

Search for top-squark pair production in the single lepton final state in pp collisions at $\sqrt{s} = 8$ TeV

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Light top squarks are favored if Supersymmetry is the not-fine-tuned answer to the hierarchy problem. A search for top squark pair production is performed selecting events with a single isolated electron or muon, high p_T jets, and large missing transverse mass. The data sample consists of pp collisions corresponding to an integrated luminosity of 19.5 fb^{-1} at a center-of-mass energy $\sqrt{s} = 8$ TeV, delivered by LHC during 2012 and recorded by the CMS experiment.

The observed data are consistent with the predicted standard model backgrounds. Constraints are set on two simplified supersymmetric models with pair produced top squarks. Assuming the top squark decay to be either to a top quark and a neutralino or to a bottom quark and a chargino, the analysis probes top squarks with masses up to about 650 GeV.

Motivation

The hierarchy problem:

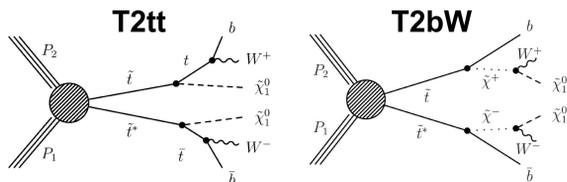
- Within the Standard Model, the corrections to the Higgs boson mass are quadratically divergent
- Fine tuning needed to reproduce the measured Higgs boson mass!**
- Within Supersymmetry (SUSY), additional loops with top squarks cancel top loop contribution to m_H
 - "Not-Fine-Tuned" models require **light top squark**
 - R-parity conserving SUSY requires **pair-produced top squark** whose decay chains end with the neutral stable lightest supersymmetric particle \rightarrow Significant **missing transverse energy** (MET)

Models Addressed

Top-squark pair-production:

- Small mass** ($\sim m_{top}$): large cross-section ($\sigma \sim 40 \text{ pb}$), but signal looks like $t\bar{t}$ ($\sigma = 234 \text{ pb}$)
- Large mass** ($> m_{top}$): different kinematics, but small cross-section ($\sigma \sim 10^{-2} \text{ pb}$ @ $m_{stop} = 650 \text{ GeV}$)

Two decay modes studied:



Analysis Strategy

Full 2012 $\sqrt{s} = 8$ TeV data sample: $\mathcal{L} = 19.5 \text{ fb}^{-1}$

Baseline selection:

- 1 high p_T isolated e/μ :** $p_T > 25$ (30) GeV for e/μ
- anti- k_T ($R = 0.5$) jets:** $p_T > 30$ GeV
nJets ≥ 4
at least one b-tagged jet
- MET > 100 GeV**
- Select events with $M_T > 120$ GeV** in several signal regions defined with a cut-based or MVA approach
- Estimate backgrounds from MC**
 - Derive corrections/uncertainties in control regions

Standard Model Backgrounds

1) $t\bar{t} \rightarrow l\bar{l} + jets$ (dominant)

- One lepton out of acceptance or not identified
- Large MET and $M_T > M_W$ due to 2 neutrinos + missed lepton
- Additional jets from ISR/FSR

2) Single lepton top

- $t\bar{t} \rightarrow l + jets$, single top \rightarrow Large M_T due to resolution effects and off-shell W

3) W + jets

4) Rare processes

- $t\bar{t}V$, tW , VV , VVV , $Z/\gamma^* + jets$

Background and Uncertainties Estimation

Control regions definitions:

SELECTION CRITERIA	exactly 1 l	> 1 l
0 b-tags	CR-0b: W+jets Validate W+jets M_T tail	---
≥ 1 b-tags	SIGNAL REGION	CR-2 l : $t\bar{t} \rightarrow 2l$ CR-2 l : $t\bar{t} \rightarrow 2l + \text{isolated trk}/\tau_{had}$ Validate physics modeling and detector effects

For each control region:

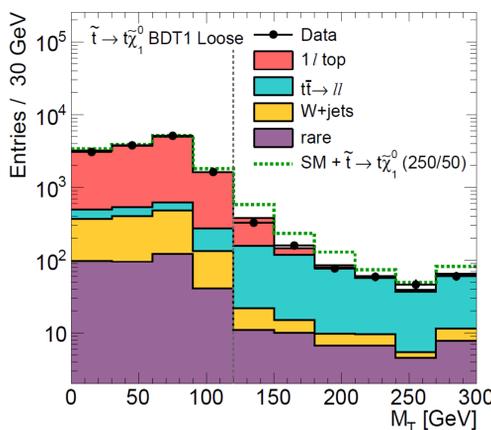
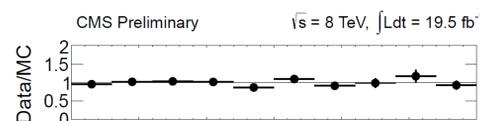
- 1) Normalize MC to data in M_T peak region \rightarrow reduce uncertainties from $\sigma(t\bar{t})$, luminosity, ...
- 2) Extrapolate to large M_T
- 3) Derive corrections and uncertainties on the "peak-to-tail" ratios

$$N_{pred} = N_{MC} \left(\frac{\text{data}}{\text{MC}} \right)_{\text{peak}} \left(\frac{\text{data}}{\text{MC}} \right)_R$$

\uparrow Predicted bkg in signal region \uparrow M_T peak normalization \uparrow Data/MC correction
"raw" MC prediction in signal region

Results

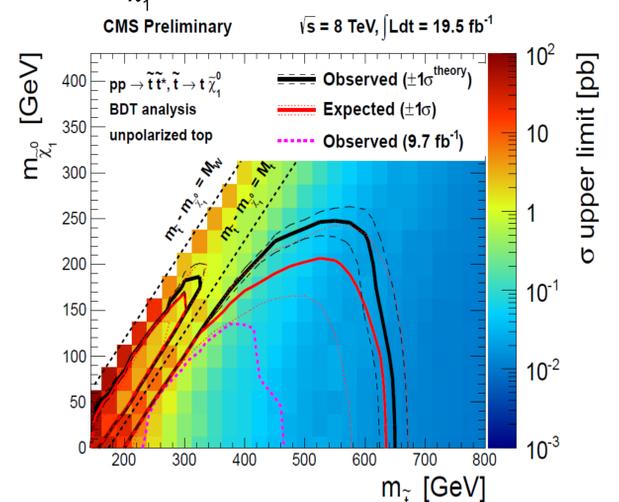
Data consistent with background prediction \rightarrow **no evidence for top-squark**



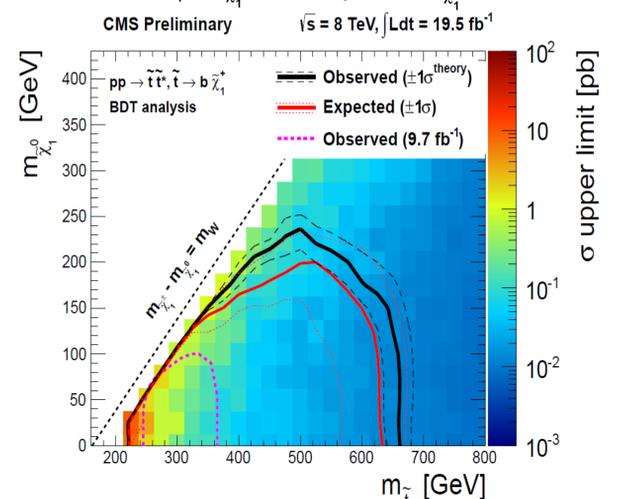
Sample	$\tilde{t} \rightarrow b\tilde{\chi}_1^+$ $x=0.5$			
	BDT1	BDT2 Loose	BDT2 Tight	BDT3
$t\bar{t} \rightarrow l\bar{l}$	40 \pm 5	21 \pm 4	4 \pm 2	6 \pm 2
1 l Top	24 \pm 10	15 \pm 7	4 \pm 3	4 \pm 2
W+jets	5 \pm 1	5 \pm 1	2 \pm 1	3 \pm 1
Rare	8 \pm 4	8 \pm 4	3 \pm 1	4 \pm 2
Total	77 \pm 12	50 \pm 9	13 \pm 4	17 \pm 4
Data	67	35	12	13
$\tilde{t} \rightarrow b\tilde{\chi}_1^+$ (250/50/0.5)	66 \pm 27	30 \pm 20	< 6.0	< 6.0
$\tilde{t} \rightarrow b\tilde{\chi}_1^+$ (650/50/0.5)	3.5 \pm 0.4	9.5 \pm 0.7	5.6 \pm 0.5	8.3 \pm 0.6

Interpretation

T2tt, $\tilde{t} \rightarrow t\tilde{\chi}_1^0$:



T2bW, $\tilde{t} \rightarrow b\tilde{\chi}_1^\pm$, $m_{\tilde{\chi}_1^\pm} = 0.5 m_{\tilde{t}} + 0.5 m_{\tilde{\chi}_1^0}$:



Conclusions

- A search for top squark pair production in a single lepton final state has been performed on the full 2012 data recorded by the CMS experiment
- Observed yields are consistent with predicted background \rightarrow **no evidence for top-squark**
- Limits have been set on SMS, testing **top squarks masses up to 650 GeV and neutralinos masses up to 250 GeV**, depending on the model

Reference



CMS Physics Analysis Summary:
CMS-PAS-SUS-13-011
<http://cds.cern.ch/record/1547550>

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