LArTPC and Photon detection System in neutrino experiments.

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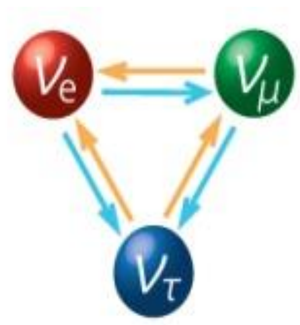
INTRODUCTION

In recent years, neutrinos have become the most mysterious and most interesting particles in physics for:

- 3 neutrino flavors.
- Neutrinos oscillate.
- Unaffected by magnetic fields
- Travel at the speed of light
- Neutral charge and less mass-> interacts with weakest forces.
- **Leptonic CP violation (PMNS Matrix)**



$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

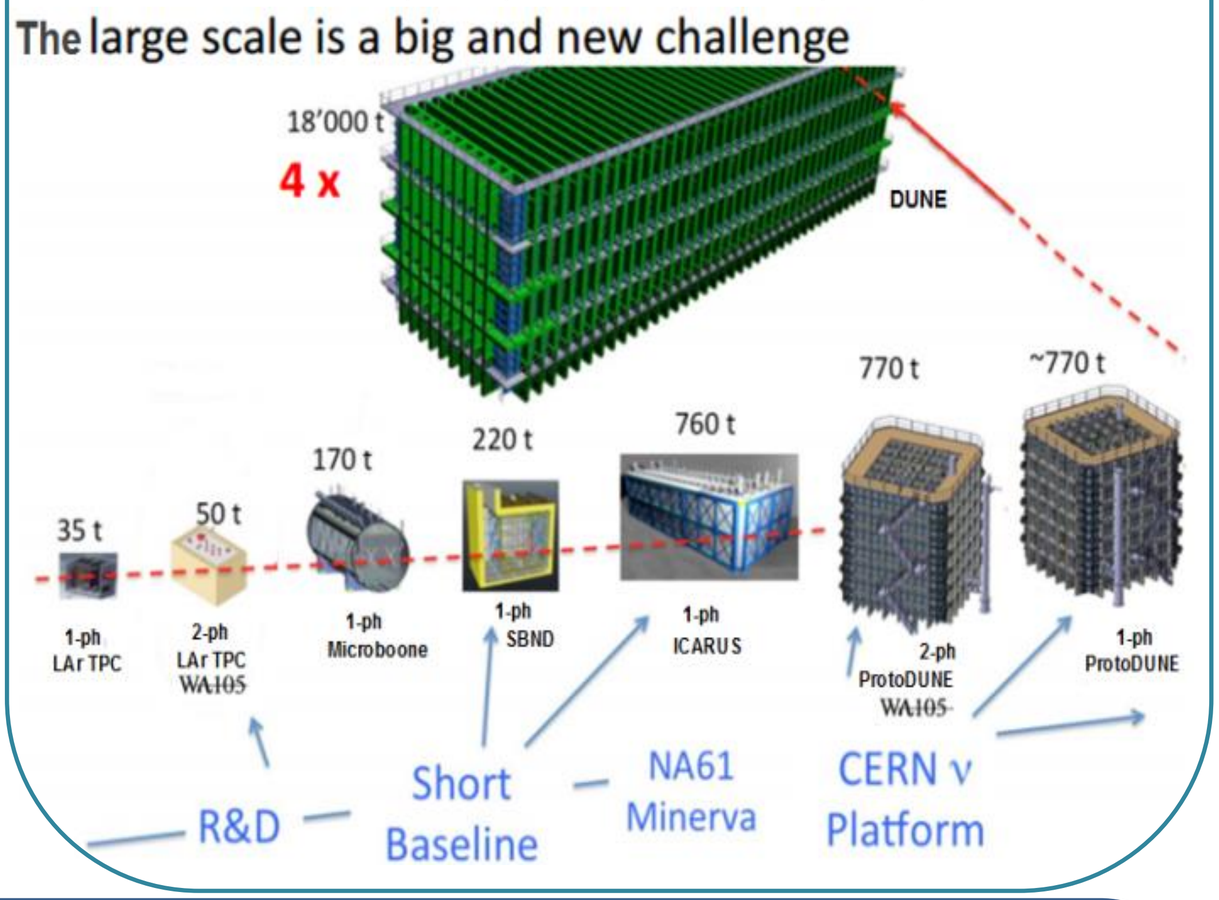
FLAVOR — PMNS matrix — MASS

Cij= cos Θij , Sij= sen Θij , δ -> Phase

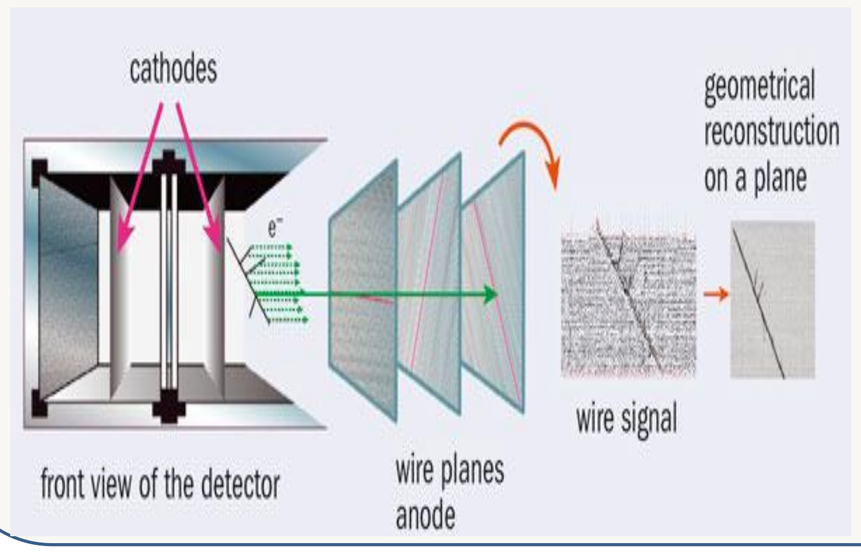
Current LArTPC experiments / projects:

ICARUS (2010)

-MicroBoone (2015) -CAPTAIN-MINERVA (2018)
-LArIAT (2014) -ArgonNeuT (2009)
-ProtoDUNE (2016) -DUNE (2023)



ELEMENTS AND CHARACTERISTICS OF THE LAr TPC



The Liquid Argon Time Projection Chamber (LAr TPC), an idea of Carlo Rubbia in 1977

Advantages:

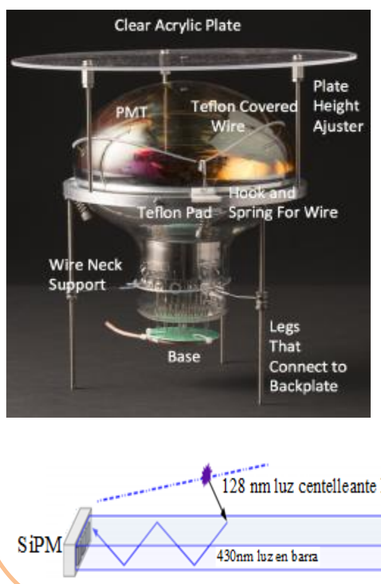
✓Allows an exact three-dimensional reconstruction of neutrino interactions.
✓They can discriminate photons from electrons,
✓Precise time of each event.
✓High operational stability,
✓Good light detection systems,
✓ Large sensitive area,
✓Excellent positioning resolution,
✓Energy resolution and particle identification,

WHY LIQUID ARGON?

	Water	He	Ne	Ar	Kr	Xe
Boiling Point [K] @ 1atm	373	4.2	27.1	87.3	120.0	165.0
Density [g/cm³]	1	0.125	1.2	1.4	2.4	3.0
Radiation Length [cm]	36.1	755.2	24.0	14.0	4.9	2.8
Scintillation [γ /MeV]	-	19,000	30,000	40,000	25,000	42,000
dE/dx [MeV/cm]	1.9		1.4	2.1	3.0	3.8
Scintillation λ [nm]		80	78	128	150	175

The liquid argon is cheap, it is not electronegative, good neutrino target, it is dense, inert and long drifts.

PHOTODETECTION SYSTEMS



The photon Detector systems are important for:

- Providing relevant information of the neutrino event.
- Complement the information of the Charge in the LArTPC.
- Contain elements for the collection of light: photodetectors, acrylic bars, wavelength shifter, system of installation in the anodic planes of the TPC.

CONCLUSIONS

- To study neutrinos, massive detectors are needed and building a LArTPC as large as DUNE´s is challenging. To achieve it, LArTPCs have been built with increasing size .
- The advances and changes that photon detector systems have presented at cryogenic temperatures in the last 3 years by the different experimental tests that have been developed for the detection of photons in a TPC with Argon Liquid.

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