CESR and CLEO present:

B-Decays at CLEO:

un-charmed hadronic — rare and not-so-rare

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Outline of the Talk

- Brief introduction to detector, data sets.

- Update on 2-body charmless B-decay results.

Reference: hep-ex/0302026

- Inclusive production of □′ in charmless B-decay

References: hep-ex/0303009, Phys. Rev.**D67**, 112002, 17 July 2003

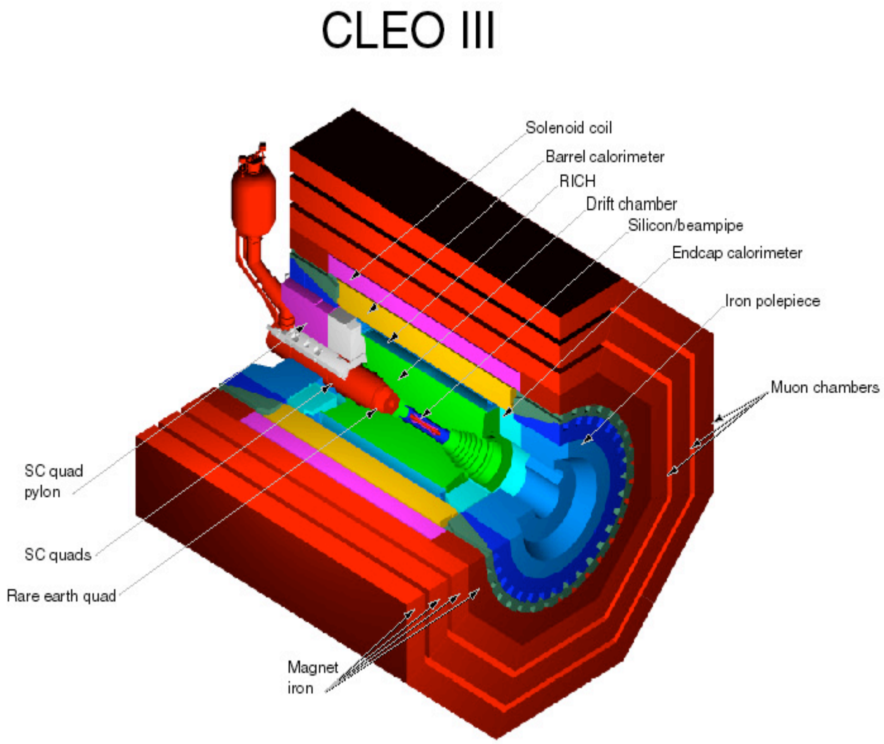
The CLEO Detector at CESR

CESR: a symmetric e^+e^- collider on the Cornell campus. Soon to become CESR-c

Cleo III: the penultimate version of the CLEO detector. 4-layer SVX, RICH PID, CsI(Tl), 1.5 T field, low-Z gas … CLEO II lacked RICH and silicon. A well-understood detector, with good resolution for charged and neutral particles.

- 15.3 fb^{-1} at Υ(4S) in CLEOII/CLEO III data set.

- 6.6 fb^{-1} taken 60MeV below Υ(4S) for understanding of continuum backgrounds.



CLEO III Performance Summary

- Good momentum resolution for charged B-decay products

~0.5% or 12.5 MeV/c at p=2.5 GeV/c

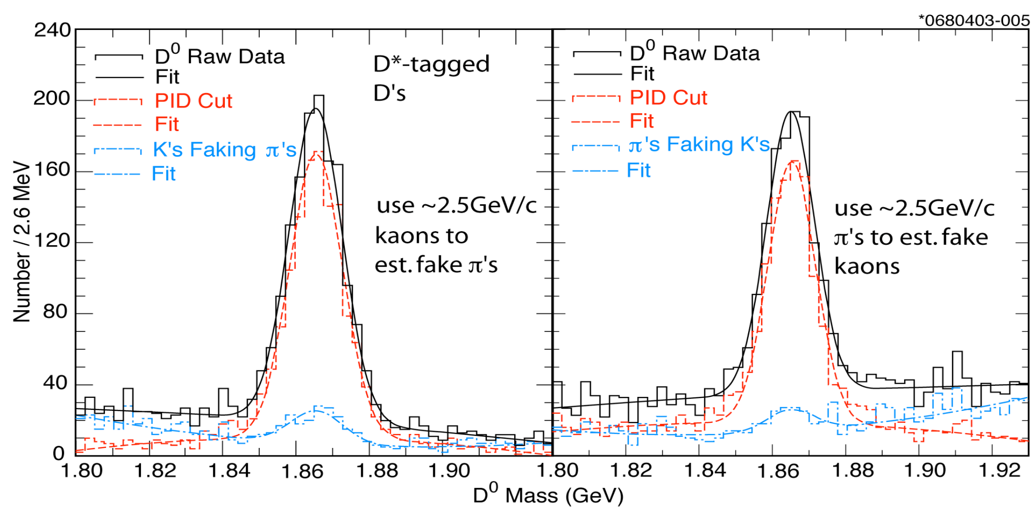
- Likewise for photons/□°

~2% or 40 MeV/c at p=2.5 GeV/c, □^{0} mass □~ 7MeV

- Combined PID performance of RICH and dE/dX at 2.5 GeV/c

□ eff. □ fake-rate	□ eff. □ fake-rate	$\overline{P}$/P eff. □ fake-rate
90% 8%	90% 11%	72%/76% 1%

PID calibrated on □'s and K's From tagged D*



Two-body charmless decays of *B* mesons

Updated CLEOIII/CLEOII results for 13 two-body modes.

- Penguin, tree, baryonic, and "exotic": all $O(10^{-5})$ or less.
- need continuum rejection/understanding and efficient PID: small systematic errors make CLEO competitive.

Method: cut loosely on ΔE and M_B, harder on $\cos\theta_{sph.}$ Do PID. Form likelihood from M_B, ΔE, F, $\cos\theta_B$ PDF's.

Each mode gets signal, background, and "crossfeed" components.

Fit via unbinned max.likelihood.

$M_B = (E_b^2 - (\Sigma \mathbf{p}_i)^2)^{1/2}$, $\Delta \mathbf{E} = E - E_b$

θ_{sph} = angle between candidate. axis and sphericity axis of event

θ_B = angle between cand. direction and beam

F=Fisher discriminant.: direction of candidate, energy flows about 2-body axis, θ_B , shape info

RESULTS!

- 6 B.R.'s (>3□) significance) & 7 U.L.'s

- □+□□ U.L. at<10^{-6}

- good agreement with CLEO*, Babar, and Belle, (as of Spring 2003).

*D.M.Asner *et al.*, Phys. Rev,D**65** 031103 (2002) and predecessors.

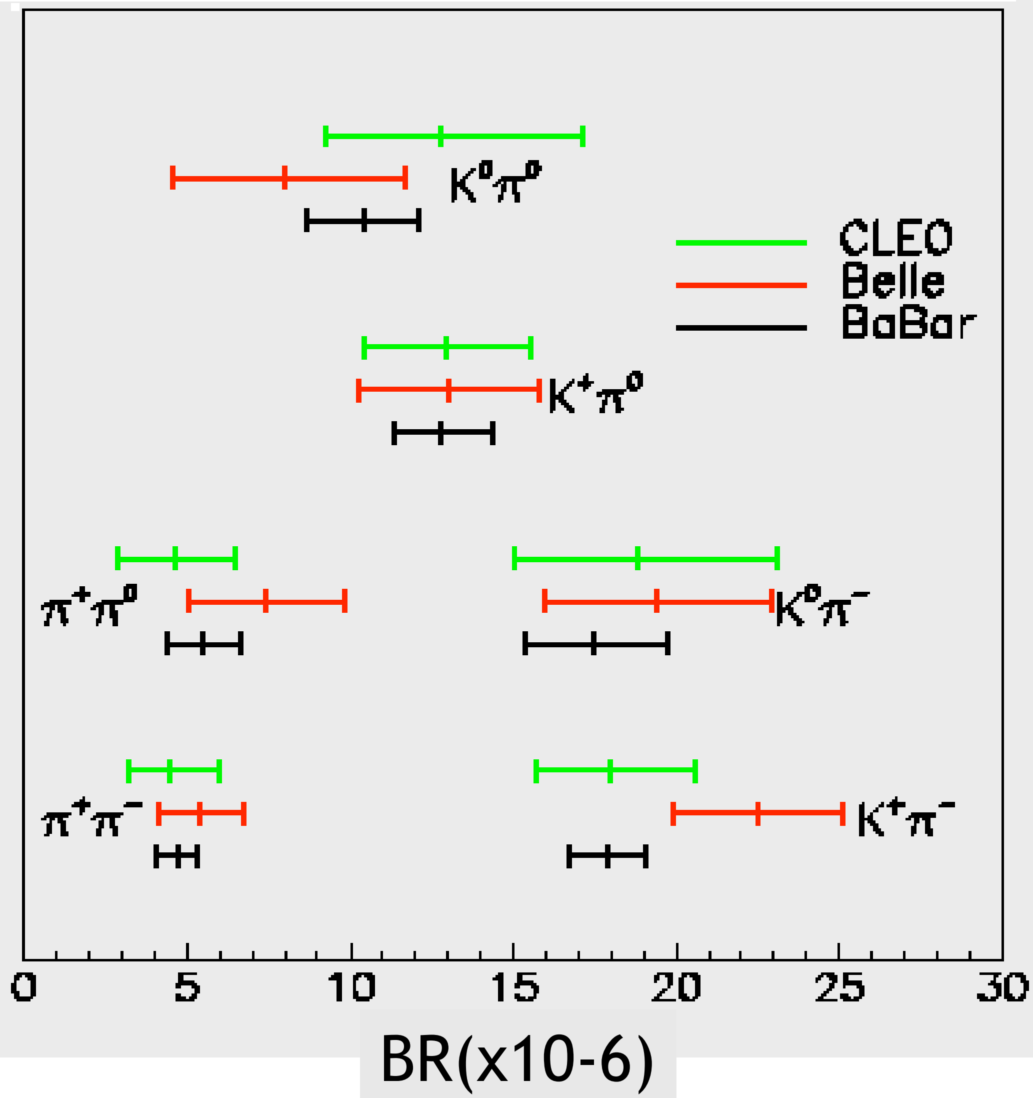


Table of Results

Mode	CLEO II - Ref. 4 Significance	CLEO II - Ref. 4 $\mathcal{B}\times10^6$	CLEO III Significance	CLEO III $\mathcal{B}\times10^6$	Combined Significance	Combined $\mathcal{B}\times10^6$
$\pi^+\pi^-$	4.2	$4.3^{+1.6+0.5}_{-1.4-0.5}$	2.6	$4.8^{+2.5+0.8}_{-2.2-0.5}$	4.4	$4.5^{+1.4+0.5}_{-1.2-0.4}$
$\pi^+\pi^0$	3.2	$5.6^{+2.6+1.7}_{-2.3-1.7}$	2.1	$3.4^{+2.8+0.8}_{-2.0-0.3}$	3.5	$4.6^{+1.8+0.6}_{-1.6-0.7}$
$\pi^0\pi^0$	2.0	(< 5.7)	1.8	(< 7.6)	2.5	(< 4.4)
$K^+\pi^-$	12	$17.2^{+2.5+1.2}_{-2.4-1.2}$	> 7	$19.5^{+3.5+2.5}_{-3.7-1.6}$	> 7	$18.0^{+2.3+1.2}_{-2.1-0.9}$
$K^0\pi^+$	7.6	$18.2^{+4.6+1.6}_{-4.0-1.6}$	4.6	$20.5^{+7.1+3.0}_{-5.9-2.1}$	> 7	$18.8^{+3.7+2.1}_{-3.3-1.8}$
$K^+\pi^0$	6.1	$11.6^{+3.0+1.4}_{-2.7-1.3}$	5.0	$13.5^{+4.0+2.4}_{-3.5-1.5}$	> 7	$12.9^{+2.4+1.2}_{-2.2-1.1}$
$K^0\pi^0$	4.9	$14.6^{+5.9+2.4}_{-5.1-3.3}$	3.8	$11.0^{+6.1}_{-4.6} \pm 2.5$	5.0	$12.8^{+4.0+1.7}_{-3.3-1.4}$
K^+K^-	-	(< 1.9)	-	(< 3.0)	-	(< 0.8)
K^0K^-	-	(< 5.1)	-	(< 5.0)	-	(< 3.3)
$K^0\overline{K^0}$	-	(< 6.1)	-	(< 5.2)	-	(< 3.3)
$p\bar{p}$	-	(< 7.0)	-	(< 1.4)	-	(< 1.4)
$p\bar{\Lambda}$	-	(< 2.0)	-	(< 3.2)	-	(< 1.5)
$\Lambda\bar{\Lambda}$	-	(< 1.8)	-	(< 4.2)	-	(< 1.2)

First error statistical, second systematic, dominantly #BB and efficiencies uncertainties.

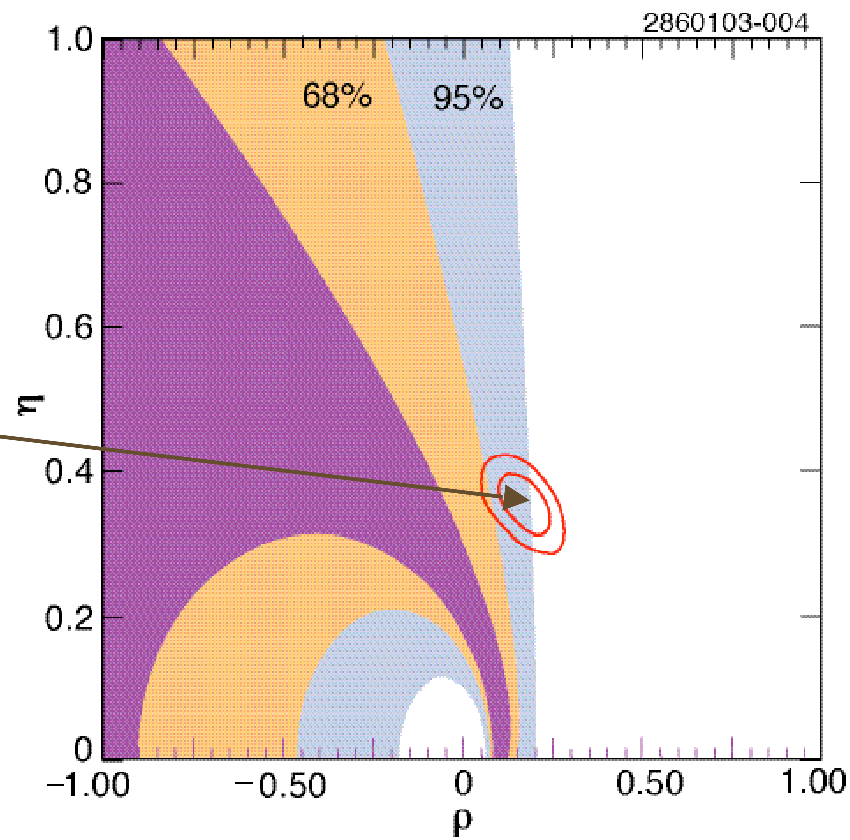
Implications

- No sign of annihilation channels or new physics (no $K\bar{K}$)

- Neubert, *et al.**, say: world averages imply that γ is likely **greater** than 90°. (use SU(3) and ratio of B.R.'s)

Purple zone preferred by $\pi\pi$ and $K\pi$ results

Current apex of CKM triangle with 1&2 σ contours. Conflict??



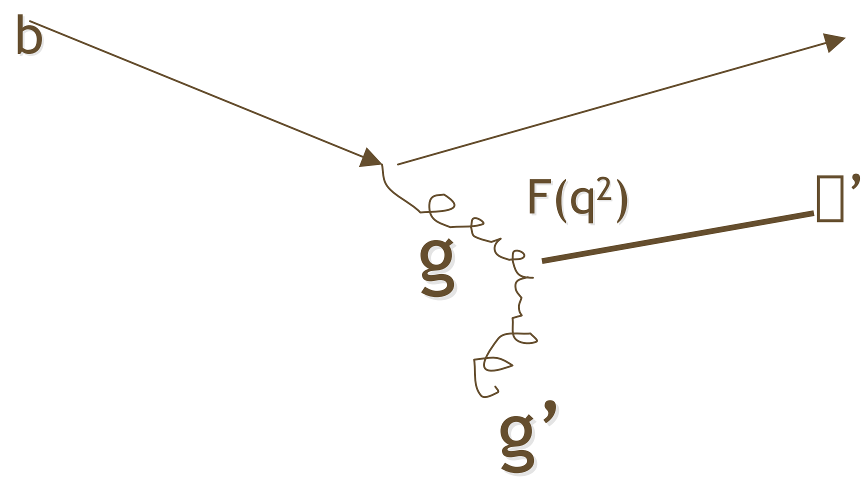
* See hep-ph/0207327

B decay to □′ X_s

In 1998 CLEO observed "copious" inclusive production of high-p □'s in B-decay (B.R. ~6 10^{-4}), as well as exclusive a large □'K rate. Babar and Belle have since confirmed that result .

Theorists have searched for explanations: enhanced gluonic coupling to □' via the anomaly, intrinsic cc; etc. See Fritzsch and Zhou, **hep-ph/0301038**, and Eeg et al., hep-ph/0304274 for recent efforts.

CLEO has now redone its earlier CLEO II analysis for the entire 9.1fb^{-1} (on 4S) and 4.4 fb^{-1} (off) CLEO II + CLEO II.V data sample.



OR $C\bar{C}$

OR ??

Features of Analysis

- Better statistics and use of techniques from b–> s□ studies.

Steps (a bit complicated):

1) Find □' in □' -> □□$^{+}$□$^{□}$, □->□□ signal: 2.0 <$P_{□'}$ <2.7GeV/c save continuum bkgd. from ctrl. region, 1.6< $P_{□'}$ <1.9GeV/c

2) Perform "pseudo-reconstruction" of B mass using □' a K, and up to 4 □'s, one of which may be neutral.

3)Collect shape variables, □E, M_b, presence of leptons….

4)construct a neural net (trained on MC) to tell signal from continuum, use weights to optimize total error.

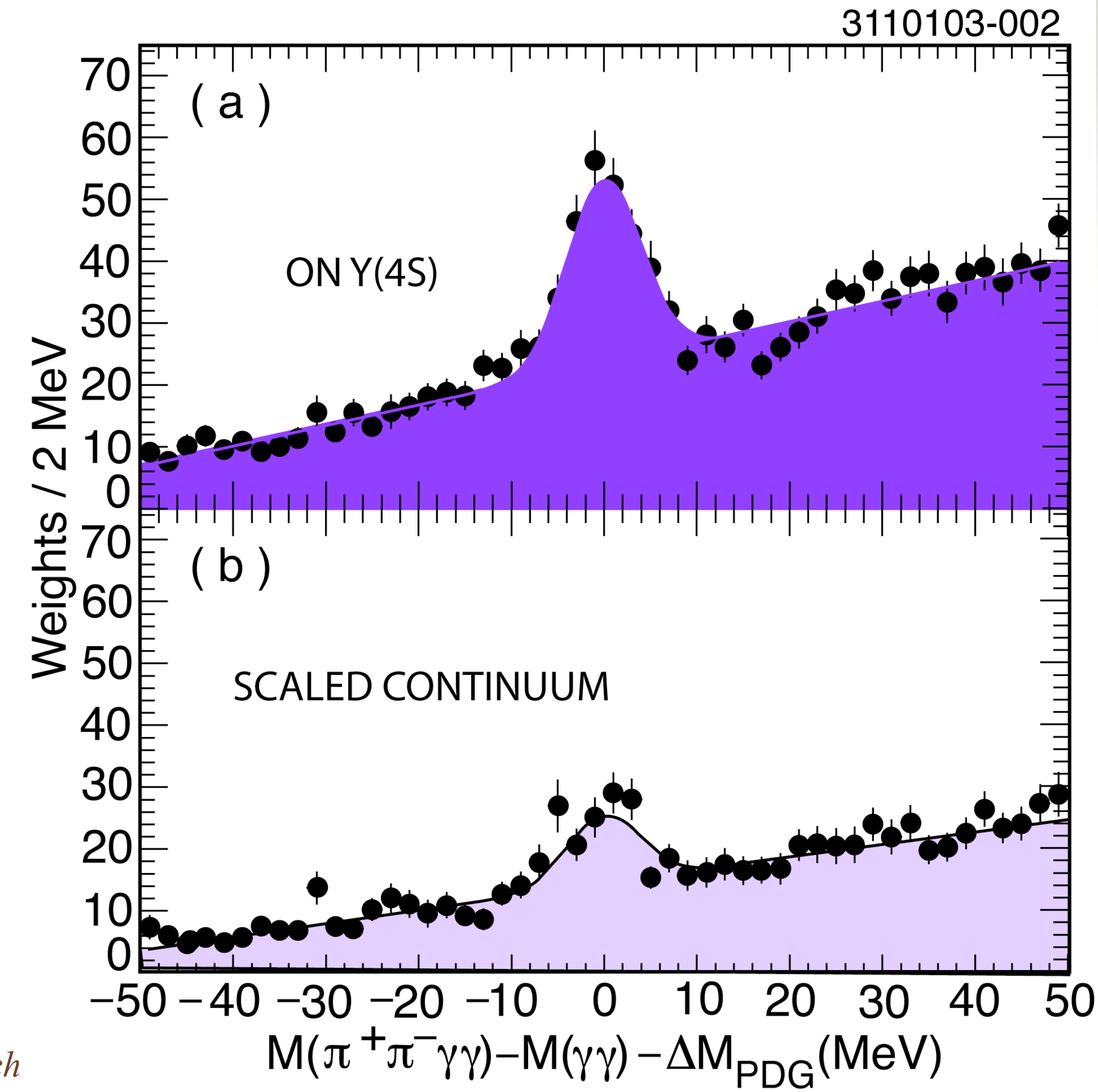
5)subtract scaled continuum yields, fit for yields

6)Use Monte Carlo for charm contribution, scaled to agree in control region, 1.6< $P_{□'}$ <1.9GeV/c . ISGW2 assigned 50% systematic uncertainty at D**.

□′ Yields , ON and OFF Y(4S)

yield in the "signal region"

2.0< P <2.7 GeV/c

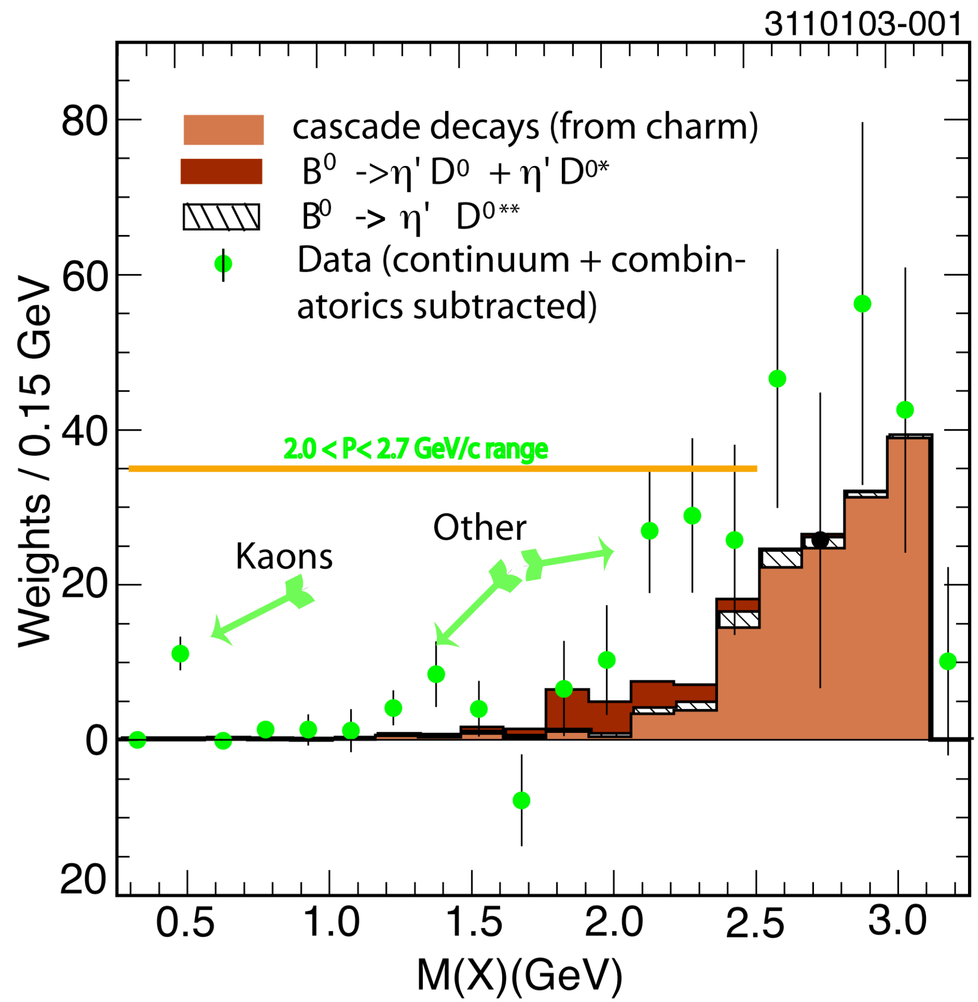


Missing Mass recoiling against ’

- Region above 2.5 GeV corresponds to “control” region dominated by charm

- signal at 0.5 GeV, ~1.4GeV, ~2.2 GeV

- no K*(890)



Answers & Conclusions

After all that, we find 61.2±13.9 (stat.) weights for the inclusive non-charmed yield in the range 2.0 GeV/c <P< 2.7 GeV/c.

This corresponds to a final B.R.:

$$[4.6 \pm 1.1(\text{stat.}) \pm 0.4(\text{sys.}) \pm 0.5(\text{bkgd.})] \mathrm{X}10^{-4}$$

Efficiencies(mostly)

Charm subtraction

Consistent with earlier result. Study of detection efficiencies says that we have measured B.R.(B->□'X_s) + .79•B.R.(B->□'$X_{u,d}$)

What's the status of explanations ??

Conclusions, concluded

Still no firm explanation for high η' rate.

• CLEO, in hep-ex/0211029 and in M. Artuso, *et al.* ,Phys. Rev. Letters **87**, 141801 (2001), finds no support for a slowly falling η'g*g coupling. Few high-P η' in Y(1S) decay!

Intrinsic $c\bar{c}$ within η' predicts B-> η'K* rate ~0.5 x η'K rate— larger than observed by CLEO or Babar.

Perhaps, it will all be made clear at this conference !