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Probing the Stau-Neutralino Coannihilation Region at the LHC with a soft tau lepton and an ISR jet

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We present a feasibility study, to search for dark matter at the LHC, in events with one soft hadronically decaying tau lepton and missing transverse energy recoiling against a hard p_T jet from initial state radiation. This methodology allows the search for Supersymmetry in compressed mass spectra regions, where the mass difference between the lightest neutralino, $\tilde{\chi}_1^0$, and the stau (the tau superpartner), $\tilde{\tau}$, is small. Several theoretical models predict a direct connection between thermal Bino dark matter and staus within this scenario. We show that compressed regions, not excluded by ATLAS nor CMS experiments, are opened up with the increase in experimental sensitivity reached with the proposed methodology. The requirement of a hard jet from initial state radiation combined with a soft tau lepton is effective in reducing Standard Model backgrounds, providing expected significances greater than 3σ for $\tilde{\chi}_1^{\pm}$ masses up to 300 GeV and $\tilde{\tau}$-$\tilde{\chi}_1^0$ mass gaps below 25 GeV with only 30 fb^{-1} of 13 TeV data from the LHC.

I. INTRODUCTION

The identity of Dark Matter (DM) is one of the most interesting and relevant topics in particle physics today. Currently, there are several direct and indirect searches for DM performed by different experiments, such as superCDMS [1], LZ [2], AMS2 [3], ATLAS [4] and CMS [5], among others. These experiments are trying to find evidence of the existence of DM particles motivated by hypothetical models, in some cases, or by indirect cosmological observations. Nevertheless, there is no conclusive evidence thus far that could shed some light on the particle nature of DM.

At the CERN LHC accelerator, the ATLAS and CMS experiments have an extensive physics program to search for DM, especially in new physics models of Supersymmetry (SUSY)[6–10], which resolves many problems inherent in the Standard Model (SM) and naturally provides a DM candidate in the form of the lightest neutralino ($\tilde{\chi}_1^0$). A broad set of final states have been used to probe the $\tilde{\chi}_1^0$ using cascade decays of heavier colored and electroweak SUSY particles [11–15]. The production of these DM candidates has been excluded, by both experiments, for $\tilde{\chi}_1^0$ masses that range from 100 GeV to roughly 800 GeV, depending on the final state studied and on the physics model used to interpret the data. Nevertheless, compressed mass spectra regions, where the mass difference Δm between the heavier SUSY particles and the $\tilde{\chi}_1^0$ is small, are very difficult to probe at the LHC, due to constrains driven by the ability to trigger, with low enough rate, on events containing low p_T objects in addition to experimental difficulties involved with identifying them with high enough efficiency amongst the large hadronic activity associated with a proton-proton collider. For example, searches for chargino ($\tilde{\chi}_i^{\pm}$) and neutralino ($\tilde{\chi}_j^0$) production in final states with one or more leptons and missing transverse momentum exhibit limited sensitivity to models with SUSY particles that decay predominantly to τ leptons, with exclusion limits of $\approx$ 100 GeV for $\Delta m < 50$ GeV, due to the larger backgrounds associated with τ lepton reconstruction.

The main focus of this letter is to propose a new search at the LHC to target compressed mass spectra regions in the electroweak sector, in models which predominantly produce τ leptons, where the current experimental sensitivity is limited. The study of compressed $\tilde{\tau}$'s is of special interest in thermal Bino DM cosmology models considering $\tilde{\tau} - \tilde{\chi}_1^0$ co-annihilation, as it is proposed in several papers [16, 17], in order to obtain the correct relic DM density observed today.

The use of Vector Boson Fusion (VBF) topologies to target difficult compressed mass spectra scenarios for the production of SUSY with $\tilde{\tau}$'s, has been proposed as a new experimental handle at the LHC [18]. This search has been recently published by CMS [19], showing better sensitivity in very compressed regions with respect to previous searches by ATLAS and CMS [20, 21]. Although VBF is a good tool to probe compressed spectra and DM [22], with better signal-to-background ratios due to its rejection power for QCD processes, the small VBF signal cross-sections motivate us to find a complementary method with higher production rate, which translates in less luminosity needed for a potential discovery in the short term. We propose a complementary handle to target compressed staus, searching for the production of one hadronic τ lepton (τ_h) and at least one high p_T jet from initial state radiation (ISR).

The SUSY $\tilde{\tau}$'s can be produced directly in pairs or through cascade decays of the lightest chargino, $\tilde{\chi}_1^{\pm}$, and the next-to-lightest neutralino, $\tilde{\chi}_2^0$, in processes such as $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp} \rightarrow \tilde{\tau}\tilde{\tau}\nu_\tau\nu_\tau$, $\tilde{\chi}_2^0\tilde{\chi}_2^0 \rightarrow \tilde{\tau}\tilde{\tau}\tau\tau$, $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow \tilde{\tau}\nu_\tau\tilde{\tau}\tau$ and $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^0 \rightarrow \tilde{\tau}\nu_\tau\tilde{\chi}_1^0$. Hadronic decays of τ leptons have the largest branching fraction and thus final states with a τ_h provide the best experimental sensitivity.

While the above processes result in final states with multiple τ leptons, the compressed mass spectra scenario of interest in this paper results in low p_T visible decay products, making it difficult to reconstruct and identify multiple τ leptons. Furthermore, semi-leptonic decays of τ leptons result in lower average p_T than hadronic decays, while also being largely indistinguishable from prompt production of electrons and muons.

Therefore, the above characteristics motivate us to focus on events with one τ_h candidate. Similar to the monojet searches, the use of a high p_T ISR jet in the event topology is expected to create a recoil effect that facilitates both, the detection of missing transverse momentum in the event (p_T^{miss}), and the identification of the soft τ_h due to the natural kinematic boost. Additionally, the inclusion of a high p_T jet in the event topology provides an experimental handle to trigger on these type of events with soft τ_h candidates.

II. SAMPLES AND SIMULATION

Signal and background samples were simulated using an interface between MadGraph (v2.2.3) [23] for the events generation, PYTHIA (v6.416) [24] for the hadronization process and Delphes (v3.3.2) [25] to include detector effects. The main background sources come from the production of Z and W vector bosons with associated jets, referred to as Z+jets and W+jets. Background events with up to two associate jets were generated. Jet merging and matching was performed based on the MLM algorithm [26]. This algorithm requires the optimization of two variables related to the jet definition, qcut and xqcut. The xqcut is defined as the minimal distance required among partons at MadGraph level. The qcut is a measure of the minimum energy spread for a clustered jet in PYTHIA. The optimization is performed by studying the differential jet rate distribution until obtaining a smooth transition between events with zero and one jets, and between events with one and two jets. The optimal values found for our simulations were a xqcut of 15 for both backgrounds, and a qcut of 35 GeV for Z+jets and 30 GeV for W+jets. At generation level, leptons were required to have a $p_T(\ell) > 10$ GeV and $|\eta(\ell)| < 2.5$, while jets are required to have a minimum p_T threshold of 20 GeV and $|\eta| < 5.0$. For Z+jets events, an additional constrain on the reconstructed mass of the two leptons was applied, in order to suppress events with masses below 50 GeV.

The signal samples were produced considering two cases in the context of the R-parity conserving Minimal Supersymmetric Standard Model (MSSM). The first case considered direct production of $\tilde{\tau}$ pairs and an ISR jet and the second case included additional production of $\tilde{\tau}$ events through cascade decays of $\tilde{\chi}_1^{\pm}$ or $\tilde{\chi}_2^0$. The benchmark signal samples were produced under the three following assumptions. First, the $\tilde{\chi}_1^{\pm}$ and the $\tilde{\chi}_2^0$ are wino-like and mass degenerate, while the $\tilde{\chi}_1^0$ is mostly Bino. Second, we considered only scenarios where the mass difference between the $\tilde{\tau}$ and the $\tilde{\chi}_1^0$ is always less or equal to 25 GeV, aimed at the $\tilde{\tau}$-$\tilde{\chi}_1^0$ co-annihilation region, and with mass equal to $m(\tilde{\tau}) = 0.5m(\tilde{\chi}_1^{\pm}) + 0.5m(\tilde{\chi}_1^0)$. Finally, we studied regions where the mass difference between the $\tilde{\chi}_1^0$ and the $\tilde{\chi}_1^{\pm}$ is below 50 GeV, in order to study areas of the SUSY phase space where the ATLAS and CMS searches have limited experimental sensitivity. We scaned the regions of interest using $\tilde{\chi}_1^{\pm}$ masses ranging from 100 GeV to 400 GeV, in steps of 100 GeV, and $\Delta m(\tilde{\tau}, \tilde{\chi}_1^0)$ from 5 GeV to 25 GeV, in steps of 5 GeV.

III. EVENT SELECTION CRITERIA

The event selection criteria used in the analysis is summarized in Table I. The p_T threshold for the highest p_T jet ($p_T^{lead}(jet)$) was defined through an optimization process, based on the $S/\sqrt{S+B}$ figure of merit, to estimate the signal significance. The $p_T^{lead}(jet)$ selection was also chosen to provide an experimental handle to trigger on these types of events at ATLAS and CMS. In order to focus on events where the ISR jet can naturally boost the p_T^{miss} in the opposite direction, jets are constrained to be within the tracker acceptance region, $|\eta_{jets}|$ <2.5. We selected the highest p_T jet in the event, as the ISR jet. The highest p_T jet correctly identifies the ISR jet with greater than 95% accuracy. Events containing an isolated electron or muon, with $p_T > 20$ GeV, have been removed in order to suppress the contribution from the W+jets, Z+jets and $t\bar{t}$ backgrounds. The contribution from di-boson events, is heavily suppressed after vetoing events with two or more leptons. Events with top quarks become negligible after vetoing jets, tagged as bottom quarks, with $p_T > 20$ GeV and $|\eta| < 2.5$. Events are required to have exactly one τ_h with $15 < p_T(\tau_h) < 35$ GeV and $|\eta(\tau_h)| < 2.3$. The selection criteria on the pseudo-rapidity of τ_h, $|\eta(\tau_h)| < 2.3$, is also motivated by the geometric acceptance of the tracker sub-detectors in both experiments and the isolation cones placed around the τ_h candidates, commonly used to reject jets from QCD processes that can mimic the signature of a τ_h. Jets and τ_h candidates passing the outlined selection criteria are required to be well separated in $\eta - \phi$ space by a cut of $\Delta R(\tau_h, jet) = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ greater than 0.4. The $p_T(\tau_h)$ and p_T^{miss} thresholds were optimized in a two dimensional plane, after passing the selection criteria described above, allowing us to find the most suitable combination of the two variables. The signal benchmark sample with $m(\tilde{\chi}_1^0) = 150$ GeV, $m(\tilde{\chi}_1^{\pm}) = 200$ GeV and $m(\tilde{\tau}) = 175$ GeV, was used for the optimization. The best significance is achieved when $p_T(\tau_h)$ is within the range 15 GeV $< p_T(\tau_h) <$ 35 GeV, with a p_T^{miss} requirement above 230 GeV. After requiring a p_T^{miss} threshold of 230 GeV, the contribution from QCD events becomes negligible. Figure 1 shows the results of the $p_T^{max}(\tau_h)$ vs. p_T^{miss} optimization process, using events selected with $p_T^{lead}(jet) > 100$ GeV, $p_T(\tau_h) > 15$ GeV, and satisfying the extra lepton and b-jet vetoes. The increase in signal significance due to the requirement of a soft τ_h, as shown in Figure 1, highlights the importance of having good τ_h identification at low p_T. On average, a 20%

TABLE I. Cuts used to select events with one τ_h and at least one high p_T ISR jet. The highest p_T jet is tagged as the ISR jet.

Criterion	Selection
$N(e/\mu)$	0
$N(\tau_h)$	1
$\|\eta(\tau_h)\|$	< 2.3
N(b-jets)	0
$p_T^{lead}(jet)$	100 GeV
$\Delta R(\tau_h, jet)$	> 0.4
$\|\eta(jet)\|$	< 2.5
$p_T(\tau_h)$	> 15 GeV & < 35 GeV
p_T^{miss}	> 230 GeV

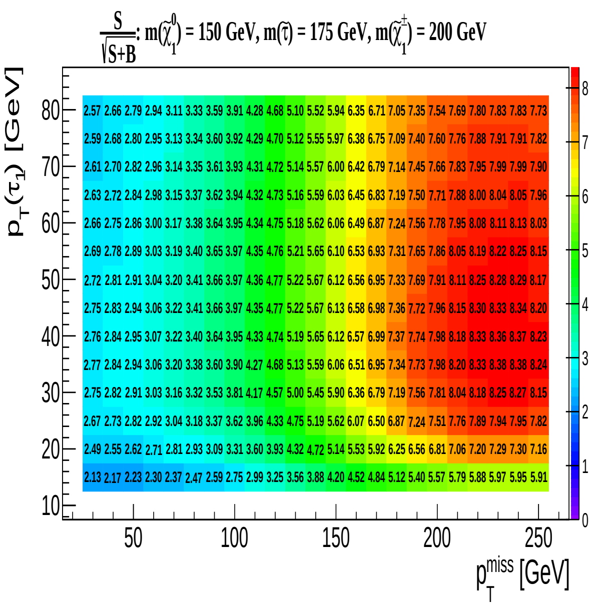

FIG. 1. Results of the $p_T^{max}(\tau_h)$ vs. p_T^{miss} optimization process, targeting best significance $S/\sqrt{S+B}$, using events selected with $p_T^{lead}(jet) > 100$ GeV, $p_T(\tau_h) > 15$ GeV, and satisfying the extra lepton and b-jet vetoes. The benchmark signal point used was $m(\tilde{\chi}_1^0) = 150$ GeV, $m(\tilde{\chi}_1^{\pm}) = 200$ GeV and $m(\tilde{\tau}) = 175$ GeV.

improvement in the overall signal significance for very compressed $\tilde{\tau} - \tilde{\chi}_1^0$ scenarios, is observed by lowering the $p_T(\tau_h)$ threshold from 20 GeV to 15 GeV.

Other sets of topological variables were analyzed, such as different combination of variables related to the angular difference in the ϕ plane between the highest p_T jet, the τ_h and the p_T^{miss}. However, no significant additional discrimination between the hypothetical signal and the background was observed. Similarly, other distributions such as the scalar sum of the p_T of the jets in the event (H_T) and the ratio of p_T^{miss} to $p_T^{lead}(jet)$, R_m [27], were also studied. Neither the H_T nor the R_m variables yield additional signal to background discrimination.

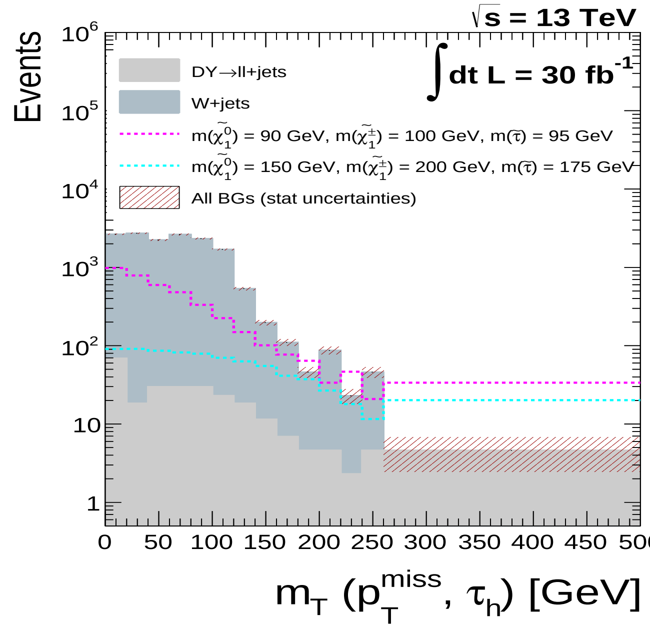

FIG. 2. $m_T(\tau_h, p_T^{miss})$ distribution for the main backgrounds and two chosen signal benchmark points, after applying the final event selection criteria.

The transverse mass distribution between the τ_h and the p_T^{miss}, defined in Equation 1, is proposed as the main signal to background discriminant, to search for a possible broad enhancement of signal events in the tails of the distributions that would indicate the presence of new physics at the LHC.

$$m_T(\tau_h, p_T^{miss}) = \sqrt{2 p_T^{miss} p_T(\tau_h)(1 - cos\Delta\phi(\tau_h, p_T^{miss}))} \quad (1)$$

Figure 2 shows the $m_T(\tau_h, p_T^{miss})$ distribution for the main backgrounds and two different signal points, after applying all the event selection criteria outlined in Table I. The backgrounds are stacked on top of each other while the signal is overlaid with the expected background yields. The bulk of the background distribution resides at low m_T, while the signal begins to dominate in the tails of the distribution (e.g. $m_T \sim 175$ GeV for the benchmark signal samples shown in Figure 2).

Tables II and III present the change in the production cross section and the relative efficiencies for two signal points and the main backgrounds, after each step of the event selection criteria. The tables also contain information for different m_T cuts, aimed to help the reader determine the sensitivity of the analysis.

IV. RESULTS

The proposed shape based analysis of the m_T distribution is performed using a binned likelihood following the

TABLE II. Change in the production cross section and relative percentage efficiencies after each step of the event selection criteria, for two signal points. The cross sections are in femtobarns and the relative efficiencies are presented in parenthesis: $\sigma(\varepsilon)$. Signal 1 corresponds to $m(\tilde{\chi}_1^0) = 150$ GeV, $m(\tilde{\chi}_1^{\pm}) = 200$ GeV, $m(\tilde{\tau}) = 175$ GeV and signal 2 to $m(\tilde{\chi}_1^0) = 90$ GeV, $m(\tilde{\chi}_1^{\pm}) = 100$ GeV, $m(\tilde{\tau}) = 95$ GeV.

Criterion	Signal 1	Signal 2
No cuts	1331.0	10700.0
$p_T(j_1) > 20$ GeV	1292.4 (97.1)	9854.7 (92.1)
N(e/μ) = 0	1023.6 (79.2)	9844.8 (99.9)
N(τ_h) = 1	237.5 (23.2)	2480.9 (25.2)
$\lvert\eta(\tau_1)\rvert < 2.3$	234.9 (98.9)	2441.2 (98.4)
N(b-jets) = 0	215.8 (91.9)	2282.5 (93.5)
$p_T(j_1) > 100$ GeV	132.1 (61.2)	808.0 (35.4)
$\lvert\eta(j_1)\rvert < 2.5$	128.3 (97.1)	776.5 (96.1)
15 GeV $< p_T(\tau_h) <$ 35 GeV	59.9 (46.7)	285.0 (36.7)
$\vec{E}_T^{miss} > 230$ GeV	25.9 (43.2)	131.4 (46.1)
$m_T > 150$ GeV	6.1 (23.6)	11.0 (8.4)
$m_T > 200$ GeV	2.6 (9.9)	4.5 (3.4)
$m_T > 250$ GeV	0.8 (3.1)	1.4 (1.1)

TABLE III. Change in the production cross section and relative percentage efficiencies after each step of the event selection criteria, for the main backgrounds. The cross sections are in femtobarns and the relative efficiencies are presented in parenthesis: $\sigma(\varepsilon)$.

Criterion	DY+jets	W+jets
No cuts	2240000.0	31800000.0
$p_T(j_1) > 20$ GeV	1019200 (45.5)	11543400.0 (36.3)
N(e/μ) = 0	354681.6 (34.8)	7122277.8 (61.7)
N(τ_h) = 1	148966.3 (42.0)	1403088.7 (19.7)
$\lvert\eta(\tau_1)\rvert < 2.3$	148519.4 (99.7)	1391864.0 (99.2)
N(b-jets) = 0	143172.7 (96.4)	1333405.7 (95.8)
$p_T(j_1) > 100$ GeV	7158.6 (5.0)	90671.6 (6.8)
$\lvert\eta(j_1)\rvert < 2.5$	6764.9 (94.5)	84415.2 (93.1)
15 GeV $< p_T(\tau_h) <$ 35 GeV	1928.0 (28.5)	28532.3 (33.8)
$\vec{E}_T^{miss} > 230$ GeV	9.6 (0.5)	513.6 (1.8)
$m_T > 150$ GeV	1.2 (12.5)	11.29 (2.2)
$m_T > 200$ GeV	0.6 (6.25)	5.29 (1.0)
$m_T > 250$ GeV	0.3 (3.6)	0.0 (0.0)

test statistic based on the profile likelihood ratio, using the ROOTFit [28] toolkit. As can be seen from Figure 2, the signal sensitivity with the integrated luminosity considered is dominated by the signal and background yields in the tails of the m_T distribution, where statistical uncertainties are expected to be more important than systematic uncertainties. However, since the proposed search strategy entails a fit of the entire m_T distribution, it is appropriate to consider reasonable experimental systematic uncertainties to calculate projected significance as this fitting procedure can have important correlations to the background and signal uncertainties at low m_T, where statistical uncertainties are small. The dominant sources of systematics are expected to be the uncertainty on τ_h identification (6% based on [29]), p_T^{miss} trigger efficiency (1% based on [30]), modeling of ISR (5% based on [30]), pileup effects, and the uncertainty on transfer factors used to estimate the backgrounds. While it is beyond the scope of this paper to perform studies on background estimation methods, we refer to the monojet searches with 8 TeV data [30] as a reasonable choice for the uncertainty on the transfer factors used to estimate backgrounds ($\sim 5.1\%$ for $p_T^{miss} > 250$ GeV). Therefore, a 10% total systematic uncertainty on the signal and background yields is a reasonable choice. In our studies, the systematic uncertainties are incorporated via nuisance parameters following the frequentist approach. A local p-value is calculated as the probability under a background only hypothesis to obtain a value of the test statistic as large as that obtained with a signal plus background hypothesis. The significance z is then determined as the value at which the integral of a Gaussian between z and ∞ results in a value equal to the local p-value.

Figure 3 shows the expected signal significance without considering any systematic effects. Figure 4 shows the expected signal significance after considering a flat 10% systematic effect, completely correlated across m_T bins, in the signal and background yields. The proposed methodology can provide 5σ (3σ) significance for $\tilde{\chi}_1^{\pm}$ masses up to approximately 250 GeV (300 GeV) and with $m(\tilde{\tau}) - m(\tilde{\chi}_1^0) < 25$ GeV, allowing the ATLAS and CMS experiments to probe previously unreachable parts of the $\tilde{\tau} - \tilde{\chi}_1^0$ co-annihilation phase space important to the connection between particle physics and cosmology. The assumption of a completely correlated systematic uncertainty with respect to m_T is based on the belief that the τ_h identification and p_T^{miss} trigger efficiencies do not depend on the value of m_T. This assumption depends on the performance of the improved and updated reconstruction algorithms of the CMS and ATLAS experiments under future running conditions, which is outside the scope of this paper. However, for the luminosity considered, the conclusions have been tested to be independent of the assumption of a completely correlated systematic uncertainty with m_T.

Although the benchmark signal samples considered thus far focus on the case where the $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ is mostly Wino and the LSP is mostly Bino (when co-annihilation can give rise to the correct LSP DM relic density), a study is also performed on the impact of Wino and Bino compositions of the $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ and LSP, respectively, to the signal sensitivity. This allows for a more general overview of the impact of the proposed search to compressed SUSY, independent of the connection to cosmological DM. For this purpose, signal samples were produced by fixing the $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ and LSP masses and varying the μ parameter, which controls the gaugino mixing. For example, for $m(\tilde{\chi}_1^{\pm}) = 100$ GeV and $m(\tilde{\chi}_1^0) = 50$ GeV, the μ parameter was decreased to produce LSP Bino compositions ranging from 50% to 97%. Decreasing the μ parameter in order to decrease the LSP Bino composition makes the Higgsinos more important and thus simultaneously decreases the Wino composition for $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ (i.e. they are no longer mostly wino-like). The Wino compositions for $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ range from $\approx 40\%$ to 99%. Figures 6 and 5 show the expected signal significance, using an integrated luminosity of 30 fb^{-1}, as a function of $m(\tilde{\chi}_1^{\pm})$ and LSP Bino composition for fixed Δm of 25 GeV and 5 GeV respectively. For a fixed set of masses, the predicted signal yields decrease as the LSP Bino and $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ Wino compositions decrease, resulting in $\approx 55\%$ decrease in signal significance for a LSP Bino composition of 50%. The signal significances shown in Figures 6 and 5 were calculated using the same statistical procedure outlined above and

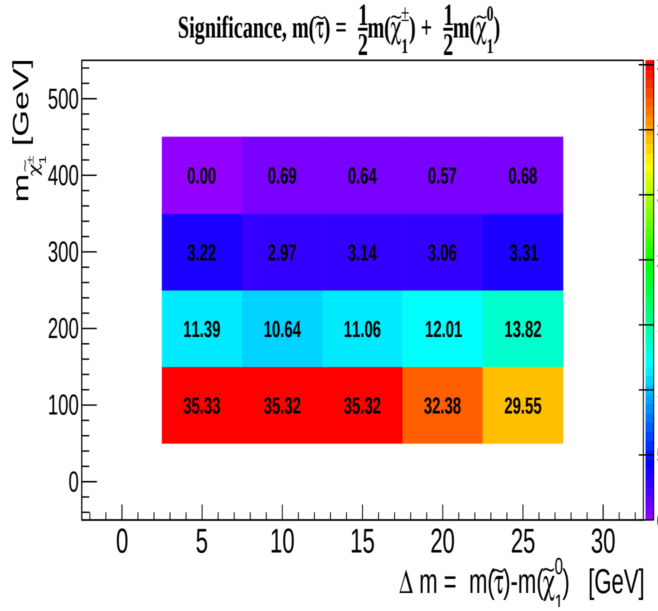

FIG. 3. Signal significance, using a shape based statistical analysis of the m_T distribution, as a function of $\tilde{\chi}_1^\pm$ mass and $m(\tilde{\tau}) - m(\tilde{\chi}_1^0)$. No systematic effects have been considered.

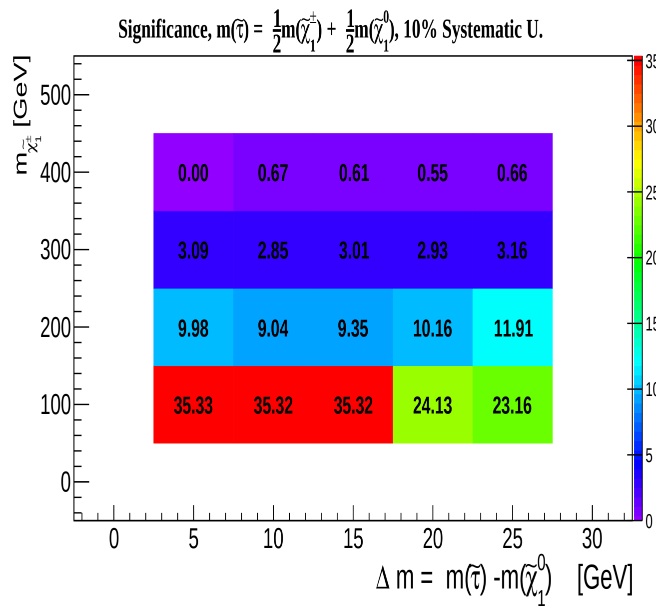

FIG. 4. Signal significance, using a shape based statistical analysis of the m_T distribution, as a function of $\tilde{\chi}_1^\pm$ mass and $m(\tilde{\tau}) - m(\tilde{\chi}_1^0)$. A flat systematic effect of 10%, completely correlated across m_T bins, has been considered on the signal and background yields.

similarly considering a 10% systematic uncertainty.

V. DISCUSSION

The main result of this paper is that the $\tilde{\tau}$-$\tilde{\chi}_1^0$ co-annihilation region with $\Delta m < 50$ GeV, where experimental sensitivity is limited from current searches performed at the LHC, can be probed using a search strategy of one soft hadronically decaying tau lepton and large missing transverse energy recoiling against a hard p_T jet from initial state radiation. These regions of SUSY also play a decisive role in thermal Bino DM cosmology models which require $\tilde{\tau}$-$\tilde{\chi}_1^0$ co-annihilation to obtain the correct relic DM density observed today. A major highlight of the proposed search strategy is the ability to select low p_T hadronic tau decays, facilitated by the use of p_T^{miss} triggers from the boost effect of the high p_T ISR jet, in order to maximize signal acceptance in these compressed scenarios while simultaneously providing large reduction against SM backgrounds. The ability of the ATLAS and CMS experiments to provide good τ_h identification at low p_T is a key ingredient. We find that for $m(\tilde{\tau}) - m(\tilde{\chi}_1^0) < 25$ GeV, gaugino masses up to 300 GeV (250 GeV) can be probed at 3σ (5σ) level with 30 fb^{-1} of 13 TeV data from the LHC. We emphasize that the experimental constraints for the SUSY parameter space with $m(\tilde{\tau}) - m(\tilde{\chi}_1^0) < 25$ GeV with the ATLAS and CMS data to date do not exceed those of the LEP experiments, and thus the proposed new search can nicely complement the current analyses performed at the LHC.

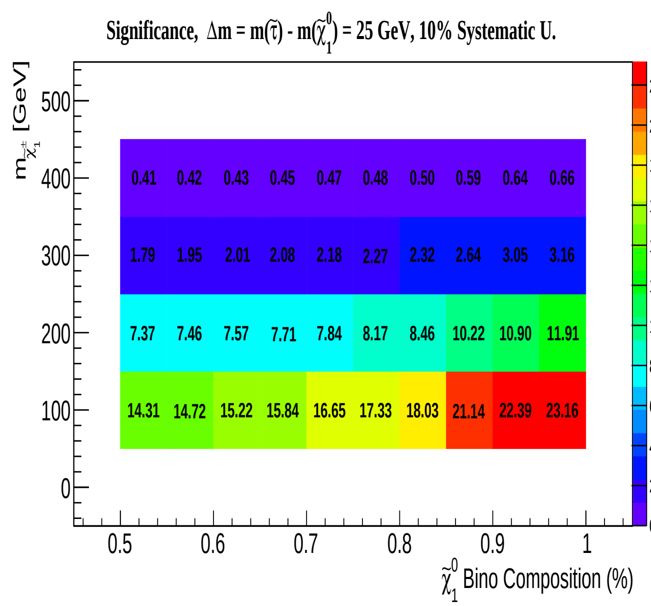

FIG. 5. Signal significance, using a shape based statistical analysis of the m_T distribution, as a function of $\tilde{\chi}_1^\pm$ mass and the fraction of Bino composition of the LSP, for the scenario with $m(\tilde{\tau}) - m(\tilde{\chi}_1^0) < 25$ GeV. A flat systematic effect of 10%, completely correlated across m_T bins, has been considered on the signal and background yields.

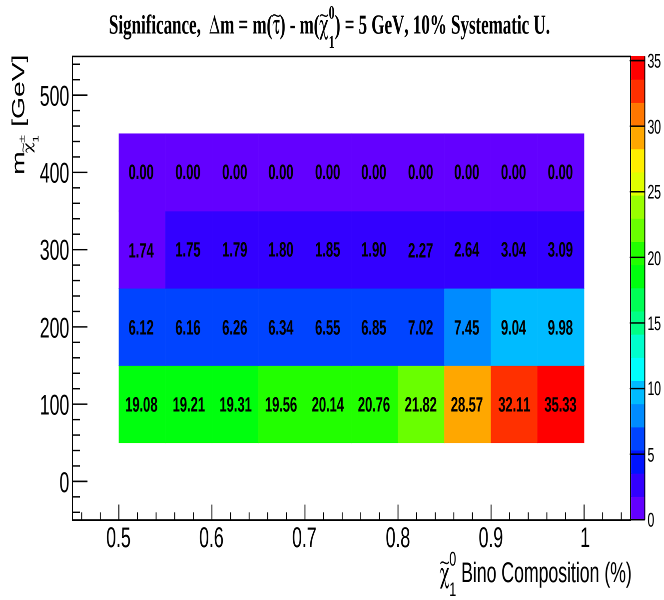

FIG. 6. Signal significance, using a shape based statistical analysis of the m_T distribution, as a function of $\tilde{\chi}_1^\pm$ mass and the fraction of Bino composition of the LSP, for the scenario with $m(\tilde{\tau}) - m(\tilde{\chi}_1^0) < 5$ GeV . A flat systematic effect of 10%, completely correlated across m_T bins, has been considered on the signal and background yields.

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