Methods of reconstruction of multi-particle events in the new coordinate-tracking setup

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Abstract. At the Unique Scientific Facility NEVOD (MEPhI), a large coordinate-tracking detector based on drift chambers for investigations of muon bundles generated by ultrahigh energy primary cosmic rays is being developed. One of the main characteristics of the bundle is muon multiplicity. Three methods of reconstruction of multiple events were investigated: the sequential search method, method of finding the straight line and method of histograms. The last method determines the number of tracks with the same zenith angle in the event. It is most suitable for the determination of muon multiplicity: because of a large distance to the point of generation of muons, their trajectories are quasiparallel. The paper presents results of application of three reconstruction methods to data from the experiment, and also first results of the detector operation.

1. Introduction

The large coordinate-tracking detector based on drift chambers (DC) [1] for investigations of muon bundles generated by ultrahigh energy primary cosmic rays is developed at the Unique Scientific Facility NEVOD. The purpose of the installation is solving the problem of the excess of muon bundles, the magnitude of which increases with the energy of primary cosmic rays that can be caused both by cosmophysical and nuclear physical reasons [2]. The only characteristic of cosmic rays, which reacts differently to changes in the composition of cosmic rays and to the inclusion of new physical processes, but which has not been investigated to date, is the energy of the muon component of EAS. Existing coordinate detector DECOR together with Cherenkov water detector (CWD) NEVOD [3] measures multiplicity and energy release of muon bundles. The supermodules of DECOR do not cover the full side of the CWD so some particles can pass between them, the two track resolution of DECOR is 3 cm, these complicate muon bundle study. The new detector will cover entire side of the water volume of the CWD with the possibility of distinguishing close tracks at a distance of 4-5 mm.

At the moment, the coordinate-tracking unit based on drift chambers (CTUDC) has been developed [4]. It is a prototype of the full-scale installation. Detector contains 16 drift chambers forming 2 coordinate planes by 8 DC at opposite sides of the CWD (figure 1). The total area of the detector is 29.6 m².

Multiwire drift chambers of CTUDC have been developed in Institute of High Energy Physics (IHEP) [5]. The chamber has an array of field-forming wires arranged on the perimeter, 10 cathode and 4 signal wires in the center (figure 2). The signal wires are alternately shifted
from the center by 0.75 mm to solve left-right ambiguity. Drift chamber allows reconstructing the track on a plane perpendicular to the signal wires. The measured drift times of electrons to each signal wire let to determine the ionization points along the particle track, uniformity of electric field allows considering the drift velocity constant.

![Drift Chamber Diagram](image)

**Figure 1.** Location of planes of CTUDC relative to CWD, DECOR and calibration telescope system (CTS).

![Track Detection Principle](image)

**Figure 2.** The principle of detecting a track of a particle in a multiwire IHEP drift chamber.

### 2. Methods of reconstruction

Three methods were applied for reconstruction of multi-particle events registered by drift chamber: the sequential search method, method of finding the straight line and method of histograms.

The sequential search method enables to reconstruct each possible combination of the points using the least square method (LSM) and choose the combination with minimal sum of the squared deviations. After finding the first best track, the next one is selected from the remaining points until at least one channel has no unused points.

Method of finding of the straight line draws straight lines between each pair of points on two selected signal channels. Then each line is extrapolated to remaining channels. If the ionization points are within the allowed region $\Delta X$ around the line, reconstruction using LSM is carried out.

Method of histograms was developed for finding and reconstruction of parallel tracks. It draws corridors with a width $\Delta X$ at an angle $\alpha$ through each point on the first channel to the others (figure 3). If there is at least one point on each channel in the corridor, all this points are reconstructed by a sequential search method. All $\alpha$ angles are enumerated in the range from $25^\circ$ to $155^\circ$, for each value the number of found tracks is counted. The chosen reconstruction of an event is the one for which the greatest number of tracks is found.
3. Reconstruction of parallel muon bundles in CTUDC

Reconstruction with method of histograms in CTUDC and parallel tracks counting are carried out simultaneously in all chambers. The selection of events is carried out according to the following criteria: the minimum number of tracks is 3, tracks are reconstructed in at least two chambers.

Also, a comparison of joint events registered with the CTUDC and DECOR installations was conducted. The Figure 5 shows the reconstruction of one event in these installations. As seen from the figure, the reconstructions fit each other. At this stage, the angles in the joint events coincide with an accuracy of about 4°. Further improvements of the method and chamber calibration will allow to reduce this difference.
Figure 5. Comparison of the reconstruction of the event in CTUDC (up) and DECOR (down). The difference in the definition of the angle is $1^\circ$.

4. Conclusion
For the reconstruction of multi-particle events in the IHEP drift chambers, the sequential search method, method of finding the straight line and method of histogram were applied. The main purpose of the new coordinate-tracking setup is to determine the zenith angle and multiplicity of the muon bundles, for this purpose the method of histograms has been found the most suitable.

The method was studied using simulation and experimental data. The comparison of reconstructions of multiple events based on the data of CTUDC and DECOR showed the correctness of the method.

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