Development of D_2 gas-filled drift chamber for spectroscopy measurements of pionic atoms in inverse kinematics

Y. N. Watanabe,[*1,*2] H. Fujioka,[*1,*3] R. S. Hayano,[*2] K. Itahashi,[*1] T. Nishi[*1,*2] and Y. K. Tanaka[*1,*2]

We report the development of a D_2 gas-filled drift chamber for spectroscopy measurements of pionic atoms. We plan to perform missing-mass spectroscopy measurements of deeply bound pionic atoms in inverse kinematics of the (d,^{3}He) reaction. We will employ a D_2 gas-filled multi-wire drift chamber (MWDC) as an active target in a magnetic field of $\sim$ 1 T. A heavy ion beam is injected into the chamber inside which the reaction occurs. The reaction angle and the energy of forward scattered ^{3}He are measured using the MWDC and silicon strip detectors, which are installed inside the MWDC. The energy of the ^{3}He is approximately 60 MeV. The feasibility of the measurements was investigated through simulations in a previous study.[1)] According to the results of the simulations, a position resolution of 500 μm and enough gain to measure 60 MeV ^{3}He are required for the MWDC.

To check the performance of the D_2 gas-filled MWDC, we fabricated a prototype of the detector. For the MWDC, hexagonal wire geometry, in which a sense wire is surrounded by six potential wires, is adopted. The side length of the hexagon is 6 mm. The MWDC consists of 10 planes, five of which are tilted (two U planes at 18° and three V planes at -18° as shown in Fig. 1) to measure the vertical position of charged particles. The outer cells serve as guard wires against chamber walls to eliminate field deformation.

Figure 2 shows the measurement setup. Inside the MWDC, an α source (^{241}Am, 4.3 kBq) was placed and a silicon strip detector (12 strips, 37.5 × 50 mm^2, 300 μm thick) was installed on the opposite side. The trigger was initiated by the signal of the silicon detector and the timing of the MWDC signal was recorded using a TDC. In this measurement, the chamber was filled with 1 atm H_2 gas instead of D_2 gas as the first step.

Tracking analysis was performed and position resolution was evaluated when a HV of -1420 V was applied to the potential wires. The α-ray detection efficiency was higher than 99% for all planes except for the first one. Figure 1 shows a typical event display. The drift length in each cell is expressed as a circle and the hit strip in the silicon strip detector is painted black. The track was successfully reconstructed as indicated by the red line in Fig. 1. The position resolution of the planes with vertical and tilted wires was evaluated to be 100 – 150 μm and 100 – 250 μm. The resolution is sufficient for the experiment if the magnetic field does not deteriorate the resolution considerably.

*1 RIKEN Nishina Center
*2 Department of Physics, University of Tokyo
*3 Department of Physics, Kyoto University

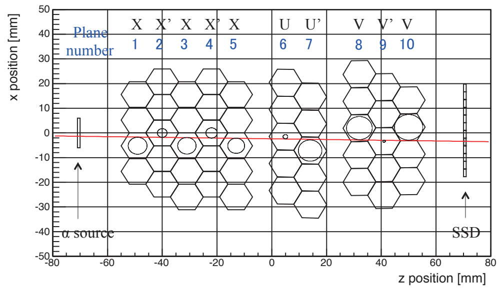

Fig. 1. An example of an event display. There are potential wires on the vertices and sense wires at the center of the hexagons. The circles represent the drift length for each wire and the straight line is the deduced track.

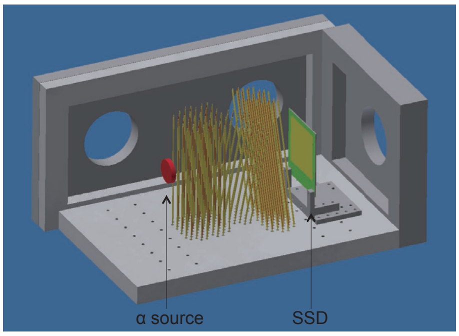

Fig. 2. A schematic drawing of the measurement setup. An α source was placed in front of the first plane and a silicon detector was placed on the opposite side.

In the measurement, we observed the position dependence, i.e., the plane dependence of gas gain. In the fifth – eighth planes, facing blank regions, the gas gain was more than five times larger than that in the other planes when HV was -1420 V. This was due to the geometrical configuration of the wires, and it was qualitatively confirmed through Garfield[2)] calculations that the electric field strength in these planes was effectively 5% higher. Geiger-mode behavior in these planes caused a rapid increase of current and made it difficult to apply higher voltage. We found that extra guard wires were needed facing the blank regions. Under the current condition, the detection efficiency for 60 MeV ^{3}He in the low-gain planes was estimated to be less than 20%.

As the next step, we will improve gain uniformity by applying discrete voltage to each plane.

References

1) K. Okochi et al.: Accel. Prog. Rep. **46**, 79 (2013).
2) R. Veenhof: Garfield, (http://garfield.web.cern.ch/garfield)