

Highlights from Flavor Physics

- ➊ The Physics Program
- ➋ The CKM Matrix and the Unitary Triangle
- ➌ The Unitary Triangle by Sides
- ➍ The Unitary Triangle by Angles
- ➎ Search for N.P. & Constraints on the SM
- ➏ Conclusions & Perspectives

B-Physics Program

Study the flavor sector of the S.M. and search for new physics:

- Unitary Triangle
- CP Violation in B decays
- rare processes involving B,D mesons and τ leptons

A Disclaimer:

- B-experiments released several hundred articles to-date
- Many very interesting measurements ~ constant publishing rate
- Will only highlight the most important (based on my own judgment)



TOPICS:

- ★ The Physics Program
- The CKM Matrix and the Unitary Triangle
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The CKM matrix

- Expresses in the Standard Model the coupling between quarks of different flavor
- Four independent parameters, three Euler's angles and one phase

$$V_{CKM} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}$$

- CKM paradigm :

All CP violating phenomena in transitions between hadrons are described in terms of a unique parameter, the CKM phase

The Wolfenstein Parameterization

An approximation, precise to $o(\lambda^3)$, underlining the observed
(yet unexplained) hierarchy of CKM parameters

$$V_{CKM} \simeq \begin{bmatrix} 1 - \lambda^2/2 & \lambda & A\lambda^3(\rho + i\eta) \\ -\lambda & 1 - \lambda^2/2 & A\lambda^2 \\ A\lambda^3(1 - \bar{\rho} + i\bar{\eta}) & -A\lambda^2 & 1 \end{bmatrix}$$

$$\lambda = \sin \theta_C = 0.2258 \pm 0.0011$$

$$A, \rho, \eta = o(1)$$

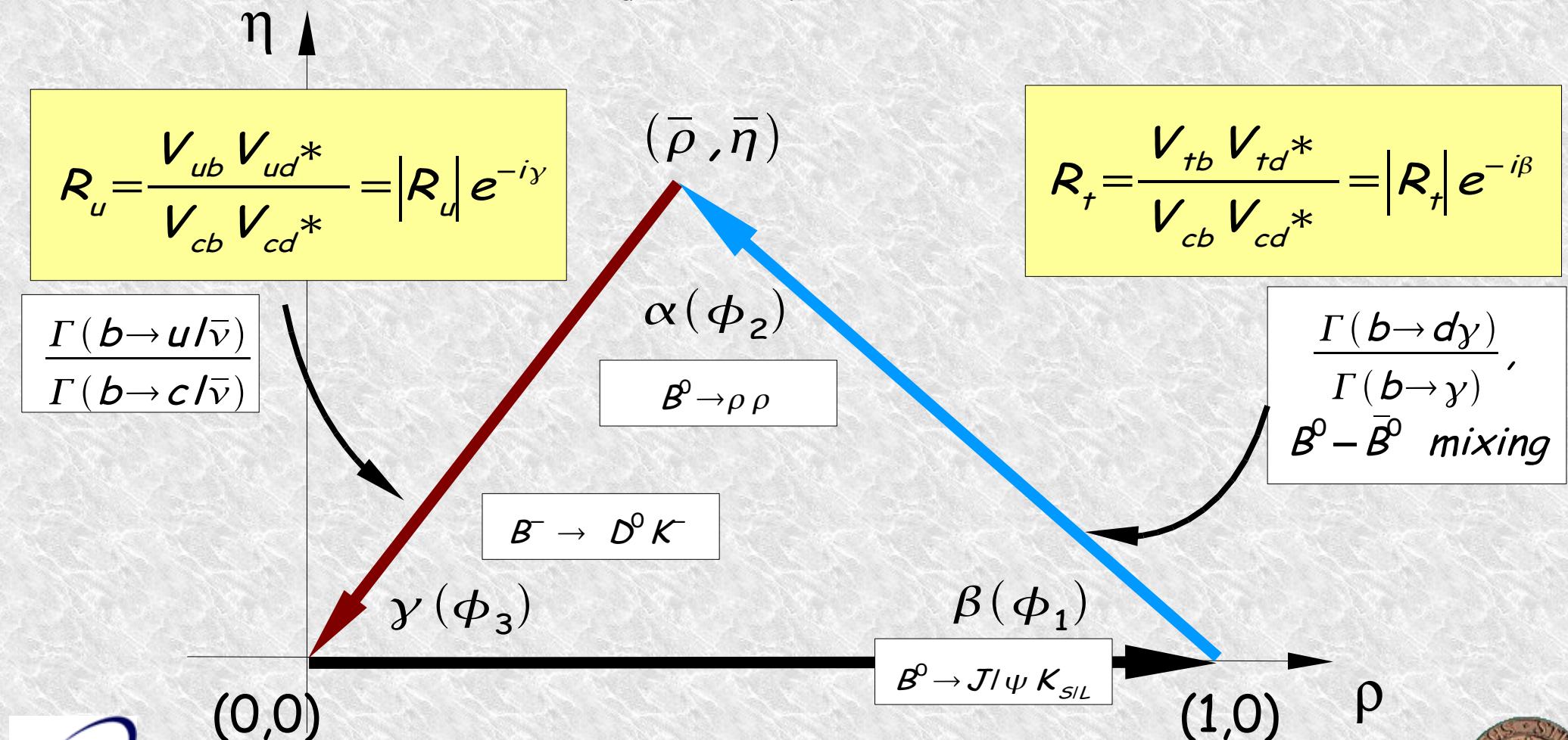
$$\bar{\rho} = \rho \cdot (1 - \lambda^2/2)$$

$$\bar{\eta} = \eta \cdot (1 - \lambda^2/2)$$

CP Violation : $\eta \neq 0$

CKM and the Unitarity Triangle

- Unitarity Condition: $V_{ub} V_{ud}^* + V_{cb} V_{cd}^* + V_{tb} V_{td}^* = 0$
- Rescaled Triangle: $R_u + 1 + R_t = 0$

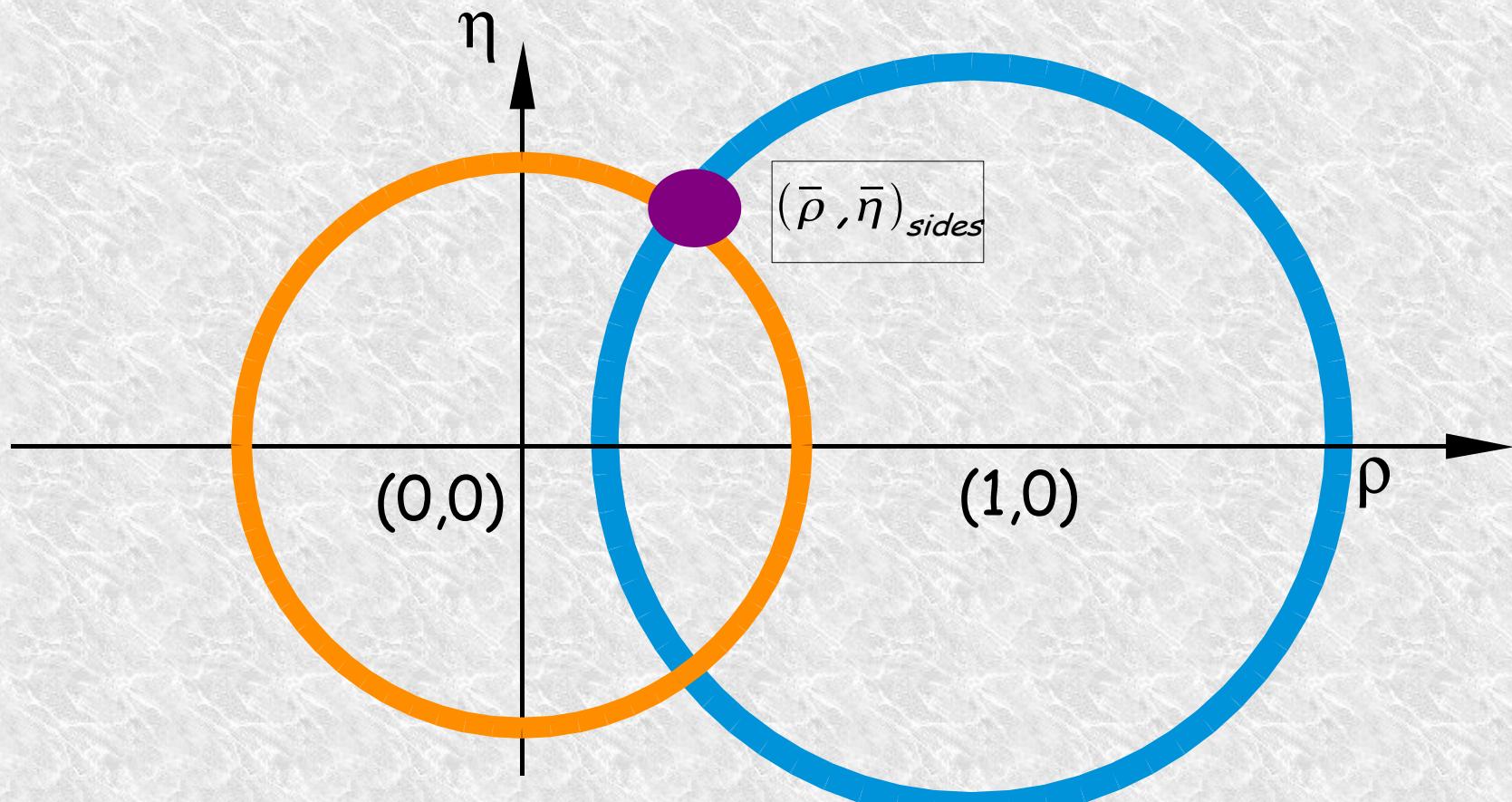


Constraining the UT

- Determine sides and angles of the UT
- Consistency: get apex coordinates (ρ, η) of UT

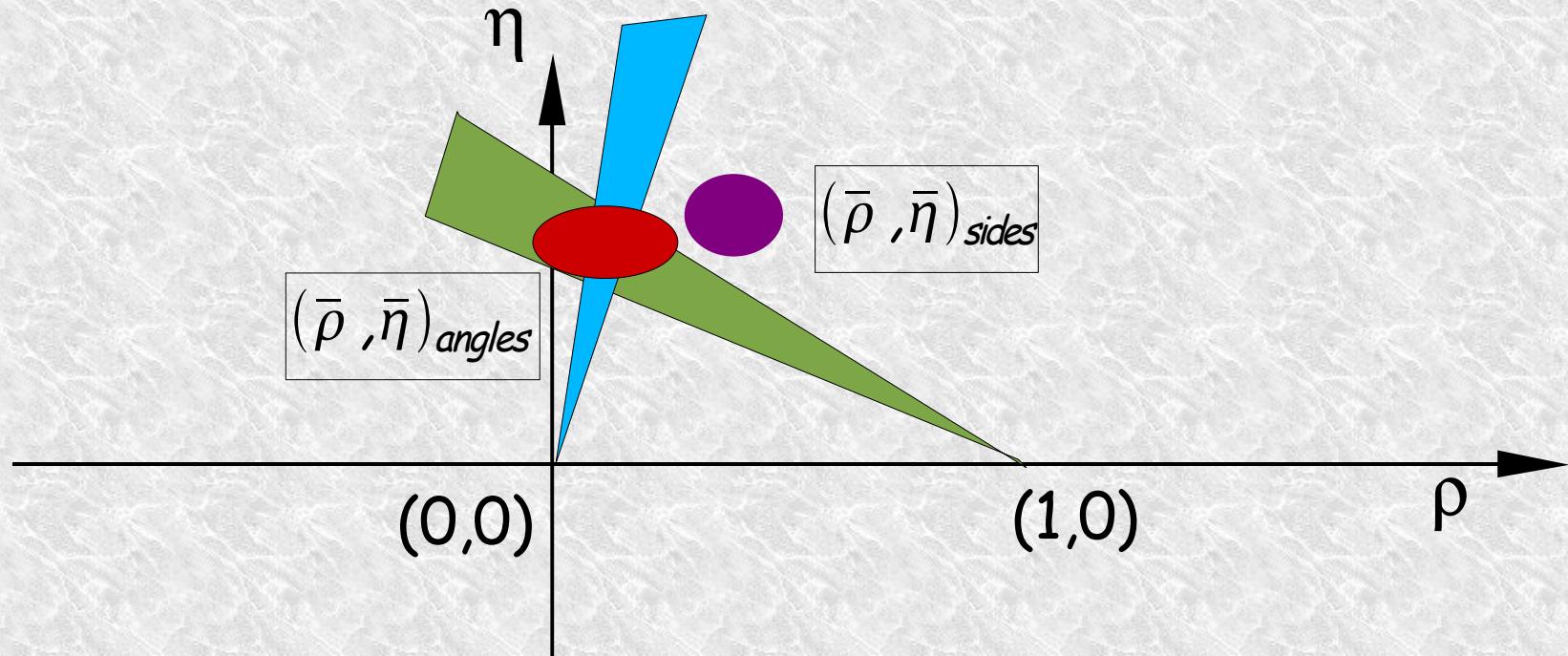
Constraining the UT

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 - by intersecting sides ($|R_u|, |R_f|$)



Constraining the UT

- Determine sides and angles of the UT
- Consistency: get apex coordinates (ρ, η) of UT
 - by intersecting sides ($|R_u|, |R_f|$)
 - by intersecting angles (α, β, γ)



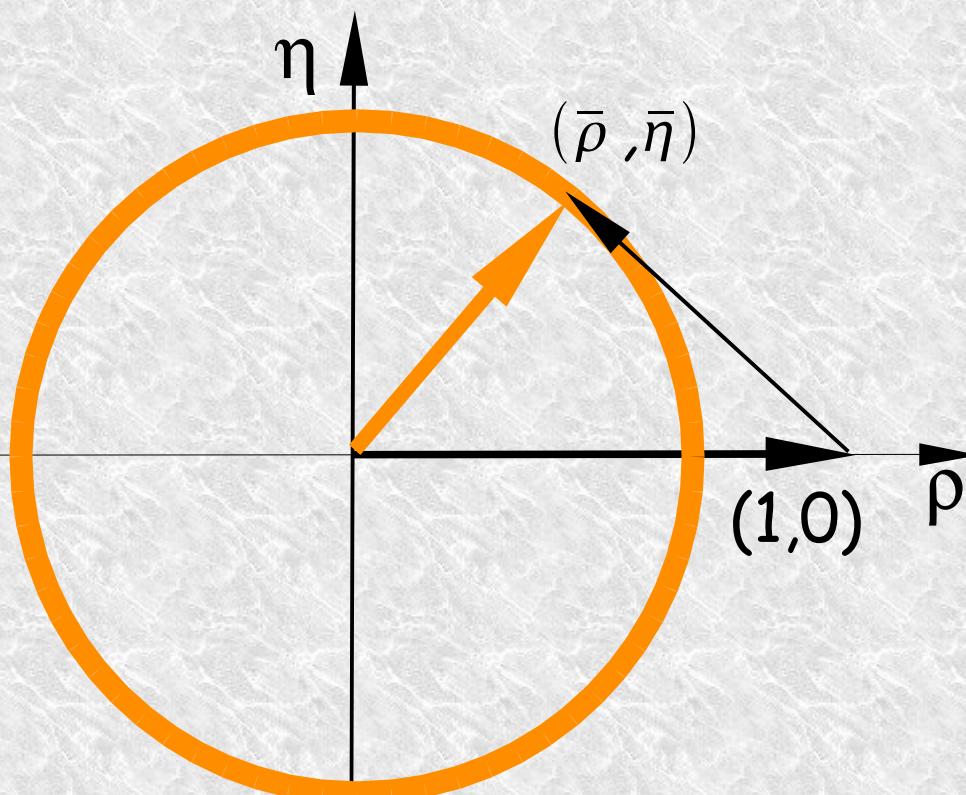
Mismatch: New Physics beyond the S.M.

TOPICS:

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- ★ **The Unitary Triangle by Sides**
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The sides : $|R_u|$

$$|R_u| = \left| \frac{V_{ub} V_{ud}^*}{V_{cb} V_{cd}^*} \right| = \frac{1}{\tan \theta_c} \left| \frac{V_{ub}}{V_{cb}} \right| = \bar{\rho}^2 + \bar{\eta}^2$$



$$\sin \Theta_c = 0.2258 \pm 0.0011$$

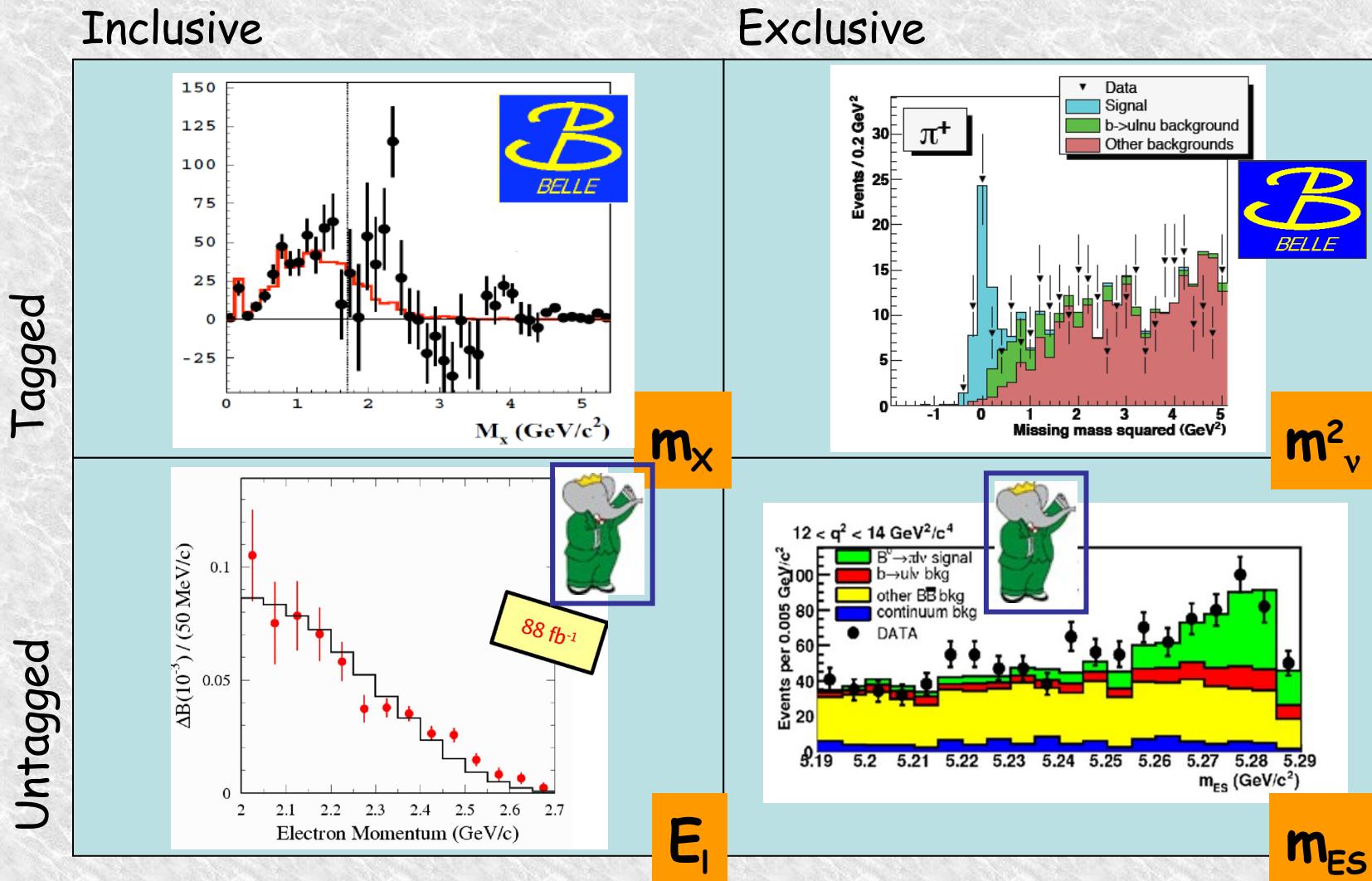
$$|V_{cb}| = (41.6 \pm 0.7) \times 10^{-3}$$

HFAG 2007

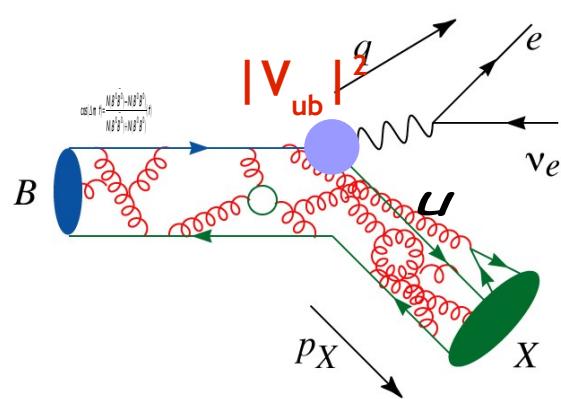
Error dominated by $|V_{ub}|$ measurement

Determination of $|V_{ub}|$

- Use semileptonic decays:



Inclusive Spectra

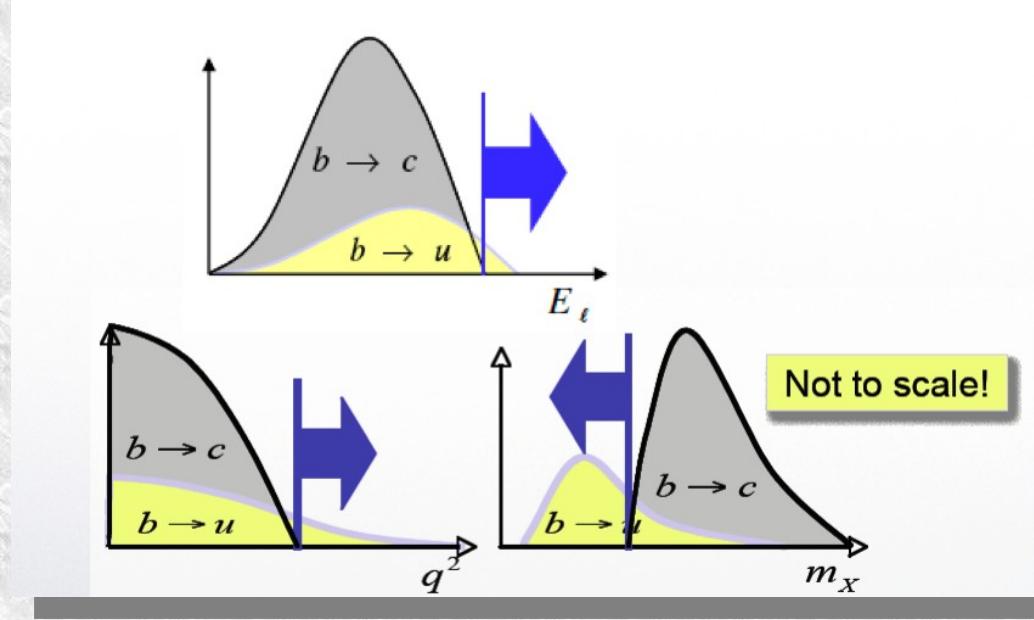


$$\Gamma(b \rightarrow u/\bar{v}) \propto |V_{ub}|^2$$

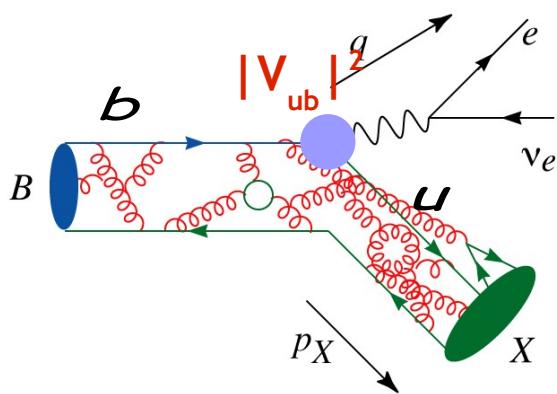
OPE : $|V_{ub}|$ from $\Gamma(b \rightarrow u/\bar{v})$ with 5% error

- Apply hard cuts to reduce $b \rightarrow c/\bar{v}$ background

$$\frac{\Gamma(b \rightarrow c/\bar{v})}{\Gamma(b \rightarrow u/\bar{v})} \simeq 50$$



Inclusive Spectra



$$\Gamma(b \rightarrow u/\bar{\nu}) \propto |V_{ub}|^2$$

OPE : $|V_{ub}|$ from $\Gamma(b \rightarrow u/\bar{\nu})$ with 5% error

- Apply hard cuts to reduce $b \rightarrow c/\bar{v}$ background

$$\frac{\Gamma(b \rightarrow c/\bar{\nu})}{\Gamma(b \rightarrow u/\bar{\nu})} \simeq 50$$

- Measure *partial Branching Ratio* ΔBr ,
get $u/\bar{\nu}$ decay width:

$$\Gamma(b \rightarrow u/\bar{\nu}) = \frac{\Delta Br}{\tau_B} \cdot f_u$$

- Acceptance correction f_u : QCD-inspired models, educated by data

non perturbative
"shape function"

$$f_u = \iiint H(q^2, E_1, M_X) \otimes F(\tilde{k} \wedge m_b, \Lambda, \mu_\pi^2, \dots)$$

parton level



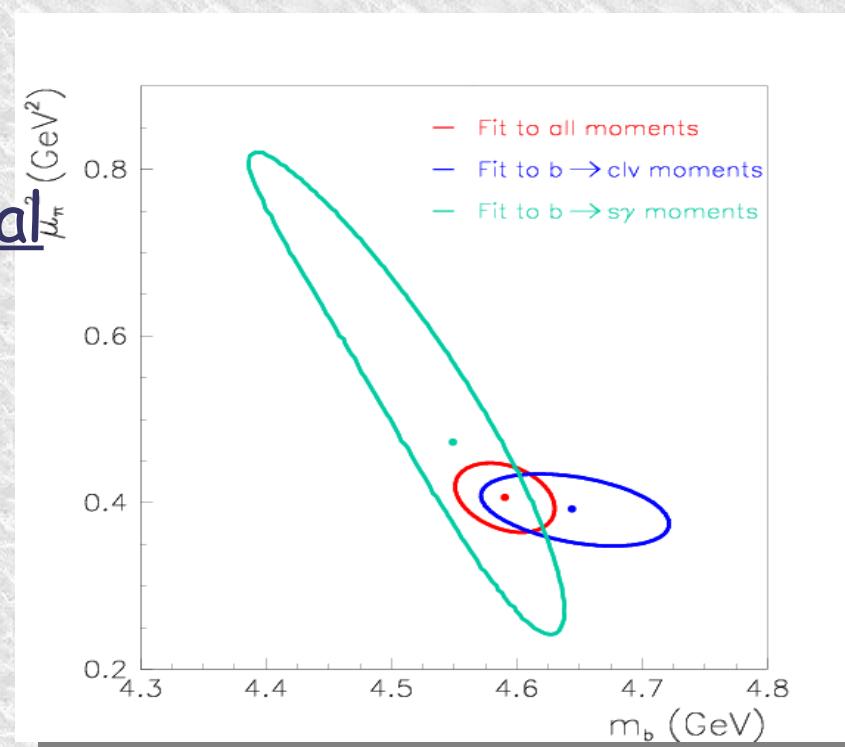
The infamous Shape Function

f_u depends on non-perturbative parameters

- m_b : b-quark mass
- μ_π^2 : b-quark kinetic energy in B hadron rest frame
- Λ : motion of the light quark
- ...

determined in the ansatz of an universal
(shape) function from moments of:

- E_γ ($b \rightarrow s\gamma$ decays)
- E_{lep}, M_{had} ($b \rightarrow c\bar{c}$ decays)



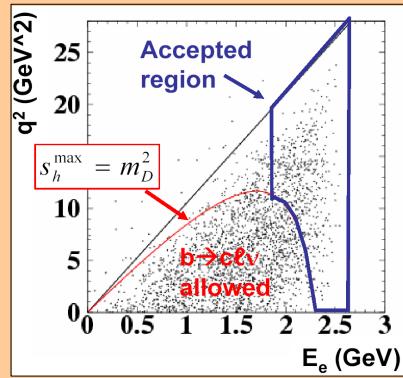
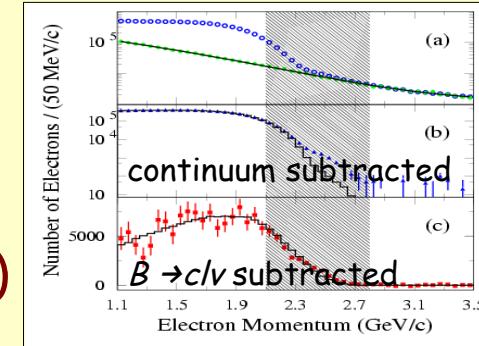
$|V_{ub}|$: inclusive measurements

E_e end point (80 fb^{-1})

CLEO (1994) : $E_e > 2.3 \text{ GeV}$, (c threshold)

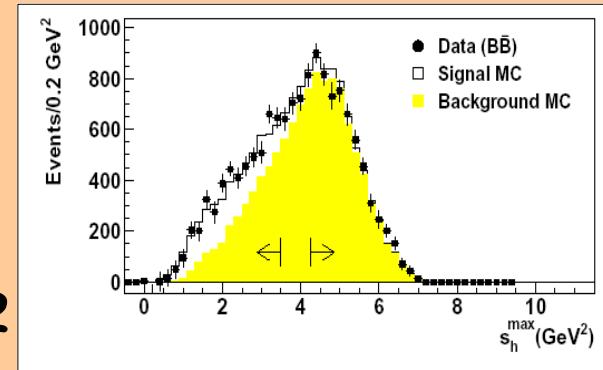
BABAR,Belle: $E_e > 2.0, 1.9$ (↓ model uncertainty)

$$S/B \sim 1/14, f_u = 0.250 \pm 0.026$$

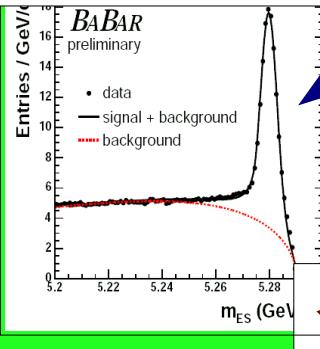


$E_e - q^2$ (80 fb^{-1})

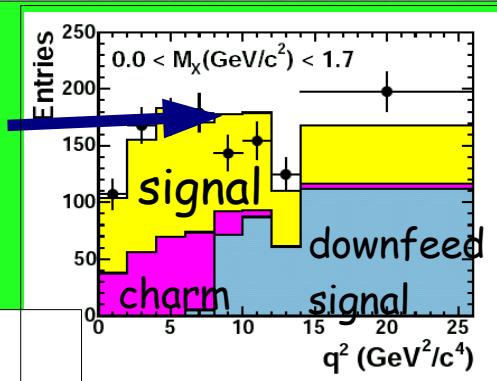
\vec{p}_ν from missing momentum
correlated cut to reduce c
 $S/B \sim 1/2, f_u = 0.163 \pm 0.012$



Recoil Hadrons



Fully reconstruct tag B (↓ efficiency)
Mass (M_x) and q^2 of recoil hadrons (X_u)
Count events in high- q^2 , low- M_x bin
 $S/B > 1/1, f_u = 0.300 \pm 0.026$



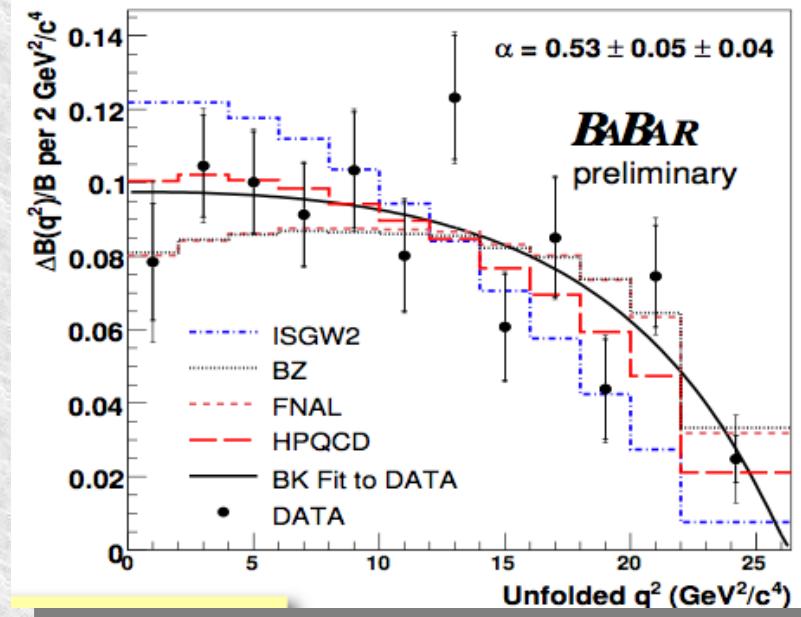
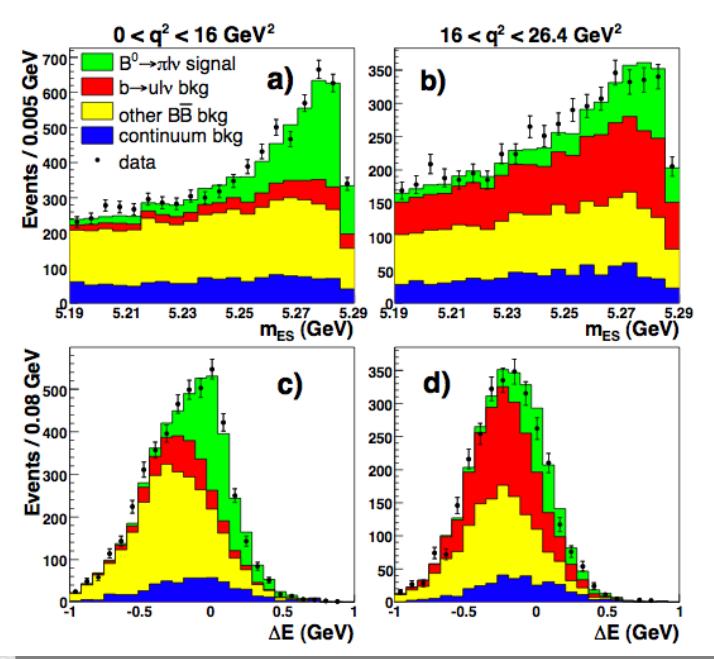
$|V_{ub}|$ from $B \rightarrow \pi l \nu_l$

- Exp. : measure

$$\frac{d\Gamma(B \rightarrow \pi l \nu)}{dq^2 d \cos \theta_\ell} = |V_{ub}|^2 \frac{G_F^2}{32\pi^3} |\vec{p}_\pi|^3 \sin^2 \theta_\ell |f^+(q^2)|^2$$

- Th. : compute F.F.:

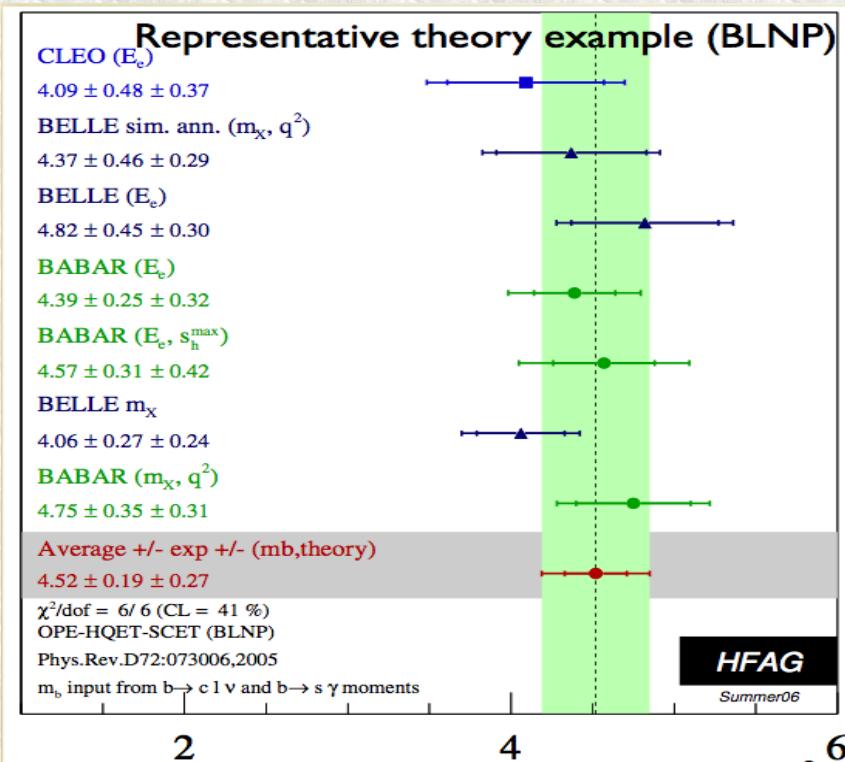
$\left\{ \begin{array}{l} \text{LCQD } (q^2 > 16 \text{ GeV}^2) \\ \text{Light Cone Sum Rules (low } q^2) \end{array} \right.$



Experiments test theory

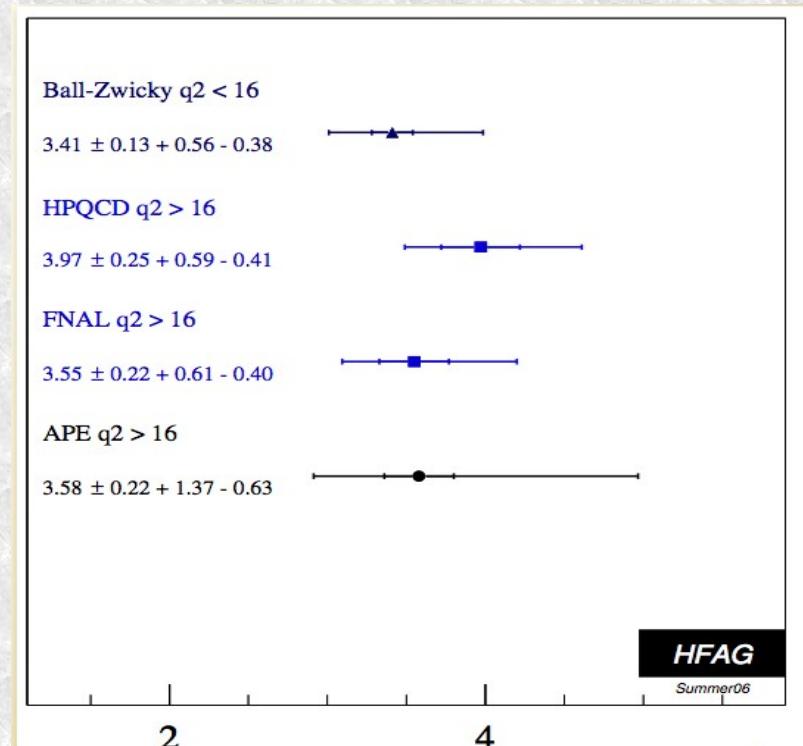
$|V_{ub}|$: results

Inclusive V_{ub}



$$|V_{ub}| * 10^3 = 4.49 \pm 0.19 \pm 0.27$$

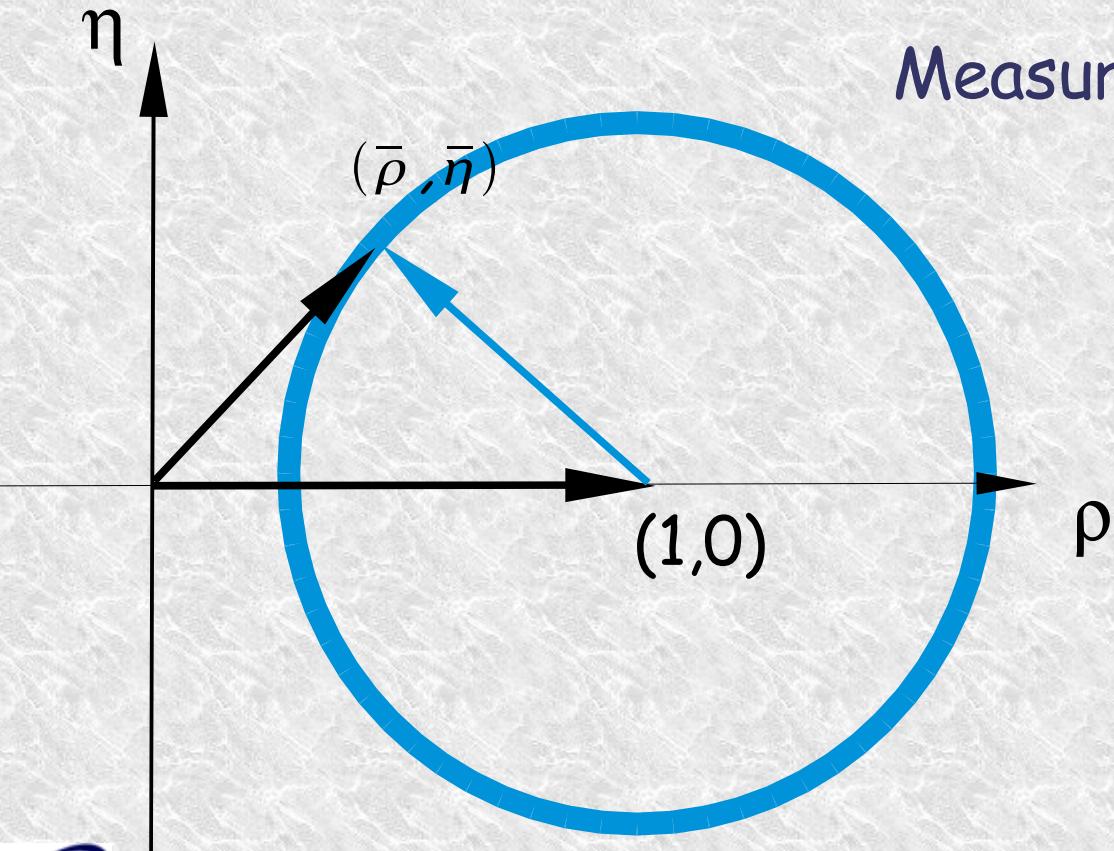
Exclusive V_{ub}



$$|V_{ub}| * 10^3 \in [3.3, 4.0]$$

The sides : $|R_t|$

$$|R_t| = \left| \frac{V_{tb} V_{td}^*}{V_{cb} V_{cd}^*} \right| = \frac{1}{\sin \theta_c} \left| \frac{V_{td}}{V_{cb}} \right| = (1 - \bar{\rho})^2 + \bar{\eta}^2$$



Measure $|V_{td}| / |V_{cb}|$ from :

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

$$\frac{\Gamma(b \rightarrow d\gamma)}{\Gamma(b \rightarrow s\gamma)}$$

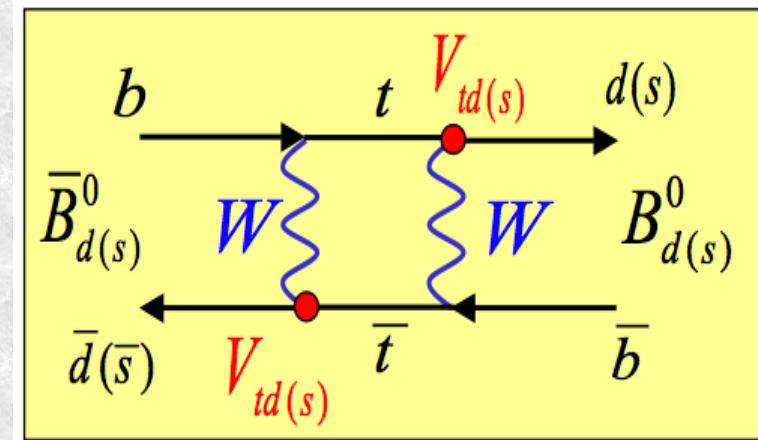
\mathcal{O}_{td} from $\mathcal{B}_d, \mathcal{B}_s$ mixing

Δm_q : frequency of $\Delta B = 2$, $\Delta q = -2$ ($q=s,d$) flavor oscillation

Standard Model predicts:

$$\frac{\Delta m_d}{\Delta m_s} = \frac{m_{Bd}}{m_{Bs}} \frac{1}{\xi^2} \frac{|V_{td}|^2}{|V_{ts}|^2} \sim \frac{m_{Bd}}{m_{Bs}} \frac{1}{\xi^2} \frac{|V_{td}|^2}{|V_{cb}|^2}$$

$$\xi = \frac{f_{Bs} \sqrt{B_{Bs}}}{f_{Bd} \sqrt{B_{Bd}}} = 1.24 \pm 0.06 \quad (LQCD)$$



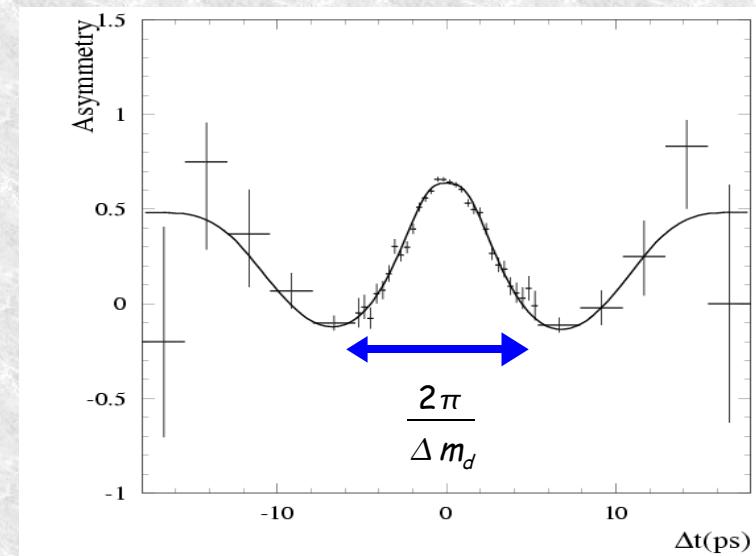
Exp.: measure fraction of "mixed" events vs proper time:

$$\cos(\Delta m \cdot t) = \frac{N(B^0 \bar{B}^0) - N(B^0 B^0)}{N(B^0 \bar{B}^0) + N(B^0 B^0)}(t)$$

$|V_{td}|$: results

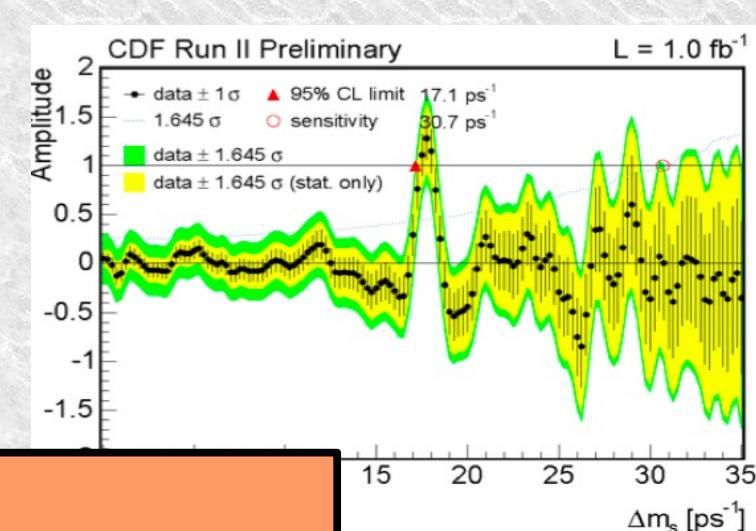
- B-factories

$$\Delta m_d = 0.505 \pm 0.05 \text{ ps}^{-1}$$



- CDF (Tevatron):

$$\Delta m_s = (17.77 \pm 0.10 \pm 0.07) \text{ ps}^{-1}$$



$$\left| \frac{V_{td}}{V_{ts}} \right| = 0.2060 \pm 0.0007^{+0.0070}_{-0.0080}$$

Best measured parameters of B Physics

Franco Simonetto INFN & Universita' di Padova

UT side-view

Prediction from sides + CP(Kaon):

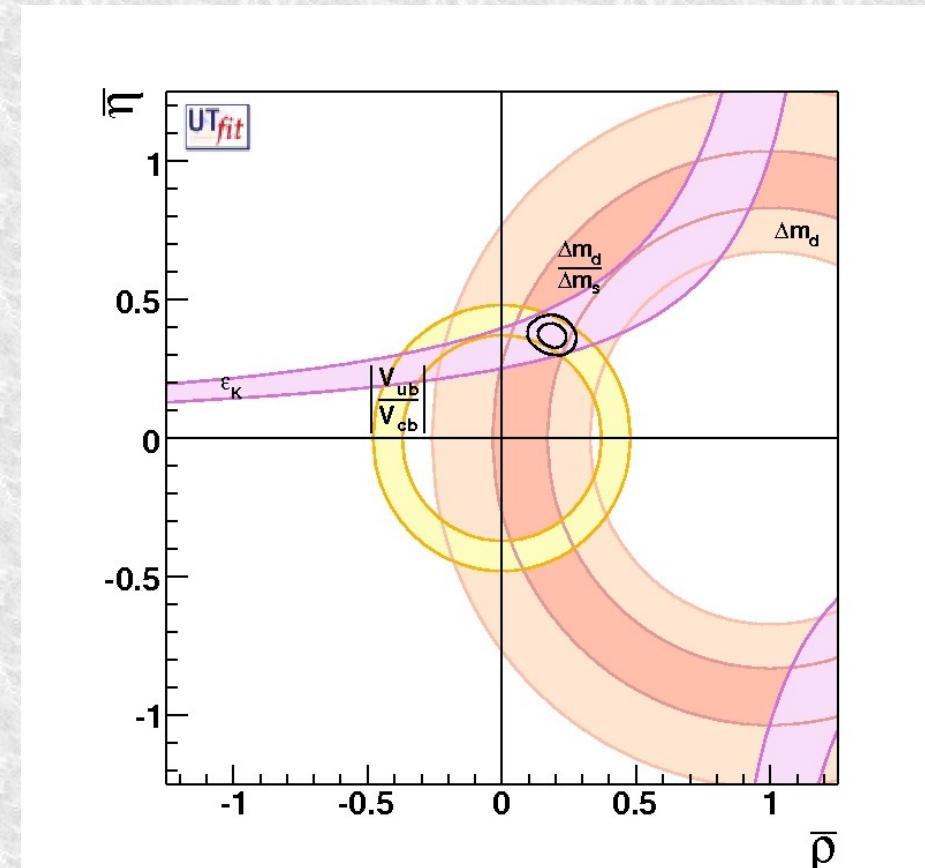
$$\bar{\rho} = 0.188 \pm 0.036$$

$$\bar{\eta} = 0.373 \pm 0.027$$

$$\sin 2(\alpha) = -0.06 \pm 0.18$$

$$\sin 2(\beta) = 0.759 \pm 0.039$$

$$\gamma = 63.3 \pm 4.9$$

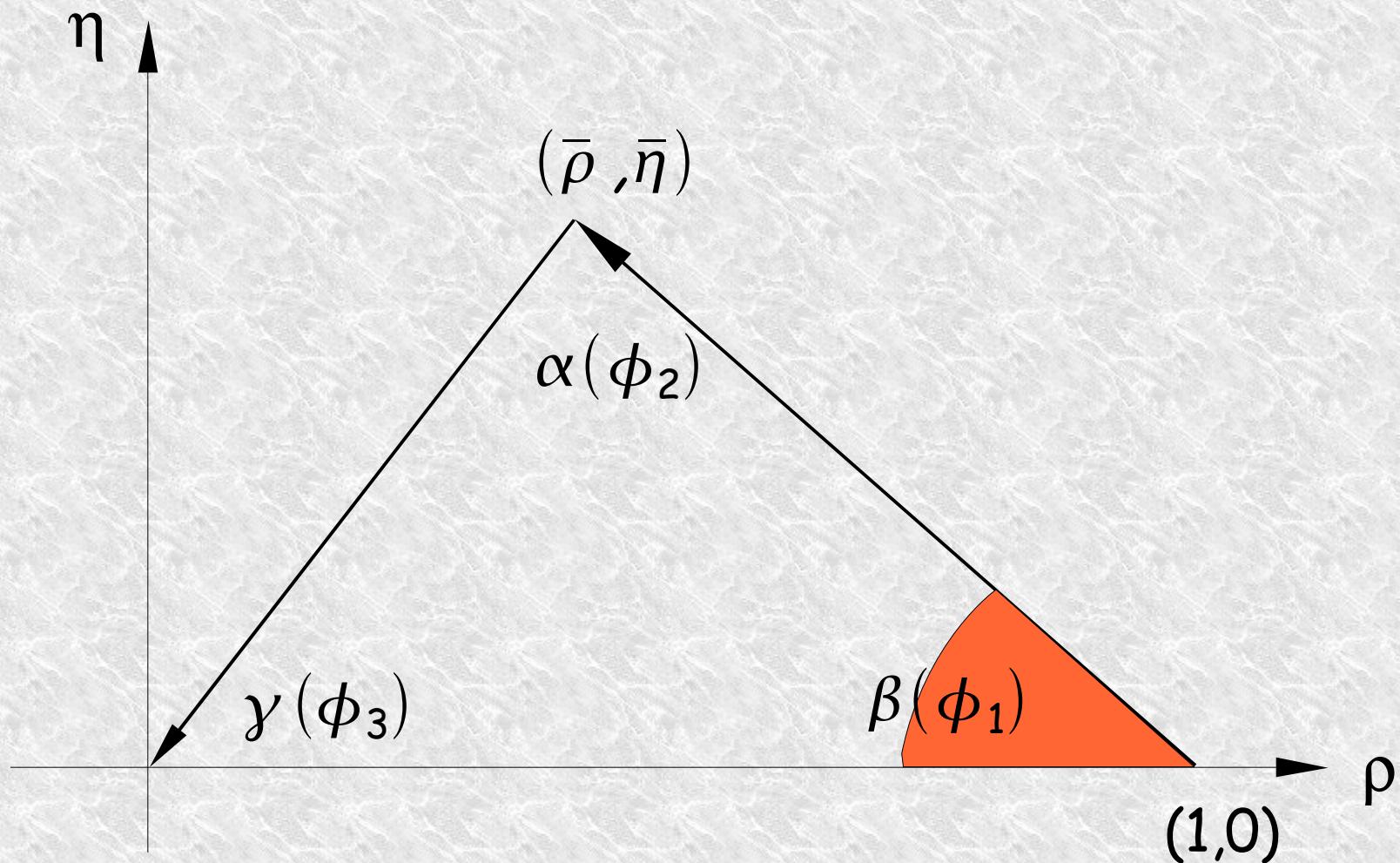


UT FIT :<http://utfit.roma1.infn.it/>

TOPICS:

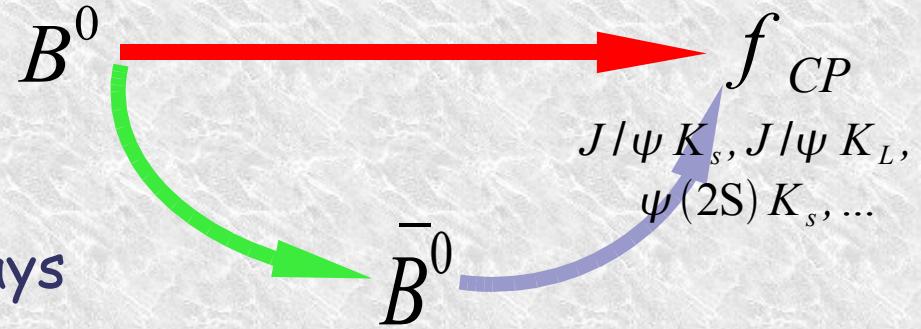
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UO angle-view: $\sin 2\beta$



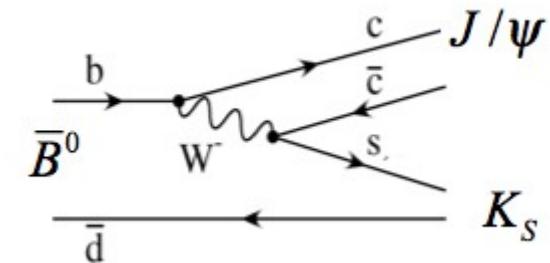
$\sin 2\beta$ from $b \rightarrow c\bar{c}s$

- Determined from interference of decays with and without mixing in $B^0 \rightarrow J/\psi K_{S/L}$



Th. clean:

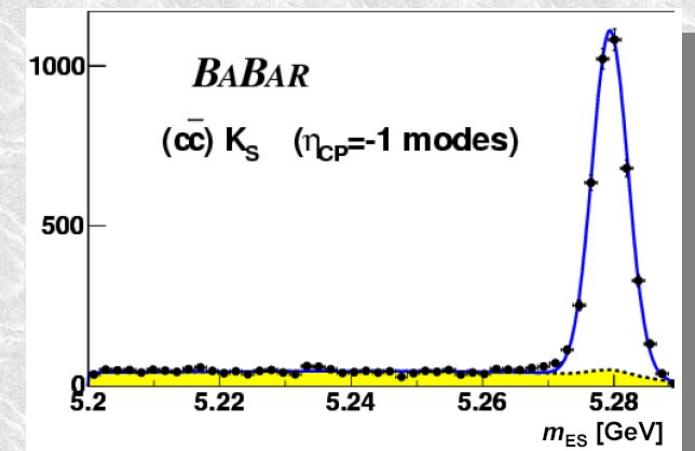
- Leading interfering penguin has same weak phase as tree
- Other weak phases reduced by $\mathcal{O}(\sin \Theta_c^2) \times \mathcal{O}(\alpha_s) \sim 1\%$



Exp. clean:

- "Large" B.R. $\mathcal{O}(\%)$
- Mass-constraints : low background

Golden Mode



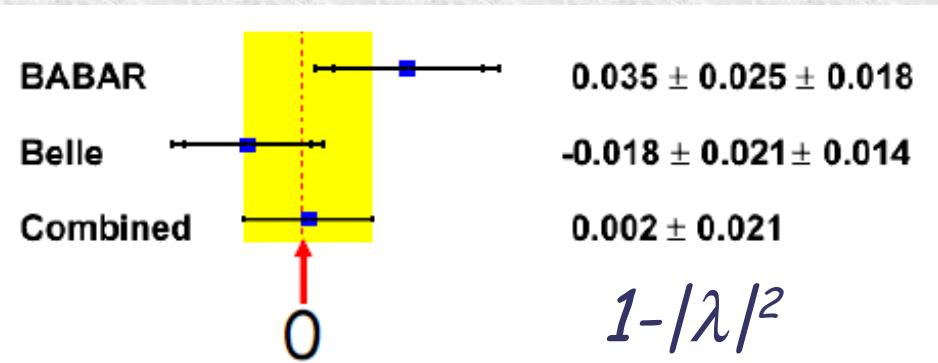
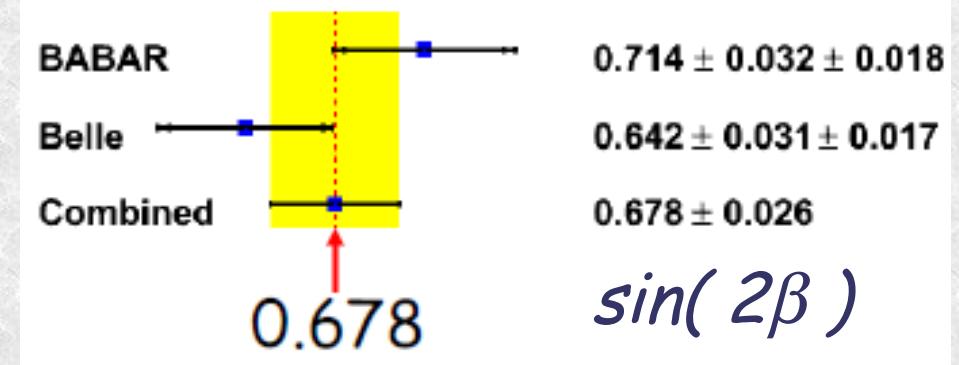
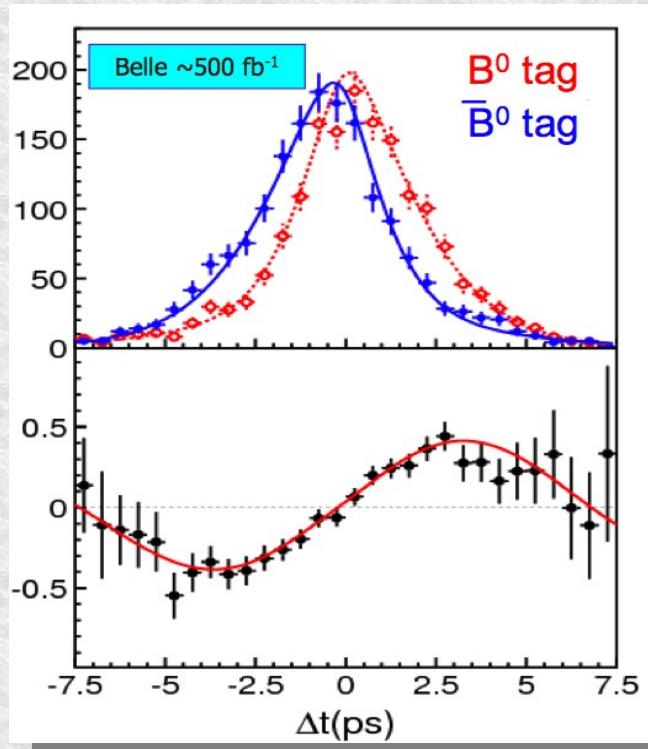
Time-dependent CP Asymmetry

$$A_{CP} = \frac{(B^0 \rightarrow J/\Psi K_{S/L}) - (\bar{B}^0 \rightarrow J/\Psi K_{S,L})}{(B^0 \rightarrow J/\Psi K_{S,L}) + (\bar{B}^0 \rightarrow J/\Psi K_{S,L})}(\Delta t) = \frac{\Im(\lambda)\sin(\Delta m\Delta t) + (1 - |\lambda|^2)\cos(\Delta m\Delta t)}{1 + |\lambda|^2}$$

$$\lambda = \frac{V_{tb} V_{td}^*}{V_{td} V_{tb}^*} \quad \frac{V_{cb} V_{cd}^*}{V_{cd} V_{cb}^*} \quad \frac{V_{cd} V_{cs}^*}{V_{cs} V_{cd}^*} = e^{-i2\beta}$$

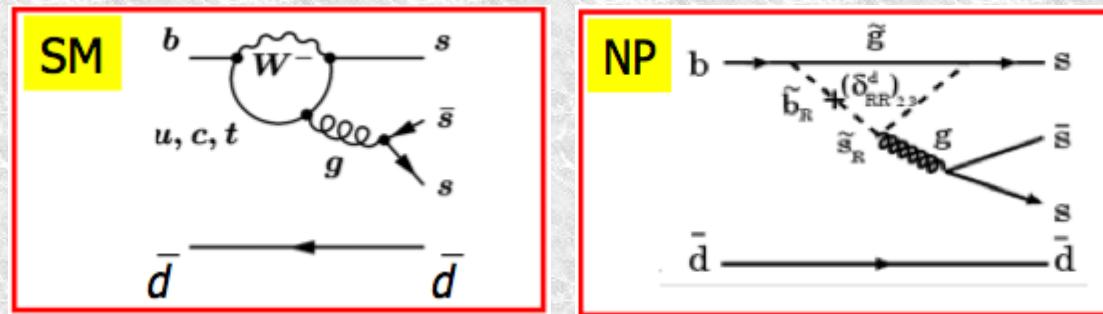
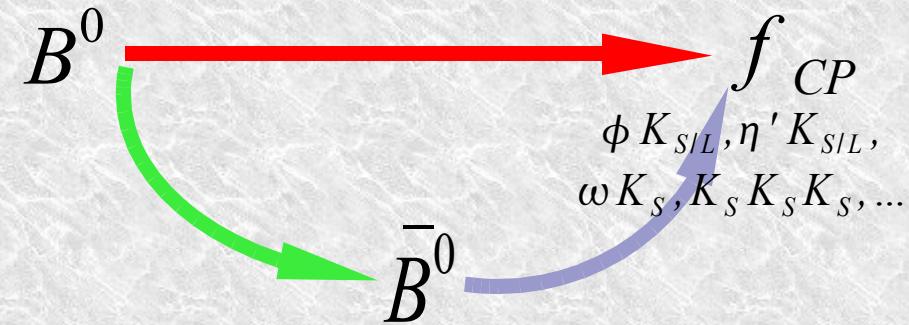
B mixing
B decay
K⁰ mixing

- λ is a pure phase
- $\text{Im}(\lambda) = \sin(2\beta)$



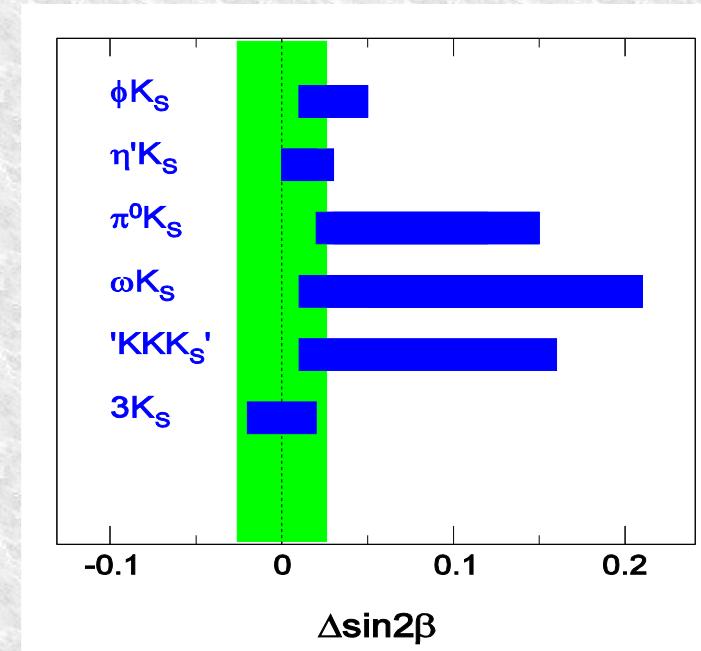
$\sin 2\beta$ from $b \rightarrow s\bar{s}s$

- No tree, penguin only
- Leading weak phase : β
- Other weak phases suppressed by $o(\sin \Theta_c)^2) \sim 5\%$

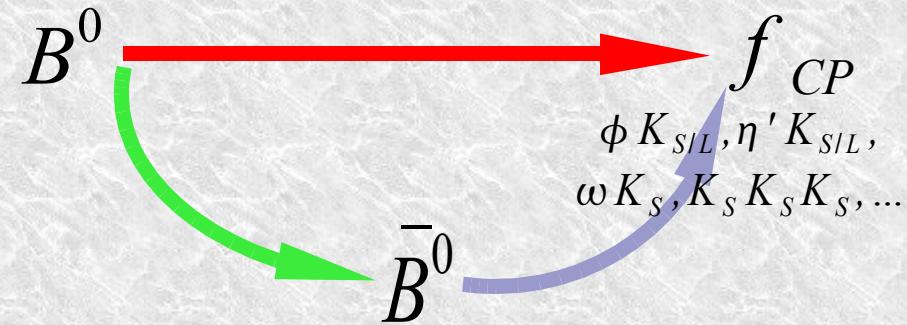


Other phases from SuSy ?

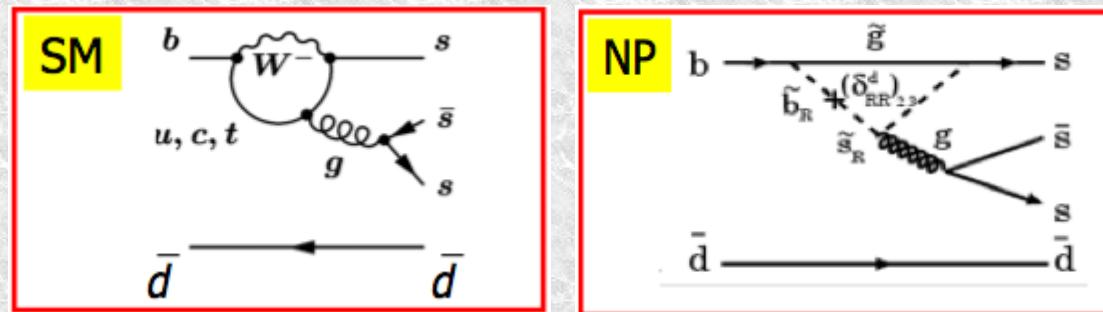
A test for New Physics:
compare to charmonium



$\sin 2\beta$ from $b \rightarrow s\bar{s}s$



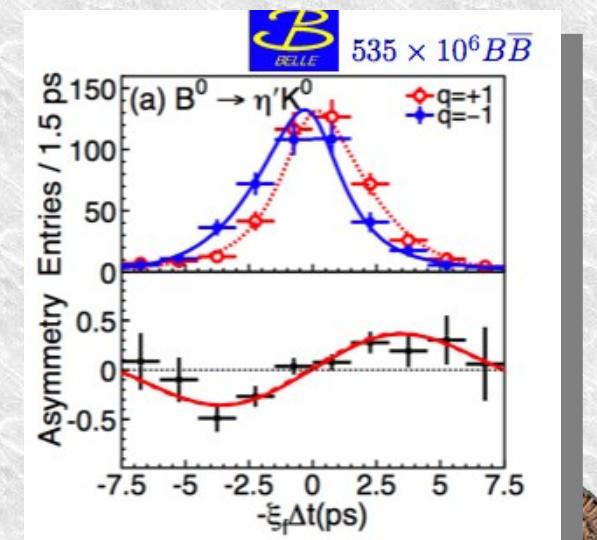
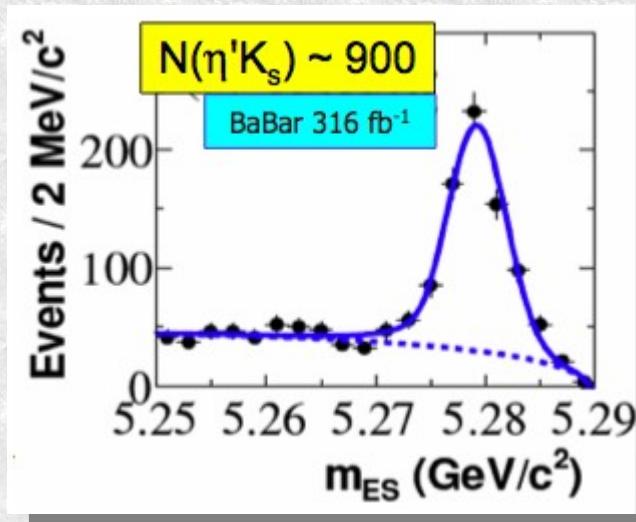
- No tree, penguin only
- Leading weak phase : β
- Other weak phases suppressed by $o(\sin \Theta_c)^2) \sim 5\%$



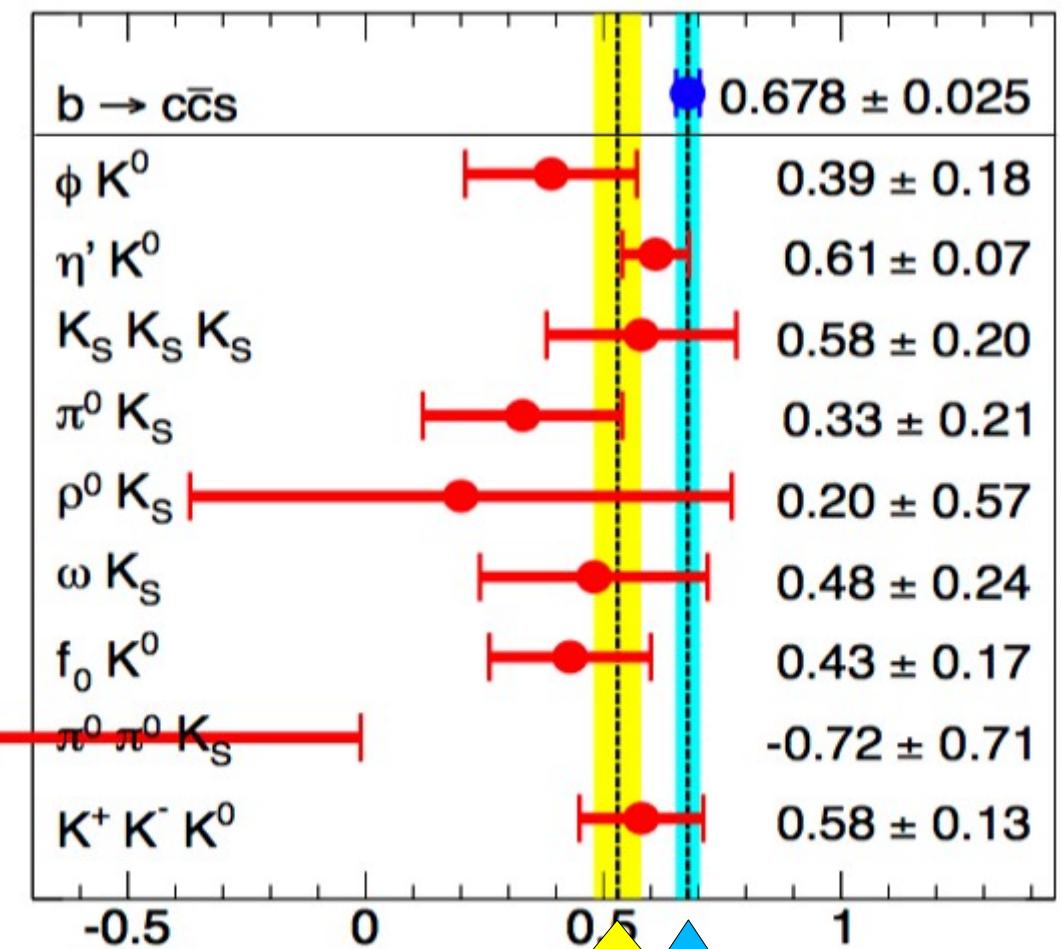
Other phases from SuSy ?

Exp Challenges:

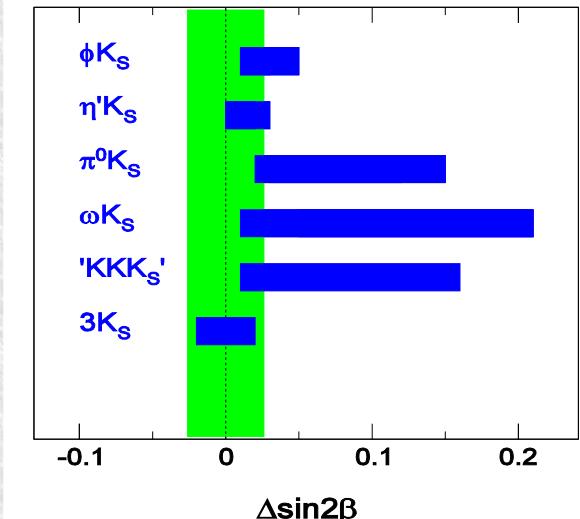
- Smaller BR ($10^{-4} - 10^{-5}$)
- Large bckg. (continuum)



$\sin 2\beta$ ss vs cc



B-factories
average



- Individual Modes Agree
- “Naive” average:
 $\sin 2\beta^{\text{eff}} = 0.53 \pm 0.05$
- 2.6σ wrt charmonium

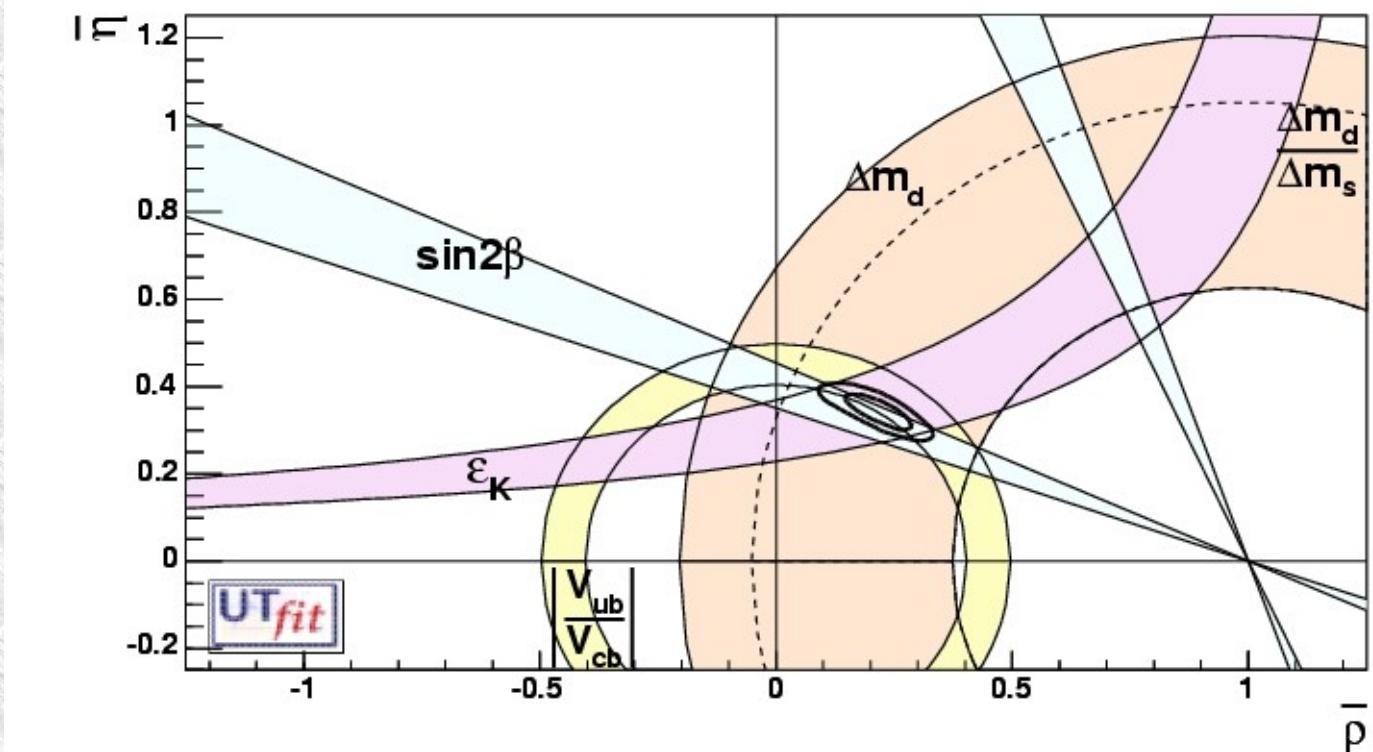


more stats for by-mode
significant test

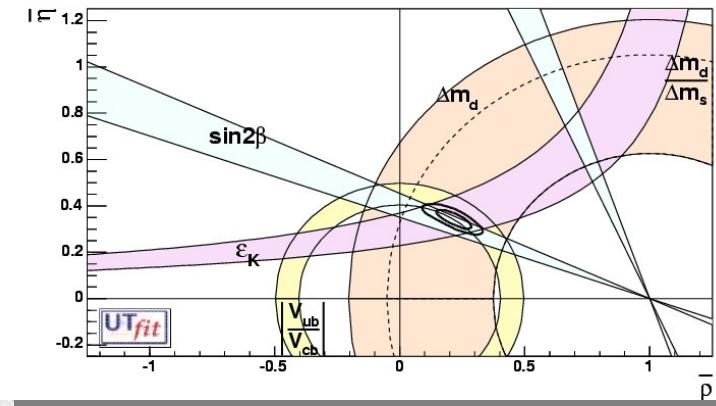
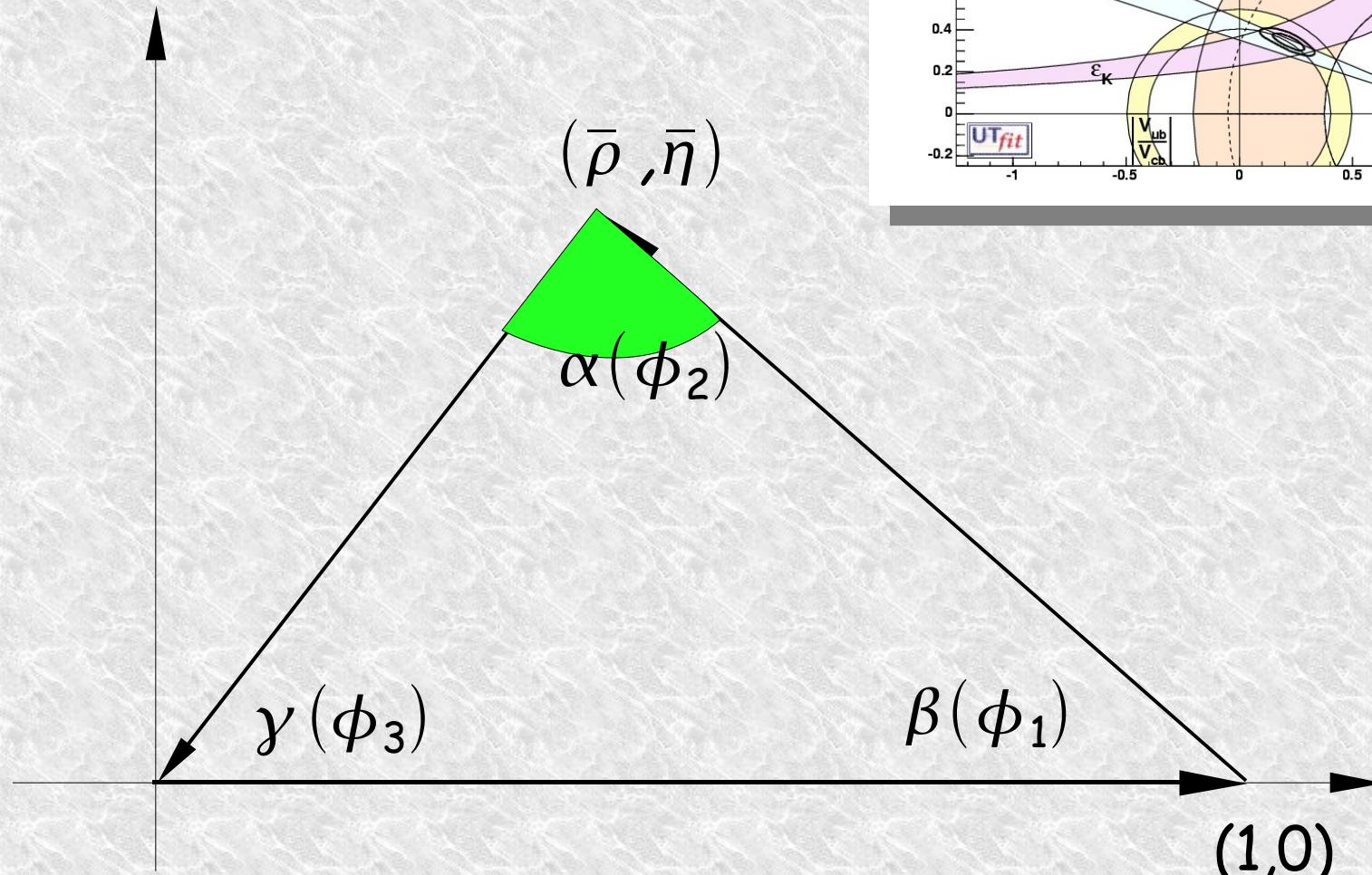
$\sin 2\beta$: prediction vs results

<i>BABAR</i> (380 fb ⁻¹)	$0.714 \pm 0.032 \pm 0.018$
<i>Belle</i> (500 fb ⁻¹)	$0.642 \pm 0.031 \pm 0.017$
Average sides + ϵ_K	0.678 ± 0.026
UT-fit prediction	0.759 ± 0.039

~ 2 σ "tension"?
More on Guido' talk



UT angle-view: $\sin 2\alpha$



$$\text{sides} + \epsilon_K + \sin 2\beta : \alpha = (93.1 \pm 5.8)^\circ$$

$\sin 2\alpha$ from $b \rightarrow u\bar{u}$

- Pure Tree :

$$\lambda = \frac{V_{td} V_{tb}^*}{V_{tb} V_{td}^*} \frac{V_{ub} V_{ud}^*}{V_{ud} V_{ub}^*} = e^{-i2\alpha}$$

- Penguin: another phase

$$\alpha \rightarrow \alpha_{eff.} = \alpha + \Delta \alpha$$

- Get T/P from Isospin:

$$\frac{1}{\sqrt{2}} A^+ - A^{00} = A^{+0}$$

$$\frac{1}{\sqrt{2}} A^- + \tilde{A}^{00} = A^{-0}$$

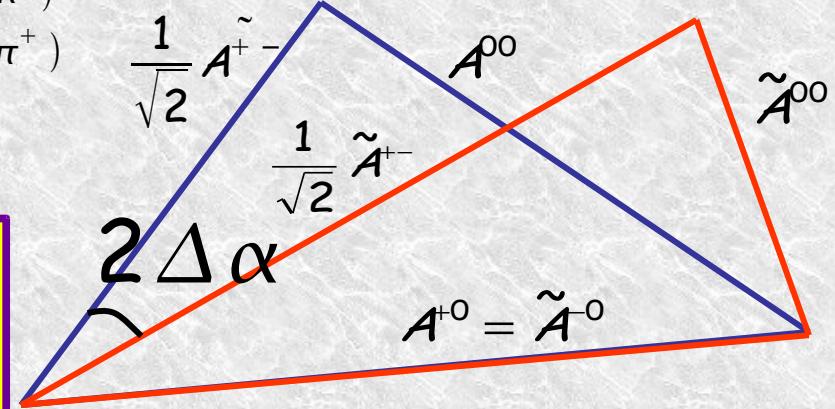
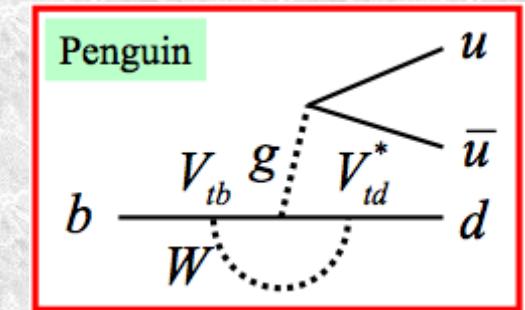
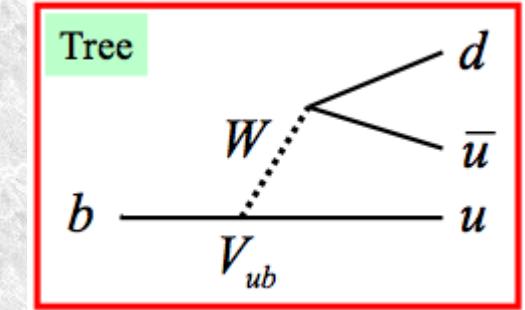
pure tree

$$A^{00} = A(B^0 \rightarrow \pi^0 \pi^0)$$

$$A^{+0} = A(B^+ \rightarrow \pi^0 \pi^+)$$

$$\dots$$

$$\sin^2(\Delta \alpha) \leq \frac{B(B^0 \rightarrow \pi^0 \pi^0) - B(\tilde{B}^0 \rightarrow \pi^0 \pi^0)}{B(B^+ \rightarrow \pi^+ \pi^0) - B(\tilde{B}^- \rightarrow \pi^- \pi^0)}$$



... and a similar triangle for ρ

Results

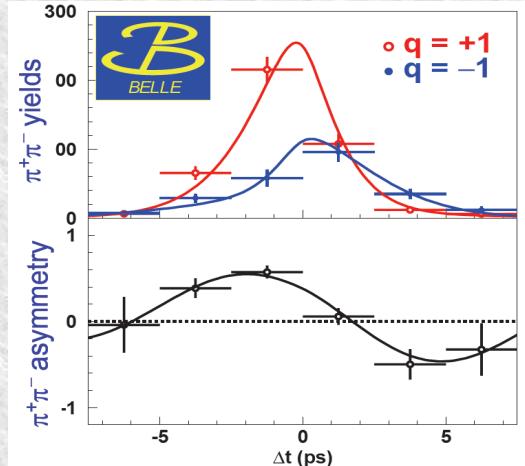
$$A_{CP} = \frac{(B^0 \rightarrow h^+ h^-) - (\bar{B}^0 \rightarrow h^+ h^-)}{(B^0 \rightarrow h^+ h^-) + (\bar{B}^0 \rightarrow h^+ h^-)}(\Delta t)$$

"direct" CP violation



$$C \cos(\Delta m \Delta t) + S \sin(\Delta m \Delta t)$$

$\sin 2\alpha_{\text{eff.}}$



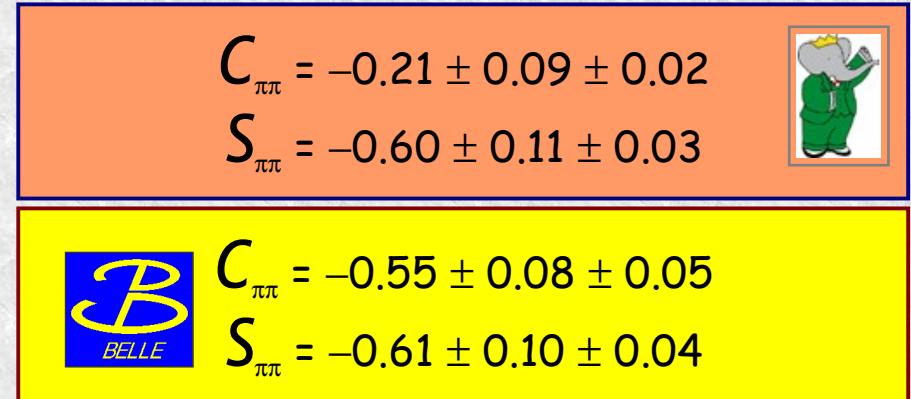
$\pi\pi$

$$\begin{aligned} C_{\pi\pi} &= 0.01 \pm 0.16 \pm 0.06 \\ S_{\pi\pi} &= -0.17 \pm 0.20 \pm 0.6 \end{aligned}$$

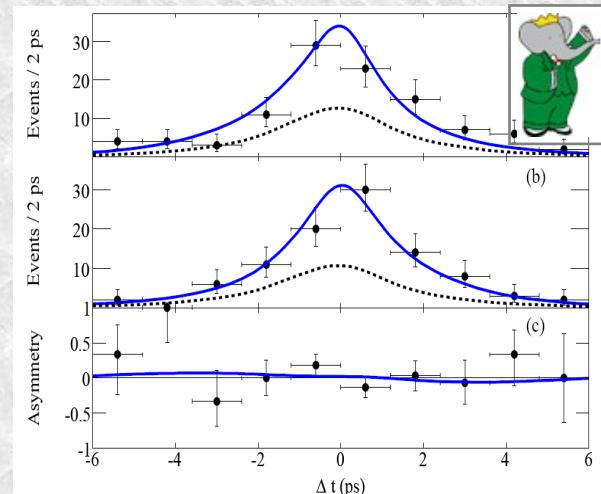


$$\begin{aligned} C_{\pi\pi} &= -0.16 \pm 0.21 \pm 0.07 \\ S_{\pi\pi} &= 0.19 \pm 0.30 \pm 0.07 \end{aligned}$$

pp



"Direct" CP > 5 σ

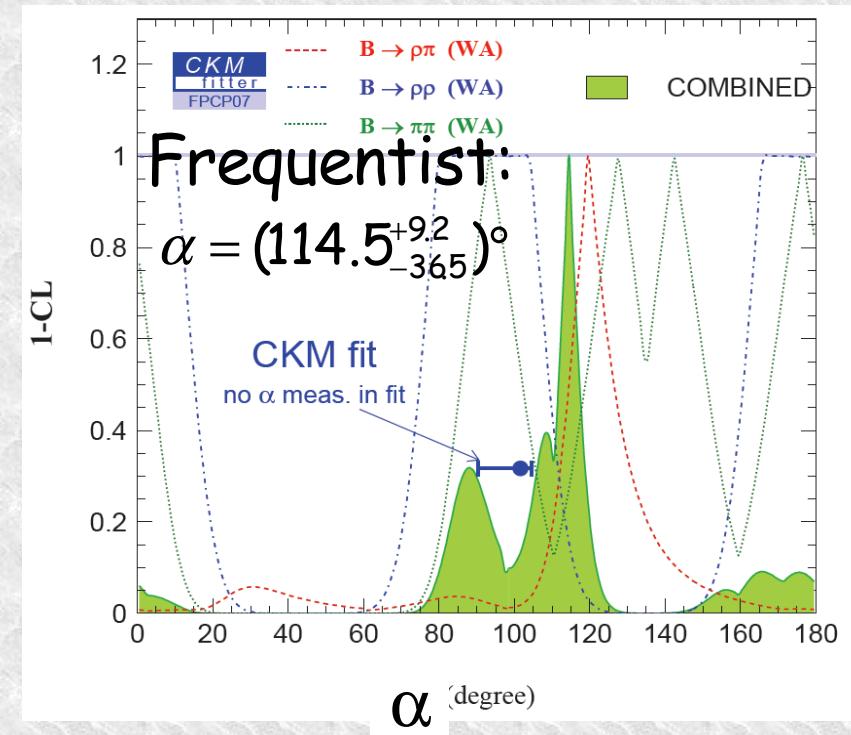
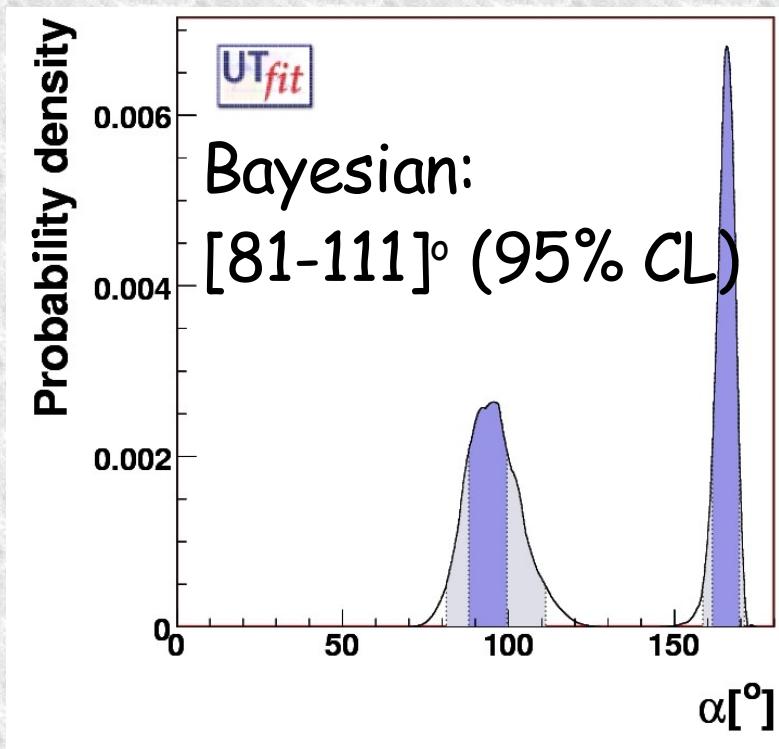


Interpretation

- Differently from the $\sin 2\beta$ case, extracting α (and γ) is not straightforward
- Results from $\pi\pi$, $p\bar{p}$ rates and asymmetries (and $p\pi$ Dalitz analysis) must be simultaneously analyzed
- On the market :
 - CKM-Fitter: Frequentist Approach
 - UT-Fit : Bayesian Analysis (see Guido' talk).

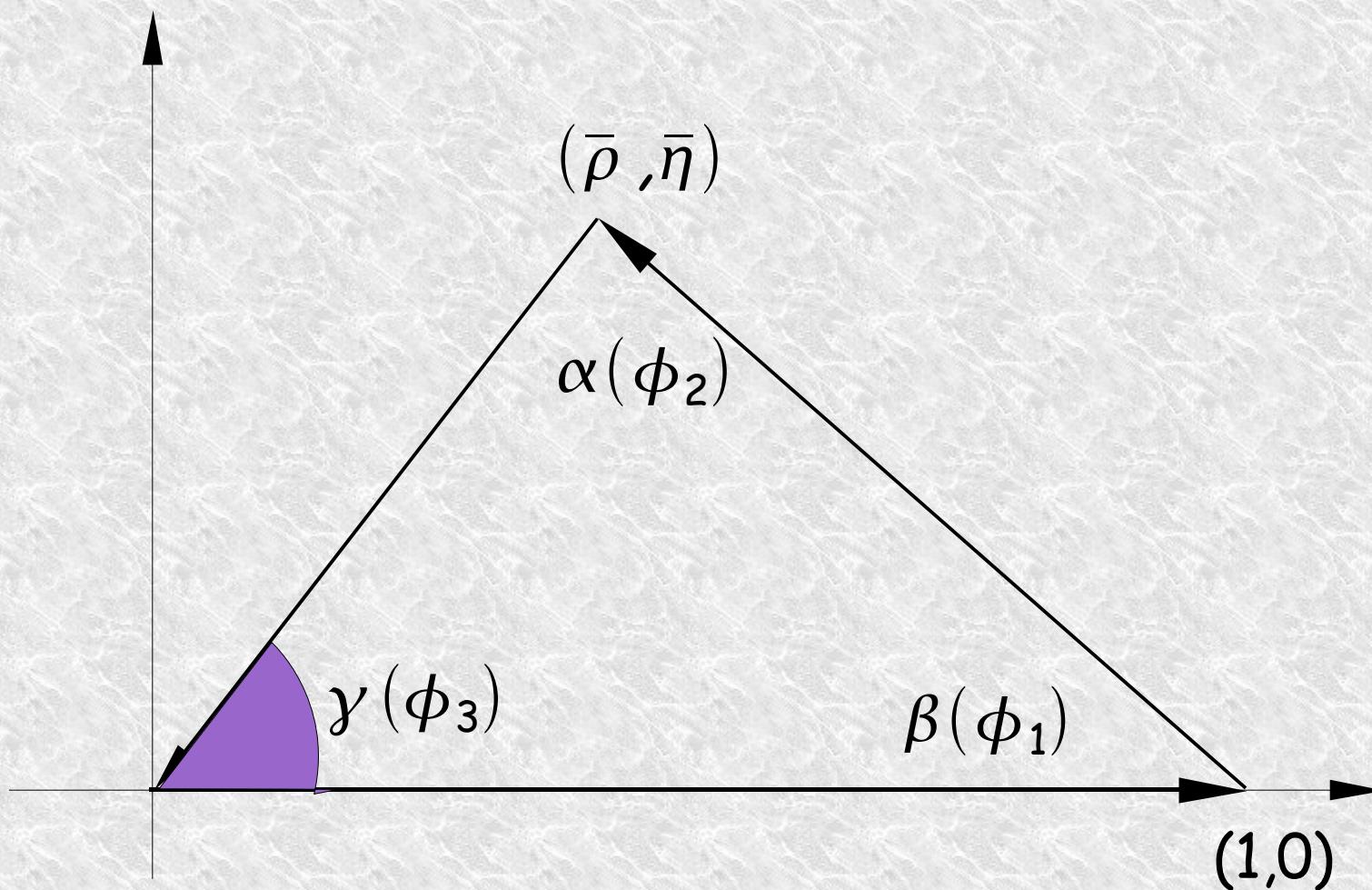
(Also a diffent interpretation of th. errors)

α : results



Prediction from sides : $91.7 \pm 0.5^{\circ}$

Angle-view: γ



- Prediction from all other constraints:

$$\gamma = (63.3 \pm 4.9)^\circ$$

Premise

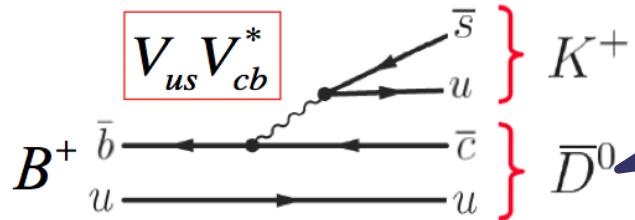
- BABAR Physics book (Oct 1998):
" Possibly the best tools to extract γ are time-dependent asymmetries in B_s decays "



Interference of pure tree transitions:

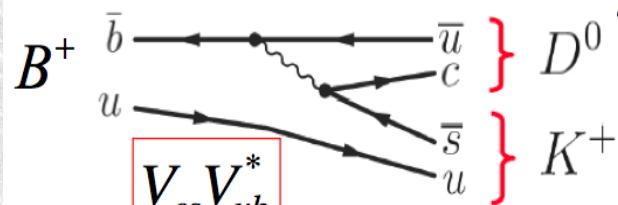
γ : the principle

Cabibbo allowed



$$A(B^+ \rightarrow \bar{D}^0 K^+) \propto V_{us} V_{cb}^* \propto \lambda^3$$

Cabibbo and color suppressed



$$A(B^+ \rightarrow D^0 K^+) \propto V_{cs} V_{ub}^* \propto \lambda^3 e^{i\gamma}$$

Common final states:

- CP eigen-states (KK, $\pi\pi$, KKK, ...)
- D^0 Cabibbo favored/suppressed ($K^-\pi^+$ / $K^+\pi^-$)
- flavor blind ($K_s \pi^+\pi^-$) + Dalitz

Gronau London Wyler

Atwood Dunietz Soni

$$\frac{A(B^- \rightarrow \bar{D}^0 K^-)}{A(B^- \rightarrow D^0 K^-)} = r_B e^{i\delta} e^{+i\gamma}$$

$$\frac{A(B^+ \rightarrow \bar{D}^0 K^+)}{A(B^+ \rightarrow D^0 K^+)} = r_B e^{i\delta} e^{-i\gamma}$$

r_B : color factor

δ : strong phase

γ : weak phase

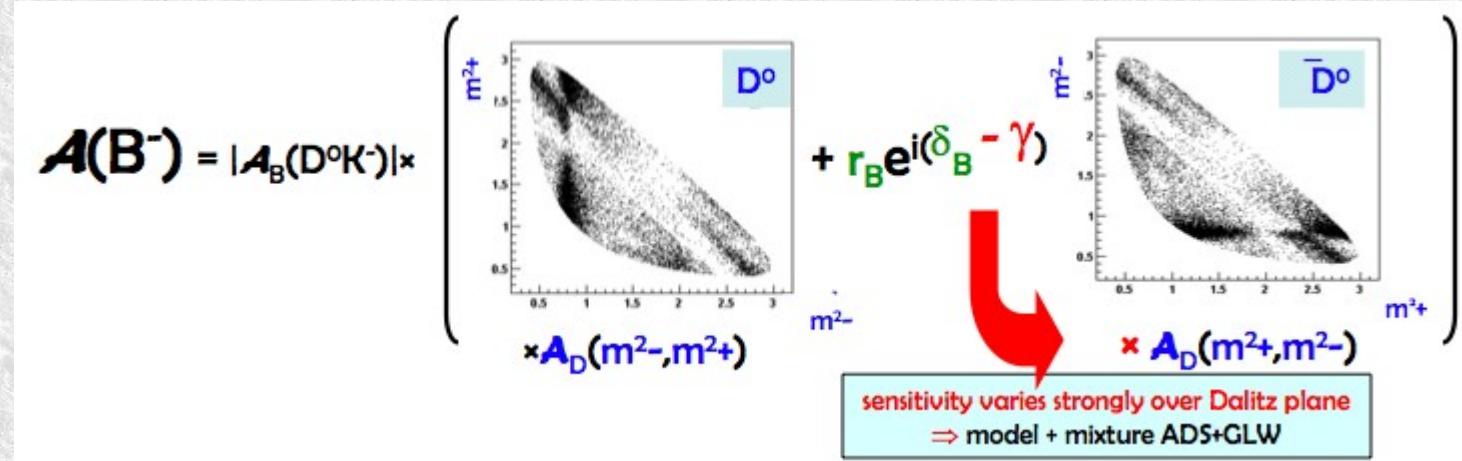
γ : Dalitz Analysis

- Exploit differences in $D^0 \rightarrow K_s \pi^+ \pi^-$ Dalitz plots:

$$A(B^-) \propto A_D(m_-, m_+) + r_B e^{i(\delta - \gamma)} A_D(m_+, m_-)$$

$$A(B^+) \propto A_D(m_+, m_-) + r_B e^{i(\delta + \gamma)} A_D(m_-, m_+)$$

$$m_{+/-} = m(Ks \pi^{+/-})$$



Dalitz model from $\sim 10^5$ tagged $c \rightarrow D^{*+} \rightarrow \pi^+ D^0 \rightarrow K_s \pi^+ \pi^-$ (and c.c.)

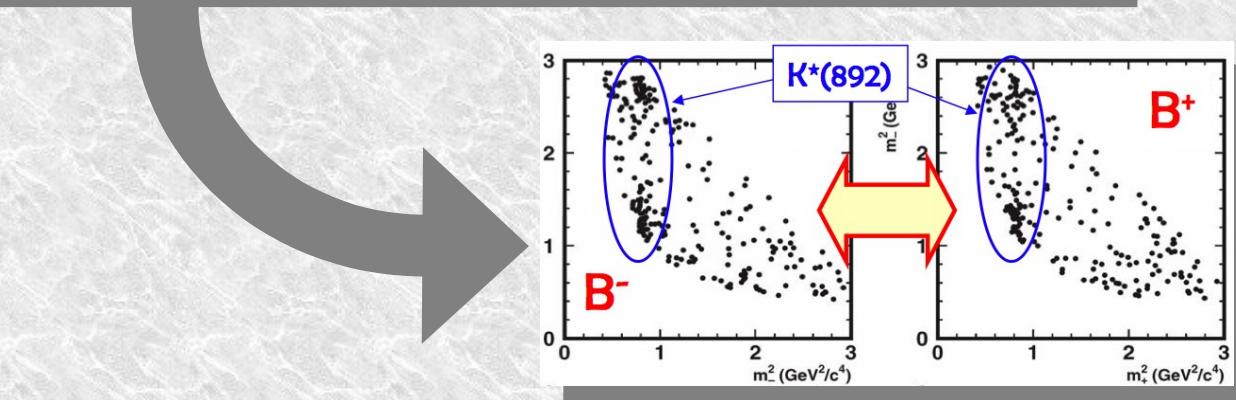
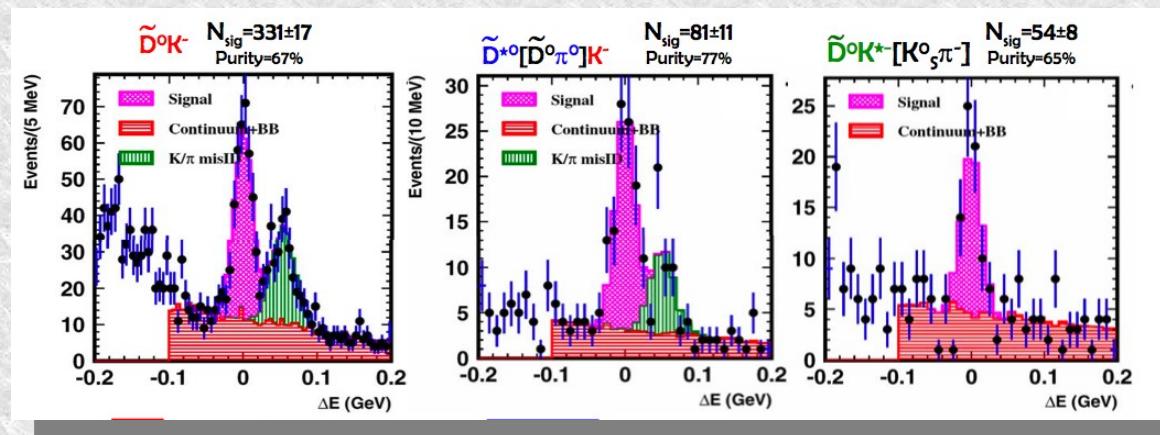
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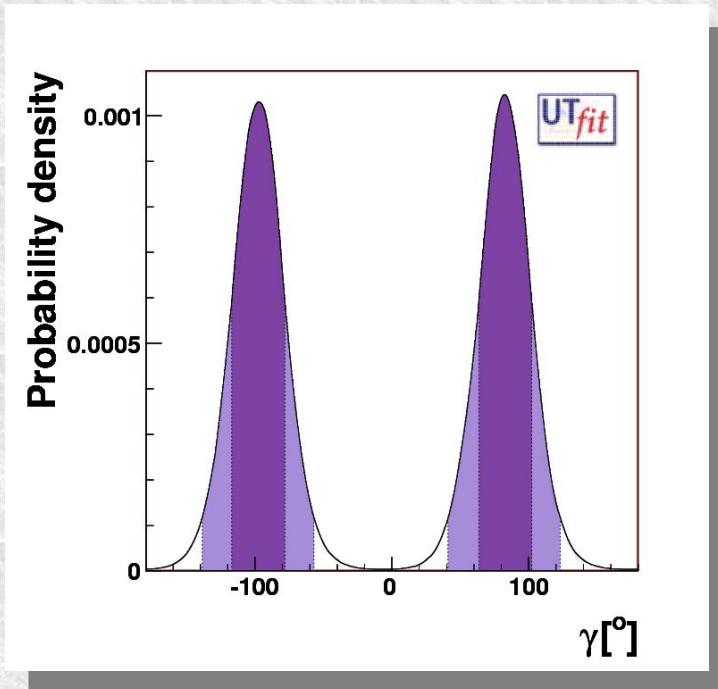
$$A(B^+) \propto A_D(m_+, m_-) + r_B e^{i(\delta + \gamma)} A_D(m_-, m_+)$$

$$m_{+/-} = m(K_s \pi^{+/-})$$



Overall γ results

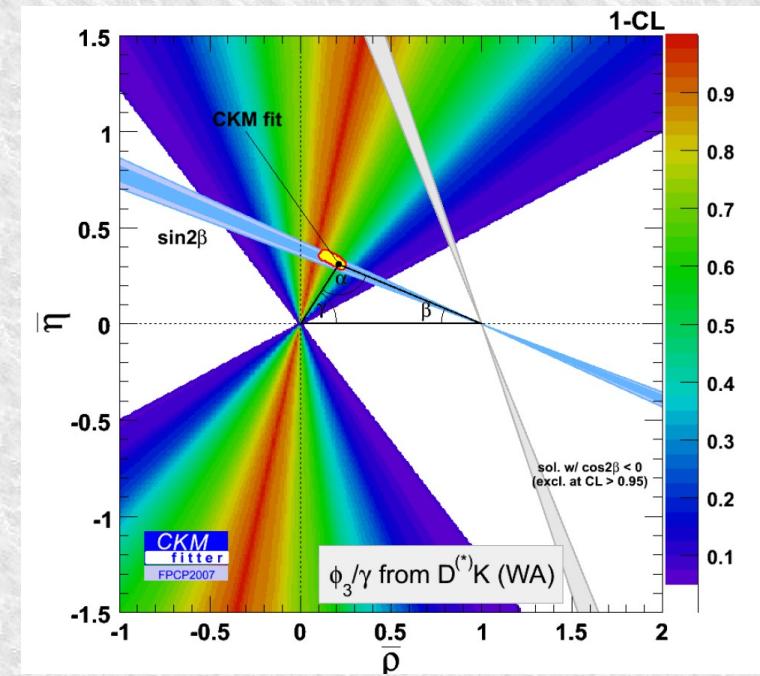
- Dalitz method: first direct measurement of γ !
- Limits on r_B from ADS,DGW help improve allowed bounds
- Of main importance to determine the actual value of r_B



Bayesian:

$$(83 \pm 19)^\circ$$

Predicted 63+5



Frequentist:

$$(77 \pm 31)^\circ$$

Summary on CKM Constraints

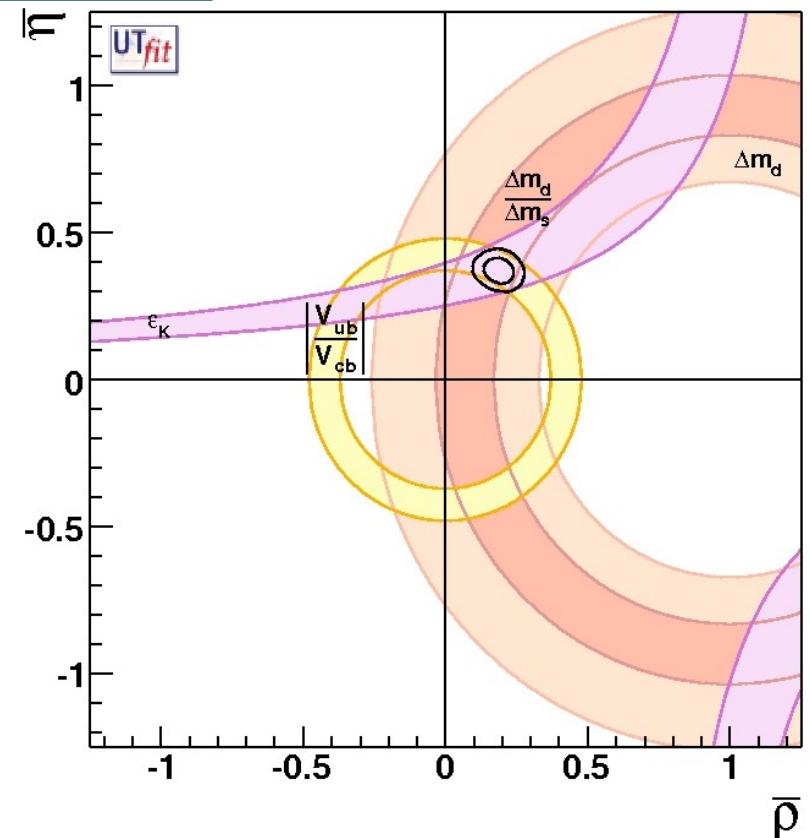
- B-factories operations allow to constrain the UT from different point of views:

Summary on CKM Constraints

- B-factories operations allow to constrain the UT from different point of views:

	$\bar{\rho}$	$\bar{\eta}$
sides	0.188 ± 0.036	0.373 ± 0.027

Sides

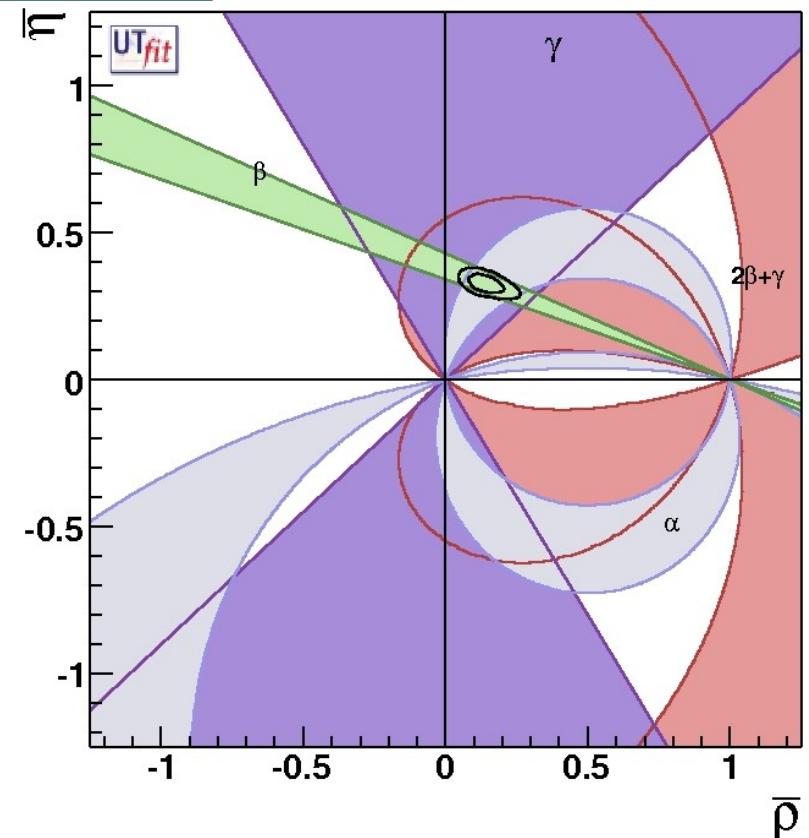


Summary on CKM Constraints

- B-factories operations allow to constrain the UT from different point of views:

	$\bar{\rho}$	$\bar{\eta}$
sides	0.188 ± 0.036	0.373 ± 0.027
angles	0.139 ± 0.042	0.325 ± 0.022

Angles

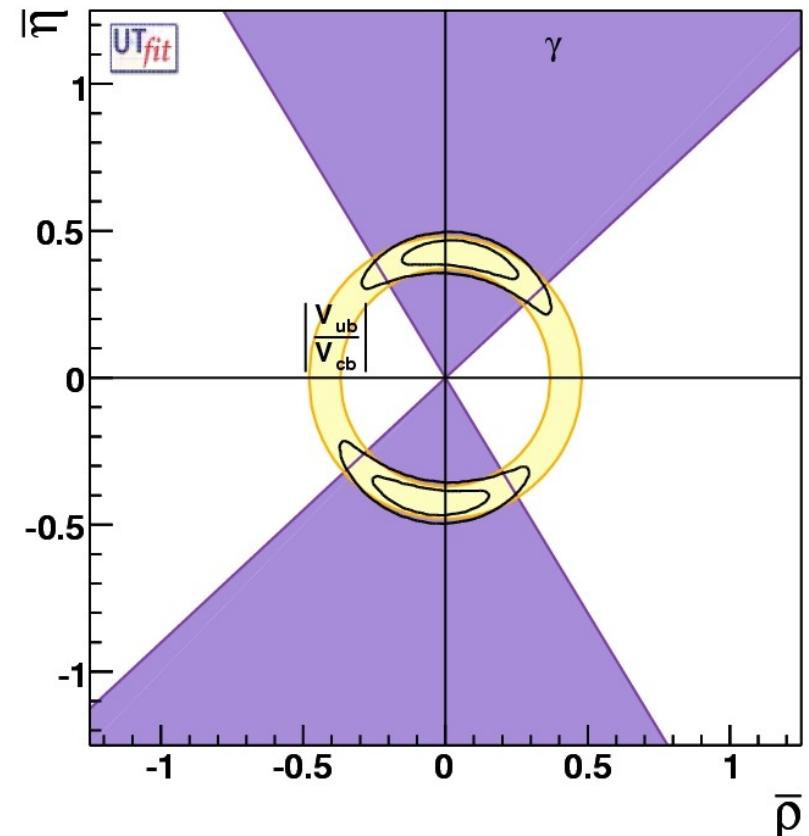


Summary on CKM Constraints

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	$\bar{\rho}$	$\bar{\eta}$
sides	0.188 ± 0.036	0.373 ± 0.027
angles	0.139 ± 0.042	0.325 ± 0.022
tree	0.00 ± 0.15	0.41 ± 0.04

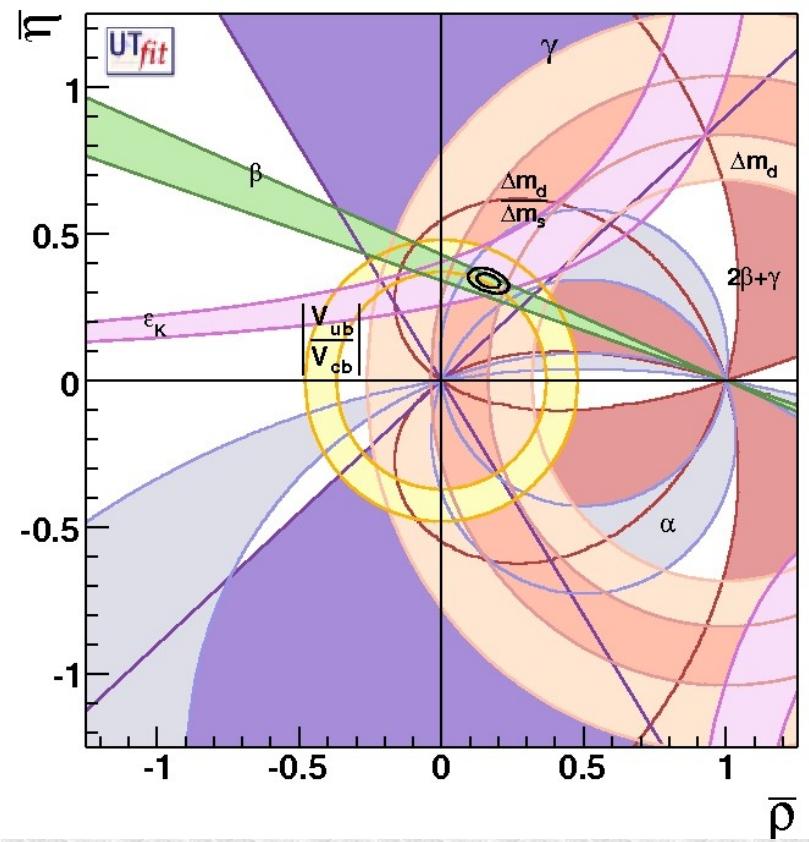
Tree Only



Conclusion on CKM Constraints

All the processes

	$\bar{\rho}$	$\bar{\eta}$
sides	0.188 ± 0.036	0.373 ± 0.027
angles	0.139 ± 0.042	0.325 ± 0.022
tree	0.00 ± 0.15	0.41 ± 0.04
all	0.164 ± 0.029	0.340 ± 0.017



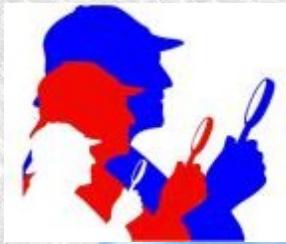
TOPICS:

- ★ The Physics Program
- ★ The CKM Matrix and the Unitary Triangle
- ★ The Unitary Triangle by Sides
- ★ The Unitary Triangle by Angles
- ★ Search for N.P. & Constraints on the SM
- ★ Conclusions & Perspectives

Rare Decays

- The Paradigm:

Search for New Physics contributions to processes
with low expected yield in the Standard Model :



$$D^0 \rightarrow \overline{D}^0$$
$$B^+ \rightarrow \tau^+ \nu$$

$$B \rightarrow s\gamma$$

$$\tau \rightarrow \mu\gamma, e\gamma, lll, \dots$$

Charm-Meson Mixing

short distance:

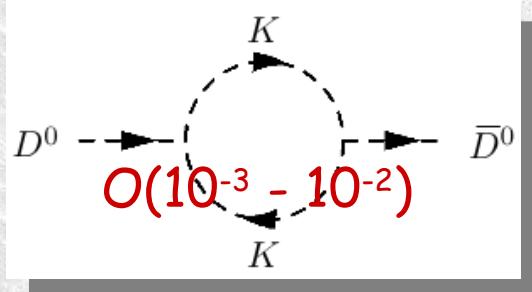
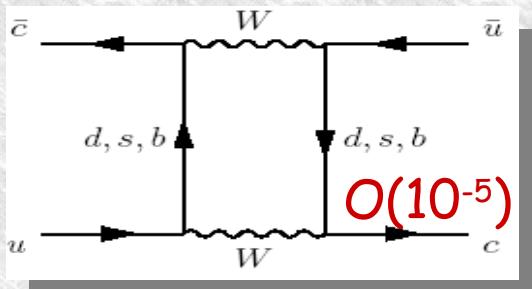
$$x \sim \Delta m / \Gamma$$

$$y \sim \Delta \Gamma / (2\Gamma)$$

long distance:

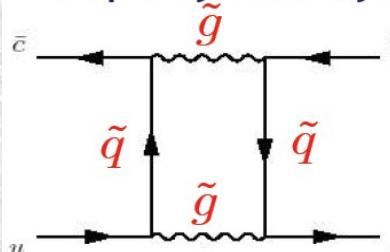
$$y \sim \Delta \Gamma / (2\Gamma)$$

Standard Model:

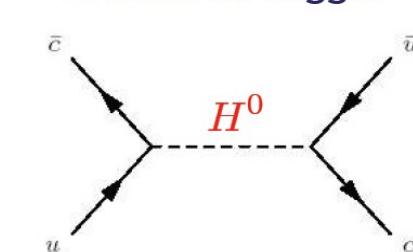


Beyond:

Supersymmetry:

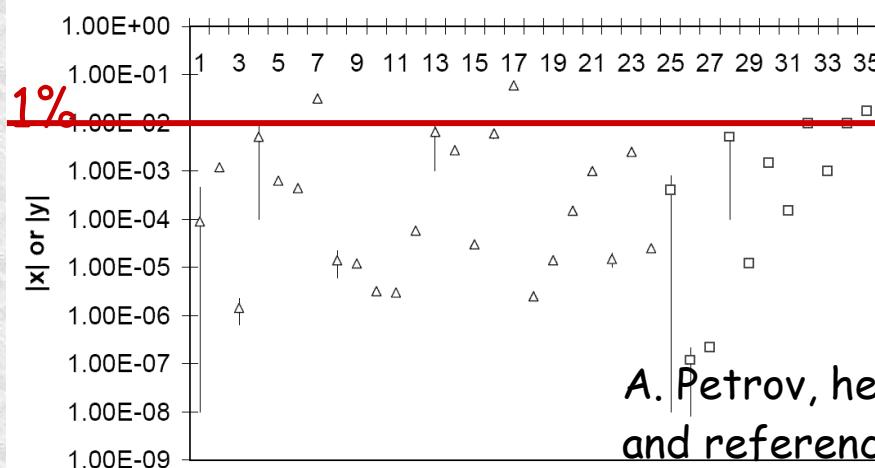


Extended Higgs:



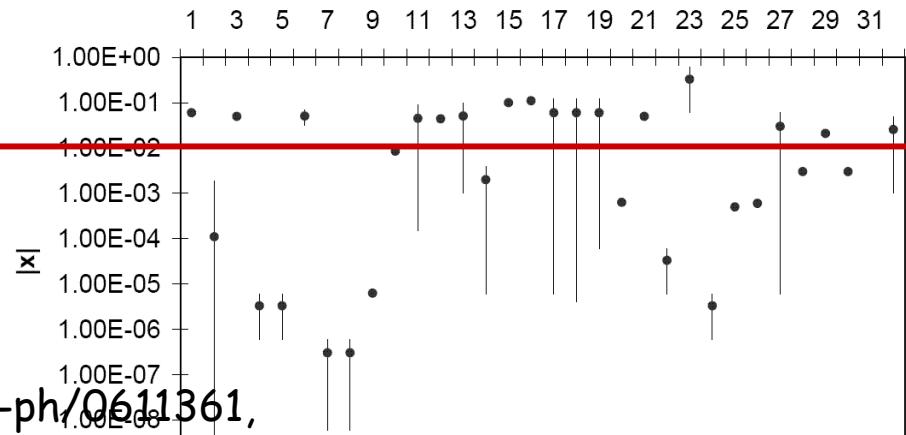
N.P.: $X \gg y$,
 CP violation

Standard Model mixing predictions



A. Petrov, hep-ph/0611361,
and references therein

New Physics mixing predictions

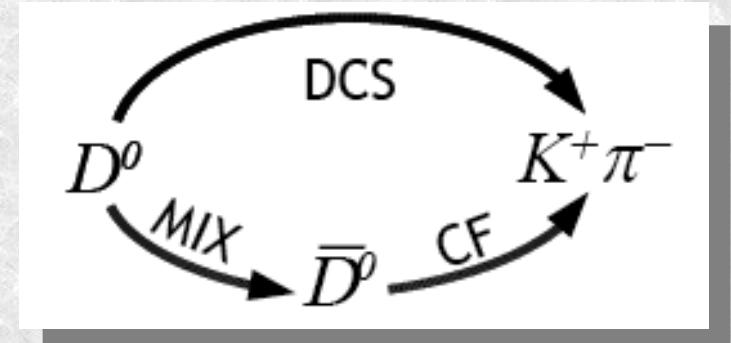


Analysis of $D^0 \rightarrow K^+ \pi^-$

Two paths to the “wrong-sign” state:

$$D^0 \rightarrow K^+ \pi^- \quad (\text{DCS decays})$$

$$D^0 \rightarrow \bar{D}^0 \rightarrow K^+ \pi^- \quad (\text{Mixing})$$



Power series expansion of the exponential decay-time distribution, including mixing:

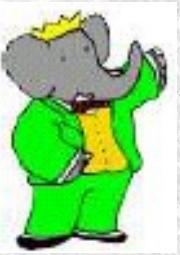
$$\frac{dN}{dt} \propto e^{-\bar{\Gamma}t} \left[R_D + \underbrace{\sqrt{R_D} y(\bar{\Gamma}t)}_{\text{interference}} + \underbrace{\frac{x'^2 + y'^2}{4} (\bar{\Gamma}t)^2}_{\text{mixing}} \right]$$

(Leading terms only)

$$x' = x \cos \delta + y \sin \delta$$

$$y' = y \cos \delta - x \sin \delta$$

Strong phase $\delta \rightarrow 0$ in SU(3) limit



Evidence for Mixing

First assume no mixing:

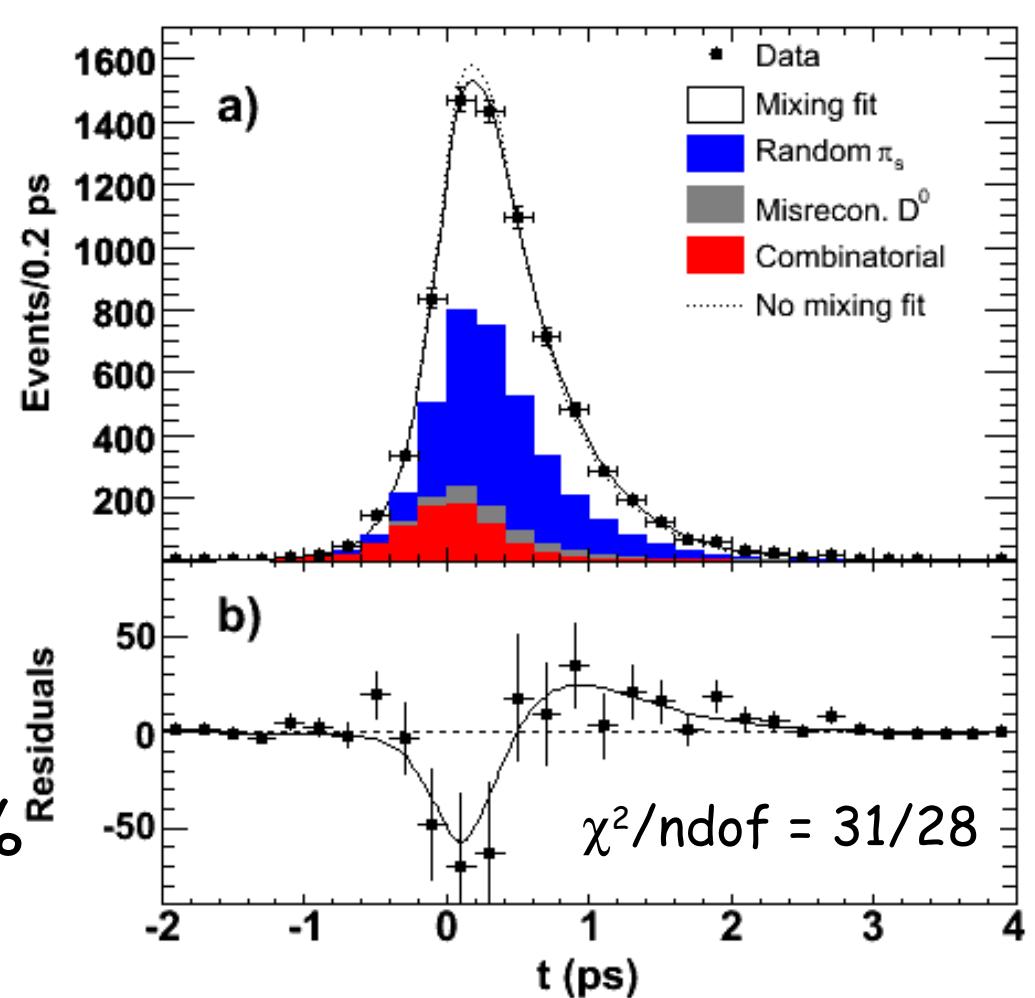
$$\frac{dN}{dt} \propto e^{-\bar{\Gamma}t} \left[R_D + \sqrt{R_D} y (\bar{\Gamma} t) + \frac{x^2 + y^2}{4} (\bar{\Gamma} t)^2 \right]$$

Mixing improves the description of the data

$$x' = (-0.022 \pm 0.030 \pm 0.021)\%$$

$$y' = (0.97 \pm 0.44 \pm 0.31)\%$$

Wrong-sign decay-time distribution



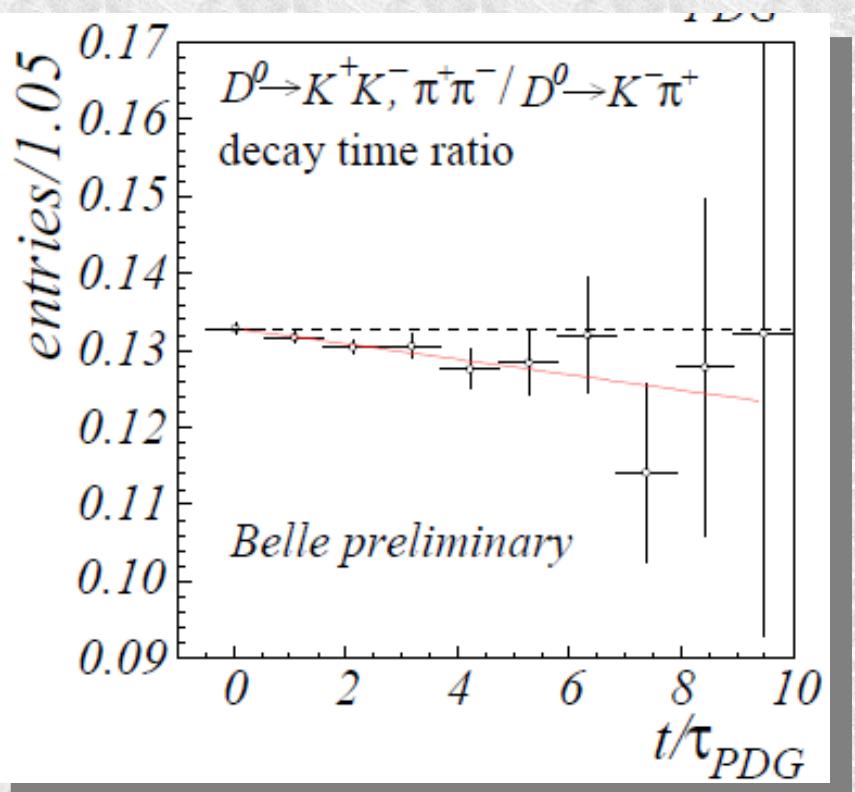
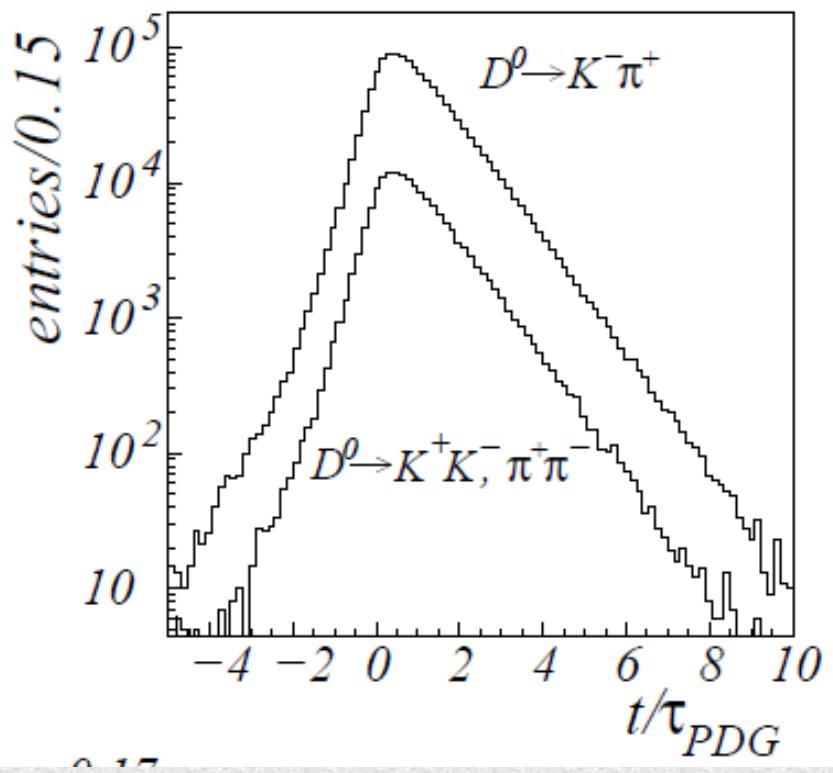
hep-ex/0703020 Submitted to PRL

Evidence for D^0 mixing

hep-ex/0703036

$$Y_{CP} = \frac{\tau(K^- \pi^+)}{\tau(K^+ K^-)} - 1 = \frac{\tau(K^- \pi^+)}{\tau(\pi^+ \pi^-)} - 1 = y \cos \Phi_D + (1 - \left| \frac{q}{p} \right|) x \sin \Phi_D$$

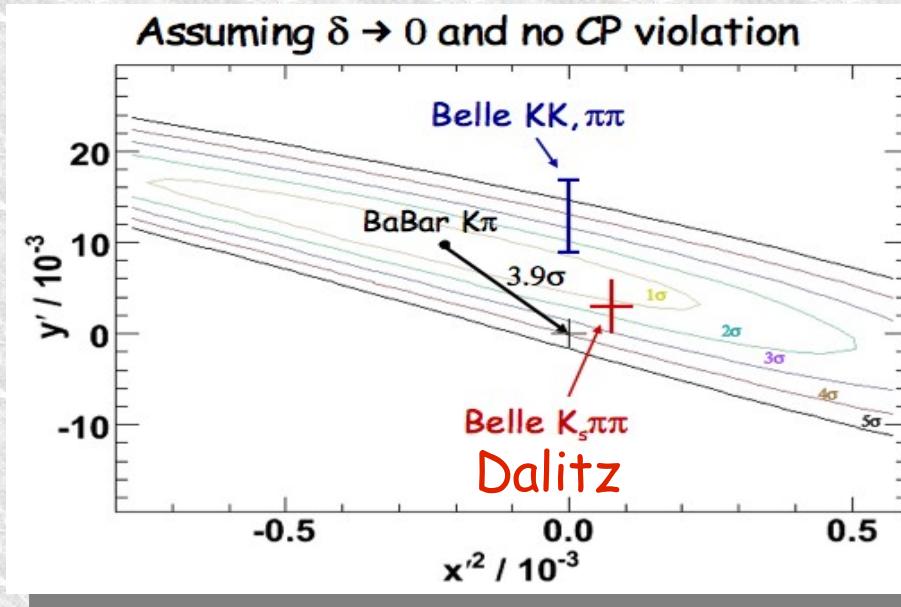
CP conserved : $y_{CP} = y = \frac{1}{2} \Delta \Gamma / \Gamma$



$$y_{CP} = 1.31 \pm 0.32 \pm 0.25 \%$$

> 3 σ evidence

Comparison of BaBar and Belle



- Overall consistency (including Belle Dalitz) depends on strong phase
- Overall good agreement
- No hint of CPv from independent measurements of D^0 and anti- D^0 (tag $D^{*+/-}$)

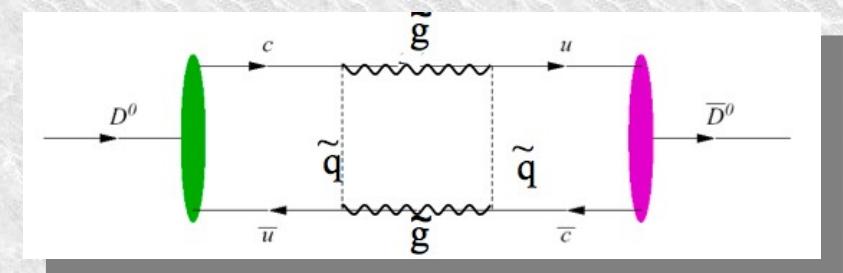
- Results constrain N.P. models:

$$m_{\tilde{g}, \tilde{q}} > 2 \text{ TeV}$$

MSSM with \tilde{g} \tilde{q} alignment

Y.Nir hep-ph/0703325

Ciuchini et al. hep-ph/0703294

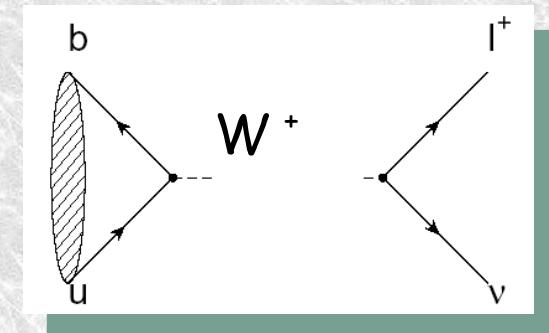


A Tree Process: $B^+ \rightarrow \tau^+ \nu$

$$\mathcal{B}(B^+ \rightarrow \tau^+ \nu_\tau) = \frac{G_F^2 m_B}{8\pi} m_\tau^2 \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B = (1.0 \pm 0.5) 10^{-4} UT - fit$$

$f_B = 0.192 \pm 0.027 \text{ GeV (LQCD)}$

- Two (and more) neutrinos: no kin. constraints
- Look for 1/3 prongs τ decays on recoil of reconstructed $B^- \rightarrow D^{(*)} h/\bar{\nu}$



A Tree Process: $B^+ \rightarrow \tau^+ \nu$

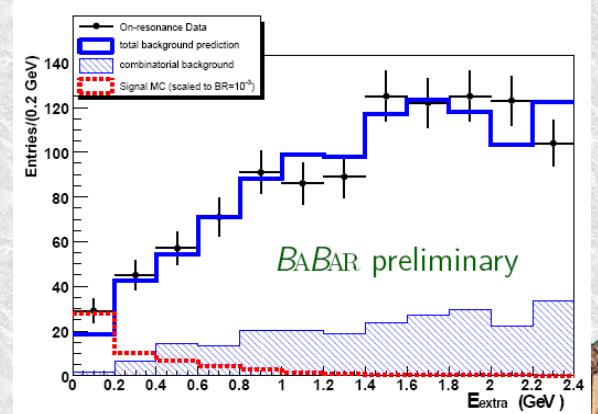
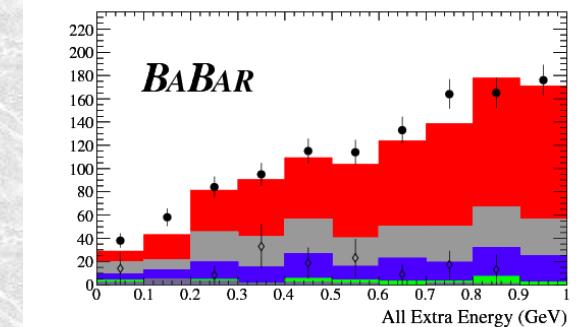
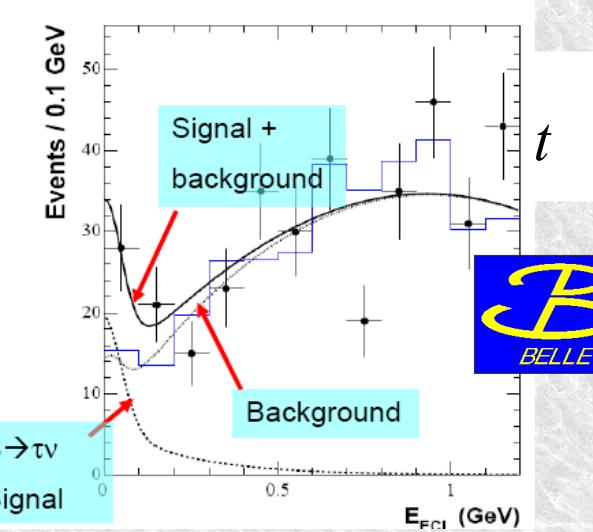
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- Look for 1/3 prongs τ decays on recoil of reconstructed $B^- \rightarrow D^{(*)} h/\ell\nu$
- Signal : small extra energy (apart τ , E_{ReC})

$$\text{Br}(B \rightarrow \tau^- \bar{\nu}_\tau) = (1.79 \pm 0.53 \pm 0.50) 10^{-4} \text{ (Belle)}$$

$$\text{Br}(B \rightarrow \tau^- \bar{\nu}_\tau) = (1.20 \pm 0.40 \pm 0.35) 10^{-4} \text{ (BABAR)}$$



A Tree Process: $B^+ \rightarrow \tau^+ \nu$

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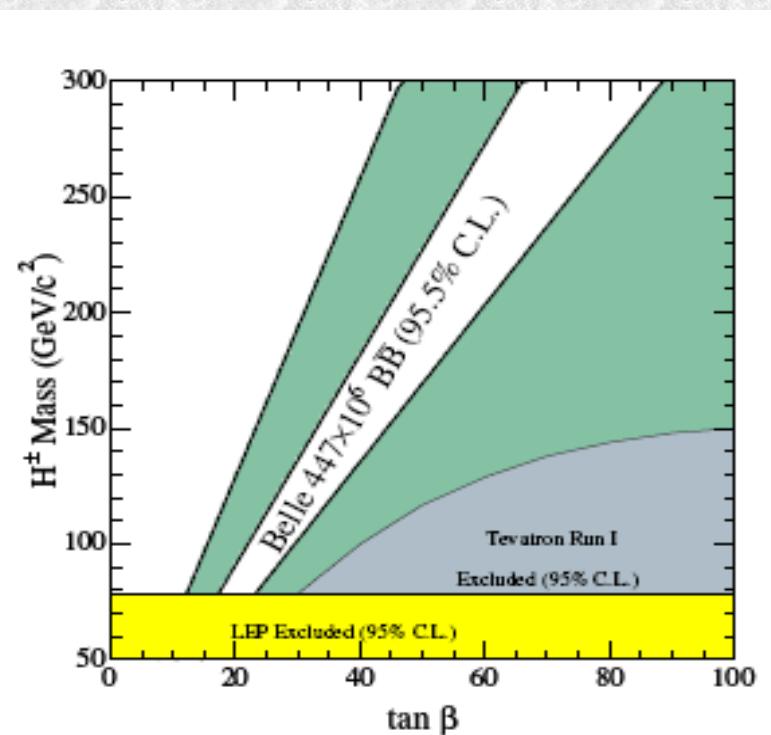
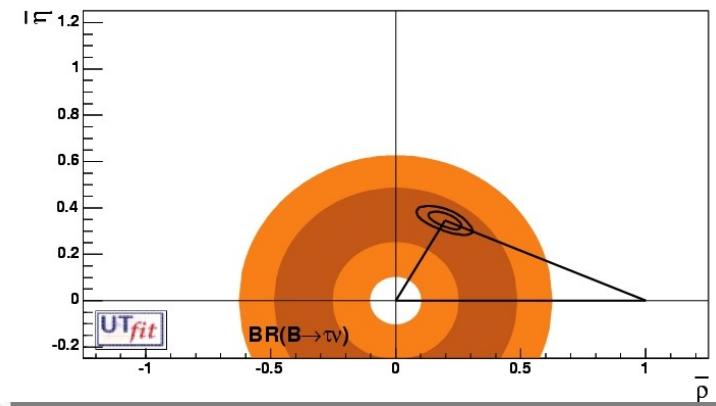
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$\text{Br}(B \rightarrow \tau^- \bar{\nu}_\tau) = (1.20 \pm 0.40 \pm 0.35) 10^{-4}$ (*BABAR*)

- Loose constraints on SM
- ... tight limits on NP



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- ★ The Unitary Triangle by Angles
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- ★ **Conclusions & Perspectives**

Conclusions

- Beauty Factories successfully pursue their program
- Collider performances and detector results outmatch expectations
- This notwithstanding
no crack in the S.M. (yet)
- However some “tension” (penguin vs tree in $\sin(2\beta)$, V_{ub} vs $\sin(2\beta)$)
- Going to \sim double the available statistics in one year
- Stay tuned

Luminosity: Perspectives

- KEK delivered 700 fb^{-1} to date
- PEP II will cross 500 fb^{-1} by July 2007 ($\times 1.5$ results shown here)
- By July 2008 $\sim 1 \text{ ab}^{-1}$ /experiment
($\times 4$)

PEP II luminosity perspective

$$\int L dt (\text{fb}^{-1})$$

BACKUP

SF parameters from $b \rightarrow s\gamma$



Parton-level :

- b -quark at rest
- two body decay

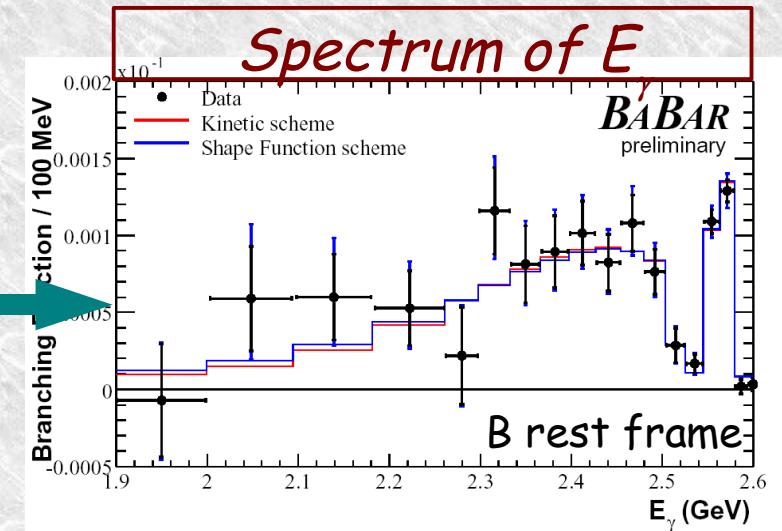
$$E_\gamma = m_b/2$$

"universal", same also for $b \rightarrow u$

Real life :

- b moves in the B -hadron
- b interacts with light dof
- s hadronizes

non-''universal''



Compute SF from the (moments of) E_γ spectrum in $b \rightarrow s\gamma$ decays:

$$E^{(1)} = \langle E_\gamma \rangle \approx \frac{m_b}{2},$$

$$E^{(2)} = \langle E_\gamma^2 - \langle E_\gamma^2 \rangle \rangle \approx \mu_\pi \approx E_{kin}(b),$$

...