



Supersymmetric Muon g-2 with/without stable Neutralino

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In collaboration with

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$(g - 2)_{\mu}$ anomaly

[Phys. Rev. LeS. 126 (2021) 14, 141801] BNL g-2 $_{\mu}$ $\stackrel{\star}{\ }$ Weak $\stackrel{<}{\ }$ FNAL g-2 + 4.2σ Hadronid-Hadronic... ...Vacuum Po **Experiment** Standard Model Average 21.5 18.0 18.5 19.0 19.5 20.5 21.0 17.5 20.0 $a_{\mu} \times 10^9 - 1165900$ from HVP. HLbLight (HL HVP EW 0.00 1165 91 810 (43) 1165 92 061 (41) = 0.00stat err dominant $a_{\mu}^{\text{exp}} - a_{\mu}^{\text{theo}} \simeq (25 \pm 6) \times 10^{-10} \simeq \Delta a_{\mu}^{\text{BSM}}$

IVIUOI

Motivation

There are many BSM scenarios that can explain the (g-2)_μ anomaly:

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Leptoquarks, Z', VLL, 2HDM, axion, ..
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Supersymmetry is particularly motivated since it offers:

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Coupling Unification, Radiative EWSB, Baryogenesis, DM, ...
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There are many studies on SUSY g-2 already:

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[Athrona, Balazsa, Jacoba, Kotlarskic, Stockingerc, Stockinger-Kim]; [Chakraborti, Heinemeyer, Saha]; [Endo, Hamaguchi, Iwamoto, Kitahara]; [Cox, Han, Yanagida]; [Baum, Carena, Shah, Wagner]; [Badziak, KS]; [Hagiwara, Ma, Mukhopadhyay'18], ...
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- Most studies assume the neutralino is the Lightest SUSY Particle (LSP) and stable.
 - Q: What happens if neutralino is unstable? (e.g. RPV, Gravitino LSP)
 - A: DM constraints go away, but LHC constraints change. How?

QED HVP EW
$$a_{\mu}^{\text{theo}} = 0.00 \quad 1165 \quad 91 \quad 810 \quad (43)$$

$$a_{\mu}^{\text{exp}} = 0.00 \quad 1165 \quad 92 \quad 061 \quad (41)$$

• The deviation is size of the EW correction in SM:

$$a_{\mu}^{\text{exp}} - a_{\mu}^{\text{theo}} \simeq (25 \pm 6) \times 10^{-10} \sim \mathcal{O}\left(\Delta a_{\mu}^{\text{SM,EW}}\right)$$

We need very light BSM particles OR enhancement from couplings

$$\Delta a_{\mu}^{\mathrm{BSM}} \sim \Delta a^{\mathrm{SM,EW}} \cdot \left(\frac{m_{W}^{2}}{m_{\mathrm{BSM}}^{2}}\right) \cdot \text{coupling}$$

$$\mathcal{O}(1)$$

Chiral (tanß) enhancement in SUSY

• (g-2) operator requires chirality flip:

$$\mathcal{L}_{\text{eff}} \ni i \frac{a_{\mu}}{m_{\mu}} \cdot \bar{\psi}_{L} \sigma^{\mu\nu} \psi_{R} F_{\mu\nu}$$

SM:
$$a_{\mu}^{\rm SM} \propto Y_{\mu} \langle H \rangle = m_{\mu}$$

$$\overrightarrow{\mu} = g\left(\frac{e}{2m}\right)\overrightarrow{s}$$

$$a_{\mu} = \frac{(g-2)}{2}$$

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$$\begin{array}{c|c} & \langle H_u \rangle \\ \tilde{H}_u^+ & \tilde{W}^+ \\ \hline \tilde{H}_d^+ & \tilde{\nu}_\mu & \mu_L \end{array}$$

$$\frac{\langle H_u \rangle^2 + \langle H_d \rangle^2}{\uparrow} = \langle H \rangle^2$$

$$(246 \,\text{GeV})^2$$

Chiral (tanß) enhancement in SUSY

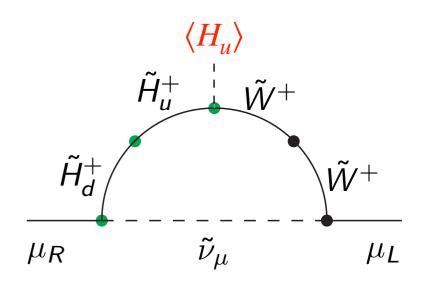
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SM:
$$a_{\mu}^{\rm SM} \propto Y_{\mu} \langle H \rangle = m_{\mu}$$



$$\langle H_u \rangle^2 + \langle H_d \rangle^2 = \langle H \rangle^2$$

$$\uparrow$$
(246 GeV)²

$$\Delta a_{\mu}^{\rm BSM} \sim \Delta a^{\rm SM,EW} \cdot \left(\frac{m_W^2}{m_{\rm SUSY}^2}\right) \cdot \tan \beta$$

$$\tan \beta \in [5 - 60]$$

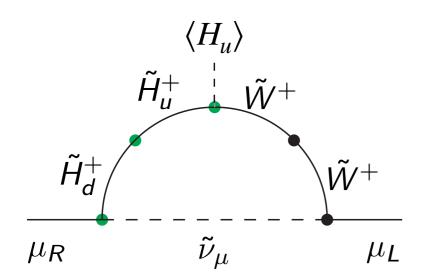
- Due to strong LHC constraints, we *decouple coloured SUSY particles* (they do not contribute to (g-2)_μ anyway).
- a_μSUSY depends on 5 mass parameters and tanβ:

$$\begin{array}{ll} \textit{M}_{1}: \text{Bino mass} & \left(\begin{array}{c} \textit{m}_{\tilde{\ell}_{R}} \equiv \widetilde{m}_{\tilde{\ell}_{R}}^{2} = \widetilde{m}_{\tilde{\ell}_{R}}^{2} \\ \\ \textit{M}_{2}: \text{Wino mass} & \left(\begin{array}{c} \textit{m}_{\tilde{\ell}_{L}} \equiv \widetilde{m}_{\tilde{\ell}_{e}} = \widetilde{m}_{\tilde{\ell}_{\mu}} = \widetilde{m}_{\tilde{\ell}_{L}} = \widetilde{m}_{\tilde{\ell}_{L}} = \widetilde{m}_{\tilde{\ell}_{L}} = \widetilde{m}_{\tilde{\ell}_{L}} \\ \\ \textit{\mu}: \text{Higgsino mass} & \tan \beta \equiv \langle H_{u} \rangle / \langle H_{d} \rangle \end{array} \right) \end{array}$$

no LFV due to universal soft masses: avoid strong constraint from $\mu \rightarrow e \gamma$

$$\Delta a_{\mu}^{\text{SUSY}} = \Delta a_{\mu}^{\text{WHL}} + \Delta a_{\mu}^{\text{BHL}} + \Delta a_{\mu}^{\text{BHR}} + \Delta a_{\mu}^{\text{BLR}}$$

$$\Delta a_{\mu}^{\rm SUSY} = \Delta a_{\mu}^{\rm WHL} + \Delta a_{\mu}^{\rm BHL} + \Delta a_{\mu}^{\rm BHR} + \Delta a_{\mu}^{\rm BLR}$$

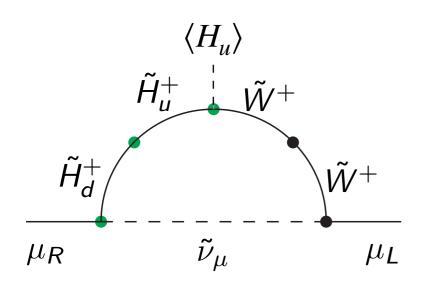


$$\Delta a_{\mu}^{\text{WHL}}(M_2, \mu, m_{\tilde{l}_L}) = \frac{\alpha_W}{8\pi} \frac{m_{\mu}^2}{M_2 \mu} \tan \beta \cdot f_{\text{WHL}}(\{\mathbf{m}\})$$

 M_2 : Wino (\tilde{W}) mass

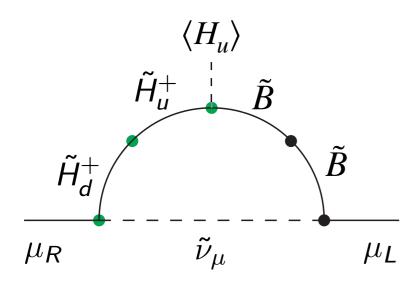
 μ : Higgsino $(\tilde{H}_u, \tilde{H}_d)$ mass

$$\Delta a_{\mu}^{\rm SUSY} = \Delta a_{\mu}^{\rm WHL} + \Delta a_{\mu}^{\rm BHL} + \Delta a_{\mu}^{\rm BHR} + \Delta a_{\mu}^{\rm BLR}$$



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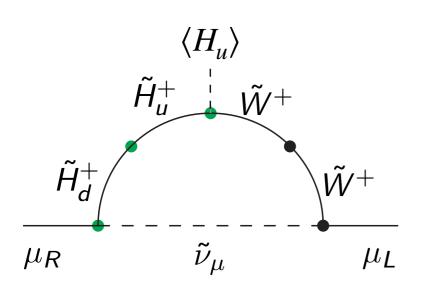
$$\Delta a_{\mu}^{\text{BHL}}(M_1, \mu, m_{\tilde{l}_L}) = \frac{\alpha_Y}{8\pi} \frac{m_{\mu}^2}{M_1 \mu} \tan \beta \cdot f_{\text{BHL}}(\{\mathbf{m}\})$$

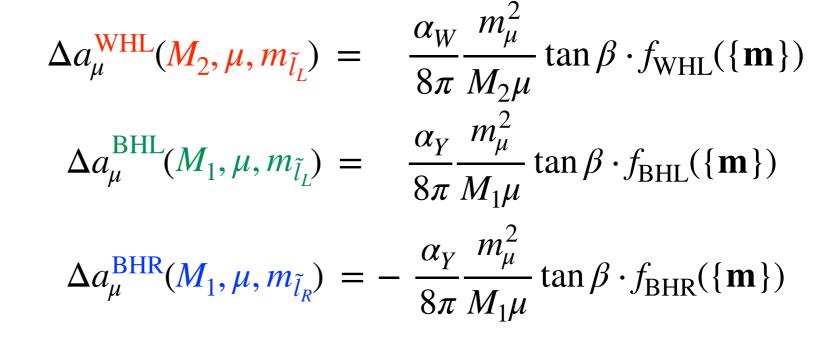


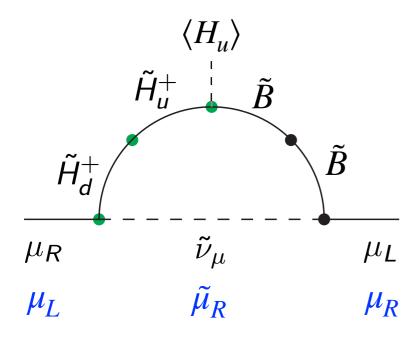
 M_2 : Wino (\tilde{W}) mass

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$$\Delta a_{\mu}^{\rm SUSY} \, = \, \Delta a_{\mu}^{\rm WHL} \, + \, \Delta a_{\mu}^{\rm BHL} \, + \, \Delta a_{\mu}^{\rm BHR} \, + \, \Delta a_{\mu}^{\rm BLR}$$



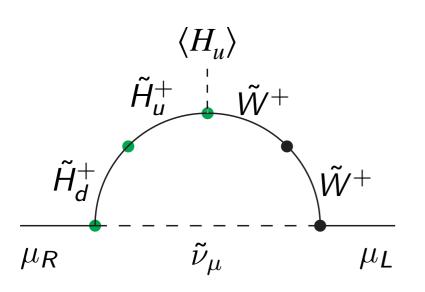


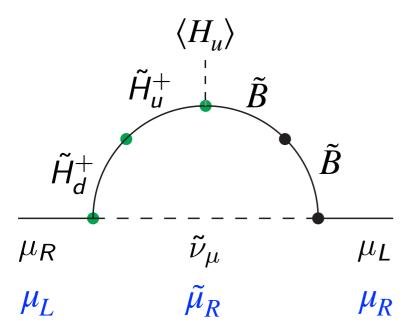


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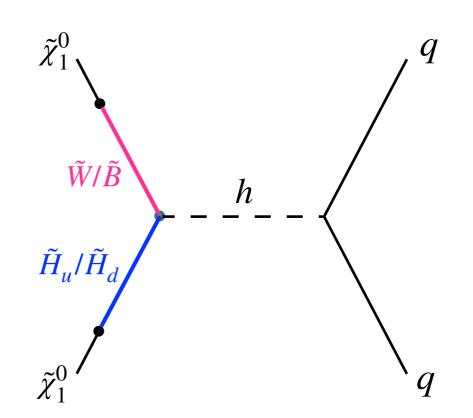
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$$\Delta a_{\mu}^{\text{WHL}}(M_2, \mu, m_{\tilde{l}_L}) = \frac{\alpha_W}{8\pi} \frac{m_{\mu}^2}{M_2 \mu} \tan \beta \cdot f_{\text{WHL}}(\{\mathbf{m}\})$$

$$\Delta a_{\mu}^{\text{BHL}}(M_1, \mu, m_{\tilde{l}_L}) = \frac{\alpha_Y}{8\pi} \frac{m_{\mu}^2}{M_1 \mu} \tan \beta \cdot f_{\text{BHL}}(\{\mathbf{m}\})$$

$$\Delta a_{\mu}^{\text{BHR}}(M_1, \mu, m_{\tilde{l}_R}) = -\frac{\alpha_Y}{8\pi} \frac{m_{\mu}^2}{M_1 \mu} \tan \beta \cdot f_{\text{BHR}}(\{\mathbf{m}\})$$

Large gaugino-Higgsino mixing leads to a large cross-section for DM Direct Detection:



$$\Delta a_{\mu}^{\text{SUSY}} = \Delta a_{\mu}^{\text{WHL}} + \Delta a_{\mu}^{\text{BHL}} + \Delta a_{\mu}^{\text{BHR}} + \Delta a_{\mu}^{\text{BLR}}$$

$$\Delta a_{\mu}^{\text{BLR}}(M_{1}, m_{\tilde{l}_{L}}, m_{\tilde{l}_{R}}; \mu) = \frac{\alpha_{Y}}{4\pi} \frac{m_{\mu}^{2} M_{1} \mu}{m_{\mu_{L}}^{2} m_{\mu_{R}}^{2}} \tan \beta \cdot f_{\text{BLR}}(\{\mathbf{m}\})$$

$$\uparrow \qquad \qquad \uparrow \qquad \qquad \downarrow \qquad \qquad \downarrow$$

Constraints:

Stau mass² becomes negative or too small!

$$(\tilde{\tau} \text{ mass matrix}) \sim \begin{pmatrix} m_{\tilde{\tau}_R}^2 & Y_{\tau} \mu \langle H_u \rangle \\ Y_{\tau} \mu \langle H_u \rangle & m_{\tilde{\tau}_L}^2 \end{pmatrix}$$

- charge breaking vacuum: m²stau1 > 0
- LEP bound: m_{stau1} > 90 GeV
- stau LSP: m_{stau1} > m_{neutralino1}
- Vacuum (meta-)stability:

$$\left| m_{\tilde{\ell}_{LR}}^2 \right| \leq \left[1.01 \times 10^2 \, \text{GeV} \sqrt{m_{\tilde{\ell}_L} m_{\tilde{\ell}_R}} + 1.01 \times 10^2 \, \text{GeV} (m_{\tilde{\ell}_L} + 1.03 m_{\tilde{\ell}_R}) - 2.27 \times 10^4 \, \text{GeV}^2 + \frac{2.97 \times 10^6 \, \text{GeV}^3}{m_{\tilde{\ell}_L} + m_{\tilde{\ell}_R}} - 1.14 \times 10^8 \, \text{GeV}^4 \left(\frac{1}{m_{\tilde{\ell}_L}^2} + \frac{0.983}{m_{\tilde{\ell}_R}^2} \right) \right]$$

[Kitahara, Yoshinaga 13]; [Endo, Hamaguchi, Kitahara, Yoshinaga 13]

� Overproduction of Bino-like neutralinos in the early universe: $\Omega_{ ilde{\chi}_1^0} < \Omega_{
m DM}$

slepton-coannihilation needed ⇒ m_{slepton} ~ m_{Bino}

Summary of g-2 in MSSM

$$\Delta a_{\mu}^{\text{SUSY}} = \Delta a_{\mu}^{\text{WHL}} + \Delta a_{\mu}^{\text{BHL}} + \Delta a_{\mu}^{\text{BHR}} + \Delta a_{\mu}^{\text{BLR}}$$

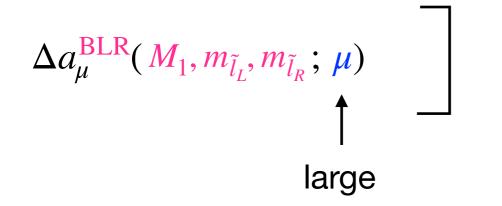
$$\Delta a_{\mu}^{\mathrm{WHL}}(M_2,\mu,m_{\tilde{l}_L})$$

$$\Delta a_{\mu}^{\mathrm{BHL}}(M_{1},\mu,m_{\tilde{l}_{L}})$$

$$\Delta a_{\mu}^{\mathrm{BHR}}(M_{1},\mu,m_{\tilde{l}_{R}})$$

 $\Delta a_{\mu}^{\mathrm{WHL}}(M_{2},\mu,m_{\tilde{l}_{L}})$ Higgsino, one gaugino, one sle $\Delta a_{\mu}^{\mathrm{BHL}}(M_{1},\mu,m_{\tilde{l}_{L}})$ \Rightarrow subject to LHC constraint Higgsino, one gaugino, one slepton all must be light:

gaugino-Higgsino mixing ⇒ DM direct detection



Bino and both L and R sleptons must be light:

- ⇒ subject to LHC constraint
 - \Rightarrow Bino abundance $\Omega_{\widetilde{\gamma}^0_1} < \Omega_{\mathrm{DM}}$
 - **→ Vacuum stability**

Unstable Neutralino (Gravitino, RPV)

$$\Delta a_{\mu}^{\text{SUSY}} = \Delta a_{\mu}^{\text{WHL}} + \Delta a_{\mu}^{\text{BHL}} + \Delta a_{\mu}^{\text{BHR}} + \Delta a_{\mu}^{\text{BLR}}$$

$$\Delta a_{\mu}^{\text{WHL}}(M_2, \mu, m_{\tilde{l}_L})$$

$$\Delta a_{\mu}^{
m BHL}(M_1,\mu,m_{ ilde{l}_L})$$

$$\Delta a_{\mu}^{\mathrm{BHR}}(M_{1},\mu,m_{\tilde{l}_{R}})$$

Higgsino, one gaugino, one slepton all must be light:

 $\Delta a_{\mu}^{\mathrm{BHL}}(M_{1},\mu,m_{\tilde{l}_{L}})$ \Rightarrow subject to LHC constraint \leftarrow Modified

gaugino-Higgsino mixing ⇒ DM direct detection

$$\Delta a_{\mu}^{\mathrm{BLR}}(M_{1}, m_{\tilde{l}_{L}}, m_{\tilde{l}_{R}}; \mu)$$

| large

Bino and both L and R sleptons must be light:

- ⇒ subject to LHC constraint ← Modified
- \Rightarrow Bino abundance $\Omega_{\hat{\gamma}^0_1} \leftarrow \Omega_{\rm DM}$
- **→ Vacuum stability**

regions above the contours satisfy the assumption that the NI not be applied. In the lower right region, the NSL1 and the lower right region, the NSL1 and the lower right region.

Graphical policy applied the lightest neutralino into the gravitino are given by [13,35]

• In the gauge-mediated SUSY breaking (GMSB) scenario, light gravitino into the gravitino are given by [

naturalness:

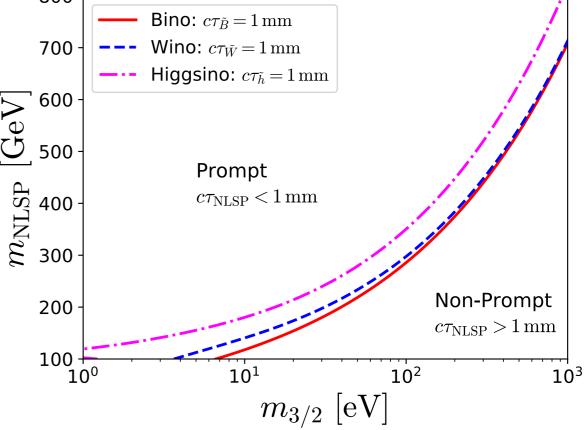
$$\Gamma(\tilde{\chi}_{1}^{0} \to \tilde{G}Z)\tilde{\chi}_{1}^{0} \to \tilde{G}Z)\tilde{\chi}_{1}^{0} \to \tilde{G}Z) = \left(\begin{array}{c} N_{12}c_{W} - N_{11}s_{W} \\ N_{12}c_{W} - N_{13}s_{A} \\ N_{13}c_{A} - N_{14}s_{A} \\ N_{14}s_{A} - N_{14}s_{A} \\ N_{14}s_$$

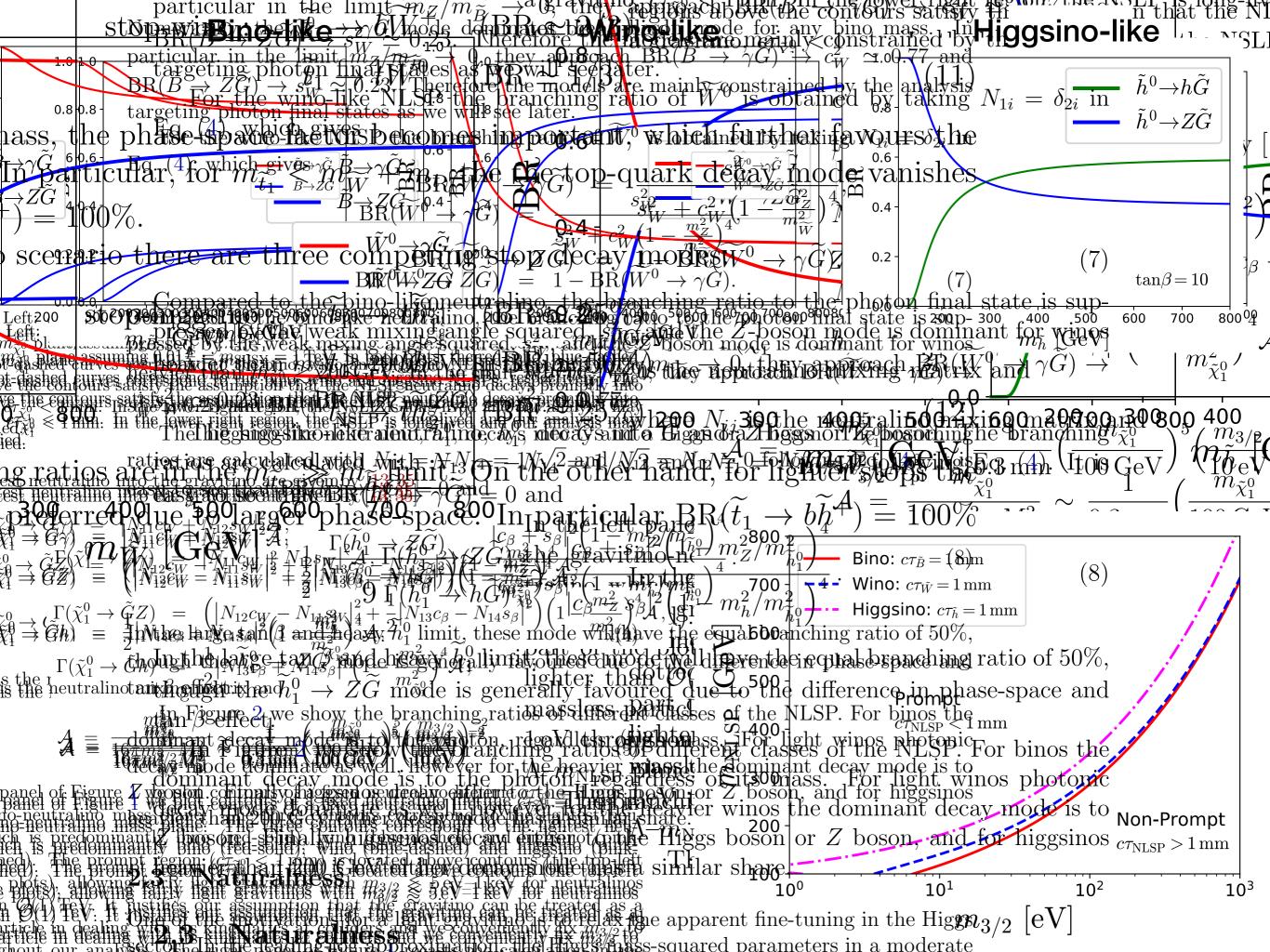
The continues consistent the interval of the New promptly into the continue of the continue o est neutraline stravitines are given by [13,35] the neutraline decays are prompt. $^{16\pi m_{\rm pl}^2}$ In the left pane Bino: $c\tau_{\tilde{B}} = 1 \,\mathrm{mm}$

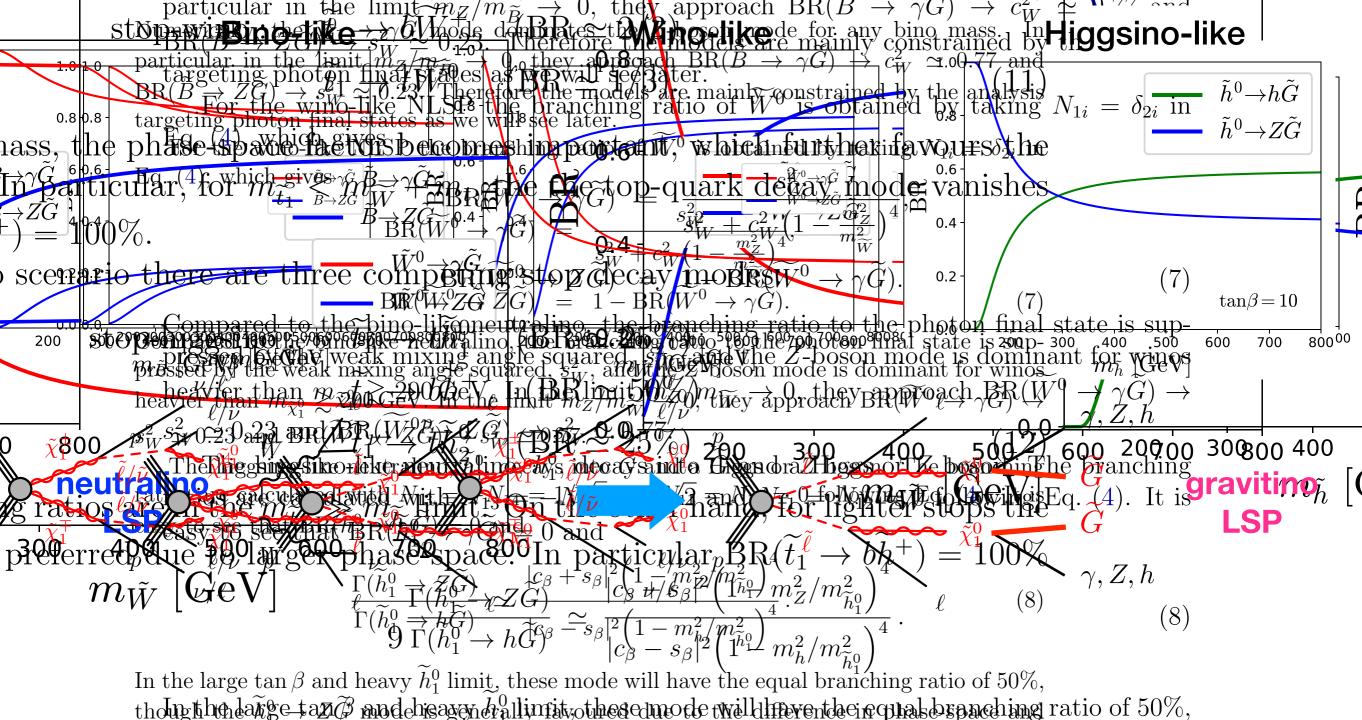
 $\inf_{\substack{\text{S the neutralino mixing matrix and}}} \Gamma(\tilde{\chi}_1^0 \to \tilde{G}h) = \frac{1}{2} |N_{13}c_{\beta} + N_{14}s_{\beta}|^2 \left(1 - \frac{m_h^2}{m_{\tilde{\chi}_1^0}^2}\right)^4 \mathcal{A},$ lighter than to massless particl

$$A \equiv \frac{m_{20}^{50}}{10\pi m_{20}^{20}} \approx \frac{1}{100000} \left(\frac{m_{20}^{50}}{10000}\right)^{\frac{5}{5}} \left(\frac{m_{3/2}}{1000}\right)^{\frac{-2}{2}} : \frac{1 \text{ eV throughbold for the plane of Figure 1 we plot contours of a fixed neutralino diffetime $c_{7/20} = 1.5 \text{ multiparties}$$$

of Figure 1 we plot contours of a fixed neutralino litetime $c\tau_{\infty}$ 1 mm in Vi Th itticle in dealing with its kinematics at colliders and we conveniently his



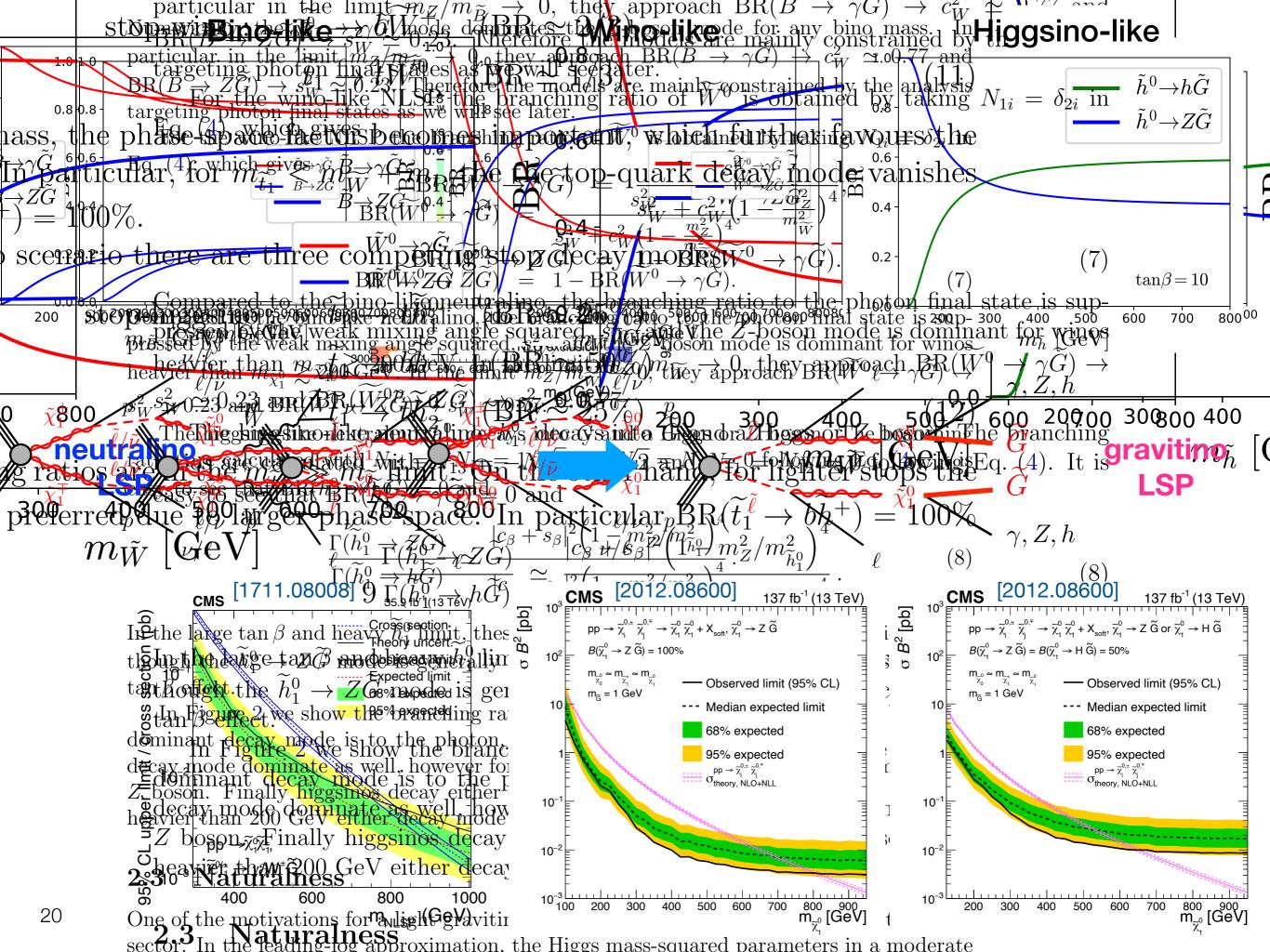




thoughthelage taze and heavy h_1 mine these mode will have the equal stationary ratio of 50%, tanthought the $h_1^0 \to ZG$ mode is generally favoured due to the difference in phase-space and the factor of the branching ratios of different classes of the NLSP. For binos the dominant decay mode is to the photon regardless of its mass. For light winos photonic ratios of different classes of the NLSP. For binos the decay mode dominate as well, however for the heavier winos the dominant decay mode is to the photon regardless of its mass. For light winos photonic z boson. Finally higgsinos decay either to the Higgs boson or z boson, and for higgsinos heavier than 200 deventuer according to the Higgs boson or z boson, and for higgsinos z boson. Finally higgsinos decay either to the Higgs boson or z boson, and for higgsinos

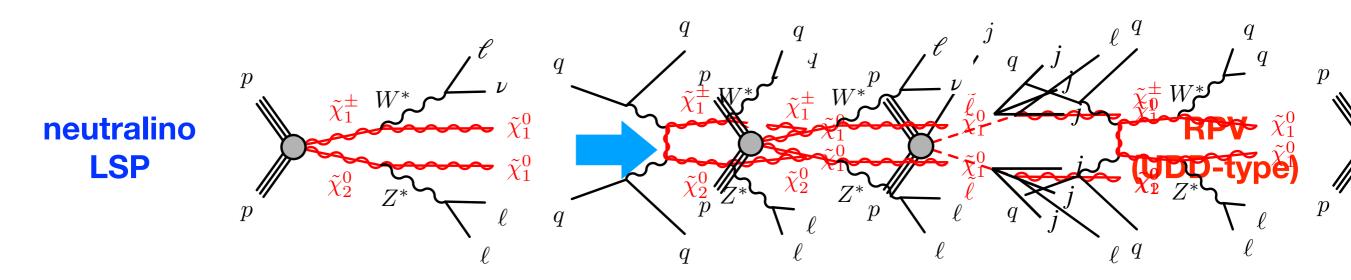
2.3 eavier than 200 GeV either decay mode has a similar share.

One of the motivations for a light gravitino is to relax the apparent fine-tuning in the Higgs sector. In the leading-log approximation, the Higgs mass-squared parameters in a moderate



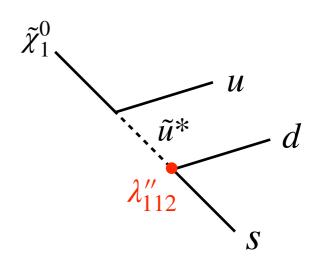
 These terms give mass to quarks and leptons. $W_{\rm MSSM} = (Y_u)_{ij} Q_i U_j^c H_u = (Y_d)_{ij} Q_i U_j^c H_d + (Y_d)_{ij} Q_i U_j U_d + (Y_d)_{ij} U_i E_i H_d + \mu H_u H_d$ Automatically get extra terms $W_{\text{MSSM}} = (X_{\text{W}})_{ij} Q_i U_i^c H_{\text{M}} + (Y_e)_{ij} Q_i U_i^c H_{\text{M}} + (Y_e)_{ij} L_i E_j^c H_d + \mu U_i^c U_i^c H_{\text{M}} + (Y_e)_{ij} L_i E_j^c H_d + \mu U_i^c U_i^c U_i^c H_{\text{M}} + (Y_e)_{ij} L_i E_j^c H_d + \mu U_i^c U_i^$ $W_{\text{RPV}} = \lambda_{ijk}^{"} U_i^c D_j^c D_k^c + \lambda_i D_i E_i E_i$ hg Baryon Num. Viol. Lepton Number Violating $+e^{\text{LQD}}$ and $-p^{\text{Proton}}$ ecay: $p \to \pi^0$ • LQD and UDD \longrightarrow Proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and UDD proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and proton and proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and $p \to \pi^0 + e^{\frac{1}{100}}$ and proton Decay: $p \to \pi^0 + e^{\frac{1}{100}}$ and proton a We introduce only the Upperator with: $\lambda'_{11j} \cdot \lambda''_{11j} < 2 \cdot 10^{-27}$ - Constraint from K0-K0bar mixing can easily be satisfied: • The supersymmetric SM is excluded! 52.8×10^{-2} 1910.09229 metry to kill at least one coup $\lambda'_{11j} \cdot \lambda''_{11j} \lambda''_{112} \lambda''_{213} = 22 \left(\frac{10^{M_d}}{100 \text{ Ge}} \right)$ - LHC signature is the most chatterging: no leptents in the Meitranal of The supersymmetric SM is excluded! $\lambda_{112}^{\prime\prime}$ Must add a symmetry to kill at least one coupling.

R-Parity Violation; UDD

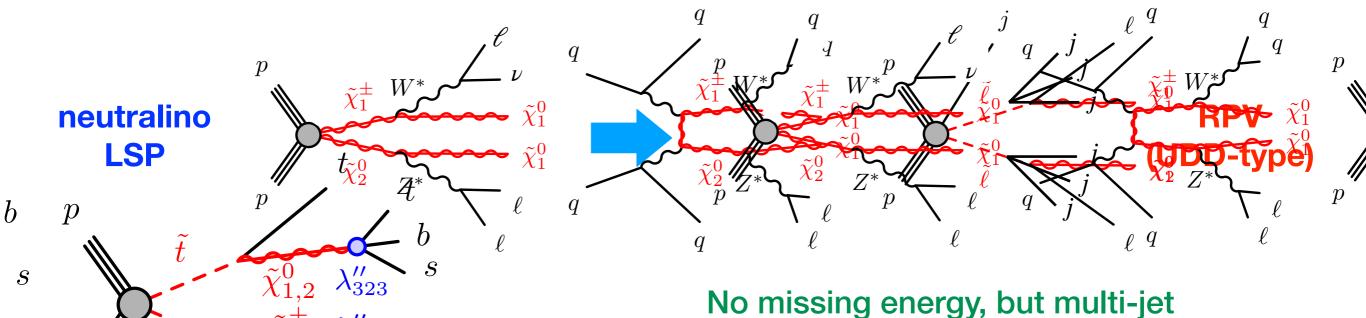


No missing energy, but multi-jet

LHC signature is the most challenging:
 no leptons, no b-jets in the neutralino decay



R-Parity Violation; UDD

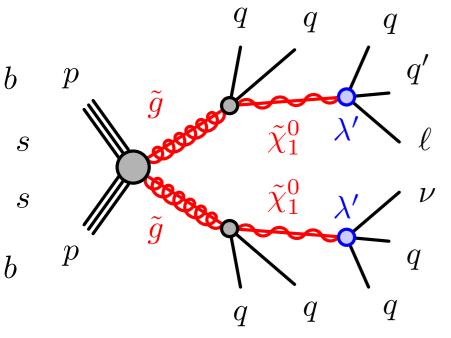


p There exist ATLAS and CMS analyses sensitive to such final states:

ATLAS [2106.09609]

b

CMS [1709.05406]



Bin	Final state	Definition
1	2 SS leptons	0 jets, $M_{\rm T} > 100 {\rm GeV}$ and $p_{\rm T}^{\rm miss} > 140 {\rm GeV}$
2	2 SS leptons	1 jet , $M_{ m T} < 100{ m GeV}$, $p_{ m T}^{\ell\ell} < 100{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
3	3 light leptons	$M_{ m T} > 120{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
4	3 light leptons	$p_{\mathrm{T}}^{\mathrm{miss}} > 250\mathrm{GeV}$
5	2 light leptons and 1 tau	$M_{\rm T2}(\ell_1, \tau) > 50{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
6	1 light lepton and 2 taus	$M_{\rm T2}(\ell, \tau_1) > 50{\rm GeV}$ and $p_{\rm T}^{\rm miss} > 200{\rm GeV}$
7	1 light lepton and 2 taus	$p_{\mathrm{T}}^{\mathrm{miss}} > 75\mathrm{GeV}$
8	more than 3 leptons	$p_{\mathrm{T}}^{\mathrm{miss}} > 200\mathrm{GeV}$

Analysis Framework

SUSY g-2: 1-loop + leading 2-loop GM2Calc [Eur.Phys.J. C76 (2016) no.2, 62]

Neutralino abundance, Direct Detection: MicrOMEGAs [2003.08621]

Decay of SUSY particles: SUSY-HIT [hep-ph/0609292]

LHC constraints:

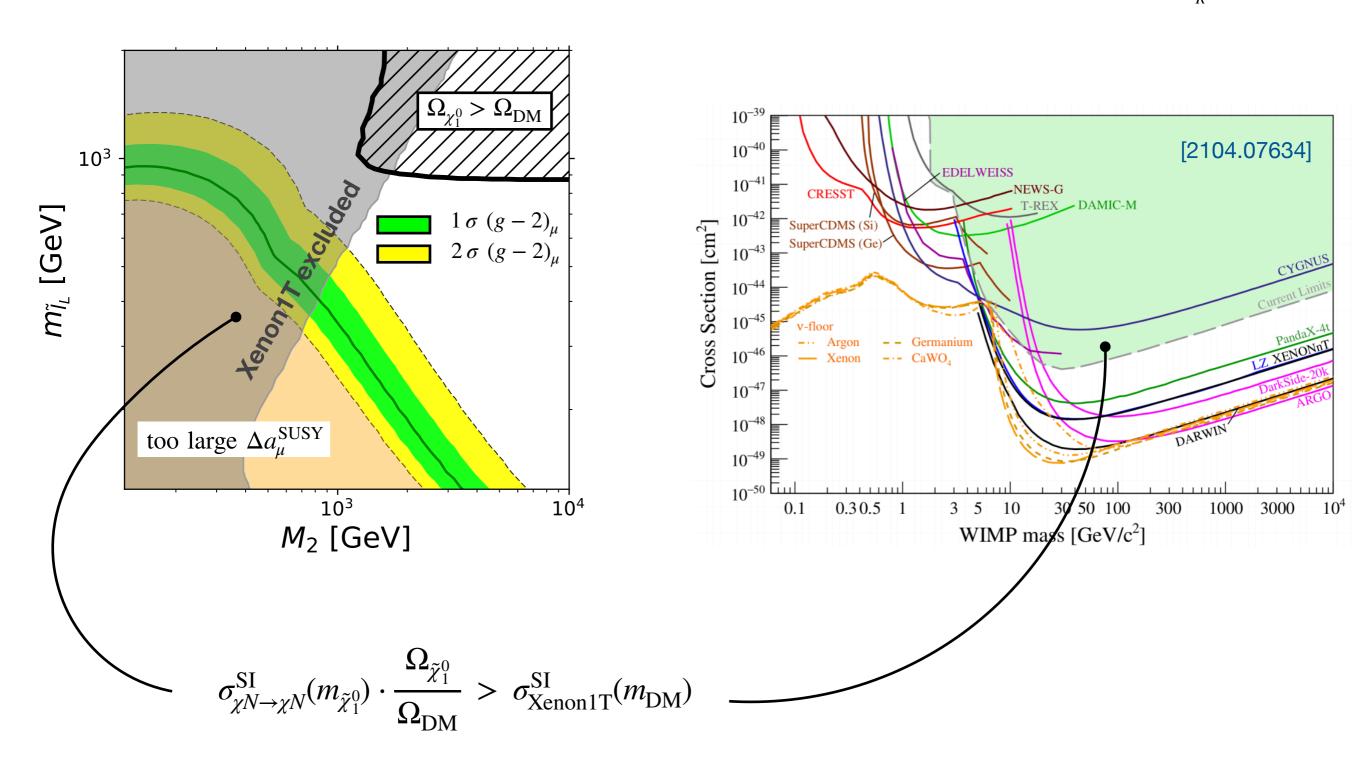
- MSSM: Fastlim/SModelS-like approach with HEP-DATA info
- Gravitino LSP: Fastlim/SModelS-like approach with HEP-DATA info
- RPV (UDD-type): Pythia 8 + CheckMATE 2 [1907.09874], [1611.09856]

All results below are preliminary

WHL (MSSM)

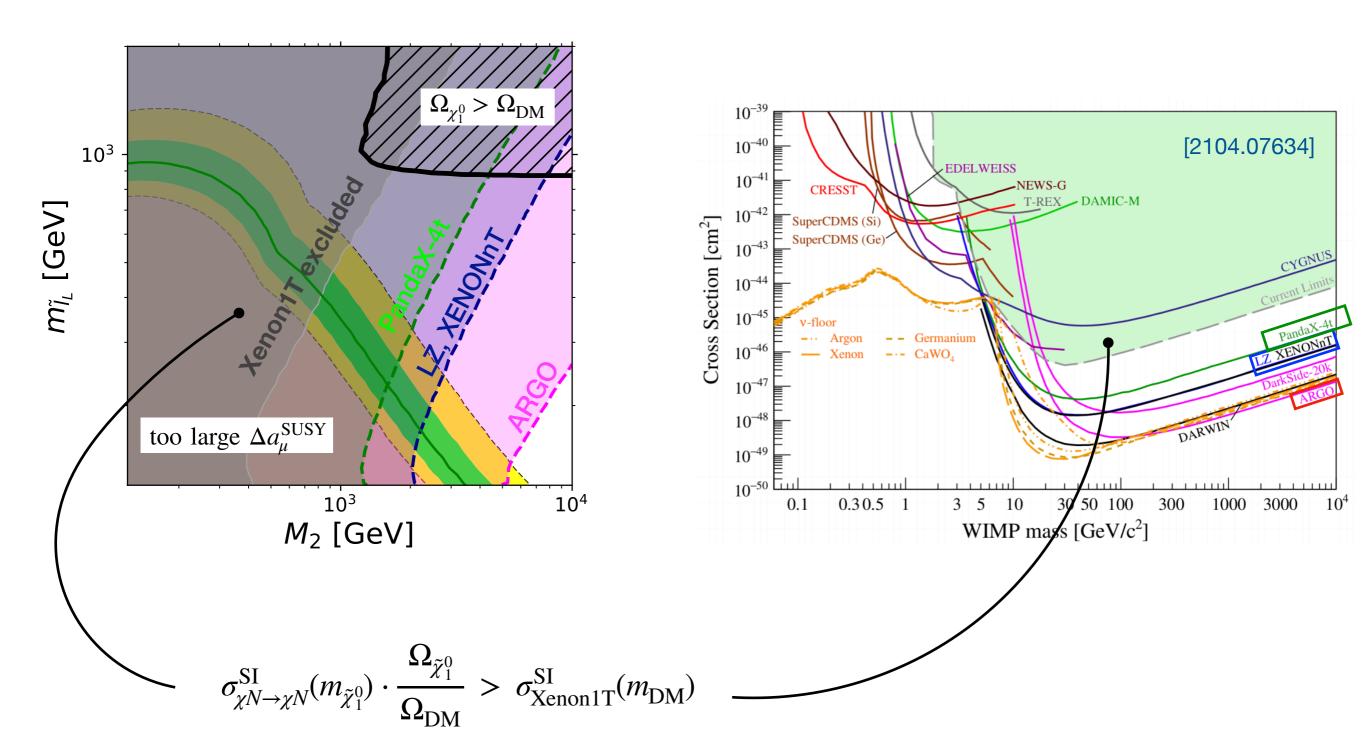
$$\mu = \min(M_2, m_{\tilde{l}_L}) - 20 \,\text{GeV}$$

 $\tan \beta = 50, \ M_1 = m_{\tilde{l}_R} = 10 \,\text{TeV}$



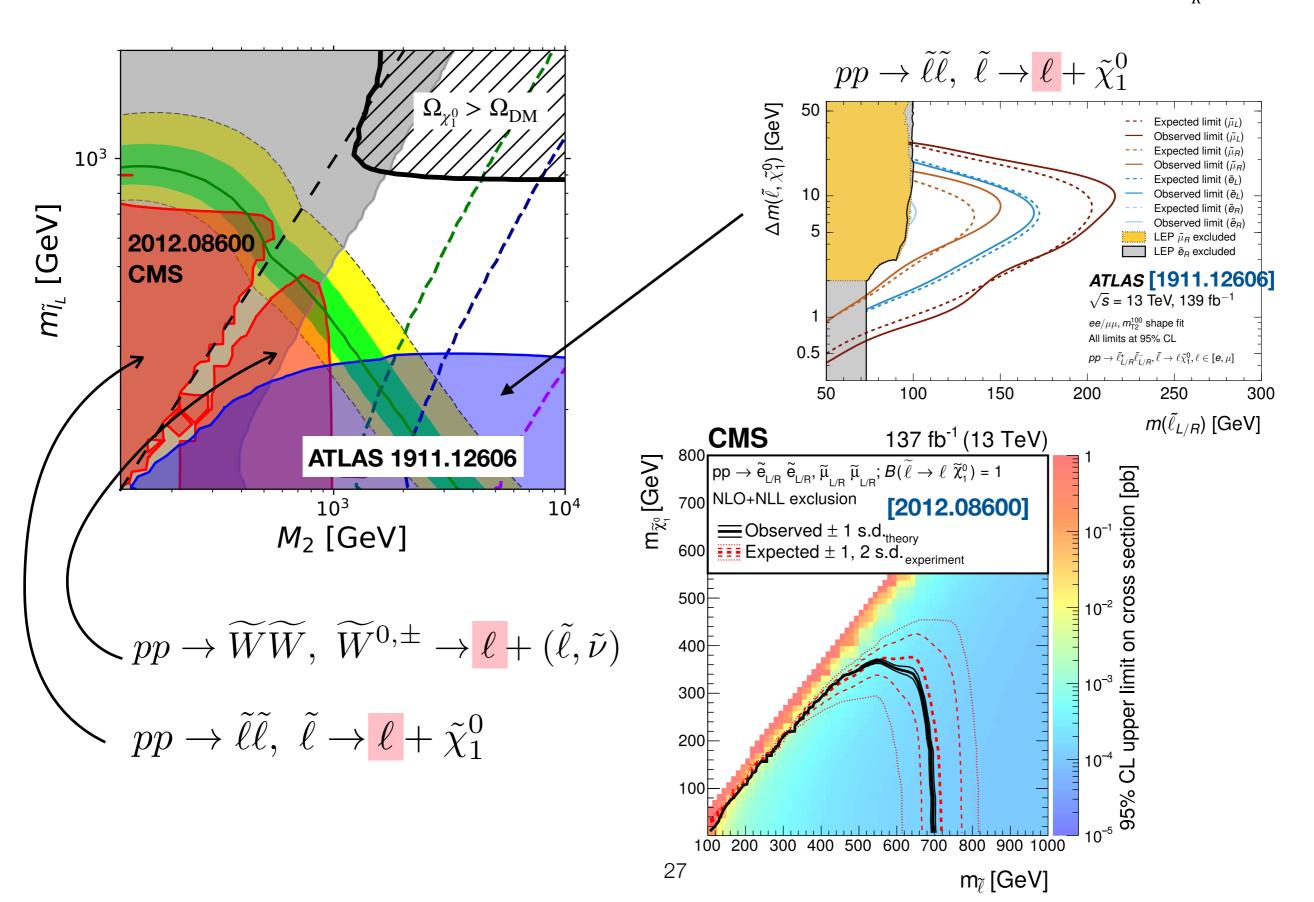
WHL (MSSM, DD prospect)

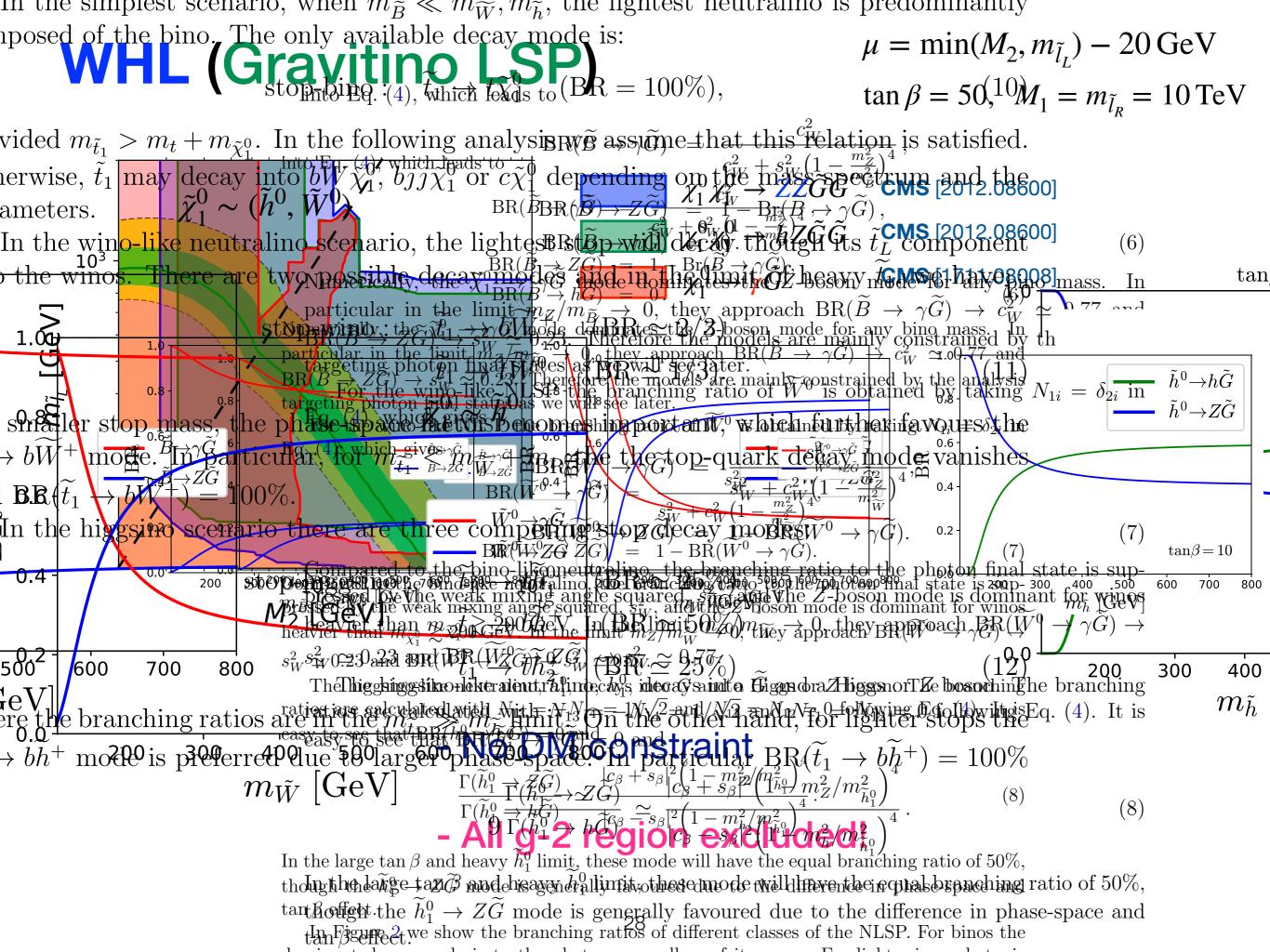
 $\mu = \min(M_2, m_{\tilde{l}_L}) - 20 \,\text{GeV}$ $\tan \beta = 50, \ M_1 = m_{\tilde{l}_R} = 10 \,\text{TeV}$



WHL (MSSM, LHC)

 $\mu = \min(M_2, m_{\tilde{l}_L}) - 20 \,\text{GeV}$ $\tan \beta = 50, \ M_1 = m_{\tilde{l}_R} = 10 \,\text{TeV}$

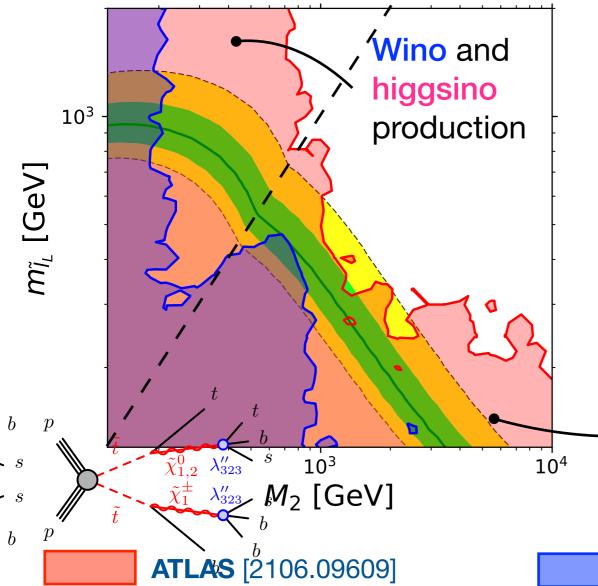




WHL (RPV UDD)

$$\mu = \min(M_2, m_{\tilde{l}_L}) - 20 \,\text{GeV}$$

 $\tan \beta = 50, \ M_1 = m_{\tilde{l}_R} = 10 \,\text{TeV}$



$$pp \to W^{\pm}W^{0,\mp}, \quad \tilde{h}^{0,\pm}\tilde{h}^{0,\mp}$$

$$p \longrightarrow \tilde{\chi}_{1}^{\pm} W^{*} \qquad \tilde{\chi}_{1}^{0} \longrightarrow \tilde{\chi}_{1}^{$$

soft lepton + multi-jet final state

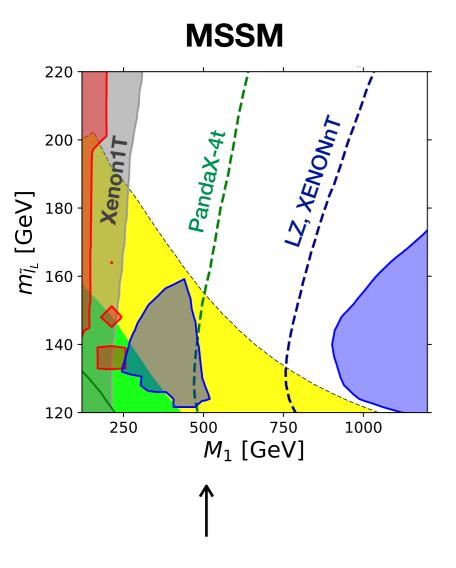
higgsino production

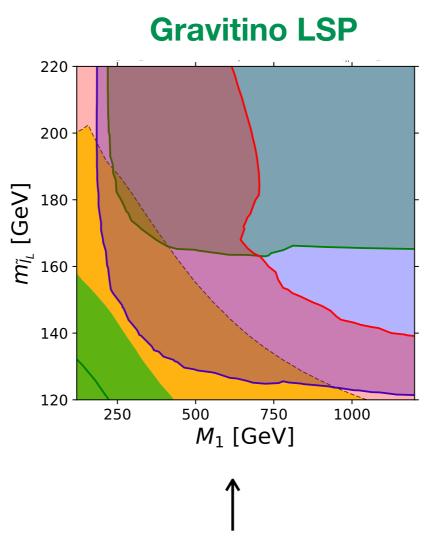
CMS [1709.05406]

Bin	Final state	Definition
1	2 SS leptons	0 jets, $M_{\mathrm{T}} > 100\mathrm{GeV}$ and $p_{\mathrm{T}}^{\mathrm{miss}} > 140\mathrm{GeV}$
2	2 SS leptons	1 jet , $M_{ m T} < 100{ m GeV}$, $p_{ m T}^{\ell\ell} < 100{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
3	3 light leptons	$M_{\rm T} > 120{\rm GeV}$ and $p_{\rm T}^{\rm miss} > 200{\rm GeV}$
4	3 light leptons	$p_{\rm T}^{\rm miss} > 250{ m GeV}$
5	2 light leptons and 1 tau	$M_{\rm T2}(\ell_1, au) > 50{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
6	1 light lepton and 2 taus	$M_{\rm T2}(\ell, au_1) > 50{ m GeV}$ and $p_{ m T}^{ m miss} > 200{ m GeV}$
7	1 light lepton and 2 taus	$p_{\rm T}^{\rm miss} > 75{ m GeV}$
8	more than 3 leptons	$p_{\mathrm{T}}^{\mathrm{miss}} > 200\mathrm{GeV}$



 $\mu = \min(M_1, m_{\tilde{l}_L}) - 20 \,\text{GeV}$ $\tan \beta = 50, \ M_2 = m_{\tilde{l}_R} = 10 \,\text{TeV}$





UDD RPV 220 200 $m_{\tilde{l}_L}$ [GeV] 180 160 140 120 750 250 500 1000 M_1 [GeV]

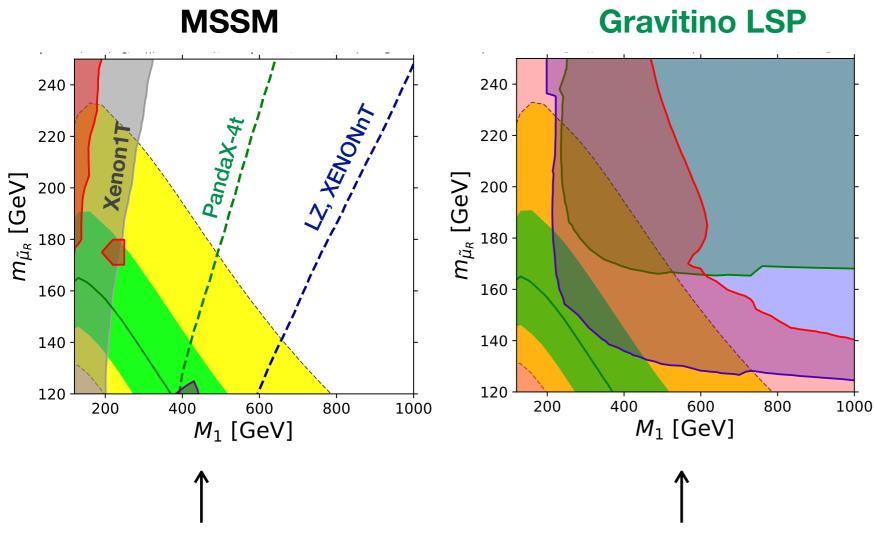
There is a region where $(g-2)_{\mu}$ anomaly can be explained. Almost entire region will be probed by the next generation DM DD experiments.

 μ < m_{IL} < 220GeV. Such a light higgsino-like NSLP is excluded in gravitino LSP scenario.

Higgsino production dominates but the mass splitting among higgsino states are tiny (< a few GeV) due to $M_2 = 10$ TeV. Leptons produced from decays among higgsino states are too soft and not detected.



 $-\mu = \min(M_1, m_{\tilde{l}_R}) - 20 \text{ GeV}$ $\tan \beta = 50, \ M_2 = m_{\tilde{l}_L} = 10 \text{ TeV}$

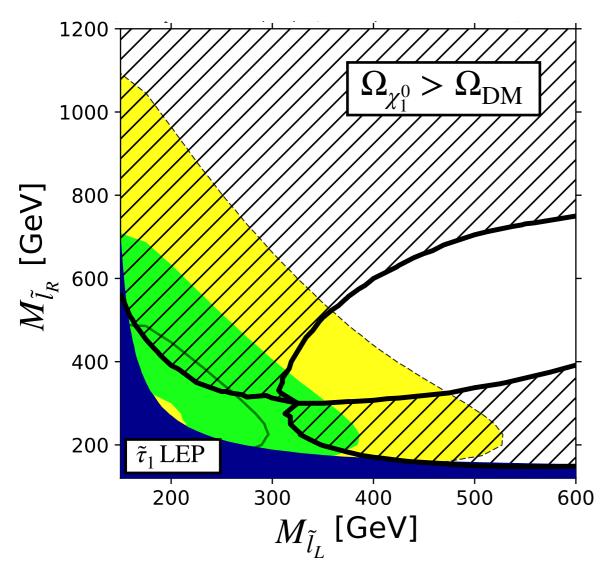


 $|\mu| < m_{IL} < 250 GeV$. Such a light higgsino-like NSLP is excluded in gravitino LSP scenario.

There is a region where $(g-2)_{\mu}$ anomaly can be explained. Almost entire region will be probed by the next generation DM DD experiments.

Higgsino production dominates but the mass splitting among higgsino states are tiny (< a few GeV) due to $M_2 = 10$ TeV. Leptons produced from decays among higgsino states are too soft and not detected.

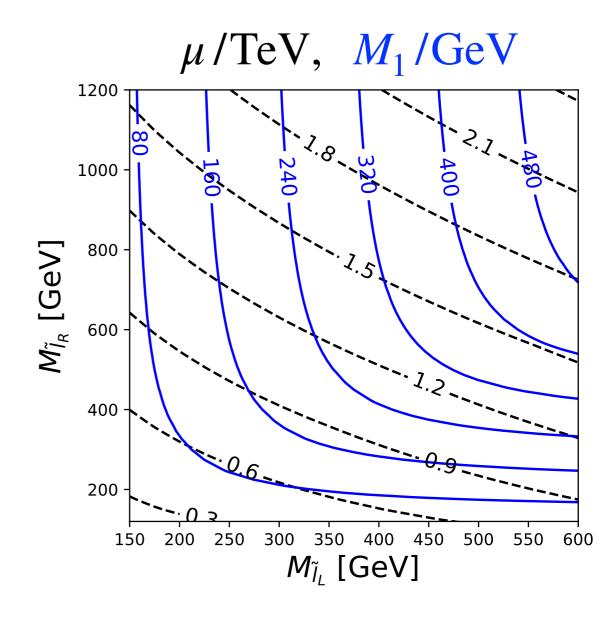




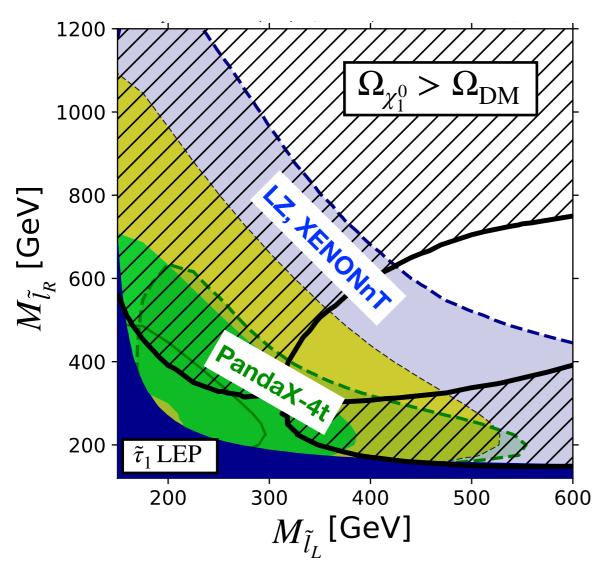
$$M_1 = m_{\tilde{\tau}_1} - 20 \,\text{GeV}, \quad M_2 = 10 \,\text{TeV}$$
 $\mu = \mu_{\text{max}}, \quad \tan \beta = 50$

maximum allowed by vacuum (meta-)stability

$$\Delta a_{\mu}^{\text{BLR}}(M_1, m_{\tilde{l}_L}, m_{\tilde{l}_R}; \mu)$$



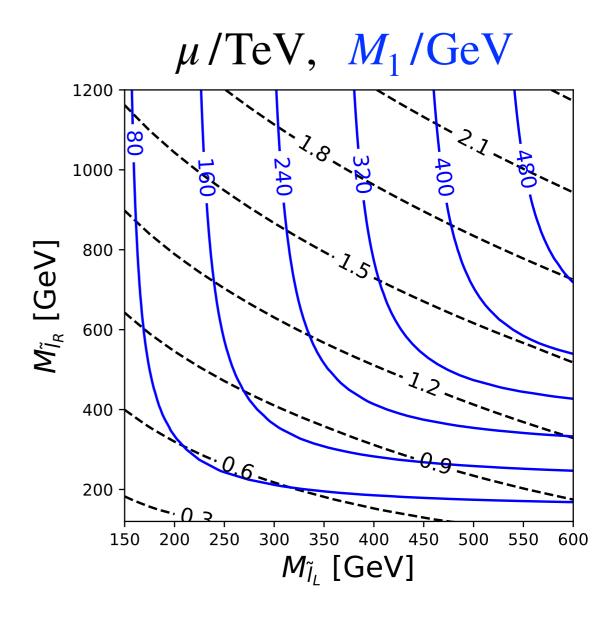




$$M_1 = m_{\tilde{\tau}_1} - 20 \,\text{GeV}, \quad M_2 = 10 \,\text{TeV}$$
 $\mu = \mu_{\text{max}}, \quad \tan \beta = 50$

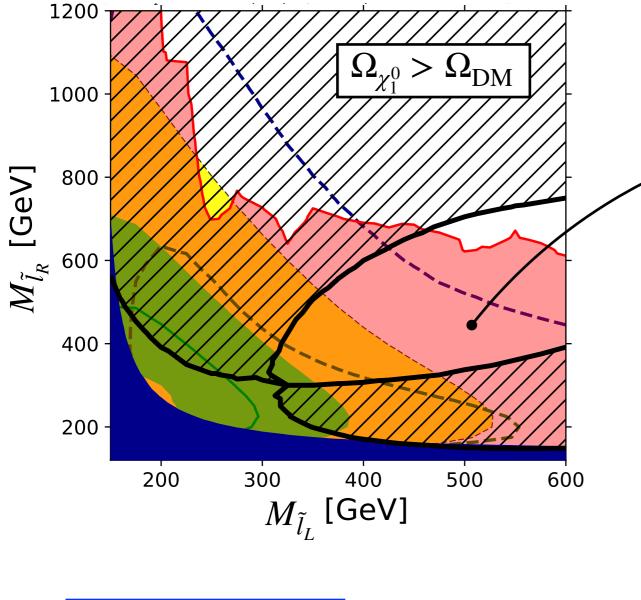
maximum allowed by vacuum (meta-)stability

$$\Delta a_{\mu}^{\text{BLR}}(M_1, m_{\tilde{l}_L}, m_{\tilde{l}_R}; \mu)$$



BLR

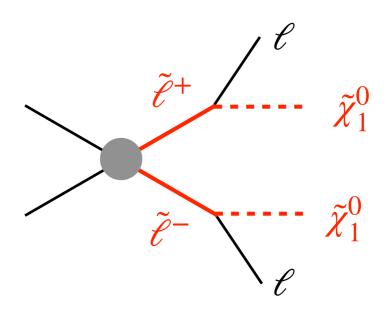
$\Delta a_{\mu}^{\mathrm{BLR}}(M_1, m_{\tilde{l}_L}, m_{\tilde{l}_R}; \mu)$

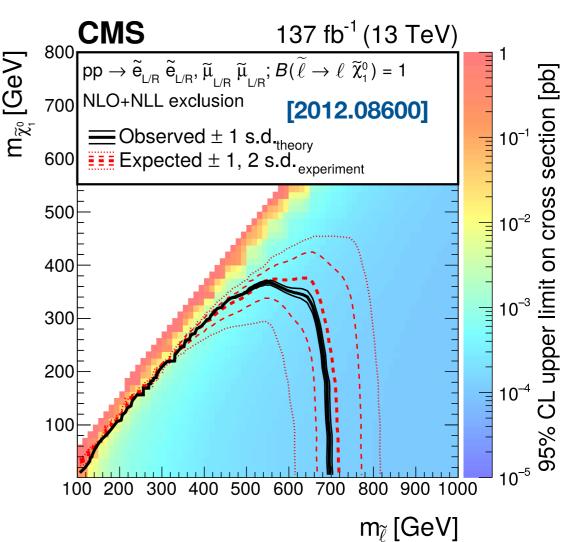


$$M_1 = m_{\tilde{\tau}_1} - 20 \,\text{GeV}, \quad M_2 = 10 \,\text{TeV}$$

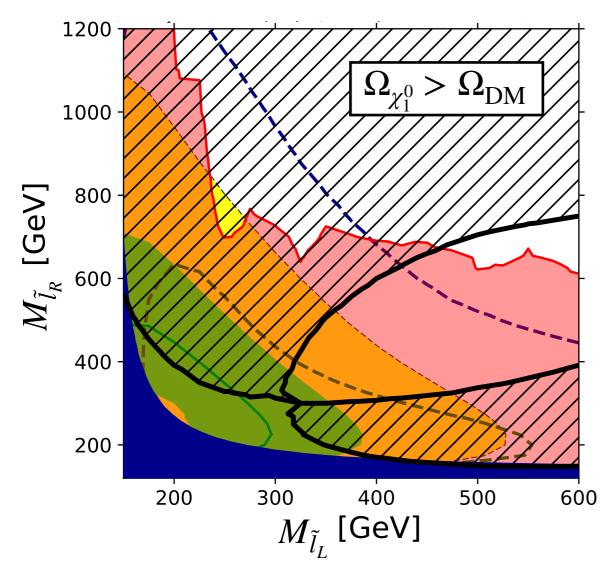
$$\mu = \mu_{\text{max}}, \quad \tan \beta = 50$$

$$\text{maximum allowed by vacuum (meta-)stability}$$



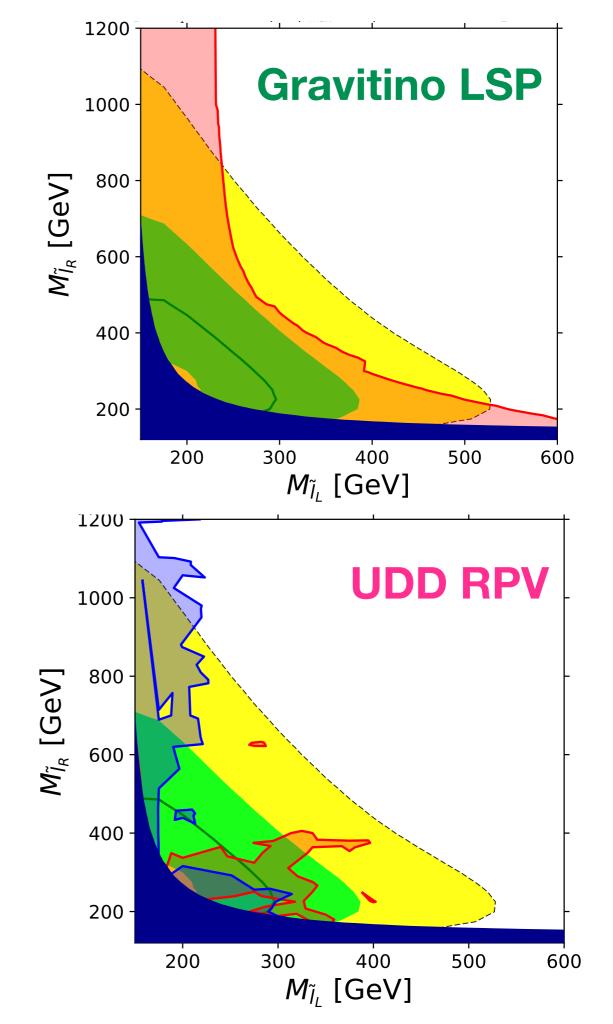


BLR



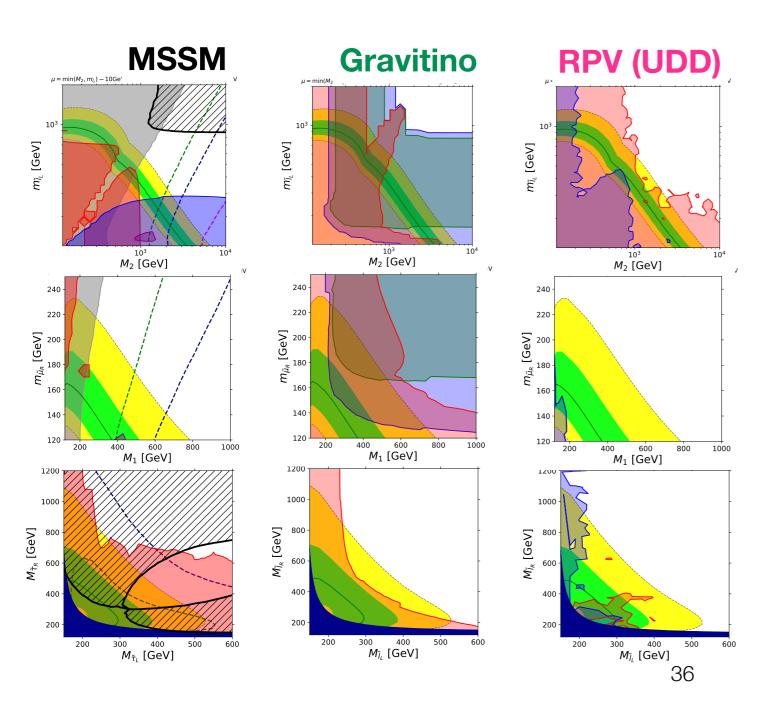
$$M_1 = m_{\tilde{\tau}_1} - 20 \,\text{GeV}, \quad M_2 = 10 \,\text{TeV}$$
 $\mu = \mu_{\text{max}}, \quad \tan \beta = 50$

maximum allowed by vacuum (meta-)stability



Conclusion

- Studied the SUSY parameter space that can explain muon g-2 anomaly.
- Phenomenological constraints depend on whether or not neutralino-1 is stable:



Stable (MSSM):

- Dark Matter:
 Overproduction, Direct Detection
 → Next generation DD exps will explore the entire 2-sigma region
- LHC constraints: Lepton + MET

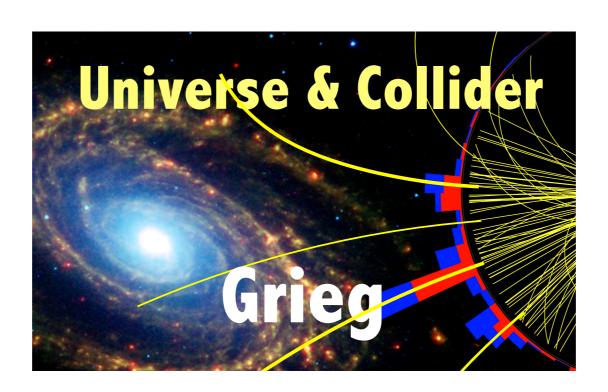
Unstable:

- No dark matter constraints:
- LHC constraints:





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Understanding the Early Universe: interplay of theory and collider experiments

Joint research project between the University of Warsaw & University of Bergen