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mSUGRA Test Points for CMS

Preamble

- Proposal by John Ellis *et al.* (hep-ph/0306219)
  - Post-LEP benchmark points (hep-ph/0106204) have been readjusted in view of the new CDM (Cold Dark Matter) results from WMAP satellite (hep-ph/0303043).
  - We have "borrowed" three points from this paper…

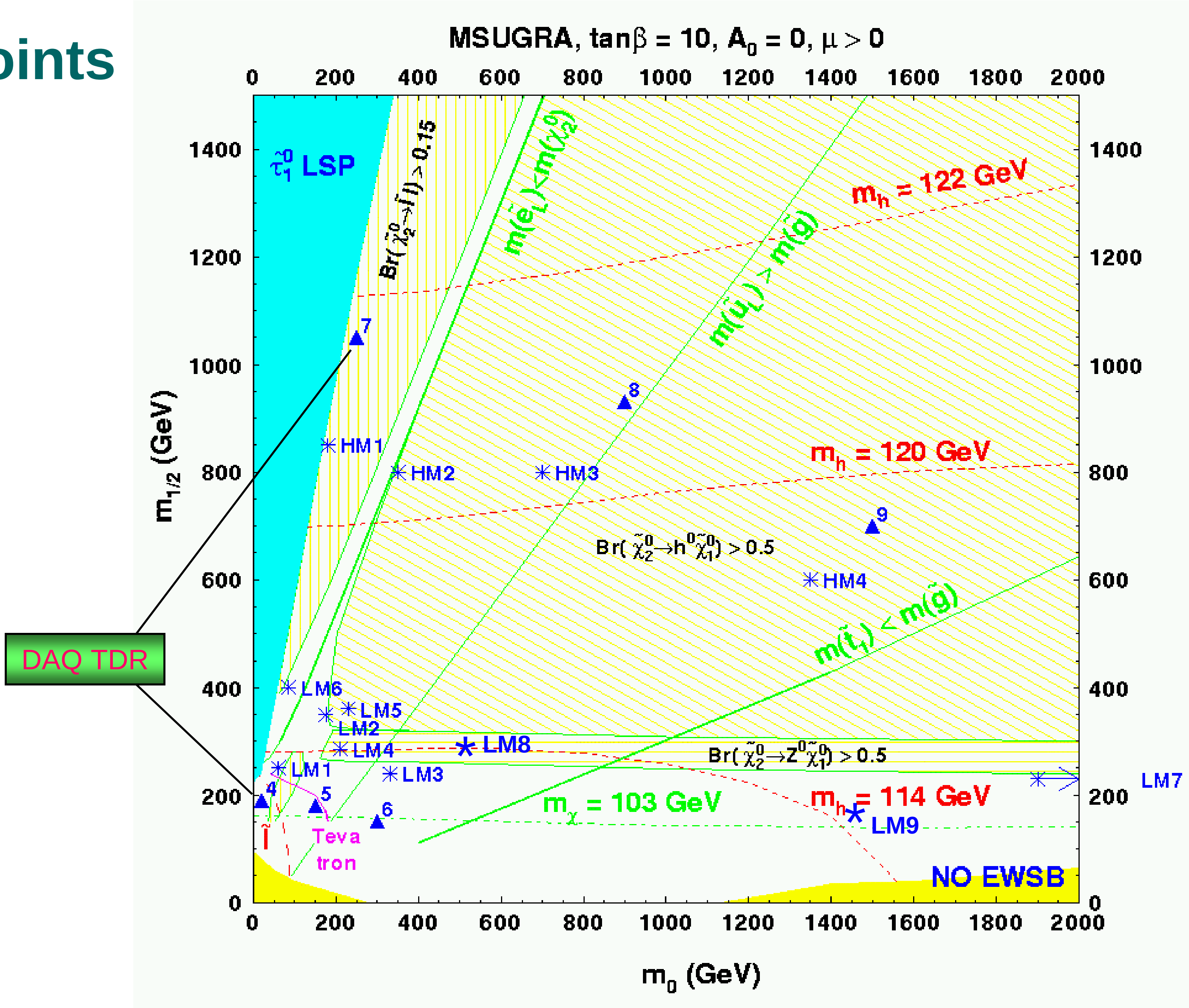
- Our primary goal is a diversity of final states at lowest possible mass scale (for LHC startup) not always keeping CDM constraints satisfied …

Low-Mass and High-Mass Points

http://cmsdoc.dern.ch/cms/PRS/susybsm/msugra_testpts/msugra_testpts.html

- "LM1-LM9" mSUGRA points proposed for CMS studies at the LHC start-up period
  - Large total production cross section, assumed to be quickly discovered – within a few months of LHC running at low luminosity
  - Low sparticle mass scale (500-800 GeV) just above Tevatron II reach
- "HM1-HM4" mSUGRA points proposed for CMS studies for the LHC running at high luminosity
  - Mass scale of strongly-interacting sparticles of 1,5-2 TeV

Points



MSUGRA, tanβ = 10, A0 = 0, μ > 0
$\tilde{\tau}_1^0$ LSP
Br($\tilde{\chi}_2^0 \to \tilde{l} l$) > 0.15
m($\tilde{e}_L$)<m($\tilde{\chi}_2^0$)
m($\tilde{u}_L$) > m($\tilde{g}$)
m($\tilde{t}_1$) < m($\tilde{g}$)
m_h = 122 GeV
m_h = 120 GeV
m_h = 114 GeV
m_χ = 103 GeV
Br($\tilde{\chi}_2^0 \to h^0 \tilde{\chi}_1^0$) > 0.5
Br($\tilde{\chi}_2^0 \to Z^0 \tilde{\chi}_1^0$) > 0.5
HM1
HM2
HM3
HM4
LM1
LM2
LM3
LM4
LM5
LM6
LM7
LM8
LM9
4
5
6
7
8
9
$\tilde{l}$
Teva
tron
NO EWSB
DAQ TDR
$m_{1/2}$ (GeV)
m_0 (GeV)

Parameters of LM Points (I)

ISASUGRA 7.69

- LM1: m0=60, m1/2=250 (B')

  $\tilde{\chi}_2^0 \rightarrow \tilde{l}_R\, l$ (11.2 %), $\tilde{\tau}_1\, \tau$ (46 %), $\tilde{\chi}_1^+ \rightarrow \tilde{\nu}_L\, l$ (36 %),

  $M(\tilde{g}) > M(\tilde{q})$: $\tilde{g} \rightarrow \tilde{q}\, q$

  Near DAQ TDR point 4, Post-LEP benchmark point B'

- LM2: m0=175, m1/2=350, tan β=35 (I')

  Br ($\tilde{\chi}_2^0 \rightarrow \tilde{\tau}_1\, \tau$) = 96 % Br ($\tilde{\chi}_1^+ \rightarrow \tilde{\tau}_1\, \nu$) = 95 %

  M(g) > M(q) : $\tilde{g} \rightarrow \tilde{q}\, q$ Post-LEP benchmark point I'

- LM3: m0=330, m1/2=240, tan β = 20

  $M(\tilde{g}) < M(\tilde{q})$: $\tilde{g} \rightarrow \tilde{b}_{1,2}\, b$ (85 %),

  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\, Z^*$, $\tilde{\chi}_1^+ \rightarrow \tilde{\chi}_1^0\, W$ (100 %)

- LM4: m0=210, m1/2=285

  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\, Z$ (97 %), $\tilde{\chi}_1^+ \rightarrow \tilde{\chi}_1^0\, W$ (99.5 %)

  Z-mass constraint can be applied

Parameters of LM Points (II)

- LM5: m0=230, m1/2=360

$\tilde{\chi}^0_2 \to \tilde{\chi}^0_1\, h$ (85 %), $\tilde{\chi}^+_1 \to \tilde{\chi}^0_1 W$ (97 %)

$h \to b\bar{b}$ (83 %)

Abundant h production

- LM6: m0=85, m1/2=400 (C')

$\tilde{\chi}^0_2 \to \tilde{l}_{L,R}\, l$ (14 %) : μ, e $\tilde{\chi}^+_1 \to \tilde{\chi}^0_1\, \tilde{l}\, \nu\, (\tilde{\nu}\, l)$ (54 %)

$\tilde{\chi}^0_2 \to \tilde{\tau}_{1,2}\, \tau$ (~18 %) *Post-LEP benchmark point C'*

- LM7: m0=3000 GeV, m1/2=230 GeV

☞ Squarks are too heavy to play any role,
m($\tilde{g}$) = 678 GeV, m($\tilde{\chi}^+_1$) = 133 GeV
EW chargino-neutralino production cross section is ~73 % of the total one.

$Br(\tilde{\chi}^0_2 \to \tilde{\chi}^0_1\, l^+ l^-) = 7\ \%$ $Br(\tilde{\chi}^+_1 \to \tilde{\chi}^0_1\, l^+ \nu) = 22\ \%$, $l = e,\mu$

Parameters of LM Points (III)

- LM8: m0=500 GeV, m1/2=300 GeV, A0 = -300 GeV

  $M(\tilde{g}) < M(\tilde{q})$: $\tilde{g} \rightarrow \tilde{b}_1\ b$ (14 %), $\tilde{g} \rightarrow \tilde{t}_1\ t$ (80 %),

  $\tilde{\chi}^0_2 \rightarrow \tilde{\chi}^0_1 Z$, $\tilde{\chi}^+_1 \rightarrow \tilde{\chi}^0_1 W$ (100 %)

  Vienna-Budapest group : search for stop in squark-gluino production in Z + 2b-jets + MET final state

- LM9: m0=1450 GeV, m1/2=175 GeV, tan β=50

  Similar to LM7

  $m(\tilde{g})$ = 507 GeV, $m(\tilde{\chi}^+_1)$ = 118 GeV

  Br ($\tilde{\chi}^0 \rightarrow \tilde{\chi}^0_1 l^+ l^-$) = 6.5 % Br ($\tilde{\chi}^+ \rightarrow \tilde{\chi}^0 l^+ \nu$) = 22 % $l = e,\mu$

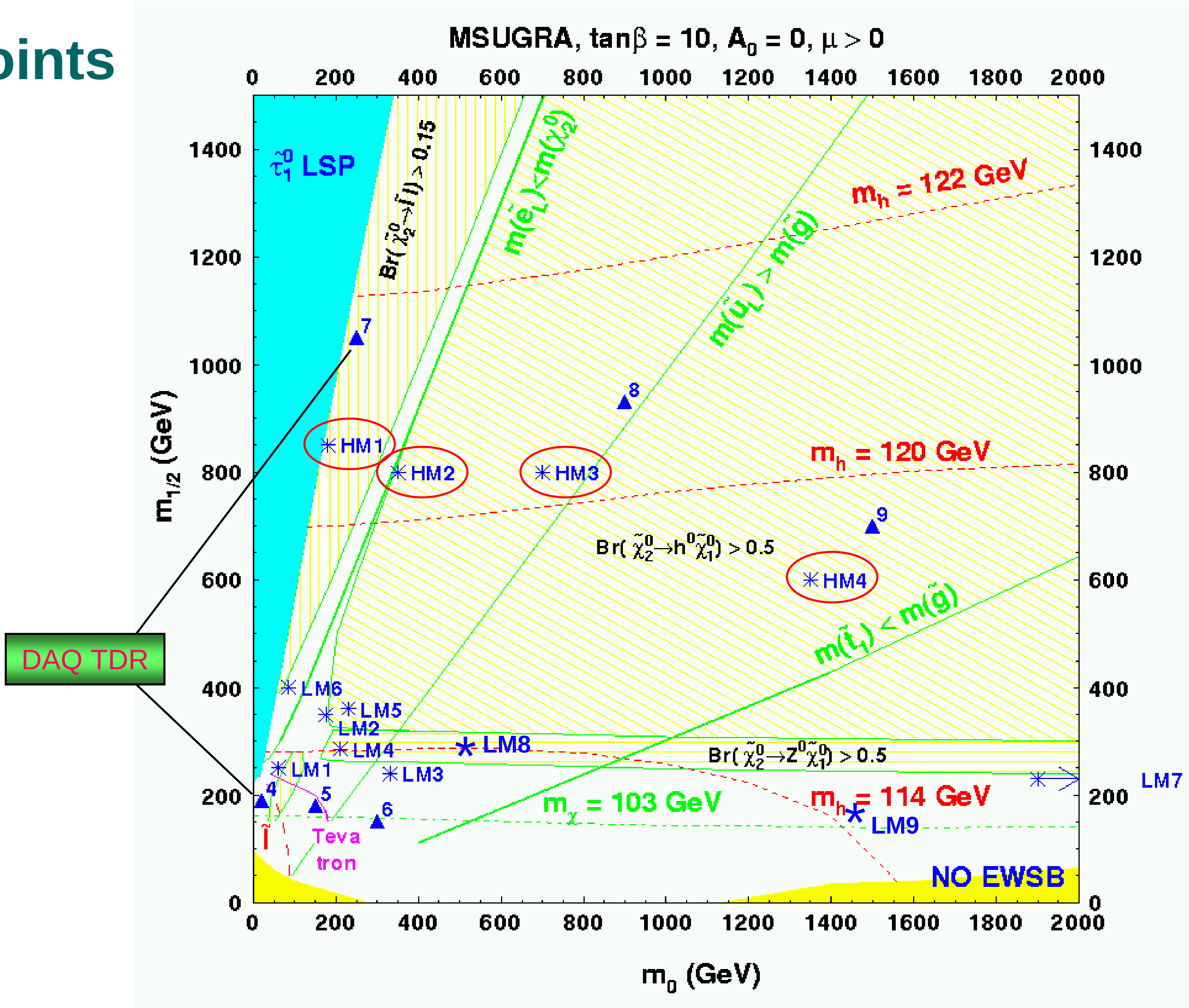
  Karsruhe group : study of point where ERGET data on diffuse gamma rays consistent with WMAP data on CDM with heavy squarks and sleptons

☞ Only 4 points (LM1, LM2, LM6 and LM9) "directly" compatible with the CDM constraints.

Parameters of HM Points (I)

- Masses and branchings – ISASUGRA (7.69)
- LO total and partial cross sections – PYTHIA 6.225
- Mass scale is taken a bit lower than for high-lumi points from DAQ TDR (7,8,9), as one may need more data for the events reconstruction (not only for the discovery excess observation).

Points



MSUGRA, tanβ = 10, A0 = 0, μ > 0
τ̃1 LSP
Br(χ̃2→l̃l) > 0.15
m(ẽL)<m(χ̃2)
m(ũL) > m(g̃)
mh = 122 GeV
mh = 120 GeV
mh = 114 GeV
Br(χ̃2→h χ̃1) > 0.5
Br(χ̃2→Z χ̃1) > 0.5
m(t̃1) < m(g̃)
mχ = 103 GeV
HM1
HM2
HM3
HM4
LM1
LM2
LM3
LM4
LM5
LM6
LM7
LM8
LM9
4
5
6
7
8
9
Teva
tron
l̃
NO EWSB
DAQ TDR
m1/2 (GeV)
m0 (GeV)

Parameters of HM Points (II)

	m_0 GeV	$m_{1/2}$ GeV	$\tan\beta$	σ_{tot} fb	P(h)	$P(\tilde{\chi}_2^0)$	$h \to bb$	$Br(\tilde{\chi}_2^0 \to \tilde{l}\, l)$	Signal estimate fb
1	180	850	10	54		0.32		0.28	4.8
2	350	800	35	66		0.32		0.78 ($\tilde{\tau}_1 \tau$)	16
3	700	800	10	48	0.41		¼*		4.9
4	1350	600	10	110	0.58		¼*		16

$A_0=0$, $\mu>0$

* to take into account (approximately) $h \to bb$ branching and b-tagging efficiency

Parameters of HM Points (III)

- HM1: m0=180 GeV, m1/2=850 GeV, tan β=10

  $\tilde{\chi}_2^0 \to \tilde{l}_L\, l$ (27.5 %), $\tilde{\tau}_2 \tau$ (15 %), $\tilde{\chi}_1^\pm \to \tilde{\nu}_L\, e(\mu)$ (37 %),

  $M(\tilde{g}) > M(\tilde{q})$: $\tilde{g} \to \tilde{q}\, q$

- HM2: m0=350 GeV, m1/2=800 GeV, tan β=35

  $\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau$ (78 %), $\tilde{\chi}_1^\pm \to \tilde{\nu}_L \tau + \tilde{\tau}_1 \nu$ (13+76 %)

- HM3: m0=700 GeV, m1/2=800 GeV, tan β=10 ("resembles" LM5)

  $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\, h$ (94 %), $\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0\, W$ (~100 %)

  $M(\tilde{g}) > M(\tilde{q})$: $\tilde{g} \to \tilde{b}_{1,2}\, b + \tilde{t}_{1,2}\, t$ (80 %)

  $\tilde{q}_L \to \tilde{\chi}_2^0\, q$ (~1/3) + $\tilde{\chi}_1^\pm\, q$ (2/3), $\tilde{q}_R \to \tilde{\chi}_1^0\, q$ (100 %)

- HM4: m0=1350 GeV, m1/2=650 GeV, tan β=10, σ_{EW} ~ 45 % of the total

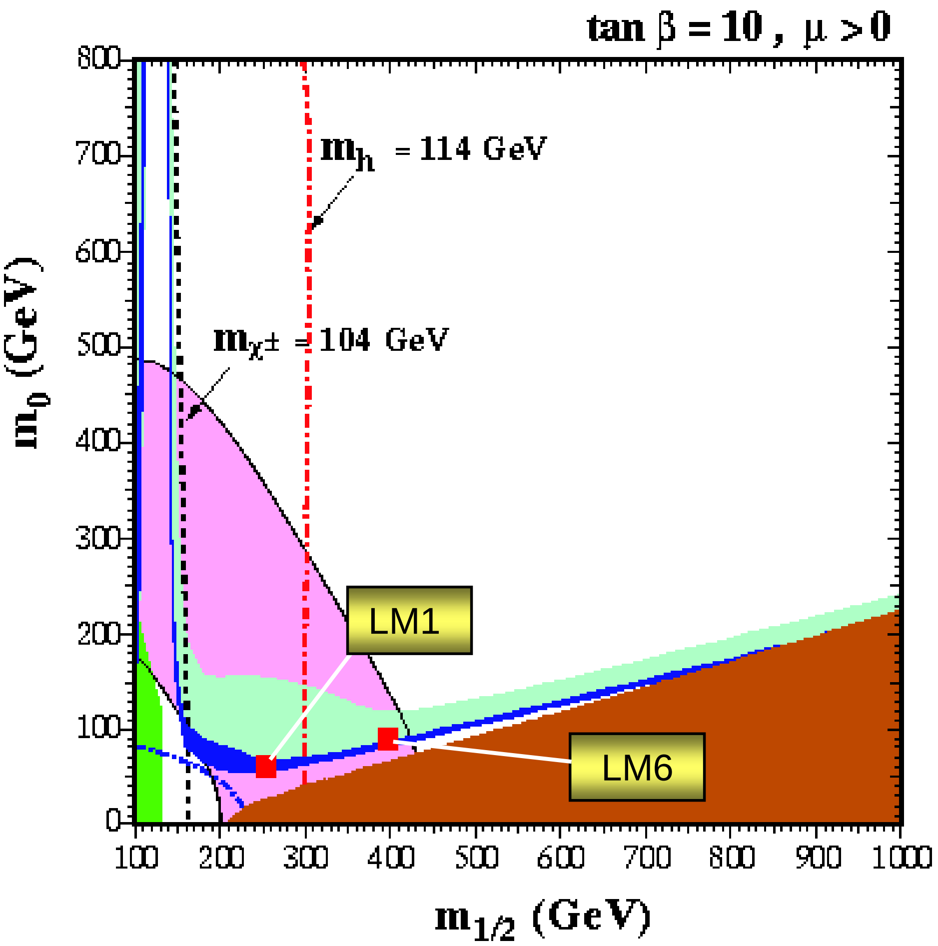
  $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\, h$ (94 %), $\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0\, W$ (~100 %)

  $M(\tilde{g}) < M(\tilde{q})$: $\tilde{g} \to \tilde{t}_1 t$ (82 %), $\tilde{q}_L \to \tilde{g}\, q$ (> 40 %), $\tilde{q}_R \to \tilde{g}\, q$ (77-93 %)

Addendum

Compatibility with CDM constraint

- J.Ellis et al., hep-ph/0303043



Legend :

- older cosmological constraint $0.1 < \Omega_\chi h^2 < 0.3$
- newer cosmological constraint $0.094 < \Omega_\chi h^2 < 0.129$
- $\tilde{\chi}_1^0$ is not LSP
- excluded by b -> s γ
- favored by $g_\mu - 2$ at 2-σ level