Update $D^+ \longrightarrow \mu^+ \, \nu_\mu$
Analysis

Nabil Menaa

Sheldon Stone

Syracuse U.
CLEO Collaboration

Key points:

- *Systematic study.*
- *Extra energy Cut*
- *Background estimation*
- *Conclusions*

Max Extra Shower cut(1)

e+ e- $\longrightarrow$ ψ (3770) (1^{--}) <u>Vector Particle</u>

D$^+$

D$^-$

K$^-\pi^+\pi^+$
K$^-\pi^+\pi^+\pi^0$

K$_s\pi^+\pi^0$

K$_s\pi^+$

K$_s\pi^+\pi^-\pi^+$

K$^-$K$^+\pi^+$

K$^-\pi^+\pi^+$

✓ The maximum extra energy present in the detector ~ the sum of the contributions from each tag.

✓ Need background free double tag sample.

$\longrightarrow$ + CC Event

Nabil Menaa
Syracuse U. CLEO

July 2005

Max Extra Shower cut(2)

Use a sample of double charged D's and kinematically fit
the event with the constraints: 5C fit

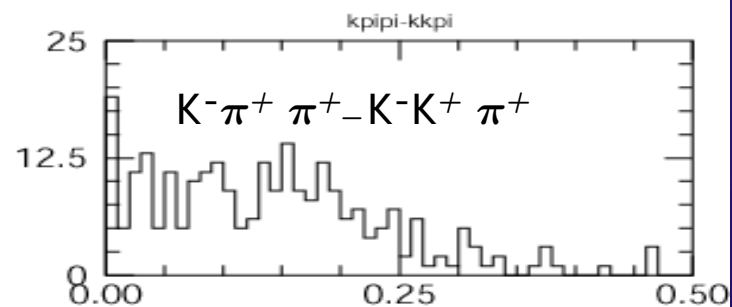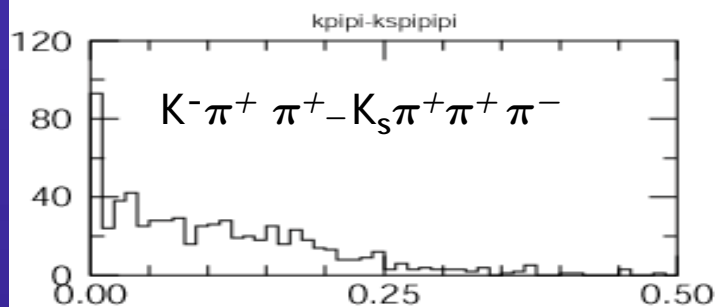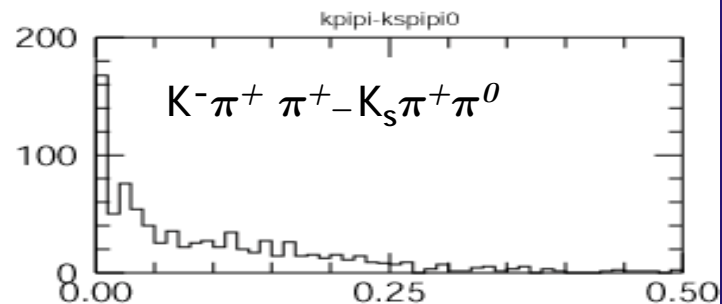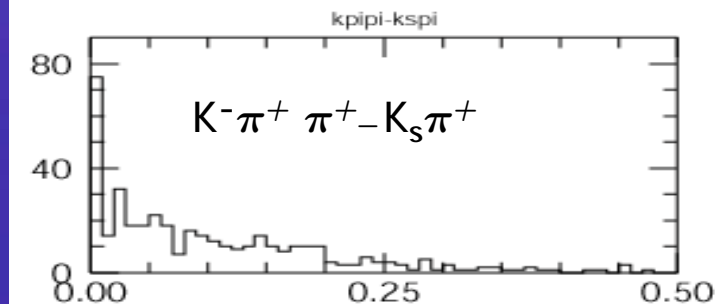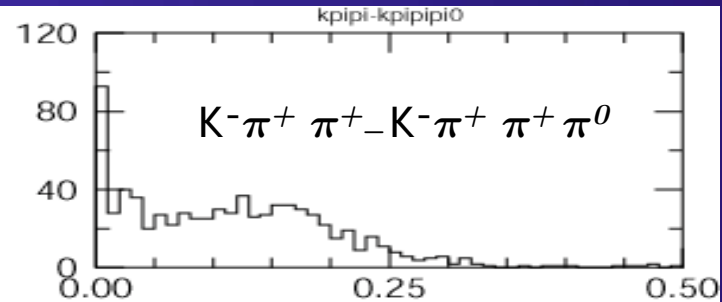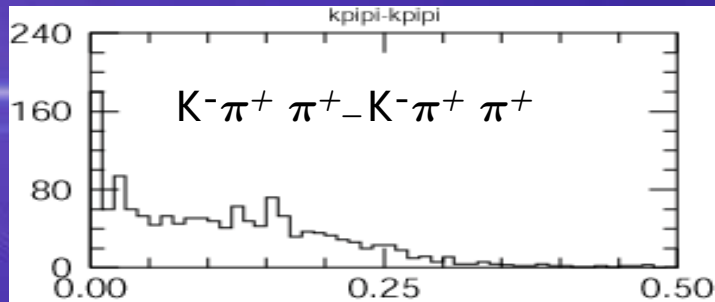$$\chi^2 = (\eta - \eta_0)^T \; V^{-1} \; (\eta - \eta_0)$$

$\eta^T = (px1, py1, pz1, E1), \ldots\ldots$

$$\vec{P}_{D^+} + \vec{P}_{D^-} = \vec{0}$$

$$E_{D^+} = eBeam$$

$$E_{D^-} = eBeam$$

Use data31,32,33,35,36 and 37 → 281pb^{-1}

Nabil Menaa
Syracuse U. CLEO

Max. Extra Showers Energy

GeV   GeV

Nabil Menaa
Syracuse U. CLEO

July 2005

Extra Shower Eff.

Max Shower cut Efficiencies		
Mode	$\varepsilon(\%)$ from MC	$\varepsilon(\%)$ from Double tag Method
$K^-\pi^+\pi^+$	94.9±0.3	95.1 ±0.4
$K^-\pi^+\pi^+\pi^0$	95.9±0.4	97.9±1.0
$K_s\pi^+$	95.8±0.4	95.3±1.5
$K_s\pi^+\pi^0$	97.2±0.4	97.4±1.0
$K_s\pi^+\pi^+\pi^-$	95.0±0.4	98.0±1.1
$K^-K^+\pi^+$	93.8±0.4	92.4±2.1
Weighted	95.4±0.3	***96.1±0.3***

- Used all available data in this study. 281pb-1
- Question: how does 2 overlapping tags compare to 2 tags which don't see each other ?

Nabil Menaa
Syracuse U. CLEO

Extra Shower Eff.(2)

- From $K\pi\pi - K\pi\pi$ MC
    Eff= (94.6 ± 0.18)%
- From $K\pi\pi - \mu\nu$ MC
    Eff= (94.9 ± 0.3)%

- This gives an estimate of the systematic error of Max extra shower cut of 0.4%

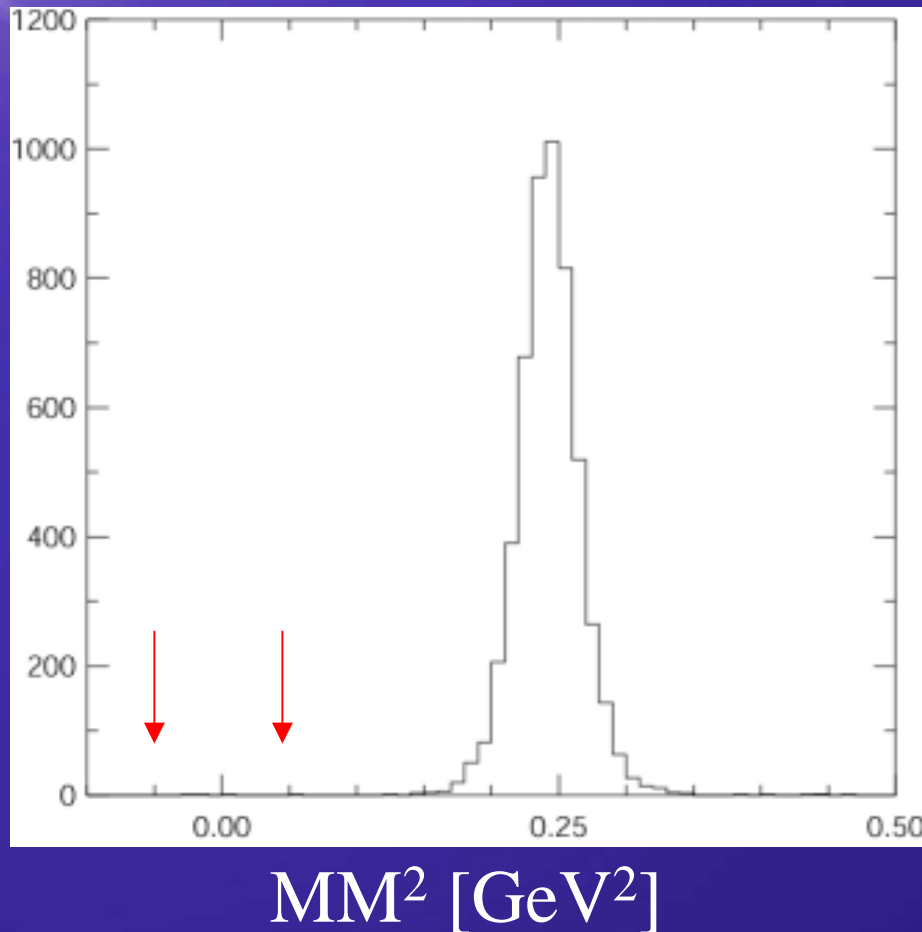Nabil Menaa
Syracuse U. CLEO

Background estimate for 281pb^{-1}

Backgrounds		
Mode	B(%)	# Events
$\pi^+\pi^0$	0.13 ± 0.02	$1.40\pm0.18\pm0.22$
$K^0\pi^+$	2.77 ± 0.18	$0.33\pm0.19\pm0.02$
$\tau^+\nu\ (\tau\rightarrow\pi^+\nu)$	$2.64*B(D^+\rightarrow\mu^+\nu)$	$1.08\pm0.15\pm0.02$
$\pi^0\mu^+\nu$	0.25 ± 0.15	negligible
Continuum	-	0
D^oD^o + other D^+D^-	-	0
Total	-	$2.81\pm0.30\pm0.22$

From data

- Statistical error only
- Add 32% C.L. for the 0 bkgnds as an upper limit.

Nabil Menaa
Syracuse U. CLEO

Background estimate (2)

MM^2 [GeV^2]

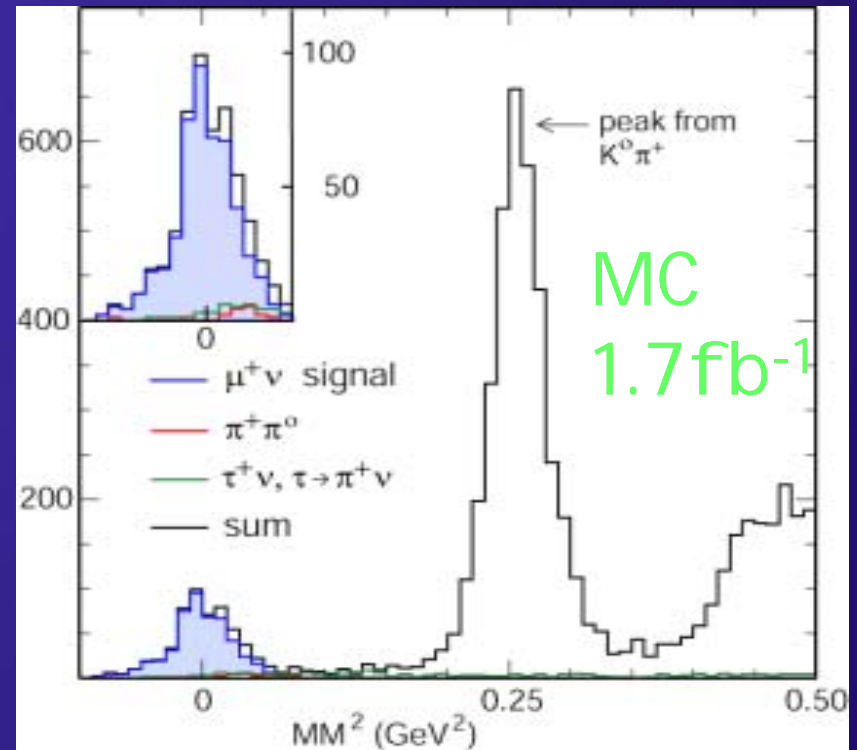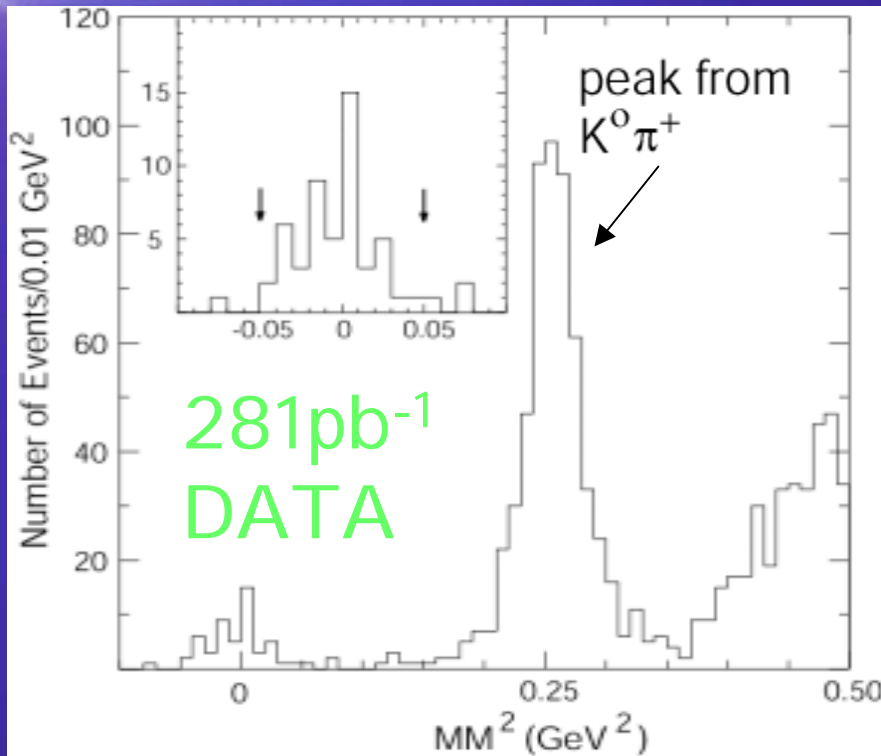- Use Double tag K$^+\pi^-$, (K$^-\pi^+$, K$^-\pi^+\pi^0$, K$^-\pi^+\pi^-\pi^+$)
- No kaon ID just Veto pions with RICH.
- MM2 of pion against the tag.
- Entries in signal region?
- 3 events
- Scale with the peak at 0.25 GeV^2

Nabil Menaa
Syracuse U. CLEO

July 2005

MM² from DATA   D⁻ -> μ⁻ ν

50 events

281pb⁻¹ DATA

peak from K⁰π⁺

MC 1.7fb⁻¹

MM² [GeV²]

Nabil Menaa
Syracuse U. CLEO

Systematic Error on Branching Ratio

- MC Statistics   0.4%
- Track Finding   0.7%
- PID cut   1.0%
- Minimum Ionization Cut 1.0%
- Extra Shower Cut   0.5%
- MM^2 width   1.0%
- Number of tags   0.3%
- Background   0.5%

Nabil Menaa
Syracuse U. CLEO

July 2005

Conclusions

- Signal region [-0.05, 0.05] GeV^2
  158354 tags and ε_{sig}=69.4%,
  $\varepsilon_{Extr.Shower}$=96.1%

$$B(D^+ \rightarrow \mu^+ \nu) = \frac{N_{sig}}{\varepsilon_{SIG} * \varepsilon_{ExtraShowes} * N_{tag}}$$

- $(47.1 \pm 7.1^{+0.2}_{-0.8})$ signal events:
  $B(D^+ \rightarrow \mu\nu) = (4.47 \pm 0.67^{+0.09}_{-0.12}) \ x10^{-4}$

$$\Gamma(M \rightarrow l\nu) = \frac{1}{8\pi} G_F^2 f_M^2 m_l^2 M_M \left(1 - \frac{m_l^2}{M_M^2}\right)^2 |V_{qq'}|^2$$

Using: - $|V_{cd}|=|V_{us}|=0.2238 \pm 0.0029$ (Nierste talk at Lepton-
Photon)
- τ=1.040$\pm$0.007 ps (PDG)

$$f_D = (224.4 \pm 16.8^{+2.8}_{-3.4}) \ MeV$$

Comparison to Theory

- CLEO-c measurement – 47.1 events

- BES measurement based on 2.67±1.74 events

- Current Lattice measurement (unquenched light flavors) is consistent

EXPERIMENT

CLEO-c $224.4 \pm 16.8^{+2.8}_{-3.4}$

MARK III   < 290 MeV @ 90% cl

BES $371^{+129}_{-119} \pm 25$ MeV

THEORY

Lattice QCD (FNAL & MILC)
Quenched Lattice QCD (UKQCD)
Quenched Lattice QCD
QCD Spectral Sum Rules
QCD Sum Rules
Relativistic Quark Model
Potential Model
Isospin Mass splittings

100   200   300   400

f_{D^+} (MeV)

Nabil Menaa
Syracuse U. CLEO