Implications of like-sign dimuon anomaly

Jure Zupan

based on work with Ligeti, Perez, Papucci (1006.0432)
and with Kagan, Perez, Volansky (0903.1794)

THE AIM

- like-sign dimuon asymmetry seen at DØ: 3.2σ away from SM DØ, 1005.2757
- show that it fits well with the $B_s \to J/\psi\phi$ mixing anomaly
- interpret in terms of minimally flavor violating NP

BEFORE WE BEGIN...

- let me remind you of two “flavor problems”

SM flavor puzzle(s)

- quark flavor sector well measured
  - 10 parameters, exhibit a hierarchy (λ=0.22)

$$\begin{array}{lll} y_t \sim 1 & y_c \sim \lambda^3 & y_u \sim \lambda^7 \\ y_b \sim \lambda^2 & y_s \sim \lambda^5 & y_d \sim \lambda^6 \\ V_{us} \sim \lambda & V_{cb} \sim \lambda^2 & V_{ub} \sim \lambda^3 \end{array} \quad + \text{O(1) phase}$$

  - lepton sector less well measured, different hierarchies
- SM flavor puzzle: why this structure?
- the answer may well not be related to TeV scale

NP flavor puzzle

- new physics expected at TeV
  - hierarchy problem
  - dark matter
- but generic flavor structure of TeV NP violates low energy flavor constraints $\Rightarrow$ $\boxed{\text{NP flavor problem}}$

THIS TALK

- will have nothing to say about SM flavor puzzle
- for NP flavor puzzle we will assume (at some point) a particular solution
  - Minimal Flavor Violation

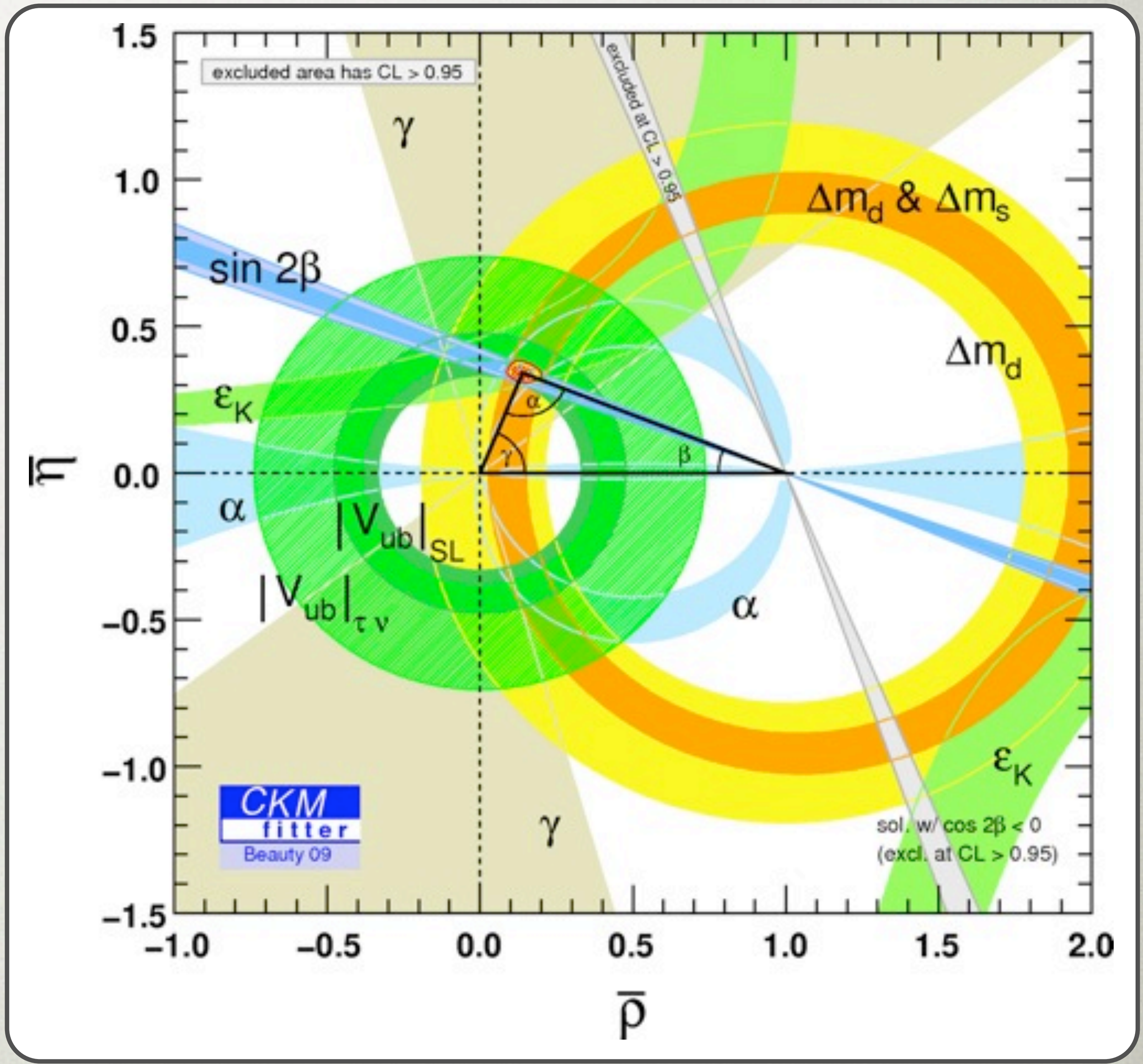
OUTLINE

- experimental situation
- model independent fit
- what it tells us about NP

EXPERIMENTAL SITUATION

PRESENT EXPERIMENTAL SITUATION

- SM CKM mechanism dominates
- global agreement between B and K systems
- but there are odd bits and pieces



TENSIONS

- determination of V_{ub} from $B \to \tau\nu$ does not agree with global fit
- there may be tension with ε_K (depends on lattice B_K)
- there is a 3.x sigma tension with SM in B_s mixing

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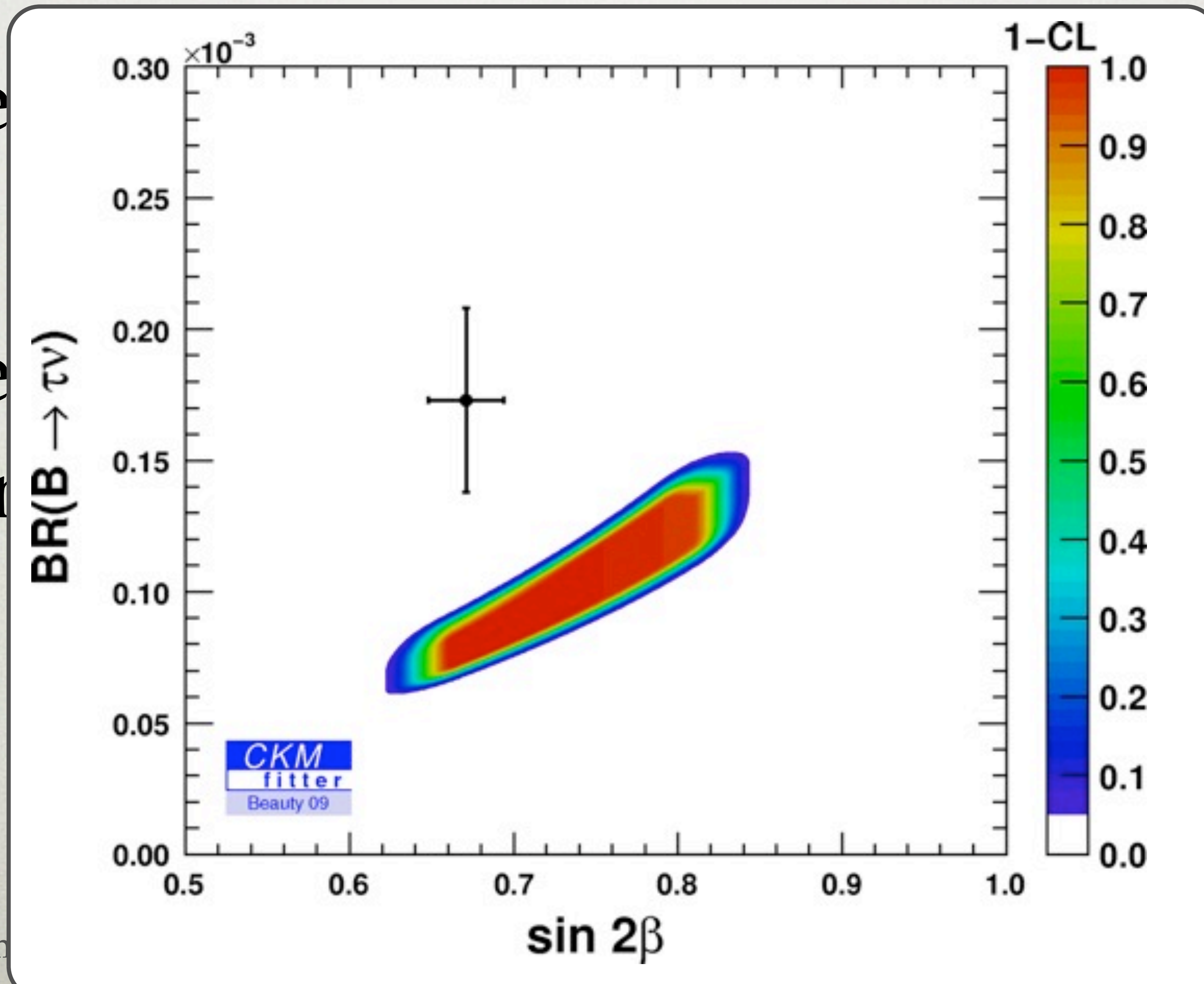

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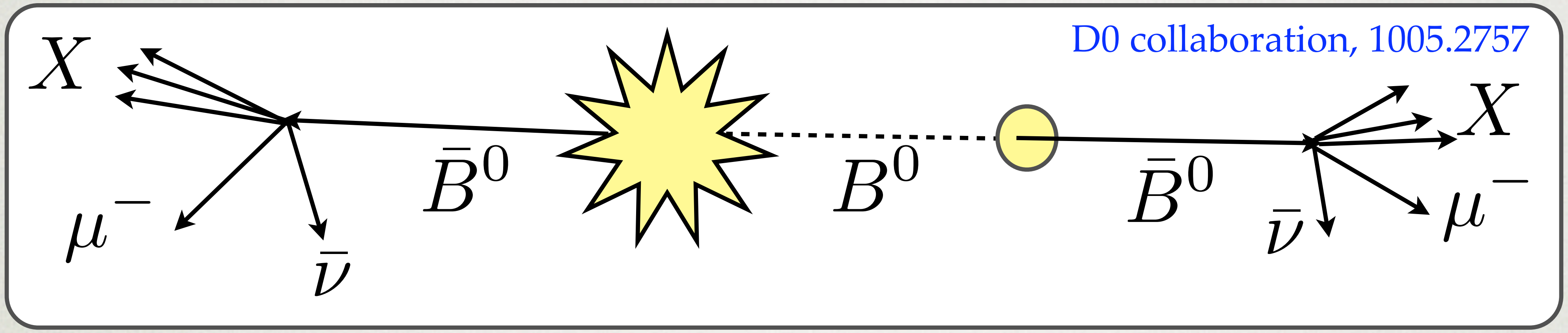
main topic of this talk

DIMUON ANOMALY



- DØ recently measured $A_{SL}{}^b$ to be 3.2σ away from SM

$$A_{SL} = \frac{N(\mu^+\mu^+X) - N(\mu^-\mu^-X)}{N(\mu^+\mu^+X) + N(\mu^-\mu^-X)}$$

$$a^b_{SL} = -(9.57 \pm 2.51 \pm 1.46) \times 10^{-3} \qquad \left(a^b_{SL}\right)^{\rm SM} = (-2.3^{+0.5}_{-0.6}) \times 10^{-4}$$

- note: exp. not known that it comes from B
- decay $\bar{B}^0 \to \mu^-\bar{\nu}X$ tags the flavor of B

COMPARISON

- at Tevatron both B_d and B_s produced

$$\boxed{a_{SL}^b = (0.506 \pm 0.043)\, a_{SL}^d + (0.494 \pm 0.043)\, a_{SL}^s}$$

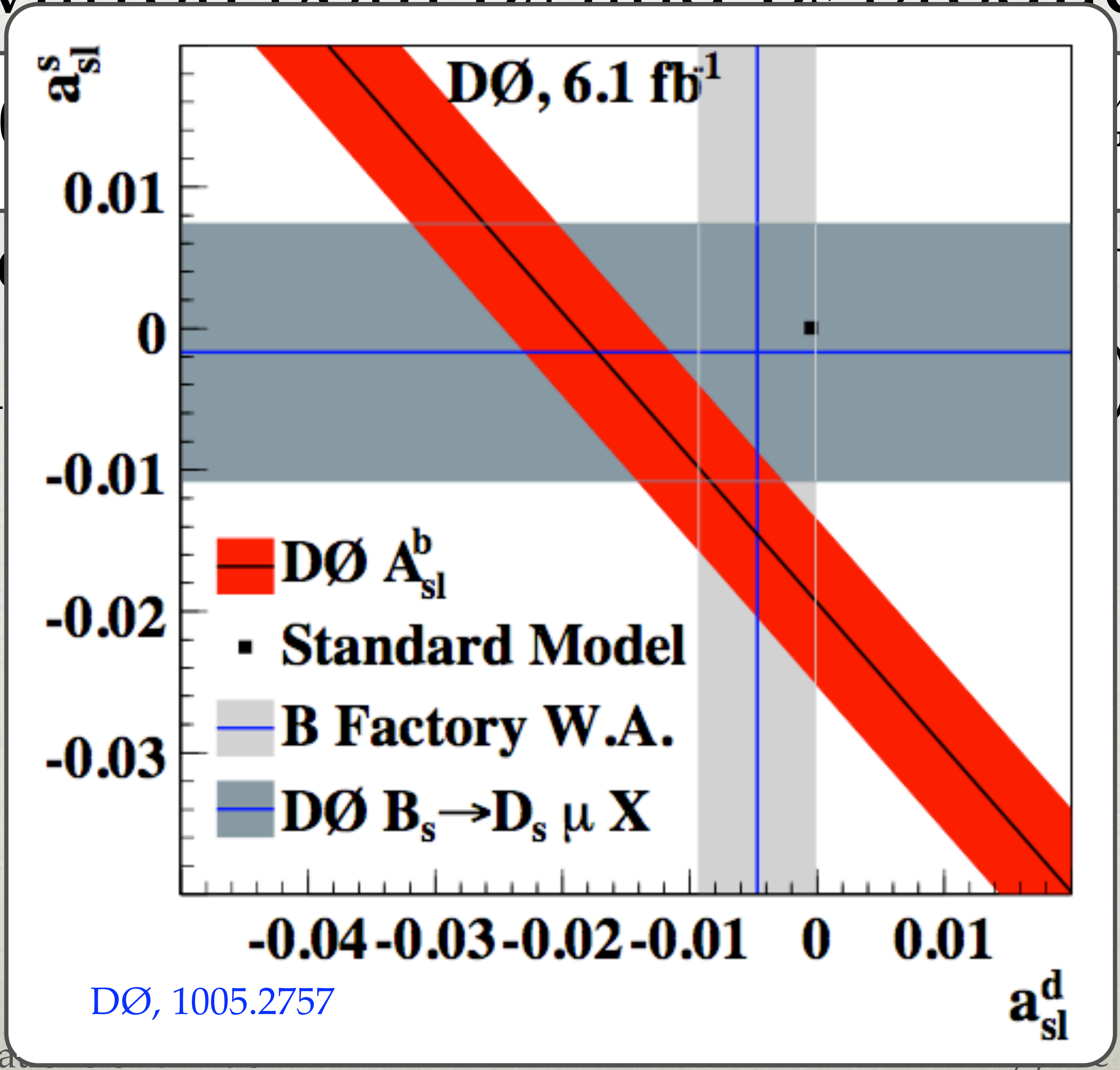
- the new measurement consistent with previous ones (but smaller errors)

COMPARISON

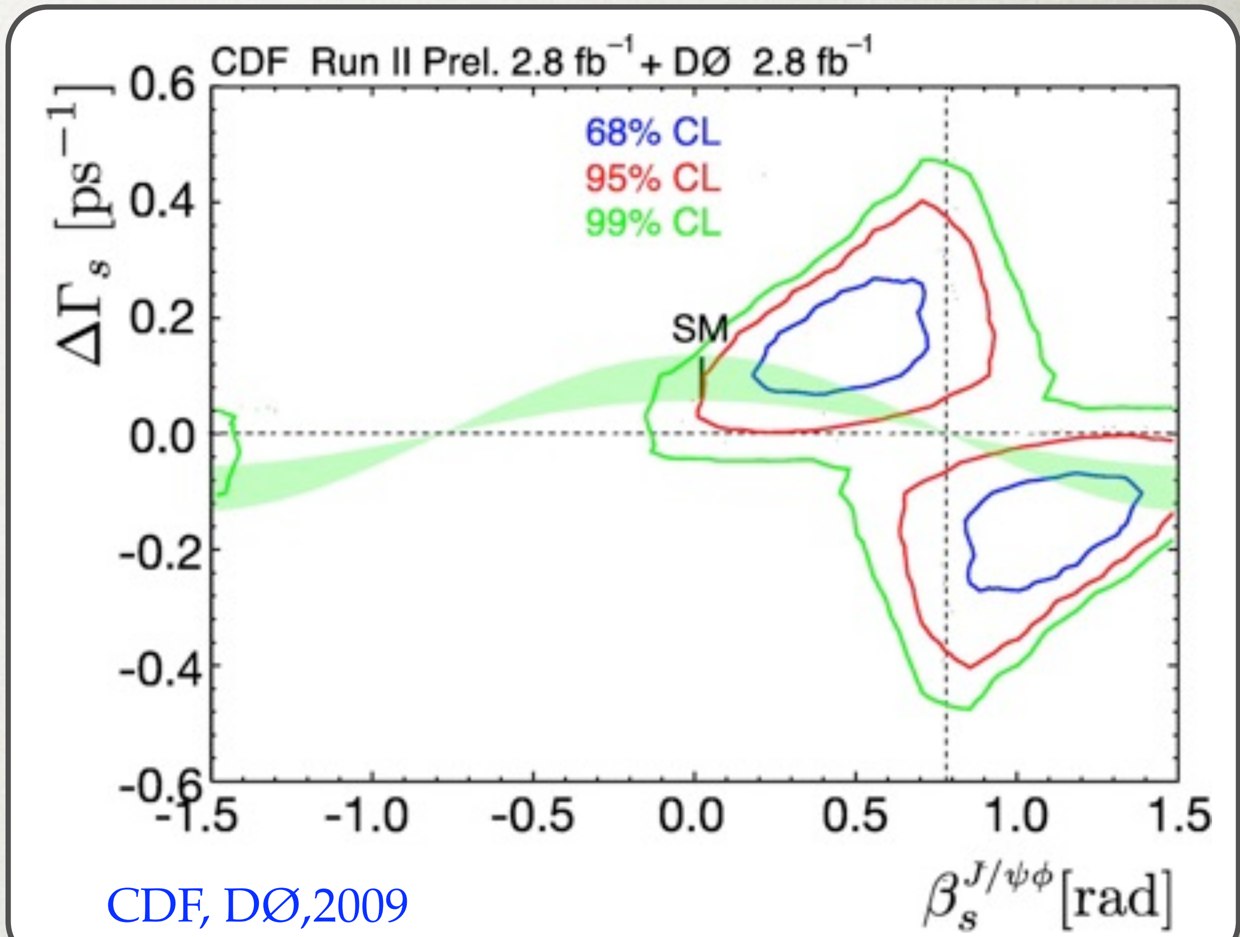
- at Tevatron both B

$a^b_{SL} = ($ … $3)\, a^s_{SL}$

- the n… with previ…)



COMPARISON WITH $B_s \to J/\psi\phi$



CDF, DØ,2009

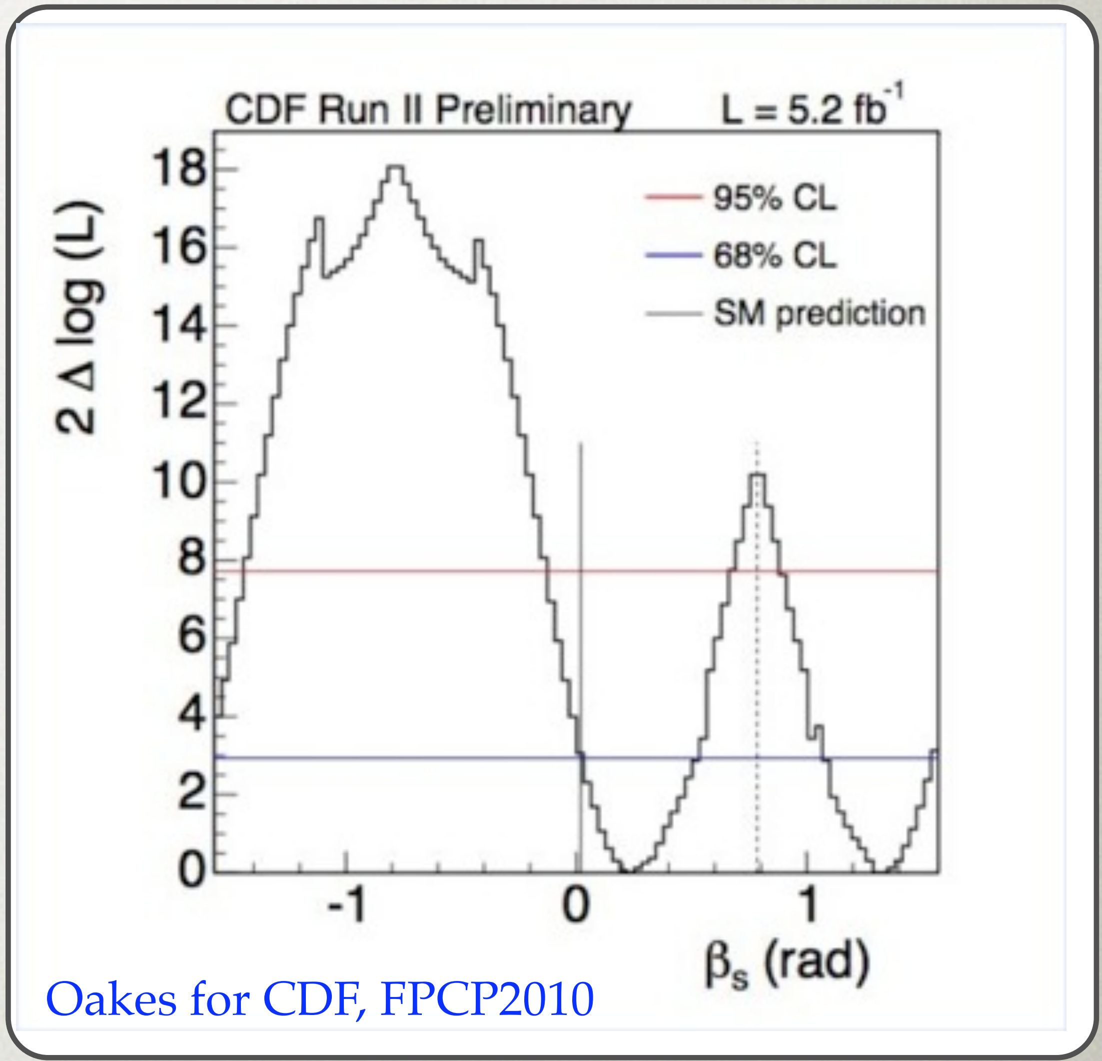
- time dependent measurement
$$\boxed{B_s(t) \to J/\psi\phi}$$
- can measure $\Delta\Gamma = \Gamma_L - \Gamma_H$ and β_s
$$\boxed{\beta_s = -\arg(-M_{12}/\Gamma_{12})}$$
- in SM $\beta_s = (1.04 \pm 0.05)^\circ$
- pre FPCP 2010 combined CDF and DØ
$$\boxed{2.12\ \sigma \text{ away from SM}}$$

COMPARISON WITH $B_s \to J/\psi\phi$

- at FPCP 2010 (May 25th) CDF showed new data

- moved closer to SM (now 0.8σ away)

- consistent with all other measurements



- no combined CDF & DØ 2D likelihood

- we use 1D likelihood of CDF, 2D of DØ

NEW PHYSICS?

- What does this all mean?
  - new physics?
  - just statistical fluctuation(s)?
- Will explore the possibility of NP
  - assume that dominant effect due to NP in the mixing
  - in the decay amplitudes has to compete with tree level

GENERAL ANALYSIS

GENERAL PARAMETRIZATION

- NP only in mixing

$$i\frac{d}{dt}\begin{pmatrix}|B_q(t)\rangle\\|\bar{B}_q(t)\rangle\end{pmatrix}=\Big(M-i\frac{\Gamma}{2}\Big)\begin{pmatrix}|B_q(t)\rangle\\|\bar{B}_q(t)\rangle\end{pmatrix}$$

- B_d and B_s systems described by 4 real parameters

$$M_{12}^{d,s}=\big(M_{12}^{d,s}\big)^{\rm SM}\,\big(1+h_{d,s}\,e^{2i\sigma_{d,s}}\big)$$

- the observables are then

$$\begin{aligned}\Delta m_q &= \Delta m_q^{\rm SM}\left|1+h_q e^{2i\sigma_q}\right|,\\ \Delta\Gamma_s &= \Delta\Gamma_s^{\rm SM}\,\cos\big[\,\arg\big(1+h_s e^{2i\sigma_s}\big)\big]\,,\\ A_{\rm SL}^q &= {\rm Im}\left\{\Gamma_{12}^q/\big[M_{12}^{q,{\rm SM}}(1+h_q e^{2i\sigma_q})\big]\right\},\\ S_{\psi K} &= \sin\big[2\beta+\arg\big(1+h_d e^{2i\sigma_d}\big)\big]\,,\\ S_{\psi\phi} &= \sin\big[2\beta_s-\arg\big(1+h_s e^{2i\sigma_s}\big)\big]\end{aligned}$$

CONSTRAINTS

- first a simplified analysis for illustration
- look just at B_s
    - i.e. set $h_d=0$
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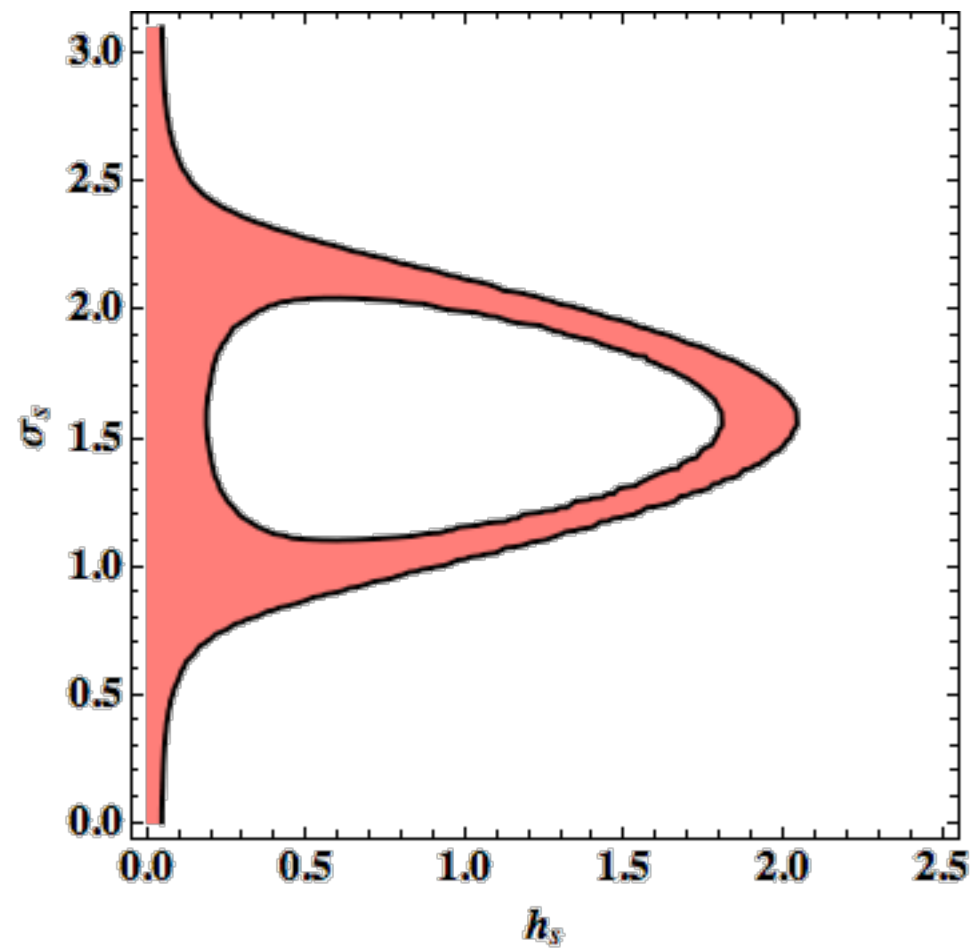

$$\Delta m_q = \Delta m_q^{\rm SM} \left|1 + h_q e^{2i\sigma_q}\right|$$

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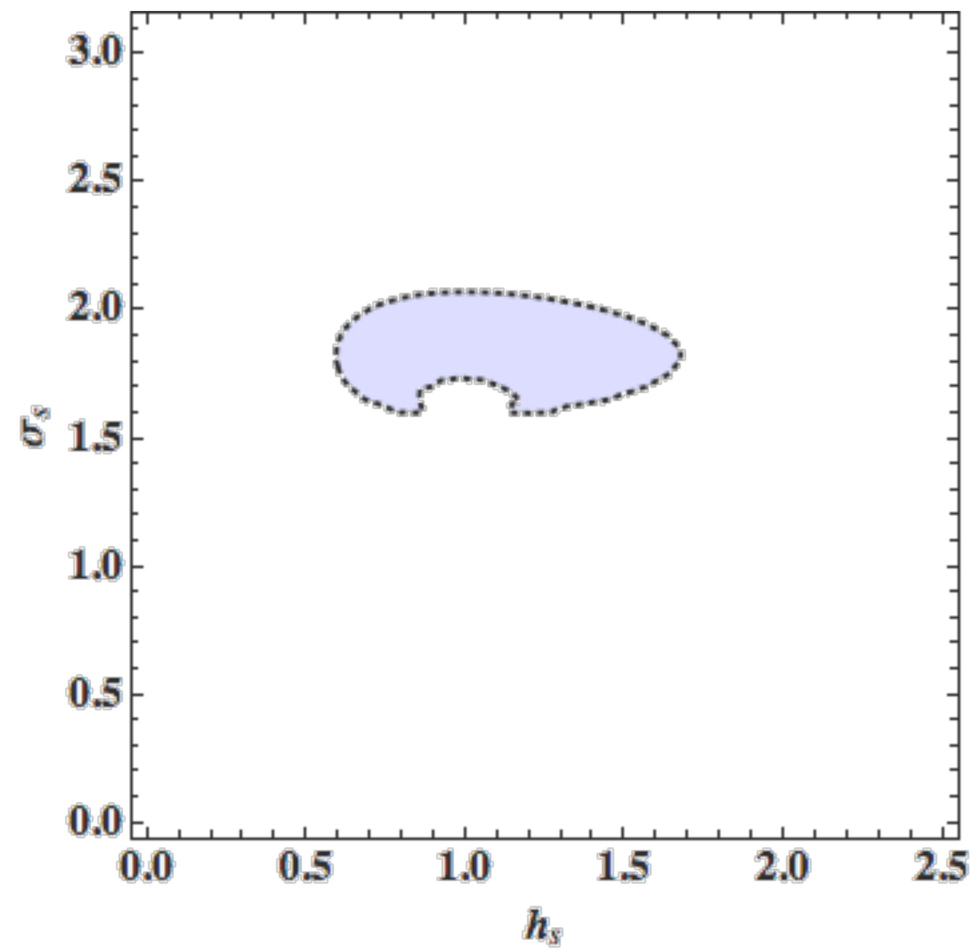

$$A^q_{\rm SL} \quad = \quad {\rm Im}\left\{\Gamma^q_{12}/\left[M^{q,{\rm SM}}_{12}(1+h_q e^{2i\sigma_q})\right]\right\}$$

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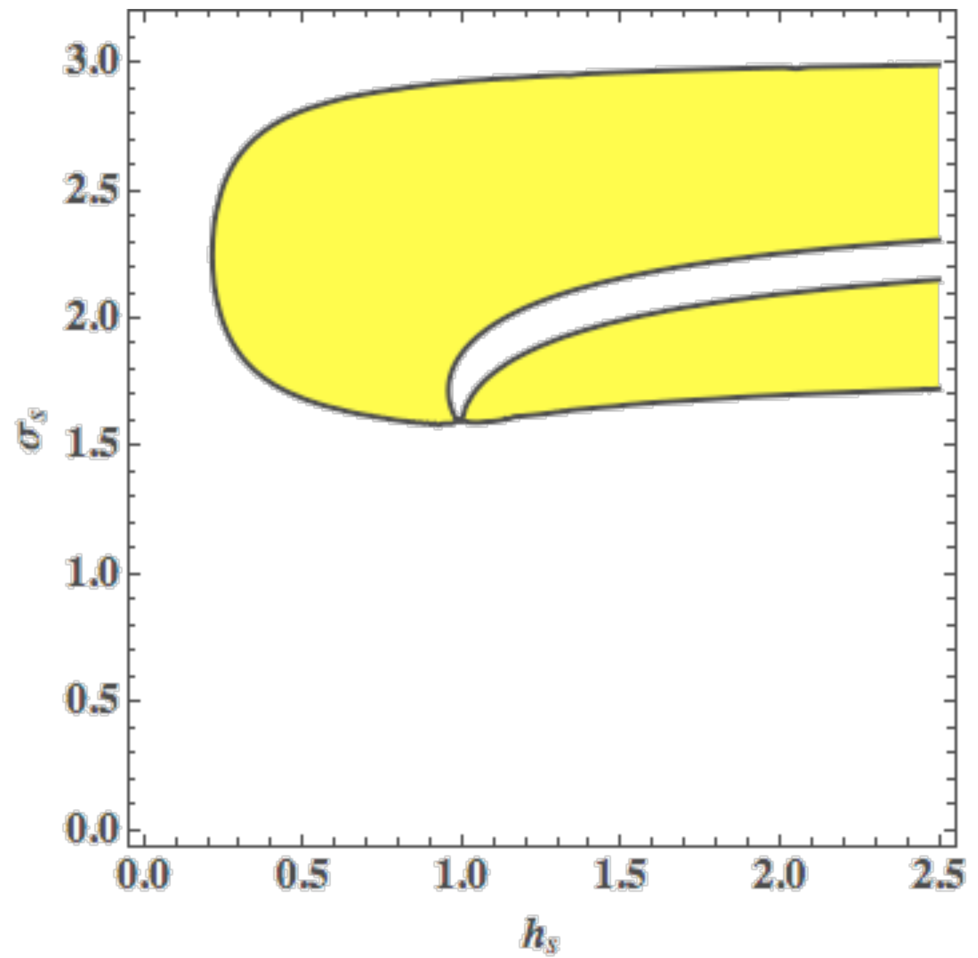

$$S_{\psi\phi} = \sin\left[2\beta_s - \arg\left(1 + h_s e^{2i\sigma_s}\right)\right]$$

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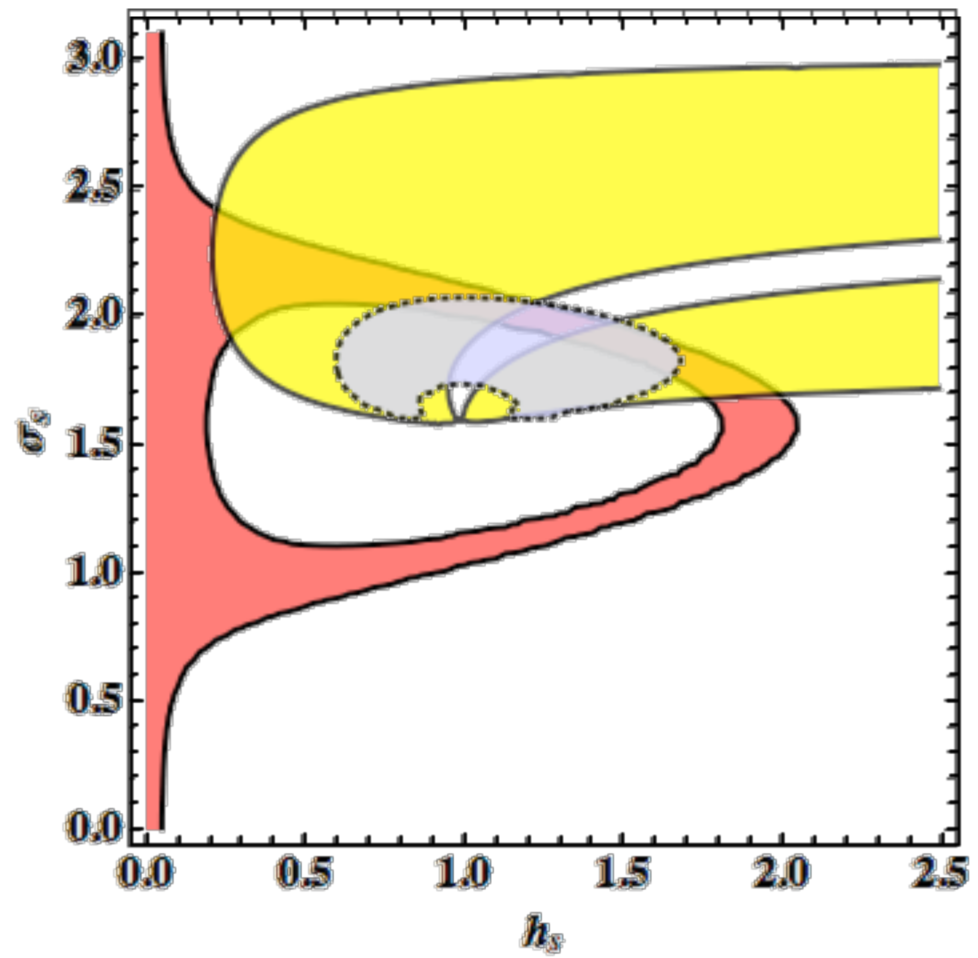

THE FIT

- the fit done using `CKMFitter` package
- correlation between B_s and B_d systems is through $A_{SL}{}^{b}$
- $\Delta\Gamma$ floated in the fit ($|\Gamma_{12}|$ in range 0-0.25 ps^{-1})
  - cf. SM pred. $|\Gamma_{12}|$=0.049±0.012 ps^{-1}

    Bauer, Dunn, 1006.1629
    Lenz, Nierste, hep-ph/0612167
  - uses OPE, eng. release only $m_b{-}2m_c$ ~ 2GeV
  - data prefers $\Delta\Gamma_s$ ~2.5 bigger than the prediction

RESULTS OF THE FIT

- no NP hypothesis $h_d = h_s = 0$ is disfavored at 3.3 σ level
- two best fit regions for $h_s \sim 0.5$ and $h_s \sim 1.8$ have large phases
- in h_s-σ_s the no NP point $h_s = 0$ disf. at 2.6σ
- in h_d-σ_d the no NP point $h_d = 0$ allowed below 2σ

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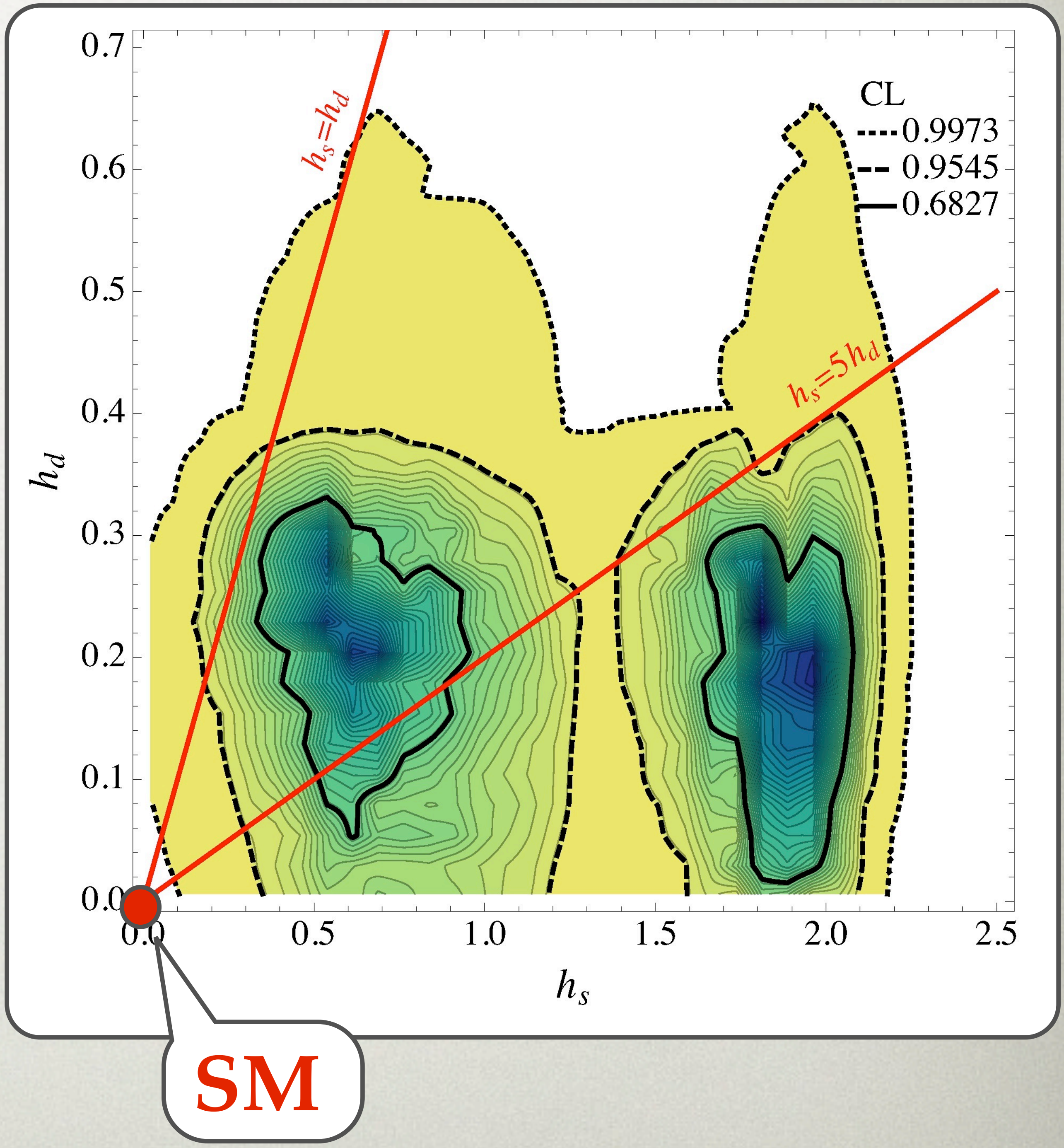

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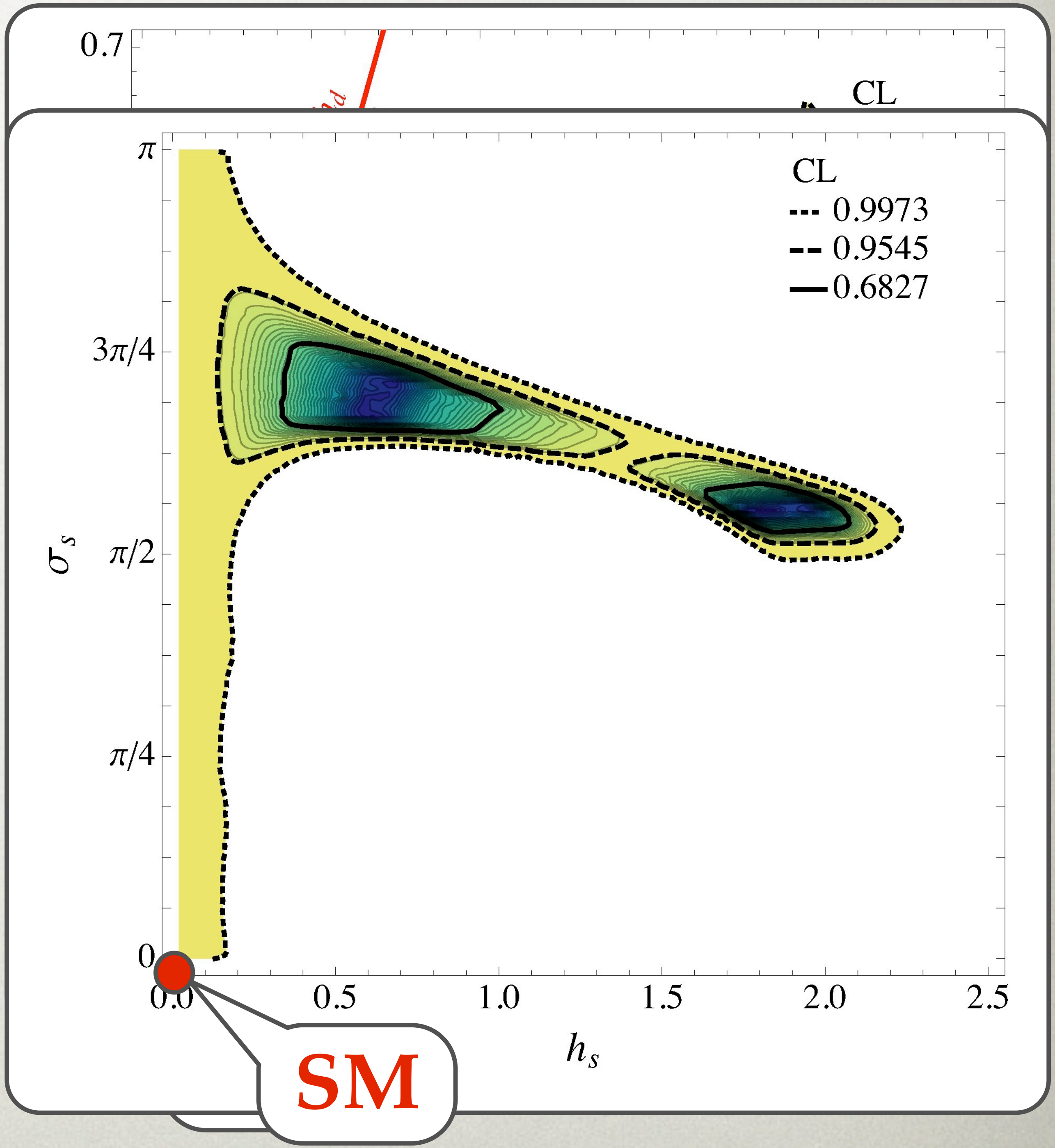

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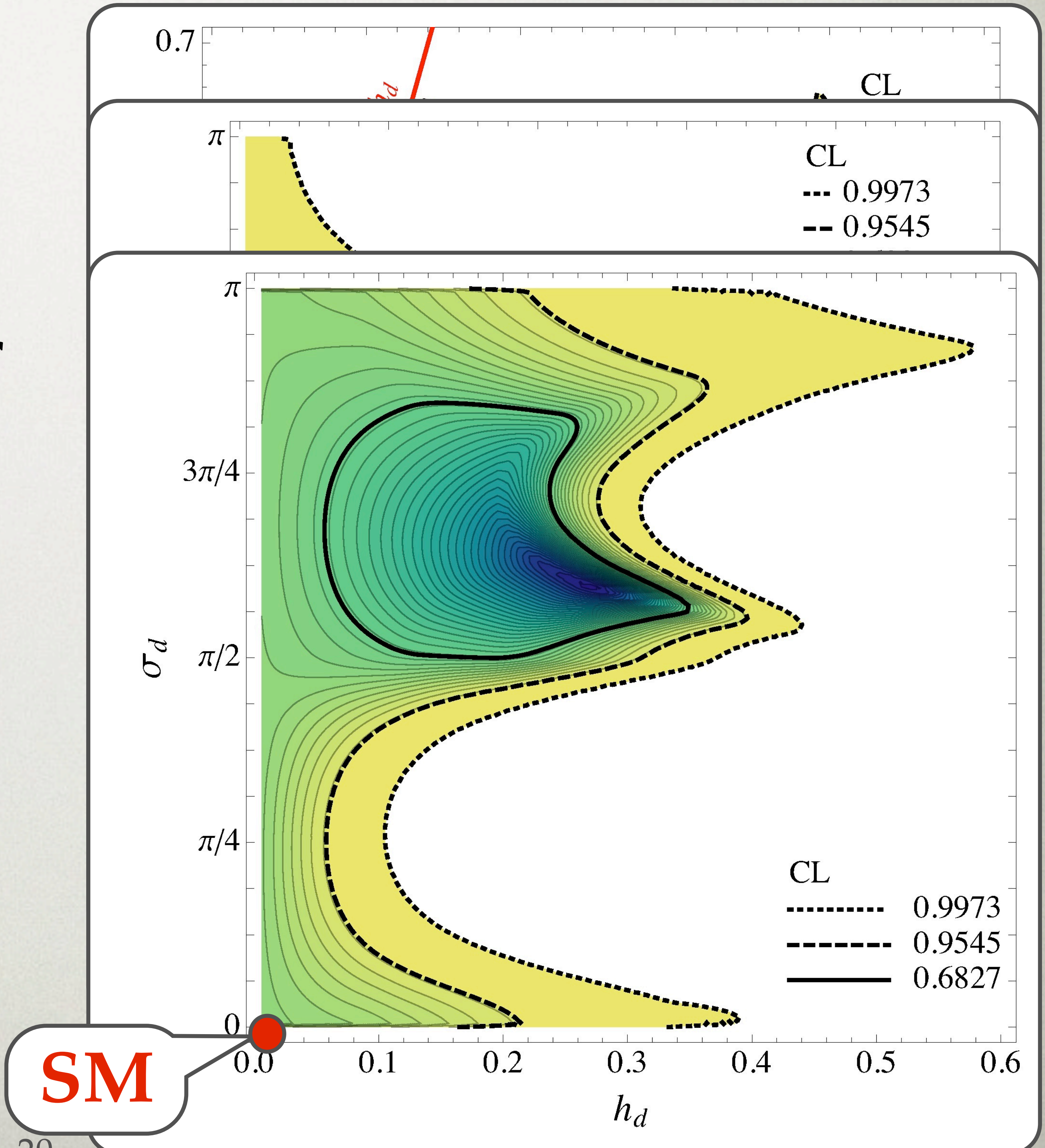
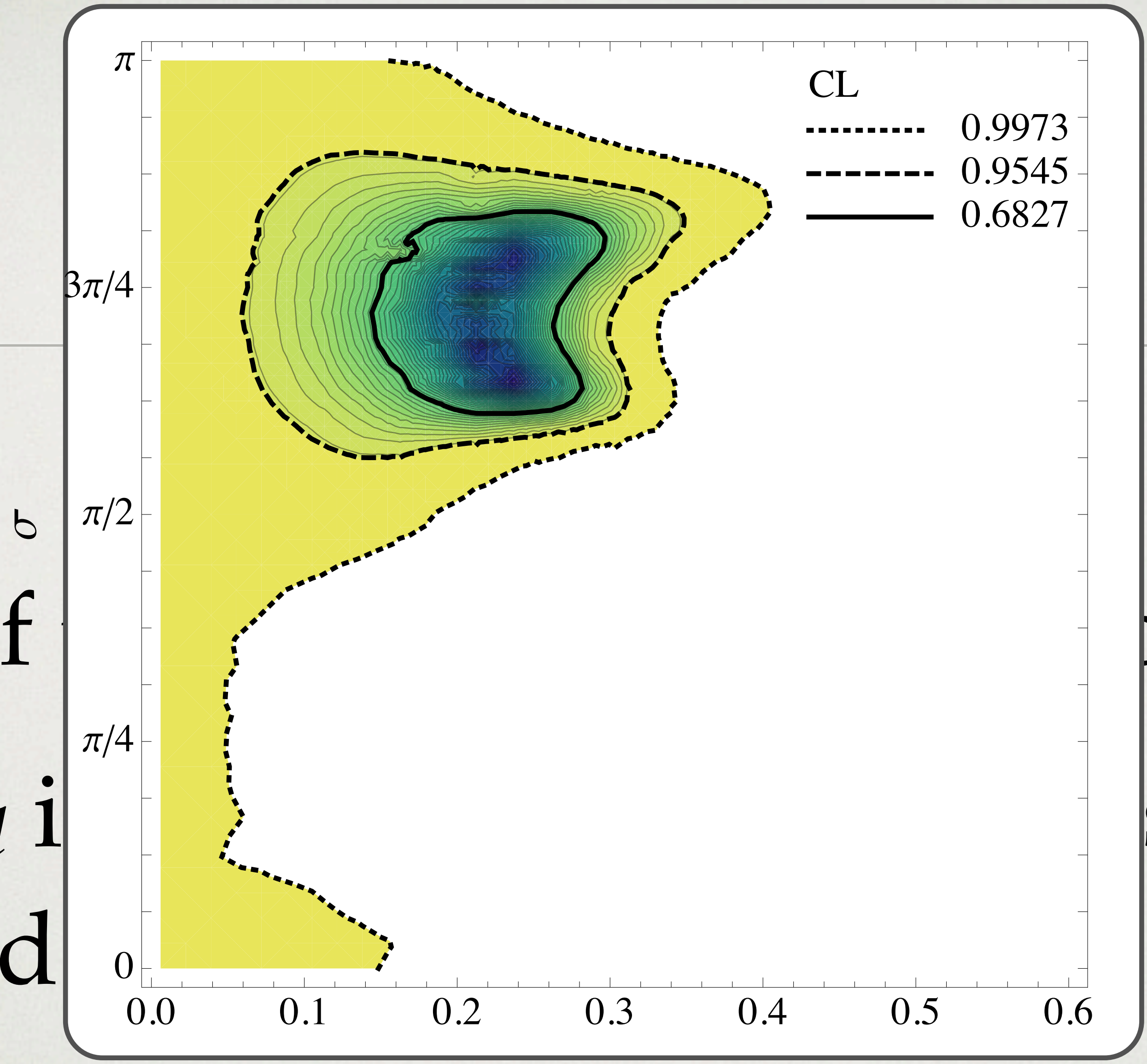


PATTERNS

- most of the favored param. space has $h_s > h_d$
- $h_s >> h_d$ is preferred, but $h_s \sim h_d$ is still allowed
- redoing the fit with $h_s = h_d \equiv h_b$ and $\sigma_s = \sigma_d \equiv \sigma_b$ worsens the fit
    - allowed region is $h_b \sim 0.25$, $\sigma_b \sim 120^o$



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SUMMARY SO FAR

- present data support the hypothesis of new CP violation contributions
  - and that it mainly contributes to $\Delta F=2$ mixing amplitude
- the SM extensions with $SU(2)_q$ "universality" are not preferred

MINIMAL FLAVOR VIOLATION & GENERAL MFV

ΔF=2 processes/NP puzzle

- NP contribs. to mixing (assuming (V-A)⊗(V-A) structure)

$$\mathcal{H}_{\rm eff} = \left(\frac{G_F^2 m_W^2}{8\pi^2}\left(V_{ti}^* V_{tj}\right)^2 C_0 + \frac{C_{\rm NP}}{\Lambda_{\rm NP}^2}\right)\left[\bar{d}_i \gamma_\mu (1-\gamma_5) d_j\right]^2$$

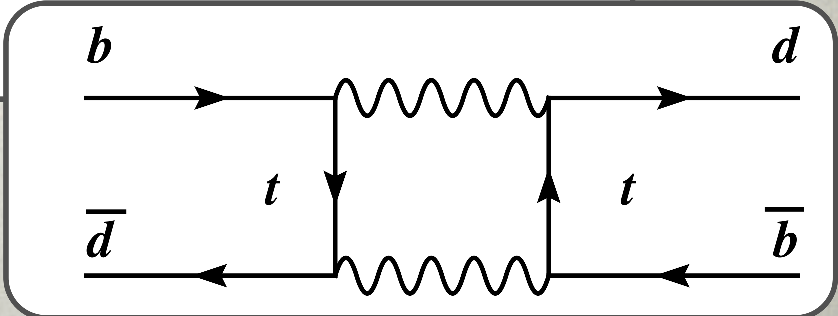
- measurms. exclude O(1) corrections

$$\boxed{K - \bar{K}\ \text{mix.:}} \quad (\underbrace{V_{ts}^*}_{\sim\lambda^2}\underbrace{V_{td}}_{\sim\lambda^3})^2 \frac{1}{\Lambda_{\rm MFV}^2} > \frac{C_{\rm NP}}{\Lambda_{\rm NP}^2} \Rightarrow \boxed{\Lambda_{\rm NP} \gtrsim 10^4\ \text{TeV}}$$

$$\boxed{B_d - \bar{B}_d\ \text{mix.:}} \quad (\underbrace{V_{tb}^*}_{\sim 1}\underbrace{V_{td}}_{\sim\lambda^3})^2 \frac{1}{\Lambda_{\rm MFV}^2} > \frac{C_{\rm NP}}{\Lambda_{\rm NP}^2} \Rightarrow \boxed{\Lambda_{\rm NP} \gtrsim 5\cdot 10^2\ \text{TeV}}$$

$$\boxed{B_s - \bar{B}_s\ \text{mix.:}} \quad (\underbrace{V_{tb}^*}_{\sim 1}\underbrace{V_{ts}}_{\sim\lambda^2})^2 \frac{1}{\Lambda_{\rm MFV}^2} > \frac{C_{\rm NP}}{\Lambda_{\rm NP}^2} \Rightarrow \boxed{\Lambda_{\rm NP} \sim 10^2\ \text{TeV}}$$

$$\Lambda_{\rm MFV} = \sqrt{8}\pi / G_F m_W \sim 6\ \text{TeV}$$



MINIMAL FLAVOR VIOLATION

D'Ambrosio, Giudice, Isidori, Strumia, 2002

Buras et al, 2000;   Chivukula, Georgi, 1987

Hall, Randall, 1990

- if NP at TeV it has a very nontrivial flavor structure
- can NP emulate the SM hierarchy?
- Minimal Flavor Violation hypothesis: flavor only broken by SM Yukawas
- a nonempty set: MSSM with gauge mediated SUSY breaking

MINIMAL FLAVOR VIOLATION

D'Ambrosio, Giudice, Isidori, Strumia, 2002

- use spurion analysis to construct NP opers./contribs.
- quark sector formally inv. under $U(3)_Q \otimes U(3)_u \otimes U(3)_d$, if the Yukawas promoted to spurions

$$\boxed{Y'_{u,d} = V_Q Y_{u,d} V^\dagger_{u,d}}$$

- constrains possible FV structures, e.g. (V-A)⊗(V-A)
  - allowed: $\boxed{\bar{Q}(Y_u Y_u^\dagger)^n Q}$
  - not allowed: $\boxed{\bar{Q} Y_d^\dagger (Y_u Y_u^\dagger)^n Q}$
- it gives SM like suppression of FCNC's since

$$\boxed{(Y_u Y_u^\dagger)^n \sim (Y_u Y_u^\dagger) = V_{\rm CKM} \mathrm{diag}(0,0,1) V^\dagger_{\rm CKM}}$$

- for (V-A) bilinear $\bar{b}_L s_L$ the suppression $\sim V_{tb} V_{ts}^*$

DIFFERENT MFV's

- sometime additional assumptions are made
    - CP only violated by Yukawas
    - only SM 4-quark operators
- we will not make such assumptions
- for simplicity work in large $\tan\beta$ limit

A QUESTION

- Y_u, Y_d have O(1) eigenvalues $y_{t,b}$:
  why are we able to expand $\bar{Q} f(\epsilon_u Y_u, \epsilon_d Y_d) Q$?
  - if $\varepsilon_{u,d} \ll 1$: series truncates after first few terms ⇒ $\boxed{\text{Linear MFV}}$ ⇒ expansion in $Y_{u,d}$
  - if $\varepsilon_{u,d} = O(1)$: higher terms important ⇒ $\boxed{\text{Nonlinear MFV}}$ ⇒ need to reorganize expansion
- can we distinguish LMFV vs. NLMFV?
  - interesting since $\varepsilon_{u,d} \propto \log(\mu_W/\Lambda_F)$ ⇒ could give a handle on physics at higher scales (with caveats)

Kagan, Perez, Volansky, JZ, 2009

GENERAL MFV

- formalism inspired by nonlinear sigma model
- G^{SM} broken by $y_{t,b}$ to H^{SM}=U(2)$_Q$⊗U(2)$_u$⊗U(2)$_d$⊗U(1)$_3$, we mod out broken symm. generators of G^{SM}/H^{SM}

$$Y_{u,d} = e^{i\hat{\rho}_Q} e^{\pm i\hat{\chi}/2} \tilde{Y}_{u,d} e^{-i\hat{\rho}_{u,d}}, \qquad \tilde{Y}_{u,d} = \begin{pmatrix} \phi_{u,d} & 0 \\ 0 & y_{t,b} \end{pmatrix}$$

- ρ_i spurion “Goldstone bosons”, can be set to zero
- χ the misalignement spurion, in down quark basis

$$\hat{\chi} = \begin{pmatrix} 0 & \chi \\ \chi^\dagger & 0 \end{pmatrix}, \quad \chi^\dagger \to i(V_{td}, V_{ts}), \quad \phi_u \to V_{\rm CKM}^{(2)\dagger} \,\mathrm{diag}\Big(\frac{m_u}{m_t}, \frac{m_c}{m_t}\Big)$$

- the bilinears are invariant under H^{SM}

$$\chi' = U_Q^{2\times 2}\chi, \qquad \phi'_{u,d} = U_Q^{2\times 2}\phi_{u,d}U_{u,d}^{2\times 2\dagger}$$

COMPARING WITH THE USUAL MFV NOTATION

- MFV LL example ($\Delta^k_{ij} = y_k^2 V^*_{ki} V_{kj}$ with i≠j)

$$\bar{Q}\big[a_1 Y_u Y_u^\dagger + a_2 (Y_u Y_u^\dagger)^2\big]Q + \big[b_2\,(\bar{Q} Y_u Y_u^\dagger Y_d Y_d^\dagger) Q + h.c.\big] + \cdots =$$
$$\bar{d}^i_L\big[(a_1 + a_2 y_t^2)\Delta^t_{ij} + a_1 \Delta^c_{ij}\big] d^j_L + \big[b_2 y_b^2\, \bar{d}^i_L \Delta^t_{ib} b_L + h.c.\big]$$

  - LMFV: $a_1 >> a_2, b_2$, NLMFV: $a_1 \sim a_2 \sim b_2$
  - $a_{1,2}$ are real, b_2 can be complex

- in GMFV notation

$$(c_b \overline{d_L^{(2)}} \chi b_L + h.c) + c_t \overline{d_L^{(2)}} \chi \chi^\dagger d_L^{(2)} + c_c \overline{d_L^{(2)}} \phi_u \phi_u^\dagger d_L^{(2)}$$

- LO: $c_b \simeq (a_1 y_t^2 + a_2 y_t^4 + b_2 y_b^2),\ c_t \simeq a_1 y_t^2 + a_2 y_t^4,\ c_c \simeq a_1$

CP VIOLATION

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- using GMFV formalism we can prove the following:

assuming MFV, there can be significant new CPV effects only if there are new flavor diagonal CP sources

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- using GMFV formalism we can prove the following:

$\boxed{\text{assuming MFV, there can be significant new CPV effects only if there are new flavor diagonal CP sources}}$

- proof: the leading CKM generated flavor-diag. phase $\chi^\dagger[\phi_u^\dagger\phi_u, \phi_d^\dagger\phi_d]\chi$ is very small

$$\boxed{[\phi_u^\dagger\phi_u, \phi_d^\dagger\phi_d] \sim (m_s/m_b)^2(m_c/m_t)^2 \sin\theta_C \sim 10^{-9}}$$

CP VIOLATION

- if new CP sources present:
  - $\overline{d_L^{(2)}}\chi\sigma_{\mu\nu}b_R F^{\mu\nu}$ would give enhanced and correlated CPV in $B \to X_s\gamma$ and $B \to X_d\gamma$
  - to ε_K can contribute $(\overline{d_L^{(2)}}\chi\chi^\dagger\phi_d d_R^{(2)})^2$: 50% contrib. to ε_K corresp. to Λ~0.8 TeV
  - contributions to both B_d and B_s mixing

CONTRIBUTIONS TO B MIXING

- 2 classes of non-hermitian ΔB = 2 effective operators
  - class-1 (no $d_R^{(2)}$): $(\overline{d_L^{(2)}}\chi b_{L,R})^2$,...
  - class-2 (with $d_R^{(2)}$): $(\overline{d_R^{(2)}}\phi_d^\dagger\chi b_L)\,(\overline{d_L^{(2)}}\chi b_R)$,...
- class-2 contribs. only to $B_s - \bar{B}_s$ mixing (up to m_d/m_s)
- class-1 contribs. ⇒ same NP phase shift in $B_d - \bar{B}_d$ and $B_s - \bar{B}_s$ (up to $SU(3)_F$ breaking in bag params.)
- class-1 contribs. dominate if Λ comparable for all ops.
- sizable CPV in B_s system requires class-2 contribs.
- barring cancelations
  NP CPV in $B_s - \bar{B}_s$ mix. > NP CPV in $B_d - \bar{B}_d$ mixing

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Observed pattern

sizable CPV in B_s system requires class-2 contribs.

barring cancelations

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CLASS-1 OPERATORS

- the operators that give $SU(2)_q$ universal contributions

$$\frac{1}{\Lambda_1^2}\left(\bar{b}_L^\alpha\gamma_\mu\chi^\dagger q_L^\alpha\right)\left(\bar{b}_L^\beta\gamma_\mu\chi^\dagger q_L^\beta\right)$$

$$\frac{y_b^2}{\Lambda_2^2}\left(\bar{b}_R^\alpha\chi^\dagger q_L^\alpha\right)\left(\bar{b}_R^\beta\chi^\dagger q_L^\beta\right) \qquad \frac{y_b^2}{\Lambda_3^2}\left(\bar{b}_R^\alpha\chi^\dagger q_L^\beta\right)\left(\bar{b}_R^\beta\chi^\dagger q_L^\alpha\right)$$

- the bounds on the scale are (equality sign, if the data hold)

$$\Lambda_{\mathrm{MFV};1,2,3} \gtrsim \{8.8,\ 13\,y_b,\ 6.8\,y_b\}\sqrt{0.2/h_b}\ \mathrm{TeV}$$

CLASS-2 OPERATORS

- class-2 operators

$$\boxed{\frac{1}{\Lambda_4^2}(\overline{d_R^{(2)}}\phi_d^\dagger \chi b_L)\,(\overline{d_L^{(2)}}\chi b_R)}$$

  - + op. w/ Fierzed color. indic. (suppr. contrib.)

- prefered solution by data
- contribs. to B_d are m_d/m_s supp. compared to B_s
- unsuppressed only in large *tanβ* limit
- data imply (equality, if indication for NP holds)

$$\boxed{\Lambda_{\mathrm{MFV};4} \gtrsim 13.2\, y_b \sqrt{\frac{m_s}{m_b}\frac{0.5}{h_s}}\ \mathrm{TeV} = 2.9\, y_b \sqrt{\frac{0.5}{h_s}}\ \mathrm{TeV}}$$

UP QUARK SECTOR AND GMFV

- in up quark mass basis one has for the spurions

$$\boxed{\chi = i(V_{ub}, V_{cb}) \qquad \phi_d = V_{CKM}^{(2)\dagger}\mathrm{diag}\,(m_d, m_s)/m_b}$$

- in NLMFV new contribs. can be greatly enhanced
- top FCNCs
  - in SM Br($t\to cX$)~O(10^{-12})
  - in NLMFV $\overline{\tilde{u}^{(2)}}\chi t$ can lead to Br($t\to cX$)~O(10^{-5})
- enhancements for CPV in D mixing
  - relevant operators

$$\boxed{(\overline{\tilde{u}}_L^{(2)}\chi\chi^\dagger u_L)^2 \qquad (\overline{\tilde{u}}_L^{(2)}\chi\chi^\dagger u_L)(\overline{\tilde{u}}_L^{(2)}\phi_d\phi_d^\dagger u_L)}$$

  - resulting CP violation in mixing

$$\boxed{\arg(M_{12}/\Gamma_{12}) = O(5\%)\,(1\ \mathrm{TeV}/\Lambda)^2\,(\sin 2\gamma, \sin\gamma)}$$

EDM constraints

- to explain nonzero B_s mixing phase CP violation beyond CKM is needed
- Q: how to avoid bounds on flavor diagonal phases from EDM's?
  - at the level of operators not possible to answer (comes from different sector)
  - can be a problem in models
  - only "ad hoc" fixes so far

Paradisi, Straub, 0906.4551

MSSM WITH MFV AND CPV

- MSSM+MFV, but not assumed CP cons.
- EDM's constrain phases

$$M_i\mu,\ A_I\mu \text{ and } A_I^* M_i$$

$$|\sin\phi_\mu| \lesssim 10^{-3}\left(\frac{m_{\rm SUSY}}{300\ \text{GeV}}\right)^2\left(\frac{10}{t_\beta}\right),$$
$$|\sin\phi_A| \lesssim 10^{-2}\left(\frac{m_{\rm SUSY}}{300\ \text{GeV}}\right)^2,$$

- if flavor blind phases $\arg(A_U)$, $\arg(A_D)$ zero

$$\text{Im}\, A_b \gg \text{Im}\, A_{s,d}$$
$$\text{Im}\, A_\tau \gg \text{Im}\, A_{\mu,e}$$

$$\text{Im}\, A_t \gg \text{Im}\, A_{c,u}$$

- then EDM's constraints are obeyed

$$\mathbf{m}_D^2 = m_D^2\Big[\mathbf{1} + \mathbf{Y}_d\Big(r_3 + r_4\mathbf{Y}_u^\dagger\mathbf{Y}_u + r_5\mathbf{Y}_d^\dagger\mathbf{Y}_d + (c_2\mathbf{Y}_d^\dagger\mathbf{Y}_d\mathbf{Y}_u^\dagger\mathbf{Y}_u + \text{h.c.})\Big)\mathbf{Y}_d^\dagger\Big],$$

$$\mathbf{A}^U = A_U\mathbf{Y}_u\Big(\mathbf{1} + c_3\mathbf{Y}_d^\dagger\mathbf{Y}_d + c_4\mathbf{Y}_u^\dagger\mathbf{Y}_u + c_5\mathbf{Y}_d^\dagger\mathbf{Y}_d\mathbf{Y}_u^\dagger\mathbf{Y}_u + c_6\mathbf{Y}_u^\dagger\mathbf{Y}_u\mathbf{Y}_d^\dagger\mathbf{Y}_d\Big),$$

$$\mathbf{A}^D = A_D\mathbf{Y}_d\Big(\mathbf{1} + c_7\mathbf{Y}_u^\dagger\mathbf{Y}_u + c_8\mathbf{Y}_d^\dagger\mathbf{Y}_d + c_9\mathbf{Y}_d^\dagger\mathbf{Y}_d\mathbf{Y}_u^\dagger\mathbf{Y}_u + c_{10}\mathbf{Y}_u^\dagger\mathbf{Y}_u\mathbf{Y}_d^\dagger\mathbf{Y}_d\Big),$$

ub, 0906.4551

MSSM

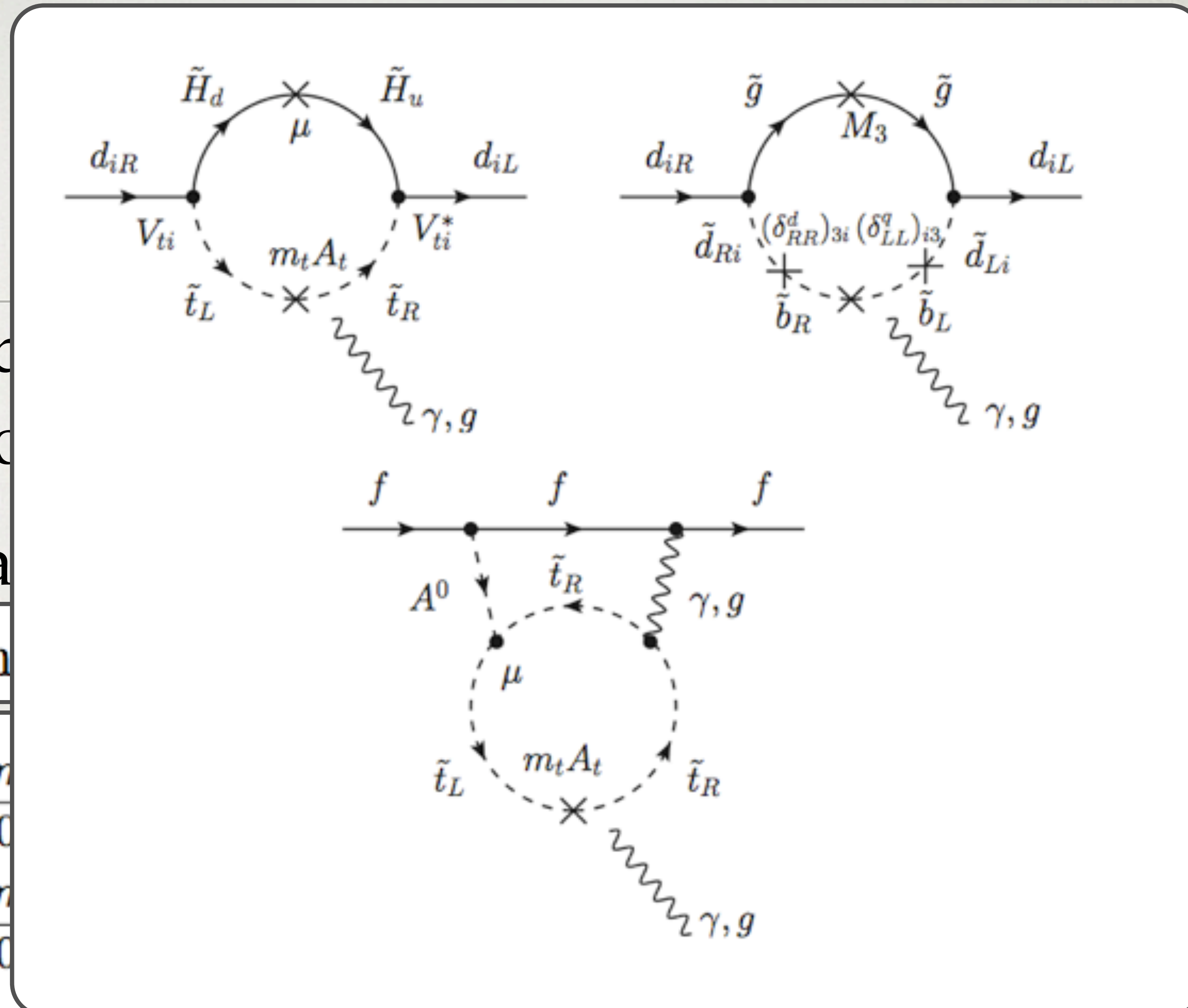
- MSSM+MFV, b
assumed CP c

- EDM's constra

$M_i\mu,\ A_I\mu$ an

$|\sin\phi_\mu| \lesssim 10^{-3}\Big($

$|\sin\phi_A| \lesssim 10^{-2}\Big($



$- r_5 \mathbf{Y}_d^\dagger \mathbf{Y}_d$

$,$

$\mathbf{Y}_u^\dagger \mathbf{Y}_u +$

$\mathbf{Y}_d^\dagger \mathbf{Y}_d\Big),$

$$\mathbf{A}^D = A_D \mathbf{Y}_d\Big(1 + c_7 \mathbf{Y}_u^\dagger \mathbf{Y}_u + c_8 \mathbf{Y}_d^\dagger \mathbf{Y}_d +$$

$$+ c_9 \mathbf{Y}_d^\dagger \mathbf{Y}_d \mathbf{Y}_u^\dagger \mathbf{Y}_u + c_{10} \mathbf{Y}_u^\dagger \mathbf{Y}_u \mathbf{Y}_d^\dagger \mathbf{Y}_d\Big),$$

- if flavor blind phases
arg(A_U), arg(A_D) zero

$$\mathrm{Im}\, A_b \gg \mathrm{Im}\, A_{s,d}$$
$$\mathrm{Im}\, A_\tau \gg \mathrm{Im}\, A_{\mu,e}$$

$$\mathrm{Im}\, A_t \gg \mathrm{Im}\, A_{c,u}$$

- then EDM's constraints are obeyed

MODELS

- explanations for dimuon anomaly proposed so far
  - 2HDM + MFV (EDM's assumed ok) Buras, Carlucci, Gori, Isidori, 1005.5310
  - uplifted MSSM Dobrescu, Fox, Martin, 1005.4238
  - leptoquarks (also enhances $\Delta\Gamma$ from $B_s \to \tau^+\tau^- X$) And, Dighe, Nandi, 1005.4051

CONCLUSIONS

- observed like-sign dimuon asymmetry is well described by NP contributions to B_s mixing
- (G)MFV can at the same time accomodate small contribs. to B_d mixing
- presented EFT analysis may be used to guide model building

BACKUP SLIDES

P_T DEP. OF ASYMMETRY