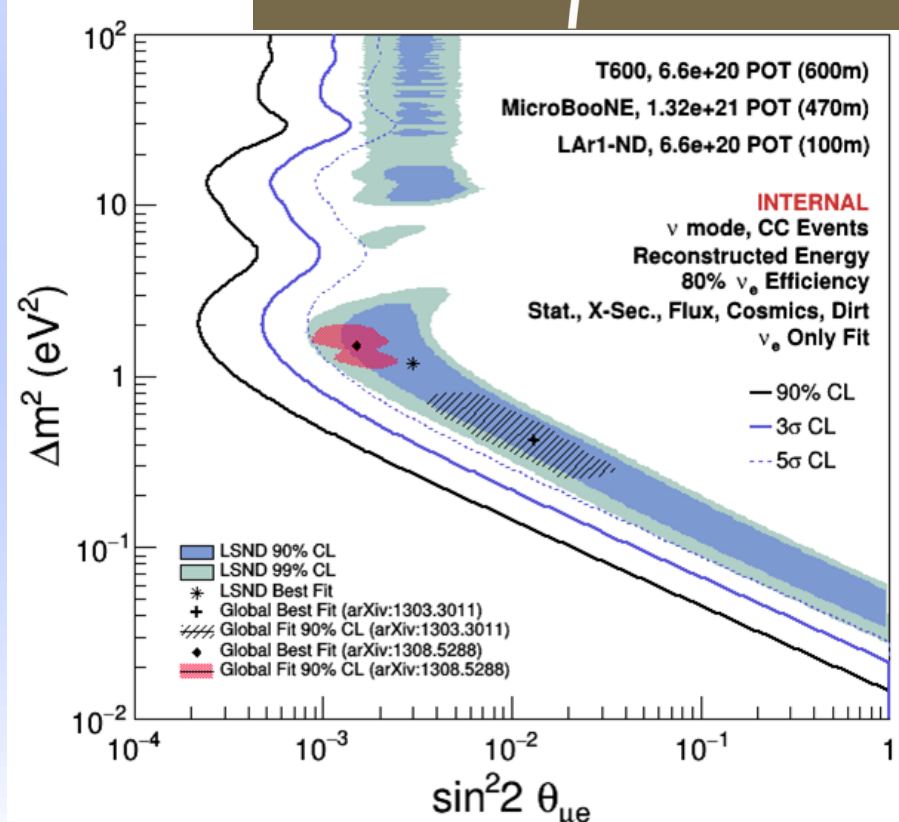
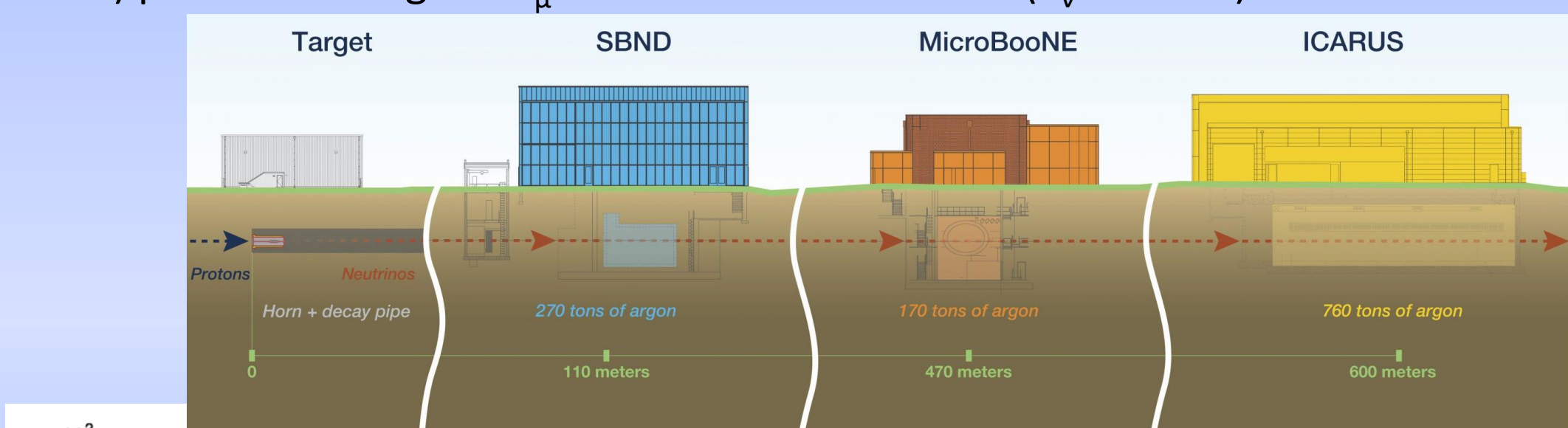


15th Pisa Meeting on Advanced Detectors
22-28 May 2022
La Biodola – Isola d'Elba

Laura Pasqualini (INFN and University of Bologna) on behalf of the ICARUS Collaboration

The SBN program to search for sterile neutrinos

- The Short-Baseline Neutrino (SBN) program aims to confirm or definitely rule out the existence of sterile neutrinos at the eV mass scale as hinted by some experimental results [1-3] by measuring the ν_e **appearance** and the ν_μ **disappearance** oscillation channel on the Booster and NuMI neutrino beams at Fermilab
- Liquid Argon Time Projection Chambers (**LAr TPCs**) at Near (110 m) and Far (600 m) positions along the ν_μ Booster Neutrino Beam ($E_\nu \sim 1$ GeV) at Fermilab

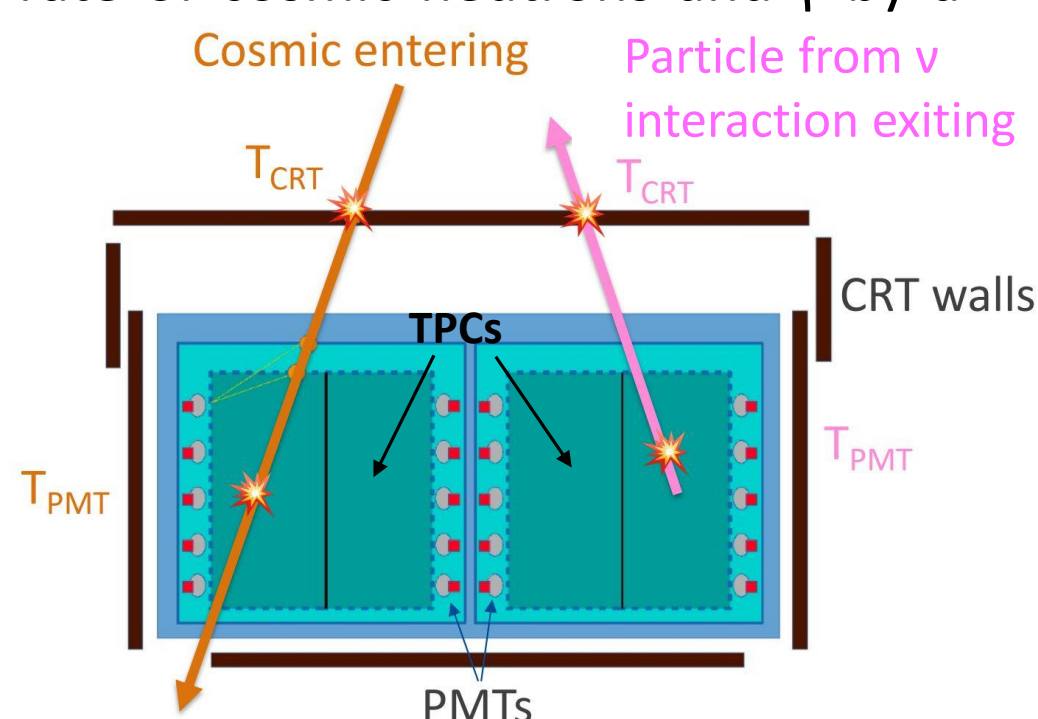


- SBN will cover the allowed parameter region $\Delta m_{14}^2 - \sin^2 2\theta_{e\mu}$ with 5σ sensitivity in 3 years (6.6×10^{20} POT)
- Additionally, it will provide high-statistic samples of ν -Ar cross-section measurements extremely useful for the upcoming DUNE experiment

A new experimental challenge

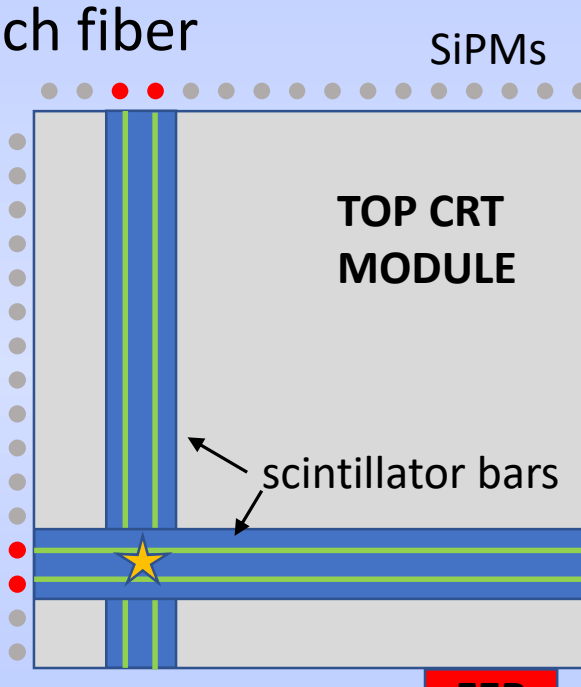
ICARUS operates at shallow depth. The high rate of cosmic ray induced signal (background) is mitigated by:

- 3 m of concrete overburden reducing the rate of cosmic neutrons and γ by a factor 200 and muons by 25%
- Photons originated by the residual muon rate (~ 10 in 1 ms TPC readout) can mimic ν_e signal interaction \rightarrow **Cosmic Ray Tagger (CRT)** system identifies in time and space particles to distinguish cosmics entering the detector from particles originated inside the TPC

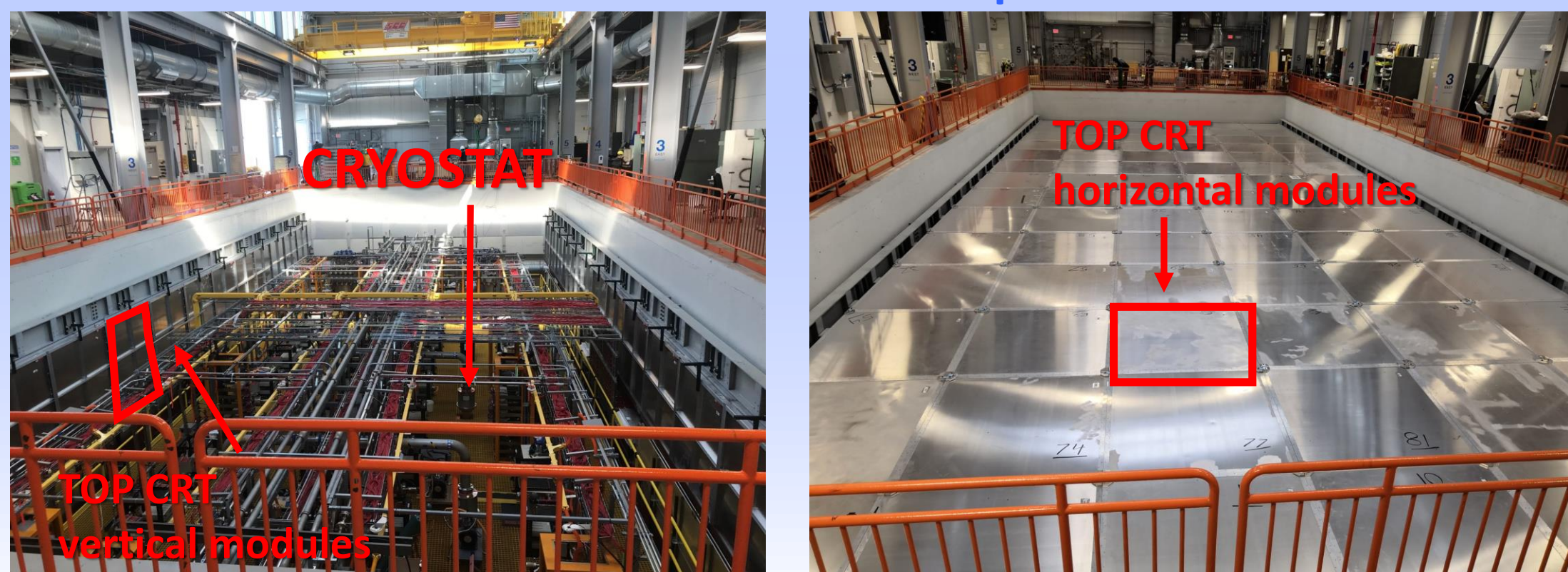


Cosmic Ray Tagger

- Three subsystem ensuring 4π coverage of the detector: Top, Side and Bottom CRT
- Side CRT** made of 8 inner and outer vertical layers on lateral walls: 1 scintillator plane/layer of 20 scintillator strips each with 1 WLS fiber readout by SiPM (at both end 8 m strips, at the same side 5 m strips)
- Top CRT** will intercept 80% of cosmic ray flux: 123 modules, 2×2 m² each, 84 horizontal installed below the overburden and 39 in vertical position on west, east, north and south rim
- Each Top CRT module composed of 2 orthogonal scintillator planes of 8 bars each:
 - 2 WLS fibers grooved on each bar + SiPM at one end of each fiber
 - Front End Board trigger: quadruple coincidence
- Top CRT modules assembled and tested at LNF and re-tested at Fermilab before installation
- Top CRT modules technical specifications:
 - Mean efficiency $\sim 96\%$
 - Time resolution 2-3 ns and spatial granularity of ~ 20 cm

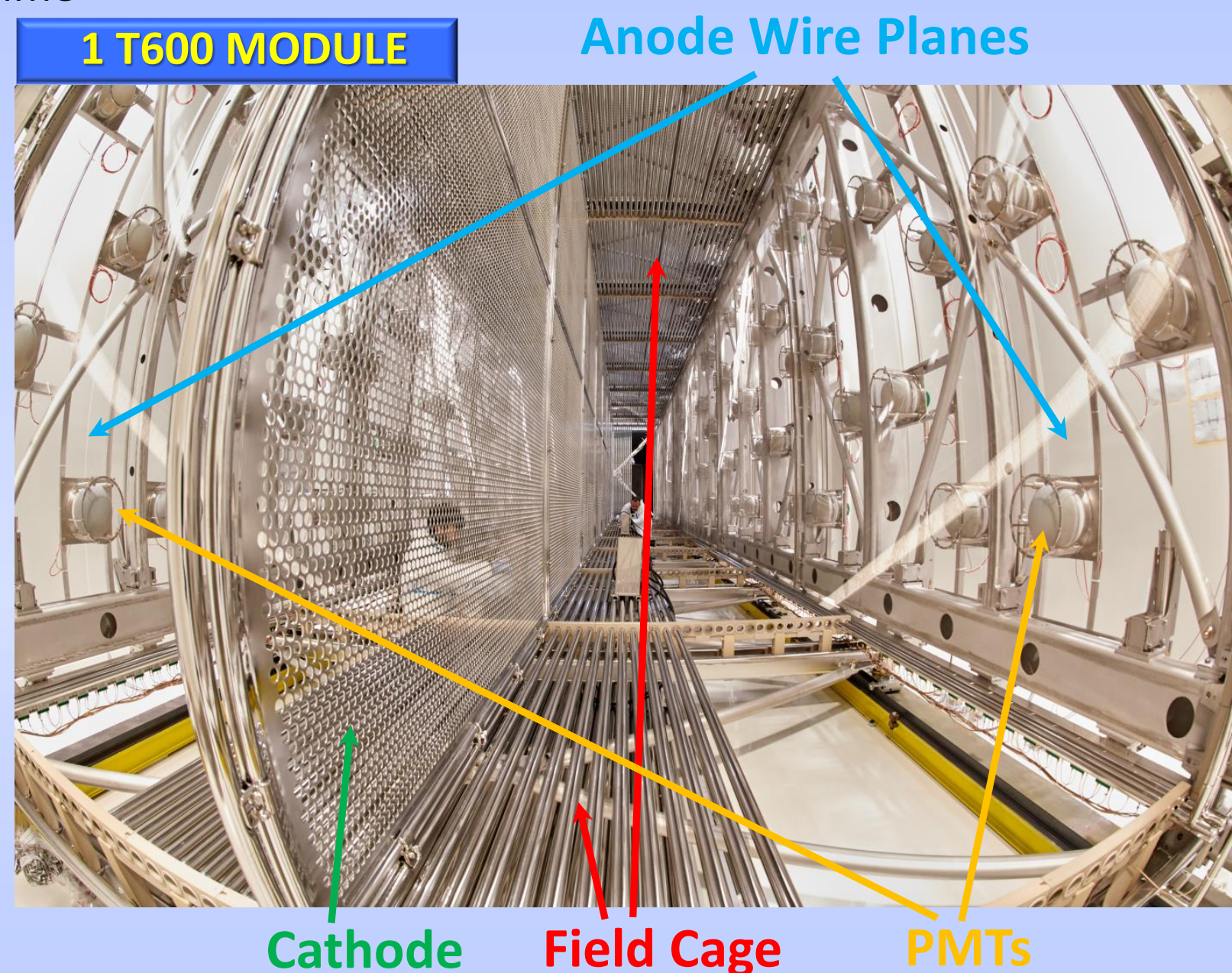


ICARUS TOP CRT installation Sept-Dec 2021

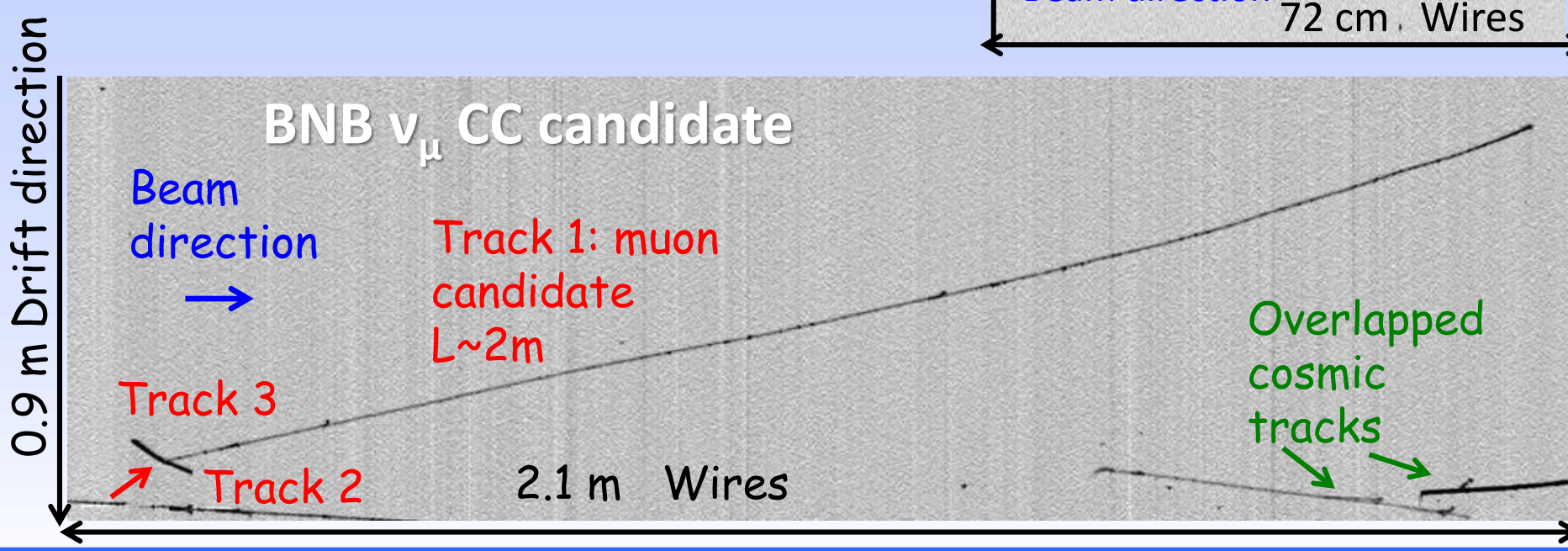


The Far Detector ICARUS T600

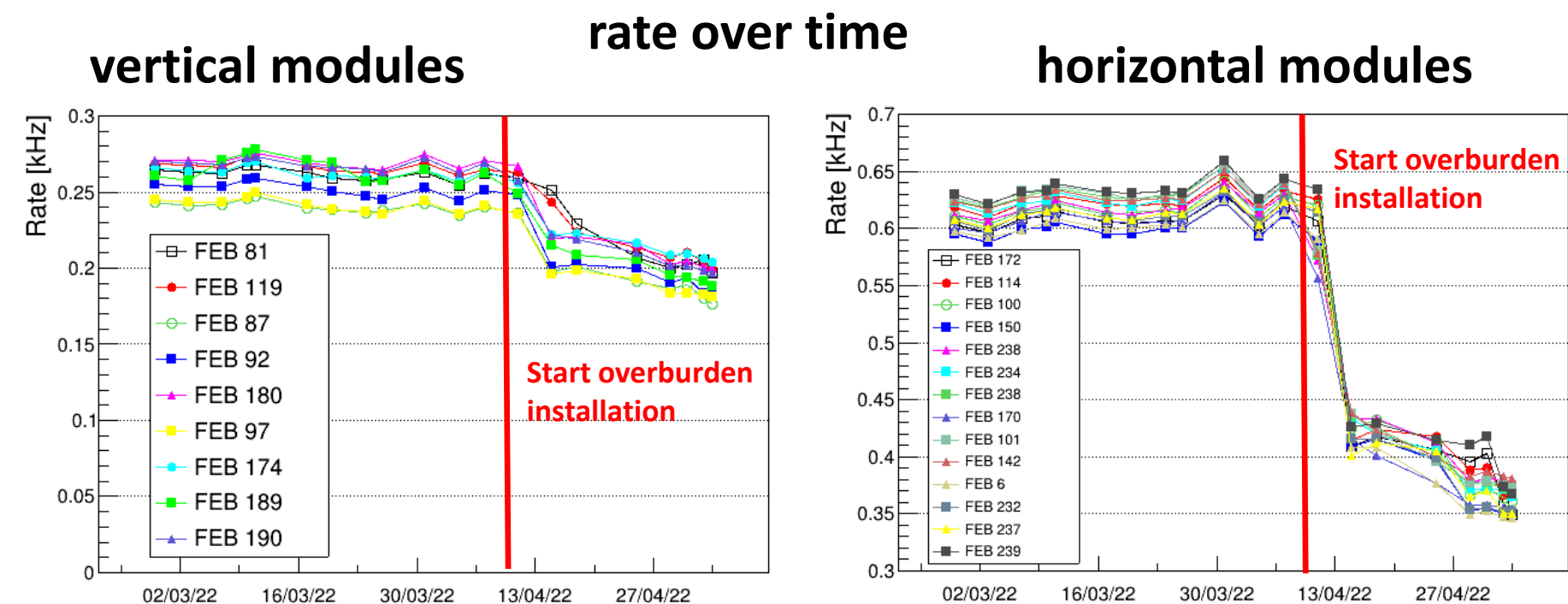
- The SBN Far Detector, ICARUS T600, was run at LNGS Lab from 2010 to 2013 as the first and largest LArTPC ever operated collecting 8.6×10^{19} POT statistics from the CNGS neutrino beam
- ICARUS is a self-triggering detector: two identical modules 19.6 (L) \times 3.6 (W) \times 3.9 (H) m³ each with a total (active) LAr mass of 760 (476) ton
- Charged particles from neutrino interactions ionize the LAr producing e^- drifting in 1 ms ($E_D = 500$ V/cm along 1.5 m drift length) towards three parallel anode wires with different orientation ($0^\circ, \pm 60^\circ$). Combining wire coordinate at different drift time \rightarrow 3D track reconstruction with resolution of \sim mm
- Scintillation light detected by photomultipliers to provide the event time



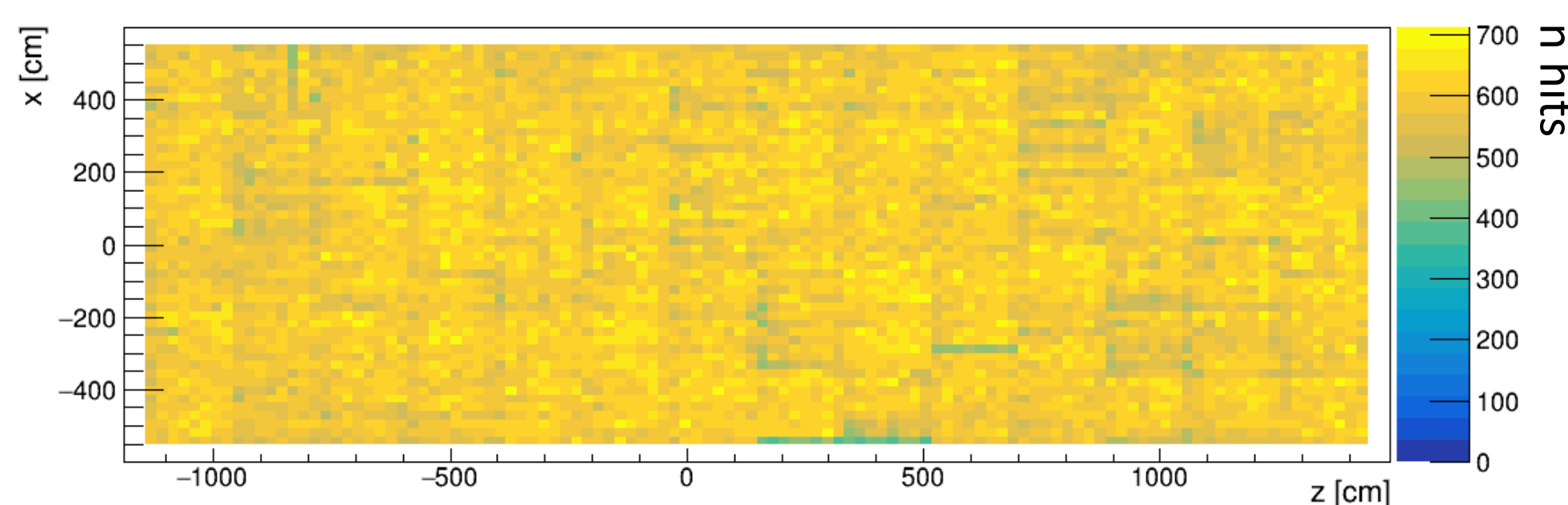
- dE/dx measurements allow to distinguish between electromagnetic showers generated by e^-/γ \rightarrow very good ν_e identification



TOP CRT commissioning



Horizontal modules reconstructed hit positions



References

- [1] LSND Collaboration, A. Aguilar et al., Phys. Rev. D 64 (2001) 112007
- [2] G. Mention et al. 2011 Phys. Rev. D 83 (2011) 073006
- [3] GALLEX Collaboration, P. Anselmann et al., Phys. Lett. B 342 (1995) 440-450