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 heavy-ion 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 lager, 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 $E_{\mathrm{induction}}$ 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 $^{132}_{54}$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.

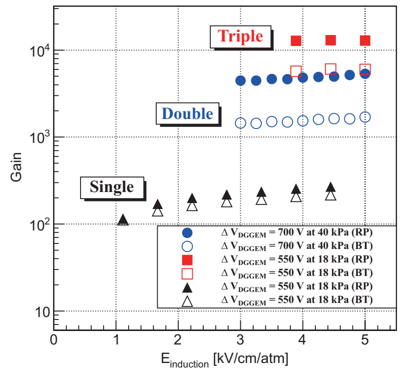

Fig. 1. Results for each layer structure of DGGEM. For each measurement, the drift field strength was 1 kV/cm/atm and the transfer field strength was 2 kV/cm/atm.

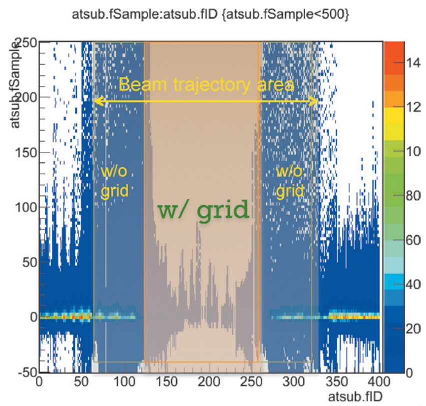

Fig. 2. An example of correlation between sampled charges after the multiplication and readout pad IDs with a defocused beam injection. Reduced multiplication of charges is achieved under the grid area. The color bar indicates the number of events.

References
1) S. Ota et al.: *CNS Annual Report 2011 CNS-REP-90* (2013) 70-71.
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