New SUSY parameter constraints from $b \longrightarrow s\gamma$

Farvah Nazila Mahmoudi

Uppsala University

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Activities

- New SUSY parameter constraints from $b \to s\gamma$
- Phenomenology of QCD: Higgs background
- SUSY: phenomenological calculations, constraints on the supersymmetric parameters, spin measurements...
- Collider signals of extra-dimensions
- B–physics

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Motivations

- A good strategy to find the information on SUSY particles would be
  - to look at where the SM contributions are vanishlingly small,
  - to study processes for which QCD corrections are known with high accuracy
  - and branching ratios can be measured at LHC even at low luminosity.
- $b \longrightarrow d, s$ transitions (FCNC) are forbidden at the tree level in SM and can only be induced via loop diagrams ("penguin" and "box" topologies)

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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

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

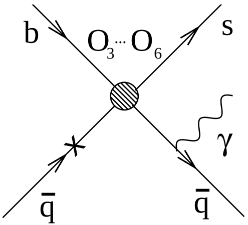
The effective coefficients evolve according to their RGE:

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

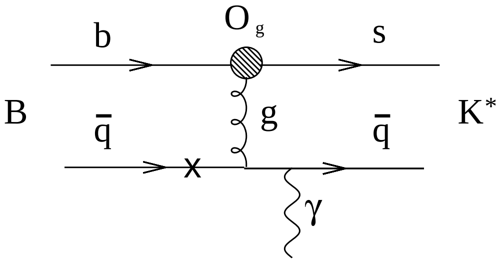
driven by the anomalous dimension matrix $\hat{\gamma}^{eff}(\mu)$:

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

Contribution to Isospin Asymmetry



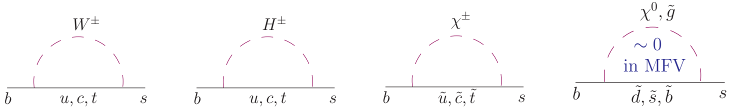
QCD penguin operators



Electro- and chromo-magnetic operators

Supersymmetric contributions

MSSM with minimal flavor violation (MFV)
$\hookrightarrow$ 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)

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)

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: $-0.047 < \Delta_{0-} < 0.093$

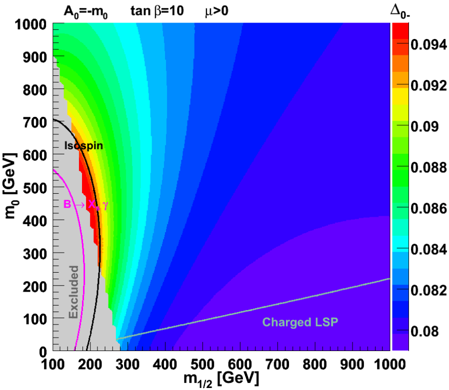
Experimental limits

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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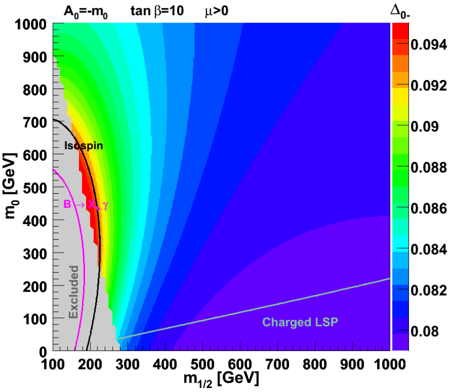

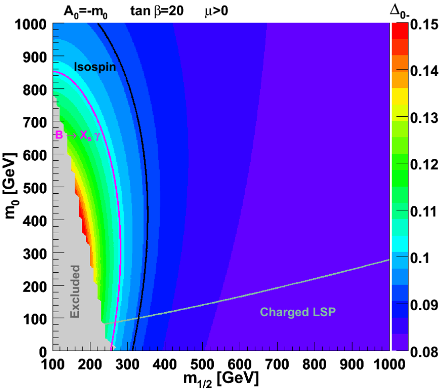

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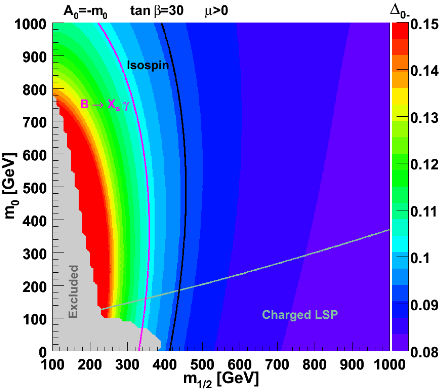

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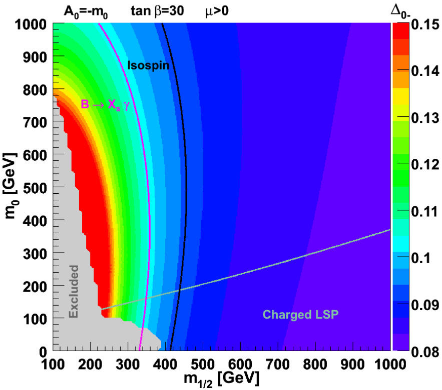

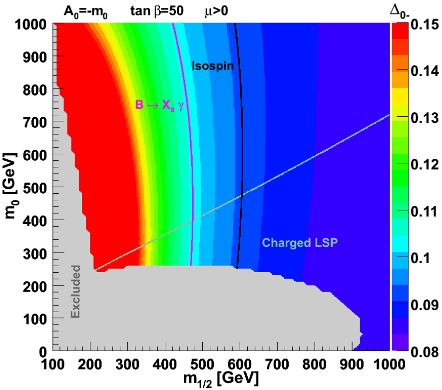

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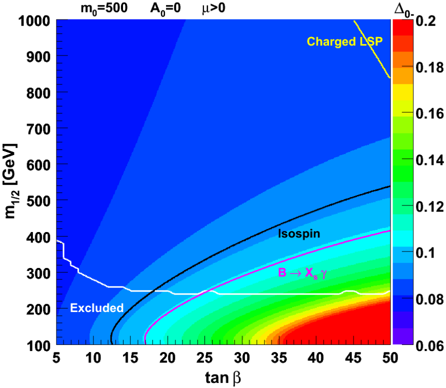

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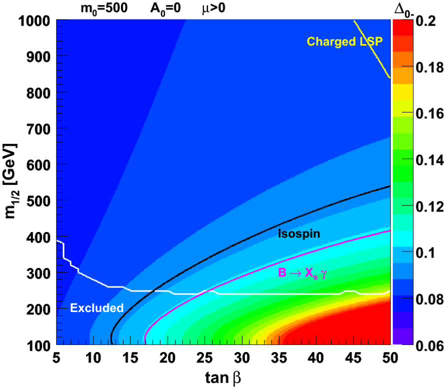

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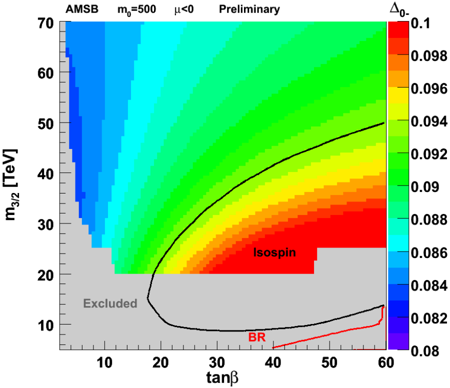
Results: AMSB



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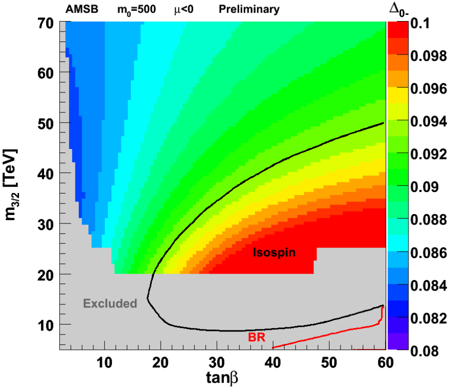

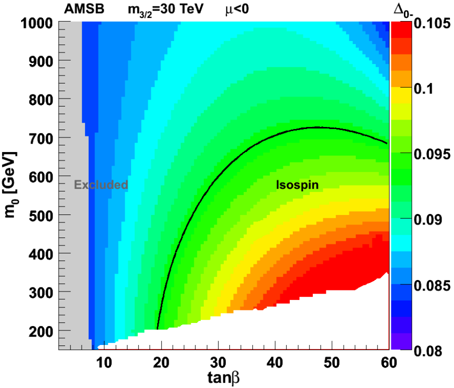

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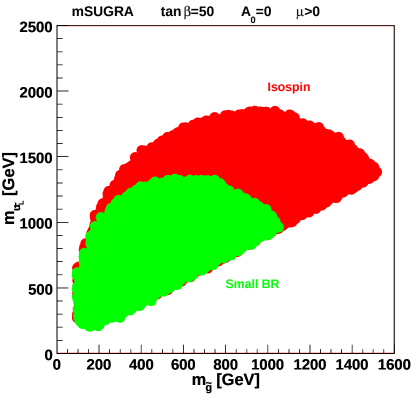

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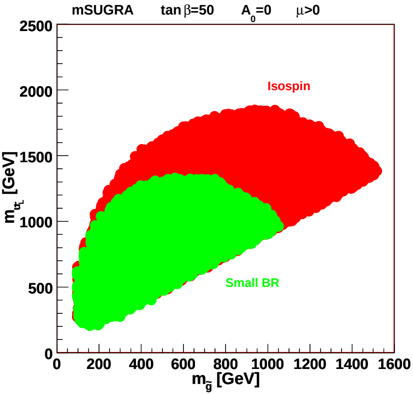
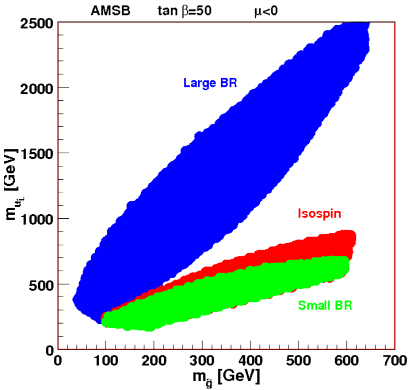


AMSB



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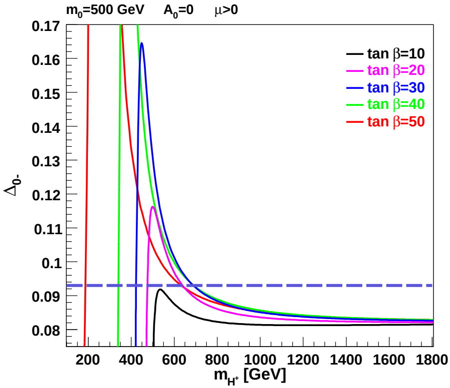

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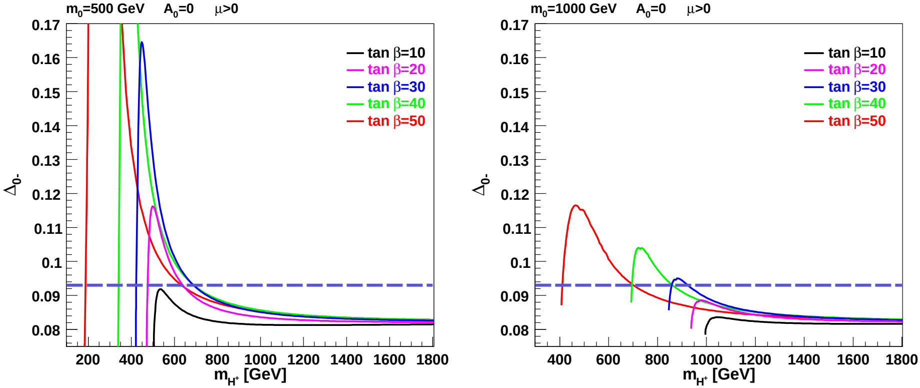

SuperIso v1.0

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

- calculation of isospin asymmetry and inclusive branching ratio,
- reads Les Houches Accord files,
- interface with Softsusy and Isajet,
- automatic calculation in mSUGRA, AMSB ans GMSB scenarios.

Can be downloaded from:

http://www.isv.uu.se/~nazila/superiso/

Conclusion

- Very tight constraints on the mSUGRA parameter space, better than the inclusive branching ratio
- Can be applied to other models
- 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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