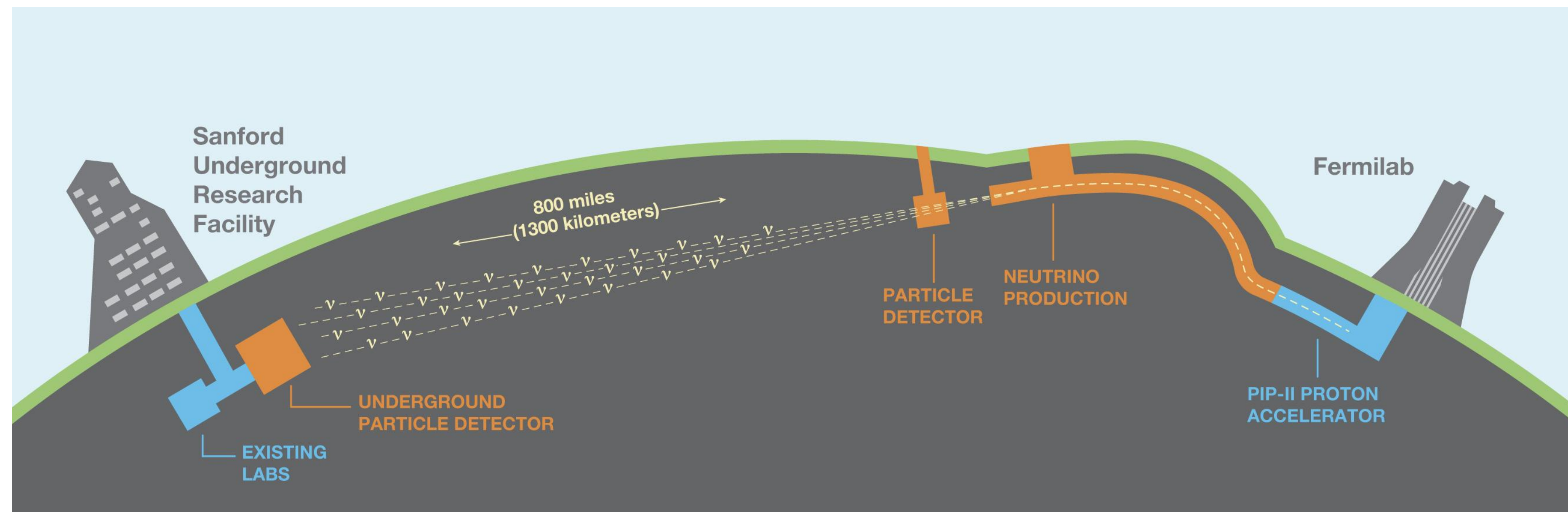


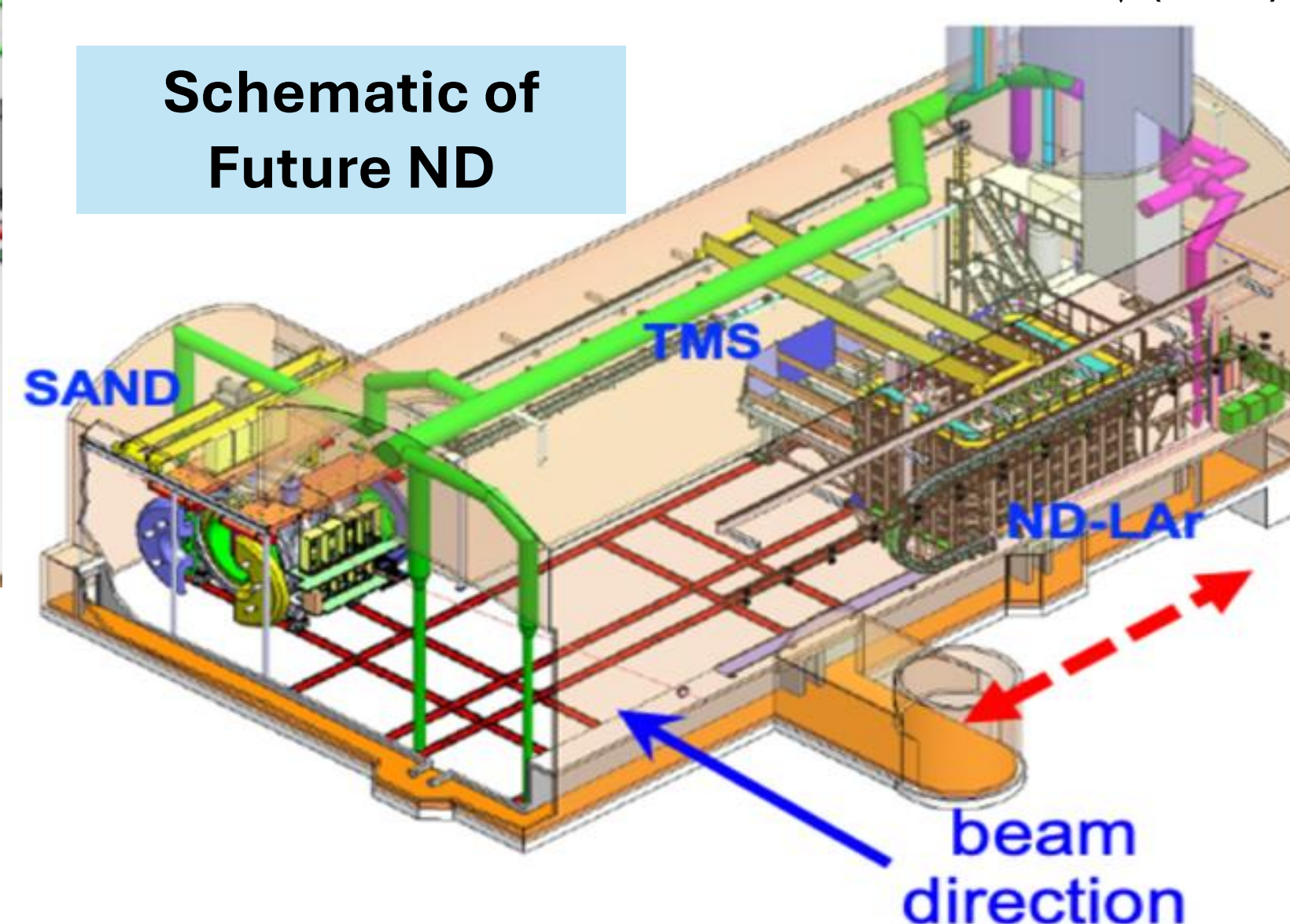
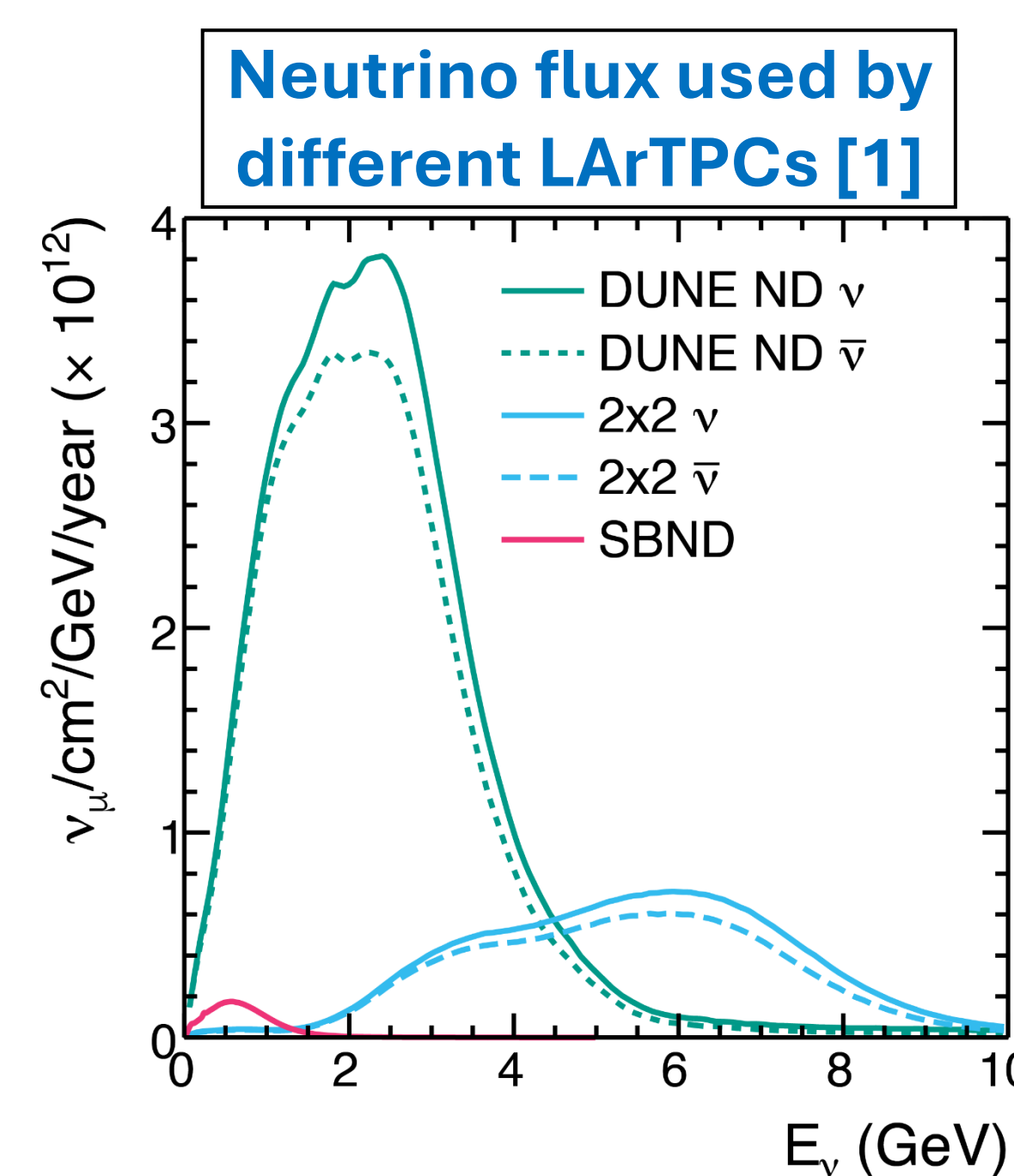
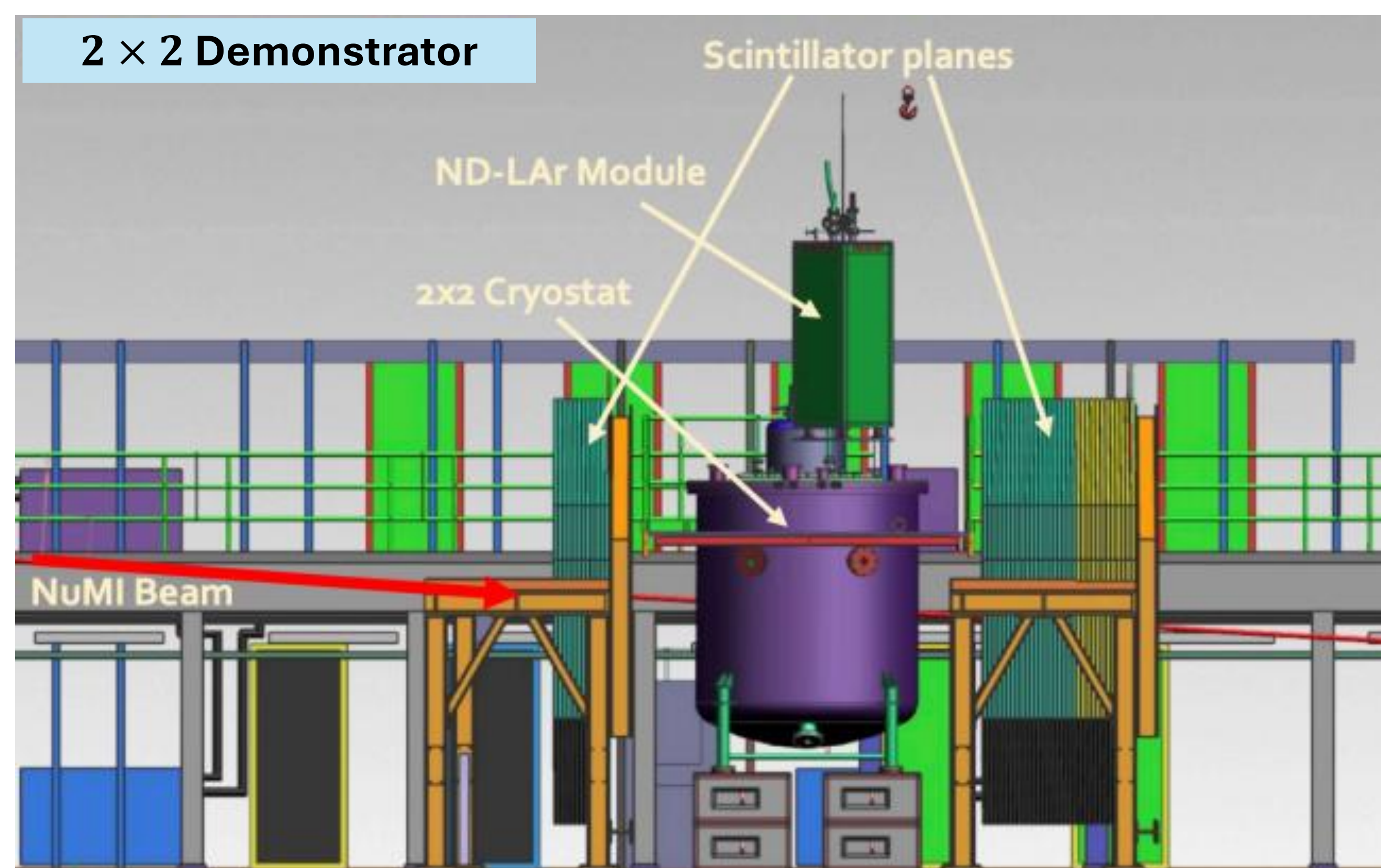
### DEEP UNDERGROUND NEUTRINO EXPERIMENT

- Neutrino oscillations establish non-zero mass, and DUNE is designed to measure CP violation and determine the neutrino mass ordering and other BSM phenomena.
- DUNE is a long-baseline experiment (1300 km, Fermilab to SURF) designed to address these open questions, using a 1.2 MW beam and Near and Far Detector systems.



### NEAR DETECTOR AND 2x2 DEMONSTRATOR

- The DUNE ND will be located 574 m from the beam source at Fermilab, with three major components: ND-LAr (liquid-argon TPC), TMS (muon spectrometer), and SAND (on-axis neutrino detector).
- The 2x2 Demonstrator [1] is a prototype of ND-LAr and aims to demonstrate DUNE ND-LAr physics capabilities early at the prototype stage.
- The 2x2 collected its first physics-quality data with anti-neutrino beam events (4.5 days) in July 2024 in the NuMI beam at Fermilab, with four modules in a 2x2 configuration with pixelated charge readout and scintillator planes (reused from MINERvA) for muon tagging.
- Physics goals include validating simulation and reconstruction, comparing 2x2 data with neutrino interaction models, and identifying systematic uncertainties.
- One of the ongoing studies is the measurement of charged-hadron multiplicity.

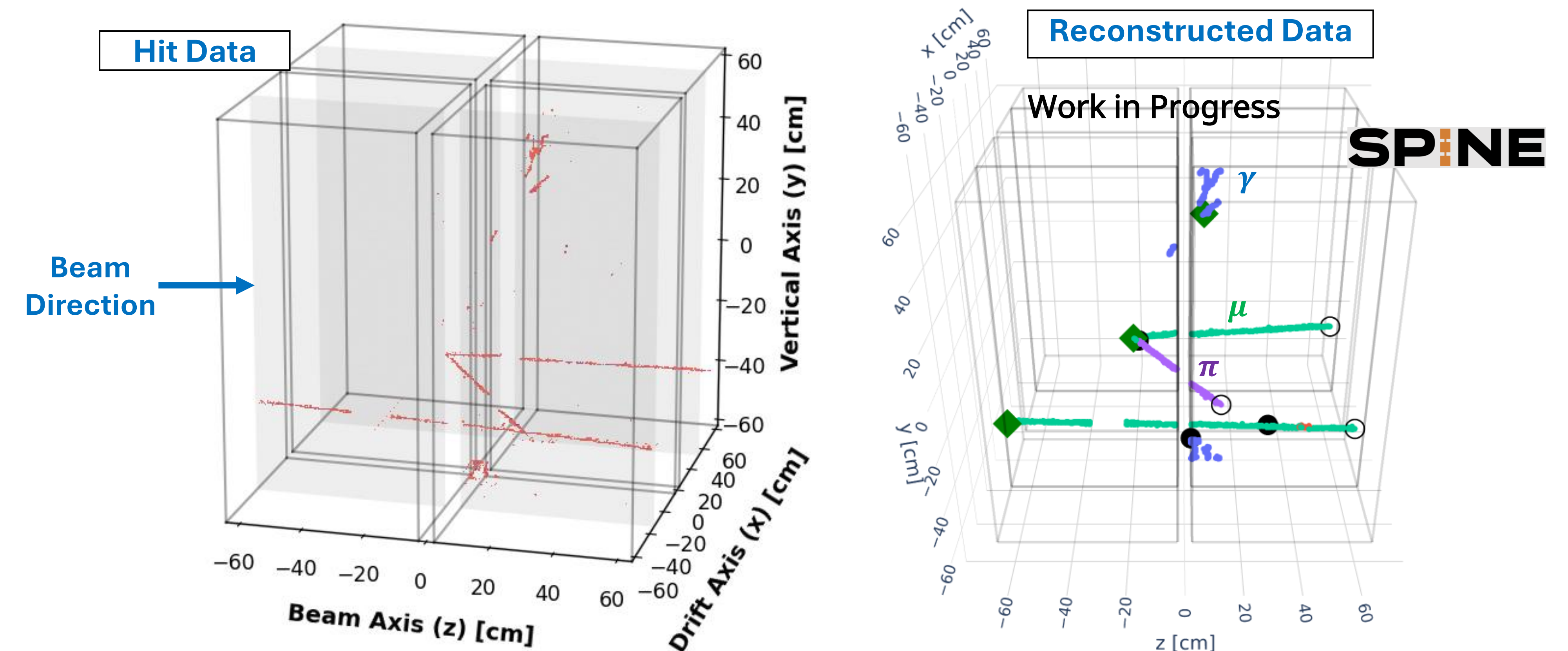


### REFERENCES

- [1] DUNE Collaboration, Instruments 10, 18 (2026)  
 [2] Drielsma et al., arXiv:2102.01033

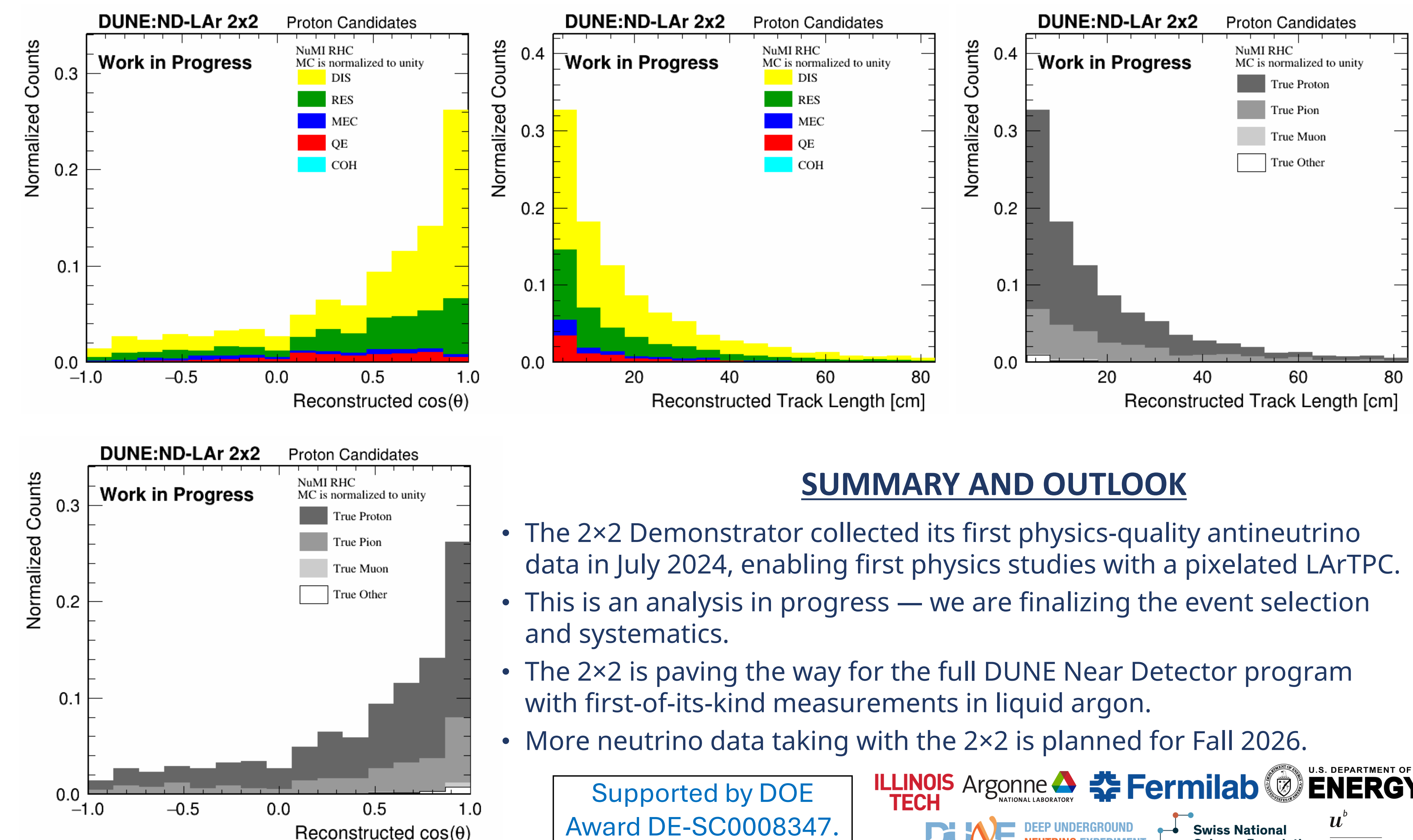
### EVENT RECONSTRUCTION IN THE 2x2

- An antineutrino candidate as recorded by the 2x2 in July 2024, with raw hits on the left and AI/ML-based reconstruction (SPINE [2]) on right.



### HADRONIC FINAL STATES IN THE 2x2

- (Anti)Neutrino interactions in the 2x2 LArTPC produce protons, pions, and kaons as dominant hadrons.
- Contained proton candidates from CC antineutrino interactions are selected within the fiducial volume as identified by SPINE. Their kinematic distributions are shown by interaction type and final-state composition.
- Particle selections such as this can potentially be used to probe the detector response.



### SUMMARY AND OUTLOOK

- The 2x2 Demonstrator collected its first physics-quality antineutrino data in July 2024, enabling first physics studies with a pixelated LArTPC.
- This is an analysis in progress — we are finalizing the event selection and systematics.
- The 2x2 is paving the way for the full DUNE Near Detector program with first-of-its-kind measurements in liquid argon.
- More neutrino data taking with the 2x2 is planned for Fall 2026.

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