Lepton flavor enrichment and the muon $g-2$ contribution through susy loops.

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Outline

- LFV susy loop and MIA.
  Discussion of two methods.

- Muon g-2 status review.
  Experimental & Theoretical.

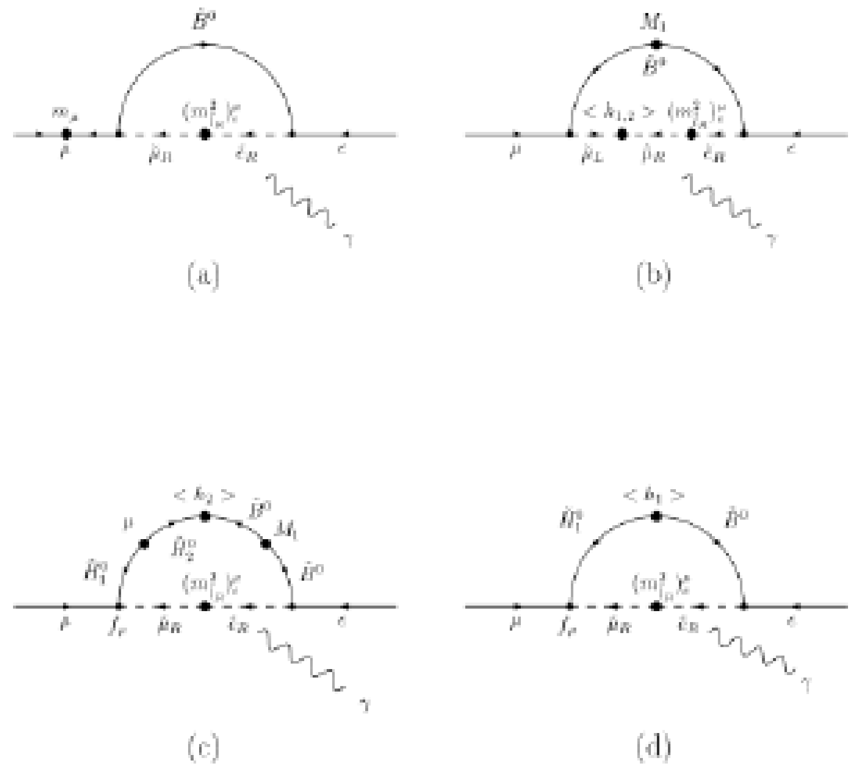
- **Non-universal sfermion masses and mixing angles**
  $\rightsquigarrow$ flavor mixing within 2nd and 3rd families.

- Phenomenological consequences on charged lepton sector.
  $BR(\tau \to \mu\gamma)$.
  $BR(h^0 \to \mu\tau)$
  $\not{F}\not{V}$ contributions to $(g-2)$.

Pioneers on Lepton Flavor Violations in MSSM using MIA

Using a qualitative aproximation in the flavor basis, known as *Mass Insertion Approximation (MIA)*,

J. Hisano, T. Moroi, K. Tobe and M. Yamaguchi, Phys. Lett. B 391, 341 (1997)



Lepton Flavor Violations in MSSM using MIA

The MIA takes the diagonal part of the flavour mass matrix is absorbed into a definition on an unphysical massive propagator and the non-diagonal parts commonly referd to as mass insertions is treated perturbatively, as part of the interaction Lagrangian.

Dedes, Paraskevas, Rosiek, Suxho, Tamvakis 2015

"The MIA is a Taylor expansion only with respect ...(to) the mass-squared difference. A small off-diagonal element does not necessarily imply a small mass difference. Instead, it may be related to small mixing angles. But then the validity of the MIA is questionable."

Guy Raz 2002

Gauge invariance Lepton flavor Violation loops

SUSY LFV contributions to EW presicion data manifest at one-loop level

① The contribution to *Lepton Flavor Violation* from susy 1-loop diagram:

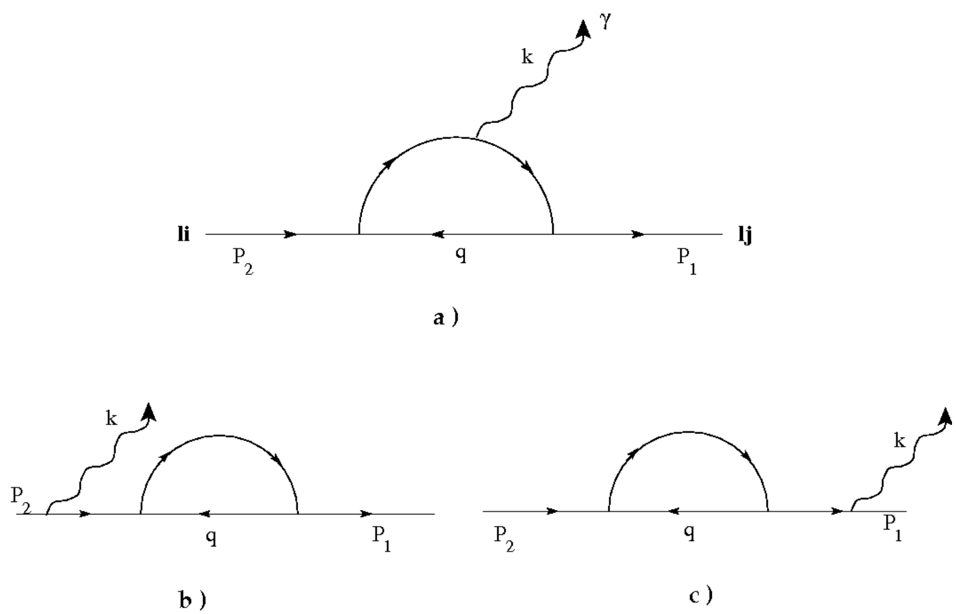


Figure 1: $\tau \to \mu\gamma$ *SUSY contribution.*

Super potential of the MSSM

Interactions $\rightsquigarrow$ SUSY and Gauge invariance

The only *freedom* that one has is the choice of the *superpotential* **W**

[A .DJOUADI, The Anatomy of ElectroWeak Symmetry Breaking Tome II: The Higgs bosons in the Minimal Supersymmetric Model]

$$W_{MSSM} = \frac{1}{2}M^{ij}\phi_i\phi_j + \frac{1}{6}y^{ijk}\phi_i\phi_j\phi_k \tag{1}$$

where ϕ are the quiral super fields.

By renormalization only bilinear and trilinear terms are permited

[see for instance S.P. Martin 07]

$\not{SUSY} \rightarrow$ *Soft-terms of MSSM*

Soft SUSY Lagrangian Kuroda 99

$$\mathcal{L}_{soft}^{MSSM} = \mathcal{L}_{gauginogluino}^{mass} - \mathcal{L}_{sfermion}^{mass} - \mathcal{L}_{Higgs} - \mathcal{L}_{trilinear} \tag{2}$$

with

$$-\mathcal{L}_{gauginogluino}^{mass} = \frac{1}{2}\left[M_1 \tilde{B}\tilde{B} + M_2 \sum_{a=1}^{3} \tilde{W}^a \tilde{W}_a + M_3 \sum_{a=1}^{8} \tilde{G}^a \tilde{G}_a + h.c.\right] \tag{3}$$

$$-\mathcal{L}_{sfermion}^{mass} = \sum_{i=gen} m_{\tilde{Q}_i}^2 \tilde{Q}_i^\dagger \tilde{Q}_i + m_{\tilde{L}_i}^2 \tilde{L}_i^\dagger \tilde{L}_i + m_{\tilde{u}i}^2 |\tilde{u}_{Ri}| + m_{\tilde{d}i}^2 |\tilde{d}_{Ri}|^2 + m_{\tilde{l}i}^2 |\tilde{l}_{Ri}|^2 \tag{4}$$

$$-\mathcal{L}_{Higgs} = m_1^2 H_1^\dagger H_1 + m_2^2 H_2^\dagger H_2 + \mu B (H_2.H_1 + h.c.) \tag{5}$$

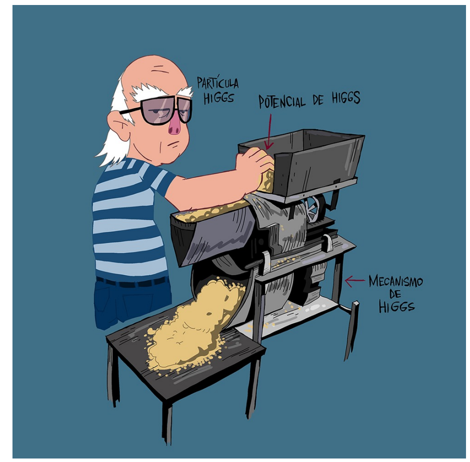
$$-\mathcal{L}_{trilinear} = \sum_{i,j=gen}\left[A_{ij}^u \tilde{Q}_i H_2 \tilde{u}_{Rj}^* + A_{ij}^u \tilde{Q}_i H_1 \tilde{d}_{Rj}^* + A_{ij}^l \tilde{L}_i H_1 \tilde{l}_{Rj}^*\right] \tag{6}$$

Reducing MSSM parameters

phenomenological, pMSSM: 22 input parameters:

$$\tan\beta;$$
$$m_1^2, m_2^2;$$
$$M_1, M_2, M_3;$$
$$\tilde{m}_q,\ \tilde{m}_{uR}, \tilde{m}_{dR}, \tilde{m}_l, \tilde{m}_{eR};$$
$$\tilde{m}_{Qt},\ \tilde{m}_{tR}, \tilde{m}_{bR}, \tilde{m}_{L\tau}, \tilde{m}_{\tau R};$$
$$A_{u,c}, A_{d,s}, A_{e,\mu}; \quad A_t, A_b, A_\tau$$

$$m_h = 125 \ \textbf{GeV}$$



We propouse a different consideration for trilinear couplings:

$$A_u, A_d, A_e; \quad A_{c,t}, A_{s,b}, A_{\mu,\tau}$$

where the two families are mixed.

The current way to analize a supersymmetric model is to fixed tha Higgs mass to the experimental value, and all of the correction adjust from there, calling this parametrization as *hMSSM*

Ligth Higgs mass as a fixed parameter: hMSSM

In order to accomplish for the previous simple relation of Higgs mass, the following choice of SUSY parameters has to be imposed:

[M. Carena (2013)]

(a) A decoupling regime with heavy A states: $m_A \sim \mathcal{O}(TeV)$
(b) $\tan\beta \gtrapprox 10$ to maximize tree-level contributions.
(c) Heavy stops squarks, $i.e.$ large SUSY mass scale M_S, to enhance logaritmic contributions.
(d) Maximal mixing scenario for trilinear stop couplings: $X_t = \sqrt{6}M_S$, maximizing stop loops.

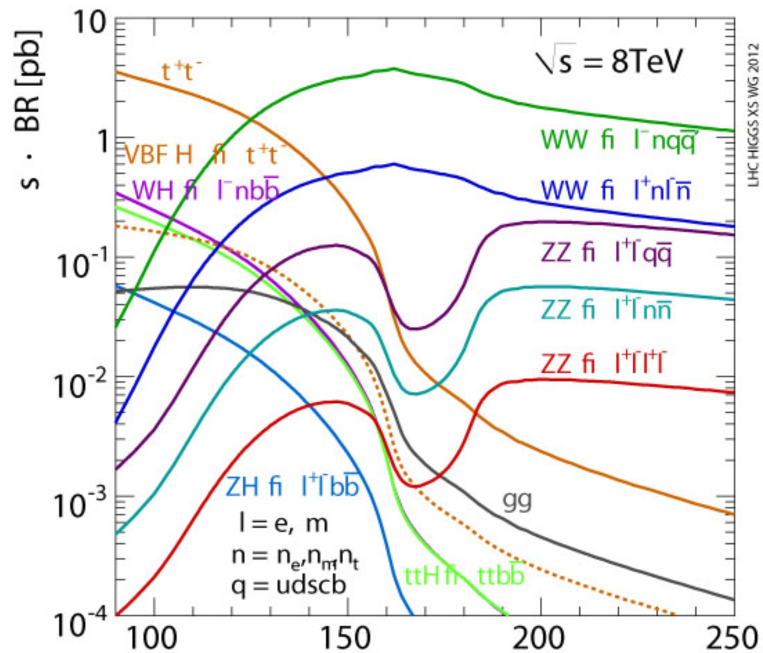
Higgs boson production

Once the Higgs mass is determined, the SM Higgs properties are fixed. Any contribution from a extended Higgs sector may shift the couplings, and hence its production and decay rates.

Arbey, Battaglia,Djouadi, Mahmoudi, Muhlleitner and Spira (2021)

Bounds on Higgs production would be proved with improved precision by HL-LHC.

process	$\sqrt{s}$	σ^{tot}
$gg \to h$	14 TeV	$\sigma^{tot}_{ggh} \approx 50pb$
$qq \to hqq$	14 TeV	$\sigma^{tot}_{VBF} \approx 4pb$
$qq \to hV$	14 TeV	$\sigma^{tot}_{hV} \approx 2.5pb$
$pp \to t\bar{t}h$	14 TeV	$\sigma^{tot}_{tth} \approx 0.6pb$
$gg \to hh$	14 TeV	$\sigma^{tot}_{gghh} \approx 50fb$

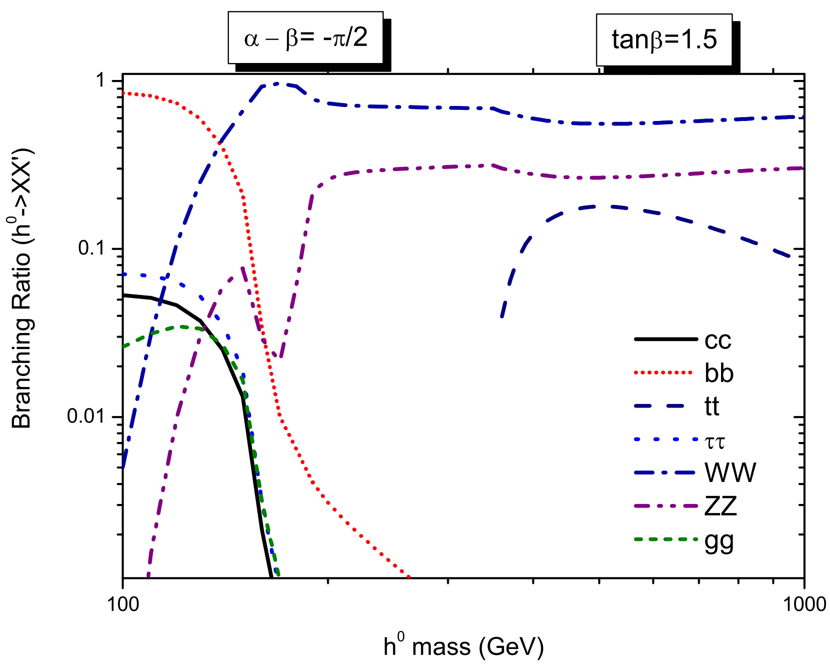


Higgs boson decay rates

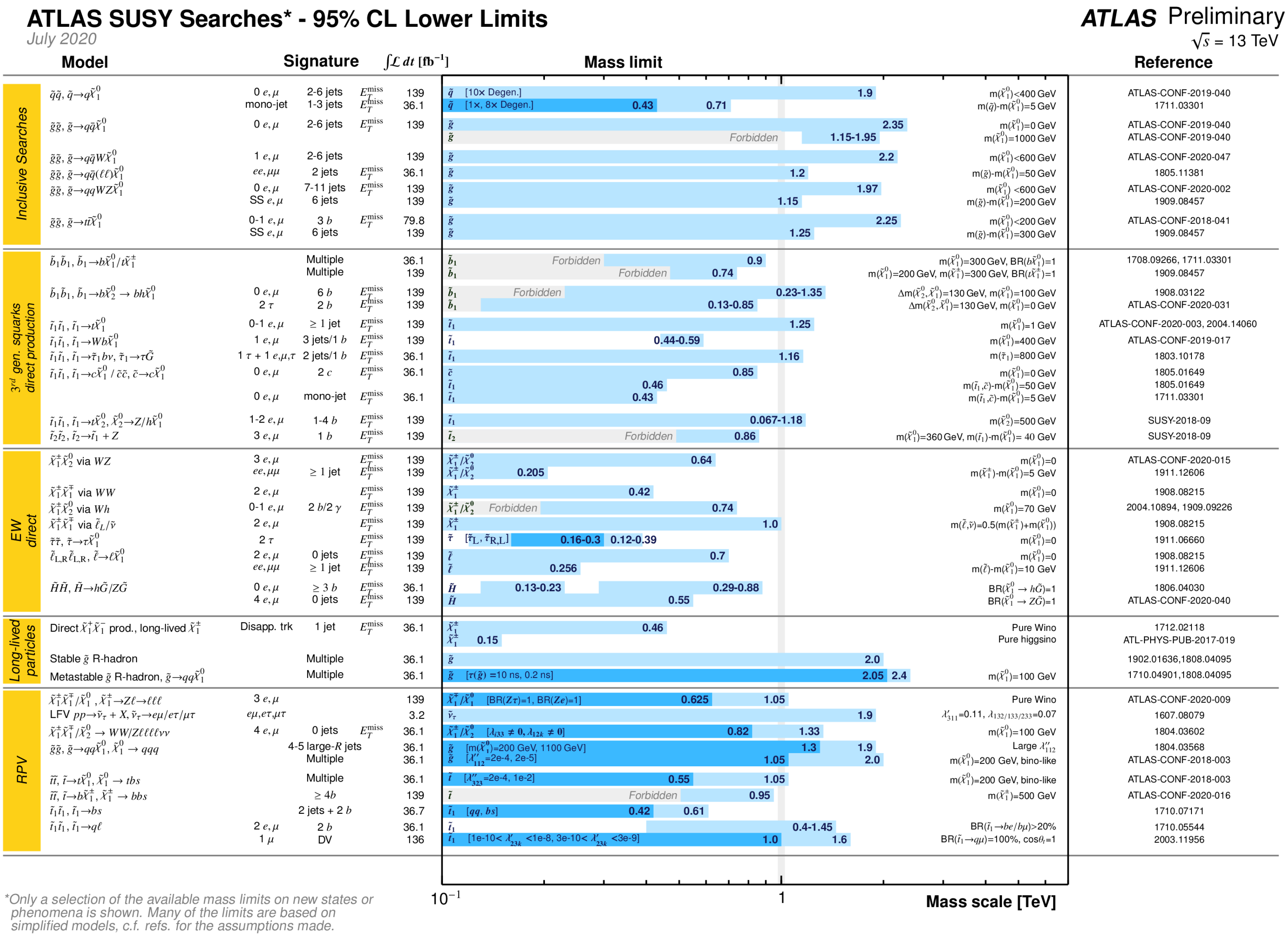
Analyze the production and decay rates using the defined coupling modifiers

$$\kappa_X = \frac{g_{hXX}^{MSSM}}{g_{hXX}^{SM}}$$

process	BR
$h \to b\bar{b}$	over 60%
$h \to W * W \to ll\nu\nu$	20%
$h \to Z * Z \to llll$	2.5%
$h \to \tau\tau$	$\approx 5\%$
$h \to gg$	8%
$h \to c\bar{c}$	3%
$h \to \gamma\gamma$	2×10^{-3}
$h \to \mu\bar{\mu}$	2×10^{-4}



Supersymmetry experimental searches.



MSSM sfermion mass matrix

The sfermion mass matrix can be written as blocks of 3×3

$$\tilde{M}^2_{\tilde{f}} = \begin{pmatrix} M^2_{LL} & M^2_{LR} \\ M^{2\dagger}_{LR} & M^2_{RR} \end{pmatrix} \tag{7}$$

The elements of this matrix decomposed on the different terms of the MSSM Lagrangian are given by,

$$\tilde{M}^2_{f} = \begin{pmatrix} m^2_{f,LL} + F_{f,LL} + D_{f,LL} & m^2_{f,LR} + F_{f,LR} \\ (m^2_{f,LR} + F_{f,LR})^\dagger & m^2_{f,RR} + F_{f,RR} + D_{f,RR} \end{pmatrix} \tag{8}$$

For charged leptons, we will have

$$\mathbf{M}^2_{\tilde{l}} = \begin{pmatrix} m^2_{slL} + m^2_l + M^2_Z \cos 2\beta (I^l_3 - Q_l s^2_{\rm w}) & m_l\, X_l \\ m_l\, X_l & m^2_{slR} + m^2_l + M^2_Z \cos 2\beta Q_l s^2_{\rm w} \end{pmatrix}, \tag{9}$$

with $X_l = A_l - \mu \tan\beta$, and we assume $m^2_{sfR} \simeq m^2_{sfL} \simeq \tilde{m}^2_0$

Flavor Ansatz for the trilinear terms

We propose that the trilinear scalar term would mix the second and third families as follows:

$$A = \begin{pmatrix} 0 & 0 & 0 \\ 0 & w & z \\ 0 & y & 1 \end{pmatrix} A_0 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & A_w & A_z \\ 0 & A_y & A_0 \end{pmatrix} \tag{10}$$

Then the sfermion mass matrix is given by

$$\tilde{M}_{\tilde{l}}^2 = \left(\begin{array}{cc|cccc} \tilde{m}_L^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & \tilde{m}_R^2 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & \tilde{m}_L^2 & X_2 & 0 & A_z \\ 0 & 0 & X_2 & \tilde{m}_R^2 & A_y & 0 \\ 0 & 0 & 0 & A_y & \tilde{m}_L^2 & X_3 \\ 0 & 0 & A_z & 0 & X_3 & \tilde{m}_R^2 \end{array}\right), \tag{11}$$

with

$$X_2 = (A_w - \mu \tan\beta) m_\mu$$
$$X_3 = (A_0 - \mu \tan\beta) m_\tau$$

New general physical masses for sfermions

Then we will have non-degenerate sfermion masses:

$$\begin{aligned}
m^2_{f\tilde{2}_1} &= \frac{1}{2}(2\tilde{m}_0^2 + X_2 + X_3 - R) \\
m^2_{f\tilde{2}_2} &= \frac{1}{2}(2\tilde{m}_0^2 - X_2 - X_3 + R) \\
m^2_{f\tilde{3}_1} &= \frac{1}{2}(2\tilde{m}_0^2 - X_2 - X_3 - R) \\
m^2_{f\tilde{3}_2} &= \frac{1}{2}(2\tilde{m}_0^2 + X_2 + X_3 + R)
\end{aligned} \quad (12)$$

where $R = \sqrt{4A_y^2 + (X_2 - X_3)^2}$

$$A_y = A_z \quad (13)$$

Mass Basis: Rotation matrix for sfermions

We write the 4×4 rotation matrix for sleptons as a 2×2 block matrix

$$\mathcal{O}_{\tilde{f}} = \frac{1}{\sqrt{2}} \begin{pmatrix} \Theta & -\Theta \\ \Theta\sigma_3 & \Theta\sigma_3 \end{pmatrix} \tag{14}$$

where σ_3 is Pauli matrix and

$$\Theta = \begin{pmatrix} -\sin\frac{\varphi}{2} & -\cos\frac{\varphi}{2} \\ \cos\frac{\varphi}{2} & -\sin\frac{\varphi}{2} \end{pmatrix} \tag{15}$$

with

$$sin\varphi \to \frac{2A_y}{\sqrt{4A_y^2 + (X_2 - X_3)^2}}, \tag{16}$$

$$cos\varphi \to \frac{(X_2 - X_3)}{\sqrt{4A_y^2 + (X_2 - X_3)^2}} \tag{17}$$

1-loop $BR(\tau \to \mu\gamma)$ *no-MIA*

The Lagrangian $\tilde{B}^0\tilde{l}l$ in mass eigenstate now is given by:

$$\begin{aligned}\mathcal{L}_{\tilde{B}\tilde{l}l} \;\; = \;\; & -\frac{g}{2\sqrt{2}}\tan\theta_W \bar{\tilde{B}}\Big\{ \left[-P_L\tilde{e}_1 + 2P_R\tilde{e}_2\right] e + \\ & -\frac{s_\varphi}{\sqrt{2}}\left[(1+3\gamma_5)\tilde{\mu}_1 + (3+\gamma_5)\tilde{\mu}_2\right]\mu + \\ & +\frac{c_\varphi}{\sqrt{2}}\left[(1+3\gamma_5)\tilde{\mu}_1 + (3+\gamma_5)\tilde{\mu}_2\right]\tau + \\ & +\frac{c_\varphi}{\sqrt{2}}\left[(3+\gamma_5)\tilde{\tau}_1 + (1+3\gamma_5)\tilde{\tau}_2\right]\mu + \\ & +\frac{s_\varphi}{\sqrt{2}}\left[(3+\gamma_5)\tilde{\tau}_1 + (1+3\gamma_5)\tilde{\tau}_2\right]\tau \Big\}\end{aligned} \tag{18}$$

We may write the coupling as

$$g_{l_i B\tilde{l}_r} = -\frac{g\tan\theta_W}{4}[S_{l_i,\tilde{l}_r} + P_{l_i,\tilde{l}_r}\gamma^5]$$

1-loop $BR(\tau \to \mu\gamma)$ gauge invariance... a)

$$\begin{aligned}\mathcal{M}_a &= -eg_C^2 \bar{u}(p_1)\left[(S_iS_j - P_iP_j) + (S_iP_j - S_jP_i)\gamma^5\right] m_{\tilde{B}} \frac{1}{(2\pi)^4}\int dq^4 \frac{2(p_2+q)\cdot\epsilon}{D_q D_1 D_2} \\ &\quad -eg_C^2 \bar{u}(p_1)\left[(S_iS_j + P_iP_j) + (S_iP_j + S_jP_i)\gamma^5\right] \frac{1}{(2\pi)^4}\int dq^4 \frac{2(p_2+q)\cdot\epsilon \not{q}}{D_q D_1 D_2},\end{aligned}$$

where $D_q = q^2 - m_{\tilde{B}}^2$, $D_1 = (q+p_1)^2 - m_{\tilde{l}_r}^2$, $D_2 = (q+p_2)^2 - m_{\tilde{l}_r}^2$, and ϵ is the photon polarization vector. For the $\tau \to \mu\gamma$ decay, we have $i = \tau$ and $j = \mu$ and the $S_{i,j}$, $P_{i,j}$ couplings are labeled as follows: $S_i = S_{\tilde{B}\tau\tilde{l}}$, $S_j = S_{\tilde{B}\mu\tilde{l}}$, $P_i = P_{\tilde{B}\tau\tilde{l}}$ and $P_j = S_{\tilde{B}\mu\tilde{l}}$. All the possible sleptons running inside the loop are indicated by the index $\tilde{l} = \tilde{\mu}_1, \tilde{\mu}_2, \tilde{\tau}_1, \tilde{\tau}_2$. The corresponding values are given in Table 1.

$\tilde{l}$	$\tilde{\mu}_1$	$\tilde{\mu}_2$	$\tilde{\tau}_1$	$\tilde{\tau}_2$
$S_{\tilde{B}\tau\tilde{l}}$	$3\sin\frac{\varphi}{2}$	$\sin\frac{\varphi}{2}$	$\cos\frac{\varphi}{2}$	$3\cos\frac{\varphi}{2}$
$P_{\tilde{B}\tau\tilde{l}}$	$\sin\frac{\varphi}{2}$	$3\sin\frac{\varphi}{2}$	$3\cos\frac{\varphi}{2}$	$\cos\frac{\varphi}{2}$
$S_{\tilde{B}\mu\tilde{l}}$	$3\cos\frac{\varphi}{2}$	$\cos\frac{\varphi}{2}$	$-\sin\frac{\varphi}{2}$	$-3\sin\frac{\varphi}{2}$
$P_{\tilde{B}\mu\tilde{l}}$	$\cos\frac{\varphi}{2}$	$3\cos\frac{\varphi}{2}$	$-3\sin\frac{\varphi}{2}$	$-\sin\frac{\varphi}{2}$

Table 1: Scalar and pseudoscalar Bino-lepton-slepton couplings with lepton flavour mixing

For the anomaly $g-2$ we set $i = j = \mu$.

1-loop $BR(\tau \to \mu\gamma)$ gauge invariance

For the diagram Fig. 1(b) we have

$$\mathcal{M}_b = -\bar{u}(p_1) e \Sigma_b \frac{[\not{p}_1 + m_i]}{m_j^2 - m_i^2} \not{\epsilon}\, u(p_2), \tag{19}$$

with

$$\begin{aligned}\Sigma_b = {} & m_{\tilde{B}} g_c^2 \left[(S_i S_j - P_i P_j) + (S_i P_j - S_j P_i)\gamma^5 \right] \frac{1}{(2\pi)^4} \int \frac{dq^4}{D_q D_1} \\ & + g_c^2 \left[(S_i S_j + P_i P_j) + (S_i P_j + S_j P_i)\gamma^5 \right] \frac{1}{(2\pi)^4} \int \frac{dq^4 \not{q}}{D_q D_1}.\end{aligned} \tag{20}$$

The amplitude for Fig. 1(c) reads

$$\mathcal{M}_c = -\bar{u}(p_1) e \gamma_\mu \epsilon^\mu \frac{[\not{p}_1 + \not{k} + m_j]}{m_i^2 - m_j^2} \Sigma_c u(p_2), \tag{21}$$

where

$$\Sigma_c = m_{\tilde{B}} g_c^2 \left[(S_i S_j - P_i P_j) + (S_i P_j - S_j P_i)\gamma^5\right] \frac{1}{(2\pi)^4} \int \frac{dq^4}{D_q D_2}$$
$$+ g_c^2 \left[(S_i S_j + P_i P_j) + (S_i P_j + S_j P_i)\gamma^5\right] \frac{1}{(2\pi)^4} \int \frac{dq^4 \not{q}}{D_q D_2}.$$

The total amplitude which is the sum of Eqs.(19, 19, 21) is written as follows:

$$\mathcal{M}_T = \bar{u}(p_1)[\imath E_{ij}\sigma^{\mu\nu}k_\nu\epsilon_\mu + \imath F_{ij}\sigma^{\mu\nu}k_\nu\epsilon_\mu\gamma^5]u(p_2)$$
$$= \bar{u}(p_1)[\frac{E_{ij}}{2} + \frac{F_{ij}}{2}\gamma^5][\not{k}, \not{\epsilon}]u(p_2) \ . \quad (22)$$

The Branching Ratio will be given by

$$\mathcal{BR}(\tau \to \mu\gamma) = \frac{(1-x^2)^3 m_\tau^3}{4\pi\Gamma_\tau}[|\sum_{\tilde{l}} E_{\tilde{l}}^{\tau\mu}|^2 + |\sum_{\tilde{l}} F_{\tilde{l}}^{\tau\mu}|^2] \ , \quad (23)$$

with $x = \frac{m_\mu}{m_\tau}$.
In the case of $i = \tau$ and $j = \mu$ we would have the expressions for E_{ij} and F_{ij}

as in Eqs.(24, 25).

$$E_{\tau\mu\tilde{l}_r} = \frac{\imath s_\varphi c_\varphi e g^2 \tan^2\theta_W}{(16\pi)^2(m_\tau^2 - m_\mu^2)(m_\tau + m_\mu)}\{ E_{1,r}(B0[m_\tau^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2] - B0[m_\mu^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2]) - E_{2,r}(1 + 2m_{\tilde{l}_r}^2 C0[m_\tau^2, m_\mu^2, 0, m_{\tilde{l}_r}^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2]) - E_{3,r}(B0[m_\tau^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2] - B0[0, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2]) + E_{4,r}(B0[m_\mu^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2] - B0[0, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2])\Big\} \quad (24)$$

$$F_{\tau\mu\tilde{l}_r} = -\frac{\imath s_\varphi c_\varphi e g^2 \tan^2\theta_W}{(16\pi)^2(m_\tau - m_\mu)(m_\tau^2 - m_\mu^2)}\Big[\Big\{F_{1,r}(B0[m_\tau^2, m_B^2, m_{\tilde{l}_r}^2] - B0[m_\mu^2, m_B^2, m_{\tilde{l}_r}^2]) + F_{2,r}(1 + 2m_{\tilde{l}_r}^2 C0[m_\tau^2, m_\mu^2, 0, m_{\tilde{l}_r}^2, m_{\tilde{B}}^2, m_{\tilde{l}_r}^2]) - F_{3,r}(B0[m_\tau^2, m_B^2, m_{\tilde{l}_r}^2] - B0[0, m_B^2, m_{\tilde{l}_r}^2]) + F_{4,r}(B0[m_\mu^2, m_B^2, m_{\tilde{l}_r}^2] - B0[0, m_B^2, m_{\tilde{l}_r}^2])\Big\}\Big] \quad (25)$$

Muon magnetic moment anomaly $(g-2)$

A discrepancy in the anomalous magnetic moment of the muon is found between SM predition and experimental measurment, calculate the possible contribution through FV SUSY.

$$a_\mu^{exp} = 116592059(22) \times 10^{-11} \ ,$$
$$a_\mu^{SM} = 116591810(43) \times 10^{-11} \ ,$$

The Muon $g-2$ Collaboration, arXiv:2308.06230v2 (2023)

The anomalous magnetic moment of the muon in the Standard Model arXiv:2006.04822v2 (2020)

$\sigma = 48.3 \rightarrow a_{mu}^{Exp} - a_{mu}^{SM} = 5.15\sigma$

New physics contribution: $a_{mu}^{SUSY} = 4.15\sigma \times 10^{-11} = 200.445 \times 10^{-11}$

Muon magnetic moment anomaly a_μ

$$a_\mu^{\rm SM} = a_\mu^{\rm QED} + a_\mu^{\rm EW} + a_\mu^{\rm Had} \quad . \tag{4}$$

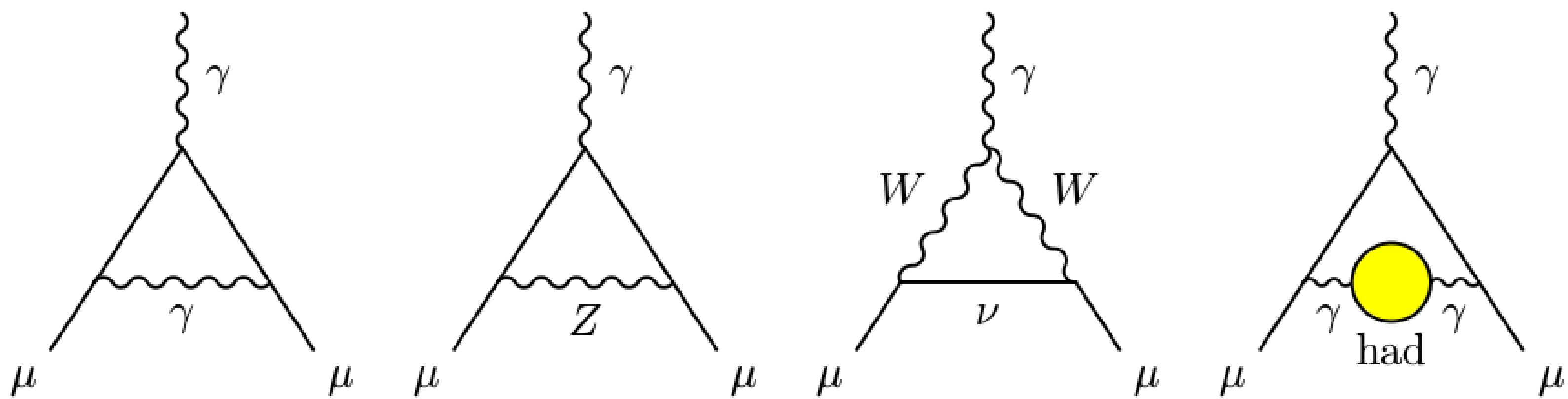


Figure 1: Representative diagrams contributing to $a_\mu^{\rm SM}$. From left to right: first order QED (Schwinger term), lowest-order weak, lowest-order hadronic.

Muon magnetic moment anomaly a_μ

We know $\vec{\mu} = -g\frac{e}{2m}\vec{s}$. Which is corrected by 1-loop diagramas, for the muon

$$\vec{\mu}_\mu = \frac{e}{2m_\mu}(1 + a_\mu)\vec{\sigma}$$

The electron spin interacts with an external electromagnetic field. Using Gordon identity

$$\Gamma^\mu = A\gamma^\mu + B(p_1 + p_2)^\mu + \cdots = F_1(q^2)\gamma^\mu + \frac{i\sigma^{\mu\nu}q_\nu}{2m}F_2(q^2)$$

F are called form factors and are functions depending on $q^2 = (p_2 - p_1)^2$. The magnetic moment anomaly is defined as

$$g = 2[F_1(0) + F_2(0)] = 2 + 2F_2(0) \to a_\mu \equiv F_2(0) = \frac{g-2}{2}$$

At lowest order: $F_1 = 1$, $F_2 = 0$

Bino-sleptons contribution to $(g-2)$

② LFV contribution to the anomalous magnetic moment of the muon:

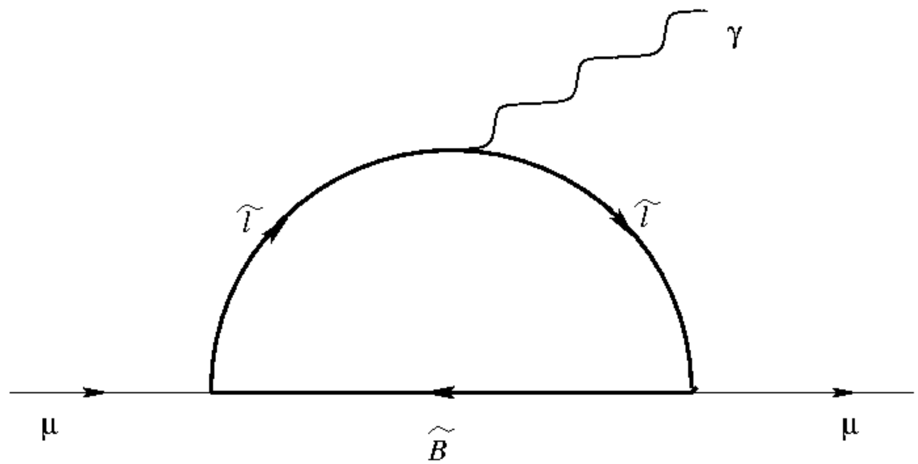


Figure 2: *muon's anomalous magnetic moment Bino-sleptons FV contribution.*

Chargino-sneutrino contribution to $(g-2)$

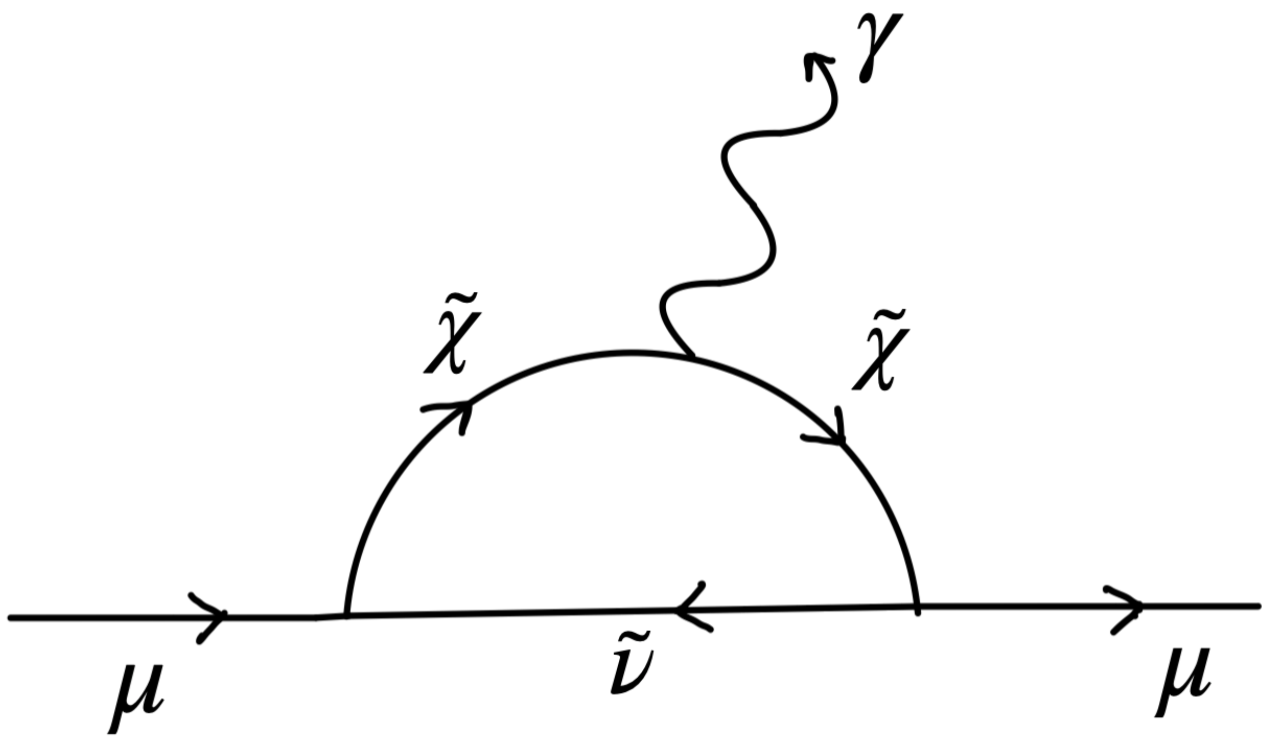


Figure 3: muon's anomalous magnetic moment chargino-snetruino contribution.

The muon anomalous magnetc moment diagram amplitude is given as

$$\begin{aligned}\mathcal{M}^{li\to\gamma li} &= \overline{u}(p_j)\frac{\imath g}{2}\left[F_1+F_2\gamma^5\right]\int\frac{dq^4}{(2\pi)^4}\frac{\imath}{q^2-m_{\tilde{\nu}}^2}\imath\left[\frac{\not{q}+\not{p}_j+m_{\chi_1}}{(q+p_j)^2-m_{\chi_1}^2}\right] \\ &\times\imath e\gamma^\mu\epsilon_\mu(k)\imath\left[\frac{\not{q}+\not{p}_i+m_{\chi_1}}{(q+p_i)^2-m_{\chi_1}^2}\right]\frac{\imath g}{2}\left[F_1-F_2\gamma^5\right]u(p_i) \\ &+\mathcal{M}(\chi_1\to\chi_2,F_1\to F_3,F_2\to F_4)\end{aligned}\tag{26}$$

where the contribution to $g-2$ comes from isolation of the term proportional to $(p_i+p_j)^\mu$, so we extract this term from all the structure of the amplitud. The numerator is given by

$$\begin{aligned}N^\mu &= (p_+\not{q}+p_+m_{\chi_1}+p_-m)\gamma^\mu(\not{q}p_-+m_{\chi_1}p_-+mp_+) \\ &= p_+^2\not{q}\gamma^\mu\not{q}+m_{\chi_1}p_+p_-\not{q}\gamma^\mu+mp_+^2\not{q}\gamma^\mu+m_{\chi_1}p_+p_-\gamma^\mu\not{q} \\ &+m_{\chi_1}^2p_+^2\gamma^\mu+m_{\chi_1}mp_+p_-\gamma^\mu+mp_-^2\gamma^\mu\not{q}+m_{\chi_1}mp_-p_+\gamma^\mu+m^2p_-^2\gamma^\mu\end{aligned}\tag{27}$$

Then the amplitud will be given as:

$$\mathcal{M}^{li\to\gamma li}=\overline{u}(p_j)\Gamma_\mu\epsilon^\mu u(p_i)\tag{28}$$

where

$$\Gamma^\mu = \Gamma_s\gamma^\mu + \gamma^5(Ap_i^\mu + Cp_j^\mu) + \gamma^5\gamma^\mu D + \imath eB(p_i^\mu + p_j^\mu) \tag{29}$$

where Γ_s is a scalar function escalar, A, D and C are also scalars.

$$\mathcal{M}^B = \overline{u}(p_j)e\imath\left[B(s^2)(p_i + p_j)^\mu\right]\epsilon_\mu u(p_i) \tag{30}$$

In the limit $s^2 \to 0$ and considering $m^2/m_\chi^2 \to 0, m^2/m_{\tilde{\nu}}^2 \to 0$.

The contribution to the anomalous magnetic moment is obteined from

$$\Delta a_\mu = \frac{g-2}{2} = \mathcal{F}_2(0) \tag{31}$$

$$\mathcal{F}_2(0) = -2mB(0) \tag{32}$$

$\Delta_{\chi_2\nu_i} = m^2_{\chi_2} - m^2_{\nu_i}$.

$h^0 \to \tau\mu$ *FV slepton loop.*

the slepton which interacts with the muon (tau) is labeled with the index i (j), see Fig 1.

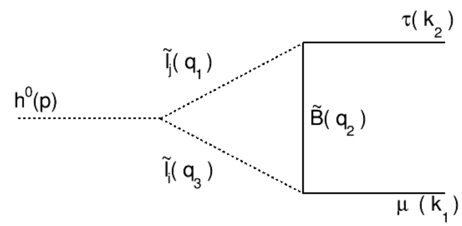


Figure 4: *1-loop SUSY slepton flavor mixing contribution to* $h^0 \to \mu\tau$.

The notation used for the coupling between the bino $\tilde{B}$, the slepton $\tilde{l}$ and the lepton l, for $l = \mu, \tau$, which is denoted as $\tilde{B}\tilde{l}l$, can be written in terms of three types of coefficients for each lepton.

Parameter space analysis considering FV and $(g-2)$

MGB, Flores-Baez, Mondragón (2016)

$\mu_{susy} \in [-15, 15]$ TeV	$A_0 \in [50, 5000]$ GeV
$\tilde{m}_S \in [50, 5000]$ GeV	$\frac{M_1}{\tilde{m}_S} \in [0.2, 5]$ GeV
$\tan\beta \in [1, 60]$	$w = -1$, $y = 1$

Table 2: The table shows the parameter space where the scan was performed. The values were taken at random for each variable within the bounds shown

$BR(\tau \to \mu\gamma)$	$\alpha_\mu^{\tilde{l}\tilde{B}}$	$\tan\beta$	M_1(GeV)	μ_{susy}(GeV)	$\tilde{m}_S$ (GeV)	A_0(GeV)
3.06×10^{-8}	2.17×10^{-9}	15.4	1205	7324.6	457.6	145.2
3.01×10^{-8}	2.06×10^{-9}	45	714	10298	991	1236.7
2.33×10^{-8}	2.42×10^{-9}	1.35	697	-2832.2	831.8	4003.5
2.22×10^{-8}	3.13×10^{-9}	30.7	363.7	12554.7	832.2	340
1.22×10^{-8}	3×10^{-9}	46.3	509.7	4681.2	691	408.5
2.06×10^{-11}	2×10^{-9}	45.6	2064	9127	1005.7	50.7

Table 3: Sample of parameter sets that solve entirely the muon $g-2$ discrepancy, consistent with the experimental bound on $BR(\tau \to \mu\gamma)$, calculated using random values of the parameters given in Table 2. For all these sets the LSP is a Bino.

Previous results $g-2$ contribution. (color code)

For $w=-1$, $y=1$.

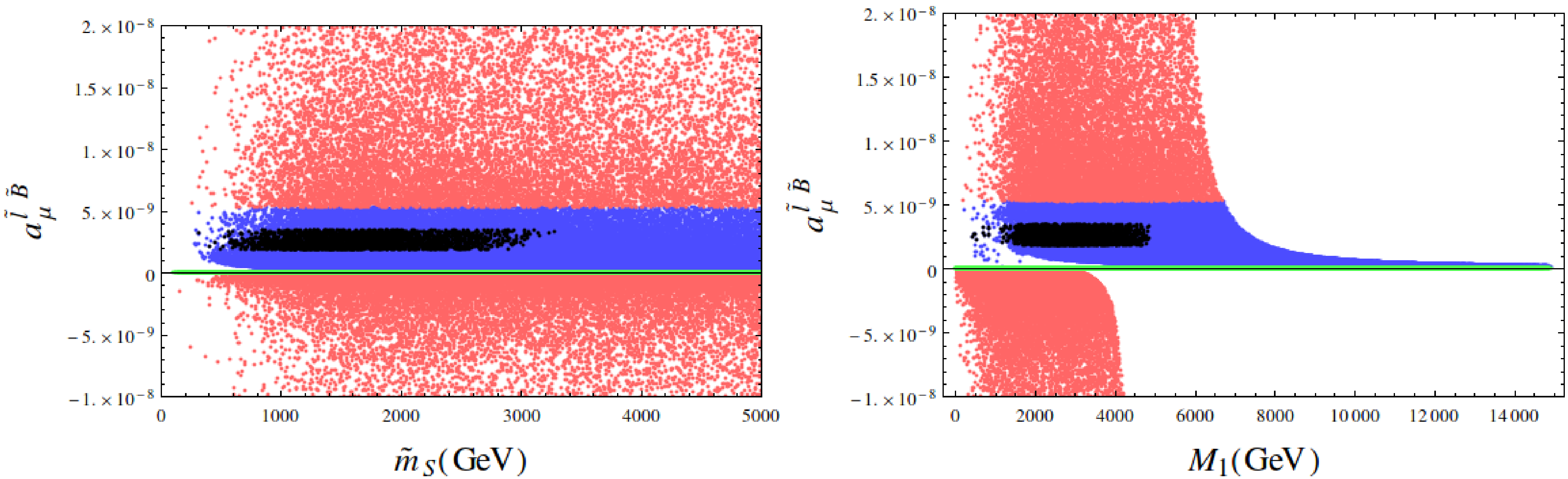


Figure 5: The plots show the dependence of the value of our calculation for $a_\mu^{\tilde{l}\tilde{B}}$ with the SUSY scalar mass (left) and the Bino mass (right). Here the color code used in Figs. 6, 8 and 9 is shown explicit as ranges of the $a_\mu^{\tilde{l}\tilde{B}}$. The green points correspond to no FV Bino-slepton loop, considering only the smuons in their mass eigenstates and $A_0=0$ the same as green points in previous figure (fig. 10).

Previous results $BR(\tau \to \mu\gamma)$

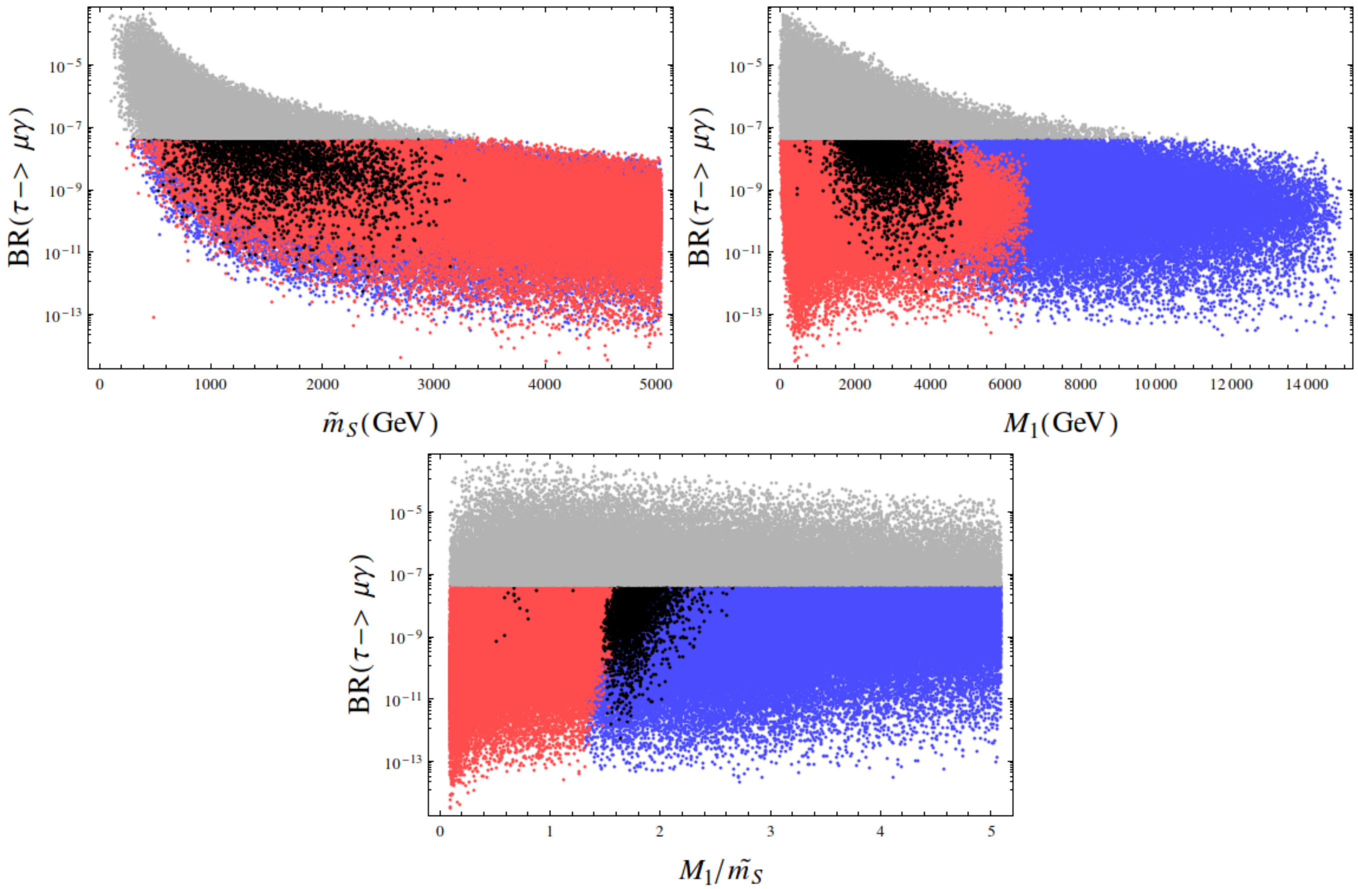


Figure 6: The plots show the dependence on $BR^{theo}(\tau \to \mu\gamma)$ on the SUSY scalar mass $\tilde{m}_S$ (left) and the Bino mass M_1 (right) and on the ratio of them (down). The gray points are excluded by the experimental bound on $BR(\tau \to \mu\gamma)$. The rest of the color code is shown explicit in Fig.5, which separates ranges of FV contributions to $g-2$.

Preliminary new results $g-2$

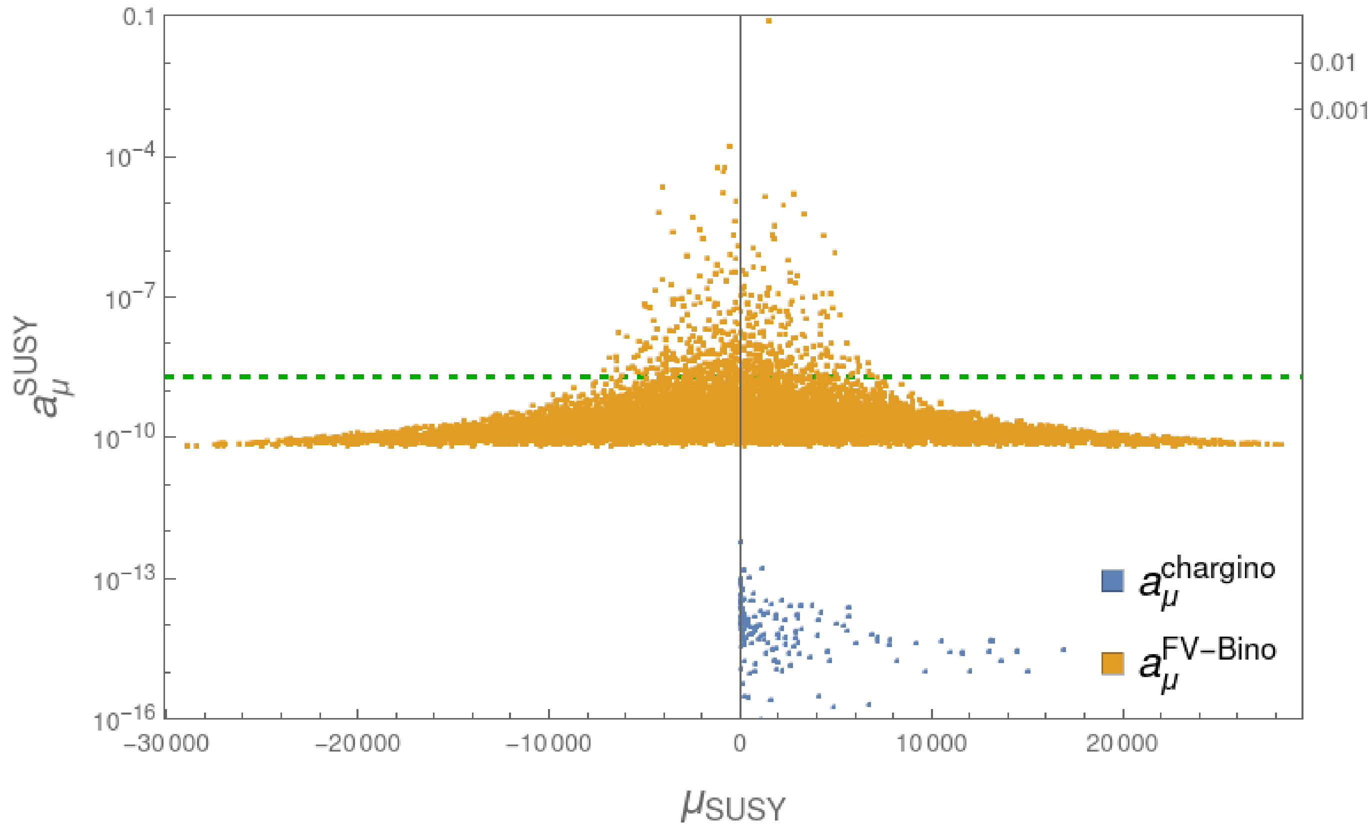


Figure 7: a_μ^{SUSY} with the μ_{SUSY} chargino-sneutrino loop and the Bino-FV slepton.

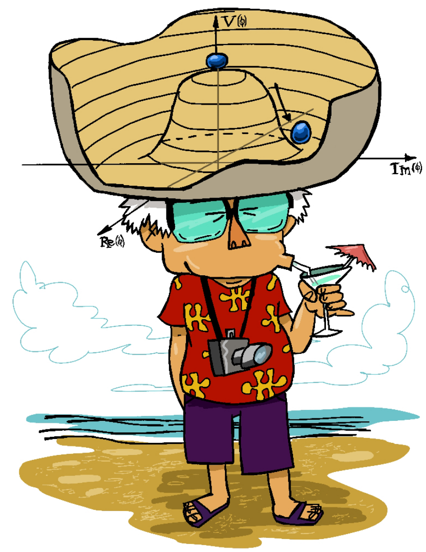
Conclusions

- We obtain analytical mixing angles for a possible flavor mixing within 2nd and 3rd sfermion families through soft breaking terms.

- We obtain FV couplings which avoids approximated methods as MI to accomplish for FV processes as:

  - $BR_{susy}(\tau \to \mu\gamma)$
    $\rightsquigarrow$2 types of diagrams: Bino-sleptones and Chargino-sneutrinos
  - $BR_{susy}(h^0 \to \tau\mu)$
    $\rightsquigarrow$ (16 diagrams Bino-FV charged sleptons)
  - $g-2$ muon anomalous magnetic moment contribution.

- We search for the MSSM-FV parameter space where is compatible with $g-2$. 2 types of diagrams: Bino-sleptones and Chargino-sneutrinos *thank you!*



Results on SUSY usual parameters

For $w = -1$, $y = 1$.

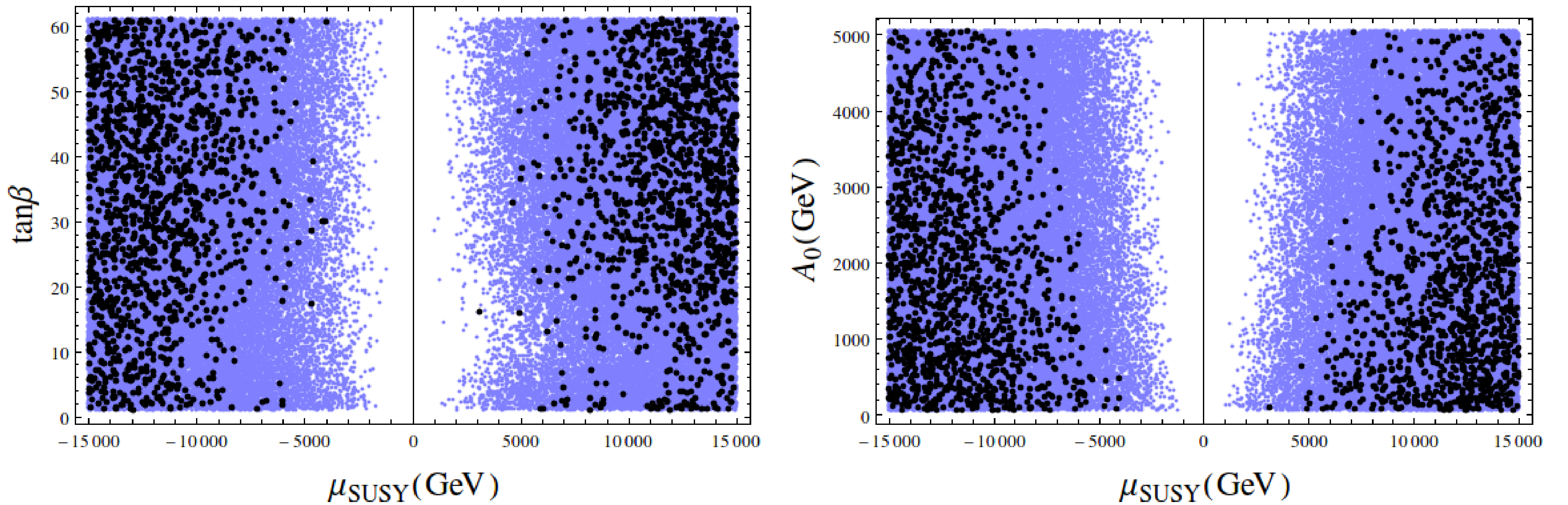


Figure 8: Values of $\tan\beta$ (left) and A_0 (right) dependence on μ_{SUSY} for which the a_μ discrepancy would get solved partially by the LFV contributions (blue), or completely up to 1σ with the restriction $M_1 < \frac{1}{3}\mu_{susy}$ (black).

Results: Stringent bounds on $M_1/\tilde{m}_S$ ratio

For $w = -1$, $y = 1$.

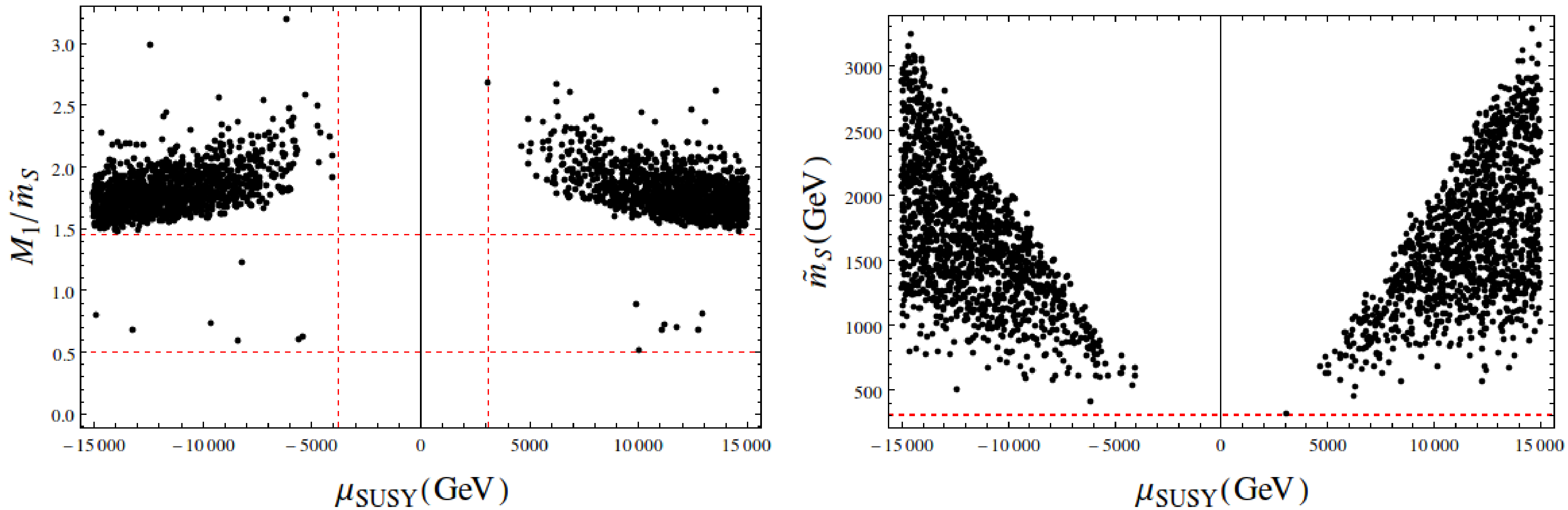


Figure 9: The values for which the LFV contribution would explain completely the a_μ discrepancy within theory and experimental data up to 1σ, considering $M_1 < \frac{1}{3}\mu_{susy}$. We show ratio on susy mass parameters $M_1/\tilde{m}_S$ (left) and $\tilde{m}_S$ (right), both with respect on μ_{susy} values.

Results: No-FV limit

For $w = -1$, $y = 1$.

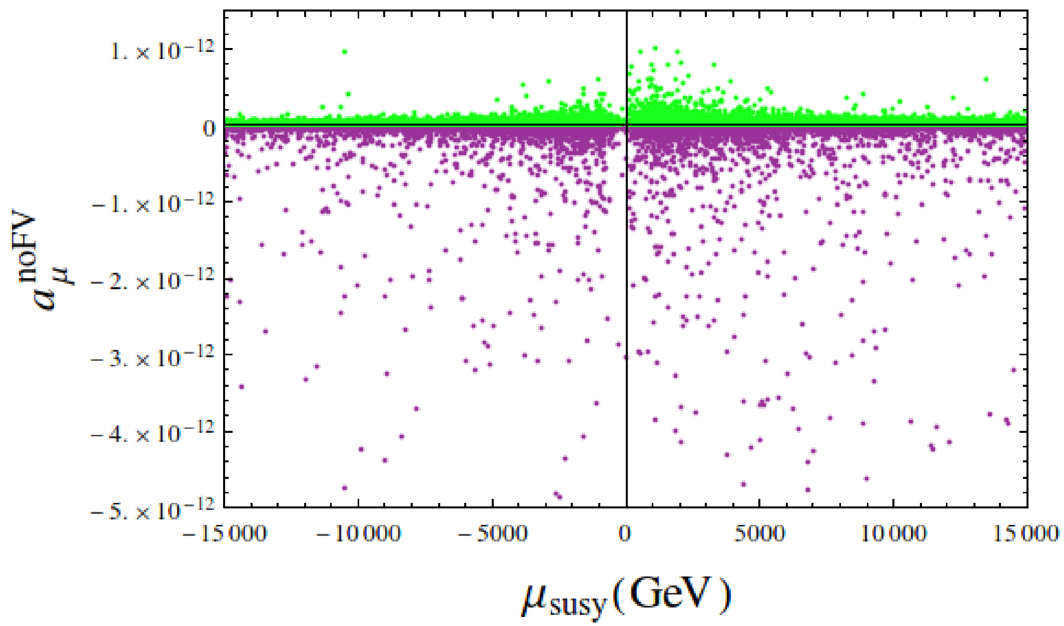


Figure 10: Complete Bino-smuon loop contribution on MSSM with no flavour violation to $g-2$, considering $A_0 = 0$ green points (lighter), and running A_0 for $(50, 5000)$ GeV purple points (darker).