Yukawa Unification in SO(10) SUSY GUTs

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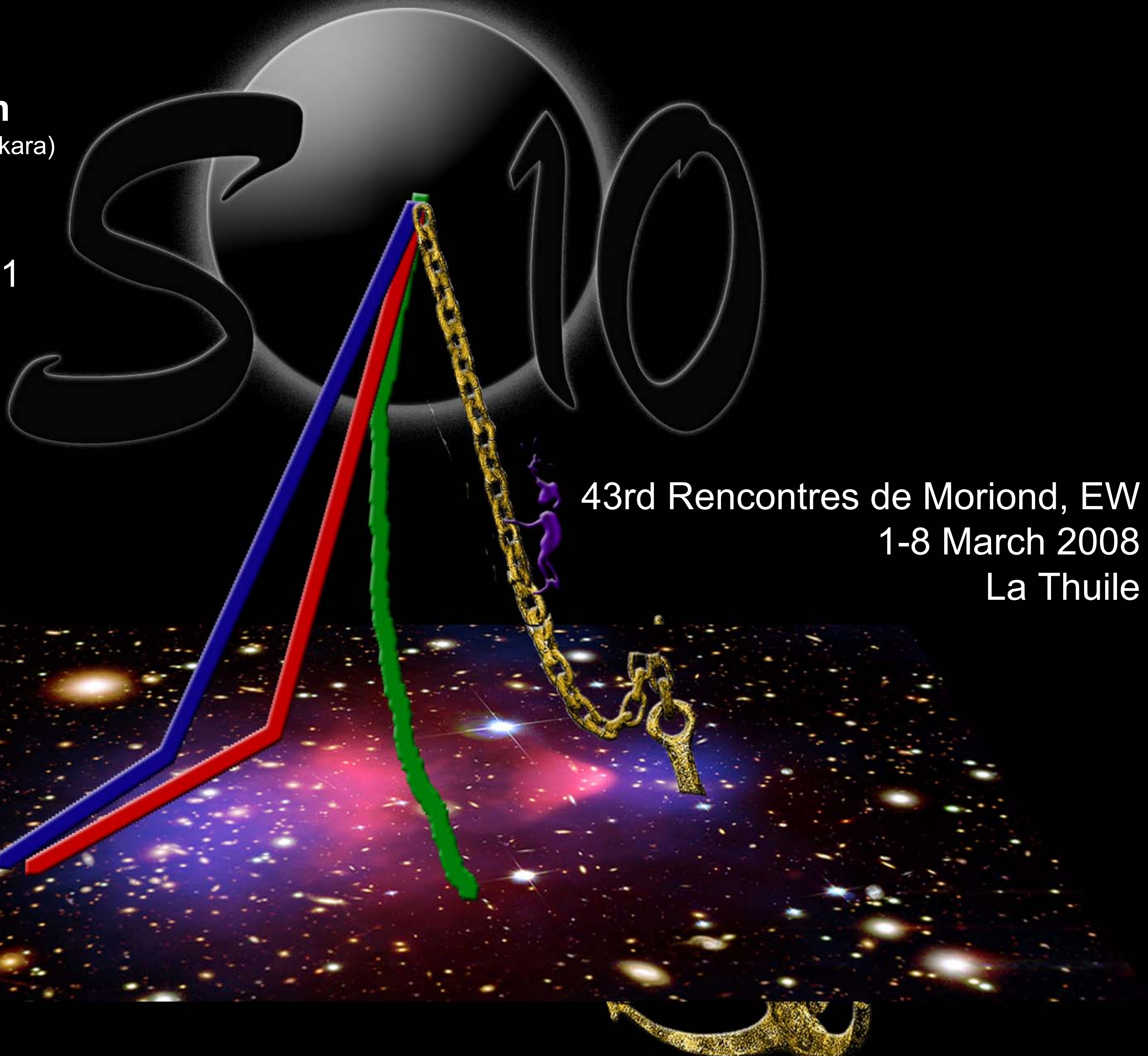

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Motivation for SO(10) SUSY GUTs

- SO(10) SUSY GUTs are highly motivated.
  - All matter fields in 16-dim irreduciible repr (includes ν_R); two Higgs doublets in 10-dim irreducible repr.
  - Neutrino sector leads to successful theory of baryogenesis
  - Left-right symmetric: solves strong CP problem, naturally induces R parity conservation
- Yukawa unification in SO(10) SUSY GUTs:
  - Superpotential contains the following term

$$\hat{f} \supset y\psi(16)_3\phi(10)_H\psi(16)_3 + \ldots$$

  - At tree level Yukawa couplings are unified at the GUT scale: $y_t = y_b = y_\tau = y_{\nu_\tau} \equiv y$
  - At loop level there are a few % corrections
  - Yukawa unification is an important signature!

SO(10) input parameters and outcome

Common GUT scale input:

$m_{16}, m_{1/2}, A_0, \tan\beta$ where $m^2_{Q,E,U,D,L,N} = m^2_{16}$

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GSH: GUT scale Higgs input:

NEW! m_{10} = Common SSB Higgs mass

NEW! m_D = $U(1)_X$ D-term magnitude

Leads to:

$$m^2_{H_{u,d}} = m^2_{10} \mp 2M^2_D$$

WSH: Weak scale Higgs input:

$$\mu, m_A$$

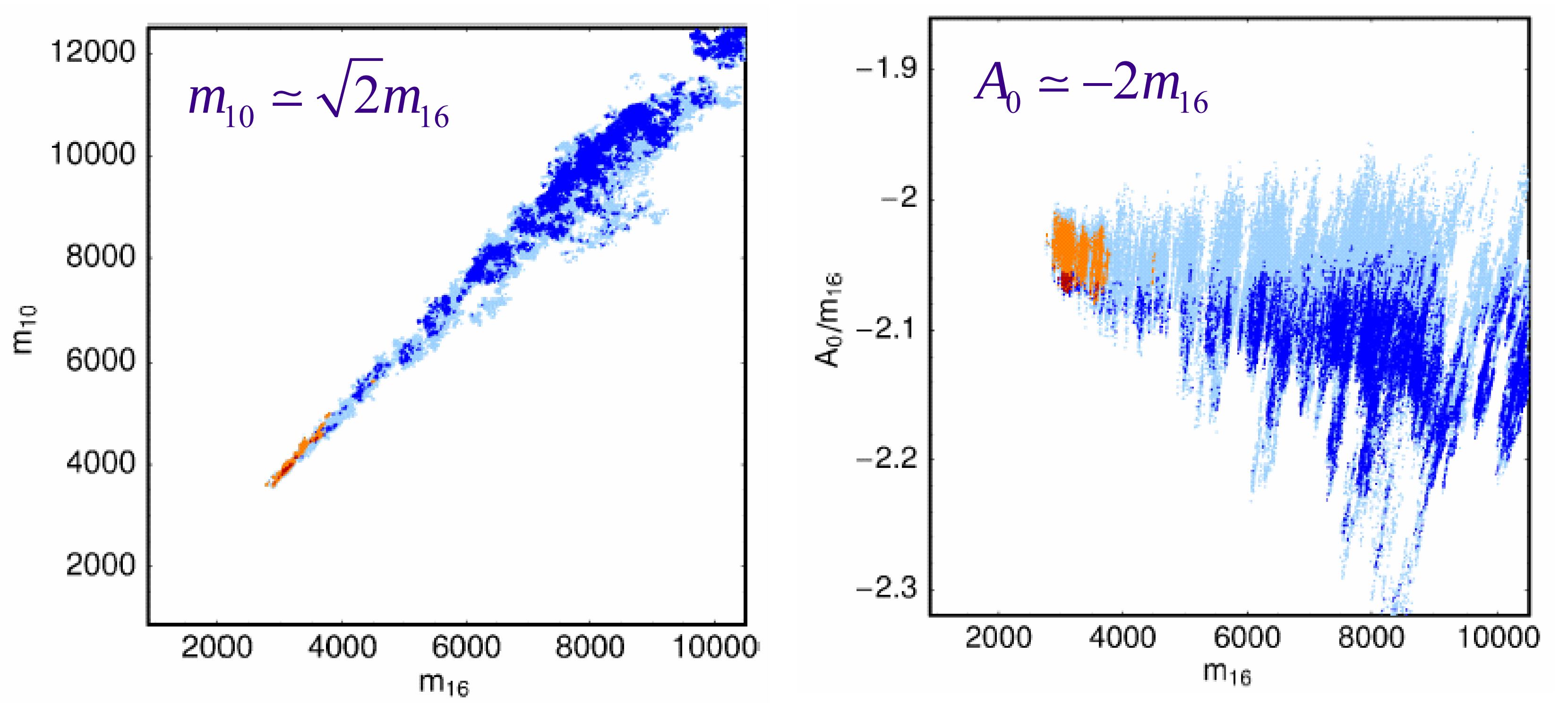
ISAJET 7.75 + micrOMEGAs 2.0.7

Masses, mixings, $\Omega h^2,\ \Delta\rho,\ g_\mu - 2,\ b \to s\gamma,\ B_s \to \mu\mu,\ \sigma_{sc}(\tilde{\chi}^0_1 p)$

MCMC: Compatible regions for GSH

We used the **Markov Chain Monte Carlo** technique to search for regions with

- Good Yukawa unification **R < 1.1** where **R = max(y_t, y_b, y_τ)/min(y_t, y_b, y_τ)**
- WMAP compatible DM relic density: **0.094 < Ωh^2 < 0.136**



R ≤ 1.10, R ≤ 1.05, R ≤ 1.10 & Ω ≤ 0.136, R ≤ 1.05 & Ω ≤ 0.136

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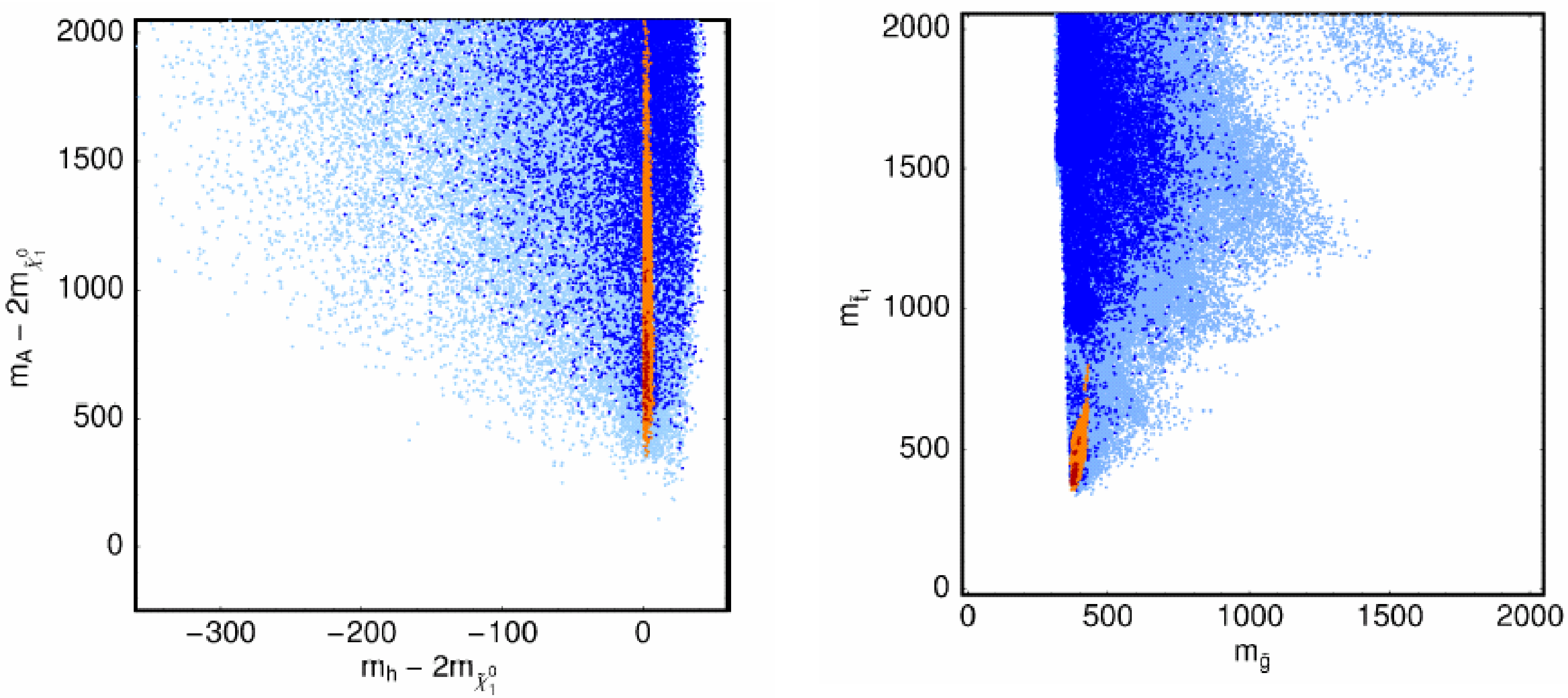

$R \leq 1.10$, $R \leq 1.05$, $R \leq 1.10$ & $\Omega \leq 0.136$, $R \leq 1.05$ & $\Omega \leq 0.136$

Results: LHC signatures

GSH:

- 1st / 2nd generation scalar masses $\geq$ 2 TeV
- 3rd generation scalars and heavy Higgses ~1 - 3 TeV

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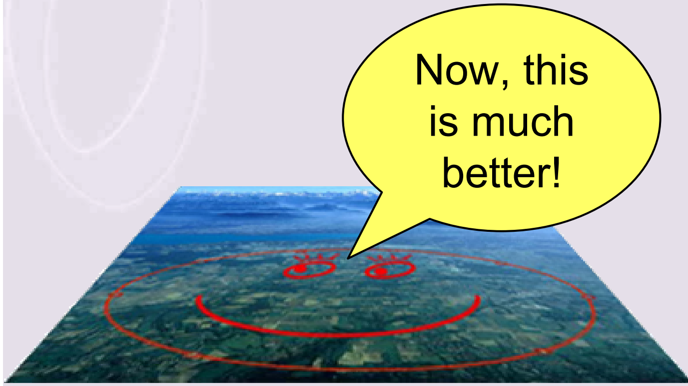
GSH:

- 1st / 2nd generation scalar masses ≥ 2 TeV
- 3rd generation scalars and heavy Higgses ~1 - 3 TeV

- Gluino mass ~ 300 – 400 GeV
- Light neutralinos/chargino masses ~ 100 – 400 GeV



- Gluino pair production with σ ~ 100 pb
- Gluino 3-body decays to b-rich final states via $\tilde{g} \to tb\tilde{\chi}_1^{\pm}, b\bar{b}\,\tilde{\chi}_1^0, b\bar{b}\,\tilde{\chi}_2^0$
- Dilepton edge from $\tilde{\chi}_2^0 \to l\bar{l}\,\tilde{\chi}_1^0$ decays at $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} \sim 50 - 75 GeV$

WSH: Good R + good Ω solutions have light pseudoscalar higgs, so they are excluded by latest D0/CDF $B_s \to \mu\mu$ measurements.

Results: Dark matter in SO(10)

- In general SO(10) SUSY GUTs predict high $\Omega_{\tilde{\chi}_1^0} h^2$
- In some cases relic density can be reduced by:
  - assuming that $\tilde{\chi}_1^0$ is unstable and decays to photon + axino
  - raising GUT scale M_1 to allow for bino-wino coannihilation
  - lowering $m_{16}(1,2)$ so that neutralinos annihilate via light $\tilde{q}_R$ exchange and neutralino-squark coannihilation
- MCMC finds a new class of solutions with m_{16} ~ 3 TeV where neutralinos annihilate via light higgs resonance.
- Direct detection cross sections for studied benchmarks are generally $\sigma_{sc}(p\tilde{\chi}_1^0) \sim 10^{-9}\, pb$