SBND in 10 minutes

New Perspectives Conference
Fermilab
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Lancaster University
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On behalf of the SBND Collaboration

FERMILAB-SLIDES-23-103-V

Introduction

The SBN Program @ FNAL

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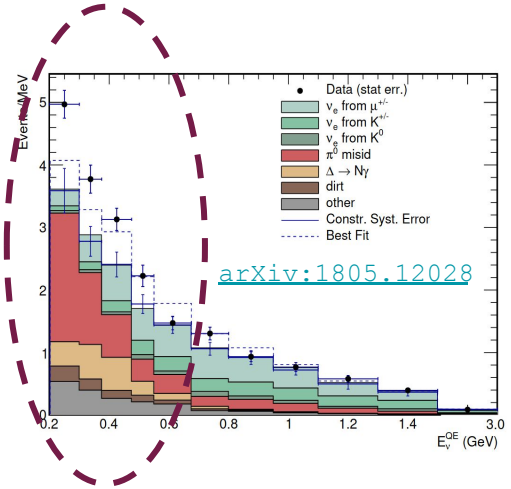

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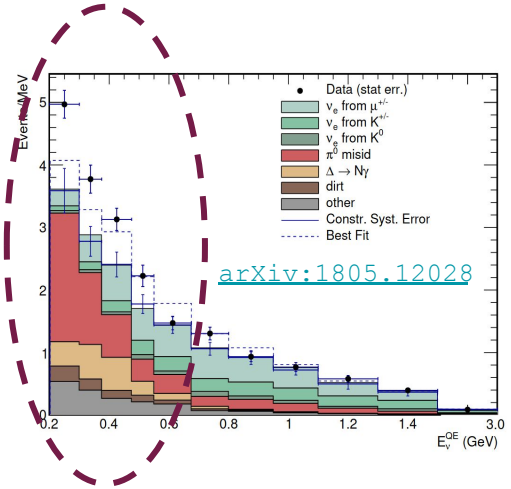

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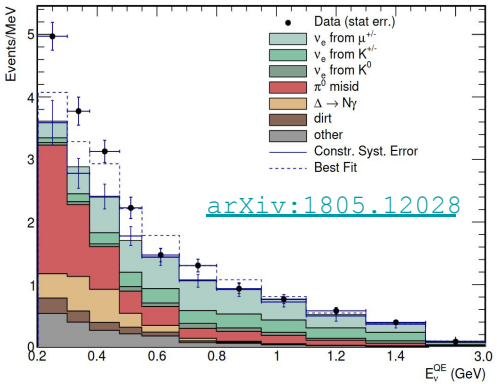

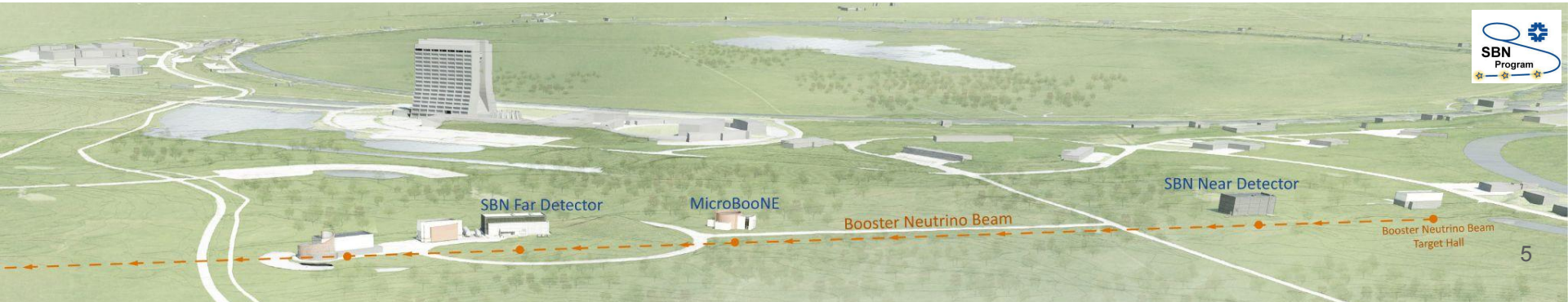

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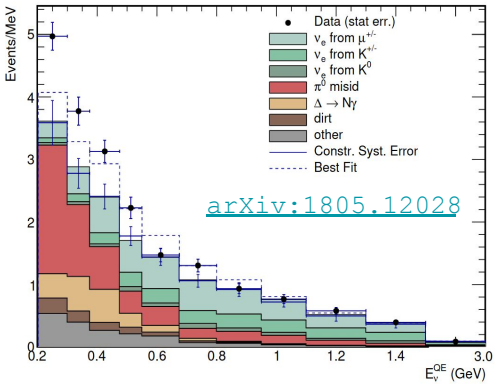

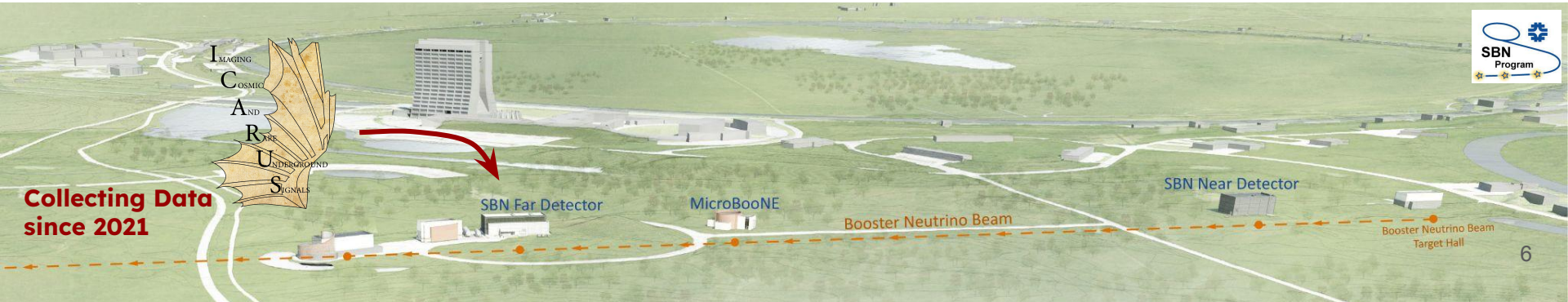

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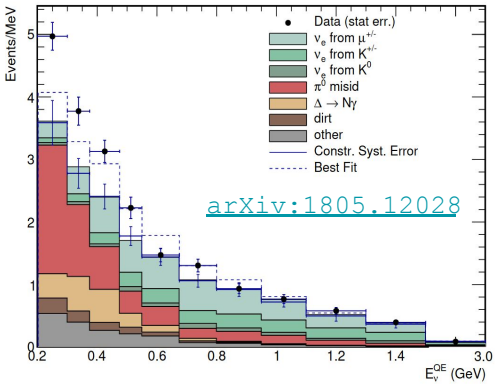

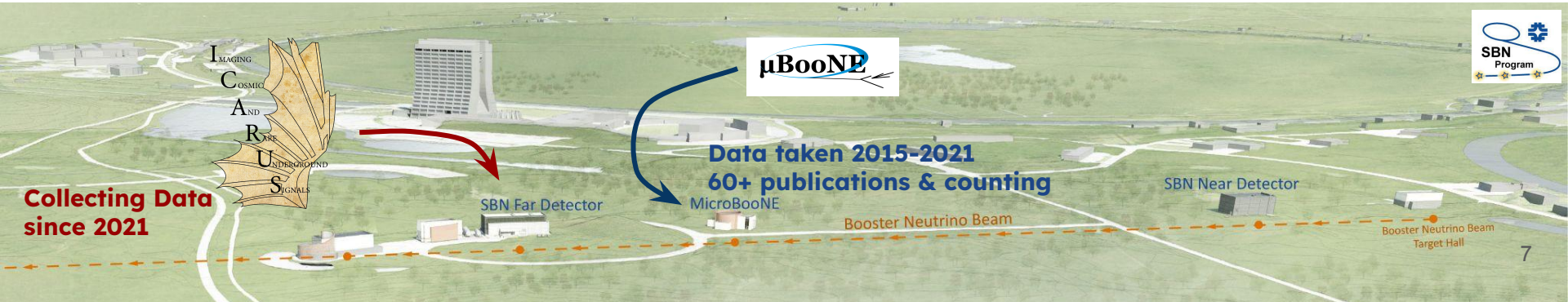

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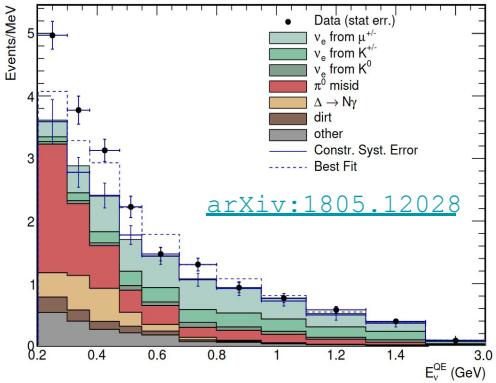
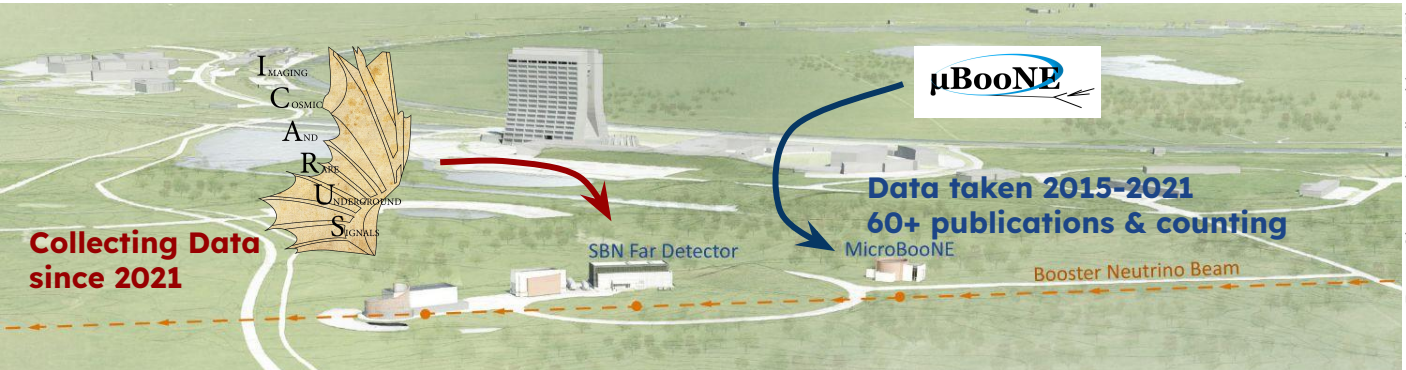
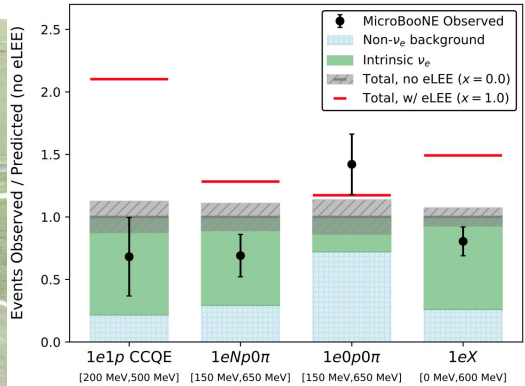


Including their first LEE searches, in which they *do not* see a MiniBooNE-like excess.





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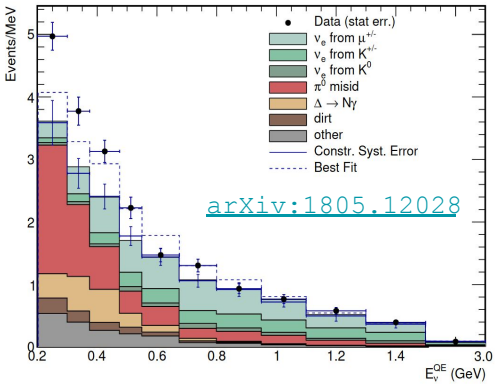

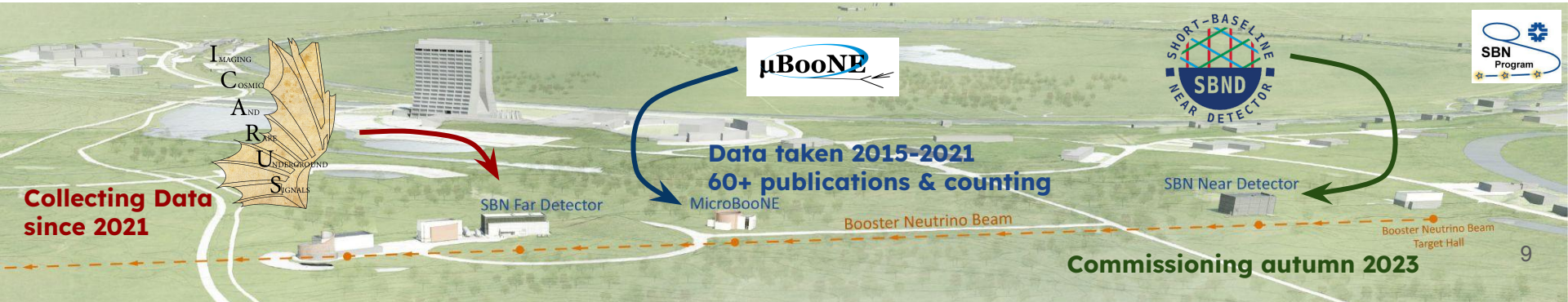

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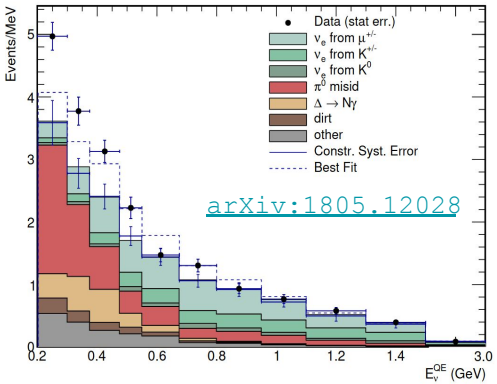
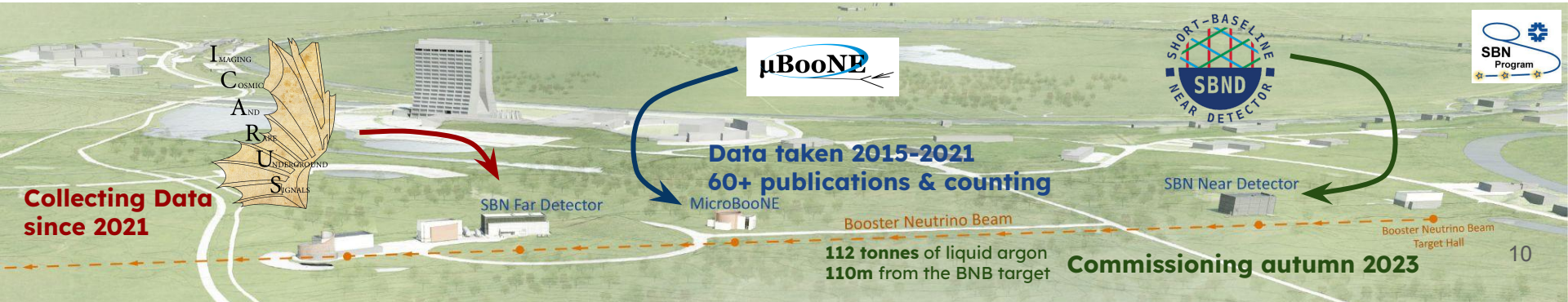
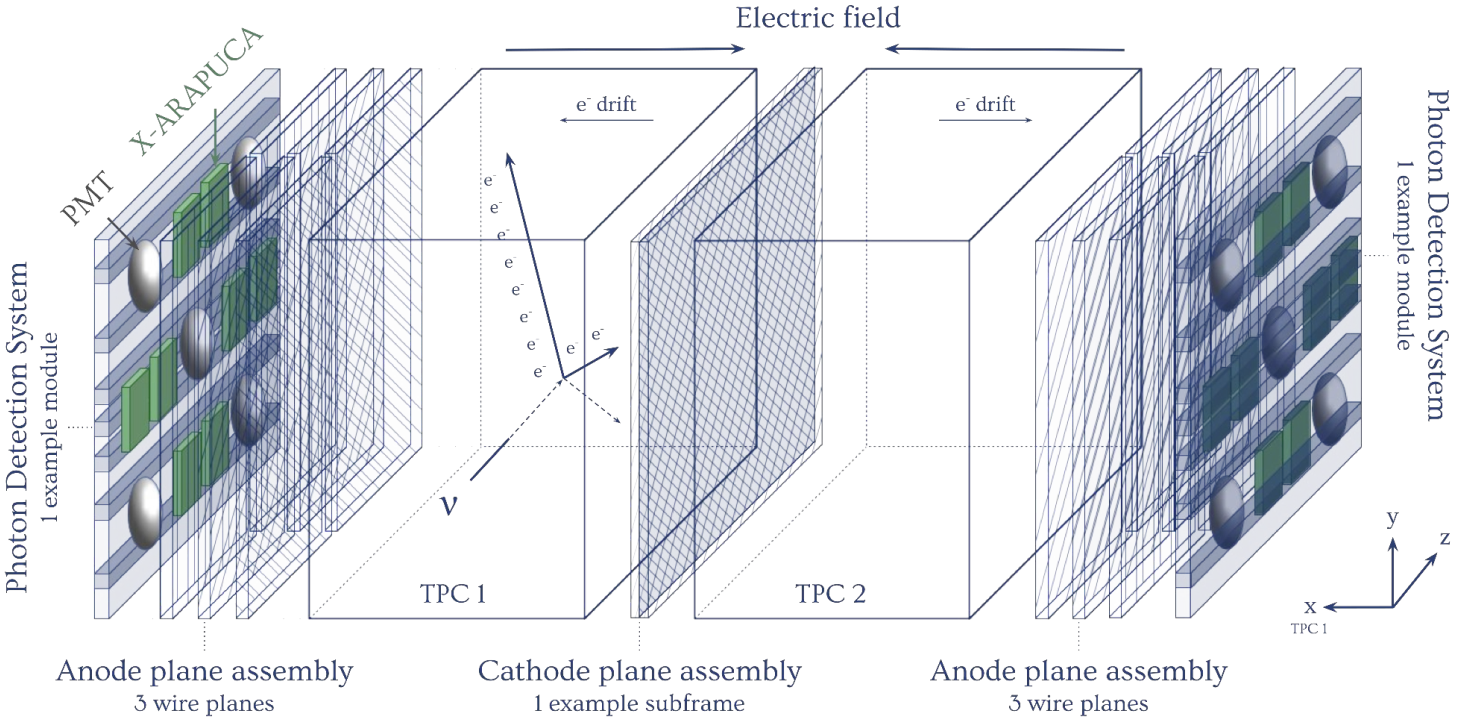




SBND

LArTPC Operating Principle



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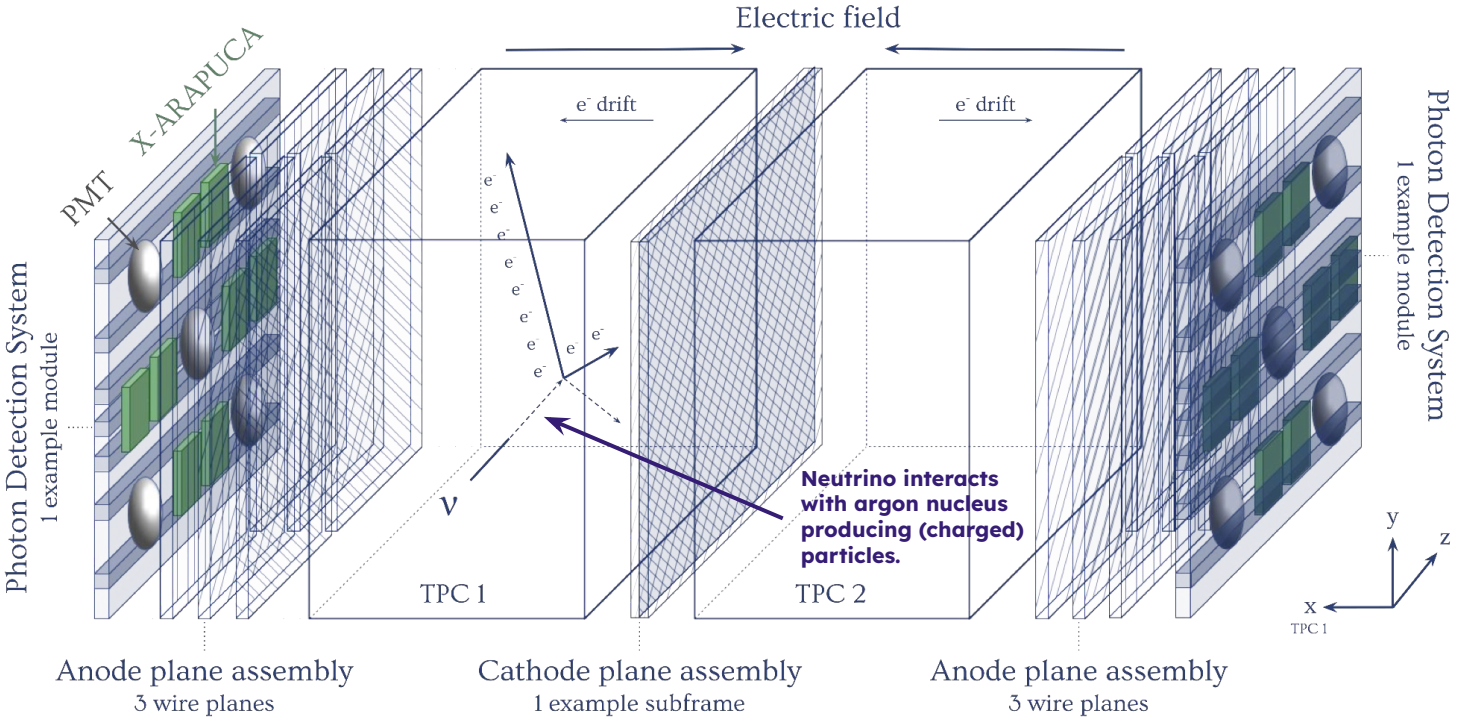
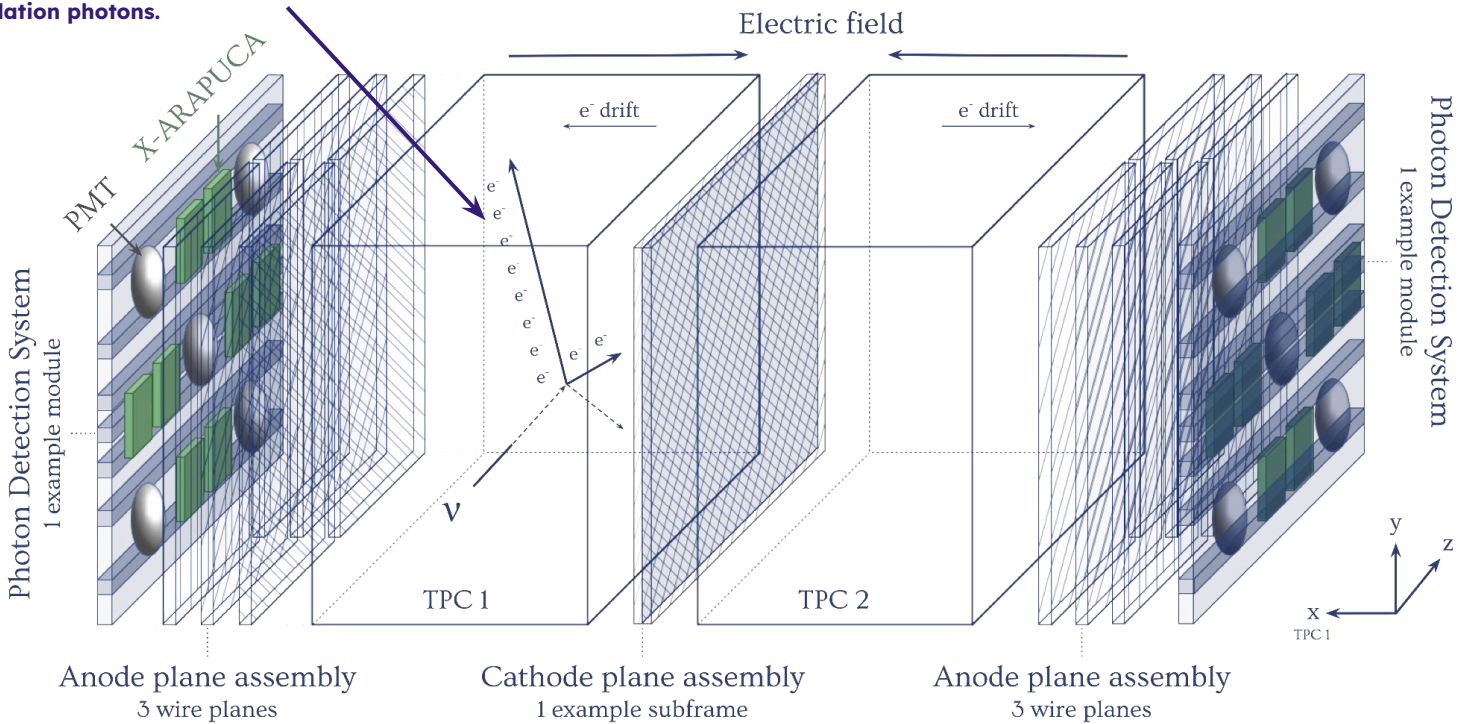


LArTPC Operating Principle

Charged particles ionise & excite argon atoms as they propagate through the detector. Creating ionisation electrons and 128nm scintillation photons.



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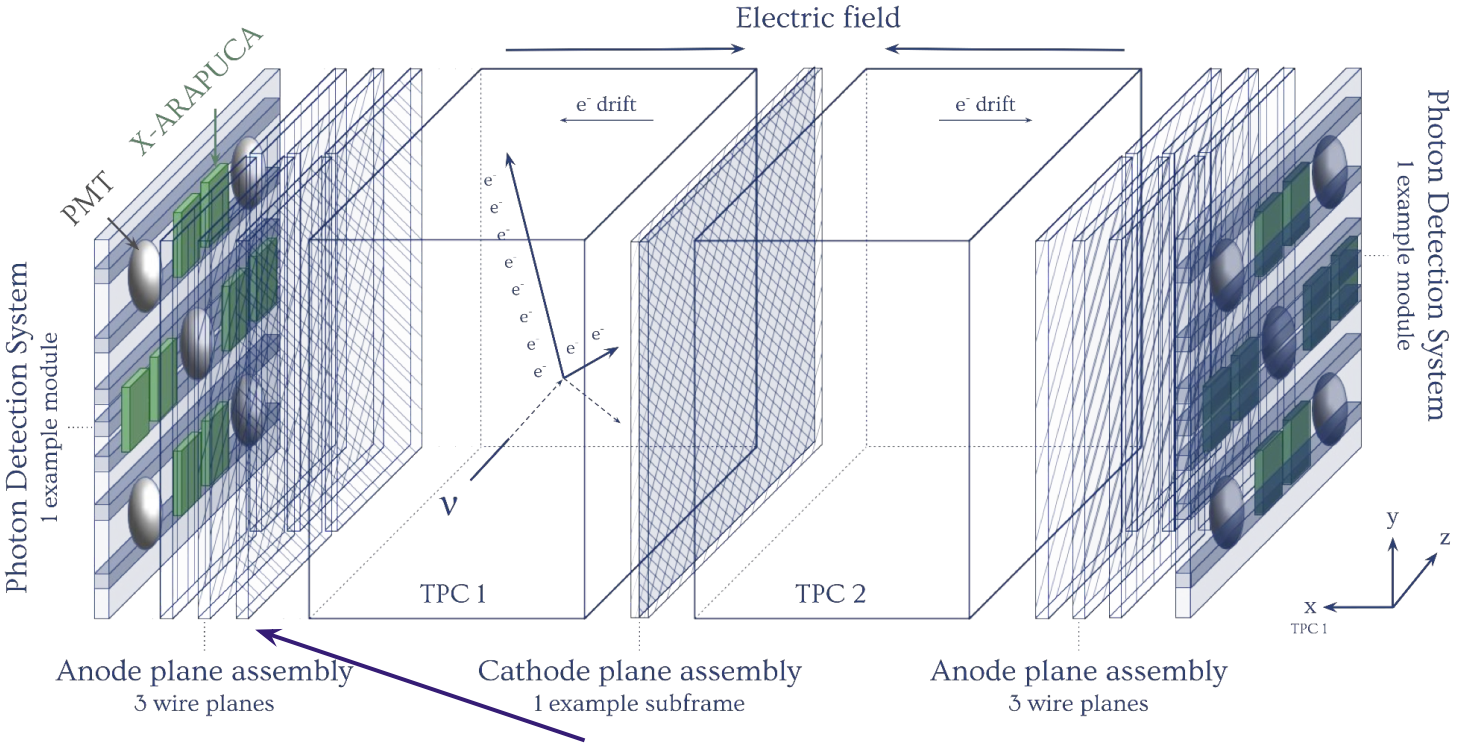
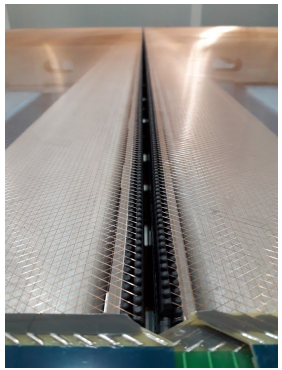


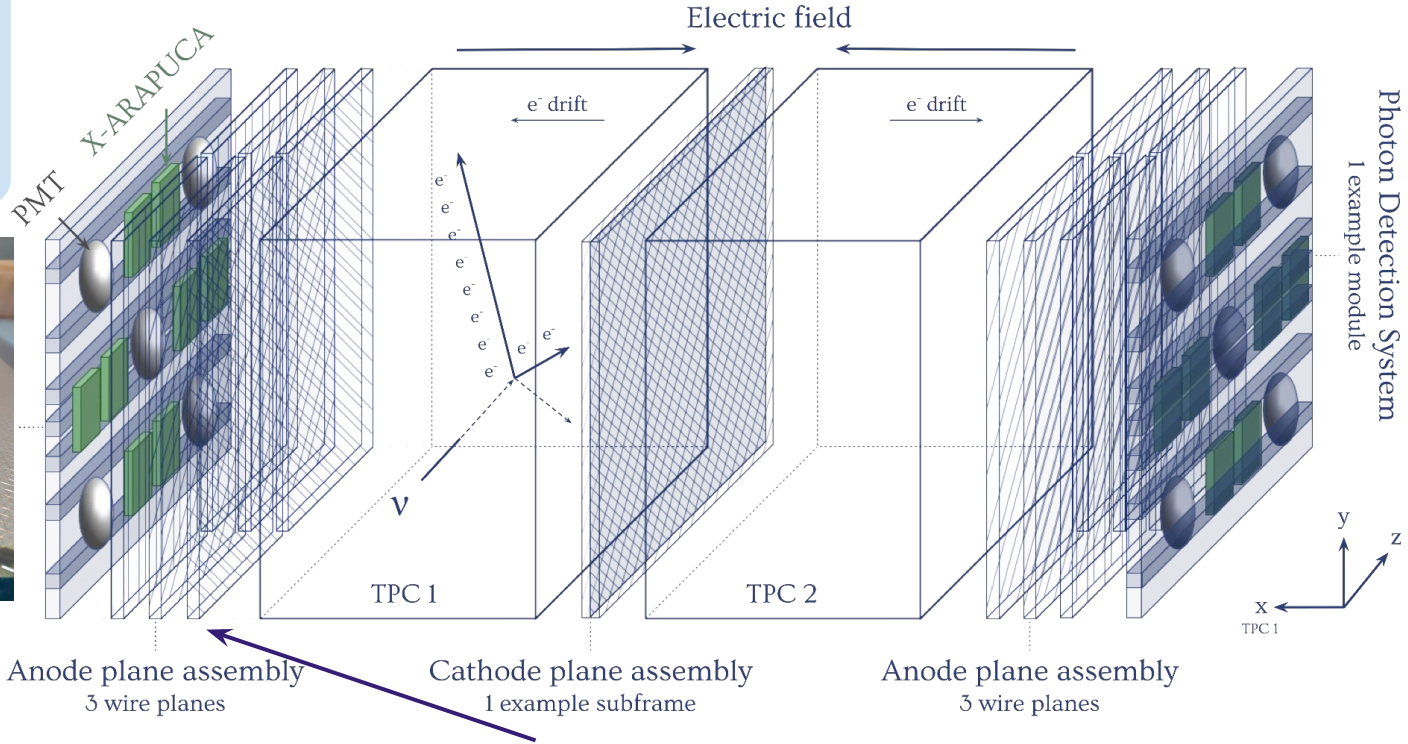
Ionised electrons drift under electric field inducing current on anode wire readout planes.

LArTPC Operating Principle

SBND

- Has 3 planes consisting of a total of ~11,000 wires.
- Planes are oriented at 0°, +60° and - 60° from the vertical.
- Wire pitch of 3mm





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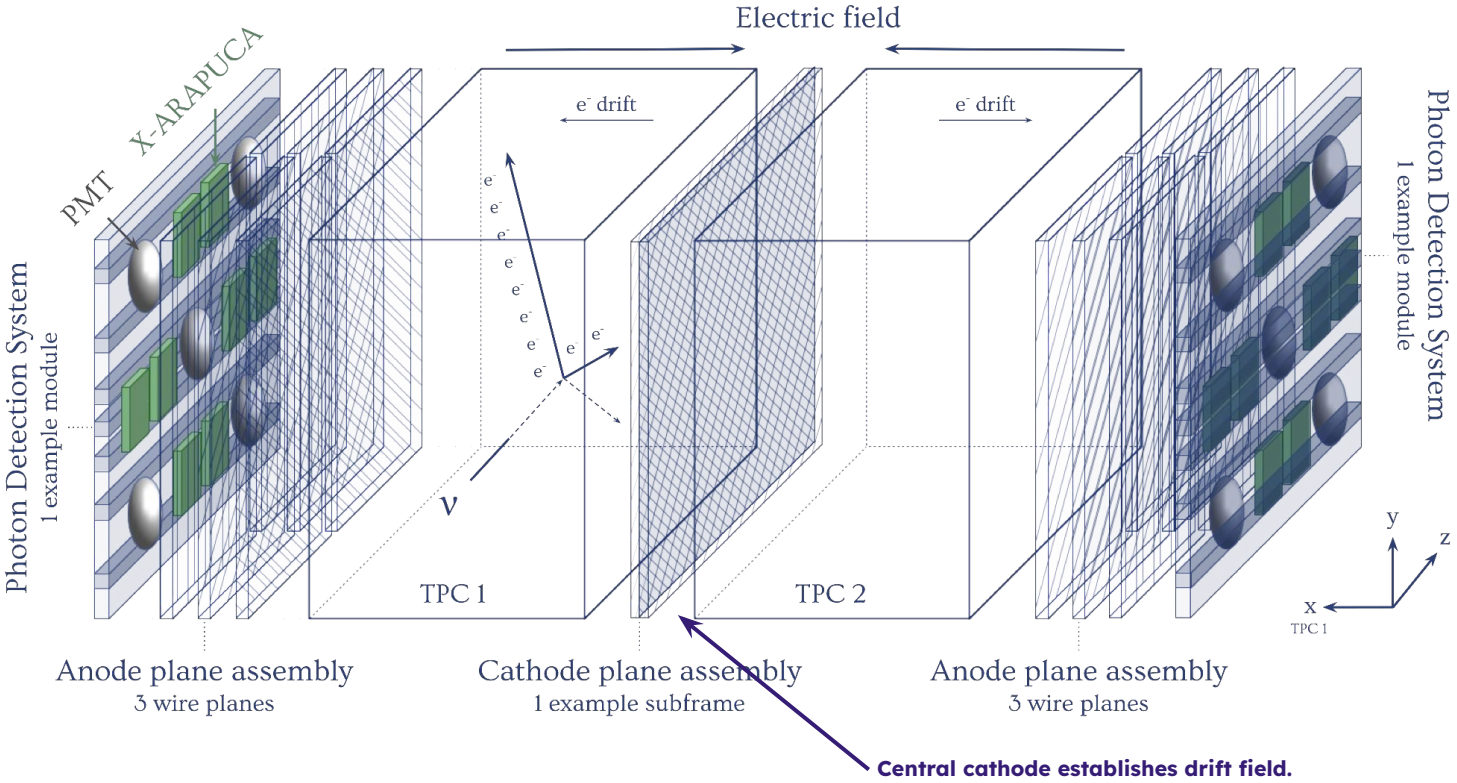

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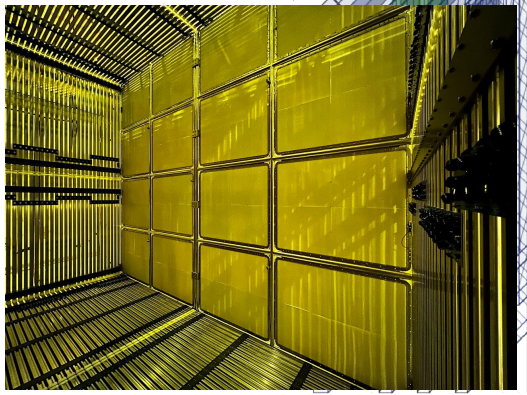
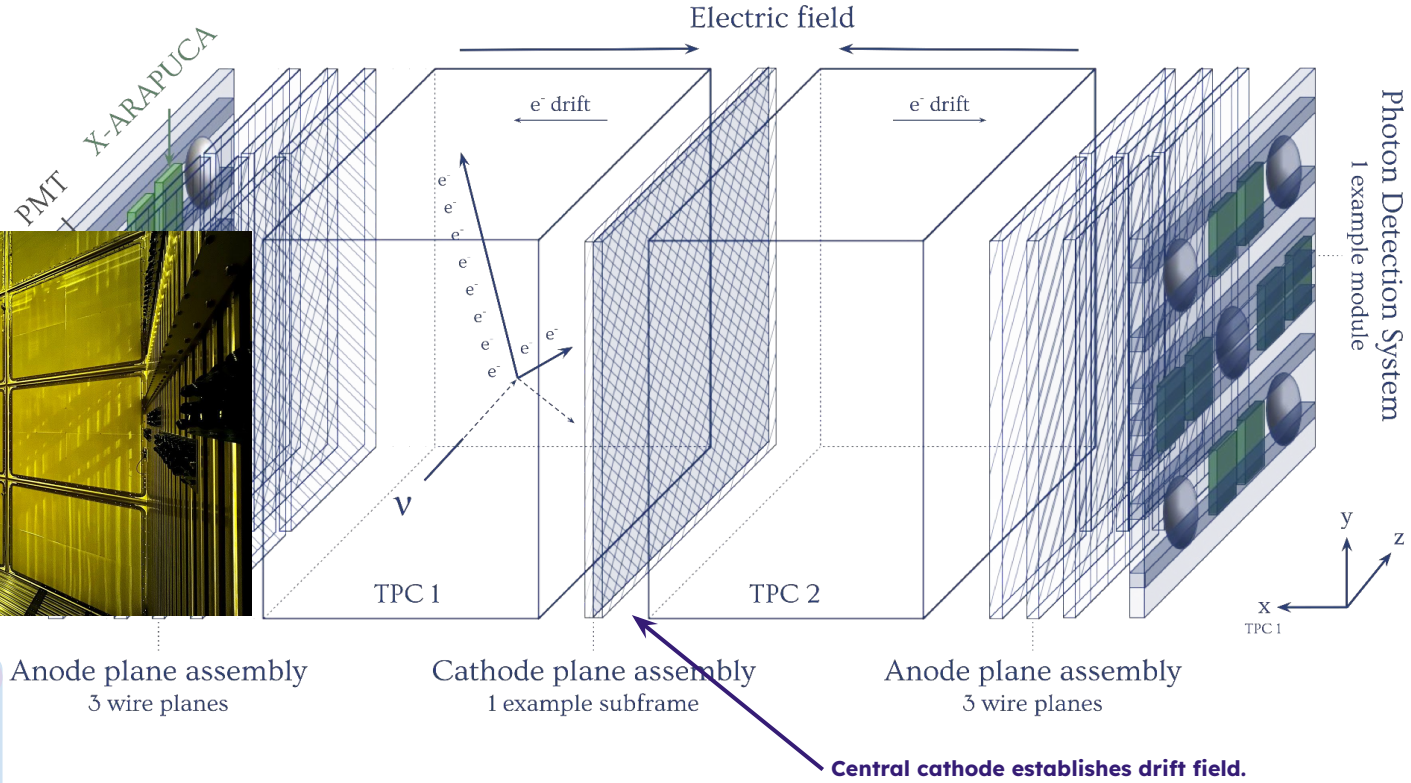
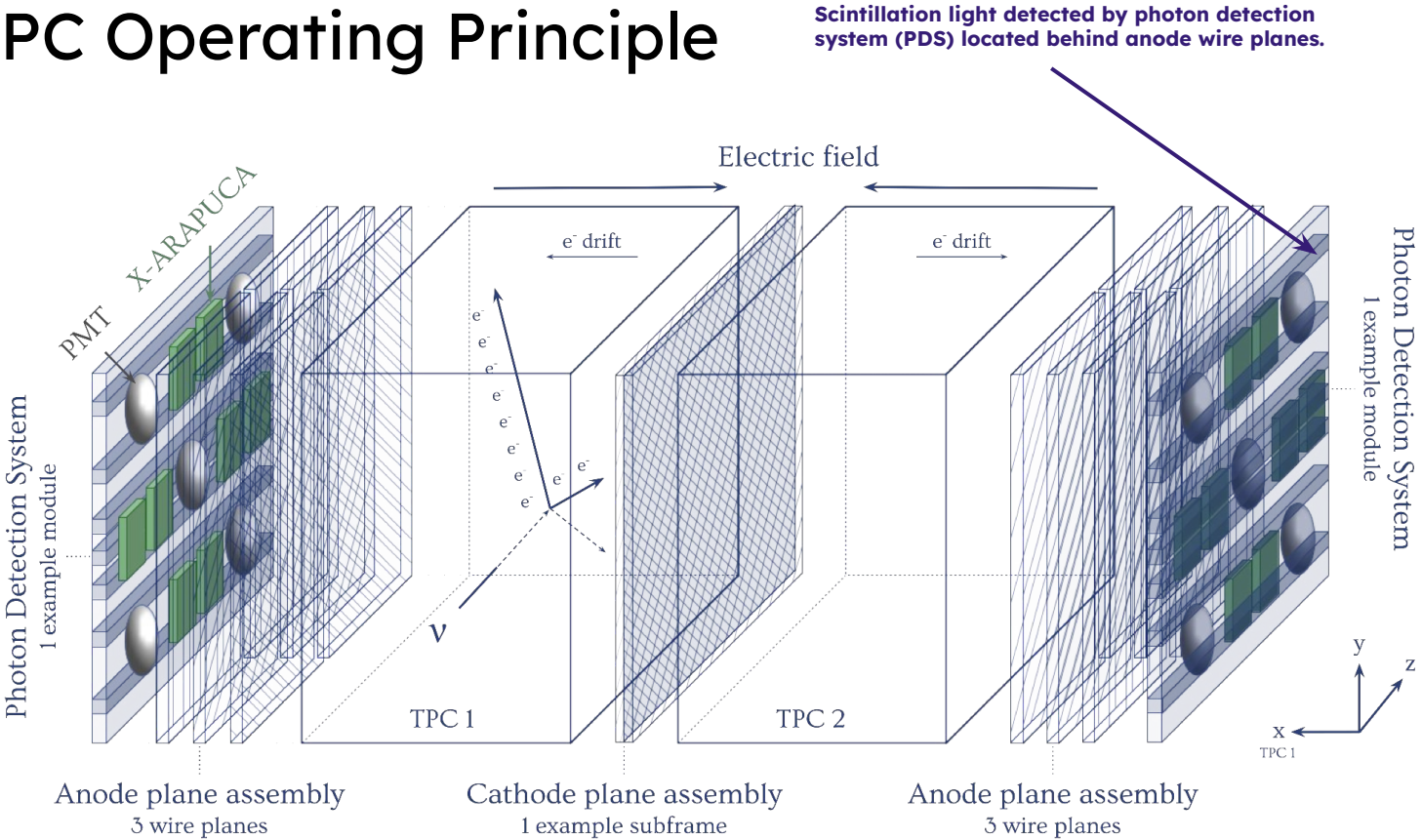




SBND

Cathode is coated with wavelength shifting TPB.

LArTPC Operating Principle



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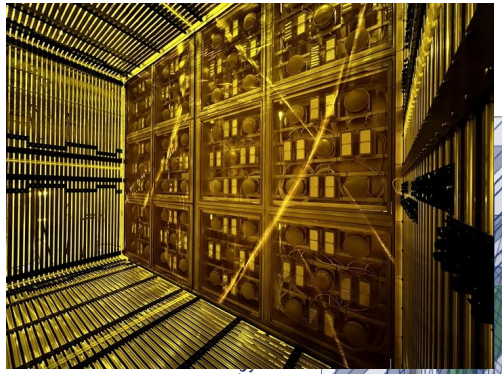
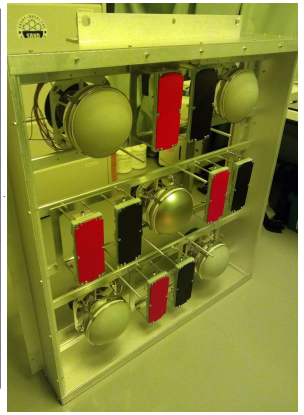
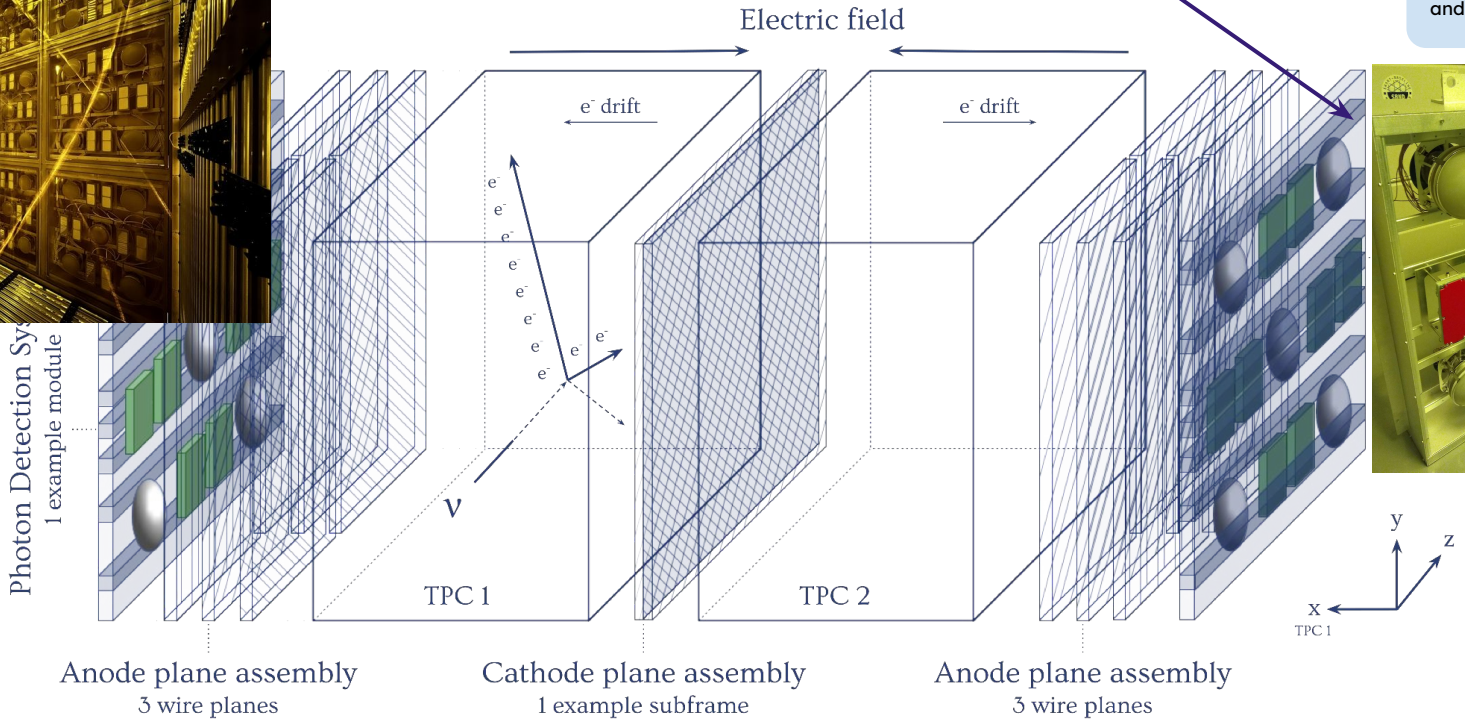


Scintillation light detected by photon detection system (PDS) located behind anode wire planes.

SBND

- 120 traditional PMTs
- 196 novel X-ARAPUCA photo detectors
- Detect both visible and UV light.





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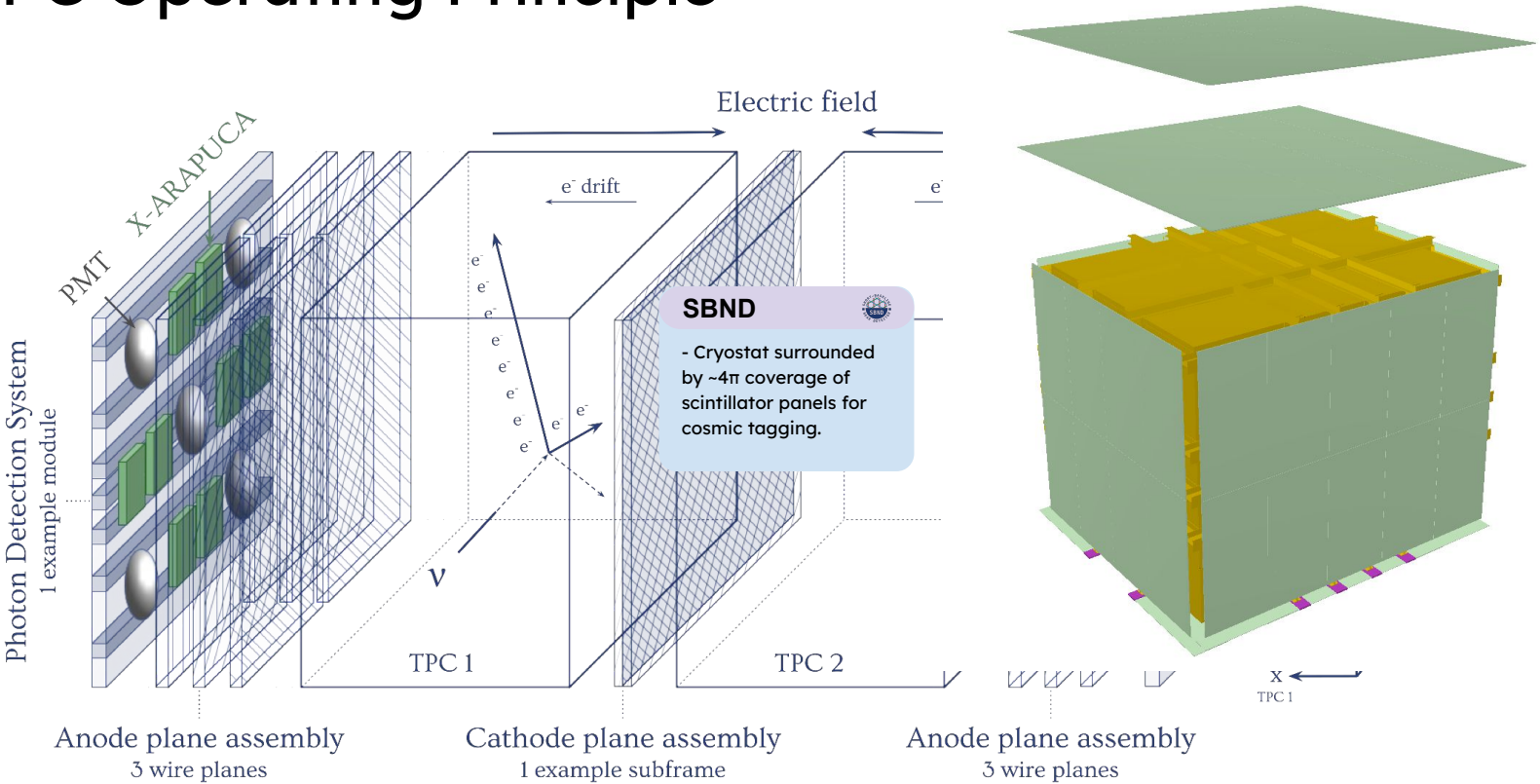
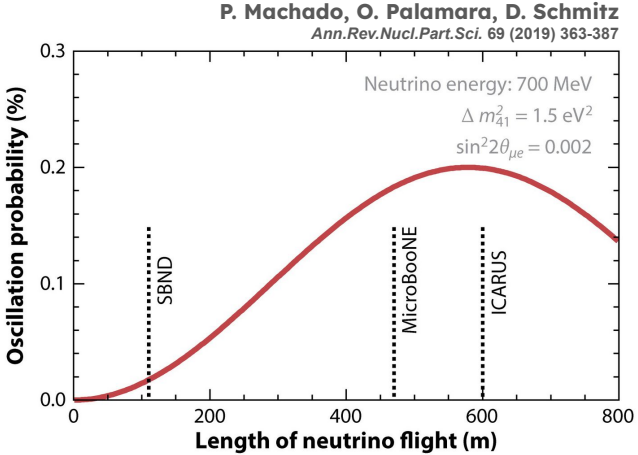


SBND Physics

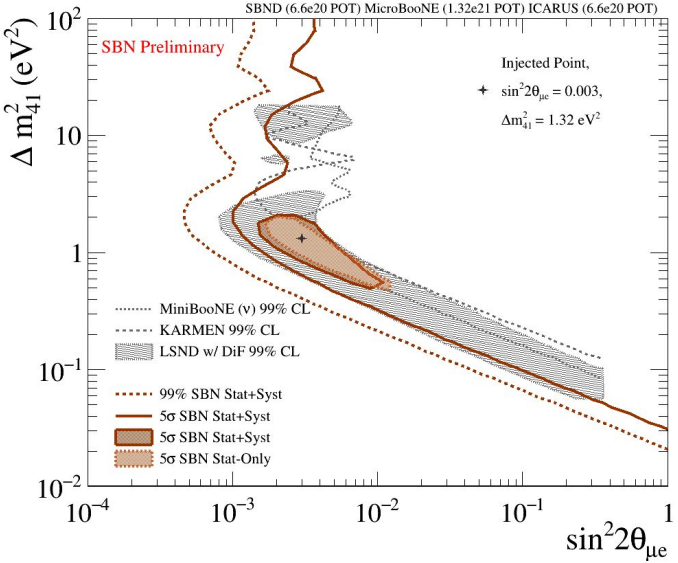
SBND Physics - Oscillations

SBN aims to resolve tension in eV-scale sterile neutrino results by **simultaneously measuring ν_μ (dis)appearance and ν_e appearance.**

SBND plays an important role in **characterising the unoscillated neutrino flux** to significantly reduce systematic uncertainties.



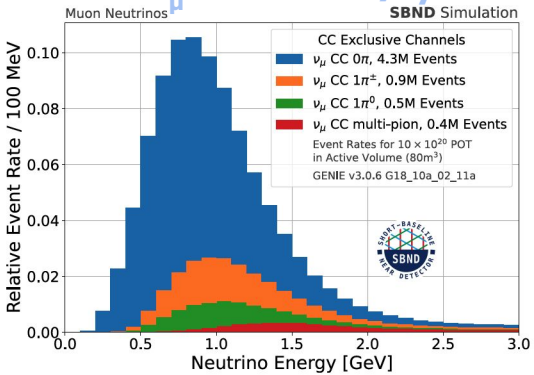
Scale of possible oscillation signature at SBN

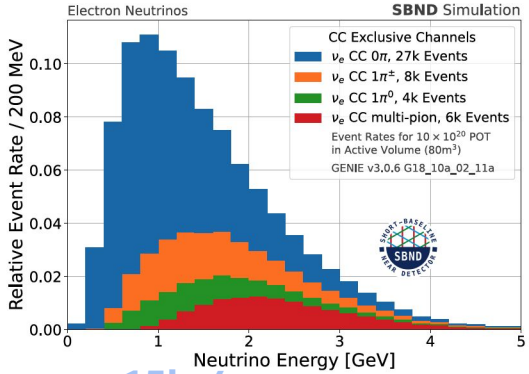


ν_e appearance

SBND Physics - Cross Sections

ν_μ ~2million / year

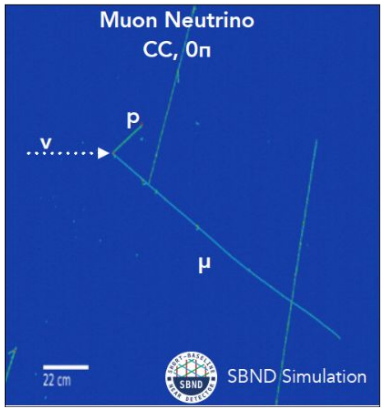


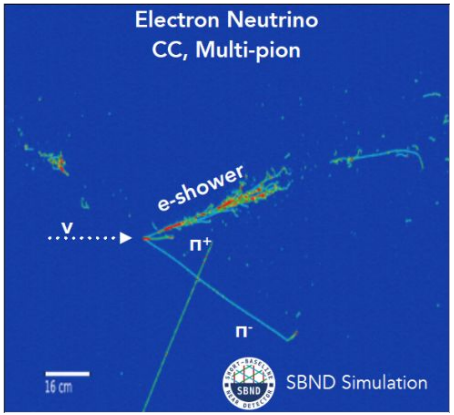


ν_e ~15k / year

SBND will collect by far the **world's largest dataset of neutrino - argon interactions**.

This will allow for **high precision cross-section measurements** of a series of inclusive and exclusive channels.



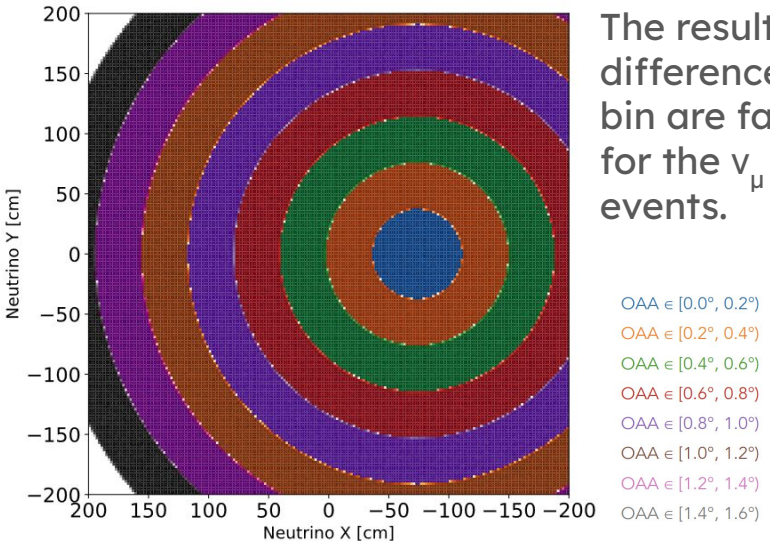


Harnessing powerful detector features:

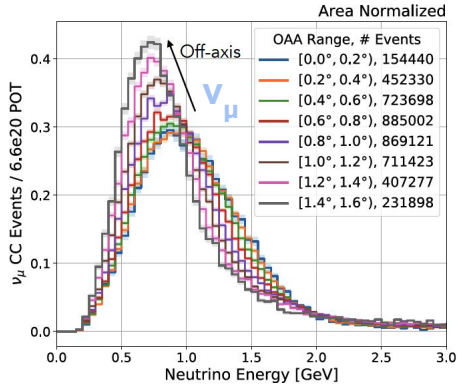
- O(ns) timing
- large photon coverage
- precision calorimetry
- O(mm) tracking

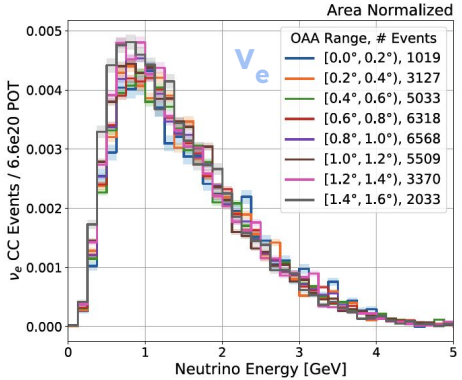
SBND Physics - PRISM

Due to SBND's proximity to the beam target *and* the intentional offset of the beam with respect to the detector centre a "PRISM" effect can be achieved without moving SBND.



The resulting flux shape differences in each angular bin are far more pronounced for the ν_μ events than for ν_e events.

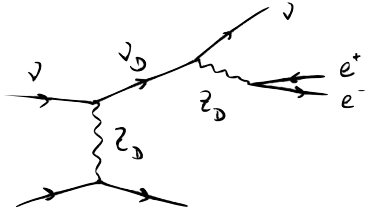




SBND Physics - BSM

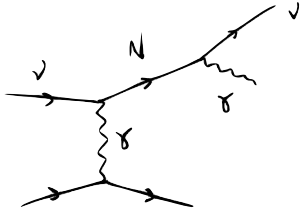
Proximity to target gives SBND sensitivity to various BSM scenarios as alternative LEE explanations.

Dark Neutrinos



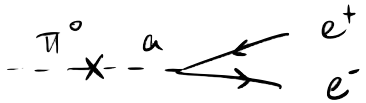
Bertuzzo Jana Machado Zukanovich PRL 2018, PLB 2019
Arguelles Hostert Tsai PRL 2019
Ballett Pascoli Ross-Lonergan PRD 2019
Ballett Hostert Pascoli PRD 2020

Transition Magnetic Moment



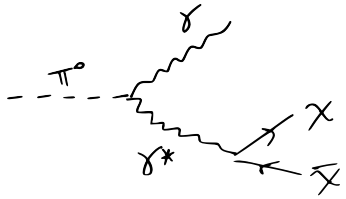
Gninenko PRL 2009
Coloma Machado Soler Shoemaker PRL 2017
Atkinson et al 2021 Vergani et al 2021

Axion-like Particles



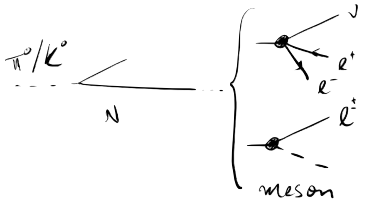
Kelly Kumar Liu PRD 2021
Brdar et al PRL 2021

Millicharged Particles



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

Heavy Neutral Leptons



Ballett Pascoli Ross-Lonergan JHEP 2017
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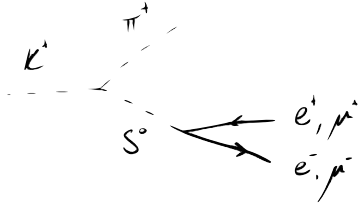
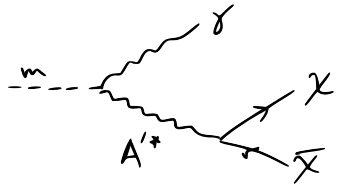
Higgs Portal Scalar



Pat Wilczek 2006
Batell Berger Ismail PRD 2019
MicroBooNE 2021

Light Dark Matter



Romeri Kelley Machado PRD 2019

Diagrams: P. Machado
Slide M. del Tutto, R. Jones

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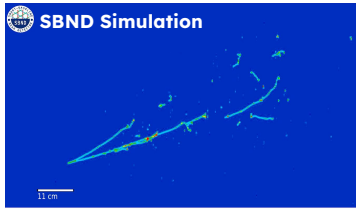

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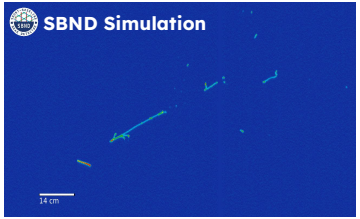

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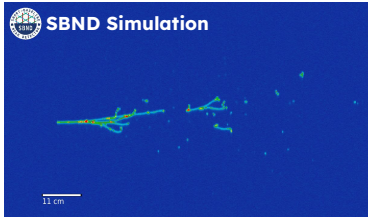

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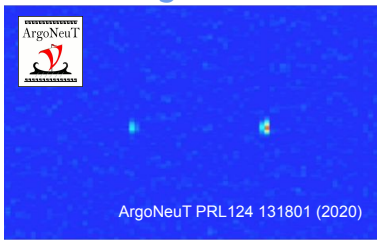
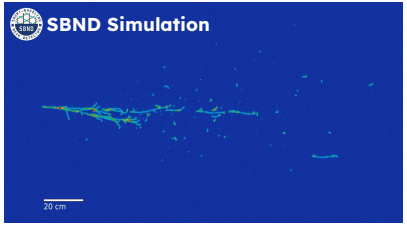
Brdar et al PRL 2021

Millicharged Particles



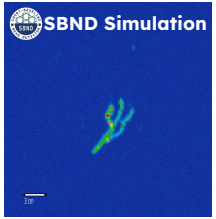
Magill, Plestid, Pospelov, Tsai, PRL 2019
Harnik Liu Palamara, JHEP 2019

Heavy Neutral Leptons



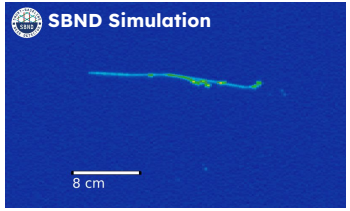
Ballett Pascoli Ross-Lonergan JHEP 2017
Kelly Machado PRD 2021

Higgs Portal Scalar



Pat Wilczek 2006
Batell Berger Ismail PRD 2019
MicroBooNE 2021

Light Dark Matter



Romeri Kelley Machado PRD 2019

Diagrams: P. Machado
Slide M. del Tutto, R. Jones

SBND Status

SBND Status

1st December 2022

Completed TPC (including PDS) transferred from DAB to SBN-ND

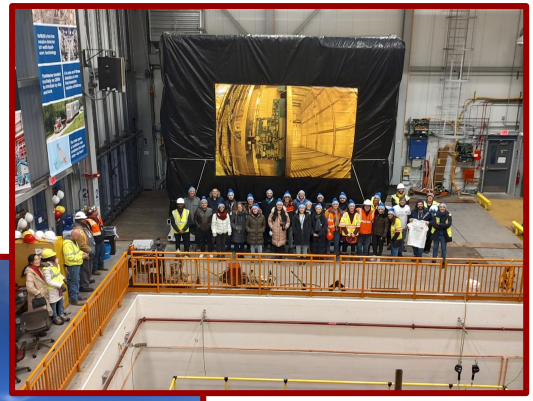
SBND Status

1st December 2022

TPC installed in the cryostat.

25th April 2023

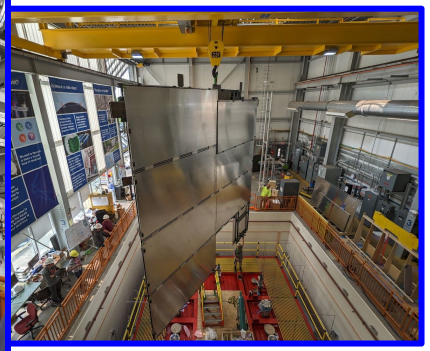
SBND Status



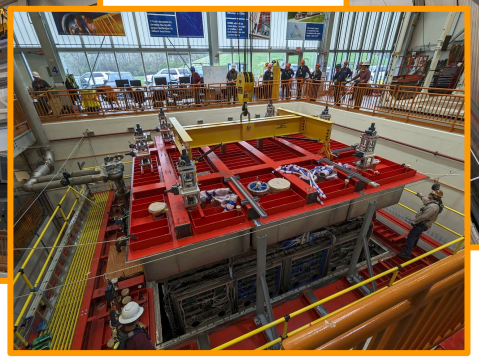
1st December 2022

First wall of cosmic ray taggers installed between cryostat and pit walls.

25th April 2023



18th May 2023



Looking forward…

- Cryostat welding — **June 2023**
- Cryo system commissioning — **September 2023 -**
- Cold detector commissioning — **Early 2024**

Looking forward…

- Cryostat welding
- Cryo system commissioning
- Cold detector commissioning

Commissioning SBND's Time Projection Chambers *One West, Fermilab*	*Maria Flavia Cicala* 15:15 - 15:30
Baseline monitoring for SBND PDS Trigger *One West, Fermilab*	*Gajendra Gurung* 15:30 - 15:45
Tagging neutrino events with the SBND's Photon Detection System *One West, Fermilab*	*Francisco Nicolas-Arnaldos* 15:45 - 16:00
Break *One West, Fermilab*	16:00 - 16:15
What Physics Can We Learn about in SBND from its "Prehistoric Era"? *One West, Fermilab*	*Jiaoyang Li* 16:15 - 16:30
Heavy Neutral Lepton Searches at the Short Baseline Near Detector *One West, Fermilab*	*Vu Chi Lan Nguyen* 16:30 - 16:45
Sterile Neutrino Oscillation Searches using the VALOR Fitting Framework at SBN *One West, Fermilab*	*Beth Slater* 16:45 - 17:00
Neutrino Electron Scattering for Flux Constraint on SBND *One West, Fermilab*	*Brinden Carlson* 17:00 - 17:15
The UV Laser Calibration System for measuring the electric field in the SBND detector *One West, Fermilab*	*Shivaraj Mulleria Babu* 17:15 - 17:30

June 2023
September 2023 - Early 2024

Right now!!!

Stay tuned for some great talks with all the details of our exciting program.

Conclusions

- SBND is an exciting experiment with physics goals ranging from the **SBN sterile neutrino oscillation** search to a **rich cross-section program** and a range of **BSM searches**.
- SBND installation is nearing completion and **cold commissioning** will begin later **this year**.

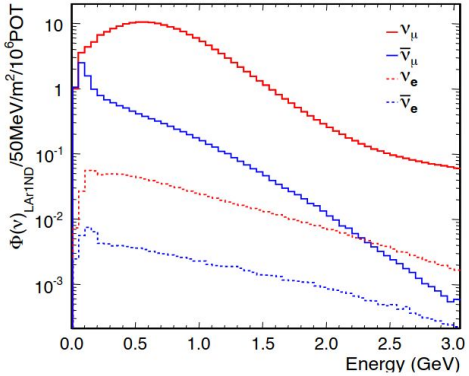
- Stay tuned for exciting results in the coming years!

Thanks!!!

SBND @ UTA just 2 weeks ago!

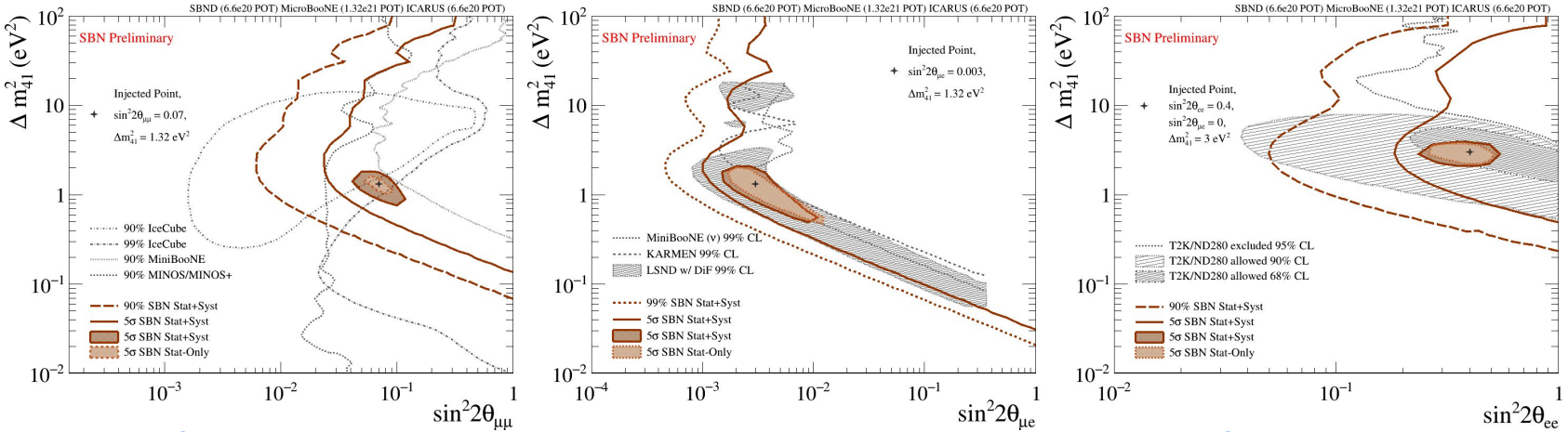
BACKUP

Booster Neutrino Beam



BNB Flux @ SBND

SBN Oscillations Sensitivity

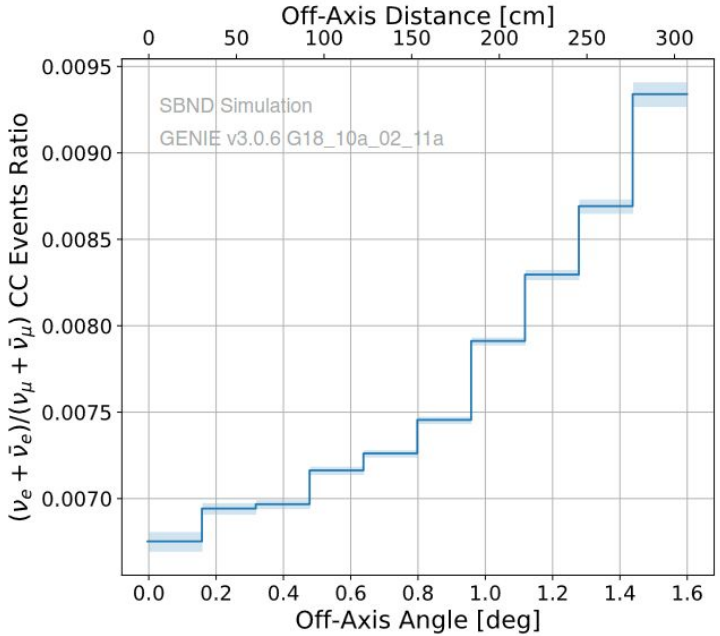


ν_μ disappearance ν_e appearance ν_e disappearance

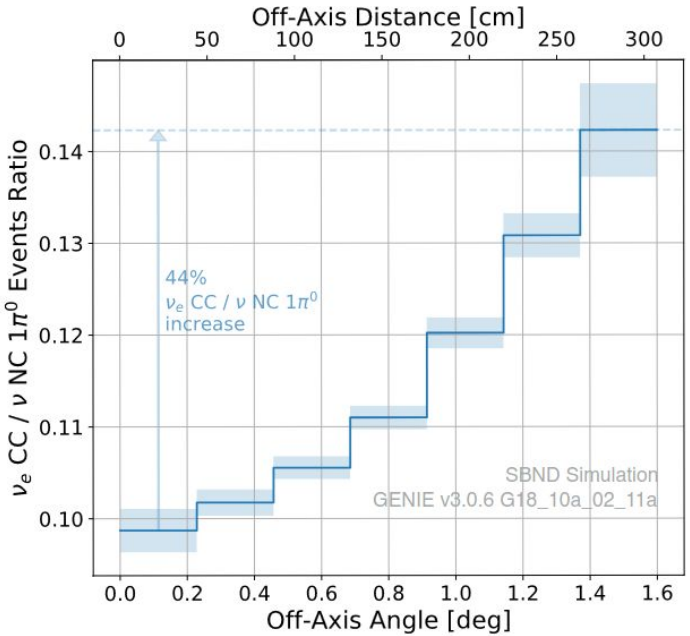
Sensitive to sterile neutrino signatures favoured by LSND / MiniBooNE at 5σ level across 2/3 channels.

SBND-PRISM Effects

ν_e/ν_μ event rate is non-constant as a function of OAA



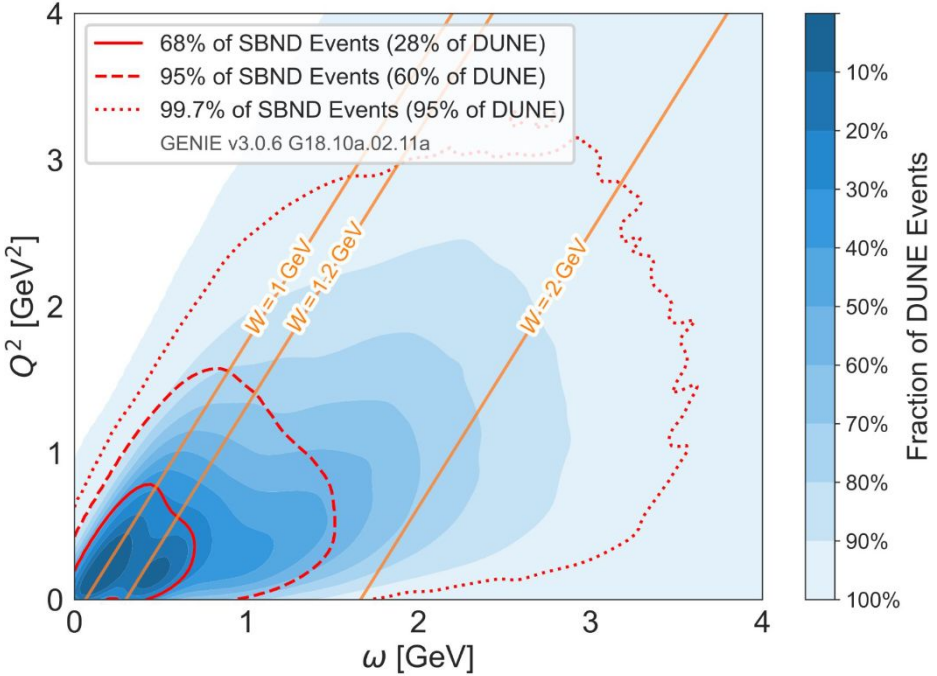
PRISM provides a natural way to reduce Neutral Current events with π^0 by moving off-axis.



SBND coverage of DUNE phase space

SBND has large coverage of the DUNE kinematic phase space.

Hence, the SBND cross-section measurement program will be critical in helping to constrain interaction systematics for DUNE.



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 Collaboration

262 Total Collaborators

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

40 Institutions

5 Brazilian Universities

CERN

1 Spanish University, 1 National Laboratory

1 Swiss University

8 UK Universities, 1 National Laboratory

18 US Universities, 4 National Laboratories