

Identifying Michel Electrons in Liquid Argon TPCs Using Machine Learning

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Introduction

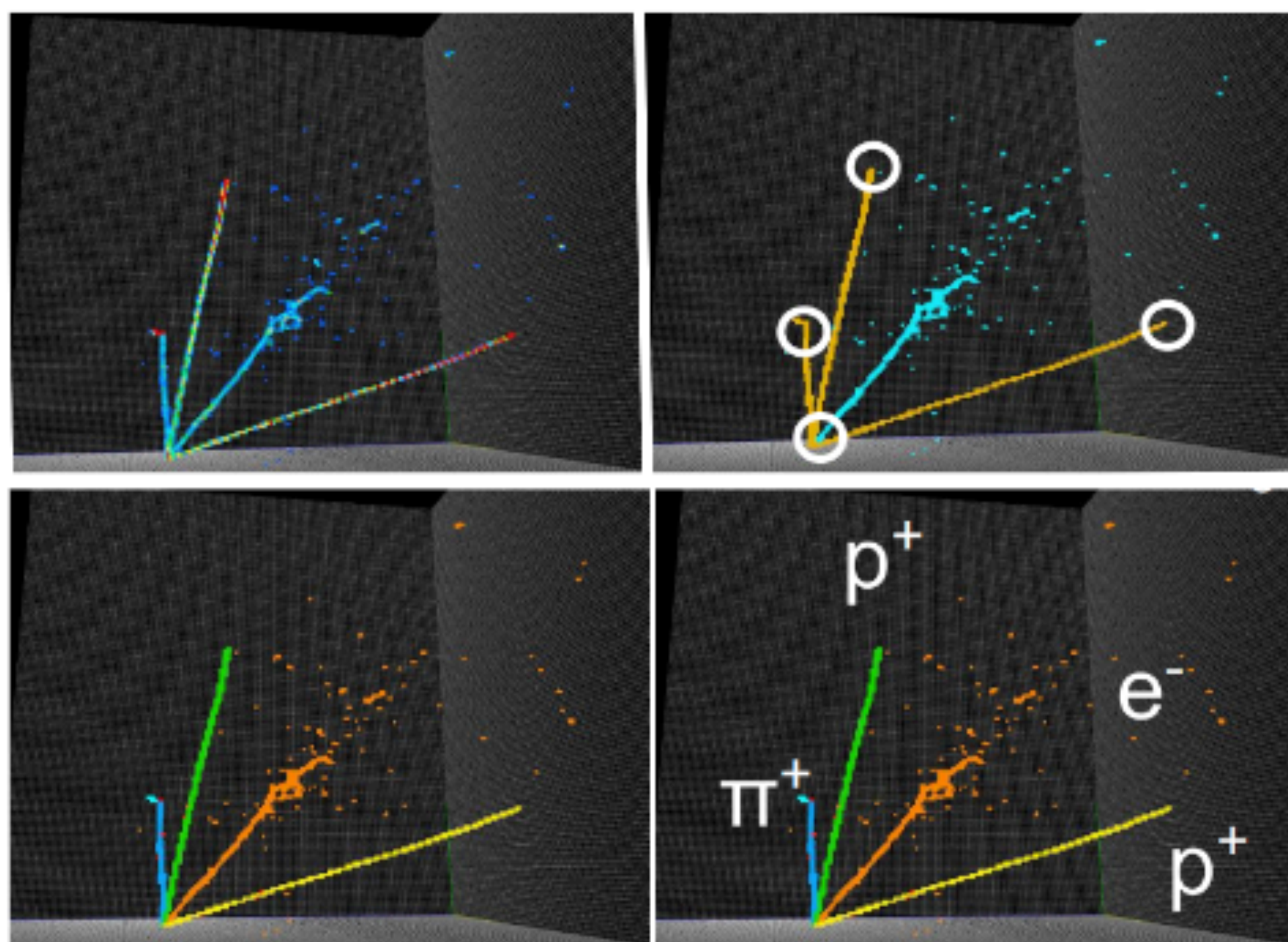
A Michel electron is an electron produced when a muon decays at rest: $\mu \rightarrow e + \nu_e + \bar{\nu}_\mu$. Their energy spectrum is well understood. In the Liquid Argon Time Projection Chamber (LArTPC) detector, they can be used to calibrate the detector's accuracy and observe the detector's response to electrons with energies up to about 50 MeV (low-energy electrons). An automated algorithm can be developed to reconstruct Michel electrons from the TPC's electron topology.

Methods: Reconstruction Process

1

Machine Learning Reconstruction

1. Tomographic reconstruction
2. CNN removes artifacts of reconstruction (deghosting)
3. Point Neural Network (PPN) classifies voxels and identifies regions of interest



2

Post-Processing

1. Reconstruction outputs are stored in HDF5 file format
2. Reconstructed and true objects are matched
3. Data processing: visualization and analysis

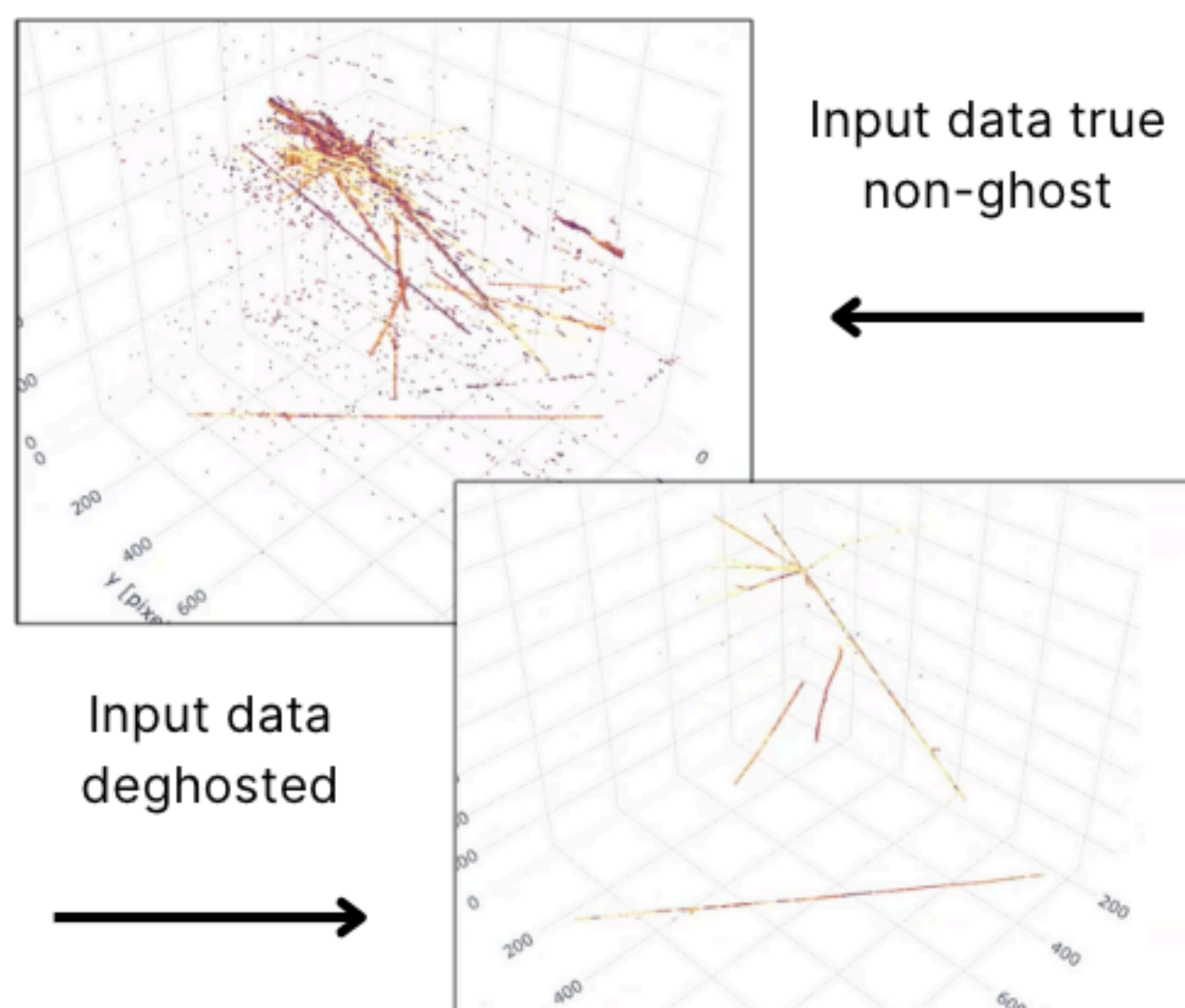
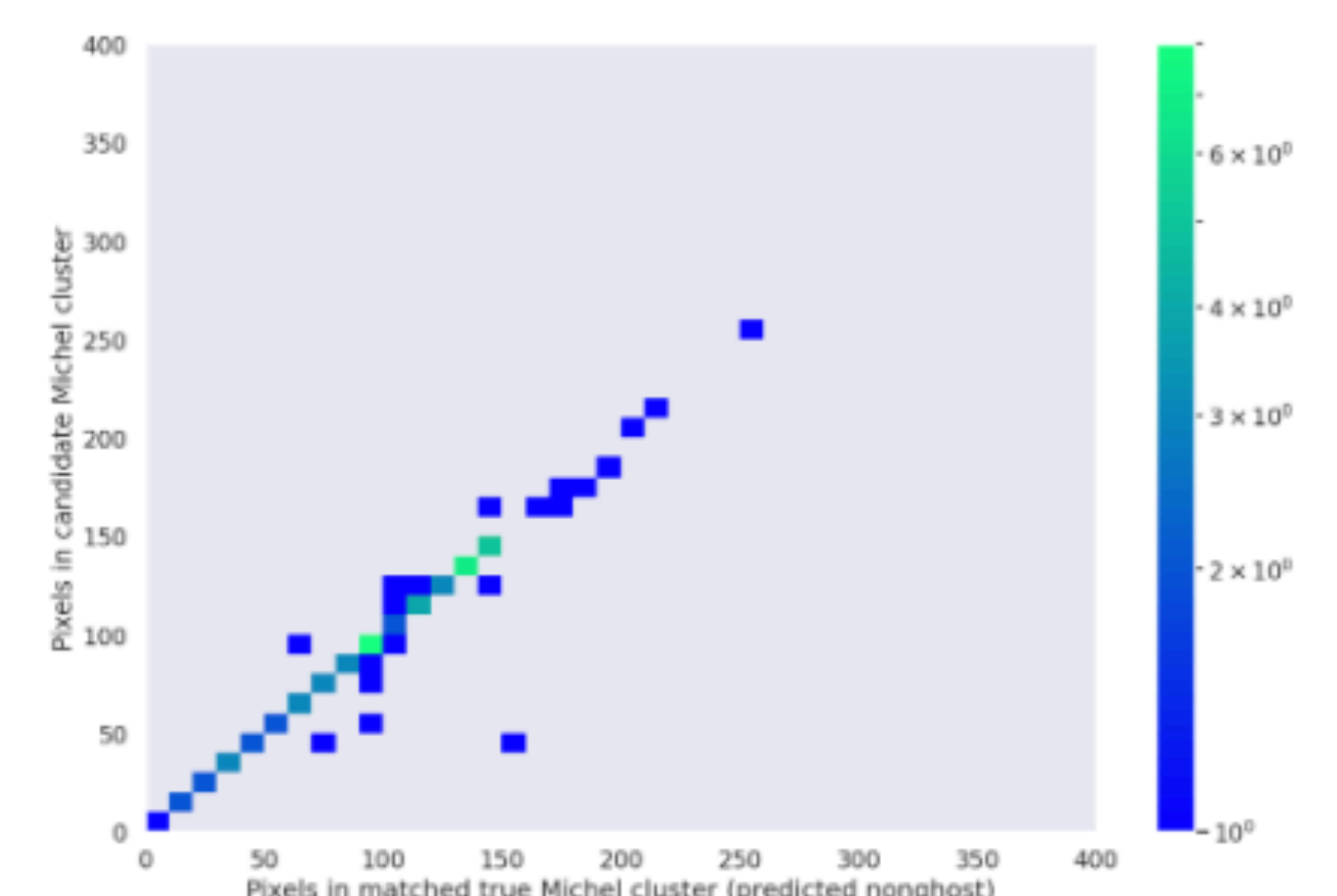


Image Credits: F. Drielsma, ML-based Reconstruction for LArTPCs (2023)

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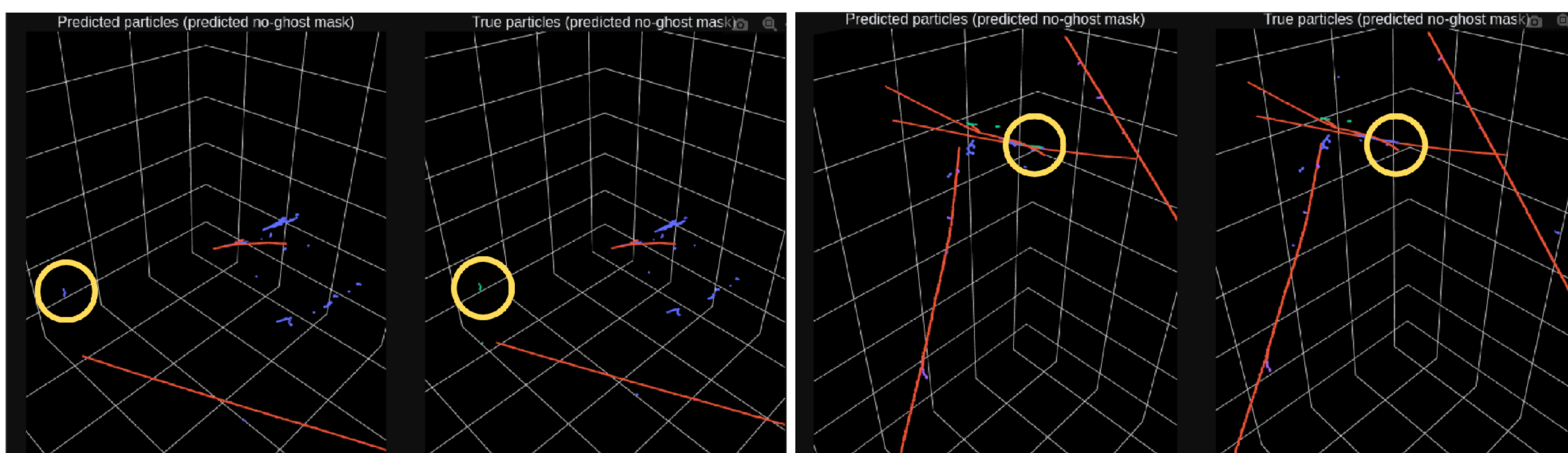
Michel Electron Analysis

1. Check reconstruction chain output with specific Michel electron identification criteria to weed out inaccurate results
2. Match true particles with reconstructed Michel electrons
3. Perform analysis on impurities and inefficiencies to improve algorithm



Results and Next Steps

The cause for the incorrectly identified particles was not due to the selection checks, but rather the PPN algorithm. Future work can include energy calibration checks for truth particles compared to reconstructed particles as well as other statistical information about the quality of the reconstruction algorithm.



This is an event display demonstrating inefficiencies in the reconstruction algorithm. The true Michel electron is unable to be identified as seen by the difference in color between the highlighted particles. A green colored particle represents a Michel electron.

This is an event display demonstrating impurities in the reconstruction algorithm. A Michel electron is predicted when there is no corresponding true particle, as seen with the lack of green in the highlighted space on the plot to the right.

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