Report experimental activities

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ABOUT ME

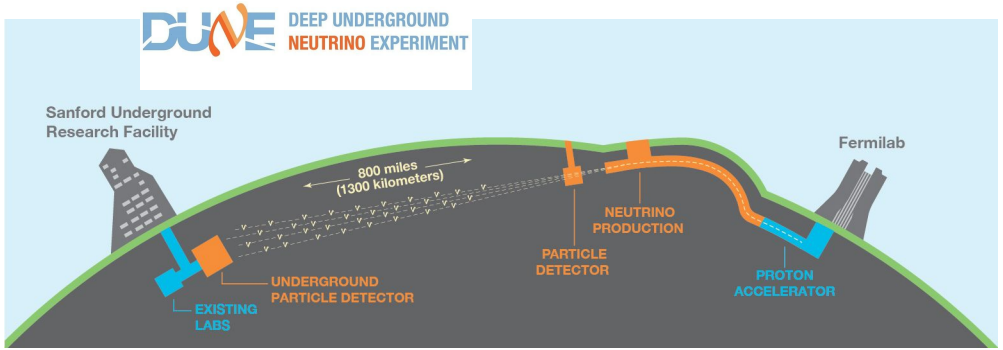
Electronic Engineer - UTFPR - Curitiba/Brazil
Master in Physics - UNICAMP - Campinas/Brazil

Università di Padova - since 2023

Working place: Napoli, **Università degli Studi di Napoli Federico II**

- Supervisor: Francesco di Capua
- **Dottorato Nazionale** in **Tecnologie per la ricerca fondamentale in Fisica e Astrofisica**
- **Curriculum: Rivelatori, laser e ottica**

DUNE - Deep Underground Neutrino Experiment
Neutrino oscillation experiment



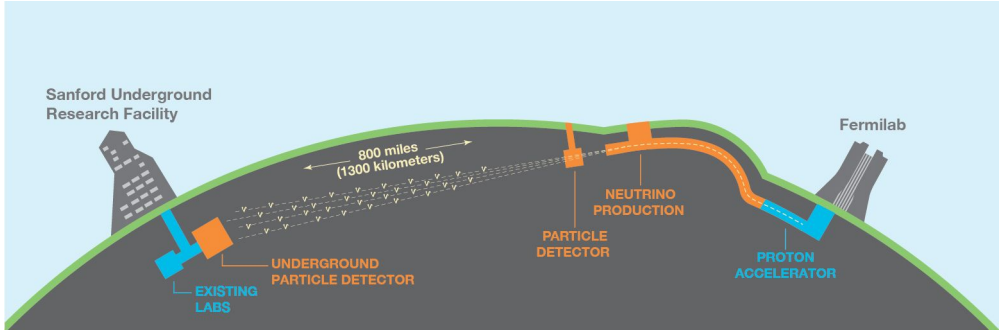
Deep Underground Neutrino Experiment (DUNE)

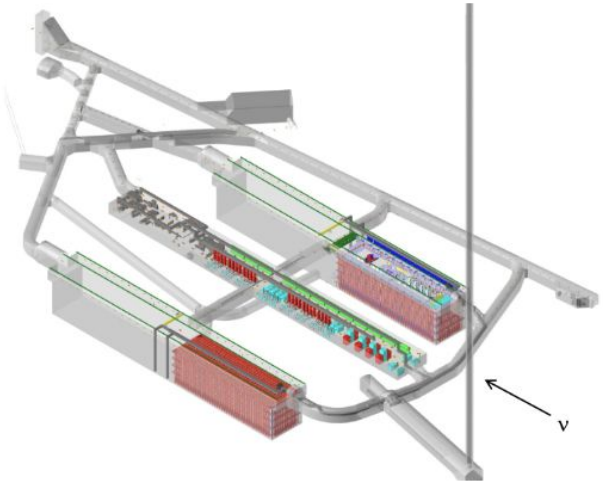
Next generation international neutrino oscillation experiment

GOALS

- Determine CP violation in leptonic sector
- Neutrino mass hierarchy
- Proton Decay
- Study of supernova neutrinos
- Others Beyond Standard Model searches

- Neutrino Beam: from 1.2 up to 2.1 MW proton beam
  → muonic neutrinos from 0.5 to 5 GeV
- Near Detector (ND): Characterize the Neutrino Beam
- Far Detector: 1300 km from ND, 4 modules



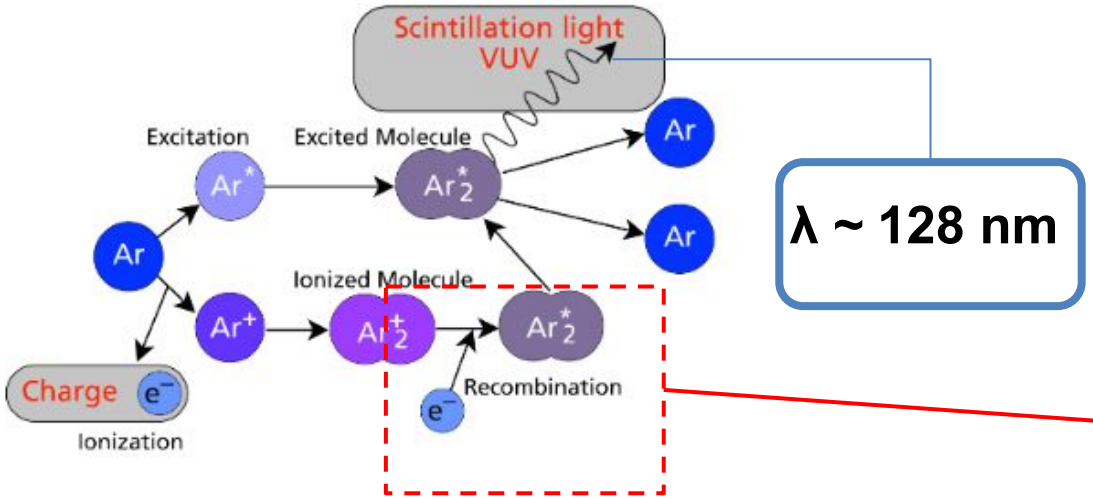


4 LArTPCs of **17 kton** each and **1.5 km** underground

- Phase I :
  - **FD1 - Horizontal Drift LArTPC**
  - **FD2 - Vertical Drift LArTPC**
- Phase II :
  - **FD3 - Vertical Drift LArTPC ***
  - **FD4 - To be decided**

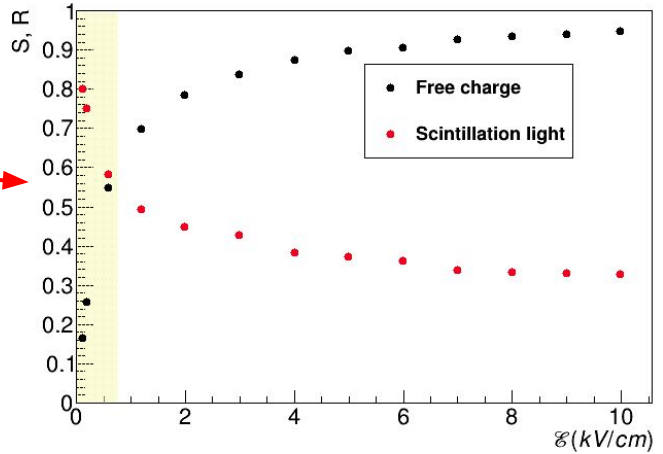
Liquid Argon Properties

- Production of photons in argon: 40000 photons/MeV @ 0 kV/cm



λ ~ 128 nm

- electron drift speed: ~ 1.6 mm/μs
- photon speed: ~ $2x10^5$ mm/μs



Slow component: 1.5 ~ 1.6 us
Fast component: 6 ~ 10 ns

Due to quenching, it is possible to do particle discrimination: Electron vs Nuclear recoil

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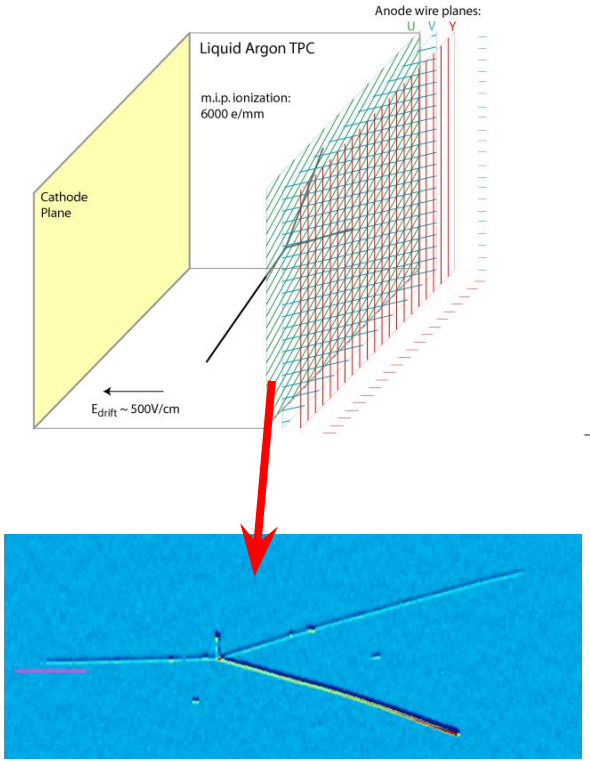
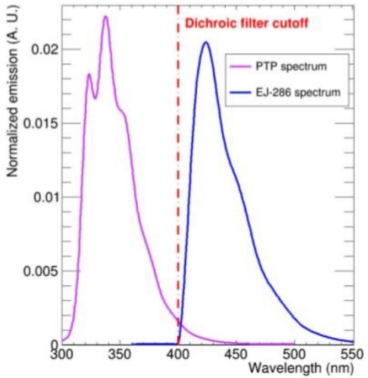
Liquid Argon Time Projection Chambers (LArTPC) and X-ARAPUCA

Charged particle in LAr produces free **ionization electrons** and **scintillation light** (128 nm)

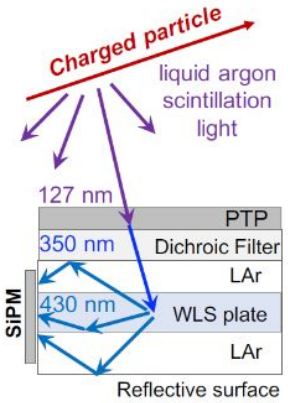


time

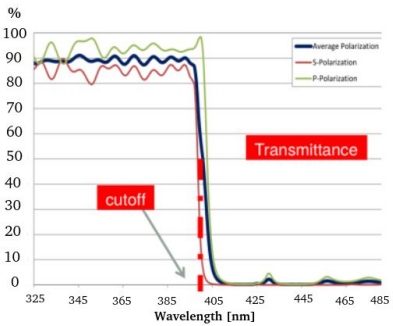


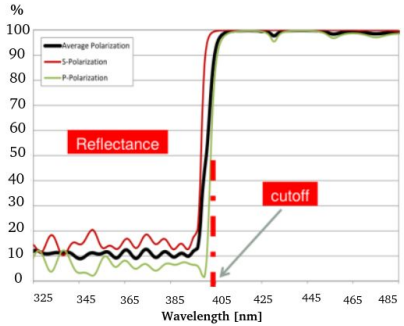
ARAPUCAs are light-collecting devices;

They are composed of:



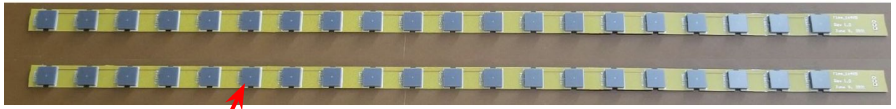
- Mechanical structure
- p-Terphenyl (pTP) layer
- Dichroic filter
- Light guide bar
- Reflective foil (Vikuiti)
- Silicon Photomultiplier (SiPMs)



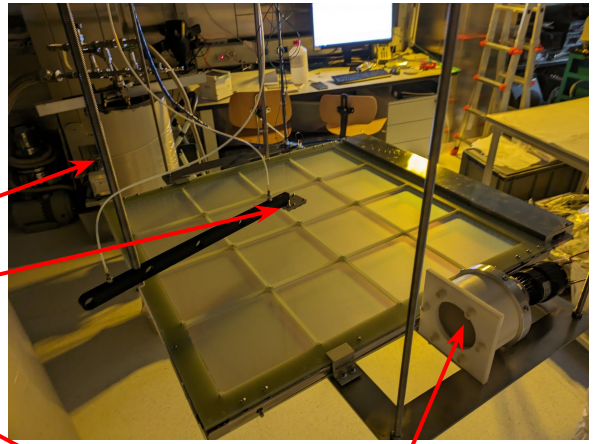


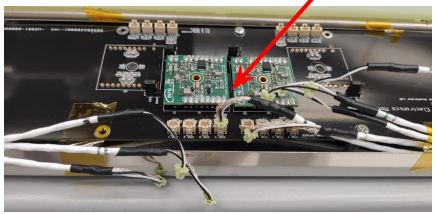
X-ARAPUCA FD2 Photon Detection Efficiency (PDE)

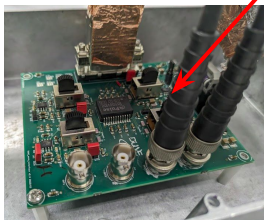
Two Data Campaigns: December 2023 and March 2024

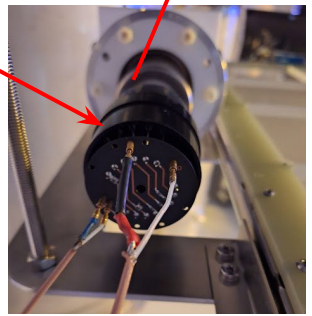


- Dimension 60x60 cm^2
- 16 dichroic filters → ZAOT filters (evaporated with PTP)
- A single large WLS light guide slab
- Glass to Power light guide slab with dimples
- Light readout by 160 SiPMs (6x6 mm^2) mounted on flexible strips
- ^{241}Am source connected to motion feedthrough (axial-rotation)
- Cryostat internal surfaces lined up with black Delrin light shield
- PMT for monitoring purity (through scintillation light slow component)
- Cold Transimpedance amplifier + Warm Amplifier



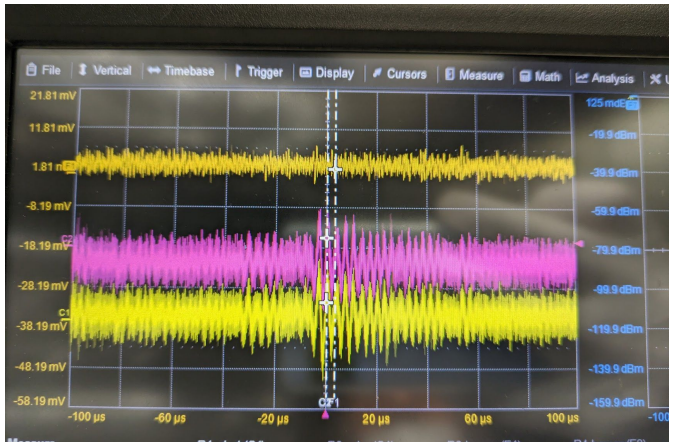


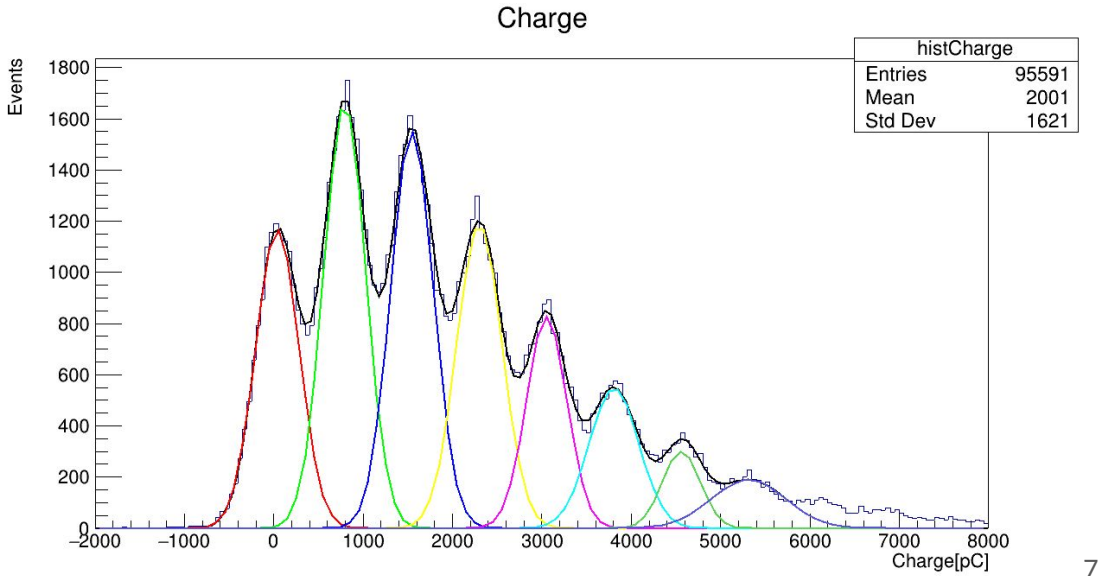




First run

- Noise problem
- Efficiency estimated using a total variation filter from literature, consumes much more computation time
- Waveforms with undershoot



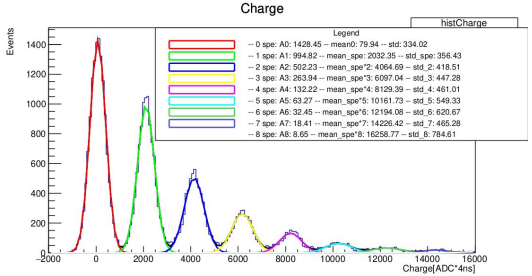


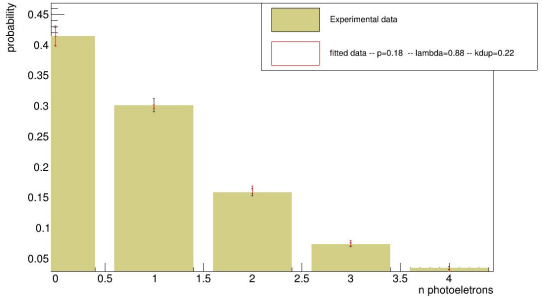
Second Run

Hunt and fix of noise problem: better grounding and use of isolation transformer

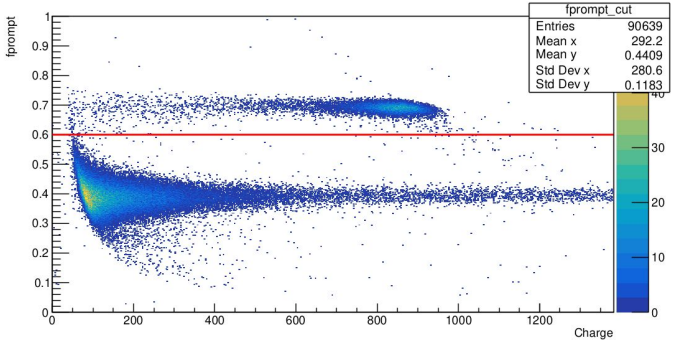
How to calculate efficiency:

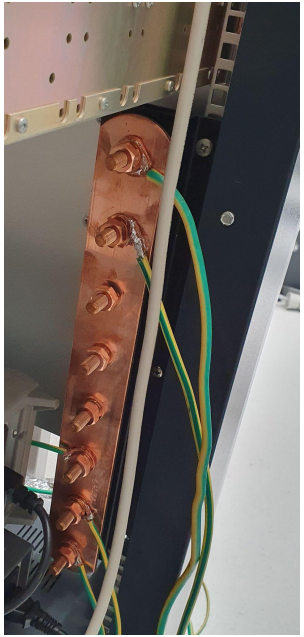
– Laser Run: finger plots + crosstalk probability

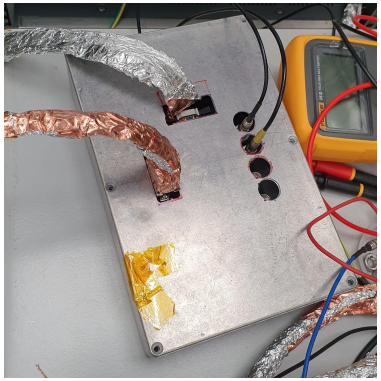


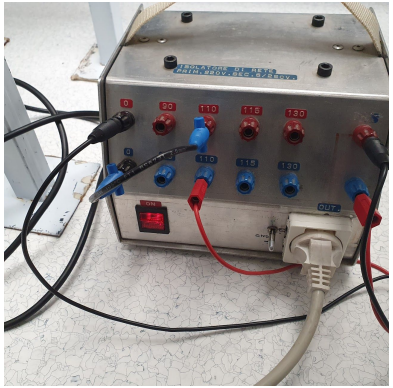


– Alpha Source Run: Alpha spectrum and compare with Monte Carlo simulation









$$eff = \frac{\text{n photoeletrons normalized 1+n photoeletrons normalized 2}}{\text{n photons monte carlo} * \text{purity}}$$

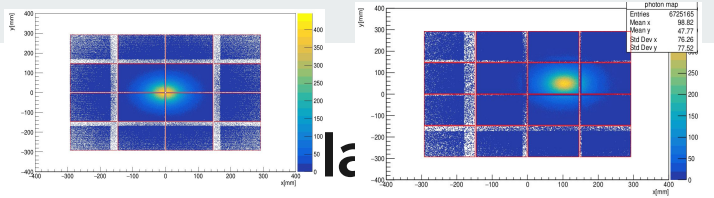
Analysis and simulation for two setups

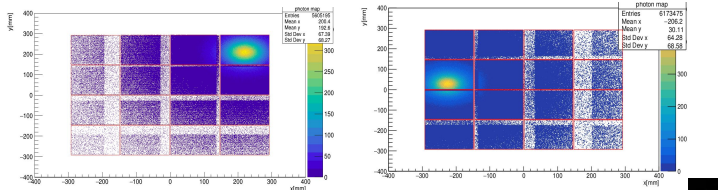
Analysis of the X-ARAPUCA efficiency of DUNE far detector vertical drift (MEGACELL)

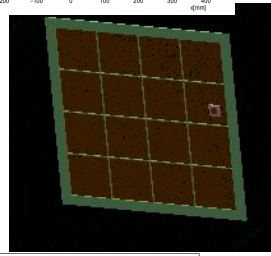
–At Naples: Analysis of the single face module

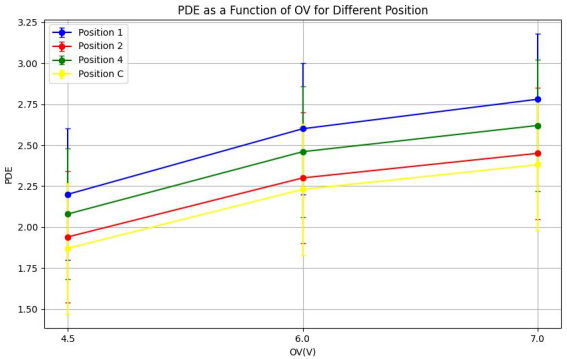
–At CIEMAT (Madrid) Analysis of double face module

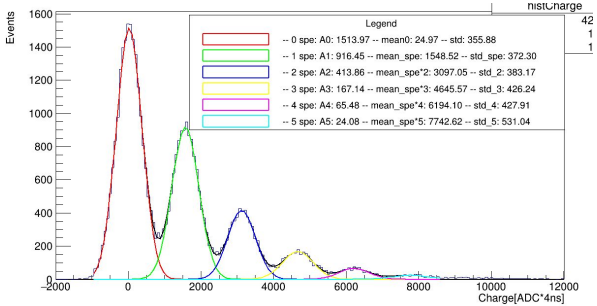
-Learned Geant4 to make Monte Carlo Simulations of the experimental setups

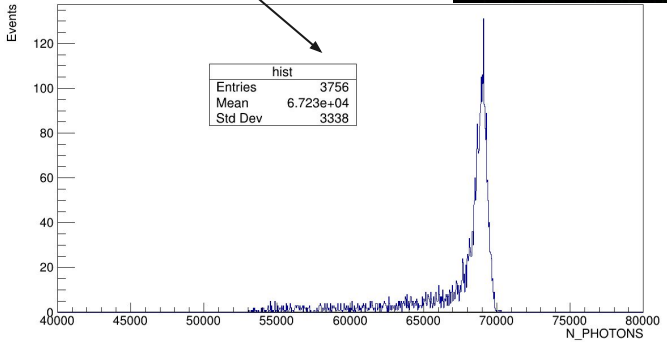






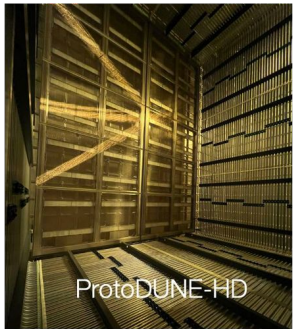


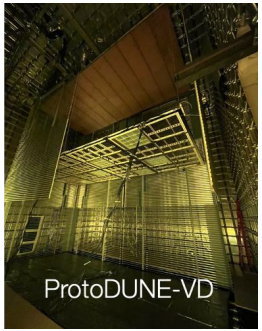


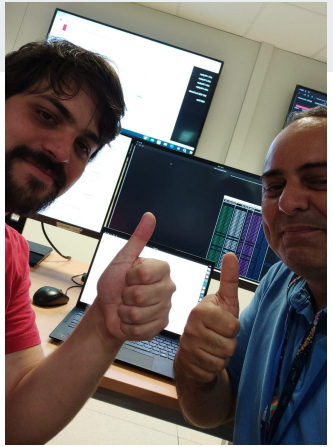


ProtoDUNE work @CERN

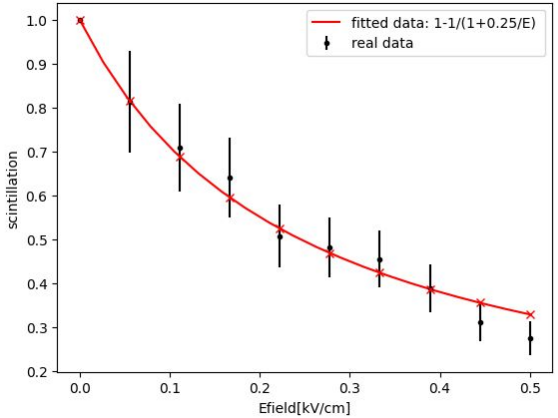
Shifts for the Proto-DUNE HD detector during the proton beam operation







Data analysis related to the scintillation yield as function of the electric field



Birk's Law:

$$Q = \frac{1}{1 + k/E}$$

$$S = 1 - \frac{1}{1 + k/E}$$

Study of electron recombination in liquid argon with the ICARUS TPC

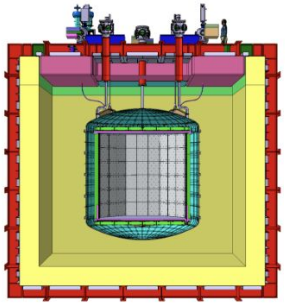
Going to present this results **tomorrow** at the DUNE Collaboration Meeting

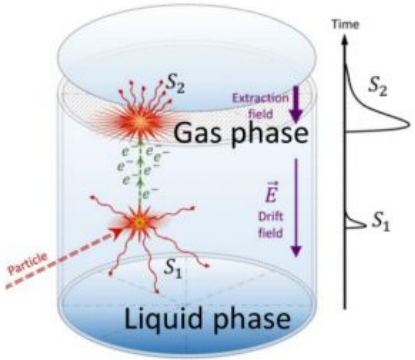
→ **Work on the PDS commissioning of ProtoDUNE-VD foreseen to the beginning of the next year**

DARKSIDE-20k:

Is experiment that uses a LArTPC for search of direct interaction of WIMPS (dark matter candidate)

– Dual Phase LArTPC





For DARKSIDE:

Responsible for the camera integration and application for the **Proto-0 experiment**

– Design and installation of mechanical structure to hold the camera and illumination system

– Installation and operating of camera and illumination system:

– WEB interface application

– Software routine for saving and compress files with photos and videos

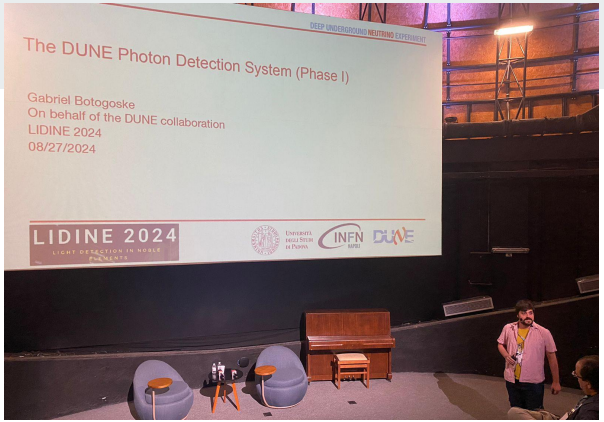
Goal:

- Check the LAr filling and level
- Gas Outlet

The light can be used also for calibration of the PDU (the photosensors)

Proto-0 is a TPC prototype of Darkside-20k experiment for R&D of liquid and gaseous argon interface, gas pocket characterization and validation of some main technical aspects

Schools and conferences



Participations:

- DarkSide Young Academy: 02/21/24 to 02/24/24 at Naples
- 15th International Neutrino Summer School 2024: 06/03 to 06/14 at Bologna
- LIDINE 2024: Light Detection In Noble Liquids: 08/26 to 08/28 in São Paulo/BRAZIL - Talk presented: **DUNE Photon Detection System**

Classes:

- **Rare event search with Time Projection Chamber –** Prof. Paolo Agnes and Prof. Mauro Caravati - need to scheduled exam
- **Cryogenics sensors for astroparticle physics -** Prof. Andrei Puiu - APPROVED
- **Cabling and Shielding for low noise applications -** Prof: Alberto Aloisio - APPROVED
- **Machine learning for physics -** Prof. Pierluigi Bortignon - need to scheduled exam
- **Vacuum Technologies -** Prof. Oscar Azzolini - April at LNL - APPROVED

Next Class:

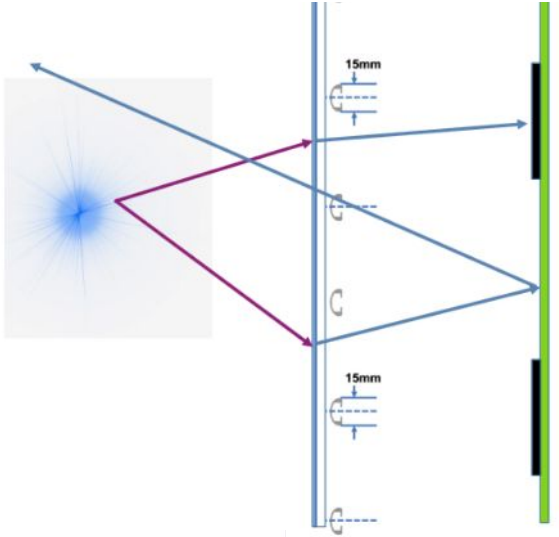
- **Applied Superconductivity: Quantum Phenomena and Quantum Systems -** September

FUTURE WORK

Study and build a small prototype of an new proposed idea for the **DUNE** Far Detector 3

Main features:

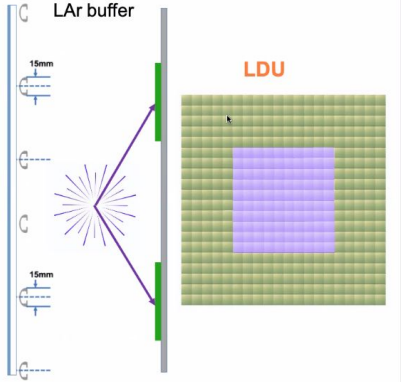
- LArTPC Vertical Drift
- Use of PEN (Polyethylene Naphthalate) as wls covering the field cage + acrylic
- Use of large matrix SiPMs (of the order about hundreds of cm^2) : SiPMs VUV and visible light sensitive



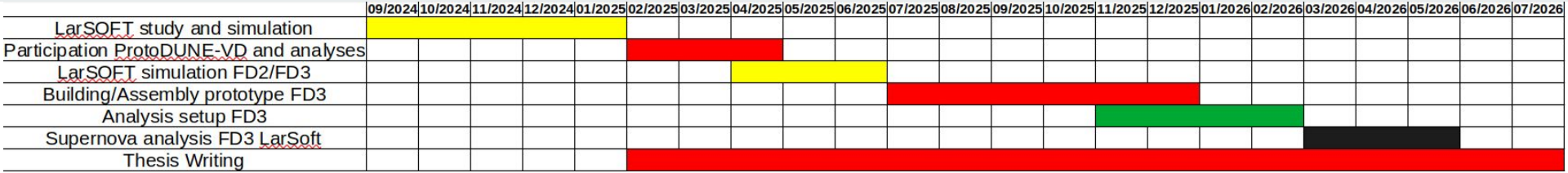
Ettore Segreto

Goal and Concept design:

- ❖ Build a small prototype with a small field cage covered with PEN
  - → test the photon efficiency collection with different sources
  - → test the veto capabilities
  - →light yeld improvement simulation using larsoft (FD2 x FD3)



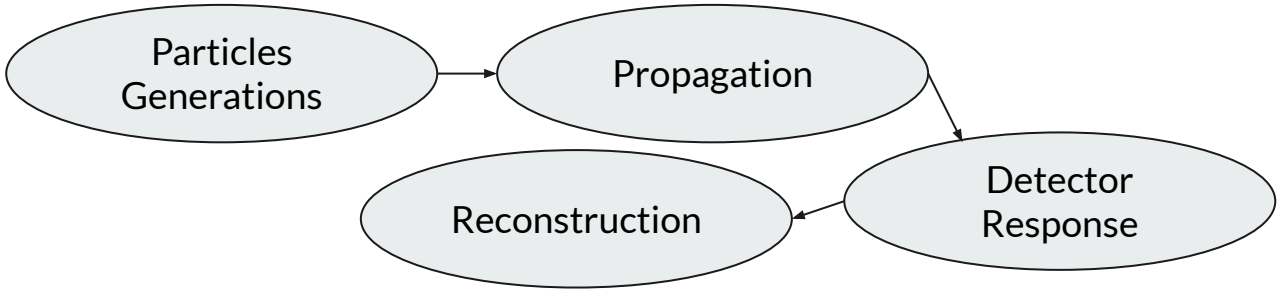
PLANNING



MORE FUTURE WORK

What is LArSoft?
A toolkit to facilitate simulation, reconstruction and analysis of events from liquid-argon TPC-based detectors

Study of Low Energy and rare events in DUNE experiment using Neural Network. The objective of this work is the use of convolutional neural networks for the detection of low-energy events, up to 5 MeV, to determine whether they were generated by solar neutrinos, supernova burst neutrinos or neutron background events. Comparison between the performances of FD2 and FD3



- Summary of performed activities
  - PDE of MEGACELL: Naples and Madrid
  - ProtoDUNE HD analysis – Light Yield at CERN
  - Camera and Illumination setup for Proto0 - Naples
  - Simulations using Geant4
  - Schools, conferences and lessons

- Future (and next coming) activities
  - Study of of new concept design of light detection system for DUNE FD3
  - Study of supernova neutrinos
  - Analysis of ProtoDUNE VD

MUITO OBRIGADO!!!!