CKM fits as a function of luminosity (time)

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e^+e^- and beyond 10^{34}
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OUTLINE

- Global CKM fits
- Present Status
- What is expected in year 2005 and 2010?
- Conclusion

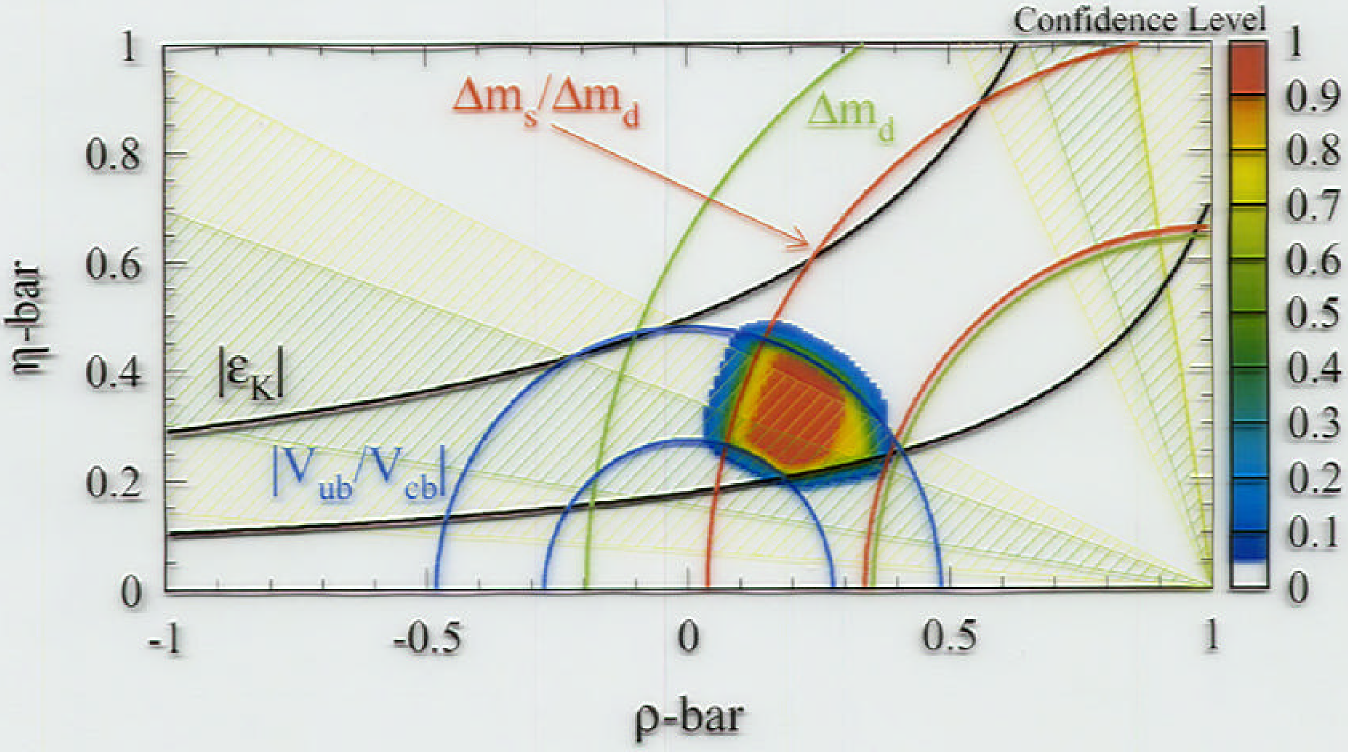
New Method: Rfit

For a given point in a parameter space, *e.g.*, $(\bar{\rho}, \bar{\eta})$, search for the best theoretical model

- Discrete scan in the $\bar{\rho}$, $\bar{\eta}$ plane and fit minimal $\chi^2(\mu_{\rm min})$, with $(\mu) \equiv (\lambda, A, m_t, \kappa)$, for each scan point
  - κ are parameters varying within their error ranges, e.g., $V_{ub}({\rm sys})$, B_K, $f_{B_d}\sqrt{B_d}$, ξ, η_{cc}, m_c, ...
  - Smaller error contributions are added quadratically to the statistical errors
- Probing the Standard Model: Find the overall $\chi^2(\mu_{\rm min,\,global})$ in the $\bar{\rho}$, $\bar{\eta}$ plane
  - Interpret the confidence level (CL) of the "best" model $\chi^2(\mu_{\rm min,\,global})$ by means of a toy MC
- Metrology: calculate the offset-corrected CL, ${\rm Prob}(\chi^2(\mu_{\rm min}) - \chi^2(\mu_{\rm min,\,global})\ , 2)$, for each point in the $\bar{\rho}$, $\bar{\eta}$ plane
  - These confidence levels are upper bounds obtained for the best possible combination of theoretical parameters at given $\bar{\rho}$, $\bar{\eta}$
- One may replace $\bar{\rho}$, $\bar{\eta}$ by any 1D or 2D parameter constellation

Present knowledge

- $|\epsilon_K|$, $|V_{ub}/V_{cb}|$, $\Delta m_s/\Delta m_d$ constraints give a consistent picture of CP violation in the SM
- Measurement of $\sin 2\beta \equiv \sin 2\phi_1$: $3.0\ \sigma$
- $\sin 2\beta \equiv \sin 2\phi_1$ in agreement with SM

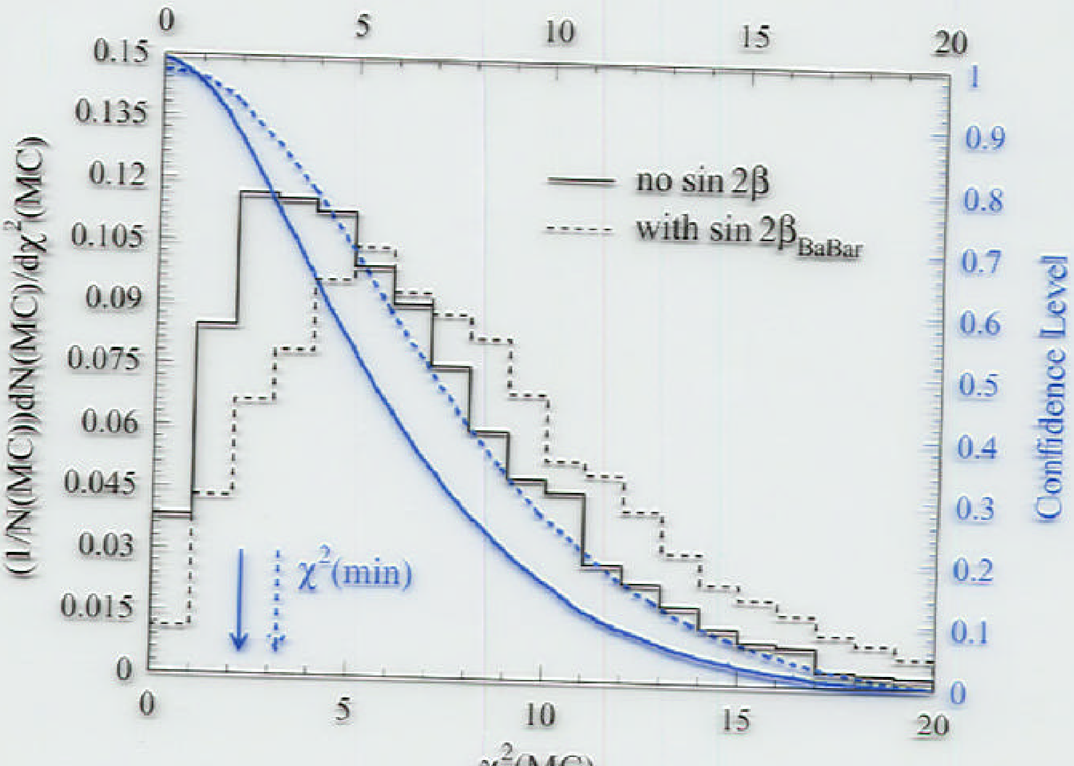


Upper bound for validity of the SM

$$\mathcal{P}(\mathrm{SM}) \leq \int_{\chi^2 > \chi^2(\mu_{\mathrm{min,\,global}})} \mathcal{F}(\chi^2) \mathrm{d}\chi^2$$

where $\mathcal{F}(\chi^2)$ is obtained from toy MC simulation

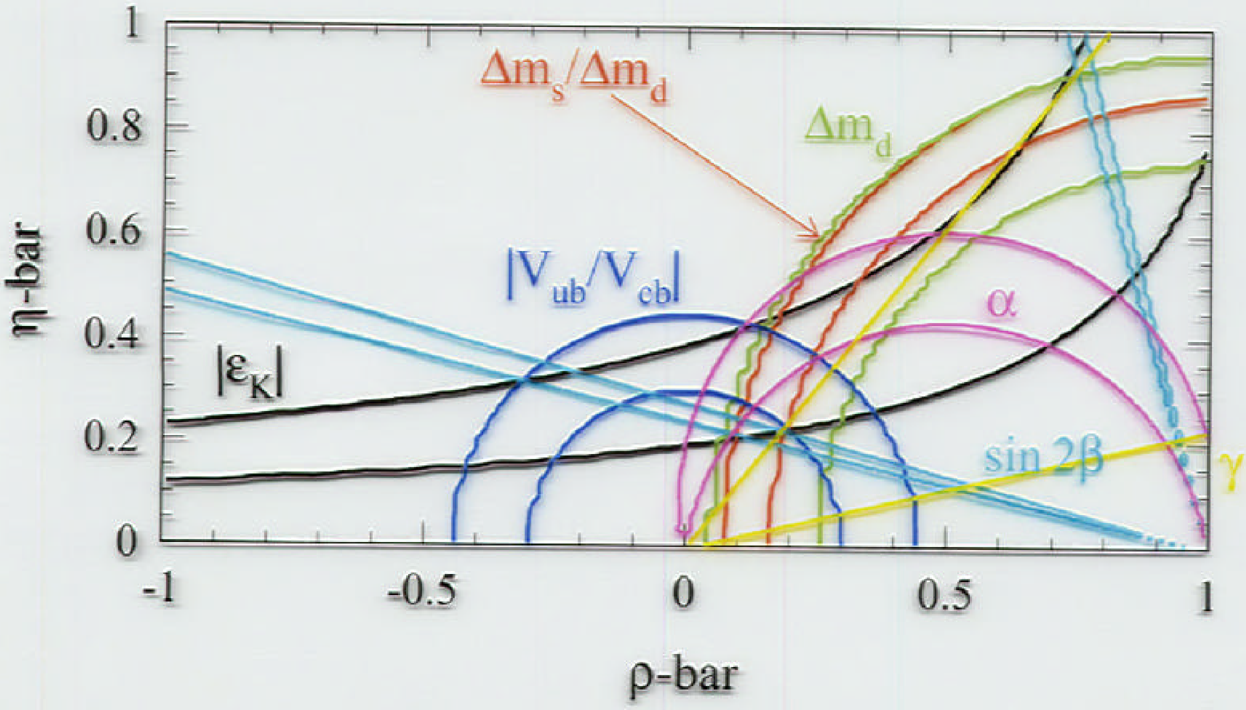
(replace central values of measurements by theor. predictions μ_{min} and fluctuate according to stat. errors)



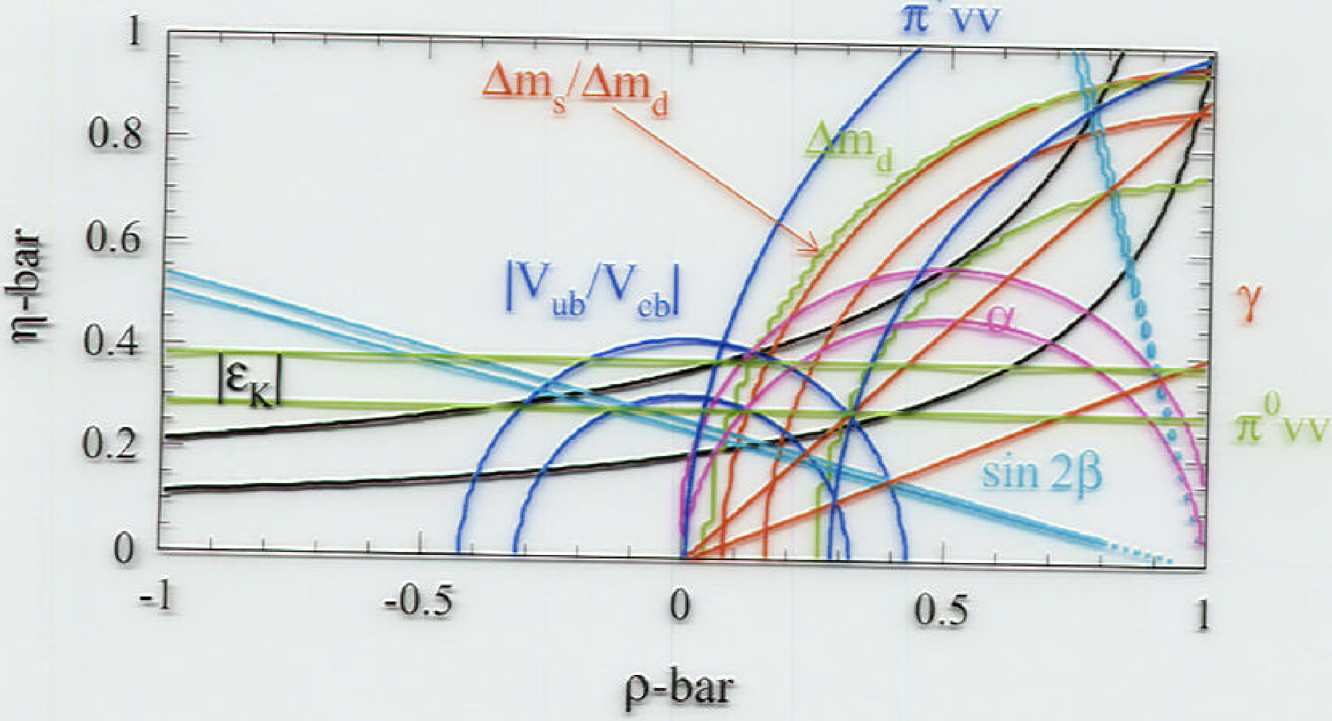
Prophecy

Element	2001	2005	2010
Belle + BaBar	$30\ fb^{-1}$	$1000\ fb^{-1}$	$4000\ fb^{-1}$
CLEO	$\approx 10\ fb^{-1}$		
Tevatron II		$15\ fb^{-1}$	
BTeV+LHC-B			
ATLAS, CMS			
$\|V_{ub}\|$	$\pm 20\%$	$\pm 10\%$	$\pm 10\%$
$\|V_{cb}\|$	$\pm 5\%$	$\pm 3\%$	$\pm 3\%$
Δm_d	$\pm 0.014\ \mathrm{ps}^{-1}$		
Δm_s	$> 15.0\ \mathrm{ps}^{-1}$	$\pm 0.2\%$ (TEV II)	
$m_t(\bar{M}S)$	± 5.0 GeV	± 3.0 GeV (TEV II)	± 1.0 GeV (LHC)
m_c	± 0.1 GeV		
B_K	$\pm 0.06 \pm 0.13$	$\pm 0.03 \pm 0.07$	
$f_{B_d}\sqrt{B_d}$	$(\pm 28 \pm 28)$ MeV	$(\pm 10 \pm 10)$ MeV	
$\xi = \frac{f_{B_s}\sqrt{B_s}}{f_{B_d}\sqrt{B_d}}$	$\pm 0.03 \pm 0.05$	0.015 ± 0.025	
$\sin 2\beta$	± 0.16	$\pm 0.01 \pm 0.01$	$\pm 0.005 \pm 0.005$
$B \to J/\Psi K_s$	BaBar+Belle+CDF	BaBar+Belle+CDF	+BTev+LHC-B +ATLAS+CMS
α	-	5°	2°
$B \to$ ~~$\rho\pi$~~ $\pi\pi\pi$ $(\pi\pi)$	-	BaBar+Belle	+BTeV+LHC-B
γ	-	10°	6°
$B_{d,s} \to D_{(s)}K$		Belle+BaBar+CDF	+BTeV+LHC-B
$K_L \to \pi^0 \nu\bar{\nu}$	Limit	KOPIO, KAMI	$BR \cdot 7\%$
$K^+ \to \pi^+ \nu\bar{\nu}$	1 evt (E787)	E949, CKM	$BR \cdot (5\% \pm 4\%)$

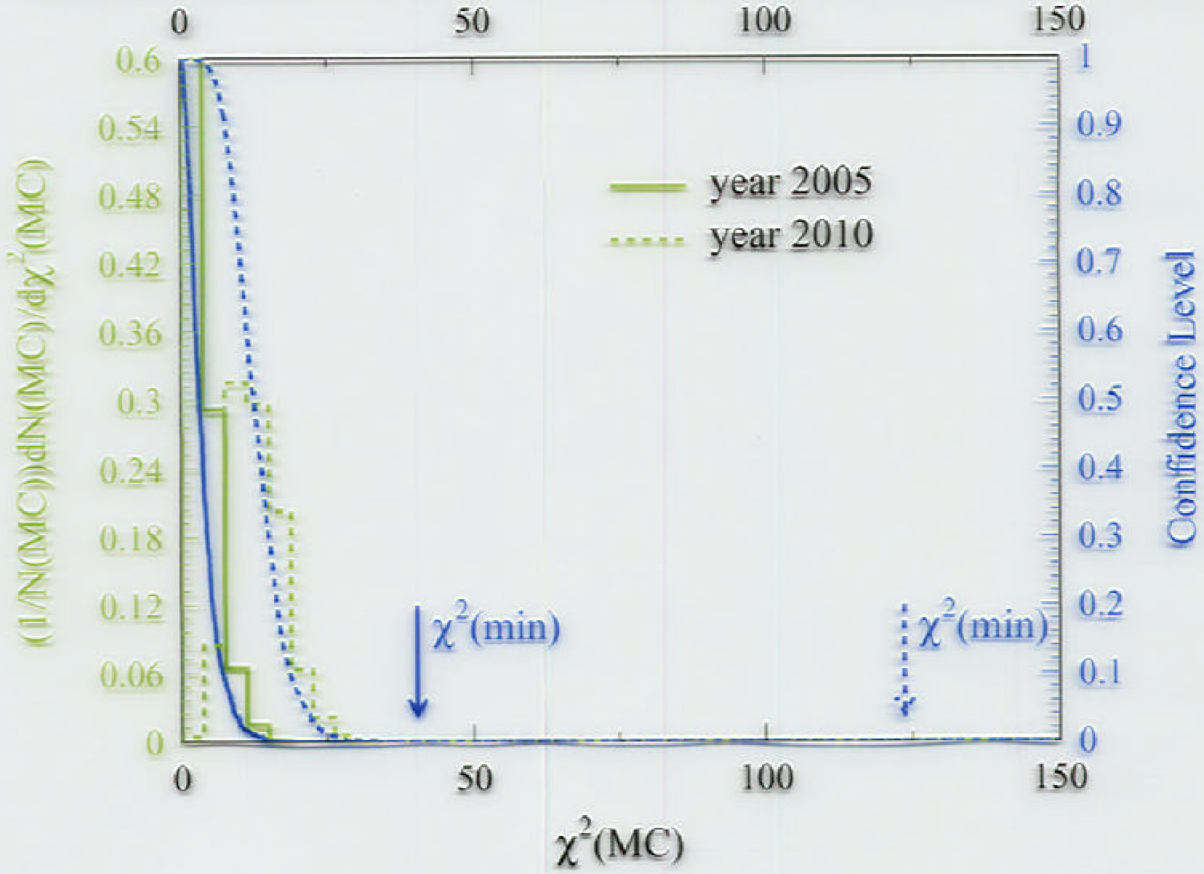
Year 2005



Year 2010



π⁺νν
Δm_s/Δm_d
Δm_d
|V_ub/V_cb|
|ε_K|
γ
α
π⁰νν
sin 2β
η-bar
ρ-bar
1
0.8
0.6
0.4
0.2
0
-1
-0.5
0
0.5
1



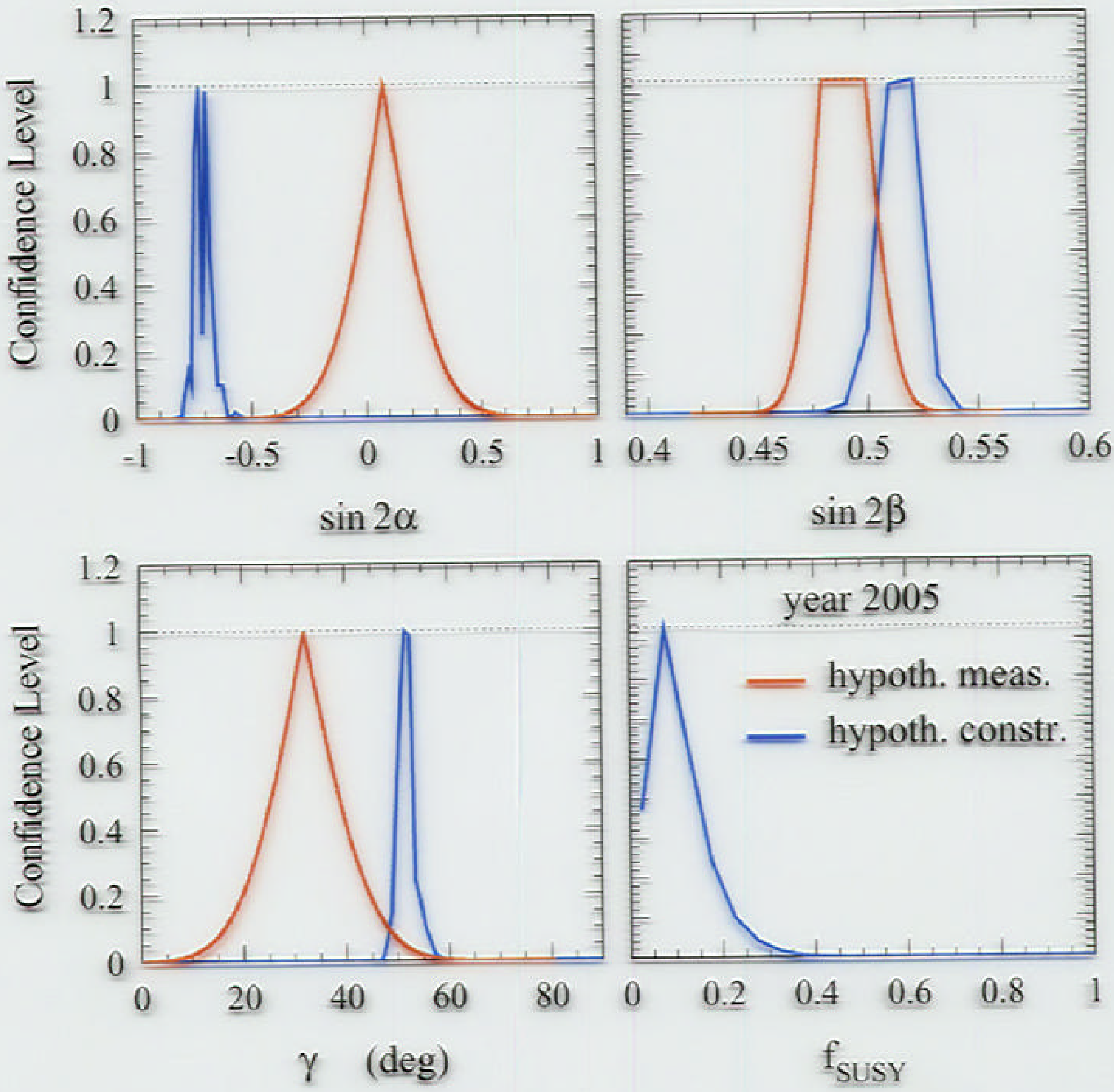
0
50
100
150
0.6
0.54
0.48
0.42
0.36
0.3
0.24
0.18
0.12
0.06
0
(1/N(MC))dN(MC)/dχ²(MC)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Confidence Level
year 2005
year 2010
χ²(min)
χ²(min)
χ²(MC)

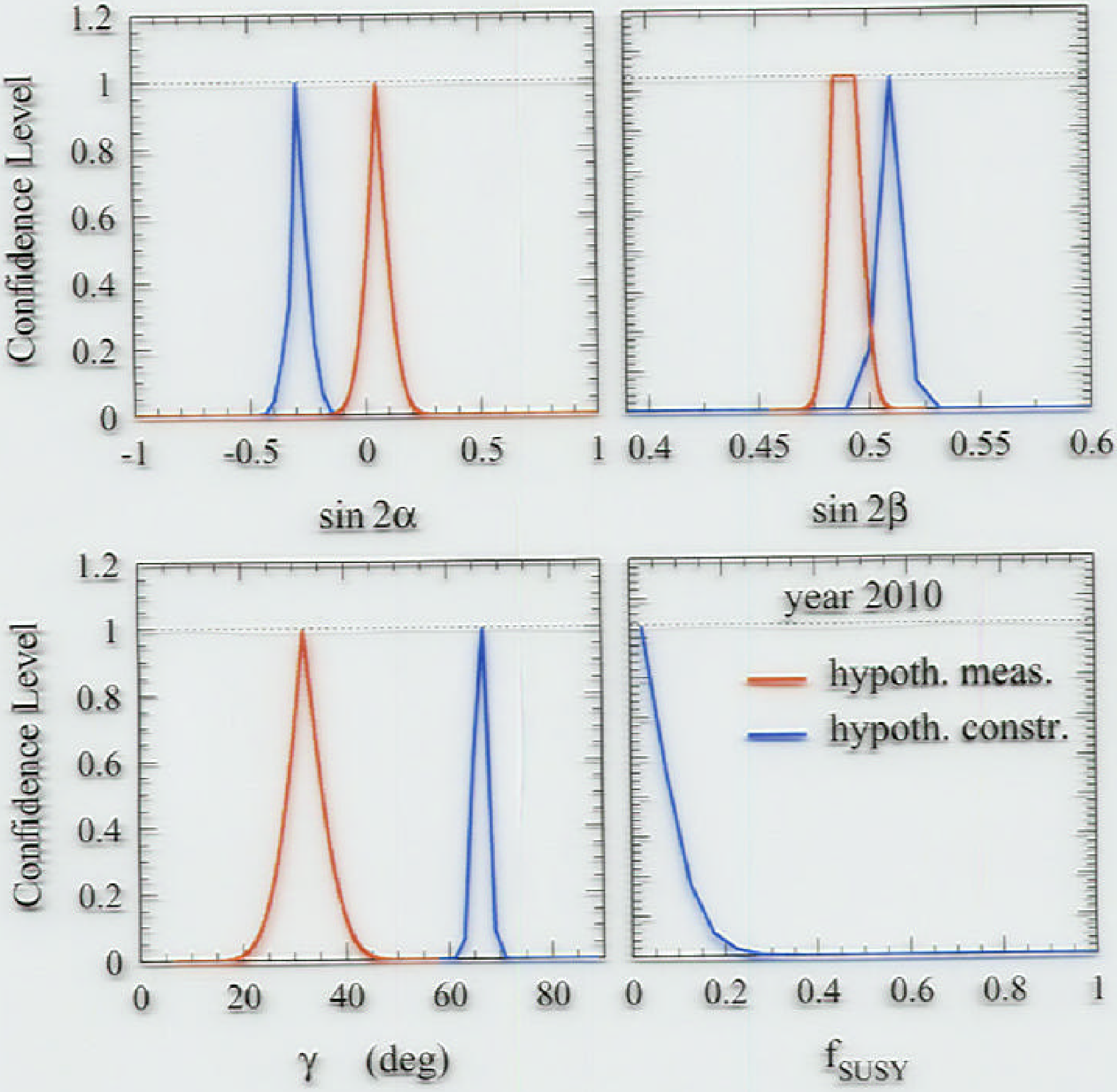
Example: A simple MSSM

- A. Ali, D. London, *Eur. Phys. J.* C9 (1999) 687

$$
\begin{aligned}
\Delta m_d(MSSM) &= \Delta m_d(SM)(1+f_d) \\
\Delta m_s(MSSM) &= \Delta m_s(SM)(1+f_s) \\
\epsilon_K(MSSM) &= \epsilon_K(SM)(S(x_t,x_t) \rightarrow S(x_t,x_t)(1+f_\epsilon))
\end{aligned}
$$

- f_i depending on masses of stop, chargino and charged Higgs and vacuum expectation values of the Higgs field to the d- and u-type leptons
- To a very good approximation: $f_d = f_s = f_\epsilon = f$


Confidence Level
1.2
1
0.8
0.6
0.4
0.2
0
-1
-0.5
0
0.5
1
sin 2α
0.4
0.45
0.5
0.55
0.6
sin 2β
0
20
40
60
80
γ (deg)
0.2
0.4
0.6
0.8
f_SUSY
year 2005
hypoth. meas.
hypoth. constr.


1.2
1
0.8
0.6
0.4
0.2
0
Confidence Level
-1
-0.5
0
0.5
1
sin 2α
0.4
0.45
0.5
0.55
0.6
sin 2β
0
20
40
60
80
γ (deg)
0.2
0.4
0.6
0.8
f_SUSY
year 2010
hypoth. meas.
hypoth. constr.

CONCLUSIONS

METROLOGY

- 2005

  $\rho - \eta$ plane already in good shape
  $\sin 2\beta = \sin 2\phi_1$ well measured
  $\alpha = \phi_2$ measured (5°)
  Better precision on $\gamma \equiv \phi_3$ desirable (10°)
  Important constraints on $\gamma \equiv \phi_3$ from $B \to \pi\pi/K\pi$?
  $\Delta m_s/\Delta m_d$ constraint theoretically limited
  $|\varepsilon_K|$, $|V_{ub}/V_{cb}|$ constraint theoretically limited
- 2010

  Metrological knowledge in $\rho - \eta$ plane remarkable
  $|\Delta m_s/\Delta m_d|$ constraint theoretically limited
  $|\varepsilon_K|$, $|V_{ub}/V_{cb}|$ constraint theoretically limited
- One might overcome these limitations:

  Unquenched calculations
  $B^+ \to \tau^+\nu$: $|V_{ub}| \cdot f_{B_d}$
  Measure f_{D_s}/f_{D_d}: check Lattice QCD calculations
  Rare K decays provide complementary information
  Other channels not mentioned
  ... $B \to X_{d,s}\nu\bar{\nu}$

WHICH LUMINOSITY IS NEEDED?

- METROLOGY can not last forever
- Theoretical input needed
- Simplified models as a guideline