Mixed neutralino dark matter in nonuniversal gaugino mass models

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Outline:

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- Introduction
- Motivation of the work :
  1. Dark matter (DM) satisfied zones in the supersymmetric (SUSY) models
  2. Can we propose any simple model where DM is heavily mixed ?
- Framework : Non Universal Gaugino Mass model (NUGM)
- Results and Discussion
- Conclusion

Introduction :

- The relic density involving neutralino DM can be calculated as $\Omega_{CDM} h^2 \simeq \frac{n_{\tilde{\chi}_1^0} m_{\tilde{\chi}_1^0}}{<\sigma_A v>}$
  WMAP limit : $0.09 < \Omega_{\tilde{\chi}_1^0} h^2 < 0.13$
- The evolution of $n_{\tilde{\chi}_1^0}$ is calculated by the Boltzmann equation:

$$\frac{dn_{\tilde{\chi}_1^0}}{dt} + 3Hn_{\tilde{\chi}_1^0} = -<\sigma_A v> \left(n^2_{\tilde{\chi}_1^0} - (n^{eq}_{\tilde{\chi}_1^0})^2 \right)$$

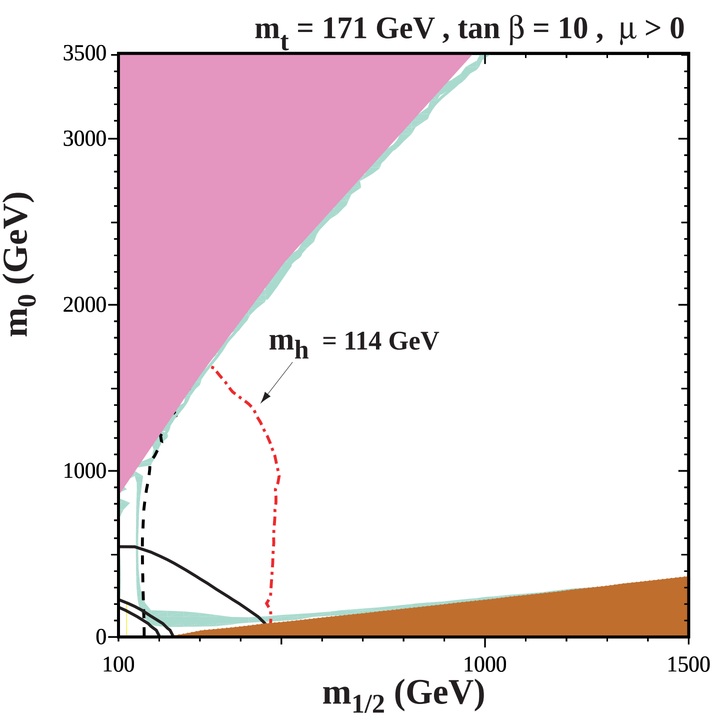
- $\tilde{\chi}_1^0$ can annihilate with other sparticles with approximately degenerate masses, known as “coannihilation” has also important contribution in $<\sigma_A v>$
- $<\sigma_A v>$ depends on LSP composition :

$$\tilde{\chi}_1^0 = N_{11}\tilde{B} + N_{12}\tilde{W}_3 + N_{13}\tilde{H}_d^0 + N_{14}\tilde{H}_u^0.$$

  N_{ij}– matrix elements that diagonalizes the neutralino mass matrix
- gaugino fraction : $F_g = |N_{11}|^2 + |N_{12}|^2$
  $\tilde{\chi}_1^0$: gaugino like if F_g is very close to 1($\gtrsim 0.9$), $\tilde{\chi}_1^0$: higgsino like if $F_g \lesssim 0.8$.
  Otherwise the LSP would be identified as a gaugino-higgsino mixed state

WMAP satisfied dark matter zones in SUSY Models: $\tilde{B}$ LSP

$\tilde{\chi}_1^0 \equiv \tilde{B}$ LSP :



Ref: Ellis *et. al.* hep-ph/0202110

- Bino does not possess any annihilations via $SU(2)$ couplings

- $\tilde{B}\tilde{B} \rightarrow f\bar{f} \Rightarrow$ Bulk annihilation region $\Rightarrow$ principal annihilation channel for small m_0 and small $m_{1/2}$ in mSUGRA

- $\tilde{B}\tilde{\tau} \rightarrow \tau\gamma, \tau Z, \tau h \Rightarrow$ Bino-stau coannihilation region $\Rightarrow$ dominant channel in the parameter space for $m_0 \ll m_{1/2}$ where $\tilde{\tau}$ becomes NLSP

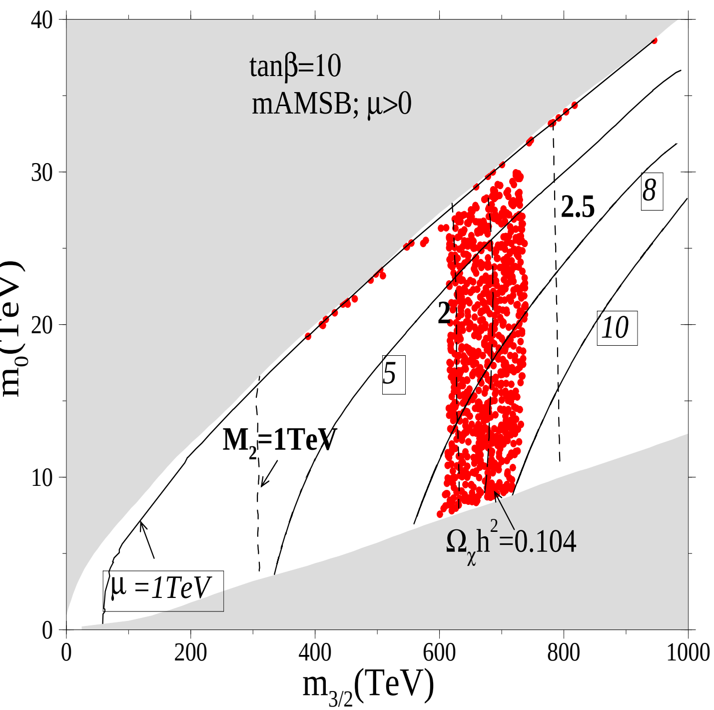
- $\tilde{B}\tilde{t} \rightarrow tg, tZ, bW^+, t\gamma ... \Rightarrow$ Bino-stop coannihilation region $\Rightarrow$ characterized by a very light $m_{\tilde{t}_1}$

- $\tilde{B}\tilde{B} \rightarrow f\bar{f}$ via A, H, h exchange $\Rightarrow$ resonance annihilation characterized by $2m_{\tilde{\chi}_1^0} \simeq m_A, m_H \Rightarrow$ requires $\tan\beta \geq 50$ and relatively large m_0 and $m_{1/2}$ in mSUGRA

$\Rightarrow$ Will be tested at LHC (at least partially)

WMAP satisfied dark matter zones in SUSY Models: $\tilde{W}, \tilde{H}$ LSP

$\tilde{\chi}_1^0 \equiv \tilde{W}, \tilde{H}$ LSP :



Ref: Chattopadhyay *et. al.* hep-ph/0610077

- Wino or Higgsino LSP possess $SU(2)_L$ interactions
- Wino LSP is viable in scenario like mAMSB while Higgsino appears as LSP in mSUGRA (with large m_0 and large $m_{1/2}$) and in NUGM:200 model
- $\tilde{W}\tilde{W}, \tilde{H}\tilde{H} \to W^+W^- \Rightarrow$ principal annihilation channel
- $\tilde{W}$ or $\tilde{H}$ like LSP may strongly coannihilate with an almost degenerate lighter chargino or a neutralino $\Rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^+ \to u_i\bar{d}_i, \bar{e}_i\nu_i, AW^+, ZW^+, W^+h$, $\tilde{\chi}_1^0\tilde{\chi}_2^0 \to u_i\bar{u}_i, d_i\bar{d}_i, W^+W^-$
- Annihilation cross-sections for both $\tilde{W}, \tilde{H}$ LSPs are much larger compared to a $\tilde{B}$ LSP $\Rightarrow$ acceptable relic density only for larger values of $\tilde{W}/\tilde{H}$ masses ($M_{\tilde{H}} \simeq 1\,\mathrm{TeV}$ and $M_{\tilde{W}} \simeq 2\,\mathrm{TeV}$)

$\Rightarrow$ cannot be tested at LHC

Annihilation channels : A few diagrams

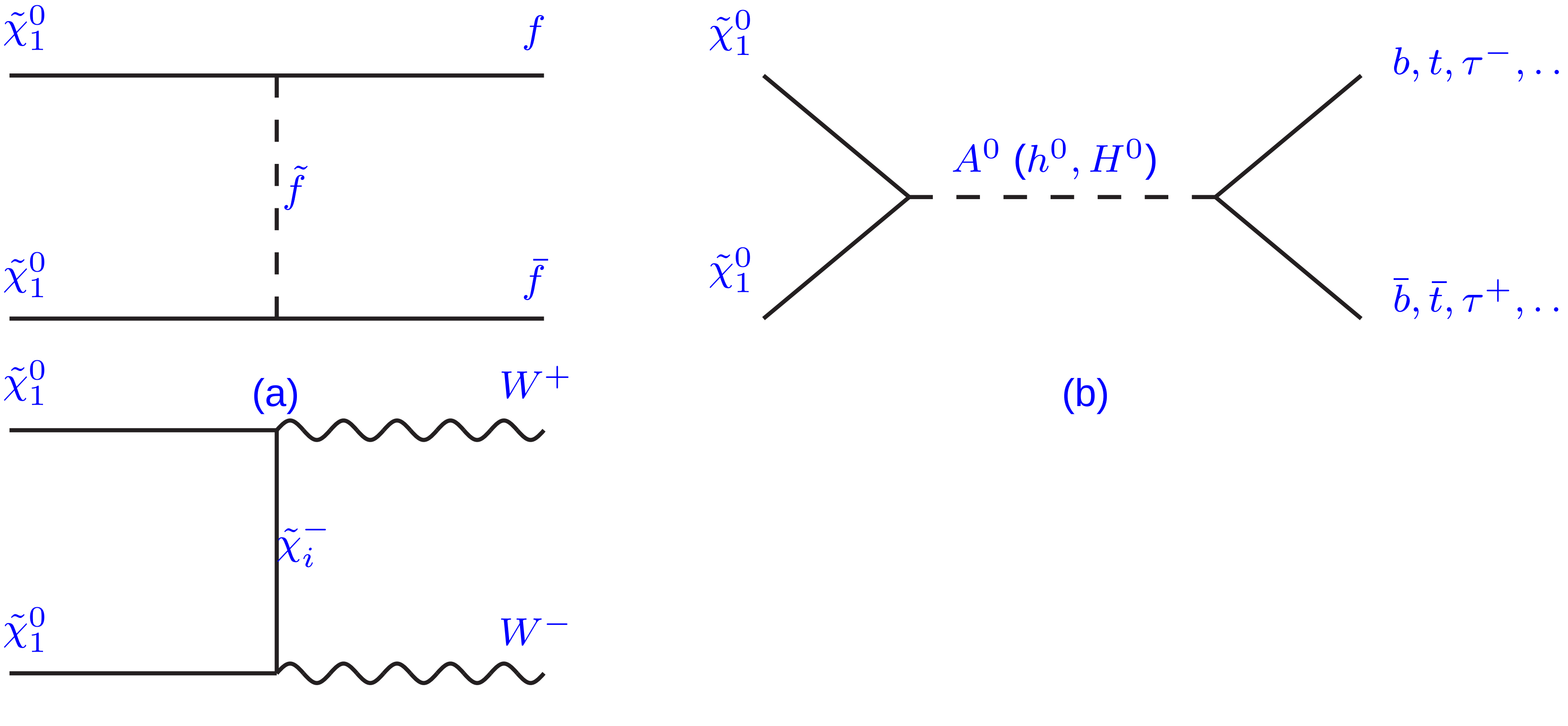


Fig-1. neutralino pair annihilation : (a) t-channel slepton and squark exchange, (b) near-resonant annihilation through a Higgs boson (c) t-channel chargino exchange

Co-annihilation channels : A few diagrams

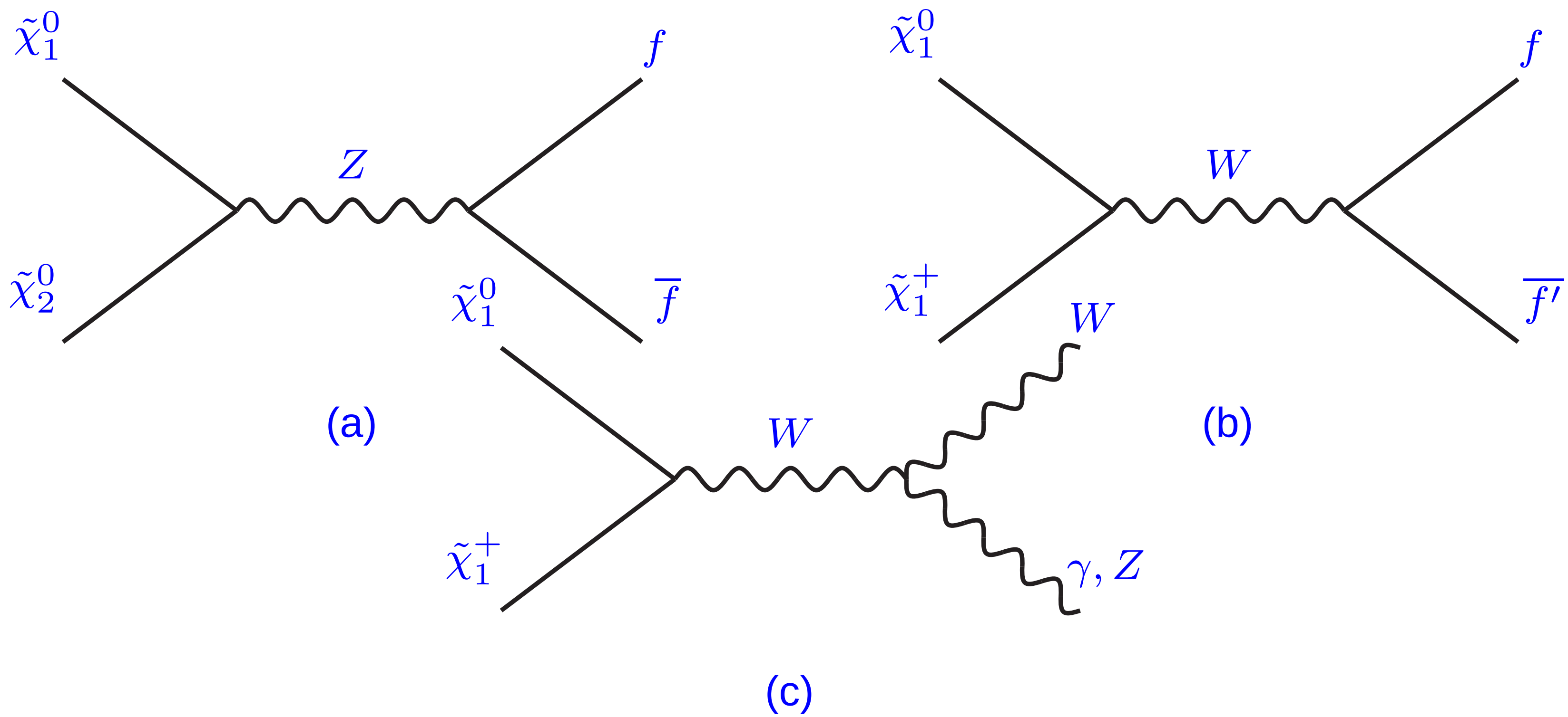


Fig-2 : some co-annihilation processes : ((a),(b) and (c)) diagrams are important if the LSP is higgsino-like,and the last two diagrams are important if the LSP is $\tilde{W}$-like

Co-annihilation channels : A few diagrams

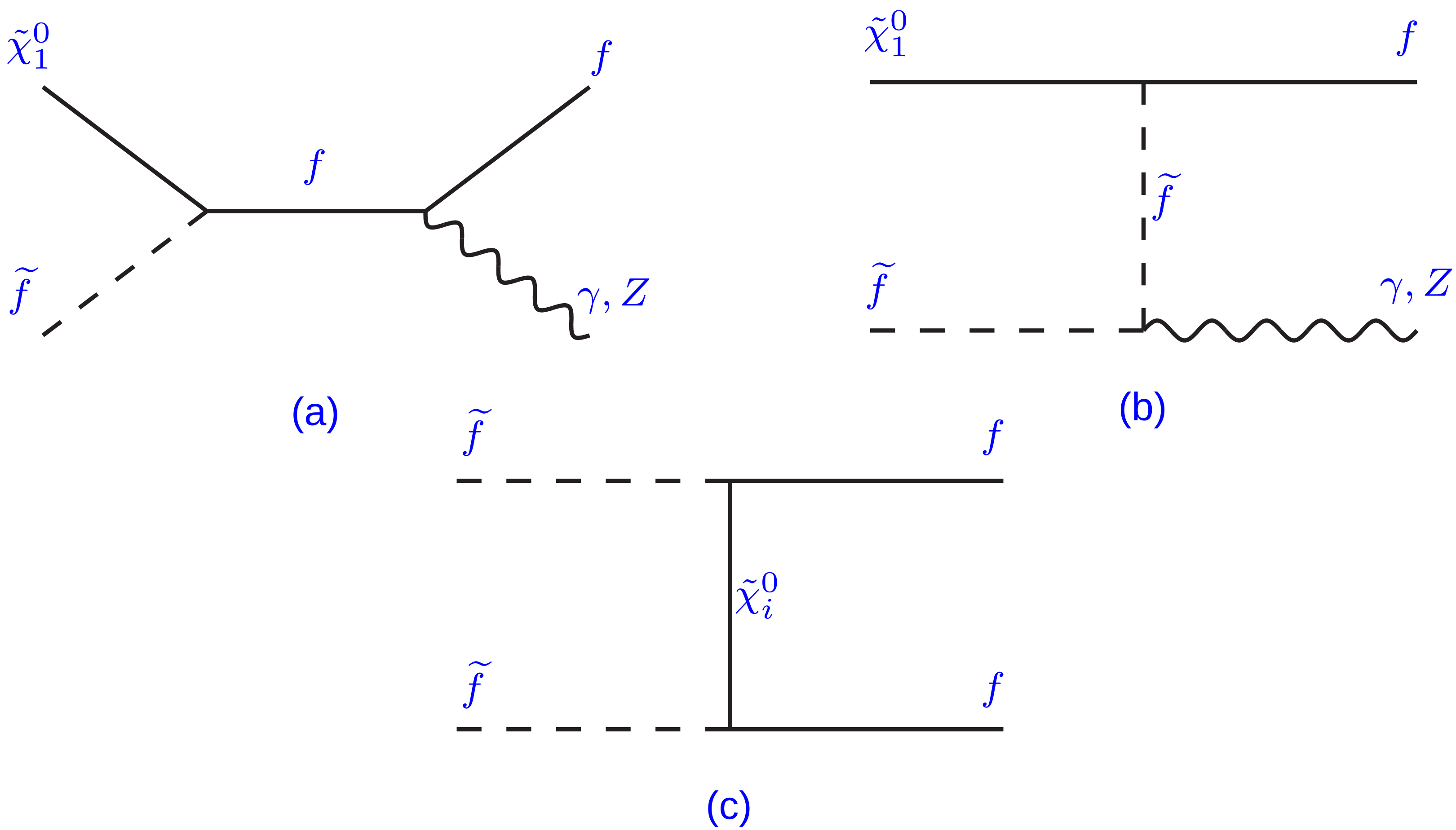


Fig-3 : Dominant co-annihilation processes for $\tilde{B}$ LSP

WMAP satisfied dark matter zones in SUSY Models: Mixed LSP

$\tilde{\chi}_1^0 \equiv \tilde{B} - \tilde{H}$ LSP :

- The thin WMAP satisfied region near REWSB boundary $\Rightarrow$ interesting as can be discovered at LHC

- Fine-tuning is within acceptable limit $\Rightarrow$ **Hyperbolic Branch - Focus Point solution** $\Rightarrow$ commonly known as HB/FP zone

- LSP is a mixed state of $\tilde{B} - \tilde{H}$ $\Rightarrow$ recently named as **well tempered neutralino**

- In this work we explore the possibilites of having other mixed LSP states like $\tilde{B} - \tilde{W}$, $\tilde{B} - \tilde{W} - \tilde{H}$

- Usually such a mixed LSP can be achieved in the non universal gaugino mass models (NUGM) $\Rightarrow$ previous works based on the NUGM models can be classified into two categories
  1. Gauginos belonging to a representation of a 'Grand Unified Gauge Group' (GUT) $\Rightarrow$ having definite mass relations at the GUT scale (M_G)
  2. Gauginos do not possess any definite mass relations at the M_G

Motivation : Why well tempered neutralino scenarios are interesing

- The over-abundance of dark matter from Bino-dominated LSPs is balanced by the large LSP pair-annihilation cross section due to Higgsino mixing
- A mixed Bino-Higgsino or Bino-Wino LSP is expected to give cosmologically compatible DM relic density for sub-TeV LSP masses $\Rightarrow$ can be accessible at LHC
- For mSUGRA Bino-Higgsino DM $\Rightarrow$ a narrow strip at the edge of the mSUGRA parameter space $\Rightarrow$ very restricted
- In this work we explore the prospects of these mixed LSP scenarios in the context of NUGM models
- we consider two scenarios having : (i) Bino-Higgsino LSP and (ii) Bino-Wino or Bino-Wino-Higgsino LSP
- We investigate the expected signals in direct and indirect DM detection experiments $\Rightarrow$ indirect detection signals in the form of high energy neutrinos or line and continuum γ rays coming from DM pair-annihilation inside the Sun/ galactic core is explored
- We discuss the expected collider signatures at LHC

Framework: Minimal Supergravity

- In the minimal version of SUGRA (mSUGRA) global SUSY is assumed to be broken at the gauge coupling unification scale or GUT scale:($M_G \sim 2 \times 10^{16}$ GeV) in the observable sector
- One further assumes the matrices for scalar squared masses and the trilinear parameters to be flavor diagonal and universal
- Gaugino masses are also universal at the M_G
- Renormalisation group evolutions(RGE) from M_G determine low energy soft SUSY breaking parameters at the EW(electro-weak scale)
- In mSUGRA, hidden sector can be paramterized by the following five parameters at $Q = M_G$.
  $m_0 \sim$ universal scalar mass
  $m_{1/2} \sim$ universal gaugino mass
  $A_0 \sim$ universal trilinear coupling
  $\tan\beta = \frac{<H_u>}{<H_d>}$
  $sign(\mu) \sim$ sign of μ parameter

REWSB :

- Radiative breaking of electro-weak symmetry is used to find μ and B at $Q = M_Z$

$$\frac{1}{2}M_Z^2 = \frac{m_{H_d}^2 - m_{H_u}^2 \tan^2\beta}{\tan^2\beta - 1} - |\mu|^2 + \Delta_R$$

$$\sin 2\beta = \frac{2|B\mu|}{m_{H_d}^2 + m_{H_u}^2 + 2\mu^2}$$

  where, Δ_R is found from the one loop radiative correction to the Higgs potential

- For $\tan\beta > 5$, the first REWSB condition leads to $\frac{1}{2}M_Z^2 + |\mu|^2 = -m_{H_u}^2$

- m_A^2 at EW scale $\equiv m_{H_d}^2 + m_{H_u}^2 + 2\mu^2$, or via $m_A^2 \sim m_{H_d}^2 - m_{H_u}^2$

Non-Universal gaugino mass models : NUGM

- In SUGRA models gaugino masses originate from

$$\mathcal{L}_{\rm gaugino} = \left[\frac{1}{4} e^{-\mathcal{G}/2} \mathcal{G}^a (\mathcal{G}^{-1})^b_a (\partial f^*_{\alpha\beta}/\partial\phi^{*b})\right] \lambda^\alpha \lambda^\beta + {\rm h.c.}$$

- Non minimal choice of $f_{\alpha\beta}$ produces nonuniversal gaugino masses at the M_G
- The function $f_{\alpha\beta}$ depends on the chiral superfields and transforms under the symmetric product of the two adjoint representations $\Rightarrow$ has been assumed to be real for simplicity
- Considering ${\rm SU}(5)$ as the GUT group $f_{\alpha\beta}$ can belong to any of the following representation

$$(24 \otimes 24)_s = 1 \oplus 24 \oplus 75 \oplus 200$$

NUGM models : Contd..

- If $\mathrm{SU}(5)$ is broken down to $SU(3) \times SU(2) \times U(1)$ by the use of of Higgses, then $M_i(M_G) = m_{1/2} \sum_r C_r n_i^r$, where C_r's give the relative weights of each contributing representation and n_i^r characterize the Higgs vacuum structure of the irreducible representation r

r	Label	M_3^G	M_2^G	M_1^G
1	mSUGRA	1	1	1
24	NUGM:24	2	-3	-1
75	NUGM:75	1	3	-5
200	NUGM:200	1	2	10

- Here we consider gauge kinetic term to receive contribution from both singlet and a nonsinglet representation of GUT group namely from singlet and the 75-dimensional, and the singlet and the 200-dimensional representations of the $\mathrm{SU}(5)$ group

NUGM Models :

- we consider two models where gauge kinetic function $f_{\alpha\beta}$ contains a mixture of : (i) singlet plus 75-plet superfields $(1+75)$ and
  (ii)singlet plus 200-plet superfields $(1+200)$
- We adjusted the relative contributions from the two superfields by introducing $\alpha_{75}, \alpha_{200}$ for the two models
- DM phenomenology is guided by the composition of the lightest neutralino $\Rightarrow$ EW scale values of M_1, M_2 and μ are the key $\Rightarrow$ considering one-loop RGEs one has

$$
\begin{aligned}
M_1 &= (\alpha_1/\alpha_G)M_1^G \simeq (25/60)M_1^G \\
M_2 &= (\alpha_2/\alpha_G)M_2^G \simeq (25/30)M_2^G \\
M_3 &= (\alpha_3/\alpha_G)M_3^G \simeq (25/9)M_3^G \\
\mu^2 + \frac{1}{2}M_Z^2 &\simeq -0.1m_0^2 + 2.1{M_3^G}^2 - 0.22{M_2^G}^2 - 0.006{M_1^G}^2 + 0.006M_1^G M_2^G + \\
&\quad 0.19M_2^G M_3^G + 0.03M_1^G M_3^G
\end{aligned}
$$

NUGM Models : contd

NUGM : $(1 + 75)$

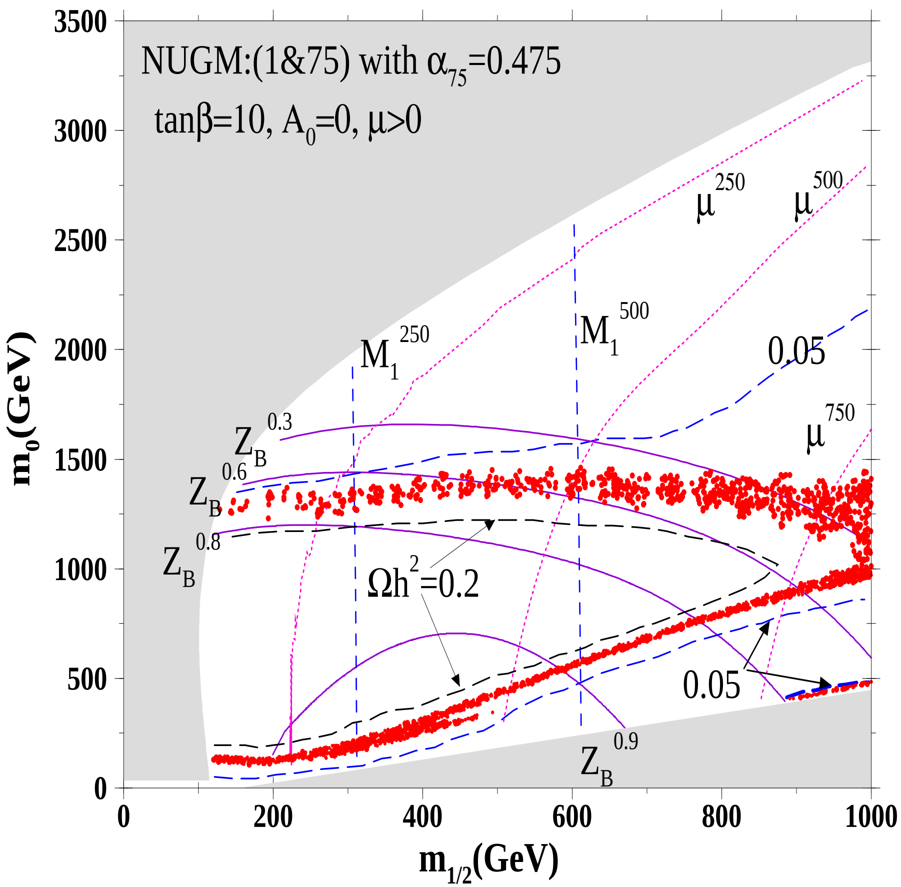
- $M_i(M_G) = \left(n_i^1(1 - \alpha_{75}) + n_i^{75}\alpha_{75}\right) m_{1/2}$
- $\alpha_{75} \equiv 0.50 \Longrightarrow |M_1| \simeq |\mu| \simeq m_{1/2} < |M_2|$ for $m_0 \geq m_{1/2}$
- This leads to a mixed Bino-Higgsino LSP
- Decreasing m_0 leads to increase of $|\mu|$ and hence decrease of Higgsino fraction of LSP

NUGM : $(1 + 200)$

- $M_i(M_G) = \left(n_i^1(1 - \alpha_{200}) + n_i^{200}\alpha_{200}\right) m_{1/2}$
- $\alpha_{200} \equiv 0.1 \Longrightarrow |M_1| \simeq |M_2| \Rightarrow$ leads to a mixed Bino-Wino LSP
- Increasing m_0 leads to decrease of $|\mu|$, resulting in a triply mixed Bino-Wino-Higgsino LSP in the large m_0 region

We have found the optimised mixing parameters to be $\alpha_{75} = 0.475$ and $\alpha_{200} = 0.12$ so as to get the most favourable DM relic density for most of the parameter space

Results:: NUGM : $(1+75)$

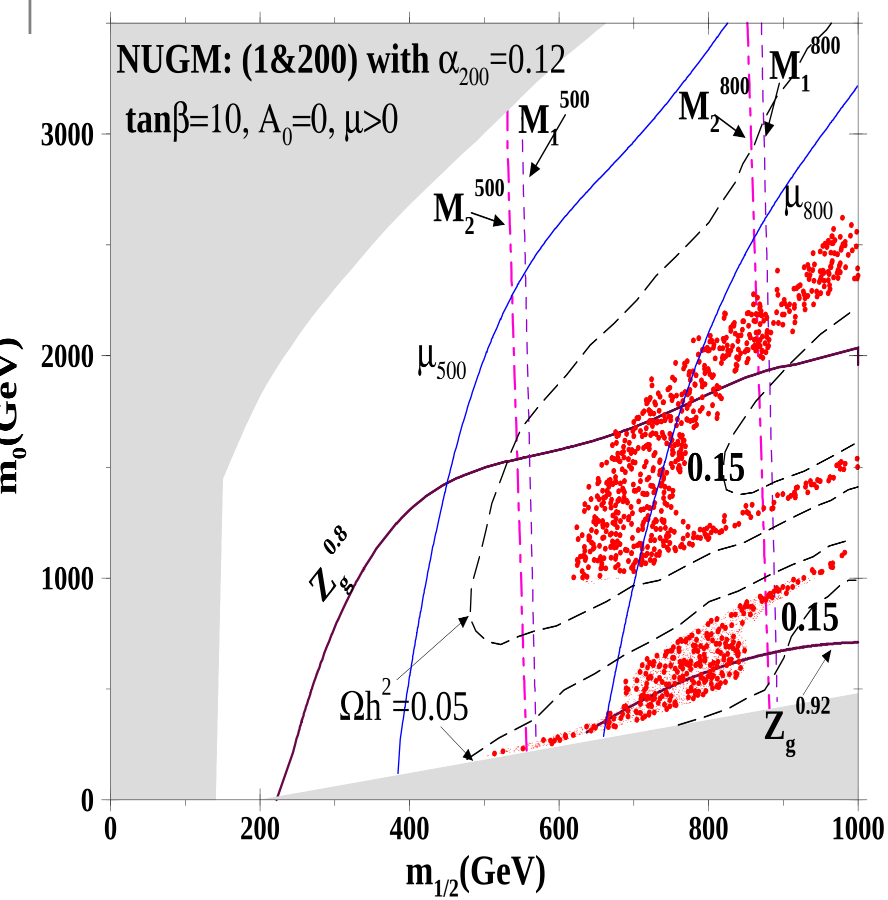


- Almost half the parameter space corresponds to DM relic density within $\Omega_{CDM}h^2 = 0.05 - 0.2$.
- The upper band $\Rightarrow$ equal admixture $\tilde{B} - \tilde{H}$ and lower band is primarily $\tilde{B}$ dominated $\Rightarrow$ approximate degeneracy among the three lighter neutralinos ($\chi^0_{1,2,3}$) and the lighter chargino ($\tilde{\chi}^+_1$) is observed
- leading annihilations/coannihilations : upper band : $\chi^0_1\chi^0_1,\ \chi^0_1\chi^0_2,\ \chi^0_1\tilde{\chi}^\pm_1\ \rightarrow\ WW,\ ZZ,\ f\bar{f}$ $(\mathrm{both\ via\ s\ and\ t-channel\ processes})$ lower band : $\chi^0_1\chi^0_1,\ \chi^0_1\chi^0_2,\ \chi^0_1\tilde{\chi}^+_1\ \rightarrow$ $t\bar{t},\ b\bar{b}, \tau\bar{\tau},\ t\bar{b},\ \tau\nu_\tau$ $(\mathrm{via\ s-channel\ A, H, H^+})$

Results : Spectra

parameter	A	B	C	D	E	F
$m_{1/2}$	300	600	800	300	600	800
m_0	1325	1400	1340	185	550	800
μ	268	496	654	323	560	694
M_1	242	493	662	237	489	660
$m_{\tilde{\chi}_1^0}$	227	468	631	231	481	645
$m_{\tilde{\chi}_2^0}$	254	489	649	302	552	689
$m_{\tilde{\chi}_3^0}$	289	524	687	334	571	711
$m_{\tilde{\chi}_4^0}$	501	970	1285	490	957	1277
$m_{\tilde{\chi}_1^+,\tilde{\chi}_2^+}$	255,501	490,970	649,1285	304,491	552,957	689,1277
$m_{\tilde{g}}$	794	1437	1845	725	1381	1809
$m_{\tilde{t}_1}$	903	1232	1435	485	965	1280
$m_{\tilde{t}_2,\tilde{b}_1}$	1256,1246	1704,1694	1993,1983	727,651	1367,1288	1800,1712
$m_{\tilde{l}}$	1300—1400	1400—1600	1440—1680	280—440	680—950	960—1300
$m_{\tilde{q}_{1,2}}$	1400—1500	1800—1940	2000—2220	650—750	1300—1480	1725—1965
$m_A(\simeq m_{H^+}, m_H)$	1382	1648	1786	534	1091	1460

Results:: NUGM : $(1 + 200)$



- LSP is an equimixture of Bino and Wino ($\tilde{B}$-$\tilde{W}$), along with a significant Higgsino component in the $m_0 > 1$ TeV region

  χ_1^0 can also be equally mixed with $\tilde{B}$-$\tilde{W}$-$\tilde{H}$

- Degeneracy among the two lighter neutralinos ($\chi_{1,2}^0$) and the lighter chargino ($\tilde{\chi}_1^{\pm}$) is observed

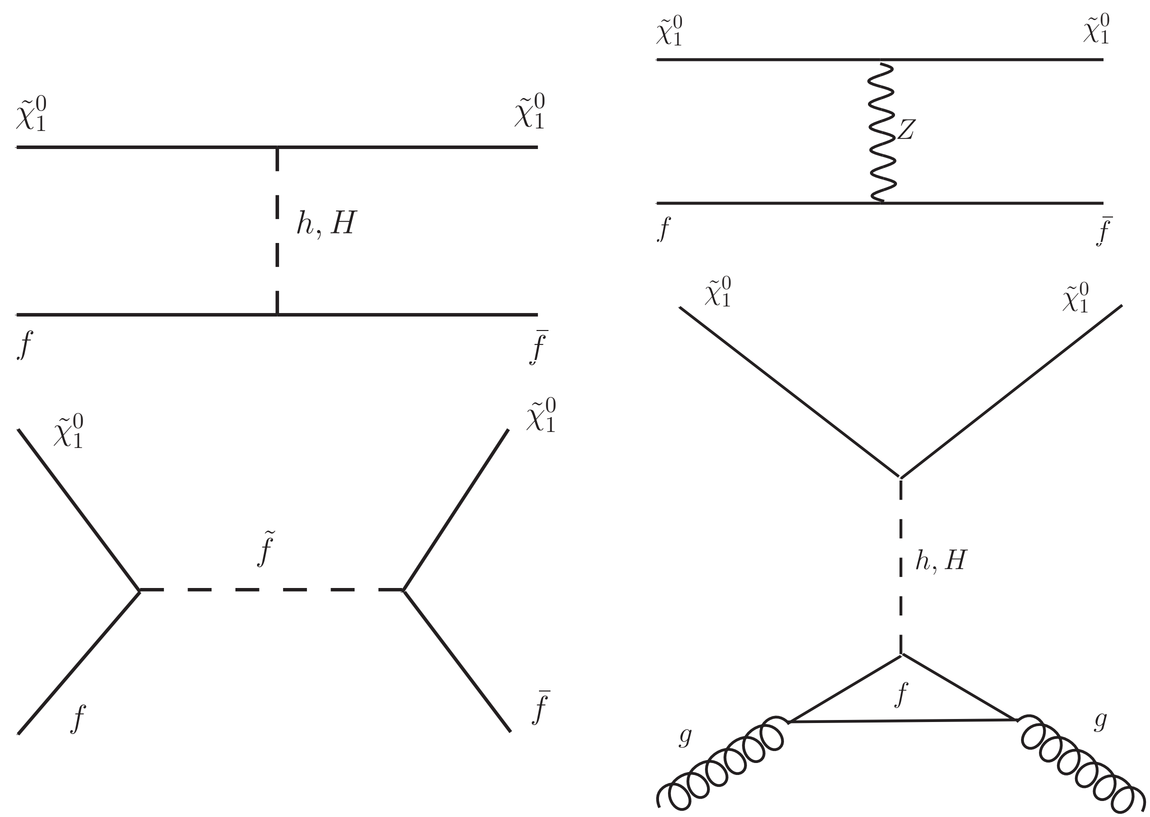
- leading annihilations/coannihilations $\Rightarrow$
  $\chi_1^0\chi_1^0,\ \chi_1^0\chi_2^0,\ \chi_1^0\tilde{\chi}_1^{\pm} \ \rightarrow\ WW,\ ZZ,\ f\bar{f}$
  $(\mathrm{both\ via\ s\ and\ t-channel\ processes})$
  $\chi_1^0\chi_1^0,\ \chi_1^0\chi_2^0,\ \chi_1^0\tilde{\chi}_1^{+} \rightarrow t\bar{t},\ b\bar{b}, \tau\bar{\tau},\ t\bar{b},\ \tau\nu_\tau$
  $(\mathrm{via\ s-channel\ A, H, H^+})$ (on the upper strip of the lower band)

Results : Spectra

parameter	A	B	C	D
$m_{1/2}$	725	900	725	900
m_0	1450	1357	590	950
μ	792	983	846	1009
M_1	652	814	646	811
$m_{\tilde{\chi}_1^0}$	633	798	633	797
$m_{\tilde{\chi}_2^0}$	657	818	650	815
$m_{\tilde{\chi}_3^0}$	794	985	848	1011
$m_{\tilde{\chi}_4^0}$	822	1009	869	1032
$m_{\tilde{\chi}_1^+,\tilde{\chi}_2^+}$	643,818	807,1005	641,865	806,1028
$m_{\tilde{g}}$	1700	2045	1637	2017
$m_{\tilde{t}_1}$	1460	1649	1216	1540
$m_{\tilde{t}_2,\tilde{b}_1}$	1813,1801	2013,2001	1478,1452	1860,1843
$m_{\tilde{l}}$	1535—1555	1505—1530	800—830	1160—1190
$m_{\tilde{q}_{1,2}}$	2000—2050	2170—2240	1520—1600	1950 —2040
$m_A(\simeq m_{H^+}, m_H)$	1726	1799	1174	1546

- The techniques are based on the measurement of the recoil energy spectrum of the nucleus which contains the information of the WIMP-target scattering
- Effective lagrangian for elastic scattering between neutralino-nucleon in MSSM: $\mathcal{L} = \alpha'_q \bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}_i\gamma_\mu\gamma^5 q_i + \alpha_q\bar{\chi}\chi\bar{q}_i q_i$. α_q and α'_q contain all SUSY model information

2nd term : WIMP-nucleon SI scattering $\Rightarrow$ Higgs exchange is dominant
1st one : WIMP-nucleon SD scattering $\Rightarrow$ Z exchange is dominant



Indirect Detection : Neutrino signal

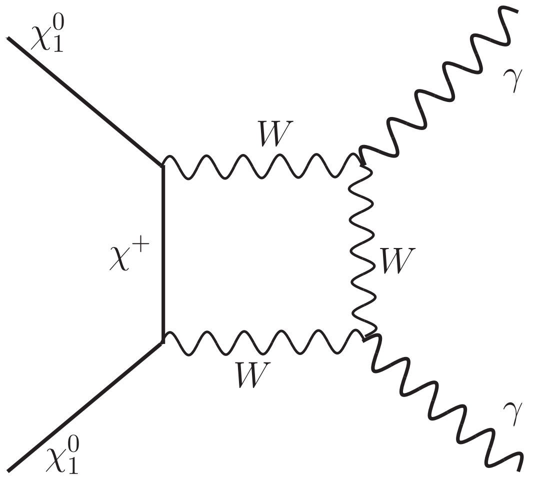
- Indirect detection techniques are based on the detection of secondary particles that come out of dark matter (DM) annihilation in the over-dense region of the universe
- Neutralinos may be captured and accumulated near the center of the astrophysical object like Sun $\Rightarrow$ SD scattering is the dominant mechanism for trapping of neutralinos via interactions with the hydrogen within the Sun
- Neutrinos may come out via the decay of the secondary particles following the pair-annihilation of neutralinos

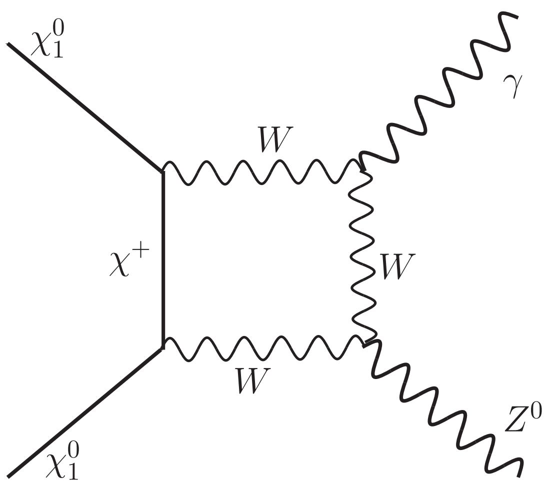
$$\chi\chi \Longrightarrow W^+W^- \Longrightarrow \mu\nu_\mu ..., \quad \chi\chi \Longrightarrow Q\bar{Q} \Longrightarrow q\mu\nu_\mu ...$$

- The neutrinos may be detected through their charged current interactions which results into muon tracks inside a detector
- The annihilation rate at equilibrium is balanced by the DM capture rate inside the Sun $\Rightarrow$ the resulting neutrino signal is $\propto \chi_1^0 - p$ cross-section

Indirect Detection : Photon signal

- We focus on the γ-rays originating from galactic center (GC) $\Rightarrow$ depends upon DM density ρ_χ^2 and $< \sigma_i v >$ $\Rightarrow$ one has following possibilities :: i) monochromatic γ-rays :





- This signal arise from processes like $\chi\chi \to \gamma\gamma$ and $\chi\chi \to Z\gamma$
- Signal will be interesting when χ_1^0 possesses significant $\widetilde{W}$ or $\widetilde{H}$ component
- Signal is small because of loop suppression
- It is clean and mono-energetic with energies $E_\gamma = m_\chi$ and $E_\gamma = m_\chi - m_Z^2/4m_\chi$ respectively

ii) Continuum γ-rays :

• Continuum γ-rays arise from neutralinos annihilating into a variety of SM particles $\Rightarrow$ hadronisation and production of π^0 would follow

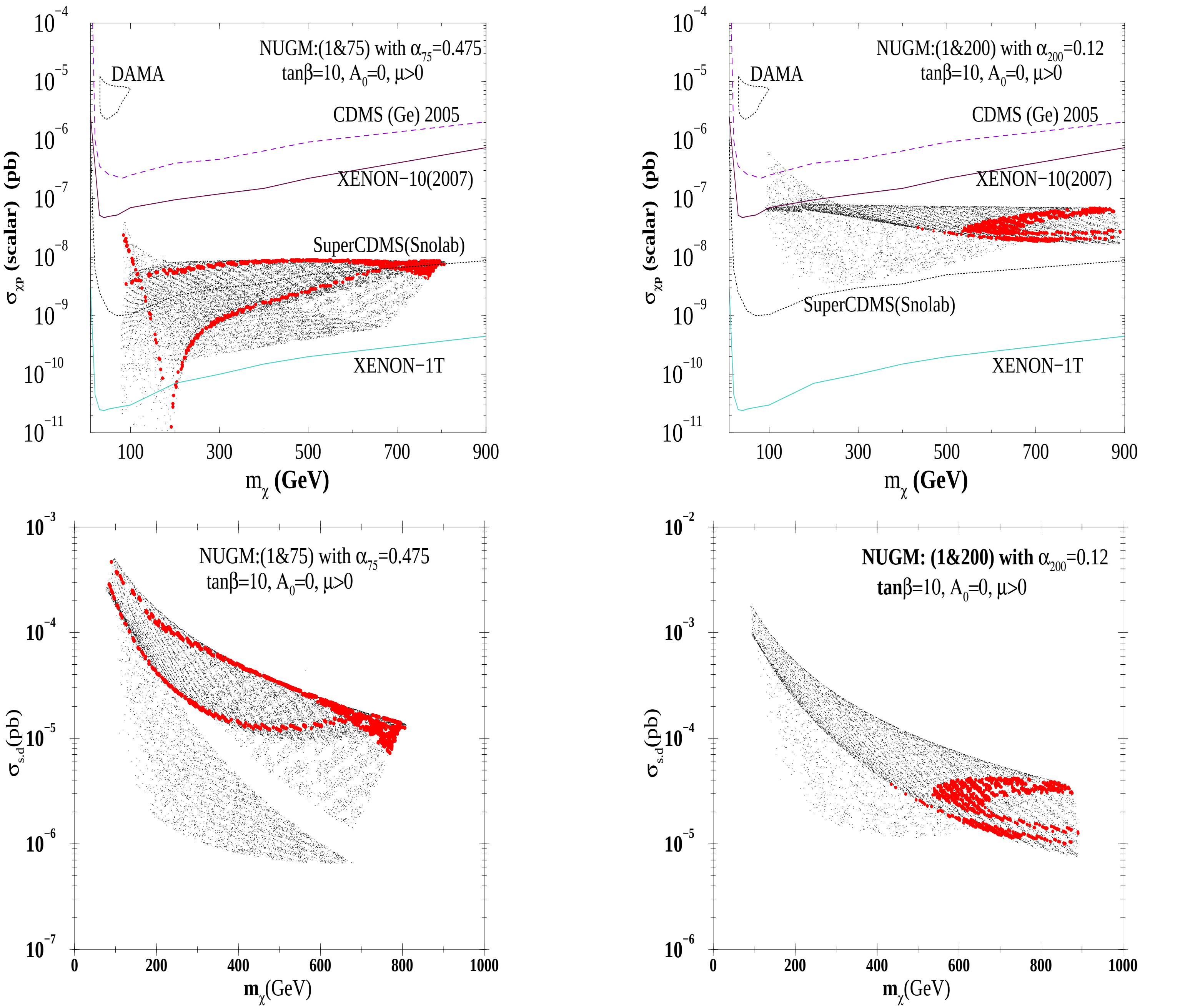
• $\pi^0 \rightarrow \gamma\gamma$ would produce a huge number of photons with varying energies

$$\chi\chi \Longrightarrow W^+W^-,\ Q\bar{Q},\ ZZ \Longrightarrow \pi^0 \Longrightarrow \gamma\gamma$$

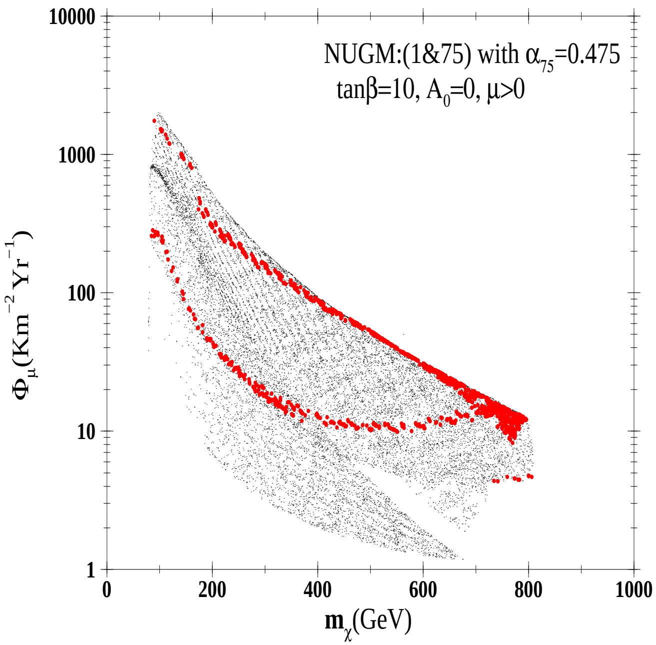
• Continuum γ-rays would produce fluxes that are 2 to 3 order of magnitude more than the that of monochromatic γ-rays

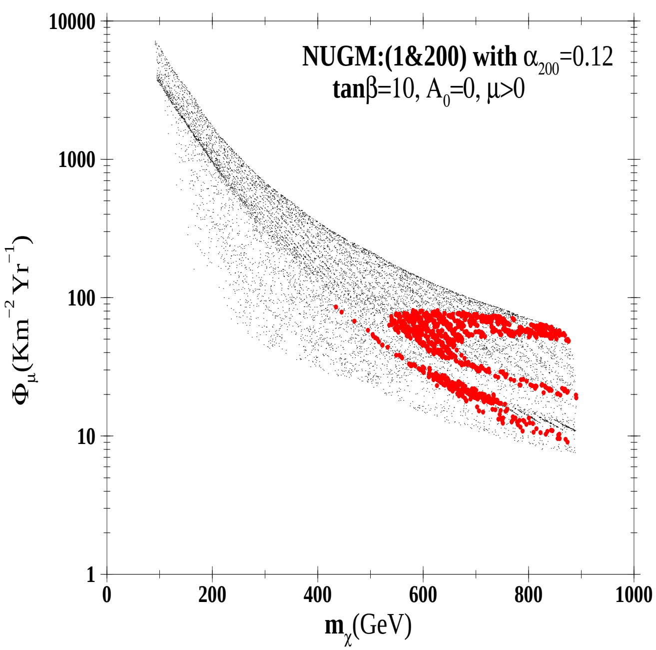
• It lacks of distinctive features which can exclude other more common sources of production if a signal is believed to be found

Results & Discussion : Direct detection

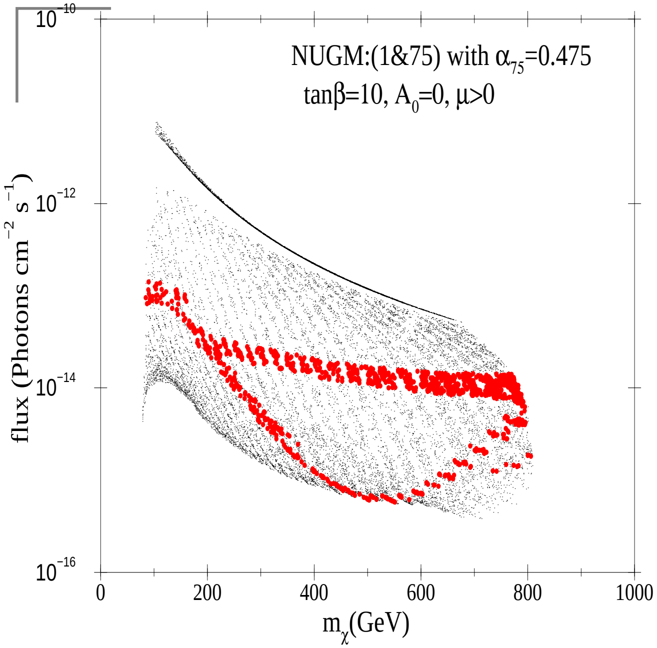


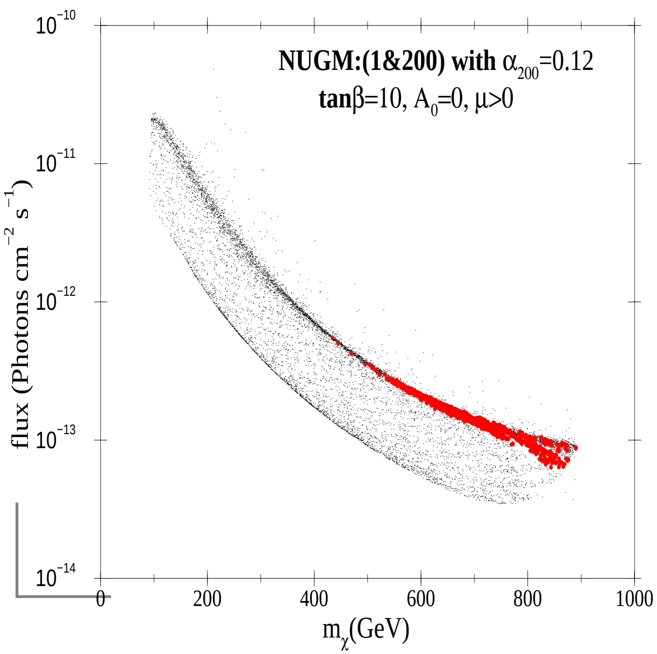
Results & Discussion : μ flux





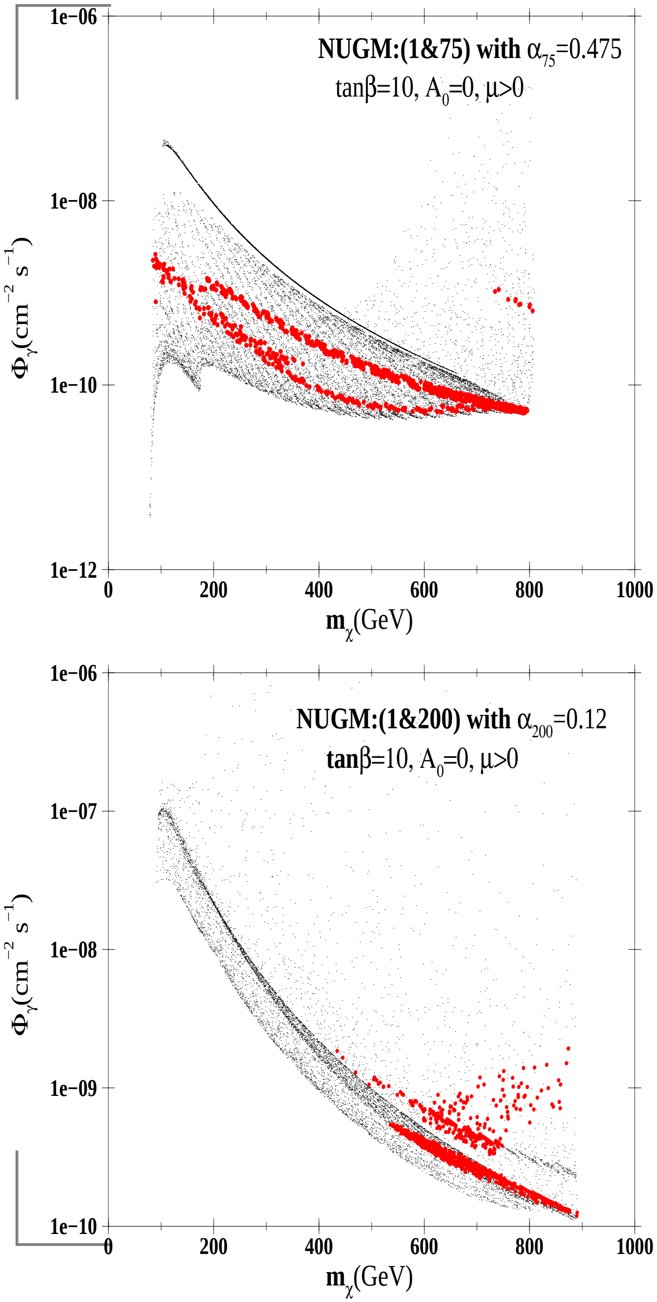
- Model prediction for the rate of muon signal events, resulting from these high energy neutrinos, in a km^2 size neutrino telescope
- Again upper and lower shaded (red) branches correspond to the upper and lower WMAP satisfying branches
- One sees a very promising signal with ≥ 10 events/year at the IceCube





- Monochromatic γ-ray:
  - We assume NFW profile of DM distribution
  - The amplitude is $\propto Z_H^2$ of the neutralino DM
  - The amplitude is $\propto Z_W^2$ of the neutralino DM $\Rightarrow$ Wino has a large Isospin gauge coupling $\Rightarrow$ the resulting signal is at least an order of magnitude larger than the (1+75) case
  - The upper and lower shaded (red) branches $\Rightarrow$ upper and lower WMAP satisfying branches
  - *Fermi Gamma-ray Space Telescope (FGST)* experiment (formerly *Gamma-ray Large Area Space Telescope (GLAST)*) would be able to probe photon-flux as low as $\leq 10^{-10}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

Results & Discussion: Continuum γ-rays



- Continuum γ-ray:

  - The $b\bar{b}$ channel is the most prominent channel for the continuum γ-rays signal, the WW and ZZ channels are also very significant

  - Again upper and lower shaded (red) branches correspond to WMAP satisfying branches of respectively. The separation is barely visible in the (1+200) model

  - The red strip on the top right corresponds to the WMAP satisfying zone which is dominated by the resonance channel

  - *Fermi Gamma-ray Space Telescope (FGST)* experiment (formerly *Gamma-ray Large Area Space Telescope (GLAST)*) would be able to probe photon-flux as low as $\leq 10^{-10}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

Signatures of the $(1+75)$ and $(1+200)$ Models

- $1+75$ model :
  - $m_{\tilde{t}_1} < m_{\tilde{q}_{1,2}}$ ($\sim 30\%$) and $m_{\tilde{t}_1} < m_{\tilde{g}}$
  - $pp \rightarrow \tilde{g}\tilde{g} \rightarrow tt\tilde{t}_1\tilde{t}_1, \quad pp \rightarrow \tilde{t}_1\tilde{t}_1$
  - $\tilde{t}_1 \rightarrow t\chi^0_{1,2,3}, \quad b\tilde{\chi}^+_1$ via gauge (Yukawa) coupling of $\tilde{t}_1$
  - $4b+$ isolated multilepton + missing $\not{p}_T$ or $2b+$ isolated multilepton + missing $\not{p}_T$
- $1+200$ model :
  - $m_{\tilde{t}_1} < m_{\tilde{q}_{1,2}}$, $m_{\tilde{g}}$
  - $\tilde{t}_1 \rightarrow t\chi^0_{1,2,3,4}, \quad b\tilde{\chi}^+_2$ since $(\tilde{\chi}^+_2, \chi^0_{3,4})$ are now Higgsino dominated
  - Search strategy is very similar
- LHC signal is quite common like the FP zone of mSUGRA
- $m_{\tilde{t}_1}$ is lighter due to small m_0, also one has $m_{\tilde{t}_1} < m_{\tilde{g}}$ which are probably unlikely in mSUGRA

Summary

- We consider two non-universal gaugino mass scenarios where $f_{\alpha\beta}$ entails chiral superfields that transforms as (i) singlet and the 75-dimensional or (ii) singlet and the 200 dimensional representation of SU(5)
- We choose mixing parameter to have
  (i) $\chi_1^0 \sim \tilde{B} - \tilde{H}$ or
  (ii) $\chi_1^0 \sim \tilde{B} - \tilde{W}\ ,\ \tilde{B} - \tilde{W} - \tilde{H}$
- we have analyzed DM properties and have obtained broad regions of parameter space in the $m_0 - m_{1/2}$ plane that satisfy the WMAP data
- We have further computed the direct and indirect detection rates of neutralino DM in the two models
- Finally, a few distinctive features of the expected LHC signals of these models are mentioned

THANK YOU