Performance test of low-pressure MWDC for missing mass spectroscopy at BigRIPS

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In December 2017, we conducted a performance test for a new low-pressure multi-wire drift chamber (MWDC) using proton beams to evaluate tracking resolution and efficiency, as well as their stability under a high-rate beam condition. In this paper, we report the online results of the test experiment.

The MWDC is developed as a tracking detector at the F5 focal plane in BigRIPS, mainly for two experiments of missing mass spectroscopy: a precise measurement of deeply bound pionic atoms via the $(d, {}^3\mathrm{He})$ reaction[1] (piAF) and a search for double Gamow-Teller giant resonance (DGTGR) via the $({}^{12}\mathrm{C}, {}^{12}\mathrm{Be})$ reaction.[2] In these experiments, the tracking detector is required for (1) the detection of light ions under a high-rate background condition (an order of MHz triton in the DGTGR experiment and proton in the piAF experiment) and (2) operation in vacuum to avoid multiple scattering from a vacuum window. For these experiments, we designed and constructed the new low-pressure MWDCs.[3]

The test experiment was conducted in 1.5 days at CYRIC, Tohoku University, by using primary proton beams of 30 MeV/u. The beam energy was selected to simulate the energy loss of the signal ^{3}He of 120 MeV/u in the pionic atom experiment. The beam was detected and identified by two plastic scintillators at the upstream and downstream of the MWDCs as shown in Fig. 1. MWDC consists of 9 planes (XX'X"(0°), UU'U"(+30°), VV'V"(−30°)), and is operated with pure isobutane gas at 13.3 kPa. Figure 2 shows the evaluated detection efficiency as a function of the voltage applied to cathode planes and potential wires. As shown in the figure, the single-plane efficiency is greater than 98% with a voltage of higher than −1300 V. The plane resolution and stability under the high-rate condition are also evaluated with voltage of −1350 V. Though the precise evaluation is still in progress, the position resolution is apparently better than 0.5 mm (FWHM), which satisfies the experimental requirement. The stability test of the MWDC was performed with $\simeq$ 100 kHz proton beams. The condition is comparable with the expected high-rate background in BigRIPS in terms of the space charge effect. Under this severe condition, we confirmed that the detection efficiency does not change by more than a few percent.

From the above results, we found that the MWDC shows satisfactory performance for the experiments at BigRIPS. The precise analysis is ongoing.

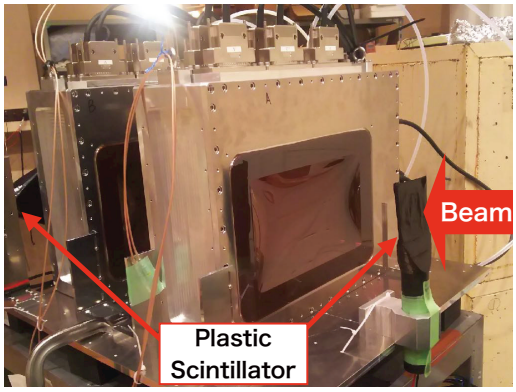

Fig. 1. New constructed MWDCs and plastic scintillators placed on the beam line at CYRIC.

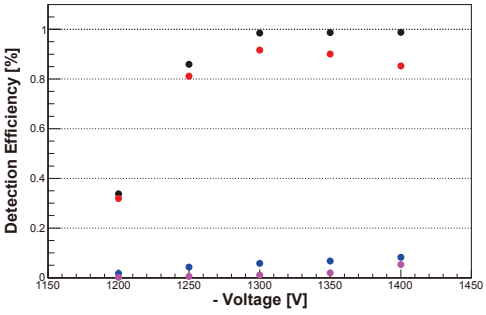

Fig. 2. Evaluated detection efficiency of the single plane as a function of voltage for cathode planes and potential wires. The red, blue, and magenta colors correspond to the multiplicity (≡ number of fired wires par plane) is one, two, and more than three in one event, and the black shows the overall efficiency of the plane.

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