DUNE: Status & Plans

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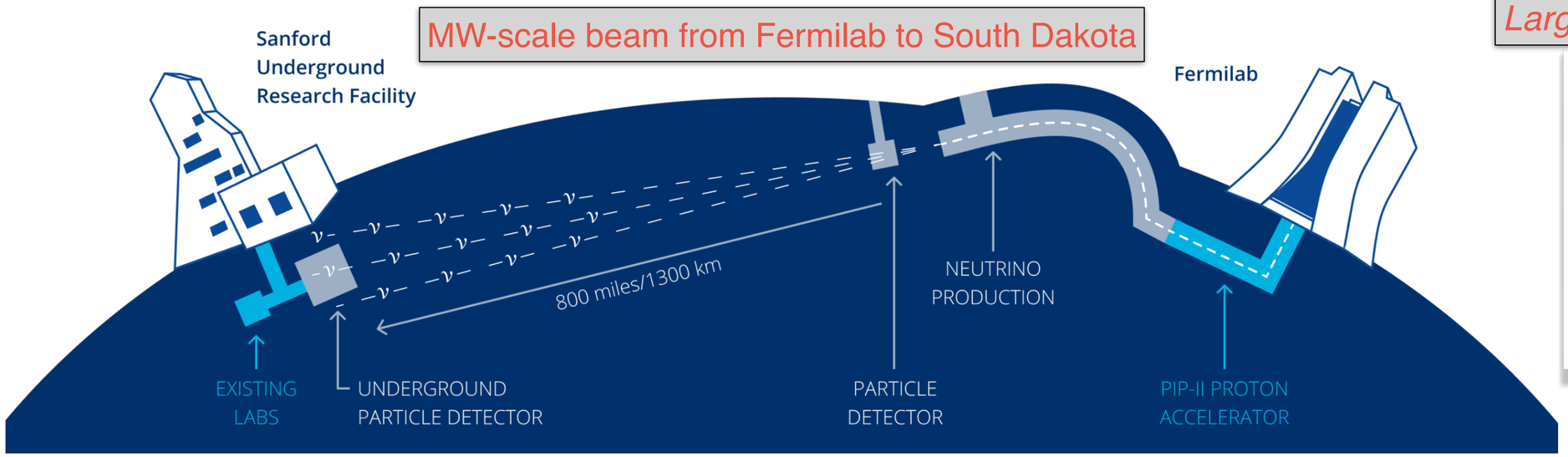
(On behalf of the DUNE Collaboration)

APS DPF Community Meeting
May 21, 2026

The Deep Underground Neutrino Experiment (DUNE)



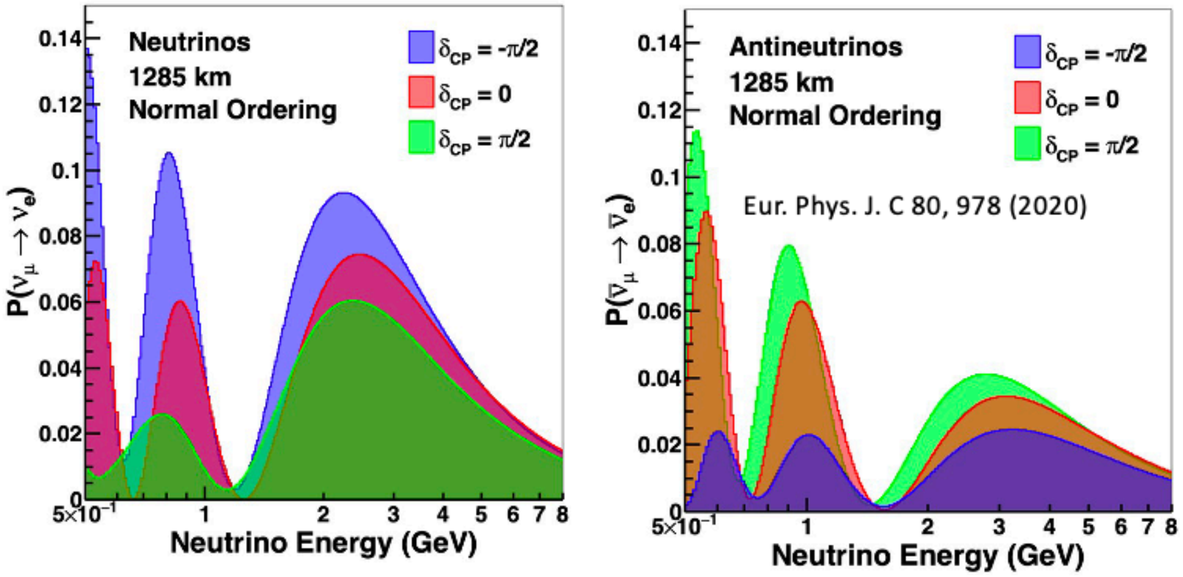
Largest neutrino collaboration in history

1500+ Collaborators
37 Countries & CERN
220+ Institutes

- A massive (70-kt total mass liquid argon equivalent) far detector a mile underground at Sanford Underground Research Facility (SURF)
- A capable near detector at Fermilab comprising of multiple technologies
- Far and Near site facilities and beam provided by the Long Baseline Neutrino Facility (LBNF)
- ***Rich physics program:*** Charge-Parity (CP) Violation, mass ordering, precision measurement of oscillation parameters, neutrino astrophysics, and BSM physics

DUNE Design Philosophy: Measure Everything in One Experiment

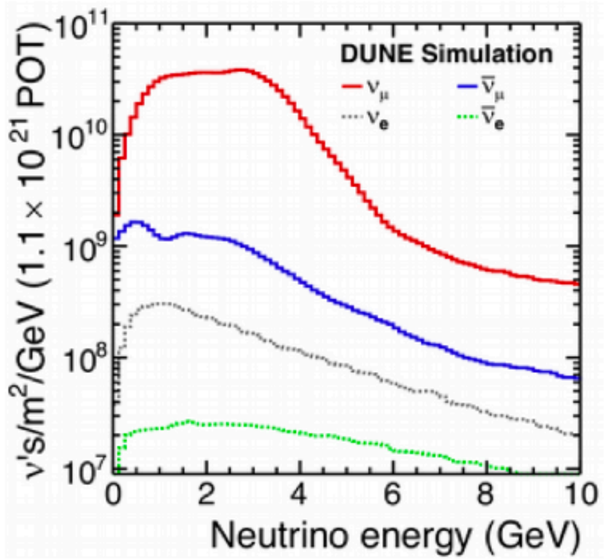
Ultimate Goal: Is out 3-flavor neutrino model correct?

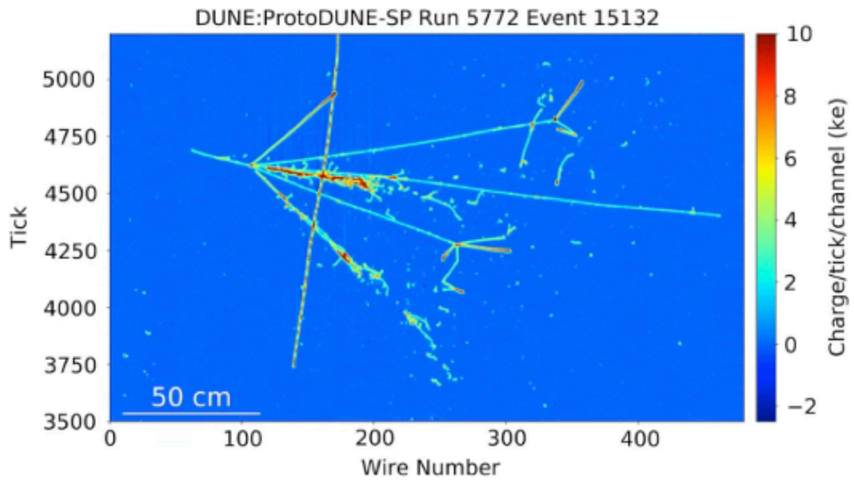


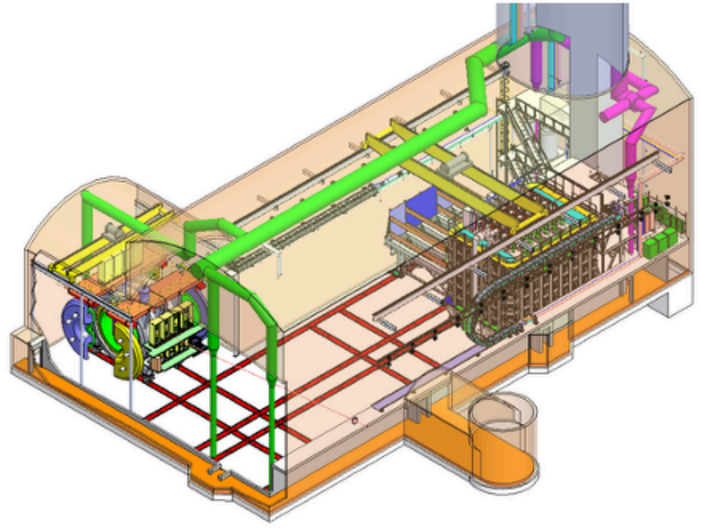
DUNE is a multi-purpose experiment, more like a collider experiment than any previous neutrino experiments that were largely designed to measure a single parameter

- DUNE will measure oscillations over >1 full period, long baseline → *parameters are not degenerate, measure everything in one experiment*
- DUNE can measure oscillation parameters at each bin of L/E → *broad L/E range is essential to resolving all parameters at once*
- It is likely that new physics would distort the result as a function of L/E → *DUNE has unique sensitivity to new physics*

DUNE's Unique Physics Program is Enabled by 4 Key Ingredients







1. **Wide-band neutrino beam** → *enable a rich physics program (mass ordering, CPV, precision measurement of oscillation parameters, New Physics etc.)*
2. **Very long-baseline** → *break degeneracies between CPV and matter effect*
3. **Liquid argon technology** → *measure neutrino interactions with unprecedented detail*
4. **Movable, high-performance Near Detector** → *unprecedented control of systematics*

DUNE Remains a Priority in European Strategy

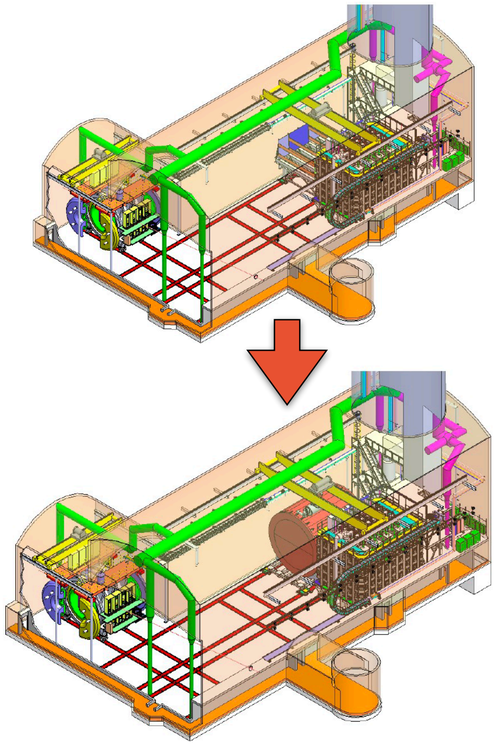
The 2025 ESPPU report was released in Jan 2026 and emphasized the importance of Neutrino Physics to maintain a broader and diverse research portfolio. The report called out that LBNF/DUNE remains a priority for CERN.

"The global neutrino programme has made significant advances towards the determination of neutrino masses and leptonic mixing, and the construction of the next generation of accelerator-based neutrino experiments is progressing rapidly. ***The CERN Neutrino Platform is a focal point of European participation in the global long-baseline neutrino programme. In particular, the current commitments to the LBNF/DUNE project have been decisive and remain a priority for CERN."***

https://cds.cern.ch/record/2950671/files/CERN-ESU-2025-002.pdf

DUNE will be Built in Two Phases

Near Detector (ND)



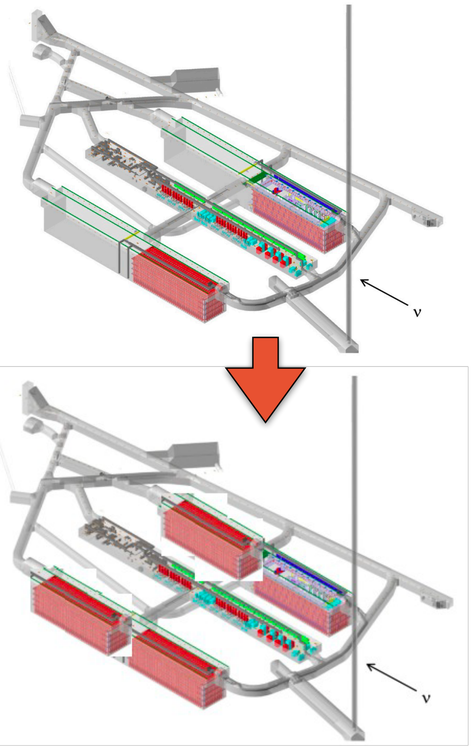
Phase I

- **Far detector:** 2 x 17 kt LArTPC modules
- **Near detector:** Movable LArTPC Near detector + muon catcher, on-axis detector
- **Beam:** 1.2 MW upgradeable beamline (PIP-II)

Phase II

- **FD:** 2 additional modules (total: 4 x 17 kt LAr-equivalent)
- **More Capable Near Detector**
- **Beam:** > 2 MW beamline

Far Detector (FD)

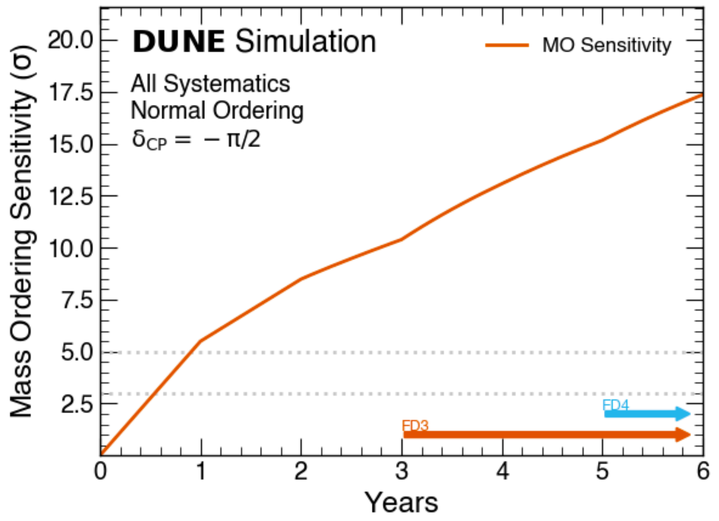


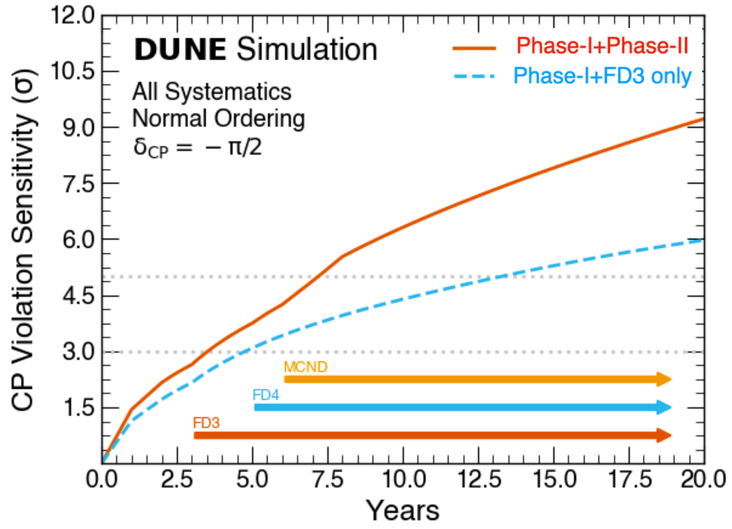
Phase-I builds the full far and near site facilities supporting Phase-II beam and detectors from the start — *simplifying Phase-II implementation*

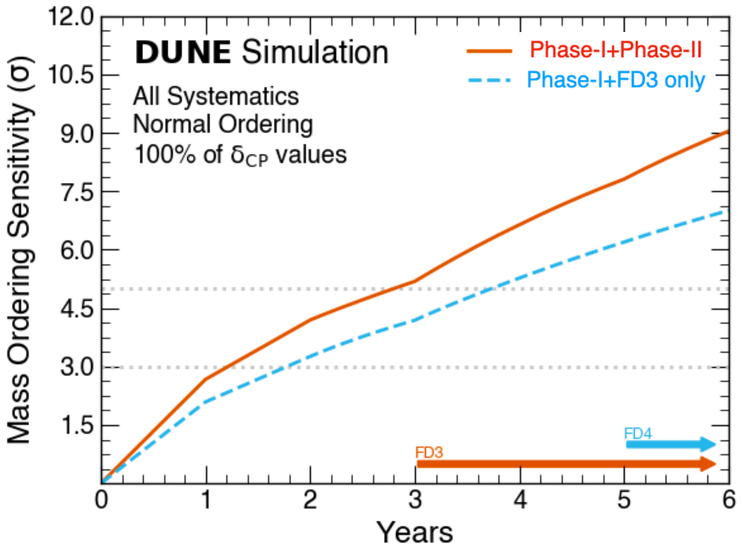
Parameter	Phase-I	Phase-II	Impact
FD mass	20 kt fiducial	40 kt fiducial	FD statistics
Beam power	up to 1.2 MW	>2 MW	FD statistics
ND configuration	ND-LAr, TMS, SAND	ND-LAr, ND-GAr, SAND	Systematics

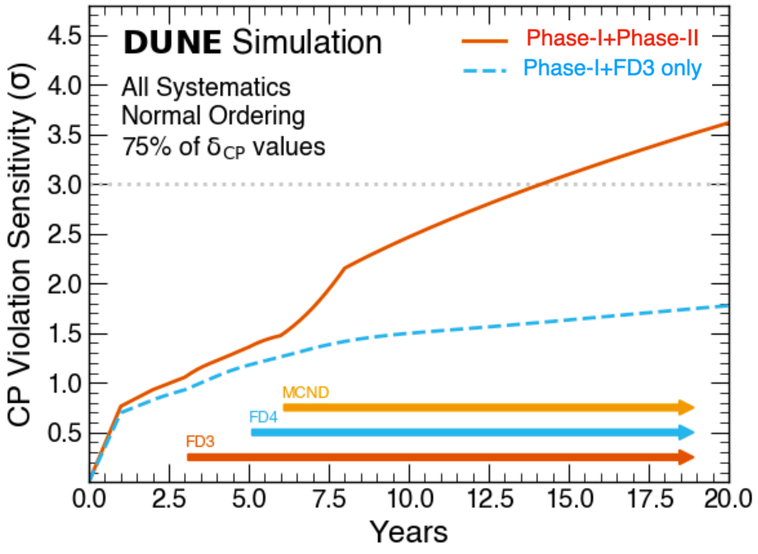
CPV & MO Sensitivities in Various Scenarios

- If nature is kind:
  - >5σ MO sensitivity in 1 year;
  - >3σ CPV sensitivity in 3.5 years;
- If nature is unkind:
  - >5σ MO sensitivity in 3 years;
  - establish CPV over 75% of δCP values at >3σ
- Phase-II is necessary to achieve science goals of DUNE *(i.e. the completion of the oscillation program and more)*



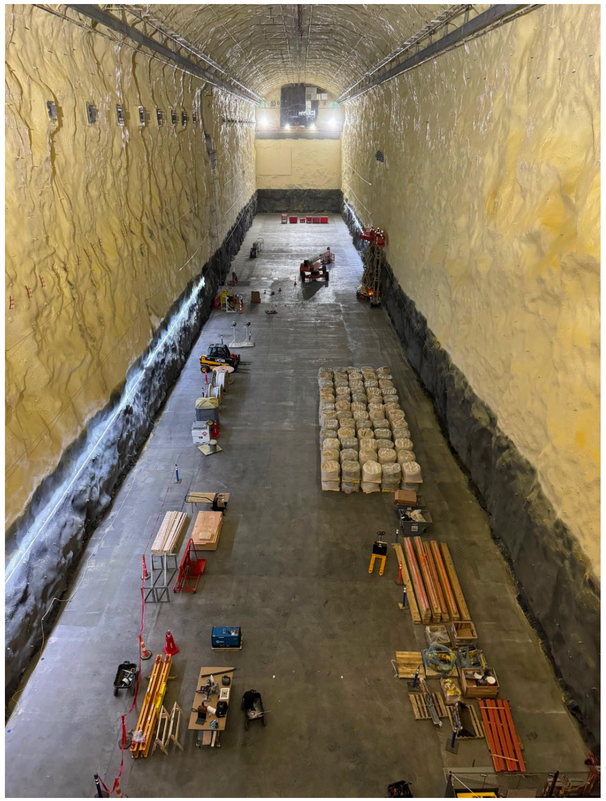


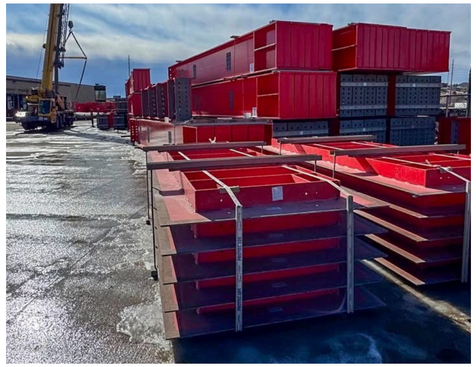




DUNE Phase-I Status: Far Site

- DUNE Caverns are excavated and outfitting complete — Wins Project of the Year award!
- All Cryostat material arrived in South Dakota
- Material being transported underground; installation to start in August 2026



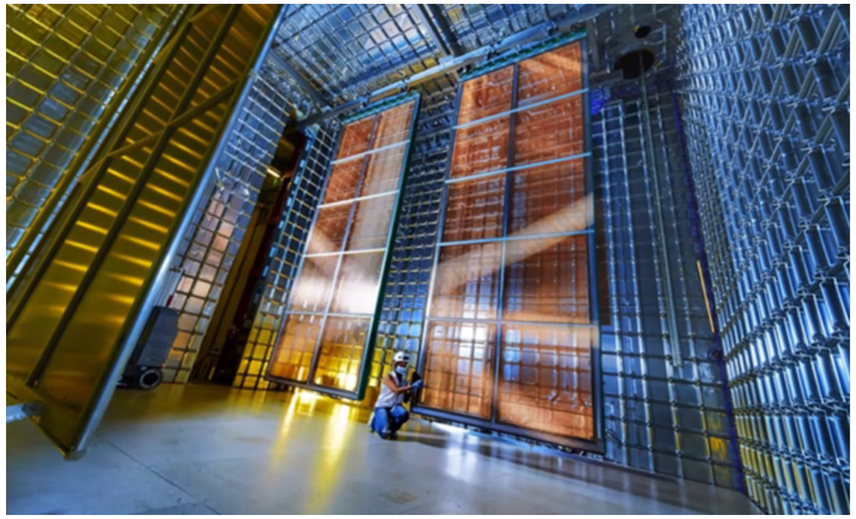


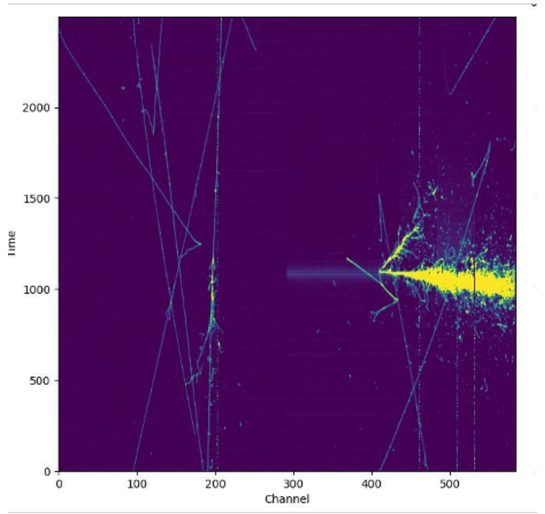
A Cryostat Beam Signing Event in Lead

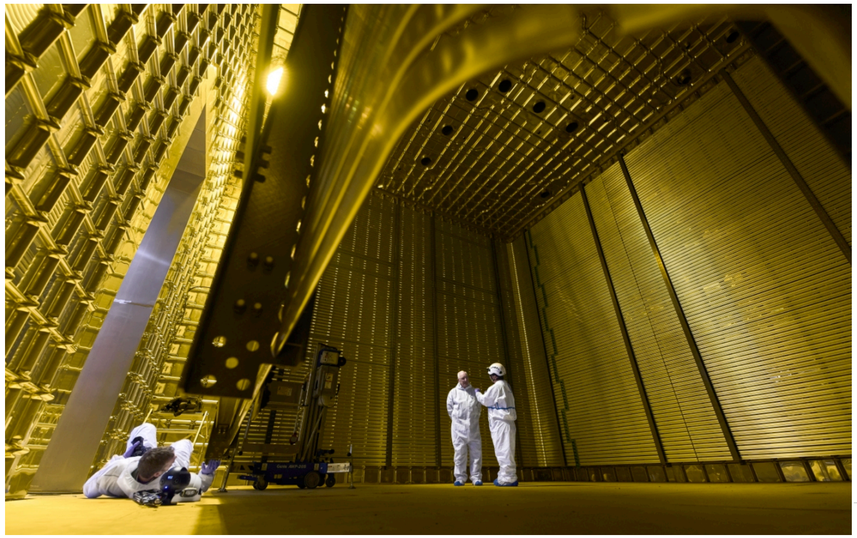
- The event this month brought together several dignitaries
  - Undersecretary for Science, South Dakota Congressional delegation, DOE representatives, CERN Directorate, Consulate Generals of various countries, Fermilab Directorate, DUNE Spokes, Directors of other national labs, DUNE RRB members etc.
- About 1000 people gathered resulting in more than 600 signatures on the cryostat beam – *great enthusiasm from general public!*

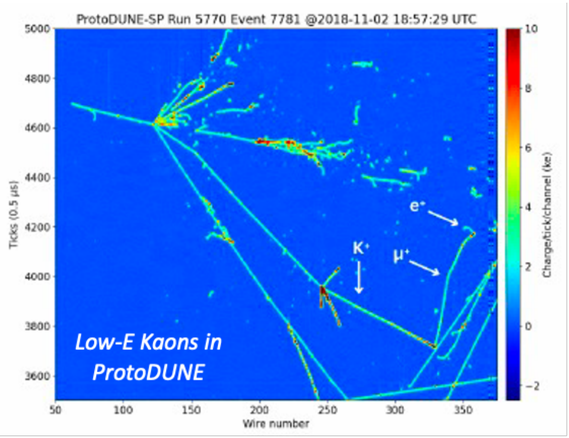
DUNE Phase-I Status: Far Detectors

- Two LArTPC technologies,
  - Horizontal-Drift (shorter drift; more segmented; wire readout)
  - Vertical-Drift (longer drift; less segmentation; strip readout)
- Both technologies successfully demonstrated at scale in ProtoDUNE (770-tons) along with physics performance
- DOE CD-2/3 approval received in March 2026
- All far detector components in production; installation to start in 2027
- Data taking with first far detector in early 2030

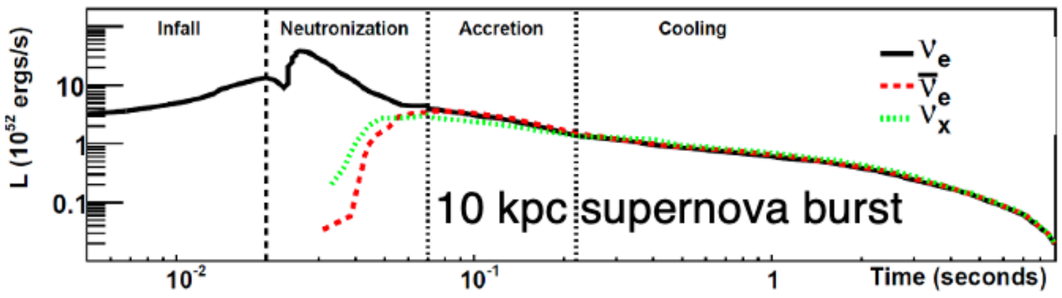


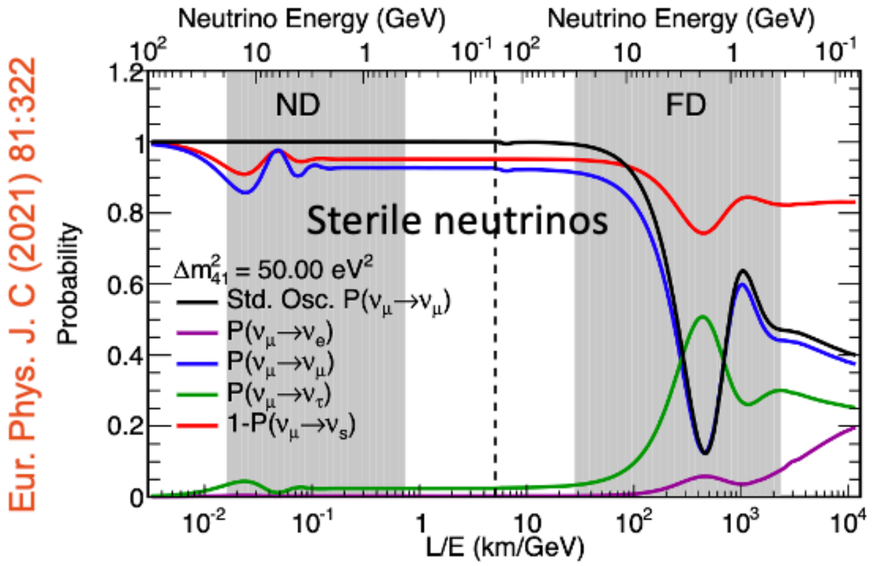






Far Detector Starts Our First Physics

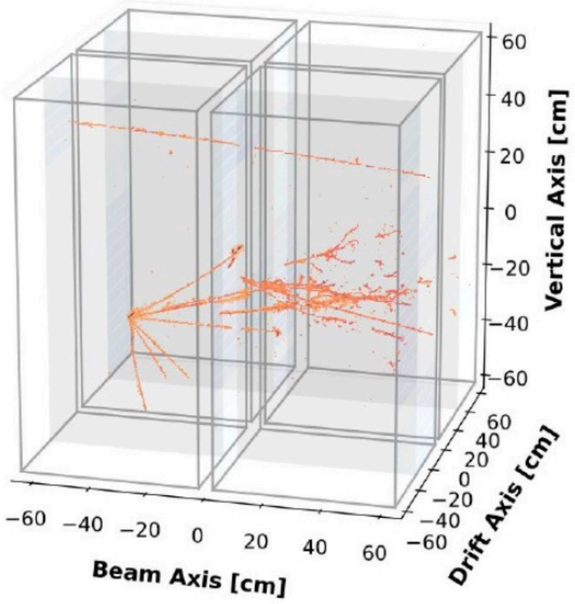




- **DUNE astro, atmospheric, and BSM program starts the moment FD is turned on**
- Supernova flux Flux includes ν_e, anti-ν_e, and other flavors (ν_x), only DUNE measures ν_e due to Argon target and reach extends beyond the Milky Way with additional modules
- DUNE has broad BSM program with ND and FD with New physics in oscillations (e.g., sterile neutrinos, CPT violation) and other areas (e.g., Dark matter, nucleon decay, heavy neutral leptons, neutrino tridents)

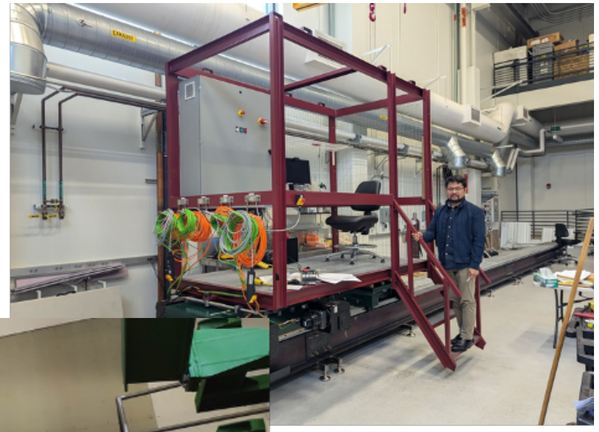
DUNE Phase-I Status: Near Detector

- Near Detector Steadily moving towards final design review with active prototyping in progress
- A Technical Design Report is underway
- “2x2” prototype of ND-LAr operated in NuMI at Fermilab in summer 2024 — *https://arxiv.org/abs/2509.07012*
- A non-beam run just concluded; 2x2 will run in fall in NuMI for ~20 weeks

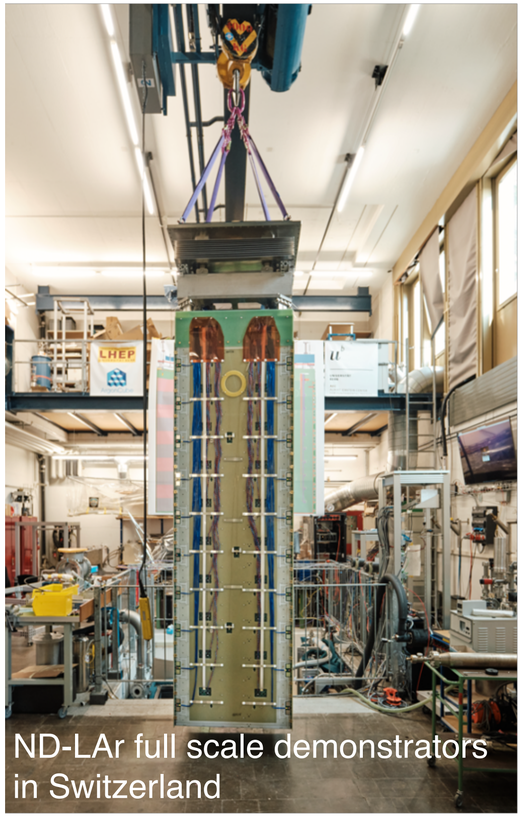


Neutrino event in “2x2”

PRISM tests at Minnesota



SAND integration tests in Italy



ND-LAr full scale demonstrators in Switzerland

DUNE is Actively Publishing

- We are publishing on physics, software and technical topics, both collaboration-wide papers and small-author technical papers
- In 2025, 3 papers published, 6 submitted to journals and 5 more in internal review
-

PUBLICATION TOPIC	PUBLISHED	UNDER REVIEW
Physics	12	5
Detector	8	2
Simulation & Reconstruction	8	1
TDR/White Papers	13	
Other	1	
FULL-AUTHOR PAPERS	**42**	**8**
Small-author technical papers	**59**	

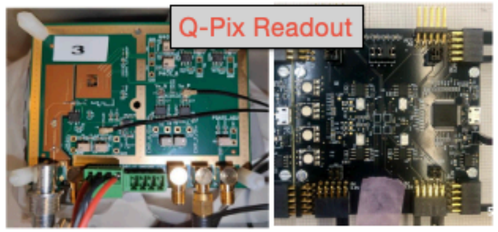
DUNE has published over 100 papers so far and more in the pipeline!

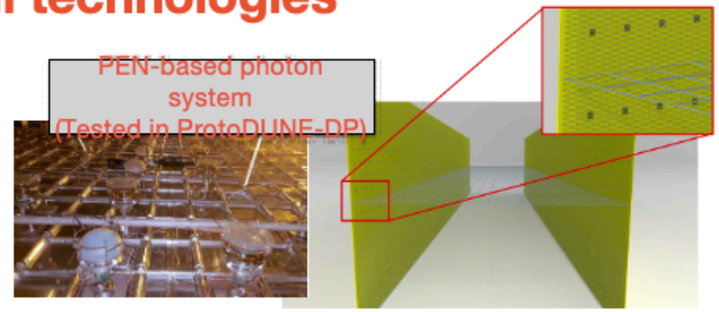
A Road Map For Phase-II

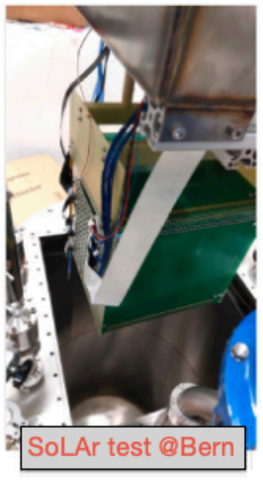
- For Phase II, DUNE is considering technology options that continue to meet DUNE's physics goals, while expanding physics reach:
  - Low-density argon gas near detector (ND-GAr)
  - Optimized Light and Charge Readout for LAr far detector modules:
    - Improved Strip-Based readout
    - Pixelated charge readout (LArPix, Q-Pix, GAMPix, SoLAr)
    - Optical charge readout (ARIADNE)
    - Improved photon detectors (APEX, PoWER, LightPix, SoLAr, Q-Pix LiLAr)
  - Non-Argon FD Option (THEIA)
  - Improved Background Mitigation
- **More detail in DUNE Phase II White Paper (2025):**
  - https://iopscience.iop.org/article/10.1088/1748-0221/19/12/P12005

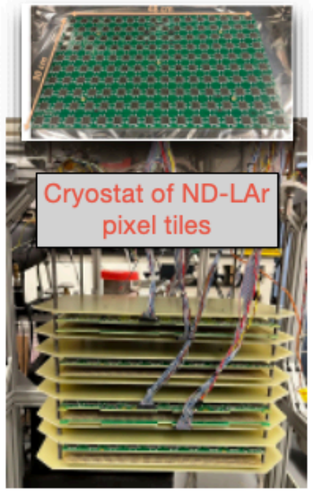
A Global R&D Effort Around DUNE Phase-II

Active prototyping underway across all technologies







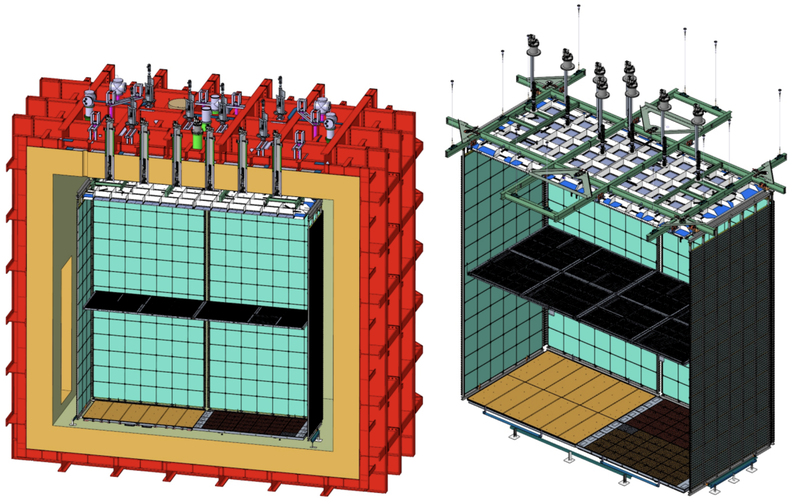


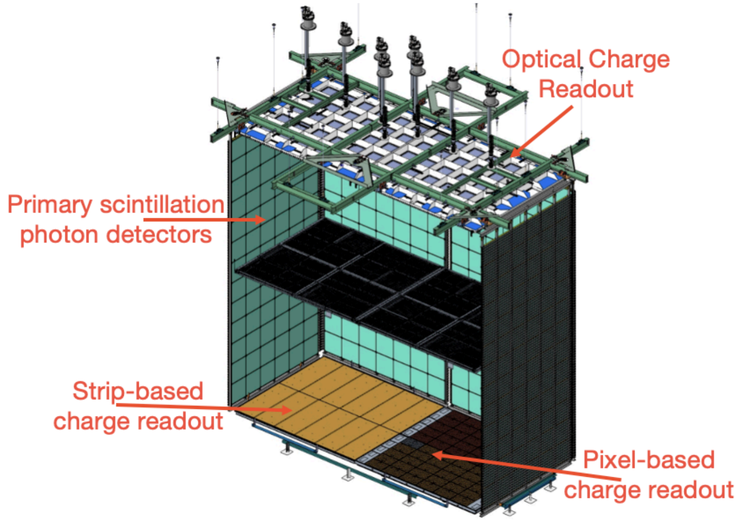
The R&D underpinning the Phase-II concepts is performed as part of a global program which includes the ***European Committee for Future Accelerators (ECFA)*** and the ***Coordinating Panel for Advanced Detectors (CPAD)*** in the United States

- Ongoing coordination between U.S. R&D Collaborations (RDCs) and non-U.S. Detector R&D (DRD) groups on synergistic areas of R&D and towards achieving common DUNE Phase-II goals
  - ***DRDs:*** *Liquid Detectors (DRD2); Gaseous Detectors (DRD1)*
  - ***RDCs:*** *Noble Element Detectors (RDC1); Photodetectors (RDC2); Gaseous Detectors (RDC6)*

A ProtoDUNE-III Run To Down Select Phase-II Technologies

- Serve as a large-scale engineering prototype for the mass production, installation and integration of several Phase II components at full FD dimensions
  - *Focus on most mature readout technologies*
- Study the performance of DUNE Phase II FD leading detection technologies over several months of operation, by detecting particles of different types and energies
- An addendum for ProtoDUNE-III submitted to CERN with a run anticipated in ~2029 — *currently being evaluated by CERN's SPSC committee*





Closing Remarks

- DUNE is well suited to explore known unknowns (CPV, MO) and unknown unknowns (New Physics), all in a single experiment.
- Far detector technologies are successfully validated at scale by ProtoDUNEs at CERN
- Far Site outfitting almost complete. CD-2/3 approval received and cryostat installation starts later this year
- First physics with Far detector in early 2030. Beam to DUNE in 2031
- ND is steadily moving towards final design review. ND installation to start end of 2030
- A road map towards Phase-II and technologies considered summarized in the Phase-II White paper
- Active R&D ongoing globally for Phase-II
- A ProtoDUNE-III run planned towards the end of the decade to test Phase-II technologies

Enormous progress across all fronts and DUNE will move into installation phase starting this year!

Thank you!

DUNE Collaboration in Rapid City & Lead, ongoing this week
>250 people in attendance in-person

EXTRAS

LBNF/DUNE Phase-I Schedule

- **FS1:** Start of far site cryostat construction
- **FS2:** Far site conventional facility transition to operations complete
- **FS3:** Start of far detector construction
- **FS4:** Start Science - First far detector transition to operations
- **NS1:** Start Near Site Civil
- **NS2:** PIP-II Early CD-4
- **NS3:** Deliever Beam to DUNE
- **NS4:** Start Beam Based Science