PHYSICS OF NON-PROMPT TRACKS

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OUTLINE

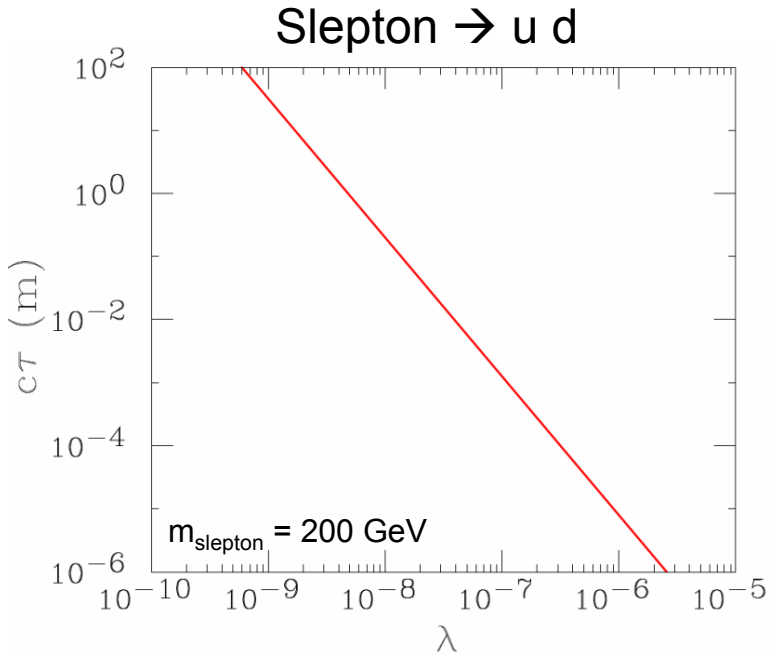
- Standard Model
  - Prompt tracks (t decays)
  - Non-prompt tracks (b decays)
  - Metastable particles (muons)
- Beyond the Standard Model
  - Generically prompt
    - couplings ~ O(1)
    - $\Delta m \sim 100$ GeV
  - But there are exceptions, some very well-motivated
- This talk: an overview of non-prompt (and metastable) examples in 4 categories

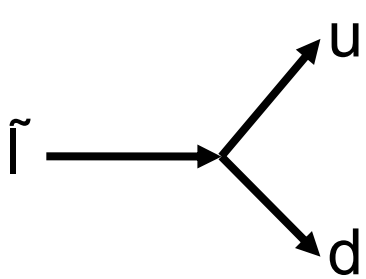
See also Tom Rizzo's talk

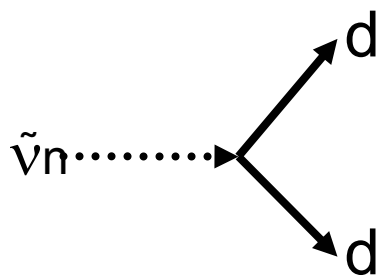
	Fine-tuned	**Natural**
Coupling Suppressed	R_p Violating SUSY	Decays to Gravitinos
Phase Space Suppressed	Slepton Decays	Wino Decays UED

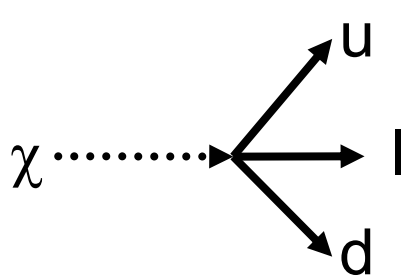
COUPLING SUPPRESSED: FINE-TUNED

- SUSY with R-parity violation
  - LSP decays
  - Many possible charge combinations
  - Coupling strengths λ unconstrained
  - Fine-tuned: non-prompt → $\lambda < 10^{-7}$



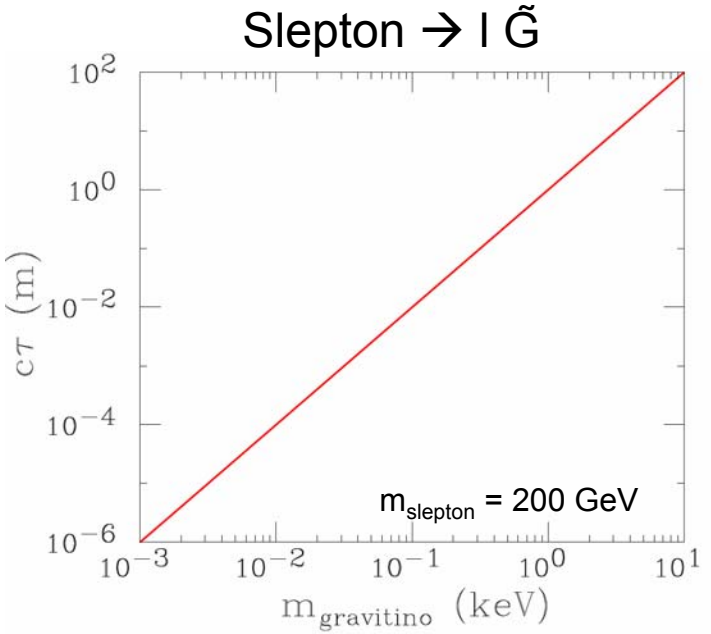


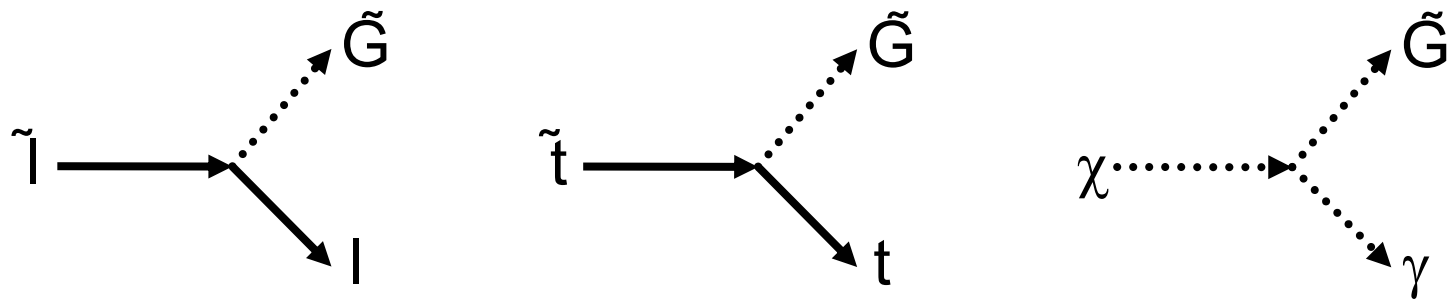




COUPLING SUPPRESSED: NATURAL

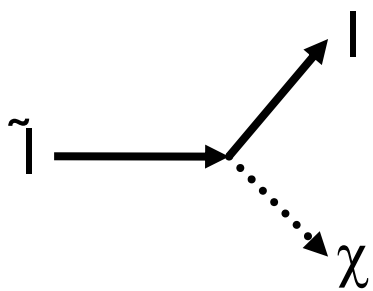
- SUSY → gravitinos
- Gravitino couplings are superweak, decays to gravitinos highly suppressed
- Appears naturally in gauge-mediated SUSY breaking

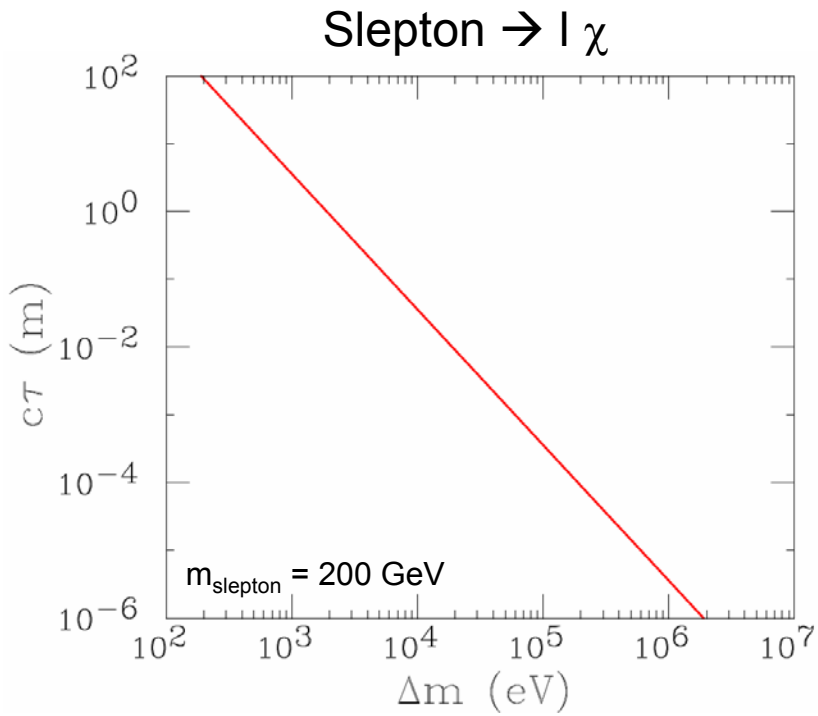




PHASE SPACE SUPPRESSED: FINE-TUNED

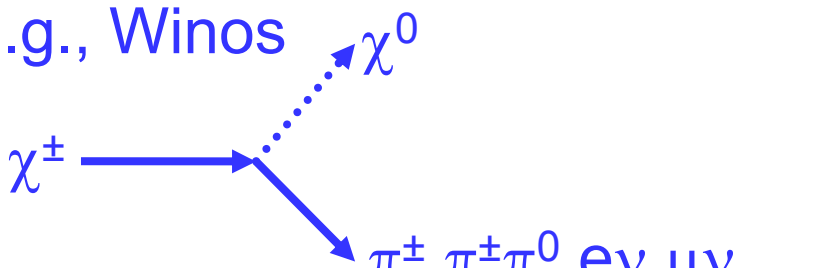
- New particles may be accidentally highly degenerate
  - E.g., in SUSY, slepton and neutralinos
  - Fine-tuned: Non-prompt → $\Delta m <$ MeV, lepton is very soft



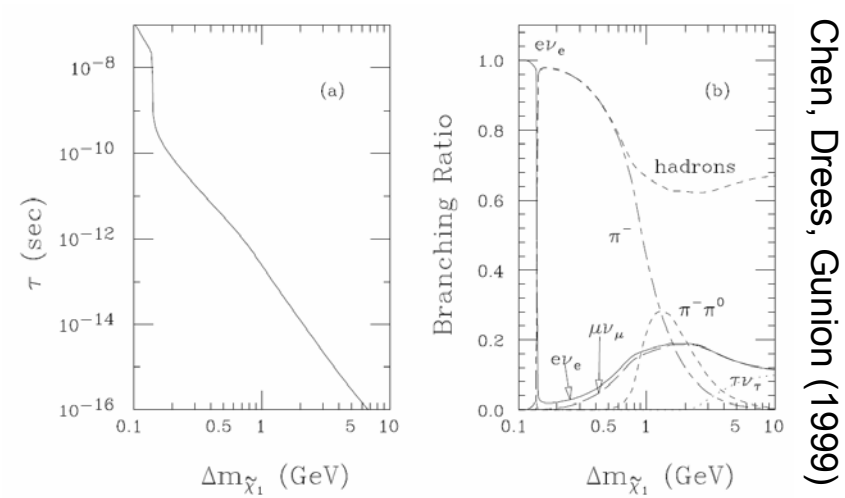


PHASE SPACE SUPPRESSED: NATURAL

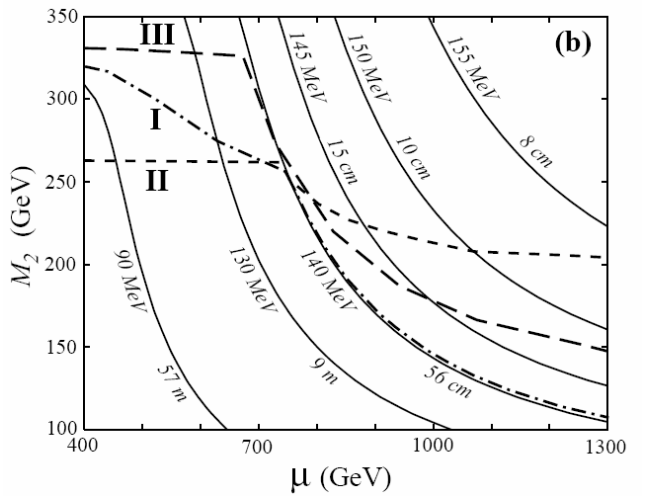
- New particles in nearly degenerate multiplets
- E.g., Winos



- Appears naturally in anomaly-mediated SUSY breaking



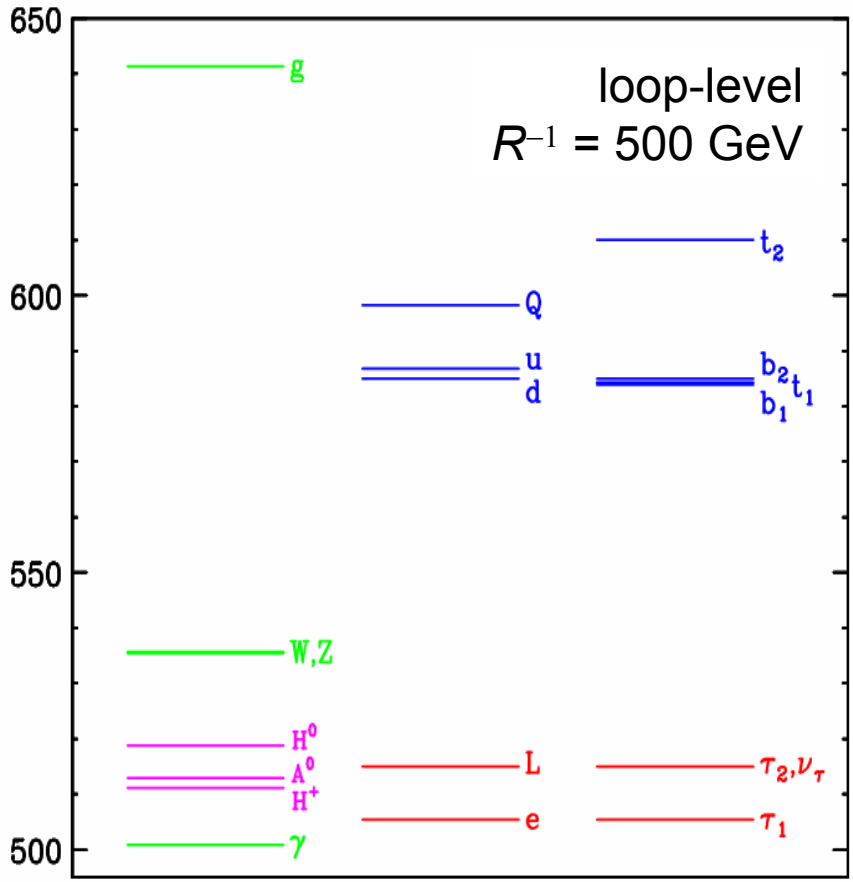
Chen, Drees, Gunion (1999)



Feng, Moroi, Randall, Sstrassler, Su (1999)

PHASE SPACE SUPPRESSED: NATURAL

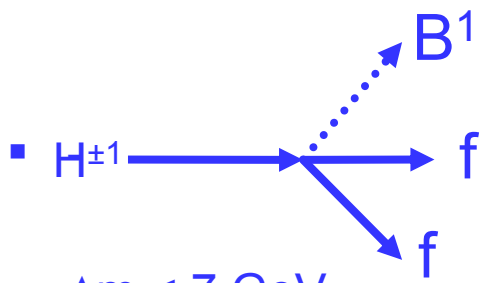
- Universal Extra Dimensions
- All KK level 1 states have mass R^{-1}
- This is broken by many effects, but the lightest KK states are still highly degenerate



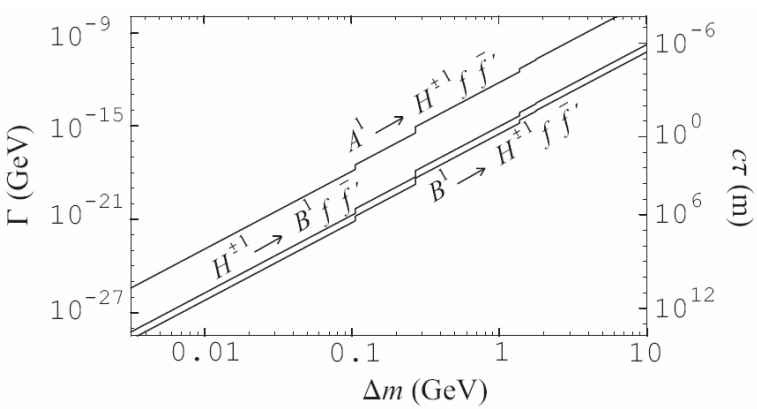
Cheng, Matchev, Schmaltz (2002)

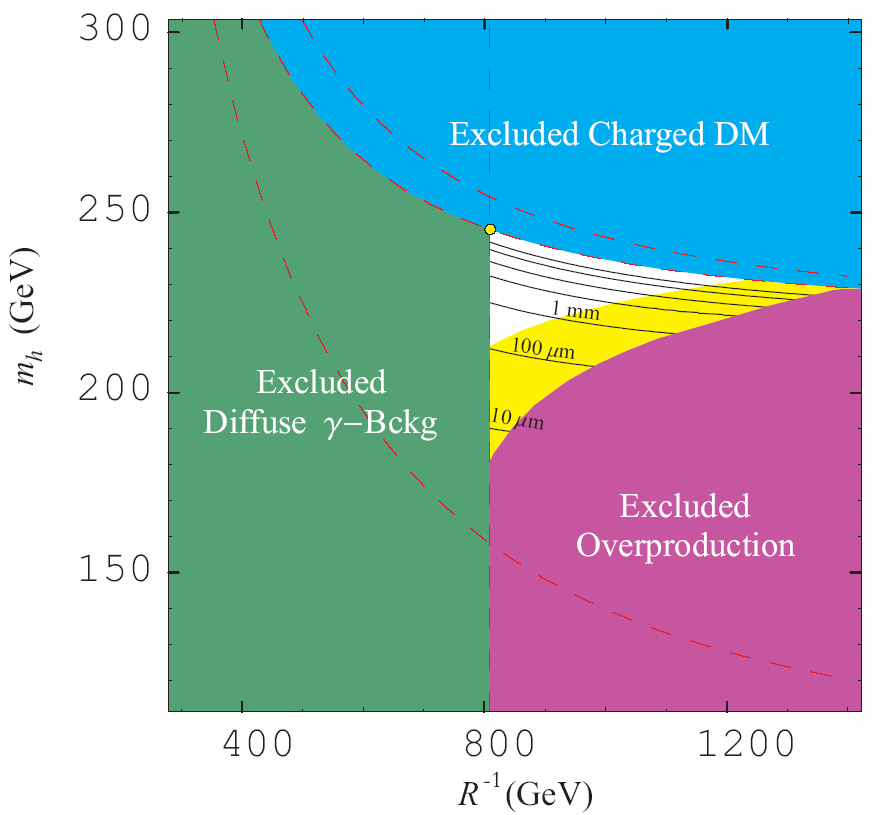
PHASE SPACE SUPPRESSED: NATURAL

- In minimal UED, after all particle and astrophysical constraints, NLKP → LKP is



  - Δm < 7 GeV
  - decay length > 10 μm

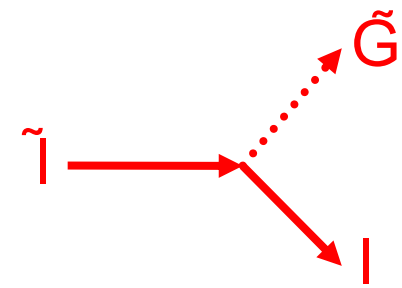




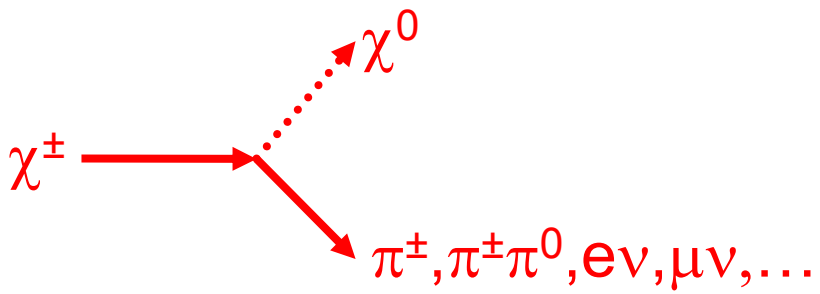
Cembranos, Feng, Strigari (2006)

SUMMARY

- Beyond the SM: many examples of non-prompt, metastable tracks
- Challenge: trigger, reconstruct, measure lifetimes, even given slow primary, soft secondaries, decay lengths varying from μm to m
- Representative examples:



coupling suppressed



phase space suppressed