Regions of Interest in RPV

(Preliminary)

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RPV

current jets + MET searches set high limits on superpartner masses

$$W \supset UDD + LQD + LLE$$

will look to see how light superpartners can be with RPV

whether current searches have missed any regions of parameter space,
or could be better tailored to see RPV

UDD

UDD

strong limits if have certain spectra, e.g. light charginos, sleptons below gluino

Best(?) limits on UDD from 6-jet searches (with or without a 3-jet resonance):

gluino > 700 GeV   essentially no limit on squarks if have only squarks and gluinos light

searching for prompt, not displaced jets?

UDD + Baryogenesis

if UDD interactions are in equilibrium in early universe will wipe out baryon number

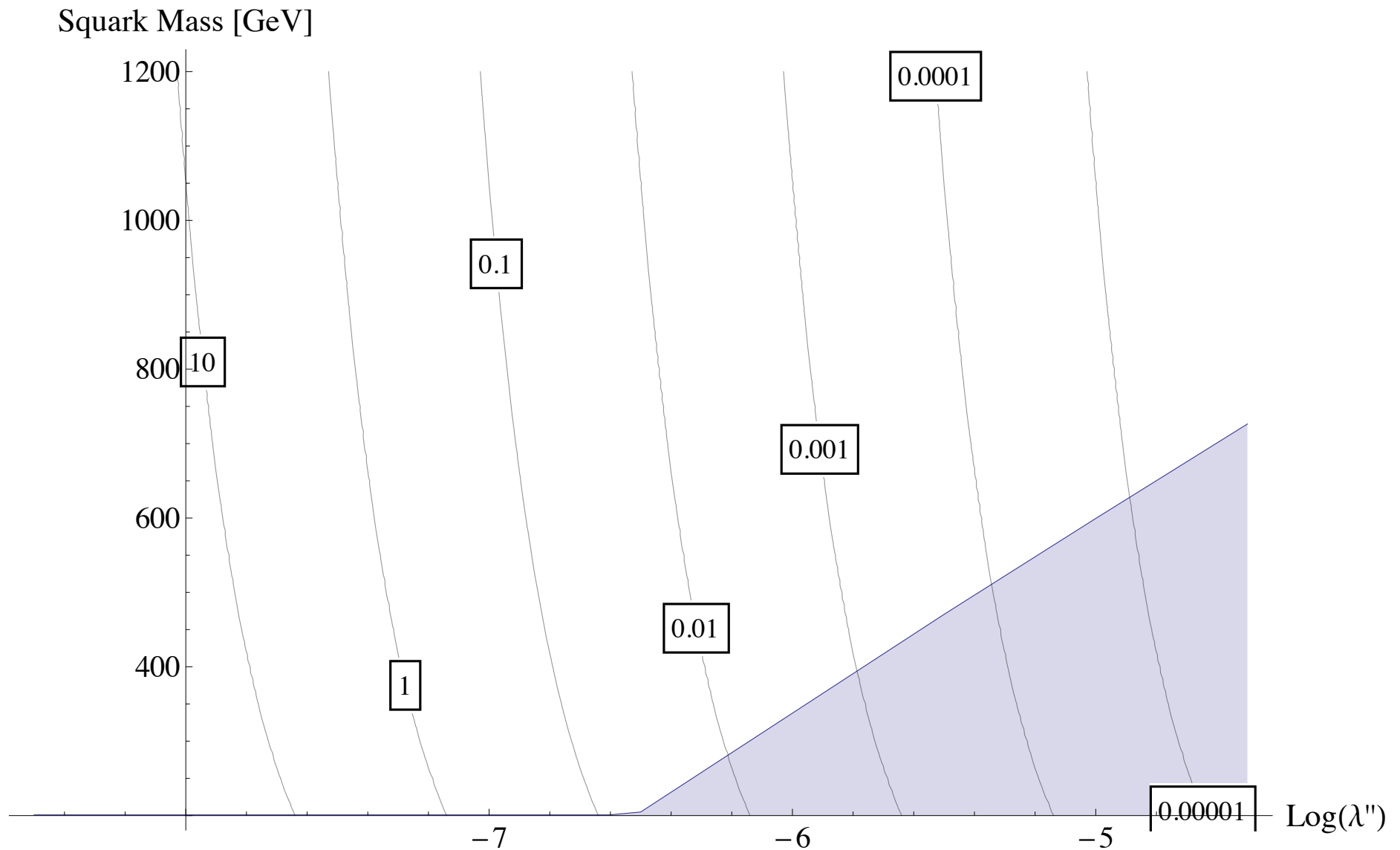these interactions present for all temperatures above ~ weak scale

e.g. squark decay rates $\quad \Gamma \sim H \sim \dfrac{(100 \text{ GeV})^2}{M_{pl}} \sim \dfrac{1}{20 \text{ cm}} \sim \dfrac{1}{\text{ns}}$

so expect long displaced vertices at LHC in order to retain baryon number in the universe

Caveat: could have a very low scale baryogenesis mechanism $\ll 10 \text{ GeV}$

Squark LSP

Baryon Destruction Region [blue]
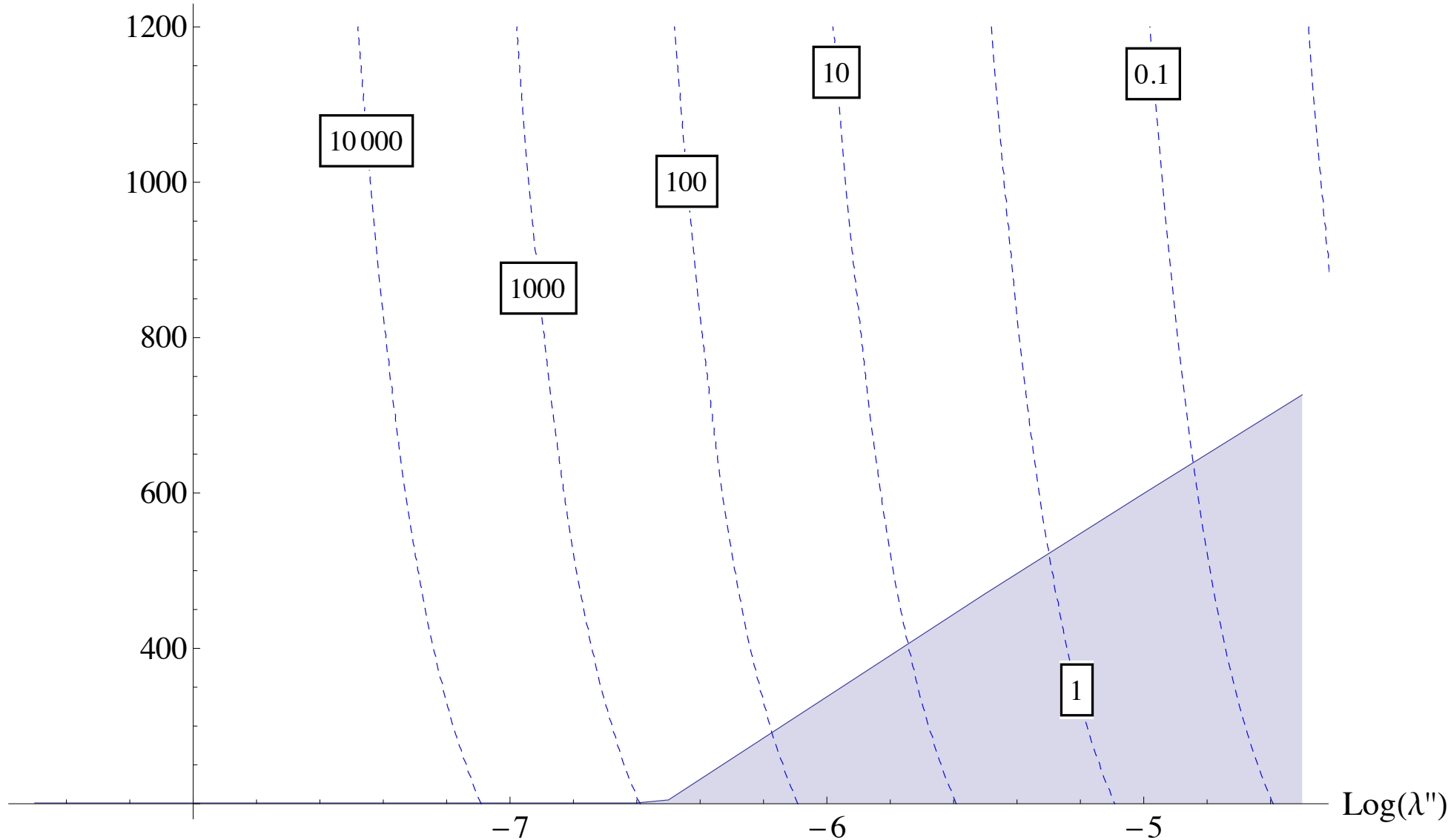
Squark Decay Length Contours [cm]

Neutralino LSP

Baryon Destruction Region [blue]

$(0.8)m_{\tilde{q}}$ Neutralino Decay Length Contours [cm]

Squark Mass [GeV]

$Log(\lambda'')$

Displaced Vertices

LHC searches usually require charged tracks to pass within 1 mm of beamline

- Lepton reconstruction typically fails
- B-tagging of jets fails
- CMS analyses reject jets without good tracks

**Many searches no longer place constraints**

LLE

Hiding SUSY with Displaced LLE?

A possible hole in the LHC coverage for displaced decays to muon + electron or muon + tau:

- 0-lepton Jets + MET searches veto events with a muon candidate

- Searches requiring leptons do not accept displaced leptons

- Displaced vertex + muon search requires ≥ 5 tracks

- Lepton isolation cuts remove collimated leptons

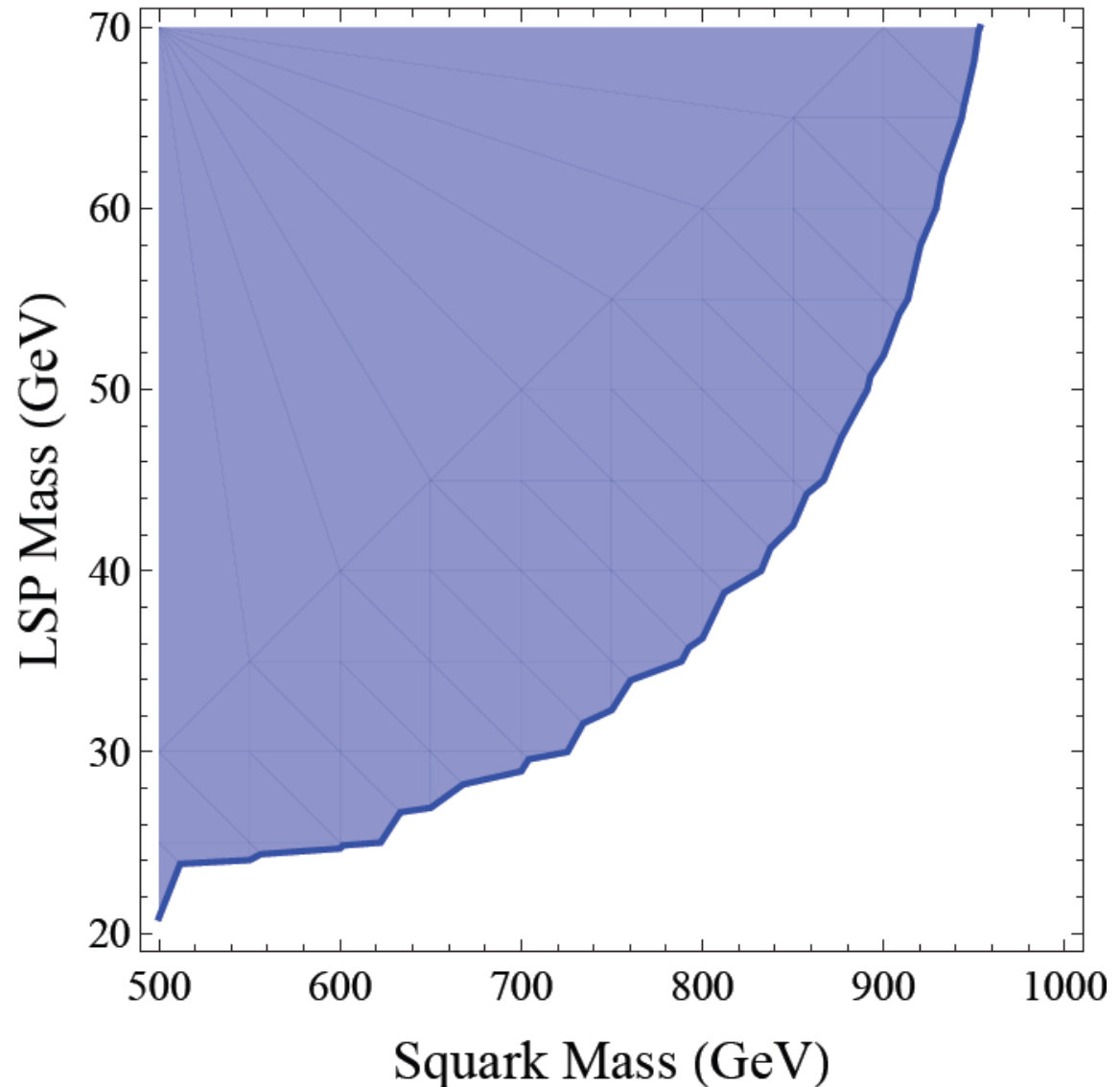- Displaced dilepton search only looks for same-flavor leptons, and requires dilepton invariant mass > 15 GeV

Hiding SUSY with Displaced LLE?
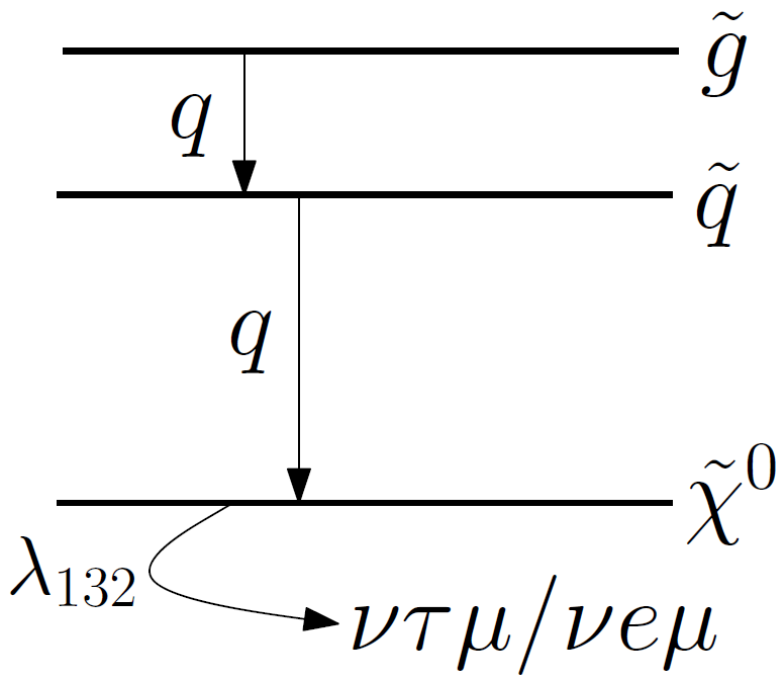
$\tilde{g}$

q

$\tilde{q}$

q

$\tilde{\chi}^0$

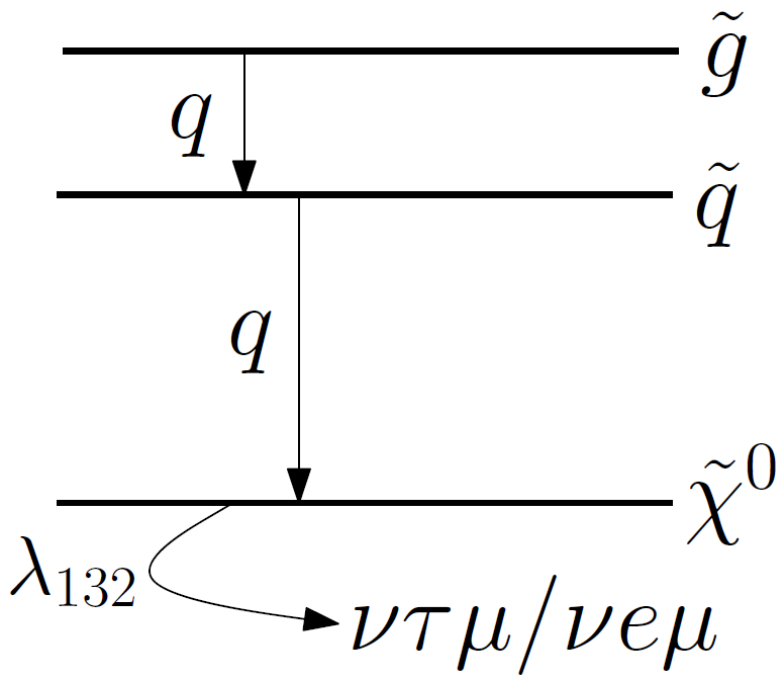λ_{132} $\nu\tau\mu/\nu e\mu$

neglect 3rd generation squarks, and assume:

$$m_{\tilde{g}} = 1.5 \times m_{\tilde{q}}$$

Constraint from CMS displaced dimuon search

Hiding SUSY with Displaced LLE?

$\tilde{g}$

q

$\tilde{q}$

q

$\tilde{\chi}^0$
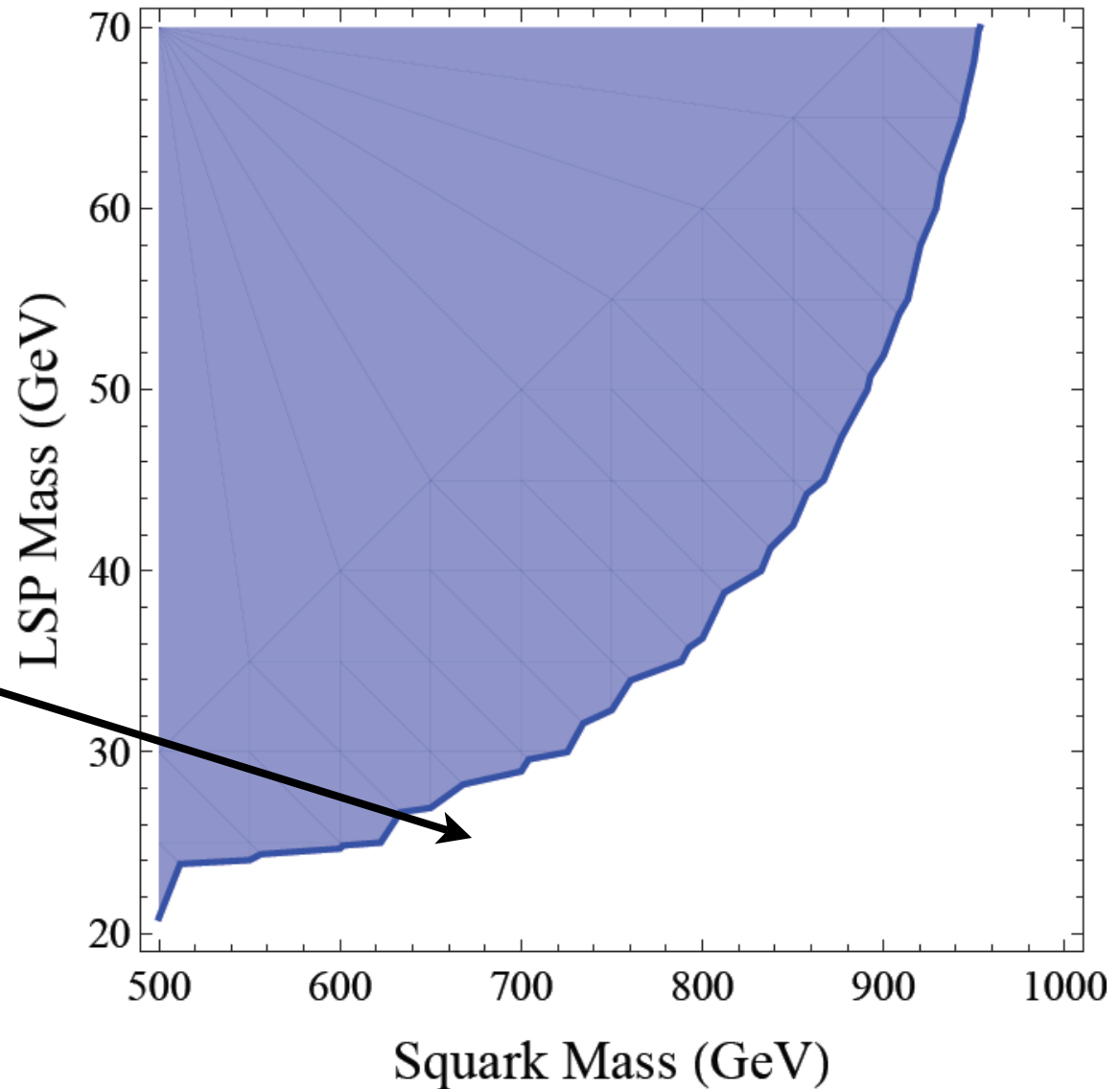
λ_{132} $\to \nu\tau\mu/\nu e\mu$

large mass hierarchy gives collimated leptons

neglect 3rd generation squarks, and assume:

$$m_{\tilde{g}} = 1.5 \times m_{\tilde{q}}$$

Constraint from CMS displaced dimuon search

LSP Mass (GeV)

Squark Mass (GeV)

LQD

Hiding SUSY with LQD

large mass splitting between gluino (or squark) and LSP makes LQD decay products collimated

- often lepton not isolated

- decreases number of jets

- decreased missing energy

signals?

- displaced vertices could be searched for if λ is small?

- prompt decays may be challenging to search for. maybe use jet substructure?

Questions

- how are displaced jets treated in main jets+MET analyses?

- veto jet or whole event?

- how deal with events with both prompt and displaced jets?

Search for squarks and gluinos with the ATLAS detector using final states with jets and missing transverse momentum at $\sqrt{s} = 8$ TeV

ATLAS-CONF-2012-109

Search for new phenomena using large jet multiplicities and missing transverse momentum with ATLAS in 5.8 fb^{-1} of $\sqrt{s} = 8$ TeV proton-proton collisions
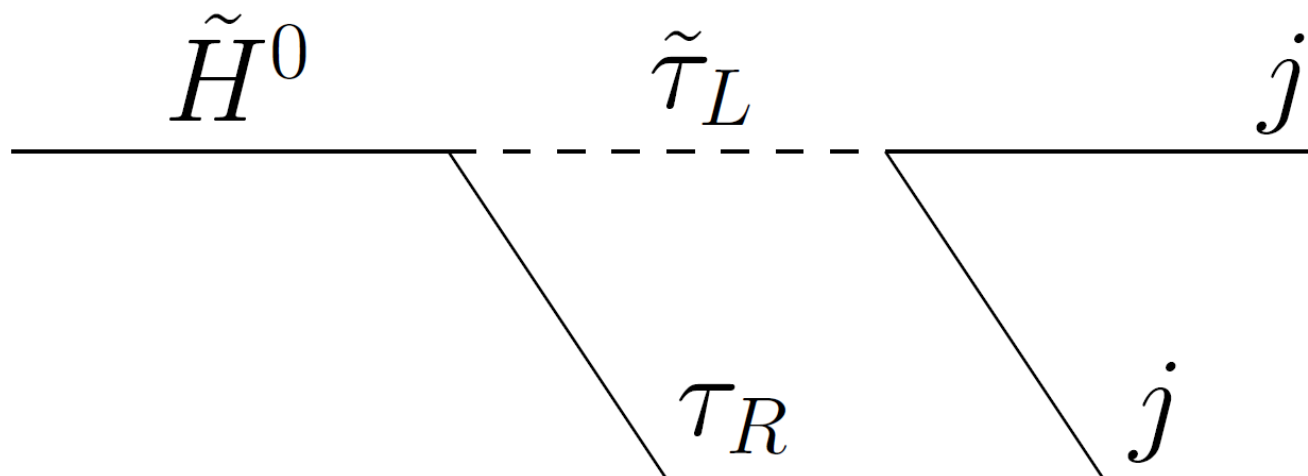
ATLAS-CONF-2012-103

Taus + Jets from LRPV

Assume:

- LQD couplings are larger than LLE couplings
- (Neutral) Higgsino is the LSP
- Sleptons are lighter than squarks

Then the LSP decays dominantly to tau + 2 jets:

$$\tilde{H}^0 \qquad \tilde{\tau}_L \qquad j$$
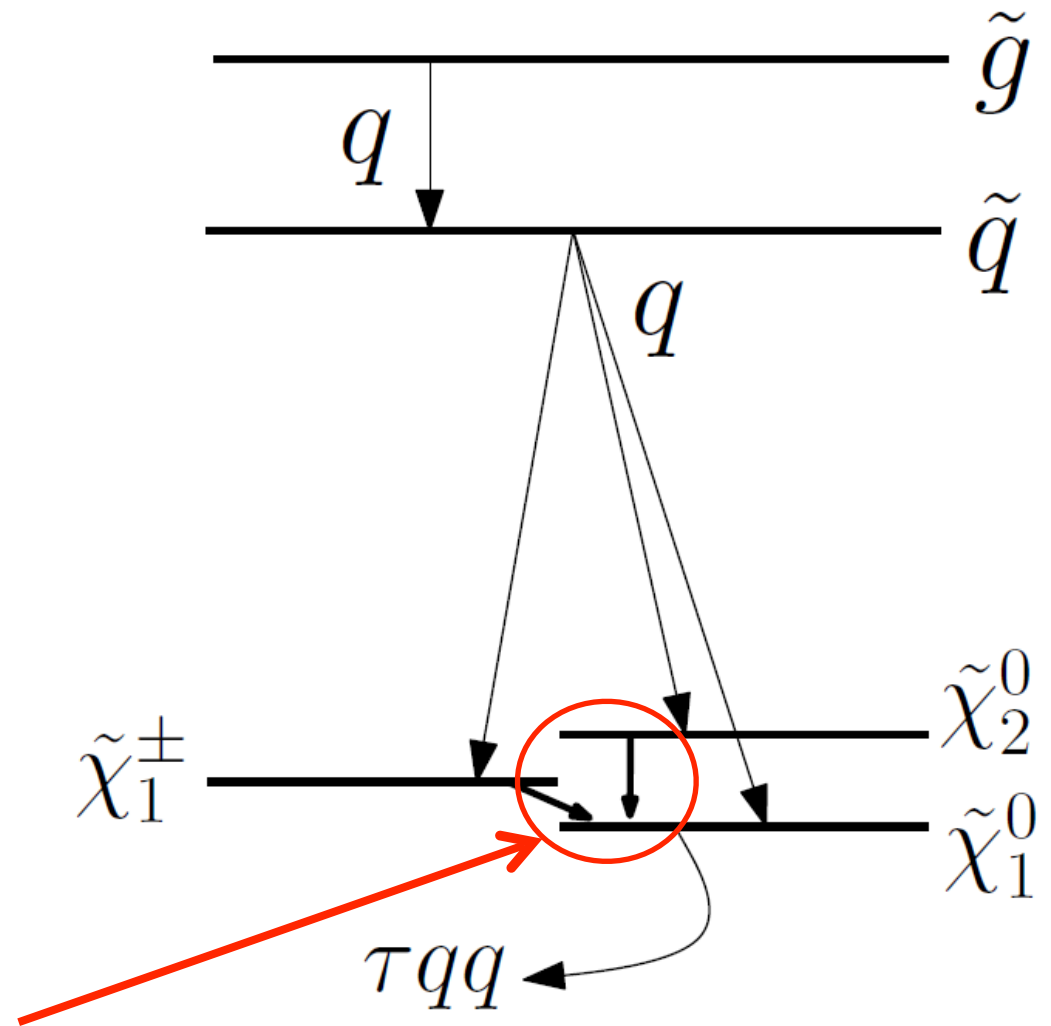
$$\tau_R \qquad j$$

Higgsino LSP spectrum

All squarks are degenerate

Bino and wino are heavier than squarks

Higgsinos are nearly degenerate: their cascades only produce soft particles

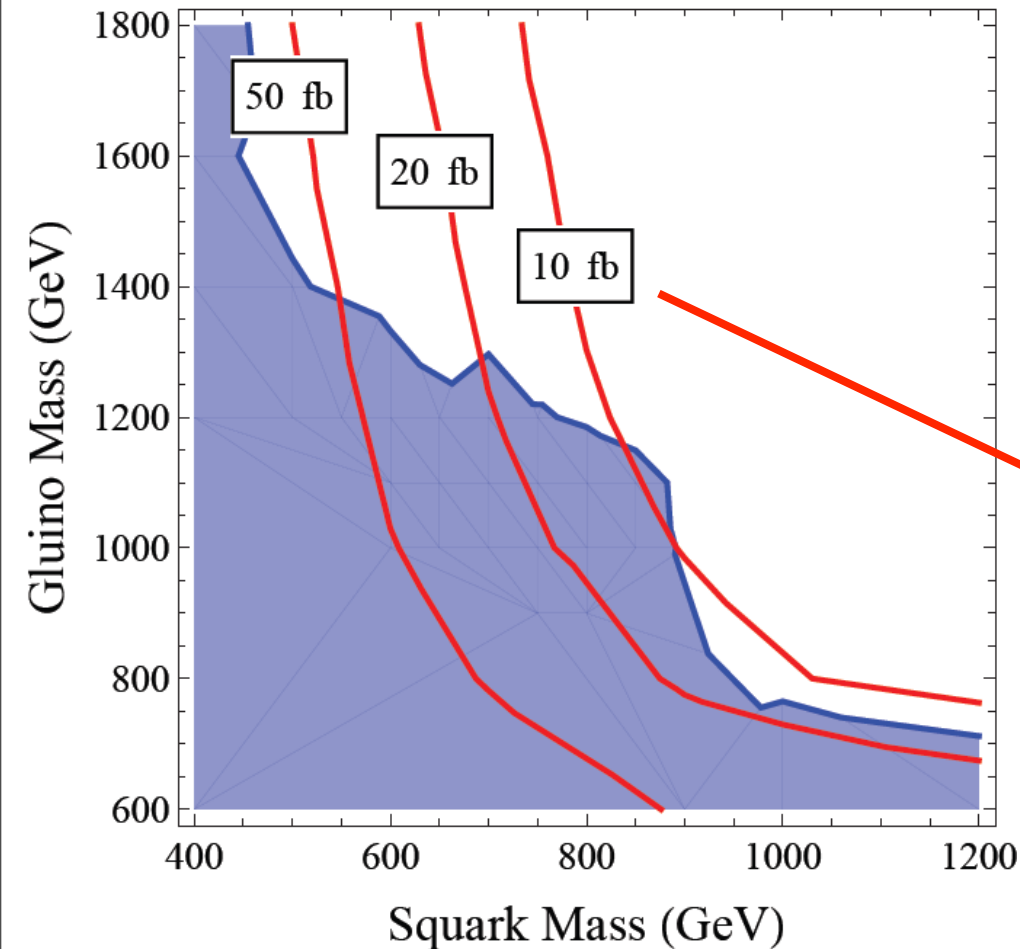# Bounds on Taus + Jets

Main constraints:

- ATLAS taus + MET (21 fb^{-1})

- ATLAS many (6+) jets + MET (6 fb^{-1})
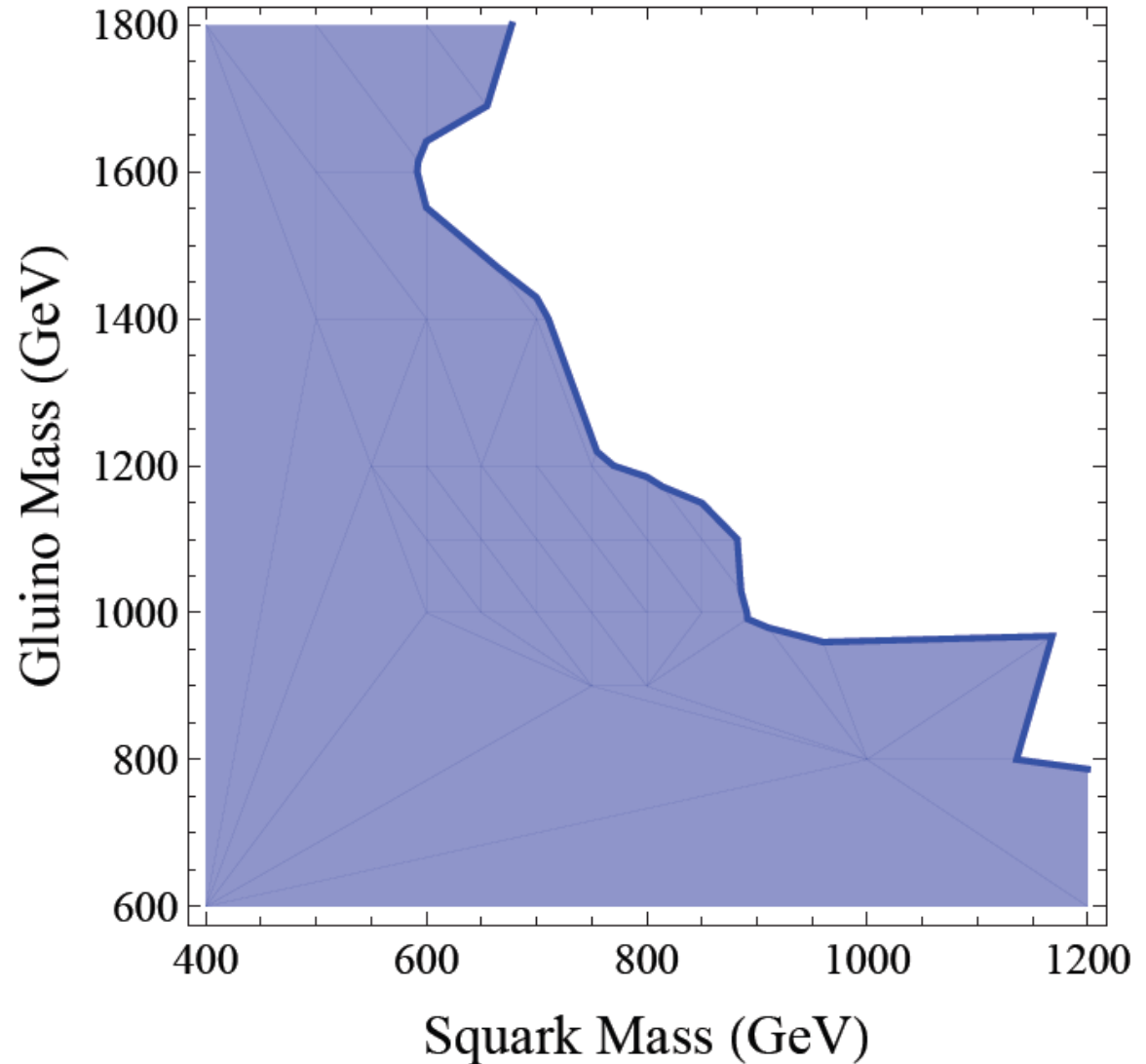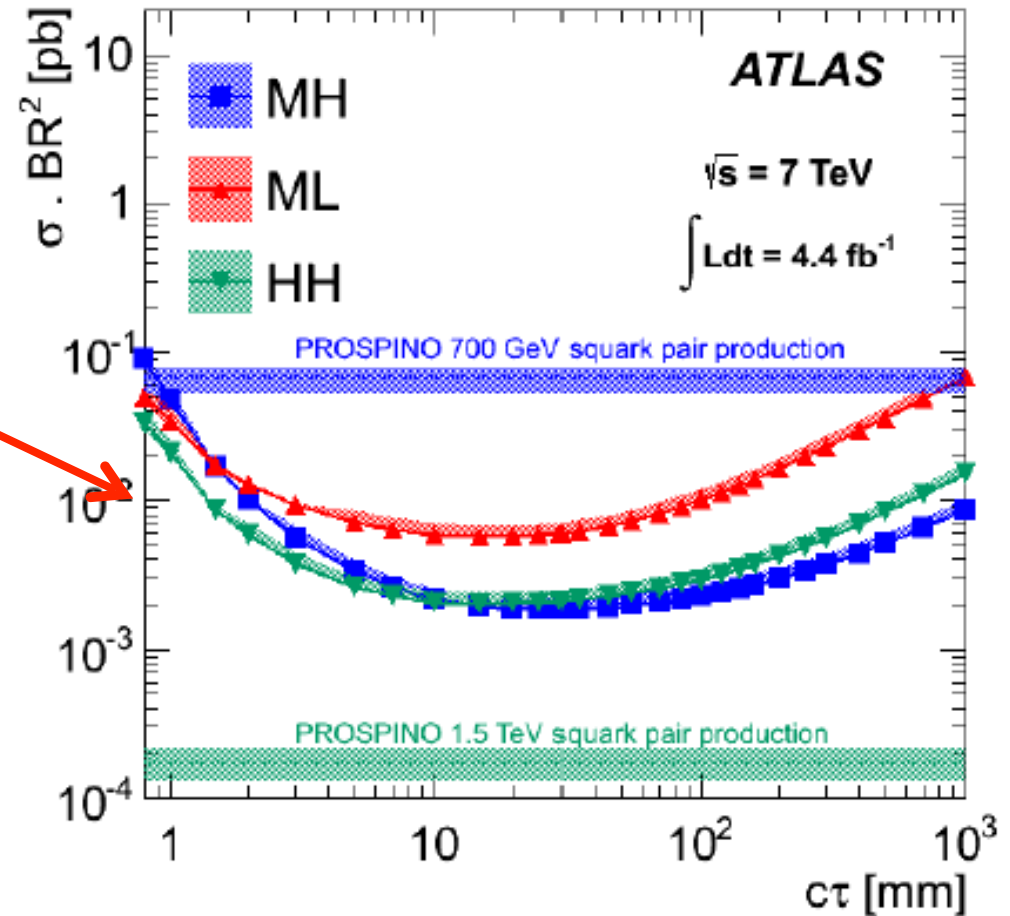
Displaced Taus + Jets

Search for prompt taus no longer sensitive
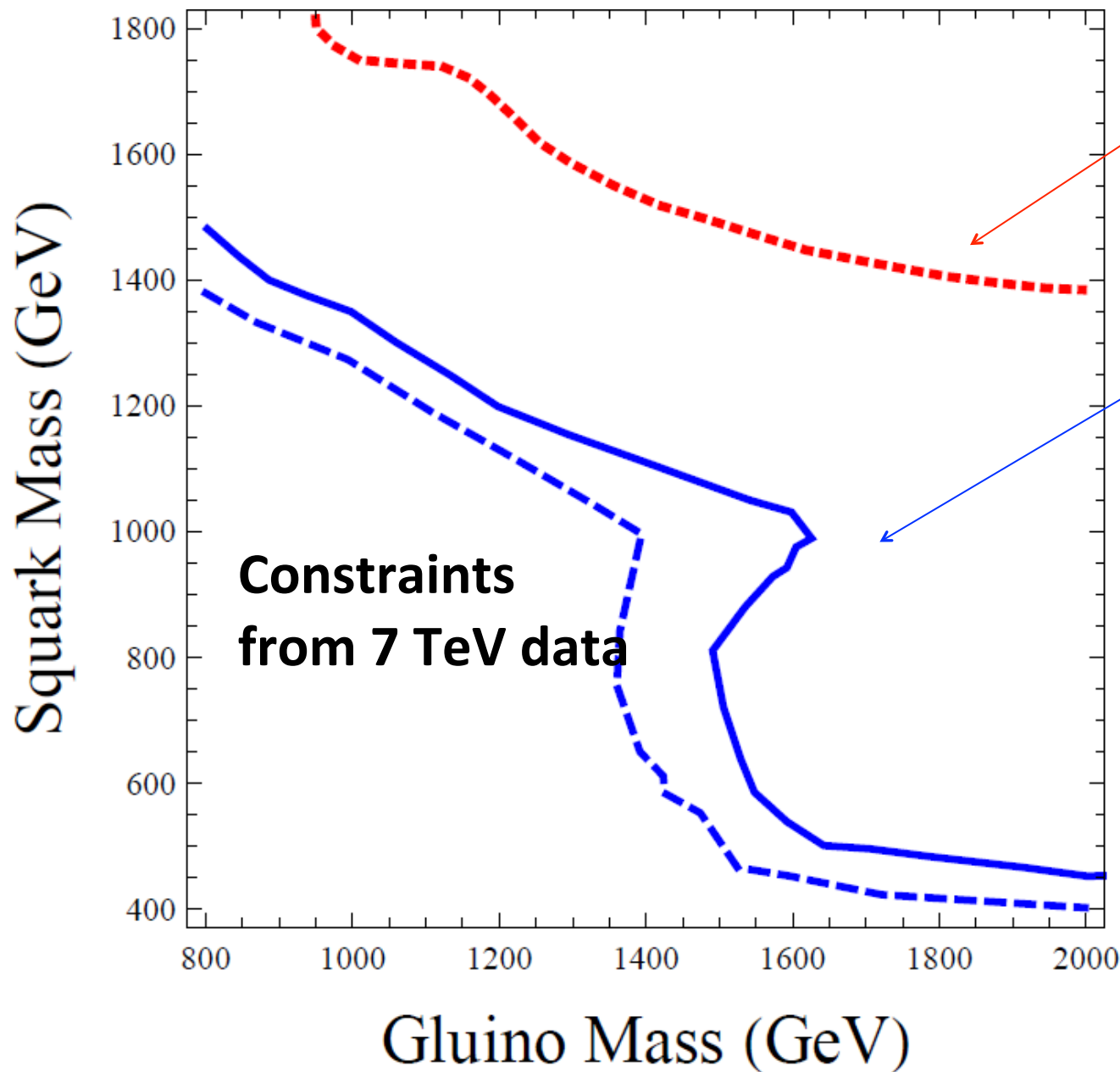Some signal efficiency for displaced vertex w/muon search

ATLAS Displaced Vertex with Muon

Existing Collider Constraints on BRPV

Bilinear RPV with displaced decays can avoid constraints from many SUSY searches:

Constraints on Bilinear RPV