Elimination LArTPC Simulation Uncertainty

Ka’ren Mkrtchyan, CCI Intern

FERMILAB-POSTER-24-0238-STUDENT

Introduction

Liquid Argon Time Projection Chambers (LArTPC) are widely used to measure muons and neutrinos. The fast moving particles collide with the argon, releasing electrons that drift towards the wire planes due to an applied electric field. The moving electrons induce current in the wires, which are measured and used to reconstruct the path of the particle (see FIG 1). The Short Baseline Neutrino (SNB) detector aims to measure neutrinos before they have time to oscillate and change flavors. However, LArTPCs suffer from a number of known effects that are difficult to disentangle and model. These include electron-ion recombination, electron diffusion, and electron attenuation. The method outlined here seeks to close the gap between simulation and data caused by these effects by modifying the amplitude and width of signals on the wires of the TPC.

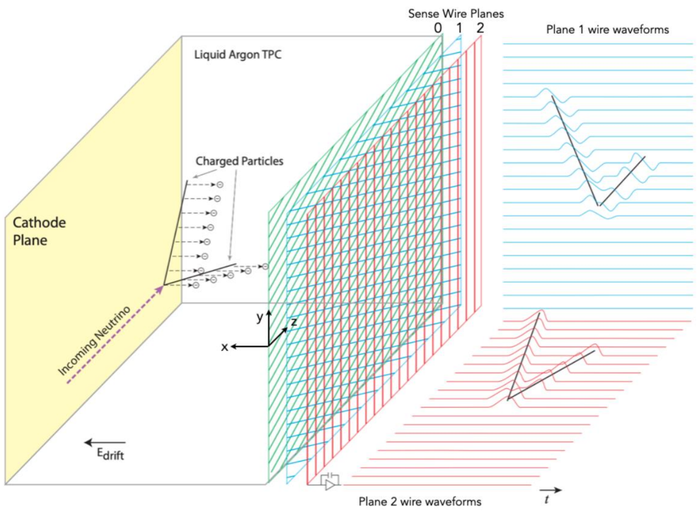


FIG 1. A model of he MicroBoonNE detector showing the 3 wire plans and the reconstructed neutrino path.

Analysis

A hit is a Gaussian fit to a current wave produced on a wire. It has an integrated charge and width associated with the number and distribution of electrons that caused the hit. In black is sample hit width data from the east side of the detector. In blue are the simulated values which have been scaled to match. In red are the simulated values that have been modified to account for detector model uncertainties and better match the data.

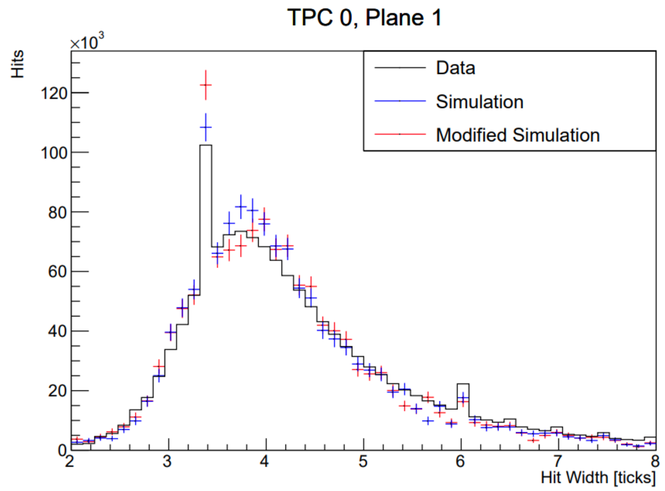


FIG 2. Histogram of the hit widths for the 2nd wireplane, first TPC of the east side detector.

The current modification algorithm seems to push the simulation further from the data and will need further revision to make this method viable.

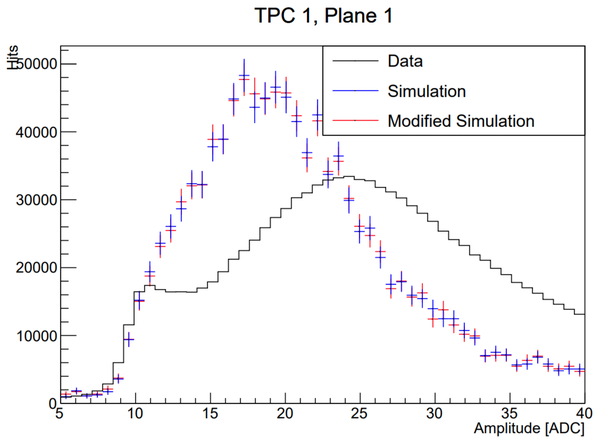


FIG 3. Histogram of the amplitudes for the 2nd wireplane, second TPC of the east side detector.

Actions to Improve

A bug was discovered in the WireModMakeHist_plug.cpp which computed the simulation and data ratios based on the heigh of each bin, but the scaling utility applied modifications on the integral of each bin.

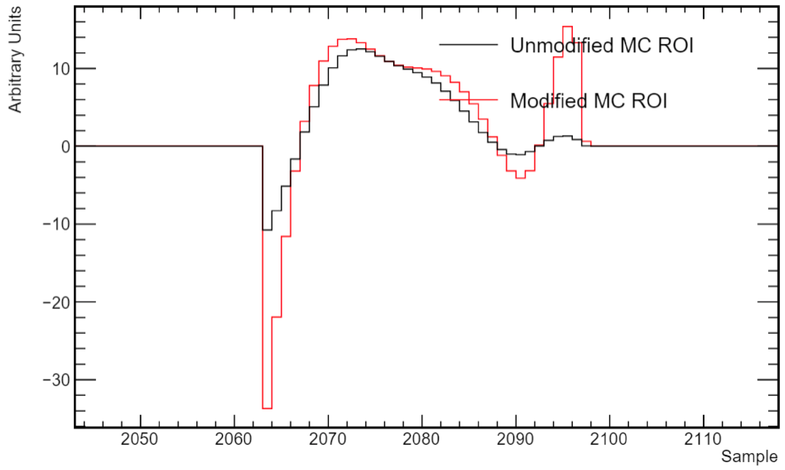
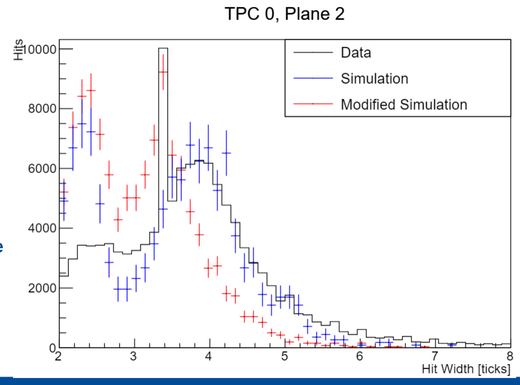


FIG 4. Histogram of the amplitudes of AC signals on a simulated wire. The modified simulation looks reasonable in the middle ranges but shifts the signal too much at the end regions of the wave where the heigh of the bins is small.

Current and future work

Currently, work is being done to correct the bugs in the code that modifies the simulation and fine tuning that model to make the simulation look more like the data. The model is overfitting for hits with width 3.33 and underfitting for widths greater than that. Multiple runs of the new modified simulation will need to be done to generate statistical confidence and reduce model uncertainty.

FIG 5. Histogram of the hit widths for the 2nd wireplane, first TPC of the east side detector. This plot was created with a new modified simulation that used the integral of each bin instead of the heigh. It better matches the peaks of the data but is worse as the overall shape.



Acknowledgement & Reference

•This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.
•This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Community College Internship (CCI)
•Abratenko, P., et al. (2022). Novel Approach for Evaluating Detector-Related Uncertainties in a LArTPC Using MicroBooNE DataarXiv preprint arXiv:2111.03556v2