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Developments and further Challenges in Unified Theories

Quantum Reduction of Couplings in QFT

Applications

- Finite Unified Theories
- MSSM

→ Predictions → Higgs mass
→ Predictions → s-spectrum and other Higgs masses

After the discovery of the Higgs boson at the LHC, the Standard Model has been very successfully completed

$\rightsquigarrow$ low energy accessible part of a (more) fundamental Theory of Elementary Particle Physics.

However it contains

- ad hoc Higgs sector
- ad hoc Yukawa couplings

$\rightsquigarrow$ free parameters (>20)

Renormalization programme

$\Longrightarrow$ free parameters

Traditional way of reducing the number of parameters

SYMMETRY

Celebrated example : GUTs

e.g. minimal $SU(5)$ → testable $\sin^2\theta_W$ → successful m_τ / m_b

However more SYMMETRY (e.g. $SO(10)$, $E(6)$, $E(7)$, $E(8)$) does not lead necessarily to more predictions of the SM parametes.

Extreme case : Superstring Ths

On the other hand

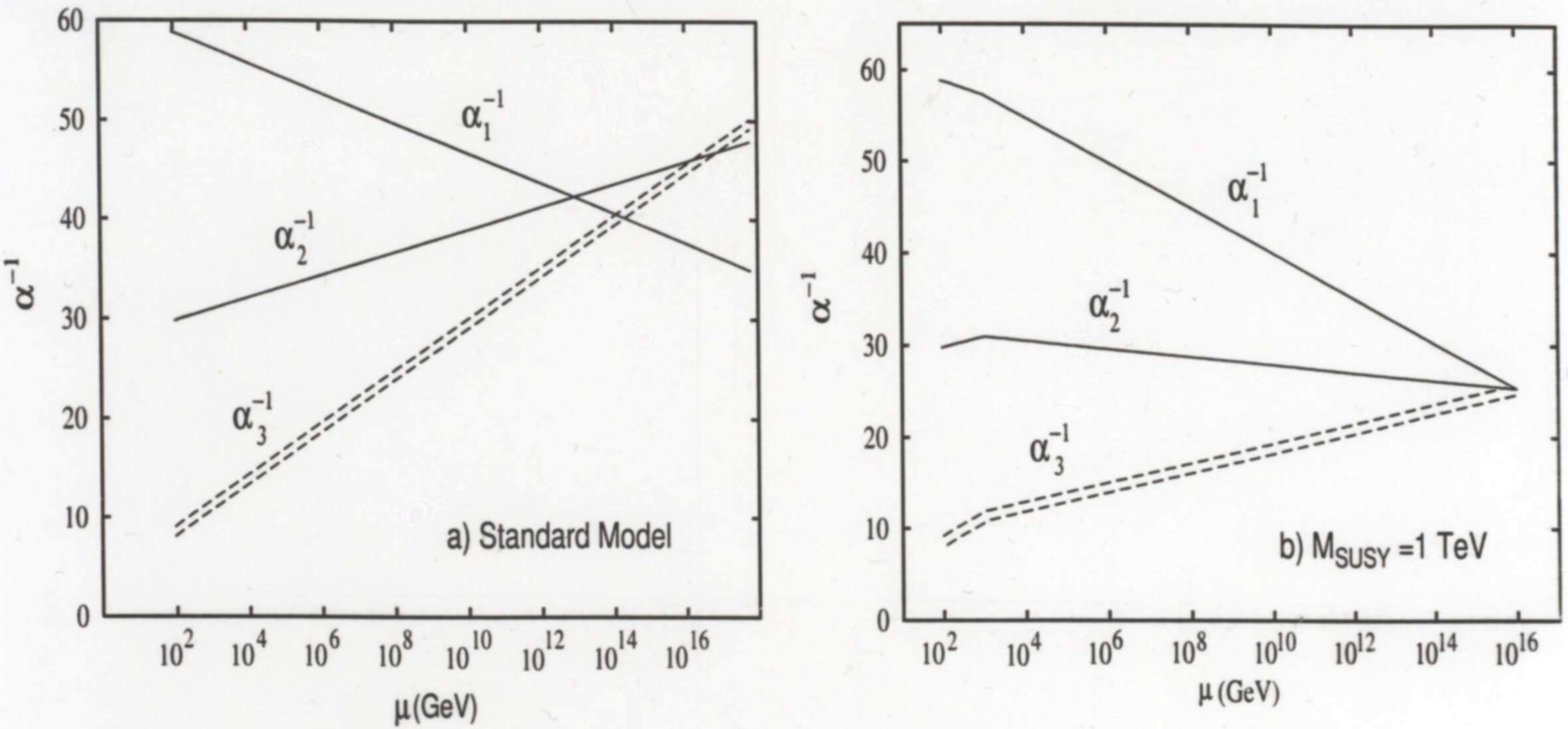
LEP data $\rightsquigarrow$ $N=1$ $SU(5)$

$\cancel{N=1}\ \cancel{SU(5)} \longrightarrow MSSM$

MSSM best candidate for Physics Beyond SM

But with >100 ! free parameters mostly in its SSB sector.

- Cures problem of quadratic divergencies of the SM (hierarchy problem)
- Restricts the Higgs sector leading to approximate prediction of the Higgs mass



60
50
40
30
20
10
0
α^{-1}
α_1^{-1}
α_2^{-1}
α_3^{-1}
a) Standard Model
10^2 10^4 10^6 10^8 10^{10} 10^{12} 10^{14} 10^{16}
μ (GeV)
b) M_{SUSY} =1 TeV

Consider the SM with 2 Higgsdoublets

$$V = -\tfrac{1}{2} m_1^2 (H_1^+ H_1) - \tfrac{1}{2} m_2^2 (H_2^+ H_2) - \tfrac{1}{2} m_3^2 (H_1^+ H_2 + h.c.)$$
$$+ \tfrac{1}{2}\lambda_1 (H_1^+ H_1) + \tfrac{1}{2}\lambda_2 (H_2^+ H_2)^2$$
$$+ \lambda_3 (H_1^+ H_1)(H_2^+ H_2) + \lambda_4 (H_1^+ H_2)(H_2^+ H_1)$$
$$+ \left\{ \tfrac{1}{2}\lambda_5 (H_1 H_2)^2 + \left[\lambda_6 (H_1^+ H_1) + \lambda_7 (H_2^+ H_2)\right](H_1^+ H_2) + h.c. \right\}$$

Supersymmetry imposes tree level relations among couplings,

$$\lambda_1 = \lambda_2 = 1/4 \, (g^2 + g'^2)$$
$$\lambda_3 = 1/4 \, (g^2 - g'^2), \quad \lambda_4 = -\frac{1}{4} g^2$$
$$\lambda_5 = \lambda_6 = \lambda_7 = 0$$

With $v_1 = \langle \mathrm{Re}\, H_1^0 \rangle$, $v_2 = \langle \mathrm{Re}\, H_2^0 \rangle$

and $v_1^2 + v_2^2 = (246\,\mathrm{GeV})^2$, $\frac{v_2}{v_1} = \tan\beta$

$\Longrightarrow \; h^0, H^0, H^\pm, A^0$

At tree level

$$M^2_{h^0,H^0} = \frac{1}{2}\left\{M_A^2 + M_Z^2 \mp \left[(M_A^2+M_Z^2)^2 - 4M_A^2 M_Z^2 \cos^2 2\beta\right]^{1/2}\right\}$$

$$M^2_{H^\pm} = M_W^2 + M_A^2$$

$$\Rightarrow \begin{cases} M_{h^0} < M_Z\,|\cos 2\beta| \\ M_{H^0} > M_Z \\ M_{H^\pm} > M_W \end{cases}$$

Radiative corrections

$$M^2_{h^0} \simeq M_Z^2 \cos^2 2\beta + \frac{3g^2 m_t^4}{16\pi^2 M_W^2} \log \frac{\tilde{m}^2_{t_1}\tilde{m}^2_{t_2}}{m_t^4}$$

- Finite Unified Theories (from Quantum Reduction of Couplings)
- Higher Dimensional Unified Theories and Coset Space Dimensional Reduction (Classical Reduction of Couplings)
- Fuzzy Extra Dimensions and Renormalisable Unified Theories

Quantum Reduction of Couplings

Consider a GUT with

g – gauge coupling

g_i – other couplings (Yukawas, self-couplings)

Any relation among the couplings

$$\Phi(g, g_1, \cdots) = \text{const}$$

which is RGI should satisfy

$$\frac{d}{dt}\Phi = 0 \quad , \quad t = \ln\mu$$

$$\frac{d}{dt}\Phi = \frac{\partial\Phi}{\partial g}\underbrace{\frac{dg}{dt}}_{\beta_g} + \sum_i \frac{\partial\Phi}{\partial g_i}\underbrace{\frac{dg_i}{dt}}_{\beta_i} = 0$$

which is equivalent to

$$\frac{dg}{\beta_g} = \frac{dg_1}{\beta_1} = \frac{dg_2}{\beta_2} = \cdots$$ characteristic system

$$\Longrightarrow \quad \beta_g \frac{dg_i}{dg} = \beta_i$$ Reduction eqs

Oehme Zimmermann

Demand power series solution to the REs

$$g_i = \sum_{n=0} \rho_i^{(n+1)} g^{2n+1}$$

Remarkably, uniqueness of these solutions can be decided already at 1-loop!

Assume

$$\beta_i = \frac{1}{16\pi^2}\left[\sum_{j,k,l} \beta_i^{(1)jkl} g_j g_k g_l + \sum_{j \neq g} \beta_i^{(1)j} g_j g^2\right] + \cdots$$

$$\beta_g = \frac{1}{16\pi^2} \beta_g^{(1)} g^3 + \cdots$$

Assume $\rho_i^{(n)}$, $n \leq r$ have been uniquely determined

To obtain $\rho_i^{(r+1)}$, insert g_i in REs and collect terms of $O\left(g^{2r+1}\right)$

$$\rightsquigarrow \sum_{\ell \neq g} M(r)_i^{\ell} \rho_\ell^{(r+1)} = \text{lower order quantities}$$

Known by assumption

where

$$M(r)_i^\ell = 3 \sum_{j,k \neq g} b_i^{(1)jk\ell} \rho_j^{(1)} \rho_k^{(1)} + b_i^{(1)\ell} - (2r+1) b_g^{(1)} \delta_i^\ell$$

$$0 = \sum_{j,k,\ell \neq g} b_i^{(1)jk\ell} \rho_j^{(1)} \rho_k^{(1)} \rho_\ell^{(1)} + \sum_{\ell \neq g} b_i^{(1)\ell} \rho_\ell^{(1)} - b_g^{(1)} \rho_i^{(1)}$$

$\Longrightarrow$ for a given set of $\rho_i^{(1)}$, the $\rho_i^{(n)}$ for all $n > 1$ can be uniquely determined if

$$\det M(n)_i^\ell \neq 0$$

for all n

Kubo et al.

Consider an $SU(N)$ (non-susy) theory with

$\phi^i(N)$, $\hat{\phi}_i(\bar{N})$ - complex scalars

$\psi^i(N)$, $\hat{\psi}_i(\bar{N})$ - Weyl spinors

λ^a $(a=1,\dots,N^2-1)$ - "

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu}^a F^{a\mu\nu} + i\sqrt{2}\left[g_Y \bar{\psi} \lambda^a T^a \phi - \hat{g}_Y \bar{\hat{\psi}} \lambda^a T^a \hat{\phi} + h.c. - V(\phi, \hat{\phi}),\right.$$

$$V(\phi, \hat{\phi}) = \frac{1}{4}\lambda_1 (\phi^i \phi_i^*)^2 + \frac{1}{4}\lambda_2 (\hat{\phi}_i \hat{\phi}^{*i})^2 + \lambda_3 (\phi^i \phi_i^*)(\hat{\phi}_j \hat{\phi}^{*j}) + \lambda_4 (\phi^i \phi_j^*)(\hat{\phi}_i \hat{\phi}^{*j})$$

Searching for power series solution of the R.E.s we find

$$g_Y = \hat{g}_Y = g;\ \lambda_1 = \lambda_2 = \frac{N-1}{N} g^2;\ \lambda_3 = \frac{1}{2N} g^2;\ \lambda_4 = -\frac{1}{2} g^2$$

i.e. SUSY

$N=1$ gauge theories

Consider a chiral, anomaly free $N=1$ globally supersymmetric gauge th. based on a group G with gauge coupling g.

Superpotential

$$W = \frac{1}{2} m_{ij} \phi^i \phi^j + \frac{1}{6} C_{ijk} \phi^i \phi^j \phi^k$$

m_{ij}, C_{ijk} – gauge invariant tensors

ϕ^i – matter fields transforming as an ir. rep. R_i of G.

Renormalization constants associated with W

$$\phi^{0i} = (Z^i_j)^{1/2} \phi^j , \quad m^0_{ij} = Z^{i'j'}_{ij} m_{i'j'} , \quad C^0_{ijk} = Z^{i'j'k'}_{ijk} C_{i'j'k'}$$

$N=1$ non-renormalization thm ensures absence of mass and cubic-int-term infinities

$$Z^{ijk}_{i'j'k'} Z^{1/2\, i'}_{i''} Z^{1/2\, j'}_{j''} Z^{1/2\, k'}_{k''} = \delta^i_{(i''} \delta^j_{j''} \delta^k_{k'')}$$

$$Z^{ij}_{i'j'} Z^{1/2\, i'}_{i''} Z^{1/2\, j'}_{j''} = \delta^i_{(i''} \delta^j_{j'')}$$

(In the background field method)

$$Z_g Z_V^{1/2} = 1$$

$\rightarrow$ Only surviving infinities are Z^i_j (Z_V)

i.e. one infinity for each field.

The 1-loop β-function of the gauge coupling is

$$\beta_g^{(1)} = \frac{dg}{dt} = \frac{g^3}{16\pi^2}\left[\sum_i \ell(R_i) - 3C_2(G)\right]$$

$\ell(R_i)$ - Dynkin index of R_i

$C_2(G)$ - quadratic Casimir of the adjoint rep.

β-functions of C_{ijk}, by virtue of the non-renormalization thm, are related with the anomalous dim. matrix γ_{ij} of ϕ^i

$$\beta_{ijk}^{(1)} = \frac{dC_{ijk}}{dt} = C_{ijl}\gamma^l_k + C_{ikl}\gamma^l_j + C_{jkl}\gamma^l_i$$

$$\gamma^{(1)j}_i = Z^{-\frac{1}{2}}{}^k_i \frac{d}{dt} Z^{\frac{1}{2}}{}^j_k$$

$$= \frac{1}{32\pi^2}\left[C^{jkl} C_{ikl} - 2g^2 C_2(R_i)\delta^j_i\right]$$

$C_2(R_i)$ - quadratic Casimir of R_i

$C^{ijk} = C^*_{ijk}$

$$b_g^{(2)} = \frac{1}{(16\pi^2)^2} 2 g^5 \left[\sum_i \ell(R_i) - 3 C_2(G) \right]$$

$$- \frac{1}{(16\pi^2)^2} \frac{g^3}{r} C_2(R_i) \left[C^{jkl} C_{ikl} - 2 g^2 C_2(R_i) \delta^j_i \right]$$

$$r : \mathrm{tr}\, \delta^{ab}$$

Parkes, West, Jones
Mezincescu, Yau
Machacek, Vaughn

$$\gamma^{(2)i}_{\ \ j} = \frac{1}{(16\pi^2)^2} 2 g^4 C_2(R_i) \left[\sum_i \ell(R_i) - 3 C_2(G) \right]$$

$$- \frac{1}{(16\pi^2)^2} \frac{1}{2} \left[C^{ikl} C_{jkm} + 2 g^2 (R^a)^i_m (R^a)^l_j \right]$$

$$\cdot \left[C^{mpq} C_{lpq} - 2 \delta^m_l g^2 C_2(R_i) \right]$$

$$b_g^{NSVZ} = \frac{g^3}{16\pi^2} \left[\frac{\sum_i \ell(R_i)(1 - 2\gamma_i) - 3 C_2(G)}{1 - g^2 C_2(G)/8\pi^2} \right]$$

Novikov – Shifman – Vainstein – Zakharov

MSSM

$$W = Y_t Q H_2 t^c + Y_b Q H_1 b^c$$

$$+ Y_\tau L H_1 \tau^c + \mu H_1 H_2$$

The REs for the top, bottom and tau couplings,

$$\frac{d\alpha_{t,b,\tau}}{d\alpha_3} = \frac{b_{t,b,\tau}}{b_3}$$

assuming perturbative expansion of the Yukawas in favour of α_3

$$\alpha_t = c_1 \alpha_3 + c_2 \alpha_3^2 + \cdots$$

$$\alpha_b = p_1 \alpha_3 + p_2 \alpha_3^2 + \cdots$$

$$\alpha_\tau = o_1 \alpha_3 + o_2 \alpha_3^2 + \cdots$$

(which being RGI hold at M_{GUT} where $\alpha_3 = \alpha_2 = \alpha_1$)

have solutions with

$$c_1 \simeq 0.892\,, \quad c_2 \simeq \frac{1}{4\pi}\, 2.42$$

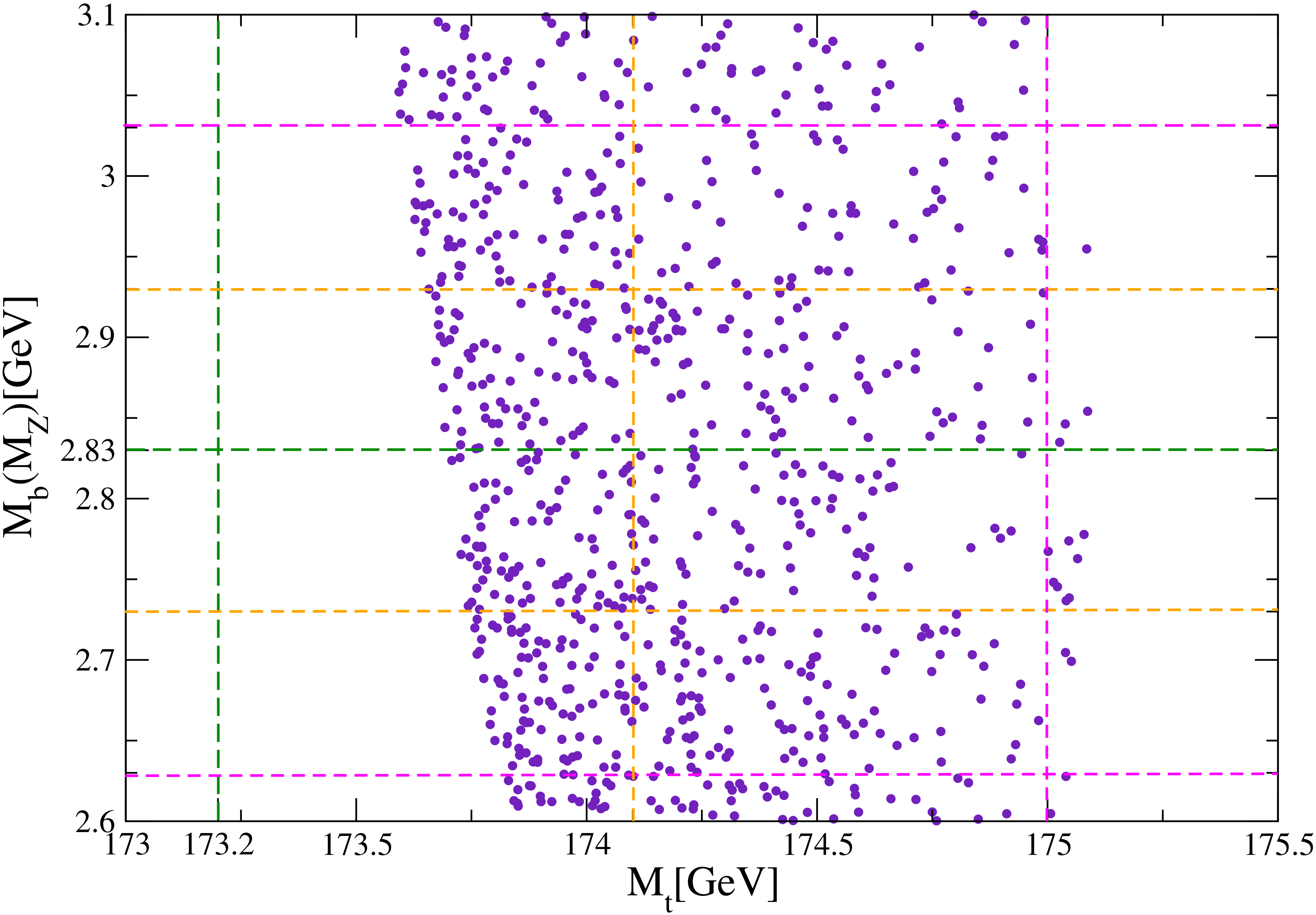
$$p_1 \simeq 0.849\,, \quad p_2 \simeq \frac{1}{4\pi}\, 2.54$$

$$o_1 \simeq -0.187\,, \quad o_2 \simeq -\frac{1}{4\pi}\, 1.46$$

Therefore $\alpha_t, \alpha_b, \alpha_3$ can be reduced, while α_T cannot and is left as a free parameter.

New observation

The $\alpha_t, \alpha_b, \alpha_3$ are not only reduced but they predict correctly the experimental values!



3.1
3
2.9
2.83
2.8
2.7
2.6
$M_b(M_Z)$[GeV]
173
173.2
173.5
174
174.5
175
175.5
M_t[GeV]

Finite Unification

Old days...

... divergences are "hidden under the carpet" (Dirac, Lects on Q.F.T., '64)

Recent years...

... divergences reflect existence of a higher scale where new degrees of freedom are excited.

Not just artifacts of pert. th.

However the presence of quadratic divergences means that physics at one scale are very sensitive to unkown physics at higher scales.

→ SUSY ths which are free of quadratic divergences in spite of any experimental evidence...

→ Natural to expect that beyond unification scale the theory should be completely finite.

- $N=4$ → finite to all orders in pert.
- $N=2$ → only 1-loop contributions to β-function. Possible to arrange the spectrum so that theory is finite.

Multiplicities for massless irreducible reps with maximal helicity 1

Spin \ N	1	1	2	2	4
1	–	1	–	1	1
1/2	1	1	2	2	4
0	2	–	4	2	6

$$N=2 \; : \; \beta(g) = \frac{2g^3}{(4\pi)^2}\left(\sum_i T(R_i) - C_2(G)\right)$$

e.g. $SU(N)$ with $2N$ fundamental reps $\rightarrow \beta(g) = 0$

$SU(5)$: $p(5+\bar{5})$; $q(10+\overline{10})$; $r(15+\overline{15})$

with $p + 3q + 7r = 10$

$SO(10)$: $p(10+\overline{10})$; $q(16+\overline{16})$

with $p + 2q = 8$

E_6 : $4(27+\overline{27})$

Finite Unified Theories

$N=1$

- 1-loop finiteness conditions

$$b_g^{(1)} = 0$$

$$\gamma^{(1)i}_{\ \ j} = 0$$ - anomalous dimensions of all chiral superfields

- Exists complete classification of all chiral $N=1$ models with $b_g^{(1)} = 0$ Hamidi - Patera - Schwarz, Jiang - Zhou

- 1-loop finiteness $\longrightarrow$ 2-loop finiteness Parkes-West, Jones, Mezincescu

... Exist simple criteria that guarantee all loop finiteness (vanishing of all-loop beta functions)

Lucchesi-Piguet
Sibold

Ermushev
Kazakov
Tarasov

Leigh-Strassler

- All-loop finite SU(5) $\Longrightarrow$ top quark mass ✓

Kapetanakis
Mondragon
Z
'92

Susy sector

Jones
Mezincescu
Yao

- 1-loop finiteness conds (require in particular universal soft susy scalar masses

$$(m^2)^i_j = \frac{1}{3} M M^* \delta^i_j$$)

•• 1-loop finiteness

→ 2-loop finiteness — Jack, Jones

Reduction of couplings

• Extension of method in SSB sector + application in min susy SU(5) — Kubo, Mondragon, Z

•• 1-loop sum rule for soft scalar masses in non-finite susy ths. — Kawamura, Kobayashi, Kubo

••• 2-loop sum rule for soft scalar masses in finite ths. — Kobayashi, Kubo, Mondragon, Z

∗ All-loop RGI relations in finite and non-finite ths — Yamada, Hisano, Shifman, Kazakov, Jack, Jones, Pickering

** All-loop sum rule for soft scalar masses in finite and non-finite ths — Kobayashi Kubo Z

•• SU(5) FUTs — Kobayashi Kubo Mondragon Z

· Prediction of s-spectrum in terms of few parameters starting from several hundreds GeV.

·· The LSP is neutralino ✓ (see e.g. Kazakov et. al. Yoshioka)

··· Radiative E-W breaking ✓ (see e.g. Brignole Ibanez, Munoz)

···· No funny ~~colour~~, ~~charge~~ ✓ (see e.g. Casas et. al)

* Prediction of Higgs masses

Lightest ~ 118 - 129 GeV

Similar results also for min susy SU(5)

Consider a chiral, anomaly free, $N=1$ gauge theory with group G.

The superpotential is

$$W = \frac{1}{6} Y^{ijk} \Phi_i \Phi_j \Phi_k + \frac{1}{2} \mu^{ij} \Phi_i \Phi_j$$

$\left.\begin{array}{l} Y^{ijk} \\ \mu^{ij} \end{array}\right\}$ gauge invariant

Yukawa couplings

Φ_i – matter superfields in irreducible reps of G

Necessary and sufficient conditions for $N=1$ 1-loop finiteness

- Vanishing of $b_g^{(1)}$ implies

$$\sum_i l(R_i) = 3\, C_2(G)$$

$l(R_i)$ – Dynkin index of R_i

$C_2(G)$ – Quadratic Casimir of G (adjoint)

$\Rightarrow$ Selection of the field content (representations) of the theory

•• Vanishing of $\gamma^{(1)i}_{\ j}$ implies

$$\underset{\text{Yukawa}}{\underset{\uparrow}{Y}}{}^{ikl}\, Y_{jkl} = 2\,\delta^i_j\, \underset{\text{gauge}}{\underset{\uparrow}{g}}{}^2\, C_2(R_i) \qquad \|$$

$C_2(R_i)$ – quadratic Casimir of R_i

$Y^{ijk} = (Y_{ijk})^*$

$\Longrightarrow$ Yukawa and gauge couplings are related.

Note • μ^{ij} are not restricted

•• Appearance of $U(1)$ is incopatible with 1^{st} condt.

••• 2^{nd} condt forbids the presence of singlets with nonvanishing couplings.

:::: $\Longrightarrow$ ~~Susy~~ by G-invariant soft terms

* 1-loop finiteness condts necessary and sufficient to guarantee 2-loop finiteness

* 1-loop finiteness condts ensure that $b_g^{(3)}$ in 3-loops vanishes but in general $\gamma^{(3)}$ does not.

Grisaru - Milewski - Zanon

Parkes - West

What happens in higher loops?

So far 1-loop finiteness condts (on γs) are telling us

$$Y^{ijk} = Y^{ijk}(g)$$

$$b_Y^{(1)ijk} = 0$$

** Necessary and sufficient condts for vanishing β_g and β_{ijk} to all orders

Lucchesi
Piguet
Sibold

1. $\beta_g^{(1)} = 0$
2. $\gamma^{(1)i}{}_j = 0$
3. $\beta_Y^{ijk} = \beta_g \dfrac{dY^{ijk}}{dg}$

admit power series solution which in lowest order is a solution of condt 2.

3. → 3'. There exist solutions to $\gamma^{(1)i}{}_j = 0$ of the form

$$Y^{ijk} = \rho^{ijk} g, \quad \rho^{ijk} - \text{complex}$$

→ 4. These solutions are isolated and non-degenerate considered as solutions of $\beta_Y^{(1)ijk} = 0$

Recall

R-invariance, axial anomaly

In massless $N=1$ ths

$U(1)$ chiral transformation R:

$A_\mu \to A_\mu$, $\lambda \to e^{-i\alpha}\lambda$,

$\phi \to e^{-i\frac{2}{3}\alpha}\phi$, $\psi \to e^{i\frac{1}{3}\alpha}\psi$, ...

$\psi_D = \begin{pmatrix} \psi \\ \bar{\chi} \end{pmatrix} \longrightarrow e^{i\alpha\gamma_5}\psi_D$

Noether current $J^\mu_R = \bar{\lambda}_D \gamma^\mu \gamma^5 \lambda_D + \cdots$

$\rightsquigarrow \partial_\mu J^\mu_R = r\left(\epsilon^{\mu\nu\rho\sigma} F_{\mu\nu} F_{\rho\sigma} + \cdots\right)$

$r = b_g^{(1)}$!

Only 1-loop contributions due to non-renormalization thm.

Adler, Bardeen, Jackiw, Pi, Shei, Zee

Supercurrent

$$J \equiv \left\{ J'^{\mu}_{R} \ , \ Q^{\mu}_{\alpha} \ , \ T^{\mu}_{\nu} \right\} , \ldots$$

vector super multiplet

associated to R-invariance — associated to susy — associated to translation inv.

Ferrara + Zumino

supercurrent is represented as vector superfield

$$V_\mu(x,\theta,\bar\theta) = R_\mu(x) - i\,\theta^\alpha Q_{\mu\alpha}(x) + i\,\bar\theta_{\dot\alpha}\bar Q^{\dot\alpha}_{\mu}(x) - 2(\theta\sigma^\nu\bar\theta)\,T_{\mu\nu}(x) + \cdots$$

- $J'^{\mu}_{R} \neq J^{\mu}_{R}$

∴ $J'^{\mu}_{R} = J^{\mu}_{R} + O(\hbar)$

In addition

Clark, Piguet, Sibold

$$S = \left\{ b_g F^{\mu\nu}F_{\mu\nu} + \cdots, \ b_g\,\epsilon^{\mu\nu\rho\sigma}F_{\mu\nu}F_{\rho\sigma} + \cdots, \ b_g\,\lambda^\beta\sigma^{\mu\nu}_{\alpha\beta}F_{\mu\nu} + \cdots, \ \ldots \right\}$$

super trace anomaly — trace anomaly of T^{μ}_{ν} — anomaly of R-current — trace anomaly of susy current

chiral super multiplet

There is a relation, whose structure is independent from the renormalization scheme, although individual coefficients (except the 1-loop values of b-functions) may be scheme dependent

$$r = b_g(1 + x_g) + b_{ijk}\, x^{ijk} - \gamma_A\, r^A$$

radiative corrections

linear combinations of anomalous dims

unrenormalized coefficients of anomalies associated to chiral inv. of superpotential

Thm: If (i) no gauge anomaly
(ii) $b^{(1)}(g) = 0$ i.e. no R-current anomaly
(iii) $\gamma^{(1)}{}^i_j = 0$ implies also $r^A = 0$
(iv) exist solutions to $\gamma^{(1)} = 0$ of the form $C_{ijk} = \rho_{ijk}\, g$, ρ_{ijk} - complex
(v) these solutions are isolated + non-degenerate

when considered as solutions of $\beta^{(1)}_{ijk} = 0$

- Then each of the solutions can be uniquely extended to a formal power series in g, and the $N=1$ Y-M models depend on the single coupling constant g with a β-function vanishing to all orders.

Proof: Inserting $\beta_{ijk} = \beta_g \dfrac{d f_{ijk}}{dg}$ in the identity and taking into account the vanishing of r, r^A

$$\rightsquigarrow \quad 0 = \beta_g \left(1 + O(\hbar) \right)$$

Its solution (as formal power series in $\hbar$) is: $\beta_g = 0$

and $\beta_{ijk} = 0$ too. //

2-loop RGEs for SSB parameters

Martin - Vaughn - Yamada - Jack - Jones '94

Consider $N=1$ gauge thy with

$$W = \frac{1}{6} Y^{ijk} \Phi_i \Phi_j \Phi_k + \frac{1}{2} \mu^{ij} \Phi_i \Phi_j$$

and SSB terms

$$-\mathcal{L}_{SB} = \frac{1}{6} h^{ijk} \phi_i \phi_j \phi_k + \frac{1}{2} b^{ij} \phi_i \phi_j$$

$$+ \frac{1}{2} (m^2)^i_j \phi^{*i} \phi_j + \frac{1}{2} M \lambda\lambda + \text{h.c.}$$

- 1-loop finiteness conditions

$$h^{ijk} = -M Y^{ijk}$$

$$(m^2)^i_j = \frac{1}{3} M M^* \delta^i_j \qquad \text{universality}$$

in addition to $\beta_g^{(1)} = \gamma^{(1)i}_j = 0$

- - 1-loop finiteness $\rightarrow$ 2-loop finiteness

Assuming

- $b_g^{(1)} = \gamma^{(1)}{}_i^j = 0$
- the reduction eq

$$b_Y^{ijk} = b_g \, dY^{ijk}/dg$$

admits power series solution

$$Y^{ijk} = g \sum_{n=0} \rho_{(n)}^{ijk} g^{2n}$$

- $(m^2)^i_j = m_j^2 \delta^i_j$

$$\rightsquigarrow \left(m_i^2 + m_j^2 + m_k^2 \right) / MM^* = 1 + \frac{g^2}{16\pi^2} \Delta^{(2)}$$

for i, j, k with $\rho_{(0)}^{ijk} \neq 0$

where $\Delta^{(2)} = -2 \sum_l \left[(m_l^2 / MM^*) - \frac{1}{3} \right] \ell(R_l)$

- $\Delta^{(2)} = 0$ for $N=4$ with $5\,Tr$ cond
- $\Delta^{(2)} = 0$ for the $N=1$, $SU(5)$ FUTs!

The SU(5) finite model

Kapetanakis, Mondragon, Z

Kobayashi, Kubo, Mondragon, Z

Content

$$3(\bar{5}+10) + 4(\overset{H_\alpha}{5}+\overset{\bar{H}_\alpha}{\bar{5}}) + 24$$

fermion supermultiplets

scalar supermultiplets

Jones-Raby
Hamidi-Schwarz
Quiros et. al
Kazakov
Babu-Enkhba
Gogoladze

$$\rightsquigarrow W = \sum_{i=1}^{3}\left[\frac{1}{2} g_i^u \, 10_i 10_i H_i + g_i^d \, 10_i \bar{5}_i \bar{H}_i\right]$$

$$+ g_{23}^u \, 10_2 10_3 H_4 + g_{23}^d \, 10_2 \bar{5}_3 \bar{H}_4 + g_{32}^d \, 10_3 \bar{5}_2 \bar{H}_4$$

$$+ \sum_{\alpha=1}^{4} g_\alpha^f H_\alpha 24 \bar{H}_\alpha + g^\lambda/3\,(24)^3$$

(with enhanced discrete symmetry after reduction of couplings)

We find

$$b_g^{(1)} = 0$$

$$b_{i\alpha}^{u(1)} = \frac{1}{16\pi^2}\left[-\frac{96}{5}g^2 + \sum_{b=1}^{4}\left(g^u_{ib}\right)^2 + 3\sum_{j=1}^{3}\left(g^u_{j\alpha}\right)^2 + \frac{24}{5}\left(g^f_\alpha\right)^2 + 4\sum_{b=1}^{4}\left(g^d_{ib}\right)^2\right] g^u_{i\alpha}$$

$$b_{i\alpha}^{d(1)} = \frac{1}{16\pi^2}\left[-\frac{84}{5}g^2 + 3\sum_{b=1}^{4}\left(g^u_{ib}\right)^2 + \frac{24}{5}\left(g^f_\alpha\right)^2 + 4\sum_{j=1}^{3}\left(g^d_{j\alpha}\right)^2 + 6\sum_{b=1}^{4}\left(g^d_{ib}\right)^2\right] g^d_{i\alpha}$$

$$b^{\lambda(1)} = \frac{1}{16\pi^2}\left[-30g^2 + \frac{63}{5}\left(g^\lambda\right)^2 + 3\sum_{\alpha=1}^{4}\left(g^f_\alpha\right)^2\right] g^\lambda$$

$$b_\alpha^{f(1)} = \frac{1}{16\pi^2}\left[-\frac{98}{5}g^2 + 3\sum_{i=1}^{3}\left(g^u_{i\alpha}\right)^2 + 4\sum_{i=1}^{3}\left(g^d_{i\alpha}\right)^2 + \frac{48}{5}\left(g^f_\alpha\right)^2 + \sum_{b=1}^{4}\left(g^f_b\right)^2 + \frac{21}{5}\left(g^\lambda\right)^2\right] g^f_\alpha$$

Considering g as the primary coupling, we solve the Red. Eqs.

$$\beta_g = \beta_a \frac{dg}{dg_a}$$

requiring power series ansatz.

$$\Rightarrow (g^u_{ii})^2 = \frac{8}{5} g^2 + \cdots, \quad (g^d_{ii})^2 = \frac{6}{5} g^2 + \cdots$$

$$(g^\lambda)^2 = \frac{15}{7} g^2 + \cdots, \quad (g^f_4)^2 = g^2, \quad (g^f_\alpha)^2 = 0 + \cdots \quad (\alpha = 1,2,3)$$

Higher order terms can be uniquely determined.

$\Rightarrow$ All 1-loop β-functions vanish

Moreover

All 1-loop anomalous dimensions of chiral fields vanish.

$$\gamma^{(1)}_{10i} = \frac{1}{16\pi^2}\left[-\frac{36}{5}g^2 + 3\sum_{b=1}^{4}\left(g^u_{ib}\right)^2 + 2\sum_{b=1}^{4}\left(g^d_{ib}\right)^2\right]$$

$$\gamma^{(1)}_{\bar{5}i} = \frac{1}{16\pi^2}\left[-\frac{24}{5}g^2 + 4\sum_{b=1}^{4}\left(g^d_{ib}\right)^2\right]$$

$$\gamma^{(1)}_{H\alpha} = \frac{1}{16\pi^2}\left[-\frac{24}{5}g^2 + 3\sum_{i=1}^{3}\left(g^u_{i\alpha}\right)^2 + \frac{24}{5}\left(g^f_{\alpha}\right)^2\right]$$

$$\gamma^{(1)}_{\bar{H}\alpha} = \frac{1}{16\pi^2}\left[-\frac{24}{5}g^2 + 4\sum_{i=1}^{3}\left(g^d_{i\alpha}\right)^2 + \frac{24}{5}\left(g^f_{\alpha}\right)^2\right]$$

$$\gamma^{(1)}_{24} = \frac{1}{16\pi^2}\left[-\frac{10}{5}g^2 + \sum_{\alpha=1}^{4}\left(g^f_{\alpha}\right)^2 + \frac{21}{5}\left(g^{\lambda}\right)^2\right]$$

$\Rightarrow$ Necessary and sufficient condts for finiteness to all orders are satisfied

- SU(5) breaks down to the standard model due to <24>
- Use the freedom in mass parameters to obtain only a pair of Higgs fields light, acquiring v.e.v.
- Get rid of unwanted triplets rotating the Higgs sector (after a fine tuning)

  see Quiros et. al., Kazakov et. al, Yioshioka
- Adding soft terms we can achieve SUSY breaking.

1) Gauge Couplings Unification

$\sin^2\theta_W, \alpha_{em} \rightsquigarrow \alpha_3(M_Z)$ Marciano+Senjanovic ⋮ Amaldi et. al.

2) Bottom-Tau Yukawa Unif.

SU(5)-type

$\rightsquigarrow m_t \sim 100-200$ GeV Barger et. al. Carena et. al.

*3) Top-Bottom-Tau Yuk Unif.

$h_t^2 = \frac{4}{3} h_{b,\tau}^2$ in SU(5)-FUT

Similar to SO(10) Ananthanarayan et. al. Barger et. al.

$\rightsquigarrow m_t \sim 160-200$ GeV Carena et. al.

*4) Gauge-Top-Bottom-Tau Unif.

e.g. FUT-SU(5): $h_t^2 = \frac{8}{5} g_U^2$; $h_{b,\tau}^2 = \frac{6}{5} g_U^2$

M_s [GeV]	$\alpha_{3(5f)}(M_Z)$	$\tan\beta$	$M_{\rm GUT}$ [GeV]	M_b [GeV]	M_t [GeV]
300	0.123	54.1	2.2×10^{16}	5.3	183
500	0.122	54.2	1.9×10^{16}	5.3	183
10^3	0.120	54.3	1.5×10^{16}	5.2	184

FUTA

M_s [GeV]	$\alpha_{3(5f)}(M_Z)$	$\tan\beta$	$M_{\rm GUT}$ [GeV]	M_b [GeV]	M_t [GeV]
800	0.120	48.2	1.5×10^{16}	5.4	174
10^3	0.119	48.2	1.4×10^{16}	5.4	174
1.2×10^3	0.118	48.2	1.3×10^{16}	5.4	174

FUTB

M_s [GeV]	$\alpha_{3(5f)}(M_Z)$	$\tan\beta$	$M_{\rm GUT}$ [GeV]	M_b [GeV]	M_t [GeV]
300	0.123	47.9	2.2×10^{16}	5.5	178
500	0.122	47.8	1.8×10^{16}	5.4	178
1000	0.119	47.7	1.5×10^{16}	5.4	178

MIN SU(5)

The predictions for the three models for different M_s

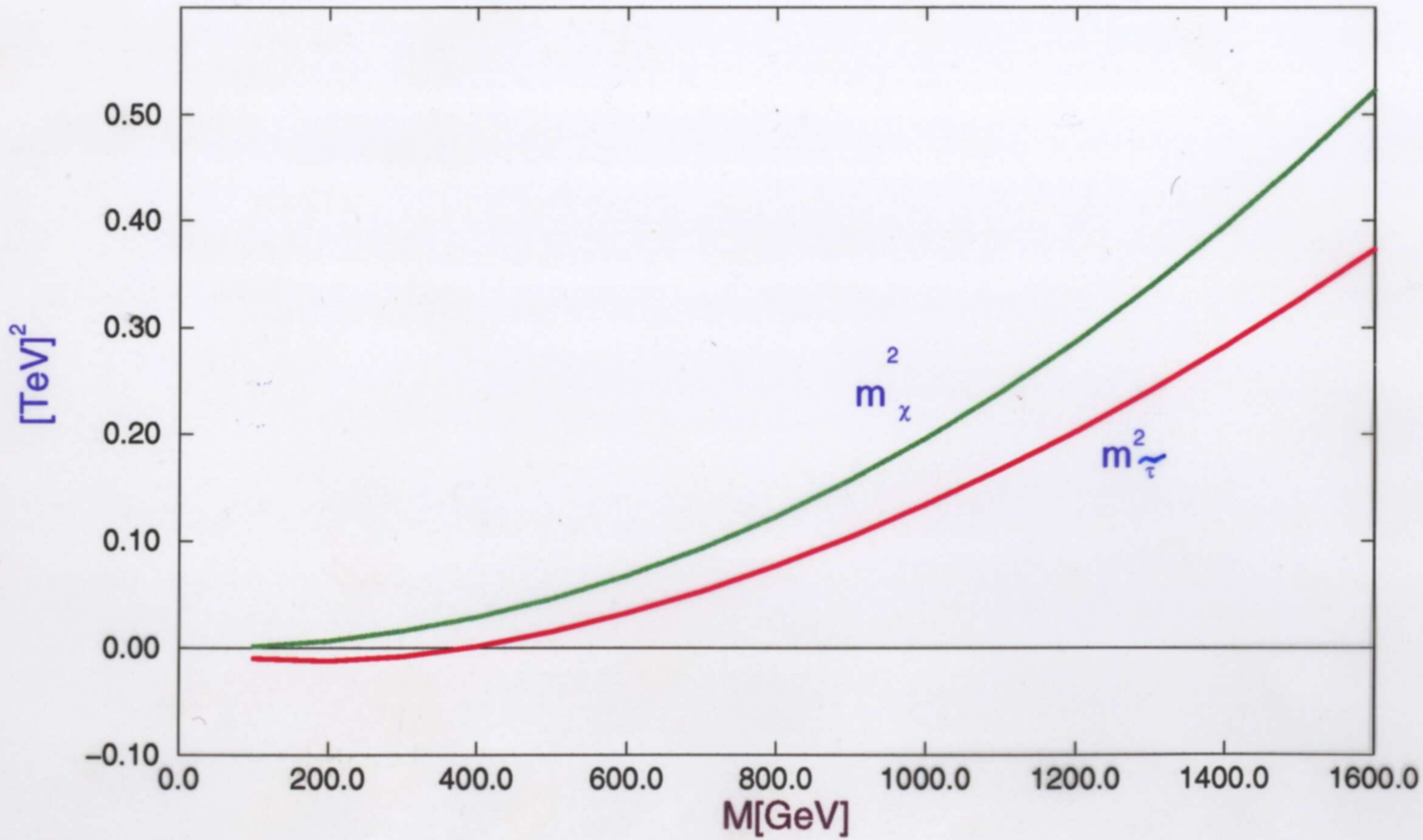
With theoretical corrections and uncertainties 8

$\sim 4\%$

$M_t = 173.8 \pm 5$ GeV; 178.0 ± 4.3 GeV
CDF + D0

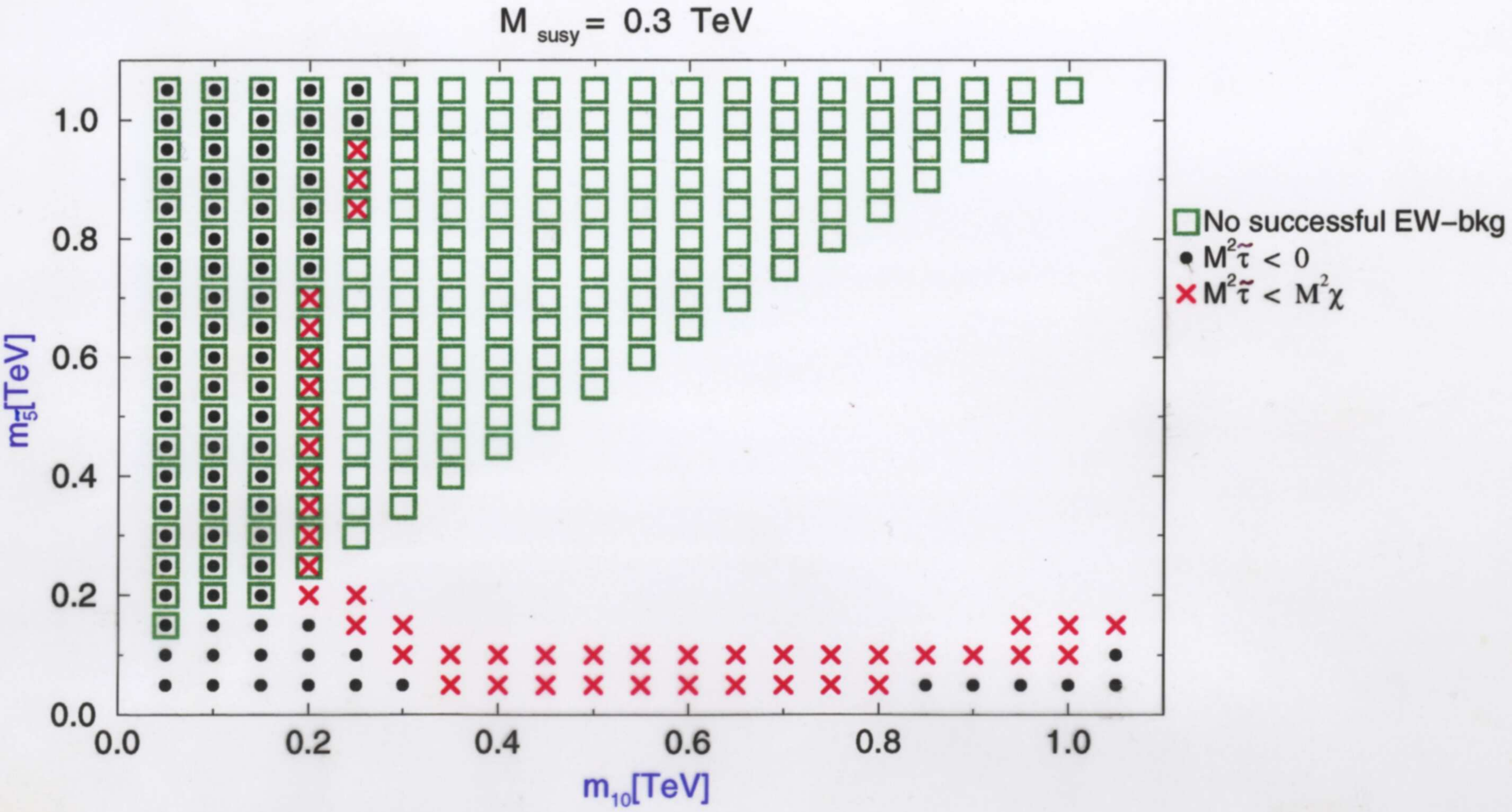
Model A

Similar behaviour holds for Model B too

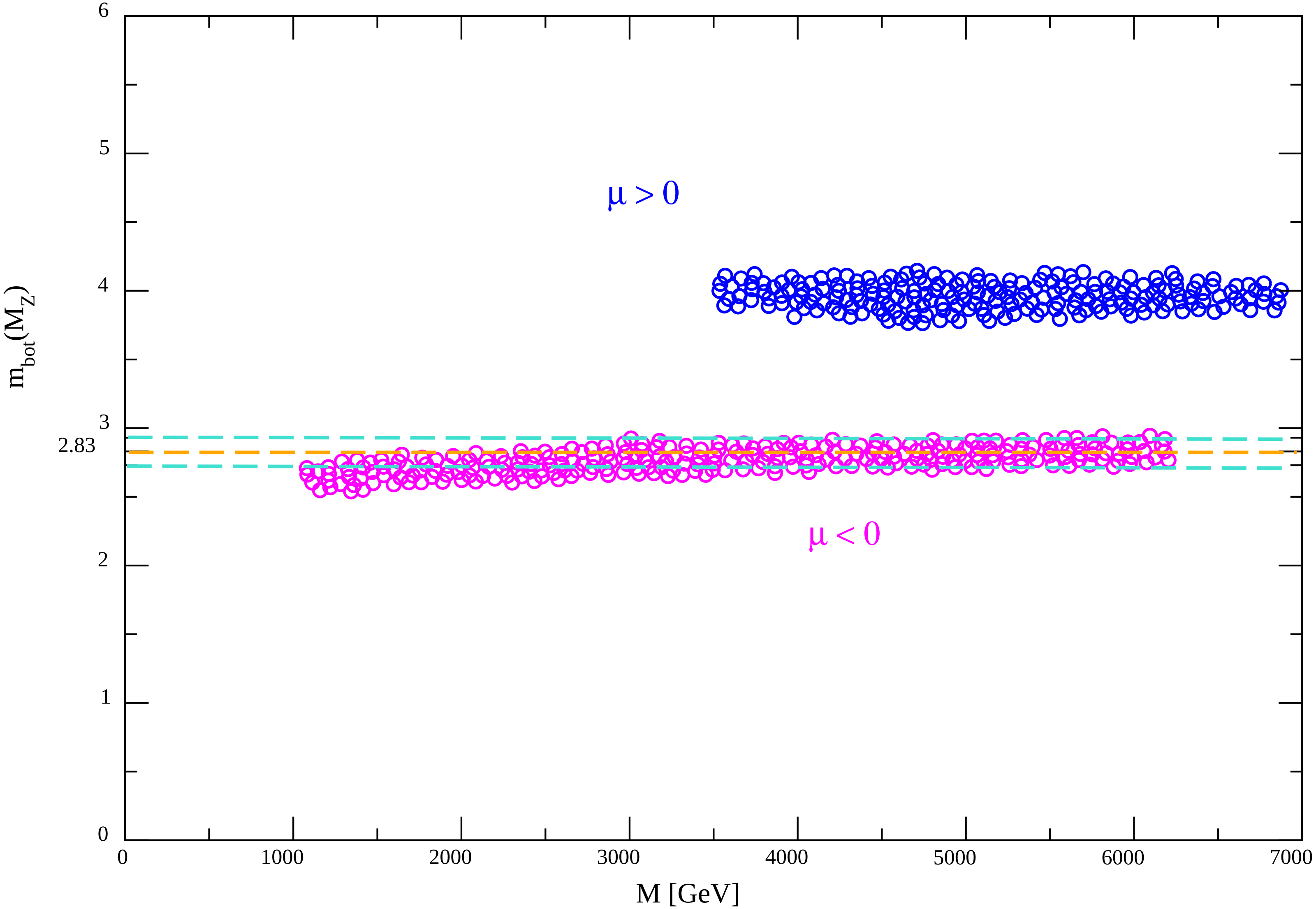


$m^2_{\tilde\tau}$ and m^2_χ for the universal choice of soft scalar masses

Model A



The empty region yields a neutralino as LSP



$\mu > 0$
$\mu < 0$
$m_{bot}(M_Z)$
M [GeV]
2.83
0
1
2
3
4
5
6
0
1000
2000
3000
4000
5000
6000
7000

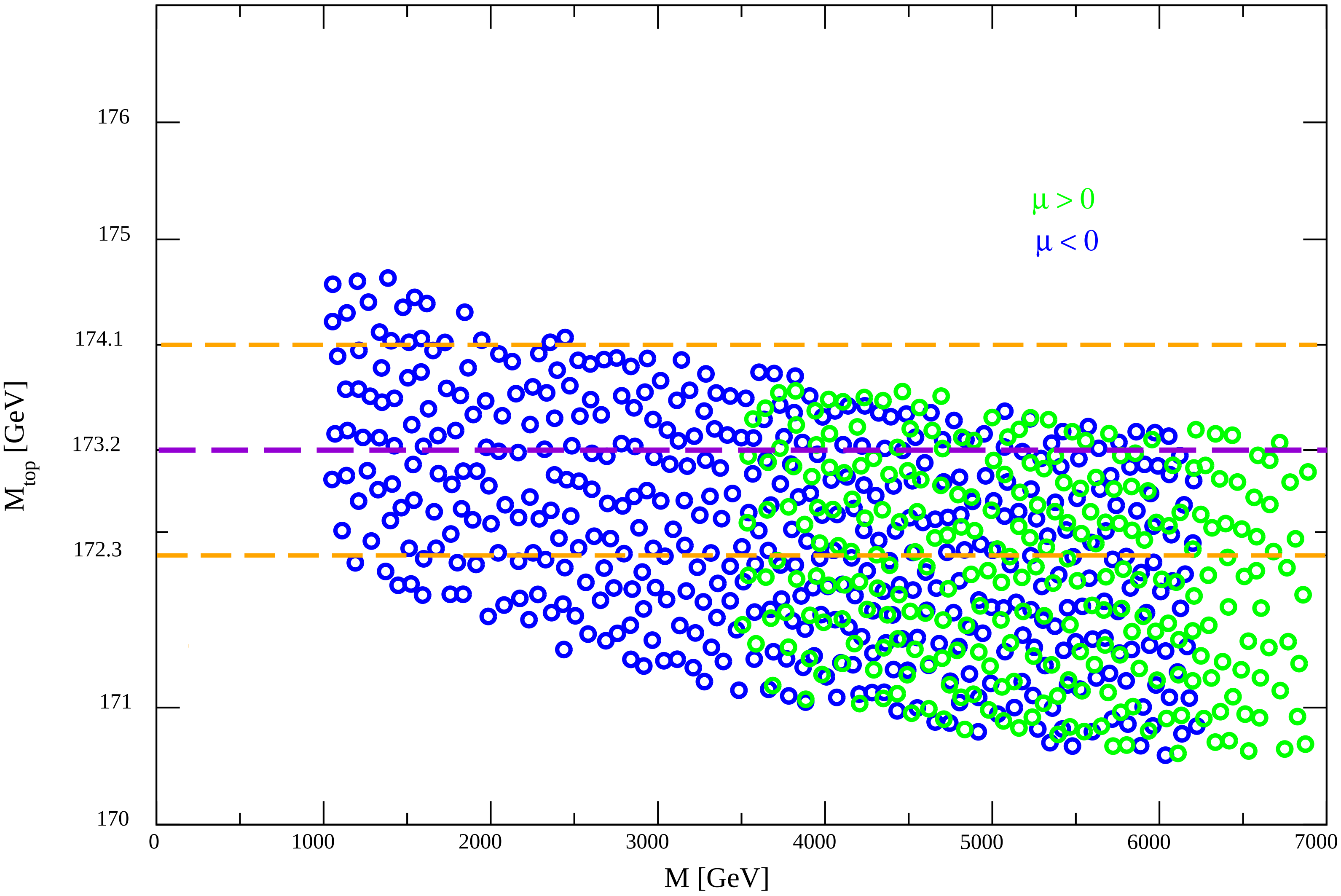
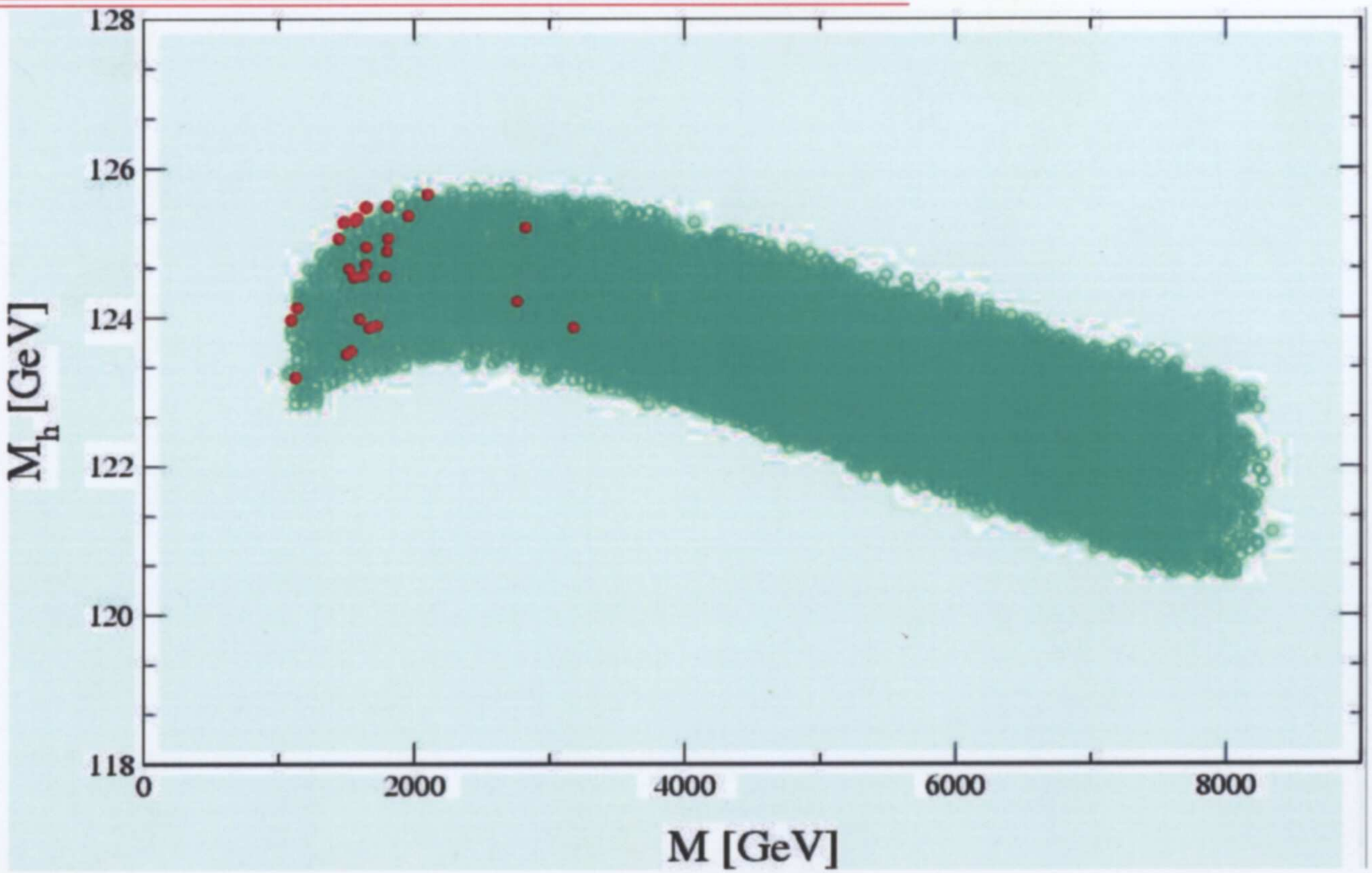


Figure 1: The bottom quark mass at the Z boson scale (upper) and top quark pole mass (lower plot) are shown as function of M for both models and both signs of μ.

3D) Predictions for the light Higgs boson



green: consistent with B physics constraints
red: agreement with (loose) CDM bound

$$118 \text{ GeV} \leq M_h \leq 129 \text{ GeV} \quad \text{(incl. theor. unc.)}$$

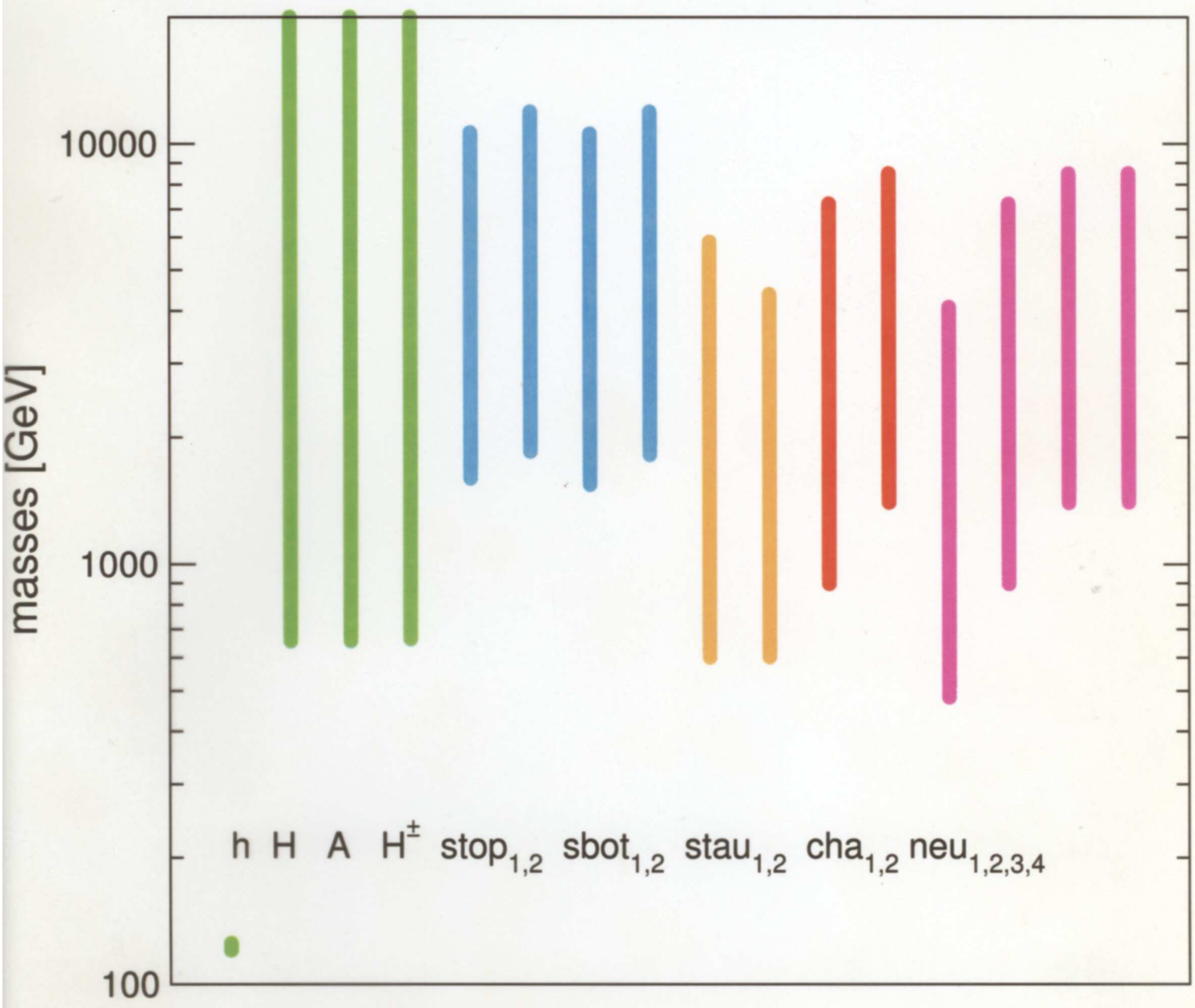
$\Rightarrow$ "easy" to find for LHC (but "only" SM-like ...)

Typical mass spectrum for FUTB- :

m_t	172	$\overline{m_b}(M_Z)$	2.7
$\tan\beta =$	46	α_s	0.116
$m_{\tilde{\chi}_1^0}$	796	$m_{\tilde{\tau}_2}$	1268
$m_{\tilde{\chi}_2^0}$	1462	$m_{\tilde{\nu}_3}$	1575
$m_{\tilde{\chi}_3^0}$	2048	μ	-2046
$m_{\tilde{\chi}_4^0}$	2052	B	4722
$m_{\tilde{\chi}_1^\pm}$	1462	M_A	870
$m_{\tilde{\chi}_2^\pm}$	2052	$M_{H^\pm}$	875
$m_{\tilde{t}_1}$	2478	M_H	869
$m_{\tilde{t}_2}$	2804	M_h	124
$m_{\tilde{b}_1}$	2513	M_1	796
$m_{\tilde{b}_2}$	2783	M_2	1467
$m_{\tilde{\tau}_1}$	798	M_3	3655

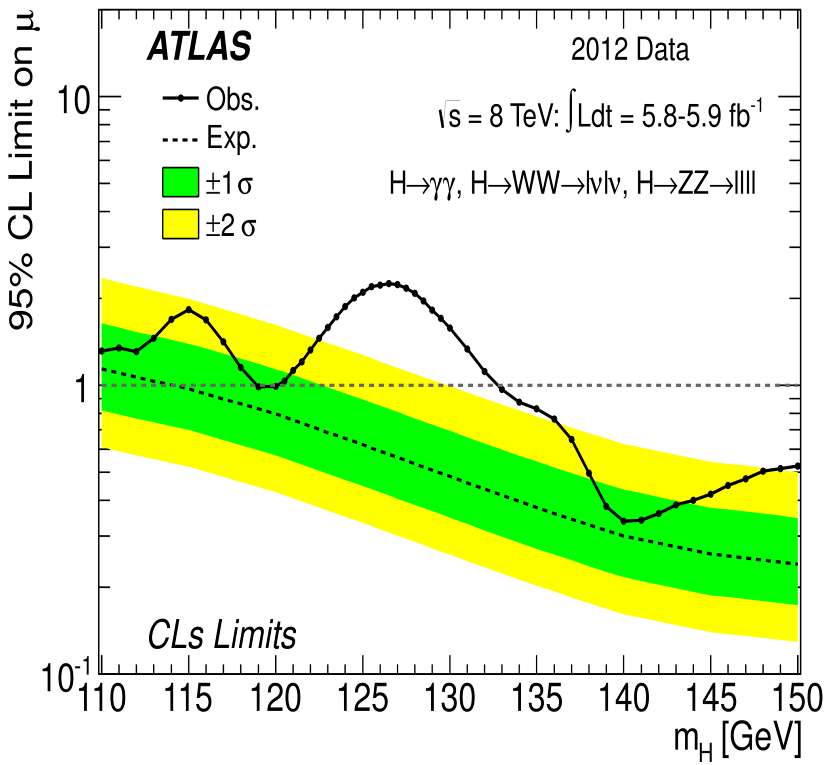
M1	580 GeV
M2	1077 GeV
Mgluino	2754 GeV
Stop1	1876 GeV
Stop2	2146 GeV
Sbot1	1849 GeV
Sbot2	2117 GeV
Mstau1	635 GeV
Mstau2	867 GeV
Char1	1072 GeV
Char2	1597 GeV
Neu1	579 GeV
Neu2	1072 GeV
Neu3	1591 GeV
Neu4	1596 GeV
Mh	123.1 GeV
MH	679 GeV
MA	680 GeV
$\mathrm{MH}^{\pm}$	685 GeV
Mtop	172.2 GeV
Mbot(M_Z)	2.71 GeV

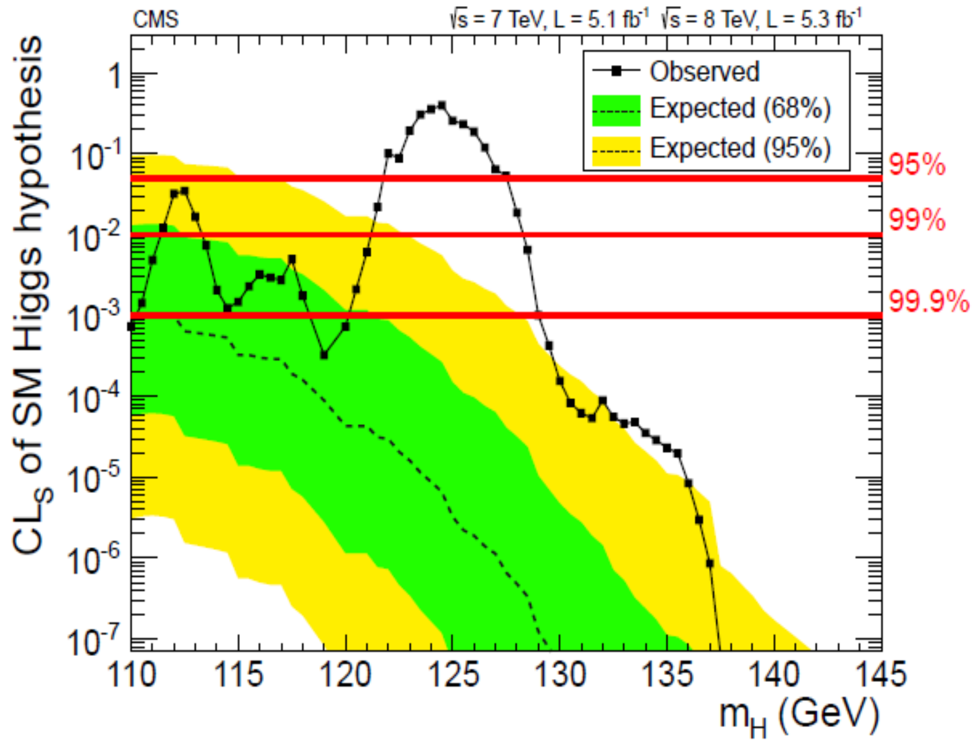
FUTB, $\mu < 0$



masses [GeV]
10000
1000
100
h
H
A
H±
stop1,2
sbot1,2
stau1,2
cha1,2
neu1,2,3,4

It is where the SM predicts it should be



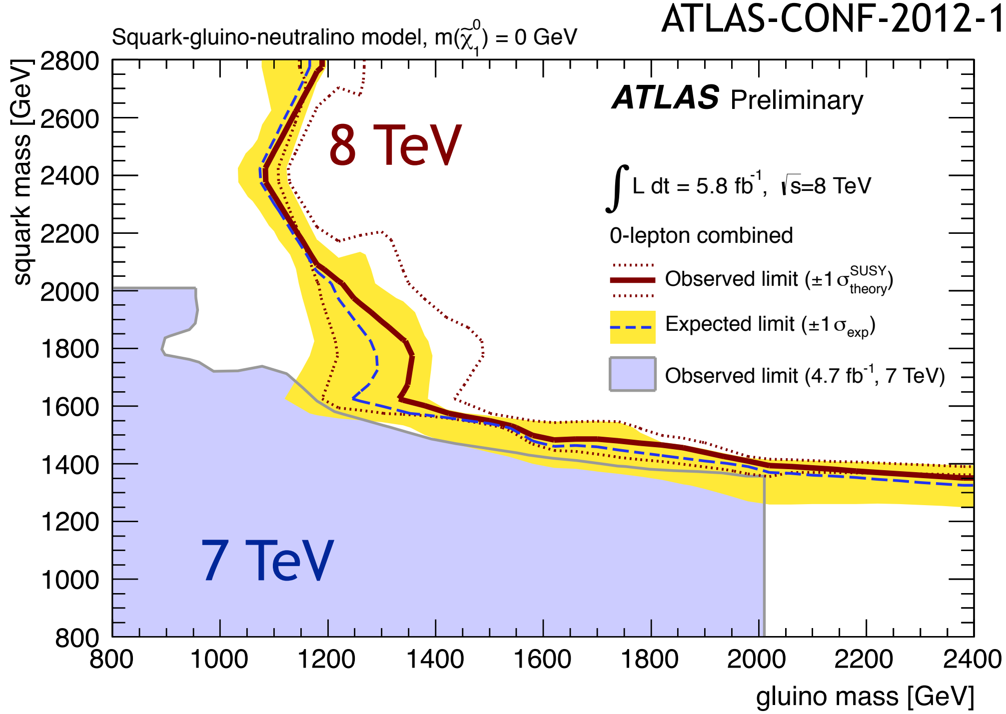


$$M_H = 126 \pm 0.4\,(stat.) \pm 0.4\,(syst.)\,\mathrm{GeV}$$

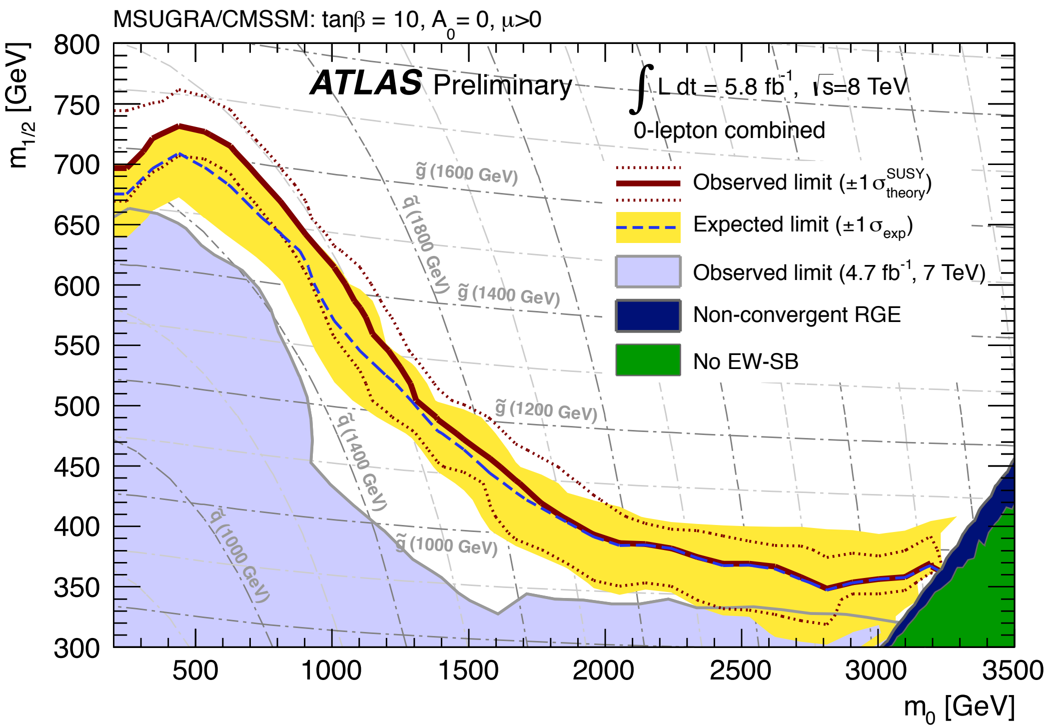
$$M_H = 125.3 \pm 0.4\,(stat.) \pm 0.5\,(syst.)\,\mathrm{GeV}$$

Jets+MET results

- Exclusions in the squark-gluino mass plane for a simplified SUSY model

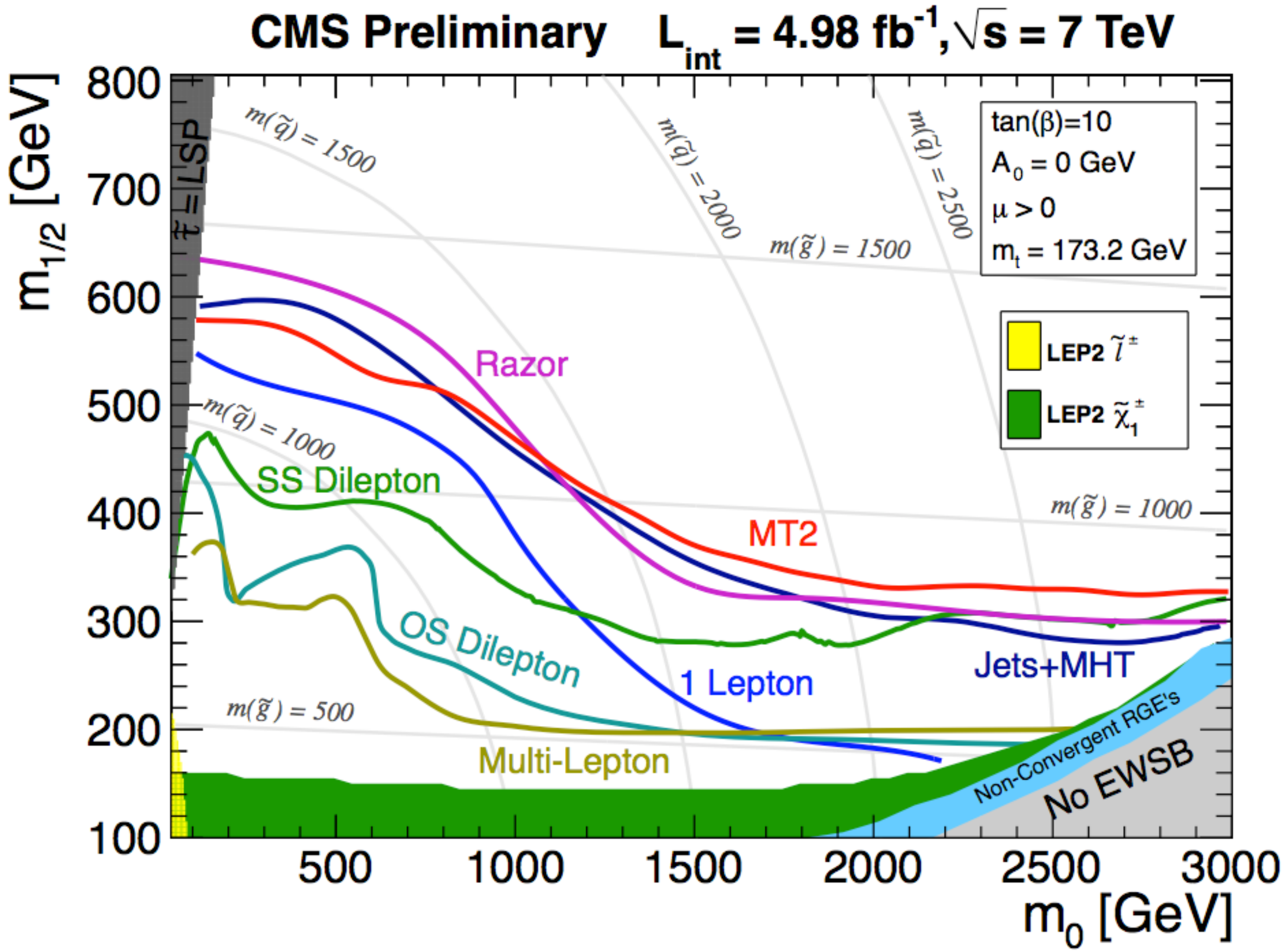


Limits stable up to ~200 GeV mass LSP



- CMSSM ($m_{1/2}$, m_0) plane: equal mass squarks and gluinos excluded below 1500 GeV

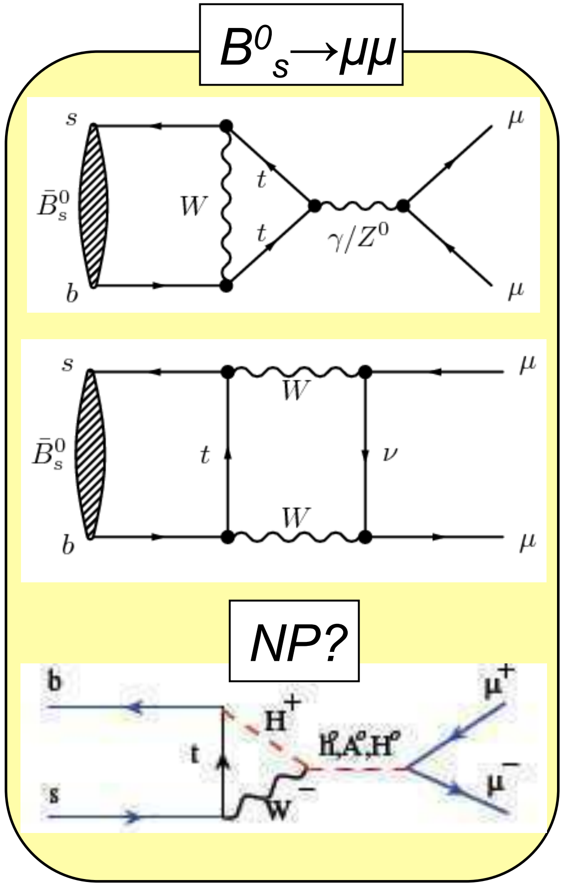
No SUSY (so far).

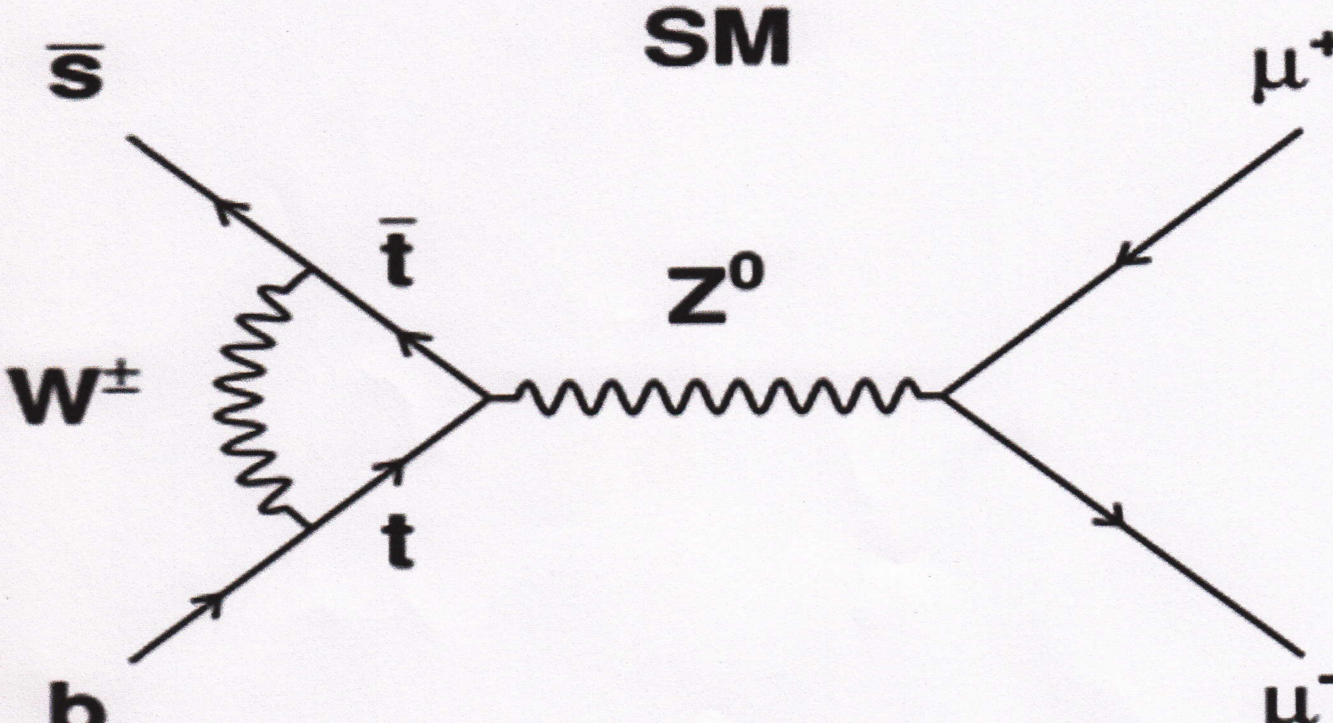


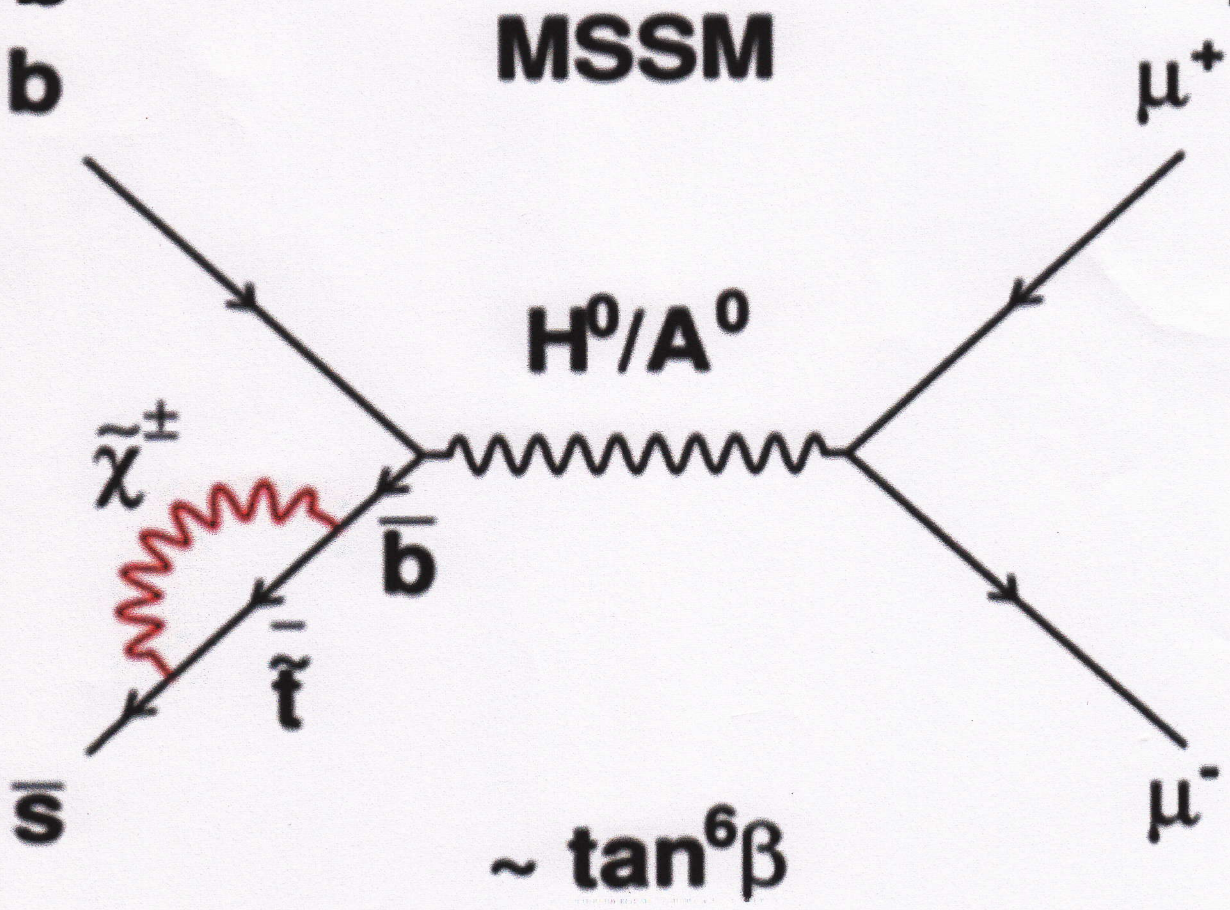
At least within constrained MSS models.

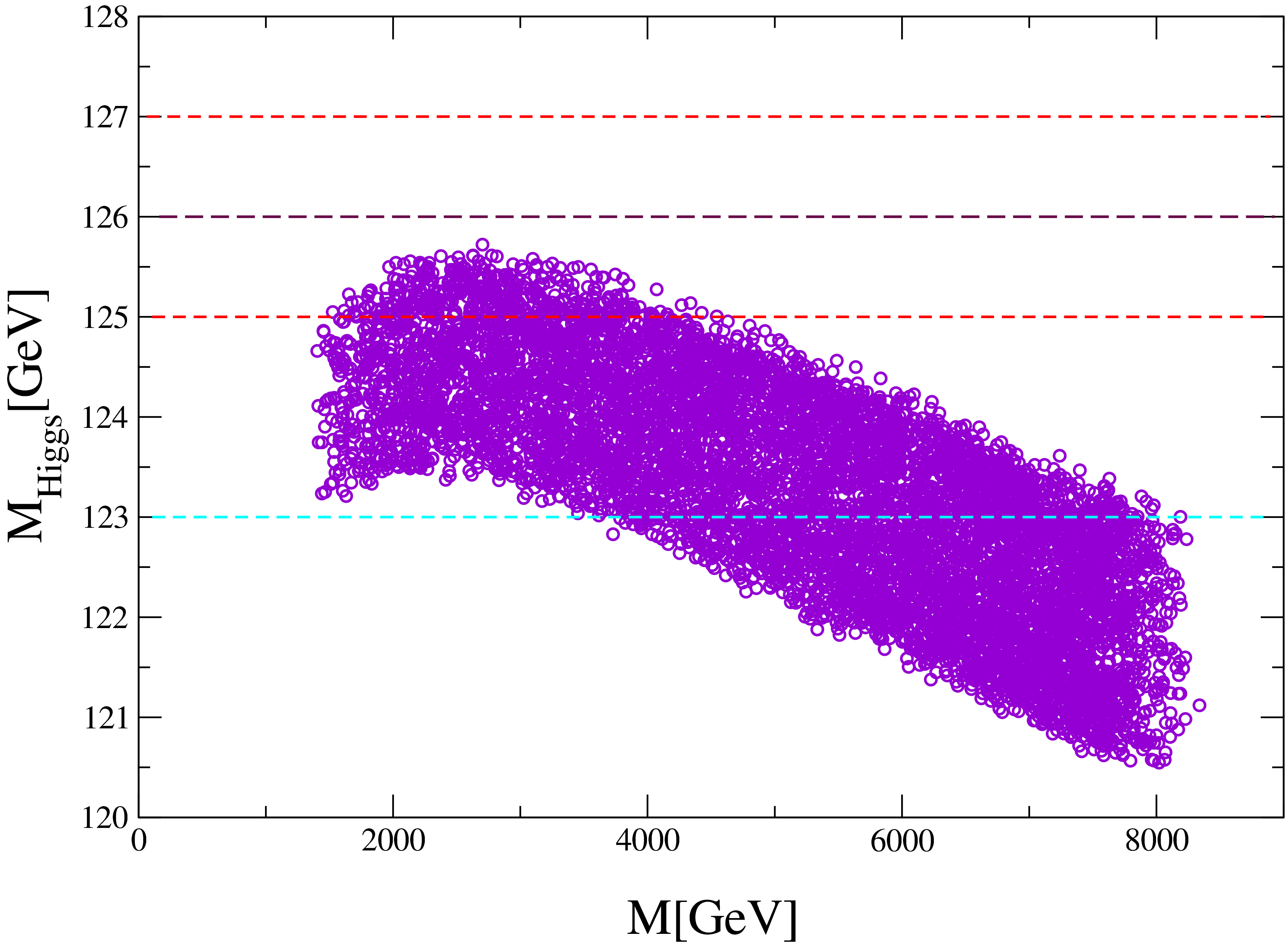
Search for NP in $B_{s(d)} \rightarrow \mu^+\mu^-$

- Highly suppressed in SM - FCNC plus helicity $(m_\mu/M_B)^2$ - and well predicted
  - $BR(B_s \rightarrow \mu^+\mu^-)$= 3.2±0.03 10^{-9}
  - $BR(B_d \rightarrow \mu^+\mu^-)$= 0.11±0.01 10^{-9}
    - A.J.Buras et al: arXiv: 1208.0934
- Sensitive to NP
  - Could be strongly enhanced in SUSY
  - In MSSM scales like ~$\tan^6\beta$ →
- Limit or measurement of $B_{s,d} \rightarrow \mu^+\mu^-$ will strongly constraint parameter space

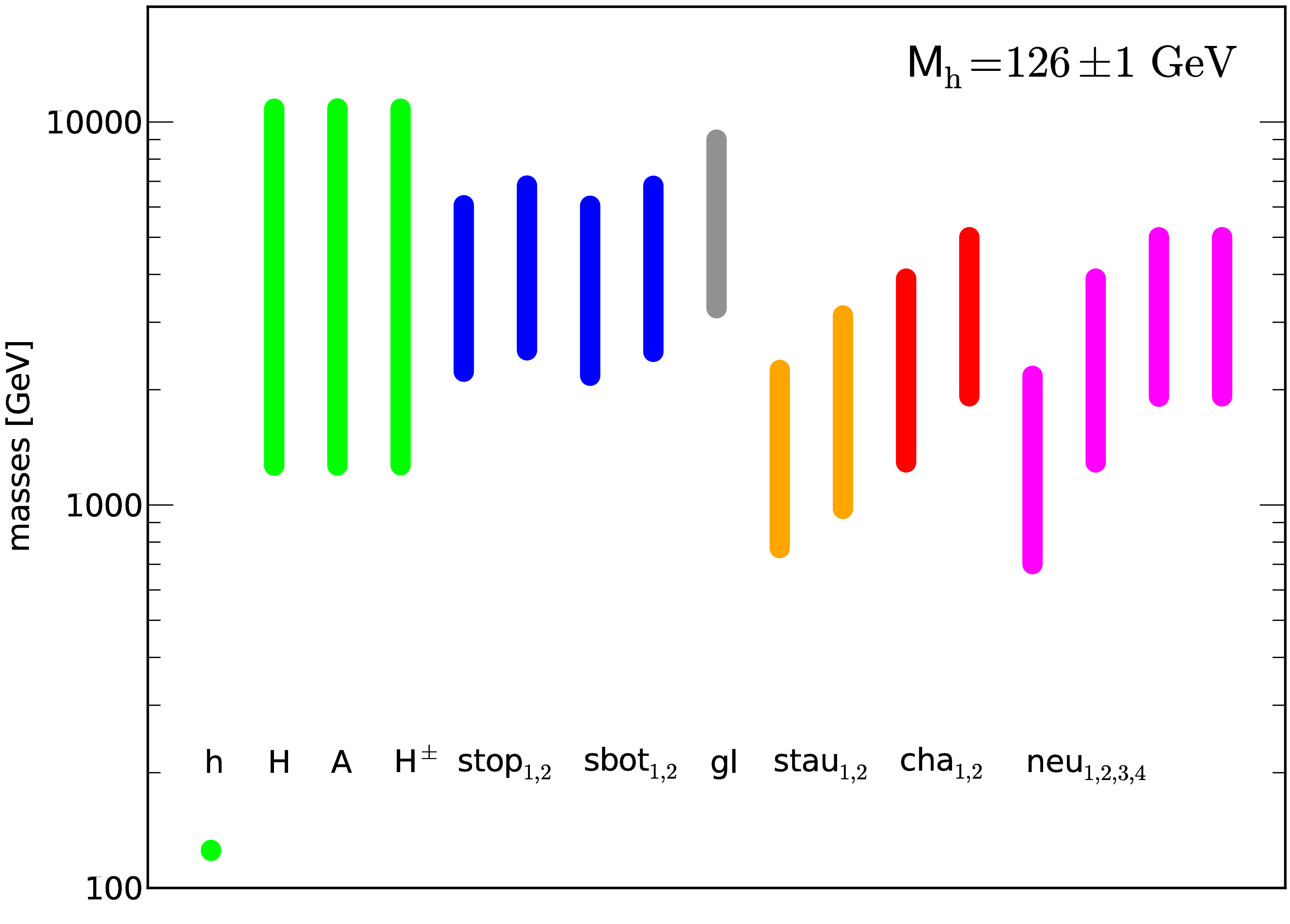


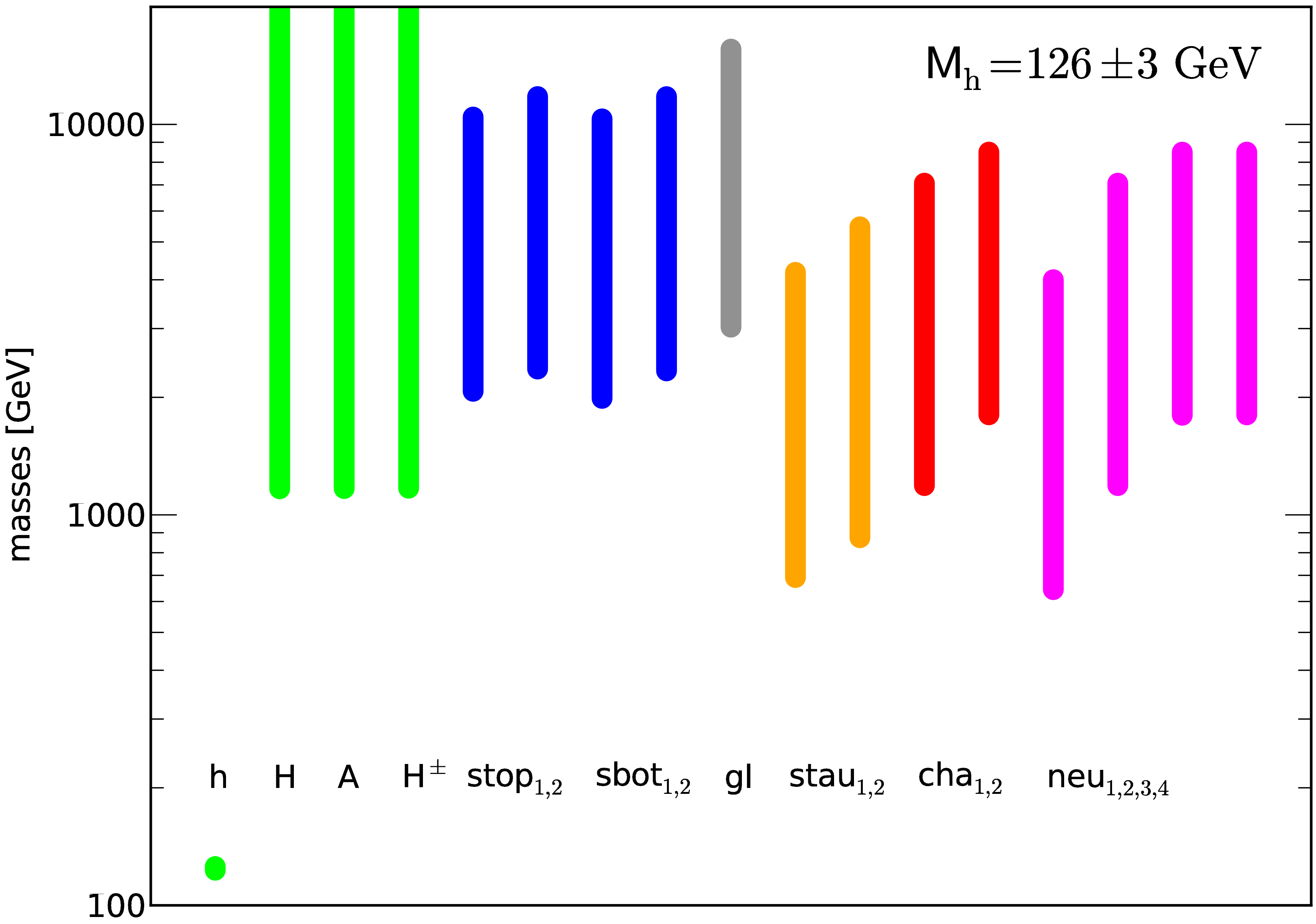

SM
s̄
μ⁺
t̄
Z⁰
W±
t
b
μ⁻


MSSM
b
μ⁺
H⁰/A⁰
χ̃±
b̄
t̃̄
s̄
μ⁻
~ tan⁶β



128
127
126
125
124
123
122
121
120
0
2000
4000
6000
8000
M_{Higgs}[GeV]
M[GeV]


$M_h = 126 \pm 1$ GeV
10000
1000
100
masses [GeV]
h
H
A
$H^{\pm}$
$stop_{1,2}$
$sbot_{1,2}$
gl
$stau_{1,2}$
$cha_{1,2}$
$neu_{1,2,3,4}$



$M_h = 126 \pm 3$ GeV
masses [GeV]
10000
1000
100
h
H
A
$H^{\pm}$
$stop_{1,2}$
$sbot_{1,2}$
gl
$stau_{1,2}$
$cha_{1,2}$
$neu_{1,2,3,4}$

MSSM

Mondragon
Tracas, Z

- Based on the new observation that top, bottom Yukawa couplings and α_s satisfy RGI relations, i.e. are successfully (theoretically and experimentally!) reduced
- • Assuming in addition a RGI relation among the trilinear couplings in the superpotential and in the corresponding ones in the soft supersymmetry breaking (scalar) sector

$\rightarrow$ Prediction of the Higgs masses and s-spectrum

All-loop relations among SSB β-functions

Yamada
Hisano-Shifman
Kazakov
Jack-Jones-Pickering

$$\beta_M = 2\mathcal{O}\left(\frac{\beta_g}{g}\right)$$

$$\beta_h^{ijk} = \gamma^i{}_l h^{ljk} + \gamma^j{}_l h^{ilk} + \gamma^k{}_l h^{ijl} - 2\gamma_1{}^i{}_l C^{ljk} - 2\gamma_1{}^j{}_l C^{ilk} - 2\gamma_1{}^k{}_l C^{ijl}$$

$$(\beta_{m^2})^i_j = \left[\Delta + X\frac{\partial}{\partial g}\right]\gamma^i_j$$

where $\mathcal{O} = \left(Mg^2\frac{\partial}{\partial g^2} - h^{lmn}\frac{\partial}{\partial C^{lmn}}\right)$

$$\Delta = 2\mathcal{O}\mathcal{O}^* + 2|M|^2 g^2\frac{\partial}{\partial g^2} + \tilde{C}_{lmn}\frac{\partial}{\partial C_{lmn}} + \tilde{C}^{lmn}\frac{\partial}{\partial C^{lmn}}$$

$$(\gamma_1)^i_j = \mathcal{O}\gamma^i_j, \quad C_{lmn} = (C^{lmn})^*$$

$$\tilde{C}^{ijk} = (m^2)^i{}_l C^{ljk} + (m^2)^j{}_l C^{ilk} + (m^2)^k{}_l C^{ijl}$$

Assuming the existence of RGI surfaces on which

a) $C = C(g)$ or equivalently

$$\frac{dC^{ijk}}{dg} = \frac{\beta_C^{ijk}}{\beta_g}$$

i.e. reduction of couplings

b) $$h^{ijk} = -M \frac{dC^{ijk}(g)}{d\ln g}$$

$$\Rightarrow \begin{cases} M = \dfrac{\beta_g}{g} M_0 \\ h^{ijk} = -M_0 \beta_C^{ijk} \\ b^{ij} = -M_0 \beta_\mu^{ij} \\ m_i^2 + m_j^2 + m_k^2 = |M|^2 \dfrac{d\ln C^{ijk}}{d\ln g} \end{cases}$$

Jack-Jones

Kobayashi-Kubo-Z

are RGI to all-loops.

In supergavity framework,

$M_0 = m_{3/2}$ gravitino mass

Sketch of proof

Assuming $C\frac{\partial}{\partial C} = C^*\frac{\partial}{\partial C^*}$

for a RGI surface $F(g, C^{ijk}, C^{ijk*})$

$$\rightsquigarrow \frac{d}{dg} = \left(\frac{\partial}{\partial g} + 2\frac{\beta_C}{\beta_g}\frac{\partial}{\partial C}\right)$$

Consider

$$\mathcal{O} = \left(M g^2 \frac{\partial}{\partial g^2} - h\frac{\partial}{\partial C}\right)$$

$$\xrightarrow{(b)} \mathcal{O} = \frac{1}{2} M \frac{d}{d\ln g}$$

and $\beta_M = M \frac{d}{d\ln g}\left(\frac{\beta_g}{g}\right)$

$$\Longrightarrow M = \frac{\beta_g}{g} M_0$$

|| Generalised Hisano - Shifman

Similarly we obtain the rest relations

Application of the RGI relations in MSSM

$$W = Y_t Q H_2 t^c + Y_b Q H_1 b^c + \mu H_1 H_2 + \cdots$$

$$\mathcal{L}_{SSB} = \sum_{\phi} m_\phi^2 \phi^* \phi + \left[m_3^2 H_1 H_2 + \sum_{i=1}^{3} \frac{1}{2} M_i \lambda_i \lambda_i + h.c. \right]$$

$$+ h_t \phi_Q H_2 \phi_{t^c} + h_b \phi_Q H_1 \phi_{b^c} + \cdots + h.c.$$

In MSSM the assumption (a) is a fact! as we have seen, i.e.

$$dY_{t,b} / d g_3 = \beta_{Y_{t,b}} / \beta_{g_3} \text{ hold.}$$

Then assuming (b), i.e. that

$$h_{t,b} = - M \, d Y_{t,b} / dg$$

is RGI to all-loops,

we obtain that

the following relations are RGI to all-loops

$$M = \beta_{g_3}/g_3 \; M_U$$

$$h_{t,b} = - M_U \, g_3 \, dY_{t,b}/dg_3$$

$$m_3 = - M_U \, g_3 \, d\mu/dg_3$$

$$m_i^2 + m_j^2 + m_k^2 = |M_U|^2 \, dY_{t,b}/d\ln g_3$$

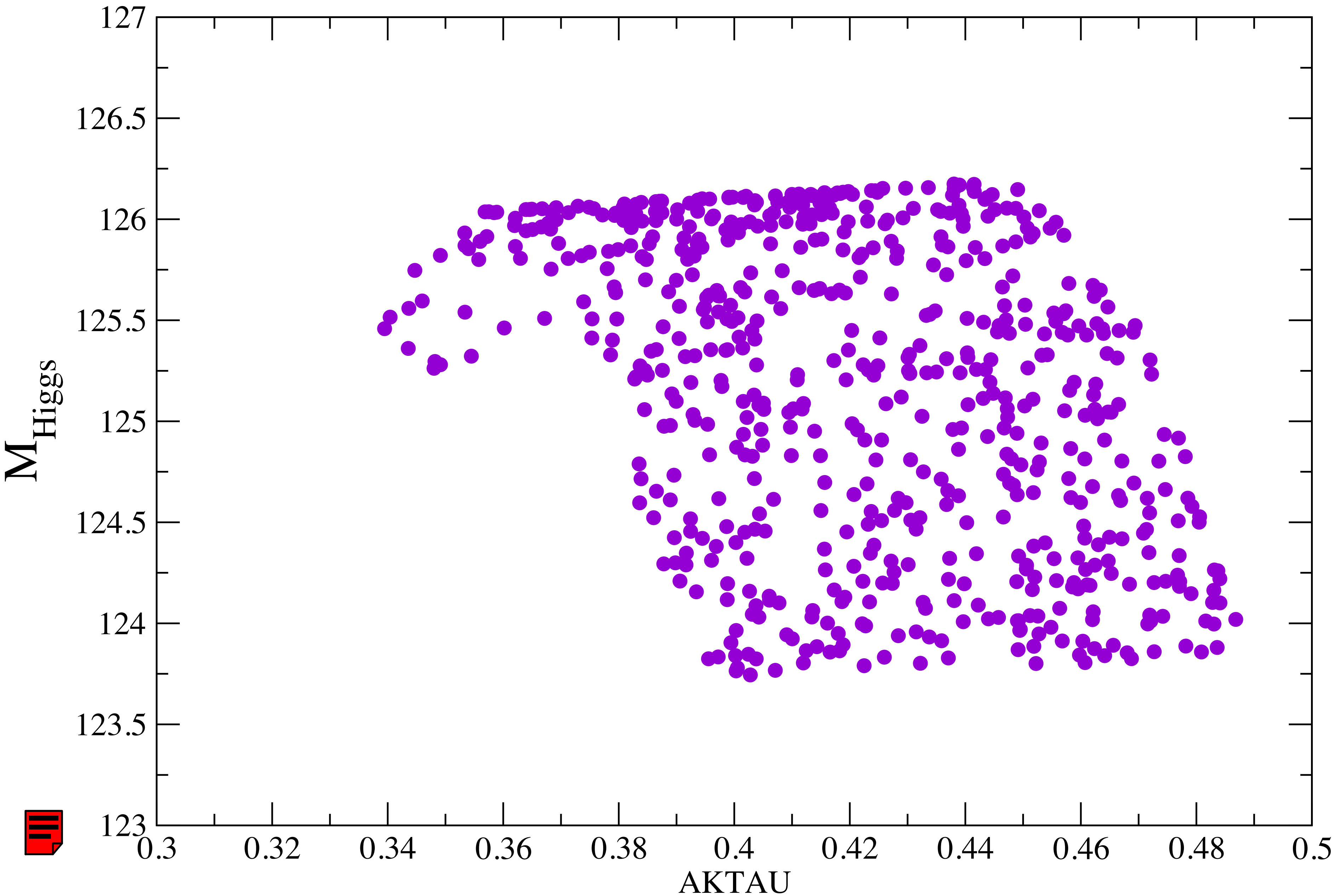
$$= 1 \quad \text{(at 1-loop)}$$

Since all gauge couplings meet at the unification scale M_U, we have the following boundary conds at M_U

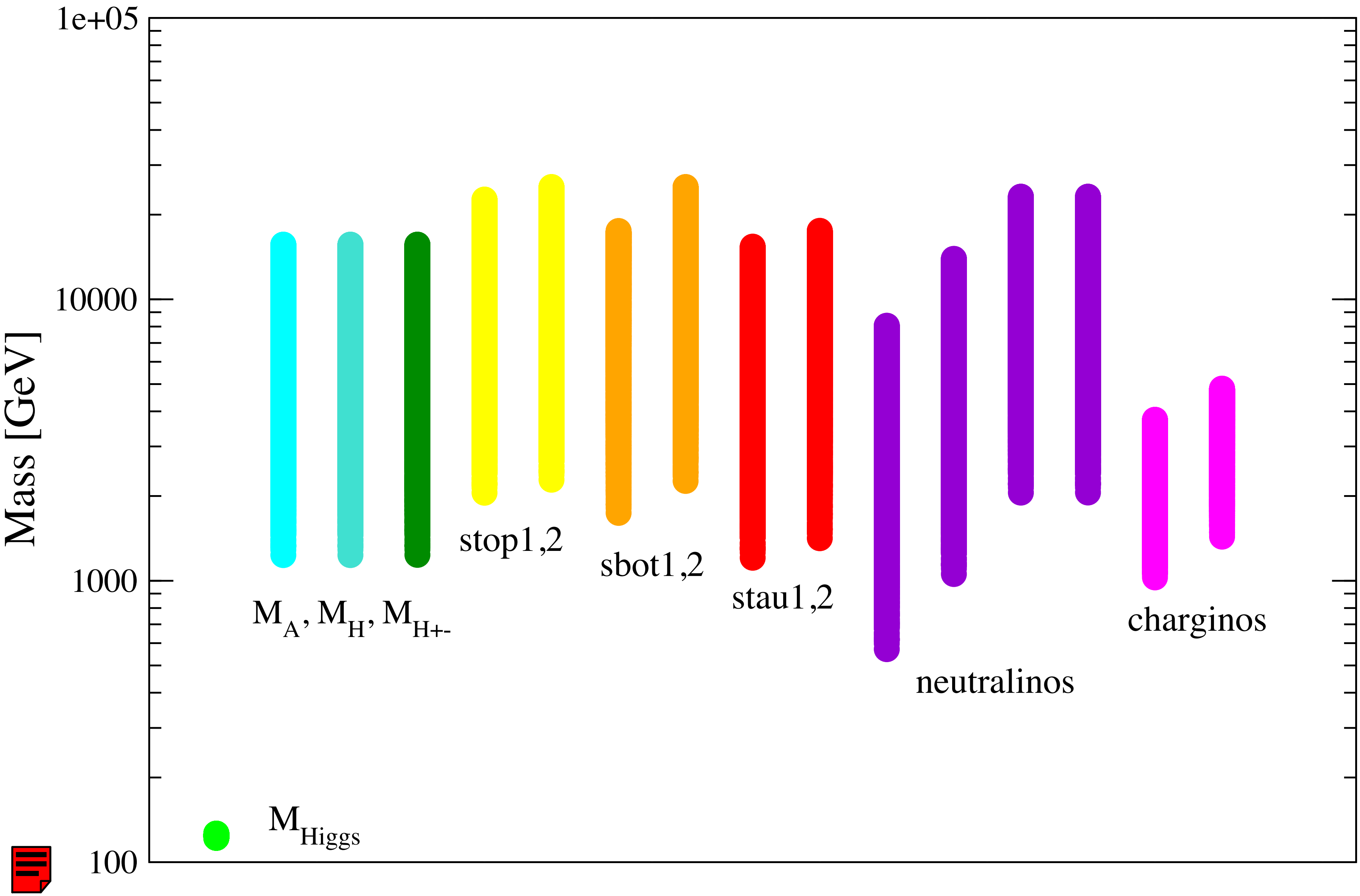
$$Y_{t,b} = c_{t,b} \, g_U \,, \quad h_{t,b} = M_U \, Y_{t,b}$$

$$m_3 = - M_U \, \mu \,,$$

$$m_{H_2}^2 + m_{\phi_Q}^2 + m_{\phi_{t^c}}^2 = M_U^2 \,, \quad m_{H_1}^2 + m_{\phi_Q}^2 + m_{\phi_{b^c}}^2 = M_U^2$$



127
126.5
126
125.5
125
124.5
124
123.5
123
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
0.46
0.48
0.5
AKTAU
M_{Higgs}



1e+05
10000
1000
100
Mass [GeV]
M_A, M_H, M_H+-
stop1,2
sbot1,2
stau1,2
neutralinos
charginos
M_Higgs

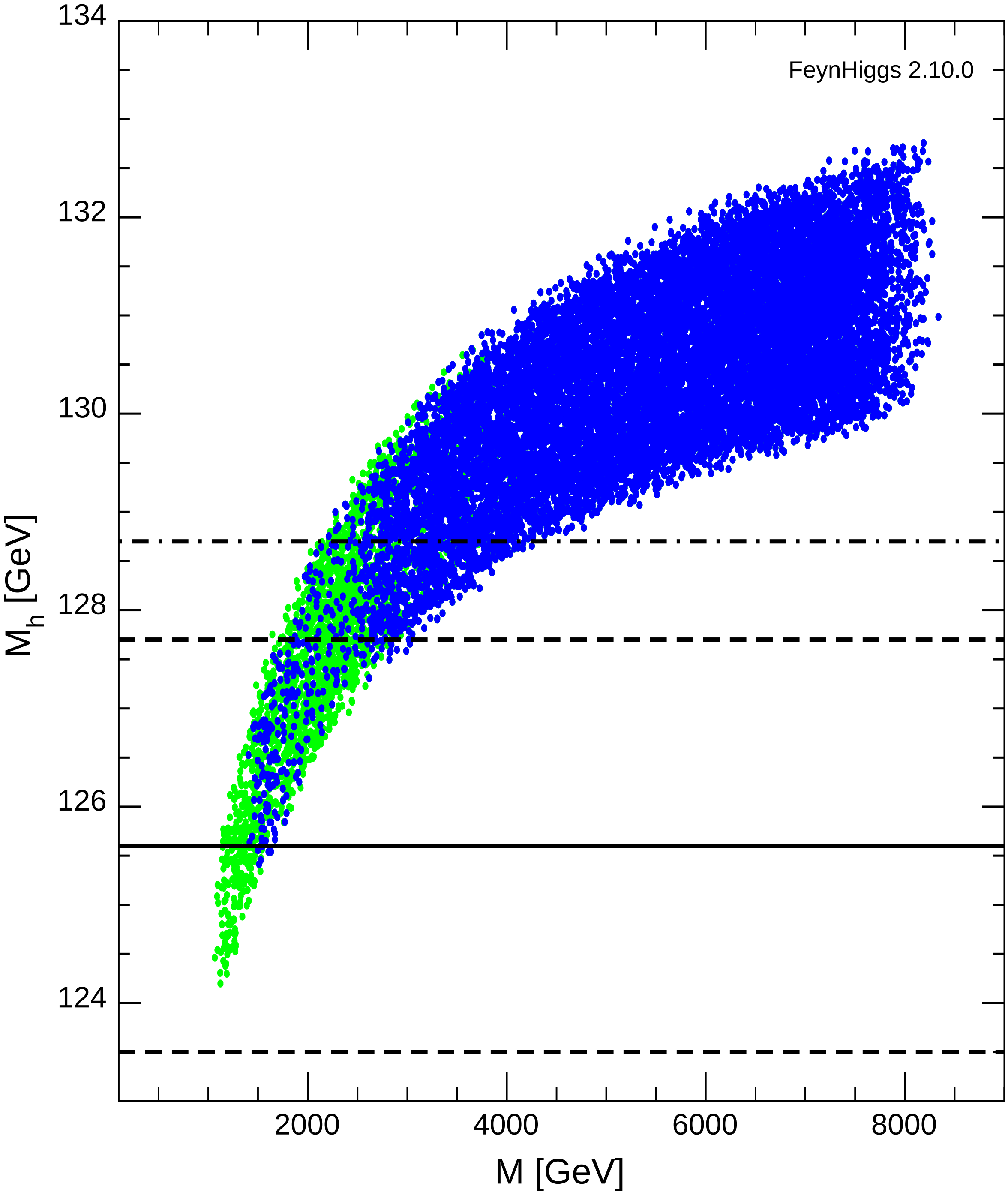


Figure 2: The lightest Higgs boson mass, M_h, as a function of M in the model $\boldsymbol{SU(5)}$**-FUT** (with $\mu < 0$) . The blue points fulfill the B-physics constraints (see text).

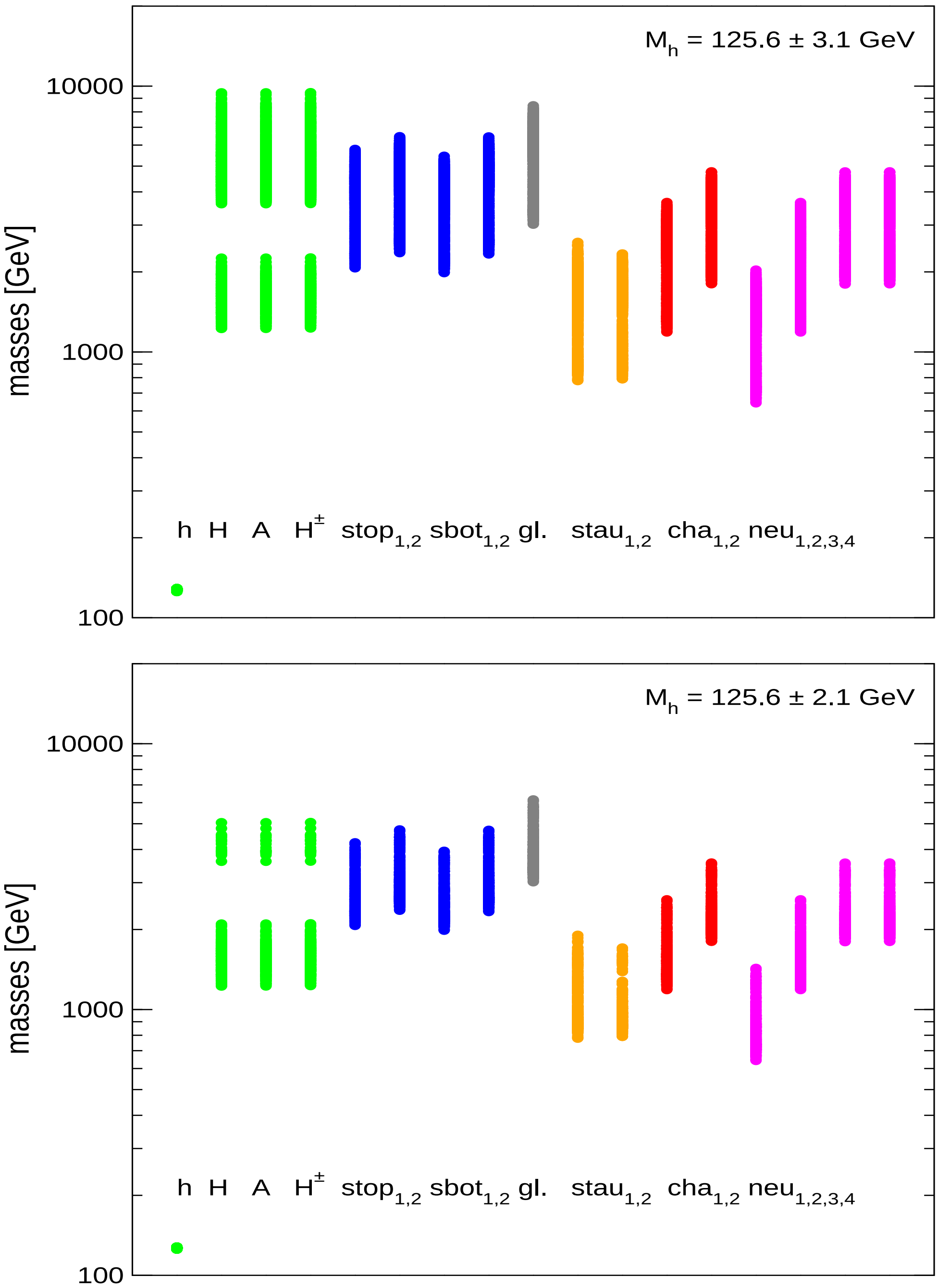


Figure 3: The upper (lower) plot shows the spectrum of $\boldsymbol{SU(5)}$**-FUT** (with $\mu < 0$) after imposing the constraint $M_h = 125.6 \pm 3.1\,(2.1)$ GeV. The points shown are in agreement with the quark mass constraints and the B-physics observables. The light (green) points on the left are the various Higgs boson masses. The dark (blue) points following are the two scalar top and bottom masses, followed by the lighter (gray) gluino mass. Next come the lighter (beige) scalar tau masses. The darker (red) points to the right are the two chargino masses followed by the lighter shaded (pink) points indicating the neutralino masses.

$m_b(M_Z)$	2.74	m_t	172.1
M_h	127.4	M_A	1514
M_H	1514	$M_{H^\pm}$	1518
$m_{\tilde{t}_1}$	2483	$m_{\tilde{t}_2}$	2808
$m_{\tilde{b}_1}$	2403	$m_{\tilde{b}_2}$	2786
$m_{\tilde{\tau}_1}$	892	$m_{\tilde{\tau}_2}$	1089
$m_{\tilde{\chi}_1^\pm}$	1453	$m_{\tilde{\chi}_2^\pm}$	2127
$m_{\tilde{\chi}_1^0}$	790	$m_{\tilde{\chi}_2^0}$	1453
$m_{\tilde{\chi}_3^0}$	2123	$m_{\tilde{\chi}_4^0}$	2127
$m_{\tilde{g}}$	3632		

$m_b(M_Z)$	2.82	m_t	172.5
M_h	128.6	M_A	4862
M_H	4861	$M_{H^\pm}$	4867
$m_{\tilde{t}_1}$	4167	$m_{\tilde{t}_2}$	4666
$m_{\tilde{b}_1}$	3913	$m_{\tilde{b}_2}$	4650
$m_{\tilde{\tau}_1}$	1593	$m_{\tilde{\tau}_2}$	1756
$m_{\tilde{\chi}_1^\pm}$	2547	$m_{\tilde{\chi}_2^\pm}$	3515
$m_{\tilde{\chi}_1^0}$	1405	$m_{\tilde{\chi}_2^0}$	2547
$m_{\tilde{\chi}_3^0}$	3512	$m_{\tilde{\chi}_4^0}$	3515
$m_{\tilde{g}}$	6066		

Table 1: A heavy (light) spectrum of a ***SU*(5)-FUT** (with $\mu < 0$) parameter point is shown in the right (left) table. Both are compliant with the B physics constraints. All masses are in GeV.

In spite of their limitations, perturbative local field theories are still of prominent practical value.

It is remarkable that the intrinsic ambiguities connected with locality and causality – most of the time associated with ultraviolet infinities – can be summarized in terms of a formal group which acts in the space of the coupling constants or coupling functions attached to each type of local interaction.

It is therefore natural to look systematically for stable submanifolds. Some such have been known for a long time: e.g., spaces of renormalizable interactions and subspaces characterized by systems of Ward identities mostly related to symmetries.

A systematic search for such stable submanifolds has been initiated by W. Zimmermann in the early eighties.

Disappointing for some time, this program has attracted several other active researchers and recently produced physically interesting results.

It looks at the moment as the only theoretically founded algorithm potentially able to decrease the number of parameters within the physically favoured perturbative models.

<u>Πρόταση</u>

του ΕΙΘΕΕ στην σημερινή δύσκολη κατάσταση της εκπαίδευσης και της έρευνας στην Ελλάδα

Διοργάνωση εκστρατείας σε παγκόσμιο επίπεδο ώστε να σωθεί η ελληνική παιδεία και η έρευνα κατά το πρότυπο των αντίστοιχων επιτυχημένων προσπαθειών για να σωθούν οι Ακαδημίες της Ρωσίας και της Βουλγαρίας.

Προτείνεται η σύνταξη επιστολής στην οποία, με έγκυρα στοιχεία:

- Αφού τονίσουμε τη διαπίστωση κοινής λογικής: η εκπαίδευση σε όλα τα επίπεδα και η έρευνα είναι τα βασικά θεμέλια της οποιασδήποτε ανάπτυξης και πρέπει να προστατευθούν ως «κόρη οφθαλμού» στις επιλογές της Ελληνικής Κυβέρνησης.
- Να αποτυπώνουμε την αγωνία μας για την εξέλιξη του επιπέδου της εκπαίδευσης και έρευνας στο άμεσο μέλλον στη χωρά μας, με βάση την τρέχουσα κυβερνητική πολιτική, παραθέτοντας έγκυρα στοιχεία.
- Να ζητάμε από τα κεντρικά όργανα της Ευρωπαϊκής Ένωσης, Ευρωπαϊκό Κοινοβούλιο, Ευρωπαϊκές Κυβερνήσεις να «εξηγήσουν» τις παραπάνω διαπιστώσεις στην Ελληνική Κυβέρνηση και την Τρόικα και να τους υποδείξουν ότι πρέπει να εξαιρέσουν την εκπαίδευση και την έρευνα από τα μέτρα που παίρνουν γιατί διαφορετικά το μακροπρόθεσμο αποτέλεσμα θα είναι αντίθετο προς αυτό που θα έπρεπε να επιδιώκει η Ελληνική Κυβέρνηση.
- Ελάχιστο αιτούμενο είναι η συνολική χρηματοδότηση να φτάσει στα προ του 2009 δεδομένα με τάση να ξεπεράσει τον ευρωπαϊκό μέσο όρο, ώστε να καλυφτεί σε κάποιο βαθμό η τεράστια ζημιά που έγινε ήδη. Ιδιαίτερα πρέπει να τονιστεί η ανάγκη δημιουργίας εκπαιδευτικής και ερευνητικής "αριστείας" με προκήρυξη σχετικών προγραμμάτων σε μόνιμη βάση και όχι περιστασιακά.

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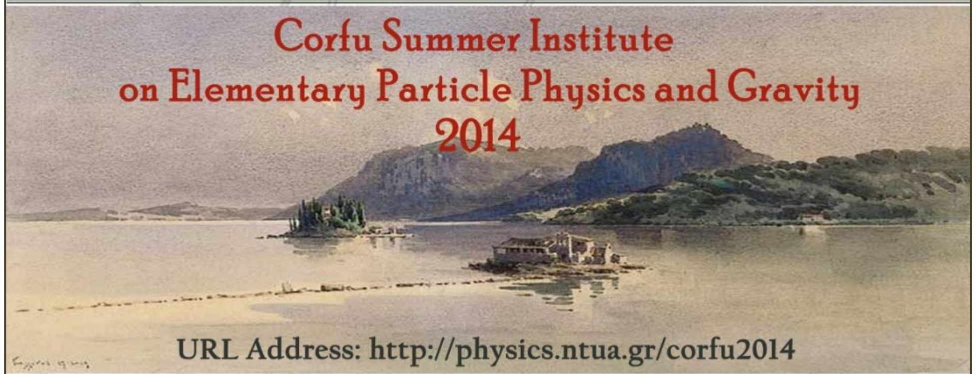

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