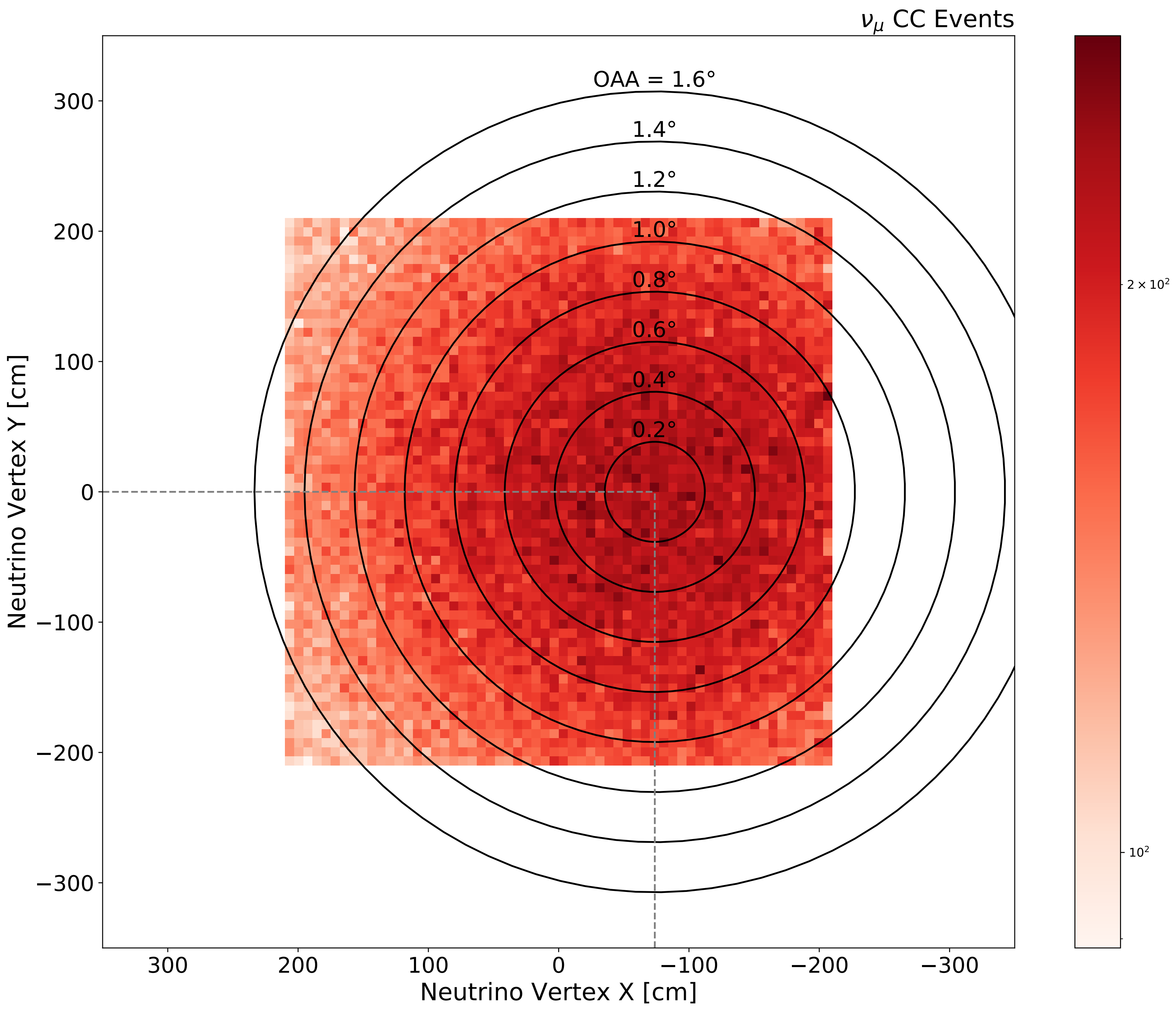
It sits before oscillations turn on @eV-scale → it will **characterize the beam** and address the dominant systematic uncertainties.

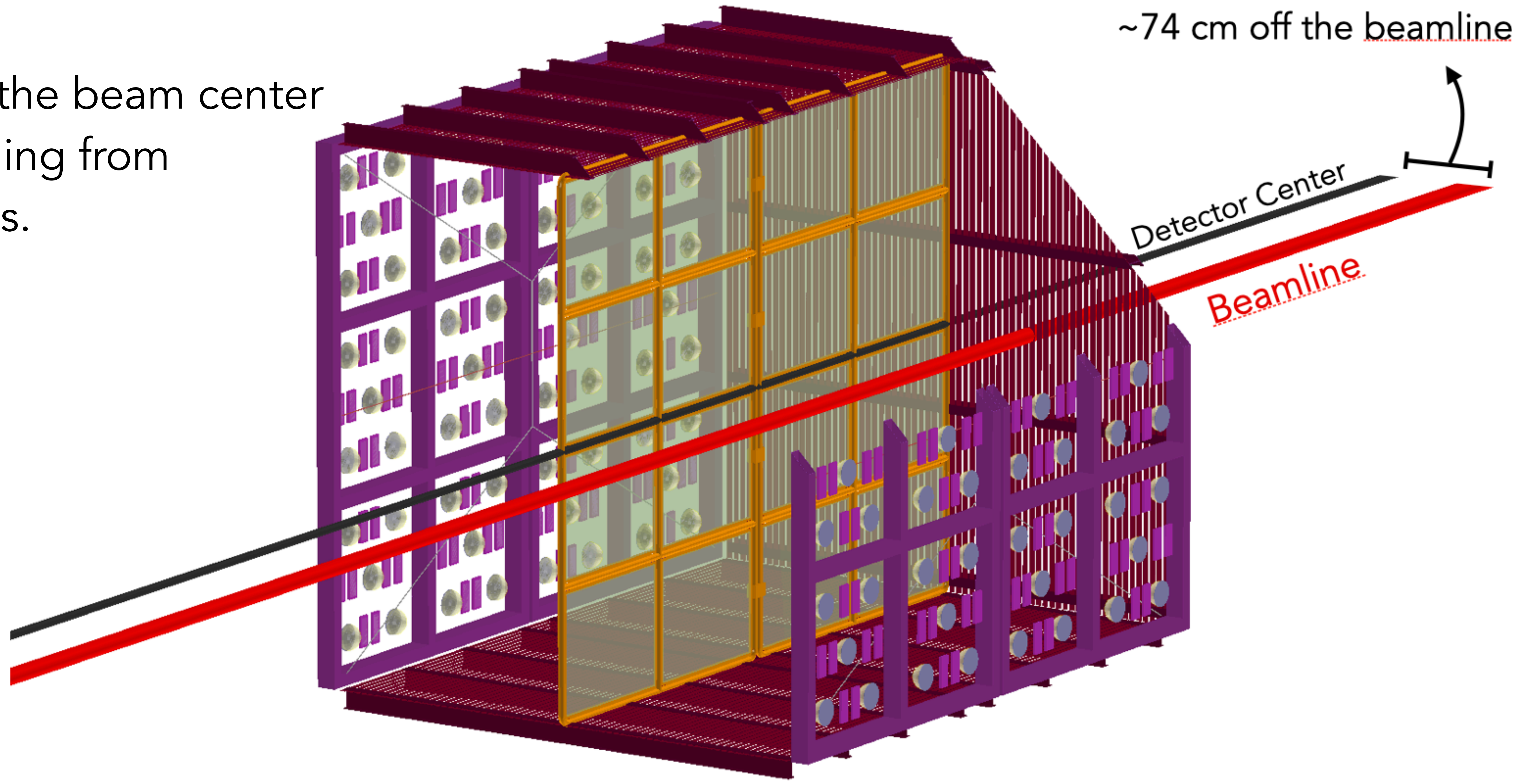
Beyond that, SBND can also extend oscillation sensitivities using the PRISM technique (see next).

A Slightly OFF-AXIS Detector

Being
- close (110 m) to the neutrino source
- intentionally positioned offset relative to the beam center

SBND detector is traversed by **neutrinos** coming from **different angles** with respect to the beam axis.





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

SBND-PRISM provides unique constraints of systematic uncertainties and **expand the SBND physic potentials.**

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

SBND-PRISM - Neutrino Fluxes

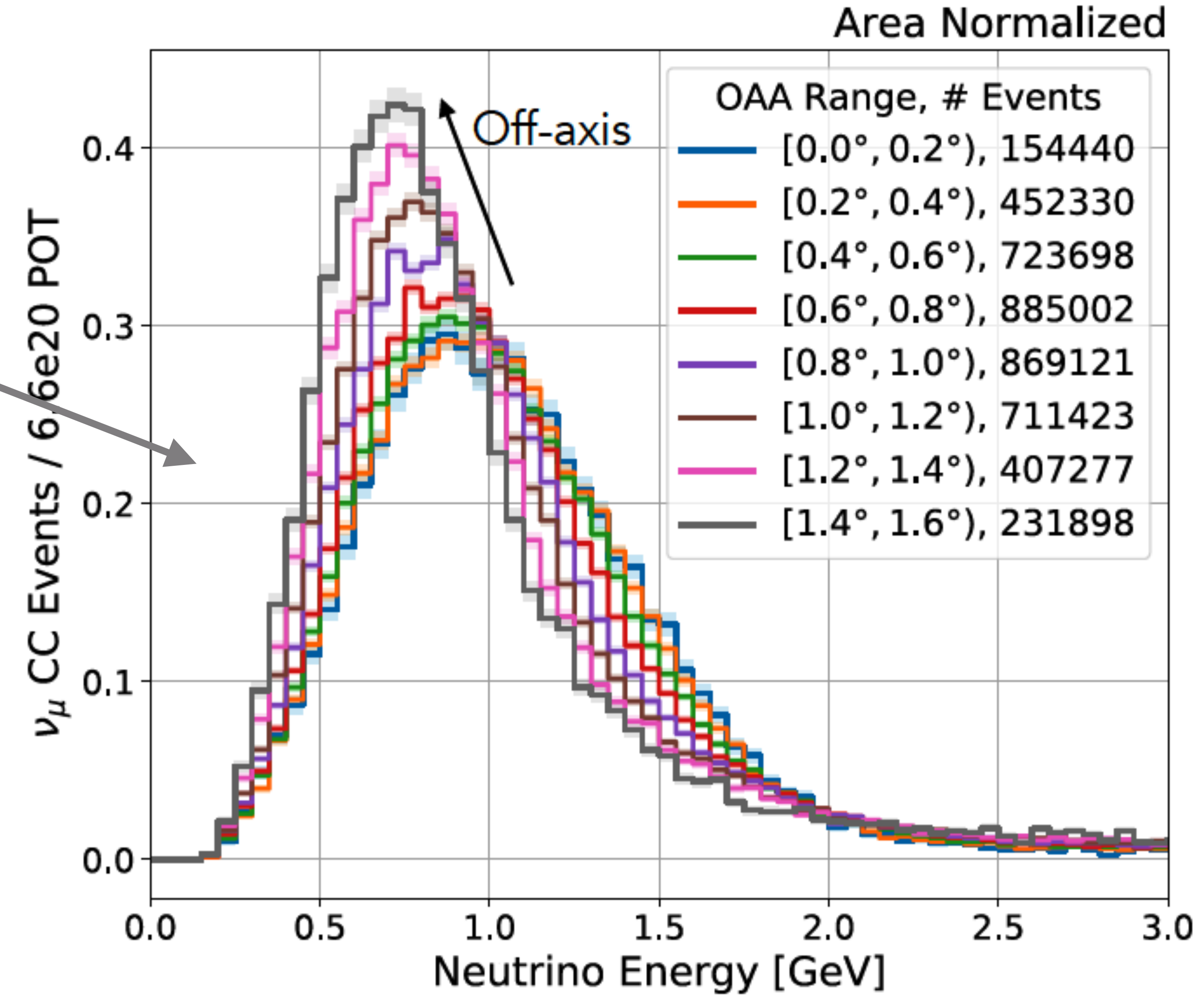
The **Muon** neutrino energy distributions are affected by the off-axis position [ν_μ come predominantly from two-body decay]. Larger off-axis angle → lower mean energy.

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!

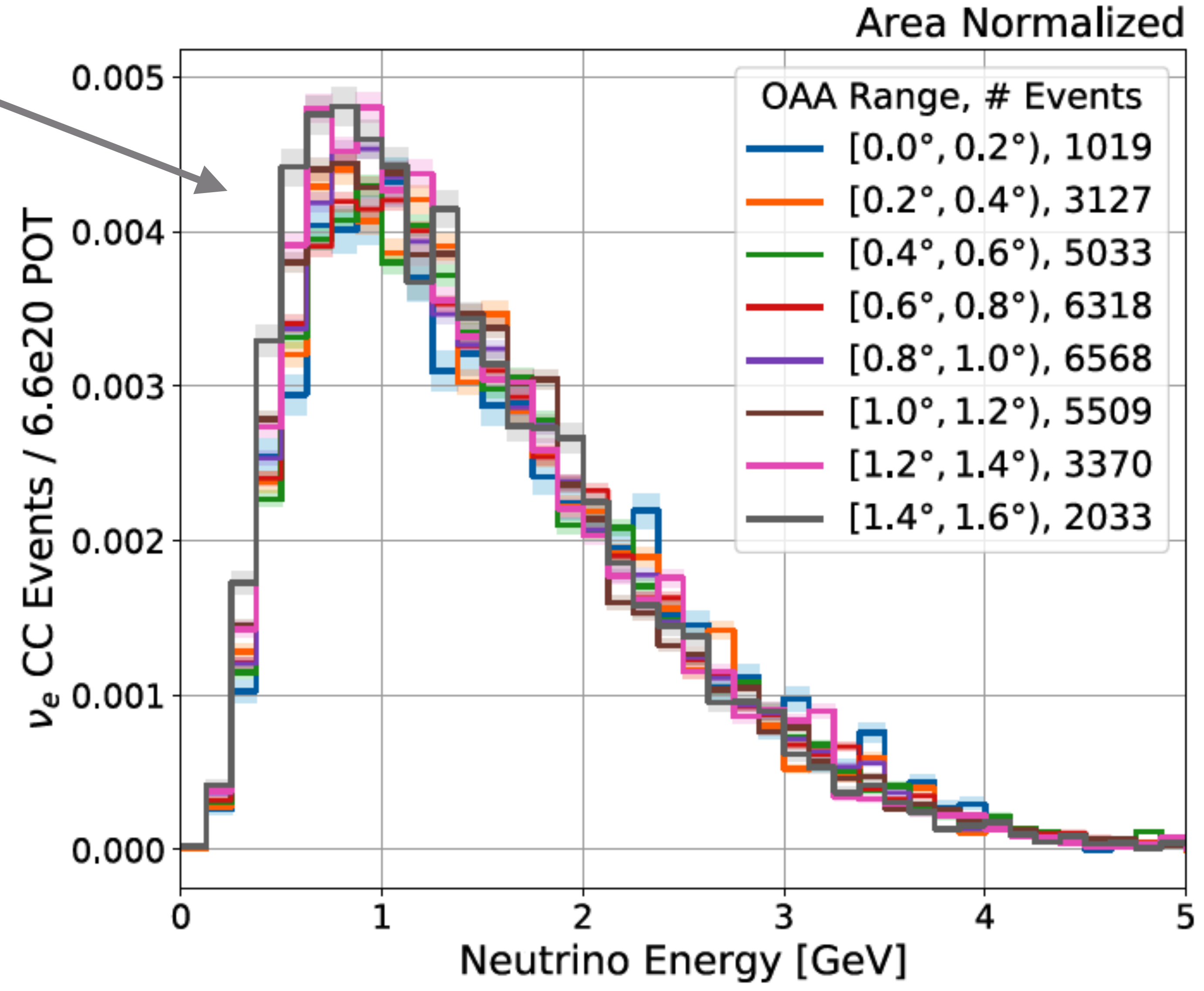
Leveraging the different behavior of muon and electron neutrinos in the OAA regions, we can improve sensitivity for sterile neutrino searches.

Neutrino Fluxes in Off-Axis Angle (OAA) regions



Muon neutrino

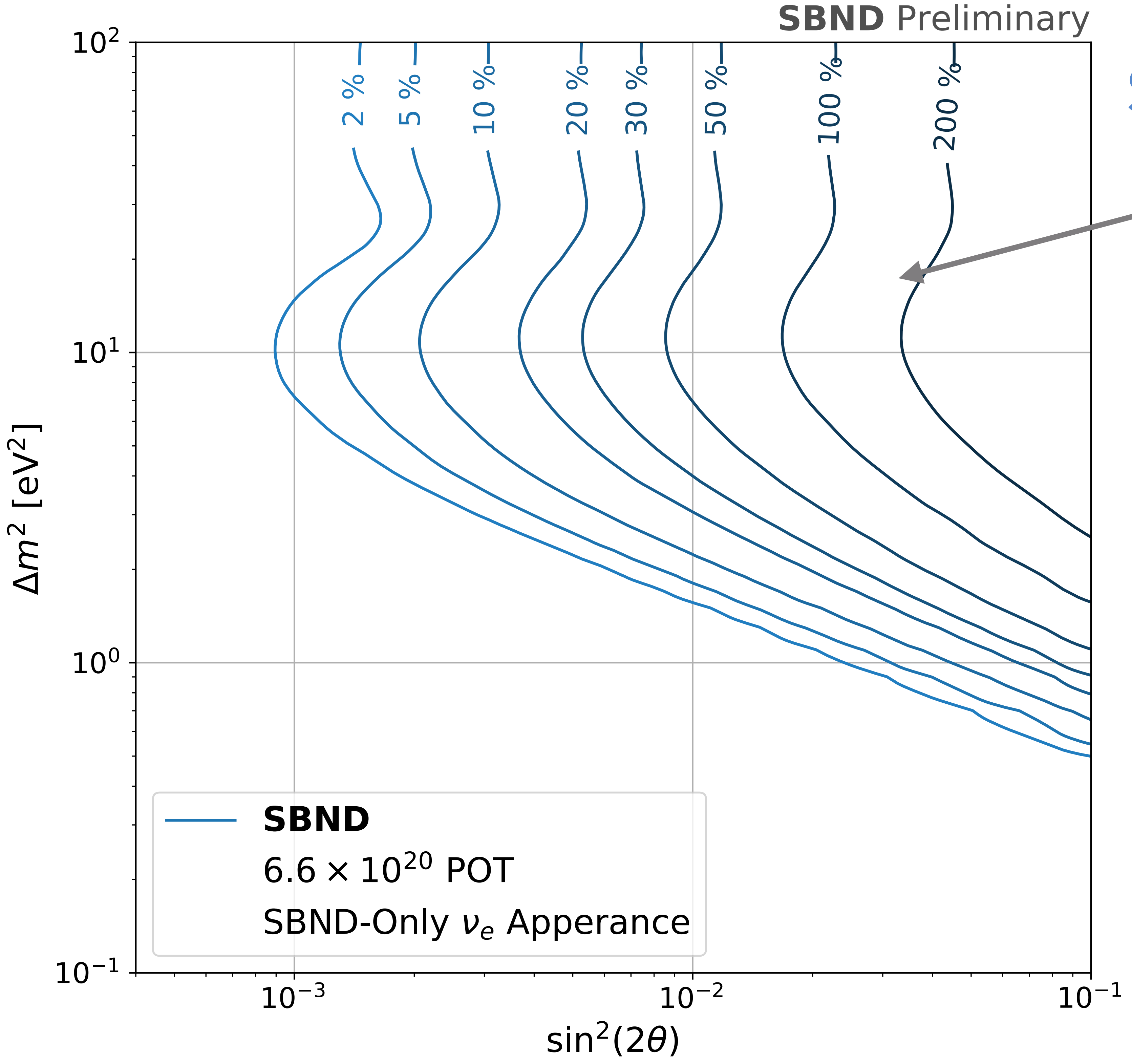
High event statistics in all off-axis regions.



Electron neutrino

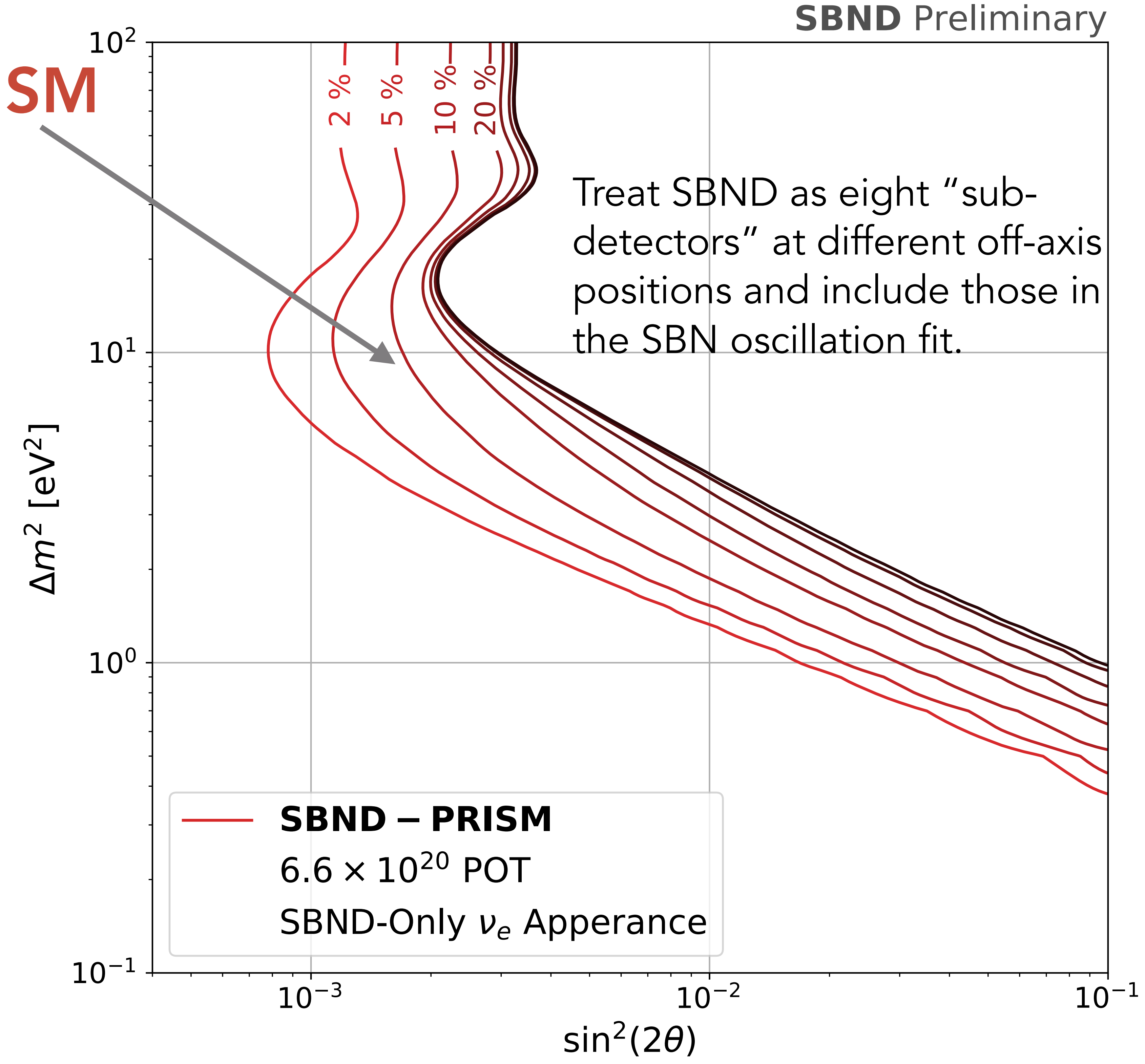
EFFECT OF SBND-PRISM ON OSCILLATION ANALYSES

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.



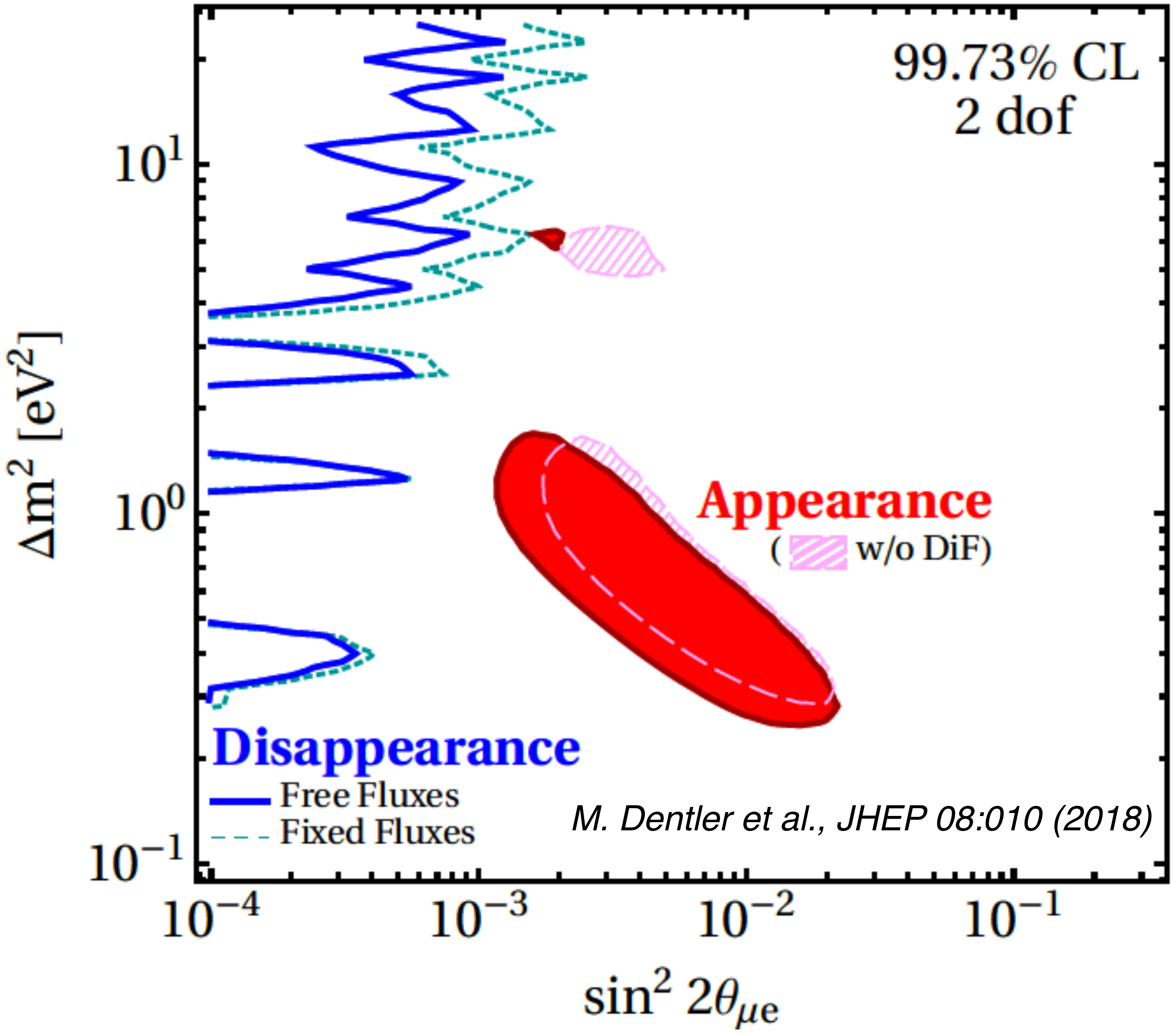
Treat SBND as eight "sub-detectors" at different off-axis positions and include those in the SBN oscillation fit.

- 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.

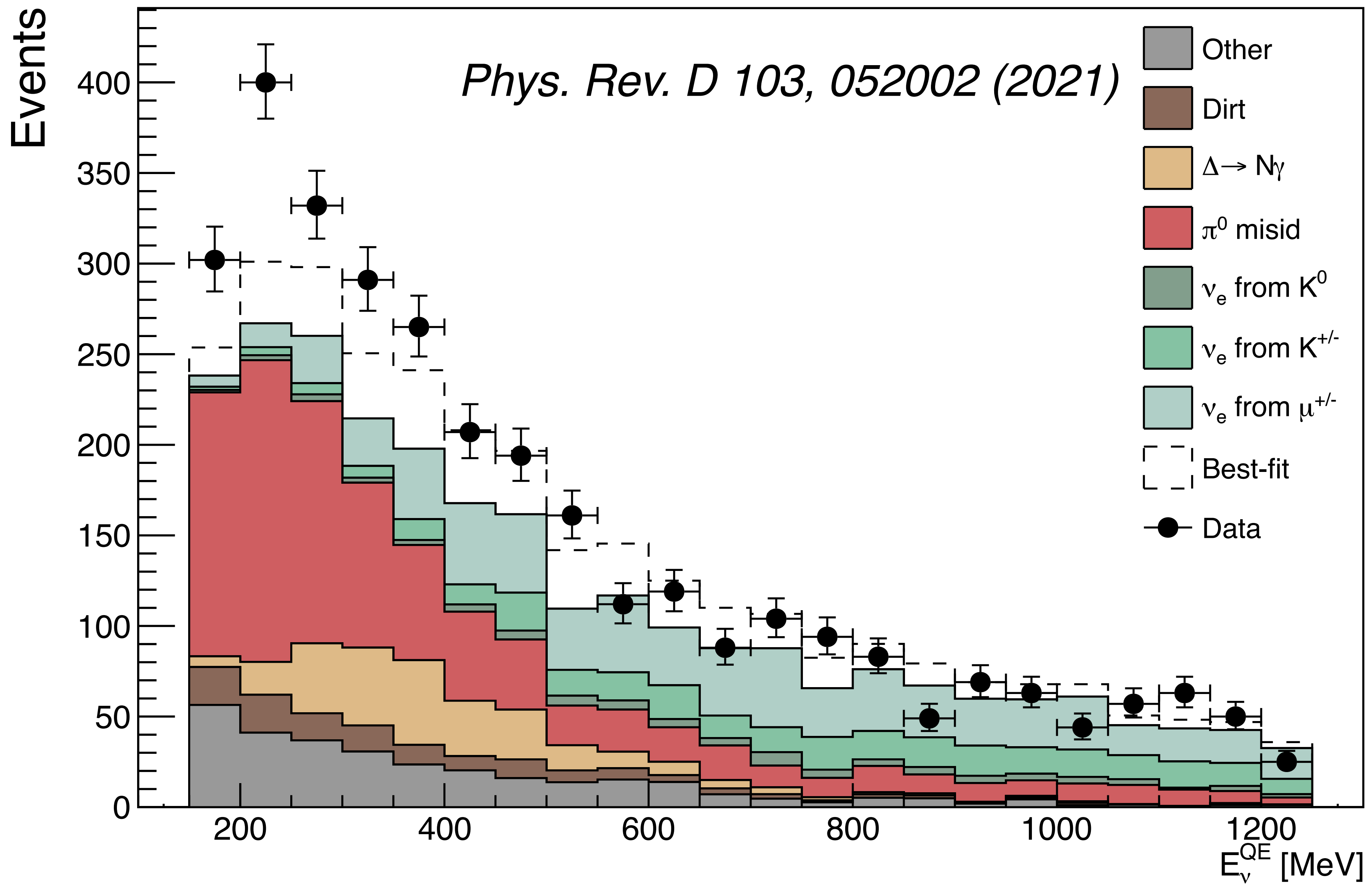
Light Sterile Neutrino - Experimental Landscape

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

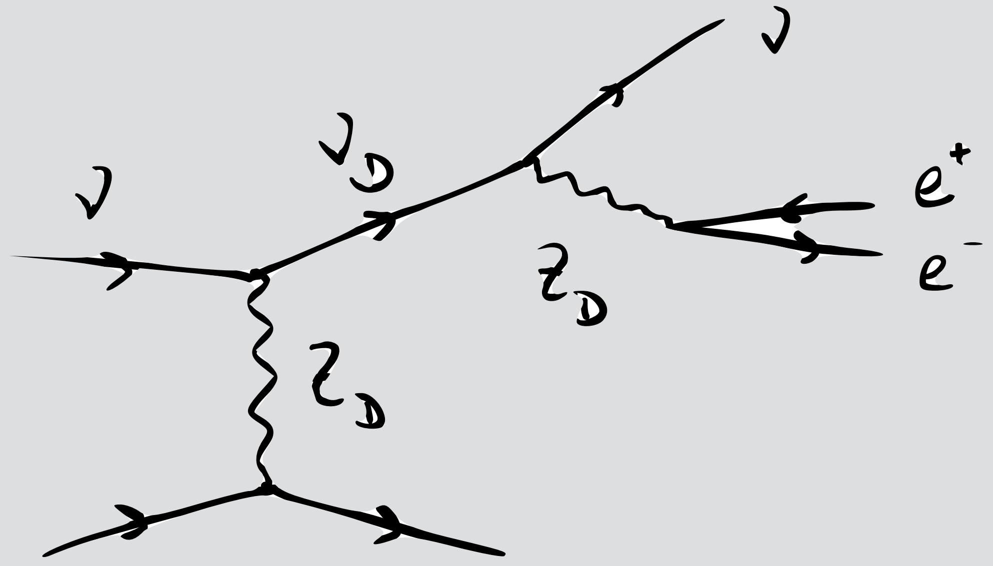


Alternative (Beyond Standard Model) explanations exist that could explain the MiniBooNE (and LSND) anomalies.

Evolving Landscape…

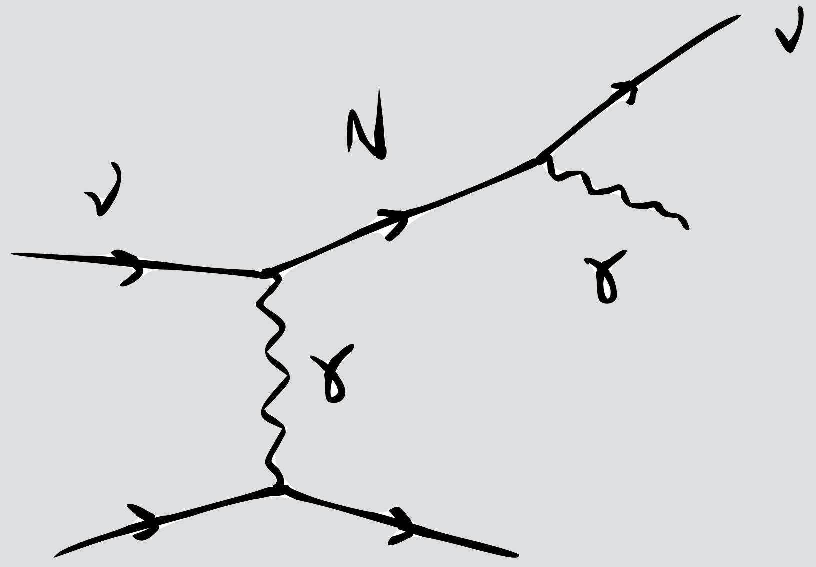
Alternative explanations of the MiniBooNE excess and other Beyond Standard Model scenarios.

Dark Neutrinos



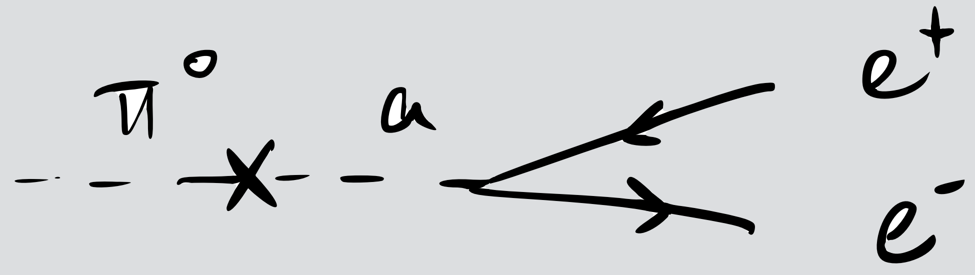
Bertuzzo Jana Machado Zukanovich PRL 2018, PLB 2019
Arguelles Hostert Tsai PRL 2019
Ballett Pascoli Ross-Lonergan PRD 2019
Ballett Hostert Pascoli PRD 2020

Transition Magnetic Moment



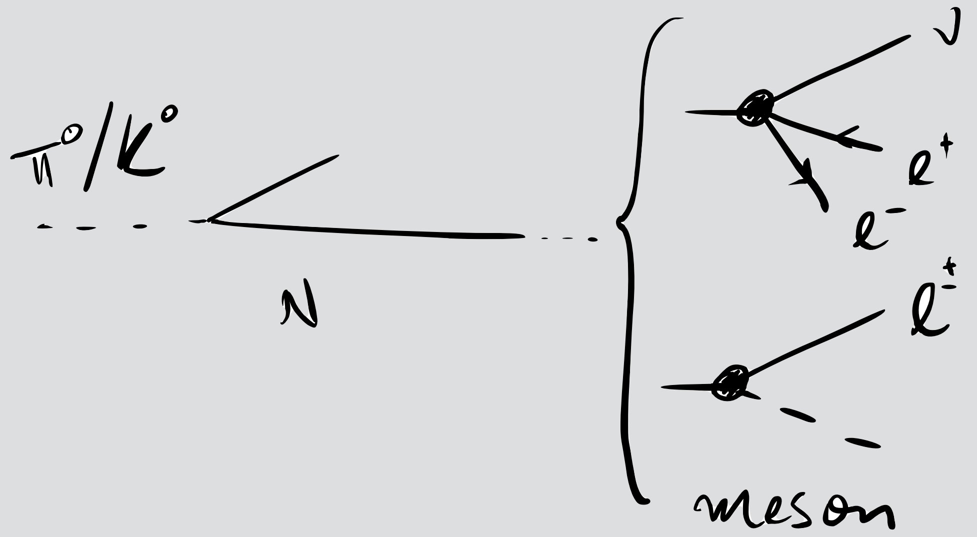
Gninenko PRL 2009
Coloma Machado Soler Shoemaker PRL 2017
Atkinson et al 2021 Vergani et al 2021

Axion-like Particles



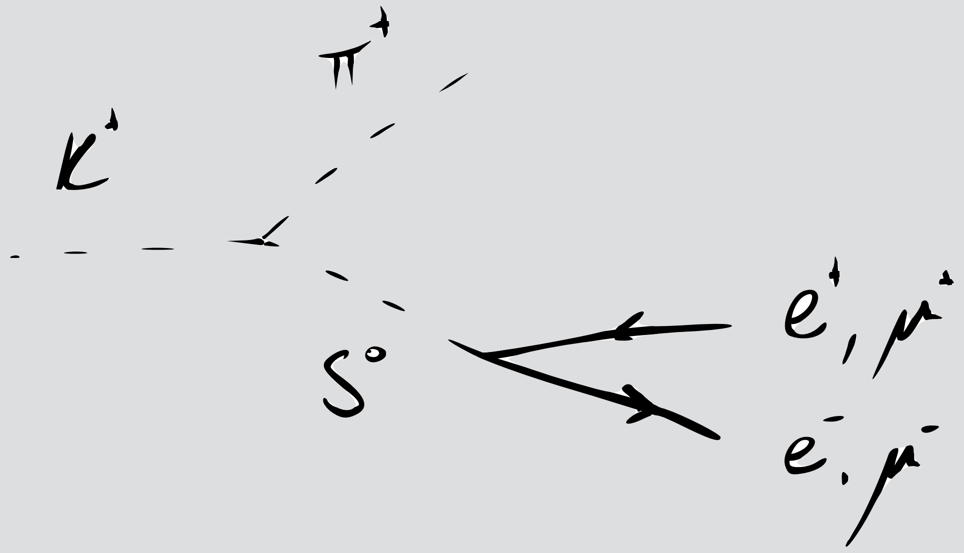
Kelly Kumar Liu PRD 2021
Brdar et al PRL 2021

Heavy Neutral Leptons



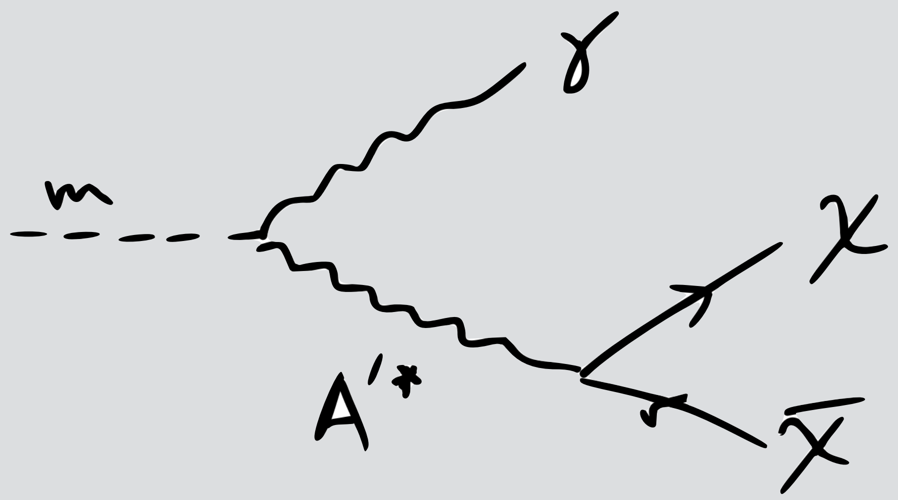
Ballett Pascoli Ross-Lonergan JHEP 2017
Kelly Machado PRD 2021

Higgs Portal Scalar



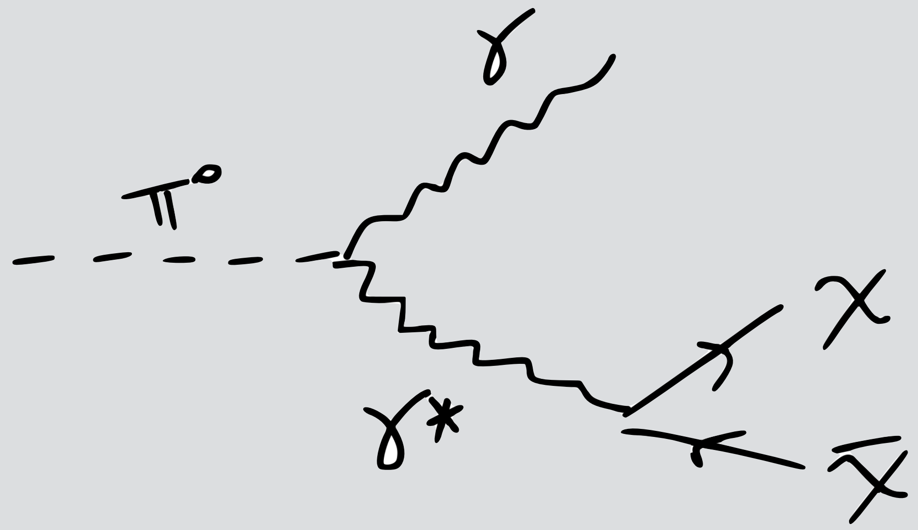
Pat Wilczek 2006
Batell Berger Ismail PRD 2019
MicroBooNE 2021

Light Dark Matter



Romeri Kelly Machado PRD 2019

Millicharged Particles



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

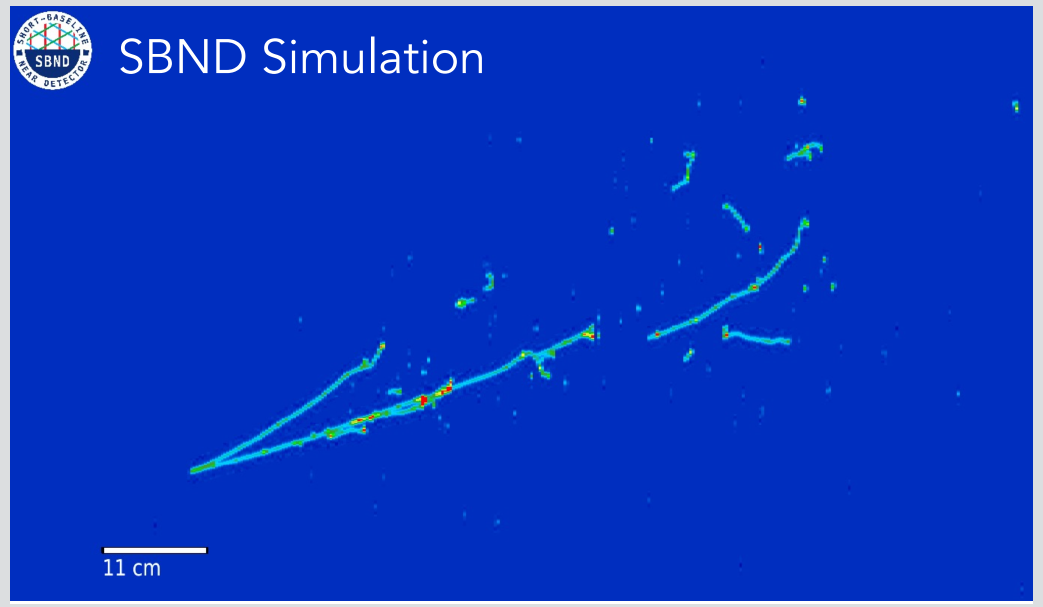
Note: not an exhaustive list!

Image credit P. Machado and M. Del Tutto

Signatures for New Physics in SBND

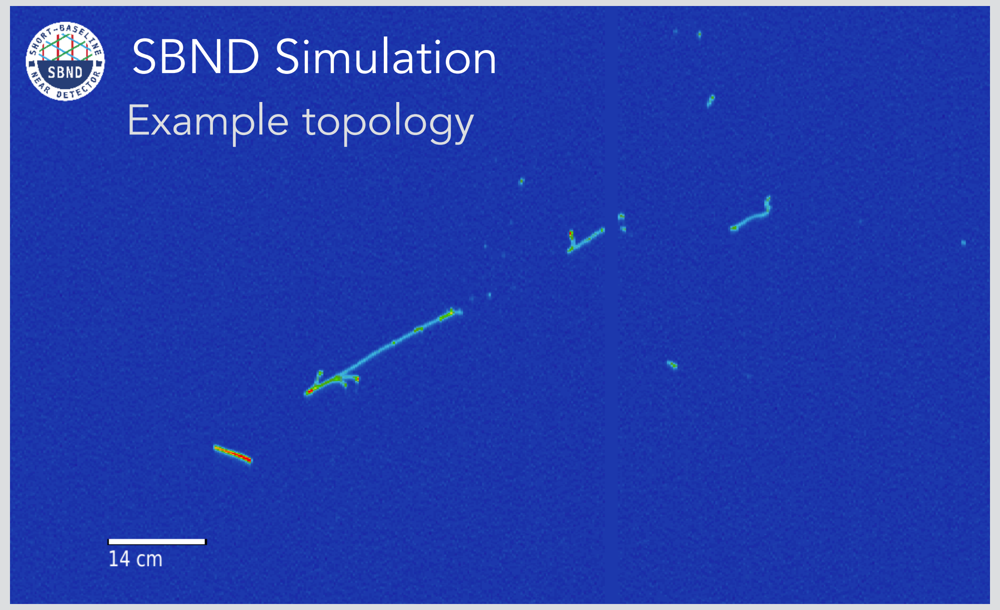
Collaboration between experimentalists and theorists is crucial for these searches.

Dark Neutrinos



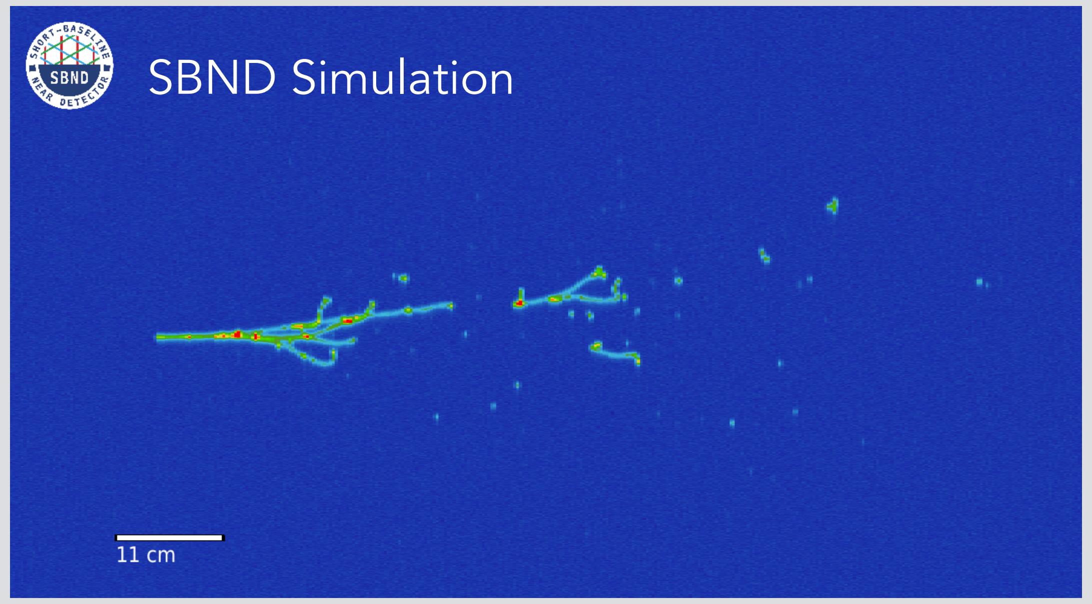
e+e- pair w/ or w/o hadronic activity

Transition Magnetic Moment



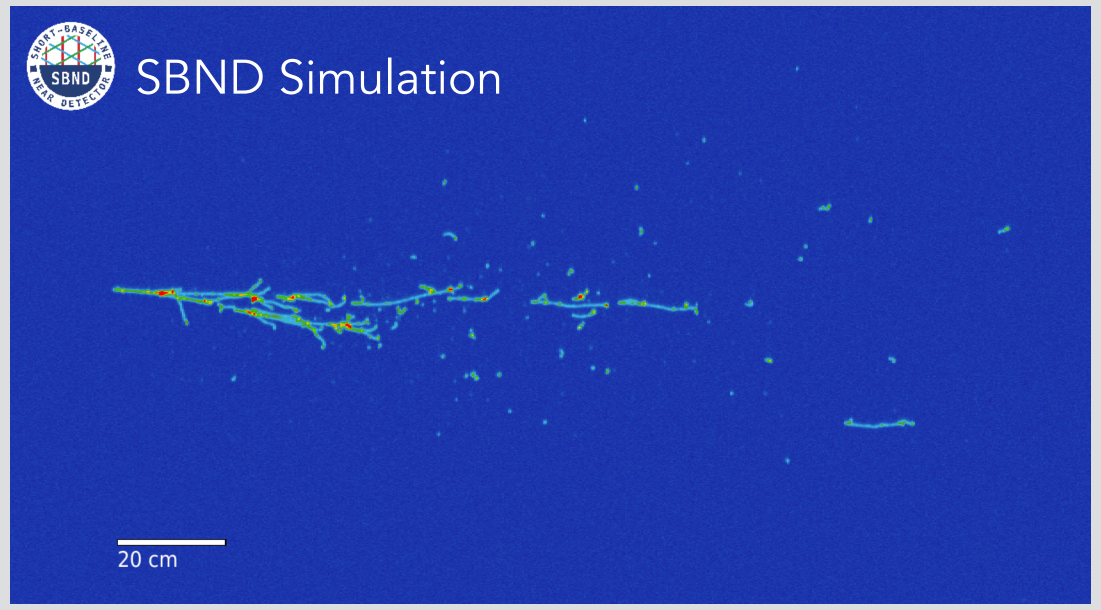
photon shower and hadronic activity

Axion-like Particles



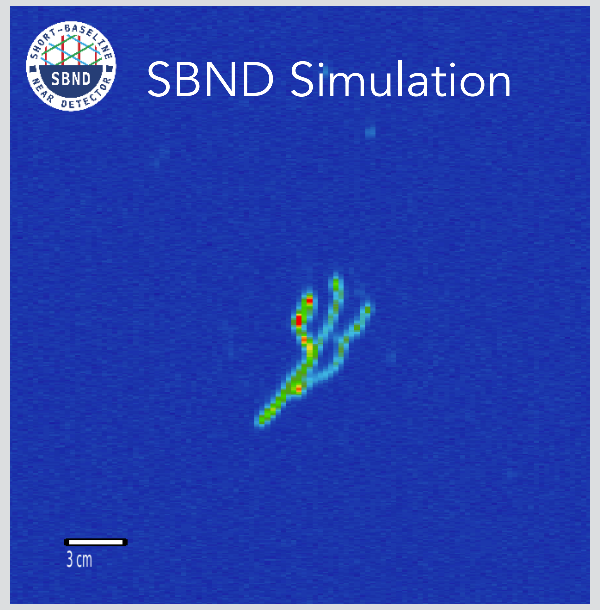
high-energy e^+e^-, $\mu^+\mu^-$

Heavy Neutral Leptons



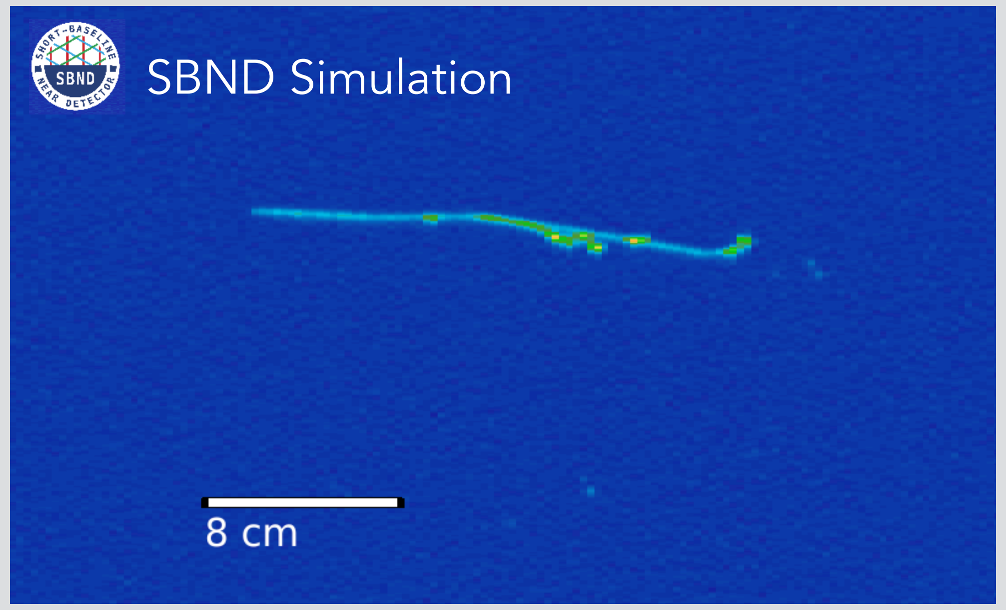
e^+e^-, $\mu^+\mu^-$, $\mu\pi$

Higgs Portal Scalar



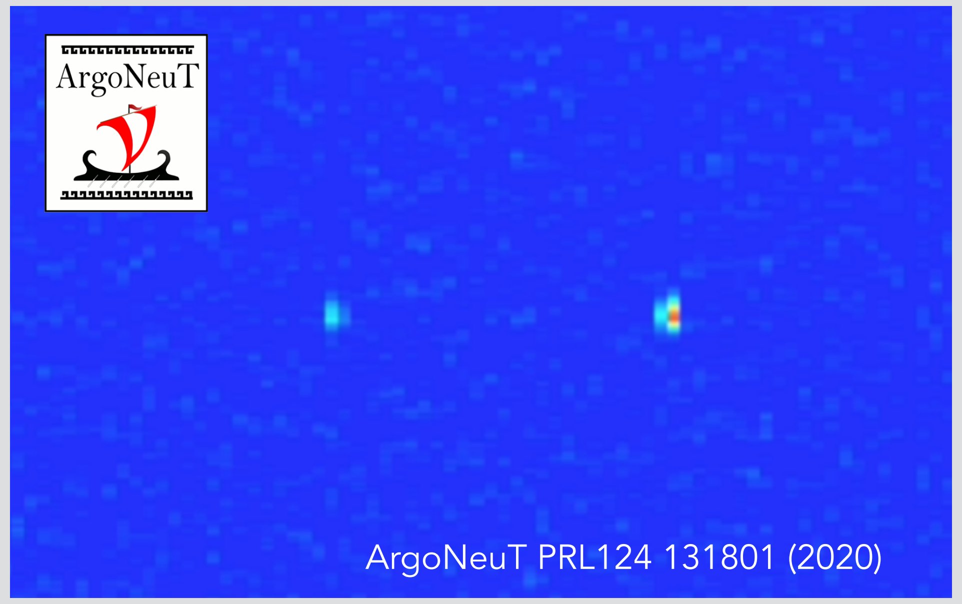
e^+e^-, $\mu^+\mu^-$, no hadronic activity

Light Dark Matter



electron scattering

Millicharged Particles



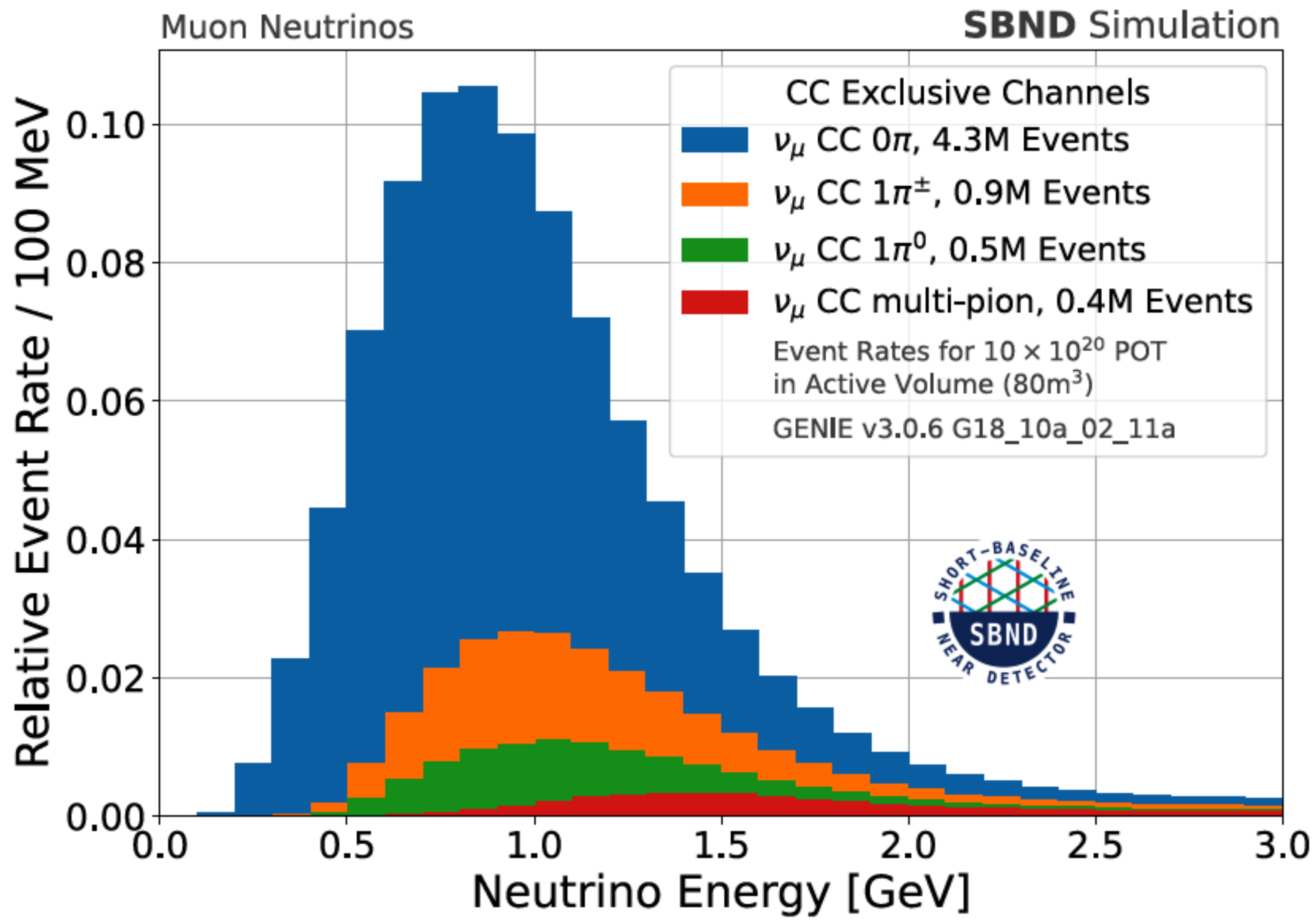
blips/faint tracks

Precision Studies of Neutrino-argon Interactions in SBND

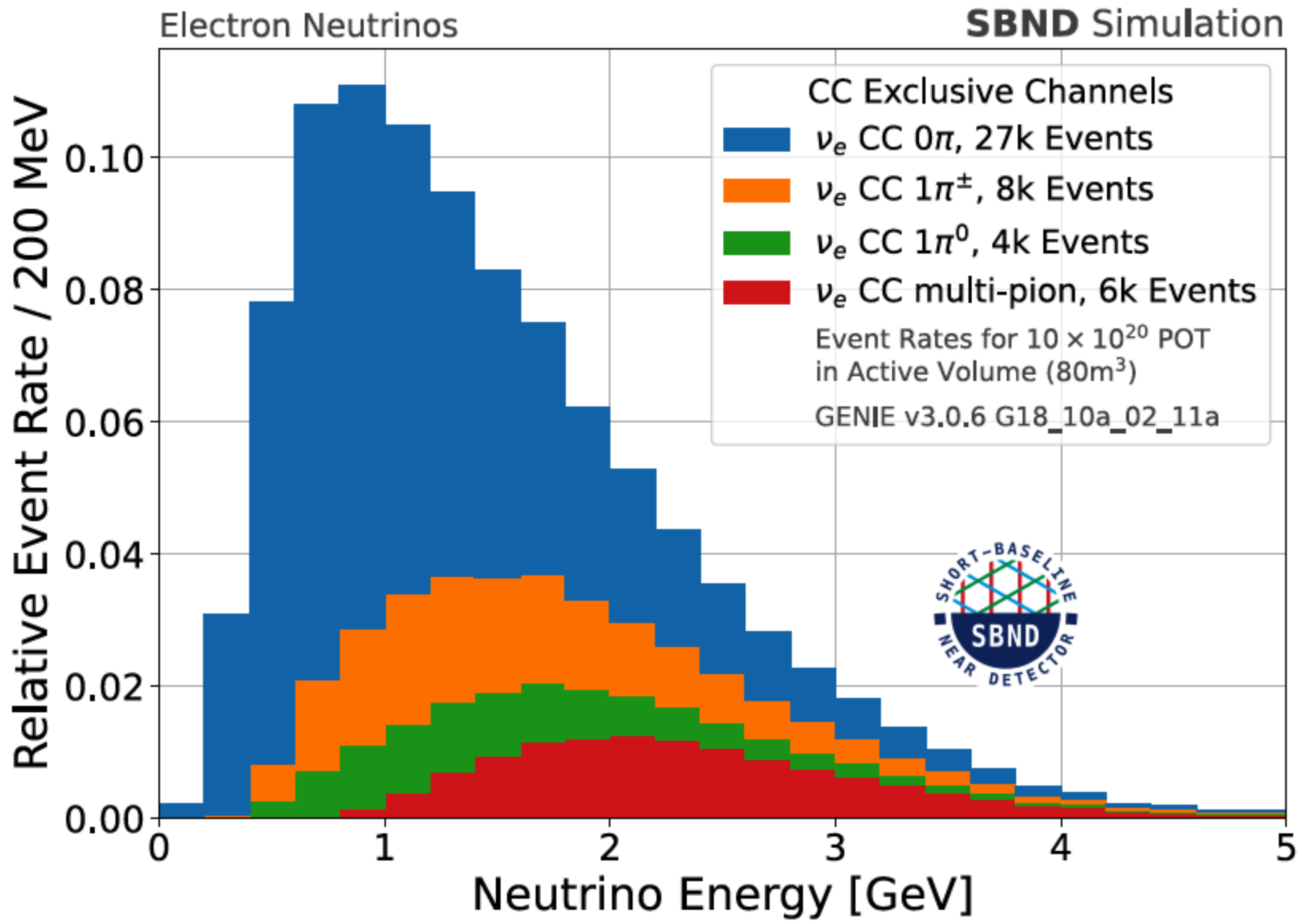
With its proximity to the neutrino source, SBND will compile neutrino data with unprecedented high event rate and will enable a **generational advance** in the study of neutrino-argon interactions in the GeV energy range.

5000 ν events/per day in SBND!

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



1.5M ν_μ CC events in 1 year



15k ν_e CC events in 1 year

PRECISION STUDIES OF NEUTRINO-ARGON INTERACTIONS IN SBND

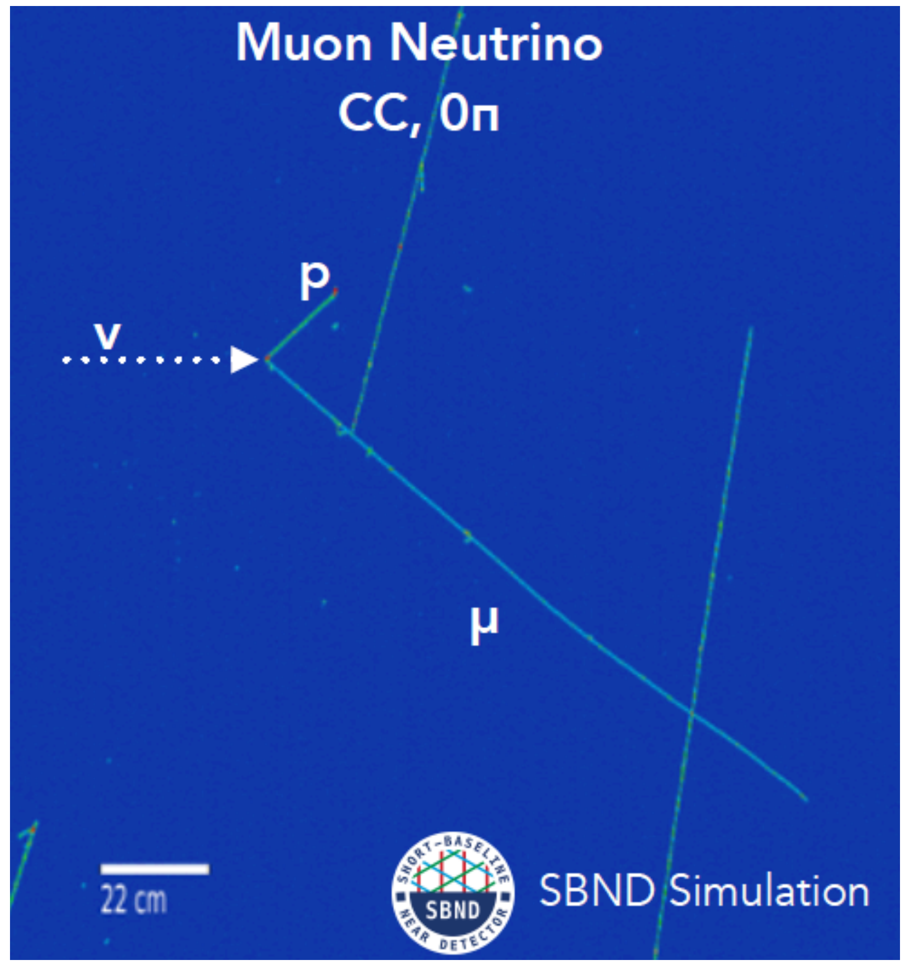
With its proximity to the neutrino source, SBND will compile neutrino data with unprecedented high event rate and will enable a **generational advance** in the study of neutrino-argon interactions in the GeV energy range.

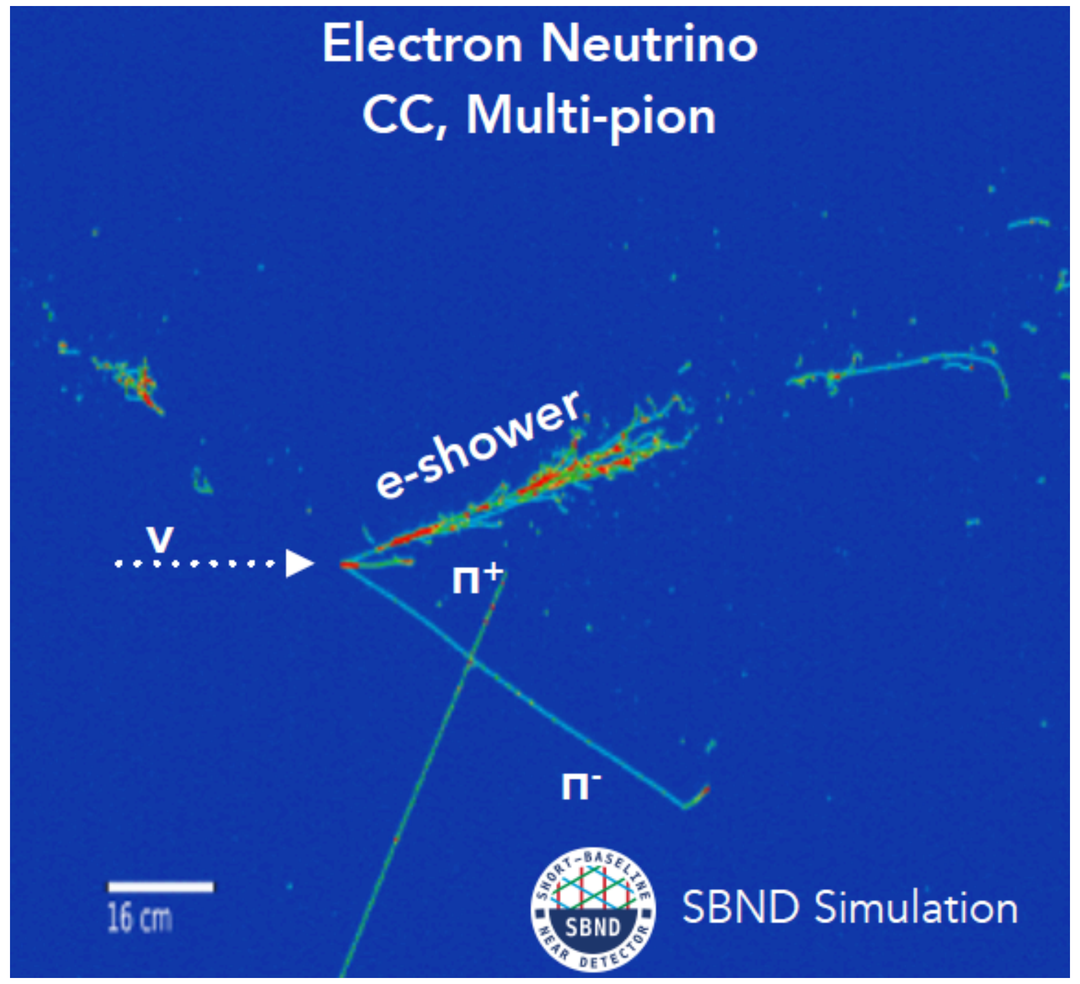
5000 ν events/per day in SBND!

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

SBND has a lot to offer! A **unique and rich neutrino interaction physics program**:

- Unprecedented statistics
- Unique detector capabilities (large photon detector coverage, low thresholds, ns timing, …)
- Multiple correlated fluxes (PRISM)

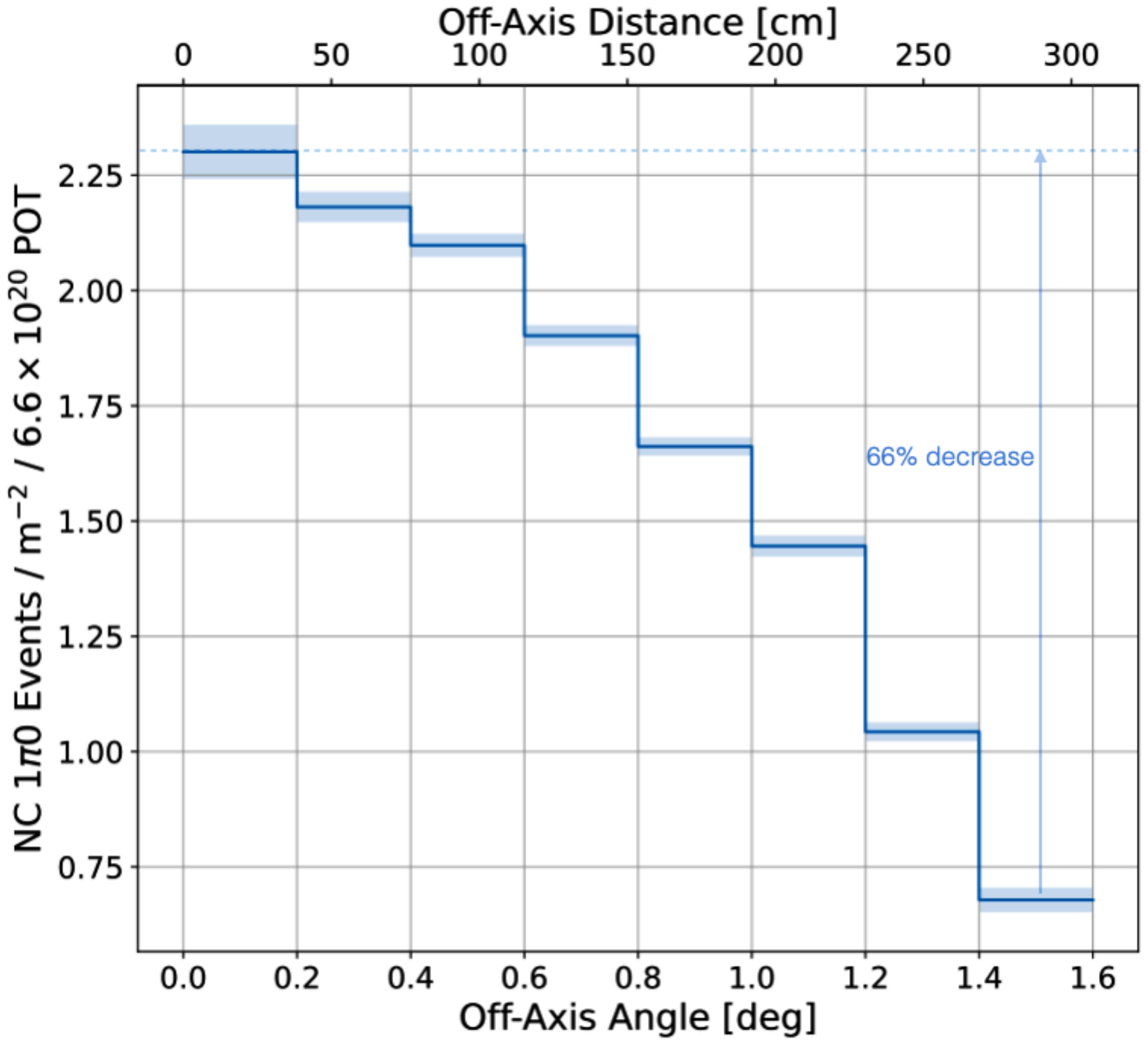




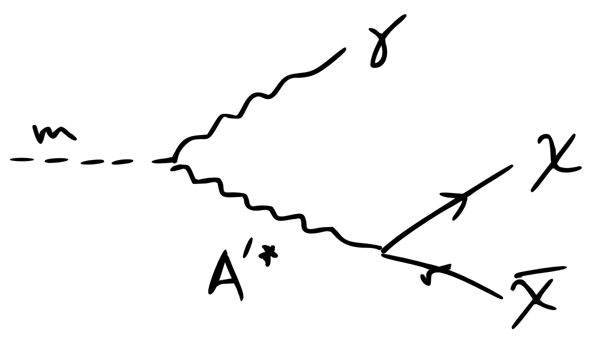
SBND-PRISM TO MITIGATE BACKGROUNDS

An example: electron neutrino measurements

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

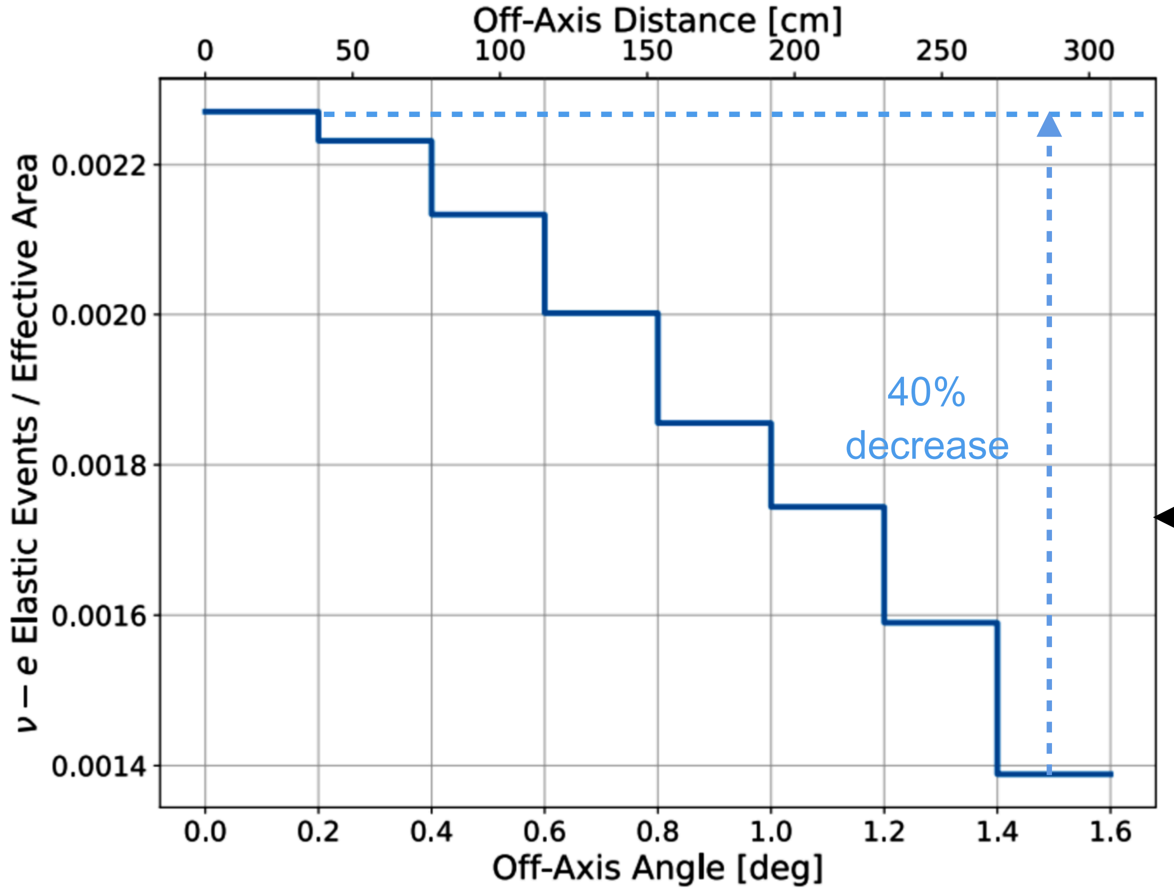


Another example: search for Light (sub-GeV) Dark Matter

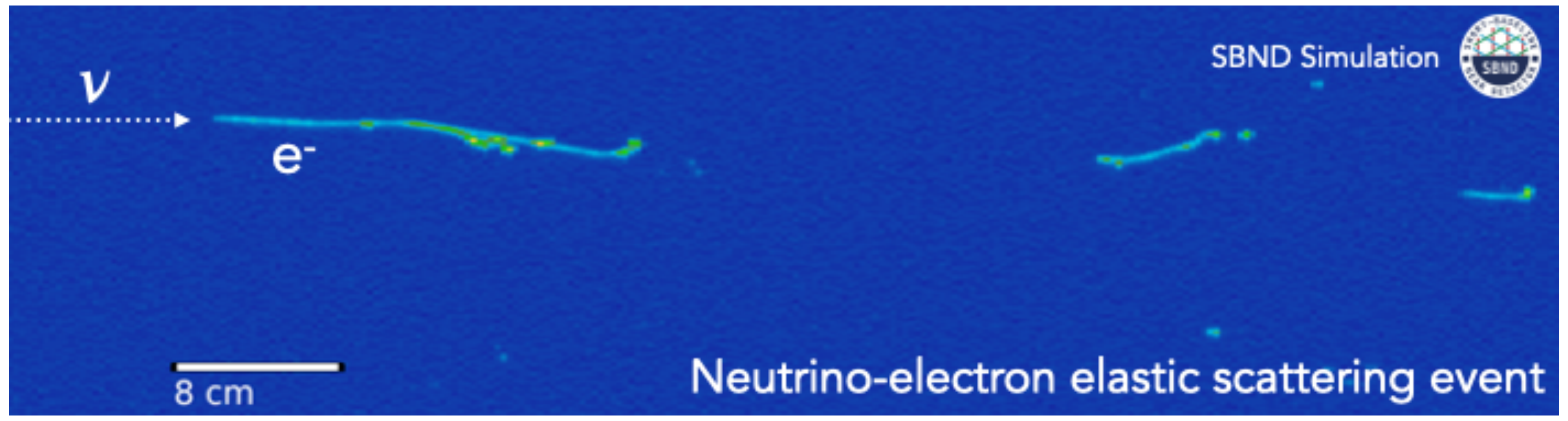


Dark photons, produced by the decay of neutral meson (pions, etas) in the target and decay into dark matter.

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.

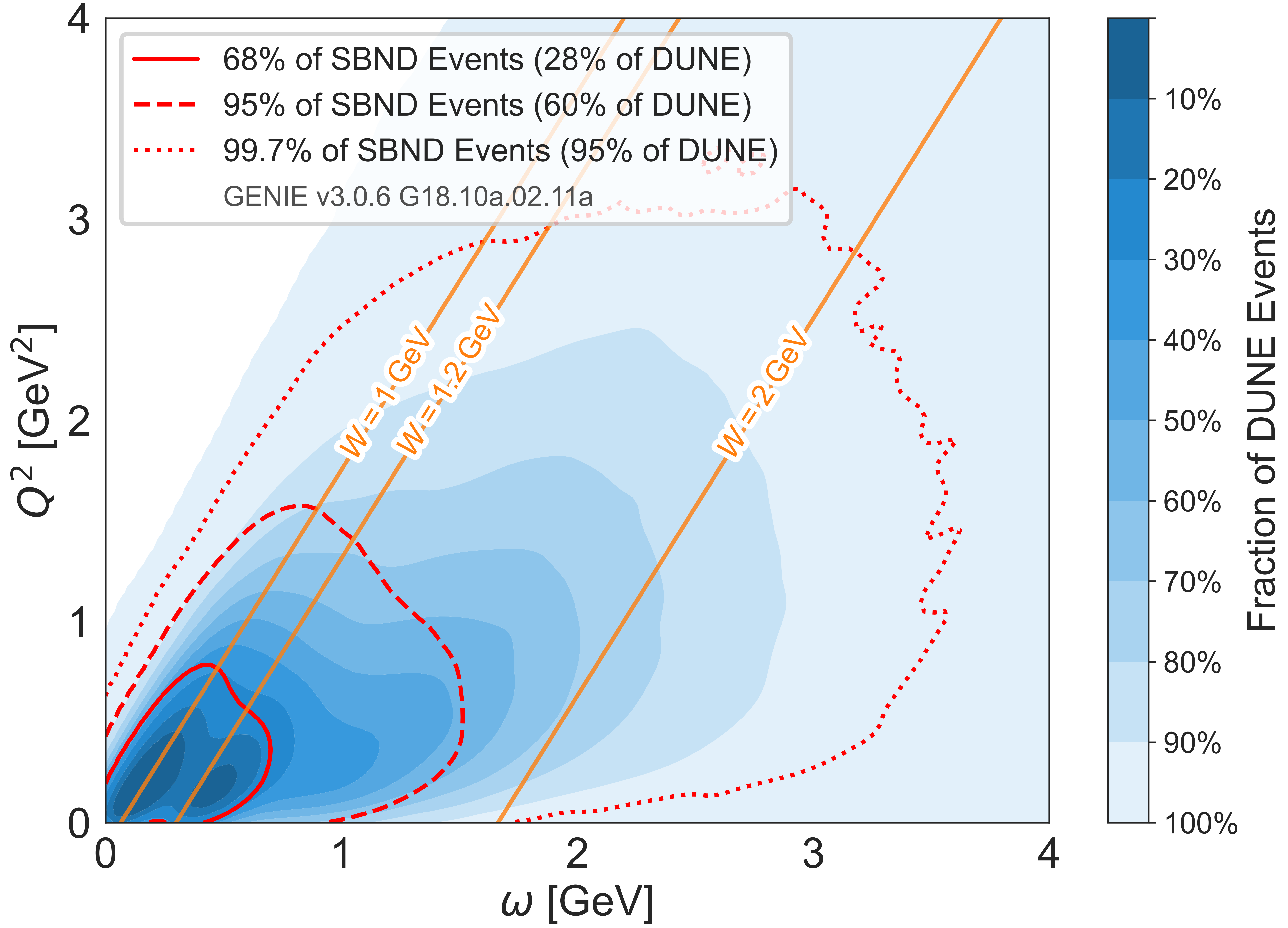


SBND-PRISM provides a natural way to **reduce backgrounds by looking off-axis**.

SBND/DUNE Phase Space

DUNE kinematic coverage is represented with the blue 2D histogram.

SBND kinematic coverage is shown with 3 contours, representing 68%, 95%, and 99.7% of all SBND data.



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

SBND Collaboration

251 Total Collaborators

204 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

- **Argonne National Lab:** Corey Adams, Zelimir Djurcic (IB), Maury Goodman, Afroditi Papadopoulou
- **University of Bern:** Silas Bosco, Igor Kreslo (IB), Lorenzo Meier, Shivaraj Mulleriababu, Michele Weber
- **Brookhaven National Lab:** Mary Bishai, Mateus Carneiro, Hucheng Chen, Jason Farrell, Jack Fried, Shanshan Gao, Jacob Larkin, Diana Mendez, Xin Qian, Veljko Radeka, Eric Raguzin, Craig Thorn, Hanyu Wei, Elizabeth Worcester (IB), Matt Worcester, Bo Yu, Chao Zhang, Manhong Zhao
- **University of California Santa Barbara:** Alex Antonakis, David Caratelli, Madeleine Leibovitch, Xiao Luo (IB), Dante Totani, Erin Yandel
- **University of Campinas:** Maria Cecilia Queroga Bazetto, Heriques Frandini, Pedro Holanda, Ana Machado, Orlando L.G. Peres, Vinicius do Lago Pimentel, Ettore Segreto (IB)
- **CERN:** Marta Babicz, Olga Beltramello, Johan Bremer, Michel Chalifour, Albert De Roeck, Letizia Di Giulio, Caroline Fabre, Jan Hrivnak, Umut Kose, Benoit Lacarelle, Dimitar Mladenov, Marzio Nessi (IB), Sandro Palestini, Francesco Pietropaolo, Xavier Pons, Filippo Resnati, Alberto Rigamonti, Elenora Seletskaya, Serhan Tufanli, Andrea Zani
- **University of Chicago:** Bonnie Fleming, Moon Jung, Gray Putnam, David Schmitz* (IB), Lynn Tung, Angela White
- **CIEMAT:** Rodrigo Alvarez-Garrote, José Crespo-Anadón, Clara Cuesta, Inés Gil-Botella (IB)
- **Colorado State University** Dan Carber, Lane Kashur, Andrew Mogan, Mike Mooney (IB)
- **Columbia University:** Lukas Arnold, Leslie Camilleri, Cheng-Yi Chi, Guanqun Ge, Daisy Kaira, Georgia Karagiorgi, Mike Shaevitz (IB), Ibrahim Safa, Bill Sippach
- **University of Edinburgh:** Alice Hamer, Li Jiaoyang, Miquel Nebot-Guinot, Andrzej Szelc (IB)
- **Federal University of ABC:** Celio Moura, Laura Paulucci (IB)
- **Federal University of Alfenas:** Gustavo Valdiviesso (IB)
- **Federal University of Sao Carlos UFSCAR:** Franciole Marinho (IB)
- **Fermilab:** Roberto Acciarri, William Badgett, Linda Bagby, Supraja Balasubramanian, Vincent Basque, Minerba Betancourt, Flavio Cavanna, Marco Del Tutto, Vito Di Benedetto, Steve Dixon, Steve Dytman, Steven Gardiner, Michael Geynisman, Herb Greenlee, Sai Manohari Kancharla, Bruce Howard, Cat James, Tom Junk, Wes Ketchum, Min Jeong Kim, Pedro Machado, Matthew Micheli, David Montanari, Trevor Nichols, Barry Norris, Sungbin Oh, Ornella Palamara*, Vishvas Pandey, Zarko Pavlovic, Fernanda Psihas, Dave Pushka, Anne Schukraft+, Shishir Shetty, Michelle Stancari (IB), Andy Stefanik, Thomas Strauss, Donatella Torretta, Matt Toups, Peter Wilson, Wanwei Wu, Tingjun Yang, Lauren Yates, Sam Zeller, Joseph Zennamo
- **University of Florida:** Brinden Carlson, Ivan Furic, Varuna Meddage, Heather Ray (IB)
- **University of Granada:** Antonio Bueno, Diego Garcia Gamez (IB), Francisco J. Nicolas-Arnaldos, Luis Pelegrina Gutiérrez, Alejandro Sanchez-Castillo, Patricia Sánchez-Lucas, Bruno Zamorano
- **Harvard University:** Roxanne Guenette (IB)
- **Illinois Institute of Technology:** William Foreman, Miguel Hernandez-Morquecho, Bryce Littlejohn (IB)
- **Kansas State University:** Glenn Horton-Smith (IB)
- **Lancaster University:** Andy Blake, Dominic Brailsford, Rachel Coackley, Henry Lay, Jarek Nowak (IB), Niam Patel, Peter Ratoff
- **University of Liverpool:** Costas Andreopoulos (IB), Tom Ham, Kostas Mavrokoridis, Dave Payne, Adam Roberts, Marco Roda, Bethany Ann Slater, Christos Touramanis
- **Los Alamos National Lab:** Jan Boissevain, Robert Fine, Sowjanya Gollapinni, En-Chuan Huang, Bill Louis (IB), Mark Ross-Lonergan, Richard Van de Water
- **Lousiana State University:** Ewerton Belchior, Hanyu Wei
- **University of Manchester:** Luciano Arellano, Aditya Bhanderi, Justin Evans, Pawel Guzowski, Luis Mora Lepin, David Marsden, Anyssa Navrer-Agasson, Marina Reggiani-Guzzo, Stefan Söldner-Rembold (IB)
- **University of Michigan:** Chris Barnes, Benjamin Bogart, Josh Spitz (IB)
- **University of Minnesota:** Andy Furmanski (IB), Chris Hilgenberg
- **University of Pennsylvania:** Josh Klein (IB), Tereza Kroupova, Jonathan Sensenig
- **Rutgers University:** Ivan Lepetic, Keng Lin, Andy Mastbaum (IB)
- **Rutherford Appleton Laboratory:** Costas Andreopoulos
- **University of Sheffield:** Anthony Ezeribe, Trevor Gamble, Rhiannon Jones, Vitaly Kudryavtsev (IB), Lan Nguyen, Harry Scott, Neil Spooner, Ed Tyley, Ala Zeglam
- **University of Sussex:** Robert Darby, Iker de Icaza Astiz, Clark Griffith (IB)
- **Syracuse University:** Amy Filkins, Monica Nunes, Rohan Rajagopalan, Ohana Benevides Rodrigues, Mitch Soderberg (IB)
- **University of Tennessee Knoxville:** Sowjanya Gollapinni (IB), Wei Tang
- **Texas A&M University:** Kevin Kelly (IB)
- **University of Texas Arlington:** Leo Aliaga-Soplin, Jonathan Asaadi (IB), Andrew Brandt, Raquel Castillo, Gabriela Vitti Stenico, Shweta Yadav, Jae Yu
- **Tufts University:** Polina Abratenko, Omar Alterkait, Zev Imani, Katie Mason, Joshua Mills, Matt Rosenberg, Taritree Wongjirad (IB)
- **University College London:** Anastasia Basharina-Freshville, Flavia Cicala, Nicola McConkey (IB), Ryan Nichol
- **Virginia Tech:** Camillo Mariani (IB)
- **Yale University:** London Cooper-Troendle, Antonio Ereditato, Domenico Franco, Lee Hagaman, Giacomo Scanavini

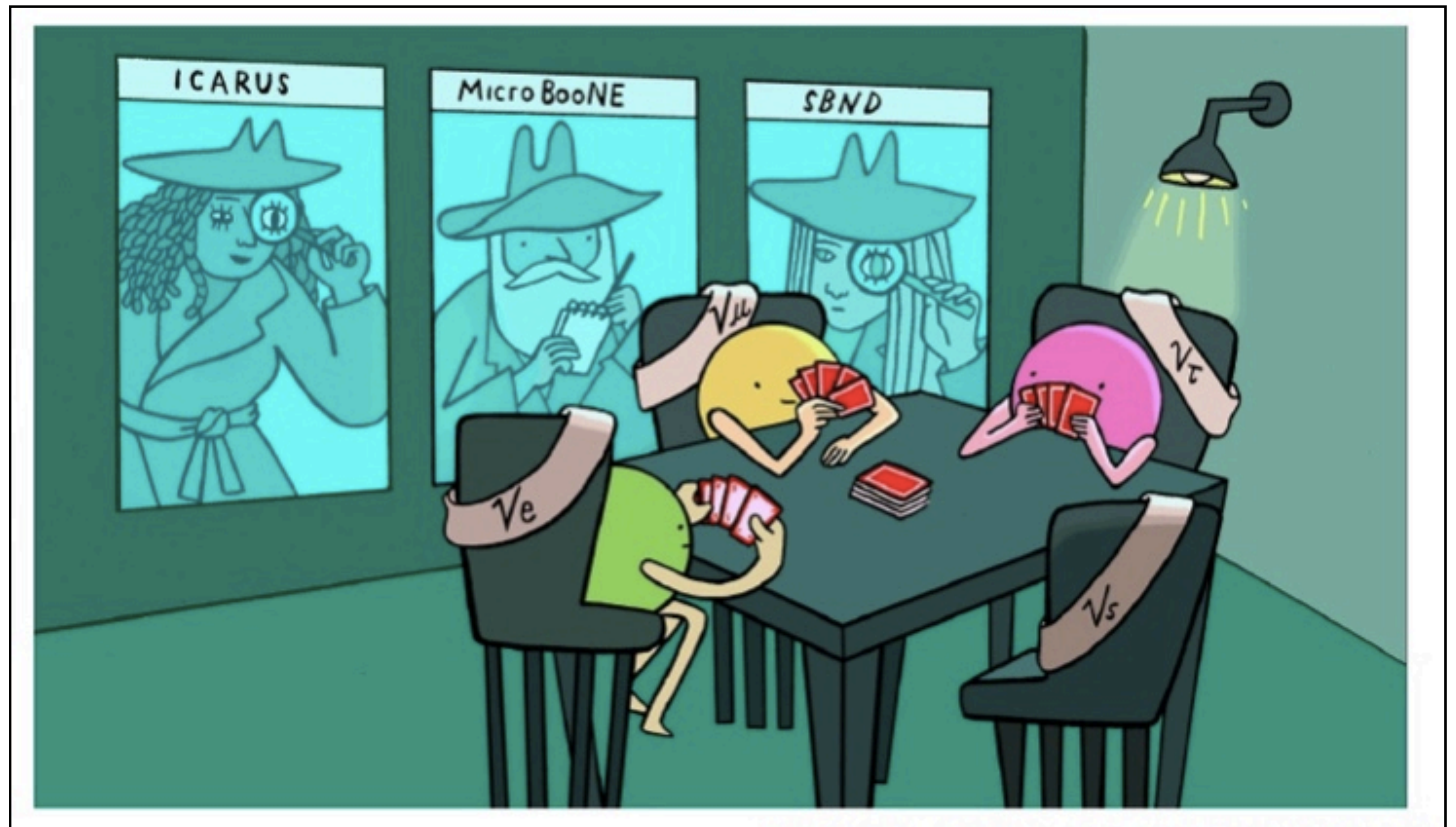
SUMMARY

Fantastic progress on SBND construction last year!

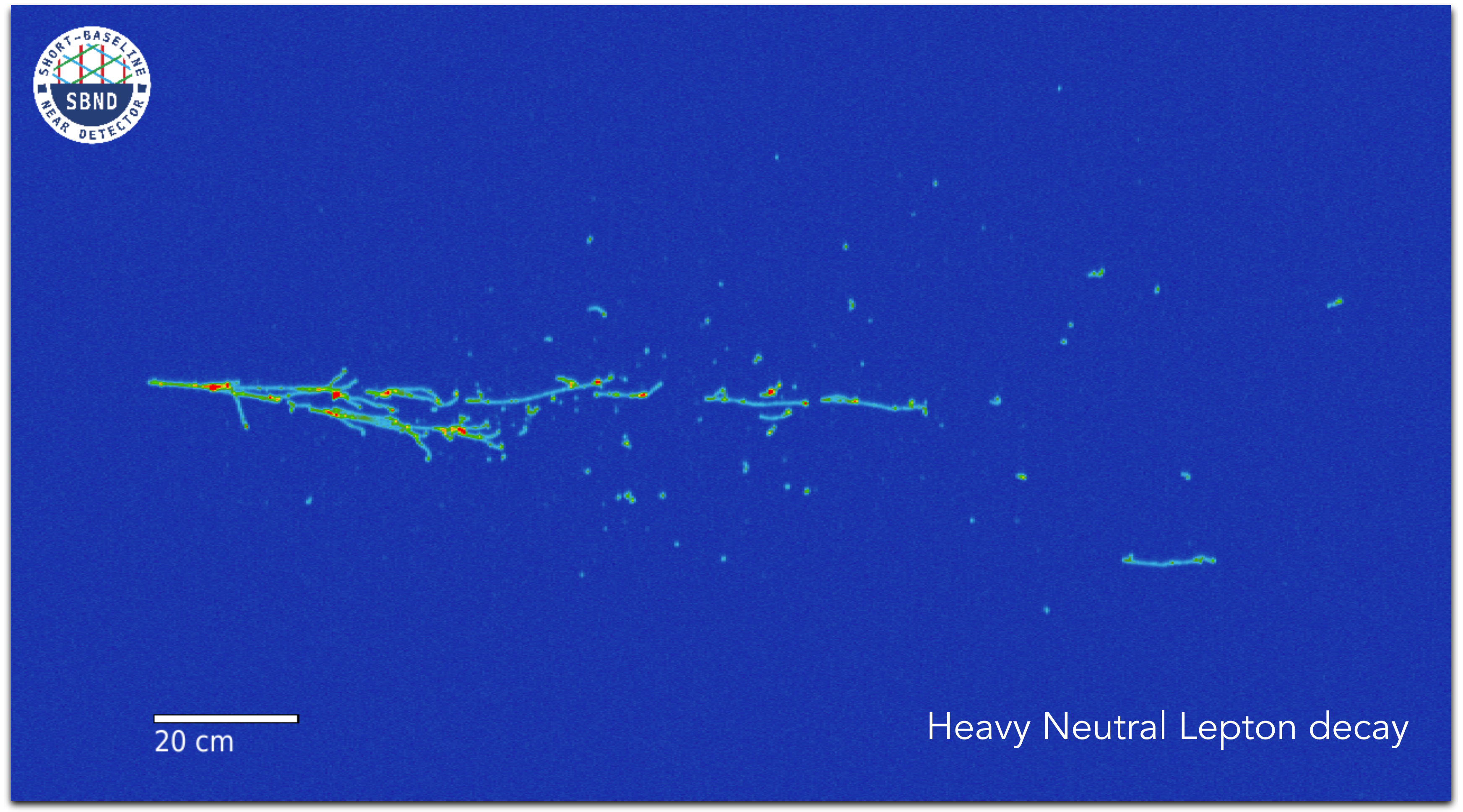
SBND will transform the physics we can do in the SBN program:

- Near detector data is essential for performing a broad, definitive test of the light sterile neutrino hypothesis - both appearance and disappearance.

Beyond oscillation searches, SBND has a broad science goal, which addresses alternative explanations of the Short-Baseline anomalies, includes other Beyond Standard Model explorations and precision studies of neutrino-argon interactions - with 20-30 times more data than we have now!



Artwork by Sandbox Studio, Chicago with Corinne Mucha

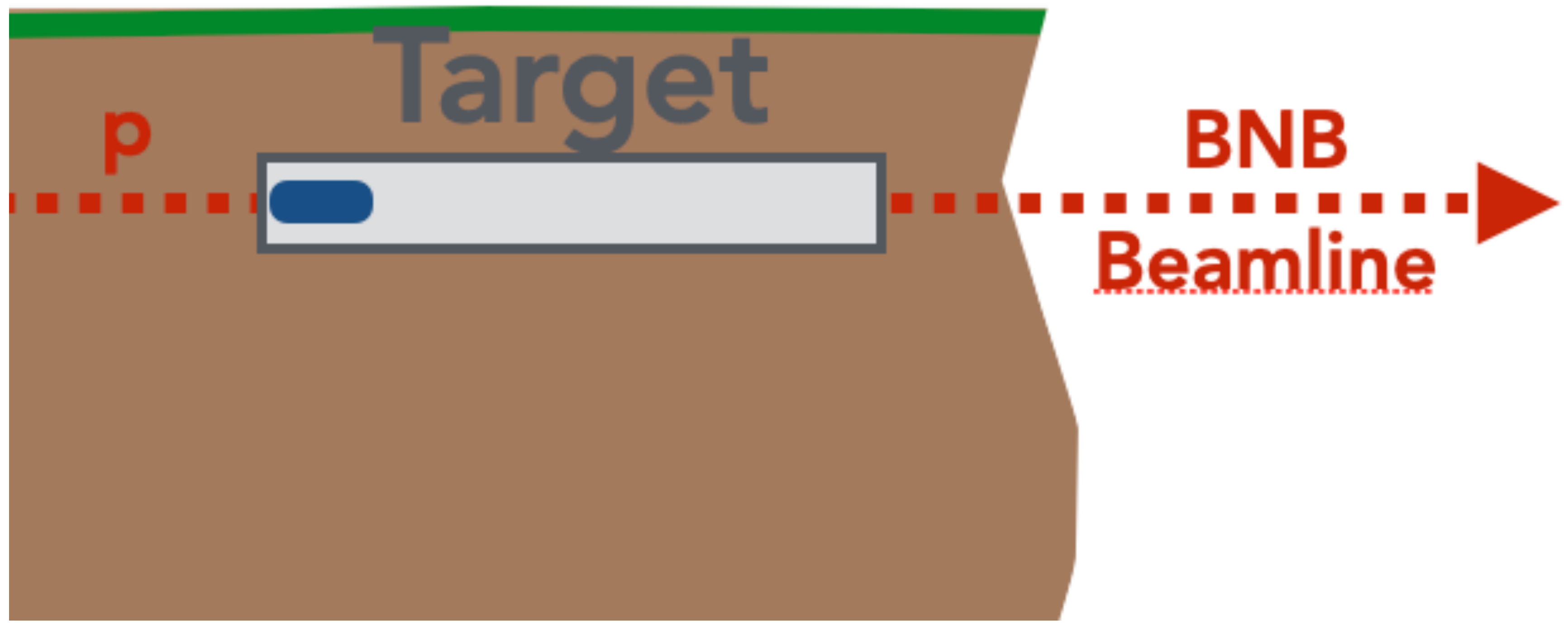


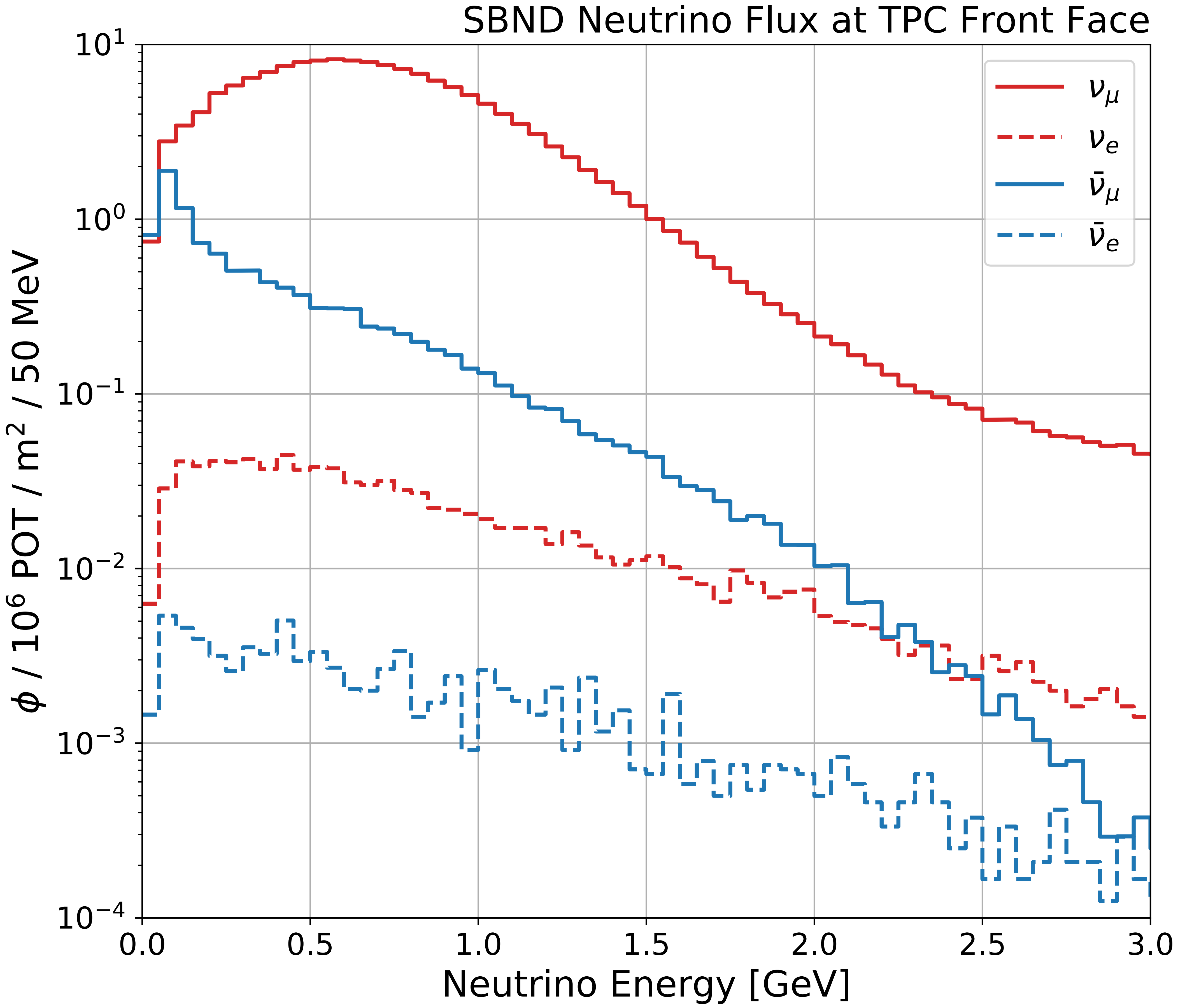
Exciting times are ahead for the Short-Baseline Neutrino Program. ICARUS is collecting data. SBND completed the construction of the detector and will begin operations in the Fall.

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%)

Detector Quality Control Plan

The SBND detector is at home

To get to this point, we tested each subsystem multiple times: during their assembly, before and after installation, and right before moving the detector.

After the move:

- Each subsystem is visually inspected and all the electrical tests are done to ensure that nothing was damaged during the transport.
- We already have all the procedures for this next step and all the reference values collected at DAB.

Tests will also be performed:

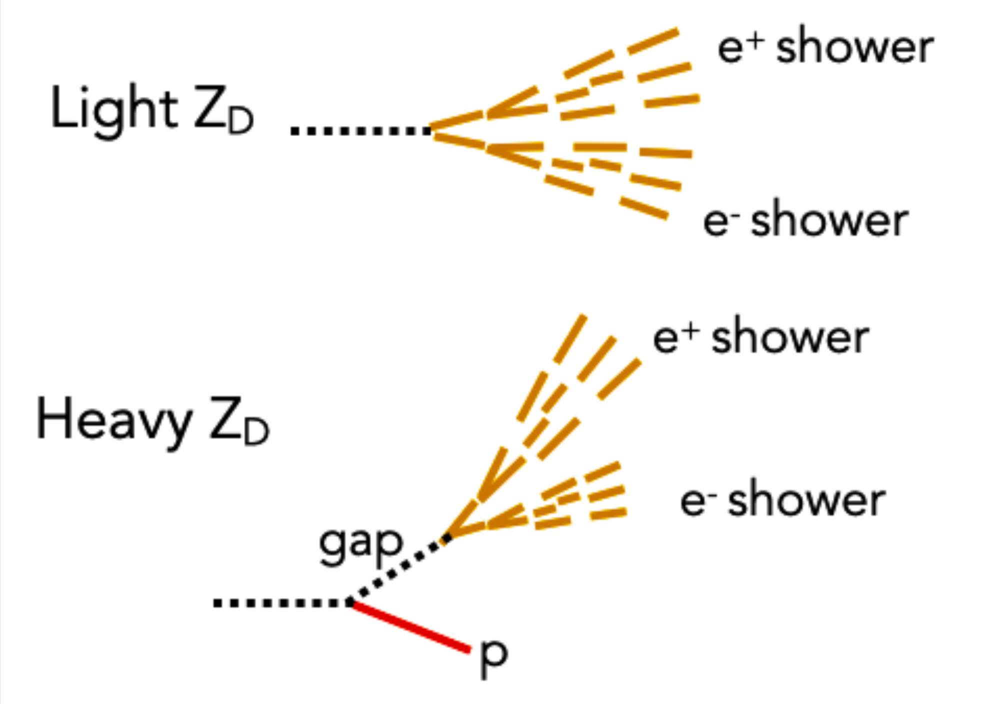
- After top cap installation
- After detector insertion in the cryostat
- After top cap welded in place
- After warm cables connected
- During cooldown → "Chilly detector Checkout"
- During and after LAr fill

Evolving Landscape…

Final state experimental signature: single photon, single electron, "trident" with di-leptons - overlapping and/or highly asymmetric,

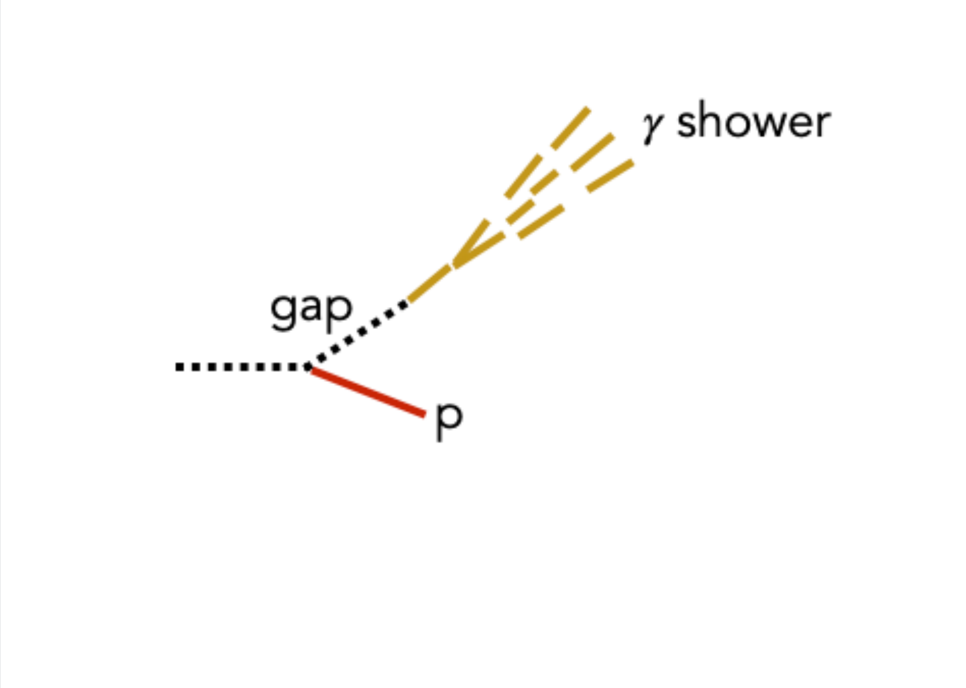
with different levels of hadronic activity.

Dark Neutrinos



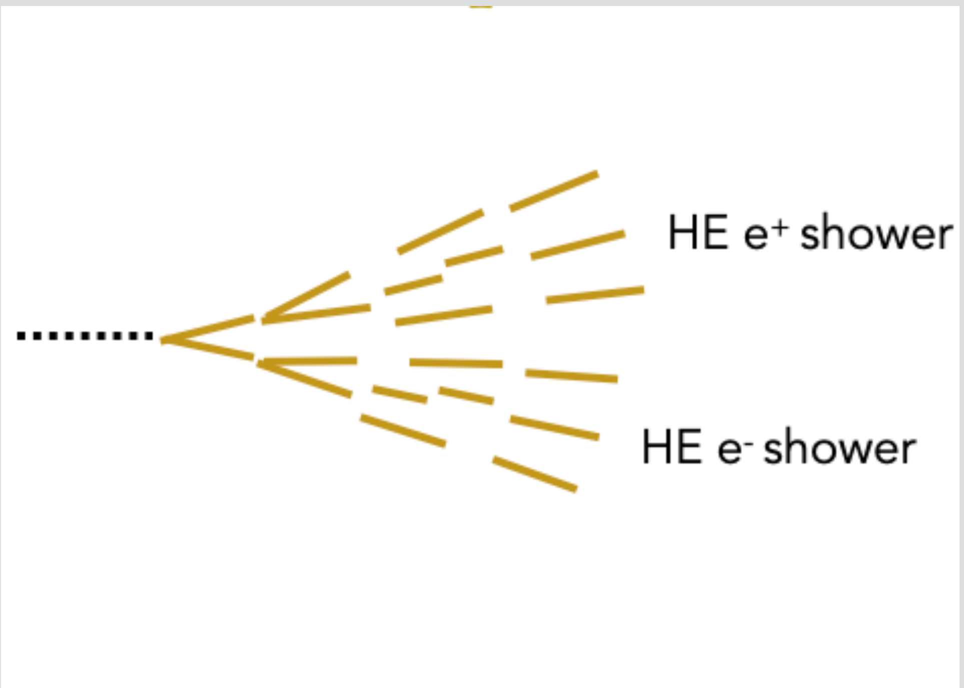
e^+e^- pair with or without hadronic activity

Transition Magnetic Moment



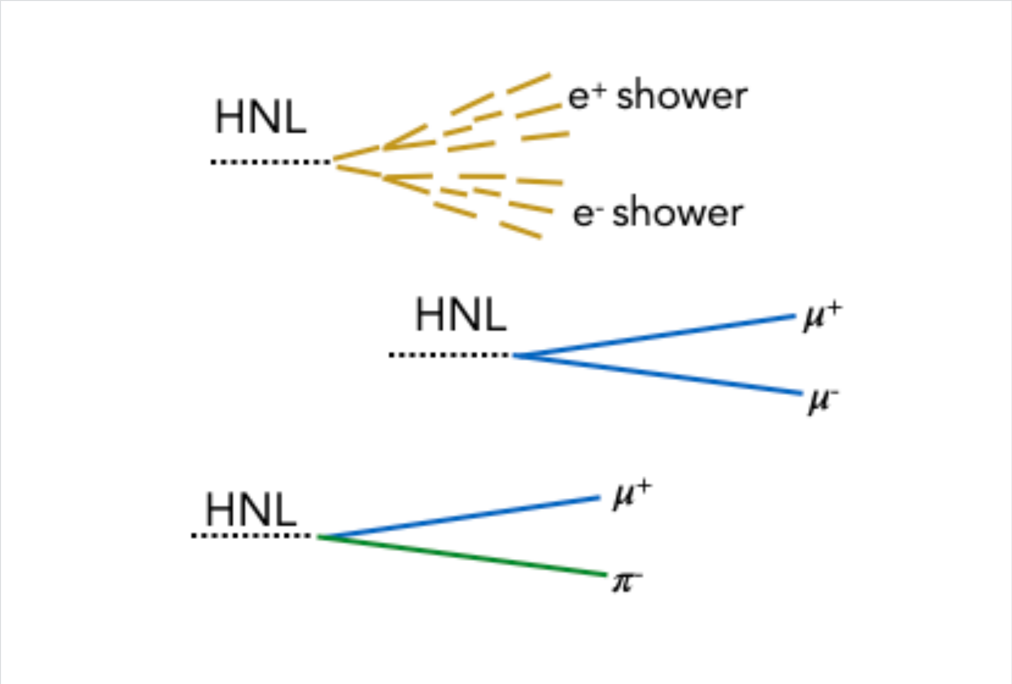
Photon and hadronic activity

Axion-like Particles



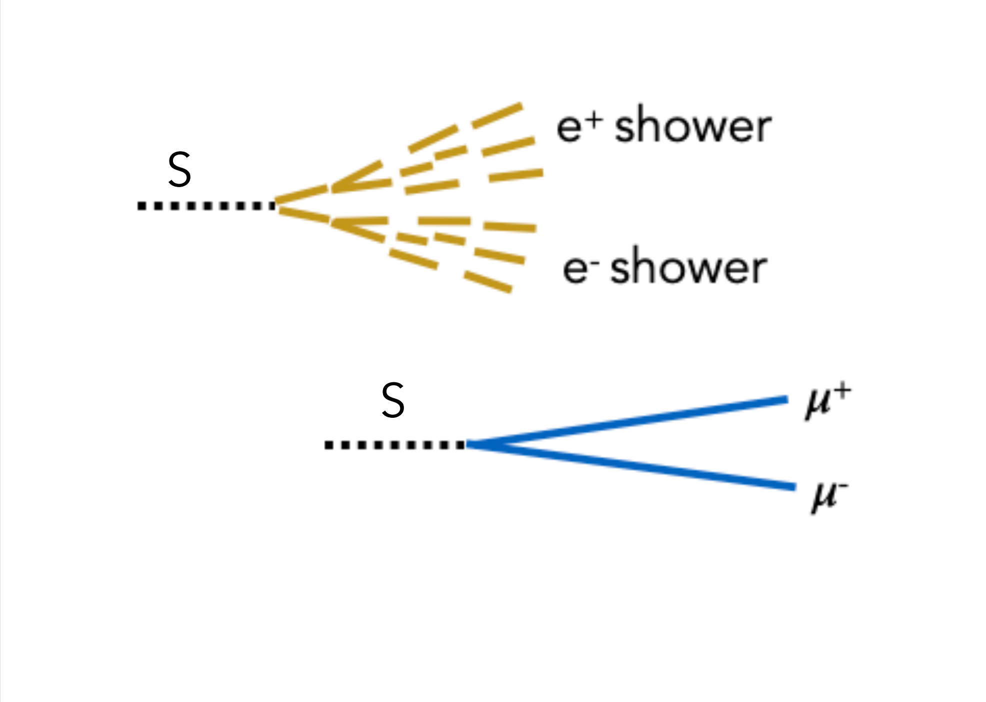
high-energy e^+e^- pair

Heavy Neutral Leptons



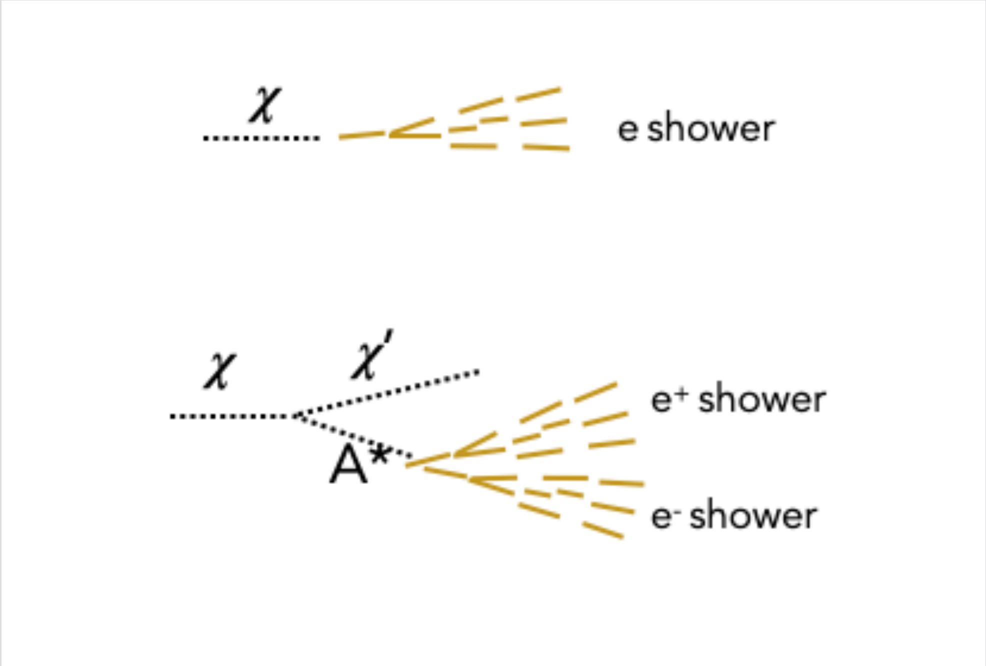
e^+e^-, $\mu^+\mu^-$, or $\mu^\pm\pi^\mp$ pair with no hadronic activity

Higgs Portal Scalar



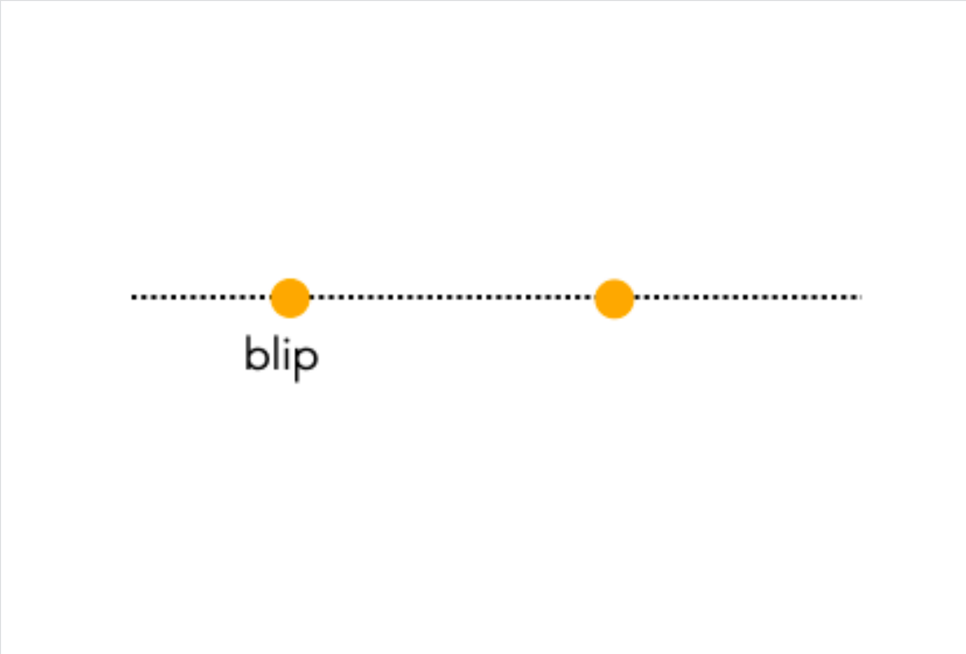
e^+e^- or $\mu^+\mu^-$ pair with no hadronic activity

Light Dark Matter



single e^- scattering or e^+e^- pair with no hadronic activity

Millicharged Particles



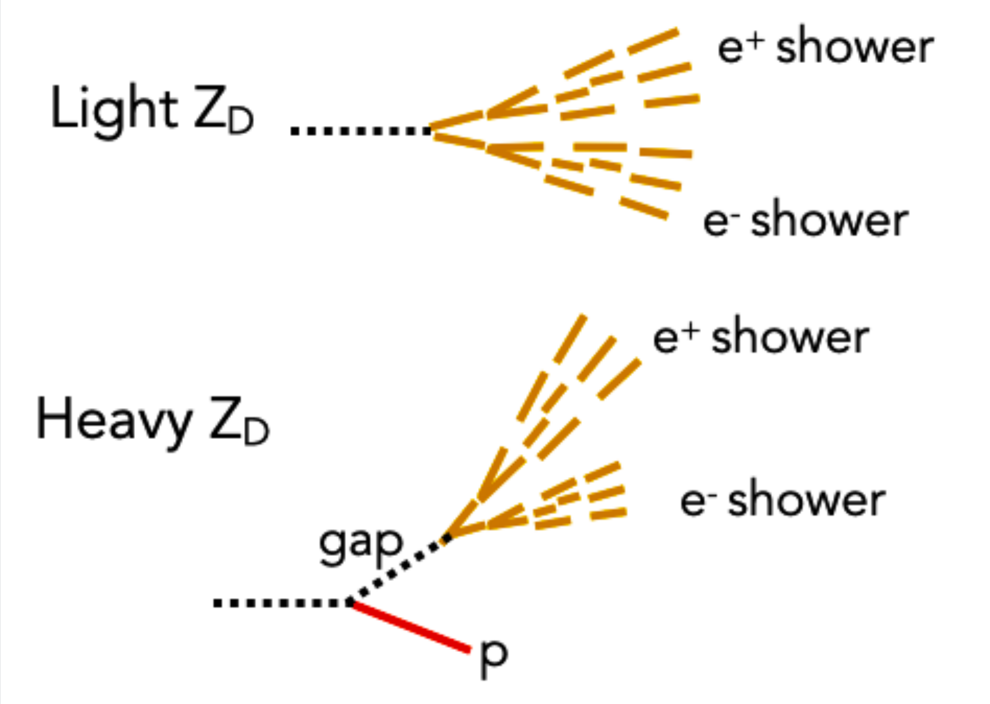
blips or faint tracks

Evolving Landscape...

The unique capabilities of the LAr TPC technology open up more information than available in a Cherenkov detector (such as MiniBooNE)

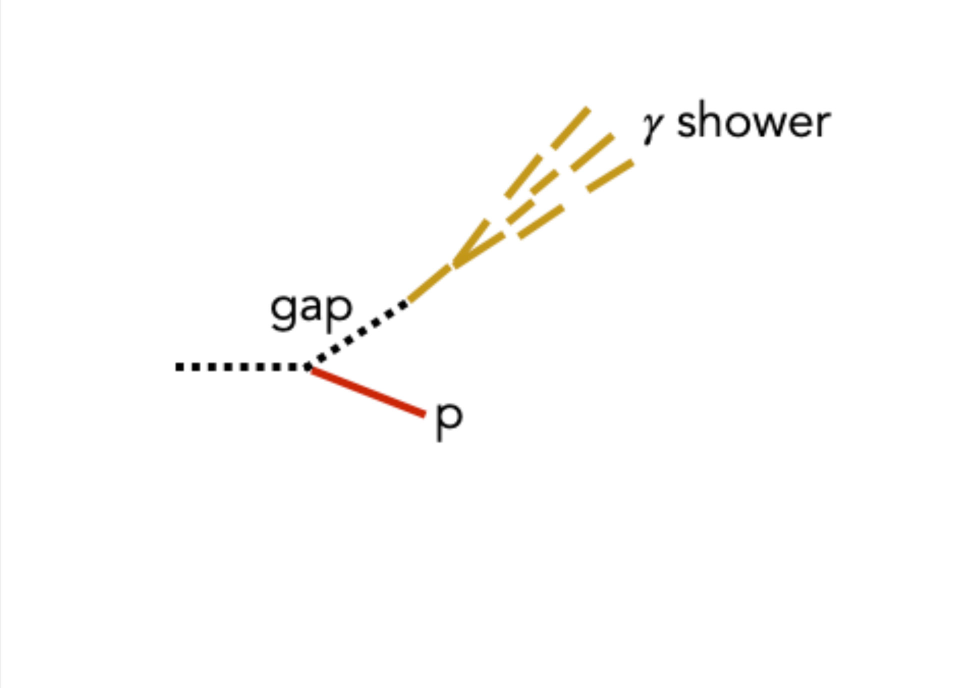
- Characterize events in term of final state particle content and kinematics.
- Recognize the presence hadronic activity.

Dark Neutrinos



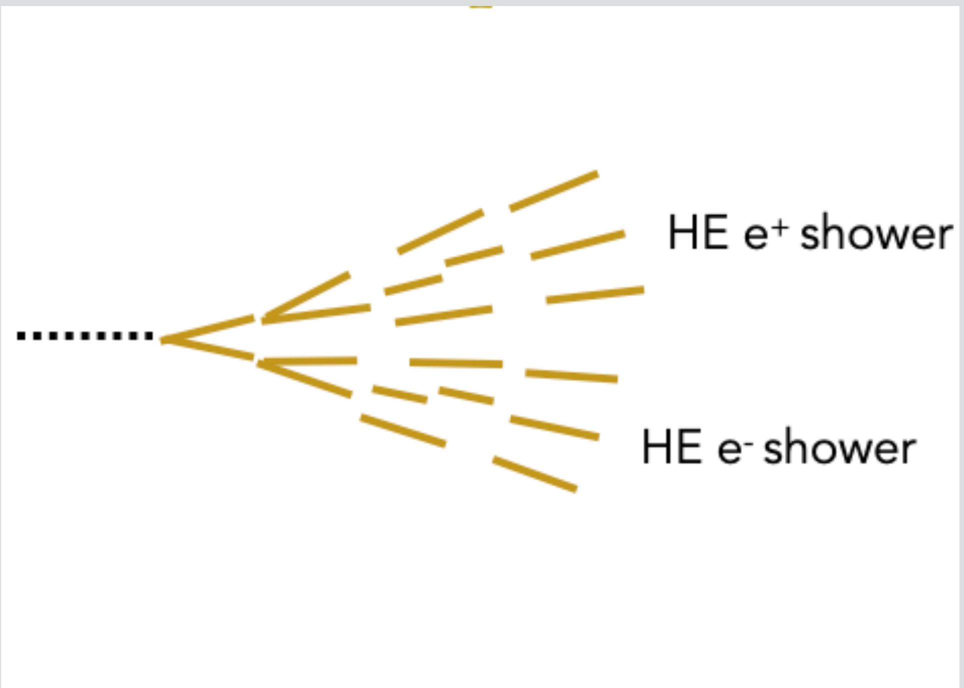
e^+e^- pair with or without hadronic activity

Transition Magnetic Moment



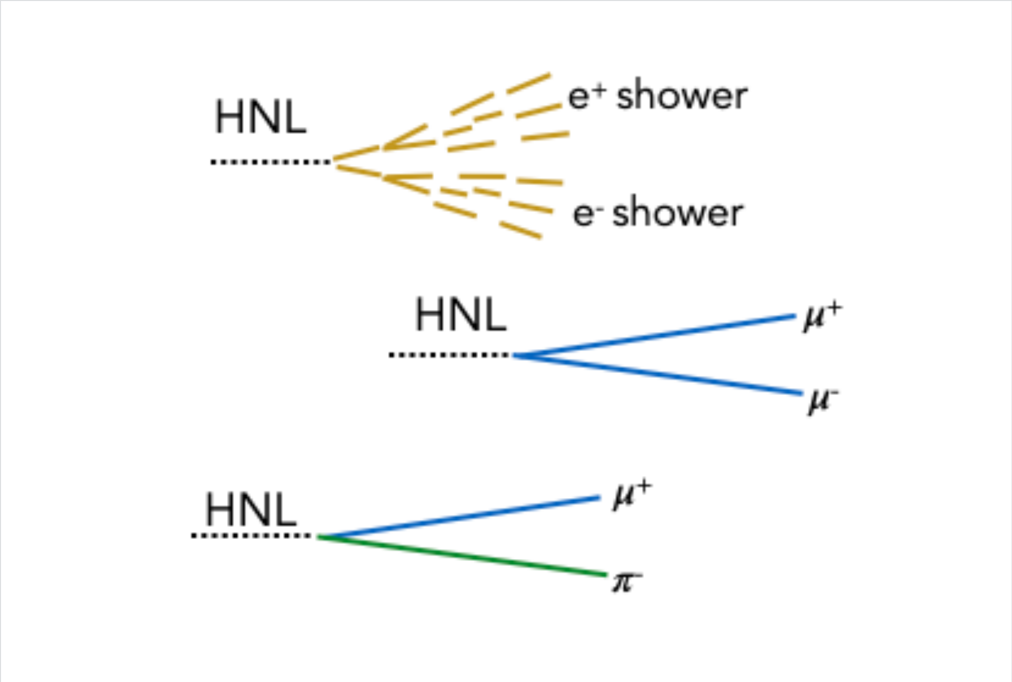
Photon and hadronic activity

Axion-like Particles



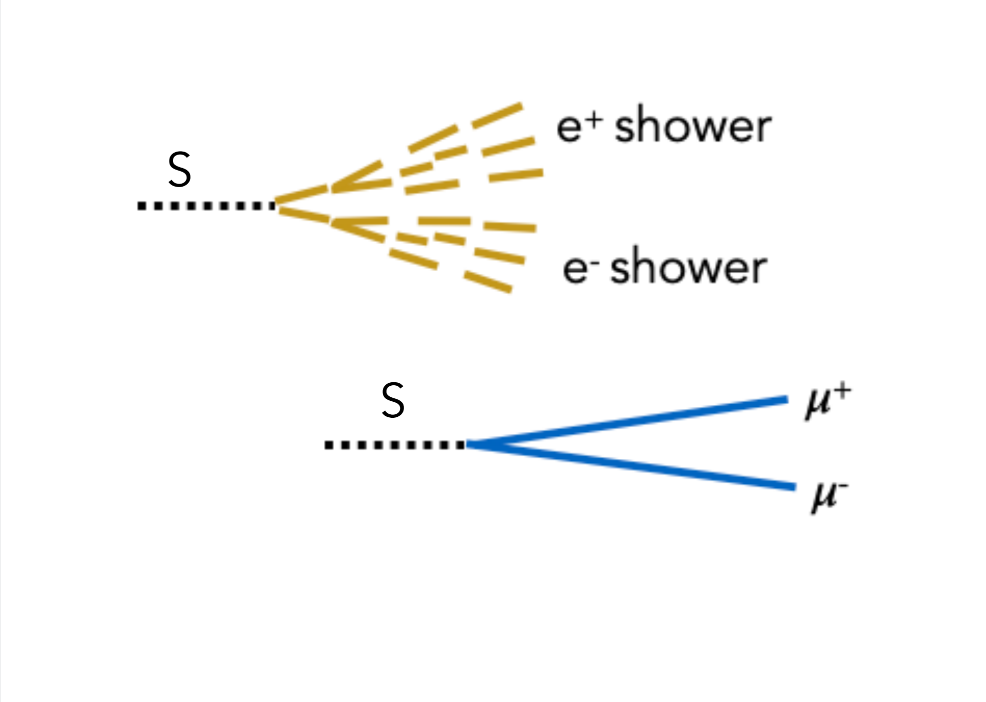
high-energy e^+e^- pair

Heavy Neutral Leptons



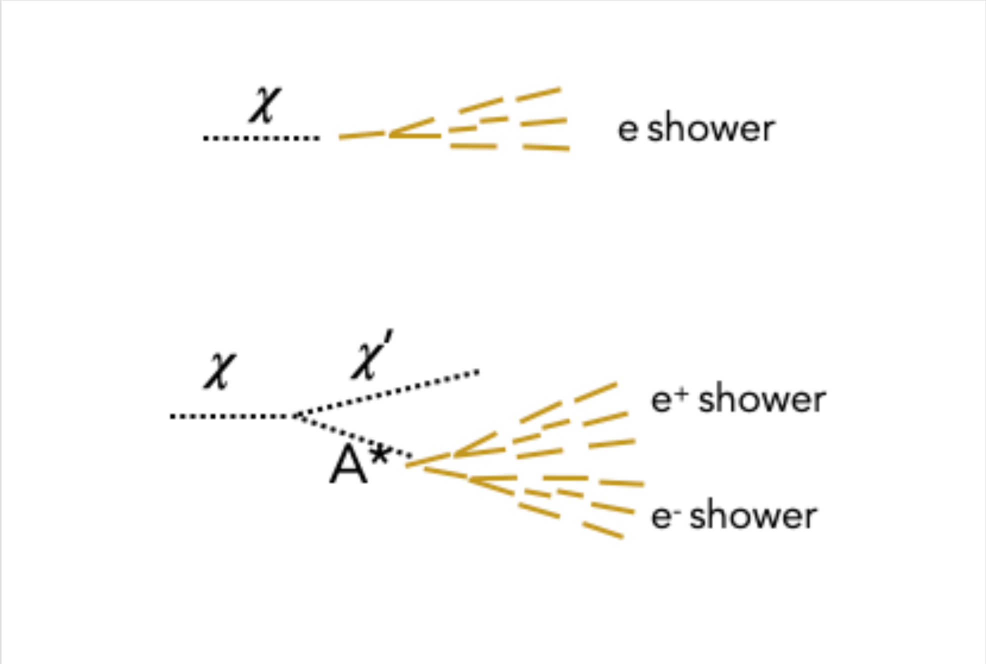
e^+e^-, $\mu^+\mu^-$, or $\mu^\pm\pi^\mp$ pair with no hadronic activity

Higgs Portal Scalar



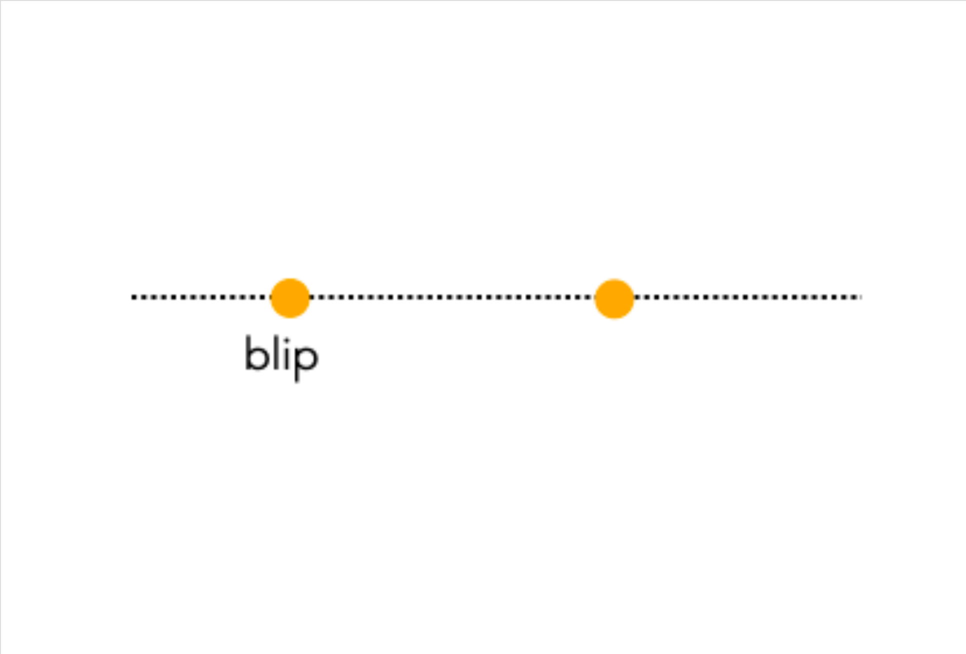
e^+e^- or $\mu^+\mu^-$ pair with no hadronic activity

Light Dark Matter



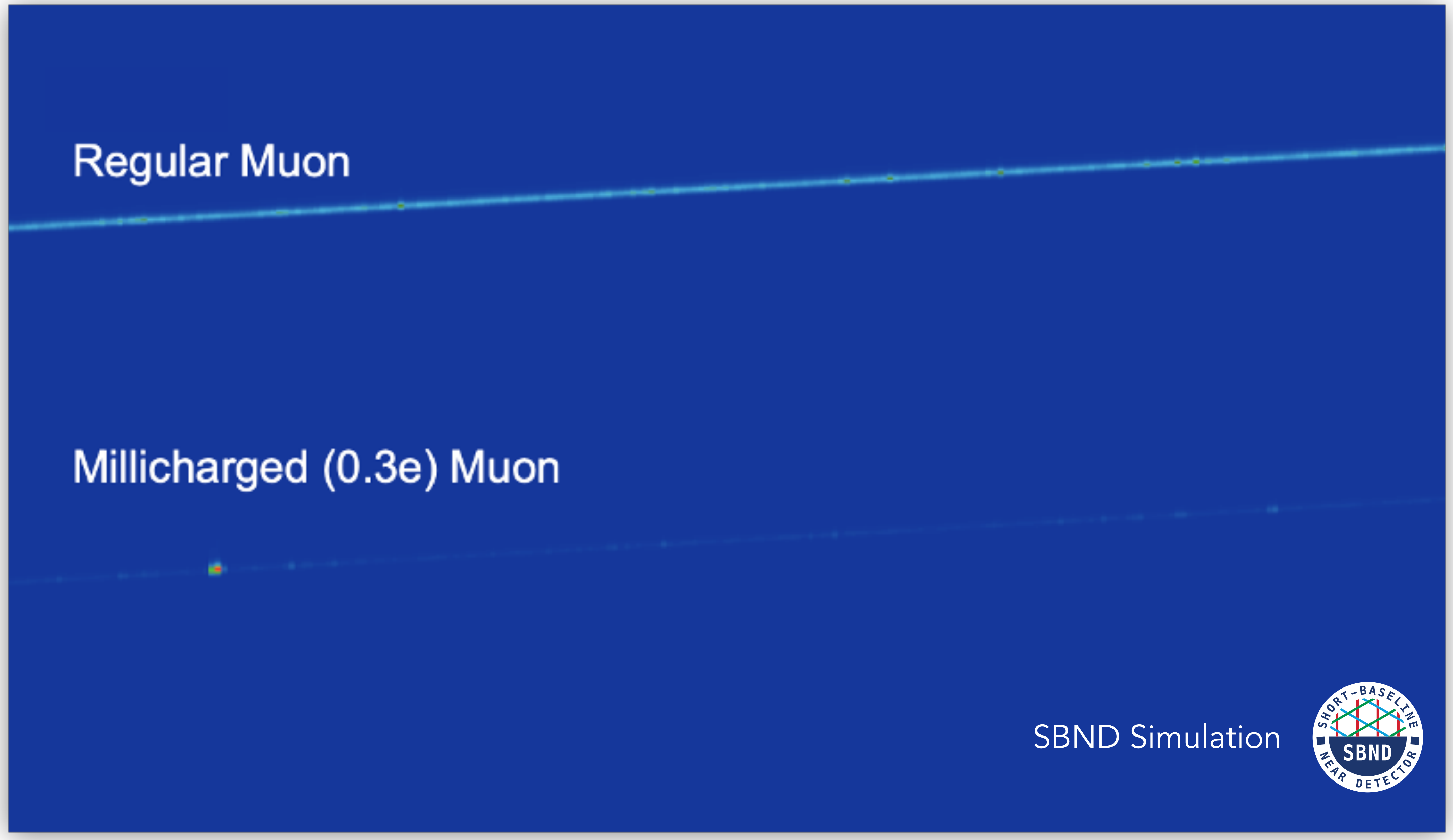
single e^- scattering or e^+e^- pair with no hadronic activity

Millicharged Particles



blips or 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

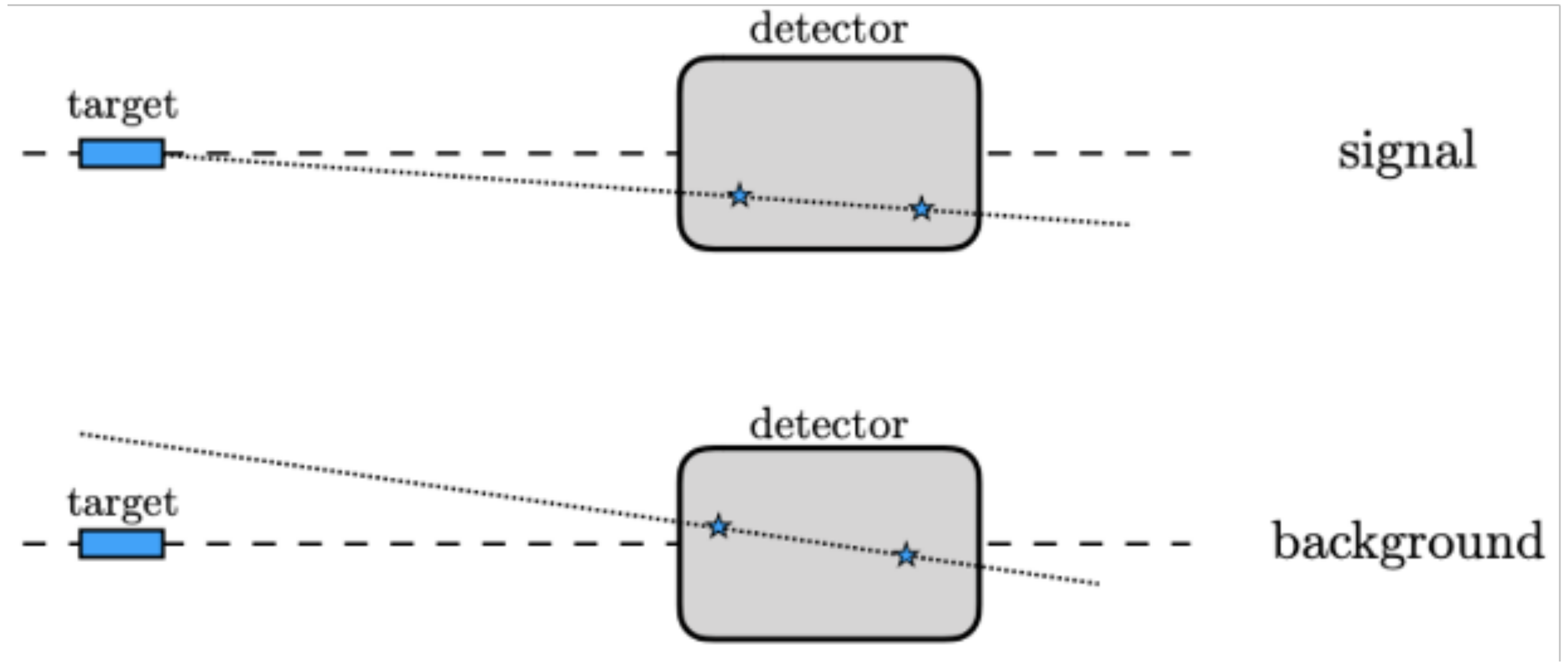
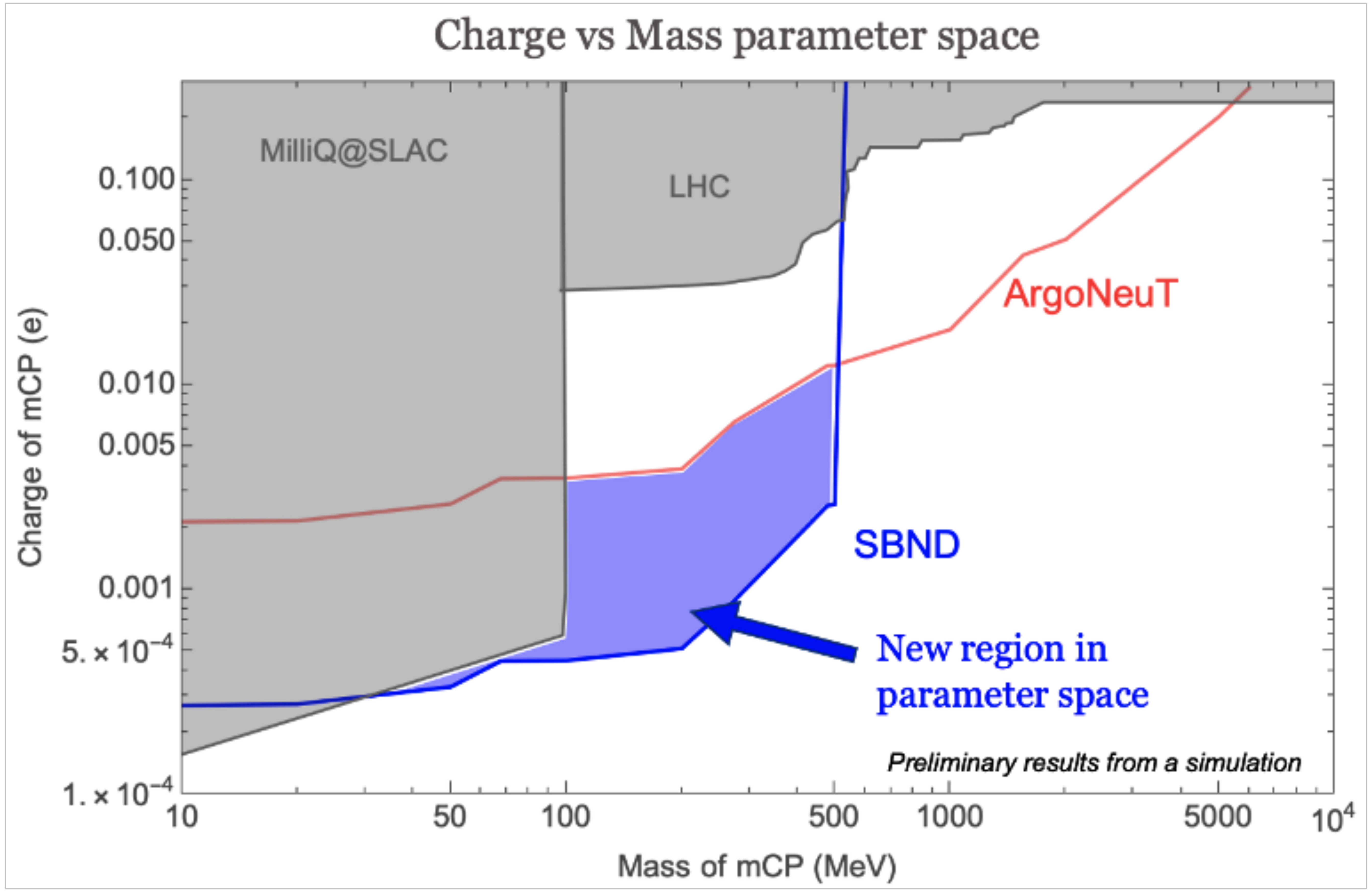
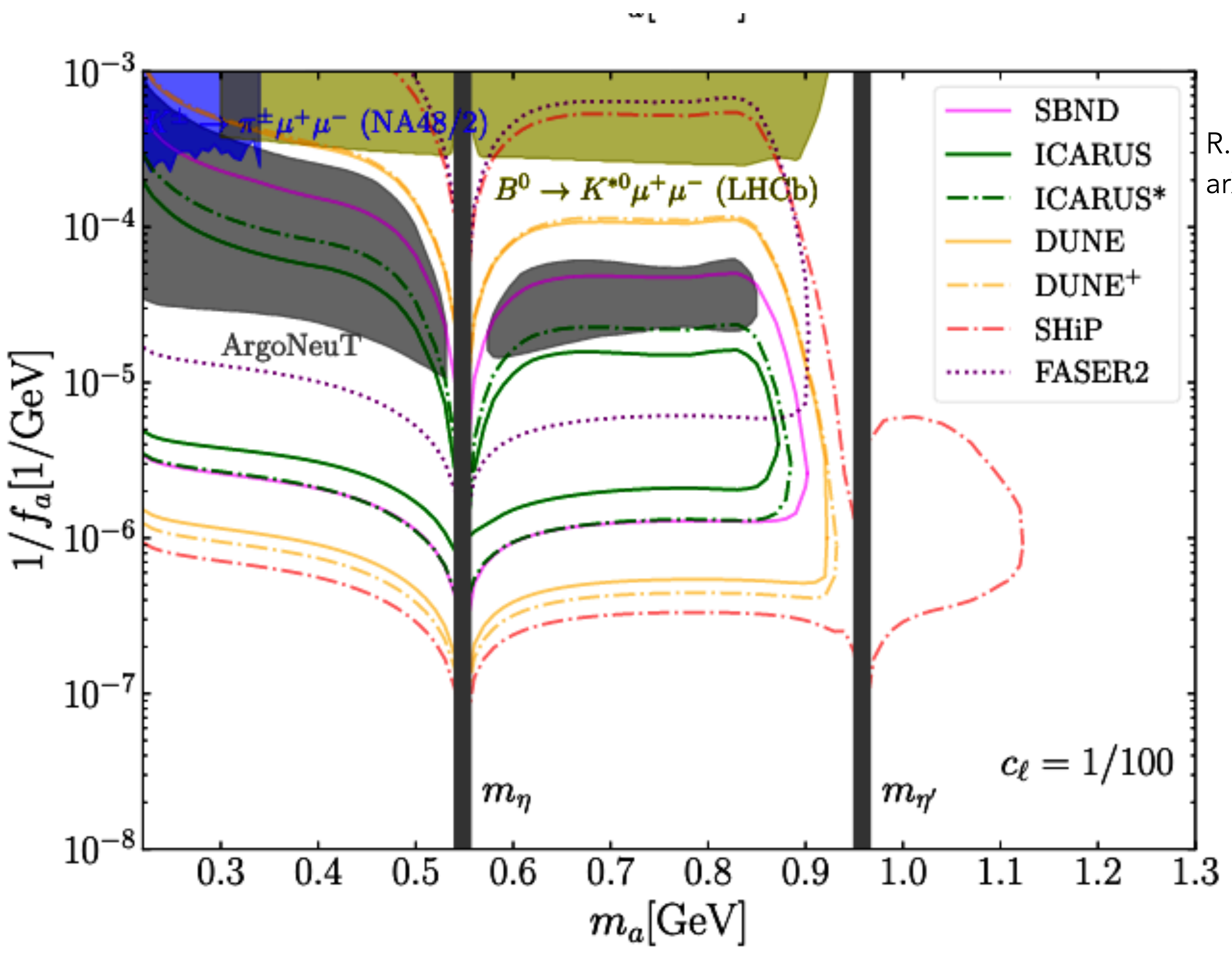


Image credit: ArgoNeuT, PRL124 131801 (2020)



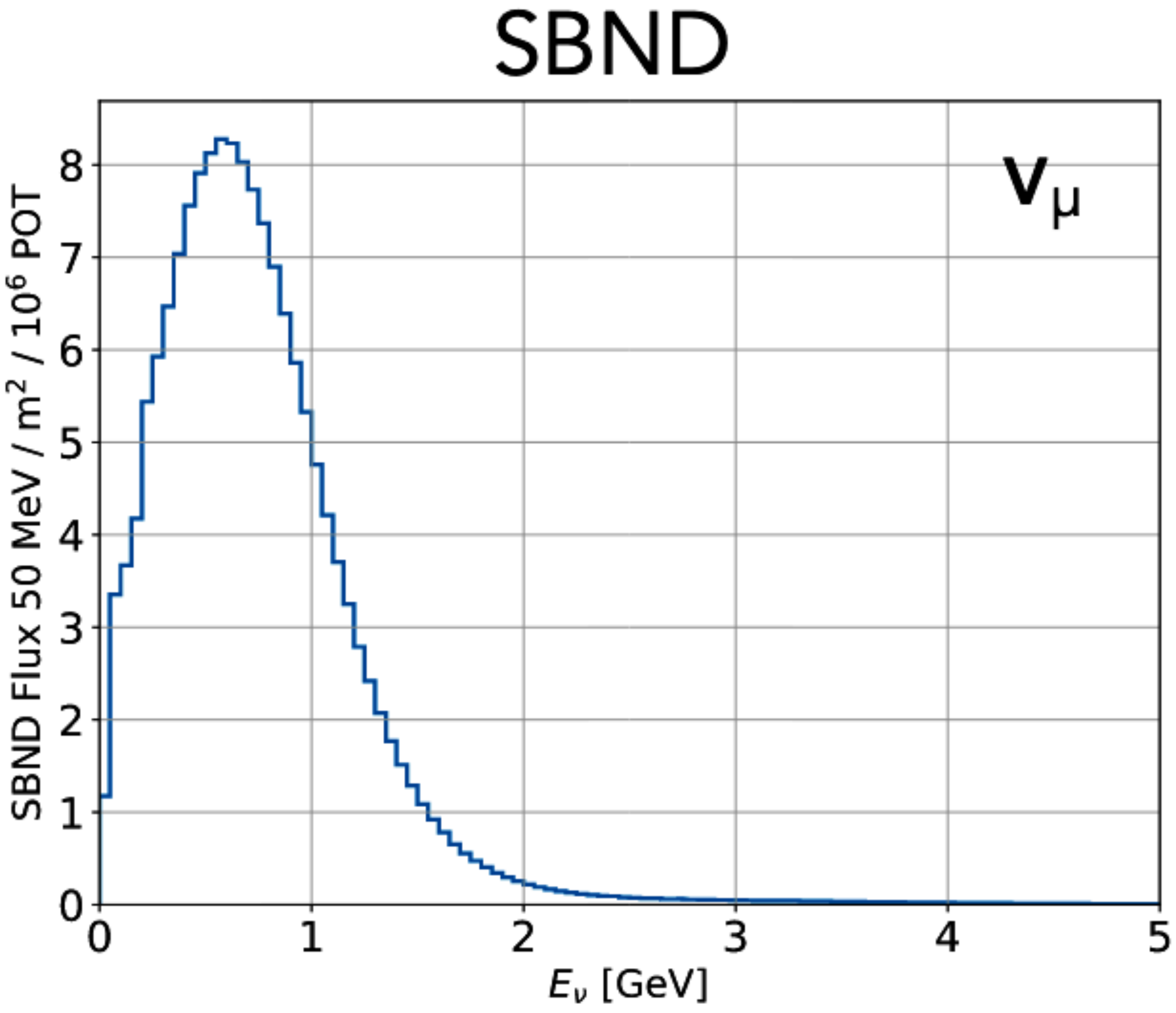
Heavy QCD Axions via Dimuon Final States

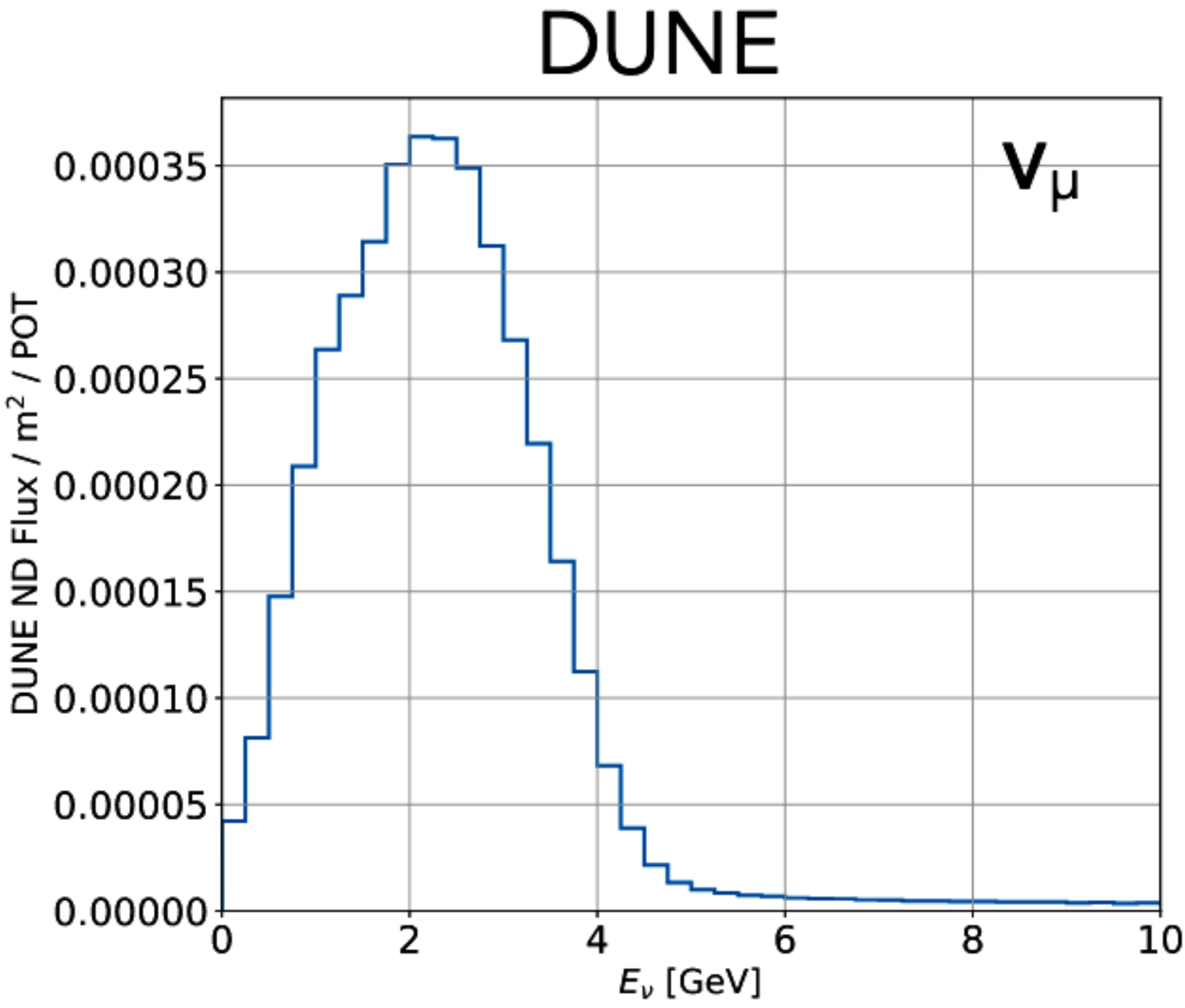


R. T. Co,1, 2, S. Kumar, and Z. Liu
arXiv:2210.02462v1

FIG. 6. Constraints (shaded-regions) and projections (curves) for $c_\ell = 1/36$ (upper panel) and $c_\ell = 1/100$ (lower panel). The curve labeled DUNE$^+$ denotes a scenario in which the axion can decay up to 30 m before the DUNE ND. The high-energy muons produced via these decays can still reach the detector. The curve labeled ICARUS* is for the reach ICARUS would have through the off-axis NuMI beam. See text for more details.

SBND/DUNE Energy Spectra





SBND Physics Organization

SBND Physics & Analysis Tools

Conveners: Costas Andreopoulos, Bill Louis, Andrzej Szelc

Commissioning

Conveners: Michelle Stancari, Lauren Yates

Simulation & Calibration

Conveners: Mike Mooney, Marco Roda, Marco Del Tutto

Neutrino Interaction Physics

Conveners: Andy Furmanski, Vishvas Pandey

Reconstruction

Conveners: Dom Brailsford, Diego Garcia Gamez

Neutrino Oscillation Physics

Conveners: Georgia Karagiorgi, Joseph Zennamo

BSM Searches

Conveners: Jose Crespo Anadon, Xiao Luo

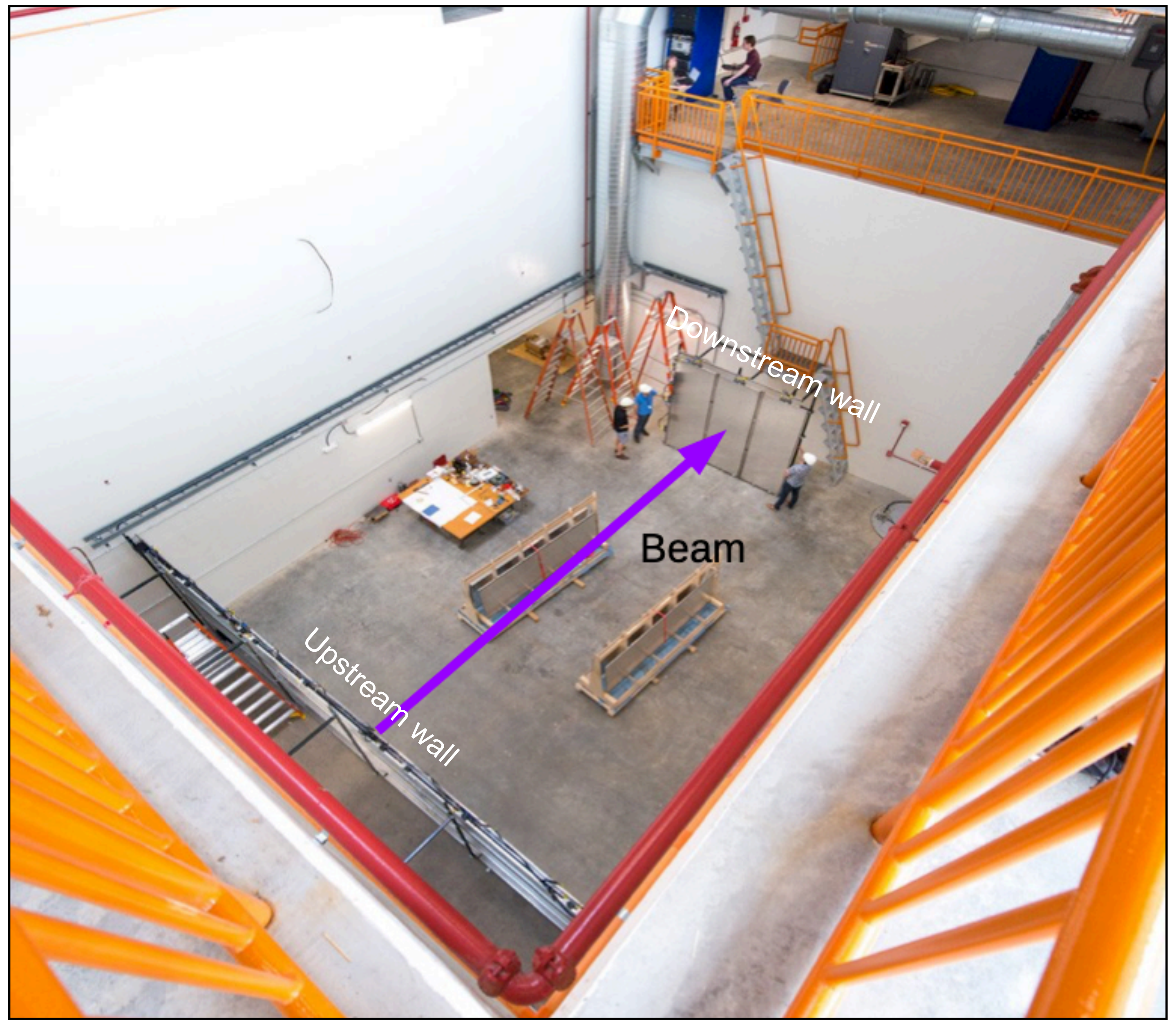
**We expect that the structure will evolve further.
This is only the current snapshot.**

Interface to SBN analysis

SBN Program

Focus on multi-detector (L-dependent) physics (oscillations)

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.