A track finding algorithm for MAIKo TPC using Hough transform method

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An active target system MAIKo has been developed to perform missing mass spectroscopy with RI beam [1]. MAIKo is based on a time projection chamber (TPC) in which detection gas is used for the target gas. In particular, helium gas with a small fraction of quench gas is filled to perform alpha inelastic scattering. Since the scattering occurs inside the TPC, the active target enables to detect low-energy recoil particles (∼1 MeV) and perform missing mass spectroscopy at forward angles under inverse kinematic condition.

The drift electrons are multiplied by μ-PIC at top of the TPC. Signals from μ-PIC are read by 256 anode strips and 256 cathode strips which are orthogonal to each other. These signals are discriminated and synchronized to 100-MHz clock. The time-over-threshold information is recorded when a trigger signal is given. The electron drift time as a function of strip number gives a two-dimensional projection of the particle trajectories in the TPC. From two projections taken from the anode and cathode, the three-dimensional trajectories are reconstructed. A typical anode track of a scattering event is shown in Fig. 1. The trajectories of the scattered and recoil particles ("a" and "d" in the figure) should be correctly reconstructed for the missing mass spectroscopy even when several beam particles ("b" and "c") are accidentally detected at the same time. This makes it difficult to apply a simple fitting method.

Here, we have adopted an image processing algorithm, Hough transform method. In this method, a point (x_i, y_i) in the two-dimensional track space is transformed into a curve in (r, θ) space (Hough space) according to the equation

$$r = x_i \cos\theta + y_i \sin\theta. \tag{1}$$

Each set of (r_a, θ_a) in the Hough space corresponds to a straight line in the track space whose equation is

$$y = -\frac{x}{\tan\theta_a} + \frac{r_a}{\sin\theta_a}. \tag{2}$$

Points in the track space which lie on one straight line share the common value of θ and r, thus the transformed curves intersect in one point in the Hough space. In our analysis, each transformed curve is voted into the two-dimensional histogram as shown in Fig. 2. After filling all curves, we search the maximum point in the histogram which determines one straight line in the track space. Next, points near the first line are eliminated and the remaining points are transformed to Hough space again. The maximum point in the second Hough space gives the second line in the track space. By repeating the above procedure, multiple tracks are separately reconstructed. In the example, four tracks drawn with the red lines in Fig. 1 were successfully extracted.

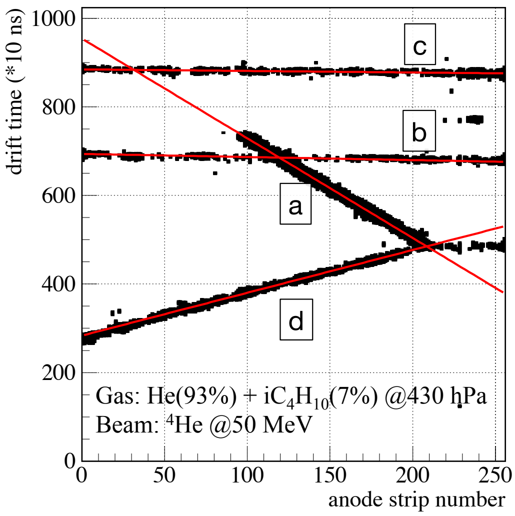

Figure 1: Typical track of a scattering event. The red lines are the reconstructed trajectories.

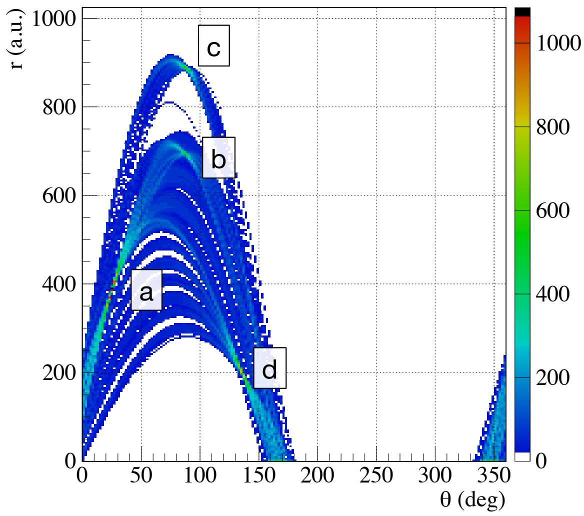

Figure 2: Hough transformation of Fig. 1. Four peaks give four lines in the track space.

References

[1] T. Furuno *et al.*, J. Phys.: Conf. Ser. **569**, 012042 (2014).