Search for pair production of tau sleptons in $\sqrt{s} = 13$ TeV pp collisions in the all-hadronic final state

The CMS Collaboration

Abstract

A search for direct tau slepton pair production in pp collisions at a center-of-mass energy of 13 TeV is presented. The data correspond to an integrated luminosity of 35.9 fb$^{-1}$ collected with the CMS detector at the Run-2 of the CERN LHC in 2016. The search is performed using events with two hadronically decaying tau leptons and a large imbalance in the measured transverse momentum of the event. The results are interpreted as upper limits on the cross section for tau slepton pair production in different helicity scenarios.
1 Introduction

The standard model (SM) has been extremely successful at describing particle physics phenomena. Nevertheless, it suffers from shortcomings such as the hierarchy problem [1–6], the need for fine-tuned cancellations of large quantum corrections to keep the Higgs boson mass near the electroweak scale, and the lack of a dark matter candidate. Supersymmetry (SUSY), based on a symmetry between bosons and fermions, is an attractive extension of the SM. A key feature of SUSY is the existence of a superpartner for every SM particle with the same quantum numbers, except for spin, which differs by one half unit. Supersymmetry can potentially provide a solution to the hierarchy problem through the cancellation of quadratic divergences in particle and sparticle loop corrections to the Higgs boson mass. In R-parity conserving SUSY models [7, 8], supersymmetric particles are created in pairs, and the lightest supersymmetric particle (LSP) is stable [9, 10] and considered to be a candidate for dark matter [11].

In thermal cosmology scenarios with a bino LSP, the annihilation cross section of dark matter particles would be too small, leading to an overabundance of dark matter compared to the current constraints from cosmological measurements [12]. The existence of another, nearly mass-degenerate, SUSY particle that could co-annihilate with the dark matter particle would reduce the amount of dark matter to a level consistent with cosmological observations. In many SUSY scenarios the tau slepton (stau) is lighter than the selectron and smuon, resulting in tau-rich final states. Co-annihilation with a light stau that has a small mass splitting with a bino LSP leads to a dark matter relic density consistent with cosmological observations [13–16]. Therefore it is important to search for evidence of stau production at the LHC.

This analysis targets a simplified model with direct stau pair production (Fig. 1), where the staus will decay to a tau lepton and a neutralino that is considered to be the LSP. So far the most sensitive searches for this production mechanism have been performed at LEP [17]. Both the ATLAS and CMS collaborations performed searches for tau slepton pair production with 8 TeV LHC data [18–20]. This note focuses on the final state in which the tau leptons decay hadronically. The production cross section of direct stau pair production depends strongly on the stau helicity. The experimental acceptance also changes considerably for different stau helicities due to differences in the polarization of the tau leptons. For example, the hadronic decay products of the tau leptons have larger visible transverse momentum ($p_T$) in the case of purely right-handed staus.

![Figure 1: Simplified model for direct stau pair production followed by each stau decaying to a τ lepton and an LSP.](image-url)
2 Triggers, event reconstruction and simulated samples

The data used in this search correspond to 35.9 fb\(^{-1}\) of pp collisions at a centre-of-mass energy of 13 TeV, recorded in 2016 with the CMS detector. The data are selected with a trigger requiring the presence of two hadronically decaying tau leptons with a \(p_T\) of at least 35 GeV in a pseudorapidity range \(|\eta| < 2.1\).

Event reconstruction uses the particle-flow (PF) algorithm [21], combining information from the tracker, calorimeter, and muon systems to identify charged hadrons, neutral hadrons, photons, electrons, and muons in an event. The missing transverse momentum, \(\vec{p}_T^{\text{miss}}\), is computed as the negative vector sum of the transverse momenta (\(\vec{p}_T\)) of all PF candidates reconstructed in an event, and its magnitude \(E^{\text{miss}}_T\) is an important discriminator between signal and SM background. Events selected for the searches are required to pass filters designed to remove detector- and beam-related noise and must have at least one reconstructed vertex. Usually more than one such vertex is reconstructed, due to pileup, i.e. multiple pp collisions within the same or neighboring bunch crossings. The reconstructed vertex with the largest value of summed physics-object \(p_T^2\) is taken to be the primary pp interaction vertex. The physics objects are the objects returned by a jet finding algorithm [22, 23] applied to all charged tracks associated with the vertex, plus the corresponding associated missing transverse momentum.

Charged particles originating from the primary vertex, photons, and neutral hadrons are clustered into jets using the anti-\(k_T\) algorithm [22] implemented in FastJet [23] with a distance parameter of 0.4. The jet energy is corrected to account for the contribution of additional pileup interactions in an event and to compensate for variations in detector response [23, 24]. Jets considered in the searches are required to have their axes within the tracker volume, within the range \(|\eta| < 2.4\). We also require them to have a \(p_T\) larger than 30 GeV.

Jets originating from b quarks are identified with the combined secondary vertex (CSV) algorithm [25, 26] using the “loose” working point. The b tagging efficiency for jets originating from b quarks is about 80% for this working point, while the misidentification rates for jets from charm quarks, and from light quarks or gluons are about 45%, and 10%, respectively.

Hadronically decaying \(\tau\) lepton (\(\tau_h\)) candidates are reconstructed using the CMS hadron-plus-strips (HPS) algorithm [27]. The constituents of the reconstructed jets are used to identify individual \(\tau\) lepton decay modes with one charged hadron and up to two neutral pions, or three charged hadrons. Candidates are required to have \(p_T > 40\) GeV and \(|\eta| < 2.1\). The presence of extra particles within the jet, not compatible with the reconstructed decay mode, is used as a criterion to discriminate \(\tau_h\) decays from other jets. The di-tau trigger is not fully efficient for offline \(\tau_h\) candidates with \(p_T > 40\) GeV and this inefficiency is measured in data. The final trigger efficiency is around 60%. Since one of the major backgrounds for this analysis is the QCD multijet background, we apply a very strict requirement on the \(\tau_h\) isolation requirement in order to reduce this background contribution. A multivariate discriminator [28] that contains isolation as well as lifetime information, is used to prevent quark and gluon jets from being identified as \(\tau_h\) candidates. The working point used in this analysis typically has an efficiency of around 55% for genuine \(\tau_h\) with a misidentification rate of approximately 0.1% for quark and gluon jets. Electrons and muons misidentified as \(\tau_h\) are suppressed using dedicated criteria based on the consistency between the measurements in the tracker, the calorimeters, and the muon detectors. Since this is a minor background, we do not apply stringent requirements on these discriminants.

We also veto events with additional electrons (\(|\eta| < 2.5\)) and muons (\(|\eta| < 2.4\)) with \(p_T > 20\) GeV. Electron candidates are reconstructed by first matching clusters of energy deposited
in the ECAL to reconstructed tracks. Selection criteria based on the distribution of the shower shape, track–cluster matching, and consistency between the cluster energy and track momentum are then used in the identification of electron candidates [29]. Muon candidates are reconstructed by requiring consistent hit patterns in the tracker and muon systems [30]. Electron and muon candidates are required to be consistent with originating from the primary vertex by imposing restrictions on the size of their impact parameters in the transverse plane and longitudinal direction with respect to the beam axis. To make sure the electron or muon candidate is isolated from any jet activity, the sum of the transverse momenta of all the particles in a cone around the candidate is required to be below a certain threshold.

The MadGraph5_aMC@NLO [31] event generator is used at leading order (LO) precision to produce simulated samples of the W+jets and Z+jets processes, using the NNPDF3.0LO [32] set of parton distribution functions (PDFs). Top quark pair production, di- and triboson production, and rare SM processes, are generated at the next-to-leading order precision with MadGraph5_aMC@NLO [31] and POWHEGv2.0 [33–36], using the NNPDF3.0NLO [32] set of PDFs. Showering and hadronization is carried out by the Pythia 8.2 package [37], while a detailed simulation of the CMS detector is based on the Geant4 [38] package. The signal models are simulated by MadGraph5_aMC@NLO at LO precision up to the production of tau leptons, which are then decayed with Pythia 8.2. The CMS fast simulation package [39] is used to simulate all signal samples, and is verified to provide results that are consistent with those obtained from the full Geant4-based simulation. Event reconstruction is performed in the same manner as for collision data. A nominal distribution of pileup interactions is used when producing the simulated samples. The samples are then reweighted to match the pileup profile observed in the collected data. The signal production cross sections are calculated at NLO with next-to-leading logarithm (NLL) soft-gluon resummation calculations [40]. The most precise cross section calculations are used to normalize the SM simulated samples, corresponding most often to next-to-next-to-leading order (NNNLO) accuracy.

3 Event selection

This analysis targets the final state in which both tau leptons decay hadronically. Both \( \tau_h \) candidates are required to pass the identification and isolation requirements described in Sec. 2. There is also a veto on additional electrons or muons in the event in order to be orthogonal to the \( e/\mu-\tau_h \) final state. To reduce possible top-related backgrounds, events with a b-tagged jet are rejected. The angle between the two \( \tau_h \) candidates \( \Delta \phi(l_1, l_2) \) provides an additional tool to reduce the SM background. To reduce the SM background processes further, we take advantage of the presence of two LSPs in the final state for signal processes. LSPs lead to additional \( E_T^{\text{miss}} \) in the event and the correlation between the \( E_T^{\text{miss}} \) and the \( \tau_h \) candidates can be exploited. The mass variables that can be calculated with the \( \tau_h \) candidates and the \( E_T^{\text{miss}} \) produce strong discriminants.

For a mother particle decaying to a visible and an invisible particle, the transverse mass \( M_T \) calculated using only the transverse components of the energy and momentum of the decay products should have a kinematic endpoint at the mass of the mother particle. Assuming that the \( E_T^{\text{miss}} \) corresponds to the \( p_T \) of the invisible particle, we calculate the transverse mass observable for the visible particle \( q \) and the invisible particle as follows:

\[
M_T(q, \vec{p}_T^{\text{miss}}) \equiv \sqrt{2E_T q E_T^{\text{miss}}(1 - \cos \Delta \phi)},
\]

In this analysis the variable \( \Sigma M_T \) is used, the sum of the transverse mass variables \( M_T(\tau_1, \vec{p}_T^{\text{miss}}) \) and \( M_T(\tau_2, \vec{p}_T^{\text{miss}}) \). In Fig. 2 (left) the \( \Sigma M_T \) distribution is shown for background and for differ-
ent signal mass hypotheses after the baseline selection of requiring two $\tau_h$ candidates. Requiring large $\Sigma M_T$ significantly reduces the SM background.

For every event we also calculate the transverse mass $M_{T2}$ [41, 42]. This kinematic mass variable is a generalization of the transverse mass variable $M_T$ for situations with multiple invisible particles. It tries to estimate the mass of pair-produced particles in situations when both particles decay to a final state containing the same invisible particle. In this case both staus decay to a hadronically decaying tau lepton and an LSP, so $M_{T2}$ would help to get a handle on the stau mass. The variable is again calculated with the transverse components of the energy and momentum of the different particles:

$$M_{T2} = \min \frac{p_{X1}^{T} + p_{X2}^{T}}{p_{miss}^{T}} \left[ \max \left( M_T^{(1)}, M_T^{(2)} \right) \right],$$

(2)

where $p_{X(i)}^{T}$ (with $i=1,2$) are the unknown transverse momenta of the two undetected particles and $M_T^{(i)}$ the transverse masses obtained by pairing any of the two invisible particles with one of the two tau leptons. The minimization is done over the possible momenta of the invisible particles, which should add up to the $E_{T}^{miss}$ in the event. The $M_{T2}$ distribution is shown in Fig. 2 (right) after the baseline selection. This variable gives a powerful handle to reduce the SM backgrounds for heavy staus.

The selection optimization was done separately for heavy and light stau masses since the kinematic variables change significantly between the two regimes. Figure 2 shows that for low stau masses $\Sigma M_T$ is a better discriminant than $M_{T2}$. Three exclusive search regions (SRs) are used in the analysis:

- **Search region 1:**
  - $M_{T2} > 90$ GeV
  - $|\Delta \phi(l_1, l_2)| > 1.5$

- **Search region 2:**
  - $40$ GeV $< M_{T2} < 90$ GeV
  - $\Sigma M_T > 350$ GeV
  - $E_{T}^{miss} > 50$ GeV
  - $|\Delta \phi(l_1, l_2)| > 1.5$

- **Search region 3:**
  - $40$ GeV $< M_{T2} < 90$ GeV
  - $300$ GeV $< \Sigma M_T < 350$ GeV
  - $E_{T}^{miss} > 50$ GeV
  - $|\Delta \phi(l_1, l_2)| > 1.5$

While search region 1 improves the sensitivity towards signal models with larger stau masses, search regions 2 and 3 mainly help to target models with smaller stau masses.

## 4 Background estimation

After requiring two high-\$p_T\$ $\tau_h$ candidates, the dominant background consists of QCD multijet and W+jets processes, where one or more of the $\tau_h$ candidates originate from a parton and is misidentified as a prompt $\tau_h$. This background is predicted using a data-driven method relying on a control region with a loose isolation requirement. We estimate how often loosely isolated
Figure 2: The $\Sigma M_T$ (left) and $M_{T2}$ (right) distributions after the baseline selection. The signatures of stau pair production with different stau masses are shown. A requirement of large $M_{T2}$, while efficient at reducing the SM background, greatly reduces the signal acceptance for low stau masses. We therefore define additional search regions with moderate $M_{T2}$ and use $\Sigma M_T$ as a discriminating variable to target smaller stau masses. Three signal hypotheses in the maximally-mixed scenario are overlaid, with the first number indicating the stau mass and the second the LSP mass.

non-prompt or misidentified $\tau_h$ candidates pass the very tight isolation requirement applied in the signal region by looking at a multijet-enriched control region where we require both $\tau_h$ candidates to have the same charge. This same-sign di-$\tau_h$ event sample is collected with the same trigger as the search sample; this is needed since the isolation requirement at the trigger level is not identical to the offline isolation requirement. We also require the $M_{T2}$ to be small to lower the possible contributions of signal and W+jets even further.

The final rate for misidentified and non-prompt leptons to pass the very tight isolation cut is around 25%, but it depends considerably on the $p_T$ and the decay mode (1 or 3-prong) of the $\tau_h$ candidate, and the jet flavor. The extrapolation is measured in bins of $\tau_h$ $p_T$ and decay modes to lower the dependence on these factors. For the dependence on the jet flavor a systematic uncertainty (of around 30%) is derived based on studies performed in simulation. We also noticed that the extrapolation depends on whether the other $\tau_h$ is isolated or not and we derive a correction and a corresponding uncertainty for this effect.

Since the isolation efficiency for prompt $\tau_h$ is only around 65%, we need to take this into account when calculating the final estimate for the background processes with non-prompt and misidentified $\tau_h$. To take this correctly into account we split the events with at least two loosely isolated $\tau_h$ candidates into three categories: events with both $\tau_h$ passing the very tight isolation, events with one passing and one failing the very tight isolation, and finally events with both $\tau_h$ failing the very tight isolation requirements. A closure test is performed in events with two oppositely-charged $\tau_h$ where the $M_{T2}$ or $\Sigma M_T$ requirements are explicitly inverted to avoid any overlap with the signal regions. Figure 3 (left) shows that the background method is able to predict the background from non-prompt and misidentified $\tau_h$ candidates within the systematic uncertainties.

The second main background is the Drell-Yan process, which is estimated from data-corrected simulation. If the Z boson mass shape or the Z boson $p_T$ spectrum are poorly modeled in the simulation, then the $E_T^{miss}$ and $M_{T2}$ distributions can be significantly different in data than in simulation, especially at the high-end tail. Therefore we measure these two spectra in $Z \rightarrow \mu\mu$
data and then apply the observed differences as corrections to the simulation. The full size of this correction is propagated through as a systematic uncertainty. The known differences in $\tau_h$ identification and isolation efficiencies, jet and $\tau_h$ energy scales, and b-tagging efficiency are used to further correct the simulation. The uncertainties corresponding to these corrections are also evaluated. These corrections are validated in a $Z \rightarrow \tau\tau$ control region at low $M_{T2}$ or $\Sigma M_T$. Additionally requiring a $p_T$ of at least 50 GeV for the di-$\tau_h$ system reduces the QCD multijet background. Figure 3 (right) shows that the corrected simulation agrees with the data within the experimental uncertainties in this control region.

Finally we have smaller contributions from other SM backgrounds, like Higgs boson and diboson production and top pair production (with or without additional vector bosons). These are estimated purely from simulation, using the known efficiency and energy scale corrections and evaluating both experimental and theoretical uncertainties as described in Sec. 5.

![Figure 3: (Left) Closure test for the fake rate method in a data control region where the $M_{T2}$ or $\Sigma M_T$ requirements are inverted. The predicted and observed yields show good agreement. (Right) The visible mass spectrum is used to validate our modeling of Drell-Yan backgrounds. A minimum di-$\tau_h$ $p_T$ of 50 GeV is required to reduce the QCD multijet background. Data and simulation agree within the experimental uncertainties.](image)

## 5 Systematic uncertainties

For most of the background estimates the dominant uncertainties are statistical in nature. For the data-driven methods these uncertainties are driven by the event yield in the data control region, while for the other background estimates they are due to the limited number of simulated events. In some regions the uncertainty in the predicted rate for non-prompt and misidentified $\tau_h$ is even larger than 100%. If the predicted yield for a certain background source is 0, then we derive an upper limit on this prediction and include the upper limit in the statistical interpretation.

To estimate the uncertainty in the prediction of non-prompt and misidentified $\tau_h$, we need to take into account the uncertainty due to the extrapolation in isolation for the non-prompt and misidentified $\tau_h$. This is driven by the uncertainty introduced by the dependence of the isolation on the jet flavor. It also includes the statistical uncertainty in the control regions where this extrapolation is measured. The uncertainty in the identification and isolation efficiency for prompt $\tau_h$ is also propagated through to the final estimate. Finally an additional uncertainty is assessed for the fact that the extrapolations for both $\tau_h$ candidates are correlated. Together this
leads to an extra uncertainty of 30-37% depending on the search region.

For the other background estimates and the signal models we rely mostly on simulation. We propagate uncertainties related to b-tagging, trigger and selection efficiencies, renormalization and factorization scale uncertainties, PDF uncertainties and uncertainties in the jet energy scale, jet energy resolution, and unclustered energy contributing to $E_{\text{miss}}^T$. For every background source a 20% normalization uncertainty is added for the production cross sections. For the Drell-Yan background we have an additional uncertainty related to the corrections applied to the mass shape and $p_T$ distribution. For the signal we add uncertainties due to the differences between the fast simulation used for the signal simulation and the full simulation used for the background estimates for the $E_{\text{miss}}^T$ resolution and lepton efficiencies. We also checked the effects of possible mismodeling of the initial-state-radiation for the signal and found it to be negligible.

The main systematic uncertainties for the signal models and background estimates are summarized in Table 1.

Table 1: The largest systematic uncertainties in the analysis for the signal models and the different SM background predictions. For the signal models the uncertainties are re-evaluated for the different mass hypotheses.

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Signal</th>
<th>Non-prompt/misID</th>
<th>Drell-Yan</th>
<th>Top</th>
<th>Rare SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tau Efficiency</td>
<td>11%</td>
<td>5%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Iso extrap. non-prompt $\tau_h$</td>
<td>–</td>
<td>28–35</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Correlations non-prompt $\tau_h$</td>
<td>–</td>
<td>8–13%</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Tau energy scale</td>
<td>2–12%</td>
<td>–</td>
<td>22–34%</td>
<td>9–18%</td>
<td>7–18%</td>
</tr>
<tr>
<td>Jet energy scale</td>
<td>1–5%</td>
<td>–</td>
<td>12–20%</td>
<td>1–5%</td>
<td>4–10%</td>
</tr>
<tr>
<td>Jet energy resolution</td>
<td>1–4%</td>
<td>–</td>
<td>29–61%</td>
<td>3–10%</td>
<td>11–31%</td>
</tr>
<tr>
<td>Unclustered energy</td>
<td>0–3%</td>
<td>–</td>
<td>12–17%</td>
<td>4–5%</td>
<td>3–10%</td>
</tr>
<tr>
<td>B-tagging</td>
<td>0.5–1%</td>
<td>–</td>
<td>2–3%</td>
<td>11–20%</td>
<td>1–2%</td>
</tr>
<tr>
<td>Drell-Yan mass &amp; $p_T$</td>
<td>–</td>
<td>–</td>
<td>18–21%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Background cross sections</td>
<td>–</td>
<td>–</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Fast versus full simulation</td>
<td>1–30%</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### 6 Results

The results of the analysis are summarized in Table 2. The background estimates for the different SM processes are shown with the full uncertainty, the quadratic sum of the statistical and systematic uncertainties. As discussed in Sec. 5 these are dominated by the statistical uncertainties in the data control regions and the number of simulated events produced. If there is no event in the control region or no event in the simulated sample, then the 68% statistical upper limit is presented and added to the likelihood using a Poissonian distribution. No significant excess is observed in any of the signal regions. The expected yields for staus with a mass of 150 GeV decaying to an LSP of mass 1 GeV are shown for three different helicity scenarios.

### 7 Interpretation

The results are now interpreted as limits on the production of stau pairs in the context of simplified models [43–46]. The produced stau is assumed to always decay to a tau lepton and an LSP.
Table 2: Final predicted and observed event yields in all SRs with all statistical and systematic uncertainties combined. For the background estimates with no events in the sideband or the simulated sample, the 68% statistical upper limit is presented. For the total background estimate the central value and the uncertainties are extracted from the full pre-fit likelihood.

<table>
<thead>
<tr>
<th></th>
<th>SR1</th>
<th>SR2</th>
<th>SR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-prompt and misidentified taus</td>
<td>0.68 ± 0.90</td>
<td>2.49 ± 1.83</td>
<td>&lt;1.24</td>
</tr>
<tr>
<td>Drell-Yan background</td>
<td>0.80 ± 0.80</td>
<td>&lt; 0.71</td>
<td>&lt; 0.71</td>
</tr>
<tr>
<td>Top-quark related background</td>
<td>0.02 ± 0.03</td>
<td>0.73 ± 0.31</td>
<td>1.76 ± 0.68</td>
</tr>
<tr>
<td>Rare SM processes</td>
<td>0.72 ± 0.38</td>
<td>0.20 ± 0.15</td>
<td>0.20 ± 0.25</td>
</tr>
<tr>
<td>Total background</td>
<td><strong>2.22</strong> ± 1.37</td>
<td><strong>4.35</strong> ± 1.75</td>
<td><strong>3.70</strong> ± 1.53</td>
</tr>
<tr>
<td>Left (150,1)</td>
<td>1.25 ± 0.40</td>
<td>2.91 ± 0.59</td>
<td>1.53 ± 0.33</td>
</tr>
<tr>
<td>Right (150,1)</td>
<td>1.09 ± 0.26</td>
<td>1.27 ± 0.20</td>
<td>0.74 ± 0.17</td>
</tr>
<tr>
<td>Mixed (150,1)</td>
<td>1.04 ± 0.22</td>
<td>1.39 ± 0.27</td>
<td>0.92 ± 0.15</td>
</tr>
<tr>
<td>Observed</td>
<td>0</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

The 95% confidence level (CL) upper limits on SUSY production cross sections are calculated using a modified frequentist approach with the CL$_S$ criterion [47, 48] and asymptotic results for the test statistic [49, 50]. Since the cross-section of stau pair production and the tau decay are strongly dependent on the stau helicity, the results are shown for three different helicity scenarios. Figure 4 shows the cross-section upper limit for stau pair production for the left-handed (left), maximally-mixed (middle) and right-handed (right) helicity scenarios as a function of the stau mass. The different rows show the results for different LSP mass hypotheses. The top row shows results assuming an almost massless LSP (1 GeV), the middle row assuming an LSP mass of 20 GeV, and the bottom row assuming an LSP mass of 50 GeV. It can be seen that the constraints get reduced for higher LSP masses due to the smaller experimental acceptance. This analysis is most sensitive to a scenario with left-handed stau of around 125 GeV and a massless LSP, where we exclude 1.5 times the expected SUSY cross-section.

8 Summary

A search for tau sleptons in the all-hadronic final state was performed in pp collisions at a center-of-mass energy of 13 TeV using three complementary search regions. The data sample corresponds to an integrated luminosity of 35.9 fb$^{-1}$. No excess was observed in any of the search regions. Upper limits on the cross section of direct tau slepton (stau) pair production are derived, for each stau decaying to a tau lepton and an LSP. The analysis is most sensitive to left-handed staus. For a left-handed stau of 125 GeV decaying to a massless LSP the observed limit is 1.5 times the expected production cross section in the simplified model.

References


Figure 4: The excluded stau pair production cross section as a function of the stau mass for the three different helicities: left-handed (left), maximally-mixed (middle), right-handed (right). The plots in the top row assume a fixed LSP mass of 1 GeV, the ones in the middle row 20 GeV, and the ones in the bottom row 50 GeV. The inner (green) band and the outer (yellow) band indicate the regions containing 68 and 95%, respectively, of the distribution of limits expected under the background-only hypothesis.


