Evaluation of effects of a large energy deposition on Deuterium gaseous active target for a high-intensity ion beam injection

C.S. Lee,[*1,*2] S. Ota,[*1] M. Takaki,[*1] Y. Kiyokawa,[*1] Y.N. Watanabe,[*2,*3] H. Tokieda,[*1] and J. Zenihiro[*2]

A deuterium gaseous active target, CNS Active Target (CAT)[1,2], has been under development for measuring the Isoscalar Giant Monopole Resonance (ISGMR) in unstable nuclei via the (d, d') reaction. In order to extract the ISGMR component by using the multipole decomposition analysis, a wide angular coverage of the distribution of the differential cross-section is required. The CAT consists of GEM-TPC and Si detectors. In the center-of-mass frame, the scattering angular region of recoil particle of θ_{CM} around 2 degrees was covered by the GEM-TPC, while the region of $\theta_{CM} \geq 5$ degrees was covered by the Si detectors. In the previous experiment[2] at HIMAC using a ^{132}Xe beam with a high intensity of around 1 MHz at 115-MeV/u incident energy, we experienced instabilities of the CAT; a sudden jump of the current value of the field cage and a fluctuation of the baseline of Si signals were observed. The instabilities can be considered as the effect of high energy-loss density in the active gas target caused by a heavy ion beam. For evaluating of such effect, we bombarded the CAT with a very intense 3-MeV proton (H^+) beam provided by a pelletron in RIKEN. In this paper, the experiment and the results are reported.

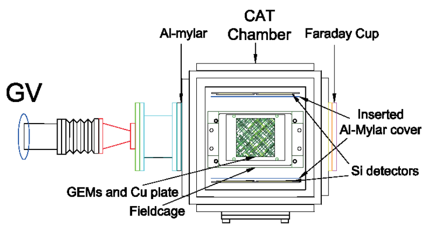

Fig. 1. A schematic view of the setup at pelletron, RIKEN.

Figure 1 shows a schematic view of the experimental setup. The CAT was connected to the exit of the pelletron beam port with a 12-μm-thick Al-mylar foil. An Al flange of the chamber at the exit of the CAT was used as a Faraday Cup (FC). A copper plate was employed to collect the charges multiplied by three thick GEMs (THGEMs) for evaluating the effective gas gain. The current outputs of the FC and the Cu plate were measured using picoammeters (ADVANTEST TR8641). The voltage and current values of each high-voltage supply were recorded using a multimeter (KEITHLEY 2701). Four Si detectors with an effective area of 9×9 cm^2 and thickness of 0.5 mm were surrounding the field cage. The Si signals were amplified using a preamplifier (mesytec MPR-32) and read out using an oscilloscope. The energy of the H^+ beam was 3 MeV, and its intensity was varied from 1 to 60 pA. The GEM-TPC was operated at an effective gas gain of about 60 in 0.4-atm H_2.

Baseline fluctuations were observed in the signals of the Si detectors for a beam intensity of 20-pA, as shown in the left panel in Fig. 2. This beam condition provides an energy-loss density equivalent to a ^{132}Xe beam with an intensity of 1.2 MHz and energy 115 MeV/u. The fluctuation disappeared, when, with the same beam condition, a 10-μm-thick Al-mylar foil was placed in front of each Si detector. Therefore, we understand that the fluctuation is possibly due to radioactive noise. At 60-pA 3-MeV H^+ beam injection, the fluctuations became smaller.

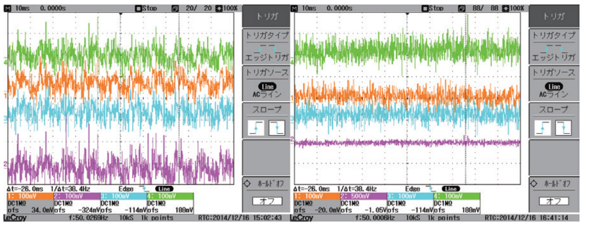

Fig. 2. Preamplifier outputs of Si detectors for a 20-pA 3-MeV H^+ beam injection without Al-mylar foil cover (left) and with Al-mylar foil cover (right).

Figure 3 shows the variation of current in the Cu plate and field cage during the 20-pA 3-MeV H^+ beam injection. The current of the field cage increased by 4-5 μA immediately after the injection of the high-intensity beam and gradually increased during the beam irradiation. This may be explained by the effect of the initial ions from the beam and the ion back flow (IBF) from the THGEMs. Although the field cage had tripped (the current limit was 1 mA) several times, a sudden jump of the current value seldom happened. This may be caused by the difference between a heavy-ion and a light-ion, such as δ-ray creation. The effect of δ-rays on both Si detectors with Al-mylar covers and the GEM-TPC will be evaluated by using a high-intensity heavy-ion beam in the near future.

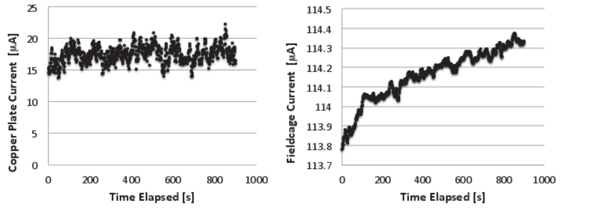

Fig. 3. Current variation of the Cu plate (left) and the field cage (right) during a 20-pA 3-MeV H^+ injection.

References

1) S. Ota et al.: CNS Annual Report **2011**, CNS-REP-90 (2013) 70-71.
2) S. Ota et al.: CNS Annual Report **2013**, CNS-REP-93 (2015) 49-50.

*1 Center for Nuclear Study, The University of Tokyo
*2 RIKEN Nishina Center
*3 Department of Physics, The University of Tokyo