Current Status of Developing MAIKo TPC for Using High Intensity Beam

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According to recent theoretical calculations, it is suggested that an exotic dilute gas-like state, which is called α condensed state, emerge in excited states of nuclei[1]. The α condensed state is expected to provide insights into the low density nuclear matter. The α condensed states are theoretically suggested to decay into multiple low-energy α particles reflecting their exotic structures[2].

We plan a new experiment to search for the α condensed state in ^{24}Mg using MAIKo time projection chamber (TPC) by measuring decay particles from the excited states in ^{24}Mg. The MAIKo TPC is capable of detecting decay particles over the large angular solid angle around the target. In order to obtain sufficient statistics about α-decay events, it is necessary to use a high-intensity beam at about 10^9 cps. If such a high-intensity beam is introduced into a conventional TPC, serious problems such as electric discharges at an amplification region, distortion of a drift field and a reduction of a gain arise because the beam ionizes a detection gas in TPC along the beam trajectory and generates a huge amount of electrons and ions. In order to solve these problems, we introduced a beam mask along the beam trajectory which can screen out electrons originated from the beam, and divided a drift cage into the left and right parts to suppress the distortion of the drift field. Figure 1 shows the structure of the newly developed MAIKo TPC.

We carried out an experiment to evaluate performance of the MAIKo TPC at the EN course, RCNP in September 2018 (E532). Figure 2 shows a schematic view of a setup of the experiment. A 130-MeV α beam is introduced into the MAIKo TPC with changing the beam intensity within a range of 10^1–10^9 cps. Beam-intensity dependence of a track finding ability by the TPC was studied by measuring collimated α particles from a source (^{241}Am) installed in the MAIKo TPC chamber at each beam intensity.

We used H_2-CH_4 (90:10, 800 hPa) as a detection gas of the TPC. Since the range of the beam intensity was wide from 10^1–10^9 cps, the beam intensity was measured by three beam monitors depending on the intensity. A plastic scintillator was used to count the beam particles when the intensity was less than 10^6 cps. When the beam intensity was 10^7–10^8 cps, a silicon detector was used to count α particles scattered from the detection gas. The counting rate of the silicon detector was normalized to the beam intensity measured by the plastic scintillator when the beam intensity is lower than 10^6 cps. When the beam intensity is higher than 10^9 cps, beam current was measured by a Faraday cup.

We could operate the MAIKo TPC at the intensity up to 10^9 cps without electric discharges. Trajectories of the α particles from the ^{241}Am source are obtained as two dimensional images projected on to the two planes perpendicular to the anode and cathode readout strips of the MAIKo TPC. Figure 3 shows typical images of tracks of α particles measured by the MAIKo TPC at each beam intensity. Although the track images of α particles measured at the intensity below 10^7 cps are similar to those measured without the beam, most of the

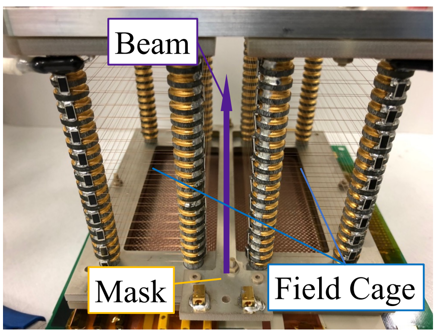

Figure 1: Structure of the newly developed MAIKo TPC.

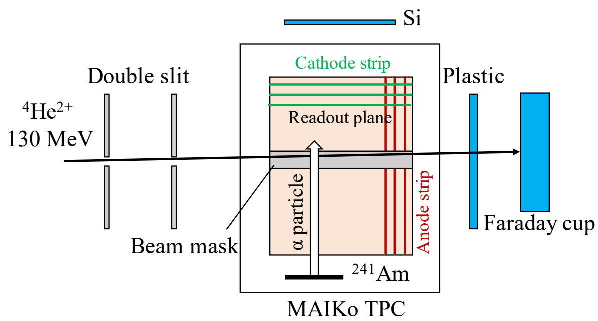

Figure 2: Schematic view of the experimental setup. The trajectories of the beam particles are collimated on the beam mask by a double slit made by SUS.

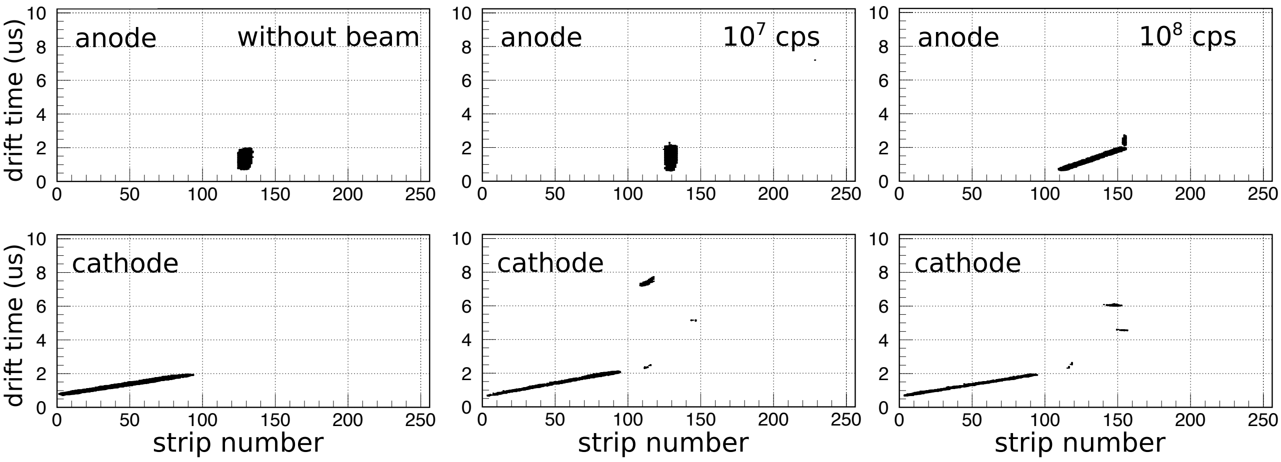

Figure 3: Typical images of the tracks of α particles at each beam intensity.

track images on the anode plane at the intensity above 10^8 cps were inscrutably tilted. The track images of α particles from the source on the anode plane should not be tilted because the tracks are parallel to the anode strips of the MAIKo TPC as shown in Fig. 2. Therefore, it is considered the tracks of α particles from the source were not measured correctly at the intensity above 10^8 cps.

Beam-intensity dependence of gain of the MAIKo TPC was also studied. Chage amount induced in the first channel of Flash ADC for the cathode strips, which is the most distant channel from the beam axis, were measured with changing the beam intensity. Figure 4 shows the gain normalized to the gain without the beam as a function of the beam intensity. The gain decreases as the beam intensity increases. Figure 5 shows the leakage current from the anode strips as a function of the beam intensity. The leakage current increases exponentially as the beam intensity increases. An increase in the leakage current causes a drop in voltage at the load resister and results in a reduction in the gain.

Although the present result shows the MAIKo TPC can be operated stably at the beam intensity of 10^7 cps, further development is necessary for stable operation at 10^9 cps. We plan to introduce a gating grid which can suppress drift electrons entering the amplification region of the TPC.

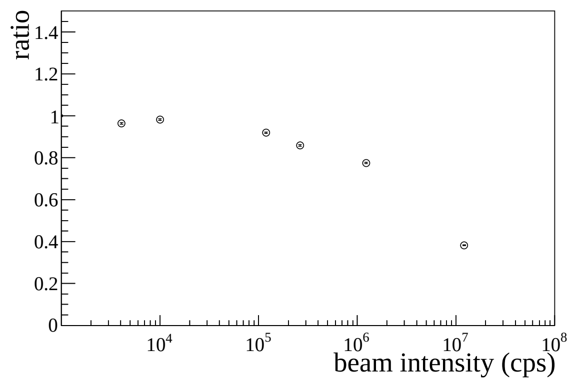

Figure 4: Relative gain measured at the first strip of the cathode strips as a function of the beam intensity.

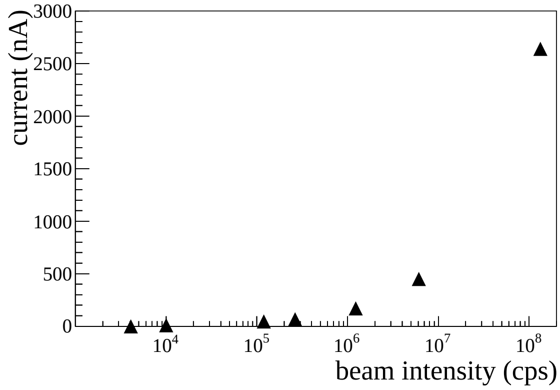

Figure 5: Leakage current at anode strips as a function of the beam intensity.

References

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