Measurement of the Branching Ratios of $D^0 \to K^- e^+ \nu_e$ and $D^0 \to \pi^- e^+ \nu_e$

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I. Introduction

• Provide information about strong interaction on the decay

• Data Sample

Our memsurement is based on the data collected at $\sqrt{s} = 4.03GeV$ with a total luminosity $22.3pb^{-1}$ in e^+e^- collision.

• Analysis Method

The paired mesons produced from $D^*\bar{D}(\bar{D}^*D)$ or $D^*\bar{D}^*$ are used for analysis. In the recoiling side we select $ke\nu$ or $\pi e\nu$ candidates and in the other side the invariant mass distribution of $D^+(D^0)$ reconstructed in the modes of $K^-\pi^+\pi^+$, $K^-\pi^+$ and $K^-\pi^+\pi^+\pi^-$ is analyzed.

According to the work on $D^0 \to \overline{K}^{*0}x$ using the double tag method by Rong Gang etc, in the recoiling side there are totally 6618±212 D^0 or $\bar{D}^0(N_{recoilD^0})$ and 2539±141 D^+ or $D^-(N_{recoilD^+})$.

Single Tag D	Recoiling Side $\bar{D}$
$K^-\pi^+$	$K^+e^-\nu_e$
$K^-\pi^+\pi^+$	$\pi^+e^-\nu_e$
$K^-\pi^+\pi^-\pi^+$	

II. The Seletion Criteria

• The Single Tagged D's momentum is in its 3σ.

• The good photon number should be no more than the two times of the π^0 number produced in $D^* \to \pi^0 D$ to suppress the modes including π^0 in the recoiling side.

• The recoiling particles' Selection:

$$\begin{array}{llll} CL(e) > 1\% & and & CL(e)/(CL(e)+CL(\pi)+CL(K)) > 0.85 & (for\ e) \\ CL(K) > 1\% & and & CL(k)/(CL(e)+CL(\pi)+CL(K)) > 0.5 & (for\ k) \\ CL(\pi) > 1\% & and & CL(\pi)/(CL(e)+CL(\pi)+CL(K)) > 0.5 & (for\ \pi) \end{array}$$

The charge of the kaon in the single tag and the electron in the recoiling should be the same.

• The limits about U:

1. $U \equiv E_{missing} - |P_{missing}| \equiv \frac{M^2_{missing}}{(E_{missing}+|P_{missing})}$.
2. U_{Ke}: The U where the recoiling is identified as $Ke\nu$.
3. $U_{\pi e}$: The U where the recoiling is identified as $\pi e\nu$.
4. $U_{\pi easKe}$:The U where the recoiling is identified as $\pi e\nu$ but the kaon mass is assigned to the track identified as the pion.

For $D^0 \to K^- e^+ \nu_e$:

$$|(U_{ke} - U_{Ke}^{peak}| < 2 \times \sigma_{U_{Ke}}$$

For $D^0 \to \pi^- e^+ \nu_e$:

$$|(U_{\pi e} - U_{\pi e}^{peak}| < 2 \times \sigma_{U_{\pi e}}$$

$$|U_{\pi easKe} - U_{\pi easKe}^{peak}| < |U_{\pi easKe} - U_{ke}^{peak}|$$

The second criterion for $D^0 \to \pi^- e^+ \nu_e$ is to suppress the misidentification from $D^0 \to K^- e^+ \nu_e$.

III. The Analysis of MC Data

• MC event number: about 1.0 times of Real Data

• For $D^0 \to K^- e^+ \nu_e$: At all 112 $Ke\nu$ events are selected within $\pm 3\sigma_{m_D}$ including 26 mis-identifieded events(Table 1).

• For $D^0 \to \pi^- e^+ \nu_e$: Totally 11 $\pi e\nu$ events are selected within $\pm 3\sigma_{m_D}$ including 4 mis-identified events(Table 2).

IV. The Candidate Events

Table 1: Mis-identification of $ke\nu$ in MC

Number	Mode
4	$K^-\mu^+\nu_\mu$
3	$K^-\pi^+\pi_0$
2	$K^-\rho^+$
2	$K^-\pi^0e^+\nu_e$
3	$K^{*-}e^+\nu_e$
2	$K^-\pi^+\pi_0\pi_0$
1	$K^-\pi^+$
1	$\bar{K^0}\pi^-e^+\nu_e$
1	$K^{*-}e^+\nu_e$
1	$\bar{K^{*0}}\pi^0$
1	$\bar{K^{*0}}\pi^0e^+$
5	Single Tag Mis-identification

• The Distribution of the Candidates' Invariant Mass : Counting the events in the signal region then subtracting the background according to the event number in the side band.

• For $D^0 \to K^-e^+\nu_e$:

$$N_{candidate}(D^0 \to K^-e^+\nu_e) = 87.5 \pm 10.2$$

• For $D^0 \to \pi^-e^+\nu_e$:

$$N_{candidate}(D^0 \to \pi^-e^+\nu_e) = 11.2 \pm 4.1$$

V. Mesurement Results

• Subtracting Misidentified Events(Fig.5)

Table 2: Mis-identification of $\pi e \nu$ in MC

Number	Mode
1	$K^- e^+ \nu_e$
1	$\pi^- \mu^+ \nu_{mu}$
1	$D^- \to \rho^0 e^- \nu_e$
1	Single Tag Mis-identification

$$N_{true} = N_{candidate} - N_{mirD^0} - N_{mirD^+}$$

$$N_{mirD^0} = N_{recoilD^0} \times (\sum_{ofD^0}^{modes} BR_i \times MIR_i)$$

$$N_{mirD^+} = N_{recoilD^+} \times (\sum_{ofD^+}^{modes} BR_i \times MIR_i)$$

• The Branching Ratios:

$$BR = \frac{N_{true}}{\epsilon \times N_{recoilD^0}}$$

$$BR(D^0 \to K^- e^+ \nu_e) = (3.54 \pm 0.49 \pm^{0.32}_{0.31})\%$$

$$BR(D^0 \to \pi^- e^+ \nu_e) = (0.354 \pm 0.209 \pm^{0.121}_{0.120})\%$$

• Notes:

1. BR_i: the Branching Ratio of the ith D^0 or D^+ decay mode.

2. MIR_i: the MisIdentification Ratio of $D^0 \to K^- e^+ \nu_e$ and $D^0 \to \pi^- e^+ \nu_e$ from the ith D^0 or D^+ decay mode.

Table 3: Candidates of $\pi e \nu$ (Real Data)

Mode	In Signal region	In Sideband	Background
$K^-\pi^+$	9	2	1.4
$K^-\pi^+\pi^+$	1	0	0
$K^-\pi^+\pi^+\pi^-$	5	7	2.4
Total	15	9	3.8

Table 4: ϵ and MIR of $Ke\nu$

Mode	EFF/MIR AV.(%)	BR(96) (%)	EFF/MIR $\times$ BR(10^{-4})
$K^-e^+\nu_e$	31.5(ϵ)	3.64	114.68
$\pi^-e^+\nu_e$	2.56	0.38	0.97
$K^-\mu^+\nu_\mu$	0.36	3.23	1.18
$\pi^-\mu^+\nu_\mu$	0.03	0.38(Theo)	0.01
$\overline{K^0}\pi^-e^+\nu_e$	0.05	2.8	0.15
$K^-\pi^+$	0.28	3.83	1.07
$K^-\pi^+\pi^0$	0.32	13.9	4.42
$\pi^-\pi^+\pi^0$	0	1.6	0
$\rho^-e^+\nu_e$	0.45	0.38(Theo)	0.17
$D^+ \to \rho^0e^+\nu_e$	0.10	0.4(Theo)	0.04
$K^-\pi^0e^+\nu_e$	7.1	1.6	11.37
$K^-\pi^+\pi^0\pi^0$	0.08	15	1.25
$D^+ \to k^{*0}\pi^0e^+\nu_e$	0.03	< 1.2	0.03
Total (MIR $\times$ Br) for D^0 ,D^+			20.58(D^0) 0.07(D^+)

3. ϵ: the efficiency of selecting events of $D^0 \to K^-e^+\nu_e$ or $D^0 \to \pi^-e^+\nu_e$ in the recoiling side.

4. Static Error: coming from the fluctuation of the numbers of the candidates and the background.

5. Systematic Error: coming from the the misidentificated events and the electron Confidence Level's variance.

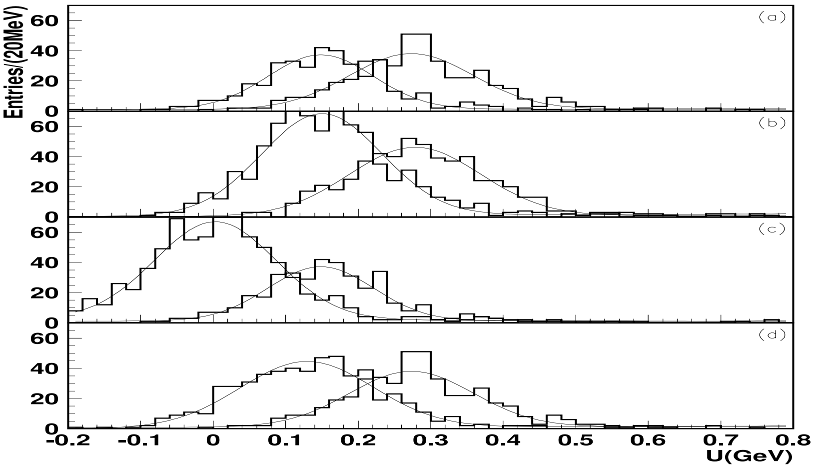

Figure 1: The U distributions from MC data. (a) U_{ke} respectively for the modes of $D^*\bar{D}, \bar{D}^*D$ or $D^*\bar{D}^*$(shadowed). (b) $U_{\pi e}$ respectively for the modes of $D^*\bar{D}, \bar{D}^*D$ or $D^*\bar{D}^*$(shadowed). (c) $U_{\pi easke}$(shadowed) and U_{ke} for the modes of $D^*\bar{D}, \bar{D}^*D$. (d) $U_{\pi easke}$(shadowed) and U_{ke} for the modes of $D^*\bar{D}^*$.

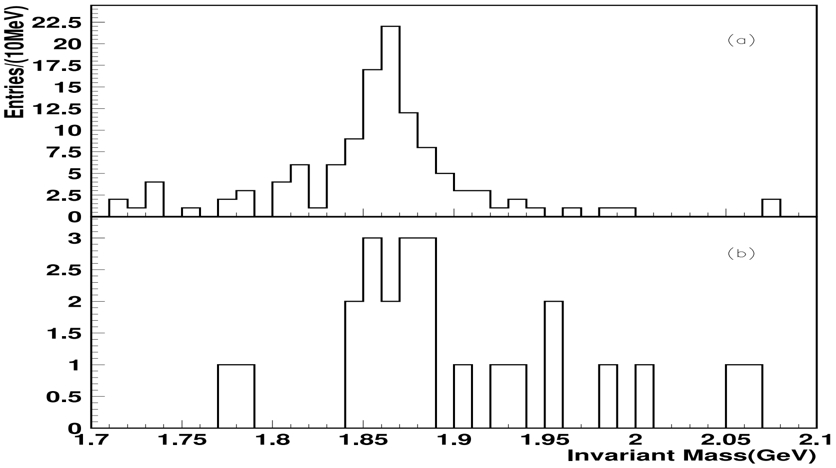

Figure 2: The distributions of the invariant mass of D tagged by $K^-\pi^+$,$K^-\pi^+\pi^+$ and $K^-\pi^+\pi^+\pi^-$ while selecting the candidates of $D^0 \to K^-e^+\nu_e$(a) or $D^0 \to \pi^-e^+\nu_e$(b) in the recoiling under the four criteria.

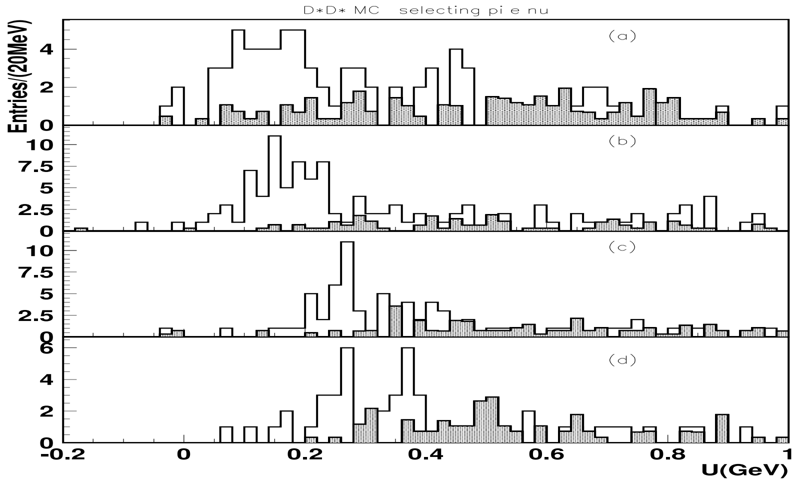

Figure 3: The distributions of the U_{ke} under the first three criteria within $\pm 3\sigma_{m_D}$ and in side-band(shadowed) while selecting the events $D^0 \to K^- e^+ \nu_e$ in the recoiling. The figure (a) and (b) respectively corresponds the real data and MC data in the modes of $D^* \bar{D}$ or $\bar{D}^* D$. The figure (c) and (d) respectively corresponds the real data and MC data in the modes of $D^* \bar{D}^*$.

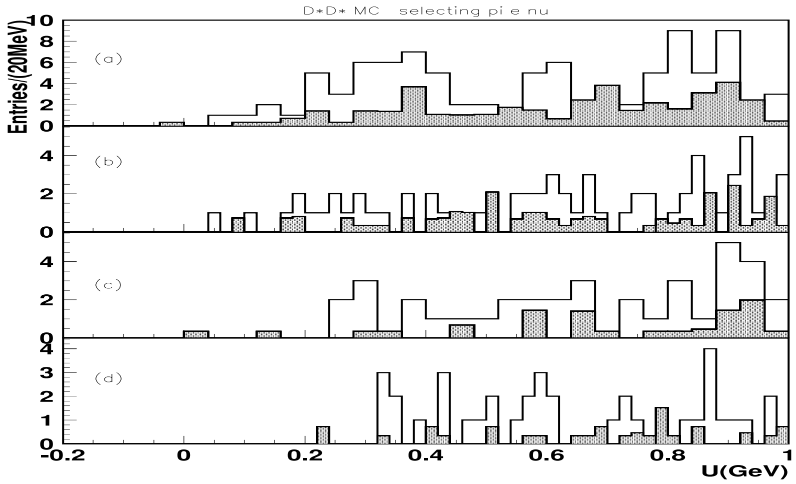

Figure 4: The distributions of the $U_{\pi e}$ under the first three criteria within $\pm 3\sigma_{m_D}$ and in side-band(shadowed) while selecting the events $D^0 \to \pi^- e^+ \nu_e$ in the recoiling. The figure (a) and (b) respectively corresponds the real data and MC data in the modes of $D^* \bar{D}$ or $\bar{D}^* D$. The figure (c) and (d) respectively corresponds the real data and MC data in the modes of $D^* \bar{D}^*$.

Table 5: ϵ and MIR of $\pi e \nu$

$K^- e^+ \nu_e$	0.91	3.64	3.33
$\pi^- e^+ \nu_e$	29.67(ϵ)	0.38	11.27
$K^- \mu^+ \nu_\mu$	0	3.23	0
$\pi^- \mu^+ \nu_\mu$	0.24	0.38(Theo)	0.09
$\overline{K^0} \pi^- e^+ \nu_e$	0.44	2.8	1.23
$K^- \pi^+$	0.05	3.83	0.20
$K^- \pi^+ \pi^0$	0	13.9	0
$\pi^- \pi^+ \pi^0$	0.09	1.6	0.14
$\rho^- e^+ \nu_e$	3.30	0.38(Theo)	1.25
$D^+ \to \rho^0 e^+ \nu_e$	0.71	0.4(Theo)	0.29
$K^- \pi^0 e^+ \nu_e$	0	1.6	0
$K^- \pi^+ \pi^0 \pi^0$	0	15	0
$D^+ \to K^{*0} \pi^0 e^+ \nu_e$	0	< 1.2	0
Total (MIR $\times$ Br) for D^0 ,D^+			6.24(D^0) 0.29(D^+)

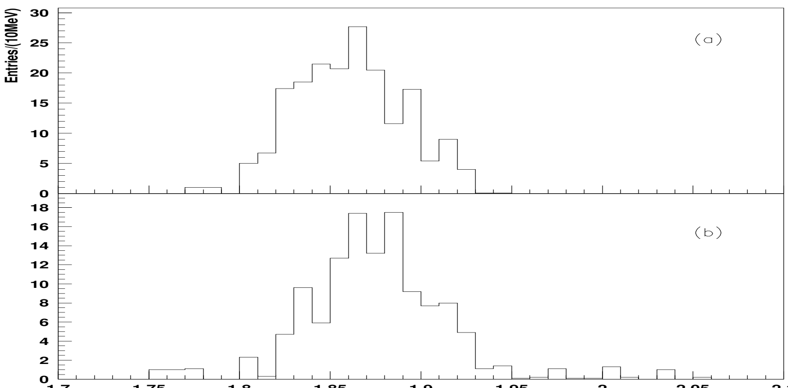

Figure 5: The sum distributions of the invariant mass of the $K^- \pi^+$ combinations to tag D while the ten decay modes of the recoil D^0 produced by MC to be mis-identified as $k^- e^+ \nu_e$(a) or $\pi^- e^+ \nu_e$(b)

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