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OBSERVATION OF D^o MESON DECAY INTO $K^-\pi^+\pi^o$ *

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ASBSTRACT

In a sample of multihadron events with a π^o from e^+e^- annihilation data at 3.77 GeV center-of-mass energy, we observe the decay $D^o \to K^-\pi^+\pi^o$ with direct observation of the π^o. The observed branching fraction is $(12 \pm 6)\%$.

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In e^+e^- annihilation data taken at the $\psi(3772)$,[1] we have observed the $K^{\mp}\pi^{\pm}\pi^{o}$ decay mode of the $D^{o}(\overline{D^{o}})$. This is the first reported observation of a D decay mode containing a π^{o}.

The data were collected with the SLAC-LBL Magnetic Detector at SPEAR,[2] augmented by a system of lead glass counters which replaced one octant of the magnet return yoke[3] for improved gamma and electron detection. This system (referred to as the LGW) consists of a 2 × 26 array of lead glass active converters 3.3 radiation lengths (X_o) thick, a 14 × 19 array of lead glass blocks 10.5 X_o thick, and three planes of magnetostrictive spark chambers. The fiducial volume of the LGW covers a solid angle of 0.053 × 4π sr. This is slightly smaller than the solid angle covered by the actual dimensions of the lead glass counters in order to insure containment of the entire shower resulting from a gamma entering the system.

Gammas are identified by energy deposited in active converters which are cleanly separated spatially from the calculated intersection points of charged tracks (identified in the inner detector) with the surface of the active converter plane. Correlated deposits in the 10.5 X_o back blocks and spark chambers are used to give complete information on the gamma energy and angles. Gammas which convert in the 1 X_o aluminum magnet coil are tagged by the spark chambers between the coil and active converters, and the appropriate energy loss correction is made (approximately 55 MeV). If only gammas with energy greater than 100 MeV are considered, there is essentially no background. Thus, in the remainder of the analysis, this energy cutoff is used. The energy resolution for gammas of energy less than 1. GeV is approximately described by $\sigma/E = 0.09/E^{1/2}$ (E in GeV) and the angular resolution is $\Delta\theta \approx 0.3^{\circ}$.

π^{0}'s are identified by pairs of gammas in the LGW which reconstruct to have a mass consistent with the π^{0} mass. Figure 1(a) shows the $\gamma\gamma$ invariant mass ($M_{\gamma\gamma}$) for a sample of multihadronic events containing two or more gammas in the LGW. Clear evidence for π^{0} production is observed. A cleaner signal which more clearly shows the magnitude and width of the π^{0} signal is obtained if the gamma energy cutoff is increased as can be seen by the shaded region in the histogram in which an energy cutoff of 150 MeV is used.

The π^{0} acceptance is calculated by means of a Monte Carlo program in which the effects of the finite size of the lead glass counters and the effects of shower spreading are included. Figure 1(b) shows the π^{0} acceptance as a function of π^{0} momentum. The decrease in acceptance at high momentum is due to the shower overlap and small opening angle at high energy so that it is sometimes not possible to separate the two gammas.

The analysis is based on a sample of approximately 25 000 multihadronic events near the peak of the $\psi(3772)$, in the center-of-mass energy ($E_{c.m.}$) range from 3.76 to 3.79 GeV. The analysis techniques are similar to those described previously as far as the charged particles are concerned.[4,5,6] Charged particle identification is based on time-of-flight measurements. We have examined invariant mass combinations which include a kaon and one or more pions in order to search for D meson decay modes. We consider all particle combinations which include a π^{0} observed in the LGW (defined by $0.08 \lesssim M_{\gamma\gamma} < 0.16$ GeV/c^2), a kaon (identified by weight greater than 0.10 as defined in Ref. 4 for charged kaons and by mass cut for K^o_s), and possibly other charged pions.

In order to improve the resolution of the invariant mass combinations, we use the property that all D mesons produced at the $\psi(3772)$ are produced in the reaction $e^+e^- \rightarrow D\bar{D}$.[6] Thus it is possible to fit the kinematic variables with the constraint

$$E_D = E_{c.m.}/2 \quad ,$$

where E_D is the sum of the energies of the decay products. An additional constraint requiring the gamma-gamma invariant mass to be equal to the π^o mass is also imposed. We find one invariant mass combination with evidence for $D^o(\overline{D^o})$ production, $K^{\mp}\pi^{\pm}\pi^o$. A plot of invariant mass vs. kinematic fit χ^2 for these $K^{\mp}\pi^{\pm}\pi^o$ combinations is shown in Fig. 2. A clustering of events is observed near the mass of the D^o with low χ^2. A cut is made at $\chi^2 = 5$ and these events are shown in Fig. 3 as a function of $K^{\mp}\pi^{\pm}\pi^o$ mass. There are nine events near the mass of the D^o with mean value of 1.861 GeV/c^2. (This is consistent with the measured value[6] of 1.8633 $\pm$ 0.0009 GeV/c^2.) The observed rms width of about 4 MeV/c^2 is consistent with the expected experimental resolution. The background estimate is 1.7 events in a 20 MeV/c^2 mass interval centered on the D^o mass based on Monte Carlo studies and the event distribution in the region 1.70 to 1.85 GeV/c^2. (The probability of observing 9 events as a result of this background is $\sim 7 \times 10^{-5}$). This leaves an excess of 7.3 $\pm$ 3.0 events above background.

Using the $K^-\pi^+\pi^o$ acceptance calculated by Monte Carlo and the measured luminosity of the data sample (1.3 pb^{-1}), the cross section times branching fraction is calculated, $\sigma \cdot B = 1.4 \pm 0.6$ nb. As in Ref. 6, we can calculate the absolute branching fraction of this decay mode by assuming that the $\psi(3772)$ is a state of definite isospin (either 0 or 1) and that its only substantial decay mode is $D\bar{D}$. The absolute branching fraction is (12 $\pm$ 6)% where a $\pm$ 20% systematic error is included.

It is also possible to set an upper limit on the $D^o \to \overline{K^o}\pi^o$ decay since no events are observed near the D^o mass and the acceptance is fairly good. A 90% confidence level upper limit of 6% is obtained for the absolute branching fraction. Branching fraction upper limits (90% c.l.) for other Cabibbo favored decay modes involving π^o's are all greater than 25% because of either poor acceptance or background. The ratio of the $K^-\pi^+\pi^o$ branching fraction to other previously measured branching fractions[6] is larger than would be expected from the statistical model.[7]

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FIGURE CAPTIONS

1. (a) Gamma-gamma invariant mass distribution for events with two or more gammas detected in the LGW. A gamma energy cutoff of 150 MeV is required for events in the shaded region. (b) π^o acceptance in the LGW as a function of π^o momentum for isotropically produced π^o's.
2. $K^{\mp}\pi^{\pm}\pi^o$ invariant mass vs. kinematic fit χ^2 for constrained events. Dashed line indicates χ^2 cutoff.
3. $K^{\mp}\pi^{\pm}\pi^o$ invariant mass distribution for constrained events with a $\chi^2 = 5$ cutoff.

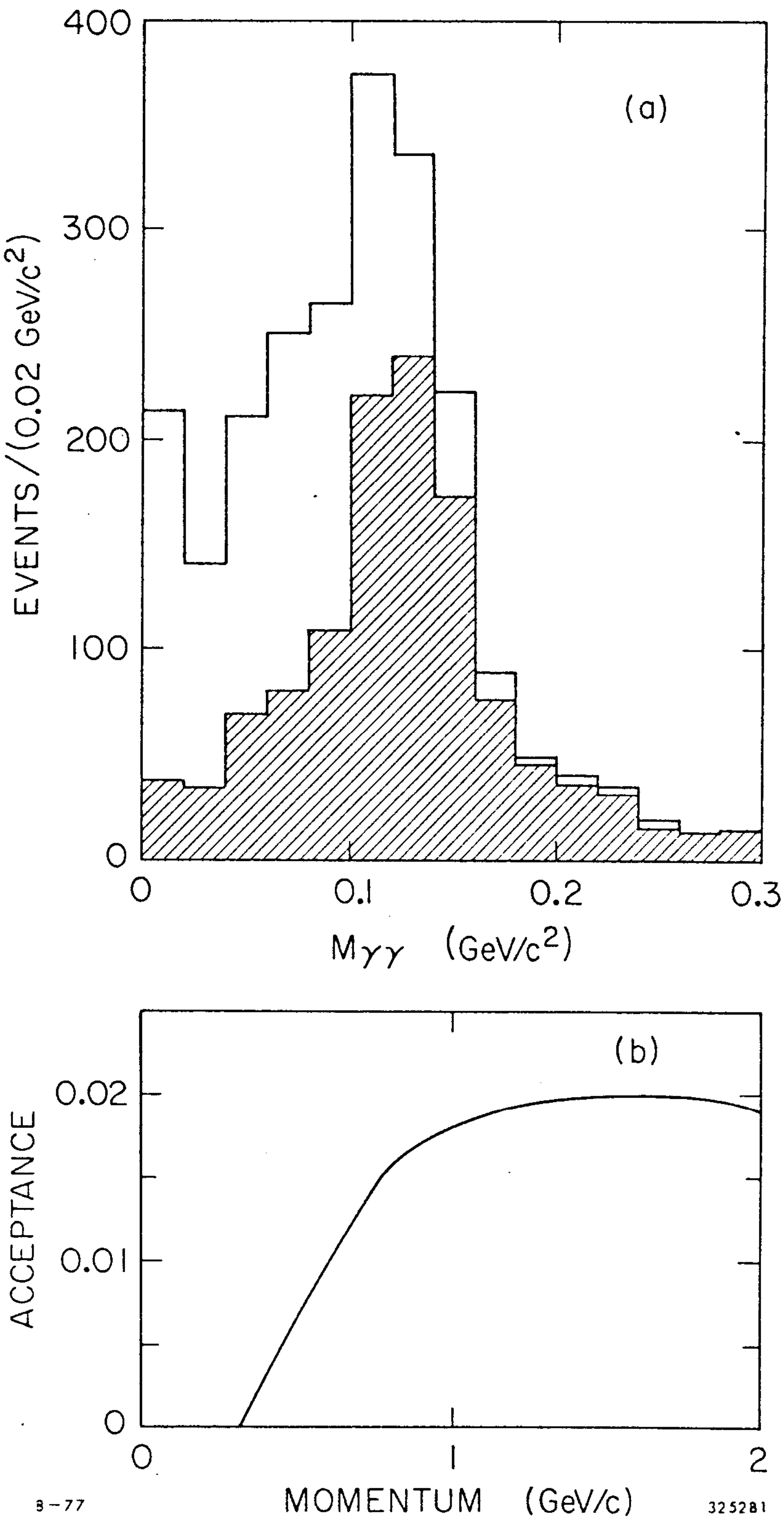
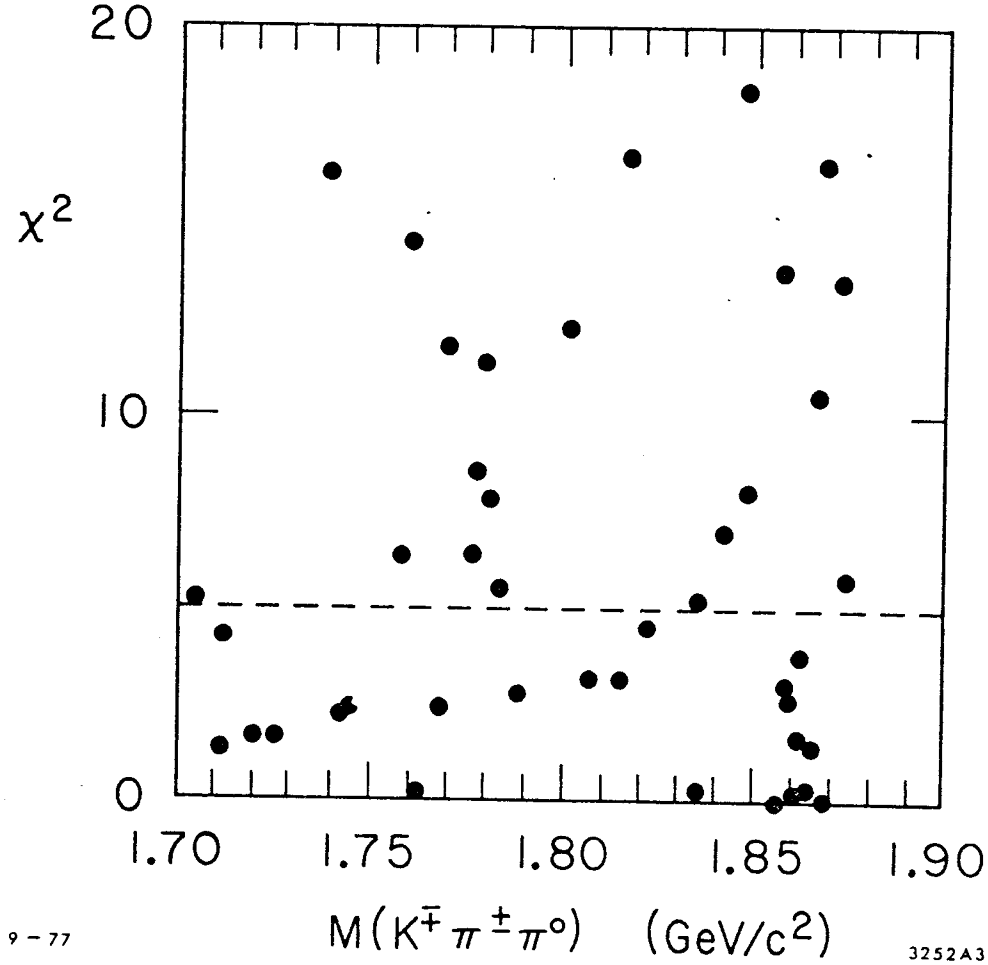
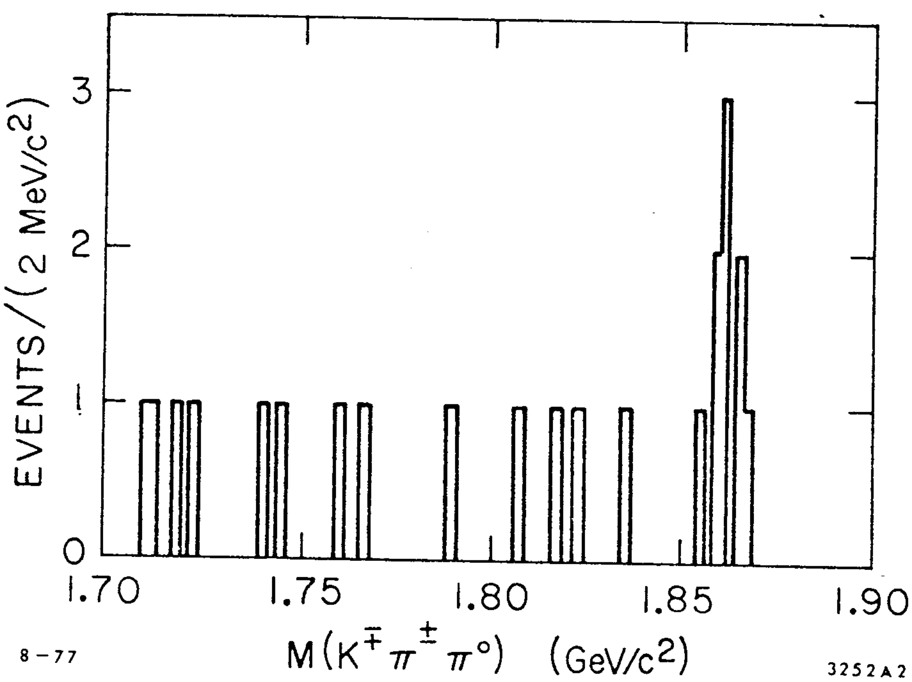

(a)
400
300
200
100
0
EVENTS/(0.02 GeV/c²)
0
0.1
0.2
0.3
Mγγ (GeV/c²)
(b)
0.02
0.01
0
ACCEPTANCE
0
1
2
MOMENTUM (GeV/c)
8-77
325281

Fig. 1



20
χ^2
10
0
1.70
1.75
1.80
1.85
1.90
9-77
M(K∓ π± π°) (GeV/c²)
3252A3

Fig. 2



3
2
1
0
EVENTS/(2 MeV/c²)
1.70
1.75
1.80
1.85
1.90
8-77
M(K∓ π± π°) (GeV/c²)
3252A2

Fig. 3