

# New bounds on sneutrino masses through collider searches

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# Introduction

- Among least-constrained sparticles are the sneutrinos
  - LEP-I measurement nearly 30 years-old (!)
  - $m_{\tilde{\nu}} > 44.7 \text{ GeV}$  ( $N(\tilde{\nu}) = 3$ )
- Various models can accommodate the sneutrino as the LSP or NLSP
  - If the sneutrino is the LSP, then it will be invisible in the detector
  - If it is the NLSP, it will decay invisibly
- Place generic bounds on sneutrino masses from two sources
  - Model-independent bound by investigating couplings in the Higgs sector
  - Repurposing mono-boson LHC searches

# Sneutrino MSSM Higgs constrains

- Left-handed charged sleptons are (nearly) mass degenerate with the sneutrinos due to the single soft mass parameter
- Mass separation comes from D-terms when Higgs VEVs are inserted

$$\Delta m := m_{\tilde{e}} - m_{\tilde{\nu}} = -\frac{m_W^2 \cos 2\beta}{m_{\tilde{e}} + m_{\tilde{\nu}}}$$

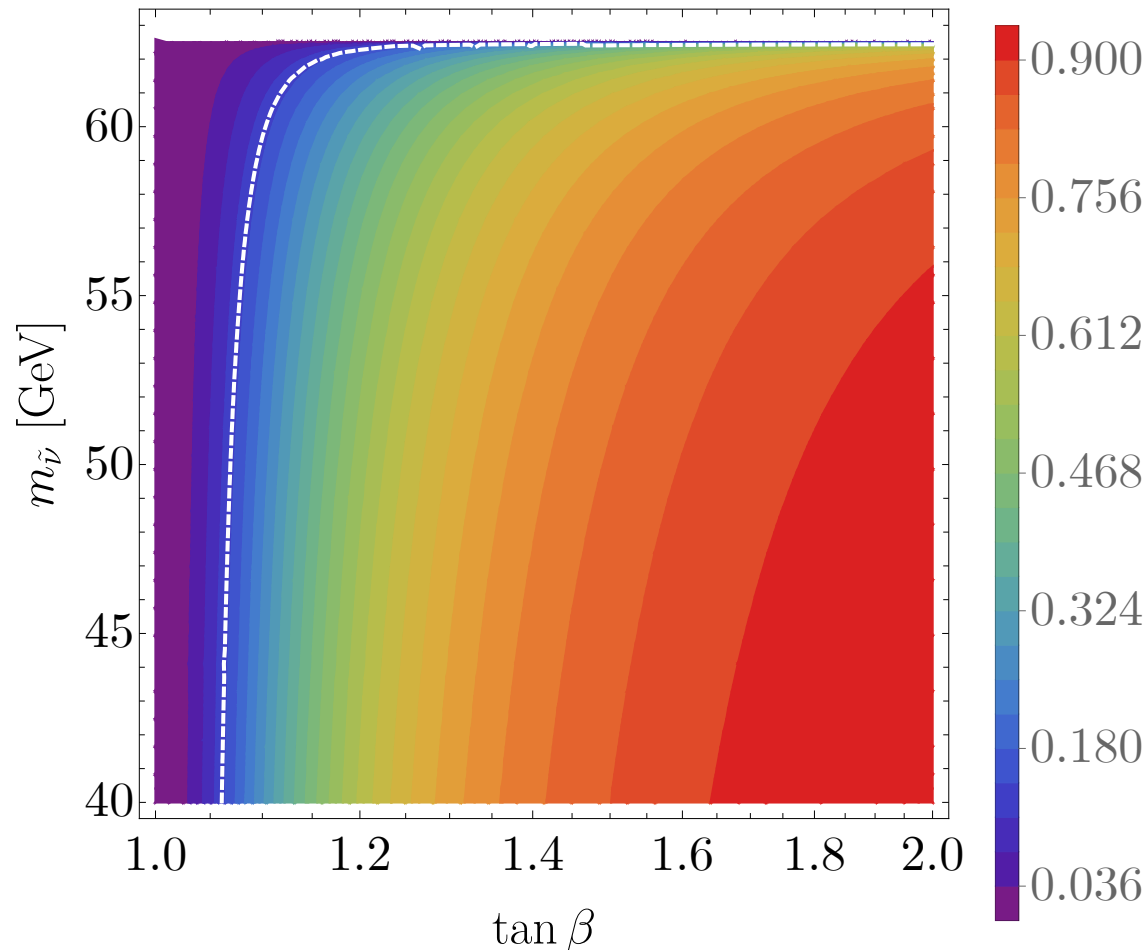
- Higgs couples to sneutrinos through tri-linear couplings

$$\text{Br}(h \rightarrow \text{inv}) := \frac{\Gamma(h \rightarrow \tilde{\nu}\tilde{\nu}^*)}{\Gamma_h} \sim 390 \times \left(\frac{4.07 \text{ MeV}}{\Gamma_h}\right) \left(\frac{|A_{\tilde{\nu}}|}{100 \text{ GeV}}\right)^2 \times N_{\tilde{\nu}} \sqrt{1 - \frac{4m_{\tilde{\nu}}^2}{m_h^2}}$$

$$V_{\tilde{\ell}} = m_{\tilde{\nu}}^2 |\tilde{\nu}|^2 + m_{\tilde{e}}^2 |\tilde{e}|^2 + A_{\tilde{\nu}} h |\tilde{\nu}|^2 \qquad A_{\tilde{\nu}} = \frac{gm_Z^2}{2m_W} \sin(\alpha + \beta)$$

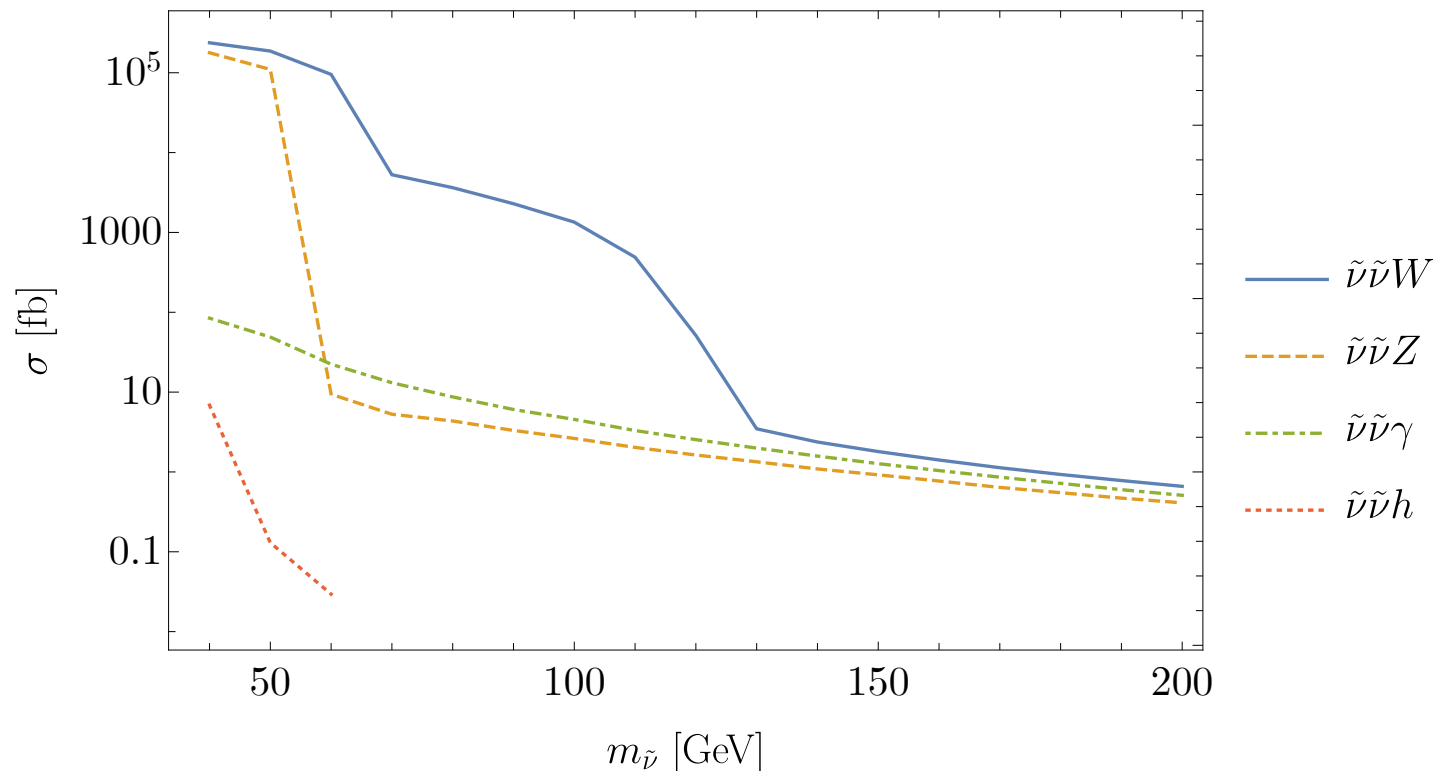
# Sneutrino MSSM Higgs constrains

- Current limit is  $BF \sim 0.13$
- Sneutrino lighter than half the Higgs mass is excluded

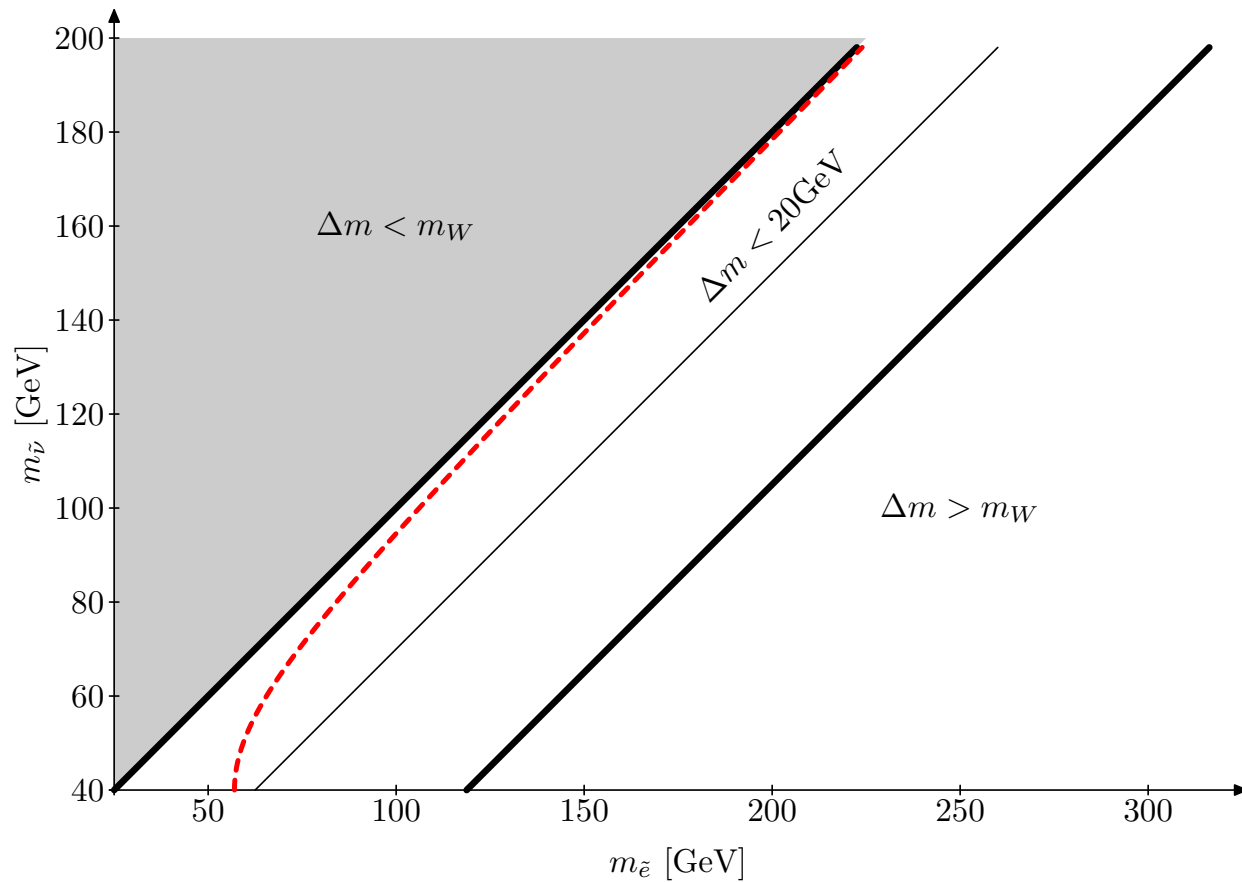


# LHC constraints

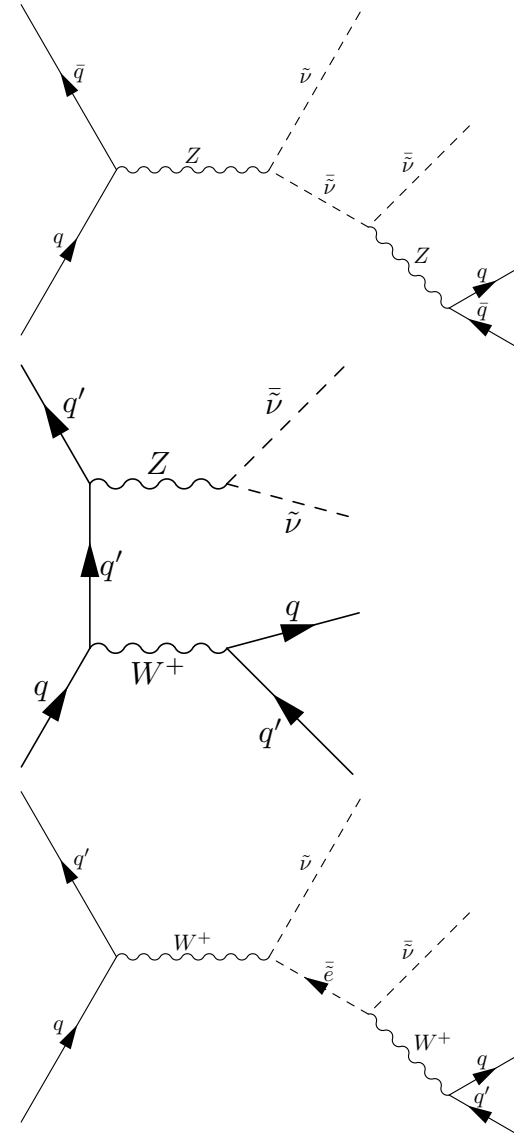
- ISR gluon events have greatest cross-section
  - And greatest background—SNR does not look promising
- Turn instead to FSR/ISR electroweak events
  - Vector mono-boson events with a hadronic v-tag



# LHC constraints



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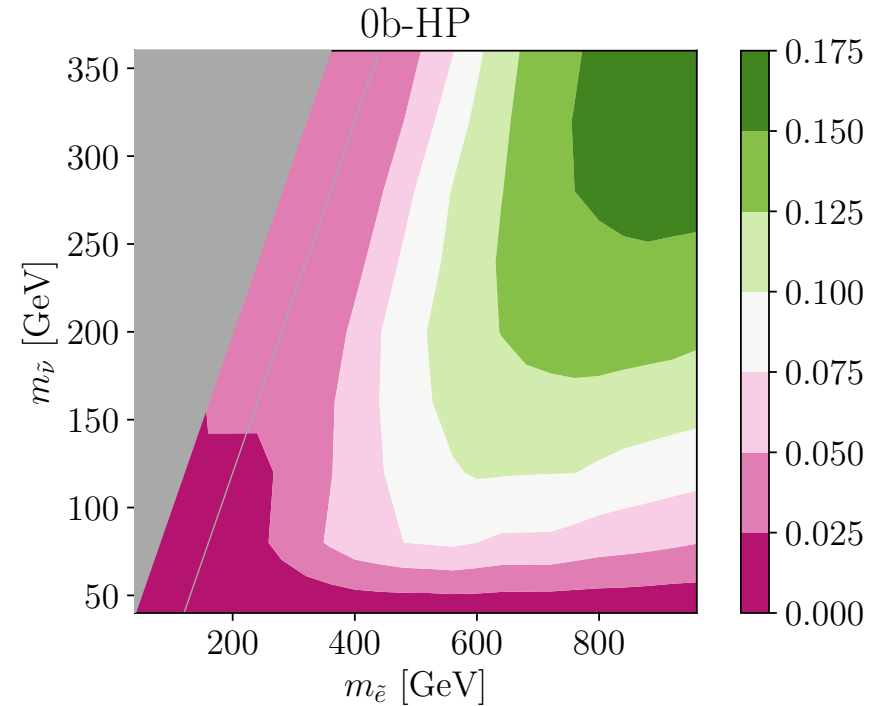
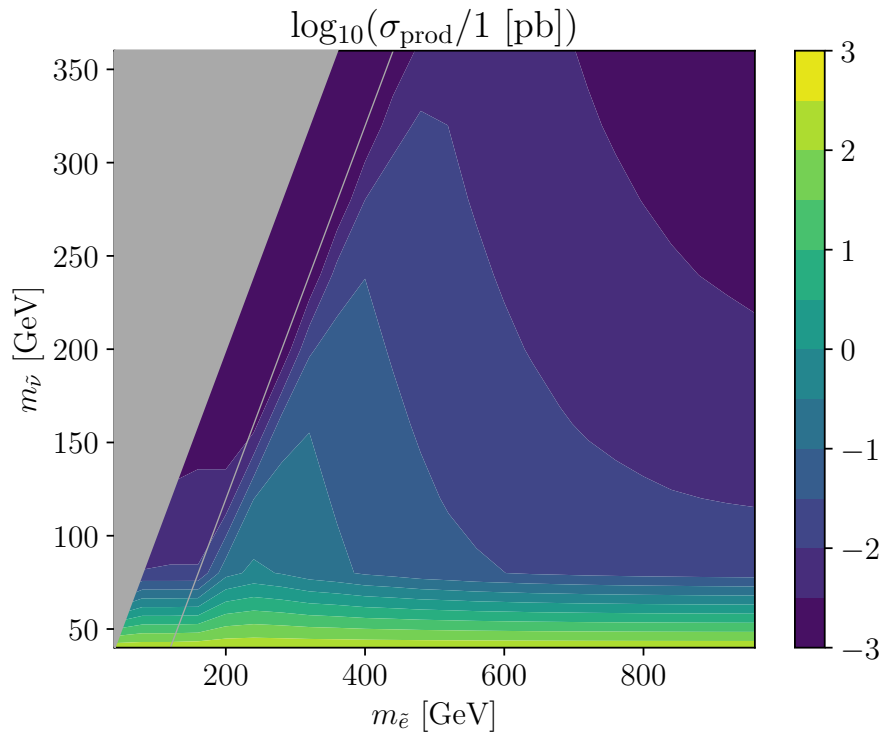


# LHC constraints

	Merged topology				Resolved topology	
$E_T^{\text{miss}}$ Jets, leptons b-jets	$> 250 \text{ GeV}$ $\geq 1J, 0\ell$ no b-tagged jets outside of $J$				$> 150 \text{ GeV}$ $\geq 2j, 0\ell$ $\leq 2$ b-tagged small- $R$ jets	
Multijet suppression	$\Delta\phi(\vec{E}_T^{\text{miss}}, J \text{ or } jj) > 2\pi/3$ $\min_{i=1,2,3} [\Delta\phi(\vec{E}_T^{\text{miss}}, j_i)] > \pi/9$ $ \vec{p}_T^{\text{miss}}  > 30 \text{ GeV}$ or $\geq 2$ b-jets $\Delta\phi(\vec{E}_T^{\text{miss}}, \vec{p}_T^{\text{miss}}) < \pi/2$					
Signal properties					$p_T^{j1} > 45 \text{ GeV}$ $\sum_i p_T^{j_i} > 120 \text{ (150) GeV}$ for 2 ( $\geq 3$ ) jets	
Signal region	0b-HP	0b-LP	1b-HP	1b-LP	0b-Res	1b-Res
$J$ or $jj$ b-jet	HP no b-jet	LP no b-jet	HP 1 b-jet	LP 1 b-jet	$\Delta R_{jj} < 1.4$ and $m_{jj} \in [65, 105] \text{ GeV}$ no b-jet                      1 b-jet	

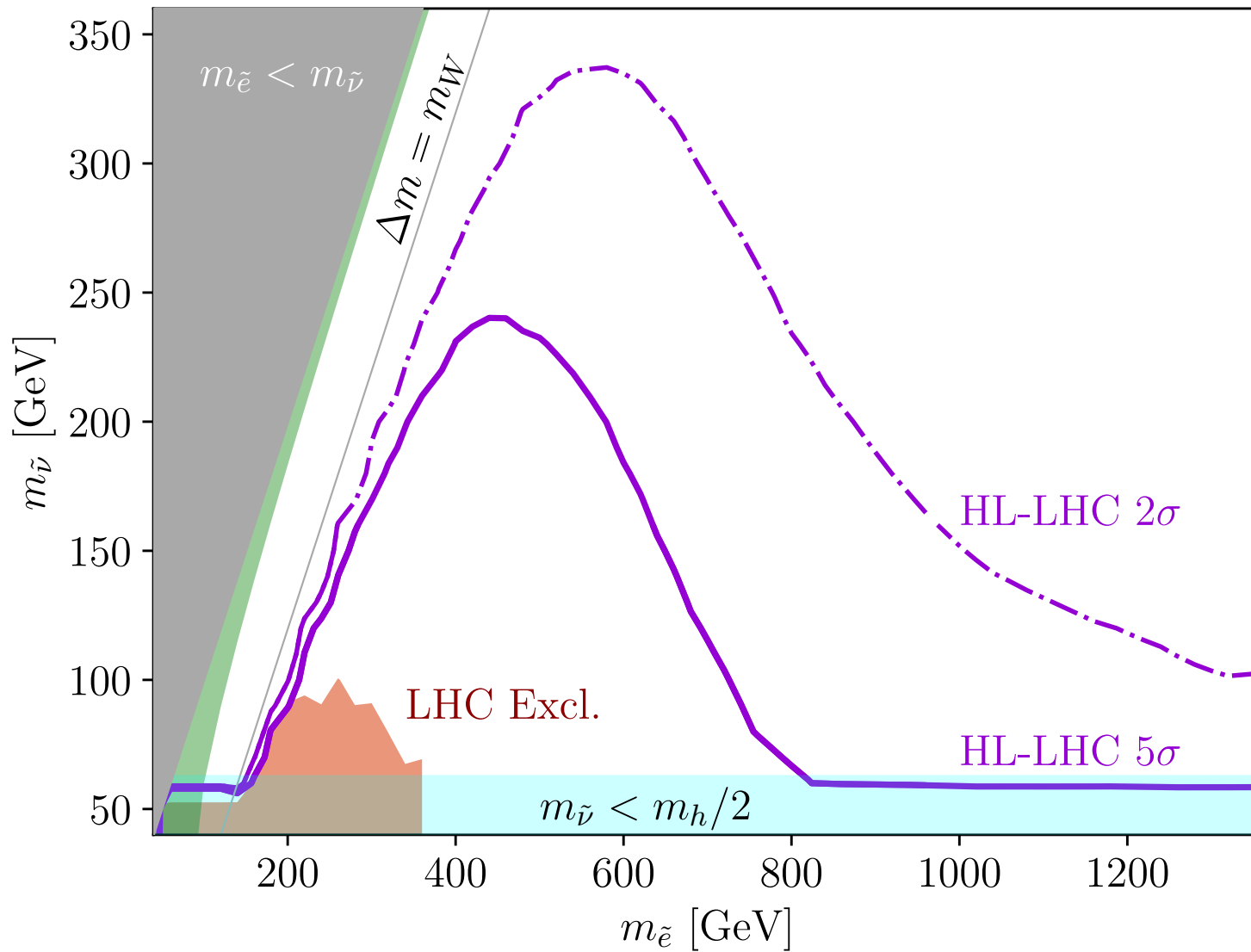
# Results

- Generated events at 13 TeV and 14 TeV
- (strongest constraints from 0b-HP)

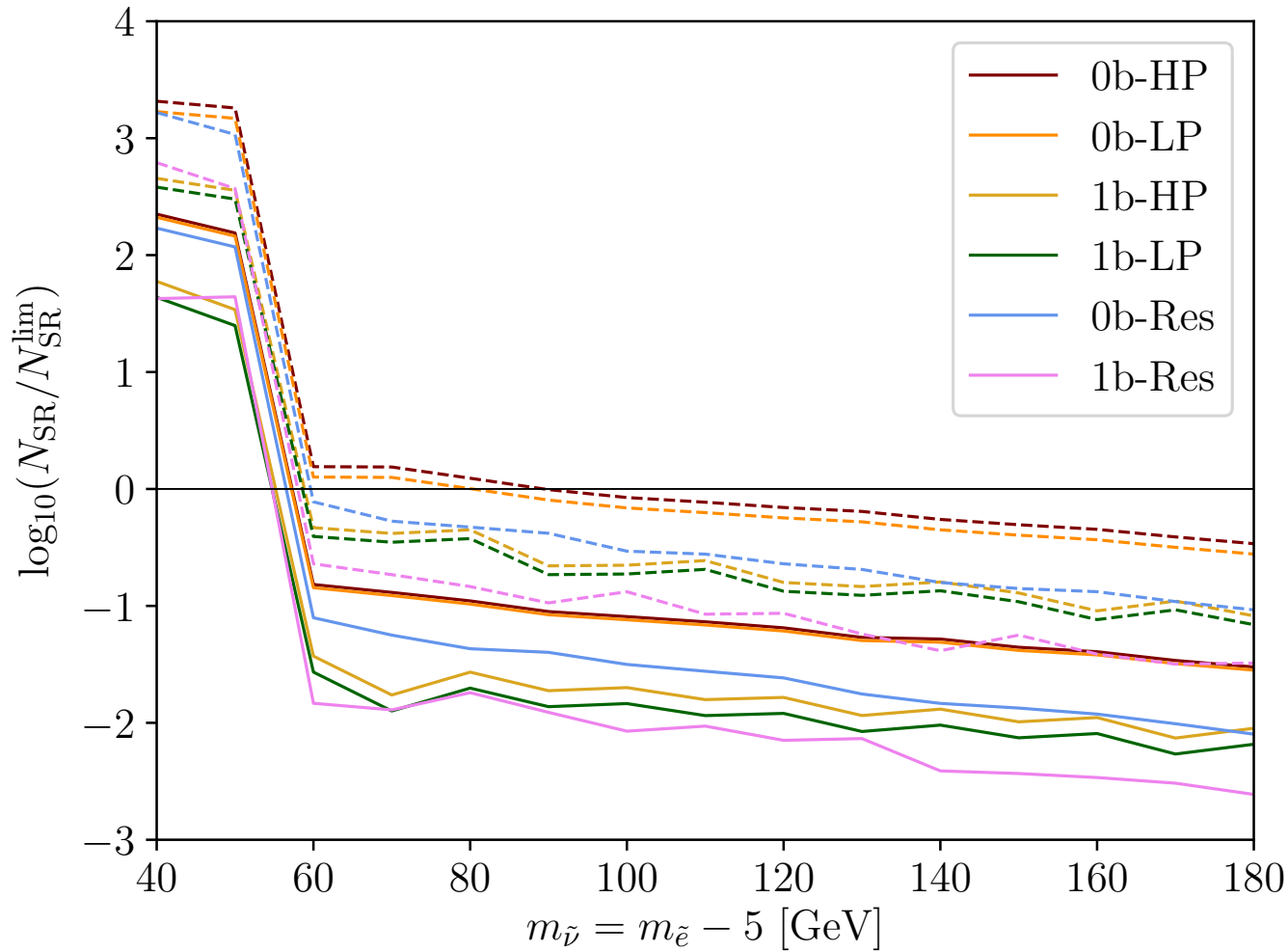




# Results



# Results



- Solid lines = 13 TeV signal region
- Dashed lines = 14 TeV signal region
- Black line = experimental limit
- Strongest constraint comes from the 0b-HP channel
- $m_{\tilde{\nu}} \sim 90$  GeV

# Summary

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- Sneutrino (N)LSP models remain as least-constrained BSM scenarios
- Challenging scenario to constrain
- Derive bounds from Higgs-sector couplings and repurposed mono-boson LHC searches
- Higgs bound is  $m_{\tilde{\nu}} > \frac{m_h}{2}$
- HL-LHC bound is  $m_{\tilde{\nu}} \sim 90$  GeV

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# Extra Slides

# Sneutrino (N)LSP models

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- There exist many scenarios where sneutrinos are the lightest or next-to-lightest sparticle
- In the LSP case, we consider a scenario where the sneutrino does not constitute a sizable fraction of dark matter
  - Strong constraints from direct detection
  - In the NLSP case, lighter sparticles, such as the gravitino or axino are required

# Sneutrino general mass constraints

- Many non-SUSY extensions of the SM contain sleptons
  - Can increase mass separation between sleptons and sneutrinos with extra SU(2) breaking
  - e.g., Dirac gaugino models

