Susy Higgs bosons

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for theoretical physics

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This talk

Aims:

- To show the info we get on SUSY models from the measurement of a SM-like Higgs boson at around 125 GeV.

- What can we learn still?
  - Non-Standard Higgs boson searches
  - Room for deviation from $\mu/\mu_{SM}=1$

It is mostly review, with some highlight about my original work/ what I think it is interesting at the moment

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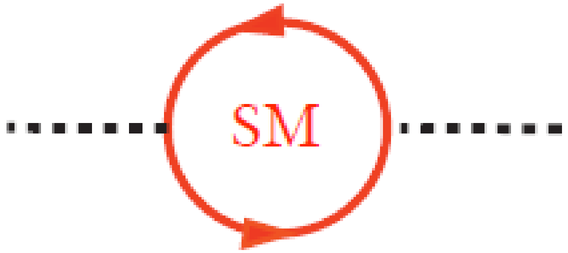
We have a particularly narrow resonance: $\Gamma_h \sim 4.1$ MeV

Even a rather small coupling to exotic (light) NP particles could lead to a measurable Higgs exotic (rare) decay

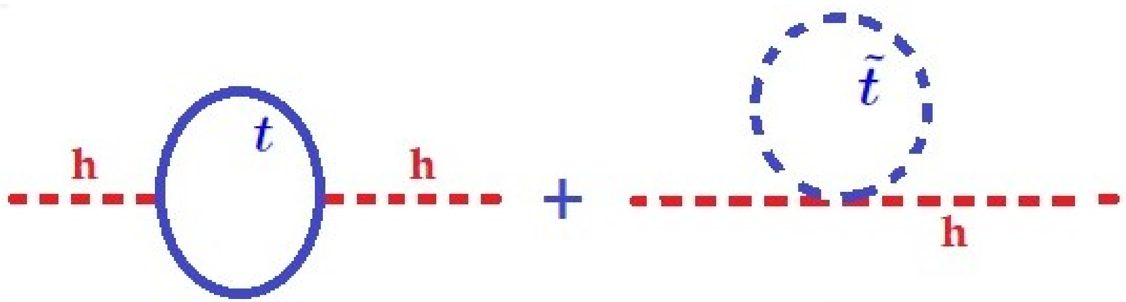
Supersymmetry and naturalness

A big **problem of naturalness**!

$$m_h^2 \sim (m_h^2)_0 + \frac{\Lambda^2}{16\pi^2} \cdot \mathrm{Coupl}$$



In Susy: Different-spin spieces combine to cancel large corrections.



One of the great features of Susy

Naturalness: huge cancelations can only arise from a (super)symmetry.

Is Susy natural?

Let me rephrase: Is Minimal Susy (MSSM) natural?

MSSM Higgs sector

- At the tree level: four free parameters m_{Hu}, m_{Hd}, μ, $B\mu$

that can be re-expressed in terms of more physical parameters: m_A, $\tan\beta$, μ, v

- From the minimization of the scalar potential:

$$\frac{m_Z^2}{2} = -|\mu|^2 - \frac{m_{H_u}^2 \tan^2\beta - m_{H_d}^2}{\tan^2\beta - 1}$$

μ, m_{Hu} expected to be at around the EW-TeV scale

- The lightest Higgs boson mass is related to the quartic couplings,

arising from gauge interactions $\frac{1}{8}(g^2 + g_1^2)(|H_u|^2 - |H_d|^2)^2$

At the tree level: $m_h \leq m_Z \cos 2\beta$

Is Susy natural?

We need ~90GeV radiative corrections!

$$\mathcal{M}^2_{stop} = \begin{pmatrix} m^2_{Q_3} + m_t^2 + D_L & m_t X_t \\ m_t X_t & m^2_{u_3} + m_t^2 + D_R \end{pmatrix}$$

$$m_h^2 \sim m_Z^2 \cos^2(2\beta) + \frac{3}{4\pi^2}\frac{m_t^4}{v^2}\left(\frac{X_t^2}{m_{\tilde{t}}^2}\left(1 - \frac{X_t^2}{12 m_{\tilde{t}}^2}\right) + \log\frac{m_{\tilde{t}}^2}{m_t^2}\right)$$

Part of the hierarchy is re-introduced

$$\delta m^2_{H_u|stop} = -\frac{3}{8\pi^2} y_t^2 (m^2_{Q3} + m^2_{u3} + |A_t|^2) \log\frac{M}{m_{\tilde{t}}}$$

$$X_t = A_t - \frac{\mu}{\tan\beta}$$

More general than the MSSM

Is Susy natural?

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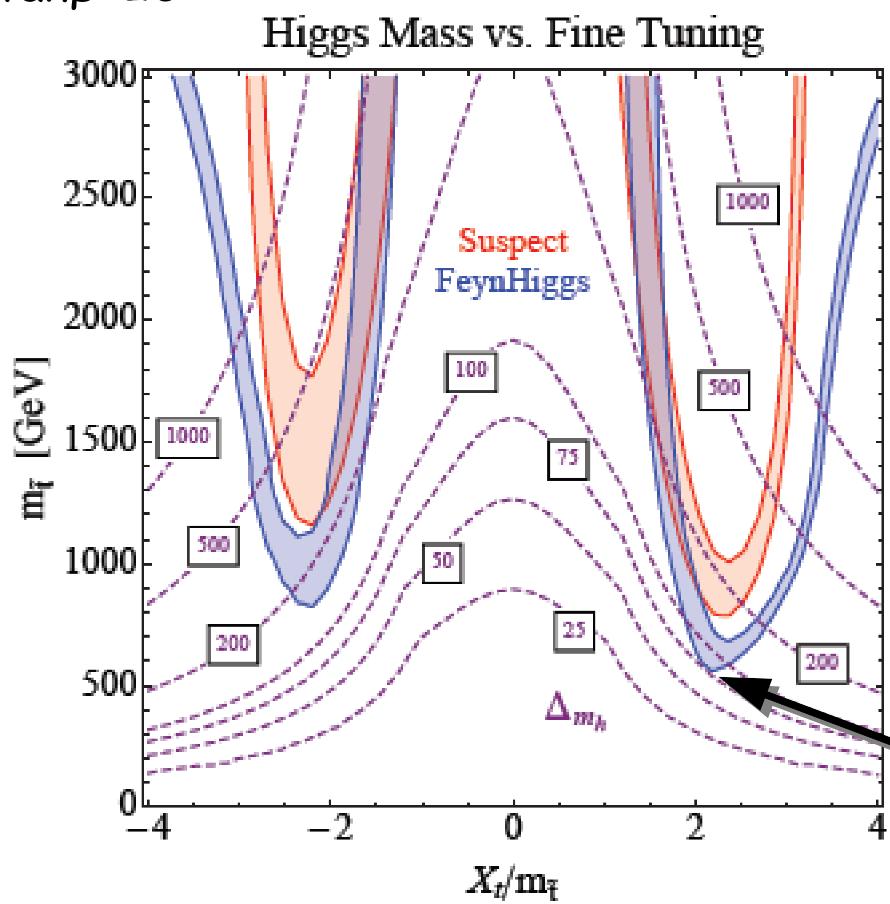
P

δ

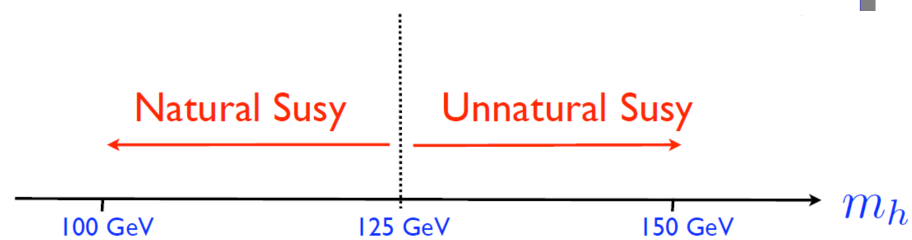
tanβ=20



Hall, Pinner, Ruderman, 1112.2703

$$\Delta_{m_h} = \max_i \left| \frac{\partial \log m_h^2}{\partial \log p_i} \right|$$

Barbieri, Giudice '91



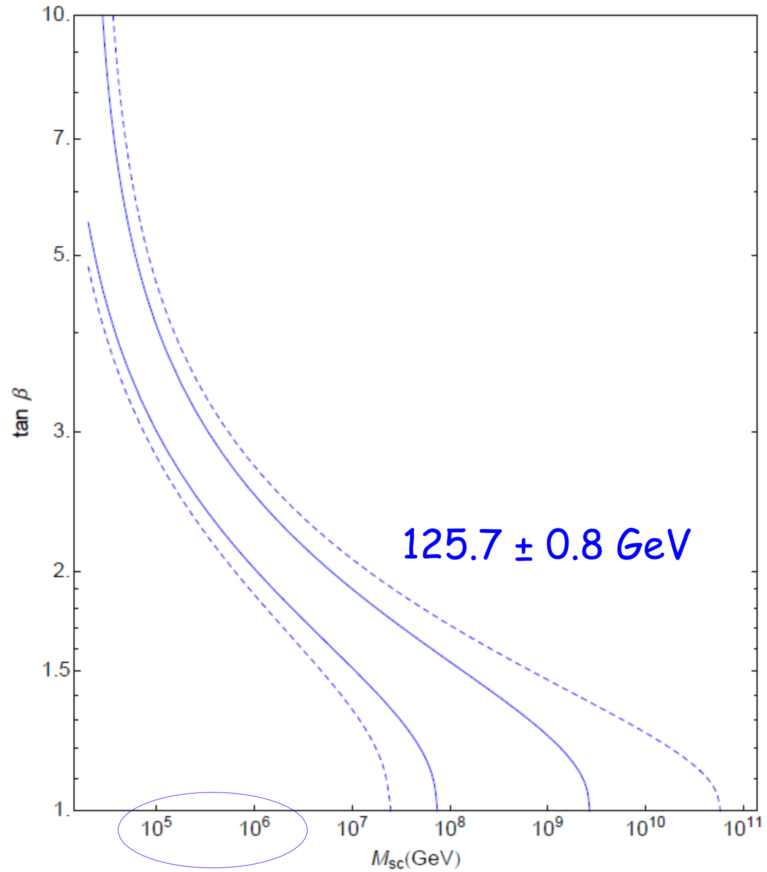
The least fine-tuned scenario is a scenario with maximal stop mixing

Several approaches

- GMSB with large trilinear terms
  (rather difficult exercise of model building)

Craig, Knapen, Shih, Zhao, 1206.4086

- Mini-split Susy



Maybe the notion of naturalness is not the right guideline...

Maybe nature is (kind of) fine tuned...

With scalars at O(100 TeV) – O(1000 TeV) a 125 GeV Higgs is "effortless"

Arkani-Hamed, Gupta, Kaplan, Weiner, Zorawski, 1212.6971

See also
Giudice, Strumia, 1108.6077
Hall, Nomura, 1111.4519
Ibe, Yanagida, 1112.2462
Arvanitaki et.al., 1210.0555

Several approaches

- Going beyond the MSSM and enhancing the tree level value for the Higgs mass

New D-terms

The Higgs is charged under an additional gauge symmetry

Ex. + SU(2) symmetry

Batra, Delgado, Kaplan, Tait, ´03

$$m_h^2 \leq \frac{1}{2}(g^2\Delta + g_Y^2)v^2\cos^2(2\beta)$$

$$\Delta = \frac{1+\frac{2m^2}{u^2}\frac{1}{g_2^2}}{1+\frac{2m^2}{u^2}\frac{1}{g_1^2+g_2^2}}, \quad \frac{1}{g^2} = \frac{1}{g_1^2} + \frac{1}{g_2^2}$$

New F-terms

Extra matter mixing with the Higgs

Most common example: NMSSM

$$W \sim \lambda S H_u H_d$$

$$m_h^2 \leq m_Z^2\left(\cos^2(2\beta) + \frac{\lambda^2}{g^2}\sin^2(2\beta)\right)$$

Additional interesting examples: adding Higgs triplets

Garcia, SG, Quiros, Vega, Vega-Morales, Yu, In preparation

Several approaches

- Going beyond the MSSM and enhancing the tree level value for the Higgs mass

erms

with the Higgs

e: NMSSM

$SH_u H_d$

$$) + \frac{\lambda^2}{g^2}\sin^2(2\beta)\Big)$$

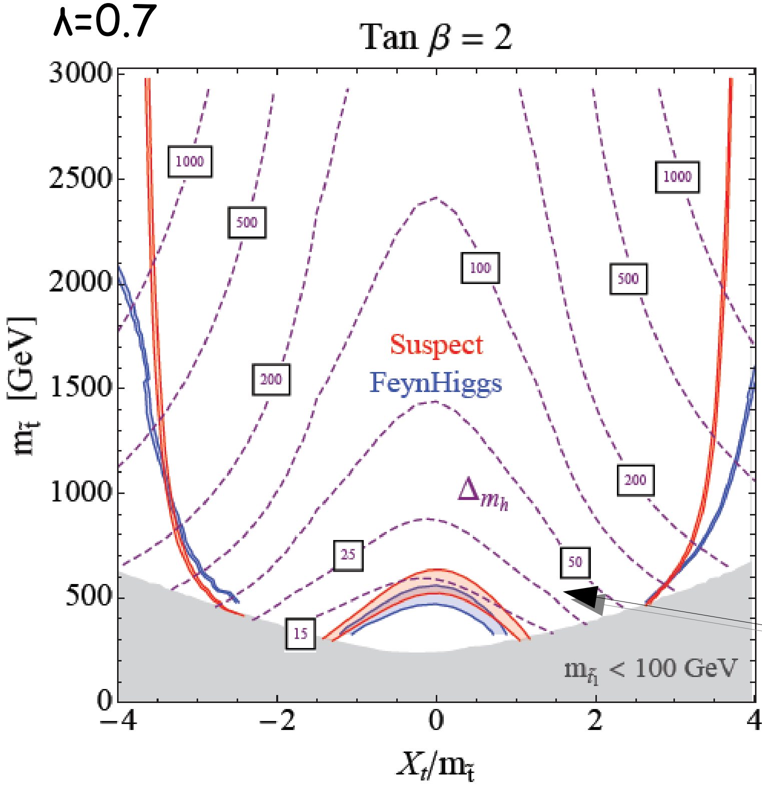
examples:

ga, Vega-Morales, Yu,

„Fat Higgs models"

Harnik, Kribs, Larson, Murayama, ´03,
Barbieri, Hall, Nomura, Rychkov, ´06

λ=0.7



Hall, Pinner, Ruderman, 1112.2703

The level of fine tuning is smaller

Still to understand the LHC null-results in searching for Susy

MSSM Higgs signatures at the LHC

A multi-Higgs model

As well known, at least two Higgs doublets are required in Susy

Inputs:
- Higgs boson at ~125GeV
- Higgs boson is SM-like

Results of LHC 7+8 TeV data

Output:
- What can we learn on the other scalars (H, $H^{\pm}$) and pseudoscalar (A)?
- How to find the additional scalars?

Two possibilities

- **The anti-decoupling limit:**

$m_A \sim m_Z$ and large $\tan\beta$

$$\alpha \sim \beta,\ \beta + \pi$$

Hagiwara, Lee, Nakamura, 1207.0802
Dress, 1210.6507
Bechtle, Heinemeyer, Stal, Stefaniak, Weiglein, Zeune, 1211.1955
Barenboim, Bosh, Ibanez, Vives, 1307.5973

$\left\{ \begin{array}{l} \text{H is the SM-like boson} \\ (h, A, H^{\pm})\ \underline{\text{light}}\text{ exotic multiplet} \end{array} \right.$

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Highly constrained by present LHC bounds:

Searches for h (with mass below 125 GeV) into τs
Charged Higgs boson contributions to $b \longrightarrow s\gamma$, $B \longrightarrow \tau\upsilon$
Constraints on charged Higgs bosons from $t \longrightarrow H^{\pm} b$

See for example Arbey, Battaglia, Djouadi, Mahmoudi, 1211.4404
Barenboim, Bosh, Ibanez, Vives, 1307.5973

Two possibilities

- **The anti-decoupling**

$m_A \sim m_Z$ and large tanβ

$$\alpha \sim \beta,\ \beta + \pi$$

5

(h, A, $H^{\pm}$) light exotic multiplet

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$$\left\{ \begin{array}{l} H \text{ is the SM-like boson} \\ (h, A, H^{\pm})\ \underline{\text{light}} \text{ exotic multiplet} \end{array} \right.$$

- **The decoupling limit:**

$m_A \gg m_Z$

$$\alpha \sim \beta - \frac{\pi}{2}$$

$$\left\{ \begin{array}{l} h \text{ is the SM-like boson} \\ (H, A, H^{\pm})\ \underline{\text{heavy}} \text{ exotic multiplet} \end{array} \right.$$

Haber ´95

(see also Carena et al. 1310.2248 for low m_A)

Decoupling limit: what can we learn?

1) Lightest Higgs boson <u>tree-level</u> (reduced) couplings

$$\alpha = \beta - \frac{\pi}{2} + O\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan\beta}$$

$$\xi_d^h = \frac{-s_\alpha + \epsilon_d c_\alpha}{c_\beta + \epsilon_d s_\beta} \sim 1 + \mathcal{O}\left(\frac{v^2}{m_A^2}\right)$$

$$\xi_\ell^h = \frac{-s_\alpha + \epsilon_\ell c_\alpha}{c_\beta + \epsilon_\ell s_\beta} \sim 1 + \mathcal{O}\left(\frac{v^2}{m_A^2}\right)$$

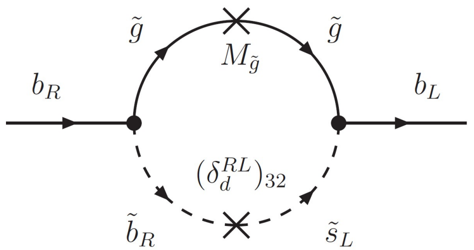
$$\xi_u^h = \frac{c_\alpha}{s_\beta} \sim 1 + \mathcal{O}\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan^2\beta}$$

$$\xi_V^h = s_{\beta-\alpha} \sim 1 + \mathcal{O}\left(\frac{v^4}{m_A^4}\right)\frac{1}{\tan^2\beta}$$

See for example
Pierce et.al. ´96
Carena et.al. ´98

Loop corrections

Ex.



$$2\frac{\alpha_s}{3\pi}\frac{\mu M_{\tilde{g}}}{\tilde{m}^2} f_1\left(\frac{M_{\tilde{g}}^2}{\tilde{m}^2}\right)\tan\beta$$

First effects due to the presence of heavy Higgs bosons would be tested in the couplings of the Higgs with taus and b-quarks

Decoupling limit: what can we learn?

2) Lightest Higgs boson loop-induced couplings

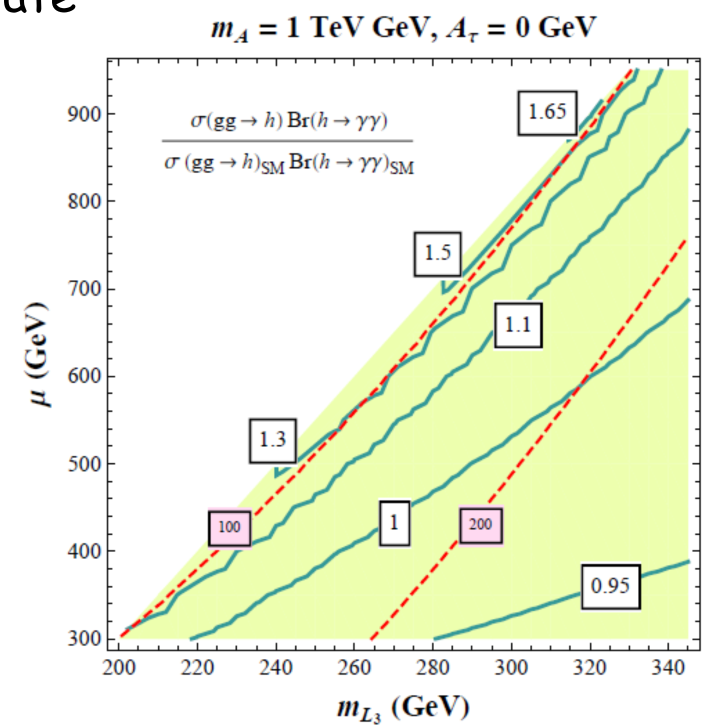
Low energy theorem: $\sim \frac{\Delta}{(4\pi)^2}\frac{h}{v}F_{\mu\nu}F^{\mu\nu}\frac{\partial \log M(v)}{\partial \log v}$

Beta function coefficients

(analogous for the coupling to glouns)

Recently, large attention to the Higgs to di-photon rate

- Light charginos: at most ~10% effect
- Light staus with large mixing



Carena, SG, Shah, Wagner, 1112.3336

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- Light stops (see for example, Djouadi, Driesen, Hollik, Illana, 9612362, Reece, 1208.1765)

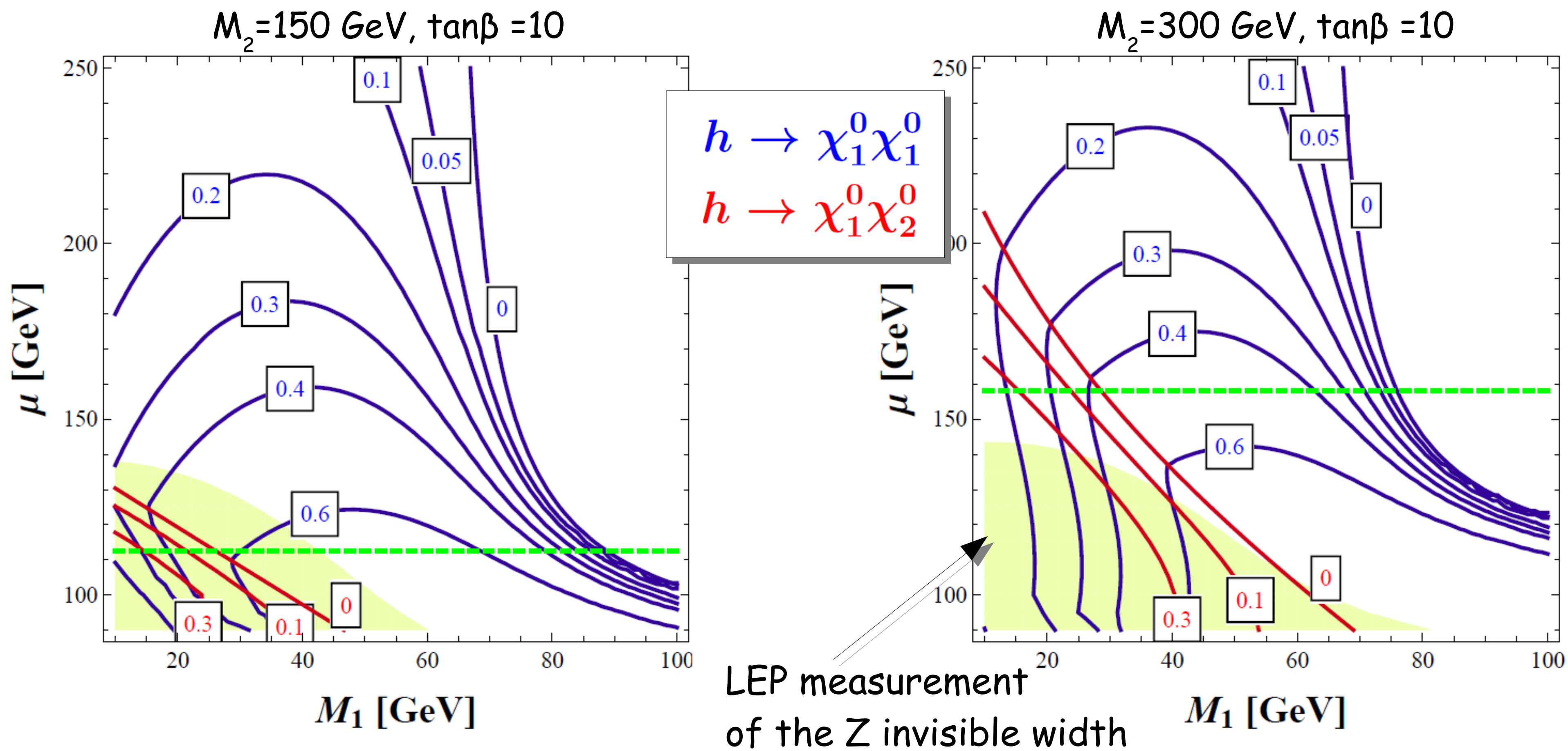
See Matt´s talk

Decoupling limit: what can we learn?

3) Possible exotic Higgs (rare) decays

See also
Arbey, Battaglia, Djouadi, Mahmoudi, 1207.1348

Assuming a LEP bound of ~100 GeV on charged particles



Higgs „invisible signature"

Review on Higgs exotic rare decays,
Curtin, Essig, SG, Jaiswal, Katz, Liu, Liu, McKeen, Shelton, Strassler, Surujon, Tweedie, Zhong, appearing soon!

And the heavier Higgs bosons?

$$m_H \sim m_{H^\pm} \sim m_A$$

$$\alpha = \beta - \frac{\pi}{2} + O\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan\beta}$$

$$\xi_u^H = \frac{s_\alpha}{s_\beta} \sim -\frac{1}{t_\beta} + O\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan\beta}$$

$$\xi_u^A = \xi_u^- = \frac{1}{t_\beta}$$

$$\xi_{d,\ell}^H = \frac{c_\alpha + \epsilon_{d,\ell} s_\alpha}{c_\beta + \epsilon_{d,\ell} s_\beta} \sim \frac{t_\beta - \epsilon_{d,\ell}}{1 + \epsilon_{d,\ell} t_\beta} + O\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan\beta}$$

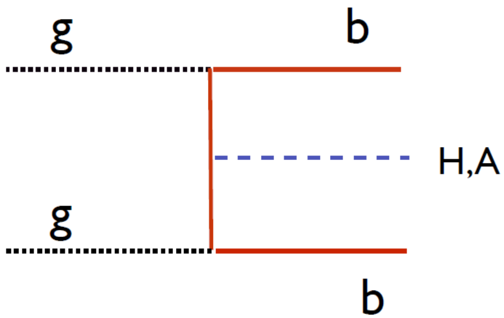
$$\xi_{d,\ell}^A = \xi_{d,\ell}^- = \frac{t_\beta - \epsilon_{d,\ell}}{1 + \epsilon_{d,\ell} t_\beta}$$

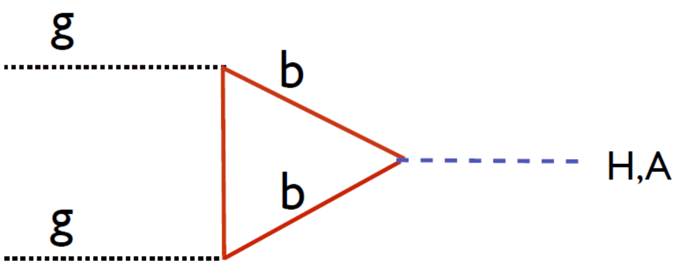
Tanβ enhanced couplings to down quarks and leptons

$$\xi_V^H = c_{\beta-\alpha} \sim O\left(\frac{v^2}{m_A^2}\right)\frac{1}{\tan\beta}$$

(Studied) heavy Higgs signatures

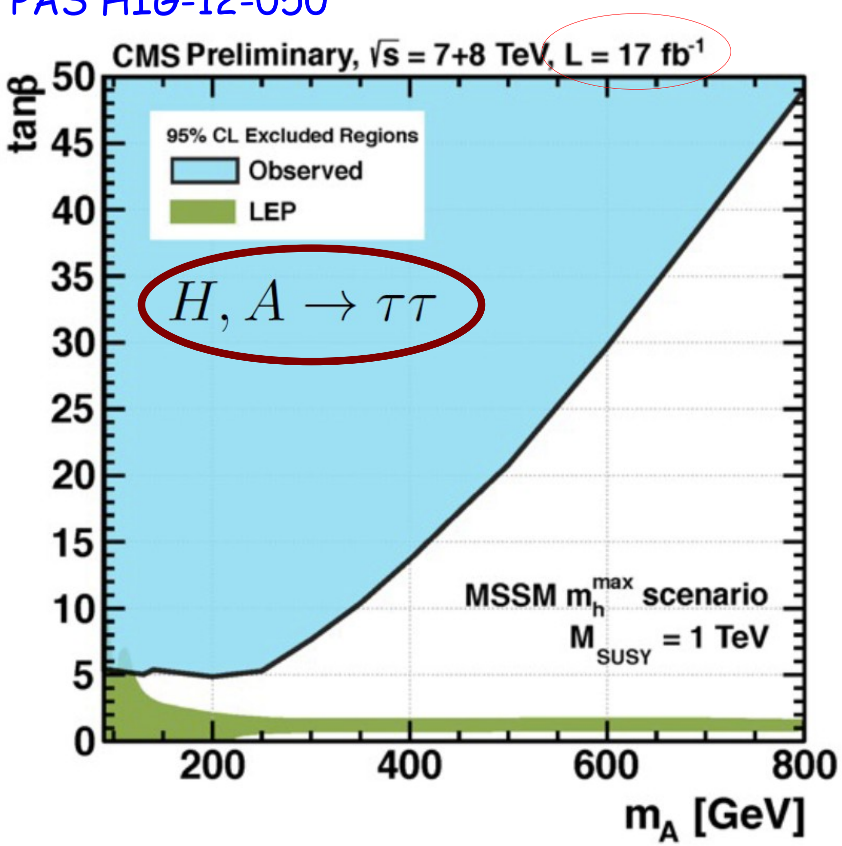
Main contribution to the production

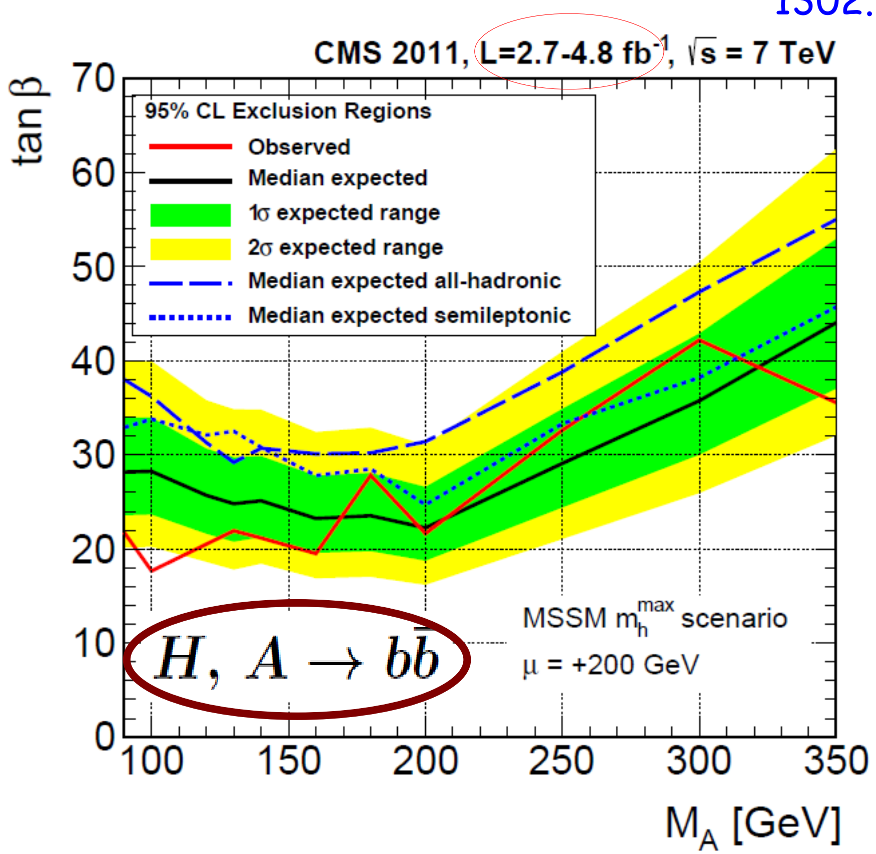




CMS PAS HIG-12-050

1302.2892





See also Carena, SG, Juste, Menon, Wagner, Wang, 1203.1041

(Un-studied) heavy Higgs signatures

The previous bounds may be modified:

- Change the radiative corrections to the b (and τ) couplings

$$\sigma(b\bar{b}H) \times \mathrm{BR}(H \to \tau^+\tau^-) \propto \frac{t_\beta^2}{(1+\epsilon_d t_\beta)^2 + 3\frac{m_b^2}{m_\tau^2}}$$

However the effect cannot be large

In particular for the benchmark used by CMS and ATLAS $\epsilon_d \sim 3 \cdot 10^{-3}$

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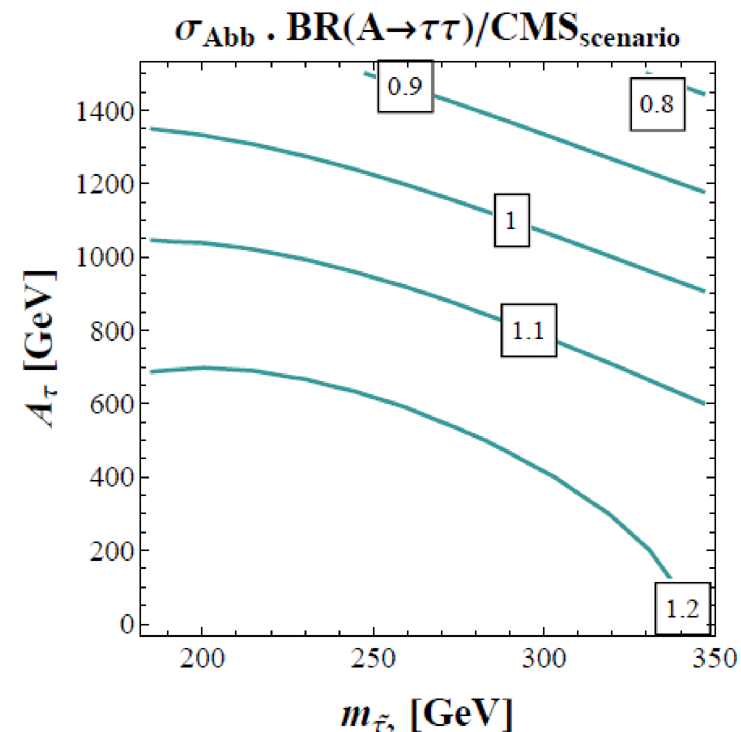
In particular for the benchmark used by CMS and ATLAS $\epsilon_d \sim 3 \cdot 10^{-3}$

- Open up additional heavy Higgs decay modes

Examples:

- In the light stau scenario

$$H \to \tilde{\tau}_{1,2}\tilde{\tau}_{1,2},\ A \to \tilde{\tau}_1\tilde{\tau}_2$$



Carena, SG, Shah, Wagner, Wang, 1303.4414

Lighter heavy Higgs bosons with sizable values of tanβ may be still hidden at the LHC

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Examples:

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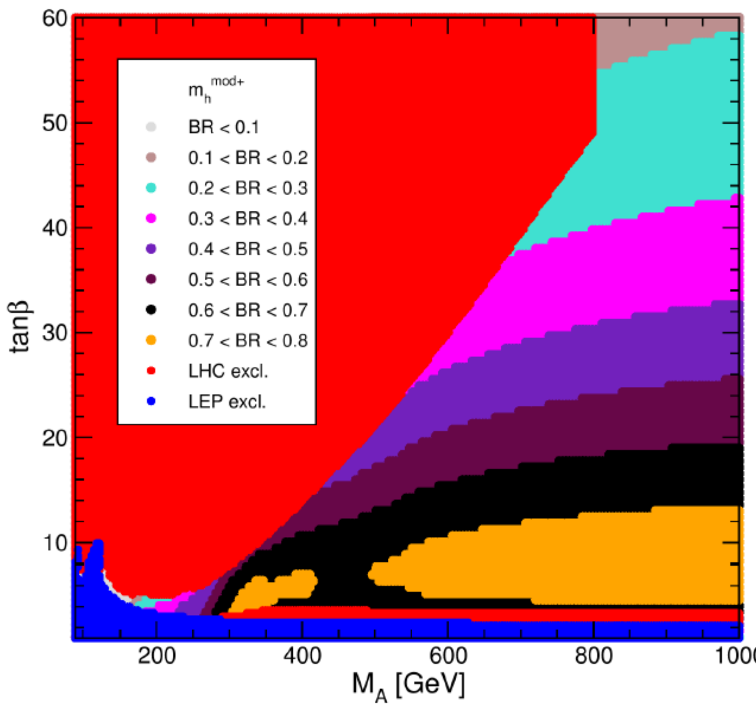
  $H \to \tilde{\tau}_{1,2}\tilde{\tau}_{1,2},\ A \to \tilde{\tau}_1\tilde{\tau}_2$
- Decays into light neutralino-chargino



Lighter heavy Higgs bosons with sizable values of tanβ may be still hidden at the LHC

Carena, Heinemeyer, Stal, Wagner, Weiglein, 1302.7033

Extending the Higgs sector of the MSSM: Higgs signatures at the LHC

NMSSM

(„Next to most studied supersymmetric model“)

NMSSM interesting benchmarks

- Field content:

  MSSM + 1 scalar + 1 pseudoscalar + 1 neutralino

- Scalar potential

$$W = \lambda S H_u H_d + \frac{k}{3} S^3$$

$$V_{soft} = m_{H_u}^2 |H_u|^2 + m_{H_d}^2 |H_d|^2 + m_S^2 |S|^2 + (-\lambda A_\lambda S H_u H_d + A_\kappa \frac{\kappa}{3} S^3 + h.c.)$$

- Some interesting scenarios:

- A „most natural NMSSM": coupling λ is large and μ is at the EW scale

- Approximate R-symmetry:

$$H_u \to H_u e^{i\phi},\ H_d \to H_d e^{i\phi},\ S \to S e^{i\phi} \Rightarrow A_\lambda \to 0,\ A_\kappa \to 0$$

- Approximate PQ-symmetry:

$$H_u \to H_u e^{i\phi},\ H_d \to H_d e^{i\phi},\ S \to S e^{-2i\phi} \Rightarrow \kappa \to 0$$

Less motivated by naturalness

A „natural" NMSSM

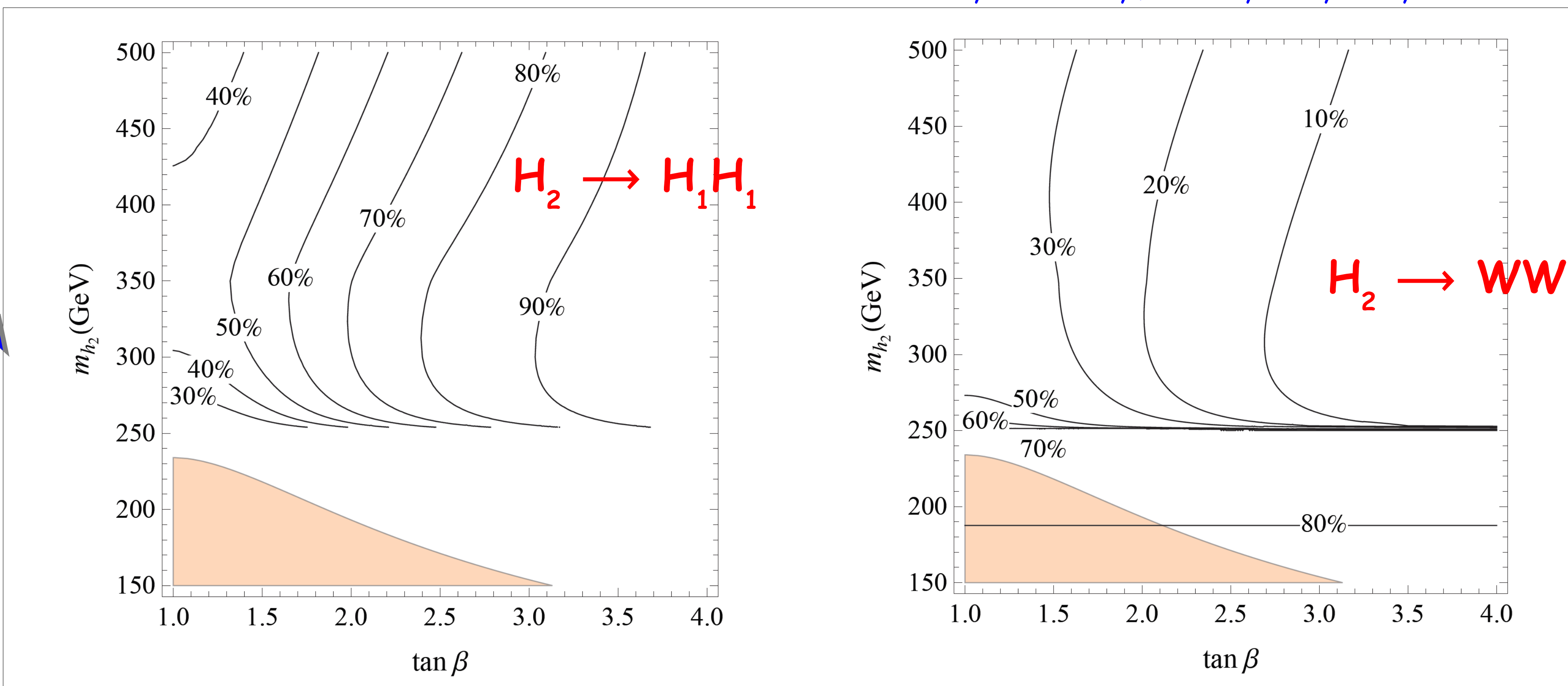
- The 125 GeV Higgs boson can be

Sizable λ regime

1. The lightest scalar
2. The second lightest scalar

- In both cases, a rich phenomenology can arise

Barbieri, Buttazzo, Kannike, Sala, Tesi, 1304.3670



A „natural" NMSSM

- The 125 GeV Higgs boson can be

  1. The lightest scalar
  2. The second lightest scalar

Ellwanger, Hugonie, 1203.5048
King, Muhlleitner, Nevzorov, Walz, 1211.5074
Kang, Li, Li, Liu,Shu, 1301.0453

- In both cases, a <u>rich phenomenology</u> can arise

Branching Ratios [%]								
	CMSSM			NMSSM (BMP I)				
Mass [GeV]	h 126	H 2256	A 2256	H_1 86	H_2 126	H_3 336	A_1 214	A_2 325
$b\bar{b}$	67.6	85.2	85.2	90.6	63.6	3.0	0.2	1.9
W^+W^-	17.7	1.7e-5	-	6.5e-7	19.6	0.2	-	-
$\tau\tau$	5.0	14.6	14.6	8.8	6.5	0.4	0.02	0.2
hh	-	8.9e-5	-	-	-	-	-	-
H_1H_2	-	-	-	-	-	41.9	-	-
A_1H_1	-	-	-	-	-	-	-	4.0
Zh	-	-	1.7e-5	-	-	-	-	-
ZH_1	-	-	-	-	-	-	0.3	26.8
$\chi_1^0\chi_1^0$	-	4.7e-5	5.3e-4	-	-	5.7	99.5	38.1
$\chi_1^0\chi_3^0$	-	-	-	-	-	20.8	-	4.2
$\chi_1^+\chi_1^-$	-	-	-	-	-	20.7	-	18.4
σ_{prod} [pb]	19.3	1.3e-5	1.3e-5	2.57	19.1	0.57	1.6e-2	0.41

$H_3 \longrightarrow H_2H_1$

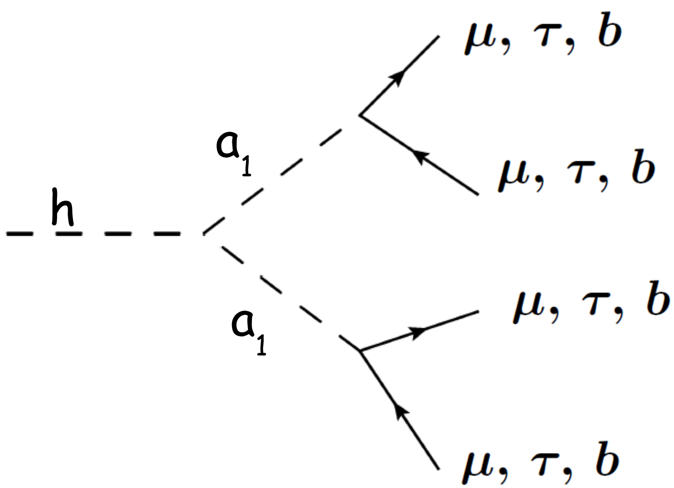
Beskidt, de Boer, Kazakov, 1308.1333

A richer pheno for the SM-like Higgs

Dobrescu, Matchev, 0008192
Dermisek, Gunion, 0502105

R-symmetric limit

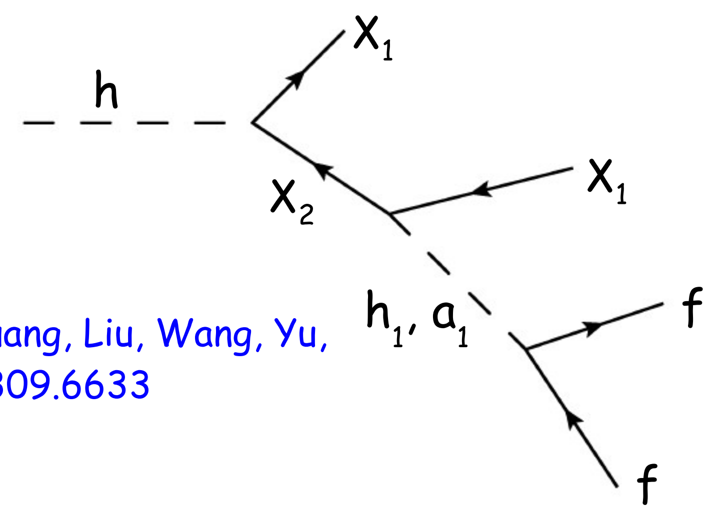
- Approximate symmetry which protects the mass of a very light pseudoscalar (a_1)
- Singlet-like CP-even Higgs (h_1) and singlino-like neutralino (χ_1) are typically not light
- $h \to a_1 a_1$ is typically significant



Draper, Liu, Wagner, Wang, Zhang, 1009.3963

PQ-symmetric + small λ limit

- a_1, h_1 (singlet-like) and χ_1 (singlino-like) can be simultaneously light
- $h \to a_1 a_1,\ h_1 h_1$ are generically suppressed
- $h \to \chi_1 \chi_2$ can be significant!



Huang, Liu, Wang, Yu, 1309.6633

Conclusions

A lot of info on SUSY models coming from
the measurement of a SM-like Higgs boson at ~125GeV!

Still interesting directions to explore

1. Better measurement of the Higgs couplings
2. Higgs exotic rare decays
3. New searches for heavy Higgs bosons

Bottom-stau contributions to the h mass

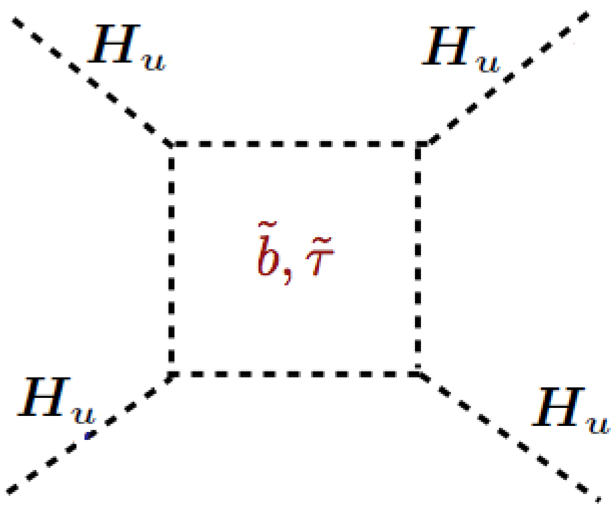
In the „quasi decoupling limit“:
($m_A \gg \lambda v$)

Additional loop corrections to the mass of the Higgs

$$\mathcal{M}^2_{\tilde{\tau},\tilde{b}} \simeq \begin{pmatrix} m^2_{L_3,Q_3} + m^2_{\tau,b} + D_L^{\tau,b} & m_{\tau,b}(A_{\tau,b} - \mu\tan\beta) \\ m_{\tau,b}(A_{\tau,b} - \mu\tan\beta) & m^2_{E_3,d_3} + m^2_{\tau,b} + D_R^{\tau,b} \end{pmatrix}$$

Sbottom (stau) mixing

$$\delta m_h^2 = - \frac{m^4_{b,\tau}}{16\pi^2 v^2} \frac{\mu^4 \tan^4\beta}{m^4_{\tilde{b},\tilde{\tau}}}$$

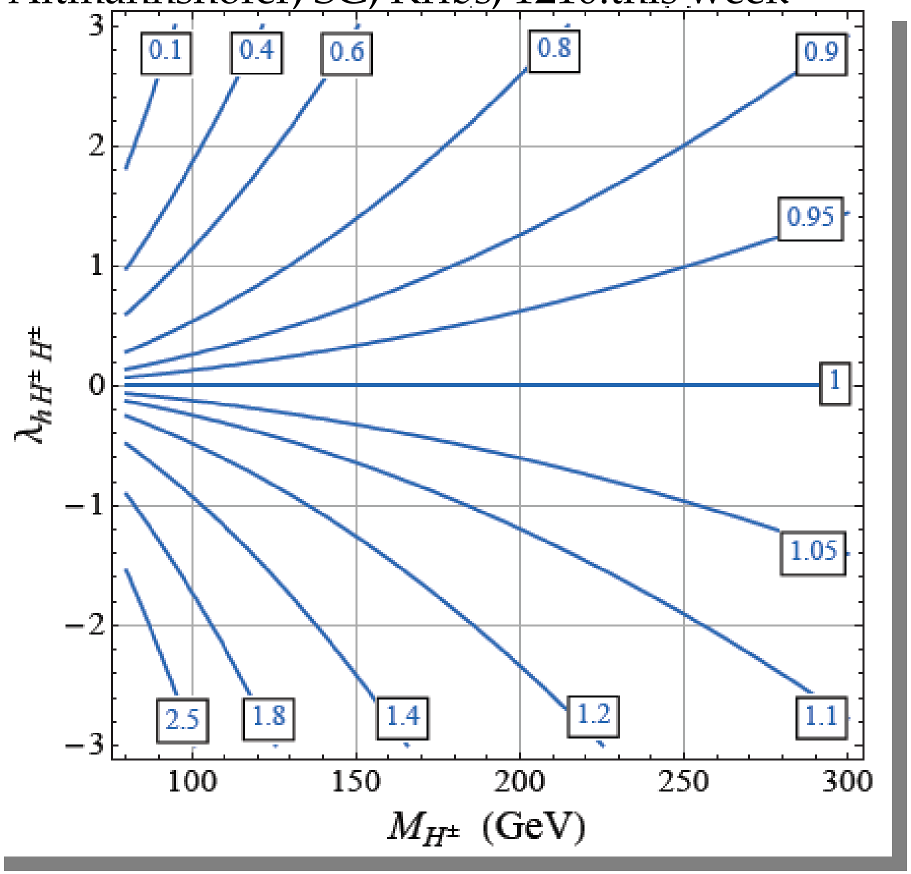


In the regime of very large tanβ and μ they can give a **few GeV effect**

Charged Higgs contributions

$$\Gamma(h \to \gamma\gamma) \sim \frac{\alpha^2 m_h^3}{1024\pi^3}\left|\frac{g_{hWW}}{m_W^2}A_1(x_W) - N_c Q_t^2 \frac{2g_{ht\bar{t}}}{m_t}A_{1/2}(x_t) + \frac{\lambda_{hH^\pm H^\pm} v}{m_{H^\pm}^2}A_0(x_{H^\pm})\right|^2$$

Altmannshofer, SG, Kribs, 1210.this week



Maximized at very small tanβ

$$|\lambda^{\rm MSSM}_{hH^\pm H^\pm}| \lesssim \frac{g^2}{2} \sim 0.21$$

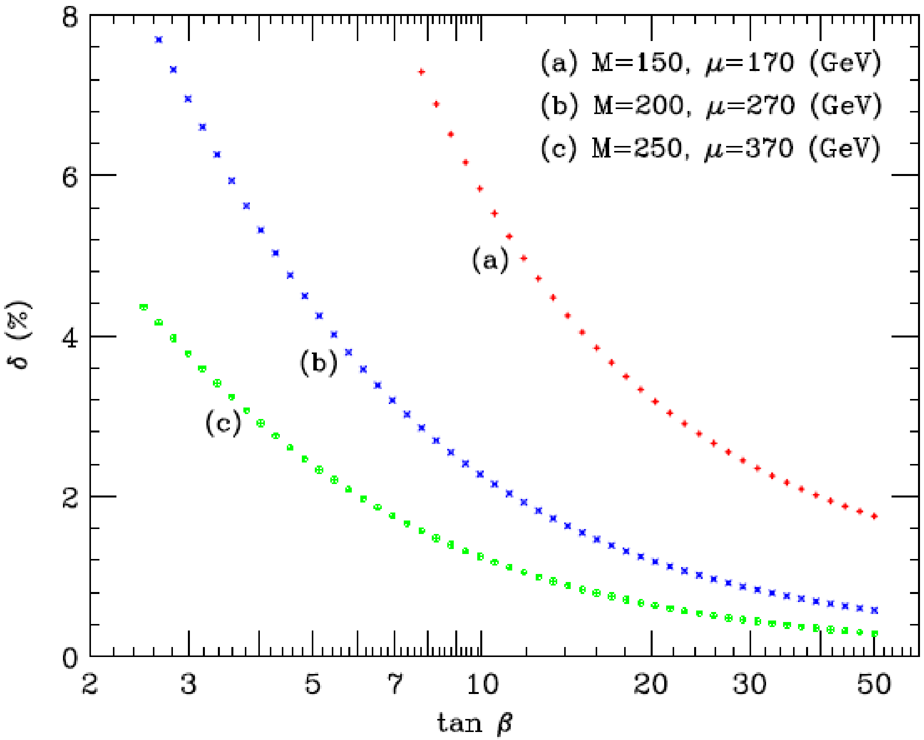
Quartic couplings in the MSSM are dictated by the gauge couplings

However see Schmidt, Staub, 1208.1683

Too small NP effects coming from the MSSM charged Higgs

Chargino contributions

Diaz, Perez, 0412066



See also Blum, D'Agnolo, Fan, 1206.5303

$$\Delta A_{\gamma\gamma} \propto -\frac{m_W^2 s_\beta c_\beta}{M_2 \mu}$$

The parameter dependence can be understood by

the low energy theorem:

Ellis, Gaillard, Nanopoulos, 1976

In presence of heavy charged particles

$$\Delta A^F_{\gamma\gamma} \propto b^F \times \frac{\partial \log(\det \mathcal{M}(v)\mathcal{M}^\dagger(v))}{\partial \log v}$$ for fermions in the loop

$$\Delta A^B_{\gamma\gamma} \propto b^B \times \frac{\partial \log(\det \mathcal{M}^2(v))}{\partial \log v}$$ for bosons in the loop

$$\mathcal{M}_{\chi^\pm} = \begin{pmatrix} M_2 & gv \sin\beta \\ gv\cos\beta & \mu \end{pmatrix}$$

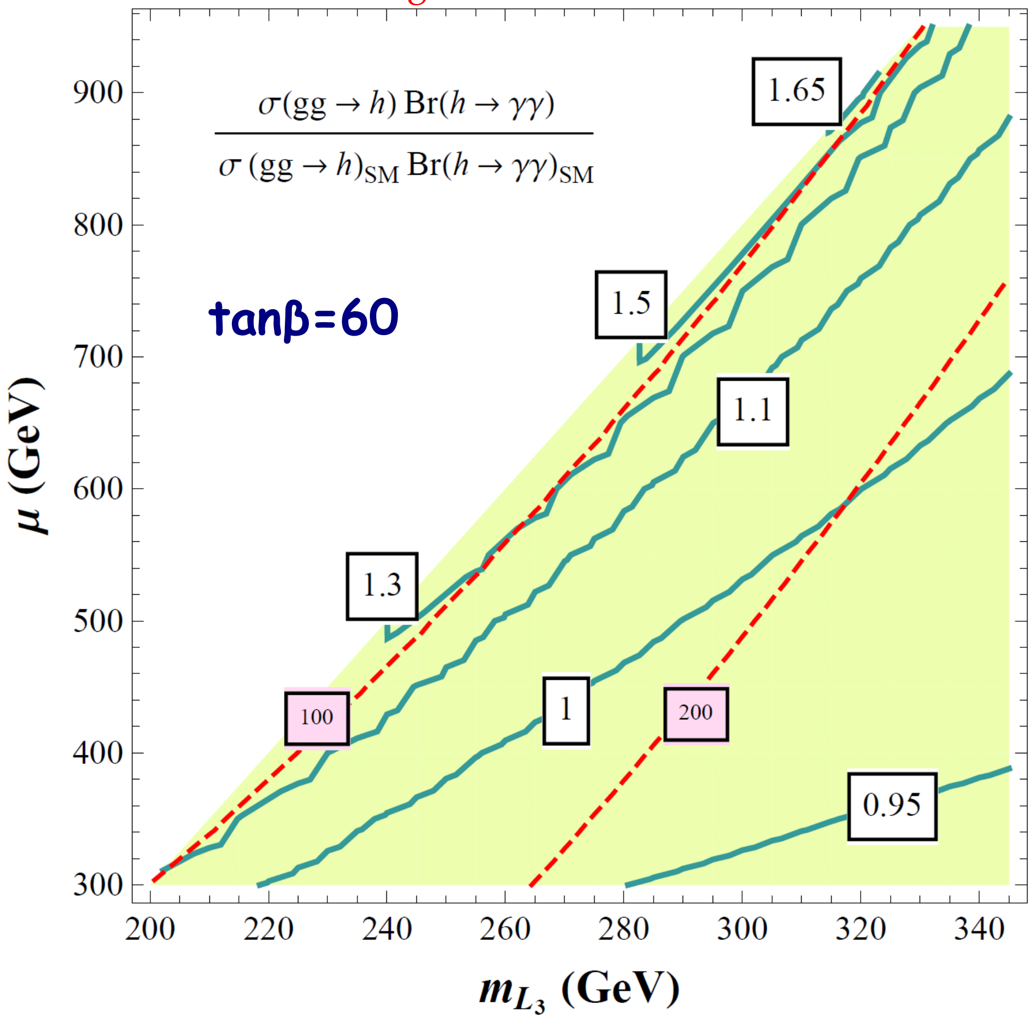
Corrections to the γγ rate are smaller than ~10% and arise only at very small tanβ

Stau contributions

$$\Delta A_{\gamma\gamma} \propto -\frac{(\mu\tan\beta)^2 m_\tau^2}{m_{L3}^2 m_{e3}^2 - m_\tau^2(\mu\tan\beta)^2} \sim -\frac{m_{\tilde{\tau}_2}^2}{m_{\tilde{\tau}_1}^2}\left(1-\frac{m_{\tilde{\tau}_1}^2}{m_{\tilde{\tau}_2}^2}\right)^2$$

For degenerate stau soft masses

Carena, S.G., Shah, Wagner, 1112.3336



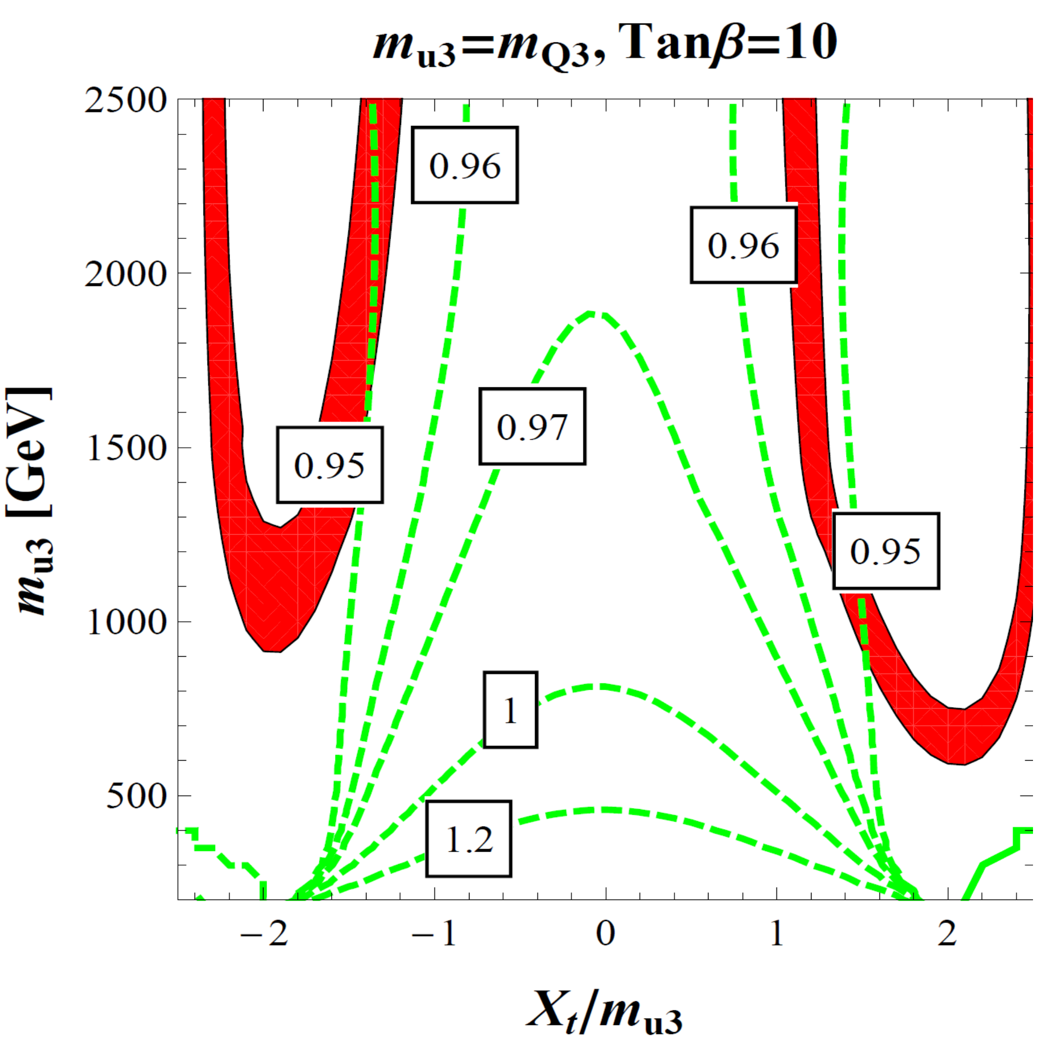
$$\mathcal{M}_{\tilde{\tau}}^2 \simeq \begin{pmatrix} m_{L_3}^2 + m_\tau^2 + D_L^\tau & m_\tau(A_\tau - \mu\tan\beta) \\ m_\tau(A_\tau - \mu\tan\beta) & m_{E_3}^2 + m_\tau^2 + D_R^\tau \end{pmatrix}$$

Heavily mixed light (LEP bound ~95GeV) staus can lead to sizable effect in the γγ rate

Stop contributions

See also Dermisek, Low, 0701235

First case: large mixing and comparable stop masses



$$\sigma(pp \to h \to \gamma\gamma) = \sigma(pp \to h)\frac{\Gamma(h \to \gamma\gamma)}{\Gamma_{tot}}$$

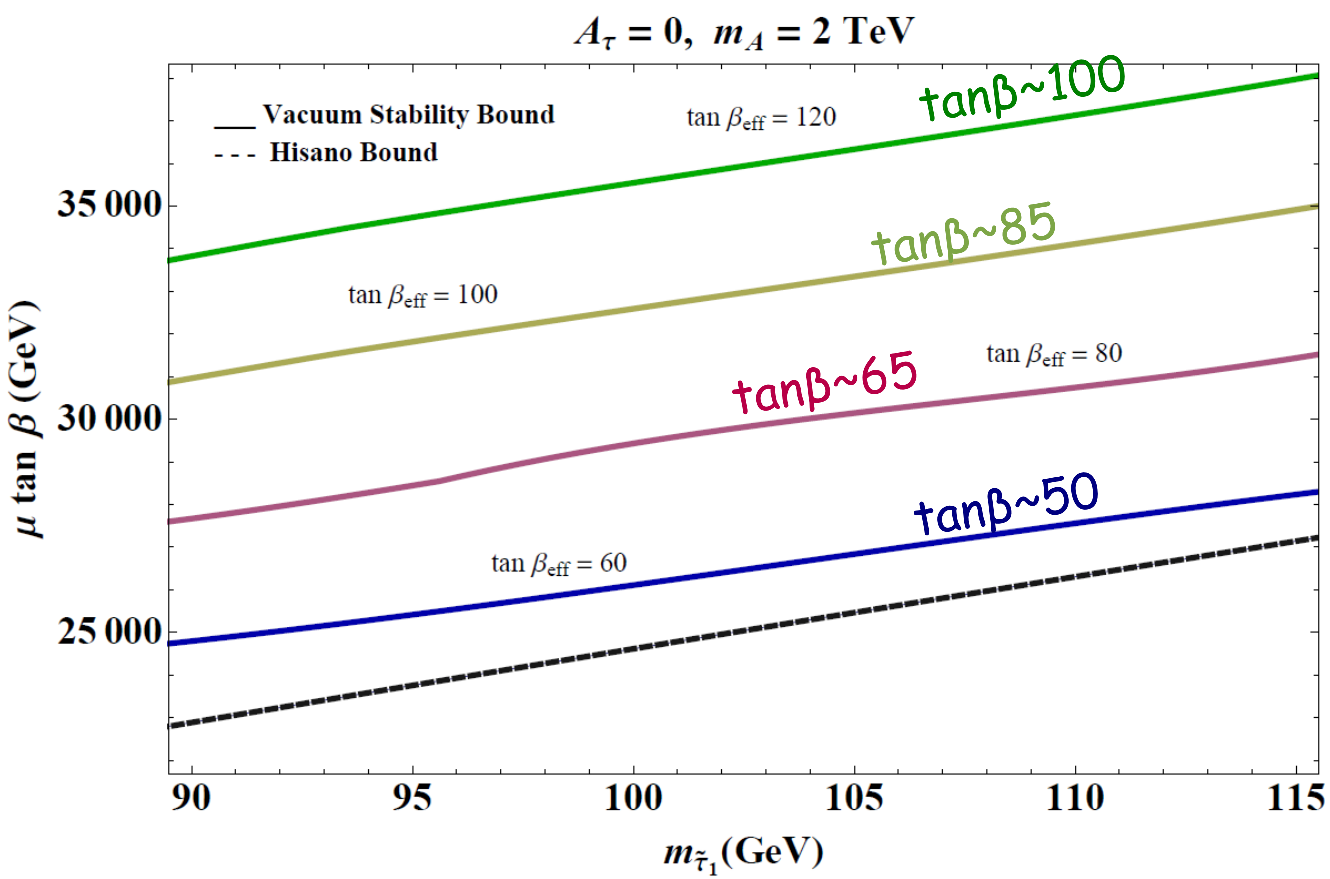
- Competing effects in gg fusion and in the γγ partial width
- Both effects are rather small in the region reproducing the correct Higgs mass
- Overall **small suppression** of the γγ rate coming from stops in this region

Vacuum stability

However this does not take into account the tanβ dependence

At very large values of tanβ, the bound can be relaxed

Also enhancement of ~(50-60)% are possible



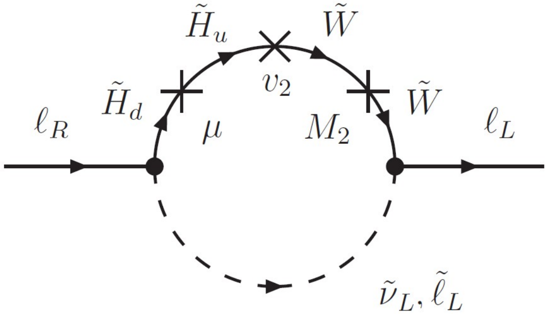
Carena, SG, Low, Shah, Wagner, in preparation

Note:

including loop corrections

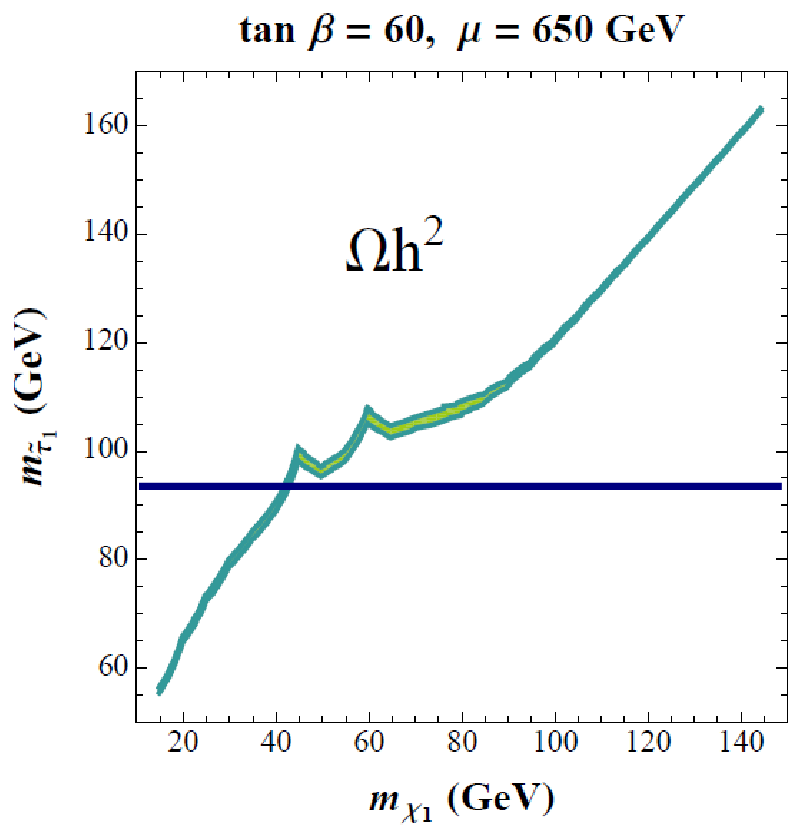
$$y_\tau = \sqrt{2}\frac{m_\tau}{v}\frac{\tan\beta}{1+\Delta_\tau}$$

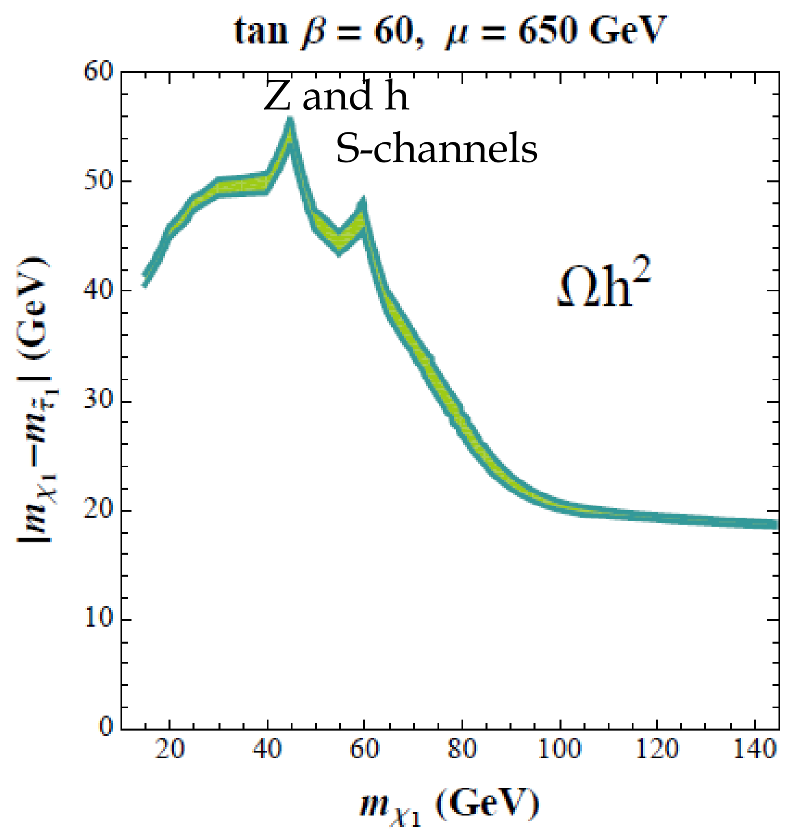
Negative in our model



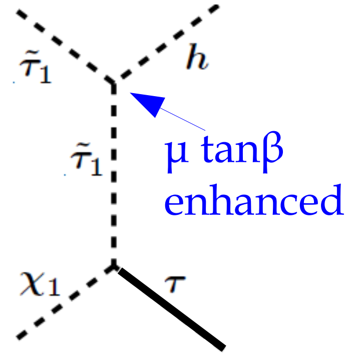
Dark matter

Carena, Gori, Shah, Wagner, Wang, 1205.5842





LSP= lightest neutralino (mainly bino)



Main coannihilation channel:

$$\chi_1 \tilde{\tau}_1 \rightarrow h\tau$$

In the region of interest:

$$m_{\chi_1} \sim 30 - 40\,\mathrm{GeV}$$

LHC staus direct searches

- LEP bound on the stau mass: Aleph, 0112011
  ~ 90 GeV in the case of no degeneracy with the lightest neutralino

- CMS bound on long lived staus: 339 GeV
  1305.0491 (7 TeV, 5 fb^{-1} + 8 TeV, 18.8 fb-1)

- ATLAS: searches for staus NLSP produced from gluino & squark cascade decays.
  Up to 4 leptons (at least one τ), jets and missing energy signature. ATLAS-CONF-2013-026

- CMS & ATLAS multilepton searches
  ≥ 2 leptons + MET final states

$$\tilde{\chi}^{\pm} \to \tilde{\chi}^{0} W, \ell\tilde{\nu}, \tilde{\ell}\nu, \quad \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 Z, \ell\tilde{\ell}$$

And also limits on sleptons produced in cascade decays

  CMS: SUS-12-022, SUS-12-026, SUS-12-027 (old @7TeV: 1204.5341)
  ATLAS: ATLAS-CONF-2013-035 (old @7TeV 1208.3144)

- ATLAS 2τ + MET search
  ATLAS-CONF-2013-028

$$\tilde{\chi}^{\pm} \to \tilde{\tau}\nu, \tau\tilde{\nu}, \quad \tilde{\chi}_2^0 \to \tilde{\tau}\tau$$
$$\tilde{\tau}\tilde{\tau} \to (\tau\tilde{\chi}_1^0)(\tau\tilde{\chi}_1^0)$$

Improved strategies to look for light staus?

Proposing new channels

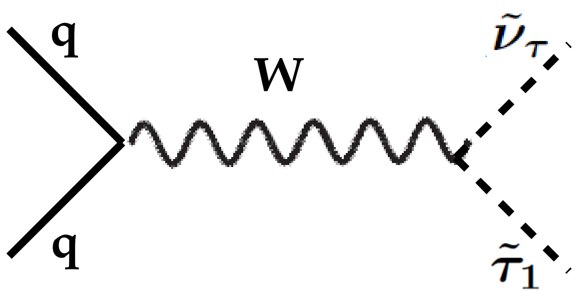
Carena, Gori, Shah, Wagner, Wang, 1205.5842

Direct production of staus/sneutrinos

2) $pp \to \tilde{\tau}_1 \tilde{\nu}_\tau \to \ell \tau \tau \not{E}_T$

$(\tilde{\tau}_1 \to \tau\,\mathrm{LSP}, \tilde{\nu}_\tau \to W \tilde{\tau}_1, W \to \ell \nu)$

Additional lepton: easier search, even if statistically limited



Production cross section for staus at ~ 95 GeV, sneutrino ~ 270 GeV:
~15 fb (8TeV), ~40 fb (14TeV)

Main backgrounds: W+ Z/γ*, W+jets

Proposing new channels

Carena, Gori, Shah, Wagner, Wang, 1205.5842

Direct production of staus/sneutrinos

2) $pp \to \tilde{\tau}_1 \tilde{\nu}_\tau \to \ell \tau \tau \not{E}_T$

	Total (fb)	Basic (fb)	Hard Tau (fb)
Signal	1.6	0.26	0.11
Physical background, $W + Z/\gamma^*$	27	0.32	$\lesssim 10^{-3}$
$W+$ jets background	10^4	39	0.25

14 TeV

Estimation at the parton level,
A more careful analysis would be needed

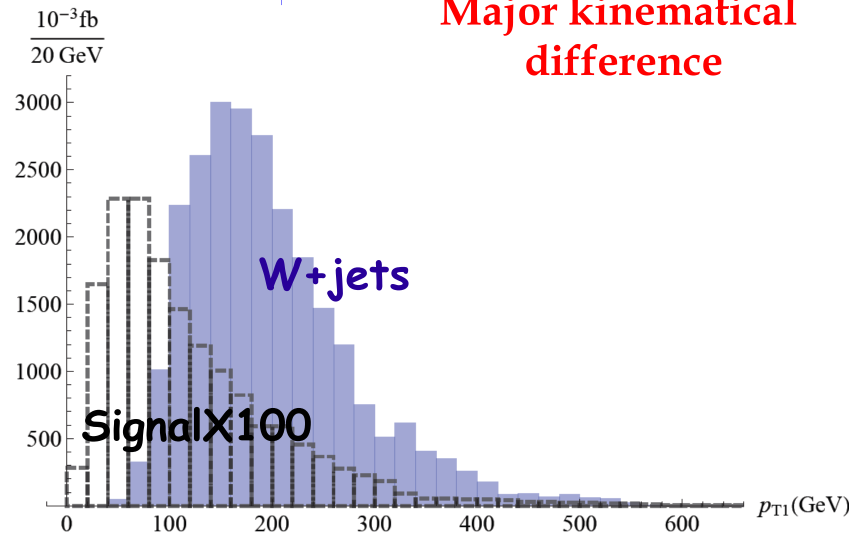
2-loose taus
$p_T^\tau > 10$ GeV,
$\Delta R > 0.4$

$p_T^\ell > 85$ GeV,
$\not{E}_T > 85$ GeV

$p_T^{\tau_1} < 80$ GeV

Major kinematical difference

Comparable numbers (after cuts)
at the 8 TeV LHC



Motivate experimentalists to perform
a dedicated search to
validate these results