Hadronic B_u and B_d decays

William T. Ford
University of Colorado
May 6, 2008

New and recent hadronic B decay measurements

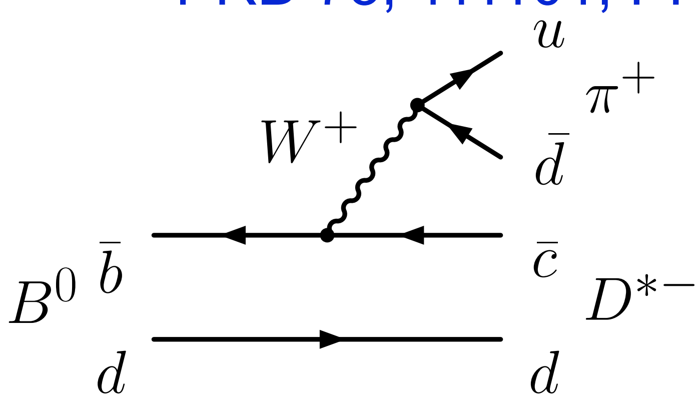
- Some $b \to c$ modes bearing on $2\beta + \gamma$ / $2\phi_1+\phi_3$
- Baryonic final states
- Charmless mesonic branching fractions and charge asymmetries
  - Modes with η, η', other pseudoscalars (P-P)
  - Vector-P modes
  - Axial-vector - P modes
  - A look at A-V decays

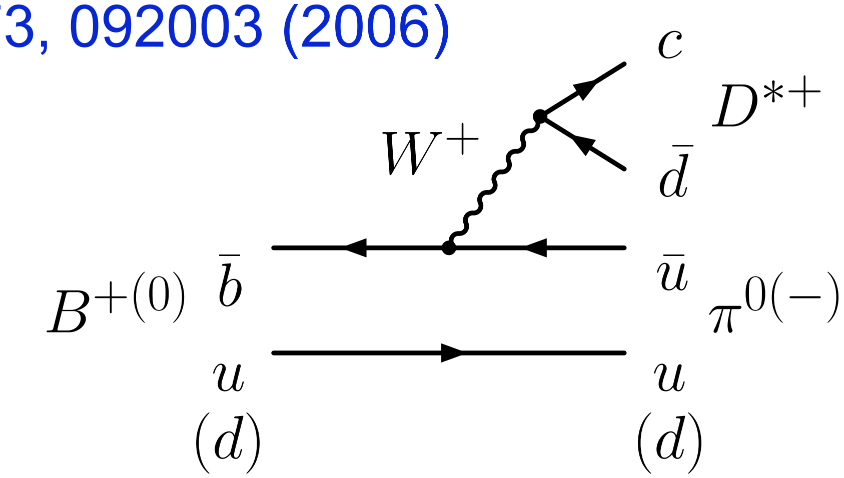
$\sin(2\beta+\gamma)$ - related branching fractions

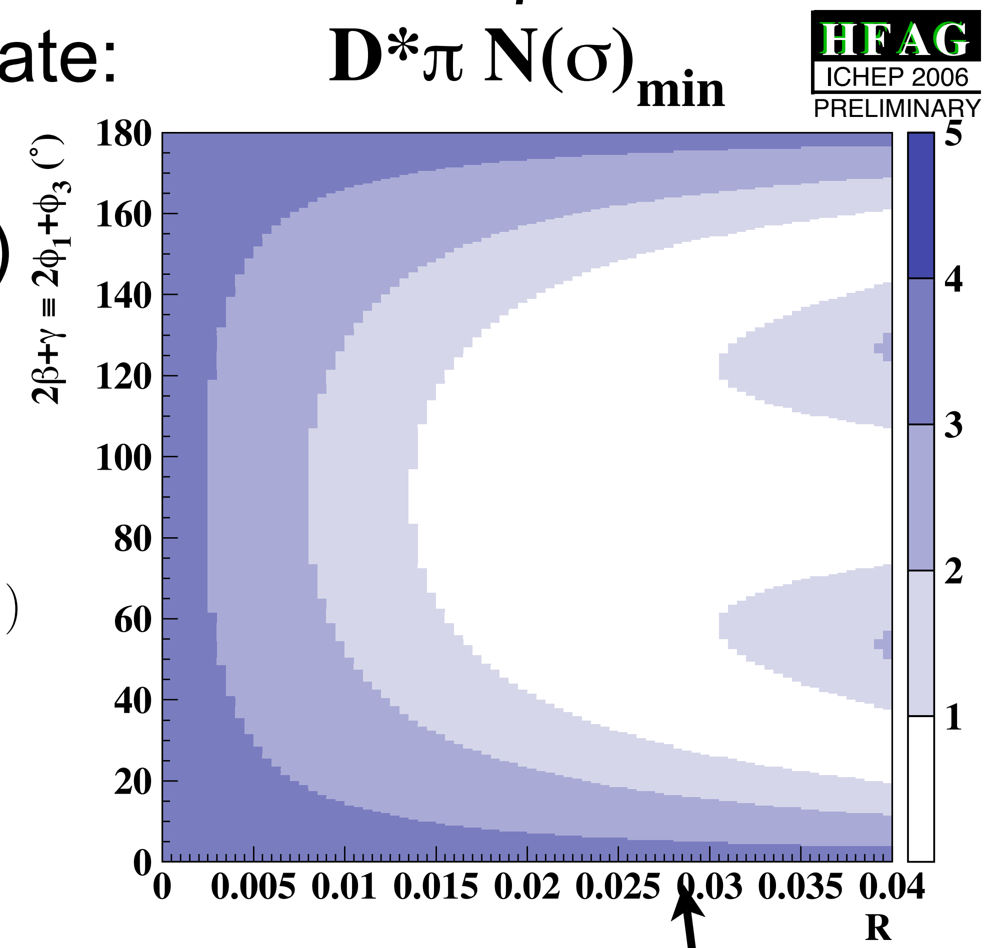
$\sin(2\beta+\gamma)$ / $2\phi_1+\phi_3$

- Determine $\sin(2\beta+\gamma)$ with decays $B^0,\bar{B}^0 \to D^{(*)+}\pi^-$ and $B^0,\bar{B}^0 \to D^+\rho^-$
- Interference between decays to the same final state:
  - Doubly Cabibbo-suppressed (DCS) (γ)
  - Mixing (2β) followed by Cabibbo favored (CF)

PRD 73, 111101, PRD 73, 092003 (2006)







- Measure time-dependent asymmetry

$$S^{\pm} = \frac{2(-1)^L\, r \sin(2\beta+\gamma\pm\delta)}{1+r^2} \qquad r(D^{(*)}\pi) = \left|\frac{A(B^0 \to D^{(*)+}\pi^-)}{A(B^0 \to D^{(*)-}\pi^+)}\right| \sim 0.02$$

- Need r from other modes:
  - $B \to D^{*+}\pi^0$ assuming isospin
  - $B \to D_s^{(*)+}\pi^-$ and $B \to D_s^{(*)+}\rho^-$ assuming SU(3) flavor symmetry

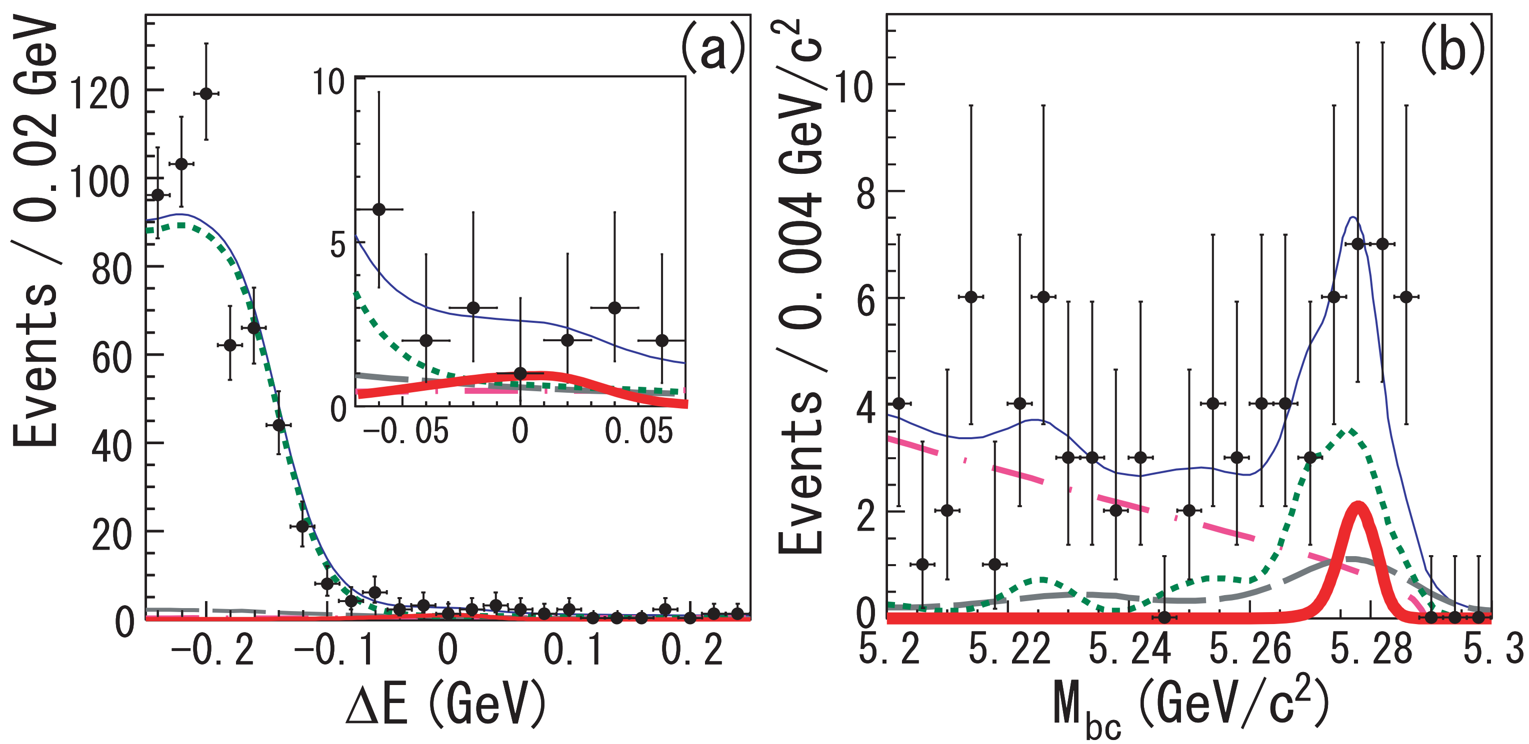
$B \to D^{(*)+}\pi^-$ from $B \to D^{(*)+}\pi^0$ (Belle)

657M $B\bar{B}$

- Obtain r from isospin:

$$r = \sqrt{\frac{\tau_{B^0}}{\tau_{B^+}} \frac{2\mathcal{B}(B^+ \to D^{*+}\pi^0)}{\mathcal{B}(B^0 \to D^{*-}\pi^+)}}$$

- No signal found:



= M_{ES}

$$\mathcal{B}(B^+ \to D^{*+}\pi^0) < 3.6 \times 10^{-6}$$

- Giving a limit on r:

$$r < 0.051 \quad (90\% \text{ CL})$$

arXiv:0804.0831

r from B → $D_S^{(*)+}\pi^-$ and B → $D_S^{(*)+}\rho^-$ (BaBar)

381M $B\bar{B}$

- Obtain r from flavor-SU(3):

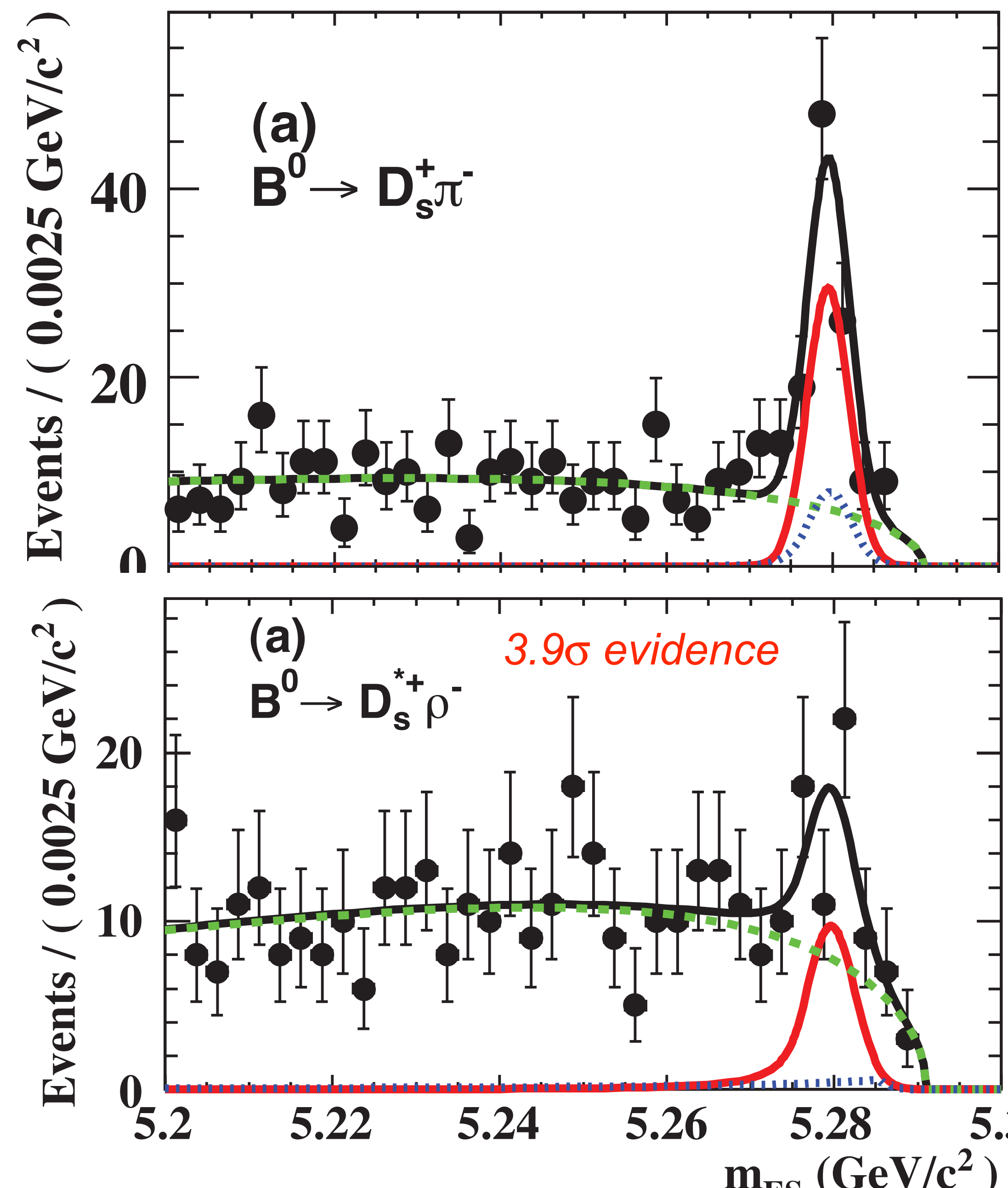
$$r(D^{(*)}\pi) = \tan\theta_c \frac{f_{D^{(*)}}}{f_{D_s^{(*)}}}\sqrt{\frac{\mathcal{B}(B^0 \to D_s^{(*)+}\pi^-)}{\mathcal{B}(B^0 \to D^{(*)-}\pi^+)}}$$

- Measure branching fractions

$$\begin{aligned}
\mathcal{B}(B^0 \to D_s^+\pi^-) &= [2.5 \pm 0.4 \pm 0.2] \times 10^{-5} \\
\mathcal{B}(B^0 \to D_s^{*+}\pi^-) &= [2.6^{+0.5}_{-0.4} \pm 0.3] \times 10^{-5} \\
\mathcal{B}(B^0 \to D_s^+\rho^-) &= [1.1^{+0.9}_{-0.8} \pm 0.3] \times 10^{-5} \\
\mathcal{B}(B^0 \to D_s^+\rho^-) &< 2.4 \times 10^{-5}\ (90\%\text{C.L.}) \\
\mathcal{B}(B^0 \to D_s^{*+}\rho^-) &= [4.4^{+1.3}_{-1.2} \pm 0.5] \times 10^{-5} \\
f_L(B^0 \to D_s^{*+}\rho^-) &= 0.86^{+0.26}_{-0.28} \pm 0.15
\end{aligned}$$

- With decay/constant ratio from lattice QCD, find

$$\begin{aligned}
r(D\pi) &= [1.75 \pm 0.14\,(\text{stat}) \pm 0.09\,(\text{syst}) \pm 0.10\,(\text{th})]\% \\
r(D^*\pi) &= [1.81^{+0.17}_{-0.14}\,(\text{stat}) \pm 0.12\,(\text{syst}) \pm 0.10\,(\text{th})]\% \\
r(D\rho) &= [0.71^{+0.29}_{-0.26}\,(\text{stat}) \pm 0.11\,(\text{syst}) \pm 0.04\,(\text{th})]\% \\
r(D^*\rho) &= [1.50^{+0.22}_{-0.21}\,(\text{stat}) \pm 0.16\,(\text{syst}) \pm 0.08\,(\text{th})]\%
\end{aligned}$$



sin(2β+γ) is still a difficult measurement!

arXiv:0803.4296

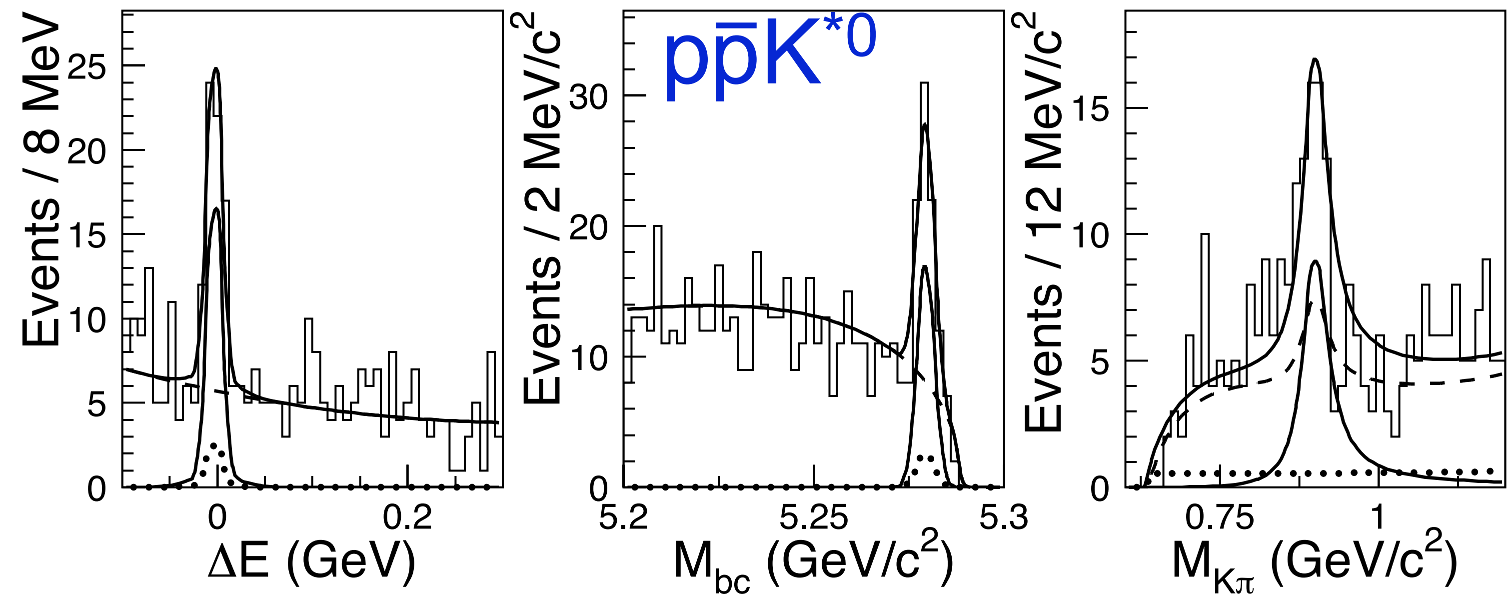
Decays to baryons

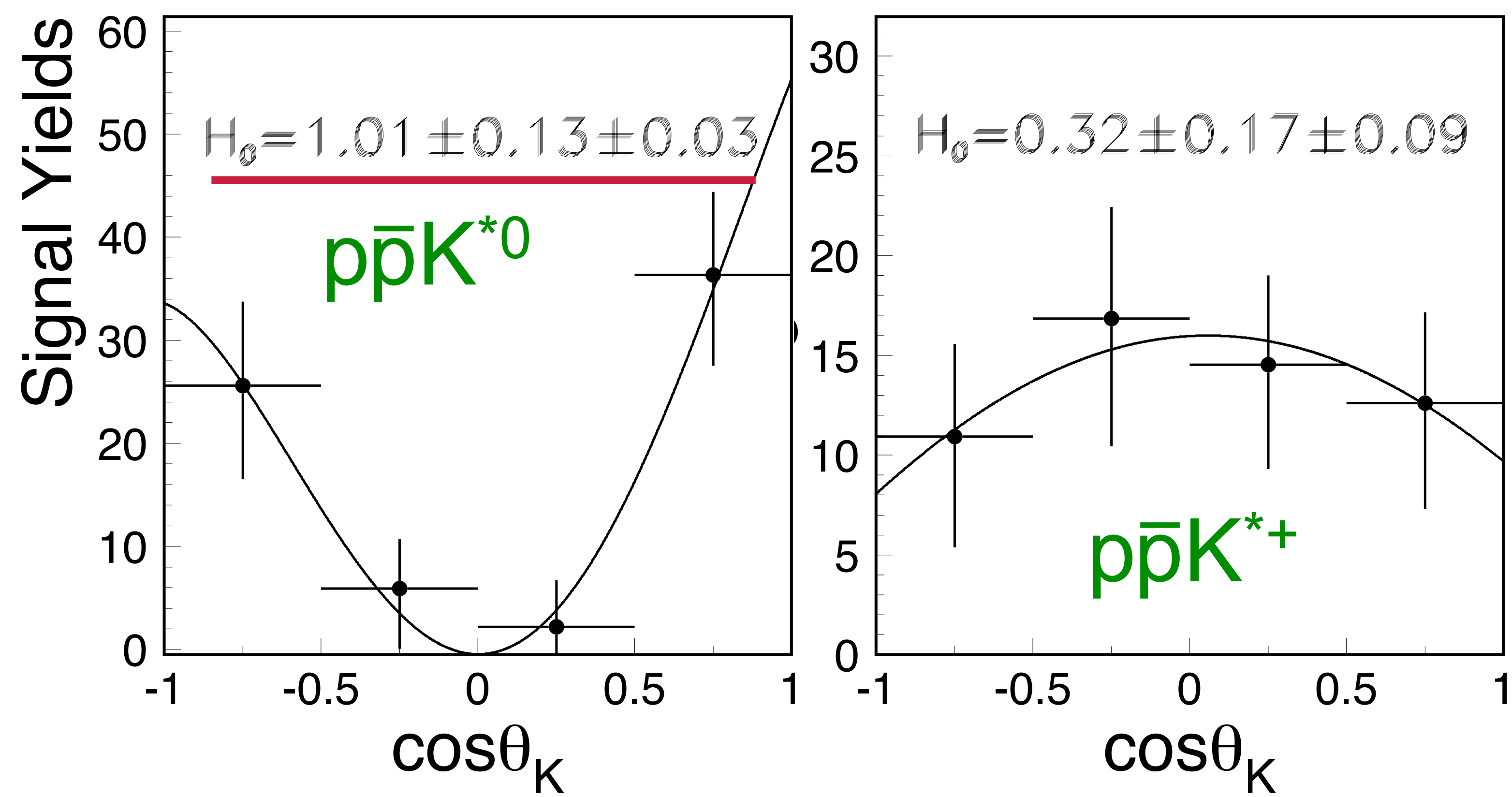
$B \to p\bar{p}K^*$

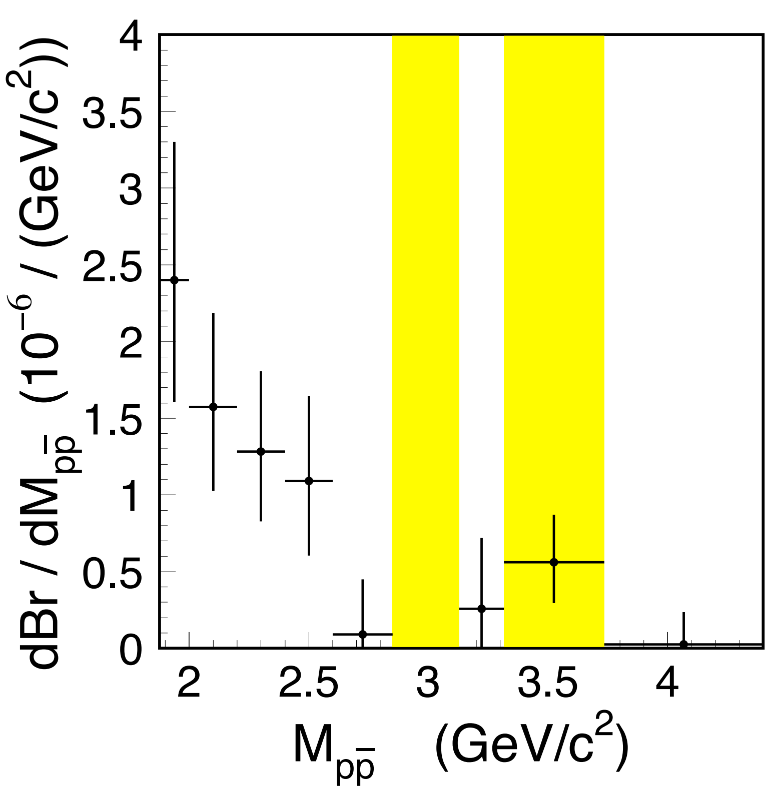
535M $B\bar{B}$

arXiv:0802.0336

- Now observe all charge states of $p\bar{p}K^{(*)}$, most recently K^{*0}.
- BF ~ 10^{-6}
  - Two-body $p\bar{p} < 10^{-7}$
  - $M(p\bar{p})$ in 3-body modes peaks at low values.





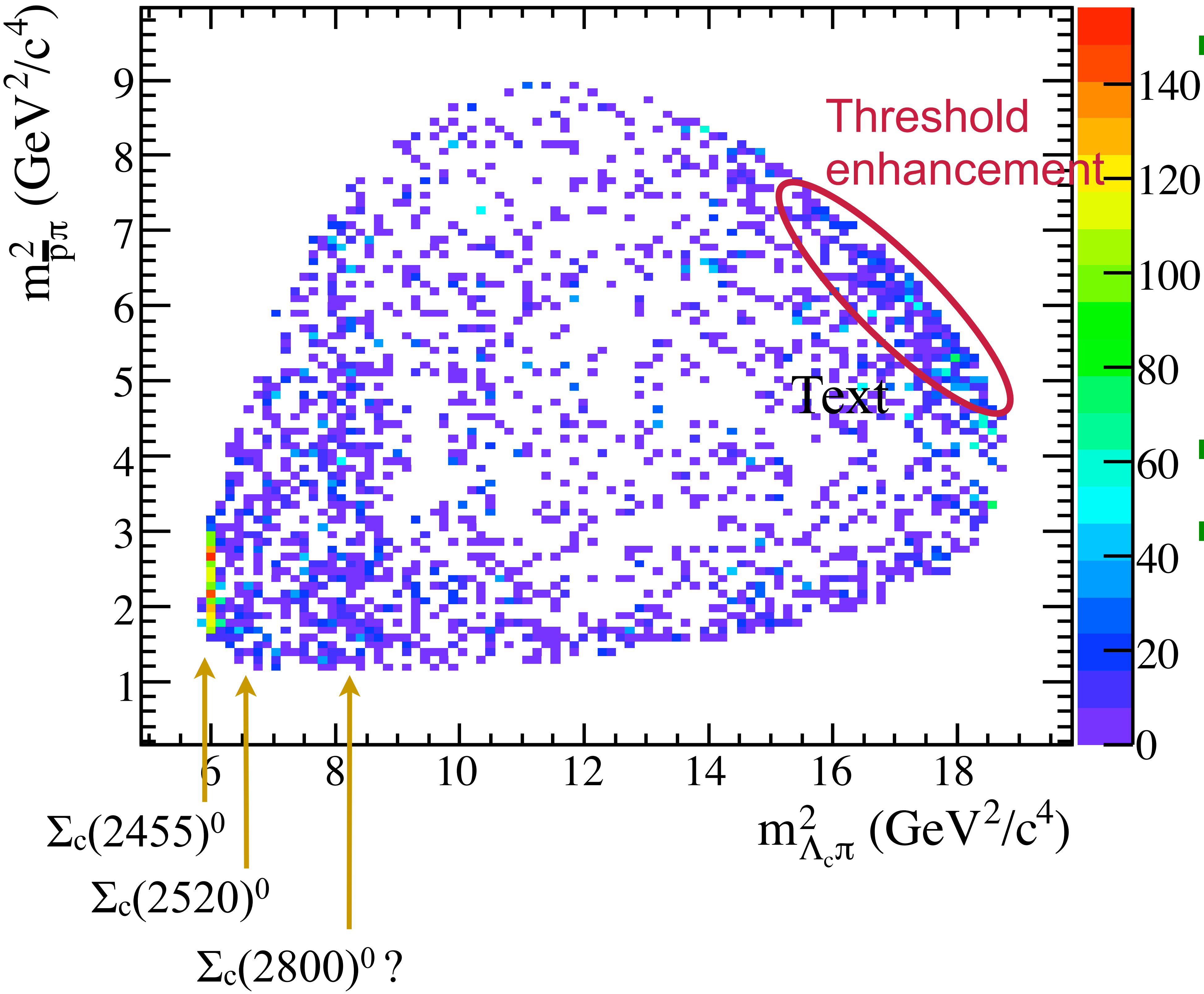


K*0 has ~100% longitudinal polarization, consistent with $b \to s$ penguin dominance.

Study of $B^- \to \Lambda_c^+ \bar{p} \pi^-$

BABAR preliminary

383M $B\bar{B}$

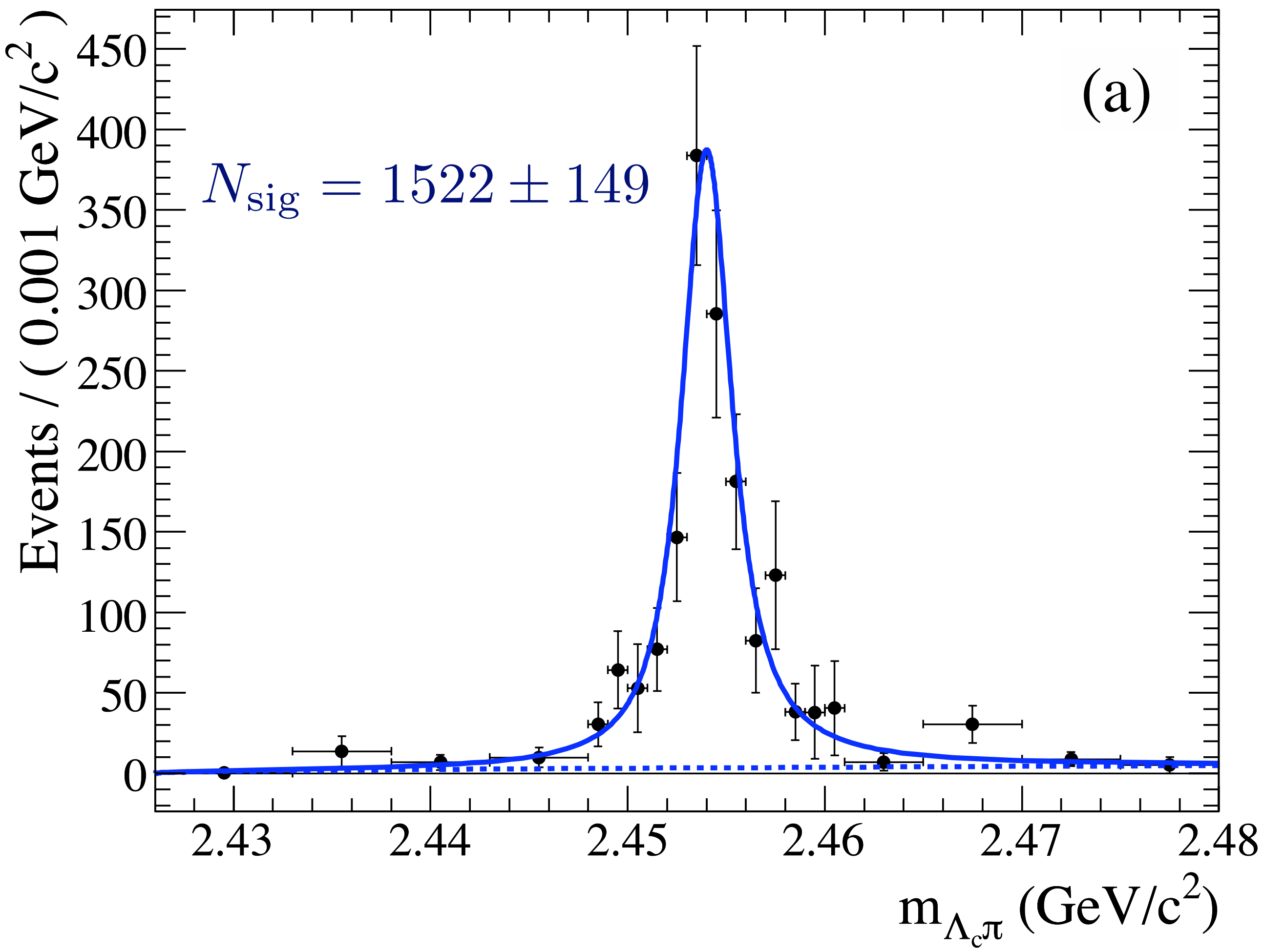


- Λ_c-$\bar{p}$ threshold enhancement, as in other baryon-antibaryon modes
- 2 Σ_c resonances
- No $\Sigma_c(2520)$ (J=3/2 suppressed?)

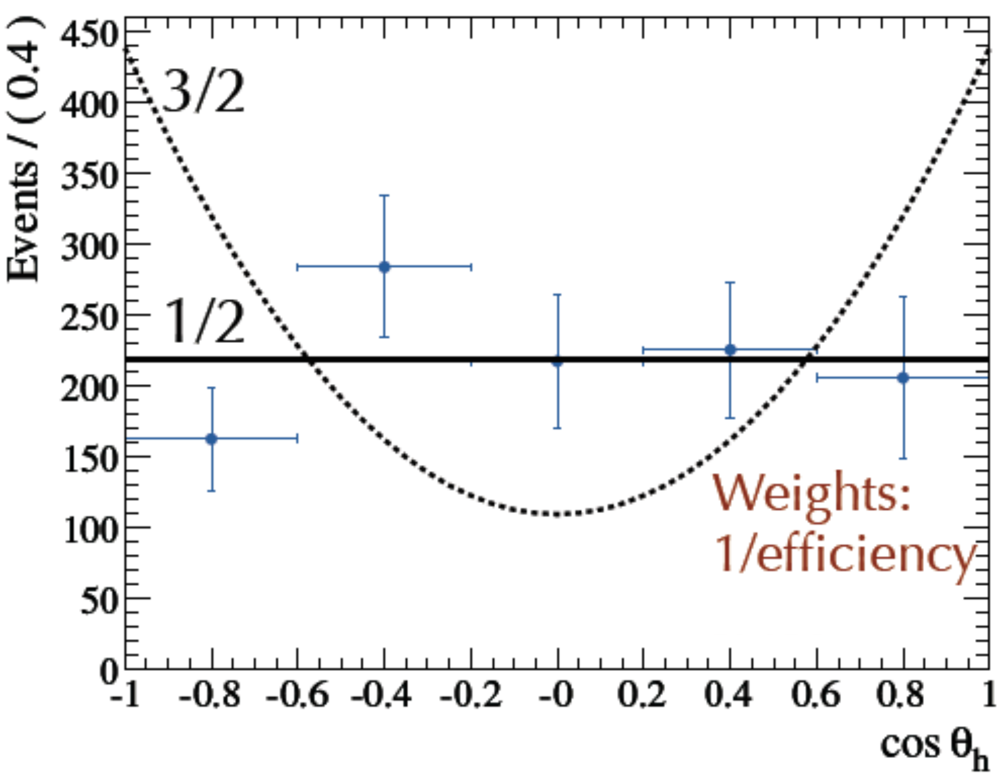
Update, new here

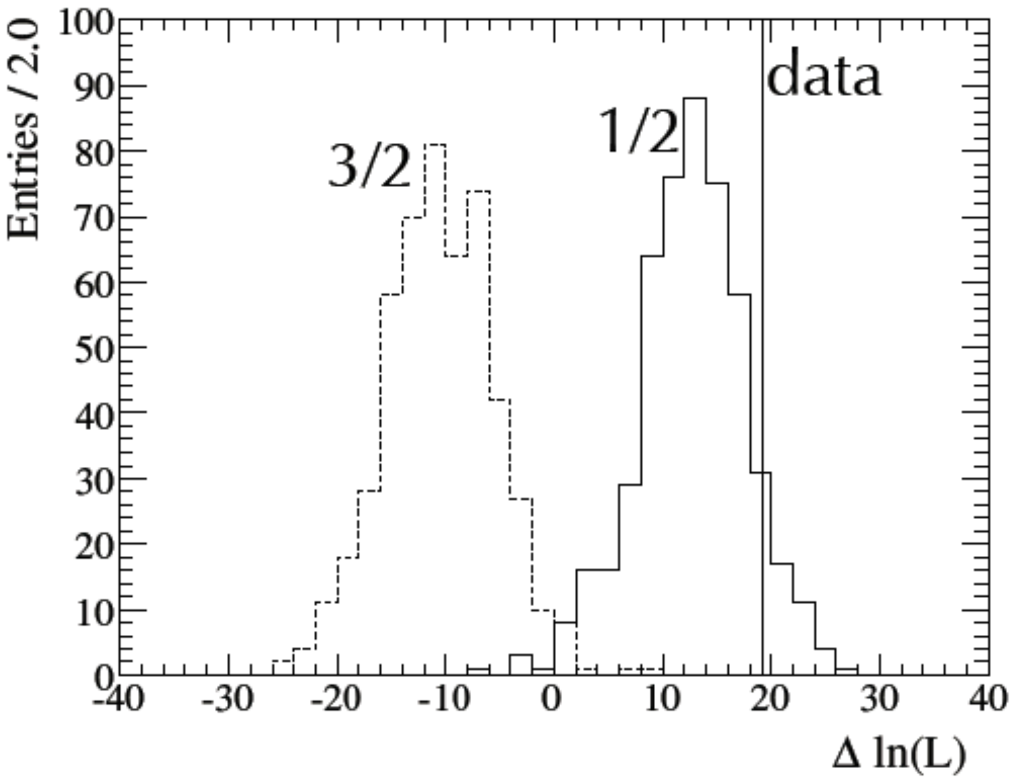
$B^- \to \Sigma_c(2455)^0 \bar{p}$

BABAR preliminary



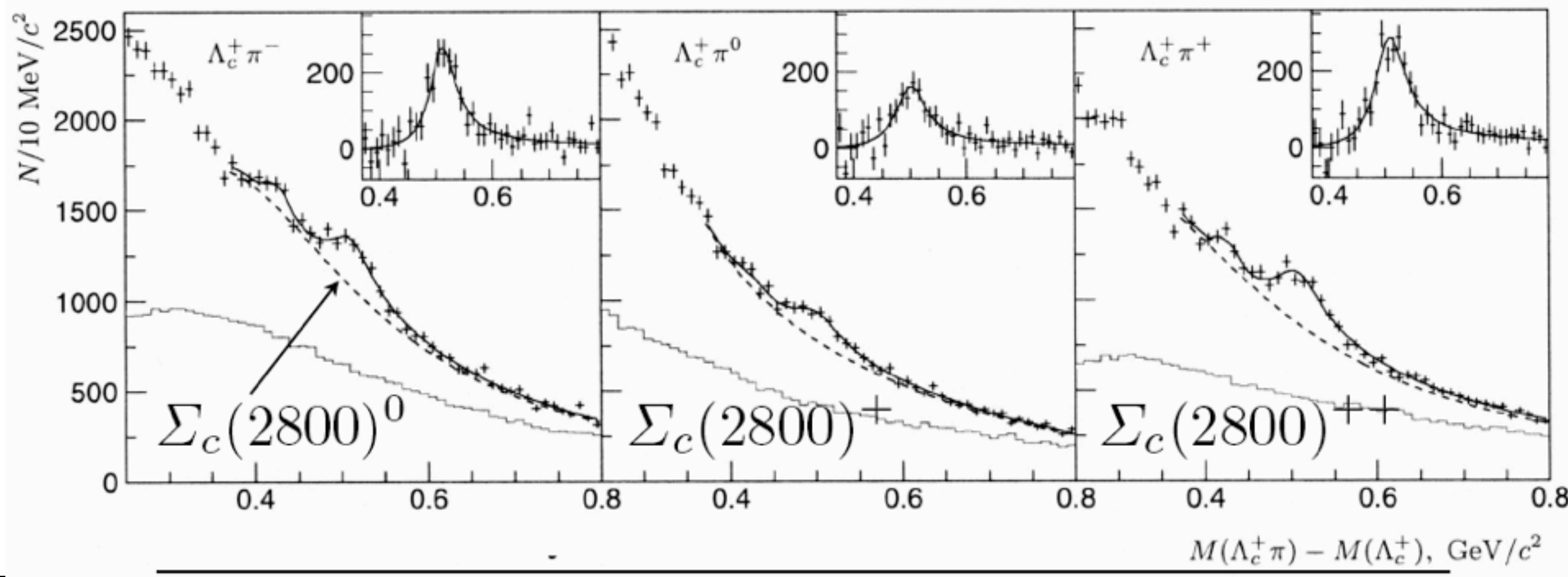
- Branching fraction
- Spin of Σ_c
- J=1/2, in agreement with quark model (assumes J (Λ_c) = 1/2)





Observation of $\Sigma_c(2800)^0$ in B decay (BaBar)

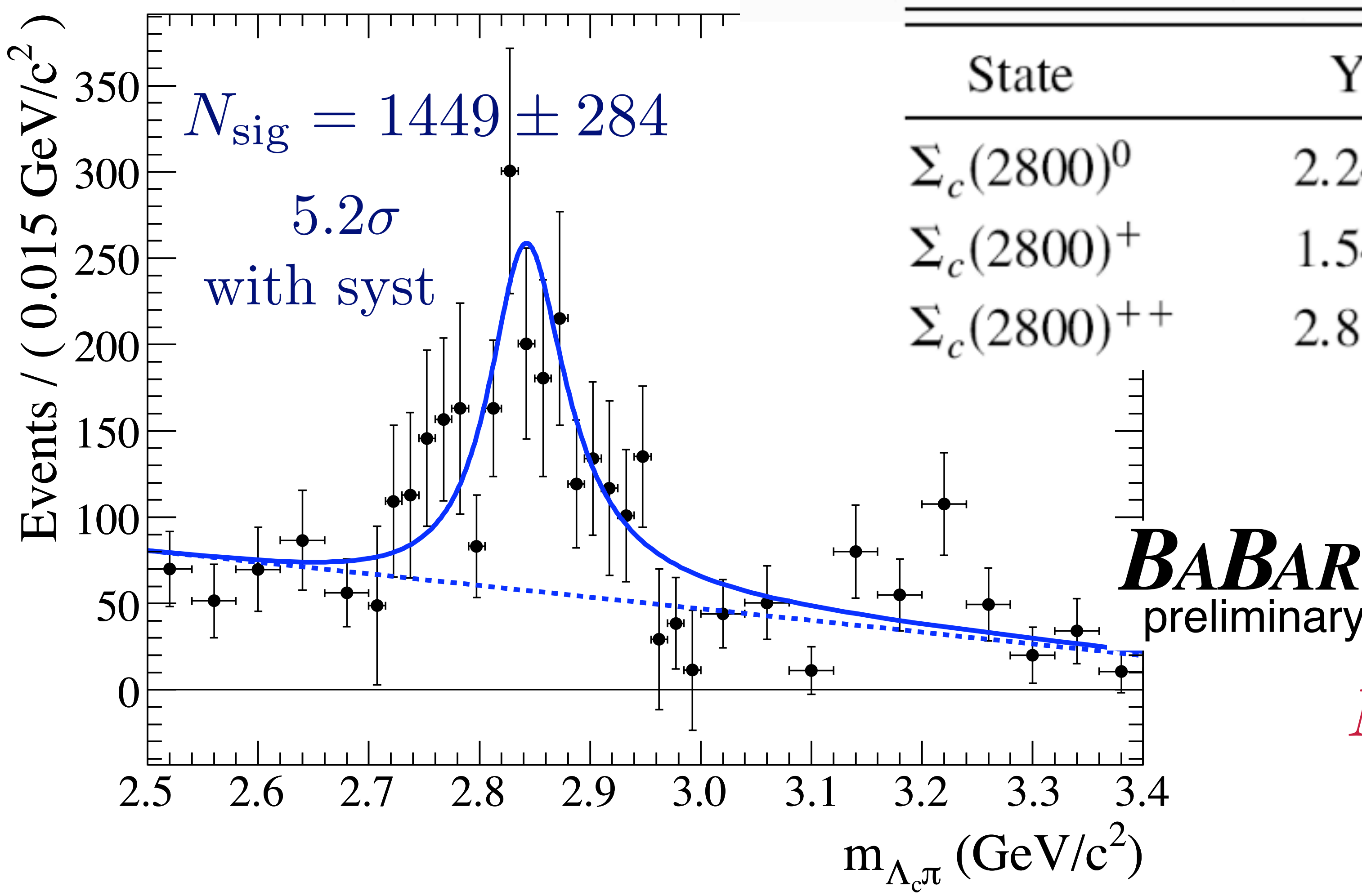
evidence from Belle in continuum $\Lambda_c\pi$



- Is this Belle's state?
- Mass is 3σ higher
- New J = 1/2 state?

State	Yield$/10^3$	ΔM, MeV$/c^2$	Γ, MeV
$\Sigma_c(2800)^0$	$2.24^{+0.79+1.03}_{-0.55-0.50}$	$515.4^{+3.2+2.1}_{-3.1-6.0}$	61^{+18+22}_{-13-13}
$\Sigma_c(2800)^+$	$1.54^{+1.05+1.40}_{-0.57-0.88}$	$505.4^{+5.8+12.4}_{-4.6-2.0}$	62^{+37+52}_{-23-38}
$\Sigma_c(2800)^{++}$	$2.81^{+0.82+0.71}_{-0.60-0.49}$ 26	$514.5^{+3.4+2.8}_{-3.1-4.9}$	75^{+18+12}_{-13-11}

PRL 94, 122002 (2005)



$M = 2846 \pm 8 \pm 10$ MeV

$B^- \to \Lambda_c^+ \bar{p}(\pi^-)$ branching fractions

$$\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p}) = (1.89 \pm 0.21 \pm 0.06 \pm 0.49) \times 10^{-5}$$
$$\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-) = (3.38 \pm 0.12 \pm 0.12 \pm 0.88) \times 10^{-4}$$

- $\mathcal{B}(\Lambda_c \to pK^-\pi^+)$ is the dominant uncertainty;
- Cancels in the ratio:

$$\frac{\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-)}{\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p})} = 15.4 \pm 1.8 \pm 0.3$$

BABAR preliminary

- For the resonances

$$\frac{\mathcal{B}(B^- \to \Sigma_c(2455)^0 \overline{p})}{\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-)} = (12.3 \pm \overset{\text{stat}}{1.2} \pm \overset{\text{syst}}{0.8})\%$$

$$\frac{\mathcal{B}(B^- \to \Sigma_c(2520)^0 \overline{p})}{\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-)} < 0.9\%$$

$$\frac{\mathcal{B}(B^- \to \Sigma_c(2800)^0 \overline{p})}{\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-)} = (11.7 \pm 2.3 \pm 2.4)\%$$

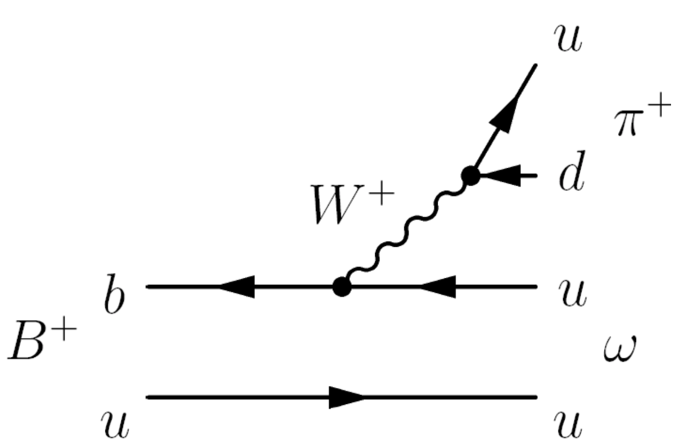
The two resonances account for about 1/4 of this final state

Charmless mesonic decays

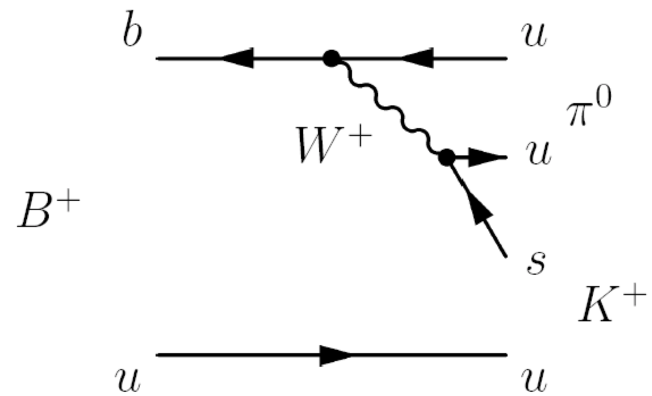
Charmless hadronic B decays

- Rich variety of interfering Standard Model amplitudes

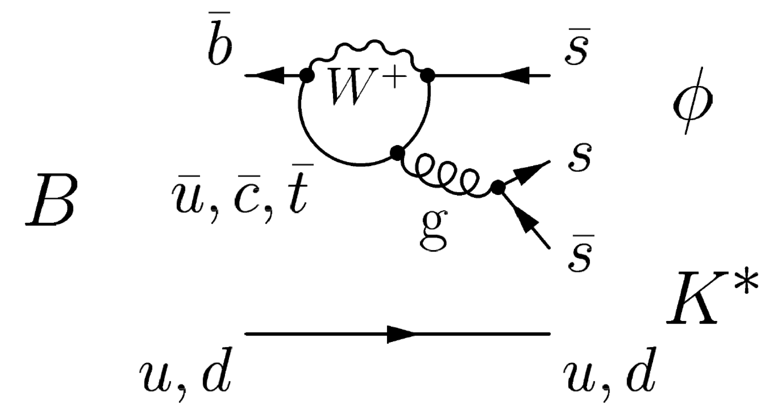
e.g.,



Tree,T



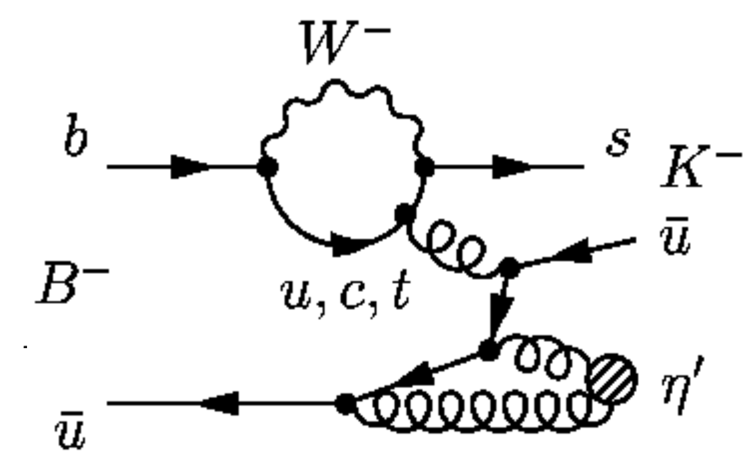
Color-suppressed tree, C'



Gluonic penguin, P'

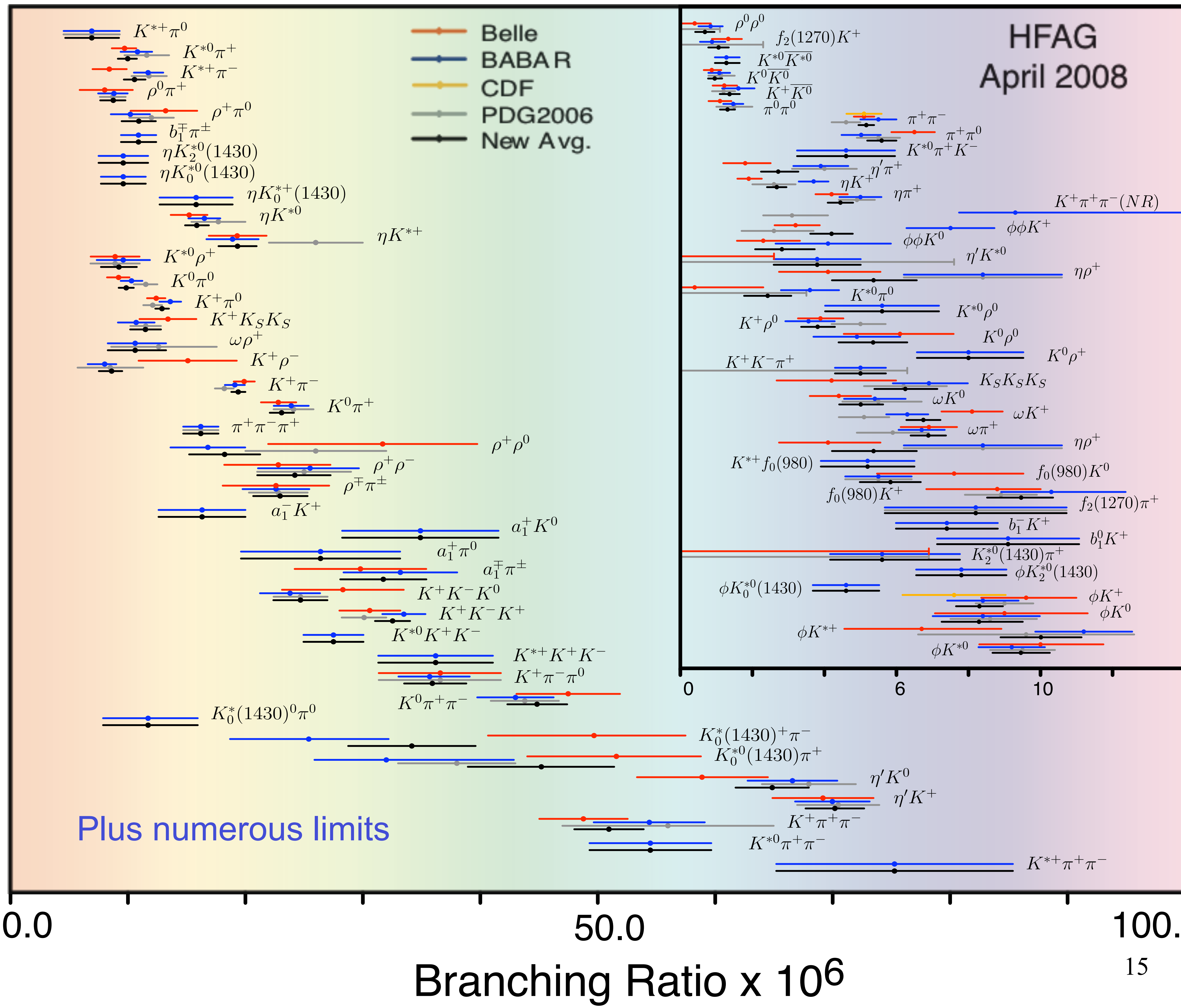
(prime denotes ΔS=1)

- Some not yet well known:
  - feed back to theory
- Where known, measure
  - CKM magnitudes and angles
  - New physics from contributions in loops (window on higher energy scales)



Flavor-singlet penguin, S'

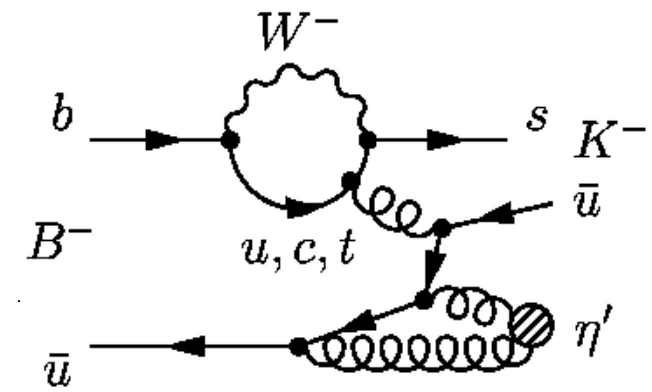
Charmless Mesonic B Branching Fractions




ΔS = 1 decays

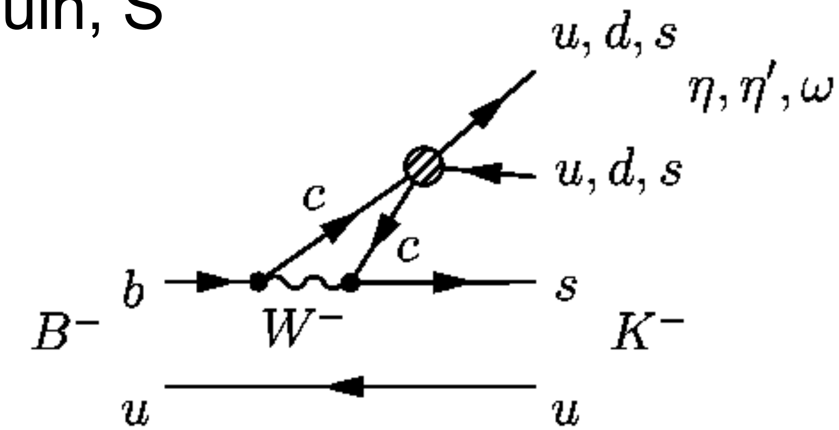
Large BF for $B \to \eta' K$

- η' strongly coupled to glue



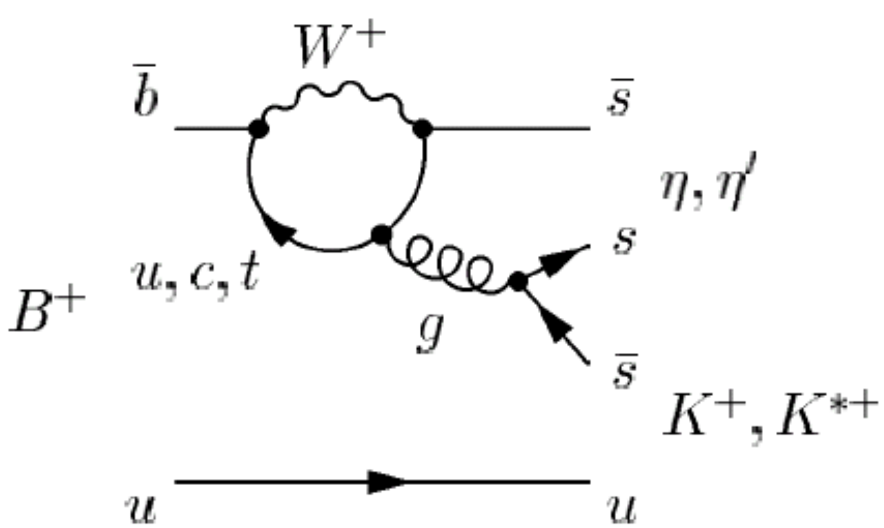
Flavor-singlet penguin, S'

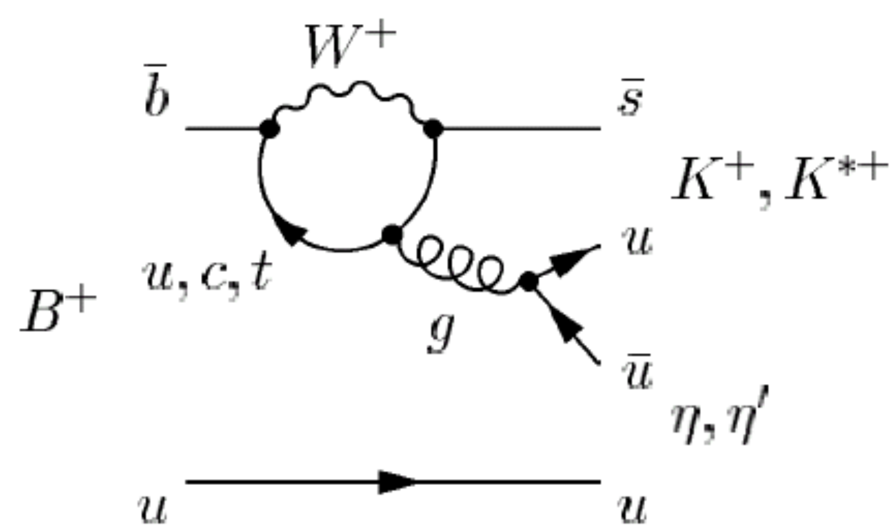
- η' strongly coupled to $c\bar{c}$



"Charming penguin"

- Constructive interference of $gs\bar{s}$, $gq\bar{q}$:





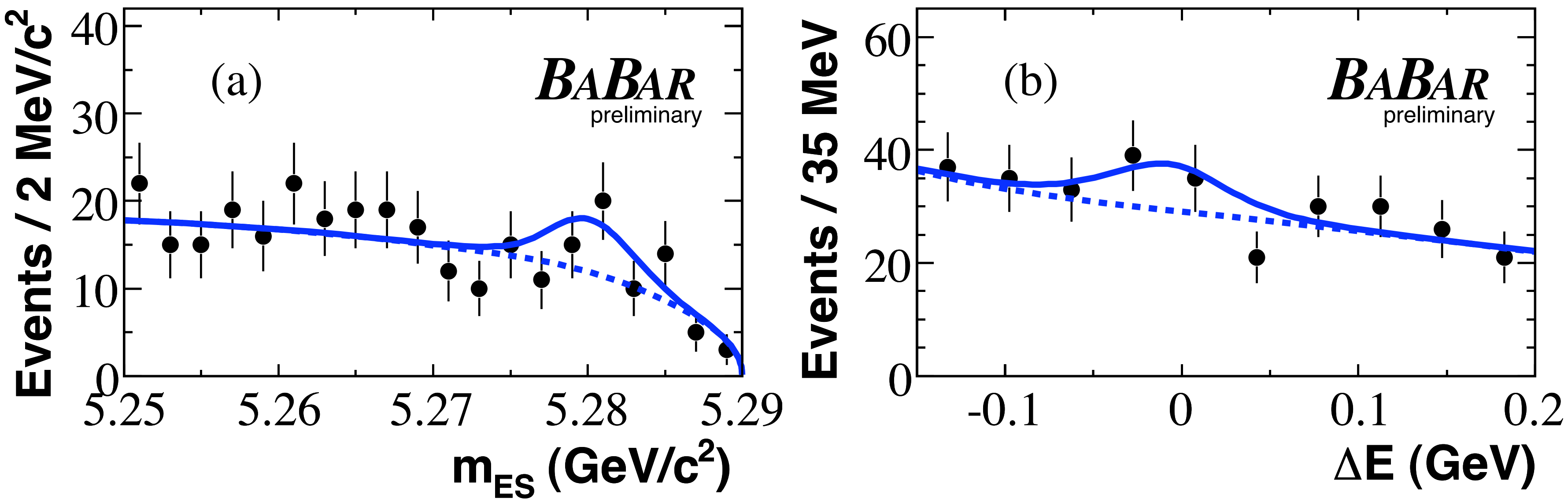
$$\eta' \cong \frac{1}{\sqrt{2}}\left(\eta_q + \eta_s\right)$$

$$\eta \cong \frac{1}{\sqrt{2}}\left(\eta_q - \eta_s\right)$$

New search for $B^0 \to \eta K^0$

- No clear signal seen

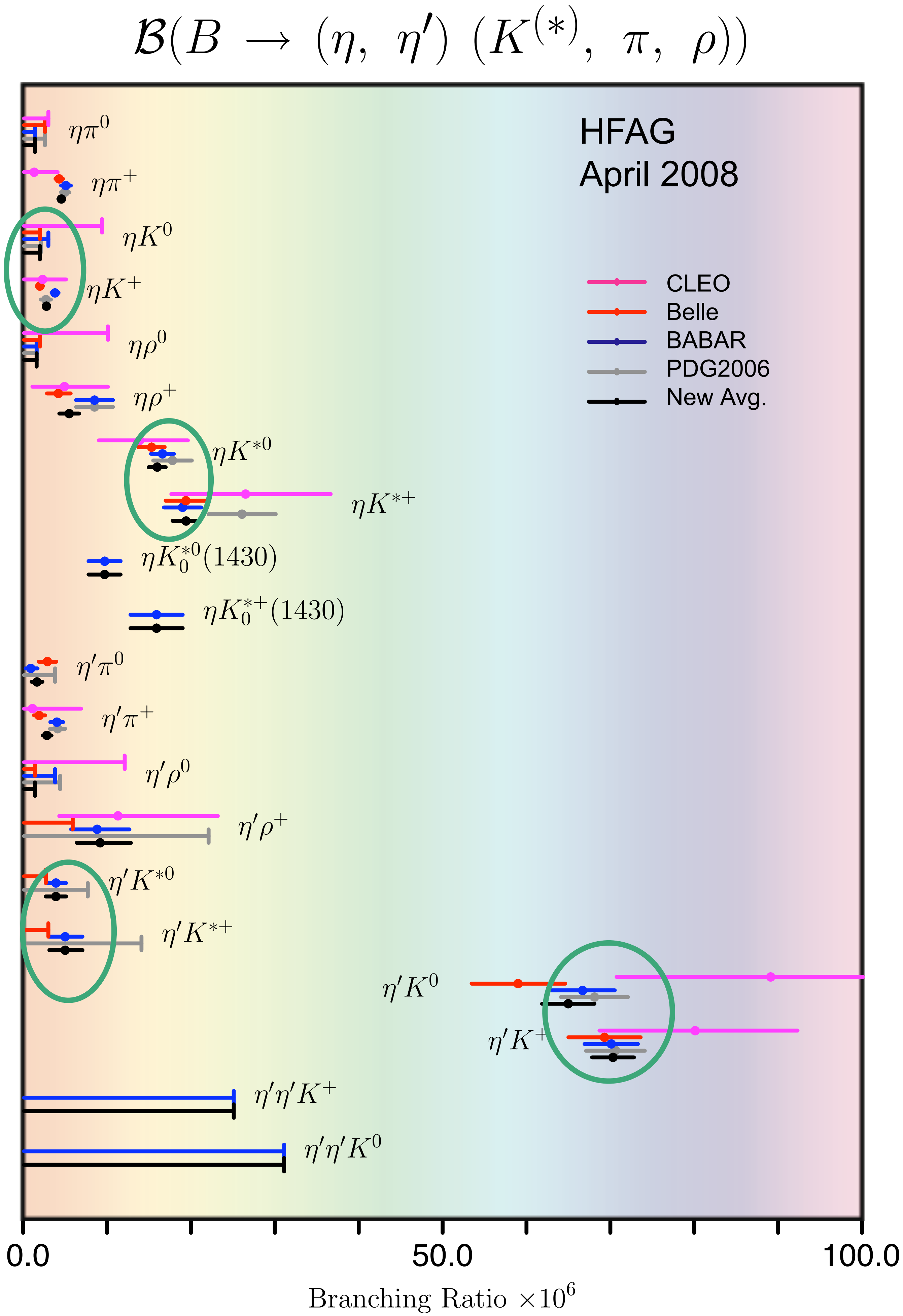
BABAR preliminary 465M $B\bar{B}$



New here

Decay Mode		BABAR	Belle	Average
ηK^0		$0.9^{+0.5}_{-0.4} \pm 0.1$ (< 1.6)	$1.1 \pm 0.4 \pm 0.1$ (< 1.9)	1.0 ± 0.3 (< 1.6)
ηK^+	$\neq$	$3.7 \pm 0.4 \pm 0.1$	$1.9 \pm 0.3^{+0.2}_{-0.1}$	2.7 ± 0.3
$\eta' K^0$		$66.6 \pm 2.6 \pm 2.8$	$58.9^{+3.6}_{-3.5} \pm 4.3$	64.9 ± 3.1
$\eta' K^+$		$70.0 \pm 1.5 \pm 2.8$	$69.2 \pm 2.2 \pm 3.7$	70.2 ± 2.5

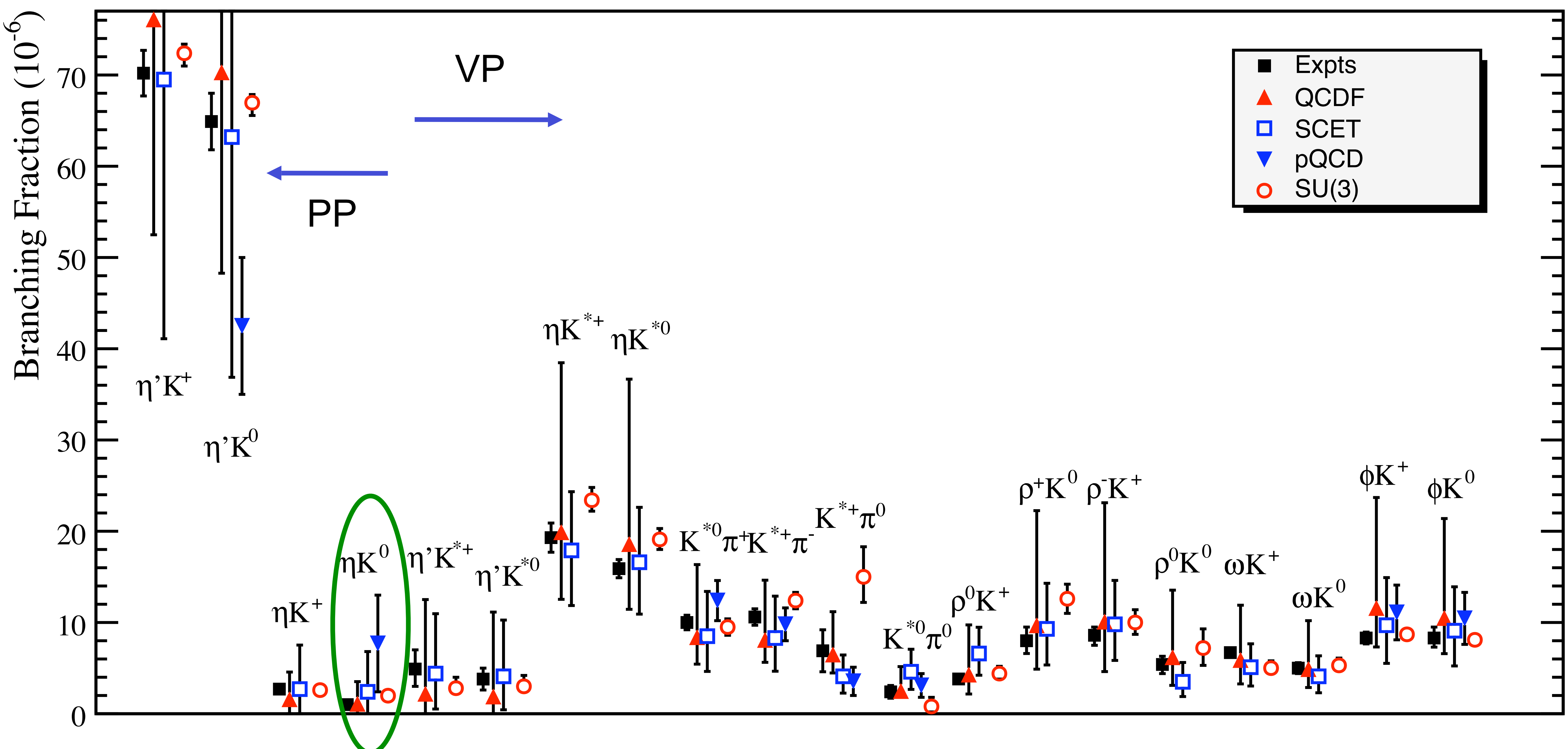
- Difference between isospin states not expected for penguin-dominated decays.
- Some tension between BaBar and Belle values for ηK^+



$B \to (\eta,\eta')(K,K^*)$ picture

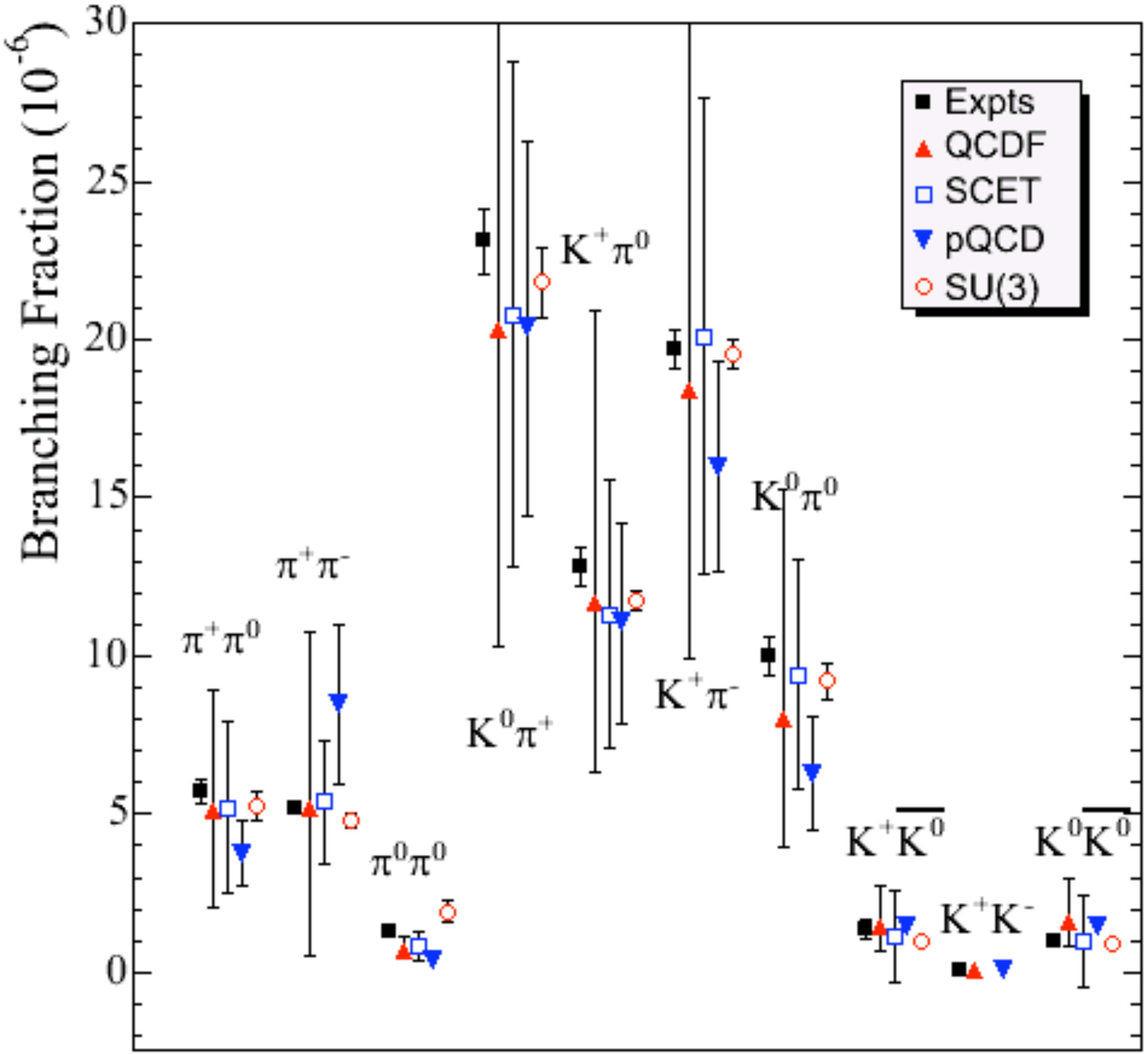
- $\eta K \ll \eta' K$
  - consistent w interference of $gs\bar{s}$, $gq\bar{q}$
  - some S' needed, else ηK even smaller
- $\eta K^* \gg \eta' K^*$
  - consistent w $gs\bar{s}$, $gq\bar{q}$ interference plus a sign flip for P-V decay (but that argument is in doubt)
- $\eta' K > \pi K$ needs charming penguins
- So, all of above contribute in detailed estimates from QCDF, SCET, SU(3)
  - All of which require fits to data for poorly known parameters

Expt vs theory, ΔS = 1 BFs (non-K,π)



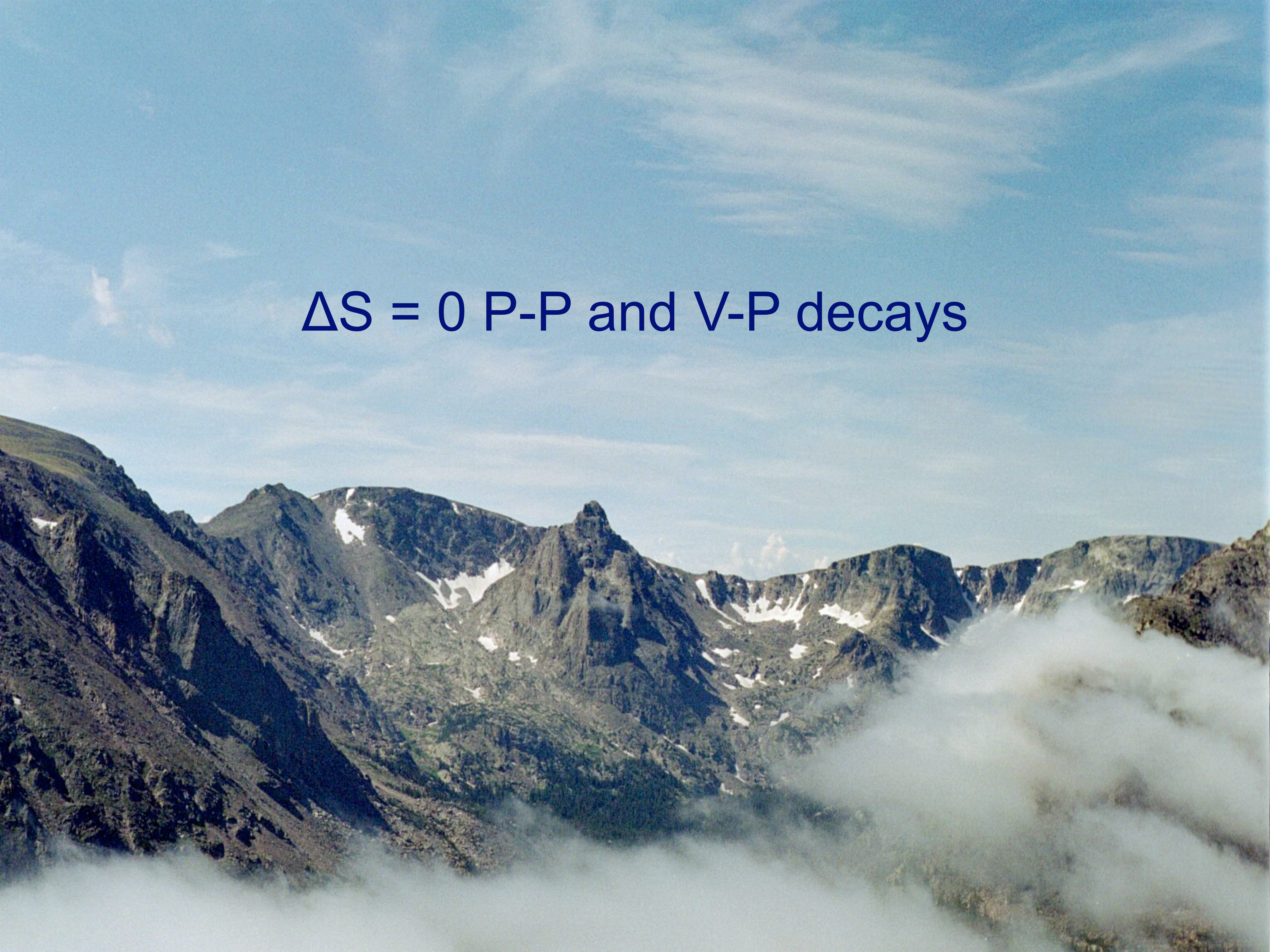
- QCDF, SCET accommodate $\eta^{(')}K^{(*)}$ BFs, but with large uncertainties
- Biggest uncertainties for QCDF (SCET): renormalization scale, quark masses, decay constants and form factors, η(') mixing

Expt vs theory, $K\pi$ branching fractions



- Data world averages from HFAG
- QCDF from Beneke, Neubert, NP B 675, 333 (2003) (“scenario 4”)
- SCET from Williamson, Zupan, PRD74 (2006) 014003, 03901; Wang, Wang, Yang, Lu arXiv: 0801.3123
- pQCD from Keum, Pramana 63 (2004) 1151
- SU(3) from Chiang, Gronau, Rosner, Suprun, PRD 70 (2004) 034020

$\Delta S = 0$ P-P and V-P decays



Flavor nonet center-state modes, P-P

Mode	$\mathcal{S}$ (σ)	$\mathcal{B}$ (10^{-6})		
$\eta\eta$	2.4	$0.8 \pm 0.4 \pm 0.1$	(< 1.4)	[2]
$\eta'\eta$	1.4	$0.5 \pm 0.4 \pm 0.1$	(<1.2)	[1]
$\eta'\eta'$	1.3	$0.9^{+0.8}_{-0.7} \pm 0.1$	(< 2.1)	[2]
$\eta\pi^0$	2.2	$0.9 \pm 0.4 \pm 0.1$	(<1.5)	[1]
$\eta'\pi^0$	3.1	$0.9 \pm 0.4 \pm 0.1$	(<1.5)	[1]

BABAR preliminary 459-465M $B\bar{B}$

1. arXiv:0804.2422
2. new here

~canceling color-suppressed tree amplitudes

- "Model-independent" constraint on tree pollution of time-dependent CP in $B^0 \to \eta' K^0$
  - GLNQ:

$$|\xi_{\eta' K_S}| < \left|\frac{V_{us}}{V_{ud}}\right| \left(0.59\sqrt{\frac{\mathcal{B}(\eta'\pi^0)}{\mathcal{B}(\eta'K^0)}} + 0.33\sqrt{\frac{\mathcal{B}(\eta\pi^0)}{\mathcal{B}(\eta'K^0)}} + 0.14\sqrt{\frac{\mathcal{B}(\pi^0\pi^0)}{\mathcal{B}(\eta'K^0)}} + 0.53\sqrt{\frac{\mathcal{B}(\eta'\eta')}{\mathcal{B}(\eta'K^0)}} + 0.38\sqrt{\frac{\mathcal{B}(\eta\eta)}{\mathcal{B}(\eta'K^0)}} + 0.96\sqrt{\frac{\mathcal{B}(\eta\eta')}{\mathcal{B}(\eta'K^0)}}\right)$$

    - SU(3) relations
  - GRZ extract a somewhat tighter limit, neglecting exchange & penguin-annihilation terms

Gronau, Rosner, Zupan PRD 74, 093003 (2006)

- But the BF limits aren't getting much tighter: hints of signals!

Grossman, Ligeti, Nir, Quinn PRD 68, 015004 (2003)

Flavor nonet center-state modes, V-P

Mode	$\mathcal{S}$ (σ)	$\mathcal{B}(10^{-6})$	
$\eta\phi$	1.7	$0.22^{+0.19}_{-0.15} \pm 0.01$	(< 0.52) [2]
$\eta\omega$	3.5	$1.0^{+0.4}_{-0.3} \pm 0.1$	(< 1.6) [2]
$\eta'\phi$	1.3	$0.5 \pm 0.4 \pm 0.1$	(< 1.2) [2]
$\eta'\omega$	3.1	$1.0^{+0.5}_{-0.4} \pm 0.1$	(< 1.7) [2]
$\pi^0\omega$	0.3	$0.07 \pm 0.26 \pm 0.02$	(<0.5) [1]

BABAR preliminary

459-465M $B\bar{B}$

1. arXiv:0804.2422
2. new here

- Tree pollution in $B^0 \to \phi K^0$ is related to V-P modes (GLNQ)
- Limits not very restrictive
- Some evidence for $\omega\eta^{(\prime)}$ at the limit of experimental sensitivity.

Observation of $B^+ \to \eta\rho^+$

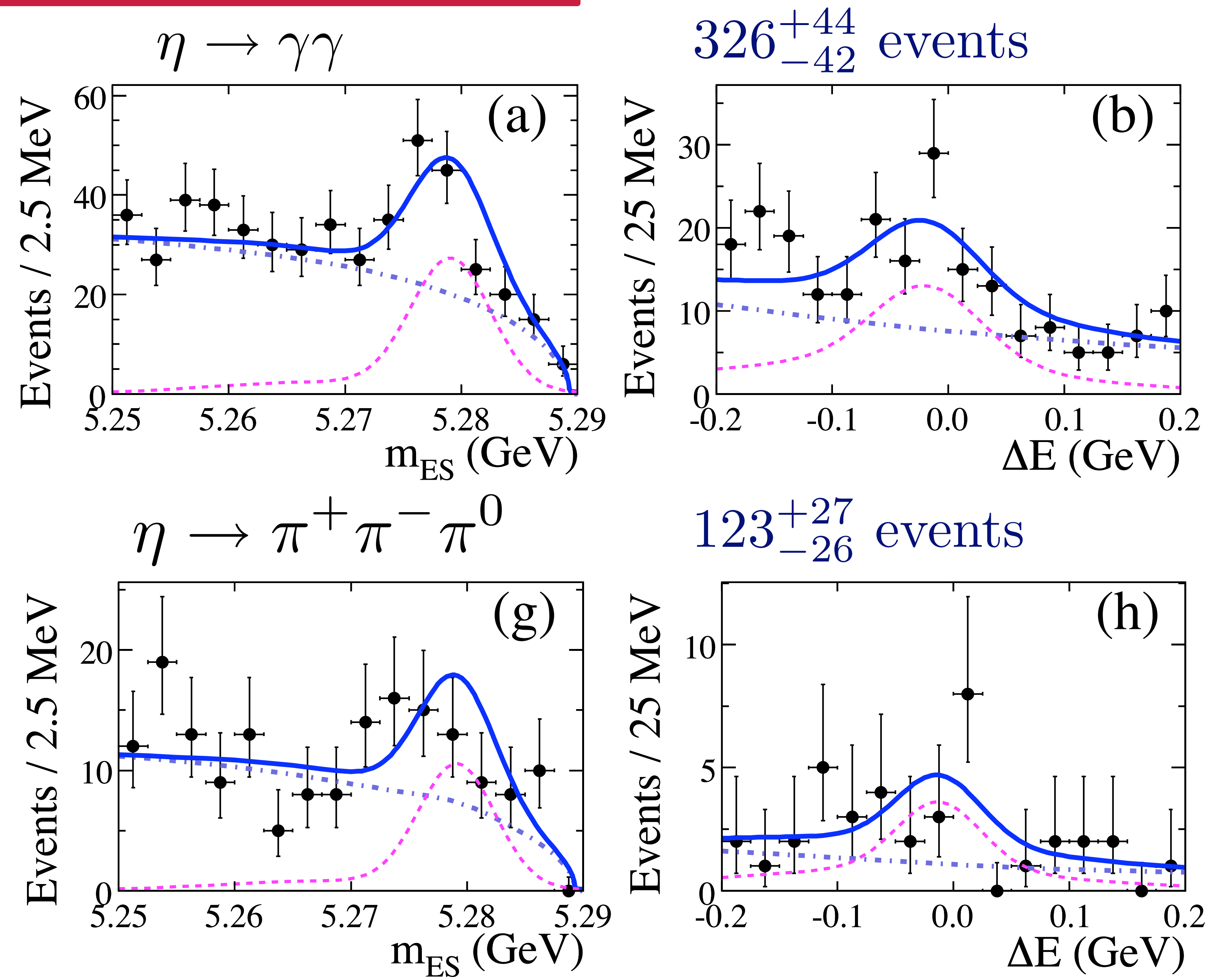
- 9.0 sigma significance

BABAR preliminary

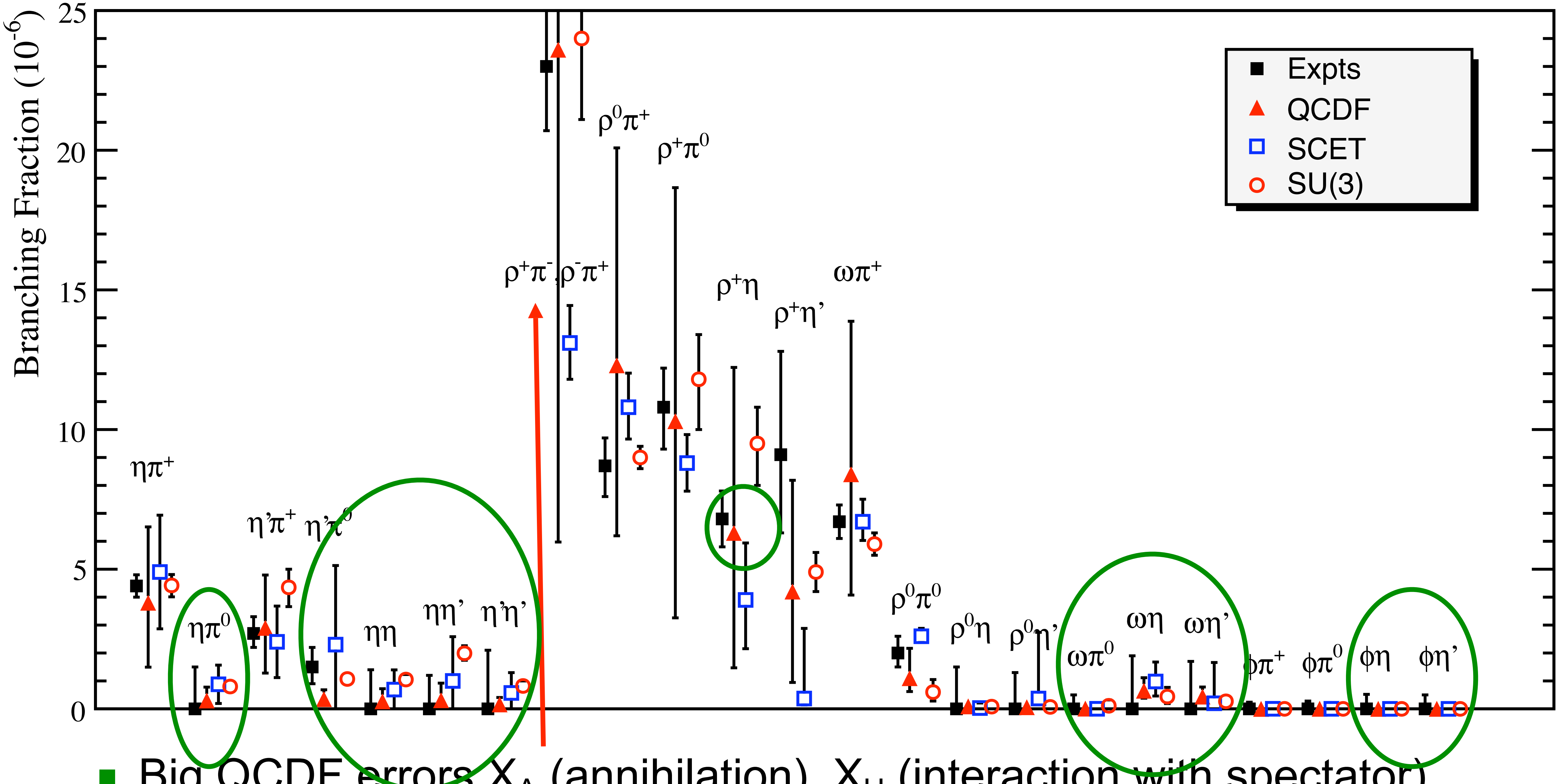
459M $B\bar{B}$

arXiv:0804.2422

$$\mathcal{B}(B^+ \to \eta\rho^+) = (9.9 \pm 1.2 \pm 0.8) \times 10^{-6}$$
$$\mathcal{A}_{ch} = 0.13 \pm 0.11 \pm 0.02$$



Expt vs theory, $\Delta S = 0$ branching fractions



- Big QCDF errors X_A (annihilation), X_H (interaction with spectator)
  - SCET error smaller, disagrees with experiment.
- Many modes not yet seen (but consistent with theoretical estimates)

$\Delta S = 0$ A-P decays

Axial vector mesons

- In the quark model, the $^1P_1$ meson nonet contains
  - $b_1(1235)$ with $I^G=1^+$
  - two isosinglets $h_1(1380)$, $h_1(1170)$
  - strange isodoublet K_{1B}
- K_{1B} mixes with K_{1A} to form the physical $K_1(1270)$, $K_1(1400)$:

$$
\begin{aligned}
K_1(1270) &= K_{1A}\sin\theta + K_{1B}\cos\theta \\
K_1(1400) &= K_{1A}\cos\theta - K_{1B}\sin\theta
\end{aligned}
$$

- K_{1A} belongs to the $^3P_1$ meson nonet containing also
  - $a_1(1260)$ with $I^G=1^-$
  - isosinglets $f_1(1420)$, $f_1(1285)$
- $B^0 \to a_1\ (\pi, K)$ observed:

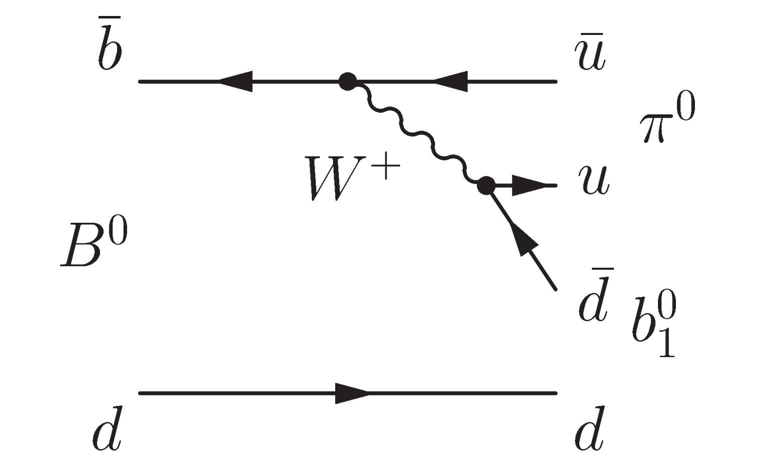
$$
\begin{aligned}
\mathcal{B}(B^0 \to a_1^{\mp}\pi^{\pm}) &= (33.2 \pm 3.8 \pm 3.0) \times 10^{-6} \\
&= (29.8 \pm 3.2 \pm 4.6) \times 10^{-6} \\
\mathcal{B}(B^0 \to a_1^{-}K^{+}) &= (8.2 \pm 1.5 \pm 1.2) \times 10^{-6}\ (5.1\sigma) \\
\mathcal{B}(B^+ \to a_1^{+}K^{0}) &= (17.4 \pm 2.5 \pm 2.2) \times 10^{-6}\ (6.2\sigma)
\end{aligned}
$$

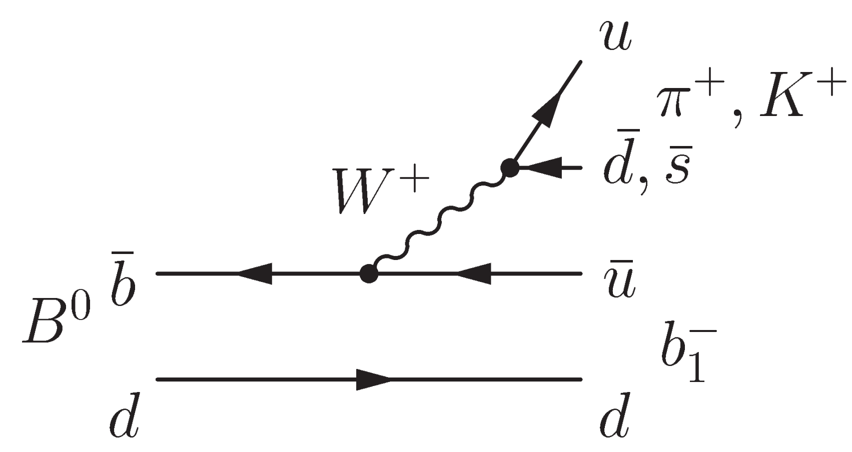
BaBar, PRL 97, 151802 (2006)
Belle, arXiv:0706.3276

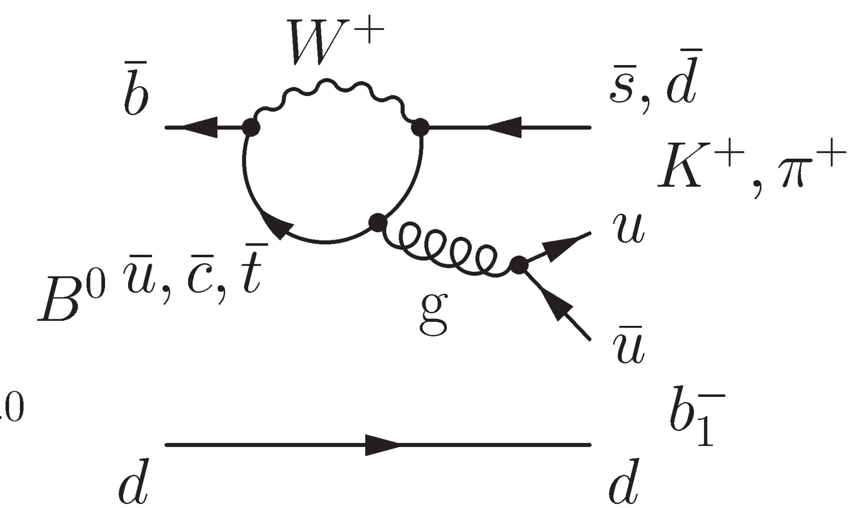
BaBar, PRL 100, 051803 (2008)

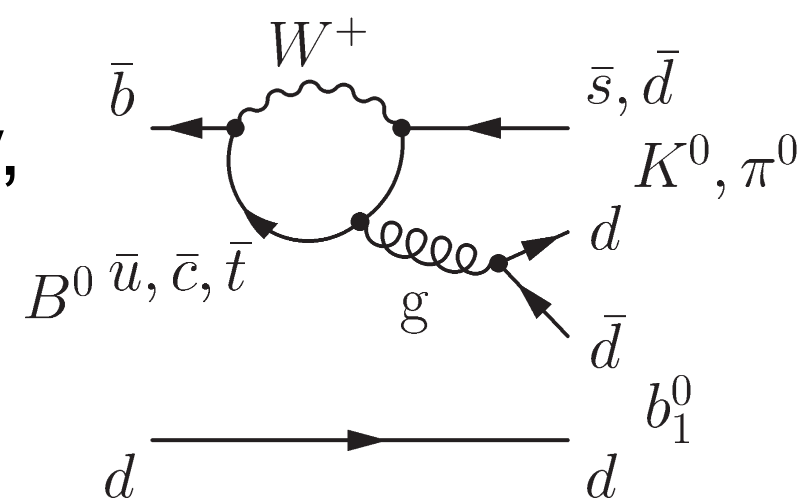
B decays to b_1

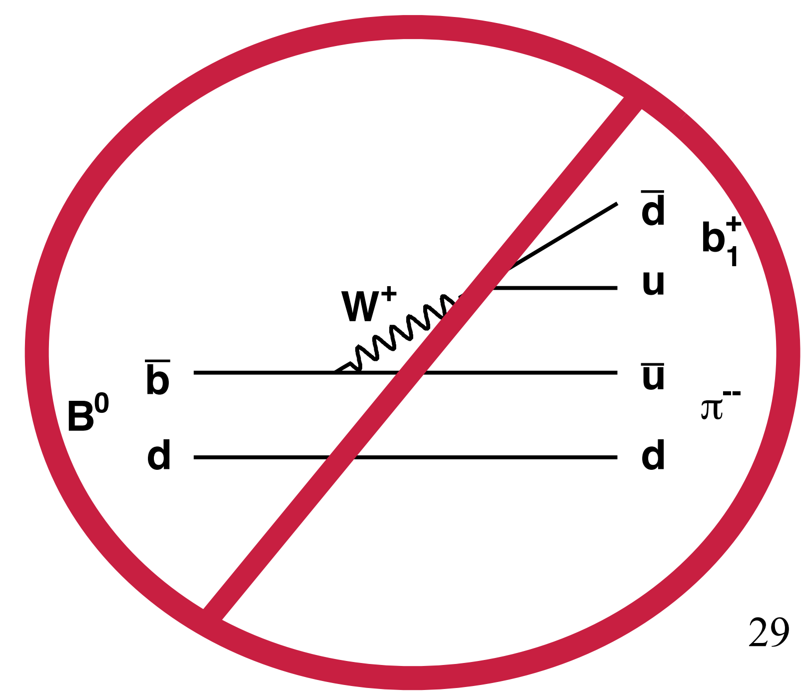
- $B \to b_1(\pi, K)$, $b_1 \to \omega\pi$ (dominant b_1 decay)
- CKM factors favor
  - (color-suppressed) tree for $b_1\pi$
  - penguin for $b_1 K$
- The weak axial vector current is odd in G-parity, b_1 even
- So we expect
  - $B^0 \to b_1^+ \pi^- \ll B^0 \to b_1^+ \pi^-$
  - $B^+ \to b_1^+ \pi^0 \sim 0$











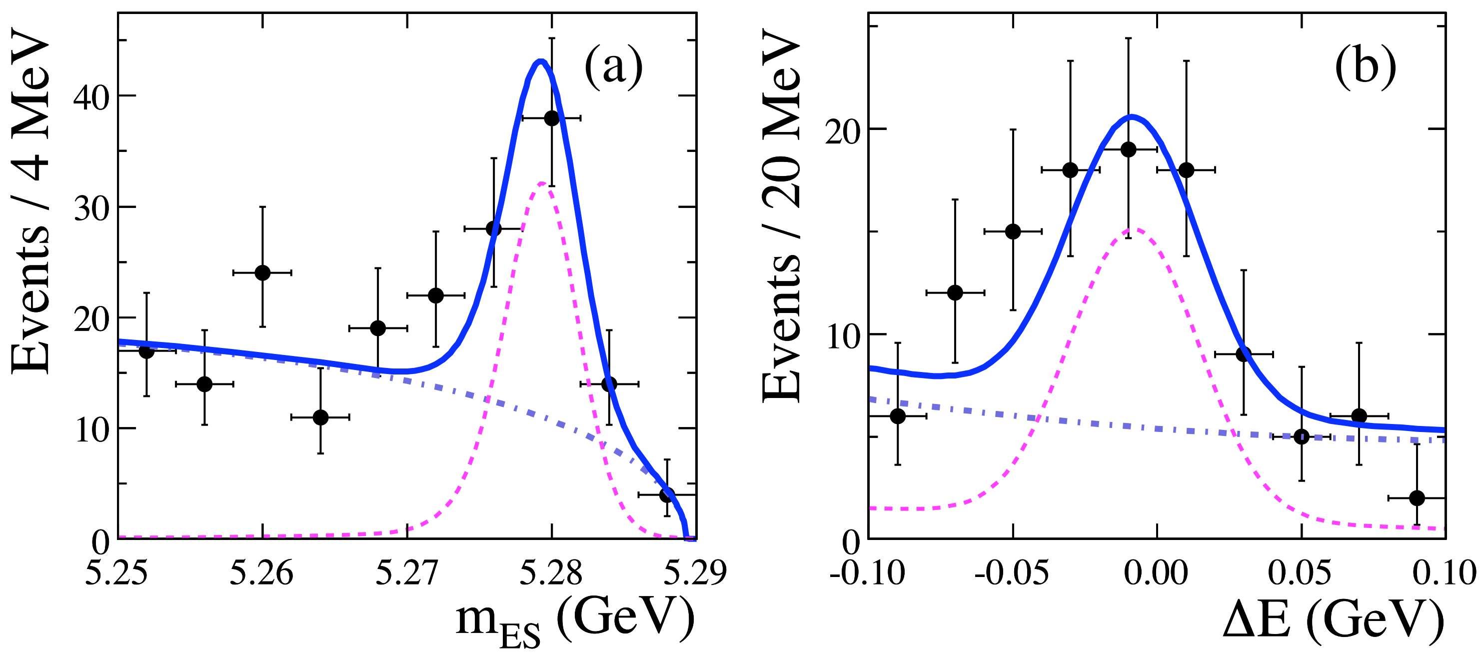
New measurements $B \to b_1(\pi^0, K^0)$

Mode	Y_S (ev.)	$\mathcal{S}$ (σ)	$\mathcal{B}$ (10^{-6})	$\mathcal{A}_{ch}$
$b_1^+ K^0$	164^{+27}_{-25}	6.3	$9.6 \pm 1.7 \pm 0.9$	$-0.03 \pm 0.15 \pm 0.02$
$b_1^0 K^0$	58^{+19}_{-17}	3.4	$5.1 \pm 1.8 \pm 0.5$	
$b_1^+ \pi^0$	71^{+35}_{-32}	1.6	$1.8 \pm 0.9 \pm 0.2$	
$b_1^0 \pi^0$	6^{+19}_{-16}	0.5	$0.4 \pm 0.8 \pm 0.2$	

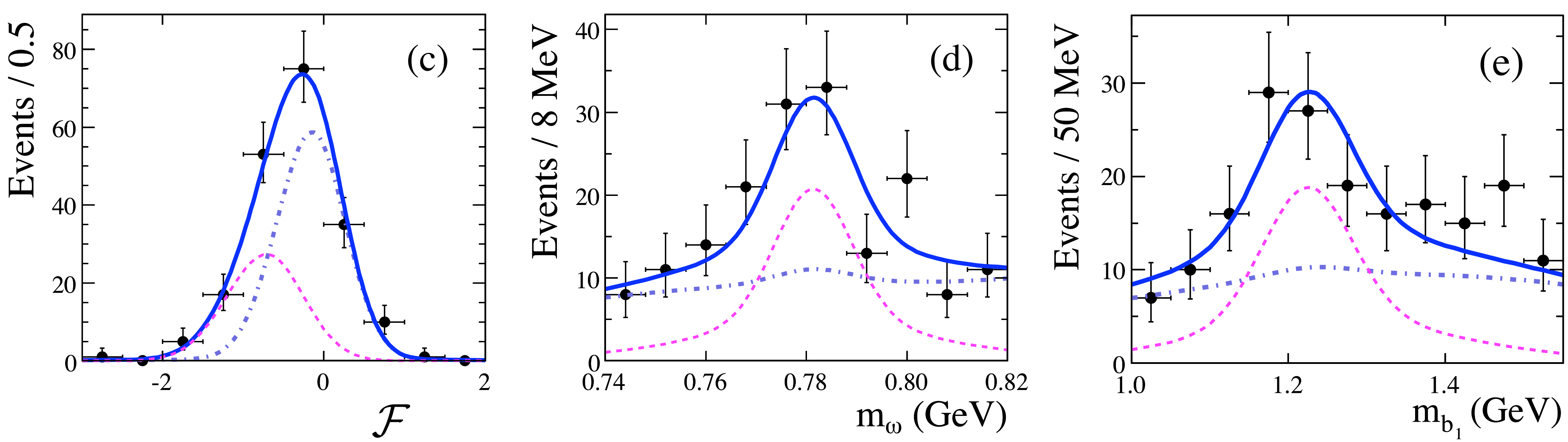
465M $B\bar{B}$

New here

BABAR preliminary



- Clear observation of $B^+ \to b_1^+ K^0$
- 3.4 sigma evidence for $B^0 \to b_1^0 K^0$



B decays to b_1 measurements and theory

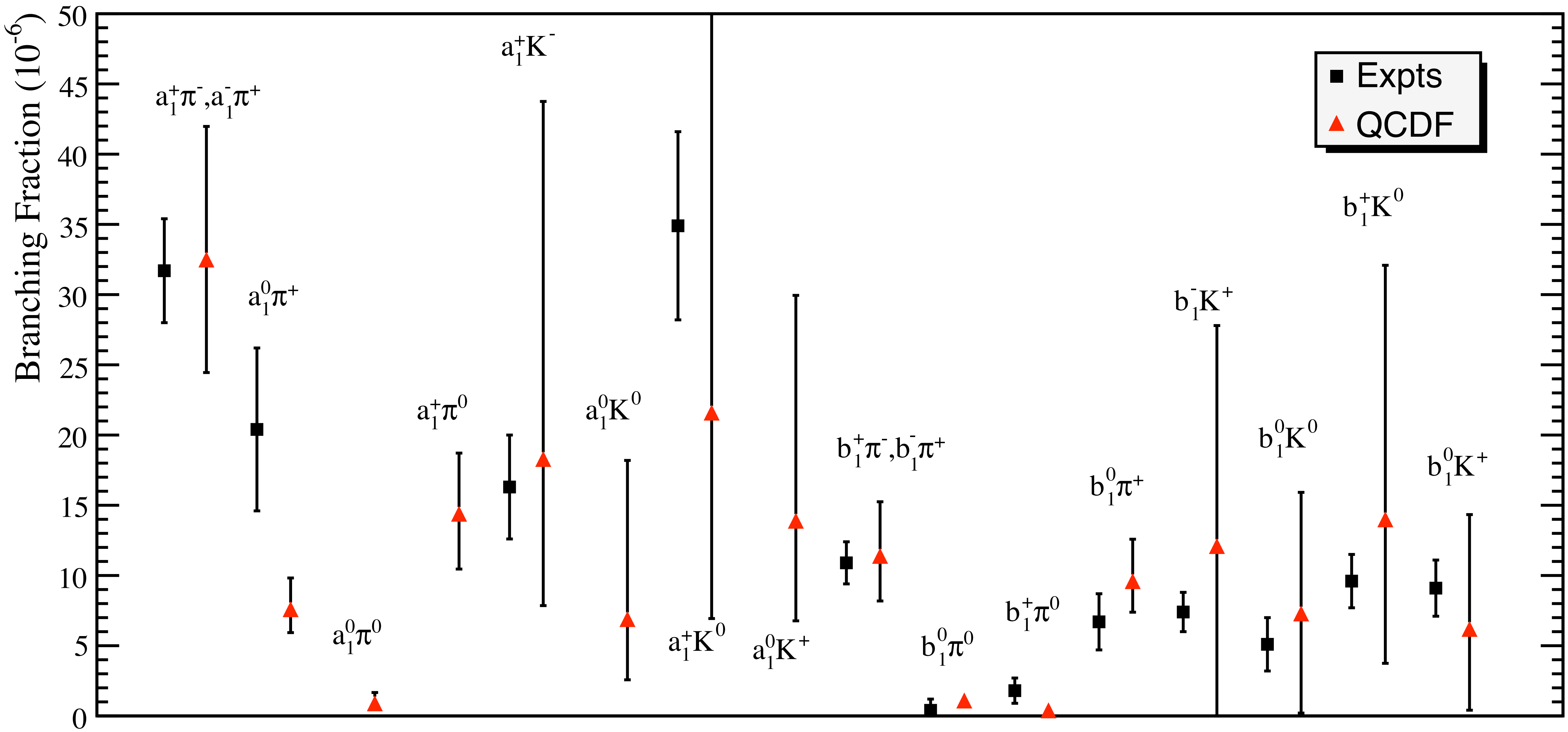
Mode	Laporta *et al.* $\theta = 32°$	Laporta *et al.* $\theta = 58°$	CMV (32°)	C&Y QCDF	Expt. (BaBar)
$B^+ \to b_1^0 K^+$	11.0	0.5	18.1	6.2	$9.1 \pm 1.7 \pm 1.0$
$B^0 \to b_1^- K^+$	24.0	2.0	35.7	12.1	$7.4 \pm 1.0 \pm 1.0$
$B^+ \to b_1^0 \pi^+$	4.5	0.4	18.6	9.6	$6.7 \pm 1.7 \pm 1.0$
$B^0 \to b_1^\mp \pi^\pm$	6.9	0.7	36.2	11.4	$10.9 \pm 1.2 \pm 0.9$
$B^+ \to b_1^+ K^0$	30.0	3.0	41.5	14.0	$9.6 \pm 1.7 \pm 0.9$
$B^0 \to b_1^0 K^0$	41.0	4.0	19.3	7.3	$5.1 \pm 1.8 \pm 0.5$ (< 7.8)
$B^+ \to b_1^+ \pi^0$	4.8	0.5	0.3	0.4	$1.8 \pm 0.9 \pm 0.2$ (< 3.3)
$B^0 \to b_1^0 \pi^0$	0.5	0.01	0.15	1.1	$0.4 \pm 0.8 \pm 0.2$ (< 1.9)

PRL 99, 241803 (2007), 385M $B\bar{B}$

- Rather good agreement with QCDF.
- (No consistent conclusion on the mixing angle between K_{1A} and K_{1B} for the naive factorization estimates)

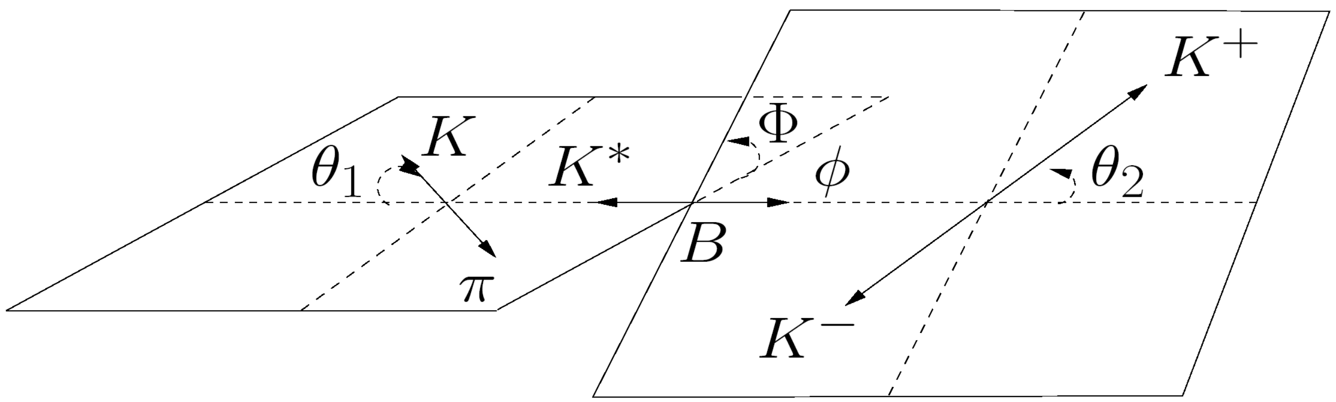
V. Laporta, G. Nardulli, and T. N. Pham, Phys. Rev. D 74, 054035 (2006), Phys. Rev. D76, 079903(E) (2007)
G. Calderon, J.H. Munoz, C. E. Vera, Phys. Rev. D 76, 094019 (2007)
H.-Y. Cheng and K.-C. Yang, Phys. Rev. D76, 114020 (2007).

Expt vs theory, A-P branching fractions

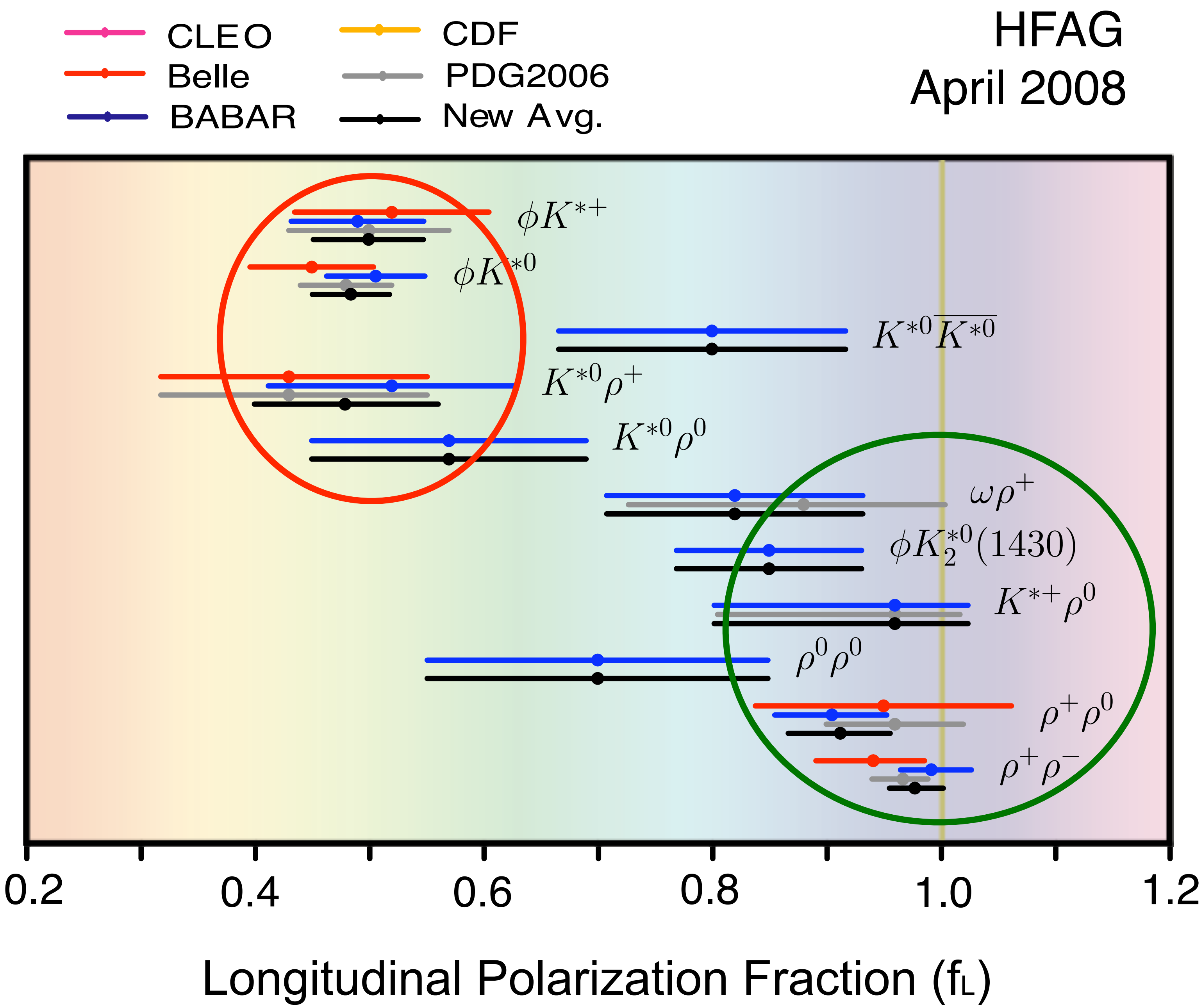



... and one A-V mode

Polarization in B → V-V(A) decays



- Helicity amplitudes A_0 (longitudinal), $A_{\pm1}$ (transverse)
- $f_L = A_0/(A_0+A_{+1}+A_{-1})$
- Naively predict $f_L = 1-m_{K^*}m_\phi/m_B^2 \approx 1$



- $f_L \approx 1$ for tree-dominated decays
- Large transverse polarization seen in the penguins unexpected
- Evidence for new physics?
- Improved understanding within QCDF
  - Penguin annihilation (Kagan)
  - Non-factorizable vertex corrections, hard spectator scattering (Beneke, Rohrer, D.S.Yang; Cheng, K.C.Yang)

New theory predictions for b_1 V modes

Mode	Cheng, Yang		CMV
$\overline{B}^0 \to b_1^+ \rho^-$	$32.1^{+16.5+12.0}_{-14.7-\ 4.7}$	$(0.96^{+0.01}_{-0.02})$	1.6
$\overline{B}^0 \to b_1^- \rho^+$	$0.6^{+0.6+1.8}_{-0.3-0.2}$	$(0.98^{+0.00}_{-0.32})$	0.55
$\overline{B}^0 \to b_1^0 \rho^0$	$0.4^{+0.4+21.3}_{-0.2-0}$	$(0.82^{+0.16}_{-0.51})$	0.002
$B^- \to b_1^0 \rho^-$	$29.0^{+16.2+5.4}_{-10.6-5.8}$	$(0.96^{+0.01}_{-0.06})$	0.86
$B^- \to b_1^- \rho^0$	$0.9^{+1.7+2.6}_{-0.6-0.5}$	$(0.90^{+0.06}_{-0.33})$	0.36
$\overline{B}^0 \to b_1^0 \omega$	$0.1^{+0.2+1.4}_{-0.0-0.0}$	$(0.10^{+1.04}_{-0.01})$	0.004
$B^- \to b_1^- \omega$	$0.9^{+1.4+2.7}_{-0.5-0.3}$	$(0.91^{+0.07}_{-0.33})$	0.38
$\overline{B}^0 \to b_1^0 \phi$	$0.01^{+0.01+0.01}_{-0.00-0.00}$	$(0.98^{+0.01}_{-0.33})$	0.0002
$B^- \to b_1^- \phi$	$0.02^{+0.02+0.03}_{-0.01-0.00}$	$(0.98^{+0.01}_{-0.33})$	0.0004
$\overline{B}^0 \to b_1^+ K^{*-}$	$7.6^{+3.3+40.7}_{-2.4-\ 7.1}$	$(0.71^{+0.17}_{-0.66})$	0.32
$\overline{B}^0 \to b_1^0 \overline{K}^{*0}$	$3.0^{+1.1+4.6}_{-0.7-2.1}$	$(0.80^{+0.20}_{-0.70})$	0.15
$B^- \to b_1^- \overline{K}^{*0}$	$12.1^{+4.4+21.2}_{-3.2-\ 2.7}$	$(0.80^{+0.20}_{-0.70})$	0.18
$B^- \to b_1^0 K^{*-}$	$6.8^{+2.4+12.5}_{-1.8-\ 4.4}$	$(0.84^{+0.15}_{-0.29})$	0.12

Cheng & Yang, arXiv:0805.0329

- New experimental search for these two modes together.
- Prediction is about 3 × that for $B^0 \to b_1^- \pi^+$

Search for $B^0 \to b_1^{\mp}\rho^{\pm}$

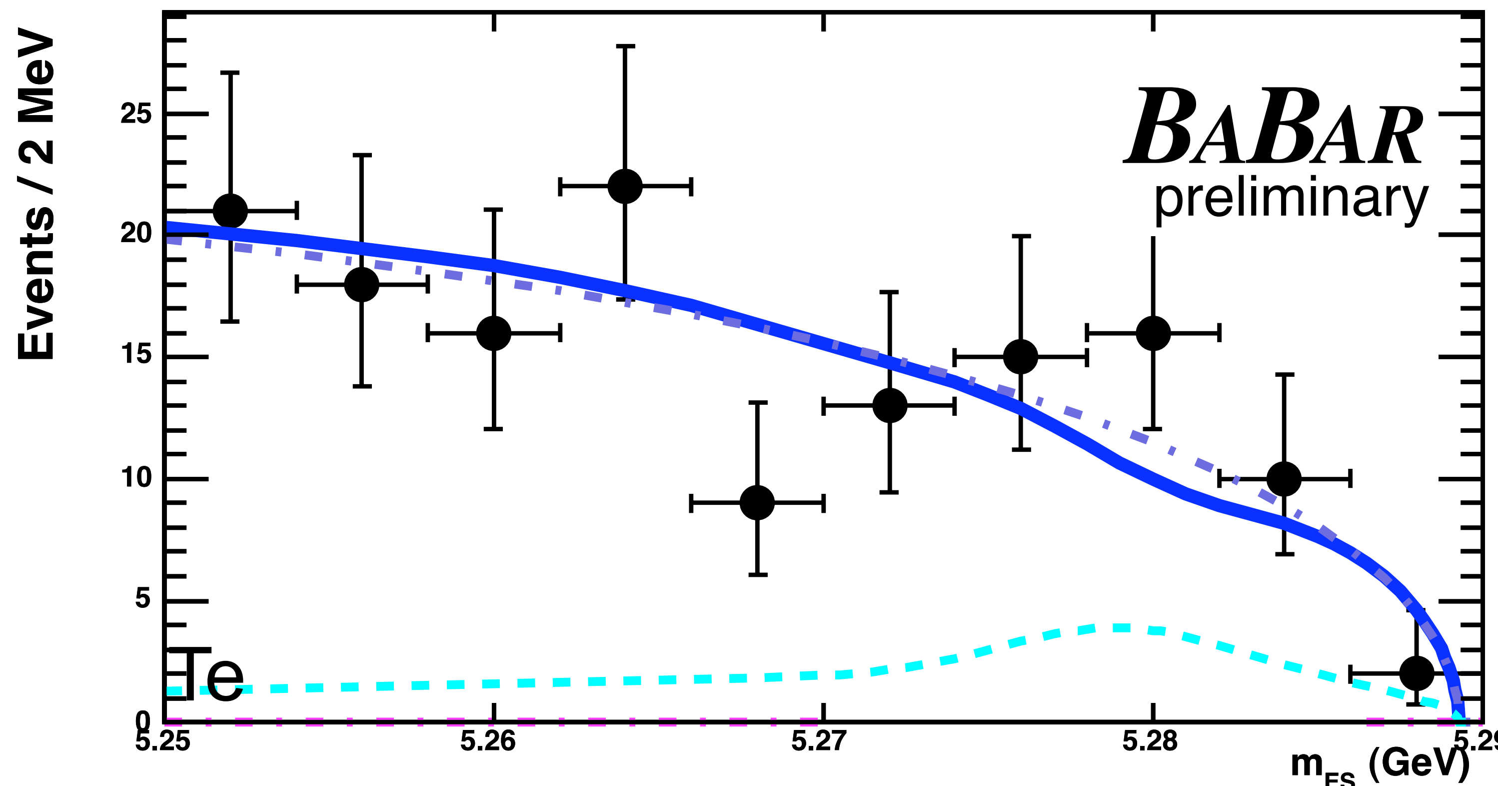
New here

465M $B\bar{B}$

- Should be $\gtrsim b_1^- \pi^+$?
- 2nd-class current rule $\Rightarrow$

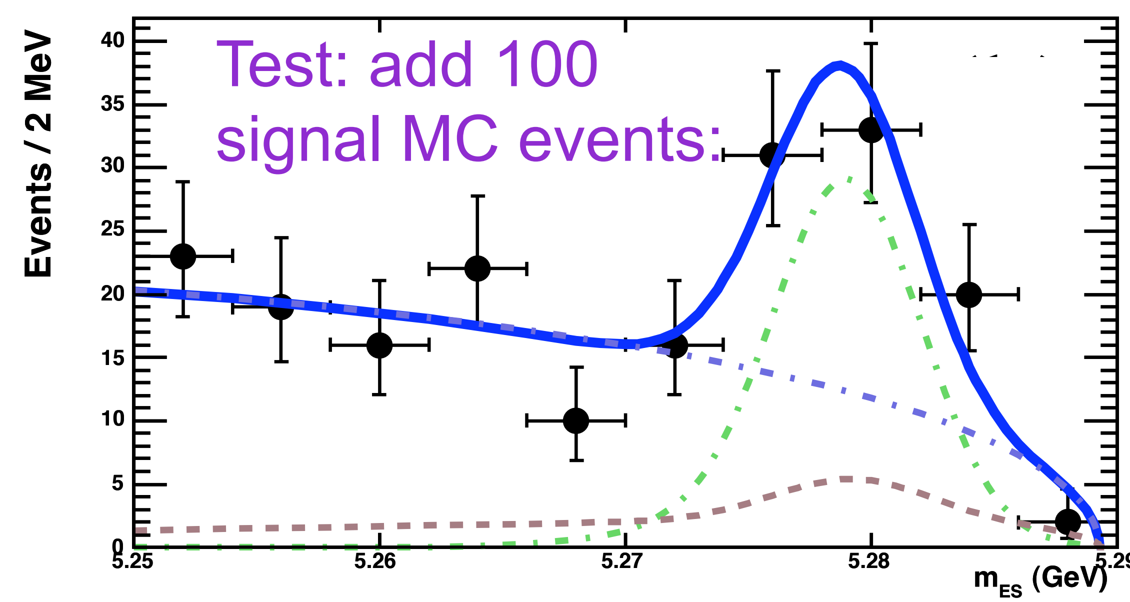
  $B^0 \to b_1^{\mp}\rho^{\pm} \gg B^0 \to b_1^{\pm}\rho^{\mp}$

  (expt. doesn't distinguish)
- Find no events.



$$\mathcal{B}(B^0 \to b_1^{\mp}\rho^{\pm}) = (-0.1 \pm 0.9 \pm 0.7) \times 10^{-6}$$
$$(< 1.7 \times 10^{-6},\ 90\%\ \mathrm{C.L.})$$

- Rather puzzling lack of agreement with the theoretical estimate.



Conclusions

- DCS *D* decay route to γ / ϕ_3 still elusive, but progress is being made.
- Dibaryon systems from B show low-mass peaking, suppression of 2-body modes; new discoveries in baryon spectroscopy.
- In eta(‘) land, many improved limits; new decay observations and hints that more lie near the sensitivity horizon of experiments.
- Many new modes seen in decays to axial-vectors.
  - Predictions working quite well for A-P modes
  - Where are the A-V modes? Stay tuned.
- Global theory-experiment interplay is expanding, very productive.