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Deep Learning Algorithm for dN/dx in TPC

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Particle identification (PID) plays a crucial role in particle physics experiments. A groundbreaking advancement in PID involves cluster counting (dN/dx), which measures primary ionizations along a particle's trajectory within a high granularity time projection chamber (TPC), as opposed to conventional dE/dx measurements. A high granularity TPC with a pad size of 0.5x0.5 mm2 has been proposed as the gaseous detector for the Circular Electron Positron Collider (CEPC) to achieve exceptional hadron identification, which is particularly vital for flavor physics studies.

One of the major challenges in dN/dx lies in the development of an efficient reconstruction algorithm capable of extracting cluster signals from 2D pixel readouts. Machine learning algorithms have emerged as state-of-the-art solutions for PID. To address this challenge, we have designed a sophisticated simulation software framework that incorporates detector geometry, gas ionization, electron drift and diffusion, signal amplification, and pixel readout to generate large datasets. A deep learning algorithm tailored for point cloud data has been developed, utilizing a graph neural network implementation of the point transformer. By training the neural network on a substantial dataset of simulated events, the particle separation power has improved by 10% to 20% for pions and kaons within a momentum range of 5 to 20.0 GeV/c, compared to traditional dN/dx reconstruction algorithm.

Primary authors: ZHAO, Guang (高能所); QI, Huirong (Institute of High Energy Physics, CAS); ZHANG, Jinxian; WU, Linghui (IHEP); DONG, Mingyi (IHEP); YU, Dian (Université Paris Cité (FR), Tsung-Dao Lee Institute (CN))

Presenters: ZHAO, Guang (高能所); YU, Dian (Université Paris Cité (FR), Tsung-Dao Lee Institute (CN))

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