PRIMARY VERTEX RECONSTRUCTION IN THE BM@N EXPERIMENT*

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This paper is related to the BM@N experiment and deals with an important step of the experimental data analysis — reconstruction of the primary vertex in events. The proposed algorithm for this task is described step by step in the paper. It is shown that the algorithm is strongly dependent on a set of free parameters. The selection of the best parameters and the algorithm tuning is presented.

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1. Introduction

Baryonic matter at Nuclotron (BM@N) [2] is the first experiment performed at the NICA complex [1]. It is a fixed target experiment with extracted heavy-ion beams from the Nuclotron. One of the main physics goals of the BM@N experiment is reconstruction of hyperons and hypernuclei, the increased yield of which may be a sign of phase transition. Reconstruction of the primary vertex is one of the most important stages of event reconstruction in high-energy physics experiments. Knowing the coordinates of the primary vertex, makes it possible to better estimate the path of neutral decayed particles like Λ-hyperons, otherwise the precise reconstruction of these particles is impossible.

2. Vertex finder algorithm

An algorithm based on virtual planes was chosen for the primary vertex reconstruction. A value of the target edge obtained from geodetic measurements is taken as an initial approximation of the primary vertex position (Z_v).

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The main steps of the proposed algorithm are shown below. These steps are repeated until the required accuracy is achieved:

1. A set of M equidistant virtual planes transverse Z axes is created in the $(Z_v - r, Z_v + r)$ range (see Fig. 1).

2. Reconstructed in the inner tracker charged particle tracks [3] (that are not marked as unused for vertex finding) are extrapolated by the Kalman filter [4] to the created virtual planes.

3. For each k virtual plane, an average distance between a pair of points (i, j) is calculated

$$d_k = \frac{1}{N} \sum_{i=0}^{N} \sum_{j=i+1}^{N} \sqrt{\left(x_i^k - x_j^k\right)^2 + \left(y_i^k - y_j^k\right)^2}.$$

4. For the set of M average distances, a minimum $(d_{\min})$ is found. The updated value of Z_v corresponding to the virtual plane with $d_{\min}$ is determined.

5. The search range is narrowed in half: $r = r/2$.

As a result of the algorithm's work, the value Z_v is calculated.

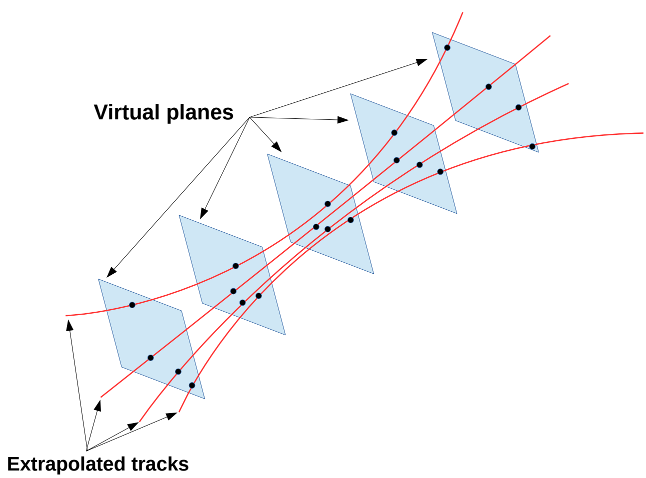

Fig. 1. Graphical explanation of vertex finder algorithm.

Then for the final check, the reconstructed tracks are extrapolated to Z_v. For the resulting set of intersection points, the standard deviation is calculated

$$\mathrm{RMS} = \sqrt{\frac{1}{N}\sum_{i=0}^{N}\left((x_i - x_{\mathrm{mean}})^2 + (y_i - y_{\mathrm{mean}})^2\right)}\,.$$

If RMS exceeds the threshold value (RMS_CUT), then a point lying the furthest from the geometric center of points is found. The track to which this point belongs is marked as not being used to find the vertex and the search algorithm is started again.

The typical profile of the reconstructed vertex is presented in Fig. 2. It is clearly seen that the main peak on the distribution corresponded to the primary vertex. Smaller peaks on the right-hand side of the distribution were produced by secondary tracks born on the elements of the experimental setup.

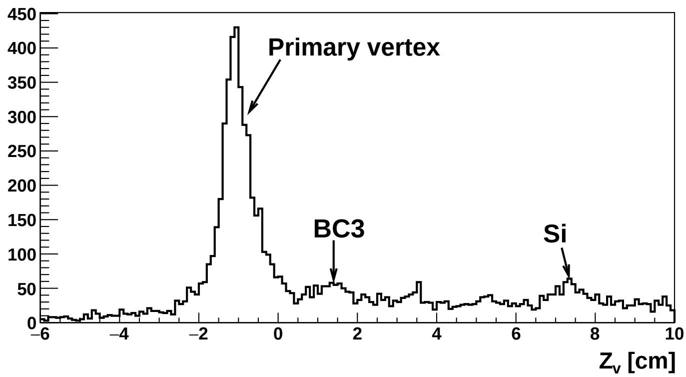

Fig. 2. Profile of the reconstructed vertex in Z direction.

3. Tuning of the algorithm

The proposed algorithm has a set of free parameters which could be used to tune the algorithm. Namely: search range r, number of virtual planes M, RMS threshold RMS_CUT, way to find d_{min}, way to estimate closeness of points on a virtual plane.

Test runs of the event reconstruction were performed to select the best algorithm parameters. At the same time, all the parameters were fixed except for one that was changing in some range.

The selection was performed by the width of the vertex distribution along the Z axis (σ) and the number of vertexes found in the range from -3 to 0 cm (Integral).

In Fig. 3, the result of the tuning procedure is presented. After analysis of σ and Integral dependencies, the next set of parameters was chosen

$$\mathrm{RMS\_CUT} = 1.5\ \mathrm{cm}\,, \qquad M = 10\,, \qquad r = 5\ \mathrm{cm}\,.$$

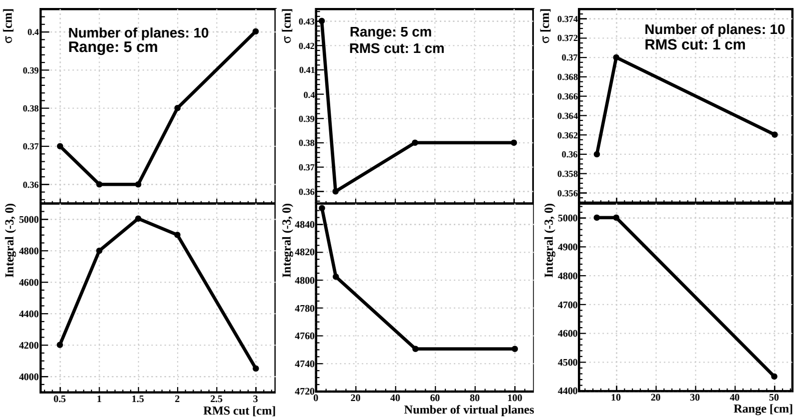

Fig. 3. Dependence of vertex quality on tuning parameters.

4. Summary

The algorithm of primary vertex reconstruction based on virtual planes was presented in the article. Results of the algorithm's work are shown. The proposed approach has a set of free parameters. One of the goals of the research was to choose the best parameters and tune the algorithm. In the next step of the current work, other parameters of the algorithm are going to be investigated.

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