Search for the direct production of charginos and neutralinos in final states with tau-leptons in $\sqrt{s}$=13TeV pp collisions with the ATLAS detector

Abstract

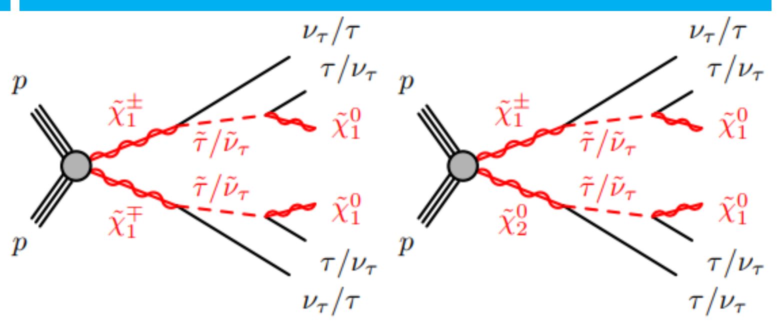
Two searches for the direct production of charginos and neutralinos with intermediate tau slepton or Wh decaying into final states with at least two hadronic τ are presented. This analysis uses a dataset of pp collisions with an integrated luminosity of 139 fb^{-1}.

Introduction

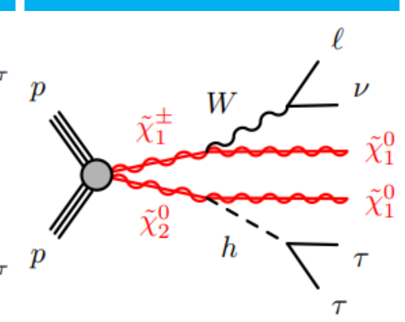
Motivation

- Light sleptons could play a role in the co-annihilation of neutralinos in the early universe.
- Models with light stau decaying to light neutralinos are consistent with dark matter searches.
- Independent studies of all three lepton flavours are necessary.

Intermediate Stau Channel



Wh Channel



Intermediate Stau Channel

Event Selection

C1N2: OS and SS regions

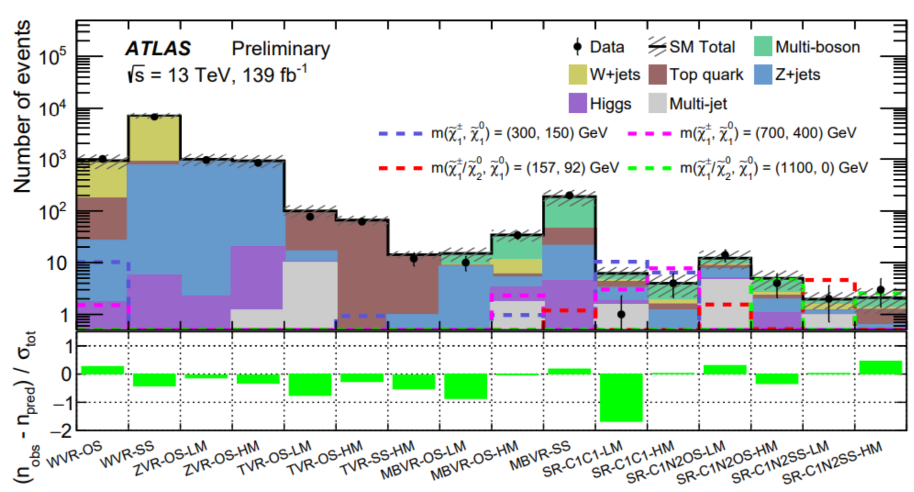
Separated LM and HM signal regions

SR-C1C1-LM	SR-C1N2OS-LM	SR-C1N2SS-LM
= 2 medium τ (OS)	$\geq$ 2 medium τ (OS)	$\geq$ 2 medium τ (SS)
$\geq$ 1 tight τ		-
asymmetric di-τ Trigger		
E_T^{miss} < 150 GeV		
b-jet veto		
Z/h veto ($m(\tau_1,\tau_2)$ > 120 GeV)		-
$\lvert\Delta\phi(\tau_1,\tau_2)\rvert$ > 1.6	-	$\lvert\Delta\phi(\tau_1,\tau_2)\rvert$ > 1.5
-	N_{jets} < 3	
E_T^{miss} > 60 GeV		m_{Tsum} > 200 GeV
m_{T2} > 80 GeV	m_{T2} > 70 GeV	m_{T2} > 80 GeV

SR-C1C1-HM	SR-C1N2OS-HM	SR-C1N2SS-HM
= 2 medium τ (OS)	$\geq$ 2 medium τ (OS)	$\geq$ 2 medium τ (SS)
di-τ + E_T^{miss} Trigger		
E_T^{miss} > 150 GeV		
b-jet veto		
Z/h veto ($m(\tau_1,\tau_2)$ > 120 GeV)		-
m_{Tsum} > 400 GeV		m_{Tsum} > 450 GeV
m_{T2} > 85 GeV		m_{T2} > 80 GeV

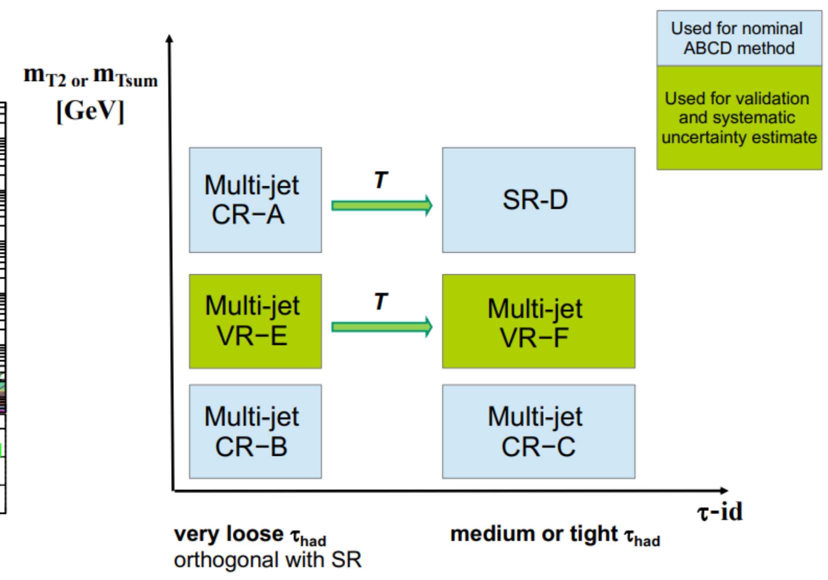
Background Estimation

- Reducible backgrounds (fake τ):
  - Multi-jet: data-driven ABCD method
  - W+jets, top(SS,HM): MC simulation shape normalized to data
- Irreducible backgrounds (real τ):
  - Z+jets, top, multi-boson
  - Estimation from MC simulation
- Dedicated VR for each process



ABCD Method

- Six orthogonal regions using two uncorrelated variables
- $N_D/N_A = N_C/N_B$
- VRs for transfer validation and systematic uncertainty from correlation



Wh Channel

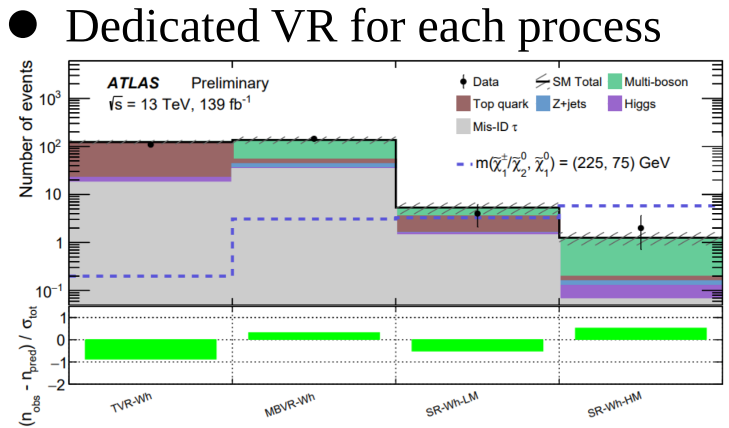
Event Selection

The two SRs are not orthogonal because of limited statistics.

SR-Wh-LM	SR-Wh-HM
= 1 light lepton	
$\geq$ 2 medium τ (OS)	
b-jet veto	
$\lvert\Delta\phi(\tau_1,\tau_2)\rvert$ < 3	
-	$\Delta R(\tau_1,\tau_2)$ < 2.2
90 < $m(\tau_1,\tau_2)$ < 130 GeV	80 < $m(\tau_1,\tau_2)$ < 160 GeV
m_{T2} > 100 GeV	m_{T2} > 80 GeV
-	$m_{\mathrm{T},\ell}$ > 80 GeV
-	m_{Tsum} > 450 GeV

Background Estimation

- Reducible backgrounds (fake τ):
  - 2 fake τ: W+jets, fake factor method
  - Top: normalized to data
- Irreducible backgrounds (real τ):
  - Multi-boson: MC simulation
- Dedicated VR for each process



Fake Factor Method

- Get the fake transfer factors in SS CR for the 2 leading taus; then apply to OS region
- Anti-τ (A): fail medium id
- Medium τ (M): pass medium id
- Three CRs: AA, MA, MM.

$$N_{fakes} = N_{AA,fakes} \times FF_{\tau 1}^{CR} \times FF_{\tau 2}^{CR}$$

Fakes in CR: $N_{fakes} = N_{data} - N_{MC}^{\geq 1\, truth\, \tau}$

$$FF_{\tau 1}^{CR} = \frac{N_{fakes,MA}}{N_{fakes,AA}},\ FF_{\tau 2}^{CR} = \frac{N_{fakes,MM}}{N_{fakes,MA}}$$

FFs for leading/sub-leading τ, for 1p/3p τ are obtained separately in bins of p_T, $\lvert\eta\rvert$.

Key Kinematics

The stransvese mass M_{T2} is defined as

$$\mathrm{M_{T2}} \equiv \min_{\vec{q}_T}[\max\{m_T(\vec{p}_{T\tau_1}, \vec{q}_T), m_T(\vec{p}_{T\tau_2}, \vec{p}_T^{miss} - \vec{q}_T)\}]$$

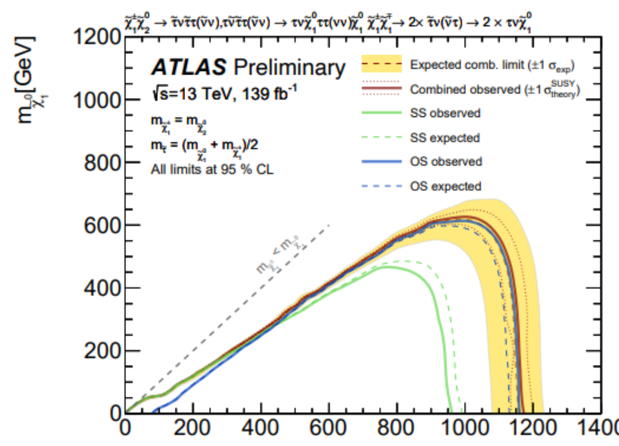
Where transverse mass m_T is

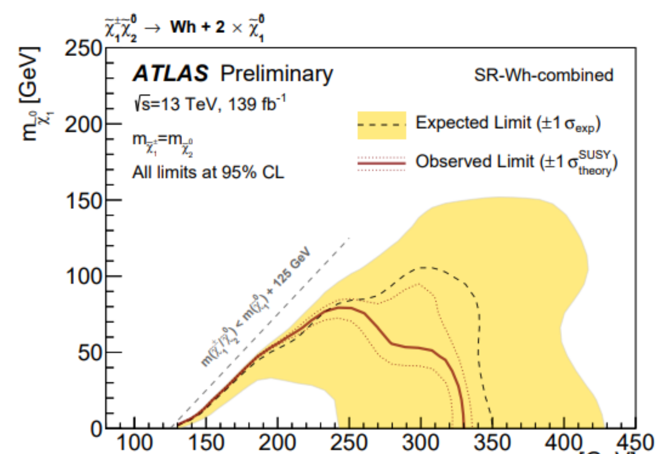
$$m_T(\vec{p}_T, \vec{q}_T) \equiv \sqrt{2(p_T q_T - \vec{p}_T \cdot \vec{q}_T)}$$

The M_{T2} distribution from 2 pair-produced particle has a upper bound at the mother particle mass, which is W mass for ttbar, WW backgrounds and $\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$ mass for our SUSY signal.

Model-dependent Limits

For stau channel, exclusion limits were improved by 340-400 GeV with massless LSP. For wh channel, it's the first exclusion limit from C1N2 Wh $1\ell 2\tau$ channel.





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