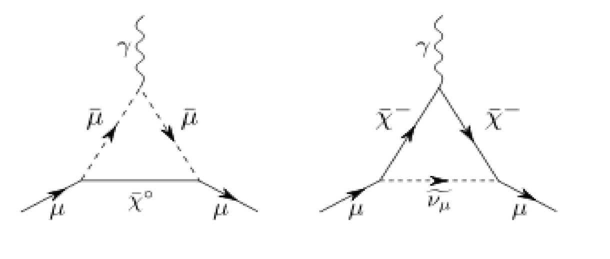
Search for supersymmetric partners of the tau lepton with CMS

Ilya Bobovnikov (DESY, Hamburg, Germany) on behalf of the CMS collaboration

Abstract

Searches for supersymmetry are presented that target the direct and indirect stau pair production. The analyses exploit the final states with two taus of opposite charge and significant missing transverse momentum. The results are based on a data set of proton-proton collisions, recorded by the CMS experiment at a center-of-mass energy of 13 TeV and corresponding to an integrated luminosity of 36 fb^{-1}. Exclusion limits on parameters of simplified SUSY models are calculated.

SUSY contribution to muon g – 2



Introduction to Supersymmetry (SUSY)

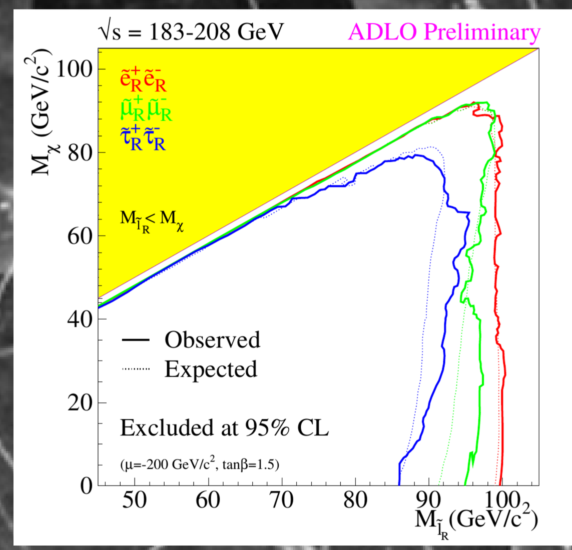
SUSY is an attractive extension of the standard model (SM) of particle physics:

- It potentially provides a solution for fine tuning and could explain the observed value of the Higgs boson mass.
- In case of R-parity conservation the lightest supersymmetric particle (LSP) is stable and could be a Dark Matter candidate.

There are several strong arguments in favor of the hypothesis of the light electroweak sector:

- LSP co-annihilation with light stau could bring the neutralino relic density to the observed value
- SUSY can explain ~3σ deviation of muon g – 2 from SM prediction → light electroweak sector

The most sensitive searches for direct stau pair production to date were performed at the CERN LEP collider.



Models and topologies

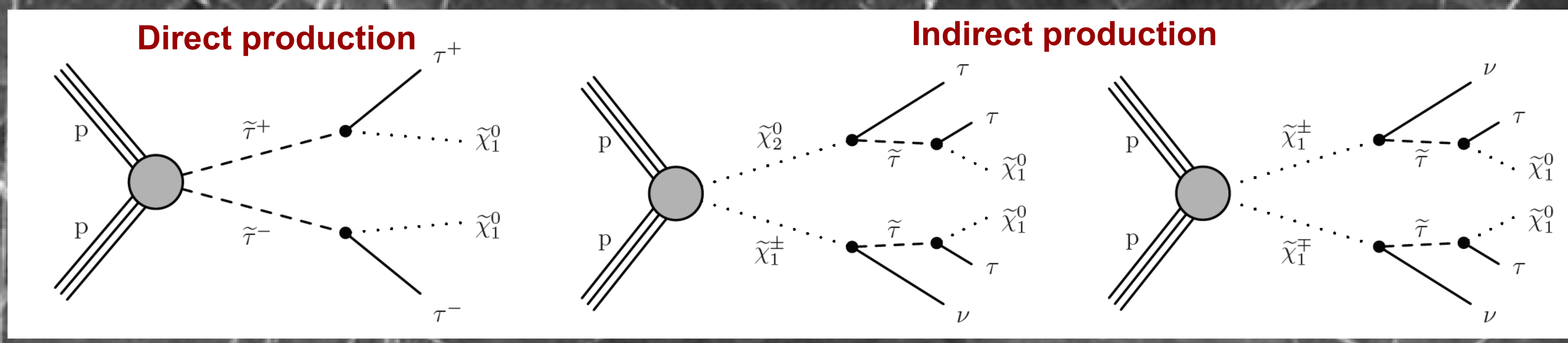
In our analysis we consider direct and indirect stau production. For direct stau production we use three different stau "chiral states":

- a purely left-handed stau
- a purely right-handed stau
- maximal mixing between the right- and left-handed eigenstates

For indirect stau production we consider simplified models of mass-degenerate chargino-neutralino and chargino pair production.

Since the tau leptons can decay hadronically or leptonically, we target different decay channels in order to increase the number of signal events:

- $\tau_h\tau_h$: both taus decay hadronically. CMS-PAS-SUS-17-003
- $\mu\tau_h$, $e\tau_h$, $e\mu$: one tau decays to a lighter lepton and neutrinos, while the other one decays hadronically or first (second) tau decays to electron (muon) and neutrinos. CMS-PAS-SUS-17-002

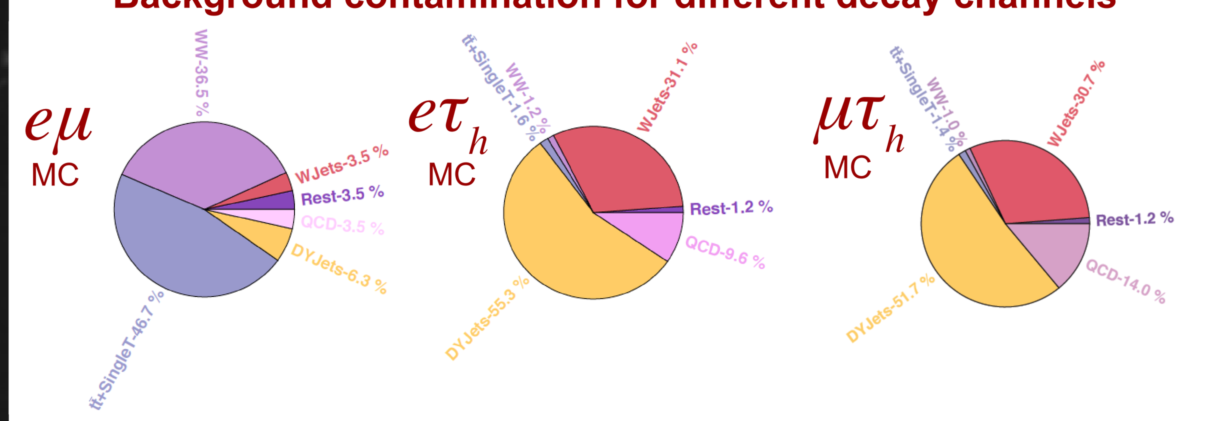


Search strategy: leptonic channel ($\mu\tau_h$, $e\tau_h$, $e\mu$)

Baseline selection:

- opposite charge pair of identified isolated leptons
- no additional leptons
- only 0 or 1 jet and no jets originating from bottom quarks.

Background contamination for different decay channels

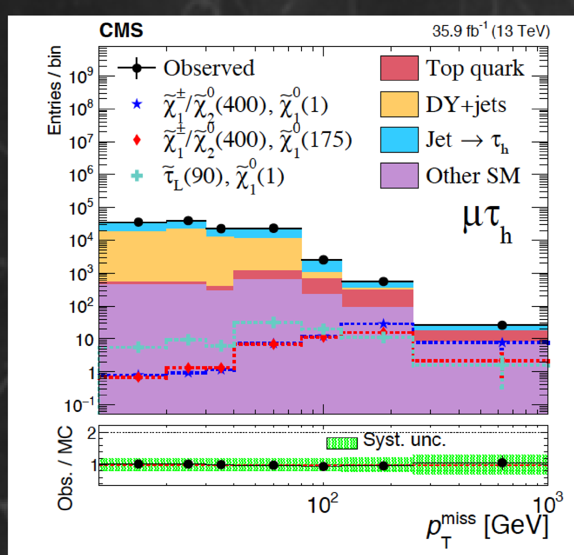


Background estimation

- Z+jets and top pair production: shape from MC is corrected by data in dimuon (mu-el) Control Region (CR) and scaled to normalization from data CR
- Jets misidentified as τ_h (only for $\mu\tau_h$ and $e\tau_h$) and QCD multijet (only for $e\mu$): shape is estimated from data CR and transfer factor is calculated as ratio of yields in orthogonal CRs
- Other rare backgrounds taken from simulation

The missing transverse momentum distribution is shown to illustrate agreement between data and background mode

132 search bins are defined with kinematic variables and jet multiplicity

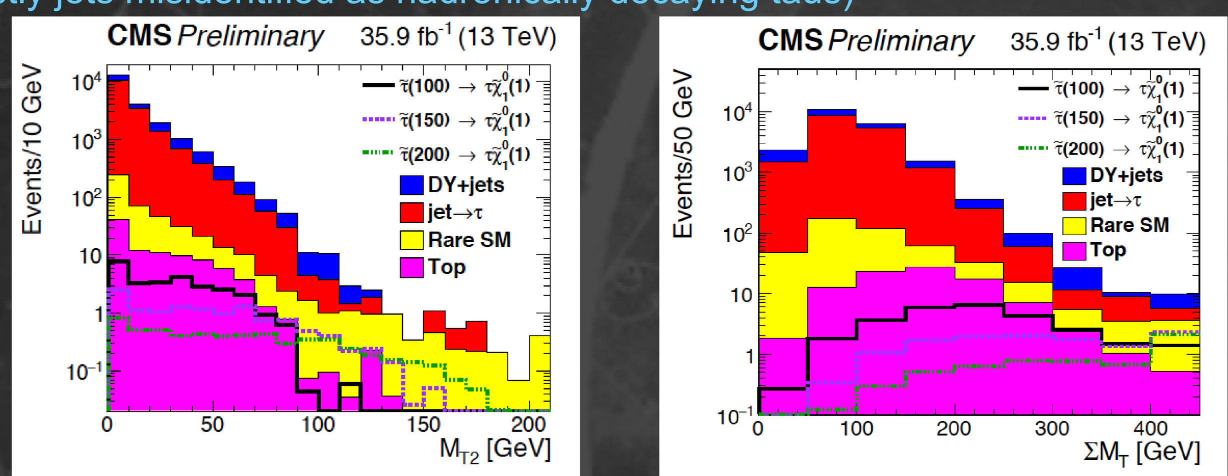


Search strategy: fully hadronic channel ($\tau_h\tau_h$)

Baseline selection:

- opposite charge pair of identified isolated hadronically decaying taus
- no additional leptons
- no jets originating from bottom quarks.

After selection our main backgrounds are Drell-Yan (DY; mostly genuine taus) and QCD (mostly jets misidentified as hadronically decaying taus)



Background estimation

- Z+jets: Check DY mass and pT spectrum in dimuon CR and correct the simulation for any discrepancies
- QCD, W+Jets: Background if jet fakes tau - fake rate derived in same sign data events and parameterized as function of pT and decay mode
- Other rare backgrounds taken from simulation

We define 3 signal regions:

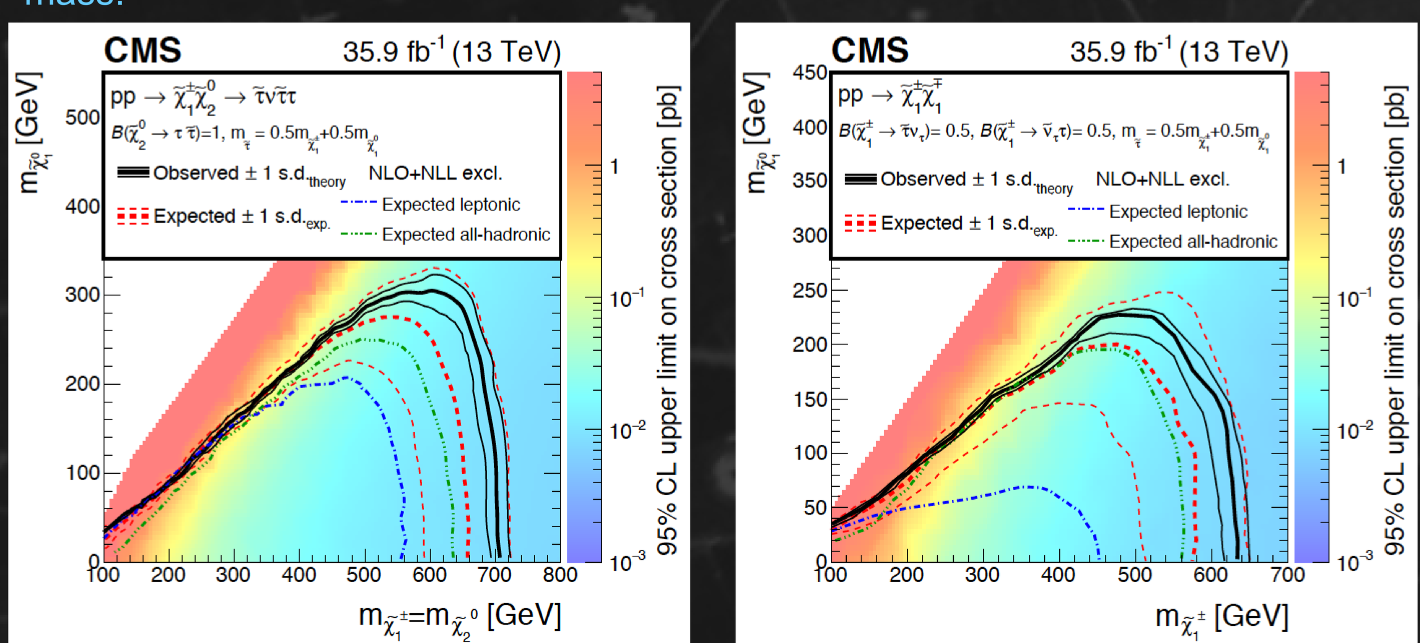
low mass	high mass	
$40\,\mathrm{GeV} < M_{T2} < 90\,\mathrm{GeV}$	$40\,\mathrm{GeV} < M_{T2} < 90\,\mathrm{GeV}$	$M_{T2} > 90\,\mathrm{GeV}$
$\Sigma M_T > 350\,\mathrm{GeV}$	$300\,\mathrm{GeV} < \Sigma M_T < 350\,\mathrm{GeV}$	$\lvert\Delta\phi(l_1,l_2)\rvert > 1.5$
$E_T^{miss} > 50\,\mathrm{GeV}$	$E_T^{miss} > 50\,\mathrm{GeV}$	
$\lvert\Delta\phi(l_1,l_2)\rvert > 1.5$	$\lvert\Delta\phi(l_1,l_2)\rvert > 1.5$	

Interpretation for indirect stau production

- For interpretation leptonic and fully hadronic channel are combined.

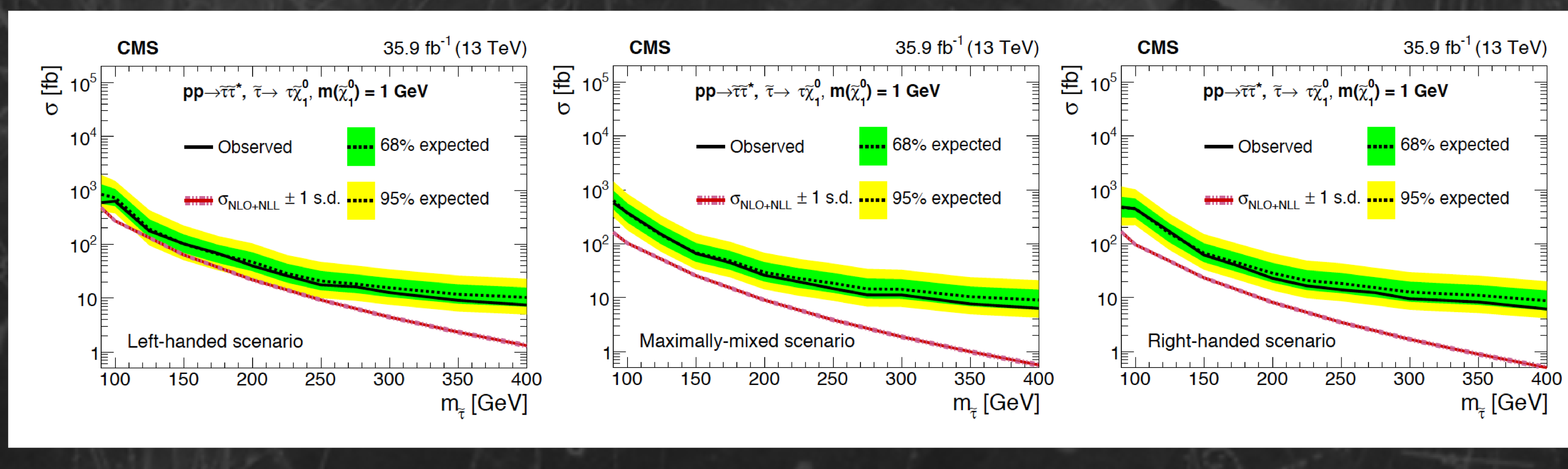
CMS-SUS-17-003

- Stau mass is an average value between the mass of the parent sparticles and LSP.
- For chargino pair production equal branching fractions are assumed for each of the two possible chargino decay chains.
- For chargino-neutralino production we set chargino mass to be equal to neutralino mass.



Interpretation for direct stau production

- Interpretation is done for three different helicity scenarios for direct stau production.



Summary

- No significant deviation in any signal region from SM
- Exclude heavy neutralino and chargino decaying through staus up to 725 GeV for chargino-neutralino production
- Exclude chargino decaying through staus up to 650 GeV for chargino pair production
- Direct stau production not yet excluded due to low cross section
- For left-handed stau of around 90 (125) GeV and the massless LSP we exclude 1.26 (1.34) times the expected SUSY cross-section

Bibliography

- LEP SUSYWorking Group (ALEPH, DELPHI, L3, OPAL), "Combined LEP Selectron/Smuon/Stau Results, 183-208 GeV", (2004). LEPSUSYWG/04-01.1.
- CMS-PAS-SUS-17-003, https://cds.cern.ch/record/2273395
- CMS-PAS-SUS-17-002, https://cds.cern.ch/record/2297162
- CMS-SUS-17-003 to be submitted shortly