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Improving ICARUS track reconstruction algorithms

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The ICARUS experiment is part of the Short-Baseline Neutrino (SBN) program at Fermilab. The main goal of the experiment is to investigate the possibility of sterile neutrinos in the O(1 eV) mass region and provide clarification of the anomaly detected from the Liquid Scintillator Neutrino Detector (LSND) and MiniBooNE experiments.

The ICARUS-T600 detector is a Liquid Argon Time Projection Chamber (LAr-TPC), that can provide excellent 3D imaging and calorimetric reconstruction of any ionizing particles. This detection technique allows a detailed study of neutrino interactions, spanning a wide energy spectrum (from a few keV to several hundreds of GeV). The detector consists of two identical adjacent modules, filled with a total of 760 tons of ultra-pure liquid argon. Each module houses two LAr-TPCs separated by a common cathode with a maximum drift distance of 1.5 m, equivalent to about 1 ms drift time for the nominal 500 V/m electric drift field. The anode is made of three parallel wire planes positioned 3 mm apart, where the stainless-steel wires are oriented on each plane at a different angle with respect to the horizontal direction ($+60^\circ$,-60°,0°). In total, 53248 wires with a 3 mm pitch and length up to 9 m are installed in the detector.

In the first stage of the reconstruction, segments of waveforms corresponding to physical signals (hits) are searched for in the deconvolved wire waveform with a threshold-based hit-finding algorithm. Each hit is then fitted with a Gaussian, whose area is proportional to the number of drift electrons generating the signal. In the second stage of the reconstruction, hits are passed as input to Pandora, a framework software composed of different pattern recognition algorithms, that performs a 3D reconstruction of the full image recorded in the collected event, including the identification of interaction vertices and tracks and showers inside the TPC. These are organized into a hierarchical structure (called slice) of particles generated starting from a primary interaction vertex.

In some cases, related to the inefficiencies in the hit detection or excessive deflection of the particle trajectory, Pandora breaks the particle's track into two or more smaller pieces and considers each piece as an independent track. We studied this phenomenon focusing on muons primary daughters of $\nu_\mu CC$ interactions contained in a single module with a track at least 20 cm long, to exclude delta rays. The study highlighted that about 7-8% of the muon tracks are broken. Approximately 80% of the times, Pandora assigns all segments of the track to the same slice (intra-slice track split), while in the remaining 20% of the cases, one of the segments is associated with another slice (extra-slice track split).

To mitigate this phenomenon, we designed an algorithm that detects and stitches the tracks broken by Pandora for the intra-slice split. In Monte Carlo simulations, the algorithm showed an efficiency exceeding 87% and a purity exceeding 90%.

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Classifica Sessioni: Frontiera dell'Energia

Classificazione della track: Frontiera dell'Energia