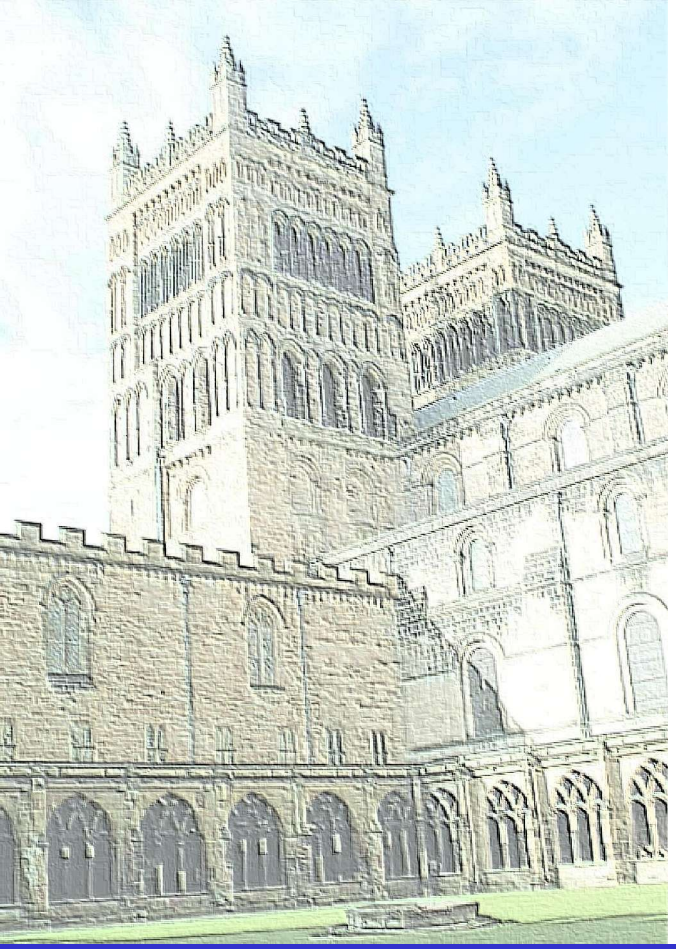

ECFA Study

Physics and Detectors for a Linear Collider

Alternate SUSY approaches to DM

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Purpose of this presentation

Help to define new SUSY workir

points

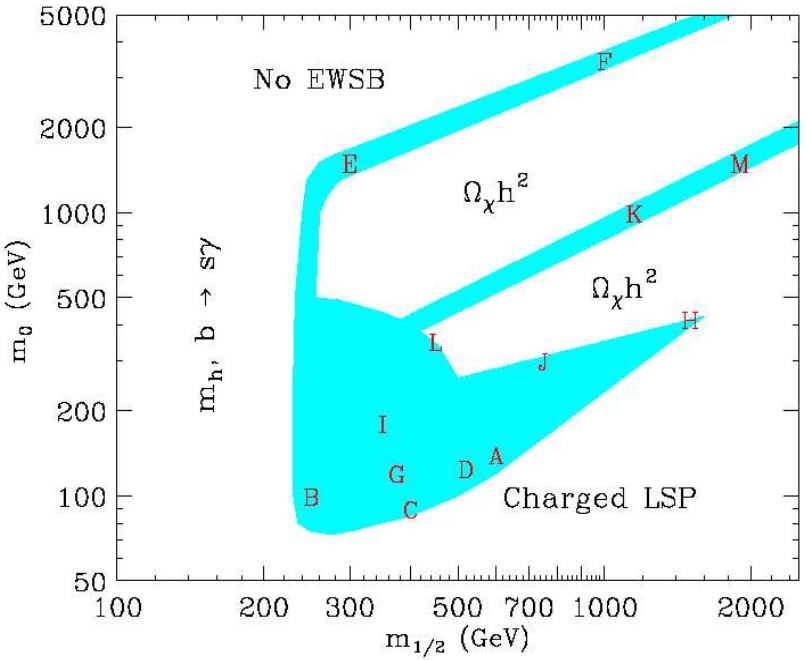
- not necessarily mSUGRA
- experimentally challenging

(if needed)

to launch new experimental stud

on DM for future colliders LC

and LHC



Introduction

- mSUGRA has been/is the favourite framework used for collider phenomenology
- There are other possible schemes e.g. :

  - without gaugino unification (e.g. AMSB)

  - without scalar universality (3d generation, Higgs parameters free)

  - string inspired models

  - ….
- mSUGRA has various problems, in particular:

  - FNCC, CPV (EDM limits for n and e)

  - τp

FT aspects of SUSY

- With LEP2 limits, SUSY already appears as seriously FT (cf Barbieri, Murayama, Strumia …)
- This can be simply understood from the EWSB equation (large tanβ assumed):

  $m^2_Z/2 \sim -\mu^2 - m^2_{Hu}$

  $\Delta m^2_{Hu} \sim -h^2_t m^2_{stop} \log(M_{UV}/M_{IR}) /\pi^2$ at loop level

  m_{stop}~500 GeV (from Higgs LEP2 limit) h_t~1 and log~10 hence $\Delta m^2_{Hu} \sim m^2_{stop} >> m^2_Z/2$ FT !
- Is this acceptable ?
- Most present extensions of the SM deal with this ' SUSY little hierarchy' problem (Fat Higgs idea, Higgs as PG boson of global symmetries…)

A more radical approach: Split SUSY SpS

- Our universe IS Fine Tuned as remarked long ago e.g. by S. Weinberg (**PRL 59, 2607, 1987**):
  - x by 100 the cosmological const -> Galaxies are lost
  - change by a few the EWSB vev hydrogen or carbon is lost
- Superstring theories indicate that there is a continuum of solutions and it is conceivable that our world is exceptional L. Susskind **hep-ph/0406197**
- Dropping FT criteria allows very large SUSY mass scales
  -> All scalars are very heavy (except h) which cures FCNC etc
  -> Keep fermions light for DM and GUT (chiral symmetry)

N. Arkani-Hamed, S. Dimopoulos **hep-th/0405159**

Similar solutions

- Within mSUGRA: FOCUS m_0 can be large with moderate FT

  $m^2_Z/2 \sim -\mu^2 + 2.7 m^2_{1/2} - 0.04 m^2_0$ -> μ can be small for large m_0

  -> LSP ~ Higgsino
- Within AMSB (in some versions):

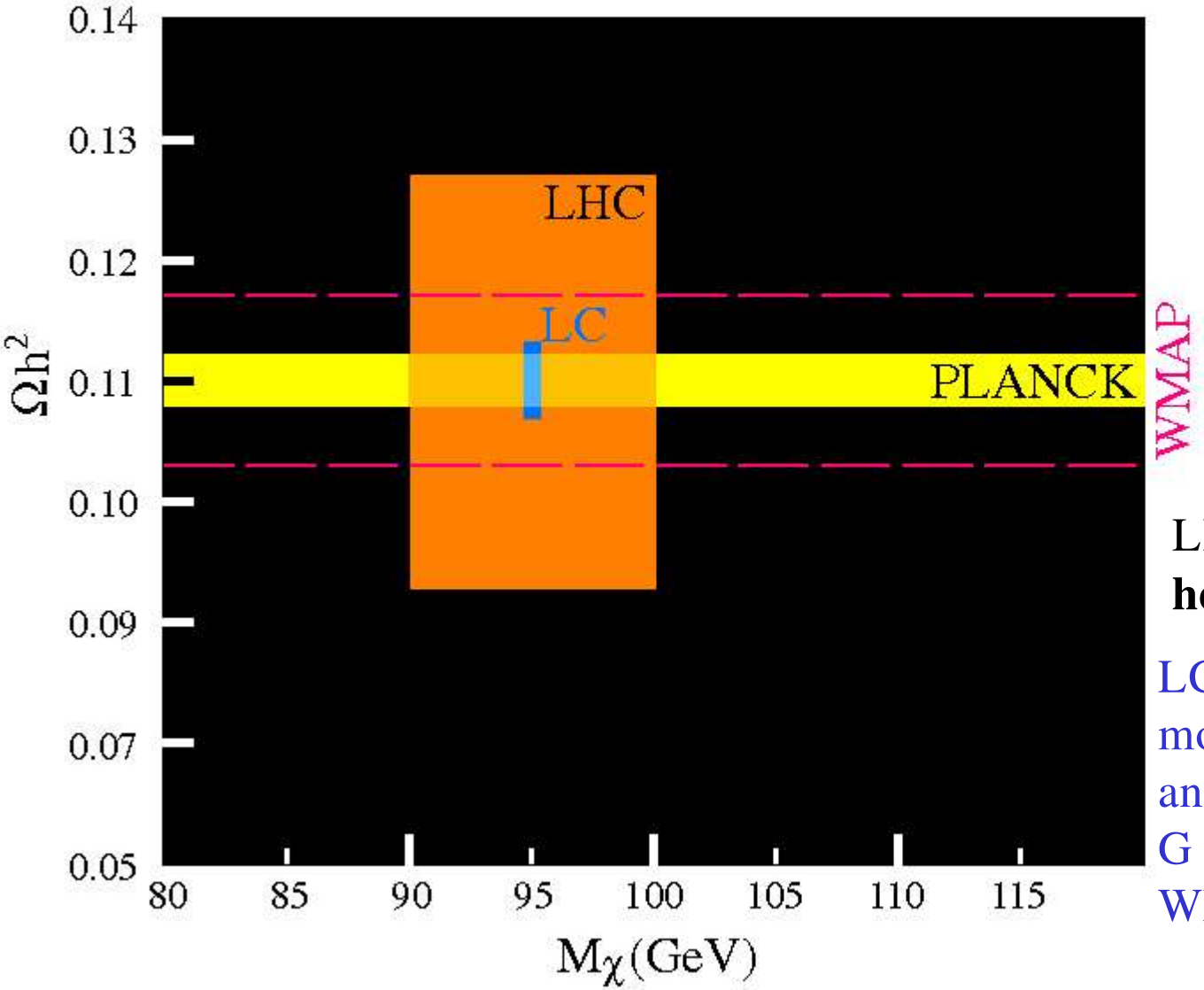
  $m_0 \sim m_{3/2}$ large $M_i \sim \beta_i m_{3/2}$ small for $m_{3/2}$ ~ 10 TeV

  -> $M_1 > M_2$ Wino solutions but then Ωh^2 cannot saturate WMAP (other sources of DM)
- These various solutions can be interpolated using a more general model 'string inspired' (e.g. 'Dilaton dominated' ~ Focus) which

  gives a continuum between Bino Higgsino and Wino

  See for instance P. Binetruy et al. **hep-ph/0308047**

Colliders and Cosmology



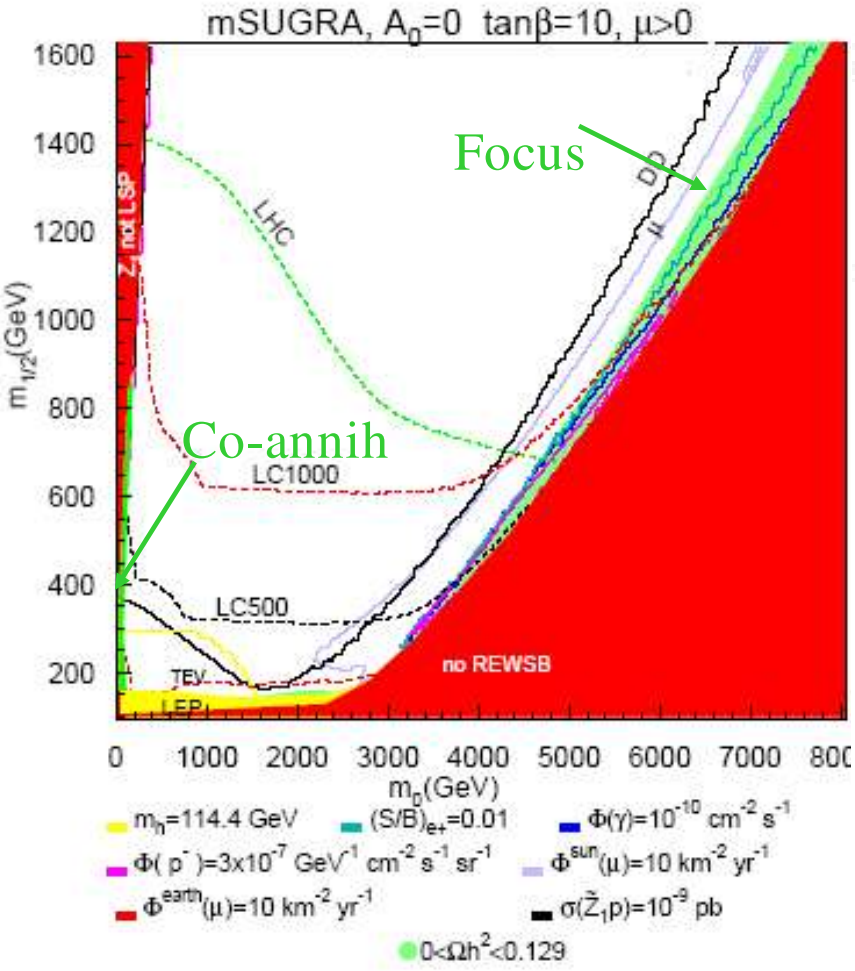
MicrOMEGAs Pt B

'WMAP'	*7 %*
LHC	*~15 %*
'Planck'	*~2 %*
CL	*~3 %*

LHC pt B: Battaglia et al **hep-ph/0306219**

LC: precision similar for most other co-annihilation points A C D G I L consistent with WMAP

H. Baer et al hep-ph/0405210



For Co-annihilation:
P. Bambade et al. hep-ph/0406010

Model	A′	C′	D′	G′	J′
Optimal $\sqrt{s}$ GeV	505	337	442	316	700
Efficiency in %	10.4	14.3	5.7	14.4	< 1.0
Error on mass GeV	0.487	0.165	0.541	0.132	> 1.0
Error on $\Omega_{DM}h^2$ in %	3.4	1.8	6.9	1.6	> 14

What about Focus type ?

What about non universal gauginos with heavy sfermions ?

A Focus solution

- Example given by H. Baer et al

P. Bambade et al. hep-ph/0406010

m_0	$m_{1/2}$	tanβ	$m\chi_1$	$m\chi_2$	$m\chi_1^\pm$	$m\chi_2^\pm$	μ
2500	300	30	85.6	135.0	113.1	274.8	121.6
		+25−11	± 0.1	± 0.3	± 0.1	±0.2	±1.4

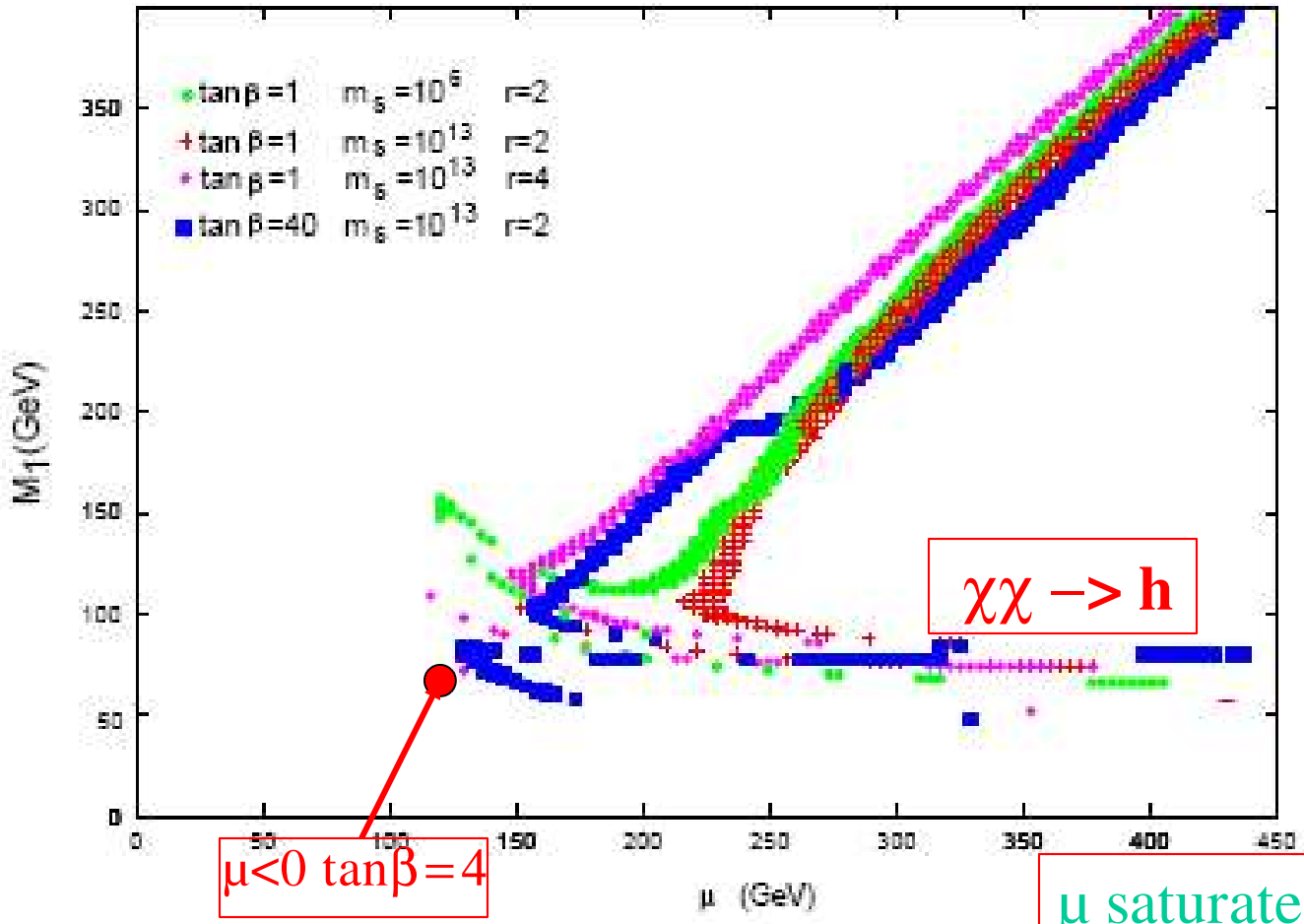
$\Omega_{DM}h^2$=0.042 +8.6 -5.9 % (tanβ contribution)

-> LC can distinguish from WMAP (> 5σ)

- What happens if $m\chi_2^\pm$ is not measured ? μ can still be measured with polarization (Choi et al. **hep-ph/0108117**) but an external lower bound on tanβ (> 10) is needed to exclude WMAP
- Baer et al disagree with suspect2 μ=400 GeV (mtop=175 GeV)
- No focus degenerate solutions (ΔM< 5 GeV) could be found consistent with WMAP

SpS Solutions

A. Pierce hep-ph/0406144



μ saturates ~ 1 TeV

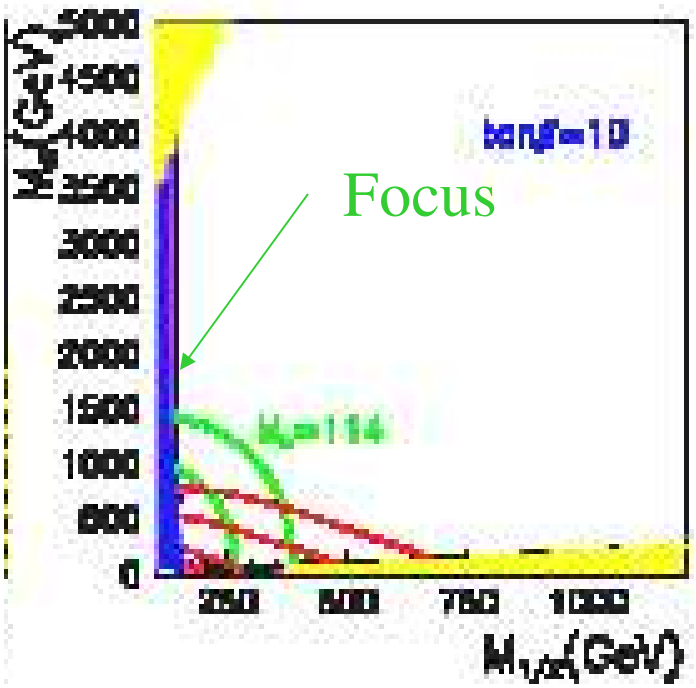
W. Kilian et al
hep-ph/048088

Giudice Romanino

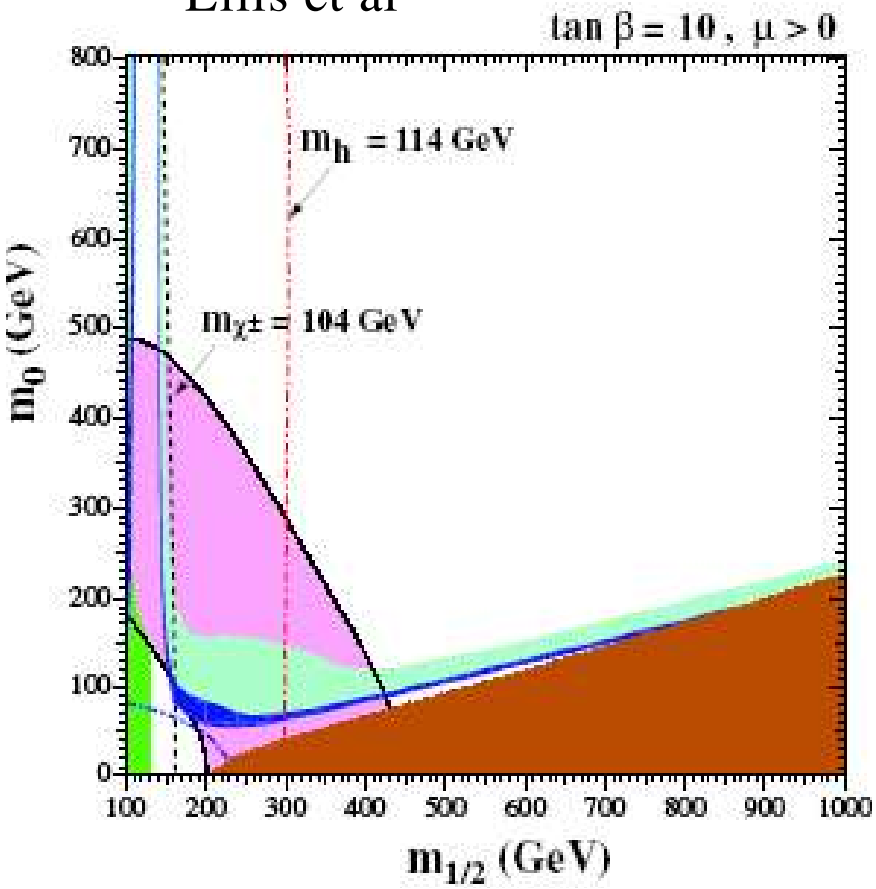
hep-pf/0406088

Inconsistencies with Focus ?

Bélanger et al **hep-ph/0407218**



Ellis et al



Inconsistencies with Focus ?

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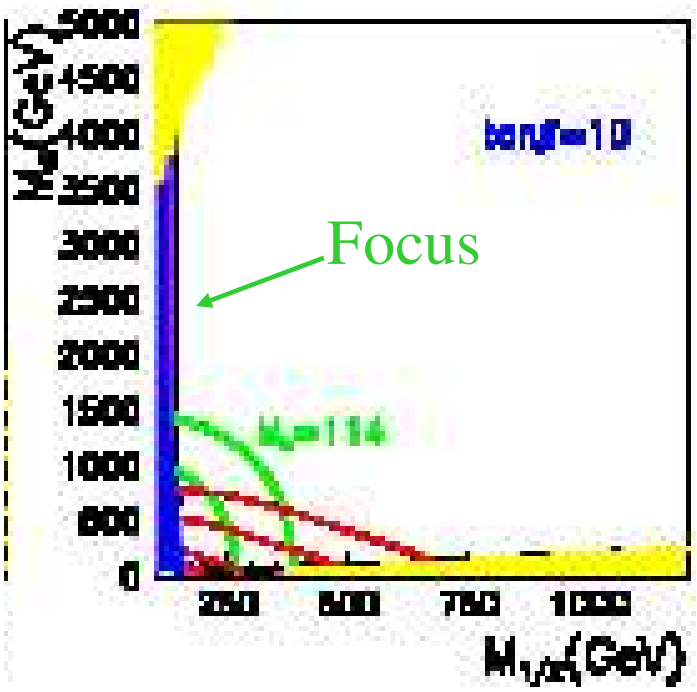
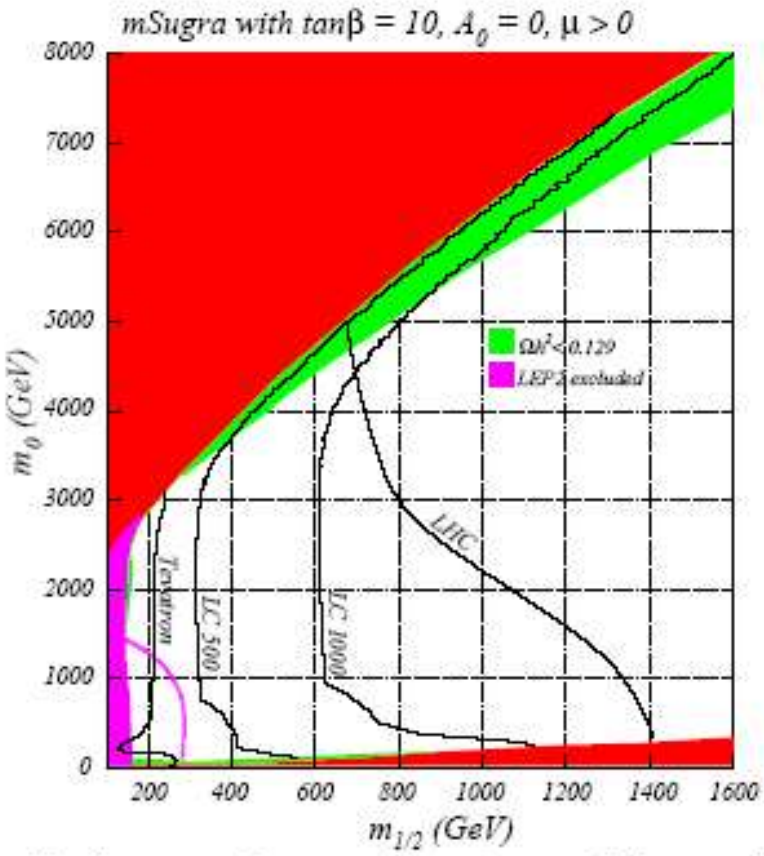


Baer et al



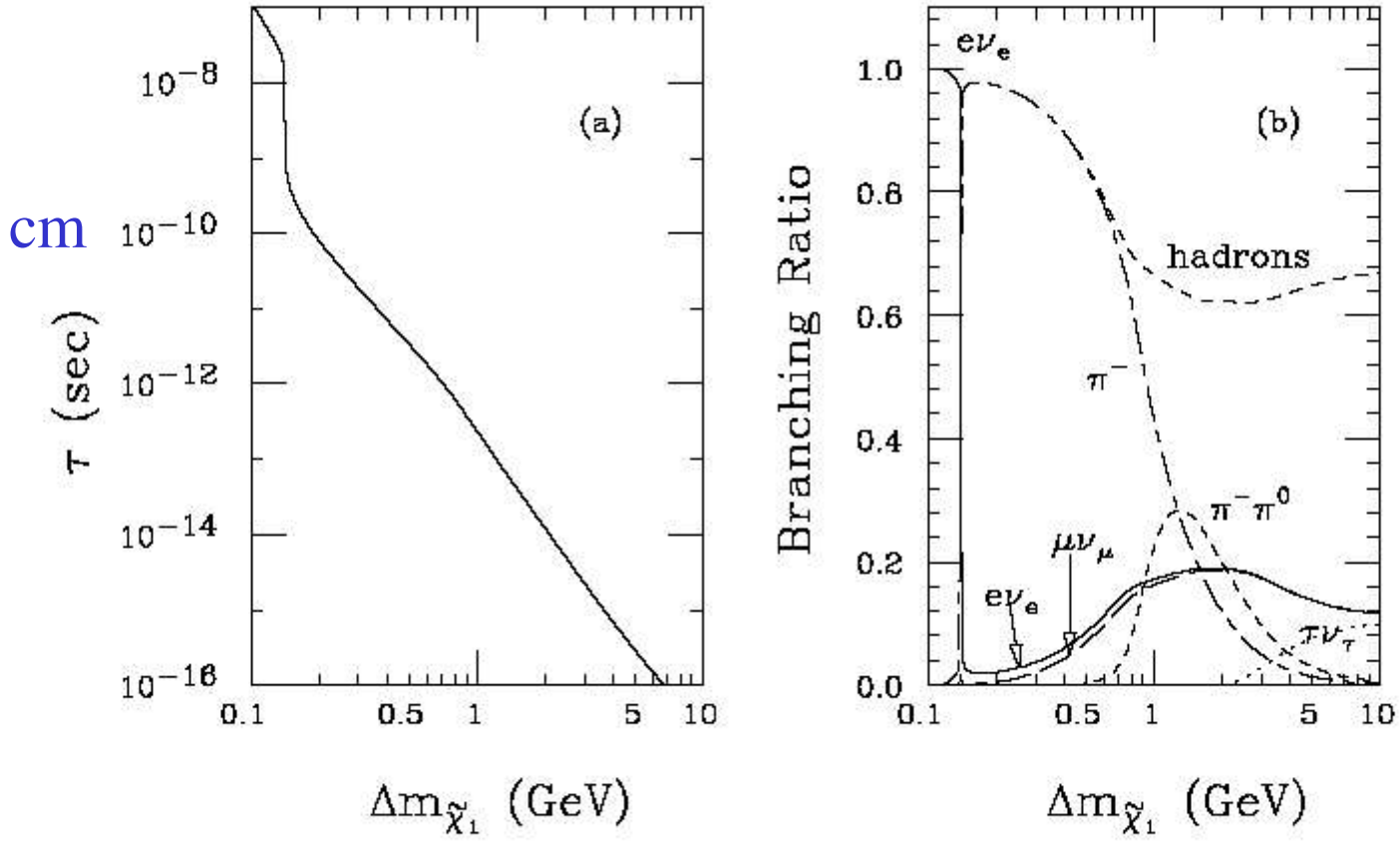
Mass Degeneracy Issue

- Possible with μ large if M1>M2 Wino-like
- ΔM> 5 GeV standard methods apply with a good fwd veto
- mπ <ΔM< 5 GeV neutrino counting method as at LEP2

  -> How precise can the mass difference be ?
- ΔM< mπ Long-life time for charginos, well identified in LC

  C.H. Chen et al **hep-ph/9902309**
- $\chi_1\chi_2$ is tagged in the same way (unless χ_2 stable !)
- Q: is precision necessary since $\Omega_{DM}h^2$ will be much smaller than WMAP (Higgsino/Wino solutions)

C.H. Chen et al **hep-ph/9902309**



Conclusions

- There are certainly SUSY DM solutions very distinct from co-annihilation to be studied
- Focus and SpS type solutions deserve investigations
- These solutions could be less precisely measured at LC than needed for cosmology if tanβ is large (to be confirmed)
- The mass degenerate chargino/neutralino solutions do not seem relevant to explain a large fraction of the DM result from WMAP (to be confirmed)
- Let's agree on some study points for LC/LHC

  after fixing discrepancies between codes