CKM Fits

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The CKM Matrix: Some Definitions

■ Phase invariant parameterisation conserving the CKM matrix unitarity at any order in λ

Wolfenstein parameterisation with Jarlskog like phase invariants as in EPJ C**41**,1-131 (2005)

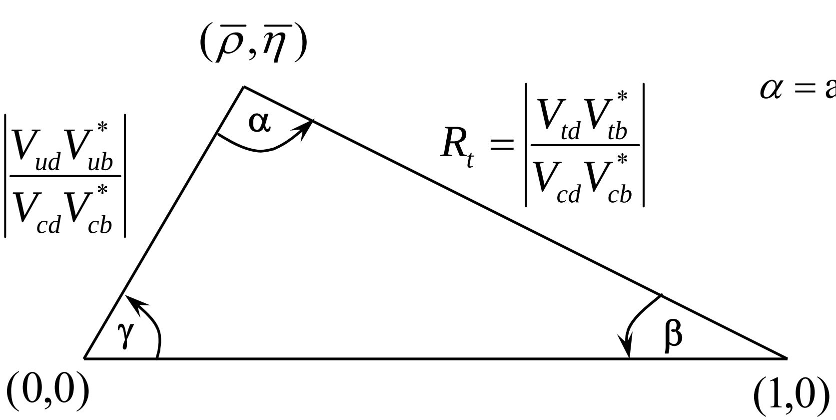
4 free parameters, $A, \lambda, \bar{\rho}$ and $\bar{\eta}$, taken such that:

$$\lambda = \frac{|V_{us}|}{\sqrt{|V_{ud}|^2 + |V_{us}|^2}}, \quad A\lambda^2 = \frac{|V_{cb}|}{\sqrt{|V_{ud}|^2 + |V_{us}|^2}} \quad \text{and} \quad \bar{\rho} + i\bar{\eta} = -\frac{V_{ud} V_{ub}^*}{V_{cd} V_{cb}^*}, \text{ with } V_{CKM} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}$$

- λ is measured from $|V_{ud}|$ and $|V_{us}|$ in superallowed nuclear β-decays and (semi)leptonic K decays, resp.
- A is determined from $|V_{cb}|$ and λ.
- $\bar{\rho}+i\bar{\eta}$ is to be determined from angles and sides measurements of the B_d unitarity triangle.

■ B_d Unitarity Triangle (UT)

$$R_u = \left|\frac{V_{ud} V_{ub}^*}{V_{cd} V_{cb}^*}\right| \qquad R_t = \left|\frac{V_{td} V_{tb}^*}{V_{cd} V_{cb}^*}\right|$$



$$\alpha = \arg\left[-\frac{V_{td} V_{tb}^*}{V_{ud} V_{ub}^*}\right], \quad \beta = \arg\left[-\frac{V_{cd} V_{cb}^*}{V_{td} V_{tb}^*}\right], \quad \gamma = \arg\left[-\frac{V_{ud} V_{ub}^*}{V_{cd} V_{cb}^*}\right]$$

$$\beta_s = -\arg\left[-\frac{V_{cs} V_{cb}^*}{V_{ts} V_{tb}^*}\right]$$

in B_s

Global Fit and Observables

■ CKM matrix fit

+ Use **Frequentist Hypothesis testing** to build statistical **significance** (p-value) functions from which estimates and **confidence intervals** are obtained; test statistic = Maximum Likelihood Ratio $=\Delta\chi^2$.
+ Dedicated ***RFit*** scheme for the treatment of theoretical systematics.

■ **data = weak ⊗ QCD** ⇒ need for hadronic inputs; **often LQCD**: Our Own Average (**OOA**)

	Observable category	Experimental sources	Theory methods & inputs
CP A,λ R_u, R_t **Modulus and sides from rates**	$\|V_{ud}\|$	Superallowed β decays	Towner & Hardy, PRC**77** 025501 (2008)
	$\|V_{us}\|$	K_{l3}, WA FlaviaNet: KLOE	$f_+^{K\pi}(0)=0.964(5)$ (most precise: RBC-UKQCD)
	$\|V_{cb}\|$	HFAG incl.+excl. $B\to X_c l\nu$	$40.59(38)(58)\times10^{-3}$
	$\|V_{ub}\|_{SL}$	HFAG incl.+excl. $B\to X_u l\nu$	**OOA** (spec. uncert. budget.): $3.87(9)(46)\times10^{-3}$
	$\mathcal{B}[B\to\tau\nu]\,(\to\|V_{ub}\|)$	2008 WA: BaBar & Belle	**OOA** $f_{Bs}/f_{Bd}=1.196(8)(23)$ & $f_{Bs}=228(3)(17)$
	$\Delta m_d\ (\to\|V_{td}\|)$	HFAG WA $\bar{B}_d$-B_d mixing	**OOA** $B_{Bs}/B_{Bd}=1.05(2)(5)$ + f_{Bs}/f_{Bd}
	$\Delta m_s\ (\to\|V_{ts}\|)$	CDF B_s-$\bar{B}_s$ mixing	**OOA** $B_{Bs}=1.23(3)(5)$ + f_{Bs}
~~CP~~ $\bar{\rho},\bar{\eta}$ **Angles from phases in interferences**	$\|\varepsilon_K\|$	K^0-$\bar{K}^0$, PDG 2008: KLOE, NA48, KTeV	PDG param. (Buchalla et al. '96) + **OOA** $B_K=0.721(5)(40)$
	α/ϕ_2	WA ππ, ρπ, ρρ **New!**	isospin SU(2), Gronau & London, PRL**65**, 3381 (1990)
	β_{cc}/ϕ_1	WA HFAG charmonium	0.671(23)
	γ/ϕ_3	WA HFAG $B^-\to D^{(*)}K^{(*)-}$	GLW / ADS / GGSZ

Compilation of numerical input values available at: http://ckmfitter.in2p3.fr/plots_Moriond09/ckmEval_results_Moriond09.pdf

RFit Treatment of Theoretical Systematics

■ *RFit* scheme

Theoretical systematics are considered as additional ***nuisance parameters*** bounded over a confident enough range. Considering the worst case –supremum-, on the latter interval the significance is flat.

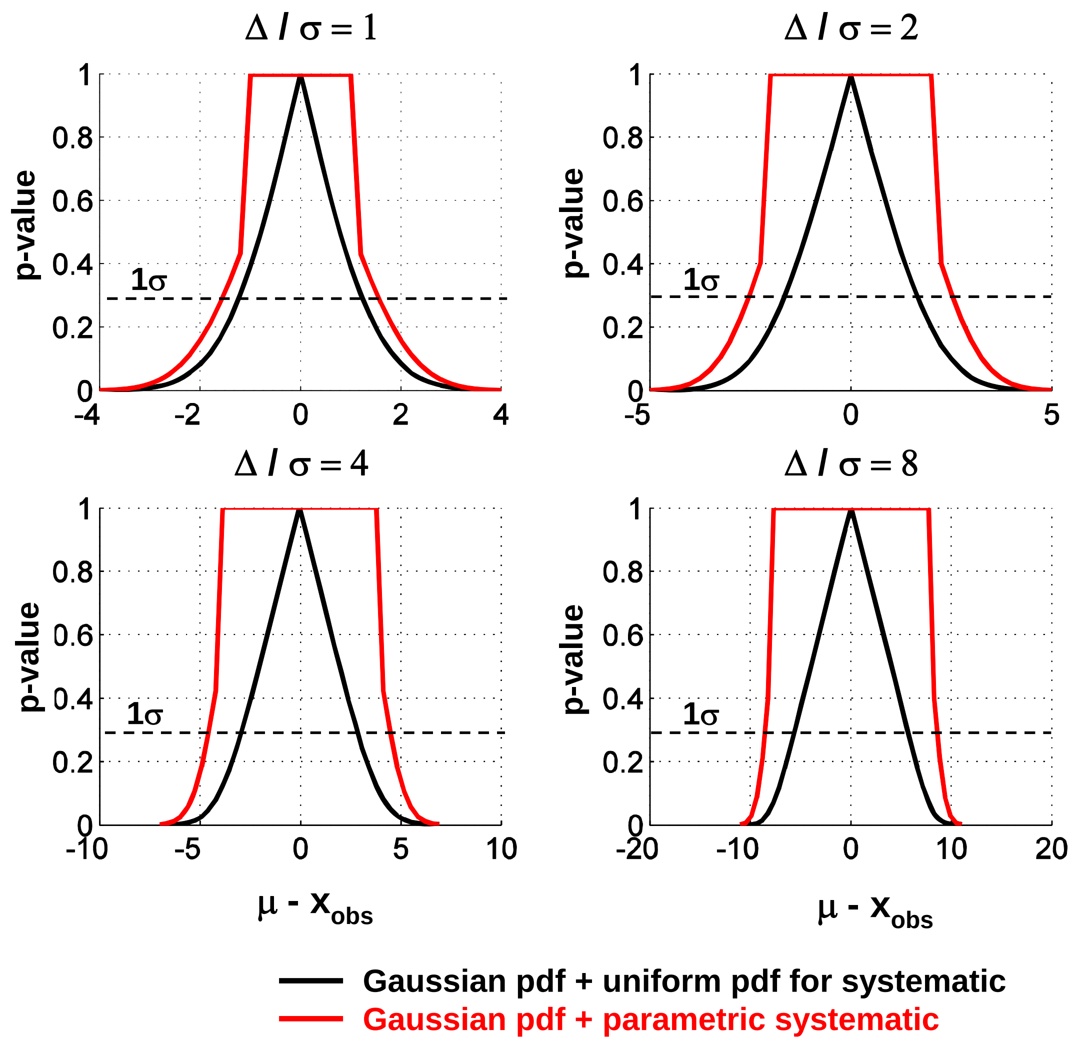
Note that this result is very different from what one would get from a statistical modelling of the systematic (ex: uniform over the range)

Simple illustrative example allowing analytical resolution:

$$x = \mu + \sigma N[0,1] + \Delta_x$$

- x: **Observation**
- μ: **Parameter**
- $\sigma N[0,1]$: **Gaussian stat. error**
- Δ_x: **Systematic bounded in [-Δ;Δ]**

$$\text{p-value} = \begin{cases} 1 & \text{if} \quad x-\mu \in [-\Delta;\Delta] \\ \frac{1}{2}\left(\text{erfc}\left[\frac{|x-\mu|+\Delta}{\sqrt{2}\sigma}\right] + \text{erfc}\left[\frac{|x-\mu|-\Delta}{\sqrt{2}\sigma}\right]\right) & \text{elsewhere} \end{cases}$$



LQCD: Our Own Average

- More and more **accurate theoretical predictions** **(ex:** f_{Bs}/f_{Bd} ~2-3%) but various methods, results and error estimates depending on collaborations. Need to **combine these results**; several methods also ☹

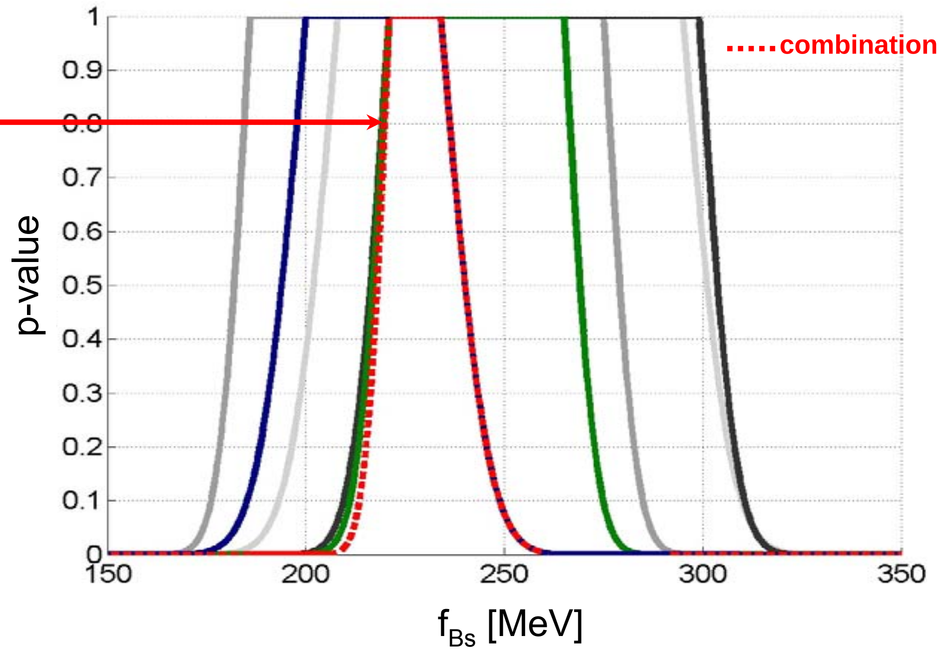
  ⇒ For now we perform **our own average** using an **algorithmic procedure**

■ Our Own Average: Educated *RFit* scheme illustrated here with f_{Bs}

1) From selected LQCD results estimate f_{Bs} **central value in the *RFit*** scheme, distinguishing statistic and systematic contributions to uncertainties.

2) Perform and **educated combination of uncertainties**; Not more nor less accurate than the most precise individual LQCD prediction.

$$\Rightarrow f_{B_s} = 228 \pm 3 \pm 17 \ \text{MeV}$$



For more details:

+ V. Tisserand (CKMfitter Group), Moriond EW 2009 proceedings [arXiv:0905.1572];

+ http://ckmfitter.in2p3.fr/plots_Moriond09/ckmEval_results_Moriond09.pdf;

Global Fit: Unitarity Triangle

CKMfitter

Observables

$|V_{ud}|, |V_{us}|$

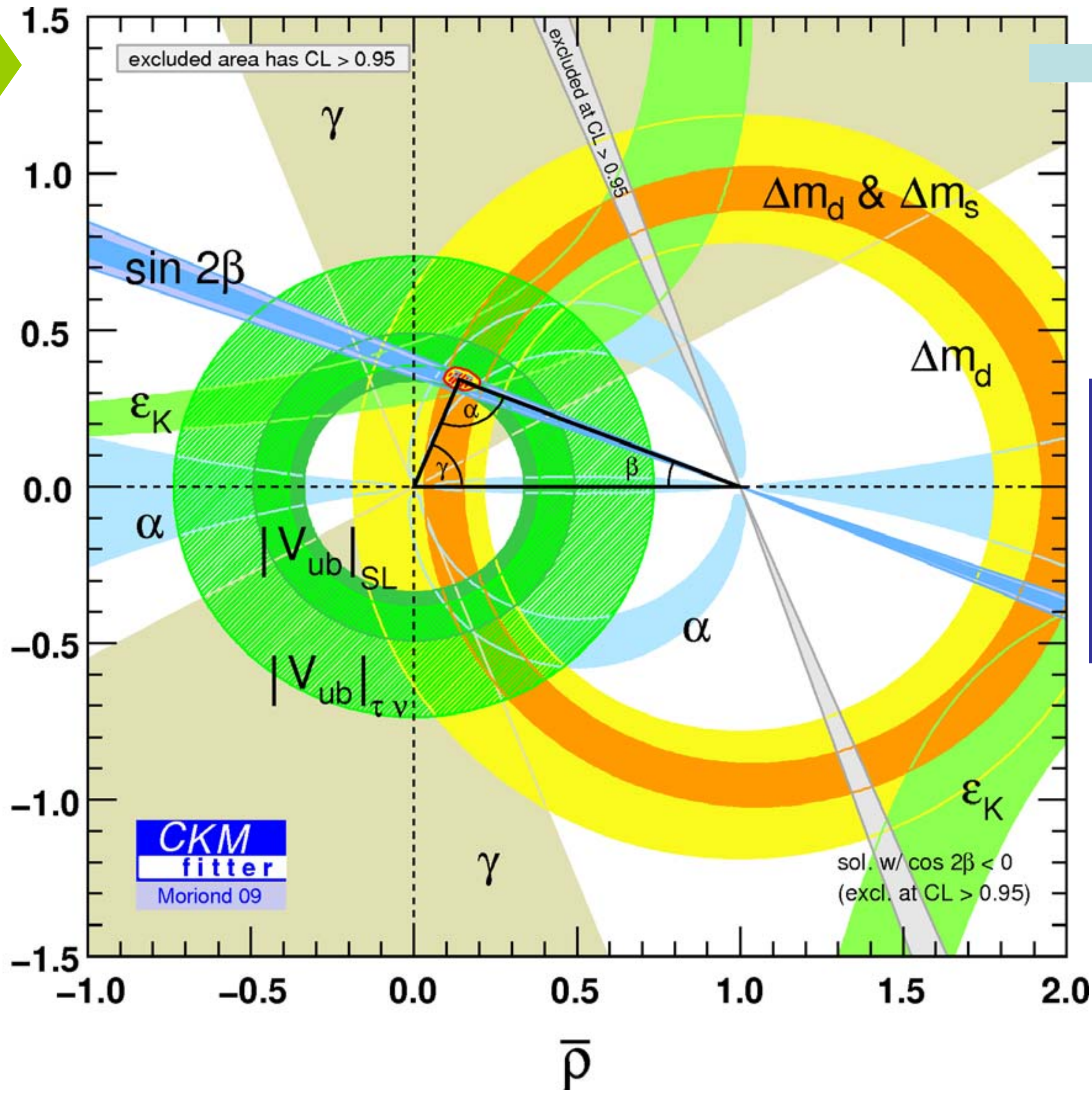
$|V_{cb}|, |V_{ub}|$

$B[B \to \tau \nu]$

$\Delta m_d, \Delta m_s$

$|\varepsilon_K|$

$\alpha, \sin(2\beta), \gamma$



$$\bar{\rho} = 0.139^{+0.025}_{-0.027}$$

$$\bar{\eta} = 0.341^{+0.016}_{-0.015}$$

(1 σ interval)

Overall consistency at 95% CL

Global Fit
p-value ≈ 45%
(0.8 σ)

The KM mechanism is the dominant source of CP̸ in B's

Fit dominated by **sin(2β), $\Delta m_d/\Delta m_s$** and α/ϕ_2 (!). Excellent agreement between these 3 inputs.
p-value ≈ 95% (0.1 σ)

Global CKM fit: Numerical Results

■ A overview of numerical results

Wolfenstein parameters and Jarlskog invariant:

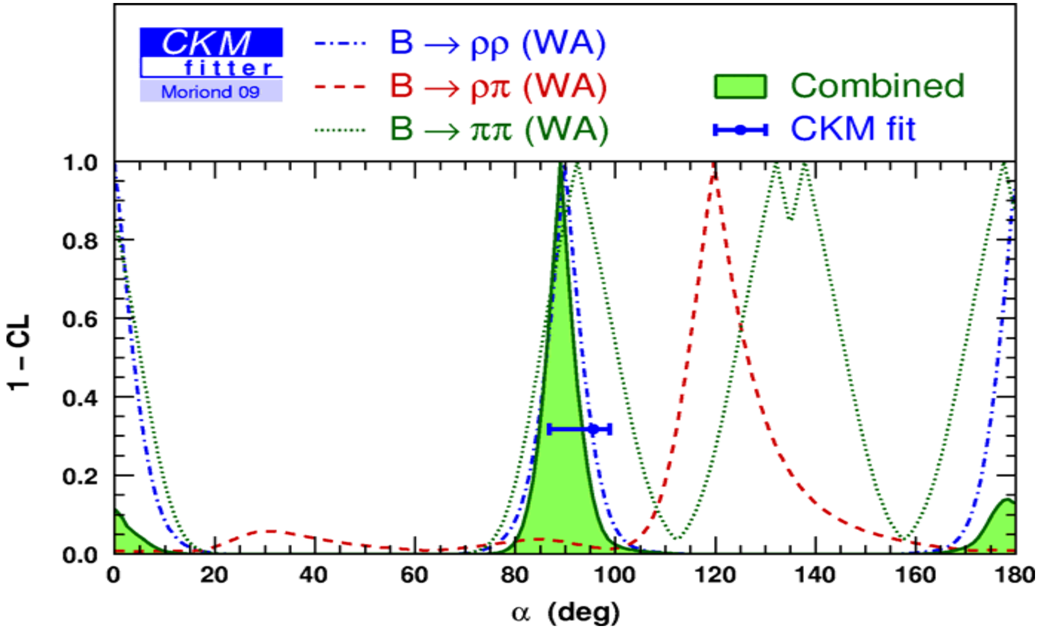
Observable	Central ± 1 σ	± 2 σ	± 3 σ
A	0.8116 [+0.0097 -0.0241]	0.812 [+0.019 -0.036]	0.812 [+0.029 -0.045]
λ	0.22521 [+0.00082 -0.00082]	0.2252 [+0.0016 -0.0016]	0.2252 [+0.0025 -0.0025]
ρbar	0.139 [+0.025 -0.027]	0.139 [+0.053 -0.040]	0.139 [+0.073 -0.052]
ηbar	0.341 [+0.016 -0.015]	0.341 [+0.032 -0.025]	0.341 [+0.048 -0.034]
J [10^{-5}]	2.92 [+0.15 -0.15]	2.92 [+0.30 -0.19]	2.92 [+0.45 -0.23]

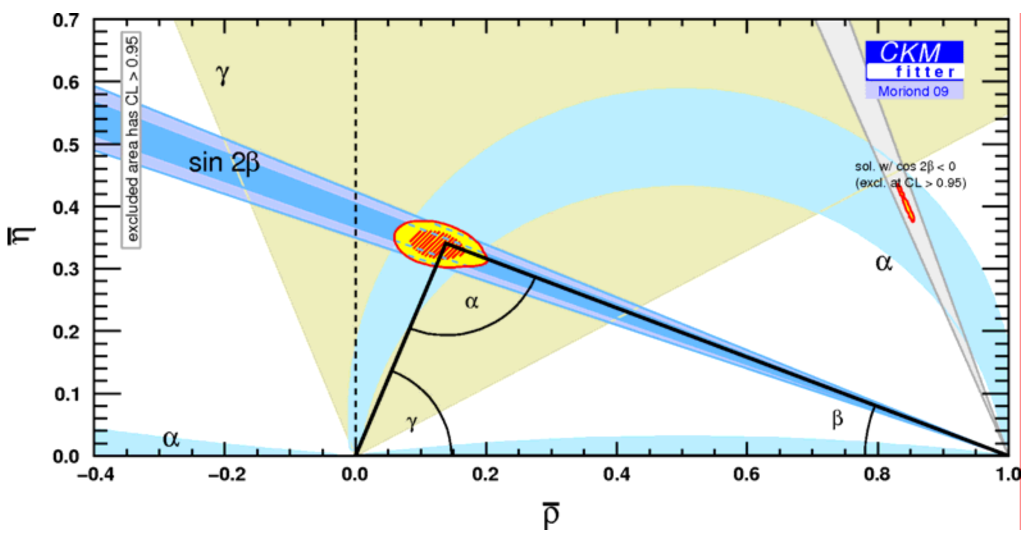
UT angles and sides:

Observable	Central ± 1 σ	± 2 σ	± 3 σ
sin 2α	-0.02 [+0.15 -0.13]	-0.02 [+0.22 -0.26]	-0.02 [+0.28 -0.35]
sin 2α (meas. not in the fit)	-0.20 [+0.30 -0.11]	-0.20 [+0.41 -0.17]	-0.20 [+0.48 -0.23]
sin 2β	0.684 [+0.023 -0.021]	0.684 [+0.046 -0.035]	0.684 [+0.068 -0.049]
sin 2β (meas. not in the fit)	0.817 [+0.026 -0.040]	0.817 [+0.039 -0.114]	0.817 [+0.052 -0.171]
|sin (2β+γ)|	0.934 [+0.023 -0.030]	0.934 [+0.039 -0.051]	0.934 [+0.049 -0.071]
α [deg]	90.6 [+3.8 -4.2]	90.6 [+7.5 -6.3]	90.6 [+10.2 -8.2]
α [deg] (meas. not in the fit)	95.6 [+3.3 -8.8]	95.6 [+5.2 -11.8]	95.6 [+6.8 -13.9]
α [deg] (dir. meas.)	89.0 [+4.4 -4.2]	89.0 [+9.1 -8.3] || 178.3 [+1.7 -5.6] || 0 [+5 -0]	89 [+21 -13] || 178.3 [+1.7 -13.8] || 0 [+12 -0]
β [deg]	21.58 [+0.91 -0.81]	21.6 [+1.8 -1.4]	21.6 [+2.8 -1.9]

Many more results and plots are available at: http://ckmfitter.in2p3.fr/plots_Moriond09

α/ϕ_2 from $B \to \pi\pi, \rho\pi, \rho\rho$





- Get α From a global fit to rates and CP asymmetries further **assuming SU(2) isospin triangular relations** between amplitudes: $A^{+-} + \sqrt{2}A^{00} = \sqrt{2}A^{+0}$, to simultaneously extract the additional strong phase; [Gronau & London PRL65, 3381 (1990)]

$$\alpha = (89.0^{+4.4}_{-4.2})^{o}$$ **p-value ≈ 86% (0.2 σ)**

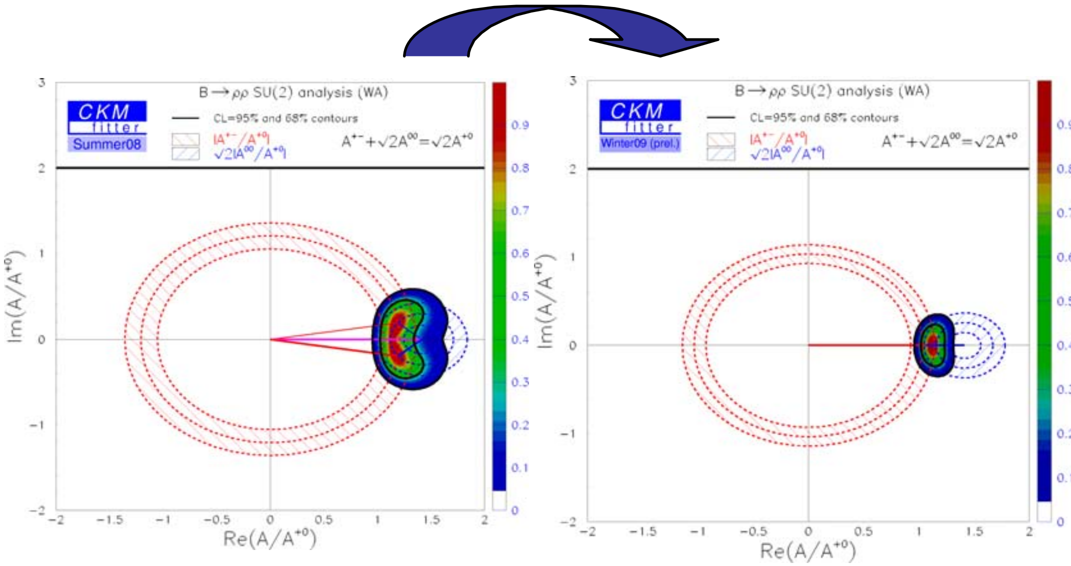
The fit is **dominated by B → ρρ** analysis

- **New measurement of $B[B^+ \to \rho^+\rho^0]$ from BaBar** (PRL**102**, 141802 (2009)) which strongly constrains the isospin triangles and hence α extraction.

α has become a precise measurement @ **5%**
comparable to β @ **4.2%**
$\sin(2\beta_{cc}) = 0.671(23)$ **[HFAG]**

Isospin Triangle Does Not Close

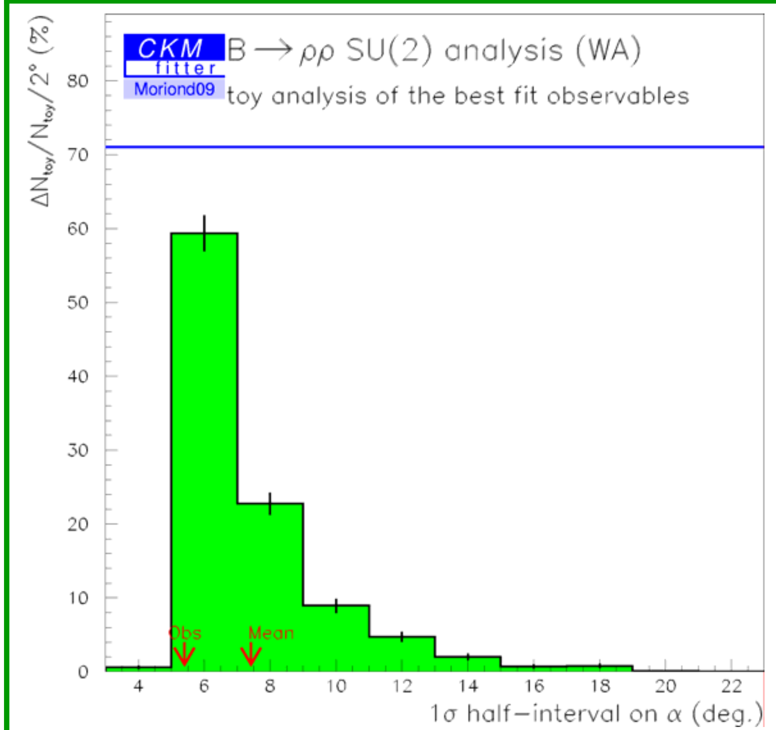
$\rho^+\rho^0$ BaBar update: normalisation A^{+0} increased



previously 2 folded solution now degenerated
$\Rightarrow$ increased accuracy by a factor ~2 on α from $B \to \rho\rho$

α from $B \to \rho\rho$ Old summer 08	α from $B \to \rho\rho$ Winter 09
$\alpha = (90.9^{+6.7}_{-14.9})^{\circ}$	$\alpha = (89.9 \pm 5.4)^{\circ}$
$\Delta\alpha = (0.5^{+12.6}_{-5.5})^{\circ}$	$\Delta\alpha = (1.4 \pm 3.7)^{\circ}$

- **How lucky are we?**



- Study from **toy Monte-Carlo** using fit best guess parameter values (plugin):

$\Rightarrow$ **Only 34% of the toy MC triangles close**

$\Rightarrow$ Average toy error is 7.5° to be compared to observed value of 5.4°. **68% of toys have larger error than the data.**

Breaking Isospin Symmetry in B → ρρ

- Various possible sources: QCD (mu ≠ md), QED, … amount to 1-3° [J. Zupan Nucl Phys Proc Suppl 170 33 2007]

Largest effect presumably comes from **finite width: $\Gamma_\rho \neq 0$ allows $\Delta I=1$ transitions**. Breaking as $\propto O(\frac{\Gamma_\rho^2}{m_\rho^2}) \approx 4\%$

Phenomenological study

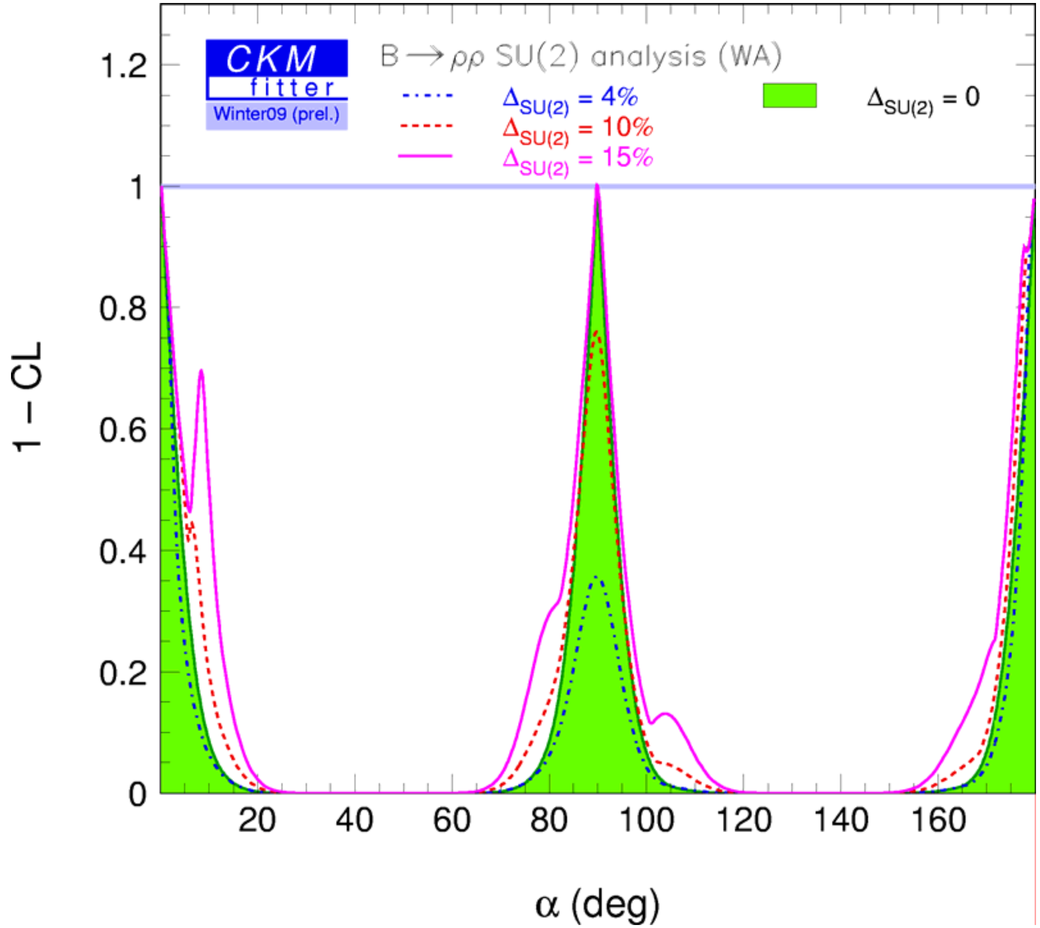
Test **4%,** 10% and 15% violation of the triangular relation with arbitrary additional amplitude:

$\Rightarrow A^{+0} \rightarrow A^{+0} + \Delta A^{+0}$

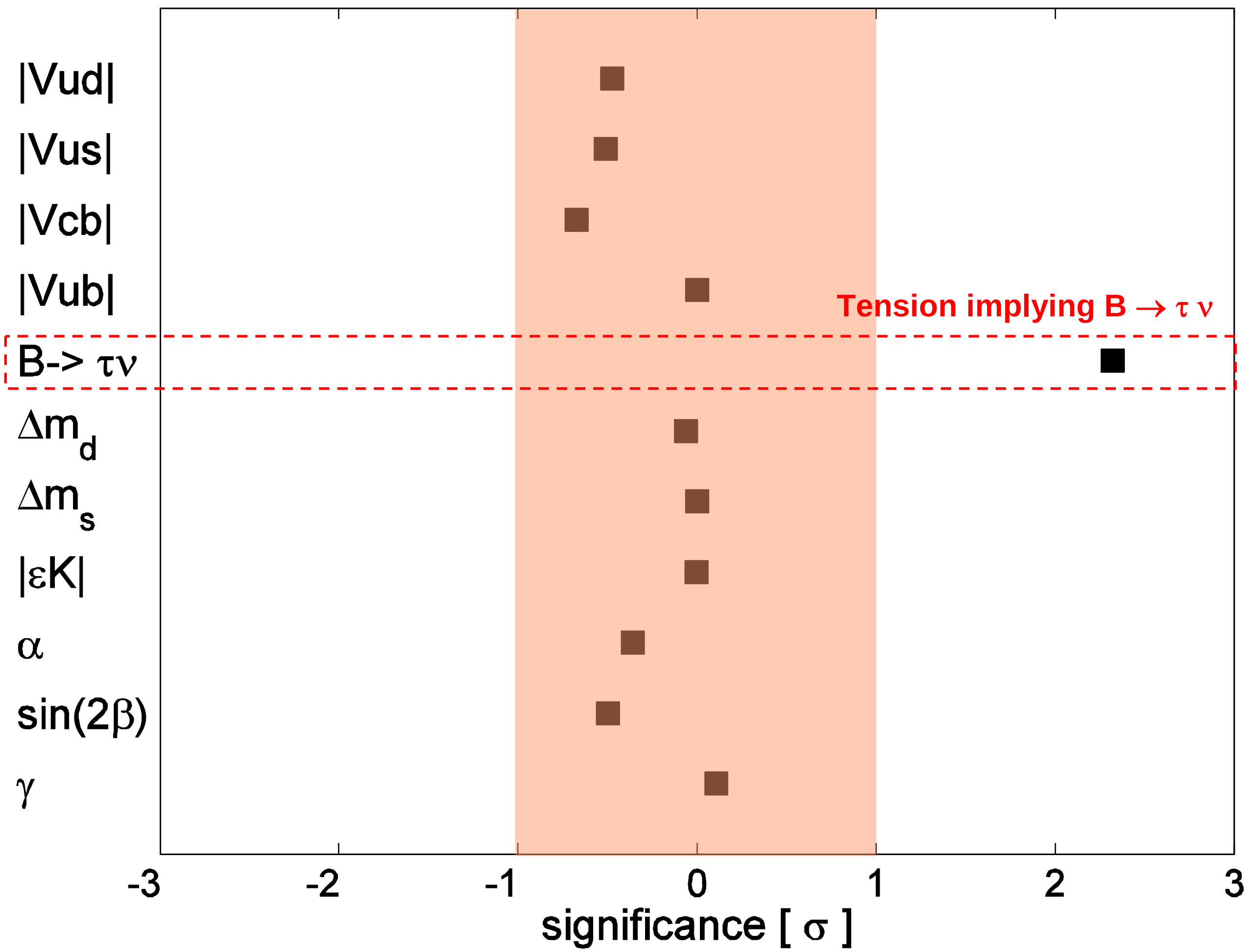
Small values of isospin breaking do not change the pattern.

Small impact on ππ, ρπ, ρρ WA combination; only visible at 95% CL

A nice constraint in any case



How Good is the Fit?



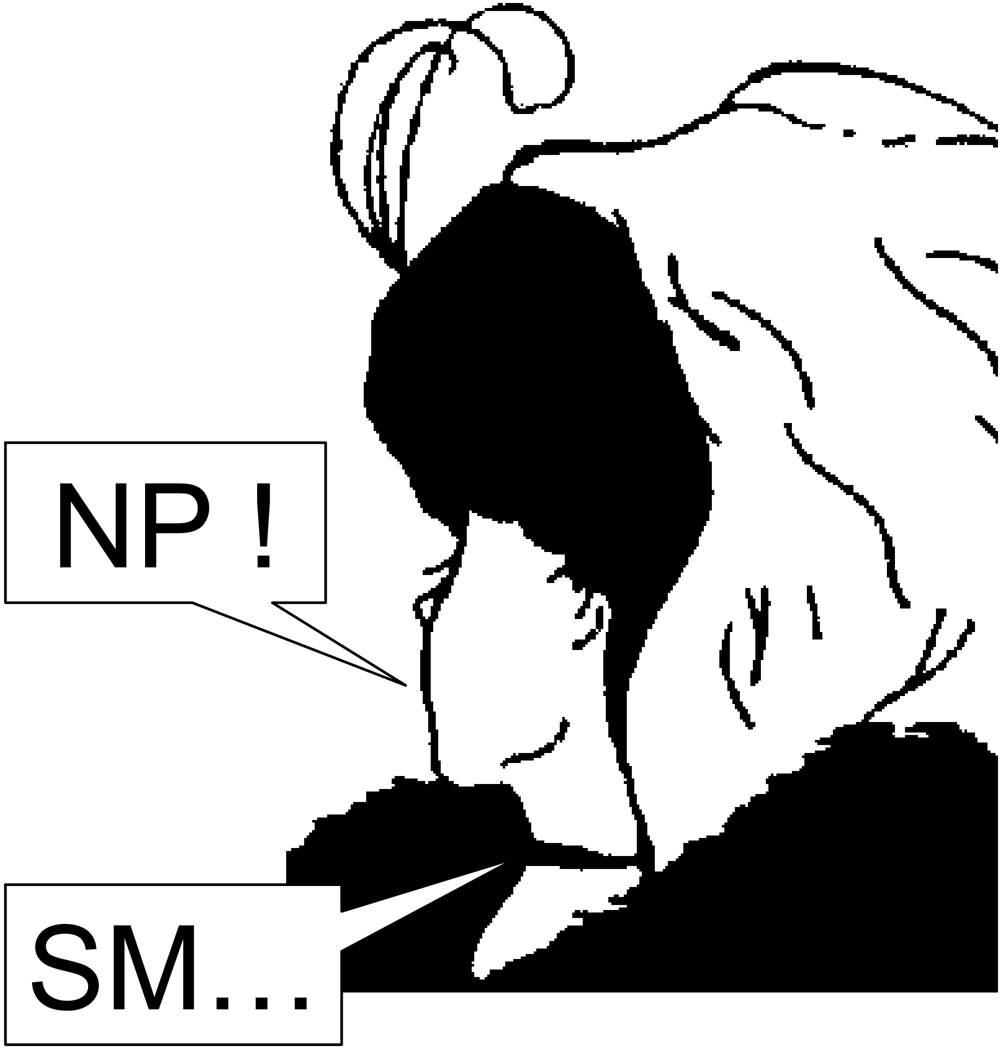
H0: the observable central value is given by the global fit best guess. The measurement is polluted by a known Gaussian error σ and a systematic lying in a known range $\pm\Delta$.

What is the significance of the observed value?

Caution: In the ***RFit*** scheme, significance close to **0** σ means that the measurement lies within the systematics range.

Conservative approach used here. Most measurements can be accommodated within the range of hadronic uncertainties

Any Tensions ?



$|V_{ub}|_{incl.}$ vs $|V_{ub}|_{excl.}$

- The *significant* difference between $|V_{ub}|$ derived from inclusive and exclusive $B \to X_u l \nu$ semileptonic measurements drops when treating systematics within the ***Educated RFit*** scheme

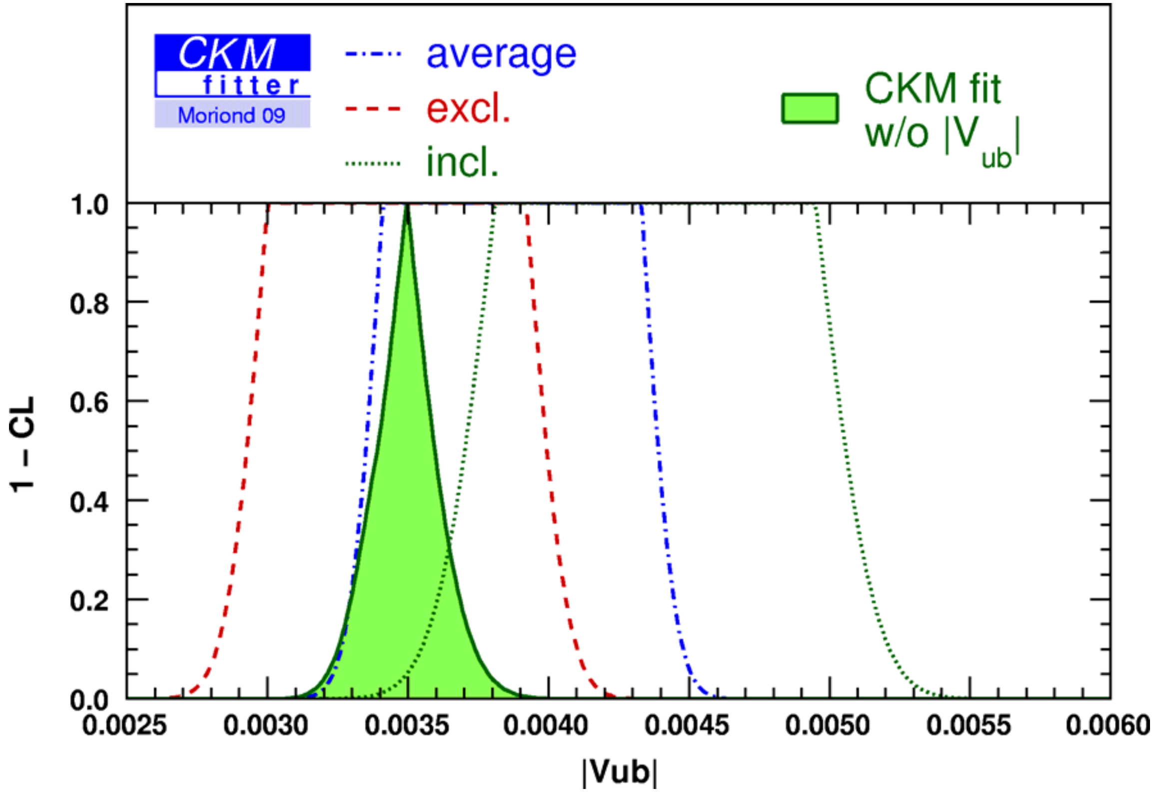
OOA adapted from HFAG summer 08

$|V_{ub}|_{incl.} = 4.38(16)(57)\ 10^{-3}$

$|V_{ub}|_{excl.} = 3.46(11)(46)\ 10^{-3}$

$|V_{ub}| = 3.87(9)(46)\ 10^{-3}$

$\Delta|Vub| = 0.92$, consistent with **OOA** error budget



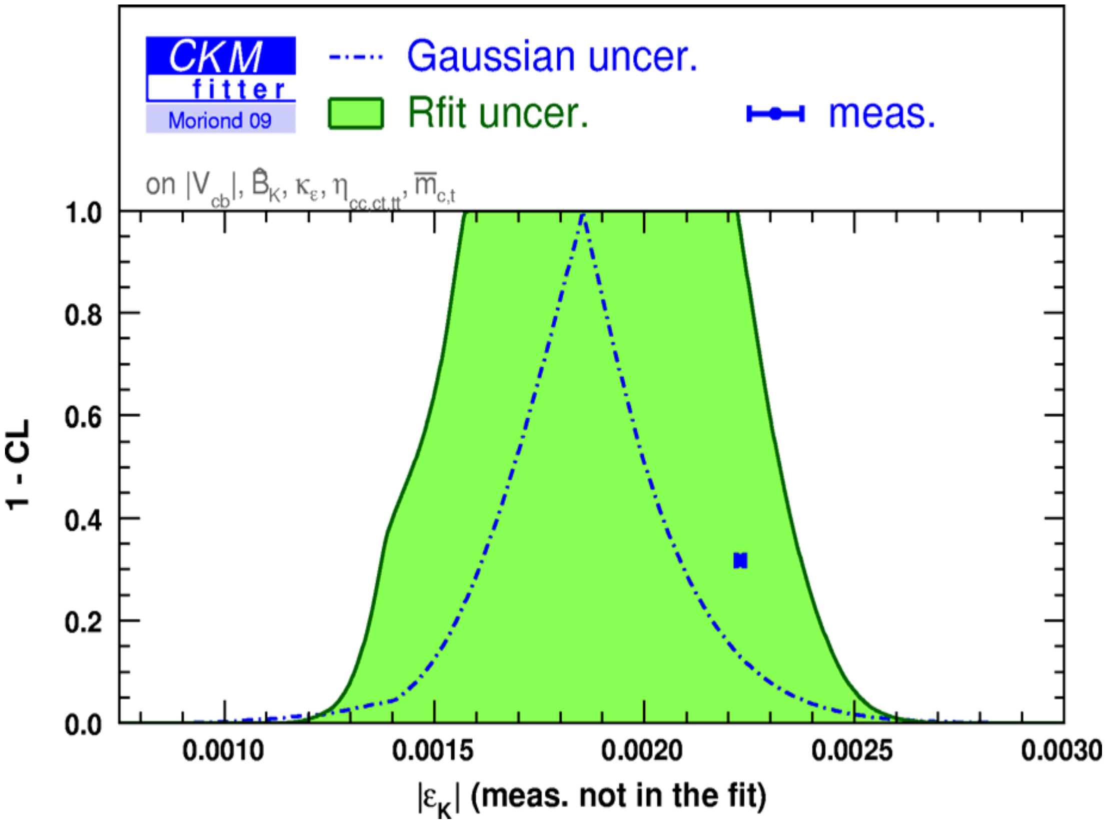
$|\varepsilon_K|$ vs $\sin(2\beta)$

■ Reminder from Buras & Guadagnoli (Phys. Rev. D78, 033005 (2008)): there is an additional suppression factor, $\kappa_{\varepsilon,}$ to $|\varepsilon_K|$, estimated to be $\kappa_\varepsilon = 0.92(2)$.
⇒ Note that this factor has not yet been accounted for in the Global Fit. Its in the line for next update

■ **Any tension between direct measurement of $|\varepsilon_K|$ and indirect measurement from the global fit (through $\sin(2\beta_{cc})$)?**

⇒ Using **Gaussian distributions** for systematic uncertainties and including the factor $\kappa_\varepsilon = 0.92(2)$ we get **1.5 σ** deviation

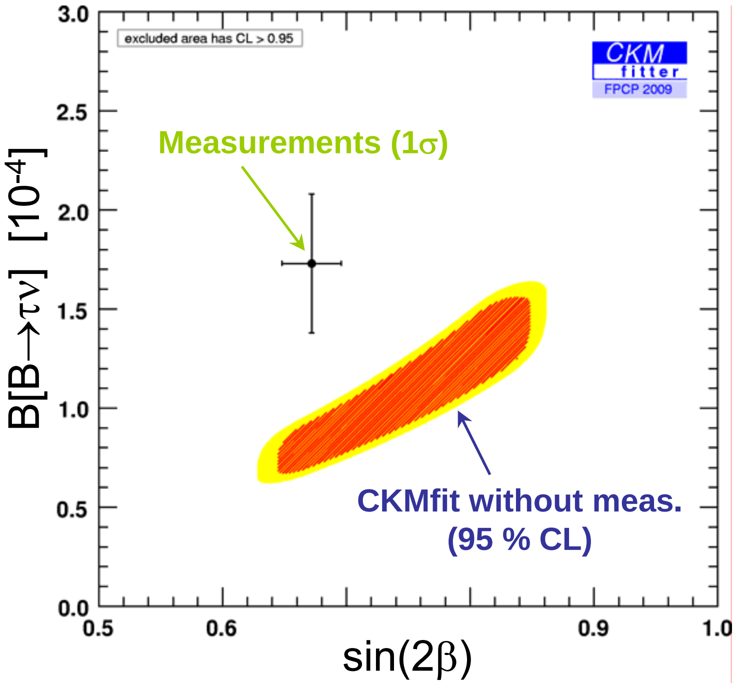
⇒ With our ***Educated RFit*** treatment of systematics **no deviation is seen**. The measurement is compatible with our fit best guess considering **uncertainties** on CKM parameters (through **$|V_{cb}|^4 \sim 7\%$**) mainly and hadronic uncertainties from **B_K (~5%)**.

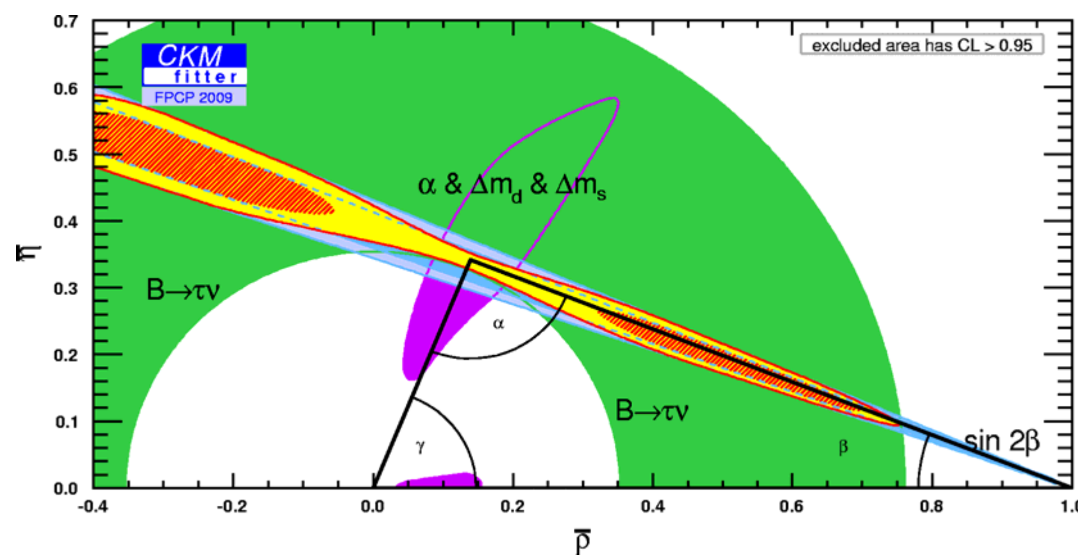


$\sin(2\beta_{cc})$ and B[B → τ ν] Tension

- The Global fit χ^2_{min} drops by **~2.4 σ** if taking out $\sin(2\beta_{cc})$ or B → τ ν.
- The combination $\sin(2\beta_{cc})$ and B → τ ν favours 2 solutions in contradictions with other inputs. Therefore **one can not accommodate both inputs simultaneously in the global fit.**

⇒ The current fit **best guess favours $\sin(2\beta_{cc})$** better measured (4% vs 20%) while reflecting most errors on B → τν





Yellow area: 95% CL for combined fit with $\sin(2\beta_{cc})$ and B → τν. The orange dashed area indicates the 1 σ confidence level.

Closer look at 3 scenarios

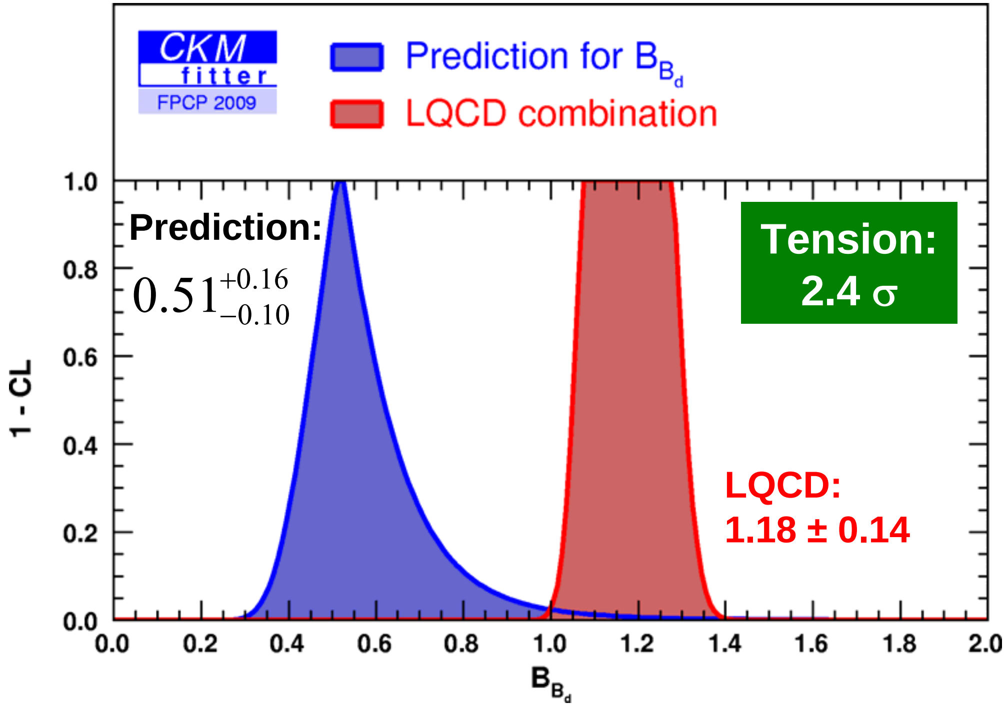
1) Underestimated hadronic uncertainties
2) Measurements, fluctuations
3) Indication of New Physics

Scenario 1: Testing LQCD inputs

■ The bag parameter B_{Bd} can be measured from the ratio of $B \to \tau\nu$ to Δm_d eliminating the dependency to f_{Bd}, as:

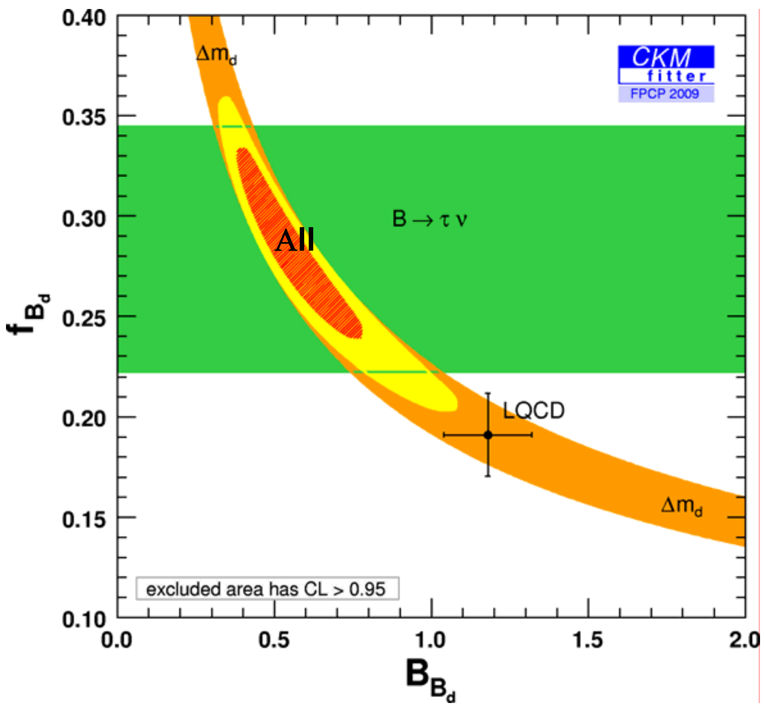
$$\frac{\mathcal{B}[B\to\tau\nu]}{\Delta m_d} = \frac{3\pi}{4}\frac{m_\tau^2\tau_B}{m_W^2\eta_B S[x_t]}(1-\frac{m_\tau^2}{m_B^2})^2\frac{\sin^2(\beta)}{\sin^2(\alpha+\beta)}\frac{1}{|V_{ud}|^2\hat{B}_{B_d}}$$

The tension is still there at ~ 2.4σ! But a factor of 2 off on B_{Bd} while keeping f_{Bd} wouldn't work in the global fit …



■ Let's let f_{Bd} and B_{Bd} be completely free and fit them from all observables. What do we get?

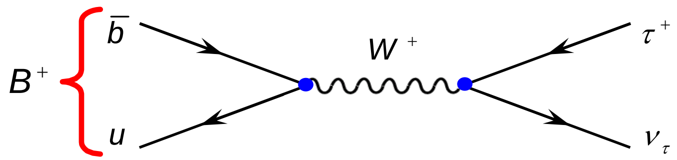
⇒ No more tension / no more constraints
⇒ The global fit is accommodated keeping $f_{Bd}^2 \times B_{Bd} \approx$ const to fit Δm_d while increasing f_{Bd} to fit $B \to \tau\nu$



Would require significantly out of range LQCD errors

Scenario 2: Experimental side

$$BR(B^+ \to \tau^+\nu) = \frac{G_F^2 m_B \tau_B}{8\pi} m_\tau^2 \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 f_{B_d}^2 |V_{ub}|^2$$



- Helicity-suppressed annihilation decay sensitive to **$(f_{Bd} \times |V_{ub}|)^2$**

Experimental measurements

	$B[B \to \tau\nu] \times 10^4$
Belle (hadronic)	1.79±0.71 [2006]
Belle (semi-leptonic)	1.65±0.52 [ICHEP08]
Belle	1.70±0.42
BABAR (hadronic)	1.80±1.00 [2007]
BABAR (semi-leptonic)	1.80±0.81 [CKM08]
BABAR	1.80±0.63
World Average	**1.73 ± 0.35**

CKMfit prediction: $(0.796^{+0.154}_{-0.093}) \times 10^{-4}$ (1σ, without meas.)

The various measurements for $B \to \tau\nu$ look consistent; we combine them using a weighted mean and assume Gaussian distributions. The p-value for this hypothesis is 11% (1.6 σ).

sin(2β) from HFAG charmonium WA

$$\sin(2\beta_{cc}) = 0.671(23)$$

No obvious tension

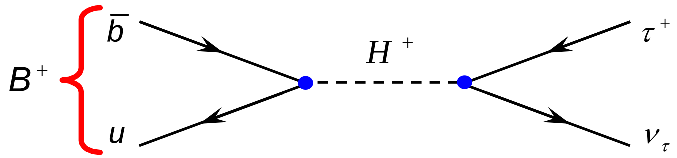
There is an overall experimental agreement that $B[B \to \tau\nu]$ is too high or $\sin(2\beta_{cc})$ too low

Scenario 3: Any New Physics?

CKMfitter

■ **Charged Higgs contributions: increase B[B→τν] prediction**

$$BR(B^+ \to \tau^+\nu) = \frac{G_F^2 m_B \tau_B}{8\pi} m_\tau^2 \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 f_{B_d}^2 |V_{ub}|^2 \times (1 + r_H^B)^2$$



■ **Charged higgs** contribution can modify B[B→τν] as a multiplicative term: $r_H^B \approx -\tan^2(\beta) m_B^2 / m_{H^+}^2$ in **2HDM Type II** model. Note that one would need $r_H^B \approx -2.5$ to fit B[B→τν] (fine tuned solution).

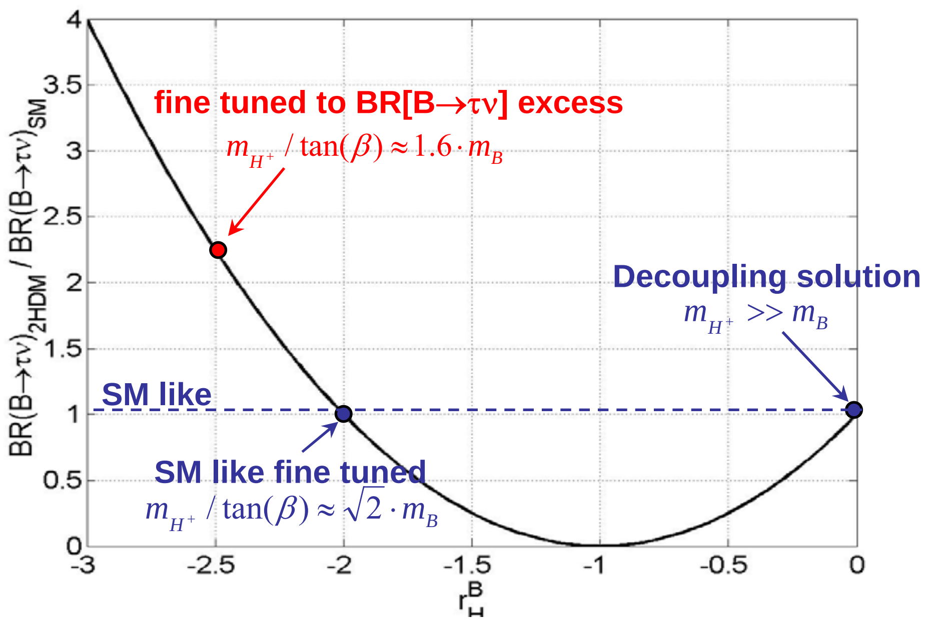
⇒ **Requires a global analysis with other observables to check implications.**

Agreement with the SM can be recovered 2 ways:

• $r_H^B \to 0 \Rightarrow m_{H+}/m_B \to \infty$ irrespective $\tan(\beta)$.
This is the **decoupling solution**

• $r_H^B = -2 \Rightarrow m_{H^+} / \tan(\beta) \approx \sqrt{2} \cdot m_B$; requires a **fine tuning of $m_{H+}/\tan(\beta)$ to the meson mass**.

Here fine tuning to adjust BR[B→τν] excess



Charged Higgs in 2HDM(II)

■ **Combined 2HDM(II) analysis** within CKMfitter including modified constraints from mesons leptonic and semileptonic tree decays and loop radiative $b \to s\gamma$ decays and $Z \to b\bar{b}$ partial width.

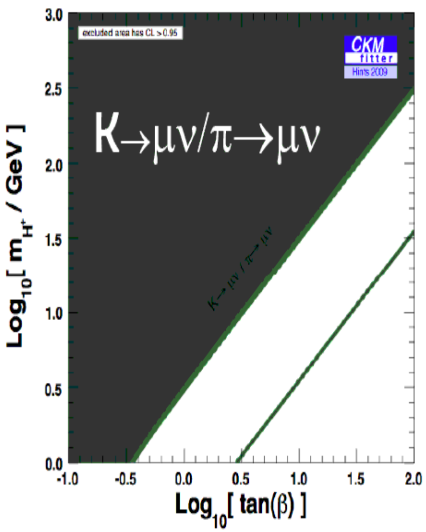
Observables

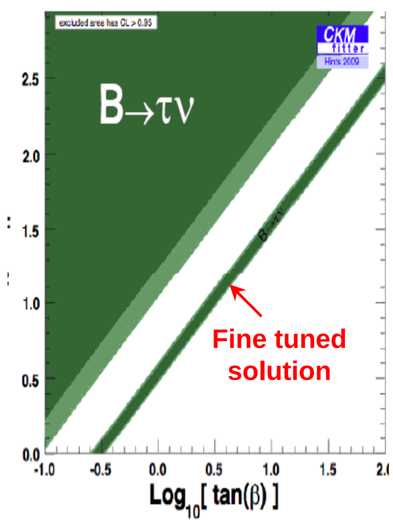
$B[B \to \tau\nu], B[D \to \mu\nu], B[D_s \to \mu\nu], B[D_s \to \tau\nu]$

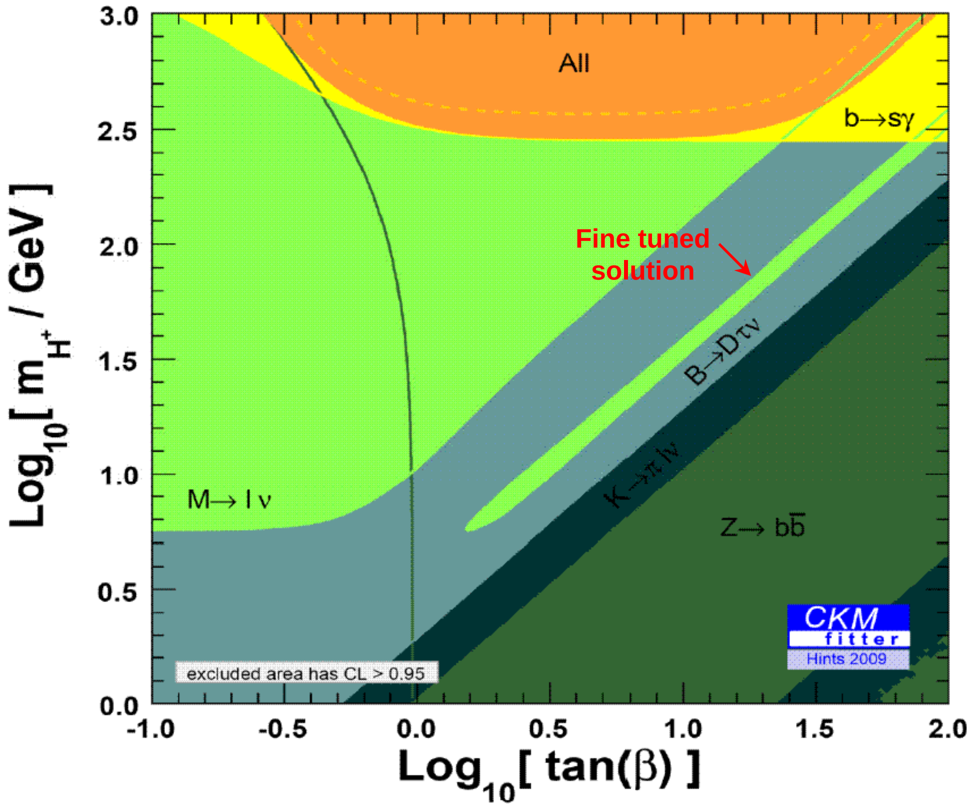
$B[K \to \mu\nu]/B[\pi \to \mu\nu], B[B \to D\tau\nu], B[K \to \pi l\nu]$

$B[b \to s\gamma], \Gamma[Z \to b\bar{b}]/\Gamma[Z \to \text{hadrons}]$

Individual constraints from some leptonic decays







Fine tuned solution ruled out at 95% CL, mostly from $B[K \to \mu\nu]/B[\pi \to \mu\nu]$ and $B[B \to D\tau\nu]$ constraints.

■ **Only marginal improvement of the χ^2_{min}** when going from SM to 2HDM(II), $\Delta\chi^2_{min} = 1.4$ which corresponds to a p-value of 31%, **1.0 σ effect**, from a toy Monte-Carlo study.

⇒ **We see no particular indication for a charged Higgs effect in a 2HDM(II) scheme**

Scenario 3: Any New Physics?

New Physics in $B_{q=d,s}$ mixing: decrease $\sin(2\beta_{cc})$ prediction

Assume that **NP only** affects shorts distance Physics in **$\Delta B = 2$**. Model independent parameterisation. Use Cartesian coordinates (Lenz&Nierste 2006):

$$\langle B_q | \mathrm{H}^{\mathrm{SM+NP}}_{\Delta B=2} | \overline{B}_q \rangle = \langle B_q | \mathrm{H}^{\mathrm{SM}}_{\Delta B=2} | \overline{B}_q \rangle \times \left(\mathrm{Re}[\Delta_q] + i\,\mathrm{Im}[\Delta_q] \right)$$

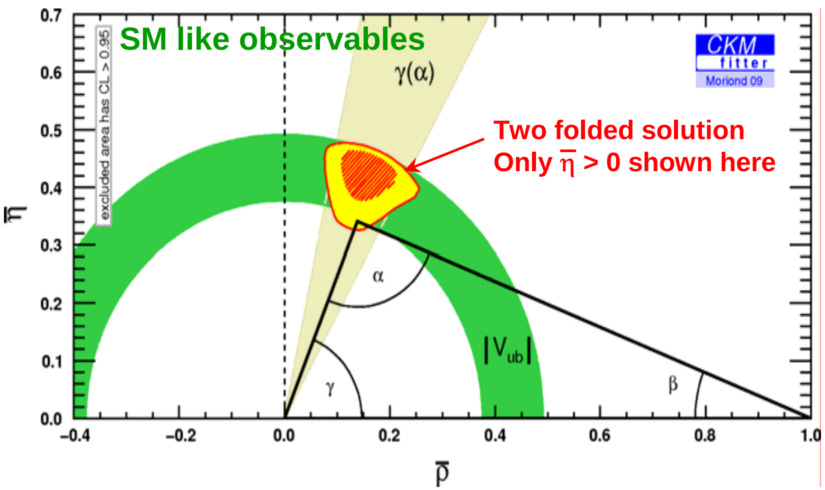
Note that:

$$\Delta q = |\Delta q| e^{2i\Phi_q^{NP}}$$

parameter	prediction in the presence of NP
Δm_q	$\lvert\Delta_q^{\mathrm{NP}}\rvert \times \Delta m_q^{\mathrm{SM}}$
2β	$2\beta^{\mathrm{SM}} + \Phi_d^{\mathrm{NP}}$
$2\beta_s$	$2\beta_s^{\mathrm{SM}} - \Phi_s^{\mathrm{NP}}$
2α	$2(\pi - \beta^{\mathrm{SM}} - \gamma) - \Phi_d^{\mathrm{NP}}$
$\Phi_{12,q} = \mathrm{Arg}[-\frac{M_{12,q}}{\Gamma_{12,q}}]$	$\Phi_{12,q}^{\mathrm{SM}} + \Phi_q^{\mathrm{NP}}$
A_{SL}^q	$\frac{\Gamma_{12,q}}{M_{12,q}^{\mathrm{SM}}} \times \frac{\sin(\Phi_{12,q}^{\mathrm{SM}} + \Phi_q^{\mathrm{NP}})}{\lvert\Delta_q^{\mathrm{NP}}\rvert}$
$\Delta\Gamma_q$	$2\lvert\Gamma_{12,q}\rvert \times \cos(\Phi_{12,q}^{\mathrm{SM}} + \Phi_q^{\mathrm{NP}})$

phases (2β, $2\beta_s$, 2α, $\Phi_{12,q}$)

$$|V_{ud}|, |V_{us}|, |V_{cb}|, |V_{ub}|_{SL+B\to\tau\nu}, \gamma, \gamma(\alpha) = \pi - \alpha - \beta$$



New Physics in B_d Mixing

Inputs:

Δm_d

Δm_s

$\sin(2\beta)$

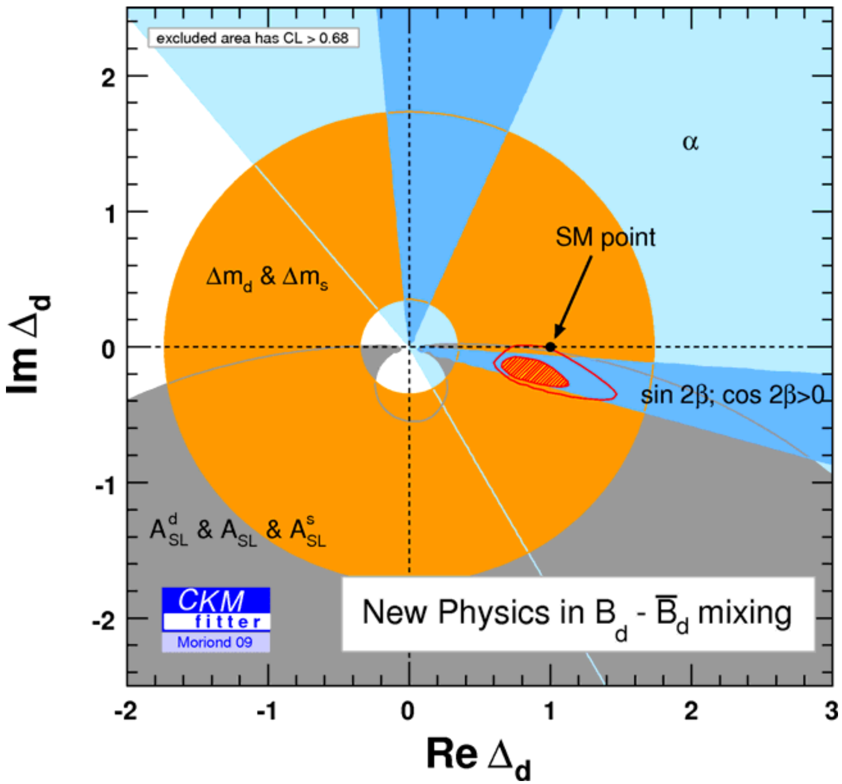
α

$\Delta\Gamma_d$

$A_{SL}^{B_d}$

$A_{SL}^{B_s}$

Warning : only 68% CL regions are shown



- **Dominant constraint from β and Δm_d.** Semi leptonic asymmetries A_{SL} exclude the symmetric solution with $\eta < 0$. Note that the constraint resulting from **$\sin(2\beta_{cc})$ is shifted from real axis** due to the tension with $B\to\tau\nu$.

- **The additional phase can accommodate** the discrepancy between $\sin(2\beta_{cc})$ and $B\to\tau\nu$. For the hypothesis $\Delta_d = 1$ one recovers the **SM**. The latter is **disfavoured at 2.1 σ.** At 95 % CL one would have:

$$\Phi_d^{NP} = (-12^{+9}_{-6})^{o}$$

Note that **taking out $B\to\tau\nu$** one recovers agreement with the SM hypothesis at **0.6 σ**.

The Cartesian parameterisation $\Delta_d = \mathrm{Re}(\Delta_d) + i\,\mathrm{Im}(\Delta_d)$ allows for a simple geometrical interpretation of each individual constraints.

No striking evidences for NP but it can be seen that sizeable NP contributions (ϕ_d^{NP}~10°, $|\Delta_d|$ ~{0.5;1.5}) in B_d system are still allowed

New Physics in B_s Mixing

Inputs:

ϕ_s

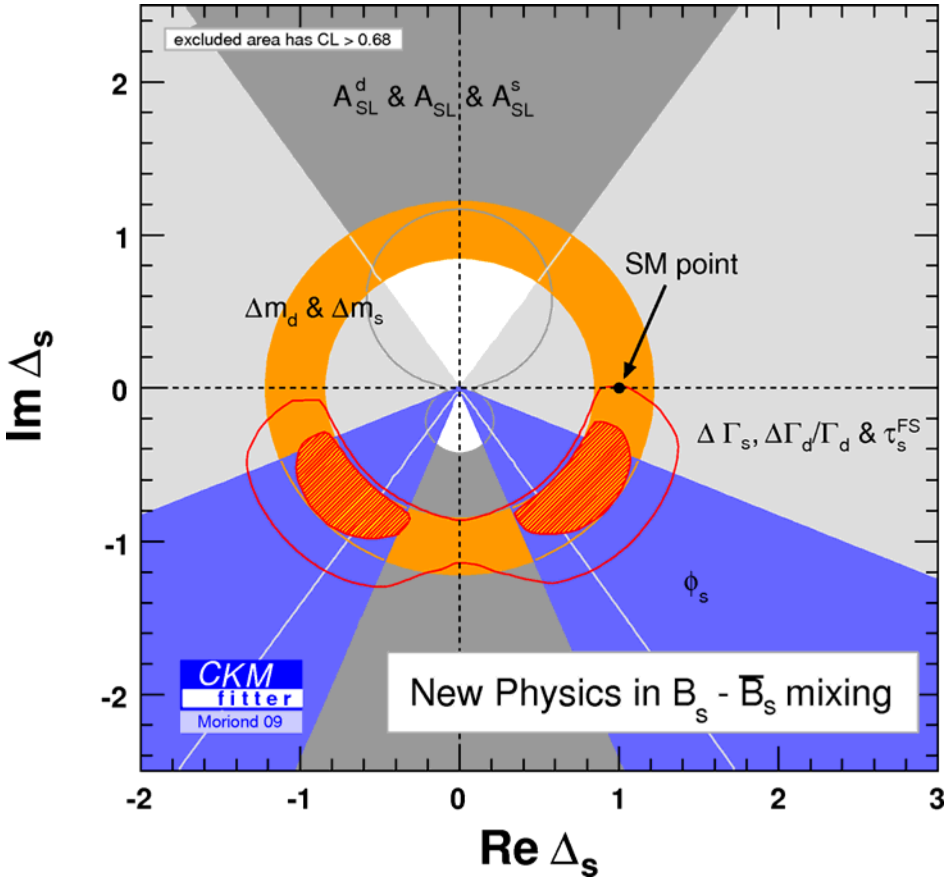
Δm_s & Δm_d

$A_{SL}^{B_d}$ & $A_{SL}^{B_s}$

$\Delta\Gamma_s$ & τ_s^{FS}

$B \to \tau\nu$

Warning : only 68% CL regions are shown



- **Dominant constraints** from Tevatron direct measurement of (**$\phi_s = -2\beta_s$**, $\Delta\Gamma_s$) in $B_s \to J/\psi\,\phi$ and from **Δm_s**.

  ϕ_s D0/CDF (HFAG 08 update, CDF 1.35 fb^{-1} only) is **2.2 σ away from SM** prediction.

  Δm_s agrees with SM which constraints $|\Delta_s|$ to ~1.

- The **SM** 2D hypothesis $\Delta_s = 1$ is **disfavoured at 1.9 σ** with or without $B\to\tau\nu$. The tension is almost completely driven by ϕ_s alone.

Eagerly awaiting the Tevatron update. With the expected LHC luminosity in 2010, LHCb is competitive.

Summary

- **Standard Model CKM fit**

 - Very good agreement with the SM for most observables; the **KM phase is the dominant source of CP violation at the EW scale**.
 - There is an ongoing **2.4 σ tension** between **$\sin(2\beta_{cc})$** and **$B[B\to\tau\nu]$.** Caution: in the current SM fit the tension reflects mostly on $B\to\tau\nu$ which suffers from larger experimental uncertainties.

95% CL interval:

$$\bar{\rho} = 0.139\ ^{+0.053}_{-0.040}$$
$$\bar{\eta} = 0.341\ ^{+0.032}_{-0.025}$$

From all constraints:

$$\gamma = (67.8^{+4.2}_{-3.9})^{o}$$

- **Origin of the tension?**

 - Seems hard to explain by LQCD uncertainties; Measurements look consistent on both sides.
 - **New Physics**: an additional phase in B_d mixing could accommodate the measurements. Sizeable effects of ~10° / ~40% on mixing amplitude are still allowed.

Agreement with SM:

Hypothesis	Deviation
$\Delta_d = 1$	2.1 σ
$\Delta_s = 1$	1.9 σ
$\Delta_d = \Delta_s = 1$	2.5 σ

- **Outlooks**

 - Further taking into account the deviation of ϕ_s, in a generic scenario of New Physics in mixing the **SM is disfavoured at 2.5 σ**
 $\Rightarrow$ Waiting for **new data** to confirm or infirm this.
 - 2HDM(II): we see no particular indication for a charged Higgs effect; preferred solution: decoupling (large m_{H+} irrespective $\tan(\beta)$).

- **Winter 2009 SM & NP fit results are available at:**
 http://ckmfitter.in2p3.fr/plots_Moriond2009/

Appendix

LQCD: Our Own Average

More details in: V. Tisserand (CKMfitter Group), Moriond EW 2009 proceedings [arXiv:0905.1572]
Or full details at: http://ckmfitter.in2p3.fr/plots_Moriond09/ckmEval_results.html

■ Our Own Average: *Educated RFit* Scheme

1) **Preselection**: Use only **unquenched** results with **2 or 2+1** dynamical fermions (sea quarks), also include **staggered fermions**.
⇒ papers & proceedings: RBC, UKQCD, HPQCD, JLQCD, CP-PACS, FNAL Lattice, MILC, ETMC, NPLQCD …
2) For error budget: **split into statistical and systematic uncertainties**.
3) Fit the central value of the LQCD observable according to the ***RFit*** scheme.
4) Quadratic average of statistical errors. **Systematic**: add linearly contributions to a single LQCD prediction. Take the systematic of the **most precise method**; not more nor less than the most accurate prediction.

■ Sources of LQD uncertainties

Euclidian, finite, discrete box. Observable = **statistical average over gauge configurations** weighted according to **gauge and fermion actions**.

Statistical: size of the ensemble of gauge configurations; part of errors below when scaling with size of gauge configurations.

Systematics: Fermions action (N_f=2, staggered); continuum limit $a \to 0$; finite volume effects $L \to \infty$; Quark mass extrapolation (chiral or heavy quark limit).

Numerical Inputs: Raw Values

Input	Central	Stat.	Syst.	Reference
$\|V_{ud}\|$	0.97418	0.00026		Towner/Hardy [arxiv:0710.3181]
$\|V_{us}\|$	0.2246	0.0012		Flavianet Vus (K_{l3} only) [arxiv:0801.1817]
$\|V_{ub}\|$	$3.87 \cdot 10^{-3}$	$0.09 \cdot 10^{-3}$	$0.46 \cdot 10^{-3}$	OOA [arXiv:0905.1572]
$\|V_{cb}\|$	$40.59 \cdot 10^{-3}$	$0.38 \cdot 10^{-3}$	$0.58 \cdot 10^{-3}$	OOA [arXiv:0905.1572]
$\|\varepsilon_K\|$	$2.229 \cdot 10^{-3}$	$0.010 \cdot 10^{-3}$		PDG 08* (no κ_K in the fit)
Δm_d	0.507	0.005		PDG 08
Δm_s	17.77	0.12		CDF, PRL 97, 242003 (2006)
α	*	*	*	HFAG (BaBar/Belle)
$\sin 2\beta$	0.671	0.023		HFAG charmonium
$\cos 2\beta$	0.5		0.5	cos2beta>0
γ	*	*	*	
$B(B\to\tau\nu)$	$1.73 \cdot 10^{-4}$	$0.35 \cdot 10^{-4}$		ICHEP08+CKM08(BABAR) WA
$\bar{m}_c$	1.286	0.013	0.040	
$\bar{m}_t$	165.017	1.156	0.11	Tevatron Electroweak Working Group [arXiv:0808.1089]
$\alpha_S(m_Z)$	0.1176		0.0020	PDG 08
B_K	0.721	0.005	0.040	OOA [arXiv:0905.1572]
f_{Bs}	0.228	0.003	0.017	OOA [arXiv:0905.1572]
B_{Bs}	1.23	0.03	0.05	OOA [arXiv:0905.1572]
f_{Bs}/f_{Bd}	1.196	0.008	0.023	OOA [arXiv:0905.1572]
B_{Bs}/B_{Bd}	1.05	0.02	0.05	OOA [arXiv:0905.1572]
η_{ct}	0.47		0.04	Herrlich&Nierste [Nucl. Phys. B 419, 292 (1994)]
η_{tt}"	0.5765		0.0065	Herrlich&Nierste [private comm.]
δ_1	0		1	Nierste [private comm.]
η_B	0.551		0.007	Buchalla *et al.* [Rev. Mod. Phys. 68, 1125 (1996)]

2HDM(II): Leptonic Decays