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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

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A.A.CHILINGARIAN, S.V.TER-ANTONIAN

ON THE POSSIBILITY OF IMPROVING THE MULTI-LAYERED DETECTOR ENERGY RESOLUTION

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A.A.CHILINGARIAN, S.V.TER-ANTONIAN

ON THE POSSIBILITY OF IMPROVING THE MULTI-LAYERED DETECTOR ENERGY RESOLUTION

A new method of treating the calorimetric information is described for the first time by an example of the μ -meson energy determination problem by means of a spark calorimeter. A comparison is carried out with the existing methods of energy estimate.

Yerevan Physics Institute

Yerevan 1981

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С.В.ТЕР-АНТОНЯН, А.А.ЧИЛИНГАРЯН

ОБ ОДНОЙ ВОЗМОЖНОСТИ УЛУЧШЕНИЯ ЭНЕРГЕТИЧЕСКОГО РАЗРЕШЕНИЯ МНОГОСЛОЙНЫХ ДЕТЕКТОРОВ

На примере задачи определения энергии μ - мезона с помощью искрового калориметра впервые описывается новый метод обработки калориметрической информации. Проводится сравнение с существующими методами оценки энергии.

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1. The passing particle energy correlation with the quantity and power of the secondary electromagnetic (EM) showers is the basis of the methods of μ -meson energy estimate by means of the multi-layered installation [1-4].

The muon energy is determined by the K quantity of detectors which registered the showers with the number of particles larger than the threshold one.

The functional relationship parameters

$$E = f(K) \tag{1}$$

are defined by Monte-Carlo (M.C.) calculations [2, 4].

Another method of muon energy estimate is based on an "ideal calorimeter" approximation - the EM cascades are attenuating in the absorber not extending to the next row [1, 3]. In this case the method of maximum likelihood (ML) is used with the function of likelihood

$$\Phi(M/E) = \prod_{i=1}^{N} g(m_i/E) \; , \; \sum_{i=1}^{N} m_i = M \tag{2}$$

where N is the number of the installation rows, $g(m_i/E)$ is the probability to register m_i secondary particles in the i-th row of the calorimeter, if the passing particle energy is equal to E. The multiplicity method (1) is not accurate enough since it does not use the correlation with the number of secondary electrons, the ML method (2) is not applicable at high energies, when the "ideal calorimeter" approximation becomes incorrect. The suggested method treats the problem of energy estimate as the classification of the experimental information vector $\vec{X}$ (X_i is the number of secondary electrons in the i-th row), according to the list of alternatives available, and has a claim on the most complete consideration of the distinctive information on the particle passage through the calorimeter [5].

2. In the N -dimensional indication space L -classes are given, each representing a realization set of the passage simulation M.C. programme (the training sample). Vector $\vec{X}$ is produced for recognition. It is necessary to define to what class it is most "close". The distance function is used as a rule in the N -dimensional space as a similarity measure. The space metrics is chosen so that the distinguishable information is accounted most completely. As the correlations between the signal levels increase in the adjacent rows with the energy growth, it is advisable to choose the metrics sensitive to the correlations between the vector components. The Mahalonobis distance answers this requirement [6].

$$R(\vec{X}, \vec{A}) = (\vec{X} - \vec{A})^T \Sigma^{-1} (\vec{X} - \vec{A}) \tag{3}$$

where Σ is the sample covariance matrix of the class to which vector $\vec{A}$ belongs.

The nonparametric decision rule is chosen to carry out the classification which is based on the concept of the nearest neighbourhood - the NN classifier [7]. The distance from vector $\vec{X}$ to all the members of the training sample is calculated. The set of distances is ranged and K vectors of the training sample corresponding to the shortest distances are determined. Vector $\vec{X}$ refers to the class with the largest number of representatives among KNN .

3. The Aragats spark calorimeter (8 rows of the wide-gap spark chambers interlayered by the 5 cm thick lead absorbers) energy resolution was studied by means of the KNN classifier. The energy interval was divided into 13 classes with the energies: E = 10, 20, 50, 100, ..., 100000 GeV.

Each class of the training sample consisted of 100 realizations of the M.C. programme [8]. "Pseudo-experimental" vectors, i.e. the events with the well-known classification, were produced for recognition. One can judge of the classification efficiency while calculating the portion of the correctly classified events. The figure shows the Aragats spark calorimeter energy resolution for the muon energy of 100, 500, 1000 GeV (pointed by an arrow) corresponding to the techniques described. At the energy of 100 GeV, when the EM showers attenuate in one row, the ML method offers a well-grounded and effective estimate, but with the energy growth and, consequently, with the correlation increase between the points in the adjacent rows the recognition method gives much better results.

4. During recent years the calorimetric way of the high-energy particle study became wide-spread together with the experimental ones in cosmic ray field as well as on the accelerator. Therefore the development of the accurate methods of pattern recognition in calorimetric systems is highly urgent [9].

Together with the improving the energy resolution the suggested technique will permit one to distinguish the electromagnetic and hadron cascades, to discern the showers generated by various particles, i.e. to draw the statistic conclusions on the event relation to one or the other type with the most confidence.

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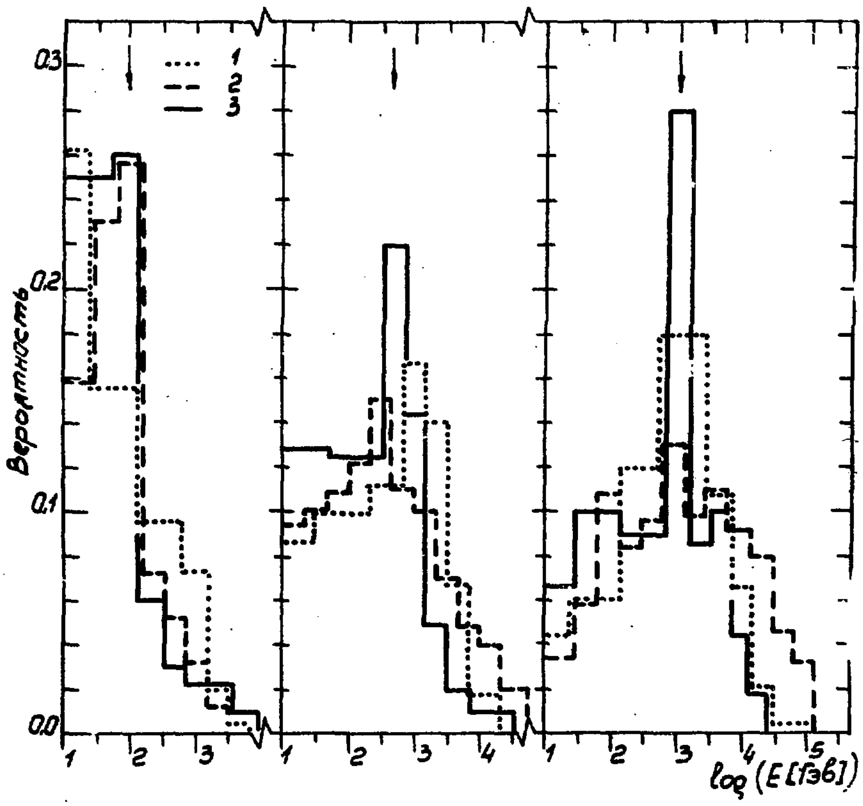

Figure. The energy resolution of the Aragats spark calorimeter

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