Congresso di Dipartimento e della Sezione INFN
17-18 febbraio 2026

Innovative photo-detection systems for Liquid Argon TPC neutrino detectors

F. Boffelli, S. Copello, C. De Vecchi, A. Menegolli, C. Montanari, A. Rappoldi, G. L. Raselli, M. Rossella

(Pavia ICARUS-DUNE group)

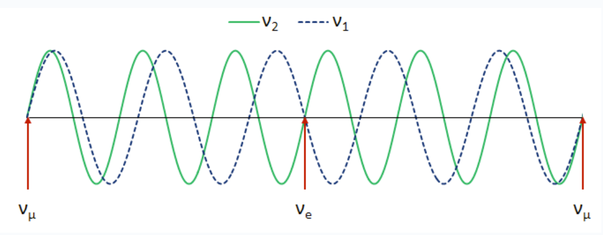
1. Neutrino Oscillation Physics in a few words

Neutrino oscillation is a quantum mechanical phenomenon proposed already in 1957 by B. Pontecorvo: oscillations are generated by the interference of different massive neutrino states ("Neutrino Mixing").

Mixing described by the unitary PMNS matrix:

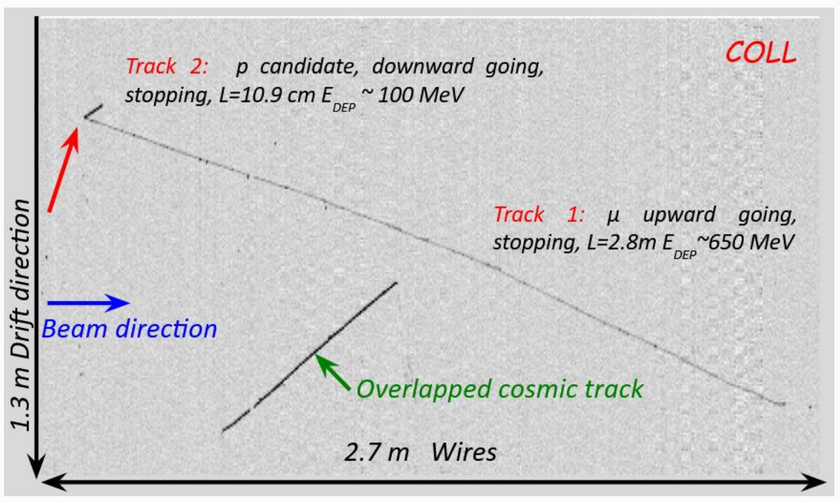
$$|\nu_\alpha> = \sum_k U^*_{\alpha k} |\nu_k> (\alpha = e, \mu, \tau)$$

Because these states have different masses, they evolve differently in time, leading to the observation of a different neutrino flavor at a detector placed at a suitable distance from the source.



2. Liquid Argon Time Projection Chambers

One of the most employed techniques to detect neutrinos is the Liquid Argon Time Projection Chamber (LAr-TPC), allowing for the reconstruction of particle tracks with *O*(mm) spatial resolution.



3. ICARUS T600 LAr-TPC

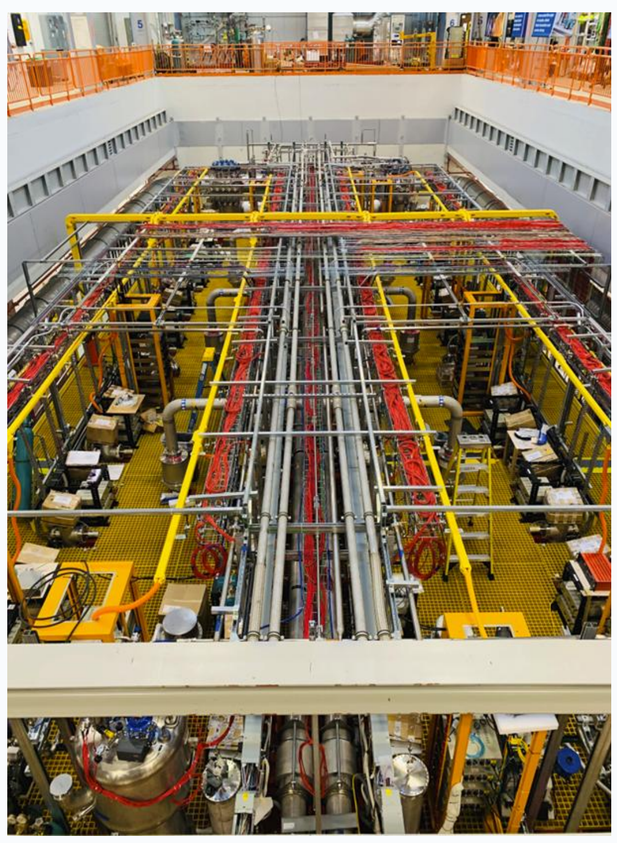
Many years of long R&D at INFN Pavia and at CERN culminated in first large-scale LAr-TPC experiment in a neutrino beam at LNGS underground labs: ICARUS-T600, 0.76 kt ultra-pure LAr (2010-2013)

ICARUS run at LNGS (2010-2013)

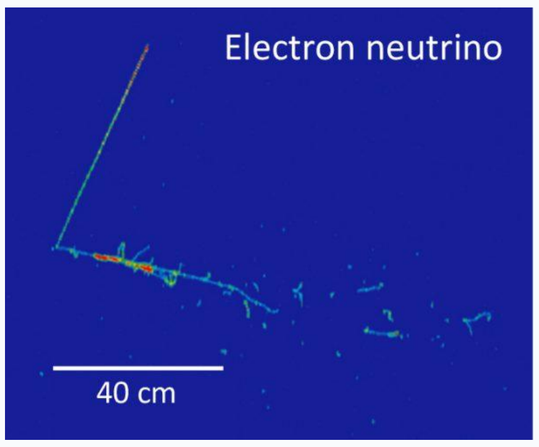
ICARUS refurbishing at CERN (2015-2017)

ICARUS positioning at Fermilab (2018)

ICARUS installation at Fermilab (2018-2020)



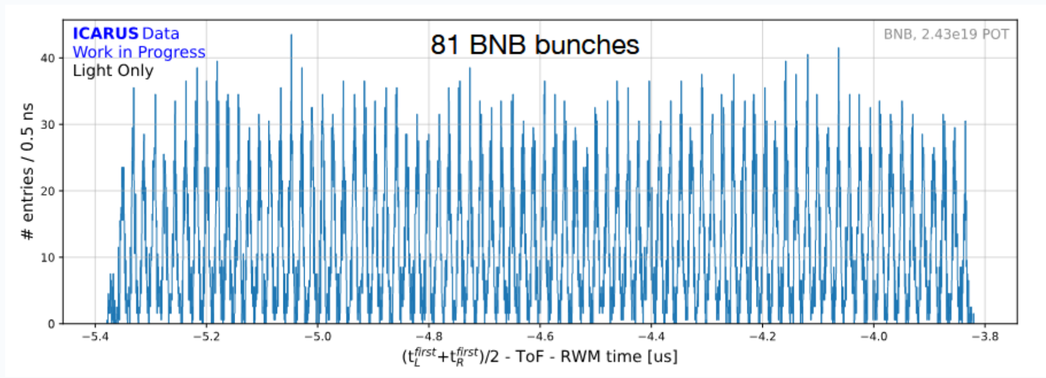
First ICARUS electron neutrino candidate



4. ICARUS T600: Photo-Detection System

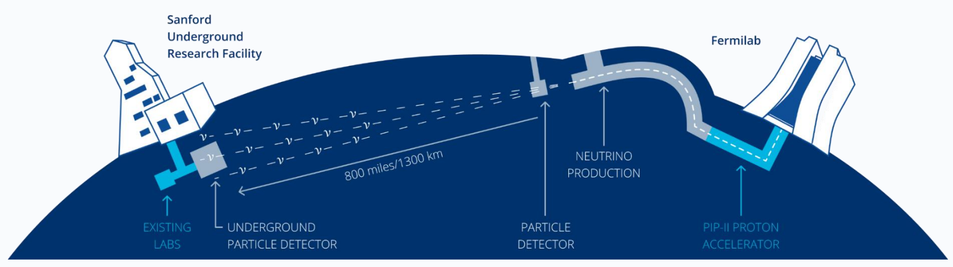
The detection of scintillation light from liquefied noble gases is employed for trigger and timing applications. The emitted VUV photons are collected by large-area photosensitive detectors, typically photomultiplier tubes (PMTs), operated directly in the cryogenic liquid.

Pavia group designed the ICARUS PMT system at Fermilab: 360 8" Hamamatsu R5912-MOD cryogenic PMTs

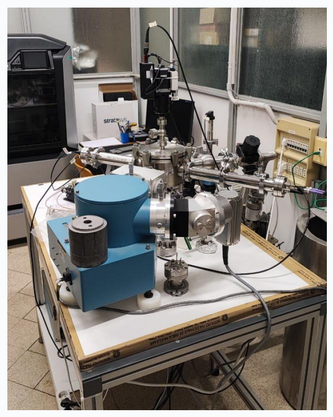


Reconstruction of the time of interactions of the BNB neutrinos in ICARUS using the PMT information only!

5. A look at the future… new photo-detectors for DUNE



Pavia group is involved in the realization of the new photo-detection system for the ultimate neutrino experiment in USA: DUNE (Deep Underground Neutrino Experiment)



DUNE-Pavia photo-detector lab