Decaying Supersymmetric Dark Matter and 130 GeV Fermi Gamma-ray Line

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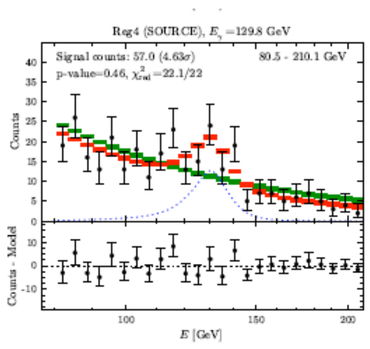
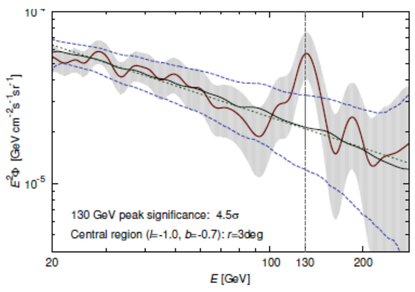
Introduction

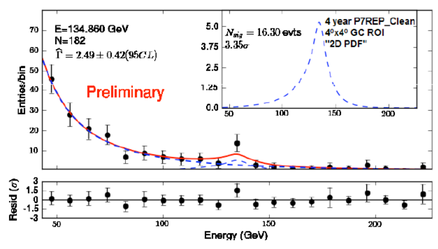
•Studies on γ-rays from the Fermi data have found excess of gamma-rays at energy 130 GeV from the Galactic Center.
•There are many possible explanations of this signal (instrumental errors, pulsar wind effects etc.).
•We focus on explaining the signal with supersymmetric (SUSY) dark matter (DM).



C. Weniger [1204.2797]



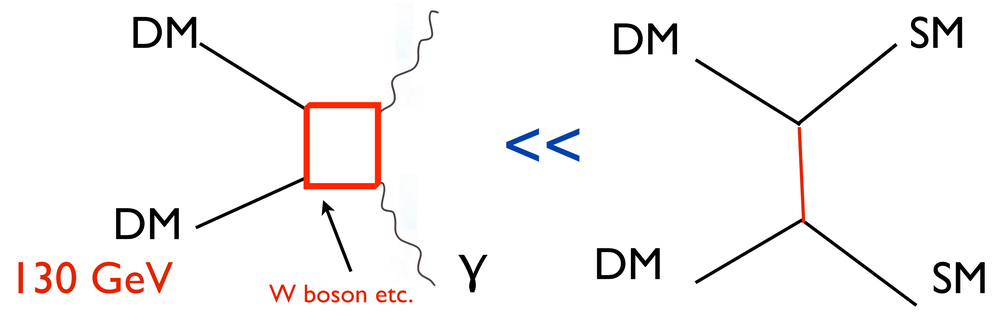
E. Tempel et al. [1205.1045]



A. Albert's talk, Fermi Symposium Nov. 2012

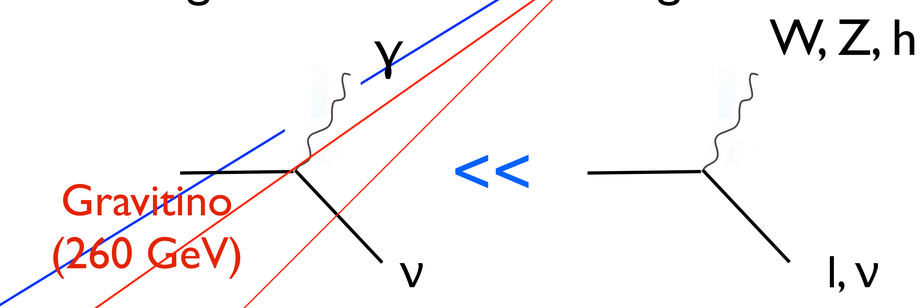
Annihilating Dark Matter

• The most popular annihilating SUSY DM is the neutralino.
•However, it is in general difficult to produce the line feature with annihilating DM since DM does not directly couple to photon.
•Decays to other Standard Model particles would conceal the line signal.



Gravitino without bilinear R-parity

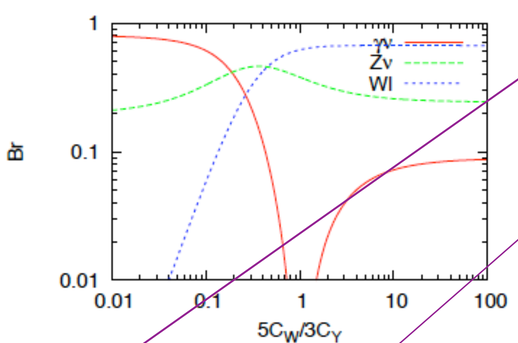
•Gravitino is a popular decaying DM candidate. By introducing small bilinear R-parity violations, gravitino can decay into photon and neutrino.
•However, photino does not couple directly with neutrino. The branching ratio of decay into photon and neutrino is very small.
•Decays to other Standard Model particles would again conceal the line signal.

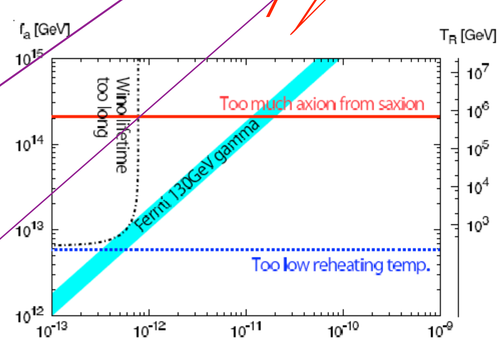


Axino without bilinear R-parity

• Axino is the superpartner of the axion introduced to resolve the strong CP problem.
•By assigning appropriate Peccei-Quinn charges, it is possible to obtain decay branching ratio large enough to produce the 130 GeV line.

$$\mathcal{L}_{\tilde{a}\lambda A} = i\frac{\alpha_Y C_Y}{16\pi f_a}\bar{\tilde{a}}\gamma_5[\gamma^\mu,\gamma^\nu]\tilde{B}B_{\mu\nu} + i\frac{\alpha_W C_W}{16\pi f_a}\bar{\tilde{a}}\gamma_5[\gamma^\mu,\gamma^\nu]\tilde{W}^a W^a_{\mu\nu}$$



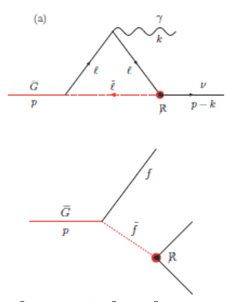


M. Endo, K. Hamaguchi, SPL, K. Mukaida, K. Nakayama [1301.7536]

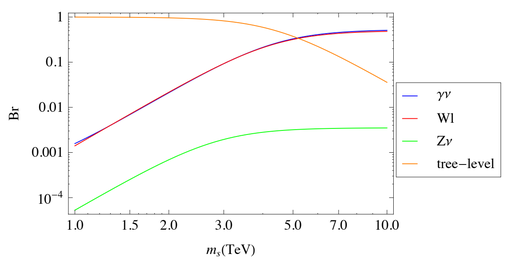
Gravitino without trilinear R-parity

• Tree-level decay is relatively phase-space suppressed since it is a three-body decay.
•Loop-induced decay can produce γ-ray line, and the derivative coupling of the gravitino interaction can cancel out contributions from the propagator.

$$\mathcal{L}_{int} = -\frac{i}{\sqrt{2}\,M_{\rm Pl}}\left[\left(D^*_\mu\phi^{i*}\right)\bar{\psi}_\nu\gamma^\mu\gamma^\nu P_L\chi^i - \left(D_\mu\phi^i\right)\bar{\chi}^i P_R\gamma^\nu\gamma^\mu\psi_\nu\right]$$



S. Lola, P. Osland, A.R. Raklev [0707.2510]



SPL [1304.1992]

Conclusion

•The 130 GeV γ-ray line might be a smoking gun signature of dark matter!
•Both axino and gravitino (without trilinear R-parity) are capable of explaining the signal, and they both have interesting cosmological implications. Future observations will clarify the γ-ray line DM interpretations.