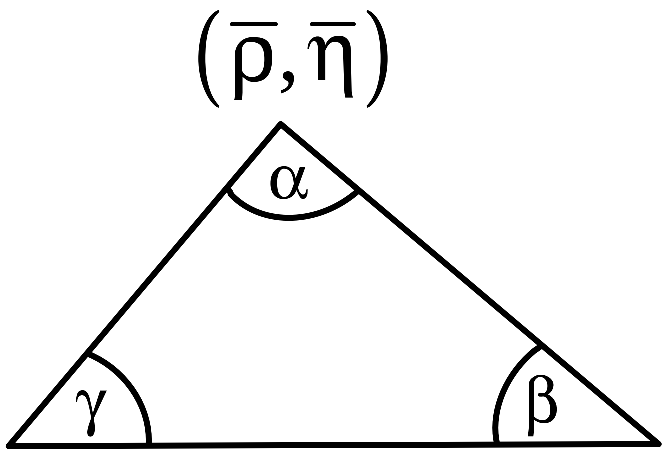
Unitarity Triangle 2002



Andrzej J. Buras
(Technical University Munich)

Blois, June 18th, 2002

1. CKM Matrix and the Unitarity Triangle
2. Theoretical Framework
3. Standard Analysis of the Unitarity Triangle
4. Outlook

1.

CKM Matrix and the Unitarity Triangle

Kobayashi-Maskawa Picture of CP Violation

CP Violation arises from
a single phase δ
in $W^{\pm}$ interactions of Quarks

ud $c_{12}c_{13}$	us $s_{12}c_{13}$	ub $s_{13}e^{-i\delta}$
cd $-s_{12}c_{23}-c_{12}s_{23}s_{13}e^{i\delta}$	cs $c_{12}c_{23}-s_{12}s_{23}s_{13}e^{i\delta}$	cb $s_{23}c_{13}$
td $s_{12}s_{23}-c_{12}c_{23}s_{13}e^{i\delta}$	ts $-s_{23}c_{12}-s_{12}s_{23}s_{13}e^{i\delta}$	tb $c_{23}c_{13}$

Four Parameters: $(\theta_{12} \approx \theta_{cabibbo})$

$s_{12} = |V_{us}|, \quad s_{13} = |V_{ub}|, \quad s_{23} = |V_{cb}|, \quad \delta$

$c_{ij} \equiv \cos\theta_{ij}$; $s_{ij} \equiv \sin\theta_{ij}$; $c_{13} \cong c_{23} \cong 1$

Wolfenstein Parametrization

Parameters: λ, A, ρ, η (Wolfenstein)

$\lambda=0.22$

	d	s	b
u	$1-\frac{\lambda^2}{2}$	λ	V_{ub}
c	$-\lambda$	$1-\frac{\lambda^2}{2}$	V_{cb}
t	V_{td}	V_{ts}	1

$V_{us}=\lambda+0(\lambda^7)$

$V_{cb}=A\lambda^2+0(\lambda^8)$

$V_{ts}=-A\lambda^2+0(\lambda^4)$

($A=0.83\pm0.02$)

$$V_{ub} \equiv A\lambda^3(\rho - i\eta) \qquad V_{td} = A\lambda^3(1-\bar{\rho}-i\bar{\eta})$$

$$\bar{\rho} = \rho\left(1-\frac{\lambda^2}{2}\right) \qquad \bar{\eta} = \eta\left(1-\frac{\lambda^2}{2}\right)$$

(AJB, Lautenbacher, Ostermaier, 94)

$$R_b \equiv \sqrt{\bar{\rho}^2+\bar{\eta}^2} = \left(1-\frac{\lambda^2}{2}\right)\frac{1}{\lambda}\left|\frac{V_{ub}}{V_{cb}}\right|$$

Circle around $(\bar{\rho},\bar{\eta})=(0,0)$

$$R_t \equiv \sqrt{(1-\bar{\rho})^2+\bar{\eta}^2} = \frac{1}{\lambda}\left|\frac{V_{td}}{V_{cb}}\right|$$

Circle around $(\bar{\rho},\bar{\eta})=(1,0)$

Particular Definition of λ, A, ρ, η

$$s_{12} \equiv \lambda$$
$$s_{23} \equiv A\lambda^2$$
$$s_{13}e^{i\delta} \equiv A\lambda^3(\rho - i\eta)$$

BLO: Phys.Rev. (94); (Schmidtler, Schubert)

At $0(\lambda^5)$ equivalent to (Branco, Lavoura, 88)

Basic Virtues of this Definition:

$$V_{us} = \lambda + 0\left(\lambda^7\right)$$

$$V_{ub} = A\lambda^3\left(\rho - i\eta\right)$$

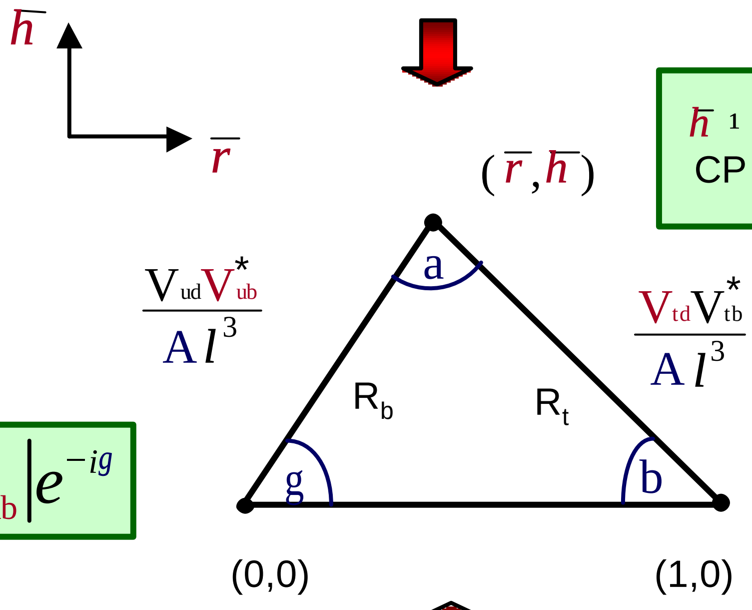
$$V_{cb} = A\lambda^2 + 0\left(\lambda^8\right)$$

$$V_{td} = A\lambda^3\left(1 - \bar{\rho} - i\bar{\eta}\right)$$

The apex of UT given by $\left(\bar{\rho}, \bar{\eta}\right)$ (BLO)

Unitarity Triangle

$$V_{ud}\,V_{ub}^{*} + V_{cd}\,V_{cb}^{*} + V_{td}\,V_{tb}^{*} = 0$$

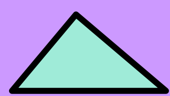


$\bar{\eta} \neq 0$ Signals CP Violation

$$V_{ub} = |V_{ub}|e^{-i\gamma}$$

$$V_{td} = |V_{td}|e^{-i\beta}$$

An Important Target of Particle Physics

$$J_{CP} = \lambda^{2}\,|V_{cb}|^{2}\,\bar{\eta} = 2\cdot$$ 

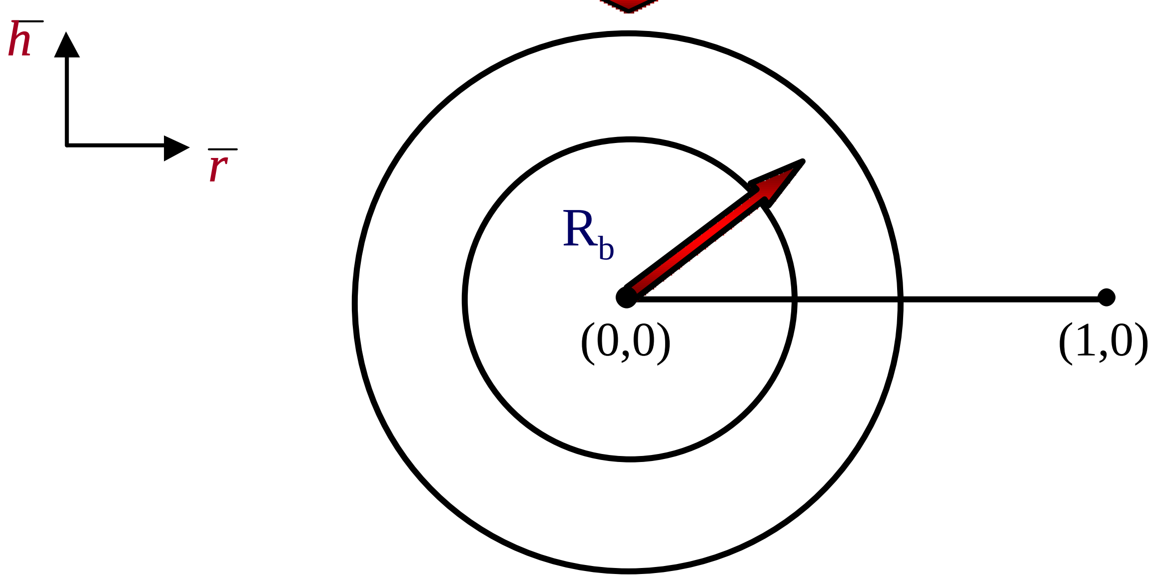
Area of unrescaled UT

Information from Tree Level Decays

$$|V_{us}| = 0.221 \pm 0.002 = \lambda$$

$$|V_{cb}| = (40.6 \pm 0.8)\cdot 10^{-3} \qquad (A = 0.83 \pm 0.02)$$

$$\left|\frac{V_{ub}}{V_{cb}}\right| = 0.089 \pm 0.008 \qquad (R_b = 0.39 \pm 0.04)$$



Apex of Unitarity Triangle somewhere on this Band

To find it **GO TO**

Loop Induced Decays

CP-Violation in K-Decays

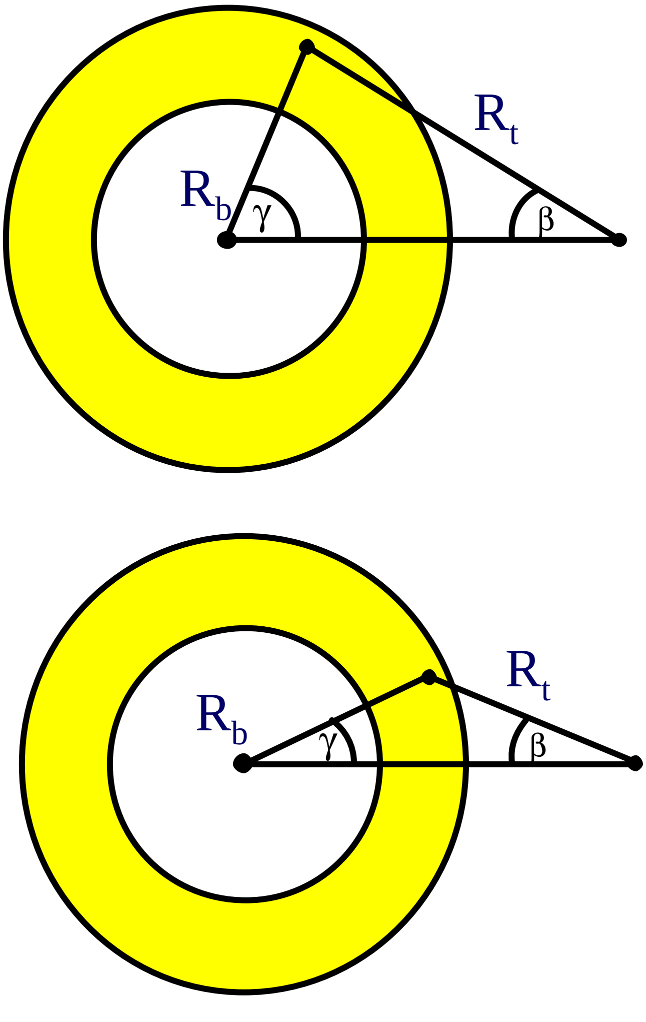
CP-Violation in B-Decays

Results on $|V_{ub}|$ and $|V_{cb}|$

Parameter	Value	Gaussian σ	Uniform half-width
$|V_{us}|$	0.221	0.002	-
$|V_{cb}|$(excl.)	$42.1 \cdot 10^{-3}$	$2.1 \cdot 10^{-3}$	-
$|V_{cb}|$(incl.)	$40.4 \cdot 10^{-3}$ **(Artuso Barberio)**	$0.7 \cdot 10^{-3}$	$0.8 \cdot 10^{-3}$
$|V_{ub}|$(excl.)	$32.5 \cdot 10^{-4}$	$2.9 \cdot 10^{-4}$	$5.5 \cdot 10^{-4}$
$|V_{ub}|$(incl.)	$40.9 \cdot 10^{-4}$	$4.6 \cdot 10^{-4}$	$3.6 \cdot 10^{-4}$
$|V_{cb}|$(incl.)	$41.7 \cdot 10^{-3}$ (CKM)	$0.7 \cdot 10^{-3}$	$0.8 \cdot 10^{-3}$

Unitarity Connection: $|V_{ub}|e^{-i\gamma} \Leftrightarrow |V_{td}|e^{-i\beta}$

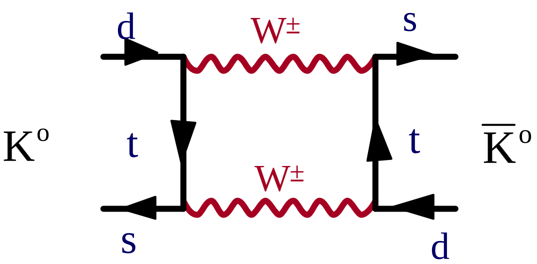
$$R_b e^{i\gamma} + R_t e^{-i\beta} = 1$$

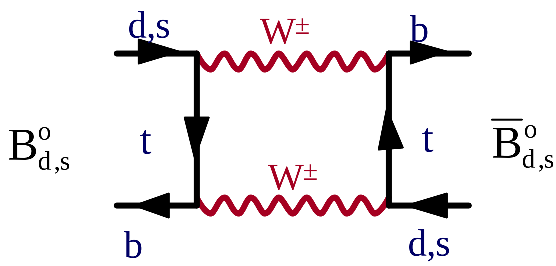


R_b = Independent of New Physics

R_t, β, γ = Can be affected by New Physics

View at Short Distance Scales

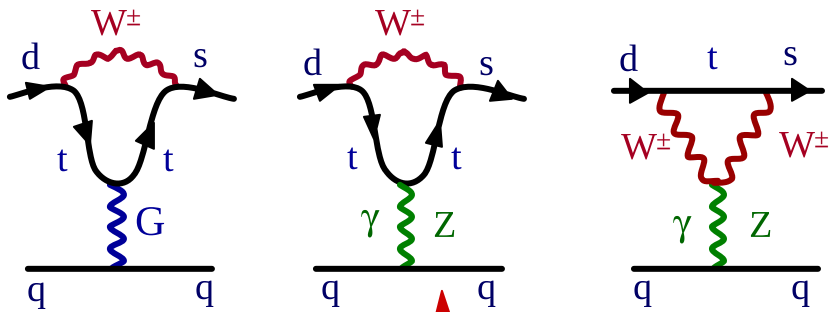




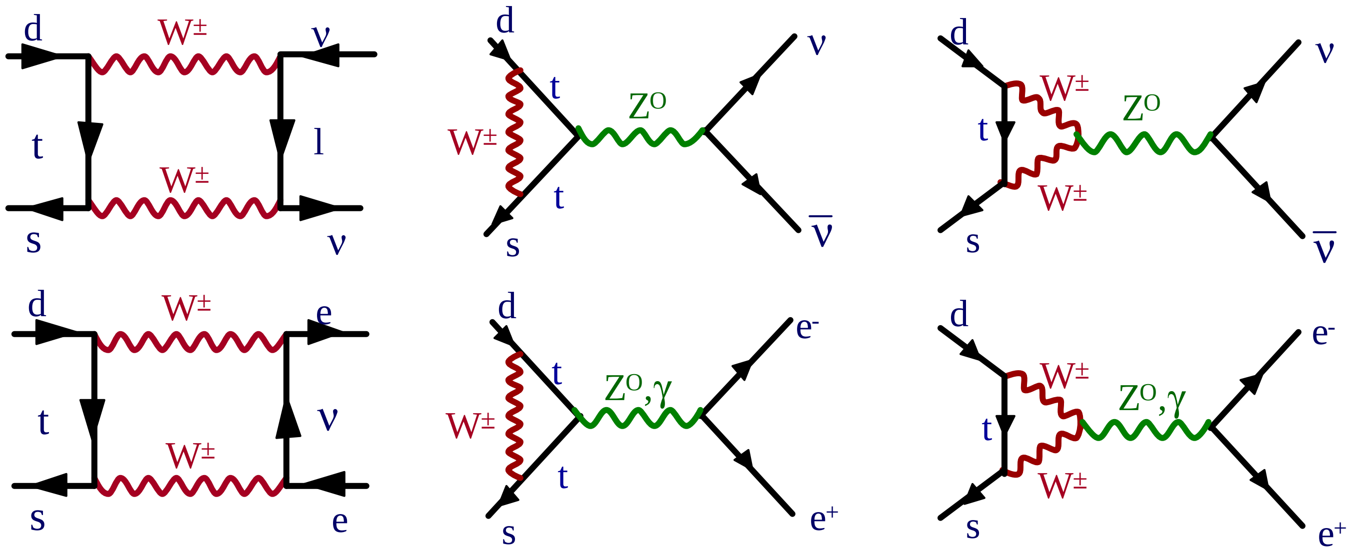
~~CP~~ ε_K-Parameter
ΔM (K_L-K_S)

$B^o_d - \overline{B}^o_d$ Mixing

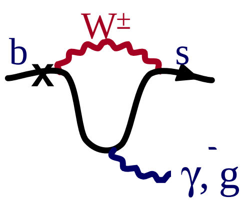
ε'



$K^+ \to \pi^+ \nu\bar{\nu}$, $K_L \to \pi^0 \nu\bar{\nu}$ $K_L \to \mu\bar{\mu}$, $B \to \mu\bar{\mu}$, $B \to X_S \nu\bar{\nu}$



$K_L \to \pi^0 e^+ e^-$ $B \to X_S e^+ e^-$, $X_S \mu\bar{\mu}$

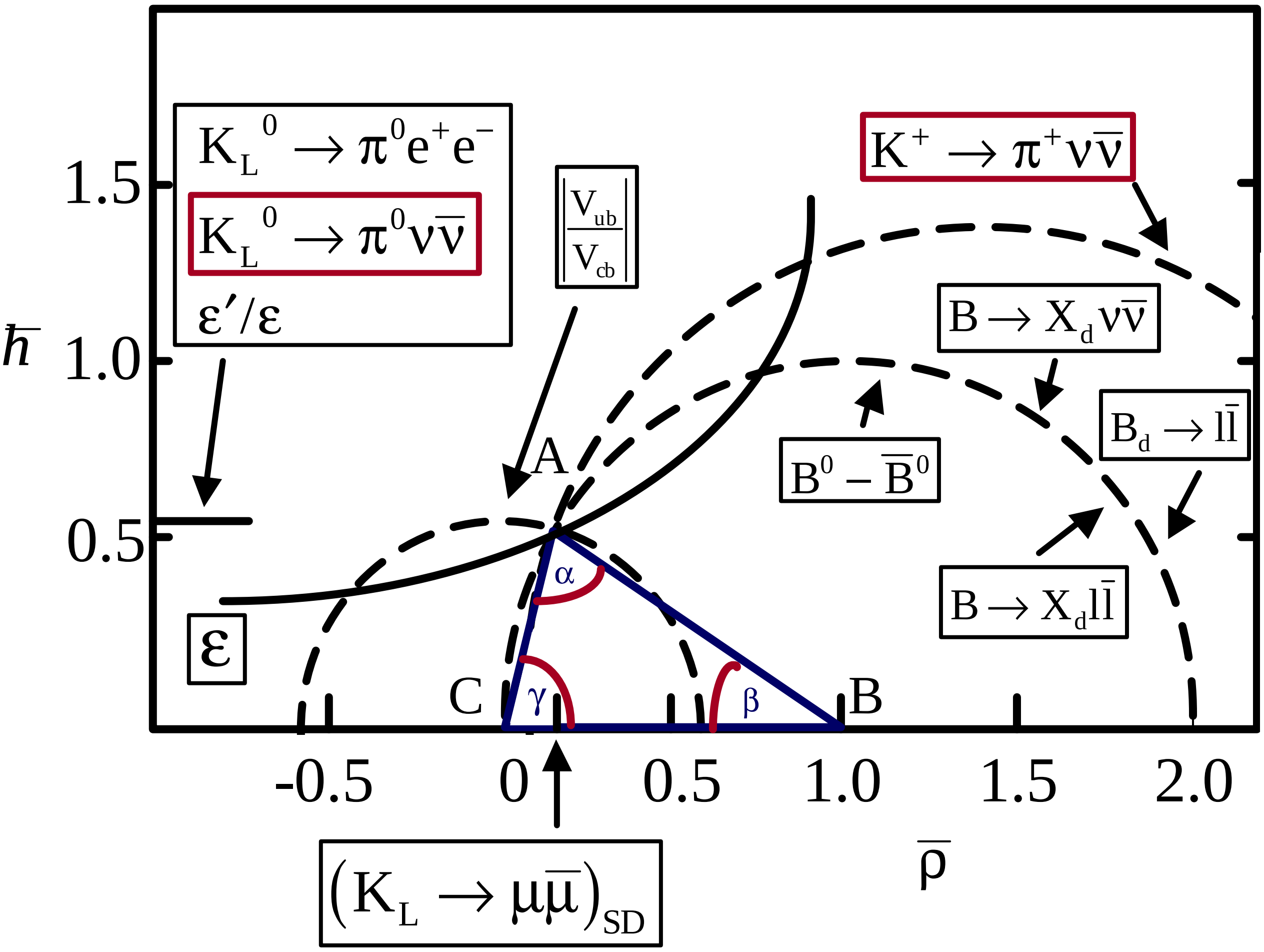


$B \to X_S \gamma$ $B \to K^* \gamma$

$B \to X_d \gamma$ $b \to s$ gluon

Hunting Δ with Rare and ~~CP~~ Decays

2011:



★ **Quark Mixing and CP Violation closely related in the St. Model**

★ $\left\{\begin{array}{l}\text{CP Asymmetries} \\ \text{in} \\ \text{B-Decays}\end{array}\right\} \Rightarrow \left\{\begin{array}{c}\alpha \\ \beta \\ \gamma\end{array}\right\}$

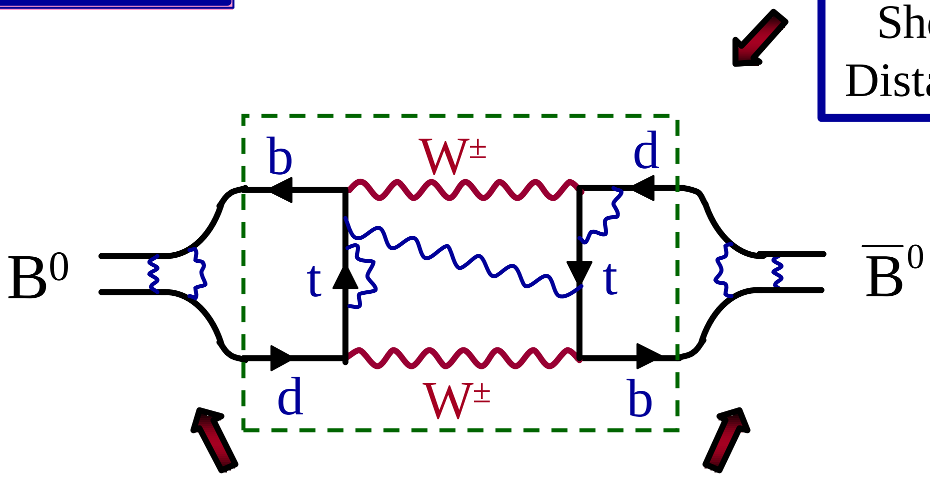
2.

Theoretical Framework

The Problem of Strong Interactions

$B_d^0 - \overline{B}_d^0$ Mixing (SM)

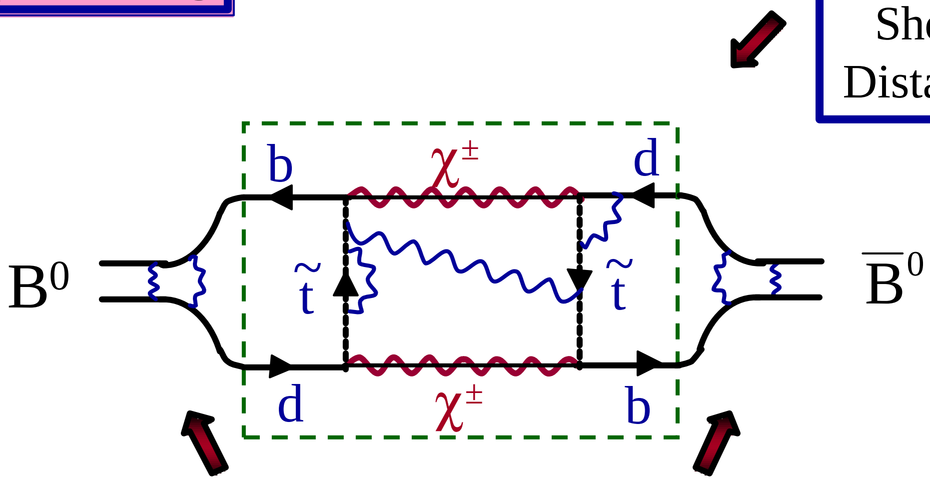
Short Distance



Long Distance

$B_d^0 - \overline{B}_d^0$ Mixing (MSSM)

Short Distance



Long Distance

SD : Perturbative (Asymptotic Freedom)

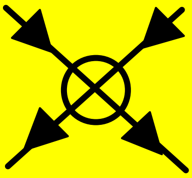
LD : Non-Perturbative (Confinement)

Operator Product Expansion

{Wilson Coefficients} {Local Operators}

$$H_{eff} = \frac{G_F}{\sqrt{2}} V_{CKM} \sum_i C_i(\mu)\, Q_i$$

Q_i ⟷



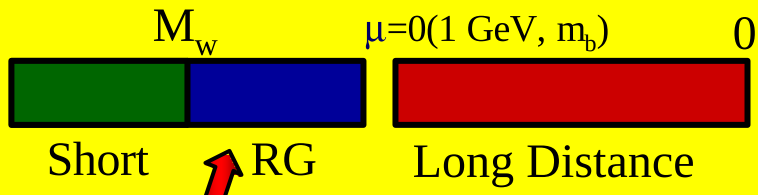
Four Quark Interaction Vertex $\quad (\bar{s}d)_{V-A}(\bar{s}d)_{V-A}$

$C_i(\mu)$ ⟷ Coupling Constants $\quad C(\mu) = \left[\frac{\alpha_s(M_W)}{\alpha_s(\mu)}\right]^{\frac{6}{23}}$

{K, B, D,...}

$$A(M \to F) = \frac{G_F}{\sqrt{2}} V_{CKM} \sum_i C_i(\mu) \langle F | Q_i(\mu) | M \rangle$$

$\left\{ \pi\pi,\ \pi\nu\bar{\nu},\ \mu\bar{\mu},\ K^*\gamma, \ldots \right\}$



{ Top SUSY H±... }

{ Renormalization Group $\sum \left(\alpha_s \log \frac{M_W}{\mu}\right)^n$ }

{ Lattice, 1/N HQET, QCDS ChPTh }

$$\langle \bar{K}^0 | (\bar{s}d)_{V-A}(\bar{s}d)_{V-A} | K^0 \rangle = \frac{8}{3} \hat{B}_K F_K^2 m_K^2 [\alpha_s(\mu)]^{2/9}$$

Master Formula for Weak Decays

Non-Perturbative Factors in the SM

QCD RG Factors

Short Distance Loop Functions (Penguins, Boxes)

Represent different Dirac and Colour Stuctures

$$A(\text{Decay}) = B_i \, \eta^i_{QCD} \, V^i_{CKM} \left[F^i_{SM} + F^i_{New} \right]$$

$$+ B^{New}_i \left[\eta^i_{QCD} \right]^{New} V^i_{New} \left[G^i_{New} \right]$$

Non-Perturbative Factors beyond SM

New Flavour-Changing Parameters

Short Distance Loop Functions (Penguins, Boxes)

F^i_{SM}, F^i_{New}, G^i_{New} : Fully calculable in Perturbation Theory

η^i_{QCD}, $\left[\eta^i_{QCD}\right]^{New}$: Fully calculable in RG improved Perturbation Theory

B_i, B^{New}_i : Require Non-Perturbative Methods or can be extracted from leading decays

(represent $\langle Q_i \rangle$)

Possible Dirac Structures in $K^0 - \bar{K}^0$ and $B^0_{d,s} - \bar{B}^0_{d,s}$

SM: $$\gamma_\mu (1-\gamma_5) \otimes \gamma^\mu (1-\gamma_5)$$

Beyond SM:

$$\gamma_\mu (1-\gamma_5) \otimes \gamma^\mu (1+\gamma_5)$$
$$(1-\gamma_5) \otimes (1+\gamma_5)$$
$$(1-\gamma_5) \otimes (1-\gamma_5)$$
$$\sigma_{\mu\nu} (1-\gamma_5) \otimes \sigma^{\mu\nu} (1-\gamma_5)$$

MSSM with large tanβ
General Supersymmetric Models
Models with complicated Higgs System

NLO $\left[\eta^i_{QCD}\right]^{New}$: Ciuchini, Franco, Lubicz, Martinelli, Scimemi, Silvestrini

AJB, Misiak, Urban, Jäger

General Structure in Models with Minimal Flavour Violation

Ciuchini, Degrassi, Gambino, Giudice;
AJB, Gambino, Gorbahn, Jäger, Silvestrini;

- **No new Operators** (Dirac and Colour Structures) beyond those present in the SM

- Flavour Changing Transitions governed by CKM. **No new complex phases** beyond those present in the SM

⇓

$$A(\text{Decay}) = B_i\, \eta^i_{QCD}\, V^i_{CKM} \underbrace{\left[F^i_{SM} + F^i_{New}\right]}_{\text{real}}$$

Examples: SM

MSSM at not too large $\tan\beta = \dfrac{v_2}{v_1}$

Universal Unitarity Triangle

AJB, Gambino, Gorbahn, Jäger, Silvestrini (00)

In the full class of MFV-models it is possible to construct quantities that depend on CKM parameters but in which the dependence on new physics parameters cancels out

↓

CKM Matrix determined without "New Physics Pollution"

↓

Universal Unitarity Triangle

Examples

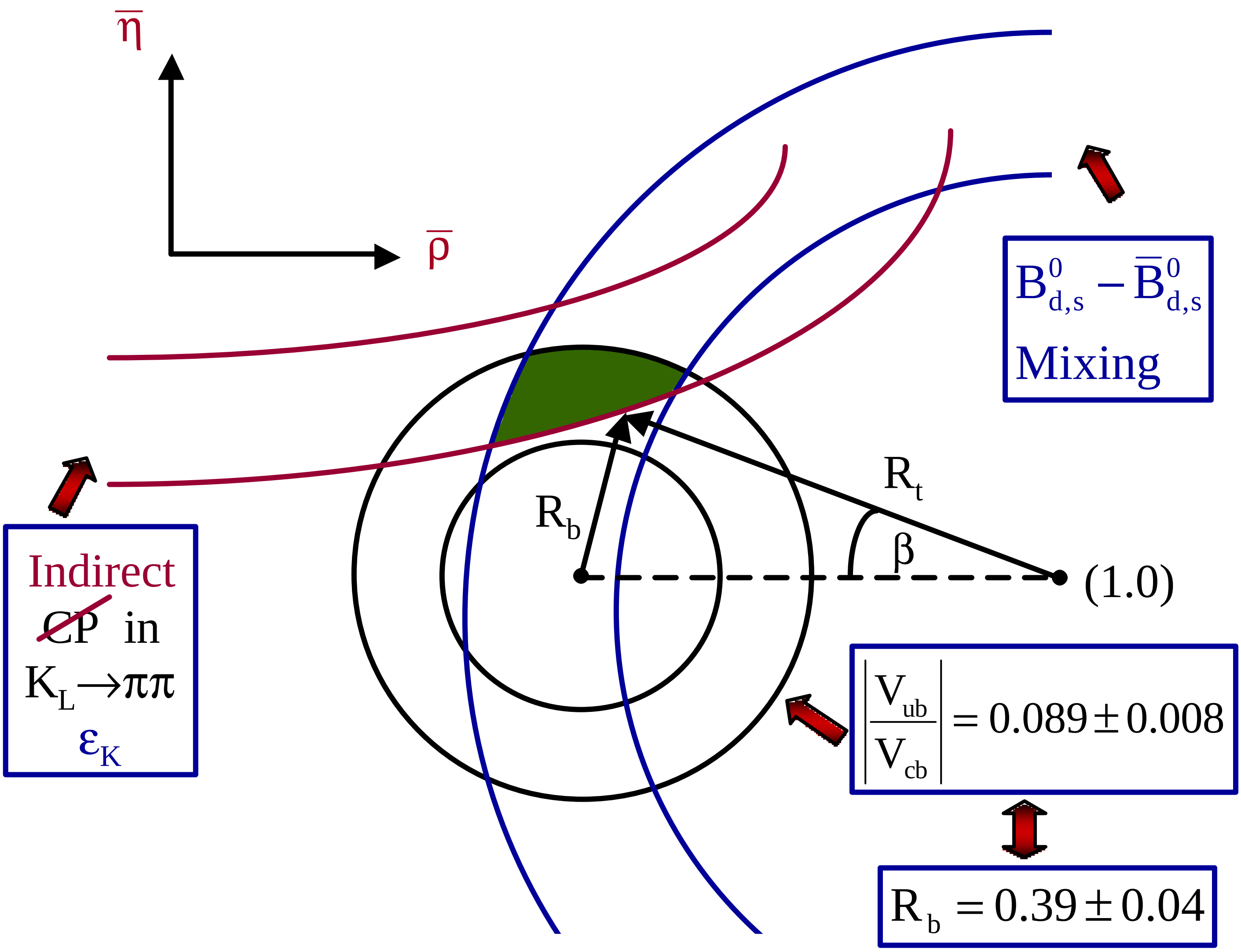
$$R_t = 0.94 \sqrt{\frac{\Delta M_d}{0.487/\mathrm{ps}}} \sqrt{\frac{15.0/\mathrm{ps}}{\Delta M_s}} \left[\frac{\xi}{1.15}\right]$$

$$a_{\psi K_s} = \sin 2\beta$$

3.

Standard Analysis of Unitarity Triangle

Standard Analysis of UT



Relevant Parameters

$$\hat{B}_K,\ F_{B_d}\sqrt{\hat{B}_{B_d}},\quad \xi = F_{B_s}\sqrt{\hat{B}_{B_s}} \,/\, F_{B_d}\sqrt{\hat{B}_{B_d}}$$

↕

$$\varepsilon_K \qquad \Delta M_d \qquad \Delta M_s / \Delta M_d$$

Basic Formulae

1. ε_K - Hyperbola

$$\bar{\eta}\left[(1-\bar{\rho}) A^2 F_{tt} \eta_{QCD}^{tt} + P_c(\varepsilon)\right] A^2 \hat{B}_K = 0.213$$

$$\eta_{QCD}^{tt} = 0.57 \pm 0.01; \quad P_C(\varepsilon) = 0.28 \pm 0.05; \quad F_{tt} = 2.38 \pm 0.11$$

Nierste

2. $B_d^0 - \bar{B}_d^0$ Mixing Constraint

$$R_t = 0.85\left[\frac{0.83}{A}\right]\sqrt{\frac{2.38}{F_{tt}}}\sqrt{\frac{\Delta M_d}{0.487/\text{ps}}}\left[\frac{230\text{MeV}}{\sqrt{\hat{B}_d} F_{B_d}}\right]\sqrt{\frac{0.55}{\eta_B^{QCD}}}$$

$$A = 0.83 \pm 0.02; \quad \Delta M_d = (0.496 \pm 0.007)/\text{ps}; \quad \eta_B^{QCD} = 0.55 \pm 0.01$$

3. $B_s^0 - \bar{B}_s^0$ Mixing Constraint ($\Delta M_d/\Delta M_s$)

$$R_t = 0.94\sqrt{\frac{\Delta M_d}{0.487/\text{ps}}}\sqrt{\frac{15.0/\text{ps}}{\Delta M_s}}\left[\frac{\xi}{1.15}\right]$$

$\Delta M_s > 14.9$ / ps LEP (SLD)

4. $\sin 2\beta$ from $A_{CP}(\psi K_S)$

$$A_{CP}(\psi K_S) \equiv -a_{\psi K_S} \sin(\Delta M_d t)$$

$$a_{\psi K_S} = \sin 2\beta \qquad \text{(SM)}$$

$$\sin 2\beta = \begin{cases} 0.79 \pm {}^{0.41}_{0.44} & \text{(CDF)} \\ 0.75 \pm \underset{\text{(stat)}}{0.09} \pm \underset{\text{(syst)}}{0.04} & \text{(BaBar)} \\ 0.82 \pm 0.12 \pm 0.05 & \text{(Belle)} \end{cases}$$

$$\left(\text{ALEPH}: 0.84 \; {}^{+0.82}_{-1.04} \pm 0.16\right)$$

⇓

$$\sin 2\beta = 0.78 \pm 0.08$$

⇓

$$\beta = \begin{cases} (26 \pm 4)^{o} & \\ (65 \pm 4)^{o} & \text{(excluded in the SM)} \end{cases}$$

Different Treatments of Errors

Particle Data Group

Gilman, Kleinknecht, Renk

"Gaussian" Approach

Ali + London; Mele, ...

Bayesian Approach

Ciuchini, D´Agostini, Franco, Lubicz, Martinelli, Parodi, Roudeau, Stocchi

Frequentist Approach

Höcker, Lacker, Laplace, Diberder

95% CL Scan Method

Plaszczynski, Shune; BaBar

Naive Scanning

Rosner; Stone; AJB

↳ Bayesian

Basic Result from Working Group III (CKM Workshop, CERN, Feb. 2002)

AJB, H. Lacker, F. Parodi, A. Stocchi
First report: CERN Courier, May 2002 (R. Forty)

The main difference between Bayesian and Frequentists approaches results from the different treatments of errors in the input parameters

Bayesian : Convolution of statistical and systematic (TH) errors

Frequentist : Linear addition of statistical and systematic (TH) errors

If the two fitting programs are fed with the same input likelihoods the allowed $(\bar{\rho}, \bar{\eta})$ regions are very similar

Input for the Unitarity Triangle

Parameter	Value	Gaussian σ	Uniform half-width
$\lvert V_{us} \rvert$	0.221	0.002	-
$\lvert V_{cb} \rvert$ (excl.)	$42.1 \cdot 10^{-3}$	$2.1 \cdot 10^{-3}$	-
$\lvert V_{cb} \rvert$ (incl.)	★ $40.4 \cdot 10^{-3}$ **(Artuso Barberio)**	$0.7 \cdot 10^{-3}$	$0.8 \cdot 10^{-3}$
$\lvert V_{ub} \rvert$ (excl.)	$32.5 \cdot 10^{-4}$	$2.9 \cdot 10^{-4}$	$5.5 \cdot 10^{-4}$
$\lvert V_{ub} \rvert$ (incl.)	$40.9 \cdot 10^{-4}$	$4.6 \cdot 10^{-4}$	$3.6 \cdot 10^{-4}$
ΔM_d	$0.496\ ps^{-1}$	$0.007\ ps^{-1}$	-
ΔM_s	$>14.9\ ps^{-1}$ at 95% C.L.	sensitivity	$19.3\ ps^{-1}$
m_t	167 GeV	5 GeV	-
$f_{B_d}\sqrt{\hat{B}_{B_d}}$	230 MeV	30 MeV	15 MeV
$\xi = \frac{f_{B_s}\sqrt{\hat{B}_{B_s}}}{f_{B_d}\sqrt{\hat{B}_{B_d}}}$	1.16	0.03	0.04
B_K	0.86	0.06	0.14
$\sin 2\beta$	0.78	0.08	-

$\lvert V_{cb} \rvert$ (incl.)	★ $41.7 \cdot 10^{-3}$ (CKM)	$0.7 \cdot 10^{-3}$	$0.8 \cdot 10^{-3}$

Universal Unitarity Triangle 2002

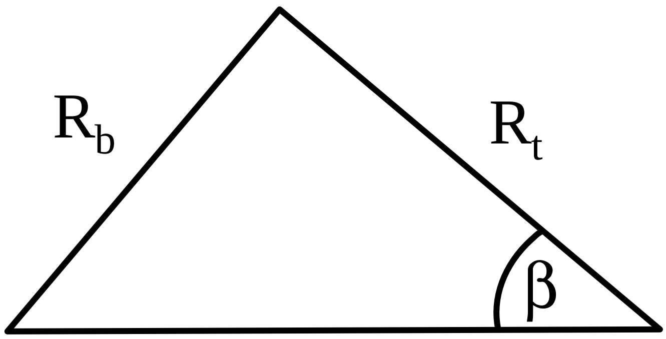
AJB, Parodi, Stocchi

Use only quantities that are independent of parameters specific to a given Minimal Flavour Violation model

$$\left|\frac{V_{ub}}{V_{cb}}\right| \Rightarrow R_b = \frac{(1-\lambda^2/2)}{\lambda}\left|\frac{V_{ub}}{V_{cb}}\right|$$

$$\frac{\Delta M_d}{\Delta M_s} \Rightarrow R_t = \frac{\xi_{th}}{\lambda}\sqrt{\frac{\Delta M_d}{\Delta M_s}}$$

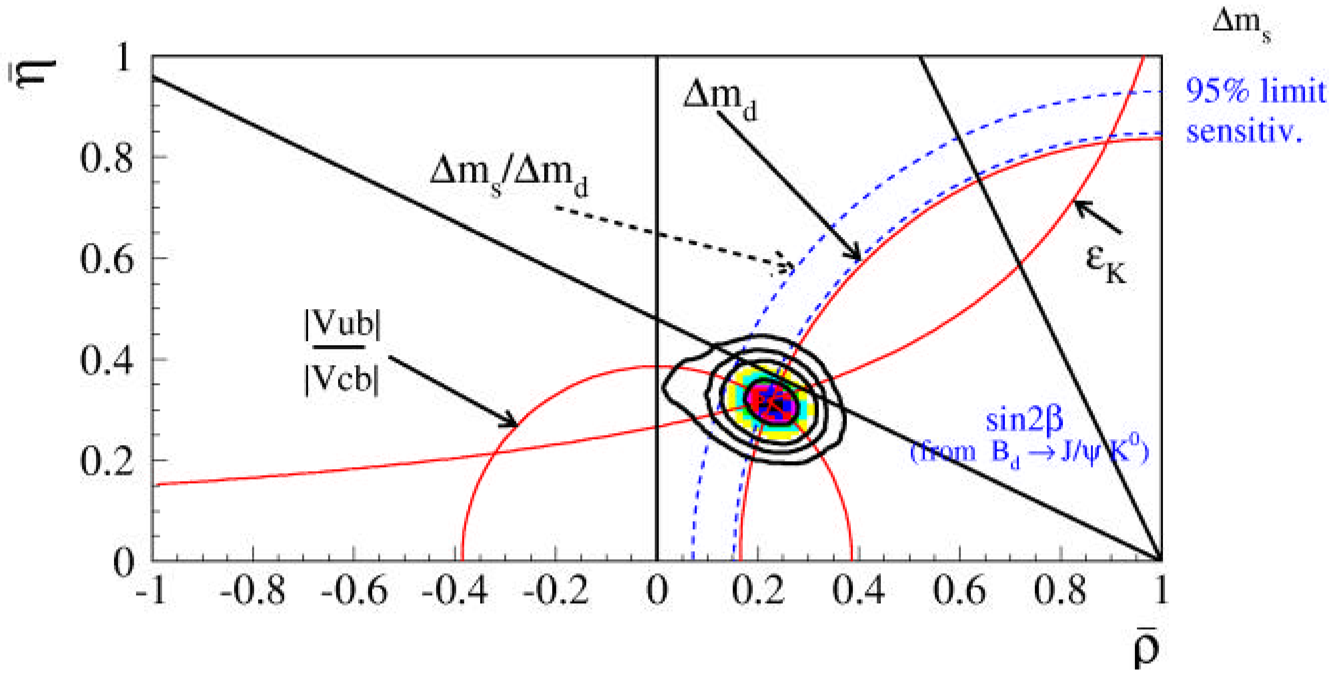
$$a_{\psi K_s} \Rightarrow \sin 2\beta$$



$$\xi_{th} = \frac{\sqrt{\hat{B}_s}F_{B_s}}{\sqrt{\hat{B}_d}F_{B_d}}$$

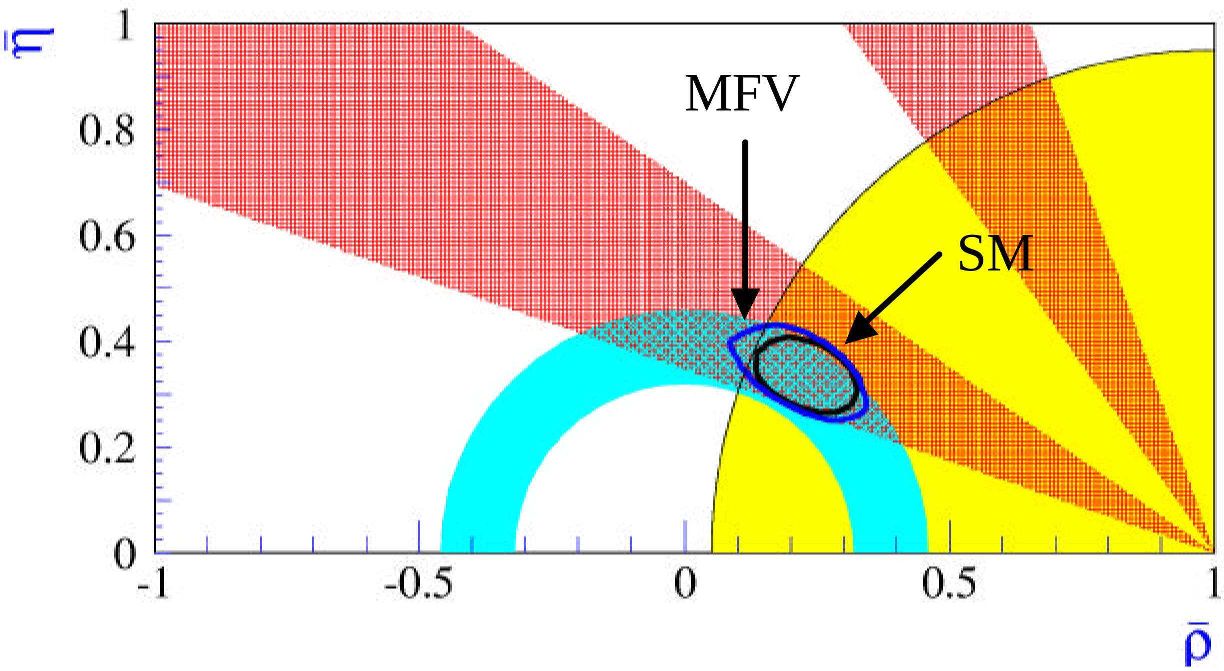
Standard Model Unitarity Triangle

(Parodi, Stocchi)



Universal Unitarity Triangle

(AJB, Parodi, Stocchi) (95% C.L. ranges)



Bayesian Output (June 2002)

AJB, Parodi, Stocchi hep-ph/0206

Input: CKM-Workshop + $\sin 2\beta = 0.78 \pm 0.08$

95% Probability Regions

	SM	**UUT**
$\bar{\eta}$	0.292-0.406	0.274-0.418
$\bar{\rho}$	0.148-0.301	0.114-0.322
$\sin 2\beta$	0.665-0.821	0.655-0.822
$\sin 2\alpha$	-0.66-0.11	-0.78-0.29
γ	$(46.1\text{-}68.6)^0$	$(42.1\text{-}73.8)^0$
R_b	0.365-0.468	0.365-0.470
R_t	0.766-0.934	0.741-0.972
$\lvert V_{td}\rvert/10^{-3}$	7.0-8.4	6.7-8.8
$\lvert \mathrm{Im}\lambda_t\rvert/10^{-4}$	1.08-1.46	1.00-1.53
$\lvert V_{td}\rvert/\lvert V_{ts}\rvert$	0.174-0.211	0.168-0.220
$\Delta M_s\,(\mathrm{ps}^{-1})$	15.1-21.0	14.1-22.0

$\left(\lambda_t = V_{ts}^* V_{td}\right)$

First Conclusions

1.

$$\sin 2\beta = \begin{cases} 0.78 \pm 0.08 & \left(a_{\psi K_s}\right) \\ 0.72 \pm 0.06 & (\text{UT fit without } a_{\psi K_s}) \end{cases}$$

Perfect agreement

$$\left(\sin 2\beta\right)_{\substack{\text{World}\\ \text{Average}}} = 0.74 \pm 0.05$$

2.

Not much room for MFV-models (low tanβ) that differ from the SM

Measurements of γ and ΔM_s will be very important to find out whether new phases and/or new operators necessary.

4.

Outlook

Future Targets

R_b

$\frac{\Delta V_{cb}}{V_{cb}} \approx 2\%$

$\left|\frac{\Delta V_{ub}}{V_{ub}}\right| \approx 5\%$

$\Delta M_s (B_s^0 - \bar{B}_s^0);\ \xi_{th} \Rightarrow R_t$

$\Delta \sin 2\beta < 0.05$

α, β, γ from various B-Decays

$$\left\{\begin{matrix} K^+ \to \pi^+ \nu\bar{\nu} \\ K_L \to \pi^0 \nu\bar{\nu} \end{matrix}\right\} \Rightarrow \left\{\begin{matrix} \sin 2\beta,\ \bar{\eta} \\ |V_{td}| \end{matrix}\right\}$$

Parameters in Electroweak Gauge Sector

$$\alpha_{QED,}\ G_F,\ \sin^2\theta_W$$

⇓

$$\alpha_{QED,}\ G_F,\ M_Z$$

⇓

$$\alpha_{QED,}\ M_W,\ M_Z$$

Flavour Sector

Until 2001

$$|V_{us}|,\ |V_{cb}|,\ \bar{\rho},\ \bar{\eta}$$

For the next years

$$|V_{us}|,\ |V_{cb}|,\ R_t,\ \sin 2\beta$$

appears like a better choice.
Or, even better:

$$|V_{us}|,\ |V_{cb}|,\ R_t,\ \beta$$

AJB
Parodi
Stocchi

Fundamental Flavour Parameters

(June 2002) AJB, Parodi, Stocchi

$$|V_{us}| = 0.221 \pm 0.002$$

$$|V_{cb}| = (40.6 \pm 0.8) \cdot 10^{-3}$$

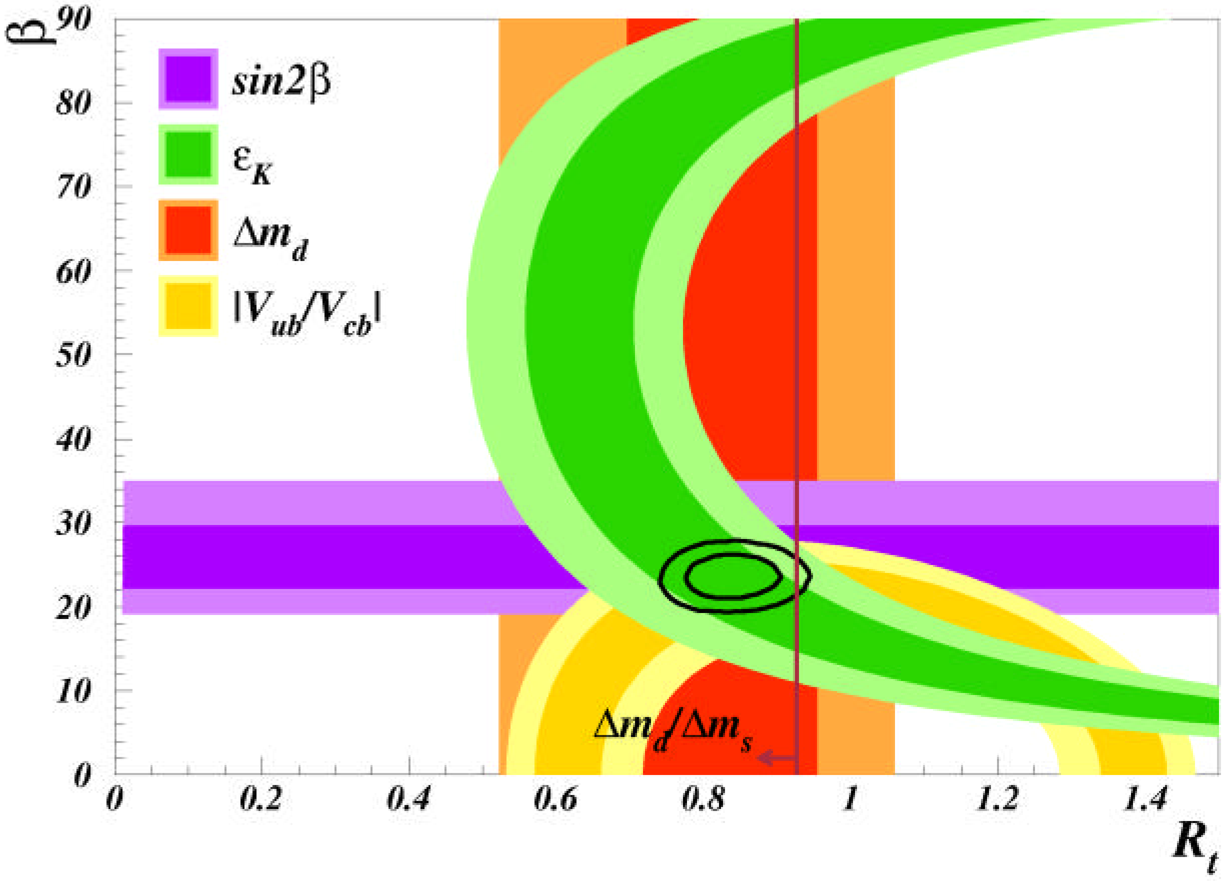
$$R_t = 0.85 \pm 0.04$$

$$\beta = (24 \pm 2)^{o}$$

$$(\sin 2\beta = 0.74 \pm 0.05)$$

(R_t, β) Plot 2002

(AJB, Parodi, Stocchi)

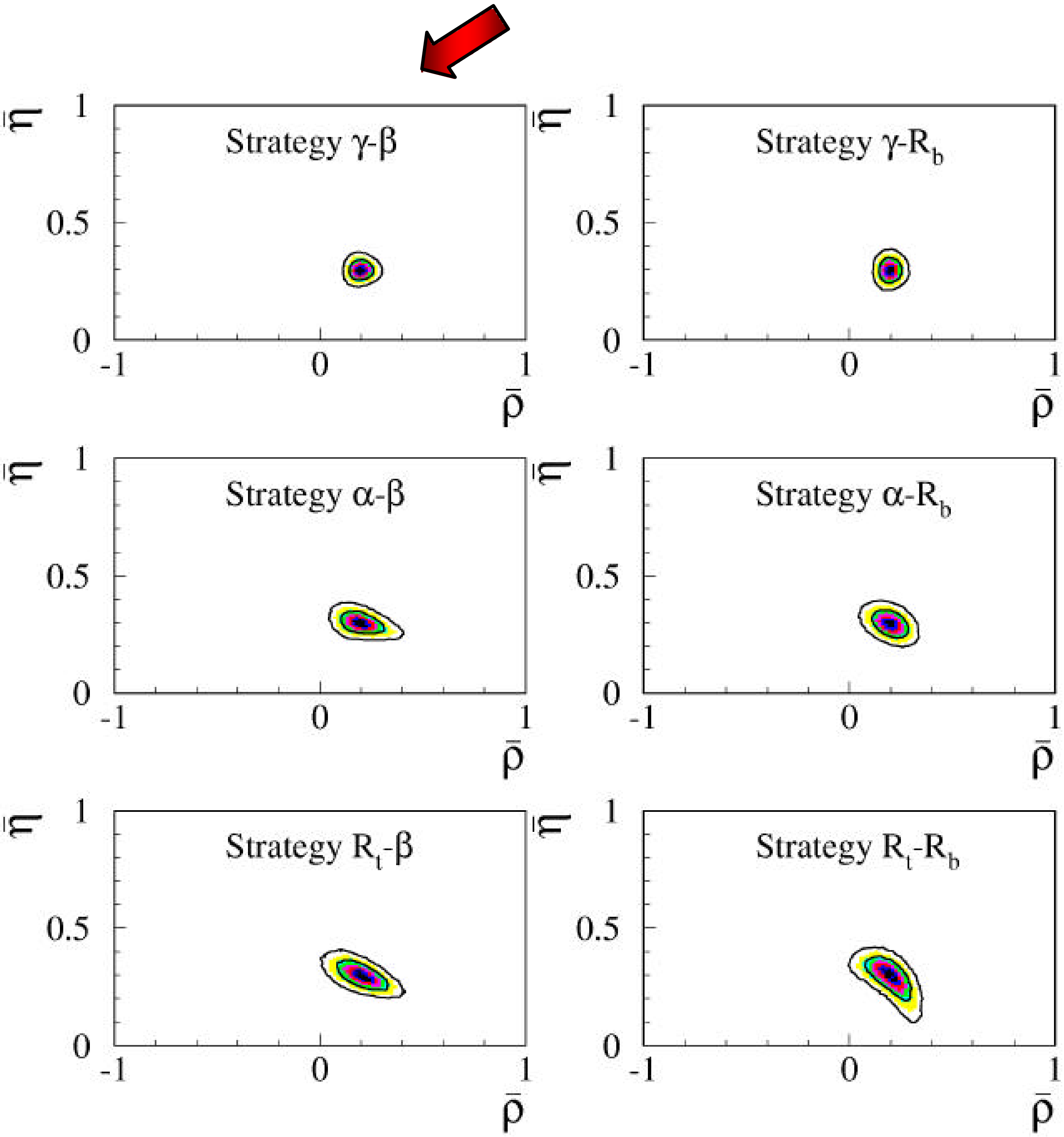


Leading Strategies for $(\bar{\rho},\bar{\eta})$

(AJB, Parodi, Stocchi)

<u>Example:</u>

$$\frac{\Delta\gamma}{\gamma}=10\%,\quad \frac{\Delta\beta}{\beta}=10\%$$



Theoretically Clean Determinations of (α,β,γ)

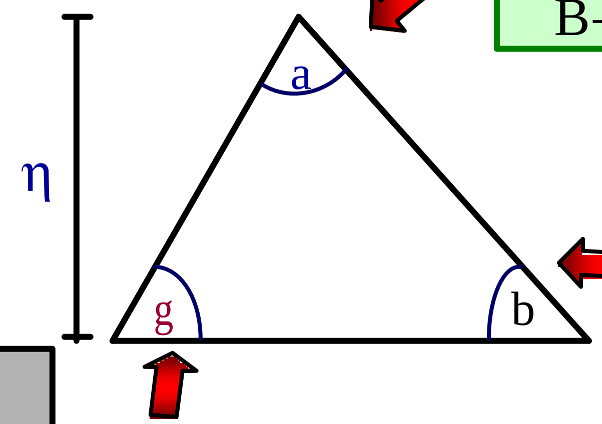
Very small Asymmetry

TD = Time dependent

$B_s \to \psi\varphi$

$B_s \to D_s^{*+} D_s^{*-}$

$\overset{(-)}{B}_d \to \pi^+\pi^-$ (Gronau + >London)
+ Isospin Analysis (TD)
$B^\pm \to \pi^\pm\pi^0$
$B \to \pi^0\pi^0 \leq 10^{-6}$



$\overset{(-)}{B}_d \to J/\psi\, K_s$ (TD)
(Bigi + Sanda)

$(B_d \to \varphi\, K_s\, ,\, D^+D^-)$

Free of Penguins

Direct ~~CP~~

$\overset{(-)}{B}{}_s^0 \to D_s^\pm K^\mp$ (Aleksan, Dunietz, Kayser) (TD)

$B^\pm \to D^0_{CP} K^\pm, \ldots$ (Gronau, Wyler)*

$B_d^0 \to \overline{D}{}^0 K^{*0}$ etc. (Dunietz)

Rates only

* Atwood, Dunietz, Soni

$B_{d,s} \to J/\psi K_S$ (Fleischer)

Some Hadronic Uncertainties (γ)

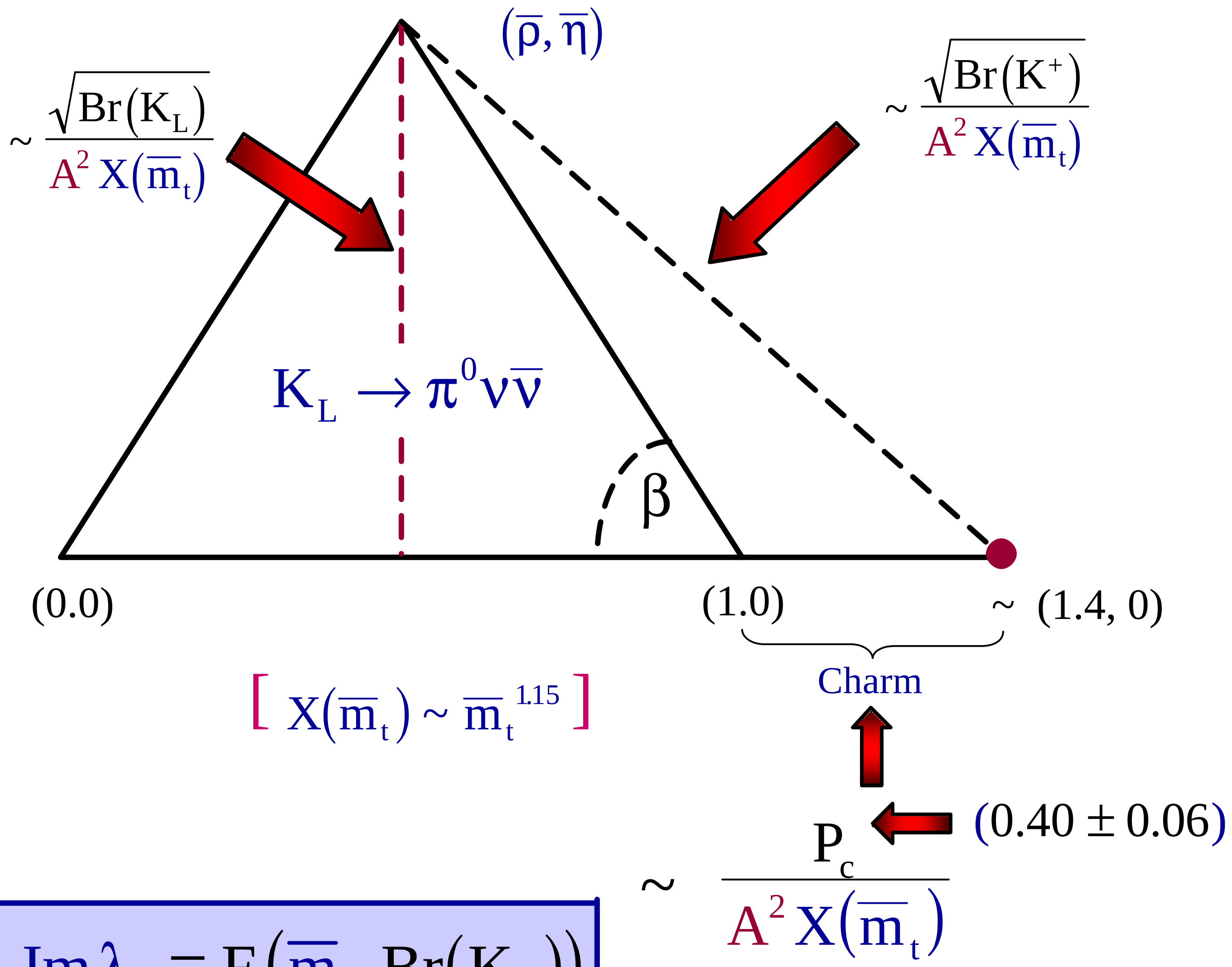
$B^\pm \to \pi^\pm K, \pi^0 K^\pm$

$B_d^0 \to \pi^0 K, \pi^\pm K^\pm$

$B_s \to K^+ K^-$

UT from $K \to \pi\nu\bar{\nu}$

Buchalla
AJB



$$\mathrm{Im}\,\lambda_t = F_1(\bar{m}_t, Br(K_L))$$

$$\sin 2\beta = F_2(P_c, Br(K_L), Br(K^+))$$

$$\lambda_t = V_{ts}^* V_{td}$$

$\sin 2\beta$ $(K \to \pi\nu\bar{\nu})$	⟺	$\sin 2\beta$ $(B \to J/\psi, K_s$ $\to \varphi K_s)$

K - Physics ⟺ B - Physics

Test of SM and Beyond

1989-1999

Electroweak Precision Studies

α_{QED} , G_F , M_Z , m_t , M_W, m_H

($\sin^2\theta_W$)

Spontaneous Symmetry Breakdown

2000-2011

CKM Precision Studies

λ , A , $\bar{\rho}$, $\bar{\eta}$, m_t

with the hope to discover **New Physics**
and learn about **Flavour Dynamics**

The Future until 2011 should be very exciting