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Charm-studies in Experiment E687 at Fermilab

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ABSTRACT

Results from analysis of data taken in 1987-88 are presented. These include branching ratios for decays of D^0 and D_s^+, and decay fractions for the nonresonant channel and channels involving K^{*+} and ρ^0 in the decay $D^0 \to K_s^0\pi^+\pi^-$. An analysis to look for the decay of P-wave D-mesons, $D^{**0} \to D^{*+}\pi^-$, is described.

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1. Introduction

Experiment E687 studies charm produced by ~200 GeV photons impinging on a beryllium target using a multiparticle magnetic spectrometer described elsewhere[1]. The experiment collected ~10^4 and ~10^5 charm events in two data-taking runs in 1987-88 and 1990-1991 respectively. The lifetimes for D^0, D^+, D_s^+, and Λ_c^+ have been measured using the data from 87-88, and published[2,3]. The decay fractions through $K^{*+}\pi^-$ and $K_s^0\rho^0$ in the decay $D^0 \to K_s^0\pi^+\pi^-$, obtained with a Dalitz plot analysis described elsewhere[4], are listed in Table I. Some branching ratios measured using the data from 87-88 are listed in Table II. The next section describes the analysis of the 87-88 data to look for $D^{**0} \to D^{*+}\pi^-$.

Table I. Decay Fractions in $D^0 \to K_s^0\pi^+\pi^-$.

Non resonant	$.26 \pm .08 \pm .05$
$K^{*-}\pi^+$	$.64 \pm .08 \pm .05$
$\overline{K}^0\rho^0$	$.20 \pm .06 \pm .03$

Table II. Branching Ratios for D^0, D_s^+ decays.

$D^0 \to \pi^-\pi^+\pi^-\pi^+ / K^-\pi^+\pi^-\pi^+$	$.108 \pm .024 \pm .008$
$D^0 \to K^-K^+ / K^-\pi^+$	$.138 \pm .027 \pm .010$
$D^0 \to \overline{K}^0K^-K^+ / \overline{K}^0\pi^-\pi^+$	$.198 \pm .057 \pm .078$
$D^0 \to \overline{K}^0\phi / \overline{K}^0\pi^-\pi^+$	$.13 \pm .06 \pm .02$
$D^0 \to \overline{K}^0(K^-K^+)_{non-\phi} / \overline{K}^0\pi^-\pi^+$	$.11 \pm .04 \pm .03$
$D_s^+ \to \phi\pi^+\pi^-\pi^+ / \phi\pi^+$	$.58 \pm .20 \pm .10$

2. Search for $D^{**0} \to D^{*+}\pi^-$

D^{**0} is a bound state of a c and a $\bar{u}$ quark with relative angular momentum L=1. Of the four spin-parity states, the state with $J^P = 2^+$ can decay to $D^*\pi$ or $D\pi$. The two states with $J^P = 1^+$ can decay to $D^*\pi$ but the decay to $D\pi$ is prohibited due to parity conservation in strong interactions. Similarly the state $J^P = 0^+$ can decay to $D\pi$ but not to $D^*\pi$. The decay chain searched for in this analysis is $D^{**0} \to D^{*+}\pi^-$, $D^{*+} \to D^0\pi^+$, $D^0 \to K^-\pi^+$ or $K^-\pi^+\pi^-\pi^+$. The charge conjugate decays are implicitly included.

D^0 candidates were selected using a procedure similar to that described in reference 2. The invariant mass $M(D^0)$ of the D^0 candidate and the invariant mass $M(D^0\pi^+)$ of the D^0 candidate with each of the pions from

the primary vertex in turn, was calculated. If the difference $M(D^0\pi)$-$M(D^0)$ was within 2.5 resolution widths of the value expected for a D*, the candidate was accepted as a D* candidate. The final event sample had 750 D* and 240 fake D* (D* candidates that were not D*). To obtain a D**0 candidate, the D* was combined with each of the pion tracks in the primary vertex in turn, which were not included in the D*, and the invariant mass $M(D^*\pi)$ of the combination calculated. The solid histograms in fig 1 show the right sign distribution ($\Delta M=M(D^{*+}\pi^-)-M(D^{*+})$) and the the wrong sign distribution ($\Delta M=M(D^{*+}\pi^+)-M(D^{*+})$).

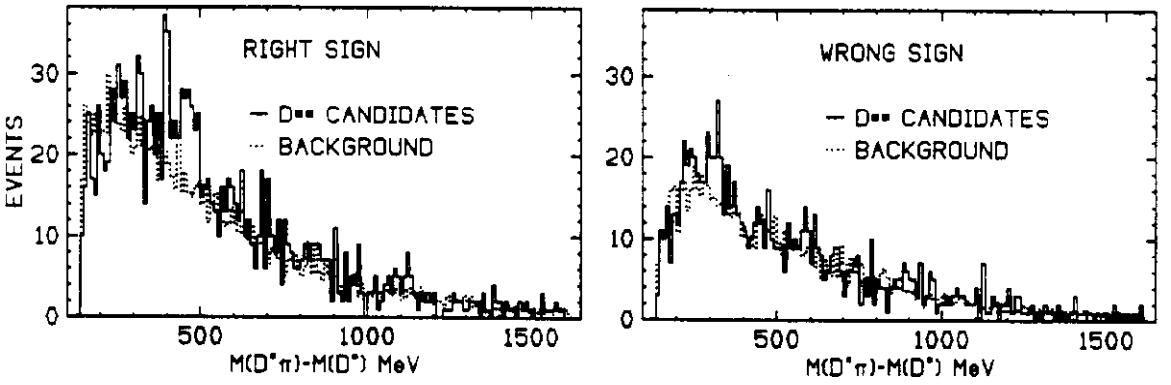

Figure 1 Distributions for $\Delta M=M(D^*\pi)-M(D^*)$

The dotted histograms in fig 1 show the background estimated using sidebands of the $M(D^*)$-$M(D^0)$ distribution, and D* events simulated with a monte carlo. Using these events, it was found that a lower momentum cut on a pion before it is combined with a D* candidate would improve the signal-to-noise ratio in the ΔM plot. The curves in figure 2 show the fraction of background events and simulated D** events that are accepted as the lower momentum cut on the pion is raised. Fig 3 shows the distribution of ΔM with a lower cut of 7 GeV on the pion momentum.

The decay to $D^+\pi^-$ of the D**(2460), believed to be a $J=2^+$ state, has been observed by several experiments[5,6,7]. The curve superimposed on the histogram in fig 3 shows a fit to a background function added to a broadened Breit-wigner peak. The mean and width of the peak were fixed at the

values obtained by other experiments for the state D**(2460). The bump at ΔM=450 MeV seems to be due to the decay of the D**(2460). The distribution in cosα of the events in the bump, where α is the angle between the pions from the decay of the D** and the D*, as measured in the D* reference frame, is expected to be proportional to $\sin^2\alpha$ if the events are from the decay of a 2^+ state. It should be proportional to $(1+3\cos^2\alpha)$ for the P-wave decay of a 1^+ state and flat for the S-wave decay of a $J=1^+$ state. The measured distribution was found to fit best to $\sin^2\alpha$, thus favouring the $J=2^+$ assignment for the D**(2460).

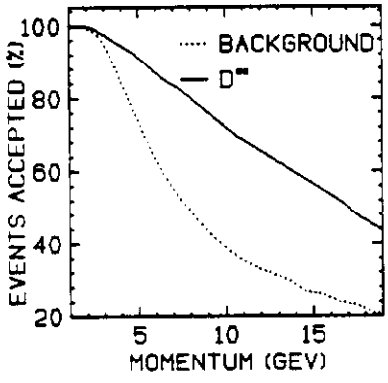

Fig 2 Fraction of events accepted vs P_π min

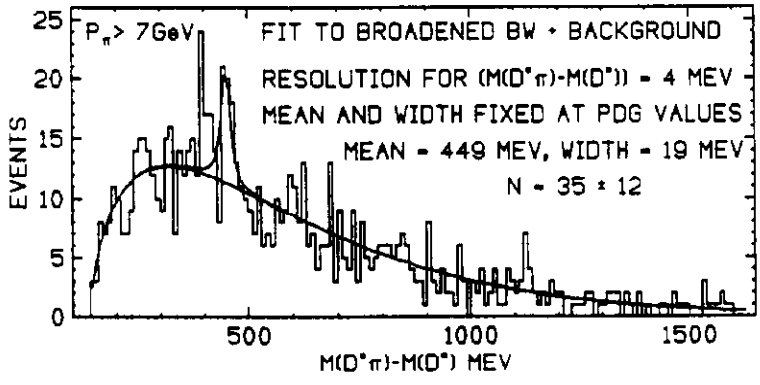

Fig 3 Distribution of $\Delta M=M(D^*\pi)-M(D^*)$ for $P_\pi > 7$ GeV.

3 . Conclusion

With the high statistics expected from the run in 90-91, some of the fields in which we hope to add significantly to the existing information are the following - $D^0\overline{D}^0$ mixing, doubly Cabibbo suppressed decays, charmed baryon lifetimes and spectroscopy, semileptonic decays, and D^{**} states including decays involving π^0 and photons. Precise determination of the angular distributions of decay products from D^{**0} is also expected.

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