SPVCNN for primary vertex reconstruction

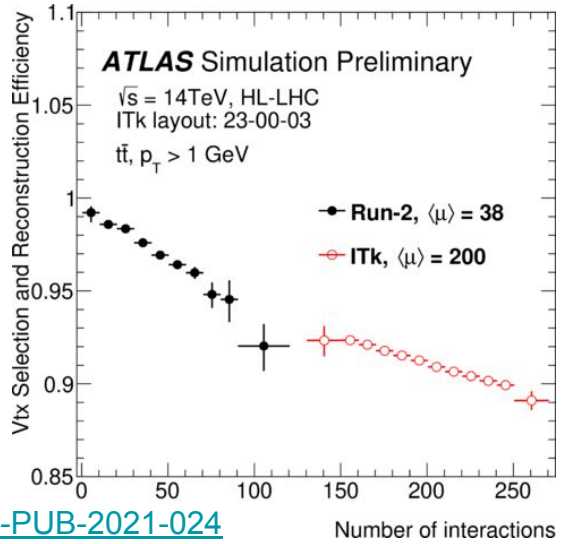
Haoran Zhao[1], Alex Schuy[1], Zhijian Liu[2], Philip Harris[2], Ke Li[1], Shih-Chieh Hsu[1], Scott Hauck[1], Song Han[2]

[1] University of Washington
[2] Massachusetts Institute of Technology

Motivation

Dense track environment in High-Luminosity LHC presents challenges for primary vertex reconstruction

- Lower vertexing efficiency at high pileup



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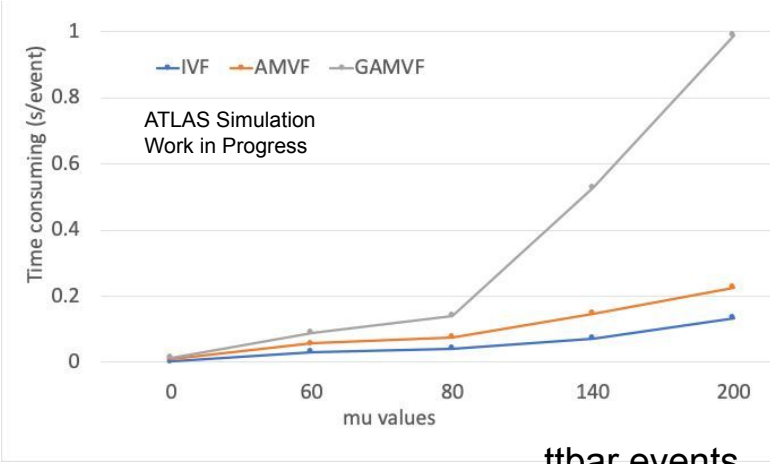
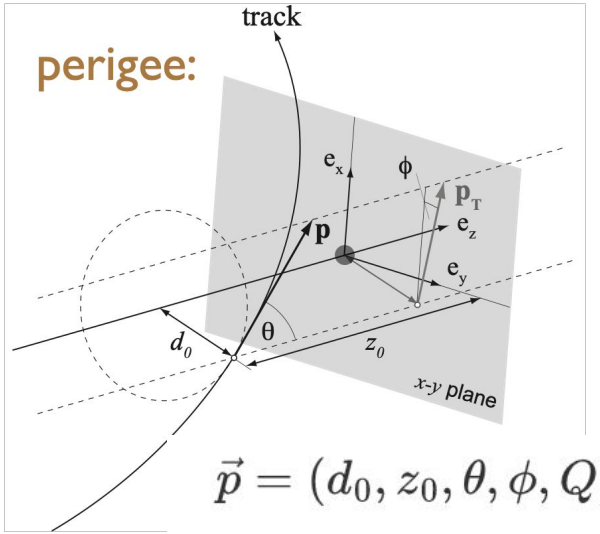
- Large timing consumption



ttbar events

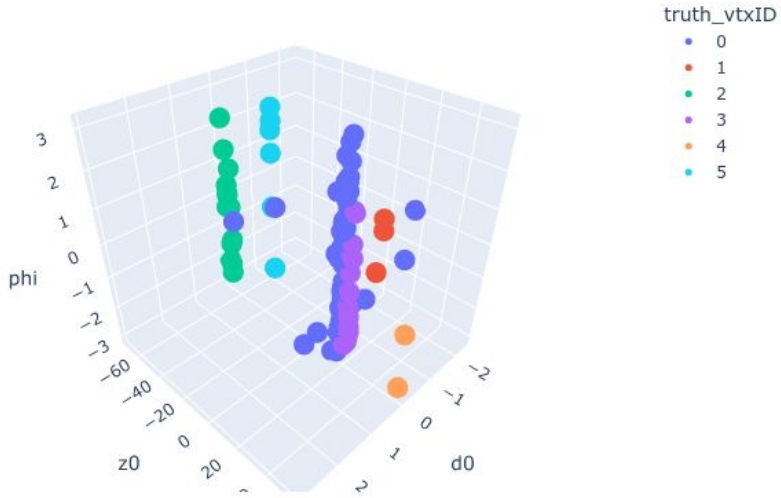
Dataset

- Full hadronic ttbar events at 14 TeV w/ PU = 10
- Pythia 8.243
- ACTS FAst TRAck Simulation
- 10K events (8:1:1 = train/val/test)



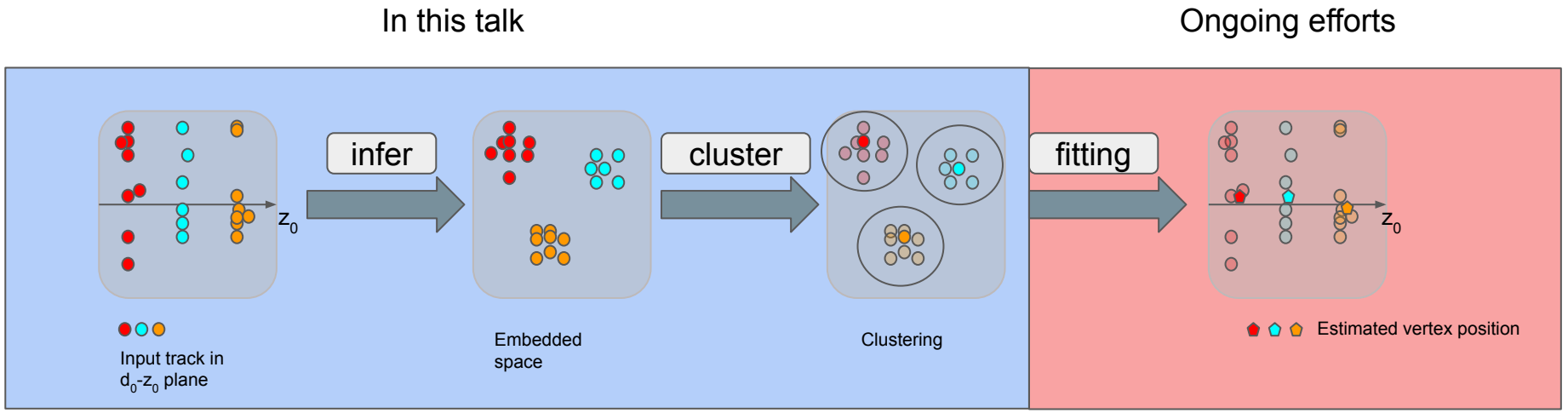
$$\vec{p} = (d_0, z_0, \theta, \phi, Q/P)$$

Cluster tracks into groups.

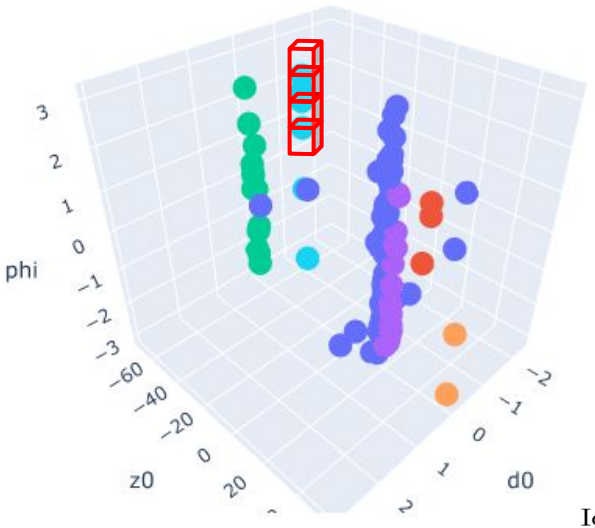


Event display in track space

Workflow


In this talk
Ongoing efforts
infer
cluster
fitting
z_0
z_0
Input track in d_0-z_0 plane
Embedded space
Clustering
Estimated vertex position

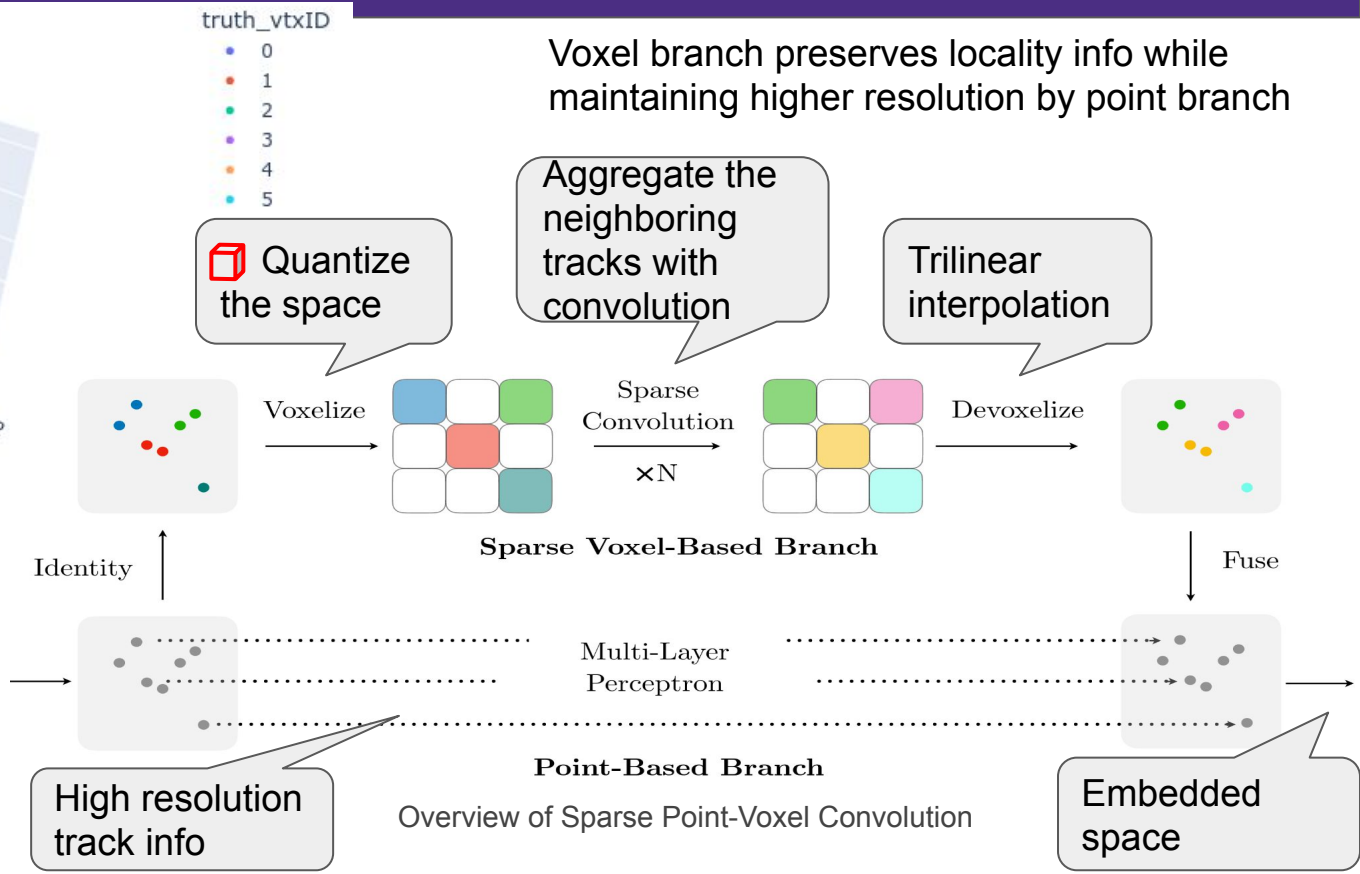
Sparse Point-Voxel Conv Neural Network



(d_0, z_0, ϕ, θ, q/p, error_d_0, error_z_0, error_ϕ, error_θ, error_q/p)

See Alex's talk

HT, ZL,et al. EECV, arxiv:2007.16100



Overview of Sparse Point-Voxel Convolution

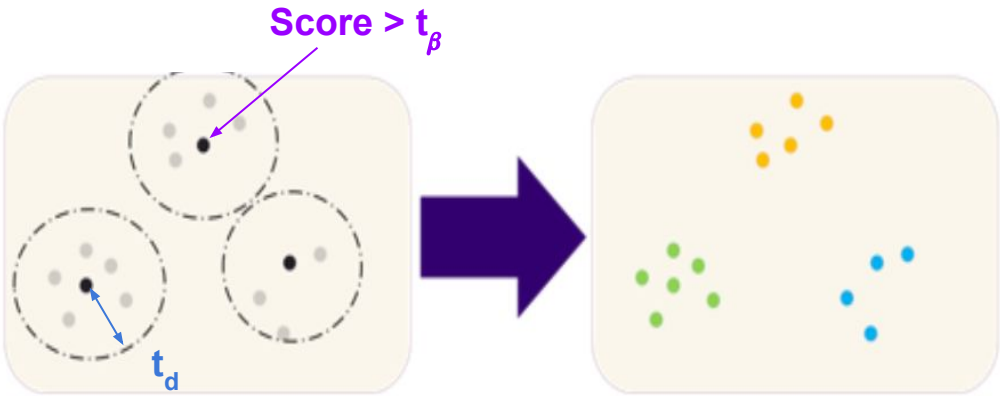
Object condensation

In the embedded space, tracks belonging to same vertex are closer.

Object condensation is run on top of SPVCNN outputs.

Object condensation

- Representative of a track, condensation score
- Setting a threshold of score, t_β
- Cluster the track within a radius, t_d



See Alex's talk

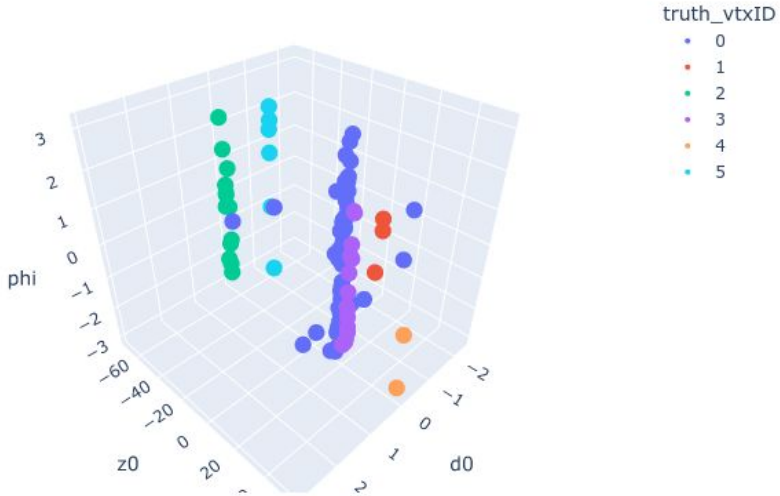
JK, arxiv:2002.03605

Event display Truth vs. SPVCNN

Overall SPVCNN reproduces the truth vertex information.

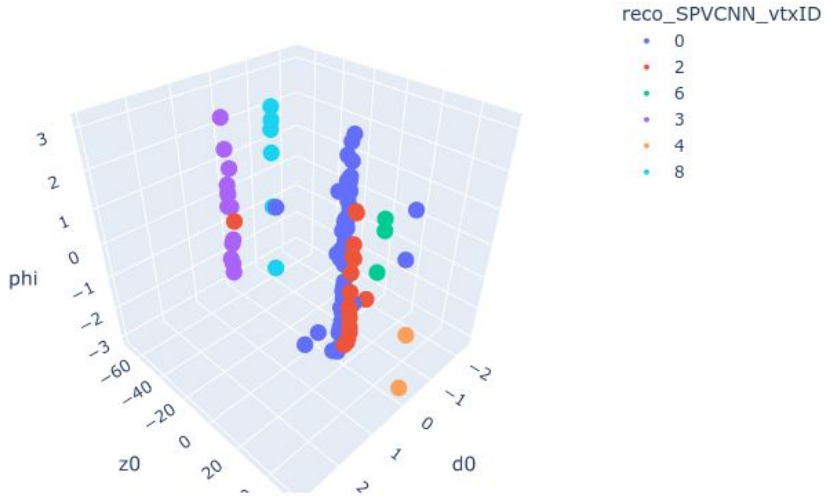
Panoptic segmentation metric PQ ~ 0.85

- Truth



PU=5

- SPVCNN

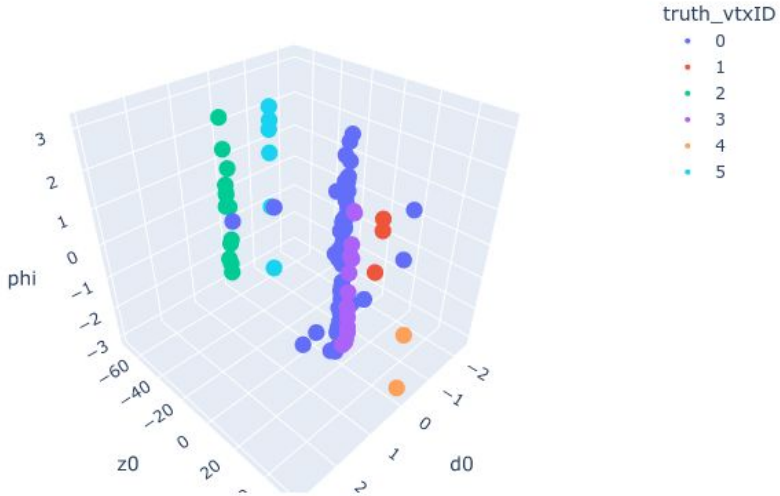


Event display Truth vs. AMVF

AMVF discards several tracks, labeled as -1

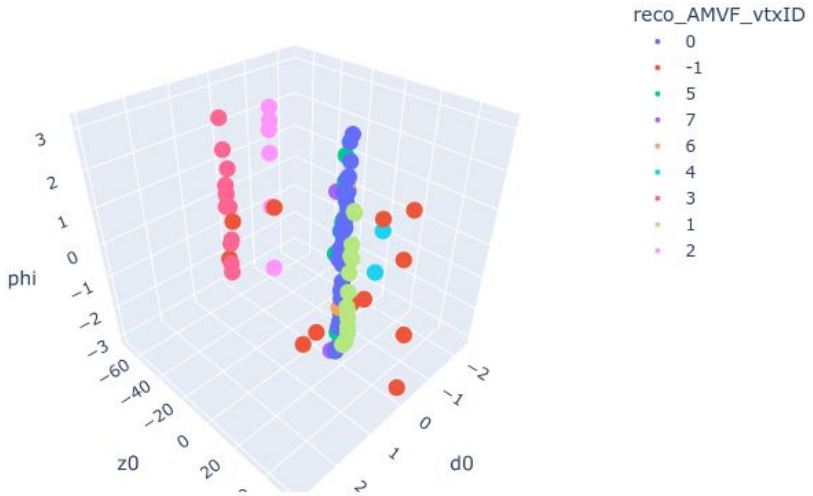
Panoptic segmentation metric PQ ~ 0.80

- Truth



PU=5

- AMVF(conventional algo)



Summary

- First application of SPVCNN to do PV finding
- Initial test with SPVCNN is promising, Panoptic Quality ~ 0.85

Next Steps

- Evaluate performance with physics metrics, e.g. PV quality, Hard Scattering(HS) vertex quality, HS reco efficiency etc.
- Systematically compare performances with other algorithms, e.g. Adaptive Multivertex finding(AMVF)
- Compare with other ML techniques, e.g. hybrid DL in LHCb
- 4D vertexing by making use of tracking time e.g. HGTD