$D^+ \to \mu^+ \nu$ and f_D from 281 pb^{-1} at $\psi(3770)$ with CLEO-c

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(CLEO Collaboration)

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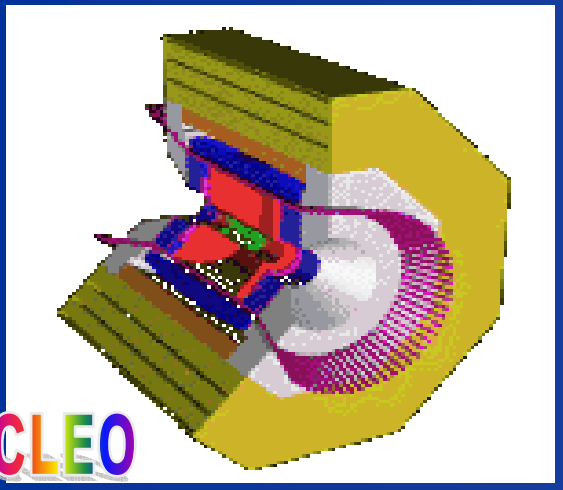
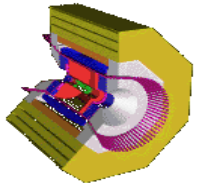




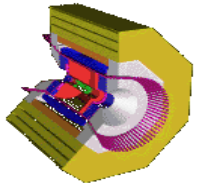
Outline

Introduction

$D^+ \to \mu^+ \nu$ and f_{D+} (281 pb^{-1} at $\psi(3770)$)

- Analysis Techniques
- Fully reconstructed D^- tags
- $D^+ \to \mu^+ \nu$ Reconstruction
- Background suppression
- Results

Summary



Flavor Physics and CLEO-c

$$\mathbf{V}_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

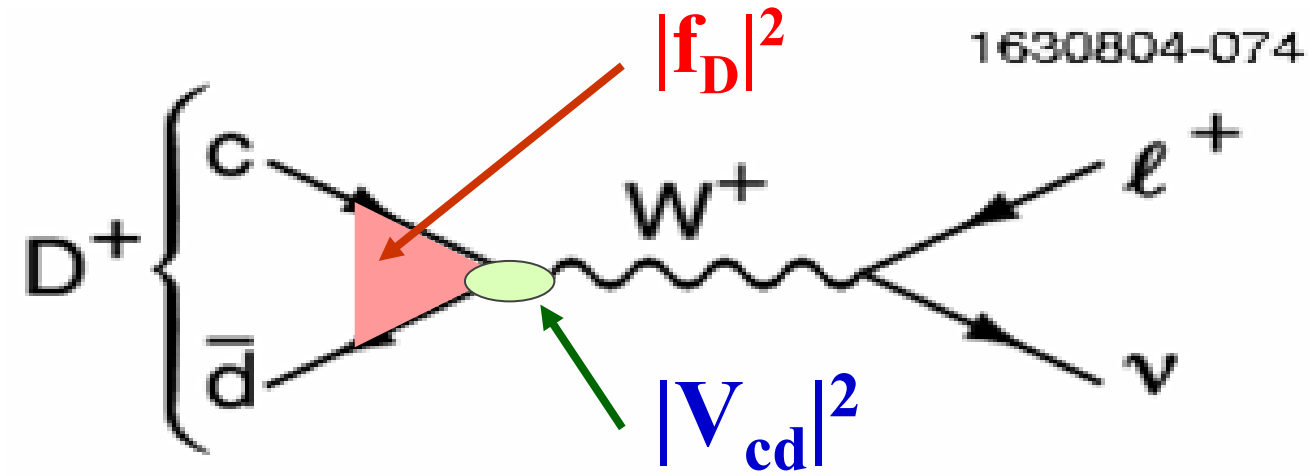
Test the SM and Search for New Physics:

- Precise measurements/over constrain of CKM
- One limiting factor: syst. error of non-pert. QCD

CLEO-c Physics at Ψ(3770):

- f_D, f_{Ds}: Validate Lattice QCD and improve f_B
- Semileptonic D decay: Form factors and V_{cd}, V_{cs}

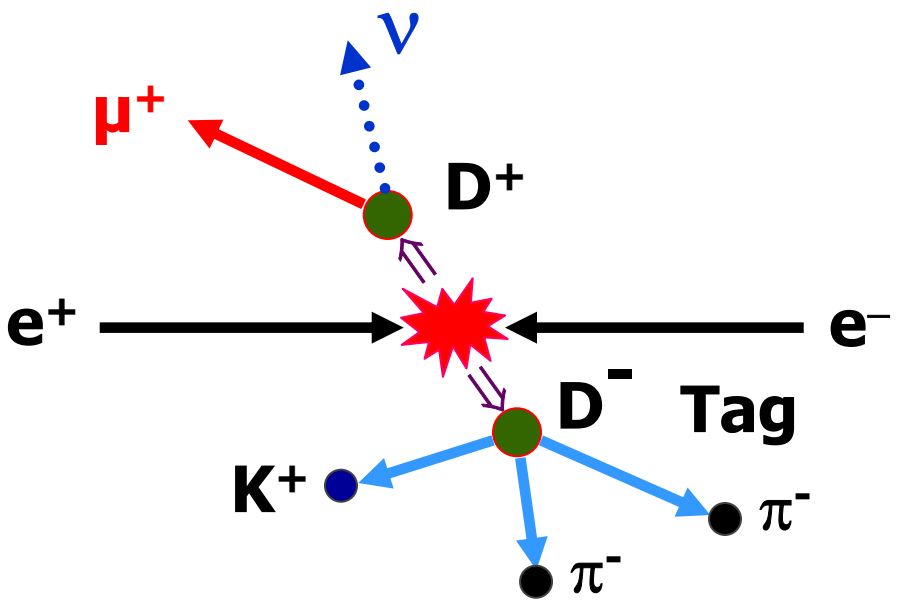
Leptonic $D^+ \to \mu^+ \nu$ Decay



$$\Gamma\left(D^+ \to l^+ \nu\right) = \frac{G_F^2}{8\pi} f_{D^+}^2 m_l^2 M_{D^+} \left(1 - \frac{m_l^2}{M_{D^+}^2}\right)^2 |V_{cd}|^2$$

Compare theoretical calculations of f_D to experimental measurement to gain confidence in theory's ability to predict f_B

ψ(3770) Analysis Techniques



The MARK III Method

Fully reconstruct 1st D "the tag", then analyze decay of 2nd D to extract exclusive or inclusive properties.

$$\Delta E = E(D) - E_{\text{beam}}$$

$$M_{BC} = \sqrt{E_{\text{beam}}^2 - |p(D)|^2}$$

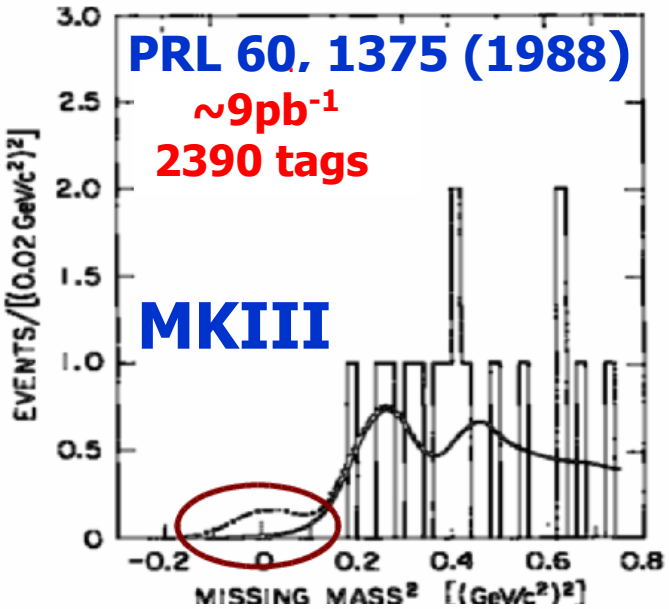
ψ(3770) ~ DDbar threshold

➔ No extra fragmentation = simpler geometry / combination

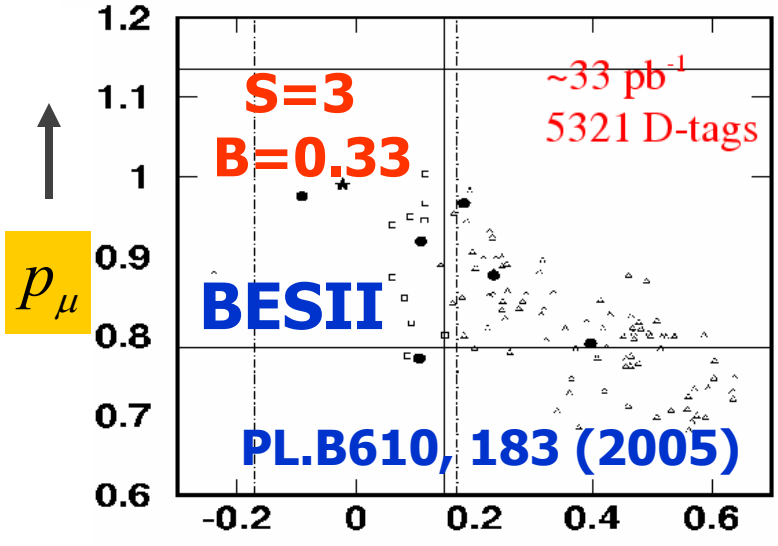
➔ Clean neutrino reconstruction

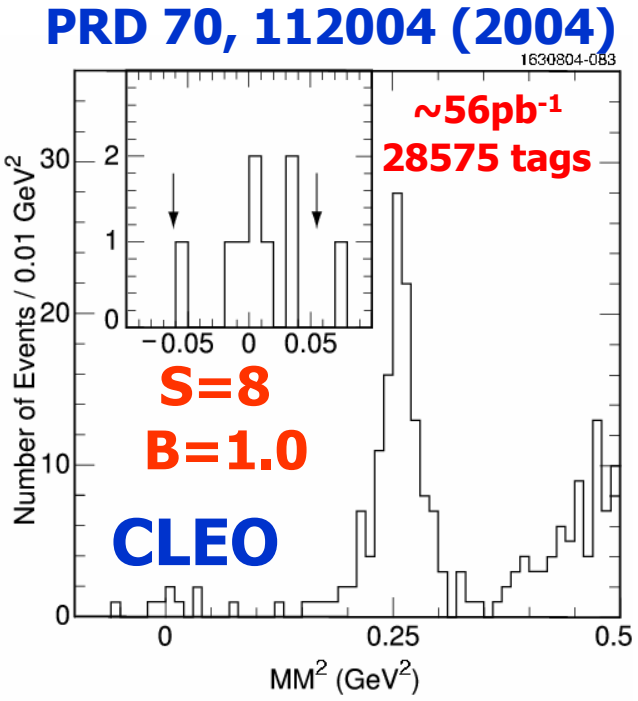
➔ High tagging efficiency at 20% of all D's produced.

f_{D+} from Absolute Br($D^+ \to \mu^+\nu$)



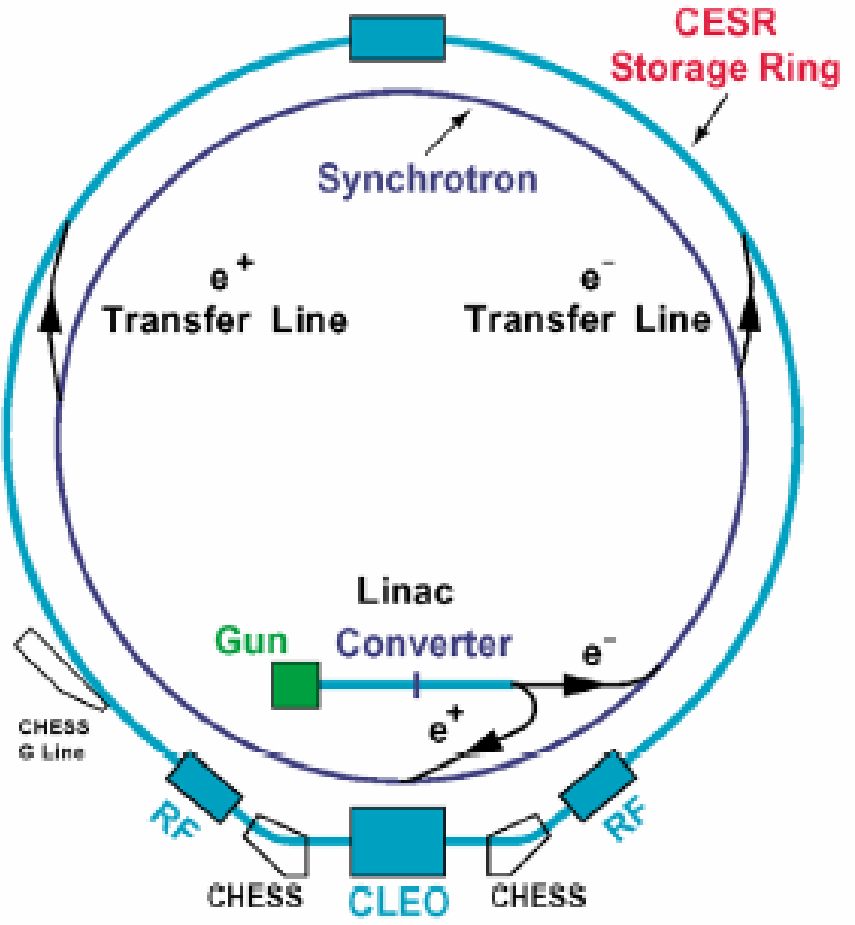
	$B(D^+ \to \mu\nu)\times 10^{-4}$	f_D MeV
MkIII	< 7.2	< 290
BESII	$12.2^{11.1}_{-53} \pm 0.11$	$371^{+129}_{-119} \pm 25$
CLEO	**3.5±1.4±0.6**	**202±41±17**



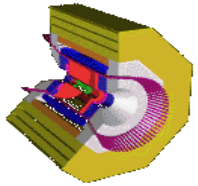


First Observation

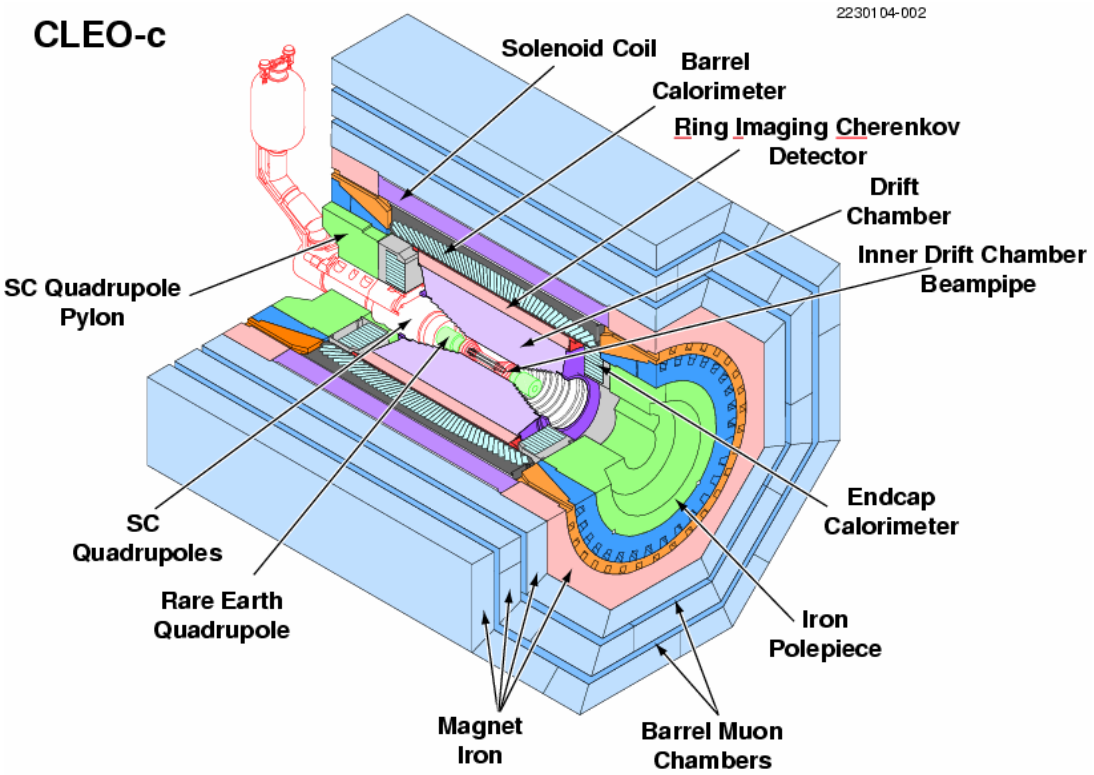
CESR-c

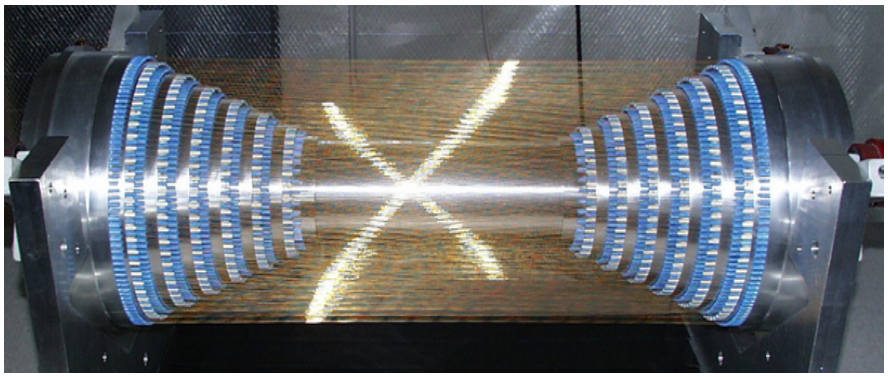


E_{beam} = 1.5 – 5.6 GeV



CLEO-c Detector & Data

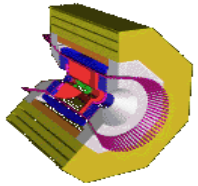




- **New inner drift chamber replaced old silicon vertex**
- **1T B field (old 1.5 T)**
- **Track (93% of 4π): σ = 0.6% @ 1 GeV**
- **PID: Rich (80% of 4π), dE/dx, EM calorimeter, muon (> 1GeV)**
- **E_γ: σ = 2.2% @ 1 GeV, 5% @ 100MeV.**

CLEO-c ≅ CLEO III

281 pb^{-1} at ψ(3770)



$\psi(3770)$ analyses at CLEO-c

$D^+ \to \mu^+ \nu$ and decay constant f_{D+} at CLEO-c

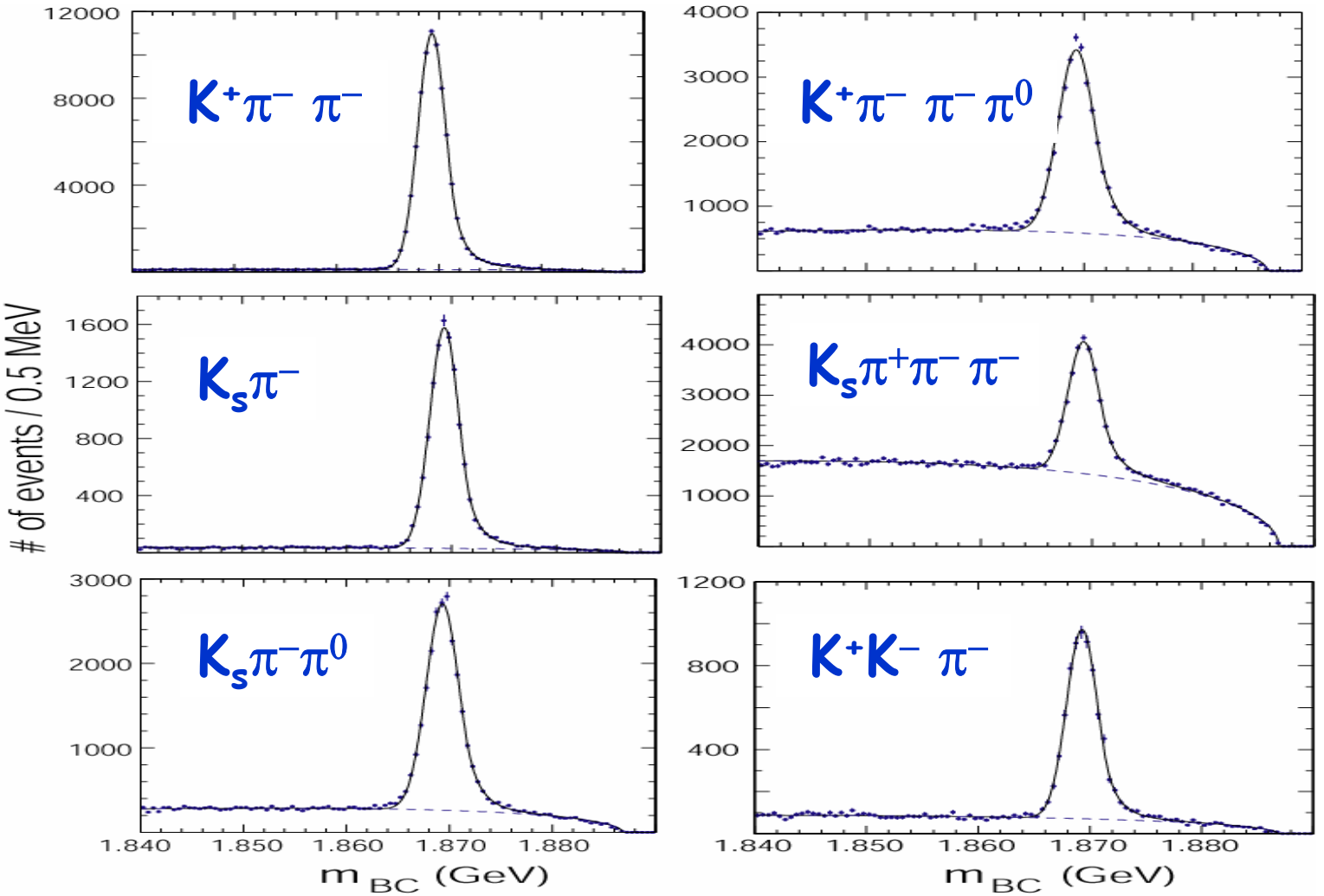
- High resolution detector with tuned MC
- Simple low multiplicity events
- Hermeticity of the detector
- dE/dx (π, K, p, e)
- RICH detector (K threshold ~ 550 MeV)
- dE/dx + RICH: Hadron ID for D tagging
- CsI Calorimeter (electron, muon identification)
- Beam energy σ_{Ecm} = 2.3 MeV

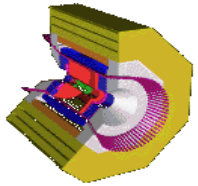
Fully reconstructed D^- tag

Preliminary

From 281 pb-1 at ψ(3770)

158K fully reconstructed D^-



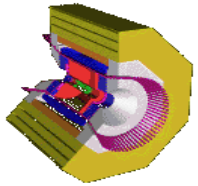


Fully reconstructed D^- tag

Mode	Signal	Background
$K^+\pi^-\pi^-$	77387 ± 281	1868
$K^+\pi^-\pi^-\pi^o$	24850 ± 214	12825
$K_S\pi^-$	11162 ± 136	514
$K_S\pi^-\pi^-\pi^+$	18176 ± 255	8976
$K_S\pi^-\pi^o$	20244 ± 170	5223
$K^+K^-\pi^-$	6535 ± 95	1271
Sum	158354 ± 496	30677

Preliminary

Reconstruction Efficiency: (20 – 55)%



Reconstruct $D^+ \to \mu^+\nu$

Neutrino MM² to discriminate signal and backgrounds:

$$MM^2 = (E_{beam} - E_\mu)^2 - (-\vec{P}_{D^-} - \vec{P}_\mu)^2$$

Signal peaks at MM² = 0

Additional cuts to suppress background:

- **No additional charged tracks from event vertex**
- **Largest unmatched shower energy less than 0.25 GeV, to suppress $D^+ \to \pi^+ \pi^0$**
- **Muon candidate consistent with minimum ionizing particle (Ecal< 300 MeV in EM cal)**

$\sim 67\%$ efficient for $D^+ \to \mu^+\nu$

Most systematic errors are determined using DATA

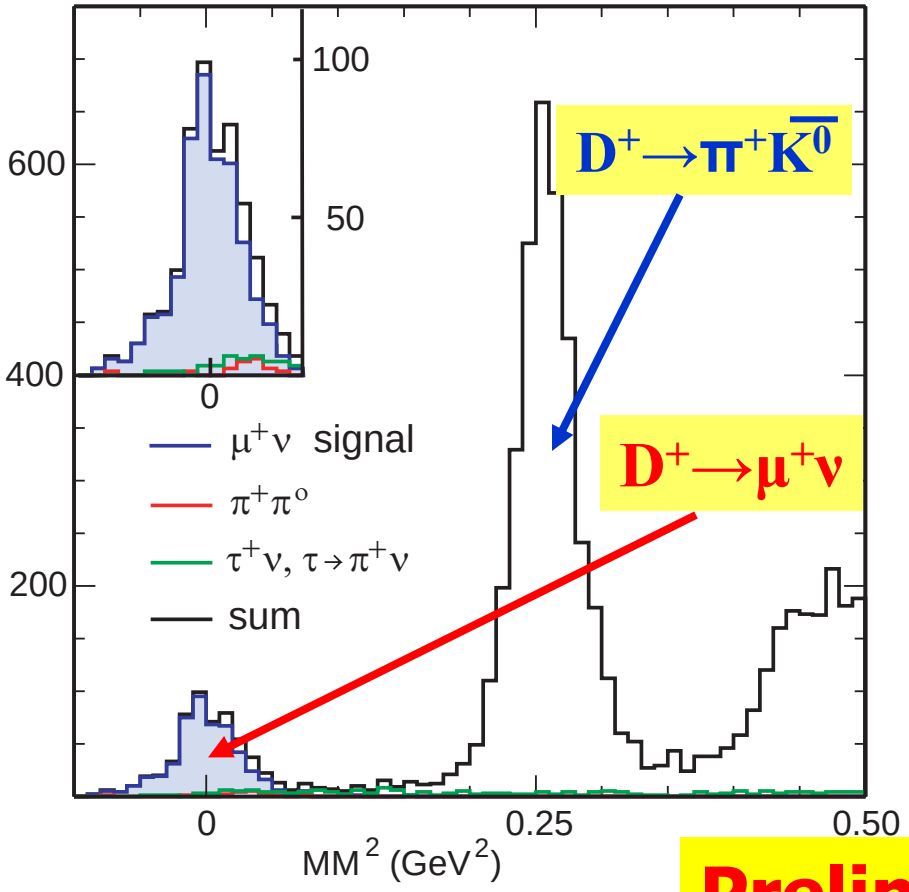
Detailed background studies based on MC+DATA

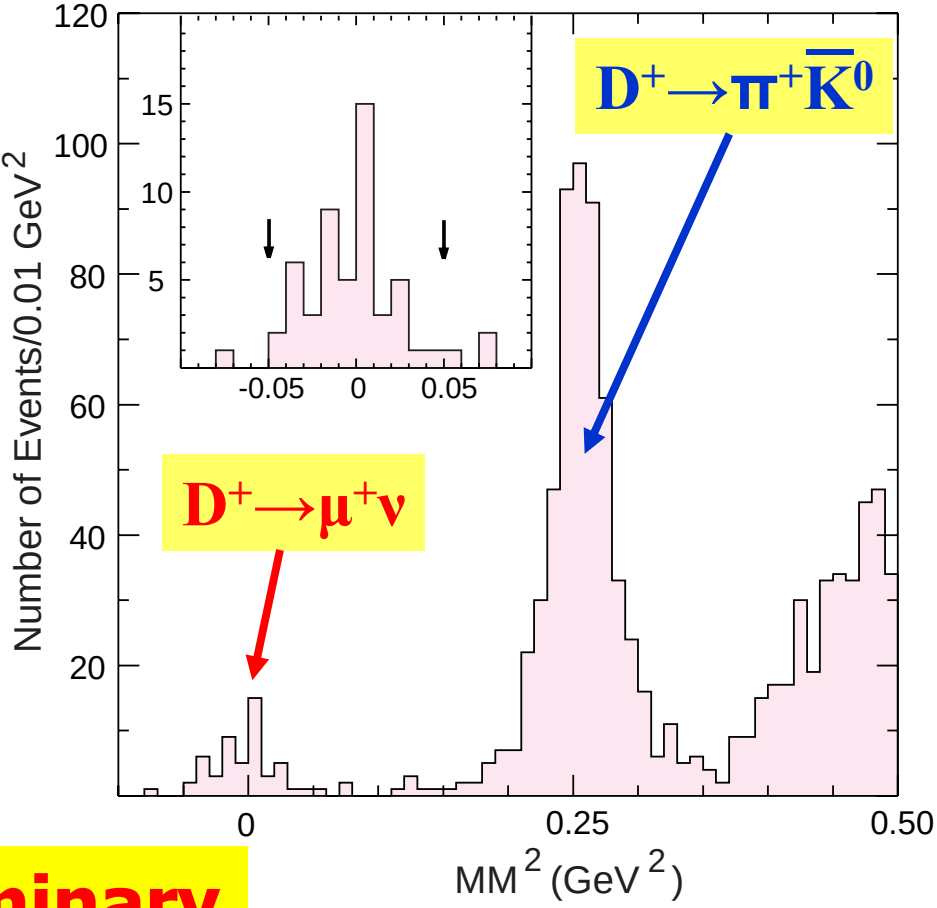
$D^+ \to \mu^+\nu$ from CLEO-c Data

MC Expectations from 1.7 fb^{-1}, 6 x data

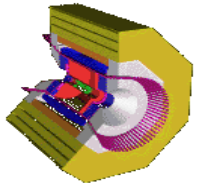
281 pb^{-1} at $\psi(3770)$

50 signal events





Preliminary



Br($D^+ \to l^+\nu$) & f_{D^+} from CLEO-c

Backgrounds		
Mode	**$\mathcal{B}$(%)**	**# Events**
$\pi^+\pi^o$	0.13±0.02	1.40±0.18
$\overline{K}^o\pi^+$	2.77±0.18	0.44±0.44
$\tau^+\nu$ ($\tau \to \pi^+\nu$)	2.65*$\mathcal{B}$($D^+ \to \mu^+\nu$)	1.08 ±0.15
Continuum D^oD^o + other D^+D^-	-	0; < 0.8 events @ 32% CL
Total	-	$2.92\pm0.50^{+0.8}_{-0}$

Preliminary

Efficiencies & BKG well understood: from data

$$\mathbf{Br(D^+ \to \mu^+\nu) =} \quad (4.45 \pm 0.67^{+0.29}_{-0.36}) \times 10^{-4}$$

$$f_{D^+} = (223 \pm 16^{+7}_{-9})\ \text{MeV}$$

No $D^+ \to e^+\nu$ events observed:

$$\mathbf{Br(D^+ \to e^+\nu) < 2.4 \times 10^{-5}\ @\ 90\%\ C.L.}$$

V_{us}(KTeV)= 0.225 ±0.0023
V_{us}(NA48)= 0.2187±0.0016(exp) ±0.0023(th)
V_{us}(NA48)= 0.2239±0.0012(exp) ±0.0023(th)
$f_+(0)V_{us}$(KLOE)= 0.216±0.001(exp) (Ke3)

Current Experiment & Theory

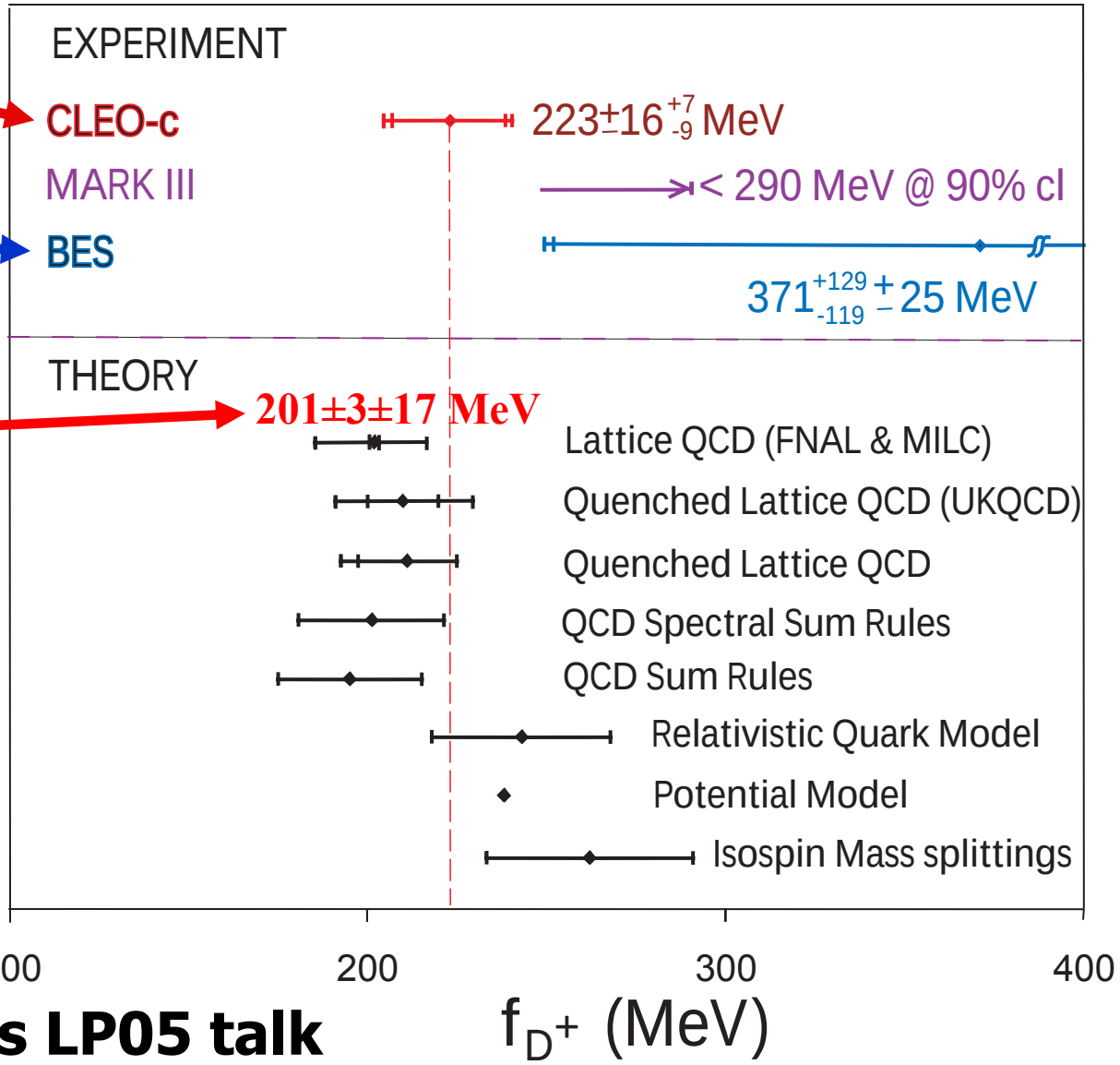
This measurement

BES measurement (2.67±1.74 evts)

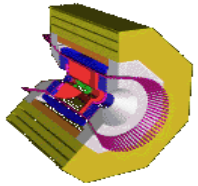
Fermilab-MILC-HPQCD (hep-lat0506030)

Chiu et al. hep-ph/0506266
$f_D = (235 \pm 8 \pm 14)$ MeV

CP-PACS:
$f_D = (202 \pm 12^{+20}_{-25})$ MeV



c.f. Artuso, Stewart's LP05 talk



Br($D^+ \to l^+\nu$) & f_{D^+} from CLEO-c

Preliminary from 281 pb^{-1} at ψ(3770):

(CLEO CONF 05-5)

158,354 ± 496 fully reconstructed D^- tags

$47.1 \pm 7.1\ ^{+2.9}_{-3.7}$ $D^+ \to \mu^+\nu$ evts observed

Br($D^+ \to \mu^+\nu$) = $(4.45 \pm 0.67\ ^{+0.29}_{-0.36}) \times 10^{-4}$

$f_{D+} = 223 \pm 16\ ^{+7}_{-9}$ MeV

Br($D^+ \to e^+\nu$) < 2.4×10^{-5} @ 90% C.L.