Antineutrino production of charged charmed vector mesons

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The yield of charmed D^{*-} mesons, which amounts to $5.5 \pm 2.2\%$ of all $\tilde{\nu}_\mu N$ interactions of the charged current, is measured in an antineutrino beam with an average energy of 35 GeV.

In our preceding experiment[1] we have measured the cross section for the production of D^{*-} mesons in $\tilde{\nu}_\mu N$ interactions and we concluded that the vector D mesons saturate to a considerable degree the cross section for the production of charm in an antineutrino beam.[2)] In our experiment[1] we detected the decays $D^{*-} \to \pi^- \tilde{D}^0$ by the "semi-inclusive" method which is based on several model-based assumptions. The new data on the relative probabilities for the decay of D^0 mesons,[3] which have been published since then, permit such a measurement to be carried out by a more direct and reliable method.

The data which were analyzed were obtained in an antineutrino-bombarded FNAL 15-foot heavy neon-hydrogen bubble chamber. Approximately 6400 $\tilde{\nu}_\mu N$ interactions of the charged current with an average energy of 35 GeV were detected in the energy interval of 10–200 GeV (the data are described in greater detail in Ref. 4).

We studied the reaction $\tilde{\nu}_\mu N \to \mu^+ D^{*-} X$ with a subsequent decay $D^{*-} \to \pi^- \tilde{D}^0$. Since the lifetime of D^0 is too short to allow the range of the particles to be observed in the bubble chamber, the search for the decays $\tilde{D}^0 \to K^+\pi^-, K^+\pi^-\pi^+\pi^-$, and $K^0\pi^+\pi^-$ was carried out by analyzing the secondary particles. In selecting the candidate combinations we stipulated that the mass of the system should differ from the mass of D^0 (1865 MeV) by no more than 1.5 standard deviations. The standard deviation, which was calculated independently for each system by transferring the measuring momentum errors and the angles of emission of all particles, is ~ 50 MeV on the average. In $K^+\pi^-$ and $K^+\pi^-\pi^+\pi^-$ systems the kaon mass is arbitrarily attributed to charged tracks which have not been identified as protons or positrons. To suppress the combinatorial background in the decay $\tilde{D}^0 \to K^+\pi^-\pi^+\pi^-$, we also introduce the cutoff $\cos\theta_K > 0.4$ for the angle of emission of K^+ in the rest frame of $\tilde{D}^0$ (relative to the direction of motion of $\tilde{D}^0$); as a result of the isotropy of the decay kaons, the acceptance of this cutoff is 30%.

In the decay $D^{*-} \to \pi^- \tilde{D}^0$ the energy release is known to amount to only ~ 6 MeV. In the events with $\tilde{D}^0$ decay candidates, we additionally examine the negative

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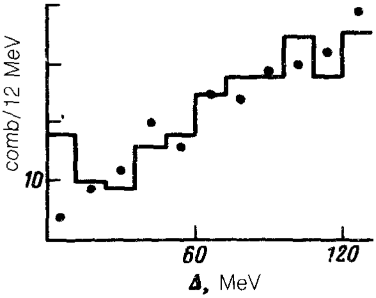

FIG. 1. Distributions in the variables Δ^- (solid line) and Δ^+ (points) defined in the text.

pions and construct a distribution in the variable

$$\Delta^- = m(X\pi^-) - m(X) - m(\pi),$$

which corresponds to the energy release (Fig. 1). In the region $\Delta^- < 12$ MeV we see a cluster to which 18 combinations (16 events) contribute. The cluster width agrees well with the width of the signal from $D^* \to \pi^- \widetilde{D}^0$, which we expect to see under the conditions of our experiment.[3)] In the background distribution in the variable $\Delta^+ = m(X\pi^+) - m(X) - m(\pi)$ (Fig. 1) only four combinations (three events) contribute to the region $\Delta^+ < 12$ MeV.

The distributions in the $\widetilde{D}^0$ decay channels for the combinations with $\Delta < 12$ MeV are given in Table I. The relation between the various channels is in agreement with the relation between the relative decay probabilities if the efficiency of the detection of K^0 ($\sim 25\%$; see Ref. 4) is taken into account.[3]

The mean values of the scaling variables for the events with $\Delta^- < 12$ MeV ($\langle x_B \rangle = 0.12 \pm 0.08$, $\langle y_B \rangle = 0.47 \pm 0.06$) are characteristic for the transition $s \to \tilde{c}$ which describes the production of charm in $\tilde{\nu}_\mu N$ interactions. Additional neutral strange particles can be seen in two of these events.

Taking into account the relative probabilities for all decays[3,5] under consideration and the experimental efficiency of the detection[4] of K^0, we find that the D^{*-}-meson yield is $(5.5 \pm 2.2)\%$ of all $\tilde{\nu}_\mu N$ interactions of the charged current, in good agreement with the preliminary results.[1]

TABLE I.

Decay mode	Combinations (events)	Background combinations (events)
$K^+\pi^-$	8(8)	1(1)
$K^+\pi^-\pi^+\pi^-$	8(7)	3(2)
$K^0\pi^+\pi^-$	2(1)	0(0)

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[2] This is the only measurement carried out to date. The recently published results of an emulsion experiment[2] allow us to conclude that charmed mesons are also produced in $\nu_\mu N$ interactions, primarily in the vector form.

[3] The measuring-error-related "smearing out" of the true energy release is estimated from a Monte Carlo calculation with a variation in accordance with a normal law governing the momenta and angles of particles in actual events with $\Delta^- < 10$ MeV. The observable energy release is less than 12 MeV with a 90% probability.

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