Development of a new cluster reconstruction method for GEM Tracker for the J-PARC E16 experiment

W. Nakai,[*1,*2] for the J-PARC E16 Collaboration

The aim of the J-PARC E16 experiment[1)3)] is to measure the mass spectra of vector mesons in nuclear matter at J-PARC to study the origin of hadron mass.

We developed the Gas Electron Multiplier[2)] Tracker (GEM Tracker) for a tracking detector. In this paper, we present a new universal analysis method to handle the signals of the GEM Tracker for a wide incident angle.

The detector requires a position resolution of 100 μm up to an incident angle of 30 degrees under a high counting rate environment of up to 5 kHz/mm^2. The GEM Tracker consists of a drift cathode, triple-GEM stack, and readout strip board. We chose a strip pitch of 350 μm to achieve the required position resolution and a very thin drift gap of 3 mm in order to reduce the signal pile-up in a high counting rate. We will record waveforms of strip signals using a flash ADC and the sampling rate of the ADC is 40 MS/s. The dynamic range of the preamplifier is 0.1 pC, and the shaping time is 50 ns.

We already achieved the required position resolution at an incident angle of up to 30 degrees with two types of analysis methods. One of the following two types of analysis methods has to be chosen according to the incident angle; the center of gravity (COG) method for 0 degrees, and the timing method, which uses arrival times of signals on each strip, for 15 and 30 degrees[4)].

We developed a new universal method independent of the incident angle, which reconstructs charge clusters generated in the drift gap by fitting several waveforms of successive strips simultaneously (two-dimensional fitting). The fitting function is

$$F(x,t) = \sum_{i=1}^{N} q_i \times I(t - z_i/v_d) \times G(x - x_i; \sigma = 300\ \mu\mathrm{m}),$$

where q_i, x_i, and z_i are fit parameters, v_d is drift velocity, N is the number of charge clusters, I is an impulse response function of preamp, and G is a Gaussian. An example of the fitting is shown in Fig 1. Because of gaussian fitting for the x-direction, the horizontal positions of clusters can be derived with the same accuracy as the COG method. Because of fitting by the impulse response of the preamp for the t-direction, the arrival timing of clusters can be obtained with the same accuracy as the timing method. Therefore, it is expected that better or equal resolution can be achieved for all incident angles.

The test experiment using a 1.0 GeV/c pion beam was performed at the J-PARC K1.1BR beam line. The result is shown in Fig 2. Using the new method, the obtained position resolution improved for all incident angles and was 74 μm for the 30 degrees track.

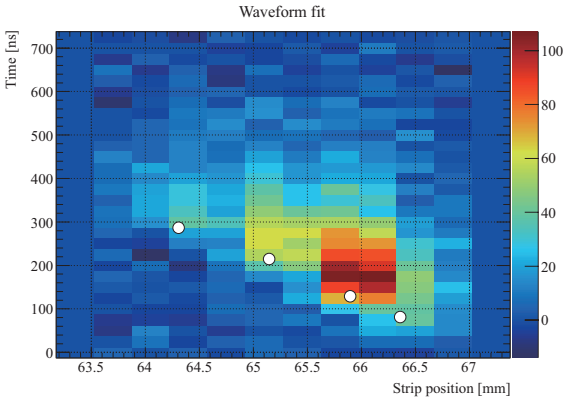

Fig. 1. Example of waveform fitting. Fitting results are indicated by white circles. Each white circle shows a cluster arrival timing and position.

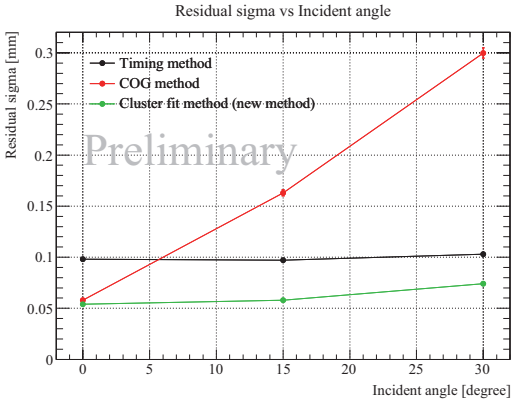

Fig. 2. Standard deviation of residual distribution as a function of incident angle. The black and red points have been reported in Ref. 4 and the green points are present study.

References

1) S. Yokkaichi et al.: in this report.
2) F. Sauli, Nucl. Instr. Meth. Phys. Res. A **386**, 531 (1997).
3) Y. Morino et al., JPS Conf. Proc. **8**, 022009 (2015).
4) Y. Komatsu et al., Nucl. Instr. Meth. Phys. Res. A **732**, 241-244 (2013).

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