Beta from Penguins:Theoretical Aspects

Amarjit Soni

(soni@bnl.gov,adlersoni@gmail.com)

CKM08, Rome

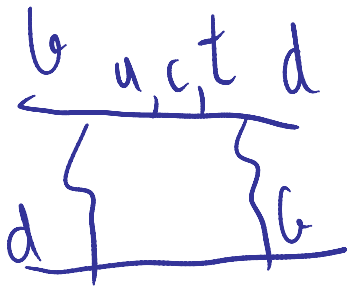
Outline

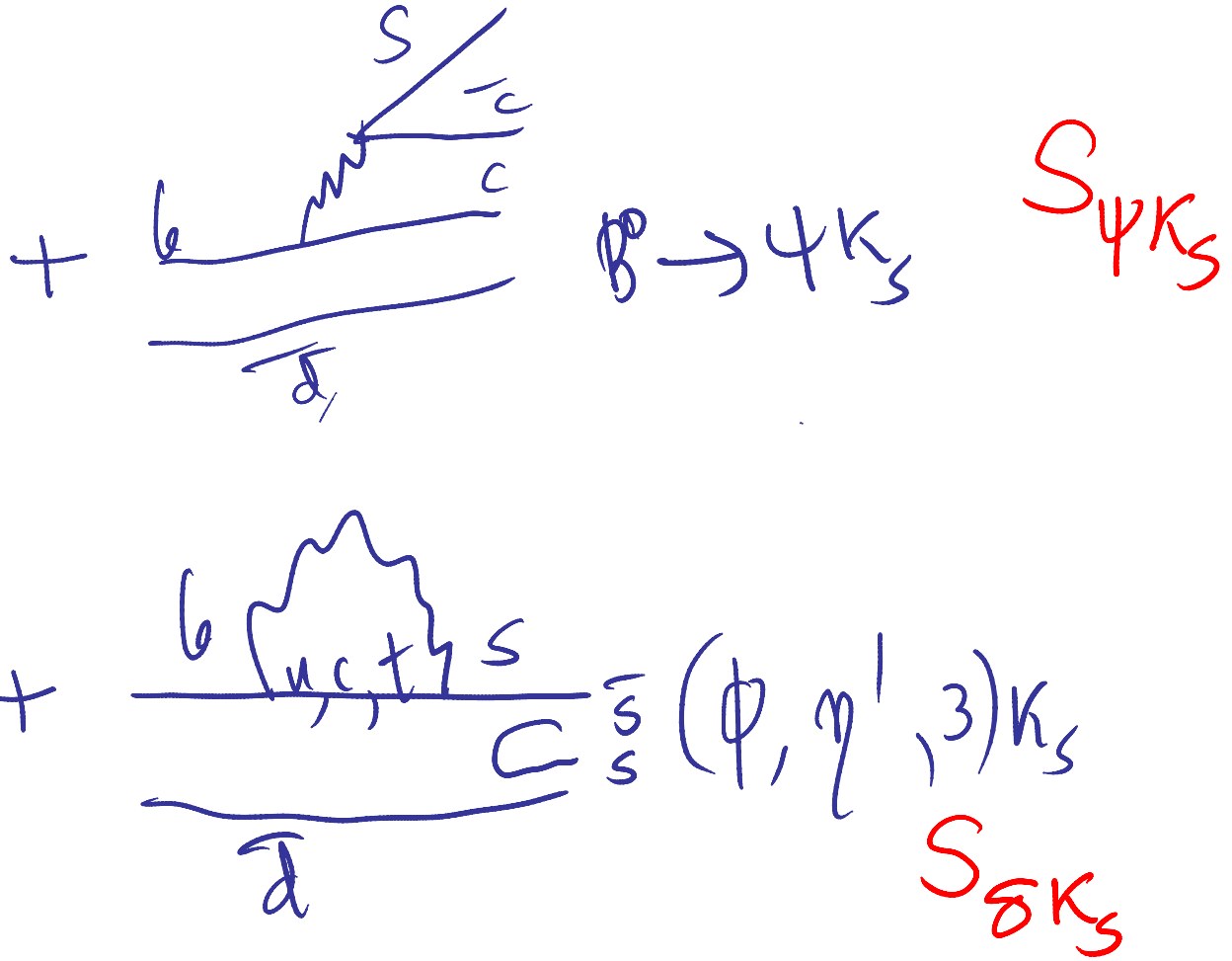
- **Introduction: Recapitulate + Exptal status**
- **Two (and not one) stab at the SM**
- **Some clean modes**
- **Interesting correlation(s)**
- **Possibility of independent verification(s)**
- **Future prospects**
- **Summary**

From Masashi Hazumi

β/ϕ_1 with penguins

$S_{\psi Ks}$ vs $S_{\delta Ks}$





Time dependent(S) versus dir CP(A)

$$\frac{\Gamma(\overline{B}(t) \to f) - \Gamma(B(t) \to f)}{\Gamma(\overline{B}(t) \to f) + \Gamma(B(t) \to f)} = S_f \sin(\Delta m t) + \mathcal{A}_f \cos(\Delta m t),$$

$$M(\overline{B}^0 \to f) = \lambda_u^{(s)} A_f^u + \lambda_c^{(s)} A_f^c;$$

$$r_f \equiv \frac{\lambda_u}{\lambda_c} \frac{A_f^u}{A_f^c} \sim \frac{A_f^u}{A_f^c} \frac{1}{50}$$

$$\Delta S_f = 2|r_f| \cos 2\beta \sin\gamma \cos\delta_f,$$
$$\mathcal{A}_f = 2|r_f| \sin\gamma \sin\delta_f,$$

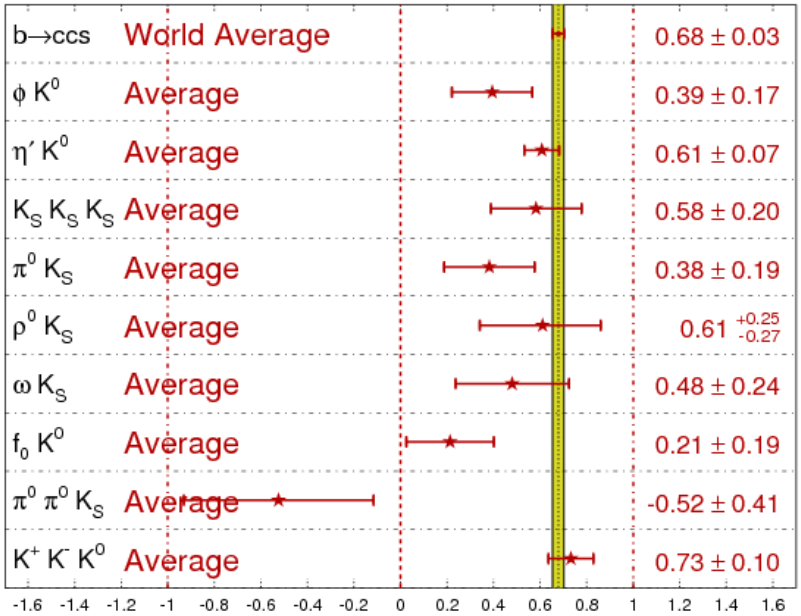
$$\left[\delta_f \equiv \arg\left(A_f^u / A_f^c\right)\right]$$

$$\Delta S_\psi \equiv S_{\psi K_S} - S_{\psi K_S}$$
penguin

Just to serve as a reminder

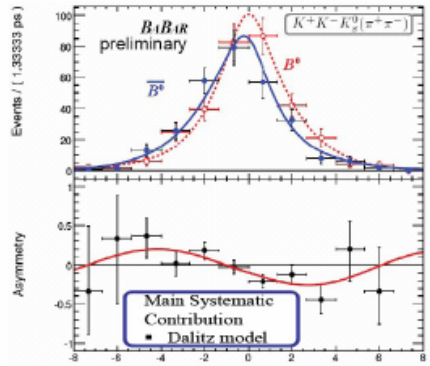
ΔS results before ICHEP 2008

$\sin(2\beta^{\rm eff}) \equiv \sin(2\phi_1^{\rm eff})$ HFAG LP 2007 PRELIMINARY



For most modes, ΔS(SM) is positive.

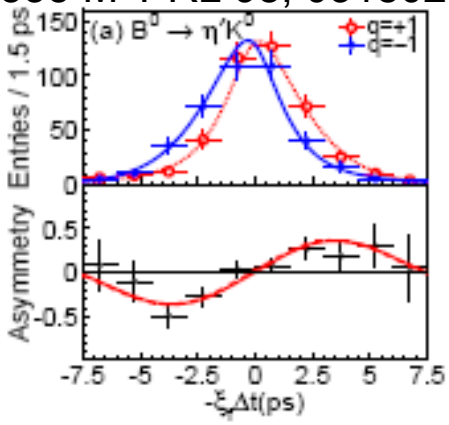
347M $B\bar{B}$ PRL 99, 161802 (2007)



Based on KKK Dalitz analysis

ϕK^0: $\sin 2\beta_{\rm eff} = +0.12 \pm 0.31({\rm stat}) \pm 0.10\ ({\rm syst})$

535 M PRL 98, 031802 (2007)



Paoti Chang (ICHEP08)

CKM08(ROMA)

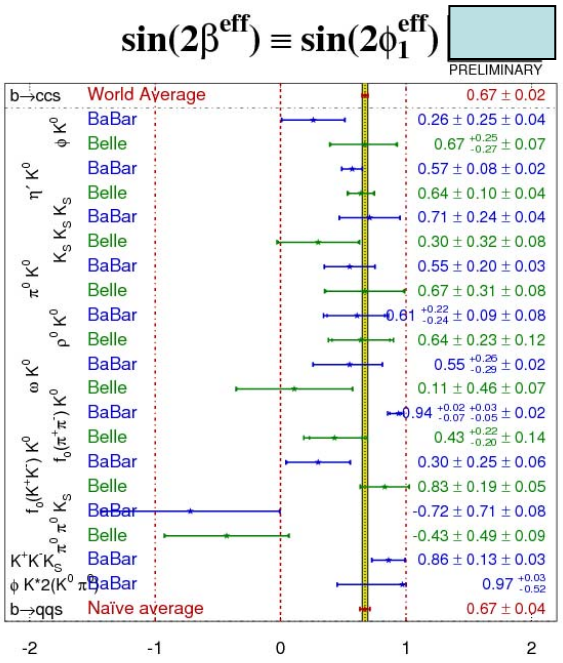
$\eta' K^0$: $\sin 2\phi_{1\rm eff}$: +0.64± 0.10 ± 0.04

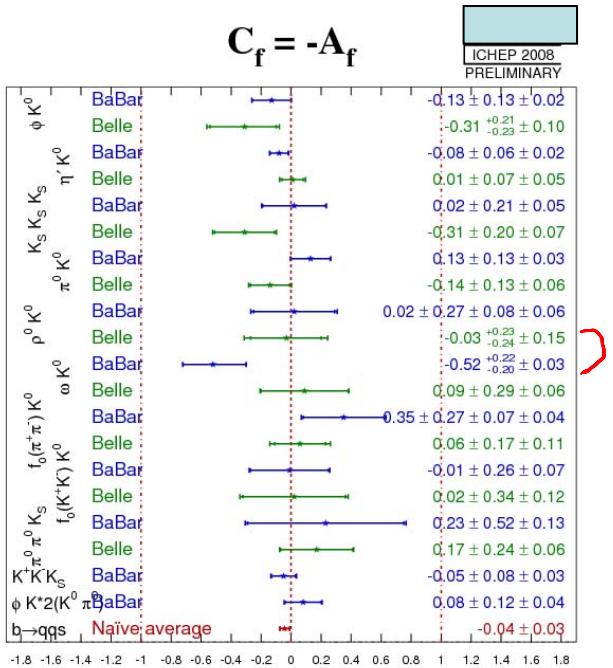
Just to serve as a reminder

TCPV Results on $\bar{b}\to s\,q\bar{q}$

Sorry official HFAG average is not ready yet!

$S(c\bar{c}s) = 0.67 \pm 0.02$





Naïve

$S(q\bar{q}s) = 0.67 \pm 0.04$

$C = -0.04 \pm 0.03$

Average

$S(q\bar{q}s) = 0.60 \pm 0.05$ after removing BaBar's $f_0(\pi\pi)K^0$ and $\phi K^0\pi^0$

CKM08(ROMA):sept.9-13 (soni)

PaotiChang(ICHEP08)

Theoretical Expectations for ΔS_ψ

	Beneke '05		Cheng, Chua + A.S. '05
1. $\eta' K_S$	$.01^{+.01}_{-.01}$	$[+.00, .03]$	$.00^{+.00}_{-.04}$
2. ϕK_S	$.02^{+.01}_{-.01}$	$[+.01, .05]$	$.03^{+.01}_{-.04}$
3. $\pi^0 K_S$	$.07^{+.05}_{-.04}$	$[.02, .15]$	$.04$
4. ηK_S	$.10^{+.11}_{-.07}$	$[-1.67, .27]$	$.07$
5. $\rho^0 K_S$	$-.08^{+.08}_{-.12}$	$[-.29, .02]$	$.04$
6. ωK_S	$.13^{+.08}_{-.08}$	$[.01, .21]$	$.01$

Only central values

$\Delta S_\psi > .05$

Browder,Gershon,Pirjol,AS,Zupan,arXiv:0802.3201(RMP)

TABLE VIII Expectations for ΔS_f in three cleanest modes.

Model	ϕK^0	$\eta' K^0$	$K_S K_S K^0$
QCDF+FSI[a]	$0.03^{+0.01}_{-0.04}$	$0.00^{+0.00}_{-0.04}$	$0.02^{+0.00}_{-0.04}$
QCDF[b]	0.02 ± 0.01	0.01 ± 0.01	
QCDF[c]	0.02 ± 0.01	0.01 ± 0.02	
SCET[d]		-0.019 ± 0.009	
		-0.010 ± 0.010	
pQCD[e]	0.02 ± 0.01		

[a] Cheng *et al.* (2005a,b)
[b] Beneke (2005)
[c] Buchalla *et al.* (2005)
[d] Williamson and Zupan (2006)
[e] Li and Mishima (2006)

Mode of special interest: $\pi^0 K_S$

$\Delta S_{\pi^0 K_S}$

Beneke

$+.07 \pm .05$ $-.04$ $(.02, .15)$

Cheng, Chua, AS

$+.04 \pm .02$ $-.03$

Buchalla, Hiller, NiR, RAZ

$.052^{+.042}_{-.031}$

BABAR $\Delta S \sim -.12 \pm .20$

BELLE $\sim 0.0 \pm .31$

See Paoti Chang talk ICHEP 08

More on π^0Ks

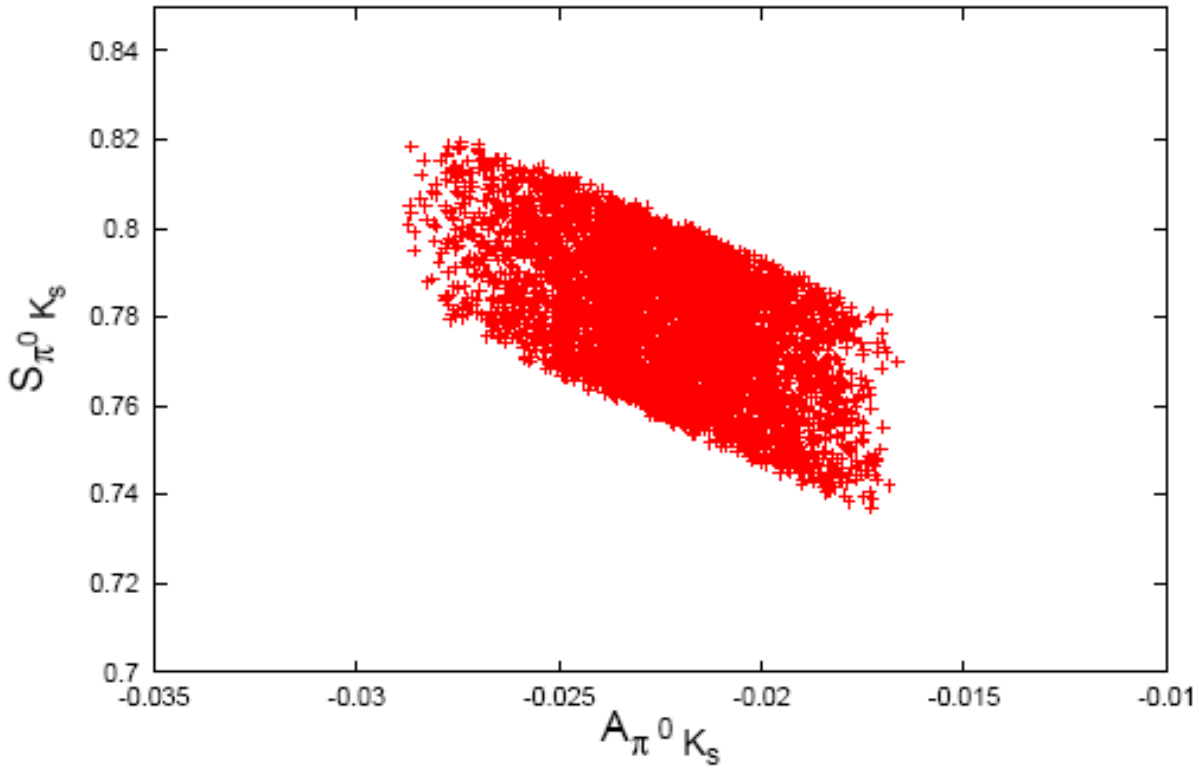
- However,Isospin povides useful relations amongs the 4 K π modes which may lead to useful constraints
- An interesting exampleFleischer,Jager,Pijol,Zupan,arXiv: 0806.2900

$\simeq 26$

$$S_{\pi^0 K_S} = 0.99^{+0.01}_{-0.07}\big|_{\rm exp.}{}^{+0.000}_{-0.001}\big|_{R_{T+C}}{}^{+0.00}_{-0.10}\big|_{R_q}{}^{+0.00}_{-0.06}\big|_{\gamma}$$

See also Gronau + Rosner arXiv:0807.3080

Giri,Mohanta,AS (WIP)



QCDF S4

Belle+Babar $S_{\pi K} \sim .61 \pm .25$; $A \sim 0 \pm .13$

TDCP studies in b->s penguins: two crucial messages NOT one

- **Focus has been just on comparison with B->ψ Ks**
- **In fact at least equally important and most likely, much more important, is that the central value of sin2β from penguins is a lot less than the SM prediction (~0.78 +-0.04) with Vub=(40.8+-3.0)X10^{-4}**
- **(~0.75+-0.04) with Vub=(37.8+-5.0)X10^{-4}**
- **(0.87+-0.09) NO Vub; thanks to improved determination of Bk (RBC-UKQCD) see Lunghi+AS arXiv:0803.4340**
- **Ignoring this 2nd point for last ~3 years has been a costly omission for the flavor community, adversely affecting its exptal program**

has not been adequately emphasized

See Lunghi's talk Thurs Special session

CKM08(ROMA):sept.9-13 (soni)

Lunghi+AS,arXiv.0707.0212

(Sin 2 β = 0.78+-.04)

Directly measured via (gold-plated) B->ψ K_S , sin β = 0.68+-.026

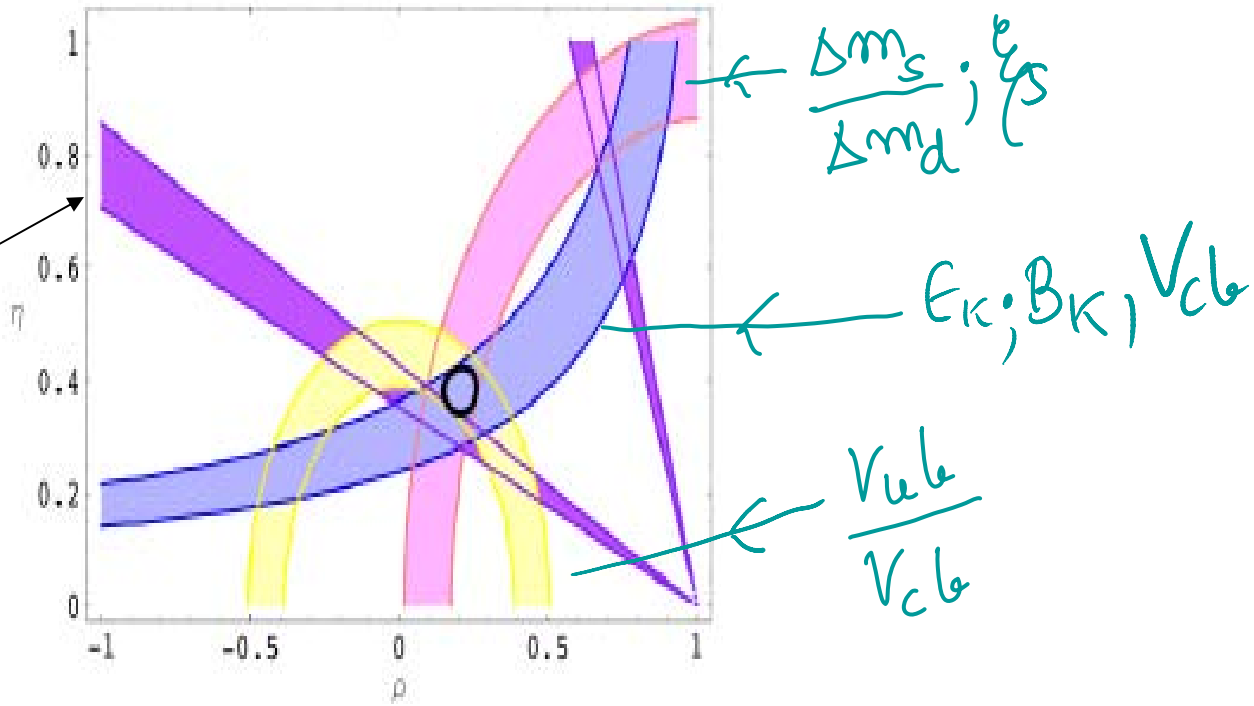


Figure 1: Unitarity triangle fit in the SM. The constraints from $|V_{ub}/V_{cb}|$, ε_K, $\Delta M_{B_s}/\Delta M_{B_d}$ are included in the fit; the region allowed by $a_{\psi K}$ is superimposed.

Leave out Vub

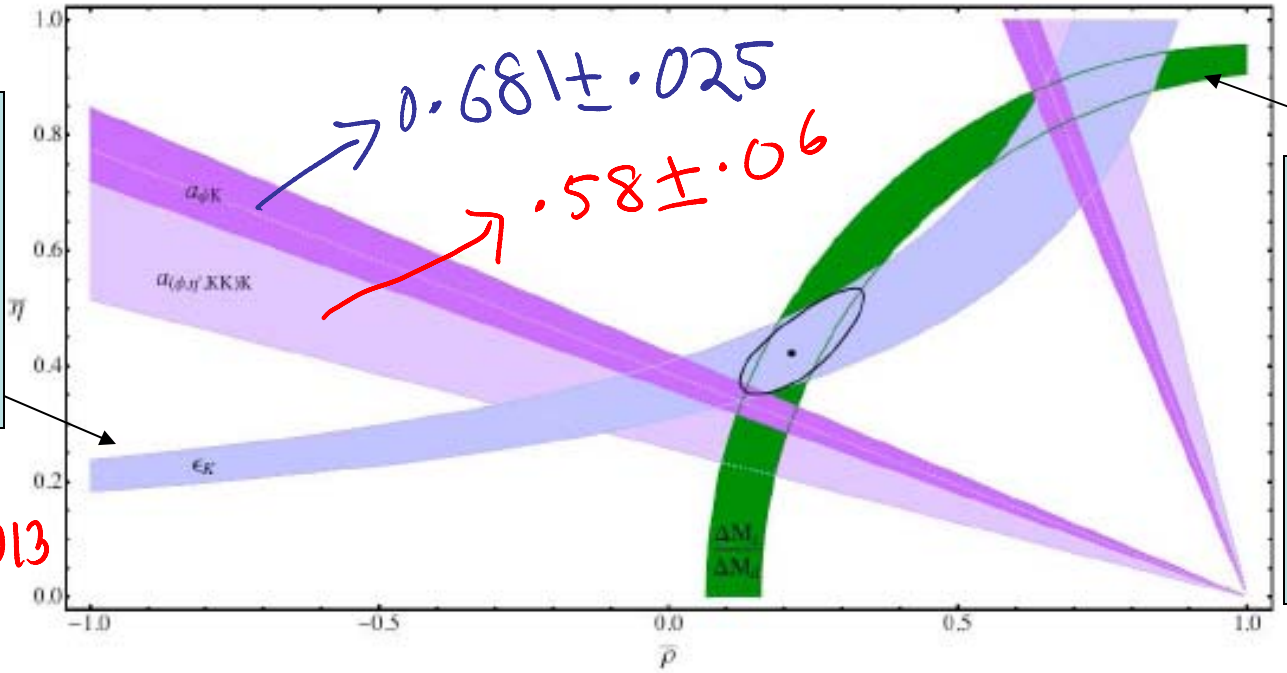
sin 2 β = 0.87+-.09{Lunghi+AS,hep-ph/08034340}

(became possible only due significantly reduced error in B_K)

Antonio et al (RBC-UKQCD) 0702042

$B_K = .720 \pm .013 \pm .037$

$|V_{cb}| = 40.8 \pm .6 \times 10^{-2}$



Gamiz et al; Becirevic; Tantalo

$\xi = 1.20 \pm .06$

FIG. 1: Unitarity triangle fit in the SM. All constraints are imposed at the 68% C.L.. The solid contour is obtained using the constraints from ε_K and $\Delta M_{B_s}/\Delta M_{B_d}$. The regions allowed by $a_{\psi K}$ and $a_{(\phi+\eta'+2K_s)K_s}$ are superimposed.

2.1-2.7 σ- deviation from the directly measured values of sin 2 β require careful follow-up

Values of sin2β

- **SM prediction (using Vub) ~0.765+-0.04**
- **SM prediction (No Vub))~0.87 +-0.09**
- **B->ψ K_S -> 0.681+-0.025**
- **B->{φ K_S , η K_S , 3 K_S } -> 0.58+-0.06**
- **ΔS ranges ~1.4 to 2.7 σ**
- **Besides central values of practically all penguin modes tends to be below ψ K_S (and of course well below SM predictions)**

Some More on ΔS

- **ΔS REMAINS an EXCELLENT TEST**
- **Sign of ΔS theoretically NOT fully reliable though in most model calculations and for most modes ΔS is positive**

- ***CONCLUSIVE evidence for NP demands $|\Delta S| > 0.10$ IN some of the CLEAN modes (though whichever $|\Delta S|$)***

Possibility of independent verfications

- **Hints of NP in penguin modes-> BSM CP-odd phase in b->s transitions**

Confirmation may come from:

A) (e.g.) AFB (B->K*ll) deviation from SM

B) Significant SCP in B_S -> ψφ

C) Lattice confirmation that SM prediction is Significantly different from direct measurements via B->ψ K_S and/or B->δ K_S

Prospects seem very high of resolution in 1-3 years

Anomalous $A_{FB}(q^2)$ in $B \to K^{(*)} ll$?

Obtain A_{FB} by a fit:

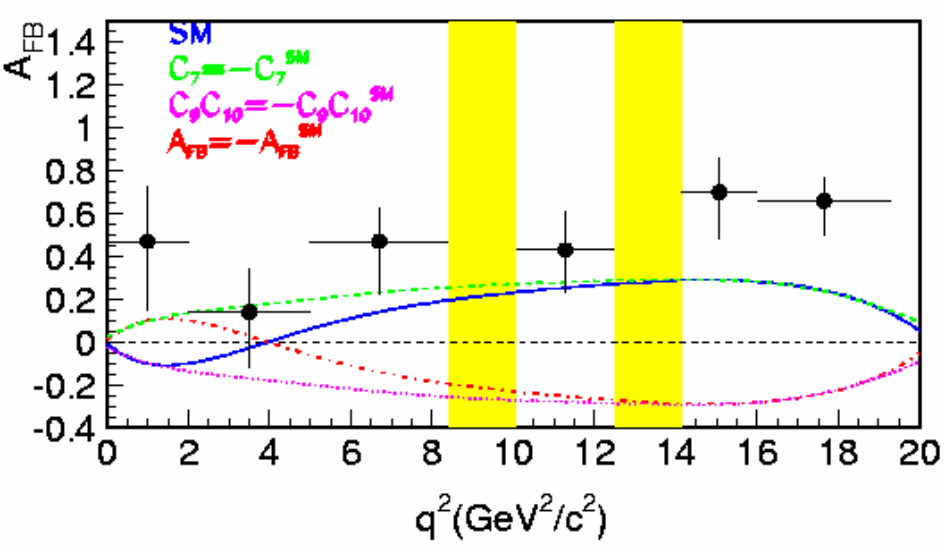
$$\frac{3}{4}F_L(1-\cos^2\theta_{Bl})+\frac{3}{8}(1-F_L)(1+\cos^2\theta_{Bl})+A_{FB}\cos\theta_{Bl}$$

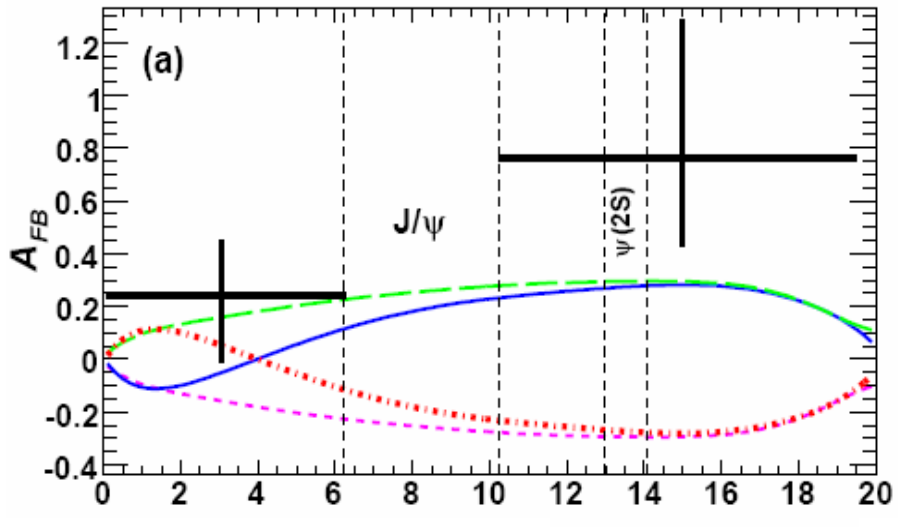
Efficiency corrected

657 M $B\bar{B}$

384 M $B\bar{B}$

Paoti Chang ICHEP08





Data show positive A_{FB} at low q^2, while the SM predicts negative A_{FB}.

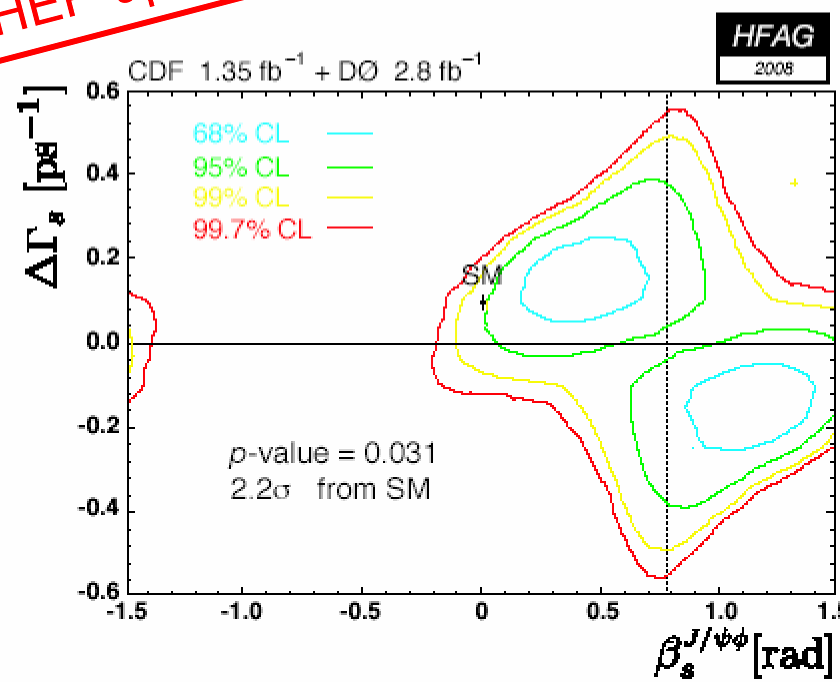
At high q^2, data above the SM expectation.

Diego Tonelli @ICHEP08

Tevatron combination

ICHEP update

- D0 observes a fluctuation consistent with CDF (see J. Ellison just after me)
- Combine CDF and D0 iso-CL regions previously checked for coverage:

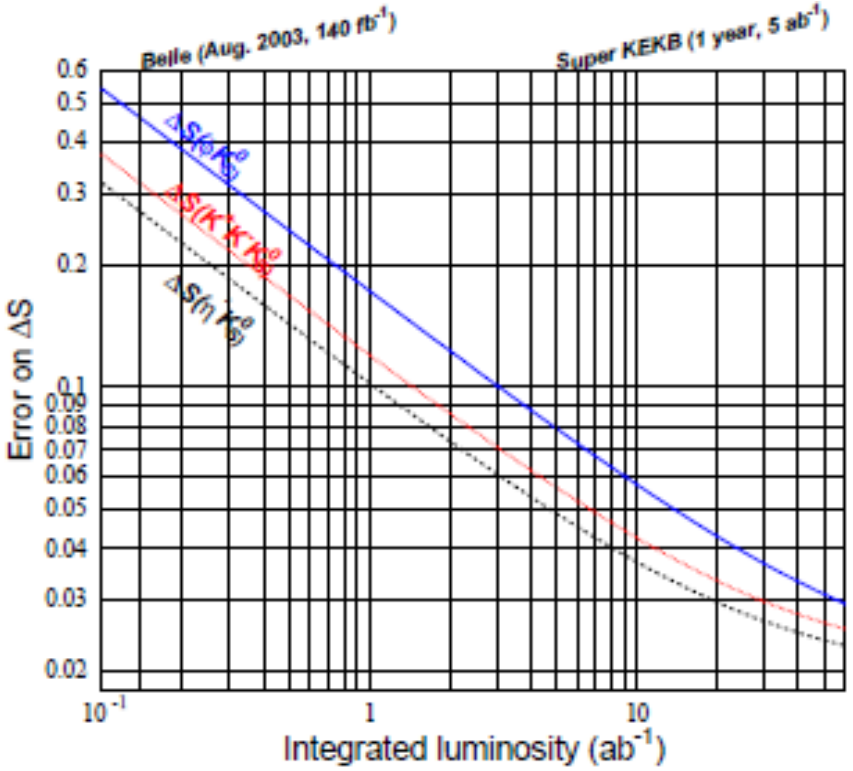


hep.physics.indiana.edu/~rickv/hfag/combine_dGs.html

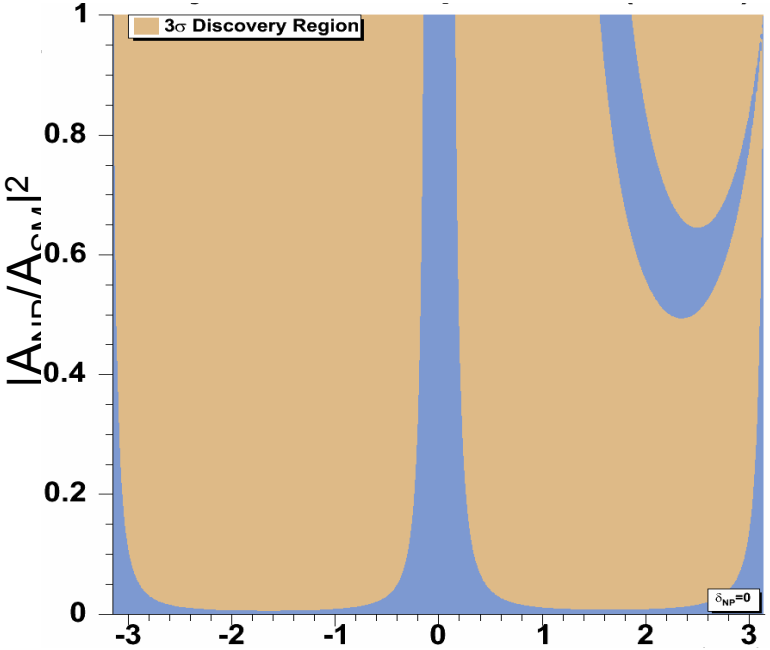
Far Future Prospects

Sensitivity to new CP phases

Estimated error in the measurement of time dependent CP violation



Discovery region with 50 ab^{-1}



Masa Yamauchi

Browder,Gershon,Pirjol,AS,Zupan,arXiv:0802.3201(RMP)
Super Flavor Factory Prospects ~50-75/ab

	SFF	NOW
$S(\phi K^0)$	0.02–0.03	0.17
$S(\eta' K^0)$	0.01–0.02	0.07
$S(K_S K_S K^0)$	0.02–0.03	0.20

Browder,Ciuchini,Gershon,Hzumi,Hurth,Okada,Stocchi,arXiv:0710.3799
SFF Prospects

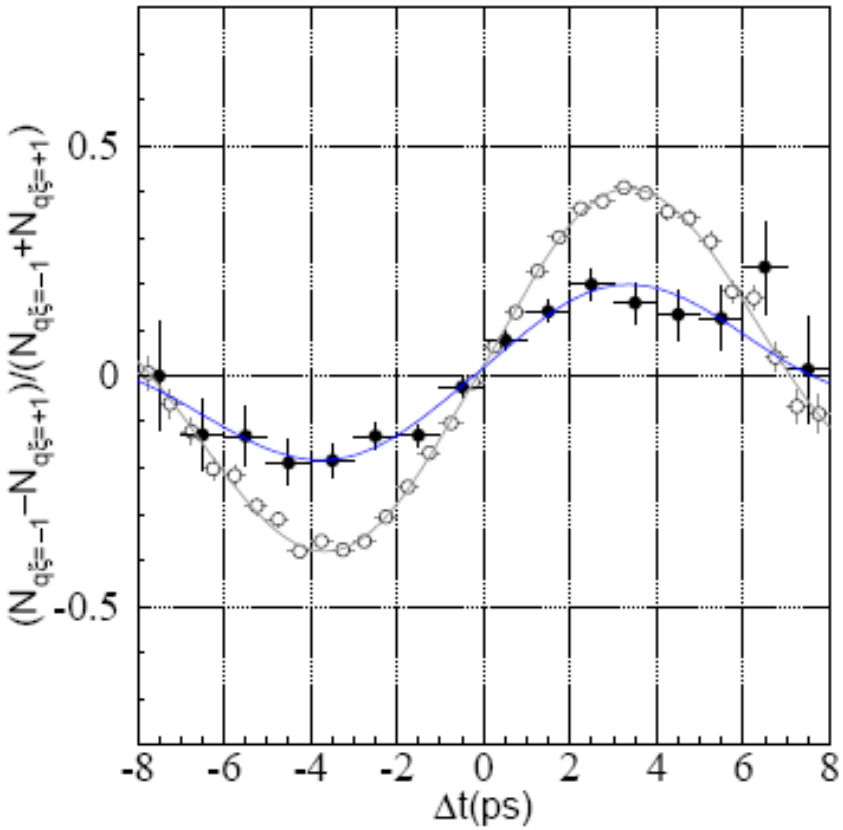


Fig. 1: Simulation of new physics effects in $B^0 \to \phi K^0$, as could be observed by a SFF. The open circles show simulated $B^0 \to J/\psi\, K^0$ events, the filled circles show simulated $B^0 \to \phi K^0$ events. Both have curves showing fit results superimposed. From [6].

Prospects at LHCb

One may consider the potential of a hadronic machine to address these modes. At present, it appears that ϕK_S is difficult, but not impossible to trigger and reconstruct in the hadronic environment, due to the small opening angle in $\phi \to K^+K^-$; $\eta' K_S$ is challenging since neutral particles are involved in the η' decay chain; for $K_S K_S K_S$ meanwhile, there are no charged tracks originating from the B vertex, and so both triggering and reconstruction seem highly complicated. Modes containing K_L mesons in the final state may be considered impossible to study at a hadron machine. Furthermore, due to the theoretical

Browder,Gershon,Pirjol,AS,Zupan,arXiv:0802.3201(RMP)

Summary & Conclusions

- Sin 2β from penguins continues to be a very good test of the SM; in particular
- B->{φ K_S , η K_S , 3 K_S } appear rather clean
- B->π^0 K_S may also emerge as a viable constraint
- For now data is suggestive of a new phase in b->s penguin transitions
- Independent verification may come from (in 1-3 years):
- (e.g) AFB (B->K^* l l)
- SCP (B_S -> ψ φ)
- Confirmation from the lattice that SM "predicted" value of sin2β is significantly above either of direct measurements
- Eventually SBFs should be able to tell decisively