Pressure dependence of effective gas gain of THGEM in deuterium gas

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A low-pressure gaseous active target called CNS active target (CAT) has been developed for a deuteron inelastic scattering off unstable nuclei[1)]. The CAT consists of a combination of gas electron multipliers (GEMs) and time projection chamber (TPC) as a vertex tracker, and Si detectors as a total kinetic energy detector for high momentum recoil particles. Three 400 μm-thick thick gas electron multipliers (THGEMs) are employed for the amplification inside the TPC in order to achieve an effective gas gain of 10^4 at 0.4 atm deuterium gas. This gas gain of 10^4 fulfils the detection of the minimum energy deposition of our interest, 5 keV/cm, which is the energy loss per centimeter of a recoiling deuteron to 9° in the centre-of-mass frame from ^{132}Sn(d, d') reaction at 100 MeV/nucleon. The properties of a double THGEM configuration in 0.2-, 0.3- and 0.4-atm deuterium were investigated for the first time by corresponding authors[2)]. In addition to the previous work, the pressure dependence and the long-term stability of the effective gas gain were investigated by using a triple THGEM configuration.

A schematic view of the experimental setup is shown in Fig. 1. The collected electrons on the readout pad were integrated with a charge-sensitive preamplifier, which has a conversion gain of 200 mV/pC and a time-constant of 80 ns. The output signal from the preamplifier was treated by a shaping amplifier (ORTEC 571), and the pulse height of the shaped signal was recorded by a multi-channel analyser (MCA) (Kromek 102). The effective gas gain G_{eff} is derived from the equation:

$$G_{eff} = \frac{Q_{pads}}{q_e \cdot \Delta E / W_i} \tag{1}$$

where G_{eff} is the effective gas gain of GEM, ΔE is the energy loss of particle, W_i is mean energy for ion-electron pair creation of certain gas (36.4 eV for D_2), q_e, the elementary charge, and Q_{pads} is the collected charges on the readout pad. Figure 2 shows the obtained gain curves including the achievable gain from a triple THGEM configuration for 0.18-0.5 atm D_2 as a function of the voltage between the upper and the lower electrodes of THGEM, $\Delta\ V_{THGEM}$. A triple THGEM configuration provides the effective gas gain of more than 10^4 for every pressure, and even more than 10^5 for under 0.35-atm.

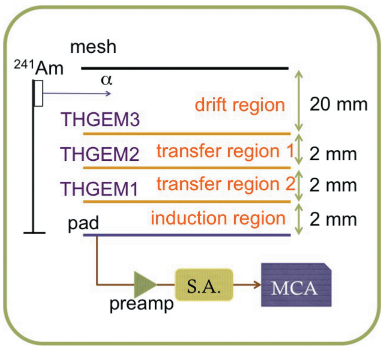

Fig. 1. Experimental setup of this work. Voltages to the THGEMs are supplied from a single channel of a HV module, by using a register chain, where each ΔV_{THGEM} is equally provided.

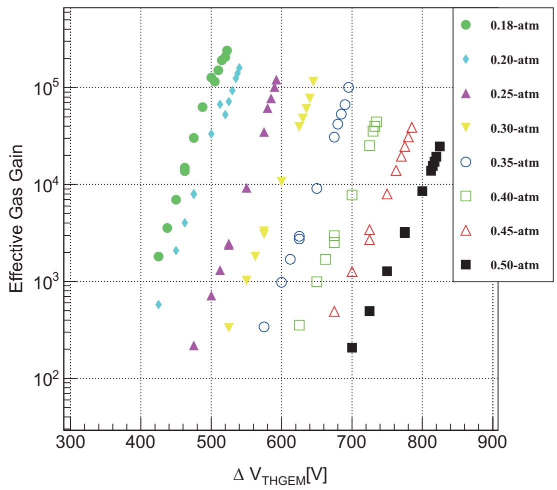

Fig. 2. Gain curves of a triple THGEM configuration at 0.18-0.5 atm D_2 as a function of $\Delta\ V_{THGEM}$.

Every set of measurements for each pressure was suspended when a normal spectrum can hardly be taken due to the discharge problem. In this measurement, the ratio of the voltages on each electrode of the THGEMs was retained in constant by using a resistance chain. The strength of the transfer field was 2.25 to 4.16 kV/cm/atm where the transfer efficiency is almost maximum and reached a plateau. The strength of the induction field was 3.0 to 5.56 kV/cm/atm.

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References

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