Methods to determine drift characteristics of the ANKE drift chambers

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An important task for the analysis of drift-chamber information is the determination of their drift characteristics (drift-distance to drift-time relation $R(t)$). The construction and the results of radioactive-source tests of the drift chambers for the ANKE backward detector were described in [1]. In order to study the influence of the magnetic stray field of the ANKE magnet D1 on the drift characteristics, a simulation has been made using the Garfield program. It turned out that the influence of the magnetic stray field is negligible under the conditions at ANKE. In Fig.1a the calculated drift characteristics is shown. The obtained drift velocity (50 μm/ns) is in good agreement with the experimental results[1]. These drift characteristics can be used for simulations of time spectra of the ANKE drift chambers.

Let us briefly describe several methods which may be used to determine of drift characteristics of the chambers used at ANKE. All these methods use only the time information and the numbers of the wires which fired.

— “Autocalibration” method.

This method is based on the analysis of time spectra [2]. Assuming a uniform particle flux within the drift cell, the time spectrum represents the drift velocity as a function of drift time. The integral of the time spectrum (with normalization coefficient F) is the coordinate dependence on the drift time (d is the length of the drift cell):

$$R(t) = \frac{d}{F}\int_{T_0}^{t}\frac{\mathrm{d}N}{\mathrm{d}T}\mathrm{d}T \qquad \left(F = \int_{T_0}^{T_{\max}}\frac{\mathrm{d}N}{\mathrm{d}T}\mathrm{d}T\right),$$

— “Iterative” method.

This method allows to determine $R(t)$ from particle trajectories. Starting with some initial $R_1(t)$, the track parameters are reconstructed which allows to obtain the dependence of the coordinates from the drift times. Subsequent averaging of this dependence leads to a new approximation of $R_2(t)$ and so on. The convergence of this method strongly depends on the initial approximation of $R(t)$.

— “Analytical” method.

The problem of the determination of $R(t)$ by trajectories can be solved in another way using an analytical representation of $\chi^2_{\rm min}$ in the space of the track parameters. This method is fully equivalent to the “iterative” one, but requires less computation time and does not depend on any initial approximations. For a statistical sum of K trajectories (in straight-line approximation) $\chi^2_{\rm min}$ has the following form [3]

$$\chi^2_{\rm min} = \frac{1}{K}\sum_{k=1}^{K}\sum_{l=1}^{N}\sum_{i=1}^{N} x_{lk}C_{li}x_{ik},$$

$$x_{ik} = w_{ik}+s_{ik}R(t_{ik}),\ C_{li} = \delta_{li}-\frac{1}{N}-\frac{(z_l-\bar{z})(z_i-\bar{z})}{N(\bar{z^2}-\bar{z}^2)},$$

x_{ik}, z_i are the x and z-coordinates of the i-th drift chamber, s_{ik} is the “left-right ambiguity” coefficient (s_{ik}=$\pm$1), w_{ik} is the wire position and N represents the number of the chambers.

If $R(t)$ has the linear form $R(t) = V(t-T_0)$ and the drift velocity V and time delay T_0 are the same for all wires, the minimization of $\chi^2_{\rm min}$ leads to a system of two linear equations. In the case of individual drift characteristics for each wire, one obtains a system of $2\cdot N\cdot M$ linear equations (M is the number of wires in each drift chamber).

All three methods were tested with simulated data. Pions with randomly generated momenta and angles were traced through the magnetic field of the ANKE dipole D1 using the GEANT program and measured 3d field maps. Multiple scattering and interactions in matter were taken into account. The coordinates in the drift chambers with measuring errors (100 μm) were used as the “true” ones. Drift chamber time values were simulated using the drift characteristic shown in Fig.1. These times and the wire numbers were used for redetermination of the drift-chamber characteristics and calculation of the coordinates. In Fig.1b and c the results of comparison between the calculated coordinates and “true” ones for the “autocalibration” and “analytical” methods are shown. The accuracy of the coordinate determination is $\sim$330 μm for the “autocalibration” method and $\sim$130 μm for the “analytical” one. Subtracting the squared measuring error (100 μm) one can calculate the accuracy of the methods.

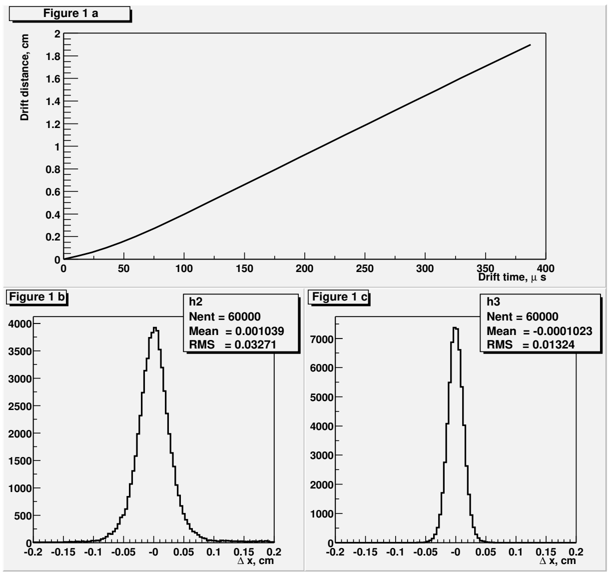

Figure 1: Characteristics of chambers and methods.

References:

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