CMS results for searches for SUSY in compressed mass scenarios

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Compressed Supersymmetry

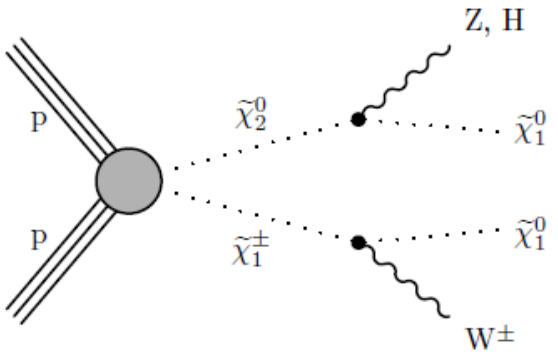
Search for evidence of SUSY at the electroweak scale well motivated

- could be dark matter candidates
- lowest lying states in electroweakino sector $(\tilde{\chi}_1^0, \tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0)$
  could be nearly mass-degenerate
- slepton production could affect muon g-2

Look for Electroweakinos, sleptons, stops

such as

TChiWZ



Compressed spectra need to be fully probed:

difference between parent sparticle and lightest stable particle

$m_{\tilde{P}} - m_{\tilde{\chi}} = (\Delta m) \sim$ small

CMS Results discussed here

- All from Run II with Integrated Luminosity 137-138fb^{-1}
- Pair produced R-parity conserving sparticles
- Simplified model constraints

1. Search for top squark production in fully hadronic final states in proton-proton collisions at $\sqrt{s}$ = 13 TeV
    - Phys. Rev. D 104, 052001 (2021)

2. Combined search for electroweak production of winos, binos, higgsinos, and sleptons in proton-proton collisions at $\sqrt{s}$ = 13 TeV
    - https://arxiv.org/pdf/2402.01888

3. New analysis using Recursive Jigsaw Kinematic Reconstruction
    - Spoiler alert: New limits aren't yet CMS approved for presentation so just presenting method here

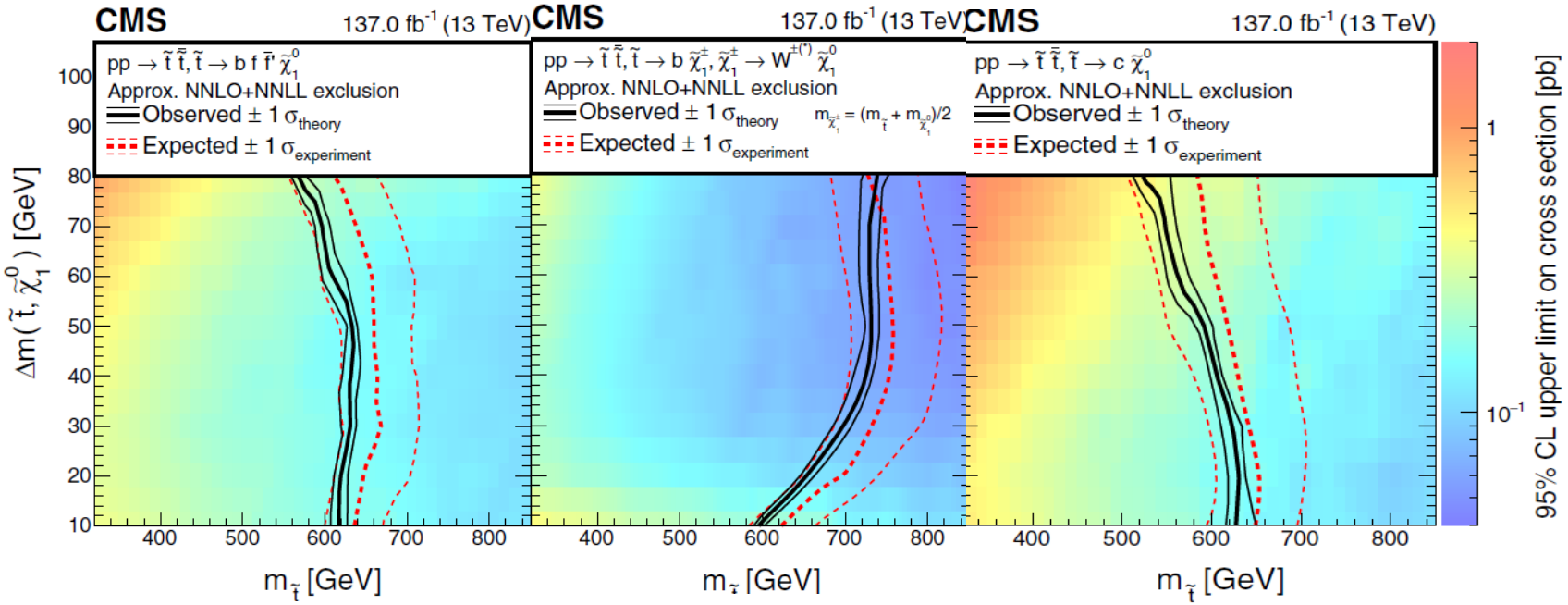
Compressed Search strategies

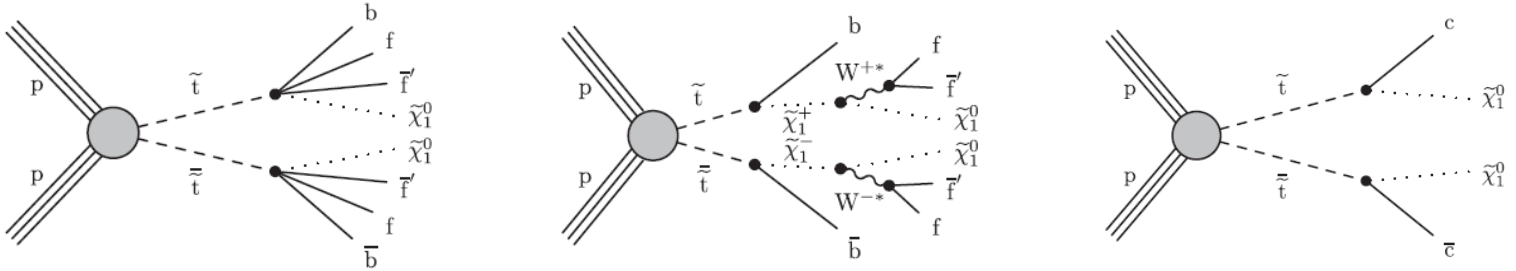
- Identify events with initial state radiation (ISR) recoiling off sparticles
  - results in greater missing tranverse energy p_T^{miss}
  - Analyses 1&2 require high p_T jet recoil
  - Analysis 3 uses Recursive Jigsaw Reconstruction (RJR) to assign different objects to different frames

- Require low momentum objects such as leptons, b-jets, or soft secondary b-vertices

Analysis 1: Stop search

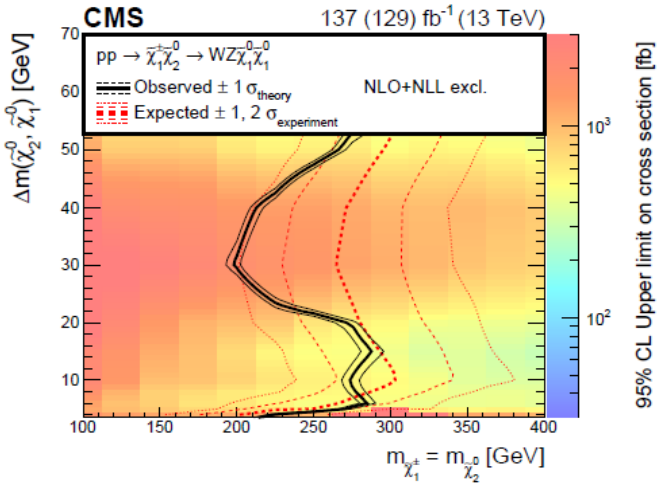
- ISR $p_T^{ISR} > 300$ GeV, $p_T^{miss} > 250$ GeV
- No top, W or resolved W tagged objects
- b jets or secondary vertices present with transverse mass cut

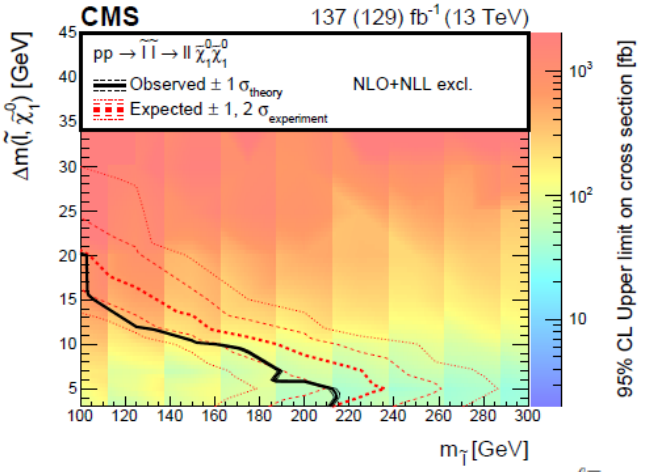




Analysis 2: Electroweakinos and Sleptons

- jet from ISR, high p_T^{miss}
- need at least 2 leptons (muons/electrons), look at charge, flavor combinations, with and without requiring mass consistent with Z
  Require at least one pair of opposite-sign, low-transverse momentum (p_T) electrons or muons together





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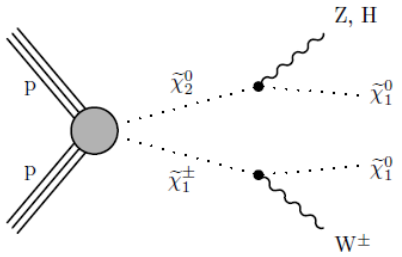
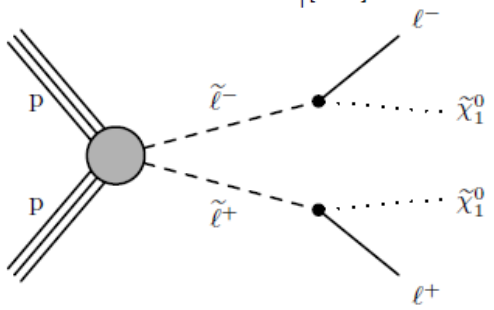


slepton



Kinematic Reconstruction Analysis 3

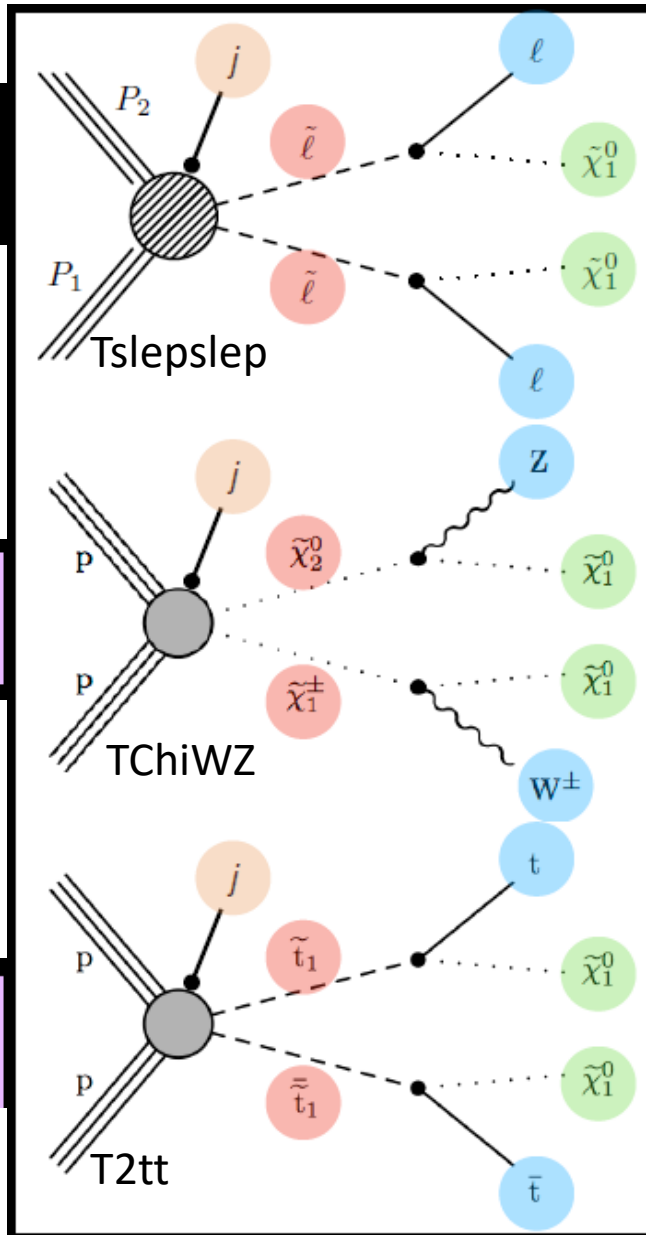
$m_{\tilde{l}} - m_{\tilde{\chi}_0} \sim$ small

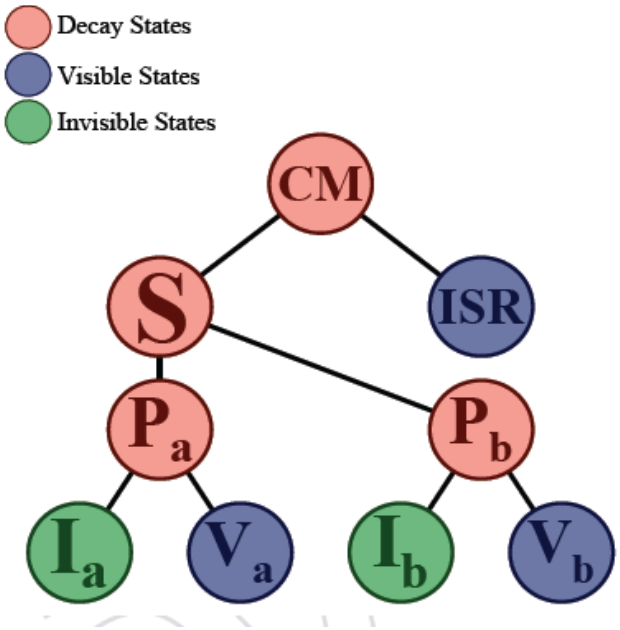
Search for sleptons, electroweakinos, stops

$m_{\tilde{\chi}_2} - m_{\tilde{\chi}_1} \lesssim m_Z$

Target compressed SUSY in multiple final states and mass regimes

$m_{\tilde{t}} - m_{\tilde{\chi}_0} \lesssim m_{top}$



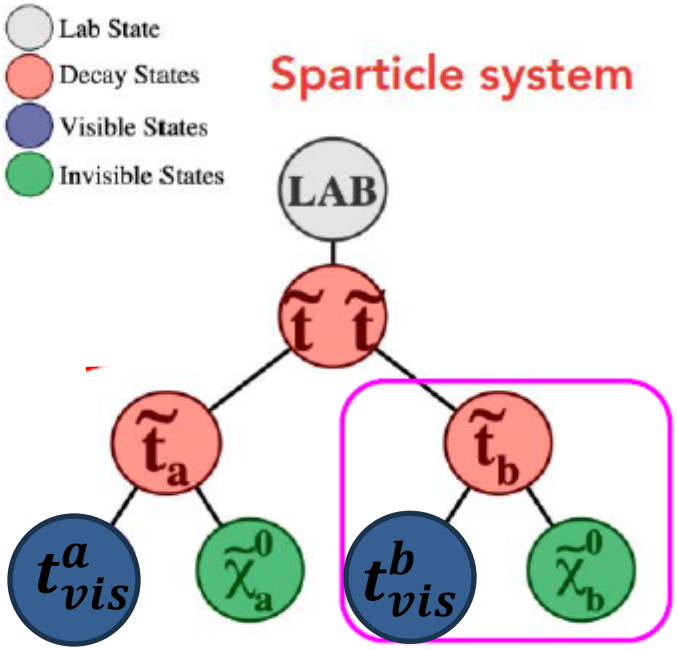


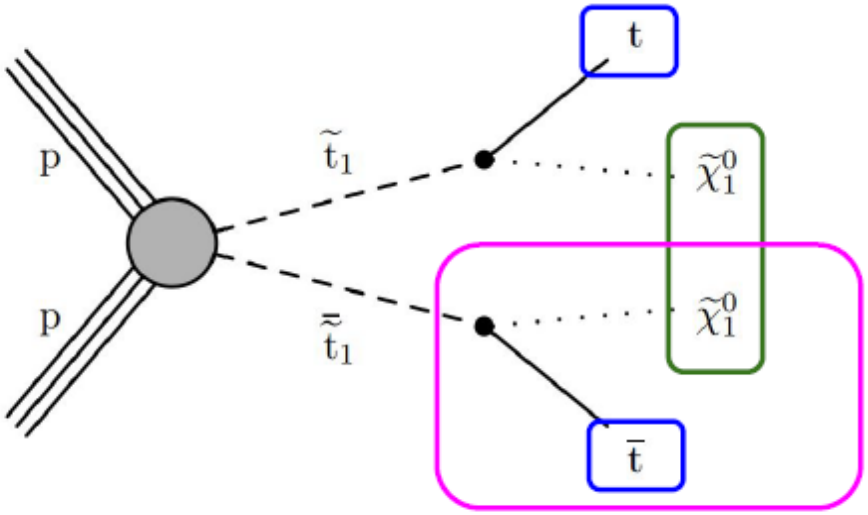
RJR reconstruction

Kinematically group objects using approximate decay tree rest frames to measure mass sensitive variables

Visible Objects used:

electrons, muons, jets, b-tagged jets, b-tagged secondary vertices



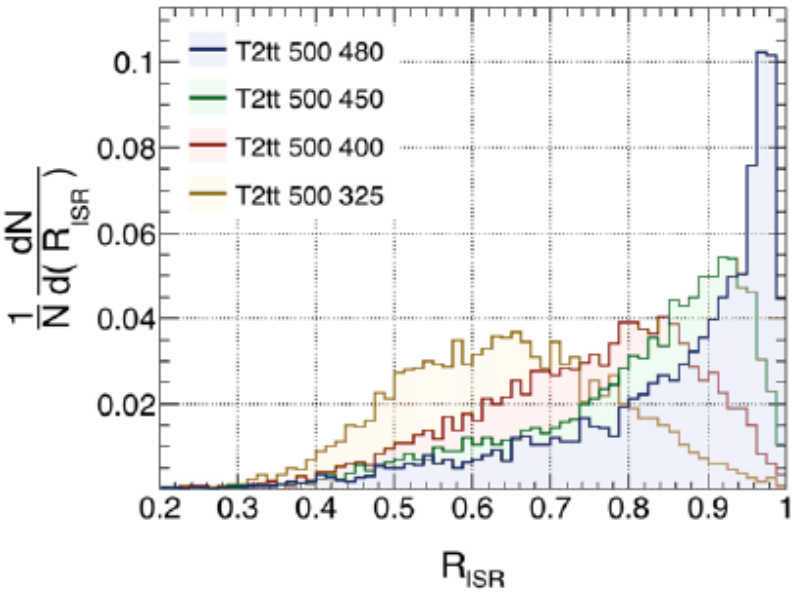


mass sensitive variables

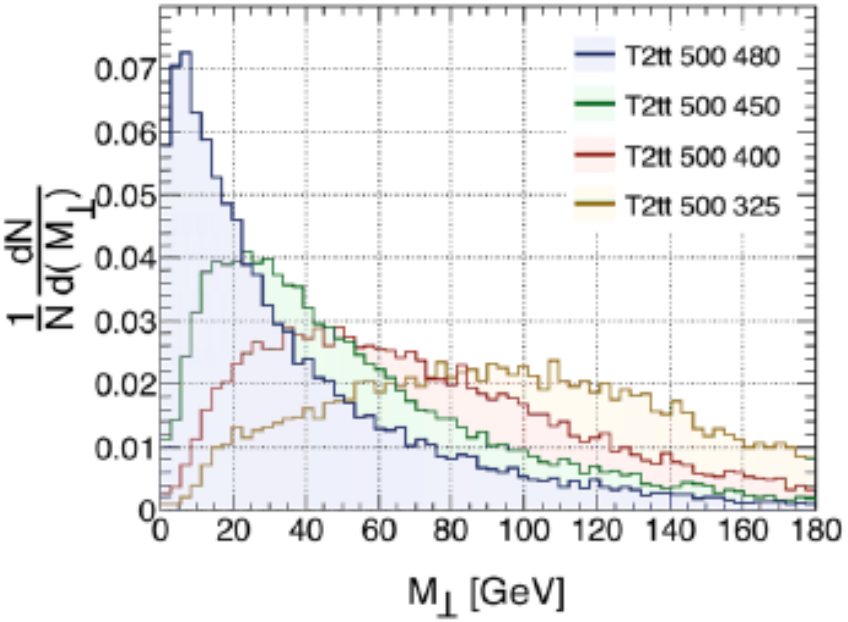
$$R_{ISR} = \frac{\vec{p}_I^{CM} \cdot \hat{p}_{ISR}^{CM}}{p_{ISR}^{CM}} \sim \frac{m_{\tilde{\chi}_0}}{m_{\tilde{P}}}$$

smaller mass ratios peak at large RISR

Private Work (CMS simulation) Region 2L_J_X



Private Work (CMS simulation) Region 1L_J_X

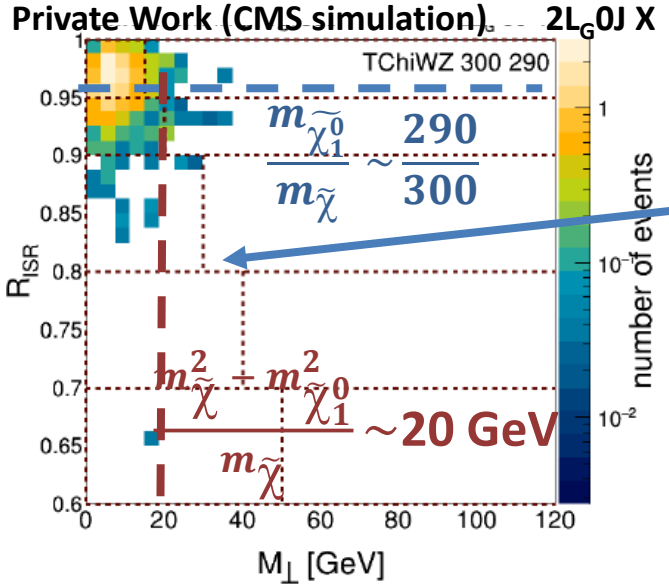


$$M_\perp = \sqrt{\frac{M_{P_a}^2 + M_{P_b}^2}{2}} \sim m_{\tilde{P}} - m_{\tilde{\chi}_0}$$

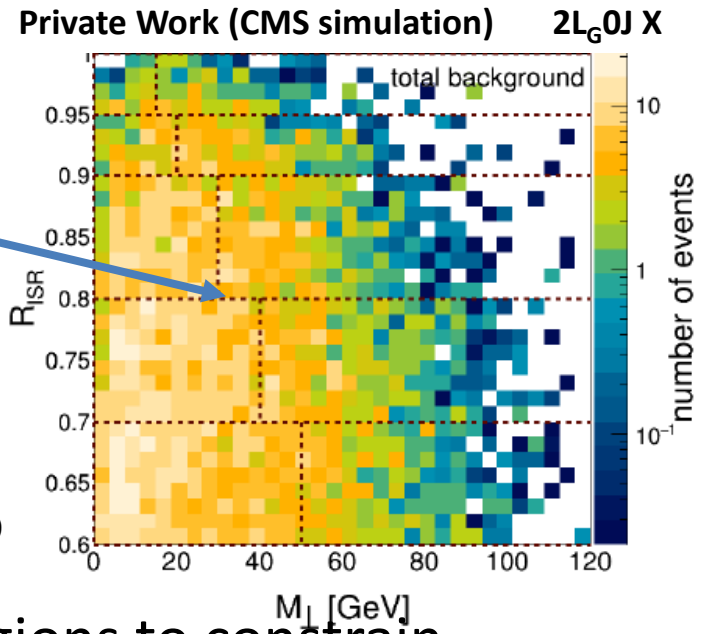
smaller mass splittings peak at low $M_\perp$

Analysis 3 strategy

- Use 0, 1, 2, 3 lepton events and group according to how many other jets, b-jets, or b SVs are present
- New deep neural network b-SV finder helps lower p_T threshold to probe tighter compression range $2 \leq p_T \leq 20$ GeV/c
- Create 2-dimensional bins with mass sensitive variables R_{ISR} and $M_\perp$



Example for 2 leptons 0 jet with bin boundaries shown



TOTAL BACKGROUND

- Use data driven fit with many control regions to constrain backgrounds

Conclusion

CMS has searched for signatures from simplified SUSY models in compressed mass region

	Δm region (GeV)	sparticle mass limit (GeV)
stops	10-80	$m_{\tilde{t}}$ > 600-700
electroweakinos,	3-50	$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$ > 200-300
sleptons	3-20	$m_{\tilde{l}}$ > 100-200

Stay tuned for latest results from the kinematic reconstruction analysis which we think will improve these exclusions