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The SBND Experiment at the Fermilab SBN program

MidTerm Review of SENSE (HORIZON-MSCA-2021-SE-01, GA 101081478)

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Short-Baseline Neutrino Program at Fermilab

Three detectors of the same technology along the same neutrino beam

ICARUS
(2021 - now)
476 tons active volume
L = 600 m
Far detector

MicroBooNE
(2015 - 2021)
85 tons active volume
L = 470 m

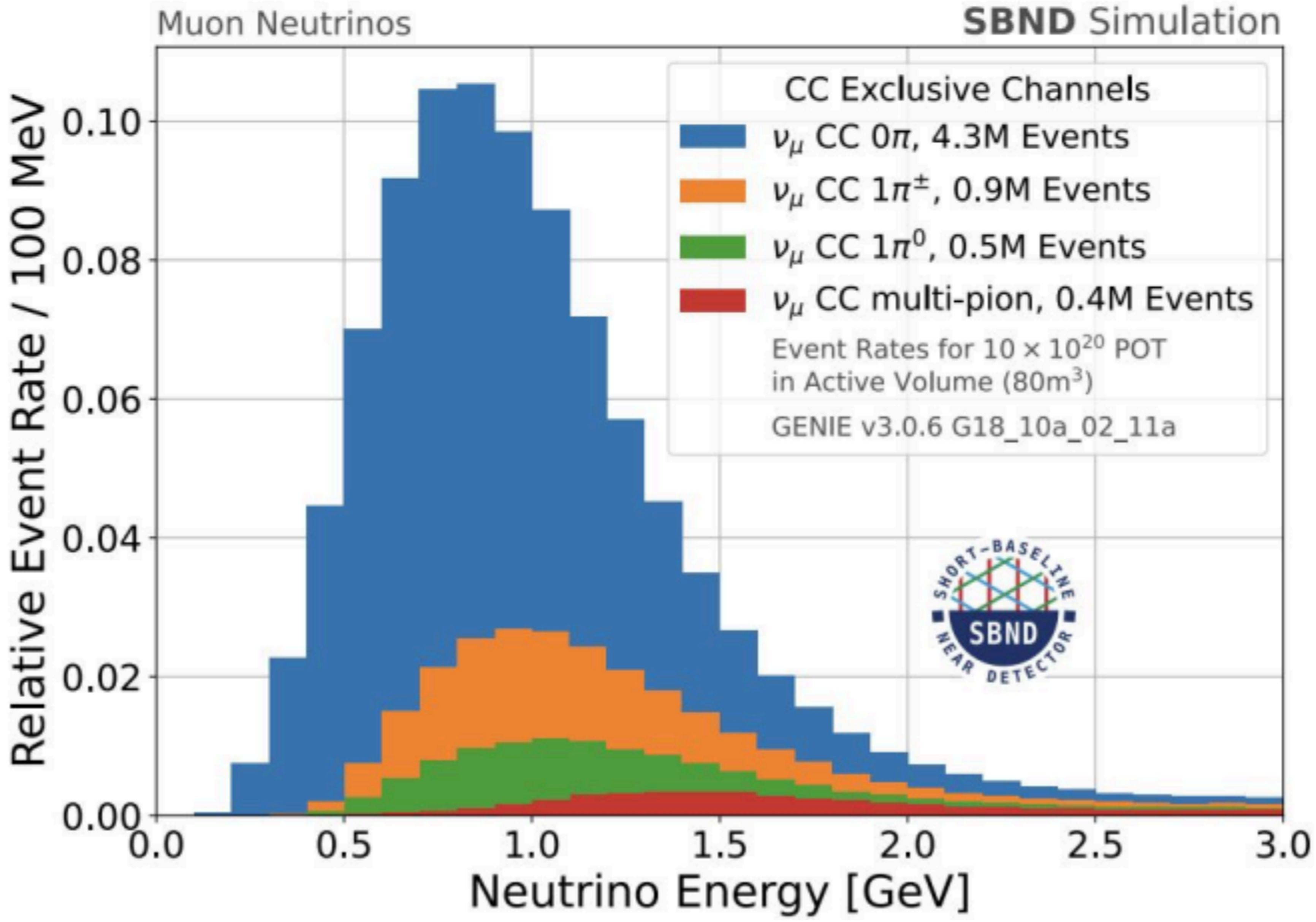
SBND
(2024 - now)
112 tons active volume
L = 110 m
Near detector

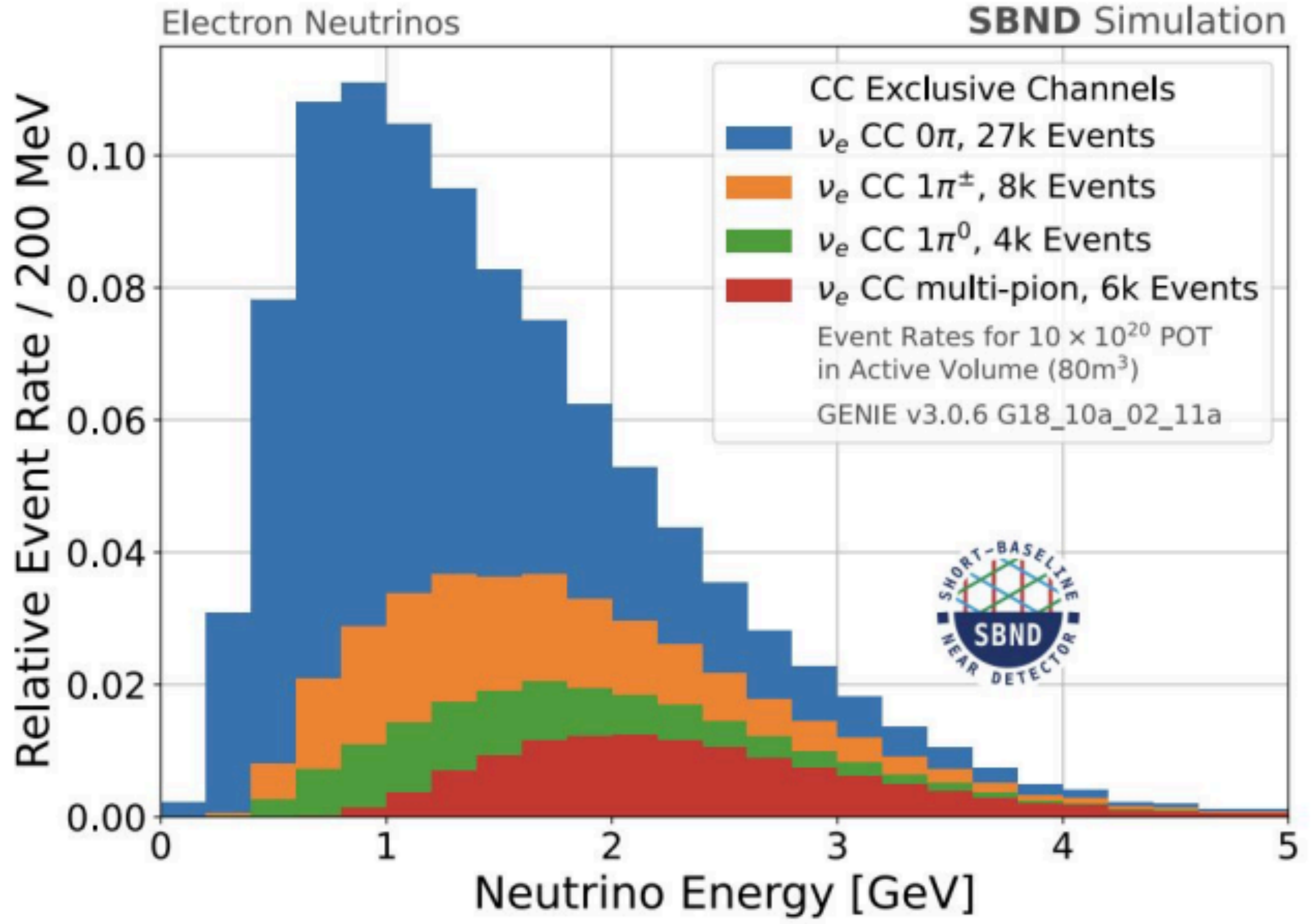
SBND in the SBN Program at Fermilab

- The goal of the SBN program is to search for sterile neutrinos through oscillations:
  - Aims to resolve the electron-like excess seen by LSND and MiniBooNE

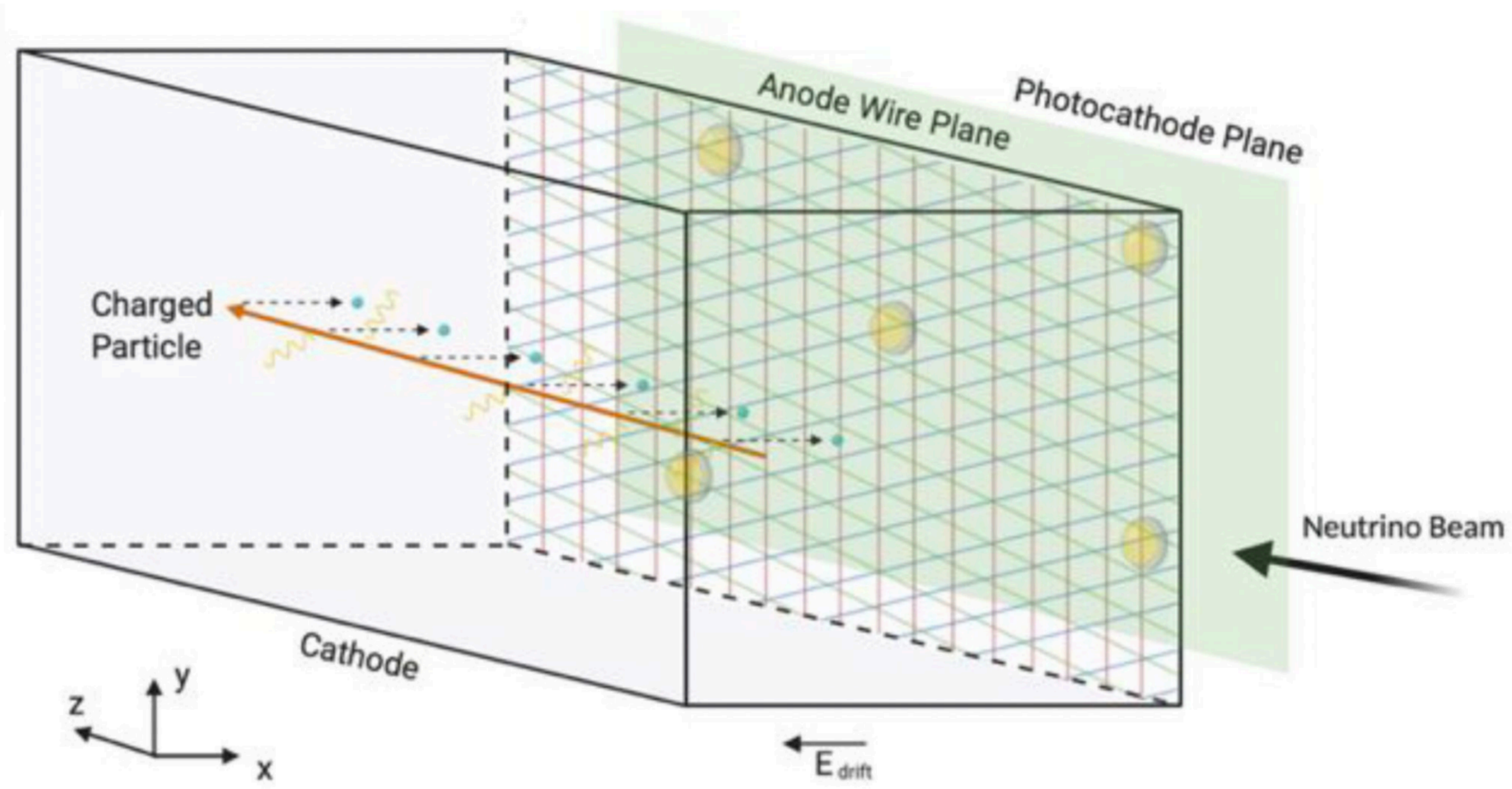
- SBND is the **Near Detector** of the SBN program

- Its location (110 m) near the neutrino source and relatively large mass (112 ton active volume) ⇒ SBND will have the world's highest statistics in ν_μ-Ar (**2M events/year**) and ν_e-Ar (**15k events/year**) interactions
  - key to mitigating large neutrino flux and cross-section uncertainties





Liquid Argon Time Projection Chamber (LArTPC)



Two complementary signals:

- Ionization electrons: drifted through an electric field and detected at the charge readout plane
- Scintillation photons: detected by the photon detection system

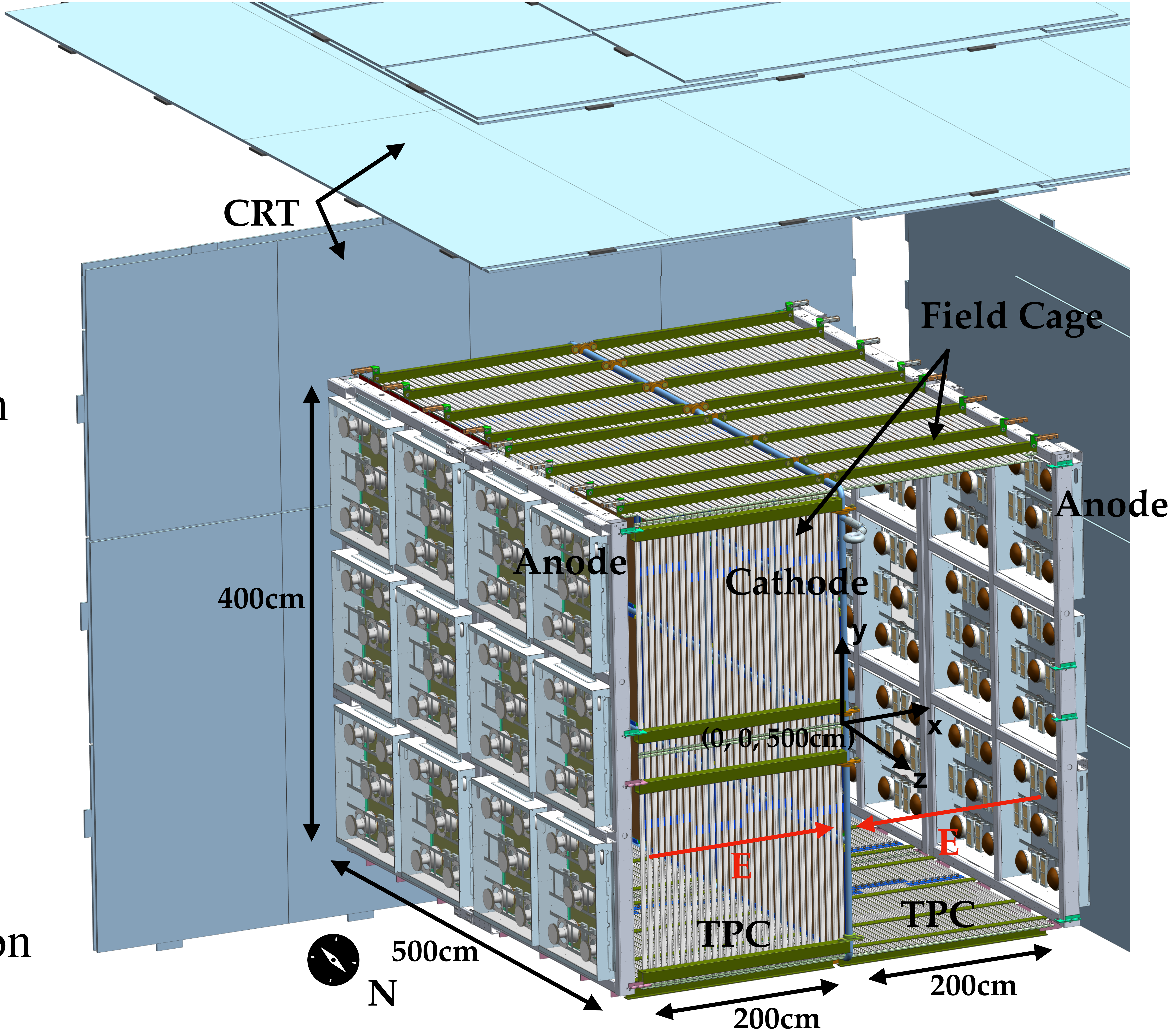
- LAr TPC detectors provide **full 3D imaging**, precise calorimetric energy reconstruction down to **very low threshold**, efficient particle identification and background rejection
  - Individual neutrino events can be categorized in terms of **exclusive topologies** observed in the final state

The SBND detector

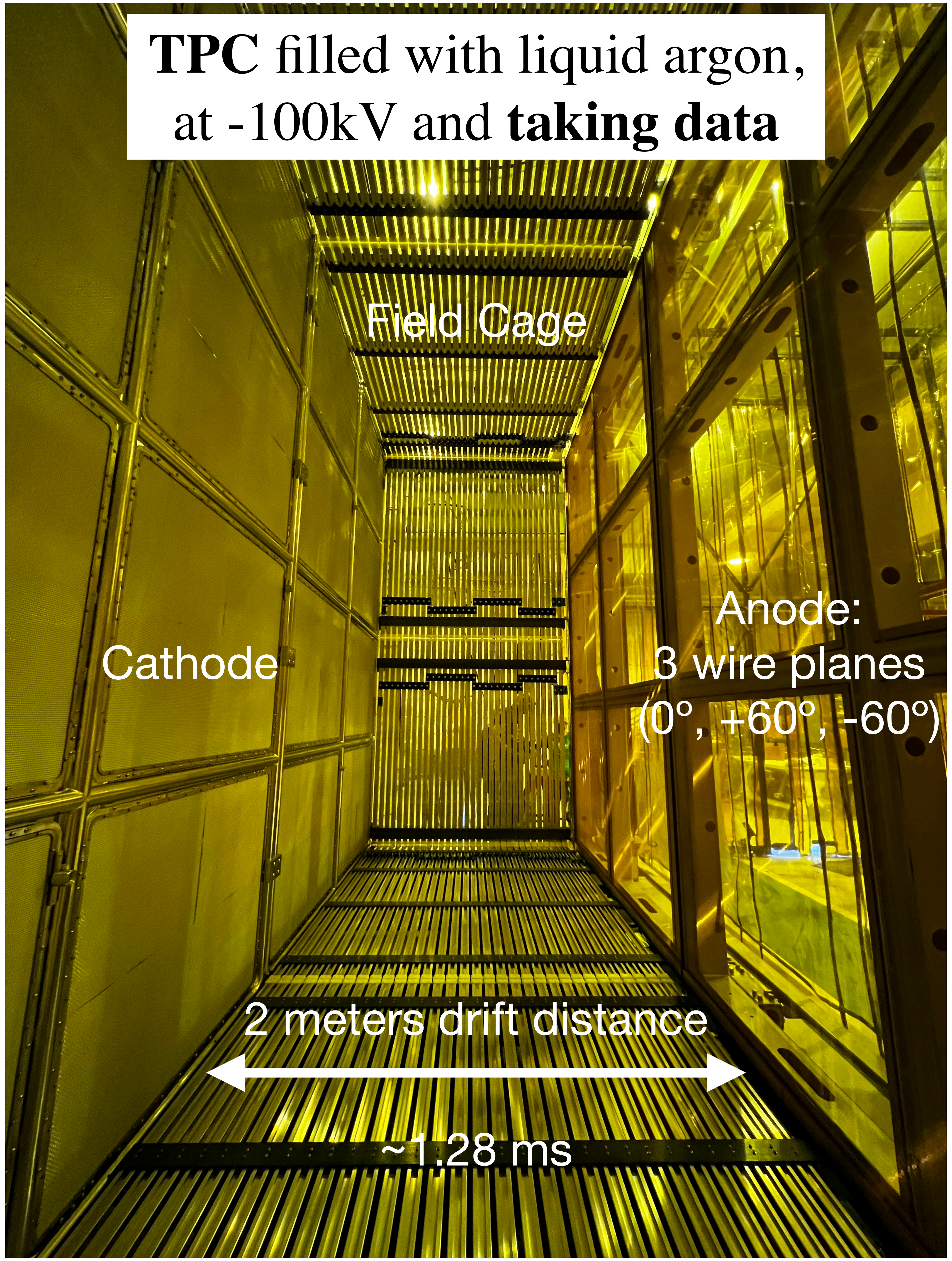
2 Time Projection Chambers (TPCs) separated by a central cathode:

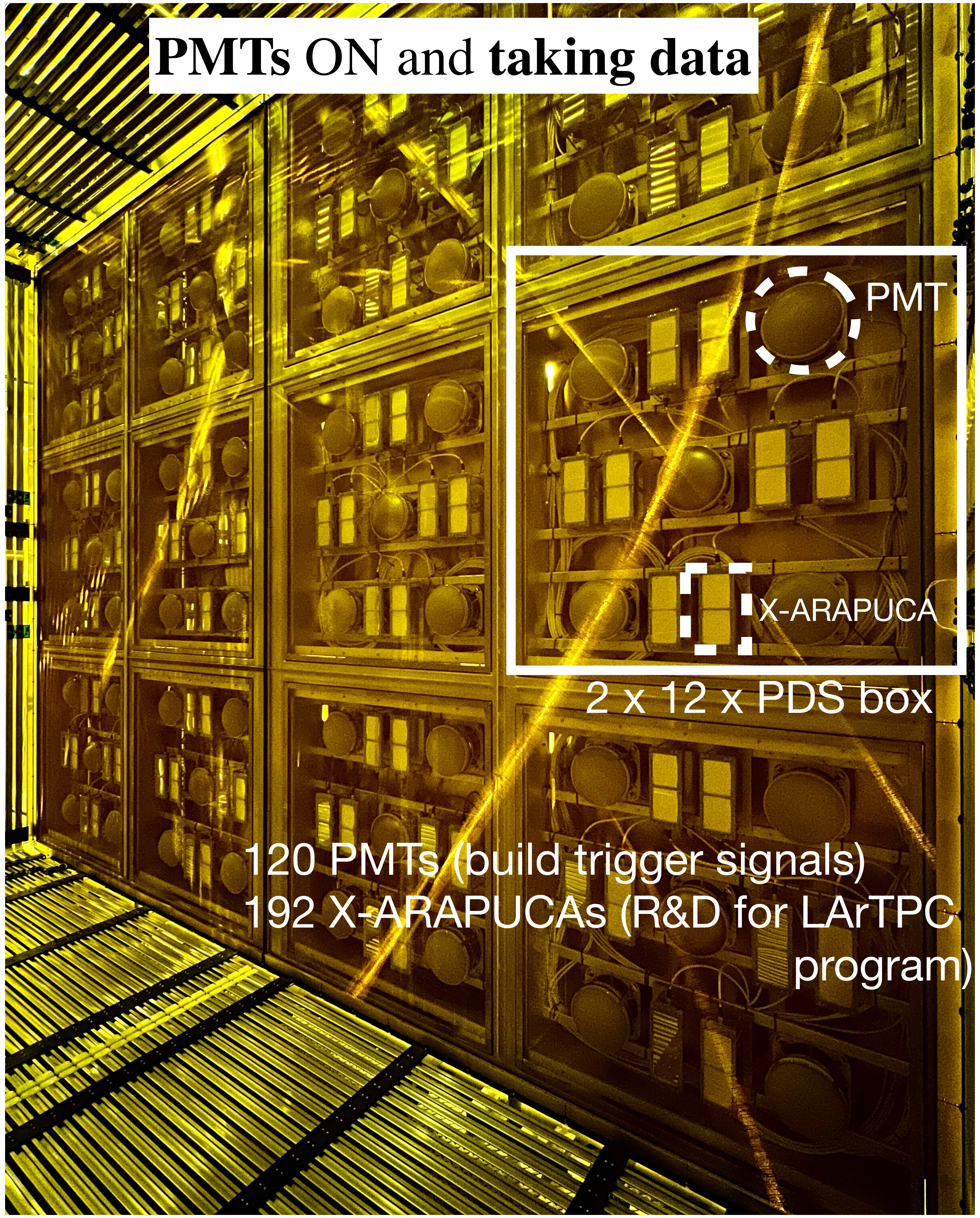
- TPC dimensions: 2m (drift) x 4m (height) x 5m (length)
- Constant Electric Field in the Active Volumes
- Charge and Light detected in the Anode planes

Cryostat surrounded by a cosmic ray tagger system for background rejection

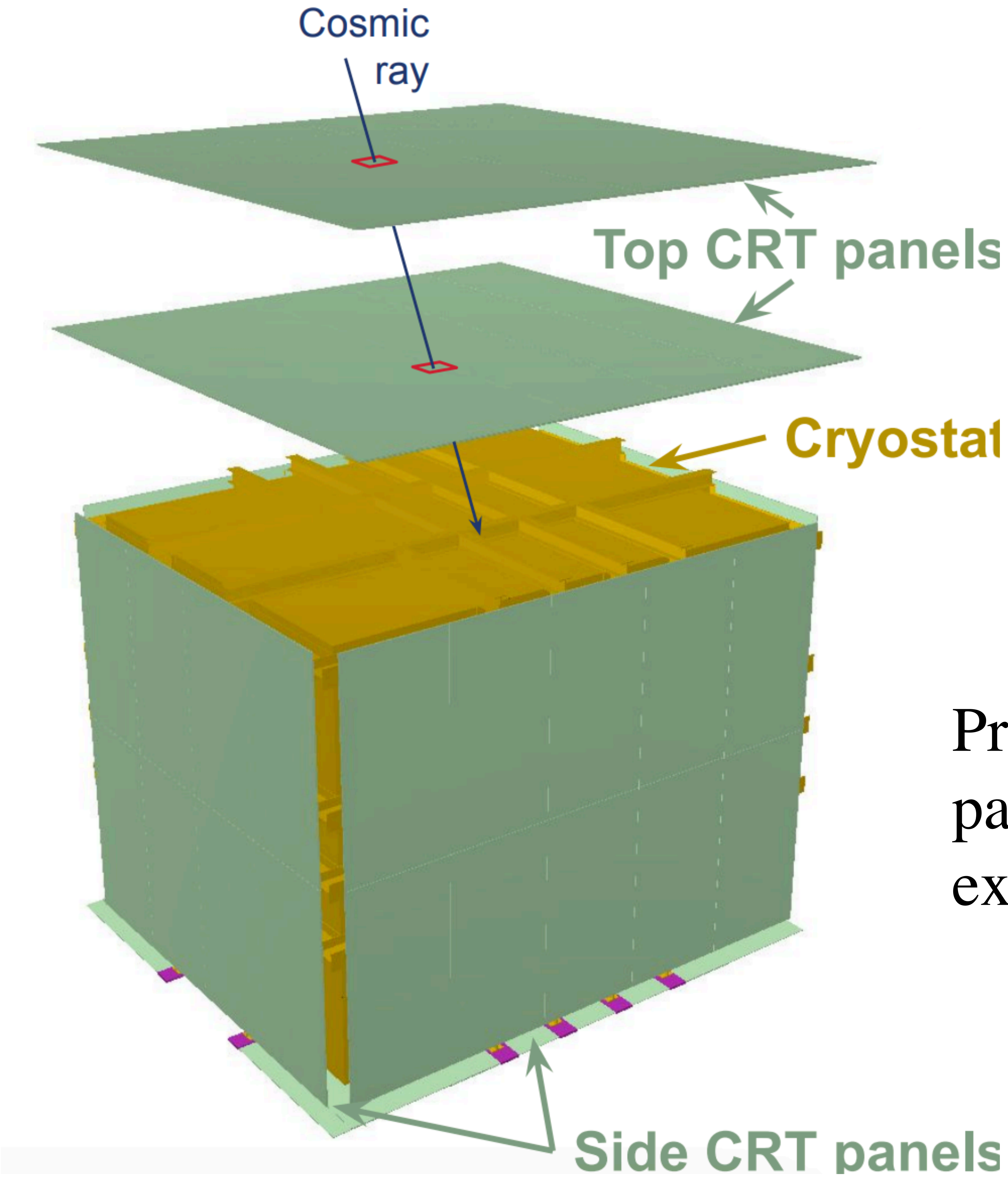


SBND TPC (left) & PDS (right)





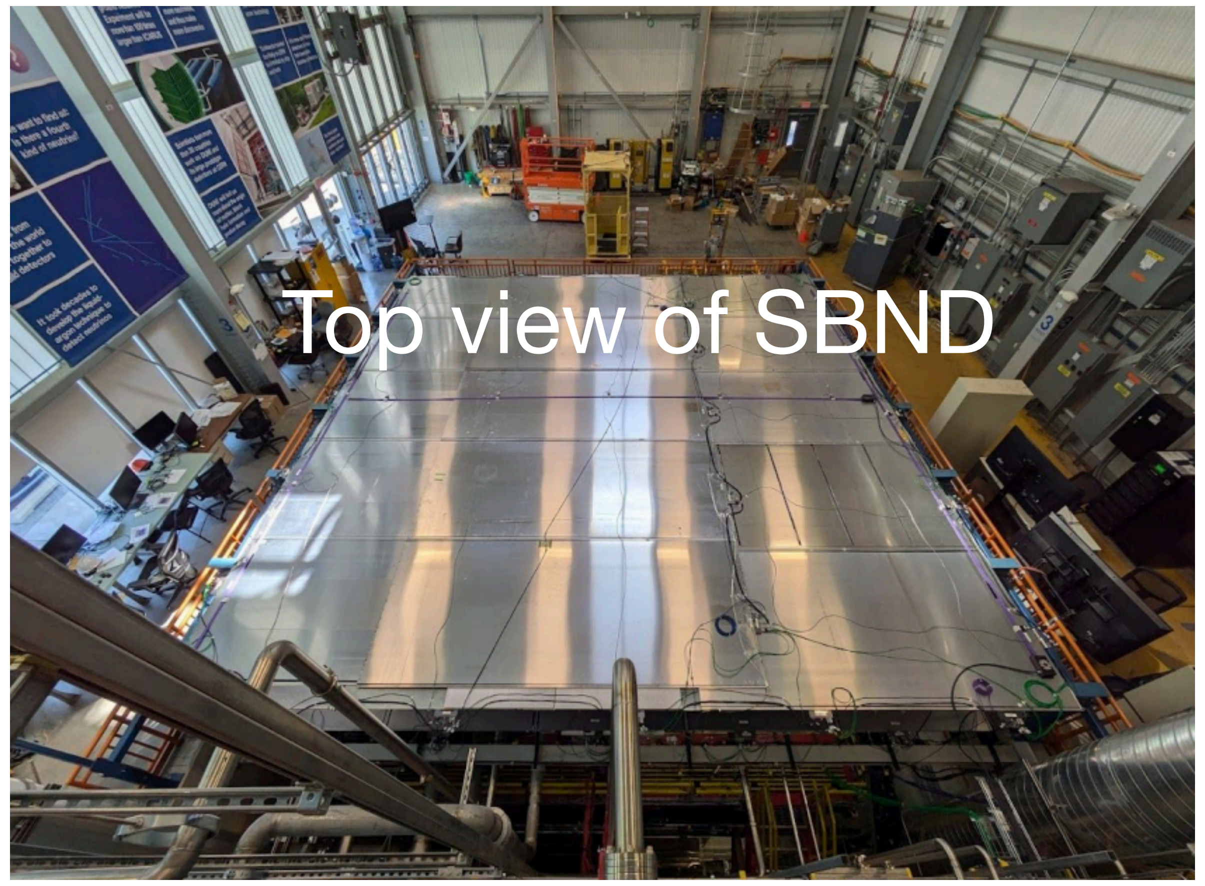
SBND Cosmic Ray Tagger (CRT) system



The SBND detector is surrounded by Cosmic Ray Taggers panels:

- Almost 4π coverage ⇒ Very important for detectors located at surface (like the SBN ones)
- Two top CRT panels ⇒ Telescope

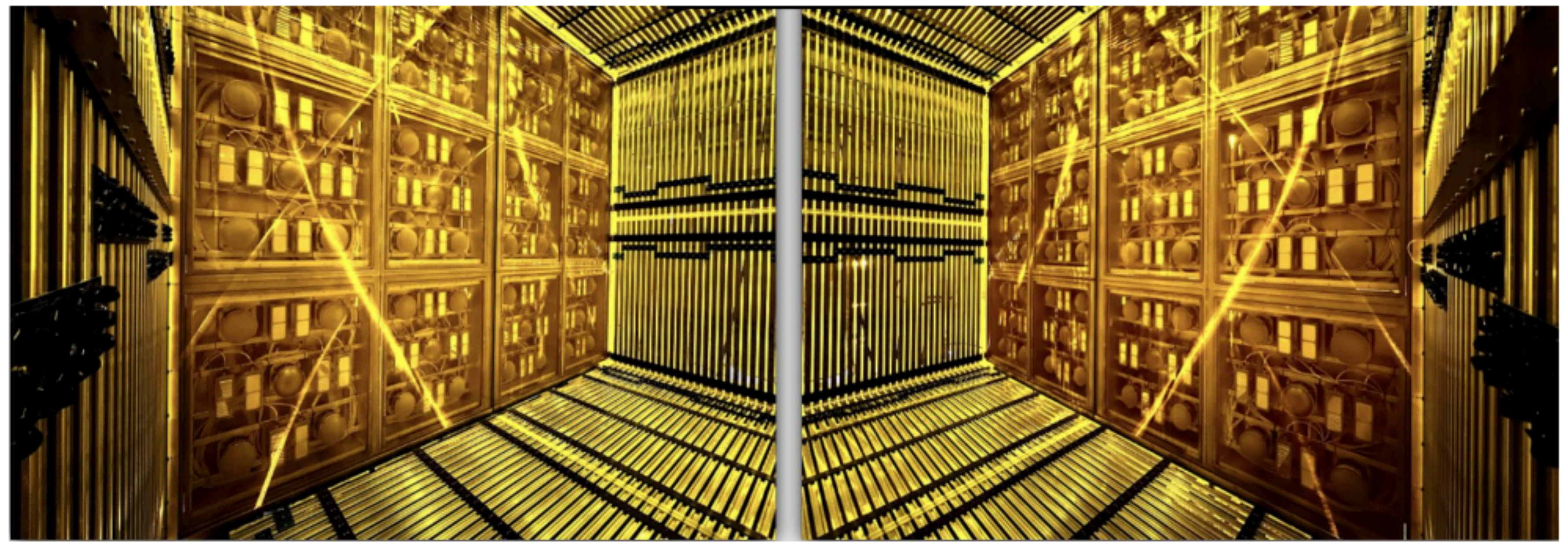
Primary goal is to provide precision tagging of particles entering / crossing / exiting the TPC

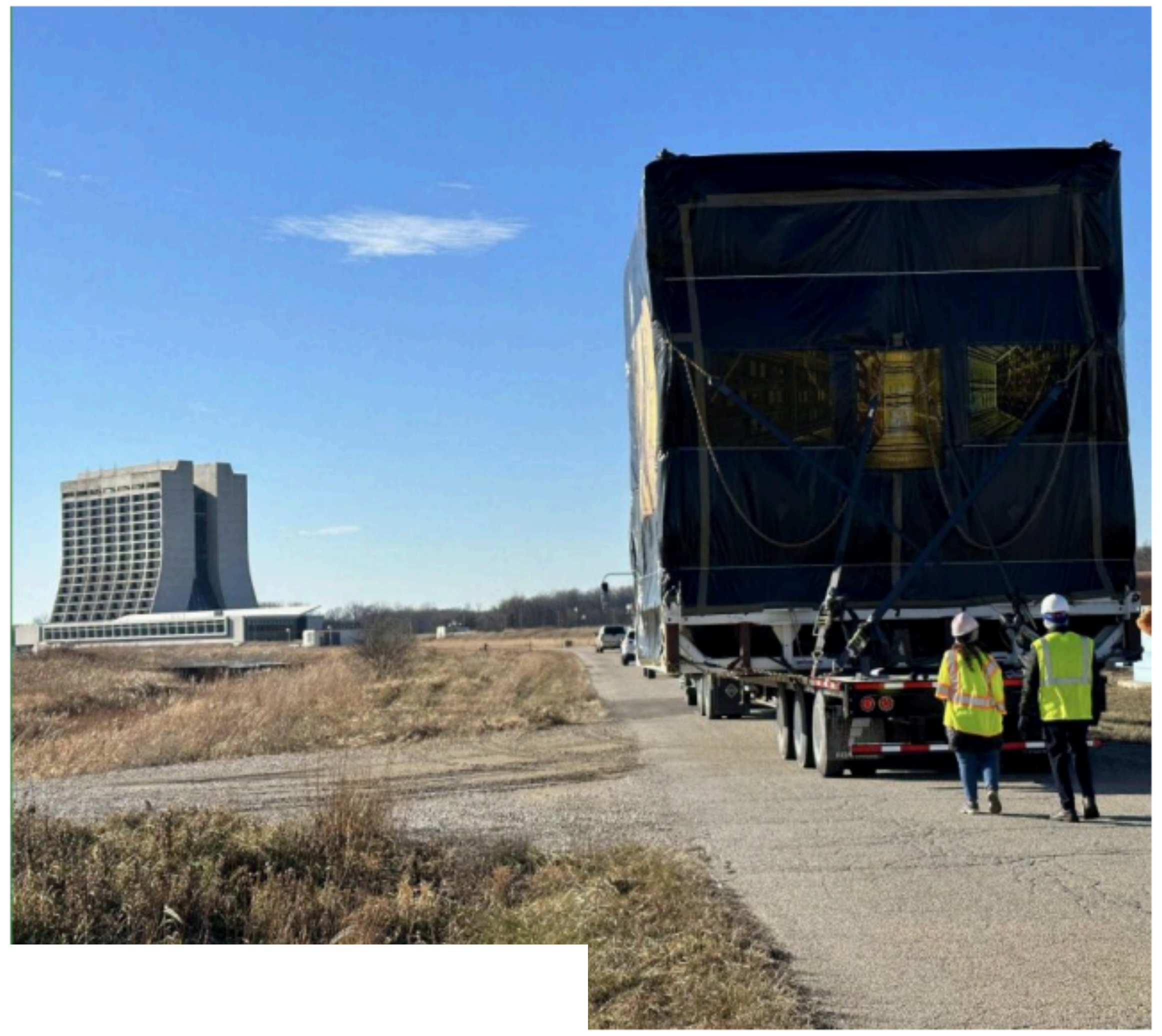


SBND Timeline

September 2022

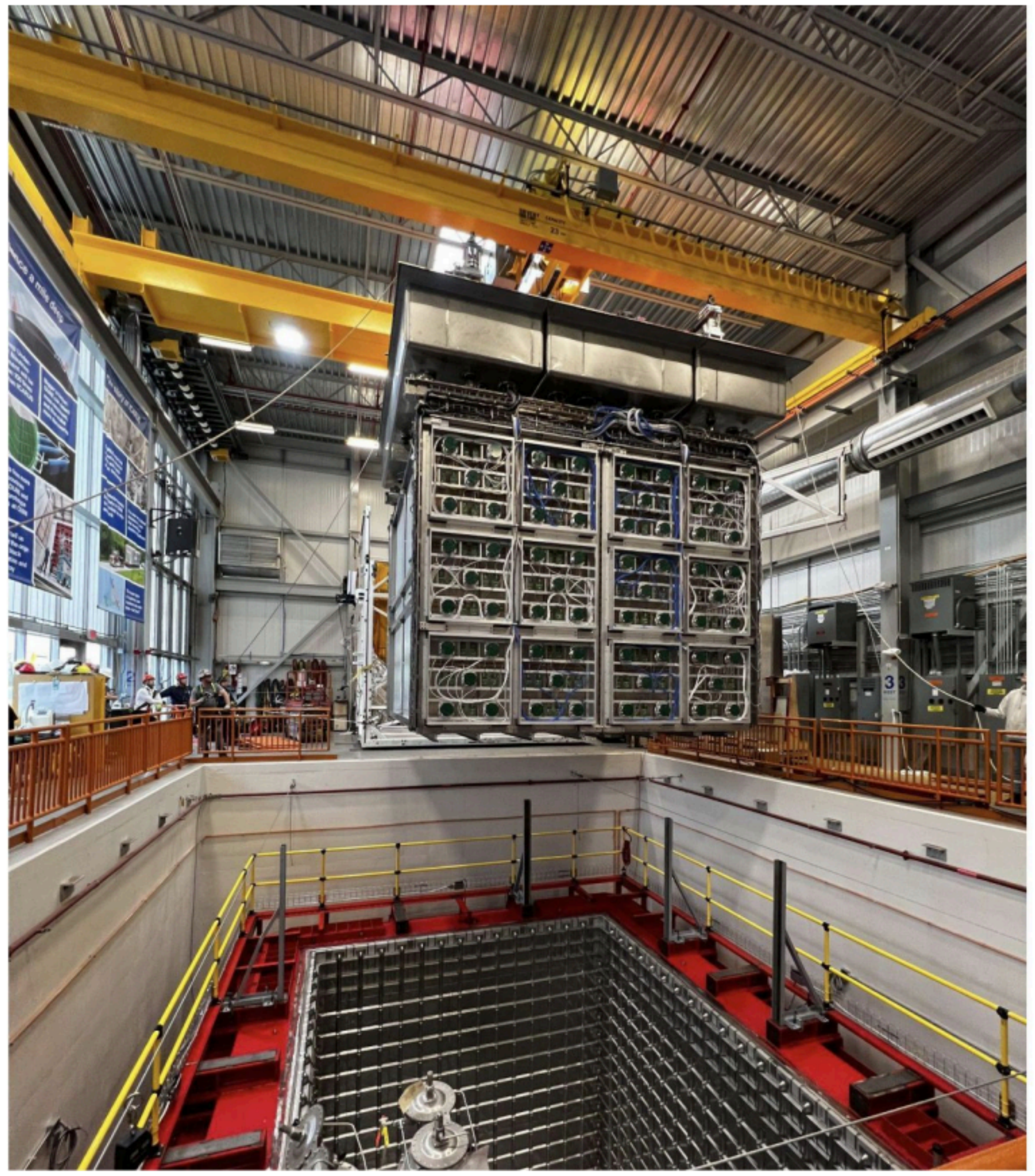
Detector assembly completed





December 2022

Detector transported to ND



April 2023

Detector lowered to cryostat

March 2024: **LAr filling completed**

July 2024

TPC high voltage ramped up

First events: Booster Neutrino Beam

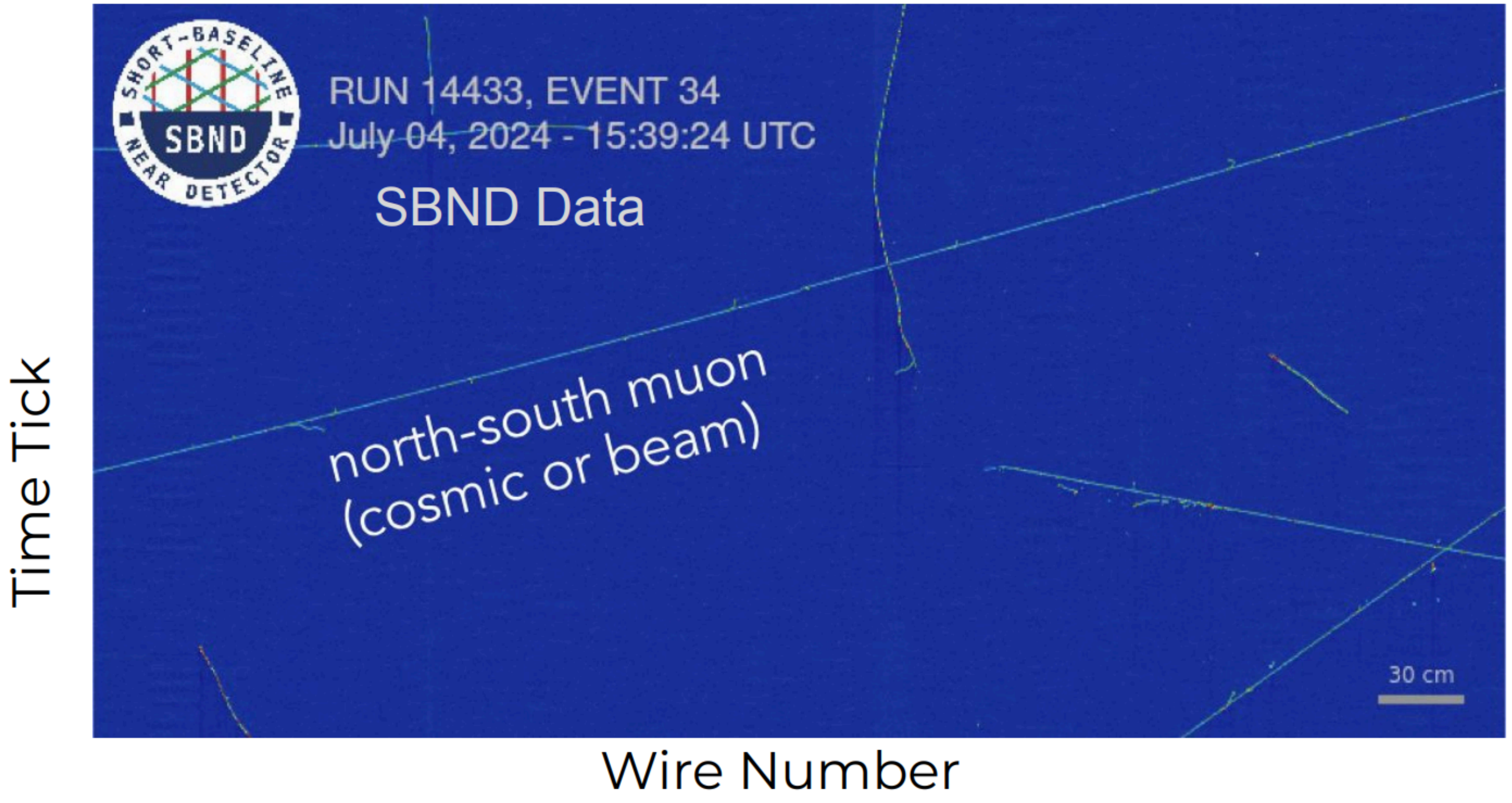
TPC high voltage operating stably since July 3rd
We are collecting **neutrino candidate** events in the detector:

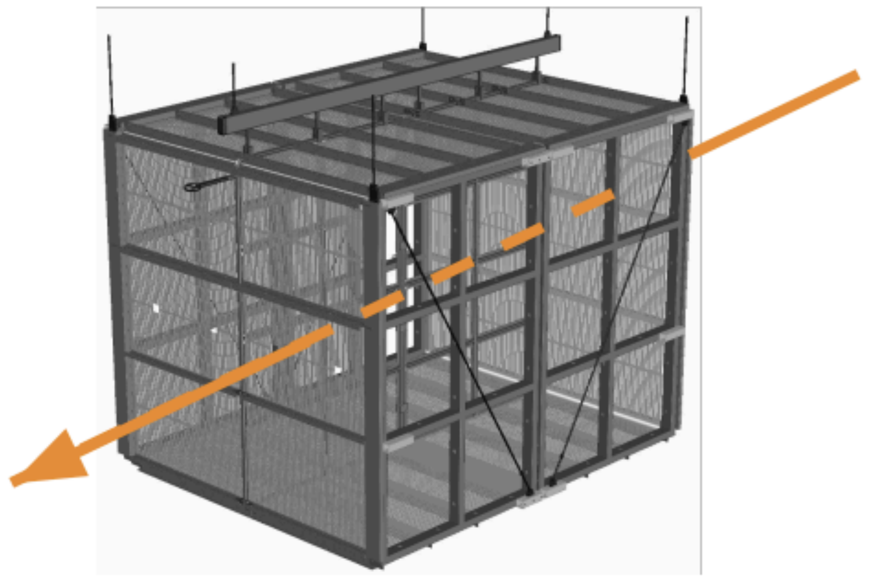
TPC Collection Plane Zoomed-In

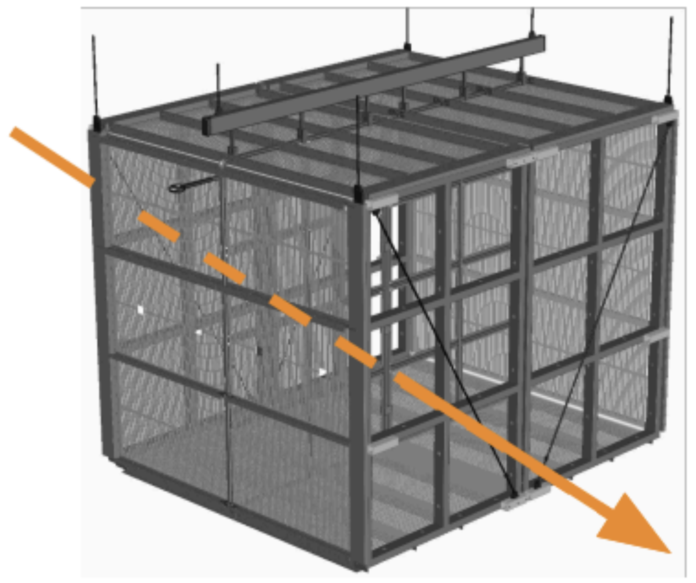
First events: Crossing Muons

Calibration and **commissioning** samples during beam downtime

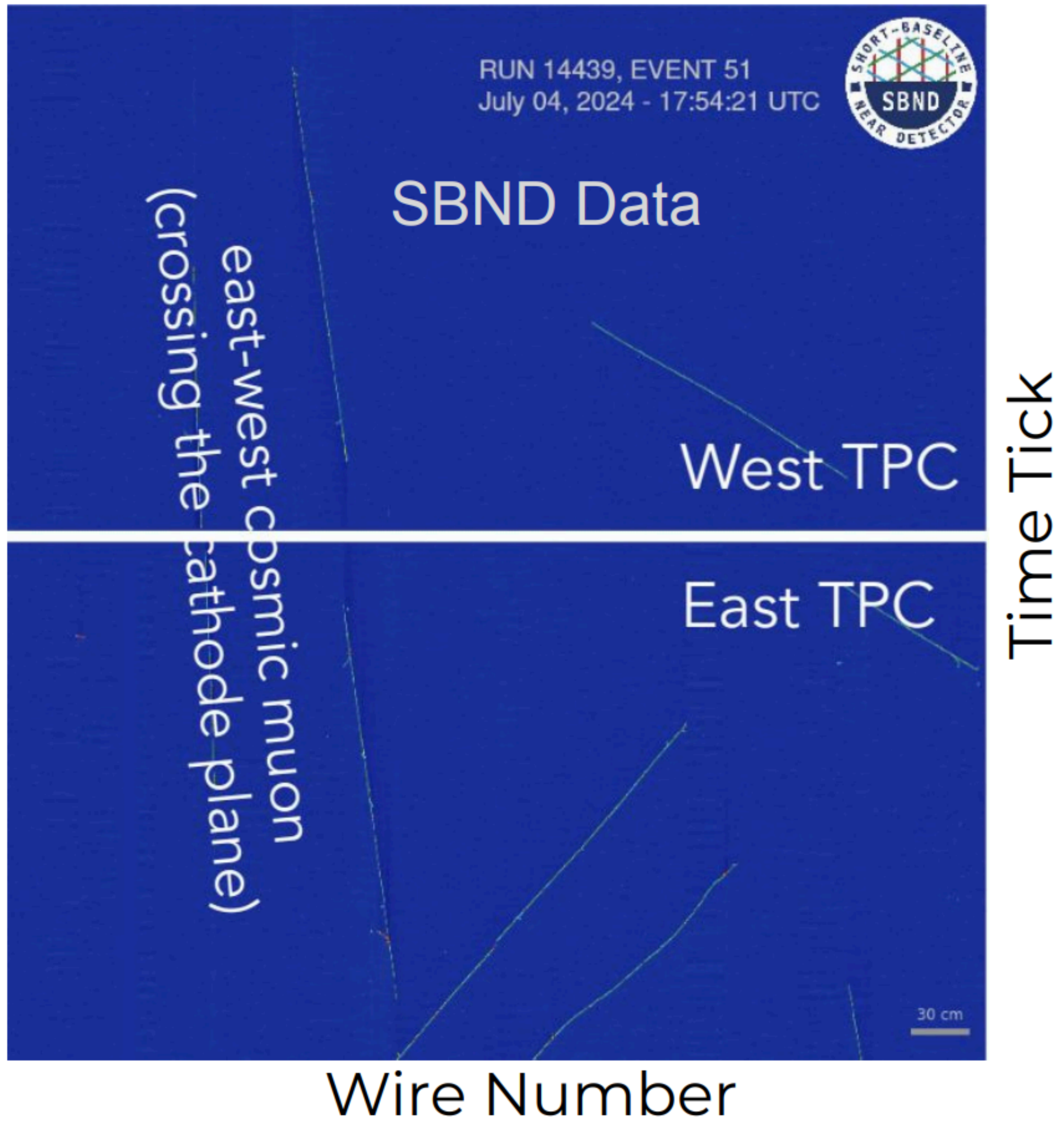
North/South CRT Coincidence Trigger





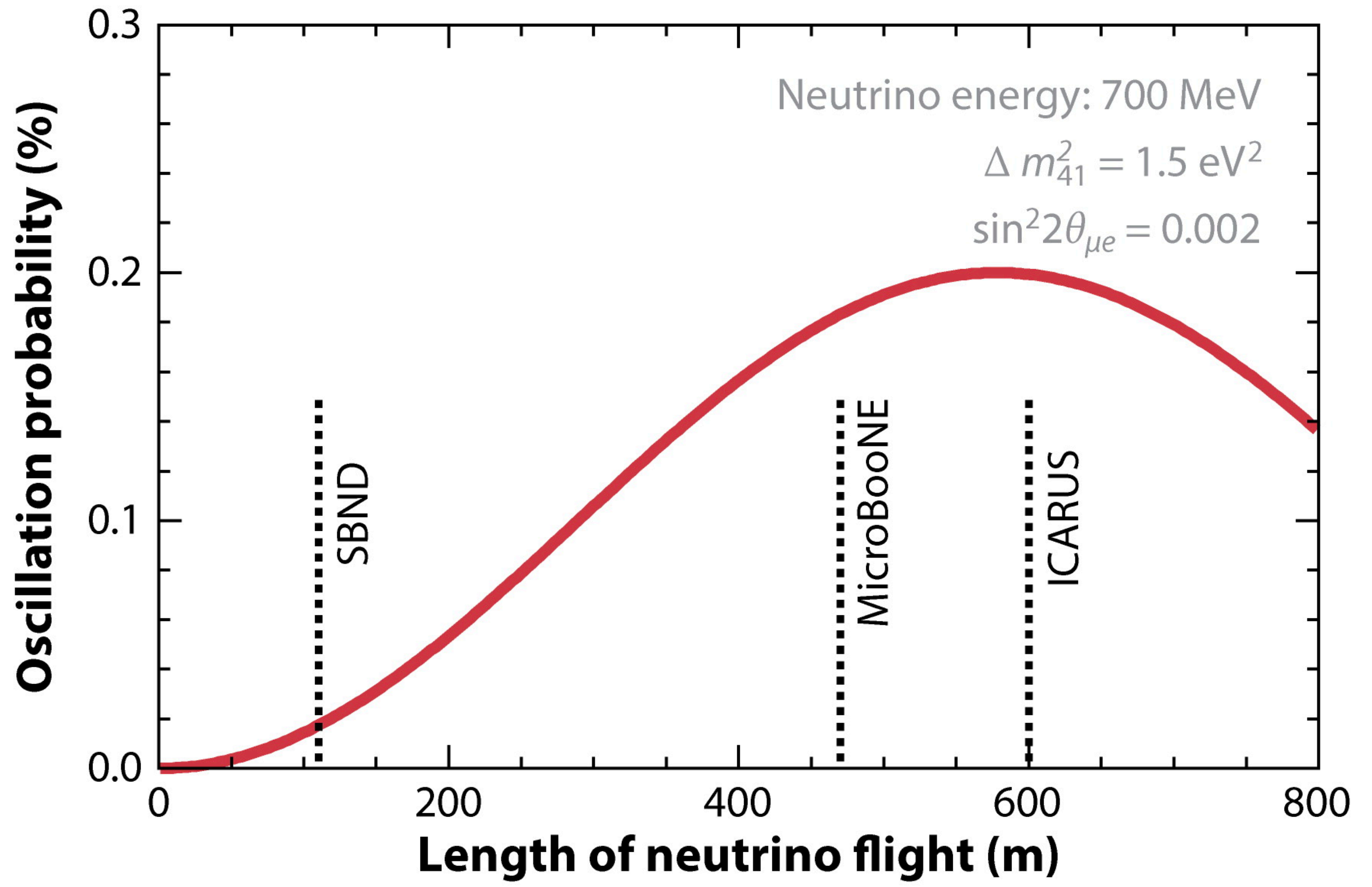


East/West CRT Coincidence Trigger

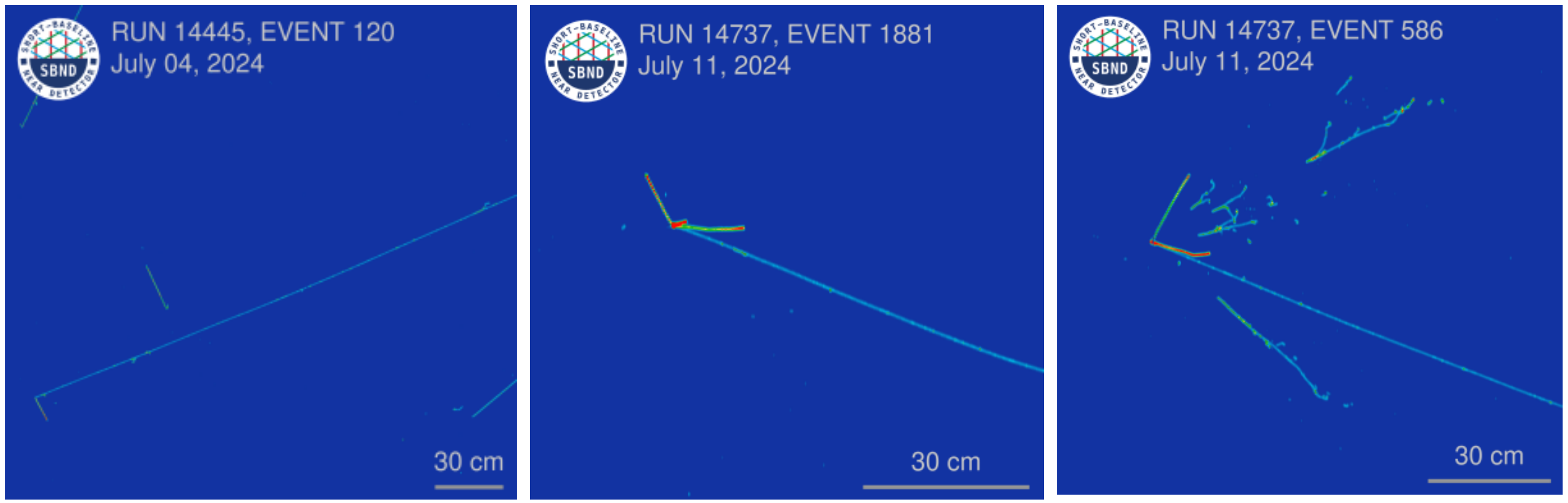


Crossing tracks observed in the TPC during crossing-muon trigger runs

Physics @ SBND

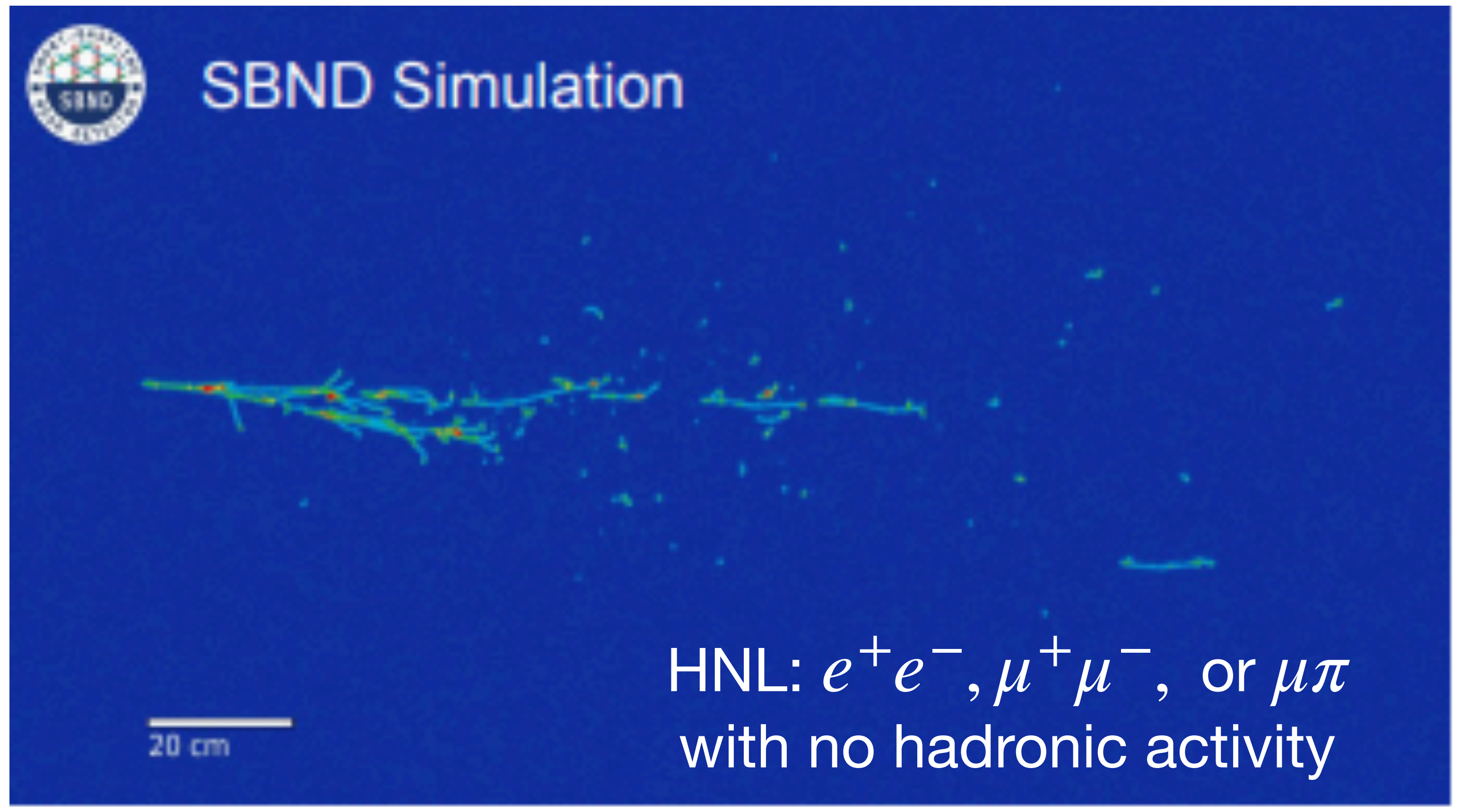


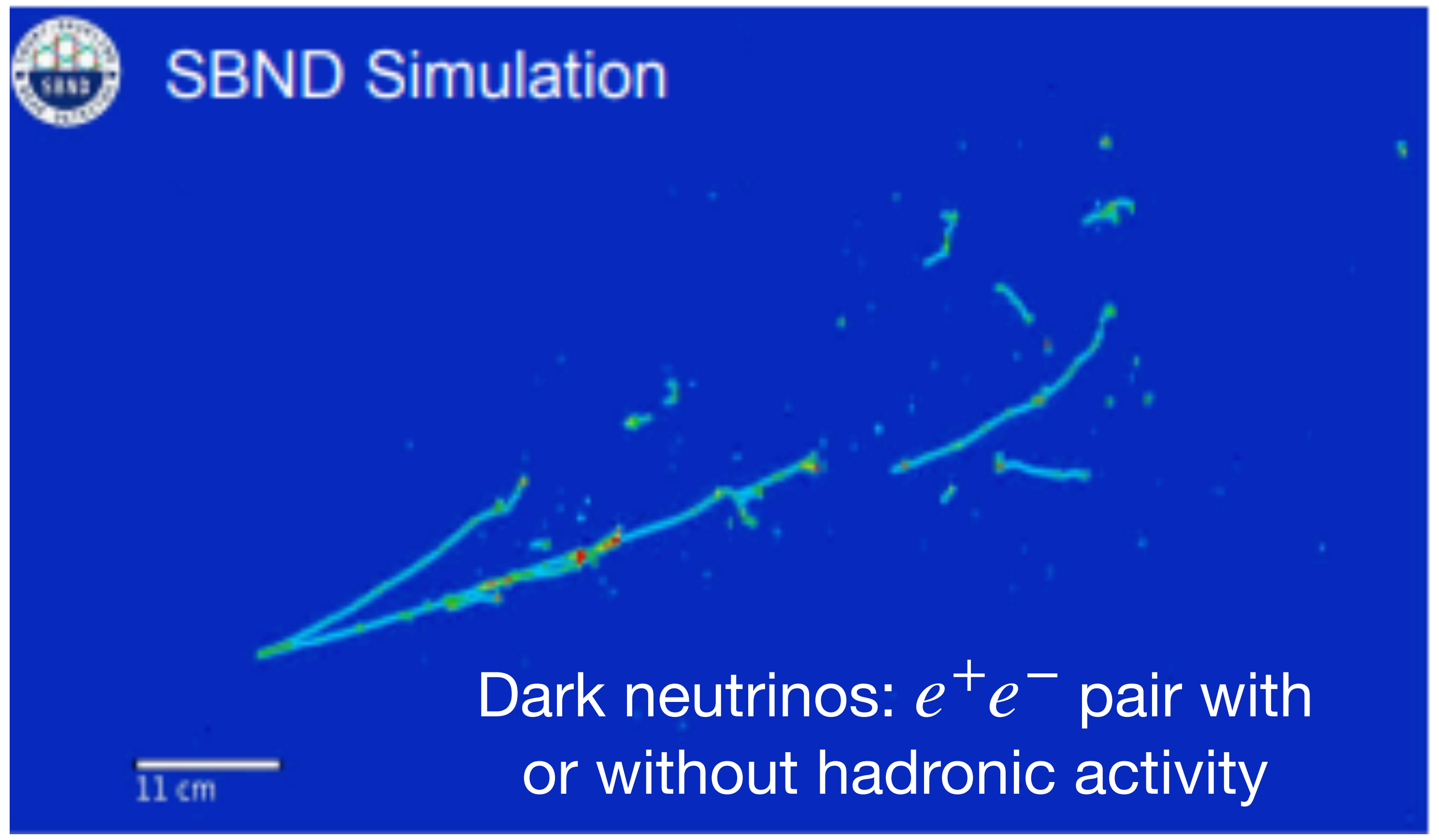
Measure the unoscillated fluxes: Enable precise sterile neutrino searches



Study neutrino-nucleus interactions: high statistics will allow a wide variety of neutrino interaction measurements ⇒ inputs for theory, generators, and future experiments (like DUNE)

Beyond the Standard Model physics: BSM particles may originate from the BNB, from charged and neutral mesons, SM neutrinos, and proton bremsstrahlung. Distinctive topologies can also be exploited





Conclusions

- **SBND has collected first data** and is getting ready for first physics analysis
  - **All sub-systems** of SBND installed and taking data
- With the **highest statistics** of any neutrino LAr experiment to date, SBND will provide opportunity for measuring neutrino **cross-sections** with unprecedented precision and potential **BSM** physics

BackUp