Hiding SUSY with Lepton Number Violation

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Work in progress with
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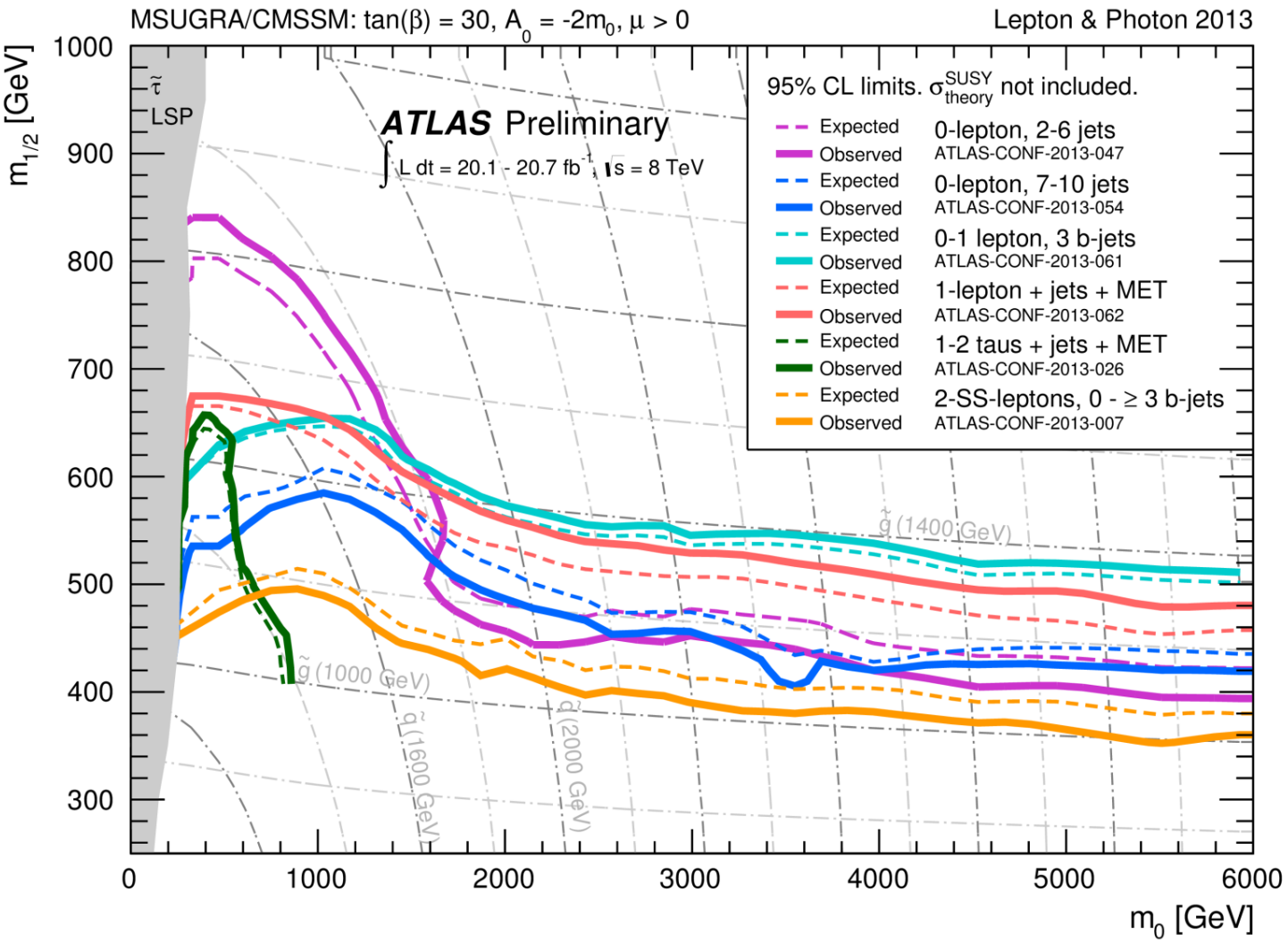
The Missing Superpartner Problem



CMSSM: Squarks > 1700 GeV and gluino > 1400 GeV

Why Hide SUSY?

Two distinct motivations:

1) Reduce the fine tuning of the theory (UV parameters)– very model dependent!

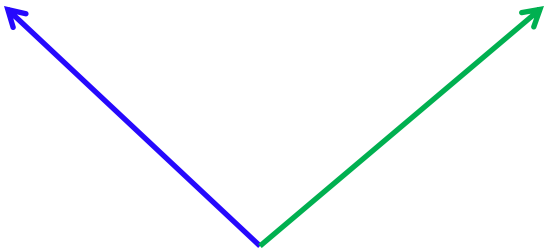
2) Check if there is anything that the LHC searches have overlooked– could SUSY still be discovered in 8 TeV data?

R-Parity Violation (RPV)

$$W_{\mathrm{RPV}} = \mu_{L_i} L_i H_u$$
$$+\lambda_{ijk} L_i L_j E_k + \lambda'_{ijk} L_i Q_j D_k + \lambda''_{ijk} U_i D_j D_k$$

Lepton Number Violation

Baryon Number Violation



Pick only one to avoid proton decay

Lepton Number Breaking: The Other RPV

Why leptonic RPV (LRPV)?

- Baryonic RPV washes out primordial baryon asymmetry
- Neutrino masses suggest that lepton number may not be a perfect symmetry
- Can still hide SUSY at colliders while giving unique signatures

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This talk

R-Parity Violation (RPV)

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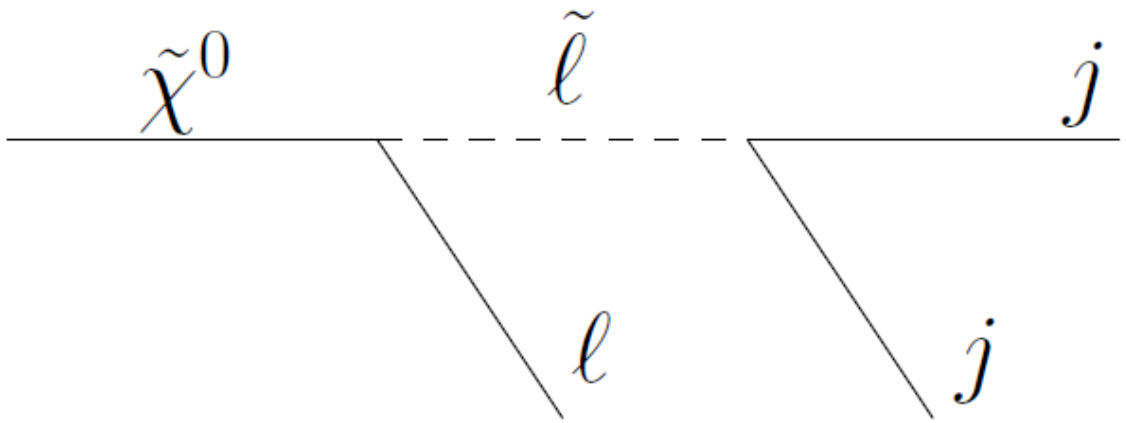


How to Hide SUSY

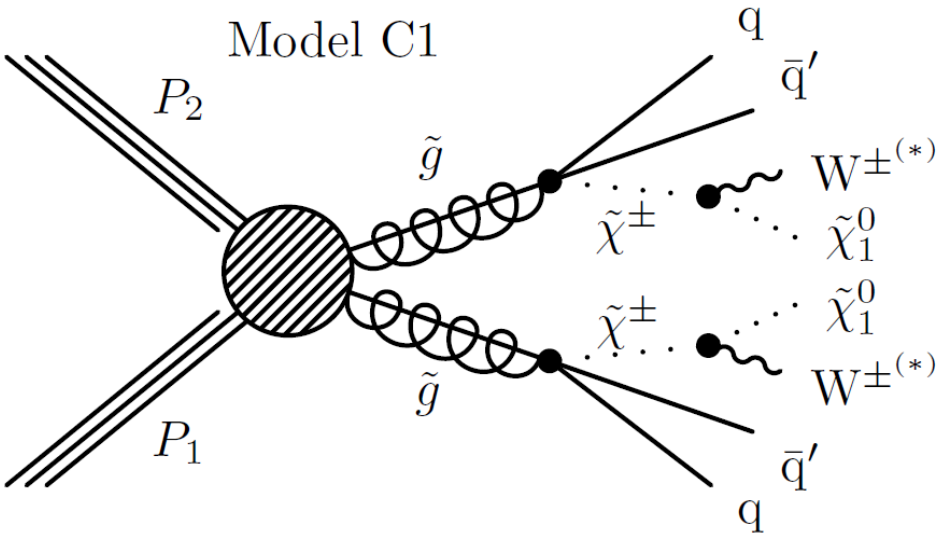
New physics searches at the LHC typically look for:

- Missing energy (stable neutralino, neutrino)
- Charged leptons (esp. same-sign)
- Many hard jets

Need to eliminate these as much as possible to hide SUSY

How Not to Hide SUSY

Cascade decays alone can give leptons/MET

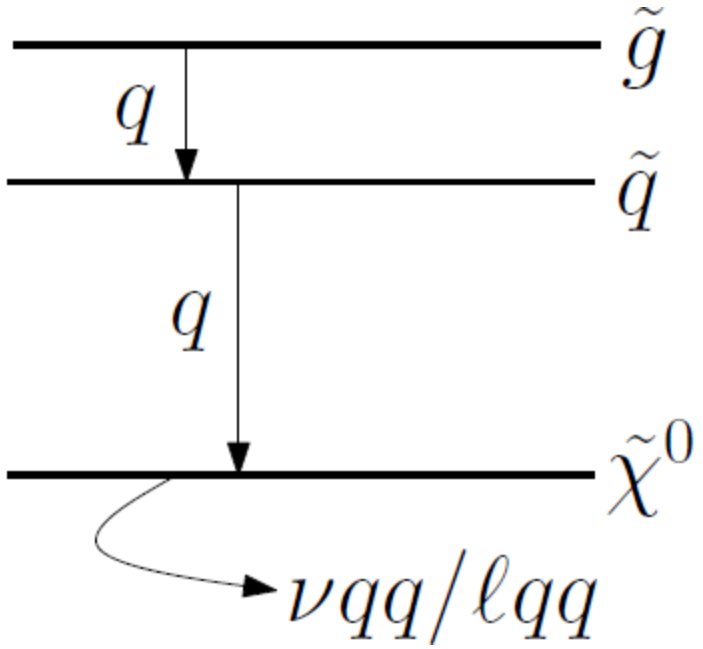


For baryonic RPV with universal gaugino masses, gluino must heavier than ~1300 GeV (M. Baryakhtar's SUSY talk "Last Vestiges of Naturalness", Thursday)

Bounds will be even tighter for leptonic RPV…

Simplified Model

- Only one neutralino (LSP)
- Focus on LQD decays
- All squarks are degenerate
- Neutralino can be very light, causing decay products to be collimated



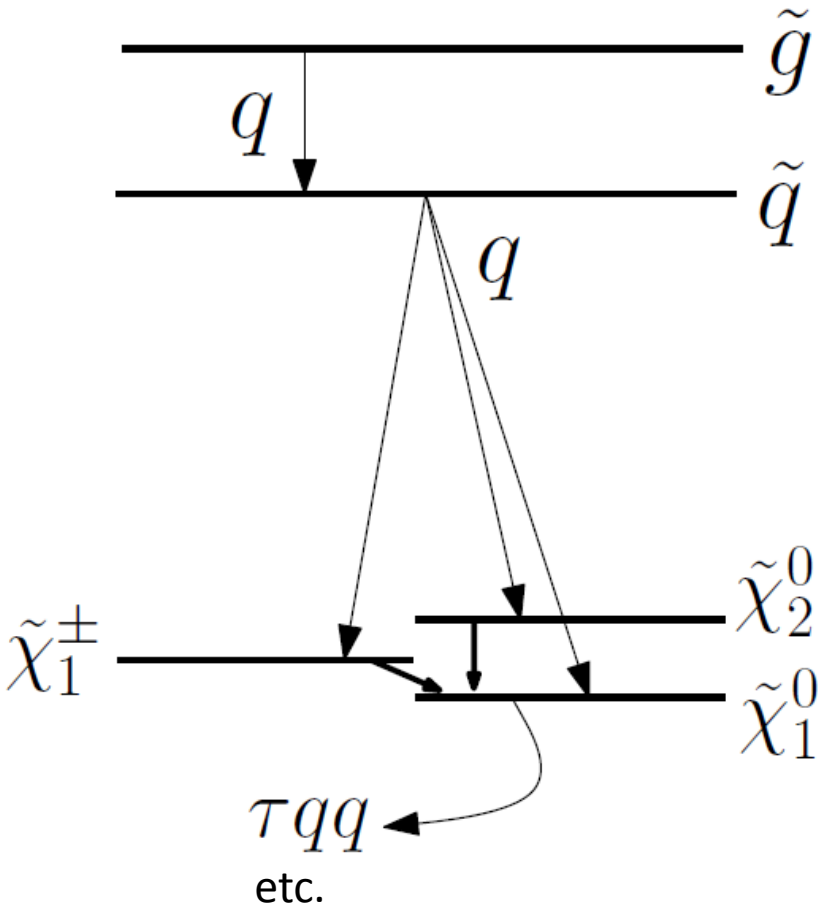
If neutralino is stable:
Squarks > 1700 GeV,
Gluino > 1500 GeV
(from ATLAS Jets + MET)

Variation on Simplified Model

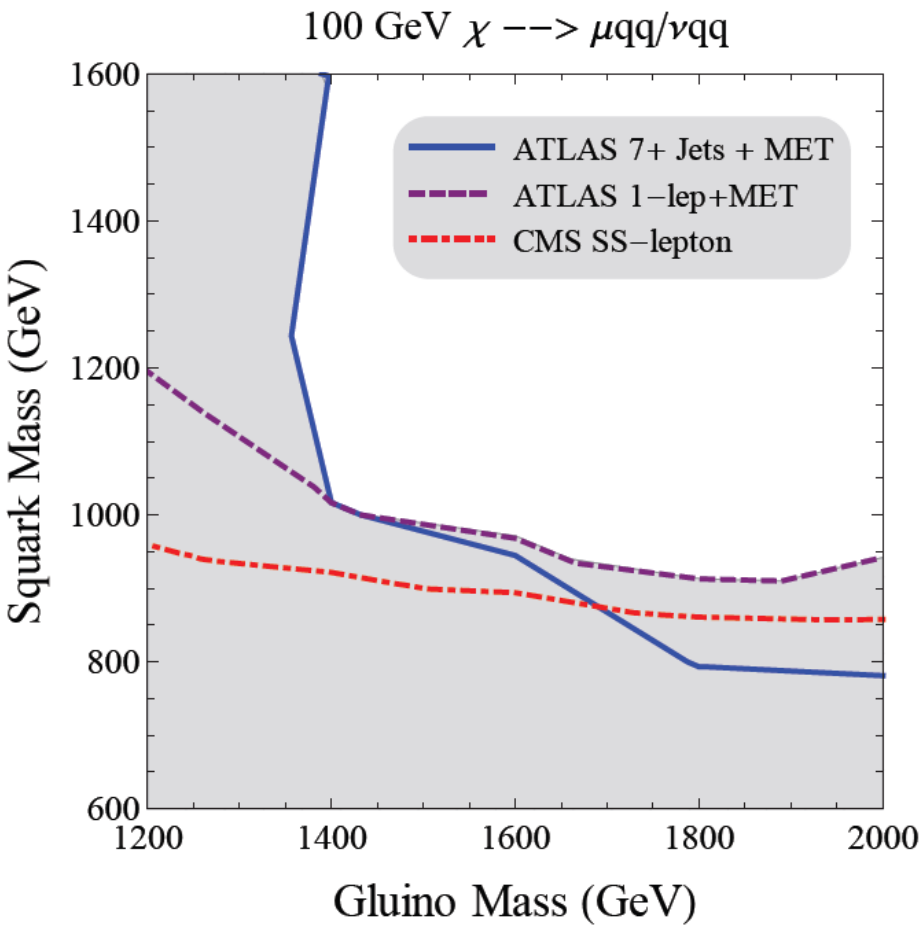
For wino or higgsino LSPs, there are other light electroweakinos

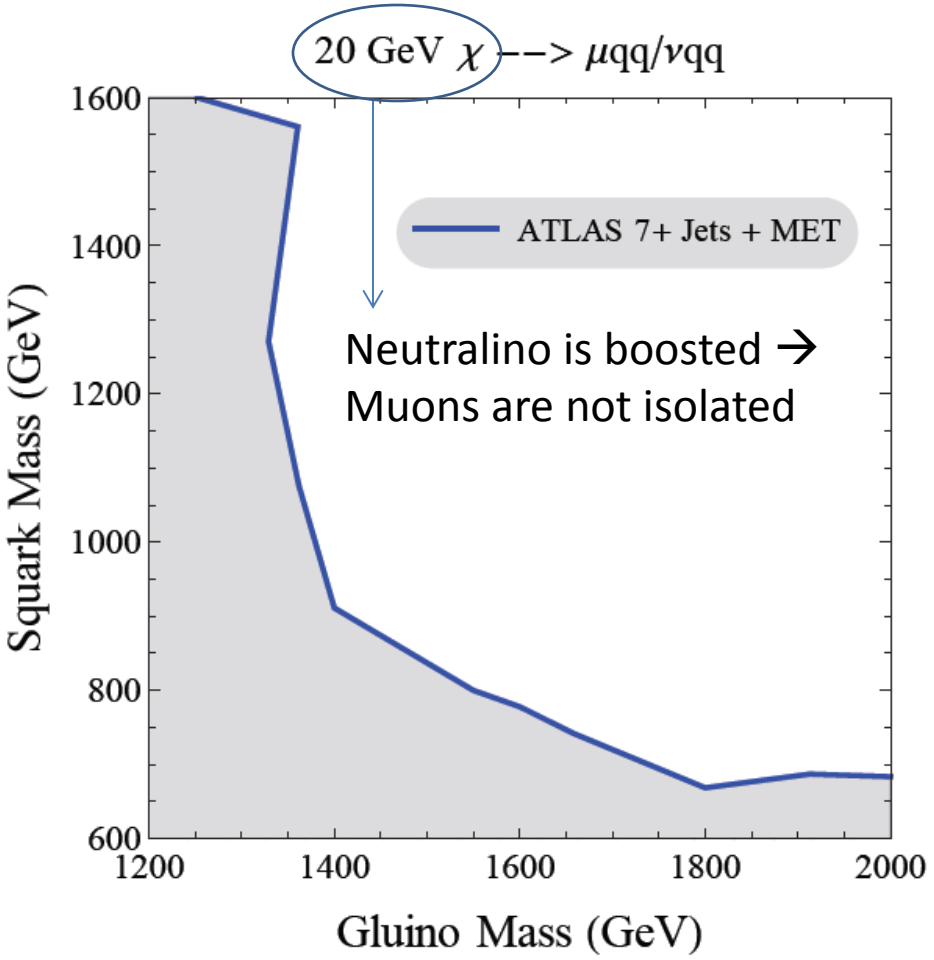
If the multiplet is sufficiently degenerate, the cascade decays will only produce soft particles

LSP must be heavier than ~100 GeV



"Generic" LRPV: $\tilde{\chi}^0 \to \ell qq, \nu qq$

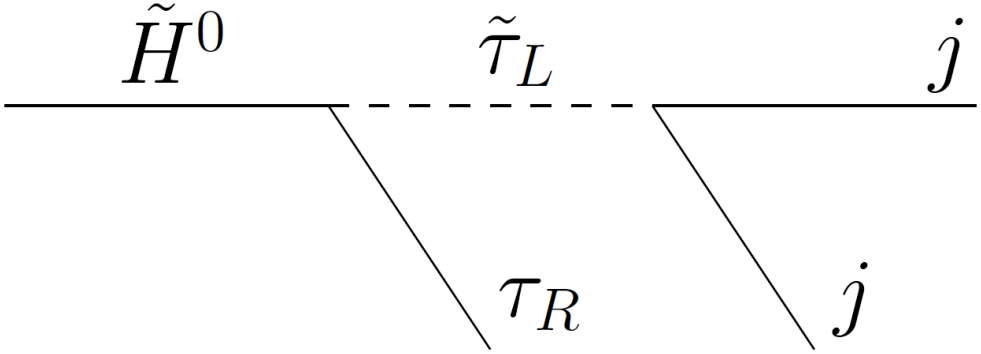




Despite highly suppressed MET, ATLAS multijet + MET search places strong bound on gluino

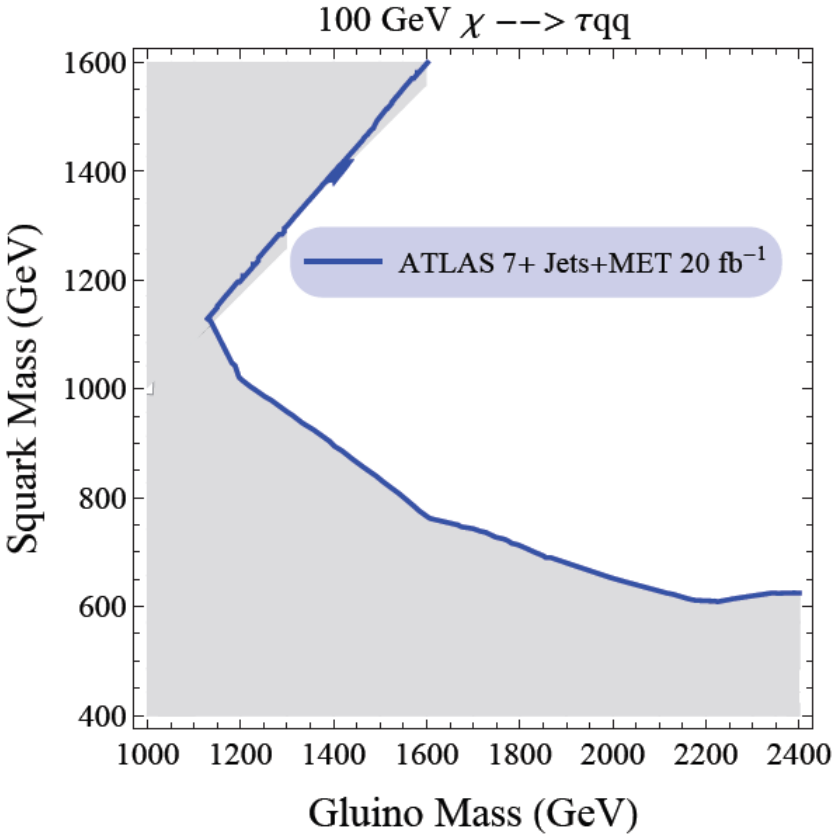
How to Avoid Neutrinos

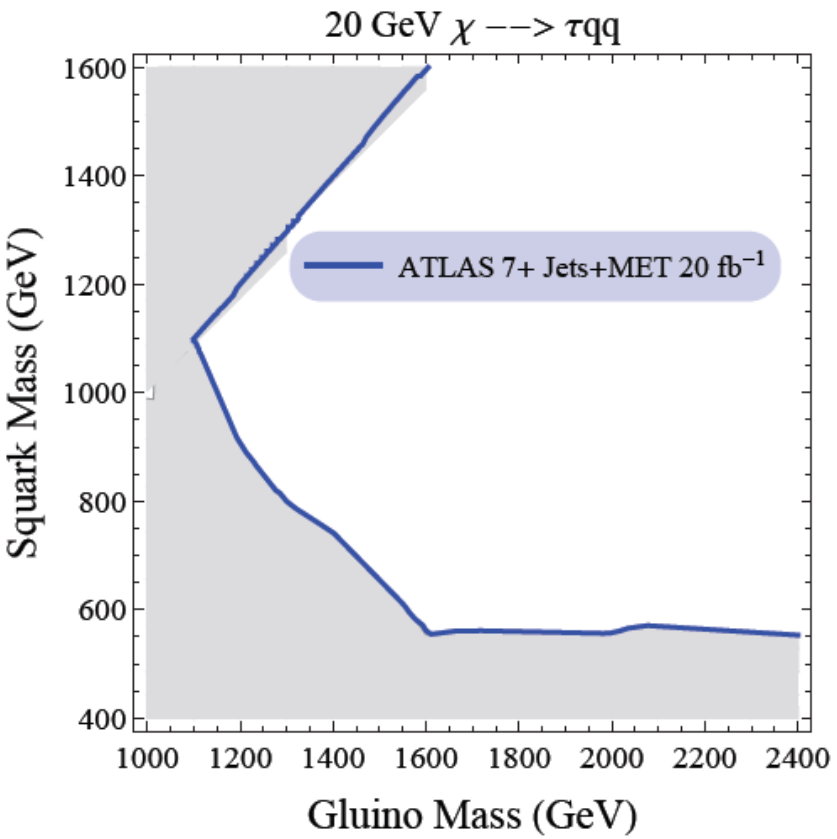
- Neutral higgsinos decaying through sleptons:



- Dimension-five operator $\dfrac{H_d Q U E}{\Lambda}$
- Large left-right slepton mixing

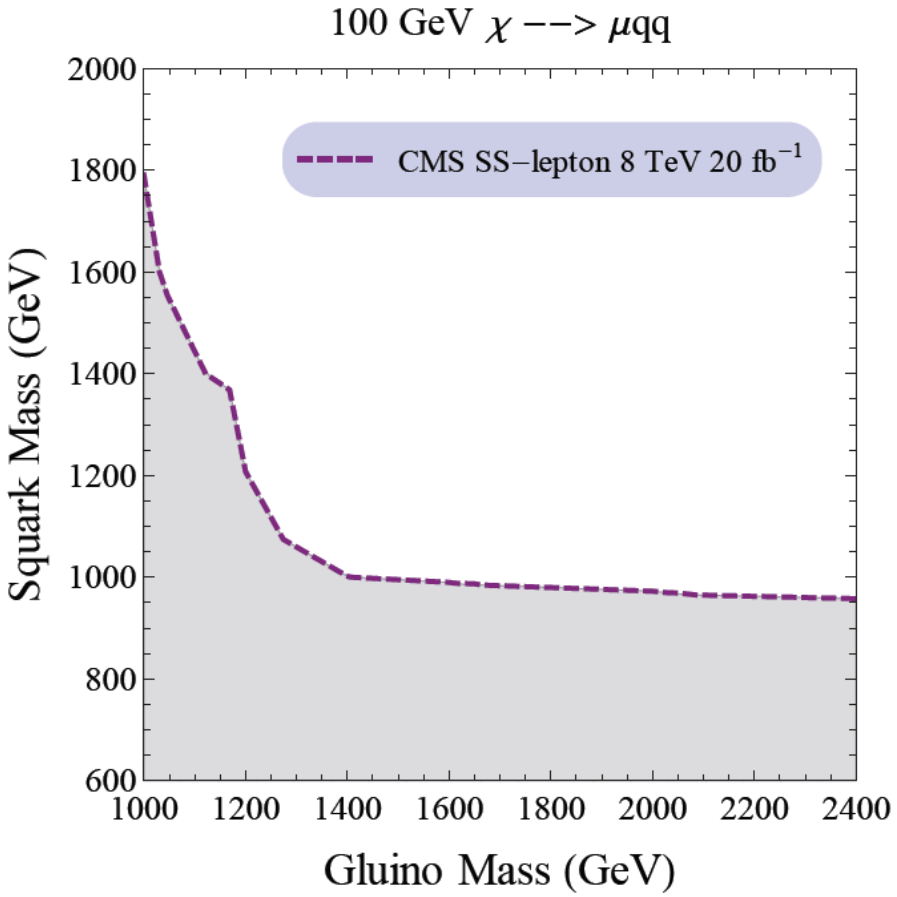
"MET-free" LRPV: $\tilde{\chi}^0 \to \tau qq$





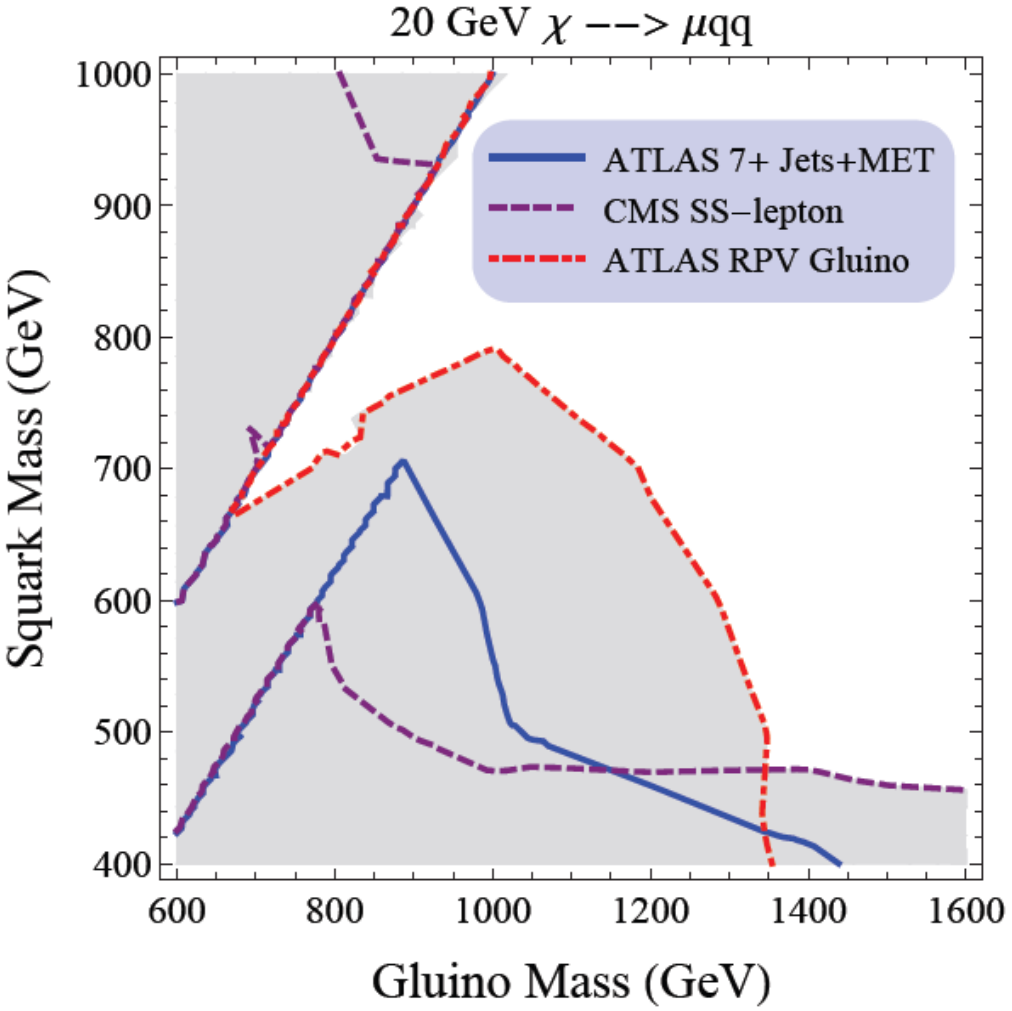
Tau decays alone give significant missing energy!

"MET-free" LRPV: $\tilde{\chi}^0 \to \mu qq$



Even though every event has two muons, these models are less constrained than those where the neutralino appears as missing energy!

“MET-free” LRPV: Boosted $\tilde{\chi}^0 \to \mu qq$



For boosted LSPs, leptonic searches are much less efficient

Remaining bounds come from jets+MET (when tops are produced) and hadronic RPV search

Conclusions

- Lepton number violation can greatly reduce the bounds on squark and gluino masses (squarks as light as 500 GeV)
- Current most constraining searches are in many jet + MET and SS-lepton final states
- Discovery potential for a many jet + lepton(s) search?