The ICARUS T600 Detector

The ICARUS detector was originally designed, built, and operated in Italy as the world’s first hundred-ton-scale LAr TPC. The ICARUS collaboration designed the detector as two separate volumes comprising the single T600 detector. Each of the chambers is further subdivided into identical drift volumes by a common central cathode. ICARUS has a total LAr mass of 760 t and an active mass of 476 t.

As part of the Short-Baseline Neutrino program, ICARUS seeks to definitively resolve the short-baseline neutrino anomalies reported by LSND [1], MiniBooNE [2], and Neutrino-4 [3].

Upgrades at CERN

After the successful LNGS run, ICARUS was transported to CERN where it underwent refurbishment during the 2016-2017 time frame.

New TPC electronics

- A front-end based on an analogue low noise/charge sensitive pre-amplifier
- More compact design - analogue and digital electronics mounted in a single flange

Upgrades to light collection system including 360 8” PMTs

- Allows for nanosecond resolution of ionizing events in the TPCs
- Events localized with <50 cm spatial resolution
- Sensitivity to low-energy events (down to ~100 MeV)

Commissioning at Fermilab

After extensive upgrades at CERN, ICARUS was transported to Fermilab, arriving in 2018. In early 2019, the cold vessels were installed in the outer warm vessel. Throughout the remainder of 2019 the supporting electronics and cryogenics were placed, allowing for the cold commissioning to commence in February 2020. The detector was completely filled in late April 2020 after two months of continuous LAr filling. During this period, a portion of the TPC readout was operated daily to monitor changes in the TPCs.

By August 2020, the TPC was fully connected for readout and the cathode high voltage was raised to 75 kV for the first time. During this commissioning phase of the experiment the Side CRT was finalized, and the first cosmic event and first BNB neutrino was observed. The Top CRT installation began in December 2021 and was followed soon after by the installation of the overburden in early 2022. Regular data taking has continued since June 2021 and will soon be transitioning to physics data taking.

First Studies with Data

The signal-to-noise ratio was extracted from a data sample of almost-vertical anode-to-cathode crossing cosmic tracks. Only hits near the anode are selected in order to avoid electron lifetime effects.

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Figure 1. An inside view of one of the chambers during upgrades at CERN

Figure 2. Left: ICARUS as it appeared before cold commissioning and Top CRT installation and Right: Increase in TPC noise observed during argon filling

Figure 3. A BNB $\nu_\mu$ CC Candidate: $\nu_\mu , n \rightarrow \mu p$ from first neutrino data

Figure 4. Left: Signal-to-Noise Ratio per plane with no angle or pitch cuts and Right: Signal-to-Noise Ratio with additional angle and pitch cuts.

Figure 5. Full distribution of stopping muon dE/dx vs. Residual Range

References


Acknowledgements

This document was prepared by ICARUS using the resources of the Fermi National Accelerator Laboratory (Fermilab), a U.S. Department of Energy, Office of Science, HEP User Facility. Fermilab is managed by Fermi Research Alliance, LLC (FRA), acting under Contract No. DE-AC02-07CH11359.

This work is supported by the United States Department of Energy under Grant No. DE-SC0017740.