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Study of double-sided silicon pixel ladders with low material budget

Double-sided silicon pixel ladders have been designed and developed as one of the vertex detector prototype concepts for the Circular Electron-Positron Collider (CEPC). With the primary goal to research the properties of Higgs particles, the vertex detector of the CEPC must be thin enough and have high position measurement accuracy to identify heavy flavor quarks and tau leptons efficiently. Two layers of pixel chips are precisely glued to both sides of the same supporting structure, thereby efficiently minimizing the material budget. Each double-sided ladder consists of two layers of MAPS chips thinned to 50 ⊠⊠, two flex cables, and a 1.8 mm thick carbon fiber support. The material budget of the double-sided ladder is about 0.24% X_0/ sensitive layer, representing a reduction of approximately 35% compared to the previous single-sided ladder.
To validate the design and study the performance of the double-sided ladder in terms of spatial resolution and detection efficiency, a beam test system was set up and tested with electron beam at Institute of High Energy Physics. The test system comprises four single-sided ladders devised as a beam telescope to provide reference tracks, with a double-sided ladder positioned at the center of this telescope, serving as the device under test (DUT). The test results show that at an electron energy of approximately 1.3 GeV, the measurement residual of each layer of the double-sided ladder is about 6.9 ⊠⊠. The detection efficiency is above 99.5%, and the fake-hit rate is less than 10^{-6}. Two hits from two layers of the double-sided ladder can be used to construct a mini-vector with a better resolution about 5.0 ⊠⊠. Considering the big beam energy spread and the effects of multiple Coulomb scattering due to low energy, the test results are reasonable and validate the technological process of the double-sided ladder.

Submission declaration

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