SUSY06

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Determining the Unitarity Triangle from Two-Body Charmless Hadronic *B* Decays

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–=≡ work in progress with Yu-Feng Zhou @ KEK ≡=–

Outline

- Current status on constraining the unitarity triangle
- Flavor diagram approach to rare *B* decays
- Global χ^2 fits with different $SU(3)_F$ breaking schemes
- Fitting results and predictions (particularly B_s)
- Summary

CKM Mechanism

- The couplings between the up-type and down-type quarks are described by the Cabibbo-Kobayashi-Maskawa (CKM) mechanism within the SM:

$$V_{\rm CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3[(1-\bar\rho)-i\bar\eta] & -A\lambda^2 & 1 \end{pmatrix}$$

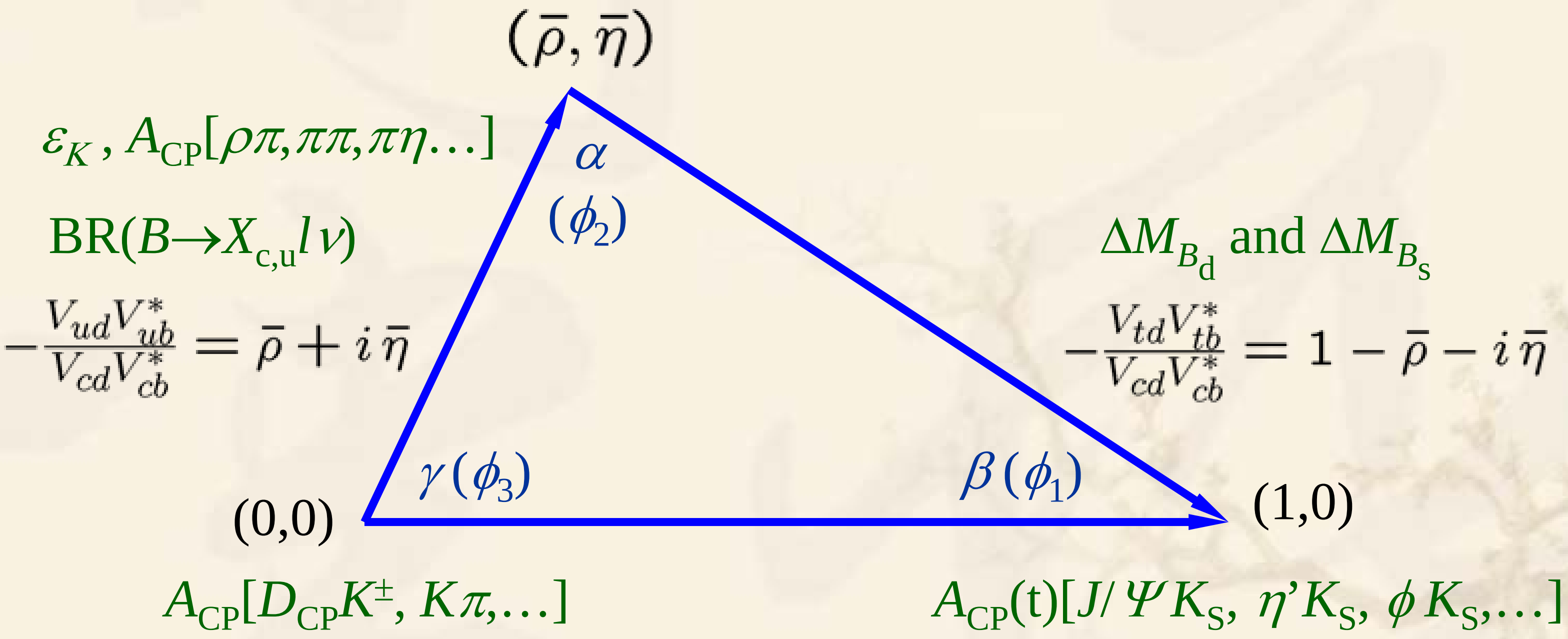
- Using the Wolfenstein parameterization, CP violation is encoded by the parameter η.
- V_{ub} and V_{td} carry the largest weak phases, but are the least known elements due to their smallness.

Unitarity Triangle

- Unitarity relation for V_{ub} and V_{td} :

$$V_{ud}V_{ub}^{\ *} + V_{cd}V_{cb}^{\ *} + V_{td}V_{tb}^{\ *} = 0\ .$$

It can be visualized as a triangle on a complex plane whose *area* characterizes CPV.



CKMfitter Results

- FPCP06 update:

[CKMfitter: http://ckmfitter.in2p3.fr/]

$\lambda = 0.2272 \pm 0.0010$

$A = 0.809 \pm 0.014$

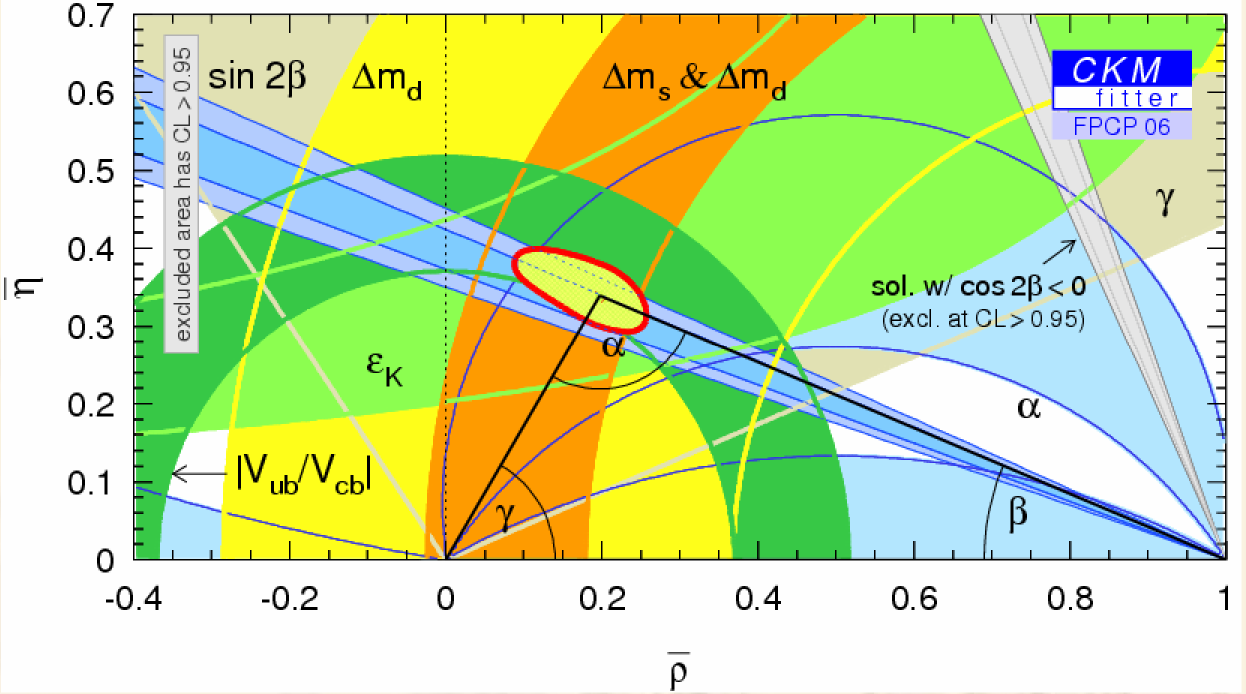
$\rho = 0.202^{+0.027}_{-0.031}$

$\eta = 0.348^{+0.020}_{-0.018}$

$\alpha = (97.3^{+4.5}_{-5.0})^{o}$

$\beta = (22.86 \pm 1.00)^{o}$

$\gamma = (59.8^{+4.9}_{-4.1})^{o}$



UTFit's Results

- FPCP06 Updates:

$\lambda = 0.2258 \pm 0.0014$

$\rho = 0.198 \pm 0.030$

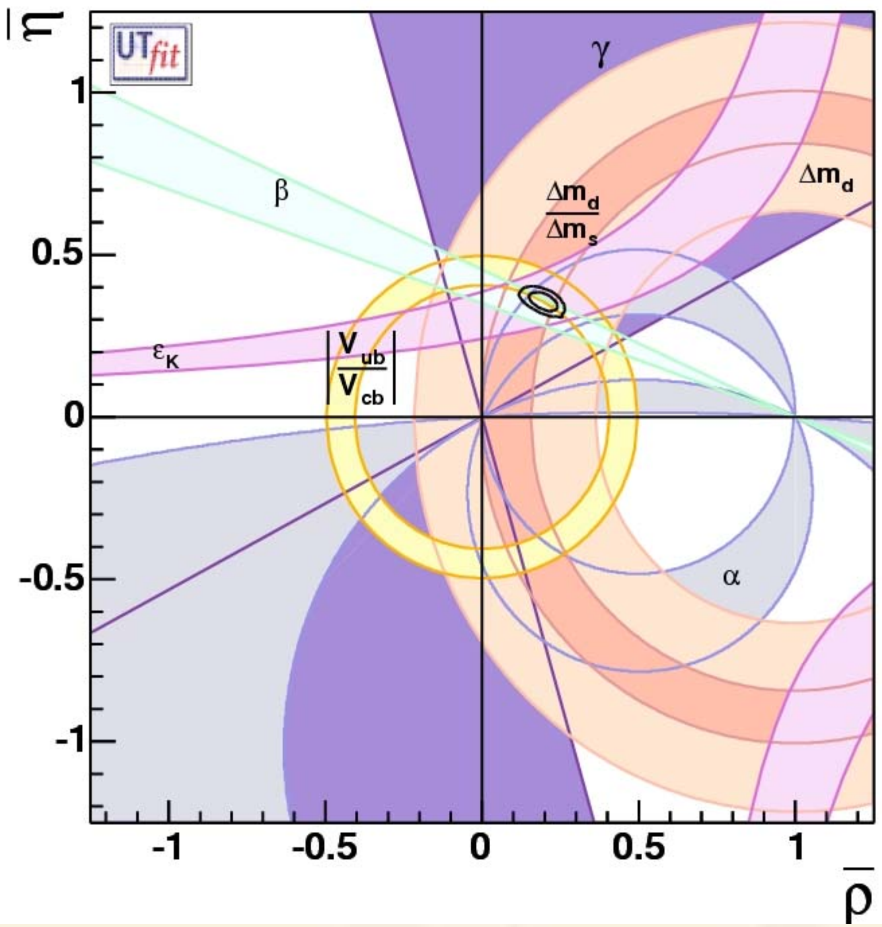
$\eta = 0.364 \pm 0.019$

$\alpha = (94.6 \pm 4.6)^o$

$\beta = (23.9 \pm 1.0)^o$

$\gamma = (61.3 \pm 4.5)^o$

[UTFit: http://utfit.roma1.infn.it/]



Questions

- Can we extract useful information for the unitarity triangle from purely charmless *B* decays also?
- Will it be consistent with other methods?
- Can the predictions of our theory (perturbative / nonperturbative) for the rare decays agree with the data? [e.g., Beneke and Neubert, 2003]
- Can we get any hint of new physics from them?

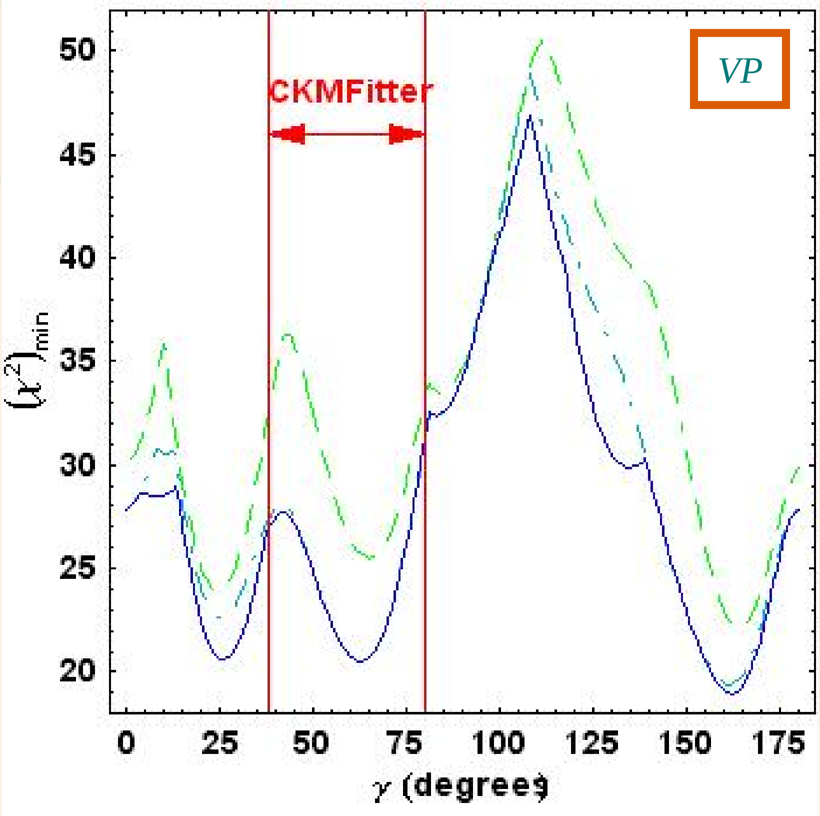
Charmless Two-Body *B* Decays

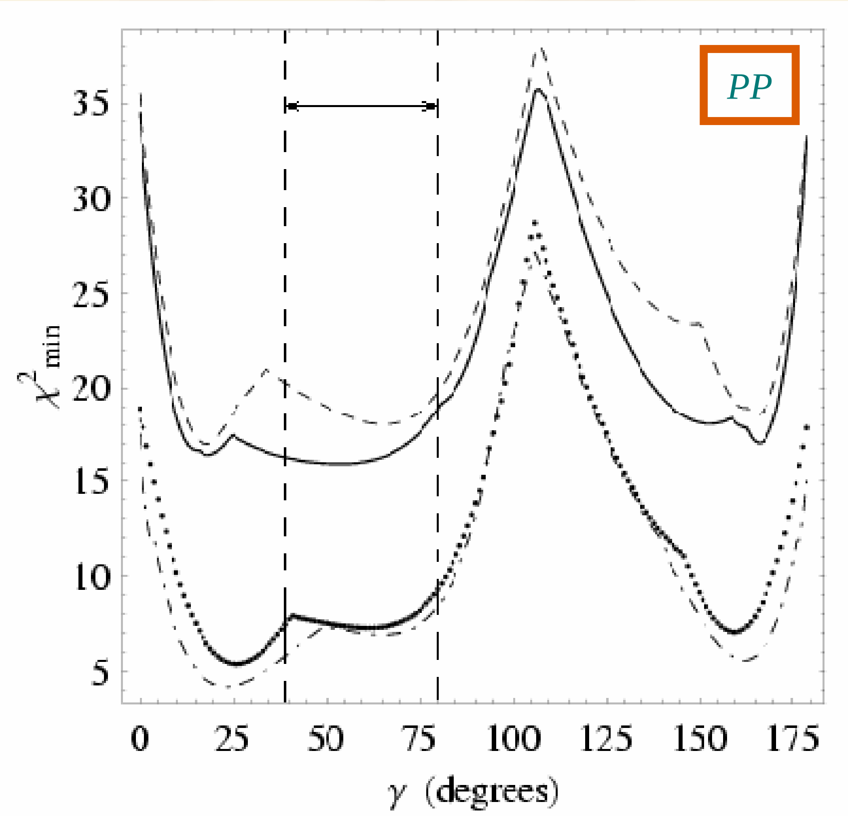
- Charmless two-body hadronic *B* decay modes are often sensitive to V_{td} and/or V_{ub}. Thus, they can play a more important role in the determination of the unitarity triangle.
- With increasing precision on the branching ratios and CPAs, it is possible to provide an additional constraint on the (ρ, η) vertex and/or some hints for new physics via a global fit.
- We distinguish two types of rare decays:
  strangeness-conserving ($\Delta S = 0$, $b \to q\, \underline{q}\, d$); and
  strangeness-changing ($|\Delta S| = 1$, $b \to q\, \underline{q}\, s$).
- The former type is dominated by the color-allowed tree amplitude; whereas the latter type is dominated by the QCD penguin amplitudes.

Old Results of Global $SU(3)_F$ Fits

[CWC, Gronau, Luo, Rosner, and Suprun, PRD **69**, 034001 (2004); PRD **70**, 034020 (2004)]

- Charmless *V P* modes, $\gamma = 57^o \sim 69^o$; charmless *P P* modes, $\gamma = 54^o \sim 66^o$; both consistent with constraints from other observables.





Flavor Diagram Approach

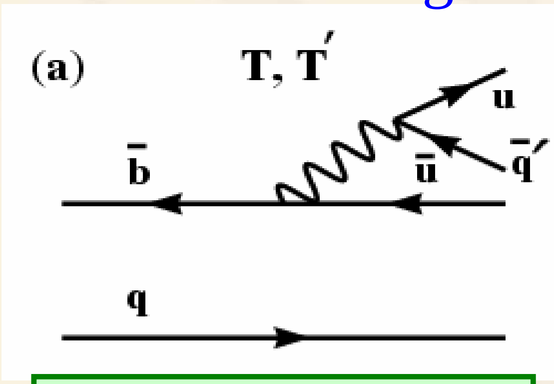
[Zeppenfeld (1981); Chau + Cheng (1986, 1987, 1991); Savage + Wise (1989); Grinstein + Lebed (1996); Gronau et. al. (1994, 1995, 1995)]

- This approach is intended to rely, to the greatest extent, on *model independent flavor SU(3) symmetry* arguments, rather than on specific model calculations of amplitudes.
- The flavor diagram approach:
  - only concerns with the *flavor flow* (nonperturbative in strong interactions);
  - has a clearer *weak phase structure* (unlike isospin analysis where different weak phases usually mix).

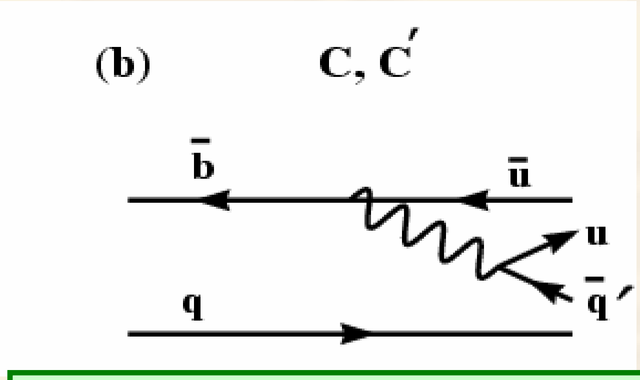
Tree-Level Diagrams

- All these tree-level diagrams involve the same CKM factor.

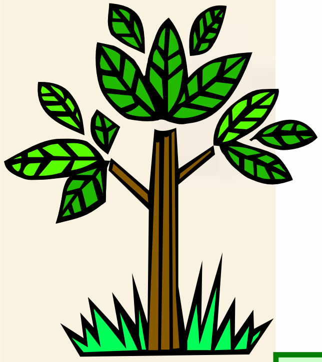
q = u,d,s
q’= d,s

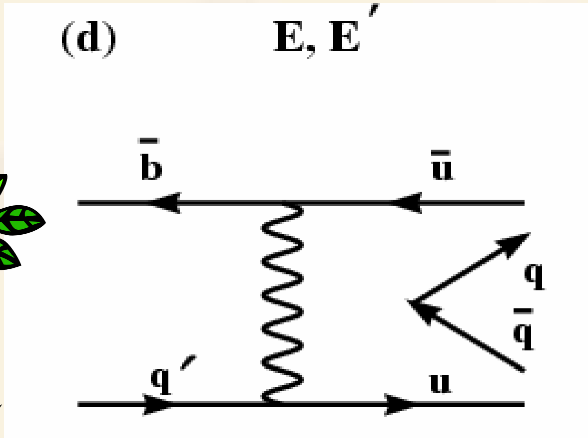


tree (external W emission)

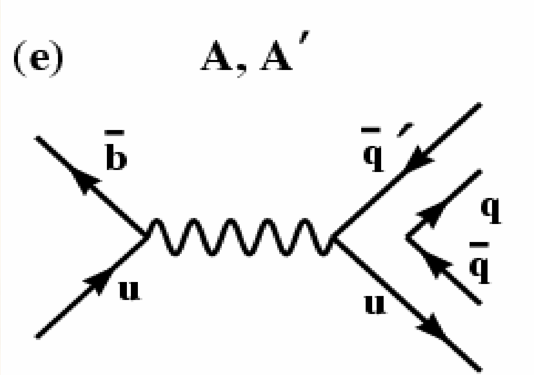


color-suppressed (internal W emission)





exchange (neutral mesons only)

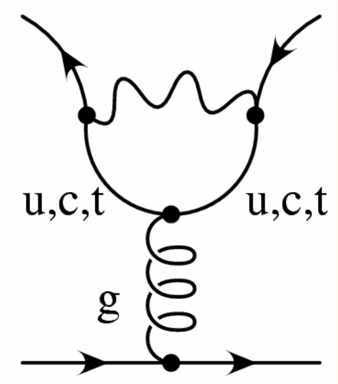


annihilation (charged mesons only)

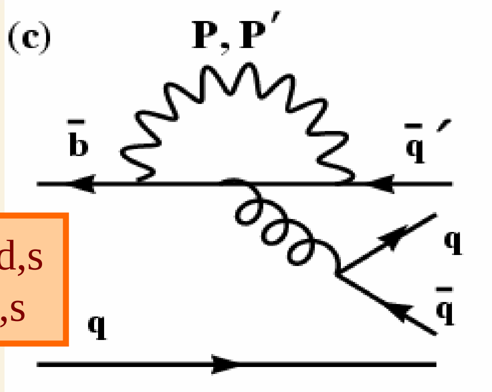
$1/m_b$ suppressed due to f_B.
-- to be ignored

Loop-Level (Penguin) Diagrams

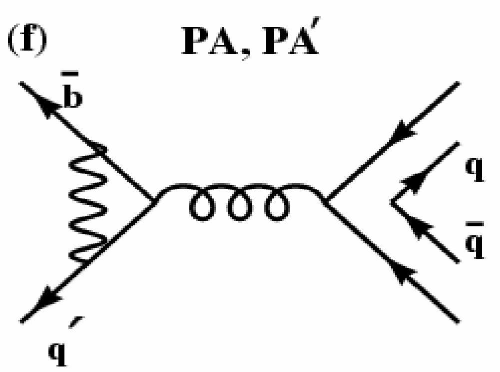
- All these loop-level diagrams also have the same CKM factors, with *u*-, *c*-, and *t*-quark running in the loop.
- Will use the unitarity condition to remove the top-mediated loop diagrams.



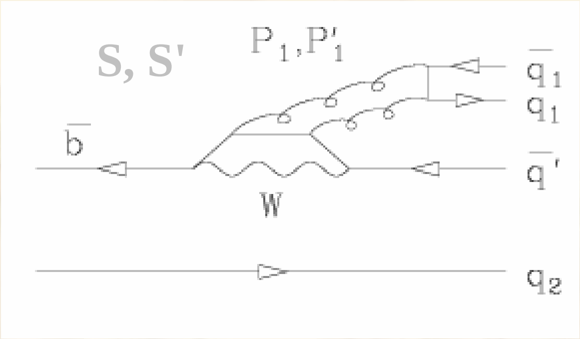
q=u,d,s
q'=d,s



QCD (strong) penguin
(internal gluon emission)



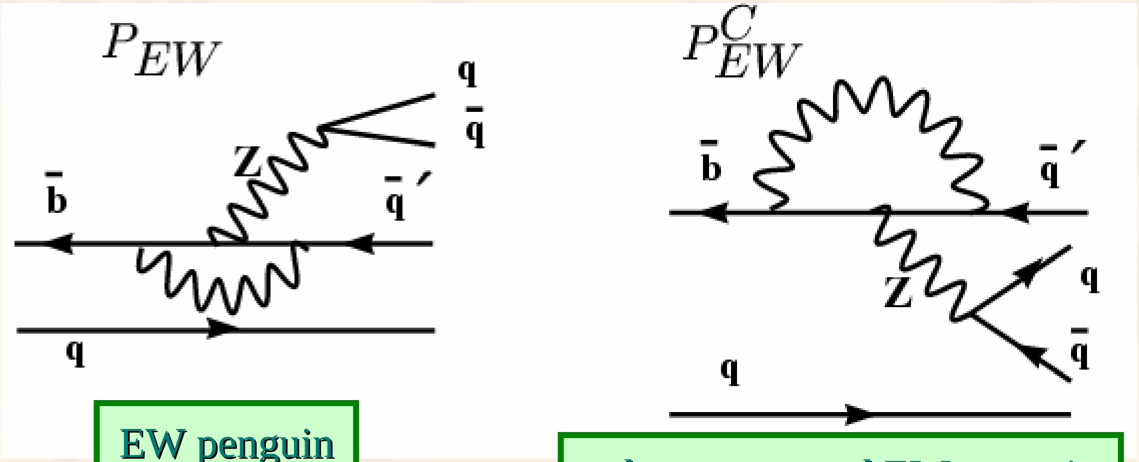
penguin annihilation
(neutral mesons)



flavor singlet
(external gluon emission)

Next-to-Leading Order Flavor Diagrams

- One also obtains one of the following diagrams whenever *T*, *C*, or *P* is seen in the amplitude list.
- They are higher order in weak interactions.



EW penguin → appear together with *C* and *S* in decay amps

color-suppressed EW penguin → appear together with *T* and *P* in decay amps

Flavor Amplitudes

- We use the following notation:

$$t \equiv Y_{db}^u T - (Y_{db}^u + Y_{db}^c) P_{EW}^C \ , \qquad t' \equiv Y_{sb}^u \xi_t T - (Y_{sb}^u + Y_{sb}^c) P_{EW}^C \ ,$$

$$c \equiv Y_{db}^u C - (Y_{db}^u + Y_{db}^c) P_{EW} \ , \qquad c' \equiv Y_{sb}^u \xi_c C - (Y_{sb}^u + Y_{sb}^c) P_{EW} \ ,$$

$$p \equiv -(Y_{db}^u + Y_{db}^c) \left(P - \frac{1}{3} P_{EW}^C \right) \ , \qquad p' \equiv -(Y_{sb}^u + Y_{sb}^c) \left(\xi_p P - \frac{1}{3} P_{EW}^C \right) \ .$$

$$s \equiv -(Y_{db}^u + Y_{db}^c) \left(S - \frac{1}{3} P_{EW} \right) \ , \qquad s' \equiv -(Y_{sb}^u + Y_{sb}^c) \left(\xi_s S - \frac{1}{3} P_{EW} \right) \ ,$$

  where $Y_{qb}^{q'} = V_{q'q} V_{q'b}^*$.

- We assume that the top-penguins dominate.
- The CKM factors have been explicitly pulled out.
- Unprimed amplitudes are used for $\Delta S = 0$ transitions and primed amplitudes for $|\Delta S| = 1$ ones.

Amplitude Decomposition

Mode		Flavor Amplitude	$\lvert A_{\rm exp}\rvert$	BR	$\mathcal{A}_{CP}$
$B^+ \to$	$\pi^+\pi^0$	$-\frac{1}{\sqrt{2}}(t+c)$	24.23 ± 1.32	5.5 ± 0.6	0.01 ± 0.06
	$K^+\overline{K}^0$	p	11.41 ± 1.43	1.2 ± 0.3	0.15 ± 0.33
	$\pi^+\eta$	$-\frac{1}{\sqrt{3}}(t+c+2p+s)$	21.54 ± 1.00	4.3 ± 0.4	-0.11 ± 0.08
	$\pi^+\eta'$	$\frac{1}{\sqrt{6}}(t+c+2p+4s)$	16.94 ± 1.79	2.6 ± 0.6	0.15 ± 0.15
$B^0 \to$	K^+K^-	$-(e+pa)$	2.41 ± 2.17	0.05 ± 0.09	-
	$K^0\overline{K}^0$	p	10.51 ± 1.31	0.95 ± 0.24	-
	$\pi^+\pi^-$	$-(t+p)$	23.67 ± 0.97	4.9 ± 0.4	0.37 ± 0.10 -0.50 ± 0.12
	$\pi^0\pi^0$	$\frac{1}{\sqrt{2}}(-c+p)$	12.87 ± 1.29	1.45 ± 0.29	$0.28^{+0.40}_{-0.39}$
	$\pi^0\eta$	$-\frac{1}{\sqrt{6}}(2p+s)$	-	< 1.3	-
	$\pi^0\eta'$	$\frac{1}{\sqrt{3}}(p+2s)$	13.31 ± 2.88	1.5 ± 0.7	-
	$\eta\eta$	$\frac{1}{3\sqrt{2}}(2c+2p+2s)$	-	< 2.0	-
	$\eta\eta'$	$-\frac{1}{3\sqrt{2}}(2c+2p+5s)$	-	< 1.7	-
	$\eta'\eta'$	$\frac{1}{3\sqrt{2}}(c+p+4s)$	-	< 10	-
$B_s^0 \to$	$K^-\pi^+$	$-(t+p)$	-	< 2.1	-
	$\overline{K}^0\pi^0$	$-\frac{1}{\sqrt{2}}(-c+p)$	-	-	-
	$K^0\eta$	$-\frac{1}{\sqrt{3}}(c+s)$	-	-	-
	$K^0\eta'$	$\frac{1}{\sqrt{6}}(c+3p+4s)$	-	-	-

Mode		Flavor Amplitude	$\lvert A_{\rm exp}\rvert$	BR	$\mathcal{A}_{CP}$
$B^+ \to$	$K^0\pi^+$	p'	50.94 ± 1.37	24.1 ± 1.3	-0.02 ± 0.04
	$K^+\pi^0$	$-\frac{1}{\sqrt{2}}(p'+t'+c')$	36.09 ± 1.19	12.1 ± 0.8	0.04 ± 0.04
	ηK^+	$-\frac{1}{\sqrt{3}}(s'+t'+c')$	16.49 ± 0.99	2.5 ± 0.3	-0.33 ± 0.12
	$\eta' K^+$	$\frac{1}{\sqrt{6}}(3p'+4s'+t'+c')$	88.09 ± 1.74	69.7 ± 2.8	0.031 ± 0.021
$B^0 \to$	$K^+\pi^-$	$-(p'+t')$	46.67 ± 0.86	18.9 ± 0.7	-0.108 ± 0.017
	$K^0\pi^0$	$\frac{1}{\sqrt{2}}(p'-c')$	36.41 ± 1.58	11.5 ± 1.0	0.02 ± 0.13 0.31 ± 0.26
	ηK^0	$-\frac{1}{\sqrt{3}}(s'+c')$	-	< 1.9	-
	$\eta' K^0$	$\frac{1}{\sqrt{6}}(3p'+4s'+c')$	87.96 ± 2.37	64.9 ± 3.5	0.50 ± 0.09 0.07 ± 0.07
$B_s^0 \to$	K^+K^-	$-(p'+t')$	64.74 ± 8.57	34 ± 9	-
	$K^0\overline{K}^0$	p'	-	-	-
	$\pi^+\pi^-$	$-(e'+pa')$	-	< 1.7	-
	$\pi^0\pi^0$	$\frac{1}{\sqrt{2}}(e'+pa')$	-	< 2.1	-
	$\pi^0\eta$	$-\frac{1}{\sqrt{6}}c'$	-	-	-
	$\pi^0\eta'$	$-\frac{1}{\sqrt{3}}c'$	-	-	-
	$\eta\eta$	$-\frac{1}{3\sqrt{2}}(2p'-2s'-2c')$	-	-	-
	$\eta\eta'$	$\frac{1}{3\sqrt{2}}(4p'+2s'-c')$	-	-	-
	$\eta'\eta'$	$\frac{1}{3\sqrt{2}}(4p'+8s'+2c')$	-	-	-

- Comparing $|p|$ from $B^0 \to K^0 \underline{K}^0$ and $B^+ \to K^+ \underline{K}^0$ with $|p'|$ from $B^+ \to K^0 \pi^+$, one gets $|p/p'| \simeq 0.22 \pm 0.02$ consistent with $|V_{cd}/V_{cs}|$, partly justifying our use of $SU(3)_F$ as the working assumption.

SU(3) Breaking

- We use ρ and η as our fitting parameters, instead of weak phases.
- We consider various SU(3) breaking schemes, and present the following four representatives:
  1. exact flavor SU(3) symmetry for all amplitudes;
  2. including the factor f_K / f_π for $|T|$ only;
  3. including the factor f_K / f_π for both $|T|$ and $|C|$ only; and
  4. including a universal SU(3) breaking factor ξ for all amplitudes on top of scheme-3.
- Including the factor f_K / f_π for $|P|$ does not improve χ^2_{min}.
- Still keep exact SU(3) symmetry for the strong phases.

Partial Fits ($\pi\,\pi$, $\pi\,K$, and $K\,K$)

- There are 22 data points in this set, including the BRs and CPAs, along with $|V_{ub}| = (0.426\pm0.036)\times10^{-4}$ and $|V_{cb}| = (41.63\pm0.65)\times 10^{-4}$ that help fix A and $\sqrt{(\rho^2+\eta^2)}$.

10 to 11 parameters

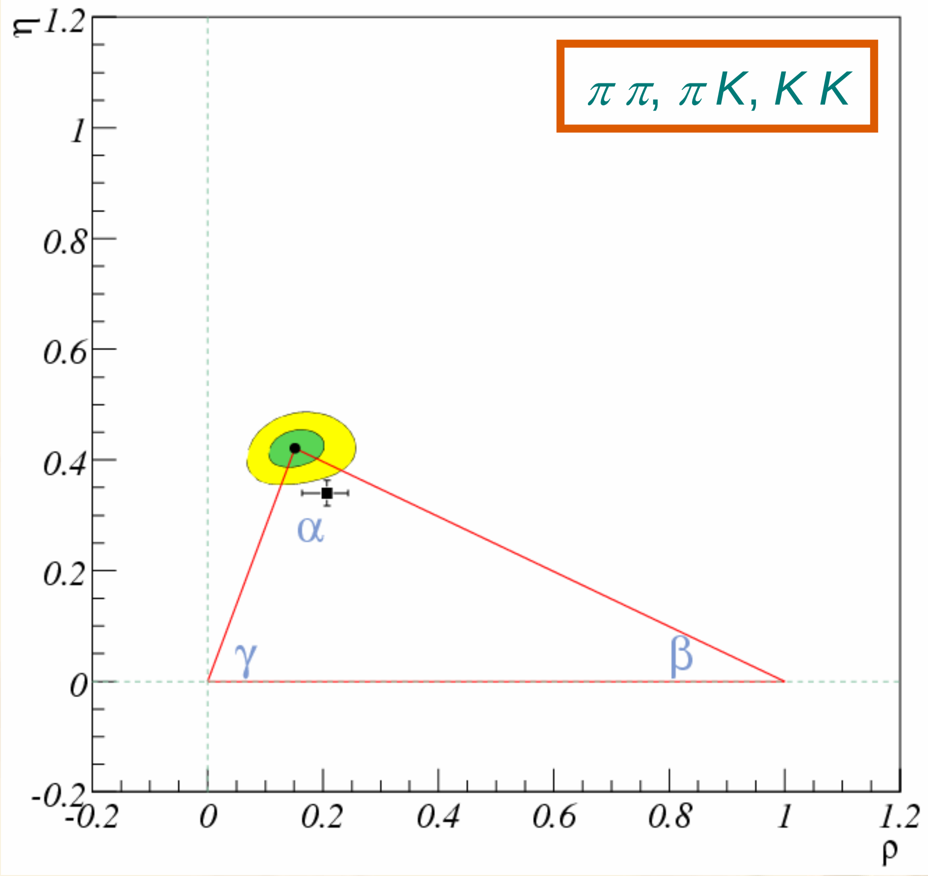
- Robust results against SU(3) breaking.
- Prefer f_K / f_π for T and C, factorizable to a good approximation.
- $\xi \simeq 1.04$.
- More reliable because no uncertainties from η and η'.

Parameter	Scheme 1	Scheme 2	Scheme 3	Scheme 4
ρ	0.16 ± 0.05	0.16 ± 0.05	0.16 ± 0.05	0.15 ± 0.05
η	0.42 ± 0.03	0.42 ± 0.03	0.42 ± 0.03	0.42 ± 0.03
A	0.81 ± 0.01	0.81 ± 0.01	0.81 ± 0.01	0.81 ± 0.01
T	$0.54^{+0.06}_{-0.05}$	$0.54^{+0.06}_{-0.05}$	$0.54^{+0.06}_{-0.05}$	$0.54^{+0.06}_{-0.05}$
C	0.38 ± 0.06	0.37 ± 0.06	0.37 ± 0.06	0.37 ± 0.06
δ_C	$-0.99^{+0.23}_{-0.21}$	$-0.95^{+0.24}_{-0.22}$	-0.93 ± 0.23	-0.93 ± 0.23
P	0.120 ± 0.003	0.120 ± 0.003	0.120 ± 0.003	0.120 ± 0.010
δ_P	$-0.49^{+0.08}_{-0.10}$	$-0.41^{+0.07}_{-0.08}$	$-0.42^{+0.07}_{-0.08}$	$-0.40^{+0.07}_{-0.08}$
P_{EW}	$0.014^{+0.011}_{-0.010}$	$0.014^{+0.011}_{-0.010}$	$0.012^{+0.011}_{-0.008}$	$0.011^{+0.011}_{-0.008}$
$\delta_{P_{EW}}$	$0.64^{+0.33}_{-1.2}$	$0.72^{+0.33}_{-1}$	$0.61^{+0.38}_{-1.2}$	$0.58^{+0.41}_{-1.3}$
ξ	1 (fixed)	1 (fixed)	1 (fixed)	1.044
χ^2/dof	15.5 / 12	14.4 / 12	13.9 / 12	13.5 / 11
CL (%)	22	28	31	26

UT from $\pi\,\pi$, $\pi\,K$, and $K\,K$ Only

- Scheme 3 only (difference from others miniscule):

$$72^\circ \le \alpha \le 92^\circ \quad (1\ \sigma)\ ,$$
$$67^\circ \le \alpha \le 102^\circ \quad (95\%\ \text{CL})\ ;$$
$$25^\circ \le \beta \le 29^\circ \quad (1\ \sigma)\ ,$$
$$21^\circ \le \beta \le 32^\circ \quad (95\%\ \text{CL})\ ;$$
$$64^\circ \le \gamma \le 75^\circ \quad (1\ \sigma)\ ,$$
$$57^\circ \le \gamma \le 81^\circ \quad (95\%\ \text{CL})\ .$$



- Slightly higher (ρ,η) vertex.

Large *C* Amplitude

- We observe a large color-suppressed tree amplitude *C*, with the ratio |*C*/*T*| being about 0.68 ± 0.08 and a sizeable relative strong phase of about $(-56 \pm 13)^{\circ}$.

  [In our old fits, the ratio and relative strong phase between *C* and *T* are ≥ 0.7 and ~ $-(110\text{-}130)^{\circ}$.]

- These are mainly driven by the facts that the $\pi^0\pi^0$ mode has a large branching ratio and that $A_{CP}(K^+\pi^0)$ is very different from $A_{CP}(K^+\pi^-)$.
- The large |*C*| and strong phase may be explained within SM by including NLO vertex corrections. [Li, Mishima, Sanda, 2005]

Electroweak Penguins

- Within the SM, the color-allowed penguin can be related to the sum of color-allowed and -suppressed tree amplitudes via a Fierz transformation: [Neubert and Rosner, 1998; Gronau, Pirjol and Yan, 1999.]

$$P_{EW} = -\delta_{EW}|T + C|e^{i\delta_{PEW}} ,$$

where $\delta_{EW} \simeq -\frac{3}{2}\frac{C_9 + C_{10}}{C_1 + C_2} \simeq 0.0135 \pm 0.0012 .$

- In our fits, we treat P_{EW} and the strong phase δ_{PEW} (~40^{o} w.r.t. T) as free parameters; their values do not vary much in different schemes and agree with the SM expectation.
- We ignore the color-suppressed penguin amplitude because it will introduce one more free parameter but not improve the fitting confidence level.

Predictions for $B_{u,d}$ Decays

$\propto p - c$, cf. exp. 1.45±0.29

$\propto p - c$, large S_{CP} expected

$\propto p' - c'$, cf. exp. 0.02±0.13

Observable	Scheme 1	Scheme 2	Scheme 3	Scheme 4
$Br(\pi^+\pi^-)$	5.2 ± 1.1	5.2 ± 1.1	5.1 ± 1.1	5.1 ± 1.1
$Br(\pi^0\pi^0)$	1.7 ± 0.5	1.7 ± 0.4	1.7 ± 0.4	1.6 ± 0.4
$Br(\pi^-\pi^0)$	5.4 ± 1.4	5.4 ± 1.4	5.4 ± 1.4	5.5 ± 1.4
$Br(\pi^+K^-)$	19.9 ± 1.1	19.8 ± 1.1	19.8 ± 1.1	20.2 ± 4.9
$Br(\pi^0\bar{K}^0)$	10.6 ± 1.8	10.6 ± 1.7	10.7 ± 1.7	11.0 ± 3.1
$Br(\pi^-\bar{K}^0)$	22.7 ± 1.2	22.8 ± 1.2	22.9 ± 1.2	23.2 ± 5.5
$Br(\pi^0K^-)$	11.3 ± 1.9	11.3 ± 1.9	11.2 ± 1.8	11.3 ± 3.1
$Br(K^+K^-)$	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
$Br(K^0\bar{K}^0)$	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	0.9 ± 0.2
$Br(K^-\bar{K}^0)$	1.1 ± 0.1	1.1 ± 0.1	1.1 ± 0.1	1.0 ± 0.2
$CP(\pi^+\pi^-)$	0.38 ± 0.08	0.33 ± 0.07	0.34 ± 0.07	0.32 ± 0.07
$CP(\pi^0\pi^0)$	0.34 ± 0.20	0.36 ± 0.20	0.35 ± 0.19	0.37 ± 0.19
$CP(\pi^-\pi^0)$	-0.05 ± 0.05	-0.05 ± 0.05	-0.04 ± 0.05	-0.03 ± 0.05
$CP(\pi^+K^-)$	-0.10 ± 0.02	-0.10 ± 0.02	-0.10 ± 0.02	-0.11 ± 0.03
$CP(\pi^0\bar{K}^0)$	-0.05 ± 0.03	-0.06 ± 0.03	-0.07 ± 0.04	-0.07 ± 0.04
$CP(\pi^-\bar{K}^0)$	0	0	0	0
$CP(\pi^0K^-)$	-0.01 ± 0.05	-0.00 ± 0.05	0.00 ± 0.05	0.01 ± 0.06
$CP(K^+K^-)$	0	0	0	0
$CP(K^0\bar{K}^0)$	0	0	0	0
$CP(K^-\bar{K}^0)$	0	0	0	0
$S(\pi^+\pi^-)$	-0.554 ± 0.143	-0.570 ± 0.140	-0.569 ± 0.140	-0.543 ± 0.151
$S(\pi^0\pi^0)$	0.849 ± 0.120	0.852 ± 0.117	0.856 ± 0.113	0.841 ± 0.118
$S(\pi^0K_S)$	0.882 ± 0.043	0.883 ± 0.042	0.894 ± 0.042	0.893 ± 0.042
$S(K^0\bar{K}^0)$	-0.025 ± 0.024	-0.025 ± 0.025	-0.025 ± 0.025	-0.025 ± 0.021

BR in units of 10^{-6}

Predictions for B_s Decays

cf. $(34\pm9)\times10^{-6}$ by CDF 2005 fluctuation or big SU(3) breaking?

involve p', can test SU(3)

involve $t + p$

involve $t'+p'$, direct CPA similar to $B\to K^+\pi^-$

Observable	Scheme 1	Scheme 2	Scheme 3	Scheme 4
$Br(\pi^+\pi^-)$	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
$Br(\pi^0\pi^0)$	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
$Br(\pi^+K^-)$	4.9 ± 1.0	4.8 ± 1.0	4.8 ± 1.0	4.8 ± 1.0
$Br(\pi^0K^0)$	1.6 ± 0.4	1.6 ± 0.4	1.5 ± 0.4	1.5 ± 0.4
$Br(K^+K^-)$	18.6 ± 1.0	18.5 ± 1.1	18.6 ± 1.1	18.8 ± 4.5
$Br(K^0K^0)$	19.8 ± 1.0	19.9 ± 1.1	20.0 ± 1.1	20.3 ± 4.8
$CP(\pi^+\pi^-)$	0	0	0	0
$CP(\pi^0\pi^0)$	0	0	0	0
$CP(\pi^+K^-)$	0.38 ± 0.08	0.33 ± 0.07	0.34 ± 0.07	0.32 ± 0.07
$CP(\pi^0K^0)$	0.34 ± 0.20	0.36 ± 0.20	0.35 ± 0.19	0.37 ± 0.19
$CP(K^+K^-)$	-0.10 ± 0.02	-0.10 ± 0.02	-0.10 ± 0.02	-0.11 ± 0.03
$CP(K^0K^0)$	0	0	0	0
$S(\pi^+\pi^-)$	0	0	0	0
$S(\pi^0\pi^0)$	0	0	0	0
$S(\pi^0K_S)$	-0.304 ± 0.254	-0.332 ± 0.245	-0.335 ± 0.244	-0.304 ± 0.247
$S(K^+K^-)$	0.132 ± 0.023	0.180 ± 0.029	0.179 ± 0.029	0.194 ± 0.036
$S(K^0K^0)$	-0.044 ± 0.004	-0.044 ± 0.004	-0.044 ± 0.004	-0.044 ± 0.004

BR in units of 10^{-6}

Global Fits (Very Preliminary)

- There are totally 34 data points to fit.
- The singlet penguin S is required to explain large branching ratios of the $\eta^0 K$ modes.
- Fitting quality is a lot worse, largely due to $S_{\eta' K_S}$ and to some extent $A_{CP}(\eta' K^+)$ and $B(\pi^+\eta')$.
- Call for the need of more theory parameters.

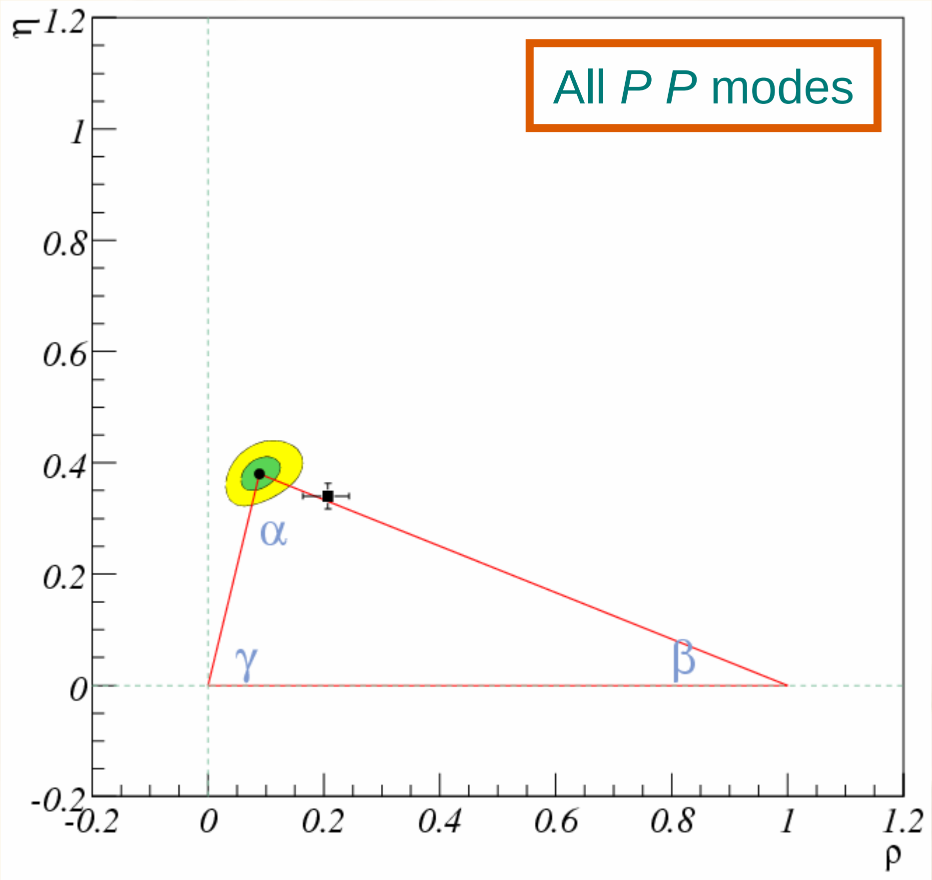
Parameter	Scheme 1	Scheme 2	Scheme 3	Scheme 4
ρ	$0.084^{+0.038}_{-0.033}$	$0.083^{+0.038}_{-0.033}$	$0.081^{+0.038}_{-0.032}$	$0.092^{+0.037}_{-0.033}$
η	0.38 ± 0.03	0.38 ± 0.03	0.38 ± 0.03	0.38 ± 0.03
A	0.81 ± 0.012	0.81 ± 0.012	0.81 ± 0.012	0.81 ± 0.012
T	$0.64^{+0.066}_{-0.059}$	$0.64^{+0.066}_{-0.058}$	$0.64^{+0.066}_{-0.058}$	$0.64^{+0.065}_{-0.057}$
C	0.48 ± 0.059	0.48 ± 0.058	0.47 ± 0.058	0.49 ± 0.059
δ_C	-1.4 ± 0.14	-1.4 ± 0.14	-1.4 ± 0.14	-1.3 ± 0.14
P	0.12 ± 0.0025	0.12 ± 0.0026	0.12 ± 0.0026	0.11 ± 0.0077
δ_P	-0.37 ± 0.063	-0.33 ± 0.055	-0.34 ± 0.055	-0.33 ± 0.053
P_{EW}	0.016 ± 0.0078	0.015 ± 0.0075	0.017 ± 0.0074	0.018 ± 0.007
$\delta_{P_{EW}}$	$-1.6^{+0.43}_{-0.24}$	$-1.5^{+0.47}_{-0.26}$	$-1.6^{+0.38}_{-0.23}$	$-1.5^{+0.36}_{-0.22}$
S	$0.057^{+0.0052}_{-0.0046}$	$0.057^{+0.0051}_{-0.0046}$	$0.056^{+0.0049}_{-0.0044}$	0.051 ± 0.006
δ_S	-1.2 ± 0.18	-1.2 ± 0.18	-1.2 ± 0.18	-1.1 ± 0.18
ξ	1 (fixed)	1 (fixed)	1 (fixed)	$1.1^{+0.09}_{-0.07}$
χ^2/dof	38.3/22	37.3/22	36.0/22	34.0/21
CL(%)	2	2	3	4

UT from Global Fits

- Scheme 3 only (difference from others miniscule):

$$73^\circ \le \alpha \le 86^\circ \quad (1\ \sigma)\ ,$$
$$66^\circ \le \alpha \le 94^\circ \quad (95\%\ \mathrm{CL})\ ;$$
$$21^\circ \le \beta \le 25^\circ \quad (1\ \sigma)\ ,$$
$$18^\circ \le \beta \le 27^\circ \quad (95\%\ \mathrm{CL})\ ;$$
$$74^\circ \le \gamma \le 83^\circ \quad (1\ \sigma)\ ,$$
$$67^\circ \le \gamma \le 87^\circ \quad (95\%\ \mathrm{CL})\ .$$

- The (ρ, η) is further shifted toward larger γ, but smaller β.



Summary

- We perform global χ^2 fits to charmless $B \to P\,P$ decays and determine theoretical parameters in various SU(3)-conserving and -breaking schemes.
- The (ρ, η) vertex obtained from the partial fits is higher than but consistent with the other fits; global fits shifts it to a smaller ρ value. These results are robust in the schemes we consider.
- We observe a large C with a nontrivial strong phase, and a P_{EW} about the right size as in the SM.
- We make predictions based upon the fitting results, particularly for the B_s system to be observed in the next few years.
- We will also look at the $V\,P$ modes.

Thank You