FERMILAB-POSTER-22-195-STUDENT

Application of Machine Learning for Low Energy Electron LArTPC Reconstruction

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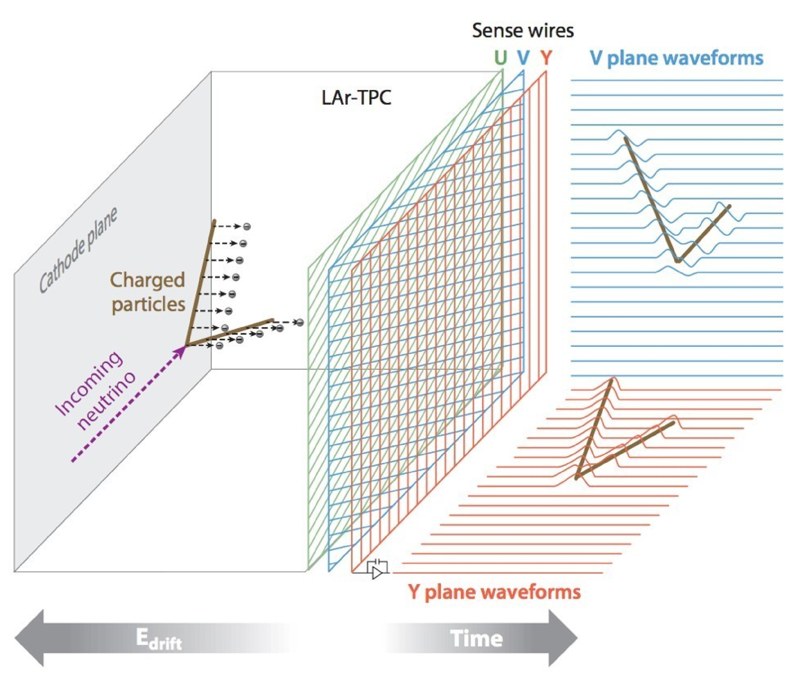
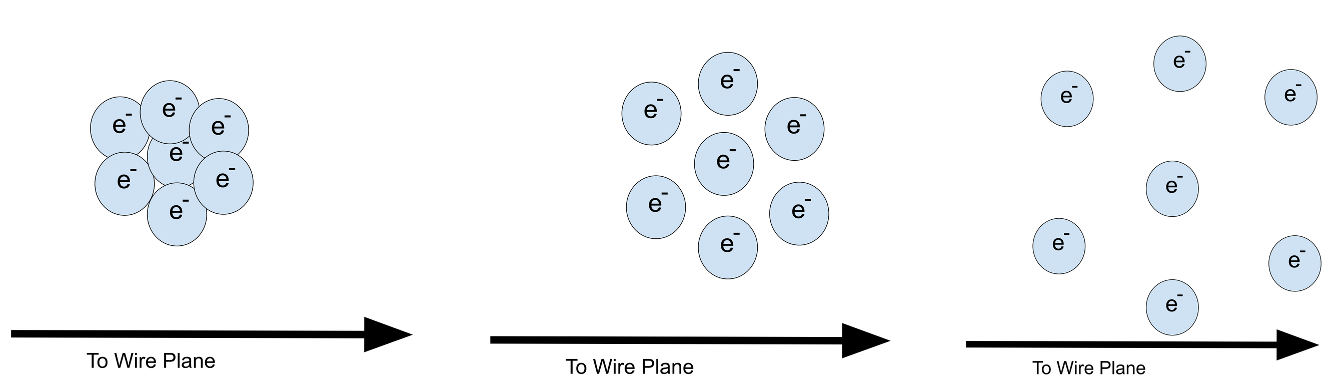
Prediction of Drift Coordinate from Electron Diffusion via Application of Machine Learning Algorithm

Detection of Low Energy Neutrino interactions in a liquid argon time-projection chamber (LArTPC) rely are reliant on detection of both ionization electrons and scintillation – emitted photons. The scintillation photons provide the necessary timing information to properly reconstruct the event. Efficiency of photon detection decreases with the energy level of the interaction. A machine learning algorithm is to be trained on simulation data to deduce the appropriate timing values from electron drift, eliminating the need for photodetection, and overall simplifying the detection apparatus.



Source: Fermilab News "Physicists achieve significant improvement in spotting accelerator-produced neutrinos in a cosmic haystack"

The workings of LarTPC: An incident neutrino strikes an argon atom, producing a flash of light and creating charged particles which ionize the surrounding argon atoms. A uniform electric field draws the electrons toward a wire plane which allows for a 2D recreation of the event. Photon detection is used for timing information.



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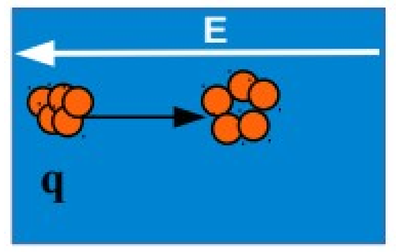


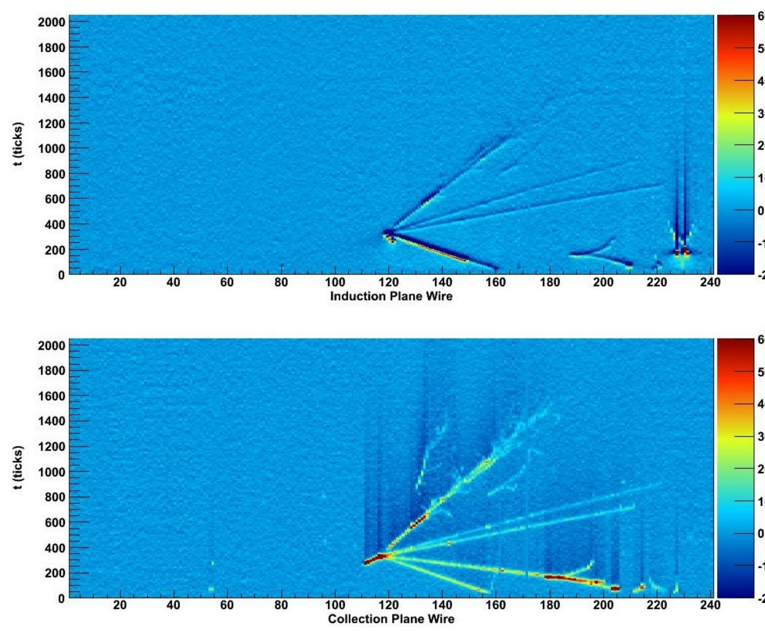
The ion diffusion (RMS spread) is related to the drift distance (Δz), the electric field (E), and the electron mobility in argon

S. Amoruso NIM **A516** (2004) 68
W. Walkowiak, NIM A449 (2000) 228

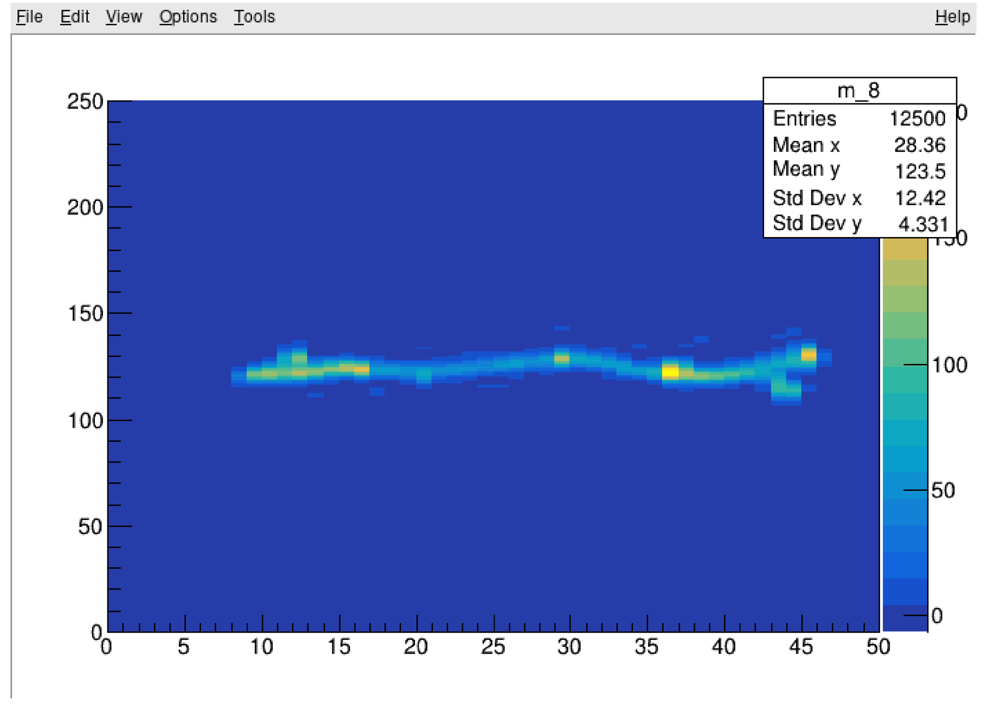
$$\sigma_{T(L)} = \sqrt{\frac{2\,\varepsilon_{T(L)}\,\Delta z}{E}} \qquad D = \mu\varepsilon$$

Jonathan Asaadi/Syracuse University

The ionization electrons will naturally diffuse over time due to their like charges. The amount of diffusion directly correlates to the amount of time that elapses between the generation of the ionization electrons, and when they collide with the wire detection plane. More diffuse electrons indicate that the event occurred further from the detection grid.



Yale/Microboone



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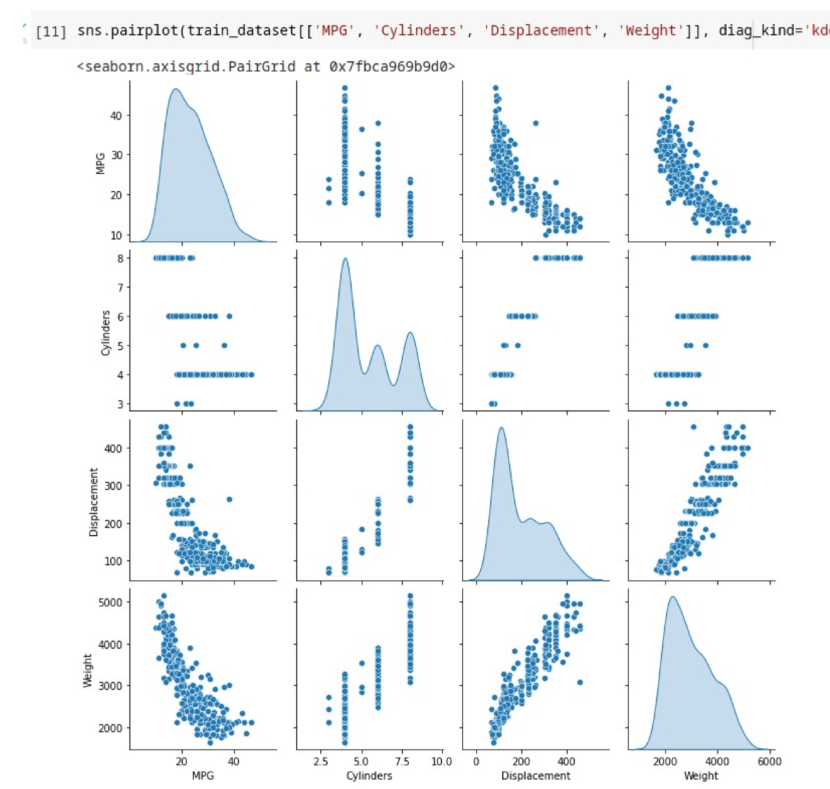
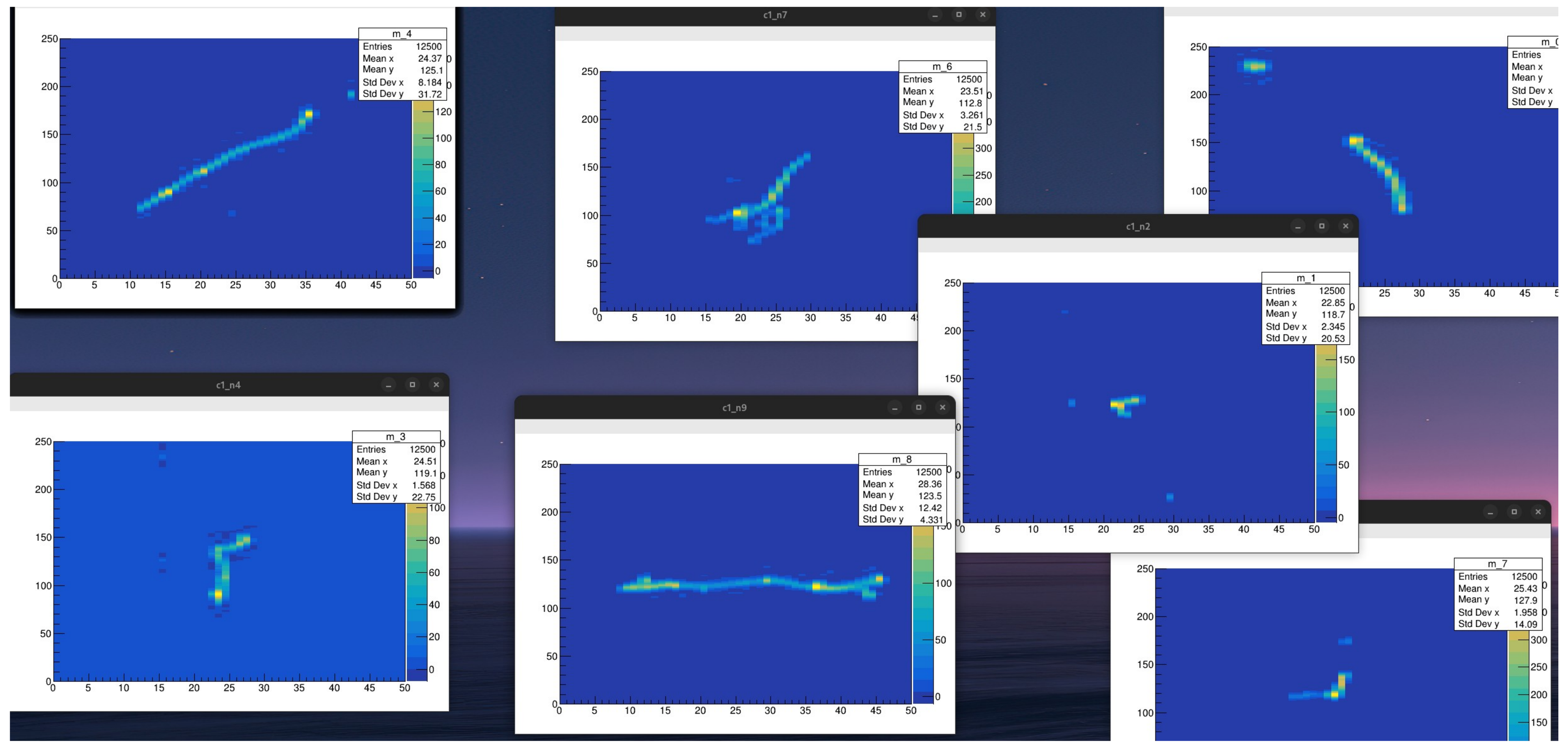
Left:LArTPC Wire output of a neutrino interaction event, right: Simulated 2.5 MeV electron.

By cropping the output as seen on the right, we can isolate the training set to focus on the event itself, minimizing the 'zeros' which dominate the output, and minimizing bias.



TensorFlow Regression Tutorial

a training set for a regression algorithm from tensorflow



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Training set of 'cropped' LarTPC Simulation output, focused on electron detections.

A neural network focused on regression can make predictions along a continuous spectrum of values. To this end, thousands of data points as to seen on the right will be used to train a ML algorithm, and since the training set is produced via simulation, the algorithm can be continuously refined for accuracy and bias. Thus, the drift coordinate can be determined without relying on scintillation photons.

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