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# AN ALGORITHM FOR IDENTIFYING EVENTS IN THE EXPERIMENT DISTO

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An algorithm for identifying useful events in the experiment DISTO is proposed. It is based on the identification of kaons among the secondary charged particles using the measurements of their velocities (with the help of a Cherenkov detector) and deflection algles in the magnetic field. It must be pointed out that within this approach an event can be fully classified by identification of all the detected secondaries.

The investigation has been performed at the Laboratory of Computing Techniques and Automation and Laboratory of Nuclear Problems, JINR within DISTO Collaboration.

## Алгоритм идентификации событий в эксперименте ДИСТО

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Предложен алгоритм идентификации полезных событий в эксперименте ДИСТО. Он основан на выделении среди вторичных заряженных частиц каонов по измерениям их скорости (с помощью черенковского счетчика) и углов отклонения в магнитном поле. В рамках этого подхода возможна четкая классификация регистрируемых событий путем идентификации всех вторичных заряженных частиц.

Работа выполнена в Лаборатории вычислительной техники и автоматизации и Лаборатории ядерных проблем ОИЯИ в рамках коллаборации ДИСТО.

## Introduction

At present an experiment is being prepared by the DISTO (Dubna — Indiana — Saclay — Torino) [1] collaboration for studying spin effects in the reaction

$$\uparrow pp \rightarrow pK^+Y$$

with the polarized proton beam of Saturne (Saclay, France). The aim is to carry out a detailed study of the reactions $pp \rightarrow pK^+\Lambda^0$, $pp \rightarrow pK^+\Sigma^0$ and $pp \rightarrow pp\,\phi^0$. For selection of the indicated events (signal events) in the presence of a dominant background, mainly due

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to $pp \rightarrow pp\,\pi^+\pi^-$ events, advantage is taken of the fact that signal events are characterized by the presence of a secondary vertex. Earlier, in ref. [2] algorithms for the selection of signal events, based on the identification of secondary vertices, were investigated.

In this paper a new approach to the classification of signal reactions is proposed. Advantage is taken, here, of another feature of the indicated reactions and of the possibility of measuring velocities of detected particles utilizing Cherenkov counters.

## 1. Experiment

The DISTO spectrometer has a cylindrical geometry and consists of two arms situated symmetrically about the beam direction. In each arm there are 5 detectors: 2 scintillation fibre chambers, 2 multiwire proportional chambers (MWPC) and an outer detector, which consists of 2 planes, vertical and horizontal, of scintillation hodoscope counters. At present the possibility of placing Cherenkov counters behind the scintillation hodoscope is investigated. They cover a scattering angle of 45° in the horizontal plane and a dip angle of ± 20°. The detectors and the liquid-hydrogen target are situated in the magnetic field, which is perpendicular to the incident beam.

The layout of the DISTO experiment is presented in Fig.1.

For effective on-line selection of signal events and rejection of back-ground events, a two-level trigger will be used. The first-level trigger is for selection of events by their multiplicity: only four-prong events are selected. For producing the trigger pulse the signals from the scintillation fibre chambers and from the scintillation hodoscopes are used (see details in the workshop Proceedings [3]). Events accepted by the first-level trigger are examined for the presence of a secondary vertex. At present, two different approaches to searching for the secondary vertex, based on RISC-processors, are under development:

1) the dual algorithm [4],

2) the method of invariant moment variables together with application of a multilayer perceptron [2].

Utilization in the detecting part of DISTO of Cherenkov counters (see, for instance, Ref. [7]) permitting measurement of the velocities of detected particles opens up a new possibility for the second-level trigger.

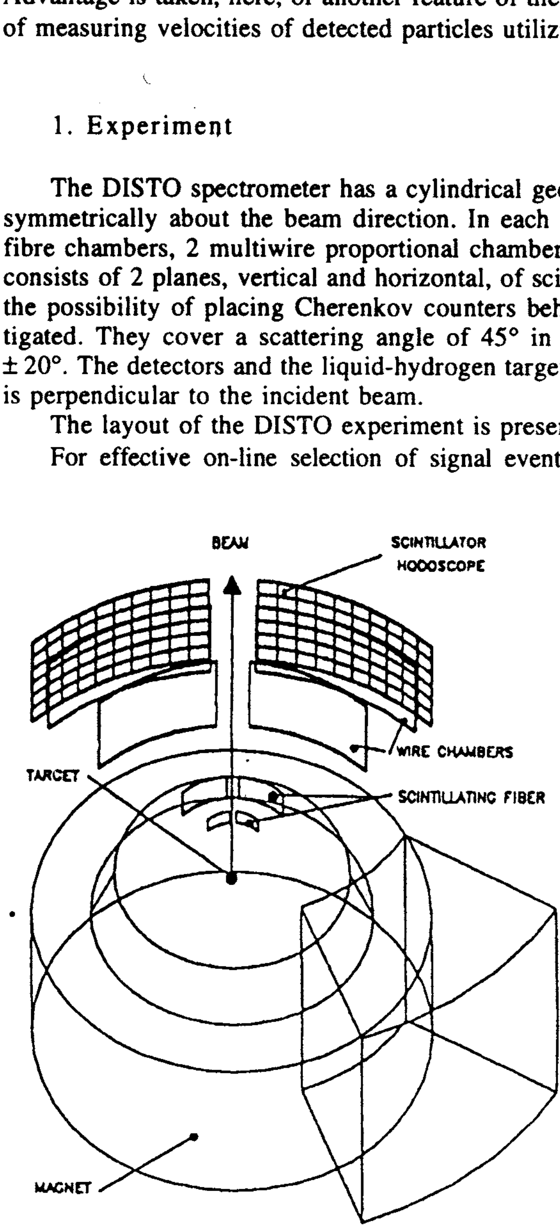


Fig.1. The layout of the DISTO experiment

## 2. Algorithm for Identifying Secondary Particles

In all the processes of interest there will be charged $K$-mesons detected in the final state. Therefore, when the selection of events by multiplicities is completed (at the stage of the I-level trigger) and the technique of cellular automata is applied for revealing the curved tracks in the horizontal plane, it will be necessary to identify the detected particles.

To this end we shall first try to reconstruct the momentum of a charged particle by the angle of its deviation in the inhomogeneous magnetic field. The drawing presented in Fig.2 illustrates how the tangent of the deviation angle $\varphi$ of a charged particle in the magnetic field is determined from the coordinates of «hits» in the fibre chambers (chambers 1 and 2) and in the MWPC chambers (chambers 3 and 4):

$$\tan \varphi = \frac{k_2 - k_1}{1 + k_1 k_2},$$

where

$$k_1 = \frac{x_2 - x_1}{z_2 - z_1}; \qquad k_2 = \frac{x_4 - x_3}{z_4 - z_3}.$$

The distribution of random values

$$C_m = \tan \varphi \quad P,$$

where $P$ is the momentum of the particle being considered, is presented in Fig.3. From this picture the conclusion can be made that for reconstruction of a great majority of the detected particles ($p$, $K^{\pm}$, and $\pi^{\pm}$) one can actually consider the field to be homogeneous, i.e., the particle momenta may be determined from the following relation:

$$P_c = \frac{\overline{C}_m}{\tan \varphi},$$

where $\overline{C}_m$ is the most probable value of variable $C_m$. The distribution of random values $\Delta P = P - P_c$ characterizing the reconstruction accuracy of momenta for secondary particles with momenta between 0 and 3 GeV/c is given in Fig.4; the distribution of random values $\frac{\Delta P}{P}$ exhibits a spread amounting to $\approx 5\%$.

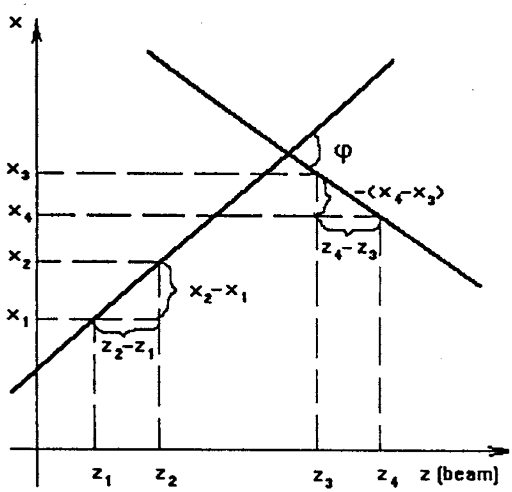


Fig.2. Deviation angle $\varphi$ of a charged particle in magnetic field determined by the coordinates of «hits» in the fibre and MWPC chambers

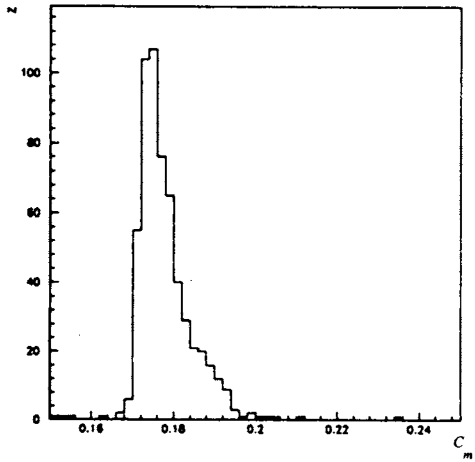


Fig.3. Distribution of random variable $C_m = \tan \varphi P$: $P$ is a charged particle momentum and $\varphi$ is its deviation angle in the magnetic field

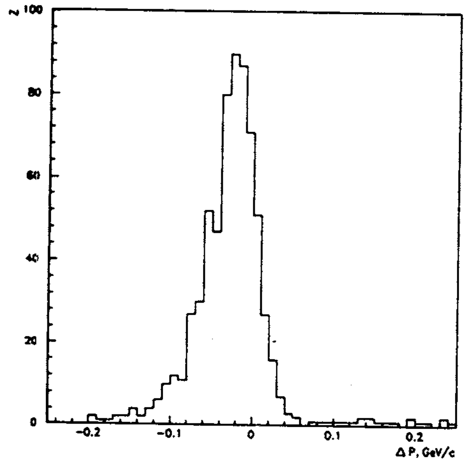


Fig.4. Distribution of random value $\Delta P = P - P_c$ characterizing the accuracy of momentum reconstruction for secondary particles

Taking advantage of the signal heights from the Cherenkov counter and of the reconstructed momenta of the secondary particles, one can select the events of interest by the presence of $K^{\pm}$-meson among the secondaries.

## 3. Results of Monte-Carlo Simulation

For simulating operation of the experimental apparatus and studying the processes of interest a computer program termed LACYL and based on the GEANT software package [6] has been used. Generation of the primary interaction is done with the aid of the GENBOD code [7], which permits Monte-Carlo simulation of multiparticle events in accordance with the Lorentz invariant Fermi phase space. Each secondary particle (reaction product) is tracked through the known magnetic field, in which it undergoes deflection depending on its charge and momentum, and then through all the detectors taking into account multiple scattering and energy losses occurring in the materials traversed. Unstable particles are allowed to decay in accordance with their lifetimes and branching ratios, and the decay products are also tracked through the apparatus.

In Fig.5. a two-dimensional distribution of the variable «$P$ vs $\beta$» is represented. In the example we use the quantity $\beta = P/E$, where $E$ is the particle energy. The value of $\beta$, obtained from the expression presented above is supplemented with an error equal to $\Delta\beta$, generated in accordance with the Gaussian distribution N(0,0.03), which corresponds to an $\approx 5\%$ error* for the whole range of $\beta$ values. From the Figure it can be seen that the secondary $p$, $\pi^+$, and $K^+$ are quite well separated.

*Estimation reveals that the experimental error should not exceed this value

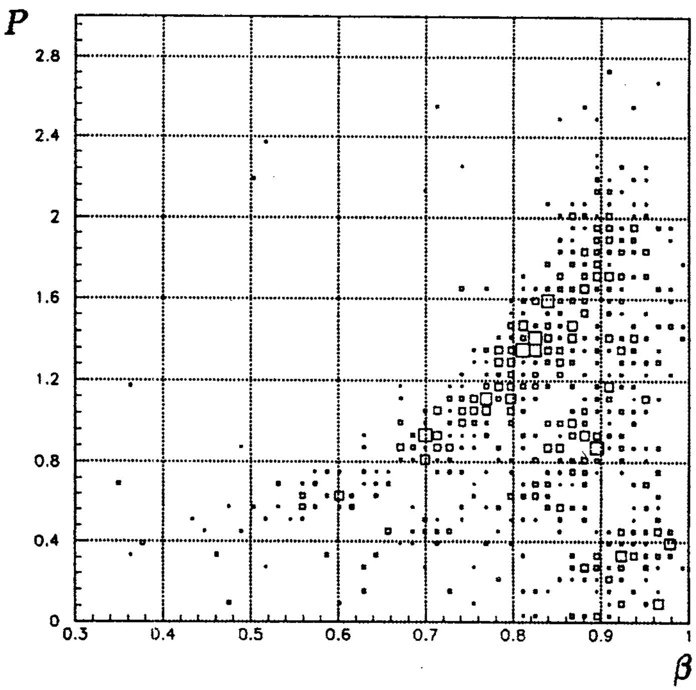


Fig.5. Two-dimensional distribution of variables $P$ *vs* $\beta$: $\beta = P/E$, where $E$ is the particle energy

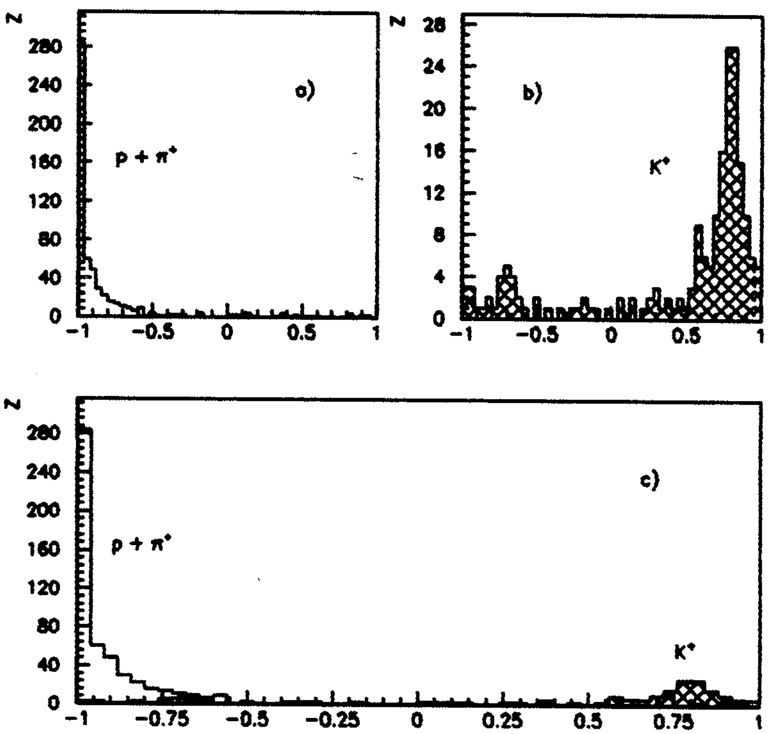


Fig.6. Distributions of output signals from neural network trained for identification of kaons: a) for tracks of $p$ and $\pi$; b) for tracks of $K^+$; c) summary

As a non-linear classifier permitting identification of the particle under consideration in the space of the indicated random variables one can utilize a multi-layer neural network of the feedforward type from the JETNET 2.0 package [8]. In Fig.6 the distribution is presented of the output signals from a neural network trained, also, for identification of kaons:

- the empty histogram corresponds to tracks of $p$ and $\pi$;
- the dark histogram corresponds to tracks of $K^+$.

The probability of identifying kaons amounted to 89%. The efficiency of kaon identification may be increased approximately to the level of 95—97%, if the particle examined is first tested as a proton and then, alternatively, as a pion or a kaon (the order is irrelevant).

## Conclusion

An algorithm for identifying signal events in the experiment DISTO is proposed. It is based on the recognition of kaons among the secondary charged particles. It must be pointed out that within this approach an event can be fully classified by identification of all the detected secondaries.

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