The Next-to-Minimal Supersymmetric Standard Model: a brief overview

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Supersymmetric models: many advantages!

Beyond the SM: several appealing, well motivated possibilities (from A to Z)

$\Rightarrow$ **Supersymmetric extensions of the SM**

- Potential and elegant solution to the **hierarchy** problem

  If SUSY is softly broken $\boldsymbol{\Delta m_H^2} \propto \boldsymbol{M_{\mathsf{SUSY}}^2}(\frac{\lambda}{16\pi^2}\mathbf{log}\frac{\Lambda_{\mathsf{UV}}}{M_{\mathsf{SUSY}}})$

- Radiative **spontaneous electroweak symmetry** breaking

  At M_{EW}, one **"naturally"** has $m_{H_u}^2 < 0$ (if $m_t \gtrsim 70$ GeV)

- Explain the origin of the EW scale $M_{\mathsf{EW}} \sim M_{\mathsf{SUSY}}$ (SUSY breaking scale)

- **Unification** of the **gauge couplings** (around 10^{16} GeV)

  (under simple SU(5) or SO(10) Grand Unified models)

- If R-parity conserving: neutral, colourless, stable **L**ightest **S**USY **P**article

  $\Rightarrow$ candidates for **cold dark matter** (usually χ_1^0 or $\tilde{\nu}$, also gravitino)

Minimal SUSY extension of the SM (MSSM)

★ **Superpotential:** $W = Y_u \hat{H}_u \hat{Q} \hat{u} + Y_d \hat{H}_d \hat{Q} \hat{d} + Y_e \hat{H}_d \hat{L} \hat{e}$ - $\boldsymbol{\mu} \hat{H}_u \hat{H}_d$

$$\Rightarrow \quad \mathcal{L} \subset Y_u H_u Q u + Y_d H_d Q d + Y_e H_d L e - \boldsymbol{\mu} \tilde{h}_u \tilde{h}_d + \ldots$$

soft-breaking terms: $-\mathcal{L}_{\text{soft}} = \boldsymbol{m^2_{H_u}} H_u^* H_u + \boldsymbol{m^2_{H_d}} H_d^* H_d + (\boldsymbol{B\mu} H_u H_d + \text{H.c.})$

$$+ (\boldsymbol{M_i} \psi_i \psi_i + \text{H.c.}) + \boldsymbol{m^2_{\tilde{F}}} \tilde{F} \tilde{F}^* + \boldsymbol{A_F Y_F} H_i \tilde{F} \tilde{F}^* + \ldots$$

★ **Physical states:** **Squarks, sleptons, gluinos**

Charginos: {winos, charged higgsinos} $\longrightarrow \tilde{\chi}^{\pm}_{1,2}$

Neutralinos: {bino, w^0-ino, neutral higgsinos} $\longrightarrow \tilde{\chi}^0_{1-4}$

Higgs: {CP-even, CP-odd, charged} $\longrightarrow \underbrace{h^0, H^0}_{H^{\text{SM}}}, A^0, H^{\pm}$

MSSM issues: the Higgs sector

★ μ **problem:** **SUSY conserving** Higgs mass term in $W = \mu \hat{H}_u \hat{H}_d$

EW sym. breaking: $m_{H_u}, m_{H_d}, \mu \sim \mathcal{O}(10-100) \times M_Z \rightsquigarrow$ $\mu \lesssim \mathcal{O}(M_{\text{SUSY}})$

LEP constraints on $\tilde{\chi}^{\pm}$ (wino/higgsino) mass: $\rightsquigarrow$ $\mu \gtrsim 100$ GeV

$\Rightarrow$ **"Unnatural"** values for a dimensionful, SUSY preserving parameter !

★ **Higgs "little fine tuning problem"** (**non-observation** of Higgs at LEP)

Theoretically..
- MSSM @ tree-level: $m_{h_1^0} \lesssim M_Z |\cos 2\beta|$
- RC $^{(t-\tilde{t})}$: $m_{h_1^0}^{\text{CMSSM}} \lesssim 125$ GeV; $m_{h_1^0}^{\text{MSSM}} \lesssim 135$ GeV

Experimentally.. $m_{H^{\text{SM}}}^{\text{LEP}} \gtrsim 114$ GeV

A narrow window for $m_{h_1^0}$...

The Next-to-Minimal Supersymmetric Standard Model

By adding a **singlet** superfield $\hat{S}$ to the **MSSM** $\Rightarrow$ NMSSM

★ **Elegant solution to the μ-problem of the MSSM**

$$\mu \hat{H}_u \hat{H}_d \quad \to \quad \lambda \hat{S} \hat{H}_u \hat{H}_d$$

$\Rightarrow$ Only **dimensionless couplings** in W; "Yukawa-like" $\lambda \tilde{h}_u \tilde{h}_d S$ term in $\mathcal{L}^{\text{SUSY}}$

$\Rightarrow$ dynamically generated μ: $\langle S \rangle \sim \mathcal{O}(M_{\text{SUSY}}) \rightsquigarrow \mu_{\text{eff}} = \lambda \langle S \rangle$

$\Rightarrow$ Scale-invariant superpotential: **EW, SUSY scale only** appearing via $\mathcal{L}_{\text{soft}}$

★ NMSSM

$\rightsquigarrow$ **Simplest** extension of the SM where the **only scale** is M_{SUSY}

$\rightsquigarrow$ **Original SUSY/SUGRA** extensions of the SM of this type [Fayet, Nilles, ...]

NMSSM new features: an introduction

$$\boldsymbol{W}_{Z_3}^{\text{NMSSM}} = Y_u \hat{H}_u \hat{Q} \hat{u} + Y_d \hat{H}_d \hat{Q} \hat{d} + Y_e \hat{H}_d \hat{L} \hat{e} - \boldsymbol{\lambda} \hat{S} \hat{H}_u \hat{H}_d + \frac{1}{3}\boldsymbol{\kappa} \hat{S}^3$$

$$-\boldsymbol{\mathcal{L}}_{\text{soft}}^{\text{Higgs}} = m_{H_i}^2 H_i^* H_i + \boldsymbol{m_S^2} S^* S + \left(-\boldsymbol{\lambda} \boldsymbol{A_\lambda} S H_u H_d + \frac{1}{3}\boldsymbol{\kappa} \boldsymbol{A_\kappa} S^3 + \text{H.c.}\right)$$

$\hat{S}$ degrees of freedom: singlino (χ_S^0); singlet scalar and pseudoscalar (S_R, S_I)

Neutralino sector:
- 5 Majorana fermions (χ^0_{1-5})
- $\boldsymbol{\tilde{\chi}_1^0} = N_{11}\widetilde{B}^0 + N_{12}\widetilde{W}_3^0 + N_{13}\widetilde{H}_d^0 + N_{14}\widetilde{H}_u^0 + \boldsymbol{N_{15}\tilde{S}}$

Neutral Higgs sector:
- 2 pseudoscalar (a_1^0, a_2^0) and 3 **scalar bosons** (h_1^0, h_2^0, h_3^0)
- $\boldsymbol{h_1^0} = S_{11} H_d^0 + S_{12} H_u^0 + \boldsymbol{S_{13} S_R}$

$\Rightarrow$ **NMSSM: Richer, complex phenomenology**

[for a review see Ellwanger, Hugonie, AMT '09]

NMSSM Higgs sector

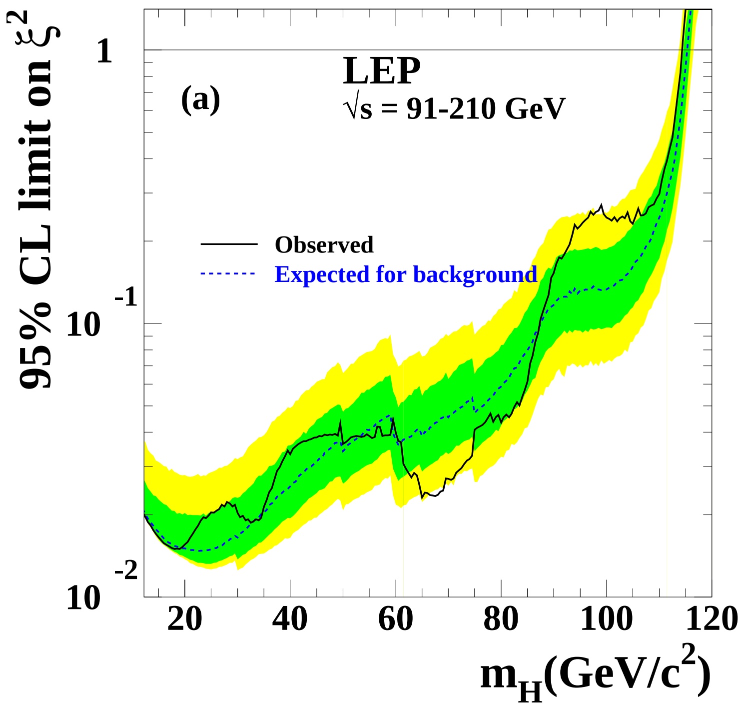
★ **NMSSM: less fine-tuning required !** [Dermisek, Gunion, Bastero-Gil, ...]

- **Theoretically** **higher upper bound** on SM-like Higgs mass (~ 145 GeV)

[Ellwanger, Hugonie]

- **NMSSM light Higgs** ($m_{h_1^0} \lesssim 114.7$ GeV) still allowed by LEP data

Combined LEP constraints



▶ Non-negligible **singlet component**

reduced coupling to gauge bosons ($C_h^V = g_{hZZ}/g_{h^{\mathrm{SM}}ZZ} < 1$)

$\Rightarrow$ $m_{h_1^0} \sim$ **very light!** $h_2^0 \sim H^{\mathrm{SM}}$ naturally above LEP bound

$\Rightarrow$ max. mixing $S - H_{u,d}$: $m_{h_1^0} \gtrsim 100$ GeV; $h_2^0 \lesssim 162$ GeV

!! [Tevatron - Jayatilaka, Moriond '11]

▶ **Unconventional Higgs decays!**

SM-like h_1^0 ($C_h^V \sim 1$), but **reduced BR($h \to b\bar{b}$)**

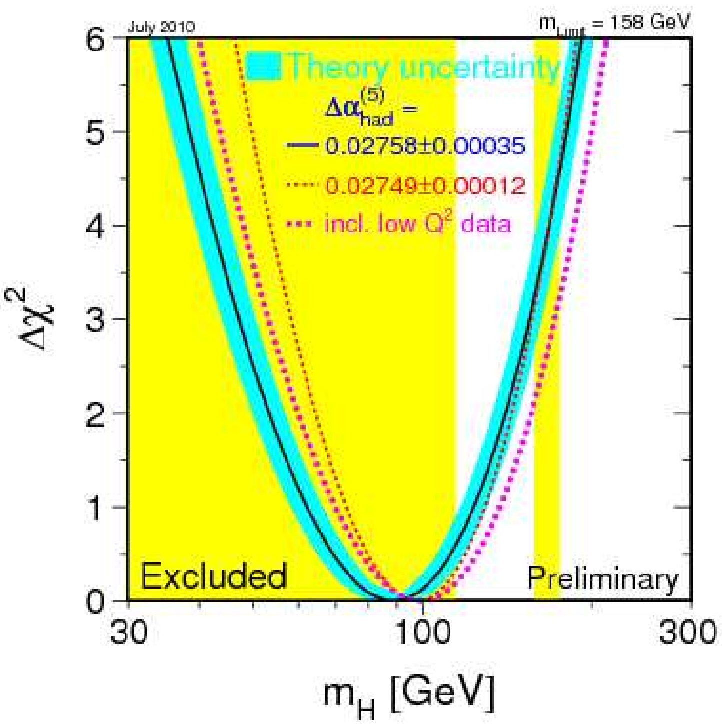
$\Rightarrow$ For $m_{a_1^0} \lesssim 2\, m_B$ dominant **decay $h_1^0 \to a_1^0\, a_1^0 \to 4\,\tau$**

Accounts for the **"observed excess"**: $m_H \sim 98$ GeV (2.3σ)

[Dermisek, Gunion]

▶ **Singlet-like with unconventional decays** ...

Unconventional Higgs decays: LEP and EW precision data



EW precision tests: **favour $m_H \sim 100$ GeV** [CERN EWWG, 2010]

… in "disagreement" with **LEP bounds !**

- NMSSM $m_{a_1^0} < 2\, m_B$ region:

  SM-like h_1^0 **dominantly** decaying into $h_1^0 \to a_1^0 a_1^0$

  with $a_1^0 \to 2\tau$, **2 jets**

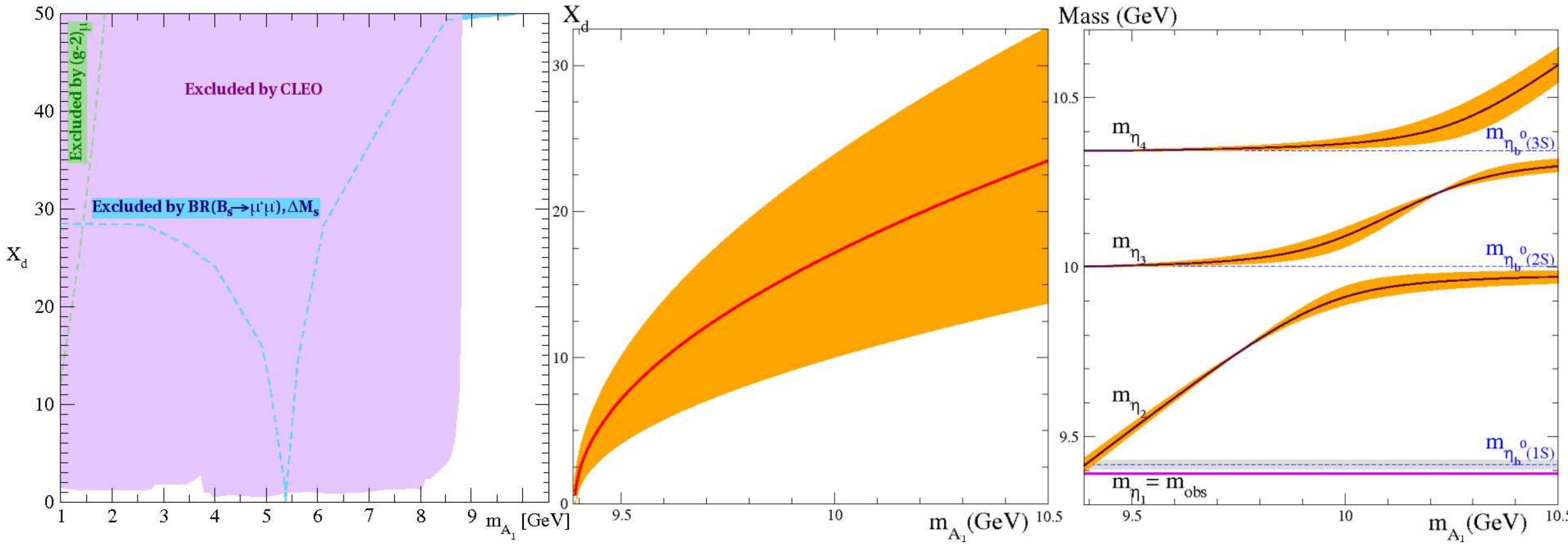
  $m_{h_1^0} \sim 100$ **GeV** $\quad (m_{\text{eff}}^{\text{EW}} \lesssim 100$ GeV$)$

NMSSM light pseudoscalars "natural": pseudo-Goldstone e.g. from broken U(1)$_R$

Unconventional Higgs decays: constraints on a light a_1^0

► **B physics**
- $m_{a_1^0} \lesssim 2\, m_B$: severe constraints from $\bar{B} \to X_s \ell^+ \ell^-$, $\bar{B}_s \to \mu^+ \mu^-$
- $\Upsilon \to \gamma(a_1^0 \to \tau\tau/\mu\mu/..)$ [BABAR, CLEO] : 9 GeV $\lesssim m_{a_1^0} \lesssim$ 10.1 GeV
  (also favoured by $\Upsilon(1s) - \eta_b(1s)$ hyperfine splitting from $a_1^0 - \eta_b$ mixing)

[Domingo et al, Hiller, Domingo...]



[Domingo et al '09 & Moriond '10]

Notice that bounds depend on $X_d = \cos\theta_A|_{\text{doublet}} \times \tan\beta$

Unconventional Higgs decays: constraints on a light a_1^0

- **ATLAS preliminary** [M. Schumacher, Moriond EW '11]

  Exclusion limits for $\sigma(gg \to A)\times$ BR$(A \to \mu\mu)$: light a_1^0 ($\lesssim 9$ GeV)

- **LEP constraints:**

$\boldsymbol{m_{a_1^0} \gtrsim 2\, m_B}$: strong constraints on $m_{h_1^0} \lesssim 100$ GeV

$h_1^0 \longrightarrow a_1^0\, a_1^0 \longrightarrow 4b$'s [OPAL '04, DELPHI '04]

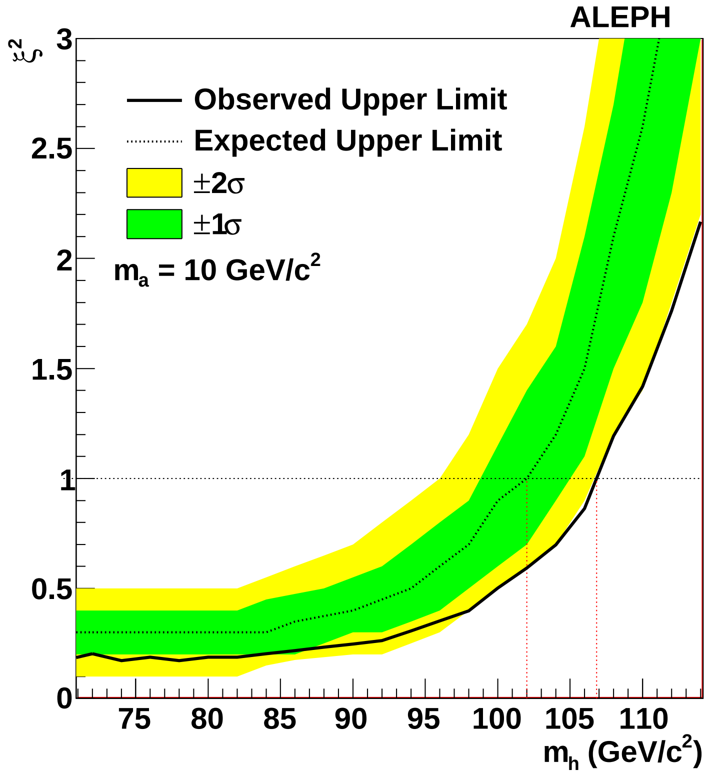
$2\, m_\tau \lesssim m_{a_1^0} \lesssim 2\, m_B$: $\boldsymbol{m_{h_1^0} \lesssim 110}$ **GeV**, Higgsstrahlung

$h_1^0 \longrightarrow a_1^0\, a_1^0 \longrightarrow 4\tau$'s [ALEPH '10]

$\Rightarrow$ $\boldsymbol{m_{a_1^0} \sim 10}$ **GeV compatible with** $\boldsymbol{m_{h_1^0} \sim 100}$ **GeV**

for BR$(a \to \tau^+\tau^-) \sim 80\%$ (i.e. $\xi^2 \lesssim 0.5 - 0.6$)

[Dermisek, Gunion '10]



$$\xi^2 = \frac{\sigma(e^+e^- \to Zh)}{\sigma(e^+e^- \to Zh)_{\rm SM}} \times \text{BR}(h \to aa) \times \text{BR}(a \to \tau^+\tau^-)^2$$

NMSSM searches

An **extended Higgs sector** does not mean **"easier to detect"!!**

- **NMSSM discovery** requires taking into account many **non-standard channels**

  Distinct production processes, intermediate states in cascade decays...

  Disentangling NMSSM from the MSSM might be complicated

- NMSSM regimes can possibly be **more visible** than the MSSM

  [Dermisek, Gunion '08; Moretti, Munir '06]

Example: **significant excess of the signal rate** $\sigma(gg \to h_1^0 \to \gamma\gamma) \sim 6 \times \sigma(gg \to H^{\mathsf{SM}} \to \gamma\gamma)$

for lighter Higgs 80 - 110 GeV (significant singlet component) [Ellwanger '10]

- NMSSM: **"No-lose" theorem** for the detection of at least one h might not apply

  "Discovery of at least one NMSSM CP even Higgs at LHC for $\int \mathcal{L} \sim 600$ *fb*$^{-1}$*"*

  if Higgs-to-Higgs decays are present (as in vast regions of the parameter space)

  [Ellwanger, Gunion, Hugonie '05]

Unconventional Higgs decays: some strategies for the LHC

$h_1^0 \to a_1^0 a_1^0 \to 4\tau$ (possibly $m_{h_1^0} < 114$ GeV)

$\Rightarrow$ **difficult to identify all 4 leptons;** large $\not{p}_T$ (as much as 8ν final state)

$\Rightarrow$ **backgrounds:** $t\bar{t}$, vector boson $+t, b$, vector boson + light jets, Υ...

- CMS: explore $2\mu + 2$jet signature [Belyaev et al '08]

- Higgsstrahlung $q\,\bar{q}' \to W\,h_i$, $W \to l\,\nu_l$: trigger on leptonic W decays; very clean signal

- Vector Boson Fusion: trigger on 2 same-sign non-isolated μ's; $\sim$ collinear τs from a_1^0

- CMS & ATLAS: central exclusive production $p\,p \to p\,h_1^0\,p$ [Forshaw et al '07]

- install purpose built low-angle proton detectors

- visible $h_1^0 \to a_1^0 a_1^0 \to 4\tau$, $m_{h_1^0}$ and $m_{a_1^0}$ determined on event-to-event basis

- $H^\pm \to W^\pm a_1^0$, $a_1^0 \to \tau^+\tau^-$ (e.g. gluon fusion) [Dermisek '10, Mahmoudi '10]

- $pp \to h_1^0 +$ resolved jet $\to \tau^+\tau^-+$jet (gluon fusion) $\Rightarrow$ light h_1^0 [Belyaev '10]

- LHC & Tevatron: a_1^0 detection in low $\tan\beta$ $gg \to (h_1^0) \to a_1^0 a_1^0 \to 4\tau,\ 2\tau 2\mu$...

Neutralinos & dark matter in the NMSSM

★ **Neutralino relic density** Ωh^2 [Belanger et al '05 - '08, ...]

Richer Higgs/neutralino sectors $\Rightarrow$ correct relic density in **large regions** of the **NMSSM**

▶ **New final states** are kinematically **open** (light h_1^0, a_1^0)

▶ **Additional** scalar and pseudoscalar $s-$channel **resonances**

▶ **Singlino-like LSP** also a good dark matter candidate!

if small higgsino component, $\chi_1^{\tilde{S}}\chi_1^{\tilde{S}} \to h_1^0 \to a_1^0 a_1^0 (X_{\mathsf{SM}} X_{\mathsf{SM}})$

co-annihilations with heavier neutralinos $\chi_1^0 \chi_i^0 \to H, A^{\text{heavy doublet}} \to t\bar{t}, b\bar{b}$

recover scenarios of **MSSM-$\tilde{\tau}$ LSP** (e.g. $m_0 \ll M_{1/2}$)

★ **Interesting prospects** for **NMSSM dark matter detection**

$\Rightarrow$ very light (2-20 GeV) $\tilde{B}$, annihilating via light a_1^0 resonance: **account for CDMS-II;**

below DAMA and CoGeNT regions [Das, Ellwanger '10]

$\Rightarrow$ **Timur Delahaye's** talk "NMSSM constraints and dark matter signals", Friday pm!

A simple and predictive scenario: the constrained NMSSM

Minimal supergravity inspired NMSSM: at M_{GUT} $M_i = M_{1/2}$; $m_0^{\tilde{F},\phi} = m_0$; $A_0^{\tilde{F},\phi} = A_0$

cNMSSM: $M_{1/2}$, m_0, A_0, λ $\quad (m_{H_{u,d}} = m_S = m_0;\ A_{\lambda,\kappa} = A_0)$

[Ellwanger et al '95,'97; Elliot et al '95]

A very **"constrained"** parameter space in the **constrained NMSSM:**

- $< S > \neq 0$ $(\mu_{\text{eff}} \neq 0) \Rightarrow m_S^2|_{\text{EW}} \sim m_S^2|_{\text{GUT}} = m_0^2 \ll M_{1/2}, A_0$ $\qquad m_0^2 \sim 0$

  $(m_0^2 \sim 0$ not viable in cMSSM $\rightsquigarrow \tilde{\tau}$ LSP!)

- Viable DM candidate: **singlino-like χ_1^0**

  efficient $\chi_1^0 - \tilde{\tau}_1$ annihilation $\Rightarrow m_{\tilde{\tau}_1} - m_{\chi_1^0} \simeq$ few GeV $\qquad A_0 \sim -\frac{1}{4} M_{1/2}$

- LEP constraints on Higgs: $\qquad \lambda < 0.02 \qquad (\lambda > 10^{-5}$ for $\Omega h^2|_{\text{WMAP}})$

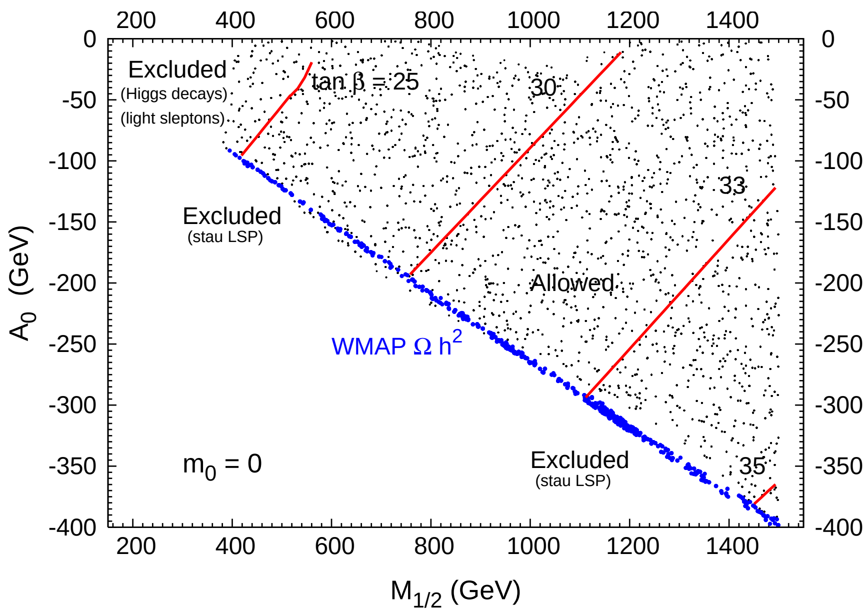
  $M_{1/2} > 520$ GeV $\qquad M_{1/2} \leq 1$ TeV favoured by $(g-2)_\mu$

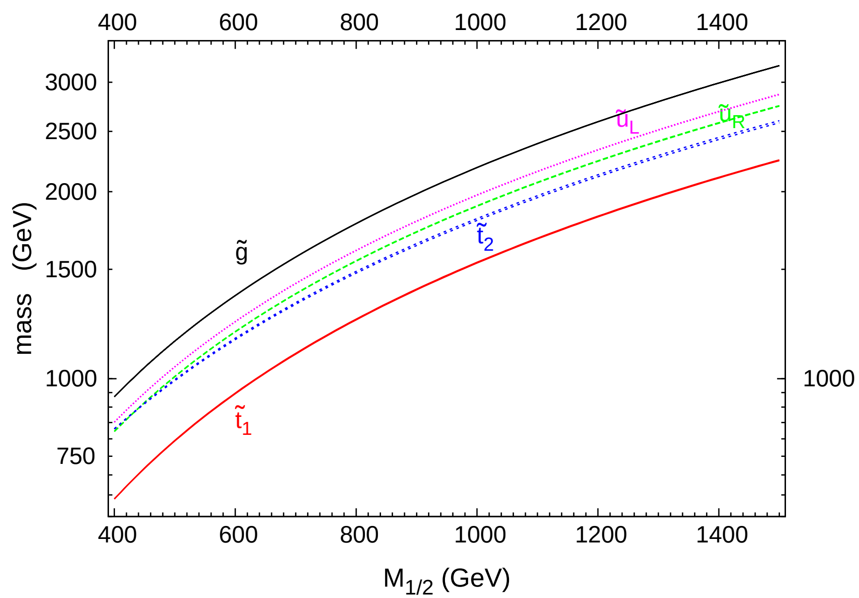
  large $M_{1/2}$ disfavoured by fine-tunning

cNMSSM: essentially one parameter $(M_{1/2})$

[Djouadi, Ellwanger, AMT '08]

cNMSSM spectrum





- **Higgs:** depending on $M_{1/2}$, h_1^0 singlet ⇝ mixed singlet/SM ⇝ SM-like
  "Cross-over": $m_{h_1^0} \approx 99$ GeV; $m_{h_2^0} \approx 117$ GeV; $|C^V_{h_1^0}| \sim 0.3 \Rightarrow$ account for "LEP excesses"!
- **Heavy squarks** ($m_{\tilde{q}} \gtrsim 1$ TeV); **Gluino heavier** than all squarks and sleptons
- Typical sparticle decay chain: $\tilde{\boldsymbol{q}} \to \boldsymbol{\chi_2^0}\, q \to \tilde{\tau}_1\, \tau\, q \to \boldsymbol{\chi_1^0}\, \tau\, \tau\, q$

Different from cMSSM! $\tilde{\tau}_1$ NLSP and 2 τ's per squark ! ($\tau|_{\chi_2^0}$ hard; $\tau|_{\tilde{\tau}_1}$ soft)

cNMSSM: "smoking guns" and Nemesis

★ **Singlino LSP**, nearly degenerate with $\tilde{\tau}_1$ (Ωh^2), small λ (LEP) $\Rightarrow$ **Long-lived $\tilde{\tau}_1$!**

cNMSSM "smoking gun": $\tilde{\tau}_1$ displaced vertices! $\mathcal{O}$(mm - cm)

★ **Dark matter detection in the cNMSSM**

▶ **Direct detection:** χ_1^0-nucleon scattering (within a detector)

cNMSSM: **effective** $\chi_1^0 - \chi_1^0 - q - q$ **coupling** $\propto \boldsymbol{\lambda^2}$

$\Rightarrow$ typical $\sigma_{\chi_1^0 p}$ well **below experimental capabilities ...**

▶ **Indirect Detection:** equally **"dark" prospects** for cNMSSM

Any dark matter signal $\Rightarrow$ tool to RULE OUT model!

cNMSSM prospects for LHC

★ **Dominant background:** $t\bar{t}$, W+jets, Z+jets, $W+Z$ ... (as for any SUSY model)

★ **Dominant production:** $\tilde{q}\tilde{g}$, $\tilde{q}\tilde{q}$

gg and VBF $\rightsquigarrow h_{1,2}^{\text{SM-like}}$; associated $b\bar{b} \rightsquigarrow$ heavier Higgses

★ **Simplest decay cascade:** $\tilde{q}_R \longrightarrow \chi_2^0\, q\,; \quad \chi_2^0 \longrightarrow \tilde{\tau}_1\, \tau\,; \quad \tilde{\tau}_1 \longrightarrow \chi_1^0\, \tau$

★ Dedicated strategies and **cNMSSM specific cuts** [Ellwanger, Florent, Zerwas '10]

- $\sqrt{s} = 14$ **TeV** & $\int \mathcal{L} = 1$ fb^{-1} $\Rightarrow$ **S/B ratio allow** for **cNMSSM discovery**

  (wide $M_{1/2}$ range for larger $\int \mathcal{L}$)

- $\sqrt{s} = 7$ **TeV** & $\int \mathcal{L} = 1$ fb^{-1} $\Rightarrow$ **~ 5 events** (low $M_{1/2}$ regime)

- **distinguish** cNMSSM from cMSSM in $\tilde{\tau}$ coannihilation region

Outlook

- **NMSSM** theoretically and phenomenologically **appealing SUSY extensions of the SM**

- New states $\Rightarrow$ **distinct phenomenology** from SM and MSSM

  light Higgs & neutralino: implications for **flavour physics, dark matter and LHC**

- Can **NMSSM scenarios** be visible at the **LHC?**

  at present only "more-to-gain" theorems, yet no **"no-lose"!**

  NMSSM unconventional decays should be included in LHC strategy

  Warning: LHC "negative results" do not necessarily apply!

- **cNMSSM** simple and minimal SUSY model; phenomenology $\sim \boldsymbol{M_{1/2}}$

  "heavy" sparticle spectrum, $\tilde{\tau}_1$ in **all** decay **cascades** (possibly long lived)

  Any dark matter detection allows to **rule out cNMSSM**

Additional slides

cNMSSM dedicated LHC search strategy

- **Cuts:**

$m_{\tilde{g}} > m_{\tilde{q}} \sim$ heavy: $\begin{cases} \text{2 hard jets/event}(p_T > 300 \text{ GeV}; p_T > 150 \text{ GeV}) \\ \text{large } p_T \text{ of jets and large } E_T^{\text{mis}} > 300 \text{ GeV} \end{cases}$

$\left.\begin{array}{l} \text{one soft } \tau \\ \text{one hard } \tau \end{array}\right\}$ require identification of ONLY one τ, $p_T > 30$ GeV

Lower limits on angle between hard jet and E_T^{mis}

Cut on transverse $M_T > 100$ GeV (from E_T^{mis} and the identified τ)

- **Signal expectation:**

		4j0l	4jtau	cNMSSM
P520	1.36pb	101±1.1fb	27±0.5fb	99±1fb
S/B		0.17	0.44	6.2
$S/\sqrt{B}$	$1\,fb^{-1}$	4.1	3.4	24.8
$S/\sqrt{B}$	$30\,fb^{-1}$	22	19	136
P600	0.70pb	47±0.5fb	13.3±0.3fb	58±0.6fb
S/B		0.08	0.21	3.6
$S/\sqrt{B}$	$1\,fb^{-1}$	1.9	1.7	14.5
$S/\sqrt{B}$	$30\,fb^{-1}$	10.5	9.3	79
P800	0.134pb	7.5±0.1fb	2.7±0.05fb	13.4±0.1fb
S/B		0.012	0.04	0.8
$S/\sqrt{B}$	$1\,fb^{-1}$	0.3	0.34	3.4
$S/\sqrt{B}$	$30\,fb^{-1}$	1.7	1.9	18
P1000	0.035pb	1.68±0.02fb	0.62±0.01fb	3.43±0.03fb
S/B		0.002	0.01	0.2
$S/\sqrt{B}$	$1\,fb^{-1}$	0.07	0.07	0.86
$S/\sqrt{B}$	$30\,fb^{-1}$	0.37	0.43	4.7

Table 3. Signal expectation for the NMSSM points at NLO after all cuts for the benchmark points. At least 120000 events per point were generated. The error is the statistical error. For every point the ratios S/B and $S/\sqrt{B}$ for an integrated luminosity of $1\,fb^{-1}$ and $30\,fb^{-1}$ are shown.

[Ellwanger, Florent, Zerwas '10]

NMSSM charged Higgs bosons

★ In the NMSSM $m_{H^\pm}$ can be somewhat lighter than in the MSSM (...$\lambda^2 v^2$)
and strongly depends on regimes for m_A and $\tan\beta$!

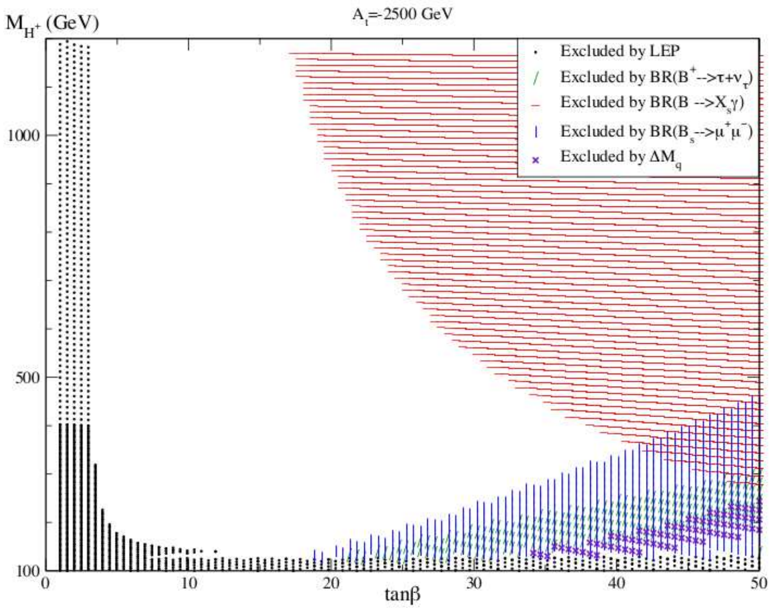
▶ Typically, positive & large A_t regime: BR($\bar{B} \to X_s \gamma$) very stringent constraint!

"SUSY" and $H^\pm$ contributions provide positive contributions (especially large $\tan\beta$!)

▶ Negative & large A_t regime: BR($\bar{B} \to X_s \gamma$)

possible cancellations between "SUSY contributions" and $H^\pm$ contributions

Not only $m_{H^\pm} \sim 100$ GeV is allowed, but for $\tan\beta \gtrsim 20$ $H^\pm$ must be large enough to avoid a large decrease of BR($\bar{B} \to X_s \gamma$) due to the SUSY diagrams!



[Domingo, Ellwanger '07]