

Recent news in neutrino oscillations physics and status of the DUNE experiment

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French-Ukrainian Workshop 2026

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Source: [New Frontiers in Neutrino Physics with the DUNE Experiment](#) – Inès Gil-Botella CERN seminar – Jan 29th, 2026
[IN2P3 Scientific Council](#) – Cédric Cerna – Mar 2nd, 2026
[12th symposium on “Large TPCs for low-energy rare event detection”](#) – YK – Dec 15th, 2025

Credit: CERN

Recent news on neutrinos!

- **Direct neutrino-mass** measurement based on 259 days of KATRIN data

Science 388 (2025) 6743

- $m_\nu < 0.45$ eV at 90%CL

- **Sterile-neutrino** searches

- MicroBooNE - *Nature* 648, 64–69 (2025)
- KATRIN - *Nature* 648, 70–75 (2025)

- Observation of an **ultra-high-energy cosmic neutrino** with KM3NeT

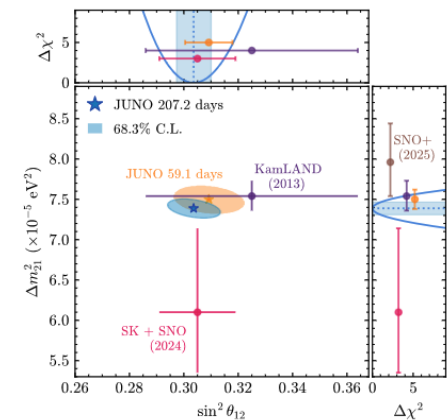
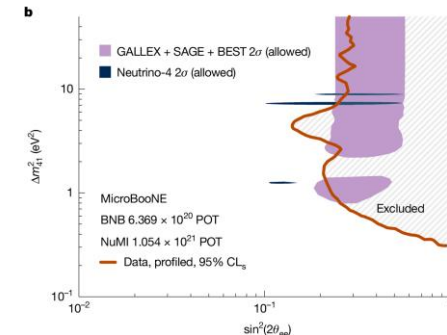
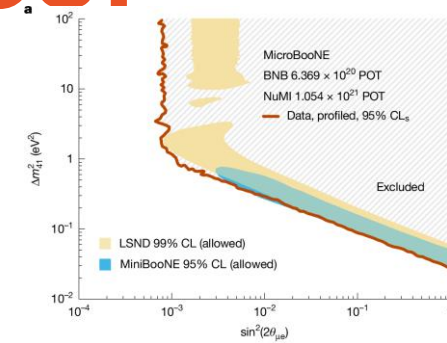
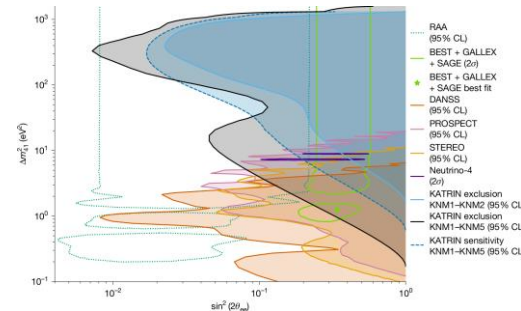
Nature 638, 376-382 (2025)

- **Constraints** on Neutrino Physics from **DESI** DRD2 BAO and DR1 Full Shape

Phys.Rev.D 112 (2025) 8, 083513, *Phys.Rev.Lett.* 135 (2025) 8, 081003

- **Neutrino oscillations**

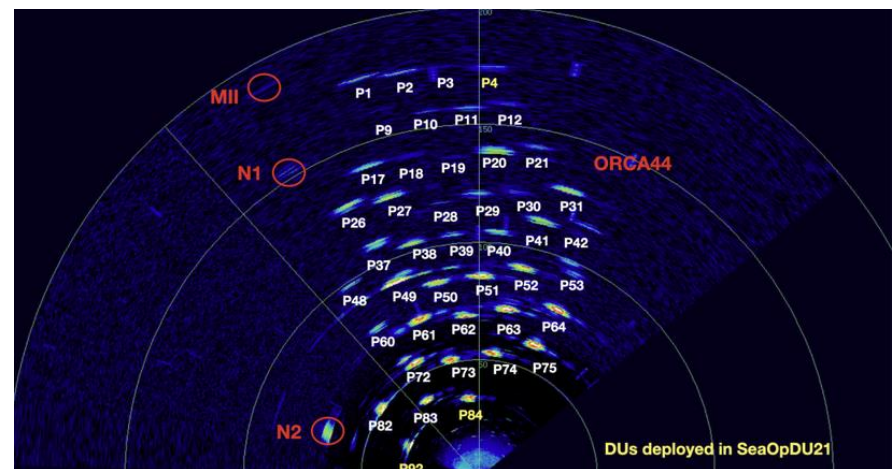
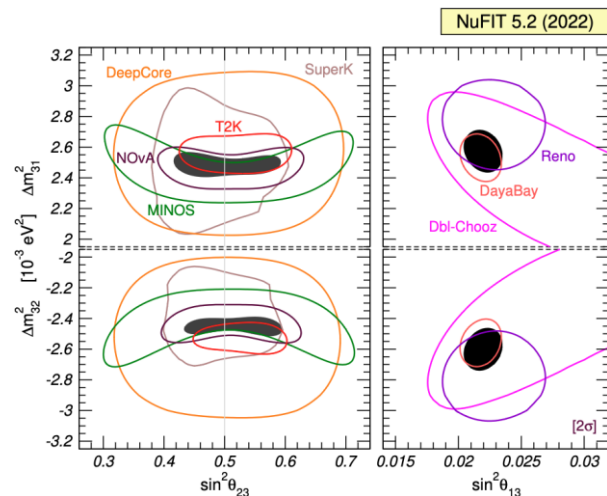
- Improved reactor neutrino oscillations at **JUNO** with **207 days of data taking**
arXiv:2609.37895
- **Joint neutrino oscillation analysis** from the **T2K** and **NOvA** experiments
Nature 646, 818-824 (2025)



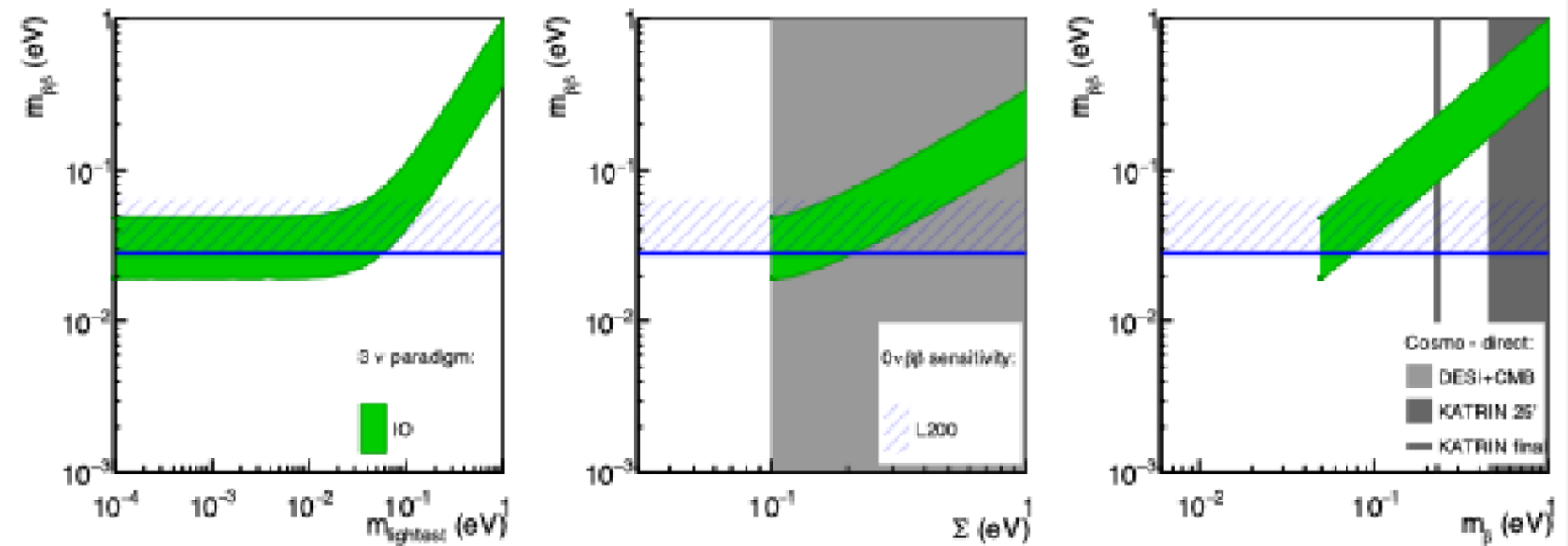
A new Nobel Prize!

Francis Halzen

- “for decisive contributions to the IceCube Neutrino Observatory and the discovery of high-energy neutrinos of astrophysical origin”
- IceCube contributes to many neutrino physics analyses including neutrino oscillations!
- Detection principle also paved the way for KM3Net – stay tuned!

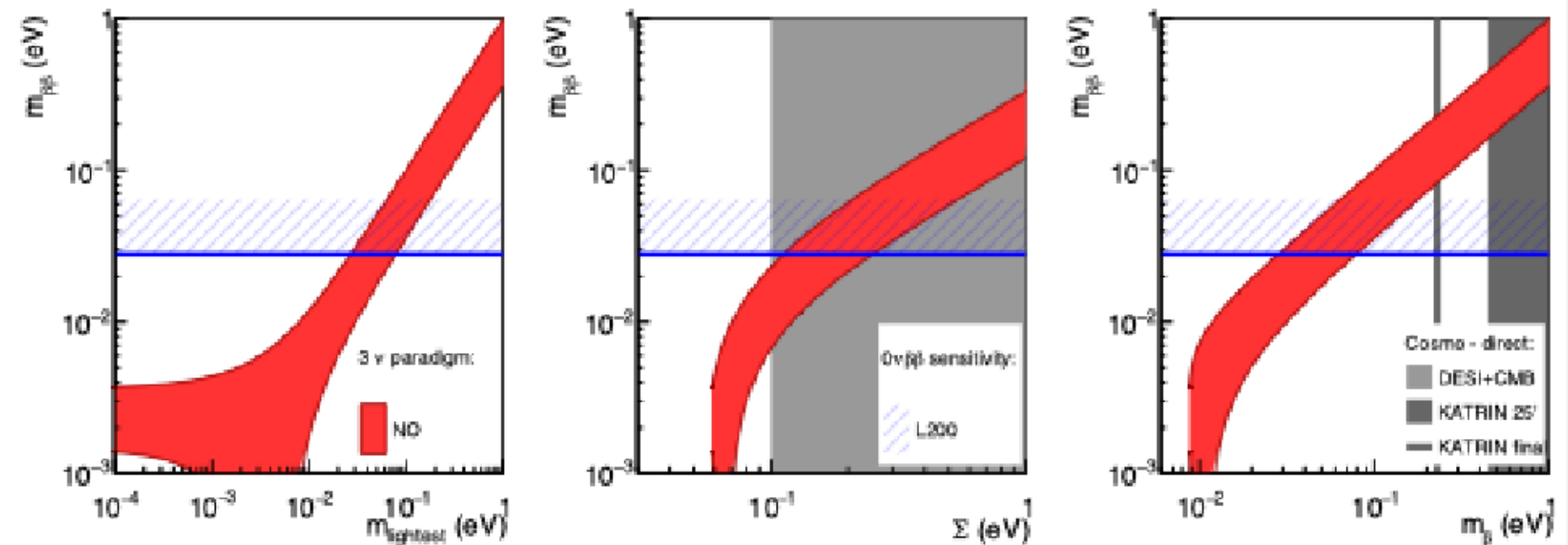


The wished scenario?



- Assumptions: Inverted ordering + improved $0\nu\beta\beta$ decay sens.
- The allowed phase space by the **3 light ν paradigm** would be critically reduced by ~2033
- May end-up where we want to be, i.e. **need for beyond BSM expl.!**

THE scenario?



- Assumptions: Normal ordering + improved $0\nu\beta\beta$ decay sens.
- The allowed phase space by the **3 light ν paradigm** would remain opened by ~ 2033
- May end-up in a **non conclusive era for long time!**

Neutrino mass ordering from JUNO

- Latest advance released in this preprint: arXiv:2609.37895
- A 2.1 sigma preference reported for Normal Ordering

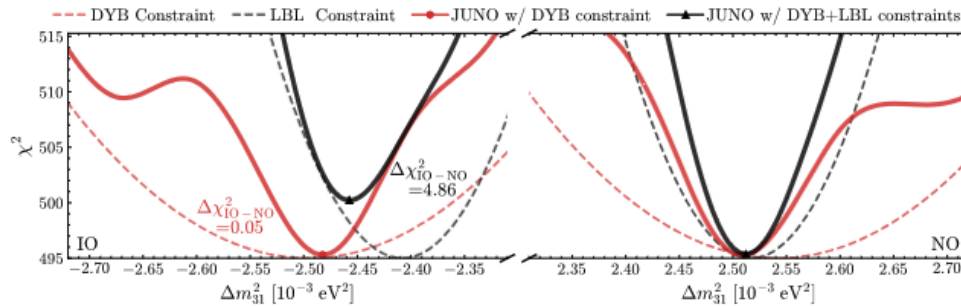


FIG. 7. χ^2 profiles versus Δm_{31}^2 for IO (left) and NO (right). Red and black solid curves show the JUNO fit with Daya Bay constraint [22] alone and with the additional NuFit LBL constraint [8], respectively; dashed curves show the corresponding pull terms. Circles (DYB) and triangles (DYB+LBL) mark the best-fit values. The LBL constraint enhances the preference for NO, as quantified by $\Delta\chi_{\text{IO-NO}}^2$ (values given in the IO panel). The fits constrain the unoscillated spectrum using TAO [21] and Daya Bay near detectors [19].

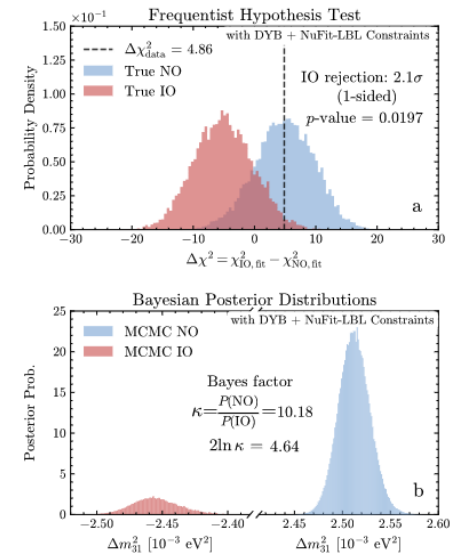


FIG. 8. (a) Frequentist distributions of the test statistic $\Delta\chi^2 = \chi_{\text{IO,fit}}^2 - \chi_{\text{NO,fit}}^2$, together with the observed value (vertical dashed-dotted line). (b) Bayesian posterior probability densities of Δm_{31}^2 obtained from the Markov Chain Monte Carlo analysis. Color convention: NO (blue) and IO (red).

The next steps

- Clear need for larger oscillated neutrino datasets!
- Two major experiments: DUNE & HK (+ORCA & IceCube)
- HK should start soon in 2028! 25'000 oscillated neutrinos in 10 years

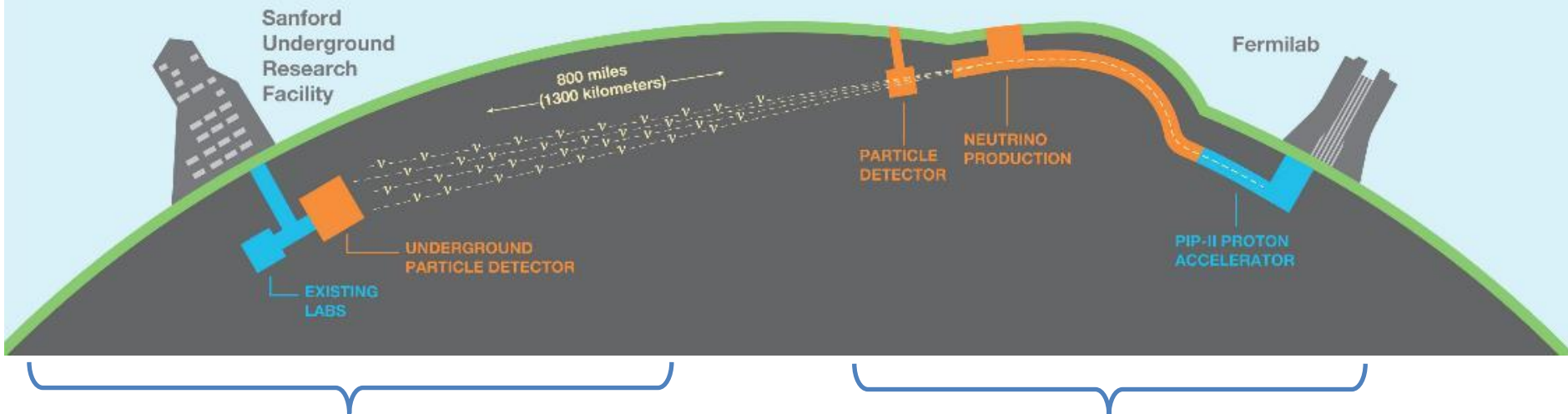


Credit:
R. Akutsu
Neutrino 2026

DUNE sub-projects

Far Site – SURF in Lead, SD
Facility/Infrastructure and Far Detectors

Near Site – FNAL in Batavia, IL
Facility/Infrastructure, Neutrino Beamline, and Near Detectors



- **FSCF-EXC** – Underground Excavation
- **FSCF-BSI** – Far Site Building & Site Infrastructure
- **FDC** – **Far Detectors** and Cryogenic Infrastructure

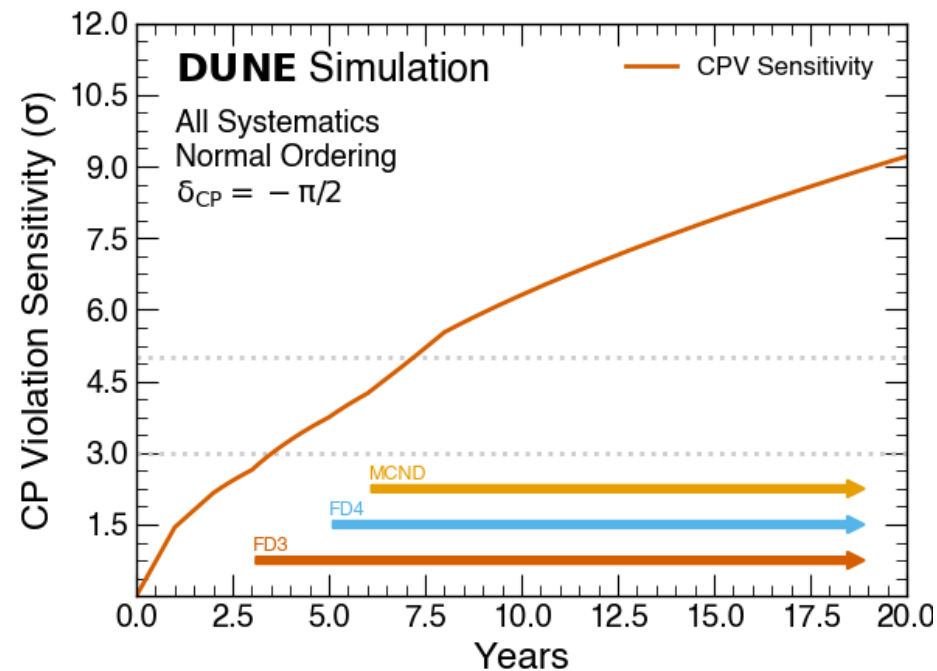
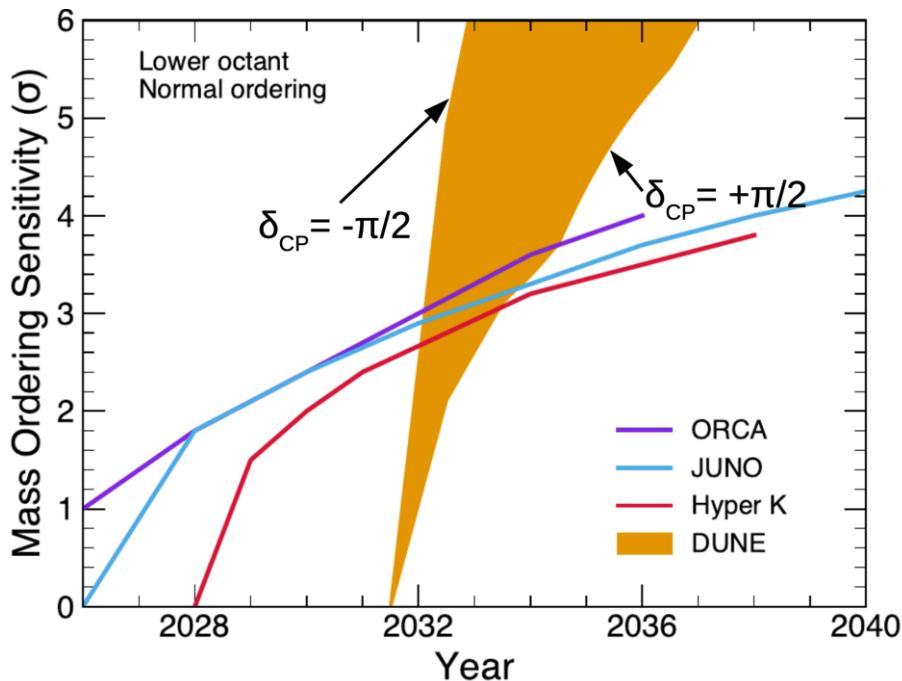
- **NSCF** - Near Site Conventional Facilities
- **Beamline** – **Proton Beam** and Neutrino Beam
- **ND** – Near Detector

-



DUNE long baseline target

- Neutrino Mass Ordering sensitivity in worst case scenario
- Leptonic CP violating phase will be measured with unprecedented precision



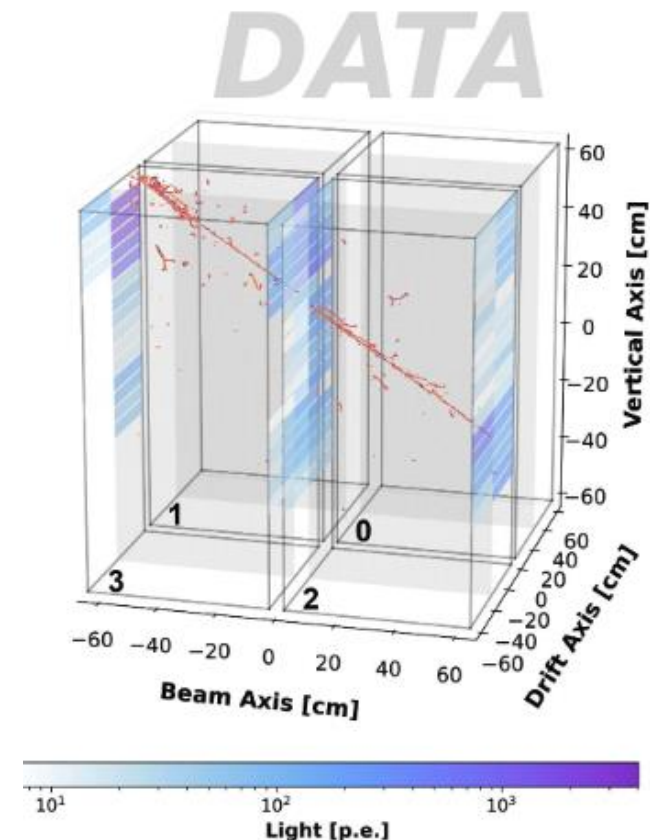
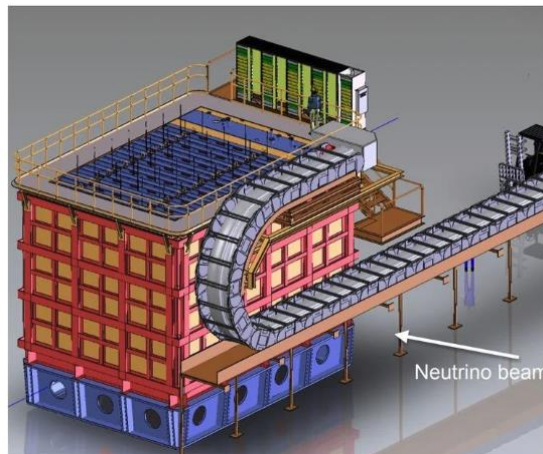
The PIP-II project



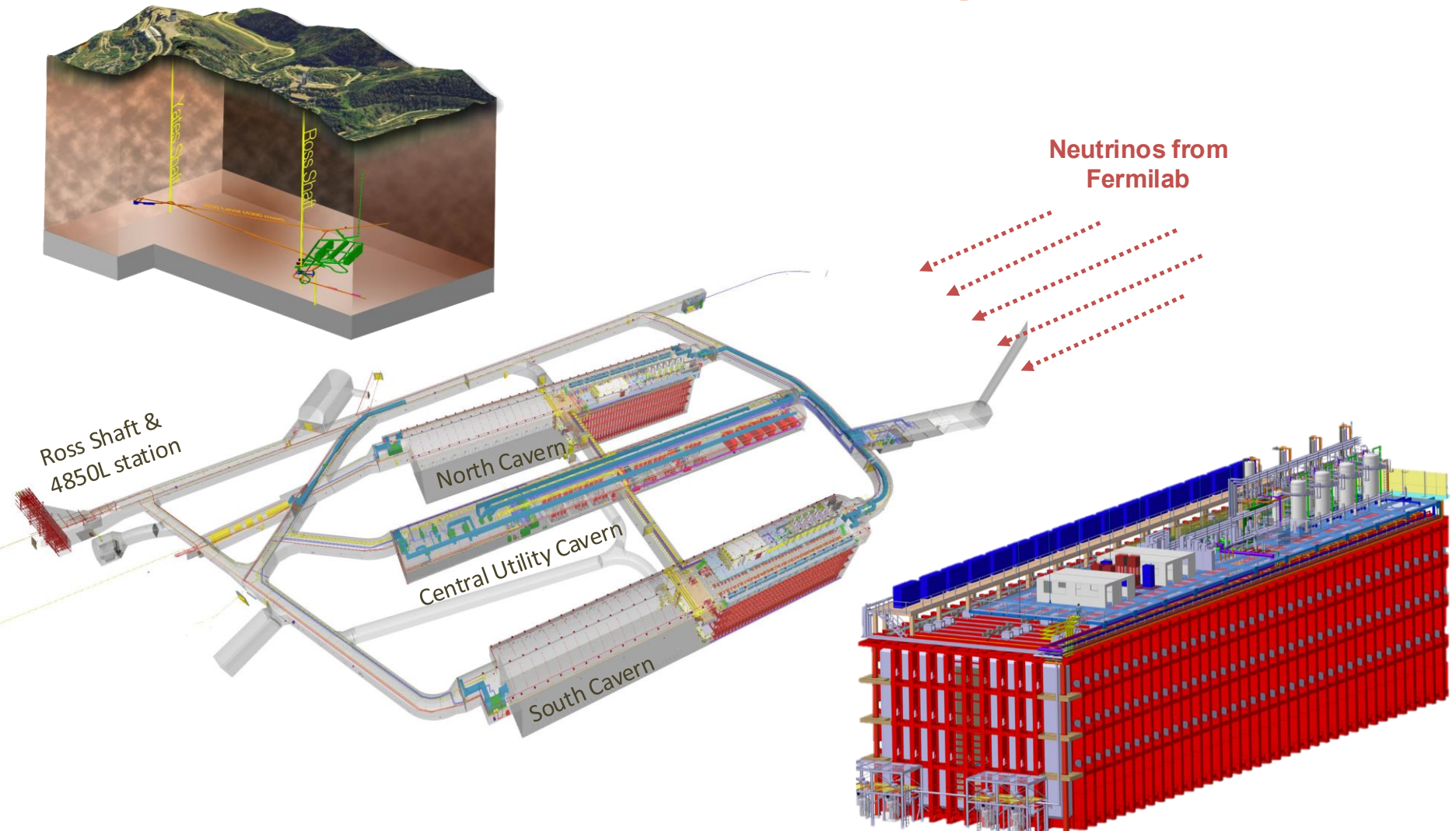
- Project well progressing (civil construction & cavities validation)

DUNE near detector

- Main body consists in a movable LArTPC
- Pixelated TPC helps resolving the pile-up and rock muons
- 2x2 module deployed on the NUMI beam
- Ongoing data taking at FNAL
- First DUNE neutrinos from beam!



DUNE far site underground lab



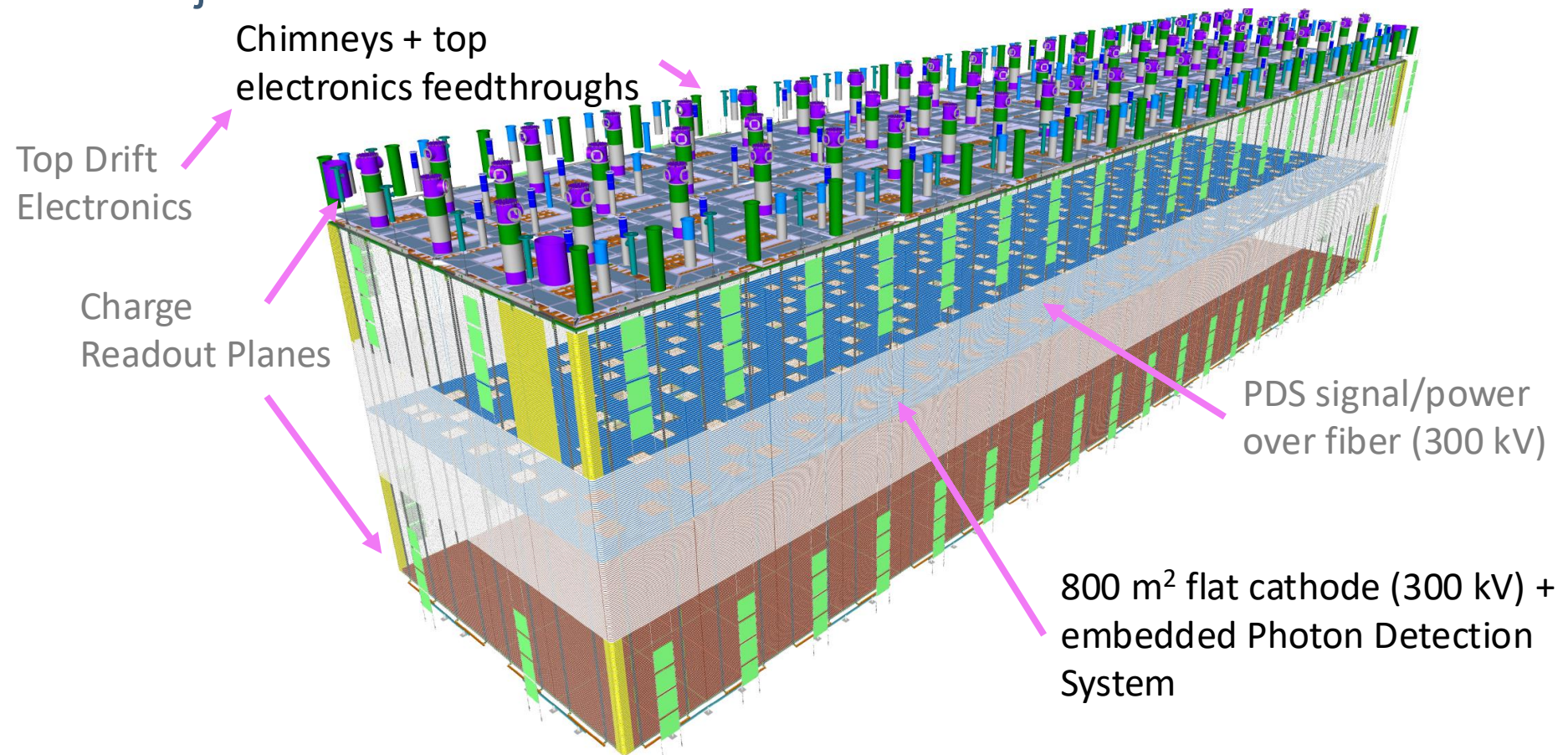
DUNE far site underground lab

- Excavation completed in 2024
- South Cavern Availability since January 2026!
- Cryostat construction will soon start (>30% of parts are underground)



Far Detector Vertical Drift

- FDVD construction starting first in 2027 then FDHD
- Major contribution from IN2P3

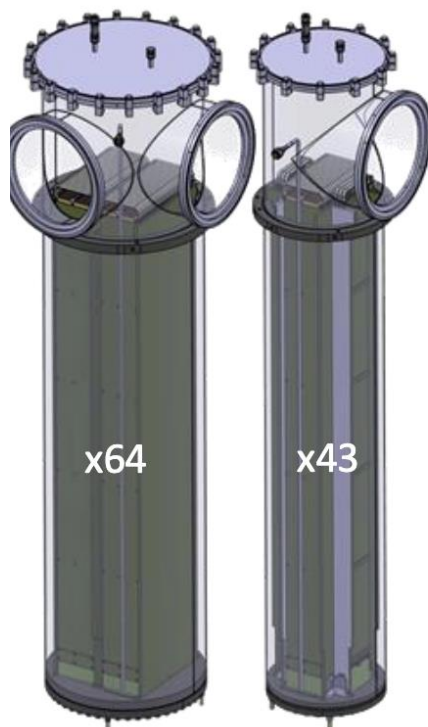
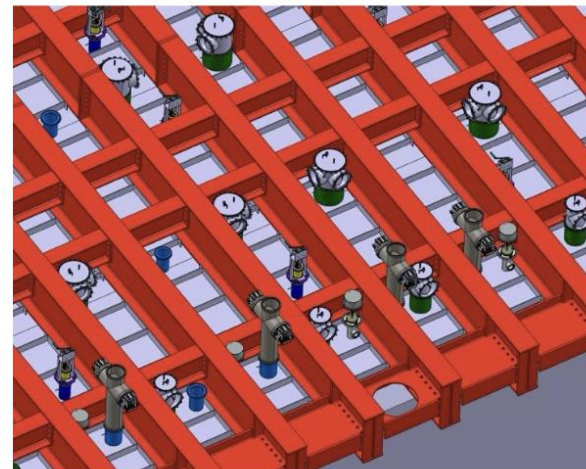
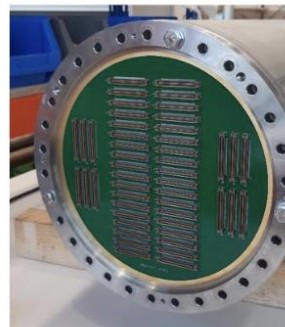


Chimneys



- IN2P3 PI Fabien Cavalier
- IN2P3 PM Véronique Puill
- Mech. Leader Rodolphe Marie

- Chimneys V24 : 40/(42+1) (100%) Received + QC OK
- Chimneys V48 : 55/(63+1) (86%) Received + QC OK
- Cold PCB: Procurement in process + PRR
- Warm PCB: validation ongoing before PRR
- Guiding system: Procurement in process
- Blades: validation ongoing before PRR
- Transport Box : validation ongoing
- 200 m² hall assembly and QC



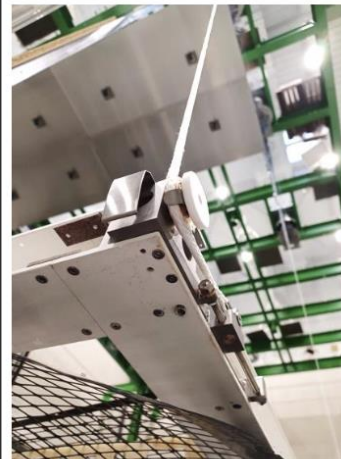
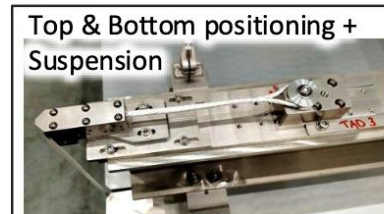
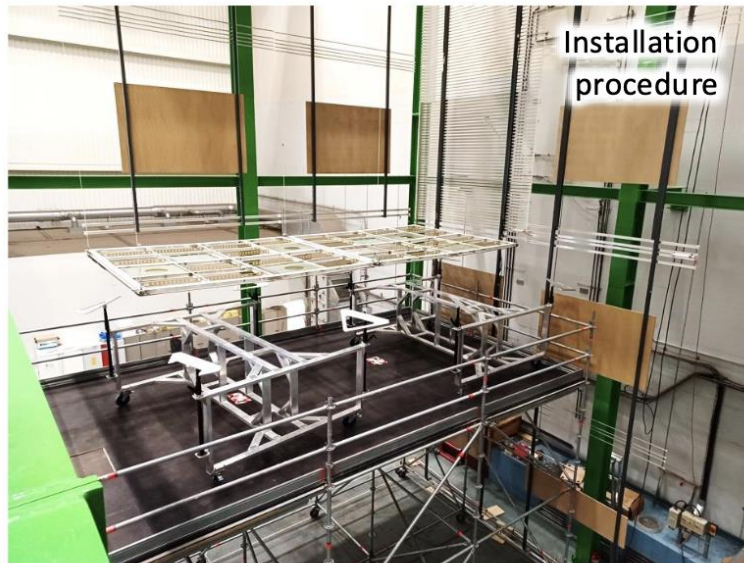
Quality Control



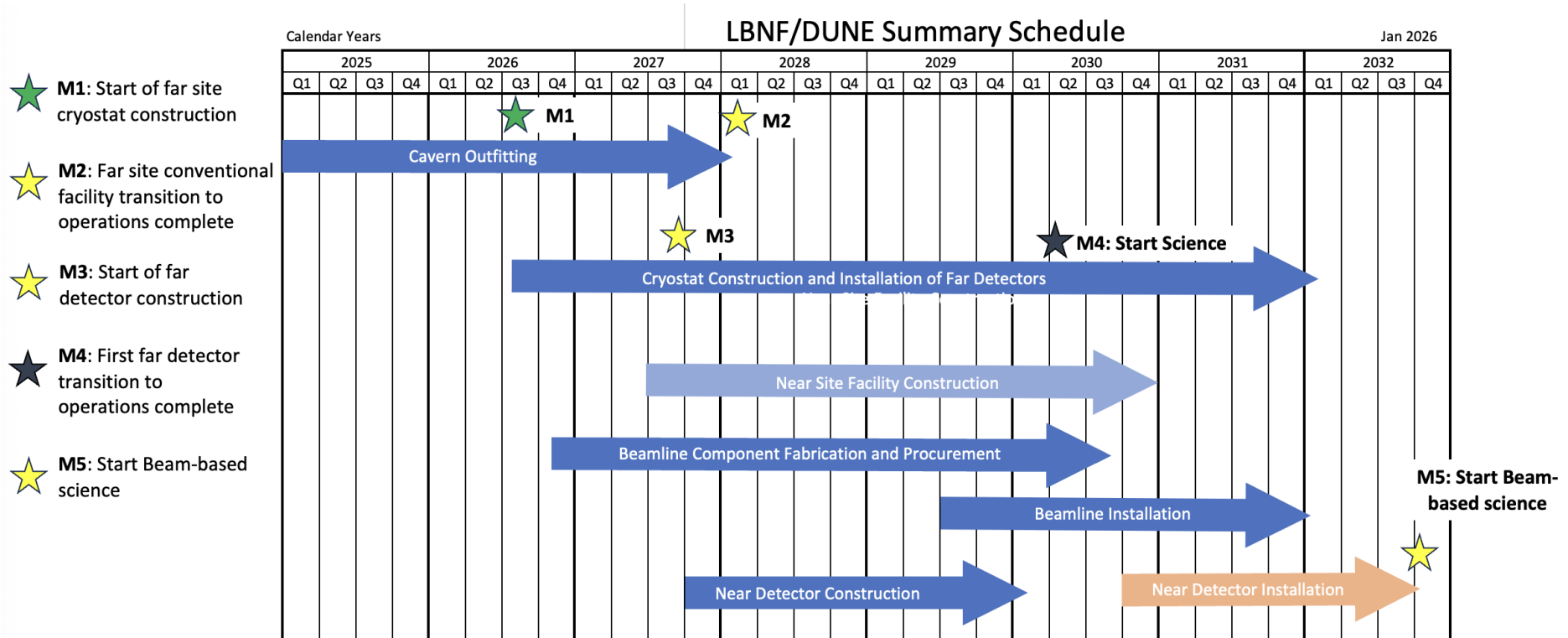
Cathode

- IN2P3 PI Fabien Cavalier
- IN2P3 PM Véronique Puill
- Mech. Leader Philippe Rosier

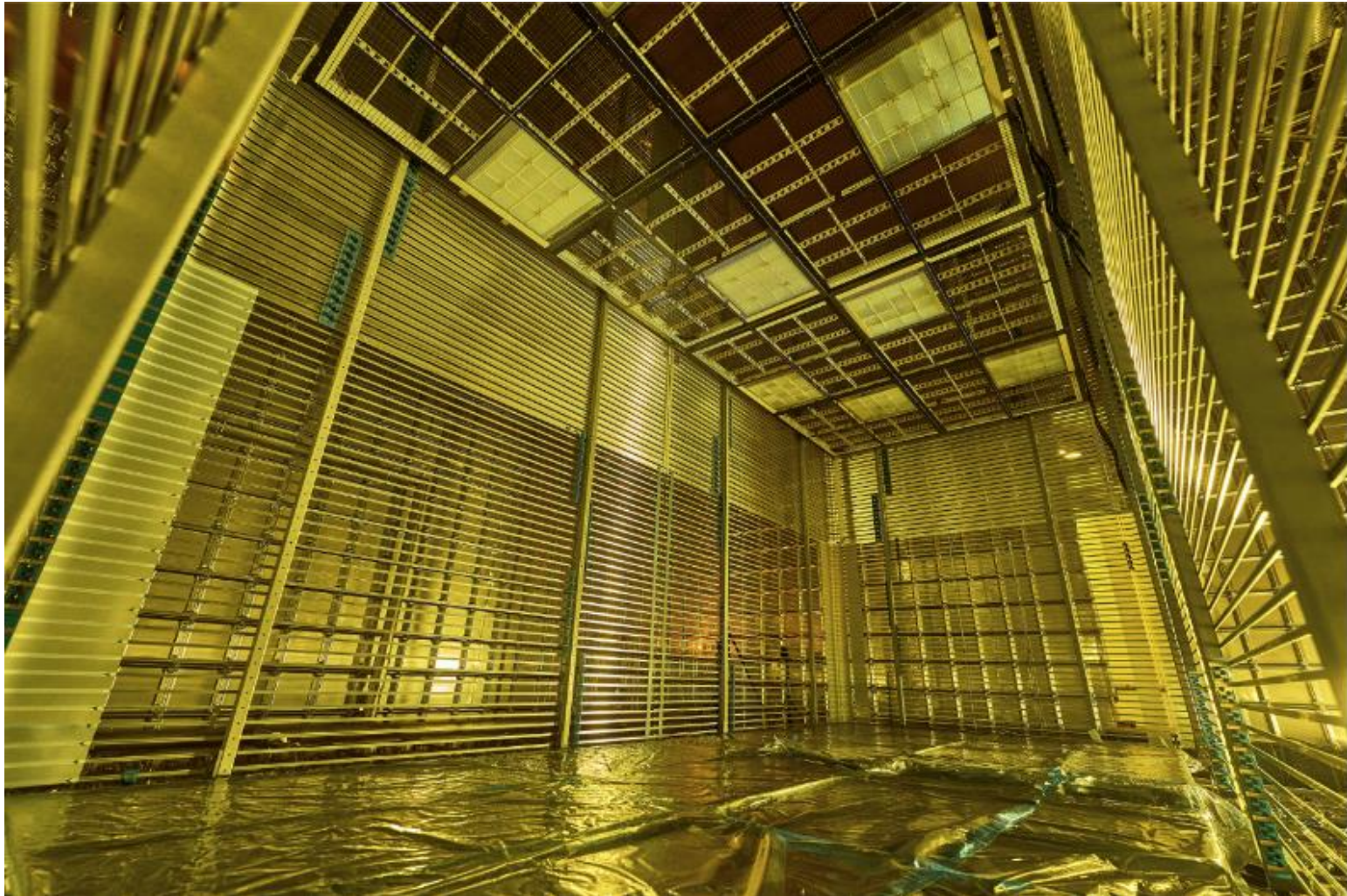
- ½ frames : 120 (70%) **Received and Validated**
- Resistive Grid: 555 (25%) **Received and Validated**
- Metallic Grid: 720 (100%) **Received and Validated**
- Suspension Cables **In production**
- Positionning (top+bottom) **In Procurement**
- Transportation Box **Final Design**
- Integration + Installation tools:
 - Carts : 2 (100%)
 - Cartwall : 1 (50%)
- 400 m² hall assembly and QC systems
- **All deliveries expected for Q1 2027**



LBNF/DUNE Schedule

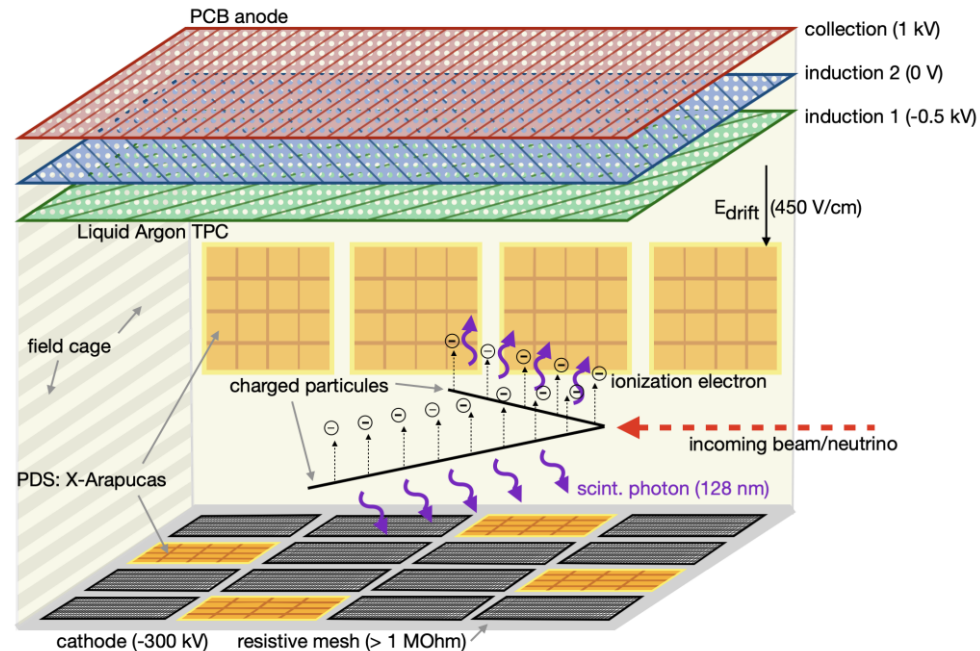
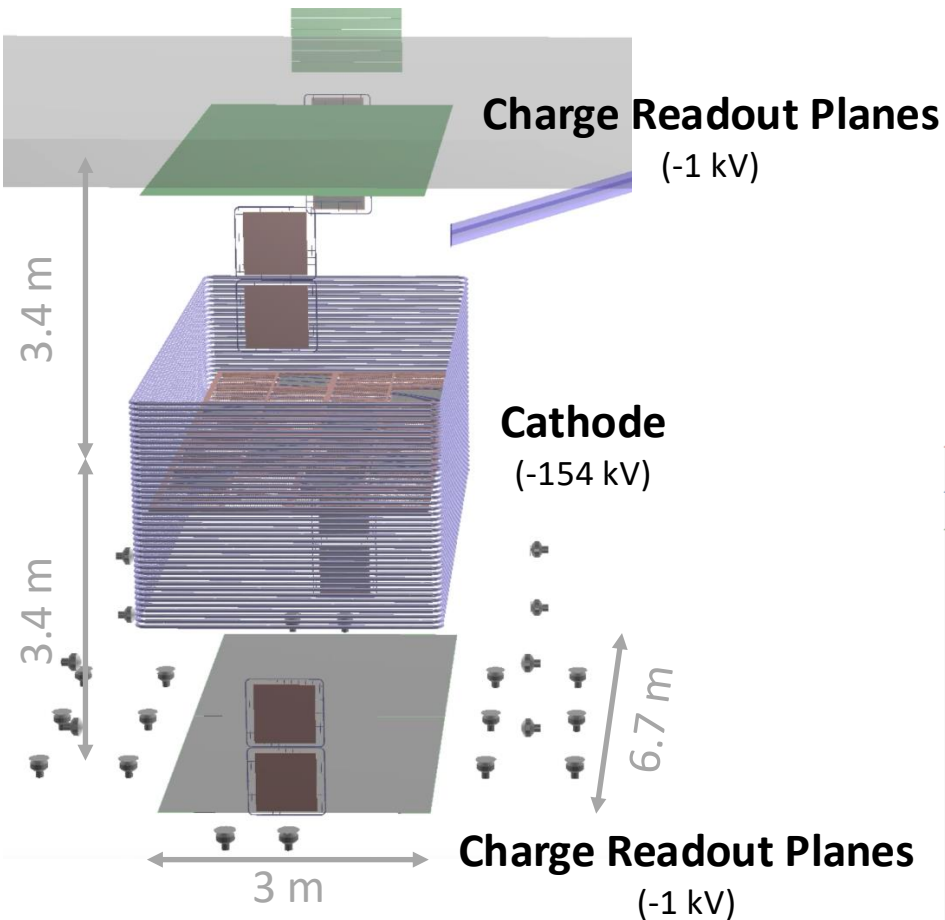


The ProtoDUNE-VD @ CERN



The ProtoDUNE-VD detector @ CERN EHN1

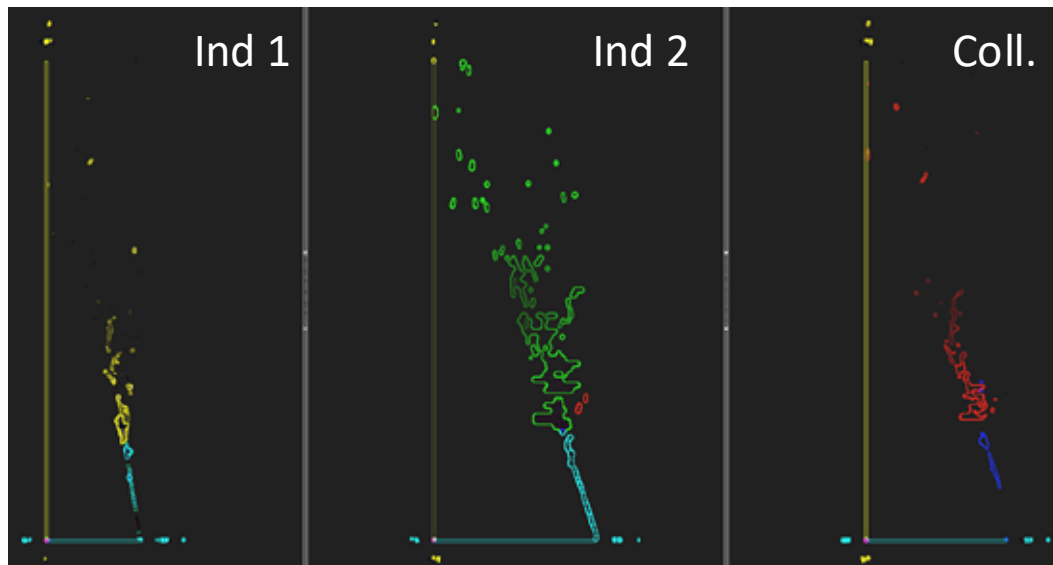
- Among the largest LAr TPC ever built
770 tons (+SBND, MicroBOONE,
ICARUS @ SBN Fermilab facility)



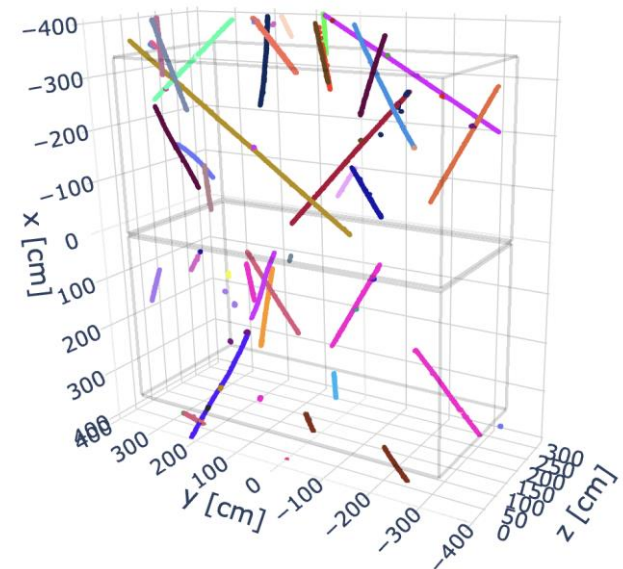
From drifting electrons to reconstructed tracks

- Perform a 3D reconstruction of energy deposits by matching the 3 views (time, channel $\rightarrow$ X,Y,Z)
- Use Pandora space point solver & tracking/showering algorithms by default
- **Use of SPINE ML pipeline software (Nived Puthumana-Meleppattu thesis)**
- **Low energy $\rightarrow$ use the reconstruction module from Émile Lavaut thesis**

Pandora 3-views matching

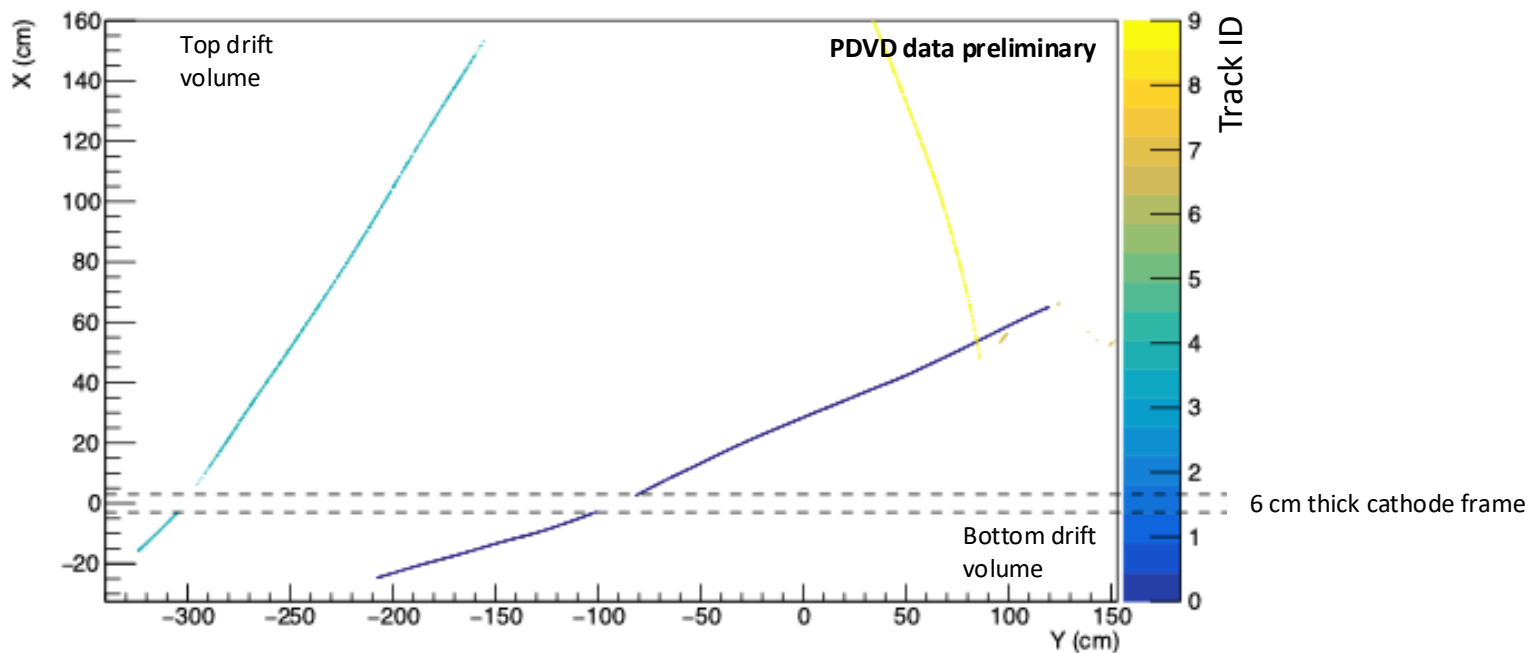


SPINE event display



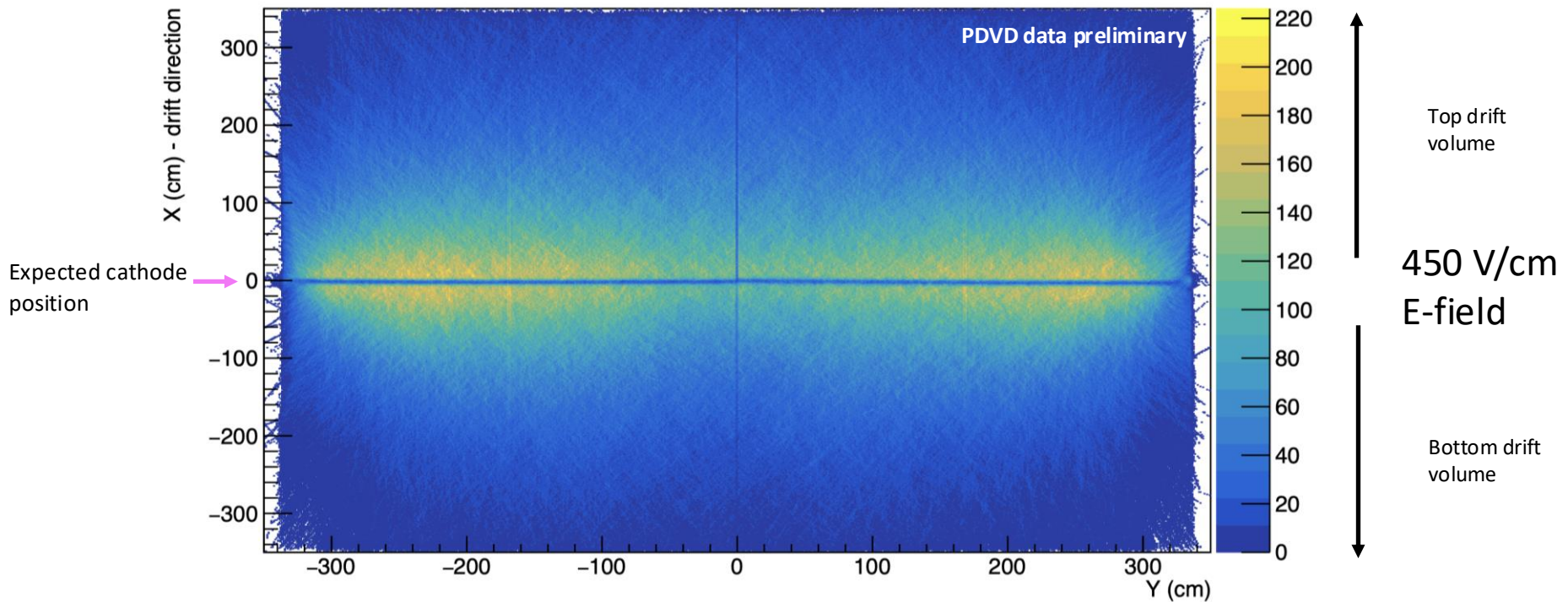
Cosmics runs

- High rate of cosmics muons allows for detailed studies of the detector response (geometry, MIP, stopping muons, ...)
- Cathode crossing tracks are a good standard candle (known depth)
- Pandora reconstruction used here for track stitching and calorimetry



Cosmics runs

- Piling-up ~40 k events, able to resolve the cathode position
- Cathode crossing tracks selection
- We manage to centre it at the cm level

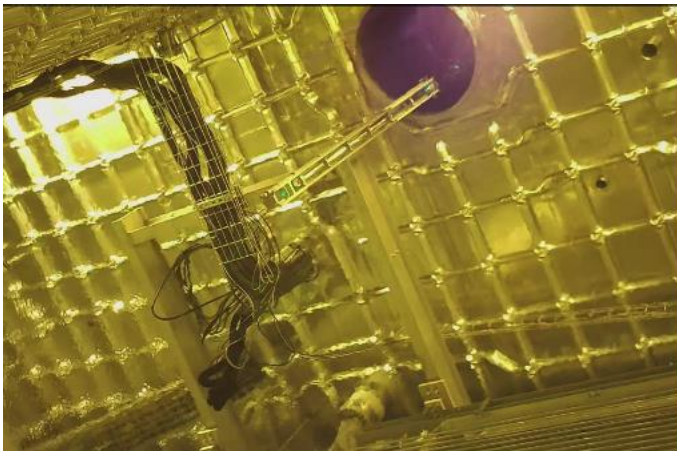


Laser system based calibration

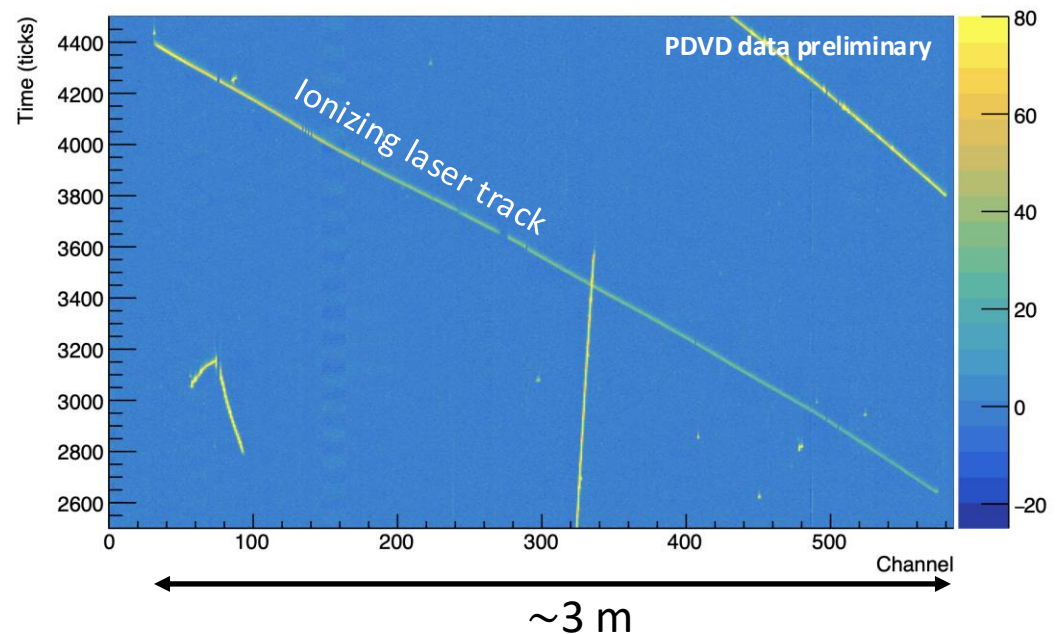
Laser tent on NP02 roof



Periscope inside the LAr cryostat

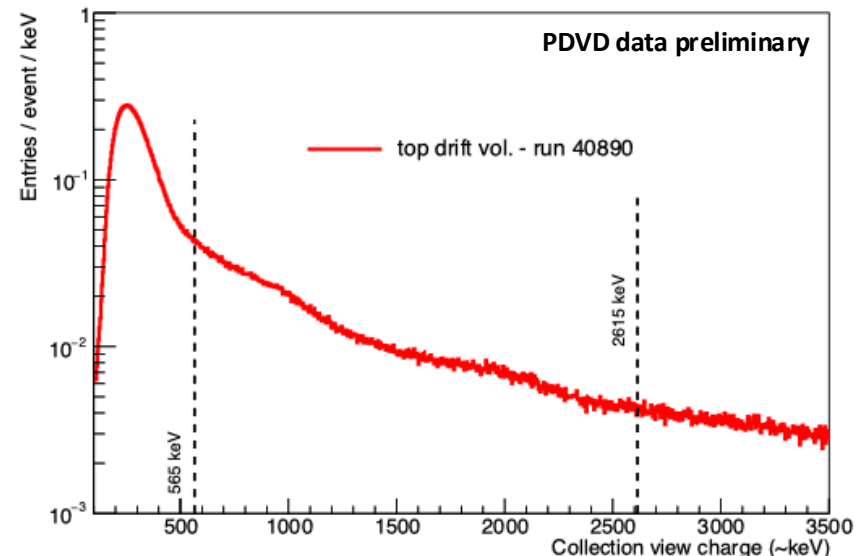
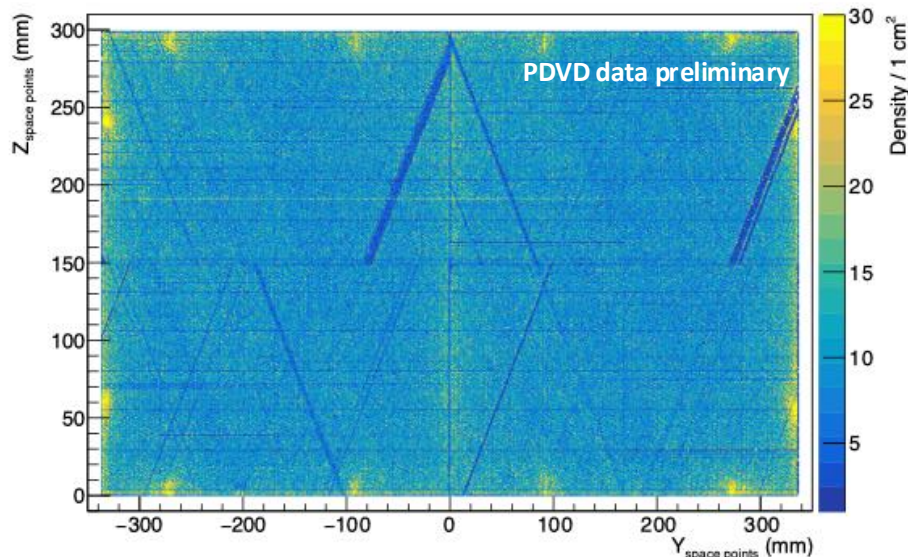


- Up to 8 laser periscopes are planned to be deployed in the FD-VD for calibration purpose
- LAr ionization from 266 nm UV laser
- Can check for E-field, dQ/dx , ... uniformity
- Test deployment started at PD-VD in Nov. 2025 with first tracks recorded!



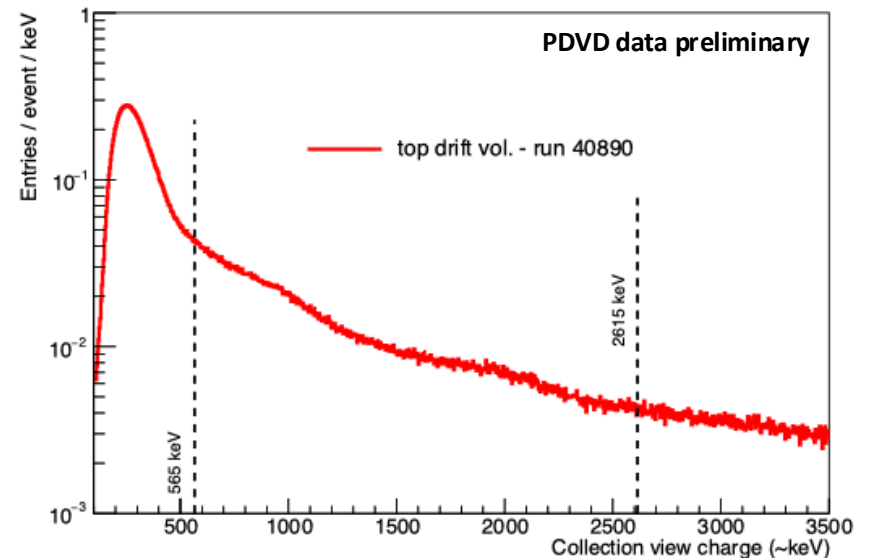
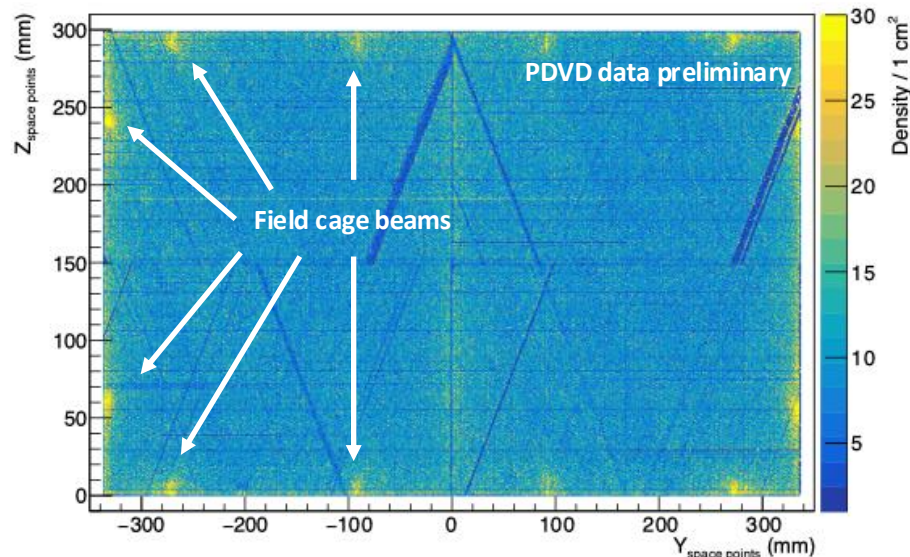
Very low energy event reconstruction

- Excellent electronics noise condition allows for very low energy studies
- Specific low energy blips reconstruction tools developed in DUNE
- ^{39}Ar spectrum partially reconstructed down to ~ 300 keV
- Structural radiologicals (^{232}Th & ^{238}U chain) visible, e.g. field cage beams



Very low energy event reconstruction

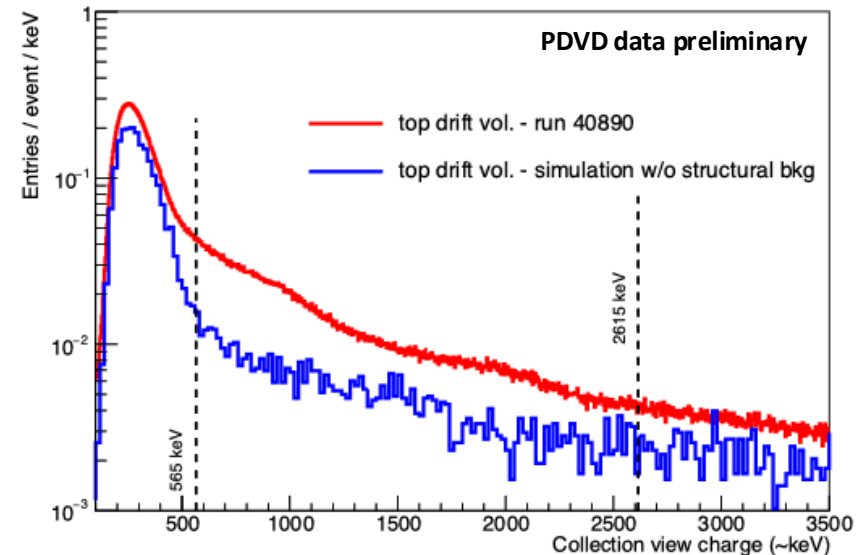
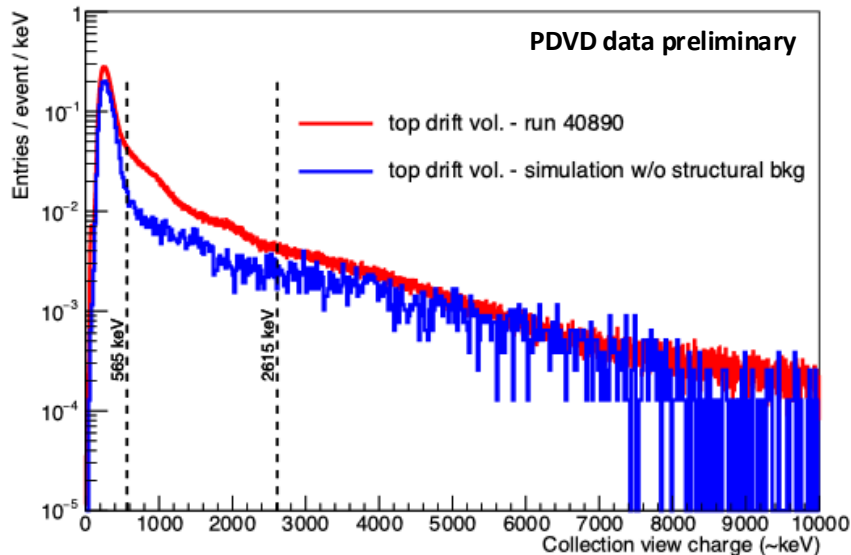
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Very low energy event reconstruction

- Low energy threshold well reproduced in MC
- As well as the higher energy tail from cosmics induced blips
- Need additional work to assess the structural activity and compare with screening data
- Will allow recombination, SCE and calibration studies with high ^{39}Ar statistics

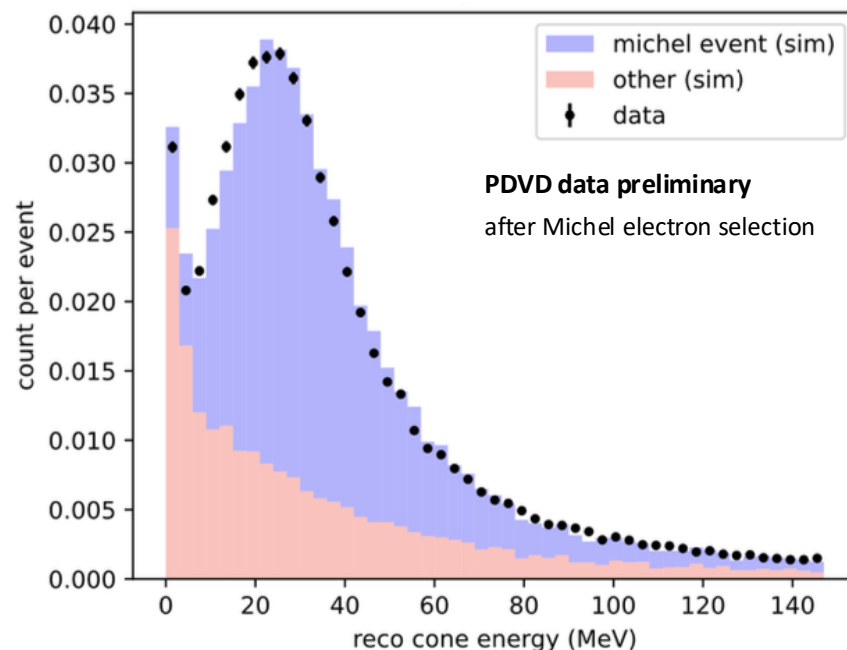
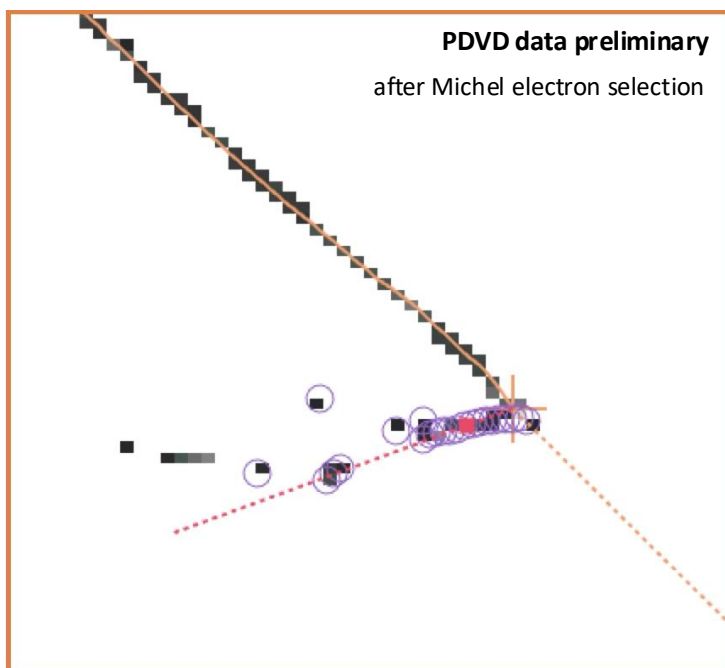
→ Work in progress



Low energy event reconstruction

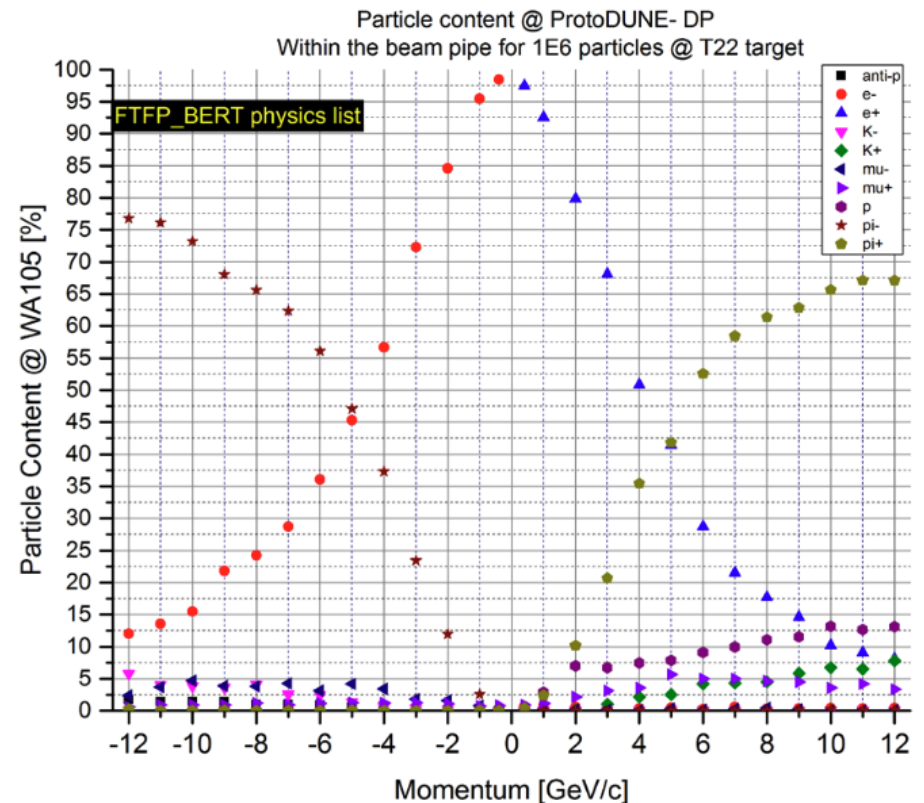
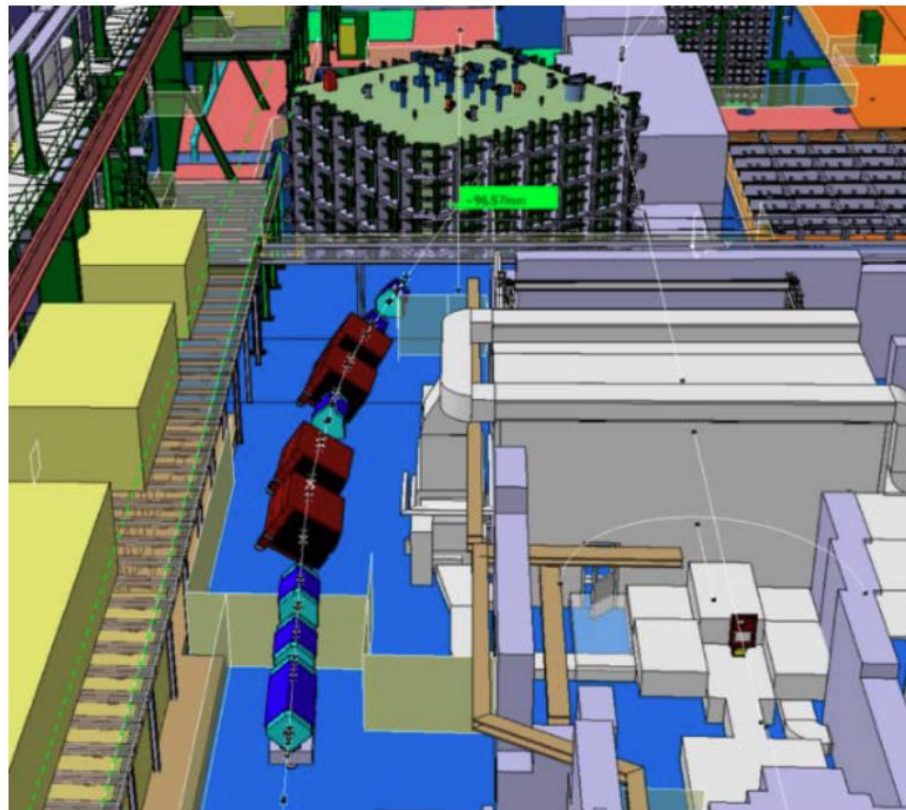
- Another standard candles are the stopping muons and eventual coincidence Michel electrons
- Energy spectrum in the [0-60] MeV range
 - relevant for inferring performance w.r.t. SuperNova Burst neutrino events

→ Work in progress



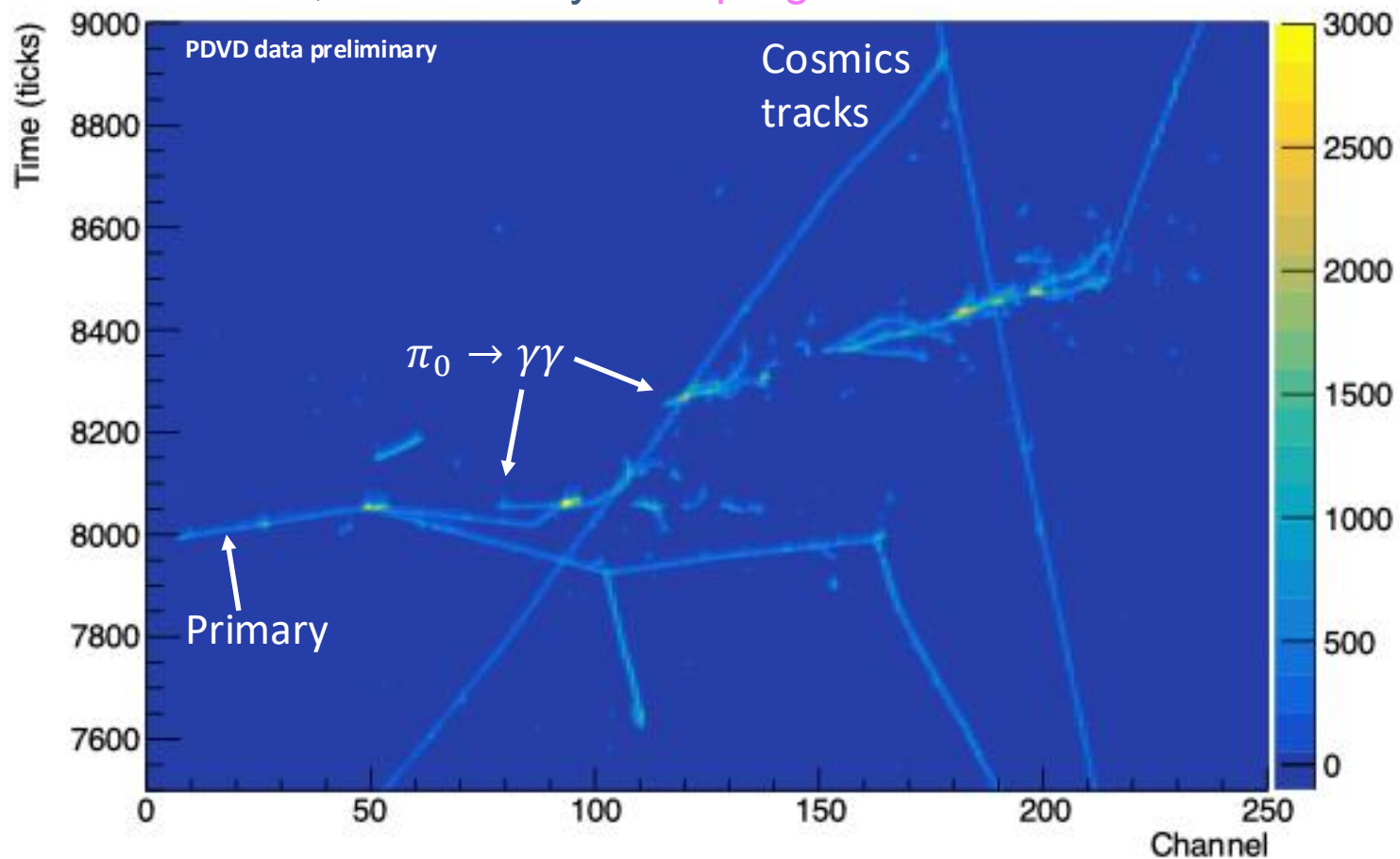
Beam runs – H2 VLE line

- H2-Very Low Energy beam line studied in 2016 with simulation for PD-Dual Phase and commissioned in 2018 at EHN1
- Can study showers from [0.5-8] GeV electrons and pion interactions [2-8] GeV

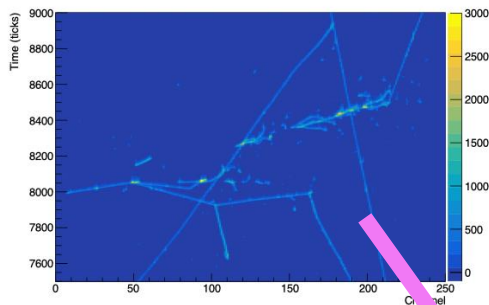


Beam runs – Event display

- 3 GeV/c pion candidate
- Full 3D reconstruction, PID & analysis **in progress**

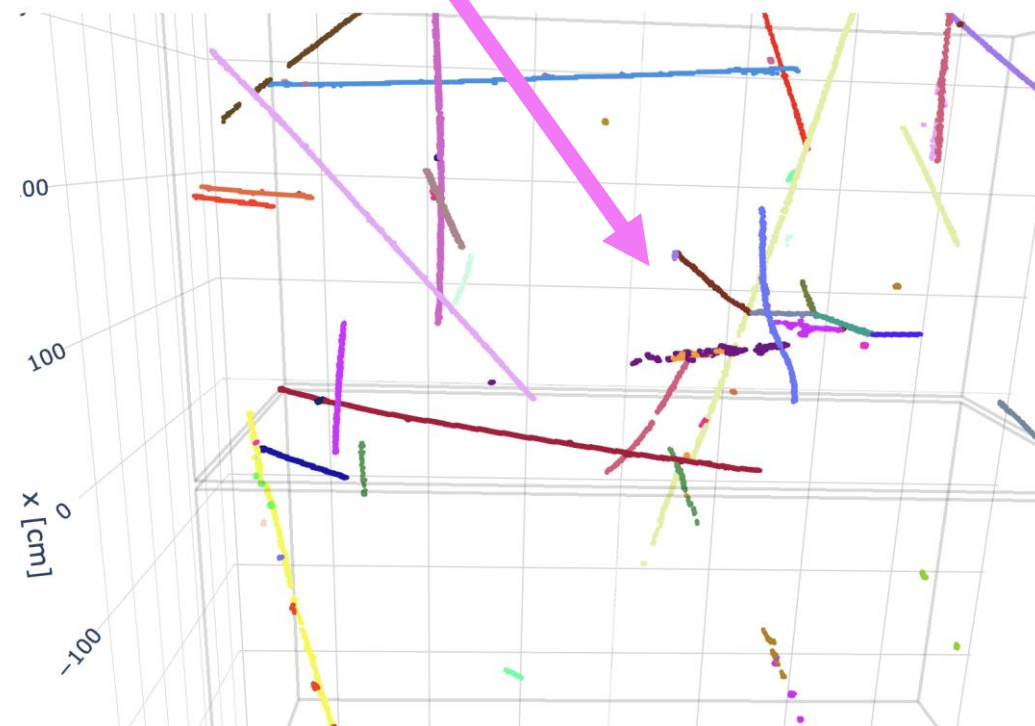


SPINE at work



- Data preparation, training sample, post-processing
- Encouraging preliminary results from inference

PDVD data preliminary



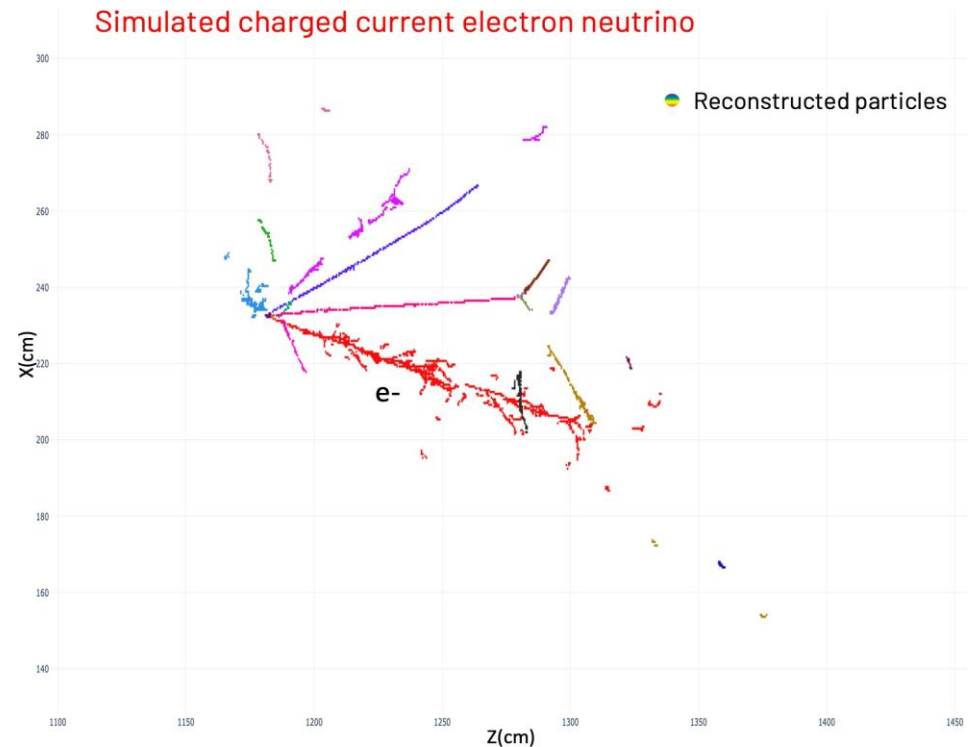
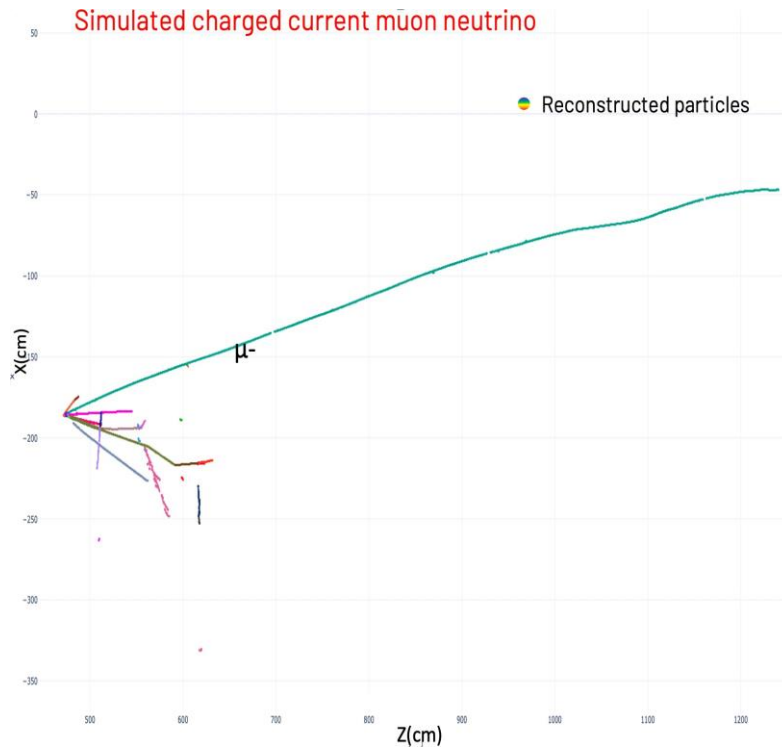
PDVD sim preliminary

Class prediction	Shower	Track	Michel	Delta	LE
LE	0.009 (40376)	0.000 (10333)	0.003 (595)	0.003 (2569)	0.901 (997929)
Delta	0.017 (77190)	0.005 (152477)	0.021 (3519)	0.755 (678841)	0.004 (4788)
Michel	0.001 (6451)	0.000 (11548)	0.821 (140166)	0.001 (1056)	0.001 (901)
Track	0.016 (73587)	0.990 (28813322)	0.068 (11537)	0.180 (161723)	0.014 (14980)
Shower	0.957 (4421248)	0.004 (120732)	0.087 (14834)	0.061 (54652)	0.080 (88950)
		Class label			

Class prediction	Photon	Electron	Muon	Pion	Proton
Proton	0.000 (0)	0.000 (0)	0.036 (138)	0.184 (9)	0.603 (38)
Pion	0.011 (1)	0.000 (0)	0.052 (198)	0.571 (28)	0.254 (16)
Muon	0.000 (0)	0.015 (1)	0.910 (3449)	0.245 (12)	0.143 (9)
Electron	0.183 (17)	0.687 (46)	0.001 (2)	0.000 (0)	0.000 (0)
Photon	0.806 (75)	0.299 (20)	0.001 (2)	0.000 (0)	0.000 (0)
		Class label			

SPINE at work

- Now being implemented for the Far Detector analysis pipeline



Outlook & perspectives

- Some advances happened in neutrino oscillation physics but yet no definite measurements of the mass ordering CP violation
- **DUNE construction is underway to address open fundamental questions in the lepton sector starting in 2030!**
- Major progress in hardware procurement at IN2P3 over the last 2 years
 - FDVD Cryostat construction starts this autumn
 - FDVD Detector construction starts in 2027
- **The Vertical Drift Far Detector prototype, ProtoDUNE-VD is taking sensible data at CERN since august 2025**
- **LAr Xe doping to enhance the light yield is being tested**
 - This is critical for the success of the light collection in the FD-VD