CLEO-c Measurements of f_D and f_{Ds}

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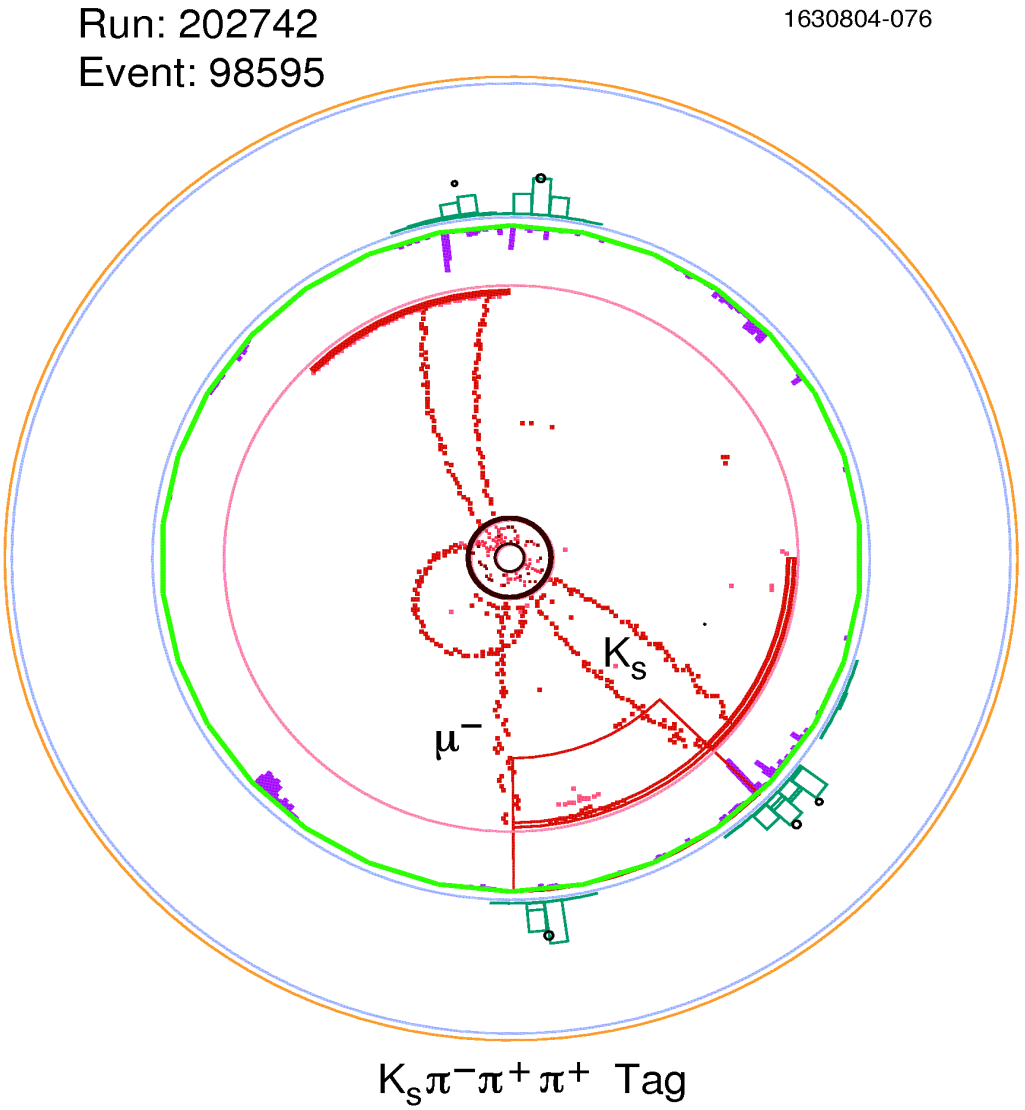
International workshop on
Tau-Charm Physics

Beijing, June 5-7, 2006

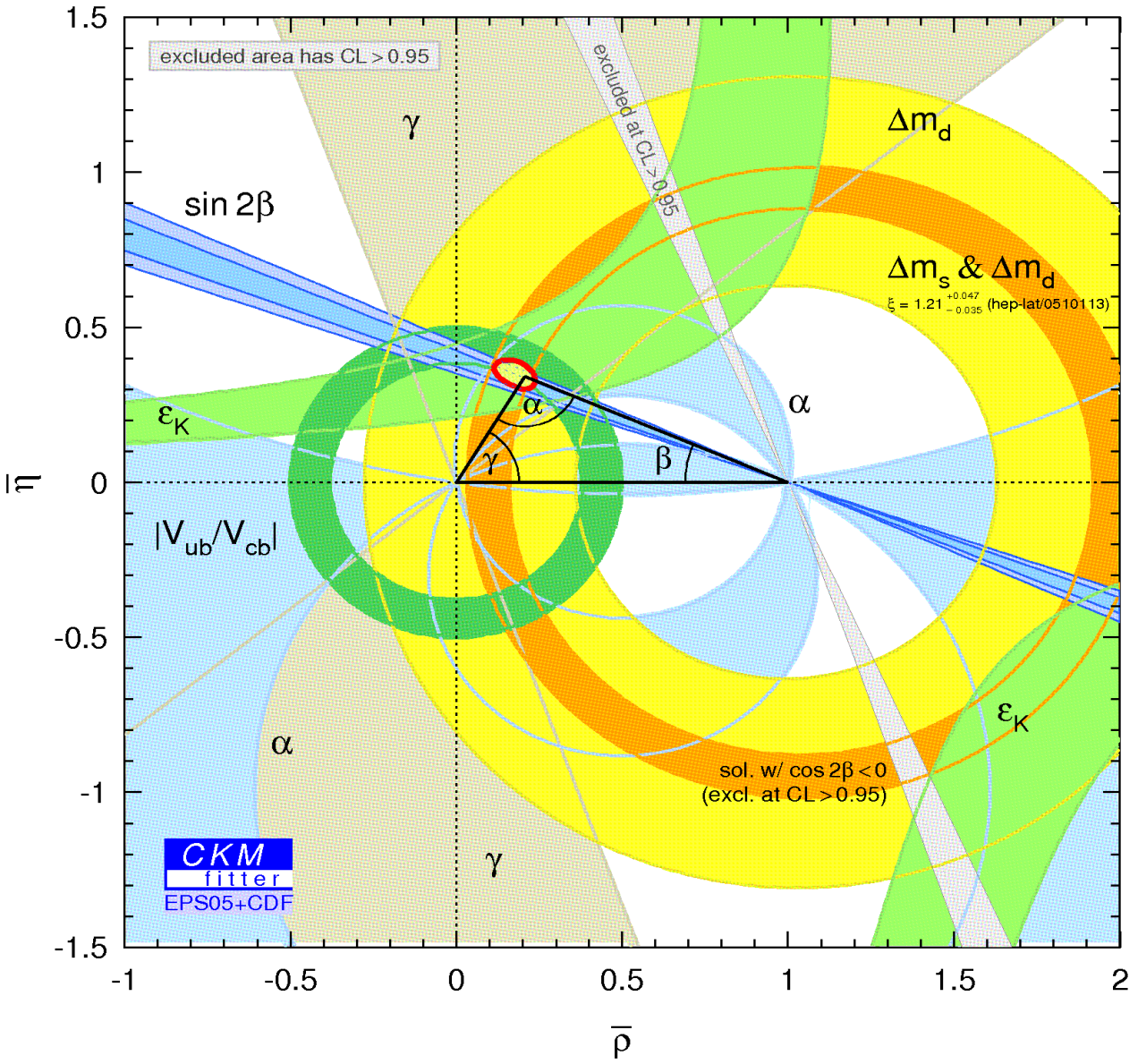
Outline:

- $D \to \mu\nu_\mu$, $D \to \tau\nu_\tau$ and f_D
- $D_s \to \mu\nu_\mu$, $D_s \to \tau\nu_\tau$ and f_{Ds}

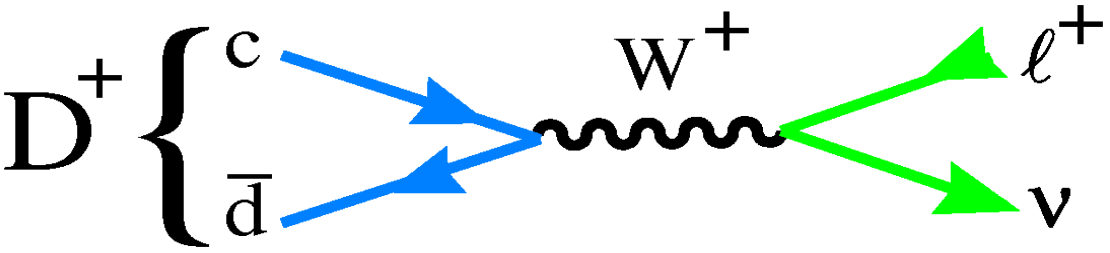


CKM Constraints

- The CLEO-c program impacts many of the CKM parameters
- In particular, leptonic D and D_s decays allow measurements of the decay constants
- This will help the determination of V_{td}



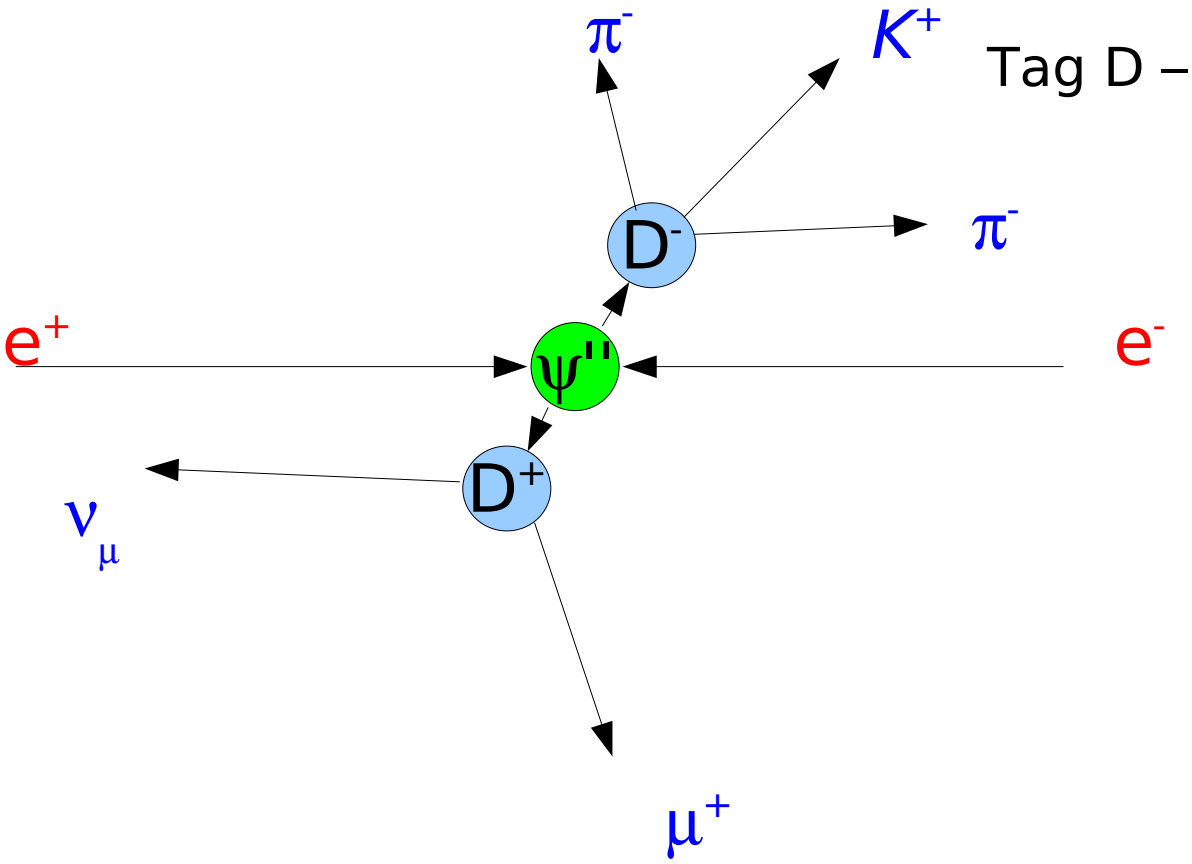
$D^+ \to \mu^+ \nu_\mu$ and f_{D^+}



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

- Rate of e:μ:τ is ~10^{-4}:1:2.65
- A precise measurement of f_{D^+} allows precise comparison with theoretical calculations, such as lattice QCD.
- This will help determining f_B .

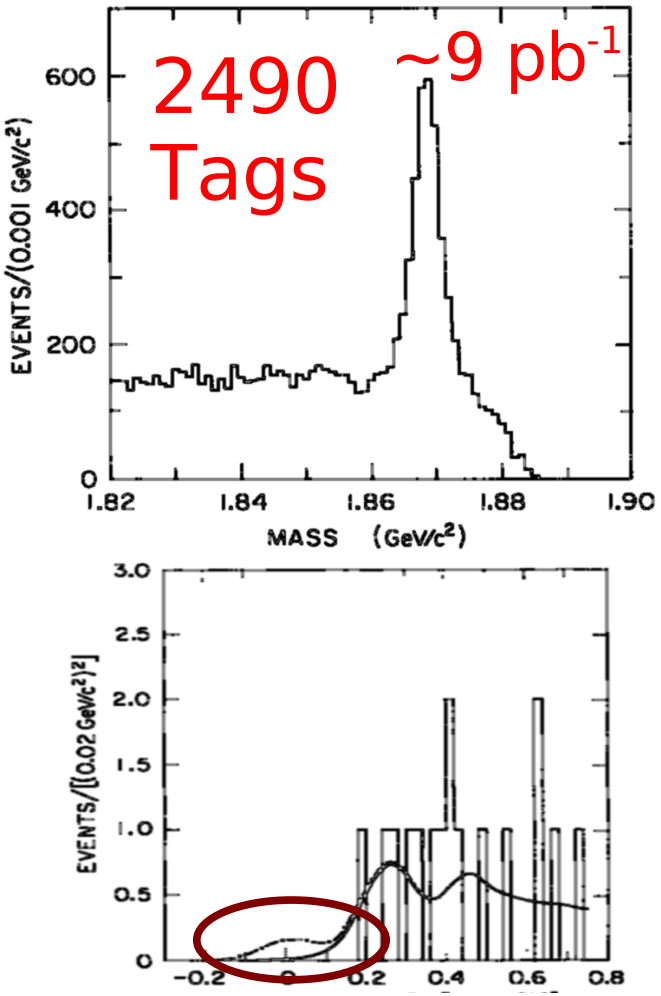
Analysis Technique



- At threshold produce only D^+D^-, no additional pions.
- Detect muon and make sure it recoiled against neutrino.
  - Extract signal in M^2_{miss} which peaks at 0.

MARK III and BES Results

MARK III

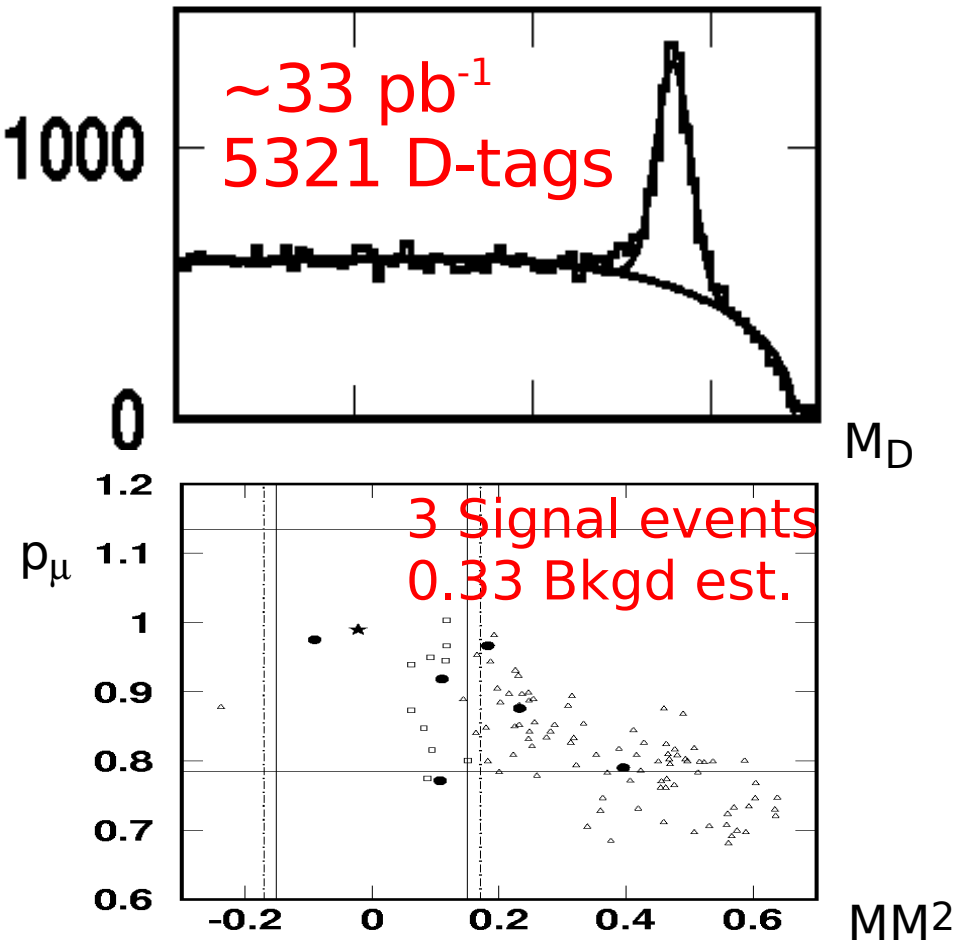


$B(D^+ \to \mu^+ \nu) < 7.2 \times 10^{-4}$

$f_D < 290\ \mathrm{MeV}$

PRD 60, 1375

BES II

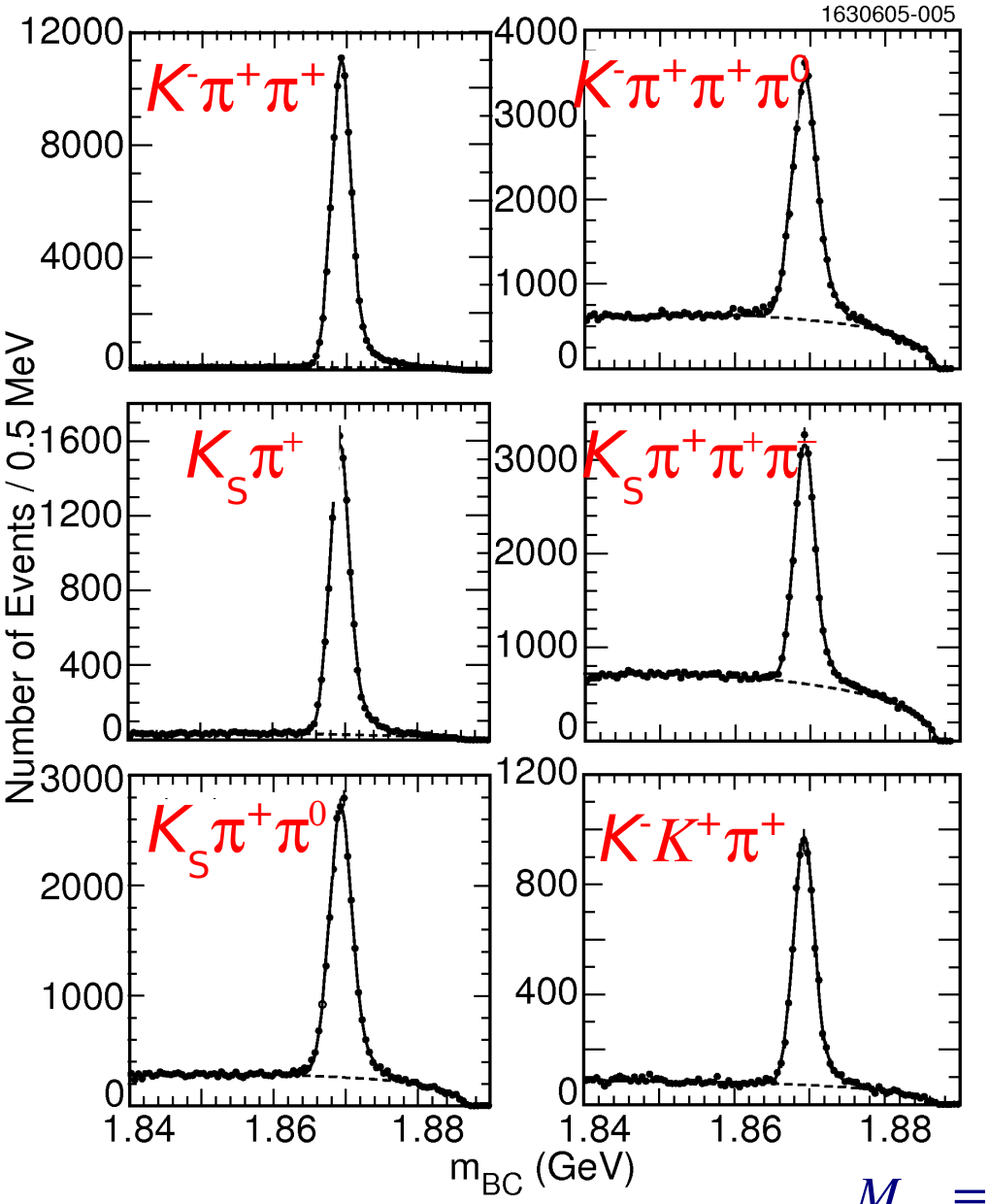


$B(D^+ \to \mu^+ \nu) = (12.2^{+11.1}_{-5.3} \pm 0.10) \times 10^{-4}$

$f_D = (371^{+129}_{-119} \pm 25)\ \mathrm{MeV}$

PLB 610 (2005), 183

CLEO-c *D*-tag Reconstruction



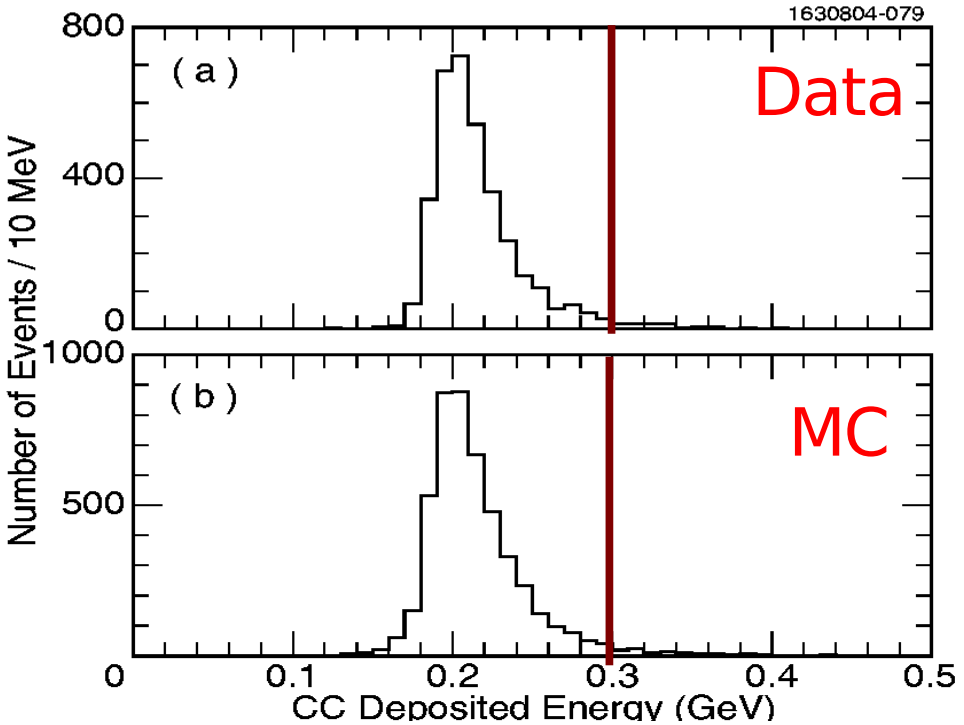
- 281 pb^{-1}
- Six tag modes used
- ~160,000 reconstructed $D^{\pm}$

Mode	Signal	Background
$K^+\pi^-\pi^-$	77387 ± 281	1868
$K^+\pi^-\pi^-\pi^0$	24850 ± 214	12825
$K_S\pi^-$	11162 ± 136	514
$K_S\pi^-\pi^-\pi^+$	18176 ± 255	8976
$K_S\pi^-\pi^0$	20244 ± 170	5223
$K^+K^-\pi^-$	6535 ± 95	1271
Sum	158354 ± 496	30677

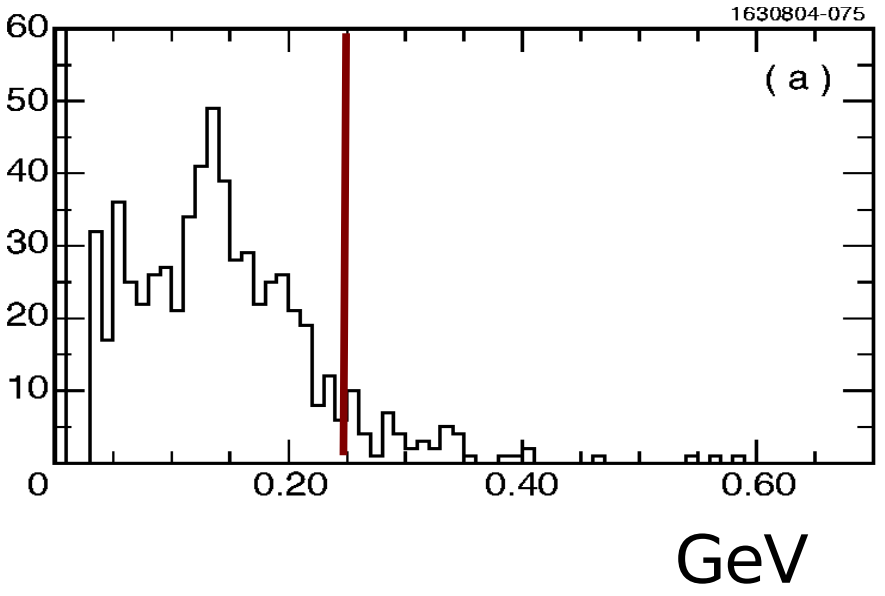
$$M_{BC}=\sqrt{E^2_{\text{beam}}-|p(D)|^2}$$

Signal Side Selection

- Require one track consistent with coming from the IP for the muon.
  - Muon candidate deposit less than 300 MeV in EM calorimeter
- No additional track from IP
- Veto background from $D^+ \to \pi^+ \pi^0$
  - Require no unmatched showers over 250 MeV



Highest energy unmatched cluster



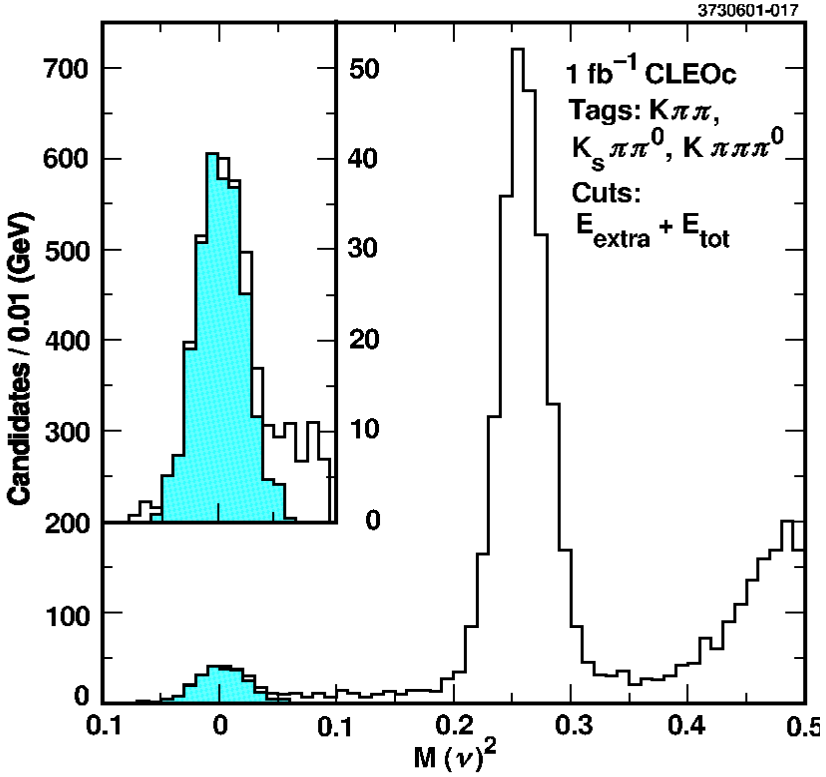
Signal Extraction

- For events with μ candidate form

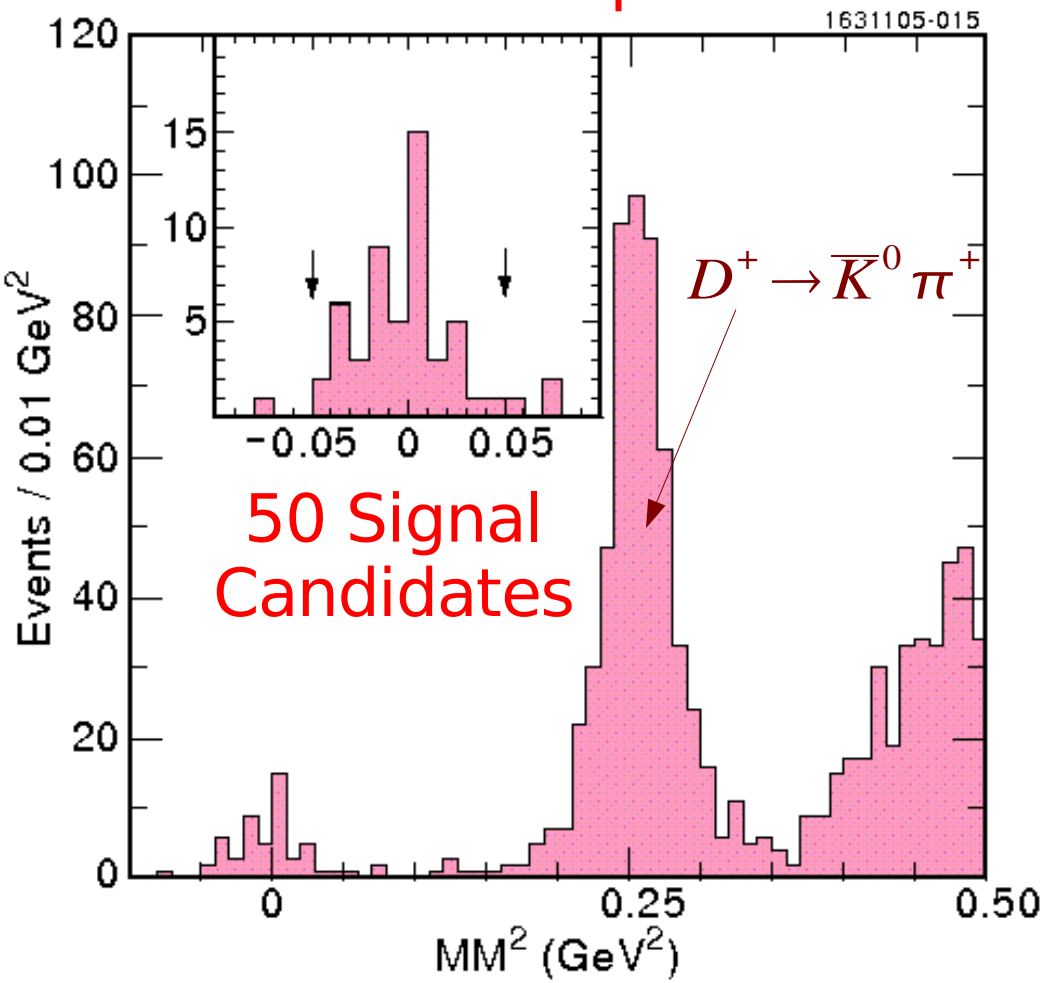
$$MM^2 = (E_{beam} - E_\mu)^2 - (-\vec{p}_{D^-} - \vec{p}_\mu)^2$$

- Signal will peak at $MM^2 = m^2_\nu = 0$

"Yellow book" MC Study



Data 281 pb^{-1}



$D^+ \to \mu^+ \nu_\mu$ Results

- 50 signal candidate events with the following backgrounds

Background	$\mathcal{B}$ (%)	# of events
$D^+ \to \pi^+\pi^0$	0.13 ± 0.02	$1.40 \pm 0.18 \pm 0.22$
$D^+ \to K^0\pi^+$	2.77 ± 0.18	$0.33 \pm 0.19 \pm 0.02$
$D^+ \to \tau^+\nu$	$2.6 \times \mathcal{B}(D^+ \to \mu^+\nu)$	$1.08 \pm 0.15 \pm 0.16$
$D^0\bar{D}^0,\ D^+D^-$	—	$< 0.4, < 0.4,$ 90% C.L.
continuum	—	< 1.2 90% C.L.
Total		$2.81 \pm 0.30 \pm^{+0.84}_{-0.27}$

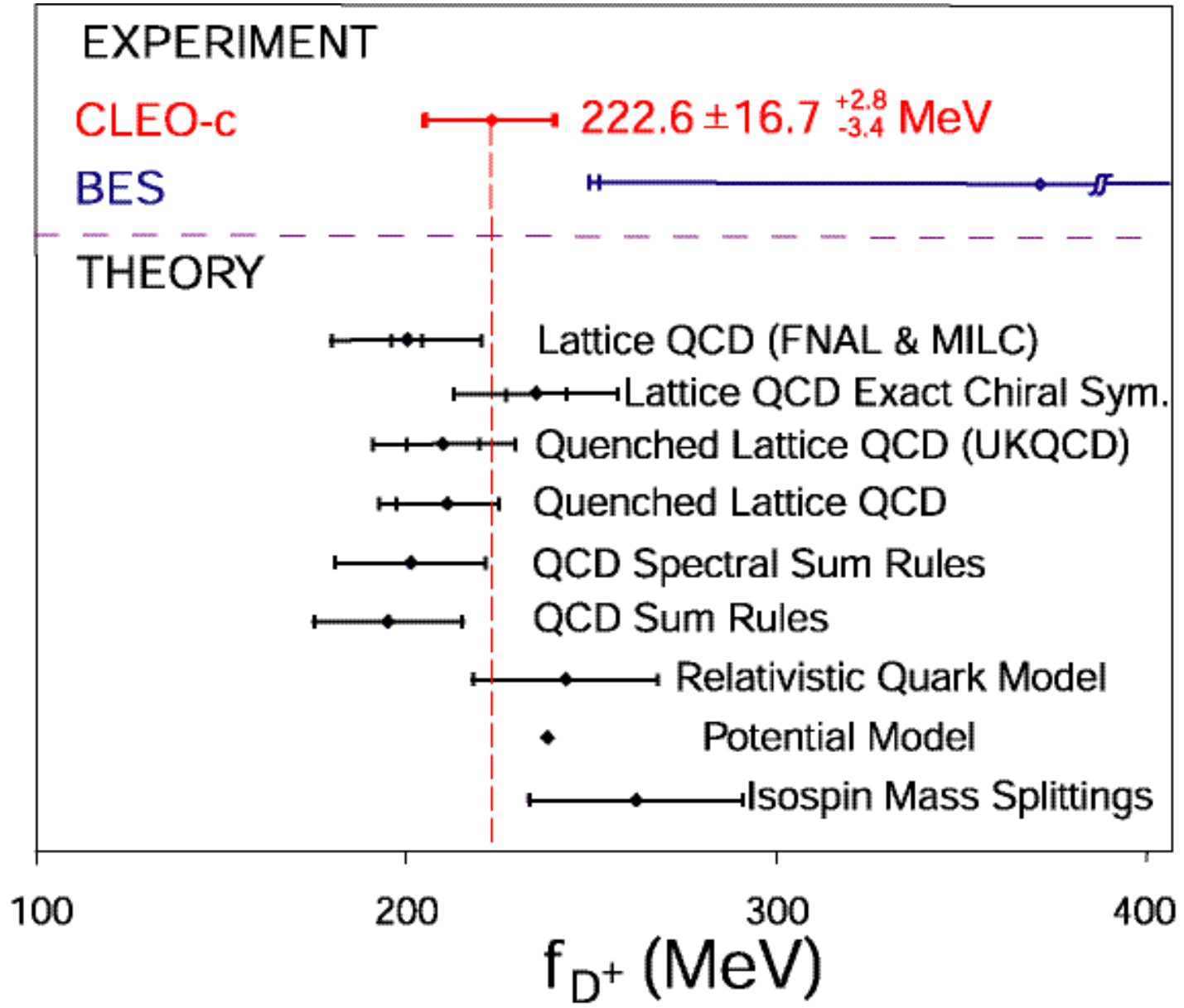
- With 158,354 D^+ tags and an efficiency of 67.7% for signal events to satisfy the selection criteria given a D^+ tag we obtain:

$$Br(D^+ \to \mu^+ \nu) = (4.40 \pm 0.66^{+0.09}_{-0.12}) \times 10^{-4} \qquad f_{D^+} = (222.6 \pm 16.7^{+2.8}_{-3.4})\ \text{MeV}$$

PRL 95, 251801 (2005)

- We also obtain $Br(D^+ \to e^+ \nu) < 2.4 \times 10^{-5}$ at 90 C.L.

Comparing with Theory



Search for $D \to \tau\nu_\tau$

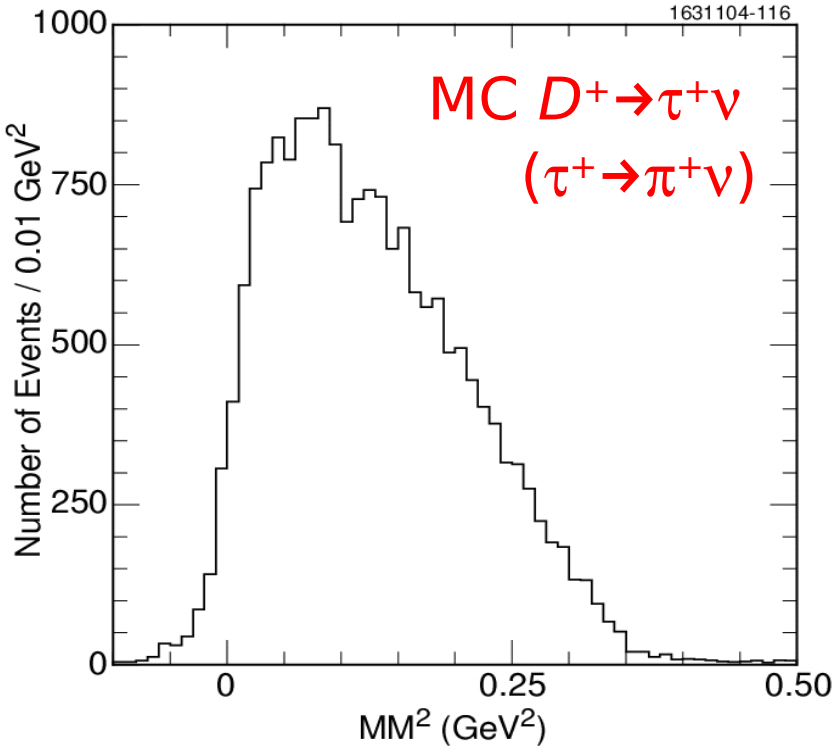
281pb^{-1} hep-ex/0604043

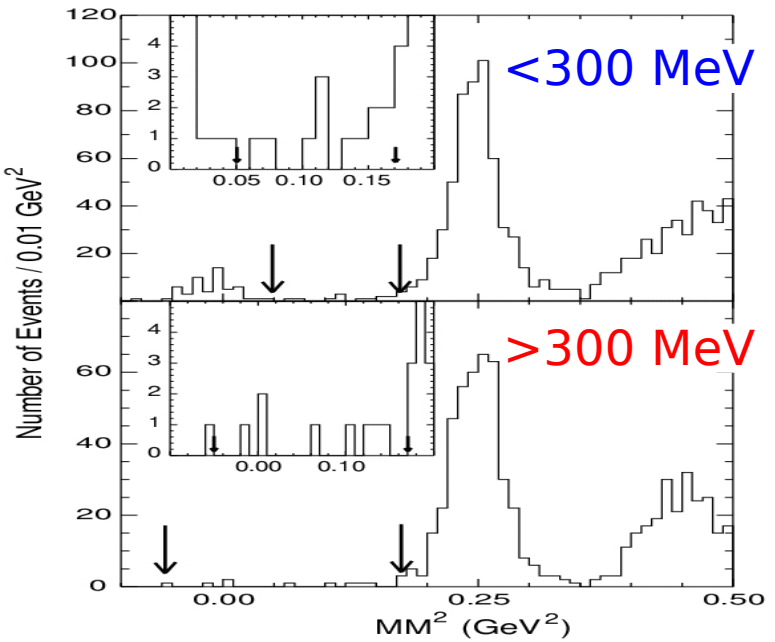
(accepted by PRD)

Look for $D^+ \to \tau^+\nu$ ($\tau^+ \to \pi^+\nu$) in events with tags selected as for $D^+ \to \mu^+\nu$.

Sample subdivided based on energy deposit of candidate track: (a) <300 MeV and (b) >300 MeV.

MM2 small due to m_τ close to m_D





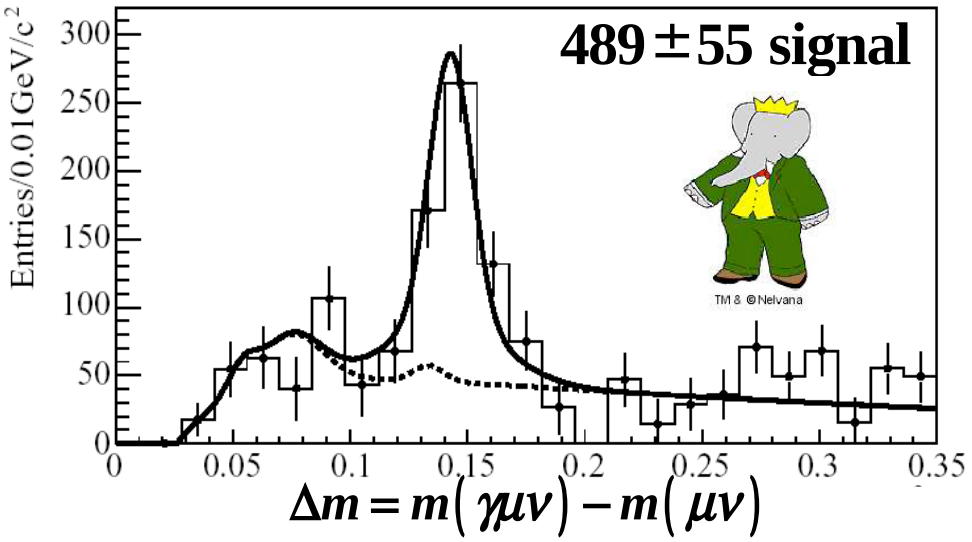
	(a)	(b)
Signal Region	12	8
Estimated BG	6.1± 0.6± 0.3	5.0± 0.6± 0.2
Net	5.9± 3.5± 0.3	3.0± 2.9± 0.2

$BF(D^+ \to \tau^+\nu) < 2.1 \times 10^{-3}$ (90%CL)

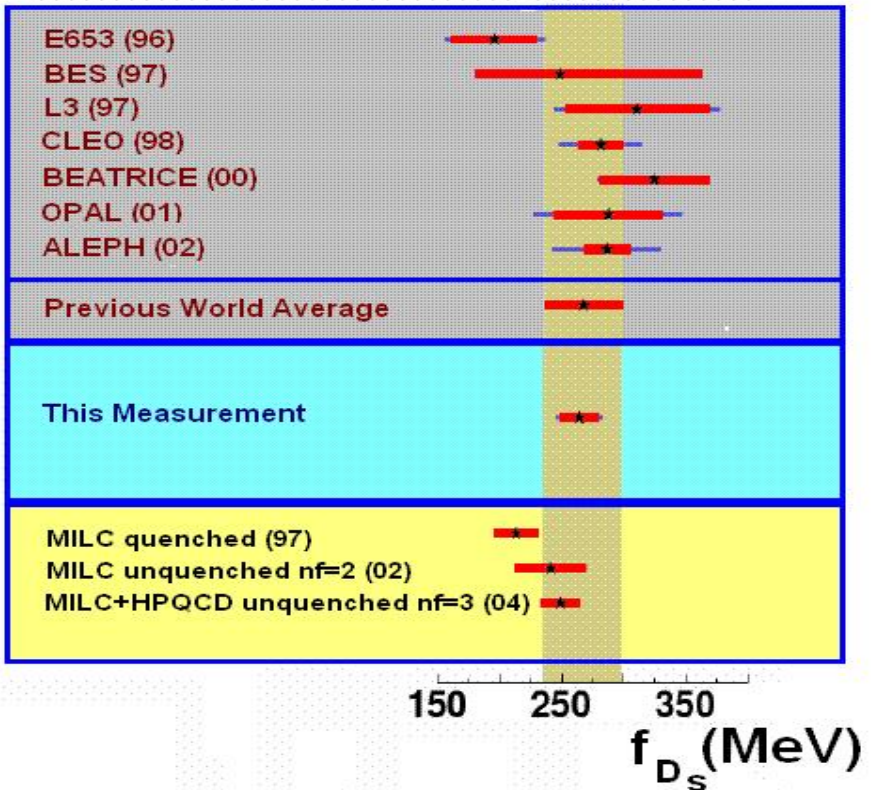
SM : $BF(D^+ \to \tau^+\nu) = (1.1 \pm 0.2) \times 10^{-3}$

$D_s \to \mu\nu_\mu$

- Current best measurement from BaBar (230 fb^{-1})
- Use D^0, D^+, D_s tags to get clean $e^+e^- \to c\bar{c}$ sample
- Have 489±55 $D_s \to \mu\nu_\mu$ candidates



From P. Patteri (Babar)



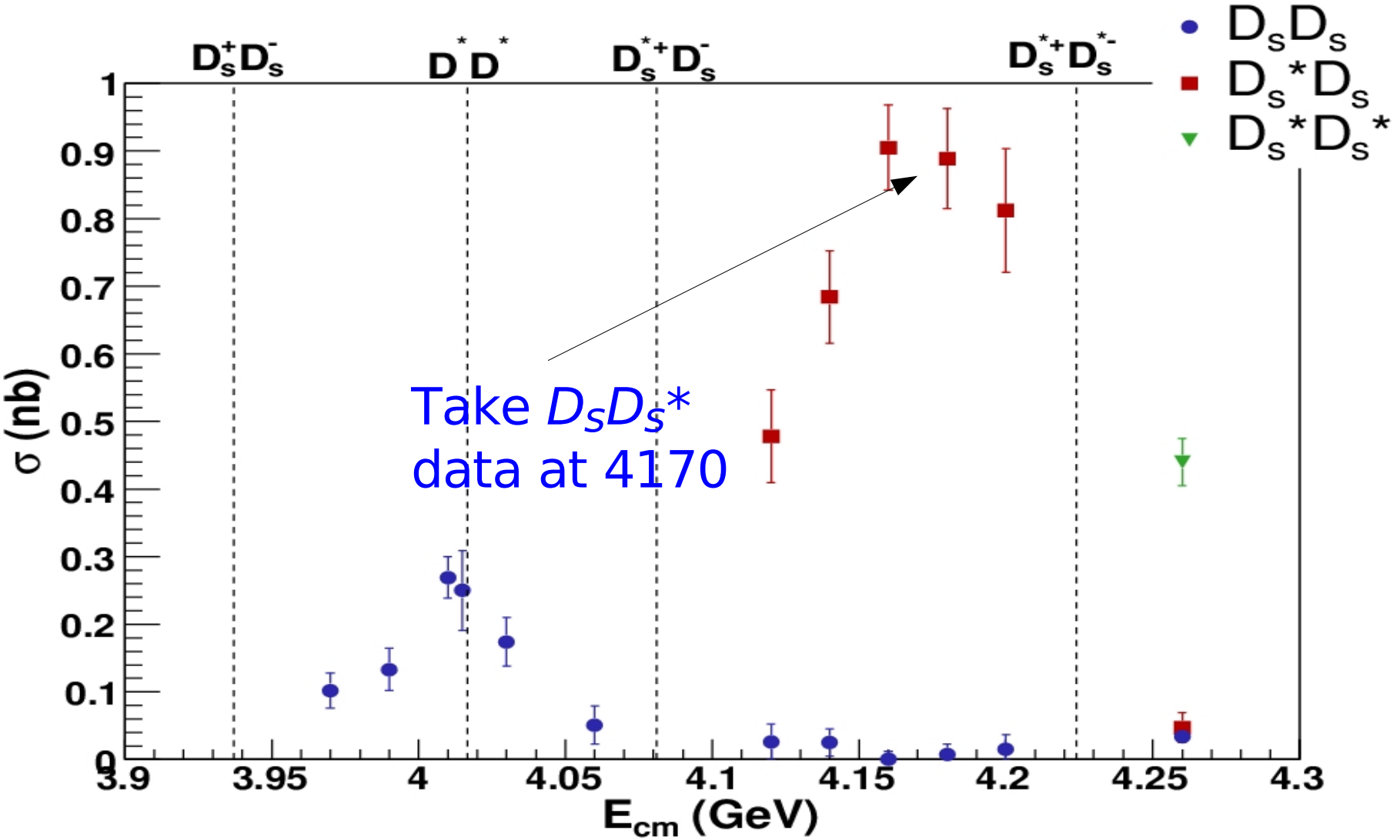
$$B(D_s^+ \to \mu^+ \nu_\mu) = (6.5 \pm 0.8 \pm 0.3 \pm 0.9) \times 10^{-3}$$

$$f_{D_s} = (279 \pm 17_{\text{stat}} \pm 6_{\text{syst}} \pm 19_{D_s \to \varphi\pi})\ \text{MeV}$$

$$f_{D_s}^{BaBar} / f_{D+}^{CLEO} = 1.25 \pm 0.14$$

(As expected from LQCD)

Scan Results: D_sD_s, $D_sD_s^*$, and $D_s^*D_s^*$



$D_s \to \mu\nu_\mu$ and $D_s \to \tau\nu_\tau$

- CLEO-c has recorded ~200 pb^{-1} at E_{cm}=4170
  - These data are being analyzed now – no results today.
  - P. Onyisi has shown hadronic branching fractions for D_s
- Will use the same tag technique as for $D^+ \to \mu\nu_\mu$.
  - The extra photon in $D_s^* D_s$ is not a significant complication.
- The cross-section for D_s is smaller than for D^+D^- and so is the efficiency for reconstructing a tag
  - But as this decay is not Cabibbo suppressed the signal yield (per pb^{-1}) should be at least as good as for $D^+ \to \mu\nu_\mu$.

Summary-Outlook

- CLEO-c has studied $D^+ \to \mu^+ \nu_\mu$ in 281 pb^{-1}
  - $Br(D^+ \to \mu^+ \nu) = (4.40 \pm 0.66^{+0.09}_{-0.12}) \times 10^{-4}$
  - $f_{D^+} = (222.6 \pm 16.7^{+2.8}_{-3.4})\,\mathrm{MeV}$
- Result is statistics limited
- Plans is to record ~750 pb^{-1} at $\psi(3770)$
  - Will measure f_{D+} to ~4.5%
- Have recorded ~200 pb^{-1} at $E_{cm} \approx 4170$ MeV
  - These data are now being analyzed
  - No results today
- Plan to take ~750 pb^{-1} at $E_{cm} \approx 4170$ MeV