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JET ISOLATION BY THE RELATIVE DENSITY METHOD

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Recently a great interest has grown to correlations research of secondary particles in processes of multiple particles formation at high energies. A number of works are dedicated to this question, e.g., Refs. 1-6 .

Both theoretical predictions of models of hard collision of interacting hadrons with subsequent cascading of quarks into hadrons resulting in jets production with high transverse momenta[7-11], and experimental acknowledgement of the existence of such jets[12-15], raise a question of criteria for the isolation of jets, a group of particles genetically connected with each other. In Ref. 16 the jets isolation in interactions is called "sphericity", "spherocity" etc., to determine which it is necessary to know the values of both momenta and angles of secondary particles. If proceeding from only angular distributions of particles producted in multiple generation, i.e. from the most accessible source of information on the process's mechanism at high energies, then narrow particle groups isolated from others can be considered as the consequence of physical processes providing probability of their production exceeds their random production[3].

We suggest jets isolating among secondary particles of interaction to be carried out over relative density, ν . Results of the analysis have shown that one can efficiently isolate narrow groups of particles using the introduced value.

The present work is the continuation of searching and studying events with the narrow groups available whose number of particles $m \geq 3$. As is mentioned in Ref. 13 , about 800 events of interactions of the 200 GeV/s proton with emulsion nuclei with $n_s \geq 7$, were scanned for visual detection of particle groups at solid angles $\theta \geq 5^\circ$ and at azimuthal angles difference $\Delta\psi \leq 30^\circ$, which are analogous for those of a unique event with evidently pronounced double-jet generation of particles (Table 1 , event 1). Six events were found, having per one particle group (events 2-7) and one event (event 8) with two groups of particles in it, which satisfy the above conditions. 4 events with $\theta \leq 5^\circ$ are also included into consideration (events 9-12). In all these cases the solid angle of the particles groups differs from the average angle of the given groups no more than $\pm 0.17\,\bar{\theta}$. Thus, the particles generating the groups in chosen interactions have close values of both quasirapidities $y = -\ln tg\,\frac{\theta}{2}$ and azimuthal angles ψ .

The introduced value of relative density ν represents the ratio of particles density in the solid angle formed by particles of the given group (jet) with solid angles θ_1 and θ_2 (the smallest and the largest angles of the particle group relative to the flight direction of the primary one) and in azimuthal angles interval $\Delta\psi$, to the average density in a spherical ring limited by the same values of solid angles with regard for the angular distribution function. Simple mathematic transformations lead to the expression

$$\nu = \frac{1}{f(\theta_1, \theta_2)} \, \frac{360}{\Delta\psi \, n_s} = \frac{1}{P} \, \frac{m}{n_s}$$

where P is the observation probability of one particle in the jet solid angle $w = 2\pi \frac{\Delta\psi}{360} (\cos\theta_1 - \cos\theta_2)$. $f(\theta_1, \theta_2)$ is the particles fraction in the angular distribution of generated particles in solid angles interval ($\theta_1 \div \theta_2$). The values of $f(\theta_1, \theta_2)$ are obtained from experimental data on inelastic proton-nuclon interactions at 200 GeV.[17]

The probability of random accumulation of particles in solid angle can be determined by formula $W = C_{n_s}^{m} P^{m} (1-P)^{n_s - m}$. Values ν for various m are presented in Table 2 at probability values of independent divergence of particles $(10^{-5} - 10^{-7})$. For $m = 6$, where ν as a function of m is more sensitive, the limiting values of relative density at $n_s = (10 - 30)$ are given. We regard it convenient to denote jets as $m^{\ln\nu}$. Note, that if product $m \ln\nu$ is more than 12, then the probability of particles accumulation in a jet with relative density ν is less than $5 \cdot 10^{-5}$.

Fig. 1 presents rapid and azimuthal-rapid diagrams of event 8 and of usual event with the same number of generated secondary particles. In the azimuthal-rapid diagram (Fig. 1a) efficiently pronounce two regions of particles accumulation in almost opposite directions in an azimuthal plane (in a rapid diagram they are presented as a single accumulation). Fig. 2 presents distributions of values ν for all possible combinations at $m = 3$ for events whose azimuthal-rapid diagrams are presented in Fig. 1. For a usual background event (Fig.2) the maximum values (12, 15, 24) obtained for particles combinations (5, 6, 7), (4, 6, 10), (1, 2 , 3) are stipulated by small values of either azimuthal angles difference or rapidities. For the selected event (Fig.2a) maximum values 180 and 300 are obtained for both (7, 8, 10) and (4, 5, 6) combinations. Note, that when there are groups in events, then the values occur in distribution ν , which highly exceed the maximum value of a background event. Thus, about 90% of all values $\nu \geq 5$ in the Fig.2a distribution are obtained as a result of combinations of two particles of one group with one particle of another group or with particle 3 which is close by rapidity.

Coming back to the earlier studied event of double-jet particle generation[13], where the lateral jet of six particles is explicitely pronounced and has the value of ν =46.9 , we can confirm on this basis of the suggested isolation method, that particles (3, 5, 6, 9, 10, 11) form a separate group as well.

Values ν and W obtained for events selected by us, are presented in Table 1. As is seen from the Table, we have 10 events of the $3^{(3,8\div 6,5)}$ type. The probability of random accumulation of this type in one event out of 800 is less than $4\cdot 10^{-2}$, and in 10 events is less than $2\cdot 10^{-21}$. Thus, the observable narrow groups of particles are mainly the consequence of physical processes taking place at high energy interactions.

It is of interest to study various characteristics of interaction in events with large ν . Measurements of momentum secondary particles were carried out in some events. Preliminary investigations have shown that these jets have mainly high transverse momenta (the estimation is given for charged particles only). As to summary balance of transverse momenta of charged particles (assuming the constancy of transverse momenta and at matching of jets directions in azimuthal plane), the availability of particles with high transverse momenta is not excluded in these interactions.

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Table 1

№	Type interact.	m	$\theta_1-\theta_2$	$\psi_1-\psi_2$	ν	W	$m^{\ln\nu}$	P_t GeV/c
I	2+0+2I	6	6.0 - 8.6	I82 - 2II	46.9	2.8 IO^{-9}	$6^{3.85}$	I.5
		6	2.7 - 4.4	59 - I03	I6.7	I.3 IO^{-6}	$6^{2.82}$	
2	5+I+I2	3	4.7 - 7.2	346 - 370	43.9	4.I IO^{-5}	$3^{3.78}$	I.4
3	2+0+I6	3	8.4 - I2.0	202 - 2I0	II7.2	2.3 IO^{-5}	$3^{4.76}$	0.5
4	4+3+I9	3	9.0 - II.0	I9I - 2I7	56.4	4.5 IO^{-5}	$3^{4.02}$	I.7
5	7+2+3I	4	8.5 - I0.3	320 - 34I	38.0	4.2 IO^{-5}	$4^{3.04}$	I.3
6	0+0+I4	3	II.0 - I3.5	265 - 282	68.8	I.8 IO^{-5}	$3^{4.22}$	
7	I9+4+35	3	II.4 - I3.0	I36 - I56	57.I	2.2 IO^{-5}	$3^{4.04}$	
8	4+2+I0	4	8.9 - I0.7	329 - 338	65.8	2.9 IO^{-7}	$4^{4.67}$	I.6
		3	II.0 - I4.6	I72 - I82	I87.0	4.9 IO^{-7}	$3^{5.22}$	I.3
9	5+0+26	3	2.6 - 3.0	237 - 245	I56.2	I.0 IO^{-6}	$3^{5.05}$	
I0	I2+3+I5	3	2,I - 2,5	I8I - I94	I54.0	I.0 IO^{-6}	$3^{5.05}$	
II	5+5+I4	3	I,2 - I,5	40 - 43	66I.0	I.2 IO^{-8}	$3^{6.5I}$	
I2	I+0+II	3	I.5 - I.7	I73 - I99	84.0	5.6 IO^{-6}	$3^{4.43}$	

Table 2

	ν		
m	I0^{-5}	I0^{-6}	I0^{-7}
3	77	I50	320
4	28	50	89
5	I5	25	40
6	9 - I2	I3 - I7	I9 - 26

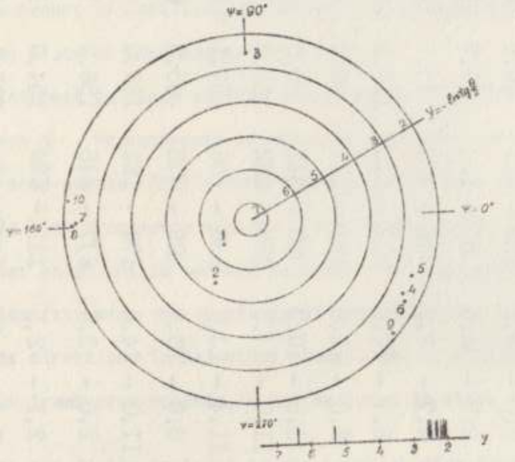

Fig. 1a

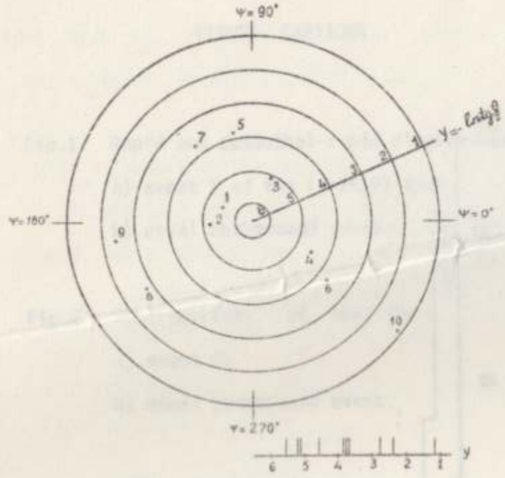

Fig. 1b

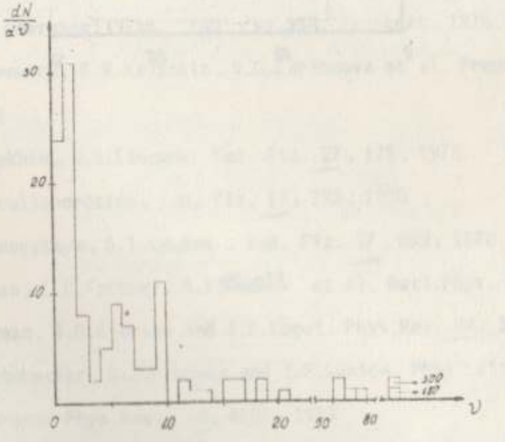

Fig.2a

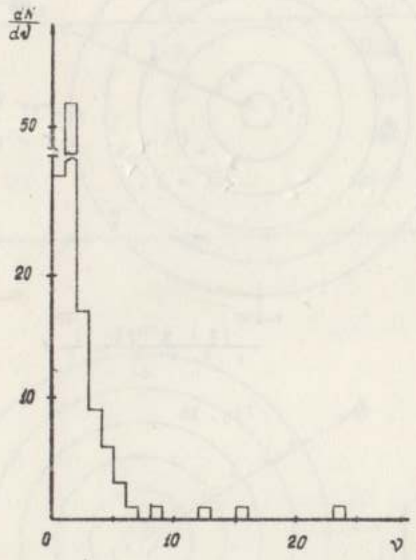

Fig.2b

FIGURE CAPTIONS

Fig.1 Rapid and azimuthal-rapid diagrams for

a) event 8 of the (4+2+10) type;

b) usual background event of the (3+1+10) type.

Fig.2 Distribution at $m_i=3$ for

a) event 8;

b) usual background event.

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