Development of a New TPC to Search for the Alpha Condensed States in ^{24}Mg

K. Inaba[1], T. Kawabata[1], T. Furuno[1] and M. Murata[1]
[1] *Department of Physics, Kyoto University, Sakyo, Kyoto 606-8502, Japan*

Recently, peculiar low-density states, which is called α condensed states, have been suggested to emerge near the $n\alpha$-decay thresholds in self-conjugate $A = 4n$ nuclei [1]. α condensed states are expected to give an insight into the low-density nuclear matter. The α condensed states are considered to decay by emitting multiple low-energy α particles [2], reflecting their peculiar structures. We plan to search for the α condensed states in ^{24}Mg by detecting low-energy decay α particles with a time projection chamber (TPC). A TPC is a gaseous detector, which can determine three-dimensional trajectories of charged particles. We can measure the decay particles with large angular coverage by installing the ^{24}Mg target in the sensitive volume of the TPC.

The hydrogen gas is the most suitable detection gas for the TPC in the present experiment because the hydrogen does not have excited states nor decay. We could not, however, detect the signals of α particles from an α source with our previous TPC filled with the hydrogen gas because of the small gas gain. We introduced triple stacked gas electron multipliers to the TPC in order to increase the gain, and successfully measured the tracks of the α particles from the α source using the pure hydrogen gas.

We should use a high-intensity beam at about 10^{10} cps to achieve sufficient statistics in the experiment. When such a high-intensity beam is introduced to the ^{24}Mg in a conventional TPC, however, there occur serious problems such as distortion of the electric field or electric discharges due to many electrons and ions induced by the high-intensity beam. In order to avoid these problems, we developed a mask to make an insensitive volume along the beam trajectories. Figure 1 shows a schematic view of the insensitive volume introduced by the mask. The ^{24}Mg target is installed at the center of the TPC. The beam axis is in the direction vertical to the paper surface, and the mask is installed along the beam trajectories in order to screen out electrons generated by the beam. Moreover, we divided a field cage into the right and left parts to suppress the distortion of the electric field in the sensitive volume. A picture of the newly developed TPC is shown in Fig. 2.

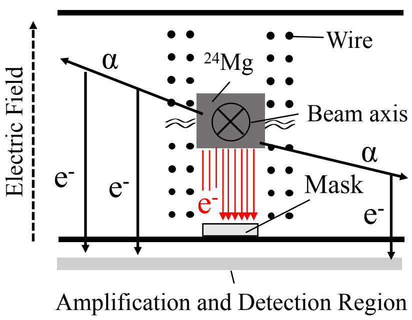

Figure 1: Schematic view of the insensitive volume introduced by the mask.

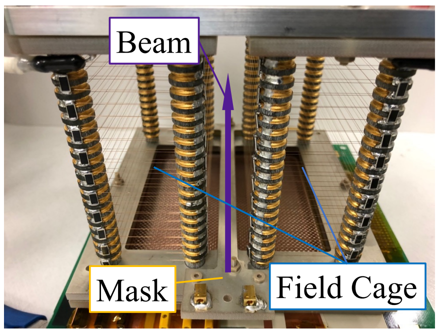

Figure 2: Picture of the TPC with the mask. A beam passes through the center of the TPC along the solid arrow. The mask is installed along the beam trajectories.

We tested performance of the newly developed TPC with the mask using an α source. A schematic top view of the setup is shown in Fig. 3. We installed the α source in front of the TPC and collimated it to limit the trajectories of α particles in the direction parallel to the beam axis. The detection gas was pure hydrogen gas at 1.5 atm. We measured the counting rate of the α particles by changing the position of the α source along the x axis, and examined the reduction of the counting rate in the masked region. The result is shown in Fig. 4. The red area is the masked region and the blue is the region out of the sensitive volume or the region where the α particles are blocked by the pillars in front of the TPC. Although the counting rate surely decreases in the masked region, it is still higher than the background even when the α source was placed at the center of the masked region. The escape of the α particles from the masked region is explained by the angular spread of the collimated α particles and the Coulomb multiple scattering of the α particles by the hydrogen gas. The reduction of the counting rate for a high-energy α beam from the accelerator is expected to be significantly better than that for the low-energy α particles from the collimated α source because the angular spread and the multiple Coulomb scattering of the beam are much smaller than those of the α particles from the α source. However, we actually need to test the TPC with a mask using a high-intensity beam. We have proposed the experiment to test the TPC using a high-intensity beam to the 83rd RCNP B-PAC held on April, 4th and 5th, 2018.

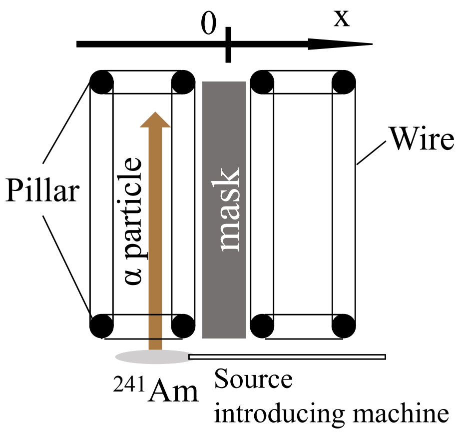

Figure 3: Schematic top view of the setup.

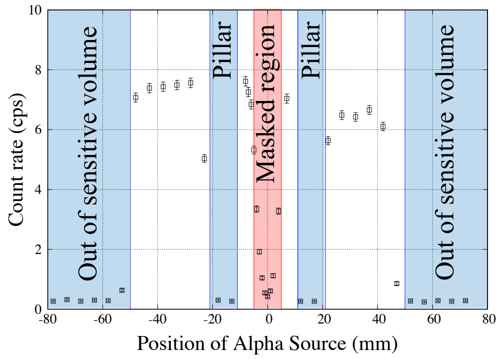

Figure 4: Counting rate of the α particles emitted from the α source as a function of the position of the source.

References

[1] T. Yamada and P. Schuck, Phys. Rev. C **69**, 024309 (2004).

[2] Tz. Kokalova, N. Itagaki, W. von Oertzen, and C. Wheldon, Phys. Rev. Lett. **96**, 192502 (2006).