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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

ЕФИ-272(65)-77

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AN EVENT OF TWO-JET PRODUCTION OF PARTICLES OBSERVED IN NUCLEAR PHOTOEMULSION

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УДК.539.I.073.7

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СОБЫТИЕ ДВУХСТРУЙНОЙ ГЕНЕРАЦИИ ЧАСТИЦ,ОБНАРУЖЕННОЕ В ЯДЕРНОЙ ФОТОЭМУЛЬСИИ.

В ядерной фотоэмульсии, облученной на ускорителе протонами 200 Гэв, обнаружено взаимодействие типа (2+0+2I)p с явно выраженным двухструйным рождением релятивистских частиц. Рассматриваются различные интерпретации этого события. Микрофотография события, по всей вероятности, наглядно демонстрирует следствие "жесткого" адрон-адронного столкновения, когда взаимодействуют кварки сталкивающихся адронов, что ведет, в частности к образованию струи (из 6 частиц) под большим углом относительно направления движения первичной, с суммарным поперечным импульсом ~ 3 Гэв/с.

Ереванский физический институт
Ереван 1977

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A (2 + 0 + 21)p type interaction with evidently expressed two-jet production of relativistic particles is observed in nuclear photoemulsion exposed to 200 GeV proton beam. Various interpretations of this event are considered. The event microphotography shows clearly the consequences of a hard hadron - hadron collision when the interaction between the quarks of colliding hadrons resulted in a jet (6-particle) production under large angle with respect to the primary particle direction with a total transverse momentum $\sim$3 GeV/c.

Yerevan Physics Institute
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Recently there is a great interest to the multiple particle production processes in high energy hadron collisions with nuclei. The experimental results on the general characteristics of proton-nucleus interaction obtained with the help of nuclear emulsion exposed to 200 GeV protons at Fermilab as well as their comparison with various theoretical models are given in the works [1 - 7].

A part of the nuclear emulsion stack exposed to 200 GeV protons has been kindly given to us by the Alma-Ata-Leningrad-Moscow-Tashkent (AALMT) collaboration.

Among a great number of nuclear interactions observed by us following along the tracks of beam particles a (2+0+21) type event with clearly expressed two-jet production of particles has attracted our attention. The microphotography of the event is given in Fig.1. Since the presence of a jet under a large angle is visually observable feature of this event the micro - photography is taken focusing the particle tracks of this cone. In thin sideral jet under a mean angle $\sim 7^{o}$ with respect to the primary particle there are six (NN12 ÷ 17, see the Table) particles. In the central jet which is much nearer to the primary direction there are 12 (NN1 ÷ 11,20) particles. The most striking feature of the event is the large space between the jets.

The angular distribution of the charged particles presented in the form of azimuthal-rapidity plot is shown in Fig.2. Such a form of presentation of the data seems to be suitable since it gives a possibility to characterize more completely the angular distribution of the secondary particles in individual interactions and demonstrate the observed azimuthal angle and quasirapidity grouping of particles. The values of the quasirapidity $y = \ln tg\,\theta/2$ are given by the magnitudes of the radius. As it is seen from Fig.2 the sideral jet particles again show a grouping as in the case of the microphotography while the central jet particles are distributed in a wide interval of azimuthal angles in a semisphere opposite to the one containing the sideral jet. It is worthy to note among them the presence of a narrow pair of hadrons (particles 8 and 9) around which again some particles are grouped.

Naturally, it was of interest to study this interaction as much as possible in order to make clear are there other characteristic features allowing to obtain additional information on the process resulting in such an angular distribution of particles. Besides the angular measurements we have a) examined all the particle tracks up to the interaction point or the stack boundary, b) estimated the momenta of secondary particles using the multiple scattering measurements, c) measured the relative ionization of the particles the momenta of which allowed to identify heavier particles among pions, d) examined the regions of the both jets and the space between them up to distances 3 cm from the interaction point looking for electron-positron pairs. Let us note that only two pairs have been revealed in the region of the central jet.

The charcteristics of the charged secondary particles are given in the Table. In the total 165 cm of secondary tracks have been examined, three secondary interactions and two events of large angle scattering (breaks) have been found. The average transverse momentum has appeared to be equal to (365 ± 16) MeV/c according to all measurements excluding the particle №6 having a transverse momentum $\geqslant 1.5$ GeV/c.

As the analysis carried out by us shows it is difficult to explain the observed jet of six particles having very close polar and azimuthal localization and produced under such large angle with respect to the primary particle direction by angular distribution fluctuation. About 800 events with $n_s \geqslant 7$ have been examined in order to find out grouping with particle number $n \geqslant 3$ at polar angles $\theta \geqslant 5^{\circ}$ and azimuthal angle interval $\Delta\psi \leqslant 30^{\circ}$ as in the case of the observed event. Six events have been found in which three particles in each event satisfied to the above mentioned conditions. Assuming that in the event under consideration it is also produced a three particle localized group while the remained three particles occasionally appear in the same angular interval for an isotropic azimuthal angle distribution one obtains an upper limit for such a probability 10^{-5}.

One cannot explain the production of the sideral jet by a secondary interaction inside the target-nucleus for the following reasons. Firstly, the interaction has taken place in a light nucleus slightly exciting it, secondly, the measured and calculated momenta of the particles of the sideral jet differ each from other by an order. The calculated momenta have been obtained assuming that all the six particles of the sideral jet are produced in a secondary interaction and the commonly accepted mean secondary particle transverse momentum equal to 350 MeV/c. In these assumptions for the transverse momentum of the particle giving the secondary interaction inside the target-nucleus we have obtained a value $\geqslant$ 20 GeV/c. According to the experimental data the particle producing the sideral jet should have a transversal momentum $\gg$ 1.5GeV/c. In both cases the sign of inequality is conditioned by the absence of experimental data on the contribution of neutral particles.

In order to explain the observed charged particle angular correlation one must, most probably, take into account the experimental fact that in the interaction there is a particle with large transversal momentum (particle N.6). Naturally in such interactions the remained particles must be produced with such parameters which provide the momentum balance of all the event. As the results of the work [8,9] show in the average the compensation is provided not by a single particle having a large and opposite transverse momentum but by a group particles. The experimental data showing that the number of the particles emitted into the azimuthal hemisphere opposite to the detected particle with large transverse momentum increases is in favour of such a fact. The observed event is a result of such an interaction. It is of interest to note that in our case the large transverse momentum is compensated not by a group of charged particles but by two groups, the particles of one group (sideral jet) being localized in a small rapidity and azimuthal angle intervals.

Let us note that the total missing transverse momentum of charged particles is ~ 1 GeV/c and it is directed toward the sideral jet. Most probably this fact shows a surplus of neutral particles in this region and allows to increase the lower limit of the total transverse momentum of the sideral jet up to the value 2.7 GeV/c which in its turn shows that more than 10% of the incident proton momentum is transferred to this jet.

The study of the characteristics of the interactions with secondary particles having large transverse momenta is of great interest. However, due to the small cross section for the production of such particles (though at $p_t \geqslant 5$ GeV/c it is some order larger than one expects from the exstrapolation of the experimental data at small p_t) the study of the characteristics of the appropriate interactions is hardly realizable by the nuclear emulsion method. The possibility to separate visually the events by the presence of particle grouping, in particular, under large angles makes much easier this problem. In this connection let us note that the experimental data obtained studying the interaction of 200 GeV protons with beryllium nuclei [10] show a large production cross section for jets with large transverse momentum compared with the production cross section of single particles with the same p_t. This is in agreement with the theoretical prodictions of the models [11-13] in which the hadrons as well as the jets with large transverse momenta are produced in an elementary act of hard collision of quarks of interacting hadrons with subsequent "cascading" of quarks into hadrons.

For the average value of the transverse momentum of the particles of the jet with large transverse momentum (with respect to their center of gravity) we have obtained about 70MeV/c.

The authors are very grateful to the Nuclear Physics Section of Academy of Science of USSR, to the management and collaborator of FNAL for the support during the experiment, to AALMT collaboration for the assignment of a part of the irradiated emulsion stack to us. They also thank A.P.Garyaka, S.G.Matinian, M.I.Tretyakova, N.L.Ter-Isaakian for discussion and Kh.P.Babajan and collaborators of our laboratory for help during this work.

Table

N.	θ degree	ψ degree	ℓ cm	p GeV/c	p_t MeV/c	θ^* degree	comments
1	0.50	122.64	8.1	35.0 ± 5.2	350	10.1	inter(11+1+14)p
2	2.33	384.91	16.2	10.0 ± 0.8	420 ± 34	45.8	
3	2.70	67.60	10.2	7.5 ± 0.7	350 ± 35	72.9	"break" 1.5°
4	2.91	316.40	7.2	6.7 ± 0.7	340 ± 35	56.7	
5	3.00	93.80	13.3	9.4 ± 0.9	492 ± 50	63.6	
6	3.50	287.60	5.1	25	1570	66.0	
7	3.56	35.47	14.1	6.1 ± 0.5	355 ± 29	65.5	
8	3.70	60.80	12.3	6.9 ± 0.6	327 ± 28	81.1	inter(5+1+2)p
9	3.75	59.50	13.0	4.7 ± 0.4	306 ± 26	71.6	
10	4.16	103.30	7.0	6.1 ± 0.7	445 ± 51	76.3	
11	4.41	91.25	7.5	2.7 ± 0.3	208 ± 23	86.9	
12	6.20	192.32	10.2	1.6 ± 0.1	174 ± 11	115.5	
13	6.50	211.20	5.3	3.9 ± 0.3	498 ± 43	102.8	
14	7.00	182.10	1.5	1.1 ± 0.2	134 ± 24	132.5	(7+1+0)p
15	7.30	206.90	5.3	3.9 ± 0.4	495 ± 50	108.0	
16	7.80	193.00	12.7	1.1 ± 0.1	142 ± 12	133.6	
17	8.50	188.90	12.0	3.5 ± 0.4	520 ± 60	116.3	
18	10.30	314.40	1.8	2.2 ± 0.3	392 ± 54	127.8	
19	18.10	43.00	0.5	-	-	153.3	"break" 41°
20	34.42	270.50	0.2	-	-	163.8	
21	36.15	350.00	1.3	1.3 ± 0.2	530 ± 91	164.0	

θ is the polar angle, ψ is the azimuthal angle, ℓ is the examined length, p is the particle momentum, p_t is the transverse momentum, θ^* is the cms polar angle. Comments describe the secondary processes observed examining the length of tracks.

Fig.1

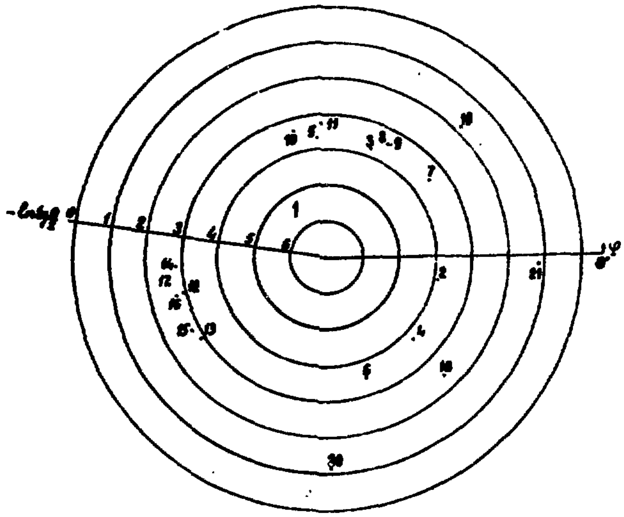

Fig.2

Figure Captions

Fig.1 Microphotography of the event (2 + 0 + 21) p.

Fig.2 Azimuthal-rapidity plot of the event (2+0+21)p.

References

1. Alma-Ata-Leningrad-Moscow-Tashkent collaboration, Preprint FIAN (Lebedev Physical Institute of Academy of Science of USSR), 9, 1974.
2. Alma-Ata-Leningrad-Moscow-Tashkent collaboration, Proc.of XVII Intern.Conf. on High Energy Physics, London 1974,p.793 (A2).
3. Alma-Ata-Leningrad-Moscow-Tashkent collaboration, Preprint FIAN, 171, 1974.
4. P.L.Iden et al., Phys.Rev.Lett. 33, 660, 1974.
5. M.I.Adamovich et al. Preprint FIAN, N.89, 1975.
6. K.G.Gulyamov et al, "Multiple Processes at High Energies" (in Russian) edition of Physical Institute of Academy of Science of Uzbek SSR, Tashkent 1976.
7. S.A.Azimov et al," Multiple Processes at High Energies" (in Russian) edition of Physical Institute of Academy of Science of Uzbek SSR, Tashkent, 1976.
8. S.D.Ellis and R.Thun, Preprint Ref.TH 1874, CERN, 1974.
9. G.Belletini, Proc.of VIII All Union School on Elementary Particle and High Energy Physics, Yerevan, Part I, 591, 1975.
10. C.Bromberg et al, Phys.Rev.Lett., 38, 1447, 1977.
11. S.M. Berman, J.D. Bjorken and J.B.Kogut, Phys.Rev., D4, 3388, 1971.
12. S.D.Ellis and M.B.Kislinger, Phys.Rev. D9, 2029, 1974.
13. R.D.Field and R.P.Feynman, Phys.Rev., D15, 2590, 1970.

The manuscript was received on the 14-th of October, 1977

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(на английском языке)

Ереванский физический институт

Тех.редактор А.С.Абрамян

Заказ 1045 ВФ-03404 Тираж 299

Подписано к печати 7/XII-77г. Формат издания 60 x 84

0,8 уч.-изд.л. 1, 6 п.

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