

The SBND detector being lifted into the cryostat (April 2023).



University of
Sheffield



SBND IN 10 MINUTES

Nguyen Vu Chi Lan (she/her)
on behalf of the SBND Collaboration

New Perspectives Conference
Fermilab

8 – 9th July 2024

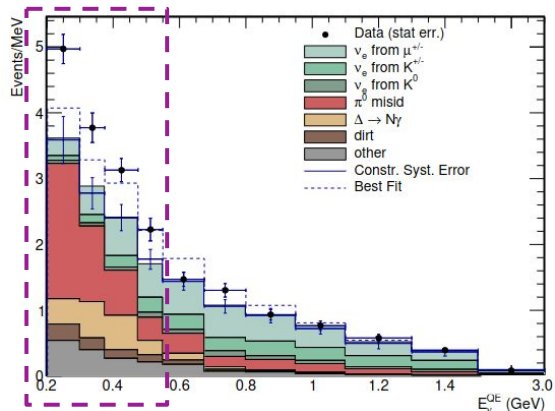


FERMILAB-SLIDES-24-0147-V

The Short-Baseline Neutrino Program

The Short-Baseline Neutrino Program

[Phys. Rev. Lett. 121, 221801](#)

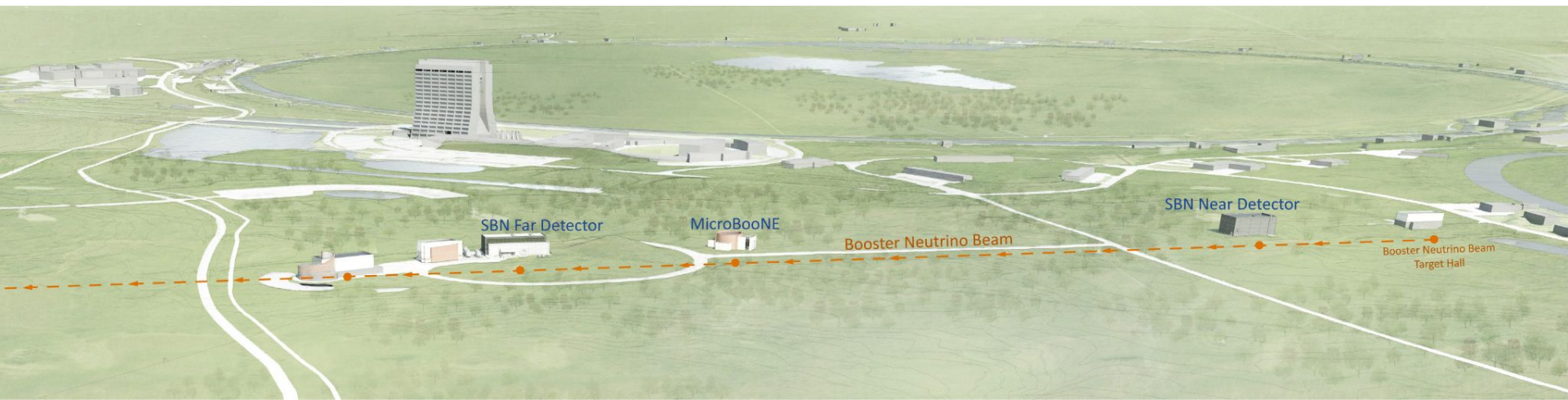


MiniBooNE & LSND reported a **Low Energy Excess** (LEE) in ν_e appearance searches – an outstanding anomaly for 10+ years.

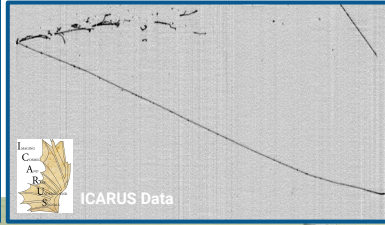
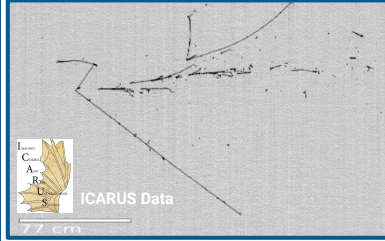
The SBN program was designed to be **the world-leading short baseline experiment** with the goal to investigate the anomaly.

Made up of **three LArTPCs along the Booster Neutrino Beam** located at Fermilab.

The same neutrino beam and detector technology will **constrain systematic uncertainty to the %-level**.



Experiments At The SBN: ICARUS

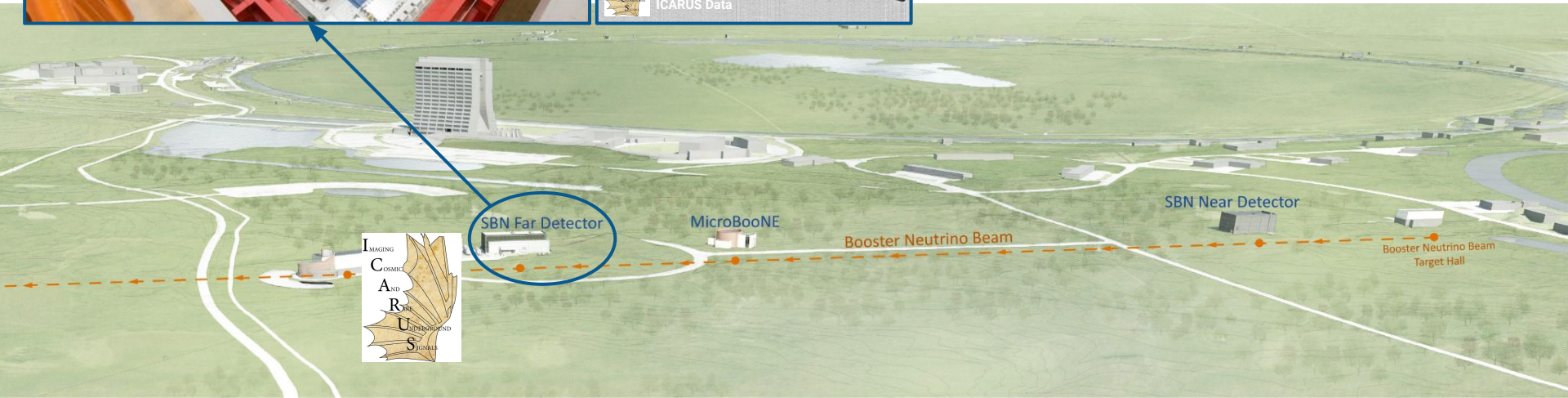


Far detector at 600 m baseline

Collecting data since 2021

First results presented at Neutrino 2024

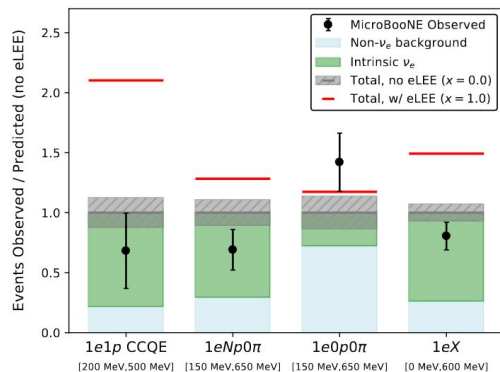
Detector papers coming soon!



Experiments At The SBN: MicroBooNE



[Phys. Rev. Lett. 128, 241801](#)

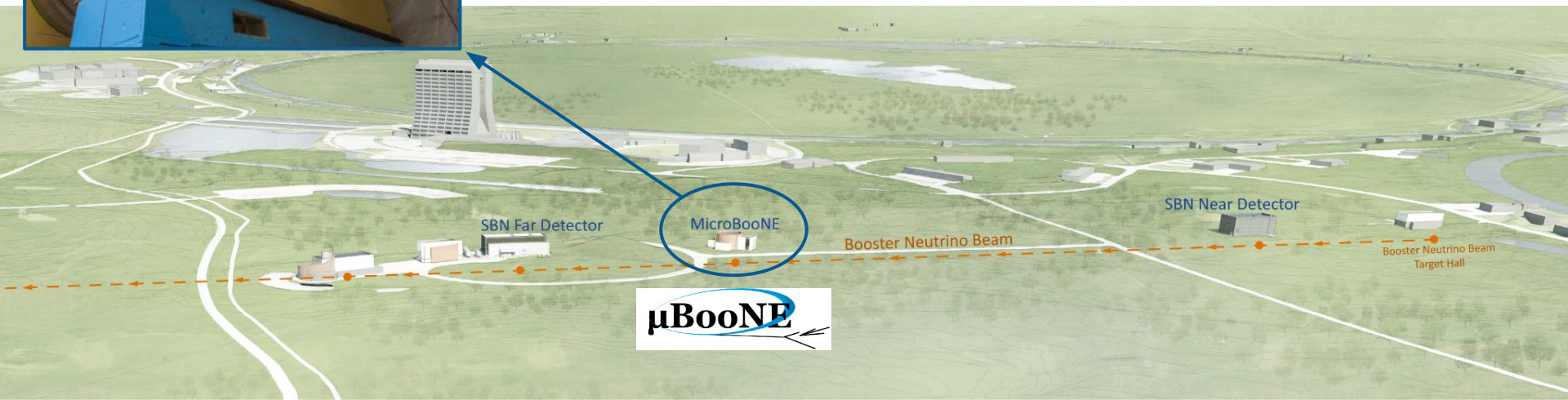


Middle detector at 470 m baseline

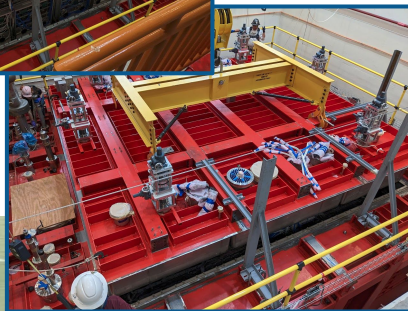
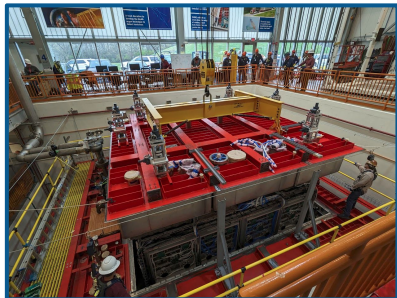
Data taken between 2015 – 2021

67+ publications and counting!

The LEE search result does not see MiniBooNE-like excess



Experiments At The SBN: Short-Baseline Near Detector

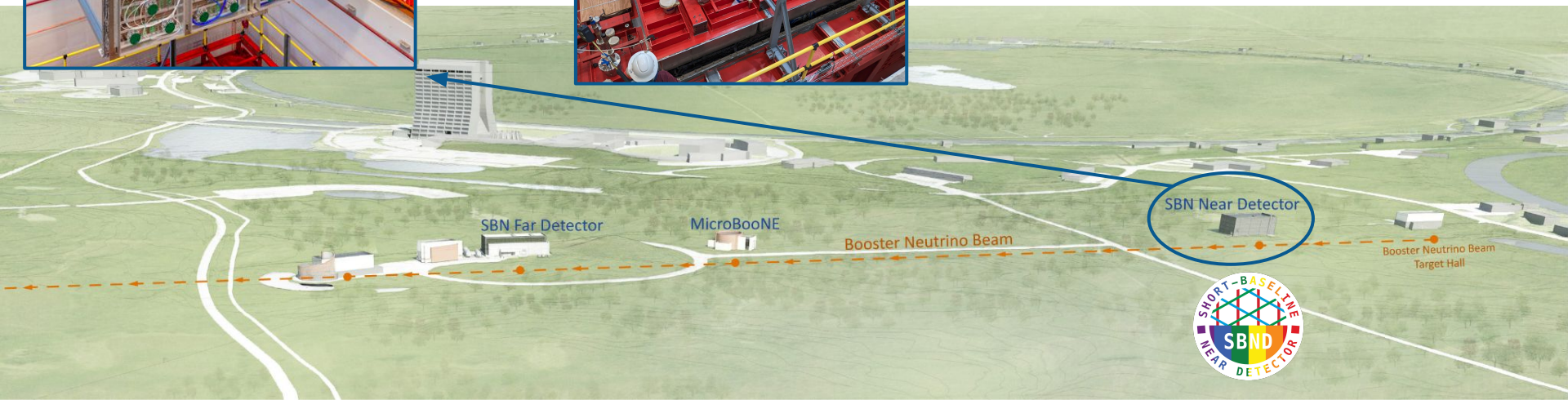


Near detector at 110 m baseline

TPC installation in April 2023

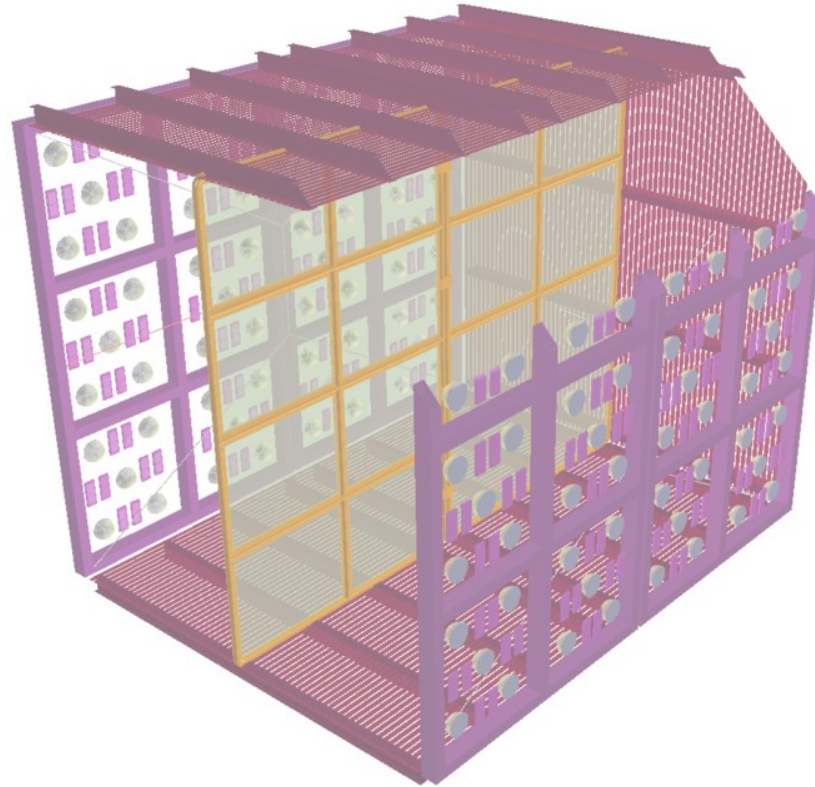
Argon fill in Feb 2024

Commissioning with data collecting NOW!

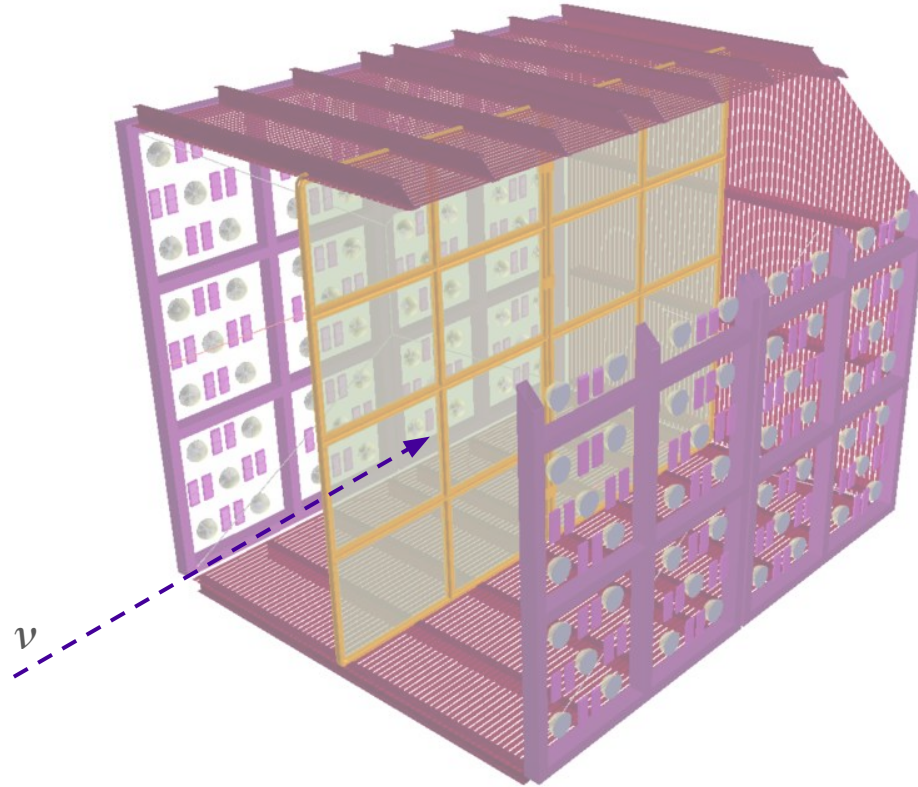


Short-Baseline Near Detector

LArTPC Operating Principles

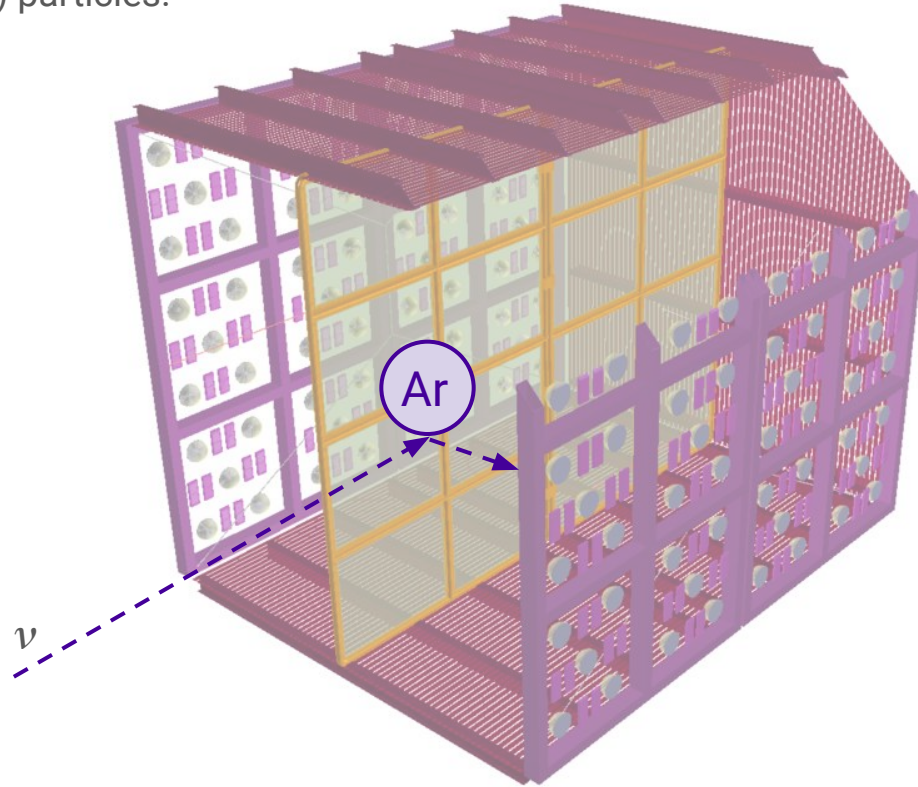


LArTPC Operating Principles



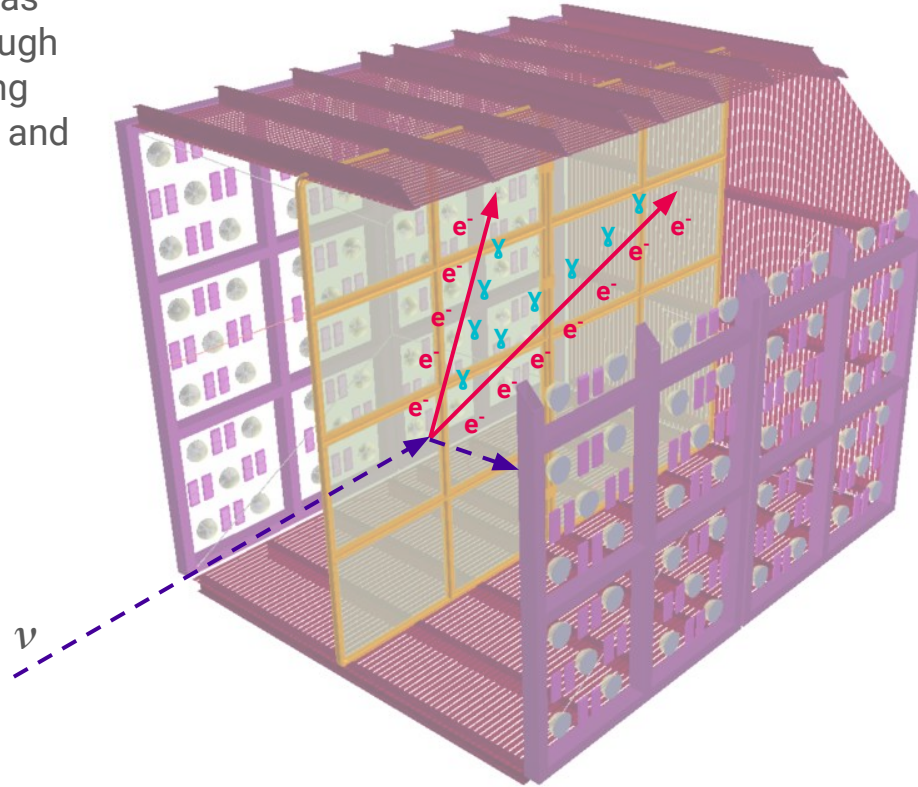
LArTPC Operating Principles

1. Neutrino interacts with argon nucleus producing (charged) particles.



LArTPC Operating Principles

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

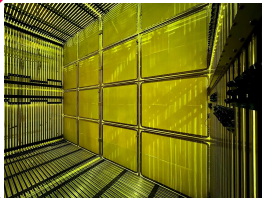
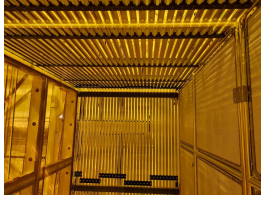


SBND Detection Systems: LArTPC

3. Ionisation electrons drift under an electric field.

Field Cage

surrounds TPC,
provides a uniform
500V/cm drift field

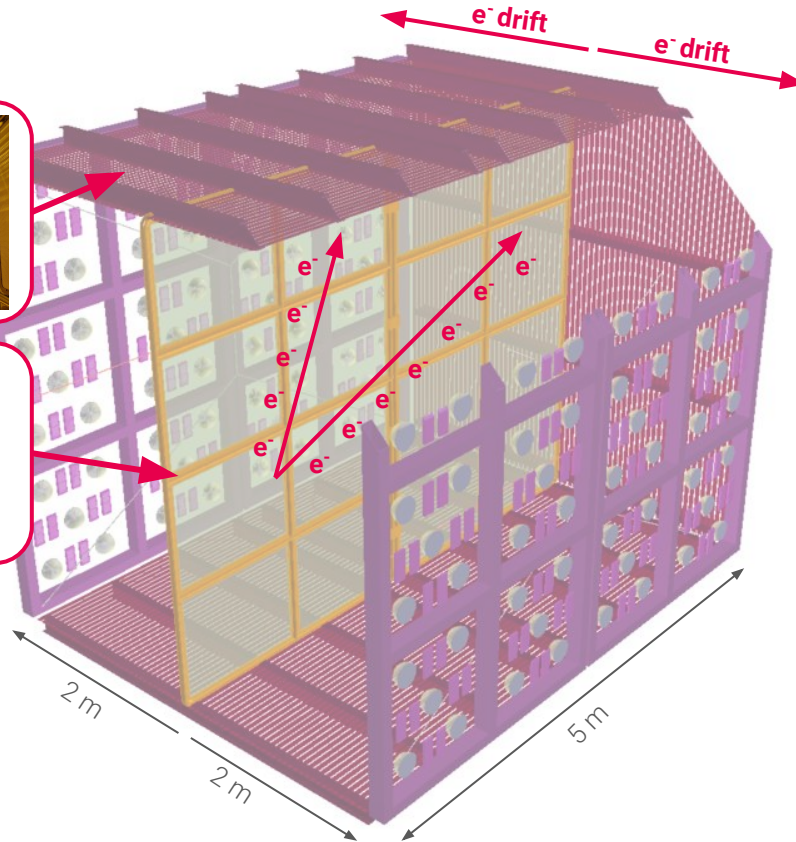


Cathode Plane

(-100 kV) splits
the detector into 2
drift volumes

SBND LArTPC Size

$4 \times 4 \times 5 \text{ m}^3$
Active volume 112 t
2 drift volumes
Drift distance 2 m

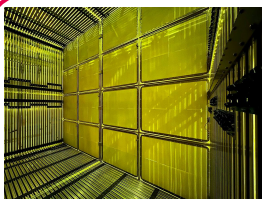


SBND Detection Systems: LArTPC

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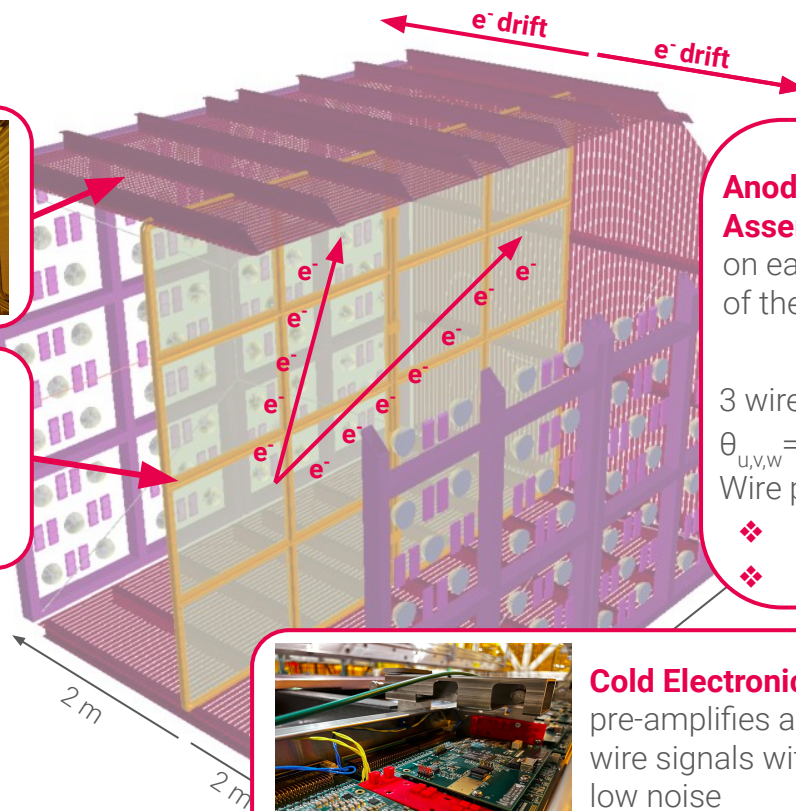


Cathode Plane

(-100 kV) splits the detector into 2 drift volumes

SBND LArTPC Size

$4 \times 4 \times 5 \text{ m}^3$
Active volume 112 t
2 drift volumes
Drift distance 2 m



4. Once arrive at the anode, ionisation electrons induce current on the wire planes.

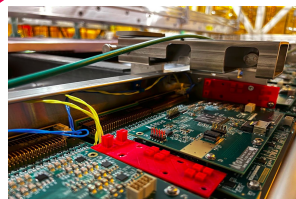
Anode Plane Assembly

on each side of the detector



3 wire planes, 11,264 wires in total
 $\theta_{u,v,w} = 0^\circ$ and $\pm 60^\circ$ from the vertical
Wire pitch of 3 mm

- ❖ Fine-granularity calorimetry
- ❖ Excellent particle identification



Cold Electronics (89K)
pre-amplifies and digitises wire signals with extremely low noise

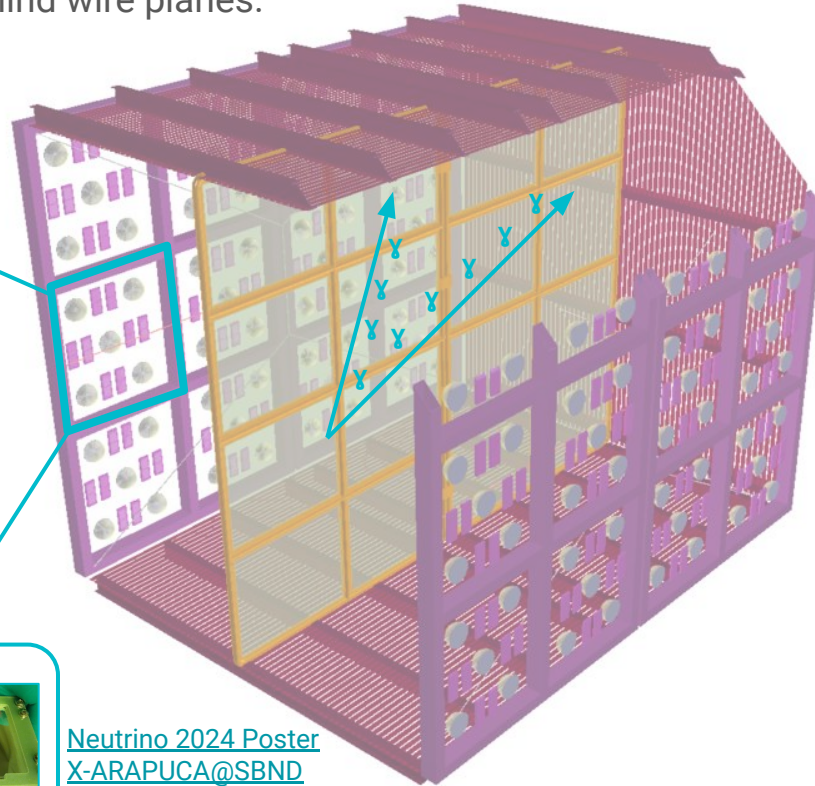
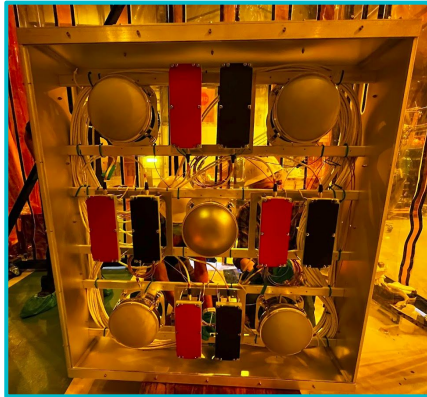
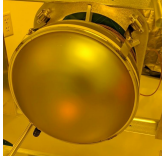
[Neutrino 2024 Poster WireCell Reco@SBND](#)
by [Avinay Bhat](#) and [Ewerton Chagas](#)

SBND Detection Systems: Photon Detection System

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

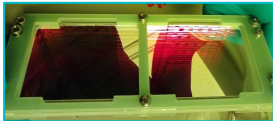
PMT

96 PMTs (TPB-coated)
24 PMTs (uncoated)



X-ARAPUCAS

192 X-ARAPUCAs,
sensitive to VUV and
visible light



[Neutrino 2024 Poster](#)
X-ARAPUCA@SBND
by Anna Machado

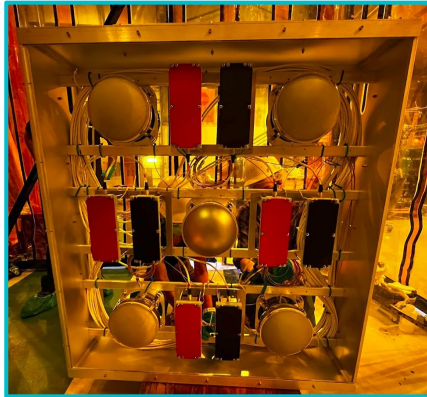
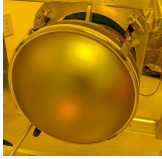
SBND Detection Systems: Photon Detection System

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

6. Additionally, scintillation photons are converted to visible by TPB-coated cathode.

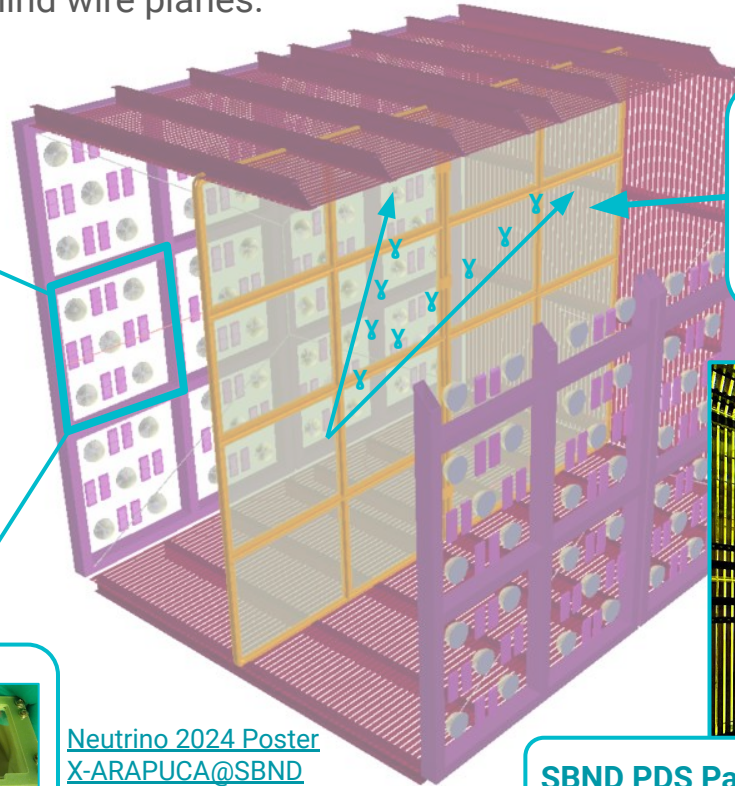
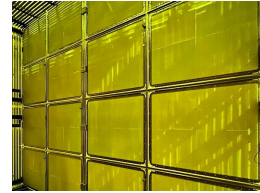
PMT

96 PMTs (TPB-coated)
24 PMTs (uncoated)



TPB-coated Reflective Foil

converts VUV into visible light, enables uniform light collection

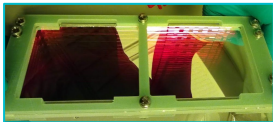


SBND PDS Paper recently published last month!

Neutrino 2024 Poster
X-ARAPUCA@SBND
by Anna Machado

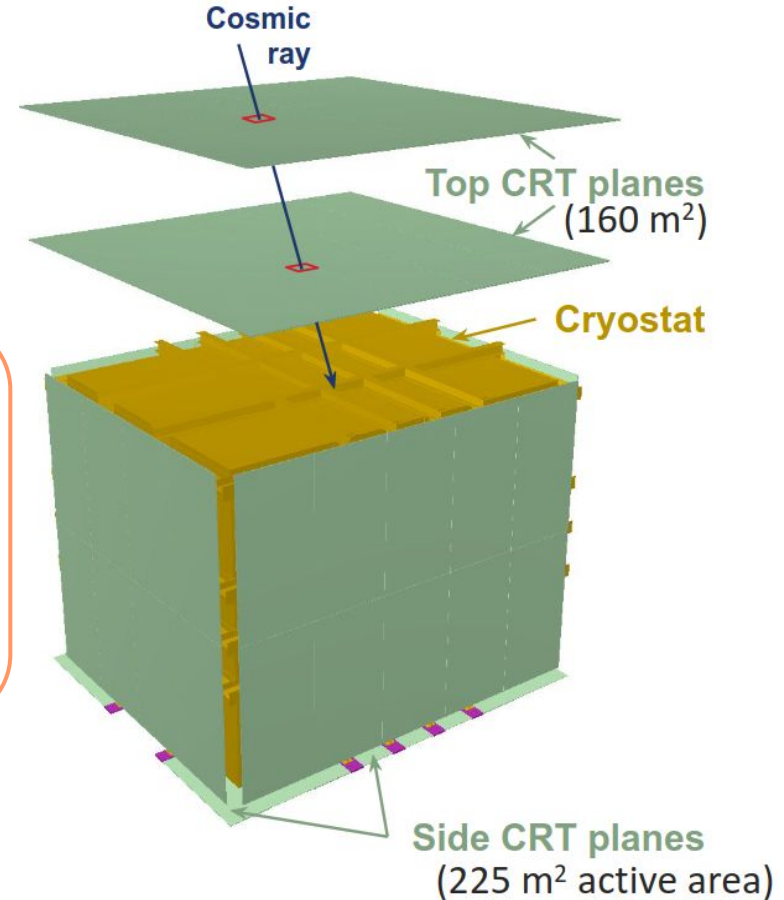
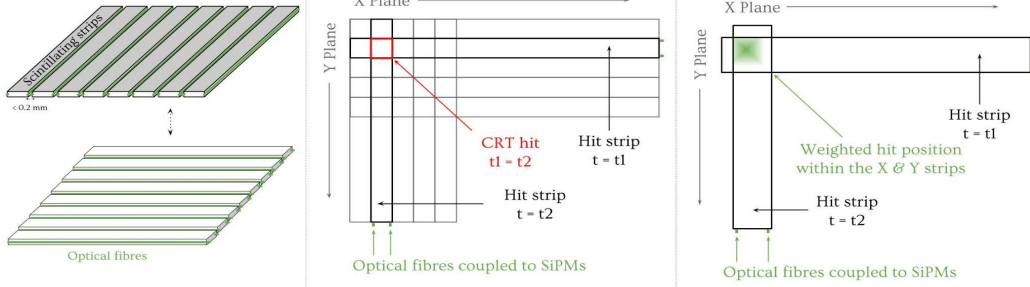
X-ARAPUCAS

192 X-ARAPUCAs,
sensitive to VUV and
visible light



SBND Detection Systems: Cosmic Ray Tagger

7. Finally, SBND cryostat is surrounded by $\sim 4\pi$ coverage of scintillator panels for cosmic tagging.



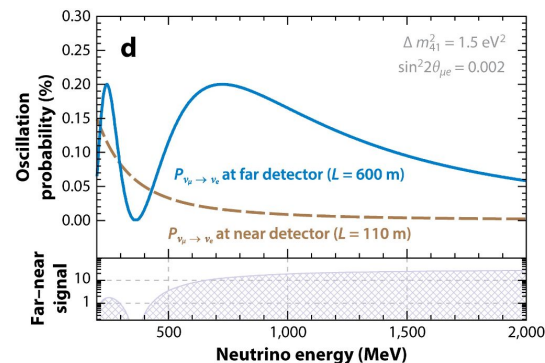
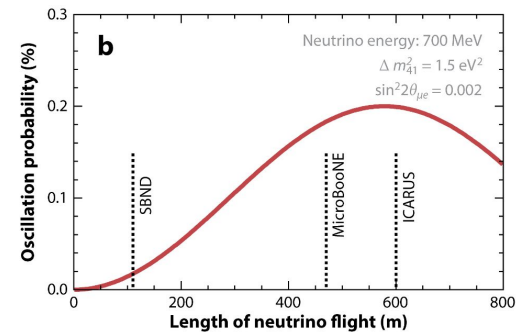
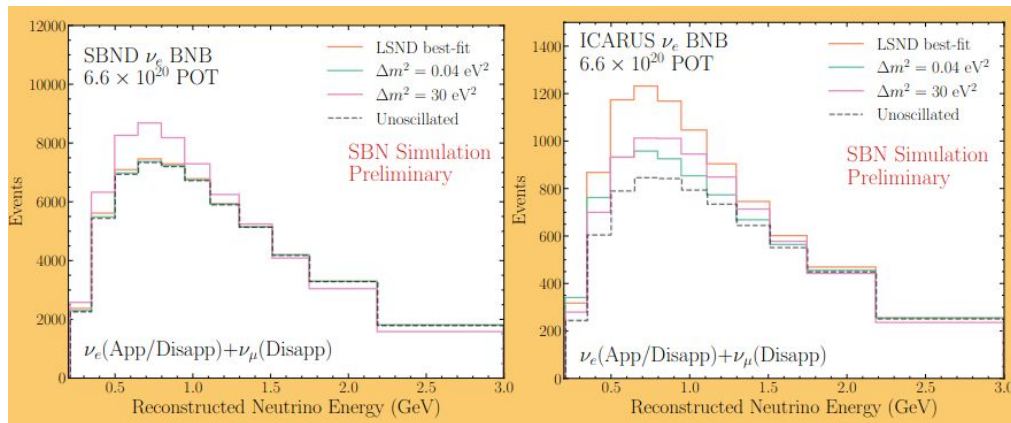
SBND Physics

SBND Physics: Oscillation

Only 110 m from the BNB target means 3 years of exposure results in 1×10^{21} POT, equivalent to **10 million total neutrino events** (CC+NC).

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

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



[Neutrino 2024 Poster](#)
[Sterile neutrino searches @SBN](#)
[by Nupur Oza and Ibrahim Safa](#)

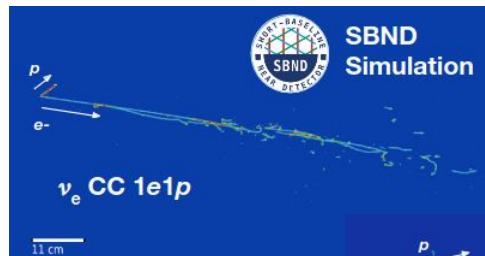
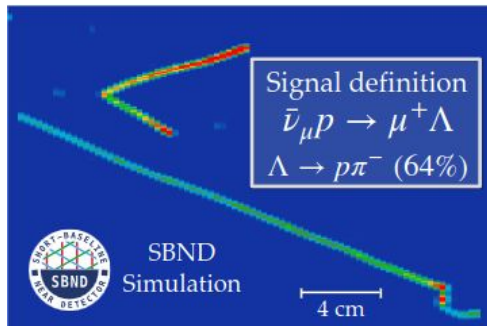
SBND Physics: Cross Sections

SBND will collect **the world's largest dataset of ν -Ar interactions**.

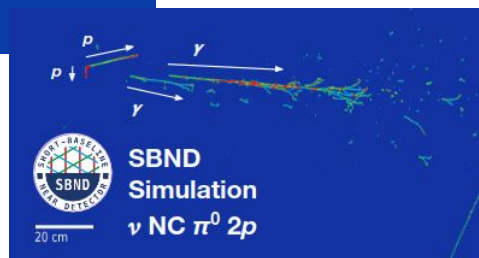
This will allow **for high precision cross-section measurements** of a series of inclusive and exclusive channels.

Cross section posters presented at **Neutrino 2024**:

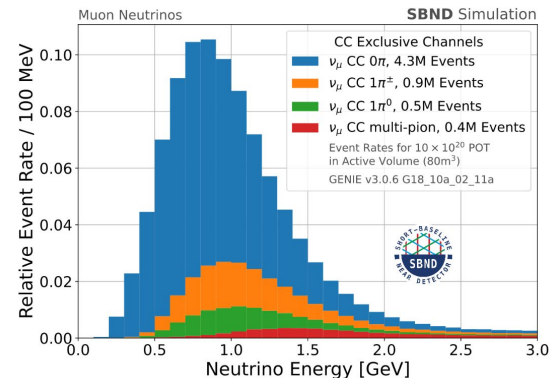
[Hyperon searches](#)
by Francisco Nicolas-Arnaldos



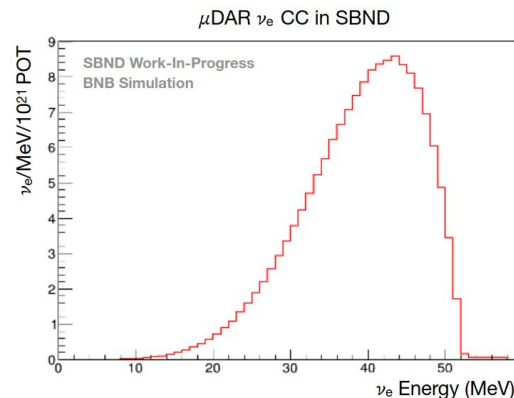
[CC \$\nu_e\$ and NC \$\pi^0\$ reco](#)
by Lynn Tung
and Henry Lay



CC event rate for 10e20 POT: $\sim 6M \nu_{\mu}$ CC



[\$\mu\$ DAR measurement](#)
by Miquel Nebot-Guinot



SBND Physics: PRISM

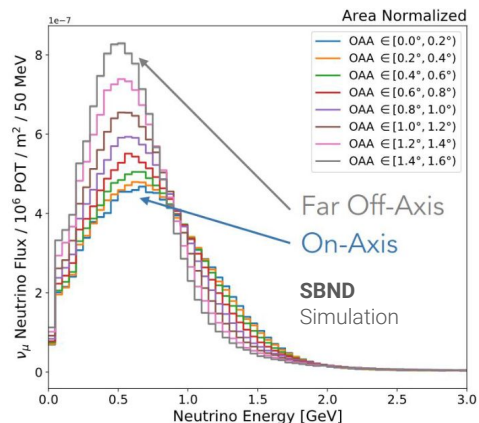
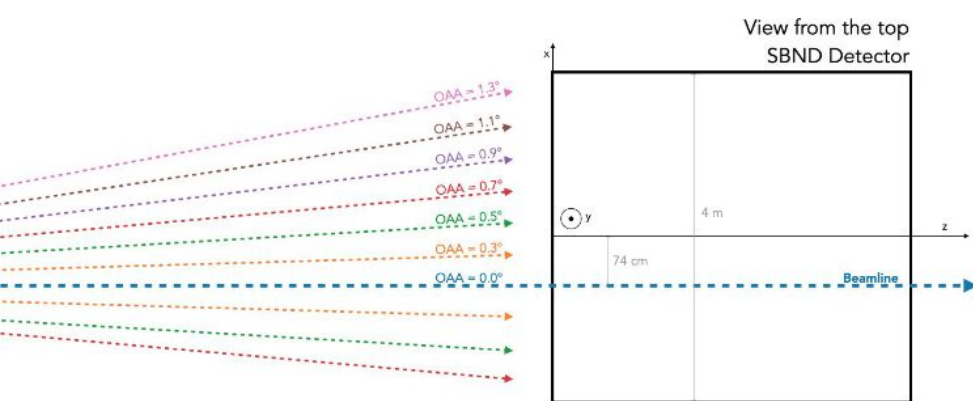
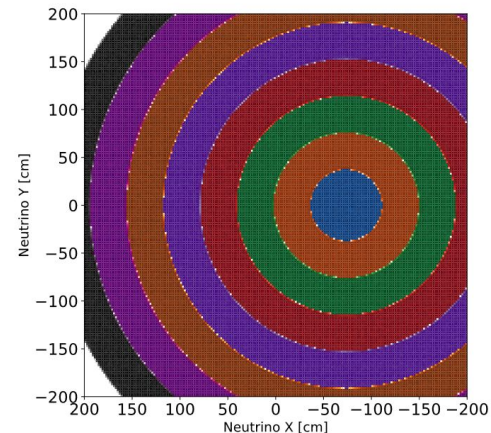
Precision Reaction Independent Spectrum Measurement

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.

PRISM provides extra handles for **improving systematic constraints**.

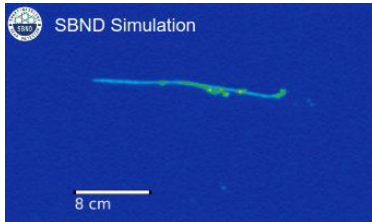
[Neutrino 2024 Poster](#)

[Sterile neutrino searches using PRISM by Beth Slater](#)



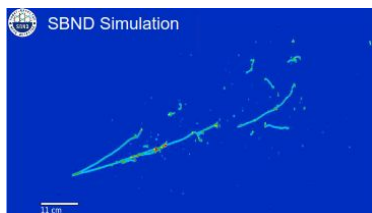
SBND Physics: Beyond Standard Model

Light Dark Matter



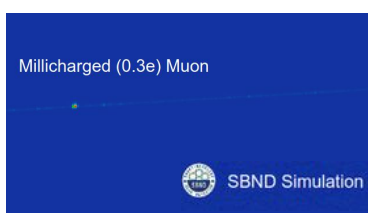
Single e^- scattering
Pair of e^+e^- and $\gamma\gamma$
No hadronic activity

Dark Neutrinos



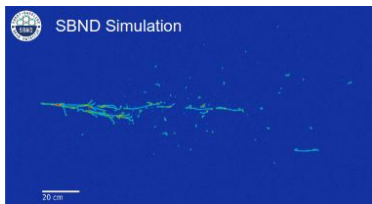
Pair of e^+e^- and $\mu^+\mu^-$
With or without hadronic activity

Millicharged Particles



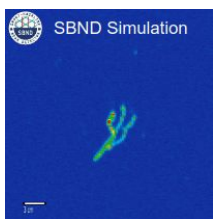
Blip or faint tracks

Heavy Neutral Leptons



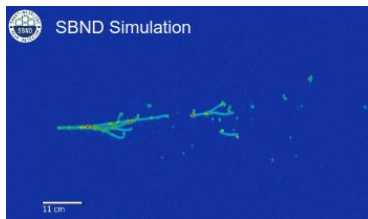
Single lepton + π
High energy pair of e^+e^- , $\mu^+\mu^-$ and $\gamma\gamma$
No hadronic activity

Higgs Scalar Portal



Pair e^+e^- and $\mu^+\mu^-$
No hadronic activity

Axion-like Particles

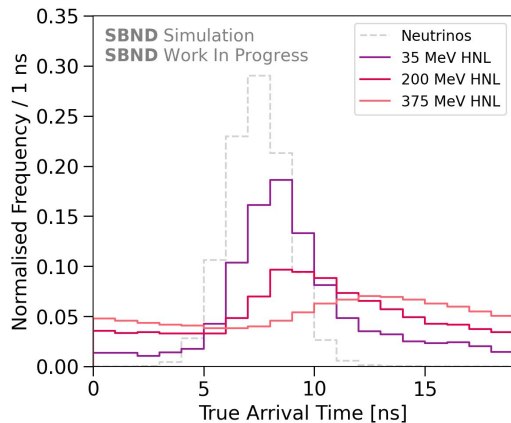


High energy pair of e^+e^- , $\mu^+\mu^-$ and $\gamma\gamma$
No hadronic activity

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

Exploit **unique features** of BSM signals:

- Late arrival due to heaviness
- Highly beam collimated
- Blip tracks



SBND Milestones

SBND Milestones



May 2023

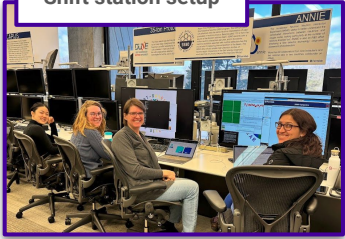
Began commissioning
across various areas.

SBND Milestones

May 2023

Began commissioning
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Shift station setup

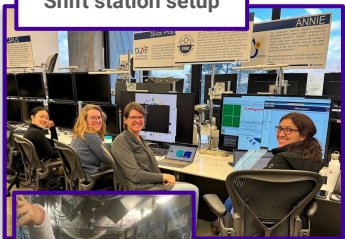


SBND Milestones

May 2023

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Shift station setup



**DAQ/
Triggering/
Monitoring
preparation**

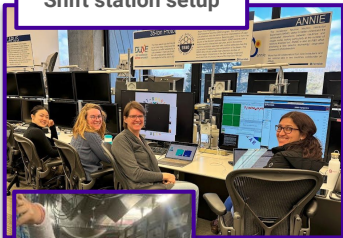


SBND Milestones

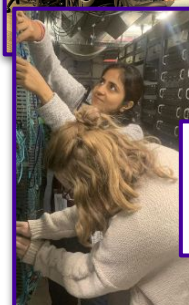
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**DAQ/
Triggering/
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Hardware QA/QC



SBND Milestones

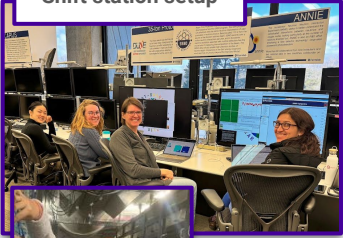
May 2023

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Dec 2023

Completed TPC installation.

Shift station setup



**DAQ/
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Hardware QA/QC



SBND Milestones

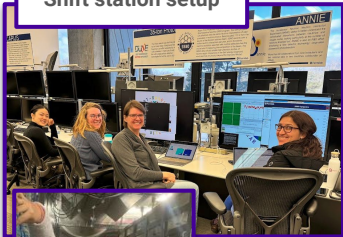
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Shift station setup



HV donut installation



DAQ/
Triggering/
Monitoring
preparation



Hardware QA/QC



SBND Milestones

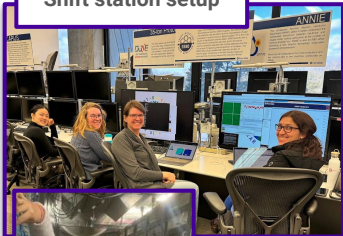
May 2023

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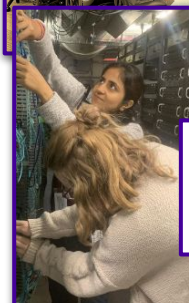
Shift station setup



HV donut installation



**DAQ/
Triggering/
Monitoring
preparation**



Hardware QA/QC



**Purity monitoring
installation**



SBND Milestones

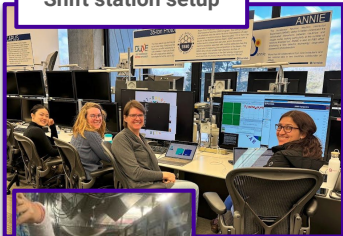
May 2023

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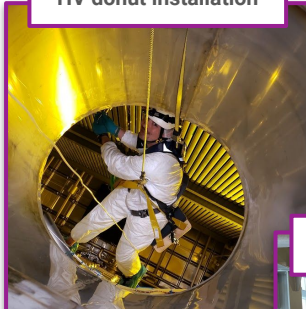
Dec 2023

Completed TPC installation.

Shift station setup



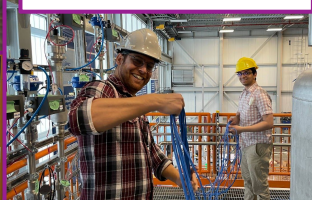
HV donut installation



DAQ/
Triggering/
Monitoring
preparation



Cables, cables and cables!



Hardware QA/QC



Purity monitoring
installation



SBND Milestones

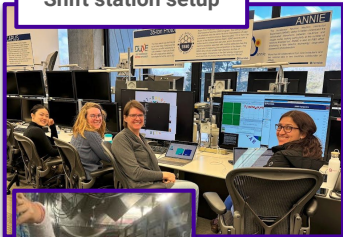
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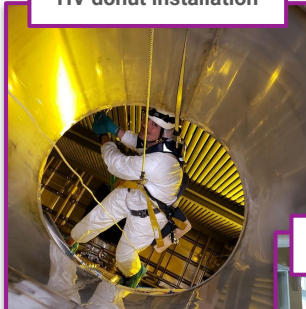
Dec 2023

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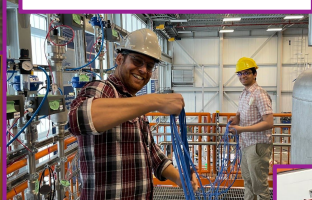
Shift station setup



HV donut installation



Cables, cables and cables!



DAQ/
Triggering/
Monitoring
preparation



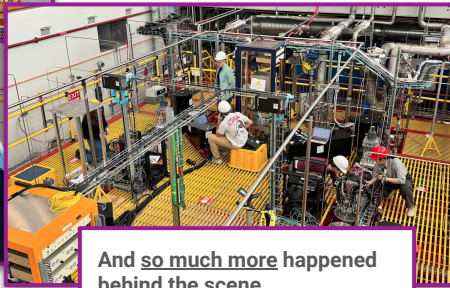
Hardware QA/QC



Purity monitoring
installation



And so much more happened behind the scene...



SBND Milestones

May 2023

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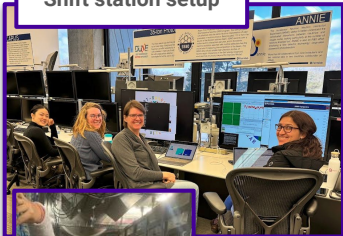
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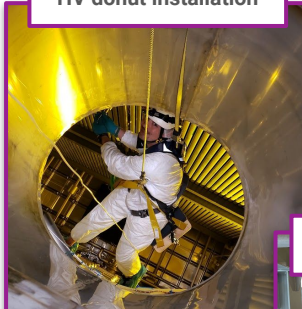
Feb 2024

Chilly detector checkout, SBND is ready for Ar fill.

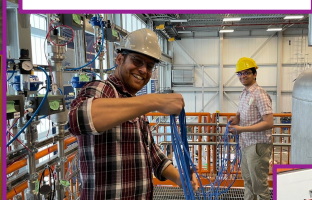
Shift station setup



HV donut installation



Cables, cables and cables!



DAQ/
Triggering/
Monitoring
preparation



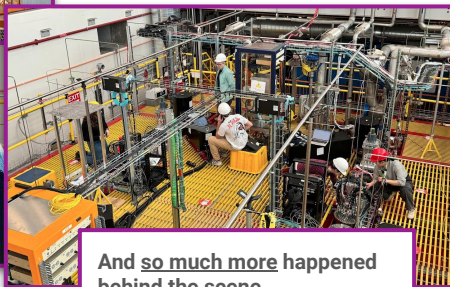
Hardware QA/QC



Purity monitoring
installation



And so much more happened
behind the scene...



SBND Milestones

May 2023

Began commissioning across various areas.

Dec 2023

Completed TPC installation.

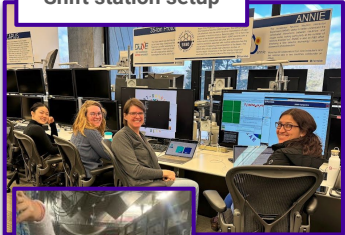
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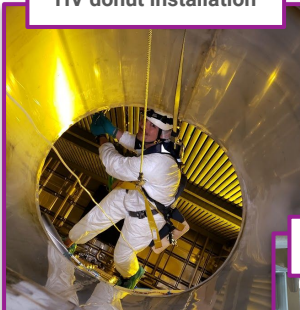
Mar 2024

Completed Ar fill. Fully commissioned the cryostat. Began commissioning TPC and PMTs in Ar.

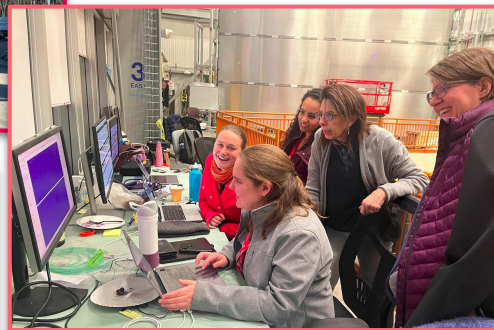
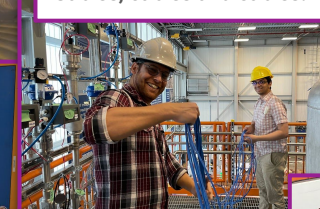
Shift station setup



HV donut installation



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DAQ/
Triggering/
Monitoring
preparation



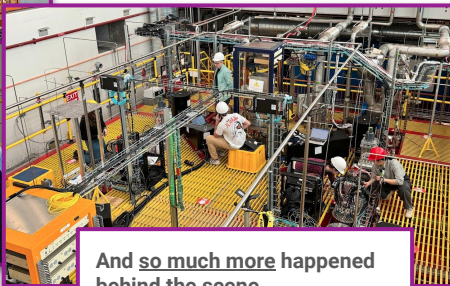
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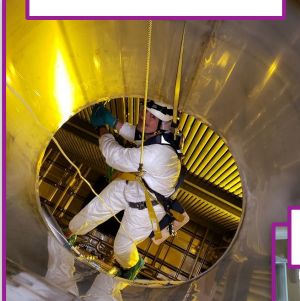
April 2024

Installed more cosmic ray tagger walls.

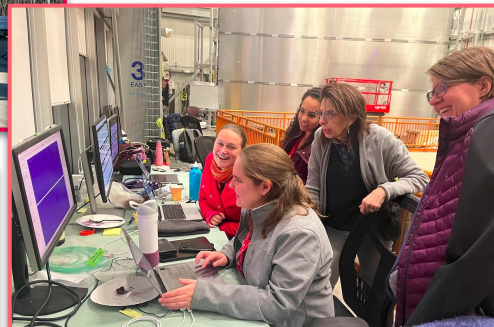
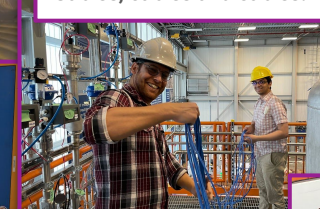
Shift station setup



HV donut installation



Cables, cables and cables!



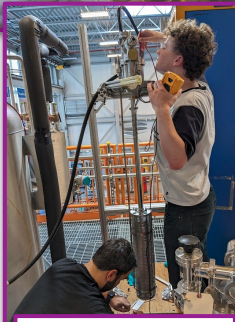
DAQ/
Triggering/
Monitoring
preparation



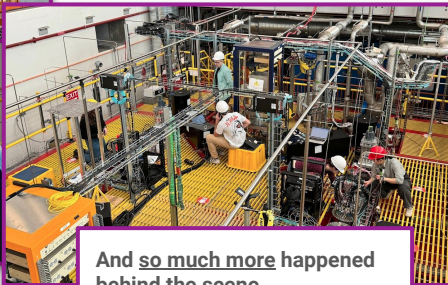
Hardware QA/QC



Purity monitoring
installation



And so much more happened
behind the scene...



North CRT wall



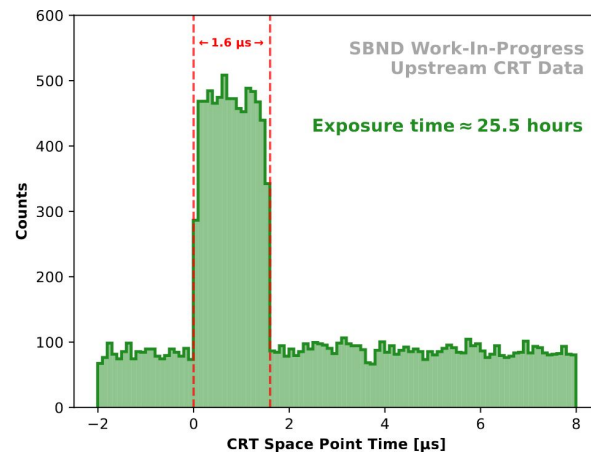
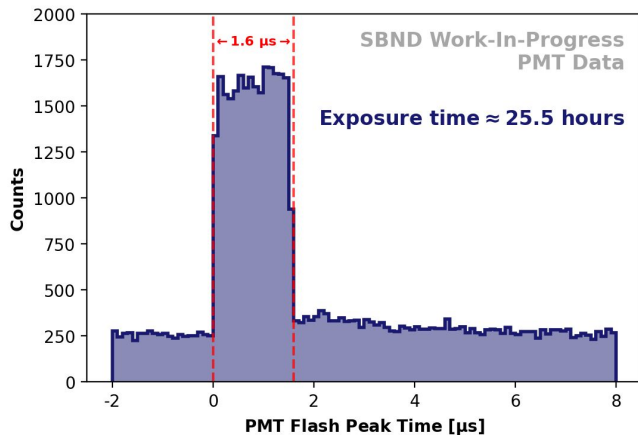
East CRT wall



Commissioning Highlights

“Top hat” plot showing an excess due to beam.

[Neutrino 2024 Poster](#)
[SBND DAQ](#)
by Amy Filkins



TPC readout electronics **show excellent signal/noise performance.**

PMTs are **powered on and collecting data**, gain calibration is in progress.

CRT modules **$\sim 70\%$ installed and commissioned.**

Both PMTs and CRTs **can see the beam!**

As of last week, the commissioning team **successfully ramped to the nominal voltage up at 100 kV!**

Conclusion

SBND is an exciting experiment with physics goals ranging from the **eV-sterile neutrino oscillation** search to a rich **cross-section program**, to the **PRISM** technique implementation and a variety of **BSM searches**.

Commissioning shows **excellent detector performance** across CRTs, PMTs and TPC electronics with **commissioning data collecting happening now**.

Physics data taking will begin later **this year**.

Stay tuned for exciting results in the coming years!

Monday 8th July

Studying Neutrino-Nucleus Interactions at SBND	<i>Brinden Carlson</i>
<i>One West, Fermi National Accelerator Laboratory</i>	13:45 - 14:00
Heavy Neutral Leptons searches on SBND	<i>Luis Pelegrina Gutiérrez</i>
<i>One West, Fermi National Accelerator Laboratory</i>	14:00 - 14:15
SBND Analysis using ML Reconstruction Chain	<i>Castaly Fan</i>
<i>One West, Fermi National Accelerator Laboratory</i>	16:30 - 16:45

Tuesday 9th July

The Search for Dark Photons at the Short-Baseline Near Detector	<i>Rohan Rajagopalan</i>
<i>One West, Fermi National Accelerator Laboratory</i>	10:45 - 11:00

Thank You! Cám ơn!
Questions and Comments are welcome!



SBND Collaboration Meeting June 2024 at Fermilab