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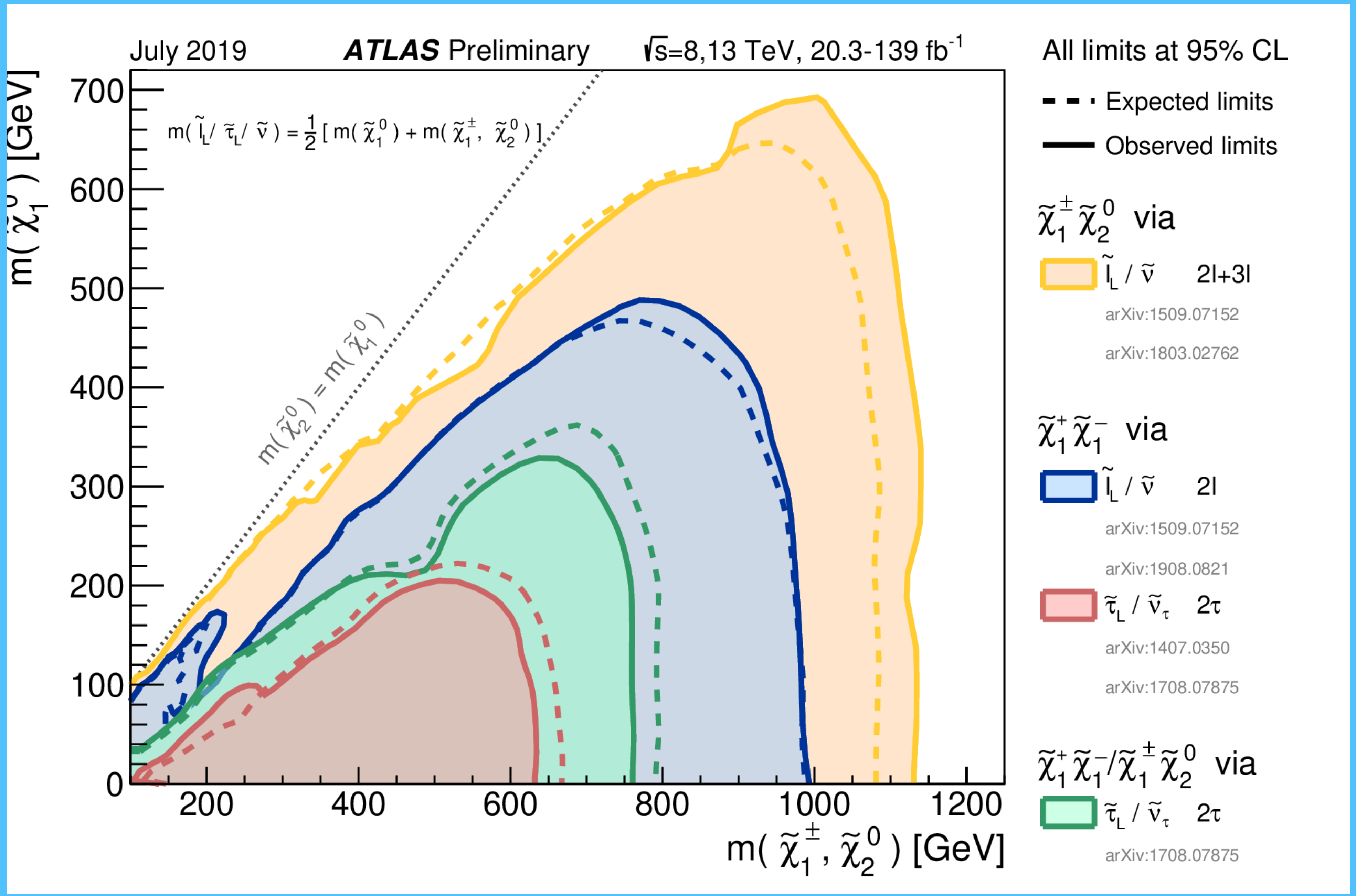
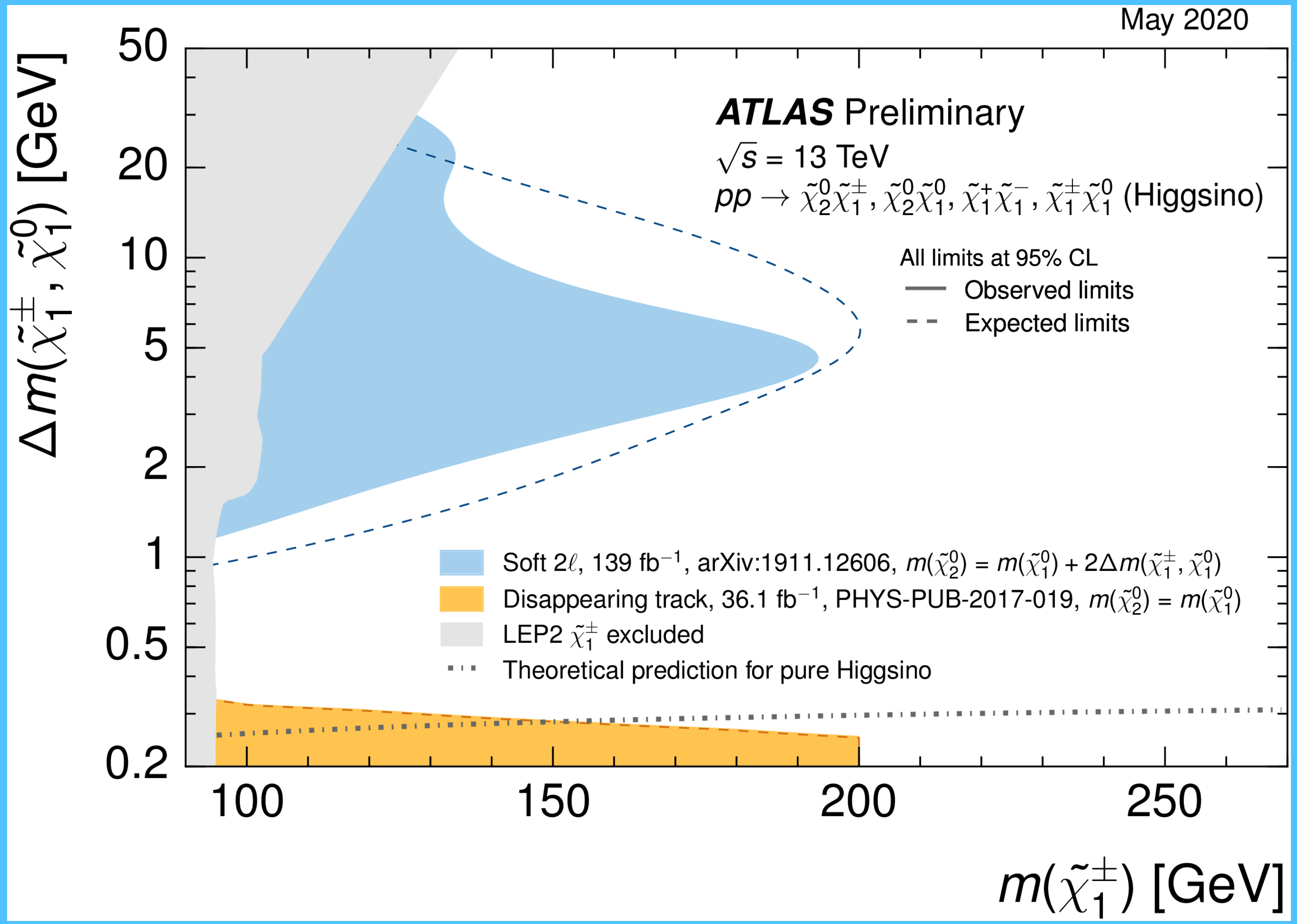
Improved $(g-2)_\mu$ measurements and SUSY

02/03/2021 BASED ON : 2006.15157, EPJC WITH SVEN HEINEMEYER AND IPSITA SAHA

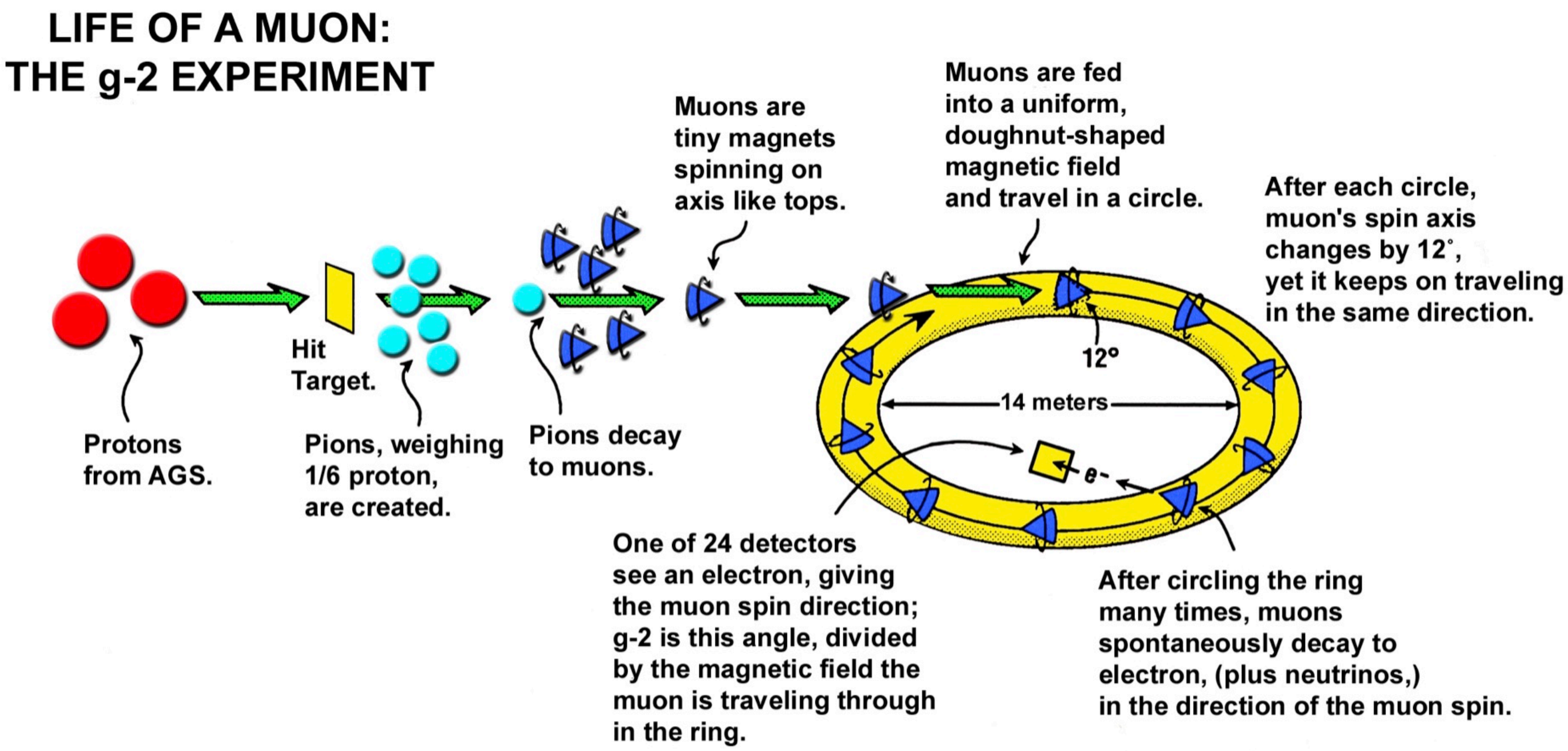
- EW sector may be hiding key to new physics
- Modest production cross section, mass bounds from the LHC comparably weak
- May show up elsewhere : DM experiments, $(g-2)_\mu$ ....
- New results from Fermilab 'MUON (g-2)' coming soon !





Outline

- Status of $(g-2)_\mu$
- EW sector of MSSM
- Experimental constraints
- Results
- Future collider prospects
- Conclusion



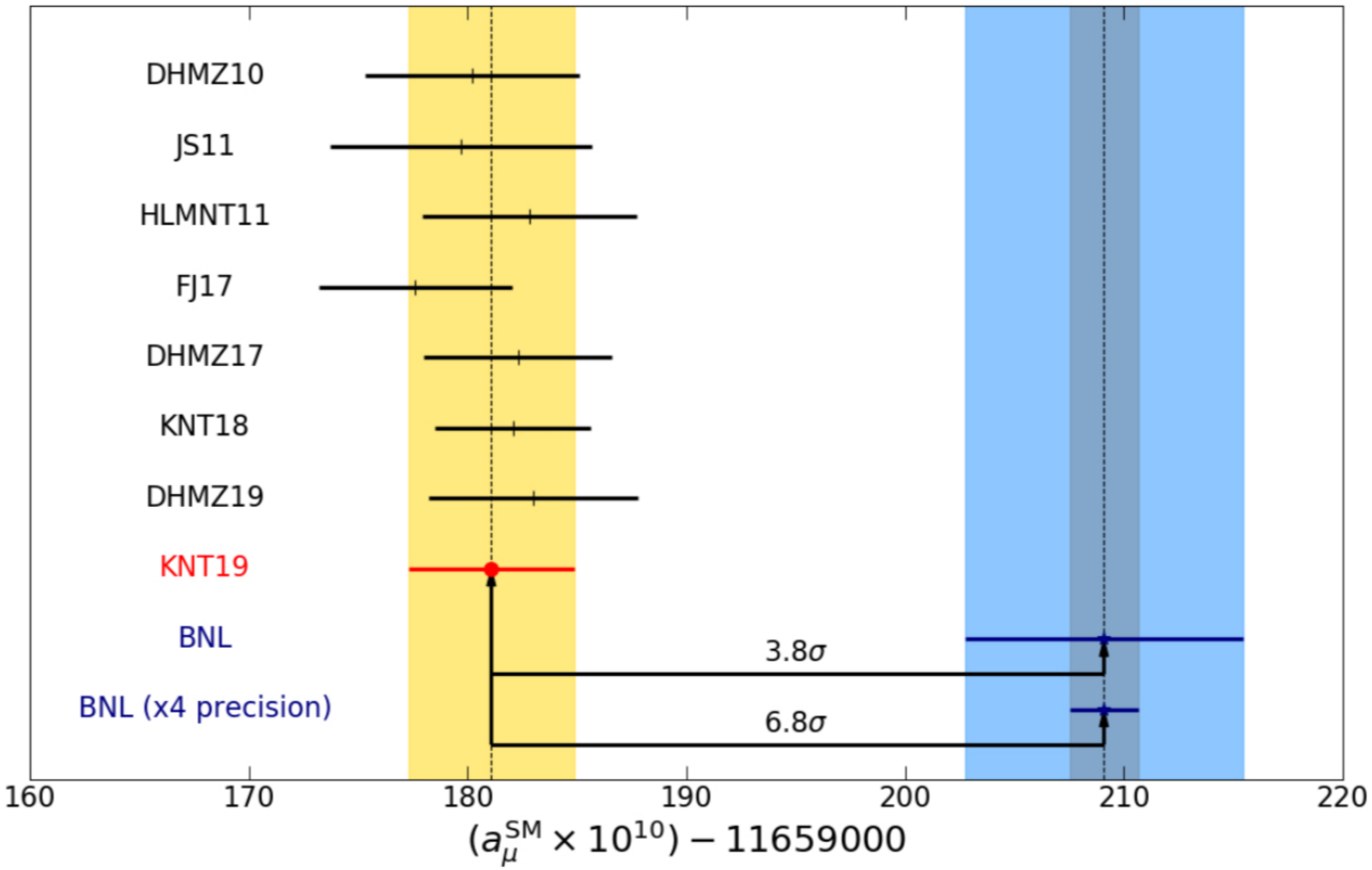
$$\vec{\mu} = g_\mu \frac{e}{2m} \vec{s}$$

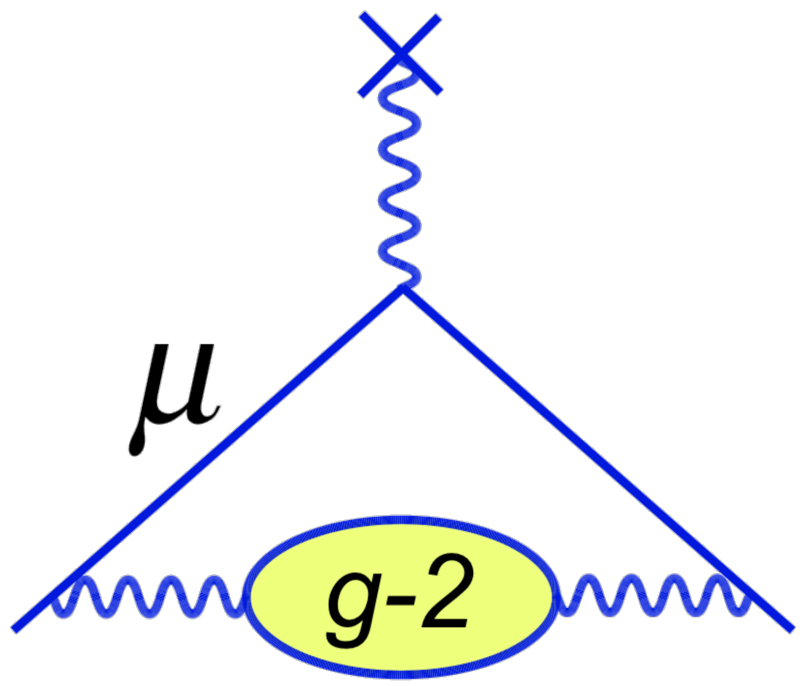
$$\bar{u}(p')[\gamma^\mu F_1(q^2) + \frac{i}{2m_\mu}\sigma^{\mu\nu} q_\nu F_2(q^2)]u(p)A_\mu$$

$$a_\mu = \frac{g_\mu - 2}{2}$$

$$F_2(0) = a_\mu$$

Muon (g-2)





$$a_\mu^{exp} - a_\mu^{theo,SM} = (27.9 \pm 7.6) \times 10^{-10}$$

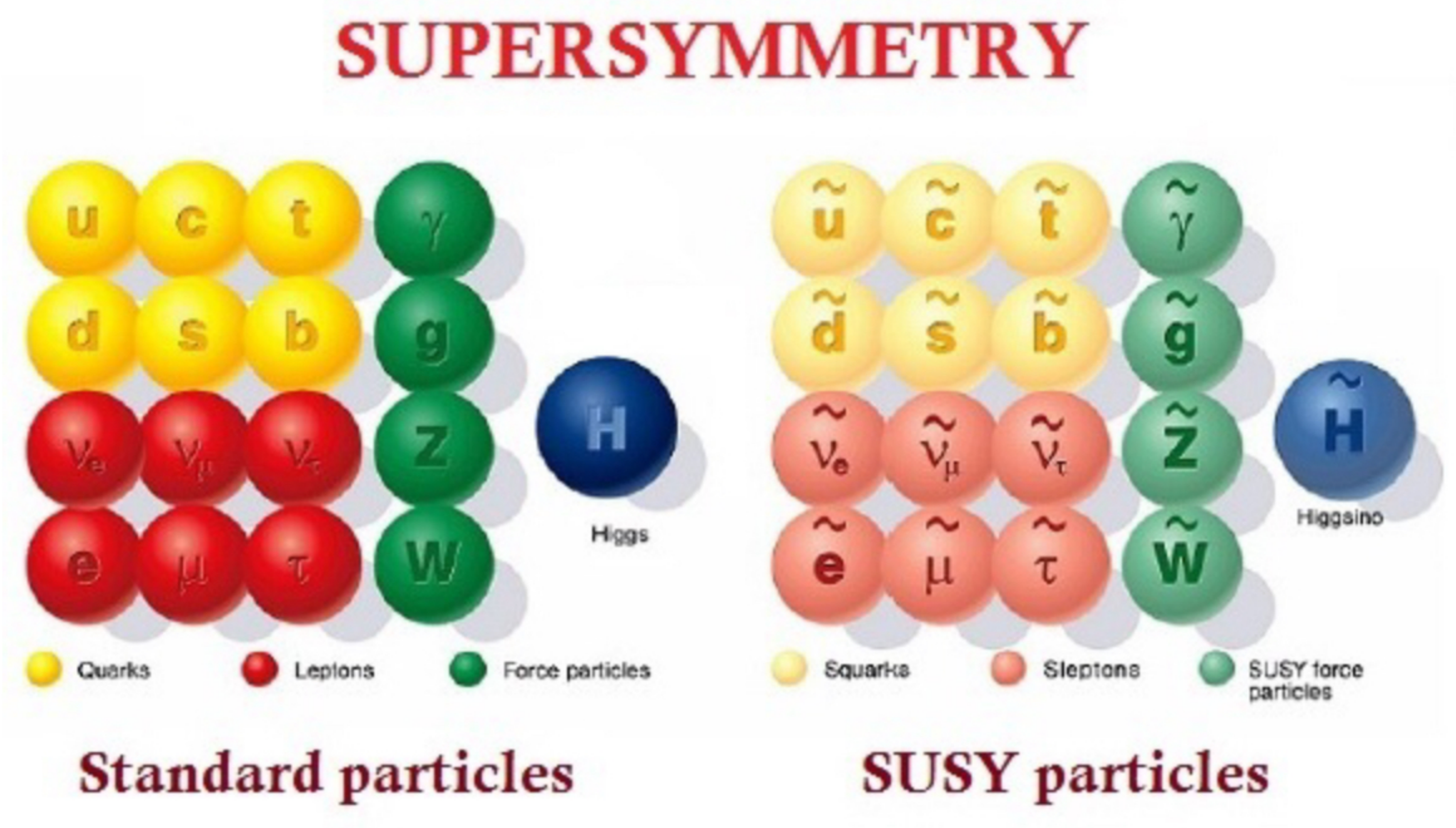
- Aoyama *et al* '20

$\sim 3.7\ \sigma$

Muon g-2 experiment at Fermilab aims at 4 x BNL precision

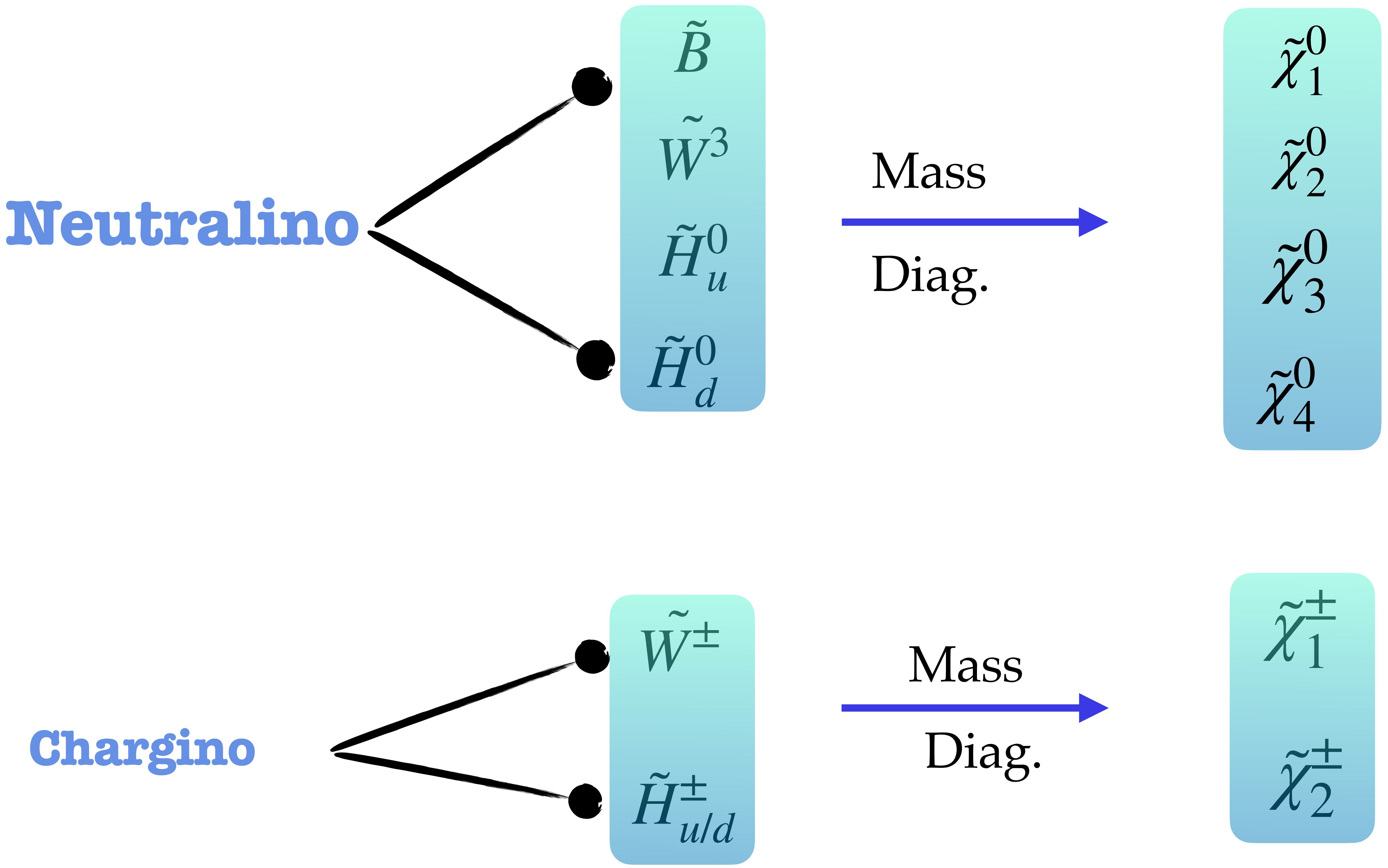
Keshavarzi, Nomura, Teubner '20

MSSM particle content



EW Gauginos

Masses and mixing are determined by U(1) and SU(2) gaugino masses M_1, M_2 and Higgs mass parameter μ.



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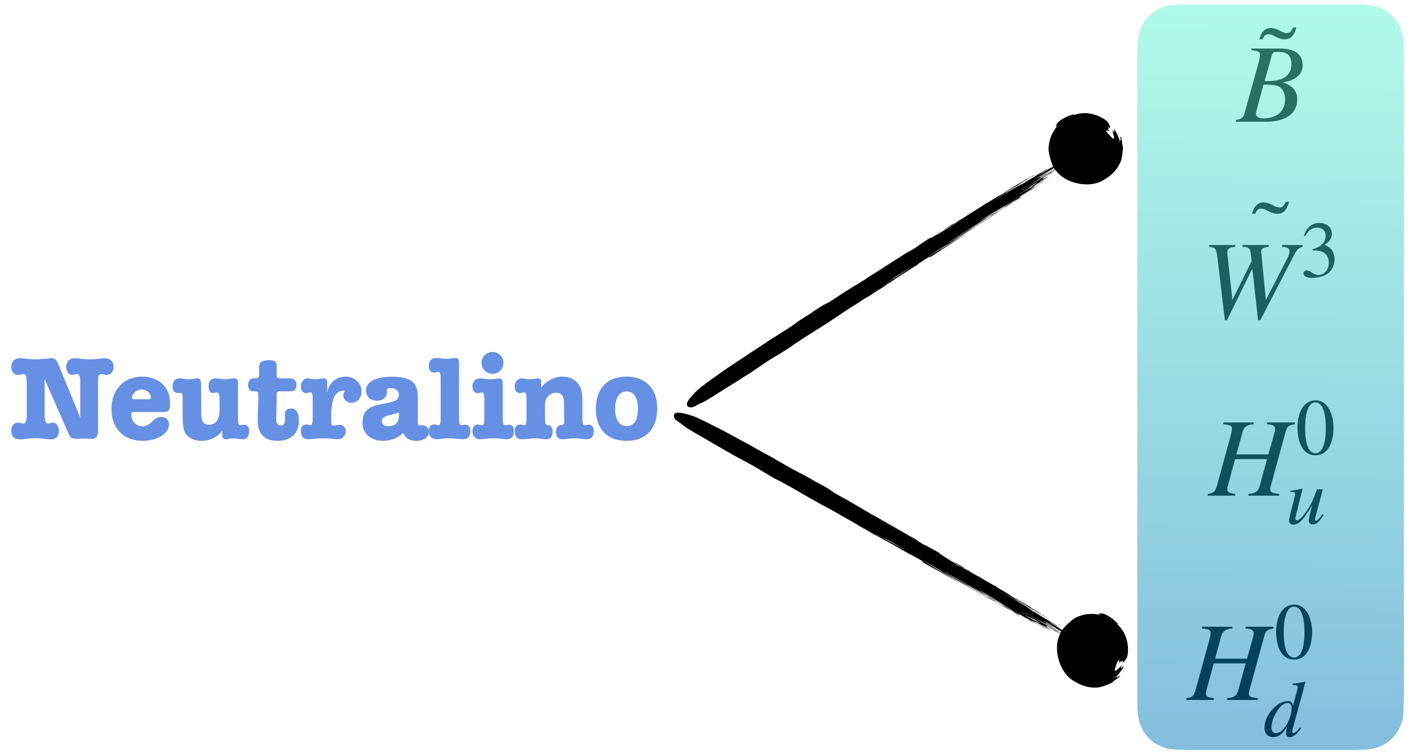
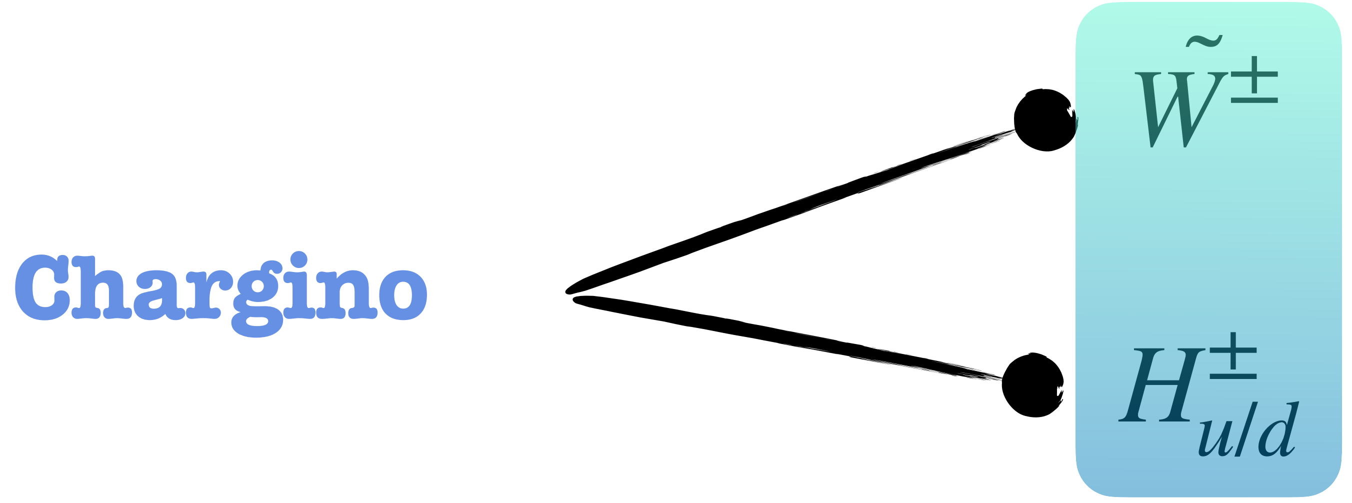


Neutralino Mass Matrix

$$M_N = \begin{pmatrix} M_1 & 0 & -M_Z\, c_\beta\, s_W & M_Z\, s_\beta\, s_W \\ 0 & M_2 & M_Z\, c_\beta\, cW & -M_Z\, s_\beta\, cW \\ -M_Z\, c_\beta\, s_W & M_Z\, c_\beta\, c_W & 0 & -\mu \\ M_Z\, s_\beta\, s_W & -M_Z\, s_\beta\, c_W & -\mu & 0 \end{pmatrix}$$



Chargino Mass Matrix

$$M_C = \begin{pmatrix} M_2 & \sqrt{2} M_W c_\beta \\ \sqrt{2} M_W s_\beta & \mu \end{pmatrix}$$

FOUR PARAMETERS → $M_1, M_2, \mu, \tan\beta$

Sleptons

Slepton Mass Matrix

$$M^2_{\tilde{L}} = \begin{pmatrix} m_l^2 + m_{LL}^2 & m_l X_l \\ m_l X_l & m_l^2 + m_{RR}^2 \end{pmatrix}$$

$$m_{LL}^2 = m_{\tilde{L}}^2 + (I_l^{3L} - Q_l s_w^2) M_z^2 c_{2\beta}$$

$$m_{RR}^2 = m_{\tilde{R}}^2 + Q_l s_w^2 M_z^2 c_{2\beta}$$

$$X_l = A_l - \mu(\tan\beta)^{2I_l^{3L}}$$

PARAMETERS $\longrightarrow$ $M_1, M_2, \mu, \tan\beta\,, m_{\tilde{L}}\,, m_{\tilde{R}}$

First two gens. $m_{\tilde{l}_1} \sim m_{LL}$ $\quad m_{\tilde{l}_2} \sim m_{RR}$

Constraints

Proper recasting is important

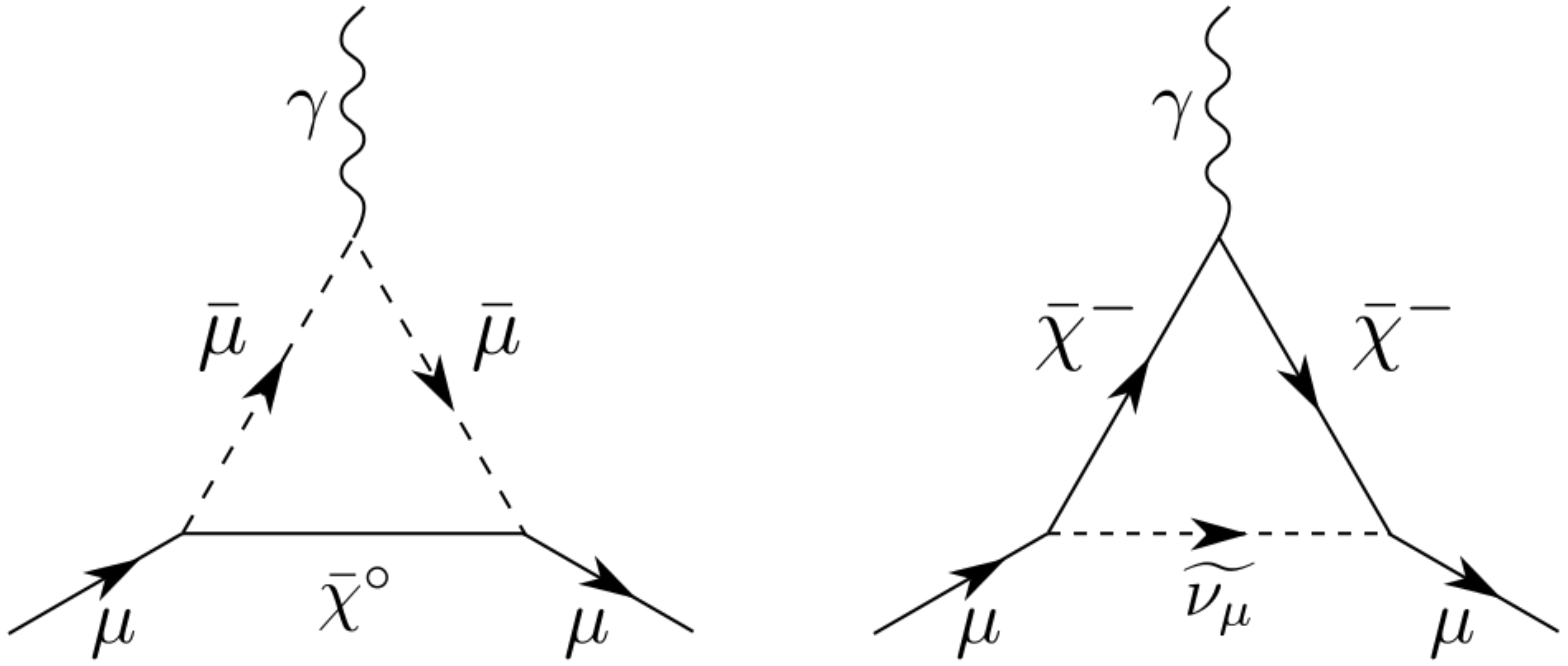
Direct Searches at LHC

- LHC searches restricted to **simplified models.**
- $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ taken to be mass-degenerate and purely wino. $\tilde{\chi}_1^0$ purely bino.
- All three generations of sleptons and sneutrinos assumed mass degenerate. In MSSM:
$$m_{\tilde{\nu}}^2 = m_{\tilde{l}}^2 + \frac{1}{2} m_Z^2 cos2\beta$$
- Heavier gauginos $\tilde{\chi}_3^0, \tilde{\chi}_4^0, \tilde{\chi}_2^{\pm}$ assumed to be decoupled.
- No sensitivity to parameters like tan β.

Indirect Constraints

- Muon (g-2).
- WMAP/PLANCK relic density.
- Spin independent direct detection data from XENON/LUX.
- Indirect detection constraints of dark matter.

Muon (g-2) in MSSM



- SUSY contributions from Chargino-Sneutrino and Smuon-Neutralino loop
- SM EW 1 loop : $\frac{\alpha}{\pi}\frac{m_\mu^2}{M_W^2}$.   MSSM , 1 loop : $\frac{\alpha}{\pi}\frac{m_\mu^2}{M_{SUSY}^2} \times tan\beta$
- SUSY can easily explain anomaly !

upper limits on EW super partner masses

SUSY contributions to $(g-2)_\mu$

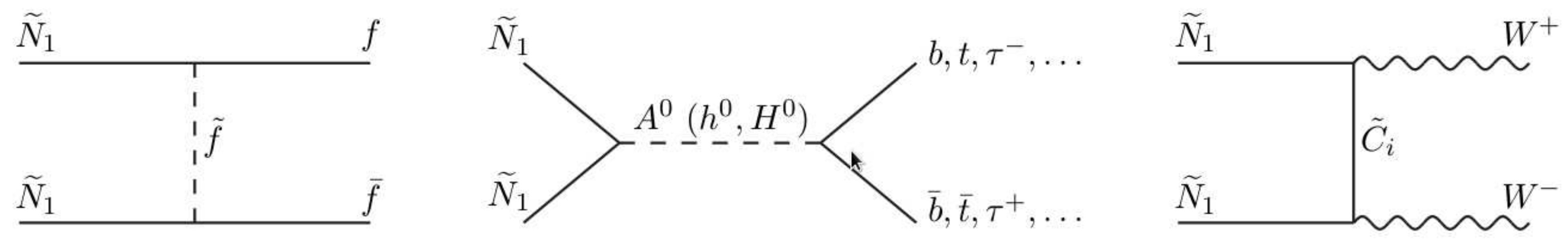
$$
\begin{aligned}
\Delta a_\mu(\tilde{W},\tilde{H},\tilde{\nu}_\mu) &\simeq \quad 15 \quad \times 10^{-9} \left(\frac{\tan\beta}{10}\right) \left(\frac{(100\,\mathrm{GeV})^2}{M_2\mu}\right) \left(\frac{f_C}{1/2}\right), \\
\Delta a_\mu(\tilde{W},\tilde{H},\tilde{\mu}_L) &\simeq -2.5 \quad \times 10^{-9} \left(\frac{\tan\beta}{10}\right) \left(\frac{(100\,\mathrm{GeV})^2}{M_2\mu}\right) \left(\frac{f_N}{1/6}\right), \\
\Delta a_\mu(\tilde{B},\tilde{H},\tilde{\mu}_L) &\simeq \quad 0.76 \times 10^{-9} \left(\frac{\tan\beta}{10}\right) \left(\frac{(100\,\mathrm{GeV})^2}{M_1\mu}\right) \left(\frac{f_N}{1/6}\right), \\
\Delta a_\mu(\tilde{B},\tilde{H},\tilde{\mu}_R) &\simeq -1.5 \quad \times 10^{-9} \left(\frac{\tan\beta}{10}\right) \left(\frac{(100\,\mathrm{GeV})^2}{M_1\mu}\right) \left(\frac{f_N}{1/6}\right), \\
\Delta a_\mu(\tilde{\mu}_L,\tilde{\mu}_R,\tilde{B}) &\simeq \quad 1.5 \quad \times 10^{-9} \left(\frac{\tan\beta}{10}\right) \left(\frac{(100\,\mathrm{GeV})^2}{m_{\tilde{\mu}_L}^2 m_{\tilde{\mu}_R}^2/M_1\mu}\right) \left(\frac{f_N}{1/6}\right).
\end{aligned}
$$

Endo, Hamaguchi, Iwamoto, Yoshinaga'13

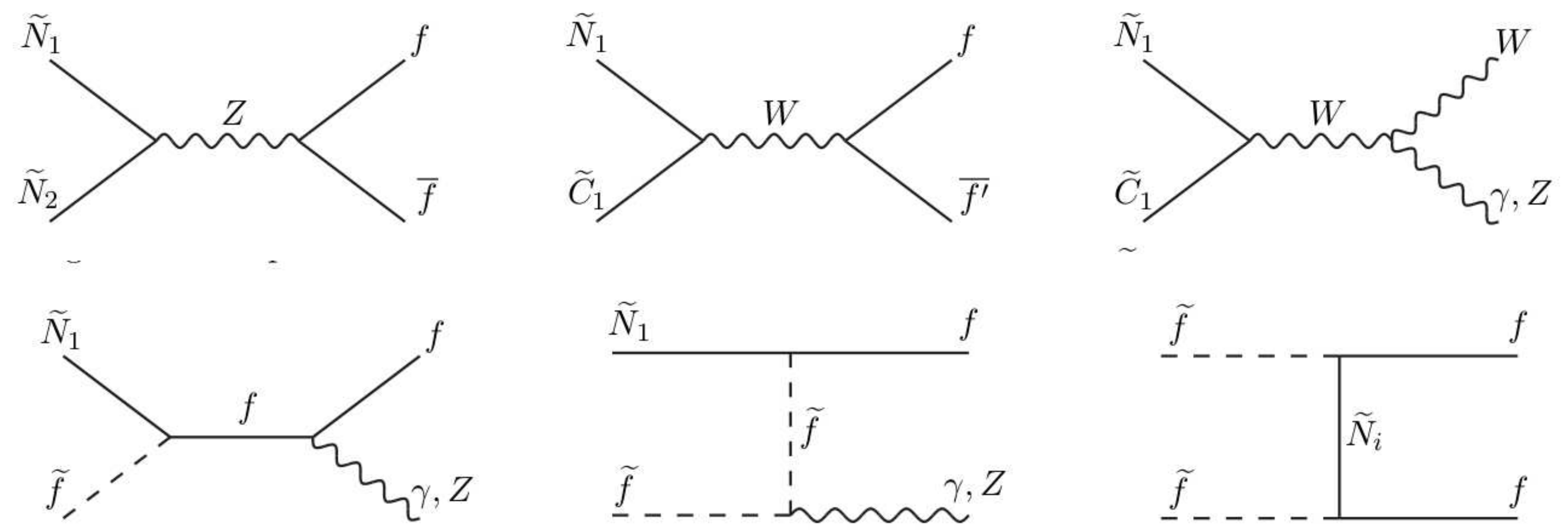
DM Constraints

Relic Density

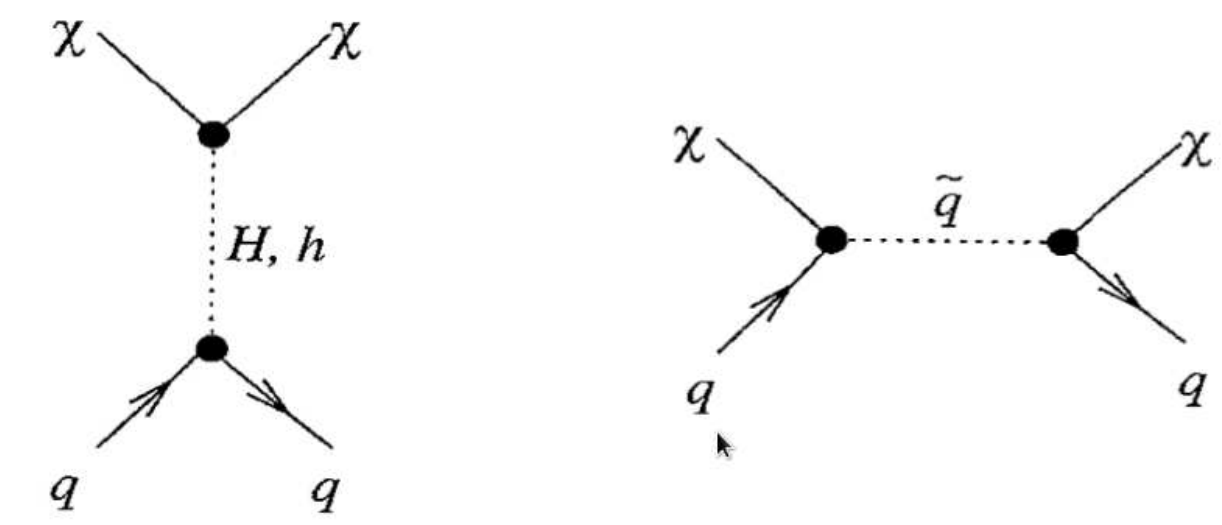
Some annihilation channels that could give right relic density :



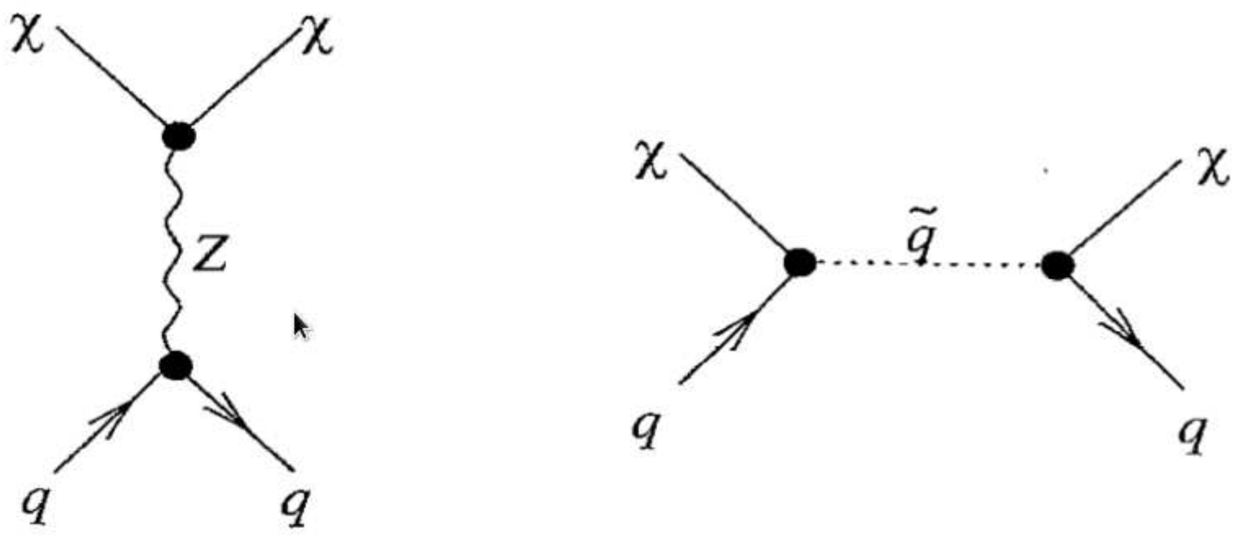
There can be coannihilations with sparticles of slightly heavier masses:



Direct Detection



Diagrams contributing to SI interactions



Diagrams contributing to SD interactions

A well-tempered bino-wino or bino-higgsino LSP ⟶ Chargino coannihilation

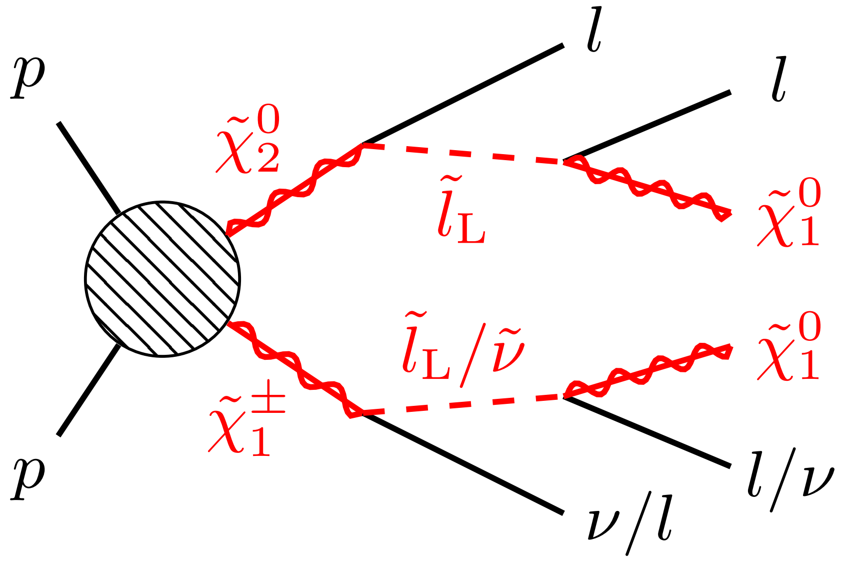
Bino - dominated LSP ⟶ Slepton coannihilation

Searches at the LHC

- Trilepton searches

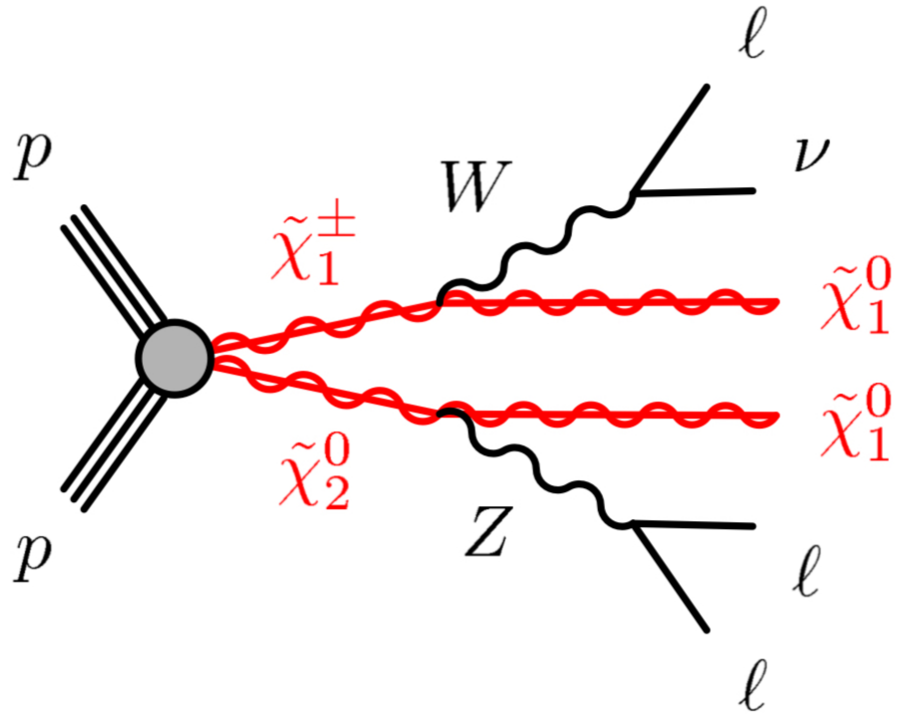
  ATLAS [1803.02762]

  13 TeV, 36 fb^{-1}

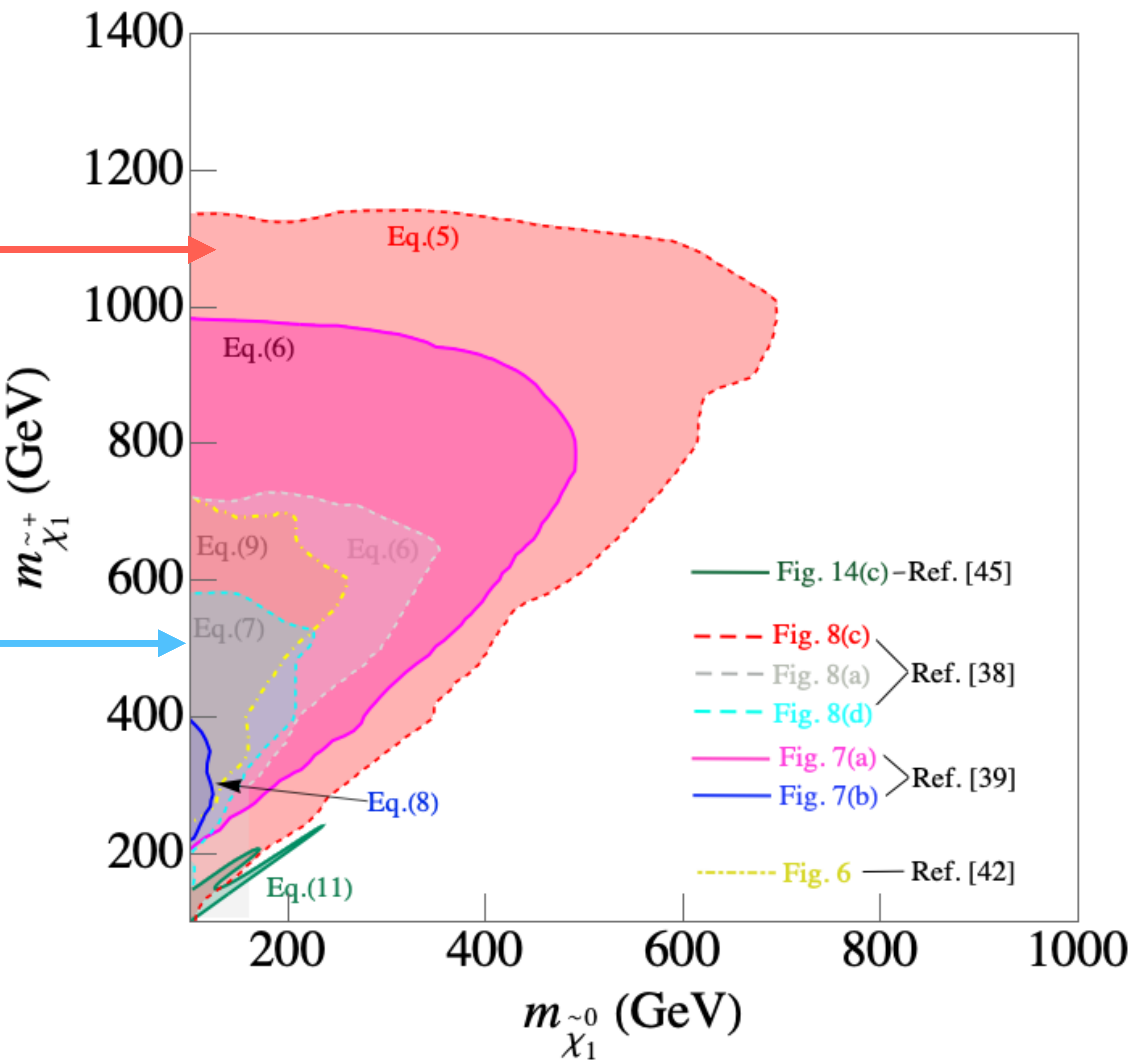


- Pure wino-bino scenario

- 100% BR



- $m_{\tilde{l}_L} = \frac{1}{2}(m_{\tilde{\chi}_1^\pm} + m_{\tilde{\chi}_1^0})$
- $m_{\tilde{l}_L} = m_{\tilde{\nu}}$
- $(\tilde{e}, \tilde{\mu}, \tilde{\tau})_L$ degenerate



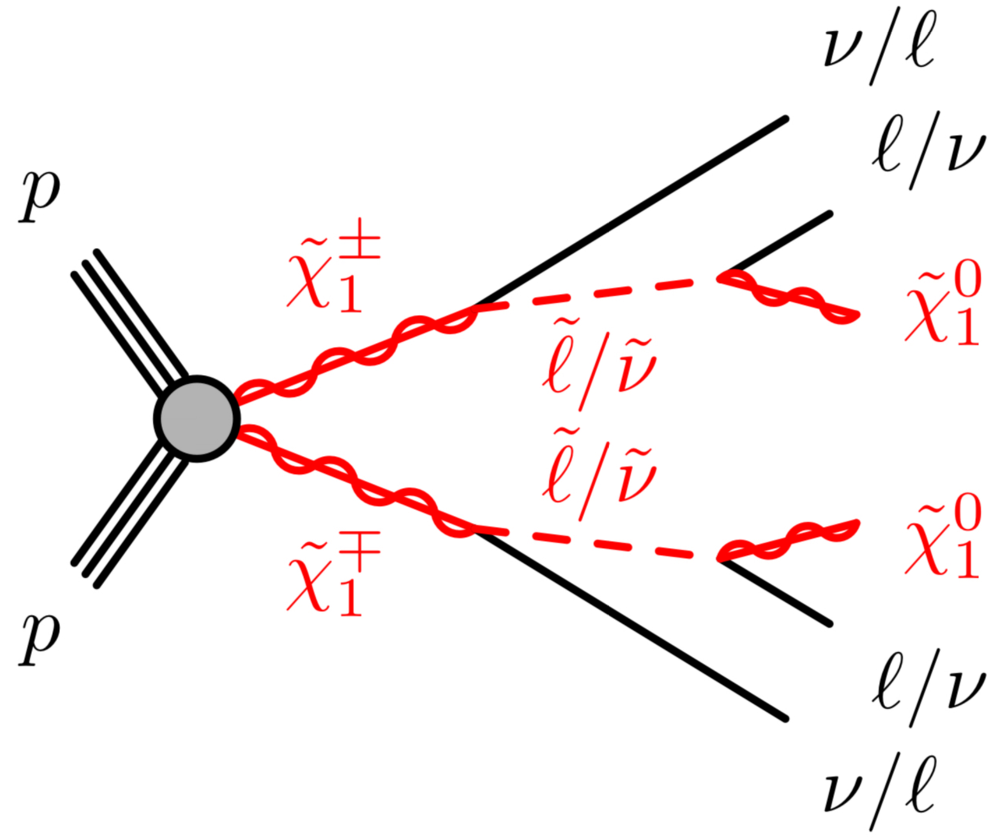
Proper recasting is important → **checkMATE**

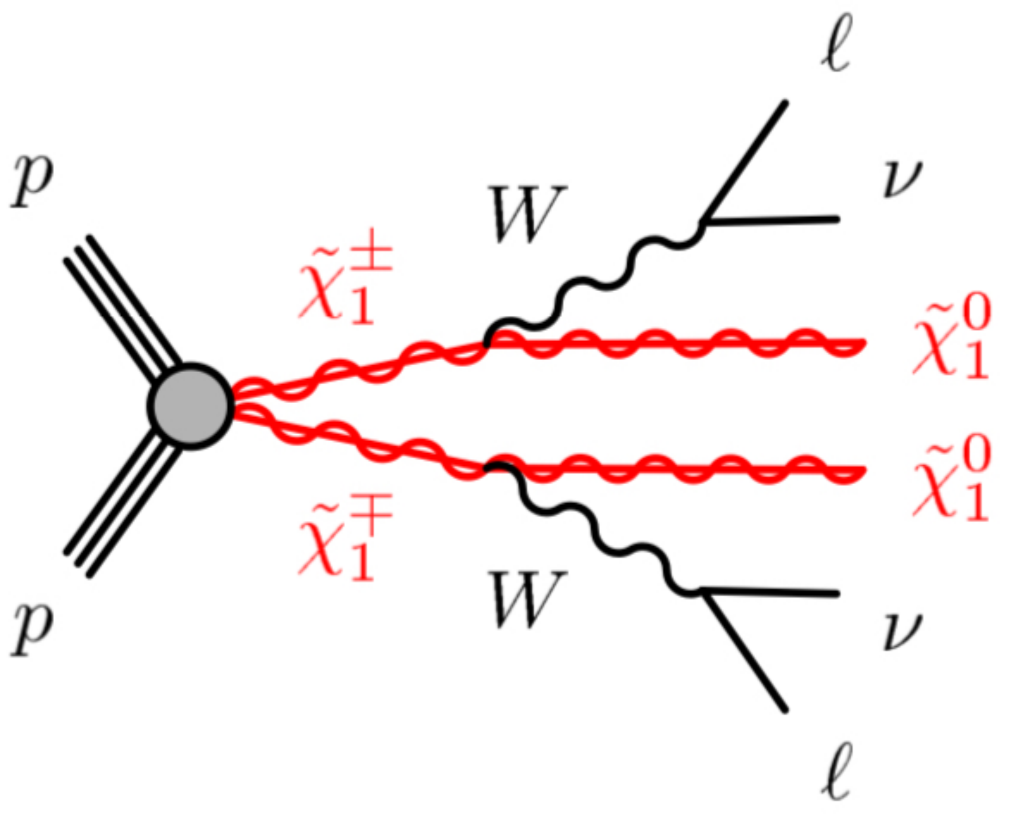
Searches at the LHC

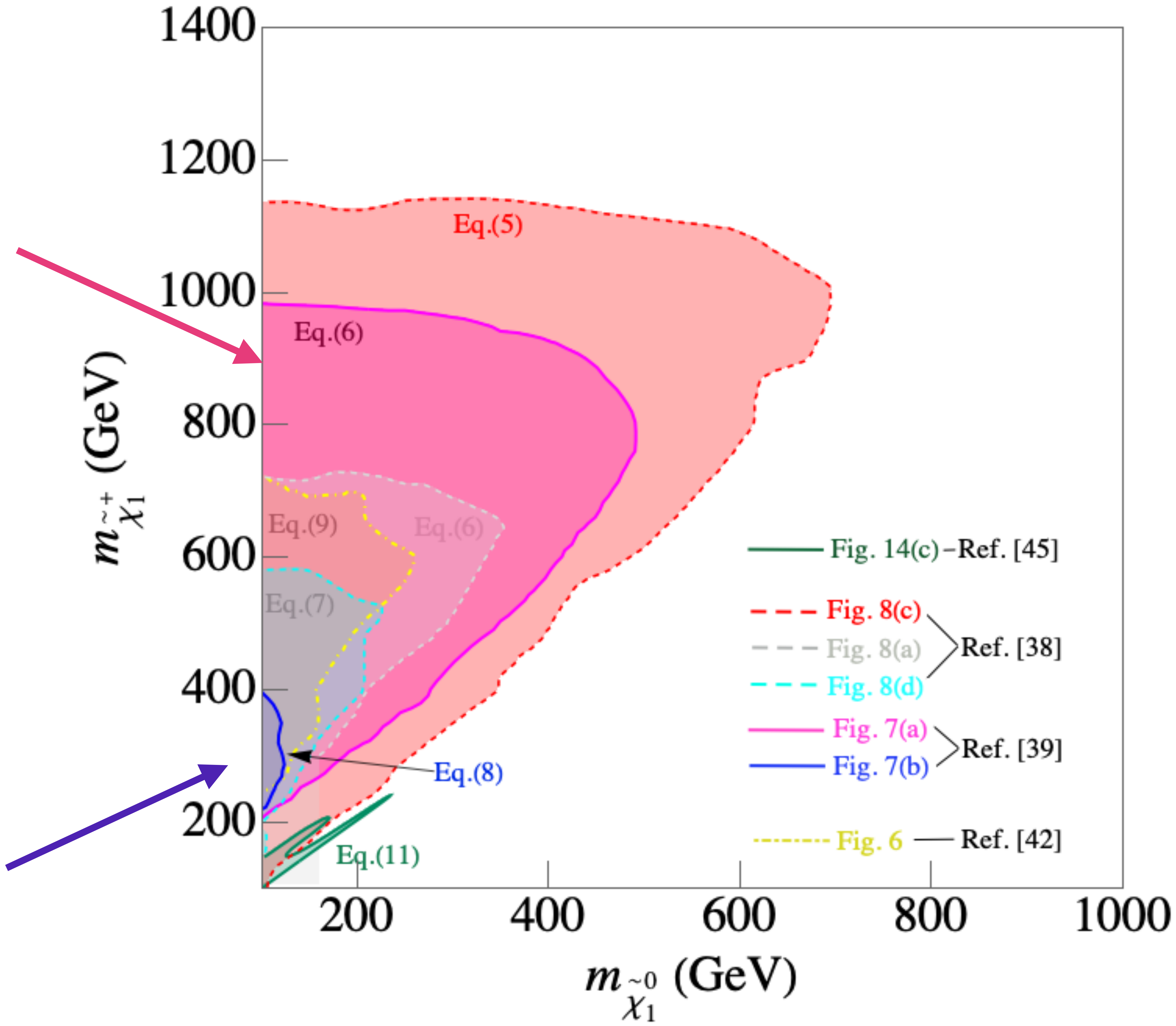
- Dilepton searches

ATLAS [1908.08215]

13 TeV, 139 fb^{-1}



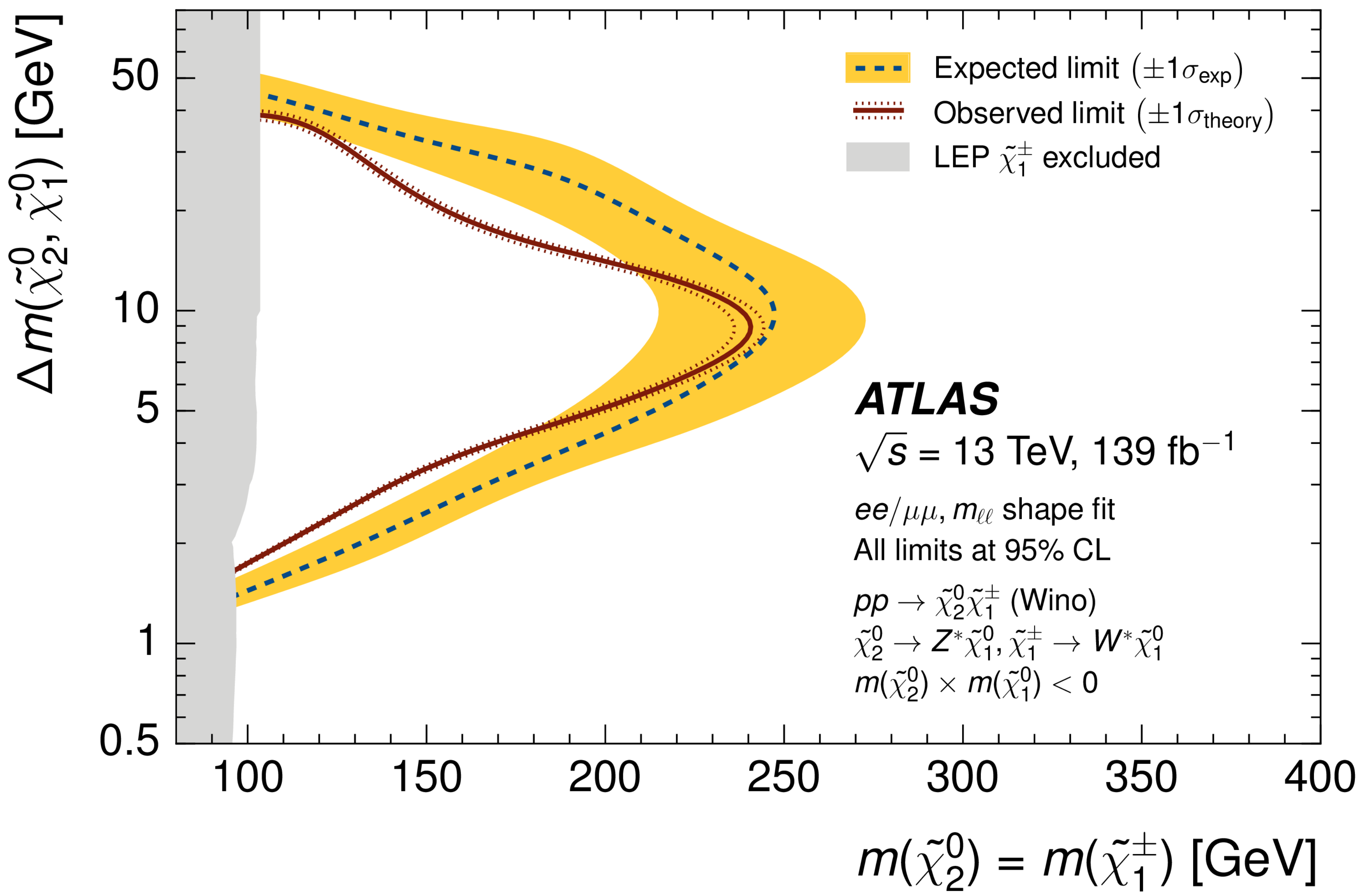




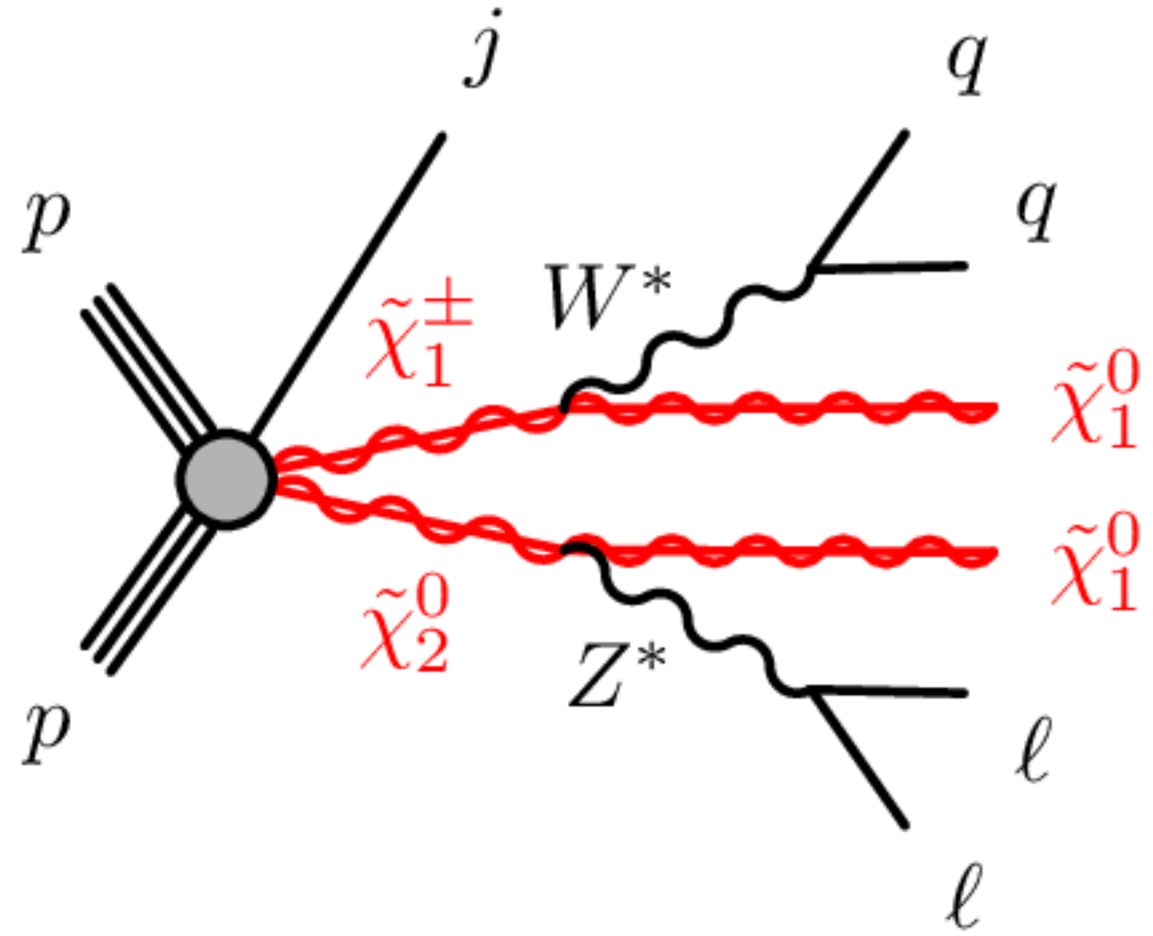
LHC searches

- Compressed spectra searches

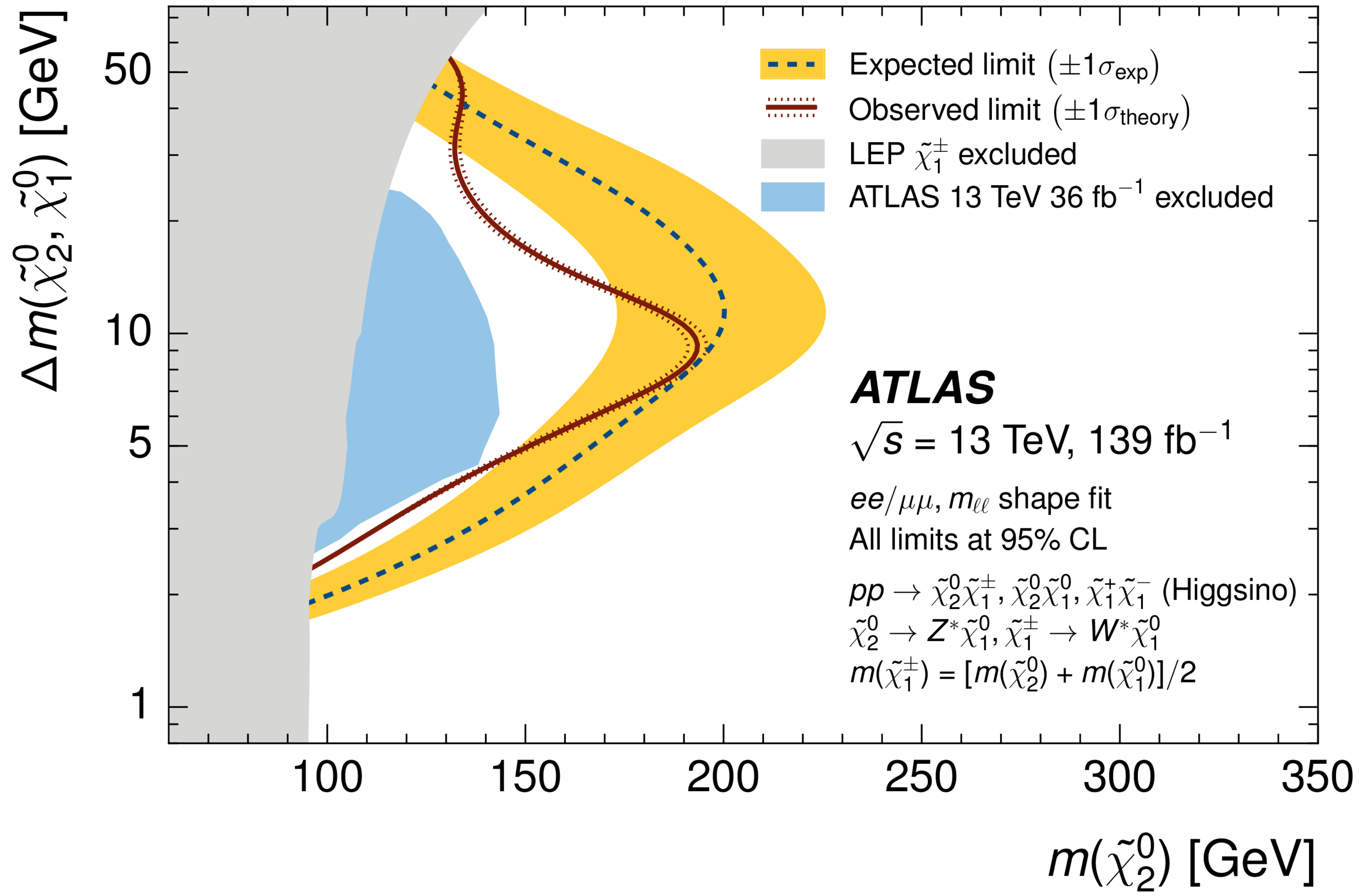
Wino



Soft leptons : ISR jet required to give boost



Higgsino



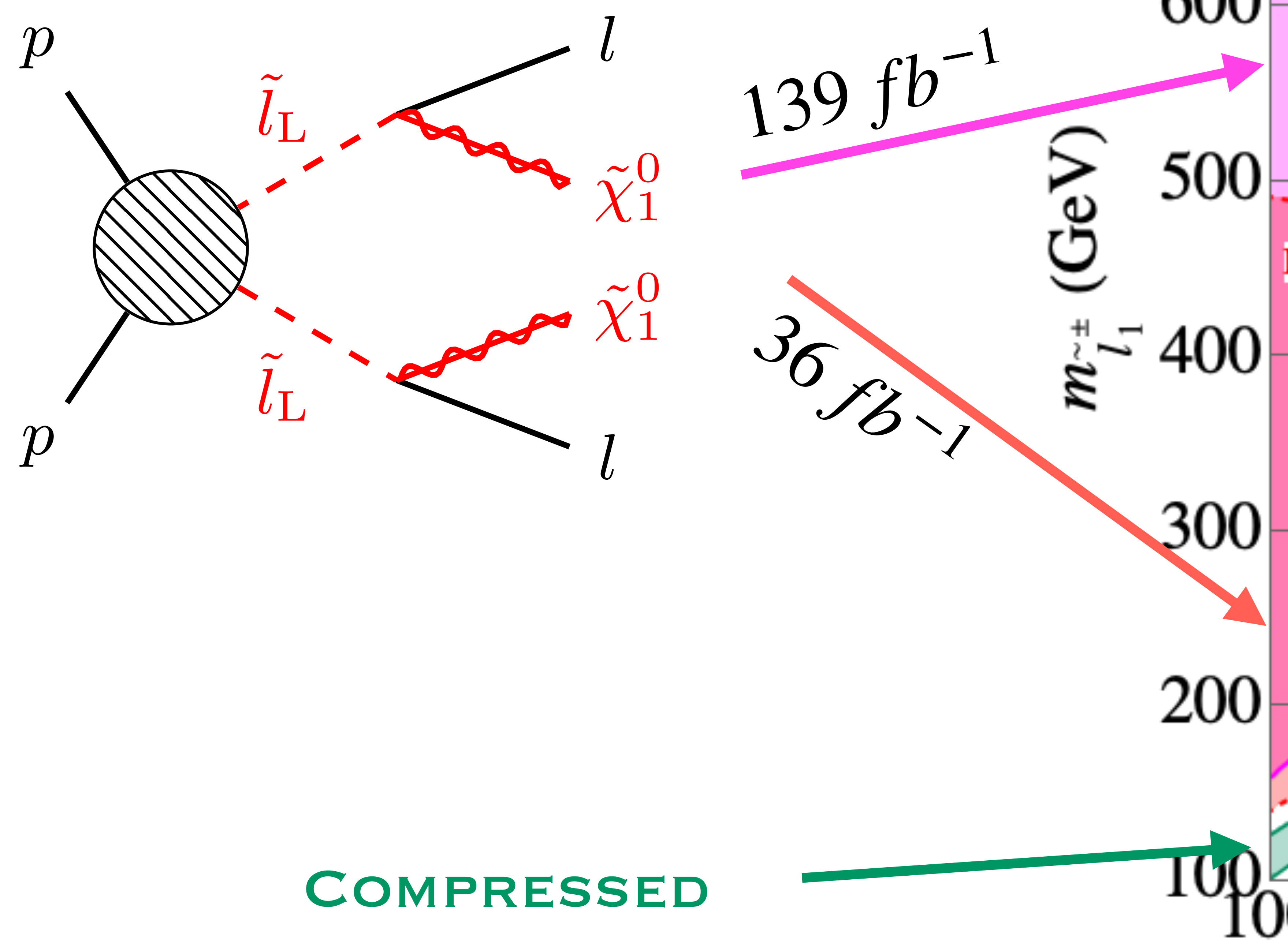
ATLAS 1911.12606

Searches at the LHC

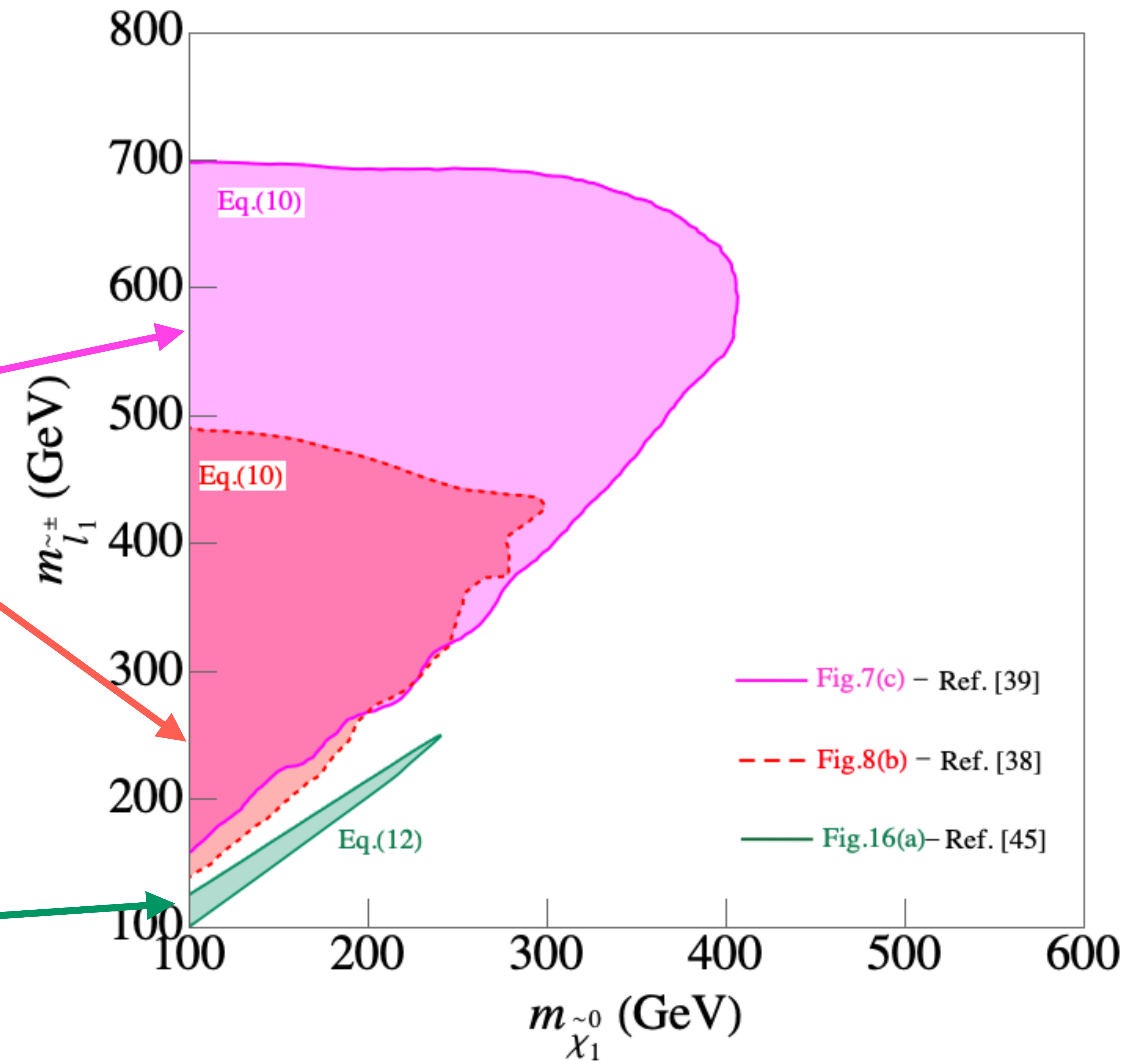
- Slepton pair production

ATLAS [1908.08215]

13 TeV, 139 fb^{-1}



ATLAS 1911.12606



Proper recasting is important → **checkMATE**

Overview of CM

Drees, Dreiner, Schmeier, Tattersall, Kim ‘13
Kim, Schmeier, Tattersall, Rolbiecki ‘15
Dercks, Desai, Kim, Rolbiecki, Tattersall ‘16

4

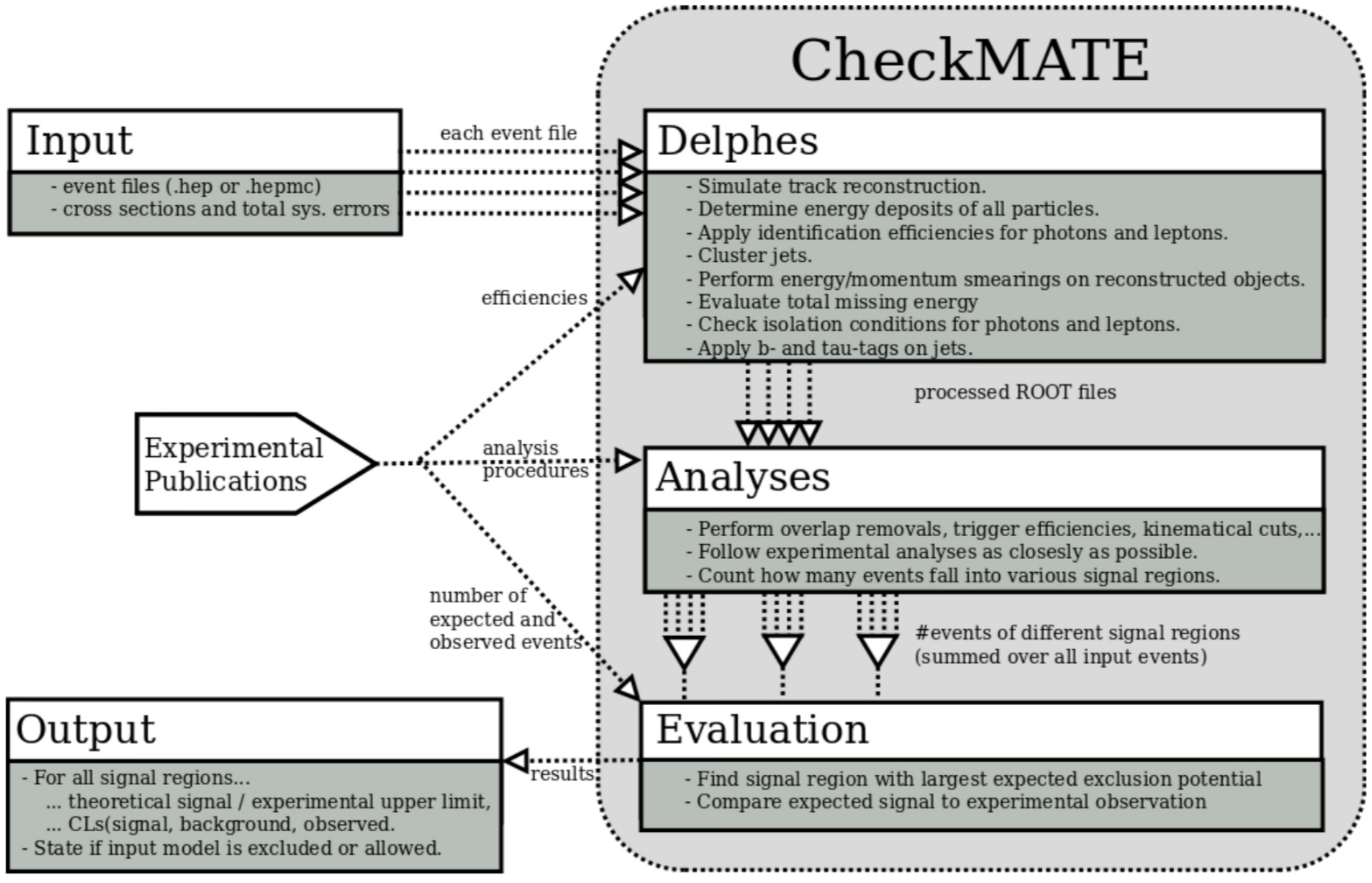


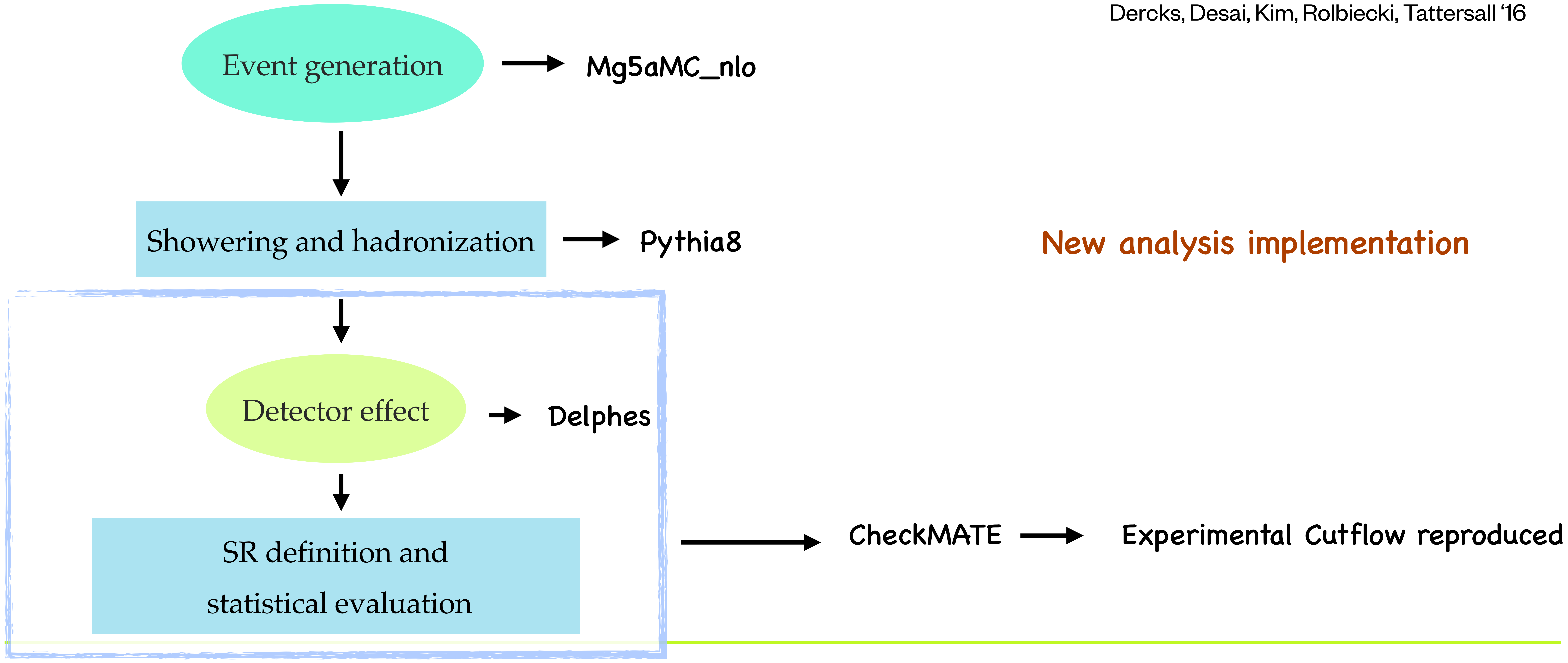
FIG. 1: Flow chart to demonstrate the chain of data processing within CheckMATE.

Model testing

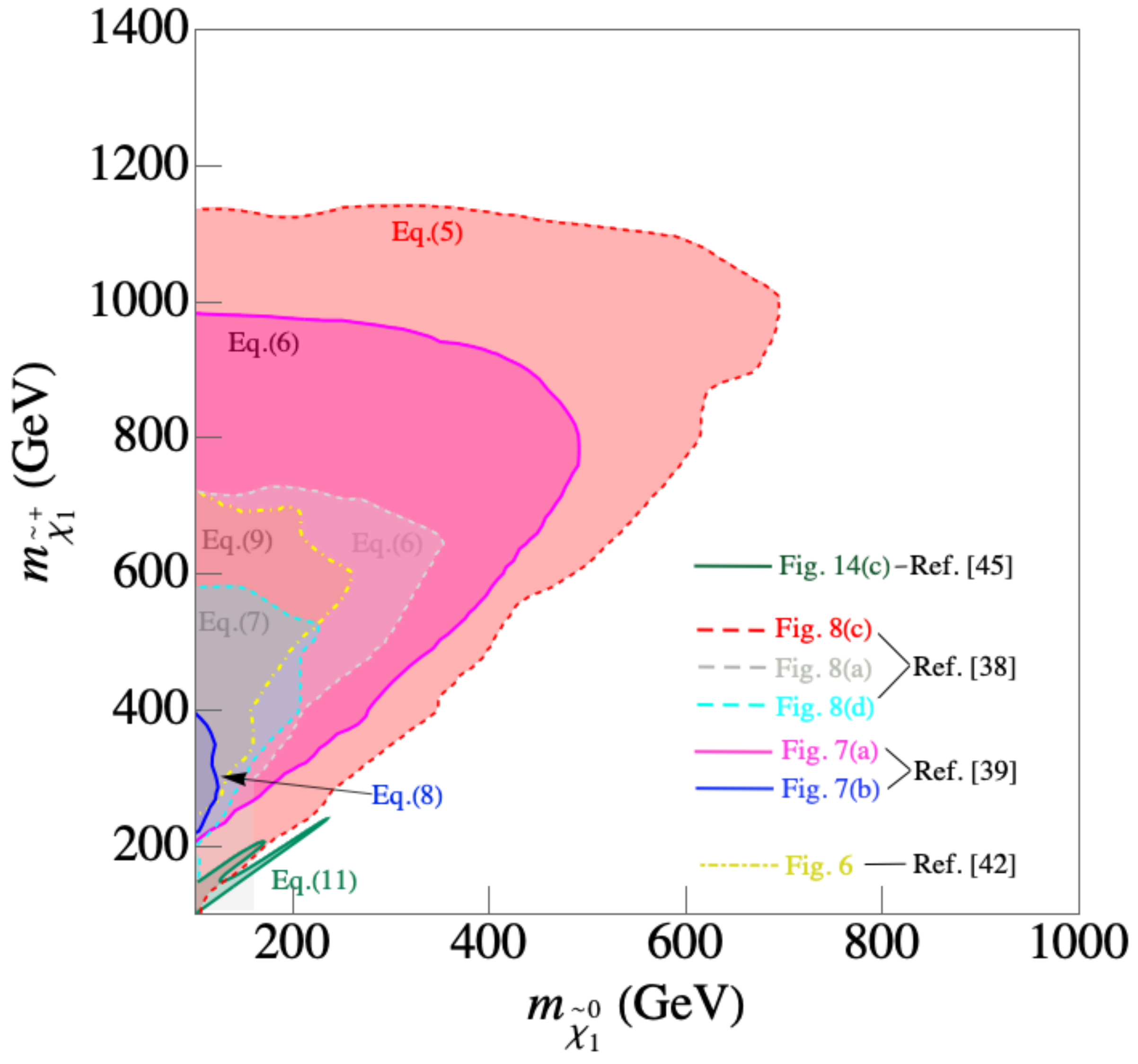
- Testing models against LHC analyses
- Signal events calculated for each SR
- Evaluation of $r = \dfrac{S - 1.96 \times \Delta S}{S^{95}_{exp}}$
- For the best SR, $r > 1 \longrightarrow$ excluded!

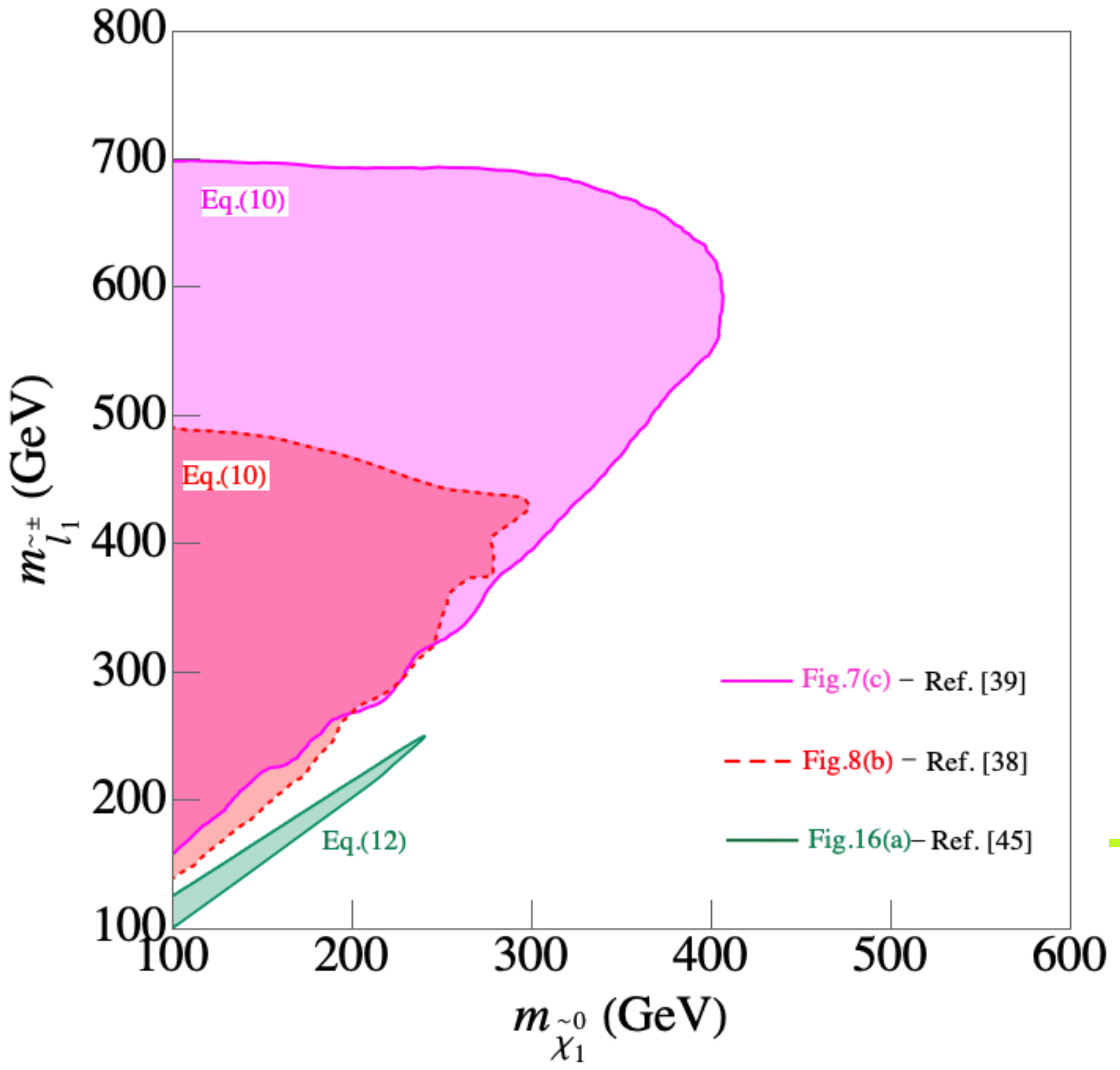
Recasting with CM

Drees, Dreiner, Schmeier, Tattersall, Kim ‘13
Kim, Schmeier, Tattersall, Rolbiecki ‘15
Dercks, Desai, Kim, Rolbiecki, Tattersall ‘16



Recasting with CM

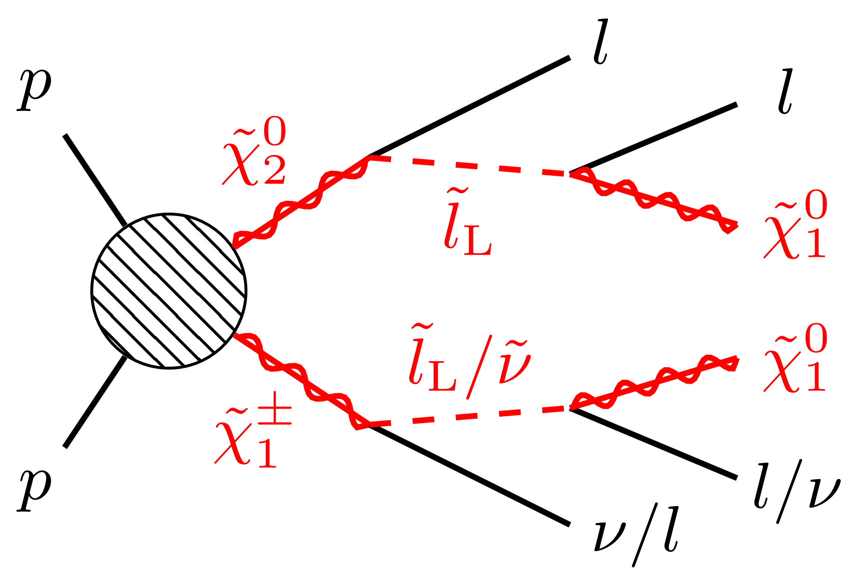




Show in the color	CheckMATE-implementation
Red dashed	✓
cyan dashed	✓
Gray dashed	✓
Magenta	✓
Blue	✓
Green	✗
Magenta	✓
Red dashed	✓
Green	✗

Compressed spectra searches applied directly

- ATLAS [1803.02762]
  13 TeV, 36 fb^{-1}



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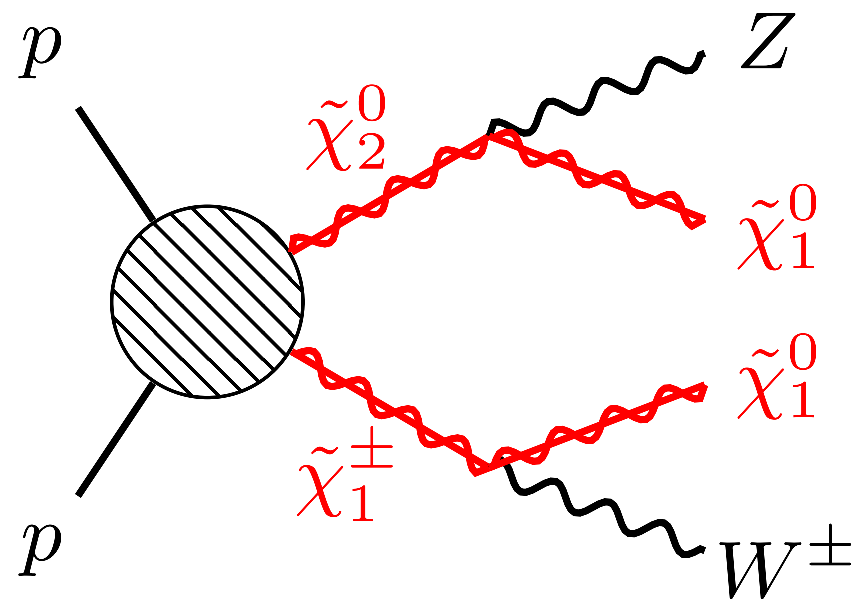

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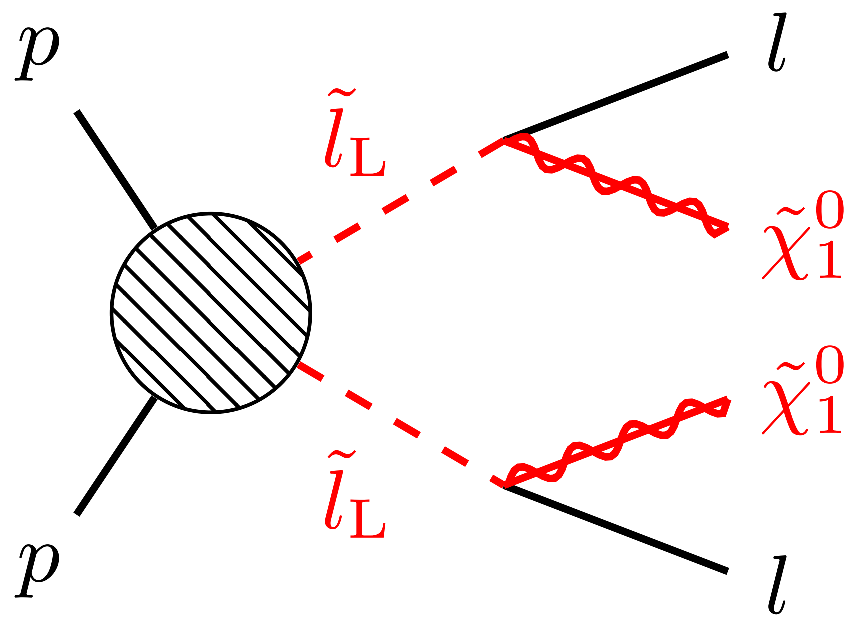
  13 TeV, 139 fb^{-1}



Most relevant in our case

Analysis flow

SuSpect → Spectrum generation

↓

GM2Calc → $(g-2)_\mu$ @ 2 loop

↓

MicrOMEGAS → DM observables

↓

CheckMATE → LHC constraints

- $\Delta a_\mu = (28.02 \pm 7.37) \times 10^{-10}$
- Anticipated future bound

  $\Delta a_\mu^{fut} = (28.02 \pm 5.2) \times 10^{-10}$
- $\Omega_{CDM} h^2 = 0.120 \pm 0.001$
- Direct detection SI bounds from XENON1T

Parameter Scanning

Chargino co-annihilation region:

$$100\ \text{GeV} \leq M_1 \leq 1\ \text{TeV}\ , \quad M_1 \leq M_2 \leq 1.1 M_1\ ,$$
$$1.1 M_1 \leq \mu \leq 10 M_1, \quad 5 \leq \tan\beta \leq 60,$$
$$100\ \text{GeV} \leq m_{\tilde{l}_L} \leq 1\ \text{TeV}, \quad m_{\tilde{l}_R} = m_{\tilde{l}_L}\ .$$

Bino-wino co-annihilation

Slepton co-annihilation region:

Case-L: SU(2) doublet

$$100\ \text{GeV} \leq M_1 \leq 1\ \text{TeV}\ , \quad M_1 \leq M_2 \leq 10 M_1\ ,$$
$$1.1 M_1 \leq \mu \leq 10 M_1, \quad 5 \leq \tan\beta \leq 60,$$
$$M_1\ \text{GeV} \leq m_{\tilde{l}_L} \leq 1.2 M_1, \quad M_1 \leq m_{\tilde{l}_R} \leq 10 M_1\ .$$

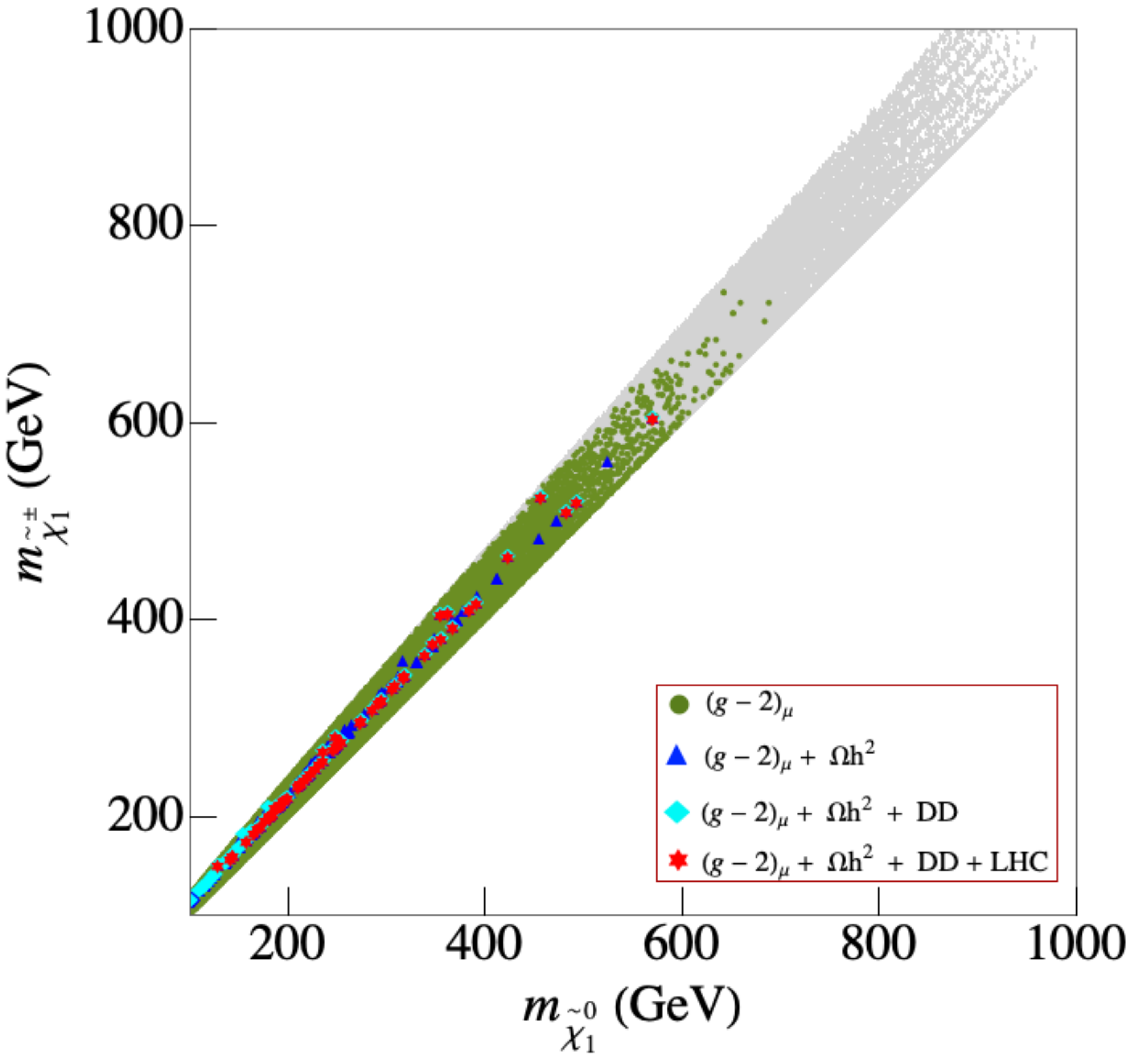
Case-R: SU(2) singlet

$$100\ \text{GeV} \leq M_1 \leq 1\ \text{TeV}\ , \quad M_1 \leq M_2 \leq 10 M_1\ ,$$
$$1.1 M_1 \leq \mu \leq 10 M_1, \quad 5 \leq \tan\beta \leq 60,$$
$$M_1\ \text{GeV} \leq m_{\tilde{l}_R} \leq 1.2 M_1, \quad M_1 \leq m_{\tilde{l}_L} \leq 10 M_1\ .$$

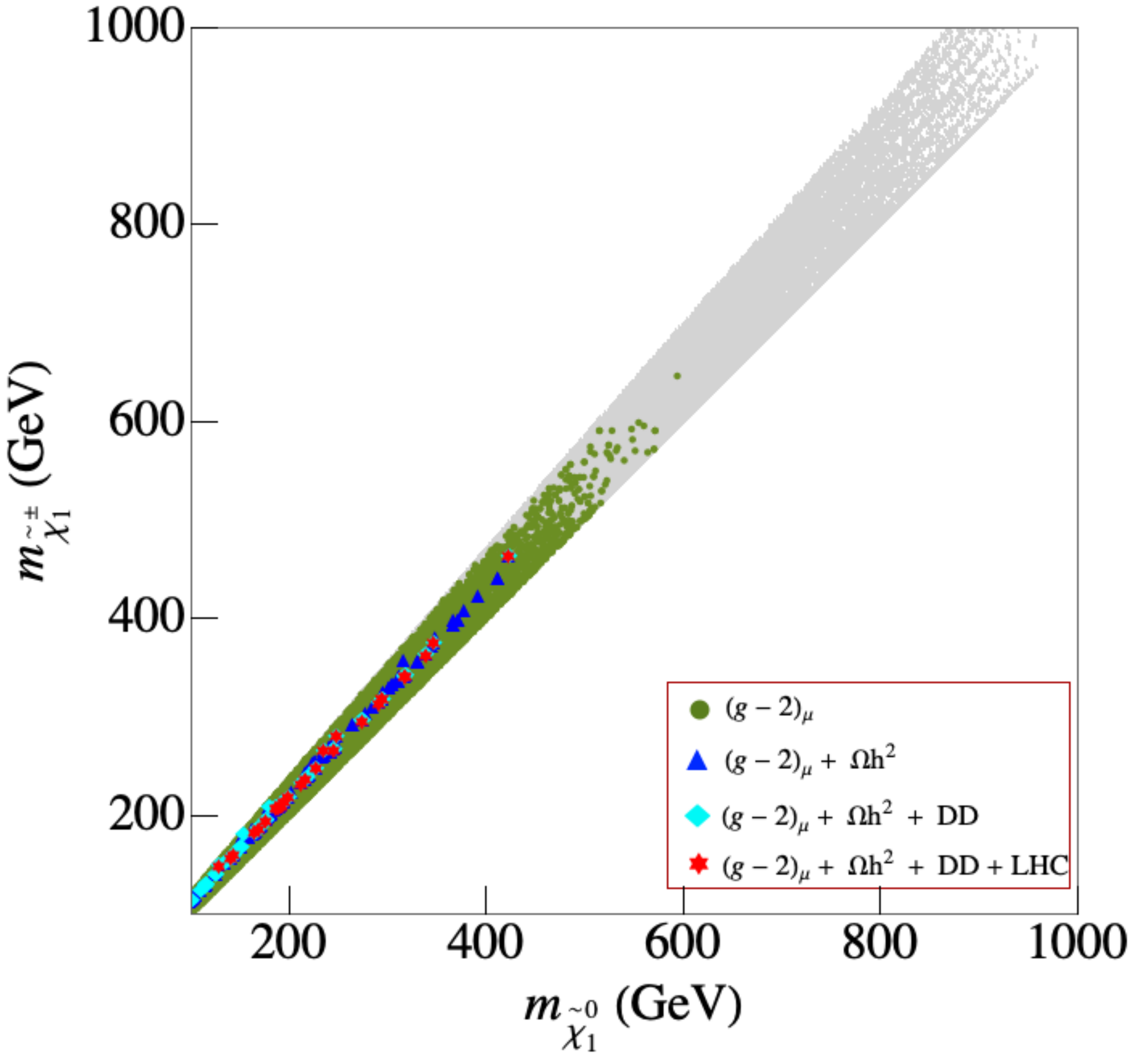
MC, S.Heinemeyer, I.Saha 2006.15157

Chargino Co-annihilation

Current $(g-2)_\mu$ limit



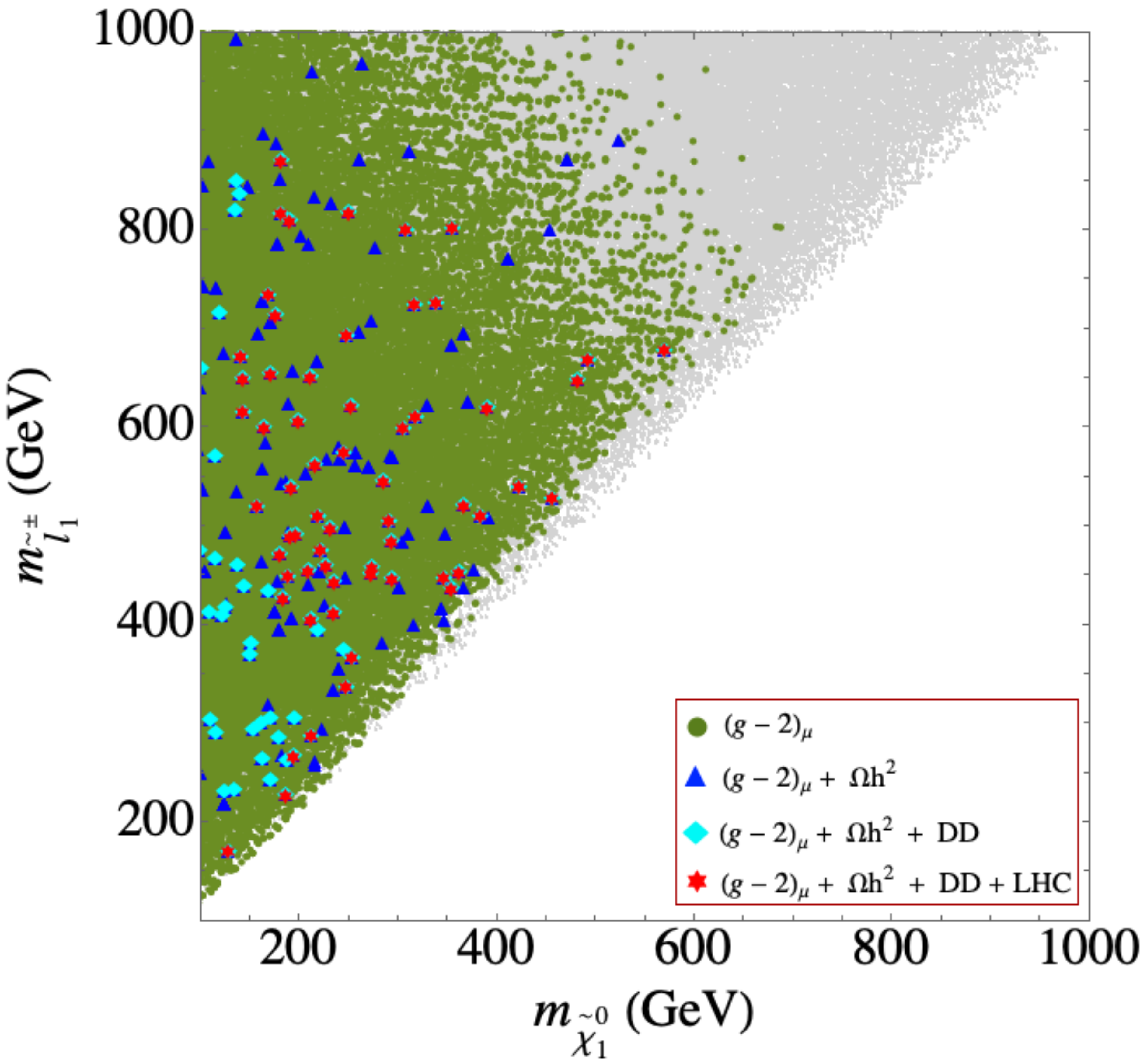
Anticipated future $(g-2)_\mu$ limit

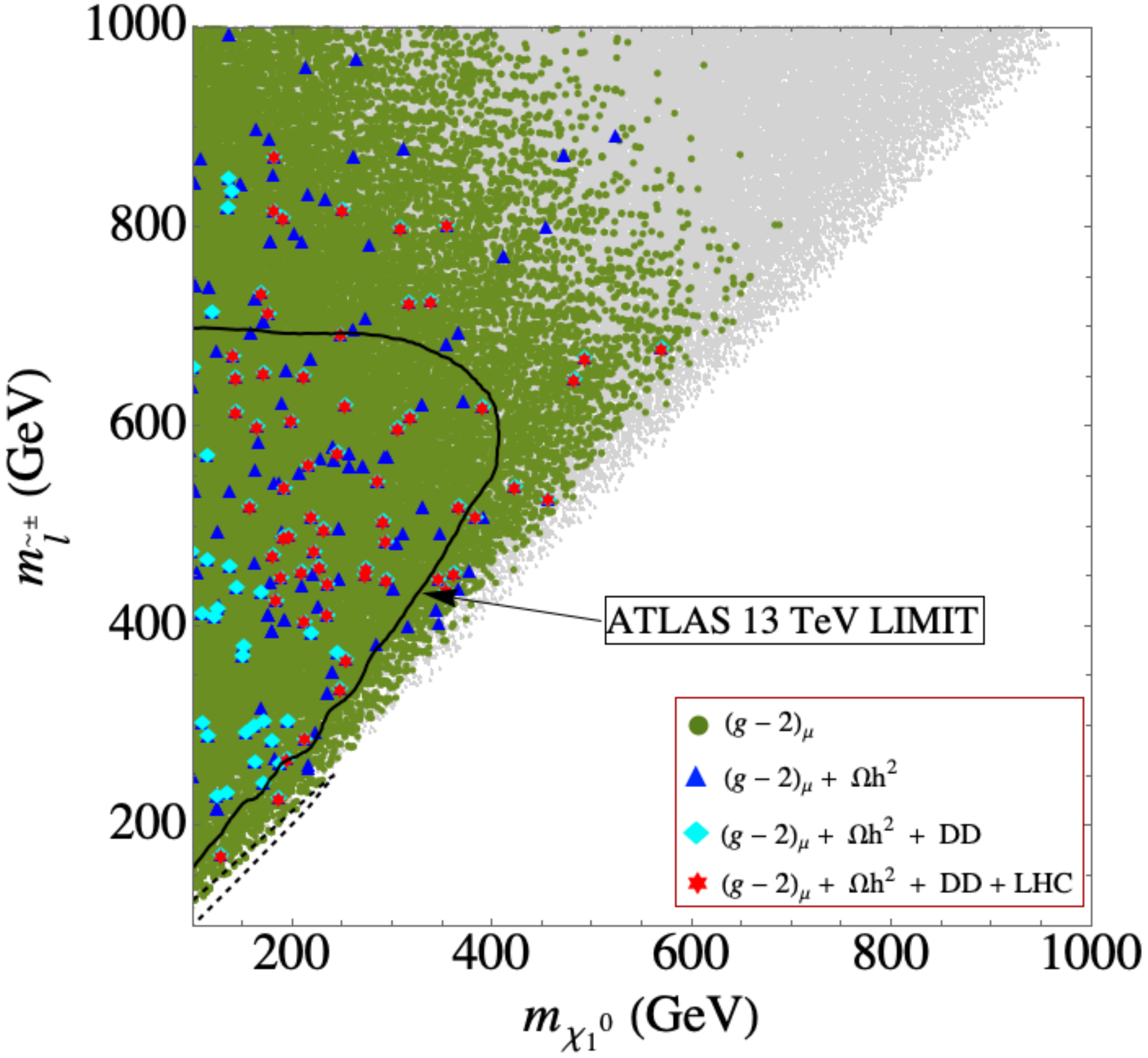


Upper and lower bounds from $(g-2)_\mu$ and LHC searches (for compressed spectrum)

Results in the $m_{\tilde{\chi}_1^0} - m_{\tilde{l}_1}$ plane

Current $(g-2)_\mu$ limit





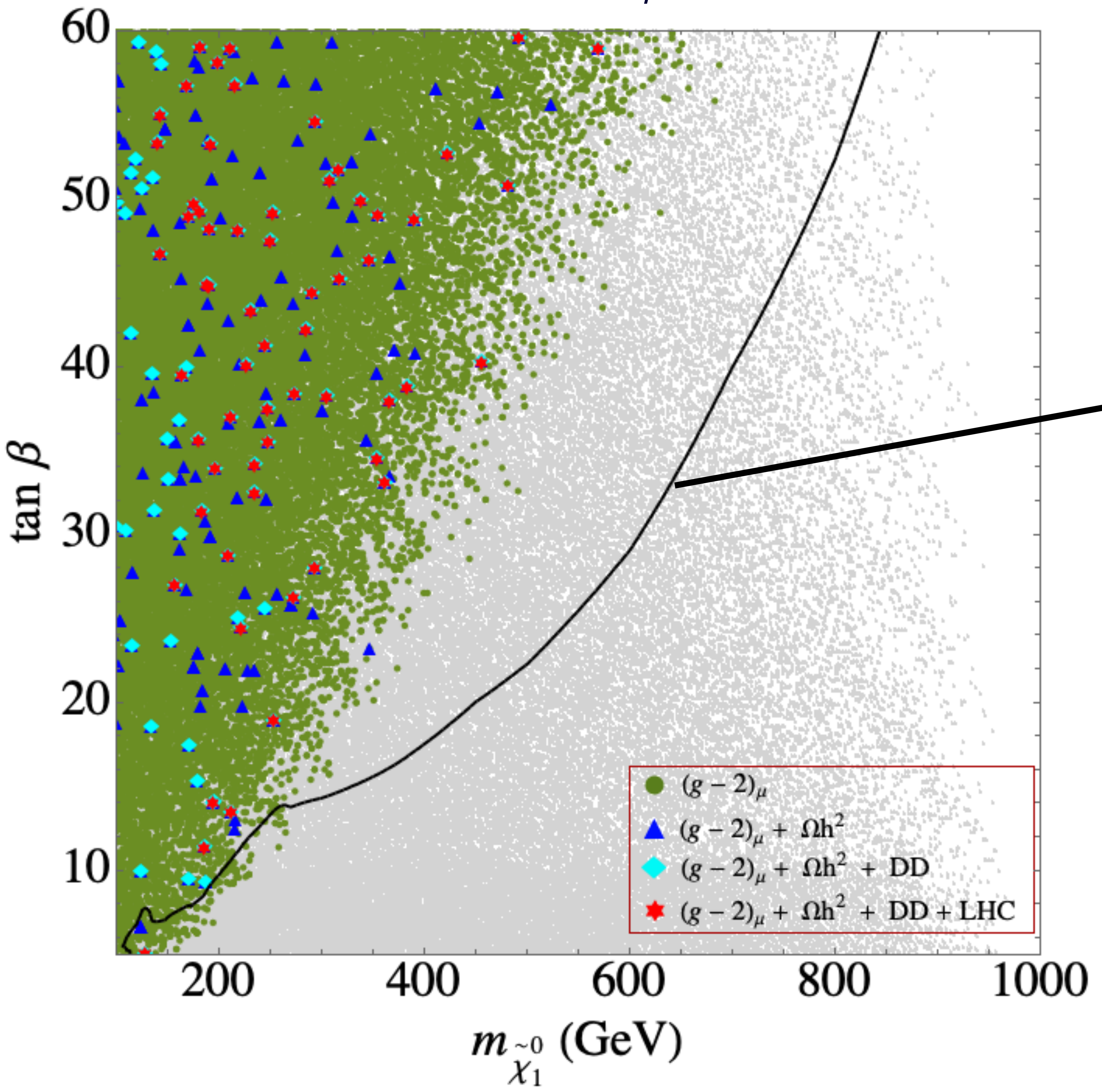
Slepton-pair production →(*2l* + missing E_T) provides important search channel ....

R-sleptons heavy, Considerable BR for $\tilde{e}_L(\tilde{\mu}_L) \to \tilde{\chi}_1^\pm \nu_e(\nu_\mu)$ ➡ Less no. of signal leptons.

Possibility of A-pole annihilation

Current $(g-2)_\mu$ limit

$$a_\mu \sim \frac{\tan\beta}{m_{EW}^2}$$



$$m_{\tilde{\chi}_1^0} = \frac{M_A}{2}$$

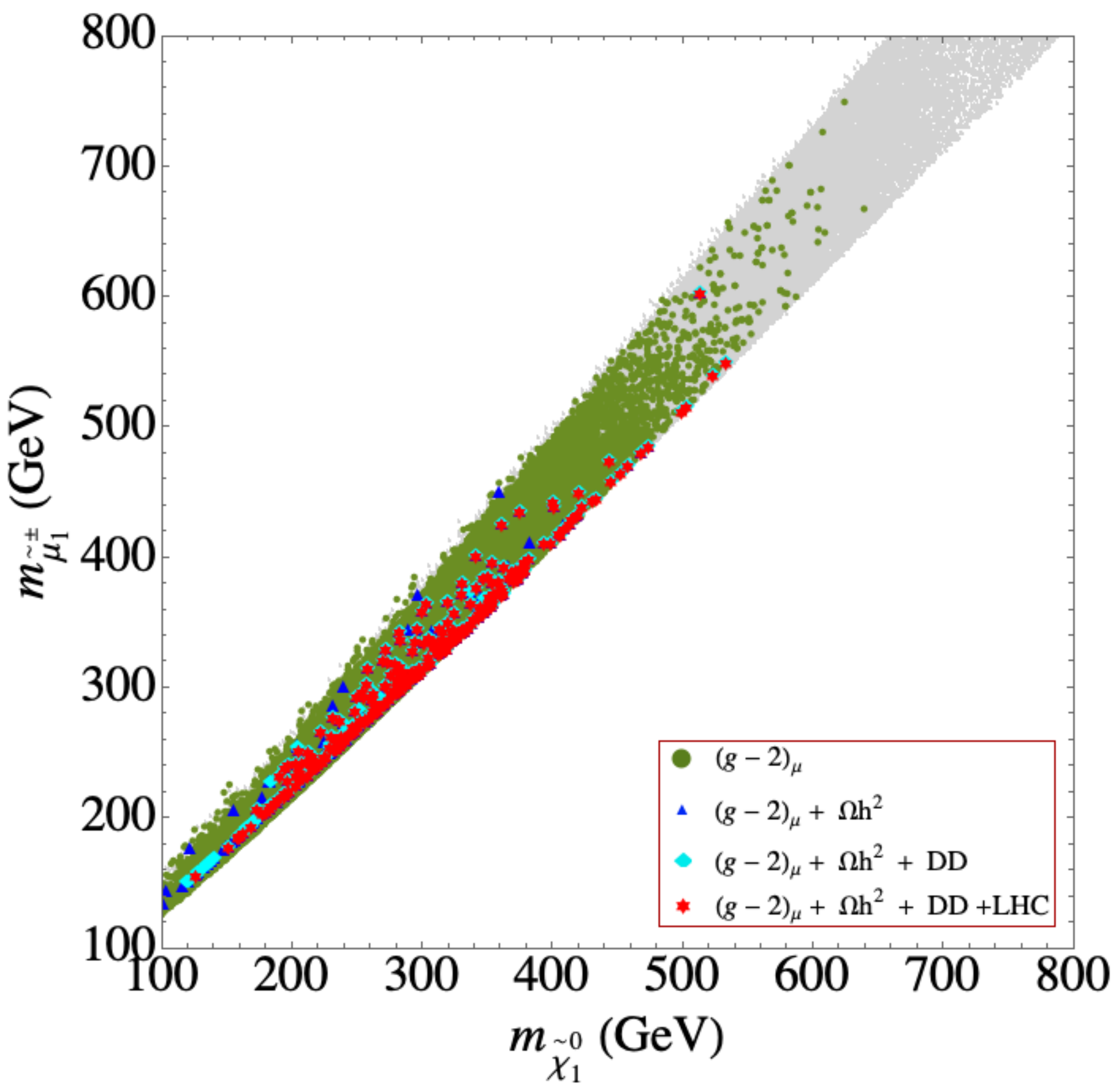
$M_h^{125}(\tilde{\chi})$ Benchmark scenario

Bagnaschi et al. '18

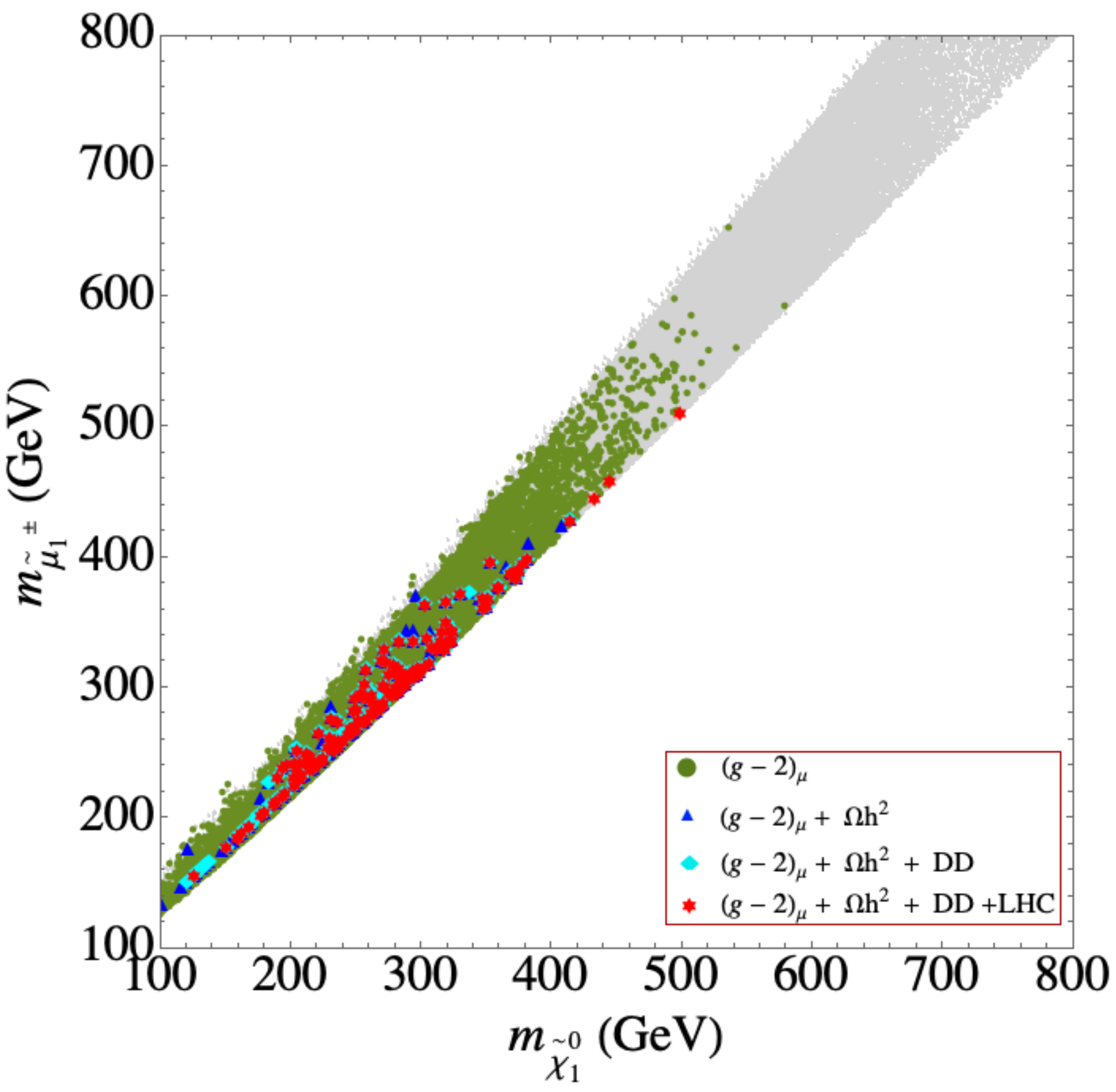
Black contour : simplified application of $H/A \to \tau^+\tau^-$ → A-pole annihilation strongly constrained

Slepton Co-annihilation: Case-L

Current $(g-2)_\mu$ limit



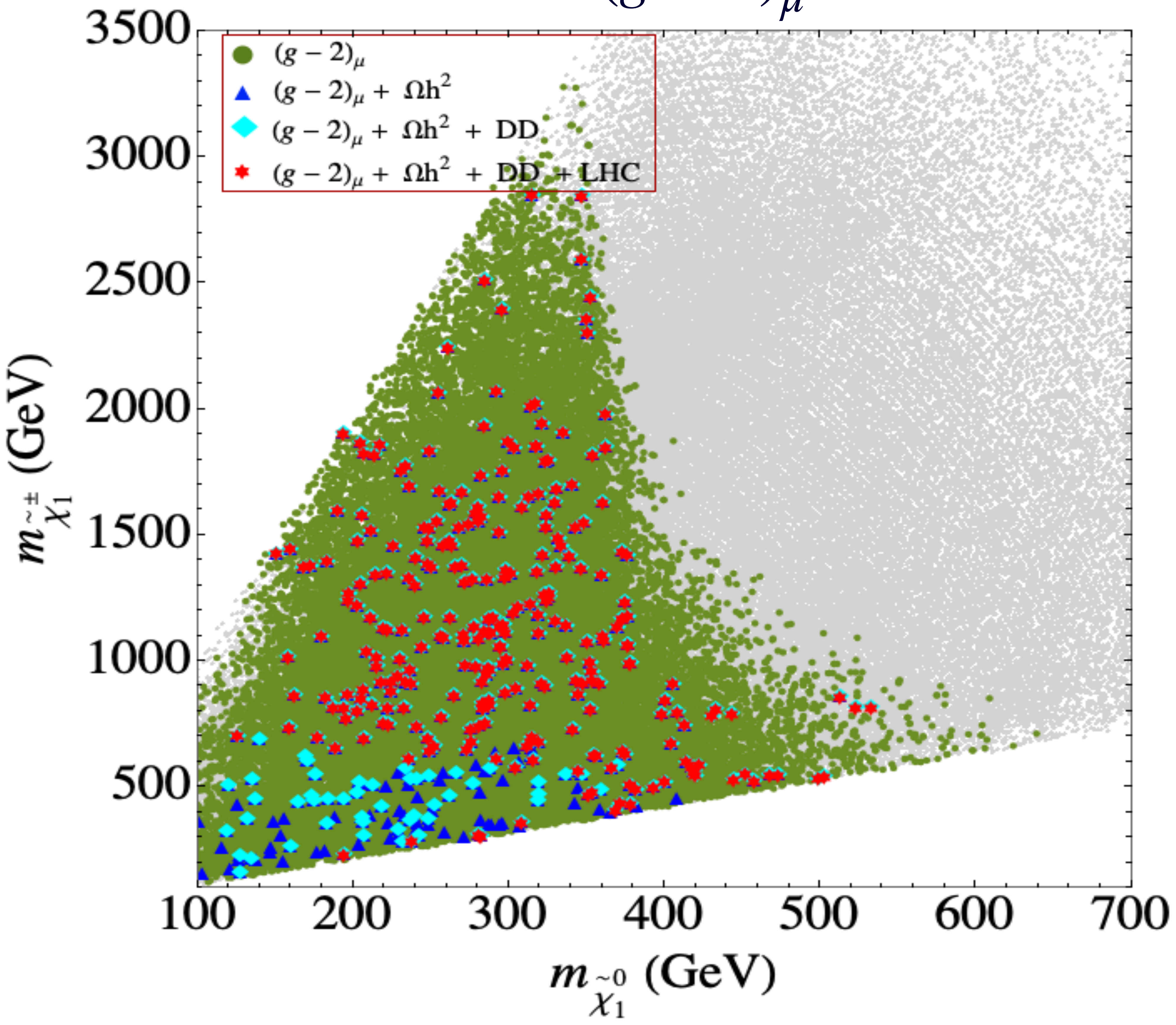
Anticipated future $(g-2)_\mu$ limit

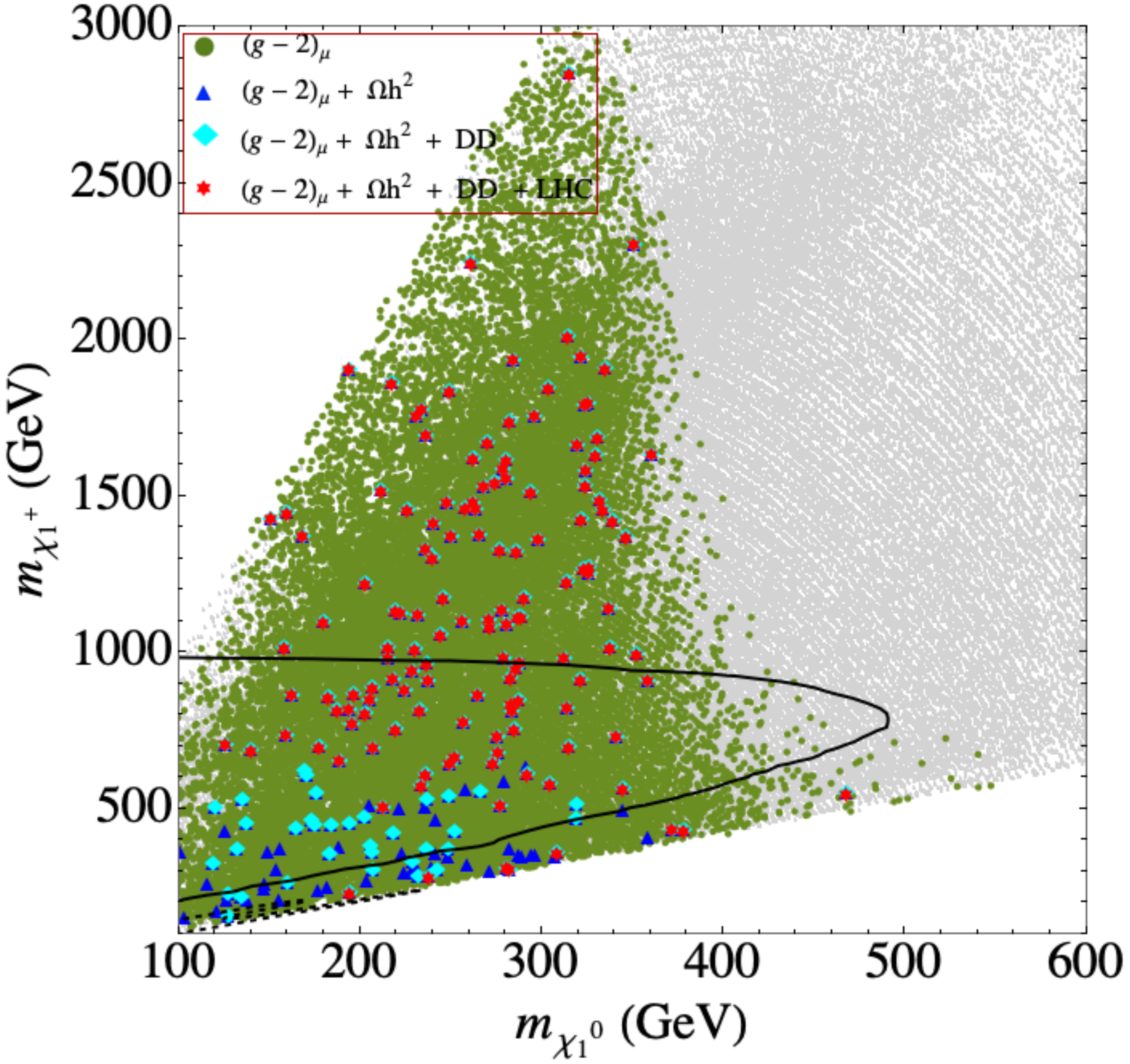


The left-sleptons and sneutrinos are close in mass to the LSP

Slepton Co-annihilation: Case-L

Current $(g-2)_\mu$ limit



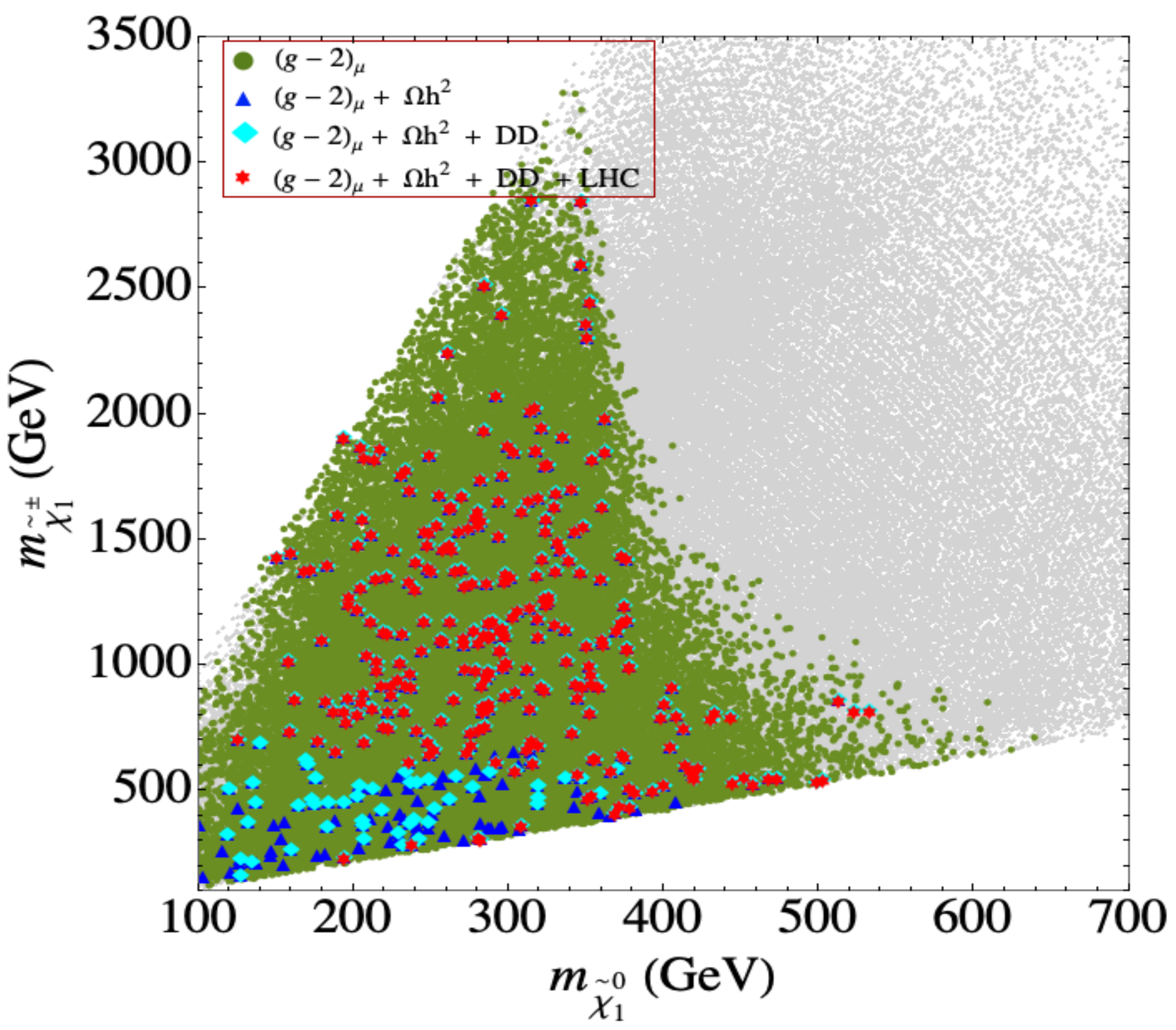


Large $\mathrm{BR}(\tilde{\chi}_1^\pm \to \tilde{\tau}_1 \nu_\tau)$ and $\mathrm{BR}(\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau)$, $\mathrm{BR}(\tilde{\chi}_2^0 \to \tilde{\nu}\nu)$

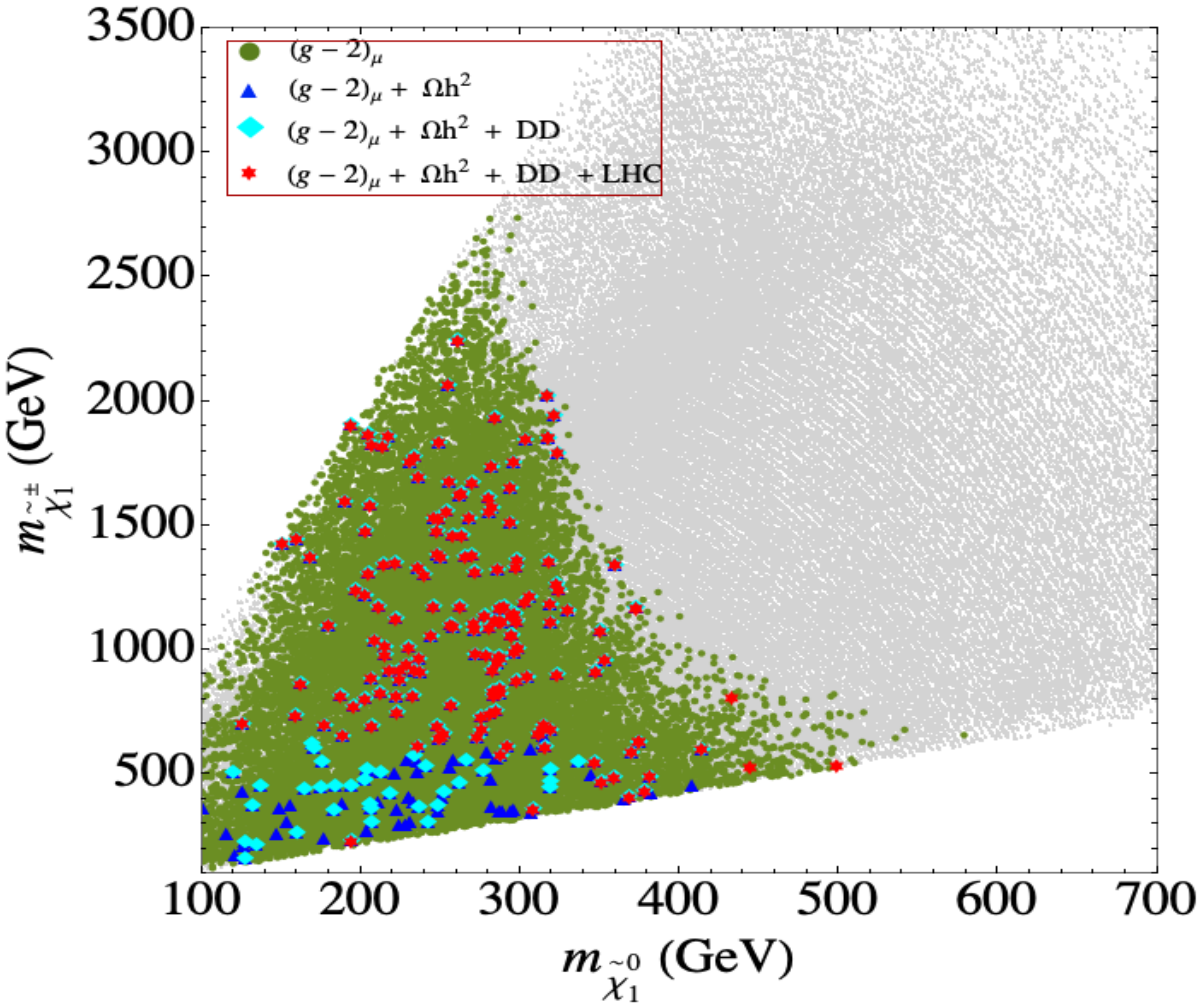
(*3l* + missing E_T) exclusion limit weakens ...

Slepton Co-annihilation: Case-L

Current $(g-2)_\mu$ limit



Anticipated future $(g-2)_\mu$ limit



DM with low abundance

$\Omega_{CDM}h^2 \leq 0.122$

2103.XXXXX , WITH SVEN HEINEMEYER AND IPSITA SAHA

DM with Low abundance

$$\Omega_{CDM}h^2 \leq 0.122$$

Wino LSP

$$100 \text{ GeV} \leq M_2 \leq 1.5 \text{ TeV}, \quad 1.1M_2 \leq M_1 \leq 10M_2,$$
$$1.1M_2 \leq \mu \leq 10M_2, \quad 5 \leq \tan\beta \leq 60,$$
$$100 \text{ GeV} \leq m_{\tilde{l}_L}, m_{\tilde{l}_R} \leq 2 \text{ TeV}.$$

Wino $SU(2)_L$ triplet

Under-abundant upto ~ 3 TeV

Compressed spectra with $m_{\tilde{\chi}_1^0} \sim m_{\tilde{\chi}_1^\pm}$

Higgsino LSP

$$100 \text{ GeV} \leq \mu \leq 1.2 \text{ TeV}, \quad 1.1\mu \leq M_1 \leq 10\mu,$$
$$1.1\mu \leq M_2 \leq 10\mu, \quad 5 \leq \tan\beta \leq 60,$$
$$100 \text{ GeV} \leq m_{\tilde{l}_L}, m_{\tilde{l}_R} \leq 2 \text{ TeV}.$$

Higgsino $SU(2)_L$ doublet

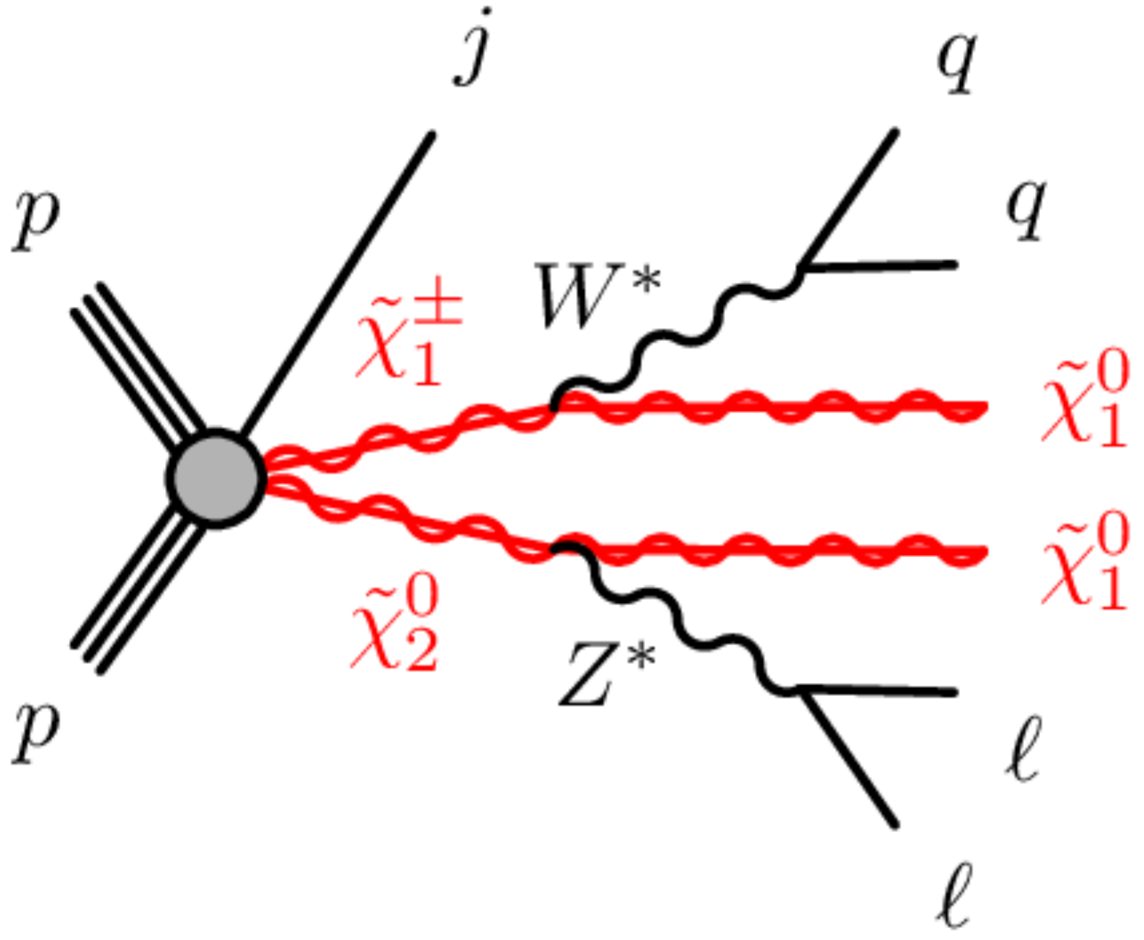
Under-abundant upto ~ 1 TeV

Compressed spectra with $m_{\tilde{\chi}_1^0} \sim m_{\tilde{\chi}_1^\pm} \sim m_{\tilde{\chi}_2^0}$

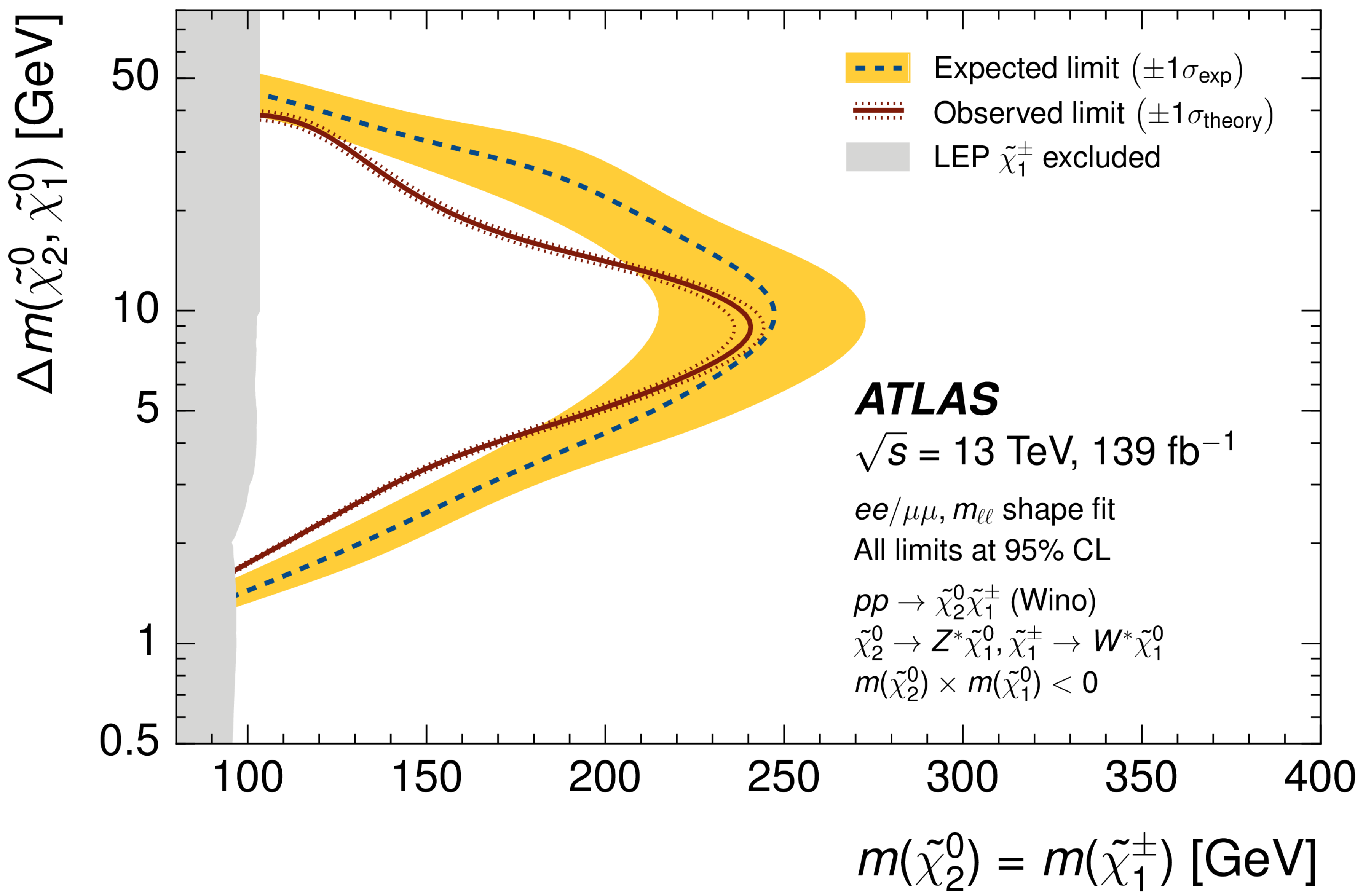
LHC searches

- Compressed spectra searches

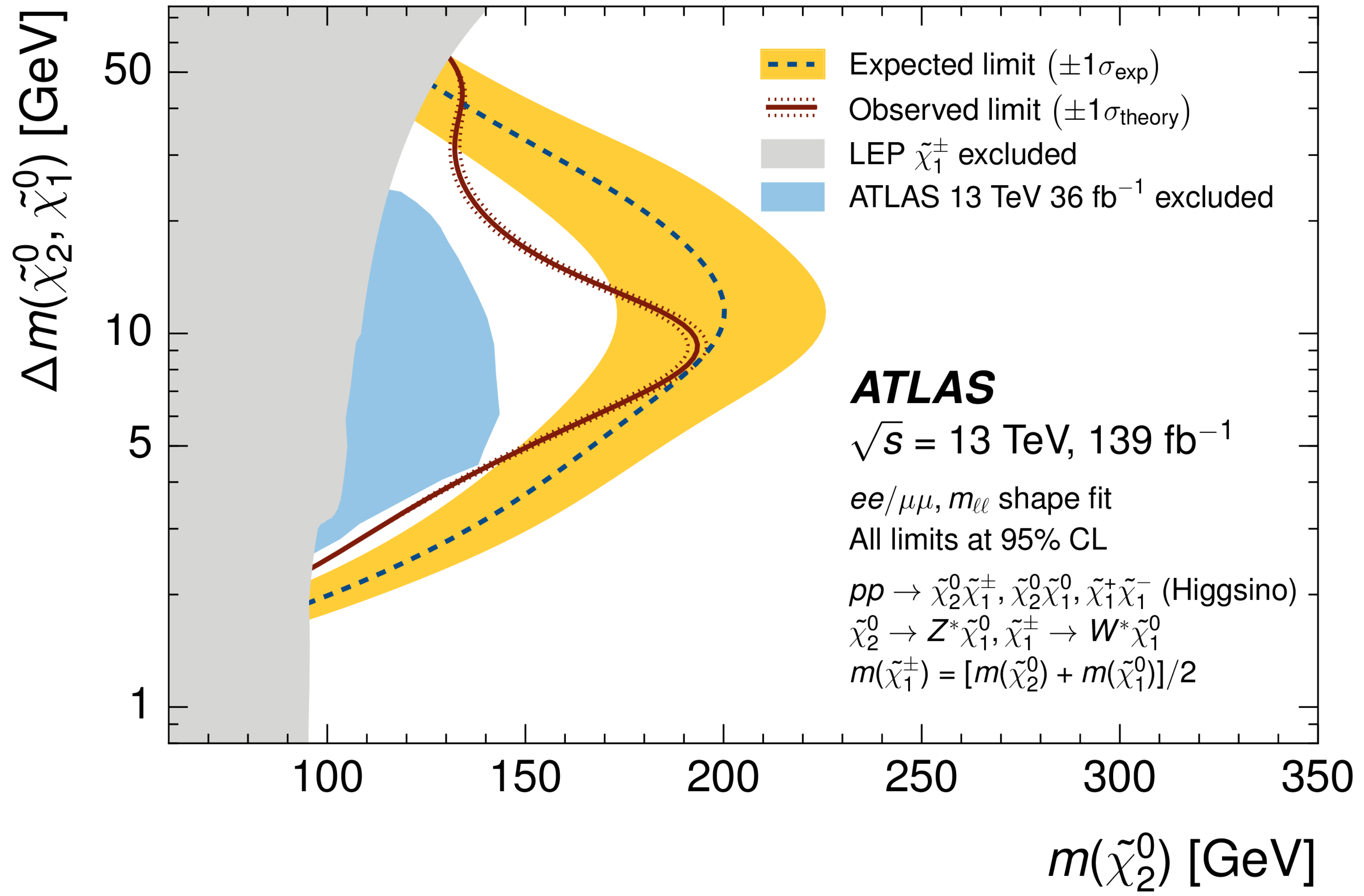
Soft leptons : ISR jet required to give boost



Wino



Higgsino



ATLAS 1911.12606

LHC searches

- Disappearing track searches

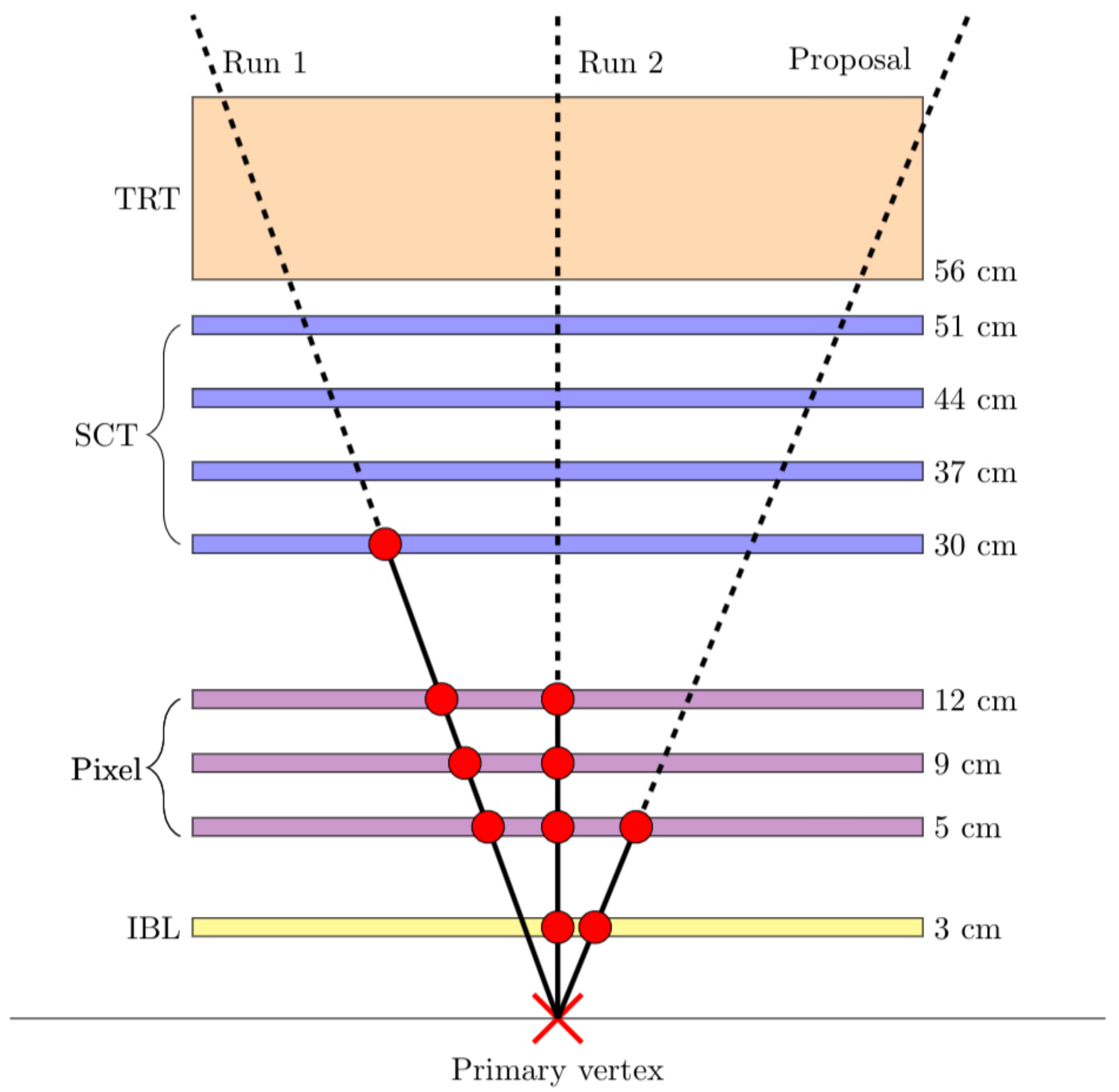


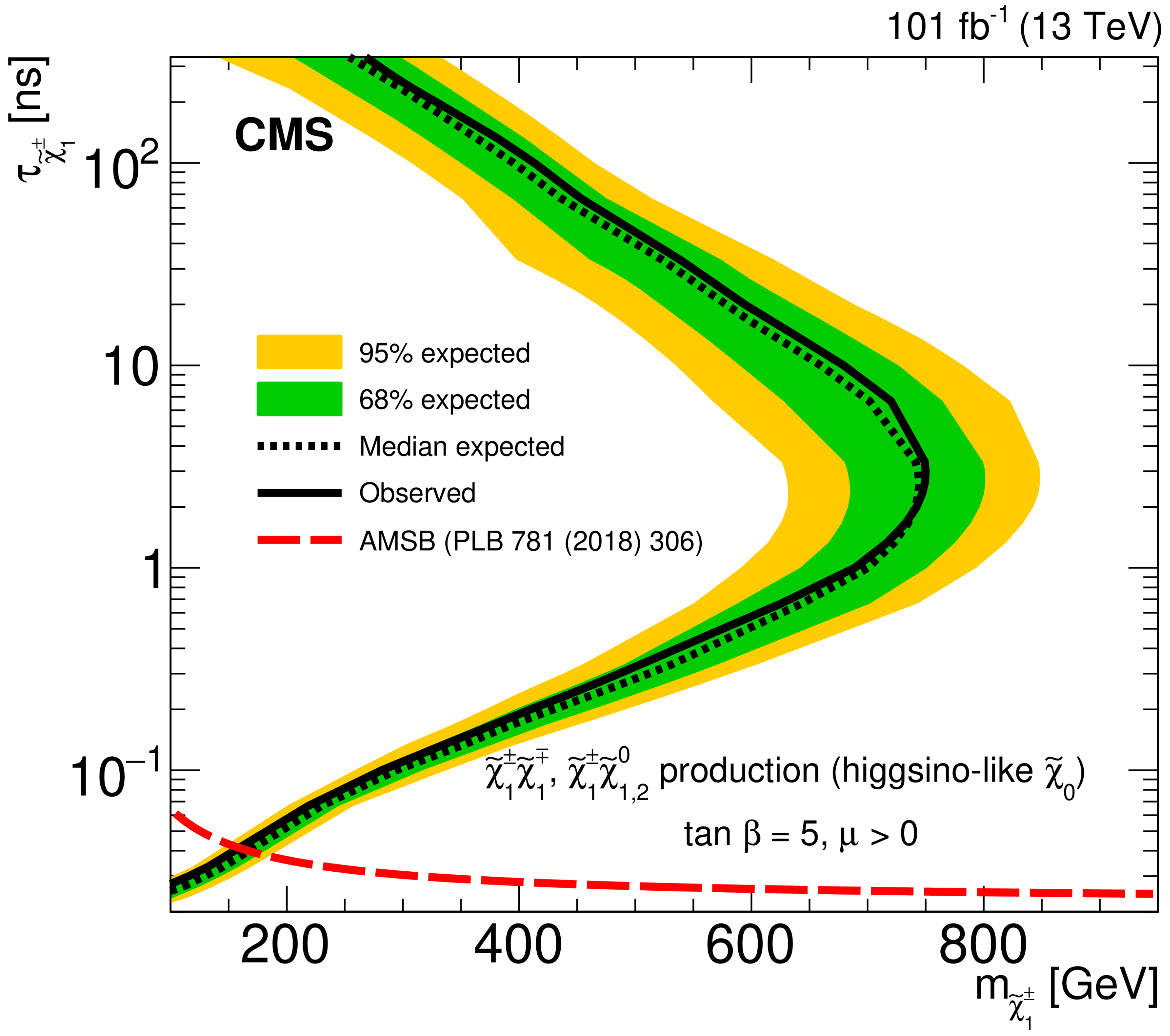
FIG. 1: Required number of hits in the ATLAS inner tracker for the analyses of Run-1&2 and ours.

$\Delta m \sim 100$ MeV

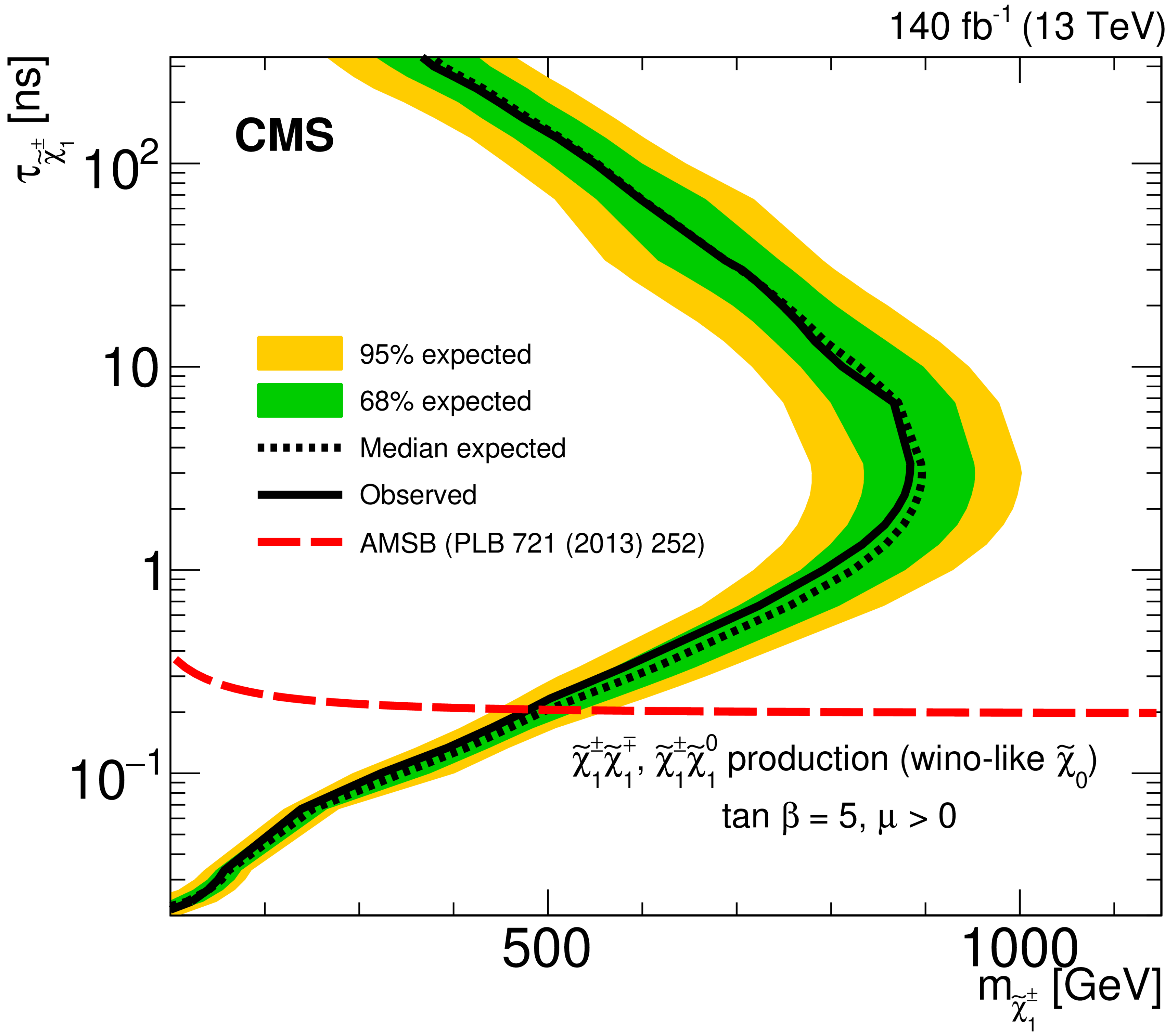
$\tilde{\chi}_1^\pm \to \pi^\pm \tilde{\chi}_1^0$

Finite lifetime, decay within detector

Higgsino



Wino

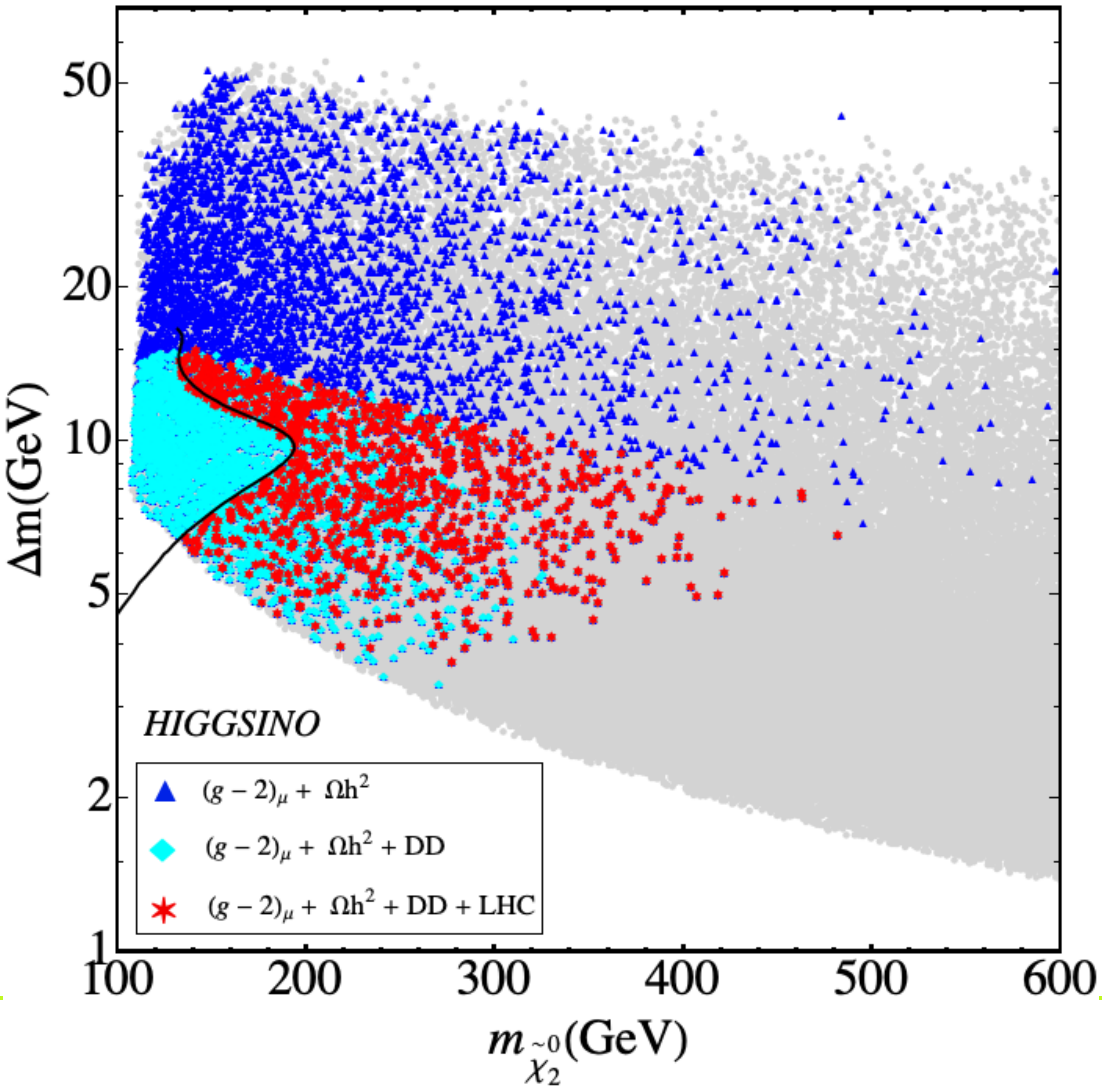


Fukuda, Nagata, Otono, Shirai '17

CMS-EXO-19-010

Higgsino LSP

Current $(g-2)_\mu$ limit

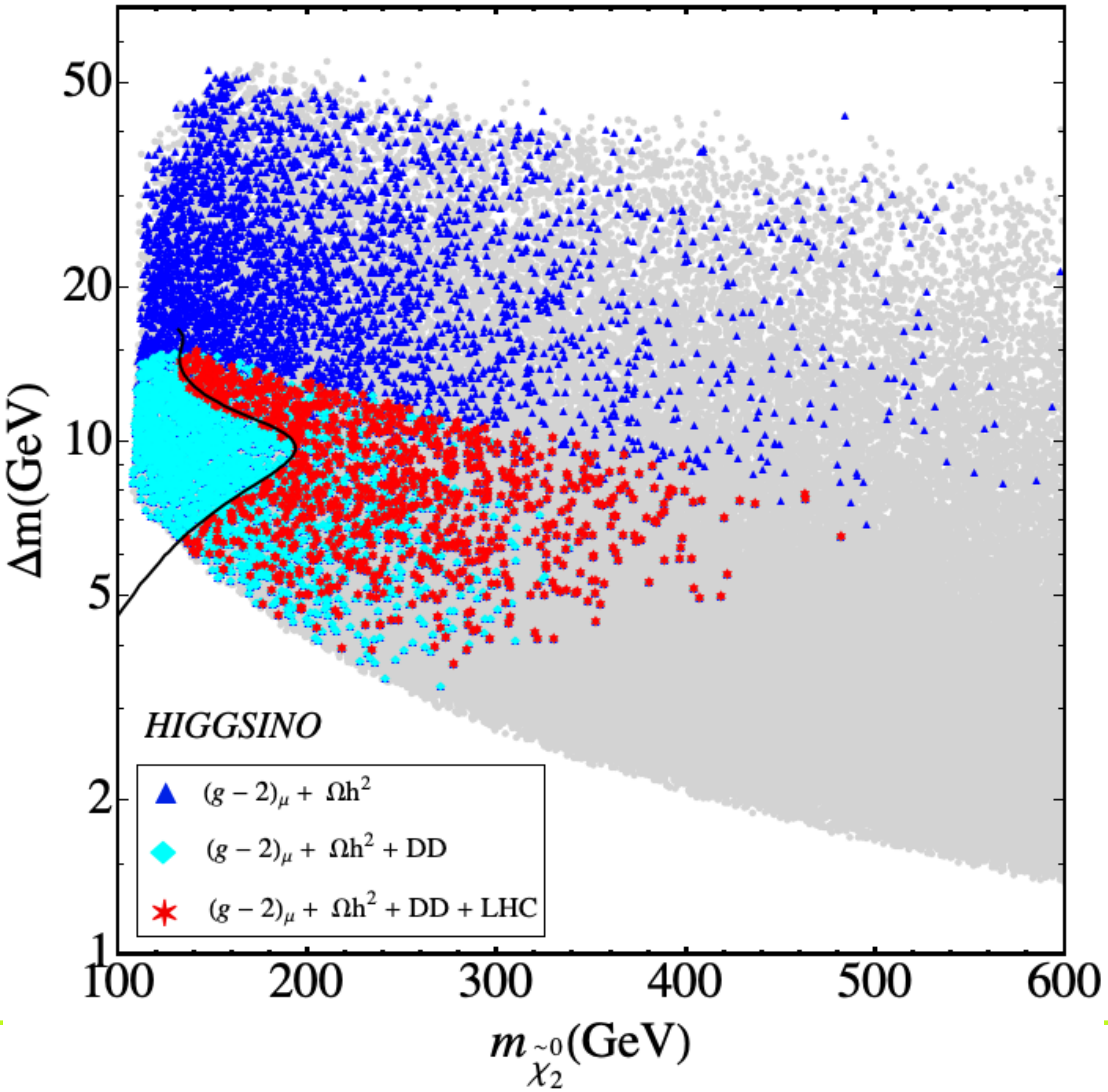


- Compressed spectra searches most important.
- Slepton pair production searches also relevant
- $\Delta m \sim \mathcal{O}(10)$ GeV → Disappearing track searches not sensitive

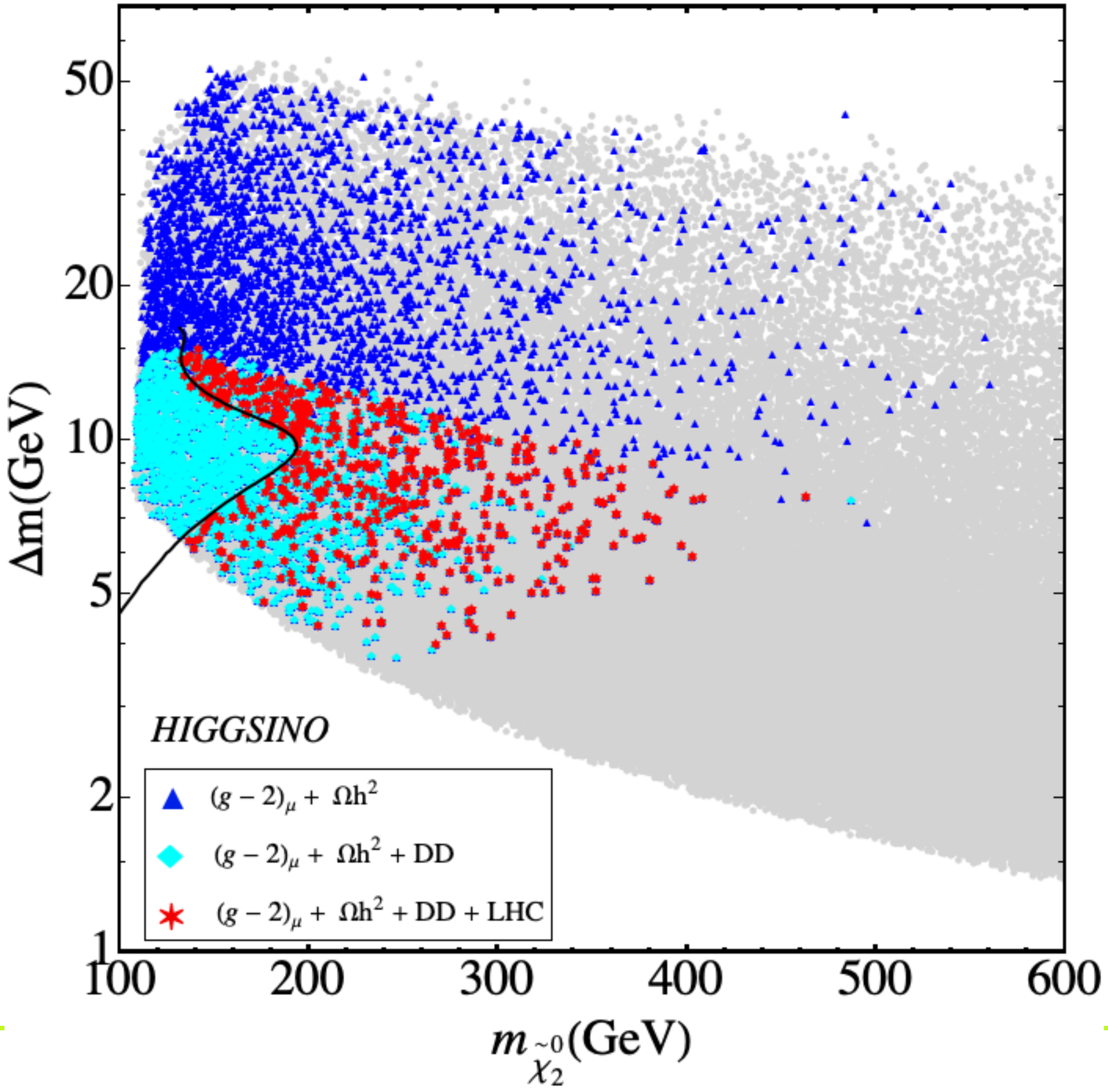
$$c\tau \simeq 0.7\ \text{cm} \times \left[\left(\frac{\Delta m_+}{340\,\text{MeV}}\right)^3 \sqrt{1 - \frac{m_\pi^2}{\Delta m_+^2}}\right]^{-1}$$

Higgsino LSP

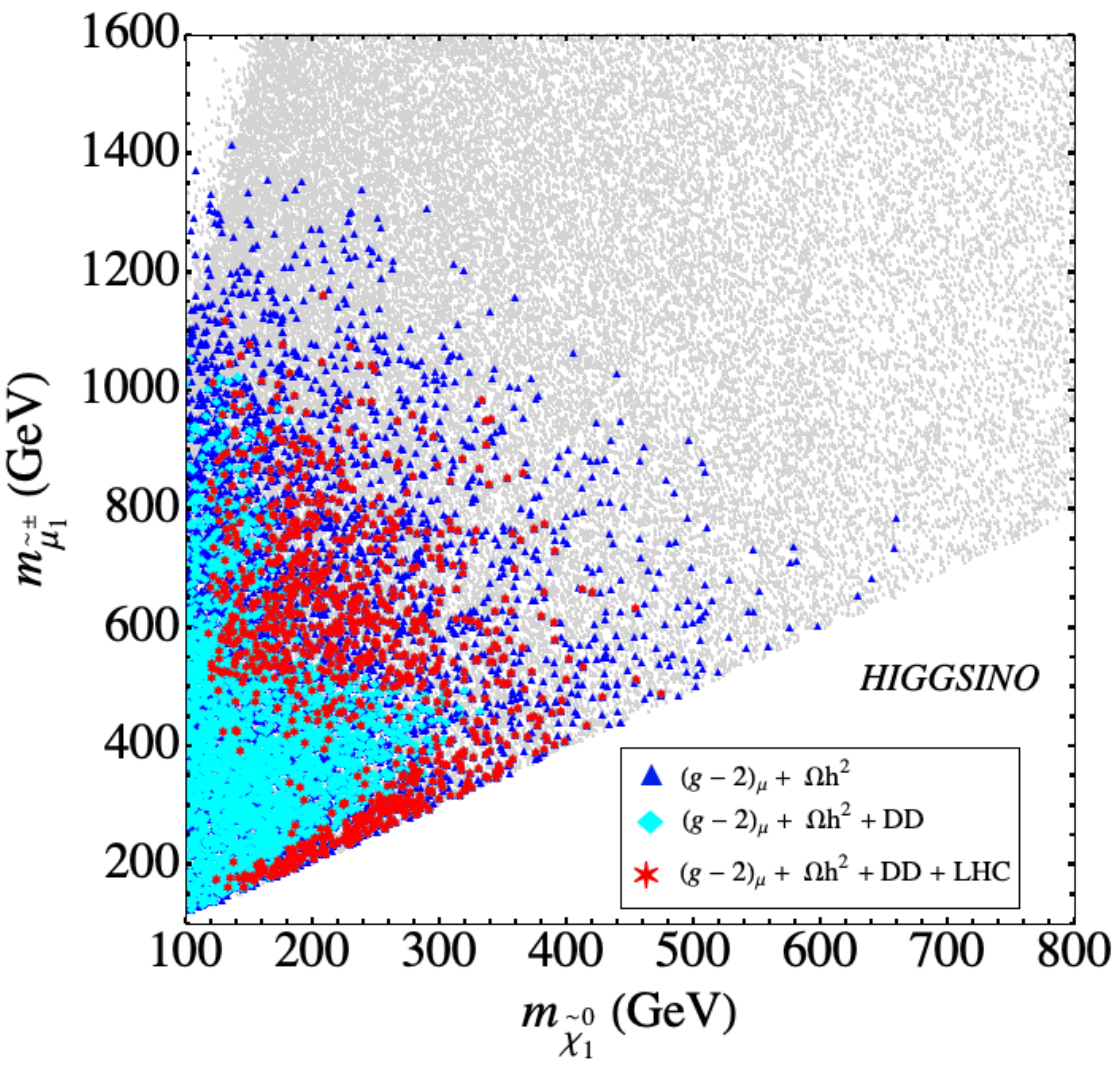
Current $(g-2)_\mu$ limit



Future $(g-2)_\mu$ limit

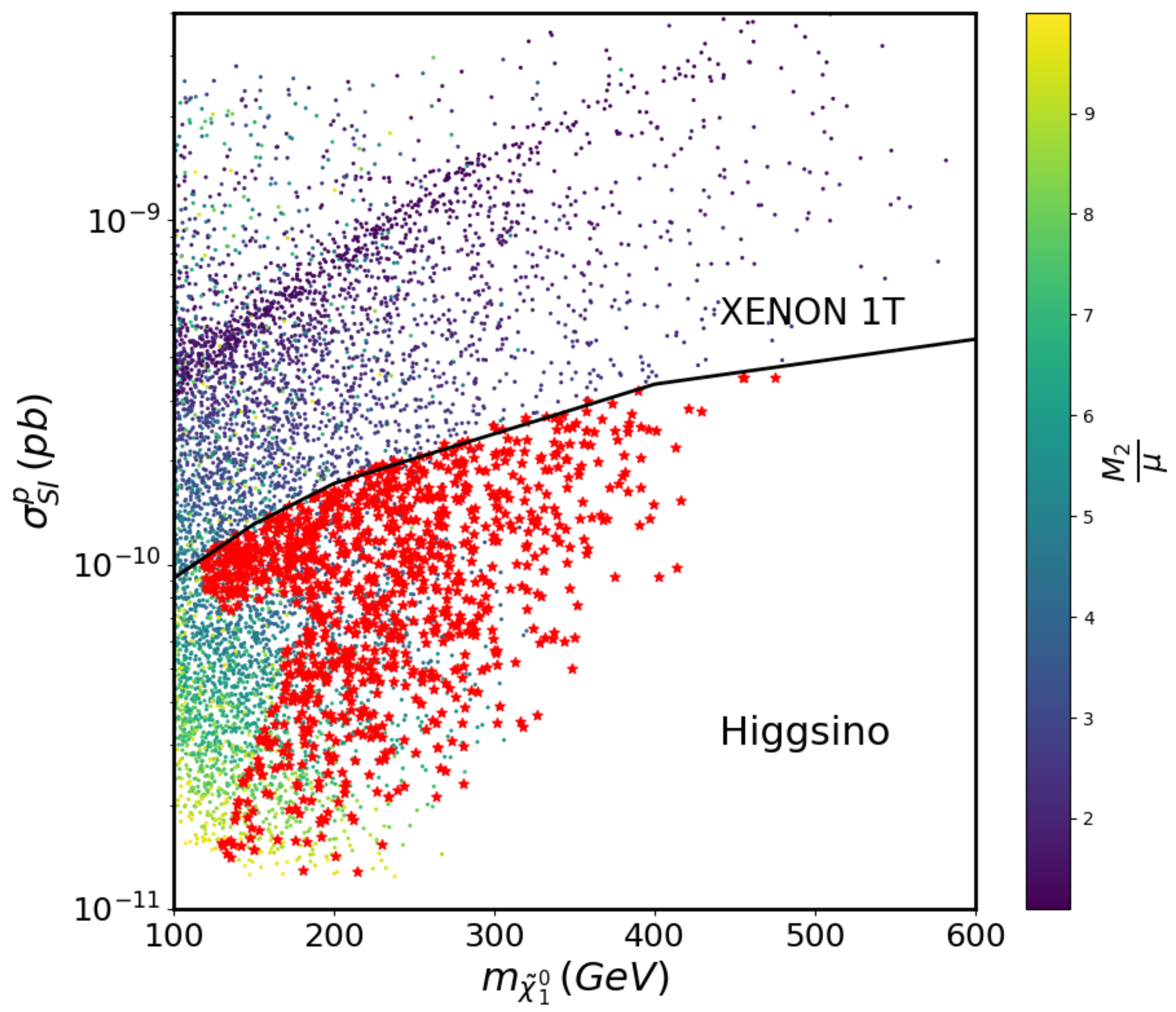


Results in the $m_{\tilde{\chi}_1^0} - m_{\tilde{l}_1}$ plane



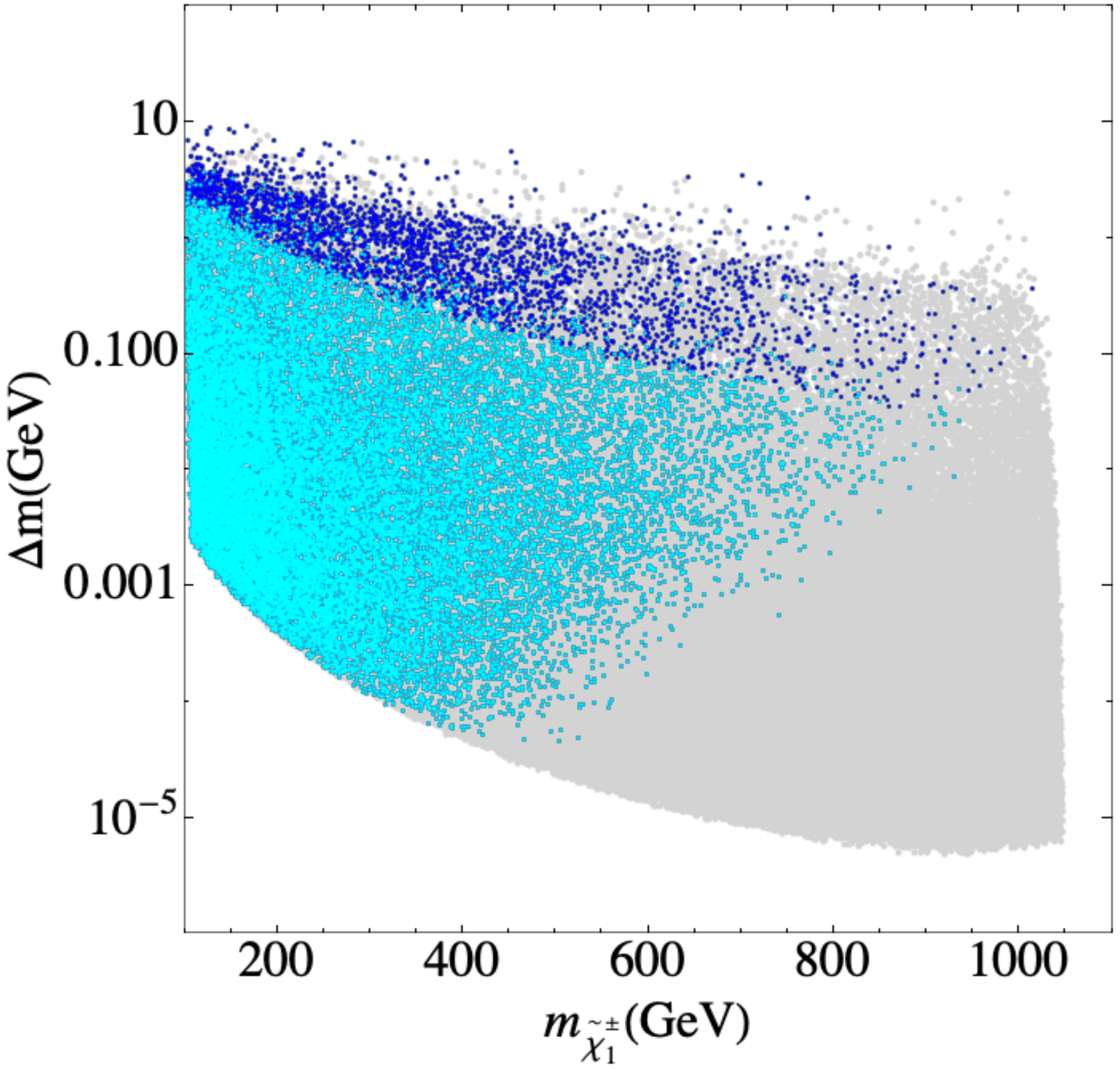
- Slepton pair production searches important
- $(g-2)_\mu$ Dominated by $\tilde{\chi}_1^\pm - \tilde{\nu}$ loop
- Higher slepton masses conflict with DM DD
- Substantial $\tilde{e}_L(\tilde{\mu}_L) \to \tilde{\chi}_1^\pm \nu_e(\nu_\mu)$
- 2 lepton + missing E_T bound weakens

Higgsino LSP direct detection



$$c_{h\tilde{\chi}_1^0\tilde{\chi}_1^0} \simeq -\frac{1}{2}(1+\sin 2\beta)\left(\tan^2\theta_{\rm w}\frac{M_W}{M_1-\mu}+\frac{M_W}{M_2-\mu}\right)$$

Wino LSP



Tree level

- Highly degenerate $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^{0}$
- Tree level splitting from $\tilde{h}$ mixing

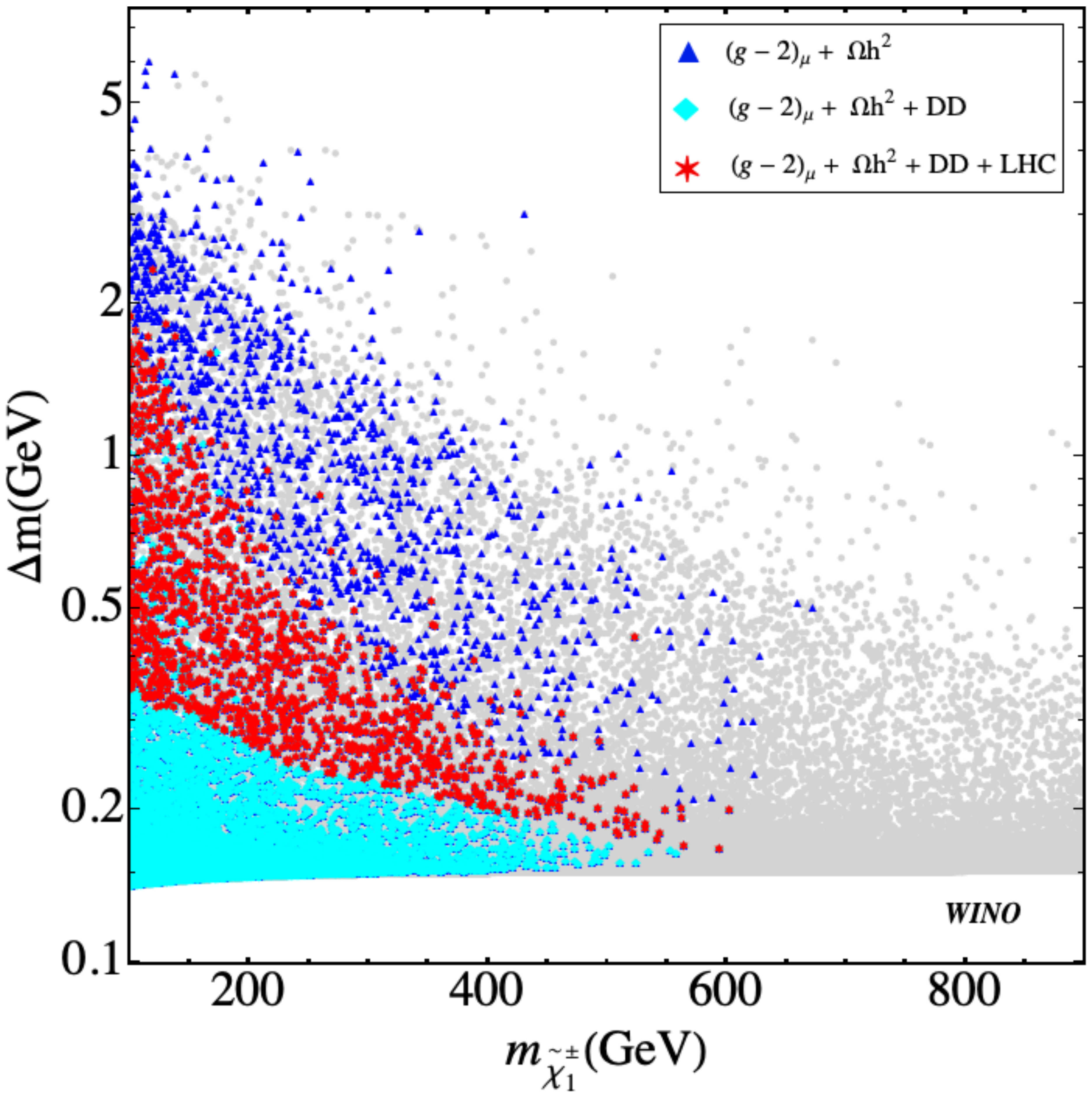
$$\simeq \frac{M_W^4 (\sin 2\beta)^2 \tan^2 \theta_w}{(M_1 - M_2)\mu^2}$$

- EW 1 loop correction $\Delta m \sim 170$ MeV

Ibe, Matsumoto, Sato '13

Wino LSP

Current $(g-2)_\mu$ limit



High Δm restricted by DD

Low Δm restricted by LHC

- Tree level splitting from $\tilde{h}$ mixing

$$\simeq \frac{M_W^4 (\sin 2\beta)^2 \tan^2\theta_{\mathrm{w}}}{(M_1 - M_2)\mu^2}$$

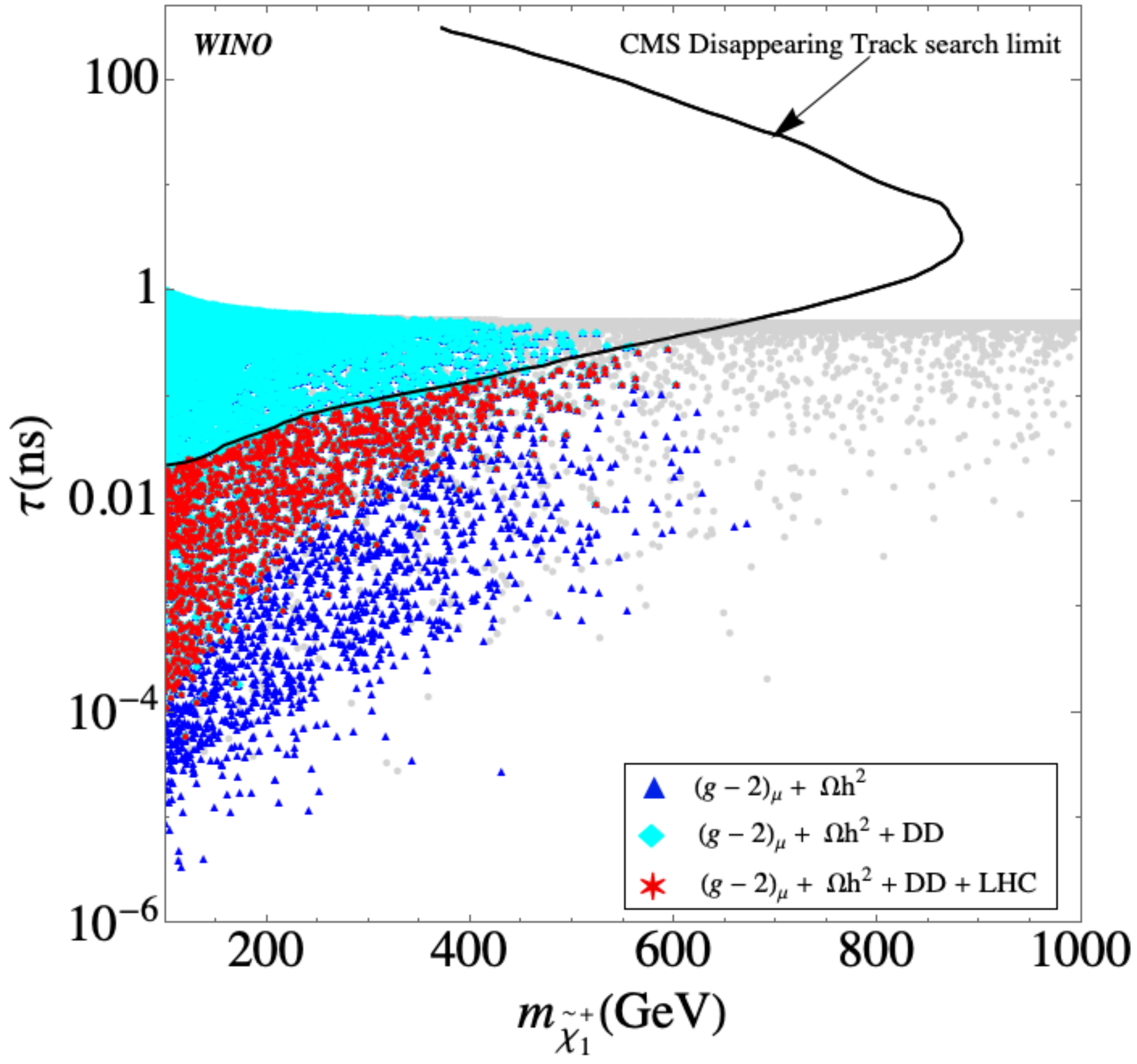
- Coupling for DD

$$c_{h\tilde{\chi}_1^0\tilde{\chi}_1^0} \simeq \frac{M_W}{M_2^2 - \mu^2}(M_2 + \mu \sin 2\beta),$$

Ibe, Matsumoto, Sato ‘13

Wino LSP lifetime

Current $(g-2)_\mu$ limit



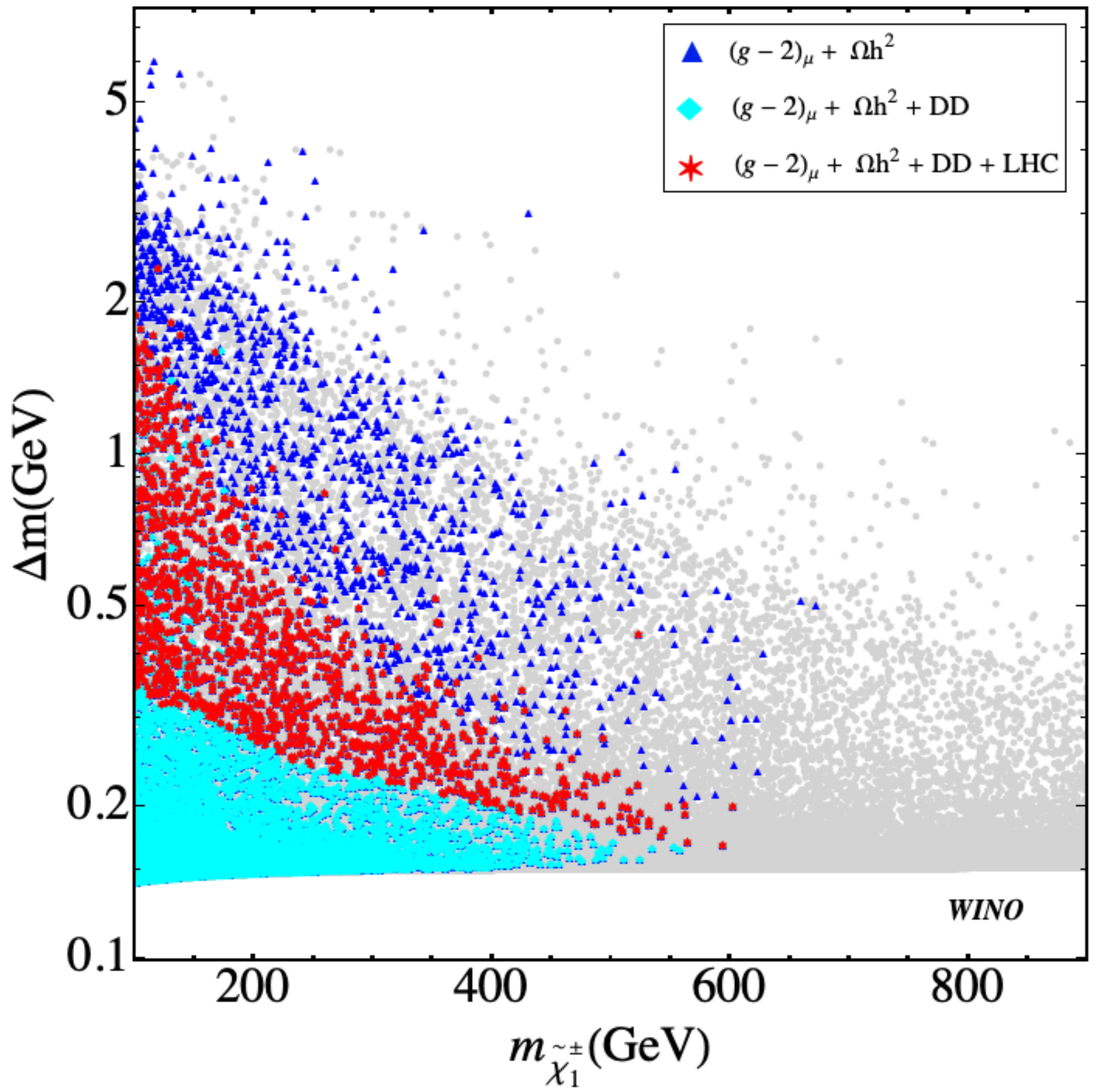
$$\Gamma(\tilde{\chi}^\pm \to \tilde{\chi}^0 \pi^\pm) = \Gamma(\pi^\pm \to \mu^\pm \nu_\mu) \times \frac{16\delta m^3}{m_\pi m_\mu^2}\left(1 - \frac{m_\pi^2}{\delta m^2}\right)^{1/2}\left(1 - \frac{m_\mu^2}{m_\pi^2}\right)^{-2}$$

$$\Gamma(\tilde{\chi}^\pm \to \tilde{\chi}^0 e^\pm \nu_e) \simeq \frac{2G_F^2}{15\pi^3}\delta m^5.$$

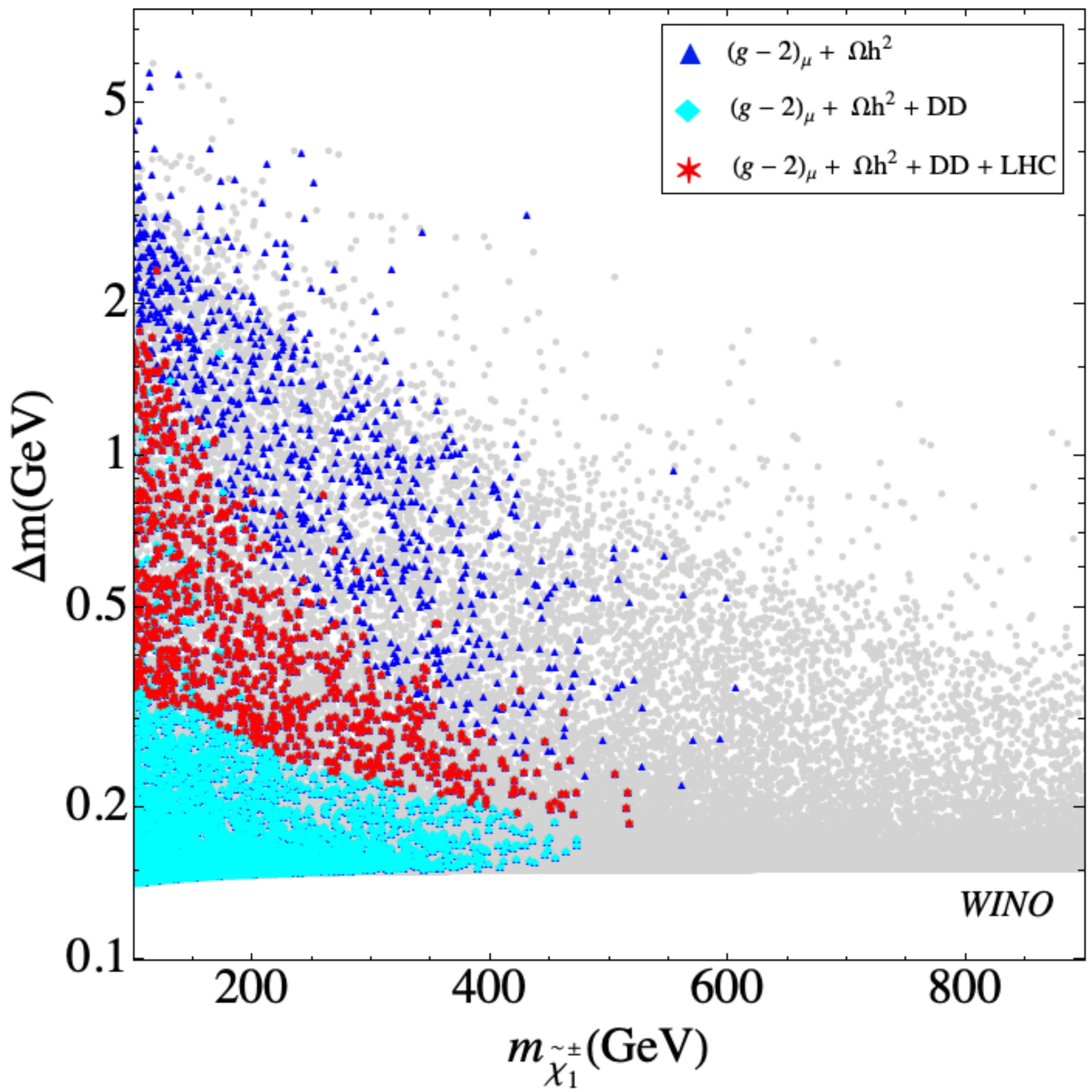
- Disappearing track searches most important.

Wino LSP

Current $(g-2)_\mu$ limit

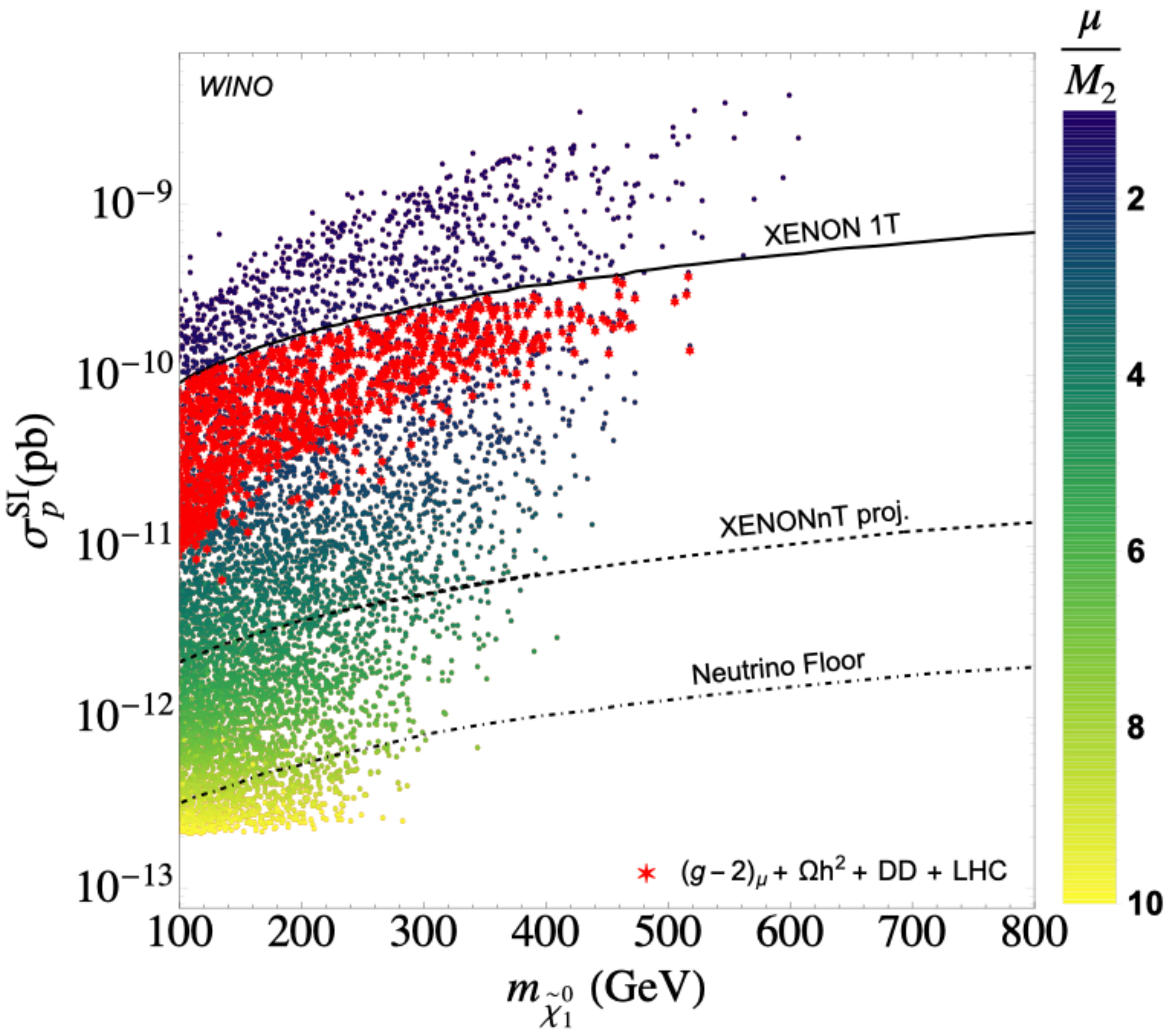


Future $(g-2)_\mu$ limit



Wino LSP : Direct detection

Current $(g-2)_\mu$ limit



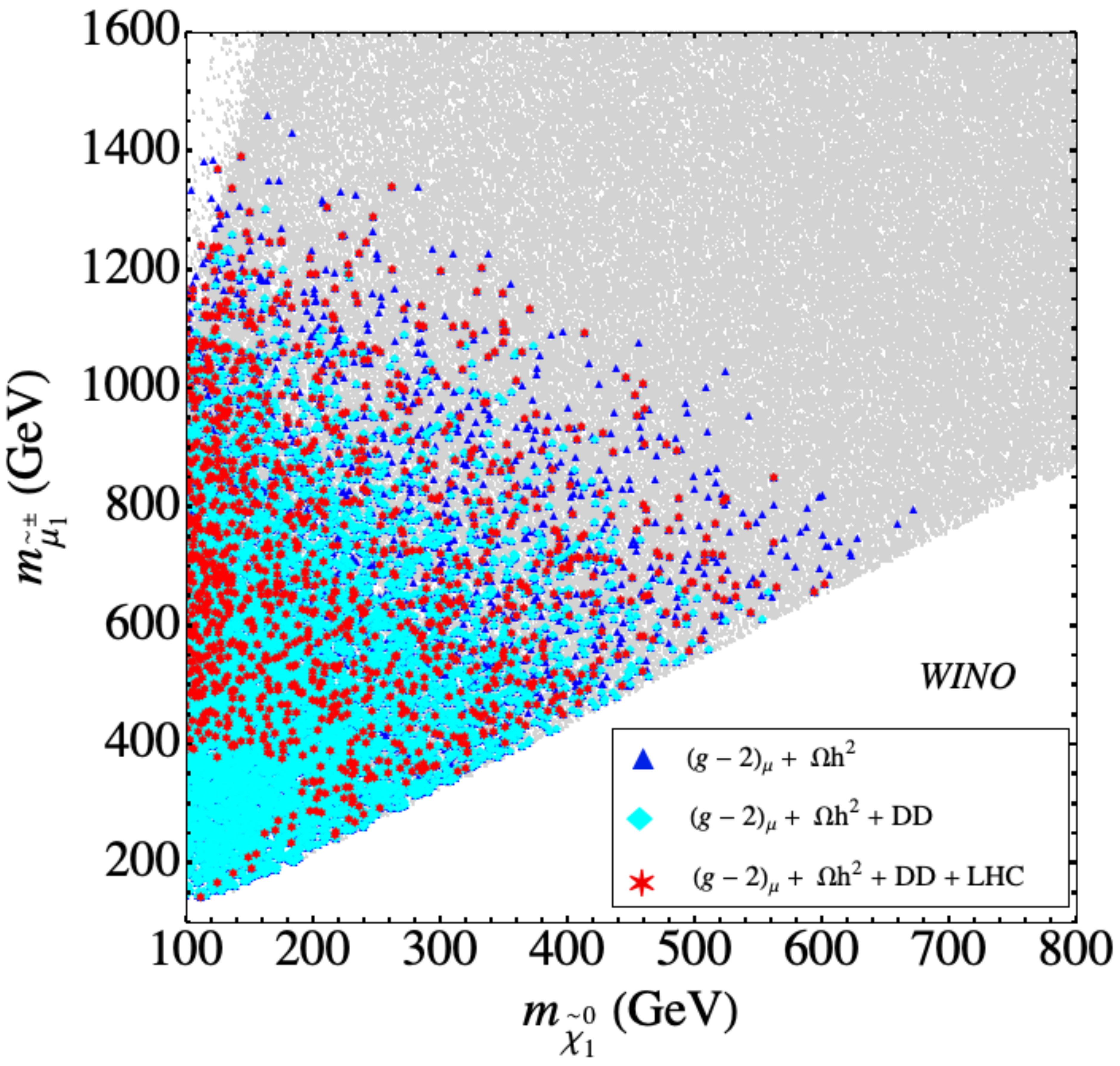
- DD coupling

$$\boxed{c_{h\tilde{\chi}_1^0\tilde{\chi}_1^0} \simeq \frac{M_W}{M_2^2-\mu^2}(M_2+\mu\sin 2\beta),}$$

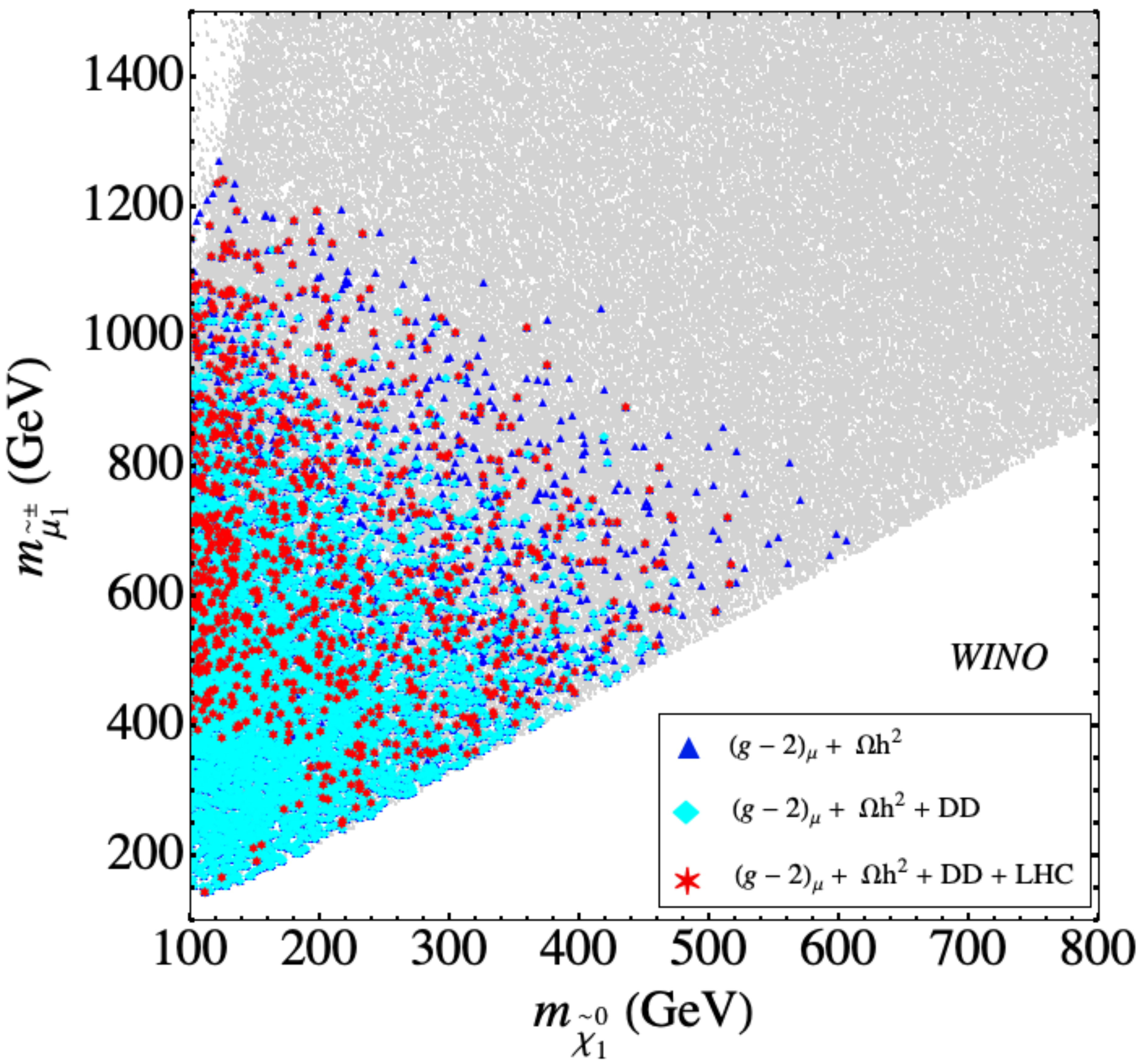
- All allowed points to be checked by XENONnT

Results in the $m_{\tilde{\chi}_1^0} - m_{\tilde{l}_1}$ plane

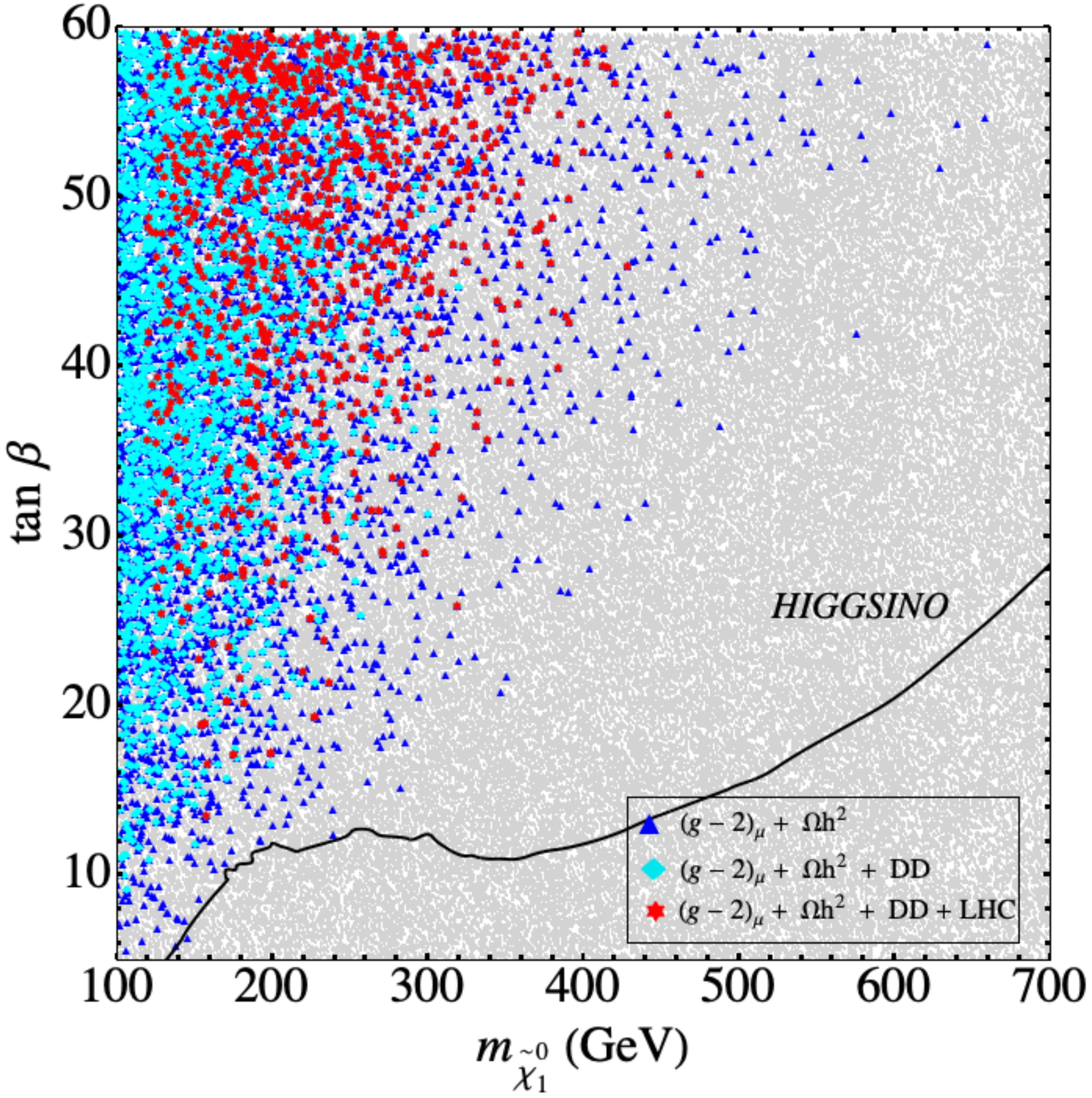
Current $(g-2)_\mu$ limit

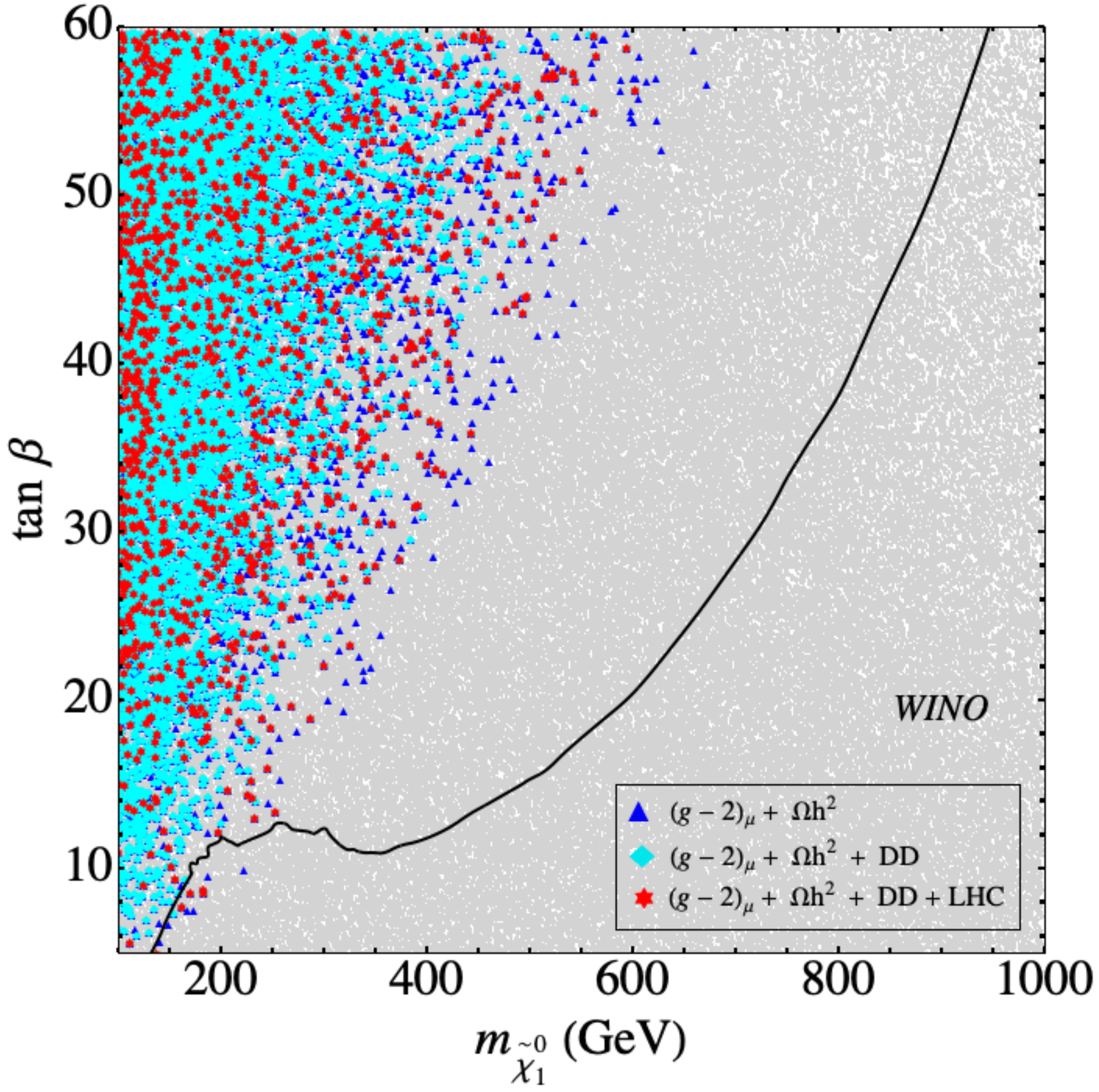


Future $(g-2)_\mu$ limit



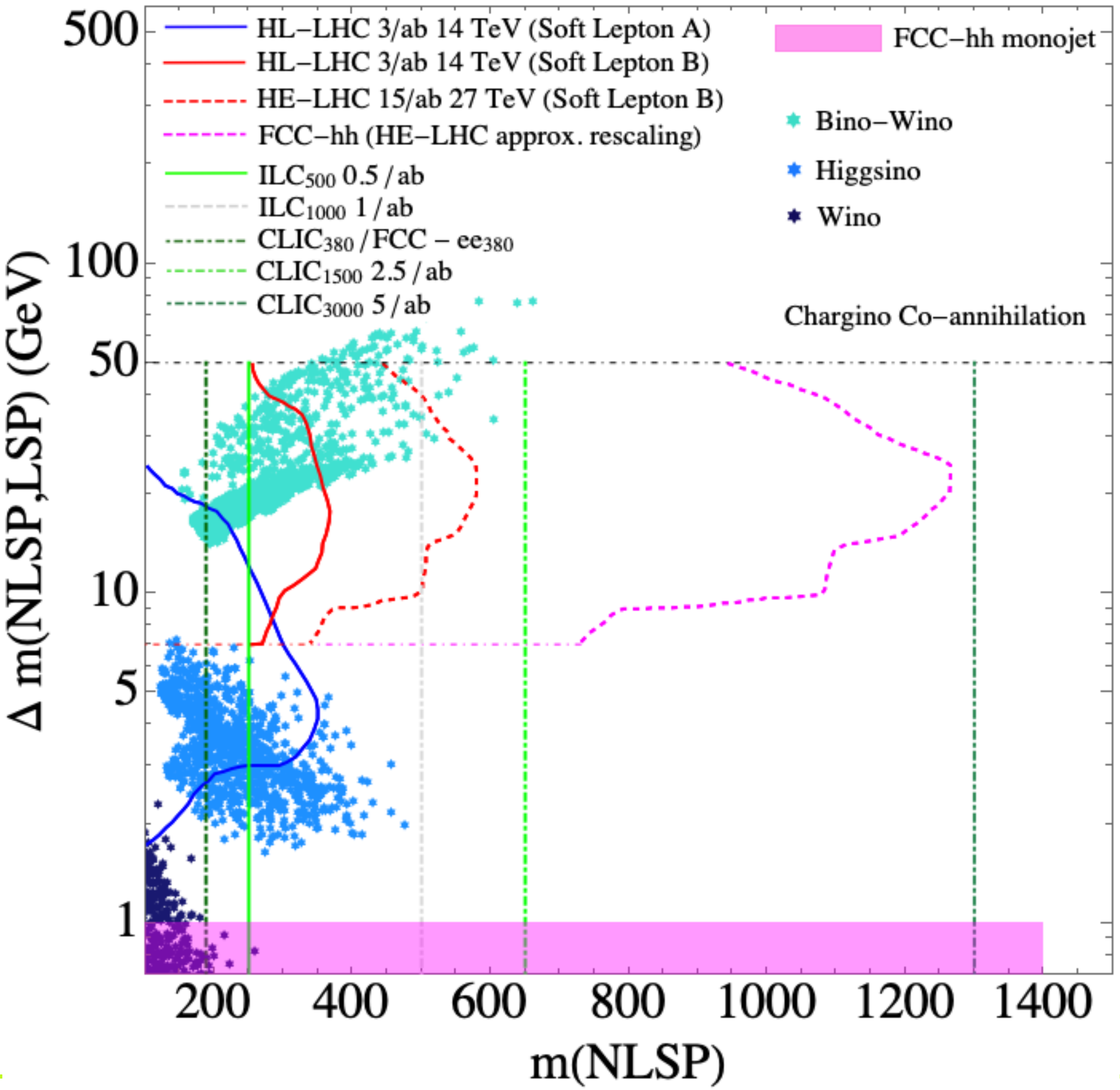
A-pole annihilation





Black contour : $H/A \to \tau^+\tau^-$, $M_h^{125}(\tilde{\chi})$ Benchmark scenario

Future prospects



Conclusions

- It is possible to constrain the EW MSSM with the help of indirect constraints along with the direct collider limits.
- DM and muon (g-2) constraints put effective upper limit on EW SUSY masses.
- LHC limits restrict the mass ranges from below.
- Proper recasting of ATLAS/CMS analyses important !
- Future collider searches and DD experiments have the potential to be conclusive.
- New experimental results for $(g-2)_\mu$ from Fermilab, J-PARC .... STAY TUNED!!!

March ?

THANKYOU!

BACKUP

MSSM Superpotential

$$W_{\mathrm{MSSM}} = \bar{u} Y_u Q H_u - \bar{d} Y_d Q H_d - \bar{e} Y_e L H_d + \mu H_u H_d$$

Soft Breaking Terms

$$\begin{aligned}
\mathscr{L}_{\mathrm{soft}}^{\mathrm{MSSM}} = & -\frac{1}{2}\left(M_3 \tilde{g}\tilde{g} + M_2 \tilde{W}\tilde{W} + M_1 \tilde{B}\tilde{B} + c.c\right) \\
& -\left(\tilde{\bar{u}}\, \mathbf{a_u}\, \tilde{Q} H_u - \tilde{\bar{d}}\, \mathbf{a_d}\, \tilde{Q} H_d - \tilde{\bar{e}}\, \mathbf{a_e}\, \tilde{L} H_d + c.c\right) \\
& -\tilde{Q}^\dagger \mathbf{m_Q^2}\, \tilde{Q} - \tilde{L}^\dagger\, \mathbf{m_L^2}\, \tilde{L} - \tilde{\bar{u}}\, \mathbf{m_{\bar{u}}^2}\, \tilde{\bar{u}}^\dagger - \tilde{\bar{d}}\, \mathbf{m_{\bar{d}}^2}\, \tilde{\bar{d}}^\dagger - \tilde{\bar{e}}\, \mathbf{m_{\bar{e}}^2}\, \tilde{\bar{e}}^\dagger \\
& - m_{H_u}^2 H_u^* H_u - m_{H_d}^2 H_d^* H_d - \left(b H_u H_d + c.c\right)
\end{aligned}$$

$(g-2)_\mu$

- Large discrepancy from the SM (more than 3σ):

  $a_\mu^{exp} - a_\mu^{SM} = (28.02 \pm 7.37) \times 10^{-10}$.

  Keshavarzi, Nomura, Teubner '19

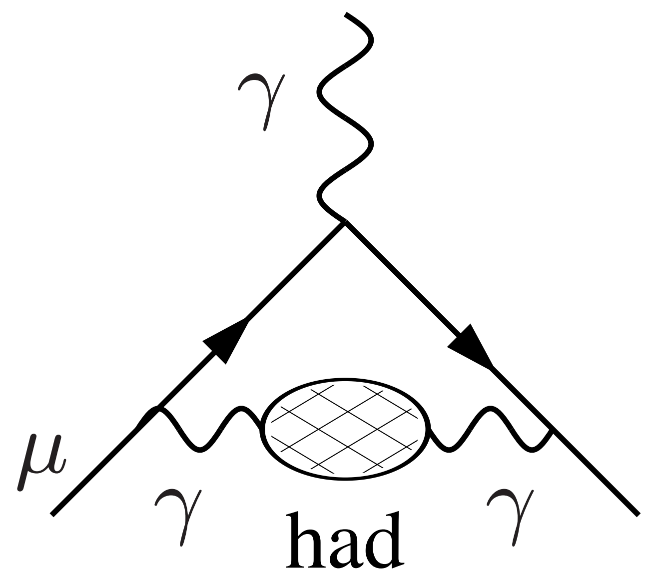
- Important probe for new physics. $\frac{\delta a_l}{a_l} \sim \frac{m_l^2}{\Lambda^2}$.

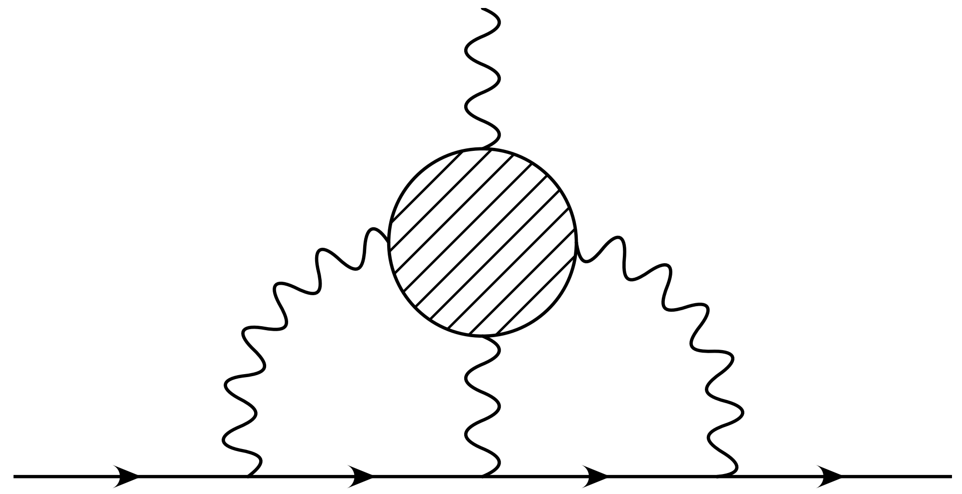
- SM contributions : QED, weak, hadronic vacuum polarization, hadronic light by light scattering.

- QED : complete calculation upto 5 loops. EW : two loops.

  Aoyama, Hayakawa, Kinoshita, Nio '17, Ishikawa, Nakazawa, Yasu '18, Heinemeyer, Stökinger, Weiglein '04

- Uncertainty dominated by non-perturbative, hadronic sector.





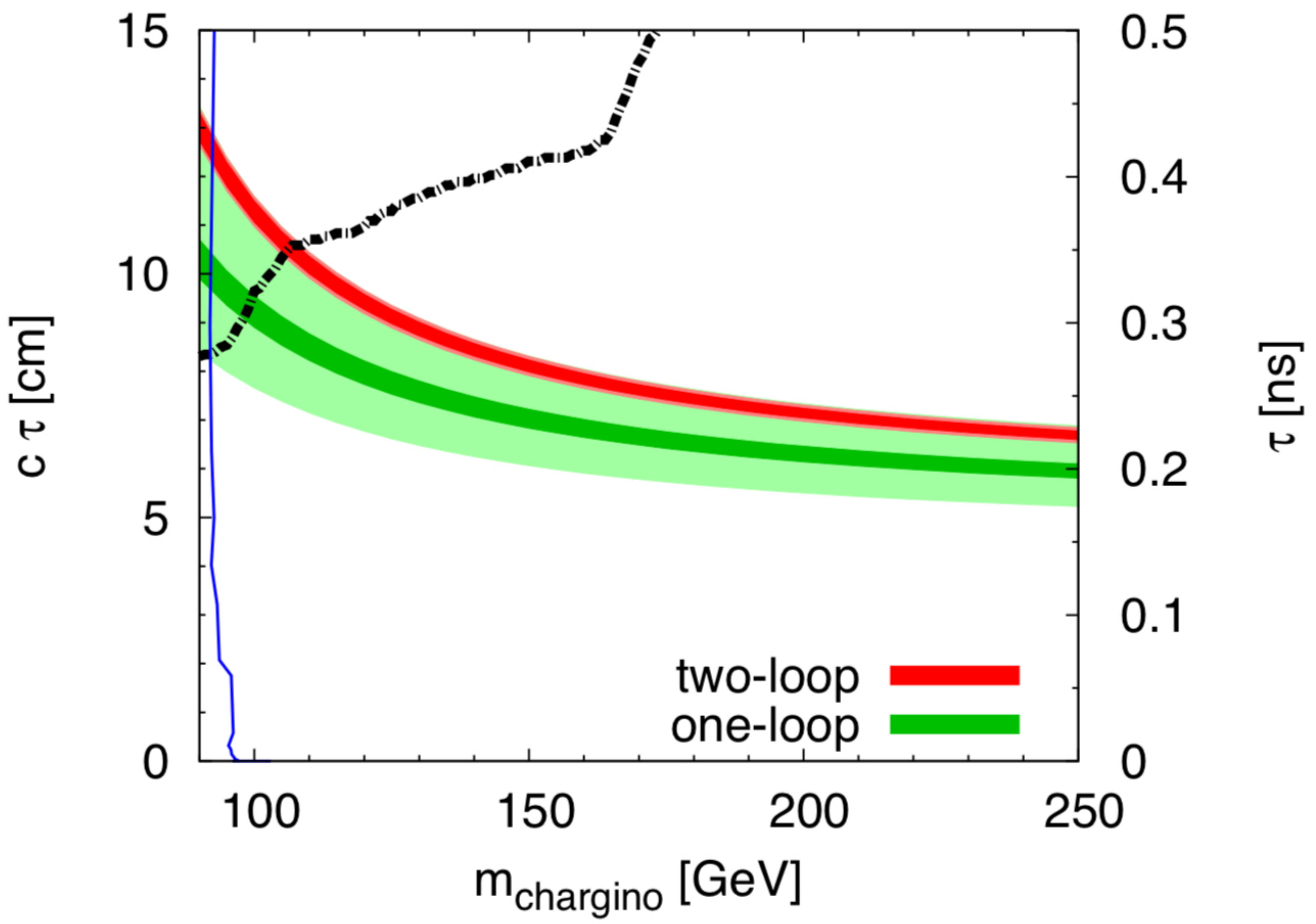


Figure 6: The lifetime of charged wino evaluated by using δm at the one-loop (green band) and two-loop (red band). We neglected the next-to-leading order corrections to the lifetime of the charged wino estimated in terms of the pion decay rate, which is expected to be a few percent correction. The black chain line is the upper limit on the lifetime for a given chargino mass by the ATLAS collaboration at 95 % CL ($\sqrt{s}$ = 7 TeV, $\mathcal{L}$ = 4.7 fb^{-1}) [28]. The blue line shows the constraints which are given by the LEP2 constraints [30]–[33].

Highest mass points

Current $(g-2)_\mu$ limit

Coannihilation	$\tilde{\chi}_1^\pm$	$\tilde{l}^\pm$ (Case-L)	$\tilde{l}^\pm$ (Case-R)
$m_{\tilde{\chi}_1^0}$	570	533	518
$m_{\tilde{\chi}_2^0}$	605	816	685
$m_{\tilde{\chi}_3^0}$	1087	1370	1098
$m_{\tilde{\chi}_1^\pm}$	605	816	685
$m_{\tilde{e}_1,\tilde{\mu}_1}$	680	549	696
$m_{\tilde{e}_2,\tilde{\mu}_2}$	680	1279	592
$m_{\tilde{\tau}_1}$	582	534	747
$m_{\tilde{\tau}_2}$	765	1286	526
$m_{\tilde{\nu}}$	675	544	692

Anticipated future $(g-2)_\mu$ limit

Coannihilation	$\tilde{\chi}_1^\pm$	$\tilde{l}^\pm$ (Case-L)	$\tilde{l}^\pm$ (Case-R)
$m_{\tilde{\chi}_1^0}$	423	499	402
$m_{\tilde{\chi}_2^0}$	464	535	448
$m_{\tilde{\chi}_3^0}$	1032	1019	830
$m_{\tilde{\chi}_1^\pm}$	464	535	448
$m_{\tilde{e}_1,\tilde{\mu}_1}$	542	511	795
$m_{\tilde{e}_2,\tilde{\mu}_2}$	541	2349	428
$m_{\tilde{\tau}_1}$	437	509	807
$m_{\tilde{\tau}_2}$	629	2350	406
$m_{\tilde{\nu}}$	536	505	792

Points satisfying $(g-2)_\mu$, DM and LHC constraints , masses in GeV.