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ELECTROWEAK BARYOGENESIS IN THE MSSM

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Outline:

1. Introduction
2. Higgs Boson and Stop Masses and Electroweak Baryogenesis
3. Higgs and Stop Searches
4. CP-violating currents and the Baryon Asymmetry
5. Conclusions

Relevant Literature

Phase Transition in the MSSM with a light stop

A. Brignole, J. Espinosa, M. Quiros and F. Zwirner '93,'94; M. Carena, M. Quiros, C.W. '96, '98; D. Delepine, J. Gerard, R. Gonzalez and J. Weyers, '96; J. Cline and K. Kainulainen, '96, '98; J. Espinosa, B. de Carlos, '96, '97 D. Bodeker, P. John, M. Schmidt, '97 M. Losada, '99, '00; P. John, S.J. Huber, M. Laine and M. Schmidt, '99,'00; F. Csikor et al, '00; M. Laine, K. Rummukainen, '98, 01.

Baryon Number Generation

P. Huet and A. Nelson, 95, 96; M. Carena, M. Quiros, A. Riotto, I. Vilja and C.W.'97; J. Cline, M. Joyce and K.Kainulainen,'98 '00, A. Riotto '98; H. Davoudiassl et al'98, Enqvist et al'98; N. Rius and V. Sanz '00; K. Olive et al '00, K. Kainulainen, T. Prokopec, M. Schmidt and S. Weinstock '01; M. Carena, J. Moreno, M. Quiros, M. Seco and C.W. '01, '02.

Based on the following articles

- M. Carena, M. Quiros, M. Seco and C.W., to appear
- M. Carena, J.M. Moreno, M. Quiros, M. Seco and C.W.,
  hep-ph/0011055, Nucl. Phys. B599 (2001) 158.
- M. Carena, M. Quiros and C.W.,
  Nucl. Phys. B524 (1998) 3.
- M. Carena, M. Quiros, A. Riotto, I. Vilja and C.W.,
  Nucl. Phys. B503 (1997) 387.
- M. Carena, M. Quiros and C.W.,
  Phys.Lett.B380:81-91,1996

Related Issues

- M. Carena, J. Ellis, A. Pilaftsis and C.W.,
  Nucl.Phys.B586 (2000) 92.
- M. Carena, H. Haber, S. Heinmeyer, W. Hollik, G. Weiglein and C.W.,
  Nucl. Phys. B580 (2000) 29.
- A. Pilaftsis and C.W.,
  Nucl.Phys.B553:3-42,1999
- M. Carena, S. Mrenna and C.W.,
  Phys.Rev.D60:075010,1999.

I. Introduction

- Observable Universe presents a clear asymmetry between Matter and Anti-Matter

$$N_B \gg N_{\bar{B}}$$

- Cosmic Rays:

$$N_{\bar{P}} \simeq 10^{-4}\, N_P$$

- Consistent with secondary emission of $\bar{P}$
- No γ-ray sources in cluster of galaxies
- What is the origin of the baryon asymmetry?
- Sakharov Requirements
  - Baryon Number Violation
    Any Baryon Number conserving process
    $N_B = N_{\bar{B}}$
  - C and CP Violation $(N_B)_{L,R} \neq (N_{\bar{B}})_{L,R}$
  - Departure from Thermal Equilibrium. In thermal equilibrium $N_B = N_{\bar{B}}$

- In S.M. Baryon Number violation mediated by Non-Trivial Topological Configurations (Instantons)
  $\Delta B = \Delta L$
- Rate exponentially suppressed at $T = 0$
  $\Gamma(T=0) \simeq \exp(-2\pi/\alpha_W) \simeq 10^{-173}$
- At finite Temperaure, instead,
  $\Gamma \simeq \beta_0 \, T \, \exp(-E_{sph}(T)/T)$
  with
  $E_{sph} \simeq 8\pi v(T)/g$,
  and $v(T)$ being the v.e.v. of the Higgs field.
- If $n_B = 0$ for $T > T_c$, independently of the source of baryon asymmetry

$$\frac{n_B}{s} = \left(\frac{n_B}{s}\right)_{T_c} \exp\left[-\frac{10^{16}}{T_c[GeV]} \exp\left(-\frac{E_{sph}(T_c)}{T_c}\right)\right]$$

- Therefore, for the preservation of the generated n_B,

$$\frac{v(T_c)}{T_c} \geq 1$$

Finite Temperature Effective Potential

$$V(\phi, T) = V_0(\phi) + V_1(\phi, 0) + \Delta V_1(\phi, T)$$

where the finite T contribution is given by

$$\Delta V_1(\phi, T) = \sum_{i=b,f} \left[\frac{n_i m_i^2(\phi) T^2}{48} - \frac{\eta_i m_i^4(\phi)}{64\pi^2} \log\left(\frac{m_i^2(\phi)}{T^2}\right)\right] - \sum_b \frac{m_b^3(\phi) T}{12\pi}$$

where $\eta_i = n_i(-1)^{2S}$ and $m_i(\phi) \leq 2T$. For large values of the particle masses, $m(\phi) \gg 2T$, the finite T-contributions are exponentially suppressed.

$$V(T) = D(T^2 - T_0^2)\phi^2 - E_B T \phi^3 + \frac{\lambda(T)}{2}\phi^4$$

$$\frac{v(T_c)}{T_c} \simeq E_B/\lambda(T_c)$$

- In the SM, $E_B \simeq \sqrt{2}(2M_W^3 + M_Z^3)/(3\pi v^3)$, while $m_H^2 \simeq 2\lambda v^2$. The condition of preservation of the generated baryon number

$$\frac{v(T_c)}{T_c} \geq 1 \qquad \text{implies} \qquad m_H \leq 40\text{GeV},$$

- Electroweak Baryogenesis in the SM is ruled out.

EW Baryogenesis implies presence of new light boson degrees of freedom, with relevant couplings to the Higgs field. The Higgs boson should remain light.

$$\frac{\phi(T_c)}{T_c} \simeq \frac{E_B}{\lambda(T_c)} \simeq \sum_b n_b \, g_{bH}^3 \, \frac{v^2}{m_H^2}$$

- Supersymmetry provides a natural framework for this scenario. Relevant Light Bosons: Supersymmetric Partners of the top quark (stops).
  Espinosa,Quiros, Zwirner '93; Carena,Quiros,Wagner '96

- Each stop has six degrees of freedom, and couplings of order one to the Higgs field.

  $$E_B \simeq \frac{g_W^3}{4\pi} + \frac{h_t^3}{2\pi} \simeq 8\, E_{SM}$$

  and hence, Higgs masses up to about 115 GeV can be accommodated within the SUSY framework.

- In the MSSM, there are two Higgs doublets H_1, H_2 and the left-handed and right-handed stop mix

  $$\mathcal{M}_{\tilde{t}}^2 = \begin{bmatrix} m_Q^2 + m_t^2 + D_L & m_t X_t \\ m_t X_t^* & m_U^2 + m_t^2 + D_R \end{bmatrix}$$

  where $m_t = h_t H_2$, $X_t = A_t - \mu^* / \tan\beta$ and $\tan\beta = H_2/H_1$.

- For $m_Q \gg m_U, |X_t|$, and either for large values of the heavy Higgs doublet mass, $m_A \gg M_Z$, or for large $\tan\beta$, for most values of m_A, there is one Higgs boson h with mass

$$m_h^2 \simeq M_Z^2 \cos^2 2\beta + \frac{3m_t^4}{8\pi^2 v^2}\left[\log\left(\frac{m_{\tilde{t}_1}^2 m_{\tilde{t}_2}^2}{m_t^4}\right)\right.$$
$$\left. + \quad 2\frac{|X_t|^2}{m_Q^2}\log\left(\frac{m_{\tilde{t}_1}^2}{m_{\tilde{t}_2}^2}\right) + \mathcal{O}\left(\frac{|X_t|^4}{m_Q^4}\right)\right]$$

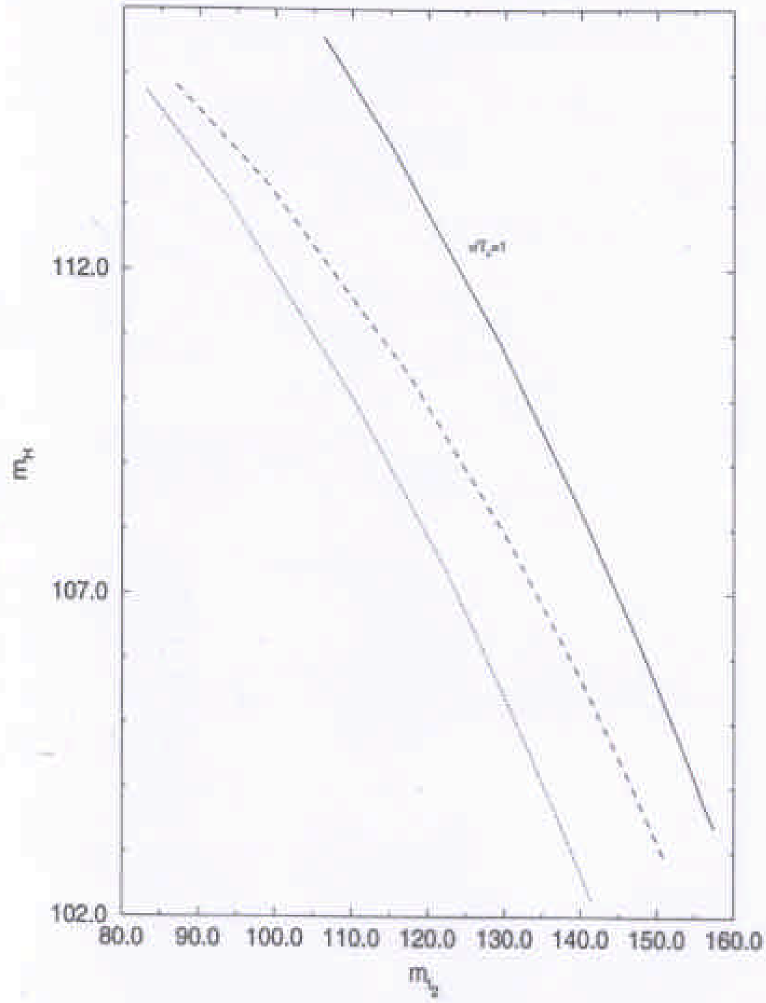
- For $m_{\tilde{t}_1} \simeq m_Q \simeq 1$ TeV (2 TeV), $m_{\tilde{t}_2} \simeq m_t$ and $|X_t| \leq 0.6 m_Q$ $[g_{\tilde{t}H}^2 = h_t^2(1 - \frac{|X_t|^2}{m_Q^2})]$,

$$m_h \leq 112\ (117)\ \mathrm{GeV}$$

In order to make a precise analysis, we should take into account

- Two loop corrections at zero and finite T. Dominant finite T corrections included. Zero T two-loop corrections, ignored here, can vary m_h by a few GeV.

  M. Carena, H. Haber, S. Heinemeyer, G. Weiglein and C. Wagner '00; J.R. Espinosa, R. Zhang, '00; A. Brignole, G. Degrassi, P. Slavich, F. Zwirner, '01

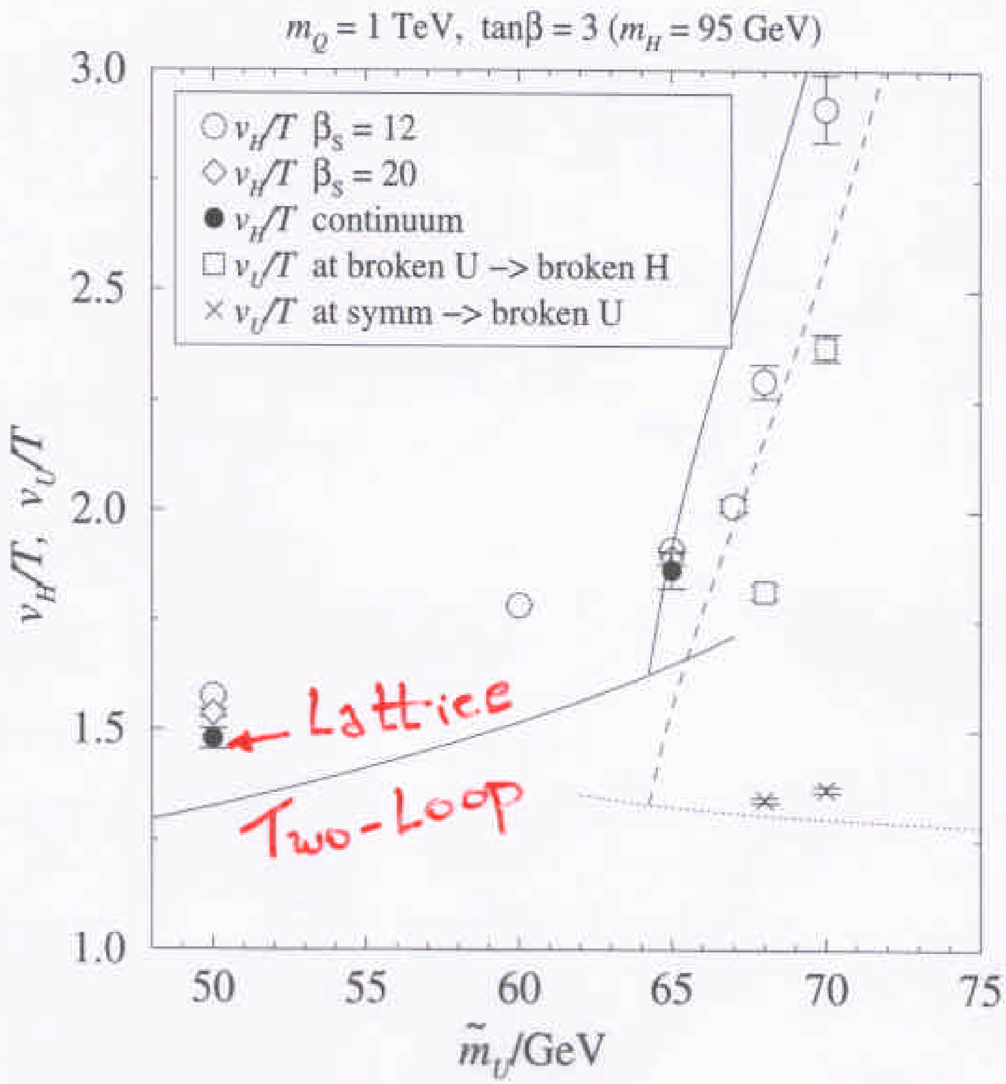


M. Losada '99

$\tilde{A}_t \lesssim 0.65\, M_S$

$m_h \lesssim 115$ GeV

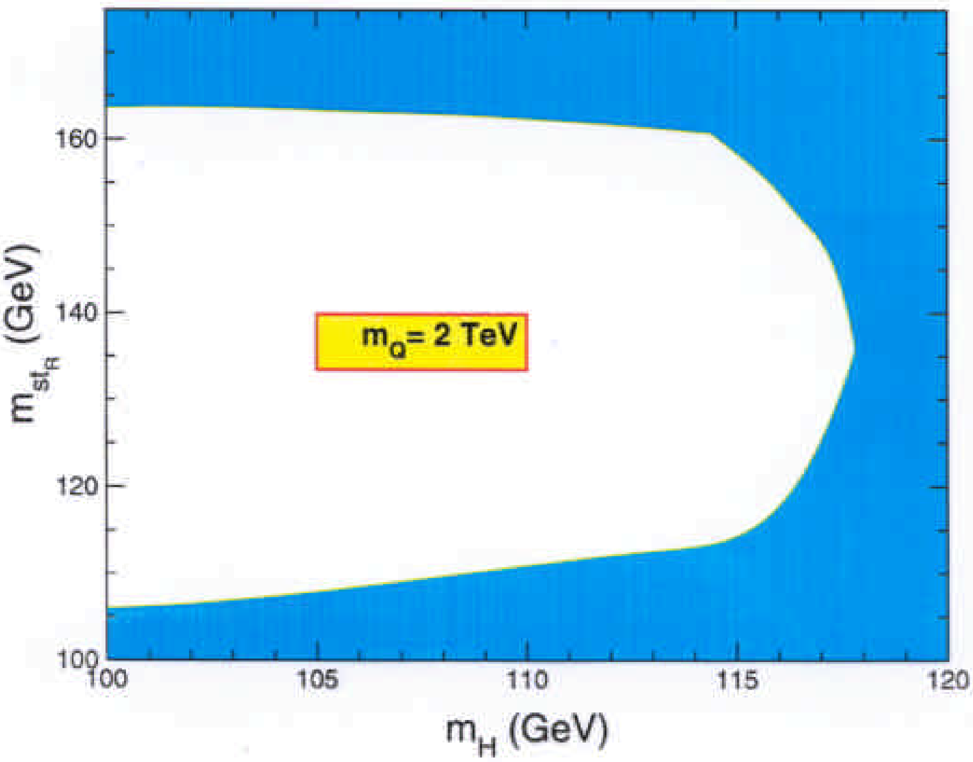
Figure 7: Allowed region of parameter space in the m_h-$m_{\tilde{t}_2}$ plane for $m_Q = 1$ TeV, $0 \leq \tilde{A}_t \leq 650$ GeV and $\tan\beta = 5$. To the left of the solid line there is a sufficiently strong first-order phase transition, to the right of the dotted line the physical vacuum is absolutely stable. The dashed line separates the region for which a two-stage phase transition can occur.



Laine, Rummukainen

Phase Transition stronger than in the continuum formulation.

Electroweak Baryogenesis in the MSSM: Stop and Higgs Mass Predictions



Carena, Wagner, Quiros'98; Quiros '01

- X_t ($\tan\beta$) grows to the left (top) of figure
- Bound $m_h \lesssim 117$ GeV obtained for $m_Q = 2$ TeV.
- Values of $v(T_c)/T_c > 0.9$ required.

The LEP Collider at CERN has reported a bound on the Standard Model Higgs mass of $m_H \gtrsim 114.1$ GeV at 95 % C.L.

A 2 σ excess of events consistent with a SM-like Higgs boson, with mass of about 115 GeV has also been reported. Great news !

To be compatible with MSSM Electroweak Baryogenesis:

- The value of $\tan\beta$ should be large
  $\tan\beta > 5.$
  Lower values of $\tan\beta$ lead to too small Higgs masses with large couplings to the gauge bosons.

- The value of m_Q should be large
  $m_Q \gtrsim 1$ TeV.

- The value of A_t should not be negligible.
  $A_t \gtrsim 0.2\, m_Q.$

- One stop should be mainly right handed and its mass should be small. Conservatively,
  $100 \text{ GeV} \lesssim m_{\tilde{t}} \lesssim m_t.$

Higgs Searches at LEP and at the Tevatron

Searches for neutral CP-even Higgs bosons at LEP and at the Tevatron rely mostly on the

$$h \to b\bar{b} \qquad\qquad H \to b\bar{b}$$

channels.

Higgs searches at LEP led to a bound on a SM-like Higgs boson mass of about 114.1 GeV.

Assuming a standard $H \to b\bar{b}$ rate, the Tevatron collider will be able to test the presence of a Higgs boson with SM-like WH production rate up to a mass of about 120 GeV (125 GeV) with 2 fb^{-1} 5 fb^{-1}.

Unless the Higgs production rates or the Higgs to $b\bar{b}$ branching ratio are suppressed, the Tevatron should test the region of parameter space not tested at LEP in the next few years.

Observe that the usually quoted bound of about 90 GeV for m_h at large $\tan\beta$ applies to h when not coupled to ZZh !

The LEP bound of about 91 GeV for m_h at large $\tan\beta$ is obtained for values of $\cos^(\beta - \alpha) \ll 1$.

This is obtained for small values of the CP-odd Higgs mass and large $\tan\beta$. For very small values of $\cos(\beta - \alpha)$, the lightest Higgs boson ZZh coupling vanishes and the bounds on its mass come from the associated production with a CP-odd Higgs boson, with $h, A \rightarrow b\bar{b}$

$$e^+e^{\rightarrow} Z^* \rightarrow \; h\; A \tag{1}$$

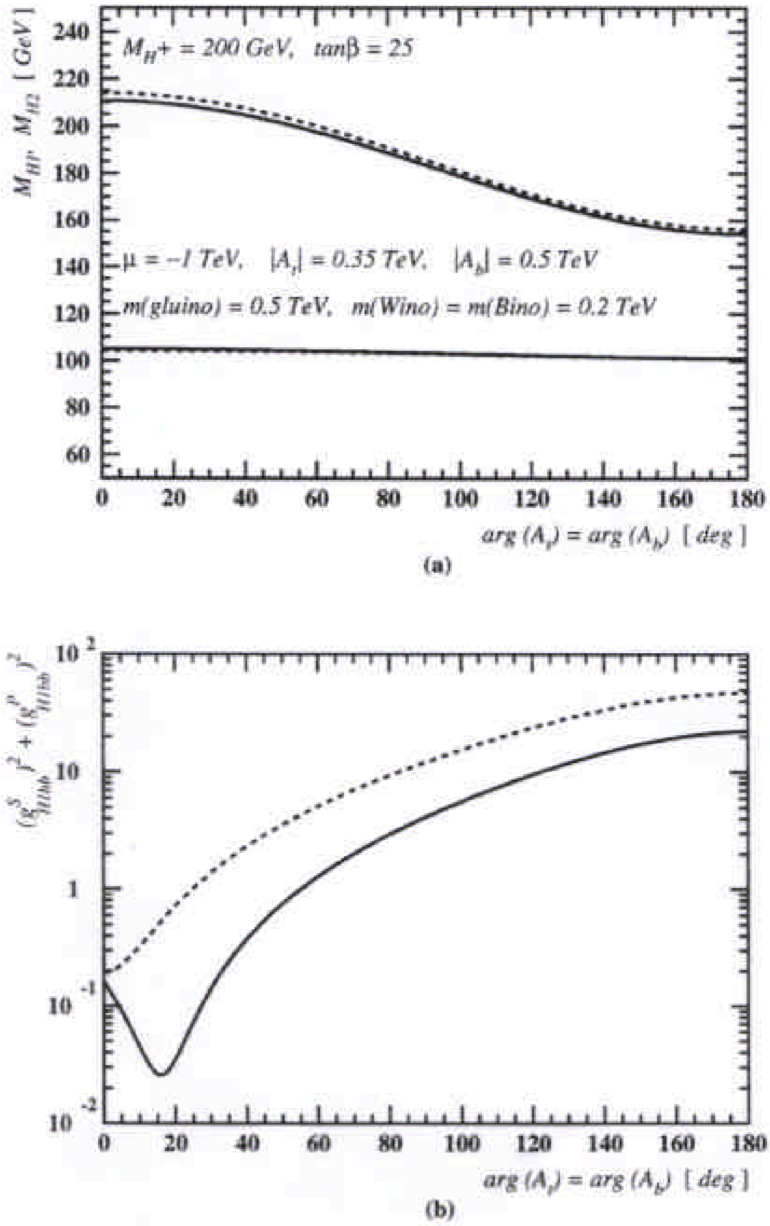
For values of $\sin(\beta - \alpha)$ of order one, instead, the bounds come from the process

$$e^+e^- \rightarrow Z^* \rightarrow Z\; h \tag{2}$$

and are very close to 114 GeV, unless $\sin^2(\beta - \alpha)\; BR(h \rightarrow b\bar{b}) \lesssim 0.3$.

In the case of EWBG, the mass constraints refer to the Higgs actively participating in the mechanism of EWSB, what is equiv. to the bounds found for h for $\sin^2(\beta - \alpha)$ close to one, or simply $m_h \gtrsim 114$ GeV unless $BR(h \rightarrow b\bar{b}) \lesssim 0.3$.

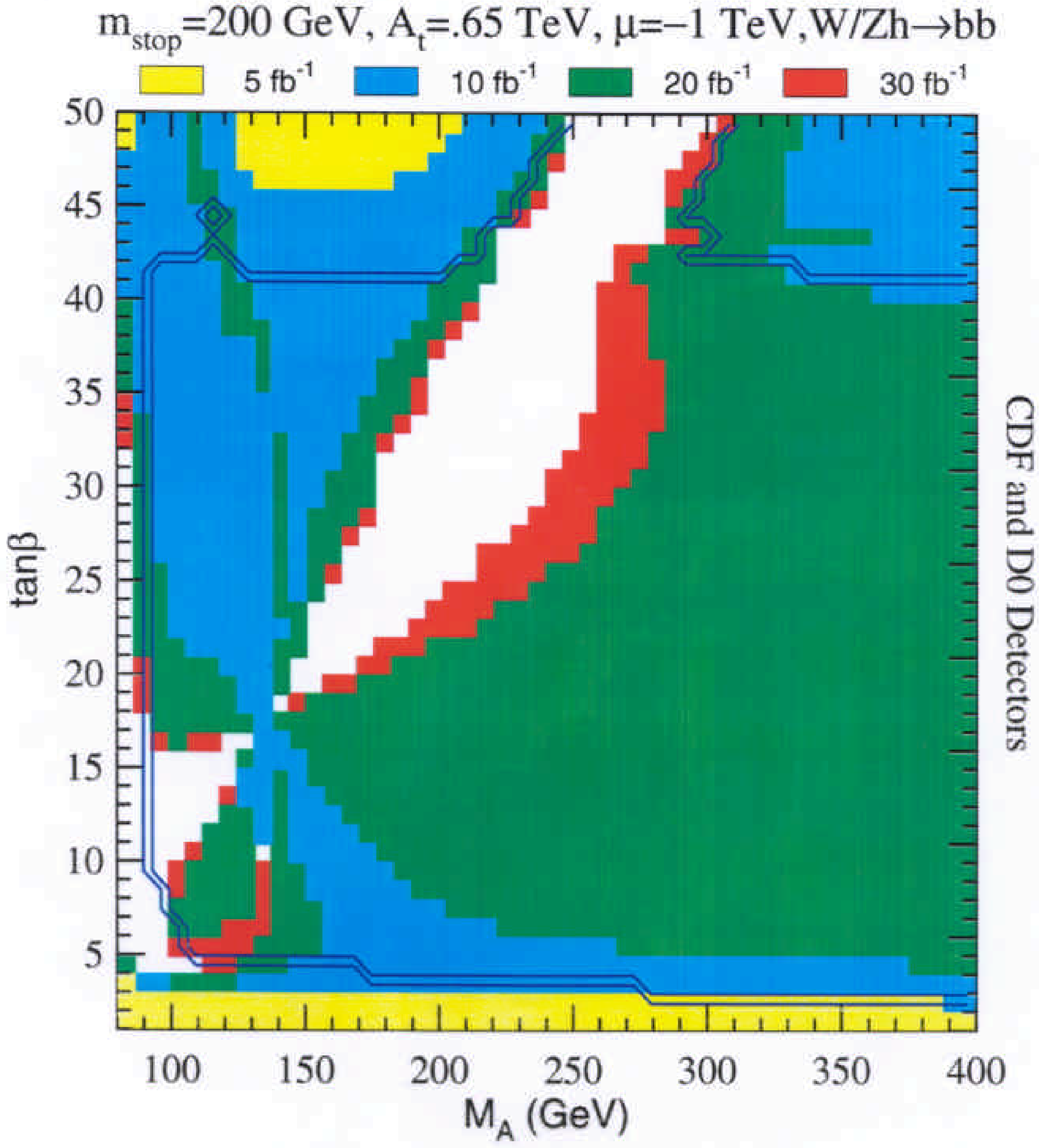
Higgs Properties vs. $arg(A_t\mu)$



M. Carena, J. Ellis, A. Pilaftsis and C.W. '00

- Dashed- and solid-lines correspond to gluino mass phase $arg(M_{\tilde{g}}) = 0$ and π, respectively.

Suppression of coupling of Higgs to b-quarks and Tevatron Reach



M. Carena, S. Mrenna and C.W. '99

Flavor Independent Searches at LEP

- The LEP experiments have performed flavor independent searches of Higgs bosons.
- Searches assume that Higgs decays into jets, without b-tagging
- LEP limit for a Higgs boson with standard model-like couplings to Z and $BR(H \to j\bar{j})$ is of about 113 GeV !
- Independently of the production and decay modes, EW Baryogenesis in the MSSM is highly constrained by Higgs boson searches at LEP !
- For the computation of the Baryon asymmetry, we chose values of the parameters such that the Higgs boson mass is in the region consistent with the excess of events observed in the LEP2 run with $\sqrt{s}$ = 206–209 GeV ($m_h \simeq 115$ GeV) .

No Higgs Bosons at LEP or the Tevatron ?

If all Higgs bosons are light, these particles may escape detection because either

- Their couplings to the gauge bosons are suppressed and/or
- Their couplings to b-quarks are suppressed

In the presence of CP-violating phases of the SUSY parameters, the three neutral Higgs boson mix and their couplings to the Z-boson fulfill

$$\sum_i g^2_{H_i ZZ} = 1, \qquad g_{H_i ZZ} = \epsilon_{ijk} g_{H_j H_k Z}$$

$$\sum_i g^2_{H_i ZZ} m^2_{H_i} < (130\text{GeV})^2 + M_Z^2 \left(\cos^2 2\beta - 1\right)$$

M. Carena, J.Ellis, A.Pilaftsis and C. Wagner '99, '00

Moreover, the couplings of the Higgs bosons to b-quarks may be strongly affected by radiative corrections.

Stop and Sbottom Searches

In many models (MSUGRA, extended Gauge– and Anomaly–Mediated) $\longrightarrow$ $\tilde{t}$'s and $\tilde{b}$'s quite light

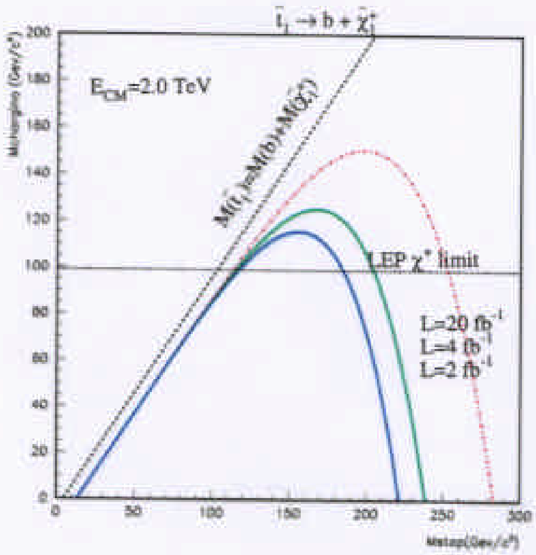
- If $m_{\tilde{t}_1} > m_{\tilde{\chi}_1^\pm} + m_b$ or $> M_W + m_{\tilde{\chi}_1^0} + m_b$
  or $> m_l + m_{\tilde{\nu}} + m_b$ or $> m_{\tilde{l}} + m_\nu + m_b$

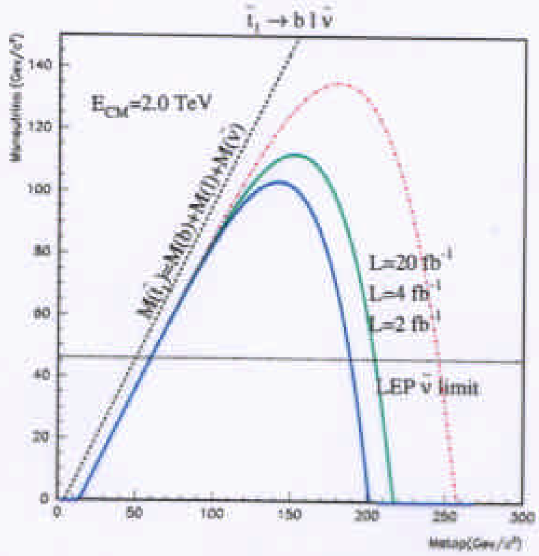
$\Longrightarrow \tilde{t}_1 \to b\tilde{\chi}_1^{\pm(*)} \to b\tilde{\chi}_1^0 f\bar{f}'$ with $f\bar{f}' = l\bar{\nu}$ or $q\bar{q}'$

Signals: 2b jets + 2 W's + $\not{E}_T$, 2b jets + 2l's + $\not{E}_T$

$\Downarrow$

Selection: b-jet + jet + l + $\not{E}_T$, 2l's + jet + $\not{E}_T$



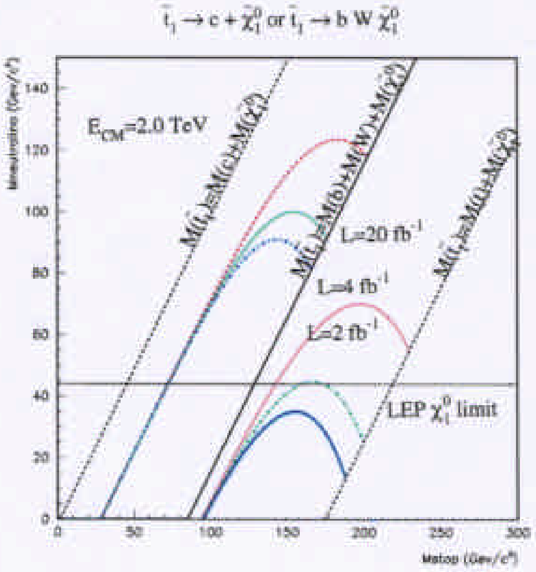


- If the above modes not kinematically allowed

$\tilde{t}_1 \to c\tilde{\chi}_1^0$

(via $b\tilde{\chi}_1^{\pm}$ loop)

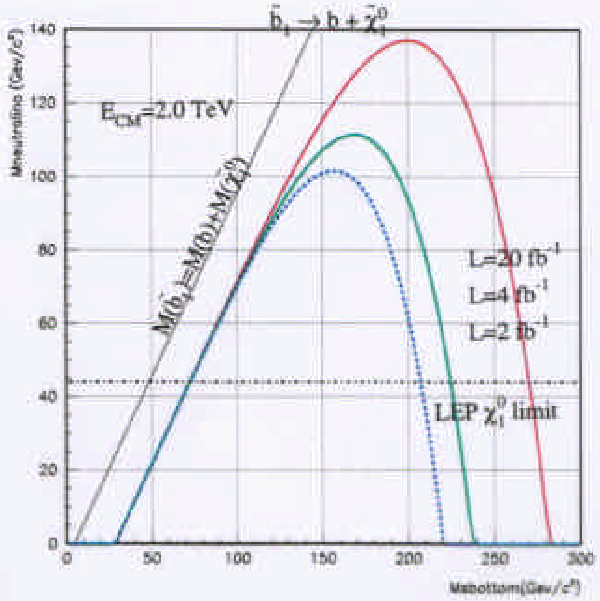
Signal/Selection:
2c jets + $\not{E}_T$



- Sbottoms:

$\Longrightarrow \tilde{b}_1 \to b\tilde{\chi}_1^0$

100 % BR
if $m_{\tilde{\chi}_2^0} > m_{\tilde{b}} - m_b$



if $\tilde{b} \to b\tilde{\chi}_2^0$ allowed, limit degraded in 30-40 GeV

In summary:

Robust studies from Theoretical/experimental collab. at the Higgs/SUSY Workshop to define Tevatron reach for stops and sbottoms

With $\int \mathcal{L}dt = 2$ (20) fb^{-1}

$m_{\tilde{t}_1} \leq 185/190$ (260/250) GeV in $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}/\tilde{t}_1 \to bl\tilde{\nu}$
$m_{\tilde{t}_1} \leq 160$ (200) GeV in $\tilde{t}_1 \to c\tilde{\chi}_1^0$
$m_{\tilde{b}_1} \leq 210$ (270) GeV in $\tilde{b}_1 \to b\tilde{\chi}_1^0$

Interesting: light right-handed stops $m_{\tilde{t}_R} \sim 150$ GeV + MSSM Higgs $m_h \sim 100$-115 GeV

$\Longrightarrow$ compatible with ELW Baryogenesis Mechanism with proper generation of Baryon asymmetry for CPV phases compatible with EDM constraints

Tevatron Run2 reach for Higgs and stops
$\Longrightarrow$ probe Baryogenesis at the Electroweak scale !

Light Stop Searches in Low Energy SUSY Breaking Models

M. Carena, D. Choudhury, R. Diaz, H. Logan and C. Wagner, hep-ph/0206167.

Above Scenario does not depend on SUSY Breaking Mechanism. Light Stop important signature.

Low energy supersymmetry Breaking: Lightest sparticle decays into its superpartner and a gravitino ($\tilde{G}$).

Relevant rate of stop pair production, with

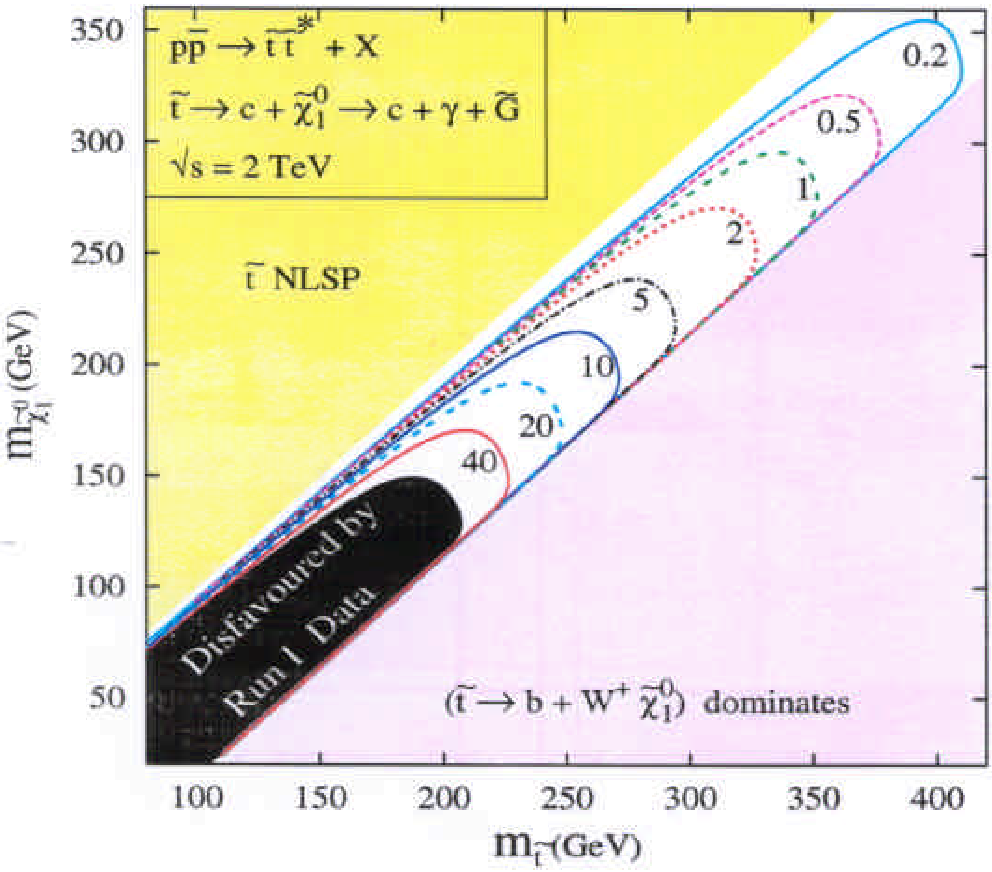
$$\tilde{t} \to c\,\tilde{\chi}^0 \qquad (3)$$

Assuming that the lightest SUSY particle is a neutralino,

$$\tilde{\chi}^0 \to \gamma \tilde{G} \qquad (4)$$

Other stop decay modes also explored.

Final state: Two jets, two photons and missing energy. After applying relevant cuts, we obtain the following cross sections,



Carena, Diaz, Logan, Choudhury, Wagner, '02

Analysis of results, considering backgrounds and approximate efficiencies, lead to a maximum stop mass reach of order 265, 285, 310, 325 GeV, for a total integrated luminosity of 2, 4, 15, 30 fb^{-1}.

Three body decay

The stops may also decay into a three body decay

$$\tilde{t} \to b\, W^+\, \tilde{\chi}^0 \tag{3}$$

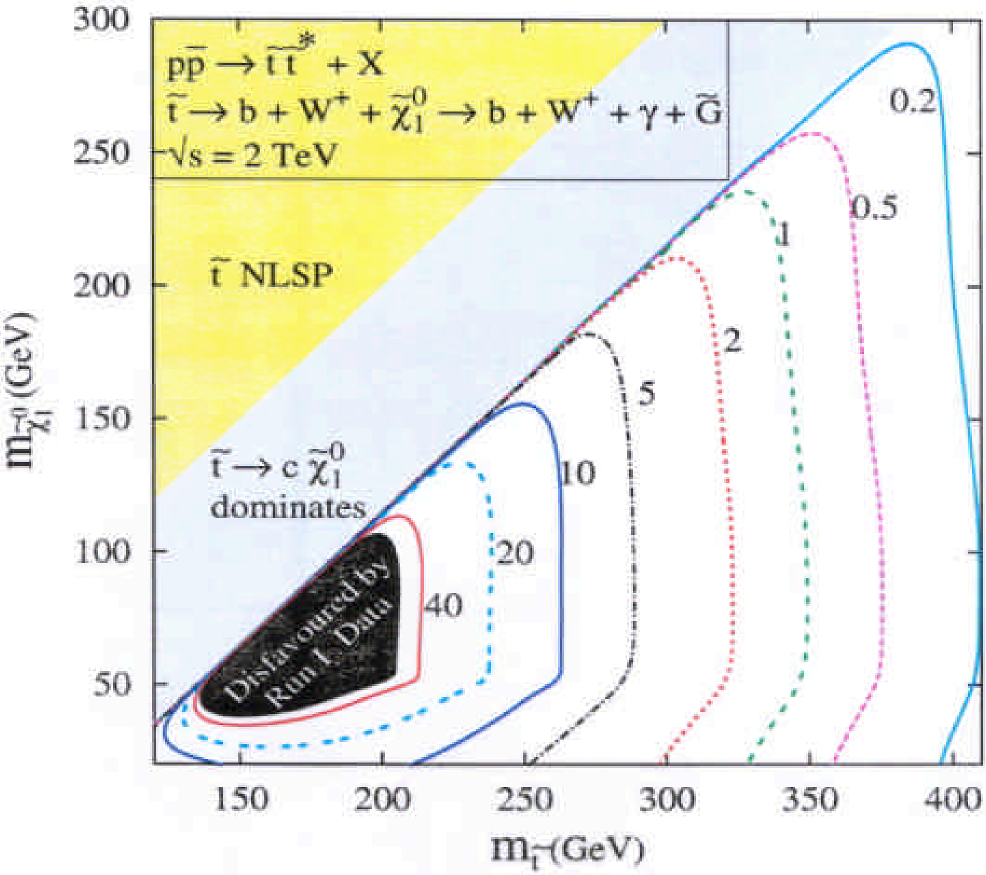
with the subsequent decay of the neutralino

$$\tilde{\chi}^0 \to \tilde{G}\, \gamma \tag{4}$$

Unless large flavor violation operators exist at tree level, this decay mode is favored compared to the flavor violating one, whenever it is kinematically allowed.

Possible final state:

Six jets, photons and missing energy.
Due to possible jet overlap, demand at least four energetic jets.



Analysis of results, considering backgrounds and approximate efficiencies lead to a maximum stop mass reach of 300, 320, 355 and 375 GeV for 2, 4, 15 and 30 fb^{-1}, respectively.

Computation of Baryon Asymmetry

M. Carena, M. Quiros, M. Seco, J. Moreno and C.W., NPB599 (2001) 158.

- We derived diffusion equations for the chiral charges induced by the passage of the wall of the expanding true-vacuum bubbles.
- We developed a method to compute the CP-Violating currents generated by the Higgs background in a derivative expansion, to all orders in Higgs mass insertions.
- Sources are dominated by chargino-neutralino currents, and proportional to $\arg(M_i\mu)$, where M_i ($i = 1, 2$) and μ are the masses of the supersymmetric partners of the gauge and the Higgs boson fields, respectively.
- Results depend slightly on the wall parameters and strongly on M_2, $|\mu|$ and m_A. The results also depend linearly on $arg(M_i\mu)$.
- Results generalize the previously found ones M. Carena, M. Quiros, A. Riotto, I. Vilja and C.W. '98, M. Carena, J. Moreno, M. Quiros, M. Seco, C.W. '00

Diffusion Equations

M. Carena, M. Quiros, M. Seco, C.W., to appear.

$$v_\omega n'_Q = D_q n''_Q + \text{Int.}(\Gamma_Y, \Gamma_m, \Gamma_{ss}) + \tilde{\gamma}_Q$$

$$v_\omega n'_T = D_q n''_T + \text{Int.}(\Gamma_Y, \Gamma_m, \Gamma_{ss}) - \tilde{\gamma}_Q$$

$$v_\omega n'_H = D_h n''_H + \text{Int.}(\Gamma_Y, \Gamma_m, \Gamma_{ss}) + \tilde{\gamma}_{\tilde{H}_+} \quad (5)$$
$$v_\omega n'_h = D_h n''_h + \text{Int.}(\Gamma_Y, \Gamma_m, \Gamma_{ss}, \Gamma_\mu) + \tilde{\gamma}_{\tilde{H}_-}$$

where v_ω is the wall velocity, D_i are diffusion constants, $n_F = n_{\tilde{f}} + n_f$ are the particle densities, $H = H_1 + H_2$ and $h = H_2 - H_1$.
Γ_i: Interaction terms, with ss, Y, m and μ standing for strong sphalerons, top Yukawa, top mass and Higgsino mass μ-induced interactions.

- Assuming Γ_{ss}, Γ_Y large, Eqs. can be solved.
- Currents induced by the passage of wall computed via the Keldysh formalism.
- Sources:

$$\Gamma_i \simeq D_i (n''_i)^B$$

n_i^B: Temporal component of currents computed in Higgs background.

On the sources for the diffusion equations

Sources may be derived starting from the corresponding Boltzman equations.

From the diffusion equations, the expression for the sources may be understood by a self-consistency relation : In the absence of interaction with the plasma fields, the currents should reduce to the ones computed in the background of the Higgs field.

It has been argued that currents proportional to $\epsilon_{ij} H_i \partial_\mu H_j$ do not contribute to sources.

We found no such cancellation.

M. Carena, M. Quiros, M. Seco and C. Wagner, to appear.

Sources and Baryon Asymmetry

- After computing the left handed currents in symmetric phase, n_L, the baryon asymmetry may be computed taking into account the weak sphaleron effects of rate Γ_{ws}
- Separation of effects of generation of n_L and of n_B justified due to the smallness of Γ_{ws}
- Effective Baryon Density n_B in the broken phase determined by solving the corresponding diffusion equation.

$$v_\omega n'_B(z) = -\theta(-z)\left[3\Gamma_{ws} n_L(z) + \mathcal{R} n_B(z)\right],$$

$$\mathcal{R} = \frac{15\Gamma_{ws}}{4}.$$

Therefore,

$$n_B = -\frac{n_F \Gamma_{ws}}{v_\omega} \int_{-\infty}^{0} dz\, n_L(z)\, e^{z\mathcal{R}/v_\omega}\,. \quad (9)$$

where n_L is determined mainly by the Higgsino currents, proportional to v_w and to $\arg(M_2\mu)$ and to $H_2\partial_0 H_1 \pm H_1 \partial_0 H_2 = \mathcal{A}_H^{\pm}$

- Enhancement for small m_A, where contribution proportional to $\mathcal{A}_H^-$ dominates.

Dependence of Baryon Asymmetry on $\tan\beta$, μ, M_2 and m_A

Total baryon asymmetry depends on two different contributions. The first one is proportional to

$$\epsilon_{ij} H_i \partial_\mu H_j = v^2(T)\partial_\mu(\beta).$$

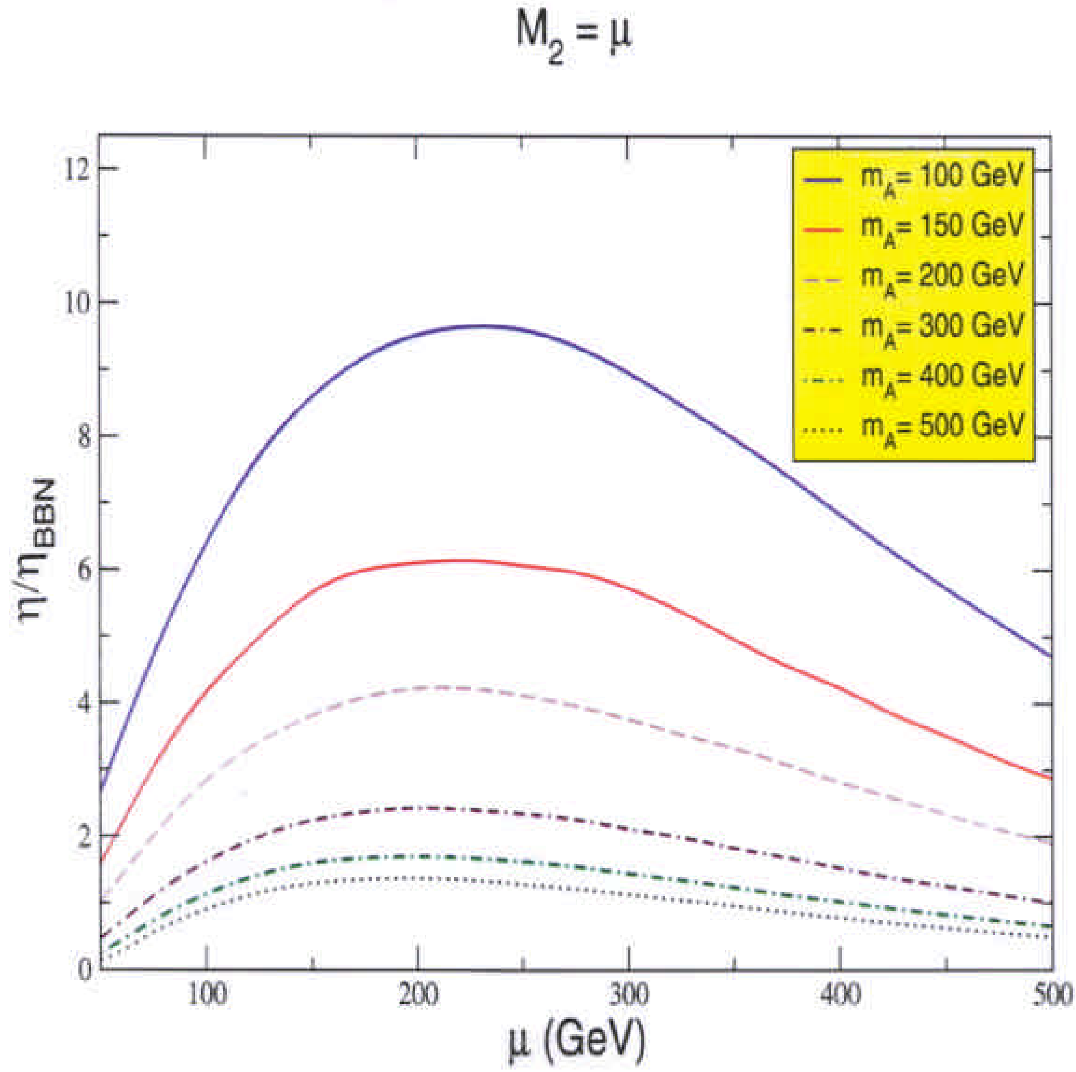
- $\Delta\beta$ tends to zero for large values of m_A.
- For large values of $\tan\beta$, β varies slightly from $\beta \simeq \pi/2$. Baryon asymmetry suppressed.
- Resonant behaviour for $M_2 = |\mu|$. Dominant for moderate values of m_A and $\tan\beta$ and values of $M_2 \simeq |\mu|$.

The second contribution depends on

$$H_1 \partial_\mu H_2 + H_2 \partial_\mu H_1 = v^2 \cos(2\beta)\partial_\mu \beta + v\partial_\mu v \sin(2\beta)$$

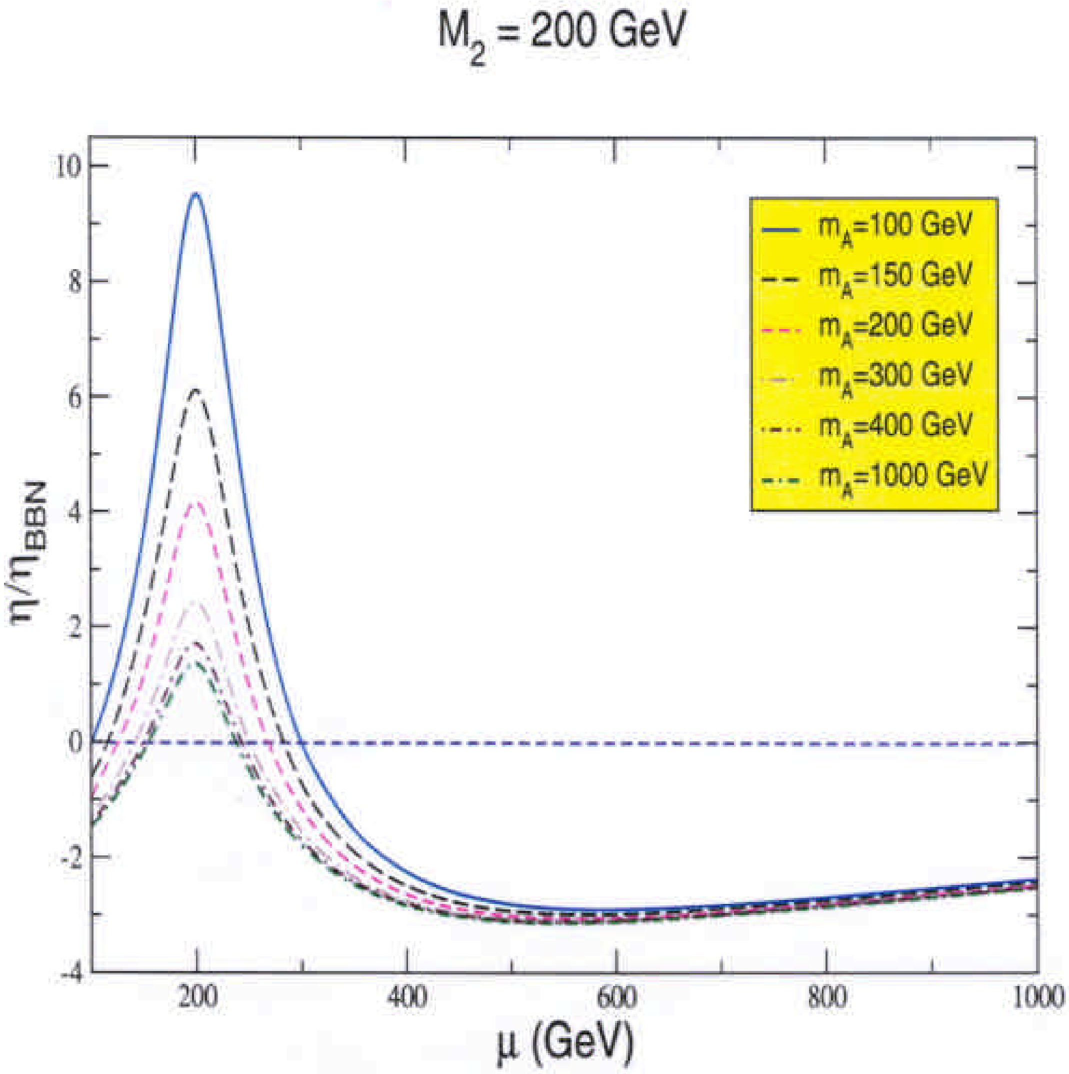
- First term suppressed for large m_A and/or $\tan\beta$.
- Second term unsuppressed for large values of m_A.
- Dominant contribution for large values of m_A, particulary for M_2 very different from $|\mu|$.

Large Baryon Asymmetry η for $arg(M_2\mu) = \pi/2$



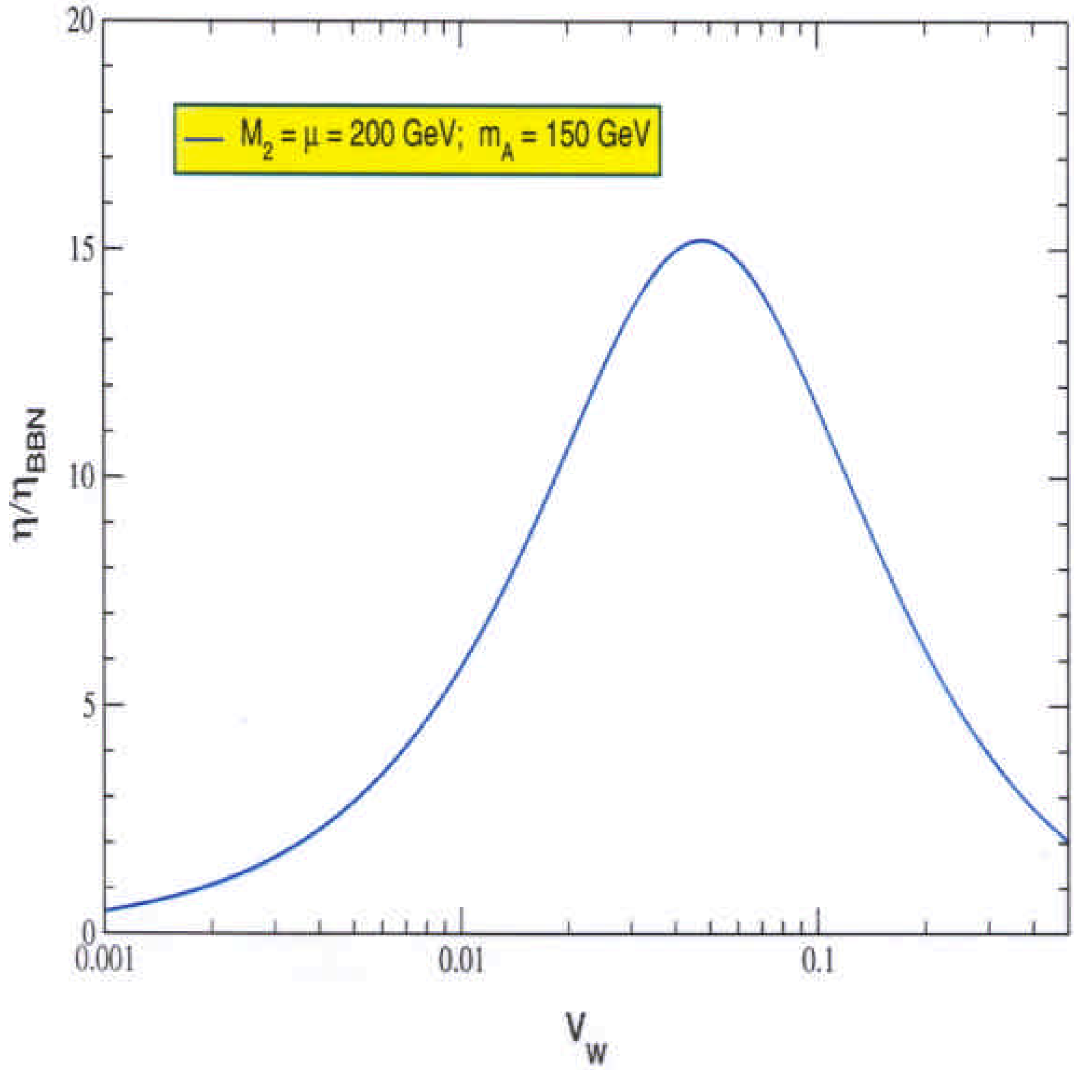
- We set $v(T_c)/T_c \geq 1$; $\tan\beta = 5$–20, $m_h \simeq$ 115 GeV for $m_Q \simeq$ 2 TeV.
- Inverse of values shown in Figure: Phases needed for consistency with Big Bang Nucleosynthesis.

Dependence of Baryon Asymmetry on μ and m_A.



- The Baryon number is enhanced for $M_2 = |\mu|$ and small m_A.
- Large m_A, still relevant contribution, with phases of order one.

Dependence of Baryon Asymmetry on v_W



- The Baryon number is enhanced for values of the wall velocity of order $v_W \simeq 0.05.$
- Very small or large v_W : Phases of order one.

On Electric Dipole Moments

The mechanism of electroweak baryogenesis in the MSSM requires relatively large phases of the μ parameter with respect to weak gaugino masses. Considering natural uncertainties in computations, $\phi_\mu > 0.01$

Large phases consistent with neutron and electron e.d.m. if first and second generation squark and slepton masses larger than or of order of 1 TeV.

Two loop contributions depending only on stop, chargino and neutralino masses survive.
D. Chang, W. Chang, W. Keung, A. Pilaftsis, '99, '00, '02.
These contributions involve the interchange of a CP-odd Higgs boson (admixture of heavy Higgs states).

Either cancellations occur (possible) or CP-odd Higgs mass large. Acceptable baryon number obtained also in second case.

Conclusions

- The scenario of Electroweak Baryogenesis can be realized in the MSSM if

  $m_h \lesssim 117$ GeV, $\qquad m_{\tilde{t}} < m_t$

- Present LEP bounds imply that if this scenario is realized if

  - Large values of $\tan\beta > 5$ and
  - Large values of $m_Q =$ 1–3 TeV .
  - Heavy first and second generation squark and sleptons preferred.

- Computation of Baryon asymmetry: Acceptable values of η/η_{BBN} for $arg(M_2\mu) \geq 0.01$.

- Values of the chargino and neutralino masses of order of the weak scale are preferred.

- If Higgs bosons not seen at LEP due to kinematic reasons or a suppression of its coupling to b-quarks, they should be seen at either a high luminosity Tevatron or at the LHC.

- Light stops, and probably light charginos should also be seen at at least one of these colliders.