SUSY Forever

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Motivation for Susy

SUSY is a “better” quantum field theory with improved ultraviolet properties. This might be useful for

- stabilization of the weak scale (hierarchy problem)
- discussions of dark energy
- models of inflation

Within particle physics (beyond the standard model) this leads to

- candidates for WIMP dark matter
- realization of grand unified models
- a variety of new particles

Predictions

There was some optimism in the early 80's:

- Experiments within the next five to ten years will tell us whether supersymmetry at the weak scale is a myth or reality. (Nilles, 1984)

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The statement was motivated in view of LEP. Today we wait for LHC results. Where are we now?

- No sign for physics beyond the Standard Model
- No (SM) Higgs boson seen either, yet?
- Do we have to worry?

A well-motivated pattern

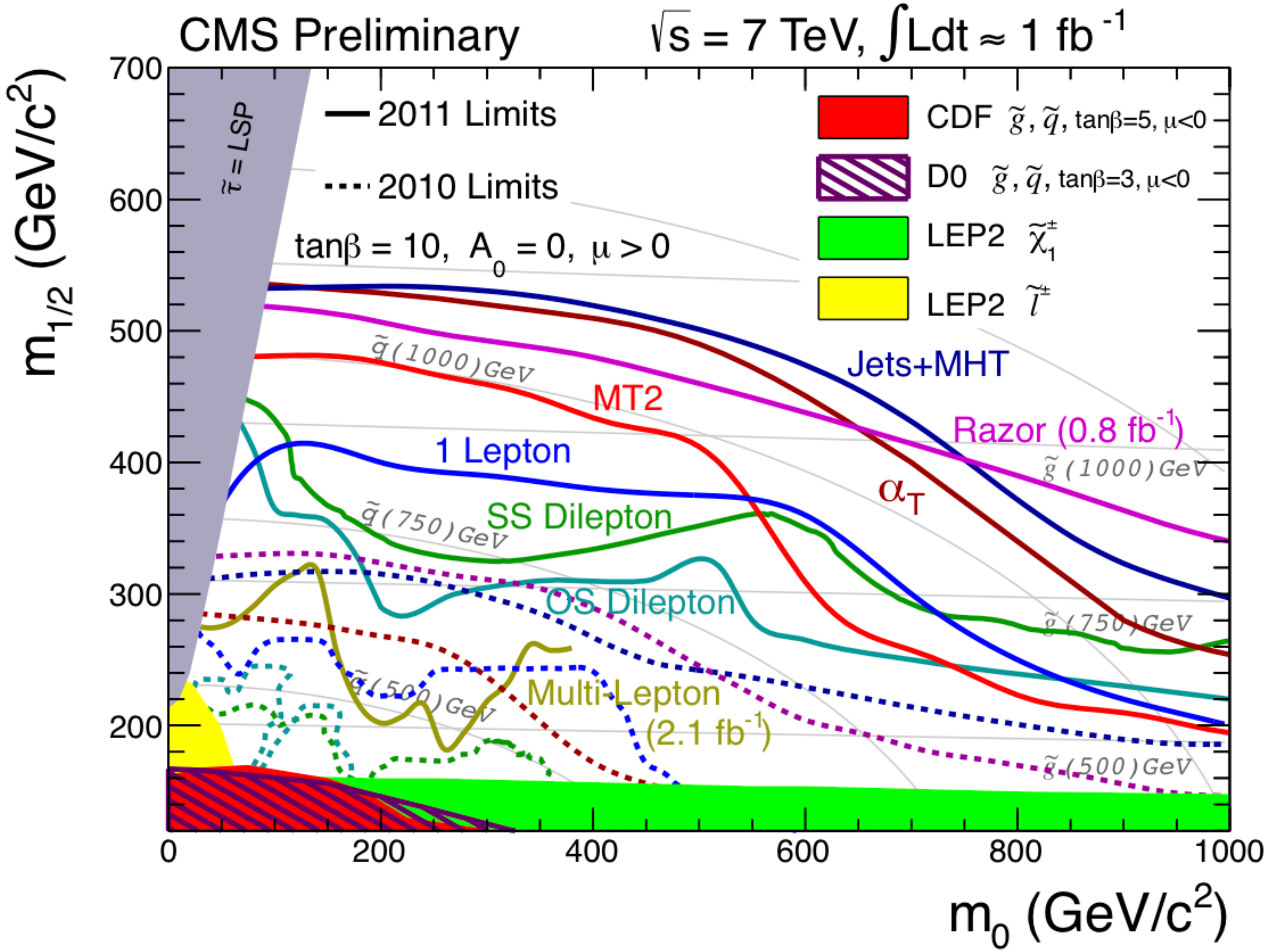
A specific pattern for the soft masses with a
large gravitino mass in multi-TeV range

- normal squarks and sleptons in multi-TeV range
- top squarks $(\tilde{t}_L, \tilde{b}_L)$ and $\tilde{t}_R$ in TeV-range (suppressed by $\log(M_{\mathrm{Planck}}/m_{3/2}) \sim 4\pi^2$)
- A-parameters in TeV range
- gaugino masses in TeV range
- mirage pattern for gaugino masses (compressed spectrum)

A well motivated pattern emerging from the heterotic string.

(Krippendorf, Nilles, Ratz, Winkler, 2012)

SUSY Search



CMS Preliminary
√s = 7 TeV, ∫Ldt ≈ 1 fb⁻¹
m1/2 (GeV/c2)
m0 (GeV/c2)
2011 Limits
2010 Limits
tanβ = 10, A0 = 0, μ > 0
τ̃ = LSP
CDF g̃, q̃, tanβ=5, μ<0
D0 g̃, q̃, tanβ=3, μ<0
LEP2 χ̃±1
LEP2 l̃±
Jets+MHT
Razor (0.8 fb-1)
αT
MT2
1 Lepton
SS Dilepton
OS Dilepton
Multi-Lepton
(2.1 fb-1)
q̃(1000)GeV
q̃(750)GeV
q̃(500)GeV
g̃(1000)GeV
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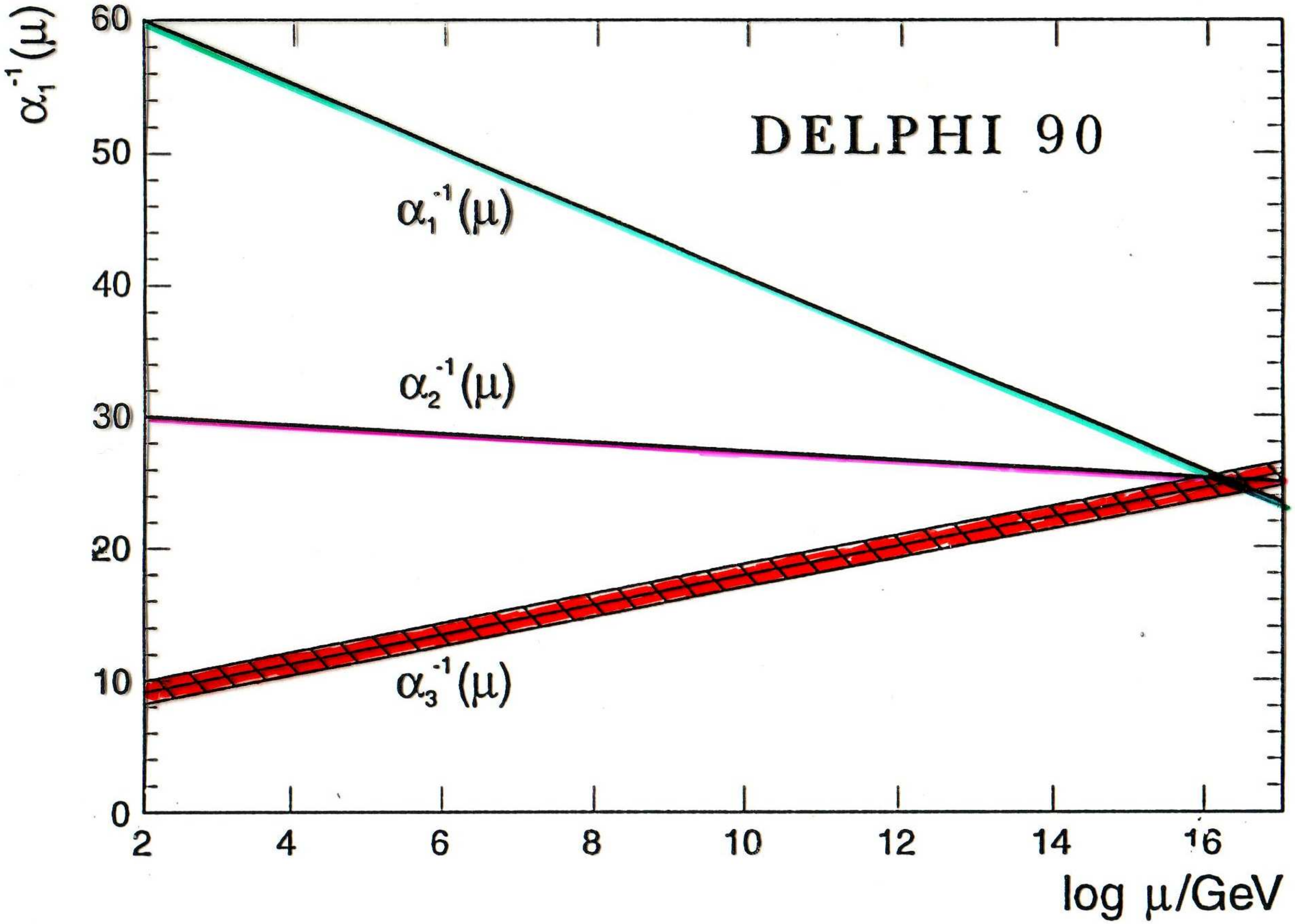
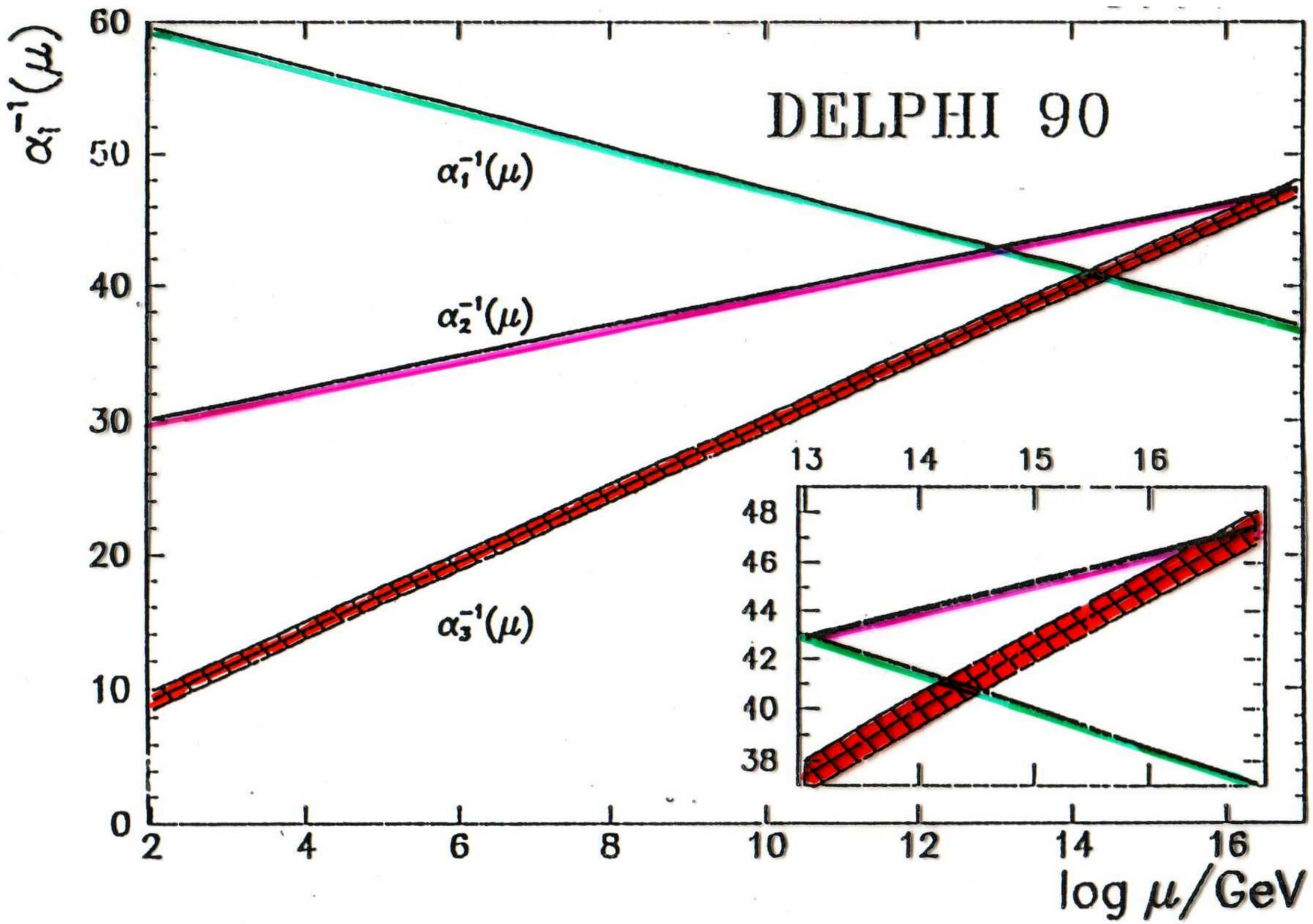
SUSY Predictions

- gauge coupling unification (mainly from gauginos)

MSSM (supersymmetric)



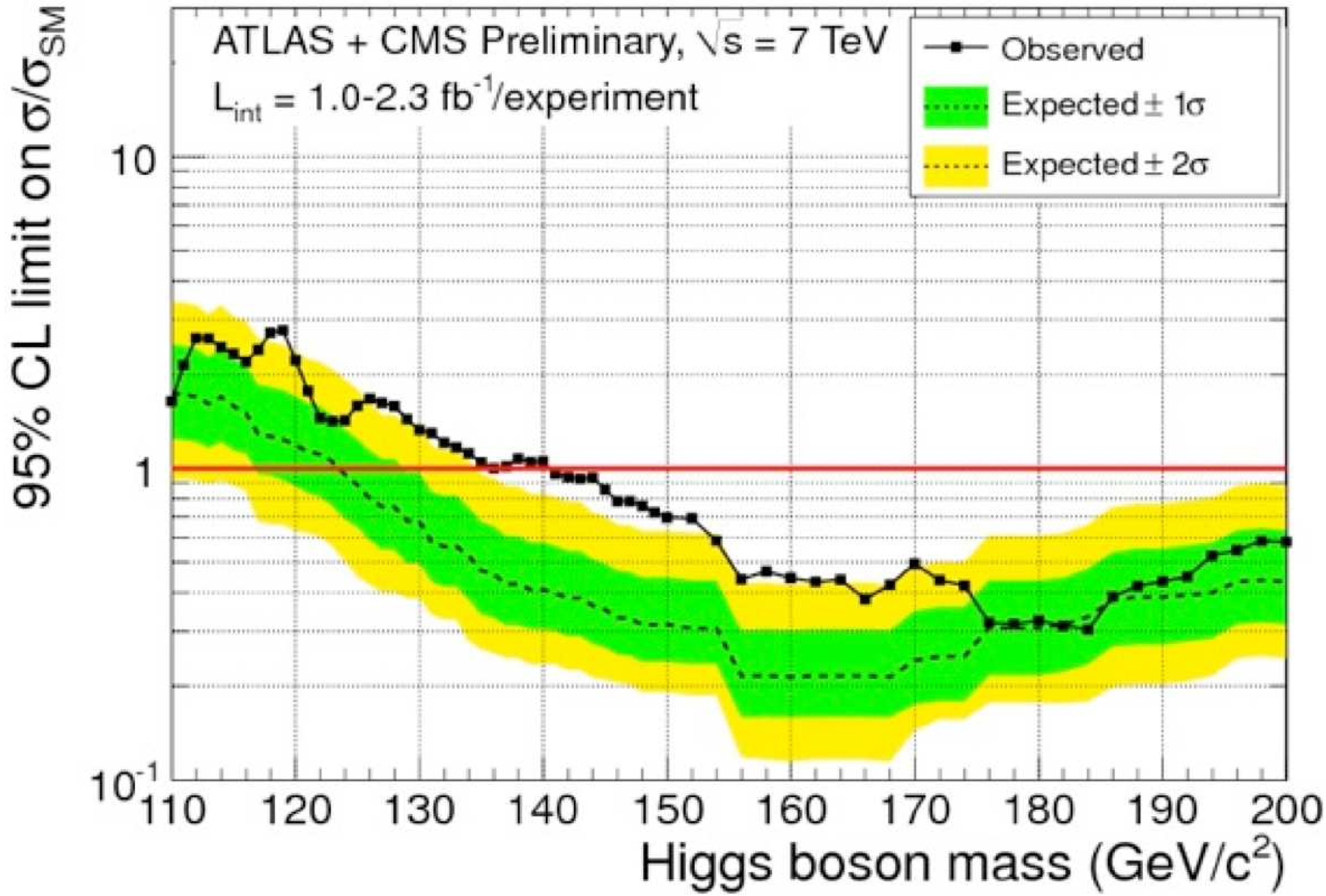
Standard Model



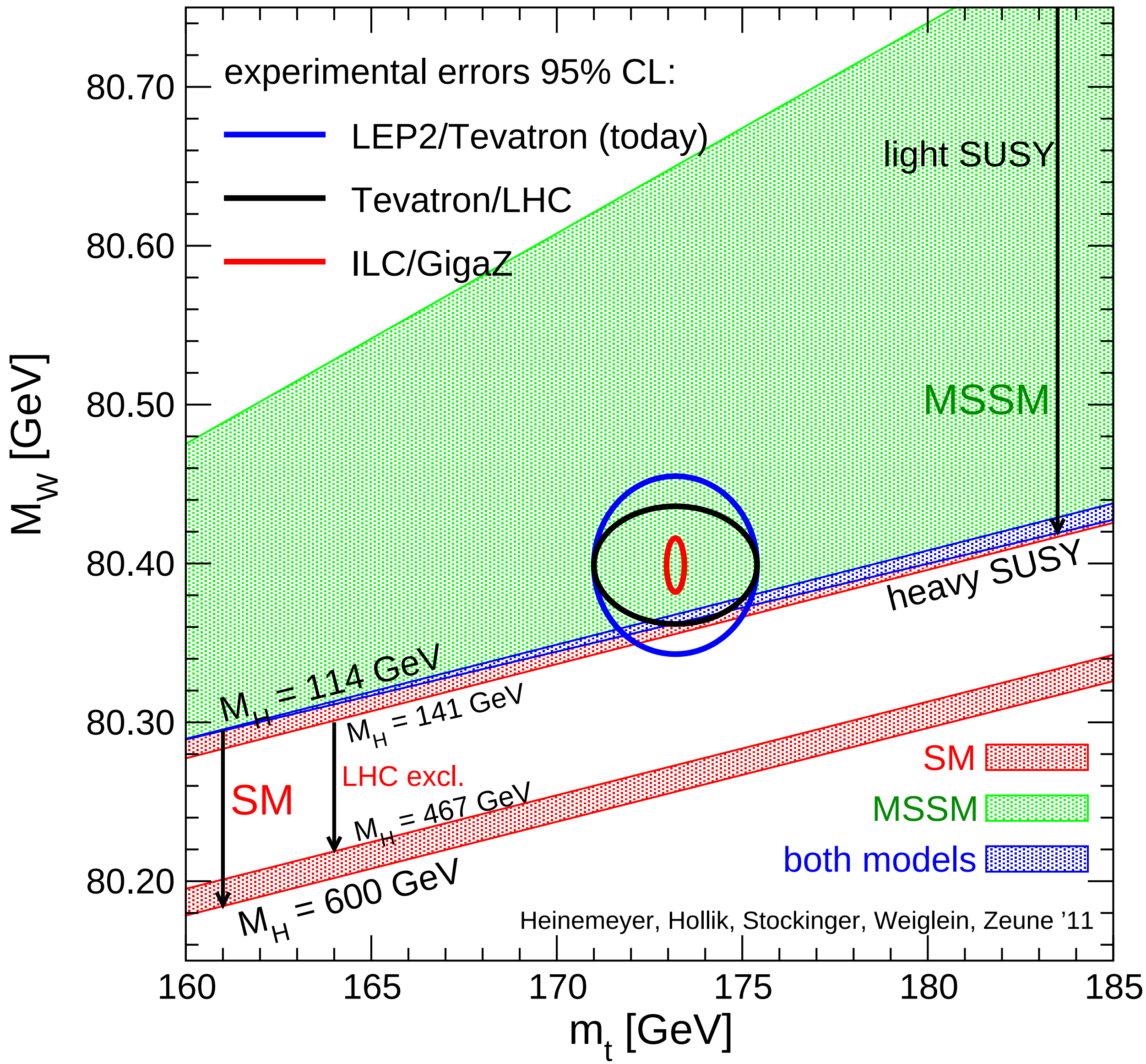
SUSY Predictions: MSSM

- gauge coupling unification (mainly from gauginos)
- 2 Higgs (super) multiplets
- heavy top quark
- upper bound on the lightest Higgs boson
  (a unique prediction compared to other scenarii for physics beyond the Standard Model)

Higgs-Window



SM versus MSSM



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What are the mass scales?

- lightest Higgs mass less than 130 GeV
- superpartners TeV or multi-TeV?
- light LSP as a candidate for WIMP dark matter
- old “No Lose” theorem: 20+20 TeV at the SSC

The “Top Story”

- tau and bottom found in the 70’s: prediction of top quark
- toponium ($t\bar{t}$) at 27 GeV
- PETRA/PEP with CM-energy up to 40 GeV
- discovery of Higgs form $t\bar{t}$ to Higgs + Gamma?

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The Top Quark is a special particle!

- early 80's: SUSY models with radiative EW-symmetry breakdown required heavy top-quark
- even 50 GeV was considered ridiculously large
- a natural reason for 175 GeV: "Gauge-Top-Unification"
- today heavy top needed for $m_H > 114$ GeV

Some questions

What are “natural” values for SUSY?

- gaugino mass pattern
- gaugino versus fermion masses
- which parameters are more “robust”

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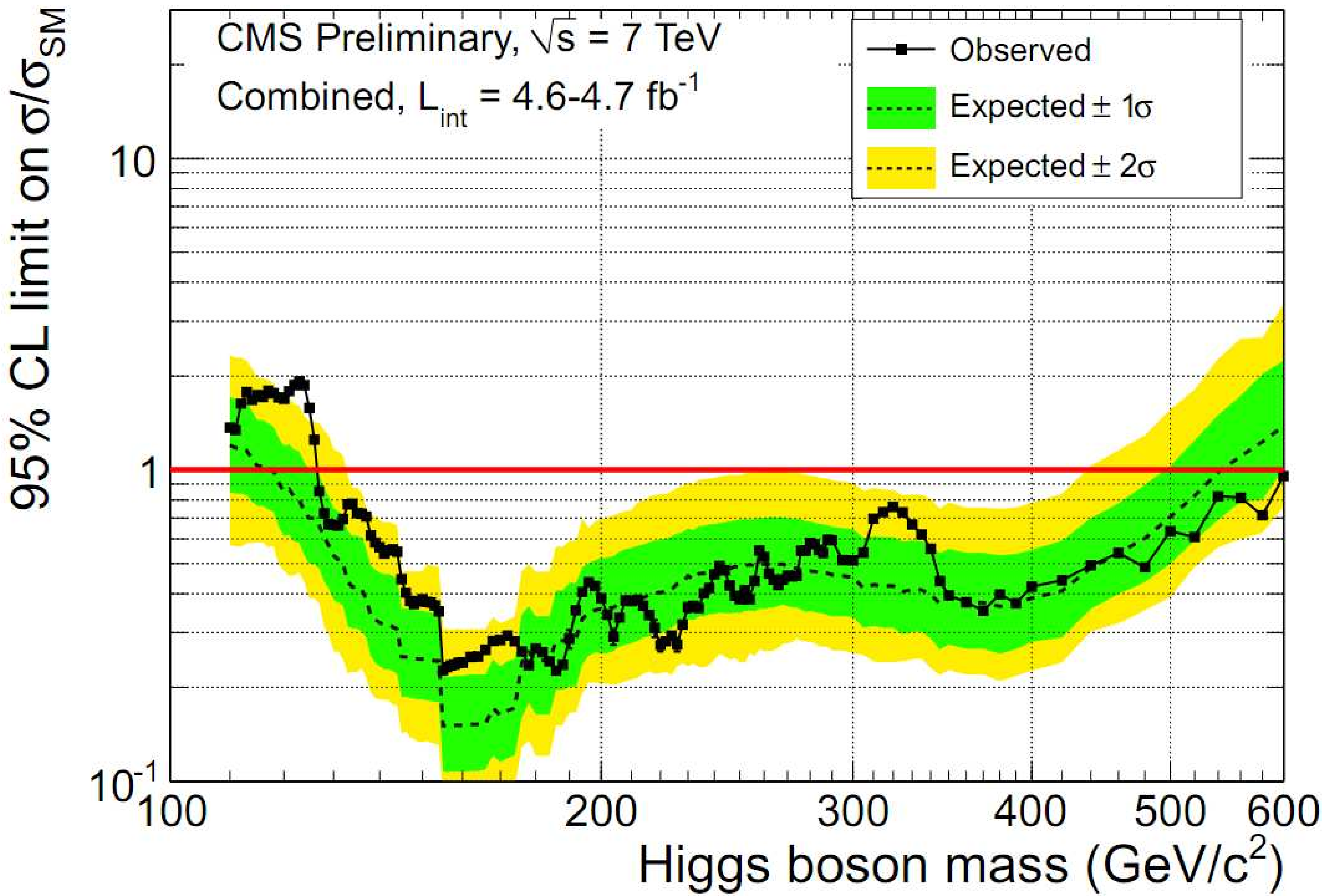
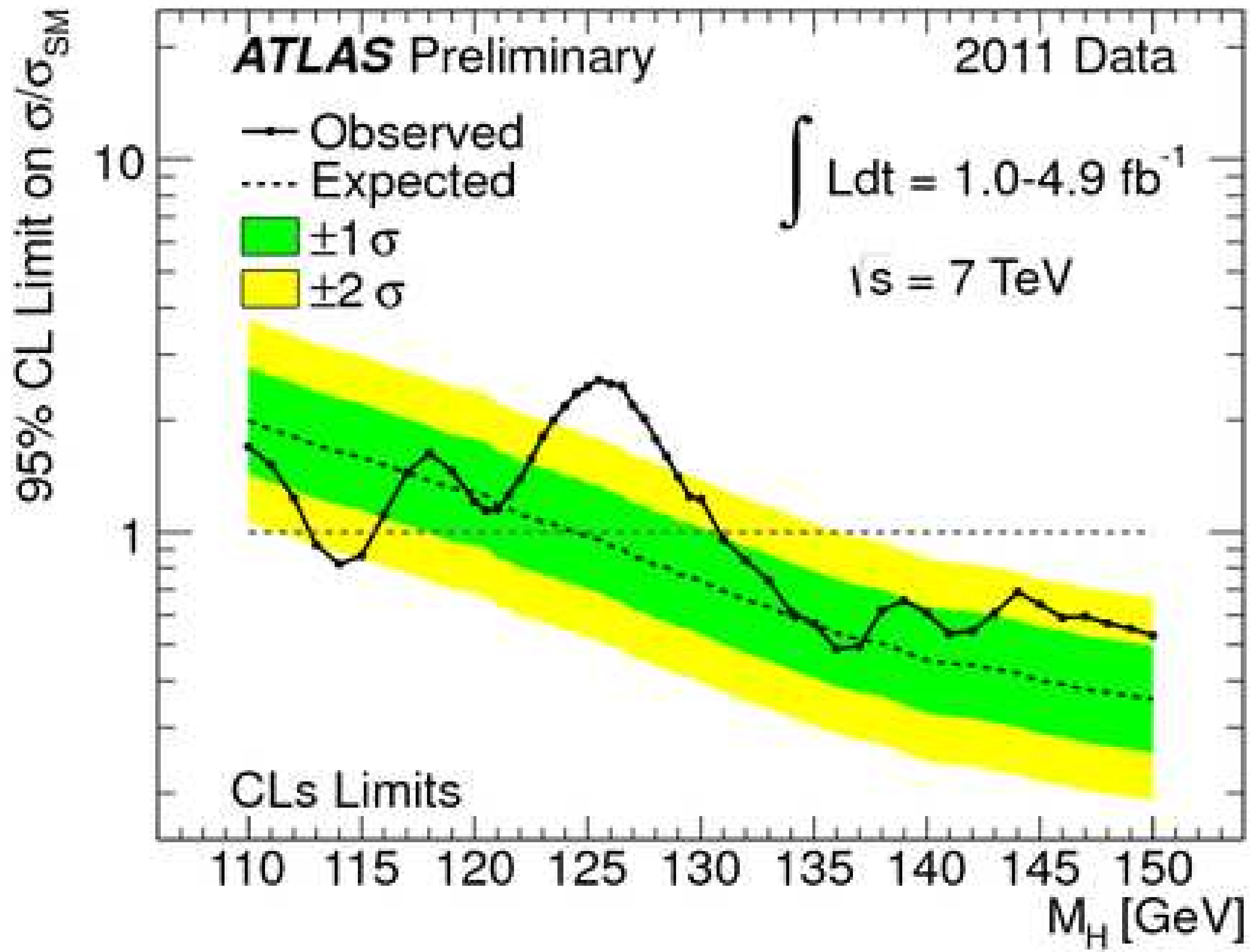
Can we rule out SUSY?

- find a heavy Higgs (this opportunity has been missed already)
- find something else as physics BeyondSM
- does SUSY die or has it to fade away?

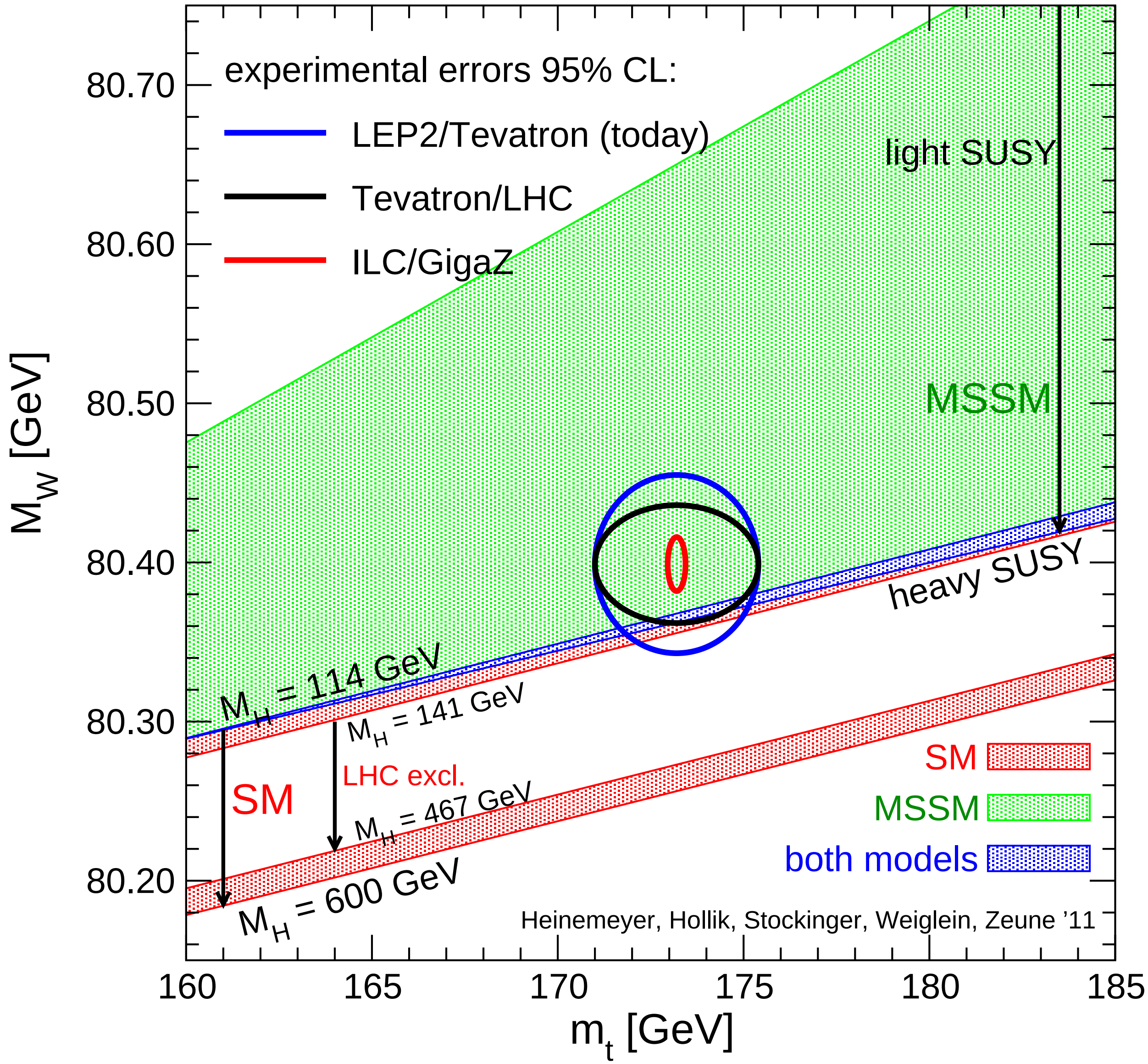
Higgs Window



Perturbative Higgs as of 13.12.11



SM vs. MSSM and the Higgs



Messages

Some theoretical guidelines:

- wait till we really know the mass of Higgs boson
- analyze the decay properties of Higgs boson
- gaugino mass predictions are robust
- predictions for scalar masses less reliable

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Potentially relevant questions:

- what is the pattern of gaugino masses?
- are super-heavy sfermions possible?
- are some of the soft mass terms suppressed?

Reading the Gaugino Code

First step to test these ideas at the LHC:

look for pattern of gaugino masses

Let us assume the

- low energy particle content of the MSSM
- measured values of gauge coupling constants

$$g_1^2 : g_2^2 : g_3^2 \simeq \; 1 : 2 : 6$$

The evolution of gauge couplings would then lead to unification at a GUT-scale around 10^{16} GeV

Gravity (Modulus) Mediation

Universal gaugino mass at the GUT scale

- mSUGRA pattern:

$$M_1 : M_2 : M_3 \simeq \; 1:2:6 \simeq \; g_1^2 : g_2^2 : g_3^2$$

as realized in popular schemes such as gravity-, modulus- and dilaton-mediation

This leads to

- LSP χ_1^0 predominantly Bino
- $G = M_{\text{gluino}}/m_{\chi_1^0} \simeq 6$

as a characteristic signature of these schemes.

Anomaly Mediation

Gaugino masses below the GUT scale are determined by the β functions

- anomaly pattern:

$$M_1 : M_2 : M_3 \simeq \; 3.3 : 1 : 9$$

at the TeV scale as the signal of anomaly mediation.

For the gauginos, this implies

- LSP χ_1^0 predominantly Wino
- $G = M_{\rm gluino}/m_{\chi_1^0} \simeq 9$

Pure anomaly mediation inconsistent, as sfermion masses are problematic in this scheme (tachyonic sleptons).

Guide lines from string theory

Is there a general pattern of the soft mass terms?

We always have (from flux and gaugino condensate)

$$W = \text{something} - \exp(-X)$$

where "something" is small and X is moderately large.

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We always have (from flux and gaugino condensate)

$$W = \text{something} - \exp(-X)$$

where "something" is small and X is moderately large.

In fact in this simple scheme

$$X \sim \log(M_{\text{Planck}}/m_{3/2})$$

providing a "little" hierarchy.

(Choi, Falkowski, HPN, Olechowski, Pokorski, 2004)

Mixed Mediation Schemes

The contribution from "Modulus Mediation" is therefore suppressed by the factor

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$$X \sim \log(M_{\mathrm{Planck}}/m_{3/2}) \sim 4\pi^2.$$

Thus the contribution due to radiative corrections becomes competitive, leading to mixed mediation schemes.

The simplest case for radiative corrections leads to anomaly mediation competing now with the suppressed contribution of modulus mediation.

For reasons that will be explained later we call this scheme

MIRAGE MEDIATION

(Loaiza, Martin, HPN, Ratz, 2005)

The little hierarchy

$$m_X \sim \langle X \rangle m_{3/2} \sim \langle X \rangle^2 m_{\rm soft}$$

is a generic signal of such a scheme

- moduli and gravitino are heavy
- gaugino mass spectrum is compressed

(Choi, Falkowski, HPN, Olechowski, 2005; Endo, Yamaguchi, Yoshioka, 2005; Choi, Jeong, Okumura, 2005)

- lightest modulus has mass $m_{3/2} \log(M_{\rm Planck}/m_{3/2})$
- and thus avoids cosmological problems with moduli fields

Top-down arguments

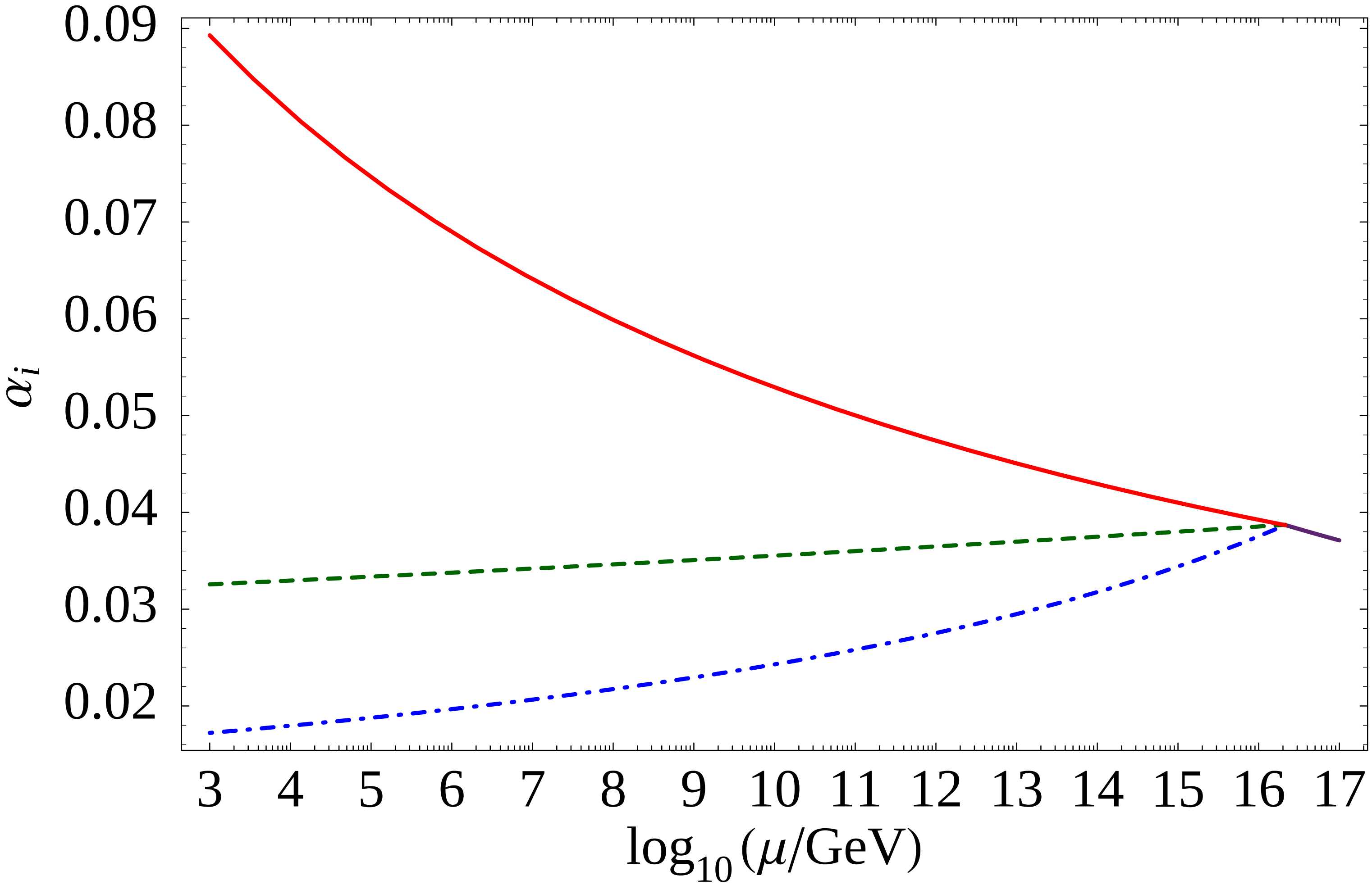
In string theory we have (from flux and gaugino condensate)

$$W = \text{flux} - \exp(-X)$$

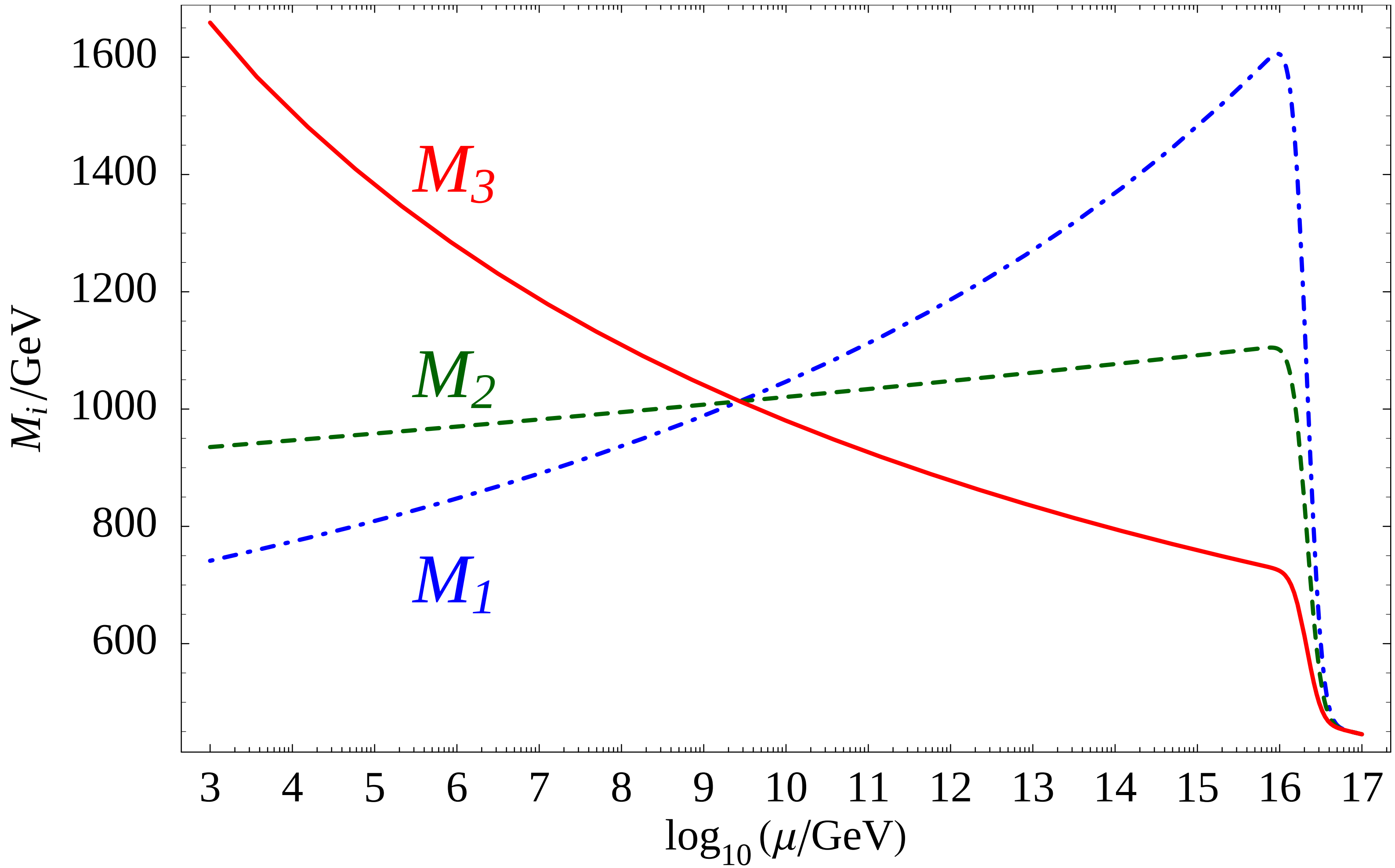
- modulus mediation suppressed
  $X \sim \log(M_{\text{Planck}}/m_{3/2}) \sim 4\pi^2$
- radiative corrections become relevant (proportional to the β function, i.e. negative for the gluino, positive for the bino)
- Mixed mediation scheme: Mirage Mediation (MMAM)
- Mirage pattern for gaugino masses:
  $m_{1/2} \sim m_{3/2}/4\pi^2$

(Choi, Falkowski, Nilles, Olechowski, 2005)

Evolution of couplings

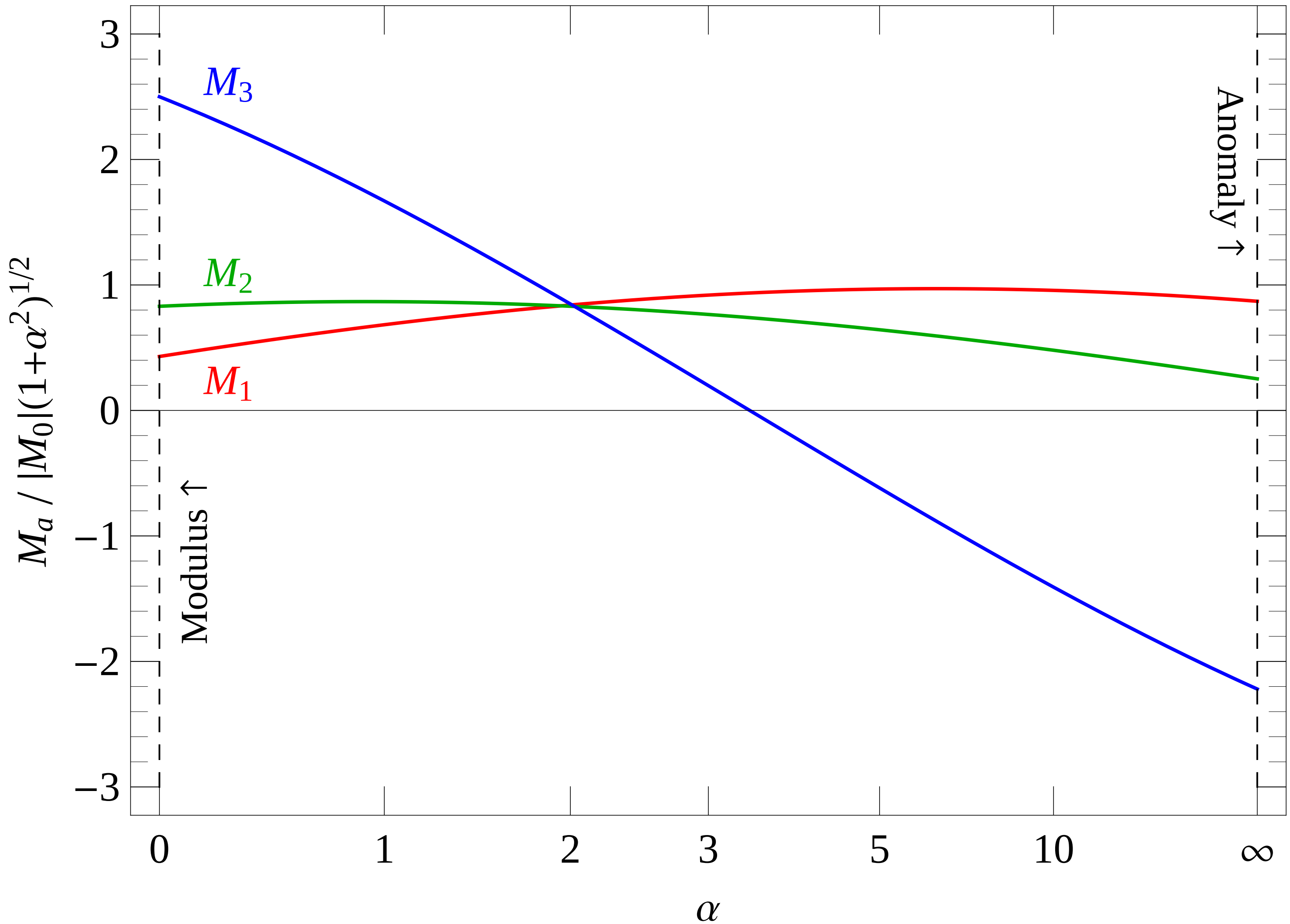


The Mirage Scale



(Lebedev, HPN, Ratz, 2005)

Gaugino Masses



Mirage Pattern

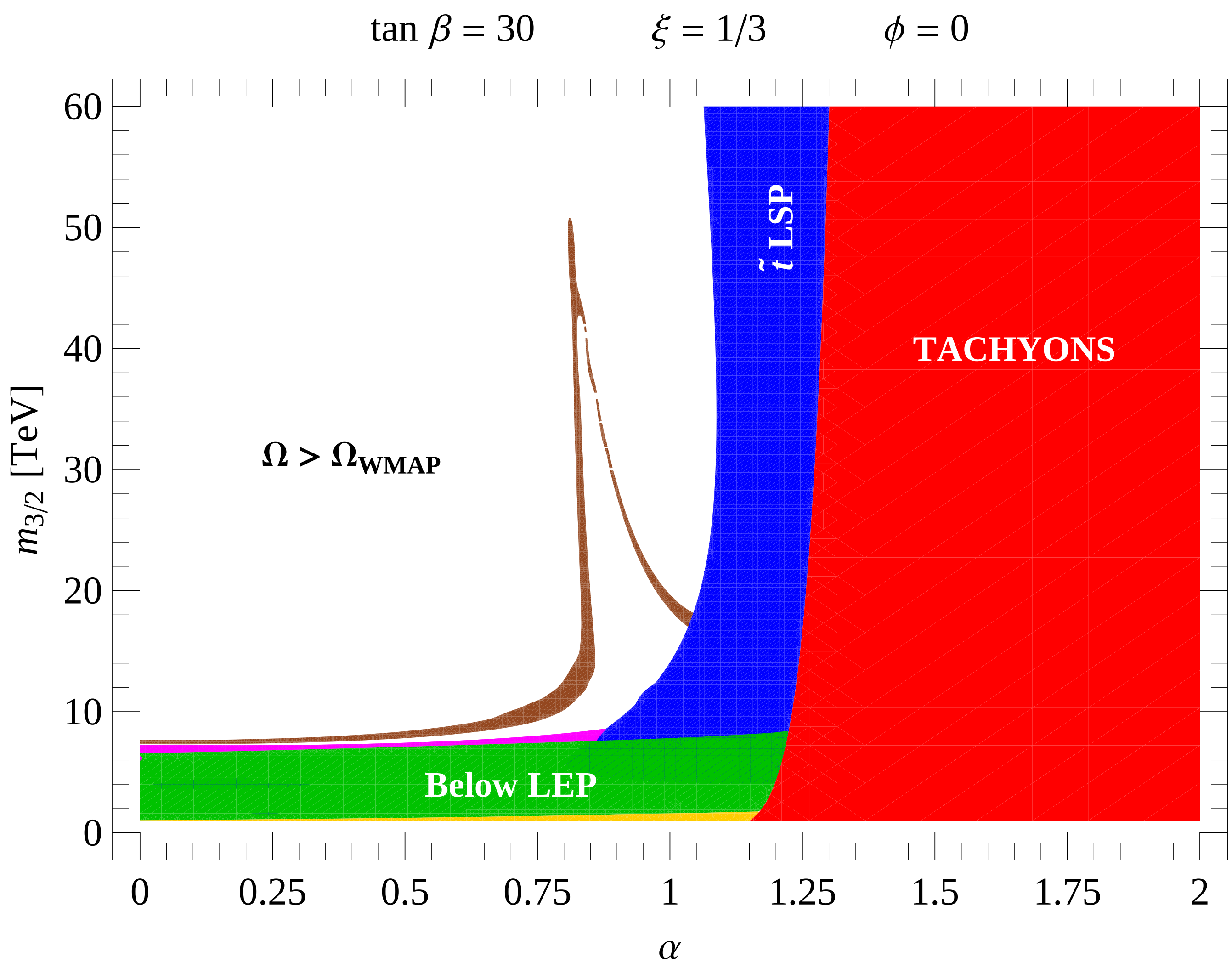
Mixed boundary conditions at the GUT scale
characterized by the parameter α:
the ratio of modulus to anomaly mediation.

- $M_1 : M_2 : M_3 \simeq\ 1 : 1.3 : 2.5$ for $\alpha \simeq 1$
- $M_1 : M_2 : M_3 \simeq\ 1 : 1 : 1$ for $\alpha \simeq 2$

The mirage scheme leads to

- LSP χ_1^0 predominantly Bino
- $G = M_{\mathrm{gluino}}/m_{\chi_1^0} < 6$
- a “compact” (compressed) gaugino mass pattern (a challenge for LHC searches).

Constraints on α



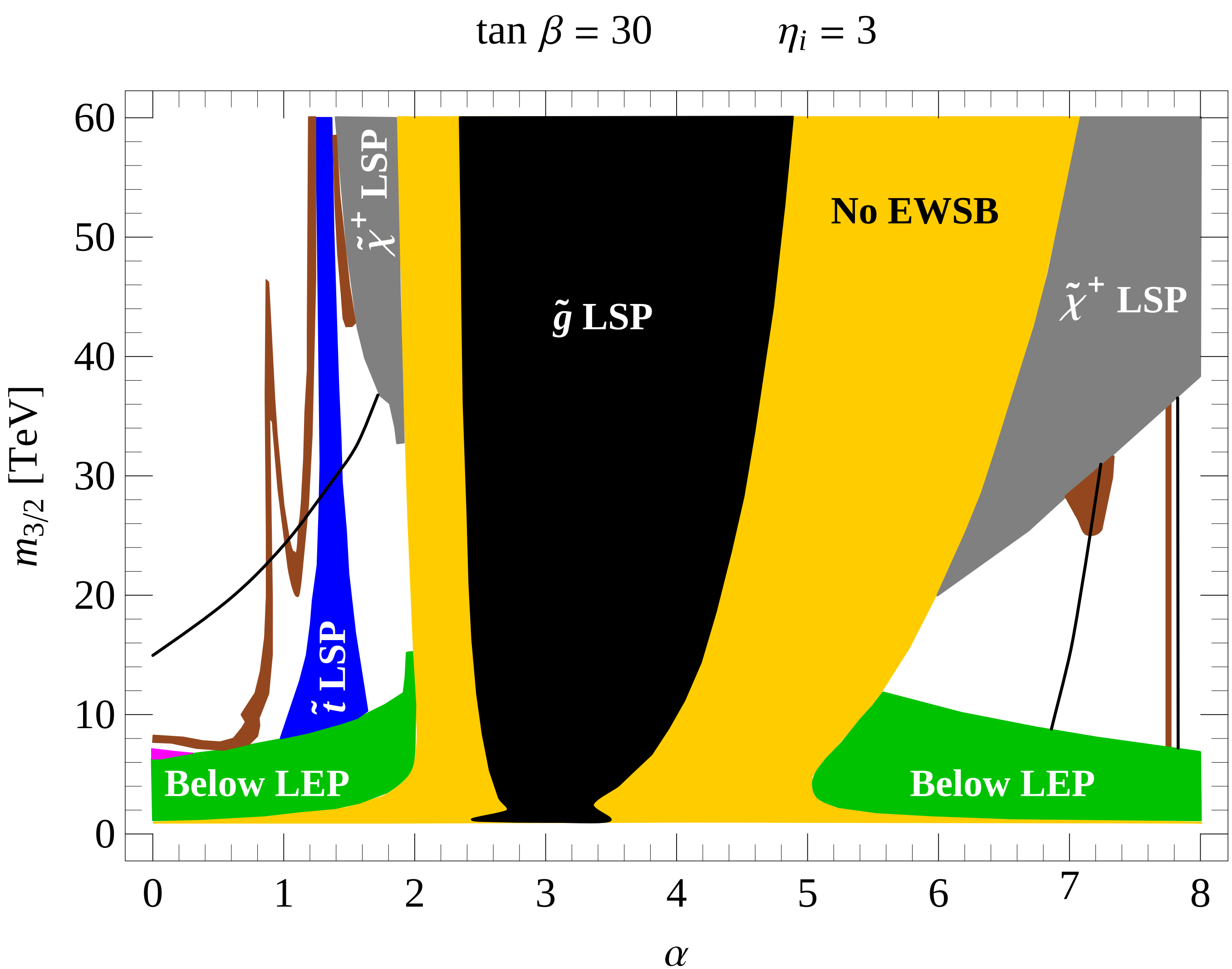
The fate of sfermion masses

- scalar masses are less protected

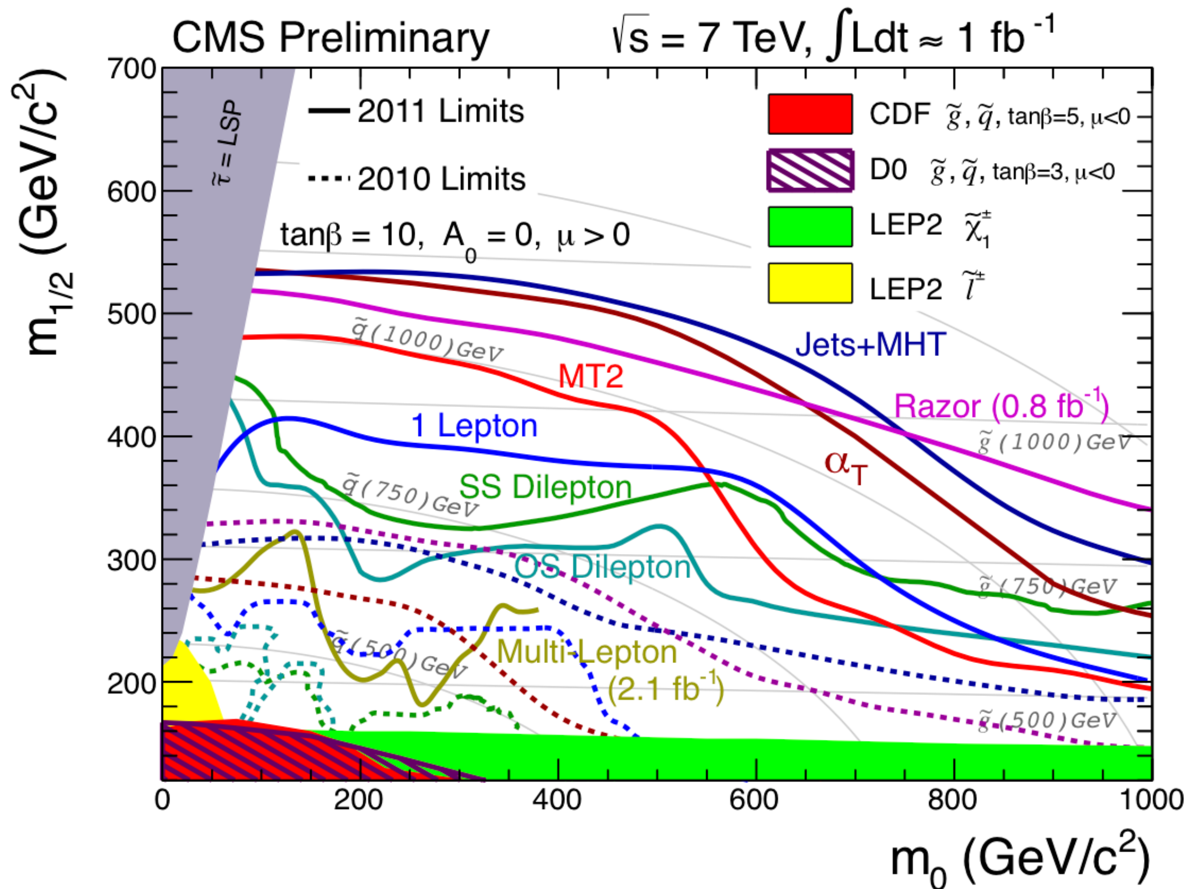
  (Lebedev, Nilles, Ratz, 2006; Löwen, Nilles, 2008)

  - large contributions to sfermion masses
  - removes potential tachyons
  - Heavy squarks and sleptons in multi-TeV range

Constraints on α



SUSY Search



Search is strongly model dependent.

It is sensitive to gluino/LSP ratio, the mass of the LSP and the nature of jets in the gluino decay chain.

The Heterotic String Pattern

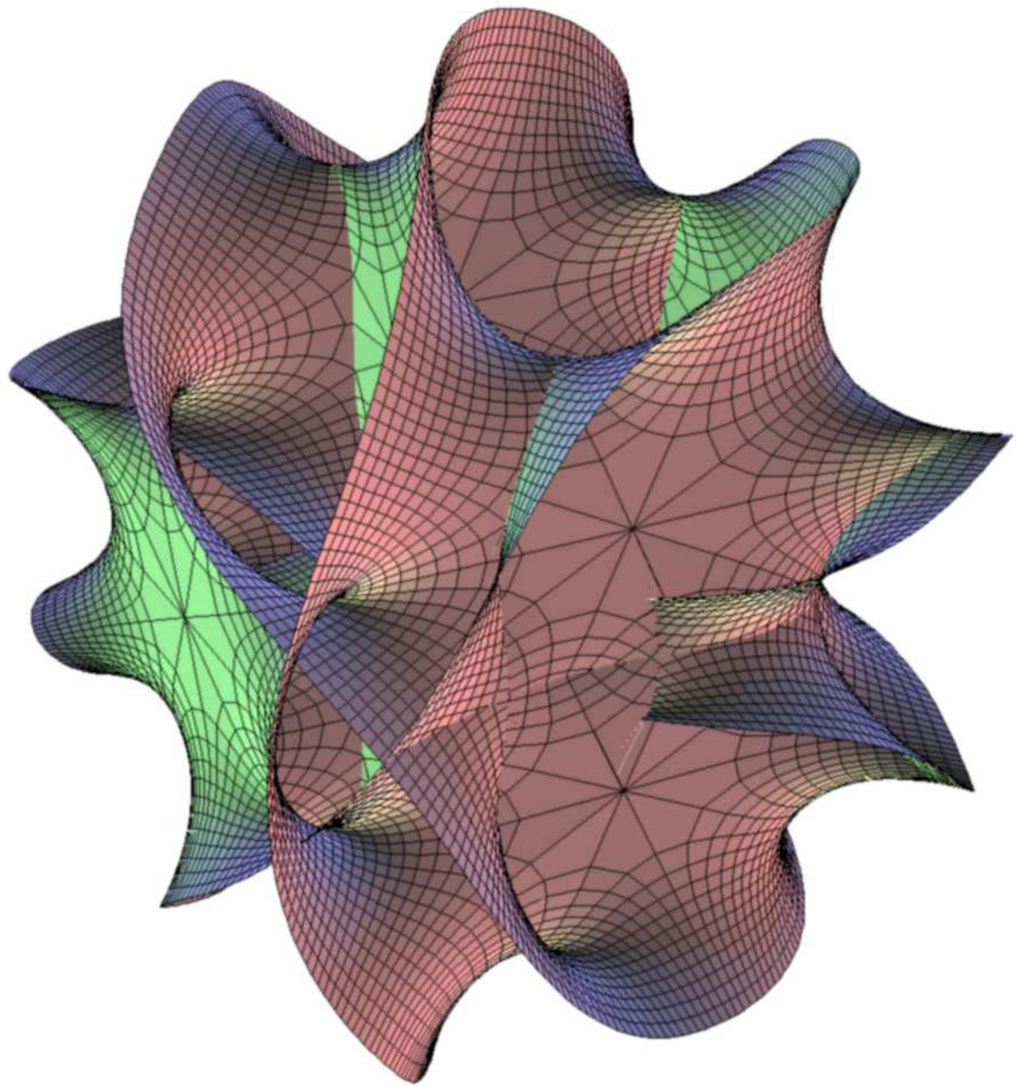
It will give us specific pattern for the soft masses with a large gravitino mass in the multi-TeV range,

(Krippendorf, Nilles, Ratz, Winkler, 2012)

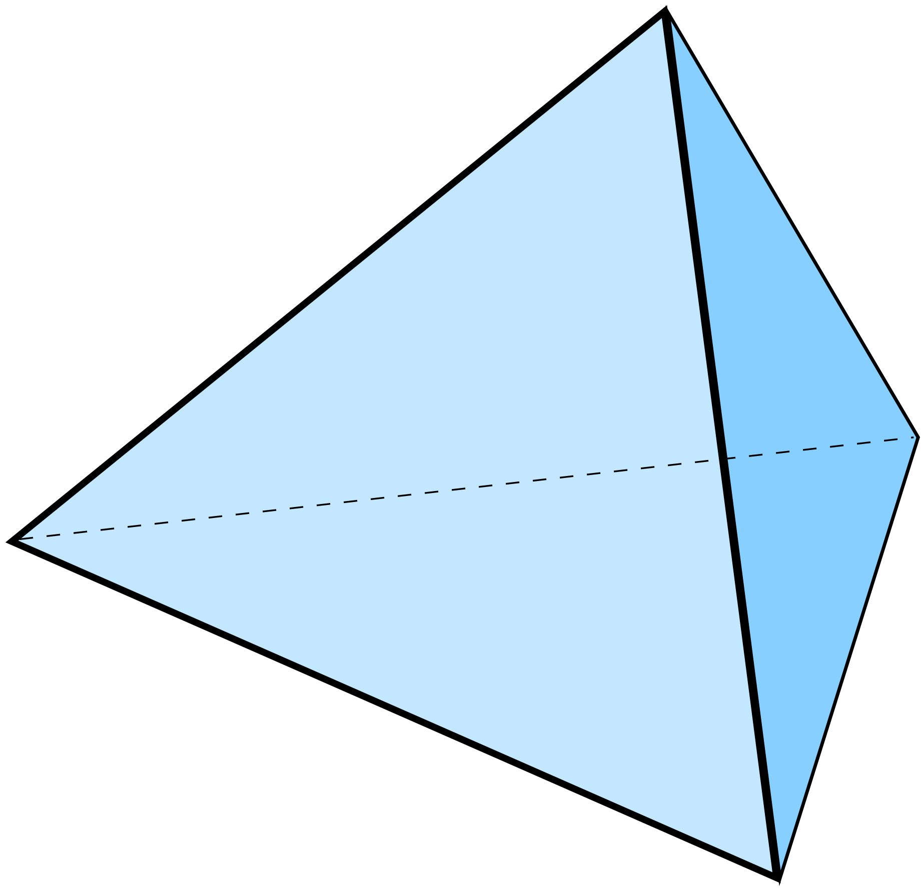
- normal squarks and sleptons in multi-TeV range,
- top squarks $(\tilde{t}_L, \tilde{b}_L)$ and $\tilde{t}_R$ in TeV range (suppressed by $\log(M_{\rm Planck}/m_{3/2}) \sim 4\pi^2$),
- heavy moduli fields,
- gaugino masses in TeV range,
- mirage pattern for gaugino masses (compressed spectrum),

reminiscent of a scheme called “Natural Susy”.

Calabi Yau Manifold



Orbifold



Geography

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- the location of quarks and leptons,
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- the relative location of Higgs bosons,

but there is also a “localization” of gauge fields

- $E_8 \times E_8$ in the bulk
- smaller gauge groups on various branes

Observed 4-dimensional gauge group is common subroup of the various localized gauge groups!

Localization

Quarks, Leptons and Higgs fields can be localized:

- in the Bulk ($d = 10$ untwisted sector)
- on 3-Branes ($d = 4$ twisted sector fixed points)
- on 5-Branes ($d = 6$ twisted sector fixed tori)

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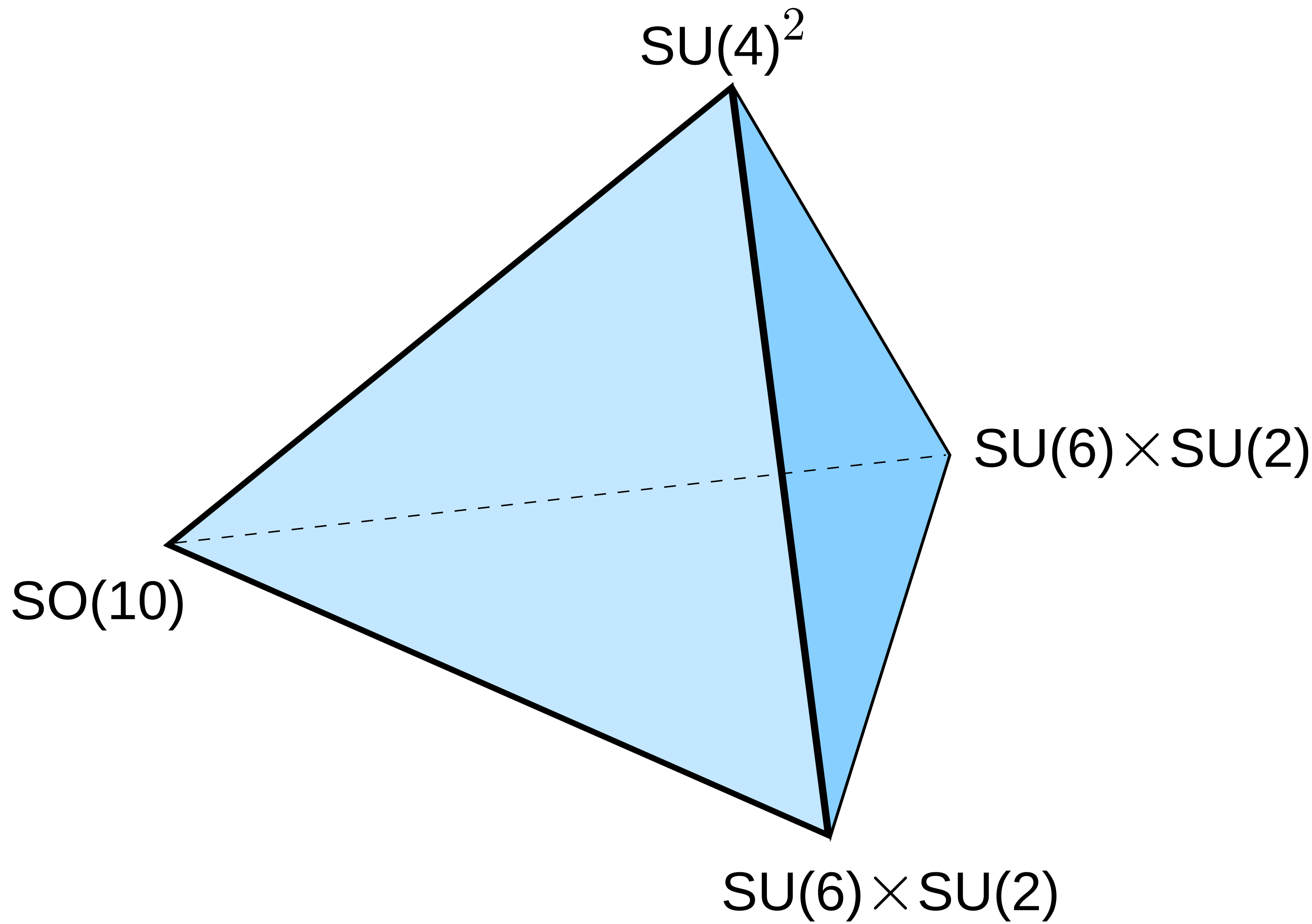
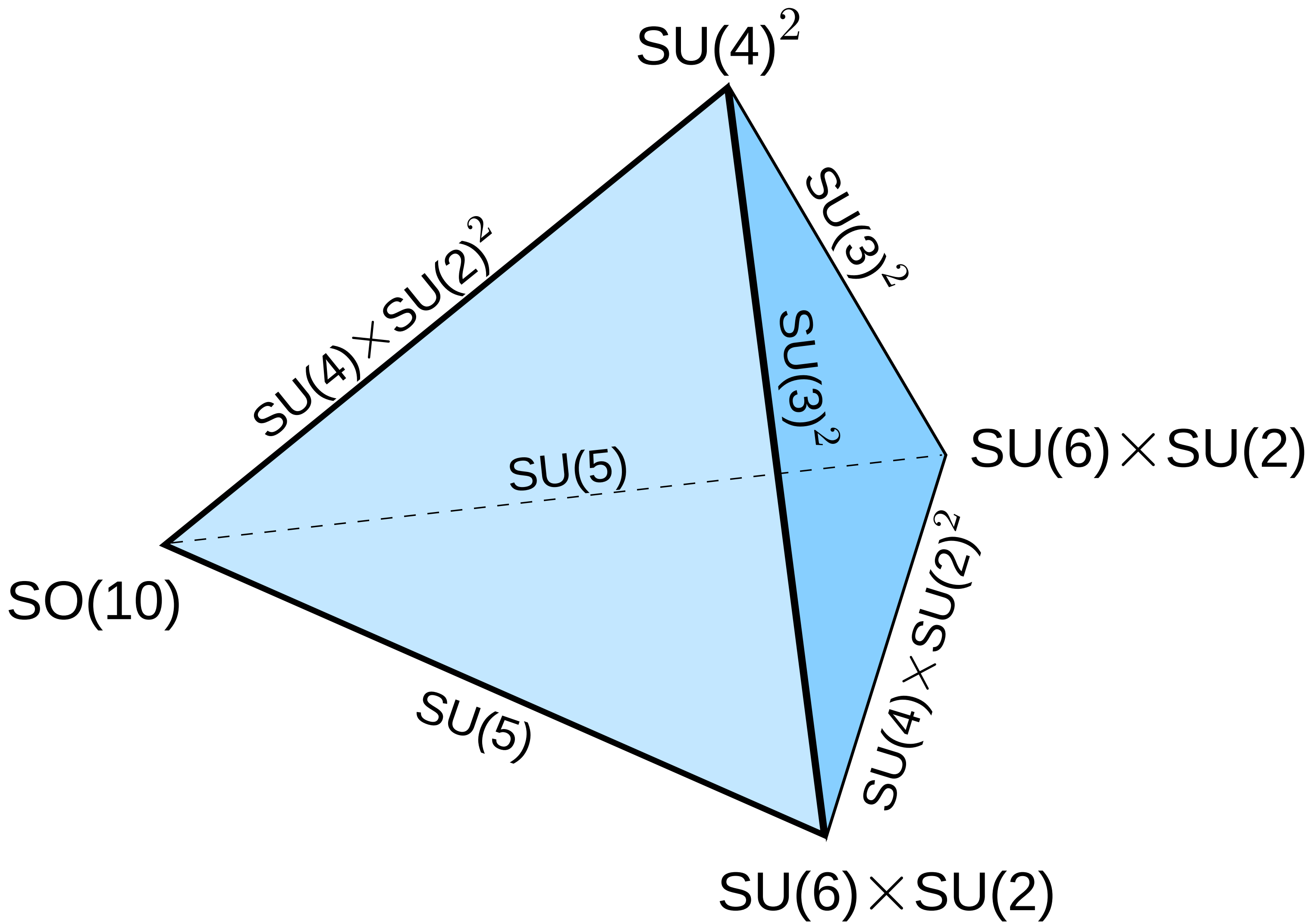
Localized gauge symmetries



(Förste, HPN, Vaudrevange, Wingerter, 2004)

Standard Model Gauge Group



Local Grand Unification

In fact string theory gives us a variant of GUTs

- complete multiplets for fermion families
- split multiplets for gauge- and Higgs-bosons
- partial Yukawa unification

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- complete multiplets for fermion families
- split multiplets for gauge- and Higgs-bosons
- partial Yukawa unification

Key properties of the theory depend on the geography of the fields in extra dimensions.

This geometrical set-up called local grand unification, can be realized in the framework of the

"heterotic braneworld".

(Förste, HPN, Vaudrevange, Wingerter, 2004; Buchmüller, Hamaguchi, Lebedev, Ratz, 2004)

The MiniLandscape

- many models with the exact spectrum of the MSSM (absence of chiral exotics)

  (Lebedev, HPN, Raby, Ramos-Sanchez, Ratz, Vaudrevange, Wingerter, 2007-2009)
- local grand unification (by construction)
- gauge- and (partial) Yukawa unification

  (Raby, Wingerter, 2007)
- examples of neutrino see-saw mechanism

  (Buchmüller, Hamguchi, Lebedev, Ramos-Sanchez, Ratz, 2007)
- models with R-parity + solution to the μ-problem

  (Lebedev, HPN, Raby, Ramos-Sanchez, Ratz, Vaudrevange, Wingerter, 2007)
- gaugino condensation and mirage mediation

  (Löwen, HPN, 2008)

A Benchmark Model

At the orbifold point the gauge group is

$$SU(3) \times SU(2) \times U(1)^9 \times SU(4) \times SU(2)$$

- one $U(1)$ is anomalous
- there are singlets and vectorlike exotics
- decoupling of exotics and breakdown of gauge group has been verified
- remaining gauge group

$$SU(3) \times SU(2) \times U(1)_Y \times SU(4)_{\mathrm{hidden}}$$

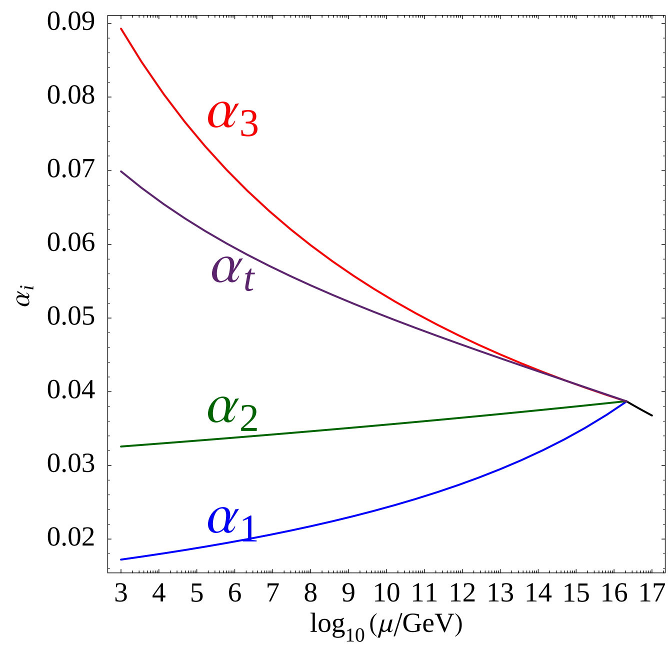
- for discussion of neutrinos and R-parity we keep also the $U(1)_{B-L}$ charges

Spectrum

#	irrep	label		#	irrep	label
3	$(\mathbf{3},\mathbf{2};\mathbf{1},\mathbf{1})_{(1/6,1/3)}$	q_i		3	$(\overline{\mathbf{3}},\mathbf{1};\mathbf{1},\mathbf{1})_{(-2/3,-1/3)}$	$\bar{u}_i$
3	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(1,1)}$	$\bar{e}_i$		8	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{1})_{(0,*)}$	m_i
$3+1$	$(\overline{\mathbf{3}},\mathbf{1};\mathbf{1},\mathbf{1})_{(1/3,-1/3)}$	$\bar{d}_i$		1	$(\mathbf{3},\mathbf{1};\mathbf{1},\mathbf{1})_{(-1/3,1/3)}$	d_i
$3+1$	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{1})_{(-1/2,-1)}$	ℓ_i		1	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{1})_{(1/2,1)}$	$\bar{\ell}_i$
1	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{1})_{(-1/2,0)}$	h_d		1	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{1})_{(1/2,0)}$	h_u
6	$(\overline{\mathbf{3}},\mathbf{1};\mathbf{1},\mathbf{1})_{(1/3,2/3)}$	$\bar{\delta}_i$		6	$(\mathbf{3},\mathbf{1};\mathbf{1},\mathbf{1})_{(-1/3,-2/3)}$	δ_i
14	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(1/2,*)}$	s_i^+		14	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(-1/2,*)}$	s_i^-
16	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(0,1)}$	$\bar{n}_i$		13	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(0,-1)}$	n_i
5	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{2})_{(0,1)}$	$\bar{\eta}_i$		5	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{2})_{(0,-1)}$	η_i
10	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{2})_{(0,0)}$	h_i		2	$(\mathbf{1},\mathbf{2};\mathbf{1},\mathbf{2})_{(0,0)}$	y_i
6	$(\mathbf{1},\mathbf{1};\mathbf{4},\mathbf{1})_{(0,*)}$	f_i		6	$(\mathbf{1},\mathbf{1};\overline{\mathbf{4}},\mathbf{1})_{(0,*)}$	$\bar{f}_i$
2	$(\mathbf{1},\mathbf{1};\mathbf{4},\mathbf{1})_{(-1/2,-1)}$	f_i^-		2	$(\mathbf{1},\mathbf{1};\overline{\mathbf{4}},\mathbf{1})_{(1/2,1)}$	$\bar{f}_i^+$
4	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(0,\pm 2)}$	χ_i		32	$(\mathbf{1},\mathbf{1};\mathbf{1},\mathbf{1})_{(0,0)}$	s_i^0
2	$(\overline{\mathbf{3}},\mathbf{1};\mathbf{1},\mathbf{1})_{(-1/6,2/3)}$	$\bar{v}_i$		2	$(\mathbf{3},\mathbf{1};\mathbf{1},\mathbf{1})_{(1/6,-2/3)}$	v_i

Unification

- Higgs doublets are in untwisted sector (bulk)
- heavy top quark in untwisted sector (bulk)
- $\mu-$term protected by a discrete symmetry



- Minkowski vacuum before Susy breakdown (no AdS)
- solution to μ-problem (Casas, Munoz, 1993)
- natural incorporation of gauge-Yukawa unification

Emergent localization properties

The benchmark model illustrates some of the general properties of the “MiniLandscape”

- exactly two Higgs multiplets (no triplets)
- the top quark lives in the untwisted sector (as well as the Higgs multiplets)
- only one trilinear Yukawa coupling (all others suppressed)

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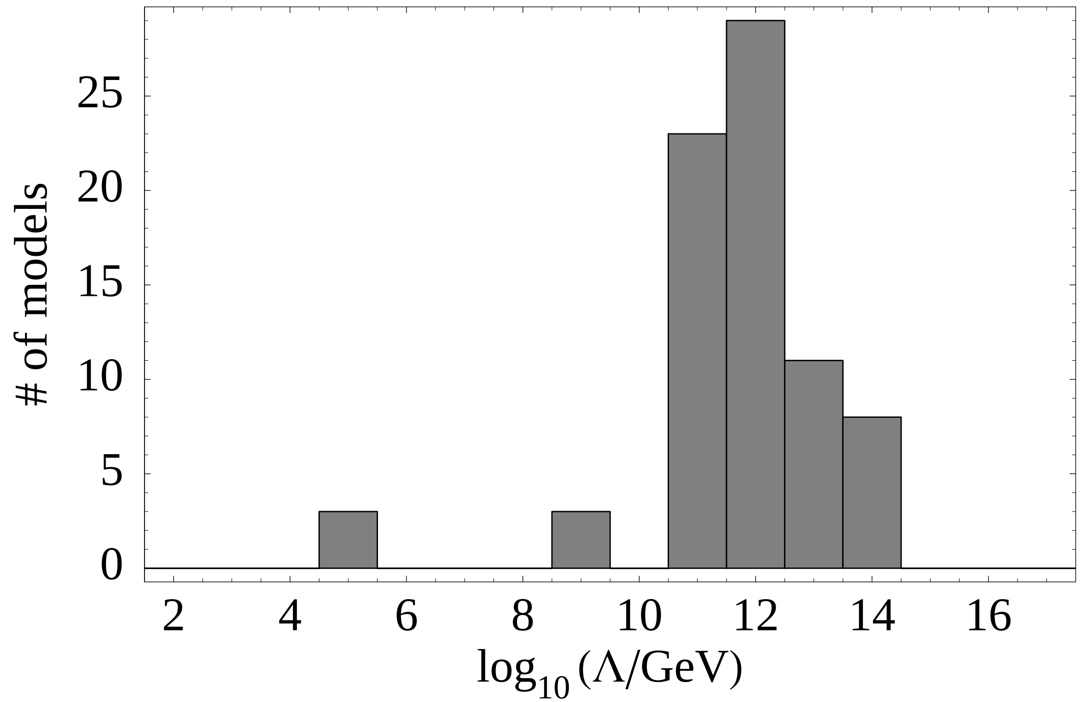
- the top quark lives in the untwisted sector (as well as the Higgs multiplets)
- only one trilinear Yukawa coupling (all others suppressed)

The fact that the top-quark has this unique property among all the quarks and leptons has important consequences for the phenomenological predictions including supersymmetry breakdown.

(Krippendorf, HPN, Ratz, Winkler, 2012)

Heterotic string: gaugino condensation



Gravitino mass $m_{3/2} = \Lambda^3/M_{\text{Planck}}^2$ and $\Lambda \sim \exp(-\tau)$

(Lebedev, HPN, Raby, Ramos-Sanchez, Ratz, Vaudrevange, Wingerter, 2006)

Heterotic string

Fixing U- and T- moduli in a supersymmetric way

(Kappl, Petersen, Raby, Ratz, Vaudrevange, 2010; Anderson, Gray, Lukas, Ovrut, 2011)

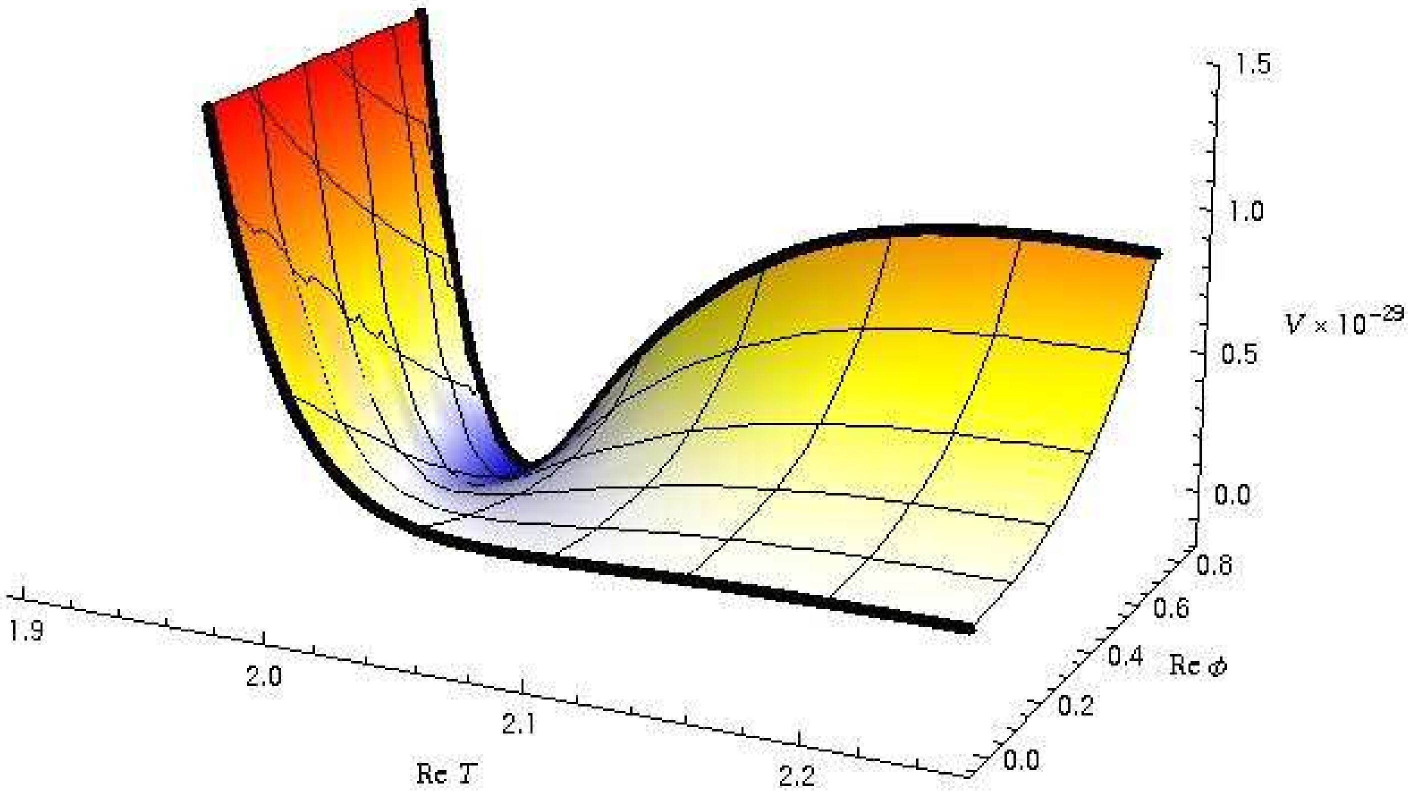
- we remain with a run-away dilaton

But we need to adjust the vacuum energy

- matter field in untwisted sector
- "downlifting" mechanism can fix τ as well (no need for nonperturbative corrections to the Kähler potential)

(Löwen, HPN, 2008)

Downlift



(Löwen, HPN, 2008)

Mirage scheme

Fixing U- and T- moduli in a supersymmetric way

(Kappl et al., 2010); Anderson et al., 2011

- we remain with a run-away dilaton

But we need to adjust the vacuum energy

- matter field in untwisted sector
- “downlifting” mechanism can fix τ as well (no need for nonperturbative corrections to the Kähler potential)
- again a mirage scheme with suppression factor $\log(m_{3/2}/M_{\mathrm{Planck}})$

(Löwen, HPN, 2008)

Soft terms

So we have mirage suppression (compared to $m_{3/2}$) of

- gaugino masses (with compressed spectrum)
- A-parameters in the (few) TeV range.

Scalar masses are less protected

- heavy squarks and sleptons: $m_0 < O(30)$TeV

But, the top quark plays a special role

- as a result of gauge-Yukawa-unification

  $g_{\rm top} \sim g_{\rm gauge} \sim g_{\rm string}$

  that explains the large value of the top-quark mass

(Lebedev, Nilles, Raby, Ramos-Sanchez, Ratz, Vaudrevange, Wingerter, 2007)

Soft terms

While normal scalar masses are less protected

- this is not true for the top- and Higgs-multiplets
- they live in the untwisted sector (bulk)
- all other multiplets live twisted sectors (branes)

This can be understood as a remnant of

- extended supersymmetry in higher dimensions
- $N = 4$ supersymmetry from $N = 1$ in $D = 10$ via torus compactification
- Higgs und stops remain in the TeV-range

(Krippendorf, Nilles, Ratz, Winkler, 2012)

The overall pattern

This provides a specific pattern for the soft masses with a large gravitino mass in the multi-TeV range

- normal squarks and sleptons in multi-TeV range
- top squarks $(\tilde{t}_L, \tilde{b}_L)$ and $\tilde{t}_R$ in TeV-range (suppressed by $\log(M_{\rm Planck}/m_{3/2}) \sim 4\pi^2$)
- A-parameters in TeV range
- gaugino masses in TeV range
- mirage pattern for gaugino masses (compressed spectrum)
- heavy moduli (enhanced by $\log(M_{\rm Planck}/m_{3/2})$ compared to the gravitino mass)

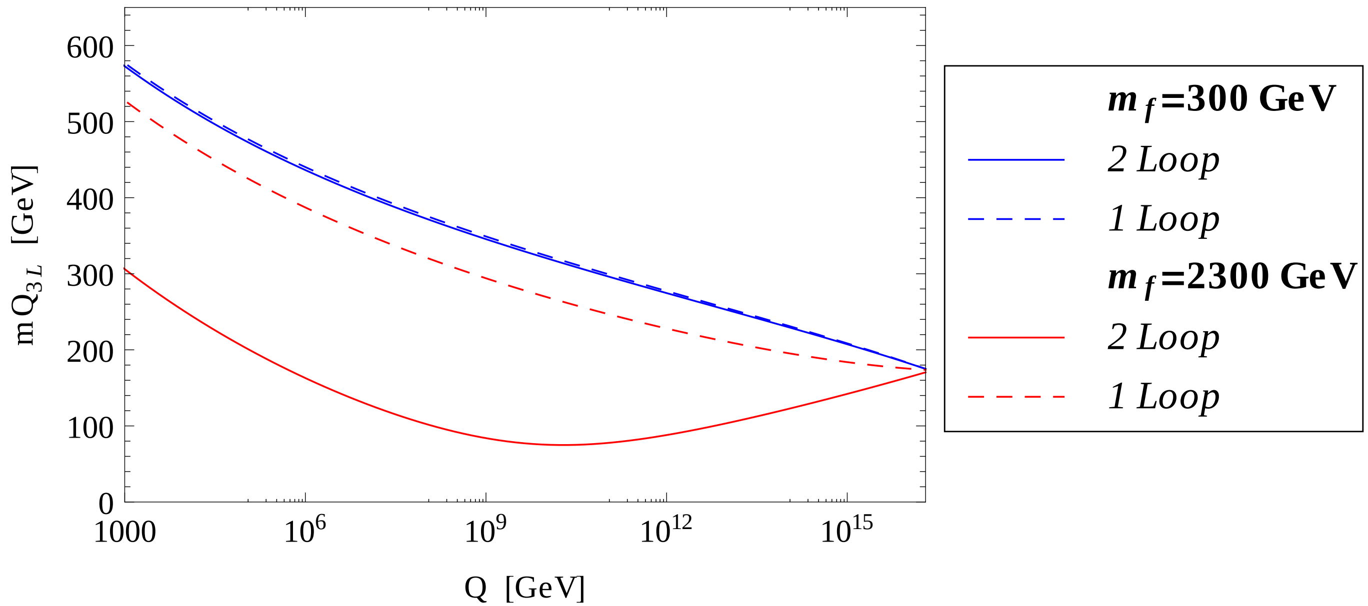
A Closer Look

A more detailed picture requires the analysis of specific models. Issues that have to be clarified:

- the appearance of tachyons,
  - partially inherited from anomaly mediation
  - two-loop effects in the presence of heavy scalars
- the hierarchy between gauginos and sfermions.
- Can we satisfy all phenomenological constraints?
  - mass of Higgs, correct electroweak symmetry breakdown etc.
  - nature and abundance of WIMP-LSP.
- Can this scheme be tested at the LHC?

Tachyons

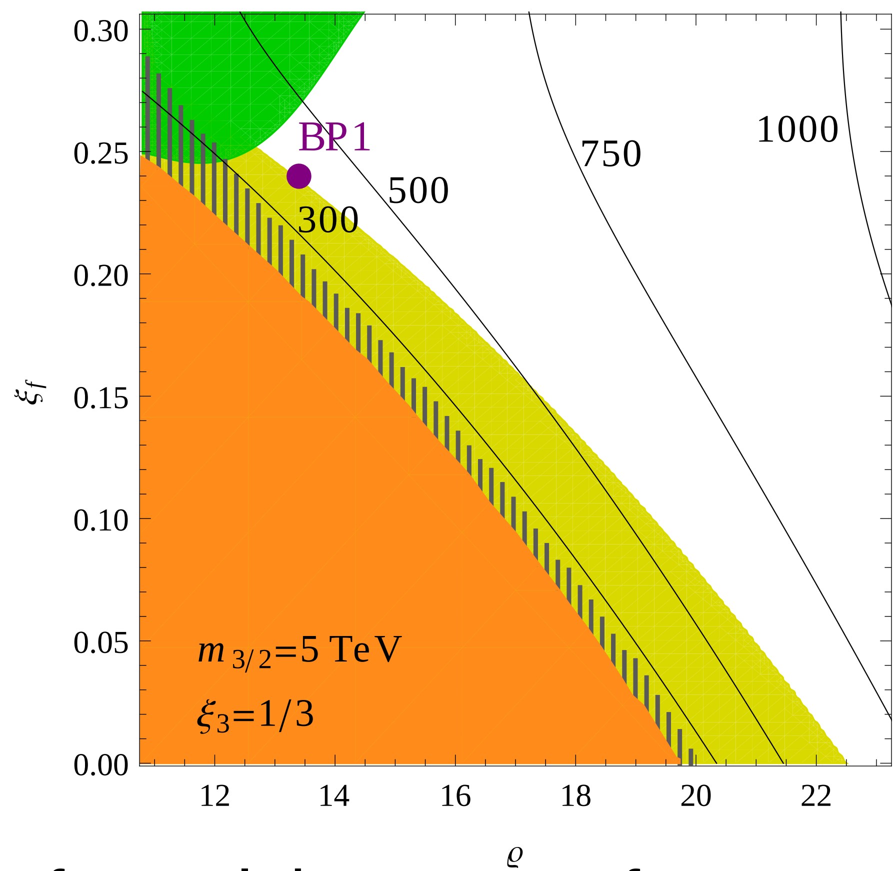
Light stops are close to the tachyonic boundary and two-loop effects might become important (a generic problem of models with heavy sfermions)



Are intermediate scale tachyons cosmologically acceptable?

(Ellis, Giedt, Lebedev, Olive,Srednicki; 2008)

Benchmark model with a TeV gluino

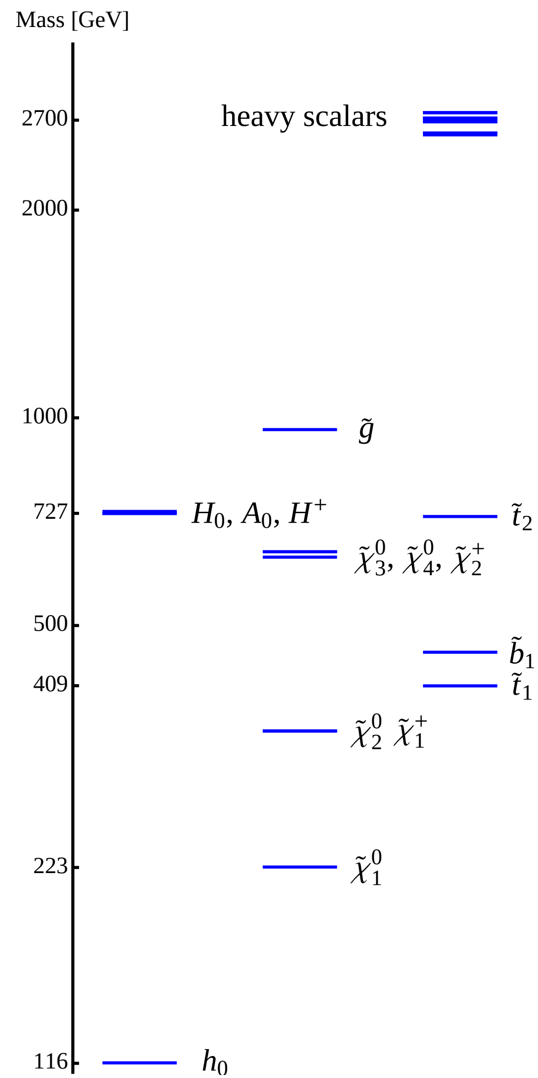


Parameter scan for a gluino mass of 1 TeV.

The coloured regions are excluded while the hatched region indicates the current reach of the LHC.

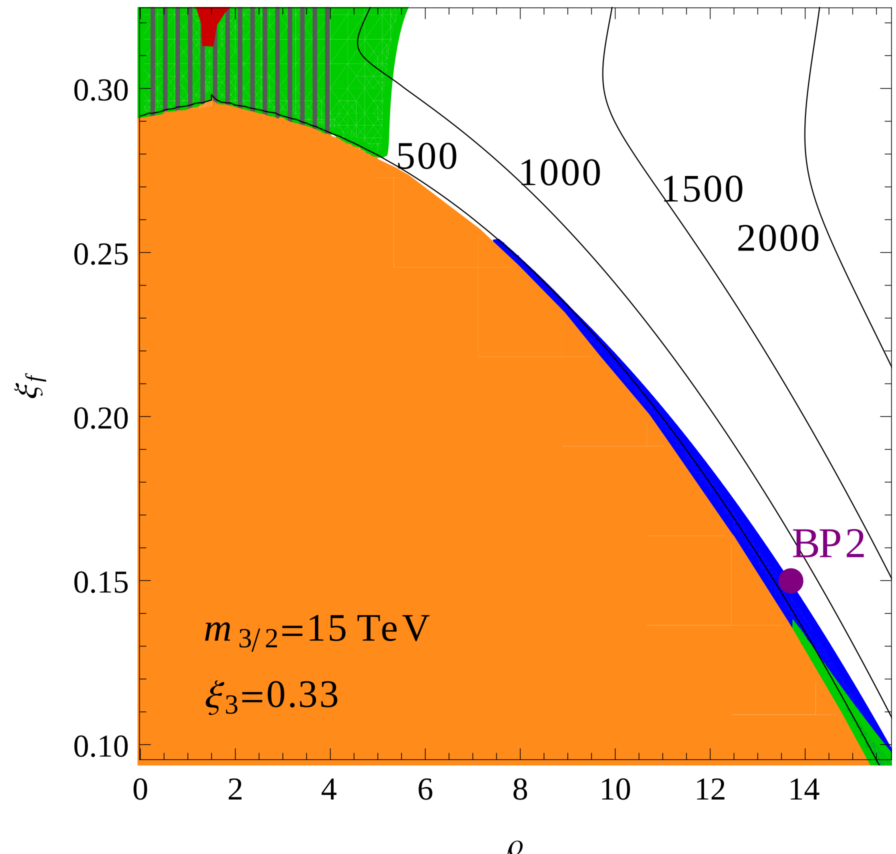
The contours indicate the mass of the lightest stop.

Spectrum 1



Mass [GeV]
2700
2000
1000
727
500
409
223
116
heavy scalars
$\tilde{g}$
H_0, A_0, H^+
$\tilde{t}_2$
$\tilde{\chi}_3^0, \tilde{\chi}_4^0, \tilde{\chi}_2^+$
$\tilde{b}_1$
$\tilde{t}_1$
$\tilde{\chi}_2^0\ \tilde{\chi}_1^+$
$\tilde{\chi}_1^0$
h_0

Model with 4 TeV gluino

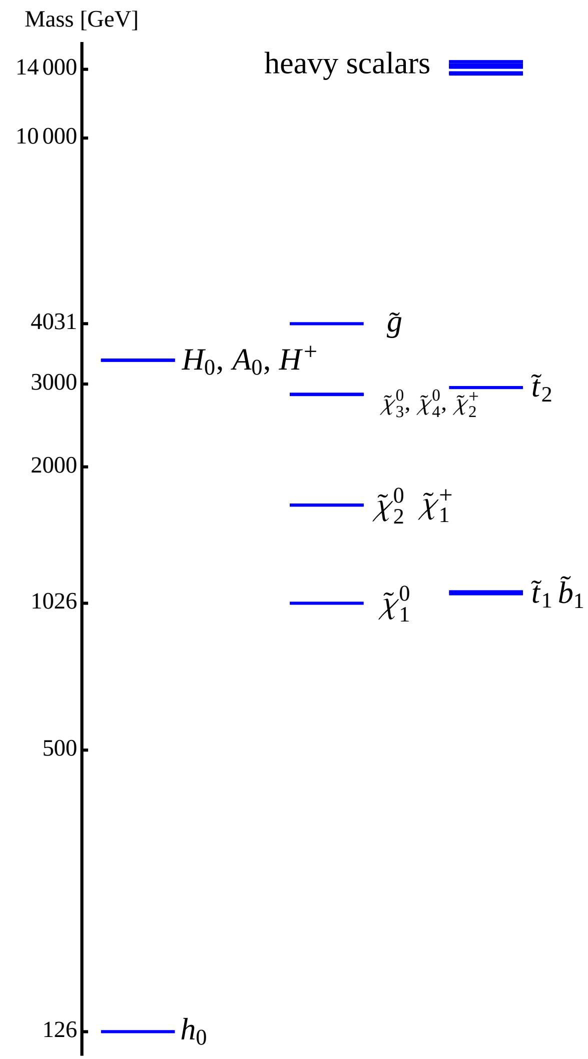


Parameter scan for a gluino mass of 4 TeV.

The coloured regions are excluded while the hatched region indicates the current reach of the LHC.

The contours indicate the mass of the lightest stop.

Spectrum of model with a 4 TeV gluino



Messages

- large gravitino mass (multi TeV-range)
- heavy moduli: $m_{3/2}\log(M_{\rm Planck}/m_{3/2})$
- mirage pattern for gaugino masses rather robust
- sfermion masses are of order $m_{3/2}$
- the ratio between sfermion and gaugino masses is limited
- heterotic string yields “Natural Susy”. There is a reduced fine-tuning because of
  - mirage pattern,
  - and light stops,
- and this is a severe challenge for LHC searches.

Comparison to other schemes

Mirage pattern for gaugino masses seems to be common for type II, G2MSSM and heterotic models

- type IIB (Kachru, Kallosh, Linde, Trivedi, 2003)
  - all sfermions unprotected
  - A-parameters in few TeV-range
- G2MSSM (Acharya, Bobkov, Kane, Kumar, Vaman, 2006)
  - all sfermions unprotected (even up to $O(100)$TeV)
  - A-parameters in multi TeV-range as well

but there are no explicit models to test a connection between the Yukawa pattern and soft breaking terms.

The mass of the lightest Higgs

The mass of the lightest Higgs should be

- somewhere between 115 GeV and 127 GeV
- depends on the value of $\tan\beta$
- usually requires some fine tuning

This fine tuning is

- severe in type IIB and G2MSSM,
- rather mild in the heterotic picture
  (as a result of the mirage spectrum of gauginos and the suppression of soft terms for Higgs- and top-multiplets).

Lessons from heterotic string theory

- scalar masses are less protected
  - heavy squarks and sleptons in the multi-TeV range
- But, the top quark plays a special role
  - a large value of the top-quark Yukawa coupling requires a special location of top and Higgs in extra dimensions of string theory

    (Lebedev, Nilles, Raby, Ramos-Sanchez, Ratz, Vaudrevange, Wingerter, 2007)
  - this is a result of gauge-Yukawa-unification

    $g_{\mathrm{top}} \sim g_{\mathrm{gauge}} \sim g_{\mathrm{string}}$

    that explains the large value of the top-quark mass
- stops and Higgs bosons remain in TeV range

  (Krippendorf, Nilles, Ratz, Winkler, 2012)

The overall scale

There is no (reliable) prediction for the gravitino mass

- except for fine-tuning arguments
- “no lose” criterion (SSC with 20+20 TeV)
- does LHC satisfy this criterion?

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Betting in the early 80’s

- I bet that supersymmetry will be discovered before SSC gets into operation
- I bet that supersymmetry will have been forgotten before SSC gets into operation

Continued prediction

There is still some optimism in 2012:

- Experiments within the next five to ten years will tell us whether supersymmetry at the weak scale is a myth or reality.

We have to wait and see.

Bavarian "Philosopher"

(K. Valentin, 1882-1948)

- Früher haben wir langsam gewartet, heute warten wir immer schneller.