

# Searches for dark matter in association with a single top quark

Jennifer Thompson

Universität Heidelberg

05.04.2018

based on arXiv:1712.08065 Plehn, JT, Westhoff



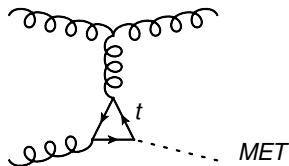
UNIVERSITÄT  
HEIDELBERG  
ZUKUNFT  
SEIT 1386

# Overview

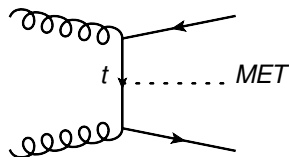
- 1 Motivation
- 2 Single Top +  $E_T^{\text{miss}}$  as a Signal
  - Features of Single Top +  $E_T^{\text{miss}}$
  - Simplified Model
- 3 Results
  - Background Control
  - BDT results
- 4 Conclusions

Current  $X + E_T^{\text{miss}}$  Searches

Consider Yukawa-like couplings:  
→ Dominant top quark couplings



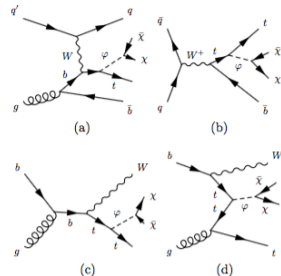
$j + \text{DM}$  e.g. Haisch and Re 1503.00691



$t\bar{t} + \text{DM}$  e.g. Haisch, Pani and Polesello  
1611.09841

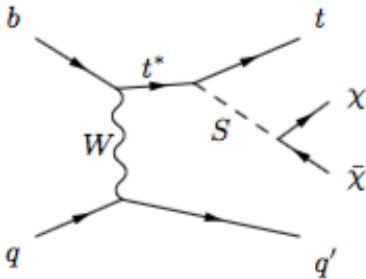
Recent Developemnts in  $X + E_T^{\text{miss}}$ 

- $t\bar{t}$ +DM searches can be sensitive to  $tj$ +DM: see Pinna et al. 1701.05195  
→ 30%-90% improvement in sensitivity
- $tW$  can be the leading channel for extended Higgs sectors/charged mediators: Pani and Polesello 1712.03874



# Can we use single top as the signal?

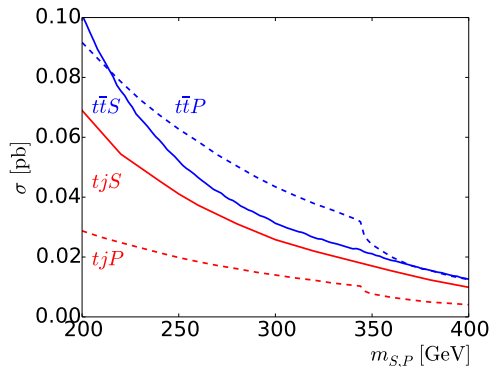
→ focus on leading  $t$ -channel



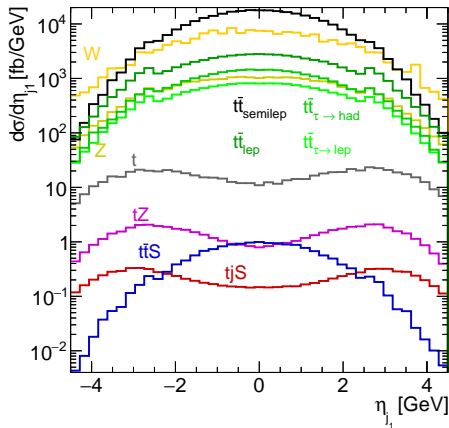
- Expect lower cross section than  $t\bar{t}E_T^{\text{met}}$   
→ Multivariate techniques
- Characteristic forward jet

# Signal total cross sections

- Larger scalar enhancement than pseudoscalar
- $\sigma_{tjS} \sim \sigma_{t\bar{t}S}$  for large masses
- $\sigma_{tjP}/\sigma_{t\bar{t}P} \sim \text{const}$



# Forward jet



- 300 GeV scalar reference
- $tjS$  larger than  $t\bar{t}S$  in forward region
- More  $t\bar{t}$  controls needed

# The Simplified Model

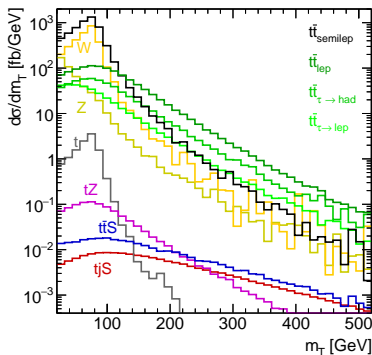
$$\mathcal{L}_S \supset g_S^X (\bar{\chi}\chi) S + g_S^t \frac{m_t}{v} (\bar{t}t) S$$

$$\mathcal{L}_P \supset ig_P^X (\bar{\chi}\gamma_5\chi) P + ig_P^t \frac{m_t}{v} (\bar{t}\gamma_5 t) P$$

- spin-0 mediators
- Yukawa-like coupling to top quarks
- fermionic Dirac DM particles

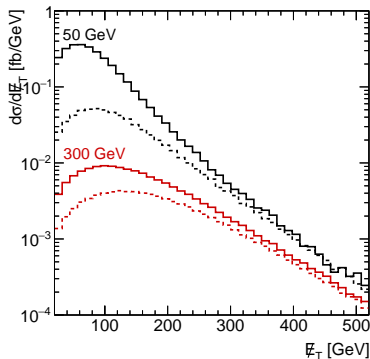
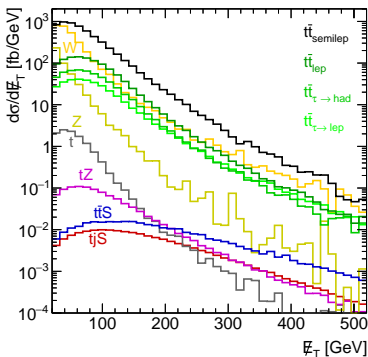


# signal kinematics



- $m_T$  for 300 GeV scalar
- Clear drop in backgrounds with a single, leptonic  $W^\pm$
- semi-leptonic  $t\bar{t}$  no longer dominant  
 → fully leptonic  
 →  $M_{T2}^W$

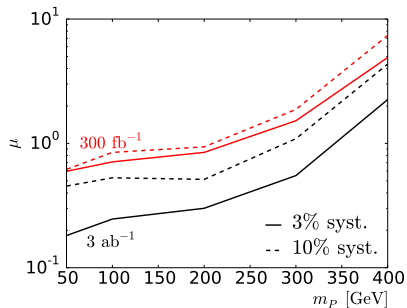
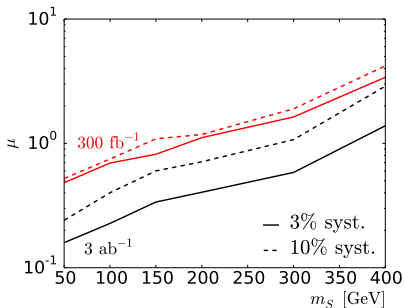
## signal kinematics



→  $tjS$  has a softer  $E_T^{\text{miss}}$  spectrum

→ pseudoscalar events harder than scalar

## CLs limits



- signal strength  $\mu$
- relative to all couplings=1

# Conclusions

- Single top+DM can be useful search channel at the LHC
- Characteristic forward jet and  $m_T$  useful for suppressing backgrounds
- $\sigma_{tj\text{DM}} \sim \sigma_{t\bar{t}+\text{DM}}$  for large mediator masses
- Similar sensitivity to  $t\bar{t}+\text{DM}$  searches

# Back-Up

# Event Selection

- 13 TeV LHC
- Leptonic top decays
- Sherpa  
→ LO merged samples
- Delphes for fast detector simulation
- BDT analysis

Observable	Cut
$N_b$	1
$N_{\text{lep}}$	1
$N_j$	$\geq 1$
$p_{Tj}$	20
$E_T^{\text{miss}}$	$> 100 \text{ GeV}$
$m_T$	$> 85 \text{ GeV}$

## BDT for scalar mediator

$$\{p_{T,l}, \eta_l, p_{T,b}, \eta_b, p_{T,j_1}, \eta_{j_1}, E_T^{\text{miss}}, \phi_{l,b}, \phi_{l,j_1}, \phi_{j_1,b}, \phi_{l,E_T^{\text{miss}}}, \phi_{j_1,E_T^{\text{miss}}}, \phi_{b,E_T^{\text{miss}}}, m_T, M_{T2}^W, m_{bj_1}, N_{\text{jets}}\}.$$

- TMVA BDT
- 600 trees

