Model-independent Analysis of the CKM Matrix

- Motivation
- Fit Method
- Inputs
- Results
- Conclusion

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MOTIVATION

- In the hunt for New Physics (Supersymmetry) the Standard Model (SM) has to be scrutinized in various areas

- Two very promising areas are CP violation and rare decays, that may reveal first signs of New Physics before the start of LHC

- BABAR/Belle have measured different CP asymmetries
  e.g. $\sin 2\beta\ (\psi K_s) = 0.736 \pm 0.049$, $\sin 2\beta\ (\phi K_s) = -0.14 \pm 0.33$
  $\sin 2\alpha\ (\pi\pi) = -0.58 \pm 0.2$
  ➔ with present statistics this is in good agreement with SM prediction that CP violation is due to phase of CKM matrix

- The phase of the CKM matrix, however, cannot predict the observed baryon-photons ratio: $n_B/n_g \cong 10^{-20} \Leftrightarrow n_B/n_g \cong 10^{-11}$
  ⇨ 9 orders of magnitude difference

- There are new phases predicted in extension of SM

- For example in MSSM 124 new parameters enter of which 44 are new phases

The Cabbibo-Kobayashi-Maskawa Matrix

- A convenient representation of the CKM matrix is the small-angle Wolfenstein approximation to order $O(\lambda^6)$

$$V_{CKM} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2-\frac{1}{8}\lambda^4 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda+A^2\lambda^5(\frac{1}{2}-\rho-i\eta) & 1-\frac{1}{2}\lambda^2-\frac{1}{8}\lambda^4-\frac{1}{2}A^2\lambda^4 & A\lambda^2 \\ A\lambda^3(1-\bar{\rho}-i\bar{\eta}) & -A\lambda^2+A\lambda^4(\frac{1}{2}-\rho-i\eta) & 1-\frac{1}{2}A^2\lambda^4 \end{pmatrix} + O(\lambda^6)$$

with $\bar{\rho}=\rho(1-\frac{1}{2}\lambda^2)$ and $\bar{\eta}=\eta(1-\frac{1}{2}\lambda^2)$

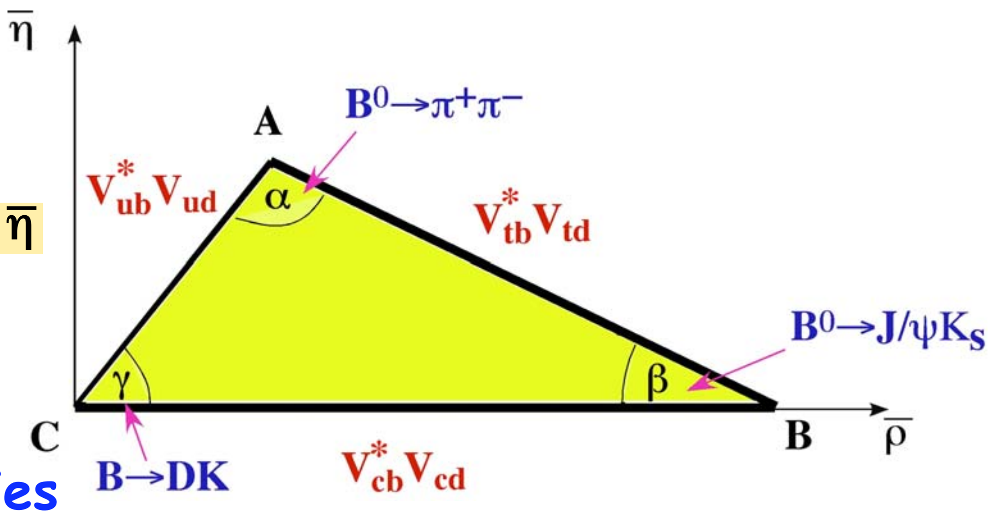
- The unitarity relation $V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$ that represents a triangle (called Unitarity Triangle) in the $\bar{\rho}$-$\bar{\eta}$ plane involves all 4 independent CKM parameters λ, A, ρ, and η

- $\lambda=\sin\theta_c=0.22$ is best-measured parameter (1.5%), $A\approx.8$ (~5%) while ρ-η are poorly known

MOTIVATION

- SM tests in the CP sector are conducted by performing maximum likelihood fits of the unitarity triangle

- Present inputs are based on measurements of B semi-leptonic decays, Δm_d, Δm_s, $a_{cp}(\psi K_S)$ & $|\varepsilon_K|$ to extract $A, \bar{\rho}, \bar{\eta}$



- Though many measurements are rather precise already the precision of the UT is limited by non gaussian errors in theoretical quantities $\Gamma^{th}(b \to u,c l\nu)$, B_K, $f_B\sqrt{B_B}$, ξ

- CKM tests need to be based on a conservative, robust method with a realistic treatment of uncertainties to reduce the sensitivity to avoid fake conflicts or fluctuations

- Only then we can believe that any observed significant conflict is real indicating the presence of New Physics

Global Fit Methods

- Different approaches exist:
  - The scanning method
    a frequentist approach first developed for the BABAR physics book (M. Schune, S. Plaszynski), → extended by Dubois-Felsmann et al
  - RFIT, a frequentist approach that maps out the theoretical parameter space in a single fit A.Höcker et al, Eur.Phys.J. C21, 225 (2001)
  - The Bayesian approach that adds experimental & theoretical errors in quadrature M. Ciuchini et al, JHEP 0107, 013 (2001)
  - A frequentist approach by Dresden group K. Schubert and R. Nogowski
  - The PDG approach F. Gilman, K. Kleinknecht and D. Renker

Model-independent Analysis of UT

- New Physics is expected to affect both $B_d\bar{B}_d$ mixing & $B_s\bar{B}_s$ mixing introducing new CP-violating phases that differ from SM phase
- This is an extension of the scenario discussed by Y. Nir in the BABAR physics book to $B_s\bar{B}_s$ mixing and $b \rightarrow s\bar{s}s$ penguins
  Y. Okada has discussed similar ideas
- Yossi considered measurements of V_{ub}/V_{cb}, Δm_{Bd}, $a_{\psi Ks}$, $a_{\pi\pi}$, we extend this to Δm_{Bs}, $a_{\phi Ks}$ ($a_{\eta' Ks}$) in addition to ε_K, $\gamma(DK)$
- In the presence of new physics:
  - i) $\mathbf{b \rightarrow u\bar{u}d:} \quad a_{\pi\pi} = a_{CP}(\pi^+\pi^-)$
    $\mathbf{b \rightarrow c\bar{c}s:} \quad a_{\psi Ks} = a_{CP}(\psi K_s^0)$
    } remain primarily tree level
  - ia) $\mathbf{b \rightarrow s\bar{s}s:} \quad a_{\phi Ks} = a_{CP}(\phi K_s^0)$ remains at penguin level
  - ii) There would be a new contribution to $K\bar{K}$ mixing
    constraint: small ε_K (ignore new parameters)
  - iii) Unitarity of the 3 family CKM matrix is maintained if there are no new quark generations

Model-independent Analysis of UT

- Under these circumstances new physics effects can be described by 4 parameters: r_d, θ_d, r_s, θ_s

$$\left(\frac{\langle B^0_{d,s}|H^{full}_{eff}|\bar{B}^0_{d,s}\rangle}{\langle B^0_{d,s}|H^{SM}_{eff}|\bar{B}^0_{d,s}\rangle}\right) = (r_{d,s}e^{i\theta_{d,s}})^2$$

- Our observables are sensitive to r_d, θ_d, r_s induced by mixing (no θ_s sensitive observable)

  In addition, we are sensitive to a new phase $\theta_s' = \varphi_s - \theta_d$ in $b \to s\bar{s}s$ transitions

- Thus, New Physics parameters modify the parameterization of following observables

$$a_{\psi K^0_s} = \sin(2\beta + 2\theta_d) \qquad a_{\phi K^0_s} = \sin(2\beta + 2\varphi_s)$$

$$a_{\pi^+\pi^-} = \sin(2\alpha - 2\theta_d)$$

$$\Delta m_{B_d} = C_t R_t^2 r_d^2 \qquad \Delta m_{B_s} = C_t R_t^2 \xi^2 r_s^2$$

The Scanning Method

- The scanning method is an unbiased, conservative approach to extract $A, \bar{\rho}, \bar{\eta}$ & New Physics parameters from the observables

- We have extended the method of the BABAR physics book (M.H. Schune and S. Plaszczynski) to deal with the problem of non-Gassian theoretical uncertainties in a consistent way

- We factorize quantities affected by non-Gaussian uncertainties (Δ_{th}) from the measurements

- We select specific values for the theoretical parameters

$$\Gamma^{th}(B \to \rho l \nu),\ \Gamma^{th}(b \to u l \nu),\ \Gamma^{th}(b \to c l \nu),\ F_{D^*}(1),\ B_K,\ f_B\sqrt{B_B},\ \xi$$

& perform a maximum likelihood fit using a frequentist approach

The Scanning Method

- A particular set of theoretical parameters we call a "model" M & we perform a χ^2 minimization to determine $A, \bar{\rho}, \bar{\eta}, r_d, \theta_d, r_s, \varphi_s$

$$\chi^2_M(A,\bar{\rho},\bar{\eta}) = \sum \left(\frac{\langle Y \rangle - Y_M(A,\bar{\rho},\bar{\eta},r_d,\theta_d,r_s,\varphi_s) \otimes F(x)}{\sigma_Y} \right)^2$$

- Here <Y> denotes an observable & σ_Y accounts for statistical and systematic error added in quadrature, while F(x) represents the theoretical parameters affected by non-Gaussian errors

- For Gaussian error part of the theoretical parameters, we also include specific terms in the χ^2

- We fit many individual models scanning over the allowed theoretical parameter space for each of these parameters

- We consider a model consistent with data, if $P(\chi^2_M)_{min}$>5%
  - For these we determine $A, \bar{\rho}, \bar{\eta}, r_d, \theta_d, r_s, \varphi_s$ and plot contours
  - The contours of various models are overlayed
  - We can also study correlations among theoretical parameters extending their range far beyond that specified by theorists

The χ^2 Function in Model-independent Analysis

$$
\begin{aligned}
\chi^2_M(A,\bar\rho,\bar\eta) = &\left(\frac{\langle\Delta m_{B_d}\rangle - \Delta m_{B_d}(A,\bar\rho,\bar\eta,r_d)}{\sigma_{\Delta m_{B_d}}}\right)^2 + \left(\frac{\langle|V_{cb}F(1)|\rangle - A^2\lambda^4|F(1)|^2)}{\sigma_{V_{cb}F(1)}}\right)^2 + \left(\frac{\langle B_{cl\nu}\rangle - \tilde\Gamma^r_{cl\nu}A^2\lambda^4\tau_b}{\sigma_{B_{cl\nu}}}\right)^2 \\
&+ \left(\frac{\langle B_{\rho l\nu}\rangle - \tilde\Gamma^r_{\rho l\nu}A^2\lambda^6\tau_B(\rho^2+\eta^2)}{\sigma_{B_{\rho l\nu}}}\right)^2 + \left(\frac{\langle B_{ul\nu}\rangle - \tilde\Gamma^r_{ul\nu}A^2\lambda^6\tau_b(\rho^2+\eta^2)}{\sigma_{B_{ul\nu}}}\right)^2 + \left(\frac{\langle|\varepsilon_K|\rangle - |\varepsilon_K|(A,\bar\rho,\bar\eta)}{\sigma_\varepsilon}\right)^2 \\
&+ \left(\frac{\langle a_{\psi K_s}\rangle - \sin 2\beta(\bar\rho,\bar\eta,\theta_d)}{\sigma_{\sin 2\beta}}\right)^2 + \left(\frac{\langle\Delta m_{B_s}\rangle - \Delta m_{B_s}(A,\bar\rho,\bar\eta,r_s/r_d)}{\sigma_{\Delta m_{B_s}}}\right)^2 + \left(\frac{\langle a_{\phi K_s}\rangle - \sin 2\beta(\bar\rho,\bar\eta,\varphi_s)}{\sigma_{\sin 2\beta}}\right)^2 \\
&+ \left(\frac{\langle a_{\eta' K_s}\rangle - \sin 2\beta(\bar\rho,\bar\eta,\varphi_s)}{\sigma_{\sin 2\beta}}\right)^2 + \left(\frac{\langle a_{\pi\pi}\rangle - \sin 2\alpha(\bar\rho,\bar\eta,\theta_d)}{\sigma_{\sin 2\alpha}}\right)^2 + \left(\frac{\langle a_{DK}\rangle - \sin\gamma(\bar\rho,\bar\eta)}{\sigma_{\sin\gamma}}\right)^2 \\
&+ \left(\frac{\langle B_K\rangle - B_K}{\sigma_{B_K}}\right)^2 + \left(\frac{\langle f_B\sqrt{B_B}\rangle - f_B\sqrt{B_B}}{\sigma_{f_B\sqrt{B_B}}}\right)^2 + \left(\frac{\langle\lambda\rangle - \lambda}{\sigma_\lambda}\right)^2 + \left(\frac{\langle m_t\rangle - m_t}{\sigma_{m_t}}\right)^2 + \left(\frac{\langle m_c\rangle - m_c}{\sigma_{m_c}}\right)^2 \\
&+ \left(\frac{\langle m_W\rangle - m_W}{\sigma_{M_W}}\right)^2 + \left(\frac{\langle\xi\rangle - \xi}{\sigma_\xi}\right)^2 + \left(\frac{\langle\tau_{B^0}\rangle - \tau_{B^0}}{\sigma_{\tau_{B^0}}}\right)^2 + \left(\frac{\langle\tau_{B^+}\rangle - \tau_{B^+}}{\sigma_{\tau_{B^+}}}\right)^2 + \left(\frac{\langle\tau_{B_s}\rangle - \tau_{B_s}}{\sigma_{\tau_{B_s}}}\right)^2 \\
&+ \left(\frac{\langle\tau_{\Lambda_b}\rangle - \tau_{\Lambda_b}}{\sigma_{\tau_{\Lambda_b}}}\right)^2 + \left(\frac{\langle f^Z_{B^{0,+}}\rangle - f^Z_{B^{0,+}}}{\sigma_{f^Z_{B^{0,+}}}}\right)^2 + \left(\frac{\langle f^Z_{B_s}\rangle - f^Z_{B_s}}{\sigma_{f^Z_{B_s}}}\right)^2 + \left(\frac{\langle f_{B^{0,+}}\rangle - f_{B^{0,+}}}{\sigma_{f_{B^{0,+}}}}\right)^2
\end{aligned}
$$

Semileptonic Observables

- Presently, consider 11 different observables

➢ V_{cb}

excl: $\langle R(\omega = 1)\rangle = \langle |V_{cb}|_{excl} \cdot F_{D^*}(1)\rangle$

phase space corrected rate in $B \to D^* l\nu$ extrapolated for $w \to 1$

incl: $B(B \to X_c l\nu) = |V_{cb}|^2 \tilde{\Gamma}^{th}_{incl} \cdot \langle \tau_b \rangle$

branching fraction at $\Upsilon(4S)$ & Z^0

affected by non-Gaussian uncertainties

➢ V_{ub}

excl: $B(B \to \rho l\nu) = |V_{ub}|^2 \tilde{\Gamma}^{th}_{excl} \cdot \tau_{B^0}$

branching fraction at $\Upsilon(4S)$

incl: $B(B \to X_u l\nu) = |V_{ub}|^2 \tilde{\Gamma}^{th}_{incl} \cdot \tau_b$

branching fraction at $\Upsilon(4S)$ & Z^0

$K^0\bar{K}^0$ CP-violating & $B^0\bar{B}^0$-mixing Observables

theoretical parameters with large non-Gaussian errors

- ε_K

$$|\varepsilon_K|(A,\bar{\rho},\bar{\eta}) = C\cdot B_K\bar{\eta}A^2\lambda^6\left\{\left[\eta_1 S_0(x_c)-\eta_3 S_0(x_c,x_t)\right]-A^2\lambda^4(1-\bar{\rho})\eta_2 S_0(x_t)\right\}$$

account for correlation of m_c in η_1 & $S_0(x_c)$

QCD parameters that have small non Gaussian errors (except η_1)

- Δm_{Bd}

$$\Delta m_{B_d}(A,\bar{\rho},\bar{\eta}) = r_d^2\frac{G_F^2}{6\pi^2}\eta_B m_{B_d} m_W^2 S_0(x_t) f_{B_d}^2 B_{B_d} A^2\lambda^6\left[(1-\bar{\rho})^2+\bar{\eta}^2\right]$$

- Δm_{Bs}

$$\Delta m_{B_s}(A,\bar{\rho},\bar{\eta}) = \frac{r_s^2}{r_d^2}\frac{G_F^2}{6\pi^2}\eta_B m_{B_s} m_W^2 S_0(x_t)\xi^2 f_{B_d}^2 B_{B_d} A^2\lambda^4$$

New Physics scale parameters r_d and r_s in $B\bar{B}$ mixing

CP-violating Observables in $B\bar{B}$ System

- $\sin 2(\beta+\theta_d)$ from ψK_S
- $\sin 2(\beta+\varphi_s)$ from ϕK_S
- $\sin 2(\alpha-\theta_d)$ from $\pi\pi$
- γ from $D^{(*)}K$

$$\sin 2\beta(\bar{\rho},\bar{\eta}) = \frac{2\bar{\eta}(1-\bar{\rho})}{\left[(1-\bar{\rho})^2+\bar{\eta}^2\right]}$$

$$\sin 2\beta(\bar{\rho},\bar{\eta}) = \frac{2\bar{\eta}(1-\bar{\rho})}{\left[(1-\bar{\rho})^2+\bar{\eta}^2\right]}$$

$$\sin 2\alpha(\bar{\rho},\bar{\eta}) = \frac{2\bar{\eta}\left(\bar{\eta}^2+\bar{\rho}(\bar{\rho}-1)\right)}{\left(\rho^2+\eta^2\right)\left[(1-\bar{\rho})^2+\bar{\eta}^2\right]}$$

$$\sin 2\gamma(\bar{\rho},\bar{\eta}) = \frac{2\bar{\eta}}{\left(\rho^2+\eta^2\right)}$$

New Physics phases in $B\bar{B}$ mixing

New phase component in $b\to s\bar{s}s$

- Note, that presently no extra strong phases in $a_{\pi\pi}$ are included
- In future will include this adding $C_{\pi\pi}$ in the global fits

Observables

Observable	Present Data Set	2011 Data Set
Υ(4S) $B(b\rightarrow ul\nu)$ [10^{-3}]	$1.95\pm0.19_{exp}\pm0.31_{th}$	$1.85\pm0.06_{exp}$
LEP $B(b\rightarrow ul\nu)$ [10^{-3}]	$1.71\pm0.48_{exp}\pm0.21_{th}$	$1.71\pm0.48_{exp}$
Υ(4S) $B(b\rightarrow cl\nu)$	0.1090 ± 0.0023	0.1050 ± 0.0005
LEP $B(b\rightarrow cl\nu)$	0.1042 ± 0.0026	0.1042 ± 0.0026
Υ(4S) $B(B\rightarrow \rho l\nu)$ [10^{-3}]	$2.68\pm0.43_{exp}\pm0.5_{th}$	3.29 ± 0.14
$\|V_{cb}\|F(1)$	0.0367 ± 0.008	0.0378 ± 0.00038
Δm_{Bd} [ps^{-1}]	0.502 ± 0.007	0.502 ± 0.00104
Δm_{Bs} [ps^{-1}]	14.4 @90% CL➔ (20 ± 5)	25 ± 1
$\|\varepsilon_K\|$ [10^{-3}]	2.282 ± 0.017	2.282 ± 0.017
λ	0.2235 ± 0.0033	0.2235 ± 0.0033
$\sin 2\beta$ from ψK_s	0.736 ± 0.049	0.736 ± 0.01
$\sin 2\beta$ from ϕK_s ($\eta' K_s$)	-0.14 ± 0.33 (0.27 ± 0.22)	0.6 ± 0.15
$\sin 2\alpha$	-0.4 ± 0.2	-0.4 ± 0.05
$\sin \gamma$	0.7 ± 0.5	0.7 ± 0.15

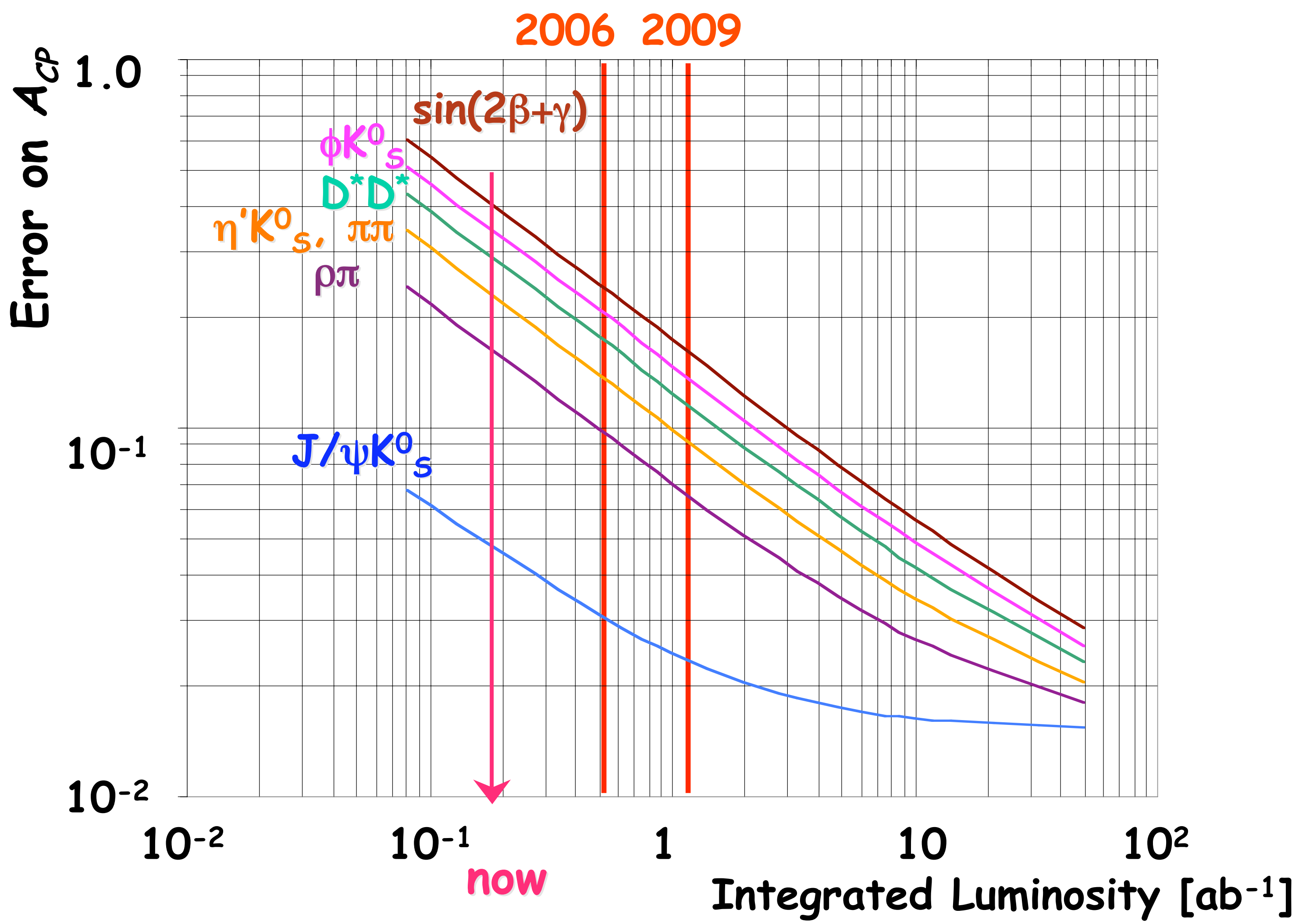
- For other masses and lifetimes use PDG 2003 values

Theoretical Parameters

Parameter	Present Value	Expected Value in 2011
$F_{D*}(1)$	0.87 — 0.95	0.90 — 0.92
$\Gamma(cl\nu)$ [ps^{-1}]	34.1 —41.2	35.7 —39.2
$\Gamma(\rho l\nu)$ [ps^{-1}]	12.0 — 22.2	11.0 — 13.4
$\Gamma(ul\nu)$ [ps^{-1}]	54.6 —80.2	60.6 —76.9
B_K	0.74 — 1.0 σ_{Bk} =±0.06	0.805 — 0.935 σ_{Bk} =±0.03
$f_{Bd}\sqrt{B_{Bd}}$ [MeV]	218 — 238 $\sigma_{fB\sqrt{BB}}$ =±30	223 — 233 $\sigma_{fB\sqrt{BB}}$ =±10
ξ	1.16 — 1.26 σ_{ξ} =±0.05	1.16 — 1.26 σ_{ξ} =±0.05
η_1	1.0 — 1.64	1.0 — 1.64
η_2	0.564 — 0.584	0.564 — 0.584
η_3	0.43 — 0.51	0.43 — 0.51
η_B	0.54 — 0.56	0.54 — 0.56

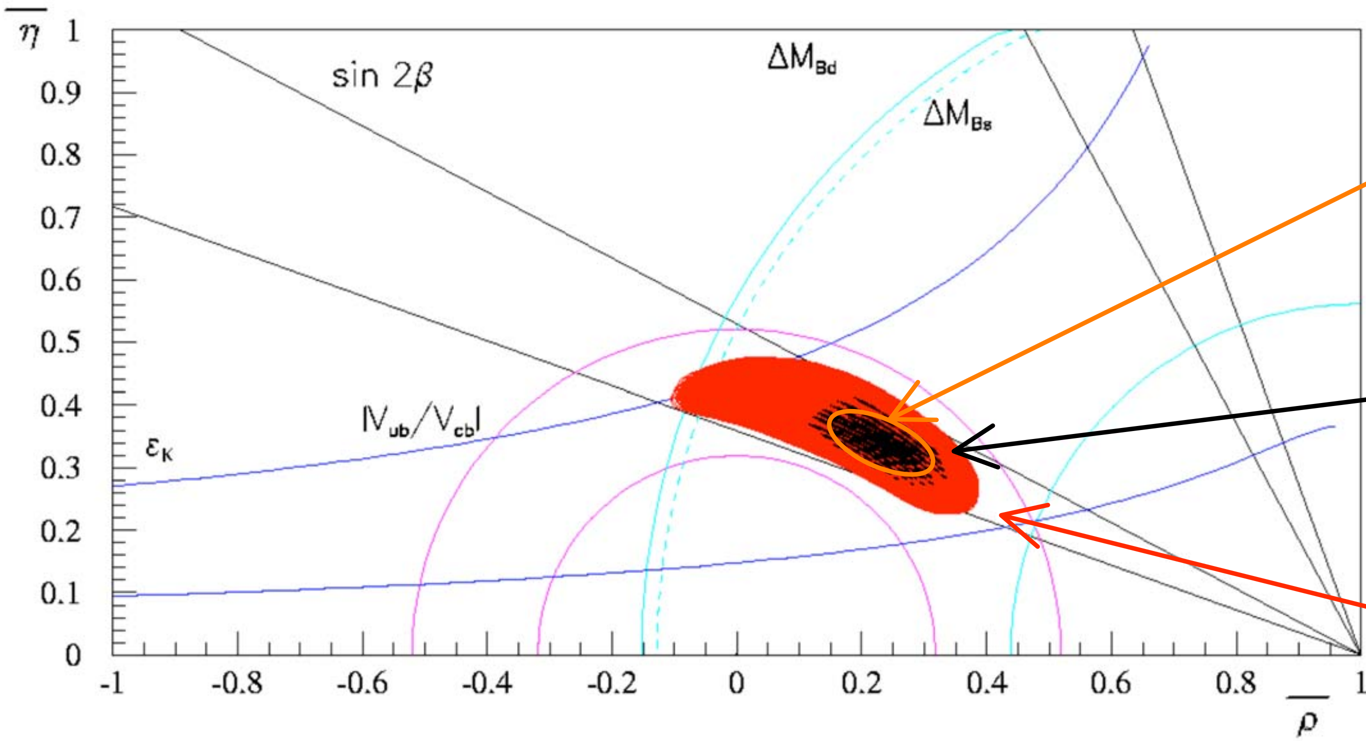
Error Projections for *CP* Asymmetries

PEP-II, KEKB → Super B-Factory >2010



Present Status of the Unitarity Triangle in SM Fit

- SM fit to A, $\bar{\rho}$, $\bar{\eta}$ using present data set



Contour of individual fit

central values from individual fits to models

Overlay of 95% CL contours, each represents a "model"

- Range of $\bar{\rho}$-$\bar{\eta}$ values resulting from fits to different models

$0.116 \le \bar{\rho} \le 0.335 \; ^{+0.027}_{-0.11}$

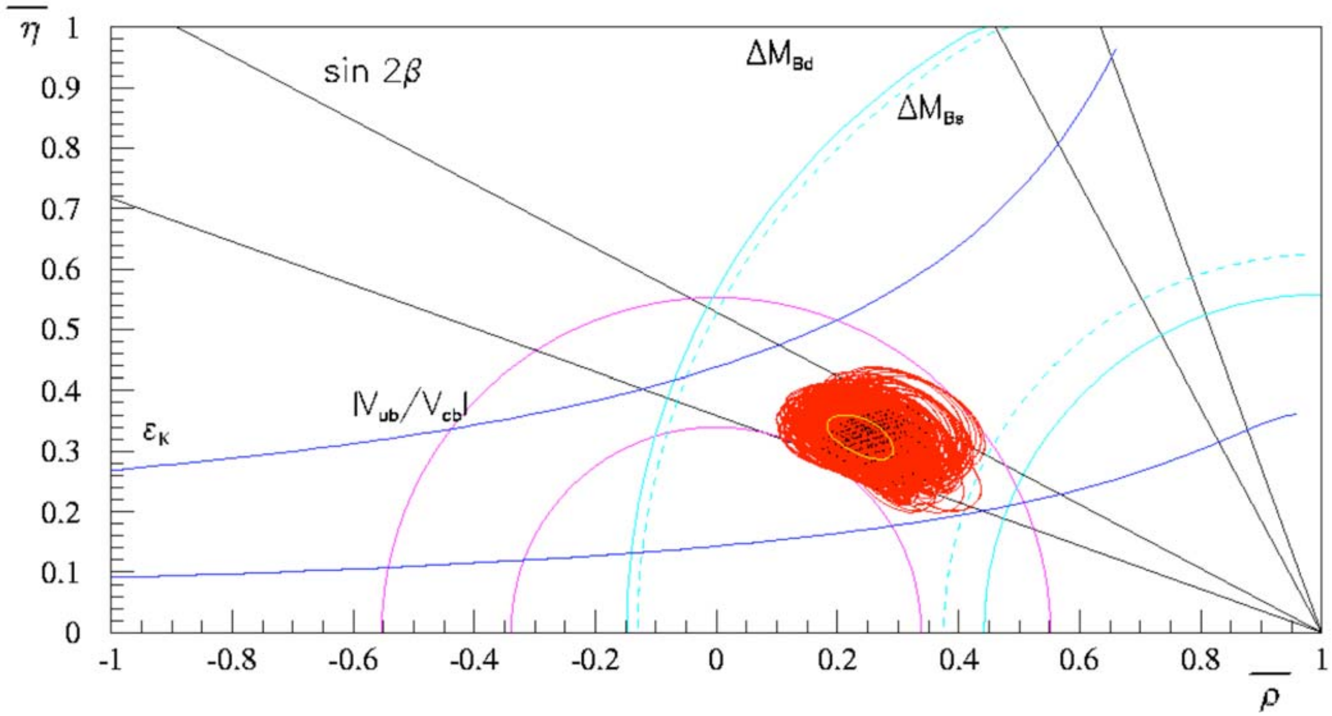
$0.272 \le \bar{\eta} \le 0.411 \; ^{+0.036}_{-0.026}$

Present Results

Parameter	Scan Method
ρ	0.116-0.335, $\sigma=\pm^{0.027}_{0.11}$
η	0.272-0.411, $\sigma=\pm^{0.036}_{0.020}$
A	0.80-0.89, $\sigma=\pm^{0.028}_{0.024}$
m_c	1.06-1.29, $\sigma=\pm^{0.18}_{0.18}$
β	$(20.7-27.0)^0$, $\sigma=\pm^{7.1}_{2.6}$
α	$(84.6-117.2)^0$, $\sigma=\pm^{5.4}_{15.8}$
γ	$(40.3-72.5)^0$, $\sigma=\pm^{8.3}_{3.3}$

Present Status of the $\bar{\rho}$-$\bar{\eta}$ Plane

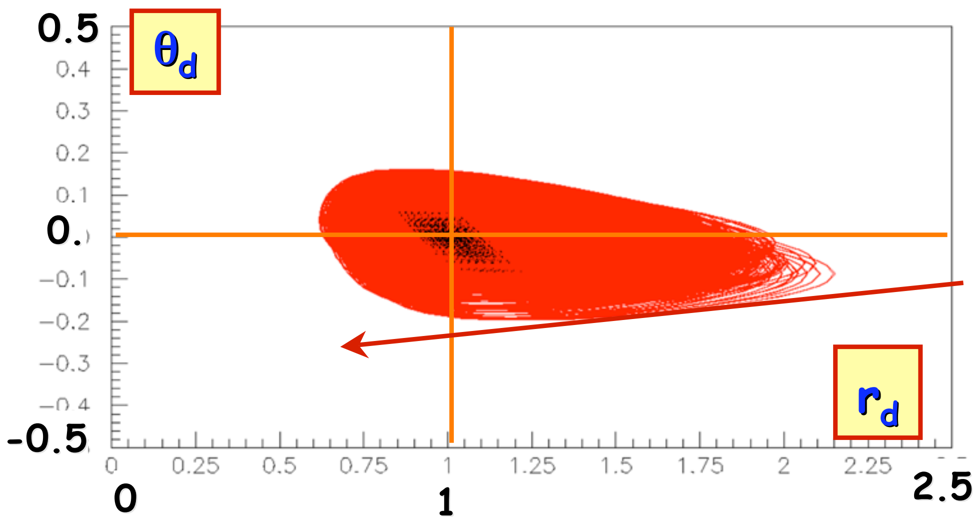
- Global fits to present extended data set including $a_{\phi K_s}$, $a_{\pi\pi}$ & $\gamma(DK)$



- The introduction of new parameters r_d, θ_d, r_s, & φ_s weakens the sin 2β constraint
- Weakening of Δm_{Bd}, Δm_{Bs} & sin 2α bounds is not visible due to large errors & impact of V_{ub}/V_{cb}, ε_K, sin γ constraints
- Negative ρ region is rejected by sin γ constraint

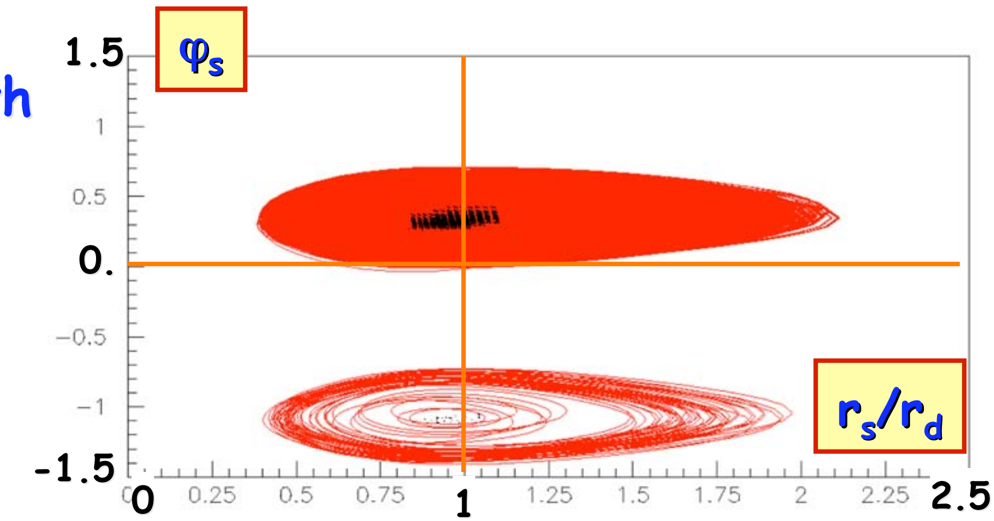
Present Status of r_d-θ_d Plane & r_s/r_d-φ_s Plane

- Global fits to present extended data set including $a_{\phi K_S}$, $a_{\pi\pi}$ & γ(DK)



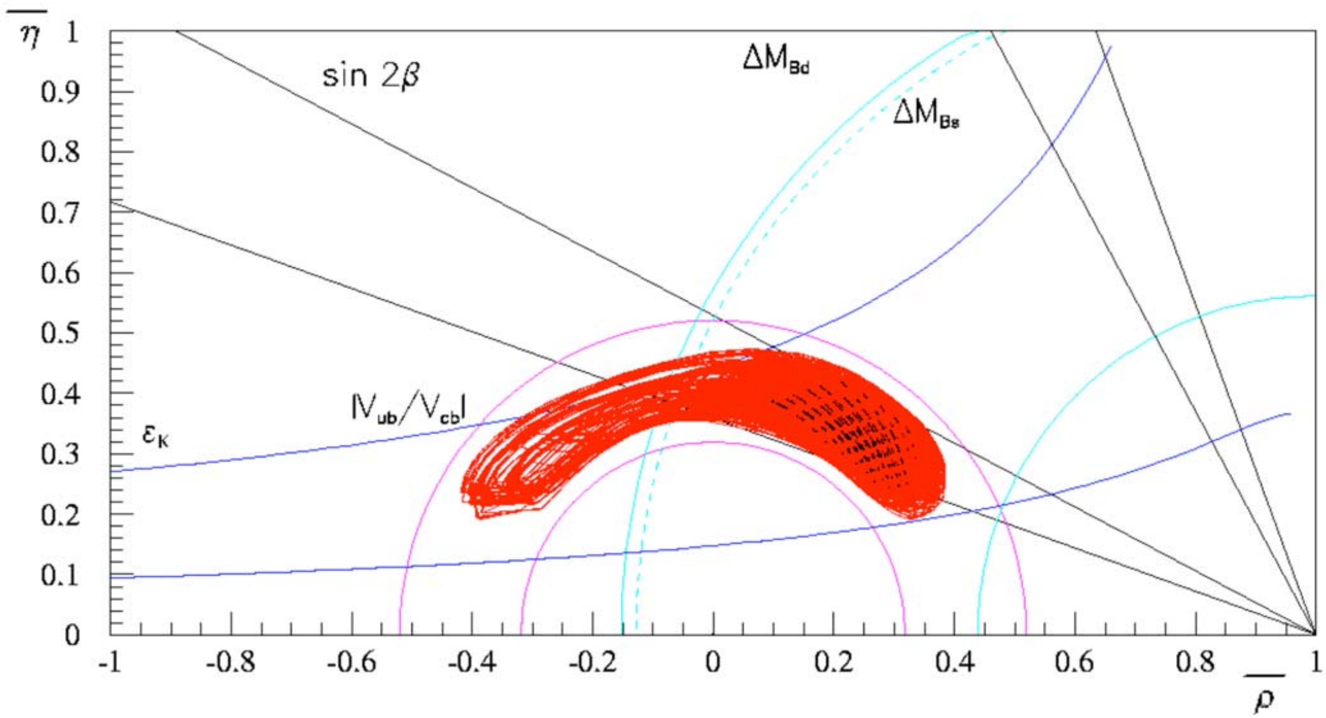
- r_d-θ_d plane is consistent with SM
- Second region (r_d<1, θ_d<0) is rejected by sin γ constraint

- r_s- φ_s plane is consistent with SM for some models
- Second region inconsistent with SM is visible



Present Status of the $\bar{\rho}$-$\bar{\eta}$ Plane

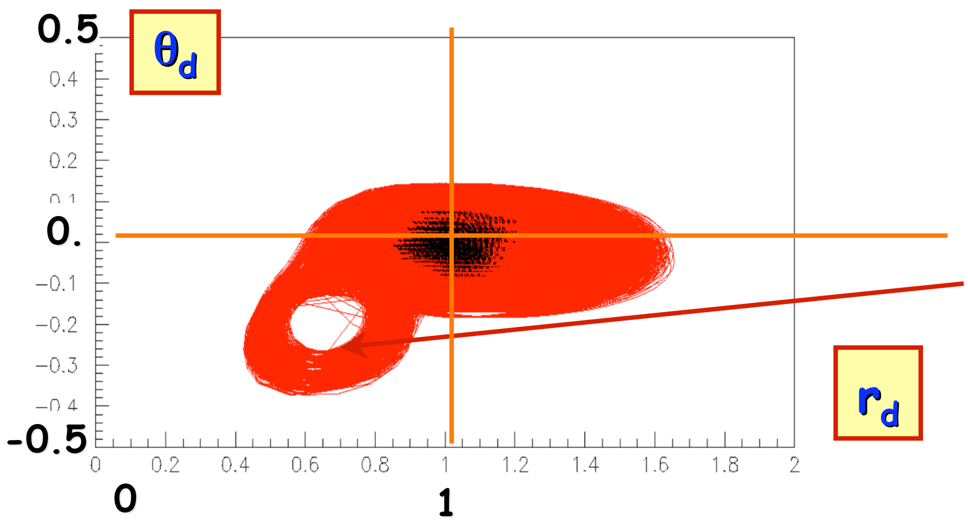
- Old global fits to present data set excluding $a_{\phi Ks}$, $a_{\pi\pi}$ & γ(DK) fitting only to r_d, θ_d



- The introduction of new parameters r_d, θ_d weakens the sin 2β constraint Δm_{Bd} & Δm_{Bs} biunds
- Fits extend into negative ρ region

Present Status of r_d-θ_d Plane & r_s/r_d-θ_s Plane

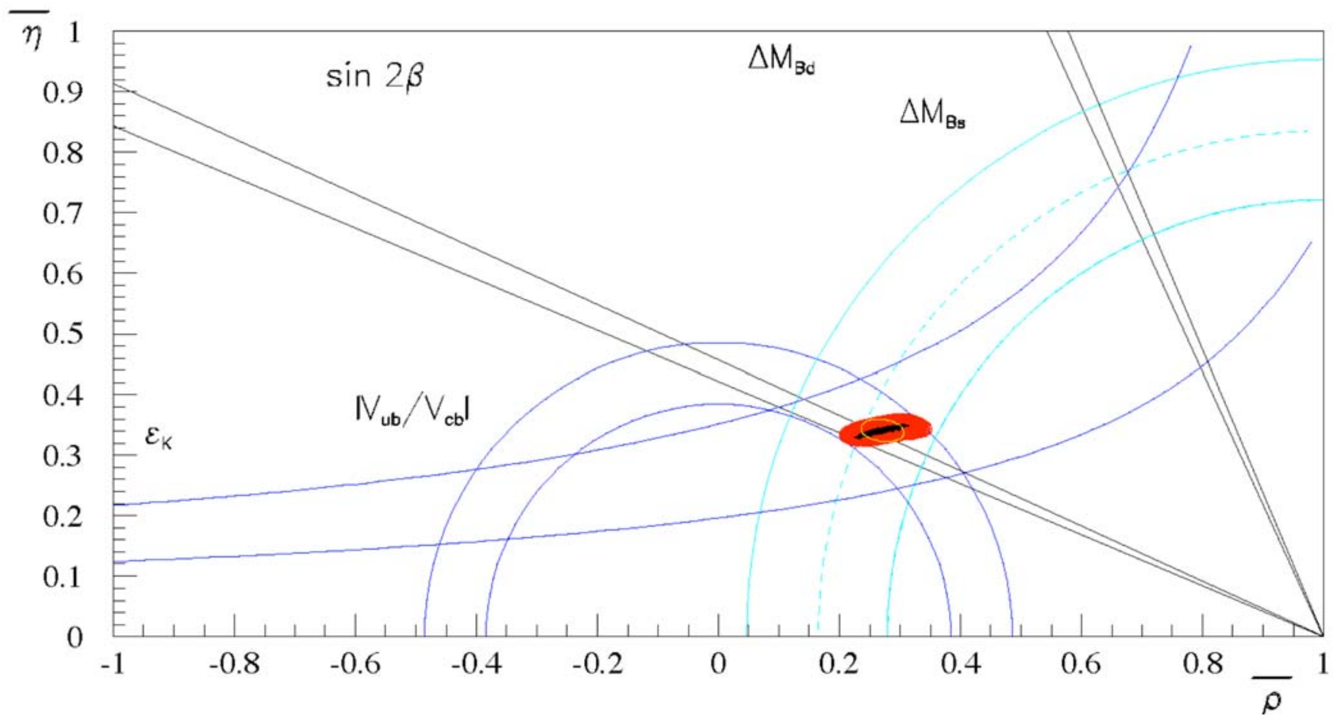
- Old global fits to present data set excluding $a_{\phi Ks}$, $a_{\pi\pi}$ & γ(DK) fitting only to r_d, θ_d



- r_d-θ_d plane is consistent with SM
- Second region (r_d<1, θ_d<0) is visible

Possible Status of the $\bar{\rho}$-$\bar{\eta}$ Plane in 2011

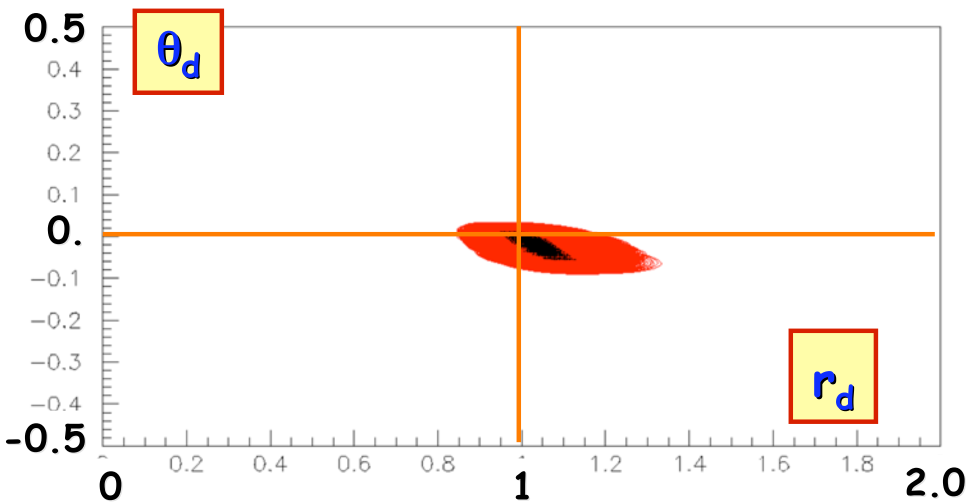
- Global fits to data set expected in 2011 including $a_{\phi K_s}$, $a_{\pi\pi}$ & $\gamma(DK)$



- Reduced errors yield smaller-size contours and a reduced # of accepted models
- The sin 2β constraint remains weak, now see also weakening Δm_{Bs} bound

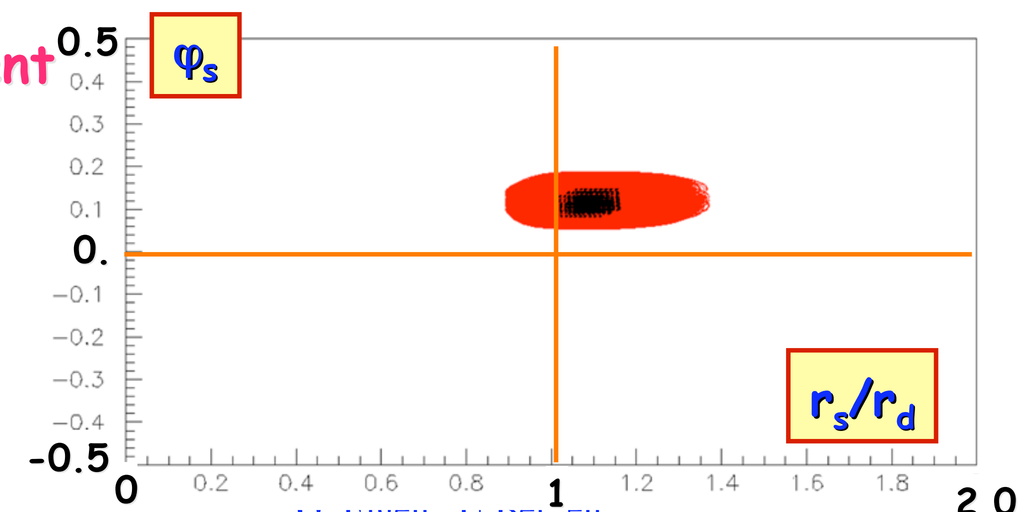
Possible Status of r_d-θ_d & r_s/r_d-φ_s Planes in 2011

- Global fits to data set expected in 2011 including $a_{\phi K_s}$, $a_{\pi\pi}$ & $\gamma(DK)$



- r_d-θ_d plane is still consistent with SM
- Size of contours are reduced substantially

- r_s- φ_s plane now is inconsistent with SM for some models
- Second region inconsistent with SM disappears



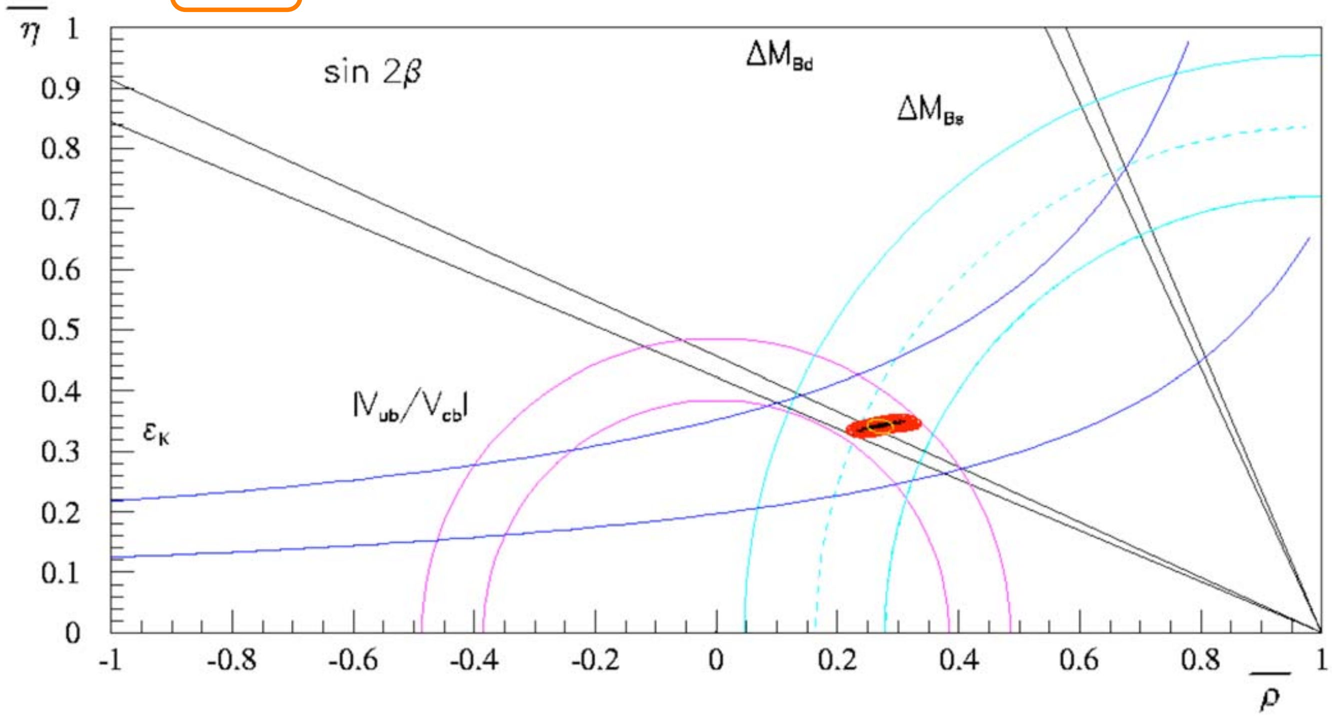
Comparison of Results

- Fit Results for parameterization with r_d, θ_d, r_s, & φ_s

Parameter	Present Results	Possible results in 2011
ρ	0.177-0.372, $\sigma=\pm^{0.022}_{0.031}$	0.227-0.313, $\sigma=\pm^{0.013}_{0.11}$
η	0.236-0.473, $\sigma=\pm^{0.025}_{0.017}$	0.329-0.351, $\sigma=\pm^{0.007}_{0.006}$
A	0.80-0.89, $\sigma=\pm^{0.030}_{0.035}$	0.81-0.88, $\sigma=\pm^{0.025}_{0.022}$
m_c	1.0-1.41, $\sigma=\pm^{0.16}_{0.18}$	1.09-1.29, $\sigma=\pm^{0.08}_{0.09}$
β	$(17.9-28.6)^0$, $\sigma=\pm^{3.1}_{1.8}$	$(23.1-26.9)^0$, $\sigma=\pm^{1.1}_{1.1}$
α	$(96.3-123.6)^0$, $\sigma=\pm^{5.0}_{6.4}$	$(101.4-105.1)^0$, $\sigma=\pm^{1.9}_{2.0}$
γ	$(34.4-61.3)^0$, $\sigma=\pm^{4.4}_{2.6}$	$(48.1-55.5)^0$, $\sigma=\pm^{1.5}_{1.3}$

Possible Status of the $\bar{\rho}$-$\bar{\eta}$ Plane in 2011

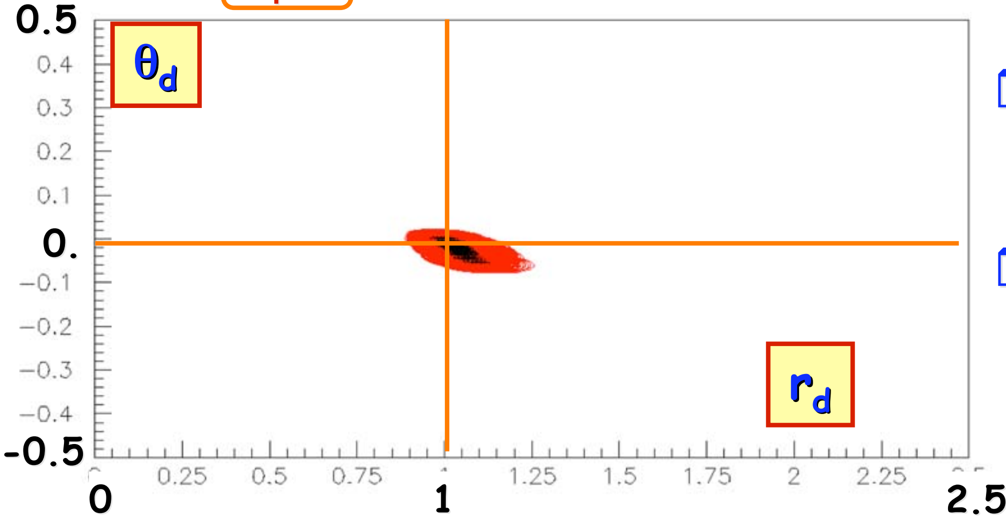
- Global fits to data set expected in 2011 including $a_{\phi K_S}$, $a_{\pi\pi}$, $\gamma(DK)$ & $a_{\eta' K_S}$



- Inclusion of $a_{\eta' K_S}$ results in reduced countours

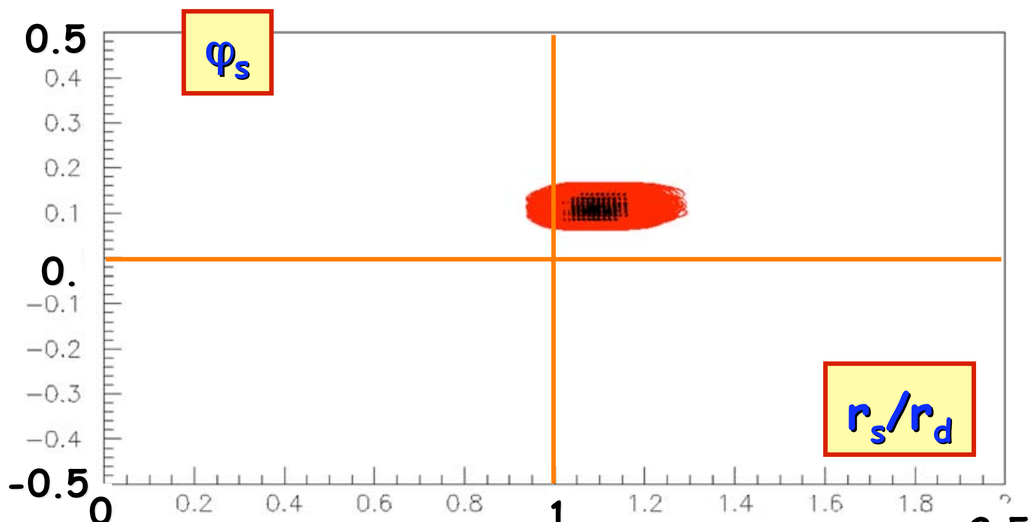
Possible Status of r_d-θ_d & r_s/r_d-φ_s Planes in 2011

- Global fits to data set expected in 2011 including $a_{\phi K_s}$, $a_{\pi\pi}$, $\gamma(DK)$ & $a_{\eta' K_s}$



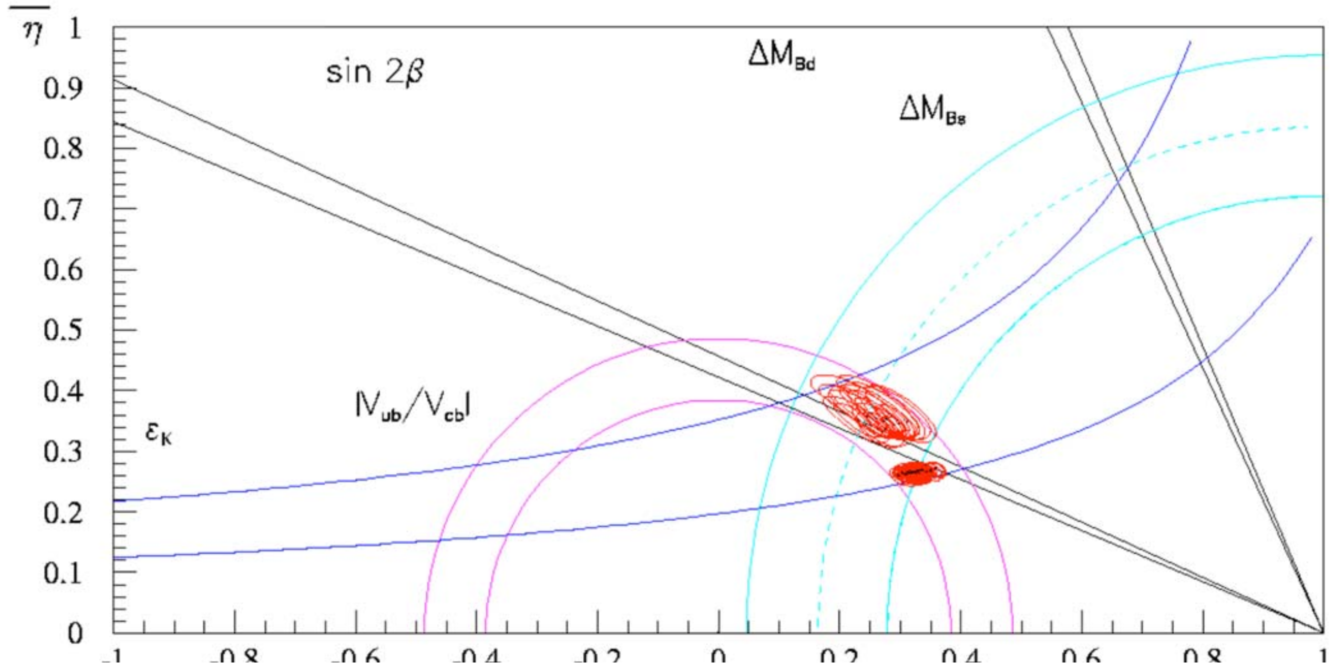
- r_d-θ_d plane is still consistent with SM
- Inclusion of $a_{\eta' K_s}$ reduces r_d-θ_d contour sizes

- r_s- φ_s plane remains inconsistent with SM for some models
- Inclusion of $a_{\eta' K_s}$ reduces r_s/r_d-φ_s contour sizes



Possible Status of the $\bar{\rho}-\bar{\eta}$ Plane after 2011

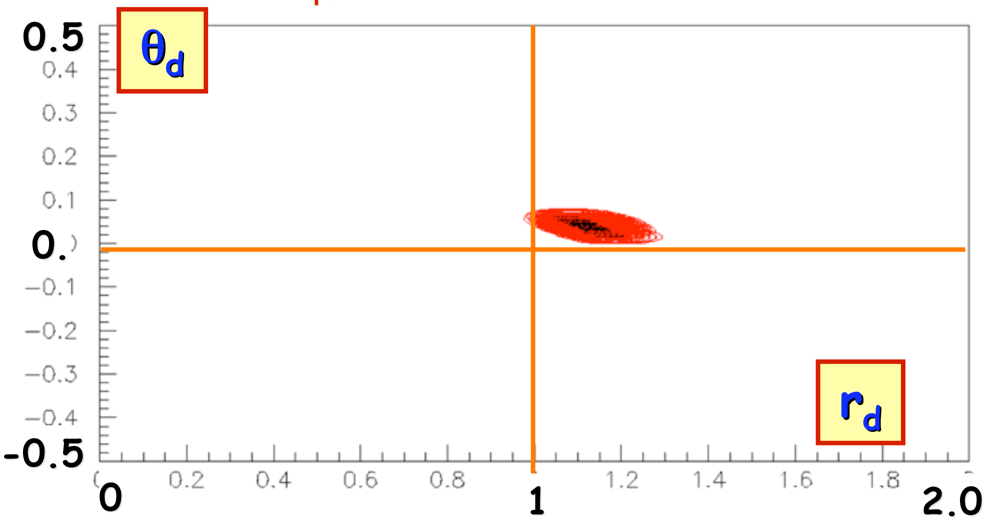
- Global fits to data set expected in 2011 including $a_{\phi Ks}$, $a_{\pi\pi}$ & γ(DK) with $a_{\phi Ks}$=-0.96±0.01 & $a_{\pi\pi}$=-0.95±0.05



- Using Belle central values with small errors changes the picture → obtain 2 separated regions in $\bar{\rho}-\bar{\eta}$ plane
- Weakening of sin 2β, Δm_{Bd}, Δm_{Bs} & sin 2α bounds is apparent now
-

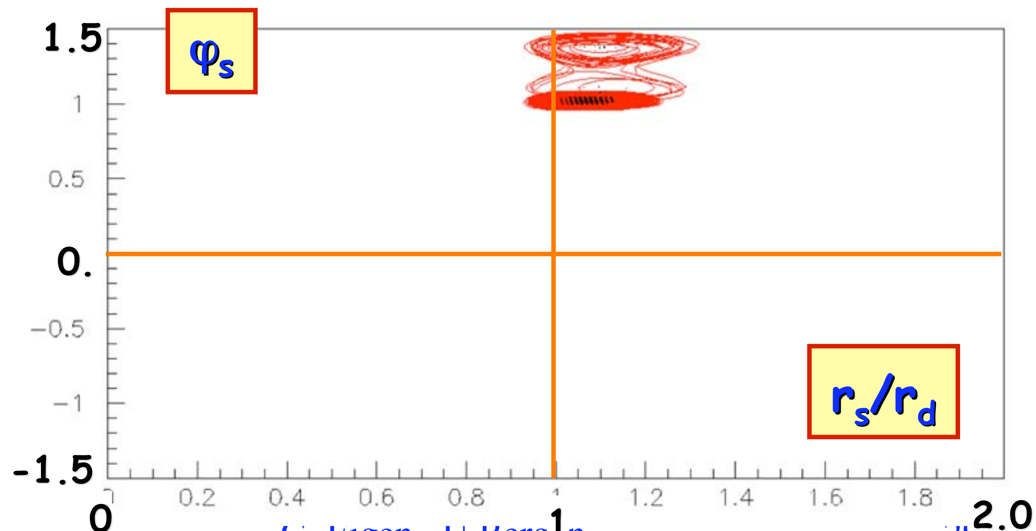
Possible Status of r_d-θ_d & r_s/r_d-φ_s Planes after 2011

- Global fits to data set expected in 2011 including $a_{\phi K_s}$, $a_{\pi\pi}$ & $\gamma(DK)$ with $a_{\phi K_s}=-0.96\pm0.01$ & $a_{\pi\pi}=-0.95\pm0.05$



- r_d-θ_d plane is shifted to $r_d>0$, $\theta_d>0$ values
- Size of contours are reduced substantially
- r_d-θ_d plane is now inconsistent with SM

- 2 $\varphi_s>0$ regions are favored
- r_s-φ_s plane now is highly inconsistent with SM



Conclusions

- Model-independent analyses will become important in the future

- The scanning method provides a conservative, robust procedure with a reasonable treatment of non-gaussian theor. uncertainties
  - ⇒ This allows to avoid fake conflicts or fluctuations
  - ⇒ This is crucial for believing that any observed significant discrepancy is real indicating New Physics

- Due to the large theoretical uncertainties all measurements are presently consistent with the SM expectation

- Deviation of $a_{CP}(\phi K_S)$ from $a_{CP}(\psi K_S)$ is interesting but not yet significant, similar comment holds for Belle's $S_{\pi\pi}$ & $A_{\pi\pi}$ results

- If errors get reduced as prognosed, $\bar{\rho}-\bar{\eta}$ plane will be substantially reduced in 2011

- The fits indicate that the impact of New Physics may be less visible in $\bar{\rho}-\bar{\eta}$ plane but show up in $r_d-\theta_d$ or $r_s-\varphi_s$ planes

- In the future we will incorporate other $\sin 2\alpha$ measurements and add further parameters for strong phases

- It is useful to include $\sin(2\beta+\gamma)$ from $B\rightarrow D^{(*)}\pi$ modes