

# A Definitive Signal of Multiple SUSY breaking at the LHC

arXiv:1004.4637

Cliff Cheung, JM, Yasunori Nomura and Jesse Thaler

Advertisement!

“Goldstini” (1002.1967) – C.Cheung, Y.Nomura and J.Thaler  
*Talk tomorrow at 10:00 by Yasunori Nomura*

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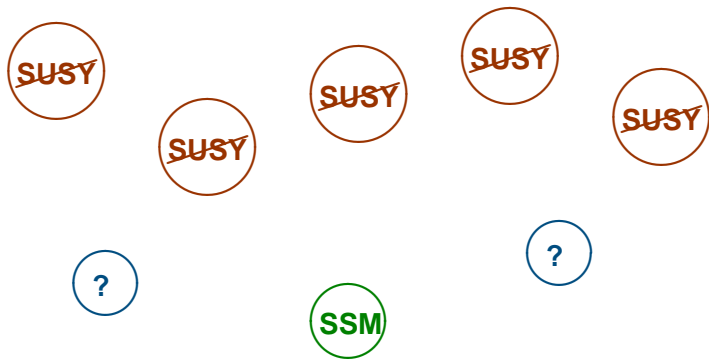
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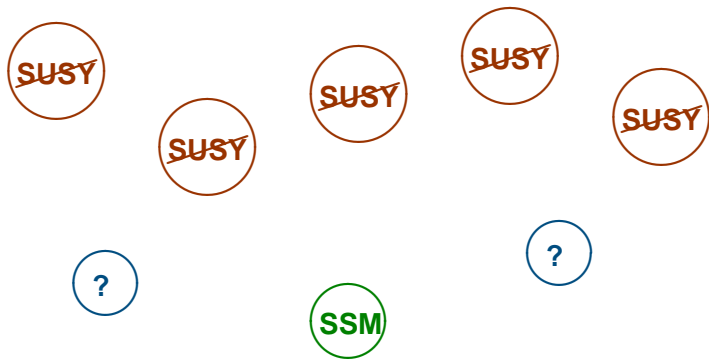
# The Goldstini framework in 60 seconds

- $N$  sequestered ~~SUSY~~ sectors  $\Rightarrow N$  “massless” goldstini
- Include gravity:  $SUSY^N \rightarrow SUGRA$ 
  - massive gravitino
  - $N - 1$  massive goldstini



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## Goldstini have:

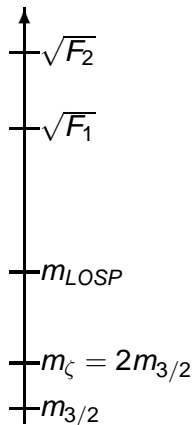
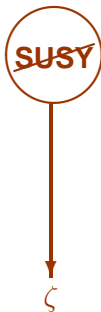
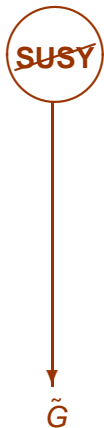
- mass =  $2m_{3/2}$  **(universal)**
- coupling to SSM scalars  $\sim \tilde{m}_i^2 / F_i$  **(free parameter)**

# An Interesting Setup

2 ~~SUSY~~ sectors

→

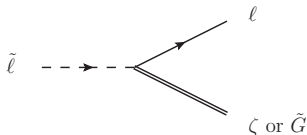
gravitino ( $\tilde{G}$ ) + 1 goldstino ( $\zeta$ )



## An Interesting Setup

2 ~~SUSY~~ sectors  $\rightarrow$  gravitino ( $\tilde{G}$ ) + 1 goldstino ( $\zeta$ )

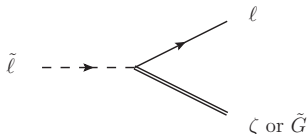
- LOSP can decay to  $\zeta$  or  $\tilde{G}$
- $F_1 \gg F_2$ :
  - $F_1$  controls  $m_{3/2}$
  - $F_2$  controls  $\zeta$ -SSM coupling



*Goldstino is like a gravitino LSP with stronger coupling to LOSP*

# A Smoking Gun Signature

- Charged slepton LOSP stopped at LHC; decay studied.

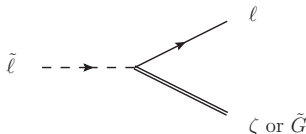


- Expect decay to gravitino
  - measurement of mass and decay rate allows reconstruction of  $M_{Pl}$  (Buchmuller et al '04)
- But decay is primarily to *goldstino*
  - mismeasurement of  $M_{Pl}$
  - search for rare decays to  $\tilde{G}$
  - predict both  $m_{3/2}$  and  $\text{Br}(\text{LOSP} \rightarrow \tilde{G})$
- Observing rare decays to gravitinos confirms the setup.



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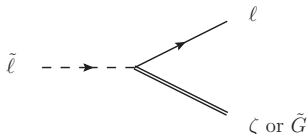
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- Is this generic?
  - Need  $m_{3/2} \gtrsim (0.05 - 0.2)m_\ell$  for mass measurement
  - Need  $\text{Br}(\tilde{\ell} \rightarrow \tilde{G}) \gtrsim 10^{-4} - 10^{-3}$

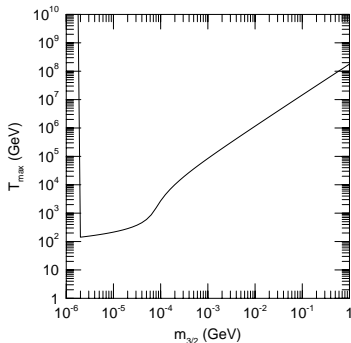
Need to be in the right part of parameter space.

### But what we learn:

- Discovery of SUGRA
- Existence of sequestered sectors with  $\text{SUSY}$

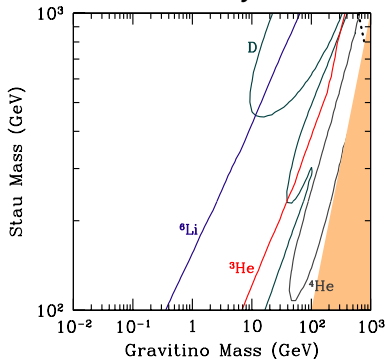
# Goldstino Cosmology 1: The gravitino problem

Overabundance



(de Gouvea et al '97)

Late LOSP decay ruins BBN

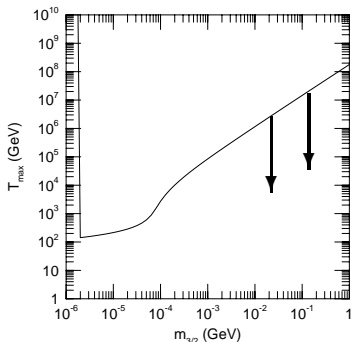


(Kawasaki et al '08)

$\tilde{G}$  heavy enough for LHC mass measurement  $\Leftrightarrow$  BBN problem

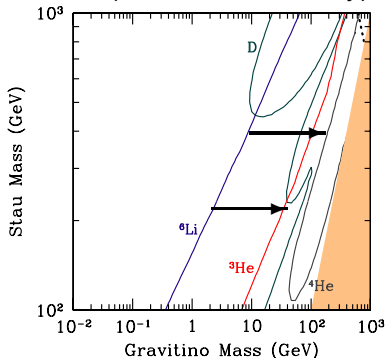
## Goldstino Cosmology 2: Alleviating the gravitino problem

*Goldstino is like a gravitino with extra large coupling to SSM*

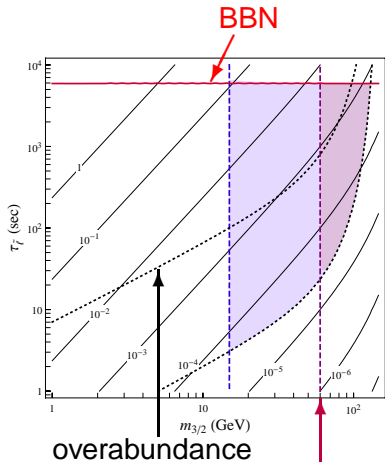
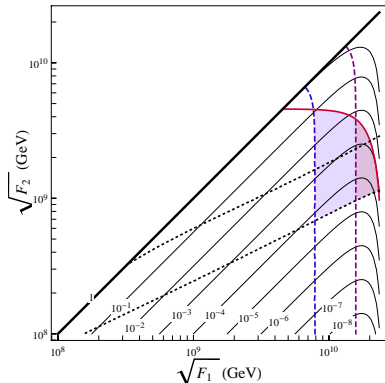


→ overabundance bound  
become stronger (*unless...*)

→ **BBN bounds become weaker** (faster LOSP decay)



# Smoking gun signature + Cosmology = Success



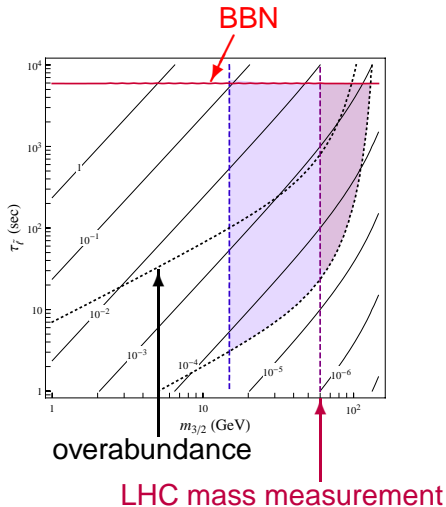
LHC mass measurement

# Smoking gun signature + Cosmology = Success

## Conclusions:

- Striking signature of SUGRA and sequestered sectors at LHC
- Consistent with cosmology

Need  $T_R \lesssim 10^5 - 10^7$  GeV?



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R symmetry in 2nd ~~SUSY~~ sector?

- Goldstino does not couple to gauginos
- Only gravitinos produced at high  $T_R$
- Can have  $T_R$  as high as  $\sim 10^{10}$  GeV



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