Accelerating Graph-Based Tracking with Symbolic Regression

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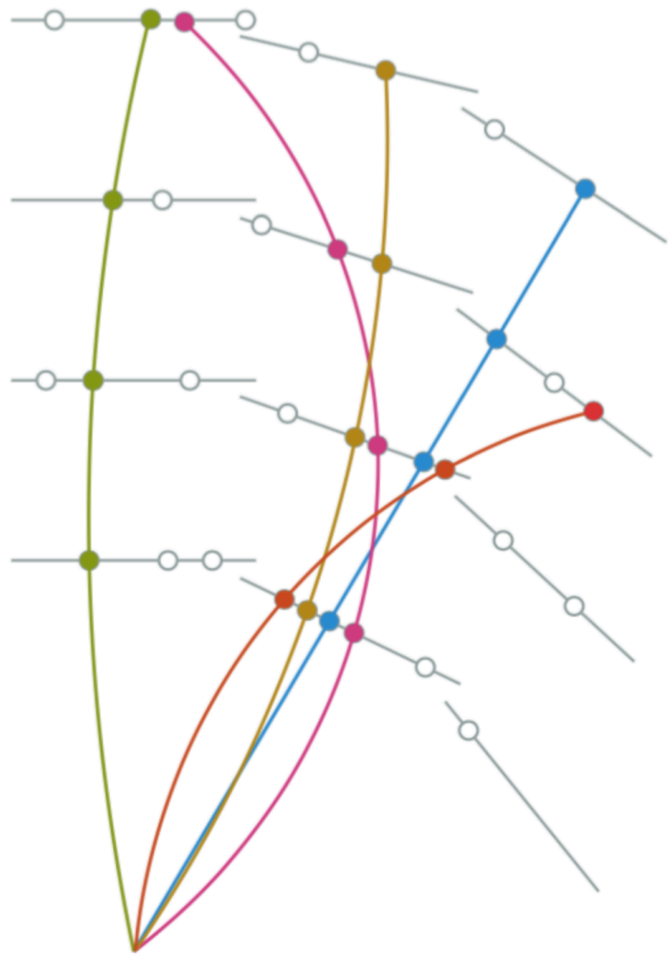
The Nail

Tracking — Identification of charged particle paths

- Currently done in post processing of data



- Tracking information is fundamental for triggers

- The lower the execution time of ML methods, the higher rates we can handle

Symbolic Regression on FPGAs for Fast Machine Learning Inference

Ho Fung Tsoi[1*], *Adrian Alan* Pol[2], *Vladimir* Loncar[3,4], *Ekaterina* Govorkova[3], *Miles* Cranmer[2,5], *Sridhara* Dasu[1], *Peter* Elmer[2], *Philip* Harris[3], *Isobel* Ojalvo[2], and *Maurizio* Pierini[6]

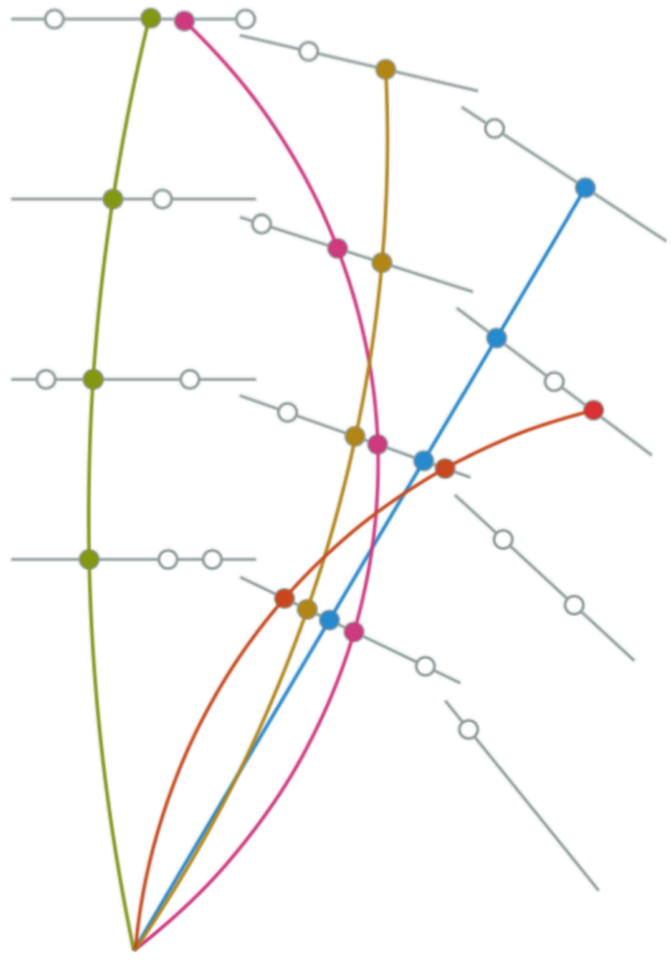
- Approximate MLP with symbolic expression
- Used for jet classification
- Easy to implement on FPGA and fast inference

Great idea ⟶ can be generalized

The Hammer

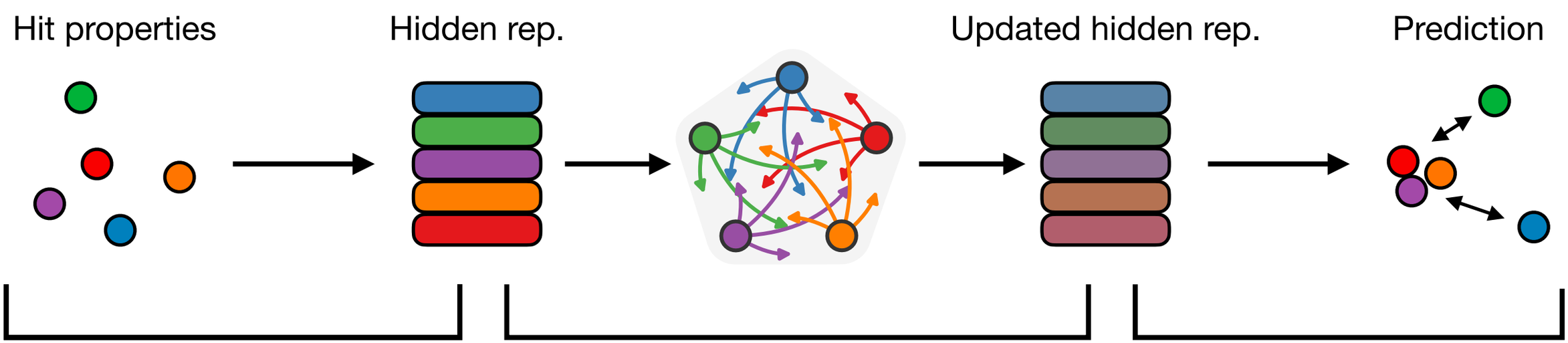
GNN with symbolic regression

- Single MLP not enough ⟶ use GNN instead
- Toy dataset for tracking:
  - resembling detector occupancy
  - single track
  - distinguish signal hits and noise

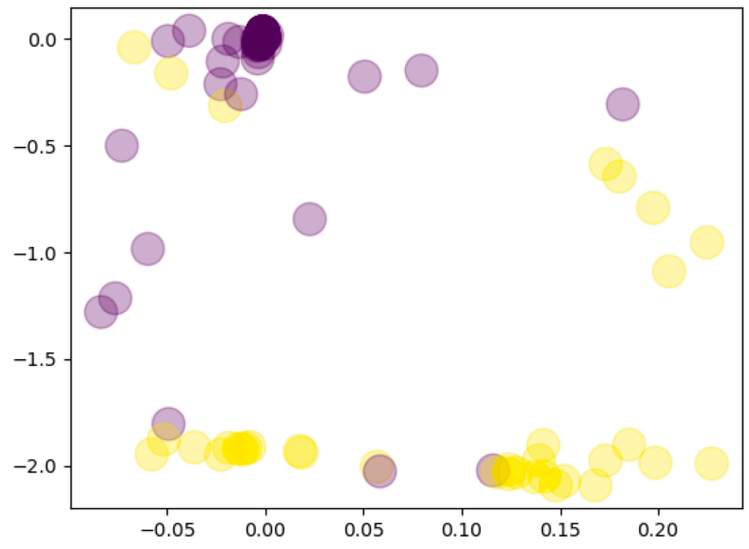


The Hammer

GNN with symbolic regression

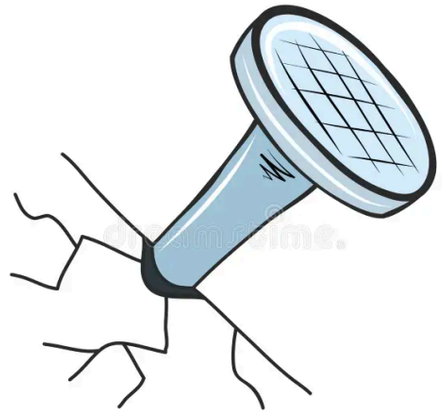


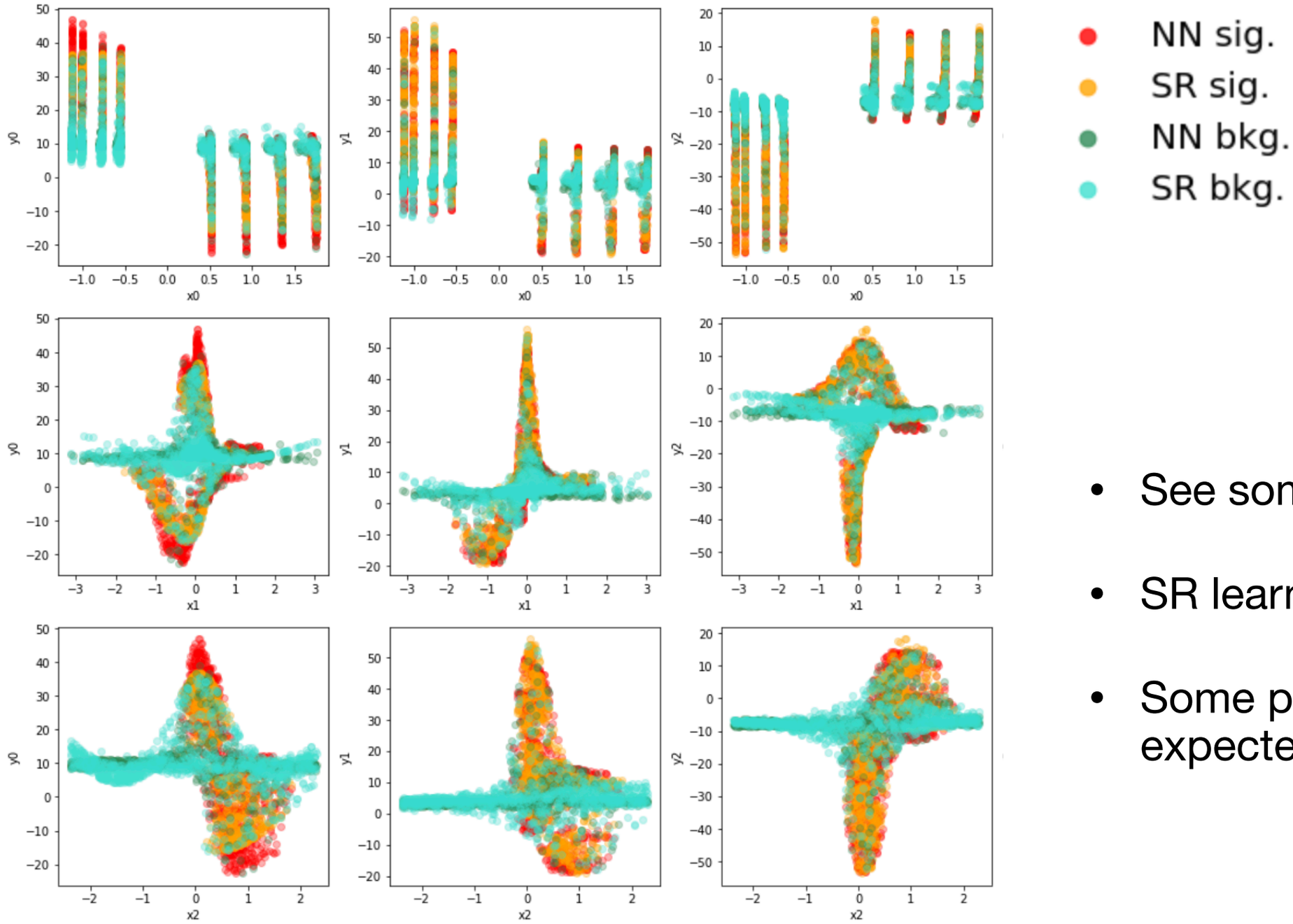
- In total we have 3 MLP to be replaced with SR
- Preserving graph structure
- After each replacement retrain rest of the network



Results

Look inside first MLP — example

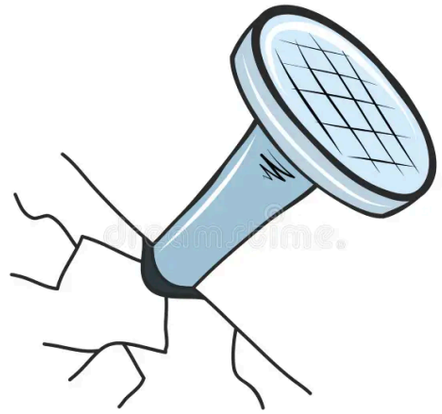


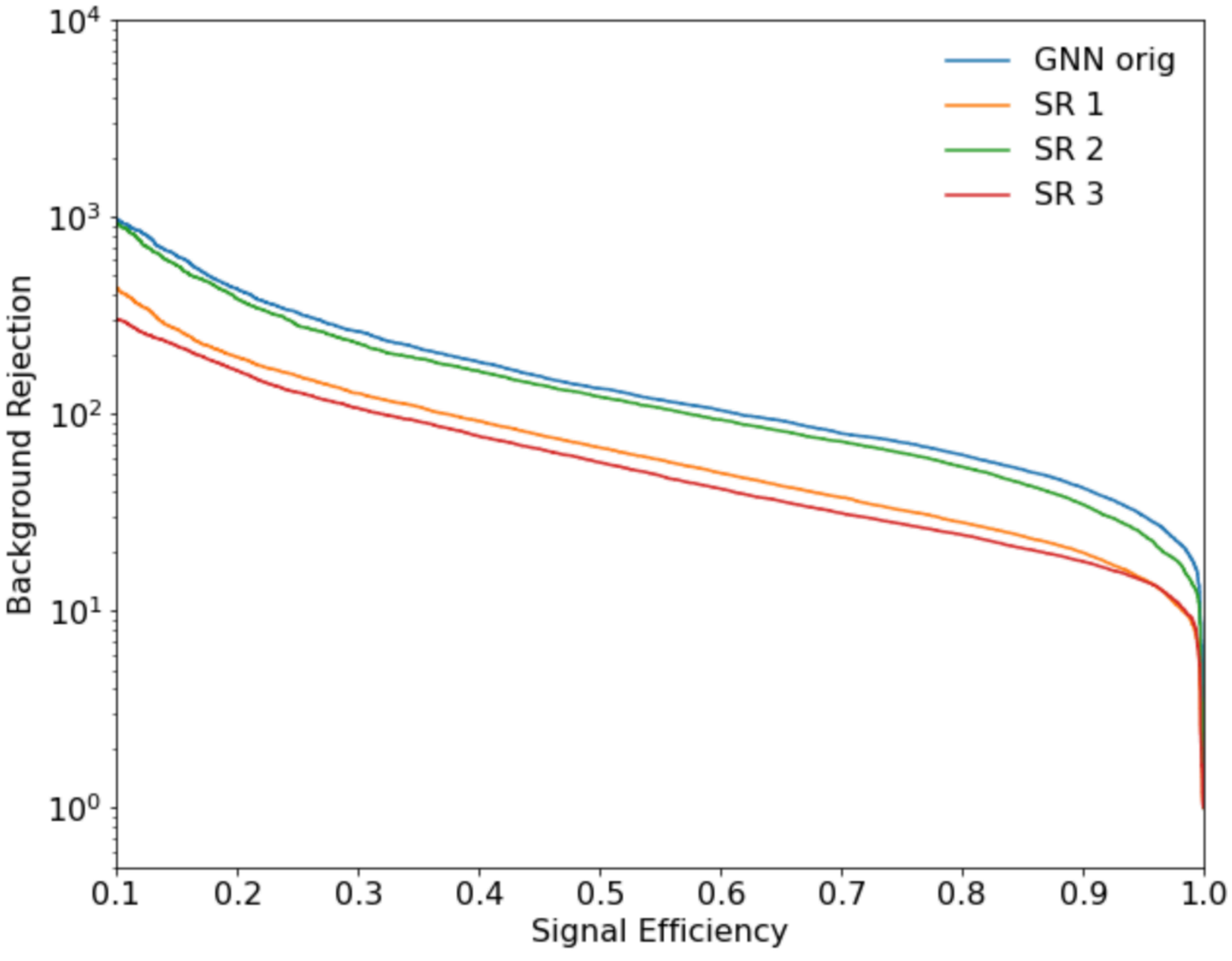


- See some clustering
- SR learns overall structure
- Some performance loss expected

Preliminary results

Performance — replacing just one part

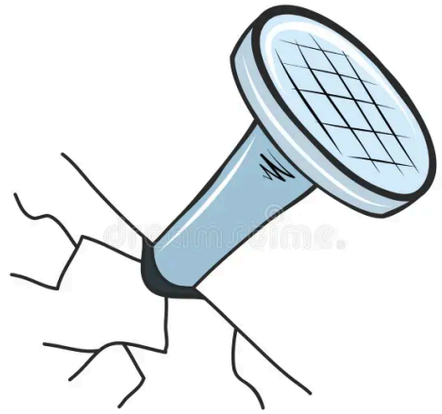


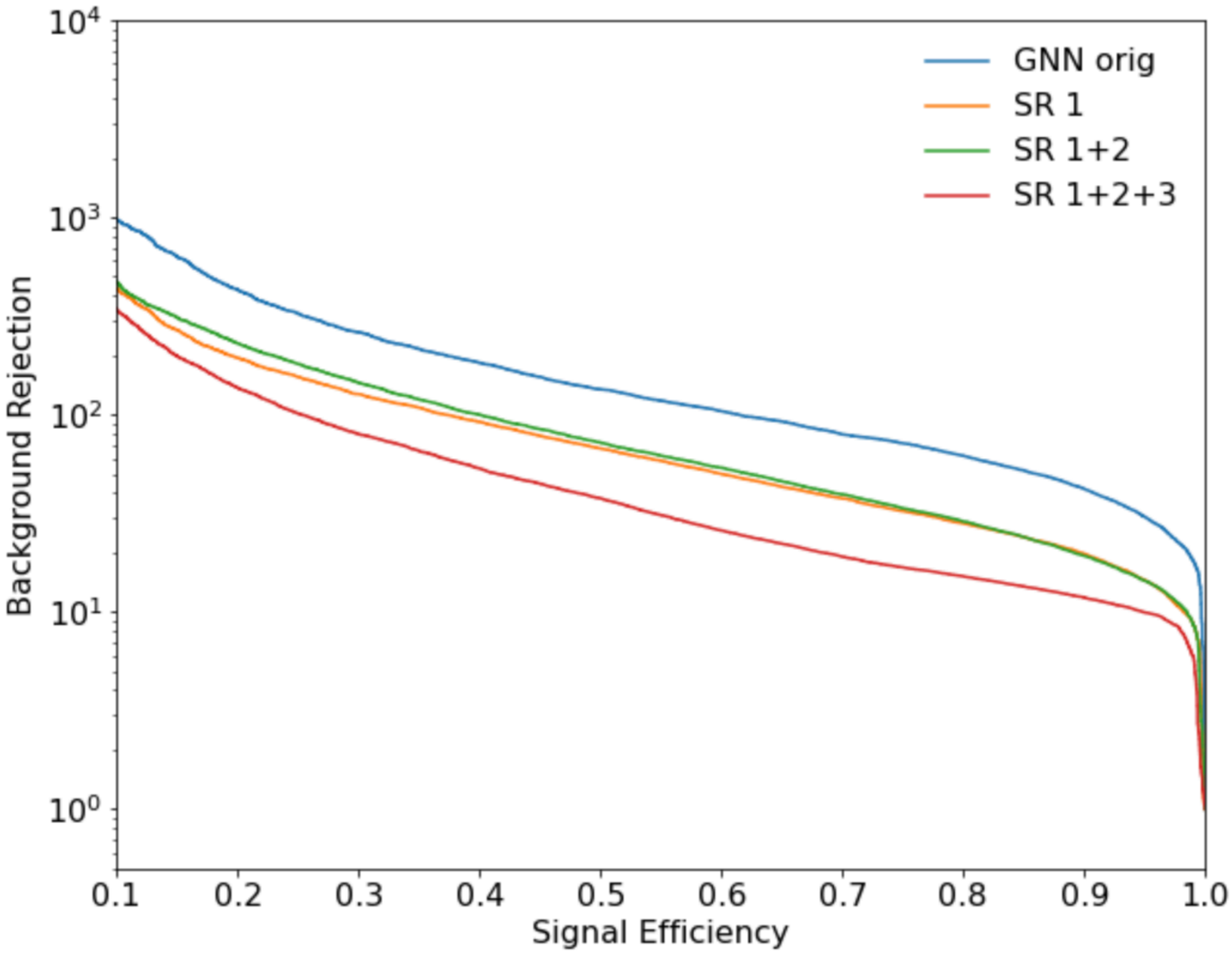


- 2nd part learned very well
- Some degradation for 1st and 3rd part

Preliminary results

Performance — combined replacements





	Timing	CPU load
GNN	105 μs	80%
SR	45 μs	10%

- Time difference will be more significant with bigger GNN
- Reduction in CPU load ⟶ more processes in parallel

Outlook

- Preliminary work in replacing partial/full GNN with SR
- Further studies to boost performance
- Can be used for high level trigger HLT
- Possible candidate for L1 trigger if implemented on FPGA