CP VIOLATION IN B DECAYS

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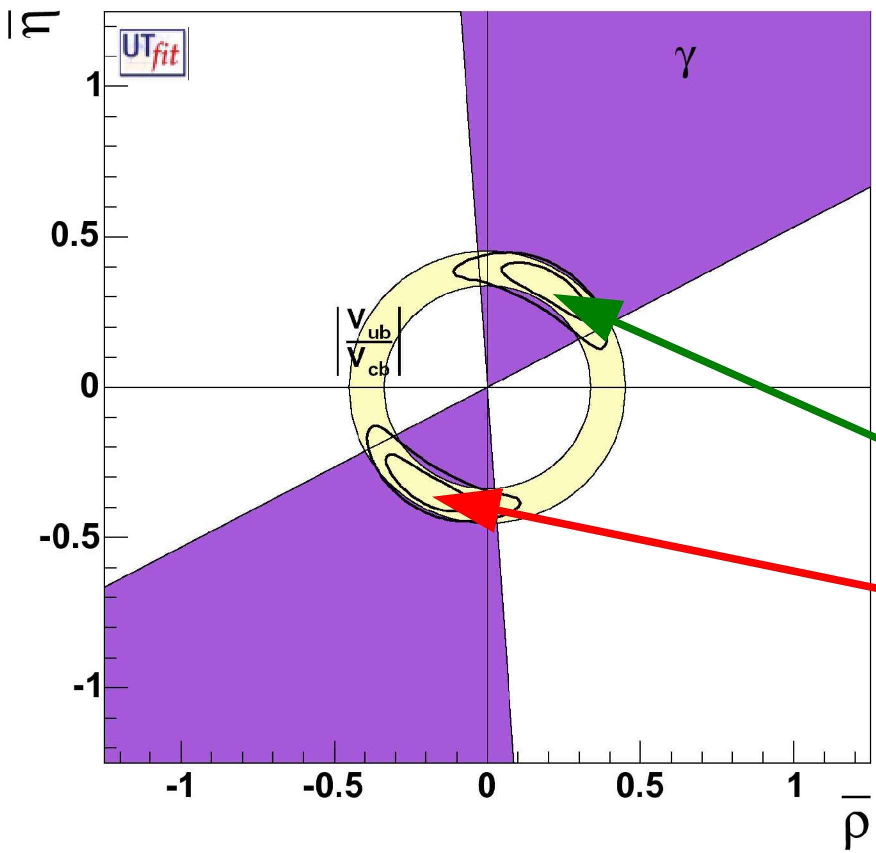
THE STARTING POINT



Utfit collaboration, hep-ph/0501199

Determination of ρ-η plane using only tree-level processes:

1) SM solution

2) Requires O(1) NP contributions to ε_K and B_d - $\bar{B}_d$ mixing

CASE 1 – STANDARD UT

- SUSY contributions to K – K and B_d – B_d mixings at the level of 10 – 20 % of SM:

  a) MFV: could show up in $B_s \to \mu\mu$ if tan β large enough and sparticles light enough

  b) small δ_{12} and δ_{13} but large δ_{23}

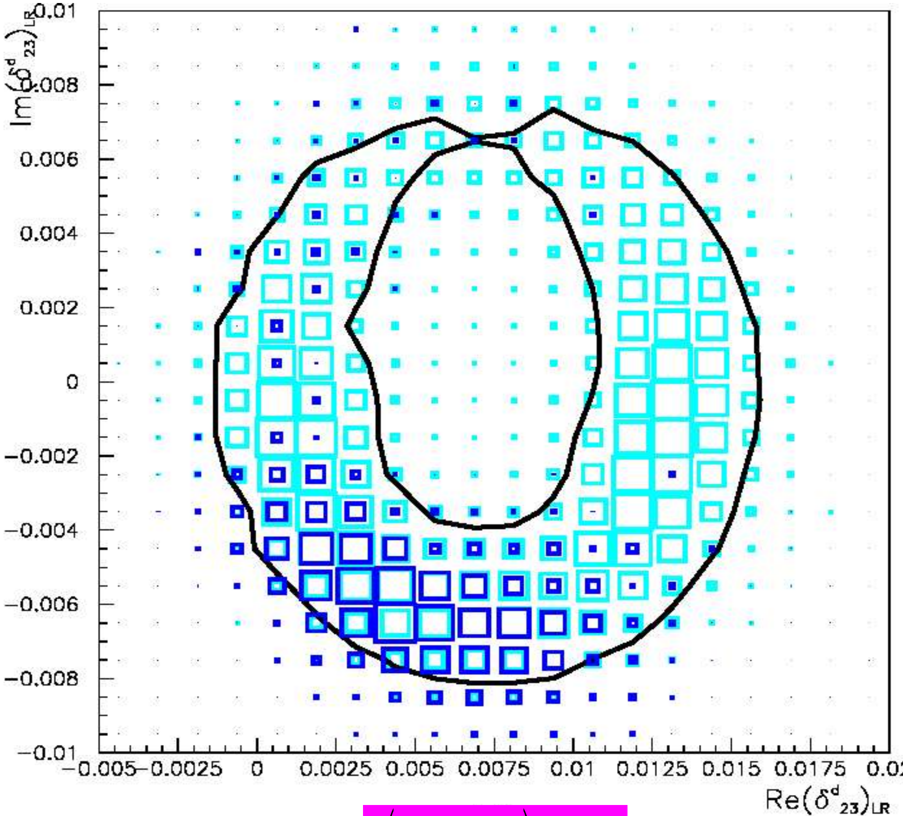
  - Nonabelian flavour symmetries
  - GUT connections with neutrino physics & LFV

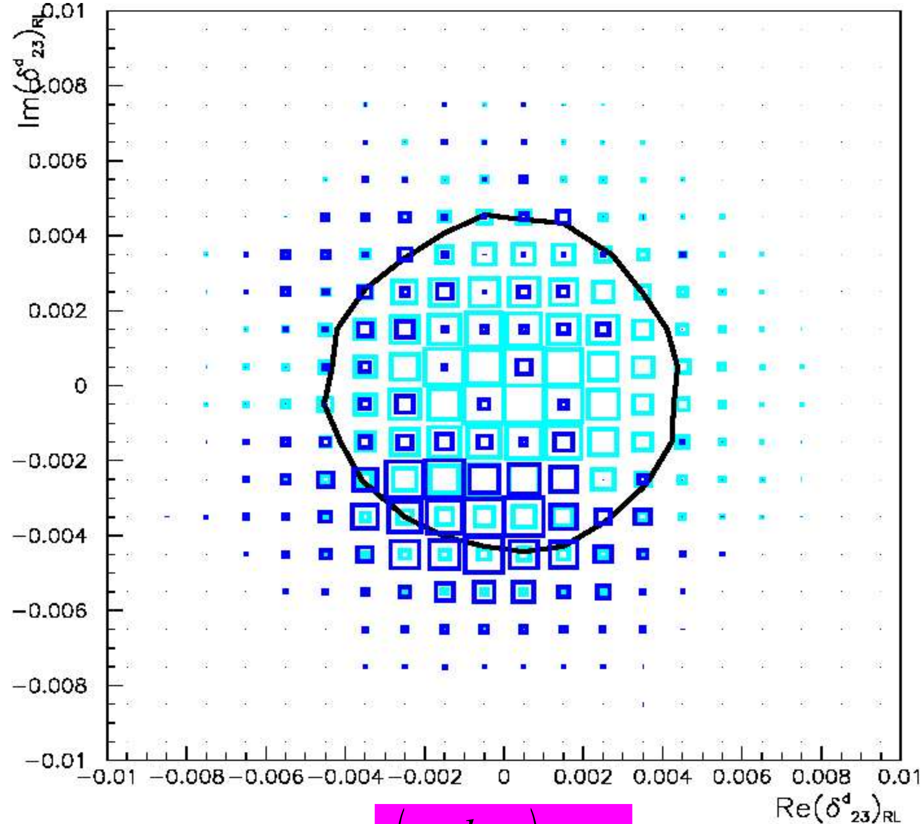
  $\rightarrow$ Interesting phenomenology!

EFFECTS OF A LARGE δ_{23}

- In general, δ_{23} can show up in $\Delta B=2$ and/or $\Delta B=1$ processes, depending on chirality and sparticle masses:
  - $\Delta B=1$ most sensitive to $(\delta_{23})_{LR,RL}$ and large $\tan\beta$ (chromomagnetic penguins)
  - $\Delta B=2$ also sensitive to $(\delta_{23})_{LL,RR}$ and moderate/small $\tan\beta$ (boxes)

CONSTRAINTS ON $(\delta_{23})_{LR,RL}$





$\left(\delta^{d}{}_{23}\right)_{LR}$

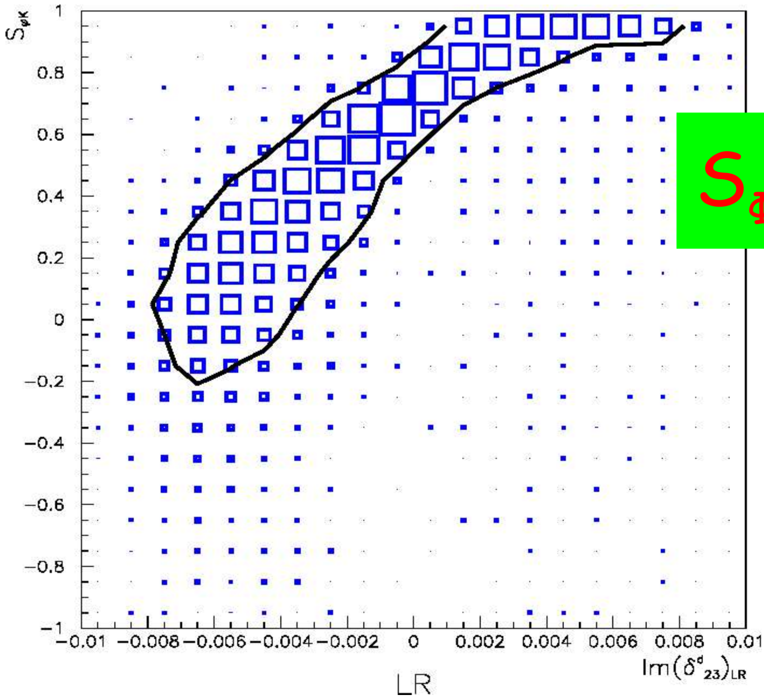
$\left(\delta^{d}{}_{23}\right)_{RL}$

$m_{\tilde{q}} = m_{\tilde{g}}$
350 GeV

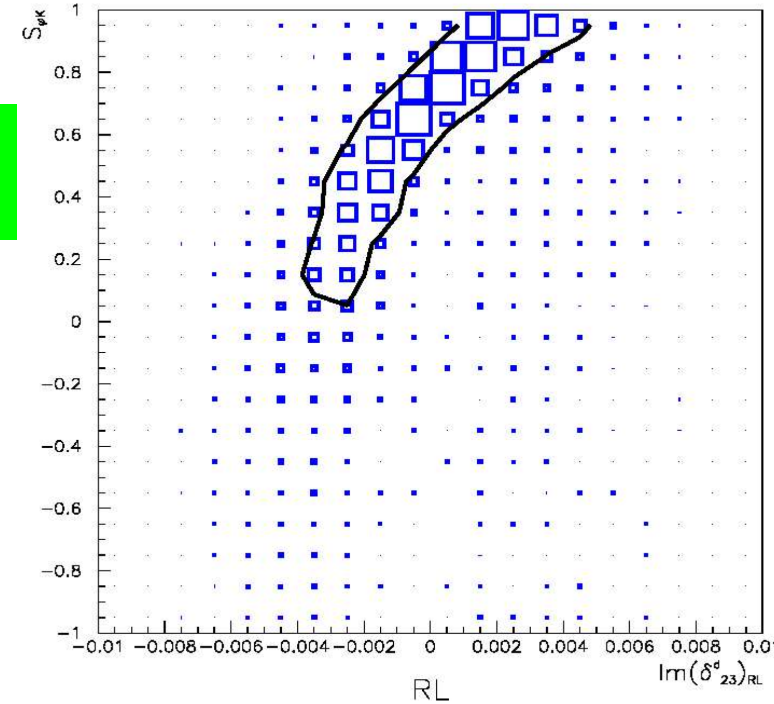
Ciuchini, Franco, Masiero & LS

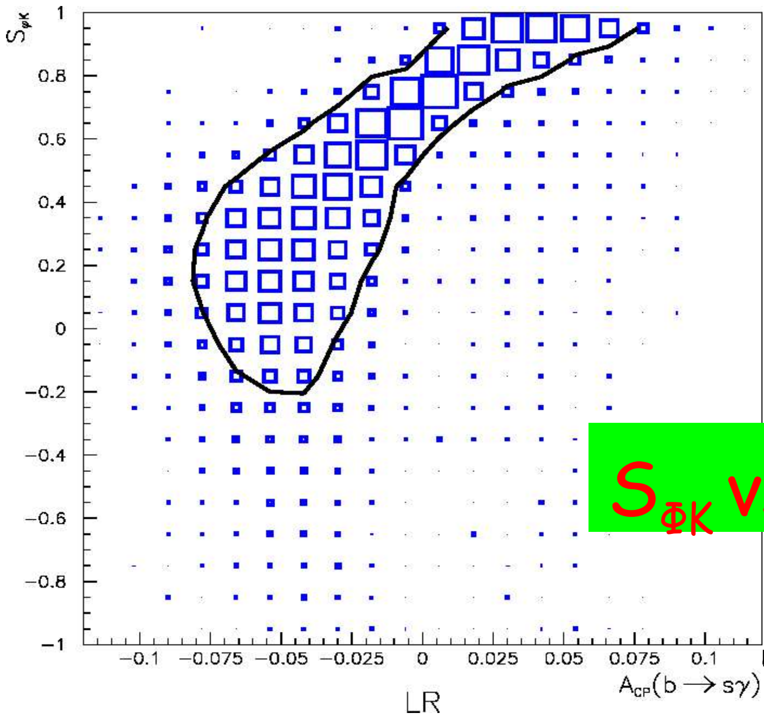
EFFECTS OF $(\delta_{23})_{LR,RL}$

- Abs $(\delta_{23})_{LR,RL}$ fixed by BR($b \to s\,\gamma$), phase constrained by $A_{CP}(b \to s\,\gamma)$. Effects
  - where this phase matters: $A_{CP}(b \to s\,\gamma)$, $A_{CP}(b \to s\, l^+ l^-)$, $A_{CP}(B_d \to K^*\gamma)$, $A_{CP}(B_s \to \phi\gamma)$, etc. Clean probes of $(\delta_{23})_{LR,RL}$
  - where chromomagnetic enters: $B_d \to \phi K$, $B_d \to \pi K$, $B_s \to \phi\phi$, $B_s \to KK$, etc. Affected by large hadronic uncertainties



$S_{\Phi K}$ vs. Im δ



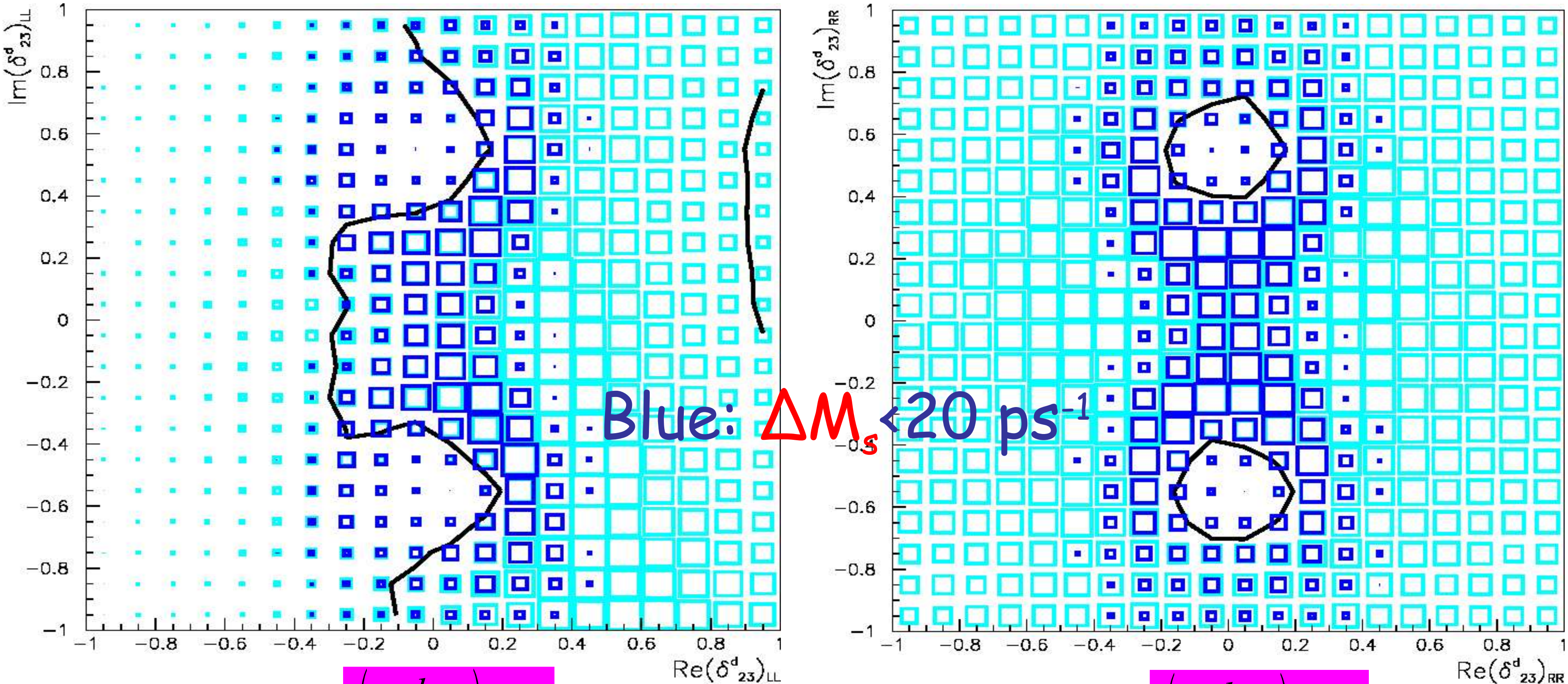


$S_{\Phi K}$ vs A_{CP}(b->sγ)

$m_{\tilde{q}} = m_{\tilde{g}}$
350 GeV

CFMS

CONSTRAINTS ON $(\delta_{23})_{LL,RR}$



$\left(\delta^{d}{}_{23}\right)_{LL}$

$\left(\delta^{d}{}_{23}\right)_{RR}$

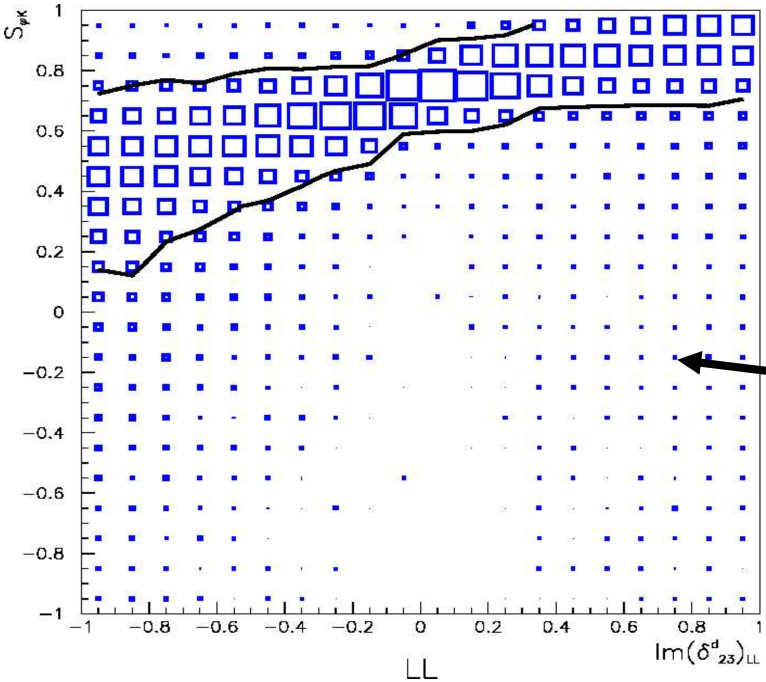
$m_{\tilde{q}} = m_{\tilde{g}}$

350 GeV

Ciuchini, Franco, Masiero & LS

EFFECTS OF $(\delta_{23})_{LL,RR}$

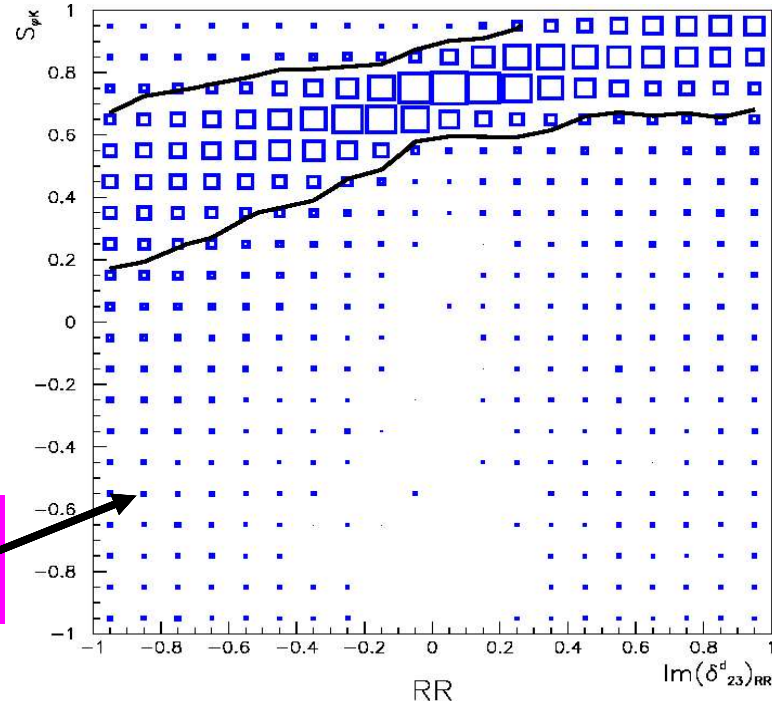
- For small or moderate tan β, Abs $(\delta_{23})_{LL,RR}$ not fixed (only a lower bound from ΔM_s).
- Large effects possible in ΔM_s and $A_{CP}(B_s \to J/\psi\phi)$, $A_{CP}(B_s \to D_s^+ D_s^-)$, etc.
- Effects in rare decays & penguins much less dramatic than LR/RL; however, for large tan β, fall back into LR/RL case

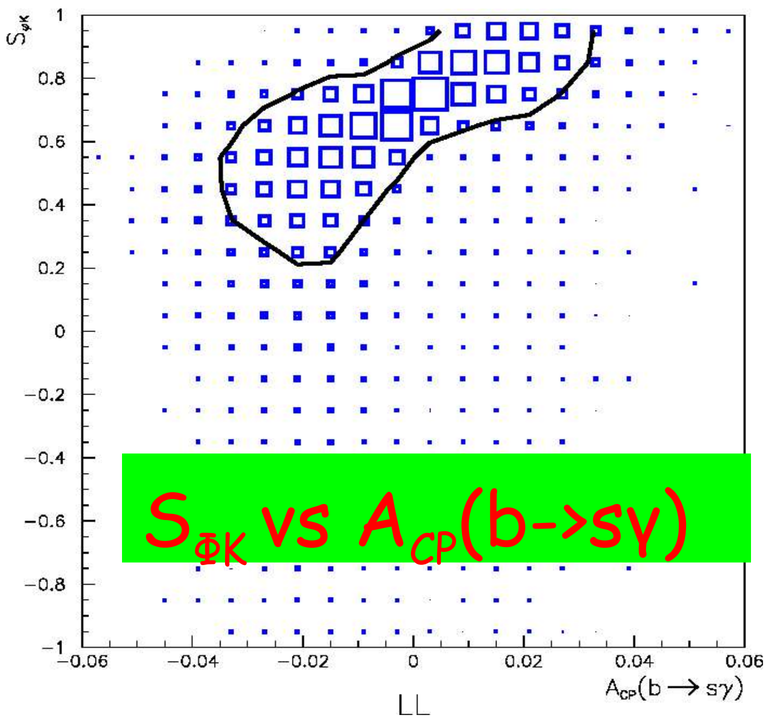


$S_{\Phi K}$ vs. Im δ

$\left(\delta^{d}{}_{23}\right)_{LL}$

$\left(\delta^{d}{}_{23}\right)_{RR}$

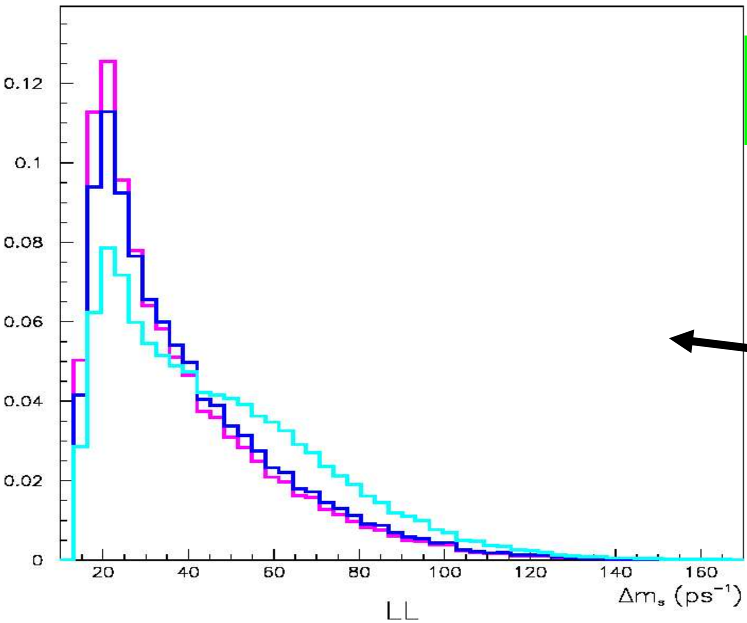




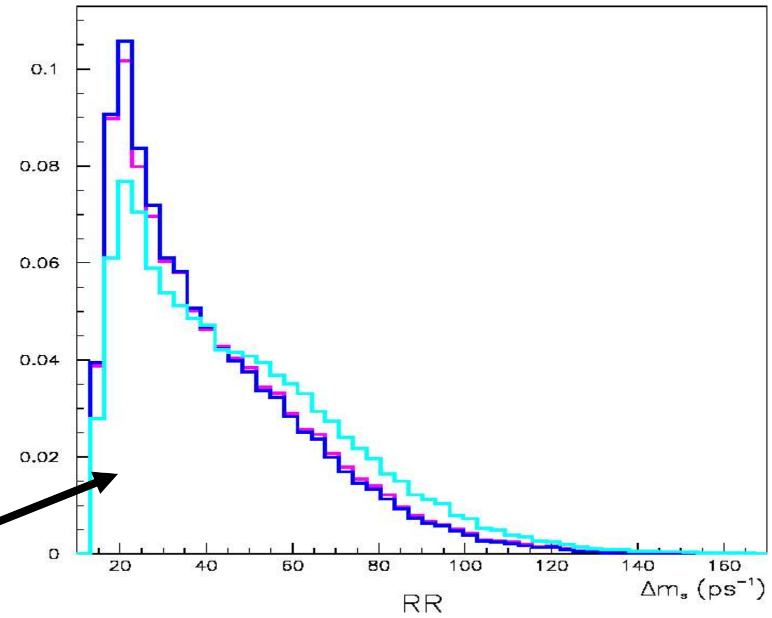
$m_{\tilde{q}} = m_{\tilde{g}}$
350 GeV

ΔM_s for

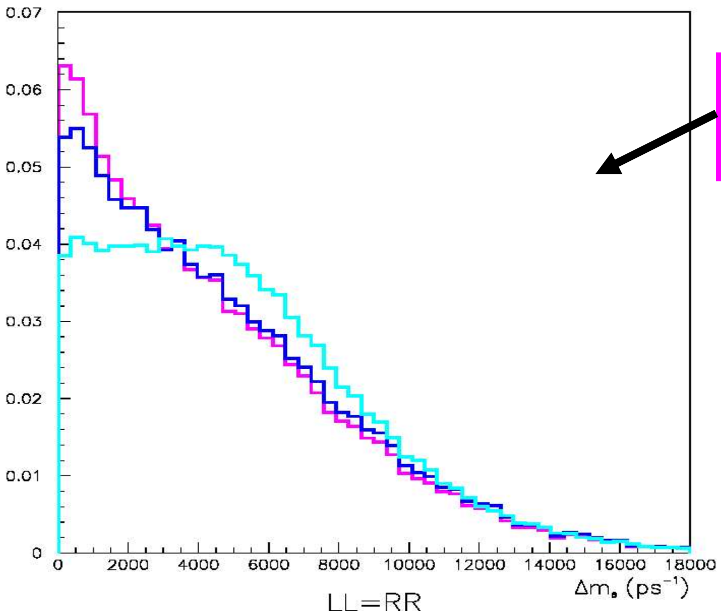
$\left(\delta^d_{23}\right)_{LL}$



$\left(\delta^d_{23}\right)_{RR}$



$\left(\delta^d_{23}\right)_{LL=RR}$



$m_{\tilde{q}} = m_{\tilde{g}}$
350 GeV

Look at the scale! Correspondingly, the phase of the mixing amplitude can be arbitrary

CFMS

CASE 2 - NONSTANDARD UT

- need SUSY contributions to K - K and B_d - B_d mixings larger than the SM one:
  - a) MFV impossible
  - b) need:
    - Im $(\delta_{12})_{LL}{}^2 \sim 10^{-6}$ or Im $(\delta_{12})_{RR}{}^2 \sim 10^{-6}$ or Im $(\delta_{12})_{RR}{}^2 \sim$ Im $(\delta_{12})_{LL}{}^2 \sim 10^{-8}$ or Im $(\delta_{12})_{LR,RL}{}^2 \sim 10^{-8}$
    - $(\delta_{13})_{LL} \sim 10^{-1}$ or $(\delta_{13})_{RR} \sim 10^{-1}$ or $(\delta_{13})_{RR} \sim (\delta_{13})_{LL} \sim 10^{-2}$ or $(\delta_{13})_{LR,RL} \sim 10^{-2}$

CASE 2 - LL/RR DOMINANCE

- If LL or RR terms do the job, then
  - no large effects to be expected in $s \to d$ or $b \to d$ transitions
  - $(\delta_{23})_{LL,RR}$ expected to be small since one must have e.g. $(\delta_{23})_{LL} \times (\delta_{31})_{LL} \sim (\delta_{12})_{LL}$, so no effects expected in ΔM_s.

CASE 2 - LR/RL DOMINANCE

- If LR or RL terms do the job, then
  - large effects should be expected in $s \to d$ or $b \to d$ transitions (ε'/ε, $B_d \to \rho\gamma$, $B_s \to K^*\gamma$,...)
  - $(\delta_{23})_{LR,RL}$ could still saturate present bounds and produce signals in $b \to s$ transitions

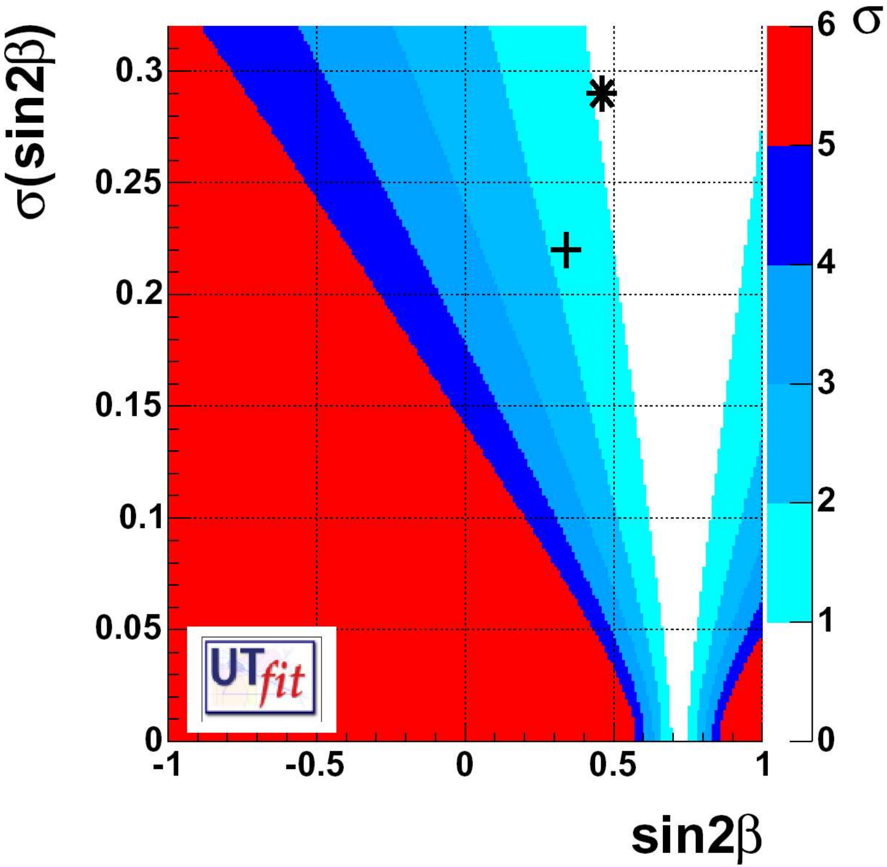
OUTLOOK

- If B-factories improve γ and do not confirm deviations from SM in $b \to s$ penguins, surprises from $B_s - B_s$ mixing or from $B_s \to \mu\mu$ still possible (and well motivated by flavour models and/or GUTs)

OUTLOOK

- UT agreement might still be accidental: surprises in $b \to d$ penguins or rare K decays still possible
- If B-factories confirm deviations in $b \to s$ penguins, rare & nonleptonic $b \to s$ decays should be investigated in depth

$B \to \phi K_s$



+ = HFAG, * = SKEPTICAL

Need a model of hadronic dynamics to quantify uncertainty on sin 2β. Using charming penguins:

$$\sin 2\beta = \begin{cases} 0.34 \pm 0.20 \pm 0.08 & \text{from } S_{\phi K^0} = 0.34 \pm 0.20 \quad \text{(HFAG)} \\ 0.46 \pm 0.28 \pm 0.08 & \text{from } S_{\phi K^0} = 0.46 \pm 0.28 \quad \text{(skeptical)} \end{cases}$$