Testing a GEM tracker in a magnetic field for the J-PARC E16 experiment

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The J-PARC E16 experiment was conducted to measure the mass modification of ϕ mesons in nuclear matter at J-PARC in order to study the origin of hadron mass. The details of this experiment are presented in another article of this report1).

We employed a tracking detector using the Gas Electron Multiplier (GEM)2), and have been developing it to be a position-sensitive detector in a magnetic field with a magnitude of 1.8 T at the center of the magnet. To use this detector, a position resolution of 100 μm up to an incident angle of 30° in a high counting rate environment up to 5 kHz/mm^2 is required. Our GEM tracker consists of a drift cathode, a triple GEM, and a readout strip board. We chose a strip pitch of 350 μm to achieve the required position resolution.

Since the directions of the electric and magnetic field in the drift gap are perpendicular, the drift velocity of ionization electrons is inclined to the E field by Lorentz angle α. Therefore we tested the operation of the detector in a large dipole magnet located at the J-PARC Hadron Hall in Apr. 2013. The setup is shown in Fig. 1. A laser with a wavelength of 266 nm was used to make the primary electrons, and the incident angle was fixed at 30°. The E fields of the drift gap, transfer gap, and induction gap were 600 V/cm, 3600 V/cm, and 3600 V/cm, respectively, and the B field was from 0.0 T to about 0.7 T.

As shown in Fig. 2, the expected Lorentz angles were calculated using a Garfield++ toolkit3). Because the Lorentz angle in the drift gap is accidentally almost equal to that of the transfer and induction gap, electrons should drift straight from where they are generated to the readout strip board. The Lorentz angle α can be represented as

$$\tan\alpha = \frac{\Delta_x}{d} \quad (1)$$

where d is the distance between the mesh and the readout, and Δ_x is a shift in the edge position of charge cluster measured in the non-magnetic field to that at readout. The result is plotted in Fig. 3. We found that the result is almost consistent with the calculation but there exists 14% of systematic difference. The reasons behind this systematic error need to be discussed.

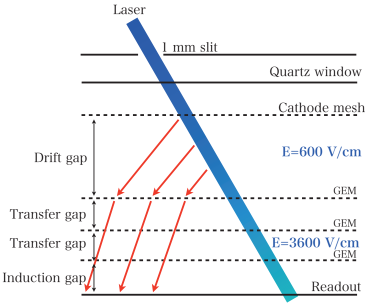

Fig. 1. A schematic view of the setup. Red arrows indicate the drift directions of electrons.

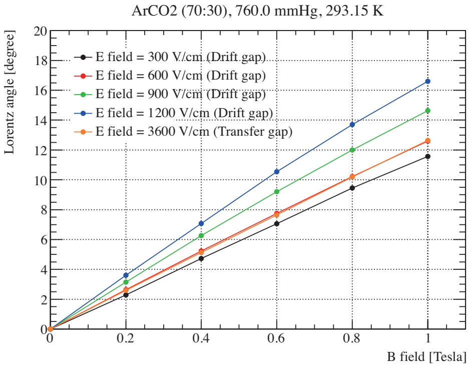

Fig. 2. The results of simulations using Garfield++ codes with various drift electric fields.

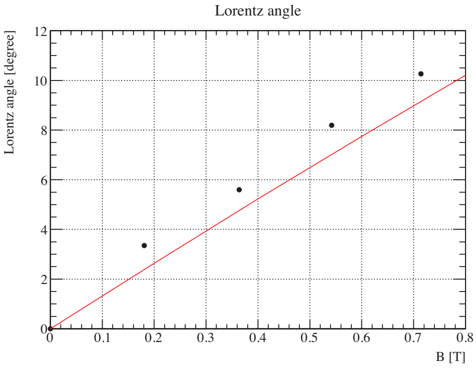

Fig. 3. The measurement of the Lorentz angle as a function of the magnetic field (black points), and the calculation using Garfield++ (red line).

References
1) S.Yokkaichi, *et al*, in this report
2) F. Sauli, Nucl. Instrum. Meth. A386 (1997) 531
3) `http://garfieldpp.web.cern.ch/garfieldpp/`

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