TWO-BODY NON-LEPTONIC B DECAYS IN THE SM AND BEYOND (selected topics for a 15' talk...)

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With M. Ciuchini, E. Franco, A. Masiero and M. Pierini

- General ideas about $B \to M_1 M_2$
- $B \to \pi\pi$, $K\pi$
- Supersymmetry in $B \to \Phi K_S$?
- Conclusions

General ideas about B -> M_1M_2 (I)

- BBNS: B decays to light mesons can be consistently computed at NLO in terms of form factors & distribution amplitudes in the $M_B \to \infty$ limit (Neubert's talk)
- Is this limit phenomenologically viable?
  - Expect $O(\Lambda/M) \approx 10$-20% corrections to leading factorized amplitudes
  - Fine unless factorized amplitude suppressed and/or corrections enhanced

General ideas about B -> M_1M_2 (II)

- Corrections to penguins in charmless b->s decays doubly Cabibbo-enhanced w.r.t tree contribution: $(\Lambda/M) x (1/\lambda^2) >> 1$ $\Rightarrow$ dominant effect! Ciuchini, Franco, Martinelli, L.S.
- Possible physical idea: long-distance contributions in penguin contractions of current-current operators:

Charming (c) and GIM (c – u) penguins

CFMS; recently revisited in SCET by Bauer, Pirjol, Rothstein & Stewart

$B \to K\pi$ DECAYS (I)

- Our analysis: BR's

Ciuchini, Franco, Pierini, L.S.

Channel	Fit x 10^6	Exp x 10^6
$K^+\pi^0$	12.2±0.6	12.8±1.1
$K^+\pi^-$	18.6±0.7	18.2±0.8
$K^0\pi^0$	8.6±0.5	11.9±1.5
$K^0\pi^+$	22.4±0.9	21.8±1.4

- $K^0\pi^0 \approx 2\sigma$ too low: "$K\pi$ puzzle"? Fleischer, Mannel; Buras, Fleischer; Buras, Fleischer, Recksiegel, Schwab; Neubert's talk

B -> Kπ DECAYS (II)

- Our analysis: CP asymmetries

CFPS

Channel	Fit x 10^6	Exp x 10^6
$K^+\pi^0$	-0.09±0.03	0.00±0.07
$K^+\pi^-$	-0.08±0.03	-0.095±0.028
$K^0\pi^0$	0.03±0.05	0.03±0.37
$K^0\pi^+$	0.00±0.04	0.02±0.06

$B \to K\pi$ DECAYS (III)

- Fitted values of parameters in $B \to K\pi$:
  - Charming: $|P_1|/F = 0.07 \pm 0.02$ OK
  - GIM: irrelevant – not determined
- To reproduce $K^0\pi^0$ need O(1) isospin breaking in P_1:
  - Are all sources of isospin breaking under control? (theoretically & experimentally)
  - New CP-violating physics in electroweak penguins? Fleischer, Mannel; Grossman, Neubert, Kagan; Yoshikawa; Gronau & Rosner; Buras, Fleischer, Recksiegel, Schwab; ...

B -> ππ DECAYS (I)

- Our analysis: BR's

Ciuchini, Franco, Pierini, L.S.

Channel	Fit x 10^6	Exp x 10^6
$\pi^+\pi^0$	5.2 ± 0.8	5.3 ± 0.8
$\pi^+\pi^-$	4.6 ± 0.4	4.6 ± 0.4
$\pi^0\pi^0$	1.6 ± 0.5	1.9 ± 0.5

- Can accommodate both BaBar and Belle results for $\pi^+\pi^-$ CP asymmetry

$B \to \pi\pi$ DECAYS (II)

- Fitted values of parameters in $B \to \pi\pi$:
  - Charming: $|P_1|/F = 0.16 \pm 0.07$ OK
  - GIM: $|P_1^{GIM}|/F=0.3 \pm 0.1$ large, but:
    - Other non-factorizable contributions neglected
    - For $|P_1^{GIM}|/F= |P_1|/F$ (i.e. no u-penguin) already get $\pi^0\pi^0$ at the level of 10^{-6}
- Penguin pollution is huge, no sensitivity to angle α since no useful bound on P/T can be obtained from present data

B -> ΦK DECAY

- B -> ΦK_S decay is a pure b->s penguin:
  - No direct CPV, in the SM $A_{CP}(t)$ measures mixing phase (sin 2β) up to $O(\lambda^2)$ (Grossman, Isidori & Worah; see also Grossman, Ligeti, Nir & Quinn)

	SM (CFPS)	BaBar	Belle
$S_{K\Phi}$	0.73 ± 0.07	0.45±0.43±0.07	-0.96±0.50±0.10
$C_{K\Phi}$	-0.01 ± 0.05	0.38±0.37±0.12	0.15±0.29±0.08

for sin2β= 0.710±0.037 (UTfit, www.utfit.org)

including constraints from B -> ΦK BR's

$B \to K_S\pi^0$ DECAY

- $B \to K_S\pi^0$ decay amplitude not pure $b \to s$ penguin: not a clean probe of $\sin 2\beta$

	SM (CFPS)	EXP
$S_{K\pi}$	0.7 ± 0.3	0.48 ± 0.48
$C_{K\pi}$	0.5 ± 0.3	0.40 ± 0.30

- $B \to \eta' K_S$ even worse… averaging these modes with $B \to \Phi K_S$ not a good idea!

Also much less sensitive to NP than ΦK_S

Can we estimate NP contributions to $B \to \Phi K_S$?

- Realistic studies of NP effects in $B \to \Phi K_S$ should take into account:
  - Hadronic uncertainties in computation of decay amplitudes
  - Correlation with other b->s observables: b->s γ, b -> s $l^+ l^-$, B->Kπ, ΔM_s, etc.
  - Possible correlations with other FCNC processes: b->d, s->d, LFV, etc.

The SUSY option

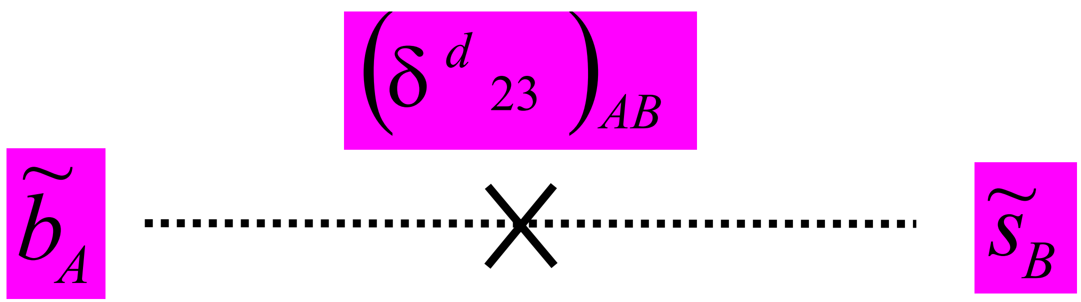
Bertolini, Borzumati & Masiero; Ciuchini et al.; Barbieri & Strumia; Abel, Cottingham & Wittingham; Kagan; Borzumati et al.; Besmer, Greub & Hurth; Lunghi & Wyler; Causse; Hiller; Khalil & Kou; Kane et al.; Harnik et al.; Baek; Hisano & Shimizu; +RPV…

- Well-motivated extension of the SM
- SUSY flavour models, SUSY-GUTS & neutrino oscillations point towards possibly large b-s mixing in the squark sector

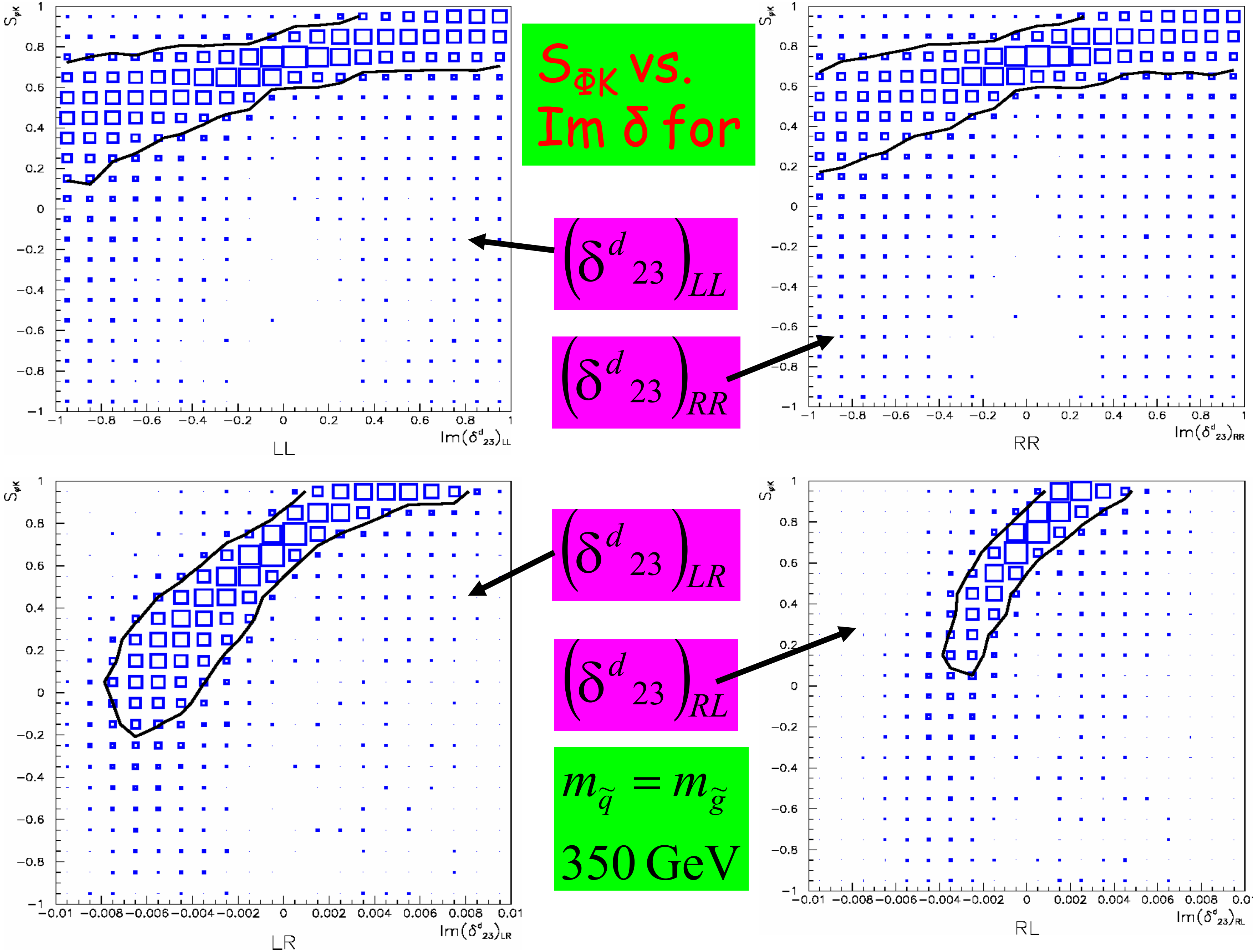
A Model-Independent Analysis

Ciuchini, Franco, Masiero & L.S.

- We consider a MSSM with generic soft SUSY-breaking terms, but
  - dominant gluino contributions only
  - mass insertion approximation



four insertions AB=LL, LR, RL, RR



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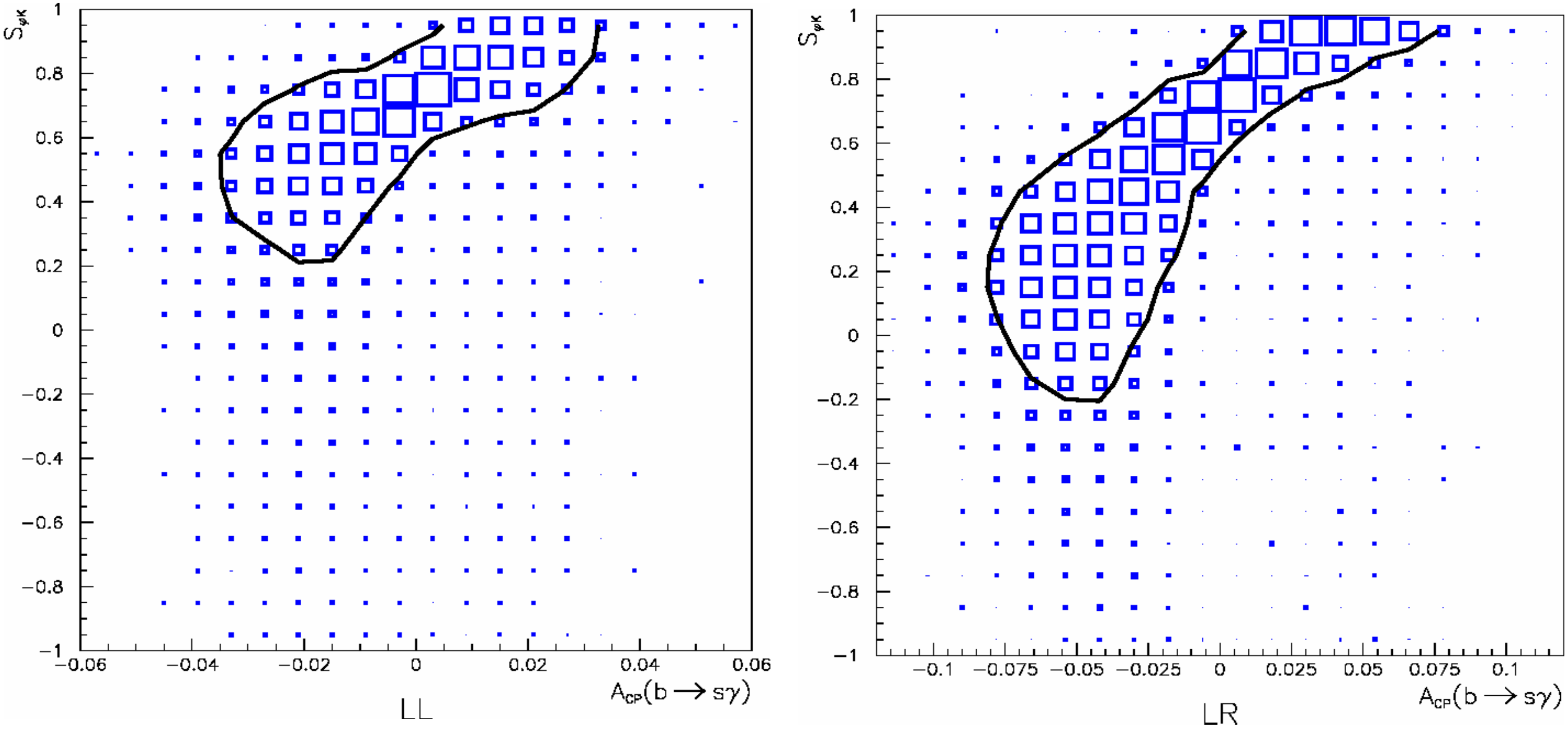
$S_{\Phi K}$ vs $A_{CP}(b\to s\gamma)$

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



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

CONCLUSIONS

- B decays to two light mesons can be reproduced considering $O(\Lambda/M)$ terms in large M limit
- $B \to K^0\pi^0$ problematic, if confirmed requires large isospin violation
- $B \to \Phi K_S$ clean and sensitive to NP
- CPV in $B \to \Phi K_S$: signal of SUSY?
- Await confirmation in $A_{CP}(B \to X_S\gamma)$, B_s mixing & CPV, $B \to X_S l^+ l^-$, ...

BACKUP SLIDES

NP in b->s penguins?

- NP in s -> d or b -> d transitions is
  - Strongly constrained by the UT fit
  - "Unnecessary", given the great success and consistency of the fit
- NP in b -> s transitions is
  - Much less (un-) constrained by the UT fit
  - Natural in many flavour models, given the strong breaking of family SU(3) (Pomarol, Tommasini; Barbieri, Dvali, Hall; Barbieri, Hall; Barbieri, Hall, Romanino; Berezhiani, Rossi; Masiero, Piai, Romanino L.S.;…)
  - Hinted at by ν's in SUSY-GUTs (Baek, Goto, Okada, Okumura; Moroi; Akama, Kiyo, Komine, Moroi; Chang, Masiero, Murayama; Hisano, Shimizu; Goto, Okada, Shimizu, Shindou, Tanaka;…)

Ingredients in the analysis

- Constraints on b-> s transitions:

$$BR(B \to X_S\gamma) = (3.29 \pm 0.34) \times 10^{-4}$$

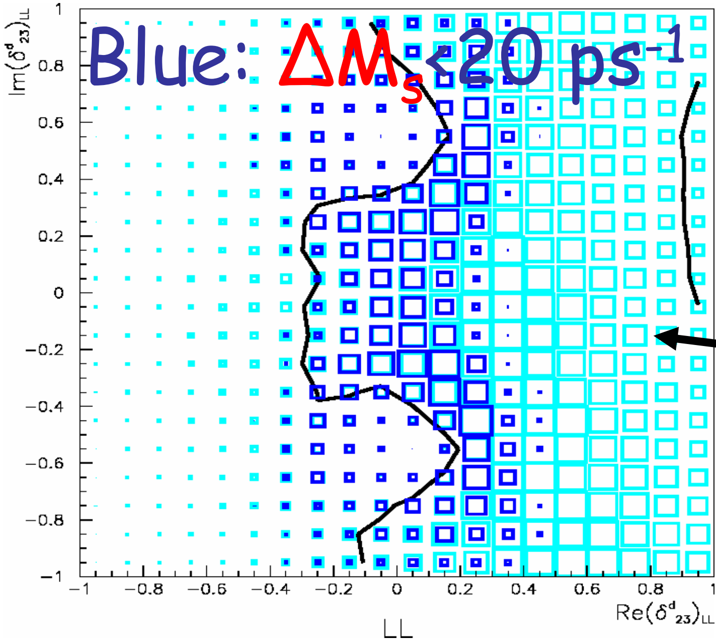
$$A_{CP}(B \to X_S\gamma) = (-0.02 \pm 0.04)$$

$$BR(B \to X_S l^+ l^-) = (6.1 \pm 1.4 \pm 1.3) \times 10^{-6}$$

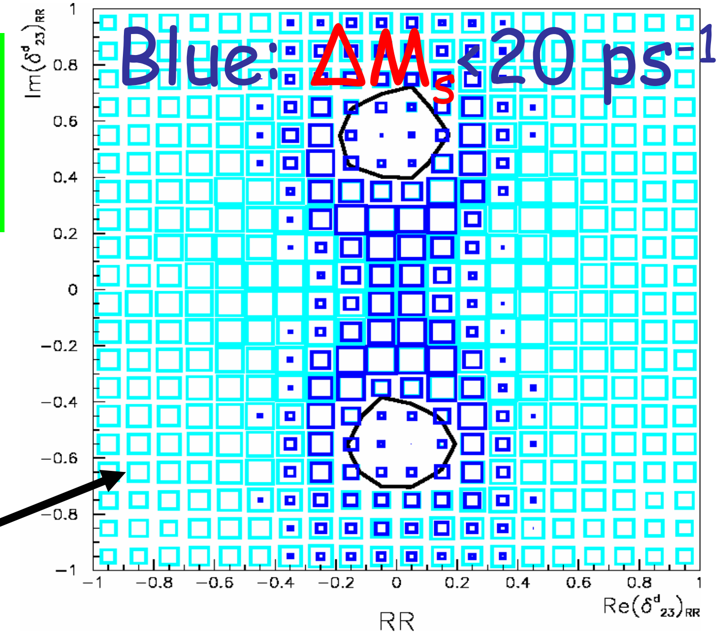
$$\Delta M_S > 14.4\ \mathrm{ps}^{-1} \qquad BR(B \to K\pi)$$

perform a MonteCarlo analysis, studying clustering in Re δ, Im δ plane. Keep in mind that hadronic uncertainties are not fully under control!

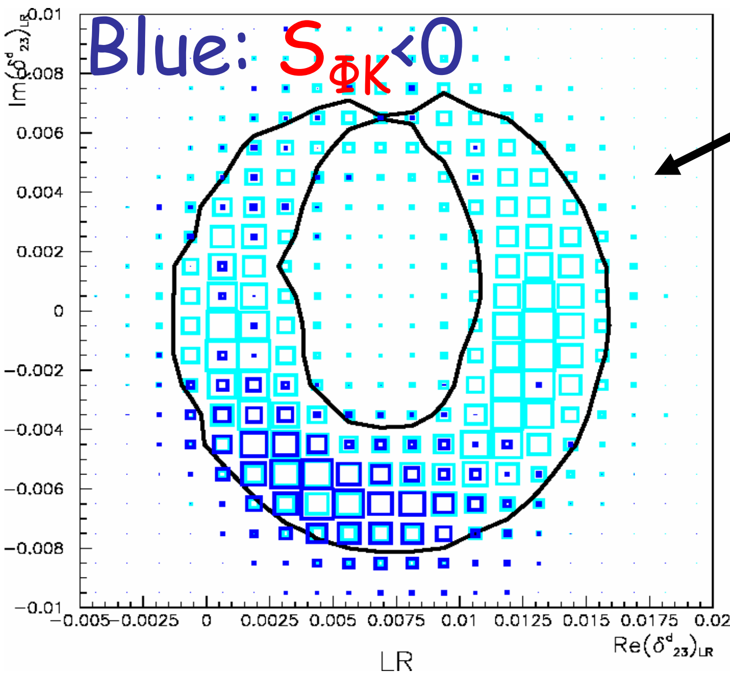
Im δ vs. Re δ for



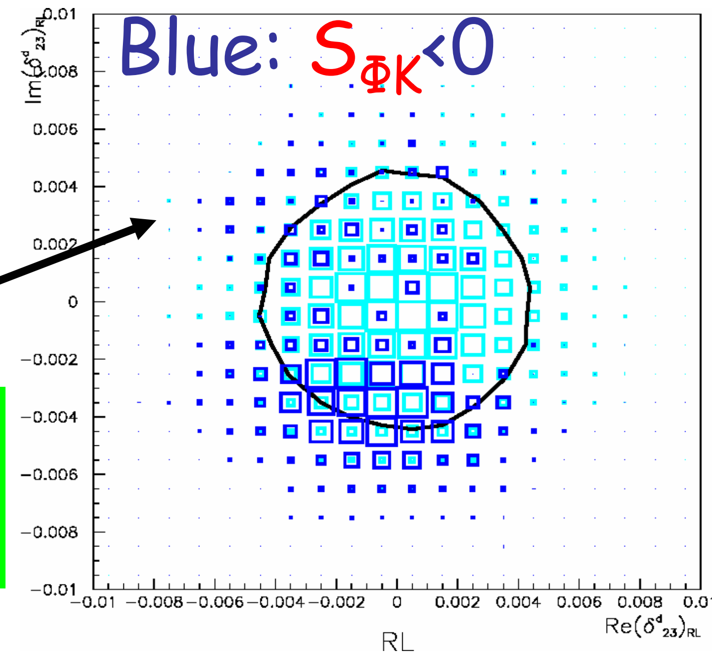
$\left(\delta^{d}{}_{23}\right)_{LL}$



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



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



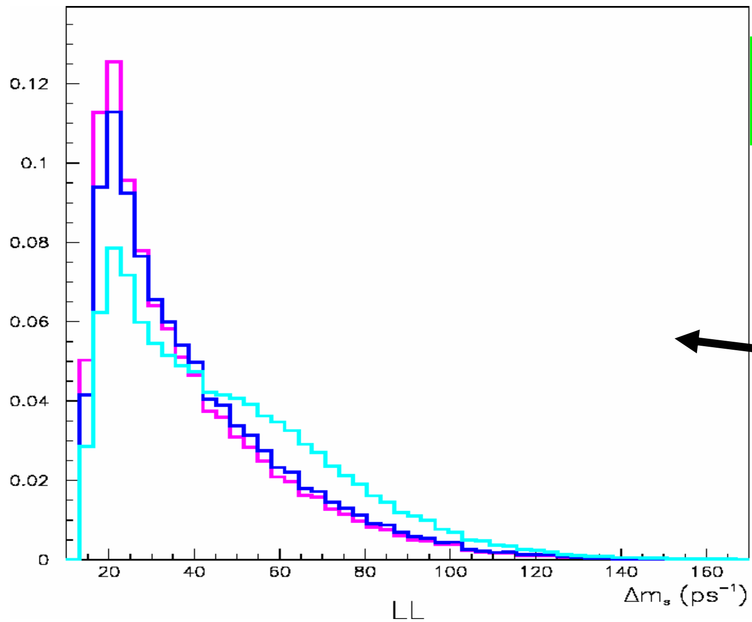
$\left(\delta^{d}{}_{23}\right)_{RL}$

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

350 GeV

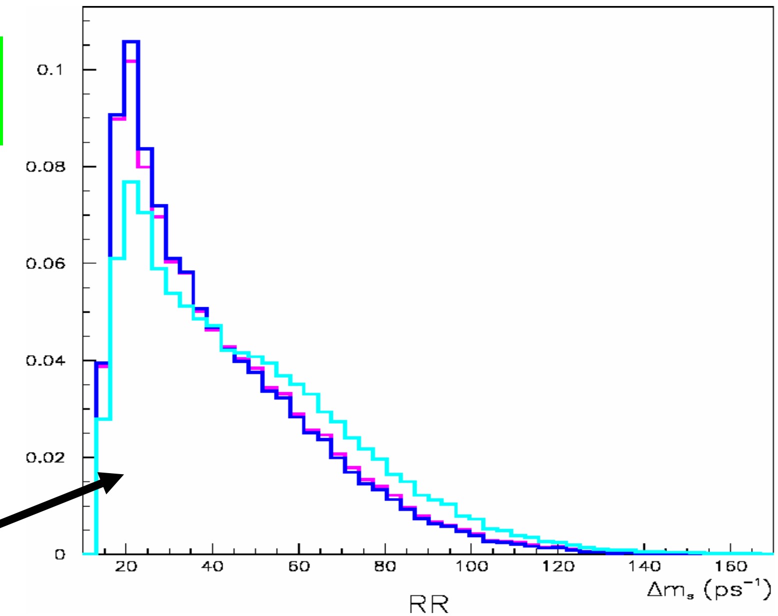
CFMS

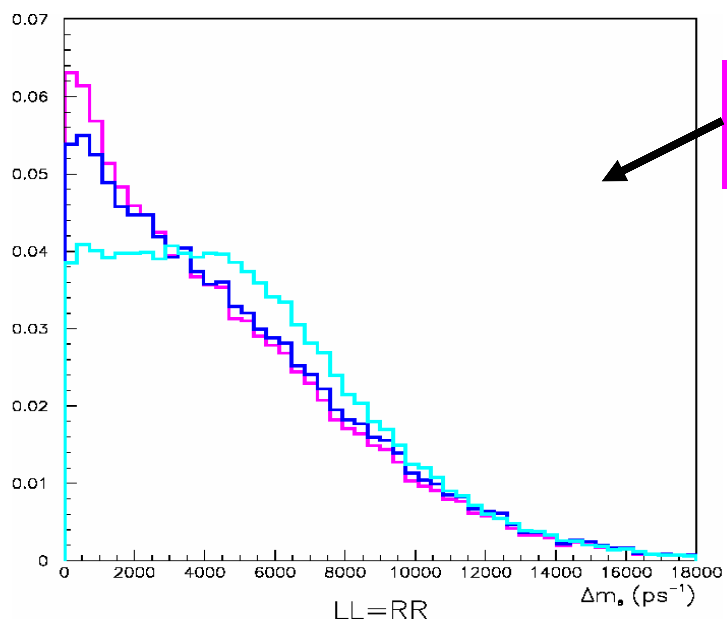
ΔM_s for



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

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





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

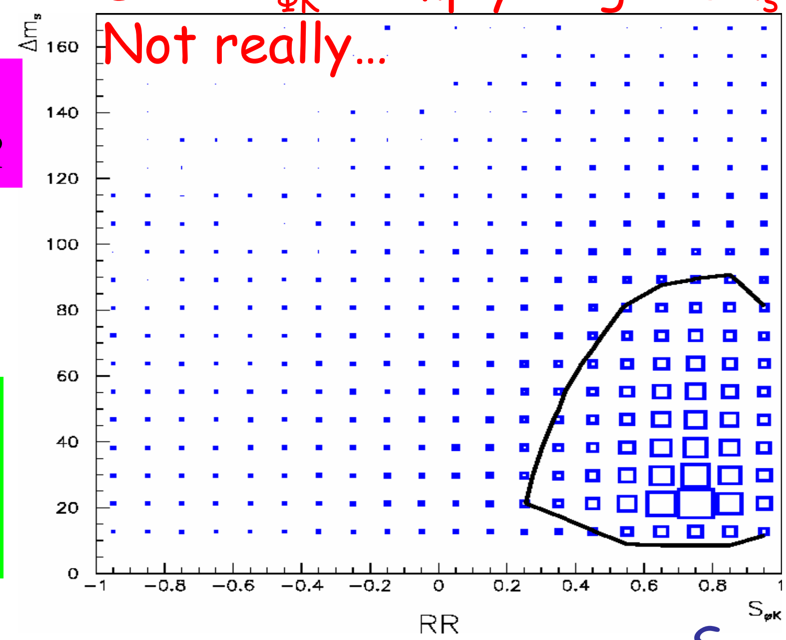
$m_{\tilde{q}} = m_{\tilde{g}}$

350 GeV

CFMS

Does $S_{\Phi K}$<0 imply large ΔM_s?

Not really…



$S_{\Phi K}$

On the sensitivity of B->KX decays to SUSY contributions

Various sources of SUSY effects in the decay amplitudes:

- Leading power in $1/m_b$
  - the chromomagnetic operator: In QCD factorization, it appears as an α_s correction
    - the one-loop proof of factorization does not apply to this term
    - other power-suppressed terms may be numerically of the same size
- m_b-suppressed corrections
  - Cabibbo-enhanced terms: which mechanism?
    - penguin annihilation (BBNS) $\Rightarrow$ *moderate* sensitivity to SUSY
    - charming penguins $\Rightarrow$ *no* sensitivity to SUSY

We use BBNS factorization to maximize the sensitivity to SUSY but, in any case, hadronic uncertainties are not fully under control