Development Of Multiple-Particle Tracking Algorithm For Forward Drift Chamber In SAMURAI

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The Superconducting Analyzer for MUlti-Particles from RadioIsotope Beam (SAMURAI)[1] has been playing an important role in studying unstable nuclei in RIBF since 2012. In April 2013, ^{16}C(α,α') experiment[2] was carried out to investigate a degree of freedom for an exotic cluster which appears above an α emission threshold in high excited states. In the SAMURAI spectrometer, four momenta of α and a residue were measured simultaneously to reconstruct the invariant mass of the excited states. Thus far, no computer code has been developed for multiple charged particle tracking, the primary issue being that track reconstruction takes a long CPU processing time to find a true hits combination from numerous hits combinations. With this background, a new algorithm for multiple charged particle tracking was developed in the anaROOT[3] framework and is described here.

In the SAMURAI spectrometer, two Forward Drift Chambers (FDC1 and FDC2) are installed to reconstruct the tracks of scattered reaction residues in the forward direction. FDC1 and FDC2 are located upstream and downstream of the SAMURAI dipole magnet, respectively. Each FDC consists of three kinds of wire orientation planes referred to as X, U, and V planes, and two planes of the same type are placed next to each other. This pair of two planes is hereafter called a super pair plane. In the X plane, the wires are parallel to the Y axis and, in the U and V planes, the wires are tilted $+30^o$ and -30^o, respectively to resolve the three-dimensional flight path. The planes are assembled in the order of X, X', U, U', V, V', X, X', U, U', V, V', X, and X' in FDC2 and in the opposite order in FDC1.

In the beginning, reliable hits on each plane are selected. When a charged particle passing through ionizing gases around a wire, a δ-ray or X-ray would generate signals on adjacent wires. Since a real hit signal reaches the wire faster than fake ones, it can be chosen as the fastest timing signal delivered from a multiple hit TDC on a common stop mode.

Using these candidates, two hits on the super pair plane are coupled if the difference between the hit wire positions is within the pitch size of the wires. Multiple use of a hit is allowed. Even if a hit is not associated in the super pair plane, it can be used with the same method for coupled hits in the following analysis.

With considerat all combinations of coupled hits among X planes, a track in X-Z plane is evaluated by a linear fitting. If the number of hits included in a track is more than 4 and if χ^2 divided by the number of degree of freedom (NDF) is within 10%, the track information is stored as a candidate. Then, a precise hit position on the plane is calculated from the drift time for the candidate tracks. Two possibilities, i.e., whether the particle passed through in the left side or right side of the wire, are resolved by calculating the minimum χ^2 configuration.

The track reconstructed in the X-Z plane is projected onto the U and V planes, and the wire positions in the Y axis are evaluated. By combining the Y position on these planes, a linear fitting is applied for them with spatial resolution of the wire pitch size. If the χ^2/NDF is less than 1, the ambiguity of the left or right side path is resolved in the same manner as in X-Z plane.

As a result, three-dimensional multiple tracks in FDC1 were reconstructed as shown in Fig.1. In this event, two tracks were found in both FDC1 and FDC2 independently. Tracks reconstructed without bias caused by other detectors enable us to estimate the intrinsic tracking efficiency. This code is applicable for any experiments performed in the SAMURAI spectrometer.

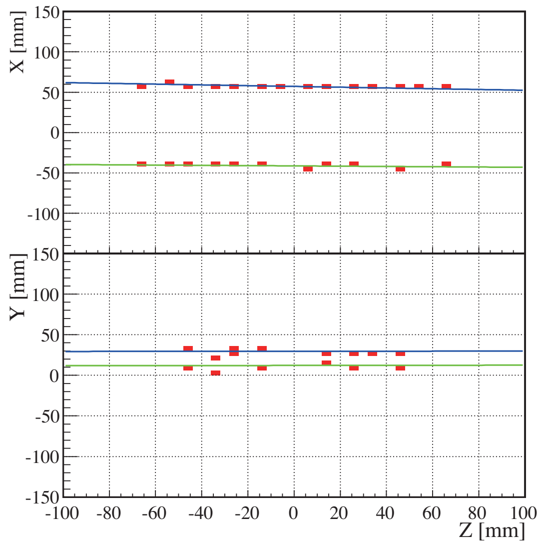

Fig. 1. Two reconstructed tracks in FDC1. Top and bottom figures show the track in the X-Z plane and Y-Z plane, respectively. The color of the linear fitting function indicates correspondences.

References
1) T. Kobayashi, et. al: Nucl. Instr. and Meth. **B**317 294-304 (2013)
2) H. Otsu, et. al.: In this report
3) `https://ribf.riken.jp/RIBFDAQ/index.php?Tools` %2FAnalysis%2FANAROOT

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