Noise Removal of the Events at Main Drift Chamber of BESIII with Deep Learning Techniques

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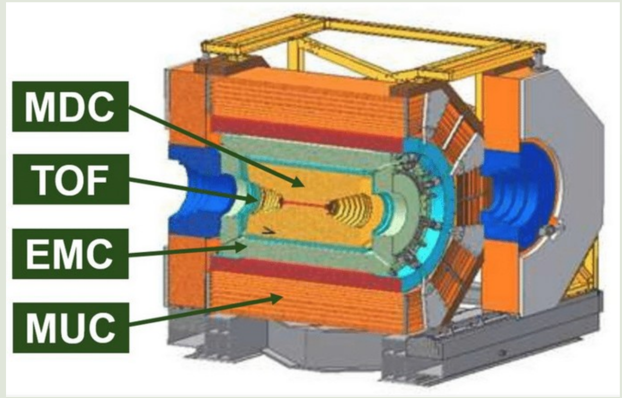
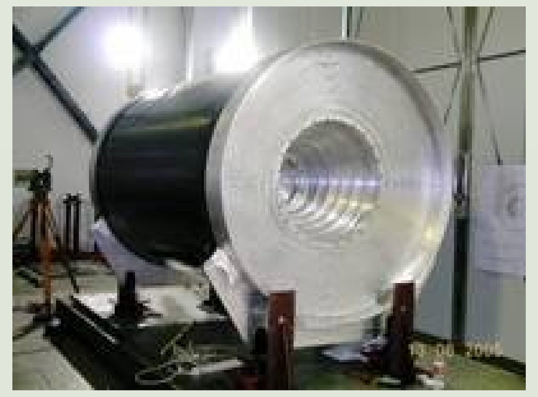
Drift Chamber of BESIII

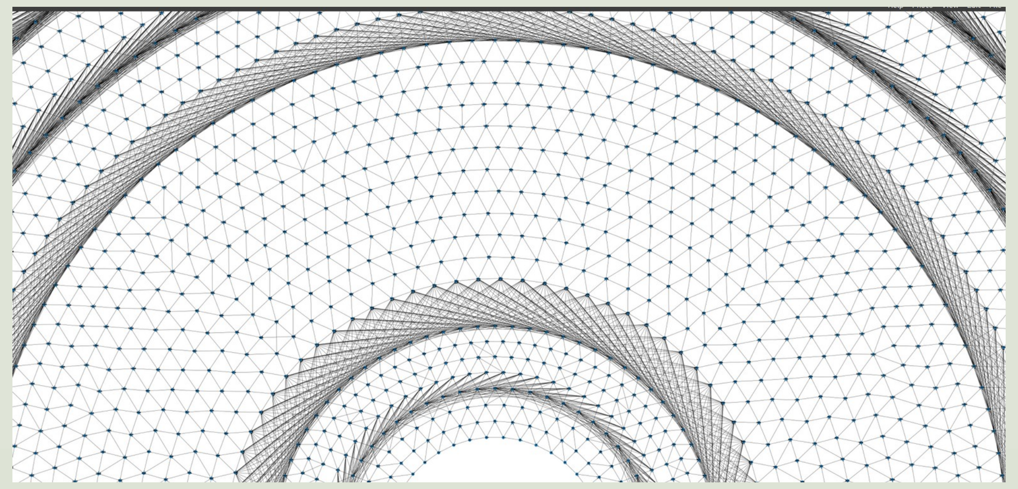
BESIII is the particle detector of Beijing Electron-Positron Collider which works with energies around 4 Gev. The first part of the detector is called the Main Drift Chamber . It consists of 6796 sense wires distributed in 43 layers.



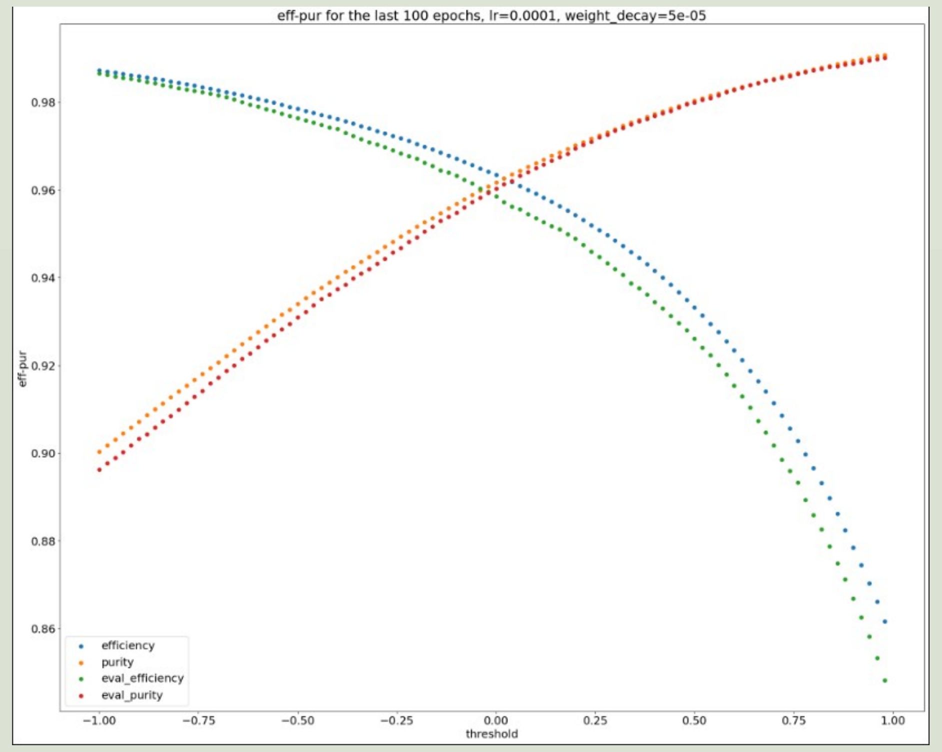


Graph Convolusional Neural Network Models

Structure of the network is similar to the CNN network of the next block. The graph is a realistic graph of the cells (as nodes) and neighboring relations (as edges).



If there is a hit on a cell, the feature of that node is the normalized raw time of the hit. Otherwise, it is zero. The Edges also have learnable weights indicating the importance of the neighboring nodes.



20000 events
600 epochs

Overview

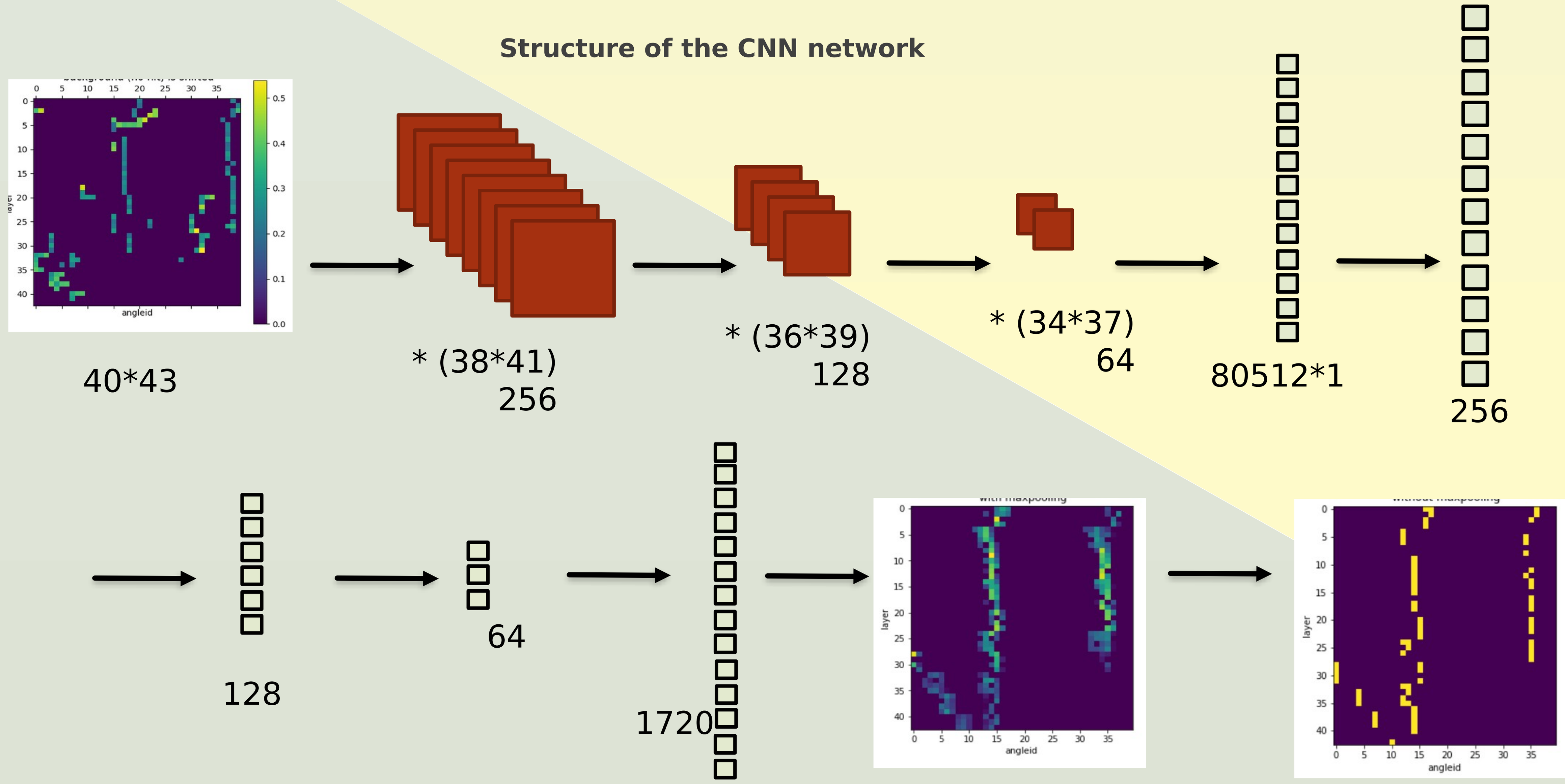
We start with simulating simple Bhabha events and build models to remove their noises. Then we gradually add other particles to the picture .

Apart with the geometry of the hits of each event, we also use raw time as a scalar feature for each recorded hit. A simple cut in time can in average remove about 30% of the noise without loosing efficiency of the signal.

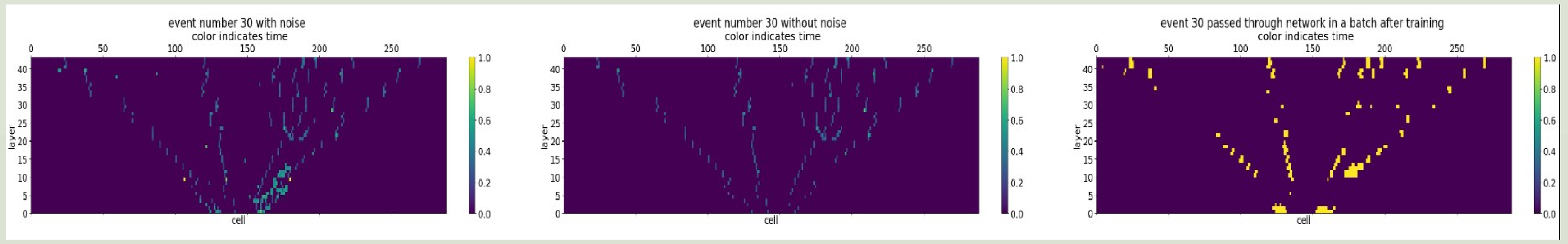
With simple deep fully connected networks, we can find suitable cuts in time for each cell independently. can remove 85% of the noise while loosing 15% of the signal as well. 85% purity and efficiency at the same time.

We have also tried Graph Neural Networks for our problem. Early models can remove noise with up to 96% efficiency and purity.

Convolusional Neural Network Models



An Example:



Training:
80000 events
200 epochs

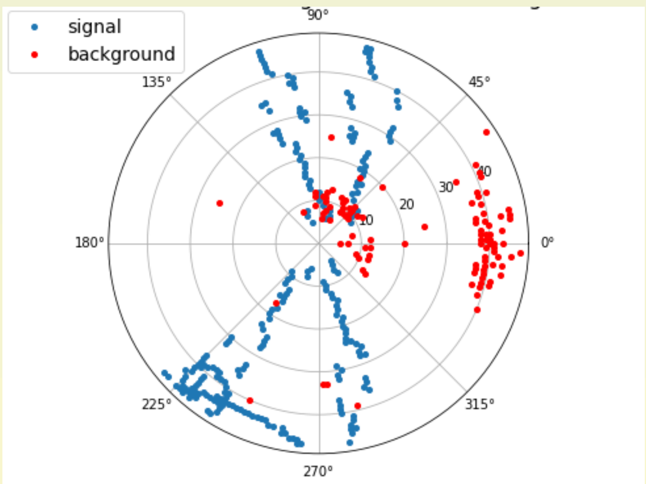
Result:
99% purity and efficiency

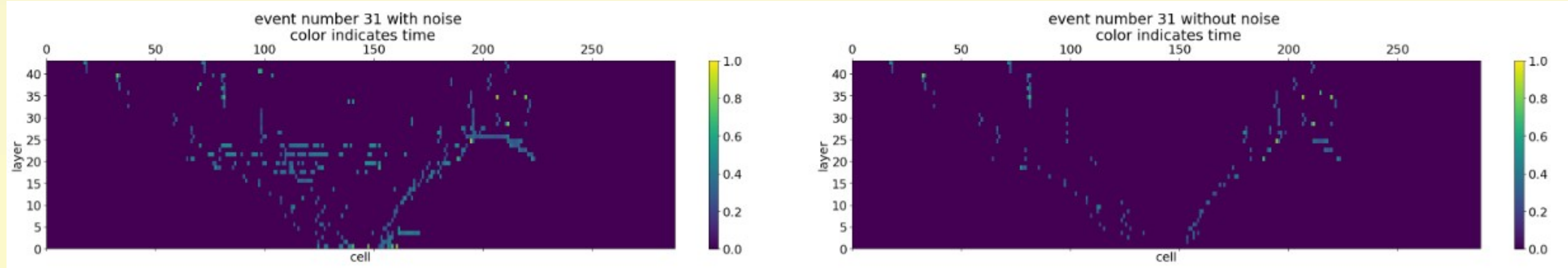
For events with high amount of noise (more than 50 percent), the result is still more than 90% purity and efficiency.

The Events

So far, we have done it for pions, protons, and electrons.

Noise happens due to different reasons such as electrical discharge. Depending on the event we are interested in, the number os noise hits can be between 10 to more than 100 percent of the signal hits.





Technicalities

We run training on A100 ans V100 GPUs of our farm. A typical training on 80000 events happens in about 5 hours.

For CNN models, we used both TensorFlow and PyTorch. For GNN we used PyTorch and Deep Graph Library.

For future

We need to include pions and protons as well and then implement the mode into the offline software system of BESIII.

In the CNN model, we have filters in three hidden layers which means each hit needs to know about five neighboring cells.. In the GNN model also we have message passing process in three of the hidden layers. We think to improve this model and make it comparable with the GNN, we need to include second neighbors in the structure of the graph.