SuperIso and new constraints from B physics

Farvah Nazila Mahmoudi

Uppsala University, SWEDEN

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Outline

Motivations

- $b \longrightarrow s\gamma$ transitions: very sensitive to new physics
  - forbidden at the tree level in SM and can only be induced via loop diagrams,
  - SM contributions are vanishingly small,
- branching ratios have been extensively used to constrain SUSY parameter space
- Study another observable: isospin asymmetry
  - already measured by BELLE and BABAR
  - calculable with the publicly available code SuperIso

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Effective Hamiltonian

The idea of $B \longrightarrow X_s\gamma$ decay begins with introducing an effective Hamiltonian:

$$\mathcal{H}_{eff} = -\frac{4G_F}{\sqrt{2}} V_{ts}^* V_{tb} \sum_{i=1}^{8} C_i(\mu) O_i(\mu)$$

$$\begin{cases} O_1 = (\bar{s}_L \gamma_\mu T^a c_L)(\bar{c}_L \gamma^\mu T^a b_L) & O_2 = (\bar{s}_L \gamma_\mu c_L)(\bar{c}_L \gamma^\mu b_L) \\ O_3 = (\bar{s}_L \gamma_\mu b_L) \sum_q (\bar{q} \gamma^\mu q) & O_4 = (\bar{s}_L \gamma_\mu T^a b_L) \sum_q (\bar{q} \gamma^\mu T^a q) \\ O_5 = (\bar{s}_L \gamma_{\mu_1} \gamma_{\mu_2} \gamma_{\mu_3} b_L) \sum_q (\bar{q} \gamma^{\mu_1} \gamma^{\mu_2} \gamma^{\mu_3} q) & \\ O_6 = (\bar{s}_L \gamma_{\mu_1} \gamma_{\mu_2} \gamma_{\mu_3} T^a b_L) \sum_q (\bar{q} \gamma^{\mu_1} \gamma^{\mu_2} \gamma^{\mu_3} T^a q) & \\ O_7 = \frac{e}{16\pi^2} m_b (\bar{s}_L \sigma^{\mu\nu} b_R) F_{\mu\nu} & O_8 = \frac{g}{16\pi^2} m_b (\bar{s}_L \sigma^{\mu\nu} T^a b_R) G^a_{\mu\nu} \end{cases}$$

Wilson Coefficients

$$C_i^{eff}(\mu) = C_i^{(0)eff}(\mu) + \frac{\alpha_s(\mu)}{4\pi} C_i^{(1)eff}(\mu) + \cdots$$

The effective coefficients evolve according to their RGE:

$$\mu \frac{d}{d\mu} C_i^{eff}(\mu) = C_j^{eff}(\mu) \gamma_{ji}^{eff}(\mu)$$

driven by the anomalous dimension matrix $\hat{\gamma}^{eff}(\mu)$:

$$\hat{\gamma}^{eff}(\mu) = \frac{\alpha_s(\mu)}{4\pi} \hat{\gamma}^{(0)eff} + \frac{\alpha_s^2(\mu)}{(4\pi)^2} \hat{\gamma}^{(1)eff} + \cdots$$

Isospin Asymmetry

$$\Delta_{0-} \equiv \frac{\Gamma(\bar{B}^0 \to \bar{K}^{*0}\gamma) - \Gamma(B^- \to K^{*-}\gamma)}{\Gamma(\bar{B}^0 \to \bar{K}^{*0}\gamma) + \Gamma(B^- \to K^{*-}\gamma)}$$

$$\Delta_{0-} = \mathrm{Re}(b_d - b_u)\,.$$

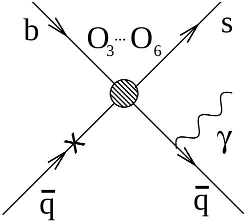
$$b_q = \frac{12\pi^2 f_B\, Q_q}{m_b\, T_1^{B\to K^*} a_7^c} \left(\frac{f_{K^*}^{\perp}}{m_b} K_1 + \frac{f_{K^*} m_{K^*}}{6\lambda_B m_B} K_2 \right)$$

$$a_7^c = C_7 + \frac{\alpha_s(\mu) C_F}{4\pi} \Big(C_1(\mu) G_1(s_p) + C_8(\mu) G_8 \Big) + \frac{\alpha_s(\mu_h) C_F}{4\pi} \Big(C_1(\mu_h) H_1(s_p) + C_8(\mu_h) H_8 \Big)$$

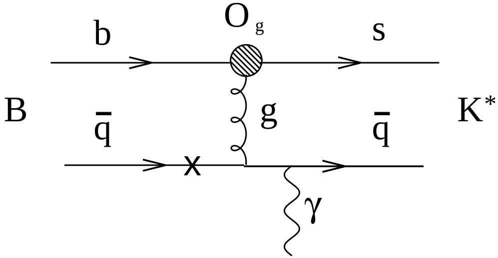
In the Standard Model: $\Delta_{0-} \simeq 8\%$

Kagan and Neubert, Phys. Lett. B 539, 227 (2002)
Bosch and Buchalla, Nucl. Phys. B 621, 459 (2002)

Contribution to Isospin Asymmetry



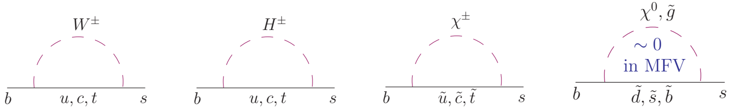
QCD penguin operators



Electro- and chromo-magnetic operators

Supersymmetric contributions

MSSM with minimal flavor violation (MFV)
↪ no more flavor/CP violation than in SM



Calculation of the coefficients at $\mu = M_W$:

$$C_i(\mu) = C_i^{W^\pm}(\mu) + C_i^{H^\pm}(\mu) + C_i^{\chi^\pm}(\mu)$$

Gómez et al. Phys. Rev. D74, 015015 (2006)
Degrassi et al. JHEP 12, 009 (2000)
Ciuchini et al. Nucl. Phys. B 534, 3 (1998)
Ciuchini et al. Nucl. Phys. B 527, 21 (1998)

SuperIso v1.0

A public C–program for calculating isospin asymmetry of $B \to K^*\gamma$ in supersymmetry.

- calculation of isospin asymmetry and inclusive branching ratio,
- automatic calculation in mSUGRA, AMSB and GMSB scenarios,
- compatible with the SUSY Les Houches Accord Format,
- modular program, with a well-defined structure.

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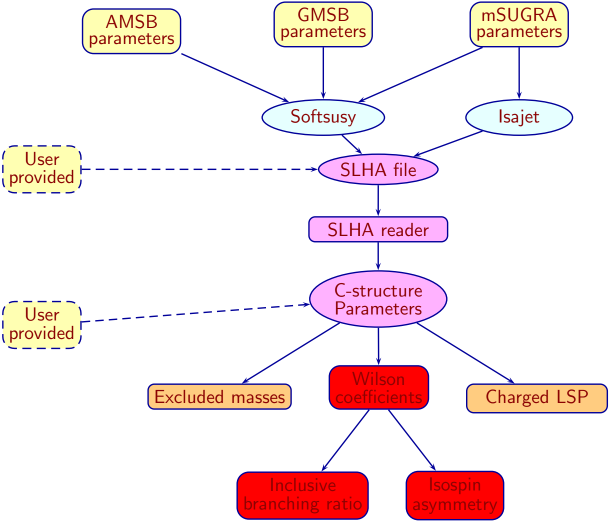


SuperIso v1.0

Can be downloaded from:

http://www3.tsl.uu.se/∼nazila/superiso/

Manual:

F. Mahmoudi, arXiv:0710.2067 to appear in Comp. Phys. Comm.

For more information:

Ahmady & Mahmoudi, Phys. Rev. D75 (2007)

F. Mahmoudi, arXiv:0710.4501, submitted to JHEP

Experimental data

BABAR

$$\Delta_{0-} = -0.006 \pm 0.058(stat) \pm 0.009(syst) \pm 0.024(R^{+/0})$$

Aubert et al. (BABAR Collaboration) Phys. Rev. D72 (2005)

BELLE

$$\Delta_{0+} = +0.012 \pm 0.044(stat) \pm 0.026(syst)$$

Nakao et al. (BELLE Collaboration) Phys. Rev. D69 (2004)

Allowed Region: $-0.018 < \Delta_{0-} < 0.093$

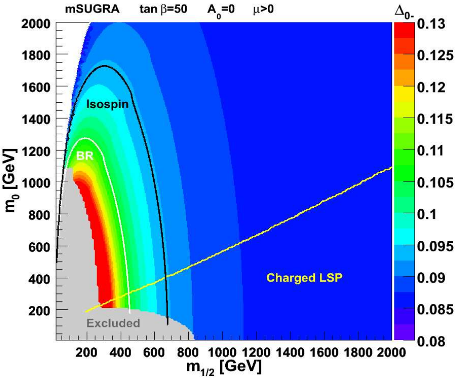
Experimental limits

Lower bounds on sparticle masses in GeV:

Particle	h^0	χ_1^0	$\tilde{l}_R$	$\tilde{\nu}_{e,\mu}$	$\chi_1^\pm$	$\tilde{t}_1$	$\tilde{g}$	$\tilde{b}_1$	$\tilde{\tau}_1$	$\tilde{q}_R$
Lower bound	111	46	88	43.7	67.7	92.6	195	89	81.9	250

Yao et al. J. Phys. G33 (2006)

Results: mSUGRA



Ahmady & Mahmoudi, Phys. Rev. D75 (2007)

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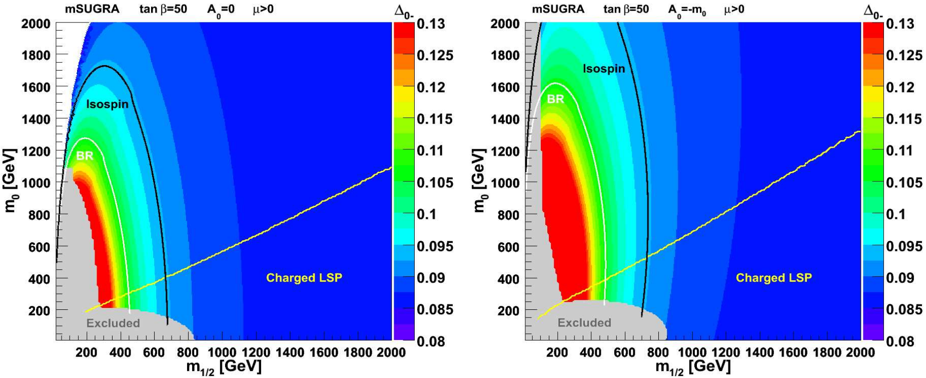

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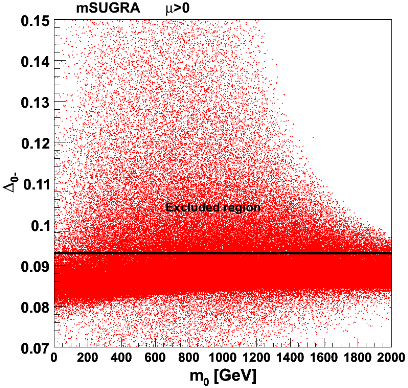

F. Mahmoudi, arXiv:0710.4501

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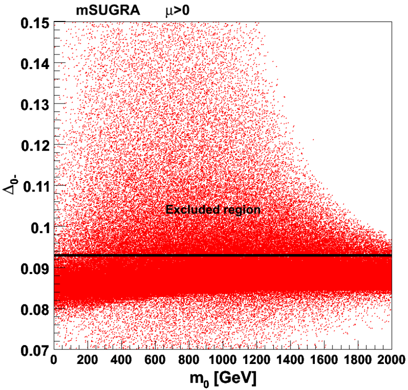

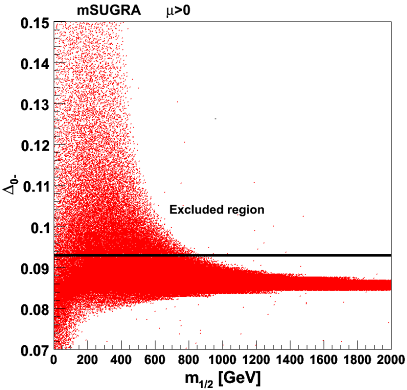

F. Mahmoudi, arXiv:0710.4501

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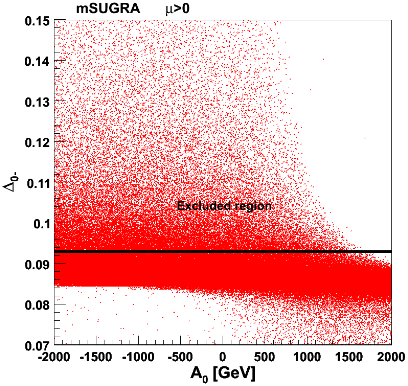

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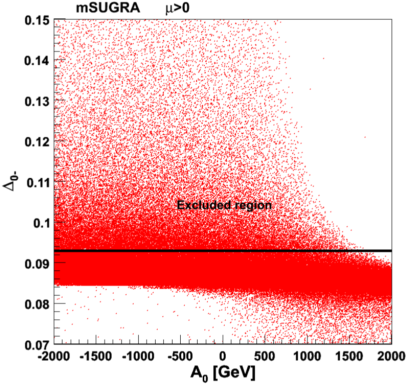
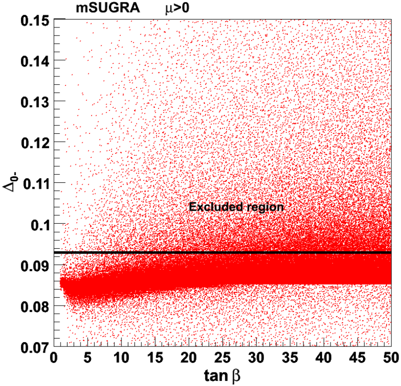
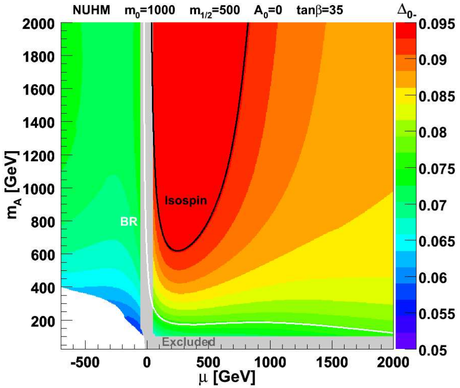




F. Mahmoudi, arXiv:0710.4501

Results: NUHM



F. Mahmoudi, arXiv:0710.4501

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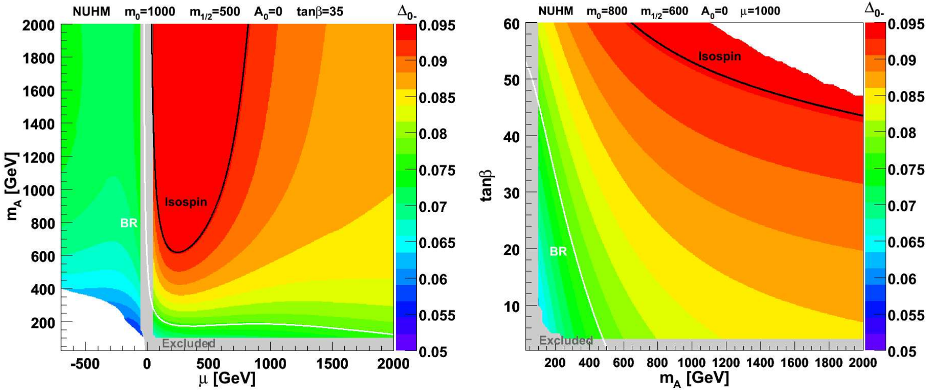
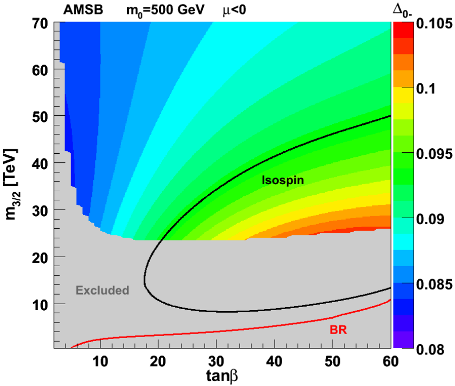


F. Mahmoudi, arXiv:0710.4501

Results: AMSB



F. Mahmoudi, arXiv:0710.4501

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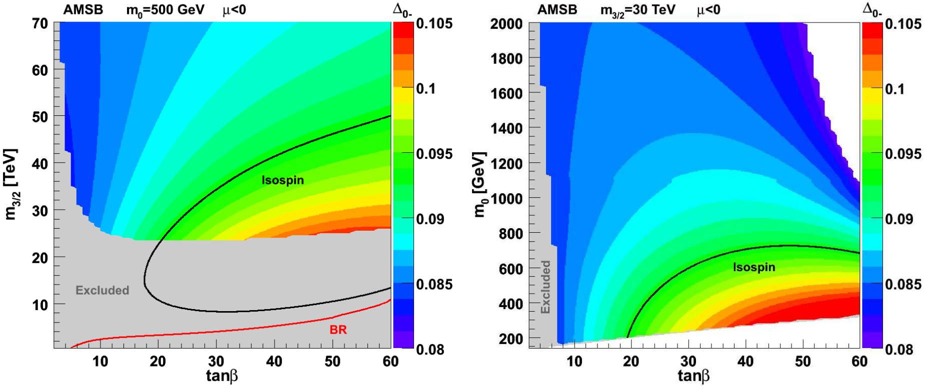
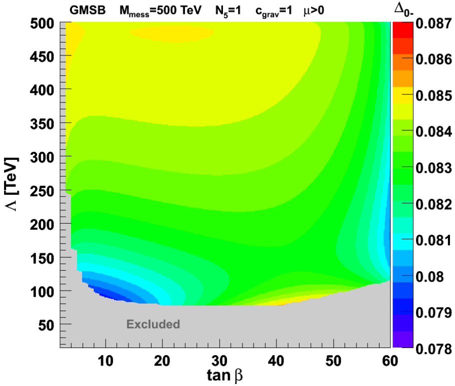


F. Mahmoudi, arXiv:0710.4501

Results: GMSB



F. Mahmoudi, arXiv:0710.4501

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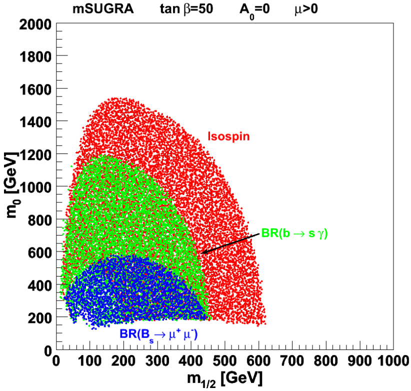
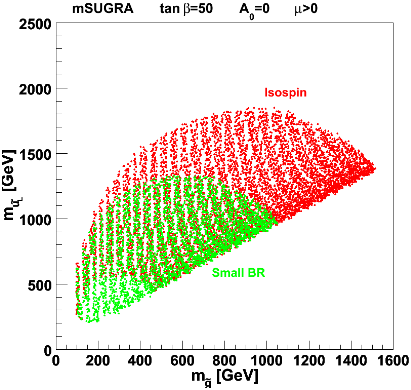


$$\mathcal{B}(B_s \to \mu^+\mu^-) < 0.93 \times 10^{-7}$$

Results:

mSUGRA



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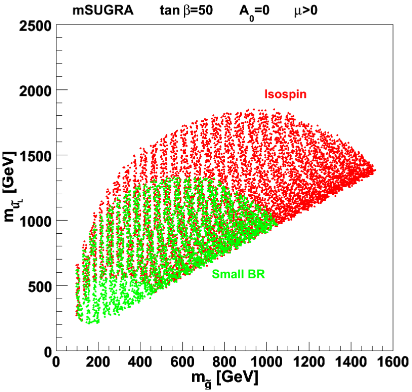
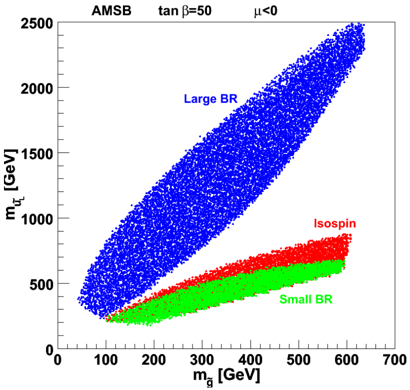


AMSB



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Conclusion

- We can obtain new constraints (new contours) using the Isospin asymmetry
- Very tight constraints on the studied parameter spaces, complementary or even more restrictive than the inclusive branching ratio
- Can be applied to other scenarios
- Isospin asymmetry seems to be an important observable in the precision test of the SM and in constraining new physics parameters

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