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NIKHEF-H/85-5

OBSERVATION OF HADRONICALLY PRODUCED CHARMED F-MESONS

The ACCMOR Collaboration,
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Contribution to the International Conference on Hadron Spectroscopy,
College Park, Maryland
April 20 - 22, 1985
Presented by H. Tiecke

ABSTRACT:

Using the NA11 spectrometer, together with a telescope of high resolution microstrip detectors, we have measured a total of twelve charmed F-meson decays into $KK\pi$ on an estimated background of four. The average mass is (1972 ± 2) MeV, the lifetime $(3.1 \pm_{0.8}^{1.2}) \times 10^{-13}$ sec.

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1. INTRODUCTION

In this paper, we complete the result published on the measurement of the lifetime of the charmed F-meson from NA11 experiment by the ACCMOR collaboration [1], by adding the results obtained from data taken with 100 GeV incident beam. In addition, some preliminary results are shown from the NA32 experiment, which is carried out by the same collaboration. In this experiment, interaction trigger data are collected and use is made of an active silicon target.

2. THE NA11 EXPERIMENT AND RESULTS

The experiment was performed at the CERN SPS using the ACCMOR spectrometer [1] in an unseparated hadron beam. Two differential Cerenkov counters are used for the identification of the beam particles. The beam is focussed on a Be target 20 mm long, 0.5 mm high and 20 mm wide. The spectrometer consists of two arms with a total of 48 drift chamber planes. The particle identification is of great importance in recognizing the charmed particles. Three multicellular Cerenkov counters enable us to have a very clean π -K separation in a large momentum window. The reconstruction of charm decays is made possible by the use of silicon microstrip detectors (VMSD). Six are used to define the beam direction; another six detectors, arranged in three pairs with strips at an angle of $\pm 14^\circ$ to the horizontal plane measure the charged particles produced in the reaction. Details on the performance of the detectors can be found elsewhere [2].

In the NA11 experiment two different trigger schemes have been used:

- a) the single electron trigger, to select interactions where a prompt electron is produced [3],
- b) the inclusive ϕ trigger, which demands the production of two oppositely charged kaon candidates. These are recognized with the last two Cerenkov counters followed by two scintillator arrays. The momenta of the kaons are reconstructed online and required to lie between the π and K threshold from the two Cerenkovs; subsequently the invariant mass of the K pair is calculated and required to be smaller than 1.15 GeV [4].

Data are collected at three different beam energies. The single electron trigger data and about 20% of the ϕ trigger data are taken with 200 GeV incident beam momentum. The analysis of these data has been published¹; they contain a total of six events which were interpreted as the $KK\pi$ decay of the F-meson. We have applied the same analysis to inclusive ϕ trigger data taken at -100/+120 GeV. Table 1 gives a summary of the different data samples.

A complete description of the data analysis is given in Ref.1. The main features are the following:

- the complete event analysis is restricted to those which have an invariant $KK\pi$ mass in the interval from 1.8-2.1 GeV.
- the $KK\pi$ vertex and the primary vertex should be separated by at least three standard deviations. The minimum allowed separation is 2 mm.
- the two kaons and the π -meson have to miss the primary vertex by at least 1σ for the closest and at least 3σ for the other tracks.
- the $KK\pi$ momentum sum vector should point to the primary vertex with a probability $> 1\%$.

These selection criteria leave us with a total of 35 events distributed over the different data samples as indicated in Table 1.

Figure 1 shows the display of one of the F-candidates, out of the -100 GeV data sample.

Figure 2a gives the $KK\pi$ mass spectrum for the selected data sample; clear signals are observed at the D and F mass. The shoulder at the low side of the D-mass is still under investigation. It could be caused by an $F \rightarrow KK\pi$ decay with a missing π^0 . Figure 2b shows the mass resolution for the individual events. Tables 2-4 summarize several quantities from the selected events.

For the events in the mass interval 1.95-1.99 GeV we find an average value for the mass $m = 1972 \pm 2$ MeV. The presence of one or more strange particles is further confirmation that the decay originates from a charmed particle. We therefore show events which have a well-identified additional strange particle hatched in Fig. 2a.

For the average lifetime of the 12 events in the mass range $1.95 < m(KK\pi) < 1.99$ GeV we obtain $(3.1 \pm_{0.8}^{1.2}) \cdot 10^{-13}$ s. Due to the ambiguity between the K and p identification, three out of those twelve events can be interpreted as Λ_c candidates. For the lifetime of the D-meson candidates in the mass range $1850 < m(KK\pi) < 1890$ MeV we obtain $(9.5 \pm_{2.4}^{3.9}) \cdot 10^{-13}$ s. All quoted errors are statistical only.

3. THE NA32 EXPERIMENT

A limitation of the NA11 experiment was the 20 mm long Be target. Many observed charm decays occurred inside the target, which can cause confusion with secondary interactions. Therefore for the NA32 experiment a new target was built out of fourteen planes of silicon strip detectors (active area $1 \times 20 \text{ mm}^2$; each plane is $280 \mu\text{m}$ thick, has 48 strips 20 mm long and $20 \mu\text{m}$ pitch; total target length is 7 mm), which enables us to recognize the interaction point very precisely, and also the presence of secondary interactions or decays inside the target. Figure 3 shows the NA32 target region in detail. A set of seven microstrip detectors analogous to the NA11 set-up complete the vertex telescope. The functioning of the target can be best illustrated with a display of an interaction as given in Fig. 4a, which gives a digitization of the ionization loss of the charged particles traversing the detectors. The ionization loss of one minimum ionizing particle is normalized to 10, which can be spread over two adjacent strips. The beam particle enters from the left. The interaction point is marked by a very large energy deposit and some high ionizing particles produced at big angles. The full lines indicate that only three particles are produced forward. Figure 4b shows the analysis of the same events using the VMSSD and drift chamber information. A total of seven secondary particles are reconstructed. A close study of the event reveals the decay of an F -meson (tracks 2,7,8) and the decay of a neutral particle (tracks 3,4), such that the observed tracks in the target are #6,5 and the F itself.

If the primary multiplicity becomes too high however, the target does not give much valuable information, so that we have to rely only on the vertex telescope for the reconstruction of charm decays.

During 1984 we have collected a total of 38 million interaction triggers. About five million of these triggers were taken with an incident K^- beam. We have analysed only 60% of the K^- data applying the same criteria as in the NA11 experiment. A preliminary result shows that 14 events remain, with a mass spectrum as given in Fig. 5; those events for which the decay is positively confirmed using the information in the active target are indicated hatched. The presence of the F -meson is clearly confirmed, and in addition two Cabibbo-suppressed D -decays are observed. Three out of the seven F -candidates have a KK effective mass within 10 MeV of the ϕ mass. Also three out of seven F -candidates are produced with $x_F > 0.5$, indicating a diffractive type of F production when a K^- beam is used. We have to wait until all the data have been analysed before more quantitative statements can be made.

REFERENCES

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Table captions

Table 1 : Data samples.

Table 2 : Properties of events from the 200 GeV data. Events indicated with A originate from the single e-trigger data, the remaining ones from the inclusive ϕ -trigger. Events 1-11 have negative incident beam; events 12-14 incident positive beam. The values given for x_F and $\tau(\tau_c)$ are assuming a $KK\pi$ decay mode. If a particle cannot be identified (for example, not traversing the Cerenkov counters) the identification probability for π , K and p is indicated by - ; if no light is found and no light expected for K and p, the identification probability for both K and p is 1.0.

Table 3 : Same as Table 2 for -100 GeV data sample. Incident beam particle indicated in column 2.

Table 4 : Same as Table 3 for +120 GeV data sample.

Table 1

	single e-trigger	inclusive ϕ -trigger	
beam momentum	-200 GeV	± 200 GeV	-100/+120 GeV
range π -K separation	6.5-44 GeV	6.5-44 GeV	3.5-22 GeV
# triggers	$4.4 \cdot 10^6$	$1.2 \cdot 10^6$	$6.0 \cdot 10^6$
# events with $1.8 < m(KK\pi) < 2.1$ GeV	$1.9 \cdot 10^4$	$0.3 \cdot 10^6$	$2.0 \cdot 10^6$
after VMSSD analysis	6	8	21

Table 2
200 GeV

Event	Momen- ta	Particle Identification Probabilities			M(KK π)	M(KK)	M(pK π)	x_F	$\tau(\times 10^{13})$	$\tau_C(\times 10^{13})$	
		π	K	p							
for KK π interpretation											
1.	A	+30.3	0	0.17	0	1874 $\pm$ 5	1016 $\pm$ 2	0.59	6.5 $\pm$ 0.3	5.3 $\pm$ 0.3	
		-32.6	0	0.13	0						
		-56.6	0.20	0.18	0						
2.	A	+12.8	0.01	1.0	1.0	1969 $\pm$ 17	1234 $\pm$ 4	2222 $\pm$ 16	0.32	6.9 $\pm$ 0.3	4.8 $\pm$ 0.3
		-46.6	0	0.15	0.04						
		-18.0	-	-	-						
3.	A	-19.5	0	0.34	0.68	1857 $\pm$ 10	1220 $\pm$ 7	2171 $\pm$ 9	0.22	3.1 $\pm$ 0.3	1.2 $\pm$ 0.3
		+25.6	0	0.15	0.68						
		+5.8	-	-	-						
4.	A	-3.6	0.37	1.0	1.0	1984 $\pm$ 6	1627 $\pm$ 5	2187 $\pm$ 6	0.11	6.8 $\pm$ 0.6	2.0 $\pm$ 0.6
		+26.7	0.02	1.0	1.0						
		+5.1	-	-	-						
5.	A	+19.2	0.01	0.03	0.36	1969 $\pm$ 5	1500 $\pm$ 4	2291 $\pm$ 5	0.18	5.1 $\pm$ 0.3	3.5 $\pm$ 0.3
		-21.0	0	0.05	0.38						
		-4.9	0.79	0	0						
Wrong sig- 6. nature A electron	A	-19.5	0	1.0	1.0	1970 $\pm$ 5	1279 $\pm$ 4	2418 $\pm$ 5	0.21	7.6 $\pm$ 0.4	1.1 $\pm$ 0.4
		+16.5	0	1.0	1.0						
		+15.0	0.16	0	0						
7.	B	-20.2	0	0.57	0.55	1869 $\pm$ 7	1023 $\pm$ 2	2215 $\pm$ 6	0.17	25.5 $\pm$ 0.3	22.9 $\pm$ 0.3
		+19.3	0	0.83	0.14						
		+3.3	-	-	-						
8.	B	-22.8	0	0.63	0.28	1874 $\pm$ 15	1017 $\pm$ 2	2326 $\pm$ 14	0.23	28.0 $\pm$ 0.3	26.3 $\pm$ 0.3
		+17.8	0	0.88	0.17						
		+12.6	-	-	-						
9.	B	-11.8	0.01	0.94	0	1970 $\pm$ 5	1011 $\pm$ 1	2423 $\pm$ 5	0.22	4.8 $\pm$ 0.3	2.8 $\pm$ 0.3
		+17.3	0	0.09	0.09						
		+25.0	0.44	0	0						
10.	B	+17.1	0	0.68	0.13	1969 $\pm$ 6	1020 $\pm$ 2	2289 $\pm$ 5	0.14	6.0 $\pm$ 0.4	0.8 $\pm$ 0.4
		-17.8	0	0.57	1.0						
		-3.2	0.37	0.20	0.20						
11.	B	+15.0	0.01	1.0	1.0	1955 $\pm$ 12	1024 $\pm$ 2	2288 $\pm$ 11	0.15	3.0 $\pm$ 0.5	0.4 $\pm$ 0.5
		-18.7	0	0.25	1.0						
		-7.8	-	-	-						
12.	B	-16.3	0	0.19	0	1861 $\pm$ 32	1019 $\pm$ 2	0.31	2.5 $\pm$ 0.5	0.5 $\pm$ 0.5	
		+10.7	0	0.81	0						
		+40.1	-	-	-						
13.	B	-29.5	0	0.98	0	1830 $\pm$ 5	1020 $\pm$ 1	0.38	2.5 $\pm$ 0.6	0.2 $\pm$ 0.6	
		+37.6	0	0.90	0						
		+14.3	0.08	0	0						
14.	B	-19.0	0	0.90	0.10	1838 $\pm$ 16	1017 $\pm$ 2	2285 $\pm$ 17	0.23	10.9 $\pm$ 1.2	5.0 $\pm$ 1.2
		+18.0	0	1.0	1.0						
		+15.2	-	-	-						

Table 3
-100 GeV
 $\Delta Z_{\min} = 2 \text{ mm}$

Event	beam	mom. [GeV]	Identification			M(KK π) (KK)	M(pK π)	τ $\bullet 10^{13} \text{ s}$	τ_c	Δz (mm)
			π	K	p					
15	π	+12.9 - 9.8 - 5.1	0 0 -	0.9 1 -	0 1 -	1831 $\pm$ 12 (1012)	2271 $\pm$ 15	5.2 $\pm$ 0.9	0.66	2.3
16	π	+19.2 -20.7 -22.7	0 0 -	0.15 0.7 -	0 0 -	1854 $\pm$ 17 (1030)		2.6 $\pm$ 0.7	0.6	2.6
17	π	+ 9.8 - 7.6 -22.7	0 0 0.9	1 1 0.1	1 1 0	1870 $\pm$ 4 (1021)	2612 $\pm$ 5	9.6 $\pm$ 0.5	6.5	6.1
18	π	-10.7 +13.4 + 4.4	0 0 -	0.9 0.5 -	0.2 0 -	1872 $\pm$ 10 (1000)		27.5 $\pm$ 2.1	21.7	12.5
19	π	-11.6 +14.9 +16.1	0 0 -	0.7 0.9 -	1.0 0 -	1922 $\pm$ 19 (1035)		9.2 $\pm$ 0.6	6.2	6.1
20	π	- 7.1 +10.5 +46.2	0 0 0.1	1.0 0.8 0.2	1.0 0 0.5	2008 $\pm$ 5 (1014)		7.8 $\pm$ 2.1	1.7	7.5
21	π	+10.2 -17.0 - 6.4	0 0 -	0.7 0.3 -	0 0 -	1845 $\pm$ 12 (1051)		7.6 $\pm$ 0.3	0.7	4.1
22	π	+18.3 -10.9 -15.0	0 0 1	0.2 0.7 0.1	0 0 0	1875 $\pm$ 6 (1031)		6.3 $\pm$ 2.1	0.1	4.4
23	π	- 6.1 + 9.5 +38.5	0 0 0.1	1.0 1.0 0.3	1.0 1.0 0	1980 $\pm$ 5 (1021)	2745 $\pm$ 6	3.2 $\pm$ 0.7	0.7	2.6
24	π	+20.9 -17.5 - 9.7	0 0 -	0.2 0.7 -	0 0 -	1873 $\pm$ 12 (1017)		10.6 $\pm$ 0.4	8.0	8.2
25	K $^-$	+ 6.1 - 8.7 -12.0	0 0 -	1.0 1.0 -	1.0 1.0 -	1842 $\pm$ 16 (1006)	2314 $\pm$ 17	5.9 $\pm$ 1.1	1.4	2.6

Table 3 (ctd.)

Event	beam	mom. [GeV]	Identification			M(KK π) (KK)	M(pK π)	τ $\bullet 10^{13}s$	τ_C	Δz (mm)
			π	K	p					
26	K $^-$	-17.4	0	0.5	0	1874 $\pm$ 4 (1387)	2860 $\pm$ 6	12.7 $\pm$ 0.9	8.5	6.1
		+ 4.0	0.1	1.0	1.0					
		+ 8.6	1	-	-					
27	K $^-$	- 5.4	0	1.0	1.0	1885 $\pm$ 18 (1020)	2310 $\pm$ 19	12.3 $\pm$ 0.8	6.8	4.5
		+ 8.2	0	1.0	1.0					
		+ 9.4	-	-	-					
28	K $^-$	+12.9	0	1	0	1968 $\pm$ 5 (1026)		6.4 $\pm$ 0.7	3.9	5.2
		-16.2	0	1	0					
		-24.6	1	0	0					
29	π	+10.0	0	0.9	1.0	1965 $\pm$ 11 (1085)		16.9 $\pm$ 5.9	12.7	7.0
		-12.5	0	0.8	0					
		- 4.6	-	-	-					

Table 4

+120 GeV

$\Delta Z_{min} = 2$ mm

30	?	+ 7.5	0	1.0	1.0	1999 $\pm$ 5 (1013)	2881 $\pm$ 17	6.5 $\pm$ 1.1	3.4	5.7
		- 8.6	0	1.0	1.0					
		-42.5	0.5	0.4	-					
31	p	+ 7.4	0	1.0	1.0	2026 $\pm$ 20 (1020)	2426 $\pm$ 20	12.2 $\pm$ 1.4	5.7	4.4
		- 8.7	0	1.0	1.0					
		- 8.3	-	-	-					
32	π	-12.6	0	0.8	1.0	1970 $\pm$ 5 (1023)	3054 $\pm$ 9	11.0 $\pm$ 2.2	5.6	13.2
		+ 9.2	0	0.5	0.5					
		+57.2	0.2	0	0					
33	π	+ 8.9	0	1.0	1.0	1973 $\pm$ 4 (1058)	2624 $\pm$ 6	8.6 $\pm$ 1.7	4.4	6.5
		-10.6	0	1.0	1.0					
		-30.4	0.8	-	-					
34	p	- 6.2	0.1	1.0	1.0	1932 $\pm$ 15 (1010)	2398 $\pm$ 20	8.0 $\pm$ 1.3	2.5	2.9
		+ 7.5	0	1.0	1.0					
		+10.0	-	-	-					
35	p	- 7.0	0	1.0	1.0	1925 $\pm$ 14 (1022)	2246 $\pm$ 13	11.3 $\pm$ 2.6	4.8	3.6
		+ 9.5	0	1.0	1.0					
		+ 3.3	-	-	-					

Figure captions

- Fig. 1 a) Computer display of an $F \rightarrow KK\pi$ decay. The full lines are tracks reconstructed in VMSDs and drift chambers. Not shown is an additional K^0 which decays behind the VMSDs.
 b) Enlarged view of vertex region.
- Fig. 2 a) $KK\pi$ mass spectrum for VMSD selected events. No distinction is made for the energy and identity of incident beam particle. The hatched events have a well-identified additional strange particle.
 b) The $KK\pi$ mass value is plotted with the mass resolution for each event.
- Fig. 3 Layout of NA32 target area.
- Fig. 4 a) Display of interaction as seen in the active target.
 b) Display of same event as a) as reconstructed in VMSD + drift chambers. The position of the interaction point, the F -decay and neutral particle decay are indicated.
- Fig. 5 $KK\pi$ mass spectrum for events where $KK\pi$ form a clear secondary vertex. For hatched events the secondary vertex is also confirmed in the active target.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5