SUSY Flavour at LHC7

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In Collaboration with
L. Calibbi, R. N. Hodgkinson, A. Masiero and O. Vives

EPS-HEP 2011
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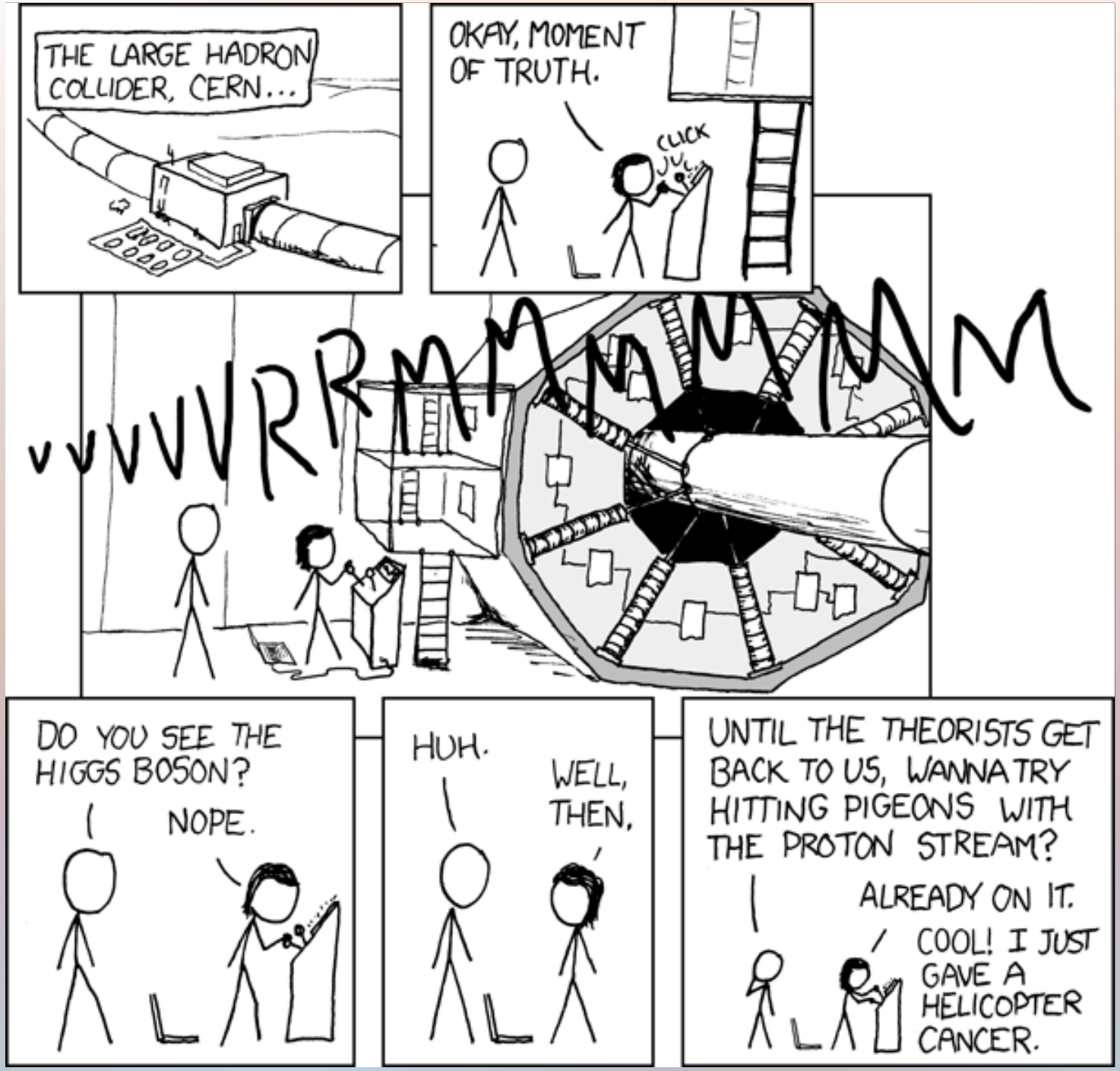

We need to wait until we get some statistics...

http://xkcd.com

LHC 7 TeV Run

- Last year's luminosity expectations for December 2011: 1 fb^{-1}
- Big Question: What if we see some new physics signal? How can flavour help to tell if it is consistent with the MSSM?
- Objective: Analyze the region of the parameter space that LHC can probe.
  - If we get a signal, what can flavour physics tell us?
  - Can there be a flavour feedback to colliders?

Outline

- Models of Interest and LHC Reach
- Flavour Constraints
- Analysis of Specific Models

Models of Interest

- CMSSM

  Can give us a general idea of what we should expect. Useful as an initial benchmark.

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Masiero, Vempati, Vives (hep-ph/0209303)

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- CMSSM + $SU(3)_F$: RVV Model

  Example of a way of entangling all flavour-dependent observables. Results are heavily model-dependent.

Ross, Velasco-Sevilla, Vives (hep-ph/0401064)

Collider Issues

- Main problem of analyzing the CMSSM is to estimate the LHC constraints and reach in a four-dimensional parameter space.
- Full collider simulation at each point in order to find out if it is ruled out or not?? Not feasible!

Collider Issues

Some results depend strongly only on m_0 and $M_{1/2}$!

- *Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in sqrt(s) = 7 TeV proton-proton collisions. (1102.5290 [hep-ex])*
- *Search for Supersymmetry in pp Collisions at 7 TeV in Events with Jets and Missing Transverse Energy. (1101.1628 [hep-ex])*

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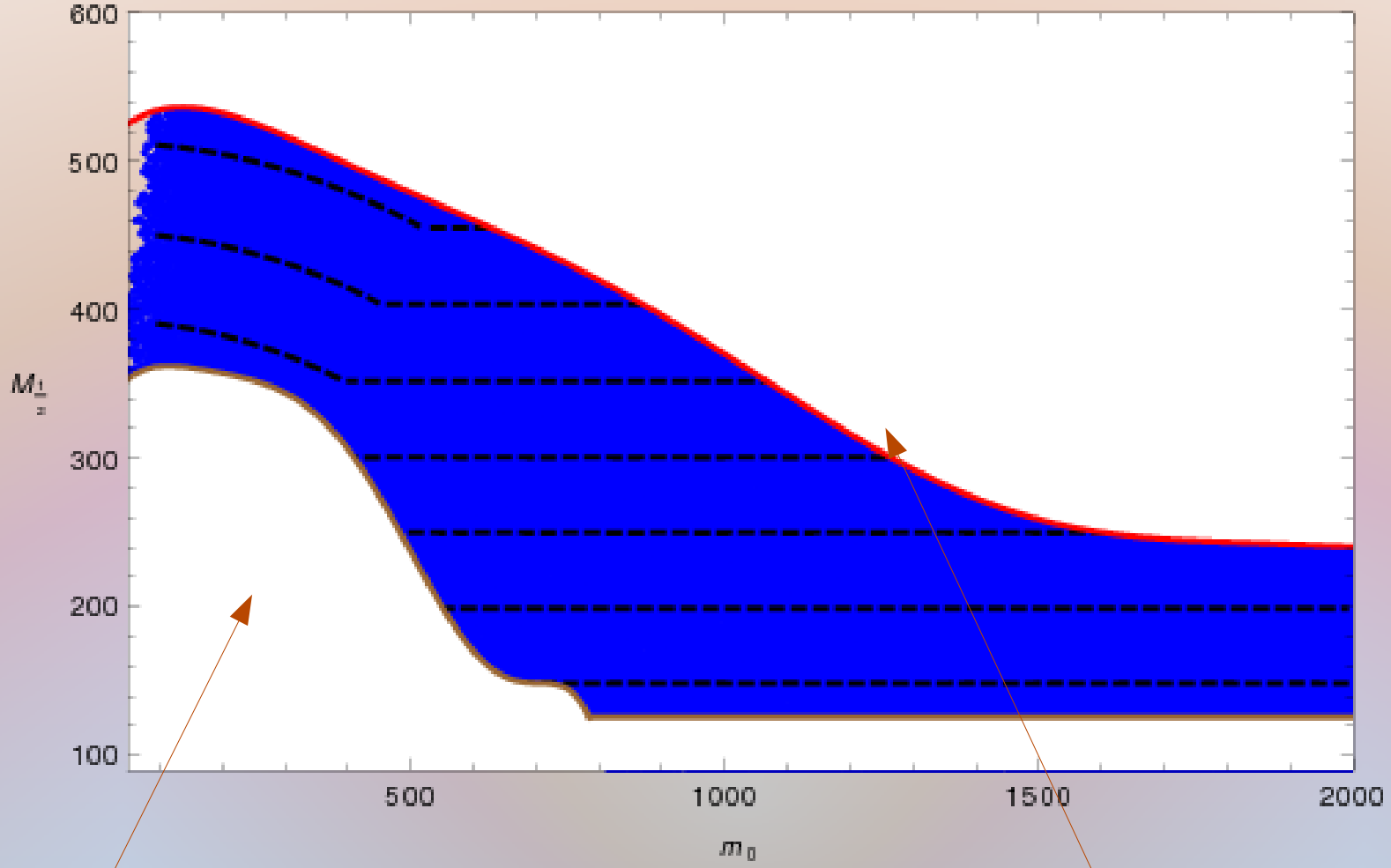
It seems possible to do a scan on the CMSSM parameter space without doing a collider simulation.

Scan shall use a modified version of SPheno 3.1.3

Porod (hep-ph/0301101)
Porod, Staub (1104.1573 [hep-ph])

Relevant Parameter Space for 2 fb^{-1}



ATLAS Collaboration (1102.5290 [hep-ex])

Baer, Barger, Lessa, Tata (1004.3594 [hep-ph])

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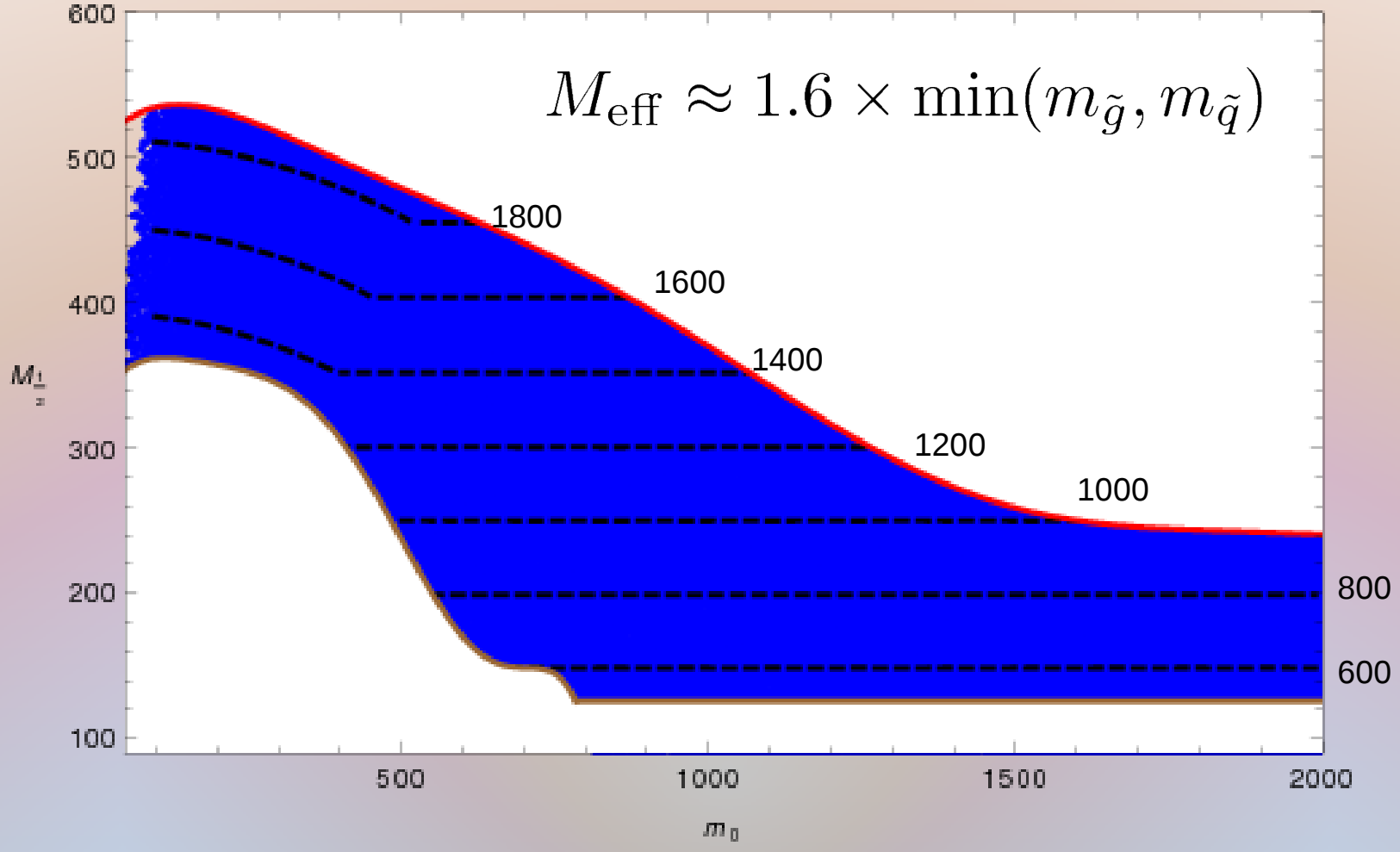
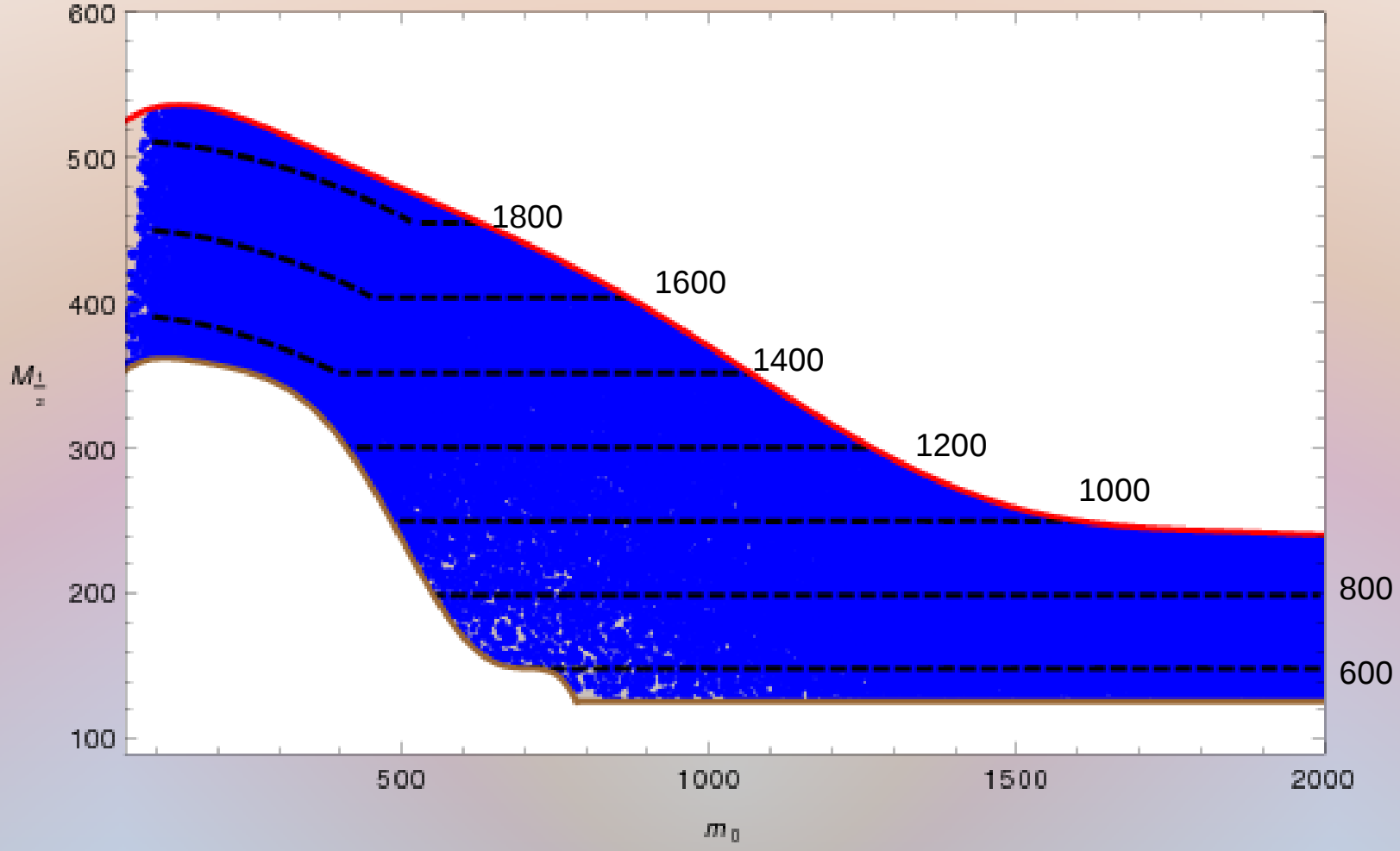


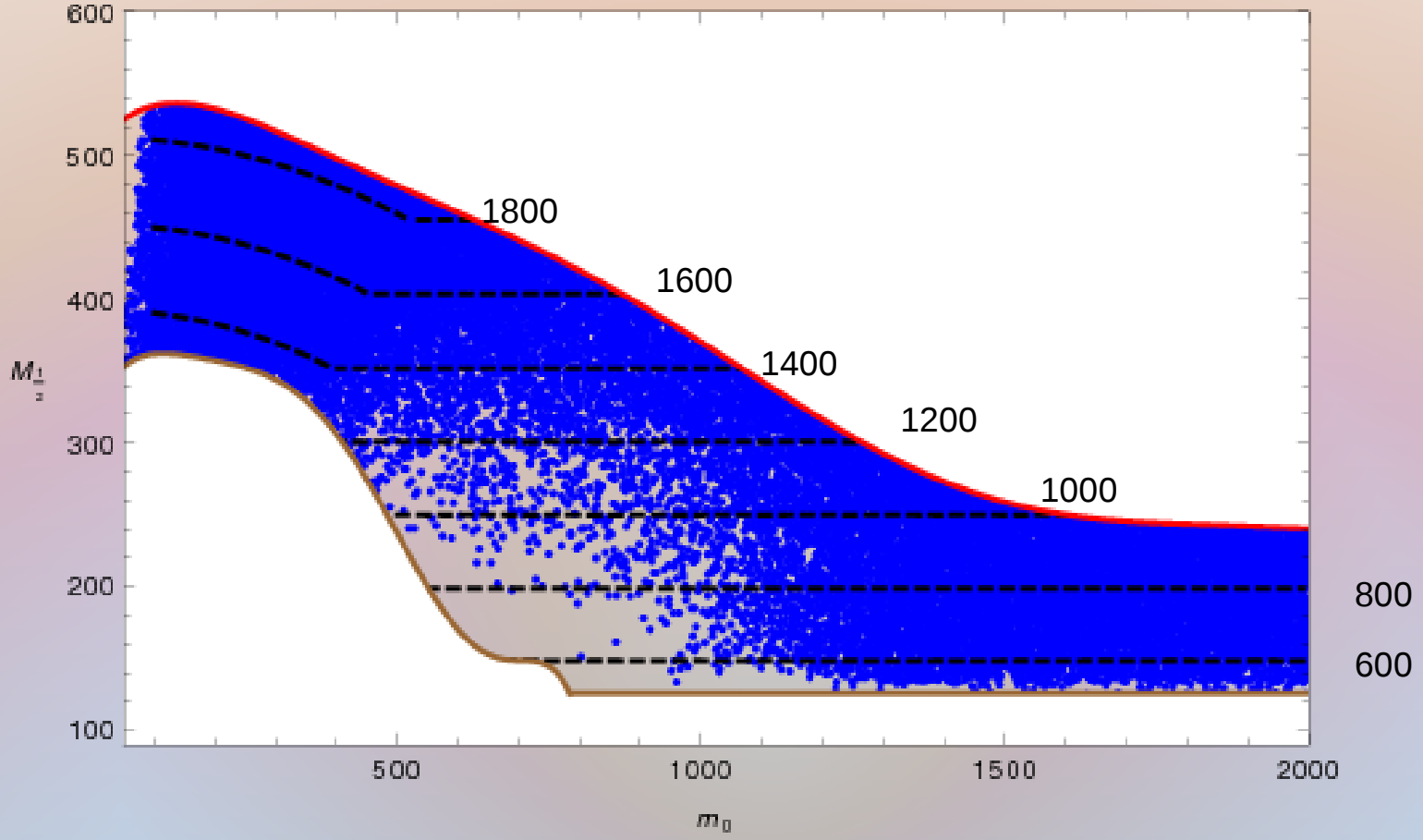
Feldman *et al* (1102.2548 [hep-ph])

Direct Search + Higgs Constraints

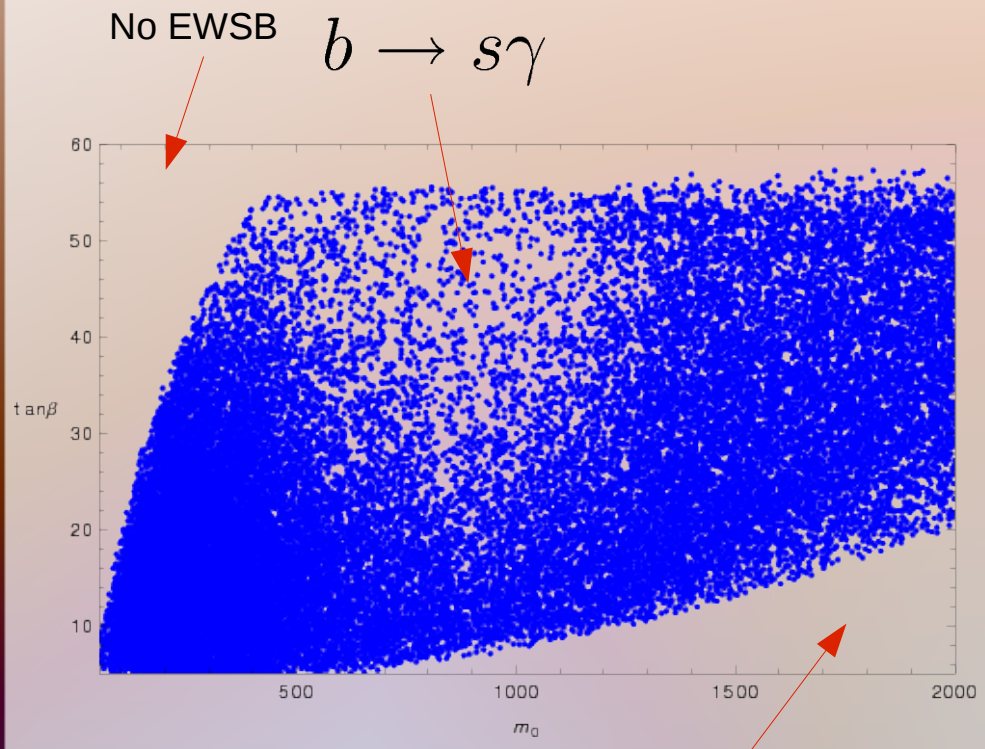


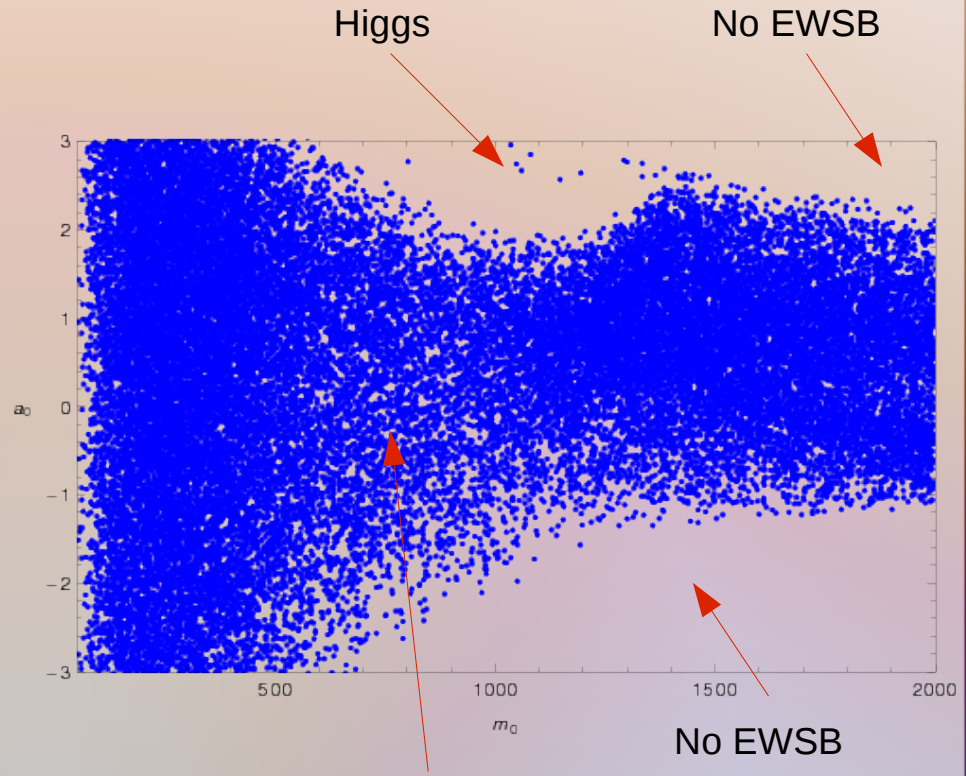
Flavour 3σ Constraints

$b \longrightarrow s\gamma$ $(g-2)_\mu$



Constraints





The Role of $B_s \to \mu\mu$

- LHCb with 2 fb^{-1}
  - Exclusion of BR($B_s \to \mu\mu$) down to 4×10^{-9}, 95% C.L.
  - 3σ evidence of BR($B_s \to \mu\mu$) down to 5×10^{-9}.
  - 5σ discovery of BR($B_s \to \mu\mu$) down to 9×10^{-9}.

R. Lambert @ Moriond

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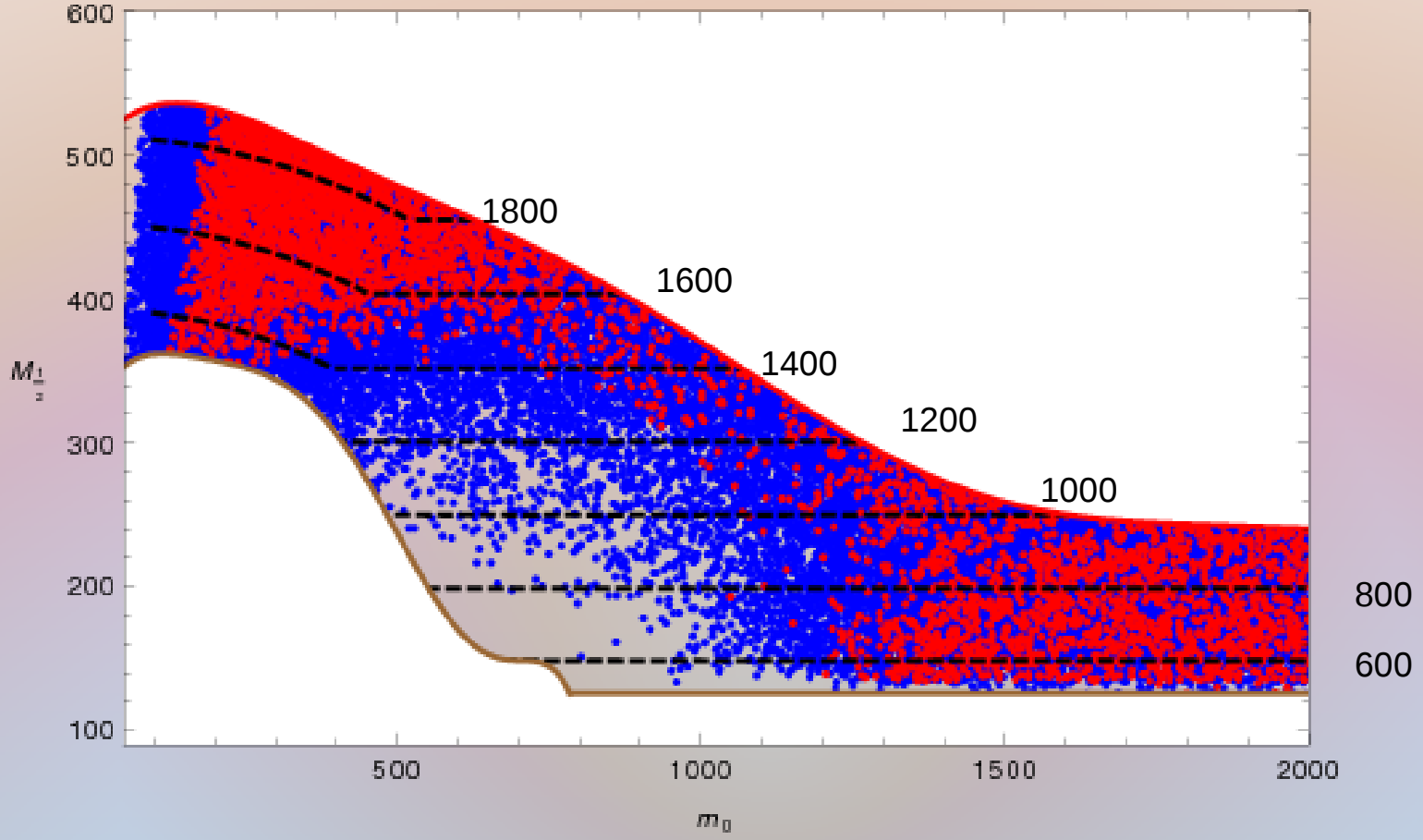
R. Lambert @ Moriond

- CDF with 7 fb^{-1}
  - $BR(B_s \to \mu\mu) = (1.8 \pm 1) \times 10^{-8}$

CDF Collaboration (1107.2304 [hep-ex])

Exclusion due to B_s -> μ μ

$$\mathrm{BR}\,(B_s \to \mu\mu) < 4 \times 10^{-9}$$



A Large B_s -> μ μ

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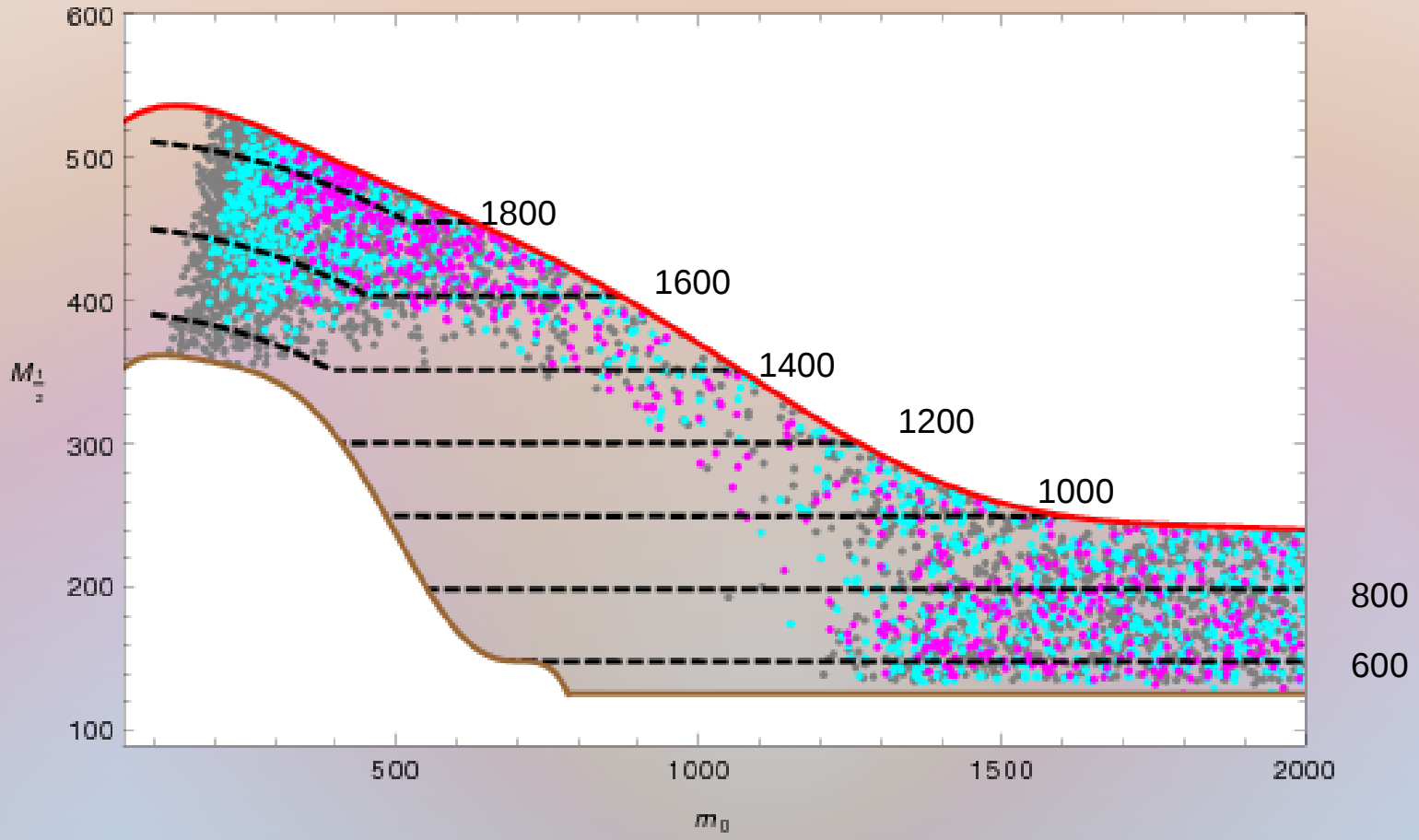

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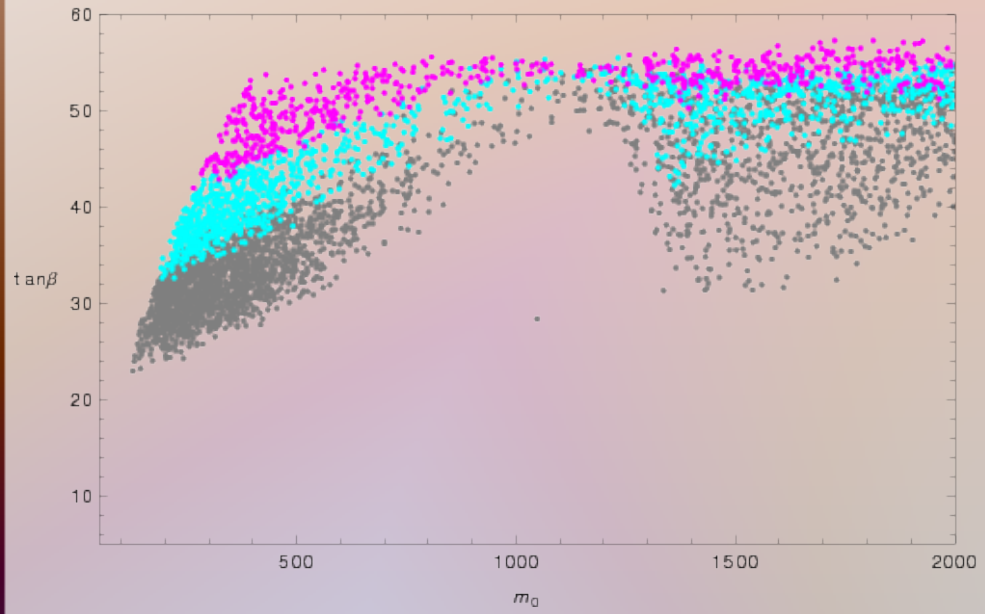

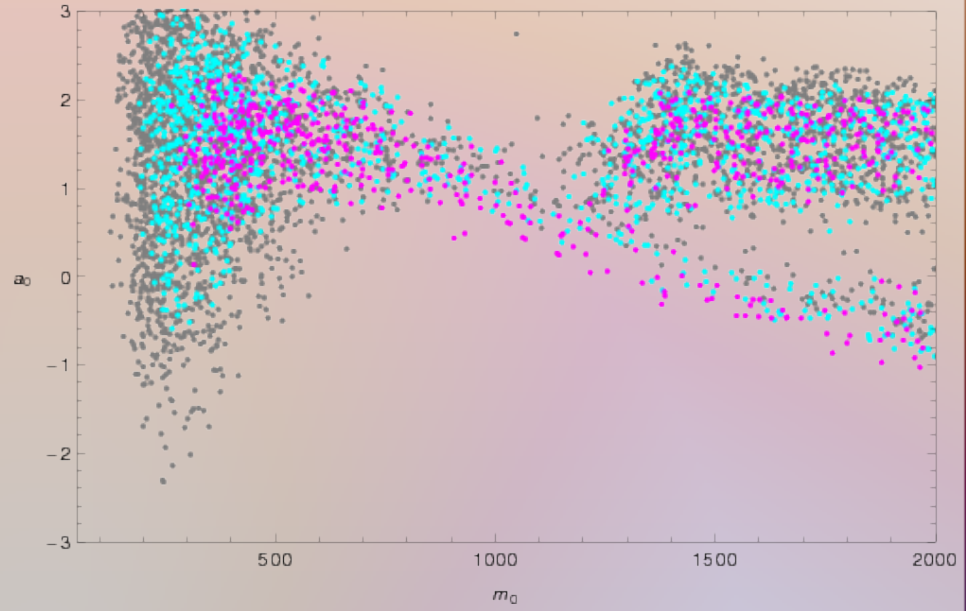

2σ Constraints

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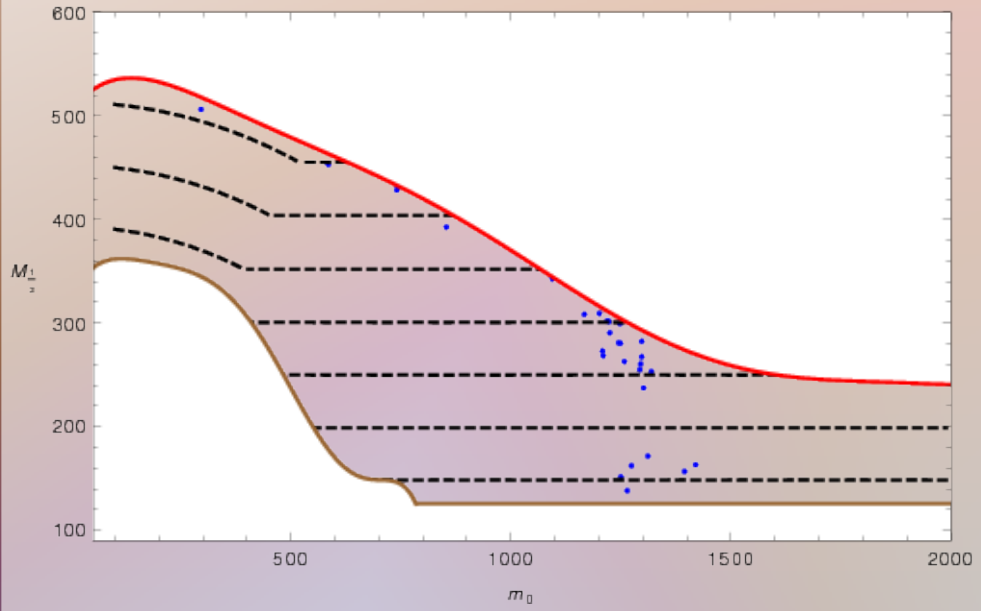

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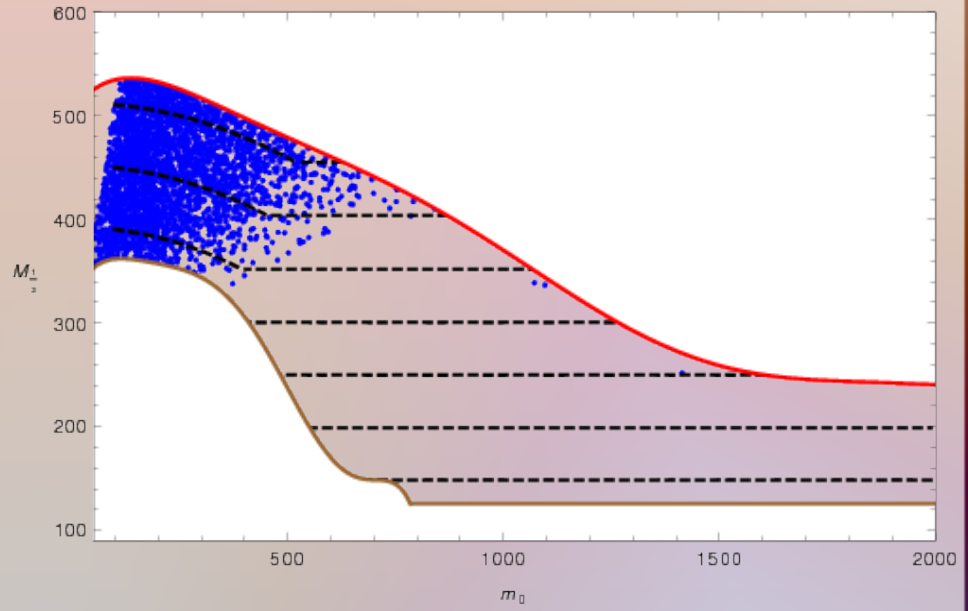

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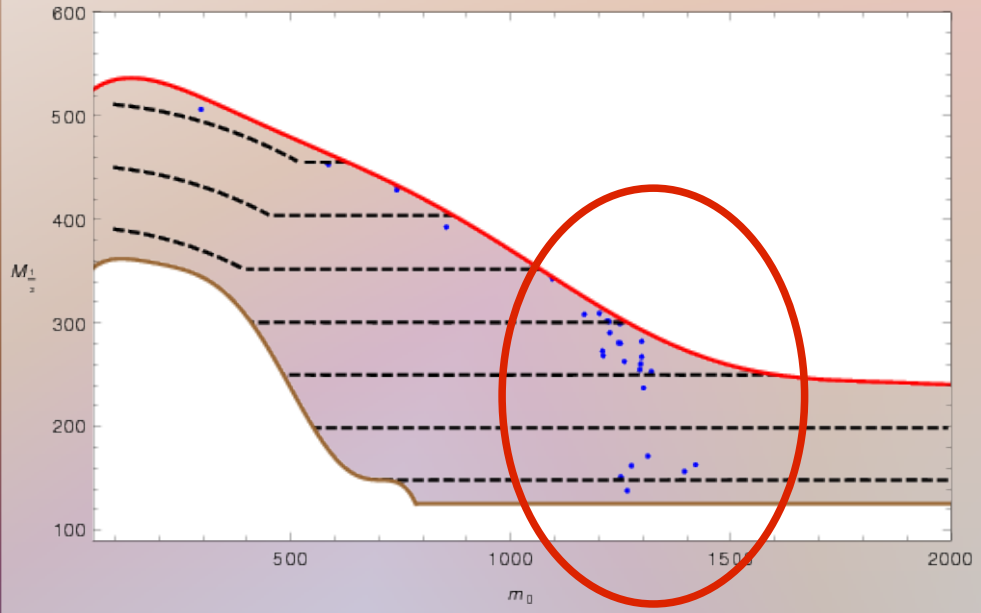

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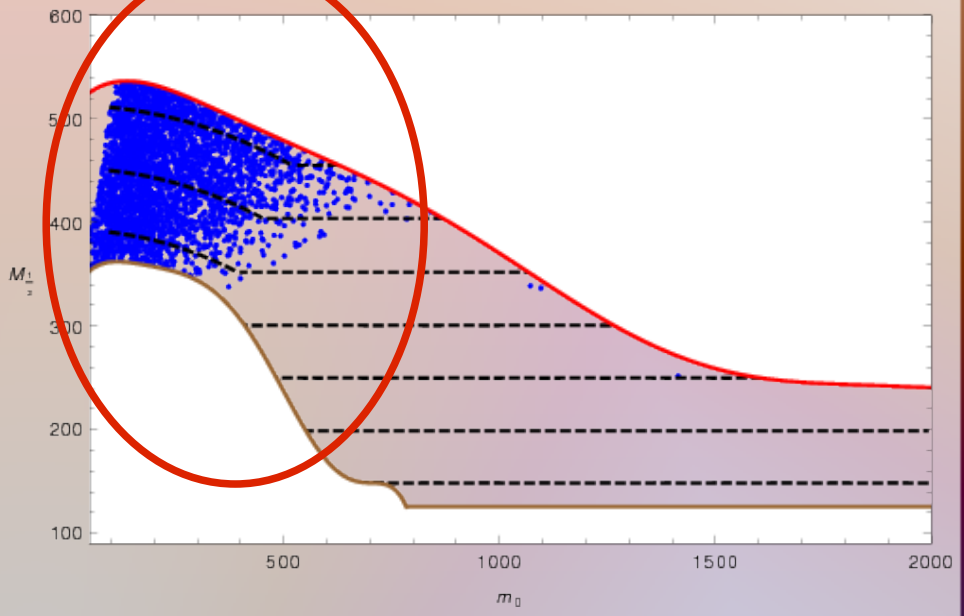

What about the Lepton Sector?

- First Assumption: $Y_\nu \sim Y_u$

Masiero, Vempati, Vives (hep-ph/0209303)

What about the Lepton Sector?

- First Assumption: $Y_\nu \sim Y_u$
- Mixings:
  - CKM-like

$$Y_\nu = V_{\rm CKM} Y_u^{\rm diag}$$

  - PMNS-like

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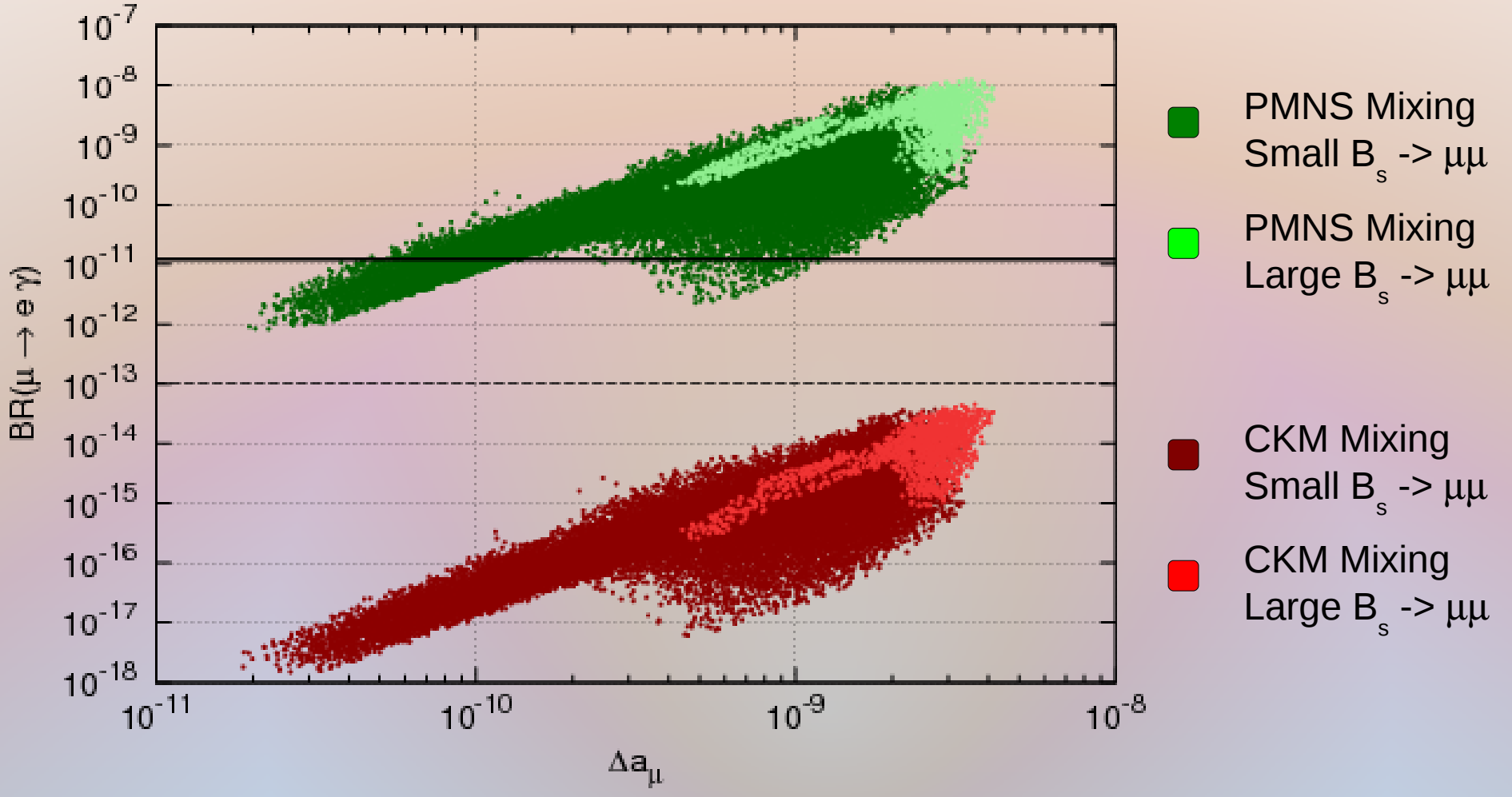
Masiero, Vempati, Vives (hep-ph/0209303)

Comparing CKM and PMNS



$m_{\nu_1} = 0.001$ eV $\qquad \sin^2 2\theta_{13} = 0.04$

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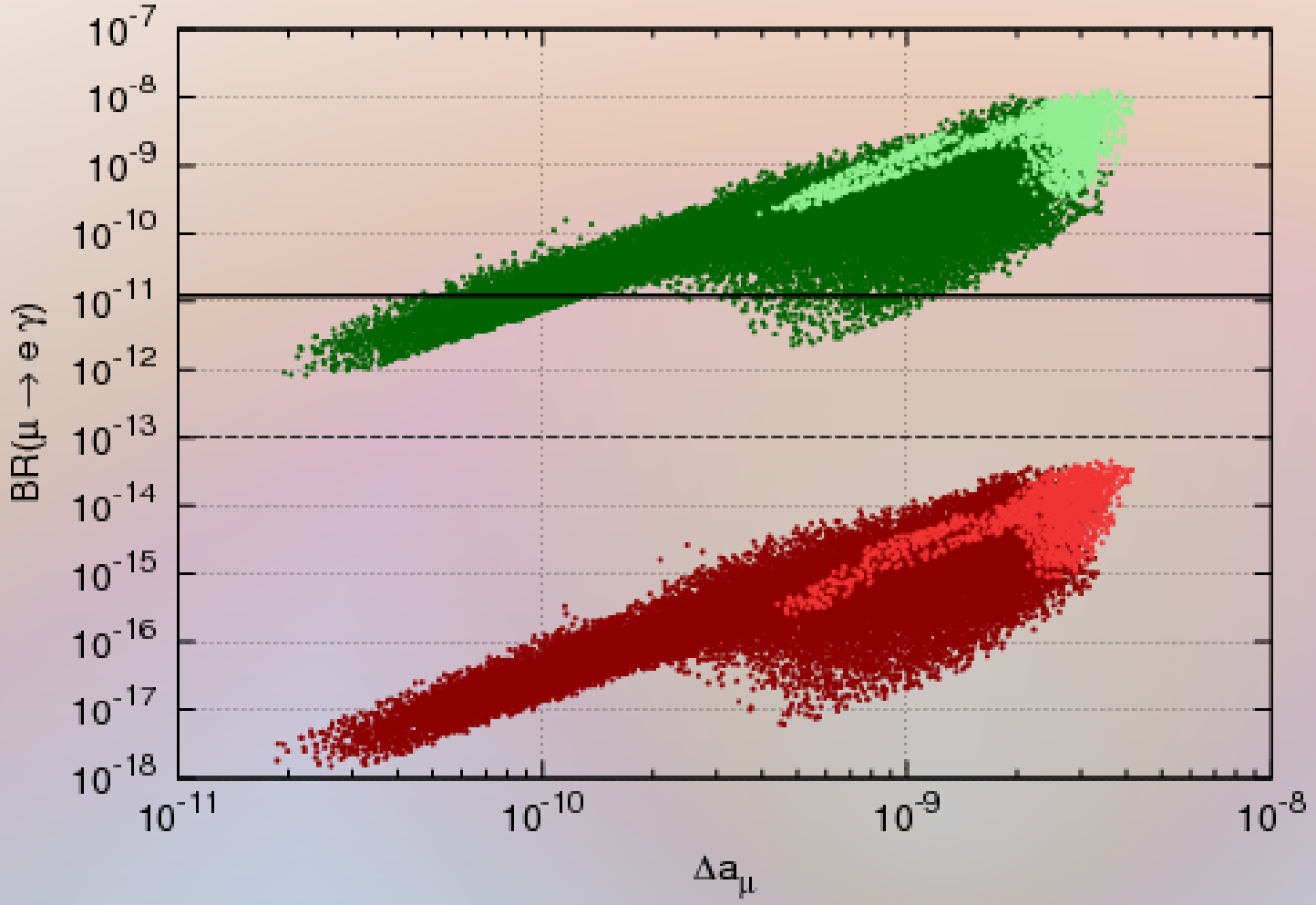

CKM-mixing with large Y_ν cannot be probed by MEG

CKM Mixing Small B_s -> μμ

CKM Mixing Large B_s -> μμ

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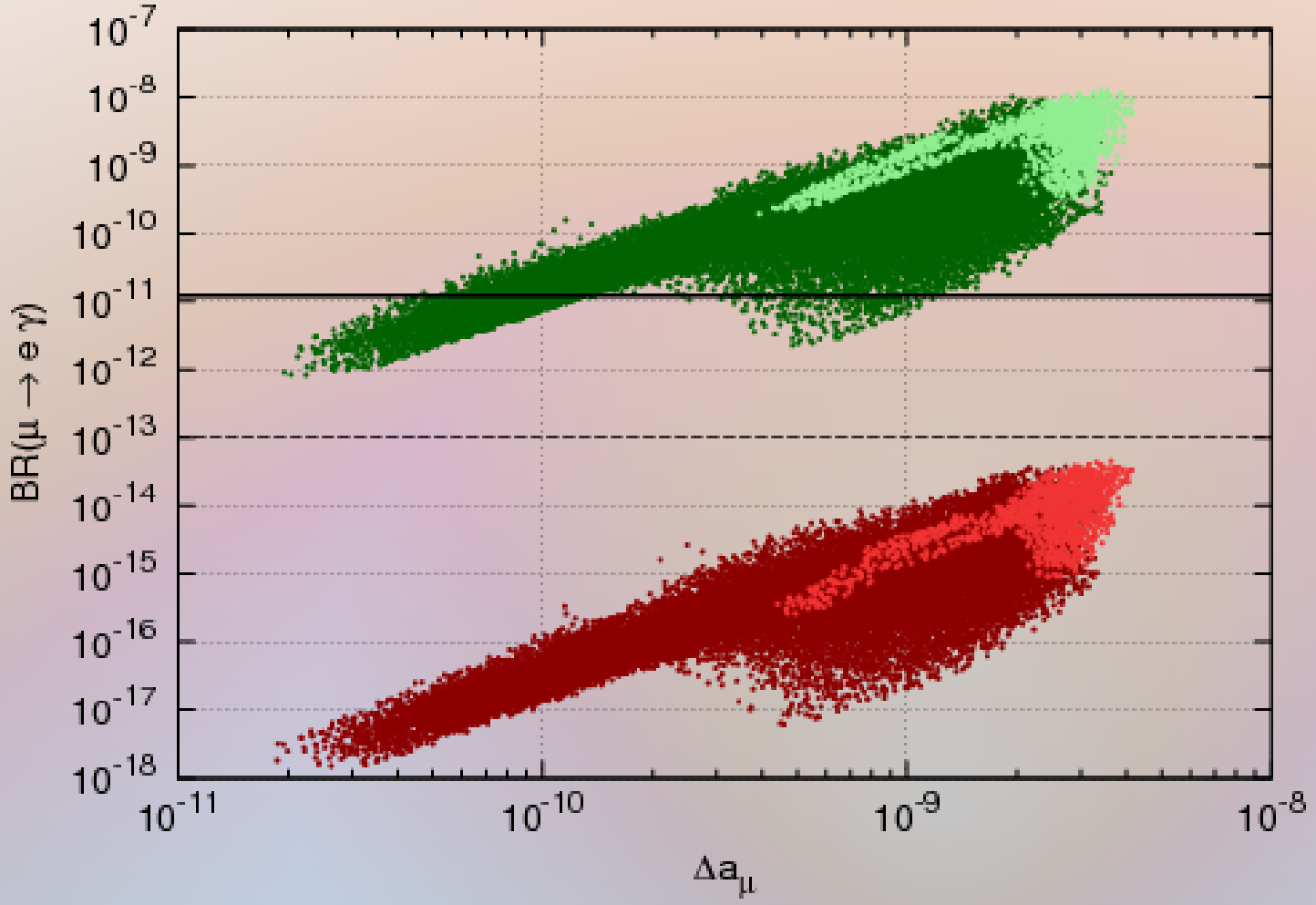


PMNS Mixing
Small B_s -> μμ

PMNS Mixing
Large B_s -> μμ

PMNS-mixing with large Y_ν is mostly ruled out by MEGA, T2K and $(g-2)_\mu$

$m_{\nu_1} = 0.001$ eV

$\sin^2 2\theta_{13} = 0.04$

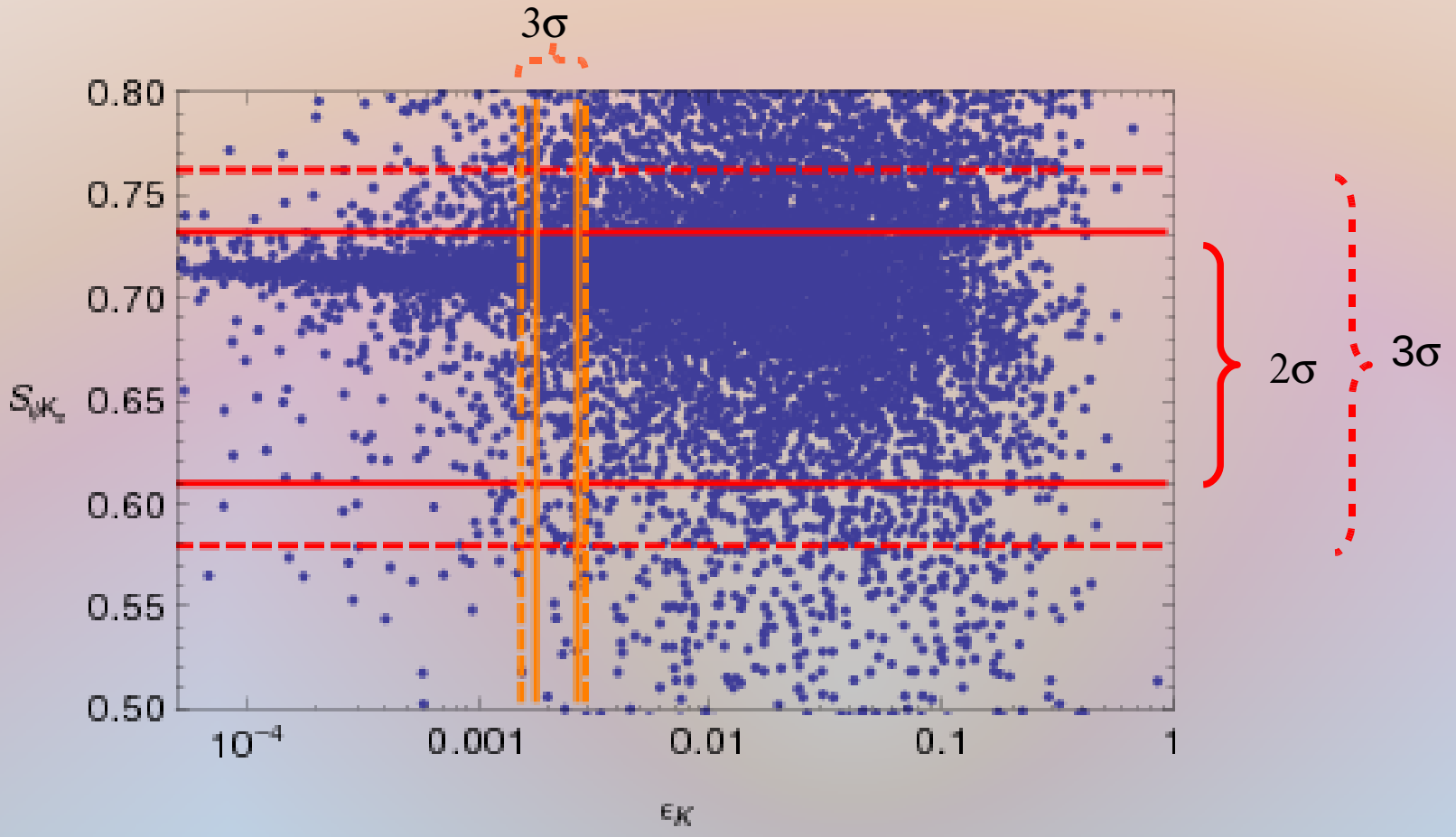
RVV Models

- Flavour model based on SU(3) symmetry.
- Structure and phases in SUSY sector related to structure and phases in SM Yukawa sector.
- Capable of solving flavour tension in ε_K, $\sin 2\beta$ and $\Delta m_B / \Delta m_{Bs}$.

Ross, Velasco-Sevilla, Vives (hep-ph/0401064)
Calibbi, JJP, Masiero, Park, Porod, Vives (0907.4069 [hep-ph])

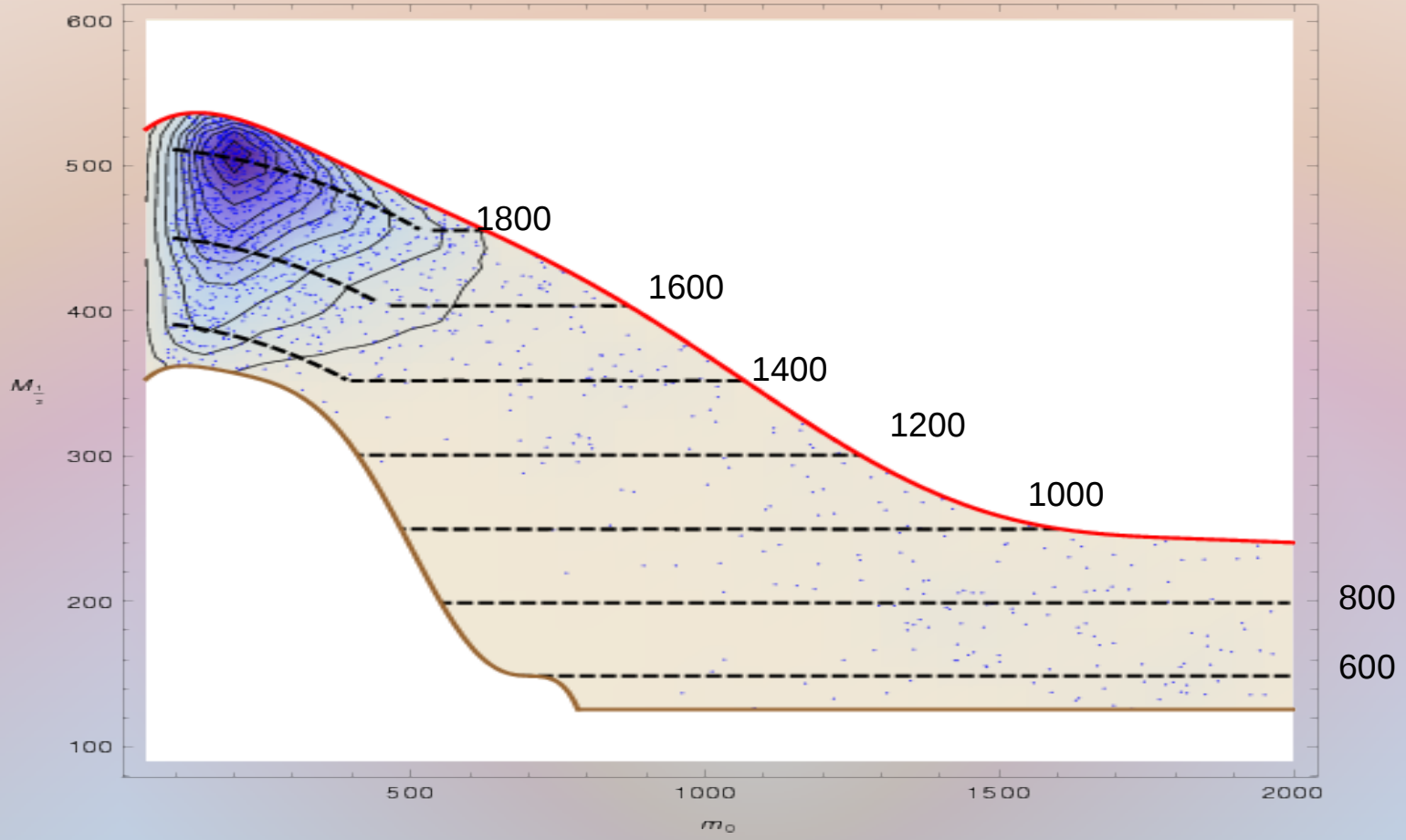
RVV Models

- ε_K and sin2β become a crucial source of constraints.



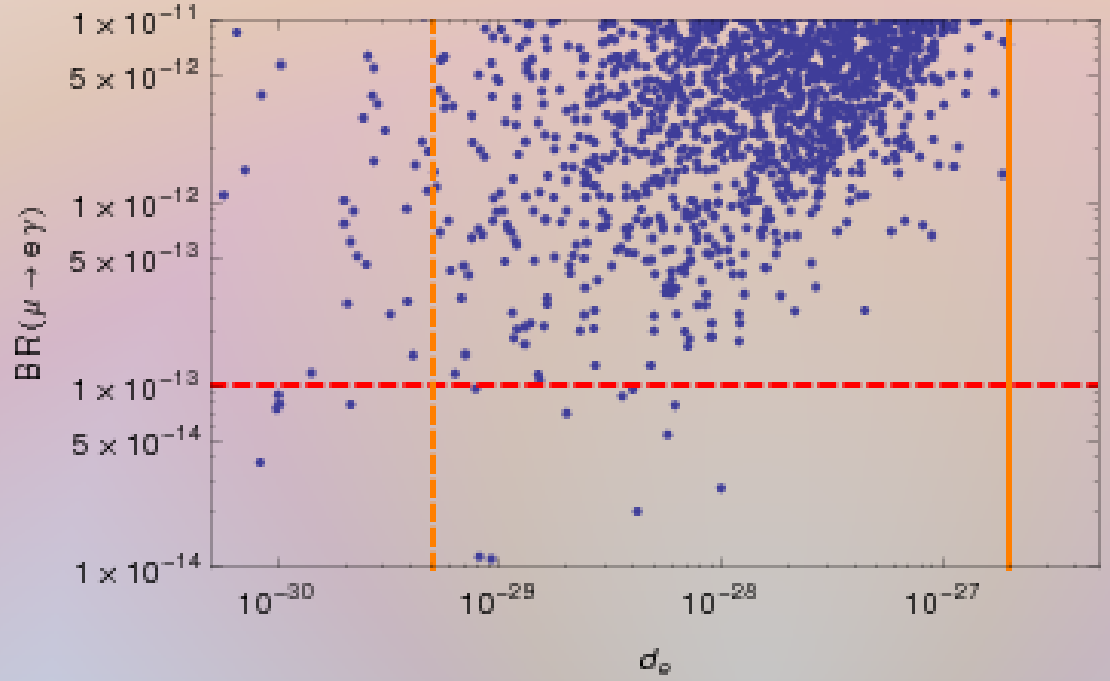
RVV Models Parameter Space

3σ constraints, solution of Flavour Tension + LFV reduce the parameter space considerably!



RVV Model and Leptons

Such a reduced parameter space allows to make very definite predictions.



For RVV to survive, MEG and eEDM experiments should give a positive signal soon!

Conclusions

Disclaimer: Upcoming conclusions should be valid for models with a CMSSM-like structure, i.e. universal $M_{1/2}$, m_0, a_0.

HANDLE WITH CARE

Conclusions

- Flavour and collider physics are complementary, as expected.
- If LHC gives a positive signal, flavour can give important hints in favour / against SUSY.
- 2σ constraints + B_s -> μ μ separate CMSSM parameter space into two regions, which can be differentiated in a collider.

Conclusions

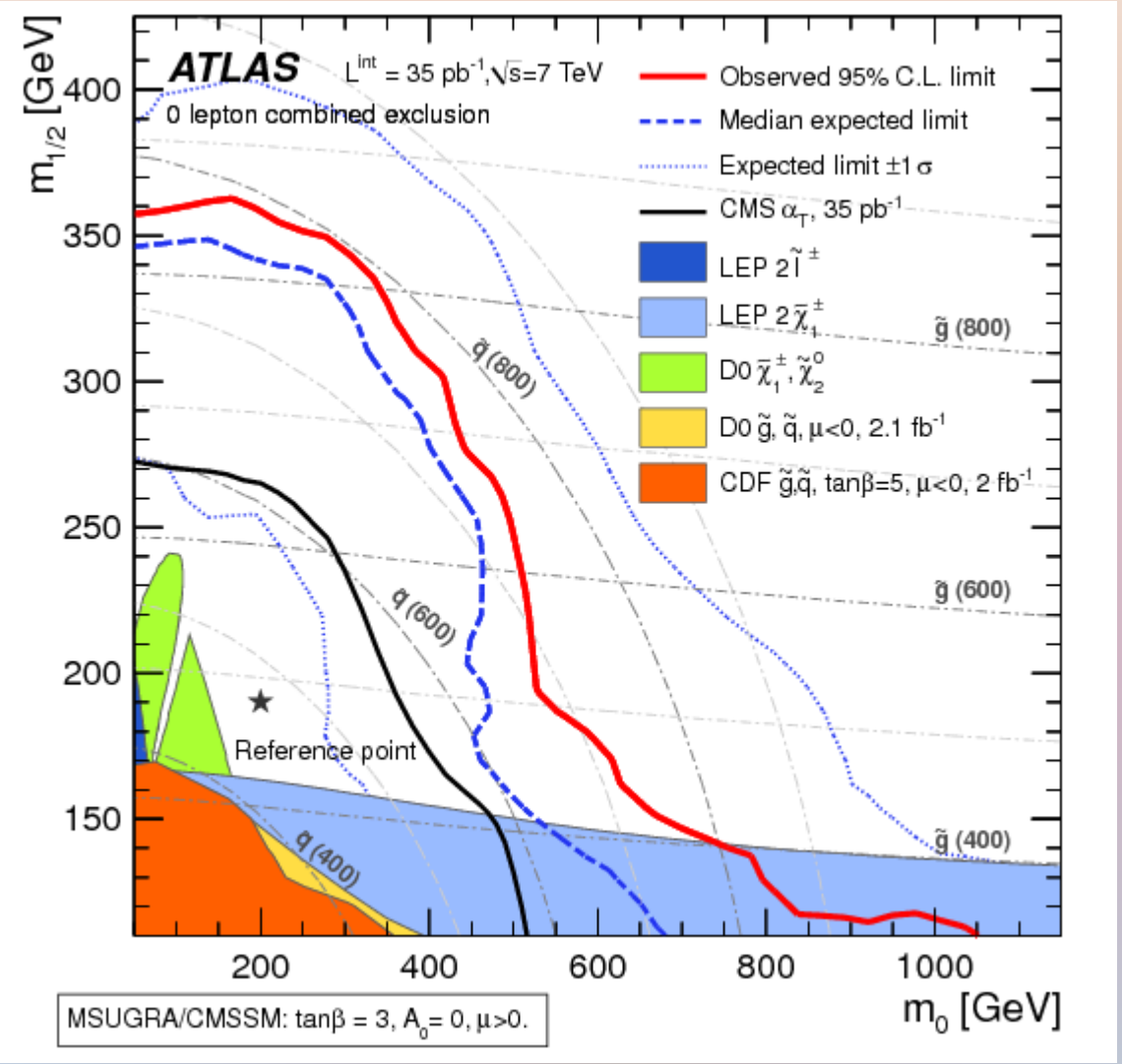
- SUSY SeeSaw models can be constrained by combination of LHC, T2K, $(g-2)_\mu$ and MEGA.
- Models with large ν Yukawas with PMNS mixing not in a good situation.
- Models with large ν Yukawas with CKM mixing should survive, but give no interesting signal.

Conclusions

- Low SUSY masses and flavour constraints push RVV flavour models into a particular region of the parameter space.
- Solution of flavour problem is still possible.
- MEG + eEDM experiments crucial for the model.

Ze Backoupé

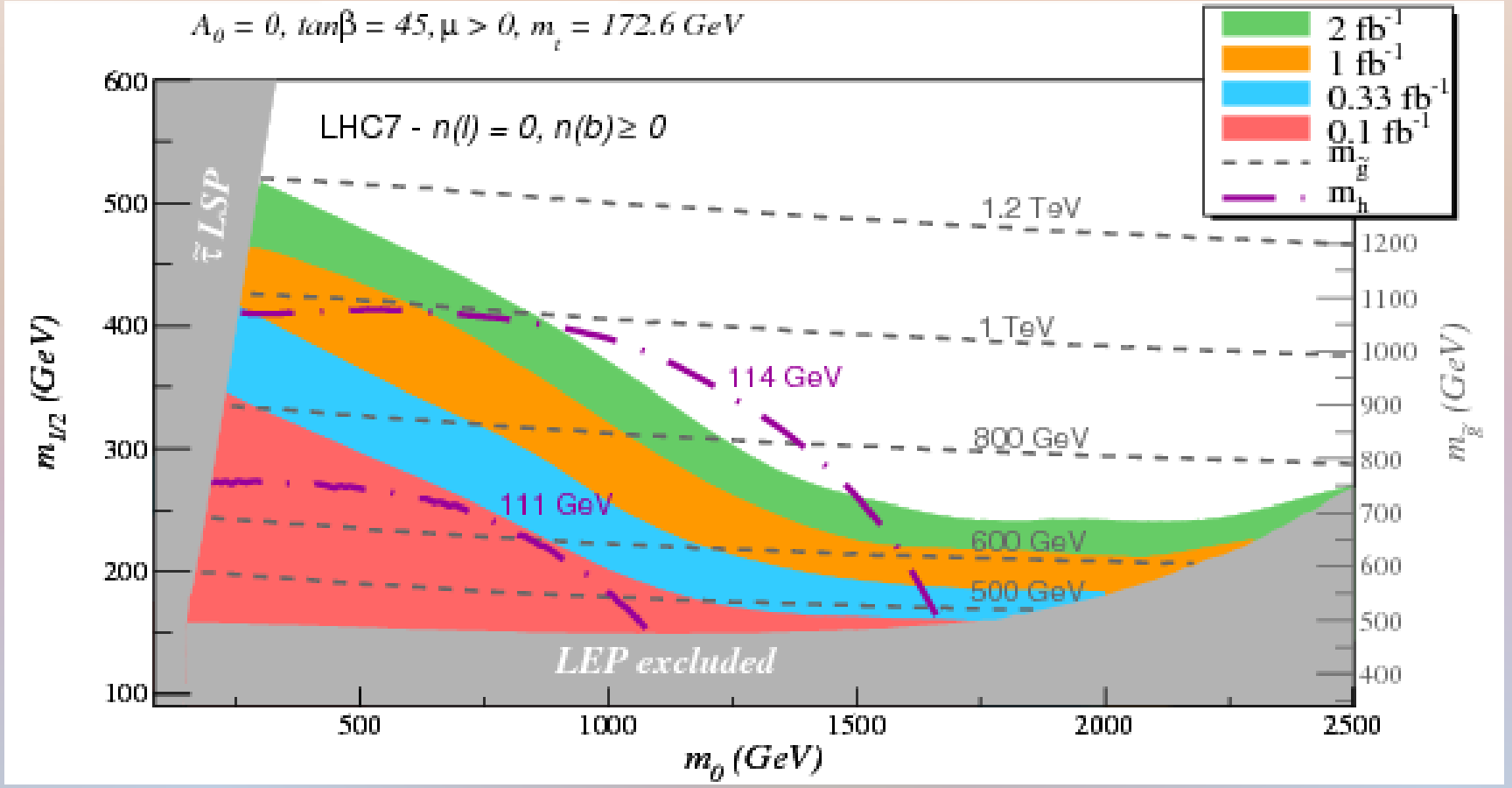
Current LHC Constraints



ATLAS Collaboration (1102.5290 [hep-ex])

Future Reach

No lepton channel:



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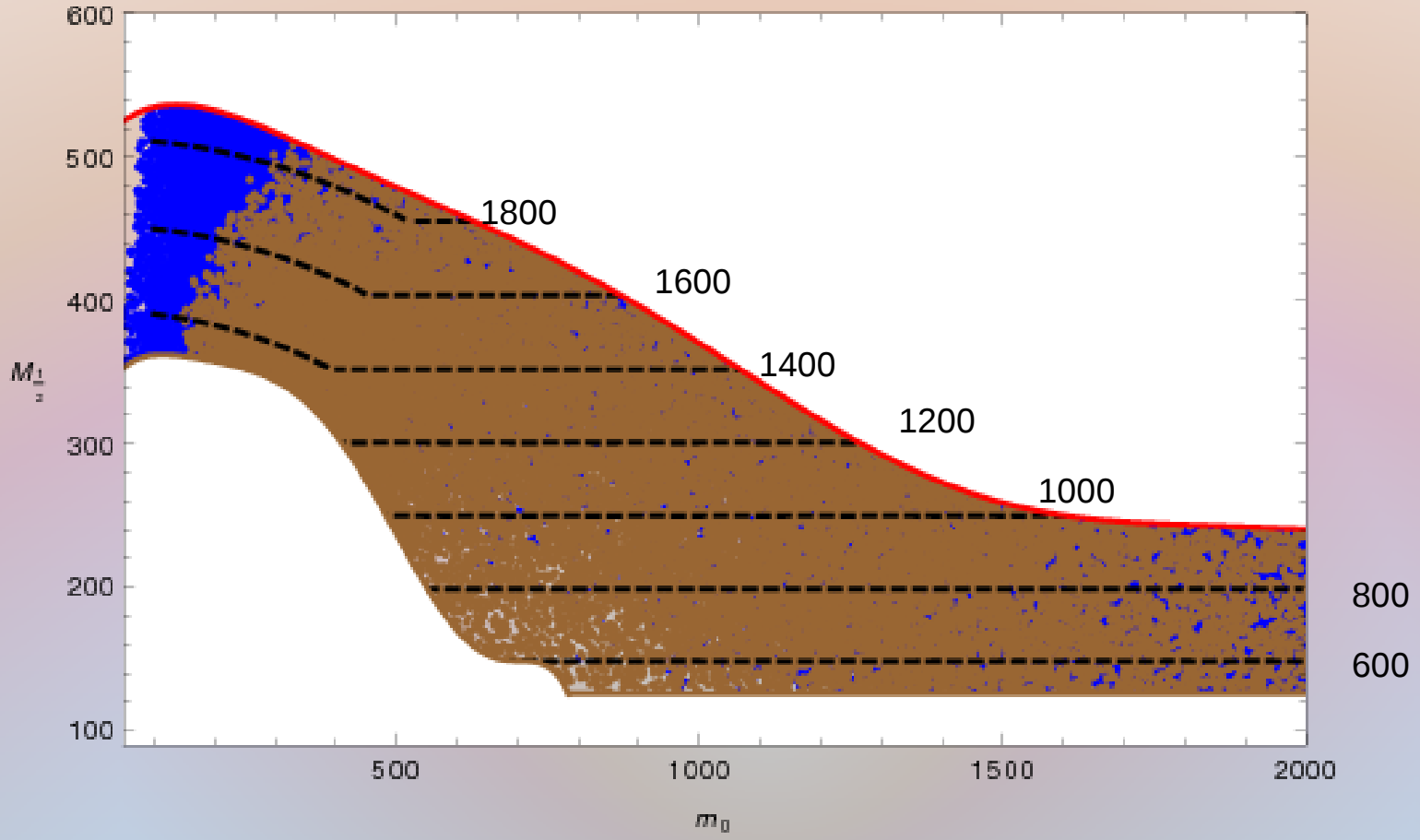

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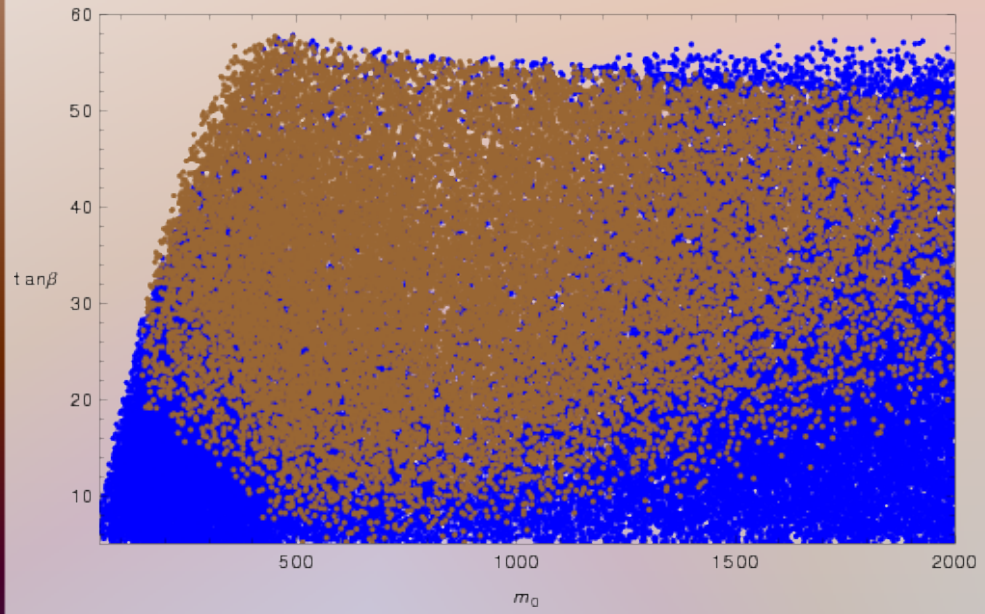

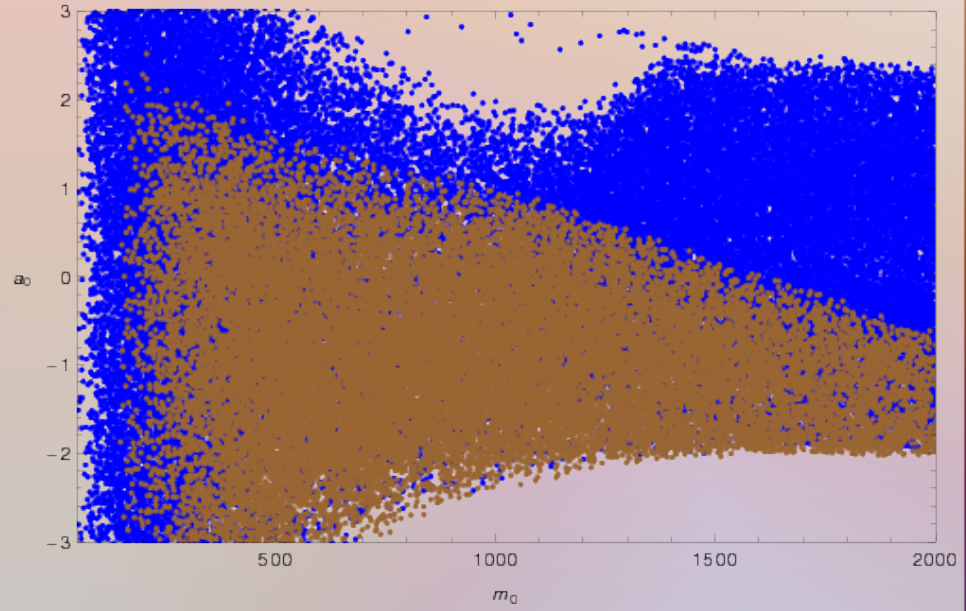

Flavour 3σ Constraints

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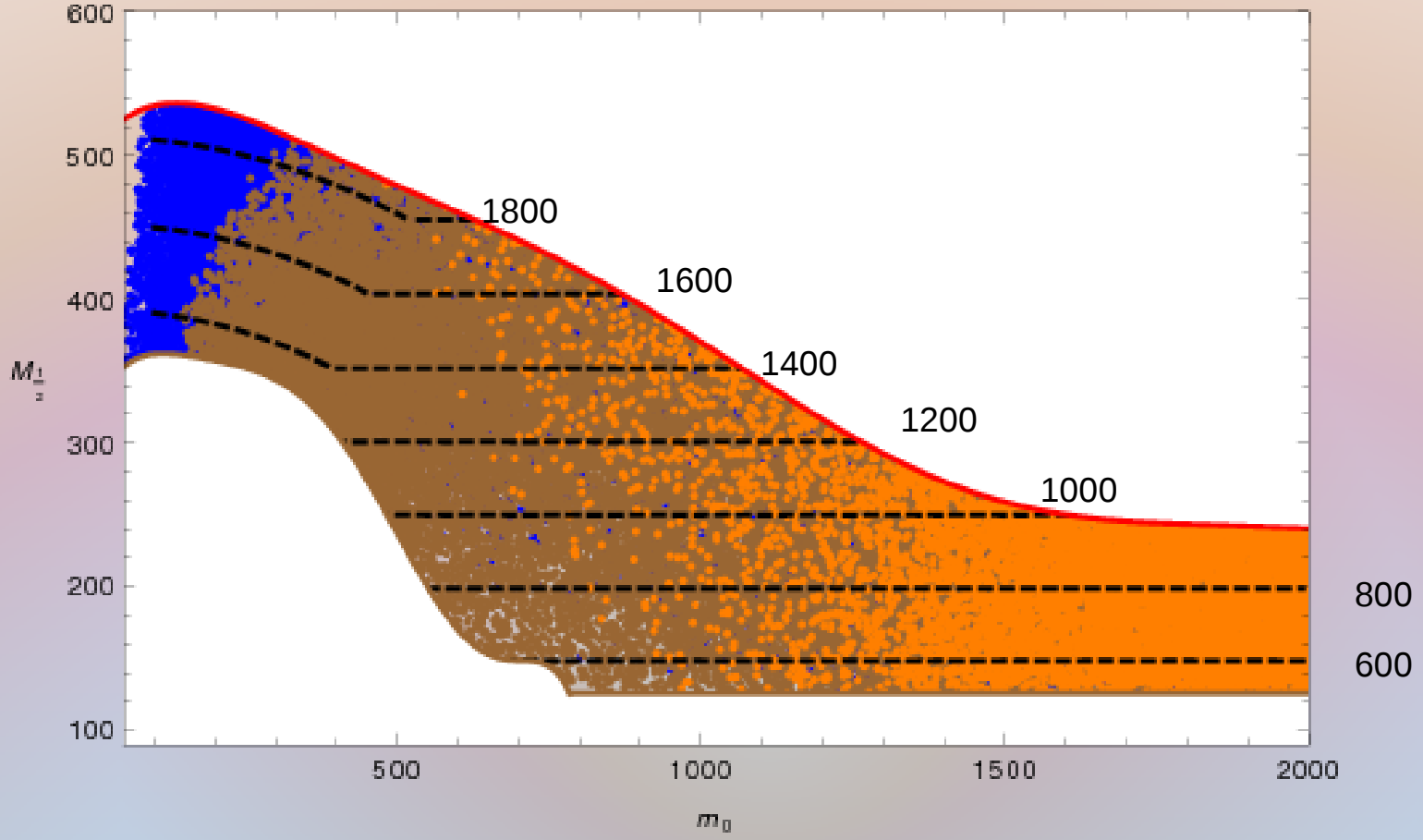

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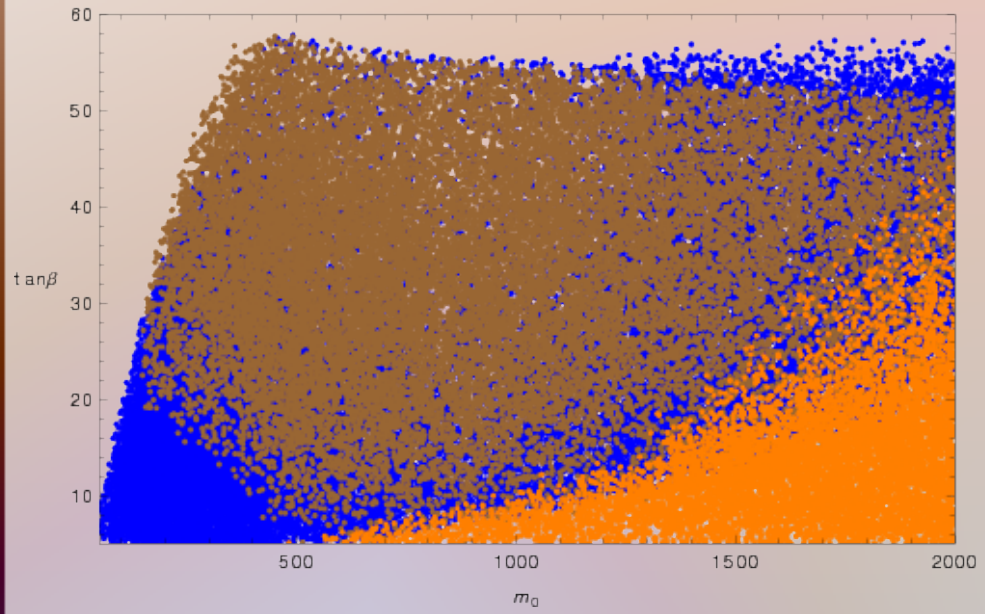

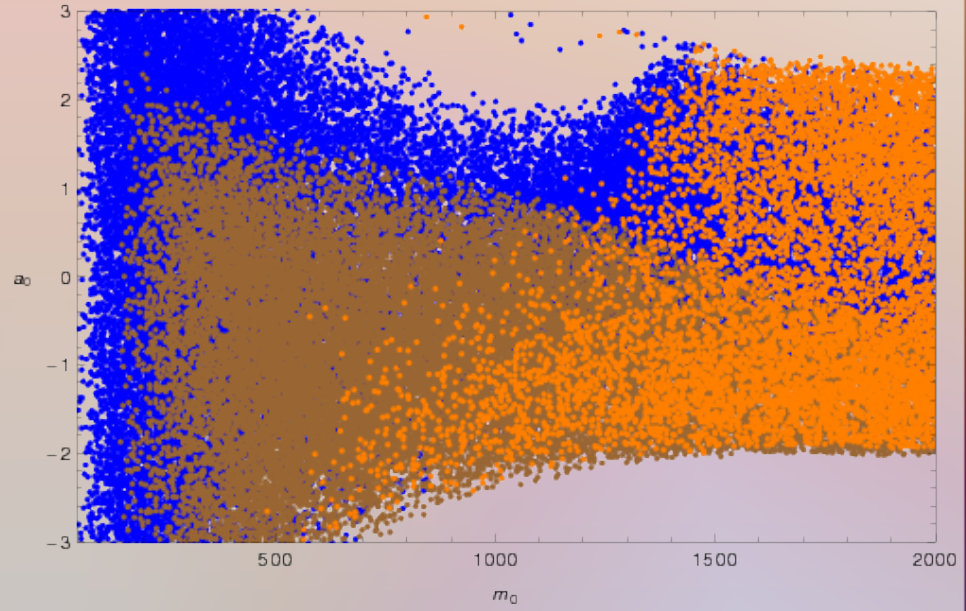

Exclusion due to B_s -> μ μ

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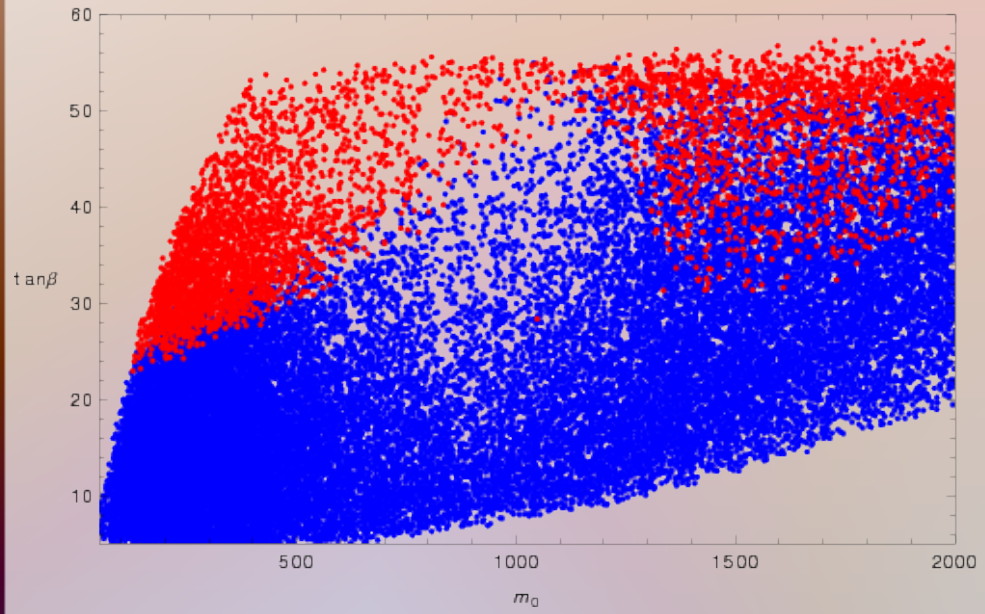

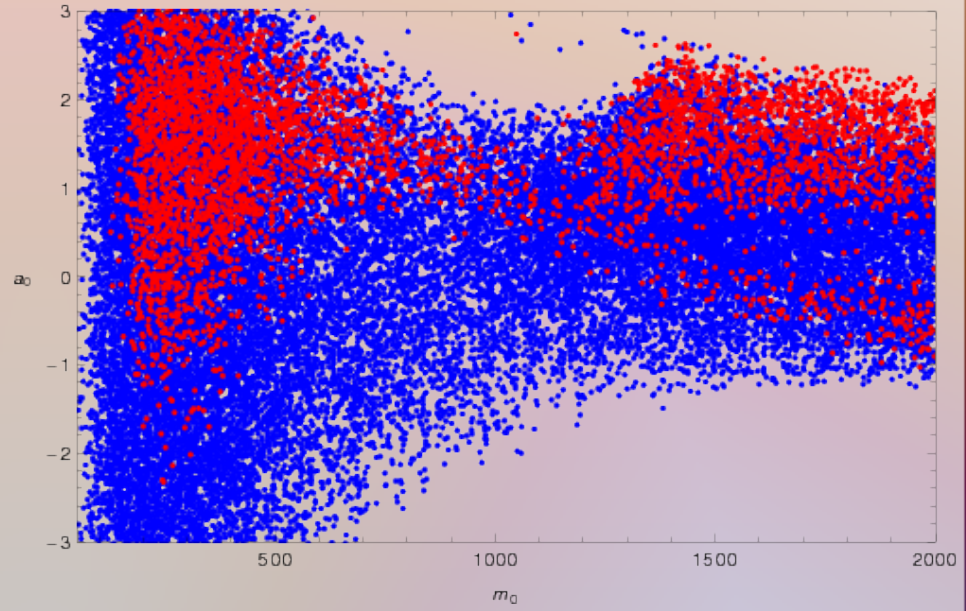

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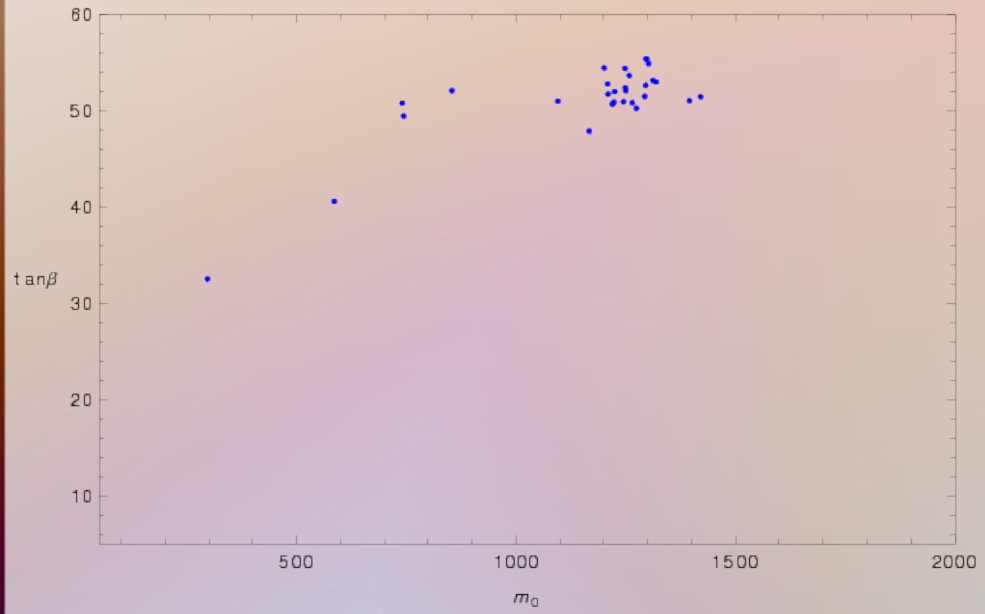

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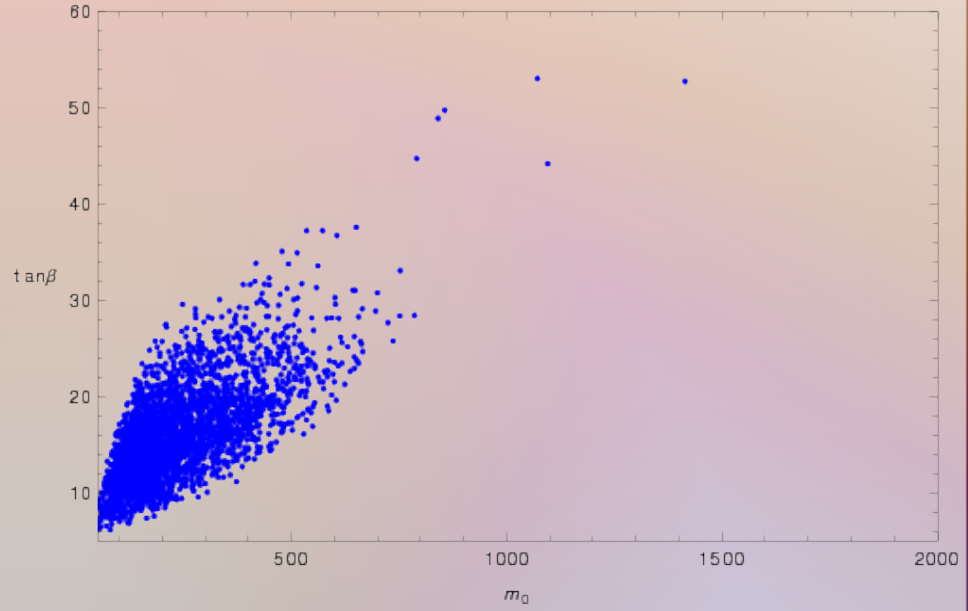

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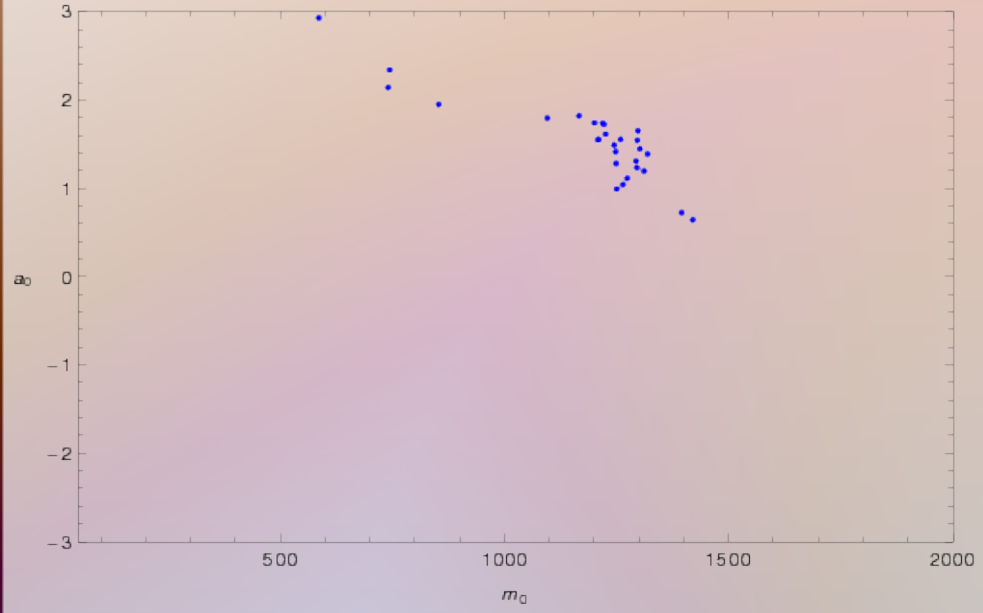

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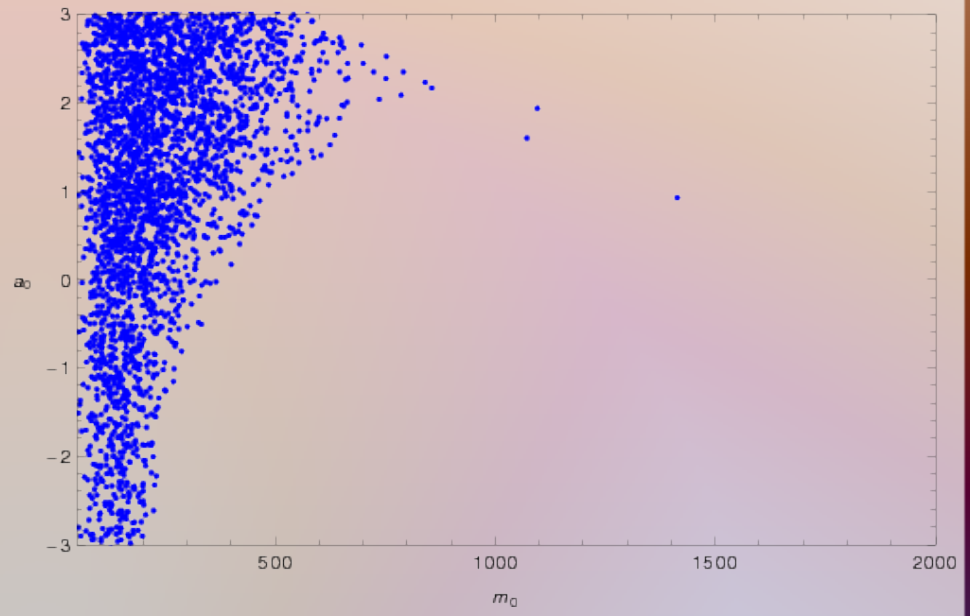
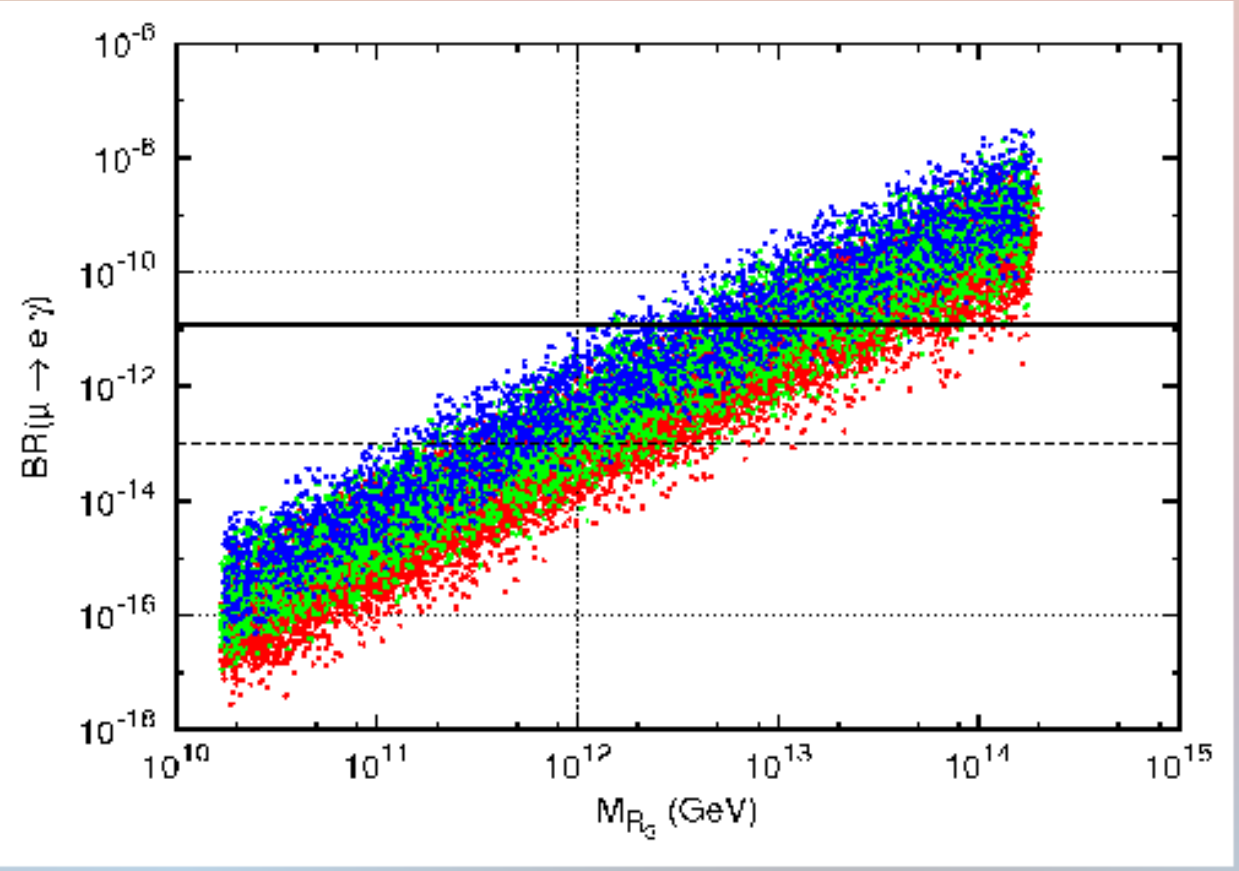


"Milder" Yukawas

$$Y_\nu = \kappa_\nu V_{\rm PMNS} Y_u^{\rm diag} \qquad \kappa_\nu = 0.01 - 1$$

$$\sin^2 2\theta_{13} = 0.03 - 0.28$$



$a_\mu < 1 \times 10^{-9}$

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$a_\mu > 2 \times 10^{-9}$

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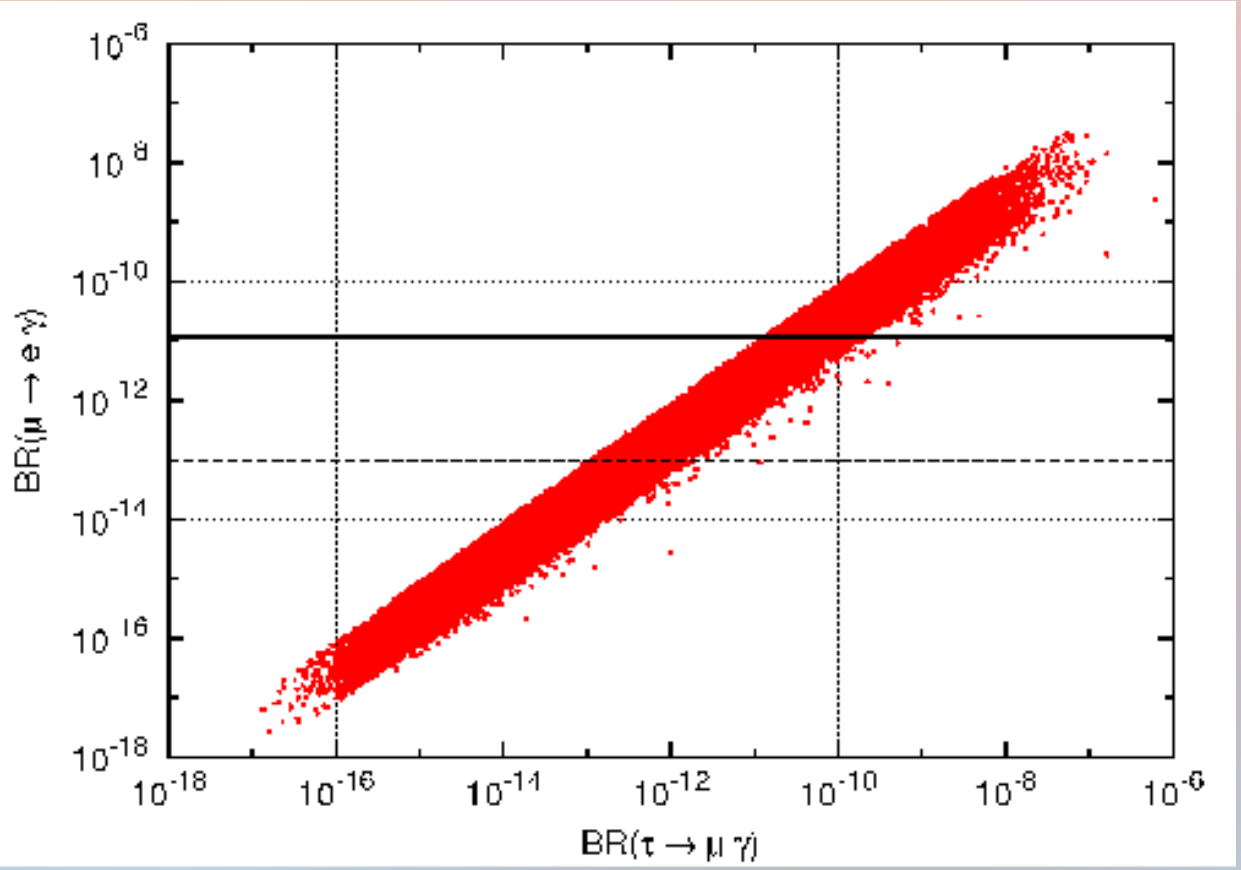

No hope for

$\tau \longrightarrow \mu\gamma$

at SuperB

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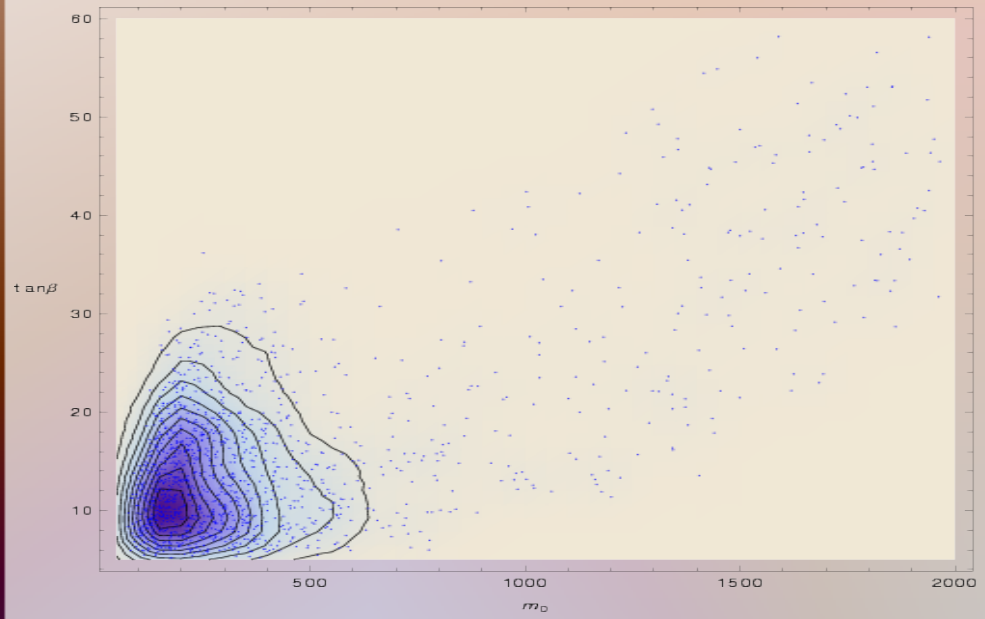

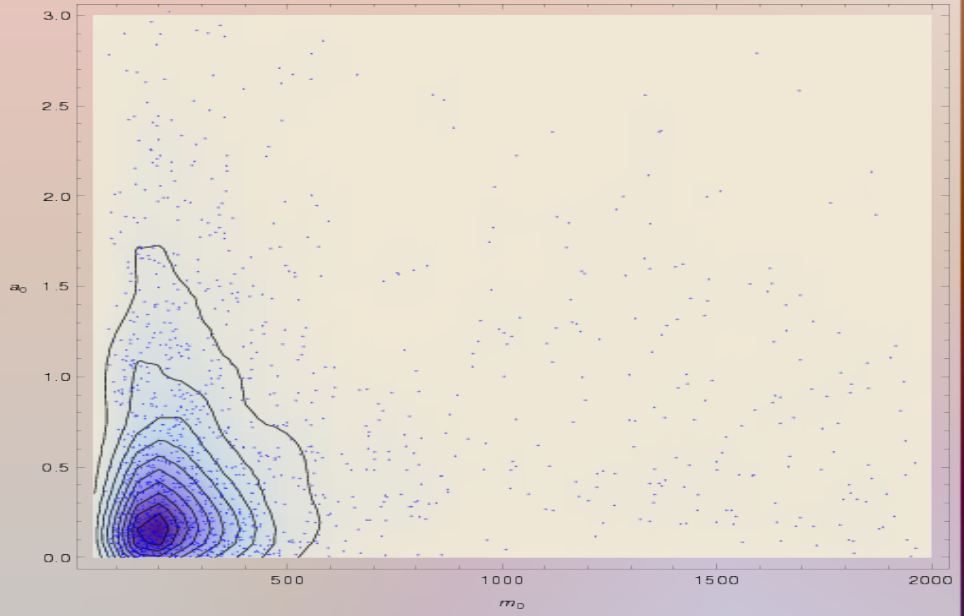

RVV Models

- Very difficult to satisfy anomalous $S_{\psi\phi}$