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THE ANALYSIS OF EVENTS WITH PARTICLE PRODUCTION IN A LIFETIME INTERVAL OF 10^{-13} s FOR INTERACTIONS OF NEGATIVE PIONS WITH NUCLEI AT (50-60) GeV/C

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The observation and analysis of new short-lived particle decays is one of the main tasks of present-day high energy physics. The search for such decays in hadron-hadron interactions has become more popular in the last few years/1-8/. Our works on a search for decays with a lifetime of $\leq 10^{-13}$ sec in interactions of protons and negative pions with nuclei at Serpukhov energies were begun in 1977/9-10/. Theoretical estimates of observation probability for such decays give small values. For example, the charmed particle production cross section for hundreds GeV is of the order of 1 mkb. Results of our works can be found in/11-13/.

In this paper we analyze nine candidates to new particles found among 46551 inelastic interactions of π^--mesons with emulsion nuclei at (50-60) GeV/c. The following questions are discussed:

1. The analysis of decays observed.
2. The analysis of primary stars with short-lived particles.
3. The production cross section of neutral mesons.

1. THE ANALYSIS OF DECAYS OBSERVED

The criteria of a search for, measurements of events and identification of secondaries have been published elsewhere/11-13/. Kinematical characteristics of new particle candidates and their secondaries can be found in the same publications.

In this report we present resulting data on the decays observed up to 150 mkm from primary stars (Table 1). In the table are shown distance from the primary stars to the decay vertex l, schemes of the assumed decay modes, mean effective masses $\overline{M}_{eff}$, Lorentz-factor γ, and lifetime τ of particles under investigation. The mean effective mass was calculated on the assumption of the isotropical angular distribution of a neutral component in the rest frame of decaying particle. The events with the emission of charged K-mesons from the primary star are marked in the comments of this table.

A part of hadrons from the decays can be identified according to the measurement of ionization losses. The symbols of these hadrons are underlined.

The analysis of the decay modes, given in Table 1, has shown that the background for the decays of neutral particles can be

Table 1

N event	ℓ (mkm)	Decay mode	$\overline{M}_{eff}$ (GeV)	γ	$\tau \cdot 10^{-14}$ (sec)	Comment
Neutral decays						
1	12	$(\pi\pi)^{\pm}K^{o}$	2.12	2.15	1.9	
		$(K\pi)^{\pm}\pi^{o}$	2.52			
2	146	$(\pi K)^{\pm}\pi^{o}$	2.32	2.07	23.5	K-meson from primary star
		$(\pi\pi)^{\pm}K^{o}$	2.17			
3.	90	$eK^{+}\nu$	0.60	3.37	8.9	- " - " -
		$ep\nu$	1.03			
4	69	$e\underline{K}^{+}\nu$	0.52	3.46	6.6	
5	45	$eK^{+}\nu$	0.62	5.60	2.7	
		$ep\nu$	1.16			
6	65	$e\underline{p}\nu$	1.15	1.42	15.3	K-meson from primary star
7	127	$(\pi\pi)^{\pm}\pi^{o}$	0.64	4.78	8.9	Background event
		$(\pi p)^{\pm}\pi^{o}$	1.28			
Charged decays						
8	157	$e\underline{\pi}K\nu$	0.82	3.67	14.3	
		$e\underline{\pi}p\nu$	1.25			
9	27	$(\pi\pi)^{\pm}e\nu$	2.34	2.14	4.2	
		$(\pi K)^{\pm}e\nu$	2.40			

initiated by the decays of strange particles and neutron-neutron interactions. For the charged particles, only the decays of strange particles can imitate background events as we have registered semileptonic decay modes.

The determination of search efficiency for the decays of neutral and charged particles has been discussed in detail in ref./13/. For the neutral particles this efficiency is equal to 0.32 ± 0.03, for the charged ones it is close to unity. In the

same paper/13/ the questions of background event estimation are considered in detail. We give here only the expected number of background events. For the hadron modes of neutral decays 1.7 events are expected to be due to strange particle decays (K^{o}, Λ^{o}, $\tilde{\Lambda}^{o}$) and 0.006 events due to the interactions of neutrons from $\pi^{-}N$ collisions with neutrons of emulsion nuclei. For semileptonic modes of these decays only 0.005 events can be strange particle decays. The number of background events for the charged particles, decaying via semileptonic modes, does not exceed $0.3 \cdot 10^{-5}$ events in our sample.

The analysis of the effective masses has shown that the events N6 and 7 can be strange particle decays. The other seven events can be divided into two mass groups. In the first group one can find the events (N1,2,9) having masses close to those of charmed particles. In the second group associated with the decays via semileptonic modes only (events N3,4,5,8), the effective masses for meson decays are rather small and vary from 0.5 to 0.8 GeV. The masses of baryon decays are close to those of strange baryons, but observation probabilities for these modes are negligibly small. The number of strange baryons should be 0.0005, but we observe 4 decays including the background event N6. Besides, there is a strong interdiction by the Cabibbo angle for the decays of charmed baryons via the modes shown in Table 1. For this reason further on we consider only the meson decay modes. Reasonable values of the effective masses for these events can be obtained at emission angles of neutrino from 1^{o} to 5^{o} in the rest frame of decaying particles (see Table 2). The nearness of these values can be interpreted as some evidence for the direction selection of neutrino emission in the semileptonic decays of neutral mesons.

Table 2

N event	Decay mode	M_{eff} (GeV)	Θ_{ν}^{o}
1	$eK^{+}\nu$	1.73	3
2	$eK^{+}\nu$	1.70	1
3	$e\underline{K}^{+}\nu$	1.81	2.5
4	$e(\pi K)^{\pm}\nu$	1.81	5

2. THE ANALYSIS OF PRIMARY INTERACTIONS

We have carried out the analysis of eight primary stars, where the candidates were observed. With this aim we have mea-

Table 3

N event	E_1^*	$(\Sigma E_i^*)_{ch}$	ΣE^*	K_{neut}	K_{ch}	K_1	Characteristic of primary star	Comment
1.	3.13	0.90 ± 0.11	4.03	0.58	0.09	0.32	3 + 1 + 3	
2.	3.08	5.03 ± 0.22	8.11	0.17	0.52	0.32	7 + 1 + 7	K-meson from primary star
3.	1.96	6.57 ± 0.70	8.53	0.12	0.67	0.20	11 + 9 + 11	- " - " - " -
4.	4.50	5.07 ± 0.20	9.57	0.02	0.52	0.46	4 + 1 + 12	
5.	1.86	5.73 ± 0.37	7.59	0.22	0.59	0.19	15 + 7 + 8	
6.	2.22	10.55 ± 0.26	12.77				11 + 23 + 16	K-meson from primary star
7.	1.95	6.57 ± 0.31	8.52	0.12	0.68	0.20	6 + 4 + 11	

sured the momenta of secondaries with $\beta > 0.7$ using the multiscattering Coulomb method. When such measurements were impossible, the momentum was estimated by the emission angle and mean perpendicular momentum determined from the measured tracks. The particle with $p\beta < 1.5$ GeV/c were identified by ionization losses. The production of charged K-mesons was observed for three primary stars. Besides, the search for other decays was made to 1 cm in the directions with an angle cone of $\leq 10^o$ and 1 mm in other directions, but nothing was found.

In Table 3 are shown the summary energies for charged particle production, $(\Sigma E_i^*)_{ch}$, and for the creation of new particles, E_1^*, in the rest frame of $\pi^- N$ interactions. The total energy of these collisions is equal to 9.73 GeV. In the table are presented the multiplicity characteristics of stars for produced particles and particles from the desintegration of target-nucleus $n_b + n_g + n_s$. The fraction of the total energy (inelasticities) consumed for the production of new (K_1), charged (K_{ch}) and neutral (K_{neut}) particles are also shown in this table.

According to the analysis of the summary energy $\Sigma E^* = E_1^* + (\Sigma E_i^*)_{ch}$, one can see that in the case of event N1 there is a sufficient energy to produce not only neutral pions but also particles with a mass of ~2 GeV. Thus, this event, together with the three events of singly charged K-meson production in the primary star, can be interpreted as events of associated charmed particle production. However, it is known/14/ that the production of charged K-mesons in ordinary interactions at our energies is observed in one event from ten. For our eight events one is expected due to the production of such K-mesons. Thus, one background event is expected from three observed. This is most probable for event N6, as in this event the production of another strange particle (Λ^o) has been already observed and the disintegration of target-nucleus is very large, i.e., a large part of the energy is consumed for pion production. The mean inelasticities for the remaining six events with candidates to new particles are equal to $\langle K_{neut.} \rangle = 0.20 \pm 0.08$, $\langle K_{ch.} \rangle = 0.51 \pm 0.09$ and $\langle K_1 \rangle = 0.28 \pm 0.05$. These values for events without the production of such particles are $\langle K_{neut.} \rangle = 0.39 \pm 0.02$ and $\langle K_{ch.} \rangle = 0.61 \pm 0.02$/15/.

3. PRODUCTION CROSS SECTION FOR NEUTRAL MESONS

A detailed description of the production cross section for neutral meson has been published/13/. In this paper this cross section is estimated as (4+3) mkb according to 4 events observed up to 100 mkm from 46551 inelastic interactions.

As the search for events was bounded to 100 mkm, this value should be corrected to infinite observation length. In our case the mean free path up to the decay of neutral mesons is equal to 360 mkm (the experimental value of $\bar{\gamma} = 3.33$ and the mean lifetime of D^o-mesons $\tau_{D^o} = 4 \cdot 10^{-13}$ sec /16/ are used for calculation).

Thus, the total number of decays should be

$$N = \frac{N_{cand}}{\varepsilon(1 - e^{-\ell/\langle\lambda\rangle})}, \qquad (1)$$

with N_{cand} the number of observed decays up to 1 mkm, ε the scanning efficiency, $\langle\lambda\rangle$ the mean free path up to the decay. Substituting $N_{cand} = 4$, $\varepsilon = 0.32 \pm 0.03$ and $\langle\lambda\rangle = 360$ mkm, we obtain N = 16.

Hence, the production cross section for neutral mesons is estimated to be ~17 mkb.

CONCLUSION

1. Three events of six candidates to charmed particle can be interpreted as events of associative charmed particle production.

2. Some evidence for the direction selection for neutrino emission from the semileptonic decay of neutral mesons is observed.

3. The production cross section per nucleon for neutral mesons in the interactions of negative pions with nuclei at (50-60) GeV/c is estimated to be ~17 mkb.

REFERENCES

1. Alibran P. et al. Phys.Lett., 1979, B74, p.134.
2. Hanse T. et al. Ibid., p.139.
3. Bosetti P. et al. Ibid., p.143.
4. Brown K. et al. Phys.Rev.Lett., 1979, 43, p.410.
5. Aleev A.N. et al. JINR, P1-81-693, Dubna, 1981.
6. Aleev A.N. et al. JINR, D1-82-895, Dubna, 1982.
7. Aguilar-Benitez M. et al. Phys.Lett., 1983, B123, p.98.
8. Aguilar-Benitez M. et al. Ibid., p.103.
9. Bannik B.P. et al. Pis'ma to JETP, 1977, 25, p.86.
10. Bannik B.P. et al. Pis'ma to JETP, 1977, 26, p.399.
11. Tolstov K.D. et al. Pis'ma to JETP, 1981, 38, p.243.

12. Tolstov K.D., Khushvaktova A.A., Shabratova G.S. JINR, P1-13037, Dubna, 1980.
13. Ali-Mussa N. et al. JINR, D1-82-715, Dubna, 1982.
14. Grishin V.G. UFN, 1979, 127, p.51.
15. Voinov V.G. et al. Yad.Fiz., 1977, 26, p.1237.
16. Kalmus G. XXI Int.Conf. on High Energy Phys., 1982, p.C3-431.

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Анализ событий с рождением частиц в интервале времен жизни 10^{-13}с во взаимодействиях отрицательных пионов с ядрами при импульсах /50-60/ ГэВ/с

Проанализировано 9 кандидатов в новые частицы, найденных при просмотре 46551 неупругого взаимодействия отрицательных пионов с ядрами эмульсии при импульсах /50-60/ ГэВ/с. Получено указание на возможную выделенность направления вылета нейтрино в полулептонных распадах нейтральных мезонов. Проведен анализ первичных событий с рождением этих частиц. Три события могут быть интерпретированы как события ассоциативного рождения очарованных частиц. Сечение рождения нейтральных мезонов оценивается равным 17 мкб.

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The Analysis of Events with Particle Production in the Lifetime Interval of 10^{-13}s for Interactions of Negative Pions with Nuclei at /50-60/ GeV/c

Nine candidates to new short-lived particles have been found from 46551 inelastic interactions of negative pions with photoemulsion nuclei at /50-60/ GeV/c. Some evidence for the direction selection for neutrino emission from the semileptonic decay of neutral mesons is observed. The analysis of primary interactions with the production of such candidates has been carried out. Three events can be interpreted as events of the associative production of charmed particles. The production cross section of neutral mesons is evaluated to be 17 mkb.

The investigation has been performed at the Laboratory of High Energies, JINR.

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