Development of dual effective gas gain multiplication in CNS Active Target for a high-intensity beam injection

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We are developing a GEM-TPC-based gaseous active target with a pure deuterium gas, called CNS Active Target (CAT),1) for performing deuteron inelastic scattering experiments. The CAT is operated with a low-pressure (0.2-0.5 atm) deuterium gas for measuring the scattering to the forward angle closer to 0°. A 400-μm Thick GEM (THGEM) is chosen for the CAT to achieve a gas gain of $10^4$ for a low-pressure deuterium gas; its performance was investigated for the first time in our previous work.2) However, when the gain of THGEM is set to such a high level as $10^4$, the amplified charges from the energy loss of the heavyion beam, which is impinged with a high-intensity of $10^{5-6}$Hz, become too large for the GEM-TPC to operate stably. The effective gas gain along the beam trajectory (BT) area should be reduced by an order of 10-100, keeping the effective gas gain in the region where the recoiled particles (RP) are measured.

A new type of THGEM, called DGGEM (Dual-Gain THGEM), was manufactured via mechanical drilling and it has a thickness of 400 μm, a hole diameter of 450 μm (900-μm-pitch) on the BT region, and a hole diameter of 300 μm (700-μm-pitch) on the RP region; the DGGEM was used to study the dependence of the gain on the hole diameter. Since the electric field is stronger in a hole with a smaller diameter, a gas gain in the RP region is expected to be larger, by a factor of four, than that in the BT region. Figure 1 shows the obtained gain curves in single, double, and triple DGGEM layer setups as functions of the induction field strength $E_{induction}$ in kV/cm/atm. The measured difference of gas gain between the BT and RP regions was much smaller than expected. Another solution was suggested, in which a grid mesh covered only the area along the beam path with a triple (normal) THGEM configuration. By changing the electric field in the drift field using the grid along the beam path, a partial gain reduction and a more stable operation of CAT is expected. A test experiment was performed with a high-intensity $^{132}$Xe (100 MeV/u) beam at the HIMAC facility. A mesh grid with a 2cm width was set along the beam path (4 mm above the THGEMs). The most suitable voltage setup for the grid was identified using a defocused $^{132}$Xe beam. Figure 2 shows the relation between the sampled charges after multiplication and the readout pad ID. The widely hatched area, pad ID 60-340, corresponds to the entire beam trajectory region; and the narrowly hatched area, pad ID 130-270, includes the grid. A significant reduction of gain was achieved only on the grid area. The CAT was stably operated via the optimized grid operation under a high-intensity injection of $^{132}$Xe beam up to $10^5$ particles per pulse, in combination with tuning of the protection circuit for the high-voltage supply. Further analysis is in progress.

Fig. 1. Results for each layer structure of DGGEM.

For each measurement, the drift field strength was 1 kV/cm/atm and the transfer field strength was 2 kV/cm/atm.

Fig. 2. An example of correlation between sampled charges after the multiplication and readout pad IDs with a defocused beam injection. Reduced multiplication of charges is achieved under the grid area. The color bar indicates the number of events.

References
2) C.S. Lee et al.: to be published on CNS Annual Report 2012.

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