SUSY in the Light of B Physics Observables and Electroweak Precision Data

Sven Heinemeyer, IFCA (CSIC–UC)

Fermilab, 04/2007

based on collaborations with
J. Ellis, W. Hollik, K. Olive, A.M. Weber and *G. Weiglein*

1. Introduction and motivation
2. The SUSY models
3. The observables
4. SUSY in the light . . .
5. Conclusions

1. Introduction and motivation

Supersymmetry (SUSY) : Symmetry between

$$\text{Bosons} \leftrightarrow \text{Fermions}$$

$$Q\ |\text{Fermion}\rangle \rightarrow |\text{Boson}\rangle$$
$$Q\ |\text{Boson}\rangle \rightarrow |\text{Fermion}\rangle$$

Simplified examples:

$$Q\ |\text{top},\ t\rangle \rightarrow |\text{scalar top},\ \tilde{t}\rangle$$
$$Q\ |\text{gluon},\ g\rangle \rightarrow |\text{gluino},\ \tilde{g}\rangle$$

$\Rightarrow$ each SM multiplet is enlarged to its double size

Unbroken SUSY: All particles in a multiplet have the same mass

Reality: $m_e \neq m_{\tilde{e}} \Rightarrow$ SUSY is broken . . .

. . . via soft SUSY-breaking terms in the Lagrangian (added by hand)

SUSY particles are made heavy: $\boxed{M_{\text{SUSY}} = \mathcal{O}(1\ \text{TeV})}$

Supersymmetry: Motivation

The SM is in a pretty good shape.

Why MSSM? (Is it worth to double the particle spectrum?)

1.) Stability of the Higgs mass against higher-order corr.

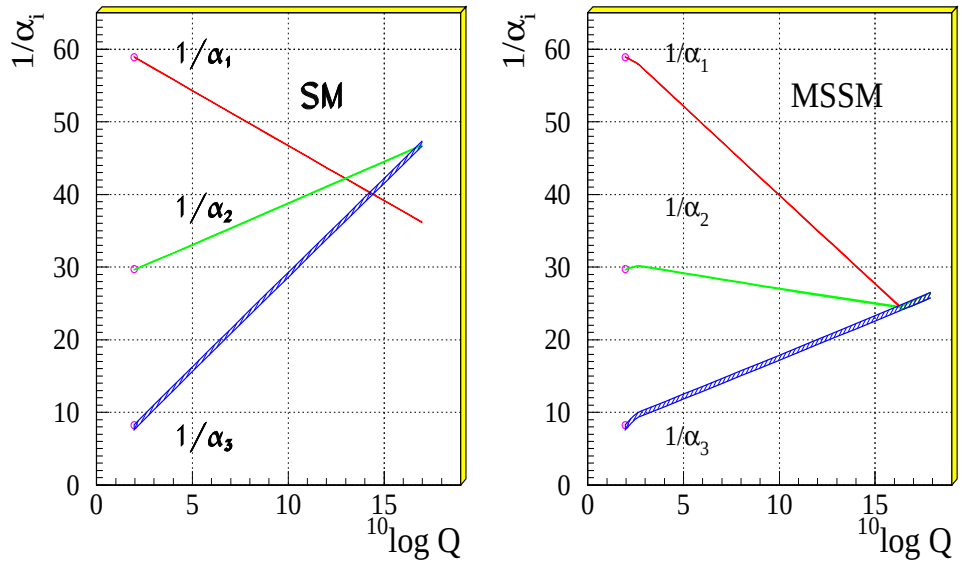
2.) Unification of gauge couplings: Not possible in the SM, but in the MSSM (although it was not designed for it.)

3.) Spontaneous symmetry breaking via Higgs mechanism is automatic in SUSY GUTs

4.) SUSY provides CDM candidate

5.) . . .

Unification of the Coupling Constants in the SM and the minimal MSSM



[*Amaldi, de Boer, Fürstenau '92*]

The Minimal Supersymmetric Standard Model (MSSM)

Superpartners for Standard Model particles

$$\left[u, d, c, s, t, b\right]_{L,R} \quad \left[e, \mu, \tau\right]_{L,R} \quad \left[\nu_{e,\mu,\tau}\right]_{L} \qquad \text{Spin } \tfrac{1}{2}$$

$$\left[\tilde{u}, \tilde{d}, \tilde{c}, \tilde{s}, \tilde{t}, \tilde{b}\right]_{L,R} \quad \left[\tilde{e}, \tilde{\mu}, \tilde{\tau}\right]_{L,R} \quad \left[\tilde{\nu}_{e,\mu,\tau}\right]_{L} \qquad \text{Spin } 0$$

$$g \quad \underbrace{W^{\pm}, H^{\pm}} \quad \underbrace{\gamma, Z, H_1^0, H_2^0} \qquad \text{Spin } 1 \text{ / Spin } 0$$

$$\tilde{g} \quad \tilde{\chi}^{\pm}_{1,2} \quad \tilde{\chi}^{0}_{1,2,3,4} \qquad \text{Spin } \frac{1}{2}$$

Enlarged Higgs sector: Two Higgs doublets

Problem in the MSSM: many scales

$\rightarrow$ CPV will mostly be neglected throughout this talk!

$\tilde{t}/\tilde{b}$ sector of the MSSM: (scalar partner of the top/bottom quark)

Stop, sbottom mass matrices ($X_t = A_t - \mu^*/\tan\beta$, $X_b = A_b - \mu^* \tan\beta$):

$$\mathcal{M}^2_{\tilde{t}} = \begin{pmatrix} M^2_{\tilde{t}_L} + m_t^2 + DT_{t_1} & m_t X_t^* \\ m_t X_t & M^2_{\tilde{t}_R} + m_t^2 + DT_{t_2} \end{pmatrix} \xrightarrow{\theta_{\tilde{t}}} \begin{pmatrix} m^2_{\tilde{t}_1} & 0 \\ 0 & m^2_{\tilde{t}_2} \end{pmatrix}$$

$$\mathcal{M}^2_{\tilde{b}} = \begin{pmatrix} M^2_{\tilde{b}_L} + m_b^2 + DT_{b_1} & m_b X_b^* \\ m_b X_b & M^2_{\tilde{b}_R} + m_b^2 + DT_{b_2} \end{pmatrix} \xrightarrow{\theta_{\tilde{b}}} \begin{pmatrix} m^2_{\tilde{b}_1} & 0 \\ 0 & m^2_{\tilde{b}_2} \end{pmatrix}$$

mixing important in stop sector (also in sbottom sector for large $\tan\beta$)

soft SUSY-breaking parameters A_t, A_b also appear in ϕ-$\tilde{t}/\tilde{b}$ couplings

$$SU(2) \text{ relation} \Rightarrow M_{\tilde{t}_L} = M_{\tilde{b}_L}$$

$\Rightarrow$ relation between $m_{\tilde{t}_1}, m_{\tilde{t}_2}, \theta_{\tilde{t}}, m_{\tilde{b}_1}, m_{\tilde{b}_2}, \theta_{\tilde{b}}$

Enlarged Higgs sector: Two Higgs doublets

$$H_1 = \begin{pmatrix} H_1^1 \\ H_1^2 \end{pmatrix} = \begin{pmatrix} v_1 + (\phi_1 + i\chi_1)/\sqrt{2} \\ \phi_1^- \end{pmatrix}$$

$$H_2 = \begin{pmatrix} H_2^1 \\ H_2^2 \end{pmatrix} = \begin{pmatrix} \phi_2^+ \\ v_2 + (\phi_2 + i\chi_2)/\sqrt{2} \end{pmatrix}$$

$$V = m_1^2 H_1 \bar{H}_1 + m_2^2 H_2 \bar{H}_2 - m_{12}^2 (\epsilon_{ab} H_1^a H_2^b + \text{h.c.})$$

$$+ \underbrace{\frac{g'^2 + g^2}{8}}_{} (H_1 \bar{H}_1 - H_2 \bar{H}_2)^2 + \underbrace{\frac{g^2}{2}}_{} |H_1 \bar{H}_2|^2$$

gauge couplings, in contrast to SM

physical states: $h^0, H^0, A^0, H^\pm$

Goldstone bosons: $G^0, G^\pm$

Input parameters: (to be determined experimentally)

$$\tan\beta = \frac{v_2}{v_1}, \qquad M_A^2 = -m_{12}^2 (\tan\beta + \cot\beta)$$

Q: Which Lagrangian describes the world?

A: Too difficult :-(

Q': What describes the world better: SM or MSSM ?

A: Two possible ways:

- Search for new SUSY particles

new SUSY particles found
$\Updownarrow$
SM ruled out

Problem:
SUSY particles are too heavy for todays colliders, only lower limits of $\mathcal{O}(100\ \text{GeV})$.

$\rightarrow$ waiting for Tevatron (2008/09. . . ?)
$\rightarrow$ waiting for LHC (2009/10. . . ? cooling problems . . .)

- Search for indirect effects of SUSY via Precision Observables

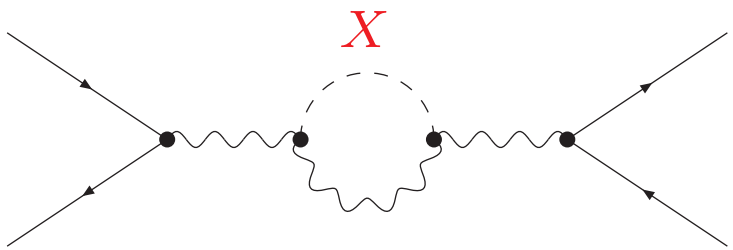
Precision Observables (POs):

Comparison of electro-weak precision observables with theory:

EW Precision data:		Theory:
$M_W, \sin^2\theta_{\text{eff}}, a_\mu$	$\leftrightarrow$	SM, MSSM , . . .

$\Downarrow$

Test of theory at quantum level: Sensitivity to loop corrections



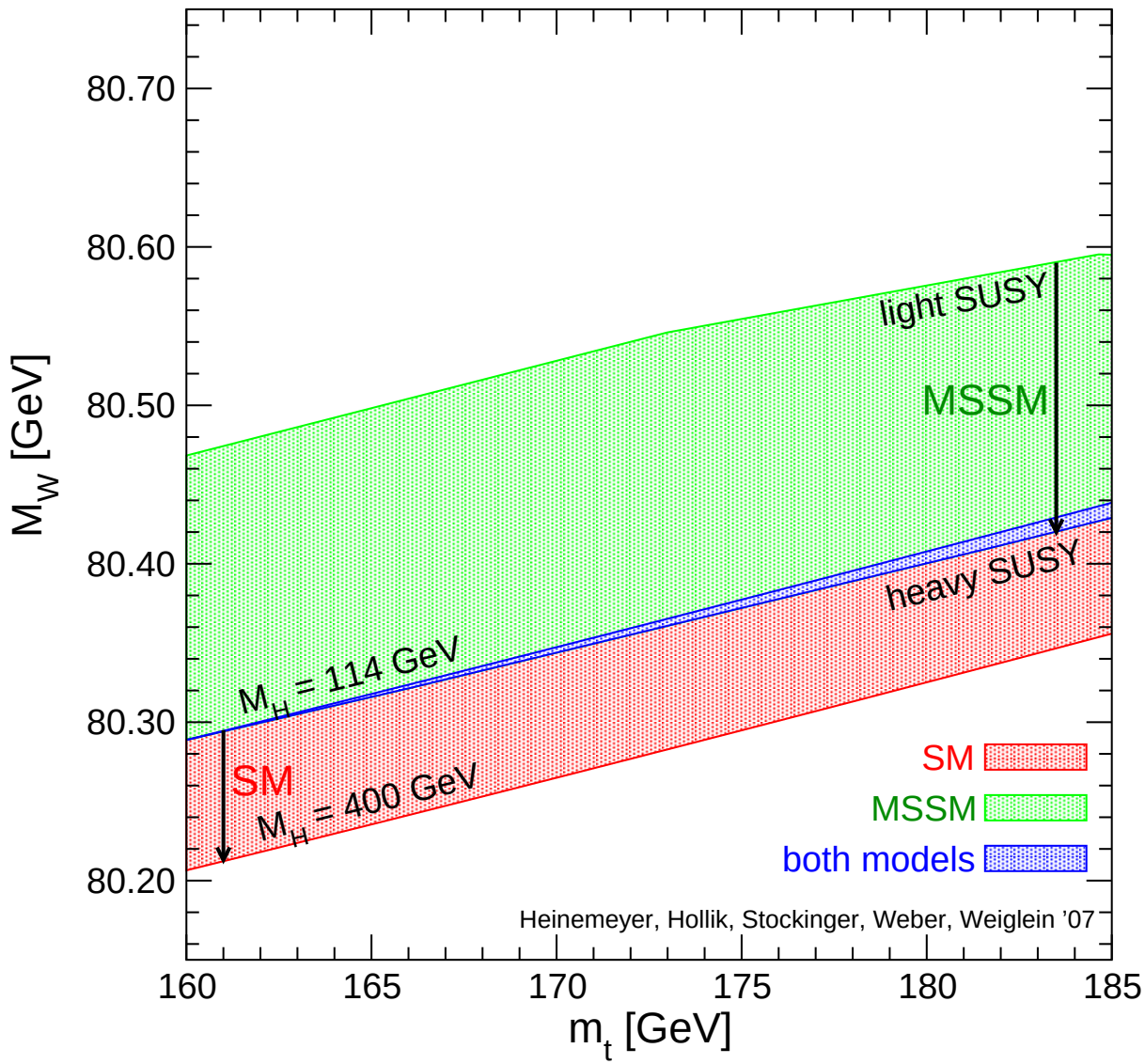
$\Downarrow$

Very high accuracy of measurements and theoretical predictions needed

- Which model fits better?
- Does the prediction of a model contradict the experimental data?

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '07*]



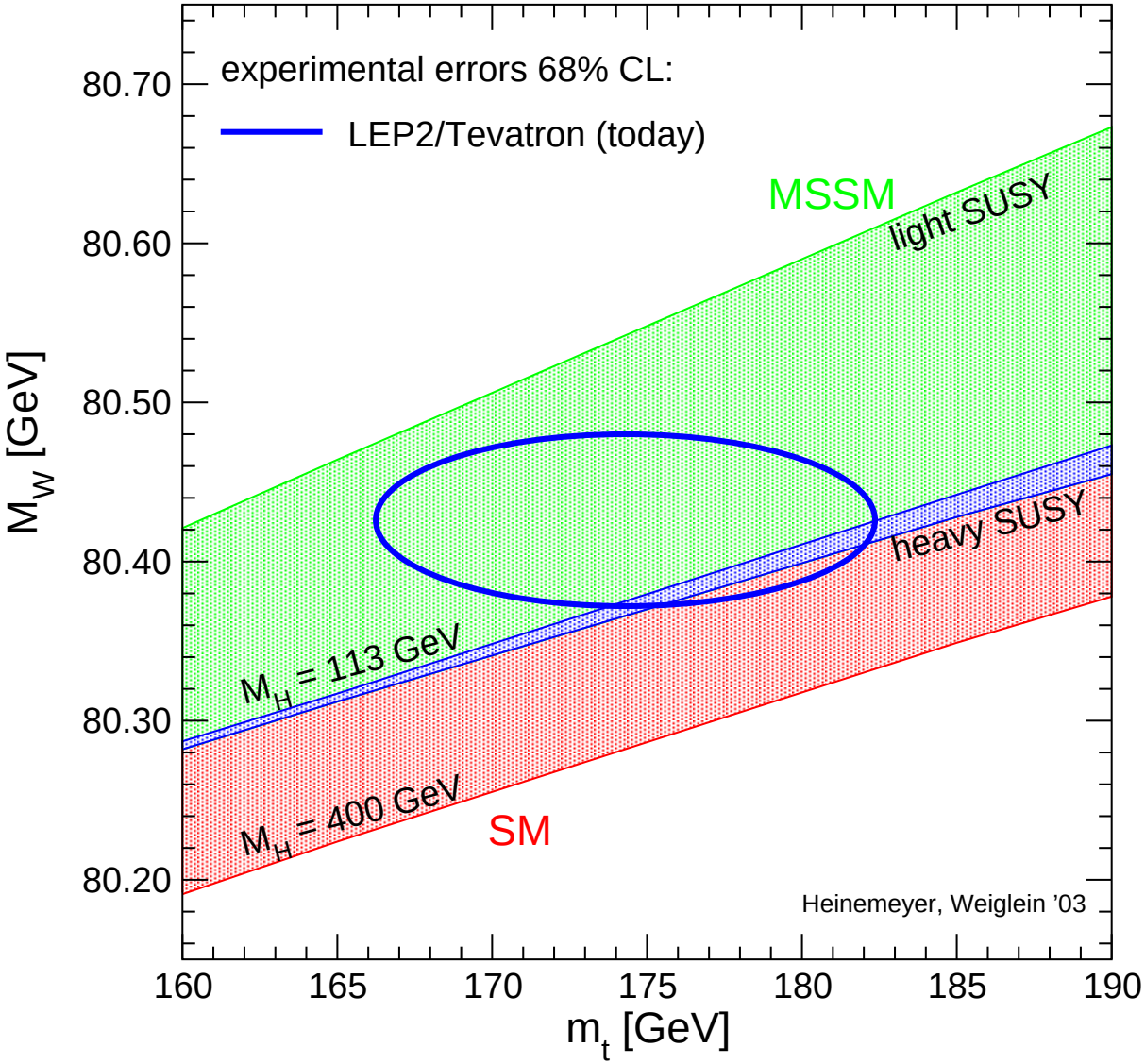
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., G. Weiglein '03*]



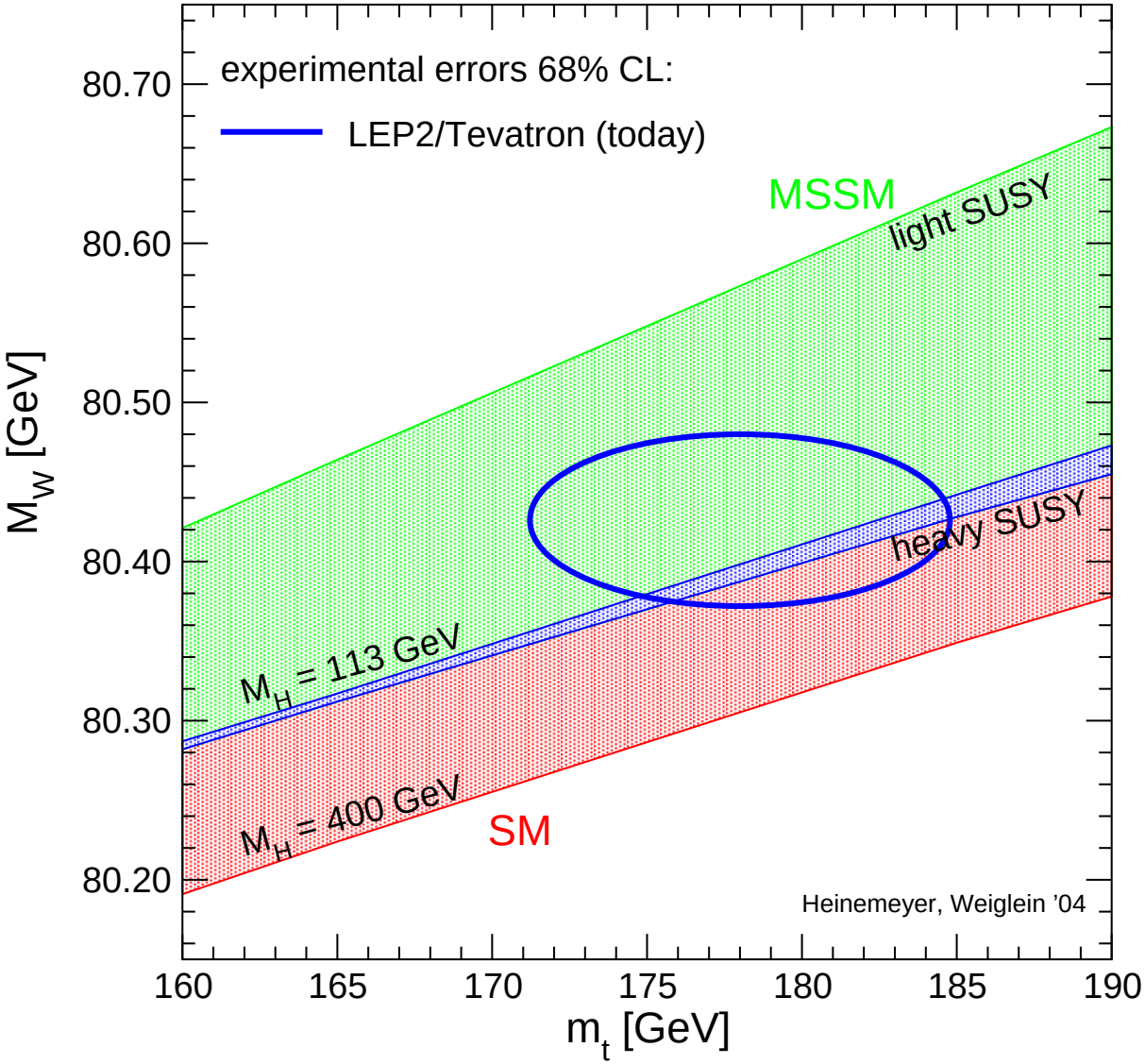
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., G. Weiglein '04*]



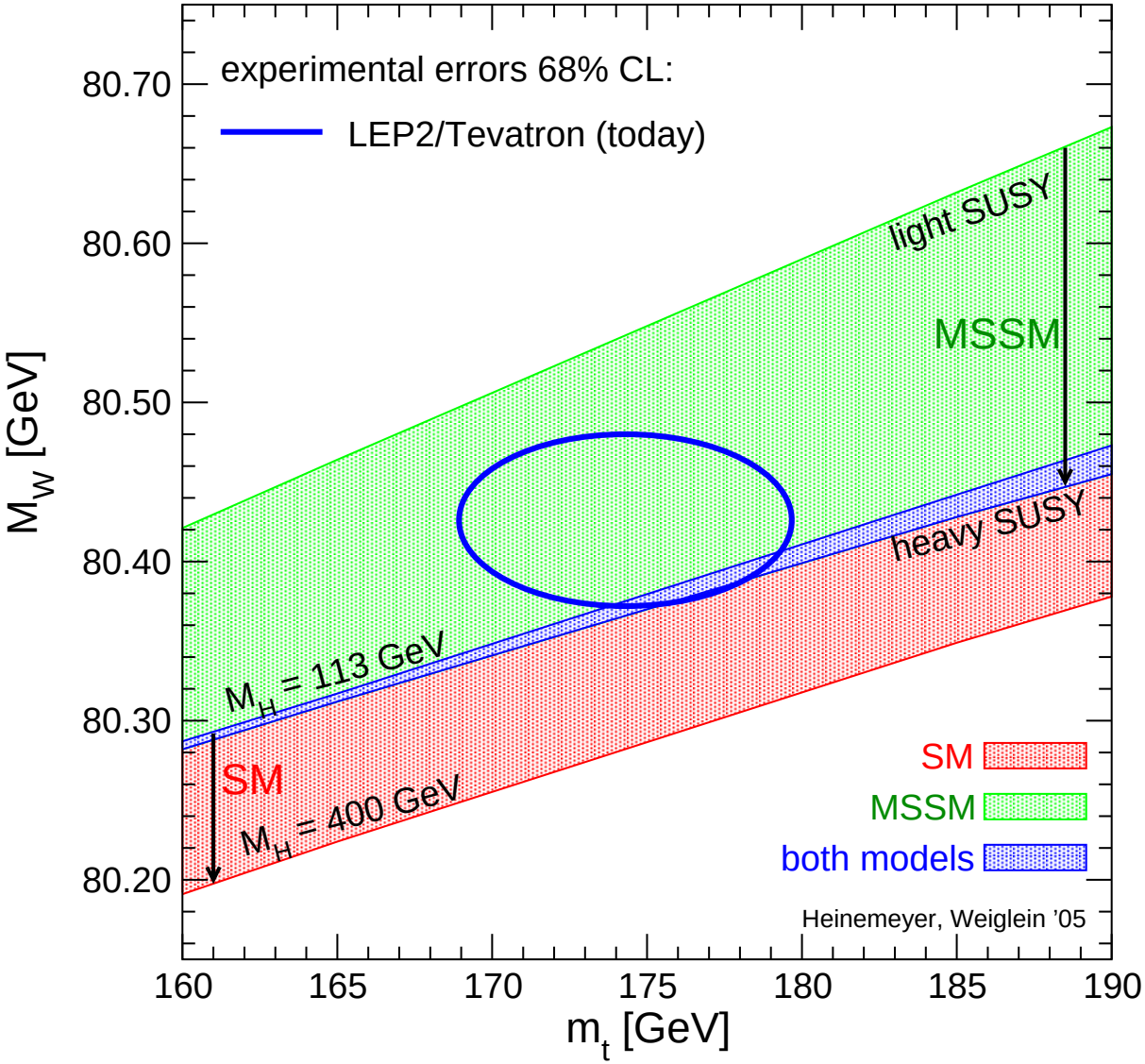
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of $M_H^{\rm SM}$

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., G. Weiglein '05*]



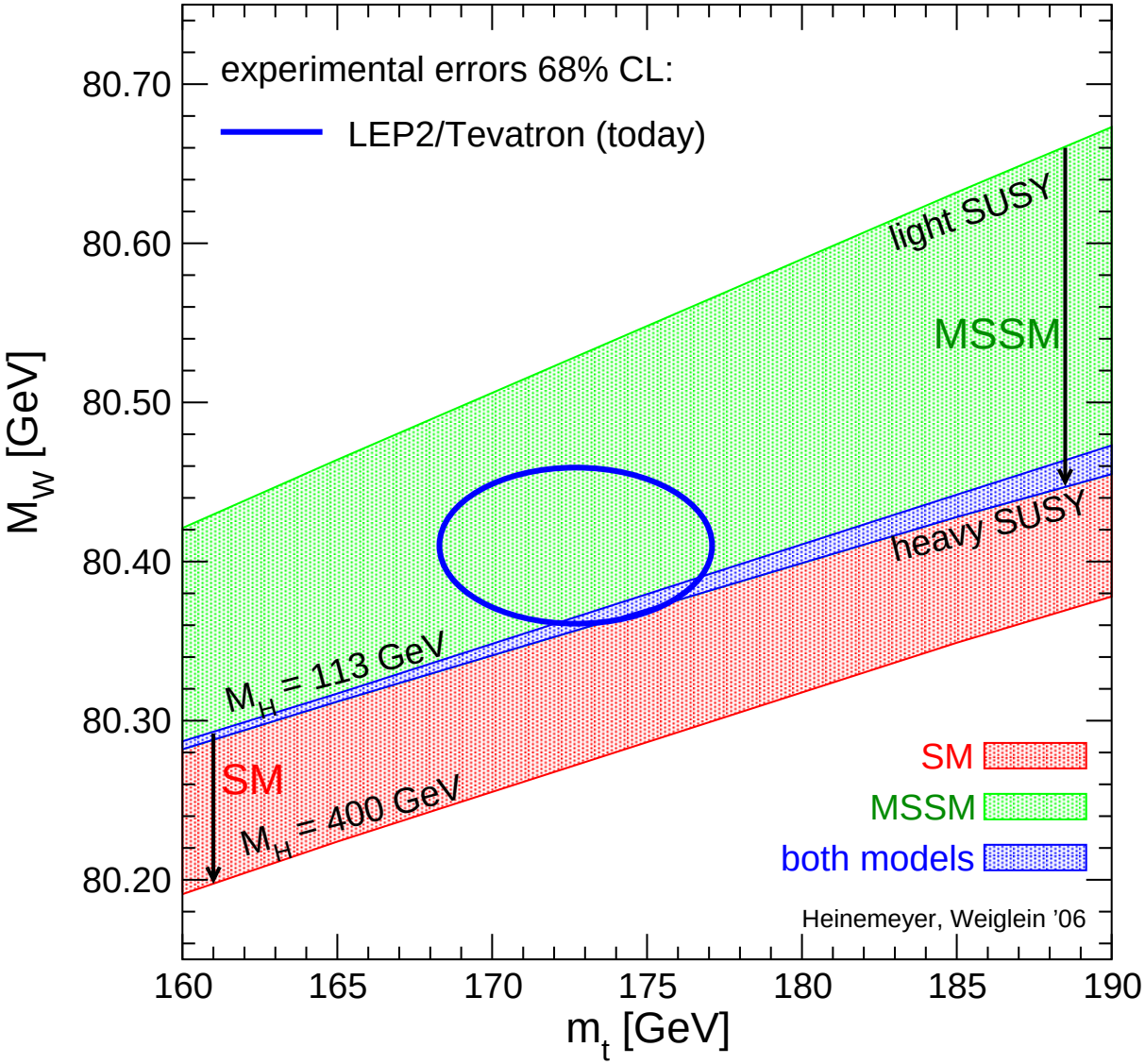
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., G. Weiglein '06*]



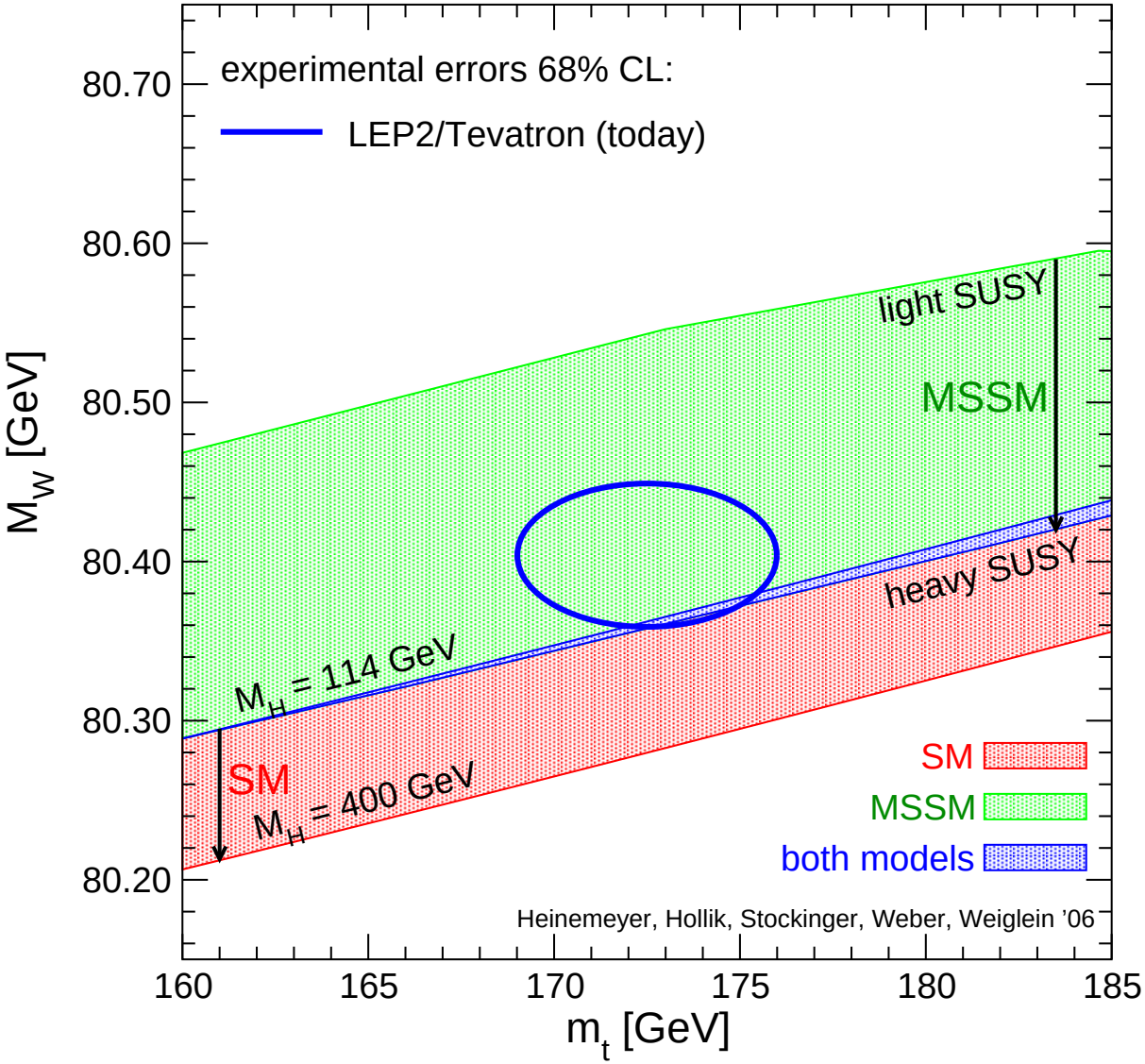
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '06*]



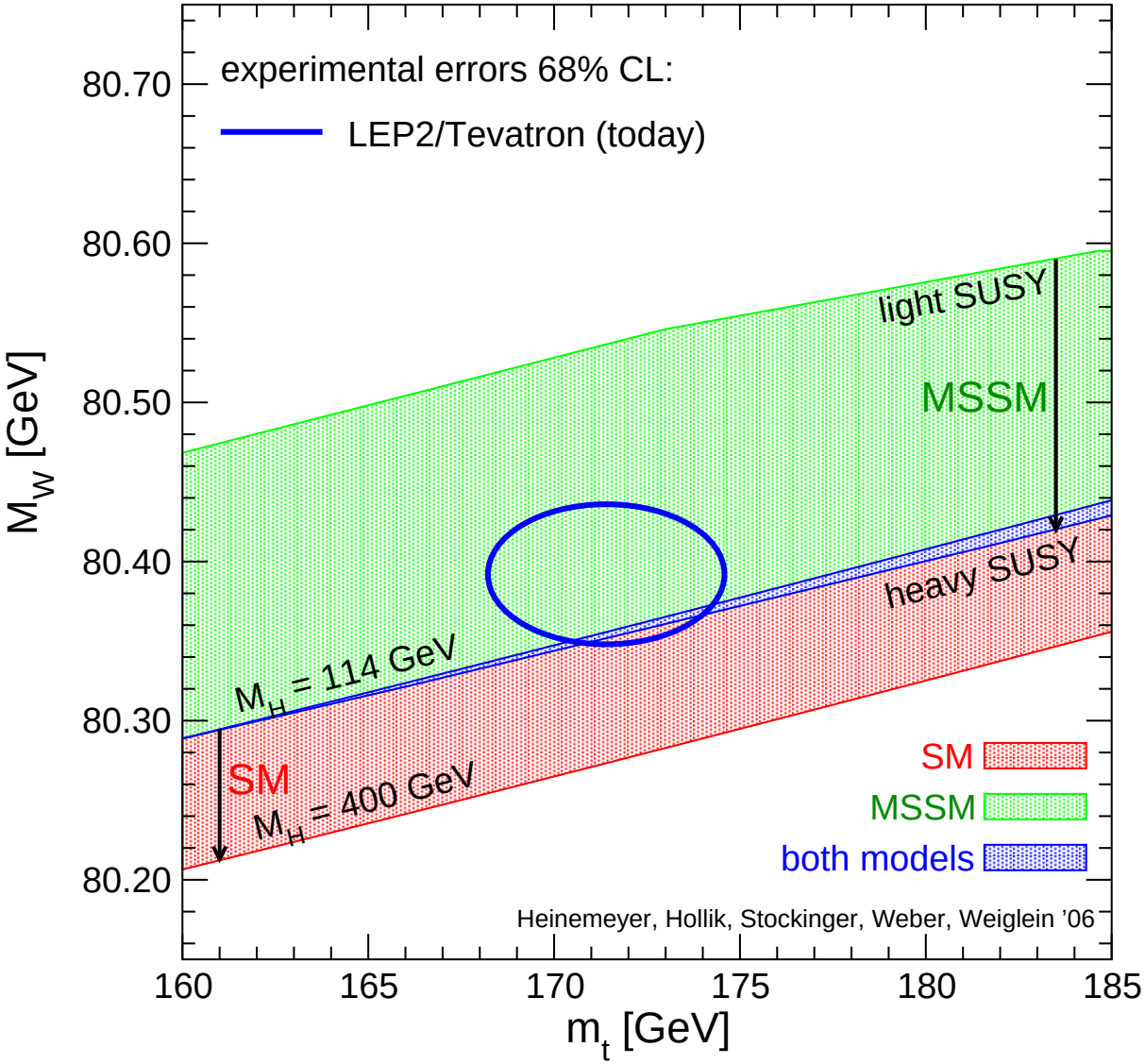
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of $M_H^{\rm SM}$

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '06*]



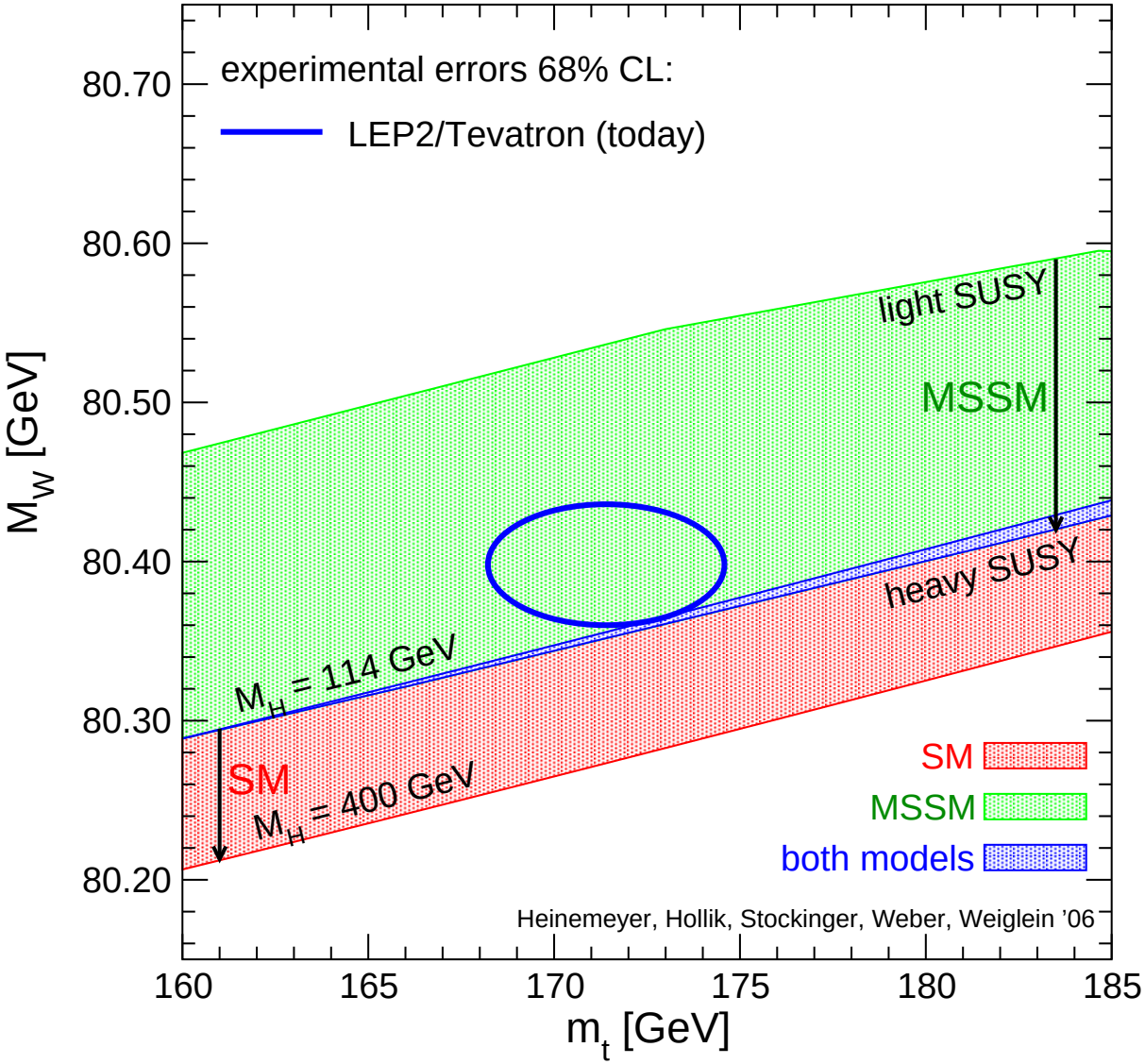
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of $M_H^{\rm SM}$

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '06*]



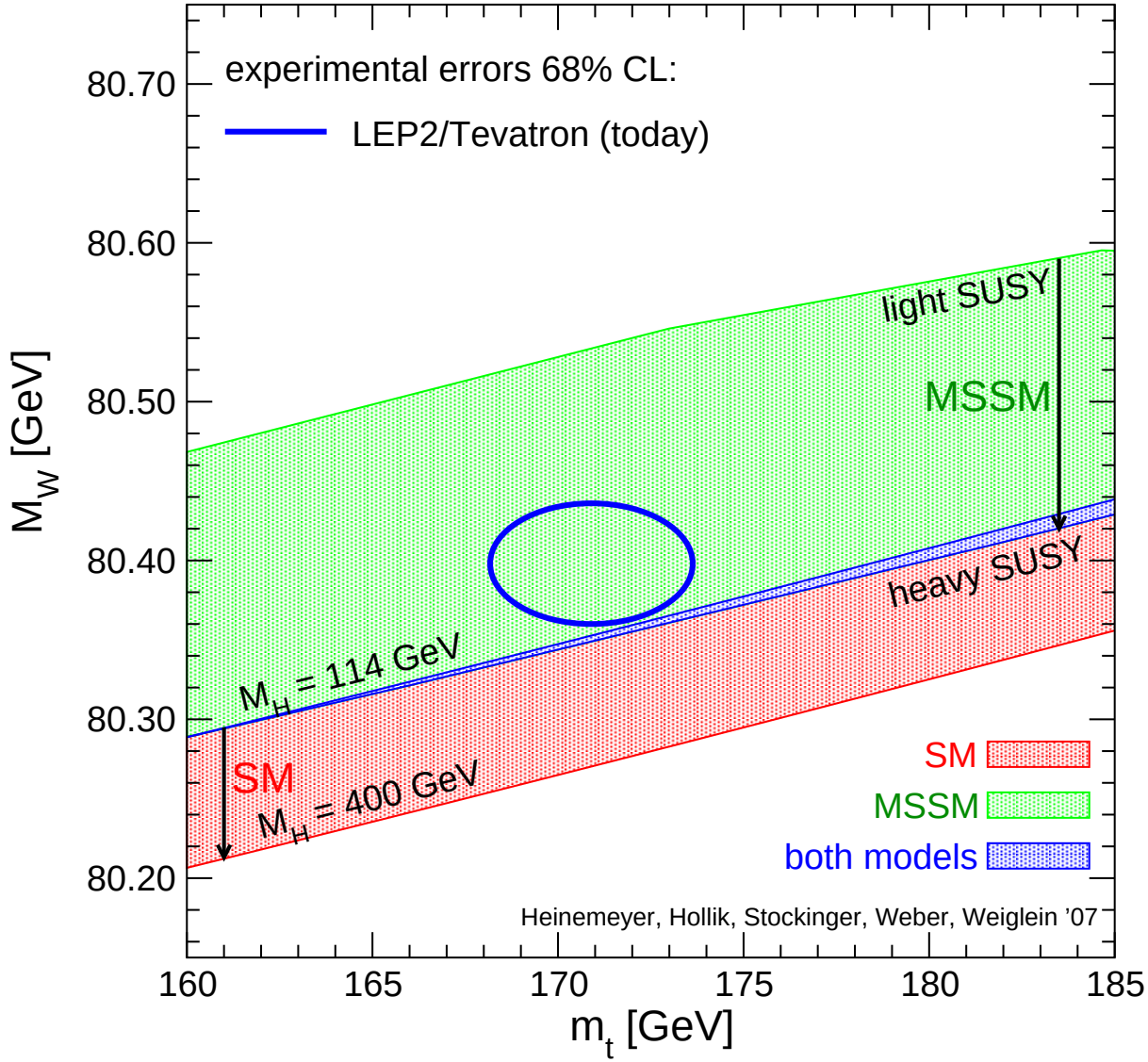
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of $M_H^{\rm SM}$

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '07*]



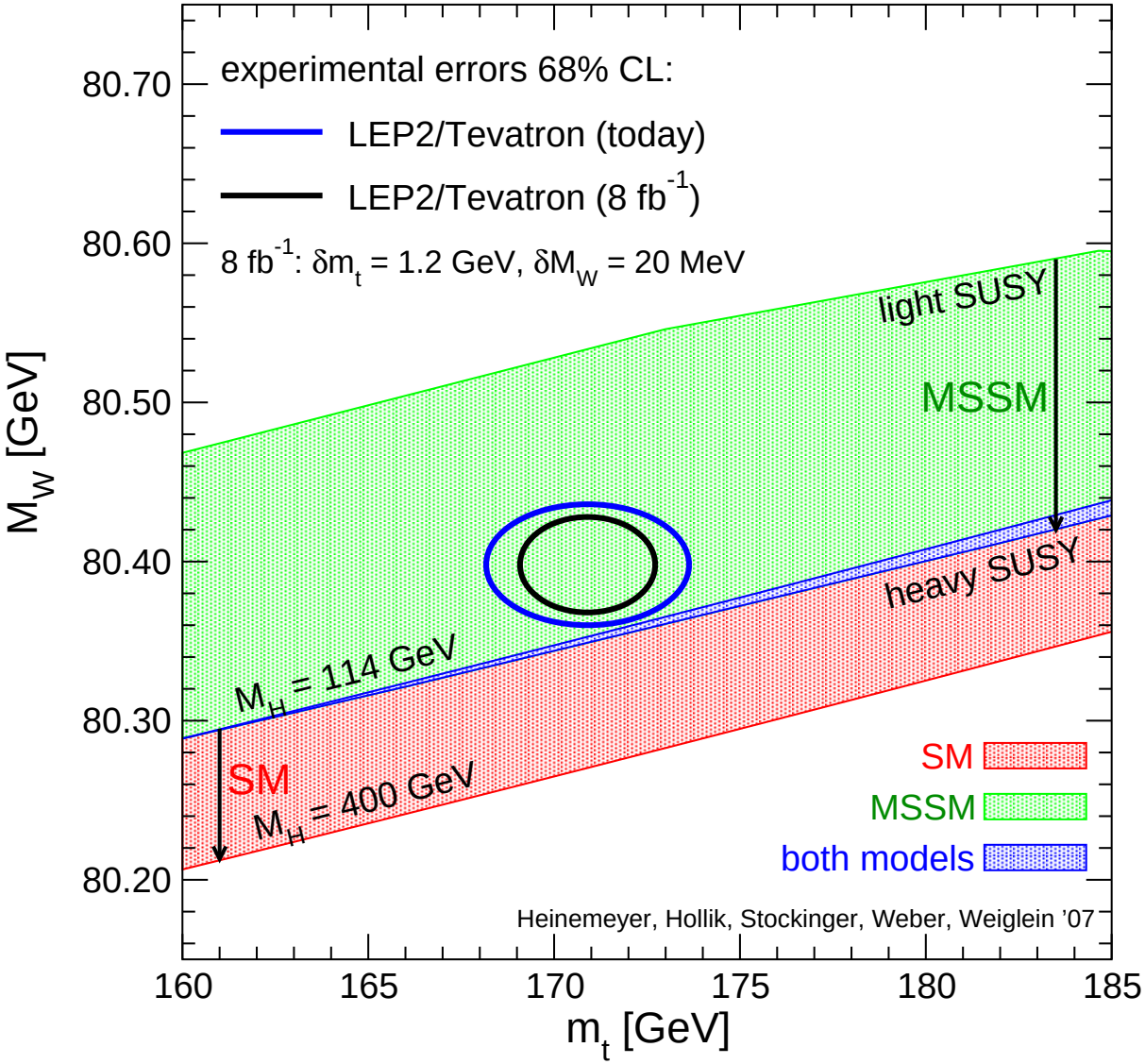
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '06*]



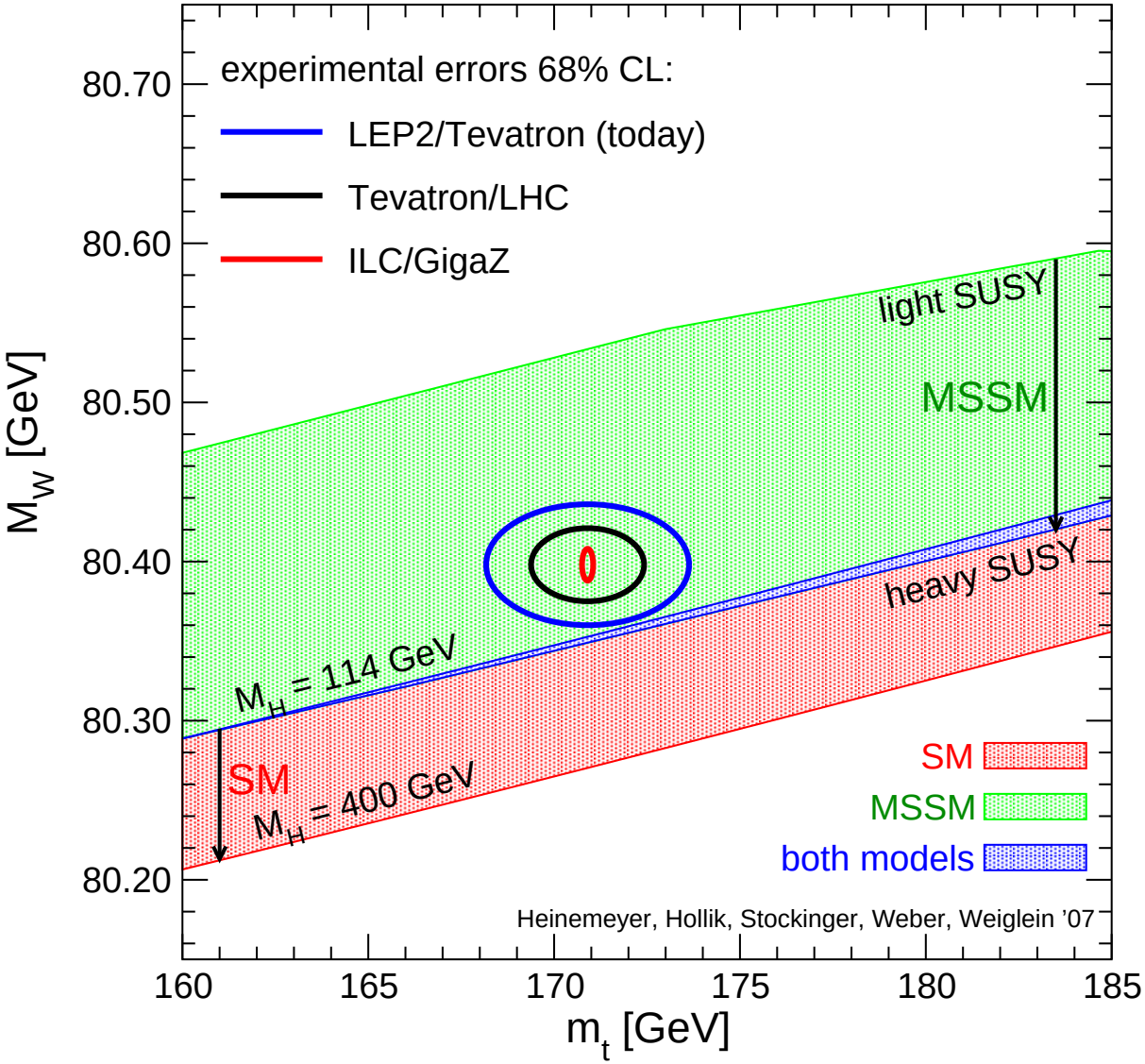
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

Example: Prediction for M_W in the SM and the MSSM :

[*S.H., W. Hollik, D. Stockinger, A.M. Weber, G. Weiglein '06*]



MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

The main idea:

What do we know about the SUSY mass scale?

1. Coupling constant unification $\Rightarrow M_{\text{SUSY}} \approx 1$ TeV

2. LSP should be cold dark matter $\Rightarrow M_{\text{SUSY}} \lesssim 1$ TeV

3. Indirect hints from existing data?
   - Focus on CMSSM and NUHM

     small number of free parameters
   - hard constraint: LSP gives right amount of cold dark matter

     CMSSM: only thin strips allowed in the $m_{1/2}$–m_0 plane

     NUHM: also strong constraints
   - Use existing data of EWPO + BPO

     $\Rightarrow \chi^2$ fit with these observables

     $\Rightarrow$ best fit values for masses, couplings, ...

Procedure:

1. Scan over parameter space:
   - CMSSM: for fixed $\tan\beta = 10, 50$
   - NUHM: certain parameter planes,
     corresponding to CMSSM best fit points

2. Perform χ^2 fit

3. Find preferred values for masses
   $\Rightarrow$ collider reach

$\Rightarrow$ most details for CMSSM
NUHM shows the same qualitative behavior

2. The SUSY models

1.) CMSSM (or mSUGRA):

$\Rightarrow$ Scenario characterized by

$$m_0,\ m_{1/2},\ A_0,\ \tan\beta,\ \text{sign}\,\mu$$

m_0 : universal scalar mass parameter

$m_{1/2}$: universal gaugino mass parameter

A_0 : universal trilinear coupling

} at the GUT scale

$\tan\beta$: ratio of Higgs vacuum expectation values

$\text{sign}(\mu)$: sign of supersymmetric Higgs parameter

$\Rightarrow$ particle spectra from renormalization group running to weak scale

Lightest SUSY particle (LSP) is the lightest neutralino

2. The SUSY models

1.) CMSSM (or mSUG

⇒ Scenario charac

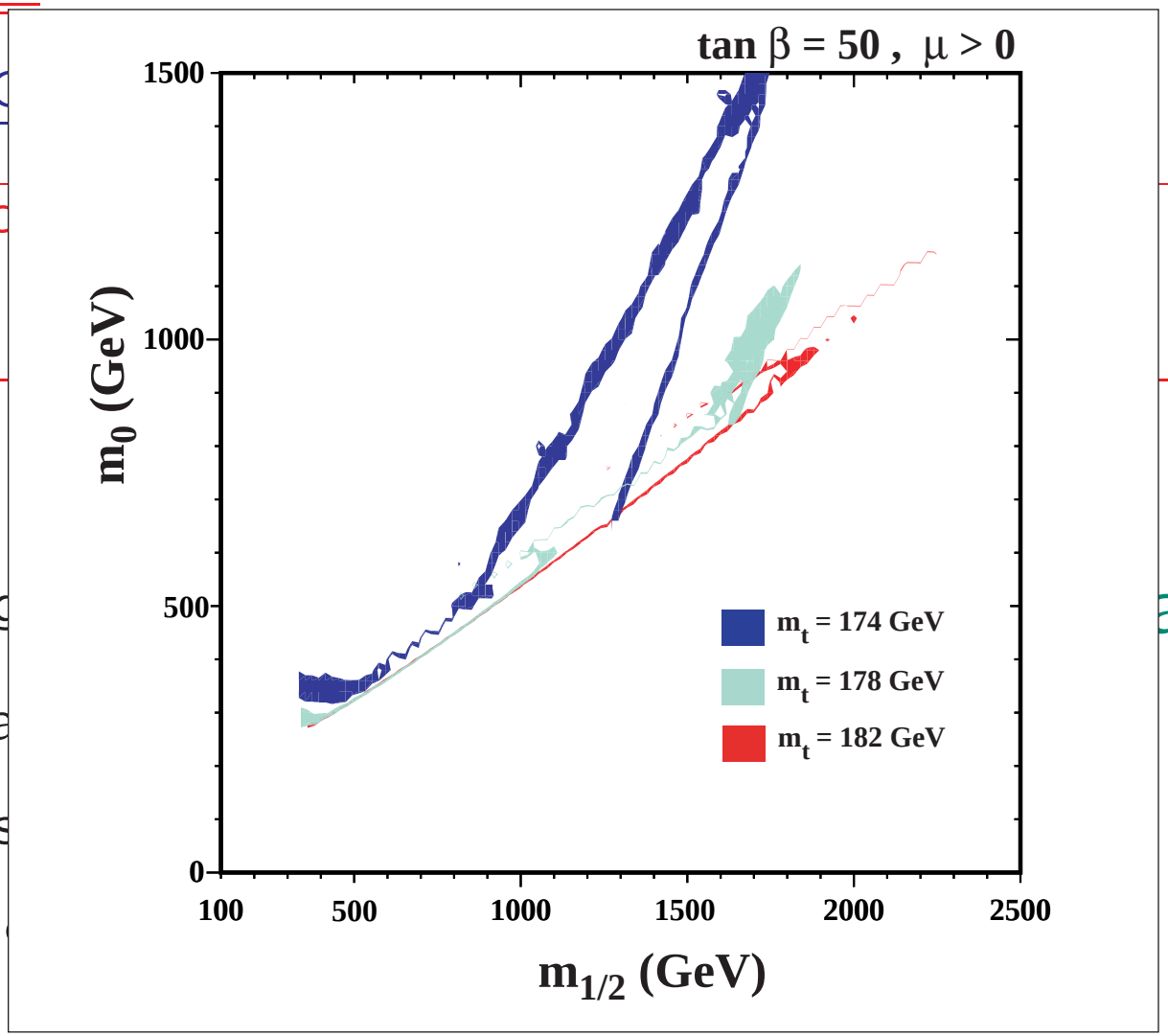
m_0 : universal scalar

$m_{1/2}$: universal gaug

A_0 : universal trilinea

$\tan\beta$: ratio of Higgs

sign(μ) : sign of sup



ale

⇒ particle spectra from renormalization group running to weak scale

Lightest SUSY particle (LSP) is the lightest neutralino

2.) NUHM: (Non-universal Higgs mass model)

$\Rightarrow$ besides the CMSSM parameters

M_A and μ

Assumption:

no unification of scalar fermion and scalar Higgs parameters at the GUT scale

$\Rightarrow$ effectively M_A and μ free parameters at the EW scale

$\Rightarrow$ particle spectra from renormalization group running to weak scale

Lightest SUSY particle (LSP) is the lightest neutralino

$\Rightarrow$ possible: M_A–$\tan\beta$ planes :-)

3. The observables

1./2./3.) M_W, $\sin^2\theta_{\text{eff}}$, Γ_Z:

1.) Theoretical prediction for M_W in terms

of $M_Z, \alpha, G_\mu, \Delta r$:

$$M_W^2\left(1-\frac{M_W^2}{M_Z^2}\right)=\frac{\pi\,\alpha}{\sqrt{2}\,G_\mu}(1+\Delta r)$$

$\Updownarrow$

loop corrections

2.) Effective mixing angle:

$$\sin^2\theta_{\text{eff}}=\frac{1}{4\,|Q_f|}\left(1-\text{Re}\frac{g_V^f}{g_A^f}\right)$$

Higher order contributions:

$$g_V^f\to g_V^f+\Delta g_V^f,\quad g_A^f\to g_A^f+\Delta g_A^f$$

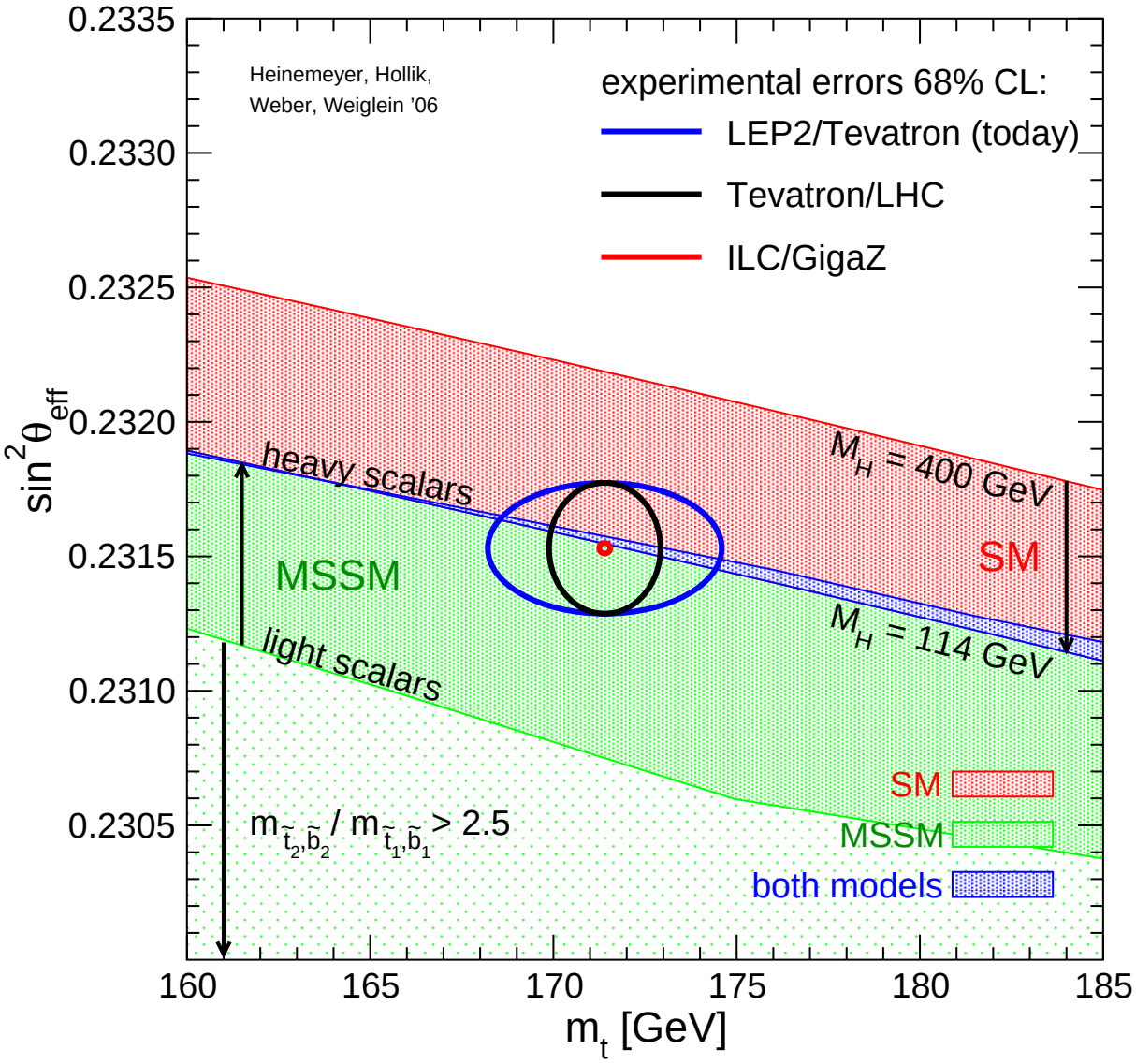
3.) Total Z width:

$$\Gamma_Z=\sum_X\Gamma(Z\to X\bar{X})$$

including higher-order corrections

Prediction for $\sin^2\theta_{\rm eff}$ in the SM and the MSSM :

[*S.H., W. Hollik, A.M. Weber, G. Weiglein '07*]



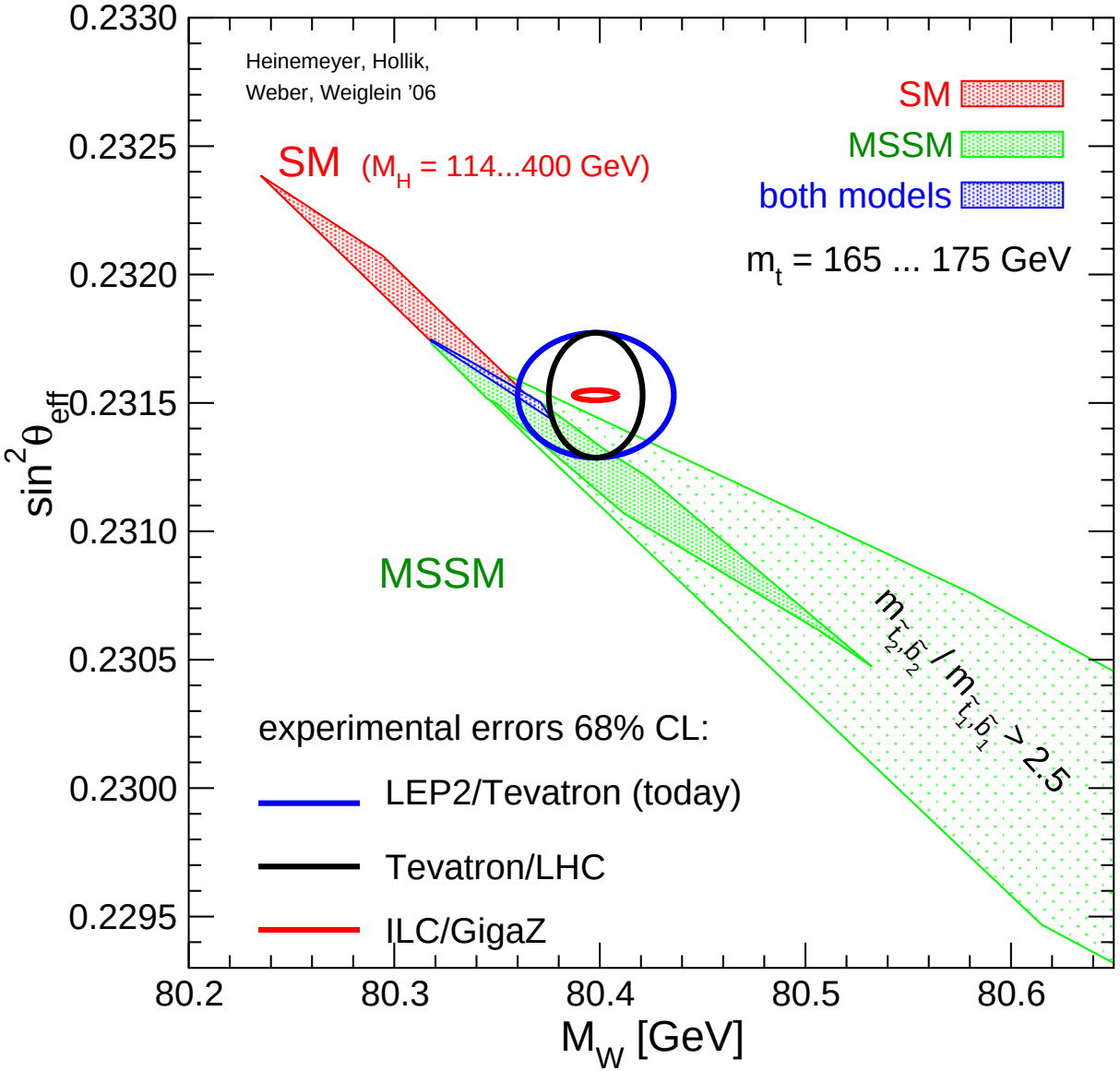
MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of $M_H^{\rm SM}$

Prediction for M_W and $\sin^2\theta_{\text{eff}}$ in the SM and the MSSM :

[*S.H., W. Hollik, A.M. Weber, G. Weiglein '07*]



MSSM band:
scan over
SUSY masses

overlap:
SM is MSSM-like
MSSM is SM-like

SM band:
variation of M_H^{SM}

For χ^2 fit:

$$\chi^2_x = \left(\frac{R_x^{\text{exp}} - R_x^{\text{theo}}}{\sigma_x} \right)^2 \qquad x = M_W, \sin^2\theta_{\text{eff}}, \Gamma_Z$$

R_x^{exp}: experimental value

R_x^{theo}: theory prediction

σ_x^2: (exp. error)^2 + (param. error)^2 + (intr. error)^2

experimental error

parametric error: from uncertainty in input parameters

intrinsic error: from unknown higher-order corrections

$\Rightarrow$ use most up to date calculations and error estimates

[*S.H., W. Hollik, G. Weiglein '04*]

[*S.H., W. Hollik, D. Stöckinger, A.M. Weber, G. Weiglein '06/'07*]

[*LEPEWWG '06/'07*]

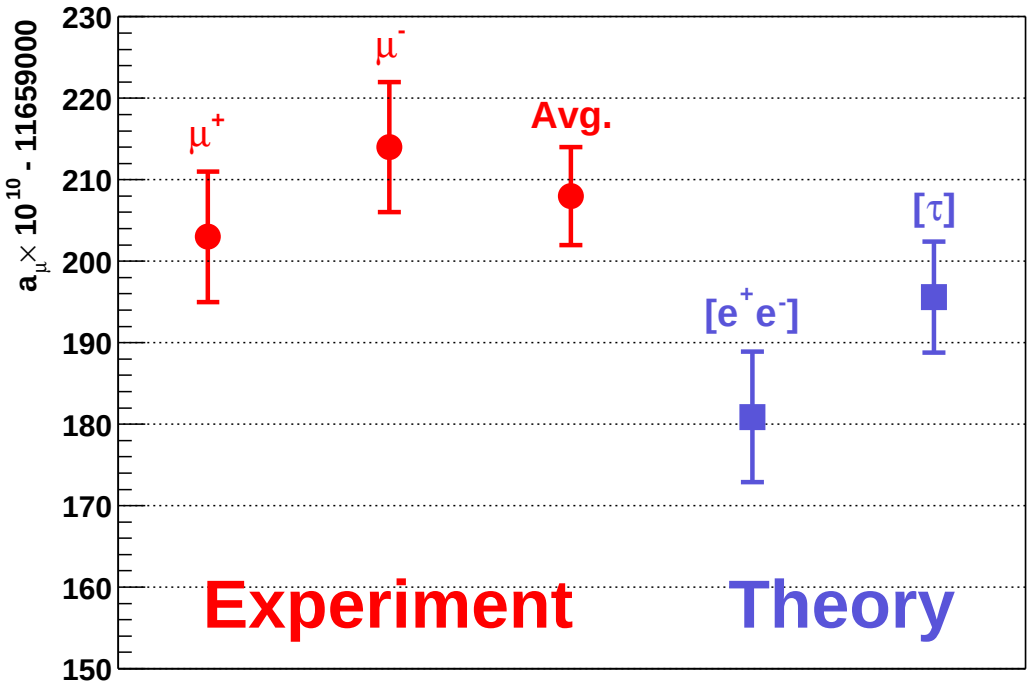
4.) anomalous magnetic moment of the muon: $(g-2)_\mu$

Coupling of muon to magnetic field : $\mu - \mu - \gamma$ coupling

$$\bar{u}(p')\left[\gamma^\mu F_1(q^2) + \frac{i}{2m_\mu}\sigma^{\mu\nu}q_\nu F_2(q^2)\right]u(p)A_\mu \qquad F_2(0) = (g-2)_\mu$$

Overview about the current experimental and SM (theory) result:

[*g-2 Collaboration, hep-ex/0401008*]



Overview of the SM theory evaluation:

Source	contr. to $a_\mu[10^{-10}]$	
LO hadr.	$\sim 695 \pm 7$ (e^+e^-)	[*Davier et al, Hagiwara et al. '03*]
		[*Ghozzi, Jegerlehner '03*]
	711.0 ± 6 (τ)	[*Davier, Eidelman, Höcker, Zhang '03*]
LBL	8 ± 4	[*Knecht, Nyffeler '02*]
	13.6 ± 2.5 tbc	[*Melnikov, Vainshtein '03*]
EW 1L	19	
EW 2L	-4	[*Czarnecki, Krause, Marciano '98*]
exp. res.	6	[*BNL E821 '04*]

$\longrightarrow$ "Isospin breaking effects" in τ data problematic

[*Ghozzi, Jegerlehner '03; Jegerlehner '07*]

e^+e^- data: good agreement between new SND, CMD2, KLOE data

$\Rightarrow$ general agreement at ICHEP'06 Moscow: discard τ data

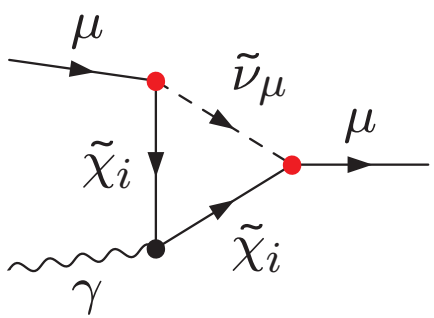
$$a_\mu^{\text{exp}} - a_\mu^{\text{theo,SM}} \approx (27.5 \pm 8.4) \times 10^{-10}$$

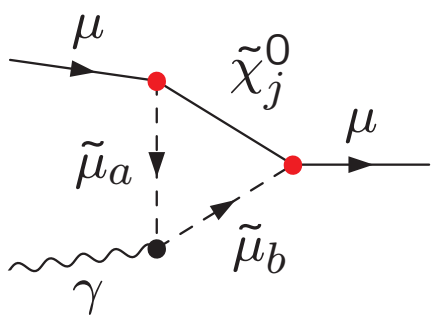
MSSM contributions to $(g-2)_\mu$:

Coupling of muon to magnetic field : $\mu - \mu - \gamma$ coupling

$$\bar{u}(p')\left[\gamma^\mu F_1(q^2) + \frac{i}{2m_\mu}\sigma^{\mu\nu}q_\nu F_2(q^2)\right]u(p)A_\mu \qquad F_2(0) = (g-2)_\mu$$

Feynman diagrams for MSSM 1L corrections:





Enhancement factor as compared to SM:

$$\mu - \tilde{\chi}_i^\pm - \tilde{\nu}_\mu \quad : \quad \sim m_\mu \tan\beta$$
$$\mu - \tilde{\chi}_j^0 - \tilde{\mu}_a \quad : \quad \sim m_\mu \tan\beta$$

For χ^2 fit:

$$\chi_x^2 = \left(\frac{R_x^{\text{exp}} - R_x^{\text{theo}}}{\sigma_x} \right)^2 \qquad x = (g-2)_\mu$$

R_x^{exp}: experimental value $= (a_\mu^{\text{exp}} - a_\mu^{\text{theo,SM}})$

R_x^{theo}: theory prediction $= a_\mu^{\text{theo,SUSY}}$

σ_x^2: (exp. error)^2 + (param. error)^2 + (intr. error)^2

experimental error

parametric error: from uncertainty in input parameters

intrinsic error: from unknown higher-order corrections

$\Rightarrow$ use most up to date calculations and error estimates

[*S.H., W. Hollik, G. Weiglein '04*]

[*S.H., D. Stöckinger, G. Weiglein '03,'04*]

[*g-2 Collaboration, hep-ex/0401008*]

5.) the lightest MSSM Higgs boson mass: M_h

Contrary to the SM: M_h is not a free parameter

MSSM tree-level bound: $M_h < M_Z$, excluded by LEP Higgs searches

Large radiative corrections:

Dominant one-loop corrections:

$$\Delta M_h^2 \sim G_\mu m_t^4 \log\left(\frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2}\right)$$

The MSSM Higgs sector is connected to all other sector via loop corrections (especially to the scalar top sector) f

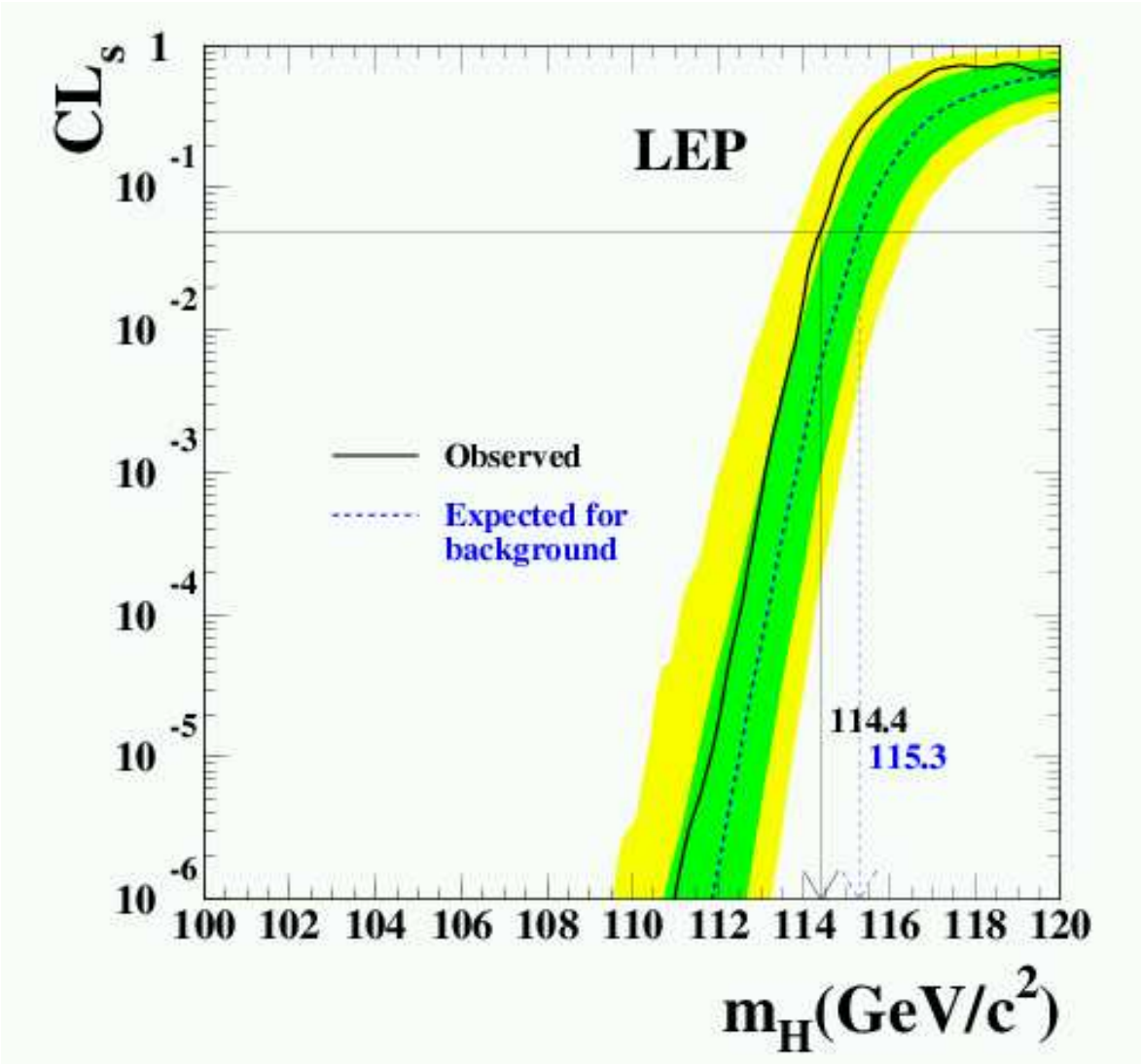
Measurement of M_h, Higgs couplings $\Rightarrow$ test of the theory

LHC: $\Delta M_h \approx 0.2$ GeV
ILC: $\Delta M_h \approx 0.05$ GeV

$\Rightarrow$ M_h will be (the best?) electroweak precision observable

In CMSSM, NUHM:

SM bound of M_H search can be used [*LEP Higgs Working Group '03*]



CL_s can be used/transformed into χ^2 values

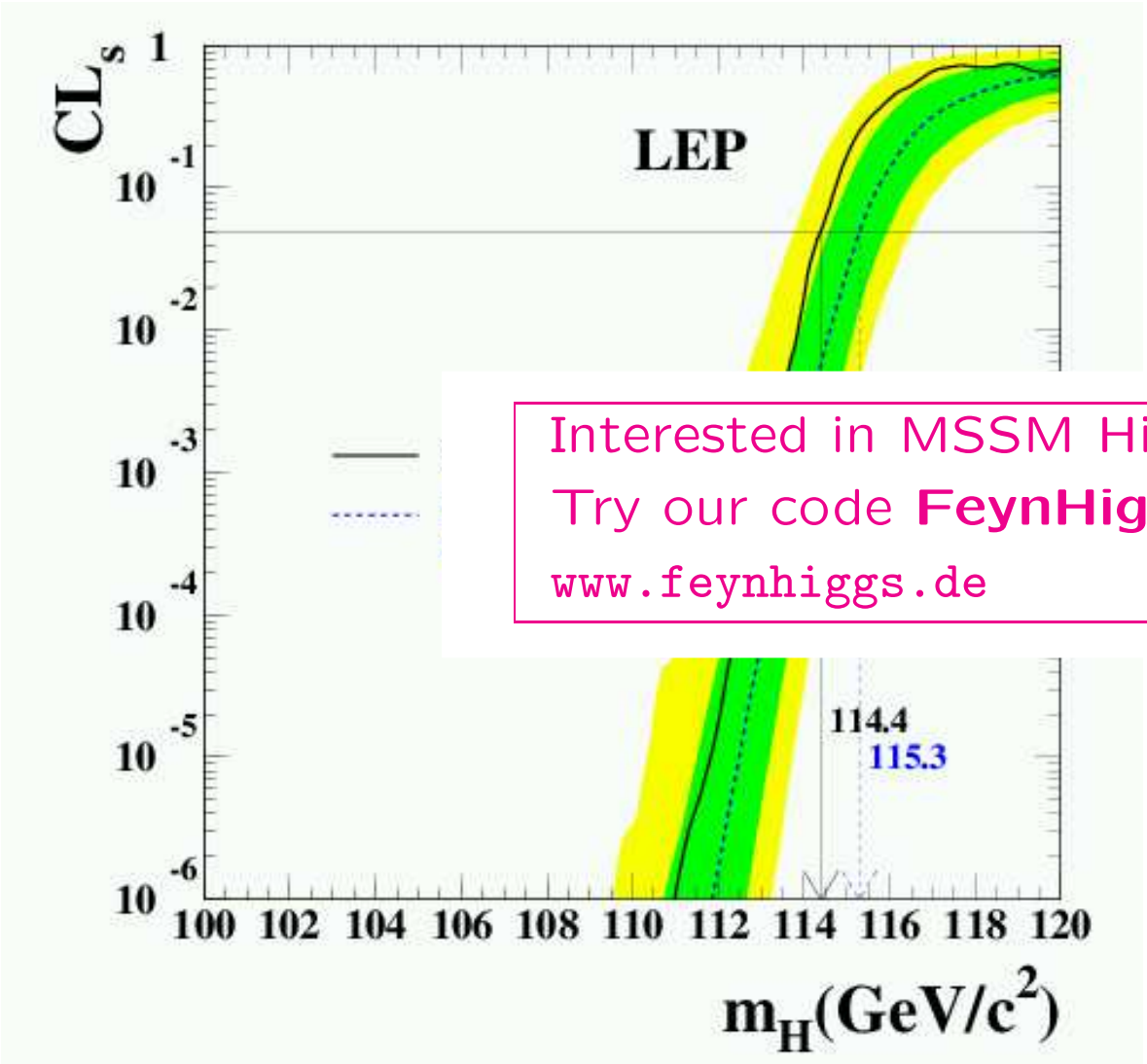
$\Rightarrow$ additional (unobserved) parameter

$\delta M_h^{\text{intr.}} \approx 3$ GeV

We use *FeynHiggs*

In CMSSM, NUHM:

SM bound of M_H search can be used [*LEP Higgs Working Group '03*]



CL_s can be used/transformed into χ^2 values

observed)

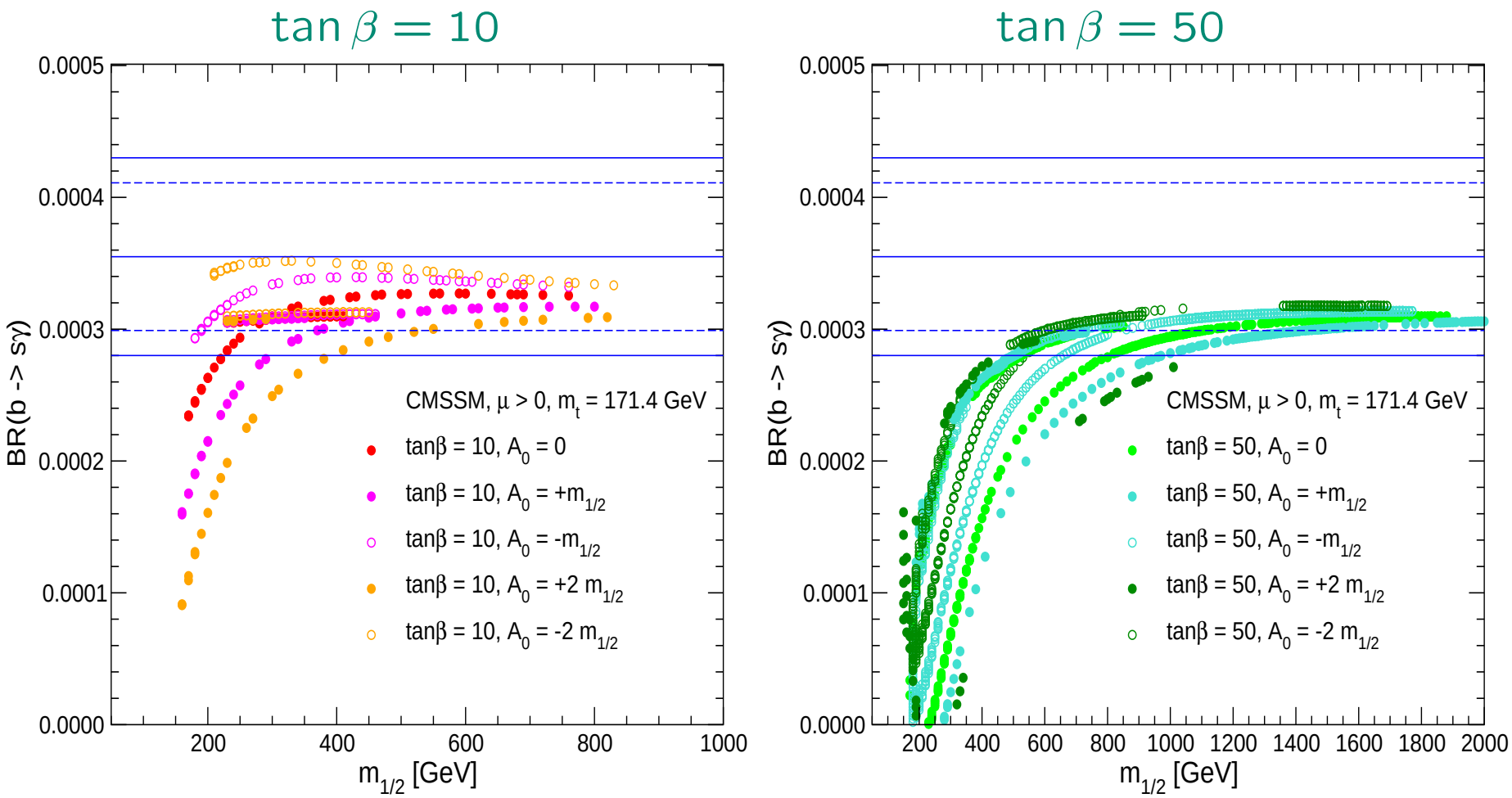
Interested in MSSM Higgs physics?
Try our code **FeynHiggs**
`www.feynhiggs.de`

$\delta M_h^{\text{intr.}} \approx 3$ GeV

We use *FeynHiggs*

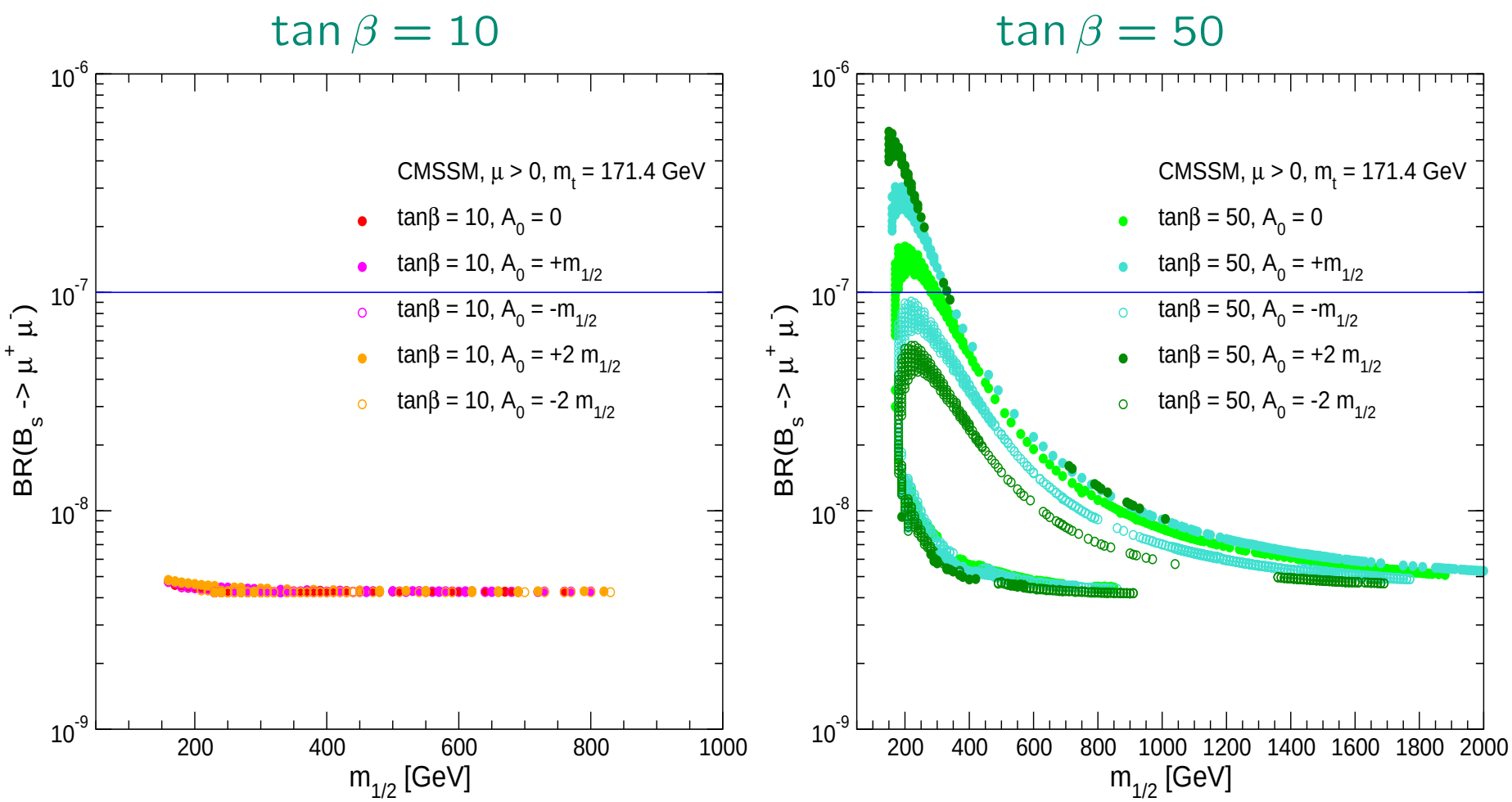
6.) $b \to s\gamma$

BR($b \to s\gamma$) MSSM vs. SM (CMSSM)



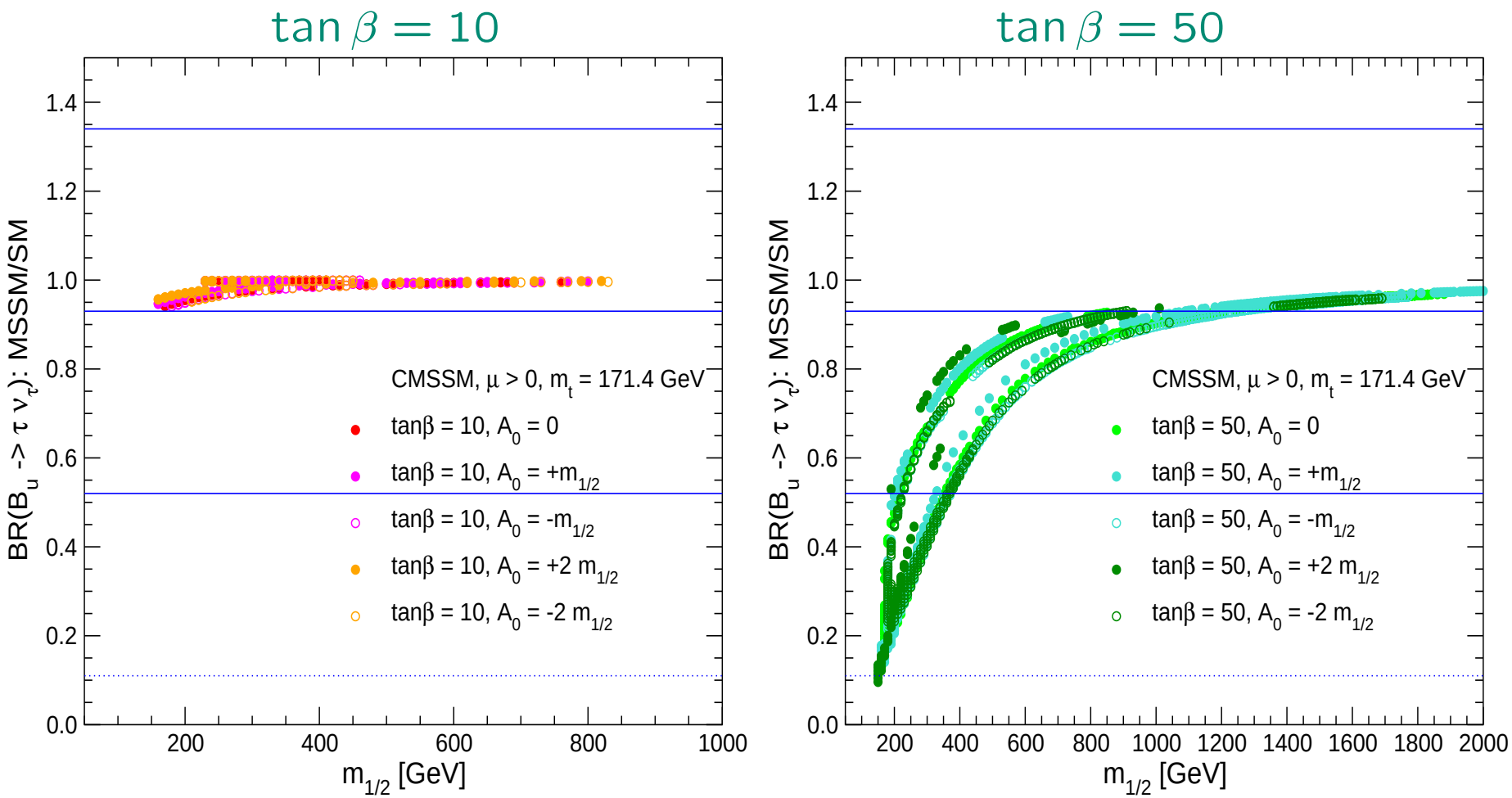
7.) $B_s \to \mu^+\mu^-$

BR($B_s \to \mu^+\mu^-$) CMSSM



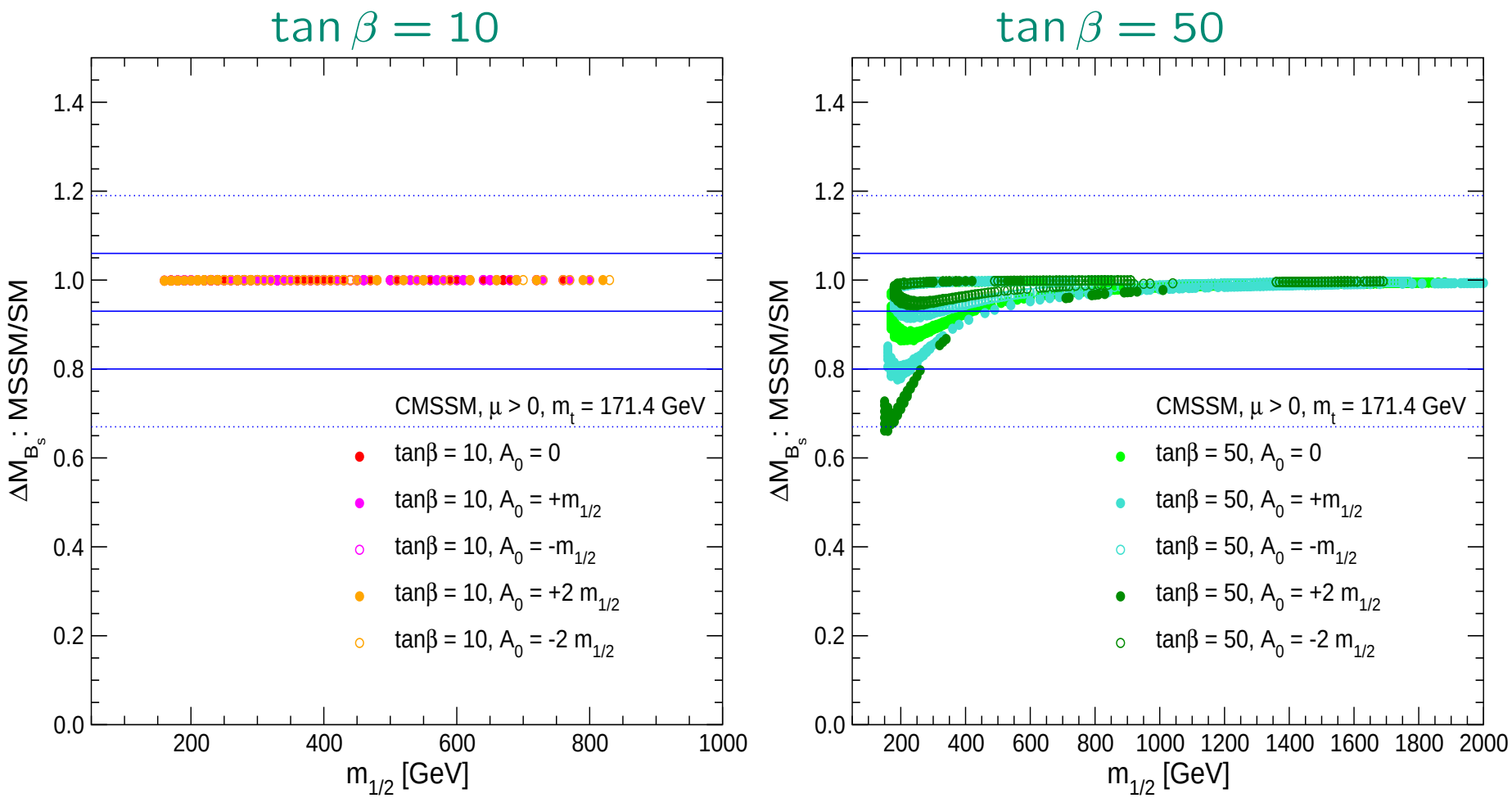
8.) $B_u \to \tau\nu_\tau$

BR($B_u \to \tau\nu_\tau$) MSSM/SM ($CMSSM$)



9.) ΔM_{B_s}

ΔM_{B_s} MSSM/SM ($CMSSM$)



For χ^2 fit:

$$\chi_x^2 = \left(\frac{R_x^{\text{exp}} - R_x^{\text{theo}}}{\sigma_x} \right)^2 \qquad x = b \to s\gamma, B_s \to \mu^+\mu^-, B_u \to \tau\nu_\tau, \Delta M_{B_s}$$

R_x^{exp}: experimental value

R_x^{theo}: theory prediction

σ_x^2: (exp. error)^2 + (param. error)^2 + (intr. error)^2

experimental error

parametric error: from uncertainty in input parameters

intrinsic error: from unknown higher-order corrections

$\Rightarrow$ use up to date calculations and error estimates

[*BaBar, Belle '04 - '07*]

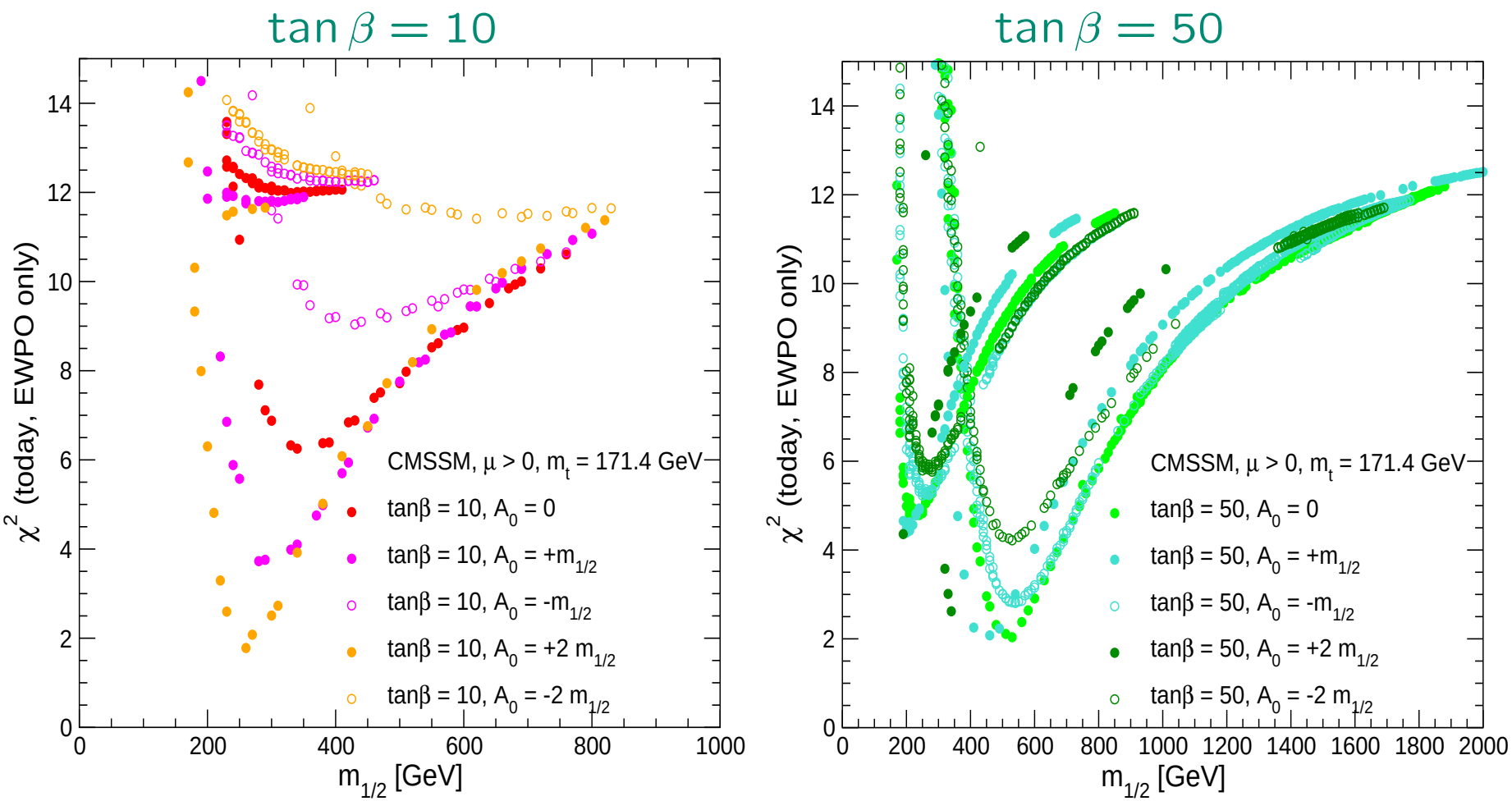
[*HFAG '07*]

4. SUSY in the light . . .

What do we know about the SUSY mass scale?

1. Coupling constant unification $\Rightarrow M_{\text{SUSY}} \approx 1$ TeV
2. LSP should be cold dark matter $\Rightarrow M_{\text{SUSY}} \lesssim 1$ TeV
3. Indirect hints from existing data?
   - Focus on CMSSM and NUHM
     small number of free parameters
   - hard constraint: LSP gives right amount of cold dark matter
     CMSSM: only thin strips allowed in the $m_{1/2}$–m_0 plane
     NUHM: also strong constraints
   - Use existing data of M_W, $\sin^2\theta_{\text{eff}}$, Γ_Z, $(g-2)_\mu$, M_h
     $\text{BR}(b \to s\gamma)$, $\text{BR}(B_s \to \mu^+\mu^-)$, $\text{BR}(B_u \to \tau\nu_\tau)$, ΔM_{B_s}
     $\Rightarrow \chi^2$ fit with these observables
     $\Rightarrow$ best fit values for masses, couplings, . . .

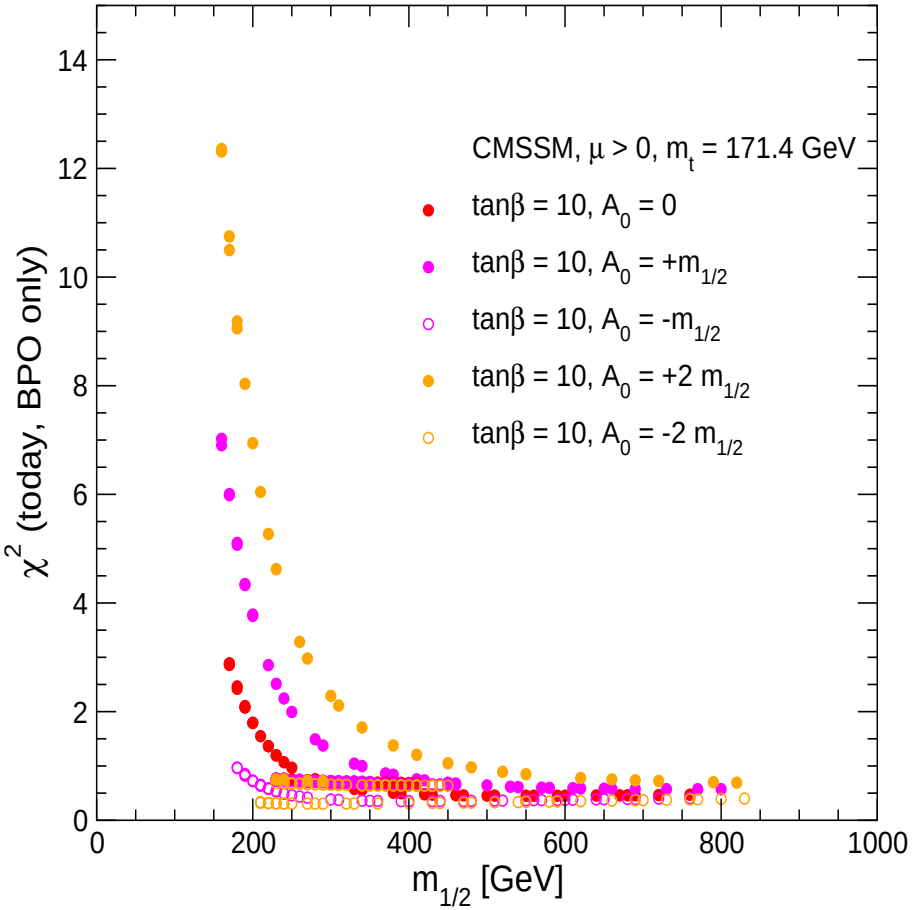
Results: CMSSM: EWPO alone



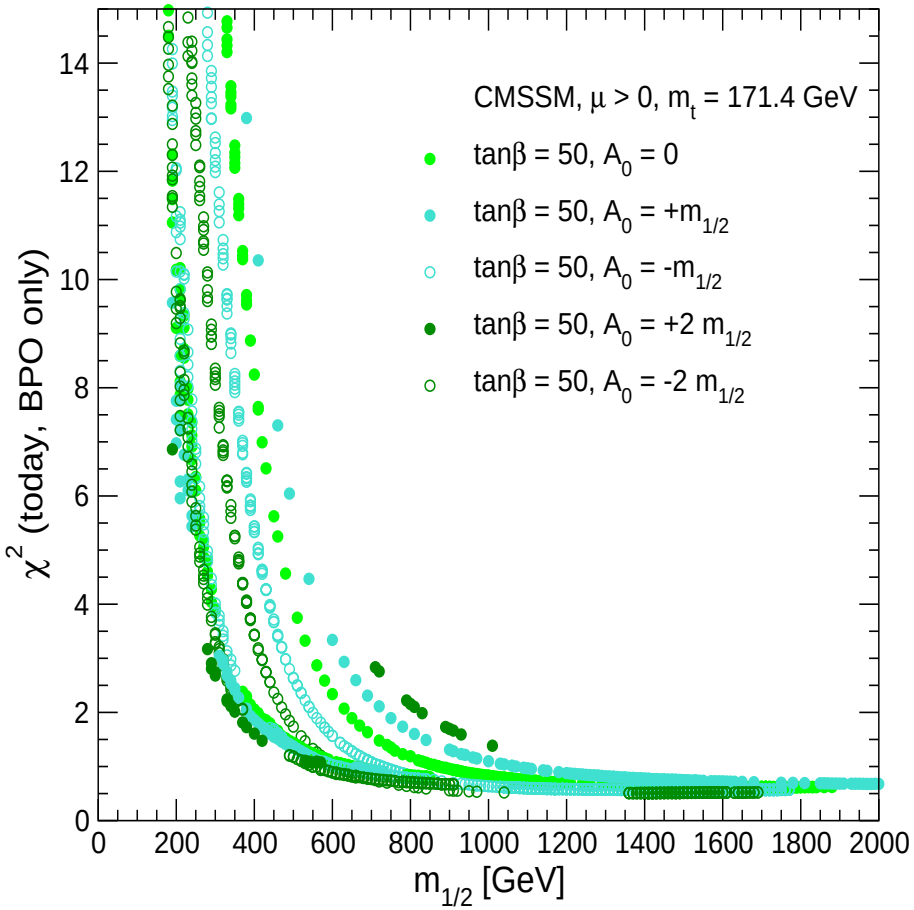
$\Rightarrow$ preference for relatively <u>small</u> $m_{1/2}$

Results: CMSSM: BPO alone

$\tan\beta = 10$

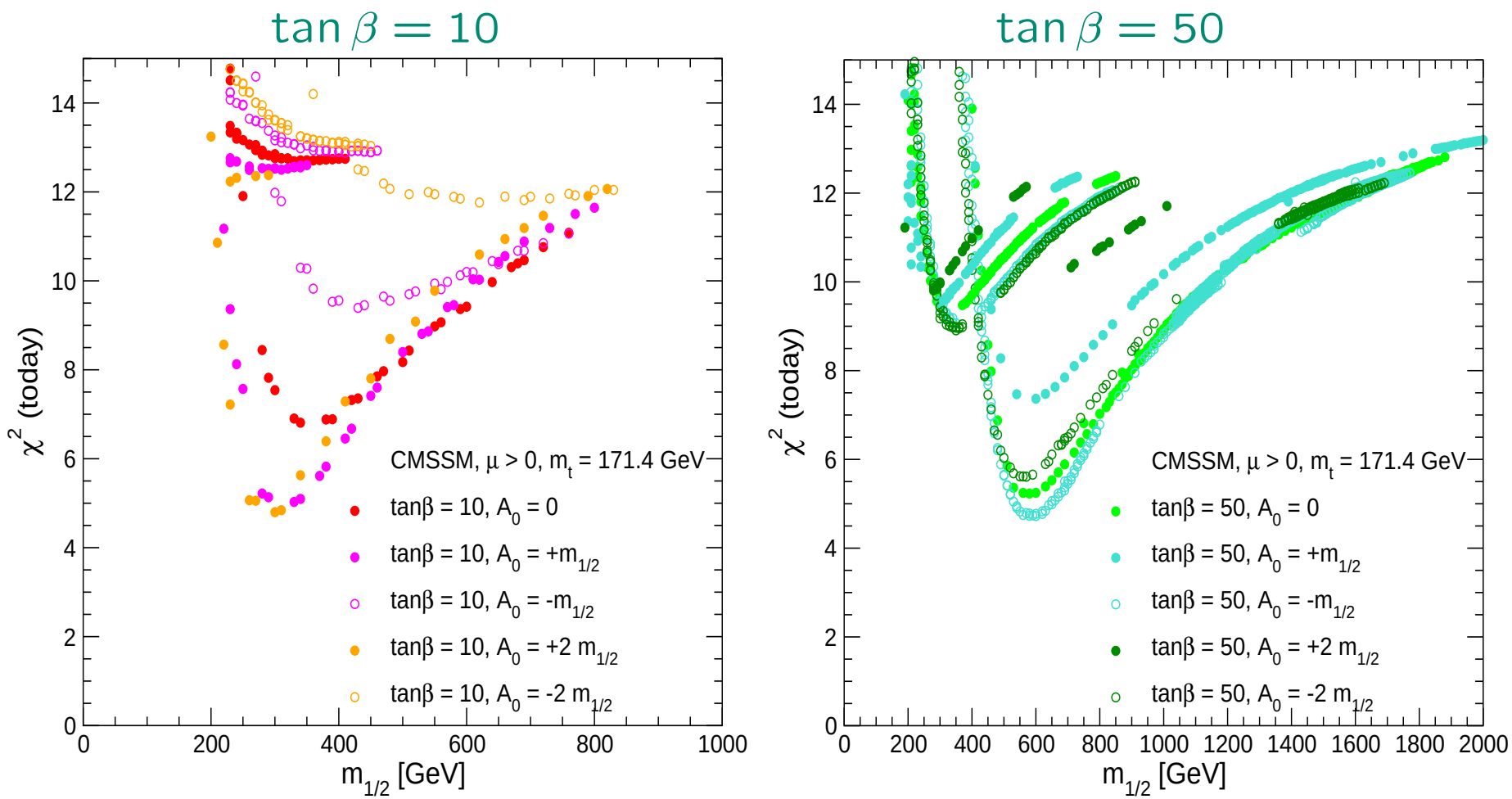


$\tan\beta = 50$



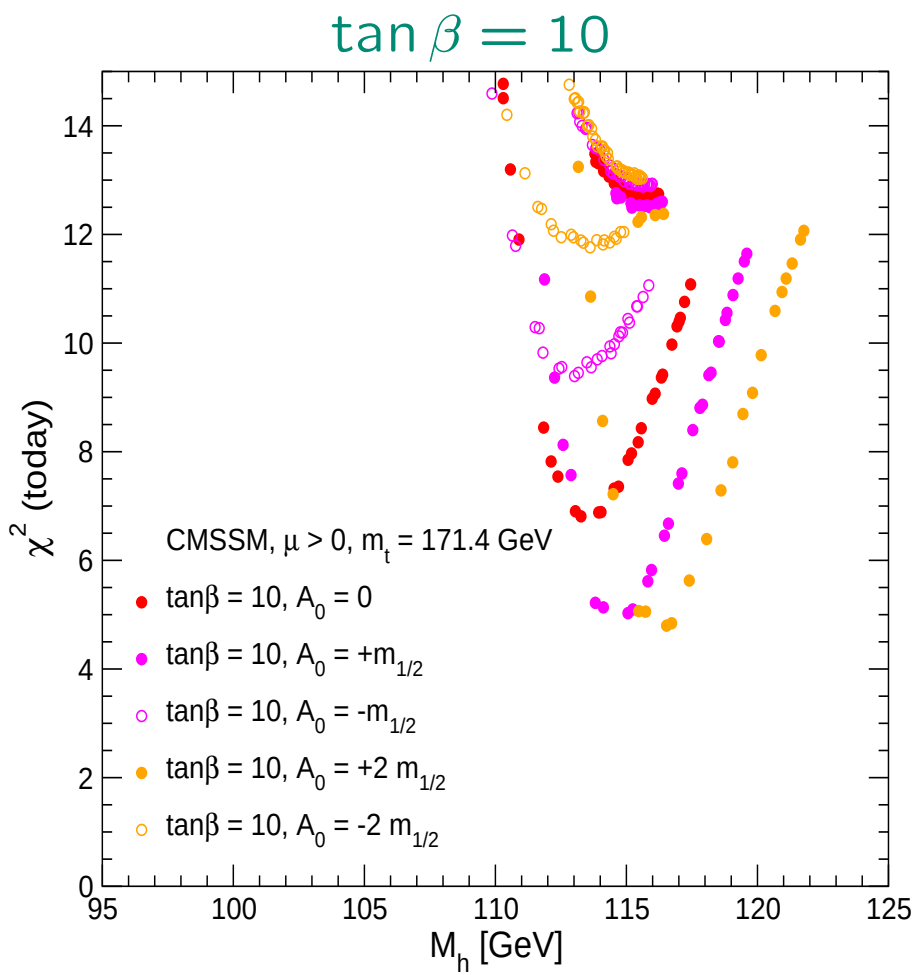
$\Rightarrow$ preference for relatively large $m_{1/2}$

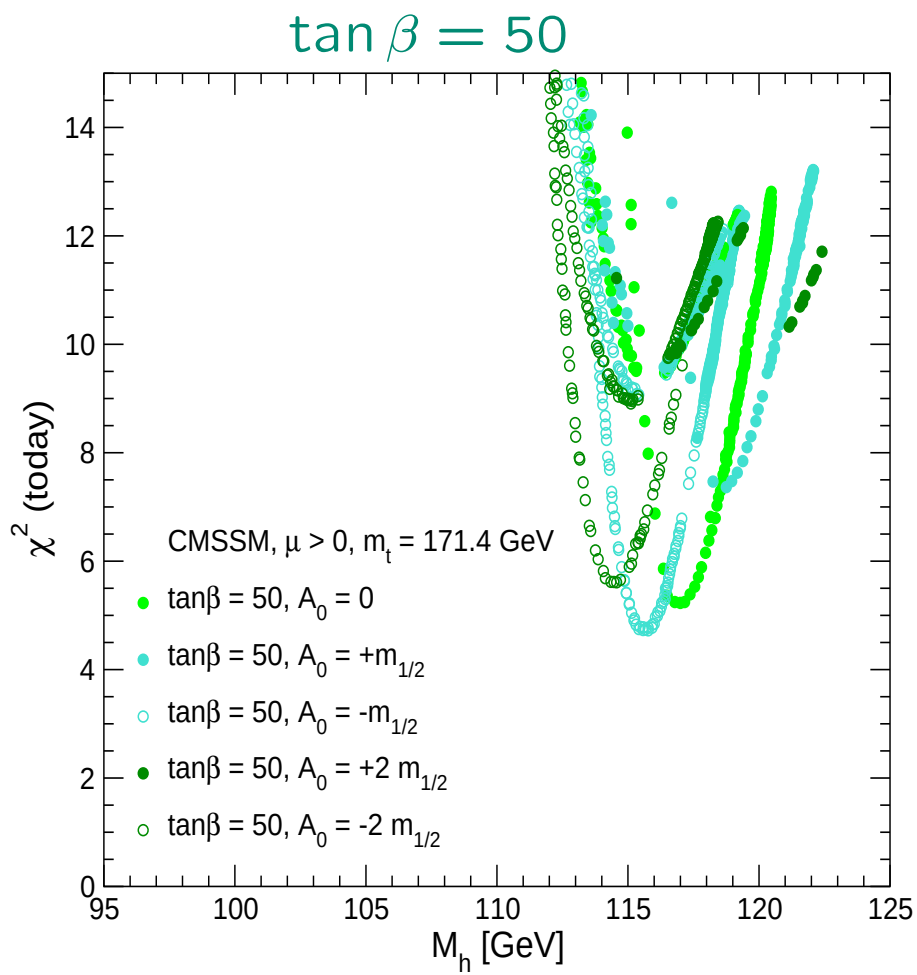
Results: CMSSM: everything combined



$\Rightarrow$ preference for somewhat smallish $m_{1/2}$ – but with a little tension

Results: CMSSM: prediction for M_h

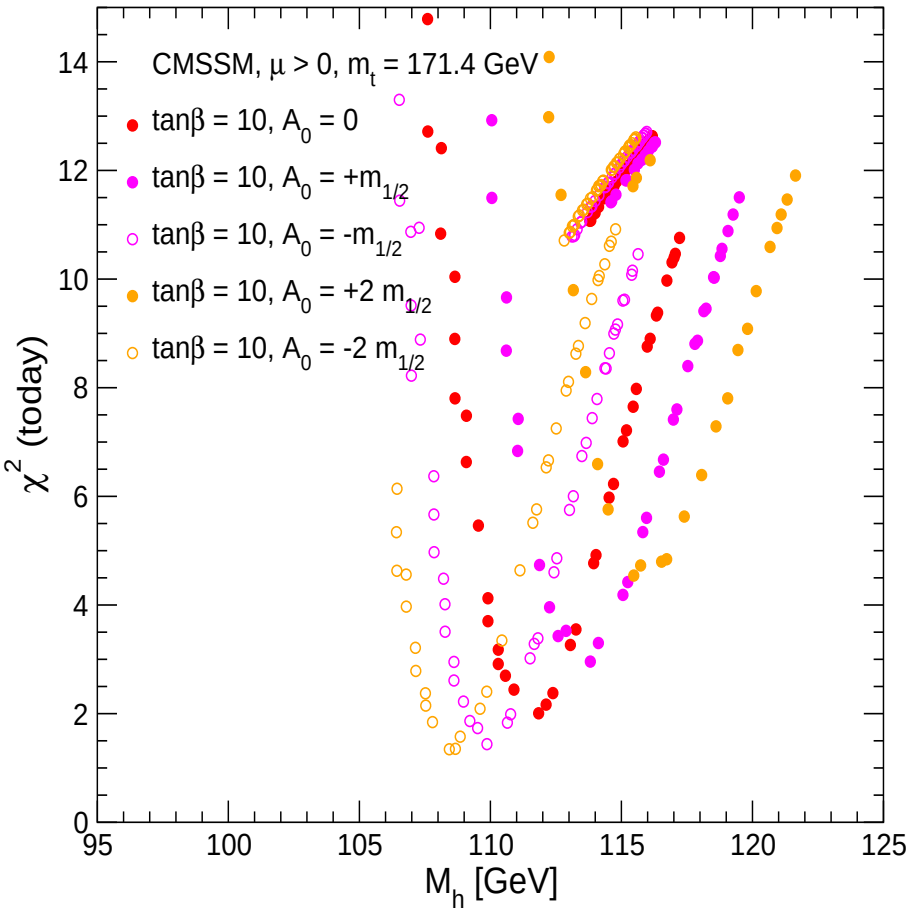




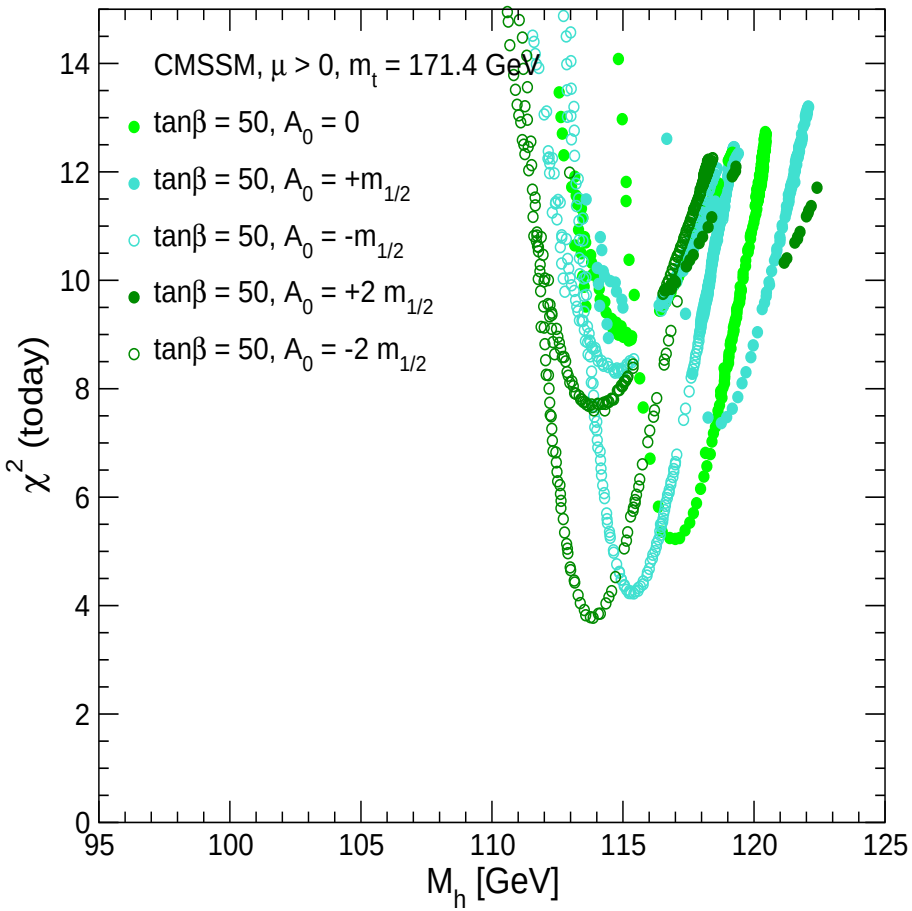
$\Rightarrow$ preference for $M_h \sim 115$ GeV (LEP . . .)

Results: CMSSM: "blue band" for M_h (without LEP results)

$\tan\beta = 10$



$\tan\beta = 50$



$\Rightarrow$ much "better" than in the SM

Results: NUHM

M_A–tan β planes in agreement with CDM

special?

Search for the MSSM Higgs bosons at LEP/Tevatron/...:

→ investigate benchmark scenarios:

→ Vary only M_A and $\tan\beta$
→ Keep all other SUSY parameters fixed

1. $m_h^{\max}$ scenario:
   → obtain conservative $\tan\beta$ exclusion bounds ($X_t = 2\,M_{\text{SUSY}}$)
2. no-mixing scenario
   → no mixing in the scalar top sector ($X_t = 0$)
3. small α_{eff} scenario
   → $hb\bar{b}$ coupling $\sim \sin\alpha_{\text{eff}}/\cos\beta$ can be zero: $\alpha_{\text{eff}} \to 0$:
   main decay mode vanishes, important search channel vanishes
4. gluophobic Higgs scenario
   → hgg coupling is small: main LHC production mode vanishes

[*M. Carena, S.H., C. Wagner, G. Weiglein '02*]

→ CDM ignored (for certain (good) reasons)

Results: NUHM

M_A–tan β planes in agreement with CDM

special?

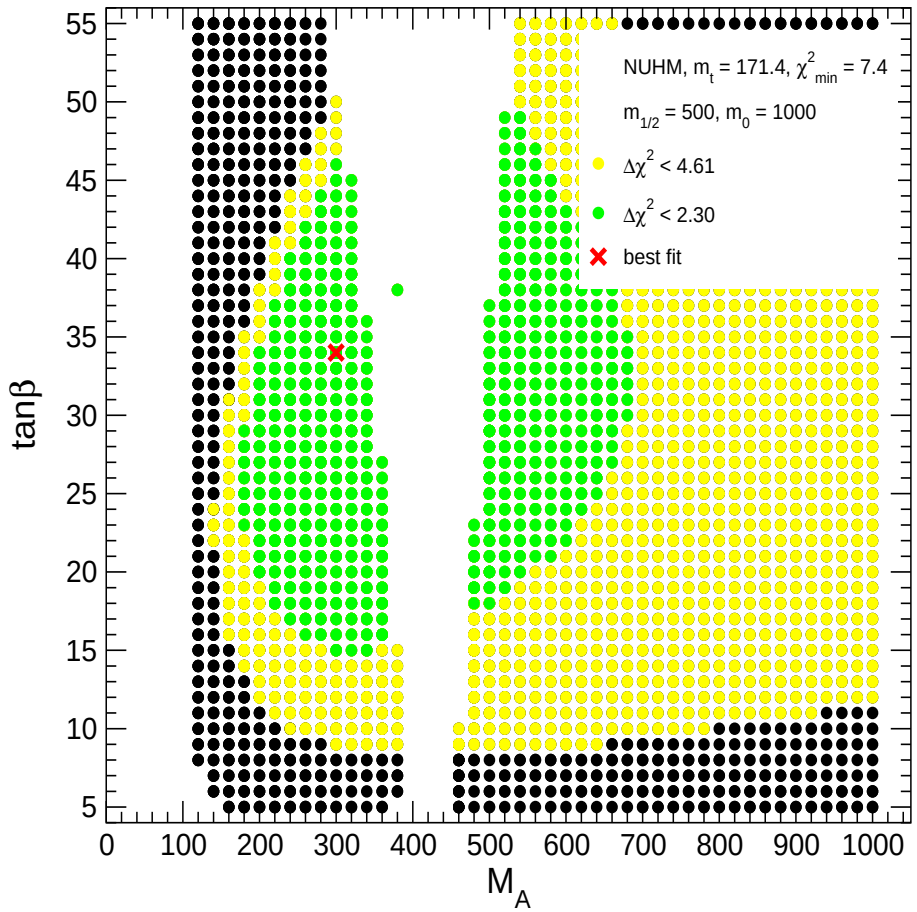
YES!

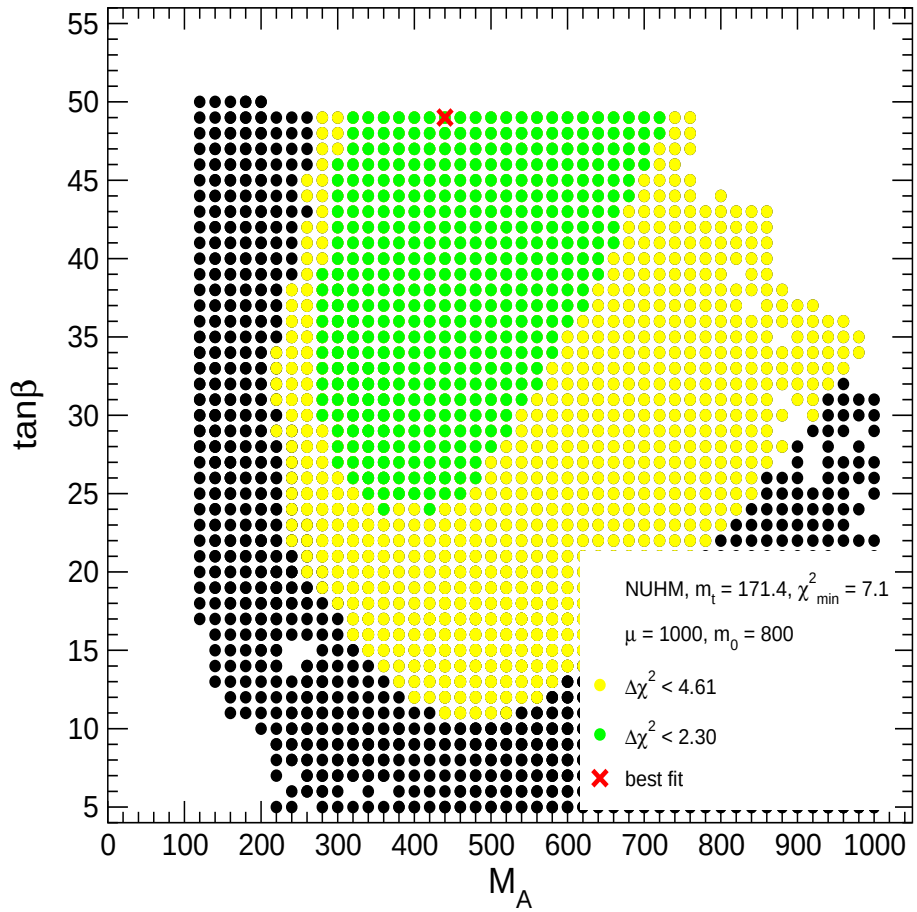
$\Rightarrow$ 4 planes; with $m_1 2$ or μ varied

What about other constraints? $\rightarrow$ see the χ^2

(Should one consider "external" constraints?
How relevant are they?
. . .)

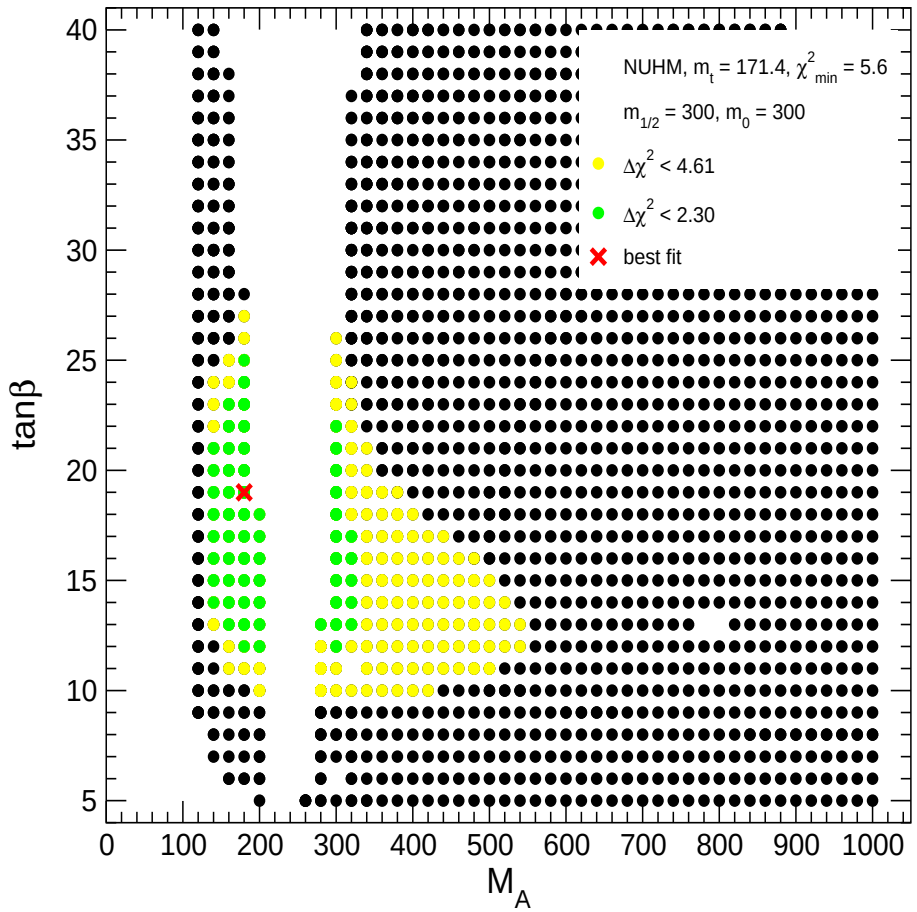
Results: NUHM: planes 2,3

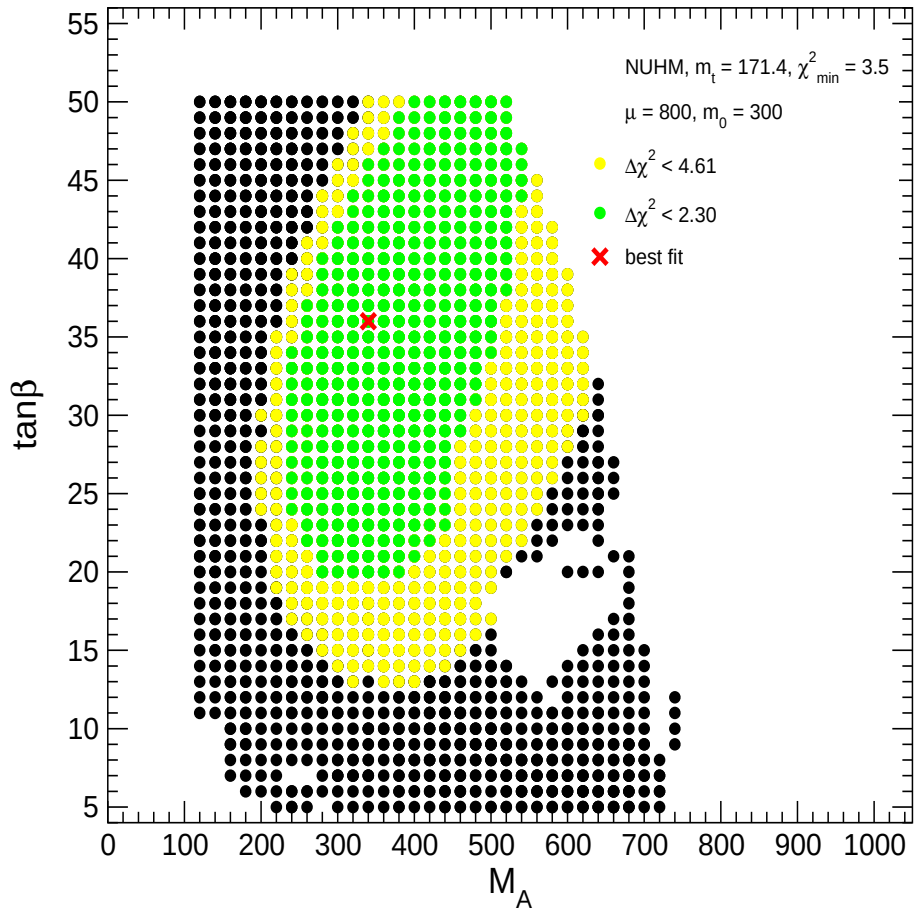




⇒ good χ^2, larger regions o.k.

Results: NUHM: planes 4,5





⇒ good χ^2, larger regions o.k.

Phenomenology on these planes?

⇒ not yet explored (stay tuned!)

You want do to analyses with these planes?

⇒ wait for the next release of `FeynHiggs`
planes will be included as possible default
Tevatron Higgs production XS, BRs, . . .

Phenomenology on these planes?

$\Rightarrow$ not yet explored (stay tuned!)

You want do to analyses with these planes?

$\Rightarrow$ wait for the next release of `FeynHiggs`
planes will be included as possible default
Tevatron Higgs production XS, BRs, ...

Enhanced BR($H/A \to \tau^+\tau^-$) possible with $M_A \approx 160$ GeV, $\tan\beta \approx 45$?

... possible in the NUHM ...

5. Conclusinos

- Precision observables
  – can give valuable information about the "true" Lagrangian
  – can provide bounds on SUSY parameter space

- investigated models: CMSSM, NUHM

- electroweak precision observables:
  M_W, $\sin^2\theta_{\text{eff}}$, Γ_Z, $(g-2)_\mu$, M_h

- b physics observables:
  $\text{BR}(b \to s\gamma)$, $\text{BR}(B_s \to \mu^+\mu^-)$, $\text{BR}(B_u \to \tau\nu_\tau)$, ΔM_{B_s}

- χ^2 fit using the EWPOs & BPOs
  important to use: best predictions $\oplus$ realistic errors
  $\Rightarrow$ low values reached:, $\chi^2_{\text{min}} = \mathcal{O}(4)$
  ... a bit of tension between EWPOs and BPOs
  $\Rightarrow$ still good prospects for the Tevatron

- NUHM: M_A–$\tan\beta$ planes in agreement with CDM
  $\Rightarrow$ interesting phenomenology! (`FeynHiggs`)