CKM and Wilson Coefficients Fits

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KEK

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Outline

1. Introduction
2. Inputs to CKM fit
3. Standard model fit
4. Fit with New Physics effect
5. Status of Wilson Coeff. fit
6. Summary and Prospects

1. Introduction

5. Summary

shown@1st BNM

- The CKM fit becomes an important tool at SuperKEKB for the search of New Physics effect.

- O(10) improvement in the $\rho-\eta$ constraint with 50/ab is shown to be a sensitive prove to NP independently of theoretical models.

- Improvements in theoretical uncertainties is essential to go further in the search of NP.

- More to come by next WS.
  - ✓* Finalize inputs to CKM fit and update $\rho-\eta$ constraint from LoI.
  - ▲* Global fit to radiative decay measurements for the determination of Wilson Coefficents with NP effect.

- More considerations are necessary on
  - ▲* Treatment of radiative/leptonic decays in NP fit
  - ×* Inclusion of $\sin2\phi_1(b\to s)$ and other NP sensitive meas.

2. Inputs to CKM fit

1. Experimental measurements

   a) SuperKEKB measurements

   - measurements with B_d decays only

   V_{ub}, $\sin 2\phi_1(J/\psi K^0)$, ϕ_2, ϕ_3, Δm_d, $Br(B \rightarrow \tau\nu)$, $Br(\rho/\omega\gamma)/Br(K^*\gamma)$

   b) LHC(b) measurements

   - measurements with B_s decays

   Δm_s - LHCb expectation for SuperB fits

   - possibility to include other measurements (ex. ϕ_3), but not taken in the fits

   c) Kaon sector measurements

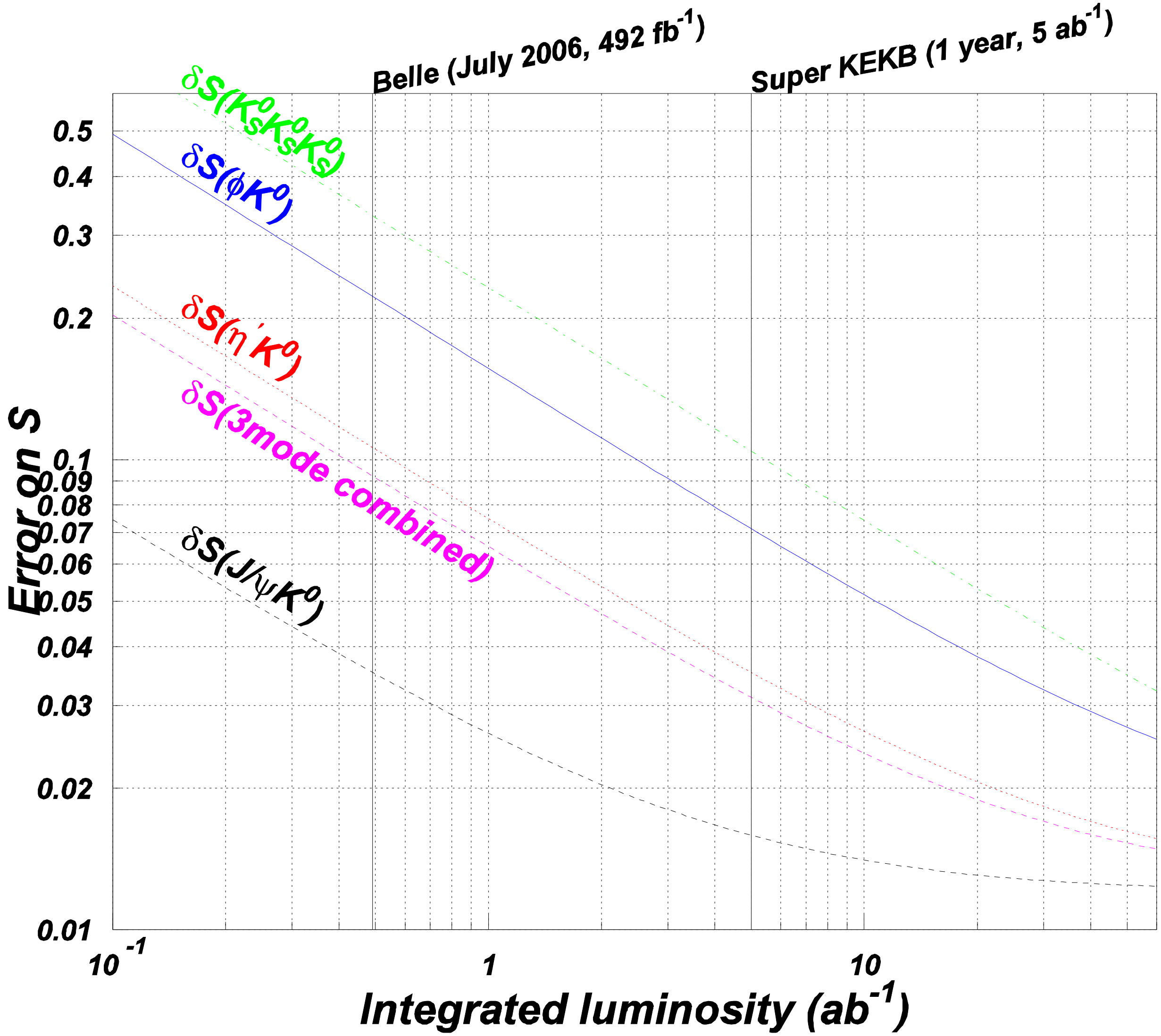
   ε_K - current best value is used in all fits

2. Theoretical inputs

   Decay constants, etc.: mostly relies on LQCD calculations

   $\rightarrow$ conservative assumption : <u>no improvements from current values.</u>

Error on $\mathcal{S}$ at Super KEKB



$\sin 2\phi_1$ error

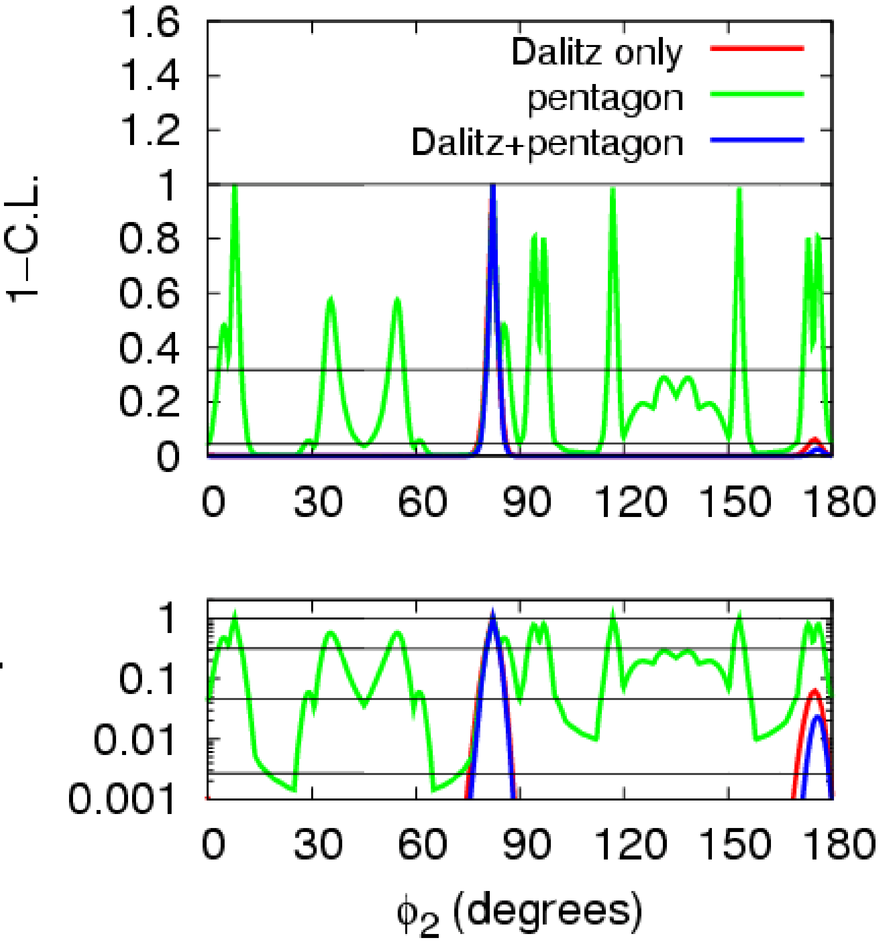
0.016@5ab^{-1}

0.012@50ab^{-1}

limited by vertexing systematic error

Expectation with 50/ab data ($B \to \rho\pi$)

- Dalitz plot only
  - Removes the discrete ambiguities by 90% C.L. (Dependent on input.)
  - Error of ϕ_2: ~2°
- Dalitz + pentagon
  - Removes the discrete ambiguities by 95.5% C.L.
  - Error of ϕ_2: ~2°



c) ϕ_3

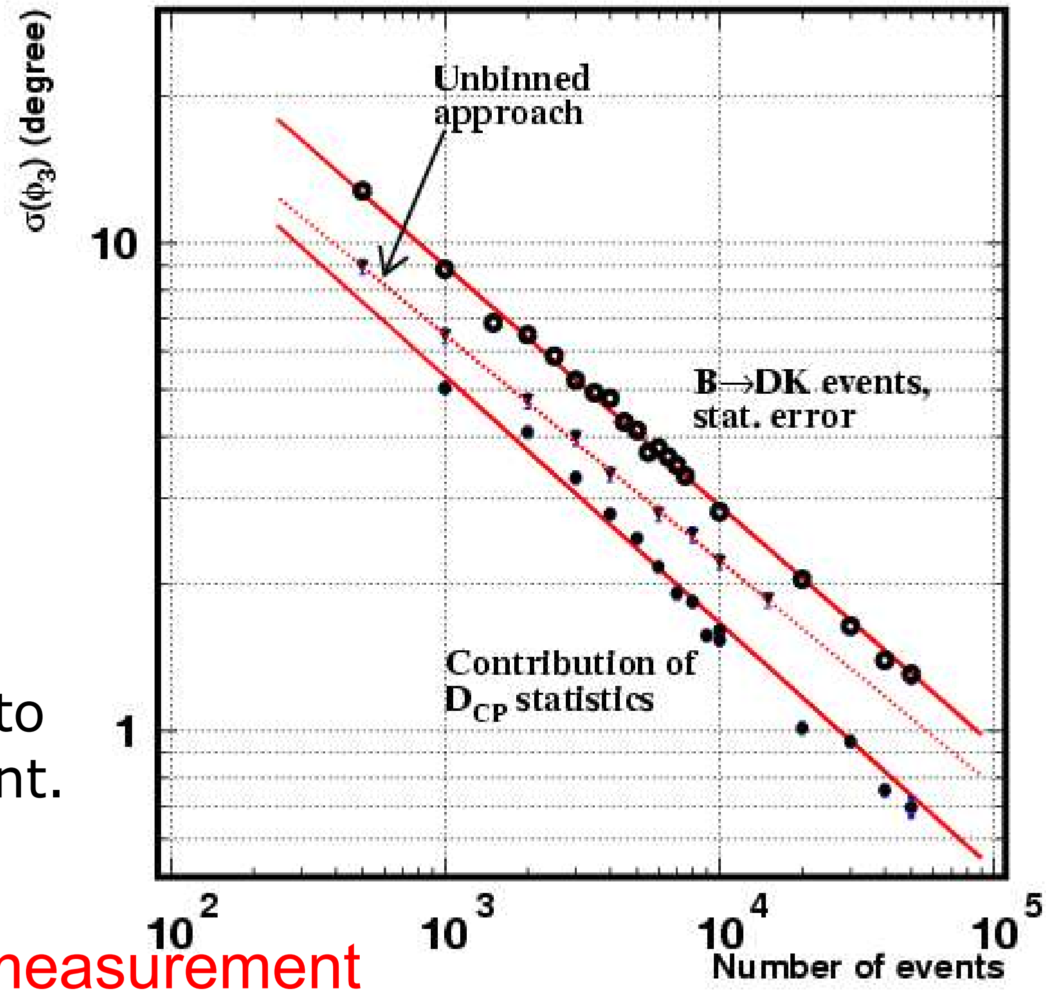
Model-independent Approach

A.Giri, Yu. Grossman, A. Soffer, J. Zupan, PRD 68, 054018 (2003)

50 ab^{-1} at SuperB factory should be enough for model-independent γ/ϕ_3 Measurement with accuracy below 2°

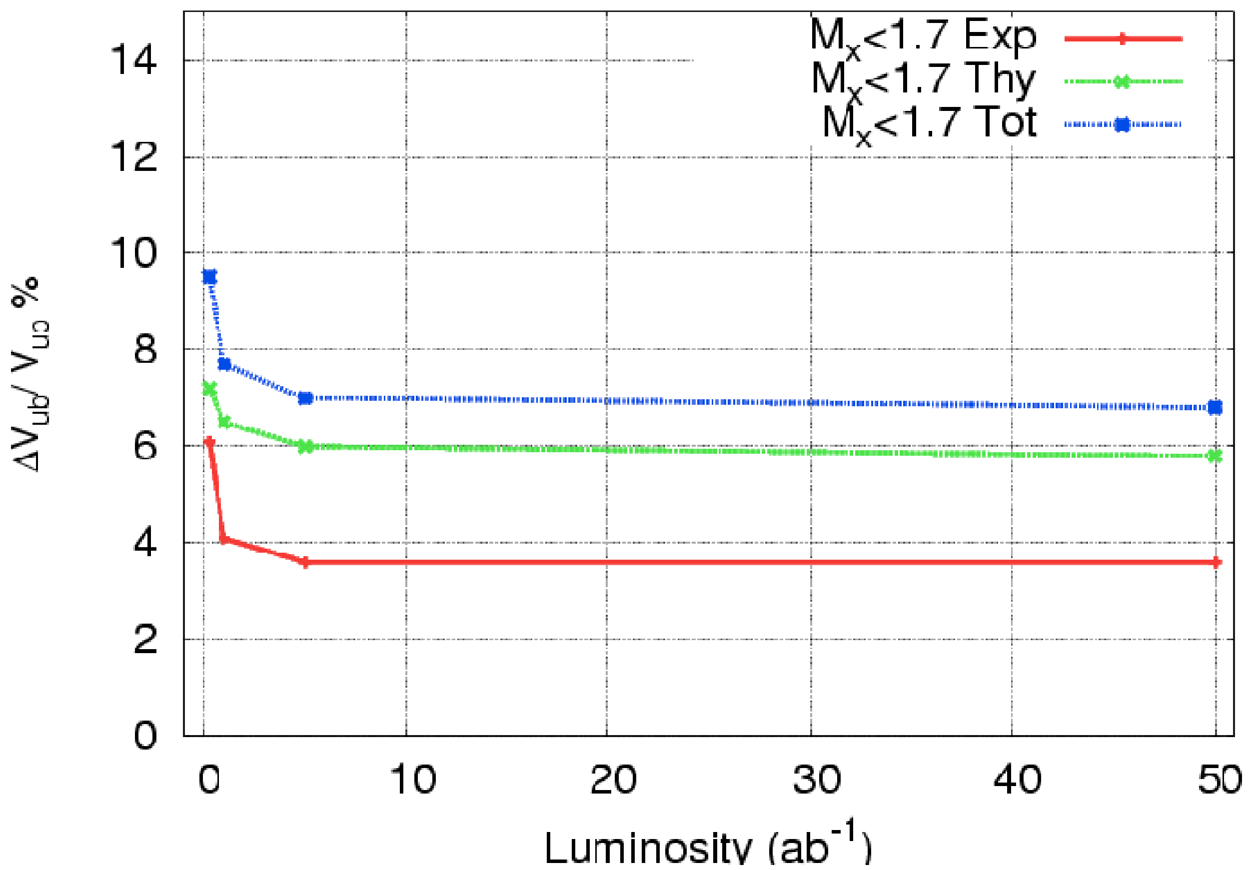
~10 fb^{-1} at $\psi(3770)$ needed to accompany this measurement.

A.Bondar, A.Poluektov hep-ph/0510246



Systematic error in $\psi(3770)$ measurement may limit the accuracy(CLEO-c) + r_B is set high(0.2). → ~3°

M_x Analysis : Total Error projections



Constraints at Super-B

- Br($B \to \tau\nu$) measurement :

  Further accumulation of luminosity helps to reduce both statistical and systematic errors

  - Some of the major systematic errors come from limited statistics of the control sample

  $$Br \propto |V_{ub}|^2 f_B^2$$

- $|V_{ub}|$ measurement:

  < 5% in future is an realistic goal

- f_B from theory

  ~10% now → 5% (?)

Assumption in the following plots ⇨

Lum.	$\Delta B(B \to \tau\nu)_{exp}$	$\Delta\lvert V_{ub}\rvert$
414 fb^{-1}	36%	7.5%
5 ab^{-1}	10%	5.8%
50 ab^{-1}	3%	4.4%

SuperKEKB measurements

	Center	σ(Belle)	σ(5/ab)	σ(50/ab)
V_{ub}	4.09×10^{-3}	6.1%	3.6%	3.6%
Δm_d	0.507	0.8% (sys.limit)	0.8%	0.8%
$\sin 2\phi_1$	0.642	5.5%	2.5%	1.9%
ϕ_2 (deg.)	93.0	11.8%[=11°]	6.5%[=6°]	2.1% [=2°]
ϕ_3 (deg.)	53.0	28.3%[=15°]	11.3%[=7°]	5.7% [=3°]
$B(B\to\tau\nu)$	1.79×10^{-4}	36%	10%	3%
$\frac{B(B\to\rho/\omega\gamma)^*}{B(B\to K^*\gamma)}$	0.032	26%	9%	5%

* Theoretically still controversial: Correlation btw ΔR and V_{td}/V_{ts}, Isospin ave. with ω...
(refer to the talk given by P.Ball in WG3); Future errors are bold guestimations...

Center values : current Belle's measurements

$\rightarrow$What will we see if they are unchanged with 50/ab?

LHC(b) measurements

	Center	σ(current)	σ(5/ab)	σ(50/ab)
Δm_s	17.77	0.7%	0.06% *	

*hep-ph/0003238

Kaon measurements

	Center	σ(current)	σ(5/ab)	σ(50/ab)
ε_K	0.002221		3.6%	

Other measurements

	Center	σ(current)	σ(5/ab)	σ(50/ab)
$\lvert V_{ud}\rvert$	0.97377		0.02%	
$\lvert V_{us}\rvert$	0.2257		0.9%	
$\lvert V_{cb}\rvert$	0.417		0.16%	
m_c	1.24		8.2%	
m_t	162.3		1.4%	

UTfit Estimated EXP errors 2015

Values to appear on CDR

	Central Value	Current error	Error in 2015
$\sin 2\beta$	0.680	0.026 (4%)	0.005 (0.7%)
α	105°	7° (7%)	1° (1%)
γ	54°	20° (37%)	1° (2%)
λ	0.2258	0.0014 (0.6%)	0.0008 (0.4%)
$\|V_{cb}\|$ (10^{-3})	41.7	2.2 (5%)	0.2 (0.5%)
$\|V_{ub}\|$ (10^{-4})	36.4	2.0 (5%)	0.7 (2%)
Δm_d (ps^{-1})	0.507	0.005 (1%)	0.002 (0.4%)
Δm_s (ps^{-1})	18.06	0.12 (0.7%)	0.05 (0.2%)
m_t (GeV)	163.8	3.2 (2%)	1.5 (1%)
BR($B \to \tau\nu$) (10^{-4})	0.83	0.48 (64%)	0.03 (4%)
ε_K	2.280	0.013 (0.6%)	0.013 (0.6%)
ASL(Bd) [10^{-3}]	- 0.7	5	0.1

Can we be smart like this?

Theoretical parameters

V_{ub}

	σ(Belle)	σ(5/ab)	σ(50/ab)
V_{ub} th.	7.2%	6.0%	5.8%

Δm_d, Δm_s, $Br(B\to\tau\nu)$

f_{Bs}	0.2365 ± 0.0315 ± 0.001
Bs	1.37 ± 0.14
f_{Bd}/f_{Bd}	1.24 ± 0.04 ± 0.06
Bs/Bd	1.0 ± 0.02
η_B	0.551±0±0.007

ε_K

B_K	0.79 ± 0.04 ± 0.09
$\alpha_S(m_Z)$	0.1176 ± 0 ± 0.002
η_{ct}	0.47 ± 0 ± 0.04
η_{tt}	0.5765 ± 0 ± 0.0065

$Br(B\to\rho(\omega)\gamma)/Br(B\to K^*\gamma)$

ς	0.85 ± 0.10
ΔR	0.1 ± 0.1

Too Conservative??

Estimated TH errors 2015

S. Sharpe, U.S. Lattice QCD executive committee
V. Lubicz, talk given at the IV SuperB workshop

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year	1-10 PFlop Year
$f_+^{K\pi}(0)$	0.9% (22% on $1-f_+$)	0.7% (17% on $1-f_+$)	0.4% (10% on $1-f_+$)	< 0.1% (2.4% on $1-f_+$)
$\hat{B}_K$	11%	5%	3%	1%
f_B	14%	3.5 - 4.5%	2.5 - 4.0%	1 – 1.5%
$f_{Bs}B_{Bs}^{1/2}$	13%	4 - 5%	3 - 4%	1 – 1.5%
ξ	5% (26% on ξ-1)	3% (18% on ξ-1)	1.5 - 2 % (9-12% on ξ-1)	0.5 – 0.8 % (3-4% on ξ-1)
$\mathcal{F}_{B\to D/D^*l\nu}$	4% (40% on $1-\mathcal{F}$)	2% (21% on $1-\mathcal{F}$)	1.2% (13% on $1-\mathcal{F}$)	0.5% (5% on $1-\mathcal{F}$)
$f_+^{B\pi}$,...	11%	5.5 - 6.5%	4 - 5%	2 – 3%
$T_1^{B\to K^*/\rho}$	13%	----	----	3 – 4%

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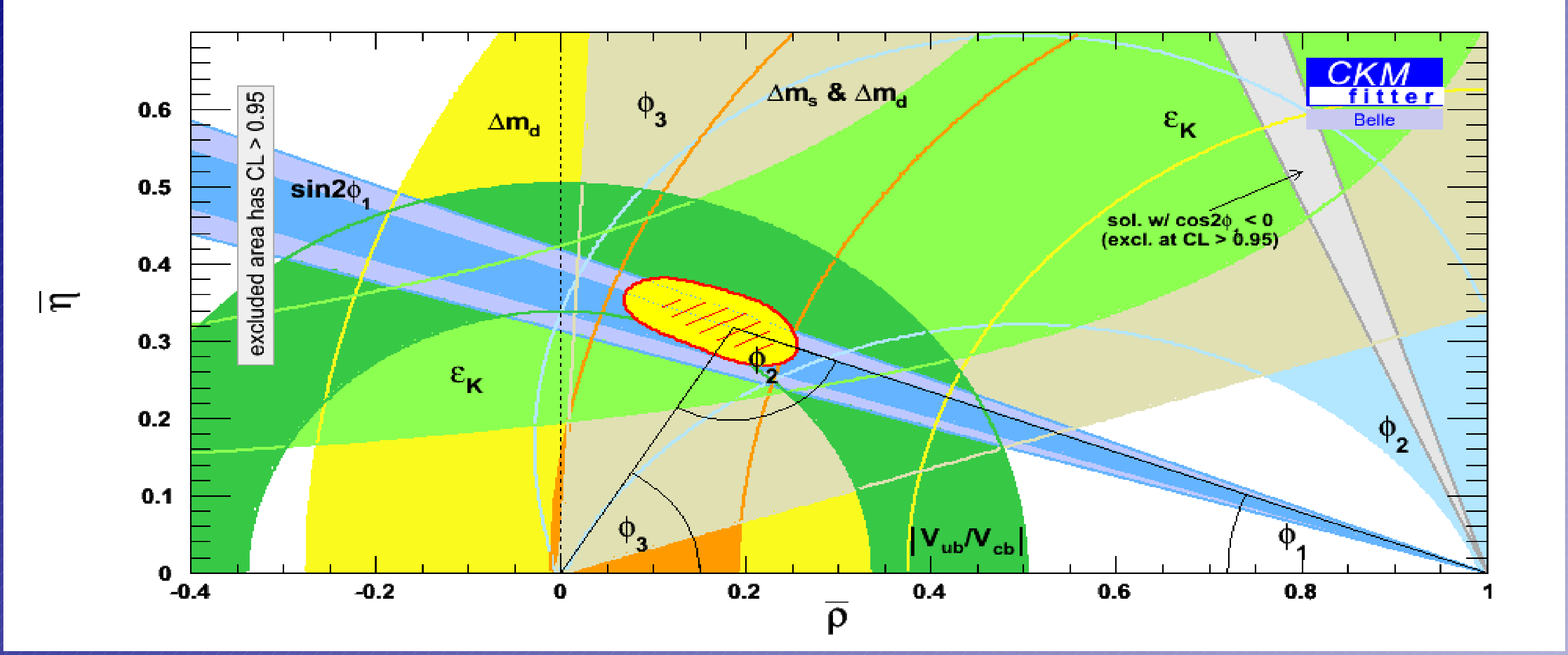
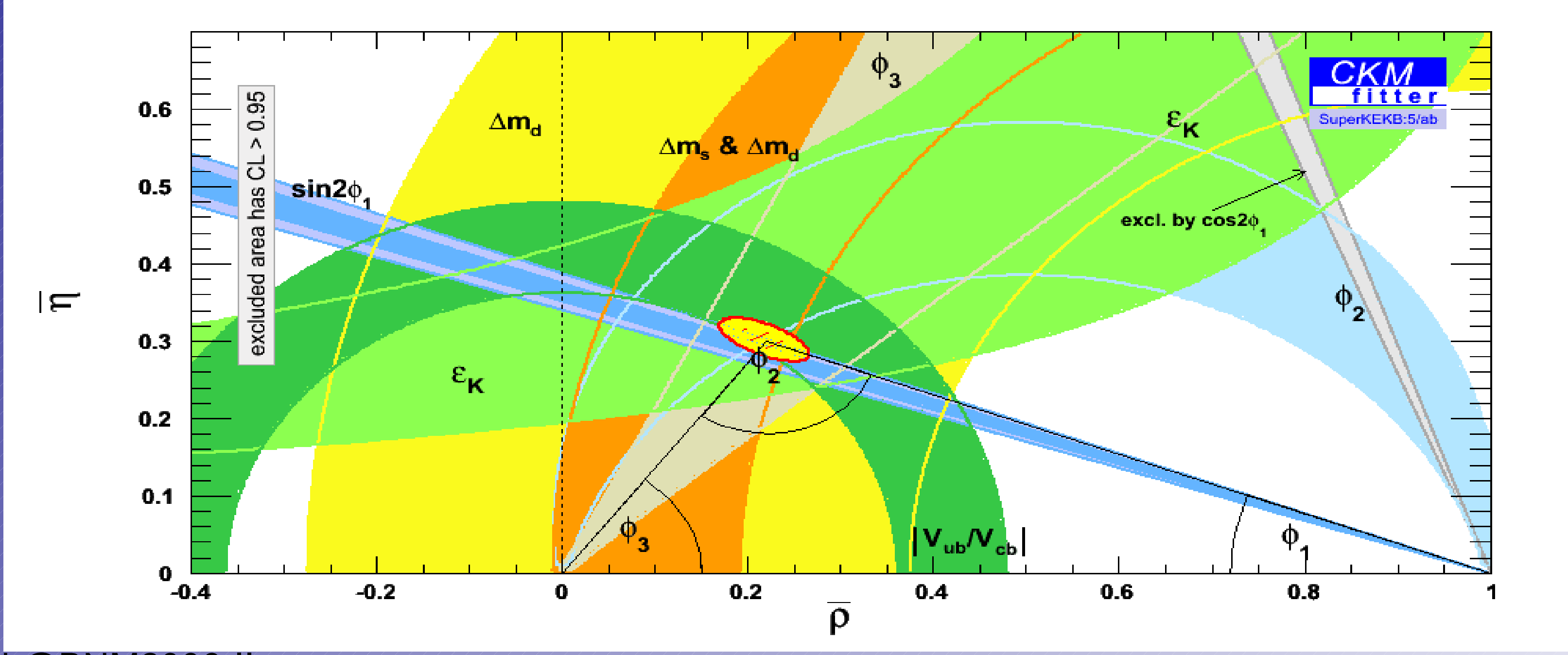
Can theorists be smart like this?

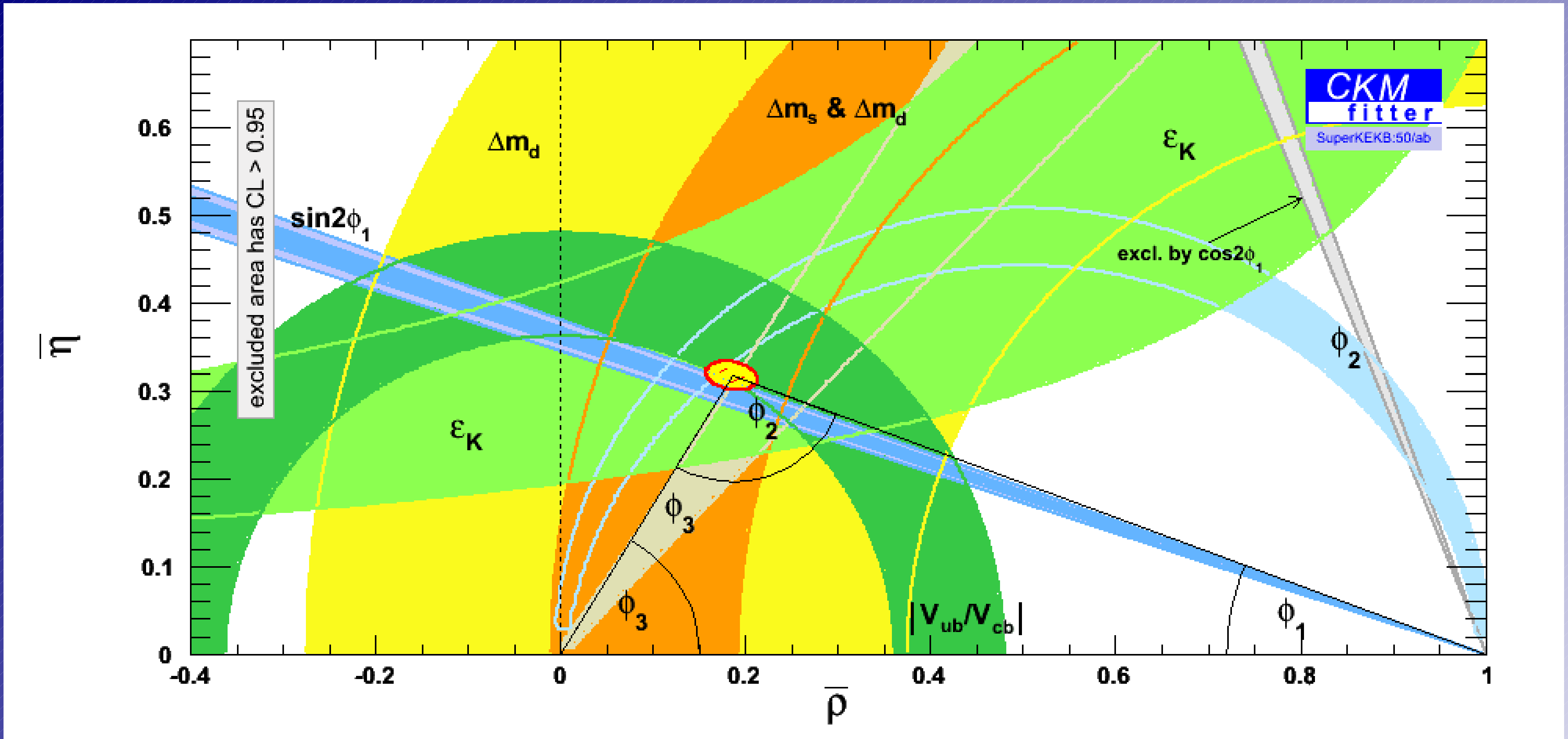
3. Standard model fit



Belle (~0.5/ab)

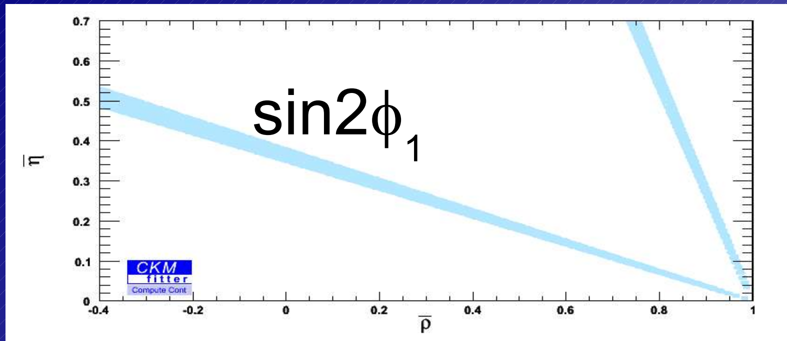


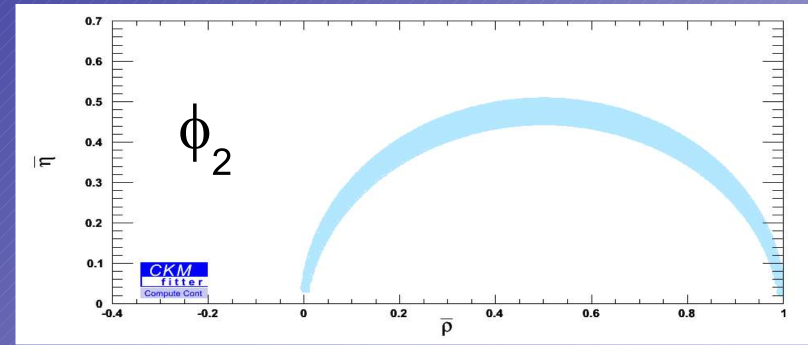
SuperKEKB (5/ab)

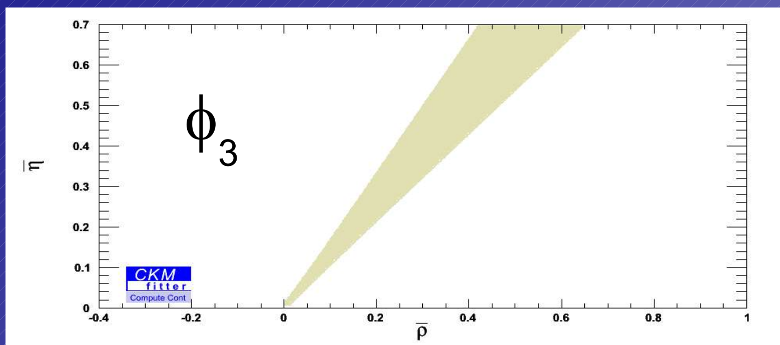


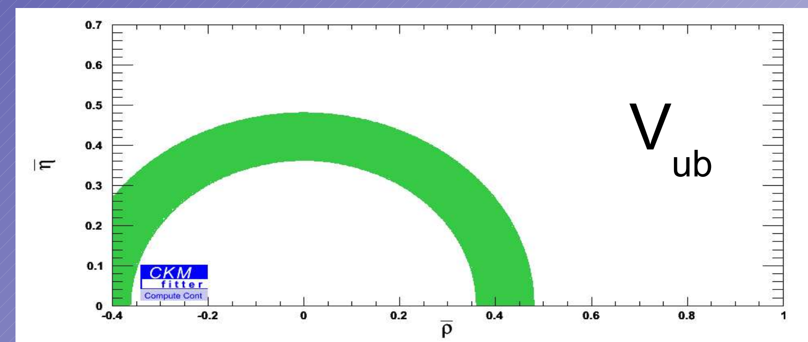
SuperKEKB (50/ab)

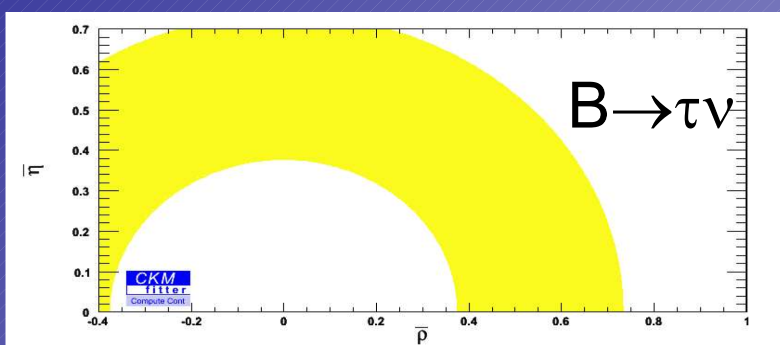
	$\sigma(\bar{\rho})$	$\sigma(\bar{\eta})$
Belle	20.0%	15.7%
5/ab	8.7%	3.6%
50/ab	5.6%	2.1%

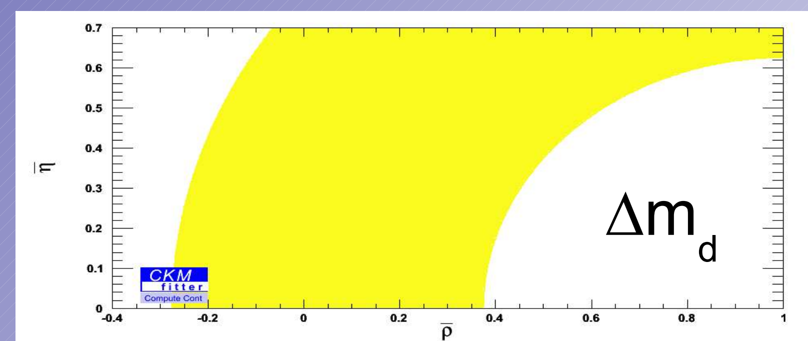


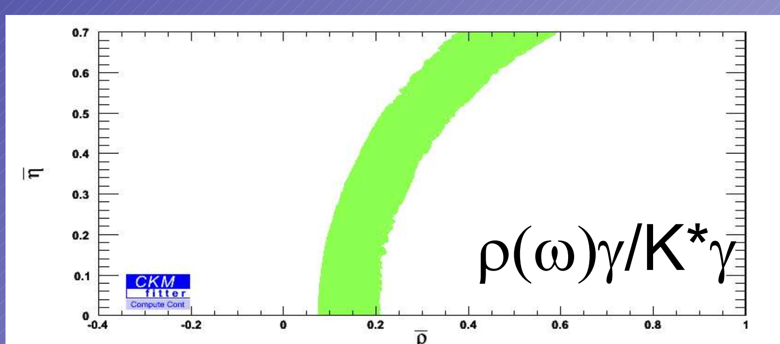






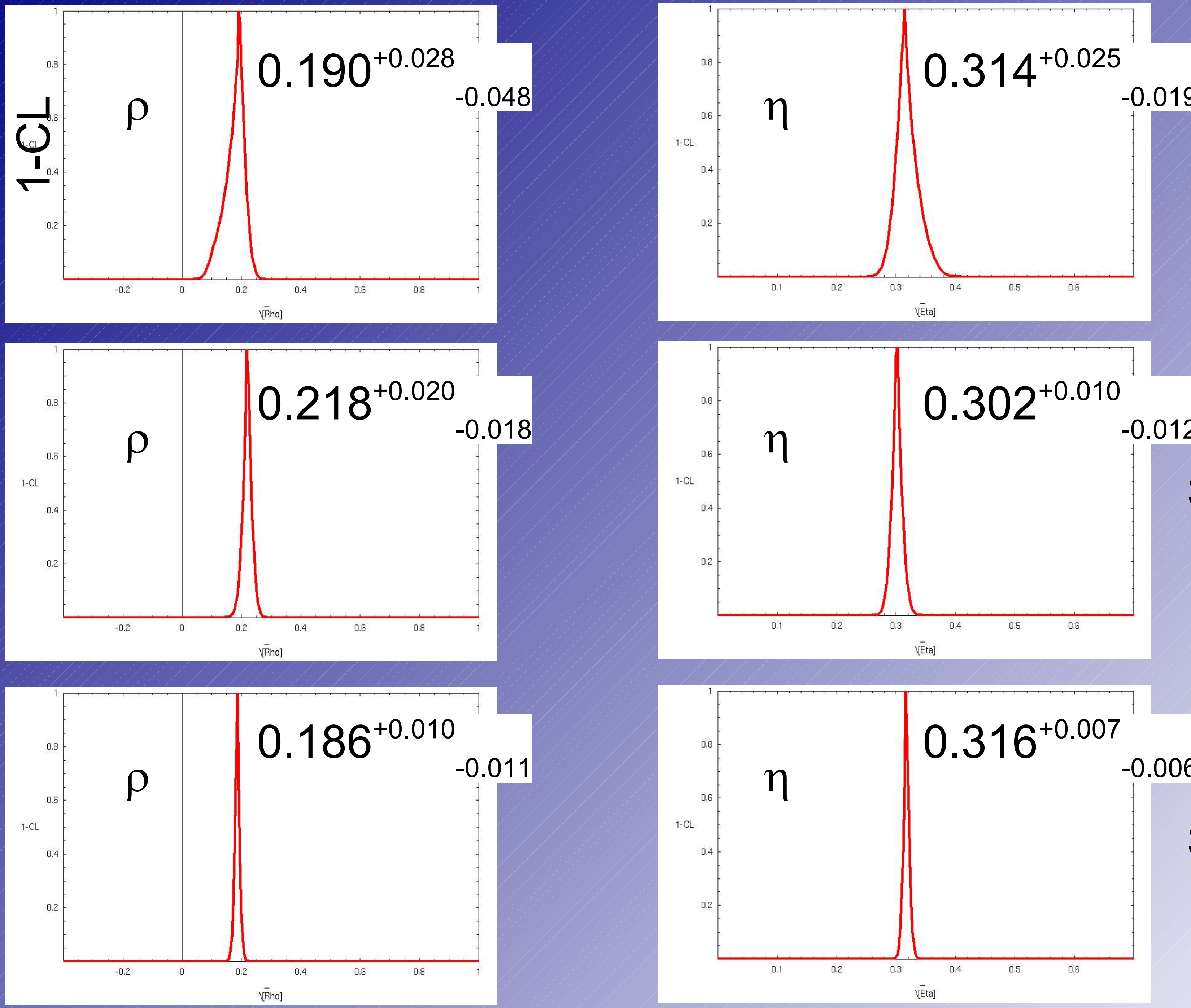






$\bar\rho-\bar\eta$ constraint by each of SuperKEKB measurement with 50/ab.

1-D constraints in ρ–η (SM fit)



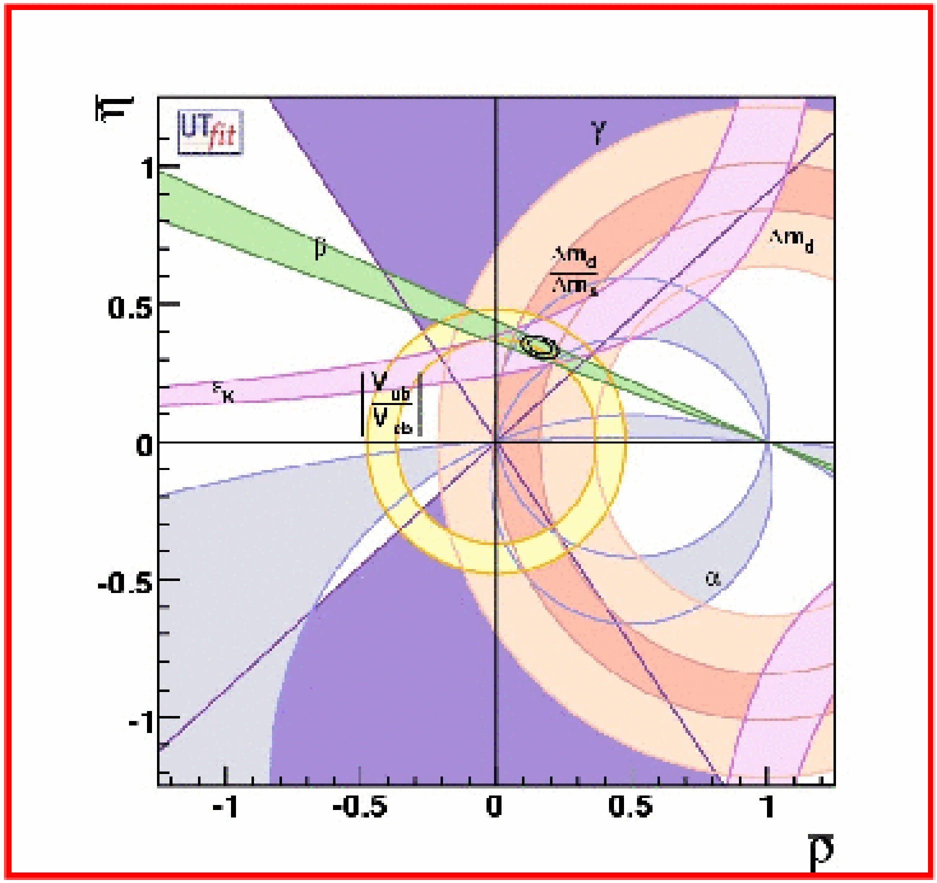
Belle (~0.5/ab)

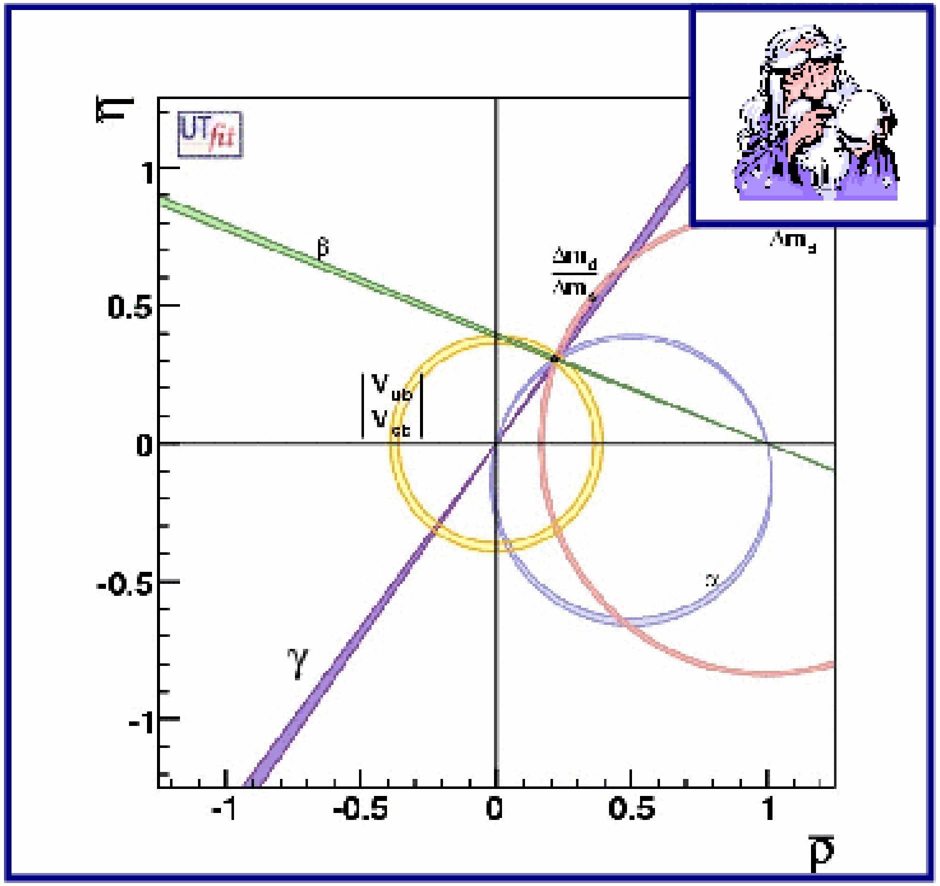
SuperKEKB (5/ab)

SuperKEKB (50/ab)

M.Pierini@CKM2006

UTfit in the SM: 2006 vs.2015





$\bar{\rho} = 0.163 \pm 0.028$
$\bar{\eta} = 0.344 \pm 0.016$

$\bar{\rho} = 0.2226 \pm 0.0028$ 1.3%
$\bar{\eta} = 0.3052 \pm 0.0024$ 0.8%

only with 30/fb!

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.... I would say "Italiens are optimistic about future"....

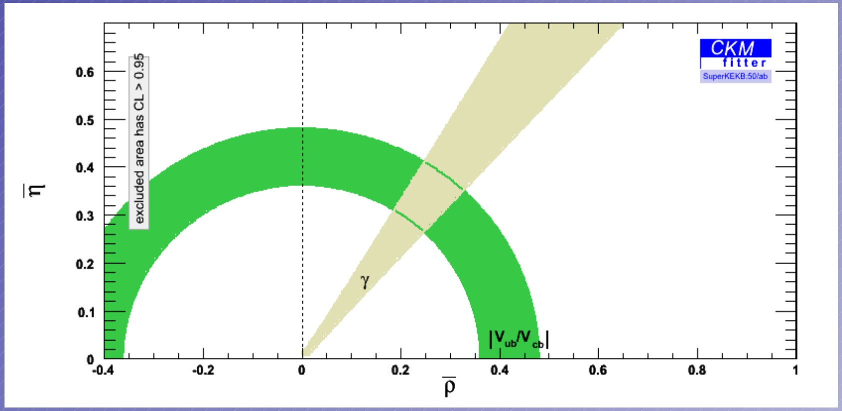
4. Fit with New Physics effect

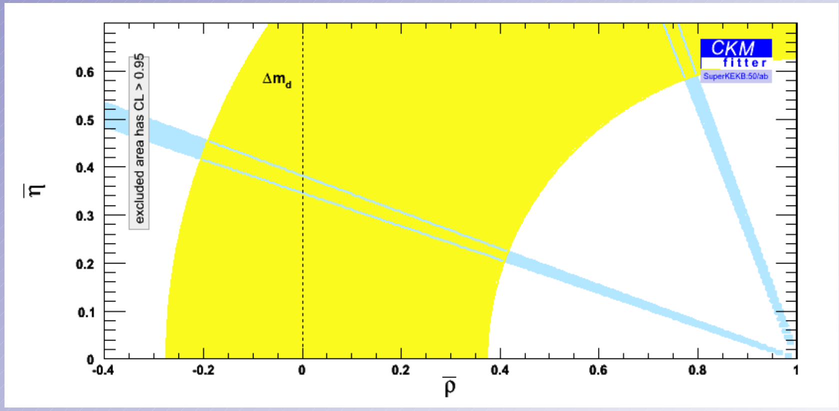
Model-independent study of New Physics(NP) can be done by comparing

- tree level measurements : $|V_{ub}|$ and ϕ_3, and
- measurements sensitive to NP :

mesasurements	*source of NP*
ε_K	$\Delta s=2$ box diagram
Δm_d, ϕ_1	B_d box diagram
Δm_s, ϕ_s	B_s box diagram
$B(K\to\pi\nu\nu)$	$\Delta s=1$ box diagram

SuperKEKB concentrate on this





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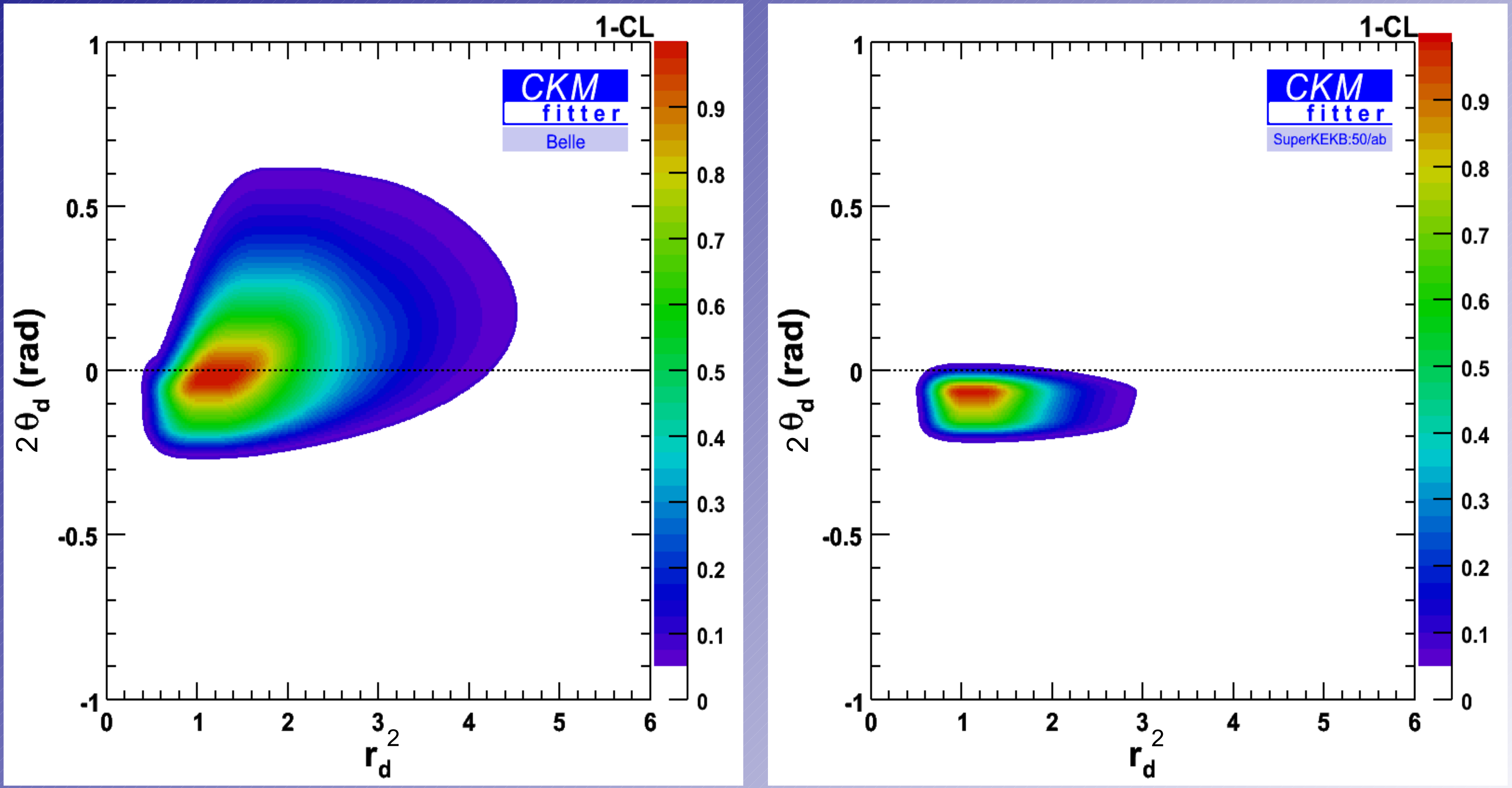
Model independent parameterization of NP effect:

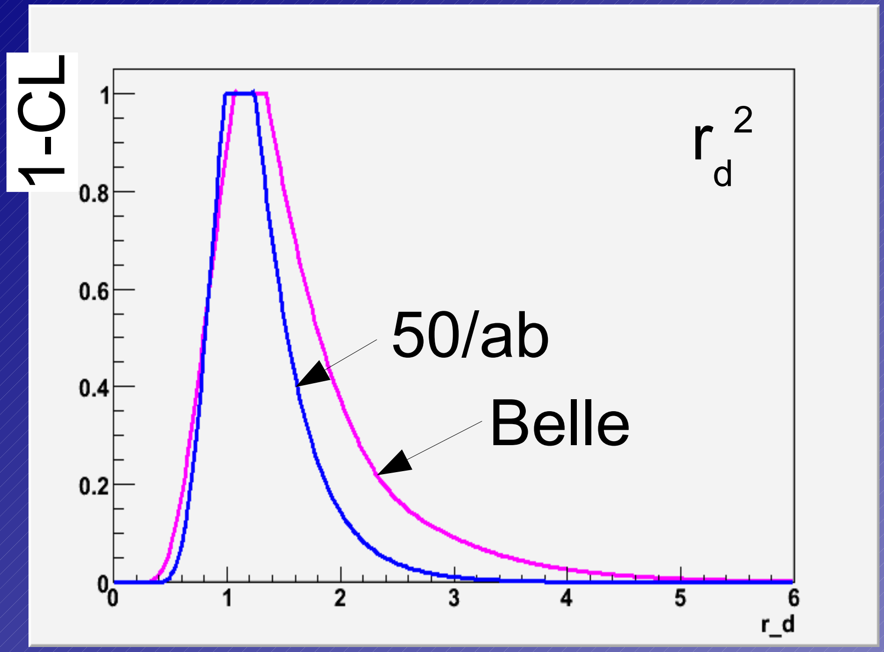
a) $M = r_d^{\,2} M_{SM} \exp(-i2\theta_d)$

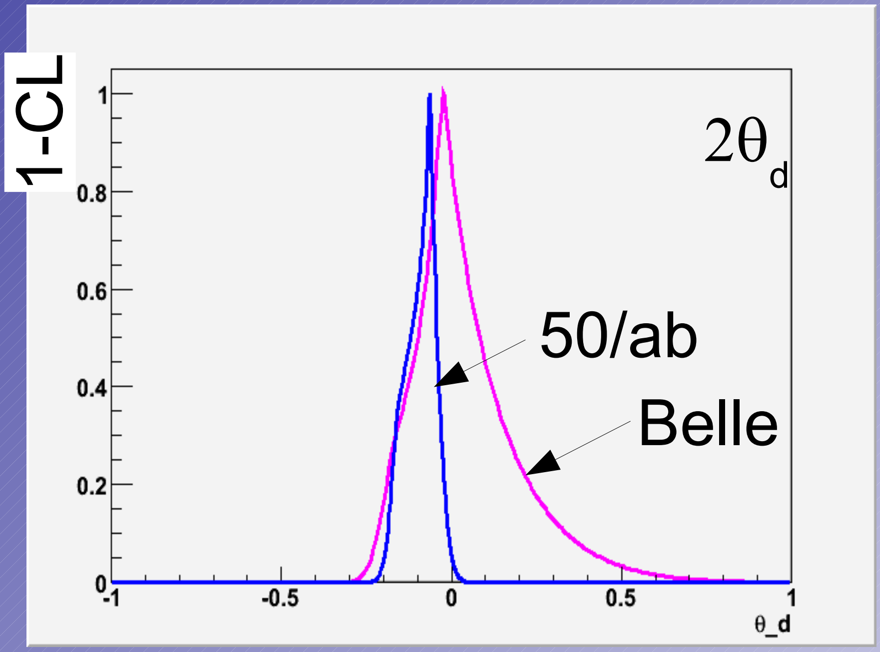
b) $M = M_{SM} + M_{new}$ → Goto et al, PRD53,6662

a) $M = r_d^{\,2} M_{SM} \exp(-i2\theta_d)$



Projections





$\sigma(r_d^2) = {}^{+0.90}_{-0.51}$: Belle

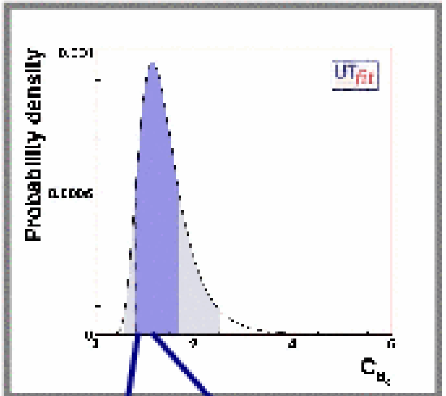
$\sigma(r_d^2) = {}^{+0.60}_{-0.37}$: 50/ab

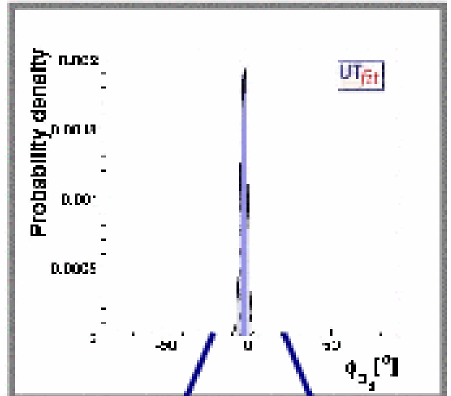
$\sigma(2\theta_d) = {}^{+0.18}_{-0.14}$ (rad) : Belle

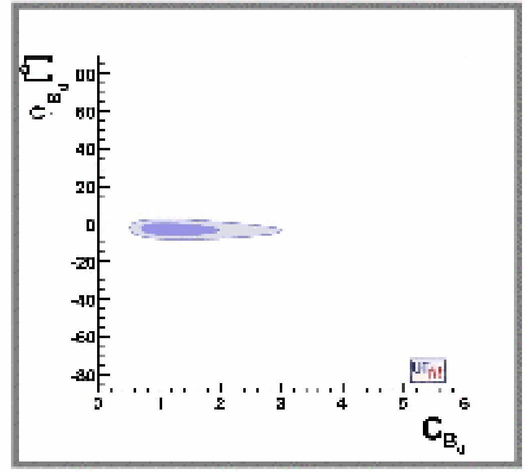
$\sigma(2\theta_d) = {}^{+0.03}_{-0.10}$ (rad) : 50/ab

* Sensitivity to r_d^2 is limited by the uncertainties in V_{ub}(theo), f_{Bd} and B_d.
  → Improvements in LQCD calculations are necessary.
* NP effect can be seen in $2\theta_d$ with 50/ab
  if current central values are unchanged!

New Physics in $\bar{B}_d - B_d$ mixing

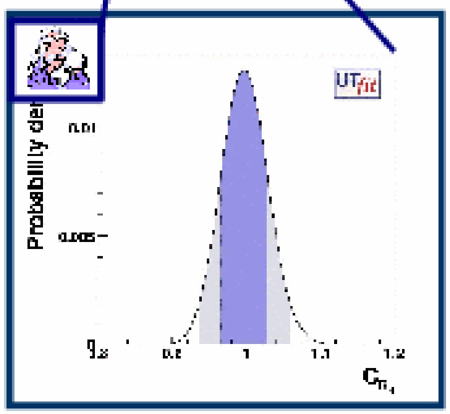


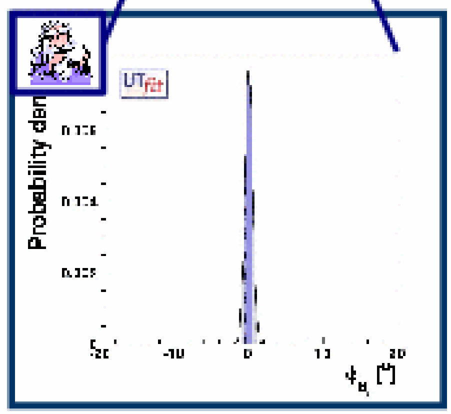


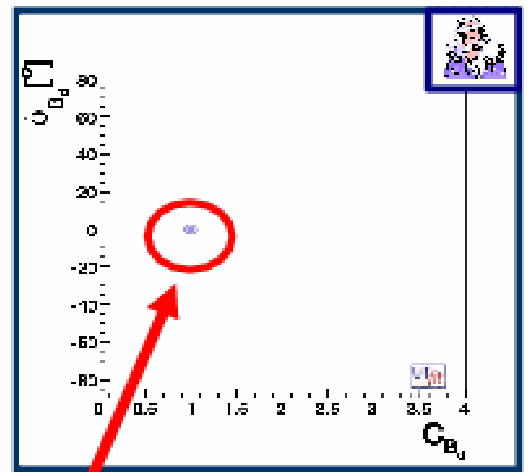


C_{Bd} = 1.24 ± 0.43

φ_{Bd} = (-3.0 ± 2.0)°







C_{Bd}=0.997±0.031

φ_{Bd}=(0.02±0.51)°

Precision test on flavor sector of NP models

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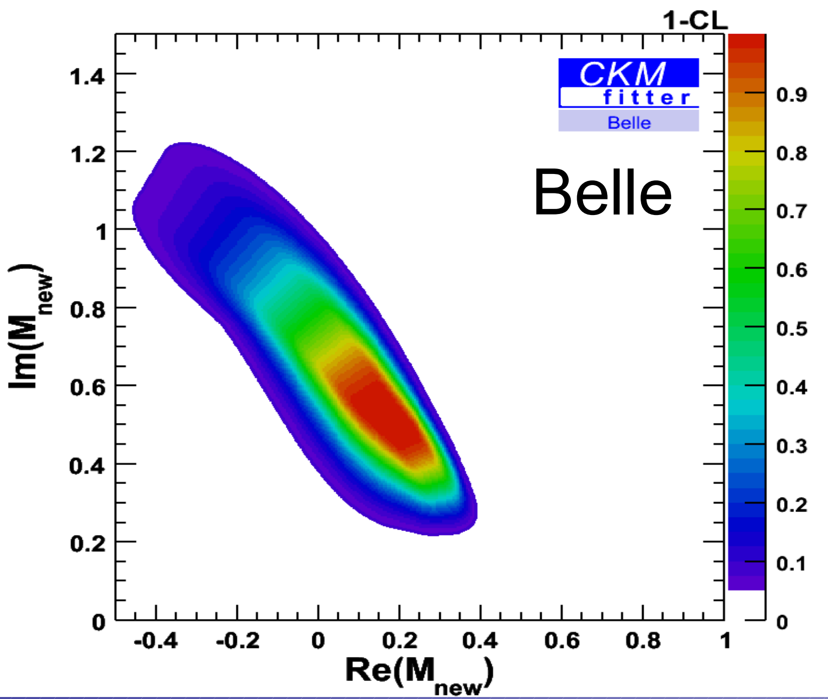
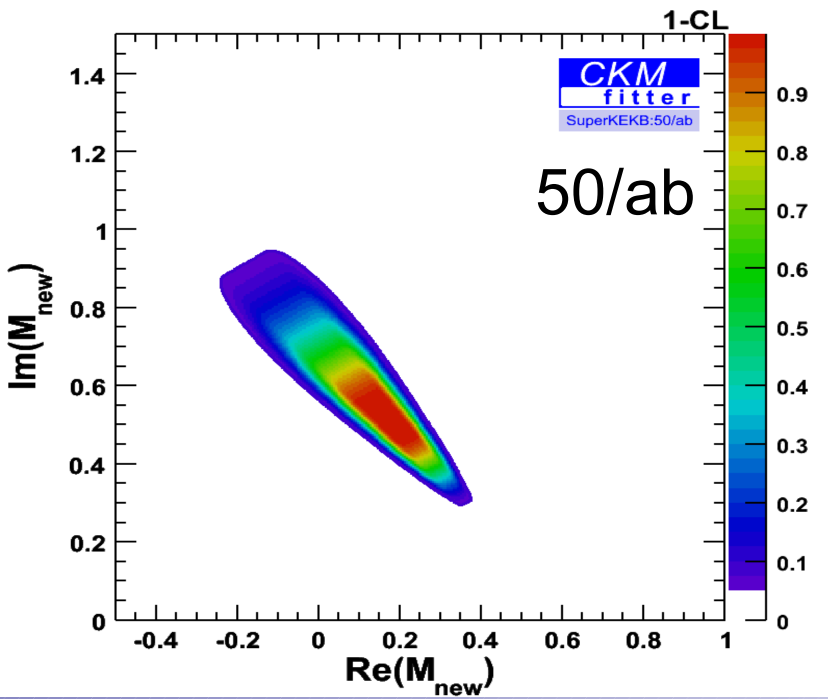
b) $M = M_{SM} + M_{new}$





$\sigma(\mathrm{Re}(M_{new})) = \pm 0.24$

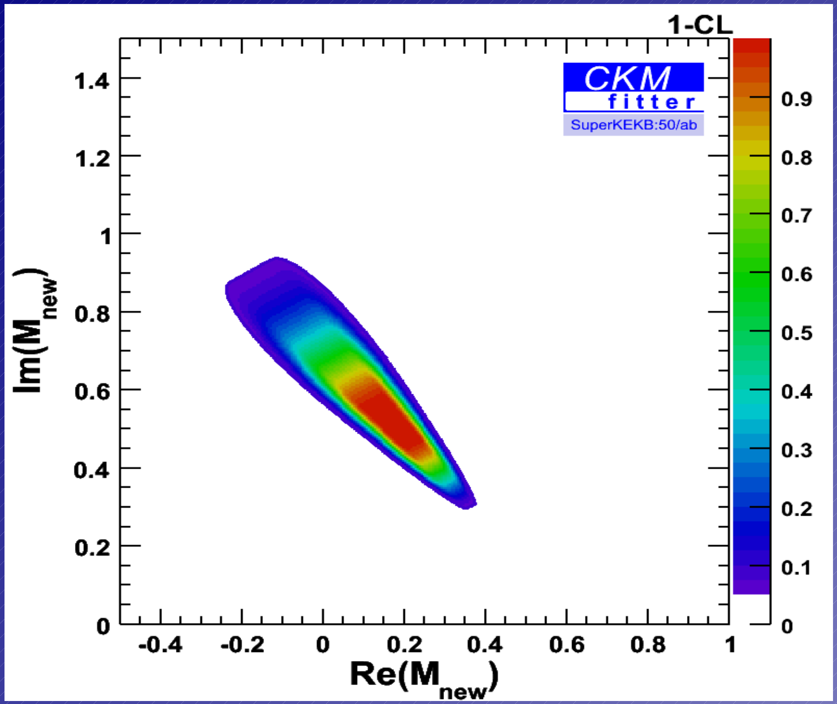
$\sigma(\mathrm{Im}(M_{new})) = \pm 0.44$

$\sigma(\mathrm{Re}(M_{new})) = \pm 0.16$

$\sigma(\mathrm{Im}(M_{new})) = \pm 0.16$

* Uncertainties in V_{ub}(theo), f_{Bd} and B_d contribute to both of real and imaginary parts of M_{new} .....

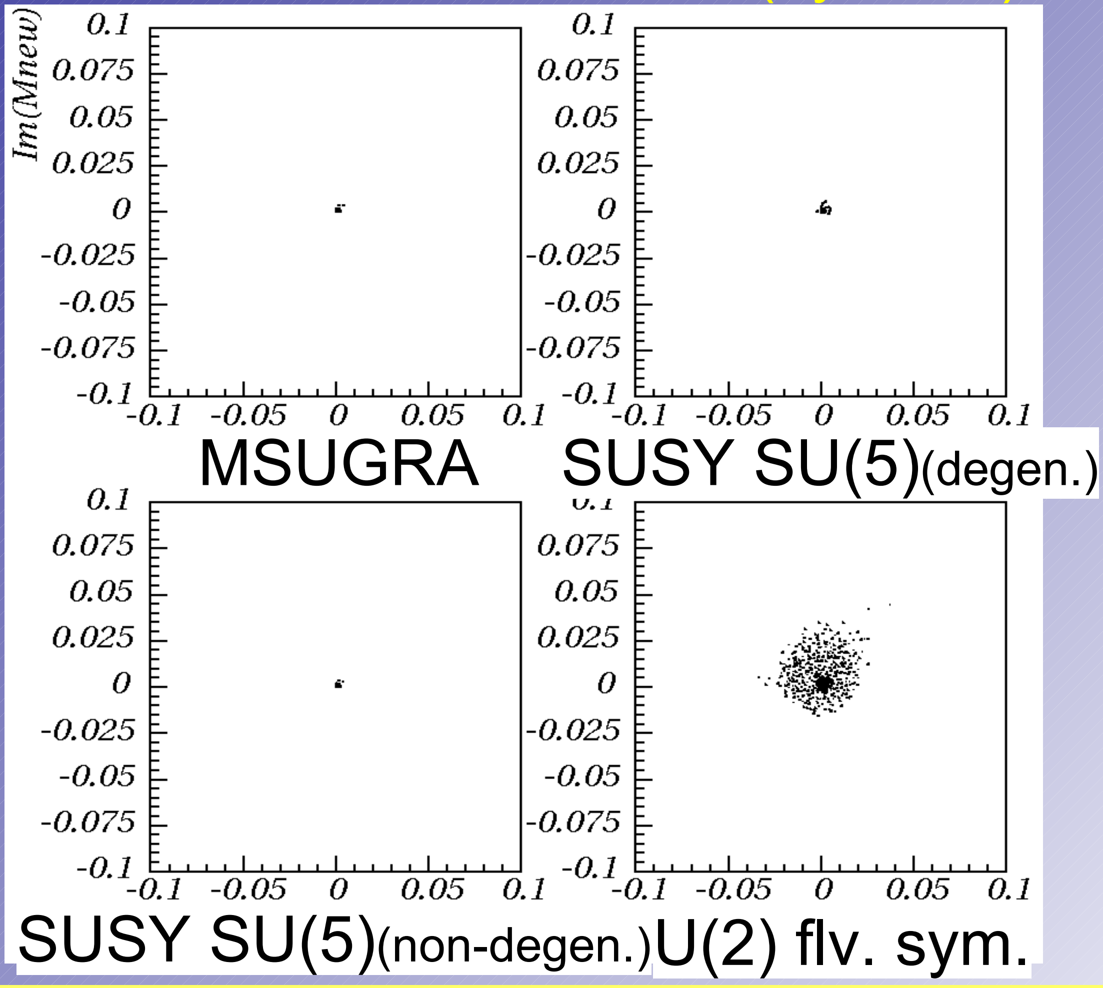
Identification of theoretical models



$\sigma(\mathrm{Re}(M_{new})) = \pm\, 0.16$

$\sigma(\mathrm{Im}(M_{new})) = \pm\, 0.16$

Model Predictions (by Goto)



- Models with a large FCNC are already excluded by various meas.
- Considered SUSY based models with soft breaking.

  FCNC effect is small. → very hard to identify
- U(2) flavor symmetry model might be able to be identified, but more resolution in NP parameters is necessary.....

5. Status of Wilson Coeff. fits

- Maybe better than $\bar{\rho}-\bar{\eta}$ fit for the NP search since dependence on LQCD uncertainties could be less.

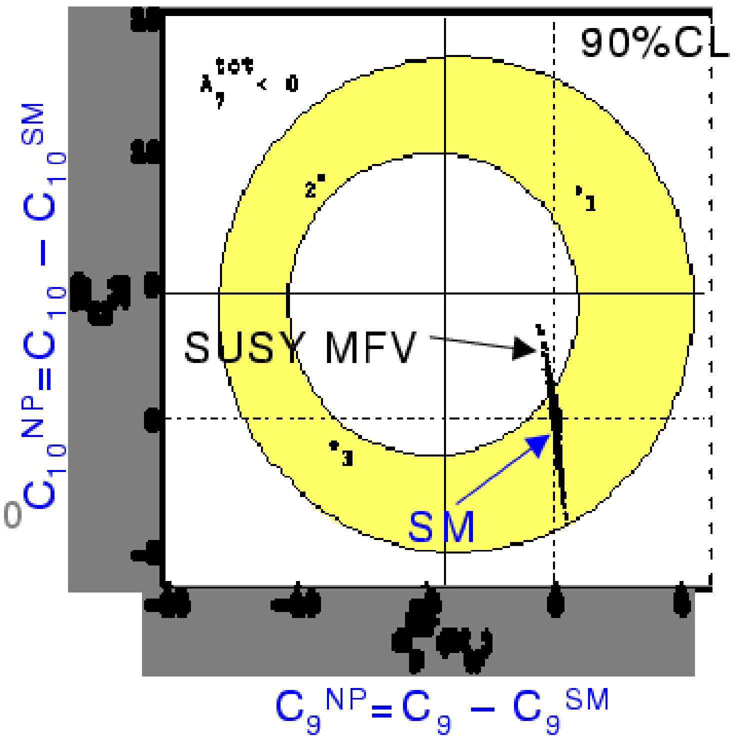
- I must confess there is no signifcant progress since last BNM.

- Coding in Mathematica version of CKMfitter has been started, however, I'm now considering how to implement Wilson coeff. based models in the CKMfitter in a consistent way.

- Once the general design of implementation of Wilson coeff. and interface to radiative models is fixed, the model implementations should be straight-forward.
    -> give me some more time......

Constraints on Wilson coefficients

- BR($b \rightarrow sll$)
  - sign of C_7
  - constraints on C_9-C_{10} (donut-shape)
- A_{FB} in $b \rightarrow sll$
  - can determine relative signs of C_7 / C_{10}, C_9 / C_{10}
- $b \rightarrow s\nu\nu$
  - C_{10} only contributes



In this talk, we cover

1) Semi-inclusive $B \rightarrow X_s l^+ l^-$
2) A_{FB} with exclusive $B \rightarrow K^* l^+ l^-$
3) Search for $B \rightarrow K^{(*)} \nu\bar{\nu}$

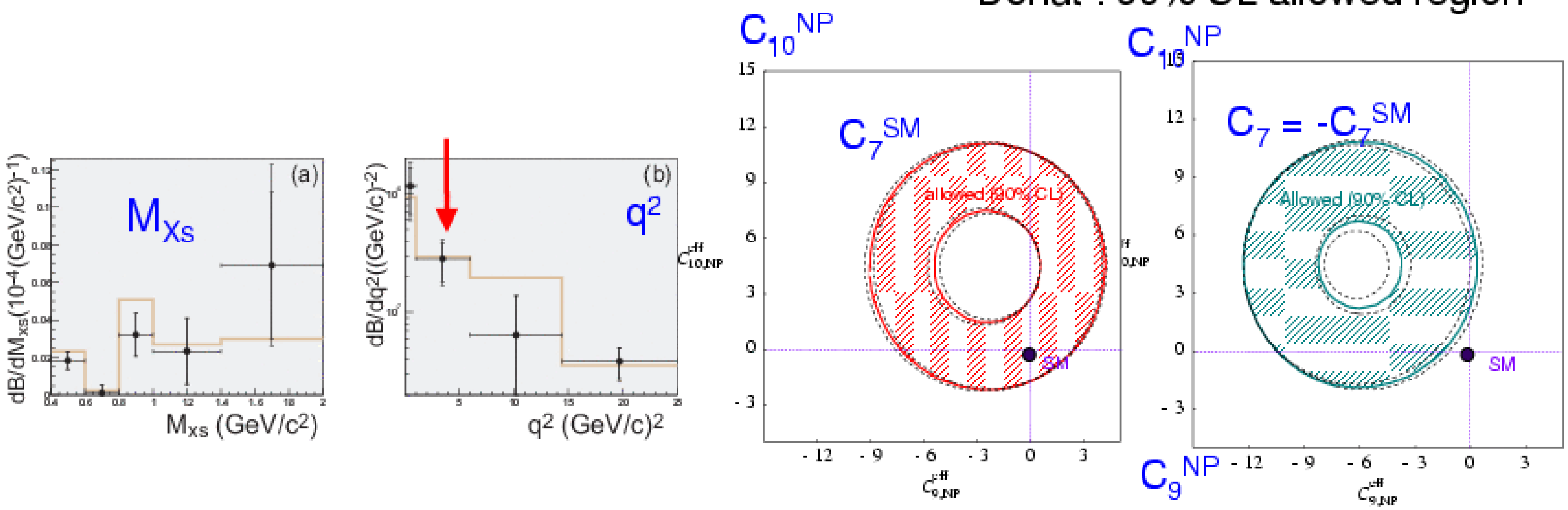
Constraints on C_i from $B(B \to X_s l^+ l^-)$

P.Gambino, U.Haisch and M.Misiak PRL 94 061803 (2005)

- Clean prediction for $B(B \to X_s ll)$ with $1<q^2<6GeV^2$ is available.
  - Combine Belle and Babar results
  - Sign of C_7 flipped case with SM C_9 and C_{10} value is unlikely.

BF	Belle	Babar	WA	SM	$C_7 = -C_7^{SM}$
$q^2>(2m_\mu)^2$	4.11 ± 1.1	5.6 ± 2.0	4.5 ± 1.0	4.4 ± 0.7	8.8 ± 0.7
$1<q^2<6GeV^2$	1.5 ± 0.6	1.8 ± 0.9	1.60 ± 0.5	1.57 ± 0.16	3.30 ± 0.25

Donut : 90% CL allowed region

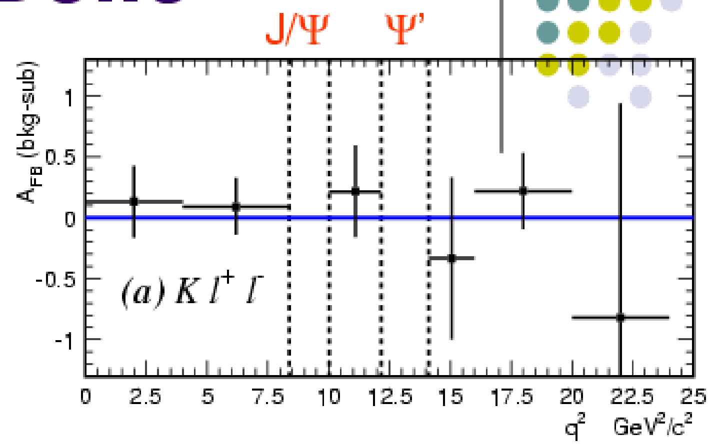


M.Iwasaki@CKM2006

A_{FB} in B→K*ll from Belle

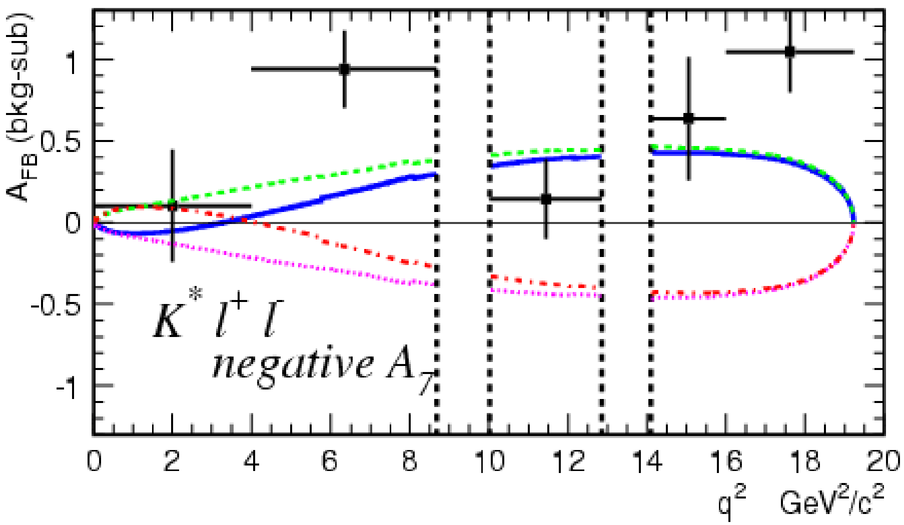
- Null test using K^+ll

$$A_{FB}^{\text{bkg-sub}}(B \to K^+\ell\ell) = 0.09 + 0.14(\text{stat.})$$



- Projection to A_{FB} for K*ll

$$A_{FB}^{\text{bkg-sub}}(B \to K^*\ell\ell) = 0.56 \pm 0.13(\text{stat.})$$



Best fit for negative A_7 (SM like)

$$A_9/A_7 = -15.3^{+3.4}_{-4.8} \pm 1.1,$$
$$A_{10}/A_7 = 10.3^{+5.2}_{-3.5} \pm 1.8,$$

SM $\quad A_9/A_7 = -12.3,\quad A_{10}/A_7 = 12.8.$

fit result
A_7A_{10} sign flipped (to SM)
Both A_7A_{10} and A_9A_{10} signs flipped
A_9A_{10} sign flipped

Sign of A_9A_{10} flipped case is excluded

5. Summary

* The constraints in $\bar{\rho}-\bar{\eta}$ plane with 50/ab data are estimated with very conservative assumptions to be

$$\sigma(\bar{\rho}) = 5.6\%$$
$$\sigma(\bar{\eta}) = 2.1\%$$

* The sensitivity to NP using model-independent fit is limited by the uncertainties in LQCD calculations.

* NPfit with MFV model?

* The Wilson coefficient fit is is now being developed in the framework of CKMfitter.

  -> Stay tuned....

Prospects of CKM (global) fit

* ~1% level constraint in $\bar{\rho}-\bar{\eta}$ is on the horizen at Super B, but measurements are already reaching at systematic limits.
  $\rightarrow$ Experimental/theoretical challenge

* For the model-independent NP search, LQCD calculations are current limiting factors (i.e. the size of NP effect $\rightarrow V_{ub}$, $\Delta m_{d/s}$).
  $\rightarrow$ How much can theorists improve them by 2015?

Can we be smarter as Italiens?

- Two versions of $\bar{\rho}-\bar{\eta}$ constraint plots should be prepared:
  a) Very optimistic one for "advertisement"
  b) Conservative one to urge us more improvements!