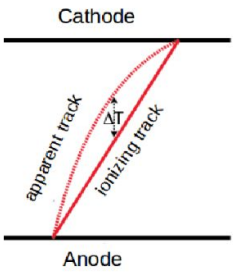
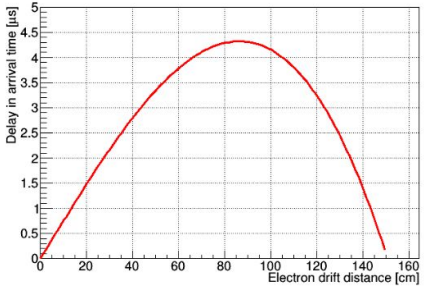
Question: How are the SCE correction histograms generated?

1) Mike Mooney conducted a numerical simulation that assumes space charge density (from cosmic-ray muon rate), and that density is used as input to the Poisson equation and solved with a Fourier series/ “ray tracing algorithm”.
2) Lane uses cathode-crossing muons to find the deviation in x compared to a straight line. Calculate offset_data/offset_mc and apply ratio to pre-existing map.





Mike Mooney: [paraphrased] SCE is small at SBND/ICARUS and so for a first pass Lane’s method is sufficient. Due to field cage issues, there are complications to the methodology that make things more difficult to do precise E field extraction. We are exploring use of differentiable simulations to do better

GNN clustering quick recap

- (1) Turn event into graph - each hit, space point becomes a node. Nearby nodes are connected by triangularization
- (2) Do message passing between all nodes
- (3a) Semantic head, for each hit, outputs binary neutrino or cosmic
- (3b) Edge head, for each edge, outputs probability that two hits are same particle
- (4) Cluster based on pre-determined edge threshold probability (here, 0.5)

Hit input features: 2D wireplane coods, charge, drift time
SP input features: charge, reco_cluster_id, aggregated hits
SP positions are used for edge-building

GNN clustering evaluation

- Re-ran Avinay's existing evaluation with dataset in his repo
- For a checkpoint trained to minimize total (semantic + embedding + edge) loss on sample of BNB enriched neutrino interactions overlaid with cosmic ray background (17500 training events, 3750 val events, 3750 test events). 8.8% neutrinos, 91.2% cosmic rays

Hits evaluated	9,640,734
Cluster ARI	0.8590
Cluster purity	0.9353
Cluster efficiency	0.9312

GNN clustering evaluation

- Re-ran Avinay's existing evaluation with dataset in his repo
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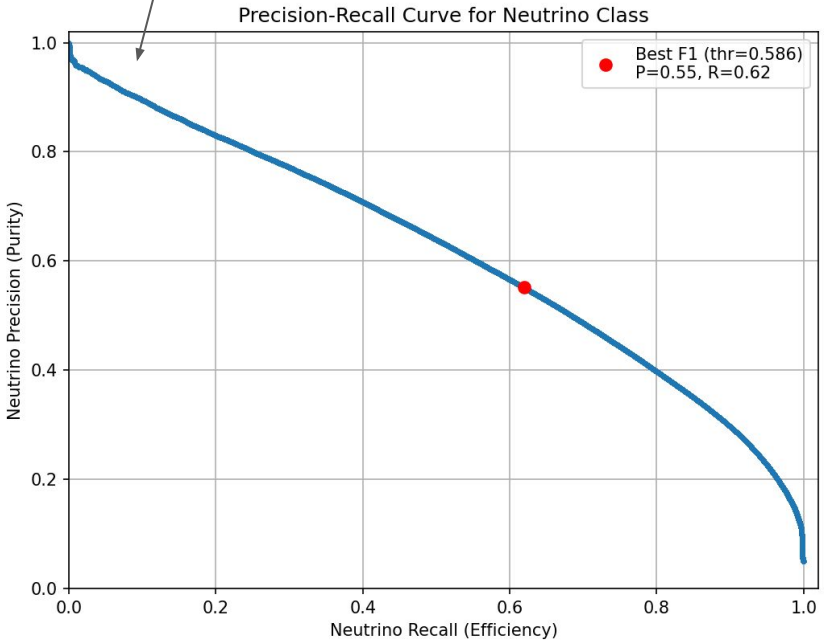
Tuning semantic threshold (per-hit neutrino prob)



GNN clustering vs Traditional WireCell clustering

- Traditional beats NuGraph on ARI, efficiency while it's pretty similar with purity. Adjusting edge threshold (currently 0.5) does not help.
- WireCell predictions are input feature, so I don't currently know what thresholds/parameters were set for that. I will rerun it myself soon.

	Traditional	**NuGraph**
ARI	0.9048	0.8590
purity	0.9354	0.9353
efficiency	0.9687	0.9312

Correct means ARI >= 0.9 with truth

	Traditional right	**Traditional wrong**	**Total**
NuGraph right	1,685 (.4503)	414 (.1106)	2,099 (.5609)
NuGraph wrong	842 (.2250)	801 (.2141)	1,643 (.4391)
Total	2,527 (.6753)	1,215 (.3247)	3,742 (1.000)

Characteristics of agreements/disagreements (medians over all events)

Avg hits / particle

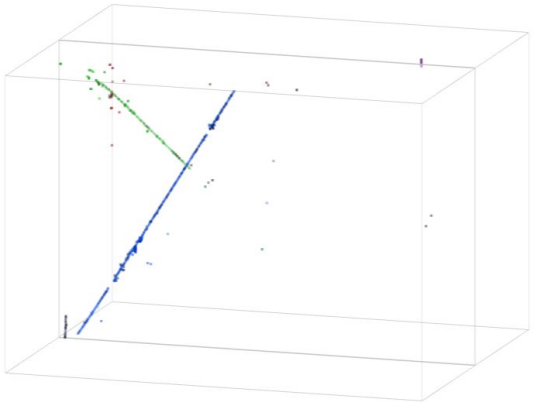
Bounding box diagonal

Fraction of edges > 65cm

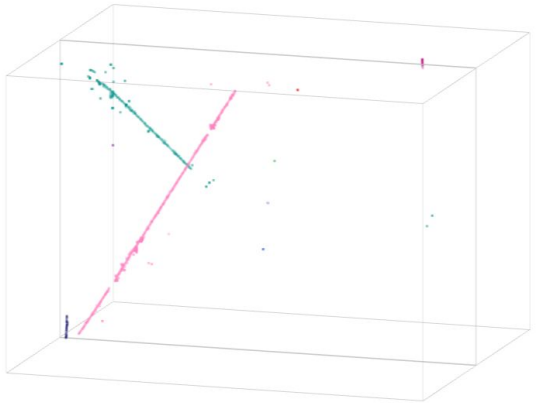
Characteristic	NuGraph ✓ Trad ✓	NuGraph ✓ Trad ✗	NuGraph ✗ Trad ✓	NuGraph ✗ Trad ✗
Particles / event	17	**25**	**18**	25
Particle size (hits)	76	**48**	**91**	52
Particle extent (cm)	123	**101**	**145**	108
Long-edge fraction	0.52	**0.46**	**0.55**	0.41
Hits / event	1350	**1254**	**1675**	1341
Charge/hit (median e^-)	32,700	32,000	34,300	33,100
NuGraph clusters made	20	27	24	29
Wire-Cell clusters made	9	10	10	10

Where does traditional succeed where NuGraph fails?

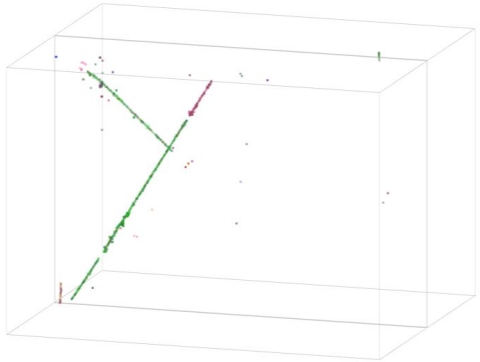
- https://www.phy.bnl.gov/twister/bee/set/c310cdd6-9869-4a74-bd27-b5e7592a3ef8/event/2/?theme=light



Truth



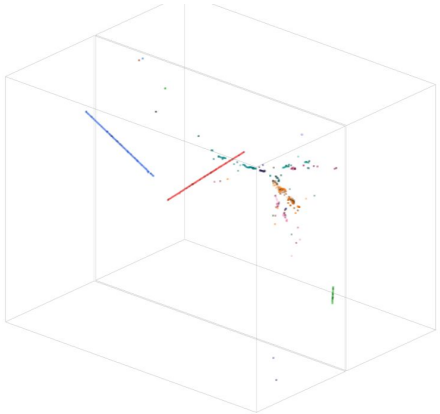
WC Trad



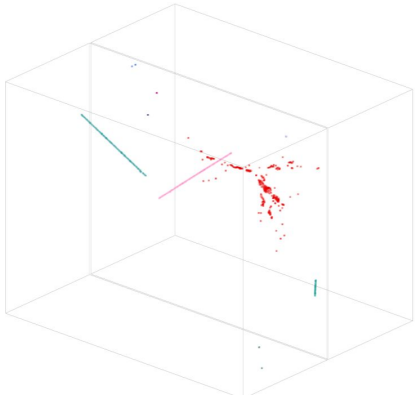
GNN

GNN clustering and traditional potentially have different goals (particle vs interaction clustering)

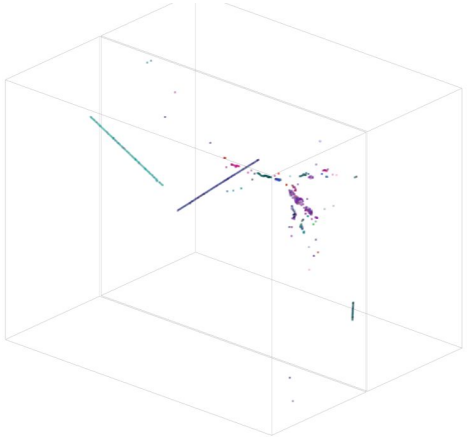
- https://www.phy.bnl.gov/twister/bee/set/d32bc652-620b-4441-804a-74ab90d95c1f/event/13/ <- first 10 events, trad beats nugraph, last 10 nugraph beats trad



Truth



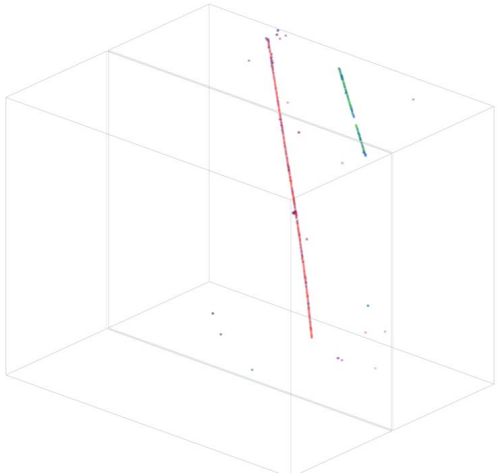
WC Trad



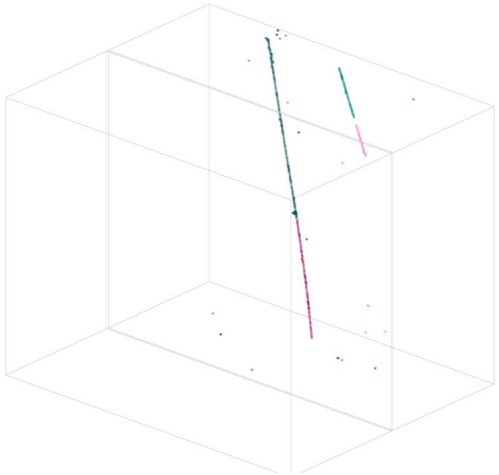
GNN

Where does NuGraph succeed where traditional fails (unambigously)?

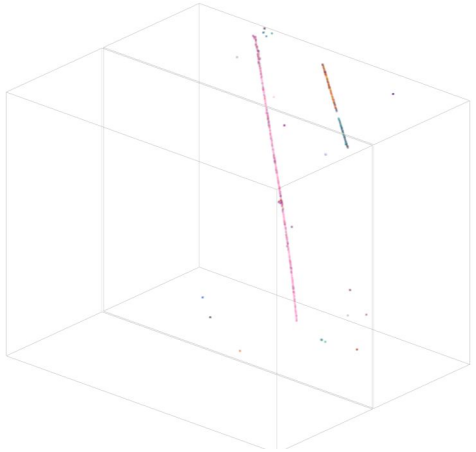
- https://www.phy.bnl.gov/twister/bee/set/d32bc652-620b-4441-804a-74ab90d95c1f/event/18/



Truth



WC Trad



GNN

Additional: Truth leakage potential regarding NuGraph

Semantic “sidecar” - tell the model first which events are neutrinos vs cosmics as an input feature and then train, to see how well clustering can be in that case. Default is OFF.

Also, truth derived vertex features vtx_dist, vtx_dx/dy/dz, are distances to true GENIE vertex, but model has use_vtx_features=False.

Extra slides

GNN clustering evaluation (cont)

- Additional metric from https://arxiv.org/pdf/2007.01335 (Clustering of Electromagnetic Showers and Particle Interactions with Graph Neural Networks in Liquid Argon Time Projection Chambers Data): Charge-weighted ARI, purity, efficiency

	Count-weighted	Charge-weighted
ARI	0.8590	0.8612
purity	0.9353	0.9380
efficiency	0.9311	0.9367