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Drift chamber with cluster counting techniques for CEPC

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The Circular Electron Positron Collider (CEPC) is a large-scale collider facility with a circumference of 100 km. It is designed to study rich physics programs, including investigations into Higgs properties, electroweak physics and flavor physics. A good identification of charged hadrons is essential for the flavor physics and benefits the determination of jet flavor and jet charge. To achieve these physics goals, a drift chamber is proposed for excellent particle identification (PID) performance with the cluster counting technique. Cluster counting measures the number of primary ionizations (dN/dx) along the particle trajectory in a gaseous detector, rather than relying on energy loss (dE/dx). This approach represents a promising breakthrough in PID. The Poissonian nature of dN/dx provides a statistically significant way to measure ionization, potentially yielding a resolution two times better than dE/dx .

A detailed PID study of the drift chamber will be presented. Simulation studies, including the detector and electronics responses, as well as the machine-learning reconstruction algorithm, are performed to optimize the detector design and performance. The PID results using dN/dx and time-of-flight show that the kaon and pion separation power, with a track length of 1.2 m, can achieve a 3σ significance for momenta less than 20 GeV/c. Mechanical design has been carried out and finite-element-analysis results demonstrate a stable design. Fast readout electronics have been developed, and a detector prototype has been tested with an electron beam. The test results validate the performance of the electronics and the feasibility of the dN/dx method.

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