SUSY: Spectra and Phenomenology

by[a]

Ben Allanach (University of Cambridge)

Talk outline

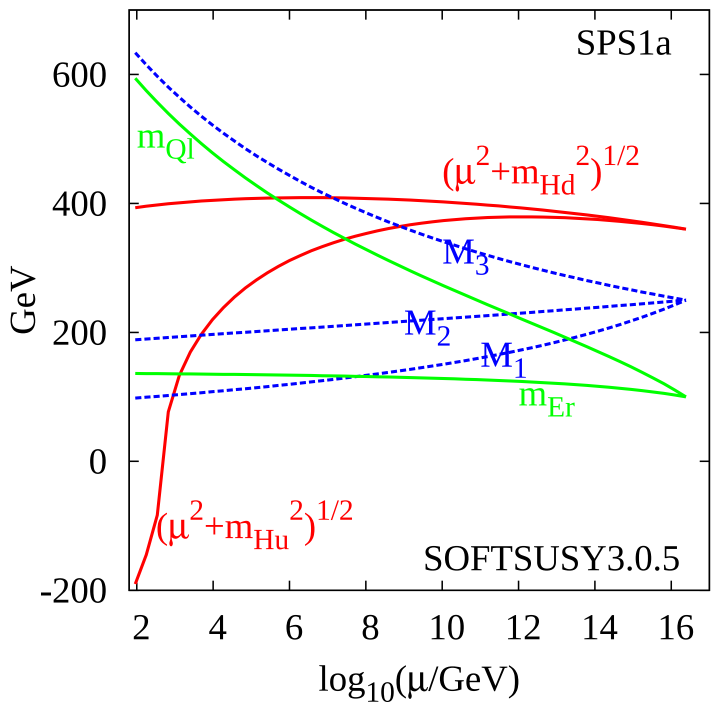
- `SOFTSUSY3.0`
- AMSB Flavour
- SUSY Fits
- $0\nu\beta\beta$ and $\not{R}_p$

[a] Or: "What I've been up to lately"

SOFTSUSY

SOFTSUSY is an MSSM spectrum generator. Like 3 other public spectrum generators, it predicts MSSM masses and couplings consistent with weak-scale data and an assumed high-scale boundary condition on SUSY breaking.

BCA, hep-ph/0104145



A New Version

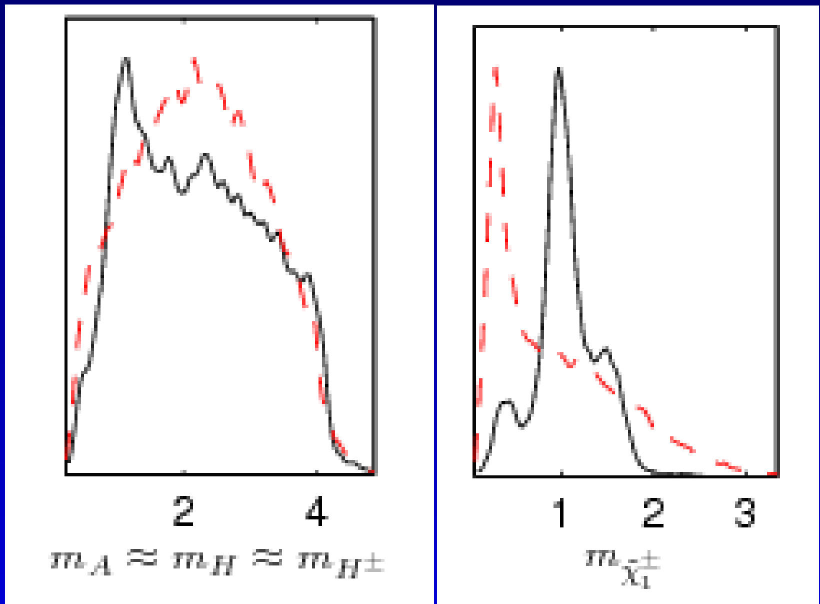
Version 3.0 includes[a]

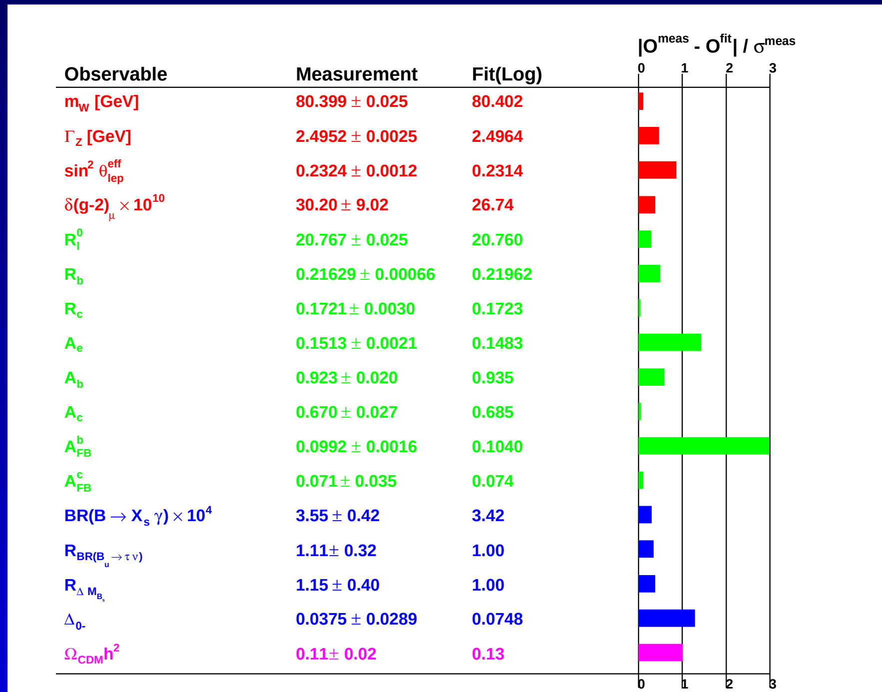
- *flavour* violation: squark/quark mixing
- $R-$parity violation
- SUSY Les Houches Accord 2 output for both of the above

[a] BCA, M.A. Bernhardt, `arXiv:0903.1805`

pMSSM Fits

Combined Bayesian fit[a] to a 25 parameter weak-scale phenomenological MSSM model to all current indirect data: relic density, B-physics, electroweak data, $(g-2)_\mu$.





Observable	Measurement	Fit(Log)
m_W [GeV]	80.399 ± 0.025	80.402
Γ_Z [GeV]	2.4952 ± 0.0025	2.4964
$\sin^2\theta^{eff}_{lep}$	0.2324 ± 0.0012	0.2314
$\delta(g-2)_\mu \times 10^{10}$	30.20 ± 9.02	26.74
R^0_l	20.767 ± 0.025	20.760
R_b	0.21629 ± 0.00066	0.21962
R_c	0.1721 ± 0.0030	0.1723
A_e	0.1513 ± 0.0021	0.1483
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.685
A^b_{FB}	0.0992 ± 0.0016	0.1040
A^c_{FB}	0.071 ± 0.035	0.074
$BR(B \to X_s \gamma) \times 10^4$	3.55 ± 0.42	3.42
$R_{BR(B_u \to \tau\nu)}$	1.11 ± 0.32	1.00
$R_{\Delta M_{B_s}}$	1.15 ± 0.40	1.00
Δ_{0-}	0.0375 ± 0.0289	0.0748
$\Omega_{CDM}h^2$	0.11 ± 0.02	0.13

[a] S.S. AbdusSalam, BCA, F. Quevedo, F. Feroz, M. Hobson, arXiv:0904.2548

Model Comparison

Calculate the *Bayesian evidence* of each model

$$\mathcal{Z}_i = \int p(\underline{d}|\underline{m}, H_i)\, p(\underline{m}|H_i)\, d\underline{m}$$

$$\frac{p(H_1|\underline{d})}{p(H_0|\underline{d})} = \frac{p(\underline{d}|H_1)p(H_1)}{p(\underline{d}|H_0)p(H_0)} = \frac{\mathcal{Z}_1}{\mathcal{Z}_0}\frac{p(H_1)}{p(H_0)},$$

$p_i/p^{lin}_{\rm mSUGRA}$	asymmetric[a] $\mathcal{L}_{\rm DM}$		
Model/Prior	linear	log	flat μ, B
mSUGRA	1	3	4
mAMSB	164	403	148
LVS	18	20	22

[a] AbdusSalam, BCA, Dolan, Feroz, Hobson, arXiv:0906.0957

Anomaly Mediated SUSY Breaking

Loop suppressed soft masses[a]

$$
\begin{aligned}
M_\alpha &= m_{3/2}\beta_{g_\alpha}/g_\alpha, \\
(m^2)^i{}_j &= \frac{1}{2}m_{3/2}^2\mu\frac{d}{d\mu}\gamma^i{}_j, \\
\gamma^i_j &= \frac{1}{2}Y^{ikl}Y_{jkl} - 2\sum_\alpha g_\alpha^2[C(R_\alpha)]^i{}_j.
\end{aligned}
$$

- Always present for a hidden sector
- Dominant in brane set-up:

$$\mathcal{L} = \mathcal{L}_{vis} + \mathcal{L}_{hid}$$

- SUSY Flavour problem ameliorated

Flavoured AMSB

Previous literature only considers (33) entries to Yukawas. We include flavour corrections, e.g.

$$\frac{(16\pi^2)^2 (m^2_{\tilde{Q}})^T}{m^2_{3/2}} = \left(-\frac{11}{50} g_1^4 - \frac{3}{2} g_2^4 + 8 g_3^4 \right) .\mathbf{1} +$$

$$(Y_U Y_U^\dagger) \left(3\mathrm{Tr}(Y_U Y_U^\dagger) - \frac{13}{15} g_1^2 - 3 g_2^2 - \frac{16}{3} g_3^2 \right) +$$

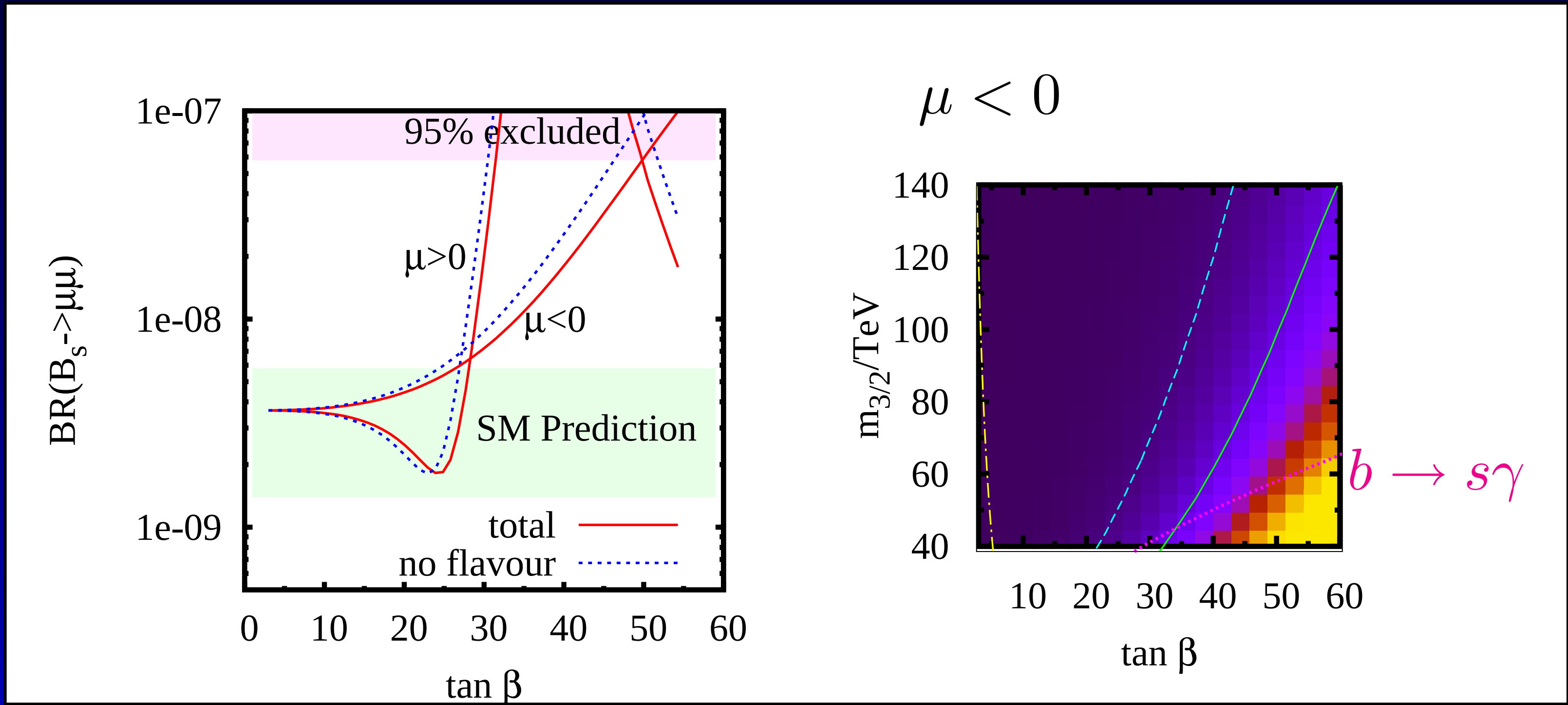
$$(Y_D Y_D^\dagger) \left(3\mathrm{Tr}(Y_D Y_D^\dagger) + \mathrm{Tr}(Y_E Y_E^\dagger) - \frac{7}{15} g_1^2 - 3 g_2^2 - \frac{16}{3} g_3^2 \right)$$

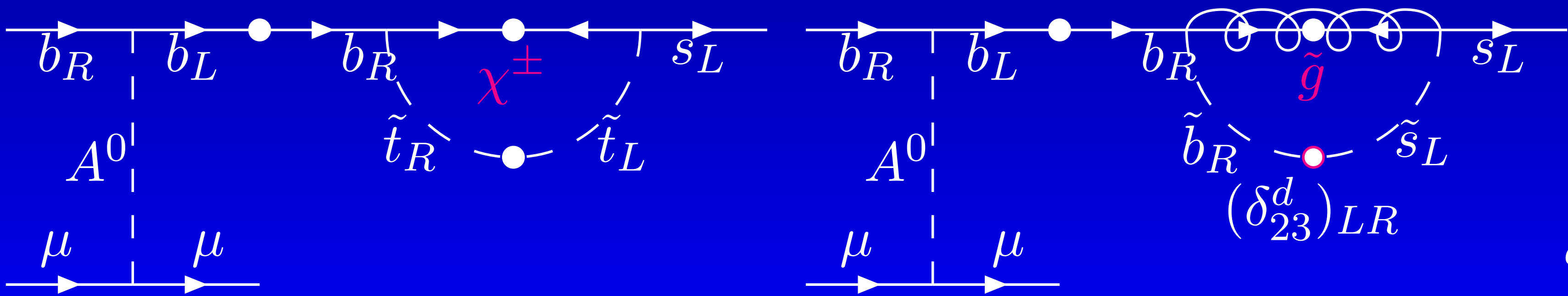
$$+ Y_U Y_U^\dagger Y_D Y_D^\dagger + Y_D Y_D^\dagger Y_U Y_U^\dagger + 3 (Y_U Y_U^\dagger)^2 + 3 (Y_D Y_D^\dagger)^2.$$

NB *Extremely predictive*. We'll use this to predict squark mixing

$BR(B_s \to \mu^+\mu^-)$: LHCb

SOFTSUSY3.0. $BR^{exp} < 58 \times 10^{-9}$,





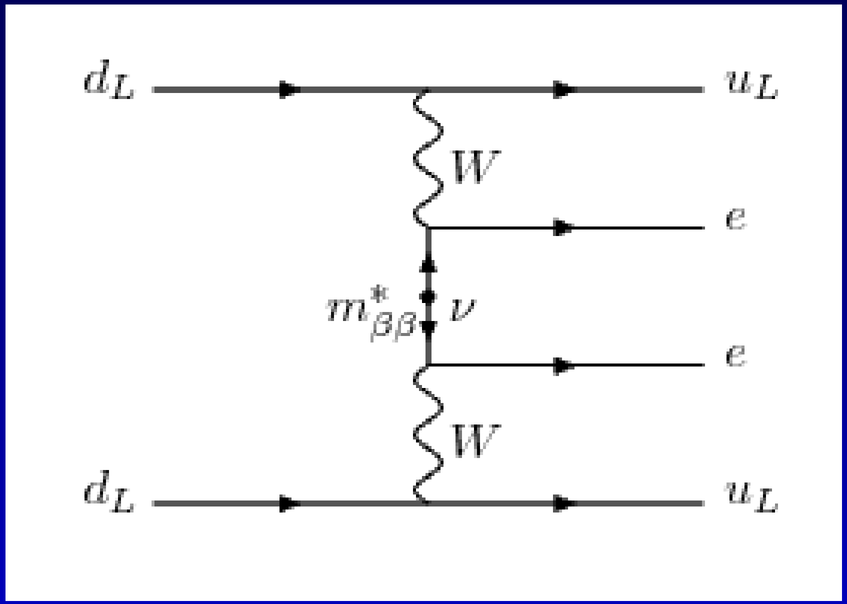
[a]

[a] BCA, Hiller, Jones, Slavich, arXiv:0902.4880

Neutrinoless Double Beta Decay

Heidelberg-Moscow limit:

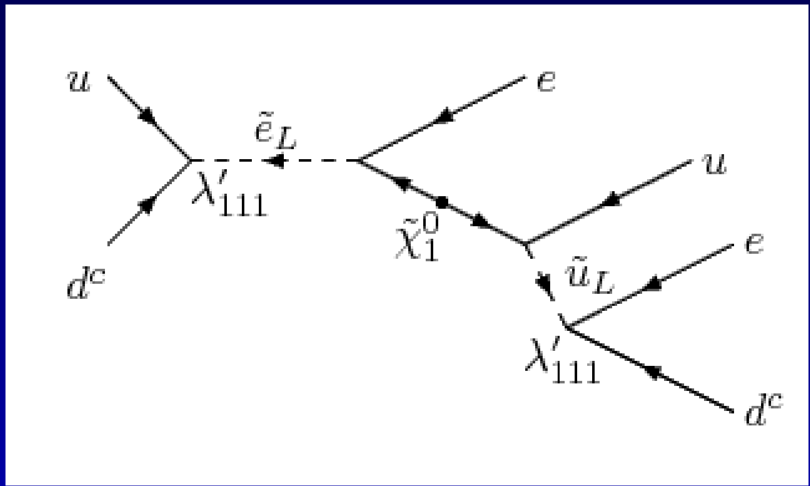
$$T_{1/2}^{0\nu\beta\beta}(\mathrm{Ge}) \geq 1.9 \cdot 10^{25}\mathrm{yrs} \Rightarrow m_\nu < 0.46\mathrm{eV}.$$

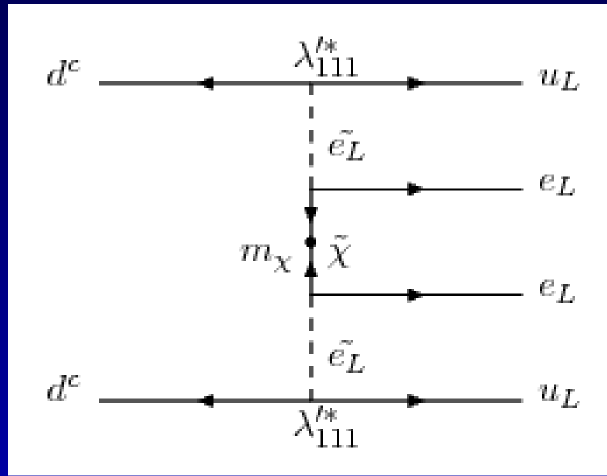


Next round of experiments are going to improve the $T_{1/2}^{0\nu\beta\beta}(Ge)$ bound by a couple of orders of magnitude

LHC Single Selectron Production

Like-sign dielectrons and two hard jets connects with neutrinoless double beta decay:





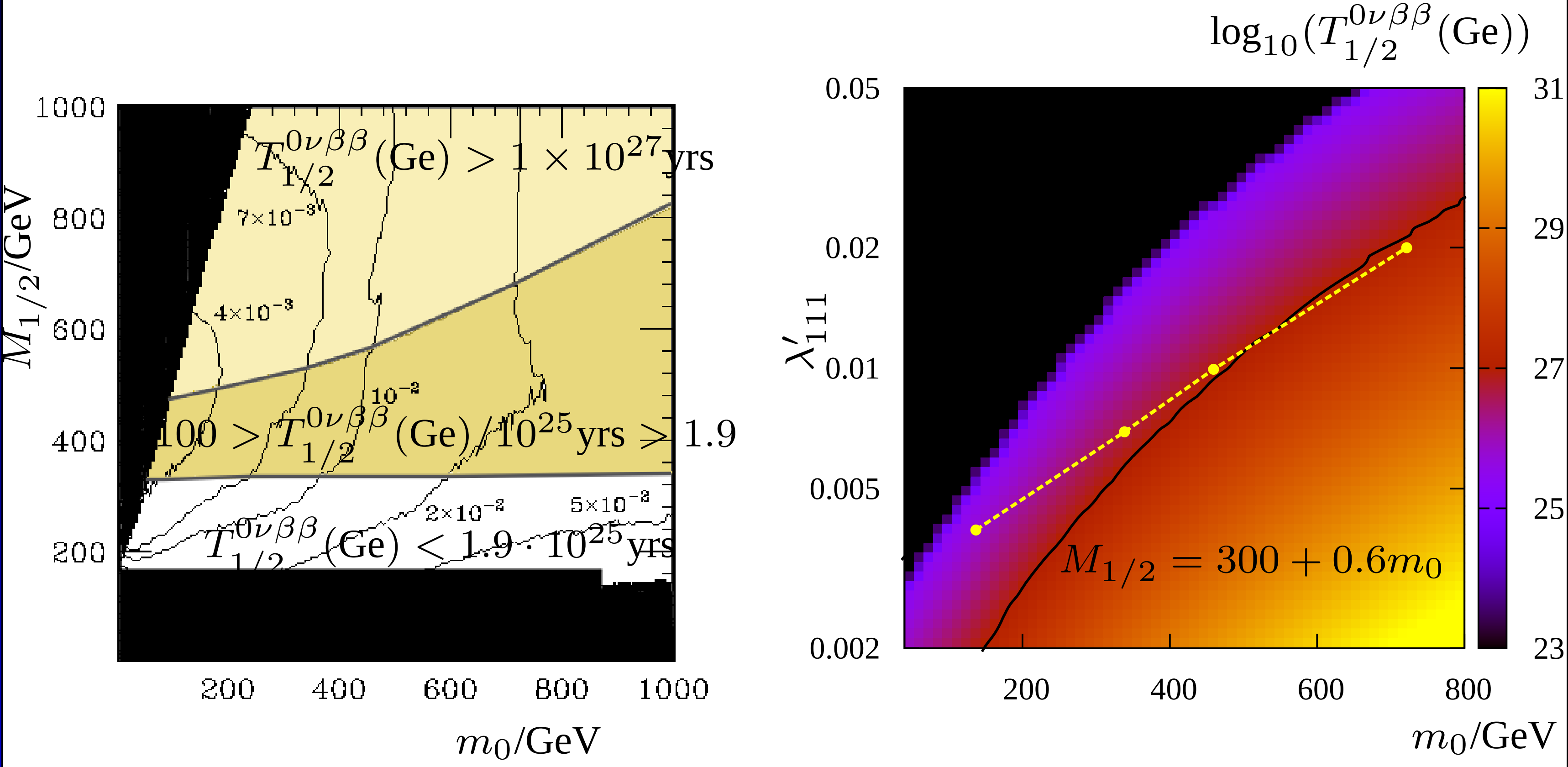
$$\sigma(pp \to \tilde{l}) \propto \frac{|\lambda'_{111}|^2}{m^3_{\tilde{e}_L}} \qquad [T^{0\nu\beta\beta}_{1/2}(\mathbf{Ge})]^{-1} \propto \frac{|\lambda'_{111}|^4}{M^{10}_{susy}}$$

So, there is an interesting interplay between the two[a]

[a] BCA, Kom, Päs, arXiv:0902.4697

Neutrinoless-LHC Interplay

Used Dreiner, Richardson, Seymour, PRD63 (2001) 055008 for reach $10\ \text{fb}^{-1}$, $\tan\beta = 10$, 5σ discovery of $\tilde{e}$



a

[a] BCA, Kom, Päs, `arXiv:0903.0347`