Review of Charm Hadronic Decays and Lifetimes

Werner Sun, Cornell University (and CLEO-c)

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D^0, D^+, D_s^+ only

Branching fractions

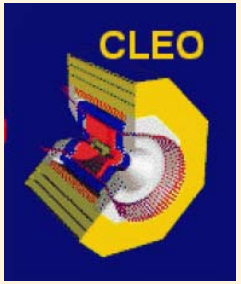
Amplitude analyses

D_s^+ lifetime

Introduction

- Topics covered reflect personal bias and new developments in past year or so.
  - Branching fractions for D^0, D^+, D_s^+ decays:
    - Important engineering numbers for B and B_s decays.
    - Overall normalization for $|V_{cb}|$.
  - Amplitude analyses of D^0 and D^+ decays:
    - Probes of strong phases.
    - Probes of D^0-$\overline{D^0}$ mixing (not discussed).
  - Lifetimes
    - Tests of theory.
    - Probes of D^0-$\overline{D^0}$ mixing (not discussed).
- Topics not covered (sorry!)
  - Charmed baryons
    - Belle's recent observation of orbitally excited $\Xi_{cx}(2980)^+$, $\Xi_{cx}(3077)^+$, and $\Xi_{cx}(3077)^0$ decaying to $\Lambda_c^+ K^- \pi^+$ and $\Lambda_c^+ K^0_S \pi^+$ [hep-ex/0606051].
  - $D_{sJ}^*(2317)^+$, $D_{sJ}(2463)^+$, and $D_{sJ}^*(2632)^+$

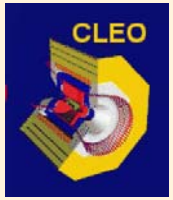
The Experiments



- *B* factories: BABAR & Belle
  - E_{cm} ~ 10.6 GeV.
  - Copious charm production in continuum and *B* decays, many states available.
  - Initial state unknown (no absolute $\mathcal{B}$s).
  - Slow pion from D^{*+} tags flavor of D^0 daughter.
- Charm factories: CLEO-c & BES
  - E_{cm} ~ 3.773 GeV and above: $D\bar{D}$ pair production.
  - Charm cross section higher, but $\mathcal{L}$ much lower.
  - Known initial state, low-multiplicity, low background.
- Fixed target experiments: FOCUS & SELEX
  - Huge charm cross sections, but high backgrounds.
  - Limited π^0 and K^0_S reconstruction efficiency.
- CDF and D0—see P. Karchin's talk

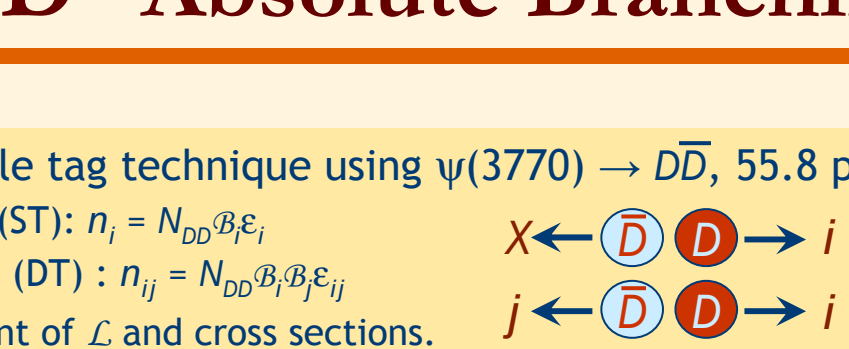
- Different sources of uncertainties make for complementary analyses.
- Many thanks to spokespersons and analysis coordinators.

Cabibbo-Favored Decays



D^0/D^+ Absolute Branching Fractions

- MARK III double tag technique using $\psi(3770) \to D\bar{D}$, 55.8 pb^{-1} [PRL 95, 121801 (2005)].
  - Single tag (ST): $n_i = N_{DD}\mathcal{B}_i\varepsilon_i$
  - Double tag (DT) : $n_{ij} = N_{DD}\mathcal{B}_i\mathcal{B}_j\varepsilon_{ij}$
  - Independent of $\mathcal{L}$ and cross sections.
  - Scale of statistical error set by sum of DT yields.
  - Combine ST and DT yields in χ^2 fit for $\mathcal{B}$ and $N_{D\bar{D}}$.
  - Many D $\mathcal{B}$s measured relative to $\mathcal{B}(K^-\pi^+)$ or $\mathcal{B}(K^-\pi^+\pi^+)$.
- To be updated soon with 281 pb^{-1}.

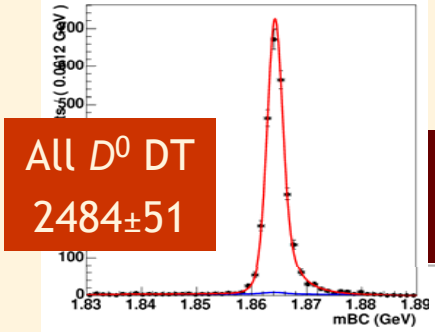


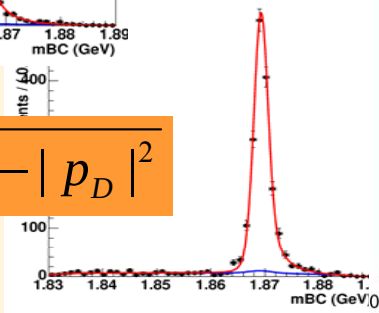
$$\Rightarrow B_i \approx \frac{n_{ij}}{n_j}\frac{\varepsilon_j}{\varepsilon_{ij}} \qquad N_{DD} \approx \frac{n_i n_j}{n_{ij}}\frac{\varepsilon_{ij}}{\varepsilon_i\varepsilon_j}$$

$N_{D^0\bar{D}^0}$	(2.01±0.04±0.02)x10^5
$\mathcal{B}(K^-\pi^+)$	**(3.91±0.08±0.09)%**
$\mathcal{B}(K^-\pi^+\pi^0)$	(14.9±0.3±0.5)%
$\mathcal{B}(K^-\pi^+\pi^+\pi^-)$	(8.3±0.2±0.3)%
$N_{D^+D^-}$	(1.56±0.04±0.01)x10^5
$\mathcal{B}(K^-\pi^+\pi^+)$	**(9.5±0.2±0.3)%**
$\mathcal{B}(K^-\pi^+\pi^+\pi^0)$	(6.0±0.2±0.2)%
$\mathcal{B}(K^0_S\pi^+)$	(1.55±0.05±0.06)%
$\mathcal{B}(K^0_S\pi^+\pi^0)$	(7.2±0.2±0.4)%
$\mathcal{B}(K^0_S\pi^+\pi^-\pi^+)$	(3.2±0.1±0.2)%
$\mathcal{B}(K^+K^-\pi^+)$	(0.97±0.04±0.04)%
$\sigma(D^0D^0)$	$(3.60\pm0.07^{+0.07}_{-0.05})$ nb
$\sigma(D^+D^-)$	$(2.79\pm0.07^{+0.10}_{-0.04})$ nb
$\sigma(+-)/\sigma(00)$	$0.776\pm0.024^{+0.014}_{-0.008}$

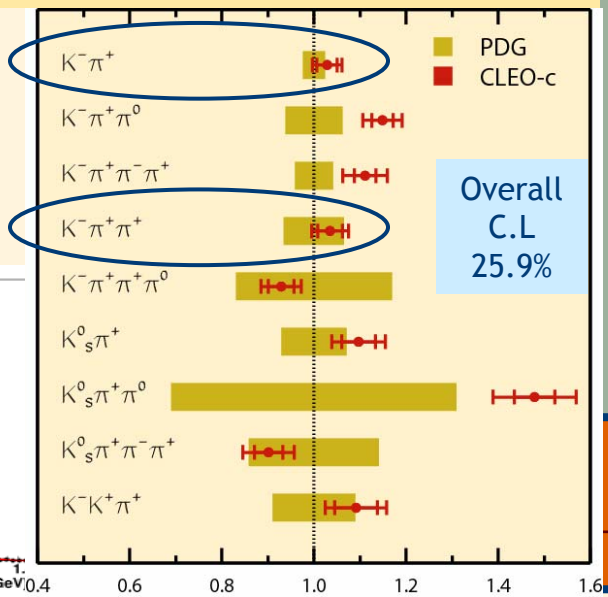
All D^0 DT 2484±51

All D^+ DT 1650±42



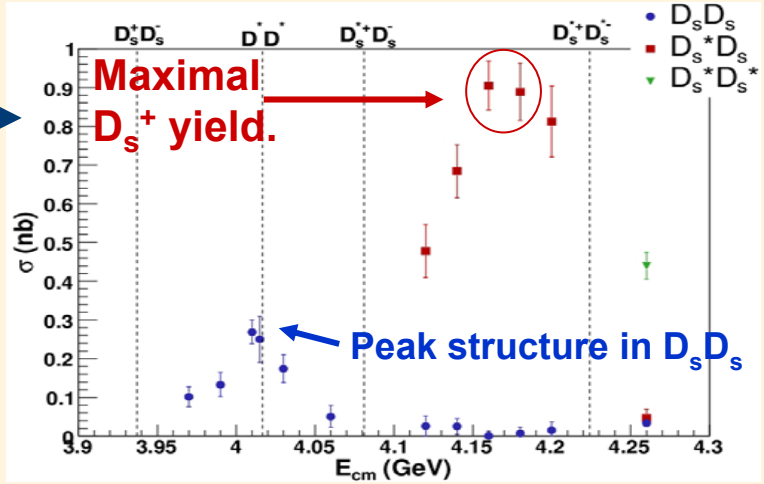


$$M_{BC} = \sqrt{E^2_{beam} - |\,p_D\,|^2}$$

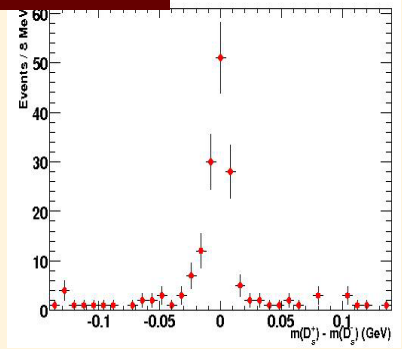


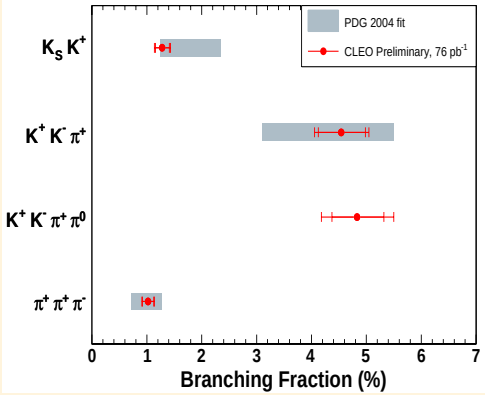
D_s^+ Absolute Branching Fractions

- Same basic technique as for D^0/D^+.
- Fall 2005: energy scan of 12 points in E_{cm} ~ 4 GeV region (60 pb^{-1}).
- $\mathcal{B}$s use 76 pb^{-1}, mostly taken at E_{cm} = 4.17 GeV; use $D_s^{*+}D_s^-$ instead of $D_s^+D_s^-$.
- Current precision: $\sigma_{\mathcal{B}}$ = 11%.
- $\sigma_{\mathcal{B}}$ < 4% with full CLEO-c dataset.
- $D_s^+ \to \phi\pi^+$ is one component of $K^+K^-\pi^+$.
  - Previous measurements ignored $f_0\pi^+$ (not high enough precision to matter).
  - Now, need Dalitz analysis to disentangle contributions.



All D_s^+ DT 118±12





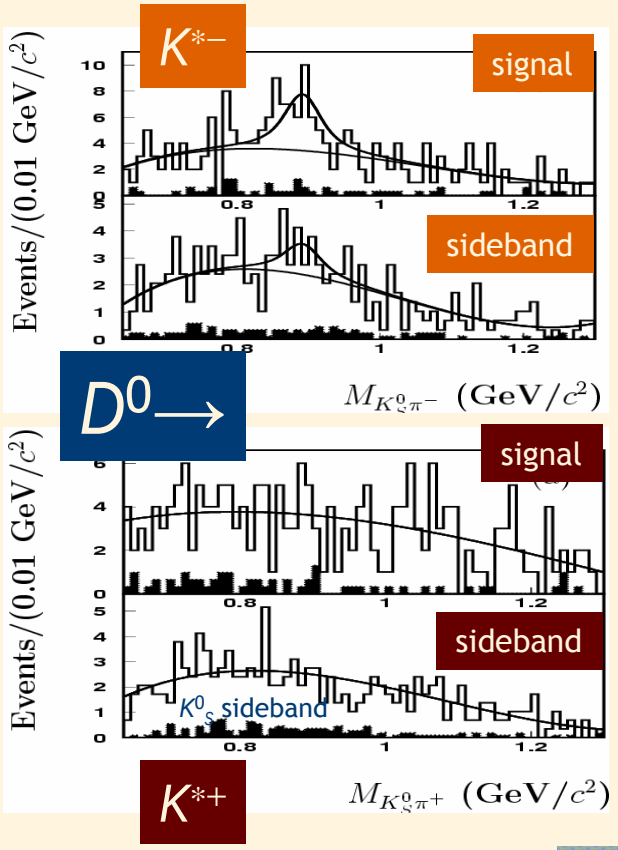
PRELIMINARY

Mode	$\mathcal{B}$ (%) (CLEO-c)	$\mathcal{B}$ (%) (PDG)
$K^0_SK^+$	$1.28\ ^{+0.13}_{-0.12}\pm0.07$	1.80±0.55
$K^+K^-\pi^+$	$4.54\ ^{+0.44}_{-0.42}\pm0.25$	4.3±1.2
$K^+K^-\pi^+\pi^0$	$4.83\ ^{+0.49}_{-0.47}\pm0.46$	---
$\pi^+\pi^+\pi^-$	$1.02\ ^{+0.11}_{-0.10}\pm0.05$	1.00±0.28

Inclusive D → K(*)X

- Probe relative strength of CF $D \to K^{(*)}$ and CS $\bar{D} \to K^{(*)}$.
- 33 pb^{-1} near $\psi(3770)$.
  - Tag one side, reconstruct $K^{(*)}$ on other side, subtract M_{BC} sidebands.

Mode	$\mathcal{B}$ (%) (BES)	$\mathcal{B}$ (%) (PDG)
$D^0 \to \bar{K}^{*0}X$	$8.7 \pm 4.0 \pm 1.2$	[PLB 625, 196 (2005)]
$D^+ \to \bar{K}^{*0}X$	$23.2 \pm 4.5 \pm 3.0$	
$D^0 \to K^{*0}X$	$2.8 \pm 1.2 \pm 0.4$	
$D^+ \to K^{*0}X$	< 6.6 (90% CL)	
$D^0 \to K^{*-}X$	$15.3 \pm 8.3 \pm 1.9$	[PRELIMINARY]
$D^+ \to K^{*-}X$	$5.7 \pm 5.2 \pm 0.1$	
$D^0 \to K^{*+}X$	< 3.6 (90% CL)	
$D^+ \to K^{*+}X$	< 20.3 (90% CL)	
$D^0 \to K^0/\bar{K}^0X$	$47.6 \pm 4.8 \pm 3.0$	42 ± 5
$D^+ \to K^0/\bar{K}^0X$	$62.5 \pm 5.6 \pm 3.4$	59 ± 7



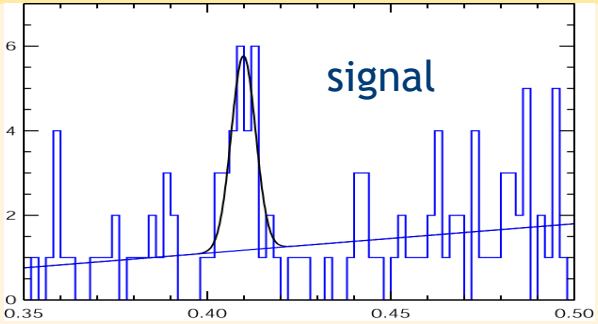
Inclusive $D_{(s)} \to \{\eta, \eta', \phi\}X$

- Inclusive $s\bar{s}$ rates expected to be higher for D_s^+ than D^0/D^+.
- $\mathcal{B}$s help determine B_s^0 production rate at $\Upsilon(5S)$.
- CLEO-c measurements with 281 pb^{-1} D^0/D^+ and 71 pb^{-1} D_s^+.
  - Tag one side, reconstruct η, η', ϕ on other side, subtract sidebands.

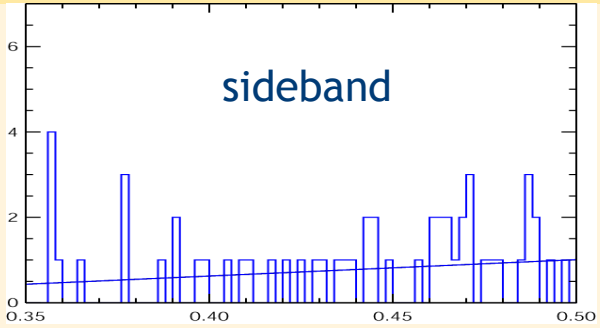
$\mathcal{B}$	η (%)	η' (%)	ϕ (%)
D^0	9.4 ± 0.4 ± 0.6	2.6 ± 0.2 ± 0.2	1.0 ± 0.1 ± 0.1
D^+	5.7 ± 0.5 ± 0.5	1.0 ± 0.2 ± 0.1	1.1 ± 0.1 ± 0.2
D_s^+	32.0 ± 5.6 ± 4.7	11.9 ± 3.3 ± 1.2	15.1 ± 2.1 ±1.5

  - η includes feeddown from η'.
  - Saturated by exclusive modes for D_s^+.

PRELIMINARY



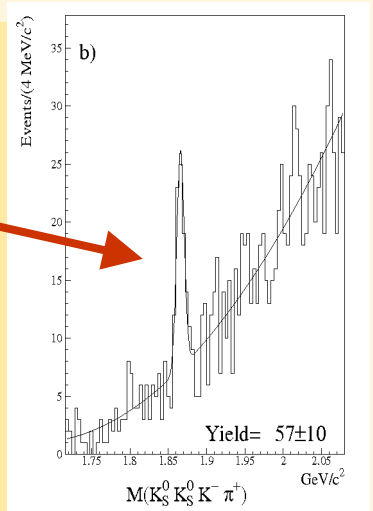
$D_s^+ \to \eta' X$: η-η' mass difference (GeV)

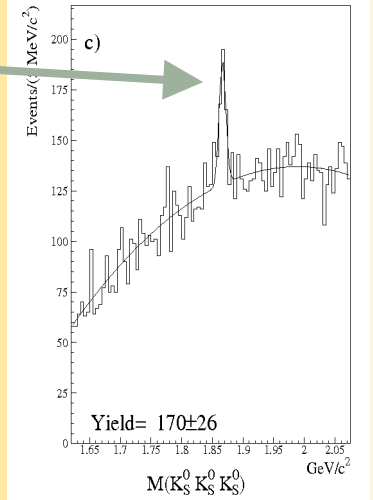


$D^0 \to$ Three Kaons + X

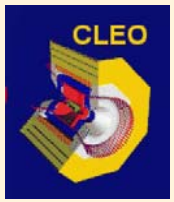
- $D^0, \bar{D}^0 \to K^0_S K^0_S K^+ \pi^-$
  - First observation.
  - Two CF modes: $D^0 \to \bar{K}^0 \bar{K}^0 K^+ \pi^-$, $\bar{K}^0 K^0 K^- \pi^+$
  - Distinguished with D^{*+} tag, both observed.
    - Assuming no contribution from CS mode $\bar{K}^0 K^0 K^+ \pi^-$.
  - $\mathcal{B}(K^0_S K^0_S K^+ \pi^-) = (6.1 \pm 1.1 \pm 0.7) \times 10^{-4}$
  - No evidence for substructure.
- $D^0 \to K^0_S K^0_S K^0_S$
  - Only proceeds via *W*-exchange or final state interactions.
  - $\mathcal{B}(K^0_S K^0_S K^0_S) = (10.4 \pm 1.6 \pm 1.7) \times 10^{-4}$
  - [PDG = $(9.2 \pm 1.6) \times 10^{-4}$]
  - No evidence for substructure.

[PLB 607, 56 (2005)]





Cabibbo-Suppressed Decays



$D^{0/+}$: Pionic Modes

[PRL 96, 081802 (2006)]
[hep-ex/0605044]
[PLB 622, 6 (2005)]

- Many new $\mathcal{B}$ measurements, rich resonant substructure.

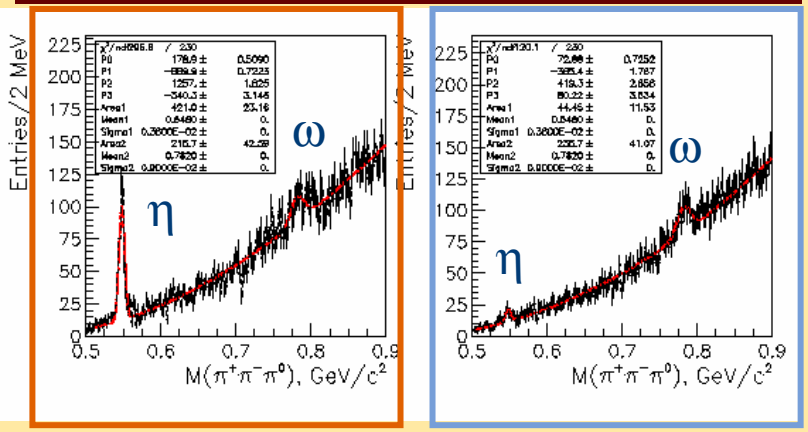
$\mathcal{B}$ (10^{-3})	CLEO-c	BABAR	BES	PDG04
$\pi^+\pi^-$	1.39 ± 0.04 ± 0.03		1.31 ± 0.27 ± 0.04	1.38 ± 0.05
$\pi^0\pi^0$	0.79 ± 0.05 ± 0.04			0.84 ± 0.22
$\pi^+\pi^-\pi^0$	13.2 ± 0.2 ± 0.5			11 ± 4
$\pi^0\pi^0\pi^0$	< 0.35 (90% CL)			---
$\pi^+\pi^+\pi^-\pi^-$	7.3 ± 0.1 ± 0.3		6.4 ± 1.5 ± 0.4	7.3 ± 0.5
$\pi^+\pi^-\pi^0\pi^0$	9.9 ± 0.6 ± 0.7			---
$\pi^+\pi^+\pi^-\pi^-\pi^0$	4.1 ± 0.5 ± 0.2			---
$\pi^+\pi^0$	1.25 ± 0.06 ± 0.08	1.22 ± 0.10 ± 0.11		1.33 ± 0.22
$\pi^+\pi^+\pi^-$	3.35 ± 0.10 ± 0.20		3.9 ± 1.0 ± 0.3	3.1 ± 0.4
$\pi^+\pi^0\pi^0$	4.8 ± 0.3 ± 0.4			---
$\pi^+\pi^+\pi^-\pi^0$	11.6 ± 0.4 ± 0.7			---
$\pi^+\pi^+\pi^+\pi^-\pi^-$	1.60 ± 0.18 ± 0.17			1.82 ± 0.25

CLEO-c isospin analysis of $\pi\pi$:
$A_2/A_0 = 0.420 \pm 0.014 \pm 0.010$
$\cos\delta = 0.062 \pm 0.048 \pm 0.058$
Evidence for final state interactions.

Substructure in D → n(π^+) m(π^0)

- Also search for η, ω contributions [PRL 96, 081802 (2006)]
  - Compare $M(\pi^+\pi^-\pi^0)$ in $\Delta E = E_{cand} - E_{beam}$ **signal** and **sideband** regions.

$D^+ \to \pi^+\pi^+\pi^-\pi^0$



Mode	$\mathcal{B}$ (x10^{-3})	PDG (x10^{-3})
$\omega\pi^+\pi^-$	1.7 ± 0.5 ± 0.2	---
$\eta\pi^0$	0.62 ± 0.14 ± 0.05	---
$\pi^0\pi^0\pi^0$	< 0.35 (90% CL)	---
$\omega\pi^0$	< 0.26 (90% CL)	---
$\eta\pi^+\pi^-$	< 1.9 (90% CL)	---
$\eta\pi^+$	3.61 ± 0.25 ± 0.26	3.0 ± 0.6
$\omega\pi^+$	< 0.34 (90% CL)	---

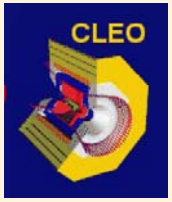
$D^{0/+}$: Kaonic Modes

[PLB 610, 225 (2005)]
[PLB 607, 56 (2005)]
[PLB 622, 6 (2005)]
[PRL 95, 121801 (2005)]

$\mathcal{B}$ (10^{-3})	FOCUS	BES	CLEO-c	PDG04
K^+K^-		4.68±0.42±0.18		3.90±0.12
$K^0\bar{K}^0$	0.84±0.19±0.11			0.74±0.14
$K^+K^-\pi^+\pi^-$	2.39±0.09±0.09	3.6±1.5±0.4		2.49±0.23
$K^0_SK^0_S\pi^+\pi^-$	1.2±0.2±0.2			1.27±0.24
$K^+\bar{K}^0$		6.64±1.11±0.41		5.7±0.5
$K^+K^-\pi^+$		11.0±1.2±0.7	9.7±0.4±0.4	8.9±0.8

- No SU(3) triangle for $K\bar{K}$:
  - $K^0\bar{K}^0$ vanishes in SU(3) limit—contributions only from SU(3) breaking and final state interactions.

Doubly-Cabibbo-Suppressed Decays



D^0 Decays

[PRL 96, 151801 (2006)] [PLB 618, 23 (2005)]
[PRL 95, 231801 (2005)] [hep-ex/0605027]
[hep-ex/0605046]

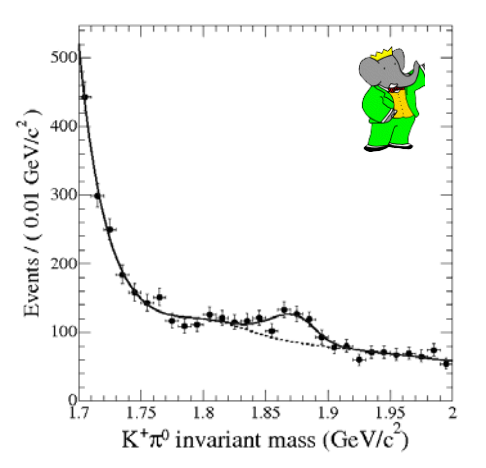
- For D^0, DCS final state is "wrong-sign" relative to CF decay.
- R_D = DCS/CF rate ratio ~ $O(\tan^4\theta_C)$
- BUT, possible contribution from mixing
  - $x = \Delta M/\Gamma$, $y = \Delta\Gamma/2\Gamma$ $\quad R_{WS} = R_D + \sqrt{R_D}\,y' + (x'^2 + y'^2)/2$
  - {x',y'} are {x,y} rotated by DCS/CF relative strong phase.
  - Phase can be measured via quantum correlations at $\psi(3770)$.
    - For $K\pi$, CLEO-c finds $\cos\delta = 1.09 \pm 0.66$ [Preliminary, hep-ex/0603031]
- Quoted values of R_D assume no mixing or CP violation.

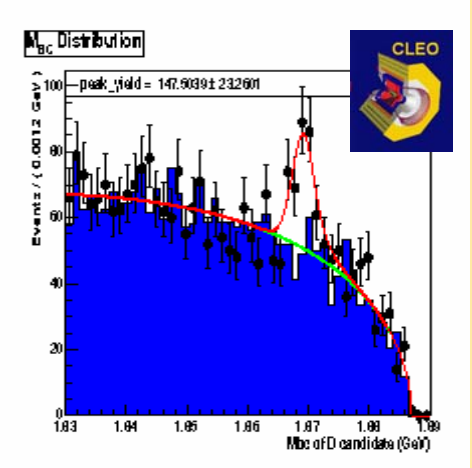
R_D (10^{-3})	$K^-\pi^+$	$K^-\pi^+\pi^0$	$K^-\pi^+\pi^-\pi^+$
Belle	$3.77 \pm 0.08 \pm 0.05$	$2.29 \pm 0.15 \pm {}^{+0.13}_{-0.09}$	$3.20 \pm 0.18 \pm {}^{+0.18}_{-0.13}$
BABAR		$2.14 \pm 0.08 \pm 0.08$	
FOCUS	$4.29\ {}^{+0.63}_{-0.61} \pm 0.27$	DCS mostly $K^{*+}\pi^-$ CF mostly $K^-\rho^+$	
CDF	$4.05 \pm 0.21 \pm 0.11$		
PDG	3.62 ± 0.29	$4.3\ {}^{+1.1}_{-1.0} \pm 0.7$	4.2 ± 1.3

D^+ Decays

- The DCS decay $D^+ \to K^+\pi^0$ has no CF counterpart.
- Recently observed by BABAR, confirmed by CLEO-c.

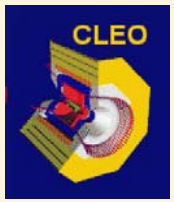
$\mathcal{B}$ (10^{-4})	BABAR [hep-ex/0605044]	CLEO-c PRELIMINARY
$K^+\pi^0$	$2.46 \pm 0.46 \pm 0.24 \pm 0.16$	$2.14 \pm 0.34 \pm 0.11 \pm 0.07$





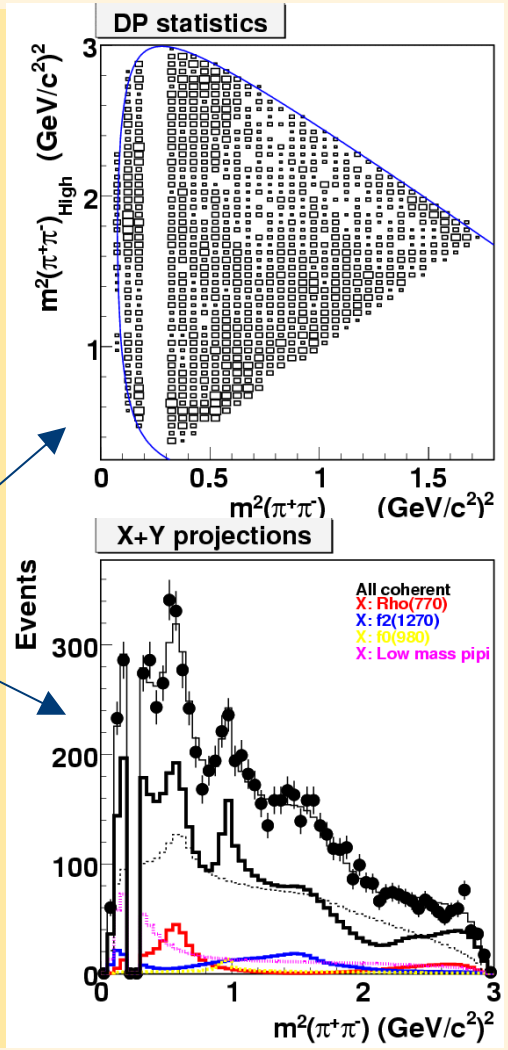
- Last uncertainty from reference $\mathcal{B}(D^+ \to K^-\pi^+\pi^+)$.

Amplitude Analyses



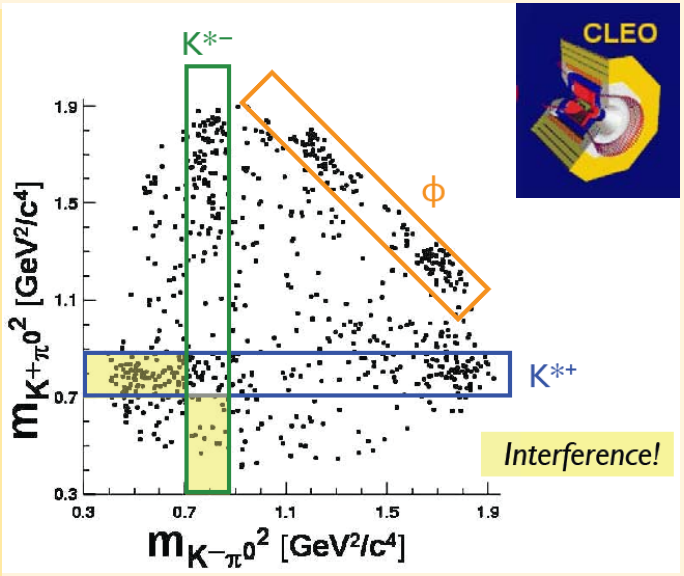
$D \to \pi\pi\pi$ Dalitz Analyses

- Decay amplitudes parametrized as sum of interfering Breit-Wigners.
- $D \to \pi^+\pi^-\pi^0$ (CLEO II.V) [PRD 72, 031102 (2005)]
  - Also used *K*-matrix parametrization of $\pi^+\pi^-$ S-wave—no evidence found.
- $D \to \pi^+\pi^-\pi^+$ (CLEO-c) PRELIMINARY
  - Results agree with E791 [PRL 86, 770 (2001)] and FOCUS [PLB 585, 200 (2004)]
  - In particular, σ fit fraction = $(41.8 \pm 1.4 \pm 2.5)\%$
    - Parametrized by complex pole: $A = 1/[\ (0.47\text{-}0.22i)\text{GeV}^2 - m^2(\pi^+\pi^-)]$.

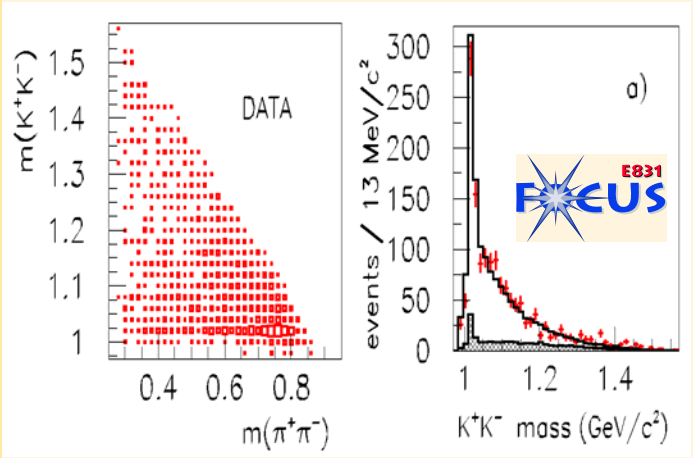


$D \to KK\pi(\pi)$ Dalitz Analyses

- $D \to K^+K^-\pi^0$ (CLEO III) [hep-ex/0606045, submitted to PRD]
  - K^{*0} and $\bar{K}^{*0}$ strong phase needed to extraction CKM parameter γ/ϕ_3 [Grossman, Ligeti, Soffer, PRD 67, 071301 (2003)].
  - Measured to be $(332 \pm 8 \pm 11)^o \to$ nearly maximal destructive interference.
  - $r_D = 0.52 \pm 0.05 \pm 0.04$



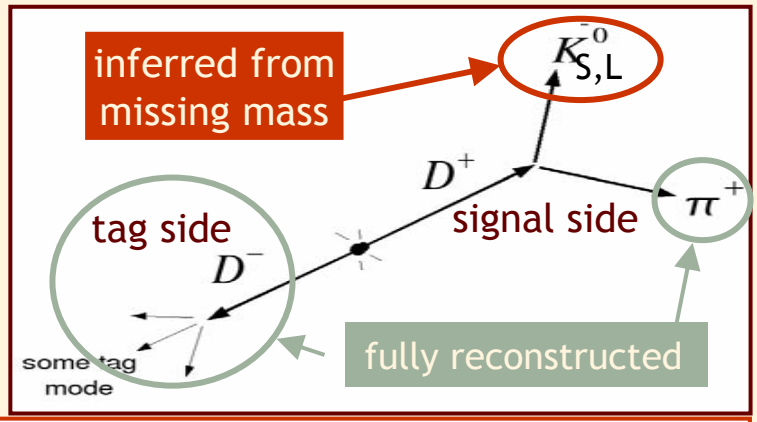
- $D \to K^+K^-\pi^+\pi^-$ (FOCUS) [PLB 610, 225 (2005)]
  - Dominated by
    AP: $K_1(1270)^+K^-$ (33%), $K_1(1400)^+K^-$ (22%),
    VV: $\rho^0\phi$ (29%).
  - In K^+K^- spectrum, ϕ line shape distorted by $f_0(980)$.

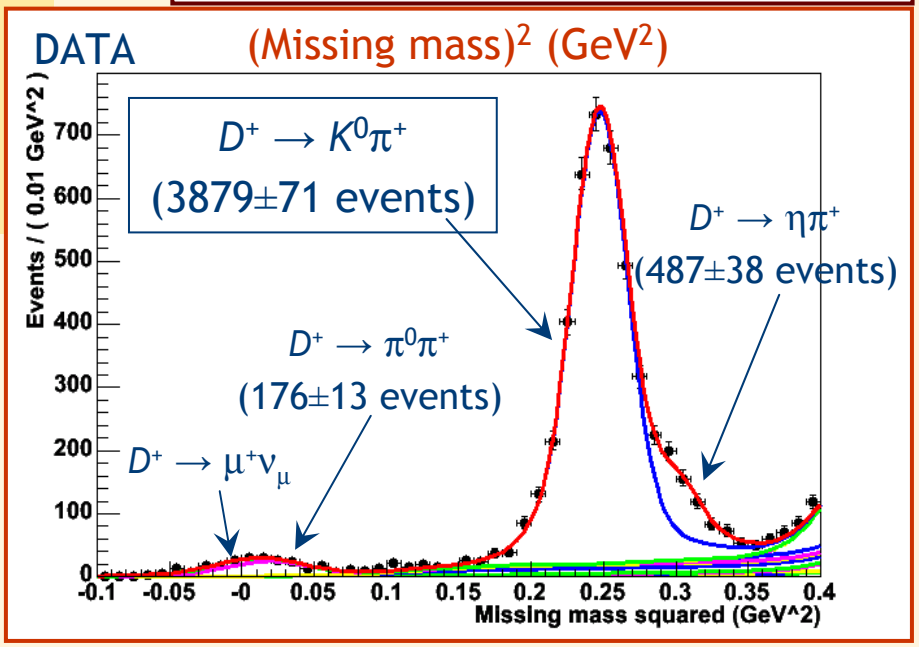


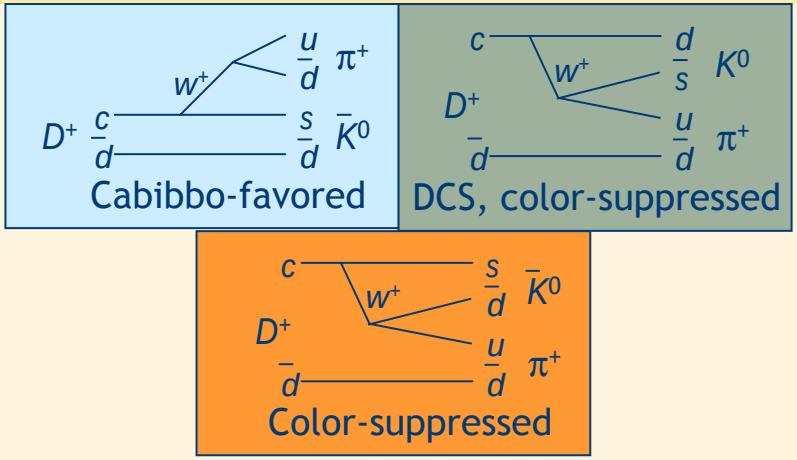
$D^+ \to K^0_{S,L}\pi^+$

PRELIMINARY

- CF/DCS interference switches sign between K^0_L and $K^0_S \to \mathcal{B}$ asymmetry.
  - Could be $O(10\%)$ [Bigi & Yamamoto, PLB 349 (1995) 363-366].
  - Depends on relative strong phases between amplitudes.
- Reconstruct $K^0_S + K^0_L$ inclusively in missing mass recoiling against π^+.
- $\mathcal{B}(D^+ \to K^0_S\pi^+) + \mathcal{B}(D^+ \to K^0_L\pi^+) = (3.06 \pm 0.06 \pm 0.16)\%$
- Asymmetry = $(K^0_L - K^0_S)/(K^0_L + K^0_S)$ $= -0.01 \pm 0.04 \pm 0.07$







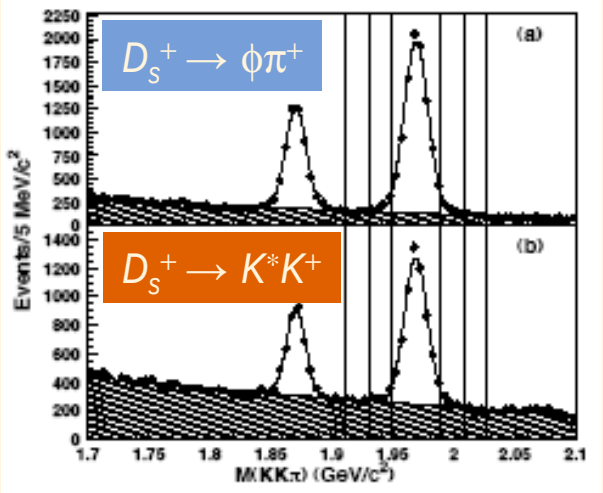
D_s^+ Lifetime

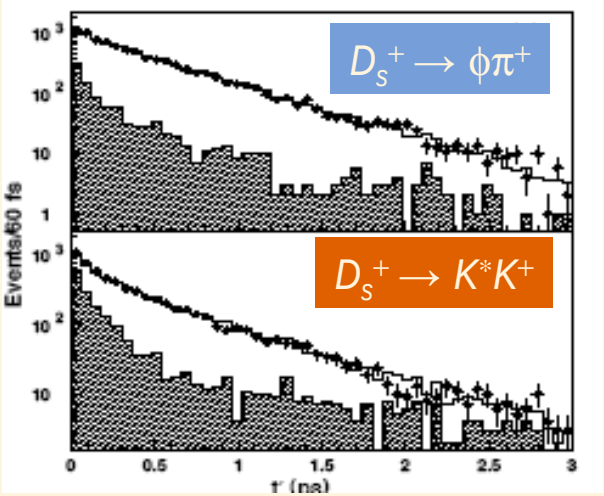
- Need lifetimes to convert $\mathcal{B}$s into partial widths.
  - Extract CKM matrix elements.
  - Test isospin invariance.
  - FOCUS dominates D^0, D^+, D_s^+ lifetimes.
- [D_{CP} lifetimes also limit mixing.]

- New FOCUS measurement for D_s^+ [PRL 95, 052003 (2005)].

(fs)	FOCUS	PDG04
$\tau(D_s^+)$	507.4 ± 5.5 ± 5.1	490 ± 9

- $\tau(D_s^+)/\tau(D^0)$ = 1.239 ± 0.017
  - Probes weak annihilation contribution.





Summary & Outlook

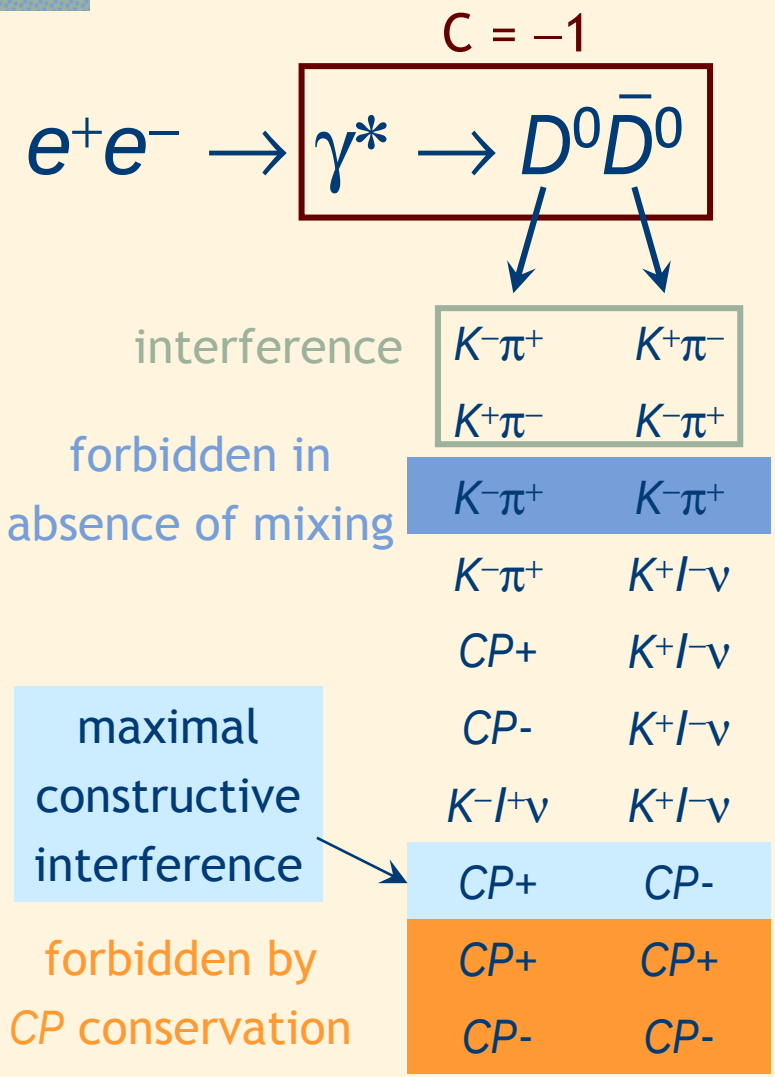
- Much recent activity in study of charm hadronic decays.
  - High-precision branching fractions.
  - Complex resonant substructure in multibody decays.
  - Interesting interference effects.

- Much more to come:
  - ***B factories*** and ***Tevatron*** are still collecting large incoherent charm datasets.
  - ***CLEO-c*** runs through March 2008; will significantly increase coherent charm datasets.
  - ***BES III*** to turn on in the next few years; expected to collect 25x CLEO-c sample!
  - Next generation fixed target experiments: ***LHCb*** & ***PANDA***.

- Charm physics will continue to be a rich area of exploration!

Backup Slides

Effect of Quantum Correlations



- $|D_{1,2}\rangle = p|D^0\rangle \pm q|\bar{D}^0\rangle$
- Because of quantum correlation between D^0 and $\bar{D}^0$, not all final states allowed. This affects:
  - total rate
  - apparent branching fractions
- Two entangled causes:
  - Interf. between CF and DCSD.
  - D mixing: single tag rates depend on $y = (\Gamma_2-\Gamma_1)/2\Gamma$.
- Semileptonic decays tag flavor unambiguously (if no mixing) → If one D is SL, the other D decays as if isolated/incoherent.
- Exploit coherence to probe DCSD and mixing—shows up in *time-integrated* rates.

Introduction

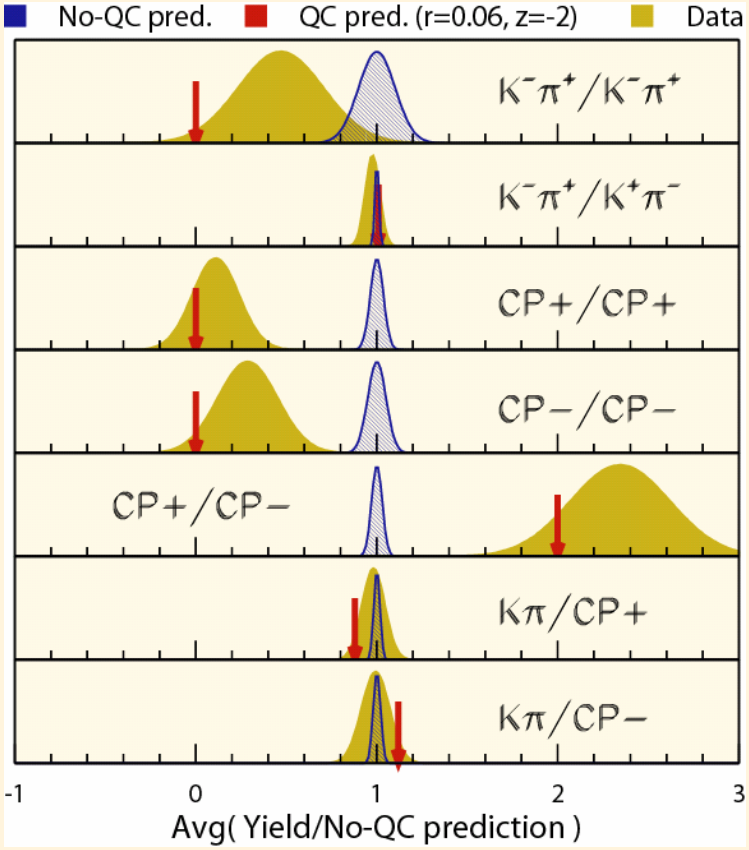
- In the Standard Model, *D* mixing strongly suppressed (CKM and GIM).
- Previous searches:
  - Double semileptonic rates give R_M.
  - Time-dependent $K\pi$: x and y rotated by δ.
- Current analysis:
  - Uses *time-independent* yields.
  - Sensitive to y at *first order*.
  - No sensitivity to $p/q \neq 1$; neglect *CPV* in decay.
- References:
  - Goldhaber, Rosner: **PRD 15, 1254 (1977).**
  - Xing: **PRD 55, 196 (1997).**
  - Gronau, Grossman, Rosner: **hep-ph/0103110.**
  - Atwood, Petrov: **PRD 71, 054032 (2005).**
  - Asner, Sun: **hep-ph/0507238.**

	Definition	Current knowledge
y	$(\Gamma_2-\Gamma_1)/2\Gamma =$ $\mathcal{B}(CP+)-\mathcal{B}(CP-)-$ $\Sigma\ \mathcal{B}_f\ r_f\ z_f$	0.008 ± 0.005
x	$(M_2-M_1)/\Gamma$ sensitive to NP	$x' < 0.018$
R_M	$(x^2+y^2)/2$	$< \sim 1 \times 10^{-3}$
r	$K\pi$ DCS-to-CF rel. amplitude	0.061 ± 0.001
δ	$K\pi$ DCS-to-CF relative phase	π(weak) + ? (strong)
z	$2\cos\delta$	None
w	$2\sin\delta$	None

Single and Double Tag Rates

Single tag: $X \leftarrow \bar{D}\ D \rightarrow i$

Double tag: $j \leftarrow \bar{D}\ D \rightarrow i$



- Hadronic rates (flavored and *CP* eigenstates) depend on mixing/DCSD.
- Semileptonic modes ($r = \delta = 0$) resolve mixing and DCSD.
- Rate enhancement factors, to leading order in x, y and r^2:

	f	$l+$	$CP+$	$CP-$
f	R_M/r^2			
$\bar{f}$	$1+r^2(2-z^2)$			
$l-$	1	1		
$CP+$	$1+rz$	1	0	
$CP-$	$1-rz$	1	2	0
X	$1+rzy$	1	$1-y$	$1+y$

- With C=+1 $D^0\bar{D}^0\gamma$ at higher energy, sensitivity to wx at first order. Not much info if w is small.

Results

PRELIMINARY

- Fit inputs: 6 ST, 14 hadronic DT, 10 semileptonic DT, efficiencies, crossfeeds, background branching fractions and efficiencies.
- χ^2 = 17.0 for 19 d.o.f. (C.L. = 59%).
- Fitted r^2 unphysical. If constrain to WA, cosδ = 1.09 ± 0.66 ± ?.
- Limit on C=+1 contamination:
  - Fit each yield to sum of C=-1 & C=+1 contribs.
  - Include CP+/CP+ and CP-/CP- DTs in fit.
  - No significant shifts in fit parameters.
  - C=+1 fraction = 0.06 ± 0.05 ± ?.
- Some branching fracs competitive with PDG.

Uncertainties are statistical *only*

Parameter	Value	PDG or CLEO-c
$N_{D^0D^0}$	(1.09 ± 0.04 ± ?)x10^6	(1.01 ± 0.02)x10^6
y	-0.057 ± 0.066 ± ?	
r^2	-0.028 ± 0.069 ± ?	(3.74 ± 0.18)x10^{-3} PDG + Belle + FOCUS
rz	0.130 ± 0.082 ± ?	
R_M	(1.74 ± 1.47 ± ?)x10^{-3}	< ~1x10^{-3}
$\mathcal{B}(K^-\pi^+)$	(3.80 ± 0.29 ± ?)%	(3.91 ± 0.12)%
$\mathcal{B}(K^-K^+)$	(0.357 ± 0.029 ± ?)%	(0.389 ± 0.012)%
$\mathcal{B}(\pi^-\pi^+)$	(0.125 ± 0.011 ± ?)%	(0.138 ± 0.005)%
$\mathcal{B}(K^0_S\pi^0\pi^0)$	(0.932 ± 0.087 ± ?)%	(0.89 ± 0.41)%
$\mathcal{B}(K^0_S\pi^0)$	(1.27 ± 0.09 ± ?)%	(1.55 ± 0.12)%
$\mathcal{B}(X^-e^+\nu)$	(6.21 ± 0.42 ± ?)%	(6.87 ± 0.28)%