Mirage Models Confront the LHC

Kähler-Stabilized Heterotic String Theory

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- This model breaks supersymmetry using gaugino condensation in the hidden sector
- Masses of the superpartners end up depending on the parameters: $m_{3/2}$, $\tan\beta$, β_+, and $\mathrm{sgn}(\mu)$

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- Determined solely by Lie group invariants; constrained to be an integer between 3 and 90
    1. E_6 requires $\beta_+ \leq 36$
    2. $SO(10)$ requires $\beta_+ \leq 24$
    3. Naïvely we prefer these lower values, though there is no reason to limit ourselves

BGW - III

- Gaugino masses, trilinear couplings and scalar masses are given by:

$$
\begin{aligned}
M_a &= \frac{g_a^2(\mu_R)}{2}\left[-3b_a m_{3/2} + \left(1 - b_a' K_s\right) F^S\right] \\
A_{ijk} &= -\frac{K_s}{3} F^S + \frac{1}{3}\gamma_i m_{3/2} + \mathrm{cyclic}(ijk) \\
M_i^2 &= (1+\gamma_i) m_{3/2}^2 - \tilde{\gamma}_i \left(\frac{m_{3/2} F^S}{2} + \mathrm{H.c.} \right)
\end{aligned}
$$

Preliminary Restrictions

- Choose $\mu > 0$
- Allow $m_{3/2}$ and β_+ to act as independent variables
- Scan over $m_{3/2}$, β_+, and $\tan\beta$
- Place the following restrictions
  1. Broken electroweak symmetry
  2. Satsify LEP limits for superpartners
  3. Neutralino LSP
  4. $\mathfrak{B}\left(B_s \to \mu\mu\right) \in [2.00, 4.09] \times 10^{-9}$
  5. $-11.4 \times 10^{-10} \leq \delta a_\mu \leq 9.4 \times 10^{-9}$

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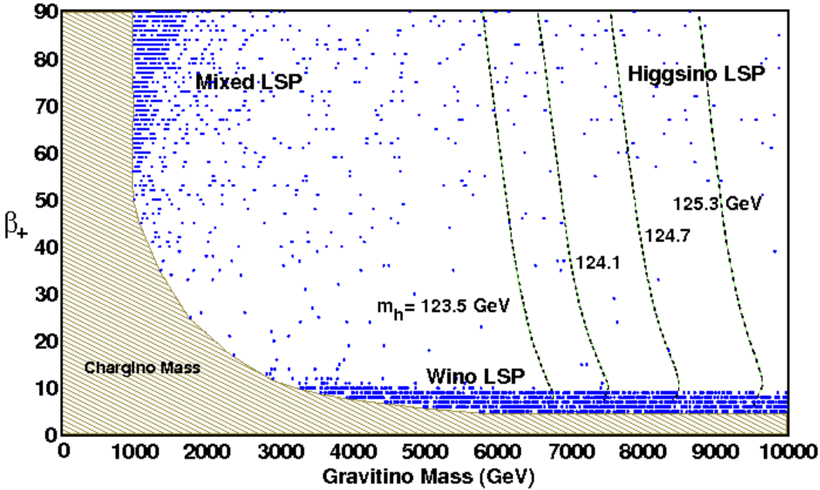
- WMAP combined results claim $\Omega_{CDM}h^2 = 0.1153 \pm 0.0019$
- PLANCK finds a slightly higher $\Omega_{CDM}h^2 = 0.1199 \pm 0.0027$
  1. Impose only a maximum dark matter content of 0.12

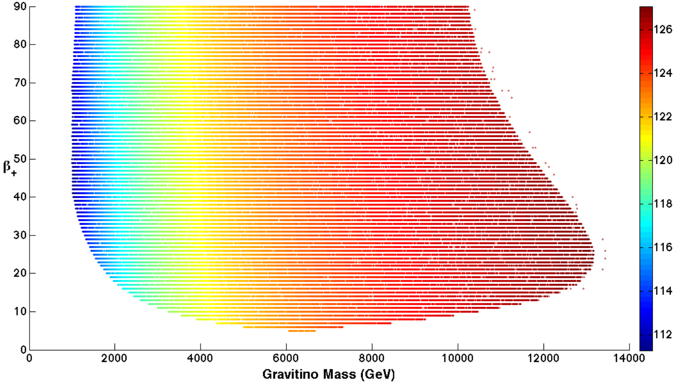
Initial Findings



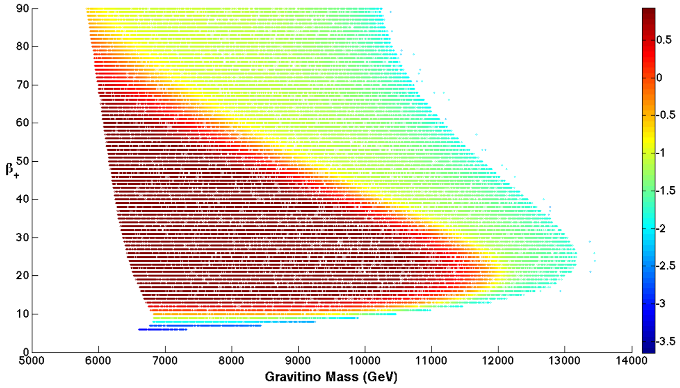
Initial Findings - II

- The remaining region has a very high $\tan\beta$, on the border of where EWSB is achievable
- Higgsino-like LSP
- Need high $m_{3/2}$; extend to 15 TeV
- Lock in $\tan\beta = 42.5$, a lower bound, and perform a two-parameter scan on $m_{3/2}$ and β_+

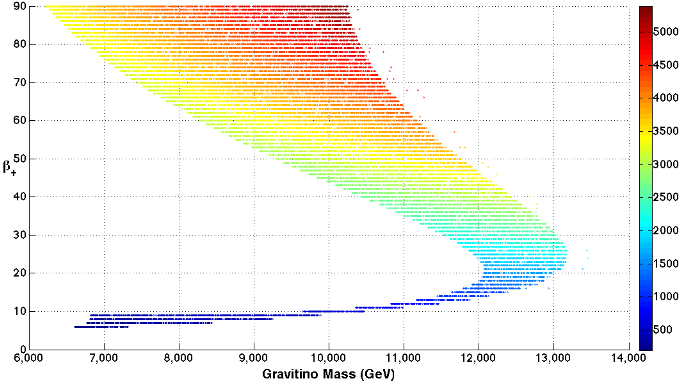
2D Scan - Higgs Mass Constraint



2D Scan - Dark Matter Constraint



2D Scan - All Constraints Applied



Direct Detection

When and where could this model be discovered? Turn to direct detection experiments for answers

- LHC
  1. Can directly produce (and hopefully detect) superpartners and their decay products
- Xenon-1T and LUX
  1. Isolated tanks of Xenon buried deep underground
  2. Ultra-low backgrounds
  3. Search for evidence of WIMP-nucleon scattering

LHC Searches

- Choose a representative sample of the remaining ∼38,000 points to perform an LHC simulation
- Consider:
  1. SUSY production cross sections
  2. Gluino production
  3. How much data must be collected before an observation could be made
- Compare benchmarks to optimized searches
  1. Low multiplicity jets, High multiplicity jets, single lepton, same-sign dilepton, same-sign dilepton + B-tagged jets

Production at the LHC

- Low $\tilde{g}\tilde{g}$ production at 8 and 13 TeV; primarily $\tilde{\chi}^{\pm}$ and $\tilde{\chi}^{0}$
- Unlike simplified models used by ATLAS, these points have $m_{\tilde{\chi}^0} > 0$
- Results in quiet events; low jet multiplicities, low m_{eff} and E_T^{Miss}
- With 7 and 8 TeV data, ATLAS can rule out models with gluinos as heavy as 1 TeV, we can only rule out gluinos at ~ 500 GeV
- Gluinos above ∼3 TeV are beyond the reach of the LHC; BGW can produce gluinos heavier than 5 TeV

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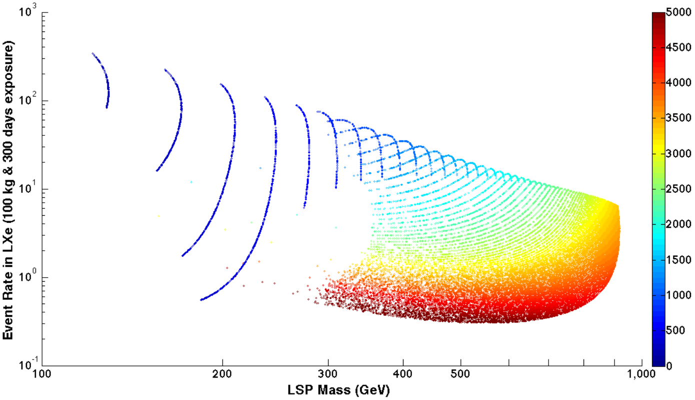
- Gluinos above ∼3 TeV are beyond the reach of the LHC; BGW can produce gluinos heavier than 5 TeV
- Turn to dark matter direct detection experiments
  1. Make a direct comparison to $\frac{\text{events}}{\text{kg}*\text{day}*(5-25)\text{keV}}$

Discovery Prospects at LUX



Looking Forward

- Heavy gluinos and LSPs mean this model will remain beyond the reach of the LHC for some time, if not forever
- LUX and Xenon-1T will be able to rule this model out within the first 1-2 years of operation
- We have a string-based model that is constrained on all sides
- This method of supersymmetry breaking via hidden sector gaugino condensation will either have supporting evidence, or be ruled out

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