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Development of a TPC detector module equipped with a positive-ion gating device using high electron transmission GEM-type foils for the ILD detector at the ILC

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The International Large Detector (ILD) concept for the International Linear Collider (ILC) features a GEM- or Micromegas-based Time Projection Chamber (TPC) as a central tracking detector.
Considering the background environment of a high density of charged tracks at the ILC, a gating system located between the drift volume and the gas amplification device of the TPC to prevent positive ions from entering the drift region is required. This gating device will enable the excellent momentum resolution needed for the ILC to be met. This is in spite of the fact that the amount of backdrift ions is much smaller for MPGD amplification than in earlier MWPC amplification.
Due to the low mobility of the ions, they will be concentrated in discs of about 1 cm thickness near the TPC readout in the case of the ILC beam time-structure, and then drift back into the drift volume. Therefore, a positive-ion gating device should be placed about 1 cm in front of the first stage of the gas amplification device. We have been developing a TPC detector with a modular end-plate readout system integrated with amplification GEMs and a gating system.
A wire gating grid has been the traditional solution for gating. However, its implementation above the amplification GEMs or Micromegas would not be simple. Hence, we decided to employ an idea to use GEM-type foil as a gating device, whose GEM is operated in low voltage mode without the function of gas amplification. This kind of Gate-GEM acts as an electron transmission film and can easily be used as a closed gate against both positive ions and drift electrons by reversing the electric field in GEM holes.
The main requirement for Gate-GEMs of the ILC-TPC is 80% electron transmission, which corresponds to the deterioration of the azimuthal spatial resolution by about 10%. The TPC will be operated in a 3.5 T axial magnetic field. The gas will have a long mean-free-time between collisions of drifting electrons with gas molecules in order to have small transverse diffusion for 2.3 m long drift of the ILD-TPC. Consequently, the motion of the electrons is strongly restricted to the direction of the magnetic field. A high optical transparency of the gate is required to ensure its high transmission rate of the electrons in the open state. In order to achieve high electron transmission, a large-aperture GEM-type foil (17 x 22 cm^2) with hexagonal holes is now under development by Fujikura Ltd; it has 30 μm rim width and 335 μm pitch (corresponds to 82% optical transparency) with grid thickness of 12.5 μm.
We will present the electron transmission rate of the new Gate-GEM to be measured by comparing the signal charge passing through the gating device to that observed without it, while being irradiated with an 55Fe source. Also presented are the results of a simulation using an ANSYS-Garfield++ framework, including evaluation of the observed transmission rate and its extrapolation to the case of 3.5 T.

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