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The first beam test for a GEM-readout TPC module with a large aperture GEM-like gating device

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At the future International Linear Collider (ILC) project a GEM- or Micromegas-based Time Projection Chamber (TPC) is a candidate for the central tracker of the International Large Detector (ILD), which is one of the two detector concepts proposed for the ILC.

The TPC has a potential problem that many ions generated in avalanche processes for gas amplification flow back into the drift volume of the TPC and distort the electric field inside of it. Primary electrons drifting in the drift volume are affected by the distorted electric field, and the quality of reconstructed tracks is degraded consequently. The required position resolution that the ILD-TPC must achieve for the physics program of the ILC project is about 100 μm over the full drift length. A degree of degradation of position resolution due to generated ions was carefully estimated to be more than 60 μm at the innermost radius of the TPC, effect on the position resolution, thereby requiring some gating device to stop ions at the closed state. In addition, our study shows that an electron transmission rate of more than 80% is needed at the open state to accomplish required position resolution for the ILD-TPC. This issue related to the Ion Back Flow (IBF) is therefore crucial for realization of the ILD-TPC.

In order to fit to a detector module of the ILD-TPC where an MPGD is used for the gas amplification device, we have developed a GEM-like gating device (gating GEM), the idea of which was originally proposed by F. Sauli, to prevent ions from back-flowing to the drift volume. Since the motion of the drift electrons is strongly restricted to the direction of a high axial magnetic field, the gating GEM has to have a high geometric aperture of more than 80% as well as high stopping power for positive ions at the closed state. Based on these requirements, we manufactured a large aperture gating GEM with an aperture of 82% and a thickness of 25 μm. We had already confirmed the performance of a small prototype gating GEM using an ^{55}Fe source. The electron transmission rate was estimated to be more than 80%. After this first study, we developed a large real-size gating GEM. The iron stopping power at the closed state was estimated to be O(10^{-4}) using an ^{55}Fe source and a laser, with the gating GEM mounted on a GEM-based prototype ILD-TPC module. Then we evaluated its performance using 5-GeV electron beam. The measurement was carried out in the 1-T magnetic field of the Large Prototype TPC at DESY. We have measured the position resolution of the ILD-TPC module with the gating GEM and the electron transmission rate. This was the world first test beam experiment of a "wireless" TPC equipped with a high performance gating device.

We report on the results on the electron transmission rate and the ion stopping power.

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