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Charm-studies in Experiment E687 at Fermilab

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MASTER

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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 $D^0 \rightarrow K_s^0 \pi^+ \pi^-$. An analysis to look for the decay of P-wave D-mesons, $D^{**0} \rightarrow D^{*+} \pi^-$, 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 elsewhere¹⁾. The experiment collected ~10⁴ and ~10⁵ charm events in two data-taking runs in 1987-88 and 1990-1991 respectively. The lifetimes for D⁰, D⁺, D_s⁺, and Λ_c⁺ have been measured using the data from 87-88, and published^{2,3)}. The decay fractions through K^{*+}π⁻ and K_s⁰ρ⁰ in the decay D⁰ → K_s⁰π⁺π⁻, obtained with a Dalitz plot analysis described elsewhere⁴⁾, 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} → D^{*+}π⁻.

Table I. Decay Fractions in D ⁰ → K _s ⁰ π ⁺ π ⁻ .		Table II. Branching Ratios for D ⁰ , D _s ⁺ decays.	
Non resonant	.36 ± .08 ± .05	D ⁰ → π ⁻ π ⁺ π ⁻ π ⁺ / K ⁻ π ⁺ π ⁻ π ⁺	.108 ± .024 ± .008
K ^{*-} π ⁻	.64 ± .08 ± .05	D ⁰ → K ⁻ K ⁺ / K ⁻ π ⁺	.138 ± .027 ± .010
K _s ⁰ ρ ⁰	.20 ± .06 ± .03	D ⁰ → K ⁻ _s ⁰ K ⁺ K ⁺ / K ⁻ _s ⁰ π ⁻ π ⁺	.198 ± .057 ± .078
		D ⁰ → K ⁻ _s ⁰ φ / K ⁻ _s ⁰ π ⁻ π ⁺	.13 ± .06 ± .02
		D ⁰ → K ⁻ _s ⁰ (K ⁻ K ⁺) _{non-φ} / K ⁻ _s ⁰ π ⁻ π ⁺	.11 ± .04 ± .03
		D _s ⁺ → φπ ⁺ π ⁻ π ⁺ / φπ ⁺	.58 ± .20 ± .10

2. Search for D^{**0} → D^{*+}π⁻

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^{*}π or Dπ. The two states with J^P = 1⁺ can decay to D^{*}π but the decay to Dπ is prohibited due to parity conservation in strong interactions. Similarly the state J^P = 0⁺ can decay to Dπ but not to D^{*}π. The decay chain searched for in this analysis is D^{**0} → D^{*+}π⁻, D^{*+} → D⁰π⁺, D⁰ → K⁻π⁺ or K⁻π⁺π⁻π⁺. The charge conjugate decays are implicitly included.

D⁰ candidates were selected using a procedure similar to that described in reference 2. The invariant mass M(D⁰) of the D⁰ candidate and the invariant mass M(D⁰ π⁺) of the D⁰ 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 wrong sign distribution ($\Delta M = M(D^{**+} \pi^+) - M(D^{**+})$).

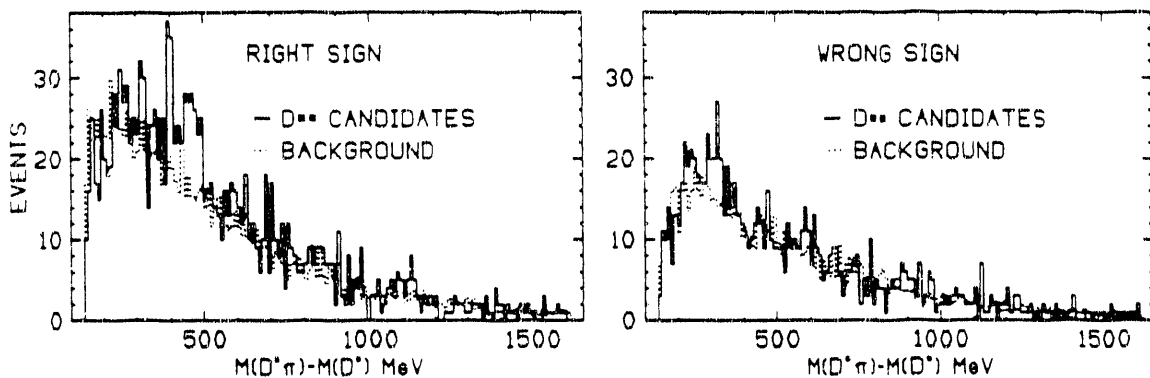


Figure 1 Distributions for $\Delta M = M(D^* \pi) - M(D^*)$

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 experiments⁵⁶⁷. 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 $\Delta M=450$ MeV seems to be due to the decay of the $D^{**}(2460)$. The distribution in $\cos\alpha$ 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 $D^{**}(2460)$.

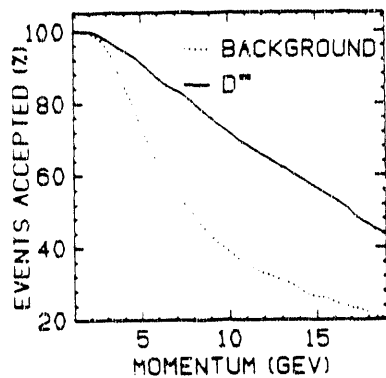


Fig 2 Fraction of events accepted vs $P_{\pi \text{ min}}$

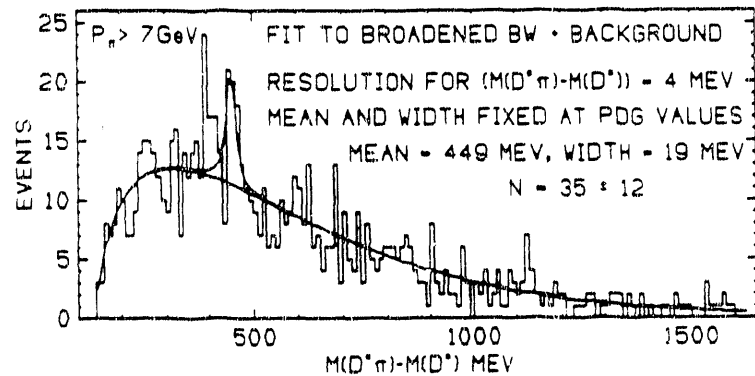


Fig 3 Distribution of $\Delta M = M(D^*\pi) - M(D^*)$ for $P_{\pi} > 7$ GeV.

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 - $D^0\bar{D}^0$ 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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