

The background is a dark blue gradient with a subtle pattern of small white dots. Overlaid on the left side is a large, semi-transparent circular graphic. It features a degree scale from 140 to 260 in increments of 10. Several concentric circles are drawn, some with arrows indicating a clockwise direction. The overall aesthetic is scientific and technical.

# TESTING THE LIGHT DARK MATTER SCENARIO OF THE MSSM AT THE 14 TEV LHC

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# 1 INTRODUCTION

- How light can neutralino dark matter can be after the  $\sqrt{s} = 7 + 8$  TeV run data?



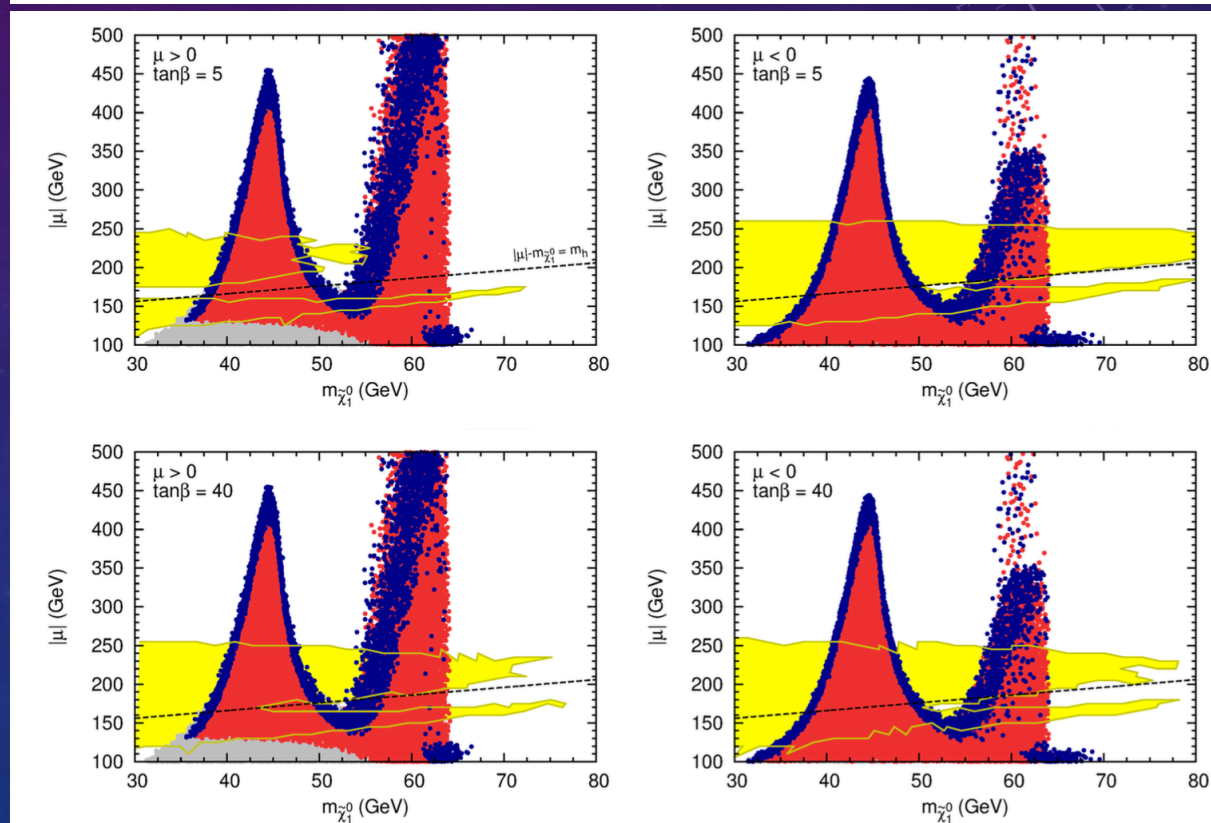
- How light can neutralino dark matter can be after the  $\sqrt{s} = 14$  TeV run data?

arXiv.org > hep-ph > arXiv:1410.5730

High Energy Physics – Phenomenology

## LHC Tests of Light Neutralino Dark Matter without Light Sfermions

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- 1 Introduction
- 2 The light dark matter scenario of the MSSM
- 3 Numerical scan and constraints
- 4 Future testing of light dark matter scenario
- 5 Conclusion

# 1 INTRODUCTION

- The lack of evidence for SUSY particles at the first phase of LHC has given stringent lower limits on their mass:

	Model	$\ell, \mu, \tau, \gamma$	Jets	$E_T^{\text{miss}}$	$\int \mathcal{L} d\mathcal{L} [\text{fb}^{-1}]$	Mass limit		Reference
						$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	
Inclusive Searches	MSUGRA/CMSSM	0-3 $e, \mu$ /1-2 $\tau$	2-10 jets/3 $b$	Yes	20.3	4.2	1.6 TeV	1507.05525
	$\tilde{q}\tilde{q}^* \rightarrow q\bar{q}l\bar{l}$	0	2-6 jets	Yes	20.3	850 GeV	$m(\tilde{l}_1^0)=m(\tilde{g})$	1405.7875
	$\tilde{q}\tilde{q}^* \rightarrow q\bar{q}l\bar{l}$ (compressed)	mono-jet	1-3 jets	Yes	20.3	100-440 GeV	$m(\tilde{g})=m(\tilde{l}_1^0)=10 \text{ GeV}$	1507.05525
	$\tilde{q}\tilde{q}^* \rightarrow q\bar{q}l\bar{l}(\ell\nu/\nu\nu)\tilde{l}_1^0$	2 $e, \mu$ (off-Z)	2 jets	Yes	20.3	780 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}$	1503.03290
	$\tilde{g}\tilde{g}^* \rightarrow q\bar{q}l\bar{l}$	0	2-6 jets	Yes	20.3	1.33 TeV	$m(\tilde{l}_1^0)=0 \text{ GeV}$	1405.7875
	$\tilde{g}\tilde{g}^* \rightarrow q\bar{q}l\bar{l} \rightarrow q\bar{q}W^+\tilde{l}_1^0$	0-1 $e, \mu$	2-6 jets	Yes	20	1.26 TeV	$m(\tilde{l}_1^0)<300 \text{ GeV}, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{g}))$	1507.05525
	$\tilde{g}\tilde{g}^* \rightarrow q\bar{q}l\bar{l}(\ell\nu/\nu\nu)\tilde{l}_1^0$	2 $e, \mu$	0-3 jets	-	20	1.32 TeV	$m(\tilde{l}_1^0)=0 \text{ GeV}$	1501.03555
	GMSB ( $\tilde{l}$ NLSP)	1-2 $\tau$ + 0-1 $\ell$	0-2 jets	Yes	20.3	1.6 TeV	$\tan\beta > 20$	1407.0603
	GGM (bino NLSP)	2 $\gamma$	-	Yes	20.3	1.29 TeV	$c\tau(\text{NLSP})<0.1 \text{ mm}$	1507.05493
	GGM (higgsino-bino NLSP)	7	1 $b$	Yes	20.3	1.3 TeV	$m(\tilde{l}_1^0)<900 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu<0$	1507.05493
	GGM (higgsino-bino NLSP)	7	2 jets	Yes	20.3	1.25 TeV	$m(\tilde{l}_1^0)<850 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu>0$	1507.05493
	GGM (higgsino NLSP)	2 $e, \mu$ (Z)	2 jets	Yes	20.3	850 GeV	$m(\tilde{l}_1^0)<850 \text{ GeV}$	1503.03290
$\tilde{g}$ gen. & med.	Gravitino LSP	0	mono-jet	Yes	20.3	865 GeV	$m(\tilde{g})>1.8 \times 10^{-4} \text{ eV}, m(\tilde{g})=m(\tilde{g})=1.5 \text{ TeV}$	1502.01518
	$\tilde{g}\tilde{g}^* \rightarrow b\bar{b}l\bar{l}$	0	3 $b$	Yes	20.1	1.25 TeV	$m(\tilde{l}_1^0)<400 \text{ GeV}$	1407.0600
	$\tilde{g}\tilde{g}^* \rightarrow t\bar{t}l\bar{l}$	0	7-10 jets	Yes	20.3	1.1 TeV	$m(\tilde{l}_1^0)<350 \text{ GeV}$	1308.1841
	$\tilde{g}\tilde{g}^* \rightarrow t\bar{t}l\bar{l}$	0-1 $e, \mu$	3 $b$	Yes	20.1	1.34 TeV	$m(\tilde{l}_1^0)<400 \text{ GeV}$	1407.0600
	$\tilde{g}\tilde{g}^* \rightarrow b\bar{b}l\bar{l}$	0-1 $e, \mu$	3 $b$	Yes	20.1	1.3 TeV	$m(\tilde{l}_1^0)<300 \text{ GeV}$	1407.0600
$\tilde{g}$ gen. squarks direct production	$\tilde{b}_1\tilde{b}_1^* \rightarrow b\bar{b}l\bar{l}$	0	2 $b$	Yes	20.1	100-620 GeV	$m(\tilde{l}_1^0)<90 \text{ GeV}$	1308.2631
	$\tilde{b}_1\tilde{b}_1^* \rightarrow b\bar{b}l\bar{l}$	2 $e, \mu$ (SS)	0-3 $b$	Yes	20.3	275-440 GeV	$m(\tilde{l}_1^0)=2 m(\tilde{l}_2^0)$	1404.2500
	$\tilde{t}_1\tilde{t}_1^* \rightarrow t\bar{t}l\bar{l}$	1-2 $e, \mu$	1-2 $b$	Yes	4.7/20.3	110-167 GeV	$m(\tilde{l}_1^0)=2m(\tilde{l}_2^0), m(\tilde{l}_2^0)=55 \text{ GeV}$	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1^* \rightarrow Wb\bar{l}\bar{l}$ or $t\bar{t}l\bar{l}$	0-2 $e, \mu$	0-2 jets/1-2 $b$	Yes	20.3	90-191 GeV	$m(\tilde{l}_1^0)=1 \text{ GeV}$	1506.0616
	$\tilde{t}_1\tilde{t}_1^* \rightarrow t\bar{t}l\bar{l}$	0	mono-jet/ $\nu$ -tag	Yes	20.3	90-240 GeV	$m(\tilde{l}_1^0)=m(\tilde{l}_2^0)<85 \text{ GeV}$	1407.0606
	$\tilde{t}_1\tilde{t}_1^*$ (natural GMSB)	2 $e, \mu$ (Z)	1 $b$	Yes	20.3	150-580 GeV	$m(\tilde{l}_1^0)>150 \text{ GeV}$	1403.5222
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	3 $e, \mu$ (Z)	1 $b$	Yes	20.3	290-600 GeV	$m(\tilde{l}_1^0)<200 \text{ GeV}$	1403.5222
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	2 $e, \mu$	0	Yes	20.3	90-325 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}$	1403.5294
EW direct	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	2 $e, \mu$	0	Yes	20.3	140-465 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1403.5294
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	2 $\tau$	-	Yes	20.3	100-350 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1407.0350
	$\tilde{t}_1\tilde{t}_1^* \rightarrow t\bar{t}l\bar{l}(\ell\nu/\nu\nu), \ell\bar{\nu}\ell\bar{\nu}(\ell\nu/\nu\nu)$	3 $e, \mu$	0	Yes	20.3	700 GeV	$m(\tilde{l}_1^0)=2, m(\tilde{l}_2^0)=0, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1402.7029
	$\tilde{t}_1\tilde{t}_1^* \rightarrow W\bar{t}l\bar{l}$	2-3 $e, \mu$	0-2 jets	Yes	20.3	420 GeV	$m(\tilde{l}_1^0)=m(\tilde{l}_2^0), m(\tilde{l}_2^0)=0, \text{ sleptons decoupled}$	1403.5294, 1402.7029
	$\tilde{t}_1\tilde{t}_1^* \rightarrow W\bar{t}l\bar{l}, h\bar{h} \rightarrow b\bar{b}/WW/\tau\tau/\gamma\gamma$	$e, \mu, \gamma$	0-2 $b$	Yes	20.3	250 GeV	$m(\tilde{l}_1^0)=m(\tilde{l}_2^0), m(\tilde{l}_2^0)=0, \text{ sleptons decoupled}$	1501.07110
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	4 $e, \mu$	0	Yes	20.3	620 GeV	$m(\tilde{l}_1^0)=m(\tilde{l}_2^0), m(\tilde{l}_2^0)=0, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1405.5086
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	2 $e, \mu$	0	Yes	20.3	140-465 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1403.5294
	$\tilde{t}_1\tilde{t}_1^*, \tilde{t}_2\tilde{t}_2^* \rightarrow t\bar{t}l\bar{l}$	2 $\tau$	-	Yes	20.3	100-350 GeV	$m(\tilde{l}_1^0)=0 \text{ GeV}, m(\tilde{l}_2^0)=0.5(m(\tilde{l}_1^0)+m(\tilde{l}_2^0))$	1407.0350



# 1 INTRODUCTION

- Searches have been started at the new round of experiments at higher energies (13 TeV). It is widely expected that much heavier sparticles will be explored very soon, which will be helpful to improve our understanding on some fundamental questions about nature.
- Obviously, discussing the potential of the future LHC experiments to test the MSSM is an important task for both theorists and experimentalists.
- In some fundamental theories such as the minimal supergravity theories, the EW sector tends to be significantly lighter than the colored sector.

# 1 INTRODUCTION

- The light EW sector can
  - be compatible with the constraints from **low energy processes** as well as from **the direct searches for the sparticles at the colliders**,
  - help to solve some experimental anomalies such as the discrepancy of the measured **muon anomalous magnetic moment** from its SM prediction,
  - explain **the Galactic Center  $\gamma$ -ray Excess** observed by the Fermi-LAT,
  - meet the minimal tree-level requirement posed by **naturalness**.



# 1 INTRODUCTION

- However, a light Higgsino-like DM can not account for the full amount of the observed relic density of the DM since it annihilated too efficiently in early universe.
- Consequently, simultaneous presence of light Bino and Higgsinos, which will mix to form a light DM, is the minimal ingredient of a natural MSSM.

$$\mathcal{L}_{\tilde{\chi}_i^0 \tilde{\chi}_j^0 Z} = \frac{g}{2c_W} Z_\rho \bar{\tilde{\chi}}_i^0 \gamma^\rho [O_{ij}^{ZL} P_L + O_{ij}^{ZR} P_R] \tilde{\chi}_j^0,$$
$$\mathcal{L}_{\tilde{\chi}_i^0 \tilde{\chi}_j^0 h} = \frac{g}{2} C_{ij}^h h \bar{\tilde{\chi}}_i^0 \tilde{\chi}_j^0,$$

$$O_{ij}^{ZL} = -\frac{1}{2} N_{i3} N_{j3}^* + \frac{1}{2} N_{i4} N_{j4}^*, \quad O_{ij}^{ZR} = -O_{ij}^{ZL*}$$

$$C_{ij}^h = \frac{1}{2} [(N_{i2} - N_{i1} \tan \theta_W)(\sin \alpha N_{j3} + \cos \alpha N_{j4}) + (i \leftrightarrow j)].$$

$$\tilde{\chi}_i^0 = N_{i1} \tilde{B} + N_{i2} \tilde{W}^0 + N_{i3} \tilde{H}_d^0 + N_{i4} \tilde{H}_u^0.$$

## 2 THE LIGHT DARK MATTER SCENARIO OF THE MSSM

- To concentrate on the lower bound of DM, we simplify the parameter space as following:
  - the masses of gluino and the first two generation of squarks are fixed to 2 TeV ,
  - for the third generation squarks, we assume  $m_{U_3} = m_{D_3}$  and  $A_t = A_b$ ,
  - the soft parameters in slepton are set as  $m_{L_{1,2,3}} = m_{E_{1,2,3}} = A_\tau$ .
- The remained free parameters are scanned in the following parameter space at 2 TeV scale :

$$\begin{aligned} &2 < \tan \beta < 60, \quad 10 \text{ GeV} < M_1 < 100 \text{ GeV}, \quad 100 \text{ GeV} < M_2 < 1000 \text{ GeV}, \\ &100 \text{ GeV} < \mu < 1500 \text{ GeV}, \quad 50 \text{ GeV} < M_A < 2 \text{ TeV} \\ &|A_t| < 5 \text{ TeV}, \quad 200 \text{ GeV} < m_{Q_3}, m_{U_3} < 2 \text{ TeV}, \quad 100 \text{ GeV} < m_L < 2 \text{ TeV}. \end{aligned}$$



## 2 THE LIGHT DARK MATTER SCENARIO OF THE MSSM

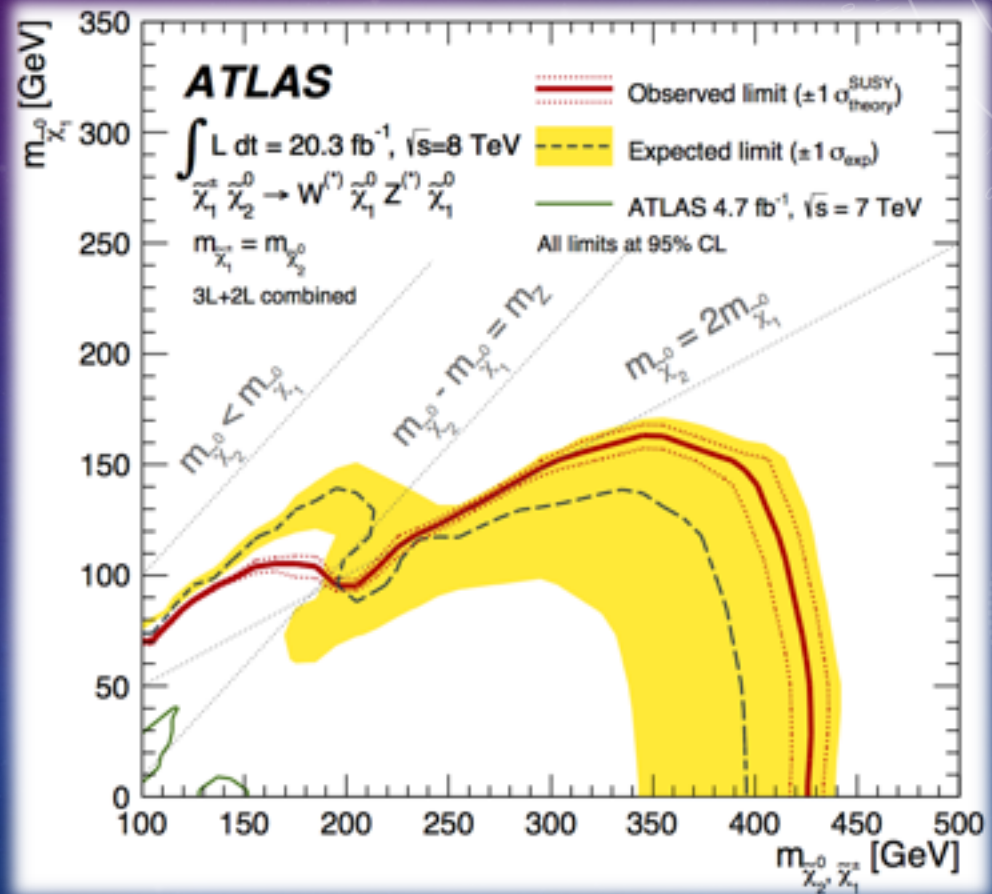
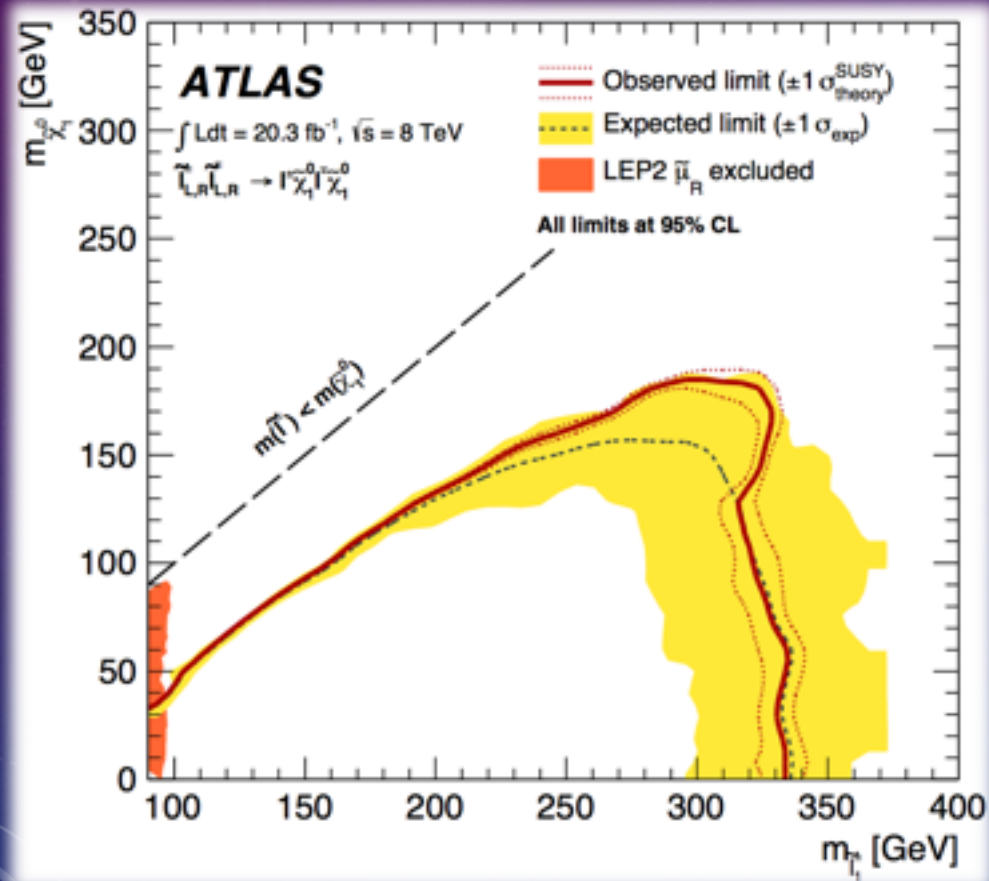
- In our scan, we impose the following constraints :
  - **DM relic density.** We require that the relic abundance smaller than the  $3\sigma$  upper limits of the PLANCK and WMAP 9-year data, i.e.  $\Omega h^2 < 0.131$ , where a 10% theoretical uncertainty is included. It will be meaningless if the sample has few contribution to the relic density. Thus we also put a lower limit  $\Omega h^2 > 0.01187$ .
  - **DM direct searches.** The result of LUX experiment is taken into consideration by requiring the  $\sigma_p^{SI}$  of neutralino DM multiplied by the ratio of  $\Omega h^2$  to 0.1187 under the exclusion bound at 90% C.L

## 2 THE LIGHT DARK MATTER SCENARIO OF THE MSSM

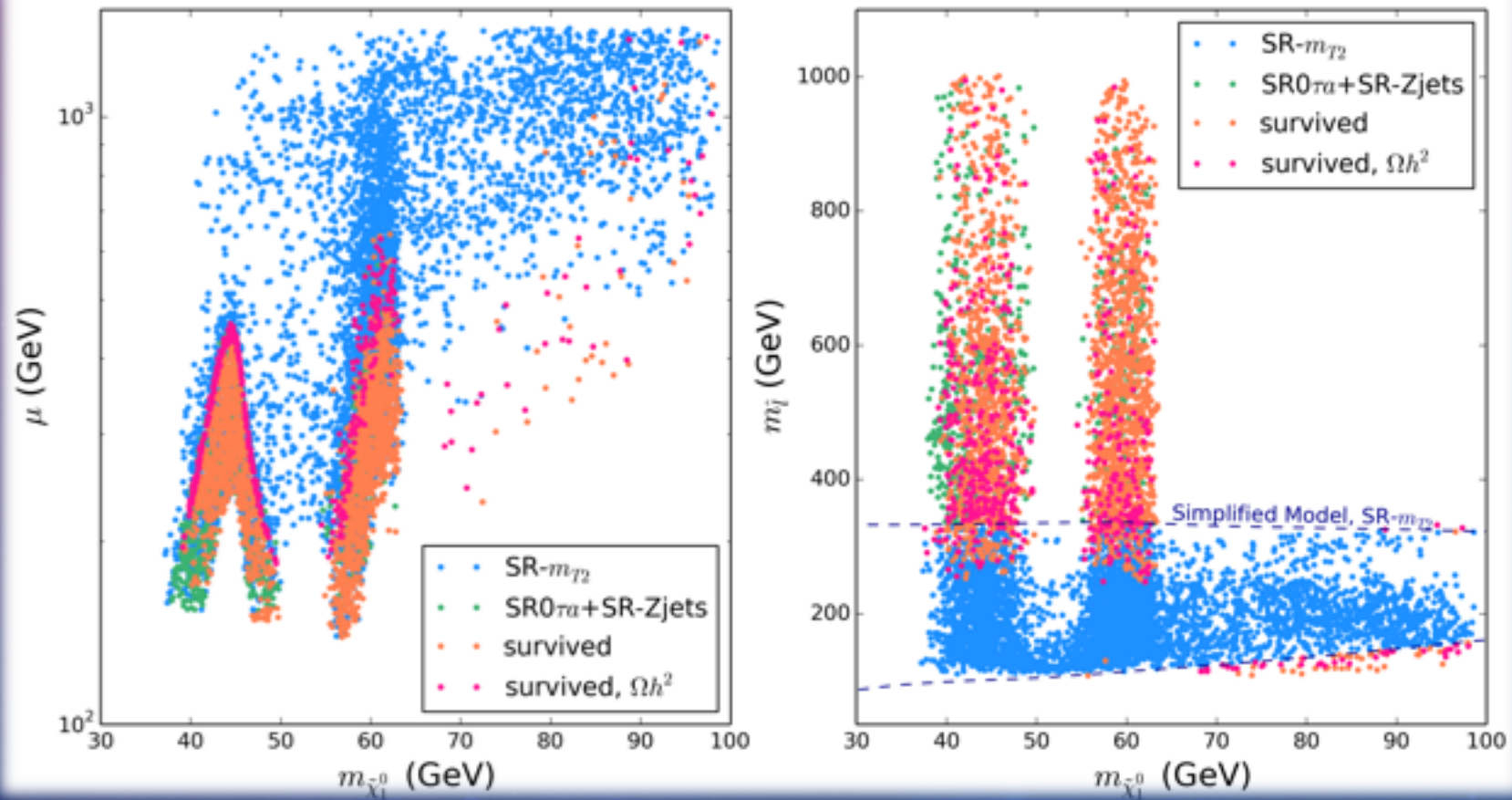
- In our scan, we impose the following constraints :
  - **The constraints from the LEP**, including  $m_{\tilde{\chi}_1^\pm} > 103$  GeV,  $m_{\tilde{l}} > 99.9$  GeV, and  $\Gamma_{Z \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0} < 1.71$  MeV.
  - **Higgs sector**. We used the package HiggsBounds and HiggsSignal to considerate the constraints of Higgs sector. We require the fit for the signal rates of SM-like Higgs to the data from Tevetron and LHC at  $2\sigma$  level.
  - **The muon anomalous magnetic moment**,  $12.7 < \alpha_\mu^{SUSY} < 44.7$ .
  - **The constraints of B-physics and the precision electroweak observables**, such as decays  $B \rightarrow X_s \gamma$ ,  $B_s \rightarrow \mu^+ \mu^-$ ,  $B_d \rightarrow X_s \mu^+ \mu^-$ ,  $B^+ \rightarrow \tau^+ \nu$  and  $\rho_l$ ,  $\sin^2 \theta_{eff}^l$ ,  $m_W$   $R_b$ .



## 2 THE LIGHT DARK MATTER SCENARIO OF THE MSSM

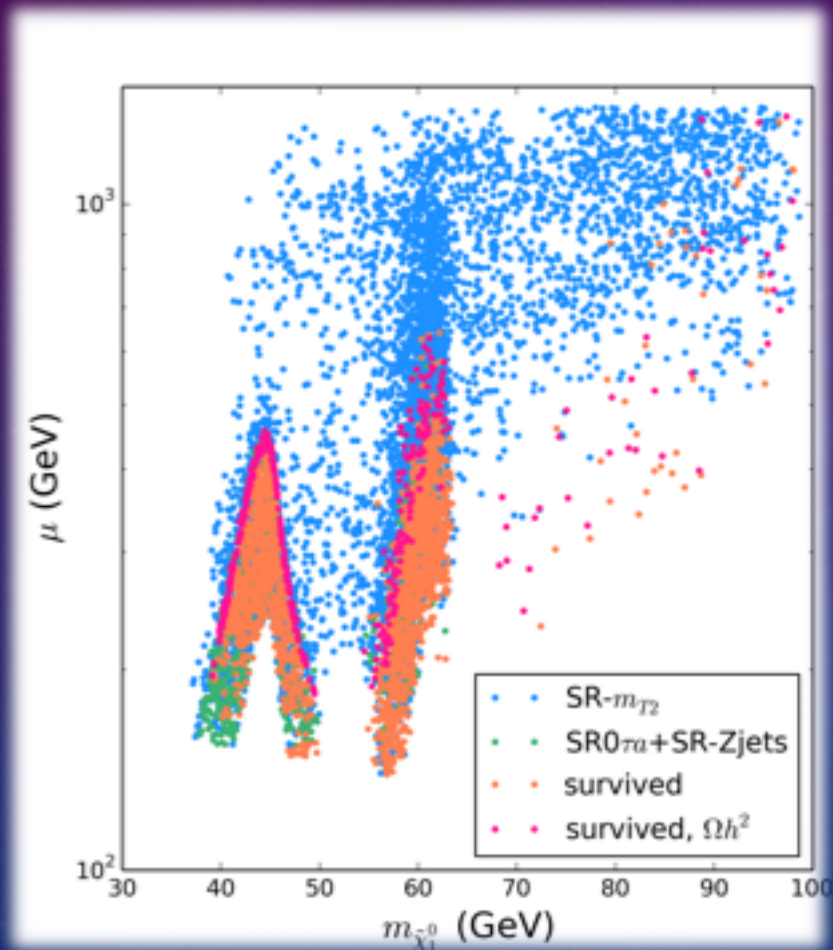


### 3 NUMERICAL SCAN AND CONSTRAINTS





### 3 NUMERICAL SCAN AND CONSTRAINTS



- The red and orange points fulfill all the constraints explained above.
- The survived samples show clearly two peaks around  $m_Z/2$  and  $m_h/2$ .

$$\mathcal{L}_{\tilde{\chi}_i^0 \tilde{\chi}_j^0 Z} = \frac{g}{2c_W} Z_\rho \tilde{\chi}_i^0 \gamma^\rho [O_{ij}^{ZL} P_L + O_{ij}^{ZR} P_R] \tilde{\chi}_j^0,$$

$$\mathcal{L}_{\tilde{\chi}_i^0 \tilde{\chi}_j^0 h} = \frac{g}{2} C_{ij}^h h \tilde{\chi}_i^0 \tilde{\chi}_j^0,$$

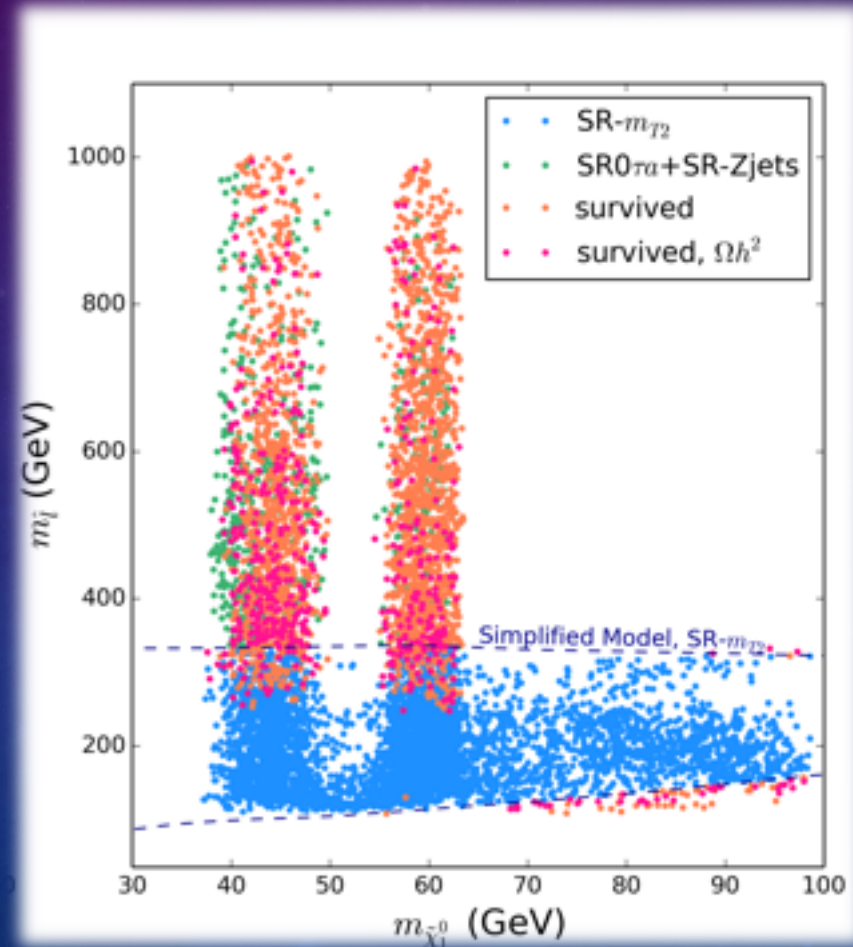
$$O_{ij}^{ZL} = -\frac{1}{2} N_{i3} N_{j3}^* + \frac{1}{2} N_{i4} N_{j4}^*, \quad O_{ij}^{ZR} = -O_{ij}^{ZL*}$$

$$C_{ij}^h = \frac{1}{2} [(N_{i2} - N_{i1} \tan \theta_W)(\sin \alpha N_{j3} + \cos \alpha N_{j4}) + (i \leftrightarrow j)].$$

$$\tilde{\chi}_i^0 = N_{i1} \tilde{B} + N_{i2} \tilde{W}^0 + N_{i3} \tilde{H}_d^0 + N_{i4} \tilde{H}_u^0.$$

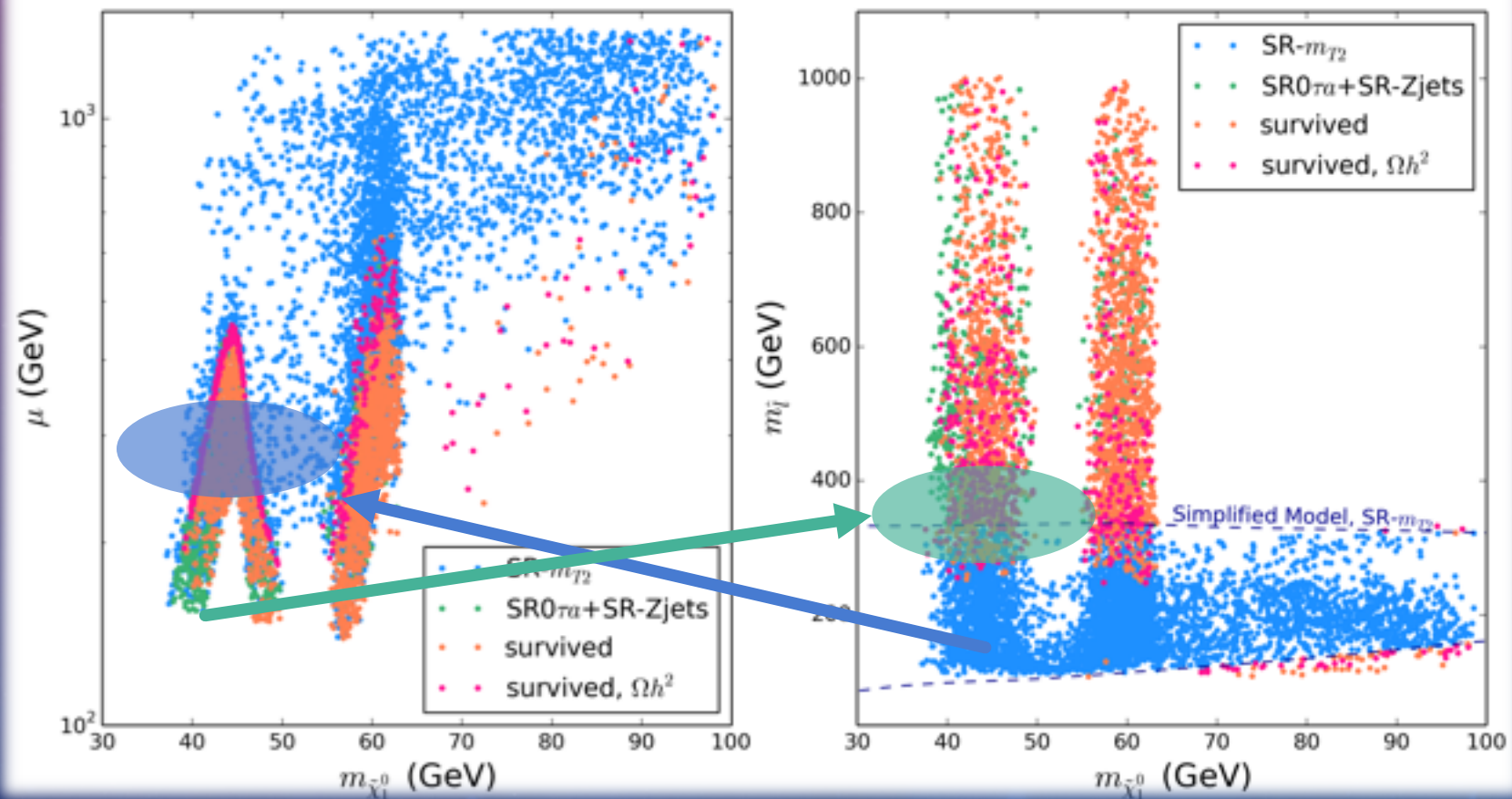
### 3 NUMERICAL SCAN AND CONSTRAINTS

- The most samples that in the early universe the DM annihilation by a light slepton are excluded by the  $2l + E_T^{miss}$  search.
- For the survived samples, the slepton has nothing to do with the relic density.
- The survived samples in the excluded region of SR- $m_{T2}$  for simplified model have the spectrum that Higgsino mass lighter than slepton mass.



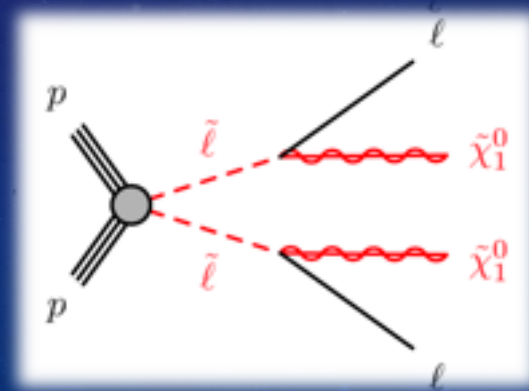
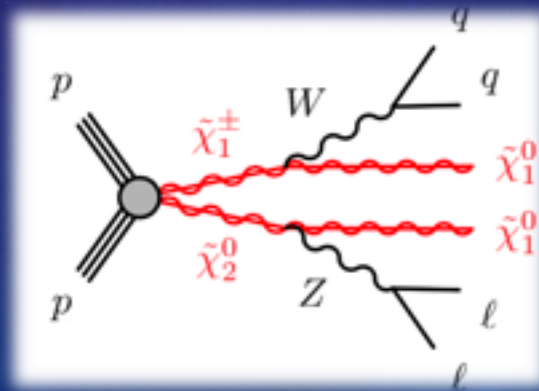
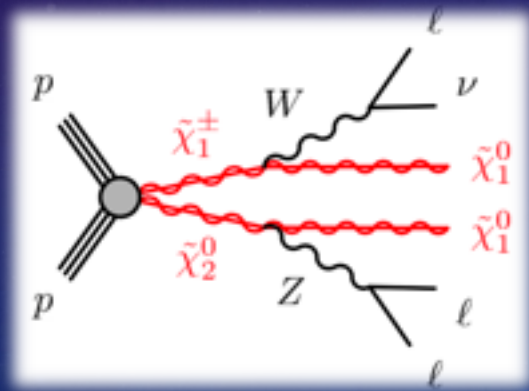


## 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO



# 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO

- Monte Carlo simulation Tools:
  - MG5\_aMC/MadEvent for generating hard events;
  - Pythia for parton showering and hadronization;
  - Delphes for fast simulation of the ATLAS detector;
  - CheckMATE for implement the cut of searches for direct production of charginos, neutralinos and sleptons.





## 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO

- To obtain accurate background events, we first calculate each background process at both the 8TeV LHC and 14TeV LHC by directly simulation to get the their ratio. Then we multiply the ratio to the background at the 8TeV LHC, which was provided in the ATLAS report.

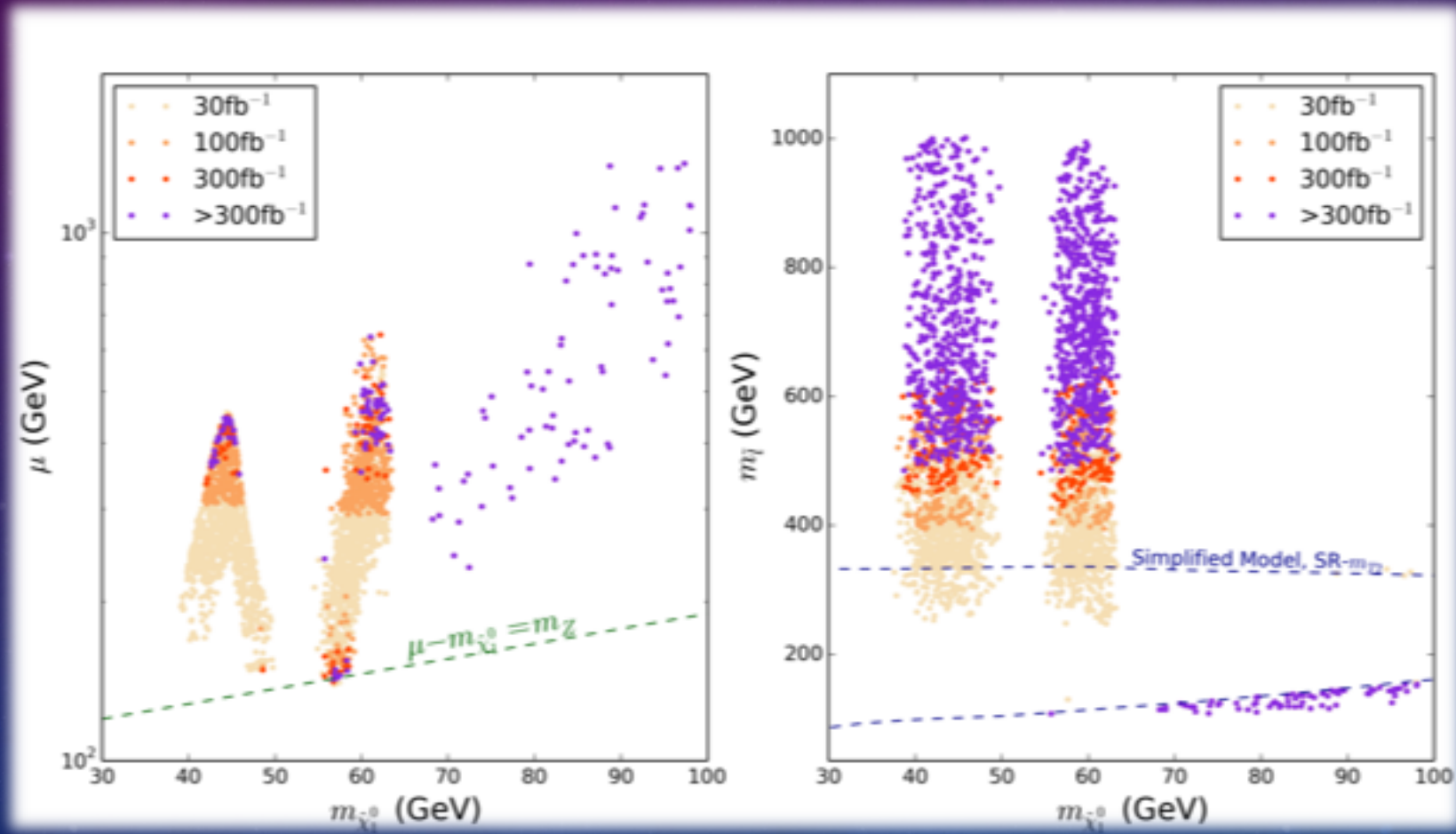
SR	$N_j$	$\Delta m_{ll,Z}$	$E_{T,rel}^{miss}$	$P_T^{ll}$	$m_{T2}$	$\Delta R_{ll}$	$m_{jj}$	WW	ZV	Other	Total
$m_{T2}^{90}$	0	$> 10$	—	—	$> 90$	—	—	1.71	1.36	0.26	3.33
$m_{T2}^{120}$	0	$> 10$	—	—	$> 120$	—	—	0.12	0.44	0.00	0.57
$m_{T2}^{150}$	0	$> 10$	—	—	$> 150$	—	—	0.02	0.19	0.00	0.21
Zjets	$\leq 2$	$< 10$	$> 80$	$> 80$	—	$[0.3, 1.5]$	$[50, 100]$	0.02	0.14	0.03	0.19

# 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO

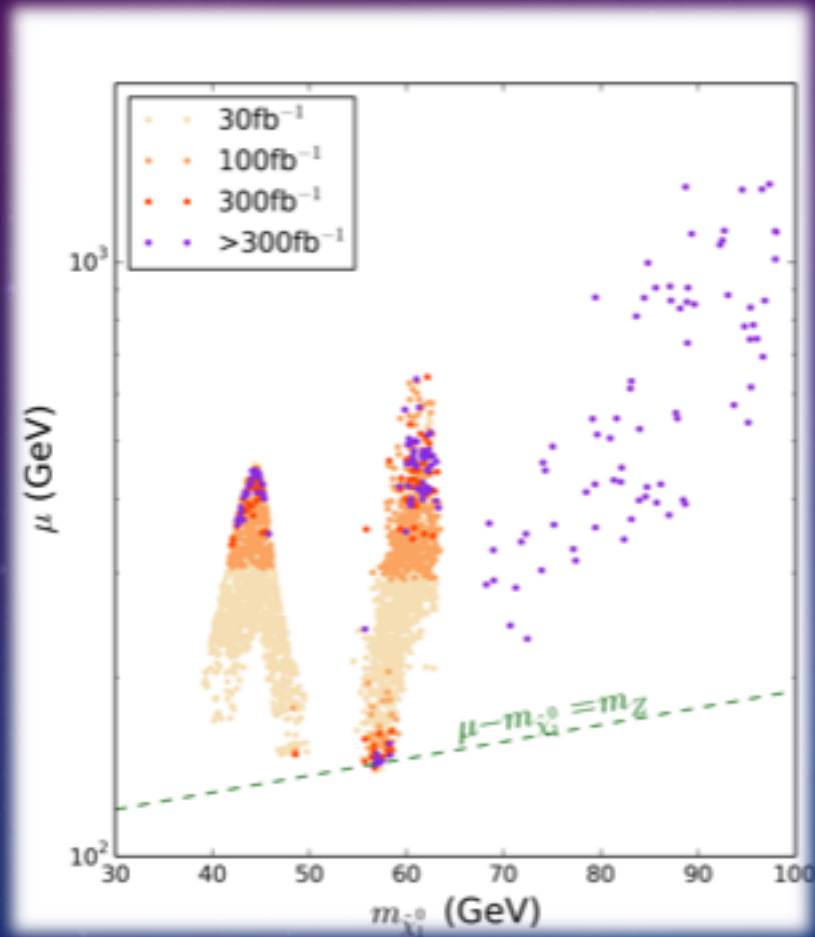
SR0 $\tau$ a	$m_{SFOS}$	$m_T$	$E_T^{miss}$	$m_{3l}$	VVV	WZ	ZZ	t	h	$t\bar{t}$	Total
1	12-40	0-80	50-90	no	0.03	1.11	0.11	0.02	0.07	1.05	2.41
2	12-40	0-80	>90	no	0.01	0.28	0.01	0.01	0.03	0.11	0.45
3	12-40	>80	50-75	no	0.02	0.66	0.03	0.00	0.07	0.22	1.00
4	12-40	>80	>75	no	0.06	0.45	0.02	0.02	0.05	0.48	1.08
5	40-60	0-80	50-75	yes	0.02	0.52	0.13	0.01	0.04	0.65	1.37
6	40-60	0-80	>75	no	0.02	0.33	0.02	0.00	0.04	0.33	0.76
7	40-60	>80	50-135	no	0.08	0.64	0.05	0.00	0.11	0.61	1.49
8	40-60	>80	>135	no	0.02	0.04	0.00	0.02	0.04	0.08	0.20
9	60-81.2	0-80	50-75	yes	0.02	1.40	0.12	0.02	0.03	0.79	2.40
10	60-81.2	>80	50-75	no	0.04	1.09	0.05	0.02	0.02	0.29	1.51
11	60-81.2	0-110	>75	no	0.06	1.75	0.07	0.07	0.04	0.99	2.98
12	60-81.2	>110	>75	no	0.07	0.34	0.01	0.02	0.02	0.16	0.63
13	81.2-101.2	0-110	50-90	yes	0.14	52.16	2.60	0.56	0.23	10.73	66.41
14	81.2-101.2	0-110	>90	no	0.10	19.95	0.56	0.44	0.15	0.42	21.62
15	81.2-101.2	>110	50-135	no	0.11	5.13	0.35	0.13	0.04	0.21	5.98
16	81.2-101.2	>110	>135	no	0.05	0.47	0.01	0.02	0.00	0.03	0.59
17	>101.2	0-180	50-210	no	0.34	4.80	0.24	0.12	0.13	2.01	7.65
18	>101.2	>180	50-210	no	0.06	0.28	0.01	0.02	0.01	0.04	0.44
19	>101.2	0-180	>210	no	0.02	0.13	0.00	0.00	0.00	0.08	0.24
20	>101.2	>180	>210	no	0.01	0.02	0.00	0.00	0.00	0.04	0.09



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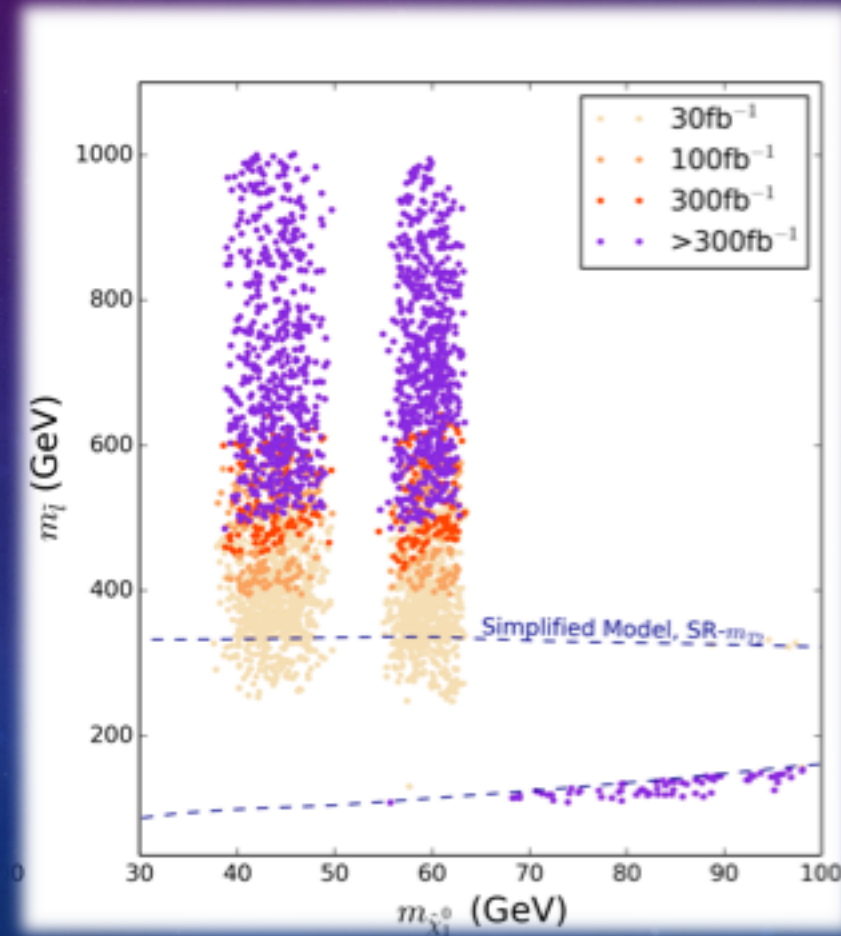


- Using  $30\text{fb}^{-1}$  of collision data at  $\sqrt{s} = 14\text{ TeV}$  LHC, a lot of points can be excluded.
- With higher integrated luminosity, more samples can reach the 95% C.L. limit.
- But at the top and the right bottom of the  $m_Z$  resonances, some samples are hard to be excluded.

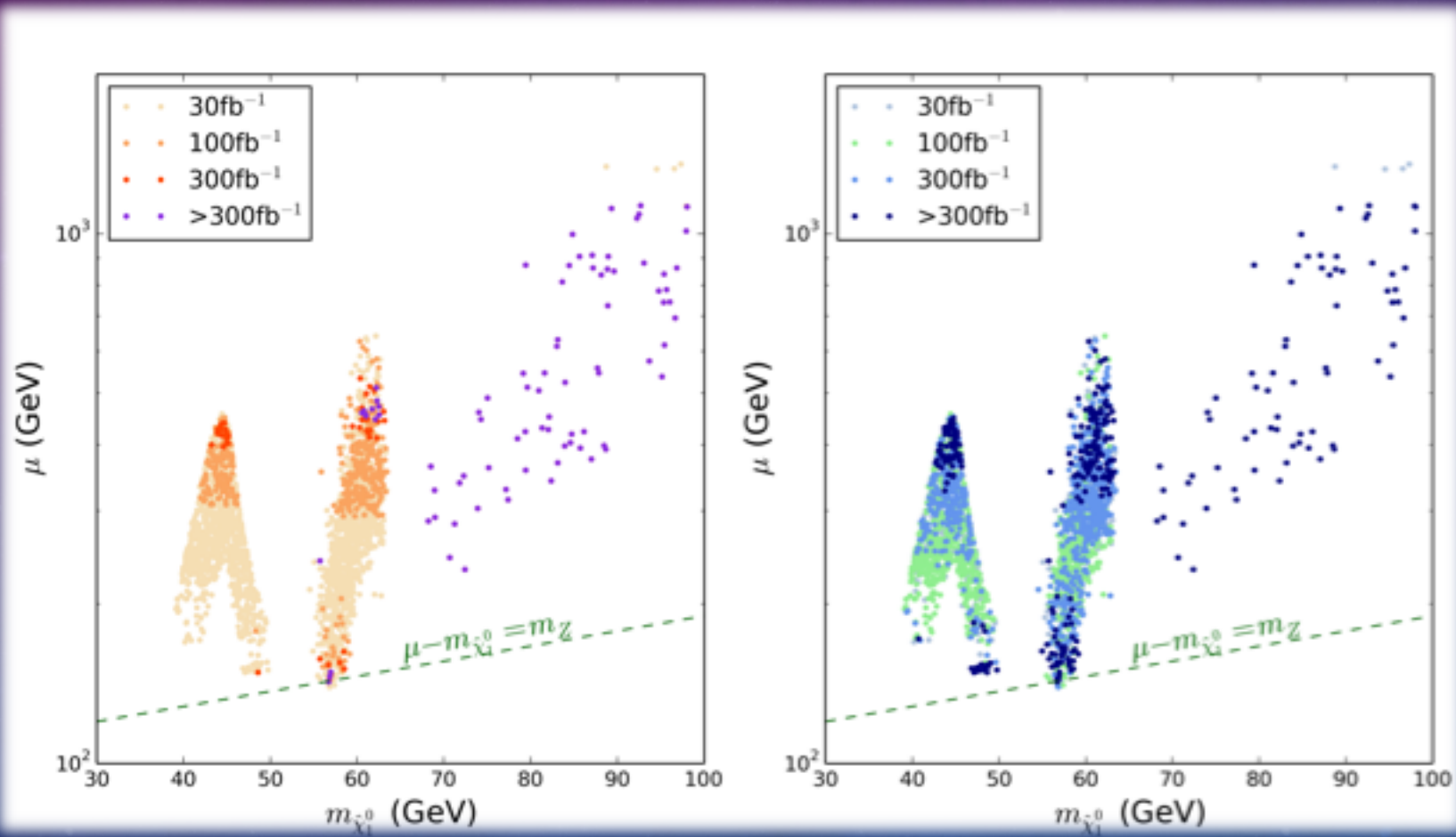


## 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO

- For the samples above the current excluded region, the exclusion limit enhance with more data.
- The mass of slepton are excluded to about 400 GeV, 450 GeV and 500 GeV at 95% C.L. with  $30\text{ fb}^{-1}$ ,  $100\text{ fb}^{-1}$ ,  $300\text{ fb}^{-1}$  respectively.
- For the lower right points, these signal regions still have no sensitive because of mass splitting.



## 4 FUTURE TEST OF LIGHT DARK MATTER SCENARIO





## 5 CONCLUSION

- The purpose of this study is to show that the light dark matter scenario of the MSSM is easy to be tested at LHC Run-II by searches for electroweakly interacting SUSY particles .
- If there is still no corresponding excess at Run-II, one should be careful in dealing with light dark matter of MSSM. According to our predictions, the samples in MSSM of  $m_{\tilde{\chi}_1^0} < 50$  GeV, which means the main annihilation mode of dark matter goes through an s-channel Z boson, will be excluded at 95% C.L. by the data of  $300 \text{ fb}^{-1}$  at the 14 TeV LHC.
- These predictions are rough but conservative.

Thank you!





Thank you!

# Future dark matter direct searches

