

Brazilian Effort on Liquid Argon Detectors for Neutrino Physics



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Brazilian Contributions
on SBN



Brazilian Effort on Liquid Argon Detectors for Neutrino Physics

This white paper describes the main activities and projects of the Brazilian groups in the neutrino program based at Fermilab.

The main efforts are:

- Deep Underground Neutrino Experiment (DUNE).*
- Short Baseline Neutrino Program (SBN).*

DUNE

- Instrumentation (DUNE and protoDUNE) – Photon Detection FD1 and FD2
 - Production and assembly of X-ARAPUCA for protoDUNE HD
 - Filters evaporation protoDUNE HD and VD
- Computing
- **New proposal for FD3**
- Tests
 - LAr tests
- Material characterization
 - Tests on adhesion of PTP on the dichroic filters
- LAr purification
 - **Inovative material for LAr purification – PULArC setup**
- Software
 - LArSoft analyses
 - Simulations
- Phenomenology

DUNE physics program



Origin of matter. Investigate leptonic CP violation.

Precision oscillation physics and test of 3-flavor oscillation

Neutrino mass hierarchy



Neutron star and black hole formation. Ability to observe neutrinos from supernova events and perhaps watch formation of black holes in real time.

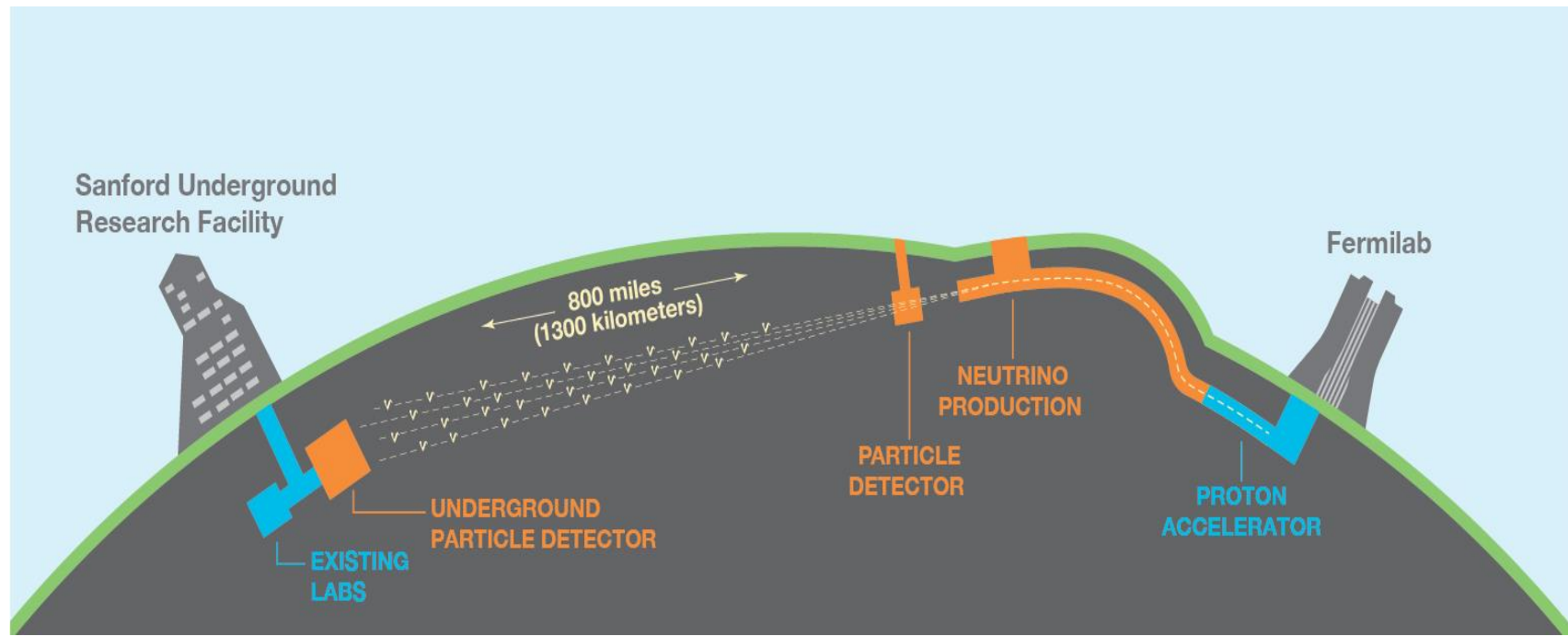


Unification of forces. Investigate proton decay, non standard interactions

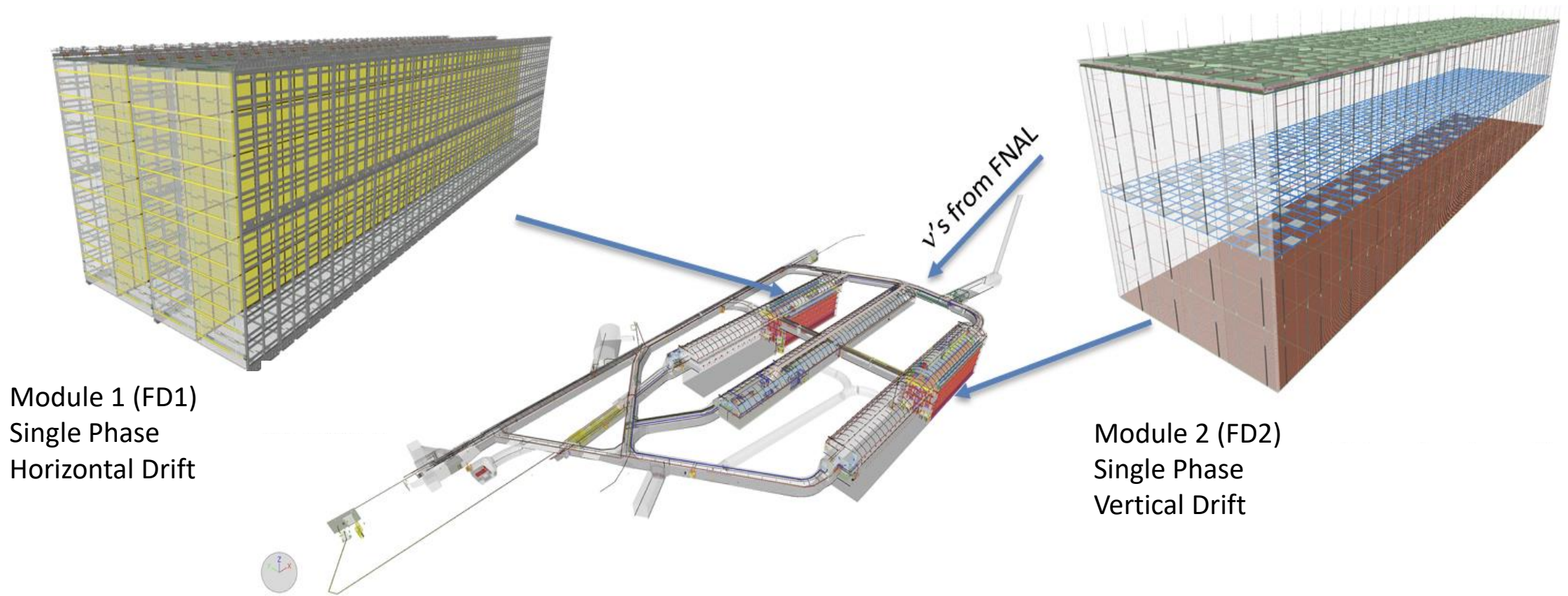


Atmospheric and Solar neutrinos.

Deep Underground Neutrino Experiment DUNE



DUNE Phase I - Far Detector



Module 1 (FD1)
Single Phase
Horizontal Drift

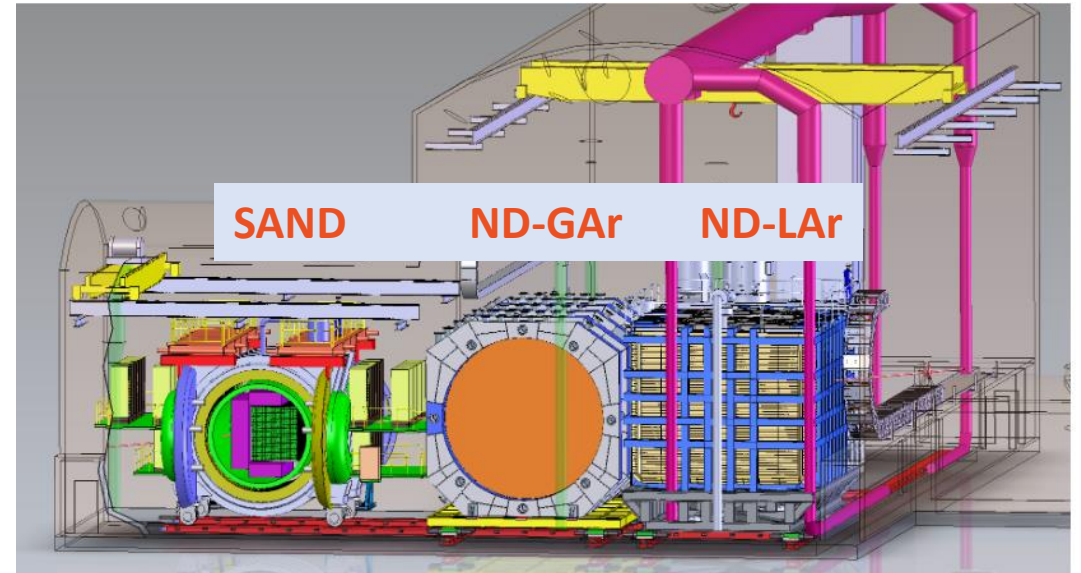
Module 2 (FD2)
Single Phase
Vertical Drift

CRP: Charge Readout Planes

APA: Anode Plane Assemblies

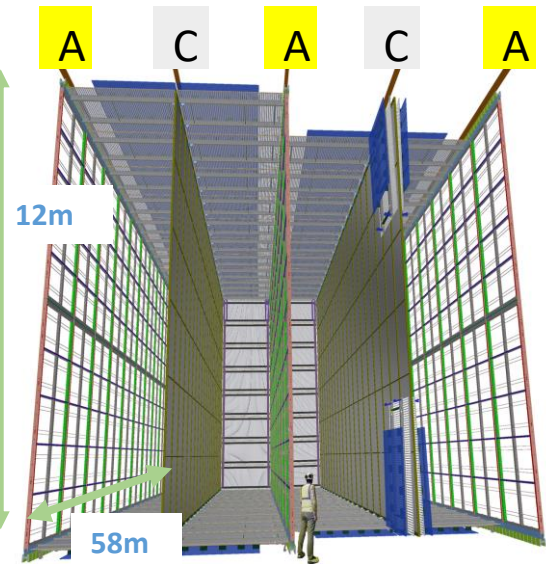
DUNE Phase II

- Beam power upgrade to 2.4MW
- Far Detector with 4 modules (**FD3 and FD4**)
- Near Detector : TMS replaced by ND-GAr
 - ND-LAr
 - ND-GAr → important for higher precision ν -Ar measurements and when the statistics reach **~200 kt-MW-yrs**
 - SAND



DUNE Far Detector (FD1 & FD2)

Horizontal Drift



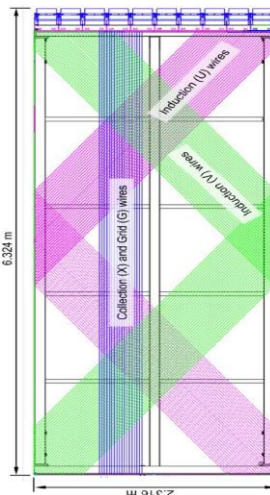
- **4 drift volumes** - 3.6 m drift
- Electric field = 500 V/cm
HV = -180 kV
- High-resistivity CPA for fast discharge prevention
- Anode: **150 APAs**, each with 4 wire planes (Grid, 2 x Induction, Collection)

- Photon Detectors: **X-ARAPUCA**
10 modules / APA

Total of **1500 modules**



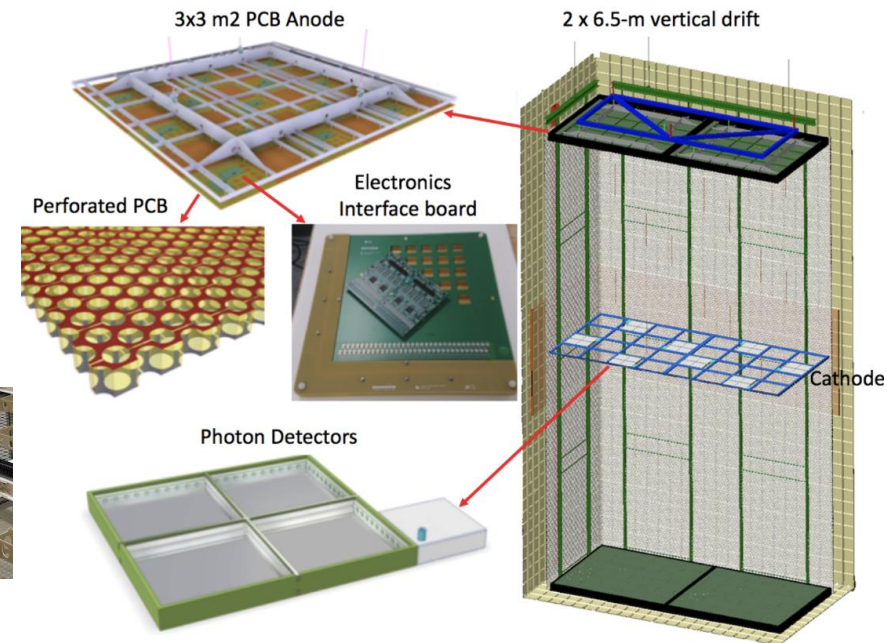
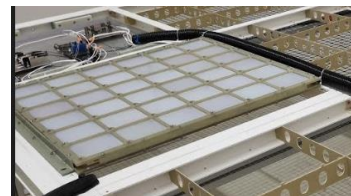
X-ARAPUCA module
(212cm x 12cm)



Vertical Drift

- **2 drift volumes** (13.5 m x 6.5 m x 60 m) → 6.5m drift
- 2 Anode planes (top & bottom)
- Charge Readout Planes (CRP) → **perforated PCB**, fully immersed in LAr
- Cathode in the center at ~300kV

PD: Large size
X-ARAPUCA tile
(0.6 x 0.6 m²)



Photon detection system – HD

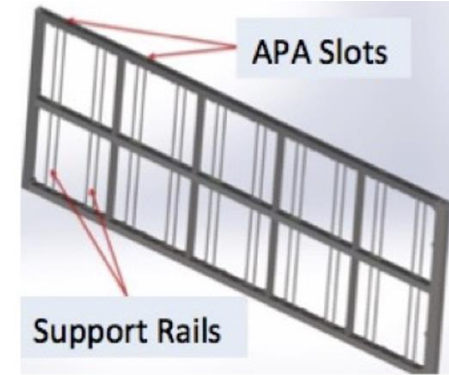
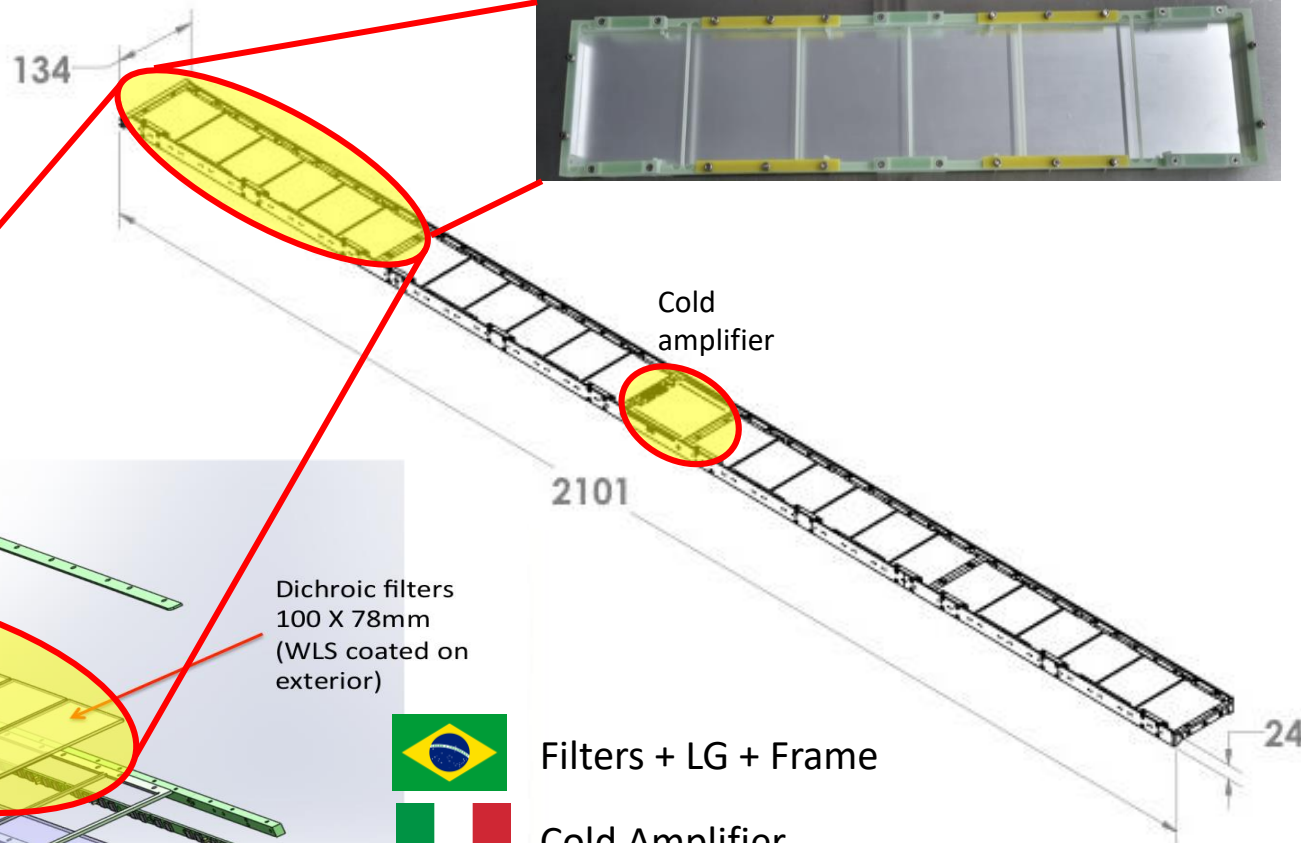
1 Module = 4 supercells

Supercell :

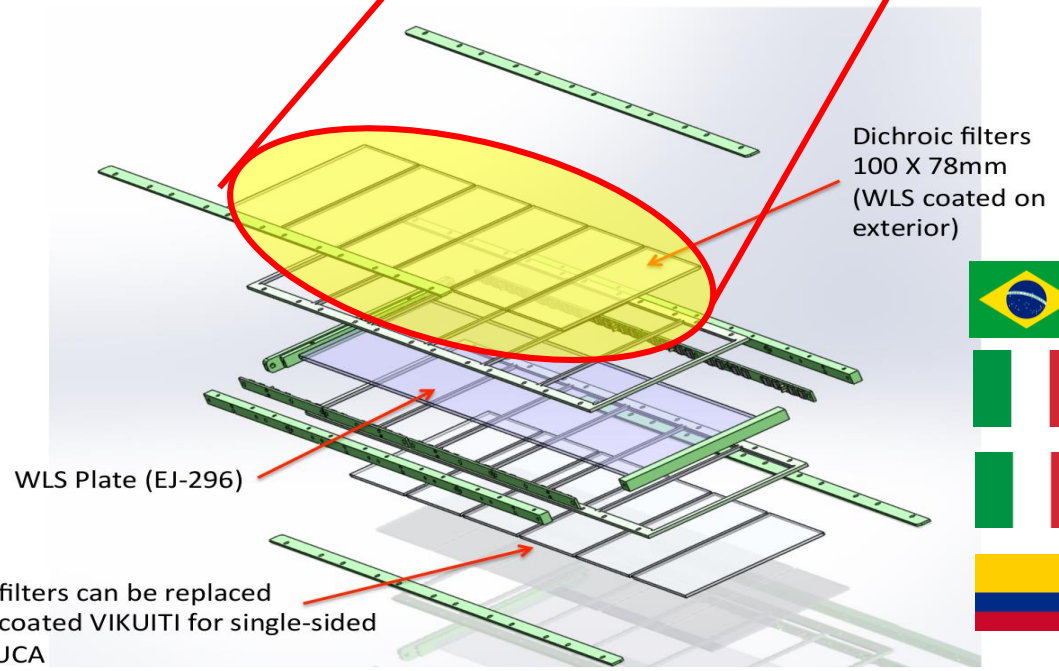
6 Dichroic Filters








48 SiPM

1 Light Guide



10 modules per APA
1500 in total
 500 double sided
 1000 single sided

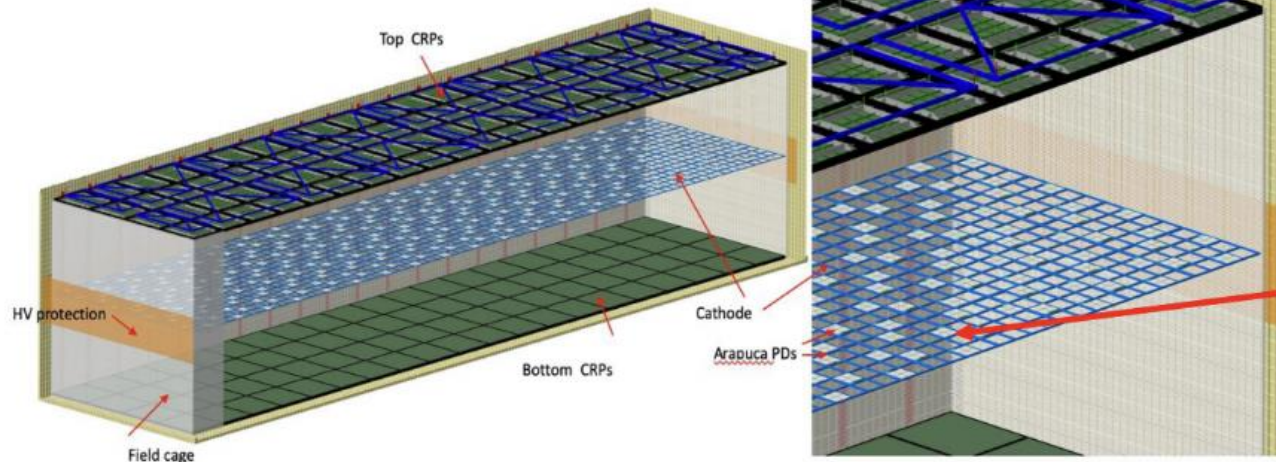


-  Filters + LG + Frame
-  Cold Amplifier
-   SiPM
-     DAPHNE

Filters → OPTO
 LG → Glass to Power
 SiPM → Hamamatsu + FBK

Photon detection system – VD

- The Vertical Drift does not have the mechanical constraints of the Horizontal Drift for the X-ARAPUCA modules.
- They have been re-designed with a square shape (60 x 60 cm²) in order to maximize the **Light Collection**
- The basic Megacell module - single sided - has 36 dichroic filters with 97X97mm²



Megacell: new version of the photon detection system

ProtoDUNE – HD & VD



We are preparing the run of **protoDUNE** to test the **final components** of Horizontal Drift and Vertical Drift far detector

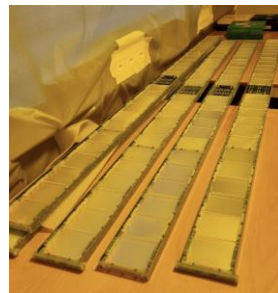
Horizontal Drift

- DUNE APA 2 top and 2 botom
- Photon Detection few different options are being evaluated

Two different SiPM type (**Hamamatsu** and **FBK**)

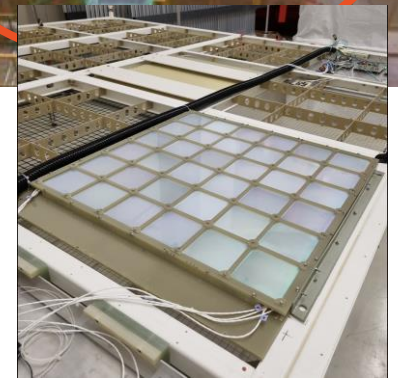
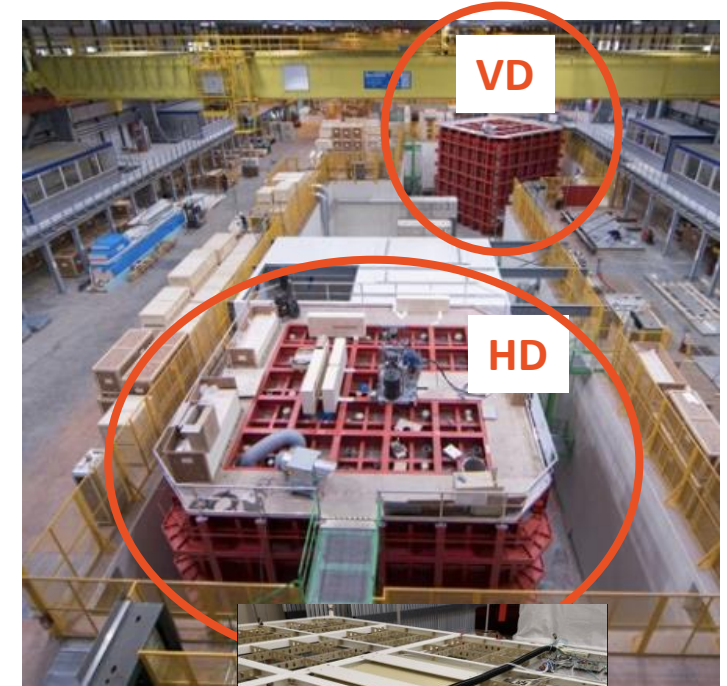
Two different light guide (**ELJEN** and **GlastoPower**)

Test of the electronics readout (**DAPHNE**)



Dichroic Filter dimensions

Size mm x mm	glass/batch #
97 x 97	25
202 x 97.5	14
150 x 150	12



Vertical Drift

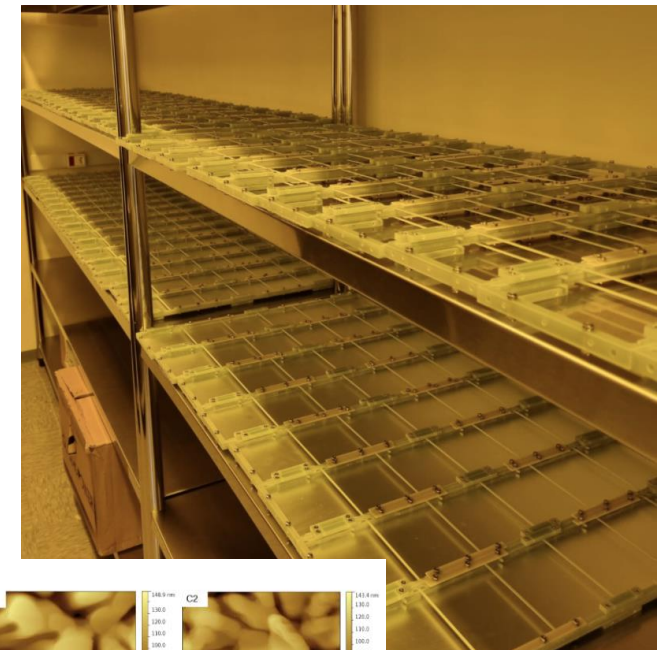
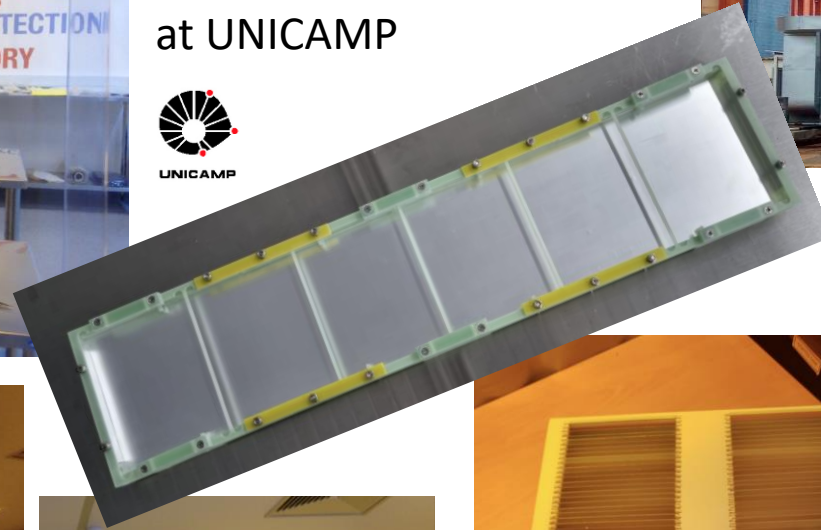
PDS

- New X-ARAPUCA modules

8 on the cathode (Power of Fiber)

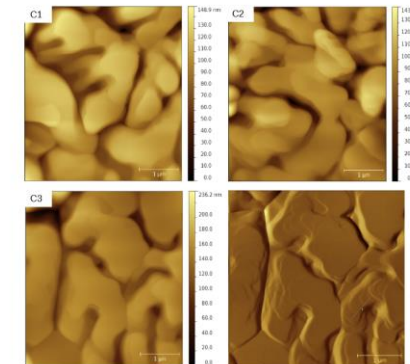
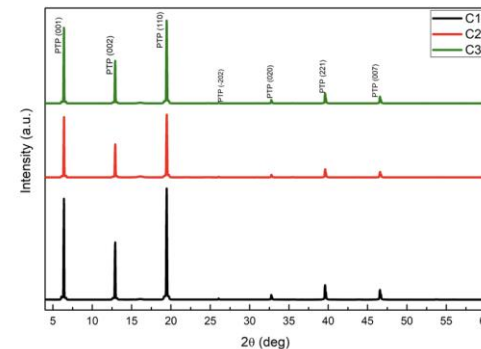
8 on the membrane

ProtoDUNE HD
200 supercells produced in
 Brazil and pre-assembled
 at UNICAMP



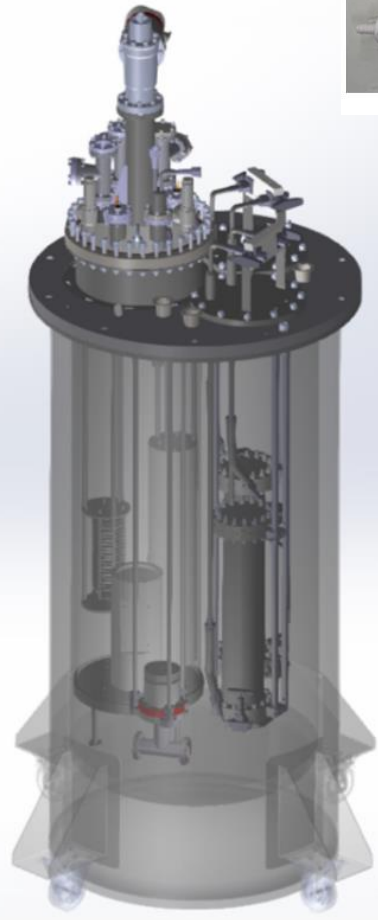
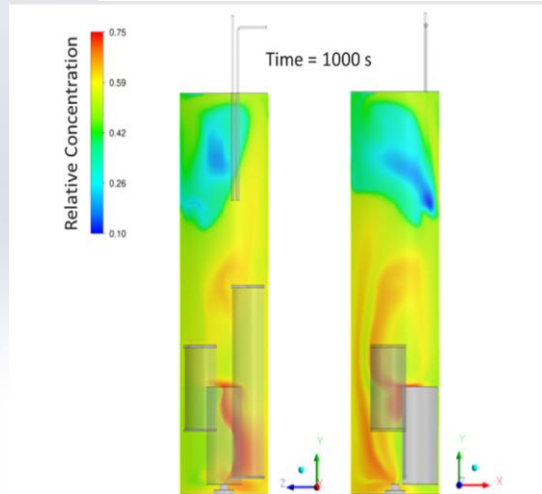
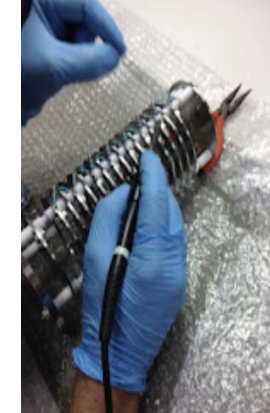
**ADHERENCE of PTP
 on dichroic filters**

1400 Short pass dichroic filters
 Produced by OPTO company
 (Brazil) – ProtoDUNE HD and VD



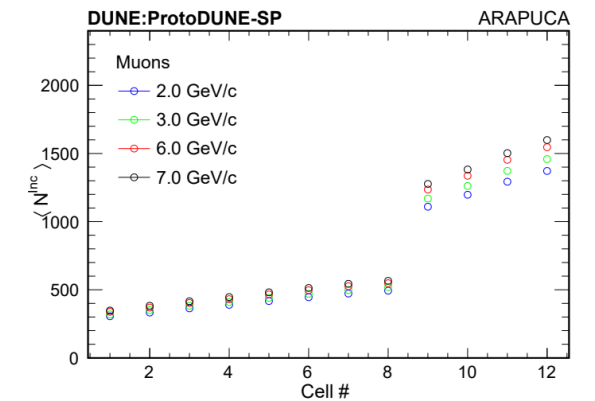
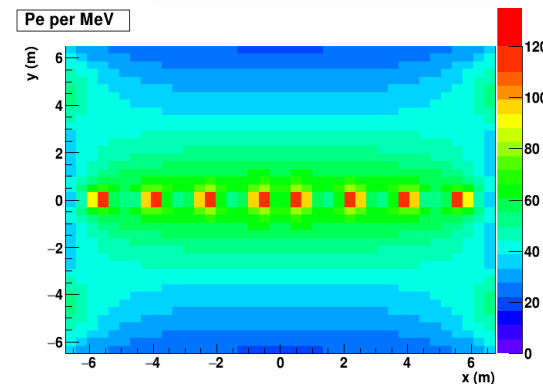
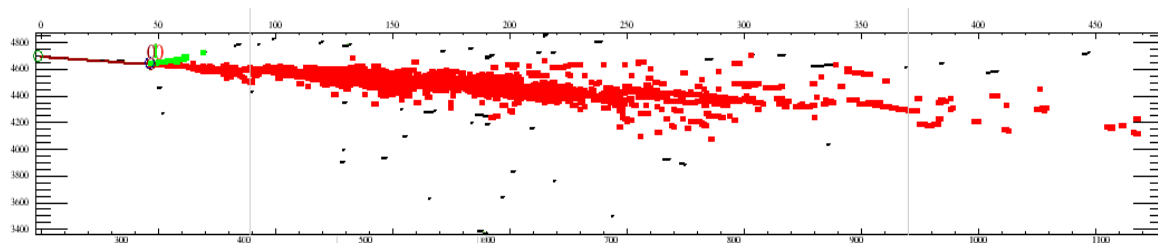
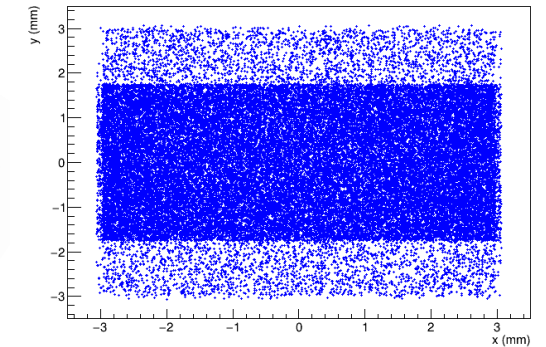
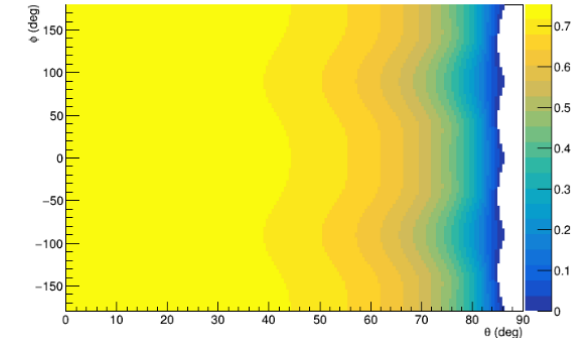
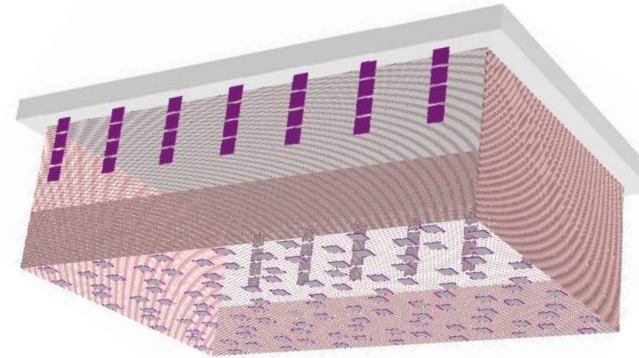
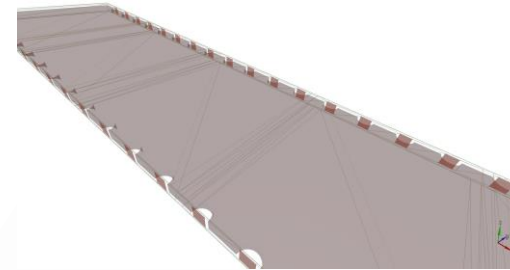
PULArC – Purification LAr Cryostat

Media Activation Cu-0226S – BASF (reference)



Software - PDS

- Simulation and data analysis of light detectors
- Modeling production and propagation of scintillation light in LAr
- Simulation and data analysis of (Proto)DUNE detectors and PDS
- Computational structure for light simulation (performance and data analysis)



UFABC – ITA – UTFPR - UNIFESP



SBND

Main contributions

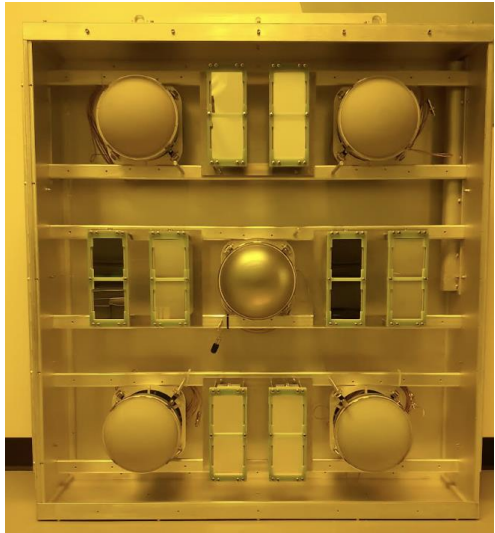
- Production, assembly, installation and tests of X-ARAPUCA system
- Evaporation of the dichroic filters
- Developments on the APSAIA readout electronics
- Developments on the ARARA readout electronics
- Simulations
- DAQ



X-ARAPUCA



PD-Box



TPC



PD-Box

APA + Photon Detection System



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DISCLAIMER

Last Minute presentation

- Because this presentation was prepared at the **last minute**, we apologize if we failed to mention all the projects and individuals involved. A more updated version will be provided soon."