

PERFORMANCE OF THE DUNE VERTICAL DRIFT TECHNOLOGY ANODES



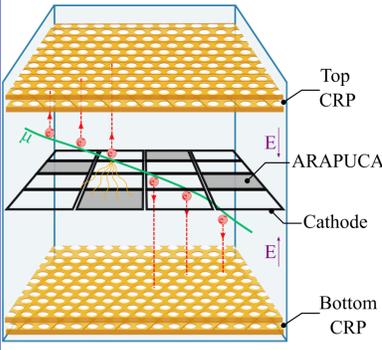
Laura Zambelli (LAPP/CNRS-IN2P3)
- For the DUNE Collaboration -



VERTICAL DRIFT LAR TPC

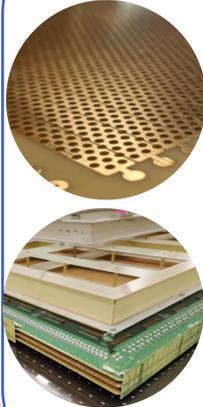
New concept for DUNE 2nd far detector module:

- Anode made of two drilled etched PCBs
- Cathode suspended, two drift volumes
- Different electronics for top and bottom anodes
- Photon detection system use x-ARAPUCA modules on the cathode and on cryostat membrane wall

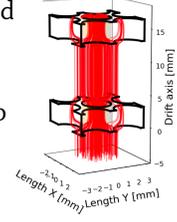


The DUNE Far Detector
Vertical Drift Technology TDR
arXiv: 2312.03130

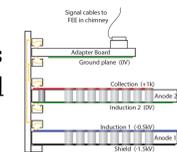
THE CHARGE READOUT PLANE



Anode made of two double sided perforated PCBs with etched copper strips at different orientation [-30°, +30°, +90°] to provide 2 inductions and 1 collection views.



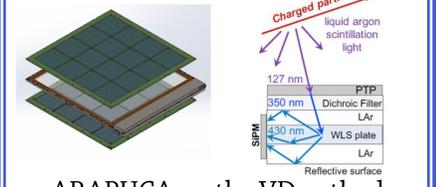
Each PCB face is biased to attract electrons through holes towards the last plane with full transparency.



The PCBs and their electronics are held in the Charge Readout Plane (CRP) modules (size of 3x3.4 m²)

LIGHT DETECTION

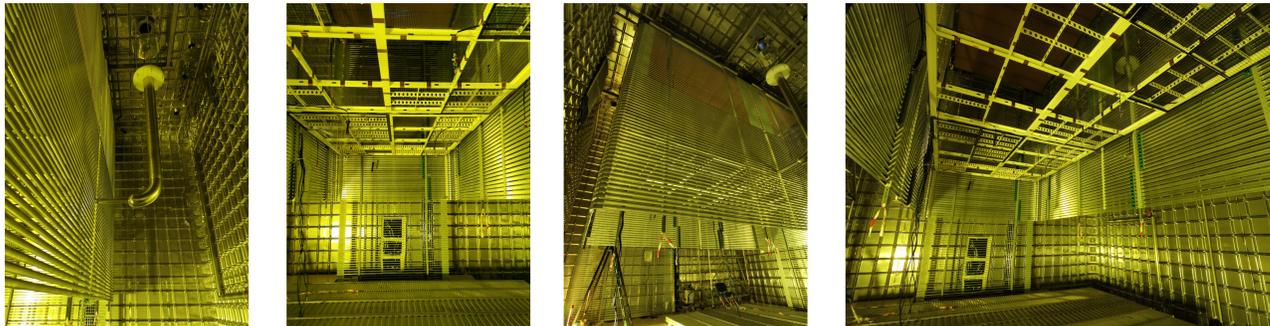
x-ARAPUCA: VUV light-trap device



x-ARAPUCA on the VD-cathode have to operate in a high voltage environment (-300kV)
↳ Signal & Power transmitted through fibers

F. Galizzi & L. Perez-Molina poster
S. Sacerdoti poster

PROTODUNE-VD

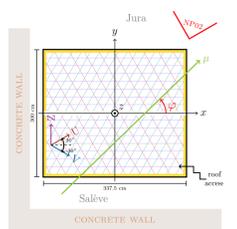


Picture credit: D. Duchesneau

Installed in the NP02 cryostat at CERN. Made of four CRPs (2 top, 2 bottom) and 16 x-ARAPUCAs (8 cathode, 8 membrane).

Active volume of 6.8 (W) × 3 (L) × 7 (H) m³

THE COLD BOX

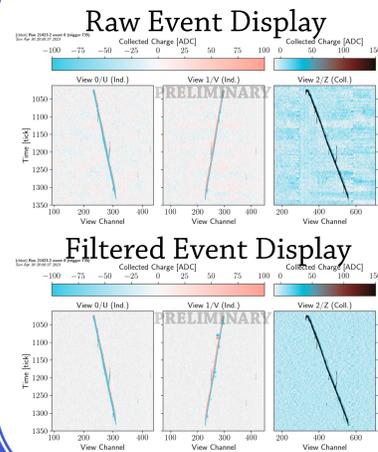


Each CRP were characterized in a small instrumented TPC with ~20 cm of drift.

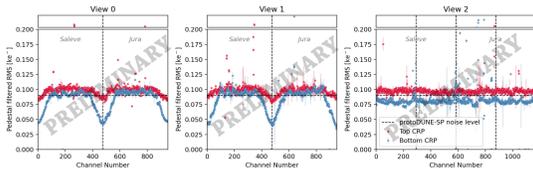


All coldbox data reconstructed by LARDON software: noise filtering, hit finder, tracking in 2D & 3D
<https://github.com/dune-lardon/lardon>

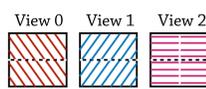
NOISE PERFORMANCE



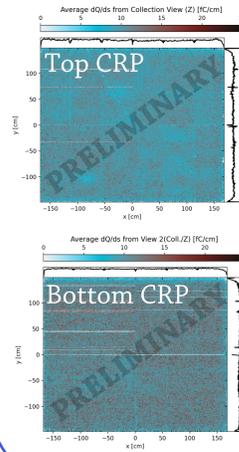
Main source of noise is the coherent noise. Filtered pedestal RMS is at same level of ProtoDUNE-SP.



Top (cold accessible) and Bottom (immersed in LAr) electronics have different behaviour to the strip and cable capacitances.



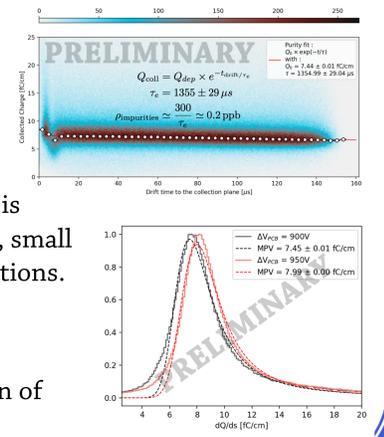
CALORIMETRIC PERFORMANCE



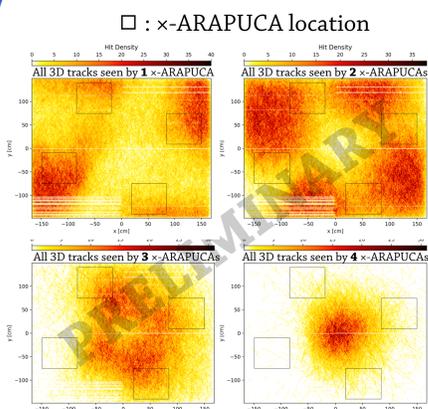
Reconstructed dQ/ds is corrected for the loss of electrons by impurities.

Average charge deposited is uniform across the CRPs, small loss at the PCB panel junctions.

Ongoing studies and simulations of the CRP transparency as a function of the bias voltages.



CHARGE & LIGHT MATCHING



Latest coldbox run successfully recorded synchronized charge & light events in the same file and format.

First analysis of reconstructed tracks matched with light peaks as a proof of principle

Four x-ARAPUCAs installed on the cathode with signal and power transmitted over fibers.

ANODE ASSEMBLY

Production of a single 3x3.4 m² PCB not industrially possible. Need to assemble PCB panels: two methods considered



3.2 mm thick rectangular panels glued on the border. Long and delicate procedure with risks due to strip connectivity (soldered) and PCB rigidity.

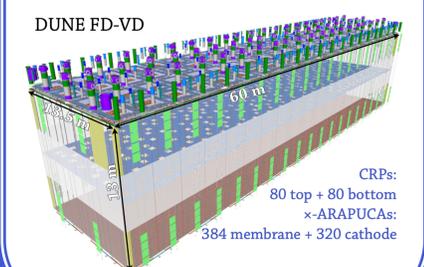


1.6 mm thick panels shaped along strip directions with adhesive tape on one face. Faster and simpler procedure but stringent constraint on hole alignment.

F. Boran poster Picture credit: D. Duchesneau

VD PLANNING

Sept'24: ProtoDUNE-VD Filling
2025: Cosmic + beam data
2027: Far detector construction
2029: FD-VD commissioning



DUNE FD-VD
CRPs: 80 top + 80 bottom
x-ARAPUCAs: 384 membrane + 320 cathode