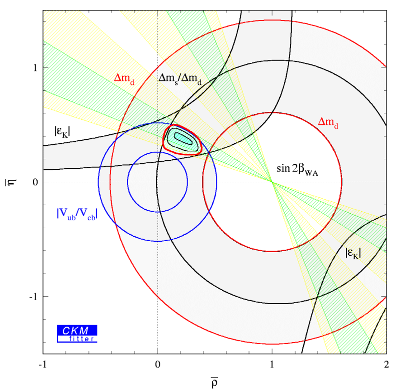
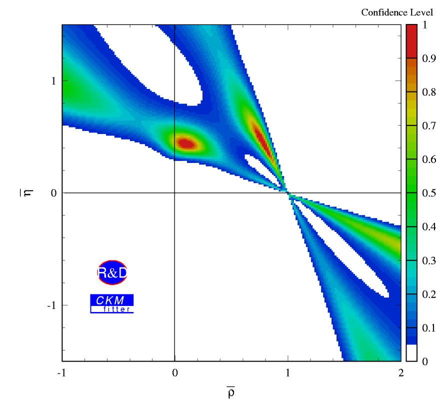


CKM FITS

9th International Symposium
on Heavy Flavor Physics
Caltech, Sept. 10-13, 2001, Heiko Lacker



- **Statistics** (Frequentist approach: ***Rfit****)
- **Input Values**
- **Global Fit Results**
- **Charmless Two-Body B-Decays**
  - BBNS
  - Fleischer-Mannel bound
    & Neubert-Rosner bound+BBNS

* A. Höcker, H. Lacker, S. Laplace and F. Le Diberder ,
Eur. Phys. J. C21/2 (2001) 225, LAL 06/01, hep-ph/0104062

Updated results and *CkmFitter* Code:
http://www.slac.stanford.edu/~laplace/ckmfitter.html

STATISTICS in *Rfit*

* Definition of the fit problem: $?^2(y_{mod}) = -2 \ln L(y_{mod})$

$$L(y_{mod}) = L_{exp}(x_{exp} - x_{theo}(y_{mod})) * L_{theo}(y_{QCD})$$

* **"Educated guesswork" (quenched approx., SU(3)-break., ...)**
  Critical piece of information from mind of physicists

Theoretical uncertainty not described by a *PDF* but considered as an *« Allowed range »*

$\ln L_{theo}(y_{QCD})=0$

within allowed range ->

No contribution to $?^2_{y_{mod}}$

PROBING THE STANDARD MODEL

Interpretation of ?² by building a test statistics

1. **Determine ?$^2_{min;y_{mod}}$ --> $y_{mod,opt}$={?, *A*, ? ??? ?? m_t, B_K,...}**

2. **Calculate $x_{exp,opt} = x_{theo}(y_{mod,opt})$ and generate x_{exp} measurements according to L_{exp}**

3. **Determine for each set x_{exp} the minimum ?²-->*F*(?²)**

$$CL(SM) ? \overset{?}{\underset{?^2 ? ? ?^2_{min;y_{mod}}}{?}} F(?^2)\, d?^2$$

METROLOGY

y_{mod} ={*a* ; μ}={? ??? ?; ?, *A*, m_t, B_K, ...}

Set Confidence Levels in the *a* space, irrespective of the ? values.

Maximize agreement between data and theory:

CL(*a*) = MAX? { CL(*a*, ?) }   (Upper bound of CL)

? ?²(*a*) = ?²$_{min;?}$ (*a*) - ?²$_{min;y_{mod}}$

CL(*a*) = *Prob*(? ?²(*a*), N_{dof})

INPUTS

$\|V_{ud}\|$	0.97394 ? 0.00089	neutron ? nuclear ? - decay
$\|V_{us}\|$	0.2200 ? 0.0025	K ? ? ??
$\|V_{cd}\|$	0.224 ? 0.014	dimuon production : ?N(DIS)
$\|V_{cs}\|$	0.969 ? 0.058	W ? $X_c X$ (OPAL)
$\|V_{ub}\|$	(3.49 ? 0.24 ? 0.55) ?10^{-3}	Incl.(LEP) ? Excl.(CLEO)
$\|V_{cb}\|$	(40.4 ? 1.3 ? 0.9) ?10^{-3}	Excl. /Incl. ? Moment Analysis (CLEO)
$\|?_K\|$	(2.271 ? 0.017) ?10^{-3}	(PDG 2000)
? m_d	(0.489 ? 0.008) ps^{-1}	(BABAR, Belle, CDF, LEP, SLD, 2001)
? m_s	Amplitude Spectrum	(CDF, LEP, SLD, 2001)
sin2?	0.793 ? 0.102	(WA, Summer 2001, not rescaled)
$m_t(\overline{MS})$	(166 ? 5) GeV	(CDF/D0, PDG 2000)
$f_{B_d}\sqrt{B_d}$	(0.230 ? 0.028 ? 0.028) GeV	(Lattice 2000)
?	1.16 ? 0.03 ? 0.05	(Lattice 2000)
B_K	0.87 ? 0.06 ? 0.13	(Lattice 2000)
$?_{cc}$	1.38 ? 0.53	(Herrlich & Nierste)

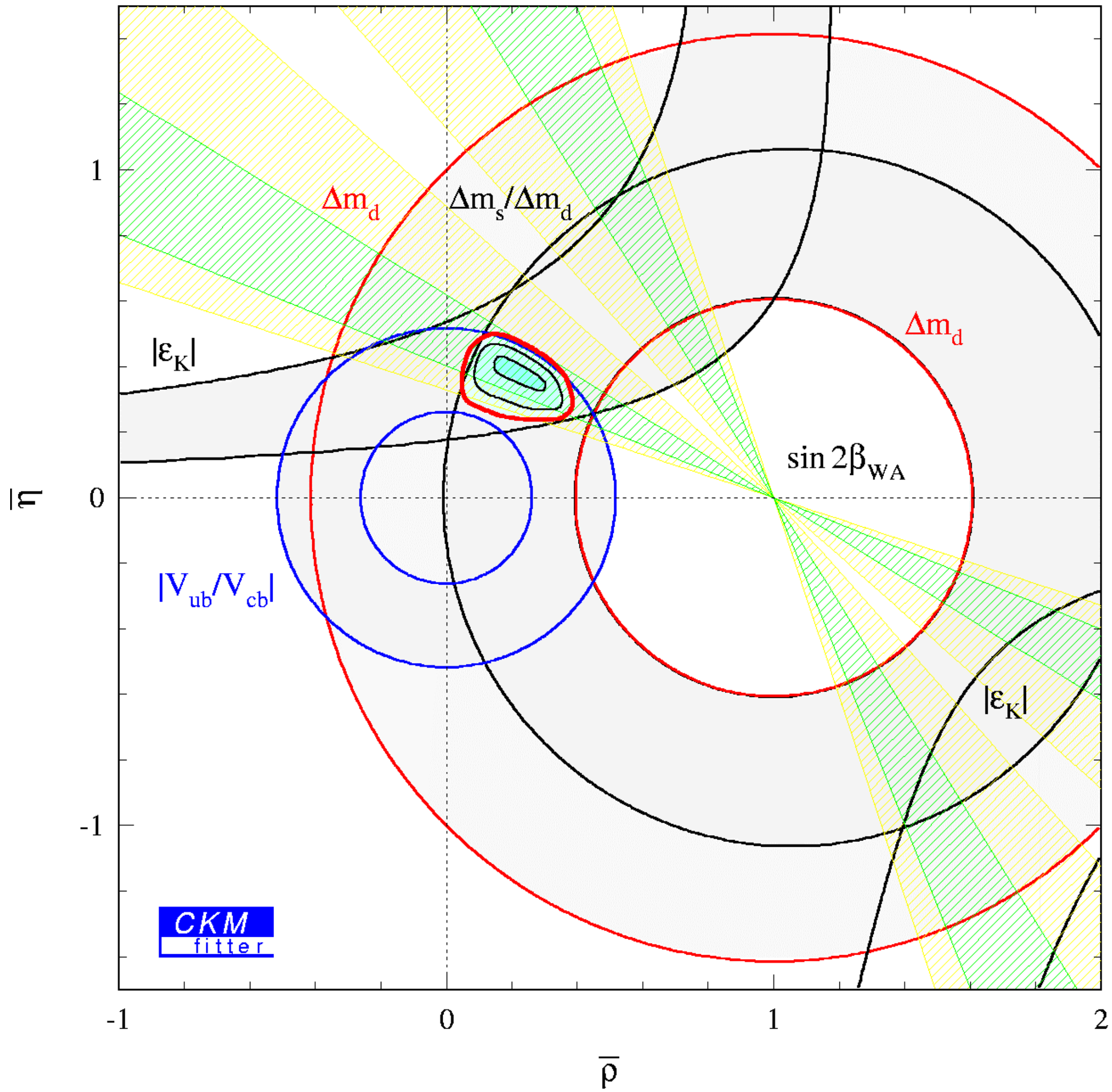
? other parameters with less relevant errors

CLEO lepton-endpoint measurement using b->s?? not included yet

F. Parodi & H. Neil

GLOBAL FIT: RESULTS

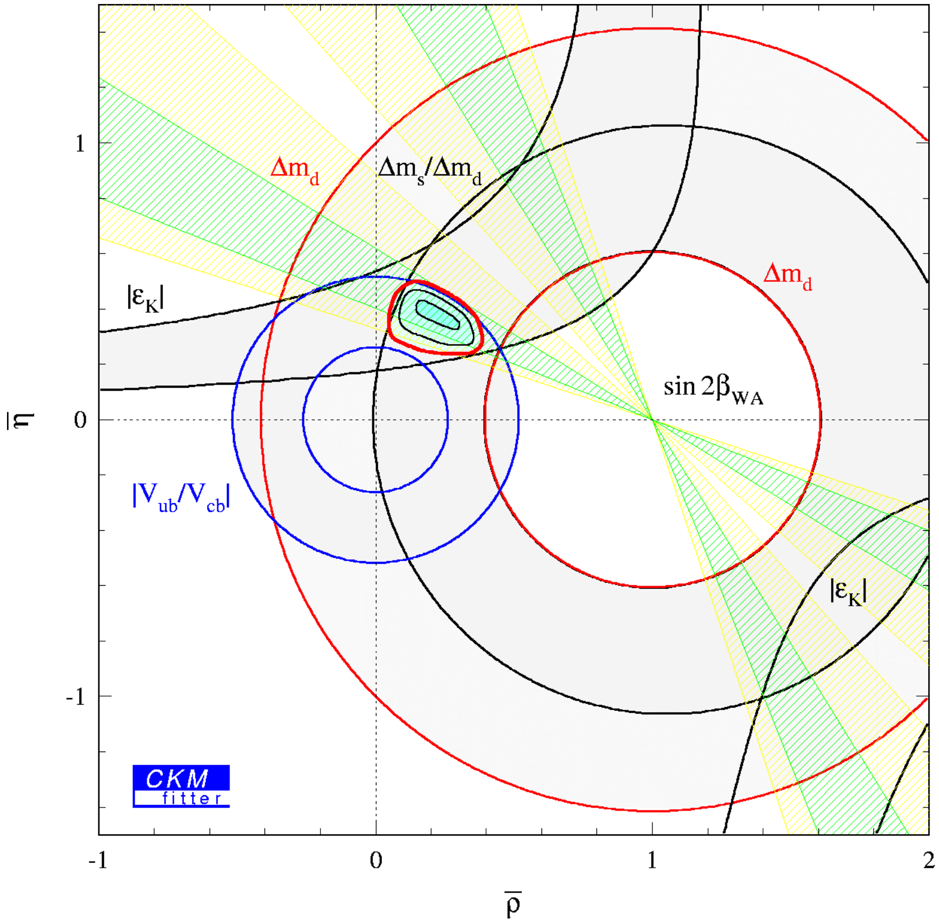
Global fit including sin2?? **?$^{2}_{min}$? 2.3 (? ? 4)**



GLOBAL FIT: RESULTS

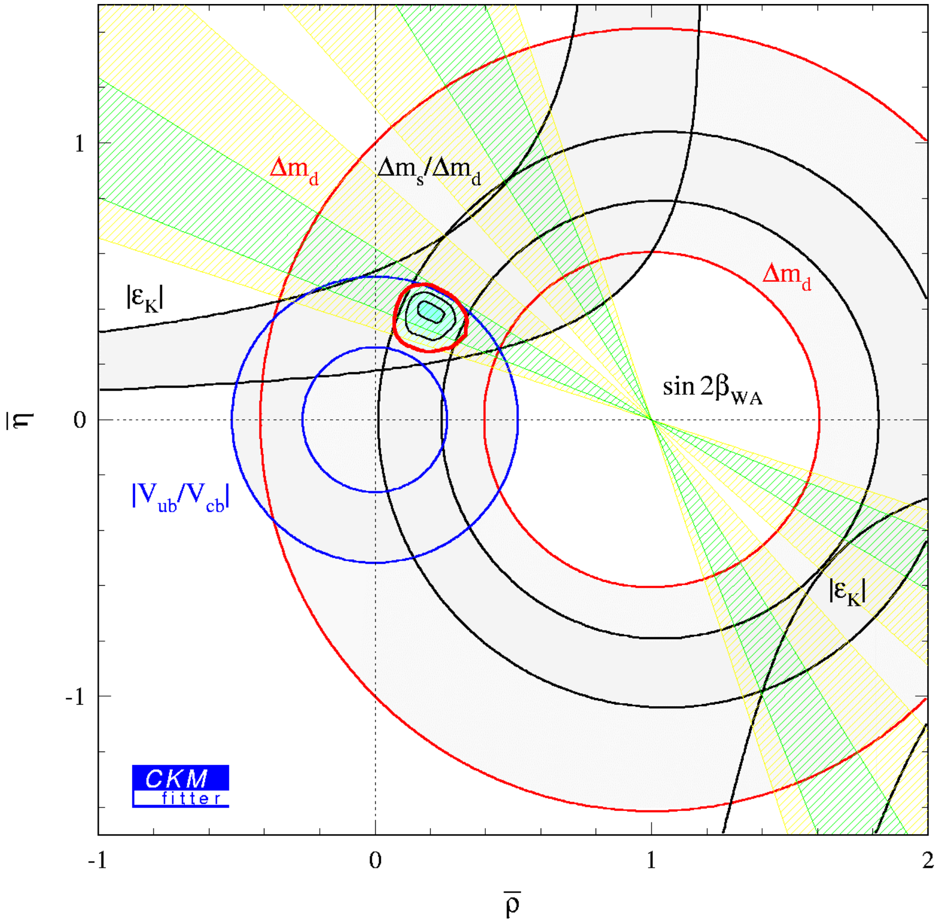
Global fit including sin2?

? ms : modified amplitude method
Used in this analysis.

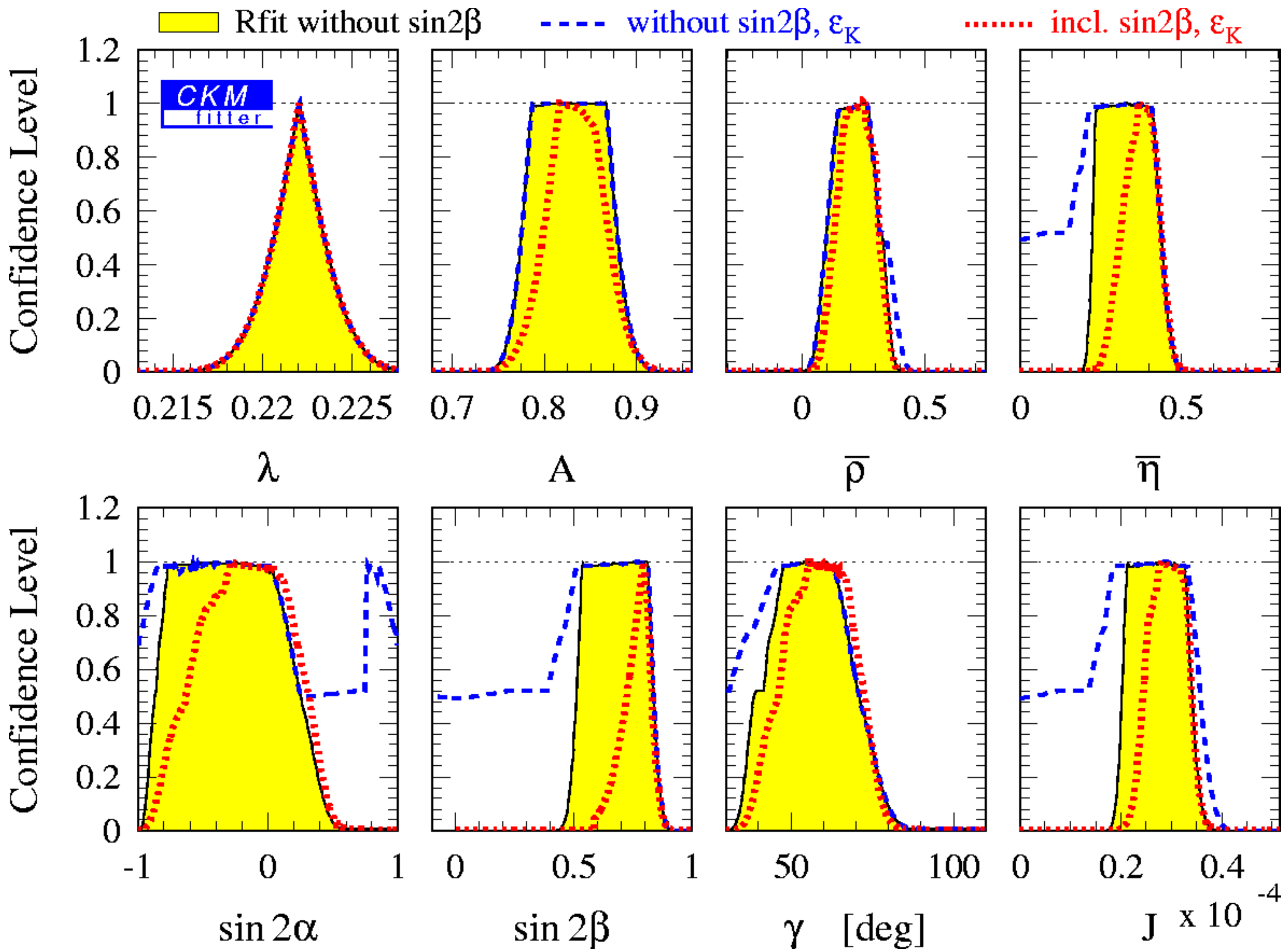


Global fit including sin2?

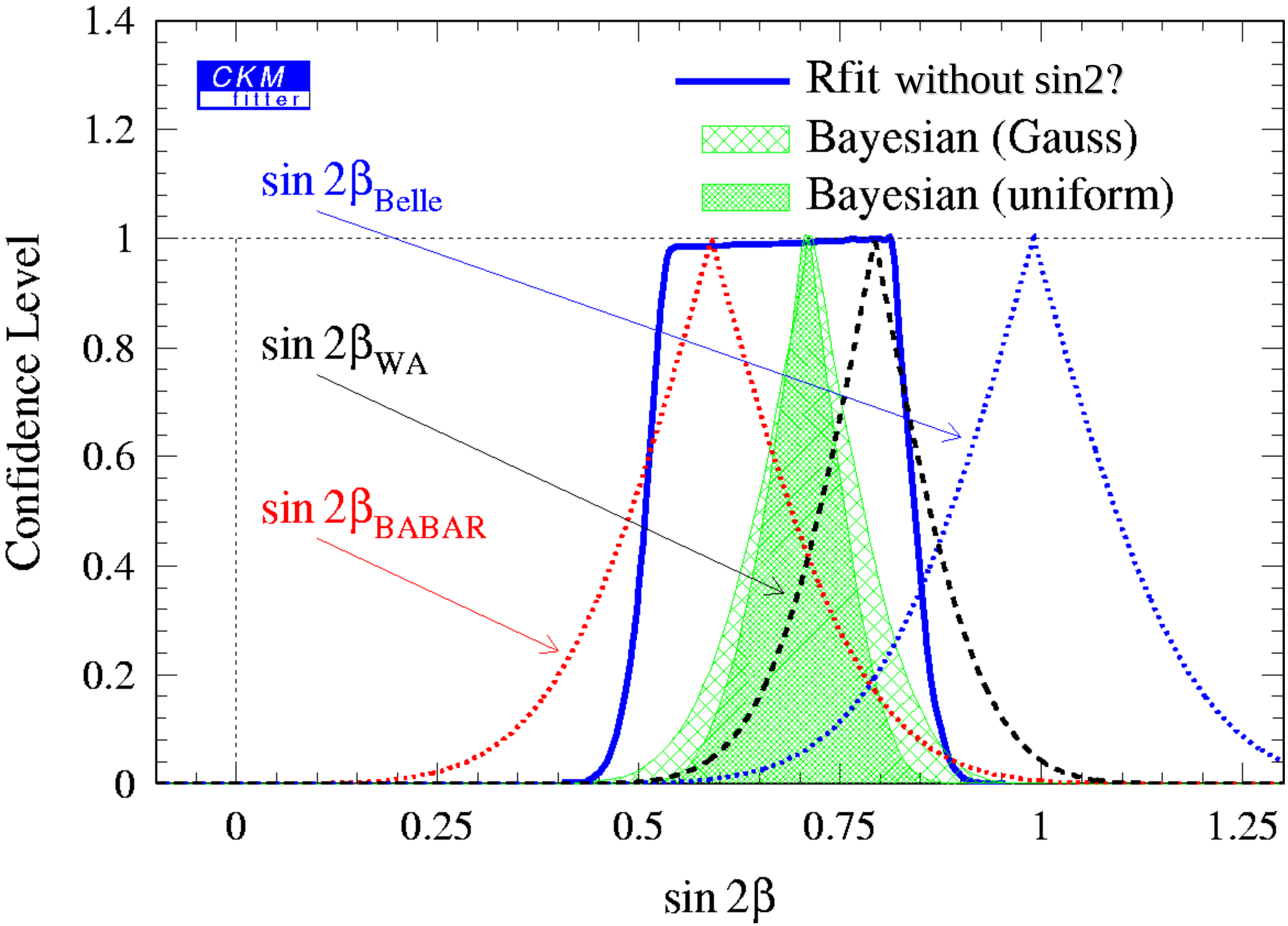
? ms : likelihood ratio
Not used in this analysis; proper translation in CL should be proven by a realistic MC simulation.



One-dimensional Constraints



Different Statistical Treatments



Results (5% CL)

?	0.2221 ? 0.0041	? $m_s\,(\mathrm{ps}^{?1})$	14.6 ? 32.0
A	0.763 ? 0.905	$f_{B_d}\sqrt{B_d}\,(\mathrm{MeV})$	192 ? 284
$\bar{?}$	0.07 ? 0.37	B_K	0.52 ? 1.68
$\bar{?}$	0.26 ? 0.49	$m_t\,(\mathrm{GeV})$	95 ? 405
$J(10^{?3})$	2.2 ? 3.7	$BR?K_L\ ?\ ?^0?\bar{?}??10^{?11}?$	1.6 ? 4.4
sin 2?	? 0.90 ? 0.51	$BR?K^?\ ?\ ?^??\bar{?}??10^{?11}?$	4.8 ? 9.4
sin 2?	0.59 ? 0.88	$BR?B^?\ ?\ ?^??_???10^{?5}?$	5.6 ? 23.8
?	$37^?$? $80^?$	$BR?B^?\ ?\ ?^??_???10^{?7}?$	2.2 ? 9.4

Charmless Twobody B-decays

BBNS: QCD FACTORISATION APPROACH

M. Beneke, G. Buchalla, M. Neubert and C.T. Sachrajda,
"QCD Factorization in B -> ?K, ???Decays and
Extraction of Wolfenstein Parameters", hep-ph/0104110

~~F1 * F2 ?~~

Endpoint Singularities?

Annihilation ?

See talk: M. Neubert

sudakov ?

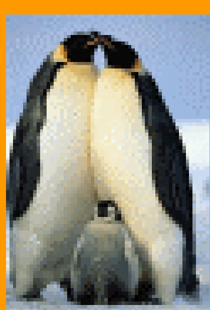
Y. -Y. Keum, H-n. Li and A.I. Sanda,
"Penguin enhancement and B ->?K decays
in perturbative QCD", hep-ph/0004173

See talk: Y. Y. Keum

M. Ciuchini, E. Franco, G. Martinelli,
M. Pierini and L. Silvestrini,
"Charming Penguins strike back",
hep-ph/0104126

$b\ (c\bar{c})\ \bar{d}$?

S. J. Brodsky and S. Gardner,
Evading the CKM Hierarchy, hep-ph/0108121



BBNS implemented in CKMfitter

Consider these fits as: R&D

INPUT VALUES: BBNS FIT

CP ? averaged BR ($10^{?6}$)			Direct CP ? Asymmetry (A_{CP})
$B^0 ? \; ?^? ?^?$	$4.44^{?0.89}_{-0.86}$	$(?^2(? \; ? \; 2) ? 0.41)$	
$B^0 ? \; K^? ?^-$	$17.37^{?1.47}_{-1.30}$	$(?^2(? \; ? \; 2) ? 0.46)$	$-0.049 ? 0.066 \; (?^2(? \; ? \; 2) ? 0.35)$
$B^? ? \; K^? ?^0$	$12.13^{?1.70}_{-1.67}$	$(?^2(? \; ? \; 2) ? 1.58)$	$-0.094 ? 0.118 \; (?^2(? \; ? \; 2) ? 1.03)$
$B^? ? \; K^0 ?^?$	$17.41^{?2.60}_{-2.51}$	$(?^2(? \; ? \; 2) ? 0.46)$	$-0.049 ? 0.135 \; (?^2(? \; ? \; 2) ? 1.85)$
$B^0 ? \; K^0 ?^0$	$10.73^{?2.66}_{-2.66}$	$(?^2(? \; ? \; 2) ? 1.65)$	
$B^? ? \; ?^? ?^0$	$5.80^{?1.57}_{-1.52}$	$(?^2(? \; ? \; 2) ? 0.46)$	

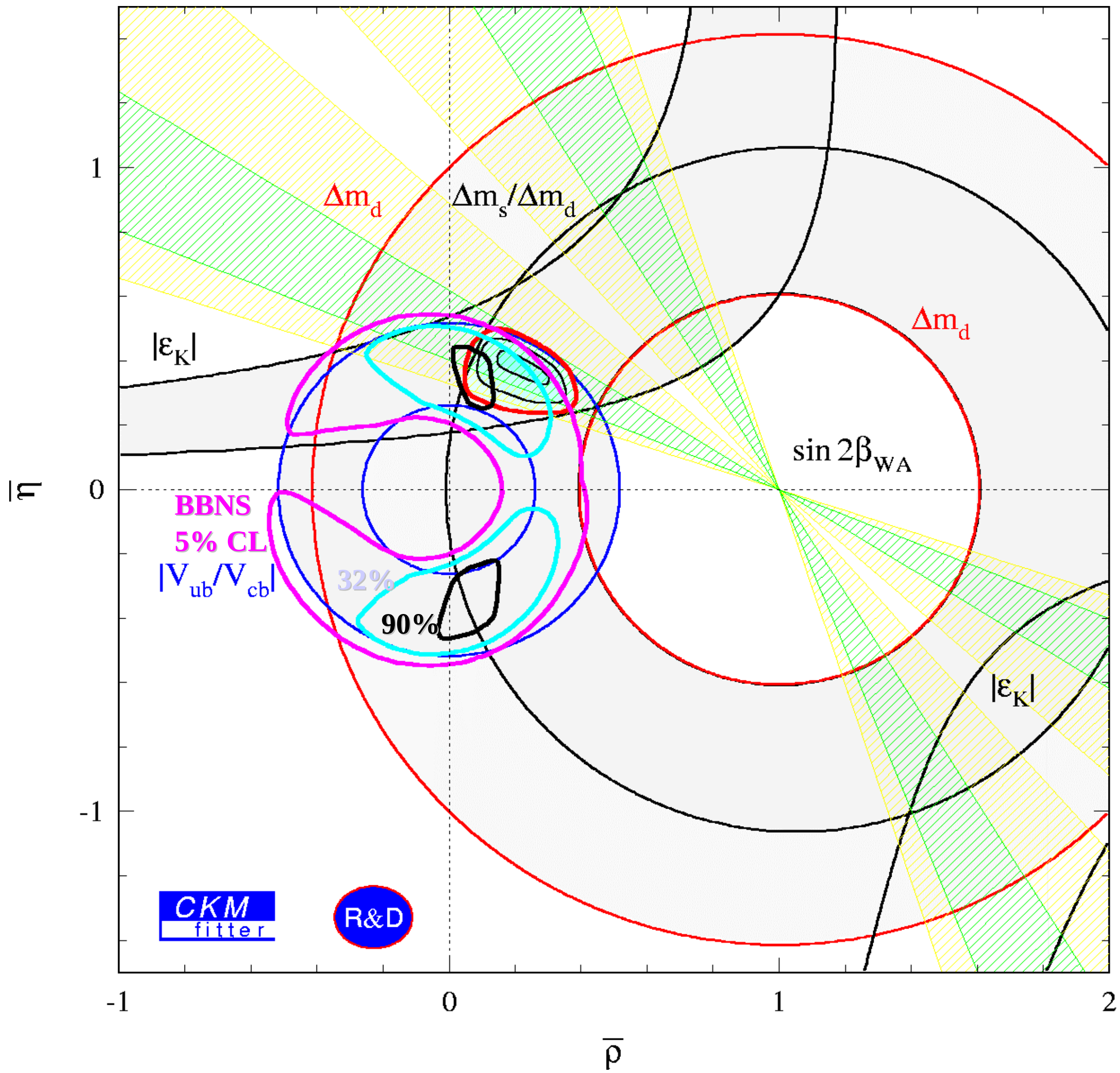
See also the talks from CLEO, Belle and BABAR at this conference

CLEO:	Phys.Rev.Lett.85 (2000) 515	Phys.Rev.Lett.85 (2000) 525
Belle:	hep-ex/0104030	hep-ex/0106095
BABAR:	hep-ex/0105061	hep-ex/0105061 & 0107074

Additional input: $|V_{cb}|$

$$A_{CP} ? \frac{BR(\bar{B} ? \; \bar{f}) ? BR(B ? \; f)}{BR(\bar{B} ? \; \bar{f}) ? BR(B ? \; f)}$$

Fit to BR and ACP within BBNS compared to standard CKM fit



Theoretical uncertainties:

ms, mc, ? ? ? R?K
scale dependance ?
Gegenbauer moments:
? 1K, ? 2K, ? 2?
F(B->?), fB
XH, XA

? $^{2}_{min}$? 2.04 (? ? 7) at (?, ?) ? (0.061, - 0.375)

Best Fits around ? ? 90?

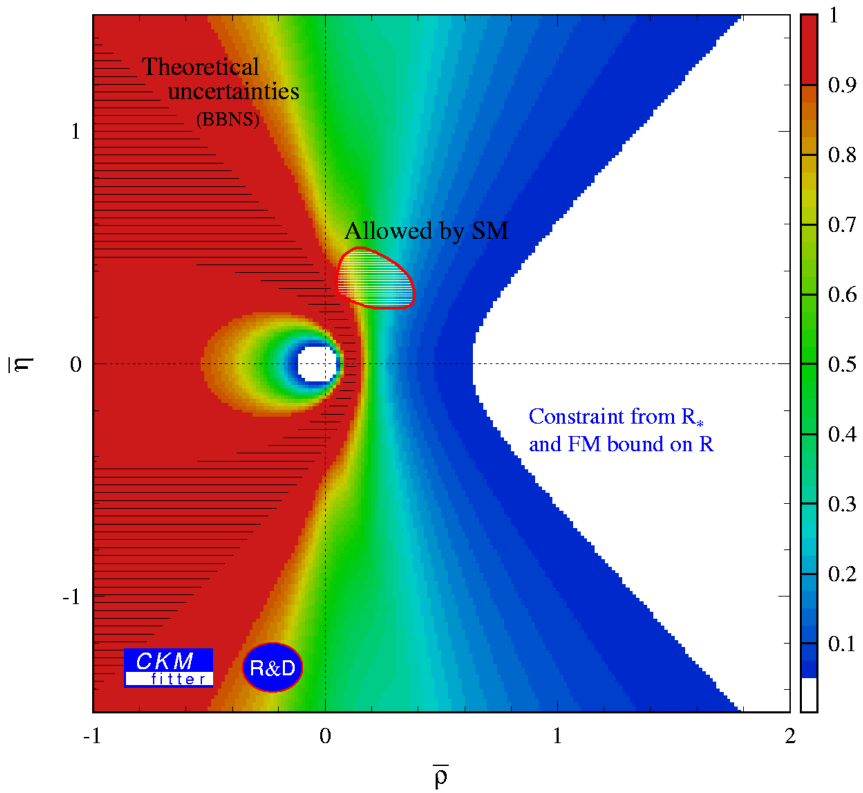
Fleischer-Mannel +Neubert-Rosner +BBNS

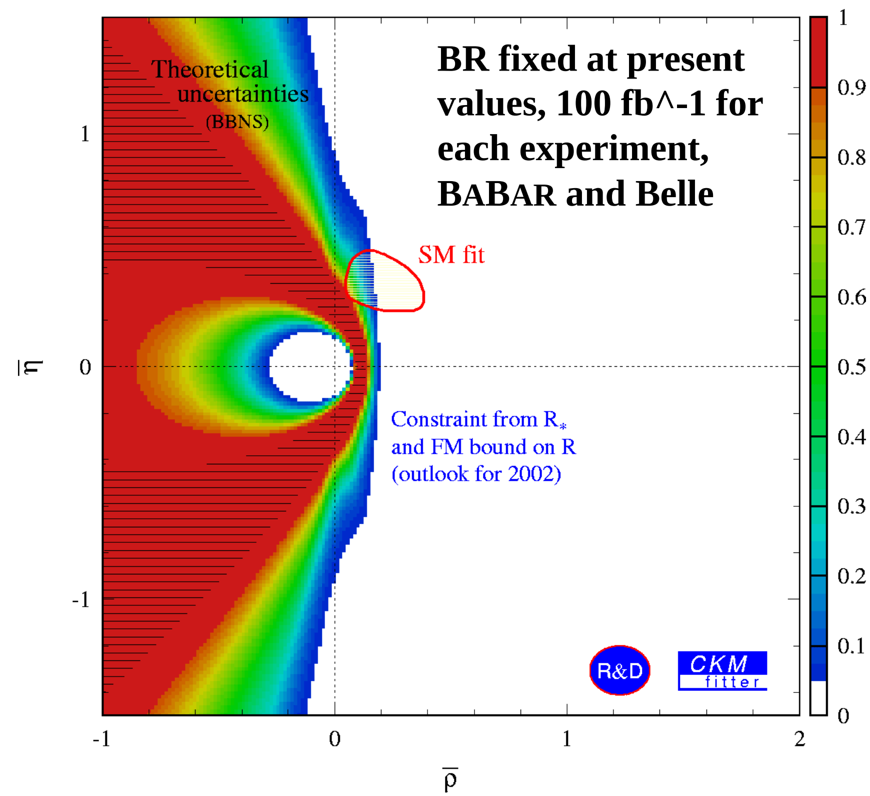
$$\mathbf{FM:}\quad R \;?\; \frac{?(B^{?})}{?(B^{0})}\,\frac{BR(K^{?}?^{?})}{BR(?^{?}K^{0})} \;?\; 1.06 \;?\; 0.18 \qquad (R\;?\;1 \quad ? \quad R\;?\;\sin^{2}?)$$

NR ? additional theoretical input :

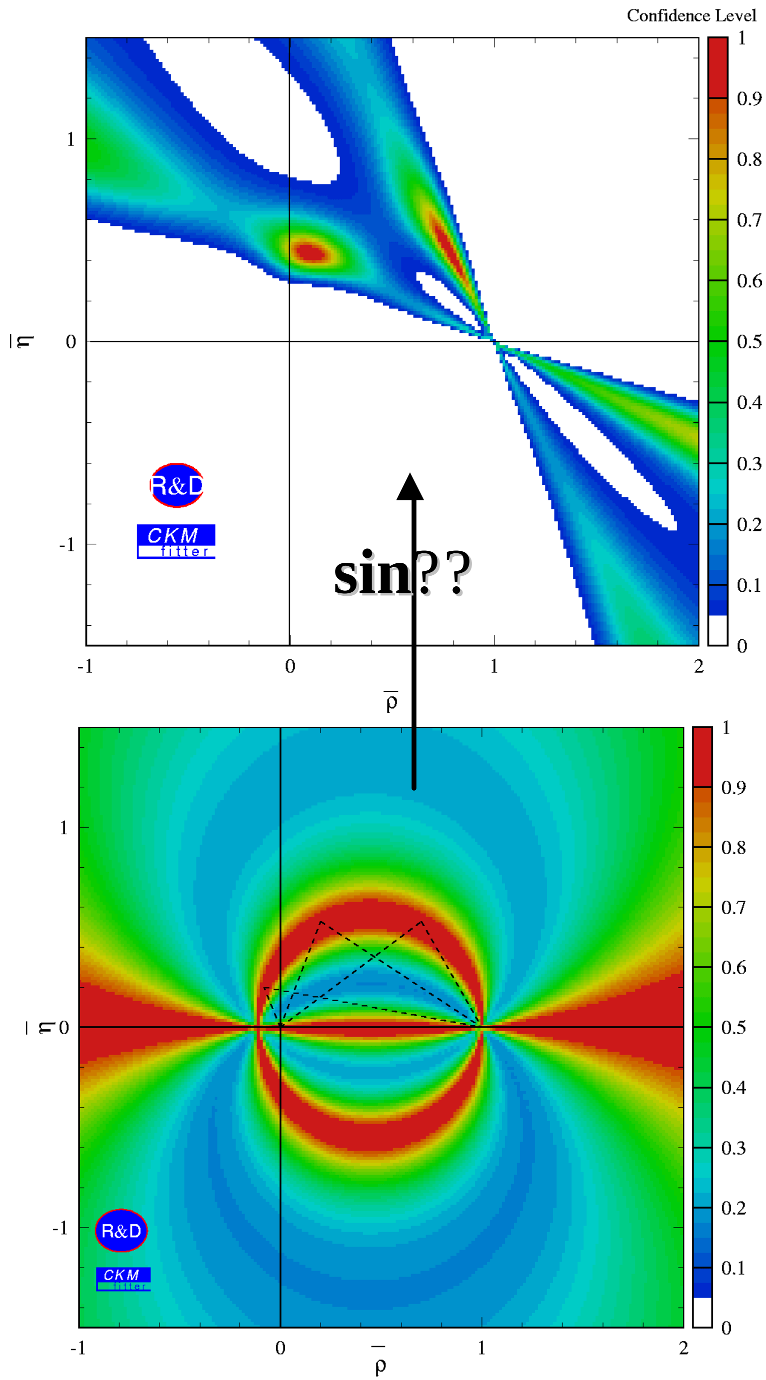
$$1.\; R^{?} \;?\; \frac{BR(K^{?}?^{0})}{BR(?^{?}K^{0})} \;?\; 0.71 \;?\; 0.14 \qquad ?\;\bar{?}^{T/P}? \qquad 2.\; ?_{3/2} \;?\; R_{th}\,?\tan?_{c}\,\frac{f_K}{f_?}\sqrt{\frac{2\,BR(?^{?}?^{0})}{BR(?^{?}K^{0})}}$$

$$3.\; FA(BBNS):\ \text{strong phases small} \qquad ?\; R_{th}(SU(3), BBNS)\;?(0.223\;?\;0.034)$$





B->?+?-: time-dependent asymmetry within BBNS

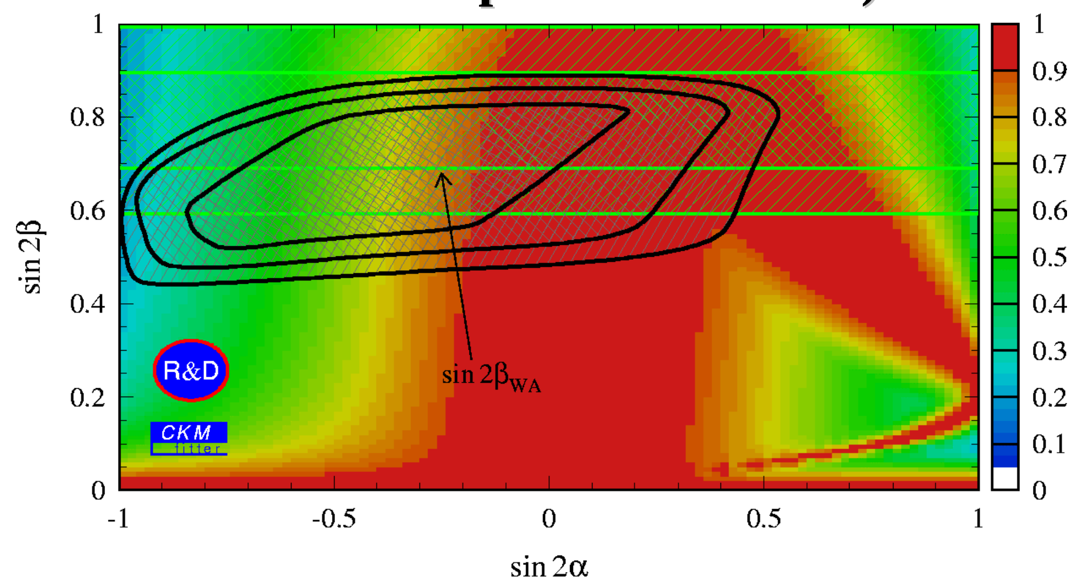


$$S_{??} \; ? \; \frac{2\,\mathrm{Im}\, ?_{??}}{1 \; ? \; |?_{??}|^2}$$

$$?_{??} \; ? \; e^{? 2 i ?} \frac{e^{? i ?} \; ? \; P_{??} / T_{??}}{e^{? i ?} \; ? \; P_{??} / T_{??}}$$

BABAR: $S_{??}$ = 0.03 +/- 0.56

+BBNS (Quoted theoretical error << Present experimental error)



SUMMARY

- - CKM fit: consistent picture
  - sin2? is competitive with the other (theoretically limited) measurements; Consistency: *BABAR* <->*Belle* ?
- - |V_{ub}|: - *LEP* experiments: all inclusive results in agreement
  - Lepton-Endpoint measurement using b->s ??(*CLEO*)
  - |V_{cb}|: - |V_{cb}|(excl.) from *Belle* agrees with *LEP* results
  - Moment analysis (*CLEO*) --> substantial improvement
  - See also the new results from the B-factories at this conference
  - ? m_s : Sensitivity limit further improved
- - BR(B->??/K?)/A_{CP}(B->K??: best BBNS fits around ?=90 deg.
  - Implementation of other approaches
  - Further theoretical discussion needed
  - More statistics to come -> Calculations to be tested in detail

|Vcb|

$|V_{cb}|$: inclusive

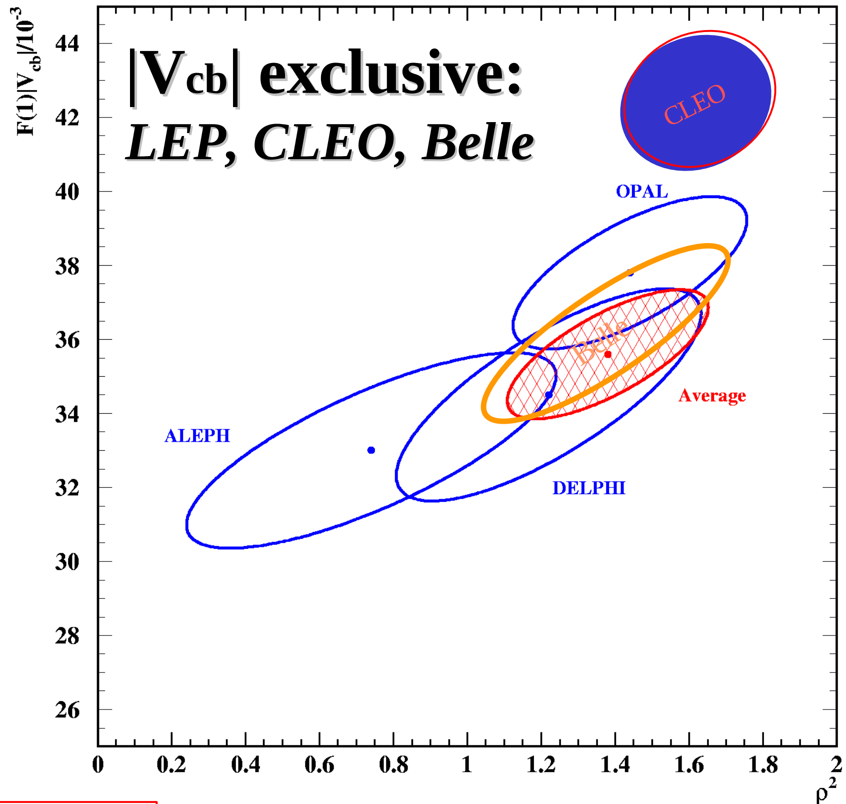
LEP : (40.7 ? 0.5 ? 2.0) ?10^{-3}

CLEO : (41 ? 2 ? 2) ?10^{-3}

$|V_{cb}|$: moment analysis (CLEO)

(40.4 ? 1.0 ? 0.9($\overline{?}$, $?_1$: exp)

? 0.8($?_s$, $1/M_B^3$)) ?10^{-3}



? sl(B) quite safe

B->D* at zero recoil more vulnerable (1/mc)

Ikaros Bigi and Nikolai Uraltsev, A Vademecum on Quark-Hadron Duality, hep-ph/0106346

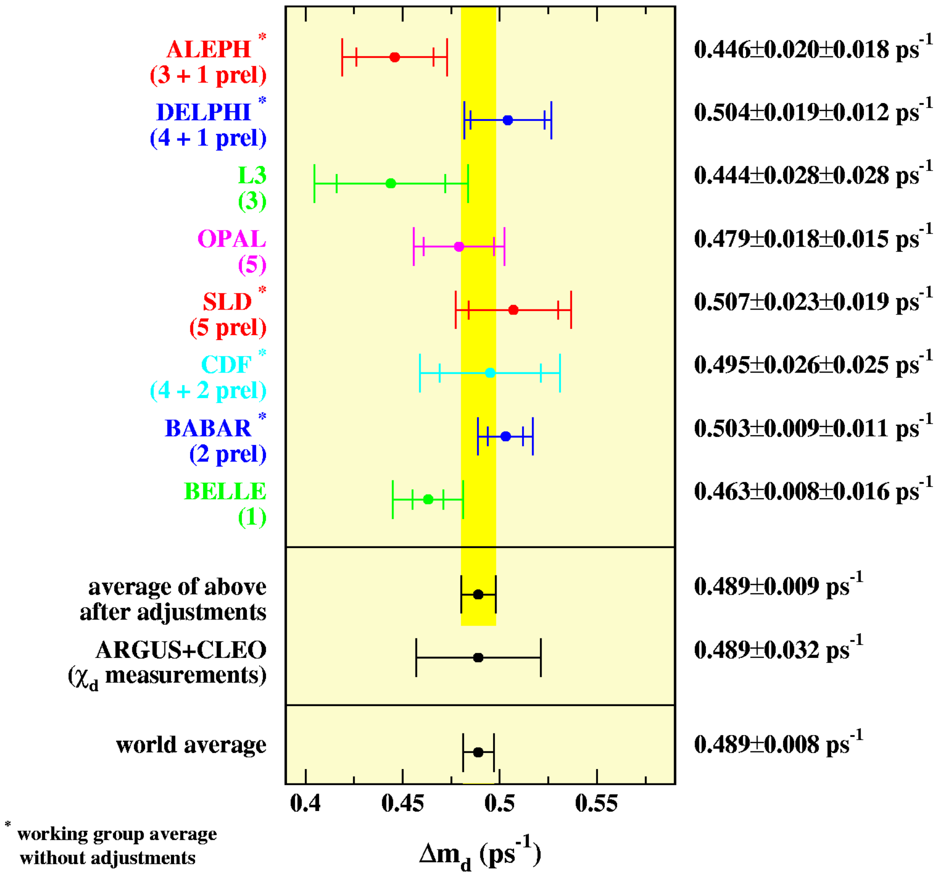
$F_{B?\ D^?}(0)$? 0.913 ? 0.042

(*BABAR* Physics Book)

$F_{B?\ D^?}(0)$? 0.89 ? 0.08

(I.I. Bigi, hep ? ph/9907270)

? md



Precision measurements of decay constants in charm sector highly welcome ! -> CLEO-C Important input for ? md/? ms !

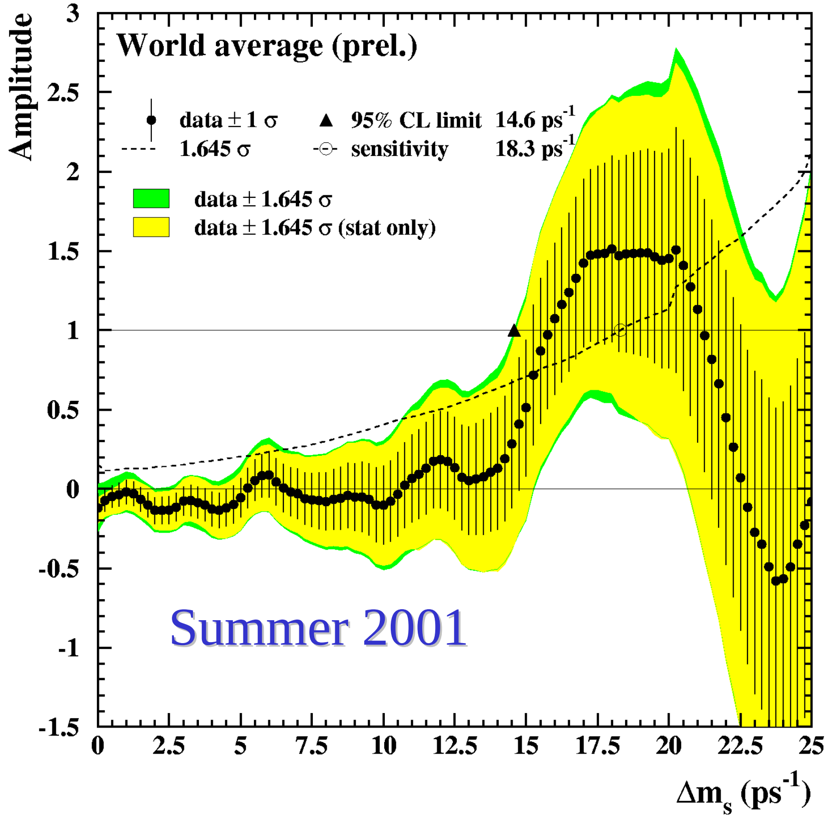
We use Lattice Results for $f_{B_d}\sqrt{B_d}$.

Recent results from Sum Rules :

A.A. Penin and M. Steinhauser
Heavy - Light Meson Decay Constant from QCD Sum Rules in Three - Loop Approximation, hep - ph/0108110

S. Narison,
c,b quark masses and $f_{D_{(s)}}$, $f_{B_{(s)}}$ decay constants from pseudoscalar sum rules in full QCD to order alpha_s^2, hep - ph/0108242

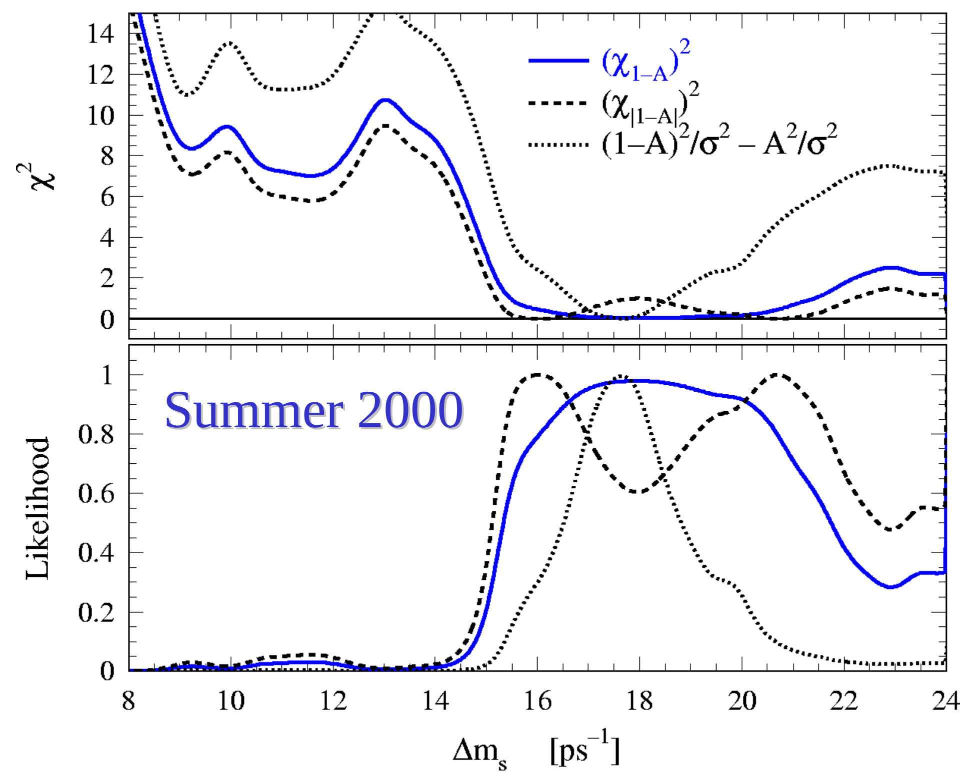
? ms



$$?^2_{|1?A|} ? \left(\frac{1?A}{?_A}\right)^2 ? ?^{CL} ? Erfc\left(\frac{|1?A|}{\sqrt{2}?_A}\right)$$

$$?^2_{1?A} ? 2\left[Erfc^{?1}\left(\frac{1}{2}Erfc\left(\frac{1?A}{\sqrt{2}?_A}\right)\right)\right]^2$$

$$2? \ln L^? ?? m_s ?? \left(\frac{1?A}{?_A}\right)^2 ? \left(\frac{A}{?_A}\right)^2$$



At present, we do not use the likelihood ratio. A rigorous proof that the likelihood ratio provides a proper CL, for the present data situation, should be given by means of a realistic Monte Carlo simulation.