Development of the active target with μ-PIC

T. Furuno[1], T. Kawabata[1], H.D. Watanabe[1], T. Tanimori[1], H. Kubo[1], A. Takada[1], T. Mizumoto[1], T. Sawano[1], S. Kabuki[1], I. Tanihata[2], J.H. Ong[2], T. Hashimoto[2], A. Yassid[2], and J. Tanaka[2]

[1]*Department of Physics, Kyoto University, Sakyo, Kyoto 606-8502, Japan*

[2]*Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*

Invariant mass spectroscopy is widely employed to obtain excitation-energy spectra in inverse kinematic experiments with RI beams. However, such spectroscopic studies are unfortunately limited in low-lying excited states because multiplicities of decaying particles are too high to detect all of the decaying particles and to determine their invariant masses in highly excited states. On the other hand, missing mass spectroscopy could be a useful method to obtain excitation-energy spectra because excitation energies are determined by detecting one recoil particle only. However, it is not easy to apply the missing mass spectroscopy to inverse kinematic experiments because recoil particles are emitted in a wide angular range and their energies are very low (less than 1 MeV) at forward scattering angles. An active target system is one of the possible solutions to solve this problem in the missing mass spectroscopy. The active target system is a kind of particle detectors which works as a scattering target. Since the scattering occurs inside the particle detector, the active target has a large angular coverage and detects even low-energy recoil particles. The active target system has a potential to make a breakthrough in RI beam experiments.

We are developing an active target system at RCNP. A schematic view of the active target system is shown in Fig. 1. Our active target works as a time projection chamber (TPC). Helium gas with a small fraction of iso-butane works as the detection gas in our TPC, and this detection gas is also used as the helium target for the inverse kinematic scattering. In order to achieve high position resolution by the TPC, we introduce a micro-pixel chamber (μ-PIC) [1] to multiply and detect drifted charges. μ-PIC consists of orthogonal cathode and anode strips which are fabricated with a pitch of 400 μm on a substrate. The number of anode and cathode strips is 256 ch + 256 ch, and the sensitive volume of the TPC is 100 $\times$ 100 $\times$ 130 mm^3. We will also install Si + CsI telescope around the TPC to detect high-energy recoil particles.

In FY 2012, we carried out a performance test of the active target using the ^{241}Am alpha source. Properties of the detection gas for the TPC were systematically examined by changing its pressure and composition, the drift-field strength, and the high voltage applied to μ-PIC. A typical track of an alpha particle determined by the TPC is shown in Fig. 2. The upper and lower panels show a trajectory of an alpha particle projected to the x-z and y-z planes, respectively. The position resolution of 200 μm was achieved. The drift speed and gas multiplication factor of the TPC were measured and compared with simulation. It was found there is a good agreement between the experimental results and simulation.

In FY 2013, a test experiment using an accelerated beam will be performed for further clarification of the detector performance. We will use a ^{6}Li beam at 30 MeV/u to examine the position and rate dependence of the detection efficiency and position resolution. We will also measure the alpha elastic scattering off ^{6}Li to demonstrate the missing mass spectroscopy with the active target in the inverse kinematic experiment.

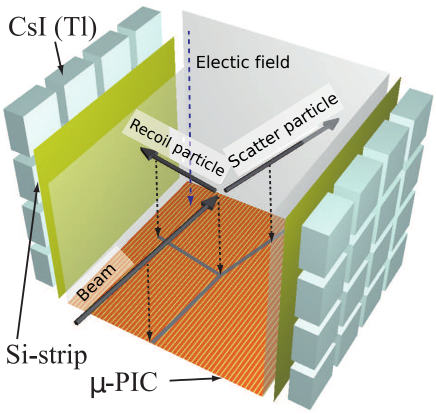

Figure 1: Schematic view of the active target.

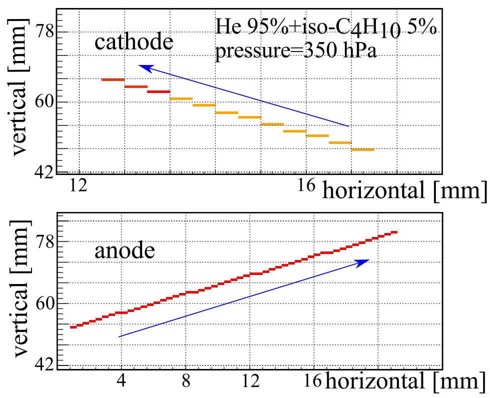

Figure 2: Typical track of α particle in the TPC.

References

[1] K. Miuchi *et al.* , Nucl. Inst. Meth. Phys. Res. A **634**, 77 (2011).