Recent Charm from CLEO

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(CLEO Collaboration)

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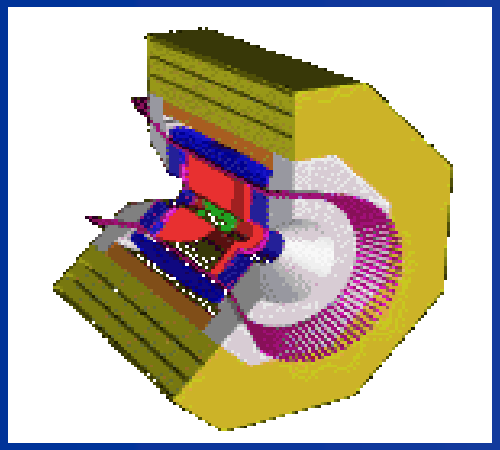
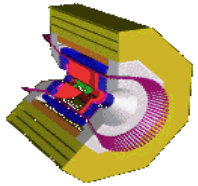
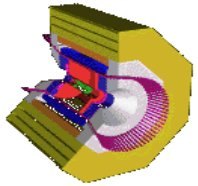




Outline

- **Introduction**
- **Rare Charm Results from CLEO**
  - $D^+ \to \pi^+\pi^0$, $K^+\pi^0$, K^+K_s
  - $D^0 \to \pi^-\pi^+\pi^0$ Dalitz Analysis
  - First Observation of $D^0 \to K_s\eta\pi^0$
  - First Search for $D^0 \to \gamma\,\gamma$
- **Future Outlook and CLEO-c**



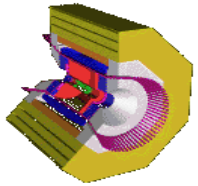
Why Rare Charm?

Hunting Ground for New Physics

- Possible New Physics in box & loop
- SM background suppressed
- Precision measurements possible
- Clean samples already exist!

BaBar BES CLEO E791

Belle CDF D0 FOCUS

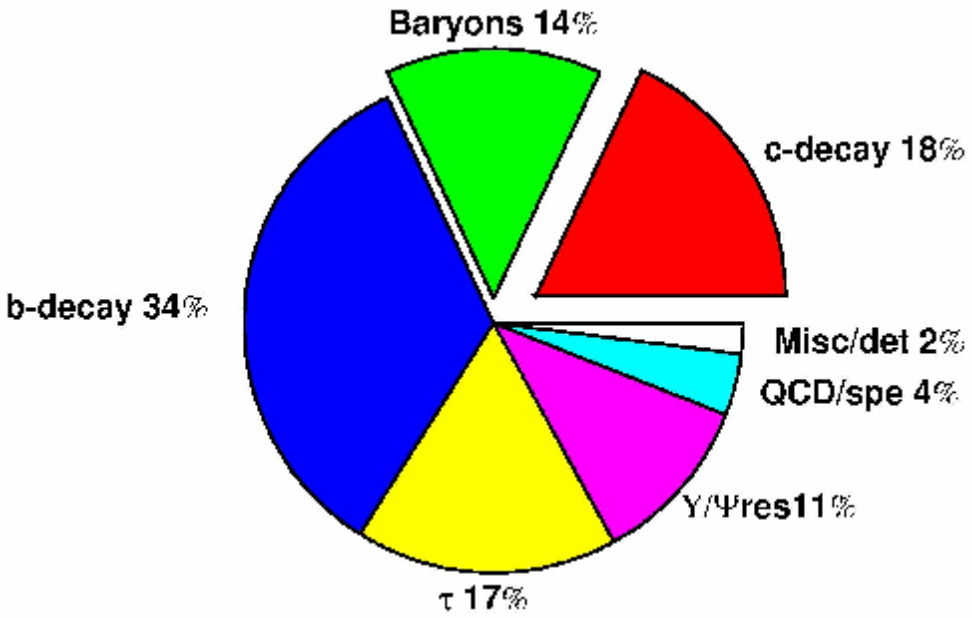


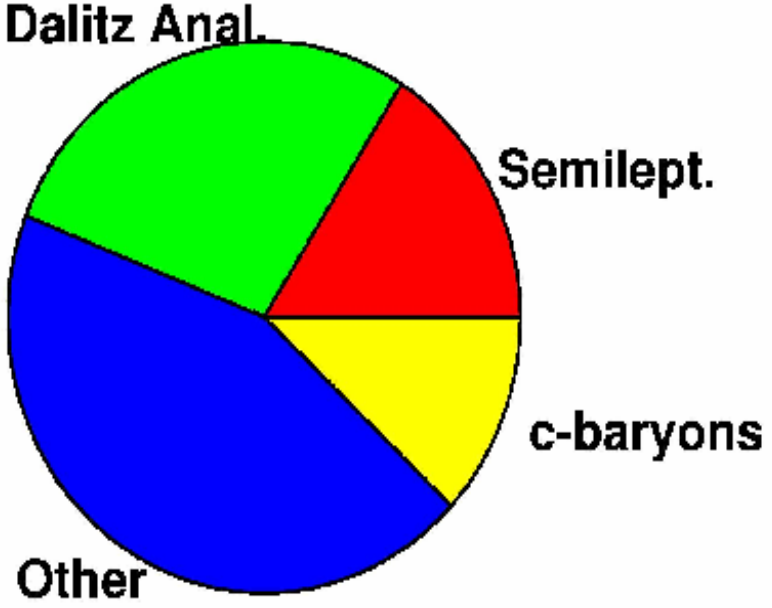
Charm Physics at CLEO

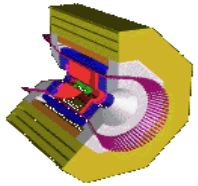
> 360 Publications since 1980

Diverse physics topics

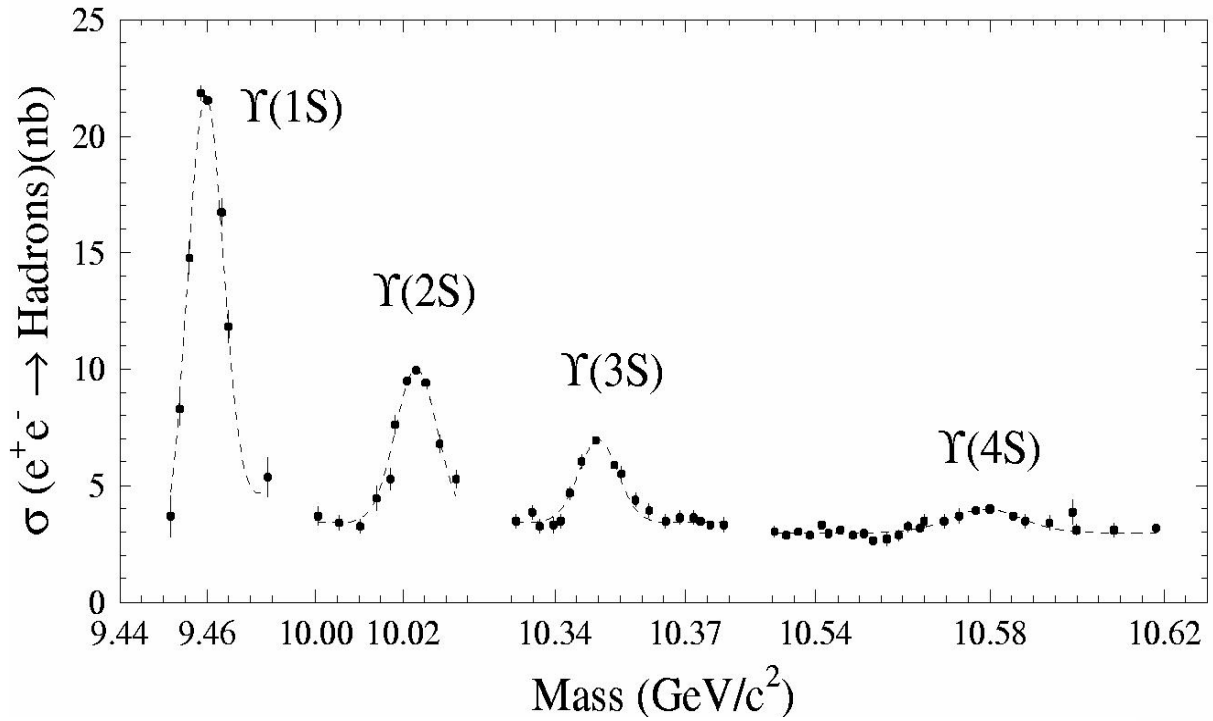
Over 30% on Charm Physics

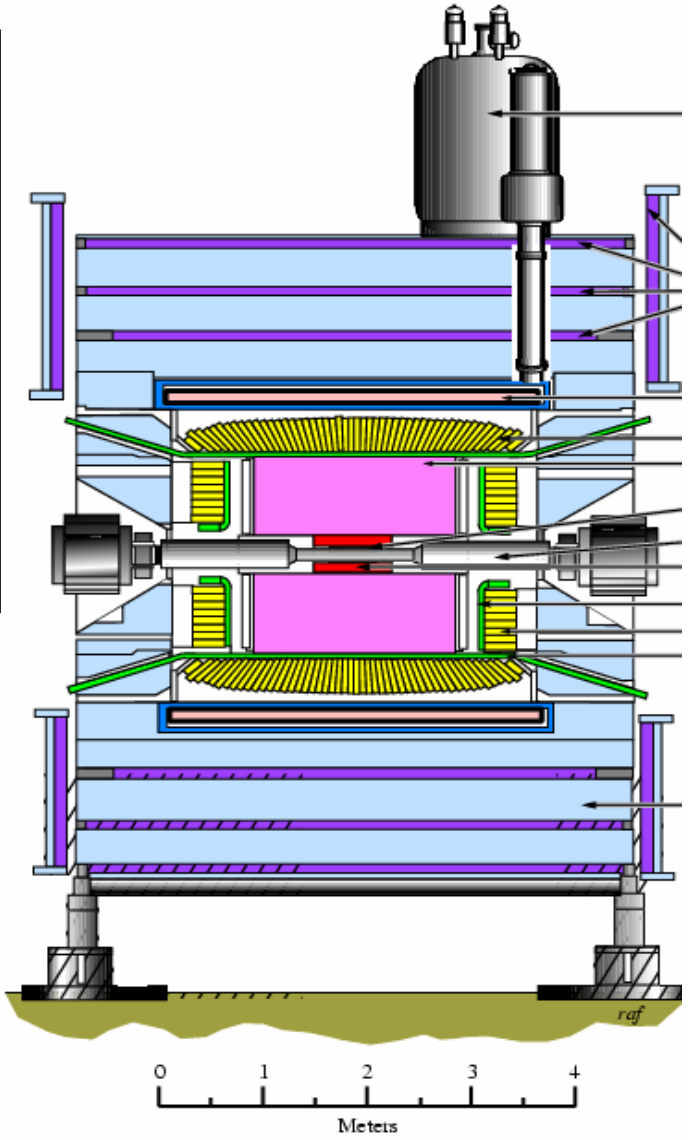






CLEO Detector



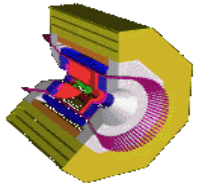


CLEO II (1989 – 1995): 4.7 fb^{-1}

CLEO II.V (1995 – 1999): 9.0 fb^{-1}

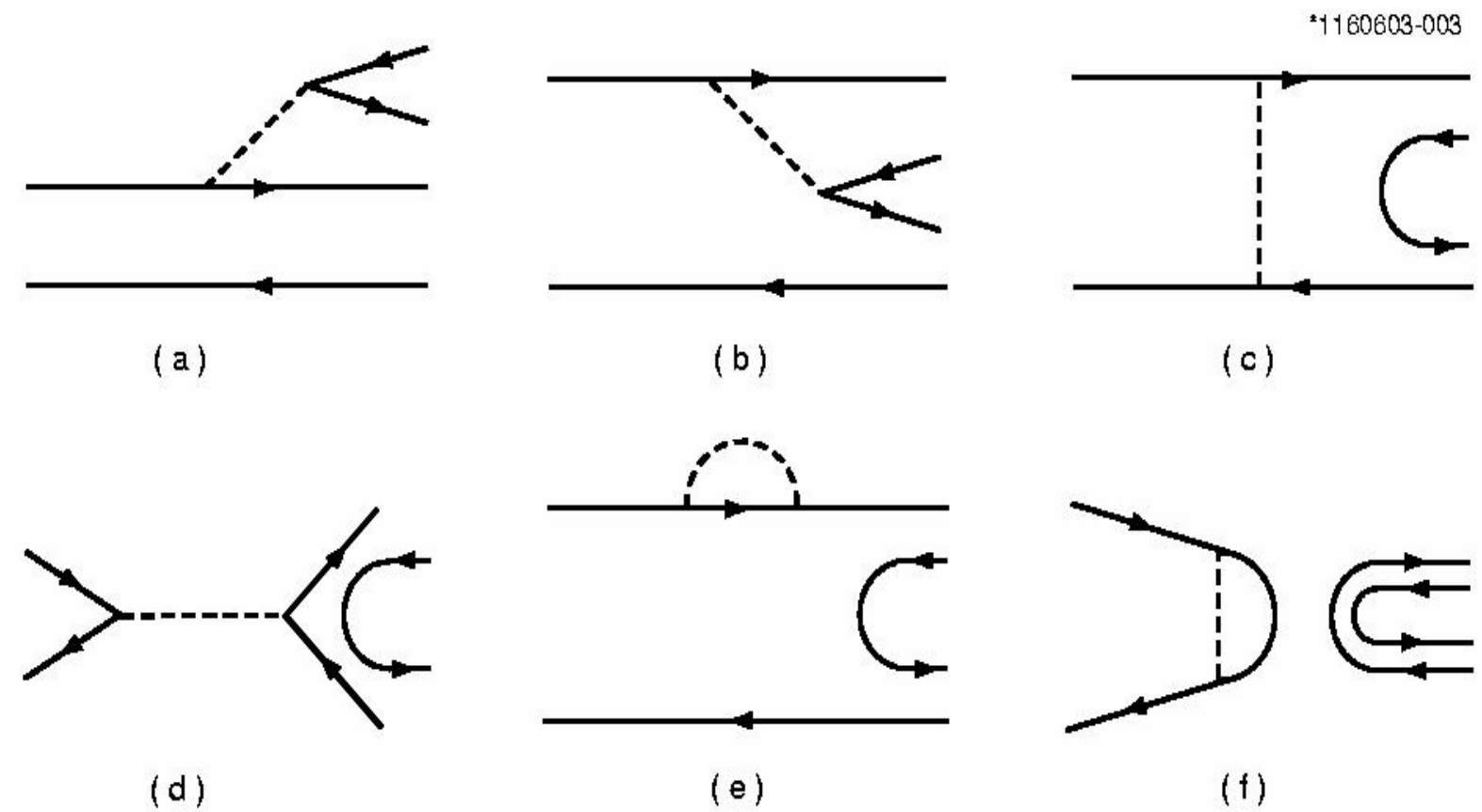
CLEO III (1999 – 2002): 16.0 fb^{-1}

CLEO-c (2003 – 2008): > 7 fb^{-1}



$D^+ \to \pi^+\pi^0$, $K^+\pi^0$, K^+K_s

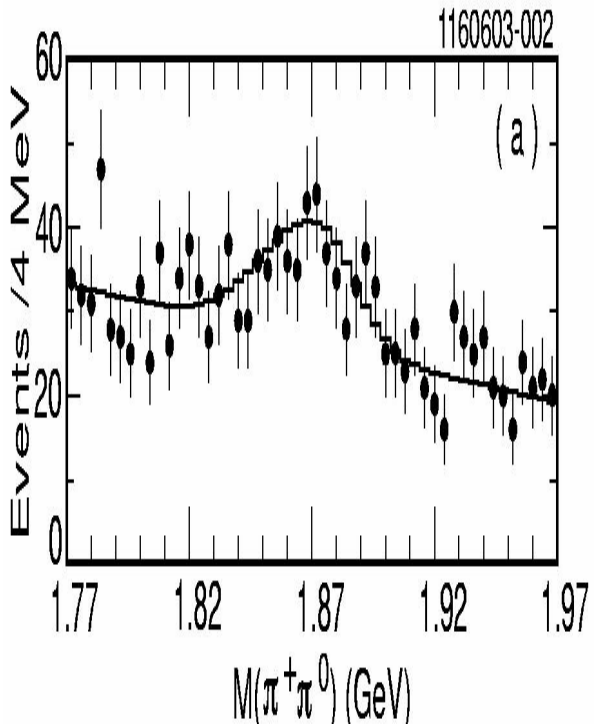
Study SU(3) Symmetry Breaking

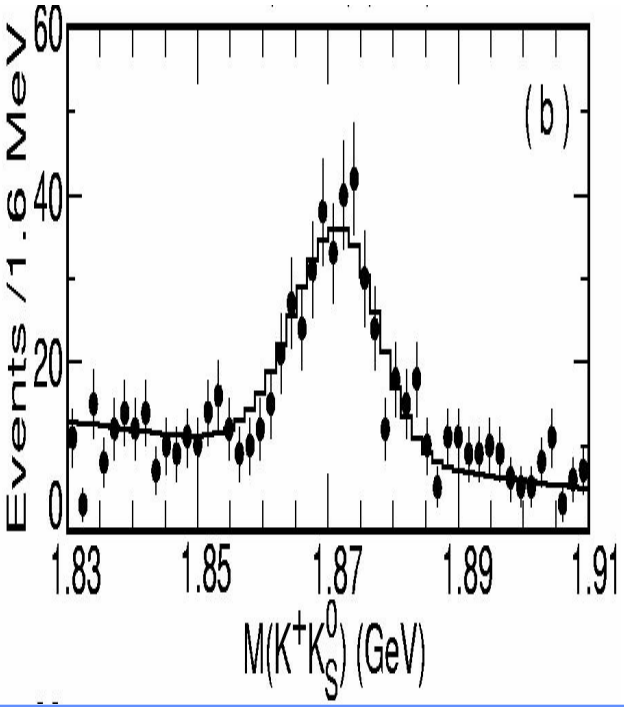


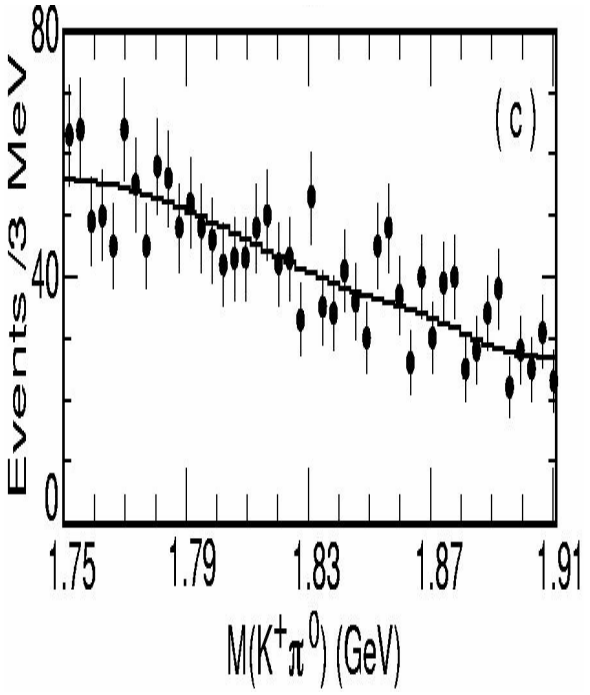
$D^+ \to \pi^+\pi^0$, $K^+\pi^0$, K^+K_s

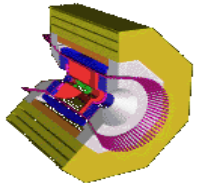
First Study →

Mode	Yield	Efficiency
$\pi^+\pi^0$	171.3 ± 22.1	$(6.20 \pm 0.11)\%$
K^+K_s	277.7 ± 20.8	$(4.94 \pm 0.23)\%$
$K^+\pi^0$	34.3 ± 20.9	$(6.08 \pm 0.22)\%$
$K^-\pi^+\pi^+$	12898.0 ± 156.6	$(6.74 \pm 0.12)\%$
π^+K_s	1434.7 ± 48.0	$(4.83 \pm 0.23)\%$









$D^+ \to \pi^+\pi^0$, $K^+\pi^0$, K^+K_s

**** Preliminary ****

$$\frac{\mathcal{B}(D^+ \to \pi^+\pi^0)}{\mathcal{B}(D^+ \to K^-\pi^+\pi^+)} = 0.0144 \pm 0.0019 \pm 0.0010$$

$$\frac{\mathcal{B}(D^+ \to K^+K_S)}{\mathcal{B}(D^+ \to \pi^+K_S)} = 0.1892 \pm 0.0155 \pm 0.0073$$

$$\frac{\mathcal{B}(D^+ \to K^+\pi^0)}{\mathcal{B}(D^+ \to K^-\pi^+\pi^+)} = 0.0029 \pm 0.0018 \pm 0.0009$$

CLEO CONF 03-02

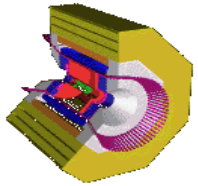
hep-ex/0306019

$$R_1 = 2 \times \left|\frac{V_{cs}}{V_{cd}}\right|^2 \frac{\Gamma(D^+ \to \pi^+\pi^0)}{\Gamma(D^+ \to \bar{K}^0\pi^+)} = 1.84 \pm 0.38$$

=1 in the limit of SU(3)

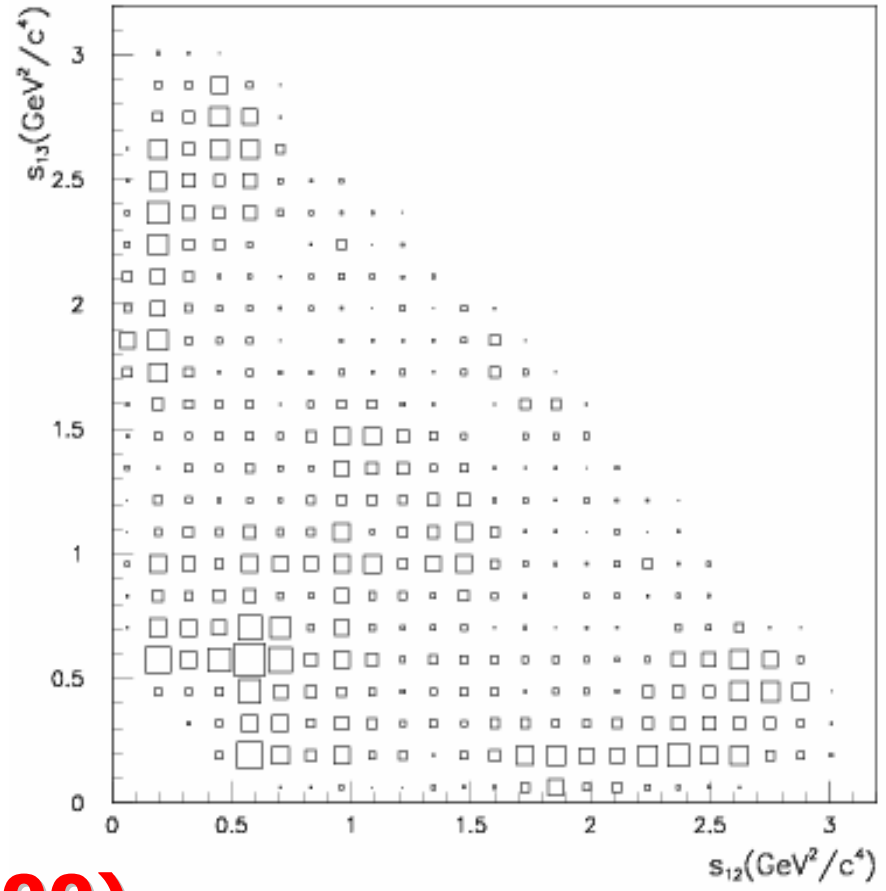
$$R_2 = \frac{1}{2} \times \frac{\Gamma(D^+ \to \bar{K}^0K^+)}{\Gamma(D^+ \to \pi^+\pi^0)} = 2.03 \pm 0.32$$

>1 indicates destructive interference Between internal & external



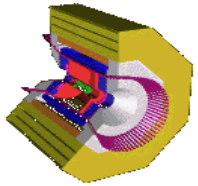
E791 $D^+ \to \pi^+\pi^-\pi^+$ Results

	Fit Frac. (%)	Fit Frac. (%)
$\rho^0(770)\pi^+$	20.8 ± 2.4	33.6 ± 3.2 ± 2.2
$f_0(980)\pi^+$	7.4 ± 1.4	6.2 ± 1.3 ± 0.4
$f_2(1270)\pi^+$	6.3 ± 1.9	19.4 ± 2.5 ± 0.4
$f_0(1370)\pi^+$	10.7 ± 3.1	2.3 ± 1.5 ± 0.8
$\rho^0(1450)\pi^+$	22.6 ±3.7	0.7 ± 0.7 ± 0.3
Non-res	38.6± 9.7	7.8 ± 6.0 ± 2.7
$\sigma\pi^+$	–	46.3 ± 9.0 ± 2.1
χ^2	254/162	138/162



Strong Evidence for σ (500)

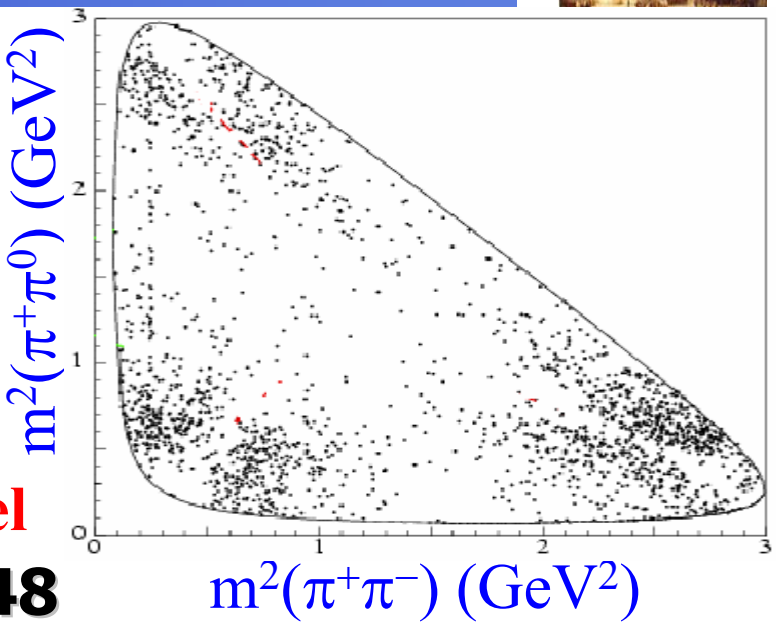
Phys. Rev. Lett. 86: 770, 2001



Dalitz Analysis of $D^0 \to \pi^-\pi^+\pi^0$

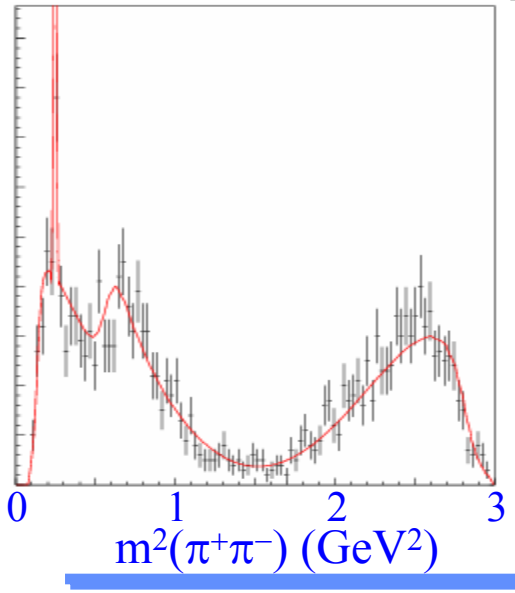
** Preliminary **

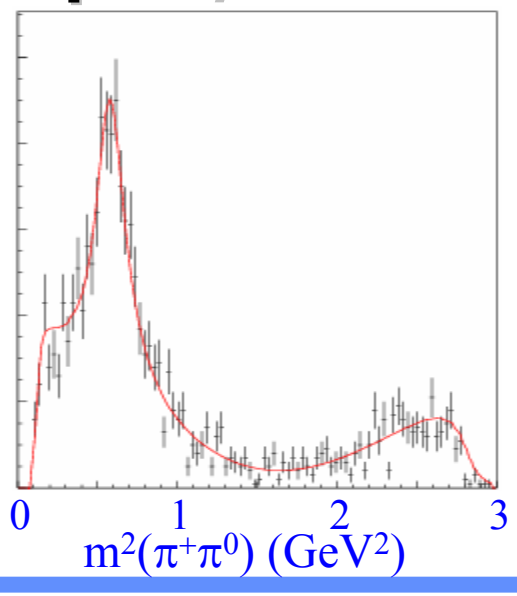
	Amplitude	Phase	Fit Fraction
$\rho^+\pi^-$	1 (fixed)	0 (fixed)	76.5±1.8±4.8
$\rho^0\pi^0$	0.56±0.02±0.07	10±3±3	23.9±1.8±4.6
$\rho^-\pi^+$	0.65±0.03±0.04	−4±3±4	32.3±2.1±2.2
NR	1.03±0.17±0.31	77±8±11	2.7±0.9±1.7

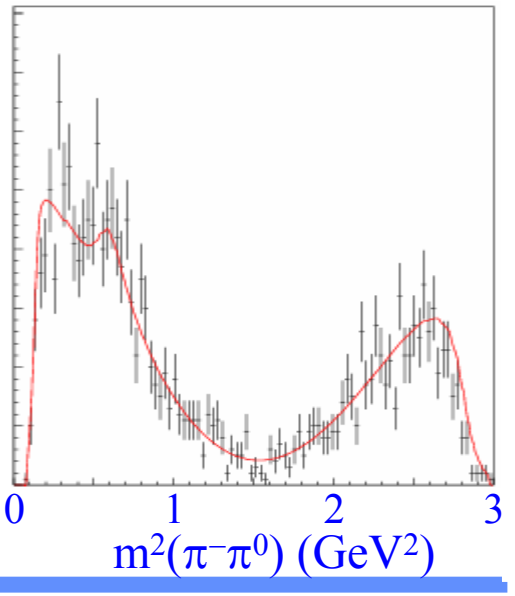


No contribution from σ(500) at ~1% level

CLEO CONF 03-03, hep-ex/0306048





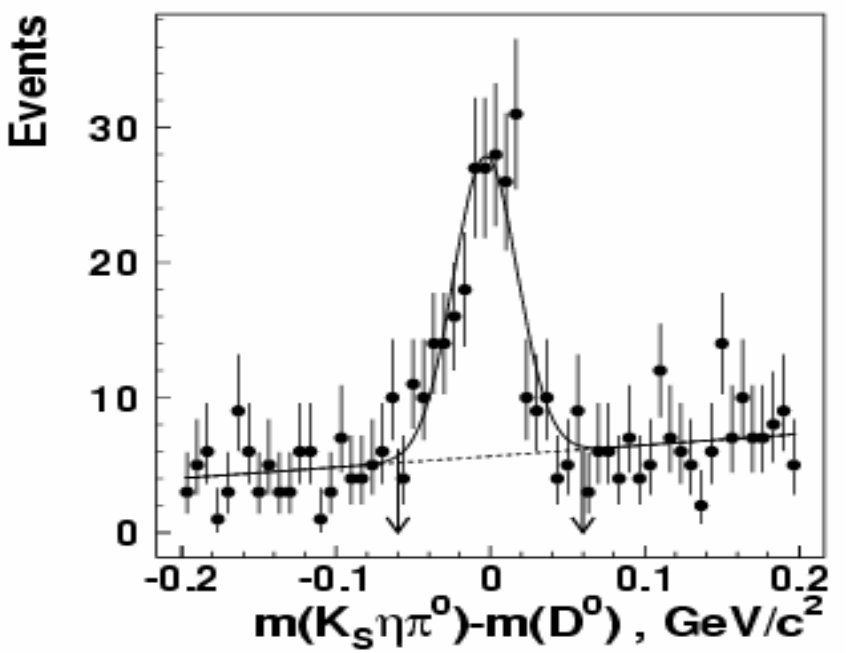


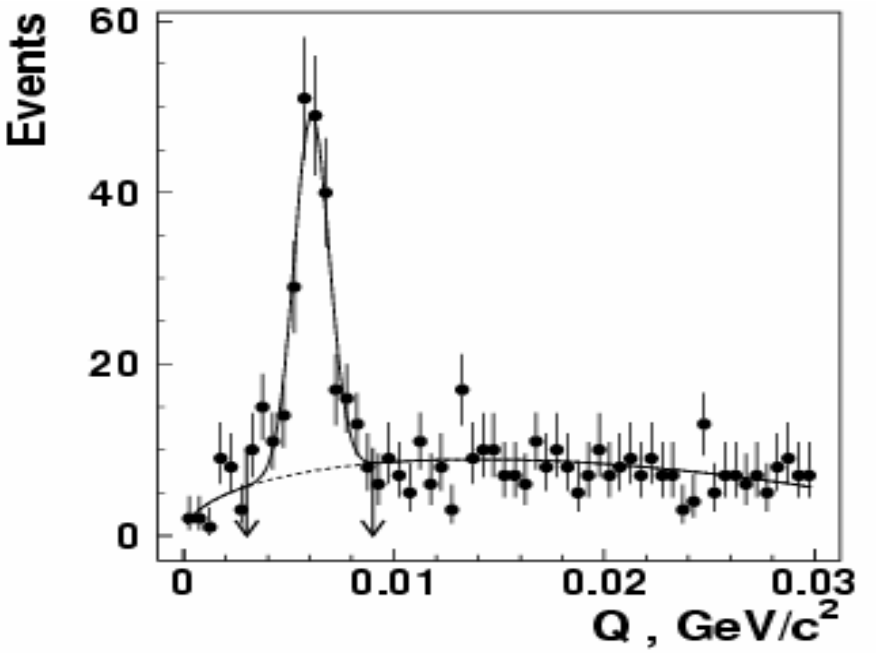
First Observation of $D^0 \to K_S \eta \pi^0$

- CLEO's $K_S\pi^-\pi^+$ and BaBar's $K_SK^-K^+$ Dalitz analyses
- $K_S a_0(980)$ seen in $K_SK^-K^+$, $a_0(980) \to \eta\pi$ is dominant

$$\frac{\Gamma(D^0 \to K_S \eta \pi^0)}{\Gamma(D^0 \to K_S \pi^0)} = 0.38 \pm 0.07 \pm 0.05$$

** Preliminary **





First Observation of $D^0 \to K_S \eta \pi^0$

** Preliminary **

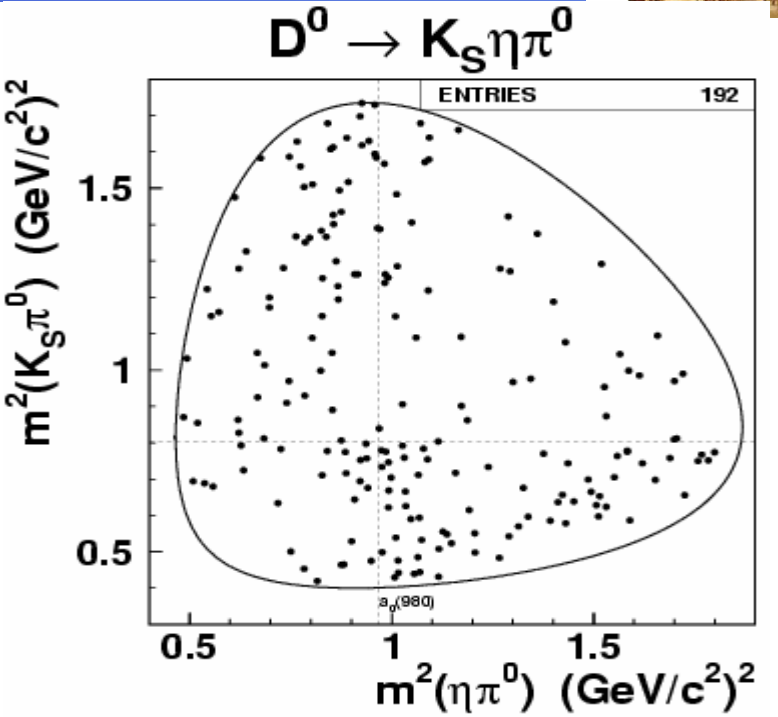
$K_S a_0(980)$ is dominant

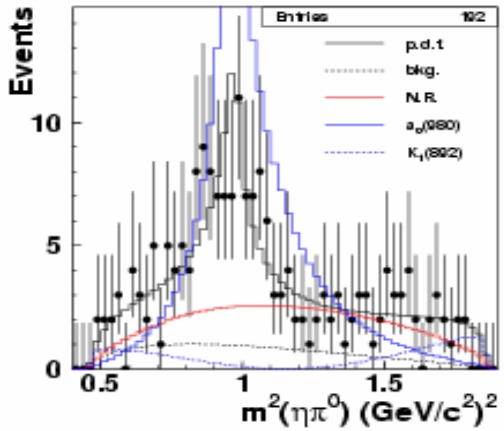
$K^*(892)\eta$ is seen

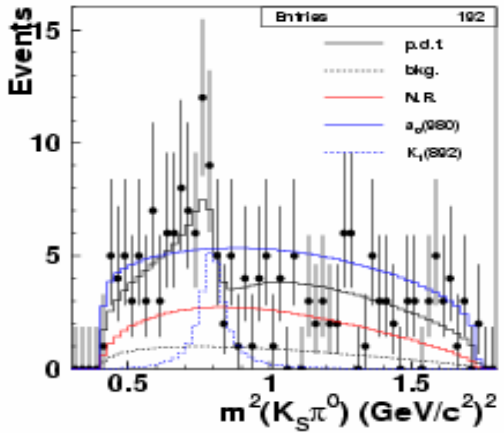
Something else is needed:

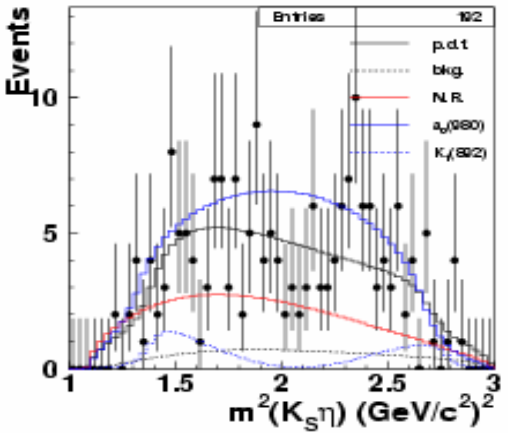
NR, $K_S a_2(1320)$, $K_S a_0(1450)$

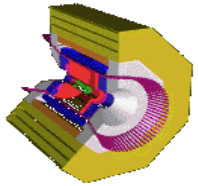
$\kappa\eta$, $K_0(1430)\eta$, $K_1(1410)\eta$ …??











First Search for $D^0 \to \gamma\gamma$

SM Prediction: $\approx 10^{-8}$

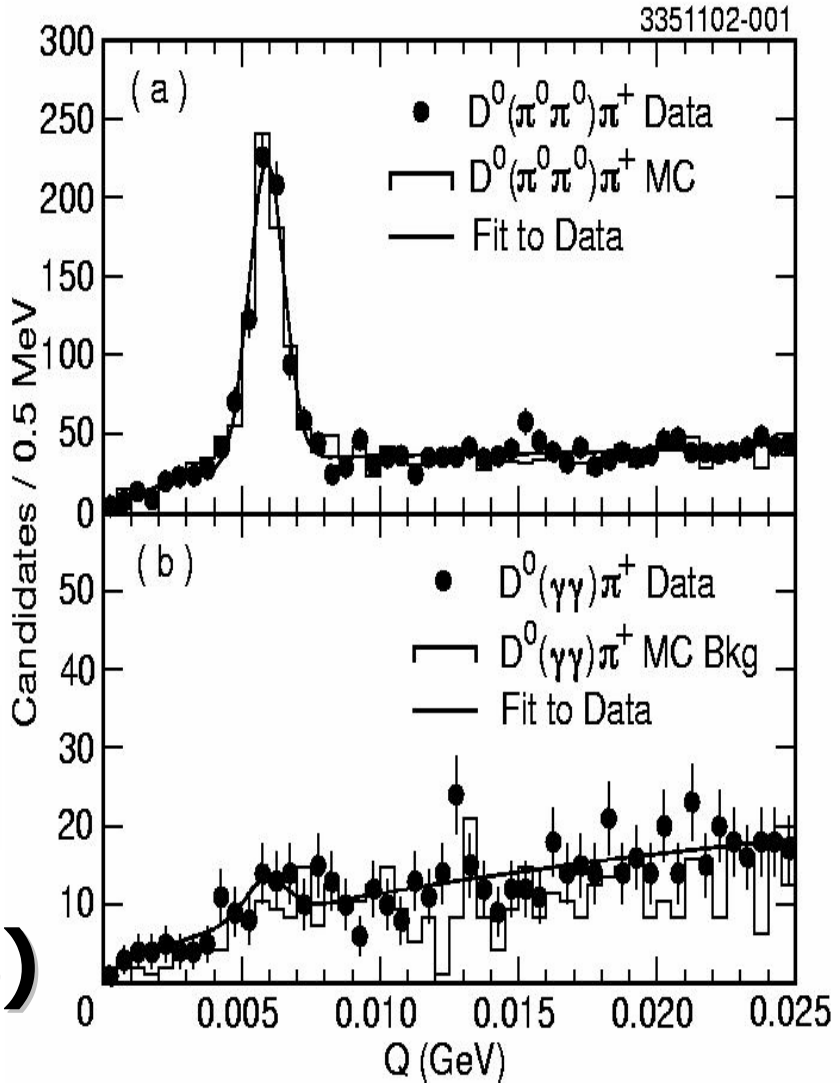
Burdman, Golowich, Hewett, Pakvasa
Phys. Rev. D66 014009 (2002)

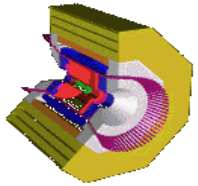
CLEO Results:

$$\frac{B(D^0 \to \gamma\gamma)}{B(D^0 \to \pi^0\pi^0)} < 0.033$$

$$B(D^0 \to \gamma\gamma) < 2.9 \times 10^{-5}$$

PRL 90, 101801 (2003)

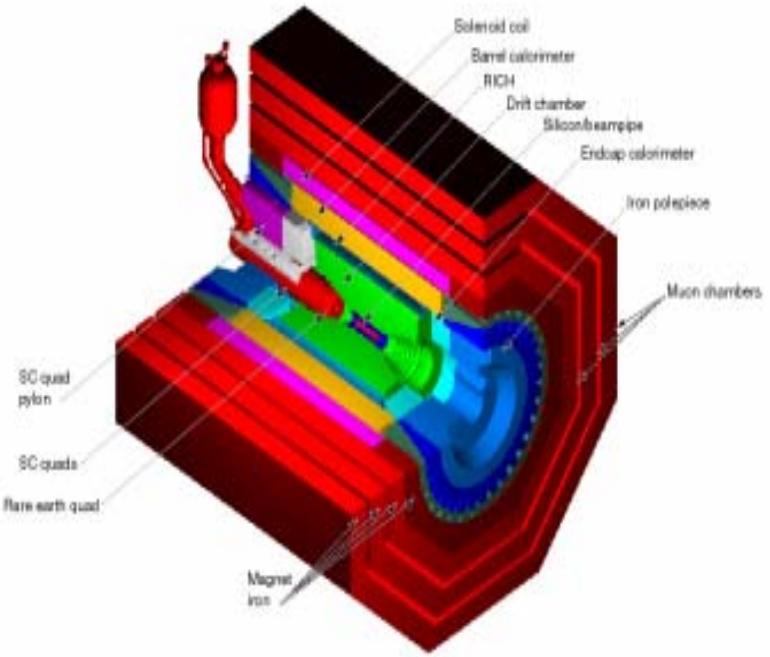


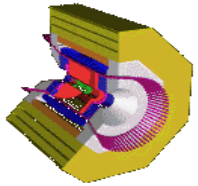


What is CESR-c & CLEO-c?

Run CESR/CLEO at Charm Threshold

- http://www.lns.cornell.edu/CLEO/CLEO-c/
- National Science Board approved in Feb. 2003
- CESR-c/CLEO-c has started in June of 2003





CLEO-c Program

Expected machine performance:

$\sqrt{s}$	L (10^{32} cm^{-2} s^{-1})
3.1 GeV	2.0
3.77 GeV	3.0
4.1 GeV	3.6

2004: $\psi(3770) \sim 3$ fb^{-1}

30 million DD events, 6 million *tagged* D decays

(310 times MARK III)

2005: $\sqrt{S} \sim 4140$ MeV ~ 3 fb^{-1}

1.5 million D_sD_s events, 0.3 million *tagged* D_s decays

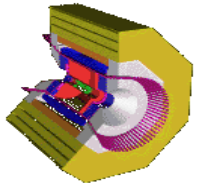
(480 times MARK III, 130 times BES)

2006: $\psi(3100)$, ~1 fb^{-1} & $\psi(3686)$

~ 1 Billion J/ψ decays

(170 times MARK III, 20 times BES II)

CLEOc



CLEO-c Future Outlook

	Reaction	Energy(MeV)	L fb^{-1}	PDG	CLEO-c
f_{Ds}	$D_s^+ \to \mu\nu$	4140	3	17%	1.7%
f_{Ds}	$D_s^+ \to \tau\nu$	4140	3	33%	1.6%
f_{D+}	$D^+ \to \mu\nu$	3770	3	UL	2.3%

Decay	$\sqrt{s}$	L fb-1	Double tags	PDG ($\delta B/B$ %)	CLEOc ($\delta B/B$ %)
$D^0 \to K^-\pi^+$	3770	3	53,000	2.4	0.6
$D^+ \to K^-\pi^+\pi^+$	3770	3	60,000	7.2	0.7
$D_s \to \phi\pi$	4140	3	6,000	25	1.9

Search for Glueballs and Hybrids

CLEO-c will take data in Oct of 2003

New collaborators are WELCOME!