**BESIII track reconstruction algorithm based on machine learning**

**Xiaoqian Jia**, **Xiaoshuai Qin**, **Teng Li**, **Xingtao Huang**, **Xueyao Zhang**, **Yao Zhang** and **Ye Yuan**

1. Shandong University, Qingdao, China 2. Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China

**Motivation**

- **BESIII**
  - Operate at Beijing Electron-Positron Collider II (BEPCII)
  - CMS: 2.0 - 4.95 GeV, τ - charm region
  - Study the electroweak and strong interactions

**Track finding algorithm**

- Play essential roles in the offline data processing
- Traditional algorithms include template matching, track segment finder and Hough transform etc.
- Potential improvement for low momentum tracks and tracks with high noise level.

**Methodology**

- Pattern Map based on MC simulation
  - The collection of sense wires that could potentially represent two successive hits on a track
  - Two million single tracks (e⁺, K⁺, μ⁺, p⁺, π⁺, π⁻) from BESIII MC truth information used to build pattern map
  - To reduce the number of fake edges during graph construction

- Graph construction
  - Edge assignment based on Pattern Map
    - Hit with its neighbors on the same layer, next layer
    - Node features
    - Raw drift time, 2D coordinates of the sense wires
  - Edge Classifier based on GNN
    - Input network
    - Node features embedded in latent space

- Clustering of Tracks Based on DBSCAN
  - Density-Based Spatial Clustering of Application with Noise
  - Hits in a cluster are considered to be in the same track

**Filtering Noise via GNN**

- Graph model
  - Node network and Edge network, MLPs
  - 8 graph iterations

- Signal selection performance
  - Single-particle (e⁺, K⁺, μ⁺, p⁺, π⁺, π⁻) MC sample
  - Mixed with BESIII random trigger data as background (~45% hits)

- Preliminary Results

  - Single-particle (e⁺, K⁺, μ⁺, p⁺, π⁺, π⁻) MC sample
  - Mixed with BESIII random trigger data as background (~45% hits)

**Conclusions**

- We demonstrate a novel tracking algorithm based on machine learning method
  - GNN to distinguish the hit-on-track from noise hits.
  - Clustering method based on DBSCAN to cluster hits from multiple tracks.

The preliminary results present promising performance, and further optimization of the model is needed to boost reconstructed performance.

**Reference**

1. Steven Farrell et al, arxiv: 1810.06111
2. Jin Zhang et al, DOI:10.1007/s41605-018-0052-4