Search for top squark production with CMS at 13 TeV

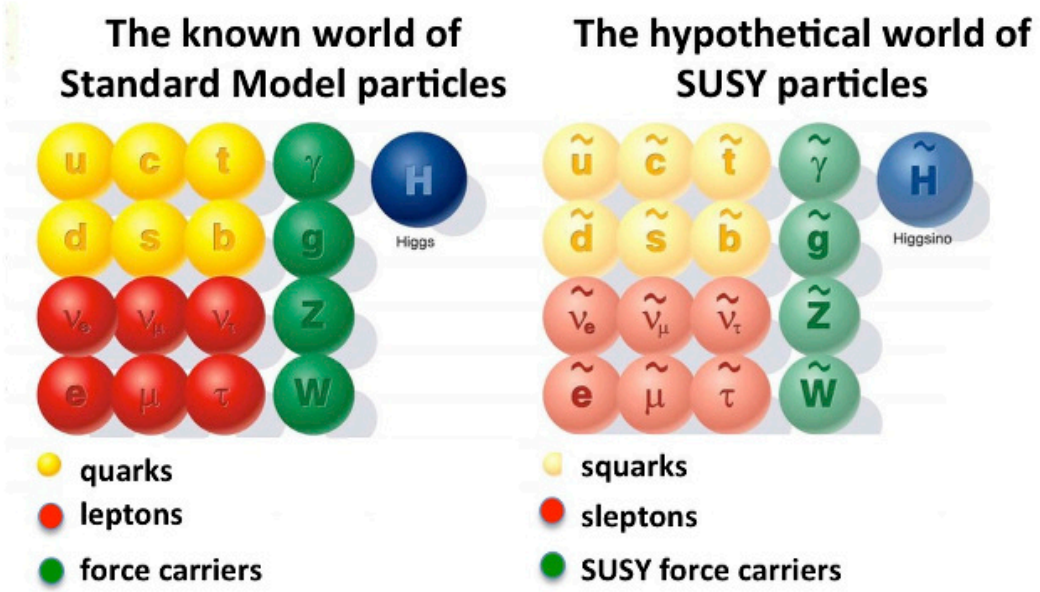
BY MATTHEW KILPATRICK

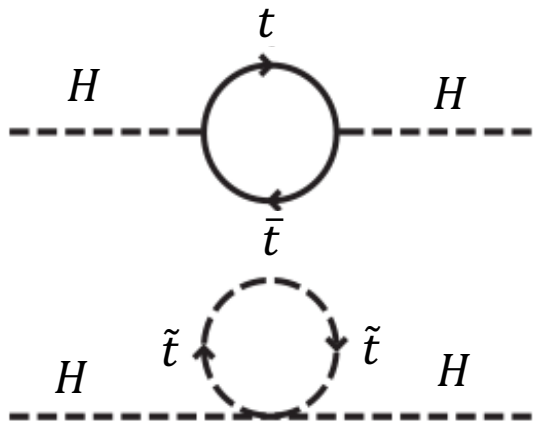
RICE UNIVERSITY

ON BEHALF OF THE CMS COLLABORATION

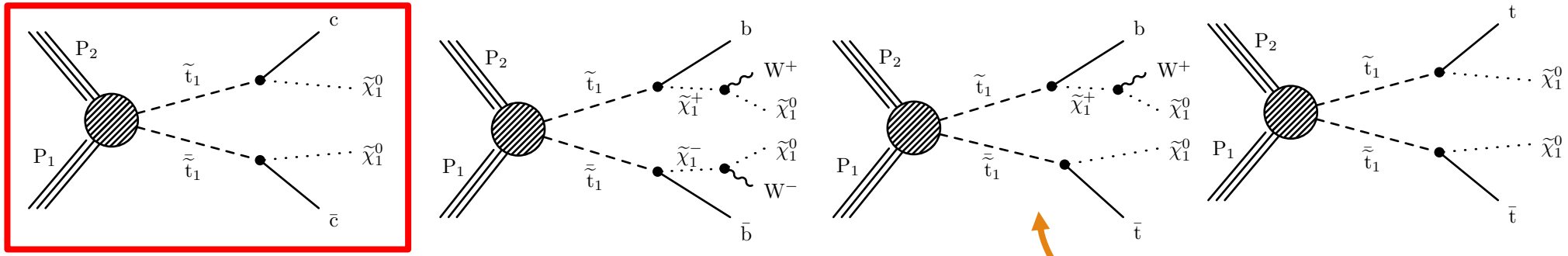
Introduction

- Supersymmetry is a promising extension of the SM
- R-parity conservation requires stable SUSY particle known as the lightest supersymmetric particle (LSP) as is a dark matter candidate
- Allows for cancellation of the Higgs boson quadratic mass renormalization for top and top squark
- Consider neutralino as LSP



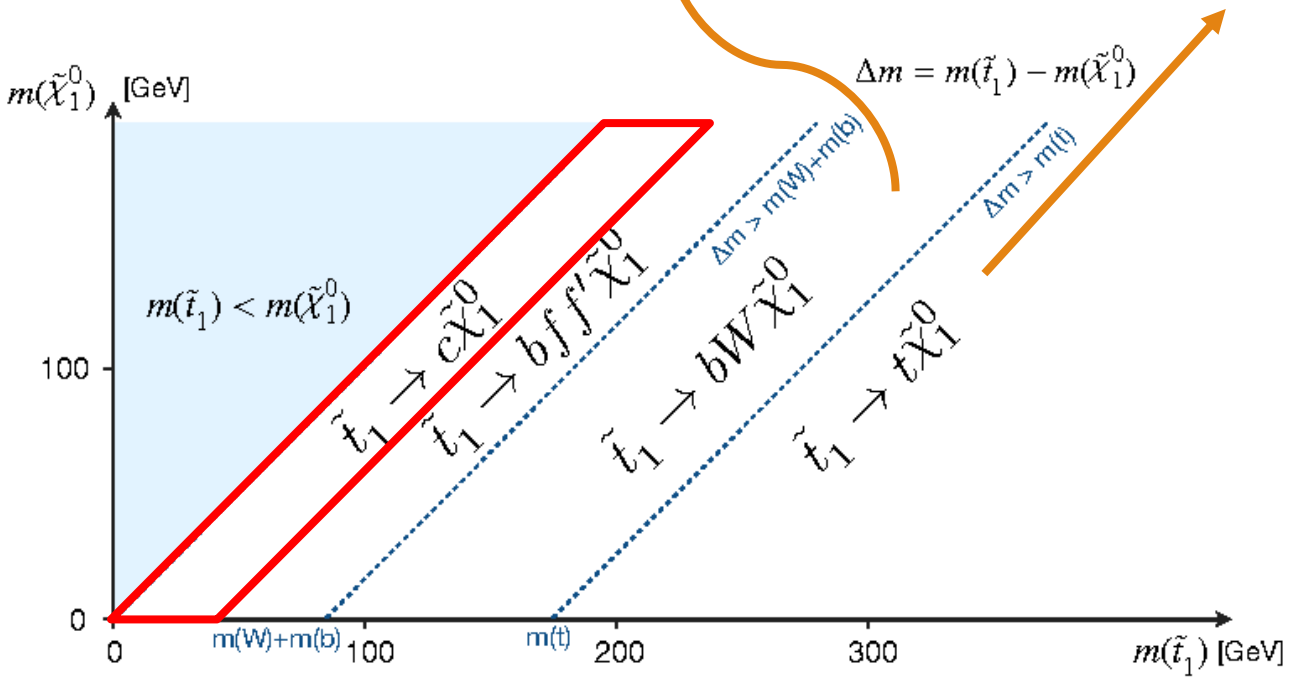


Top Squark Production



Channels

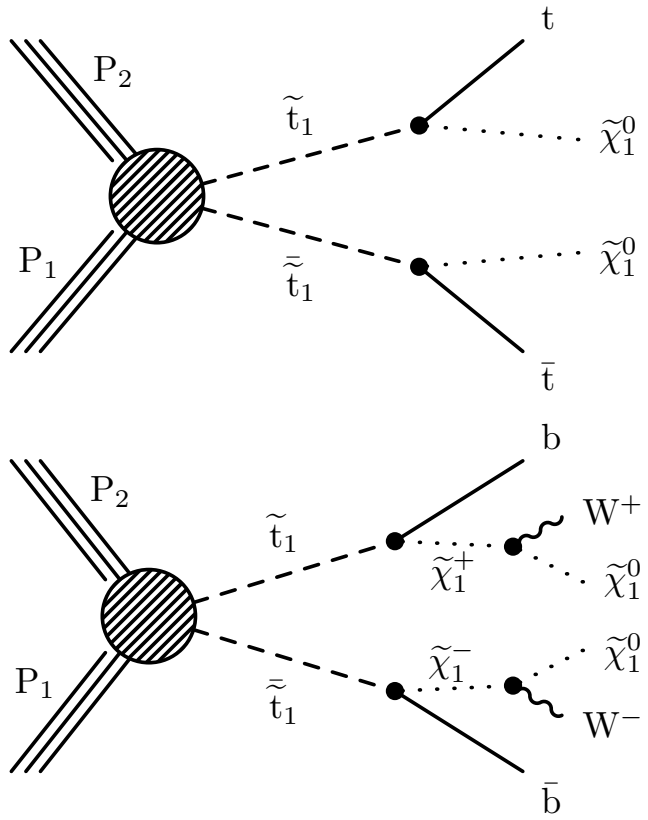
- Final states include 0,1,2 leptons
- Let's look at:
  - Single lepton (electron/muon)
  - Dilepton (2 taus in final state)
  - Zero lepton (Gravitino as LSP)



Stop 1L Search

Direct top squark search

- Isolated electron or muon final state with jets and missing transverse momentum
- Three search regions
  - $\Delta m\left(\tilde{t}, \widetilde{\chi_1^0}\right) > m_t$
  - $\Delta m\left(\tilde{t}, \widetilde{\chi_1^0}\right) \sim m_t$
  - $\Delta m\left(\tilde{t}, \widetilde{\chi_1^0}\right) \sim (m_W + m_b)$
- Concentration on $\tilde{t}_1 \to t\tilde{\chi}_1^0, \tilde{t}_1 \to b\tilde{\chi}_1^+$ decay modes



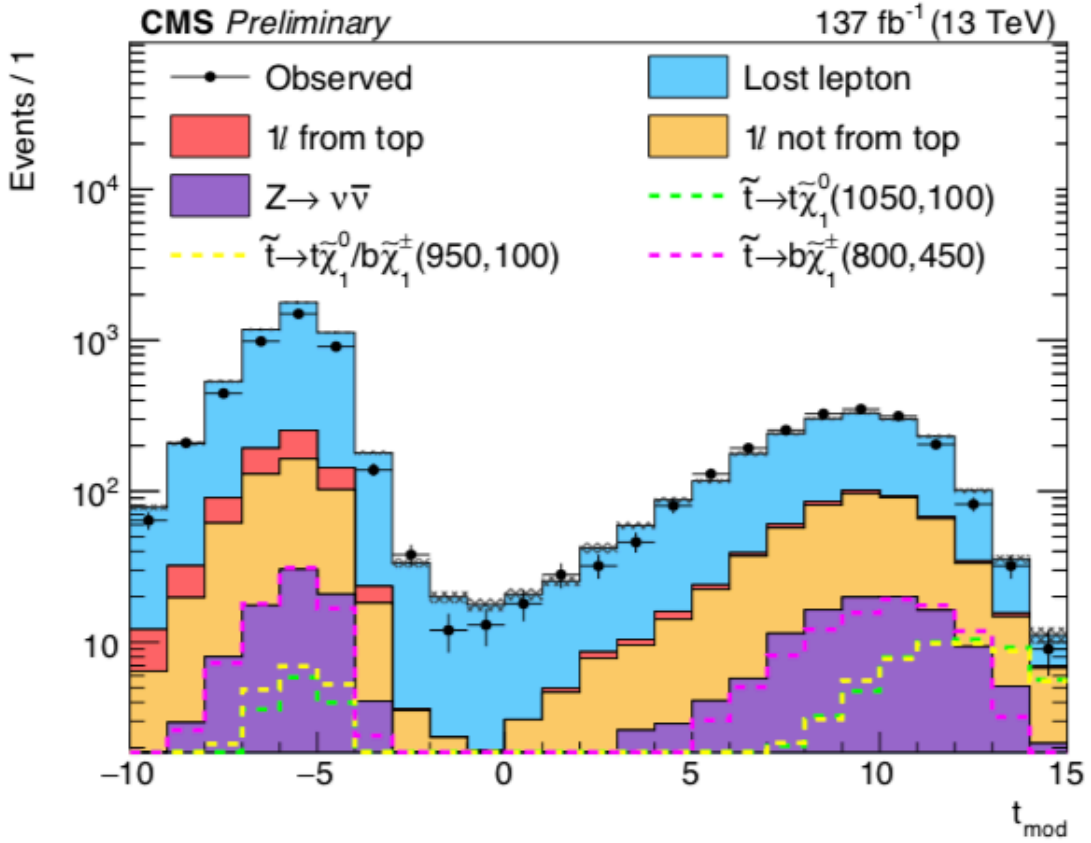
Stop 1L Search

Backgrounds

- Lost lepton from two W bosons decaying leptonically, missing one of them
- $Z \rightarrow \nu\bar{\nu}$ with single lepton from W boson

Search Strategies

- Modified topness: $t_{mod} = \ln\left(\frac{\left(m_W^2-(p_\nu+p_l)^2\right)^2}{a_W^4}+\frac{\left(m_t^2-(p_b+p_W)^2\right)^2}{a_t^4}\right)$
  - Small values likely to be dilepton $t\bar{t}$ event, signal event likely to have large values
- $M_{lb} \leq M_t\sqrt{1-\frac{M_W^2}{M_t^2}}$
- Other search region variables: $M_{lb}, N_{b,soft}, N_j$



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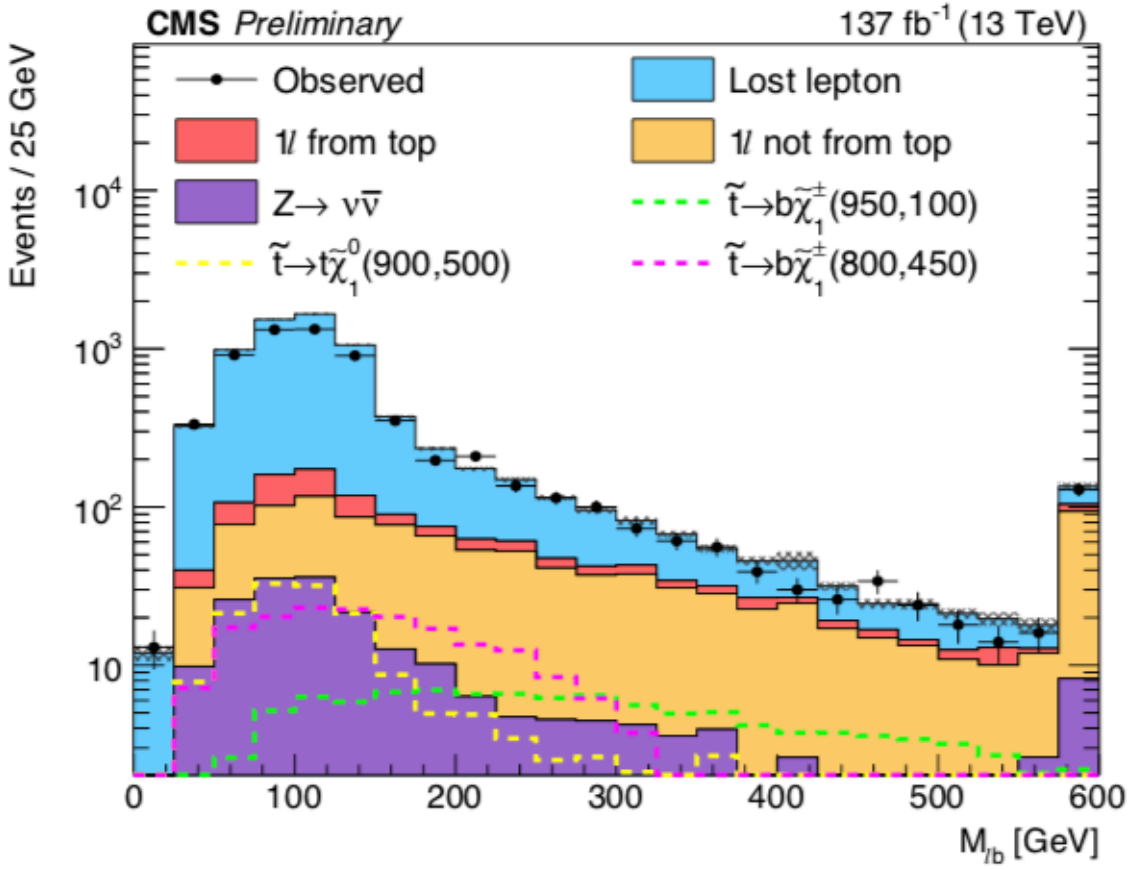
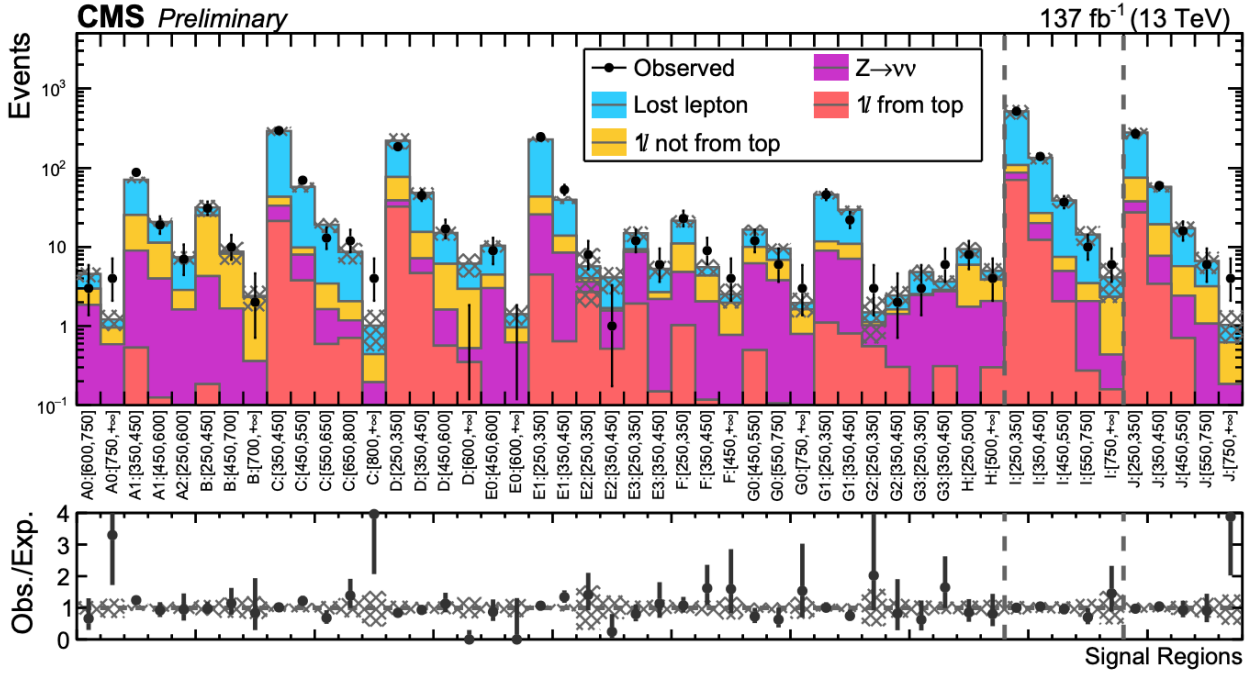
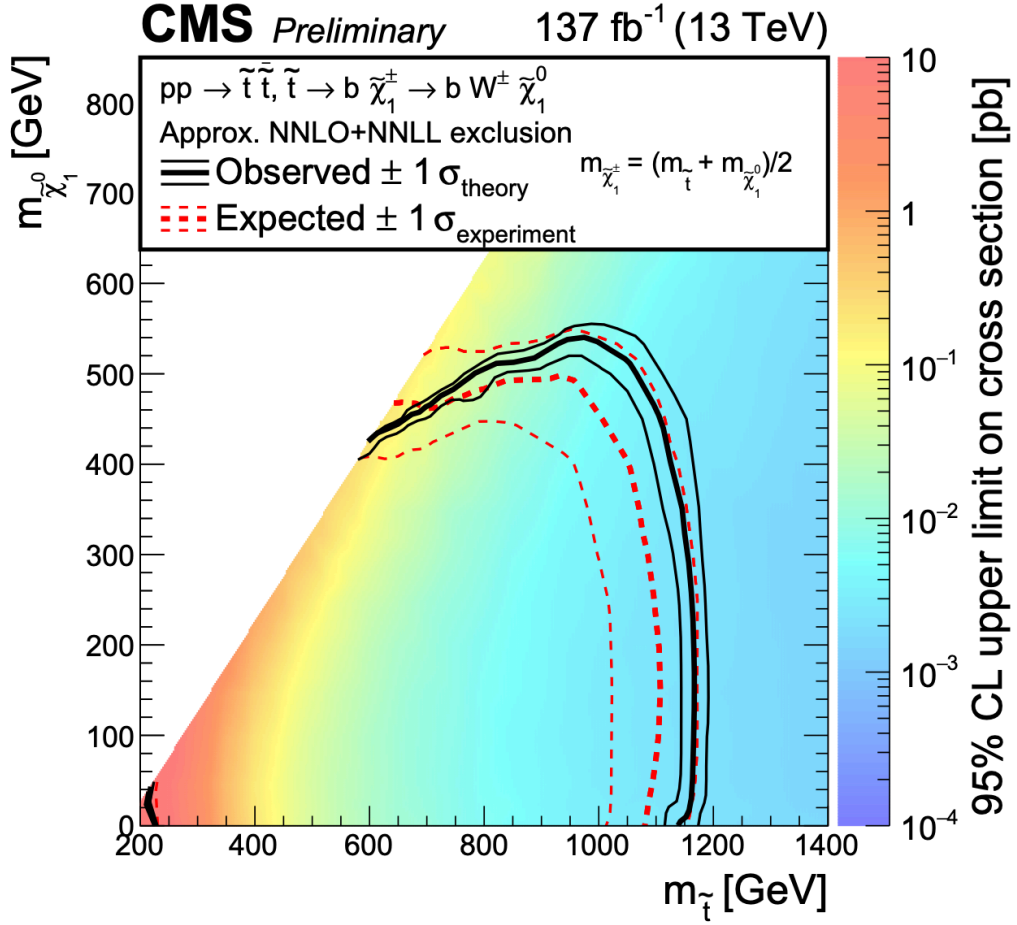


Exclusion Limits

- Consistent with SM backgrounds
- Exclude top squarks with mass up to 1.2 TeV
- [PAS-SUS-19-009]

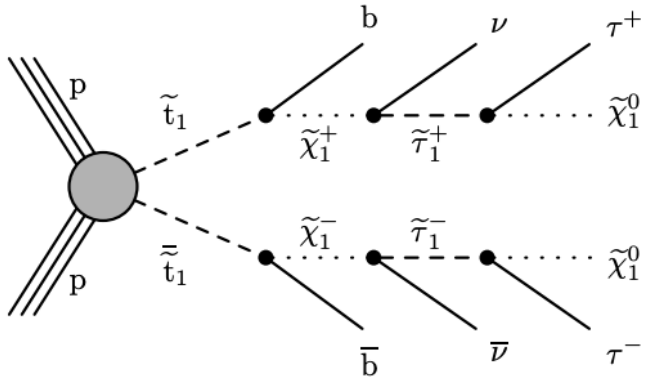




Stop: di-tau Final State

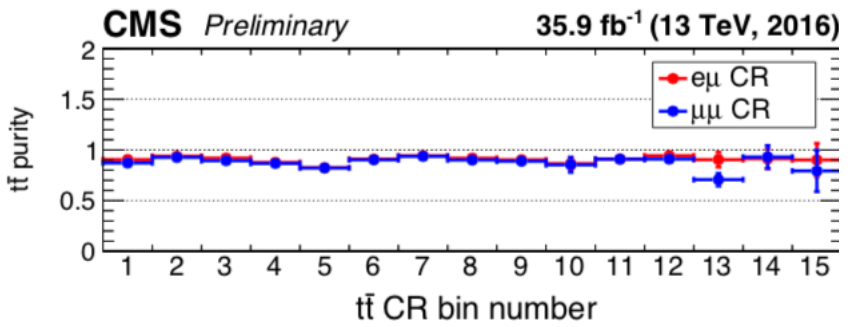
Dedicated to the di-tau final state

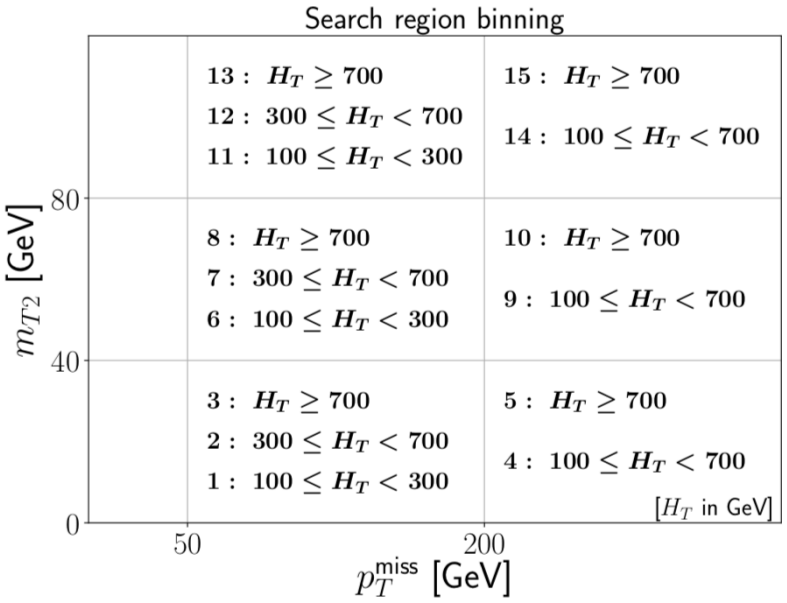
- $77.2\ \mathrm{fb}^{-1}$ from 2016/2017
- Probe MSSM where electroweak gauginos preferentially couple to third generation fermions
- Hadronically decaying tau leptons, b tagged jets, and MET
- Missing transverse momentum due to neutralinos (SUSY) or neutrinos (SM)
  - $m_T^2(\vec{p}_T^{\,vis}, \vec{p}_T^{\,inv})$ to distinguish SM and SUSY events



Backgrounds

- Dominated by $t\bar{t}$ processes
- Data driven estimation
  - $N_{i,corr\ t\bar{t}}^{\tau_h\tau_h SR} = N_{i,t\bar{t}\ MC}^{\tau_h\tau_h SR} \times \frac{N_{i,Data}^{e\mu\ CR}}{N_{i,MC}^{e\mu\ CR}}$

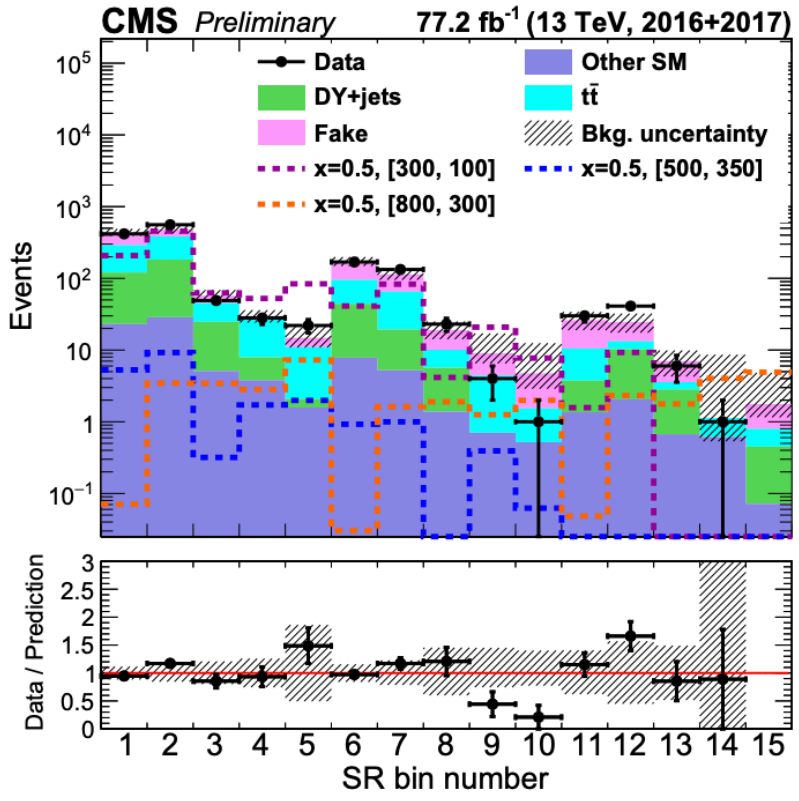


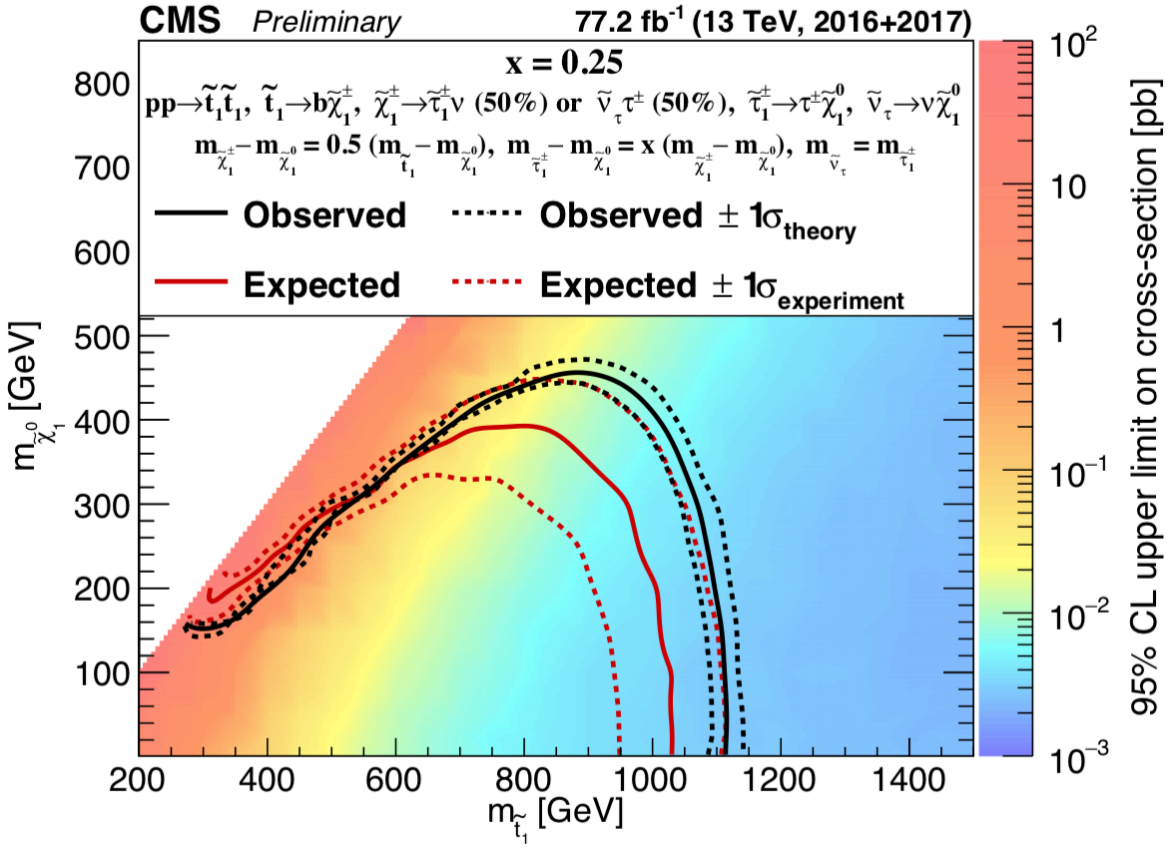


Di-tau Limits

Consistent with SM processes

- Limit on top squark mass up to 1.1 TeV
- PAS-SUS-19-003

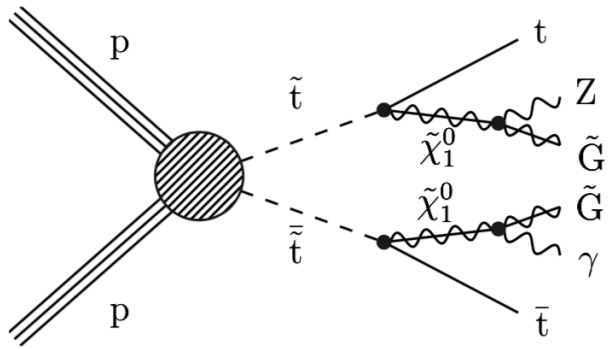




Stop with Gravitino

Models targeted motivated by gauge mediated symmetry breaking (GMSB)

- Gaugino masses proportional to their couplings
- Gravitino $(\tilde{G})$ is LSP and Neutralino $(\tilde{\chi}_1^0)$ is next-to-LSP



Signal signature

- Multiple jets, ≥ 1 photon, large missing transverse momentum
  - Must have large photon momentum, $p_T^\gamma > 100(190)$ GeV, and $H_T^\gamma > 800(500)$ GeV

Backgrounds

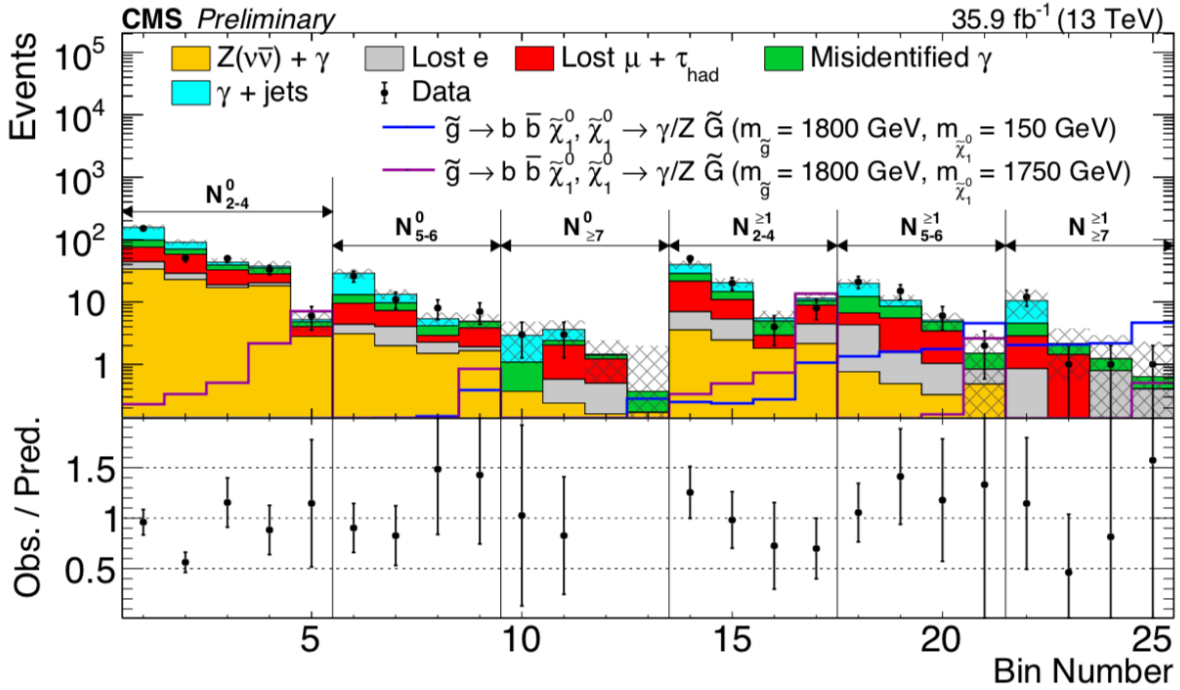
- $W\gamma + \text{jets}$ and $t\bar{t}\gamma + \text{jets}$ with lost lepton or hadronic tau decay
- $t\bar{t} + \text{jets}$ and $W + \text{jets}$ where an electron is misidentified
- $Z\gamma + \text{jets}$ with $Z \to \nu\bar{\nu}$
- $\gamma + \text{jets}$ with large mismeasurement

Stop with Gravitino

Estimation

- Transfer factor method for lost lepton estimation
- Control region estimations with leptons in place of photons
- Search region binning: N_J, N_b, p_T^{miss}

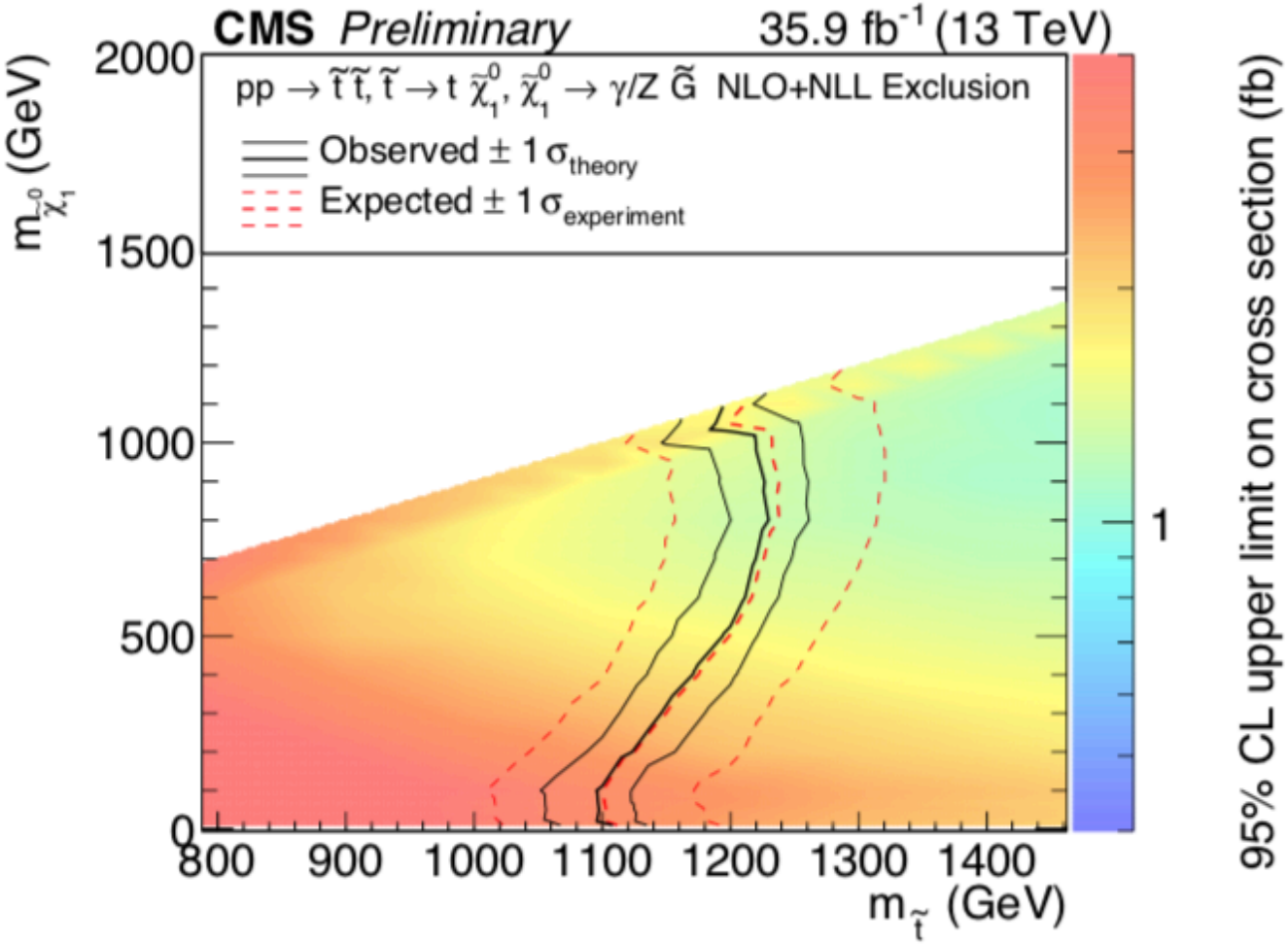
Event yields are consistent with SM backgrounds



Limits for GMSB

Limits on top squark mass up to 1230 GeV

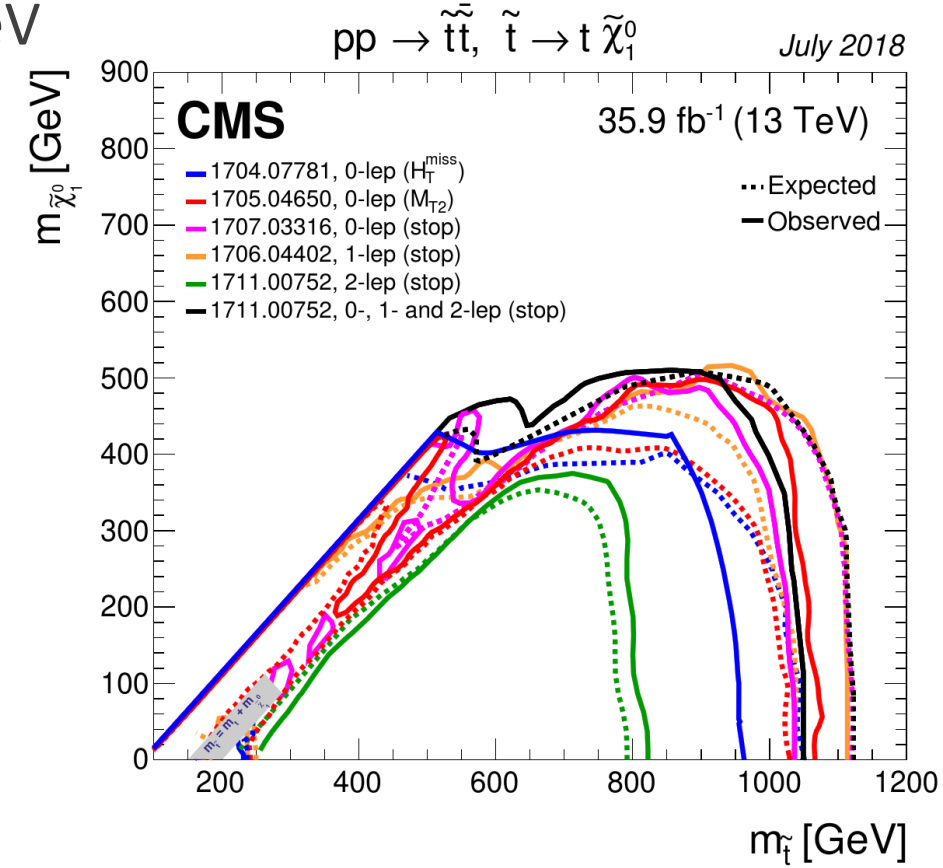
PAS-SUS-18-002



Summary

- Comprehensive analysis of LHC Run 2 with $137\ \mathrm{fb}^{-1}$ integrated luminosity from CMS
- Initial analysis give limit for top squark mass up to ~1.2 TeV
- Many more results on the way!
- Stay tuned!

- ATLAS also has interesting results see K. Yoshihara's talk next
- CMS Public SUSY Result: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS



Thank You

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