GNN LST

An overview of what we have done so far

March 31st, 2023

P. Chang, ***J. Guiang***

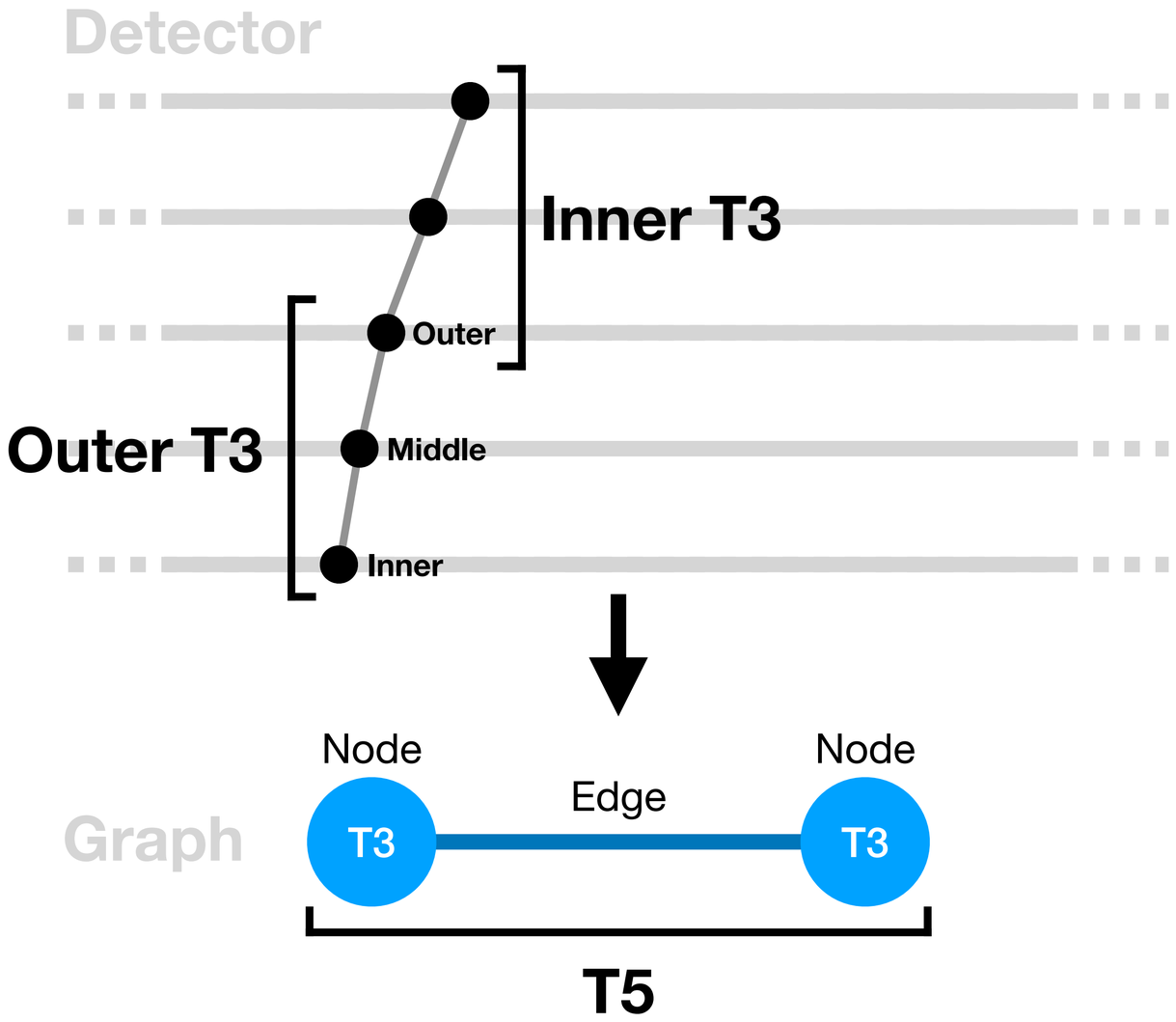
UC San Diego

UF UNIVERSITY of FLORIDA

Setup

Overview

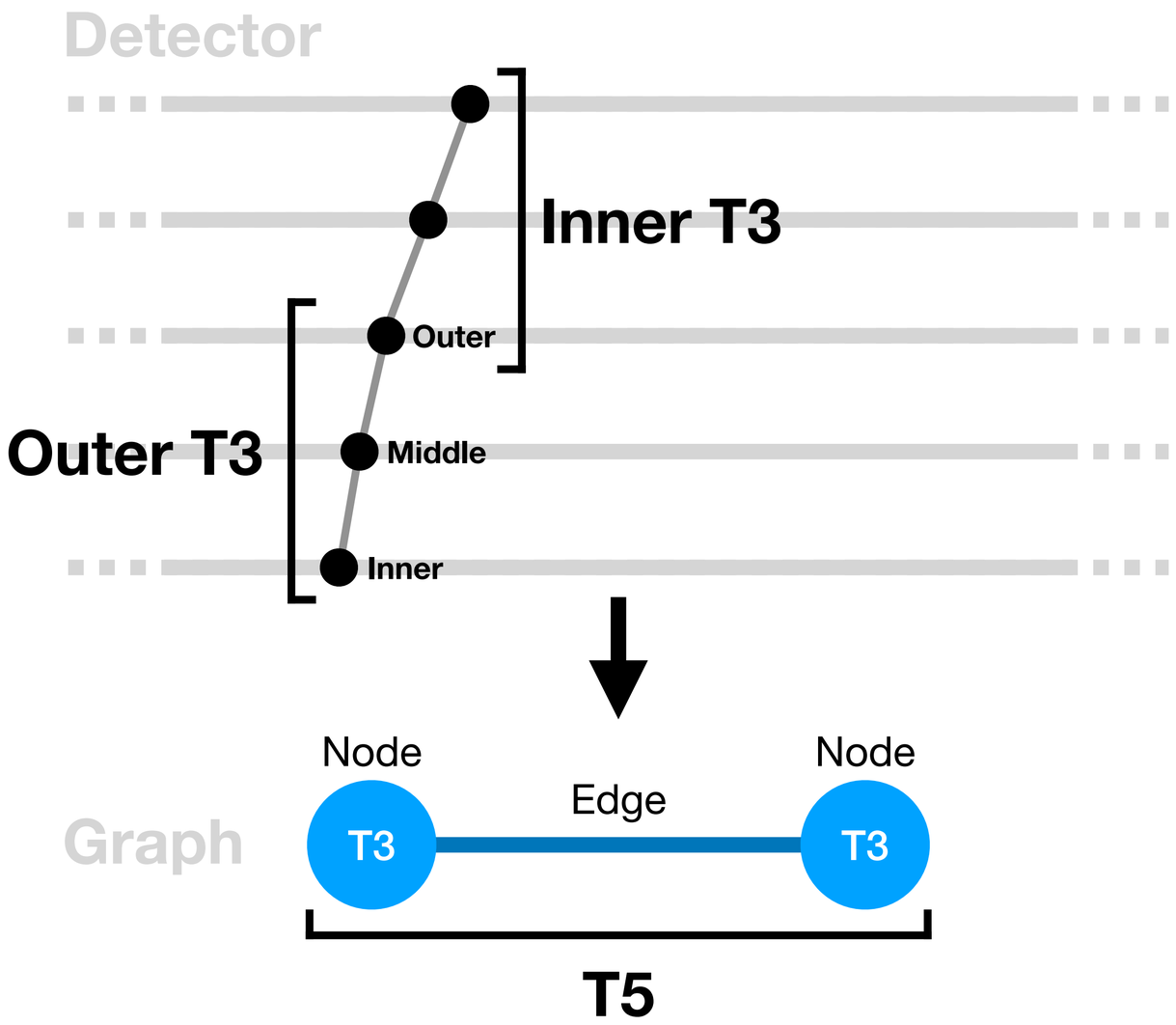
- Exploring GNN for T5 classification
  - T5s have highest fake rate
  - Maybe GNN can improve over Balaji's χ^2 "magic" cuts
- In the graph:
  - T3s become "nodes"
  - T5 candidates become "edges"



GNN Inputs

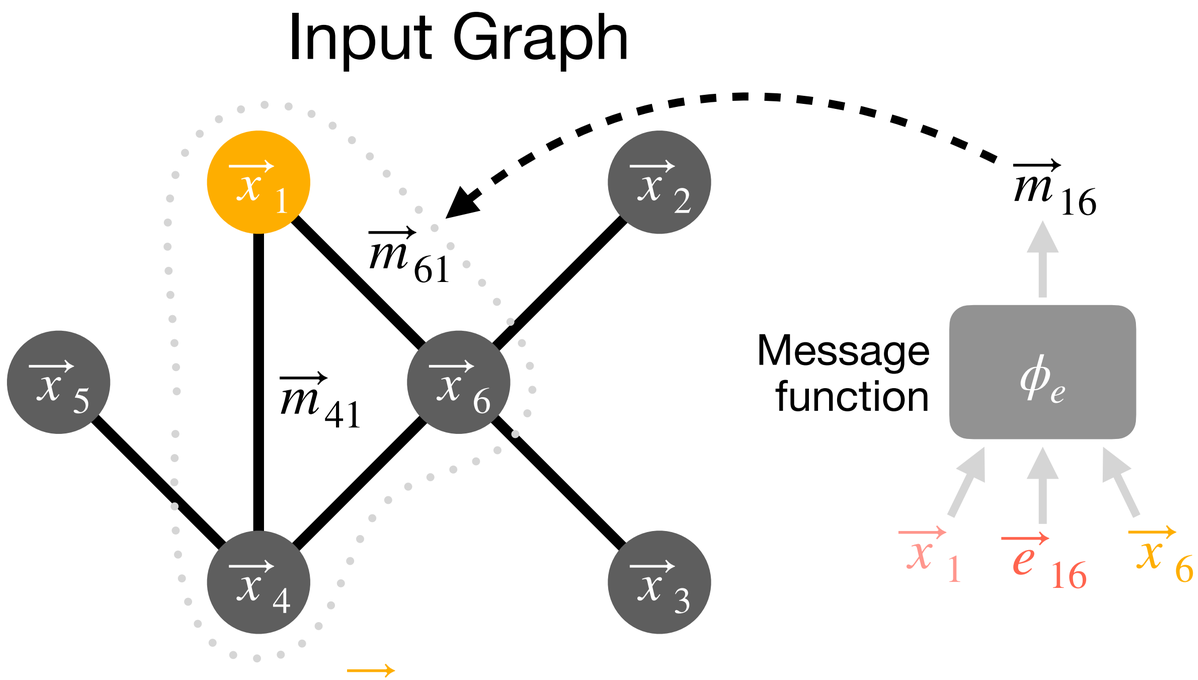
Object	Feature
Node (T3)	p_T, η, ϕ
	Inner anchor hit r, z, Δr, layer
	Middle anchor hit r, z, Δr, layer
	Outer anchor hit r, z, Δr, layer
Edge (T5)	p_T, η, ϕ
	χ^2
	Inner T3 radius
	Bridge T3 radius
	Outer T3 radius

Scaled such that all features ∈ [0, 1]

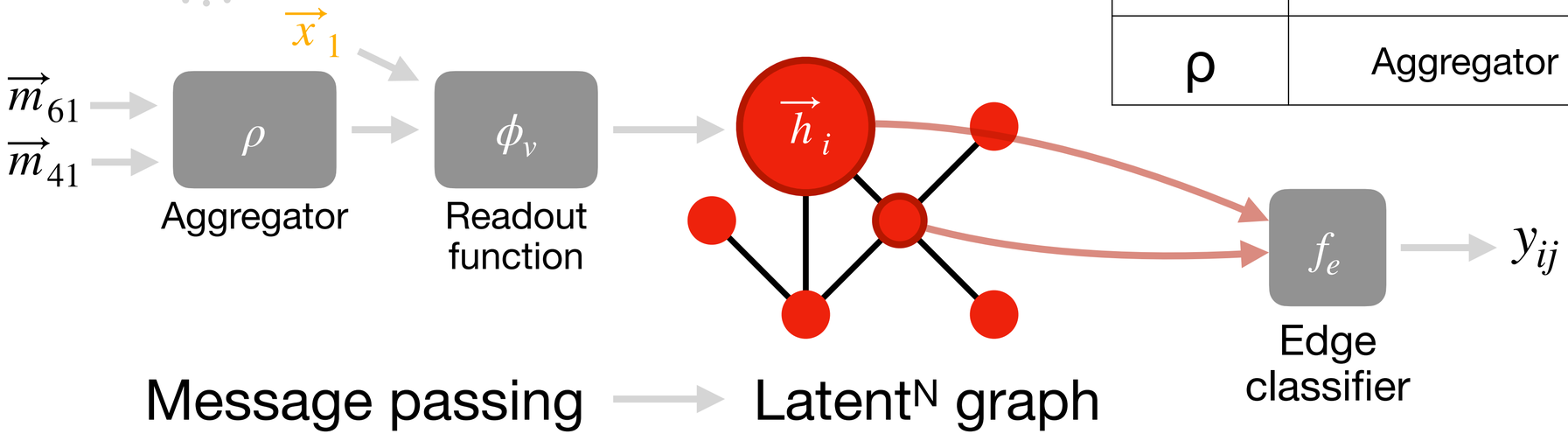


UC San Diego

GNN Configuration



Symbol	Name	Description
ϕ_e	Message function	• Neural network • 3 hidden layers • 200 nodes per layer
ϕ_v	Readout function	• Neural network • 3 hidden layers • 200 nodes per layer
f_e	Edge classifier	• Neural network • 3 hidden layers • 200 nodes per layer
ρ	Aggregator	Sum

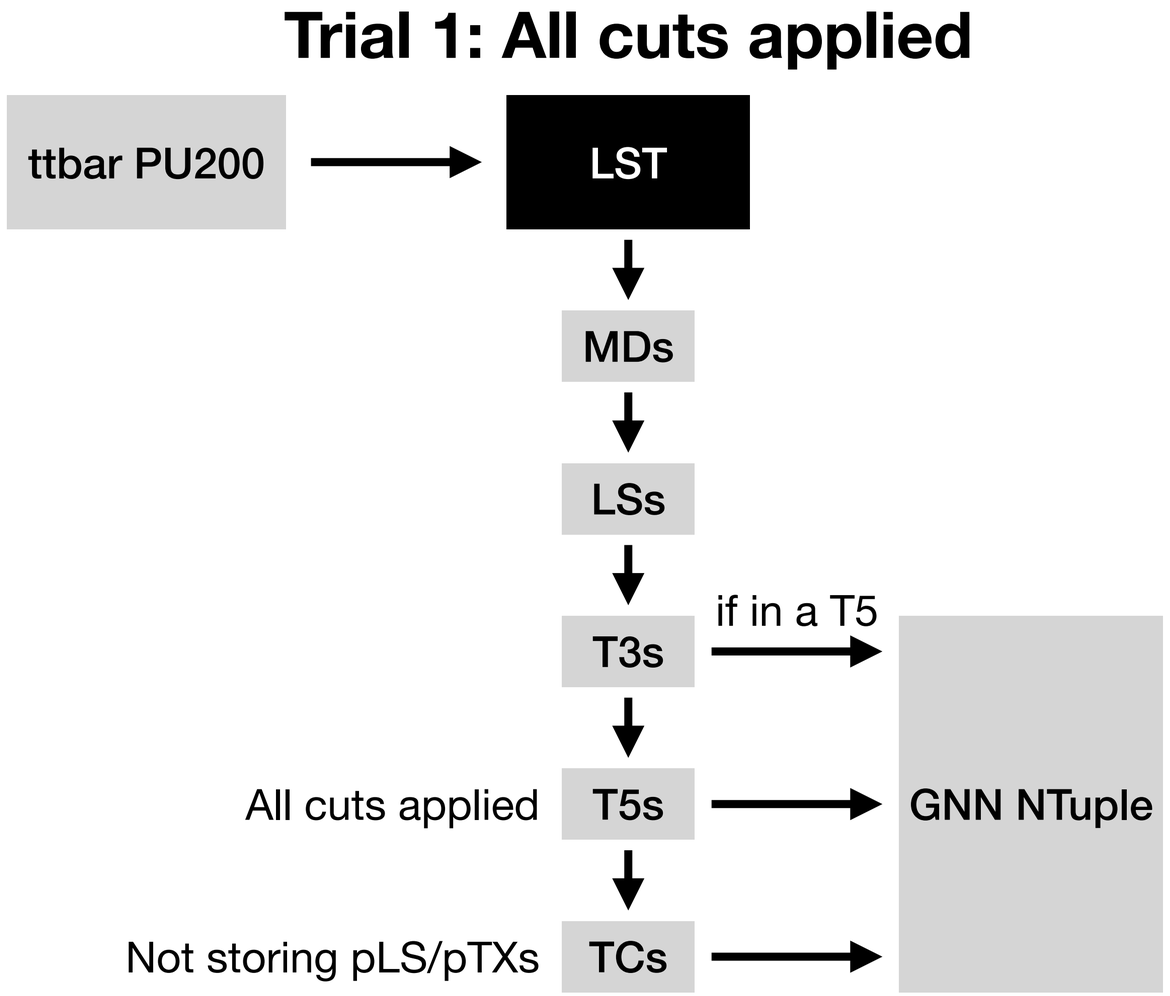


Trials

Trial 1: GNN NTuple

- Training on T5s/T3s without duplicate removal
- pLS/pTX objects are excluded from the TCs
  - i.e. only T5s in TCs
  - Duplicate removal is applied here
- **All cuts applied in T5 selection algo.**
- Target question:

Can the GNN give us anything for free?

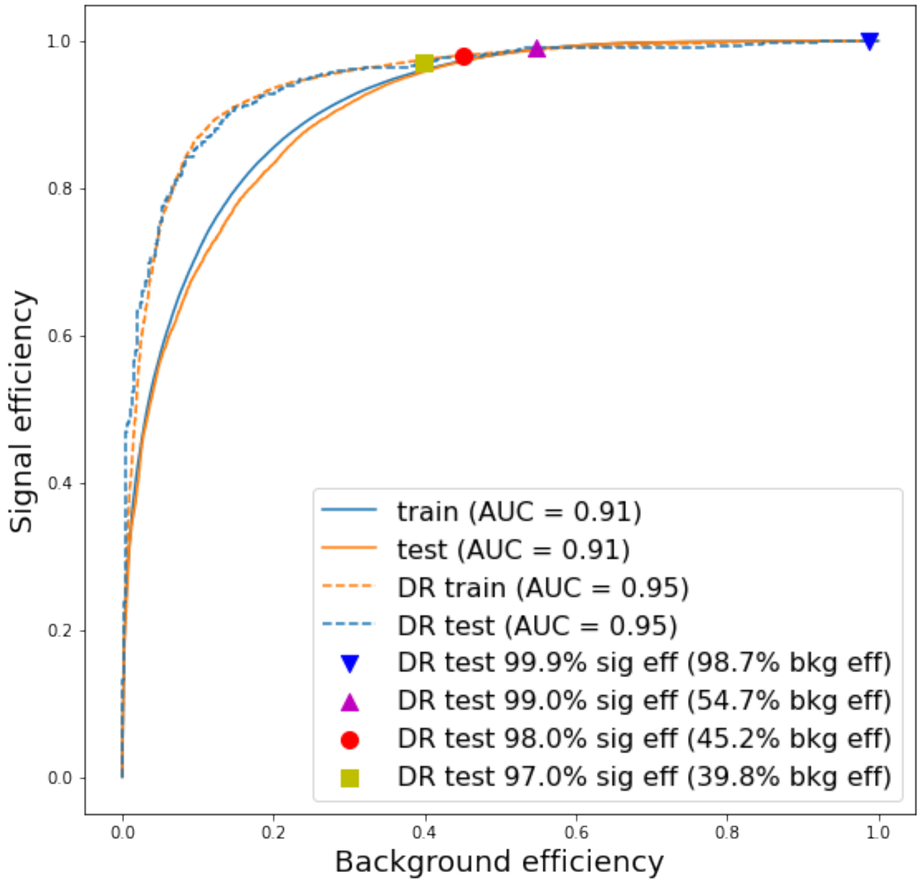


UC San Diego

Trial 1: GNN Performance

Showing inference before/after duplicate removal (DR)

- Solid curves show performance immediately after making χ^2 cuts
- Dashed curves show performance on only T5s in TC collection (i.e. after duplicate removal)
  - Q: If we run inference on only final T5s, **how many fakes can we remove** (while only removing X% of reals)?
  - A: We can **reduce fake T5s by a factor of 2** while only losing 1% of reals
- **To-do:** propagate GNN score to LST NTuple and make DP-like efficiency plots

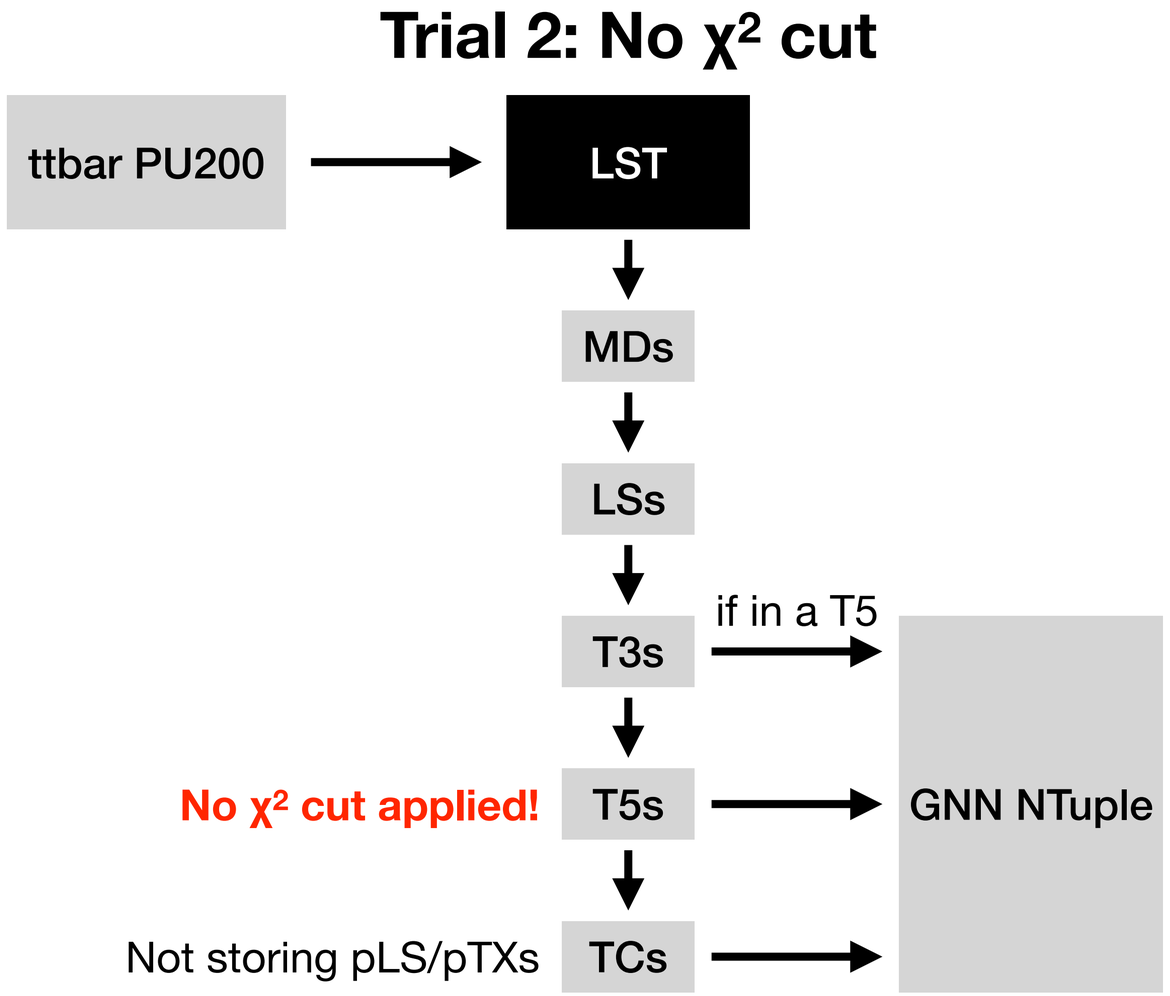


UC San Diego

Trial 2: GNN NTuple

- Training on T5s/T3s without duplicate removal
- pLS/pTX objects are excluded from the TCs
  - i.e. only T5s in TCs
  - Duplicate removal is applied here
- **Removed χ^2 cuts from T5 selection algo.**
- Target question:

Can the GNN beat the χ^2 cuts in LST?

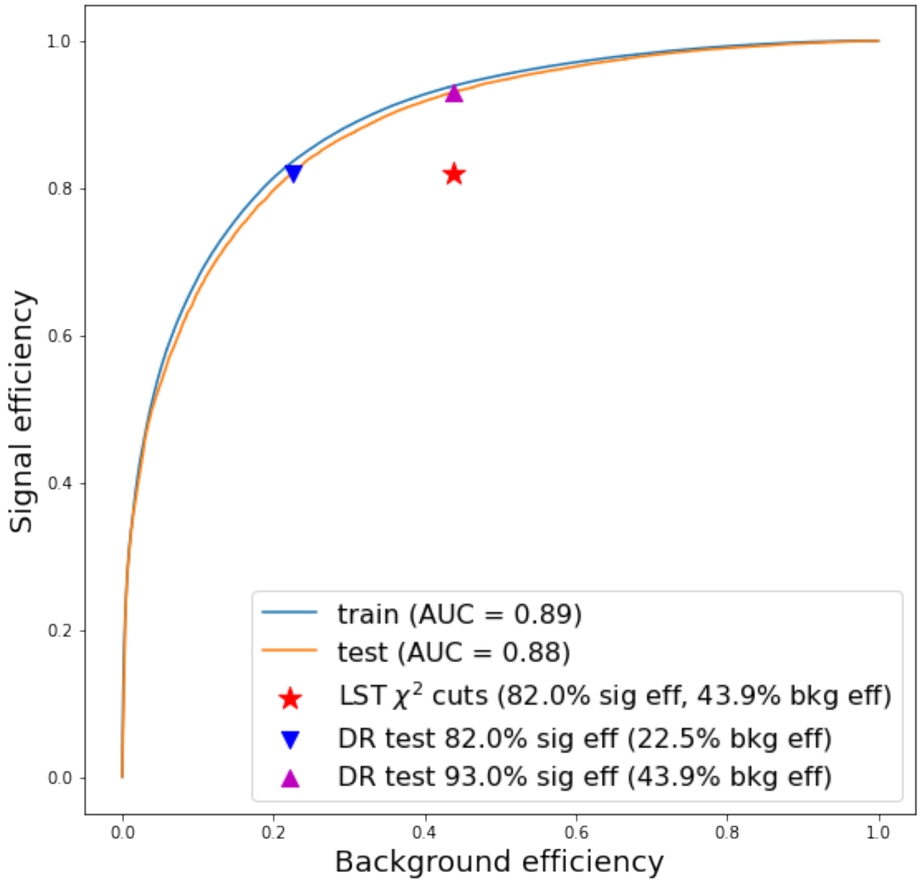


UC San Diego

Trial 2: GNN Performance

We get around 10% performance over the χ^2 cuts!

- LST efficiency point (★) determined as follows:
  - P(N) = # of real(fake) T5s
  - TP(FP) = # of real(fake) T5s after χ^2 cuts
  - Bkg. eff. = FPR = FP/N
  - Sig. eff. = TPR = TP/P
- **Caveat:** this is only comparing at the T5-building stage of LST (i.e. ***not* the final efficiency!**)
- **Caveat:** LST w/ vs. w/out χ^2 is 99.9% fair (next)

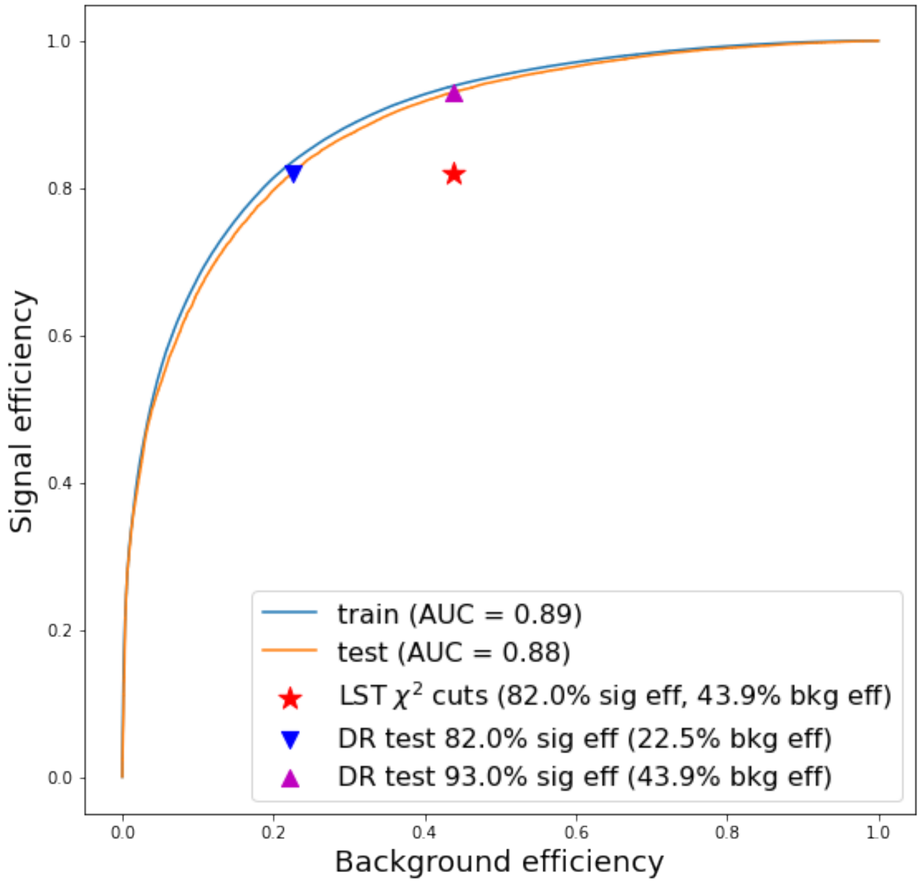


UC San Diego

Trial 2: GNN Performance

We get around 10% performance over the χ^2 cuts!

- Took TP, FP numbers from Trial 1 NTuple
- Took P, N numbers from Trial 2 NTuple
- LST is not fully deterministic, so FPR and TPR are not completely accurate
  - **Numbers seem stable**, so should be accurate anyway



UC San Diego

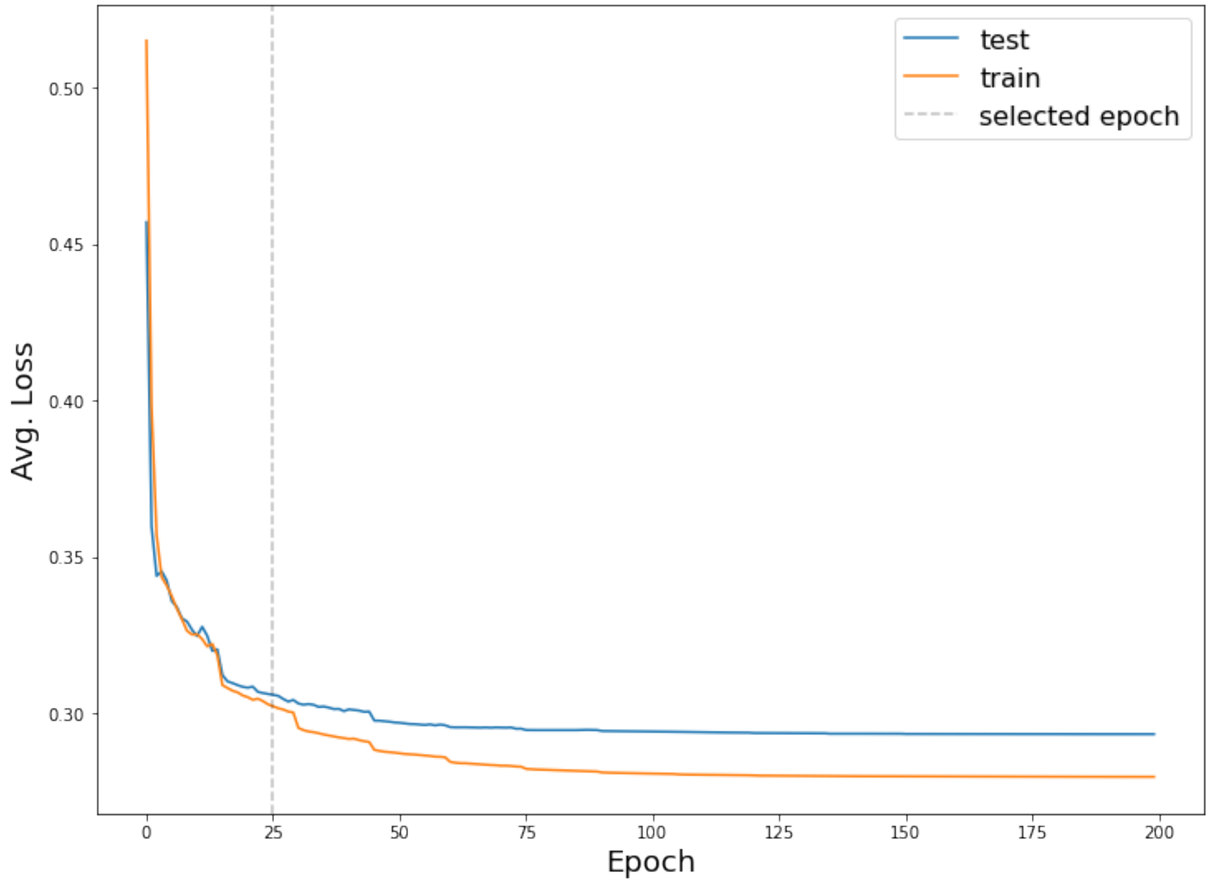
Summary

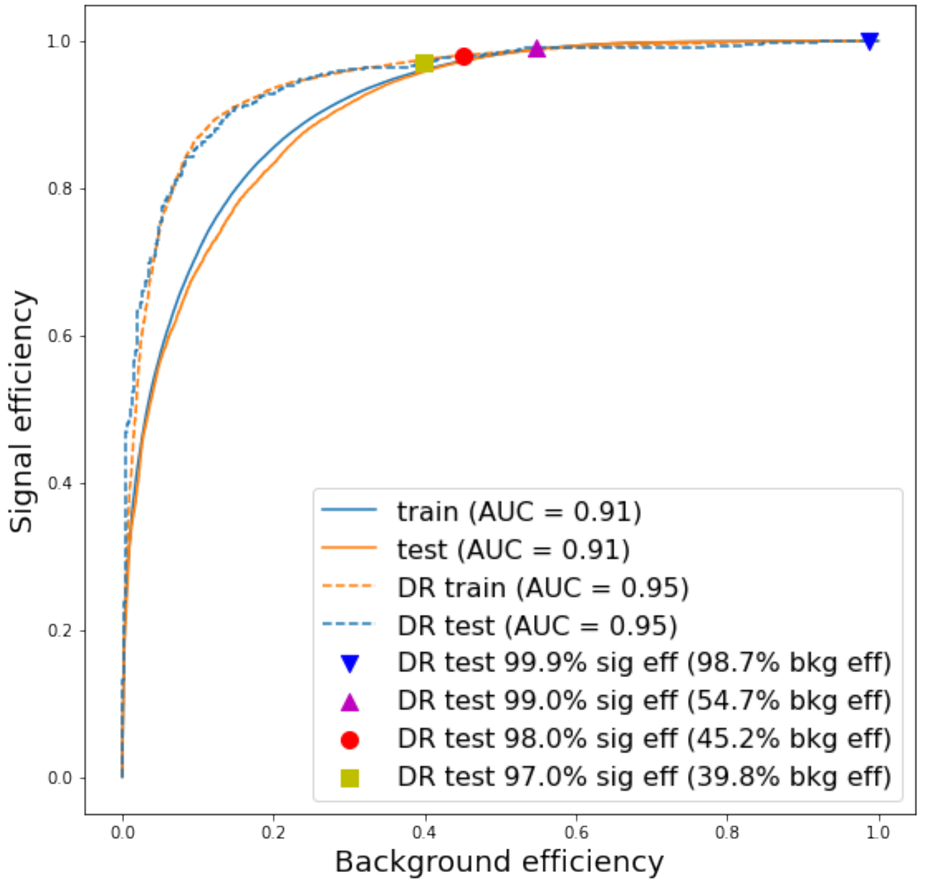
- The GNN is working, but we can probably make it better
- DR LST vs. DR GNN seems too good to be true
  - Maybe I am miscalculating somewhere?
- Next steps:
  - **Add GNN scores from Trial 1 to LST NTuple and make DP-like efficiency plots**
  - More data!
  - Experiment with GNN configuration/hyperparameters/etc.
    - Consult J. Duarte for inspiration

Backup

Trial 1: GNN Performance

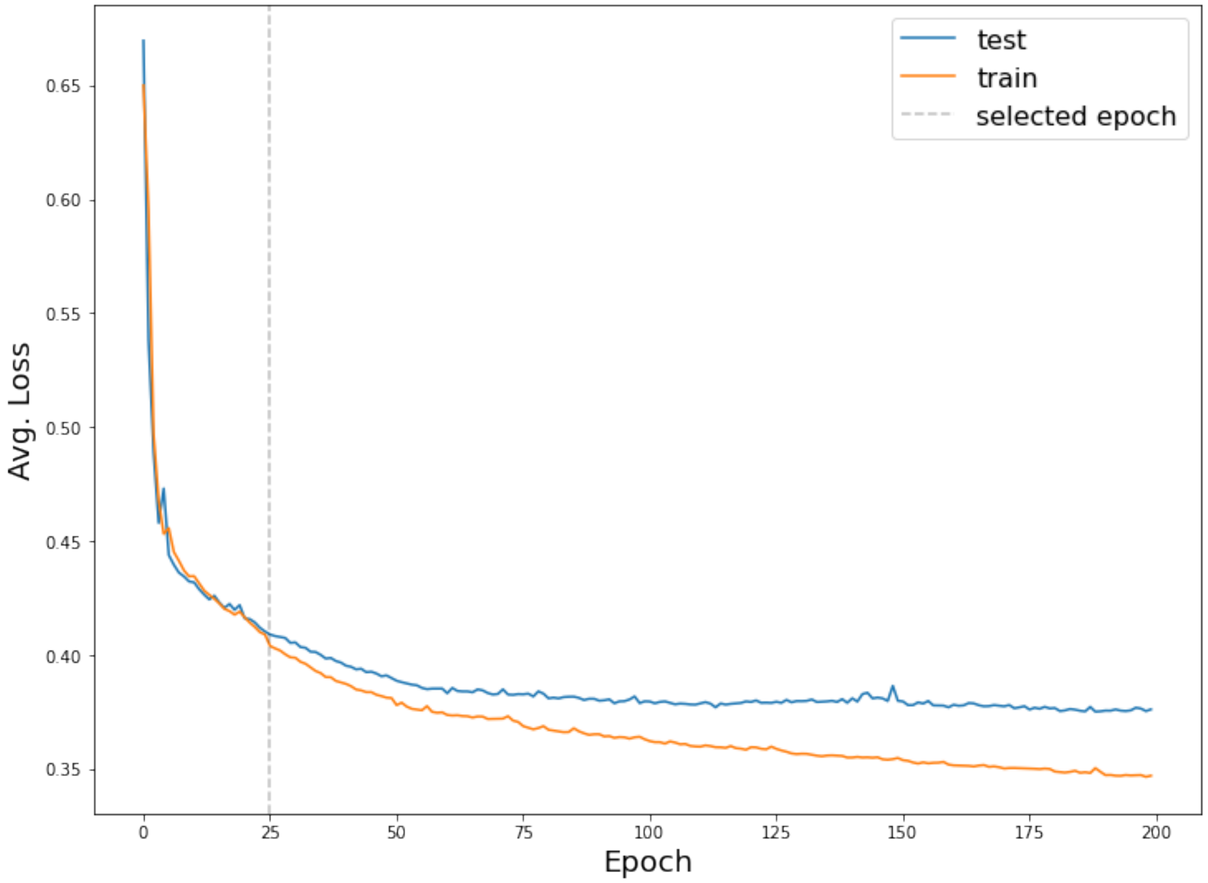
Showing inference before/after duplicate removal (DR)

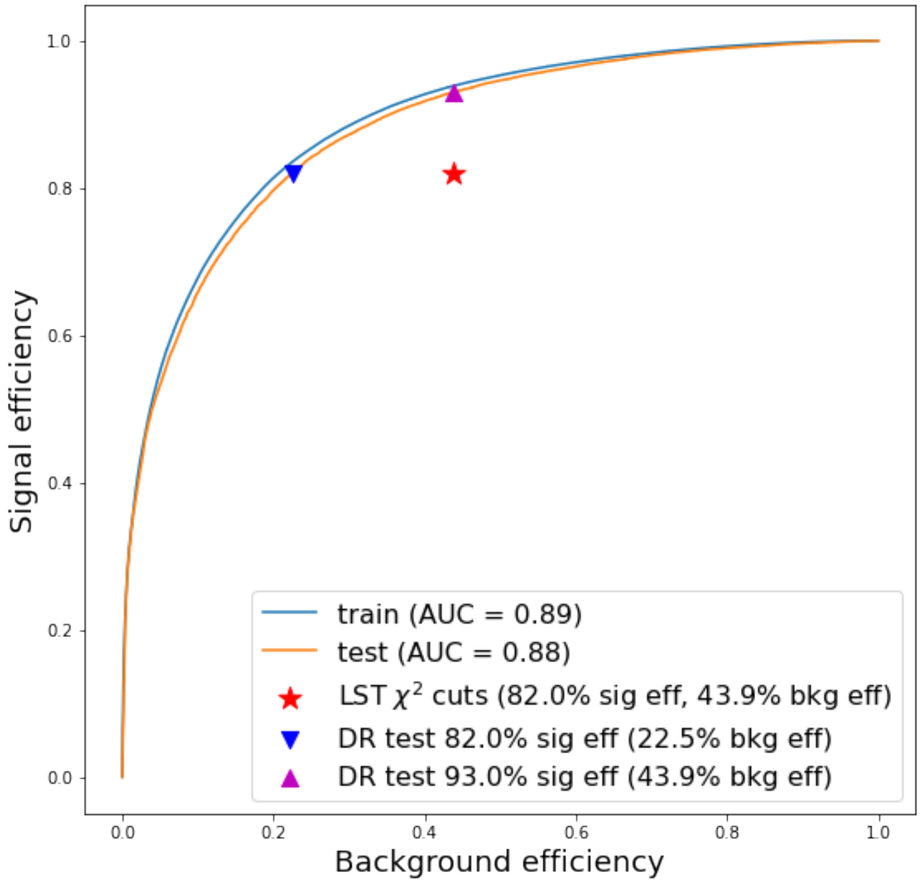




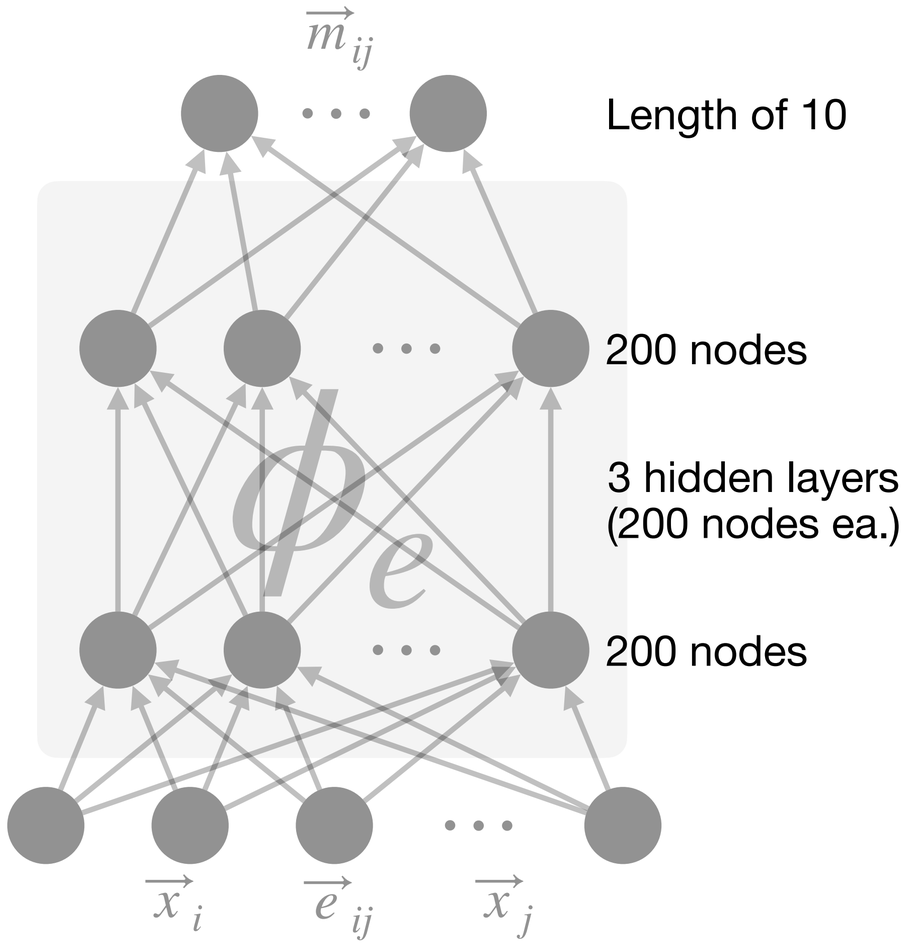
Trial 2: GNN Performance

Showing inference before/after duplicate removal (DR)

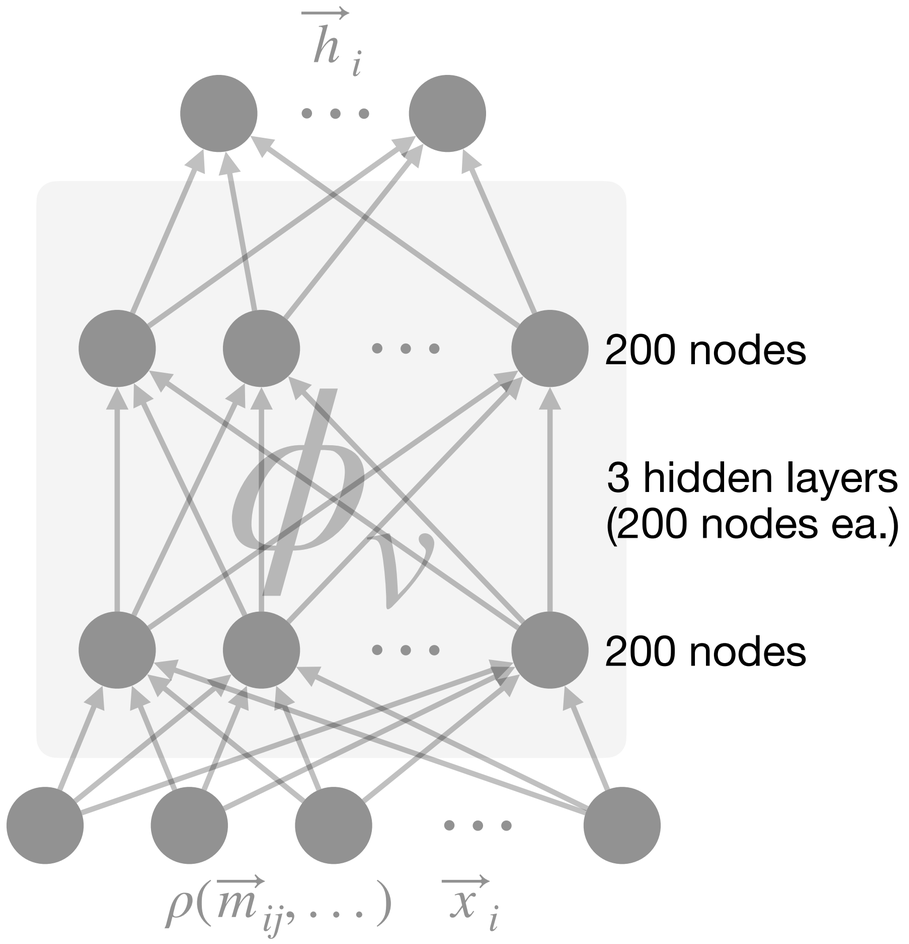




GNN Internal NN Configurations



Message function



Readout function

UC San Diego