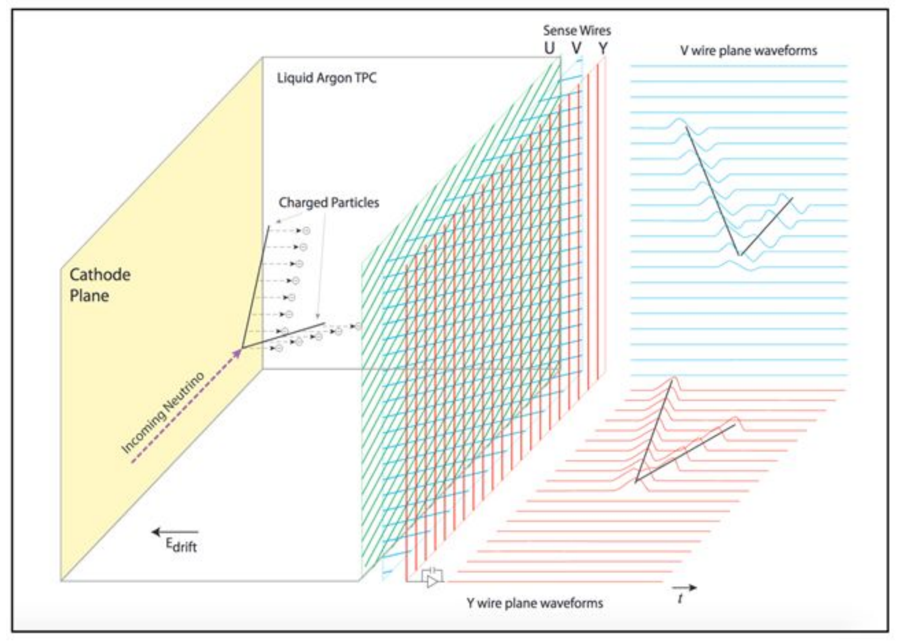
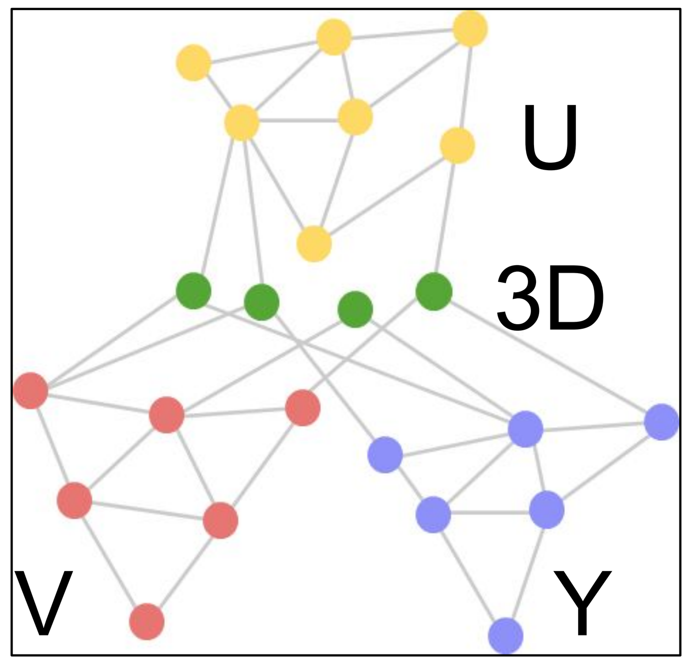
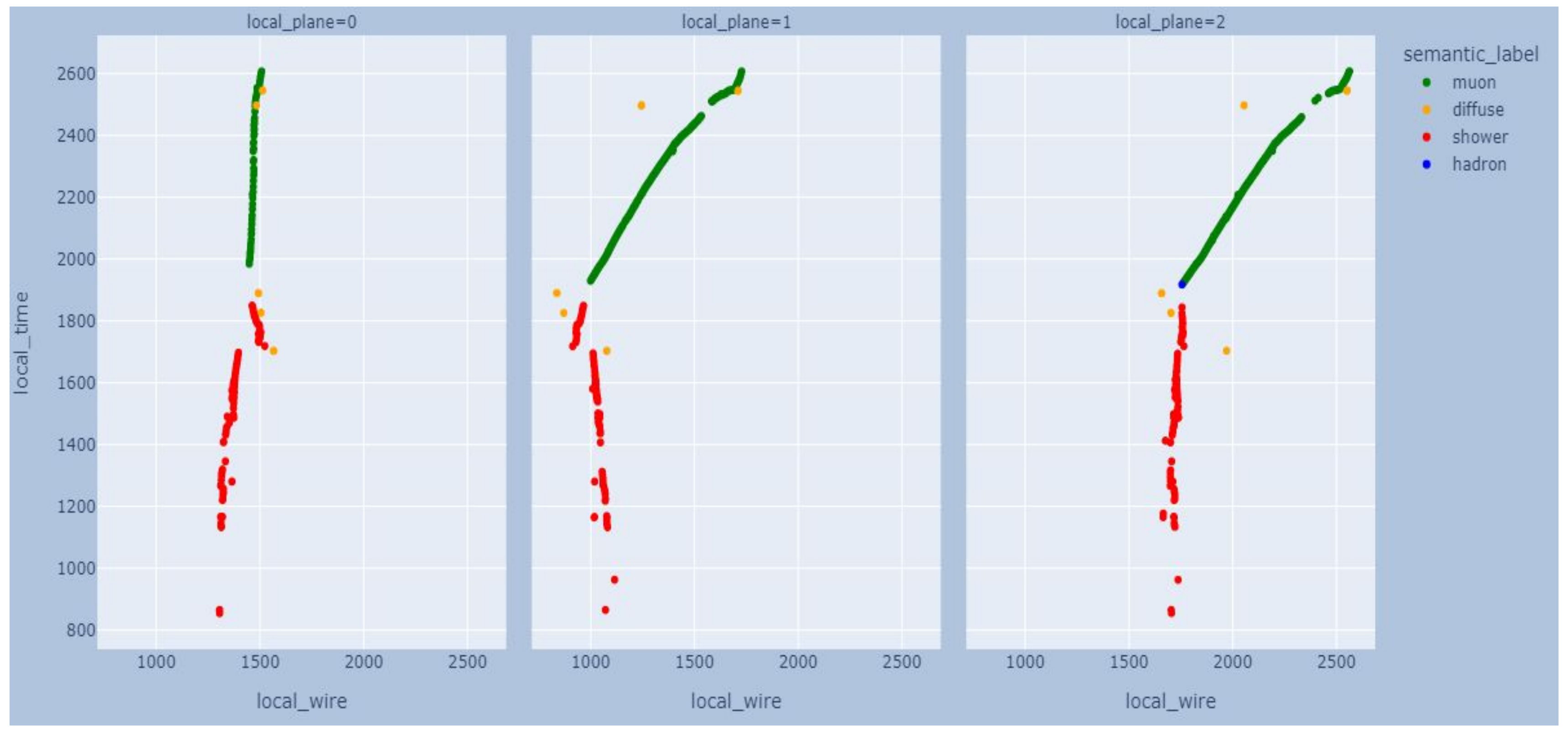
Graph Neural Network for Object Reconstruction in Liquid Argon Time Projection Chambers

The Problem

- Liquid Argon Time Projection Chamber (LArTPC) detectors are utilised by many neutrino experiments, including DUNE and MicroBooNE.
- A Graph Neural Network (GNN) technique was developed to label detector hits according to particle type in the DUNE detector (arxiv:2103.06233).
- Hits on each detector plane are considered as nodes in a graph, with edges describing relationships between hits.
- This poster explores a range of new developments to enhance the GNN's ability to classify LArTPC particle hits.





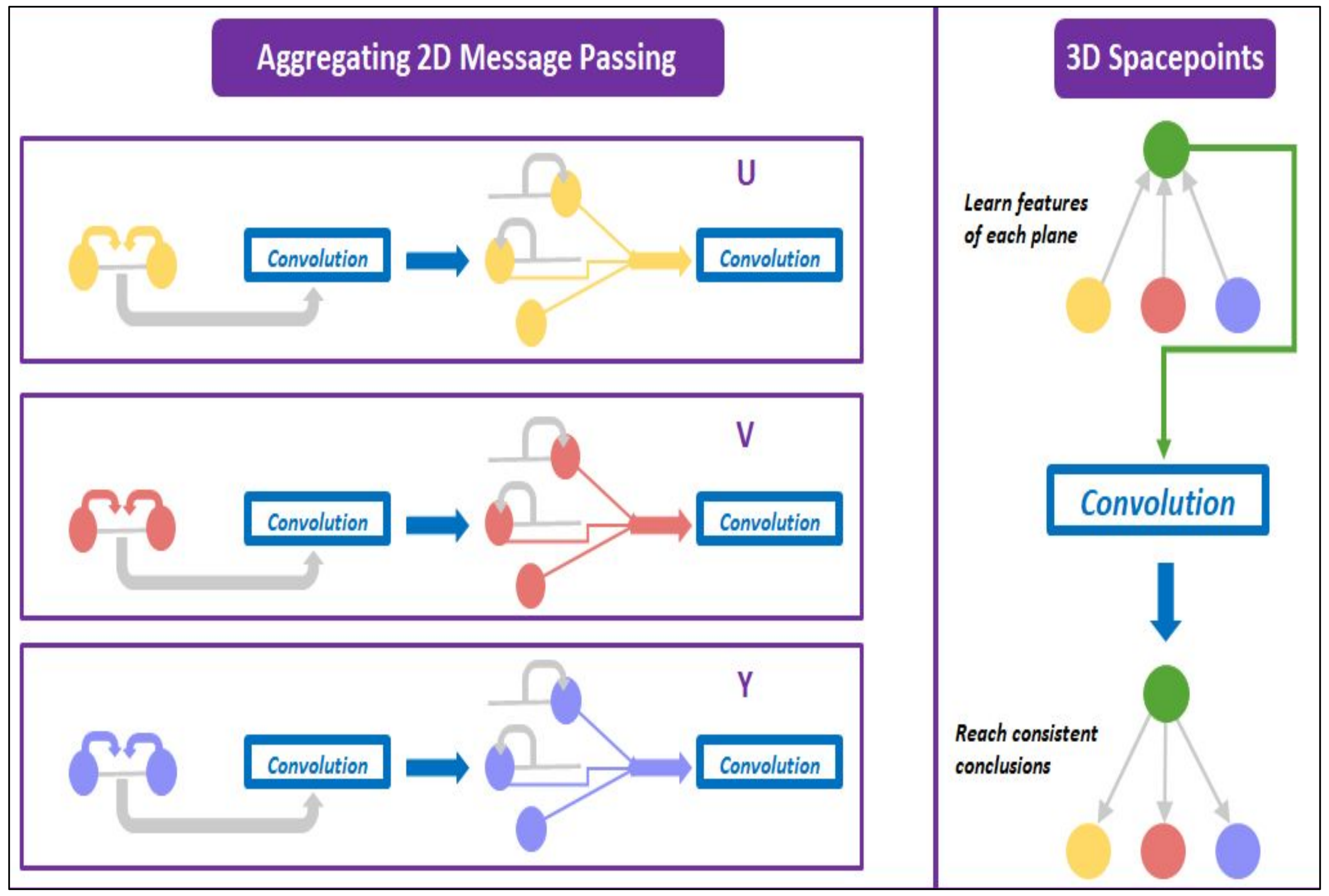


Edge Forming Techniques (2D and 3D):

- Delaunay Triangulation
- Physics-informed sliding window
- Radius
- KNN

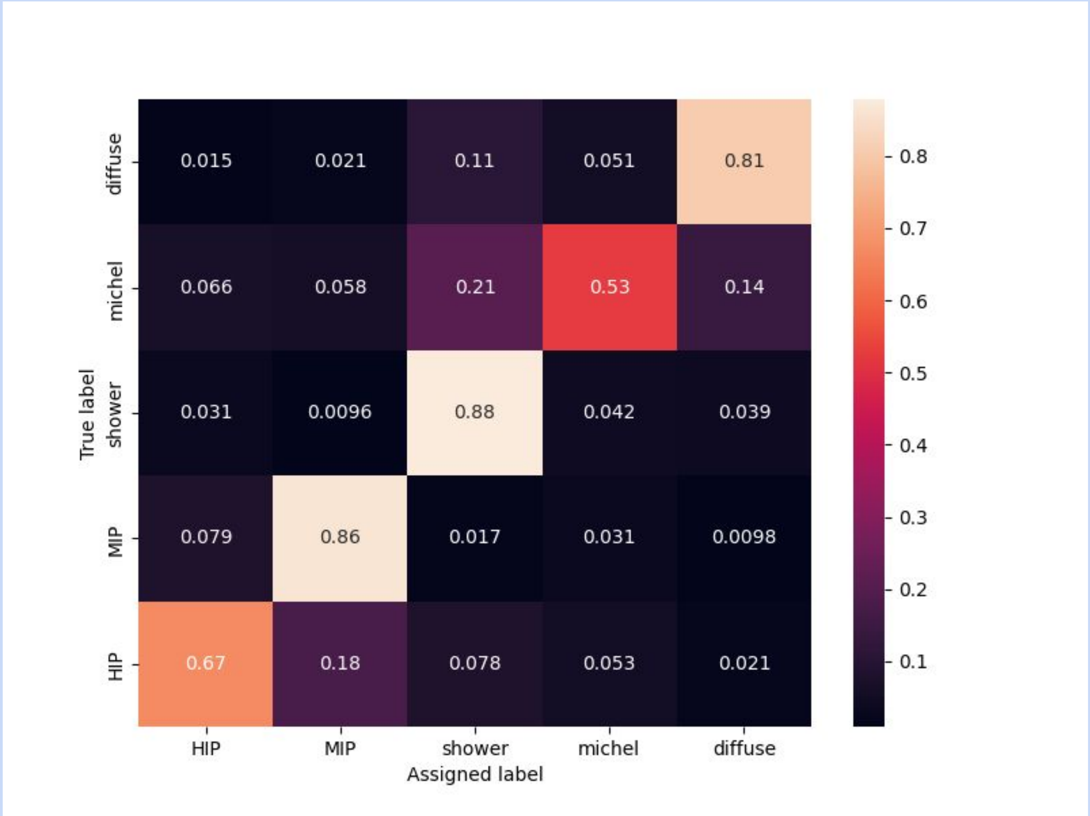
Methodology

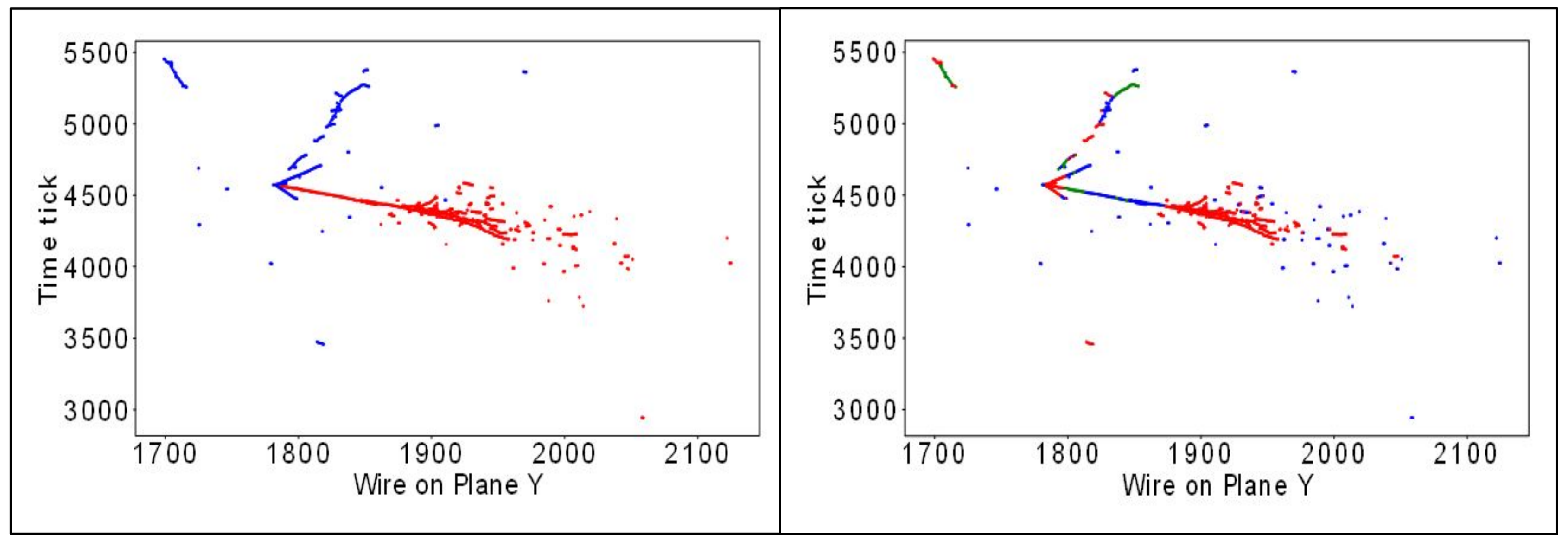
- Rather than classifying edges in a graph, we instead moved to classify nodes.
- Design more sophisticated labelling scheme:
  - Highly/minimum ionizing particles (HIP + MIP), electromagnetic showers, Michel electrons, diffuse energy depositions.
- Explore multiple edge forming schemes for graphs in 2D and 3D spaces.
- Introduce spacepoint nodes to graphs, and message-pass between 2D planes (U, V, Y) to build consistent 3D representations.



Evaluation

- Labelling graph nodes instead of edges improves classification accuracy by 15% for shower class, 7% for muon class and 7% for hadronic class.
- For window edges, 3D model improves overall accuracy from 74.9% to 75.6%.
- Optimal model configuration is 2D Delaunay GNN, with 83.5% accuracy.





Conclusions

- Refined labelling provides a rich description of physics content of interactions.
- Node classification, 3D connections and new edge schemes all improve GNN performance.

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