A Realistic Unified Gauge Coupling from the Micro-Landscape of Orbifold GUTs

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Based on work with Christian Gross (0812.4267 [hep-ph])

and on earlier idea with Gero von Gersdorff [hep-th/0504002]

General Setting

- **Orbifold GUTs (coming e.g. from anisotropic heterotic orbifolds)**
- **Size of 5th Dimension is GUT- rather than string-scale**
- **This size sets the 4d unified gauge coupling**
- **Question: What determines this 'largish' size of the 5th dimension?**

- **5d to 4d compactification:**

$$g_4^2 = \frac{g_5^2}{2\pi R}\,.$$

- **1- and 2-loop Casimir energy generate a radion effective potential**

$$V(R) \sim \frac{1}{R^4} + \frac{g_5^2}{R^5}\,.$$

(one may think of this as being due to Kähler corrections to non-scale Kähler potential for $T = R + \cdots$, cf. Luty,Okada,'02).

- **Brane-localized operators lead to log-enhancement:**

$$V(R) \sim \frac{1}{R^4} + \frac{g_5^2}{R^5}\ln(g_5^2/R)\,.$$

- **It only takes a small numerical accident to make $R_{\min}$ largish, so that $\alpha_{\mathrm{GUT}} \simeq 1/25$.**

- **The freedom of 'distributing matter between bulk and branes' (i.e. untwisted and twisted matter) easily allows for this 'accident'.**

- **Indeed, 12 of the 256 models of our 'micro landscape' have an α_{GUT} between $1/20$ and $1/30$.**

Final Comment:

We also have an interesting proposal for 'uplifting' our AdS vacuum using small 5d warping (cf. Bagger,Belyaev,'02; Bagger,Redi,'03; Falkowski,'05).

Phenomenology of Supersymmetric Gauge-Higgs Unification

Based on work with

Felix Brümmer, Sylvain Fichet, Sabine Kraml (0906.2957 [hep-ph])

and on earlier work with

John March-Russell and Robert Ziegler (0801.4101 [hep-ph])

General Setting

- **As before: Orbifold GUT, SUSY is broken by F_T and F_ϕ**
- **Further assumption: Gauge-Higgs unification based on SU(6)**
- **Crucial observation:** $35 = 24 + 5 + \bar{5} + 1$

(cf. Burdman, Nomura, 2002)

Known Facts

(Choi/Haba/Jeong/Okumura/Shimizu/Yamaguchi 2004;

cf. also Lopez-Cardoso et al., '94; Antoniadis et al., '94; Brignole et al., '95)

- **5d action in terms of $\mathcal{N} = 1$ superfields, coupled to supergravity à la Marti/Pomarol, contains terms**

$$\int d^2\theta \, T \, \mathbf{tr} W^2 \qquad , \qquad \int d^4\theta \, \bar{\varphi}\varphi \, \frac{\mathbf{tr}(\Phi + \bar{\Phi})^2}{T + \bar{T}} \, ,$$

which implies:

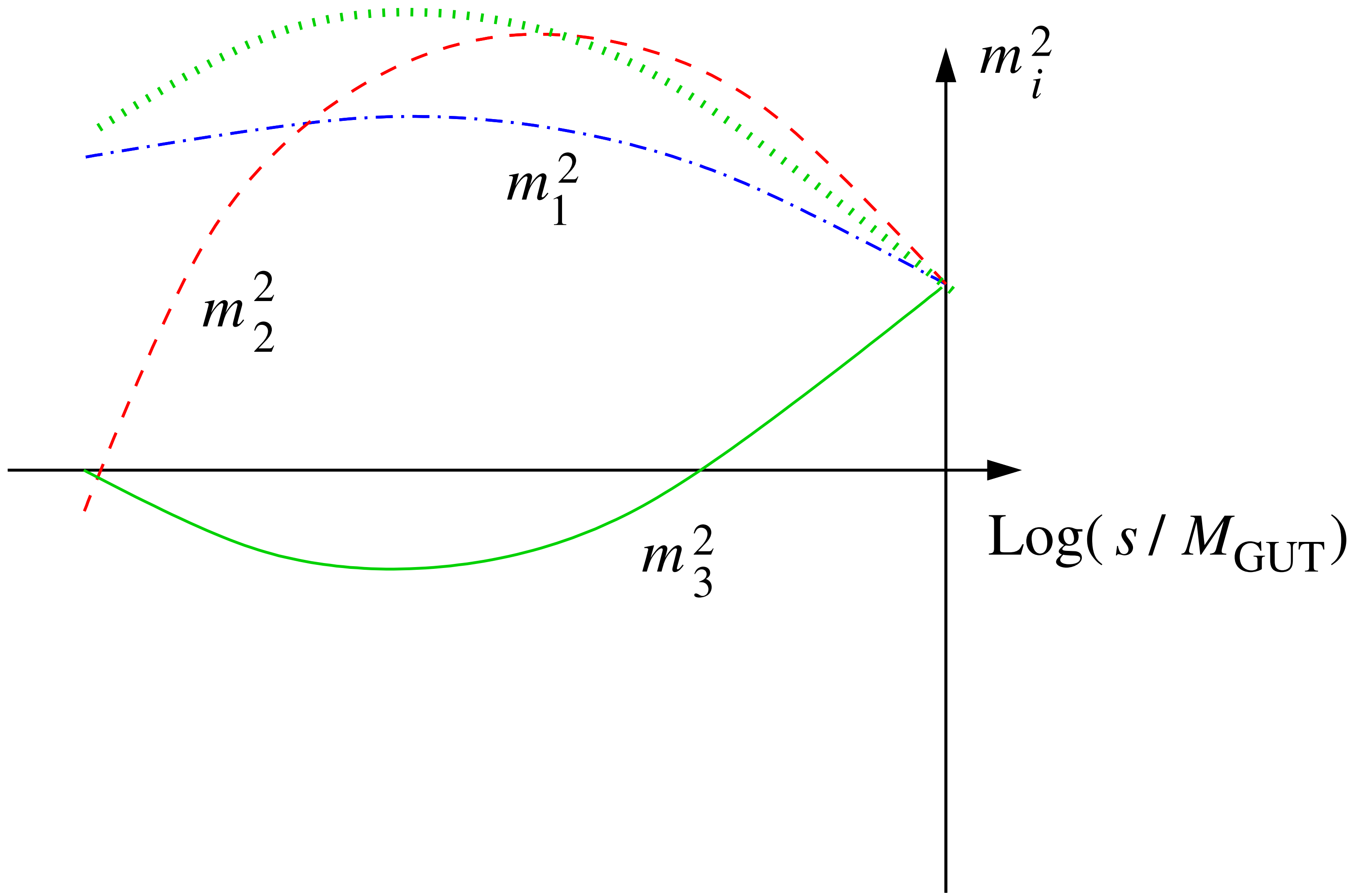
$$M_{1/2} = \frac{\bar{F}_T}{2R} \quad , \qquad \mu = \bar{F}_\varphi - \frac{\bar{F}_T}{2R} \quad , \qquad m_i^2 = |F_\varphi|^2 - \frac{F_\varphi \bar{F}_T + \mathbf{h.c.}}{2R}$$

(our conventions: $m_{1,2}^2 \equiv |\mu|^2 + m_{H_{d,u}}^2$ **and** $m_3^2 \equiv B\mu$ **).**

This is inconsistent with realistic low-energy phenomenology!

(without severe fine-tuning)

Running of $m^2_{1,2} = |\mu|^2 + m^2_{H^2_{d,u}}$ and $m^2_3 = B\mu$



Our Suggestion

- **The SUSY CS-term (generically present!) corrects**

$$\int d^2\theta\, T\, \mathbf{tr} W^2 \qquad , \qquad \int d^4\theta\, \bar{\varphi}\varphi\, \frac{\mathbf{tr}(\Phi+\bar{\Phi})^2}{T+\bar{T}}$$

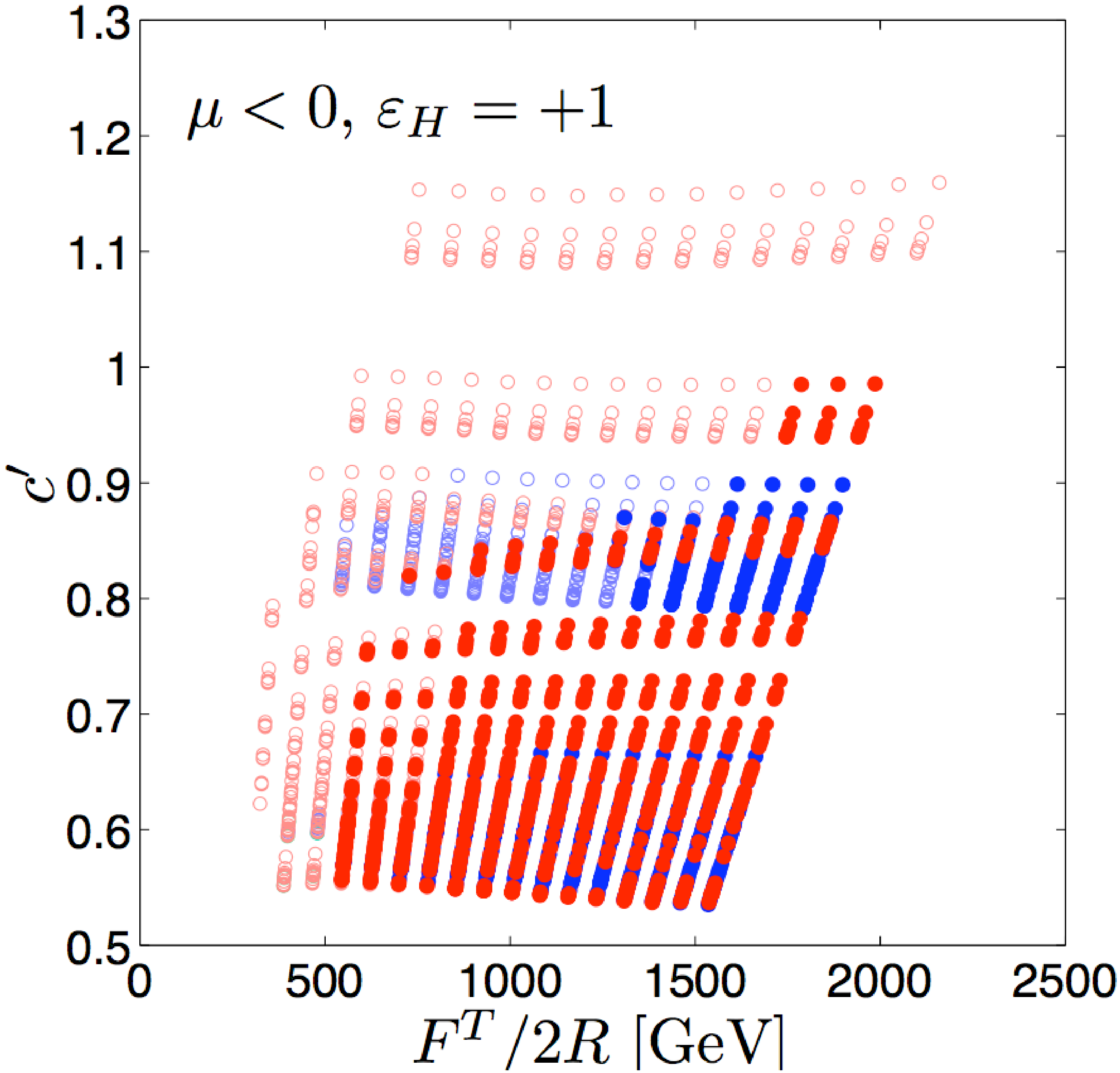
by

$$\int d^2\theta\, \mathbf{tr}\Phi W^2 \qquad , \qquad \int d^4\theta\, \bar{\varphi}\varphi\, \frac{\mathbf{tr}(\Phi+\bar{\Phi})^3}{(T+\bar{T})^2}\,.$$

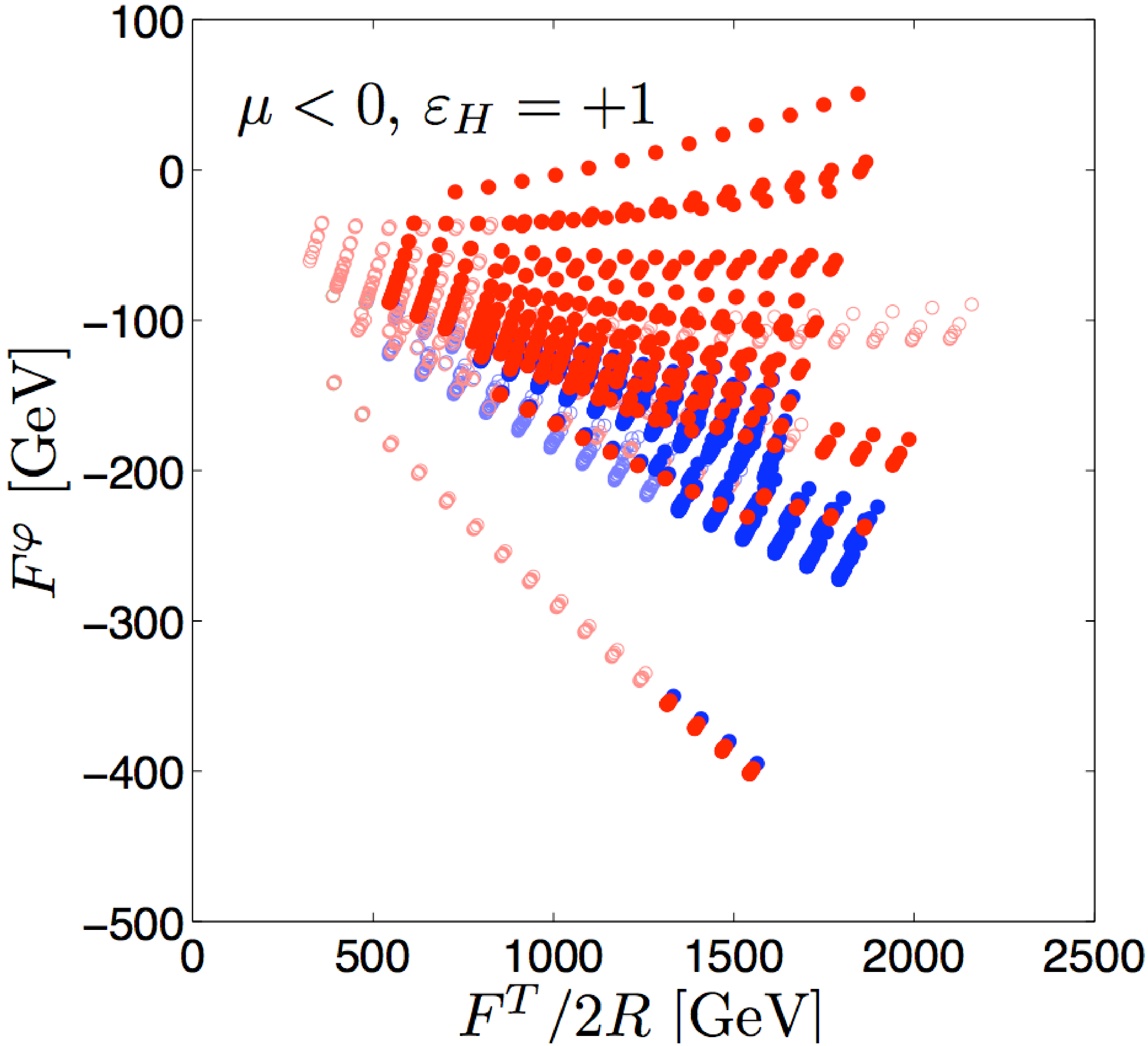
- **Due to the extra parameter ($c' \equiv$ coefficient of the CS term) one finds large regions with excellent phenomenology.**

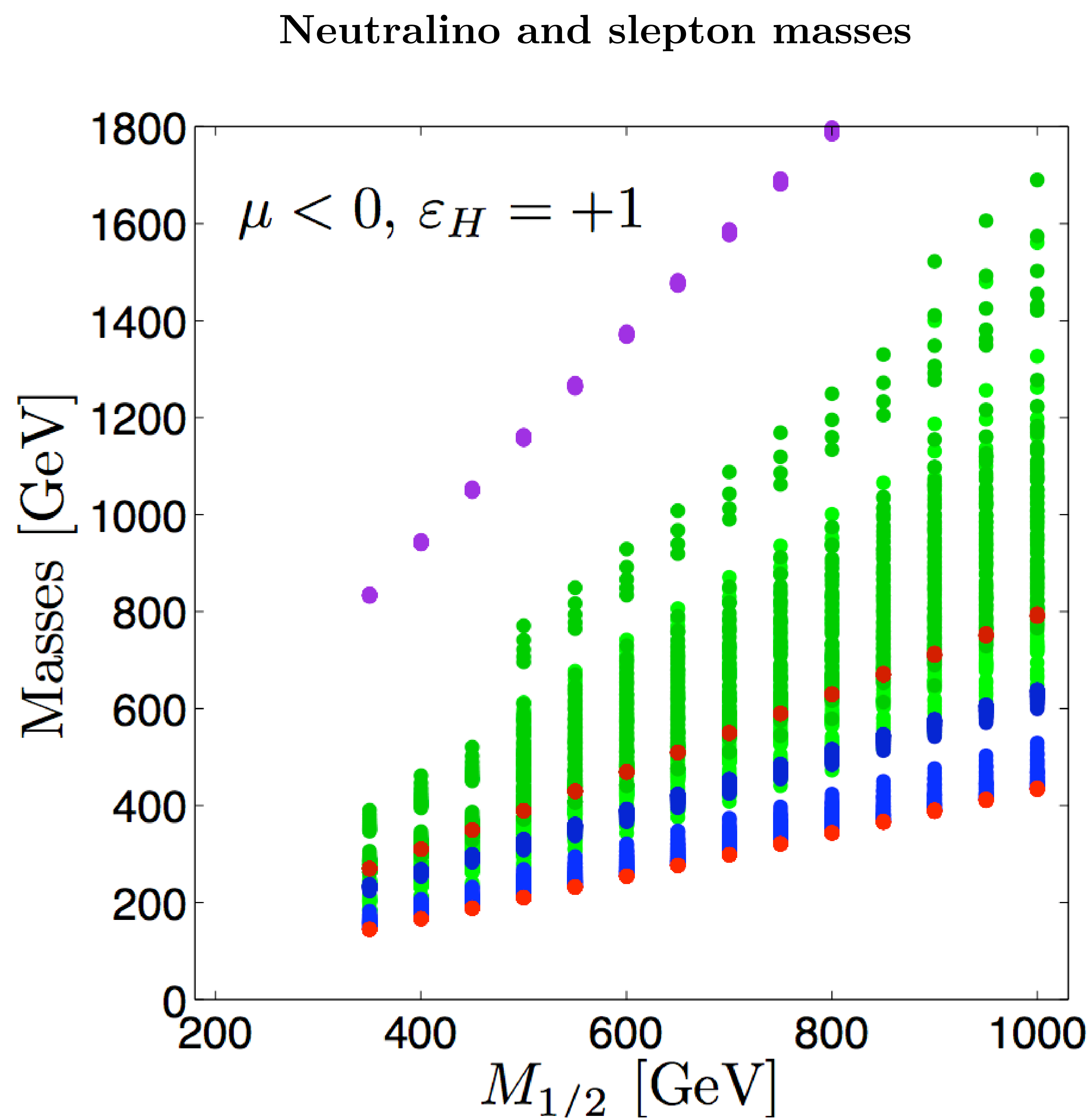
- **Similar to HENS; cf. Evans, Morrissey, Wells, '06**

Importance of Chern-Simons term



F term ratios




Neutralino and slepton masses
$\mu < 0, \varepsilon_H = +1$
Masses [GeV]
$M_{1/2}$ [GeV]
0
200
400
600
800
1000
1200
1400
1600
1800
200
400
600
800
1000