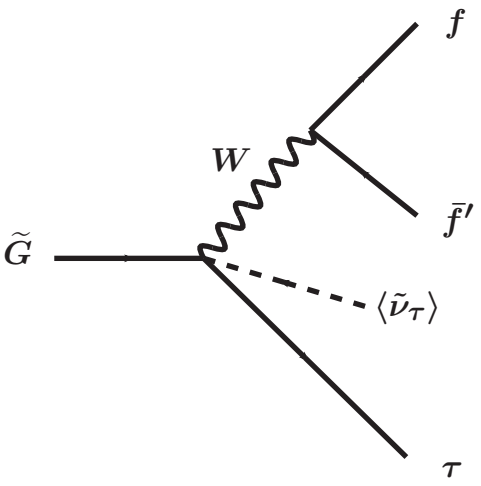
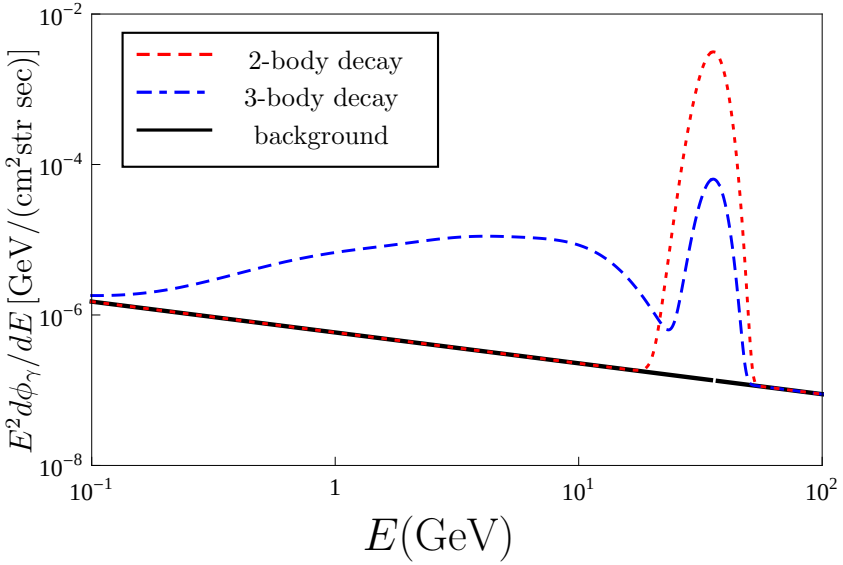
New decay modes of gravitino dark matter





Based on Phys.Rev.D81:075024,2010,
arXiv:1003.3401, PRD (with Ki-Young Choi)
and 1007.1728 (with K-Y C.,D. Restrepo,O. Zapata)

Carlos E. Yaguna

UAM and IFT

2010

In susy models with broken R-parity the gravitino is the only viable dm candidate

The LSP becomes unstable

Neutralino is not a viable dm candidate

If $\widetilde{G}$ is the LSP, it is a dm candidate

$\widetilde{G}$ lifetime $\gg$ age of the Universe

We consider bilinear $\not{R}_p$: $\langle \tilde{\nu} \rangle \neq 0$

Buchmuller, Covi, Ibarra, Moroi, Muñoz, etc

The dominant 2-body decay modes of the gravitino are $\gamma\nu$ and $W\ell$

$\tilde{G}$ decays are determined by $M_i, m_{\tilde{G}}, \langle\tilde{\nu}\rangle$

For $m_{\tilde{G}} < M_W$, $\gamma\nu$ is the only possible 2-body fs

The final states $W^*\ell$ and $Z^*\nu$ may be important

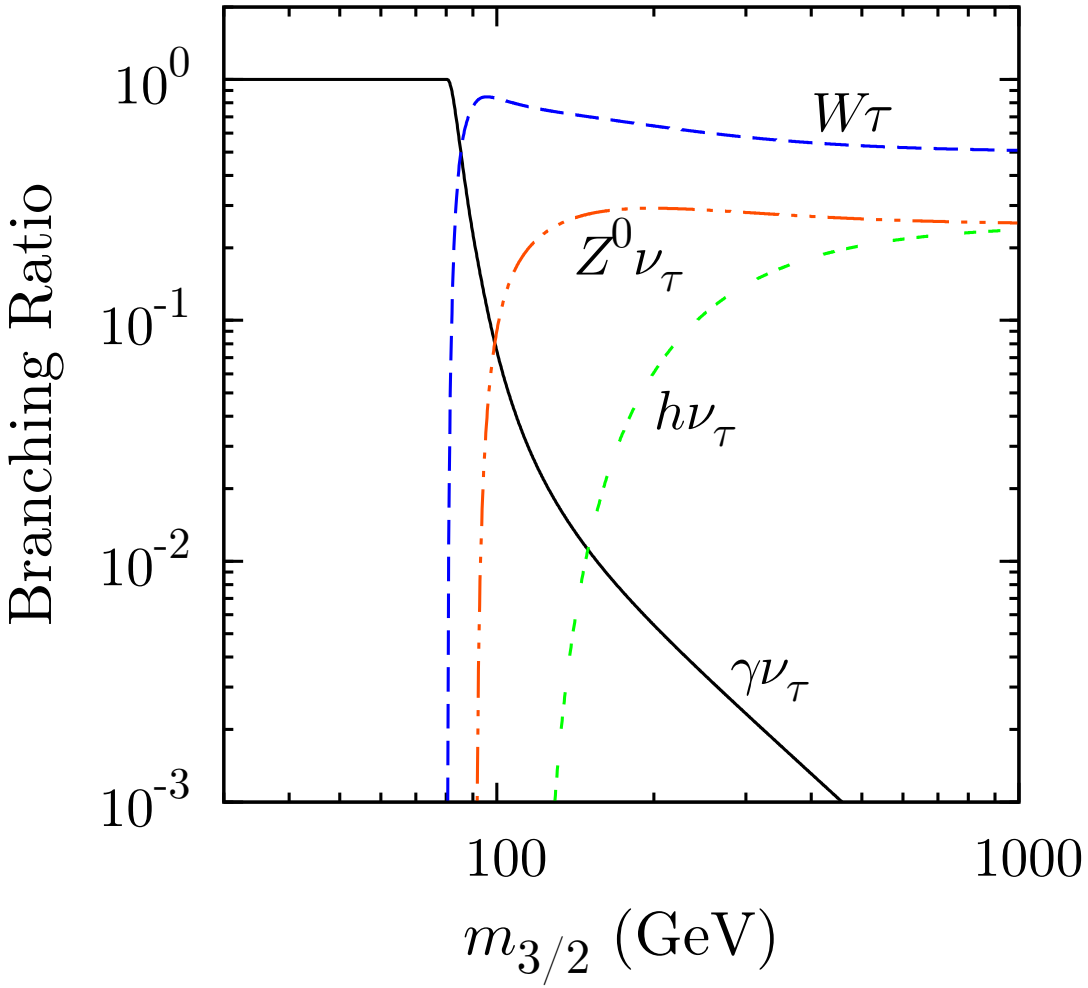
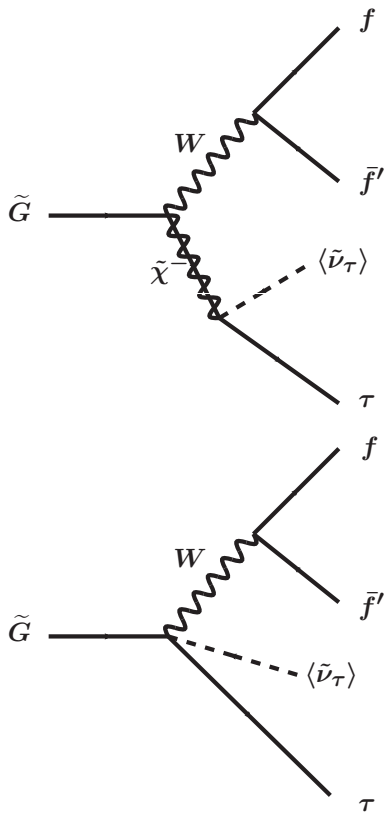


figure from 0809.5030 by Covi et al

Three-body gravitino decays into $W^*\ell$ and $Z^*\nu$ had not been considered before

Two diagrams contribute to these decays



$\propto U_{\widetilde{W}\widetilde{W}}$

The four-vertex diagram $\propto U_{\widetilde{W}\widetilde{W}} \sim M_W/M_2$

The decay into $\gamma\nu$ tends to be suppressed

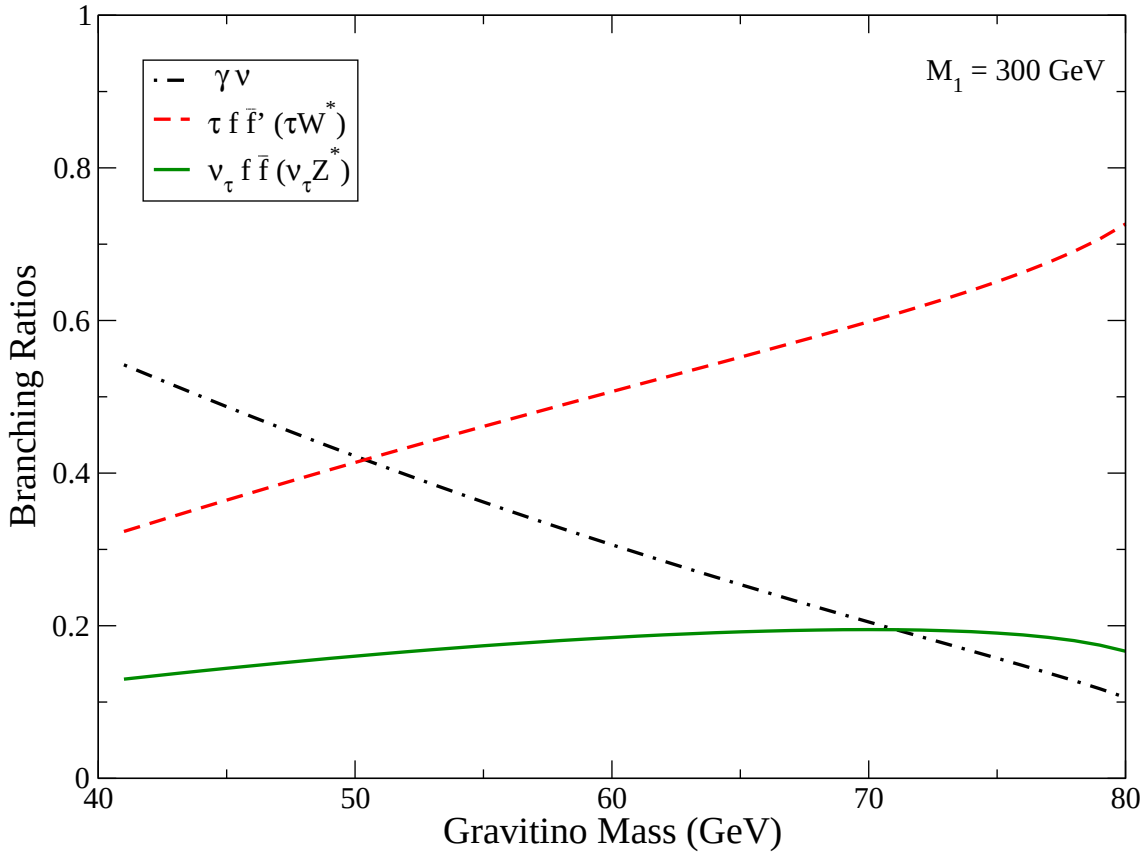
$$\Gamma(\widetilde{G} \to \gamma\nu_\tau) = \frac{\xi_\tau^2 m_{\widetilde{G}}^3}{64\pi M_P^2}|U_{\widetilde{\gamma}\widetilde{Z}}|^2 \propto 1/M_2^2$$

Gravitino decays can easily be dominated by three-body final states

$W^*\tau$ is dominant for $M_W > m_{\tilde{G}} > 50$ GeV

Even $Z^*\nu_\tau$ can be more important than $\gamma\nu$

3-body gravitino decays cannot be neglected

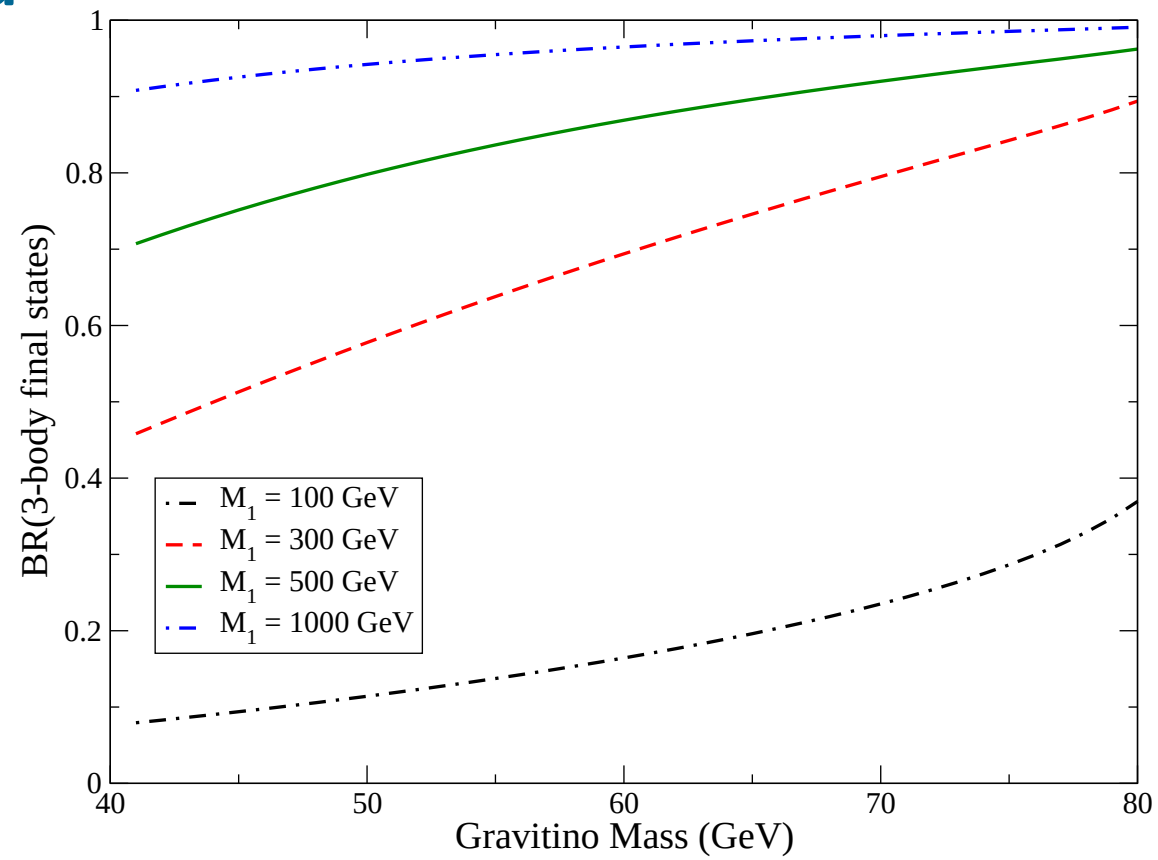


The 3-body final states become more relevant for larger gaugino masses

They can dominate over a wide range of $\widetilde{G}$ masses

The effect is significant even for small M_i

For large M_i, $\widetilde{G} \to \gamma\nu$ becomes negligible

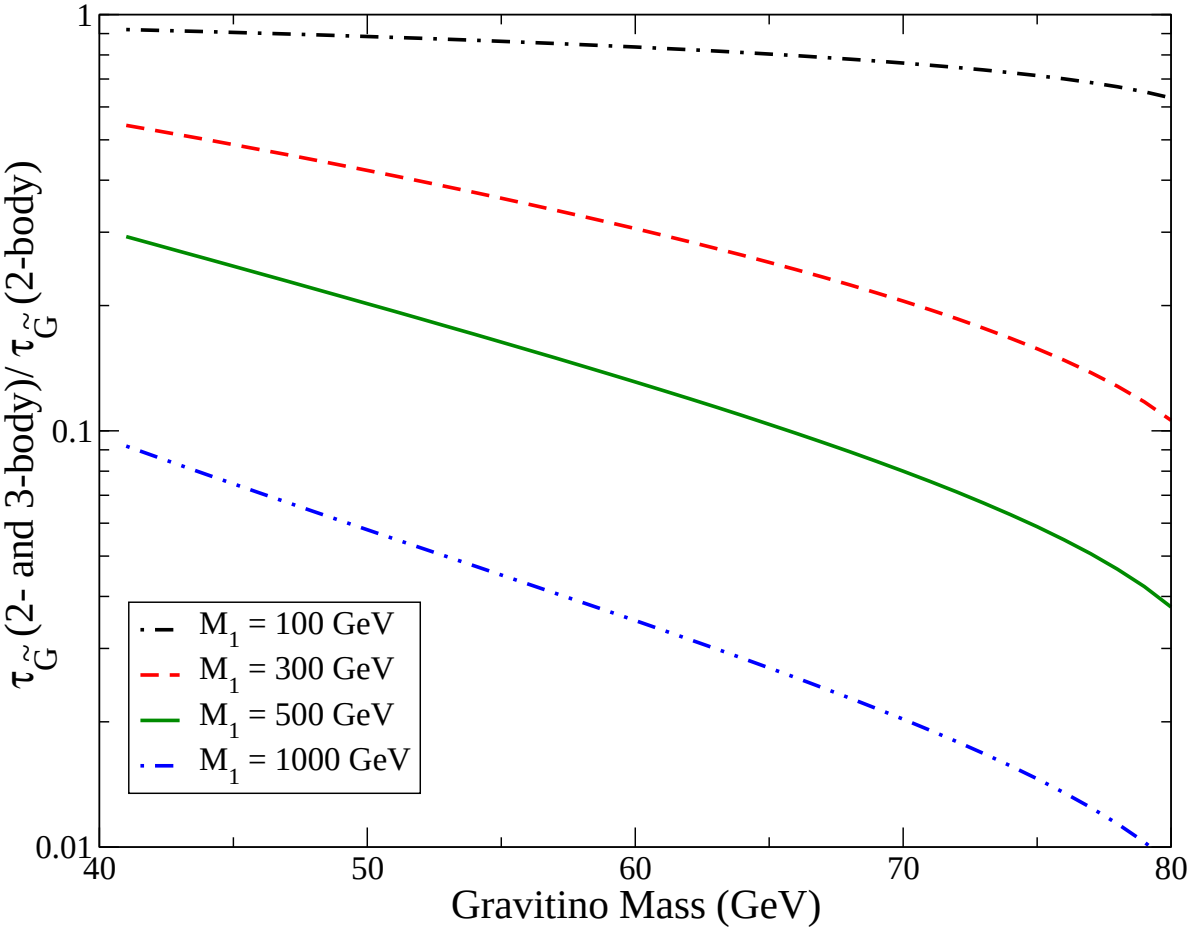


The gravitino lifetime is significantly affected by these new decay modes

It could be more than 100 times smaller

Indirect detection of $\widetilde{G}$ dm is strongly affected:

- Suppressed γ, ν lines
- New continuum of γs
- New antimatter signals

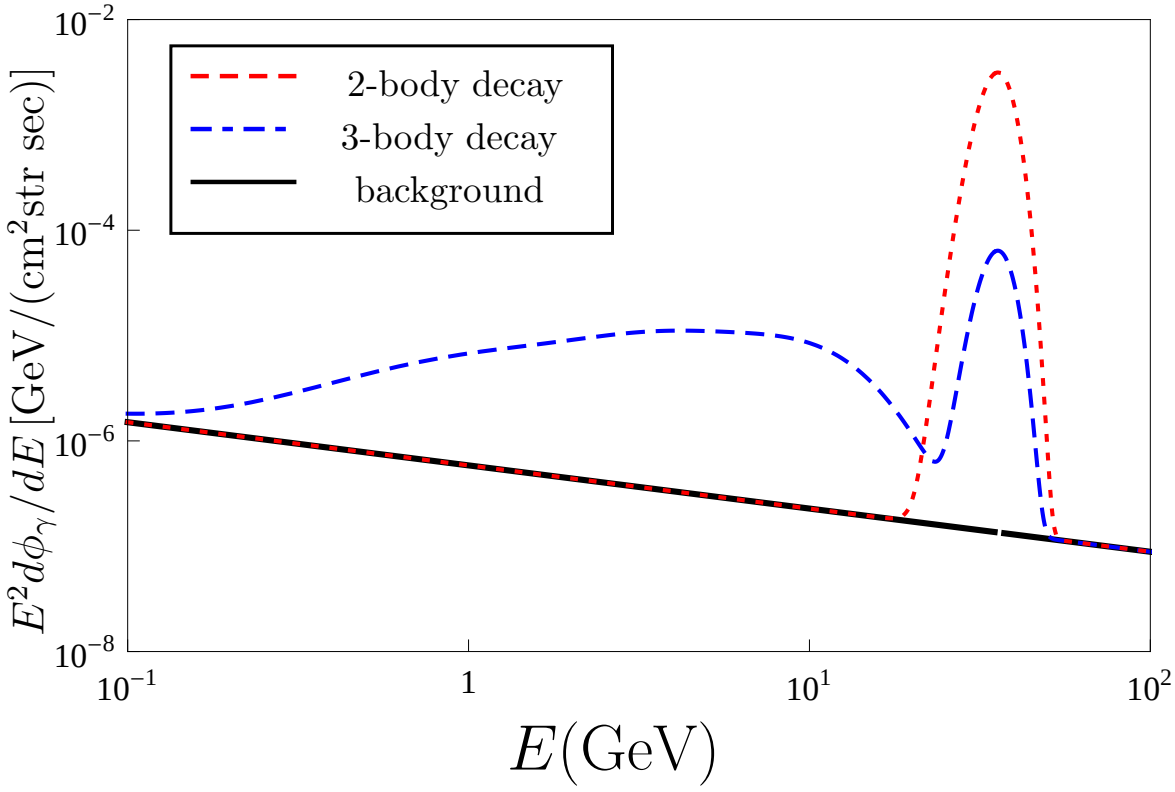


The expected gamma ray flux from gravitino decays is significantly altered

The γ line is less apparent

The new γ continuum could be observed

These effects are typically sizable

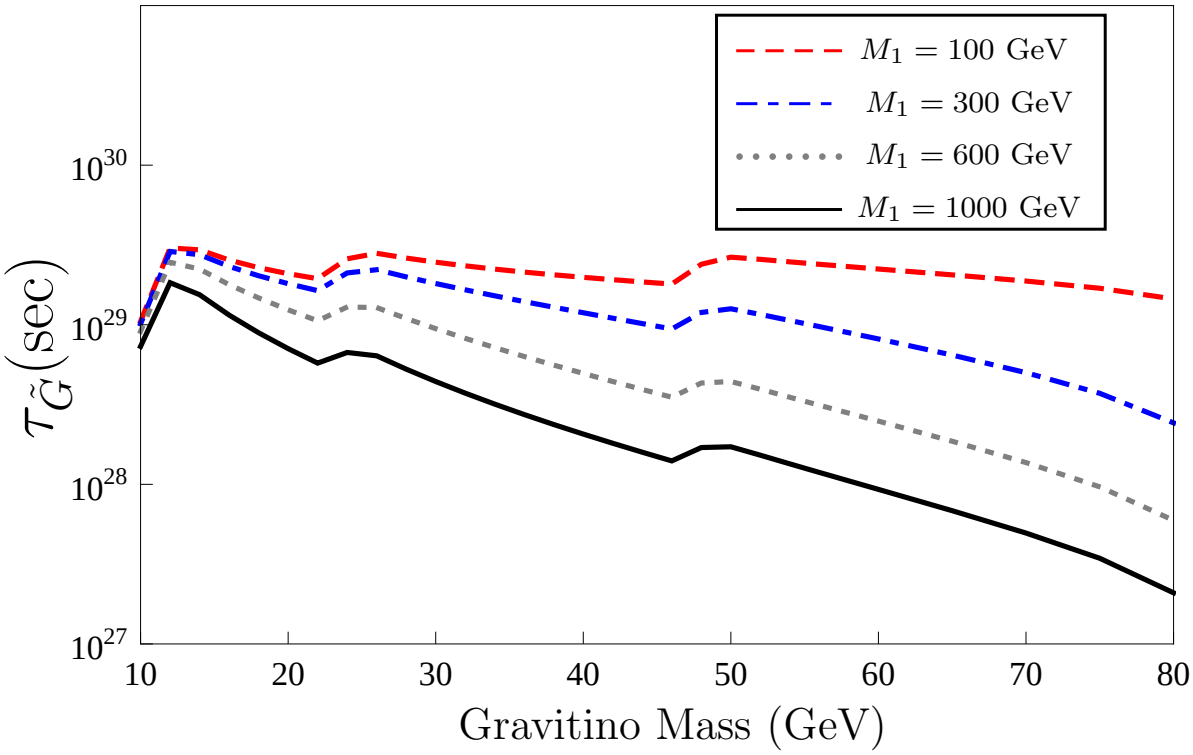


We derive new constraints on the gravitino lifetime from recent FERMI data

We used the diffuse γ-ray data

The bound depends on gaugino masses

It requires $\tau_{\tilde{G}} \gtrsim 10^{27-29}$ s depending on $m_{\tilde{G}}, M_1$

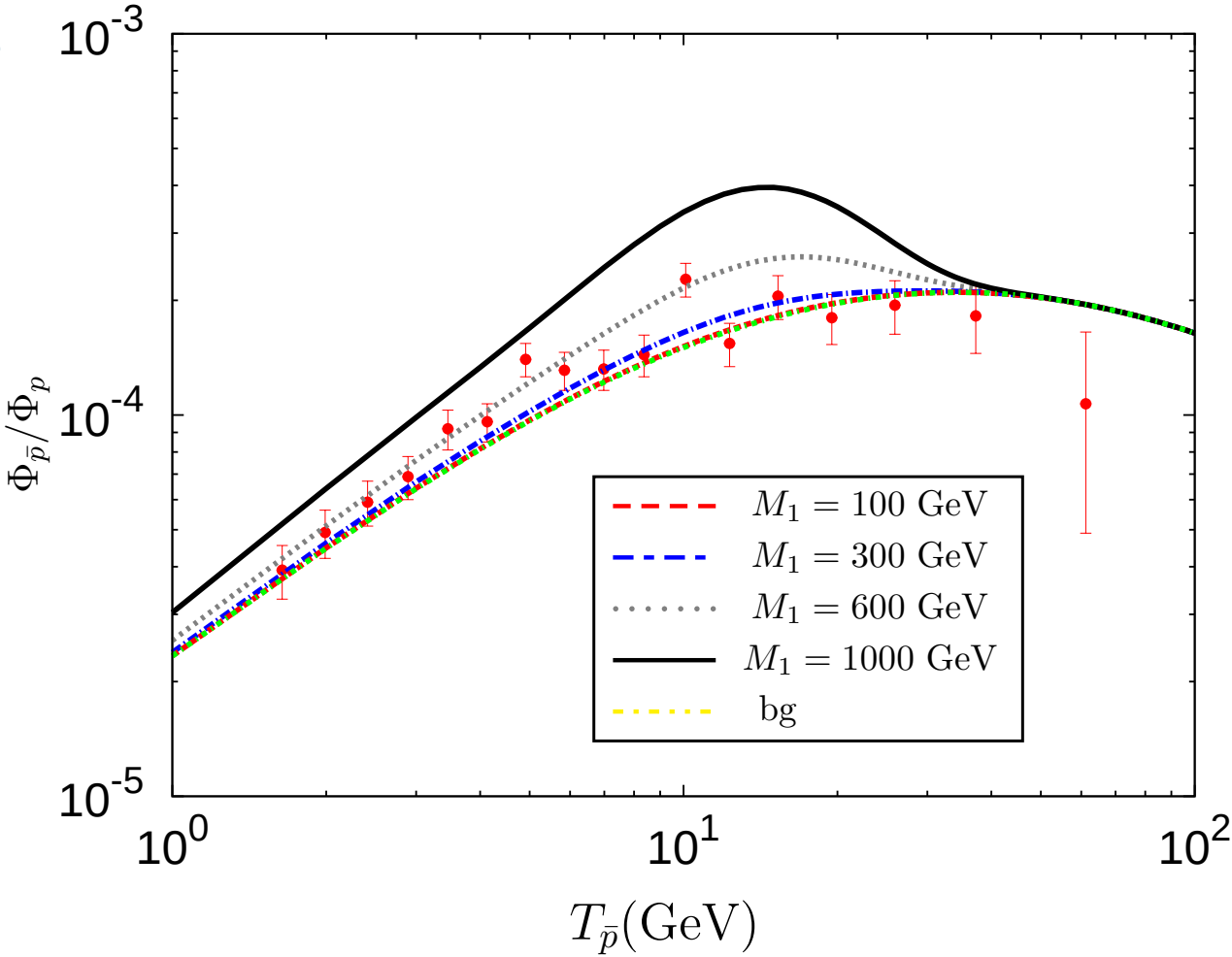


The 3-body decays of gravitinos give rise to an non-zero antiproton flux

An effect entirely due to the new decay modes

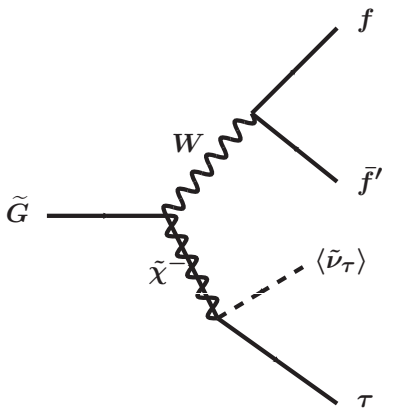
The predicted $\bar{p}$ flux may be observable

Even if the γ-ray bound is used

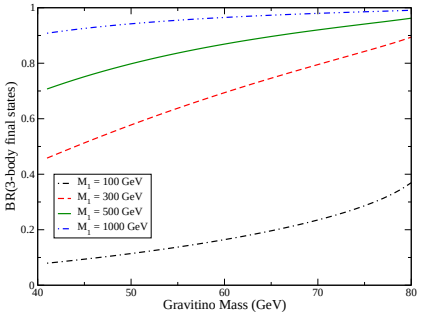


In $\not{R}_p$ models, the 3-body decays of the gravitino cannot be neglected

They are typically sizable for $M_{\tilde{G}} < M_W$



They modify the $\tilde{G}$ lifetime and BRs



They alter the $\tilde{G}$ indirect detections signals