ETH- Zurich - 11 January '12

The Higgs and the Terascale: an Outlook

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The main LHC results so far

- A robust exclusion interval for the SM Higgs.

Only a narrow window below 600 GeV: 115.5-127 GeV.

Plus some indication for $m_H \sim 125$ GeV

K. Jacobs
C. Paus

- No evidence of new physics, althouh a big chunk of new territory has been explored

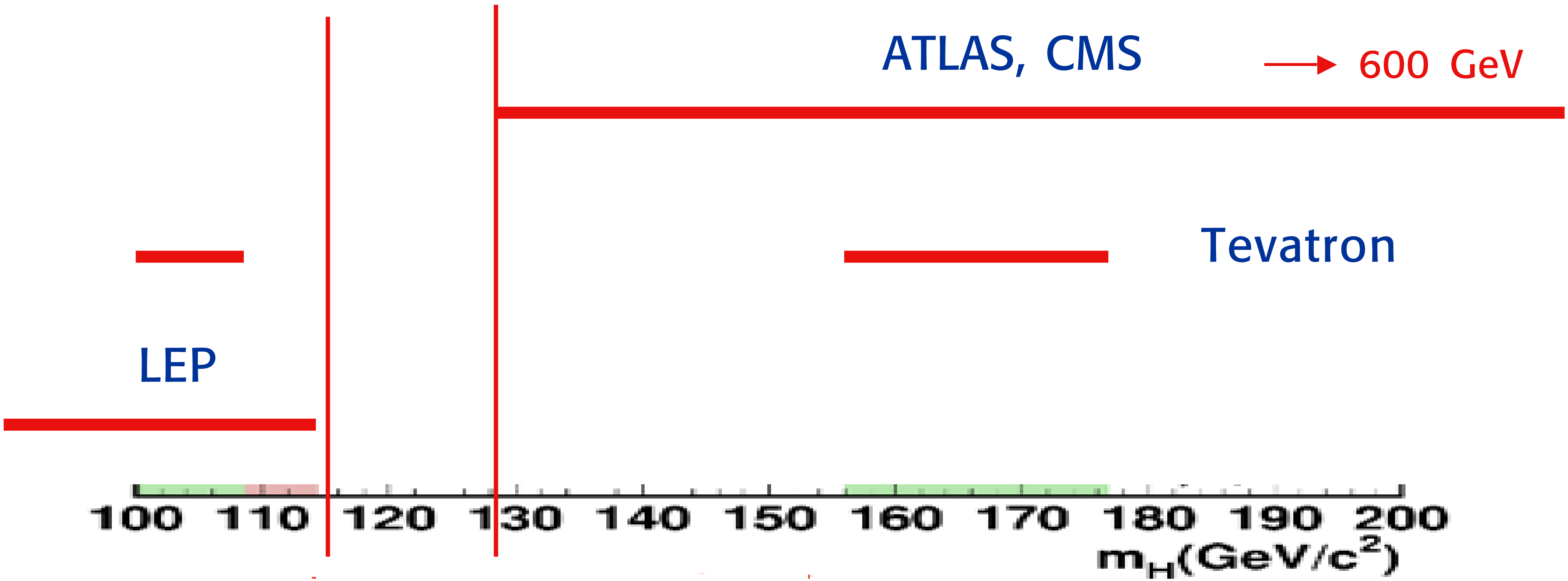
P. Sphicas

- Important results on B and D decays from LHCb

[e.g. $B_s \to J/\Psi\phi$, $B_s \to \mu\mu$, ... CP viol in D decay]

→ T. Nakada

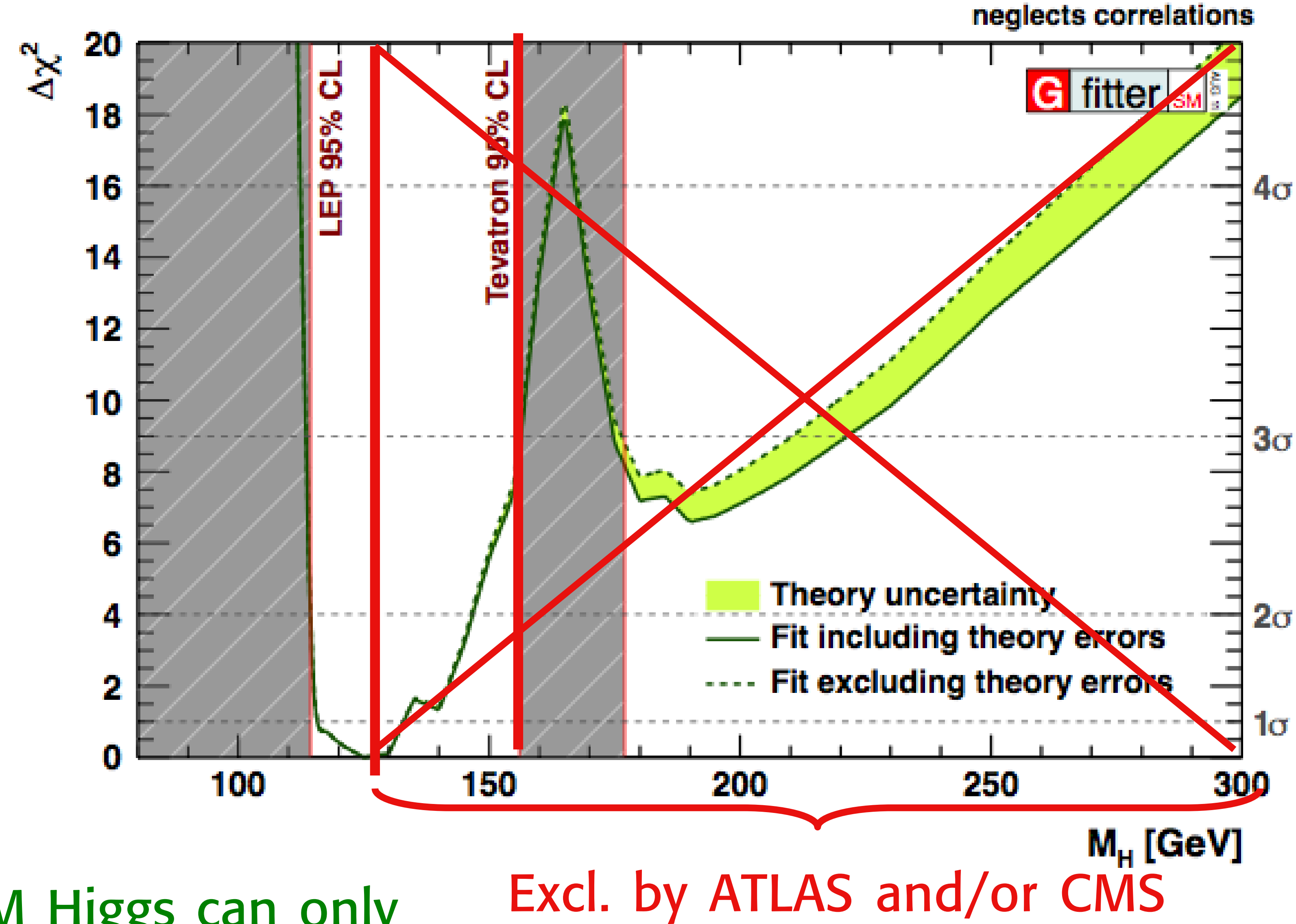
The 95% exclusion intervals for the light Higgs



115.5-127 GeV

The window of opportunity

$m_H > 600$ GeV
also allowed



A light SM Higgs can only be in 115.5-127 GeV range in agreement with EW tests

also $300 < m_H < 600$ GeV is excluded

Some "excess" was reported in the allowed m_H window

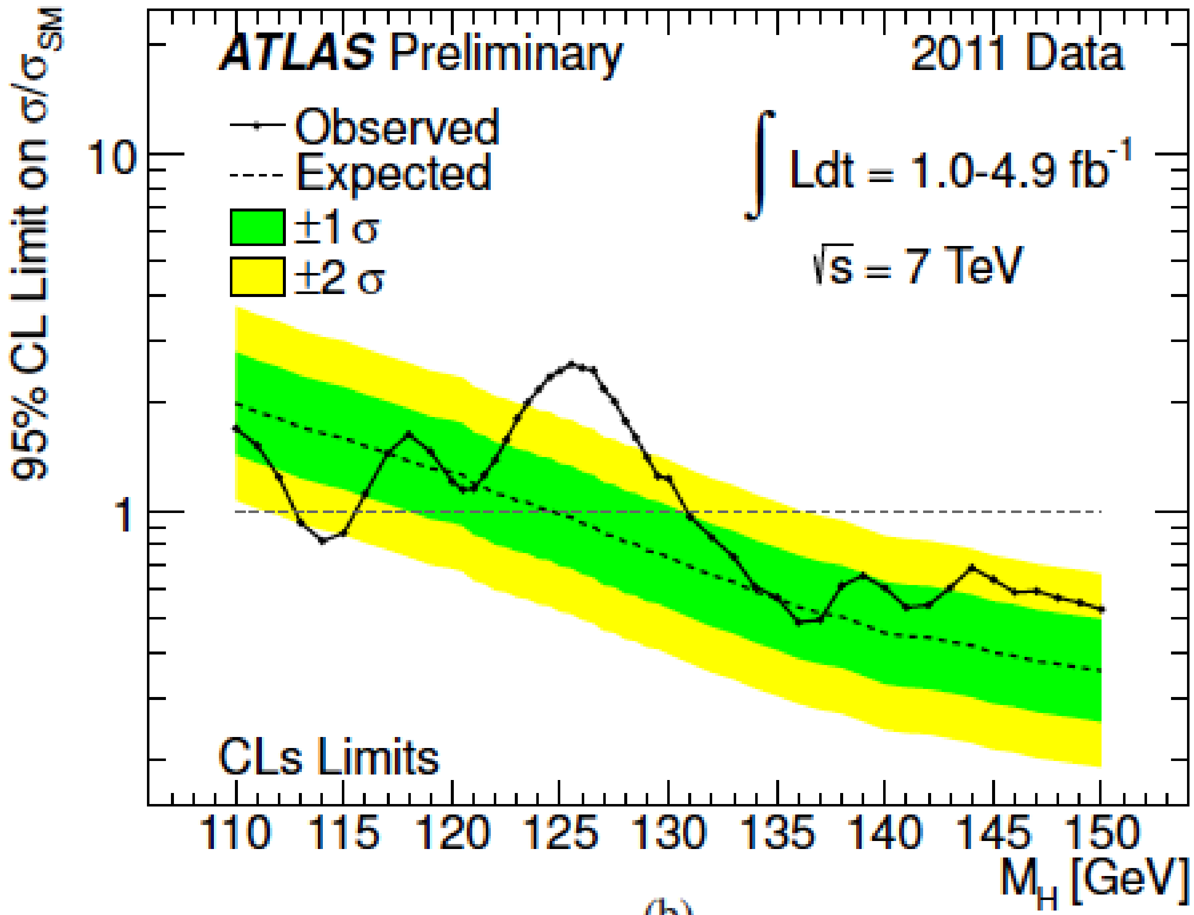
Is this the Higgs signal?

We hope yes, but the present evidence could still evaporate with more statistics

We need to wait for the 2012 run

But, assuming that the excess is the first manifestation of a signal, it is important to discuss the implications

Many papers on the ArXiv after Dec. 13th



(b)

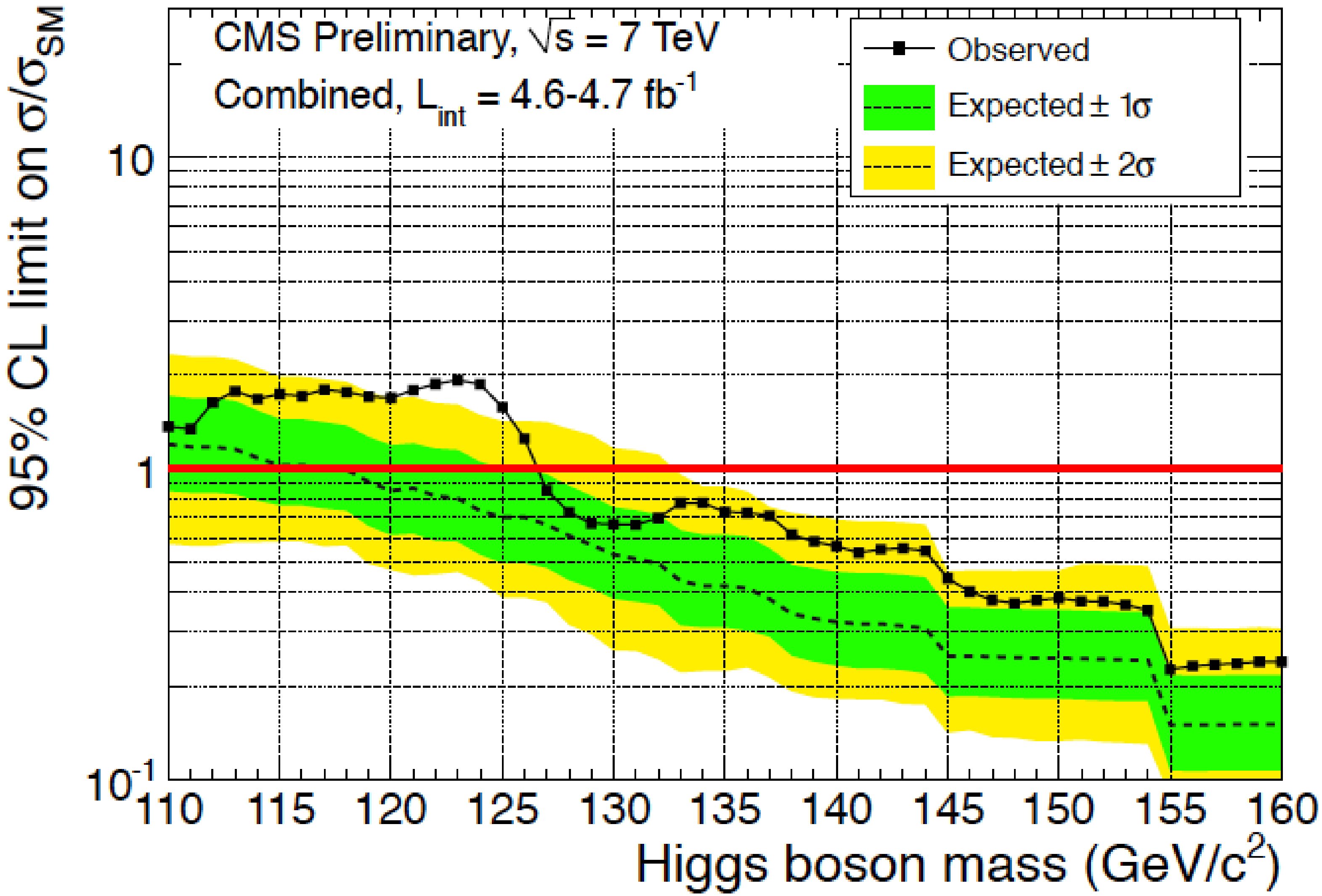
Observed excess over SM for m_H ~ 126 GeV in:

H->$\gamma\gamma$ (2.8σ), H->ZZ*->4$l^{\pm}$ (2.1σ), H->WW*-> $l\nu l\nu$ (1.4σ).

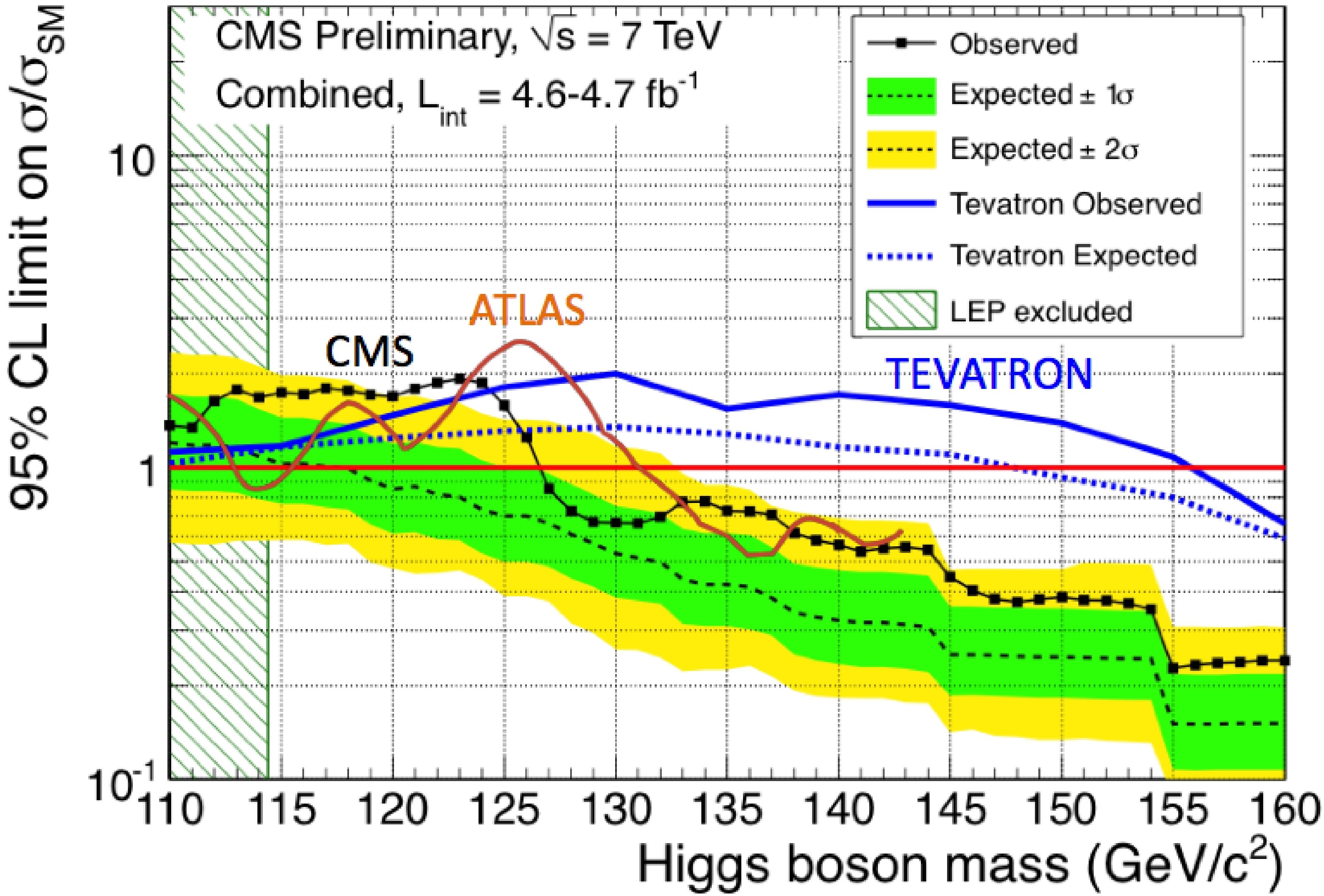
Combined: 3.6σ (but with look-elsewhere-effect 2.3σ)

The most obvious “elsewhere” is CMS

Also in CMS there is an excess, but smaller (2.6 σ)



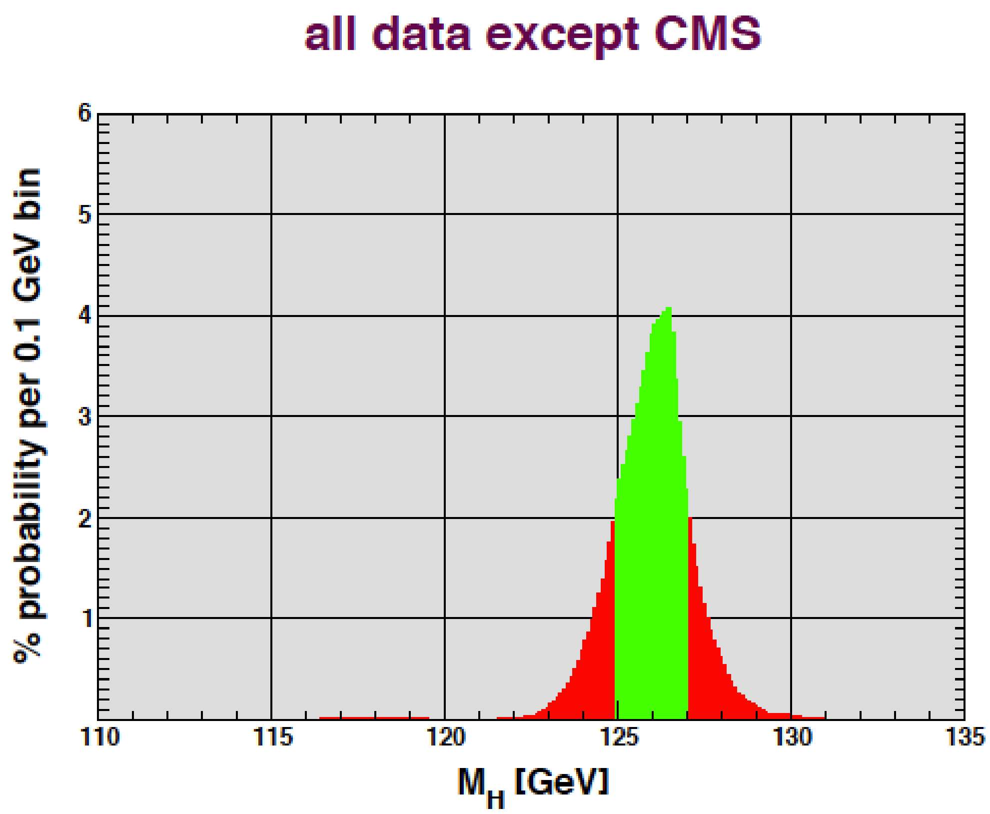
Kilminster

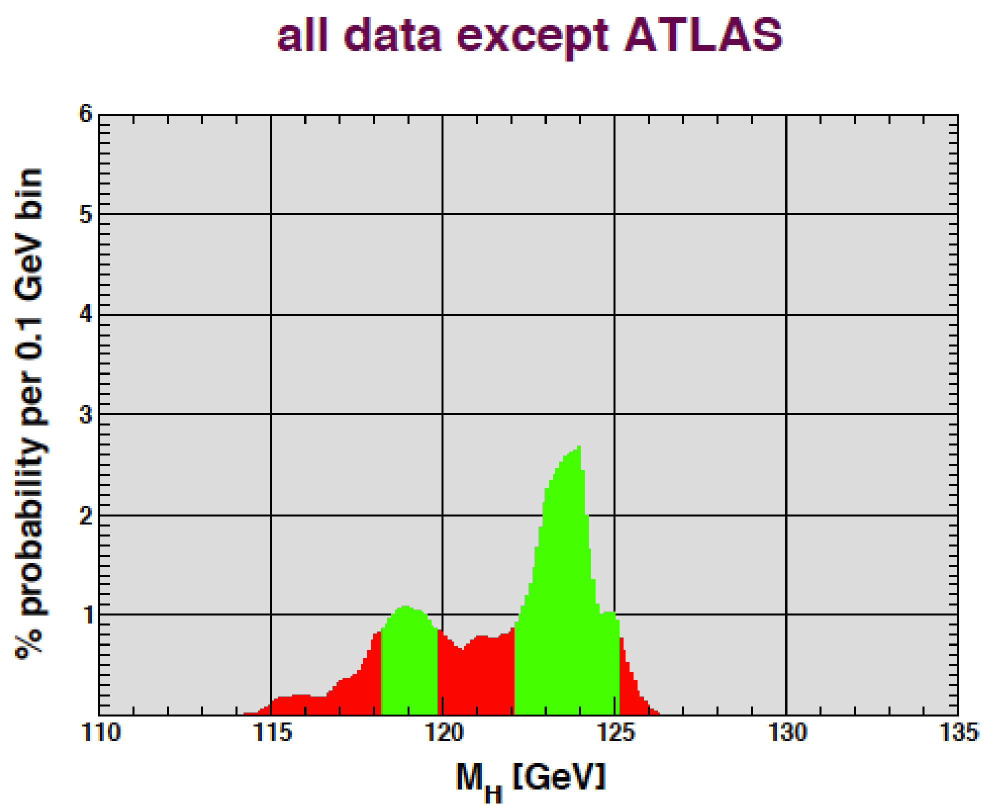


CMS Preliminary, √s = 7 TeV
Combined, L_int = 4.6-4.7 fb^-1
Observed
Expected ± 1σ
Expected ± 2σ
Tevatron Observed
Tevatron Expected
LEP excluded
ATLAS
CMS
TEVATRON
95% CL limit on σ/σ_SM
Higgs boson mass (GeV/c²)
10
1
10^-1
110
115
120
125
130
135
140
145
150
155
160

Do the masses really coincide?

Erler '11

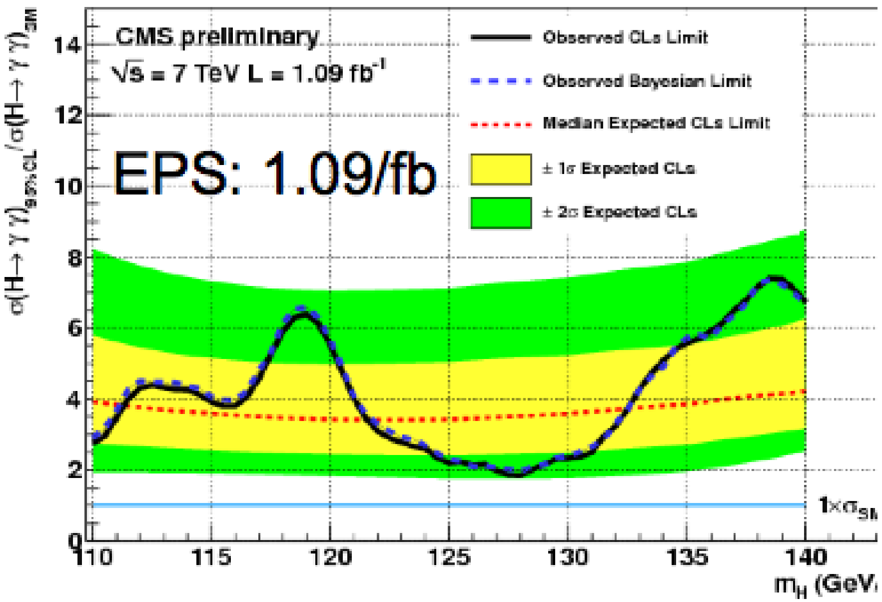


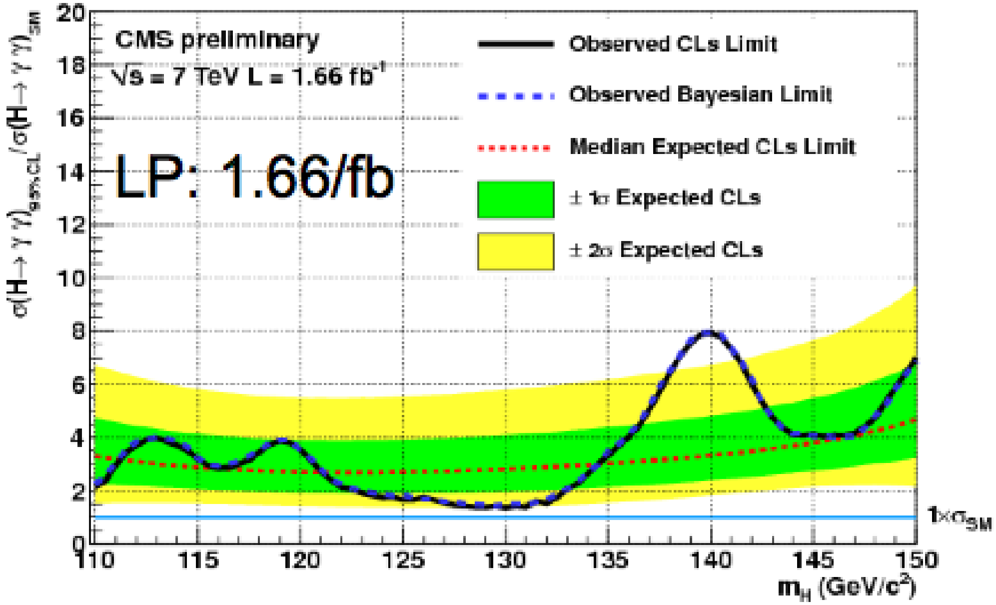


Peaks come and go!

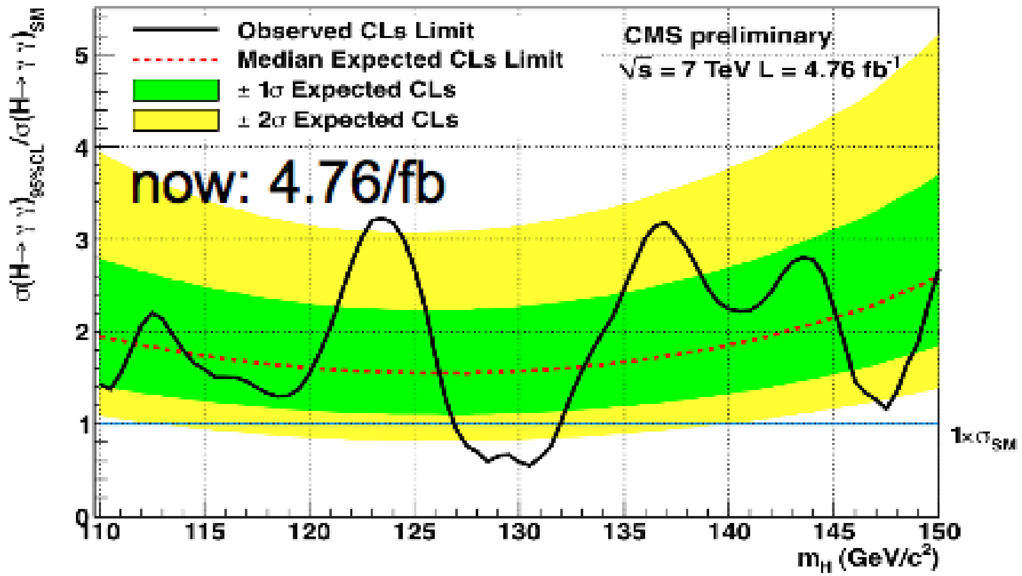
Paus

CMS History: $H \rightarrow \gamma\gamma$

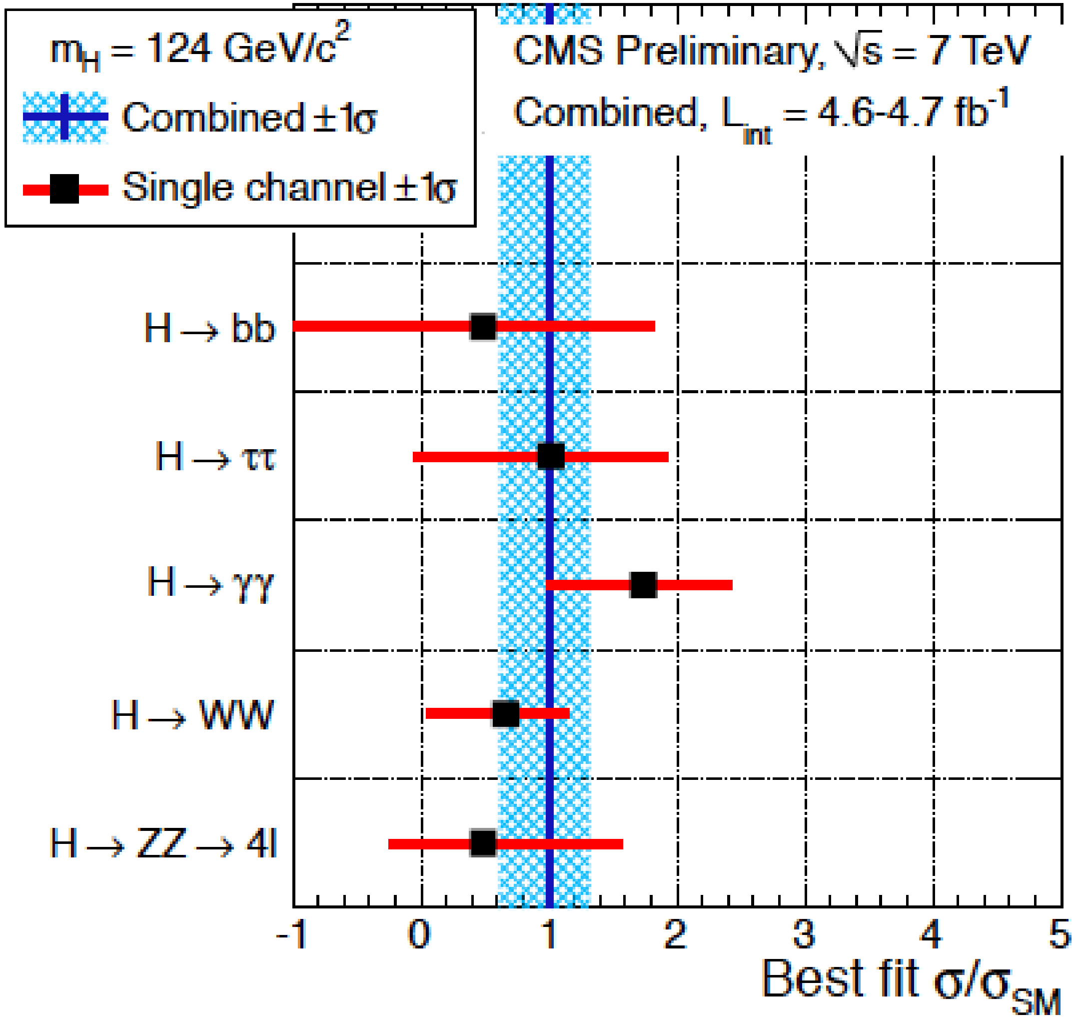




- EPS (1.09/fb) LP (1.66/fb) Dec 19 (4.76/fb)
- 'peaks' come and go
- of course now we are getting into interesting territory



A moderate enhancement of the $\gamma\gamma$ rate may be indicated



The SM Higgs is close to be observed or excluded!

Either the SM Higgs is very light (115.5 - 127 GeV)
or rather heavy (i.e. > 600 GeV)

The range m_H = 115.5 - 127 GeV is in agreement with precision tests, compatible with the SM and also with the SUSY extensions of the SM

m_H ~125 GeV is what you expect from a direct interpretation of EW precision tests: no fancy conspiracy with new physics to fake a light Higgs while the real one is heavy

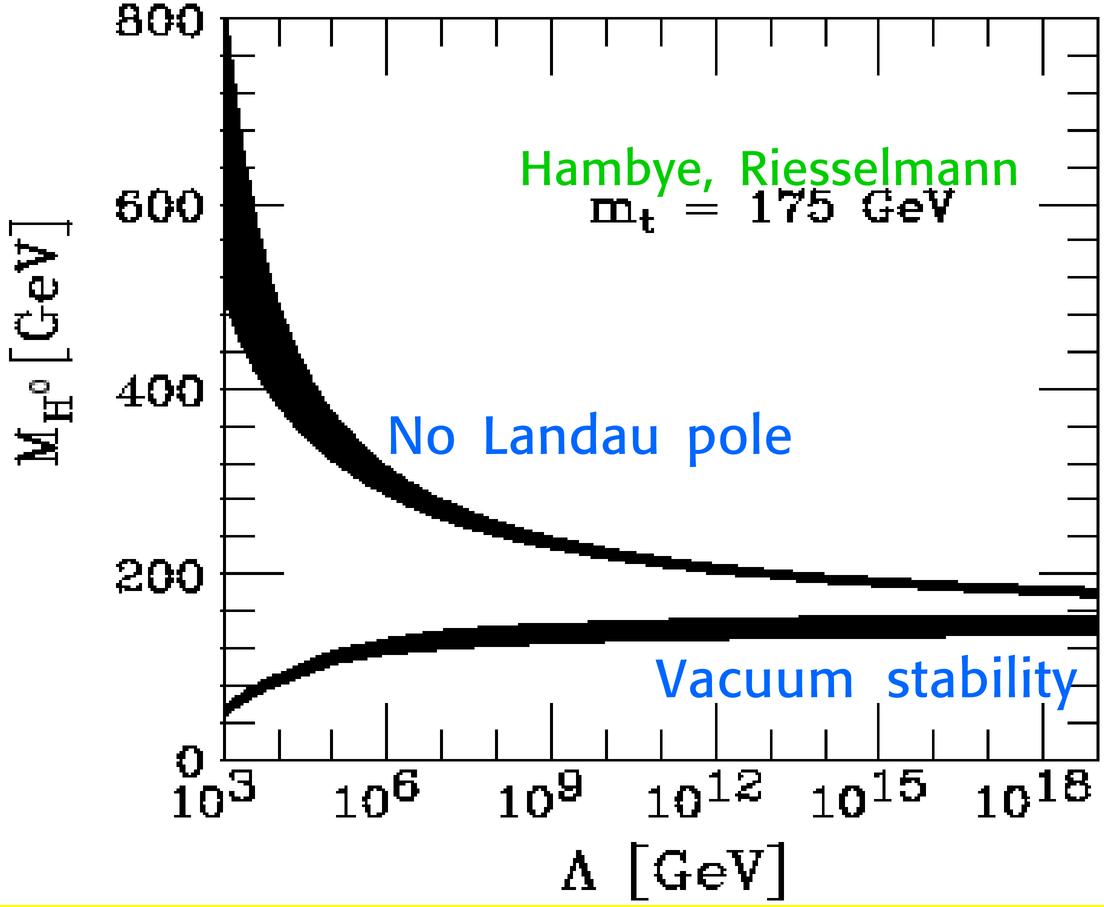
m_H > 600 GeV would point to the conspiracy alternative

Theoretical bounds on the SM Higgs mass

Λ: scale of new physics beyond the SM

Upper limit: No Landau pole up to Λ

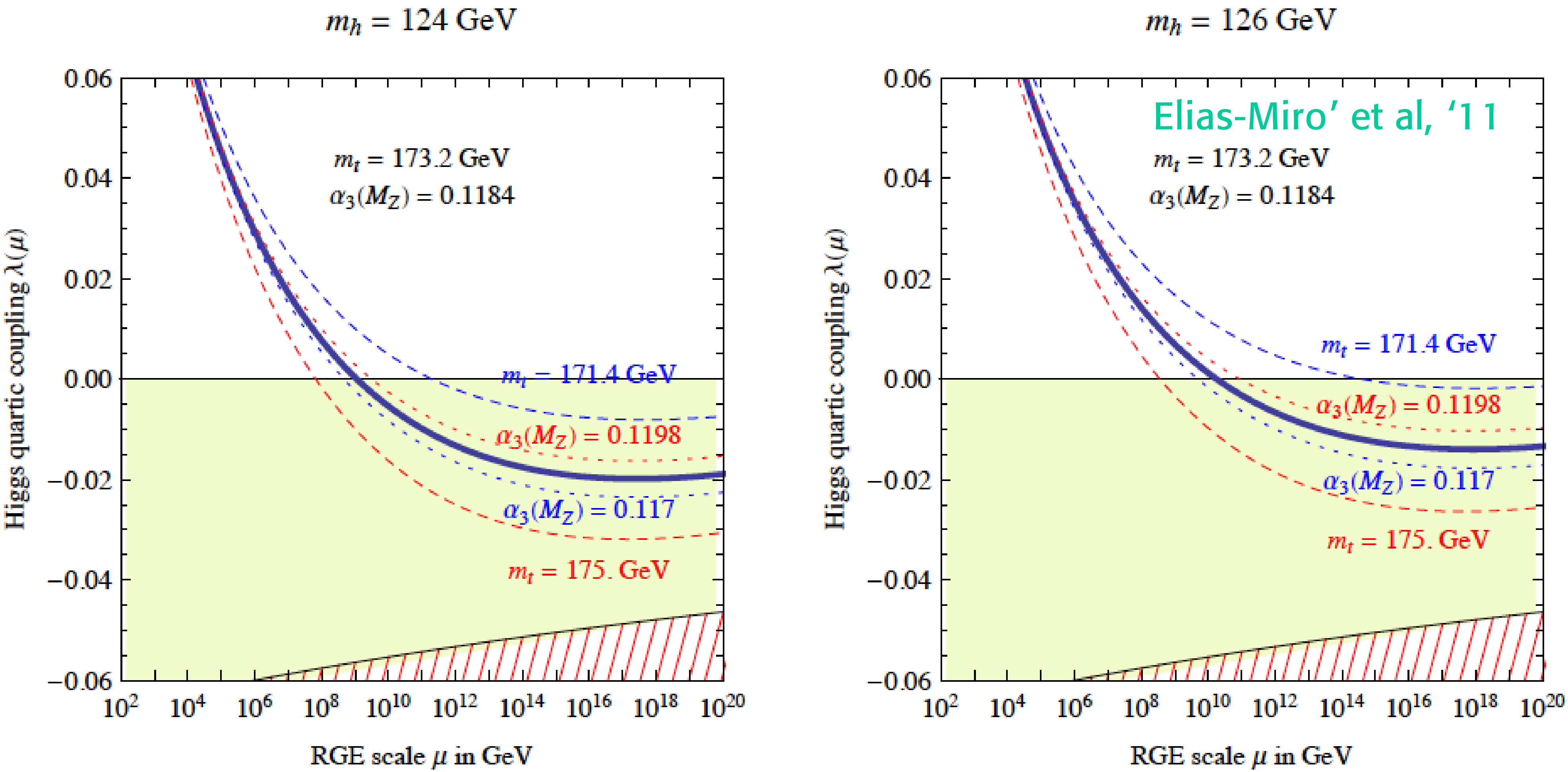
Lower limit: Vacuum (meta)stability



If the SM would be valid up to M_{GUT}, M_{Pl} with a stable vacuum then m_H would be limited in a small range

depends on m_t and α_s → 130 GeV < m_H < 180 GeV

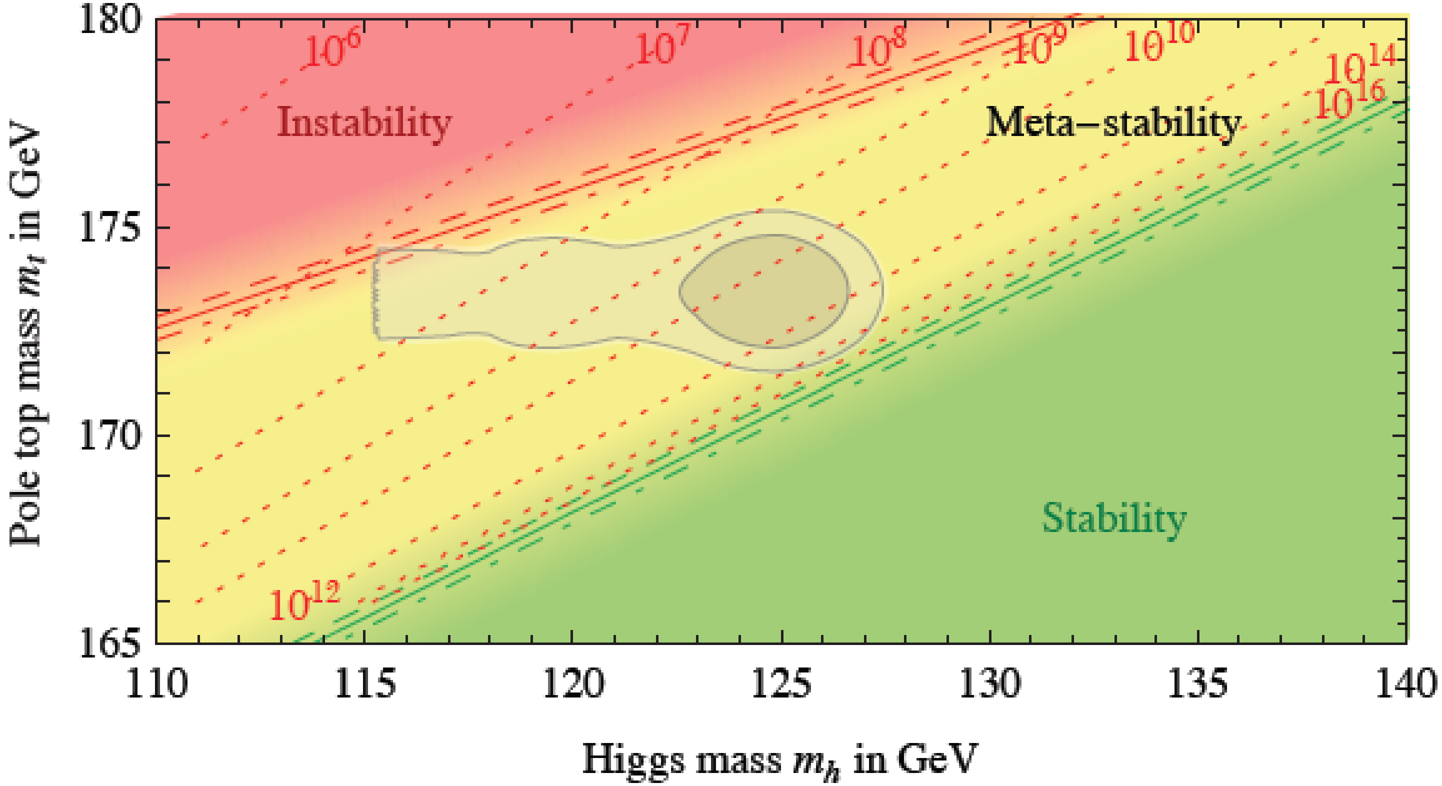
But metastability (with sufficiently long lifetime) is enough!



In the absence of new physics, for $m_H \sim 125$ GeV,
the Universe becomes metastable at a scale $\Lambda \sim 10^{10}$ GeV

And the SM remains viable up to M_{Pl} (early universe implications)

Elias-Miro' et al, '11



Note that λ=0 at the Planck scale (and no physics in between) implies $m_H \sim$ 130 GeV depending on m_t and α_s

$$m_h > 130\,\mathrm{GeV} + 1.8\,\mathrm{GeV}\left(\frac{m_t - 173.2\,\mathrm{GeV}}{0.9\,\mathrm{GeV}}\right) - 0.5\,\mathrm{GeV}\left(\frac{\alpha_s(M_Z) - 0.1184}{0.0007}\right) \pm 3\ \mathrm{GeV}$$

⊕ not far from 125 GeV

Elias-Miro' et al, Holthausen et al, Wetterich '11

The Standard Model works very well

So, why not find the Higgs and declare particle physics solved?

Because of both:

Conceptual problems

- Quantum gravity
- The hierarchy problem
- The flavour puzzle

.....

and experimental clues:

- Neutrino masses
- Coupling unification
- Dark matter
- Baryogenesis
- Vacuum energy
- some experimental anomalies: $(g\text{-}2)_\mu$, ...

Some of these problems point at new physics at the weak scale: eg
Hierarchy
Dark matter (perhaps)

insert here your preferred hints

An enlarged SM (to include RH ν's and no new physics) remains an (enormously fine tuned) option

A light Higgs

SO(10) non SUSY GUT

SO(10) breaking down to $SU(4) \times SU(2)_L \times SU(2)_R$ at an intermediate scale (10^{11-12})

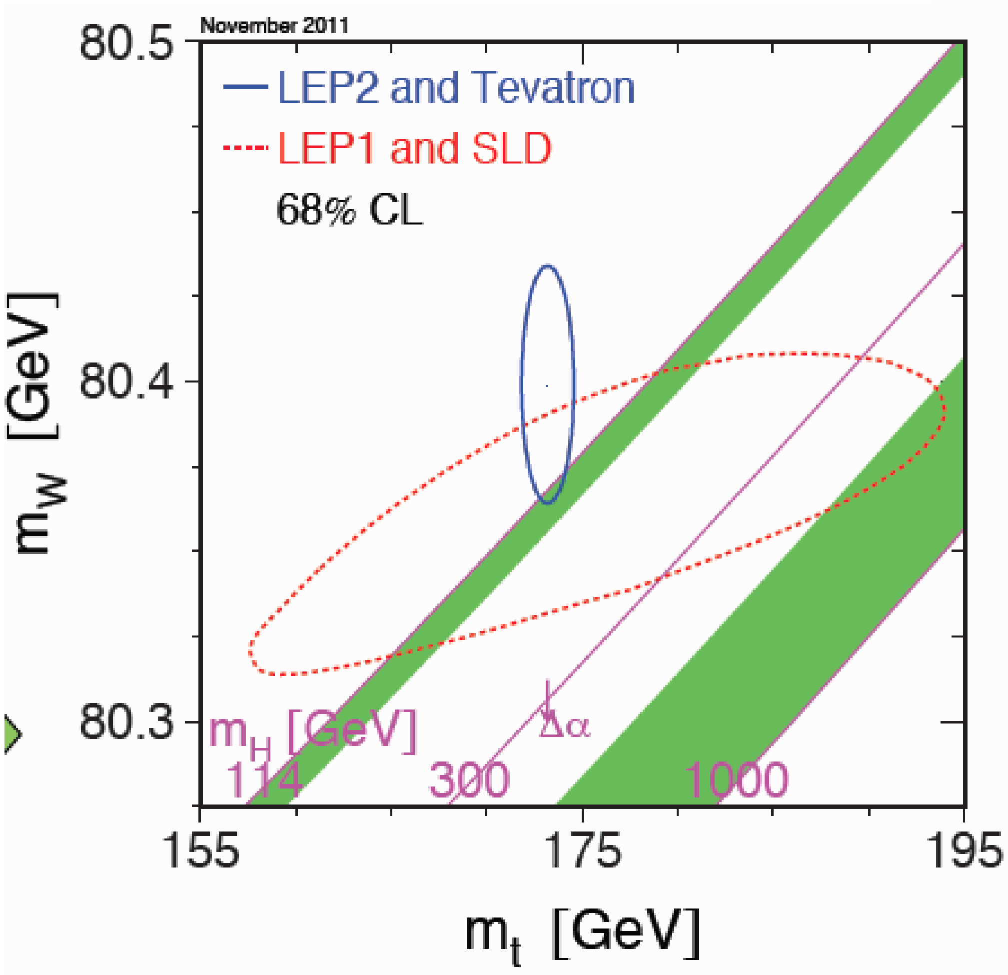
Majorana neutrinos and see-saw (-> $0\nu\beta\beta$)

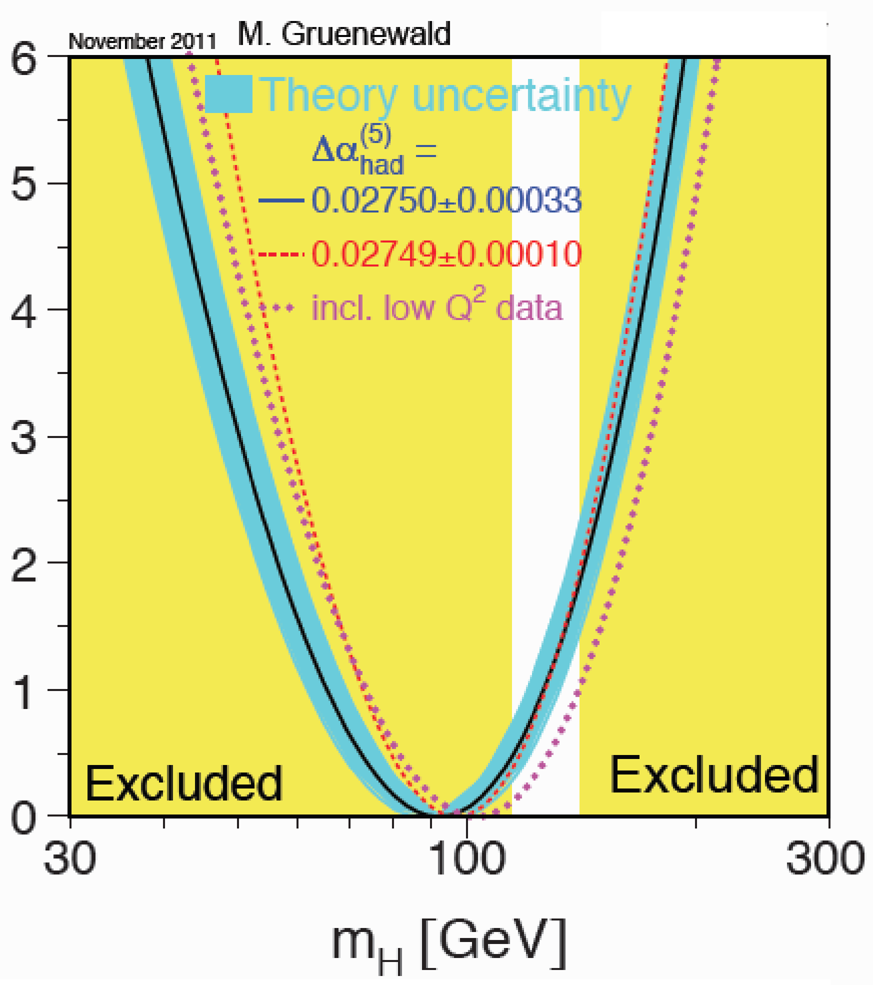
Axions as dark matter

Baryogenesis thru leptogenesis

(but: $(g-2)_\mu$ and other present deviations from SM should be disposed of)

Some amount of new physics could bring EW precision tests better into focus





The best fit m_H is low, more so if not for $A_{FB}{}^b$, m_W is a bit large

Muon g-2

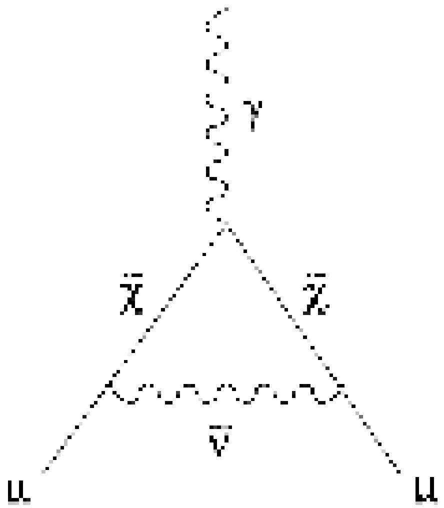
$a_\mu^{exp} - a_\mu^{SM} = (28.7 \pm 8.0) \times 10^{-10}$

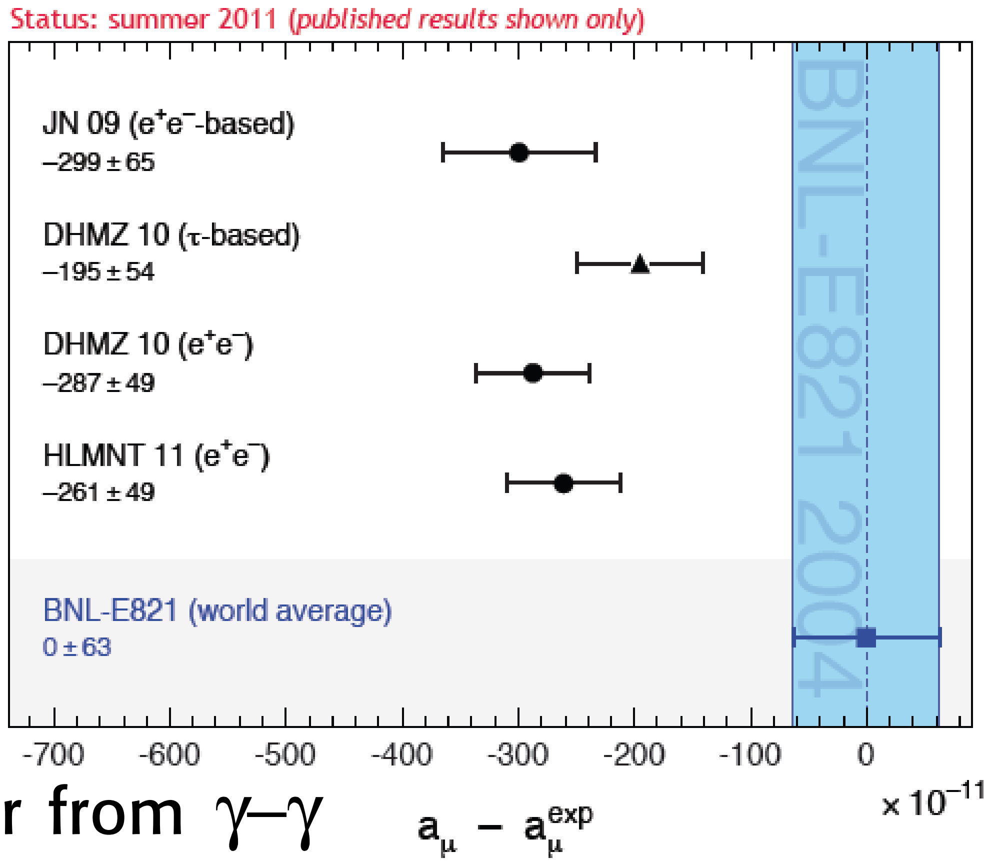
- 3.6 "standard deviations" (e^+e^-)
- 2.4 "standard deviations" (τ)

a_μ is a plausible location for a new physics signal!!

$$\delta a_\mu = 13 \cdot 10^{-10} \left(\frac{100 GeV}{M_{SUSY}}\right)^2 tg\beta$$

eg could be light SUSY (now tension with LHC)





- Error dominated by th error from γ–γ

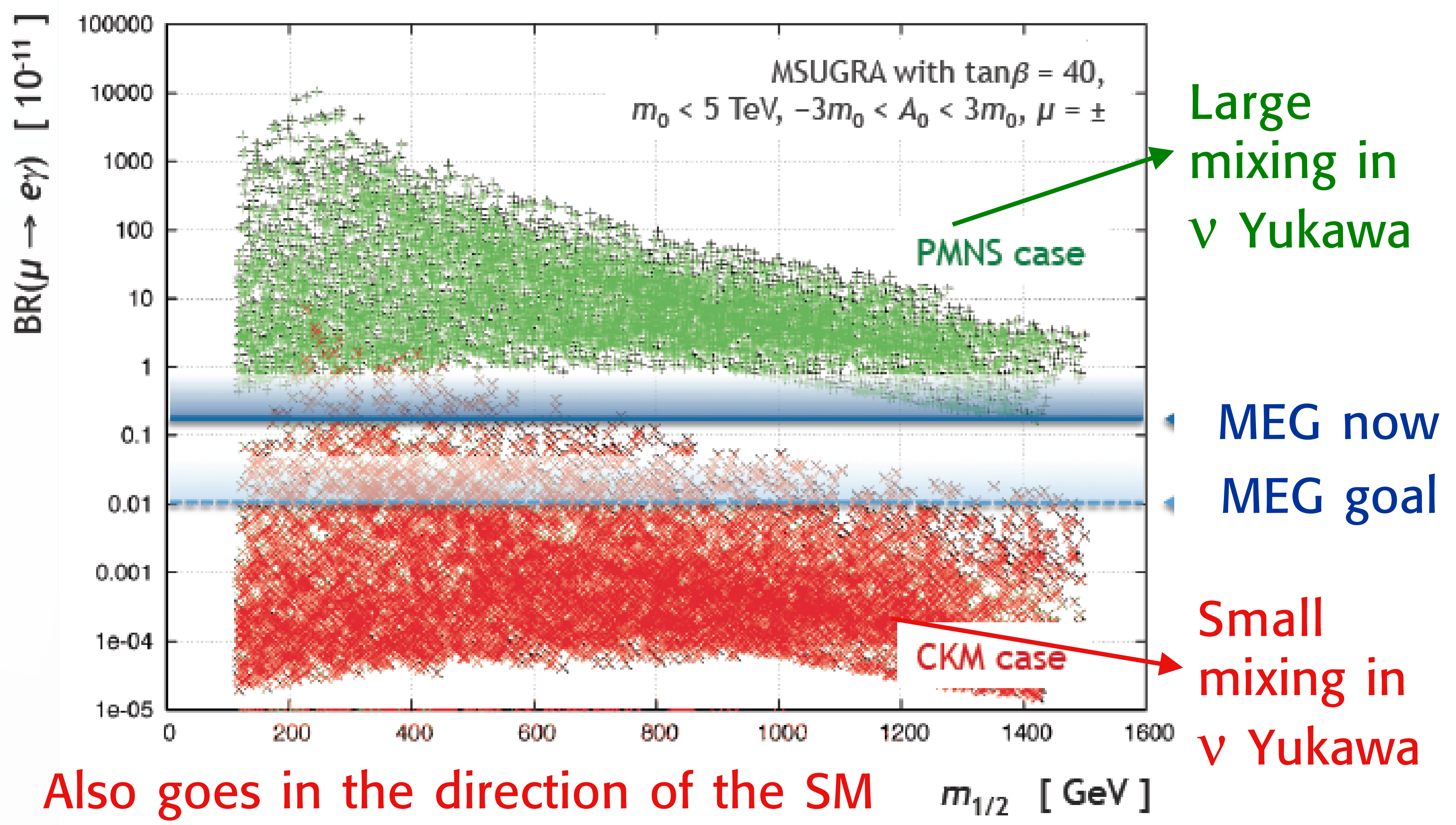
Some NP hints from accelerator experiments

A^b_{FB}	LEP	$\sim 3\sigma$
$(g-2)_\mu$	Brookhaven	$\sim 3\sigma$
tt^{bar} FB asymmetry	Tevatron (mostly CDF)	$\sim 3\sigma$ at large M_{tt}
Dimuon charge asymmetry	D0	$\sim 3.9\sigma$
Wjj excess at $M_{jj} \sim$ 144 GeV only candidate to open prod. of NP	CDF not confirmed by D0, LHC	$\sim 3.2\sigma$
$B_s \to J/\psi\phi$	Tevatron, LHCb	~went away
$B \to \tau\nu$	BaBar, Belle	$\sim 2.5\sigma$

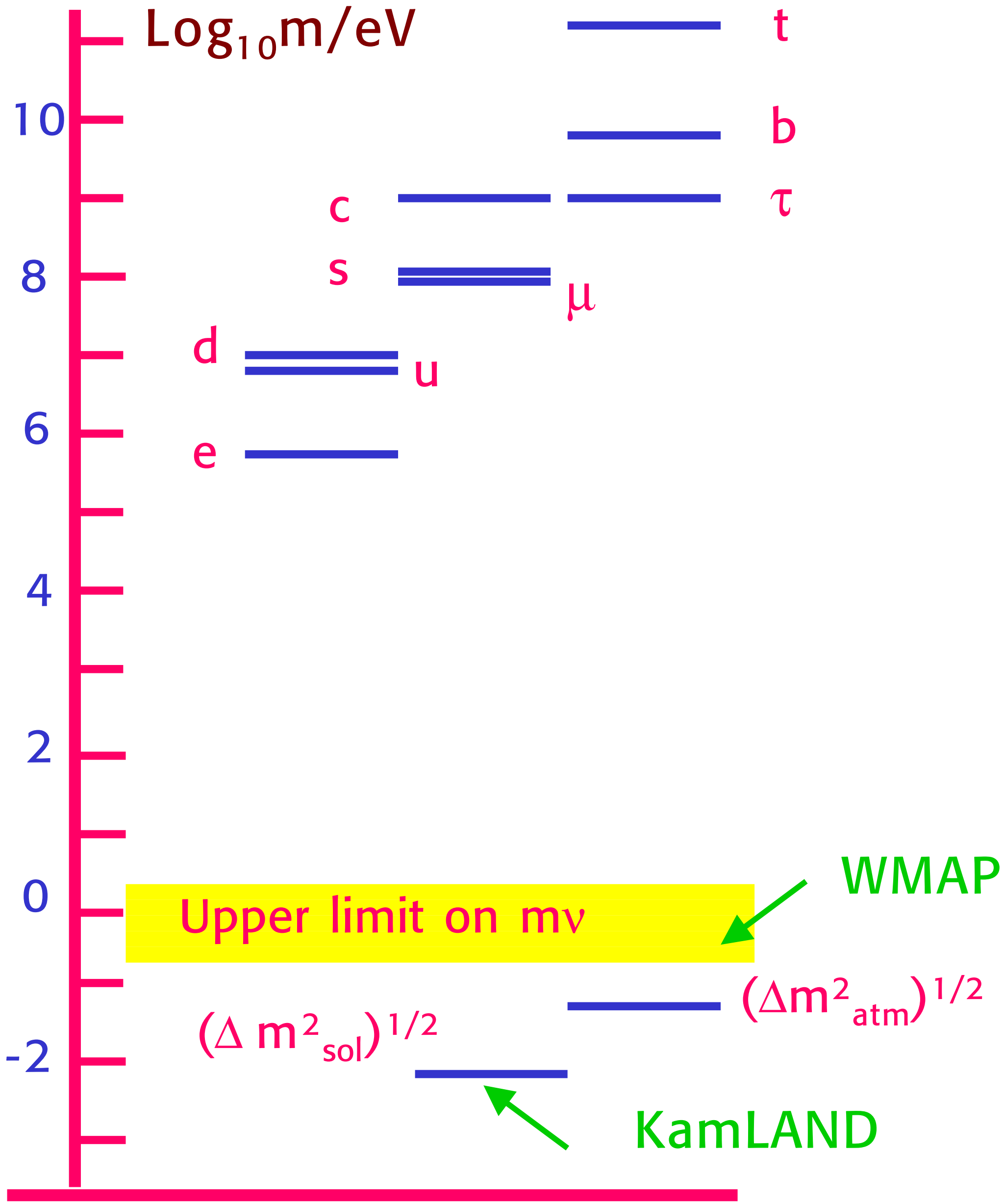
•••••••

A non-LHC very important result

MEG new limit on Br(μ -> e γ) < 2.4 10^{-12}



Also goes in the direction of the SM



Neutrino masses are really special!

$m_t/(\Delta m^2_{atm})^{1/2} \sim 10^{12}$

Massless ν's?

- no ν_R
- L conserved

Small ν masses?

- ν_R very heavy
- L not conserved

Very likely:
ν's are special as they are Majorana fermions

Are neutrinos Dirac or Majorana fermions?

Under charge conjugation C: particle <--> antiparticle

For bosons there are many cases of particles that coincide (up to a phase) with their antiparticle: $\pi^0, \rho^0, \omega, \gamma, Z^0$.....

A fermion that coincides with its antiparticle is called a Majorana fermion. Are there Majorana fermions?

Neutrinos are probably Majorana fermions

Of all fundamental fermions only ν's are neutral

If lepton number L conservation is violated then no conserved charge distinguishes neutrinos from antineutrinos

$$\begin{bmatrix} uuu\nu_e \\ ddde \end{bmatrix} \qquad \begin{bmatrix} ccc\nu_\mu \\ sss\mu \end{bmatrix} \qquad \begin{bmatrix} ttt\nu_\tau \\ bbb\tau \end{bmatrix}$$

A very natural and appealing explanation:

ν's are nearly massless because they are Majorana particles and get masses through L non conserving interactions suppressed by a large scale $M \sim M_{GUT}$

$$m_\nu \sim \frac{m^2}{M}$$

$m: \leq m_t \sim v \sim 200$ GeV

M: scale of L non cons.

Note:

$m_\nu \sim (\Delta m^2_{atm})^{1/2} \sim 0.05$ eV

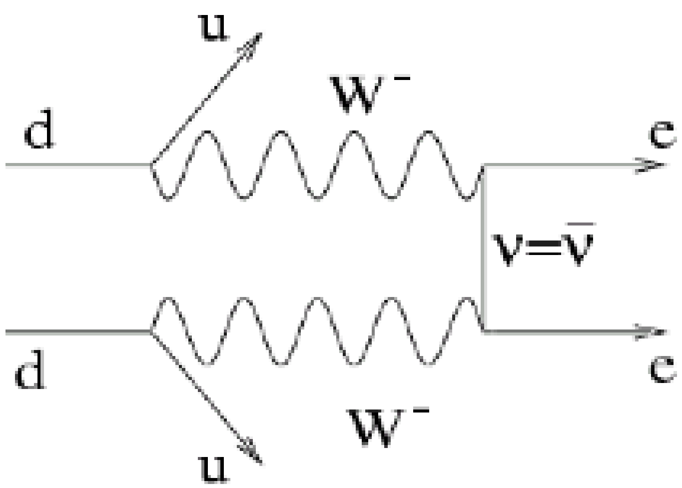
$m \sim v \sim 200$ GeV

$M \sim 10^{14} - 10^{15}$ GeV

Neutrino masses are a probe of physics at M_{GUT} !

How to prove that ν's are Majorana fermions?

All we know from experiment on ν masses strongly indicates that ν's are Majorana particles and that L is not conserved (but a direct proof still does not exist).



$0\nu\beta\beta$ = dd -> uue$^-$e$^-$

Detection of $0\nu\beta\beta$ (neutrinoless double beta decay) would be a proof of L non conservation ($\Delta L=2$).

Thus a big effort is devoted to improving present limits and possibly to find a signal.

Heidelberg-Moscow, Cuoricino-Cuore, GERDA, •••••

Baryogenesis by decay of heavy Majorana ν's

BG via Leptogenesis near the GUT scale

$T \sim 10^{12\pm3}$ GeV (after inflation)

Buchmuller,Yanagida, Plumacher, Ellis, Lola, Giudice et al, Fujii et al ….

Only survives if Δ(B-L) is not zero
(otherwise is washed out at T_{ew} by instantons)

Main candidate: decay of lightest ν_R ($M \sim 10^{12}$ GeV)

L non conserv. in ν_R out-of-equilibrium decay:
B-L excess survives at T_{ew} and gives the obs. B asymmetry.

Quantitative studies confirm that the range of m_i from ν oscill's is compatible with BG via (thermal) LG

In particular the bound was derived for hierarchy

$m_i < 10^{-1}$ eV

Buchmuller, Di Bari, Plumacher; Giudice et al; Pilaftsis et al; Hambye et al

Can be relaxed for degenerate neutrinos
So fully compatible with oscill'n data!!

Dark Matter

WMAP, SDSS, 2dFGRS….

Most of the Universe is not made up of atoms: $\Omega_{tot} \sim 1$, $\Omega_b \sim 0.045$, $\Omega_m \sim 0.27$

Most is Dark Matter and Dark Energy

Most Dark Matter is Cold (non relativistic at freeze out)
Significant Hot Dark matter is disfavoured
Neutrinos are not much cosmo-relevant: $\Omega_\nu < 0.015$

SUSY has excellent DM candidates: eg Neutralinos (--> LHC)
Also Axions are still viable (introduced to solve strong CPV)
(in a mass window around m $\sim 10^{-4}$ eV and $f_a \sim 10^{11}$ GeV
but these values are simply a-posteriori)

Identification of Dark Matter is a task of enormous importance for particle physics and cosmology

LHC?

LHC has good chances because it can reach any kind of WIMP:

WIMP: Weakly Interacting Massive Particle
with m ~ 10^1-10^3 GeV

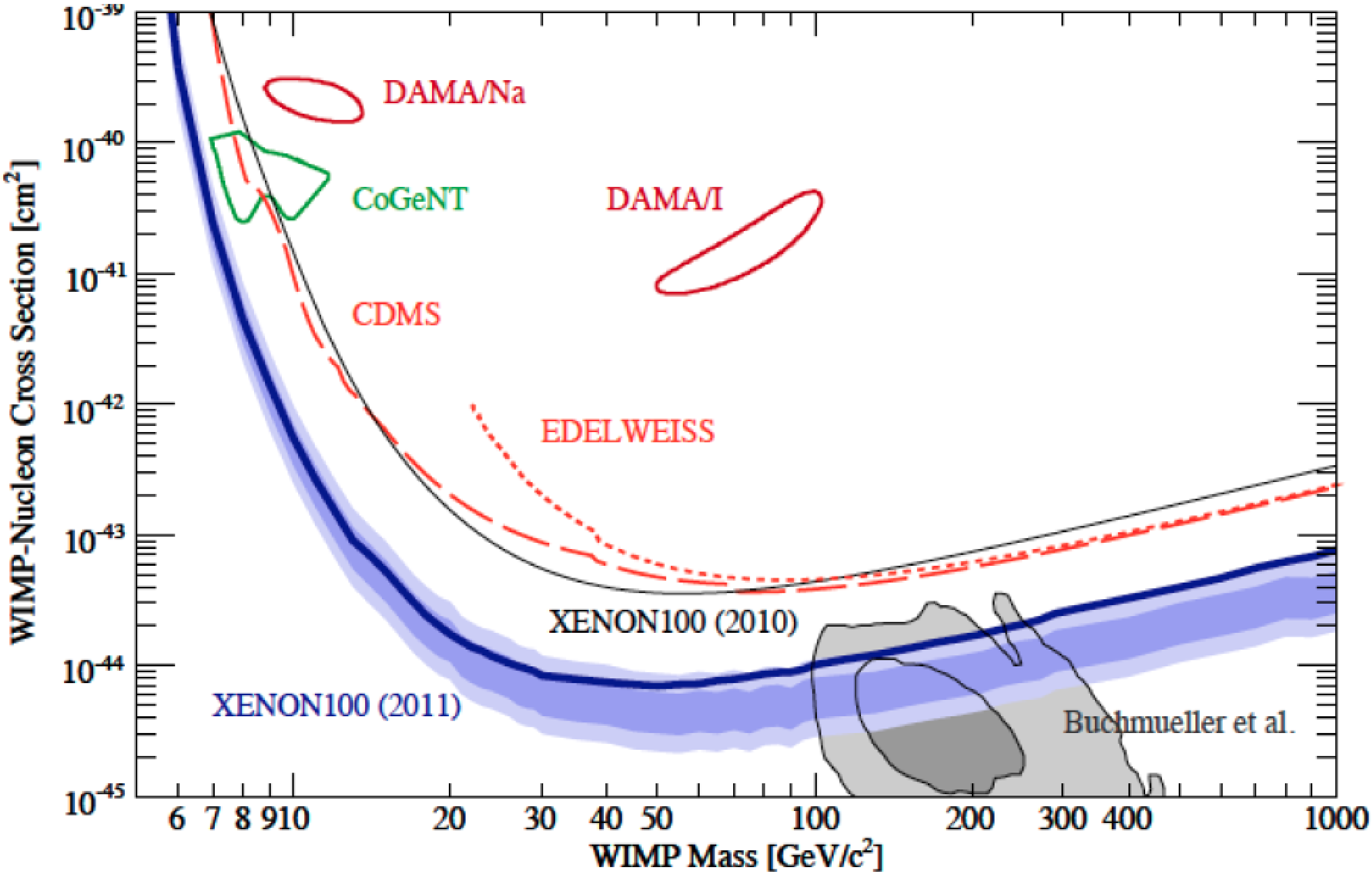
For WIMP's in thermal equilibrium after inflation the density is:

$$\Omega_\chi h^2 \simeq const. \cdot \frac{T_0^3}{M_{\rm Pl}^3 \langle \sigma_A v \rangle} \simeq \frac{0.1 \text{ pb} \cdot c}{\langle \sigma_A v \rangle}$$

can work for typical weak cross-sections!!!

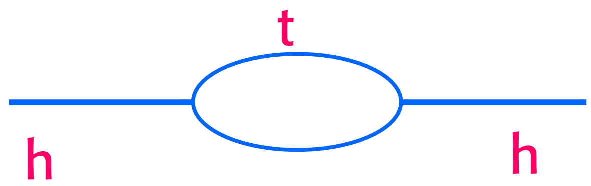
This "coincidence" is a good indication in favour of a WIMP explanation of Dark Matter

Strong competition from underground labs



The "little hierarchy" problem

e.g. the top loop (the most pressing):



$m_h^2 = m^2_{bare} + \delta m_h^2$

$$\delta m^2_{h|top} = -\frac{3G_F}{2\sqrt{2}\pi^2} m_t^2 \Lambda^2 \sim -(0.2\Lambda)^2$$

$\Lambda \sim o(1\text{TeV})$

This hierarchy problem demands new physics near the weak scale

Λ: scale of new physics beyond the SM

- $\Lambda \gg m_Z$: the SM is so good at LEP
- $\Lambda \sim$ few times $G_F^{-1/2} \sim o(1\text{TeV})$ for a natural explanation of m_h or m_W

Barbieri, Strumia

The LEP Paradox: m_h light, new physics must be close but its effects were not visible at LEP2

The B-factory Paradox: and not visible in flavour physics

Precision Flavour Physics

Another area where the SM is good, too good.....

⟶ Nakada

With new physics at ~ TeV one would expect
the SM suppression of FCNC and the CKM
mechanism for CP violation to be sizably modified.

But this is not the case

an intriguing mystery and a major challenge for models of
new physics

While it is a theorem that at the EW scale there must be the Higgs (one or more) or some other new physics (e.g. new vector bosons) because otherwise there are unitarity violations at a few TeV

On the other hand the hierarchy problem is an issue based on naturalness (the request of avoiding enormous unjustified, unnecessary fine tuning in the theory).

Given the stubborn refuse of the SM to step aside, and the terrible unexplained naturalness problem of the cosmological constant, many people have turned to the anthropic philosophy

Still, one thing is the cosmological constant and another the SM (where all is very explicit and in front of us and many ways out are known)

Solutions to the hierarchy problem

- Supersymmetry: boson-fermion symm.

  The most ambitious and widely accepted
  Simplest versions now marginal
  Plenty of viable alternatives

- Strong EWSB: Technicolor

  Strongly disfavoured by LEP. Coming back in new forms

  Composite Higgs

  Higgs as PG Boson, Little Higgs models……

- Extra spacetime dim's that somehow "bring" M_{Pl} down to o(1TeV) [large ED, warped ED, ……]. Holographic composite H

  Exciting. Many facets. Rich potentiality. No baseline model emerged so far

- Ignore the problem: invoke the anthropic principle

  Extreme, but not excluded by the data

A striking result of the 2011 LHC run (> 1 fb^{-1})
is that the new physics is pushed further away

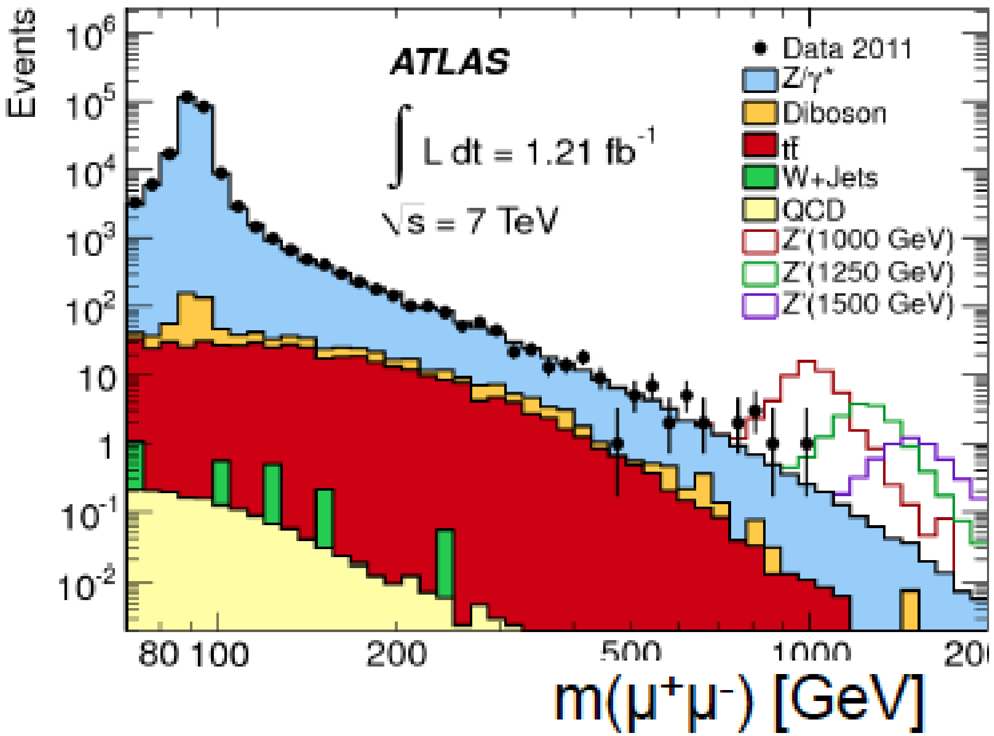
Examples:

sequential W': $m_{W'} > 2.3$ TeV
sequential Z': $m_{Z'} > 1.9$ TeV
axi-gluon: 2.5-3.2 TeV
gluino: $m_g > \sim 0.5 - 1$ TeV

Many generic signatures searched.
Not a single significant hint of new physics found

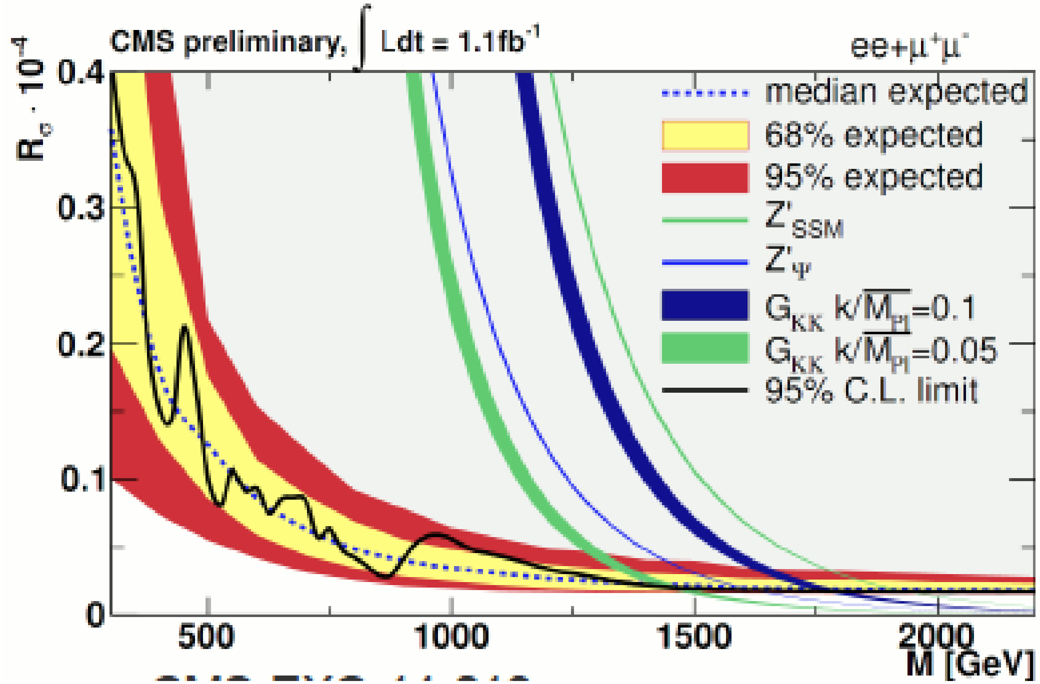
But only ~ 20-25% of the 2011 statistics has been analysed

Di-lepton Channel



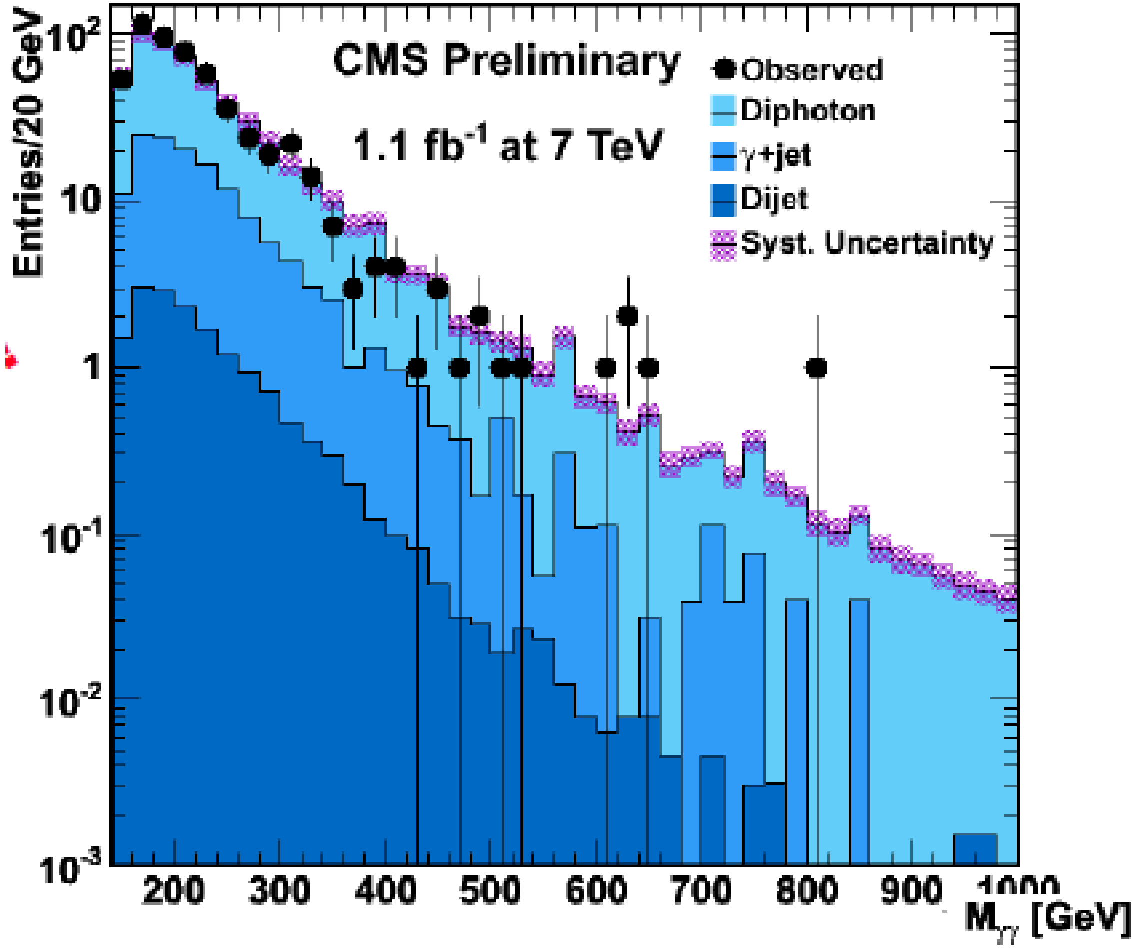
Sequential SM:
$m(Z') > 1.9$ TeV at 95% C.L.

RS graviton ($k/M_{Pl} = 0.1$):
$m(G) > 1.8$ TeV at 95% C.L.



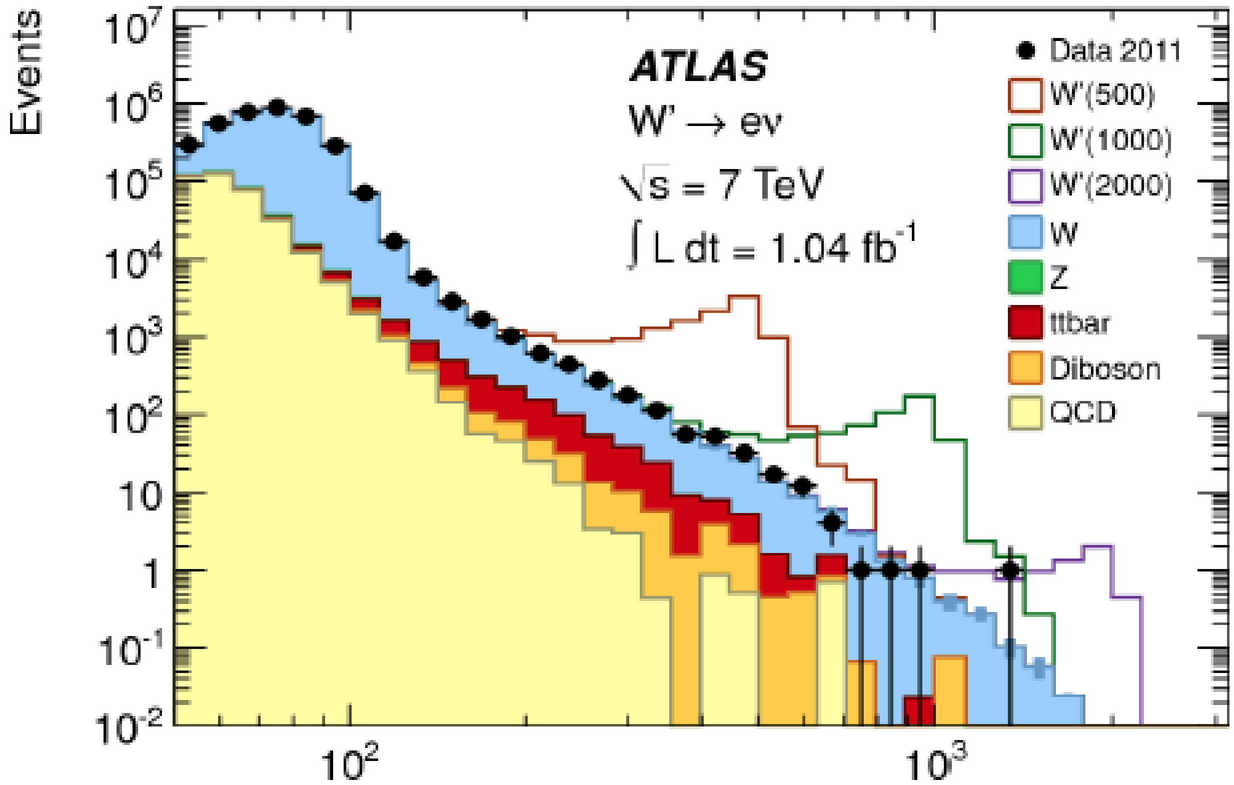
Di-photon Channel

RS graviton (k/MPl = 0.1):
m(G) > 1.7 TeV at 95% C.L.



W' -> l ν

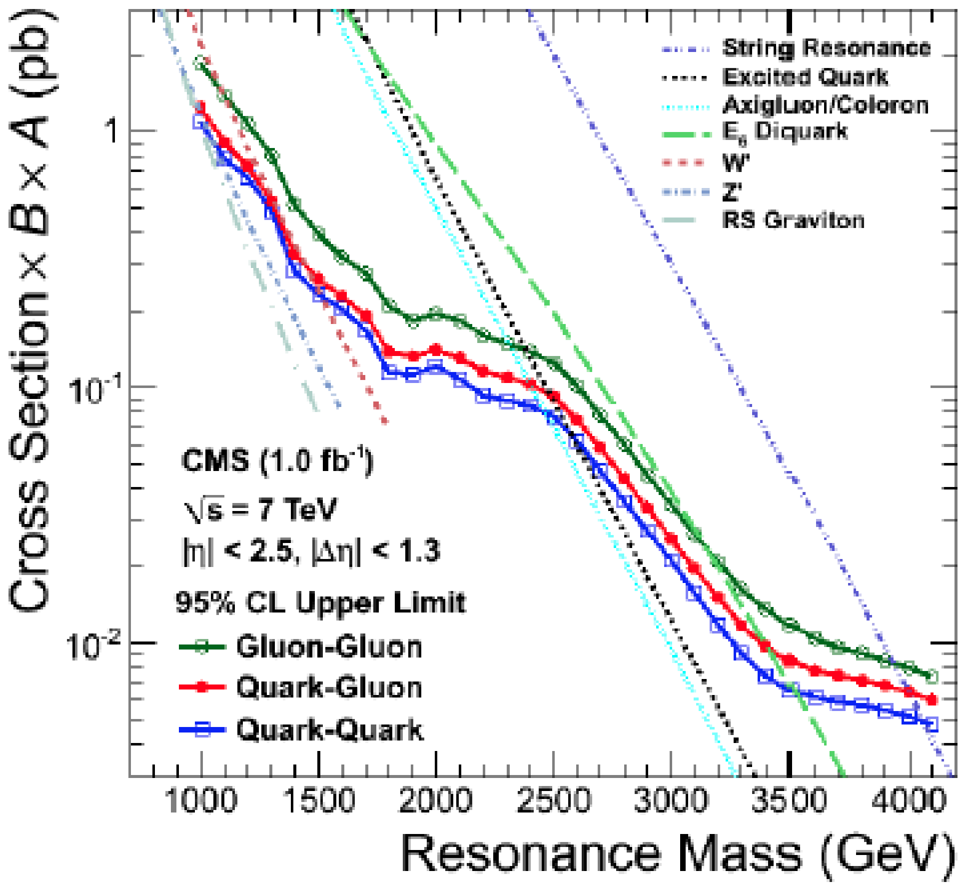
Sequential SM:
m(W') > 2.3 TeV at 95% C.L.



Dijet

Model ATL-CONF-2011-095	95% CL Limits (TeV) Expected	 Observed
Excited Quark q^*	2.77	2.91
Axigluon	3.02	3.21
Color Octet Scalar	1.71	1.91

Model CMS arXiv.1107.4771	Excluded Mass (TeV) Observed	 Expected
String Resonances	4.00	3.90
E_6 Diquarks	3.52	3.28
Excited Quarks	2.49	2.68
Axigluons/Colorons	2.47	2.66
W′ Bosons	1.51	1.40



SUSY: boson fermion symmetry

The hierarchy problem: $$\delta m^2_{h|top} = -\frac{3G_F}{2\sqrt{2}\pi^2} m_t^2 \Lambda^2 \sim -(0.2\Lambda)^2$$

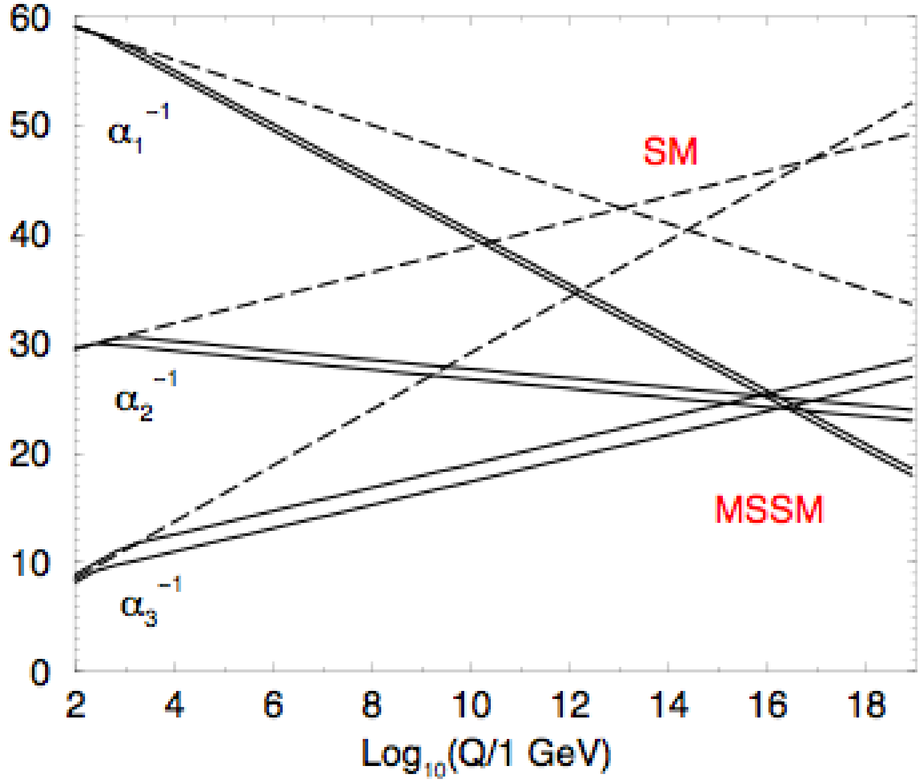
In broken SUSY Λ^2 is replaced by $(m_{stop}{}^2 - m_t{}^2)\log\Lambda$

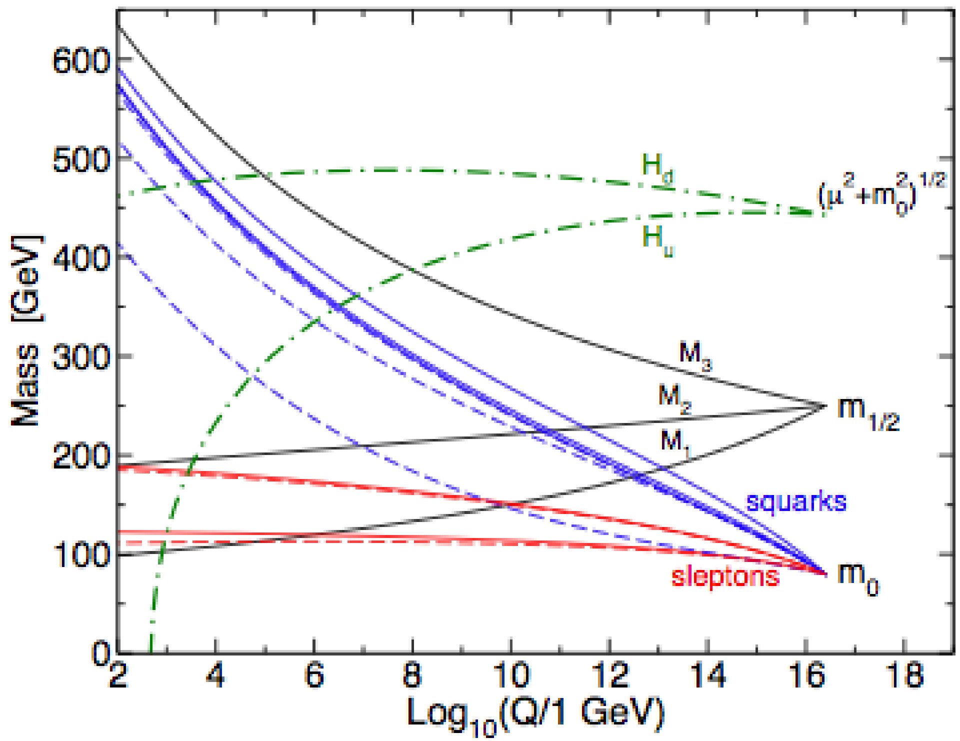
$m_H > 114.4$ GeV, $m_{\chi+} > 100$ GeV, EW precision tests, success of CKM, absence of FCNC, all together, impose sizable Fine Tuning (FT) particularly on minimal realizations (MSSM, CMSSM…).

Yet SUSY is a completely specified, consistent, computable model, perturbative up to M_{Pl} quantitatively in agreement with coupling unification (GUT's) (unique among NP models) and has a good DM candidate: the neutralino (actually more than one).

Remains the reference model for NP

Beyond the SM SUSY is unique in providing a perturbative theory up to the GUT/Planck scale

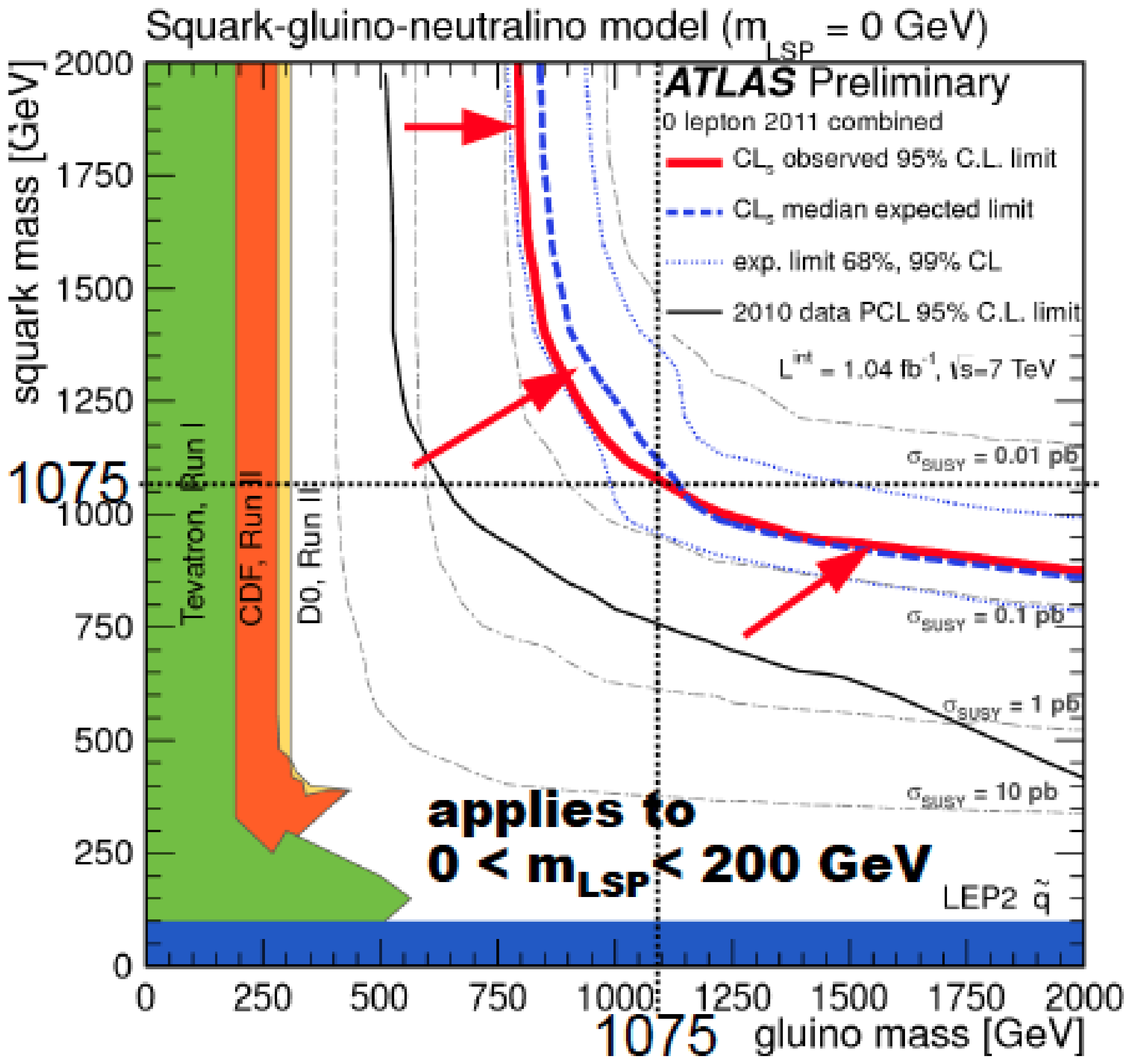


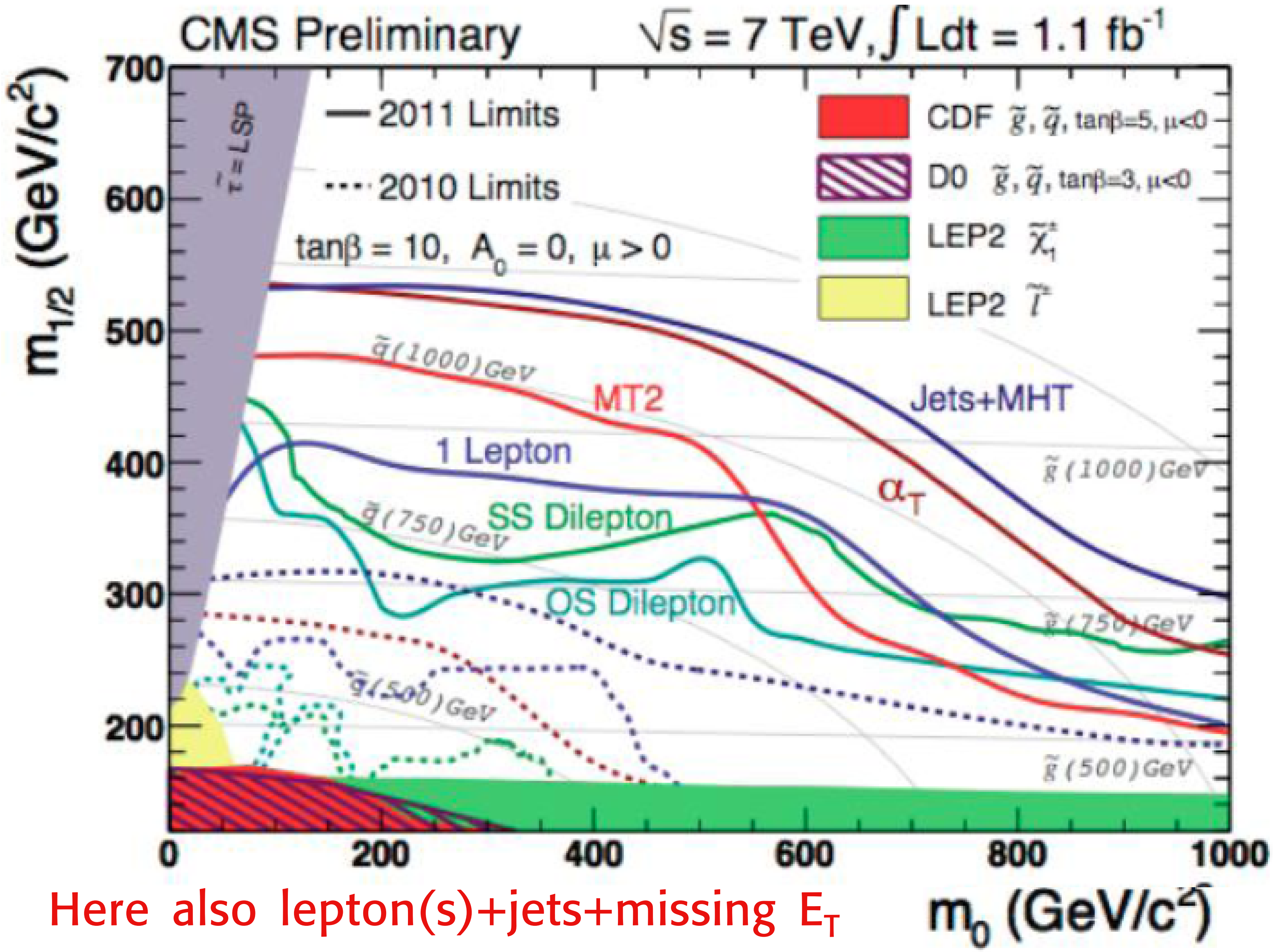


Other BSM models (little Higgs, composite Higgs, Higgsless....) all become strongly interacting and non perturbative at a multi-TeV scale

Jets + missing E_T

CMSSM (degenerate s-quarks)





Here also lepton(s)+jets+missing E_T

The general MSSM has > 100 parameters

Simplified versions with a drastic reduction of parameters are used for practical reasons, e.g.

CMSSM, mSUGRA : universal gaugino and scalar soft terms at GUT scale $m_{1/2}$, m_0, A_0, $tg\beta$, $sign(\mu)$

NUHM1,2: different than m_0 masses for H_u, H_d (1 or 2 masses)

It is only these oversimplified models that are now cornered

Impact of m_H ~ 125 GeV on SUSY models

Simplest models with gauge mediation are disfavoured (predict m_H too light)

Djouadi et al; Draper et al, '11

some versions, eg gauge mediation with extra vector like matter, do work

Endo et al '11

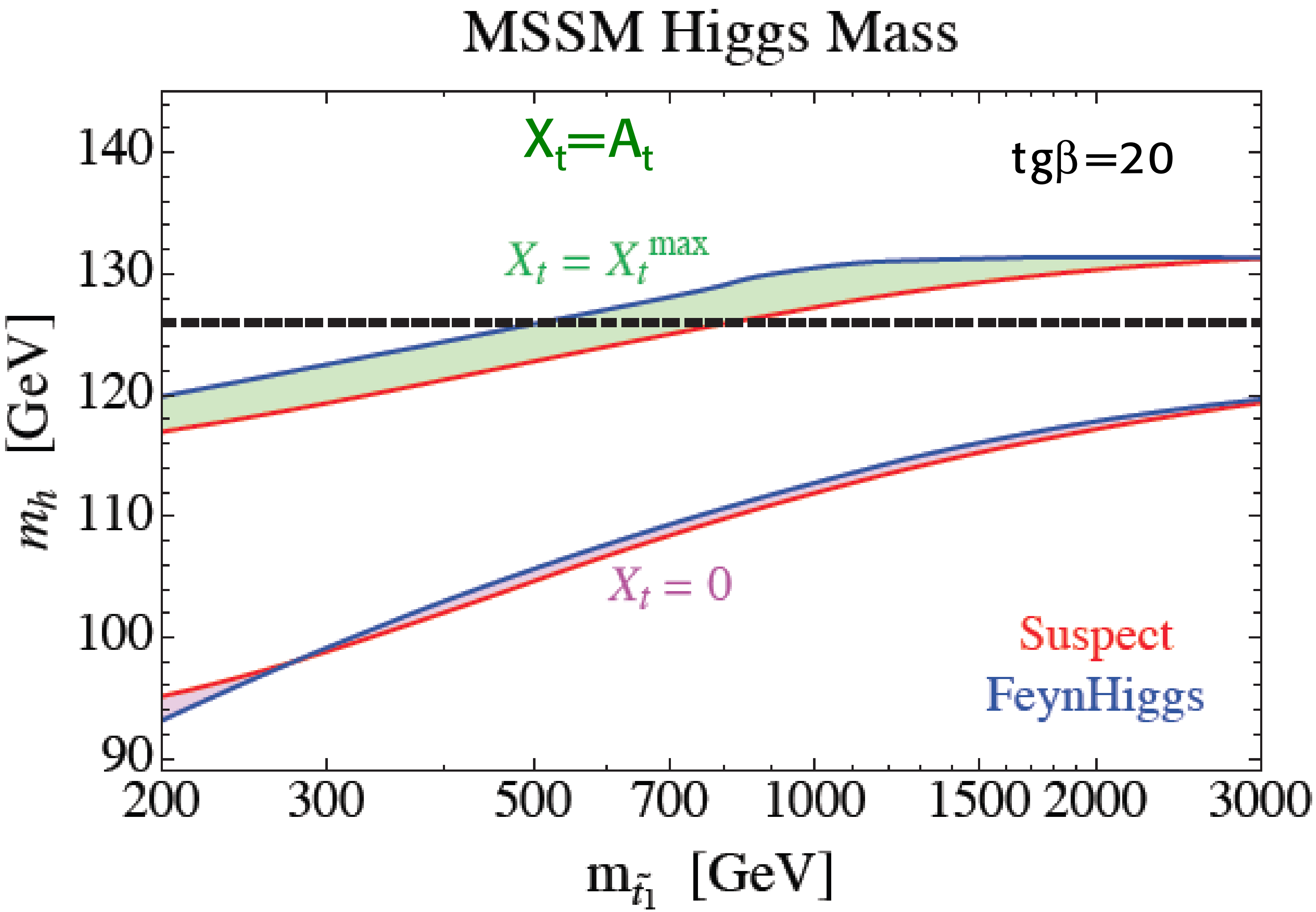
Anomaly mediation is also generically in trouble

Gravity mediation is better but CMSSM, mSUGRA, NUHM1,2 need squarks heavy, A_t large and lead to tension with g-2 (that wants light SUSY) and $b \to s\gamma$

Akura et al; Baer et al; Battaglia et al; Buchmuller et al, Kadastik et al; Strege et al; '11

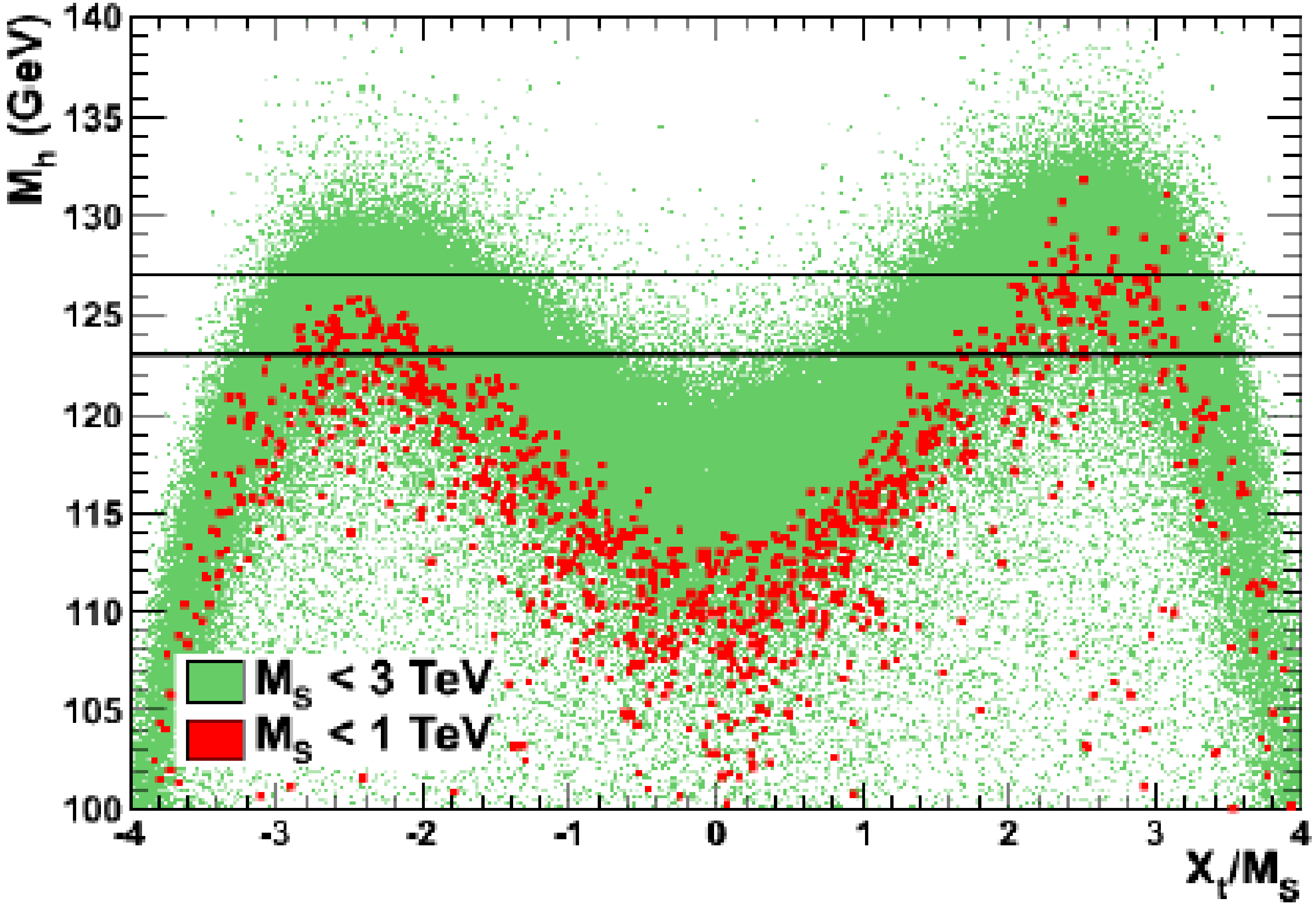
maximal top mixing is required

Hall et al '11



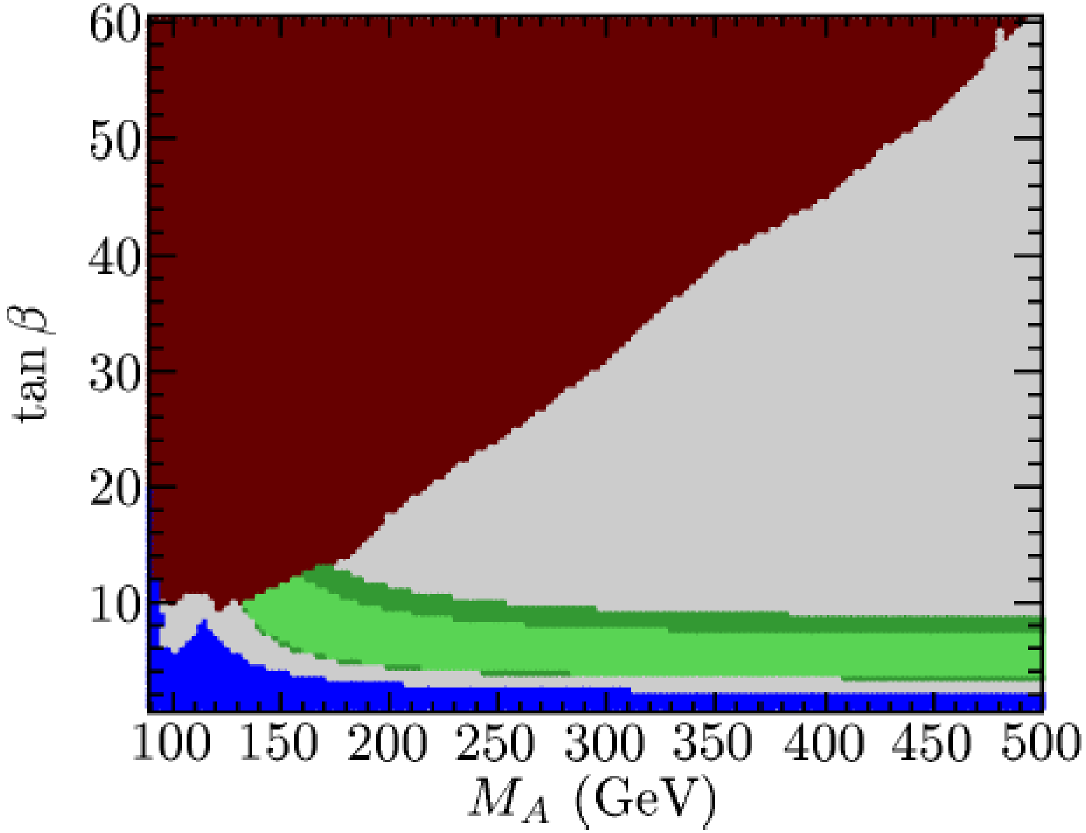
Arbey et al '11

CMSSM

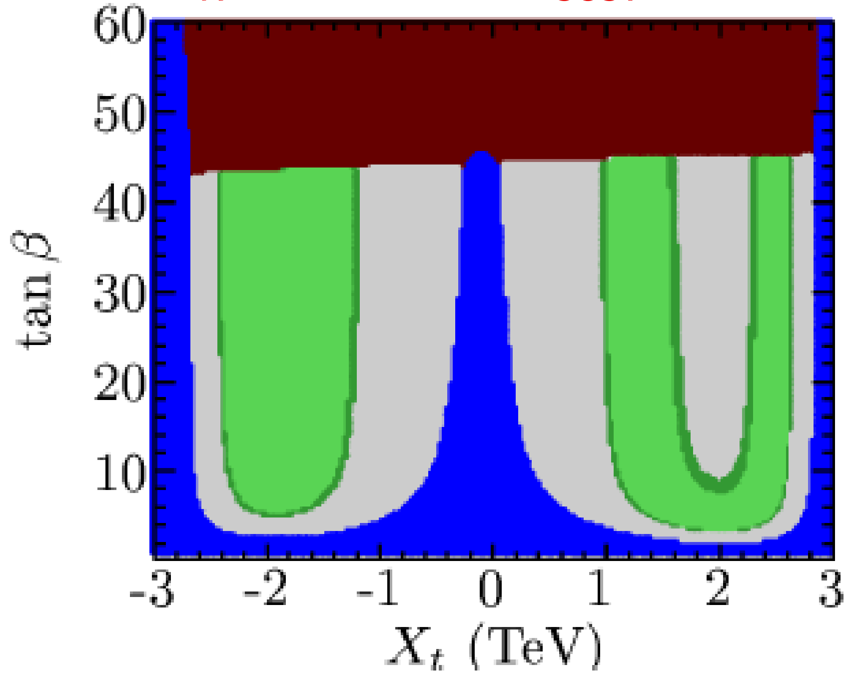


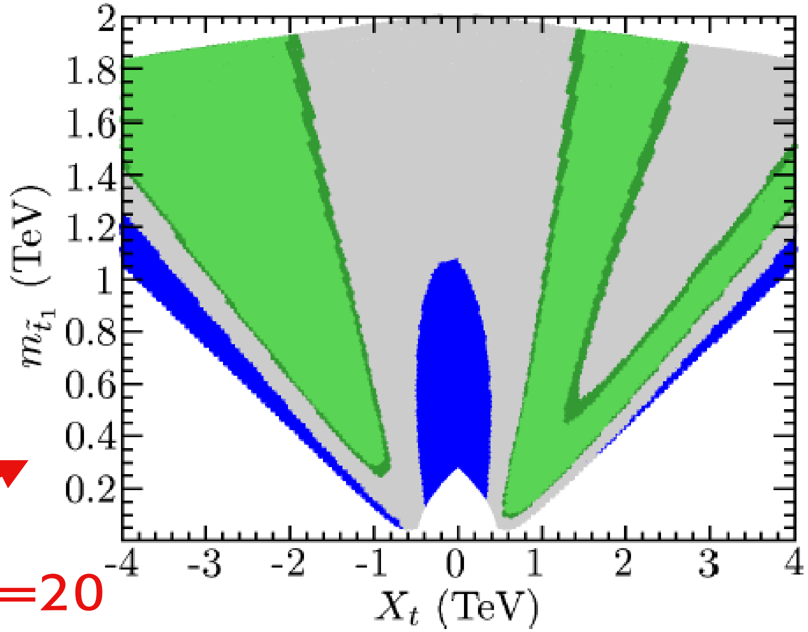
MSSM

Heinemeyer et al '11



M_A=400 GeV, M_{SUSY}=1 TeV



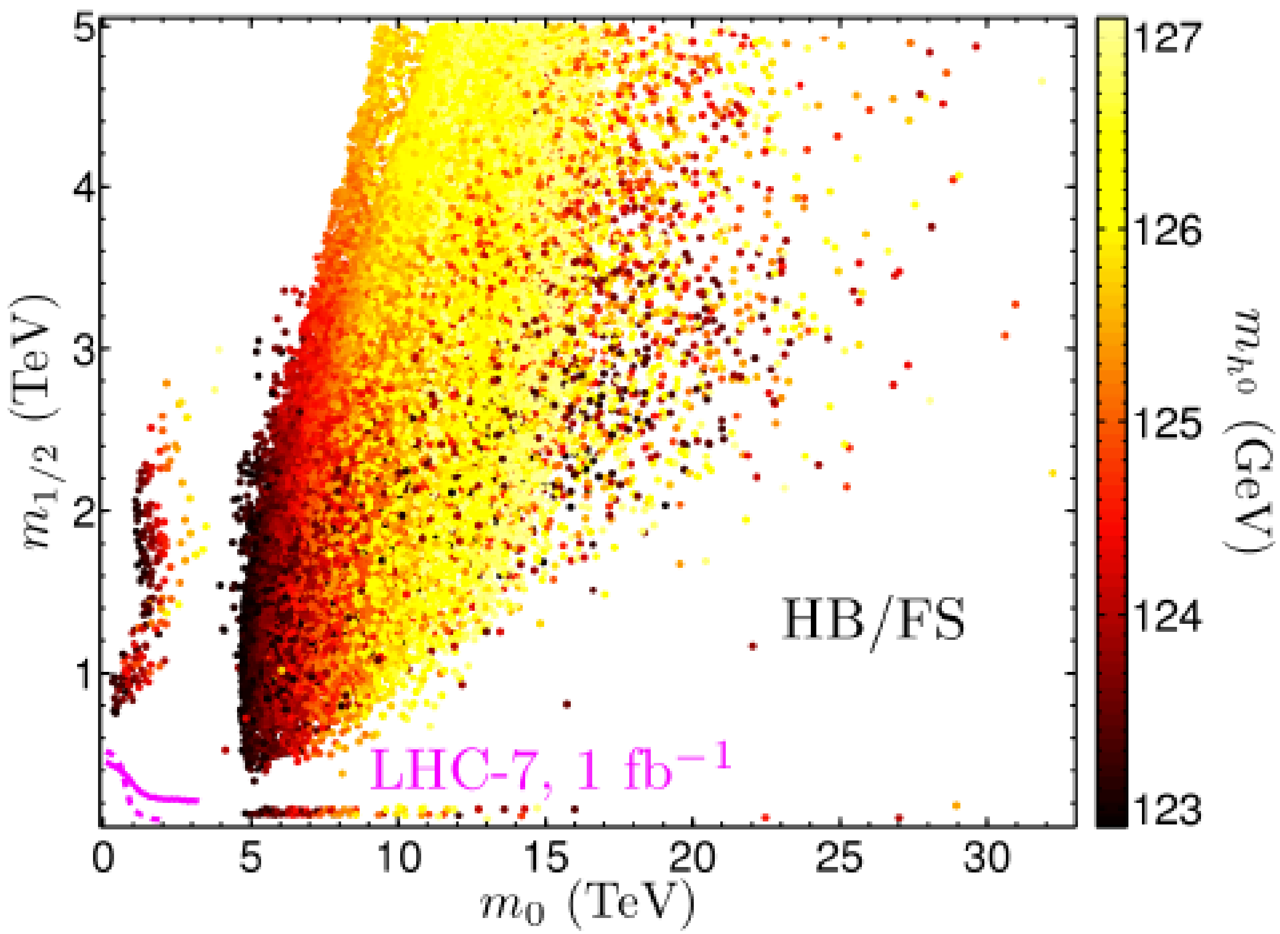


M_A= 1 TeV, tgβ=20

- Excluded by LEP
- Excluded by Tevatron
- m_H ~ 125

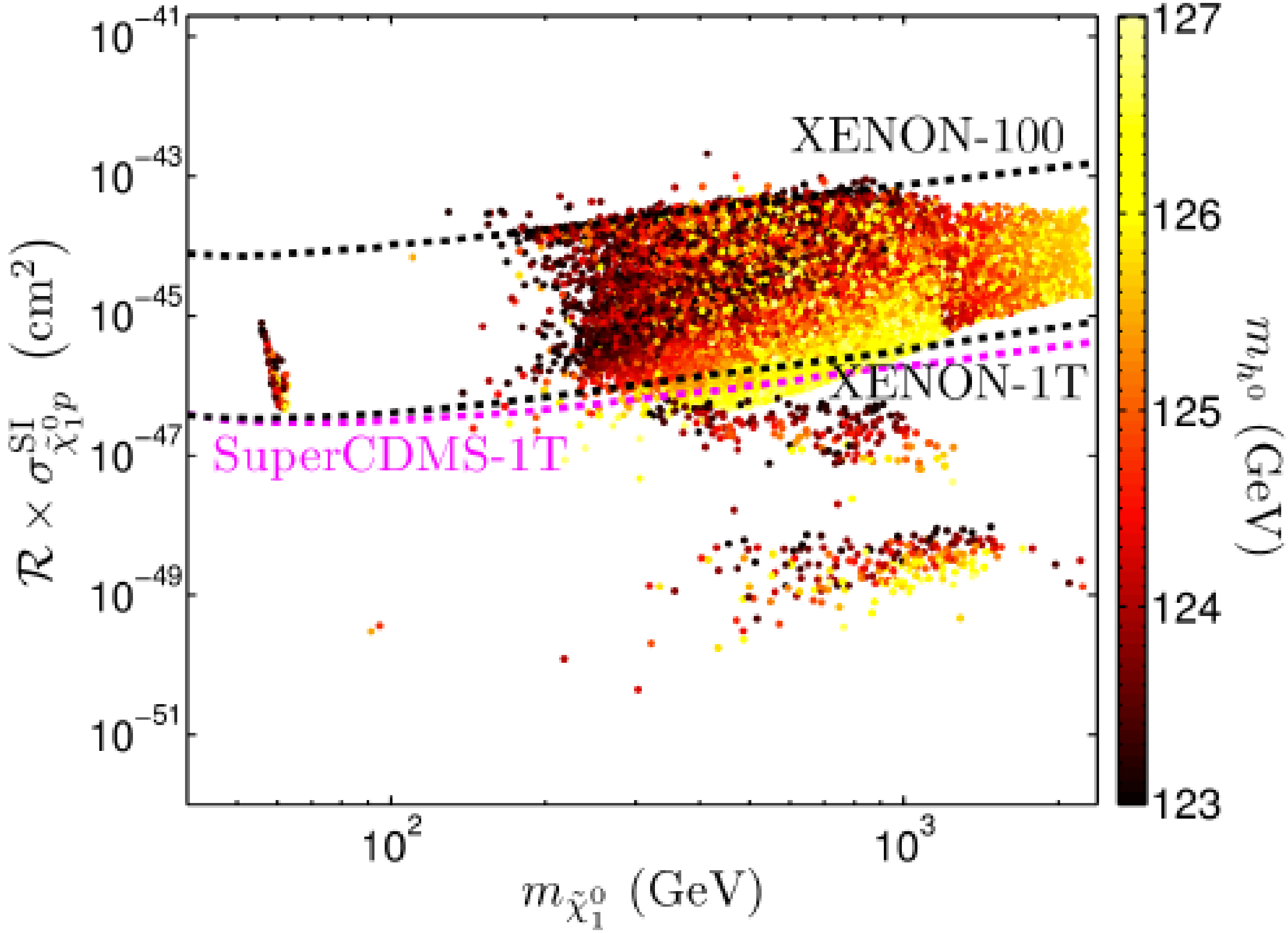
mSUGRA

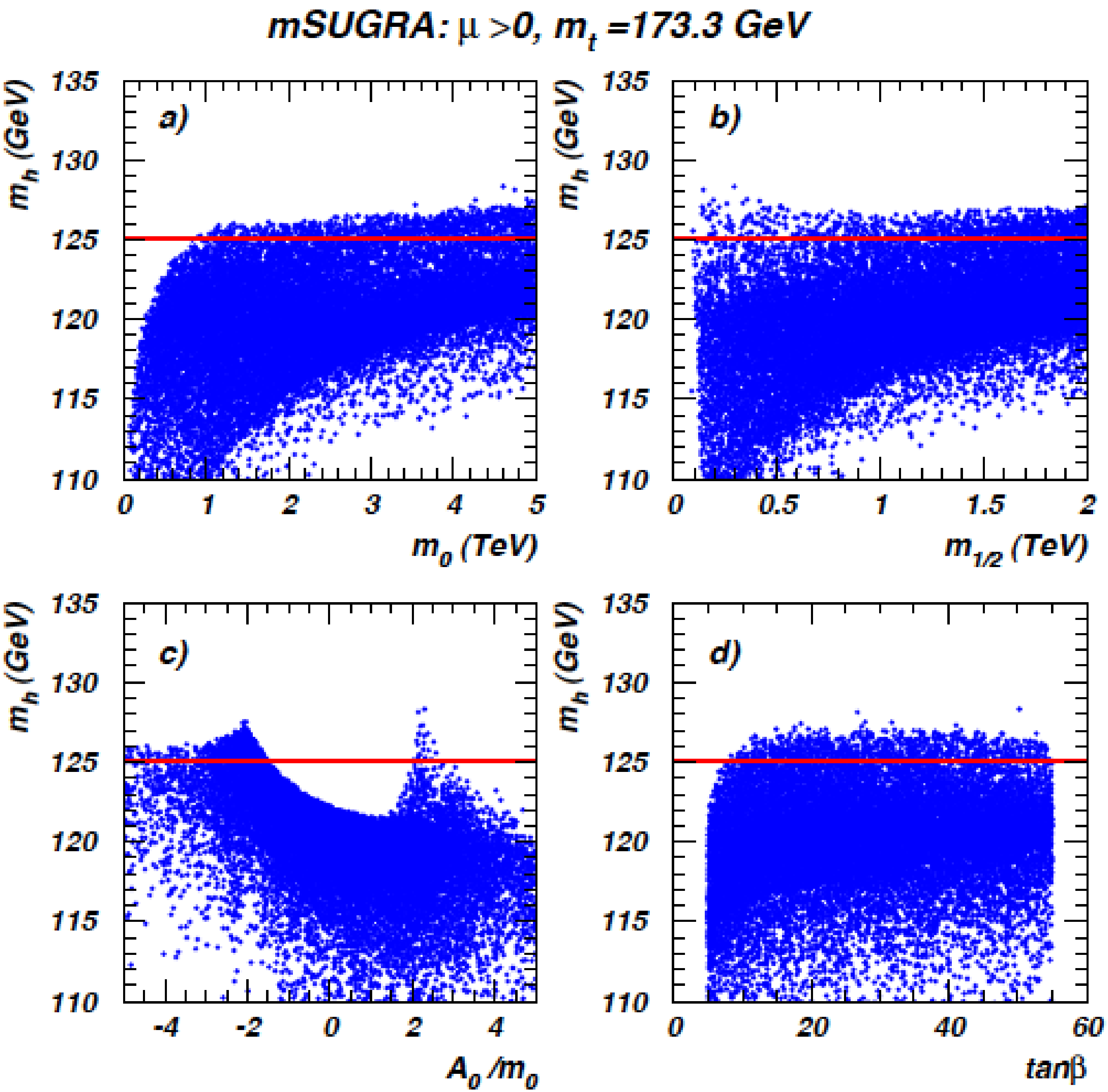
Akula et al ‘11



mSUGRA

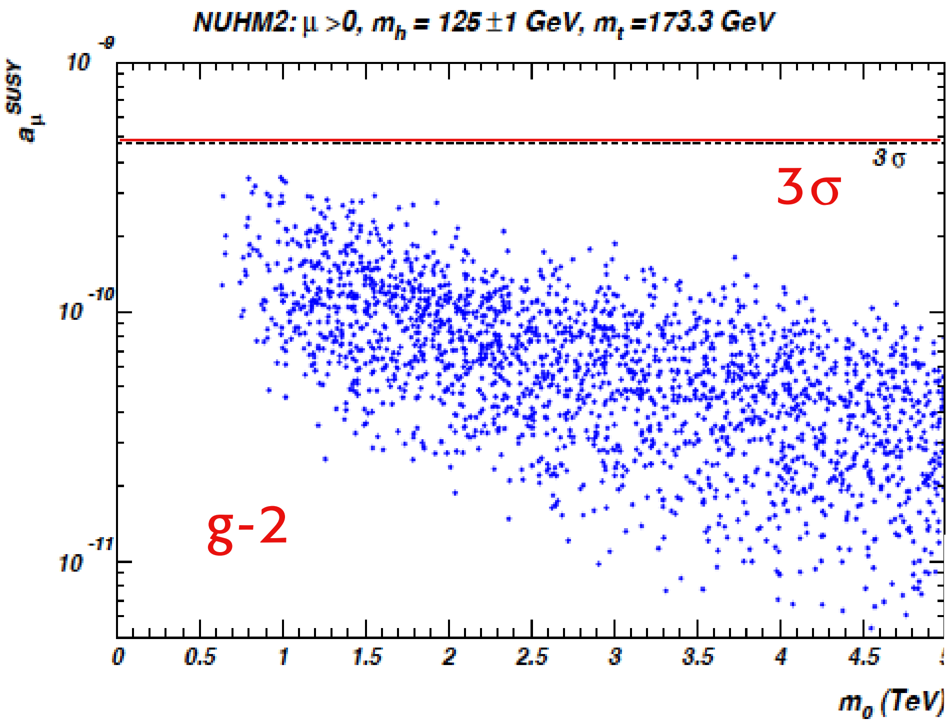
Akula et al '11




mSUGRA: μ >0, m_t =173.3 GeV
a)
b)
c)
d)
m_h (GeV)
135
130
125
120
115
110
0 1 2 3 4 5
m_0 (TeV)
0 0.5 1 1.5 2
m_1/2 (TeV)
-4 -2 0 2 4
A_0 /m_0
0 20 40 60
tanβ

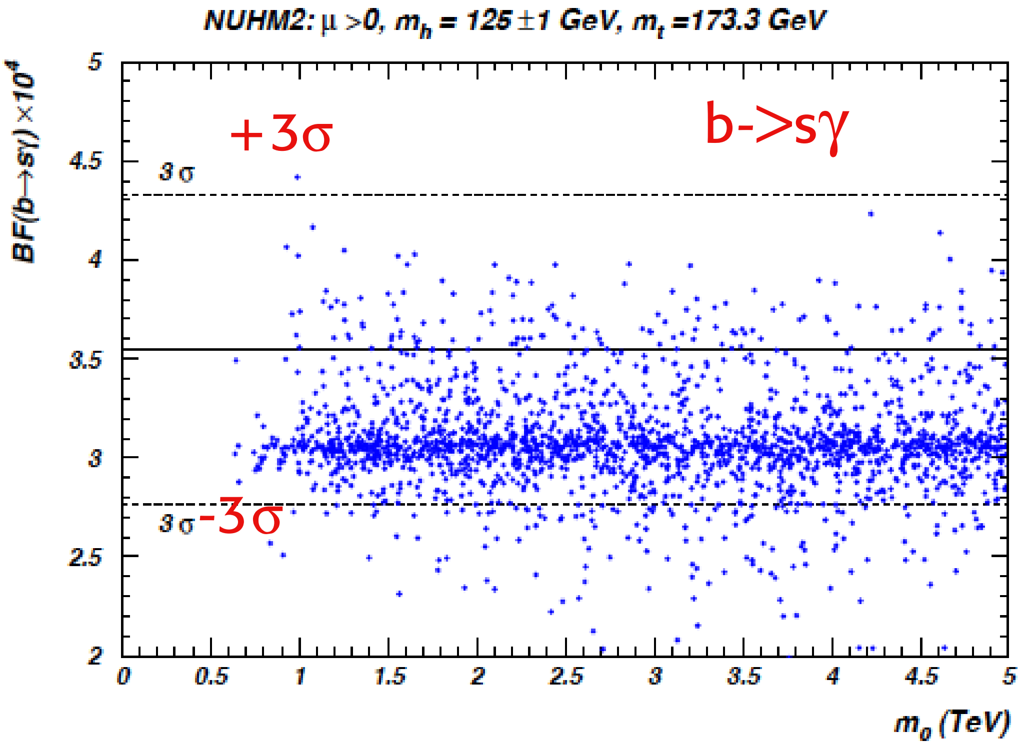
Baer et al '11

Baer et al '11



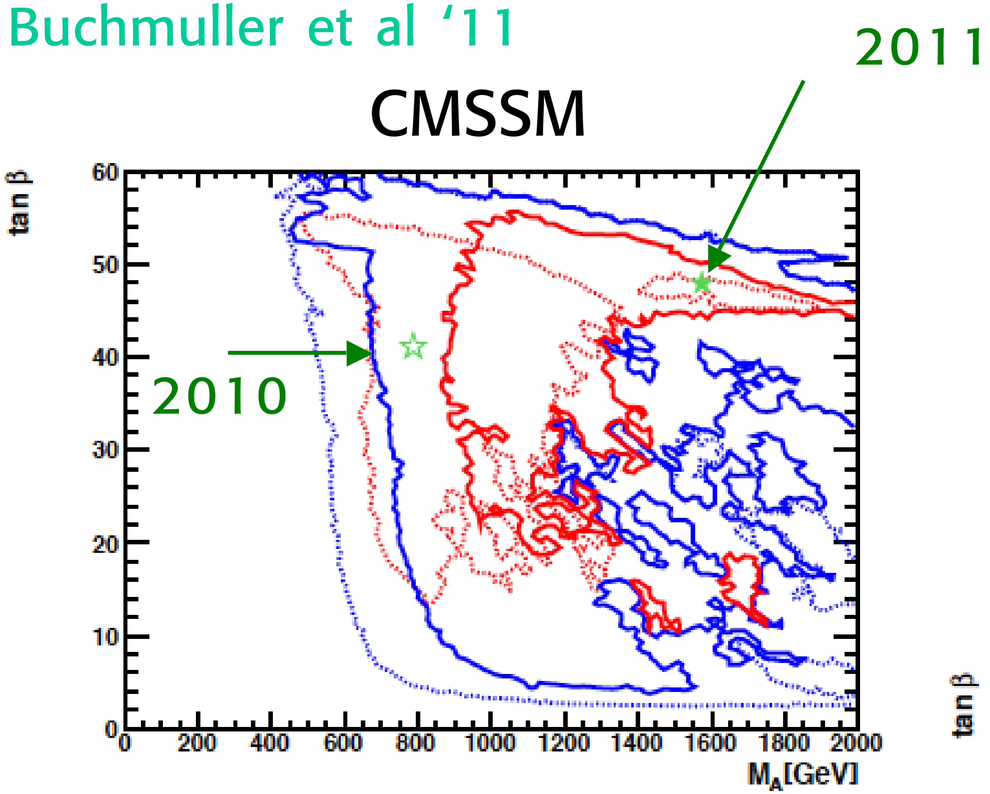
NUHM1,2

add 1 or 2 separate mass parameters for Hu, Hd



Buchmuller et al '11

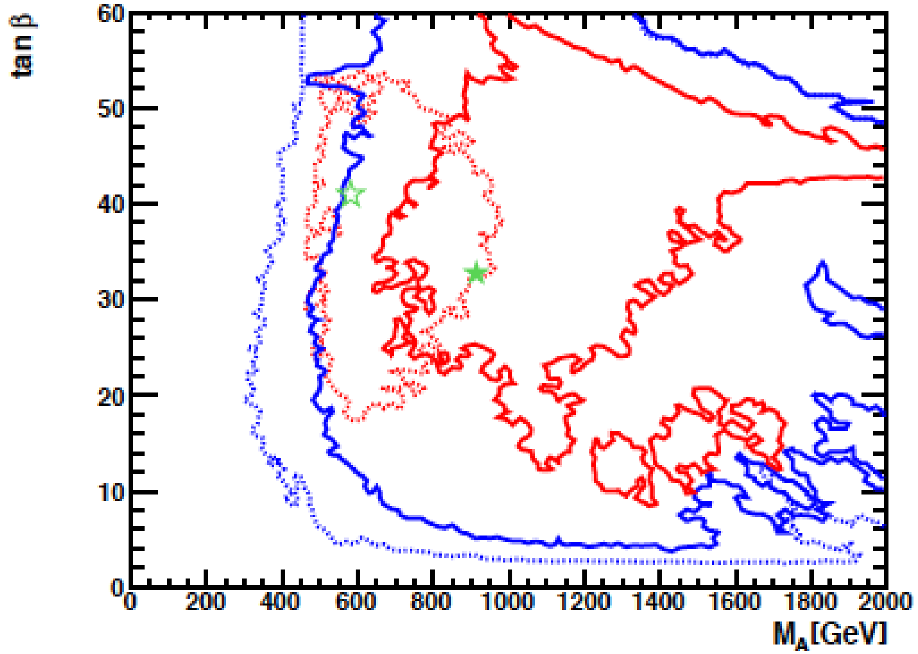
CMSSM



heavier scalars with new data

g-2 in trouble

NUHM1



with g-2 m_H ~ 119 GeV
without g-2 m_H ~ 125 GeV

J. Ellis

Input data for fits of CMSSM, NUHM1...... include

- The EW precision tests
- Muon g-2
- Flavour precision observables
- Dark Matter
- Higgs mass constraints and LHC

SUSY

With new data ever increasing fine tuning

One must go to SUSY beyond the CMSSM, mSUGRA, NUHM1,2

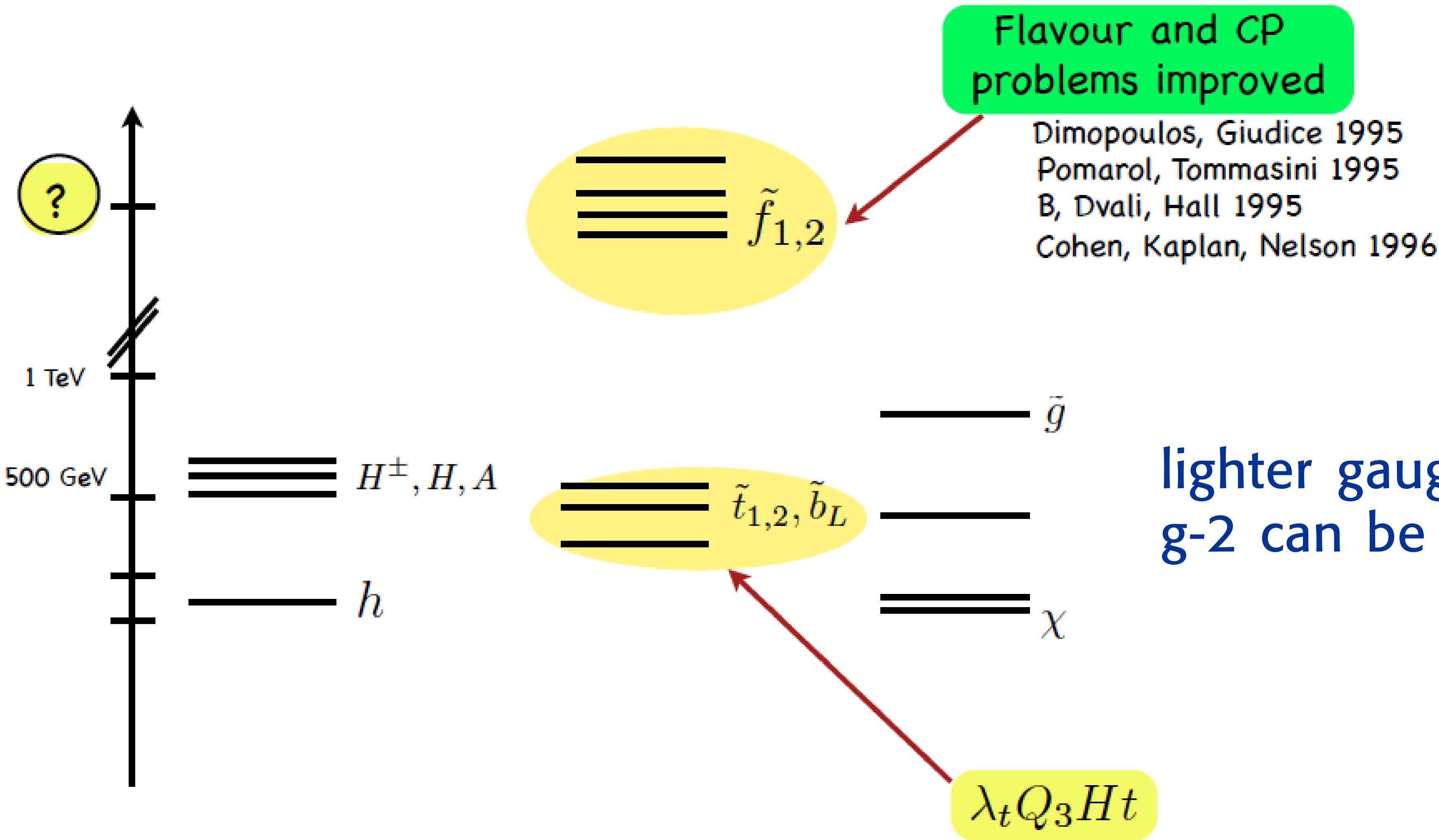
There is still room for more sophisticated versions

- Heavy first 2 generations
- NMSSM
- λ SUSY
- Split SUSY
- Large scale SUSY
- • • •

Beyond the CMSSM, mSugra, NUHM1,2

Heavy 1st, 2nd generations

Barbieri

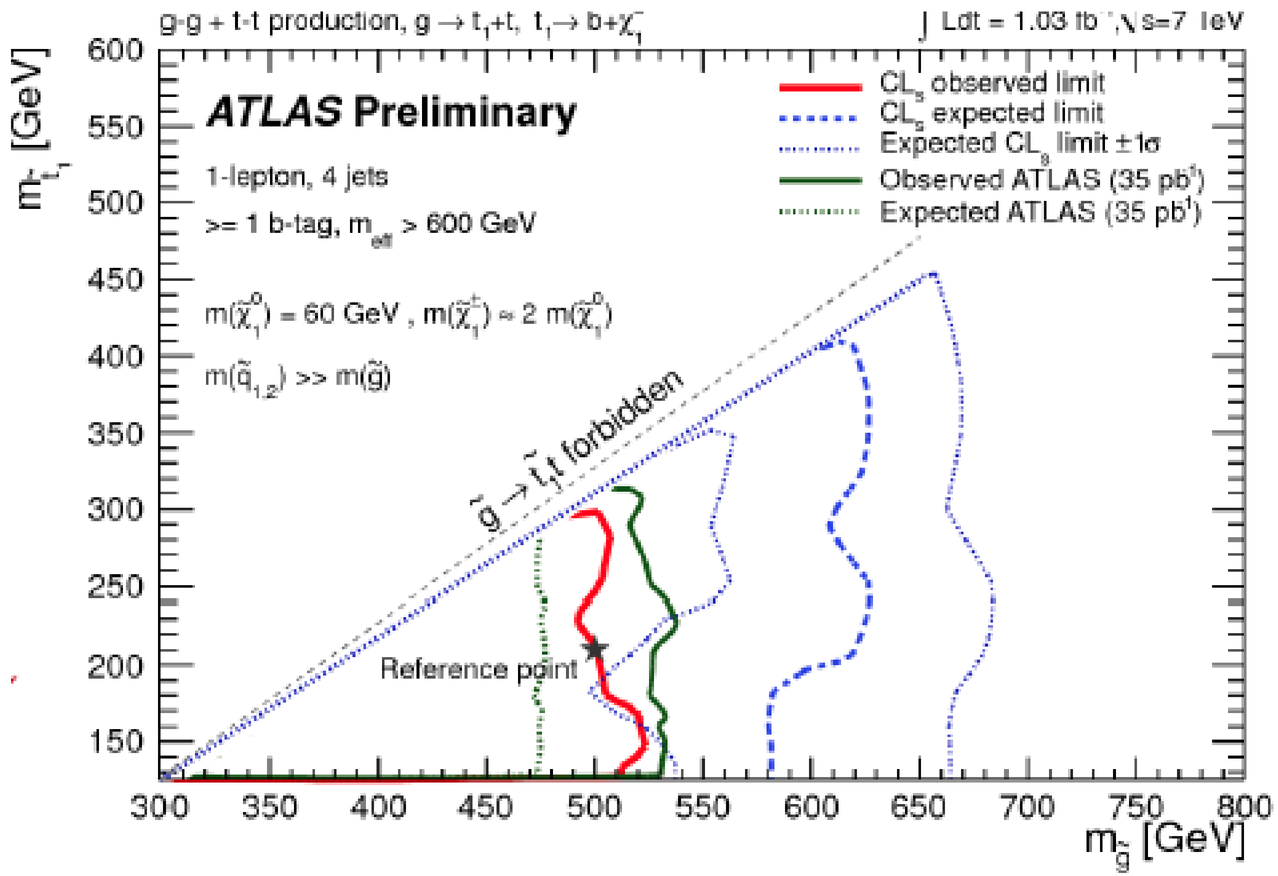


lighter gauginos,
g-2 can be rescued

For example, may be gluinos decay into 3-gen squarks

e.g. $\tilde{g} \to \tilde{t}_1 t \quad ; \quad \tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$

and $\tilde{\chi}_1^{\pm} \to W^* \, \tilde{\chi}_1^0$



m(gluino) > 500 GeV at 95% C.L. $\qquad$ $m_{s\text{-}top}$ >~250 GeV

An extra singlet Higgs

In a promising class of models a singlet Higgs S is added and the μ term arises from the S VEV (the μ problem is soved)

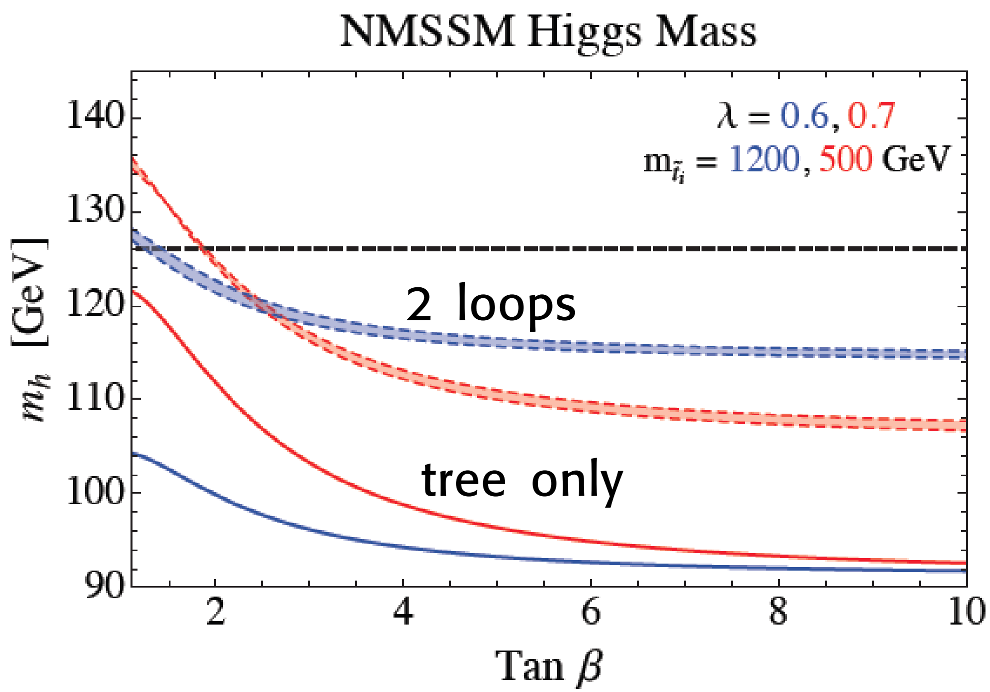
$$\lambda\, S H_u H_d$$

Mixing with S can bring the light Higgs mass down at tree level

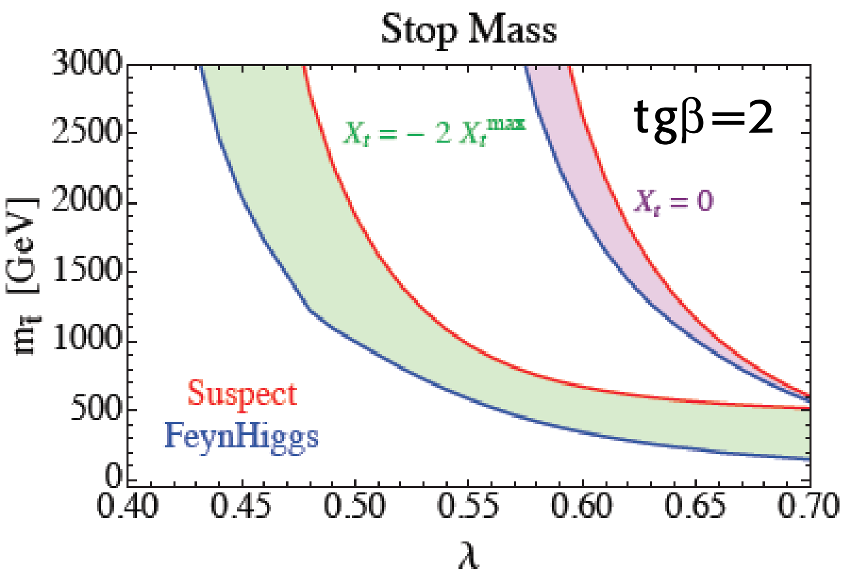
(no need of large loop corrections)

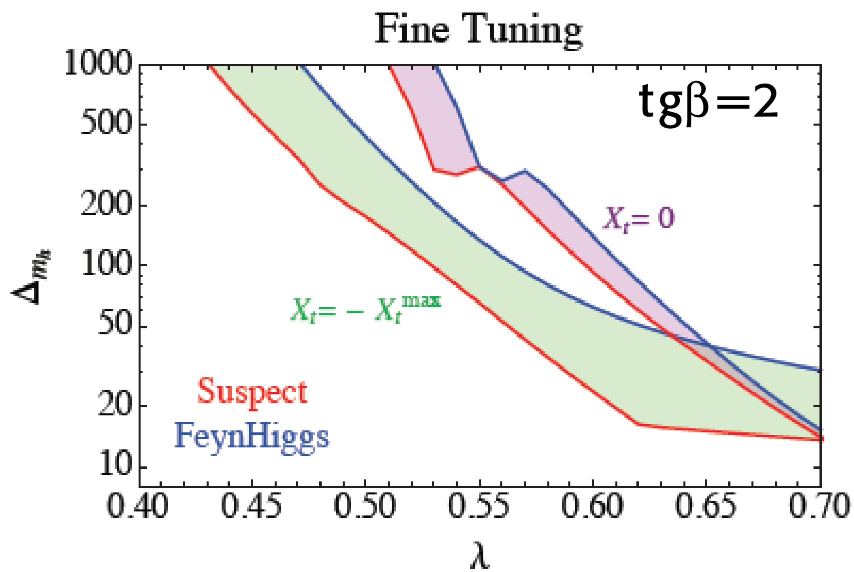
NMSSM: $\lambda <\sim 0.7$ the theory remains perturbative up to M_{GUT}
(no need of large stop mixing, less fine tuning)

λ SUSY: $\lambda \sim 1 - 2$ for $\lambda > 2$ theory non pert. at $\sim$10 TeV

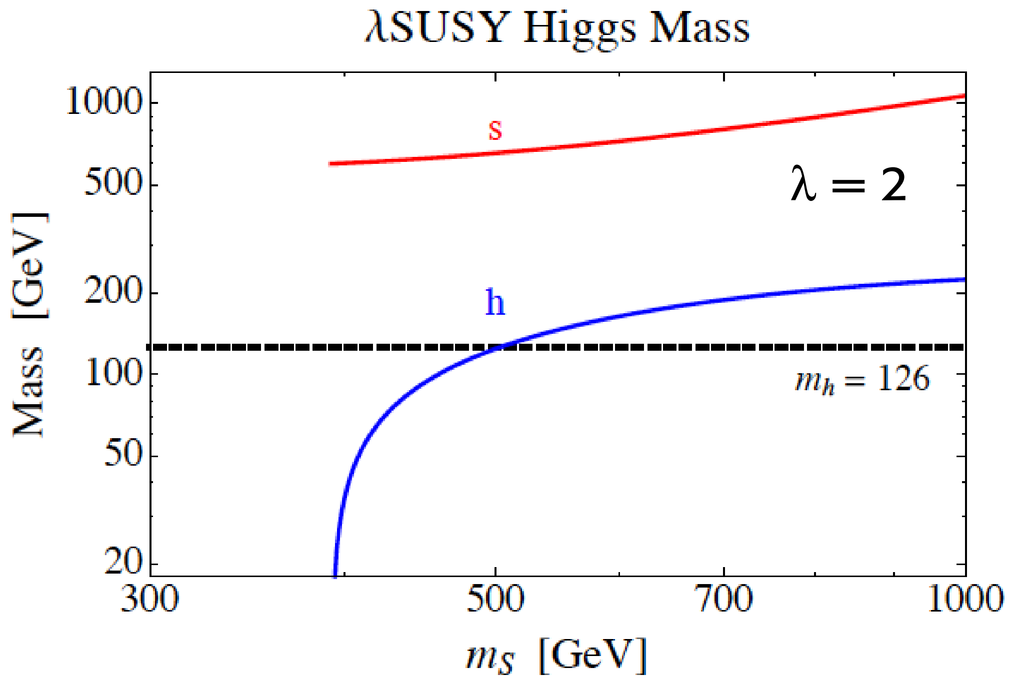

NMSSM Higgs Mass
λ = 0.6, 0.7
m_{t̃_i} = 1200, 500 GeV
2 loops
tree only
m_h [GeV]
140
130
120
110
100
90
2
4
6
8
10
Tan β

Hall et al '11


Stop Mass
tgβ=2
X_t = − 2 X_t^max
X_t = 0
Suspect
FeynHiggs
m_t̃ [GeV]
3000
2500
2000
1500
1000
500
0
0.40
0.45
0.50
0.55
0.60
0.65
0.70
λ


Fine Tuning
tgβ=2
X_t = 0
X_t = − X_t^max
Suspect
FeynHiggs
Δ_{m_h}
1000
500
200
100
50
20
10
0.40
0.45
0.50
0.55
0.60
0.65
0.70
λ

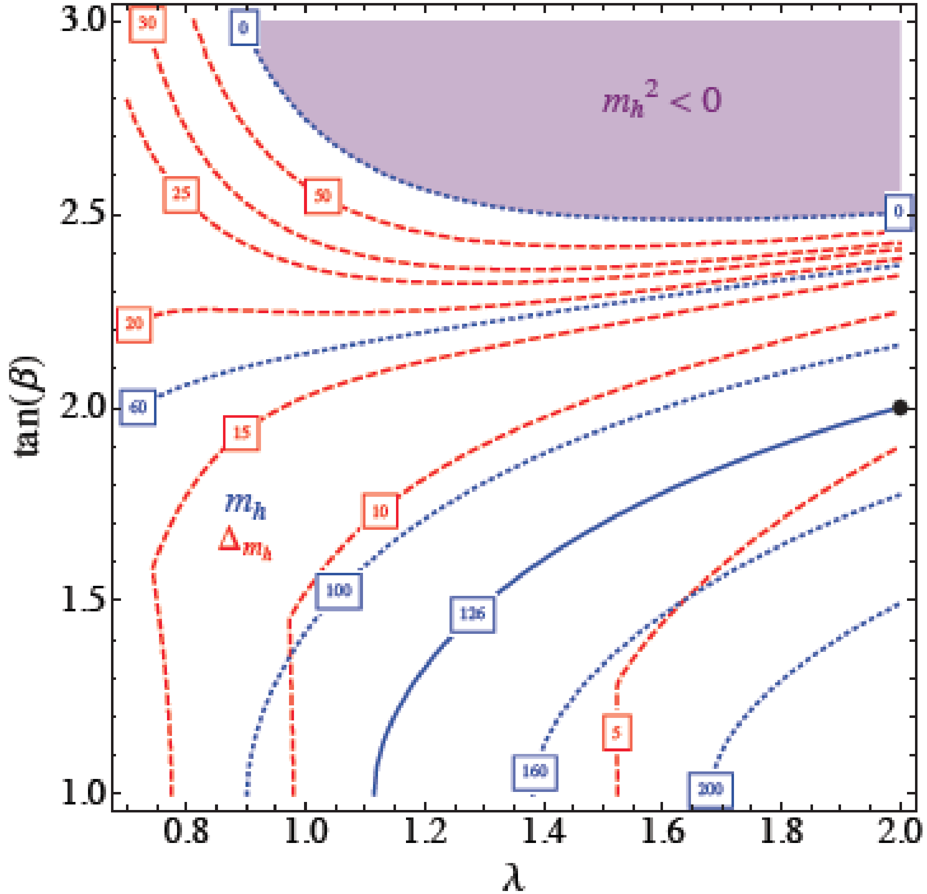
Hall et al '11



Mixing with S makes h light already at tree level

No need of loops

Fine tuning can be very small

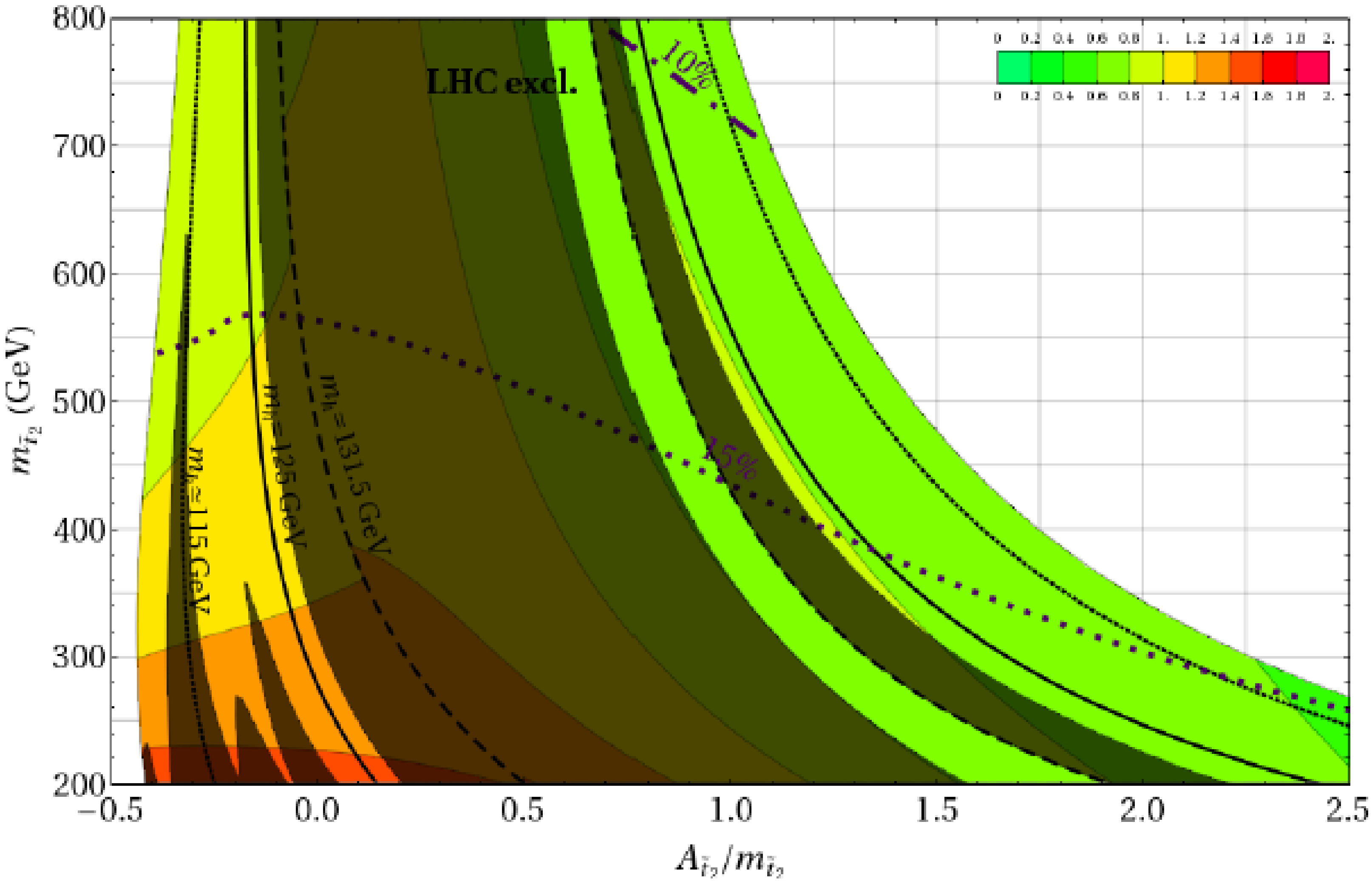


It is not excluded that
at 125 GeV
you see the heaviest of the two
and the lightest escaped detection
at LEP

$\oplus$ Ellwanger '11

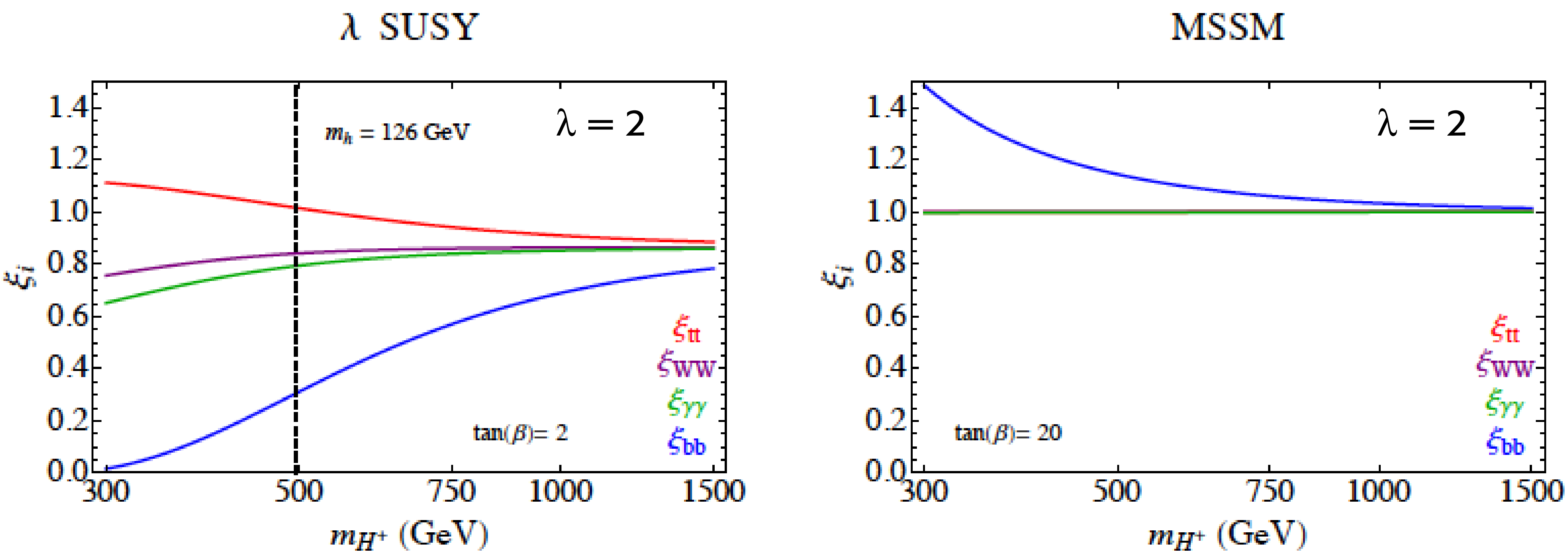
In MSSM it is not possible to obtain an enhanced γγ signal for m_H ~ 125 GeV, while it is possible eg in NMSSM or λ SUSY

Arvanitaki et al '11



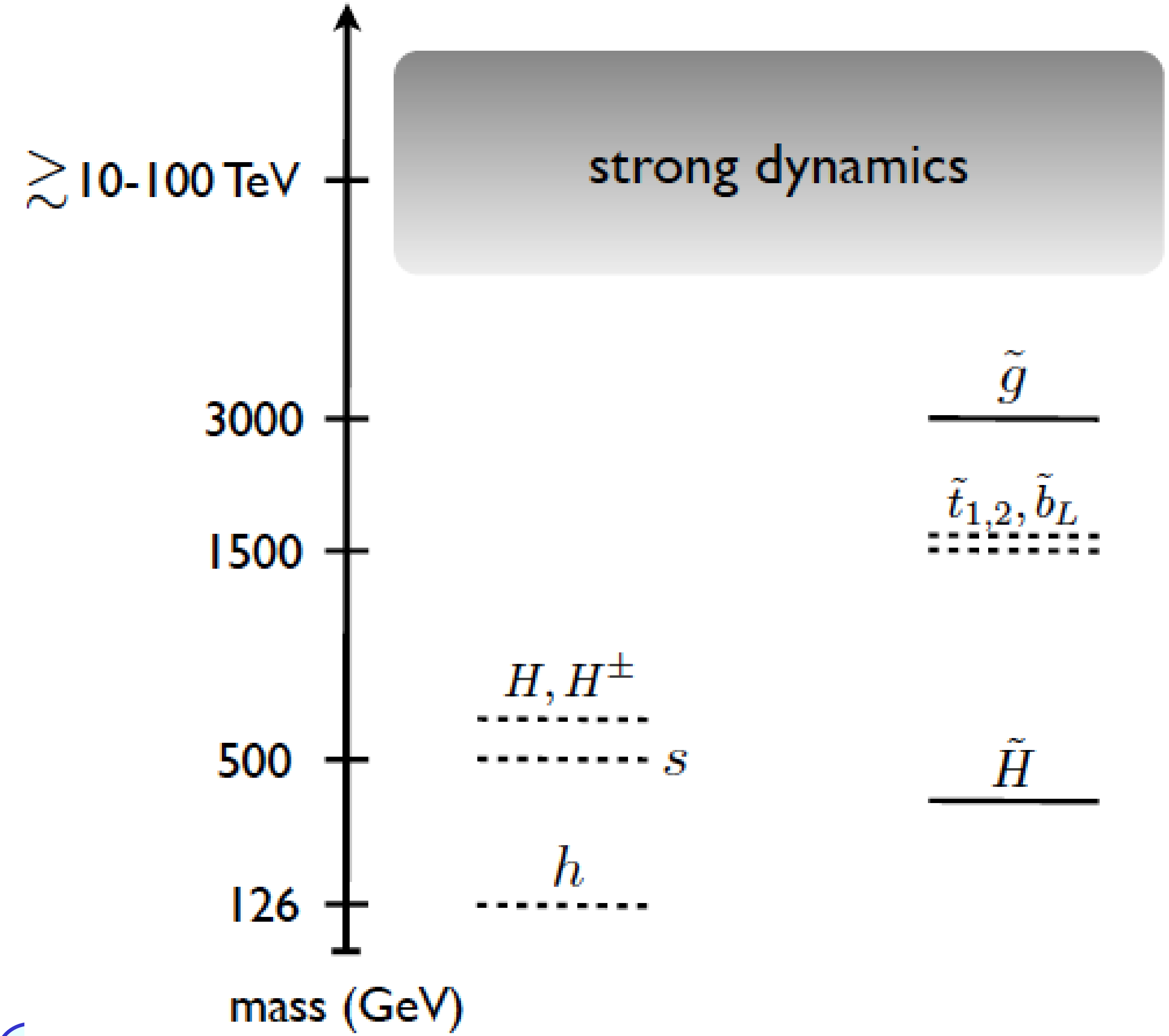
In λ SUSY the bb mode can be suppressed [so B(γγ) enhanced]

Hall et al '11



λSUSY spectrum (λ = 2)

Hall et al '11



Drawbacks:
relation with GUT's & coupling unification is generically lost

g-2?

If the Fine Tuning problem is ignored (anthropic philosophy) than SUSY particles can drift at large scales

Split SUSY: maintains coupling unification and viable DM candidate but otherwiseallows heavy SUSY particles

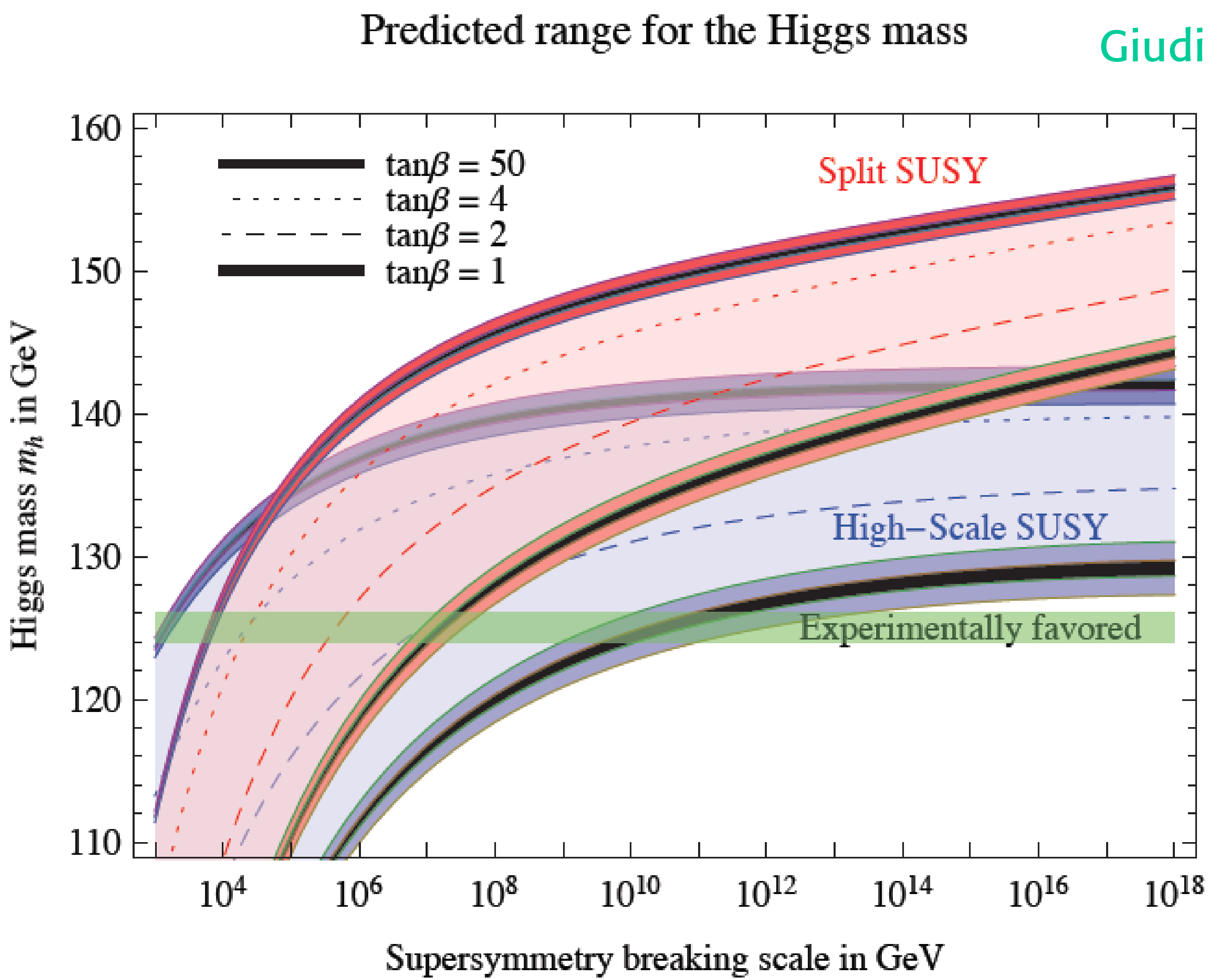
Giudice et al '11

Large scale SUSY: all sparticles heavy. The quartic Higgs coupling is fixed by the gauge coupling at the large scale and fixes m_H at the EW scale

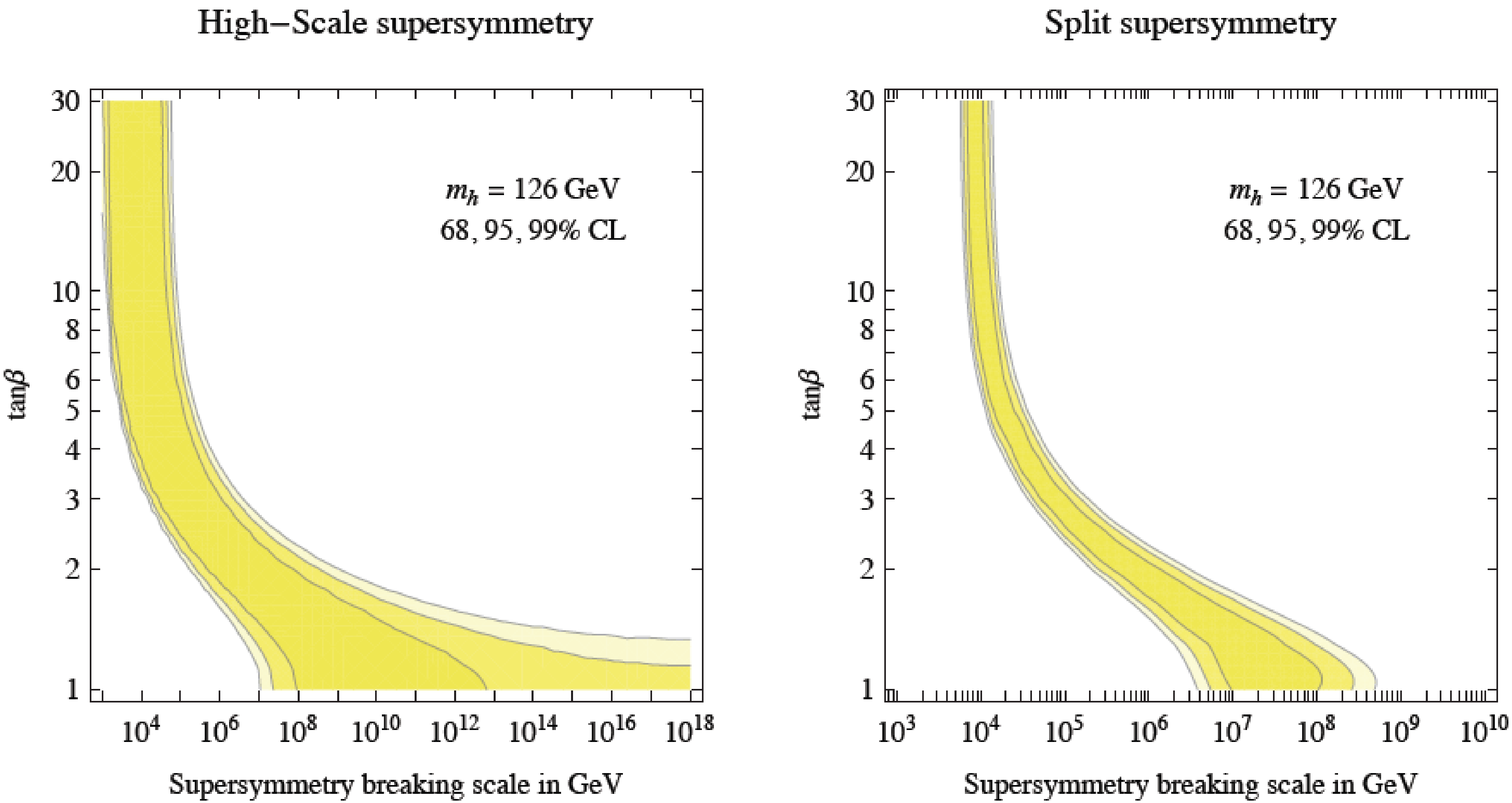
Hall et al '11

These models are strongly constrained by $m_H \sim 125$ GeV Remain valid with the large scale brought down, more so if $tg\beta$ is large)

Giudice, Strumia'11



Giudice, Strumia'11



• Composite Higgs: an alternative class of models

discussed here by Rattazzi, Wulzer, Santiago   Georgi, Kaplan '84

The light Higgs is a bound state of a strongly interacting sector.
Pseudo-Goldstone boson of an enlarged symmetry.
eg. SO(5)/SO(4)

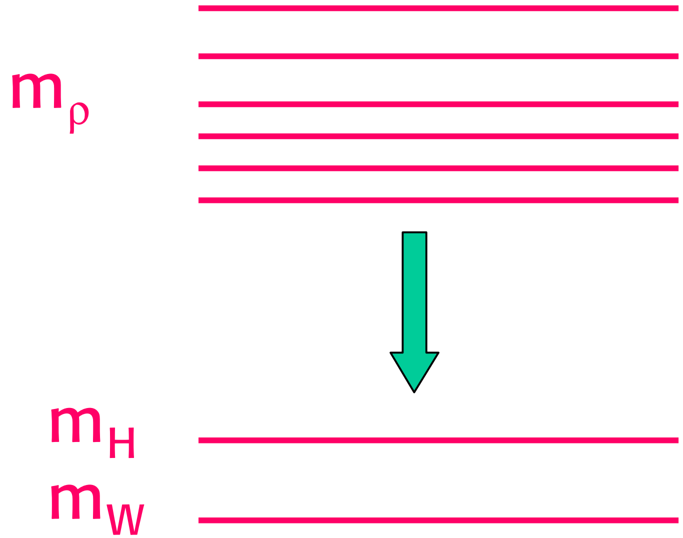
Agashe/ Contino/Pomarol/Sundrum/ Grojean/Rattazzi....

$v \sim$ EW scale $f \sim$ SI scale

$\sim f < m_\rho <\sim 4\pi f$

$\xi = (v/f)^2$

ξ interpolates between SM [$\xi \sim 0$]
and some degree of compositeness
[$\xi \sim o(1)$ limited by precision EW tests,
$\xi=1$ is as bad as technicolor]



The Higgs couplings are deformed by ξ-dependent effects

$$\mathcal{L} = \frac{1}{2}(\partial_\mu h)^2 - V(h) + \frac{v^2}{4}\mathrm{Tr}\left(D_\mu\Sigma^\dagger D^\mu\Sigma\right)\left[1 + 2a\,\frac{h}{v} + b\,\frac{h^2}{v^2} + \dots\right]$$
$$- m_i\,\bar{\psi}_{Li}\,\Sigma\left(1 + c\,\frac{h}{v} + \dots\right)\psi_{Ri} + \mathrm{h.c.}\,,$$

SM: a = b = c =1

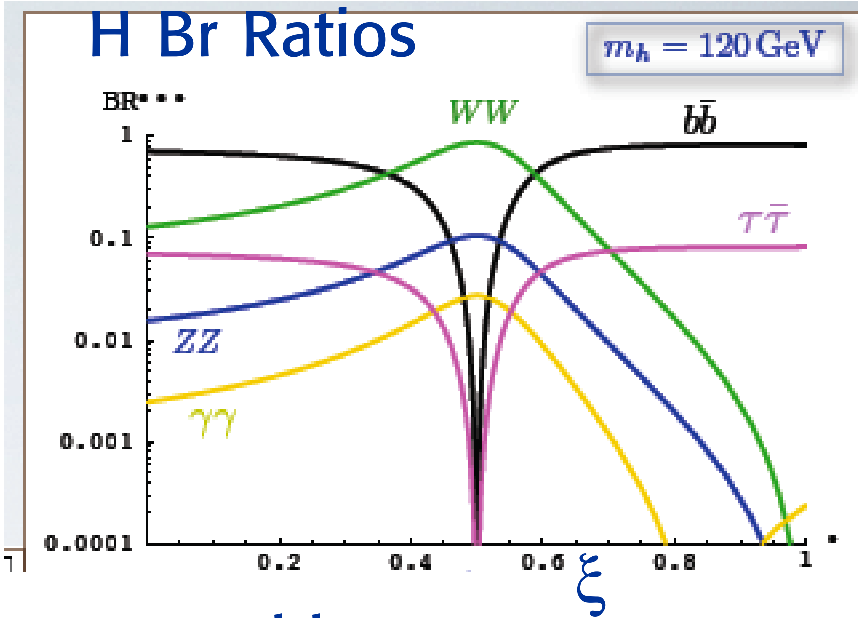
$a = \sqrt{1-\xi}$ $\qquad b = 1 - 2\xi$

for SO(5)/SO(4)

Detectable ξ effects at the LHC

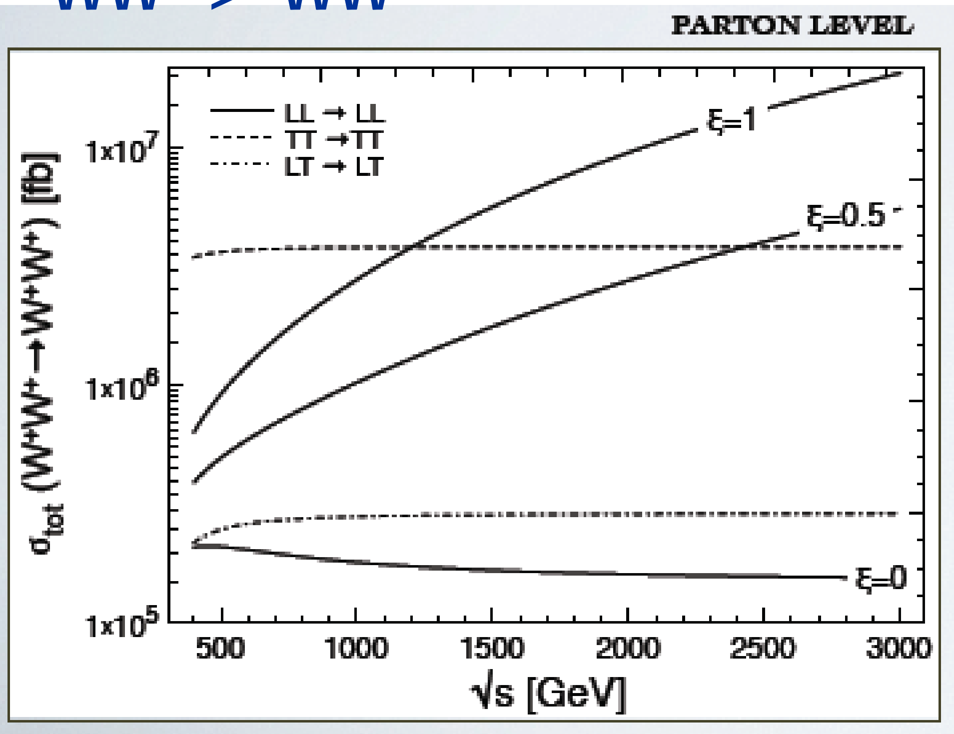
- Higgs couplings
- WW scattering
- 2-Higgs Production

H Br Ratios

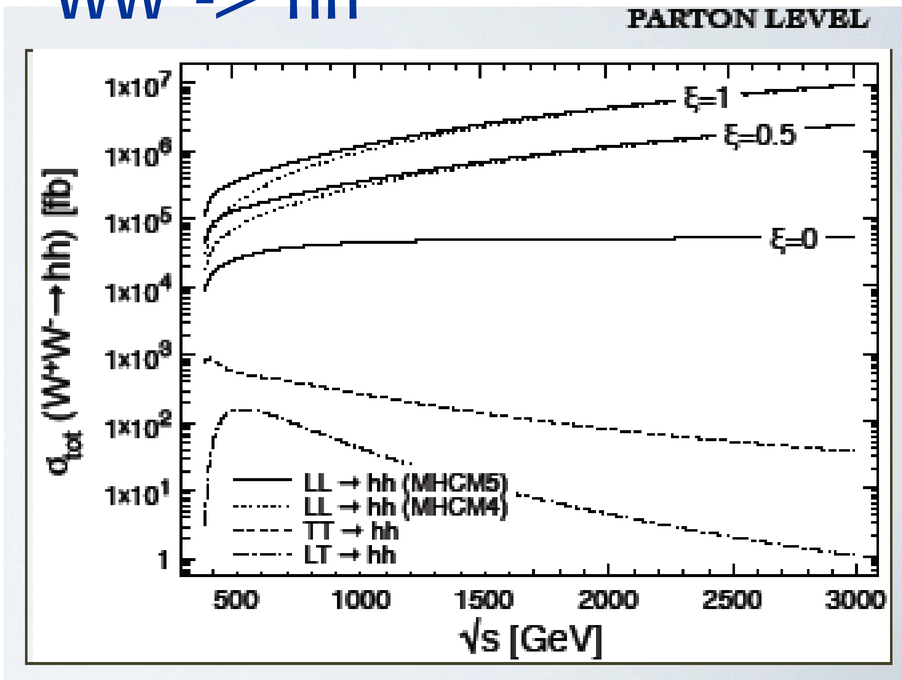


Contino et al

WW -> WW



WW -> hh



Conclusion

The Higgs comes closer

2012 will be the year of the Higgs:
yes or no to the SM Higgs

New Physics is pushed further away

But the LHC experiments are just at the start and
larger masses can be reached in 2012
and even more in the 14 TeV phase

Supersymmetry? Compositeness? Extra dimensions?
Anthropic? We shall see

As a last speaker, on behalf of all participants,
I most warmly thank the Organisers of this very
interesting Workshop that really came
at the right time with the right people