Summary - Working Group 2 Experimental

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Weak Interactions and Neutrinos 2005
June 6-11, 2005

Thank you ....

Thank you to

+ organizers: for invitation as convener
+ presenters: excellent presentation
+ Working Group 2 *et al.*: stimulating discussions

Appologies

+ cannot show everything here ....
+ radically cut contents to fit in my 20 minutes

Contents

+ highlights: kaon physics
+ unitarity triangle: status
+ what the future brings

Highlights: Kaon Physics

CP Violation

+ here is where *CP* violation started in 1964
+ $Re(\varepsilon/\varepsilon')$ by NA48 and KTeV (reasonably consistent with SM)
+ $K \rightarrow 3\pi$ future experiments

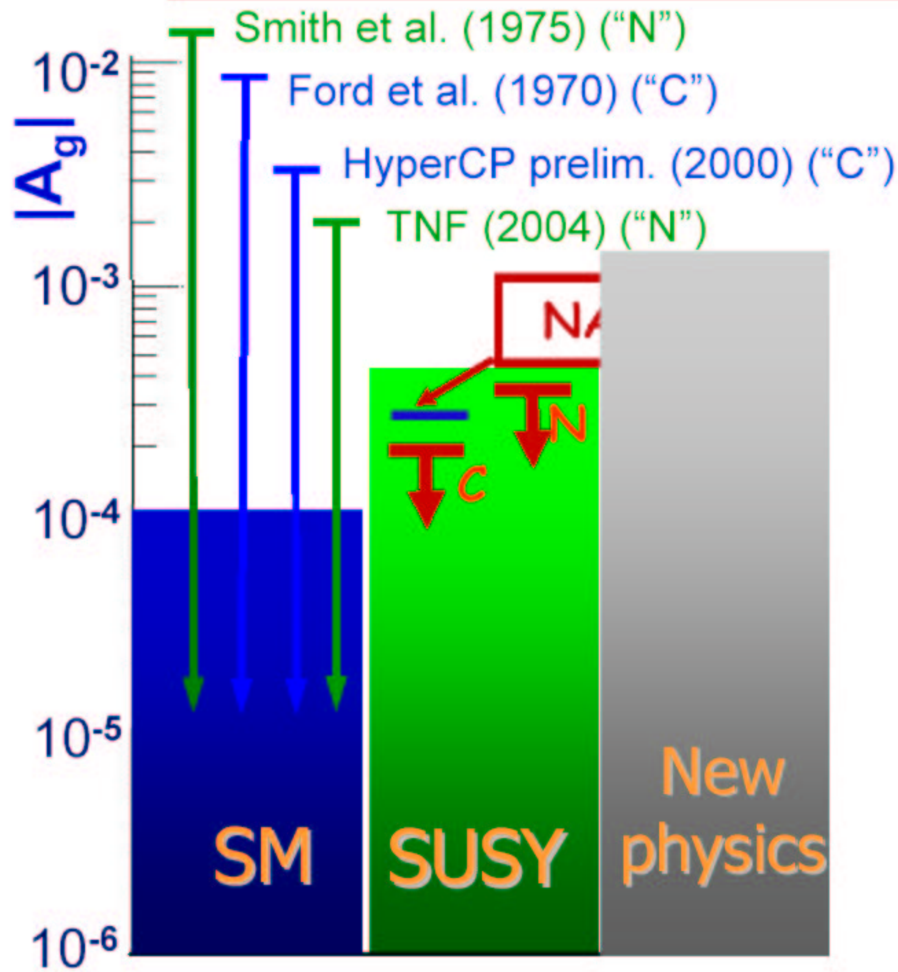
Rare kaon decays

+ observation of $K_S \rightarrow \pi^0 l^+ l^-$
+ is $K_L \rightarrow \pi^0 l^+ l^-$ becoming feasible?
+ clean theory for $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ and $K_L \rightarrow \pi^0 \nu\bar{\nu}$

Preliminary result on A_g

$$A_g = (0.5 \pm 2.4_{stat.} \pm 2.1_{stat.(trig.)} \pm 2.1_{syst.}) \times 10^{-4}$$

$$A_g = (0.5 \pm 3.8) \times 10^{-4} \text{ NA48/2 - 2003 data}$$

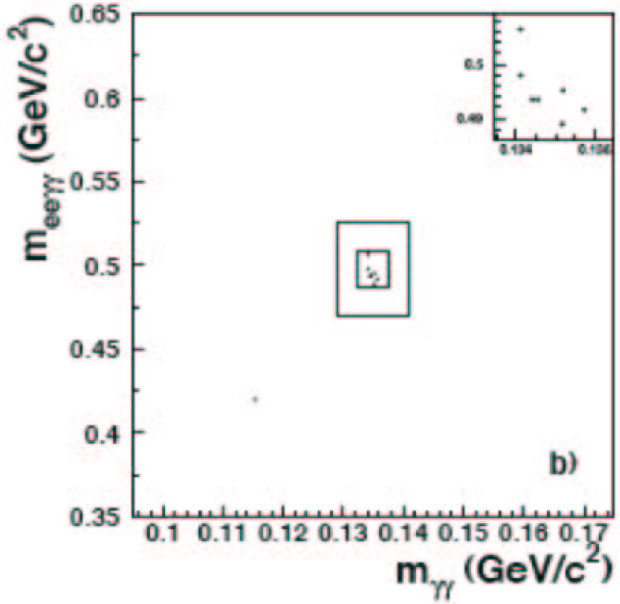


- This is a preliminary result, with conservative estimate of the systematic errors
- The extrapolated statistical error 2003+04 is $\delta A_g = 1.6 \times 10^{-4}$
- 2004 data: expected smaller systematic effects (more frequent polarity inversion, better beam steering)

First Observations of $K_S^0 \to \pi^0 \ell^+ \ell^-$ by NA48/1

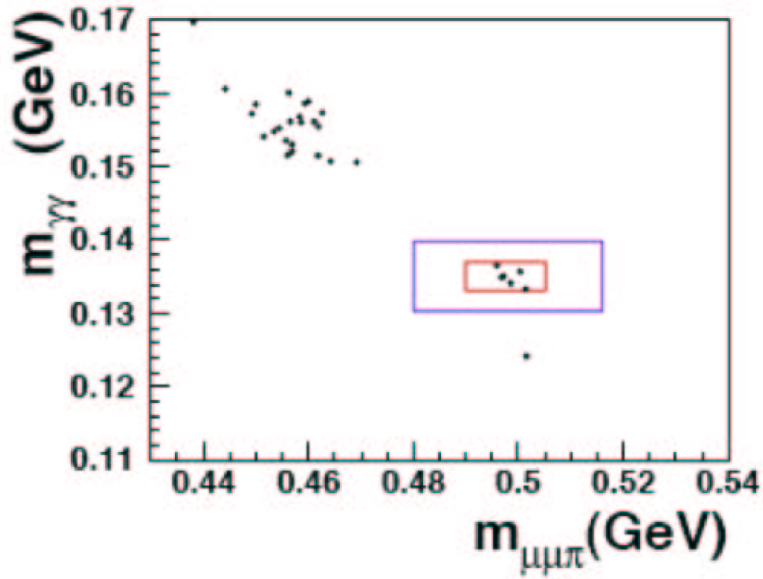
$K_S^0 \to \pi^0 e^+ e^-$

PL B576 (2003) 43



$K_S^0 \to \pi^0 \mu^+ \mu^-$

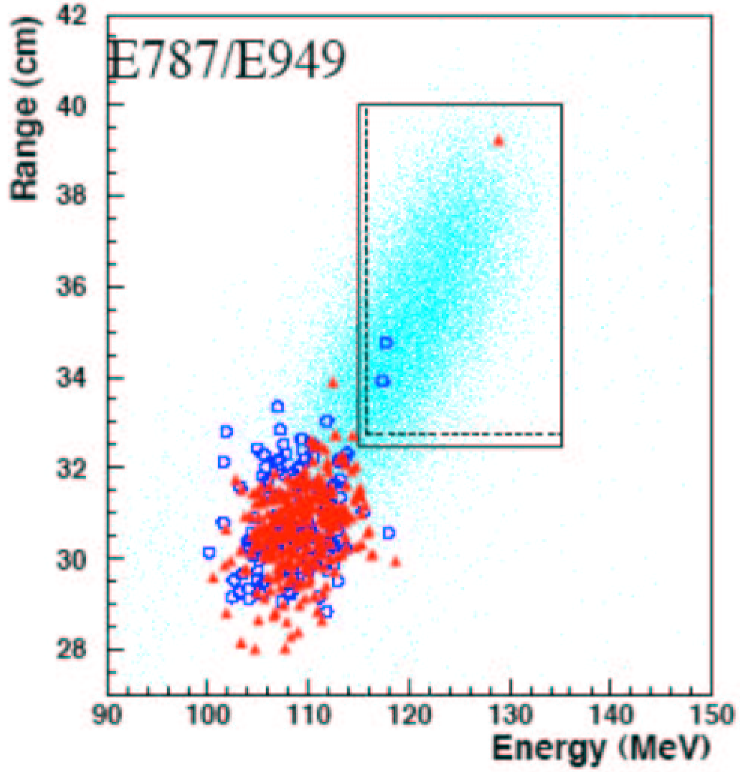
PL B599 (2004) 197



Data	Bgd	observed	BR (vector matrix element, no form factor)
$K_S^0 \to \pi^0 e^+ e^-$	$0.15^{+0.10}_{-0.04}$	7	$5.8^{+2.8}_{-2.3}(stat) \pm 0.8(syst) \times 10^{-9}$
$K_S^0 \to \pi^0 \mu^+ \mu^-$	$0.22^{+0.18}_{-0.11}$	6	$2.9^{+1.5}_{-1.2}(stat) \pm 0.2(syst) \times 10^{-9}$

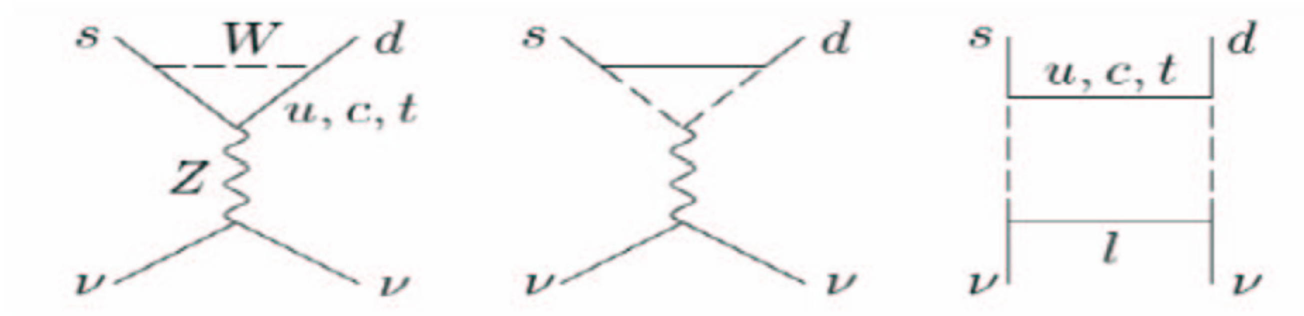
Improved Measurement of the $K^+ \to \pi^+ \nu \bar{\nu}$ Branching Ratio

E949 2002 dataset (~ 30% of E787), PRL 93 (2004) 031801



- π^+ Range vs Energy
- E949-2002 | E787 | MonteCarlo
- background: 0.30±0.03 events
  - "Blind" analysis
  - Likelihood analysis to the candidate events
- B.R. = $(1.47^{+1.30}_{-0.89}) \times 10^{-10}$ in 68%C.L. intervals
- $P_b = 0.1\%$

$K_L^0 \to \pi^0 \nu\bar{\nu}$ in the SM



Standard Model (*Buras*): $\mathrm{Im}\,\lambda_t = \mathrm{Im} V_{ts}^* V_{td} = \eta A^2 \lambda^5$

$$B(K_L^0 \to \pi^0 \nu\bar{\nu}) = 1.8\,x10^{-10} \left(\frac{\mathrm{Im}\,\lambda_t}{\lambda^5} X(x_t) \right)^2$$

$$\sim 4.1\,x10^{-10} A^4 \eta^2 = 3.0 \pm 0.6\,x10^{-11}$$

$$B(K^+ \to \pi^+ \nu\bar{\nu}) \sim 1.0\,x10^{-10} A^4 \left[\eta^2 + (\rho_0 - \rho)^2 \right] = 7.8 \pm 1.2\,x10^{-11}$$

Errors from CKM parameter uncertainties

Intrinsic errors ~7% for K+, ~2% for K_L

Highlights: Unitarity Triangle, CKM

Motivation

- measure unitarity triangle in many ways
- find inconsistency ≡ new physics

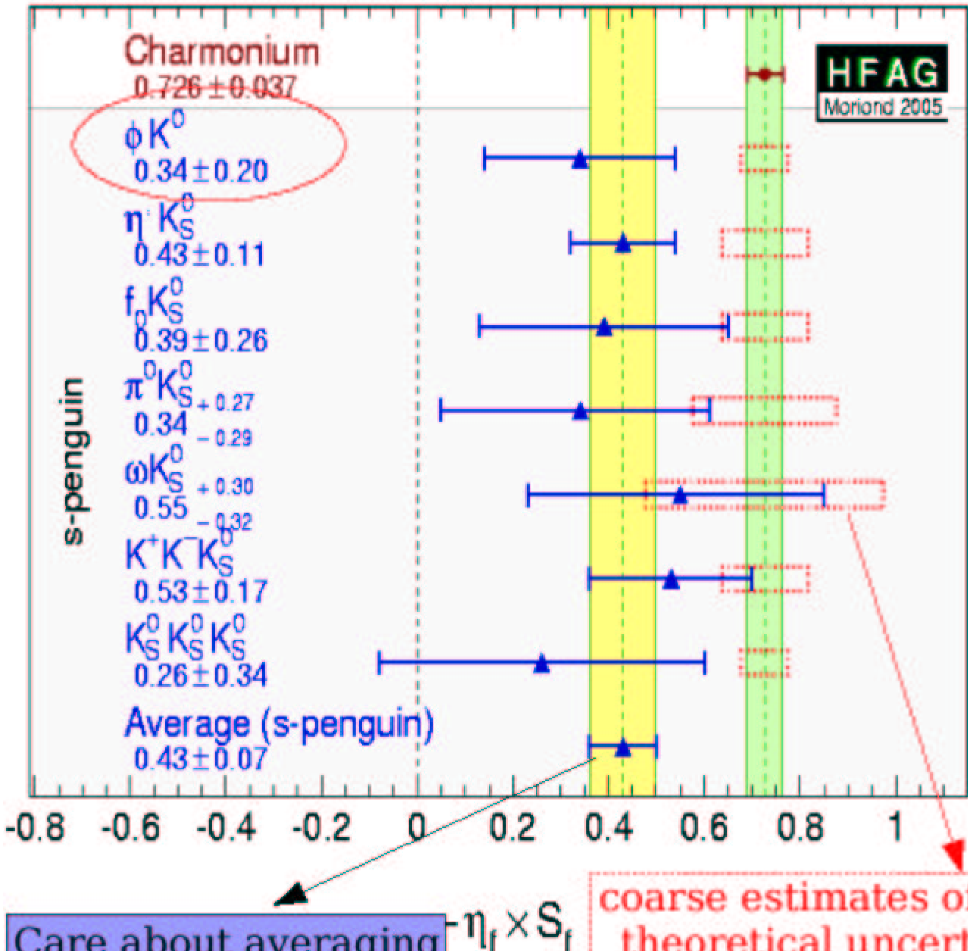
Angles

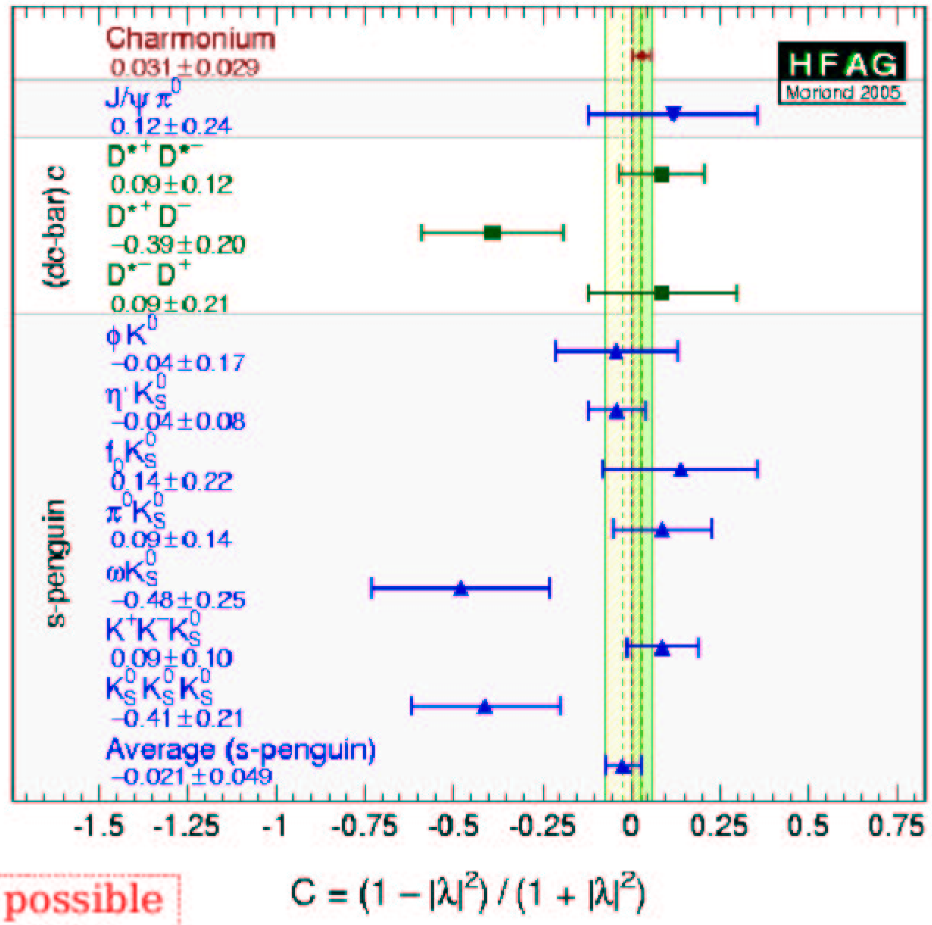
- β, α and γ

Matrix elements (Sides)

- V_{ub}
- V_{td}/V_{ts}

Summary of results





Care about averaging different SM, NP, ΔS!

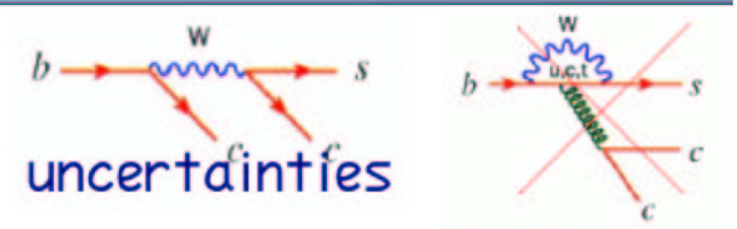
coarse estimates of possible theoretical uncertainties

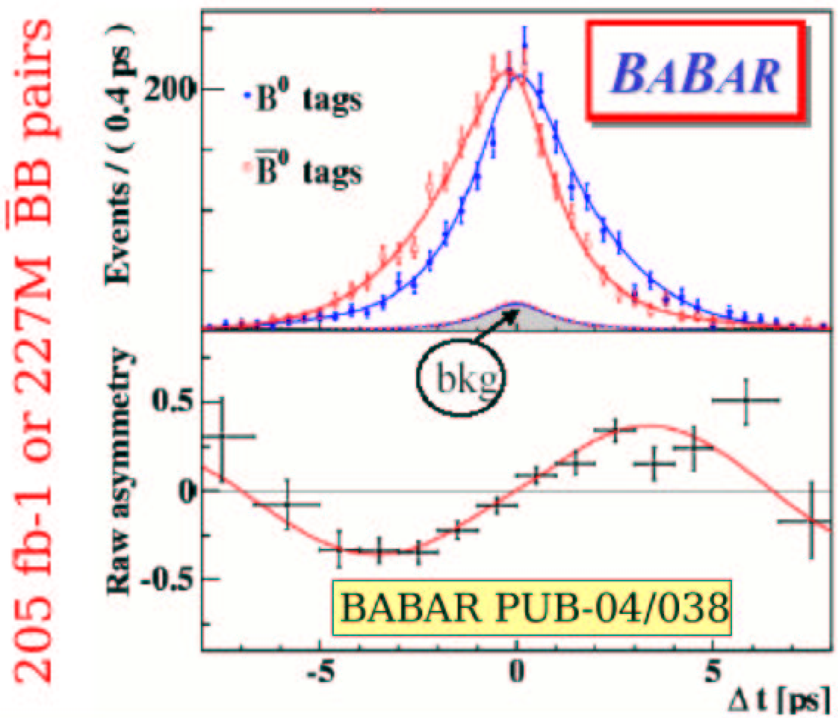
- $S_{penguins} = 0.43 \pm 0.07$
- $S_{c\bar{c}} = 0.726 \pm 0.037$

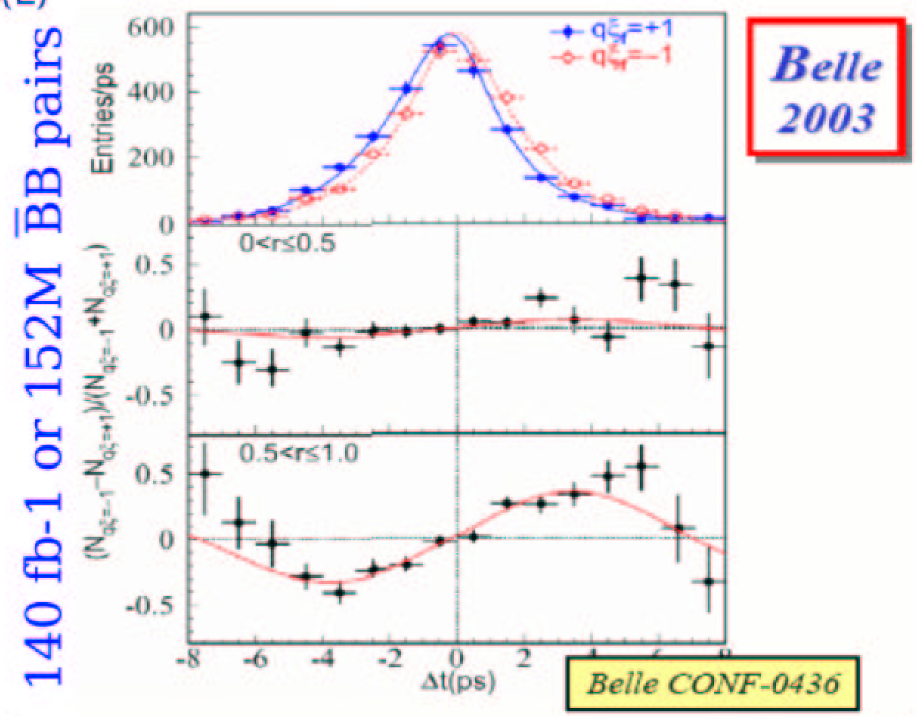
- $C_{penguins} = -0.021 \pm 0.049$
- $C_{c\bar{c}} = 0.031 \pm 0.029$

$\not{C}\not{P}$: $B^0 \to \bar{c}cK^0$

- Mixing phase $\Phi_M = 2\beta$
- Penguin/Tree ~ $A|\lambda|^2 \Rightarrow$ small hadronic uncertainties
- Definite CP content: $CP(J/\psi K_{S(L)})=+(-)1$





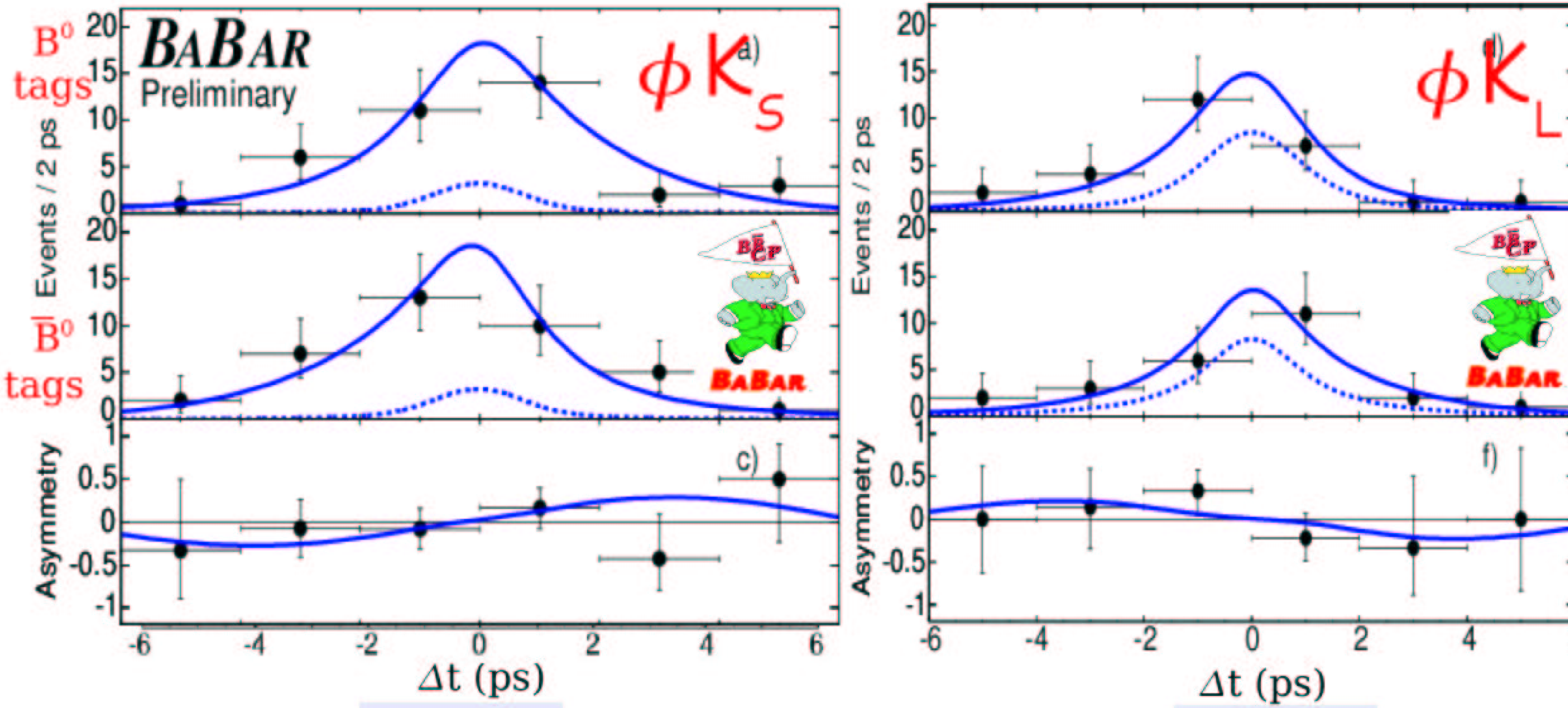


$\sin 2\beta = +0.722 \pm 0.040 \pm 0.023$
$\lambda = |\bar{A}/A| = 0.950 \pm 0.031 \pm 0.013$

$\sin 2\beta = +0.728 \pm 0.056 \pm 0.023$
$\lambda = |\bar{A}/A| = 1.007 \pm 0.041 \pm 0.033$

Combined $A_{CP}(t)$ results

The golden mode!



CP=-1

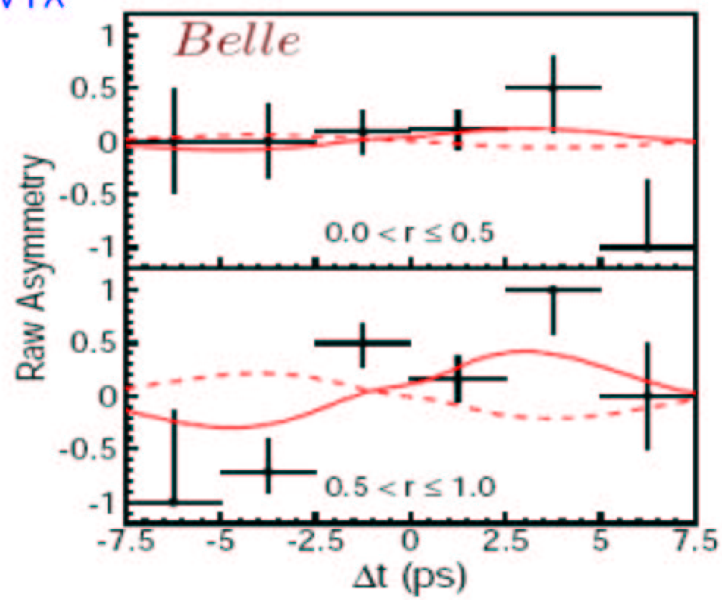
CP=+1

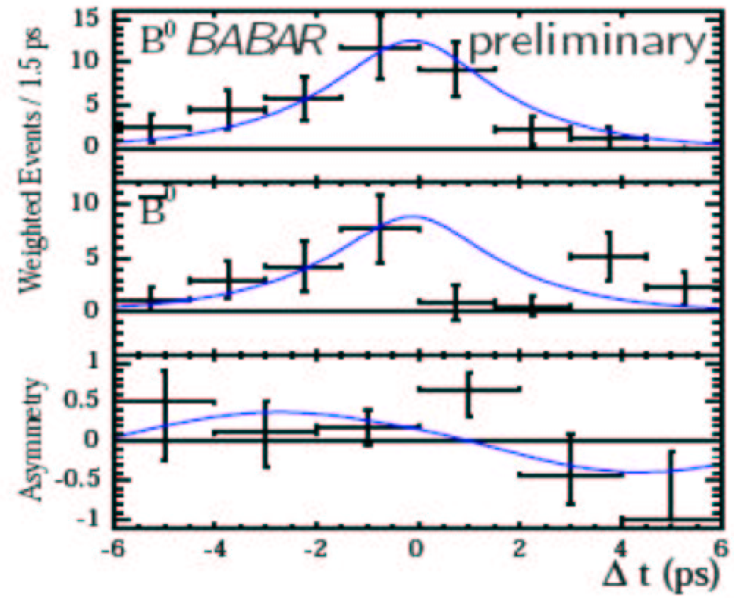
$S = +0.50 \pm 0.25^{+0.08}_{-0.05}$
$C = 0.00 \pm 0.23 \pm 0.09$

$S = +0.06 \pm 0.33 \pm 0.09$
$C = 0.08 \pm 0.22 \pm 0.09$

A 3body mode: $B^0 \to K_S K_S K_S$

- Again Beam Spot Constrained vertexing
- If one K_S decays outside the "good-vertexing" fiducial region, most likely 1 or 2 of the other K_S decay within (ϵ_{VTX}~100%)



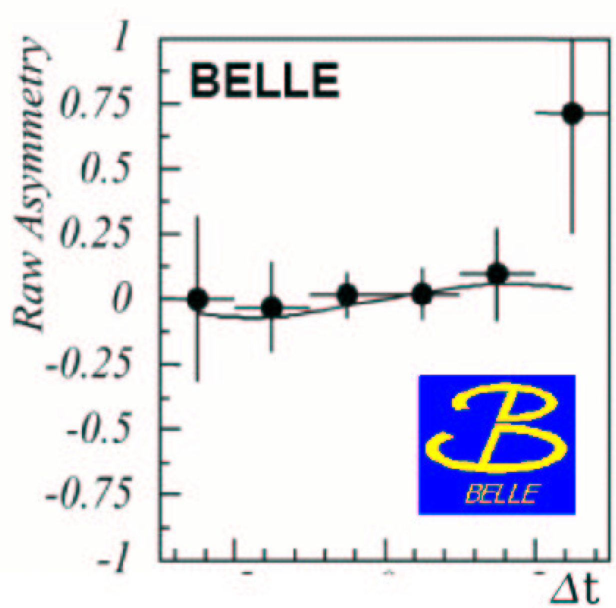


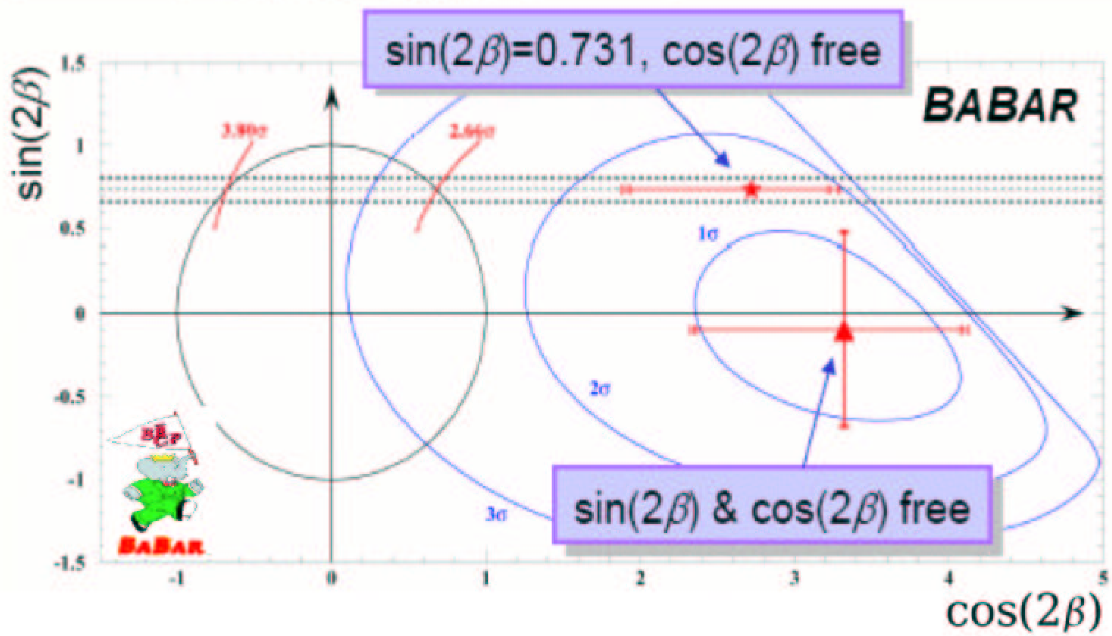
$S = +1.26 \pm 0.68 \pm 0.18$
$C = -0.54 \pm 0.34 \pm 0.08$

$S = -0.71^{+0.38}_{-0.32} \pm 0.04$
$C = -0.34^{+0.28}_{-0.25} \pm 0.05$

$\cos 2\beta$ from $B^0 \to \bar{c}cK^{*0}$: result

	BELLE	BABAR	AVERAGE (HFAG) Care !
# Events	354	104	
$\sin(2\beta/2\phi_1)$ $\cos(2\beta/2\phi_1)$	$0.30 \pm 0.32 \pm 0.02$ $+0.31 \pm 0.91 \pm 0.11$	$0.10 \pm 0.57 \pm 0.14$ $+3.32^{+0.76}_{-0.96} \pm 0.27$	0.21 ± 0.28 (CL=0.55, 0.6σ) 1.60 ± 0.67 (CL=0.026, 2.2σ)
$\sin(2\beta/2\phi_1)$ $\cos(2\beta/2\phi_1)$	0.731 (WA) $+0.31 \pm 0.86 \pm 0.11$	0.731(WA) $+2.72^{+0.50}_{-0.79} \pm 0.27$	



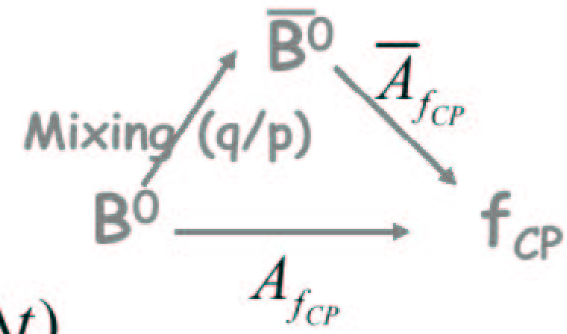


CP violation in the interference between mixing and decay

- For a CP final state f_{CP}, time-dependent asymmetry is:

$$A_{f_{CP}}(\Delta t) = \frac{\Gamma(\overline{B}^0 \to f_{CP}) - \Gamma(B^0 \to f_{CP})}{\Gamma(\overline{B}^0 \to f_{CP}) + \Gamma(B^0 \to f_{CP})}$$

$$= S_{f_{CP}} \sin(\Delta m_d \Delta t) - C_{f_{CP}} \cos(\Delta m_d \Delta t)$$



$$S_{f_{CP}} = \frac{2\,\Im(\lambda_{f_{CP}})}{1+\lambda_{f_{CP}}^2}$$

$S \neq 0$: Indirect *CP* violation

$$C_{f_{CP}} = \frac{1-\lambda_{f_{CP}}^2}{1+\lambda_{f_{CP}}^2}$$

$C \neq 0$: Direct *CP* violation

$$\lambda_{f_{CP}} = \frac{q}{p}\,\frac{\overline{A}_{f_{CP}}}{A_{f_{CP}}}$$

Final State Amplitudes

from mixing

$$|B_L\rangle = p|B^0\rangle + q|\overline{B}^0\rangle$$

$$|B_H\rangle = p|B^0\rangle - q|\overline{B}^0\rangle$$

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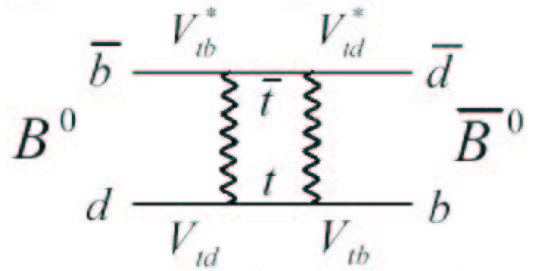
CP violation in $B^0 \to \rho^+\rho^-$

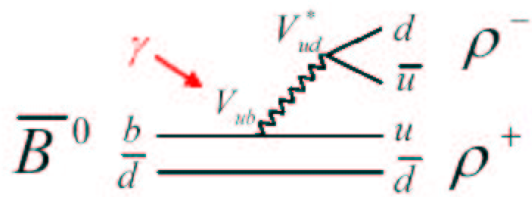
- Access to α from the interference of a $b \to u$ decay (γ) with $B^0 \bar{B}^0$ mixing (β).

$B^0 \bar{B}^0$ mixing



$q/p \propto V_{tb}^* V_{td} / V_{tb} V_{td}^*$

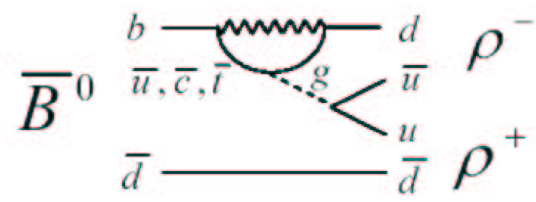
Tree decay



$A \propto V_{ud}^* V_{ub}$

$\oplus$

Penguin decay



$A \approx V_{td}^* V_{tb}$

Tree only

$$\lambda_{\rho^+\rho^-} = \frac{q}{p}\frac{\bar{A}}{A} = e^{-i2\beta} e^{-i2\gamma} = e^{i2\alpha}$$

$$S = \sin(2\alpha)$$

$$C = 0$$

Tree + Penguin

$$\lambda_{\rho^+\rho^-} = e^{i2\alpha} \frac{T + P e^{+i\gamma} e^{i\delta}}{T + P e^{-i\gamma} e^{i\delta}}$$

$$S = \sqrt{1 - C^2} \sin(2\alpha_{eff})$$

$$C \propto \sin\delta$$

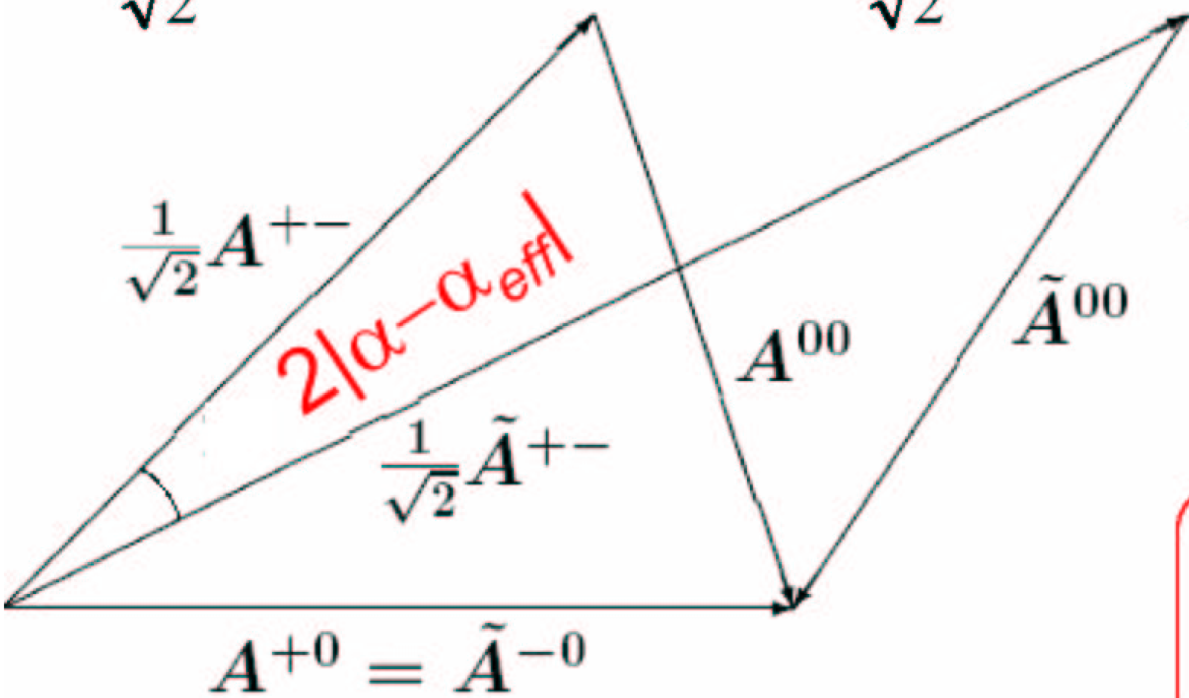
How can we obtain α from α_{eff} ?

T = tree amplitude
P = penguin amplitude
δ = strong phase difference between penguin and tree

Isospin analysis

- Use SU(2) to relate amplitudes of all ρρ modes.

$$\frac{\mathbf{A}^{+-}}{\sqrt{2}} + \mathbf{A}^{00} = \mathbf{A}^{+0} = \widetilde{\mathbf{A}}^{-0} = \frac{\widetilde{\mathbf{A}}^{+-}}{\sqrt{2}} + \widetilde{\mathbf{A}}^{00}$$



$$\mathbf{A}^{+-} = A(B^0 \to \rho^+\rho^-)$$
$$\widetilde{\mathbf{A}}^{+-} = A(\overline{B}^0 \to \rho^+\rho^-)$$

$$\mathbf{A}^{+0} = A(B^+ \to \rho^+\rho^0)$$

$$\mathbf{A}^{00} = A(B^0 \to \rho^0\rho^0)$$
$$\widetilde{\mathbf{A}}^{00} = A(\overline{B}^0 \to \rho^0\rho^0)$$

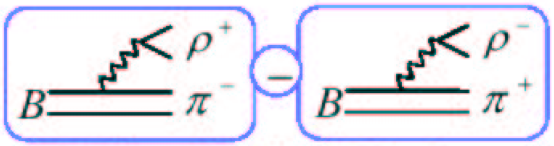
Small amplitudes

Gronau, London : PRL**65**, 3381 (1990)

Result with $B \to \pi^+\pi^-\pi^0$

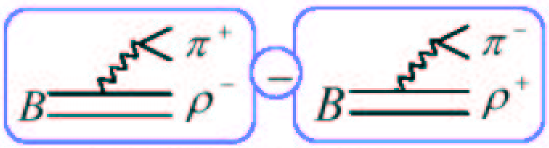
- Hint of direct *CP*-violation

$A_{\rho\pi}^{+-} \cong$

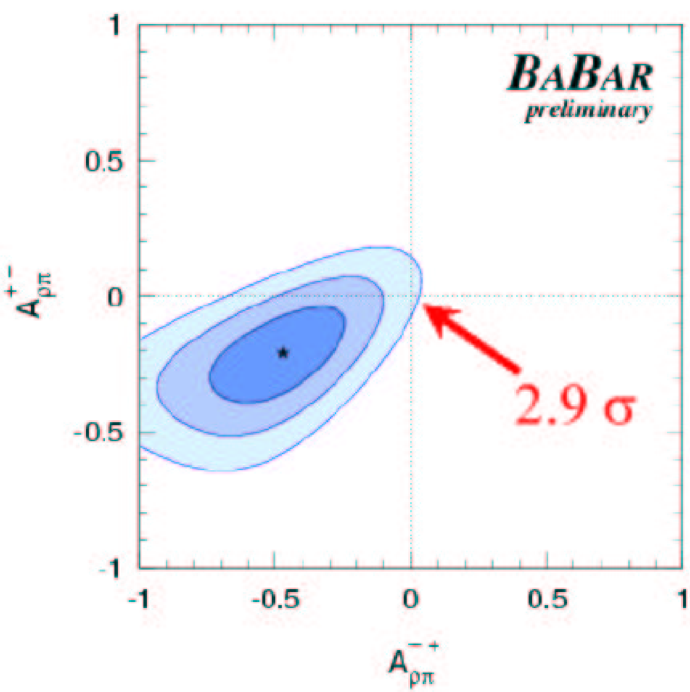


$= -0.21 \pm 0.11 \pm 0.04$

$A_{\rho\pi}^{-+} \cong$



$= -0.47^{+0.14}_{-0.15} \pm 0.06$

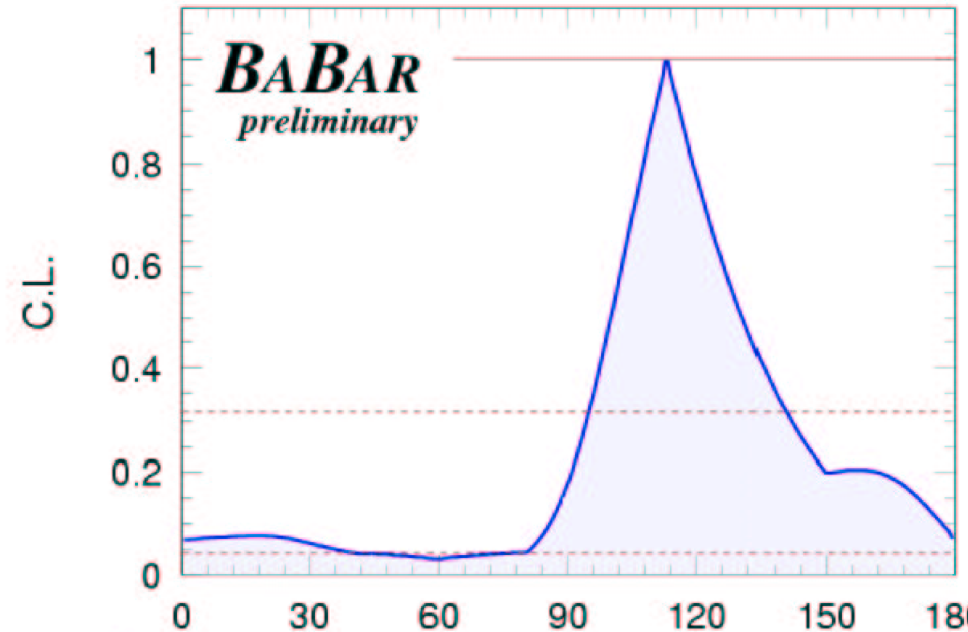


213 M_{BB}

- Likelihood scan of α using:

$$A^{\kappa} = T^{\kappa} e^{-i\alpha} + P^{\kappa}$$
$$\overline{A}^{\kappa} = T^{\overline{\kappa}} e^{+i\alpha} + P^{\overline{\kappa}}$$

$\kappa \in \{+,-,0\}$
T =tree amp.
P =penguin



$$\alpha = \left[113^{+27}_{-17}(stat.) \pm 6(syst.)\right]^{\circ}$$

Mirror solution not shown
Weak constraint at C.L.<5%

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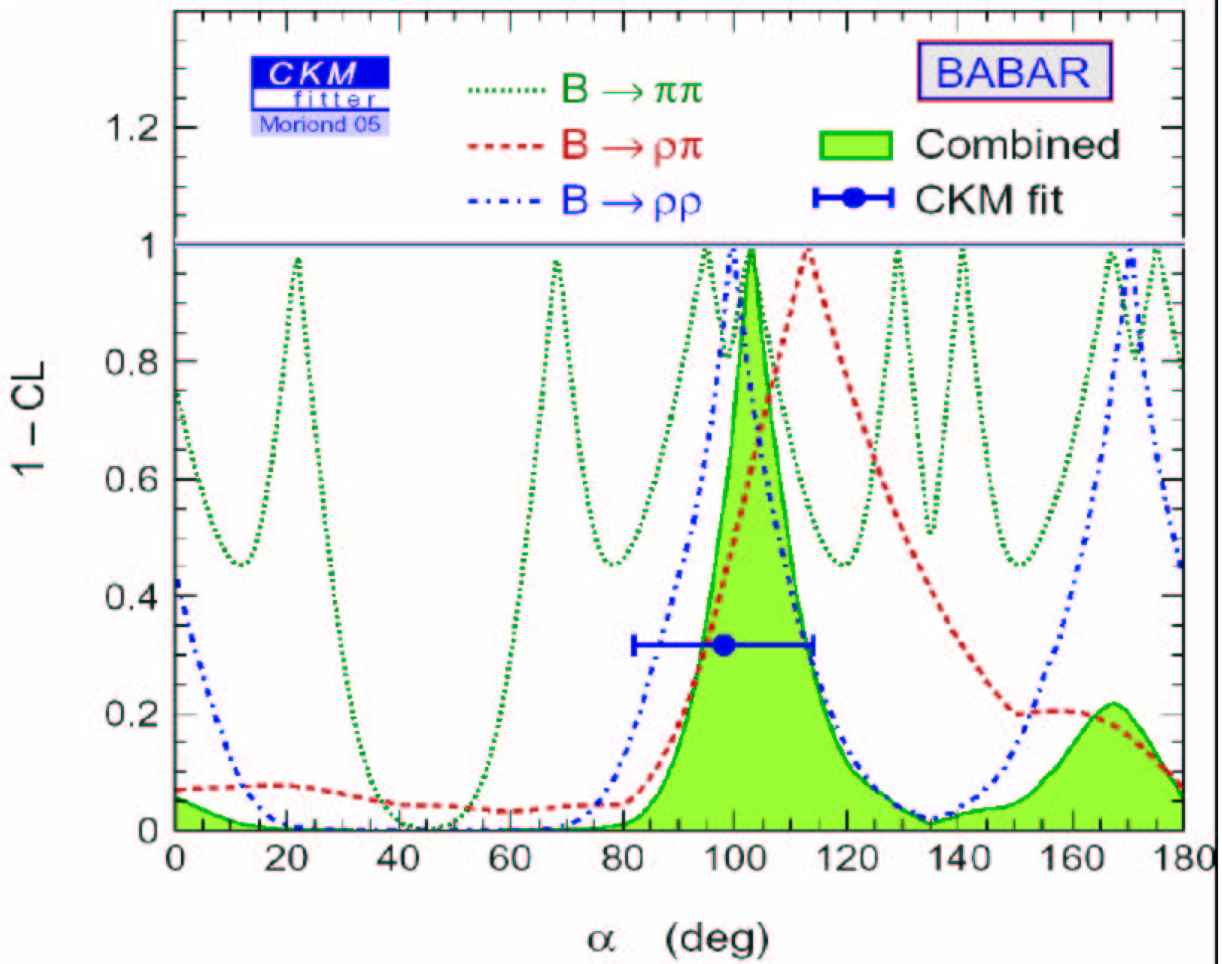
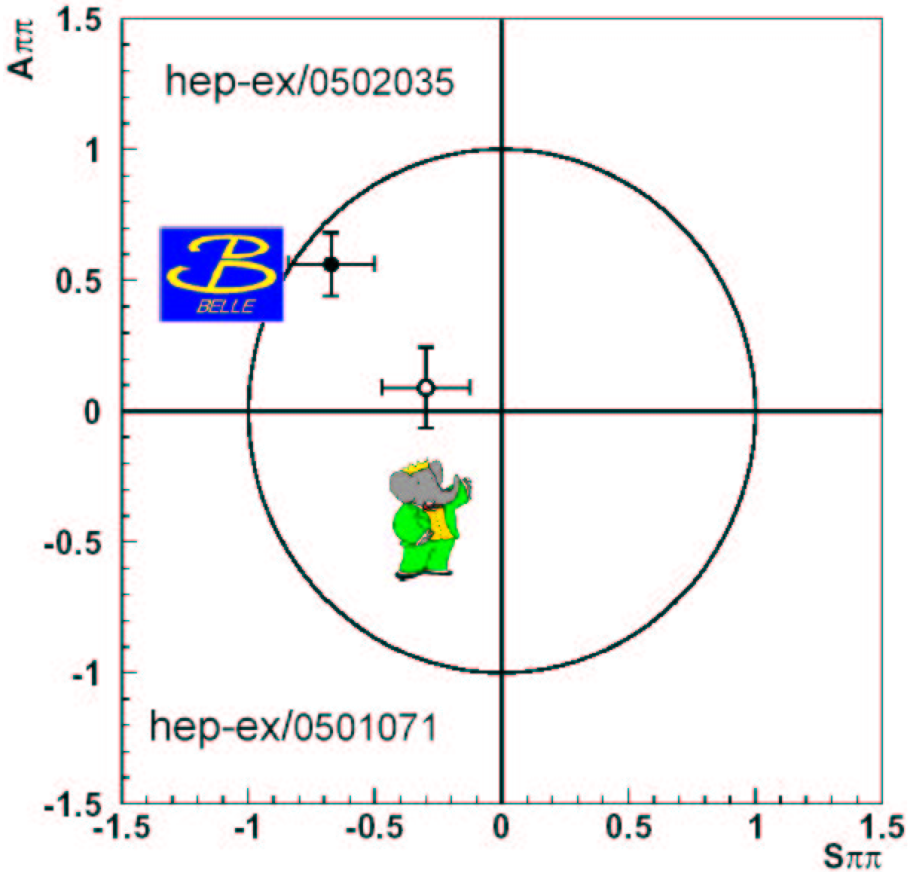
Combined α measurement

- The best individual measurement comes from $\rho\rho$.
- Mirror solution are disfavored, thanks to $\rho\pi$.
- Good agreement with global CKM fit.
- Combined value:

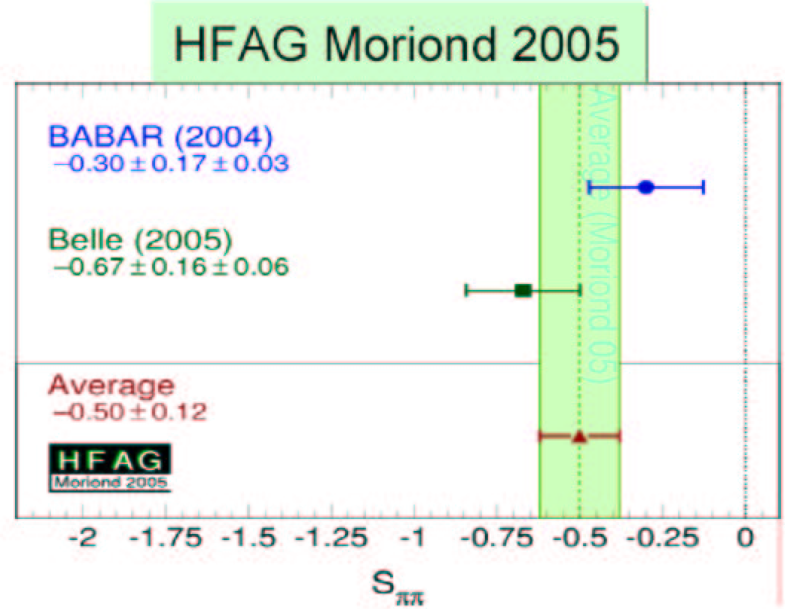
$$\boxed{\alpha = (103^{+10}_{-9})^{\circ}}$$

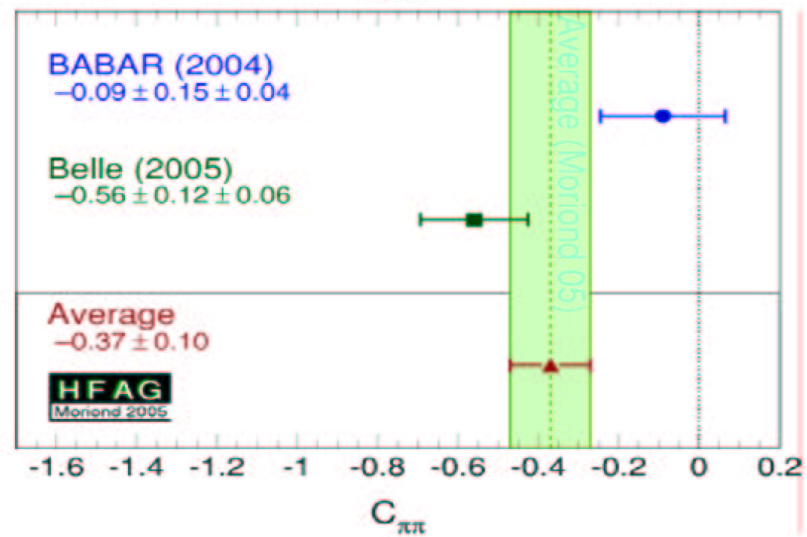


CPV parameters in $B^0 \to \pi^+\pi^-$

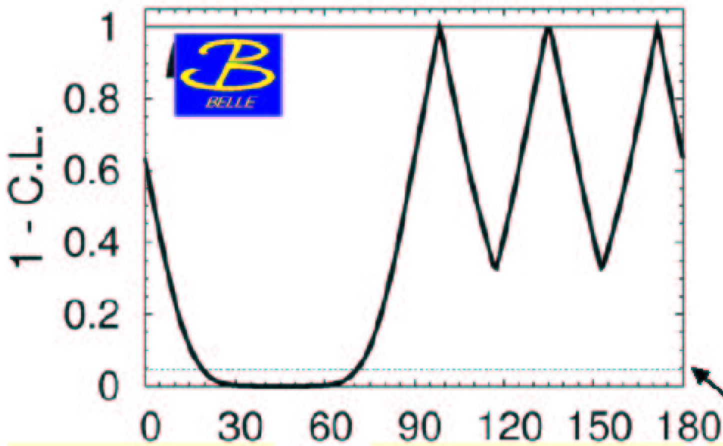


~2.3σ difference between
Belle & BaBar

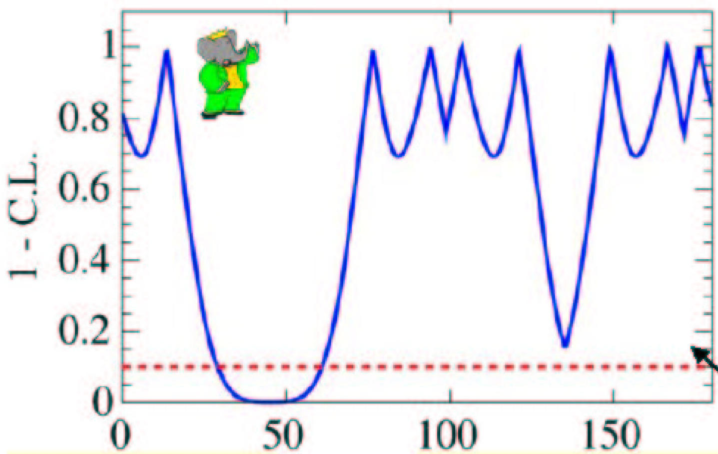




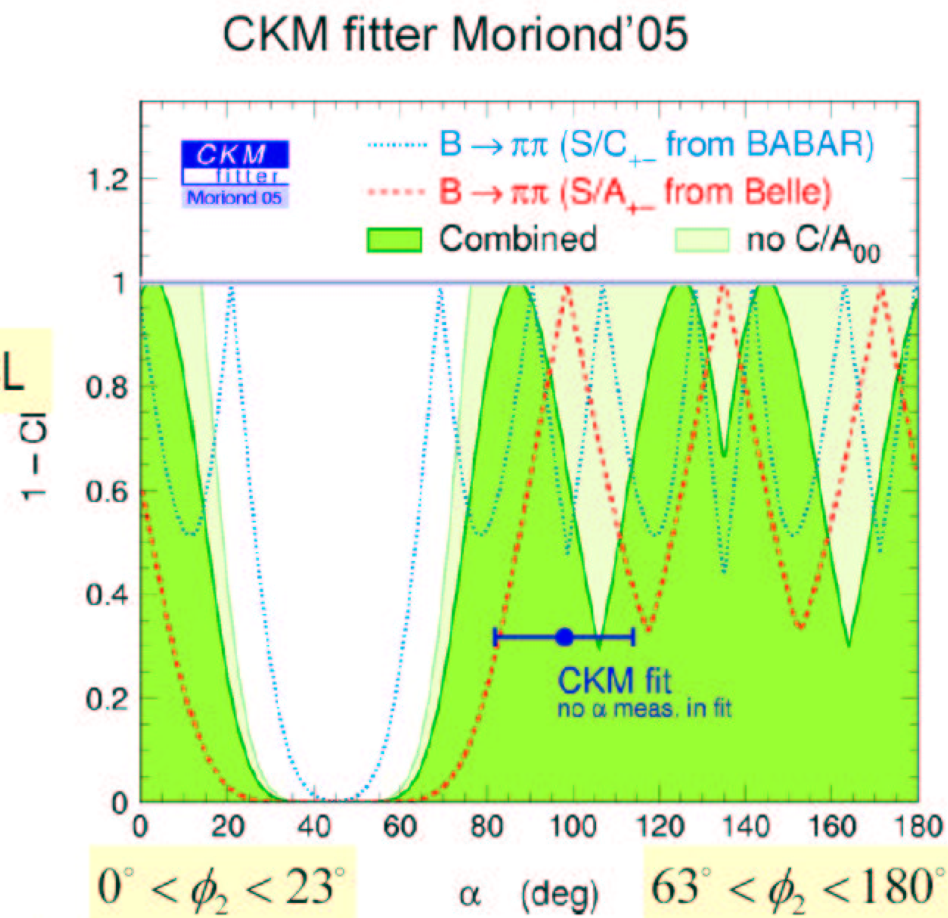
Constraints on $\phi_2(\alpha)$ from isospin analysis



$0^\circ < \phi_2 < 19^\circ$ $71^\circ < \phi_2 < 180^\circ$ 95.4% CL



$0^\circ < \phi_2 < 29^\circ$ α (degr $61^\circ < \phi_2 < 180^\circ$ 90% CL



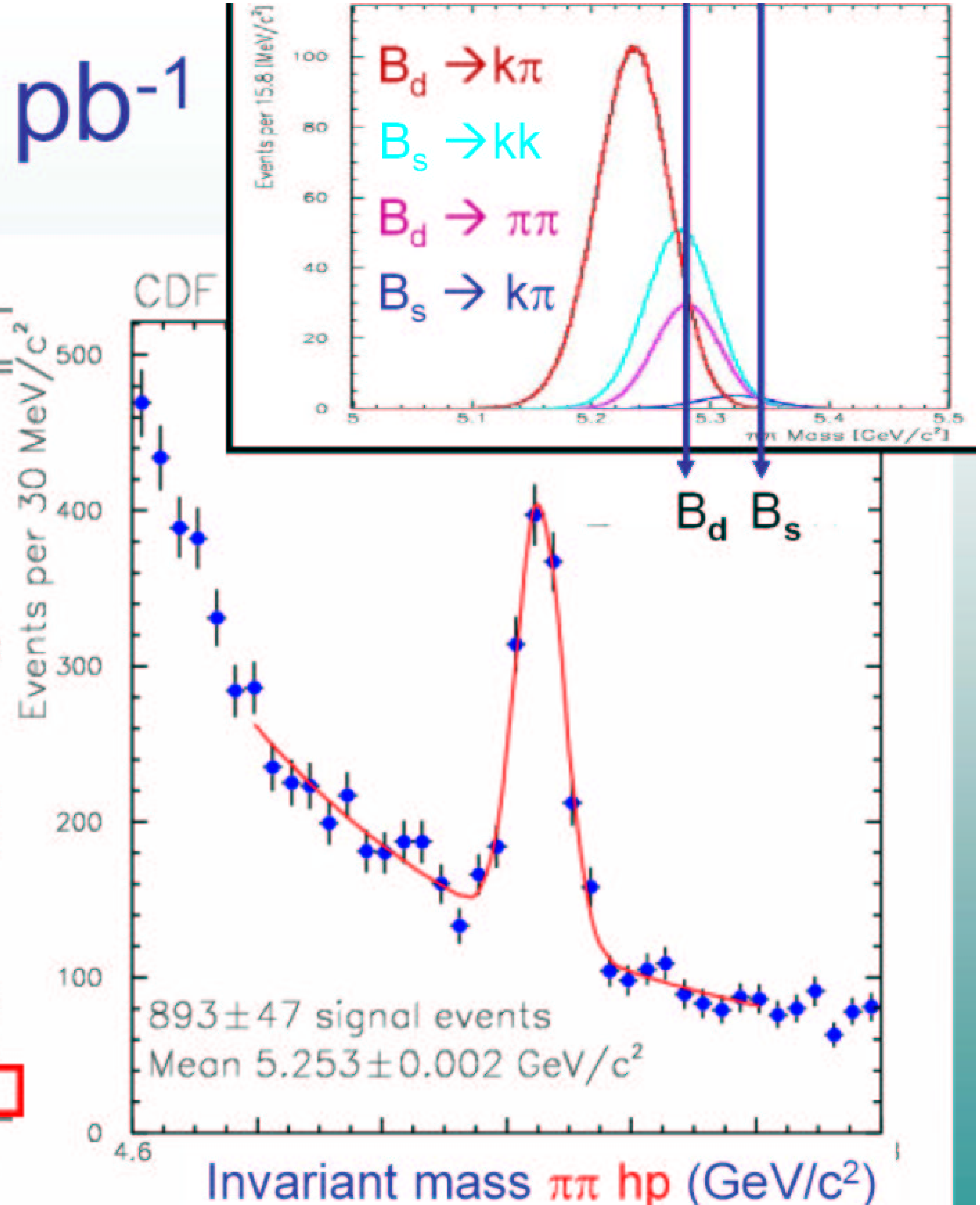
$0^\circ < \phi_2 < 23^\circ$ $63^\circ < \phi_2 < 180^\circ$

B→hh' in 180 pb^{-1}

Selection cuts

Parameter	value
# axial COT hits	≥ 20
# stereo COT hits	≥ 20
# axial SVXII hits	≥ 3
$\max(\lvert\eta(\pi_1)\rvert, \lvert\eta(\pi_2)\rvert)$	≤ 1
$\min(p_T(\pi_1), p_T(\pi_2))$	≥ 2 GeV/c
$p_T(\pi_1) + p_T(\pi_2)$	≥ 5.5 GeV/c
$q(\pi_1) \cdot q(\pi_2)$	< 0
$\Delta\phi(\pi_1, \pi_2)$	$[20°, 135°]$
$\min(\lvert d_0(\pi_1)\rvert, \lvert d_0(\pi_2)\rvert)$	≥ 0.0150 cm
$\max(\lvert d_0(\pi_1)\rvert, \lvert d_0(\pi_2)\rvert)$	≤ 0.1000 cm
$d_0(\pi_1) \cdot d_0(\pi_2)$	< 0
$\lvert\eta(B)\rvert$	≤ 1
$\lvert d_0(B)\rvert$	≤ 0.0080 cm
$L_{xy}(B)$	≥ 0.0300 cm
B isolation	≥ 0.5

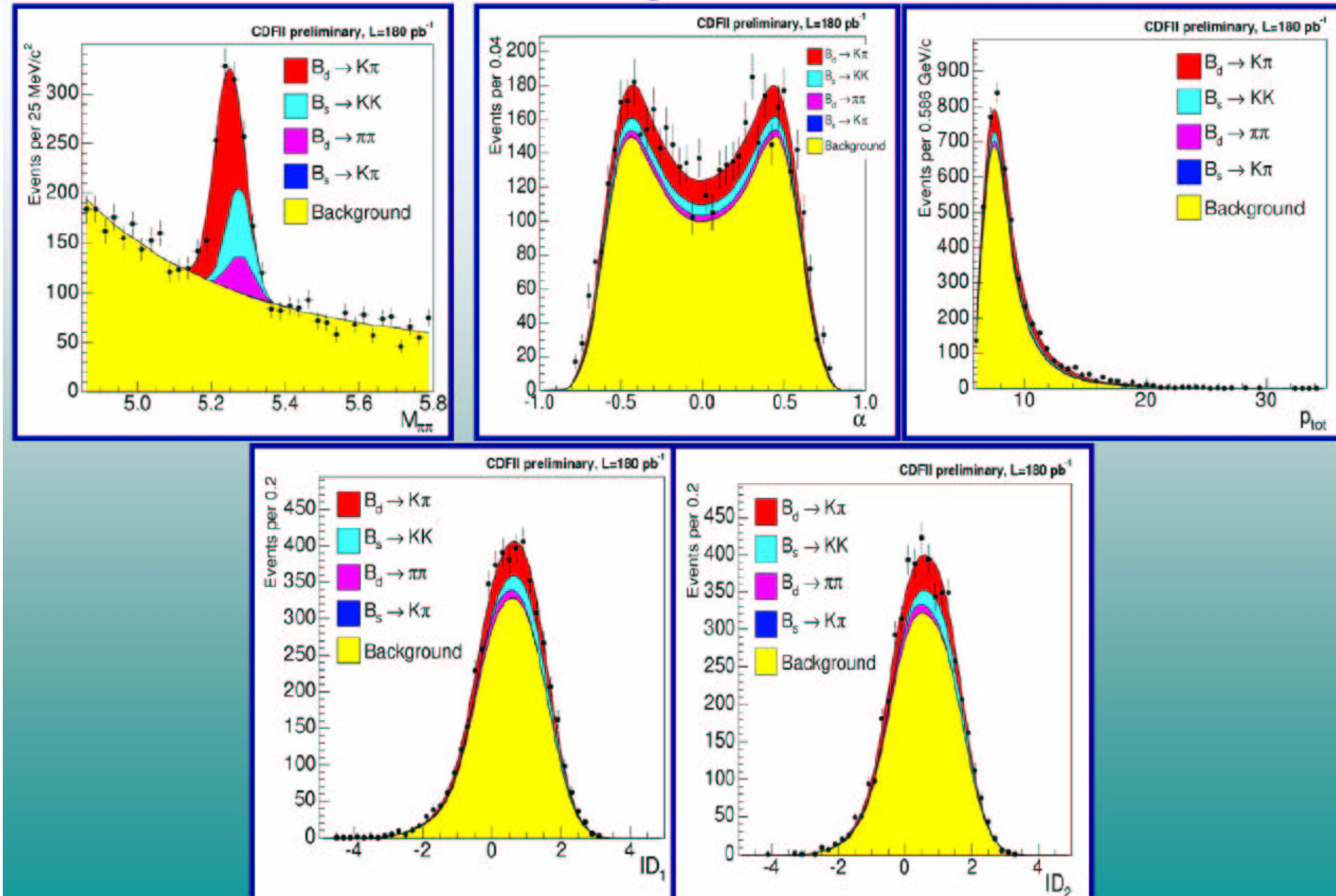
The only significant cut not already present in the trigger



Mauro Donega – WIN05

893±47 B→hh' events

Fit Projections



B→hh' results BR and Acp

Analyzed Luminosity =180 pb^{-1}

$$\frac{BR(B^0 \to \pi^+\pi^-)}{BR(B^0 \to K^+\pi^-)} = 0.21 \pm 0.05\ (stat.) \pm 0.019\ (syst.)$$

$$A_{CP} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.022 \pm 0.078\ (stat.) \pm 0.012\ (syst.)$$

$$\frac{f_d \cdot BR(B^0 \to \pi^+\pi^-)}{f_s \cdot BR(B_s^0 \to K^+K^-)} = 0.45 \pm 0.13\ (stat.) \pm 0.054\ (syst.)$$

$$\frac{f_s \cdot BR(B_s^0 \to K^+K^-)}{f_d \cdot BR(B^0 \to K^+\pi^-)} = 0.46 \pm 0.08\ (stat.) \pm 0.063\ (syst.)$$

The Gronau-Wyler-London Method (GLW)

$B^{\pm} \rightarrow D_{CP} K^{(*)\pm}$, D_{CP} is CP-eigenstate

[Phys. Lett. B 253 (1991) 483]
[Phys. Lett. B 265 (1991) 172]

CP+ : $D^0 \rightarrow \pi^+\pi^-, K^+K^-$ CP- : $D^0 \rightarrow K_S\pi^0, K_S\eta, K_S\omega, K_S\varphi, \ldots$

4 observables (3 independent)

3 unknowns

$$A_{CP\pm} \equiv \frac{\Gamma(B^- \rightarrow D^0_{CP\pm}K^-) - \Gamma(B^+ \rightarrow D^0_{CP\pm}K^+)}{\Gamma(B^- \rightarrow D^0_{CP\pm}K^-) + \Gamma(B^+ \rightarrow D^0_{CP\pm}K^+)} = \pm 2 r_B \sin\gamma \ \sin\ \delta_B / R_{CP\pm}$$

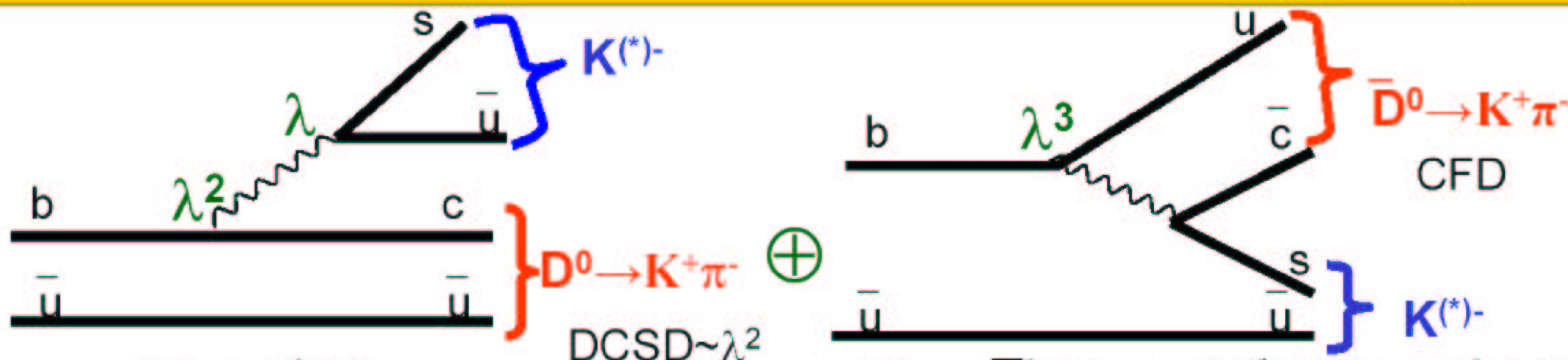
$$R_{CP\pm} \equiv \frac{\Gamma(B^- \rightarrow D^0_{CP\pm}K^-) + \Gamma(B^+ \rightarrow D^0_{CP\pm}K^+)}{2\Gamma(B^- \rightarrow D^0 K^-)} = 1 \pm 2 r_B \cos\gamma \ \cos\ \delta_B + r_B^2$$

$\mathrm{Br}(B \rightarrow DK) \sim 10^{-4} \otimes \mathrm{Br}(D \rightarrow f_{CP}) \sim 10^{-2}$

$r_B \sim 0.1$

statisticaly limited

The Atwood-Dunietz-Soni Method (ADS)



$A(B^- \to D^0 K^-)$ $\qquad$ $A(B^- \to \overline{D}^0 K^-) = r_B e^{-i\gamma} e^{i\delta} \mid A(B^- \to D^0 K^-) \mid$

both amplitudes of comparable size ⇒ big CPV, small effective Br

count B candidates with K^+K^- pairs

$$r_D = \frac{|A(D^0 \to K^+\pi^-)|}{|A(D^0 \to K^-\pi^+)|} = 0.060 \pm 0.003$$

Phys.Rev.Lett.91:171801,2003

$$A_{ADS} \equiv \frac{\Gamma(B^- \to [K^+\pi^-]K^-) - \Gamma(B^+ \to [K^-\pi^+]K^+)}{\Gamma(B^- \to [K^+\pi^-]K^-) + \Gamma(B^+ \to [K^-\pi^+]K^+)} = 2 r_B r_D \sin\gamma \, \sin(\delta_B + \delta_D)/R_{ADS}$$

$$R_{ADS} \equiv \frac{\Gamma(B^- \to [K^+\pi^-]K^-) + \Gamma(B^+ \to [K^-\pi^+]K^+)}{\Gamma(B^- \to [K^-\pi^+]K^-) + \Gamma(B^+ \to [K^+\pi^-]K^+)} = 2 r_B r_D \cos\gamma \, \cos(\delta_B + \delta_D) + r_B^2 + r_D^2$$

δ_D –D decay strong phase, unknown

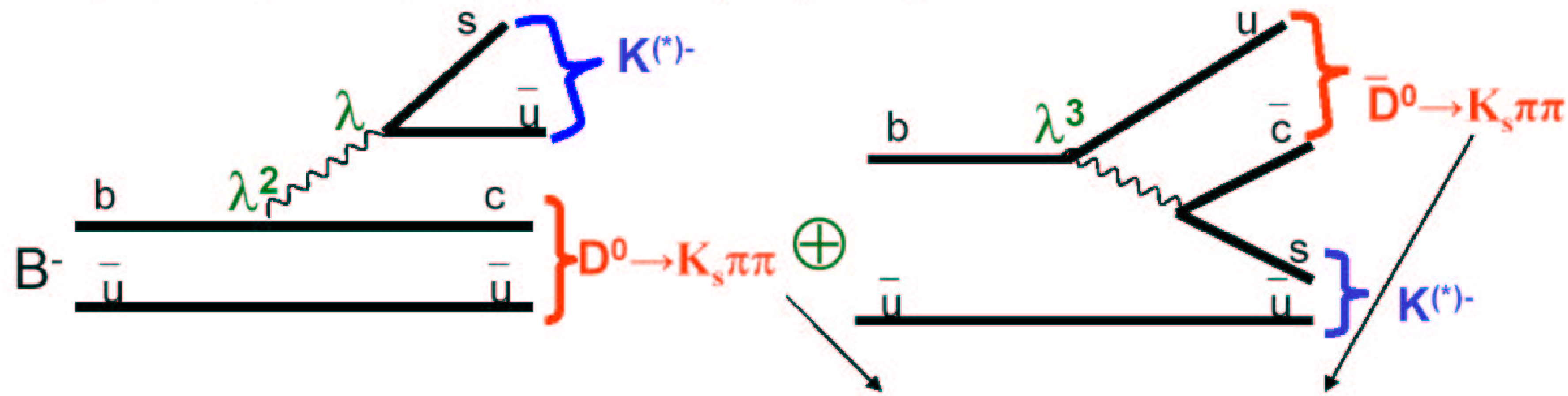
Bondar & Gershon
hep-ph/0409281

δ_D –differs by π for $D^* \to D\gamma$ & $D^* \to D\pi^0$

$R_{ADS}(D\pi) + R_{ADS}(D\gamma) = 2(r_B^2 + r_D^2)$

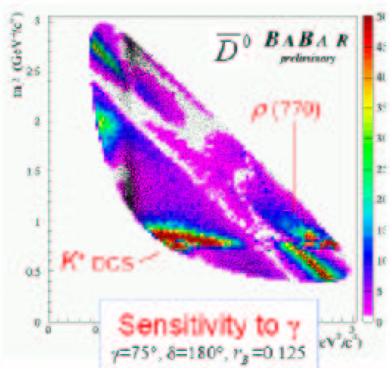
Dalitz analysis of $B^\pm \to D^{(*)0}K^{(*)\pm}$, $D^0 \to K_S\pi^+\pi^-$

Giri, Grossman, Sofer & Zupan [Phys. Rev. D 68 (2003) 054018]

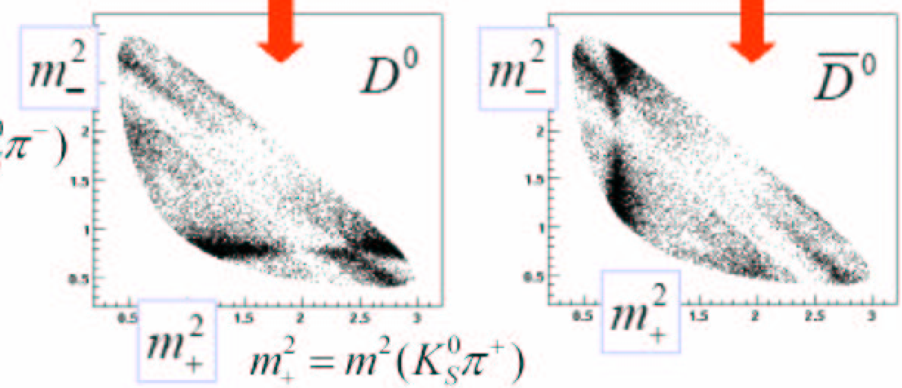


$$M_-(m_-^2, m_+^2) = |A(B^- \to D^0K^-)|\{f(m_-^2, m_+^2) + r_B e^{-i\gamma} e^{i\delta} f(m_+^2, m_-^2)\}$$

CP



$$m_-^2 = m^2(K_S^0\pi^-)$$

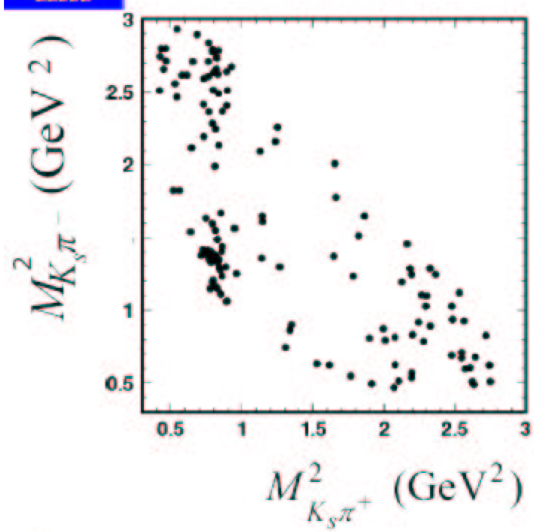


$$m_+^2 = m^2(K_S^0\pi^+)$$

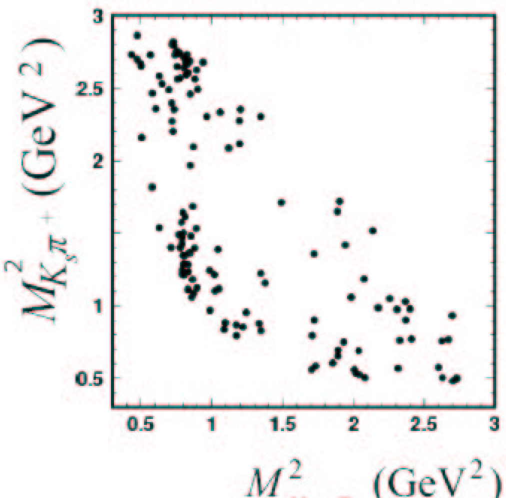
$$M_+(m_-^2, m_+^2) = |A(B^+ \to \bar{D}^0K^+)|\{f(m_+^2, m_-^2) + r_B e^{i\gamma} e^{i\delta} f(m_-^2, m_+^2)\}$$

$B^{\pm} \to DK^{\pm}$, $D \to K_S\pi^+\pi^-$ Dalitz plots

139 events



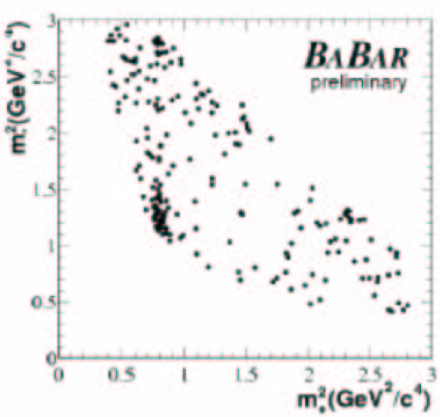
137 events

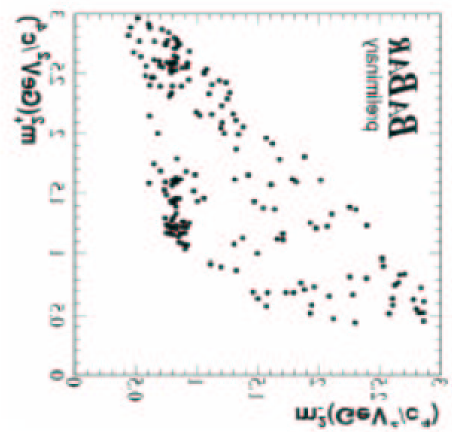


D^0 from $B^+ \to D^0K^+$

D^0 from $B^- \to D^0K^-$

(π^+ and π^- interchanged)





Fit these D^0 Dalitz plots using unbinned maximum likelihood

Free parameters: r_B, ϕ_3, δ

2-fold ambiguity:

$\phi_3, \delta, \quad \cup \quad \phi_3+180°, \delta+180°$

Constraints on $\phi_3(\gamma)$ from B→DK

Dalitz analysis

$$\phi_3 = [68^{+14}_{-15} \pm 13(sys) \pm 11(model)]^\circ$$

$$[22^\circ, 113^\circ]$$

$$r_B(D^0K) = 0.21 \pm 0.08 \pm 0.03 \pm 0.04$$

$$r_B(D^{*0}K) = 0.12^{+0.16}_{-0.11} \pm 0.02 \pm 0.04$$

$$r_B(D^0K^*) = 0.24^{+0.17}_{-0.18} \pm 0.09 \pm 0.04 \pm 0.08$$

Dalitz analysis

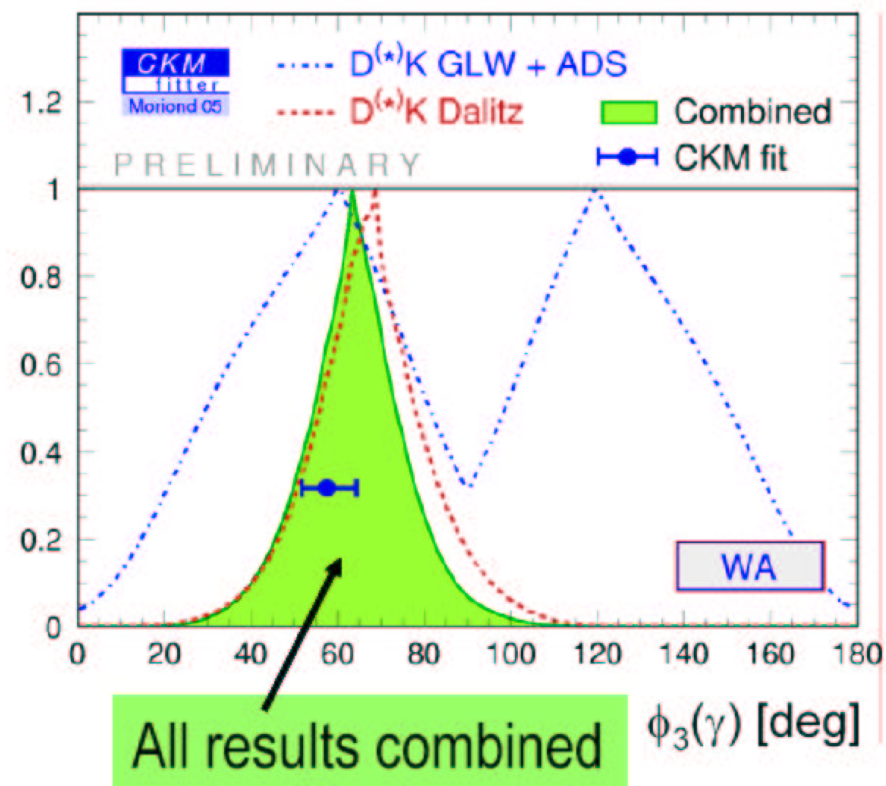
$$\gamma = [70 \pm 31^{+12}_{-10}(sys)^{+14}_{-11}(model)]^\circ$$

$$[12^\circ, 137^\circ]$$

$$r_B(D^0K) = 0.118^{+0.079}_{-0.096} \pm 0.034^{+0.036}_{-0.034}$$

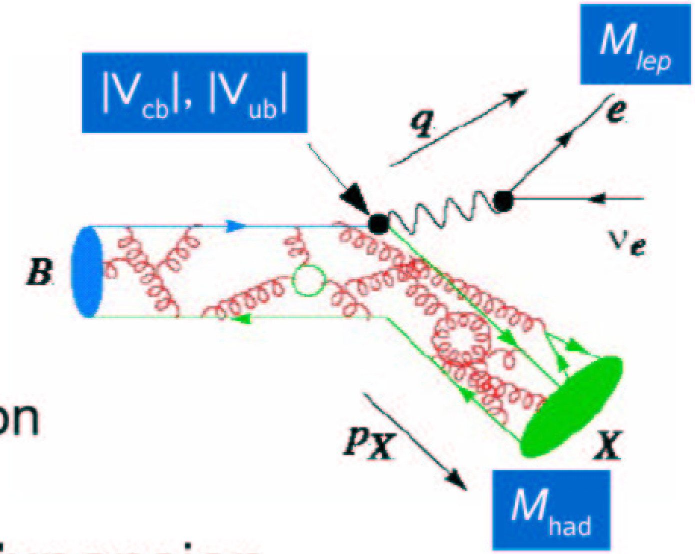
$$r_B(D^{*0}K) = 0.169 \pm 0.096^{+0.03}_{-0.028}{}^{-0.029}_{-0.026}$$

CKM fitter Moriond'05



Semileptonic B Decays

- Semileptonic B decays provide best way to measure $|V_{cb}|$ and $|V_{ub}|$
  - Hadronic and leptonic currents factorize
  - Hadronic matrix element needs to be corrected for interactions within B meson

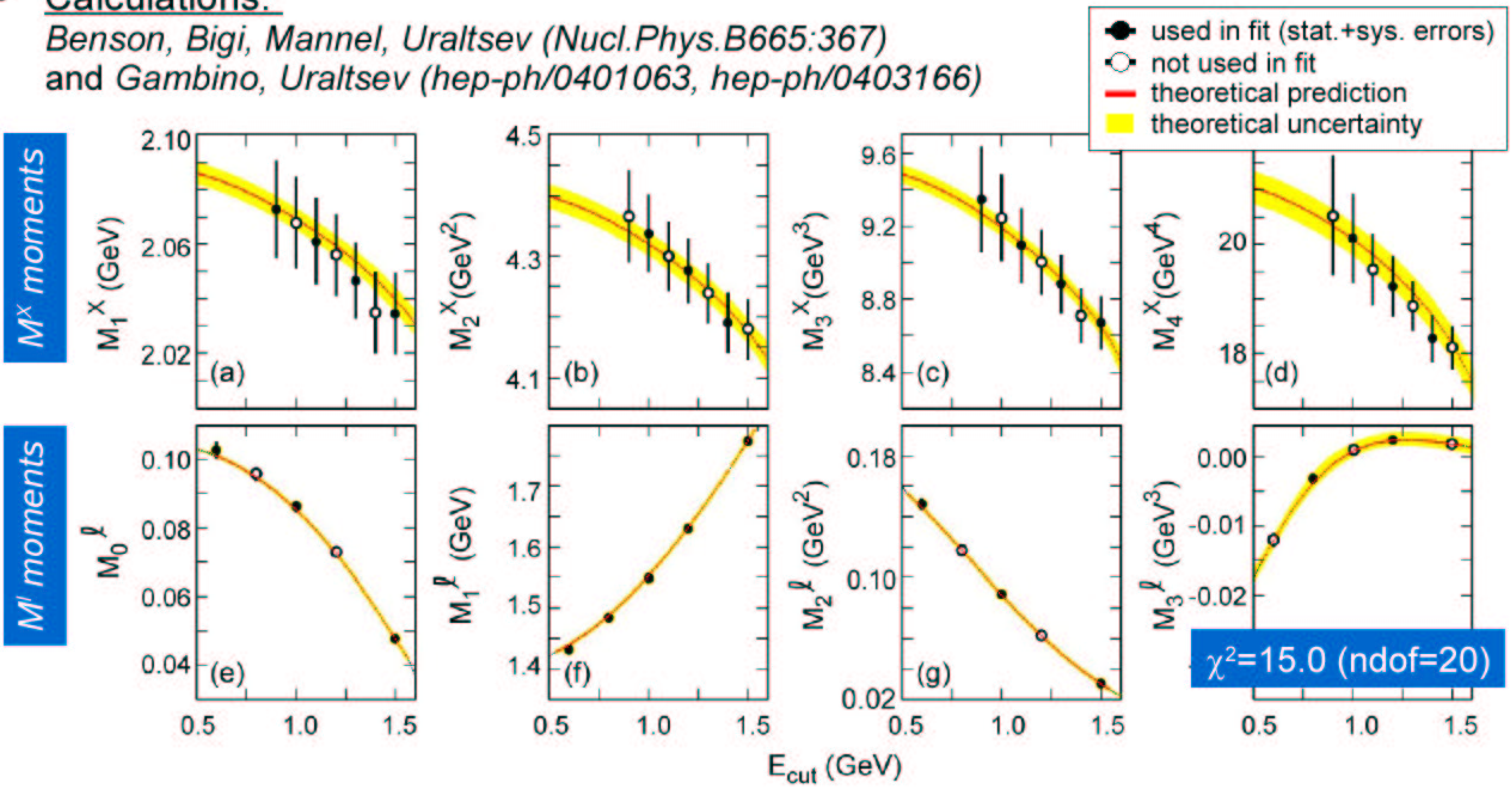


- Theoretical framework: **H**eavy **Q**uark **E**xpansion
  - Provides method to separate perturbative from non-perturbative scales
  - Expansion of M_{had} in powers of $1/(m_b\text{-}m_c)$ in terms of local operators
  - Non-perturbative physics enters through matrix elements of local operators
  - Perturbative effects enter through coefficients of operators

Combined Fit to E_e and M_x Moments

PRL 93:011803

- 8 fit parameters: $|V_{cb}|, Br(B \rightarrow X_c l \nu), m_b, m_c, \mu_\pi^2, \mu_G^2, \rho_D^3, \rho_{LS}^3$
- 27 measured moments used: 0^{th}-3^{th} E_e moments, 1^{th}-4^{th} M_x moments (highly corr.)
- Calculations:
  Benson, Bigi, Mannel, Uraltsev (Nucl.Phys.B665:367)
  and *Gambino, Uraltsev (hep-ph/0401063, hep-ph/0403166)*



Combined Fit: Results

PRL 93:011803

$$
\begin{aligned}
|V_{cb}| &= (41.390 \pm 0.437_{\exp} \pm 0.398_{HQE} \pm 0.150_{\alpha_s} \pm 0.620_{\Gamma}) \cdot 10^{-3} \\
BR_{cl\nu} &= (10.611 \pm 0.163_{\exp} \pm 0.063_{HQE} \pm 0.000_{\alpha_s})\% \\
m_b &= (4.611 \pm 0.052_{\exp} \pm 0.041_{HQE} \pm 0.015_{\alpha_s}) GeV/c^2 \\
m_c &= (1.175 \pm 0.072_{\exp} \pm 0.056_{HQE} \pm 0.015_{\alpha_s}) GeV/c^2
\end{aligned}
$$

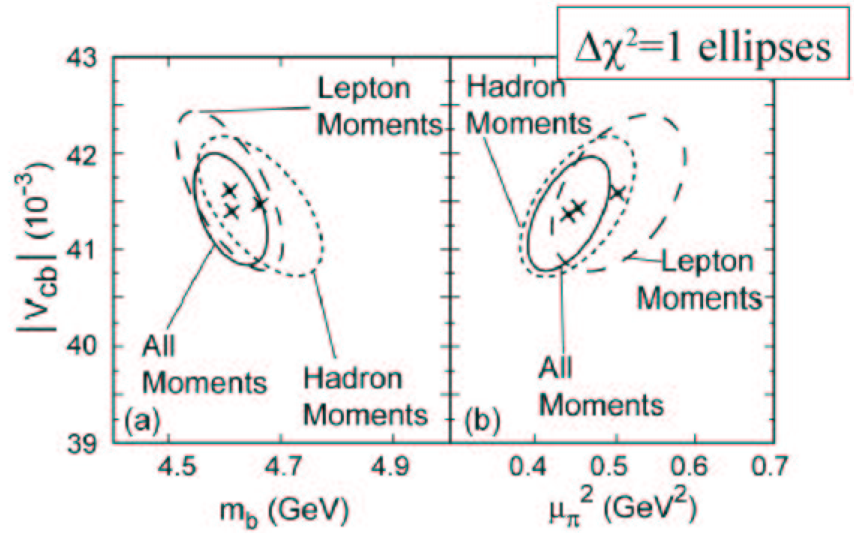
2% uncertainty

1.5% uncertainty

additional 1.5% error on Γ

$\mu = 1 GeV$

- HQE predictions agree very well with measurements
- Separate fits to E_l and M_x moments are in good agreement
- Fit results compatible with external knowledge from B-B* mass splitting (μ_G^2) and heavy-quark sum rules (ρ_{LS}^3)

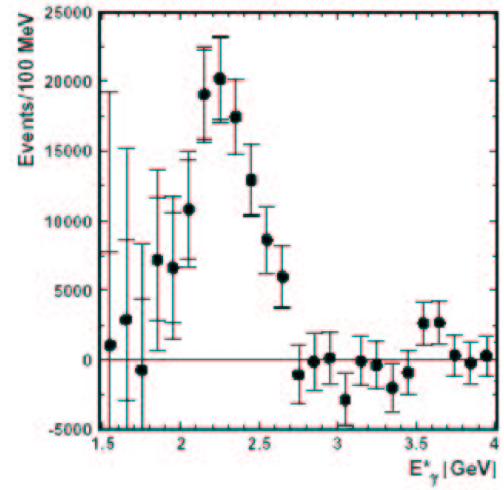


Inclusive V_{ub} with Full Reconstruction

V_{ub} Extraction with the "New" V_{ub} Method

$$|V_{ub}| = \sqrt{\frac{\Delta\mathcal{B}(B \to X_u \ell \nu)}{\mathcal{R} \cdot \tau_B}}$$

- Dirctly relate V_{ub} and $\Delta\mathcal{B}$ by $\mathcal{R}$
- Shape Function
  - similar contribution to $b \to s\gamma$ events
  - fitting γ spectrum by Belle measurement
  - $m_b = (4.52 \pm 0.07)$ GeV, $\mu_\pi^2 = (0.27 \pm 0.13)$ GeV^2
- Weak annihilation effect



	$\lvert V_{ub}\rvert$	stat	syst	b→u	b→c	SF	theo.
m_X-q^2	4.93×10^{-3}	5.0	4.4	3.1	2.7	9.3	$^{+5.0}_{-5.5}$
m_X	4.35×10^{-3}	4.6	3.5	3.1	1.1	9.2	$^{+3.6}_{-3.9}$
P_+	4.56×10^{-3}	4.7	4.6	3.2	4.4	10.2	$^{+3.4}_{-3.5}$

Summary of BABAR $|V_{ub}|$ Measurements

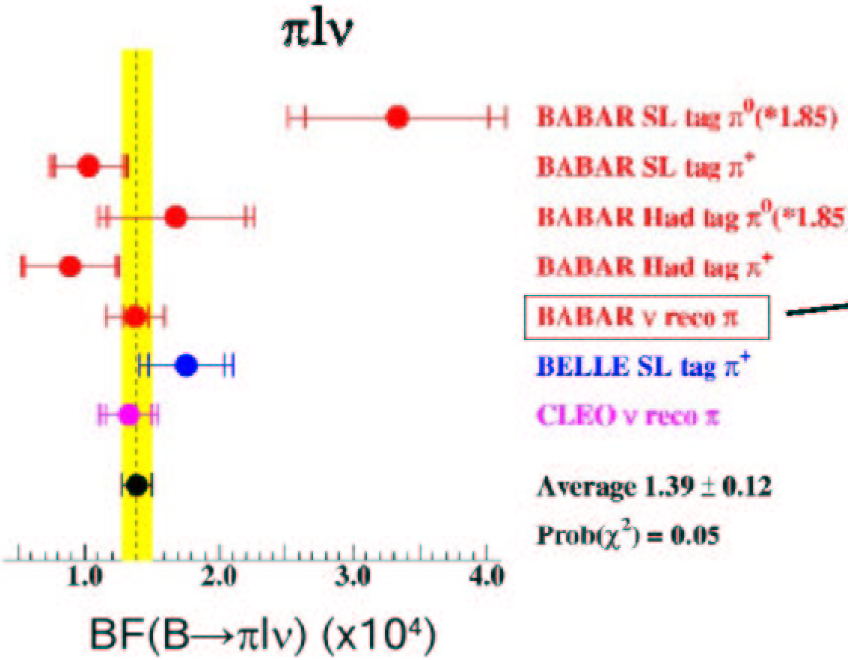
Using $\mathbf{m_b = 4.63 \pm 0.08}$**GeV** and μ_π^2**(SF) = 0.15 ± 0.07GeV²**
(correlation: -0.4)

errors: expt ± SF ± theory | expt ± (SF + theory)

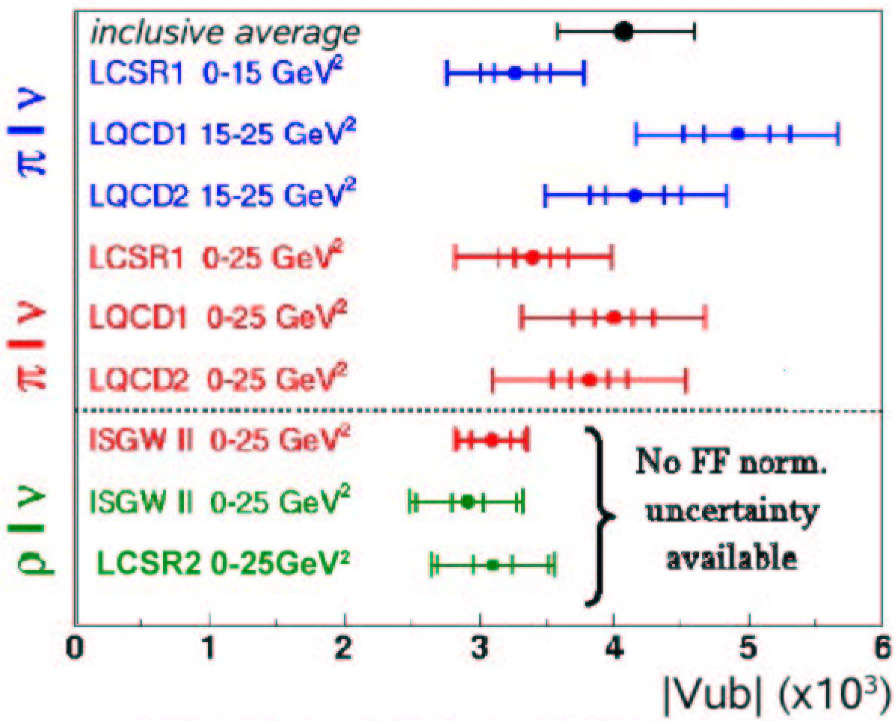
Method	ΔBr x 10^{-4}	$\lvert$Vub$\rvert$ 10^{-3} (BLNP) (SF params from $b \to cl\nu$)	$\lvert$Vub$\rvert$ 10^{-3} (ICHEP) (DFN, BELLE $b \to s\gamma$)
Endpoint	5.31 ± 0.59	3.93 ± 0.34 ± 0.38 ± 0.18 (8.7 ± 9.7 ± 4.6)%	4.40 ± 0.24 ± 0.35 (± 6.4 ± 8.6)%
q^2-E_l	4.46 ± 0.93	3.89 ± 0.40 ± 0.45 ± 0.21 (10.3 ± 11.5 ± 5.4)%	4.99 ± 0.48 ± 0.29 (± 9.6 ± 5.8)%
q^2-M_x	8.96 ± 2.04	4.45± 0.49 ± 0.40 ± 0.22 (11.1 ± 9.0 ± 4.9)%	5.18 ± 0.57 ± 0.34 (± 11.0 ± 6.5)%
Average		4.07 ± 0.51 (± 12.5)%	4.61 ± 0.46 (± 10.0)%

significant change in inclusive $|V_{ub}|$ value

Exclusive $B \to X_u l\nu$ Decays: Summary



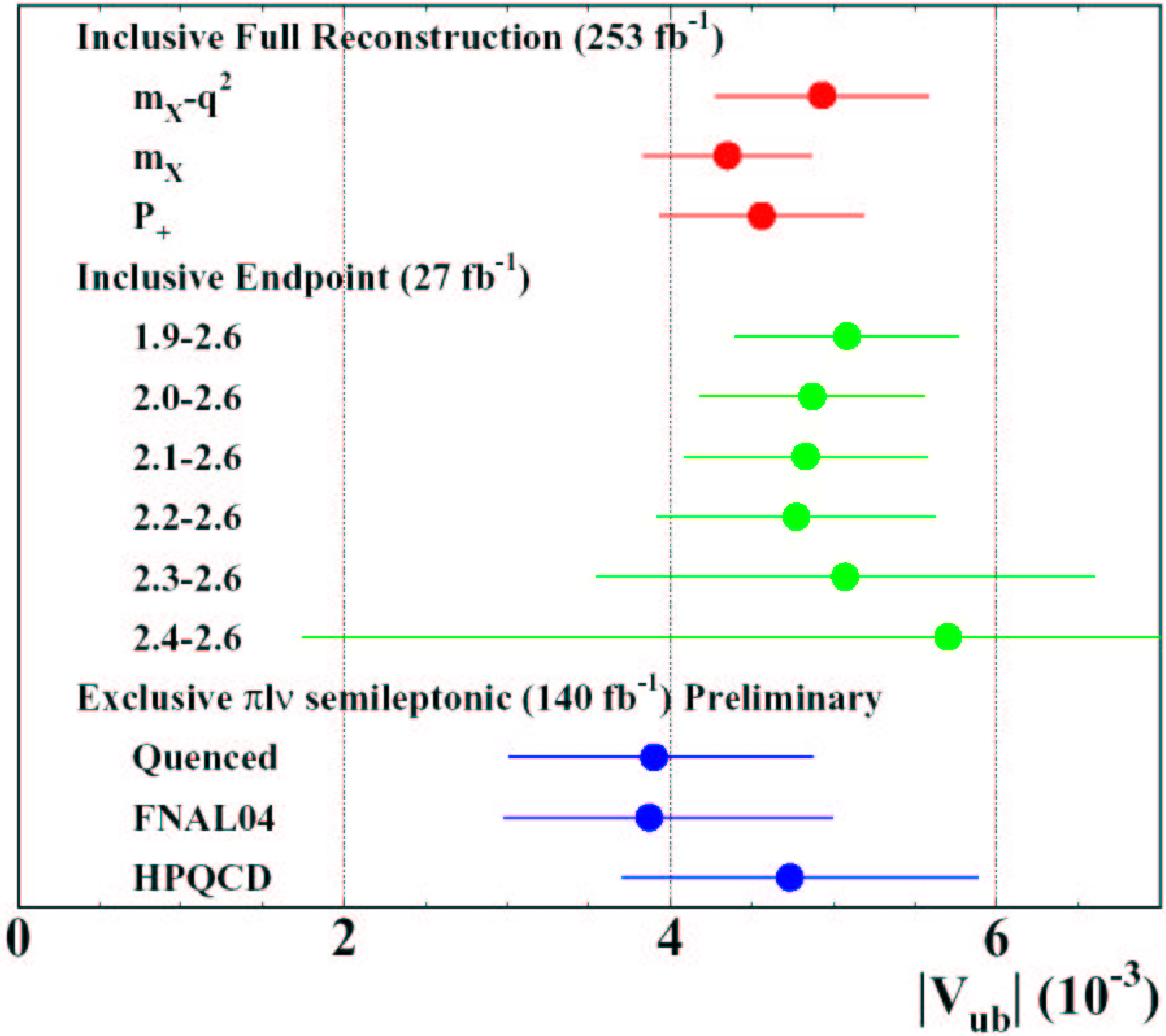
inclusive average: $|V_{ub}| = (4.07 \pm 0.51)\ 10^{-3}$



LCSR $q^2<15$GeV2, LQCD $q^2>15$GeV
or extrapolation to whole q^2 range

Light Cone Sum Rules (LCSR)
(Ball-Zwicky, Phys.Rev.D71:014015, Phys.Rev.D71:014029,2005)
New unquenched LQCD2 calculations
(*HPQCD'04, FNAL'04*)

Belle $|V_{ub}|$ Mesurement Summary



Unitarity Triangle - Who Measures What?

Appex $(\bar{\rho}, \bar{\eta})$

Squeezing along side *b*

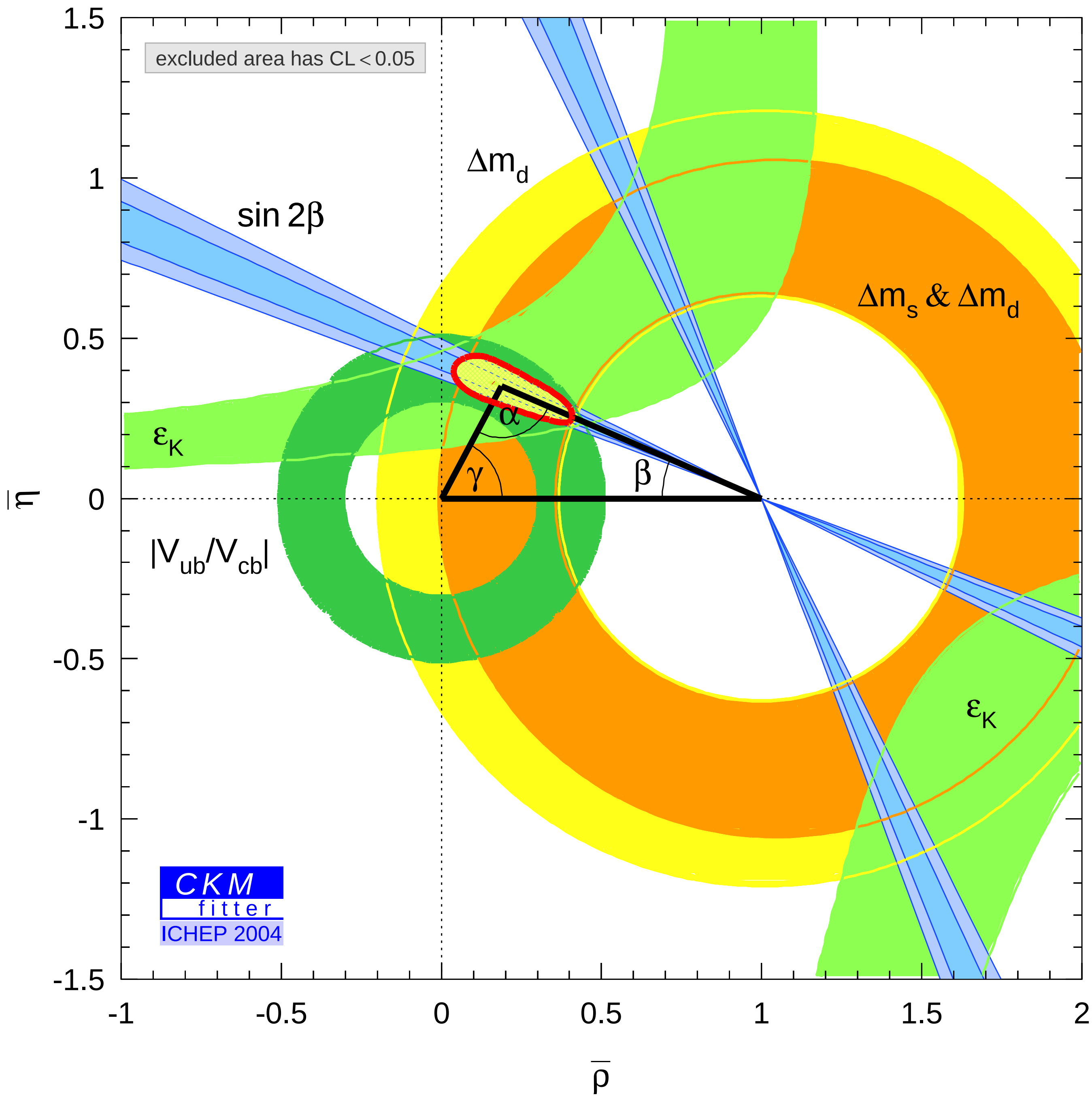
- \+ $\sin 2\beta$
- \+ V_{ub}/V_{cb}

Squeezing along side *c*

- \+ Δm_d
- \+ Δm_s

CKM fit result:

$$\Delta m_s = 17.8\,^{+6.7}_{-1.6}\,\text{ps}^{-1}$$

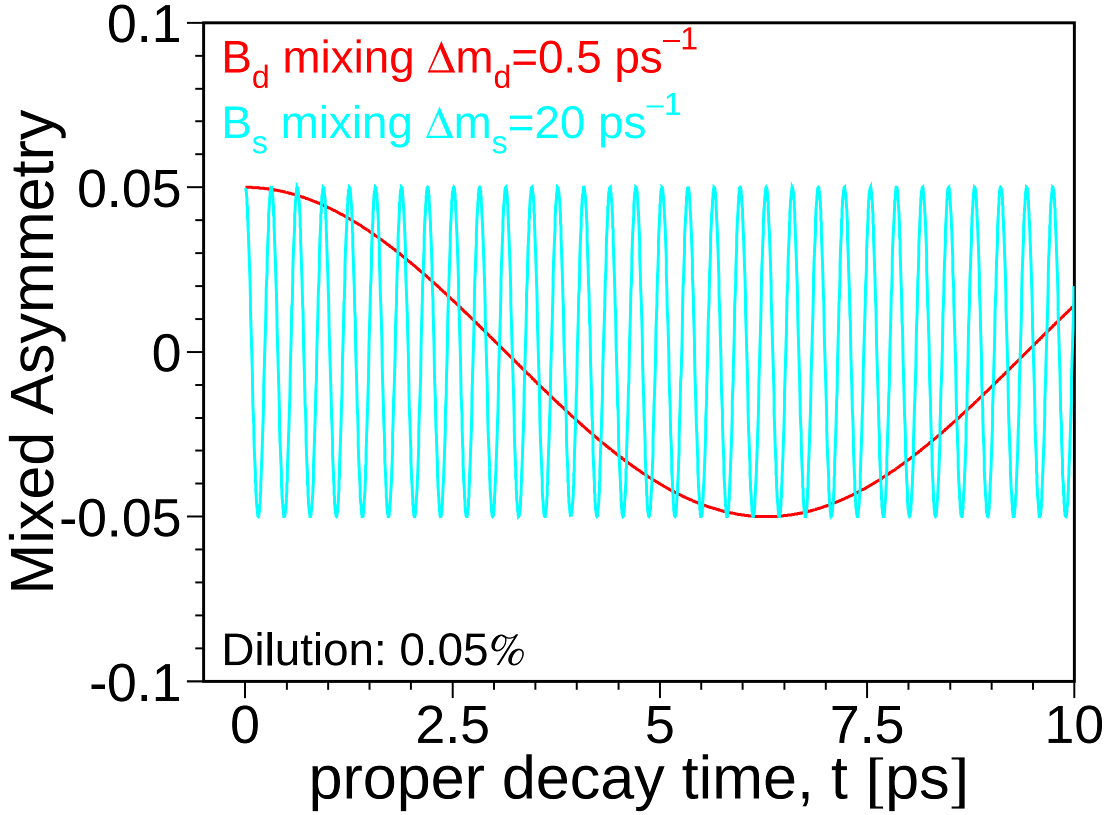


Why is that so difficult?

B_s mixing
- + very fast

Challenge
- + precise vertex
- + precise momentum
- + many events
- + tagging essential

Very tricky!

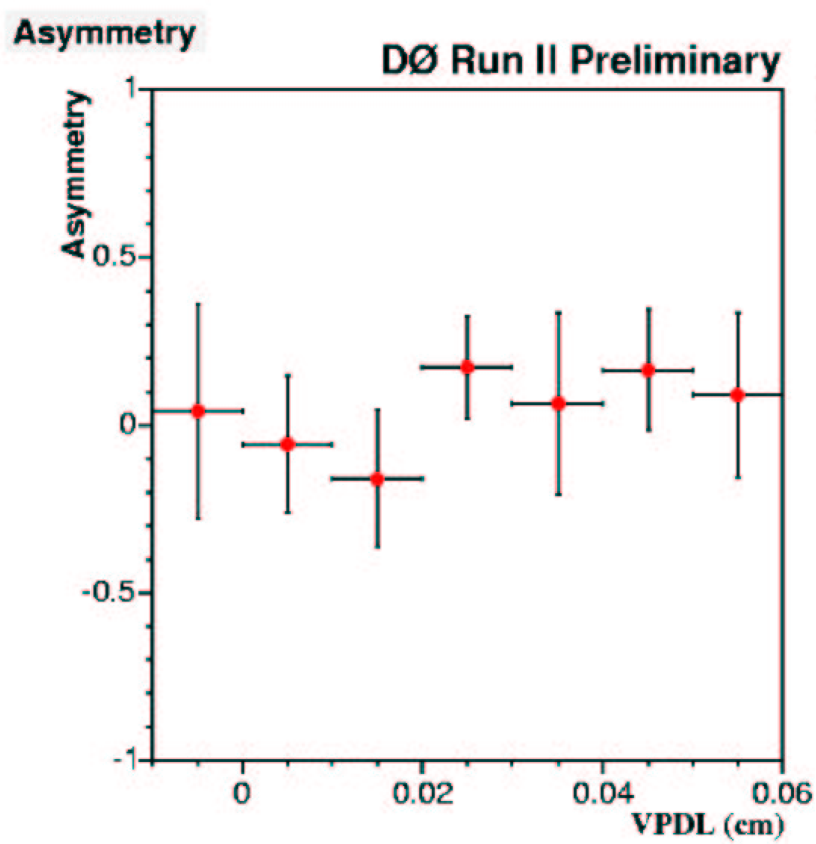


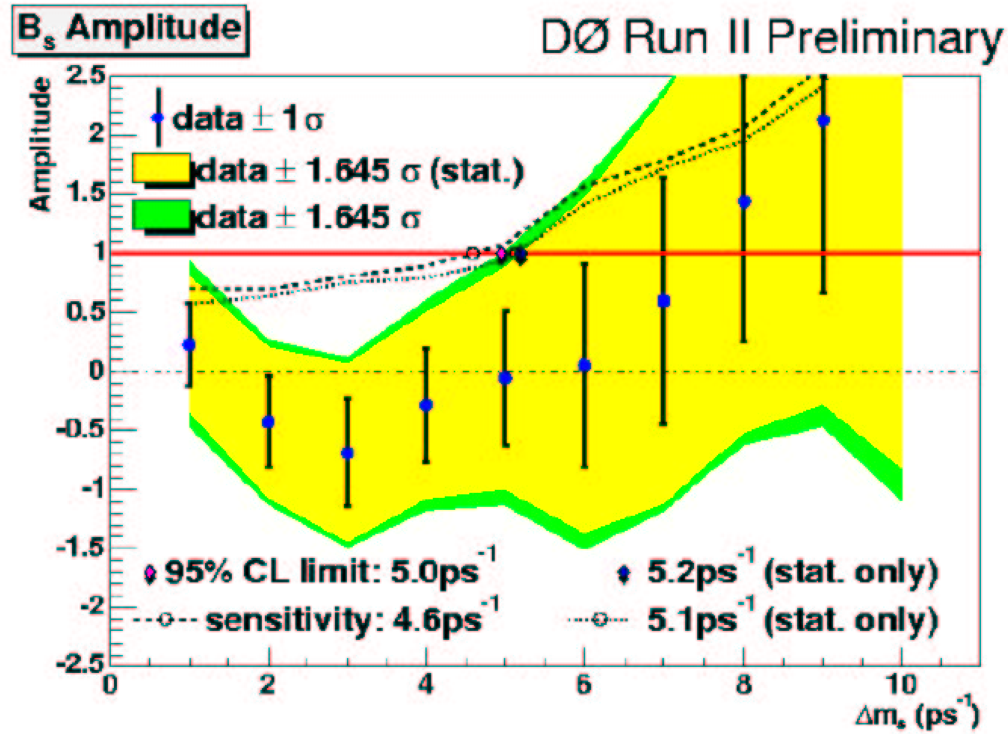
The larger Δm_S the more crucial $\sigma(ct)$

$$\text{significance} = \sqrt{\frac{S\varepsilon D^2}{2}}\sqrt{\frac{S}{S+B}}\exp\left(-\frac{(\Delta m_S \sigma_{ct})^2}{2}\right)$$

$$\sigma(ct) = \sqrt{(\sigma_{ct}^0)^2 + \left(ct\,\frac{\sigma_p}{p}\right)^2}$$

Result

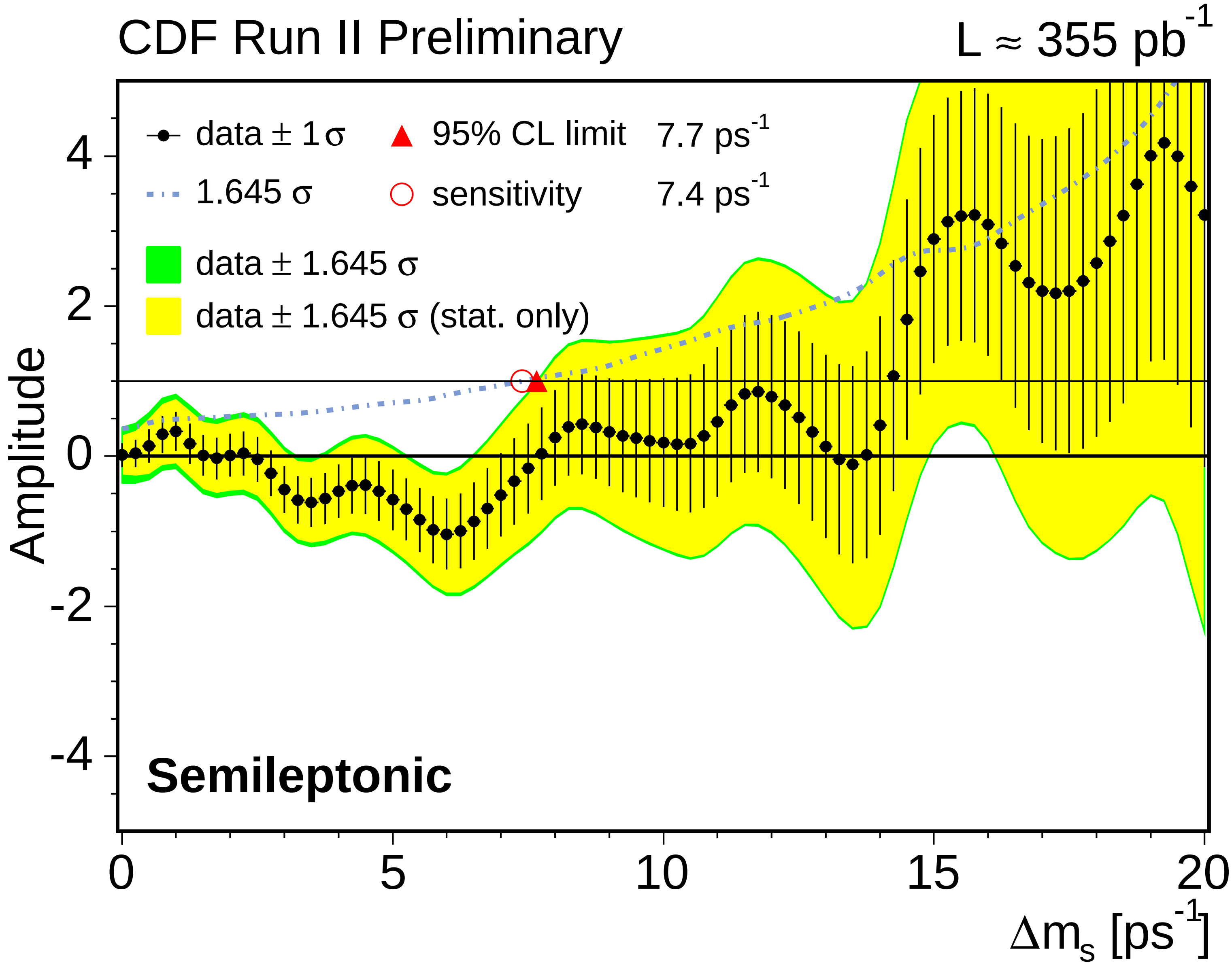




No obvious oscillations

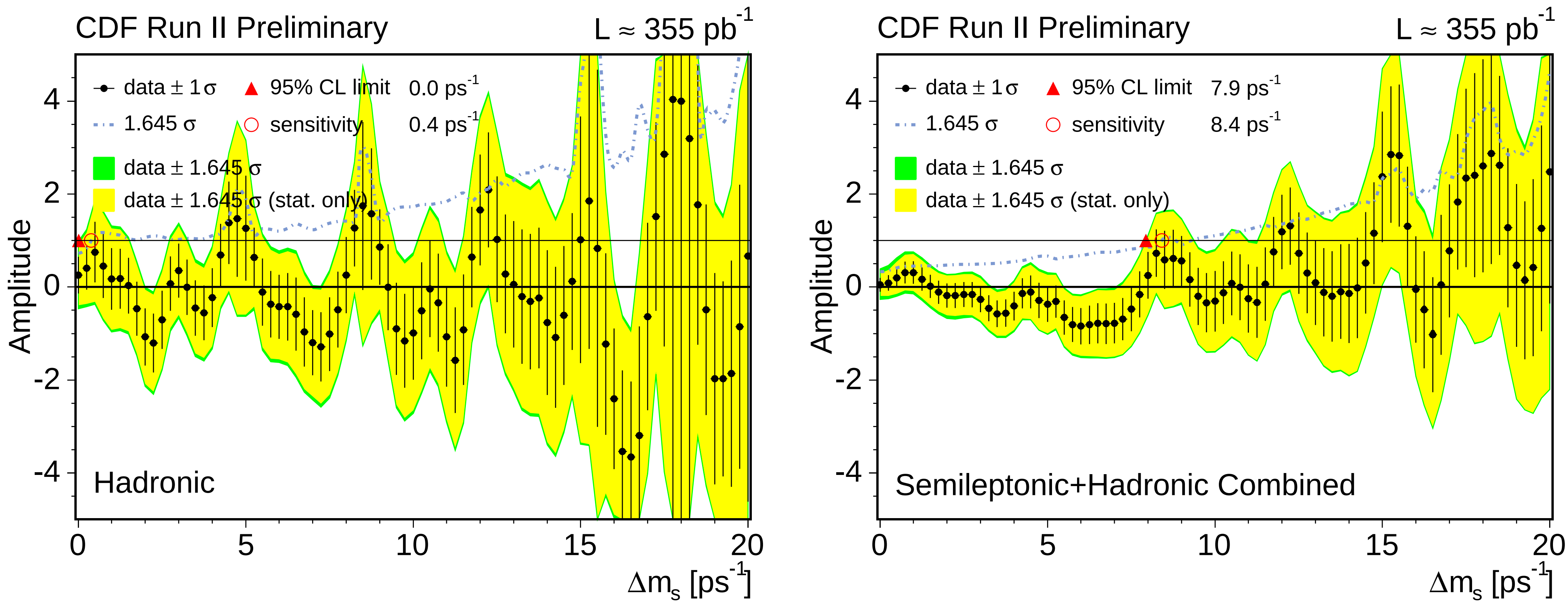
$\Delta m_s > 5.0\ ps^{-1}$ at 95% CL

Semileptonic Result



sensitivity: 7.4 ps^{-1} lower limit: 7.7 ps^{-1} at 95% CL

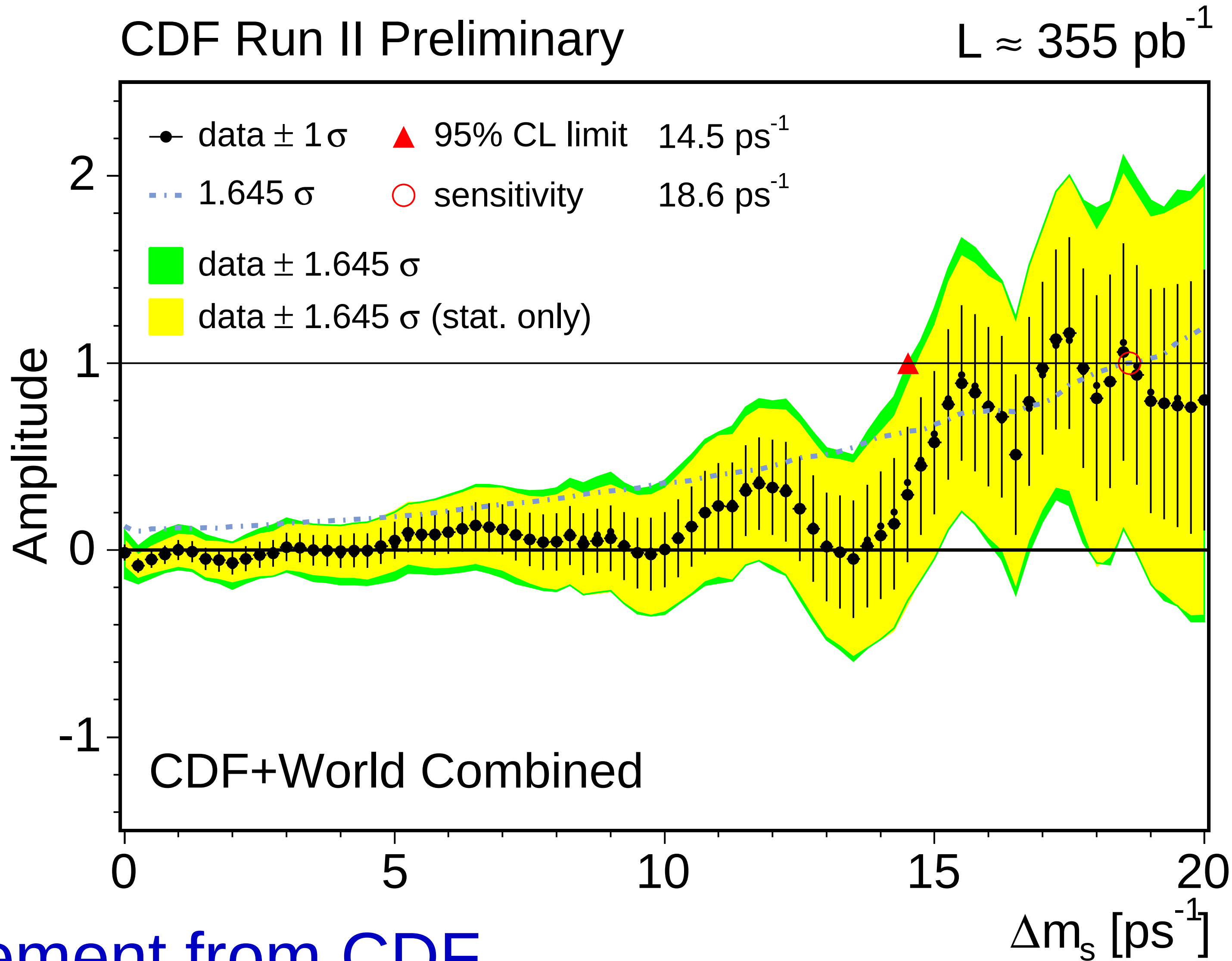
Hadronic and Combined Result



Comments

- + hadronic sample alone has no sensitive (statistics)
- + but helps semileptonic sample in high Δm_s region
- + sensitivity moves from 7.4 ps^{-1} to 8.4 ps^{-1}
- + new limit $\Delta m_s < 7.9\ ps^{-1}$ at 95% confidence level

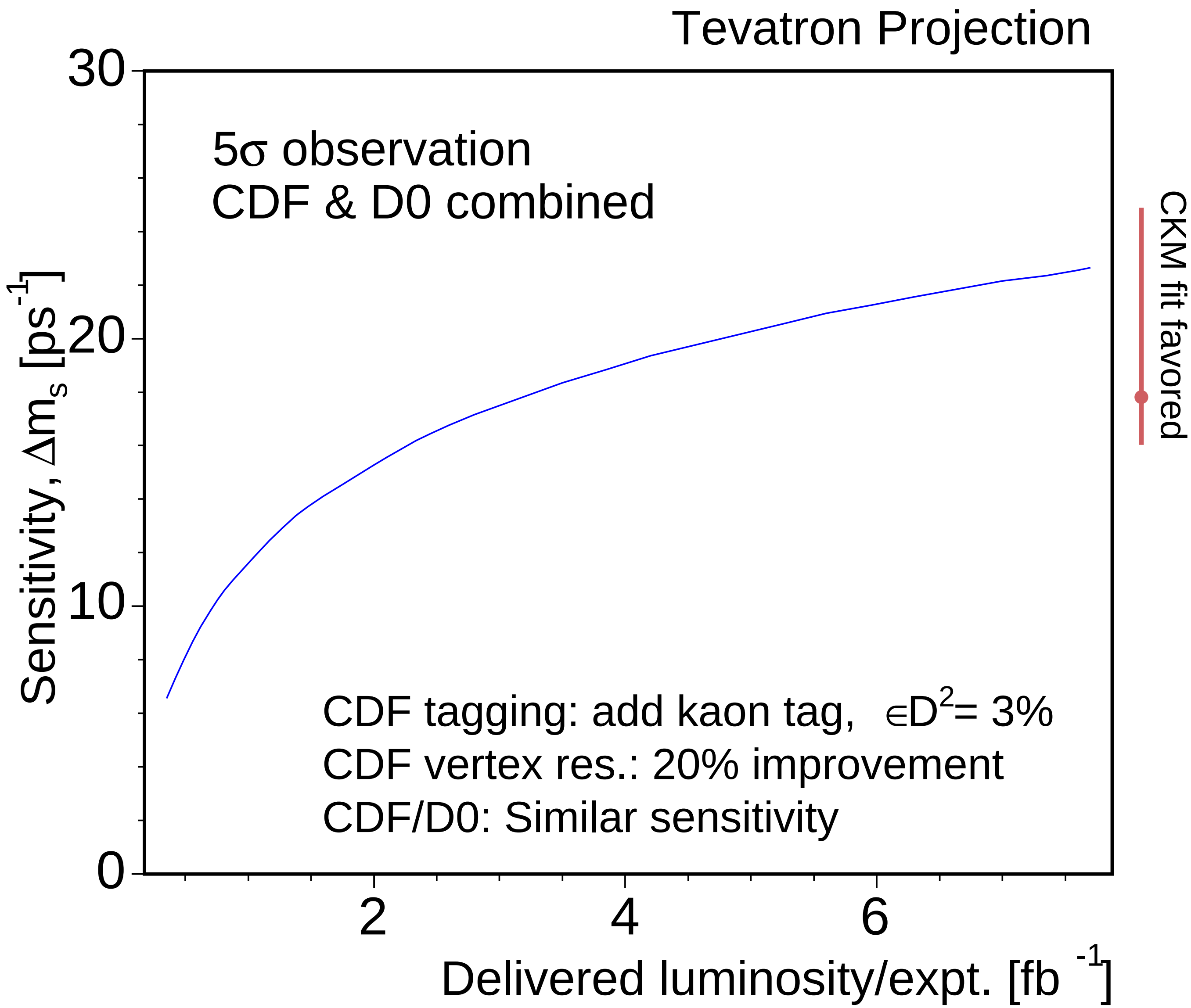
CDF II and World Combined Average



Improvement from CDF

- + limit stays the same
- + sensitivity moves from 18.1 ps^{-1} to 18.6 ps^{-1}

Tevatron Summary for Run II



$\Delta\Gamma/\Gamma$: Transversality

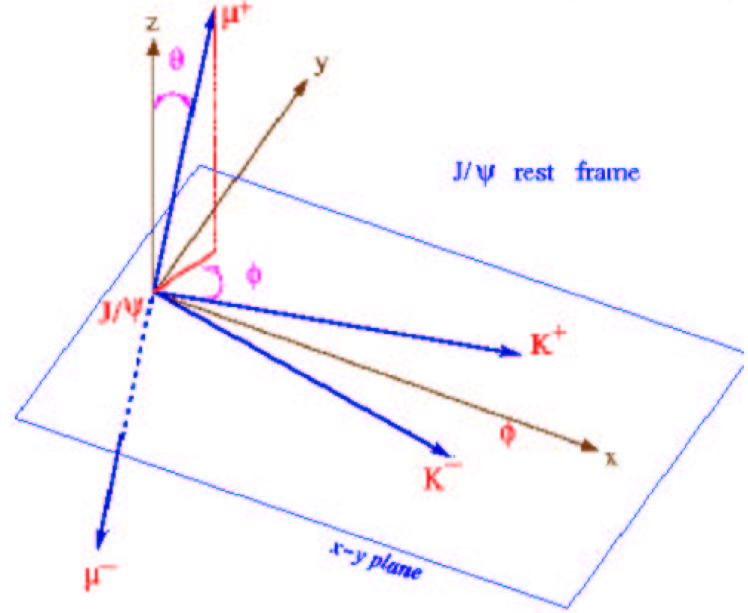
Imperial College London

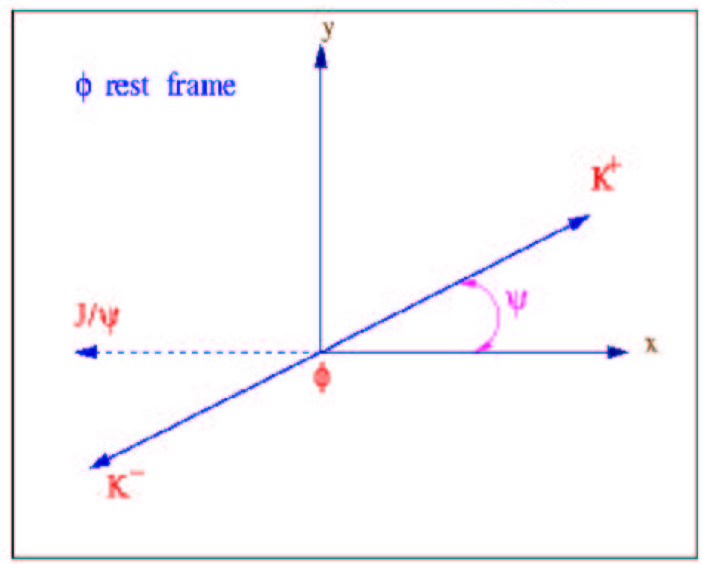
$B_s \to J/\psi\ \phi$,
Pseudoscalar → Vector Vector decay

Both CP-even and CP-odd present,
but well separated in transversity

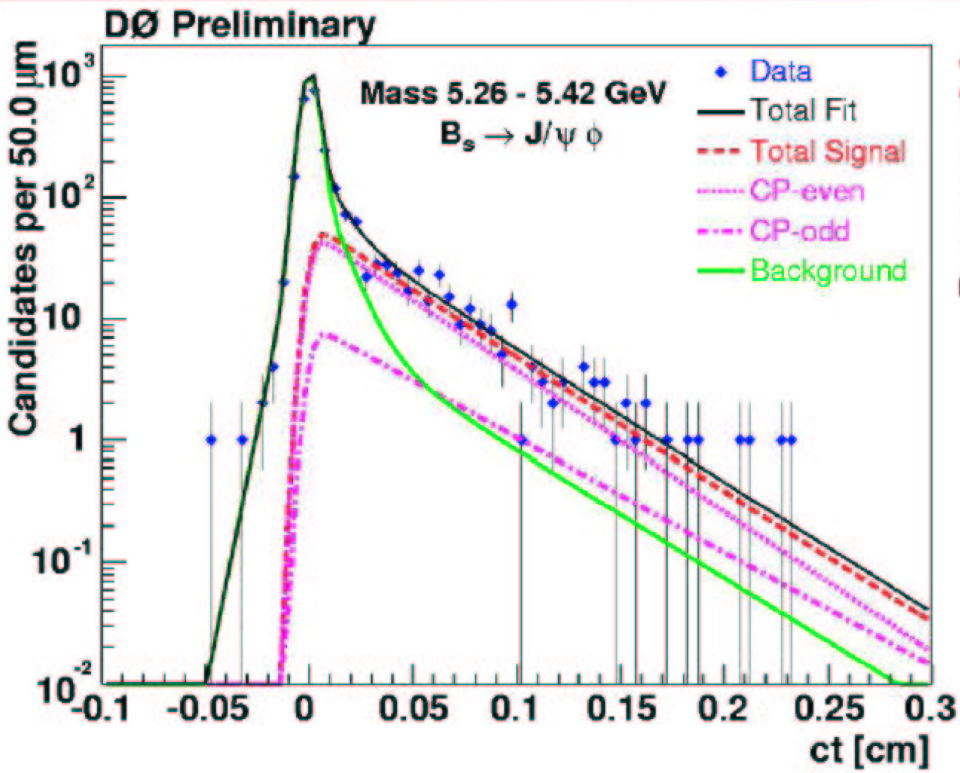
Transversity angle: $\cos(\theta)$

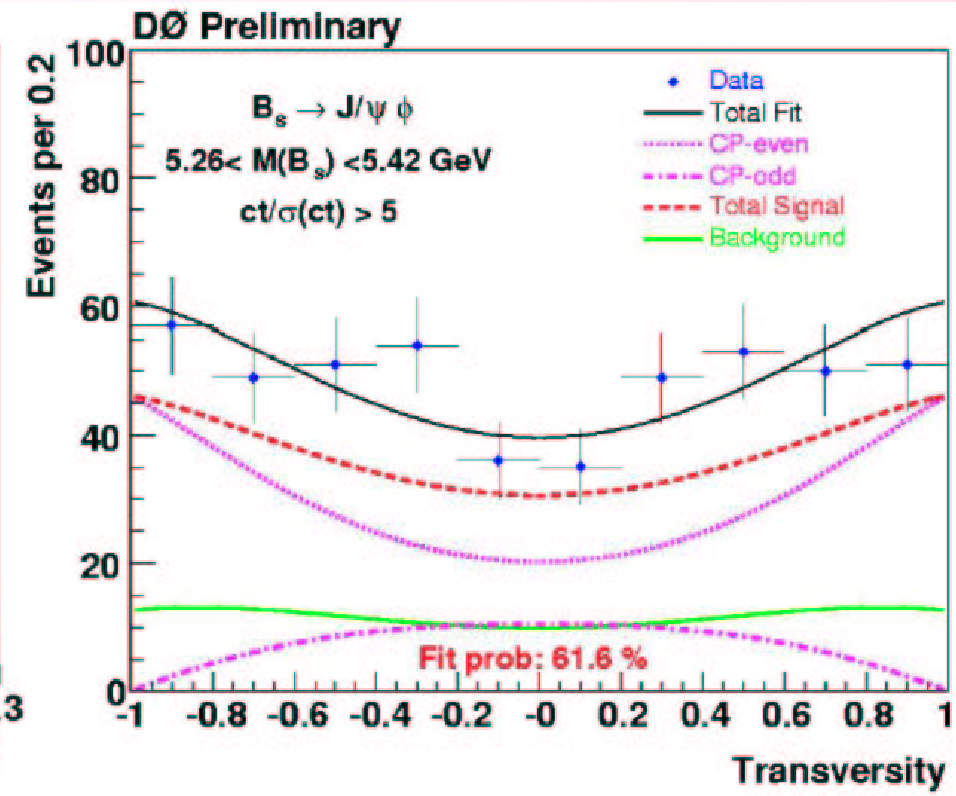
- Measure two distinct lifetimes ($equivalently$: $\Delta\Gamma/\Gamma$ and τ) by fitting time evolution and transversity distr. In untagged $B_s \to J/\psi\ \phi$ decays.
- If CP is conserved, they can be interpreted as the lifetimes of the two B_s mass eigenstates.





$\Delta\Gamma/\Gamma$: Results





$$\bar{\tau}(B_s^0) = 1.39^{+0.13}_{-0.14} \pm 0.08\,ps$$

$$\frac{\Delta\Gamma}{\bar{\Gamma}} = 0.21^{+0.27}_{-0.40} \pm 0.20$$

$$R_\perp = 0.17 \pm 0.10 \pm 0.02$$

$\Delta\Gamma/\Gamma$: Comparisons

- Consistent with $\Delta\Gamma/\Gamma$ CDF result

- Agrees well with theoretical prediction 0.12 ± 0.05

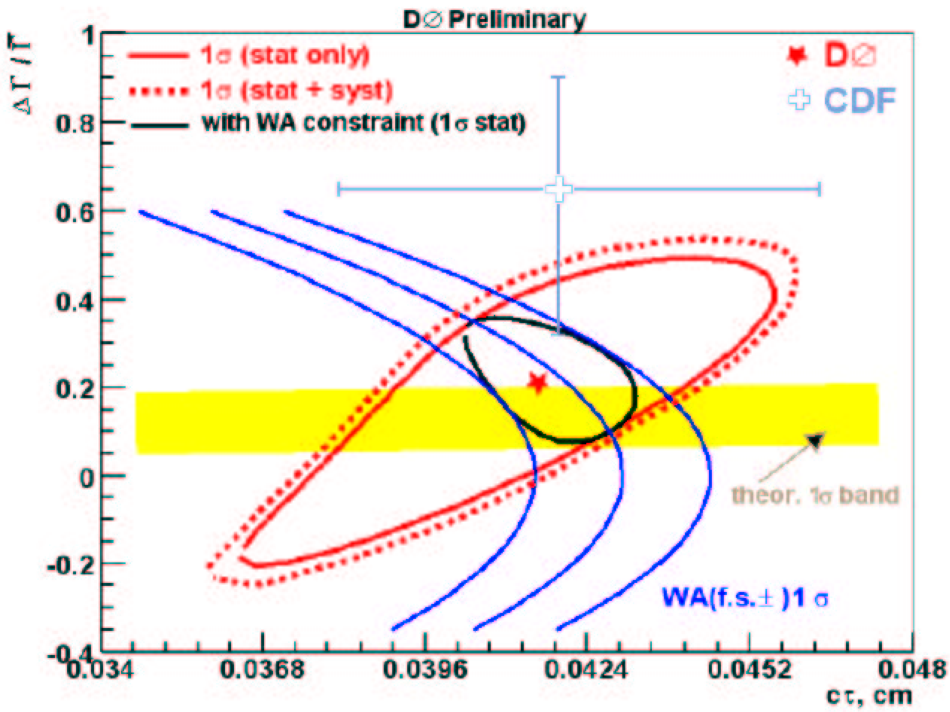
- The WA flavor specific lifetime provides independent relation of $\Delta\Gamma$ and Γ

$$\Gamma_{fs} = \overline{\Gamma}\left(\frac{1-\left(\Delta\Gamma/2\overline{\Gamma}\right)^2}{1+\left(\Delta\Gamma/2\overline{\Gamma}\right)^2}\right)$$

$$\overline{\tau_{fs}} = 1.43 \pm 0.05\, ps$$

$$\Rightarrow \frac{\Delta\Gamma}{\Gamma} = 0.23^{+0.16}_{-0.17}$$

=>significant improvement to $\Delta\Gamma$



Highlights: Rare Decays

Motivation

+ measure rare decays well predicted in SM
+ find large rate ≡ new physics

Opportunities

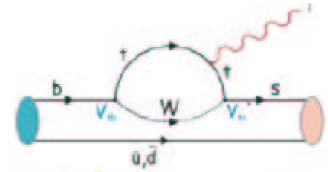
+ leptons reduce hadronic uncertainties
+ leptons often offer low rates

Examples

+ $b \to (s,d)\gamma$
+ $B \to \mu\mu$
+ $B \to \tau\nu$

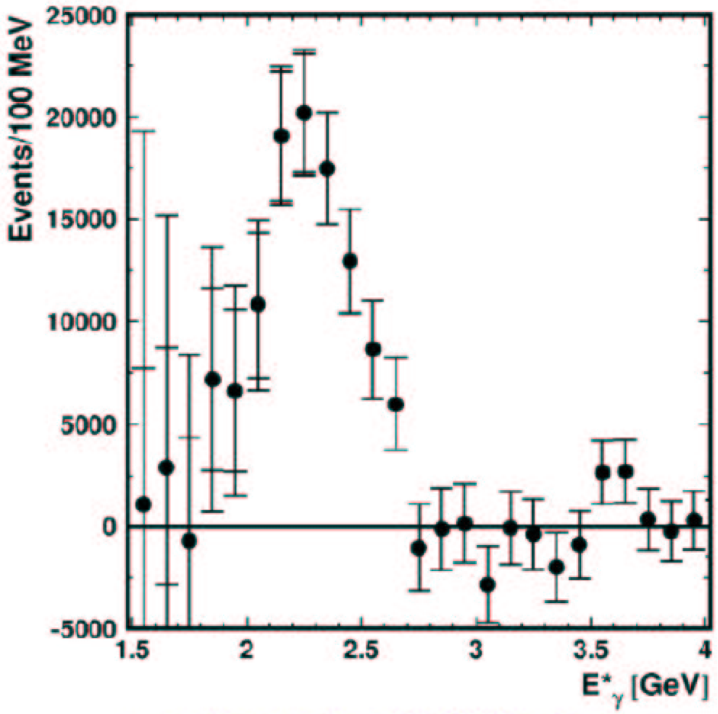
[B9]

Inclusive b -> $X_s\ \gamma$



BELLE

- Select photons with $E^*_\gamma > 1.5$ GeV (analysis done with $E^*_\gamma > 1.8$ GeV)
- Veto photons from π^0 and η decays
- Subtract background



$\langle E_\gamma \rangle = 2.289 \pm 0.026 \pm 0.034$ GeV

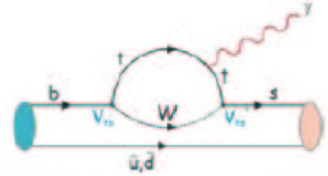
$\langle E_\gamma^2 \rangle - \langle E_\gamma \rangle^2 =$
$0.0311 \pm 0.0073 \pm 0.0063$ GeV^2

Smeared by motion of b quark inside the B meson and gluon emission => dynamics of B meson

⇒ important for V_{ub} measurement from inclusive charmless semileptonic decays [B18,B19]

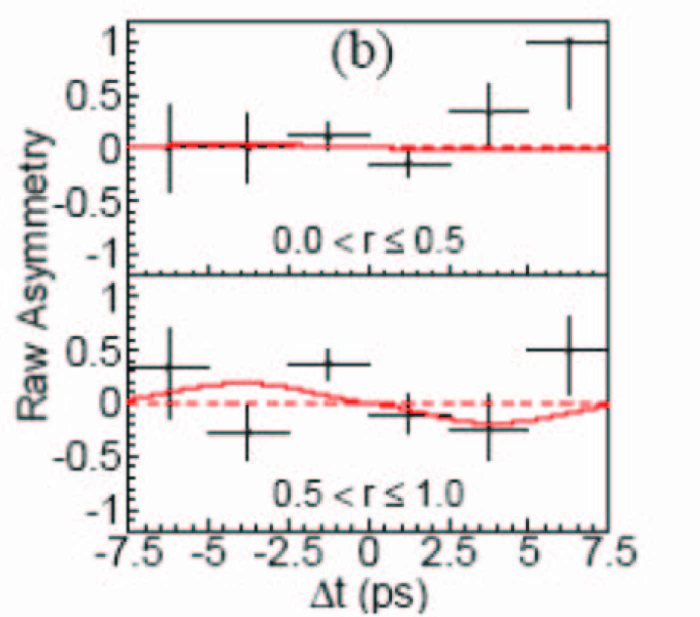
based on 140 fb^{-1}

[B17] Time-dependent CPV



Use $K^0{}_S\pi^0\gamma$ final state for time-dependent CP analysi:

$$A_{CP} = \frac{\Gamma\left(B^0(t) \to K^0_S\pi_0\gamma\right) - \Gamma\left(\overline{B^0}(t) \to K^0_S\pi^0\gamma\right)}{\Gamma\left(B^0(t) \to K^0_S\pi_0\gamma\right) + \Gamma\left(\overline{B^0}(t) \to K^0_S\pi^0\gamma\right)} = S \cdot \sin\Delta m\Delta t + A \cdot \cos\Delta m\Delta t$$



SM <0.1

$$S(K^0_S\pi^0\gamma) = -0.58\,^{+0.46}_{-0.38} \pm 0.11$$

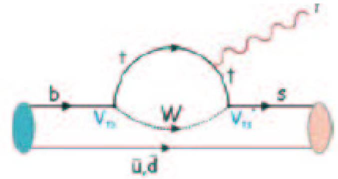
$$A(K^0_S\pi^0\gamma) = +0.03 \pm 0.34 \pm 0.11$$

SM <0.01

Atwood et al [T5]
Gronau et al [T6]

Based on 253 fb^{-1}

$|V_{td}/V_{ts}|$ from B -> $(\rho,\omega)\gamma$



$$\mathcal{BR}((\rho,\omega)\gamma) = (0.72\,^{+0.43}_{-0.39} \pm 0.28)\cdot 10^{-6}$$ Significance: 1.2σ

SM predictions:

Ali-Parkhomenko[T2]: $\mathcal{BR}(B^+ \to \rho^+\gamma) = (0.90 \pm 0.34)\cdot 10^{-6}$

Bosch-Buchalla[T3]: $\mathcal{BR}(B^+ \to \rho^+\gamma) = (1.50 \pm 0.50)\cdot 10^{-6}$

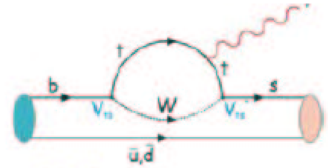
Constraint on V_{td}:

$$\frac{\mathcal{BR}(B\to(\rho,\omega)\gamma)}{\mathcal{BR}(B\to K^*\gamma)} = \left|\frac{V_{td}}{V_{ts}}\right|^2 \frac{(1-m^2_{(\rho,\omega)}/m^2_B)^3}{(1-m^2_{K^2}/m^2_B)^3}\varsigma^2(1+\Delta R)$$

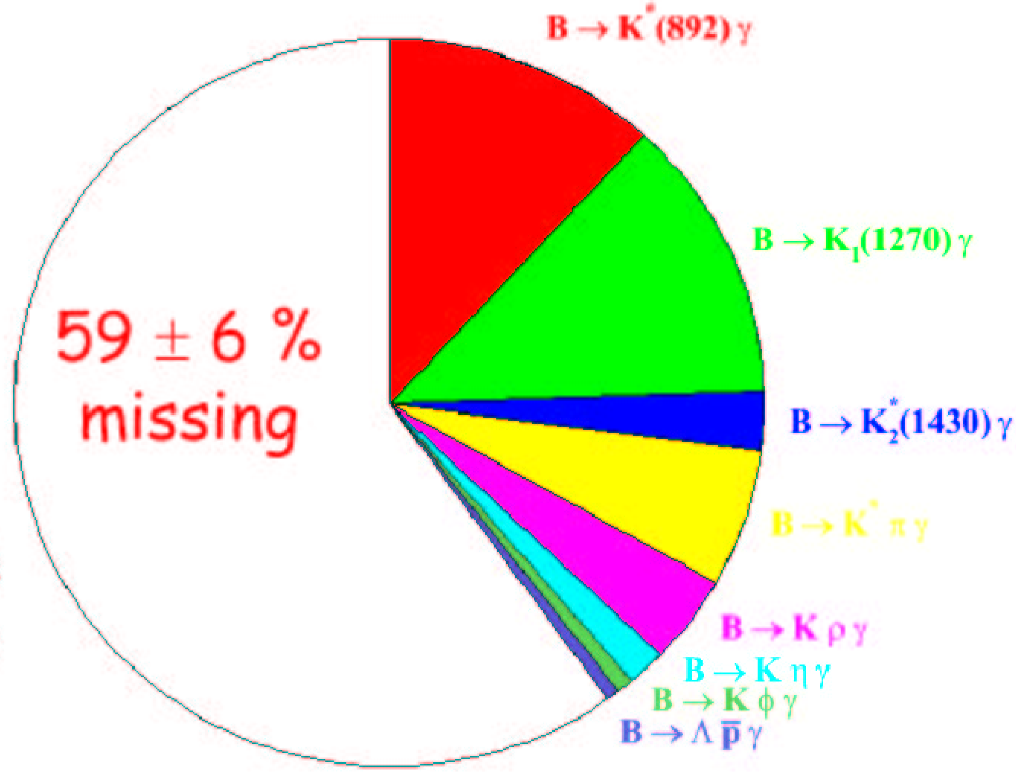
$$\Rightarrow \quad \left|\frac{V_{td}}{V_{ts}}\right| < 0.22 \quad @\ 90\%\ CL$$

Based on 253 fb^{-1}

Summary of b -> s γ

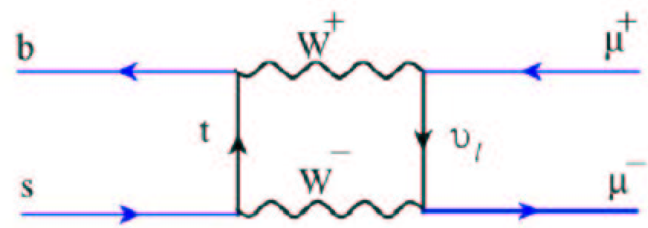


- Many neutral exclusive b -> s γ modes for time-dependent CPV!
- $K\pi\pi^0\gamma$ final state should help for photon polarization
- useful to reduce inclusive b -> s γ systematic errors
- isospin in B and $K^{(*)}$ decays is assumed



Purely leptonic B decay

- purely leptonic **B->$l^+ l^-$** decay is a flavor changing neutral current (FCNC)
- in SM forbidden at tree level
- proceeds thru penguin/box diagrams, helicity suppressed
- SM: BR($B_s \to \mu^+\mu^-$)~ 3.4×10^{-9}
- depends only on one SM operator in effective Hamiltonian, hadronic uncertainties small
- B_d relative to B_s suppressed by $|V_{td}/V_{ts}|^2$ ~ 0.04 if no additional sources of flavor violation



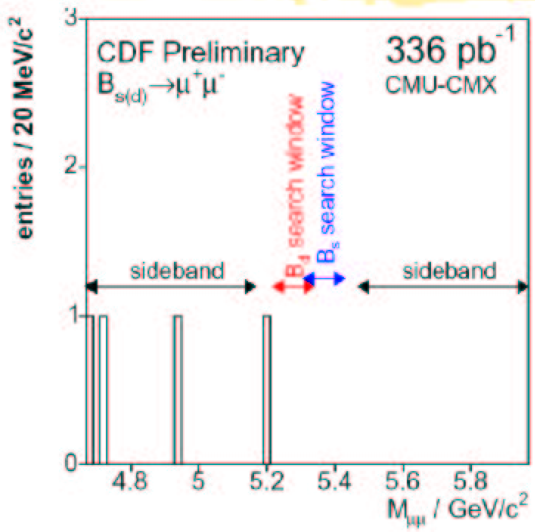
SM expectations:

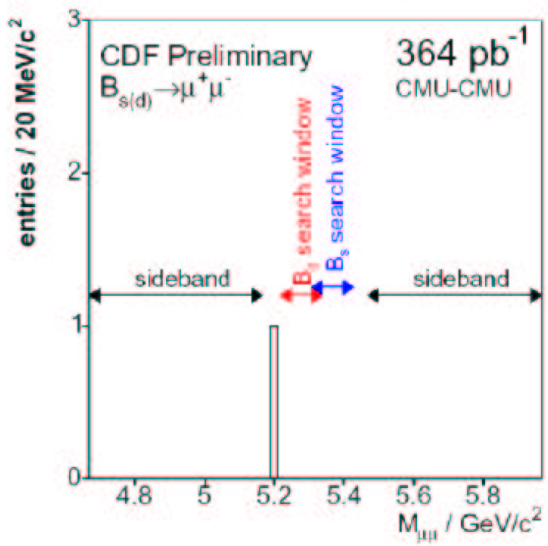
	$Br(B_d \to l^+l^-)$	$Br(B_s \to l^+l^-)$
$l = e$	3.4×10^{-15}	8.0×10^{-14}
$l=\mu$	1.0×10^{-10}	3.4×10^{-9}
$l=\tau$	3.1×10^{-8}	7.4×10^{-7}

Current published limits:

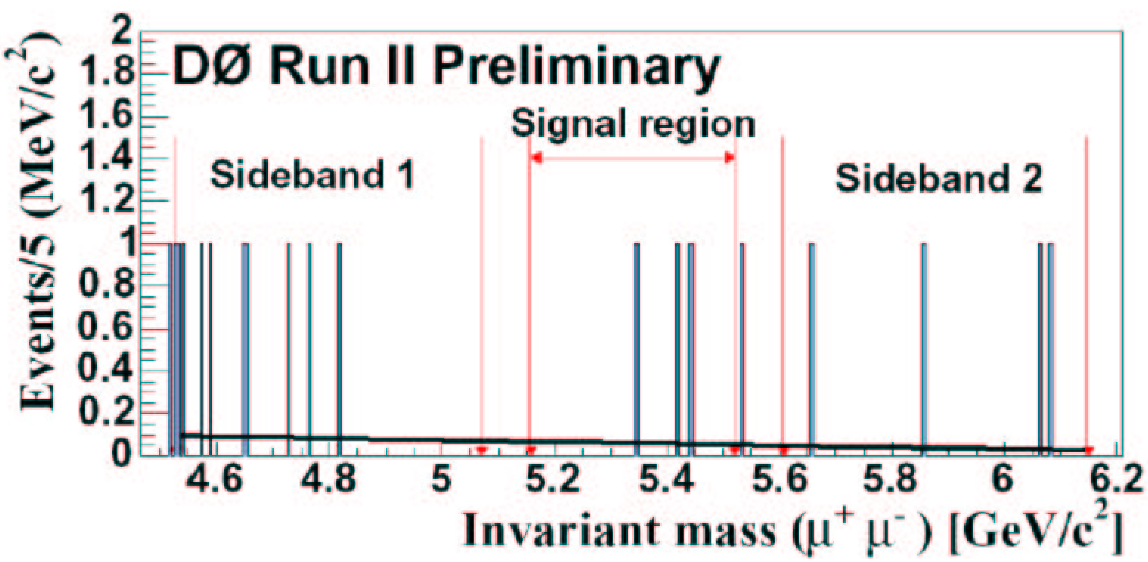
C.L. 90%	$Br(B_d \to l^+l^-)$	$Br(B_s \to l^+l^-)$
$l = e$	$< 6.1 \cdot 10^{-8}$	$< 5.4 \cdot 10^{-5}$
$l=\mu$	$< 8.3 \cdot 10^{-8}$	$< 4.1 \cdot 10^{-7}$
$l=\tau$	< 2.5%	< 5.0%

Unblinding the signal region





- CDF:
  - central/central: observe 0, expect 0.81 ± 0.12
  - Central/forward: observe 0, expect 0.66 ± 0.13
- DØ:
  - PRL: observe 4, expect 3.7 ± 1.1
  - update: observe 4, expect 4.3 ± 1.2



The Limits

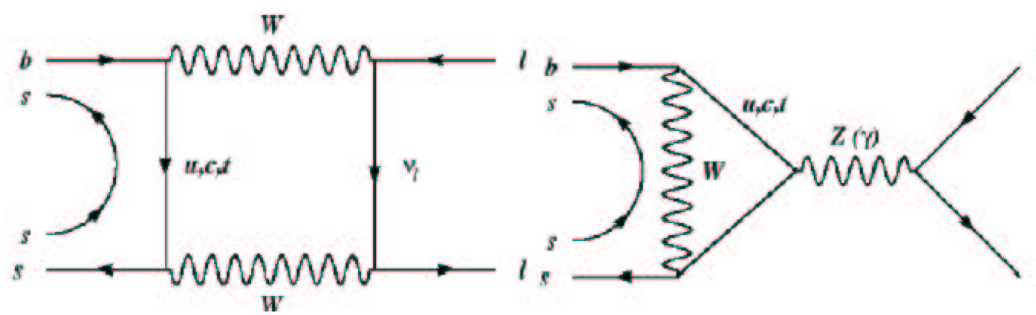
- $BR(B_s \to \mu^+\mu^-) = N_{ul}/N_{B+} \times \varepsilon_{B+}/\varepsilon_{Bs} \times f_u/f_s \times BR(B^+ \to J/\psi\, K^+) \cdot BR(J/\psi \to \mu^+\mu^-)$
  - $\varepsilon_B+/\varepsilon_{Bs}$ relative efficiencies
  - f_u/f_s fragmentation ratio (in case of B_s limit) – use world average value with 15% uncertainty
- N.B.:
  - DØ mass resolution is not sufficient to separate B_s from B_d. Assume no B_d contribution (conservative)
  - CDF sets limit on B_s & B_d channels
  - all limits below are 95% C.L. Bayesian incl. sys. error, DØ also quotes FC limit

CDF $B_s \to \mu\mu$	176 pb^{-1}	7.5×10^{-7}	Published
DØ $B_s \to \mu\mu$	240 pb^{-1}	5.1×10^{-7}	Published
DØ $B_s \to \mu\mu$	300 pb^{-1}	4.0×10^{-7}	Prelim.
CDF $B_s \to \mu\mu$	364 pb^{-1}	2.0×10^{-7}	Prelim
CDF $B_d \to \mu\mu$	364 pb^{-1}	4.9×10^{-8}	Prelim

B_d limit x2 better than published Babar limit w/ 111 fb^{-1}

Sensitivity analysis $B_s \to \mu^+\mu^-\phi$

- long-term goal: investigate $b \to s\, l^+ l^-$ FCNC transition in B_s meson
- exclusive decay: $B_s \to \mu^+\mu^-\phi$
- SM prediction:
  - short distance BR: $\sim 2\times10^{-6}$
  - about 30% uncertainty due to $B \to \phi$ form factor
- 2HDM: enhancement possible, depending on parameters for $\tan\beta$ and M_{H+}
- presently only one limit
  - CDF Run I: 6.7×10^{-5} @ 95% C.L.



Expected Limit

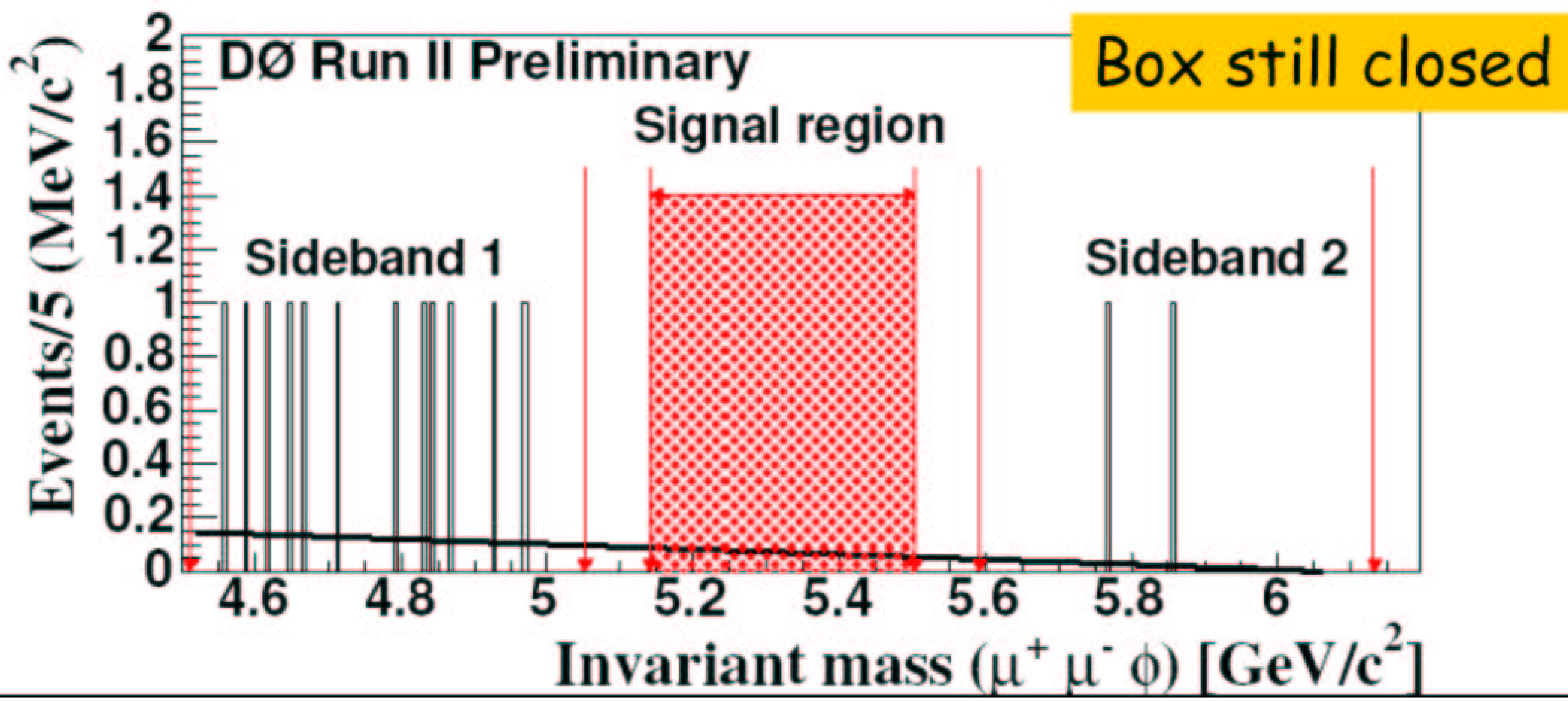
- expected background from sidebands: 5.1 ± 1.0 events
- sensitivity/average expected limit (@95% C.L):

$\langle BR(B_s \to \phi\, \mu^+\mu^-)/BR(B_s \to J/\psi\, \phi)\rangle = 1.3 \times 10^{-2}$

if $BR(B_s \to J/\psi\, \phi) = 9.3\times10^{-4}$ PDG2004 is used:

$\langle BR(B_s \to \phi\, \mu^+\mu^-)\rangle = 1.2\times10^{-5}$

expect x5 improvement w.r.t previous limit

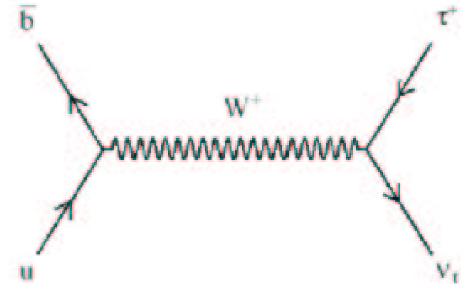


Search for $B^+ \to \tau^+ \nu$

- $B^+ \to \tau^+ \nu$ in the SM
  - Via quark annihilation into a W^+ boson
  - Decay with μ or e are helicity-suppressed
- New physics in $B^+ \to \tau^+ \nu$
  - Charged Higgs boson ($H^\pm$) as propagator
    - SUSY, two-Higgs doublet models
  - Enhancement of the BF
    - Up to a factor of 5

Hou, Phys. Rev. D **48**, 2342 (1993)

- Experimentally challenging due to neutrinos in the final state



$$\mathcal{B}(B^+ \to \tau^+\nu) = \frac{G_F^2 m_B m_\tau^2}{8\pi}\left[1 - \frac{m_\tau^2}{m_B^2}\right]^2 \tau_B f_B^2 \,|V_{ub}|^2$$

Sensitive to $f^2_B\,|V_{ub}|^2$

SM expectation $\approx 10^{-4}$

- Measurement of f_B
  - Assuming $|V_{ub}|$ known from semileptonic decays
- Measurement of $|V_{ub}|\,/\,|V_{td}|$
  - From BF($B^+ \to \tau^+ \nu$) / Δm (*)
  - Gives a constraint on the CKM unitarity triangle

(*) Δm= mass difference between the heavy and light states of the neutral B

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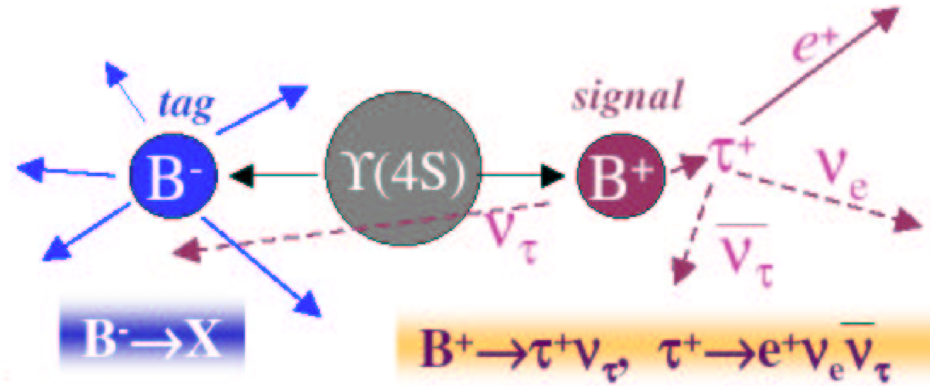
Search for $B^+ \to \tau^+ \nu$

- Analysis strategy
  - Exclusive reconstruction of one B in a certain final state ("tag B")
    - Semileptonic mode $B^- \to D^{*0} l^- \nu$ $(l = e, \mu)$
    - $D^{*0} \to D^0\pi^0$, $D^0 \gamma$
    - $D^0 \to K^-\pi^+$, $K^-\pi^+\pi^+\pi^-$, $K^-\pi^+\pi^0$, $K_s\pi^+\pi^-$
    - $K_s \to \pi^+\pi^-$
  - Search for a $B^+ \to \tau^+ \nu$ signal in the rest of the event
    - $\tau^+ \to e^+\nu\nu$, $\mu^+\nu\nu$, $\pi^+\nu$, $\pi^+\pi^0\nu$, $\pi^+\pi^-\pi^+\nu$



Also other τ decay modes reconstructed

- Main background
  - From B decays (hadronic or semileptonic)
    - Correctly tagged events
    - but some decay products on the signal side escaped tracking or calorimetry

Analysis based on 211 fb^{-1}

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Search for $B^+ \to \tau^+ \nu$: preliminary results

- No evidence for signal
  - An upper limit is set
  - Method based on a likelihood ratio estimator $Q = \mathcal{L}(s+b) / \mathcal{L}(b)$
    - A.L.Read, J.Phys. G **28**, 2693 (2002)
  - Combined with a previous BaBar result
    - Hadronic tag, 81.9 fb^{-1}
    - $BF(B^+ \to \tau^+ \nu) < 4.2 \times 10^{-4}$

Preliminary, semileptonic tag

Expected background	130.8 ± 9.3
Observed events	150 ± 12

$BF(B^+ \to \tau^+ \nu) < 2.8 \times 10^{-4}$ @ 90% C.L.

Preliminary, combined

$BF(B^+ \to \tau^+ \nu) < 2.6 \times 10^{-4}$ @ 90% C.L. $\to$ $f_B < 0.41$ GeV @ 90% C.L.

Bs and Λb Decays

Bs Decays:

- 3BR, 1 BR upper limit, 1 new semileptonic decay mode observed

$$\frac{f_d \mathcal{B}(B_s^0 \to D_s^- \pi^+)}{f_s \mathcal{B}(B^0 \to D^- \pi^+)} = 0.35 \pm 0.05(stat.) \pm 0.04(syst.) \pm 0.09(BR)$$

$$\mathcal{B}(B_s^0 \to \phi\phi) = (1.4 \pm 0.6(stat.) \pm 0.2(syst.) \pm 0.5(BR)) \times 10^{-5}$$

$$\frac{\mathcal{B}(B_s^0 \to \psi(2S)\phi)}{\mathcal{B}(B_s^0 \to J/\psi\phi)} = 0.52 \pm 0.13(stat) \pm 0.04(syst) \pm 0.06(BR)$$

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 2.0 \times 10^{-7} (95\% \text{ CL})$$

Lambda_b Decays:

- Excl. Semileptonic BR, 1 BR upper limit, 4 new decay modes observed

$$\frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \mu^- \overline{\nu}_\mu)}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \pi^-)} = 20.0 \pm 3.0(stat.) \pm 1.2(syst.)^{+0.7}_{-2.1}(BR) \pm 0.5(UBR)$$

$$\mathcal{B}(\Lambda_b^0 \to h^+ h^-) < 2.2 \times 10^{-5} \ (90\% \text{ C.L.})$$

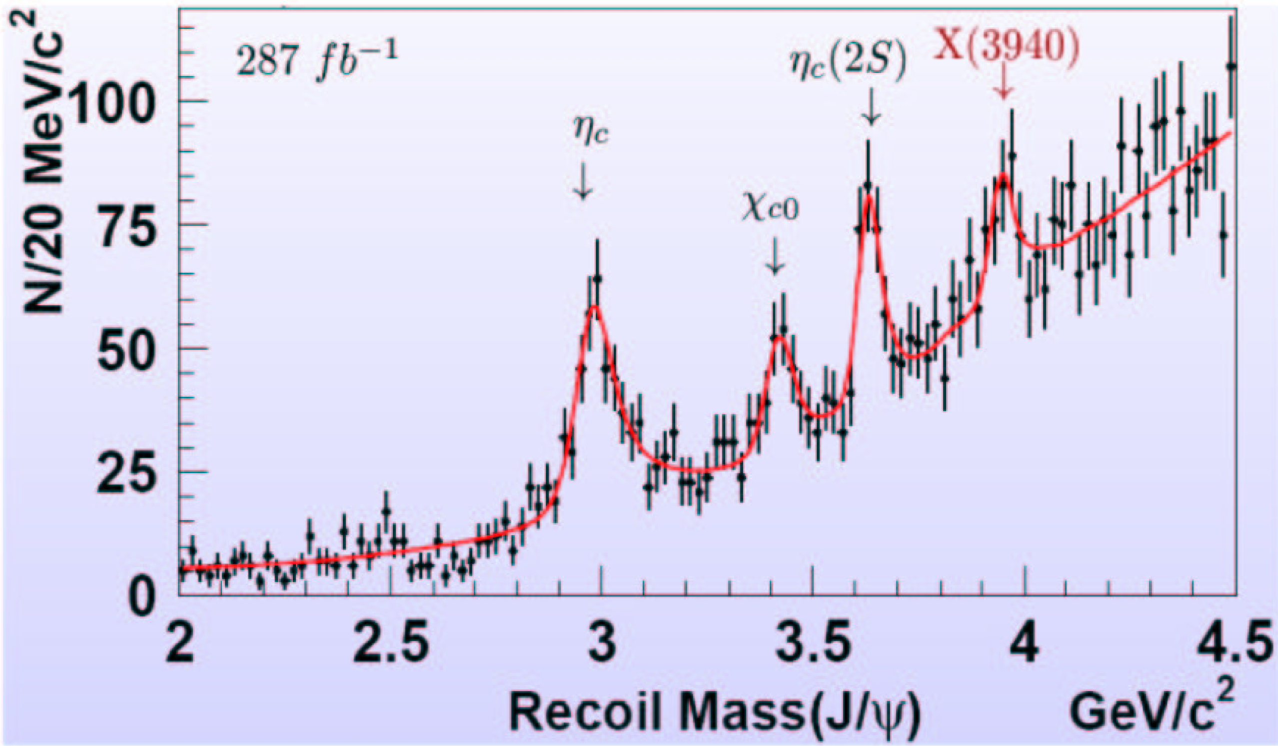
- CP and weak physics from baryons promising...

Double charmonium @ Belle

As for BaBar no evidence of J/ψ , χ_{c1} , χ_{c2} , $\psi(2S)$.

hep-ex/0412041

Charmonium production rate comparable to BaBar results



Evidence for X(3940) in double charmonium production

M(X(3940))=3940±12 MeV

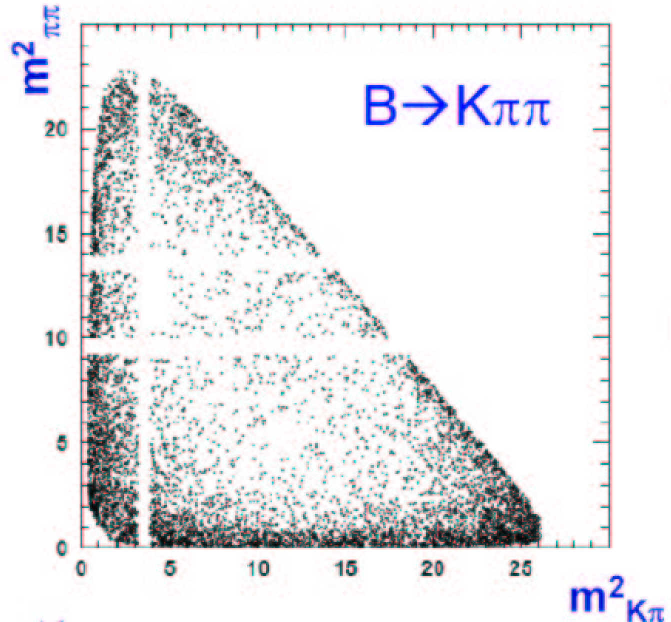
Γ(X(3940))<96MeV

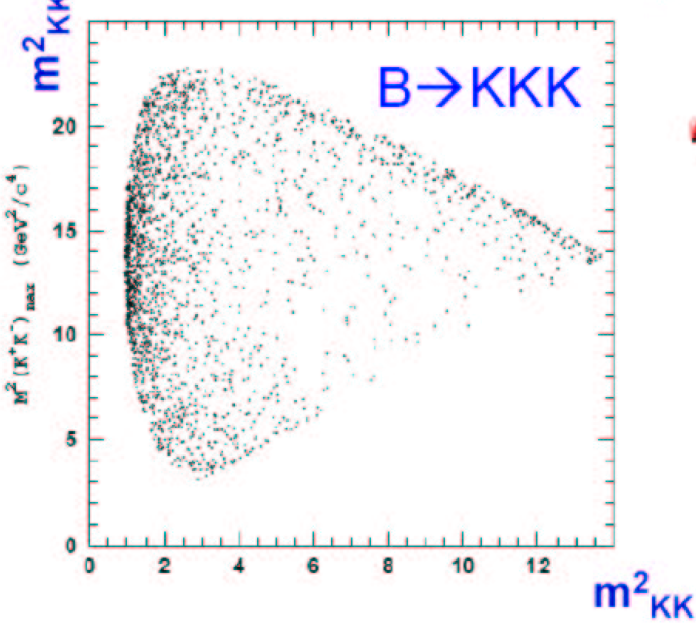
@ 90%CL

Decays into $D\bar{D}$ and $\underline{D}D^*$

$B^+ \rightarrow K^+\pi^+\pi^-$, $K^+K^+K^-$

motivation



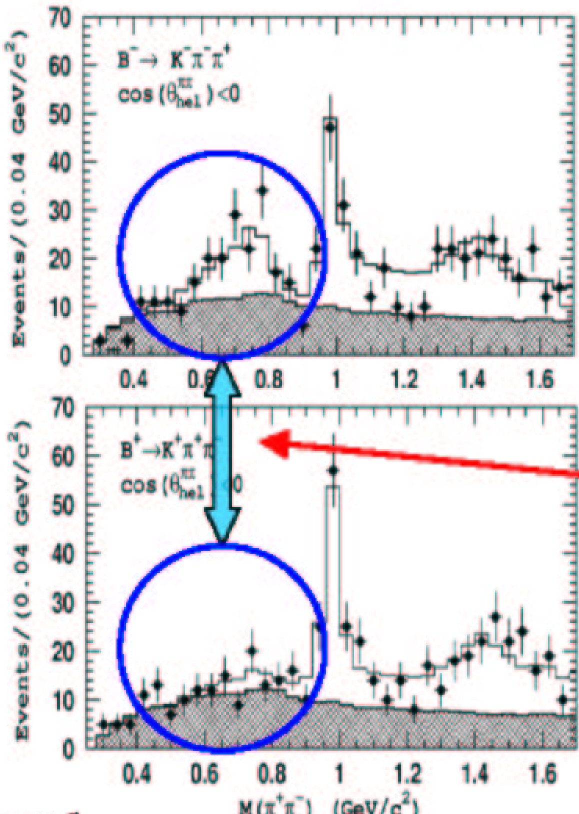


- $B \rightarrow K\pi\pi$, KKK dominated by $b \rightarrow s$ penguin process
- Full amplitude Dalitz analysis allows to reliably measure quasi-two-body branching fractions ($B \rightarrow \rho K$, $K^*\pi$ …)
- Search for direct CP violation
  - Looking for:
    - asymmetry in quasi two body Branching Ratios
    - Differences in relative phases

$B^+ \rightarrow K^+\pi^+\pi^-$, $K^+K^+K^-$

results

- Fit the B^+ and B^- samples individually to determine CP asymmetry for each quasi-two-body channel
- Model related uncertanity evaluated by repeating fit with different models



$\mathcal{L} = 253\ \mathrm{fb}^{-1}$

preliminary

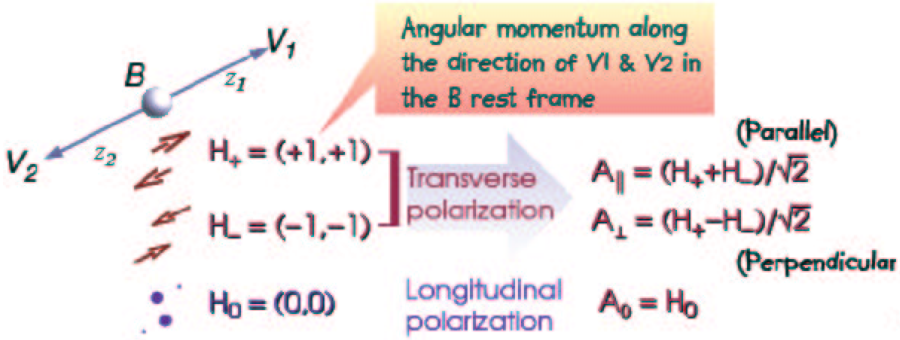
Channel	A_{CP}
$K^{\pm}\pi^+\pi^-$	$+0.046 \pm 0.030\ ^{+0.017}_{-0.012}$
$K^*(892)^0\pi^{\pm}$	$-0.14 \pm 0.08 \pm 0.02\ ^{+0.03}_{-0.07}$
$K^*_0(1430)^0\pi^{\pm}$	$+0.06 \pm 0.05 \pm 0.02\ ^{+0.01}_{-0.32}$
$\rho(770)^0K^{\pm}$	$+0.27 \pm 0.12 \pm 0.02\ ^{+0.59}_{-0.03}$
$f_0(980)K^{\pm}$	$-0.13 \pm 0.11 \pm 0.02\ ^{+0.16}_{-0.06}$
$\chi_{c0}K^{\pm}$	$-0.30 \pm 0.22 \pm 0.02\ ^{+0.42}_{-0.00}$
Non-Res.	$-0.04 \pm 0.08 \pm 0.02\ ^{+0.16}_{-0.03}$

preliminary

A 2.4σ hint for a Direct CP violation in $B^{\pm} \rightarrow \rho(770)^0K^{\pm}$

$B \to \phi K^*$

motivation

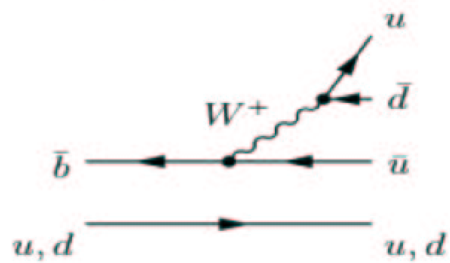


Standard Model prediction, with factorization assumption:

$$f_L = \frac{|A_0|^2}{|A_0|^2+|A_{//}|^2+|A_\perp|^2} = \frac{|A_0|^2}{|A_0|^2+|A_+|^2+|A_-|^2} = 1 - O\left(\left(\frac{m_V}{m_B}\right)^2\right) \sim 1$$

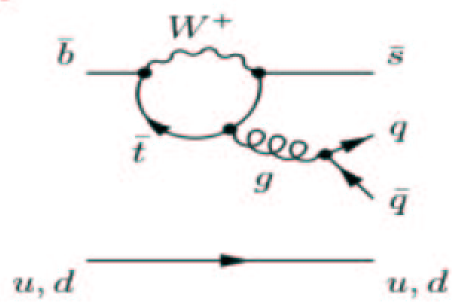
True for tree dominated decays

BaBar(89M)	$f_L(\rho^+\rho^-)$ =	$\boxed{0.99} \pm 0.03^{+0.04}_{-0.03}$
BaBar(89M)	$f_L(\rho^+\rho^0)$ =	$\boxed{0.97}^{+0.03}_{-0.07} \pm 0.04$
Belle(85M)	$f_L(\rho^+\rho^0)$ =	$\boxed{0.95} \pm 0.11 \pm 0.02$
BaBar(89M)	$f_L(\rho^+\omega)$ =	$\boxed{0.88}^{+0.12}_{-0.15} \pm 0.03$



Not true in pure penguins

BaBar(227M)	$f_L(\phi K^{*0})$ =	$\boxed{0.52} \pm 0.05 \pm 0.02$
Belle(152M)	$f_L(\phi K^{*0})$ =	$\boxed{0.52} \pm 0.07 \pm 0.05$
BaBar(89M)	$f_L(\phi K^{*+})$ =	$\boxed{0.46} \pm 0.12 \pm 0.03$
Belle(152M)	$f_L(\phi K^{*+})$ =	$\boxed{0.49} \pm 0.13 \pm 0.05$



- Many possible explanations:
  - New Physics
  - Transverse gluon
  - Annihilation
  - Rescattering

Y. Grossman, hep-ph/0310229
W.-S. Hou *et al.*,hep-ph/0408007
A. Kagan, hep-ph/0405134
P. Colangelo *et al.*, hep-ph/0406162

$B \to \phi K^*$

BELLE

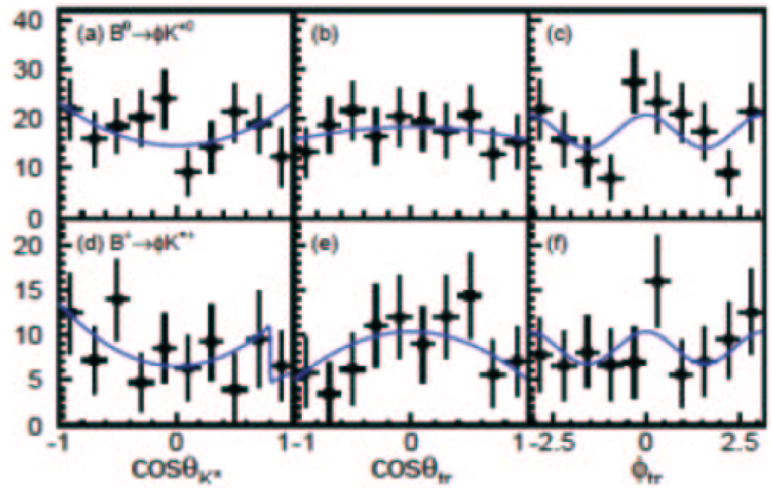
results

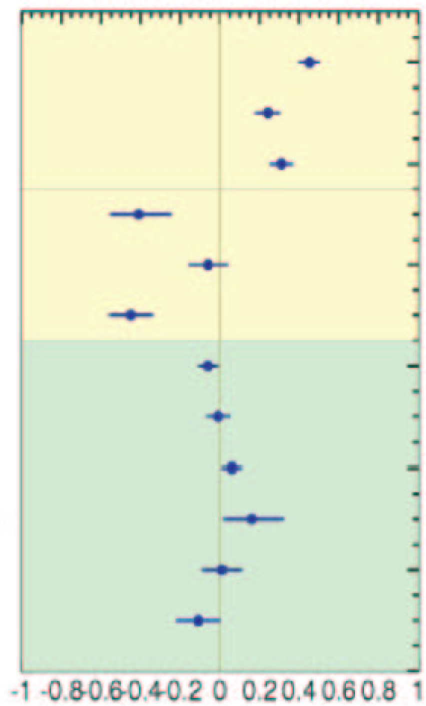
$\mathcal{L} = \mathbf{253}\ \mathrm{fb}^{-1}$

- $N_{sig}(B \to \phi K^{*0})$: 173 ±16
- $N_{sig}(B \to \phi K^{*+})$: 85^{+12}_{-11}

$A_{CP}(B \to \phi K^{*0}) = 0.02 \pm 0.09 \pm 0.02$

$A_{CP}(B \to \phi K^{*+}) = -0.02 \pm 0.14 \pm 0.03$





ϕK^* Anomaly	Λ_{00}	0.45 ±0.05 ±0.02
	$\Lambda_{\parallel\parallel}$	0.24 ±0.06 ±0.02
	$\Lambda_{\perp\perp}$	0.31 ±0.06 ±0.01
Non-0 value can be generated by FSI	$\Sigma_{\perp 0}$	$-0.41^{+0.16}_{-0.14} \pm 0.04$
	$\Sigma_{\perp\parallel}$	−0.06 ±0.10 ±0.01
	$\Sigma_{\parallel 0}$	−0.45 ±0.11 ±0.01
≠0 If NP exists	Σ_{00}	−0.06 ±0.05 ±0.01
	$\Sigma_{\parallel\parallel}$	−0.01 ±0.06 ±0.01
	$\Sigma_{\perp\perp}$	0.06 ±0.05 ±0.01
	$\Lambda_{\perp 0}(=\overline{A_T^0}-A_T^0)$	$0.16^{+0.16}_{-0.14} \pm 0.03$
	$\Lambda_{\perp\parallel}(=\overline{A_T^\parallel}-A_T^\parallel)$	0.01 ±0.10 ±0.02
	$\Lambda_{\parallel 0}$	−0.11 ±0.11 ±0.02

Most of them are consistent with zero

Longitudinal polarization >10σ away from 1

Indication of Final state interaction (also observed by BaBar)

No evidence of New Physics

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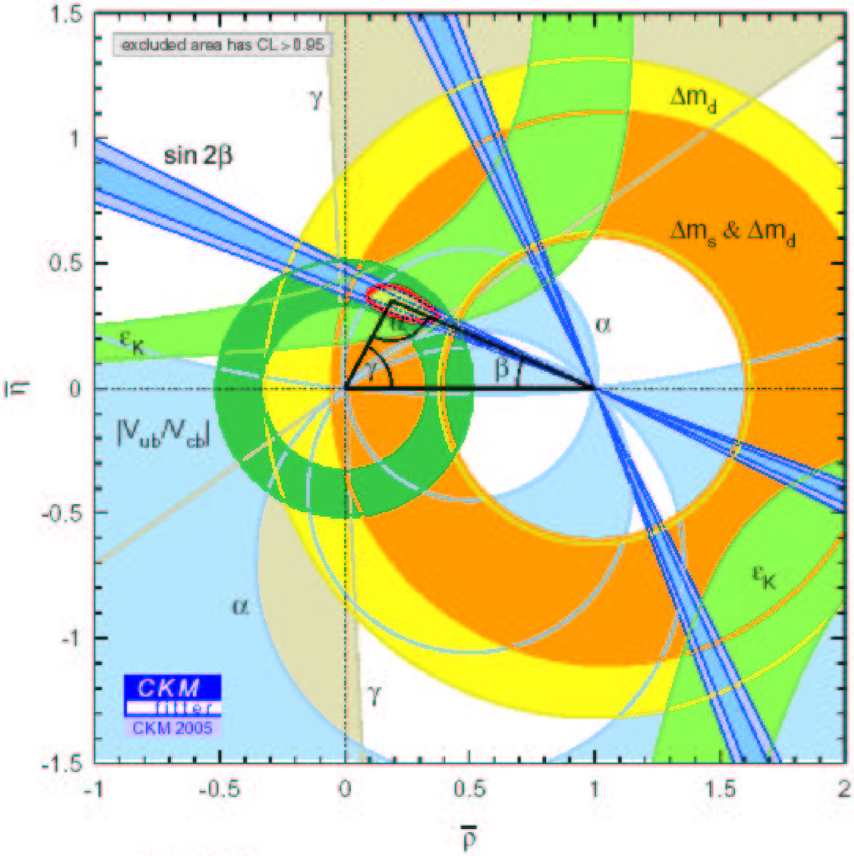
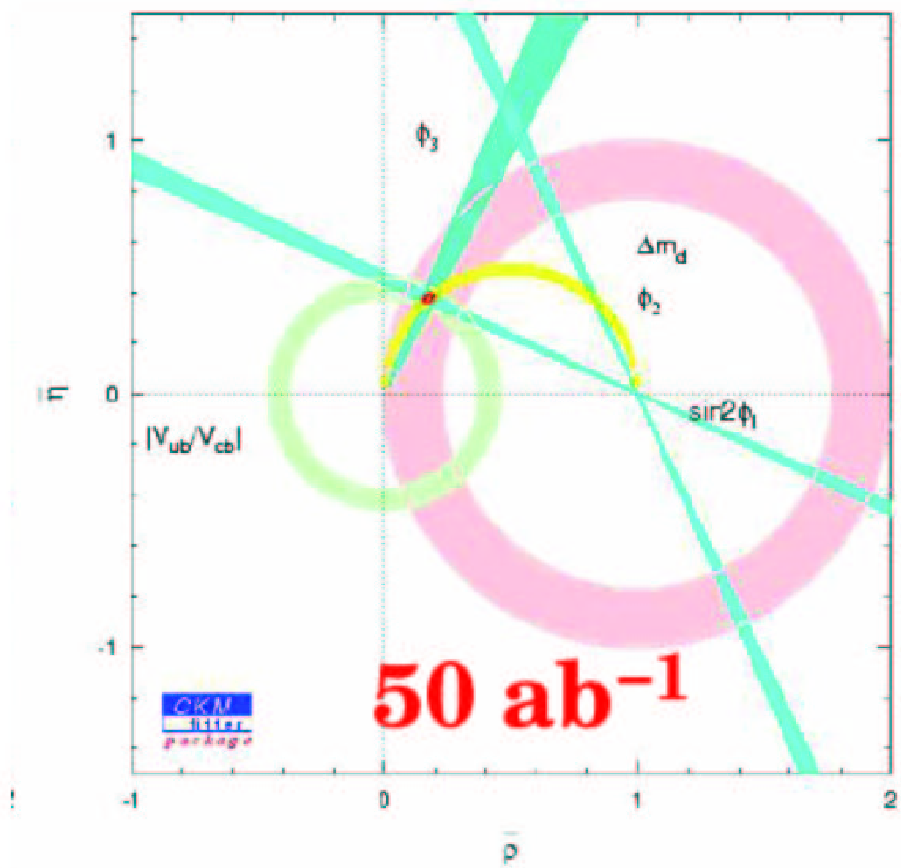
CKM Unitarity Triangle

Present



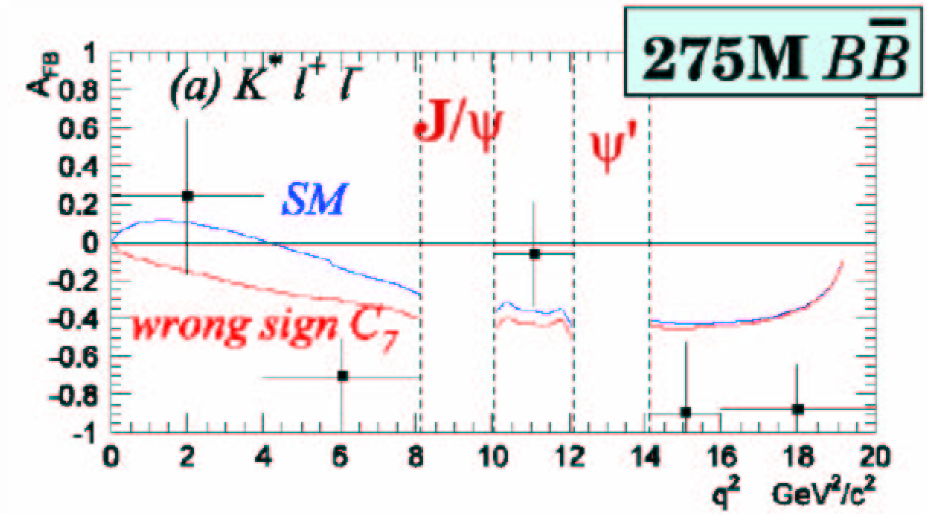
HFAG
hep-ex/0505100

Super B Factory



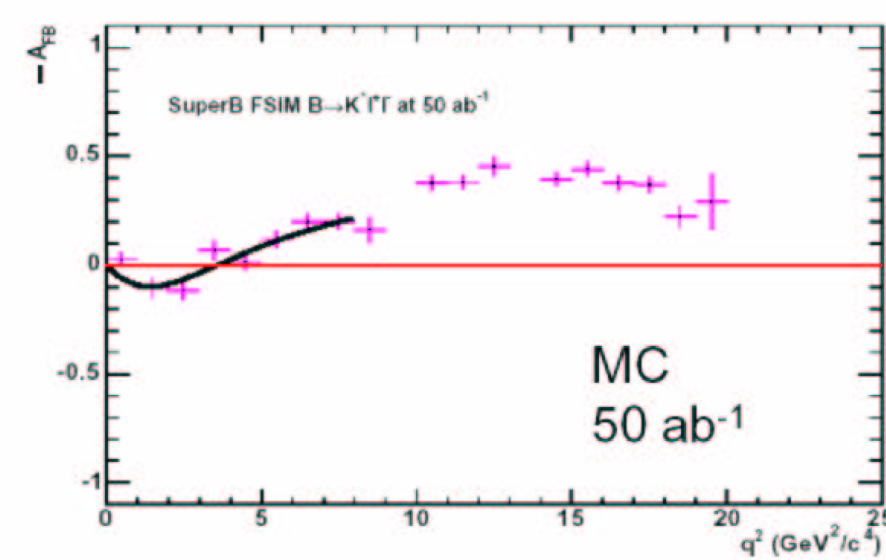
$B \to K^* l^+ l^-$ FB Asymmetry

- Sensitive test of new physics
- Can determine sign of C7
- Can measure C9 and C10



Belle

hep-ex/0410006

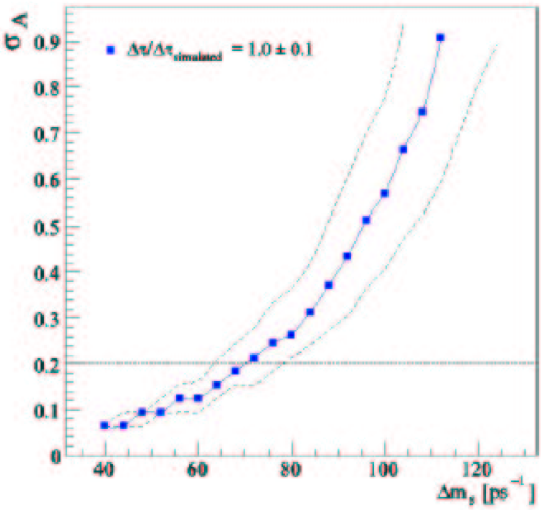


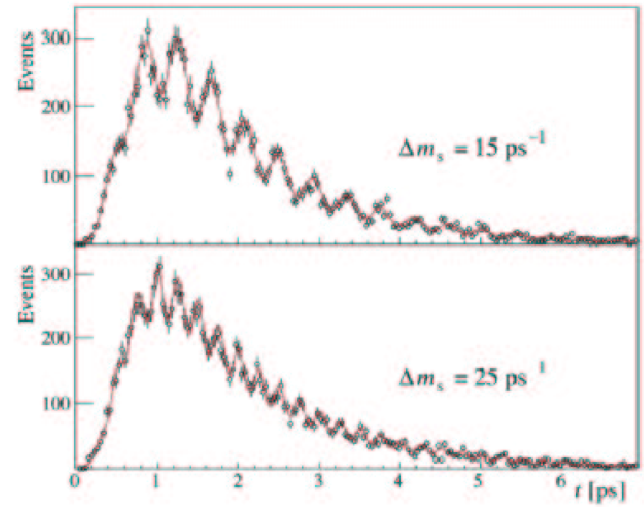
Super B factory

Opposite sign

Δm_s from $B_s \to D_s^{\pm}\pi^{\mp}$

with $B_s \to D_s^{\pm}\pi^{\mp}$, $D_s^{\pm} \to \phi\pi^{\pm}$ and $\phi \to K^+K^-$





$$\mathcal{A}^{\text{flav}} = -D\frac{\cos(\Delta m_s t)}{\cosh(\Delta\Gamma_s t)}$$

- 80K events/year
- $S/B \approx 3.1$
- 5σ observation possible up to $\Delta m_s = 68\ \mathrm{ps}^{-1}$
- Once measured: $\sigma(\Delta m_s) = 0.01\ \mathrm{ps}^{-1}$.

CLEOc: Precise f_D and Br(D, D_s)

Tevatron: Charm Rare Decay/CP Starting

BaBelle: What about τ Decays?

Organizers: EDM Part of WG2?

News on PentaQuarks: RIP

Conclusions

Rich variety of existing results

- kaon *CP* violation mostly complete
- exciting rare decays $K_L \rightarrow \pi^0 \nu \bar{\nu}$
- incredibly rich program from BaBelle and Tevatron
- taunting "discrepancies"
  - $\sin 2\beta(J/\psi K_S) \leftrightarrow \sin 2\beta(\phi K_S)$

    $2 - 3.7\sigma$ depends on faith in theory
- measurements for all angles!!
- B_s mixing analysis took first step at Tevatron
- overall SM has survived well

Bright outlook for the future

- LHCb and SuperB will take over coherently in 2007/8