Beyond the Standard Model physics: Strong Susy production searches at ATLAS & CMS

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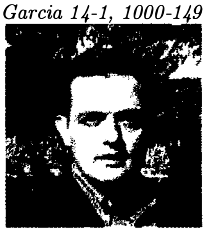

The accumulation of 20 fb^{-1} of data at 8 TeV has been a unique window for Supersymmetry searches at the LHC, allowing the ATLAS & CMS collaborations to search for specific supersymmetric particles. This article covers the search for strong production of supersymmetric particles in a variety of decay modes as well as channels. It focuses on the search for scalar quarks of third generation, the lightest scalar top (stop) which might be the only observable in the case where Supersymmetry is realized in nature, and which can play a unique role in "naturalness".

1 Introduction

Supersymmetric (Susy) theories [1] predict the existence of a scalar partner for each standard model fermion. The search for a rather low energy Susy has special interest in view of the discovery of a light Higgs boson [2], which constrains the Susy parameter space: While a Susy Higgs is being seriously constrained in the case of a τ-phobic Higgs and for a light supersymmetric tau (stau), more possibilities subsist for the realization of Susy in the case of a light stop as an example [3]. In the following sections, different searches of Susy performed by the ATLAS & CMS collaborations at $\sqrt{s}$=8 TeV and in different final states are presented; in each case, interpretations are provided in terms of sensitivity to the mass of searched supersymmetric particles. These searches consider strong production processes and cascade decays producing jets, leptons and missing transverse momentum (E_T^{miss}) from unobserved, weakly interacting particles. Unless specified, the Lightest Supersymmetric Particle (LSP) is assumed to be the lightest neutralino $\tilde{\chi}_1^0$, itself assumed to be stable. Interpretation of results are mostly provided in the context of simplified models where no assumption is made about the mechanism breaking Susy, thus about the parameters of any underlying supersymmetric theory; different mass hypothesis about the searched supersymmetric particles are considered, to render the searches as generic as possible in their interpretation.

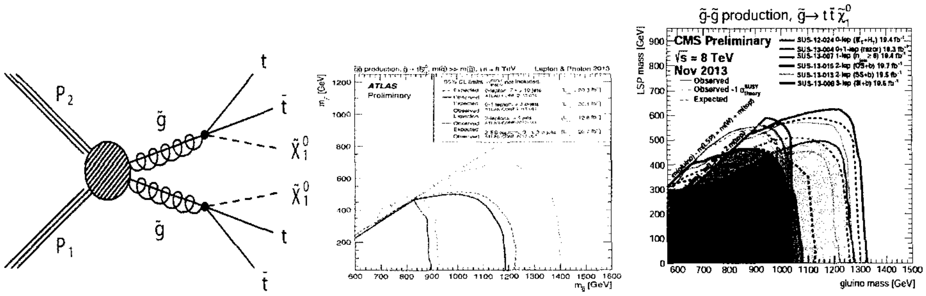

Figure 1 – Left: Gluino pair production with the decay: $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$. Centre and right: Domain of sensitivity of the gluino search in the above mentioned decay mode and in different final states in the (m($\tilde{t}_1$),m($\tilde{\chi}_1^0$)) plan, for ATLAS and CMS respectively.

2 Search for gluino pair production

The supersymmetric partner of the gluon, the gluino $\tilde{g}$, benefiting from a large production cross section (see figure 1), has been and is one of the benchmark particles searched for, from the LEP until the LHC. The decay mode of the gluino $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$ has been the most explored; at the LHC however, the energy reach of the machine allows to search for the gluino in the $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ decay mode, where four top quarks are expected thus allowing to expect a rather low background from the Standard Model (SM). The search for gluino through such a decay mode also allows, in case of discovery, cross checks across different final states; the hypothesis of these searches is: m($\tilde{g}$)≪m($\tilde{q}$). Both ATLAS and CMS collaborations have searched for gluino pair production followed by the above mentioned decay mode, this through five final state with different number of leptons: No excess of data is observed versus the predicted SM background; this absence is interpreted as 95% Confidence Limit [4] (CL) exclusion of signal as function of the mass of searched supersymmetric particles. Both experiments exclude the existence of a gluino with a mass smaller than $\sim$ 1.3 TeV/c^2 this for an LSP mass smaller than $\sim$ 700 GeV/c^2.

3 Third generation squark searches

The searches covered in the previous section are motivated by models of new physics, which are possible to interpret in many models, including Susy. Being frequently based on selections requiring high H_T (defined as the scalar sum of the p_T of all jets reconstructed in the event) and E_T^{miss}, they are most of the time sensitive to the production of rather high mass Susy objects such as gluino and light-flavor squarks, sometimes involving long decay chains. This section covers the exclusive search for direct production of squarks of third generation, purposefully searching for a supersymmetric object which is probably at the bottom of the Susy mass chain. Because of the large mass of the standard model top quark, the mixing between its chiral supersymmetric partners is the largest among all squarks; therefore the lightest supersymmetric partner of the top quark, $\tilde{t}_1$ (stop), might be the lightest squark producible at the LHC. Furthermore, the stop sector $\tilde{t}_{1,2}$ is the Susy sector most sensitive to the Higgs mass [5]. Finally, the measure of the Cold Dark Matter (CDM) density [6] gives preference to a particle whose mass is close to the one of the CDM; in the framework of Susy, this can be the lightest stop with a mass close to the one of $\tilde{\chi}_1^0$, natural supersymmetric candidate for the CDM. These arguments in favor of the lightest stop $\tilde{t}_1$ can also be applied to the lightest sbottom $\tilde{b}_1$.

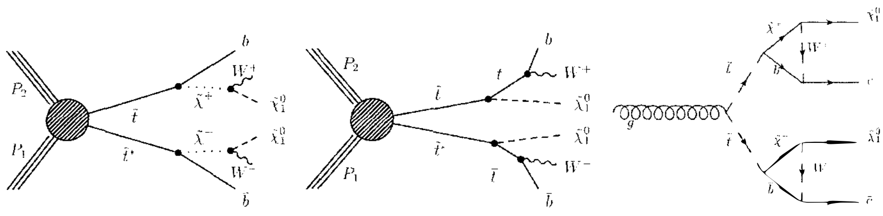

Figure 2 – Diagrams of the pair production of the lightest stop $\tilde{t}_1$ at the LHC, as considered in searches presented in this article. Different decay modes are considered: $\tilde{t}_1 \to t^{(*)}\tilde{\chi}_1^0 \to bW^{\pm}\tilde{\chi}_1^0$ (left), $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm} \to bW^{\pm}\tilde{\chi}_1^0$ (center), $\tilde{t}_1 \to c\tilde{\chi}_1^0$ (right).

3.1 Stop searches

We present in the two following subsections searches for stop pair production, in different final states, where the lightest stop $\tilde{t}_1$ decays via the $t^{(*)}\tilde{\chi}_1^0$ and $b\tilde{\chi}_1^{\pm}$ decay modes, both ultimately decaying in $bW^{\pm}\tilde{\chi}_1^0$; for these decays to take place, the mass of the lightest stop must verify the condition: $\mathrm{m}(\tilde{t}_1) \geq \mathrm{m}(b)+\mathrm{m}(W^{\pm})+\mathrm{m}(\tilde{\chi}_1^0)$ (see figure 2). If $\mathrm{m}(\tilde{t}_1) < \mathrm{m}(b)+\mathrm{m}(W^{\pm})+\mathrm{m}(\tilde{\chi}_1^0)$, other decays of the lightest stop such as $\tilde{t}_1 \to c\tilde{\chi}_1^0$ (see figure 2) can dominate; a search for stop pair production in this latter decay mode is presented in the last subsection of 3.1.

Search for direct stop production in final states with 0 lepton

The search for stop in hadronic final states performed by CMS[7] is looking at stop pair production followed by $\tilde{t}_1 \to t^{(*)}\tilde{\chi}_1^0$ decays. It is mainly characterized by the requirement of at least five jets with transverse momenta $p_T(j_{1,2}) > 70$, $p_T(j_{3,4}) > 50$ and $p_T(j_5) > 30$ GeV/c, at least one jet tagged as stemming from the hadronization of a b quark (b-tagged), and cuts on the difference between the angle of the three leading jets and the missing transverse momentum vector $\vec{p}_T^{miss}$ of the event. Since the main background of this search the top pair production, a reconstruction of the kinematics of the top is performed to better disentangle this background from the signal: A system *top*1 of 3 jets out of 5 is fully reconstructed as originating from the $t \to j_1 W^{\pm} \to j_1 j_2 j_3$ decay (requiring compatibility of jet invariant masses with the top and W masses), while the system *top*2 of remnant jets is partially reconstructed (no full kinematic reconstruction as in the case of *top*1) to gain acceptance while kinematically constraining the top quark to some extent. Then, two transverse invariant masses are formed from these two systems:

$$M_T^{3jet} = m(top1) \oplus \vec{p}_T^{miss} \quad , \quad M_T^{Rsys} = m(top2) \oplus \vec{p}_T^{miss}. \tag{1}$$

The best separation between the SM background and the signal is obtained by considering a linear combination of these two invariant masses, see figure 3. The final signal regions, where the signal is more abundantly expected, are defined as function of number of b-tagged jets and $\vec{p}_T^{miss}$. No excess of Data events has been observed in these regions, leading to the 95 % CL exclusion of signal as function of the mass hypothesis on $\tilde{t}_1$ and $\tilde{\chi}_1^0$: As can be observed on figure 3, this search excludes the lightest stop up to ~ 580 GeV/c^2 for LSP mass up to ~ 180 GeV/c^2, this, within the hypothesis of the $\tilde{t}_1 \to t\tilde{\chi}_1^0$ decay mode. It has to be noted that since this search explicitly reconstructs the kinematics of the top quark, it doesn't have any sensitivity for the kinematic region where the top of the $\tilde{t}_1$ is virtual: $\mathrm{m}(\tilde{t}_1)$-$\mathrm{m}(\tilde{\chi}_1^0)$<$\mathrm{m}(t)$.

The search for third generation squarks in hadronic final states performed by ATLAS[8] covers the search for the lightest stop $\tilde{t}_1$ and for sbottom $\tilde{b}_1$; the pre-selection is summarized in the table of figure 4. The data is scrutinized through the following topological and kinematic variables:

- $\Delta\phi_{min} = \min(|\phi_1 - \phi_{p_T^{miss}}|, |\phi_2 - \phi_{p_T^{miss}}|, |\phi_3 - \phi_{p_T^{miss}}|)$; ϕ_i: Polar angle of the jet i;

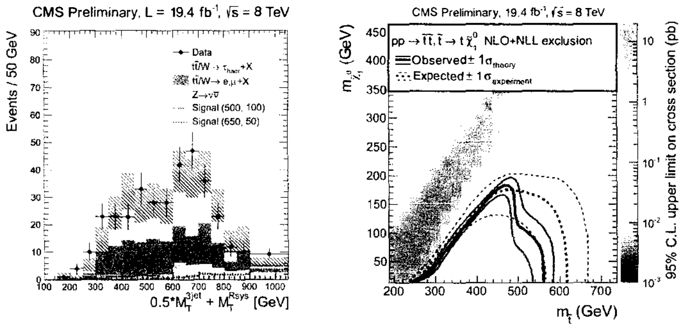

Figure 3 – Results of the CMS stop search in the hadronic final state. Left: Distribution of the linear combination of the two discriminating variables M_T^{3jet} and M_T^{Rsys}, where the contribution of observed data, expected background and benchmark signal points are shown. Right: Expected and observed sensitivity of the search in the (m($\tilde{t}_1$),m($\tilde{\chi}_1^0$)) plan.

- $m_{eff}(k) = \sum_{i=1}^{k} (p_T^{jet})_i + E_T^{miss}$: Measures of an effective invariant mass;
- $H_{T,3} = \sum_{i=4}^{n} (p_T^{jet})_i$;
- m_{bb}: Invariant mass of the 2 leading b-tagged jets;
- $m_{CT}^2(v_1, v_2) = [E_T(v_1) + E_T(v_2)]^2 - [p_T(v_1) + p_T(v_2)]^2$, where $v_{1,2}$ are two b-jets from the squark decay: m_{CT} measures masses of pair-produced and semi-invisibly decaying heavy particles: $\tilde{t}_1, \tilde{b}_1 \to X\tilde{\chi}_1^0$.

Signal regions SRA and SRB are conceived as kinematic regions respectively with a large and small Δm=m($\tilde{q}$)-m($\tilde{\chi}_1^0$). In SRA, advantage is taken from the larger available phase space to select events with a high m_{bb} (see benchmark signal point on figure 4); furthermore, differential cuts are made on m_{CT} to optimize the selection for signal points with different Δm. In SRB, advantage is taken from the jet from Initial State Radiation (ISR) which is harder and boosts to some extent the system: It is required that the leading jet to be more energetic than in SRA, to be back-to-back to the E_T^{miss} which is also required to be higher; furthermore, this leading jet is required not to be a b-tagged jet while the second and third leading jets of the event are required to be b-tagged, since two b jets are expected both in the pair production of $\tilde{t}_1$ and $\tilde{b}_1$. The absence of excess in Data versus the expected SM background is interpreted as 95 % CL exclusion of signal. The interpretation for $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$ decays is provided in figure 5 in the (m($\tilde{t}_1$),m($\tilde{\chi}_1^0$)) plan, as well as hypothesis about the $\tilde{\chi}_1^{\pm}$ mass: Depending on the mass of the lightest chargino, stop masses between $\sim$ 450 and 600 GeV/c^2 are 95% CL excluded for m($\tilde{\chi}_1^0$)$\sim$250 GeV/c^2; it has to be noted that this search doesn't have sensitivity in the kinematic region m($\tilde{t}_1$)$\geq$m($\tilde{\chi}_1^{\pm}$)+m(b), where the phase space of the signal is limited: This is due to the tight cuts made on the transverse momenta of leading jet and E_T^{miss} (see table in figure 4). The interpretation of this search for the sbottom is provided in section 3.2.

Search for direct stop production in final states with 1 lepton

The CMS exclusive search for the direct production of the lightest stop in the single lepton final state [9] considers the decays of the lightest stop in $b\tilde{\chi}_1^{\pm}$ and $t^{(*)}\tilde{\chi}_1^0$, both decaying in $bW^{\pm}\tilde{\chi}_1^0$. This search requires an electron or muon with $p_T > 30$ GeV/c, at least four jets with at lcast one of them b-tagged, a E_T^{miss} larger than 100 GeV, and a transverse invariant mass of the (lepton,E_T^{miss}) system larger than 150 GeV. Then discriminating kinematic and topological variables are fed into Boosted Decision Tree (BDT) in order to maximize the separation between

Description	Signal Regions	
	SRA	SRB
Event cleaning	Common to all SR	
Lepton veto	No e/μ after overlap removal with $p_T > 7(6)$ GeV for $e(\mu)$	
E_T^{miss}	> 150 GeV	> 250 GeV
Leading jet $p_T(j_1)$	> 130 GeV	> 150 GeV
Second jet $p_T(j_2)$	> 50 GeV,	> 30 GeV
Third jet $p_T(j_3)$	veto if > 50 GeV	> 30 GeV
$\Delta\phi(p_T^{miss}, j_1)$	-	> 2.5
b-tagging	leading 2 jets ($p_T > 50$ GeV, $\lvert\eta\rvert < 2.5$)	2nd- and 3rd-leading jets ($p_T > 30$ GeV, $\lvert\eta\rvert < 2.5$)
	$n_{b\text{-jets}} = 2$	
$\Delta\phi_{min}$	> 0.4	> 0.4
$E_T^{miss}/m_{eff}(k)$	$E_T^{miss}/m_{eff}(2) > 0.25$	$E_T^{miss}/m_{eff}(3) > 0.25$
m_{CT}	$> 150, 200, 250, 300, 350$ GeV	-
$H_{T,3}$		< 50 GeV
m_{bb}	> 200 GeV	

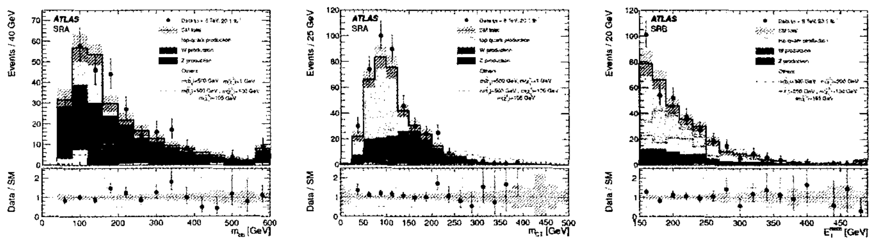

Figure 4 – ATLAS third generation squark search in the hadronic final state. Top: Pre-selection and definition of the signal regions SRA and SRB. Bottom: m_{bb} (left) and m_{CT} (center) distributions in the SRA region; E_T^{miss} (right) distribution in the SRB region; for all distributions the contribution of observed data, expected background and benchmark signal points are shown.

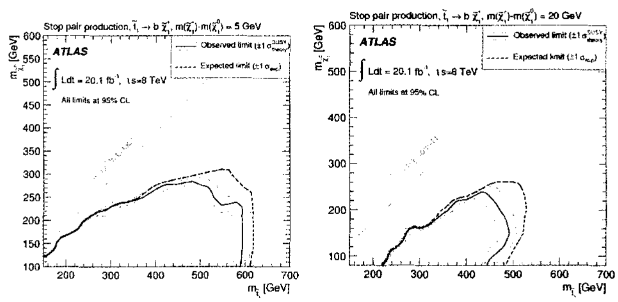

Figure 5 – Results of the ATLAS stop search in the hadronic final state: Expected and observed sensitivity of the search in the (m($\tilde{t}_1$),m($\tilde{\chi}_1^0$)) plan. The results are presented for different hypothesis about the mass of the intermediate lightest chargino: m($\tilde{\chi}_1^{\pm}$)-m($\tilde{\chi}_1^0$)=20 GeV/c^2 and 5 GeV/c^2.

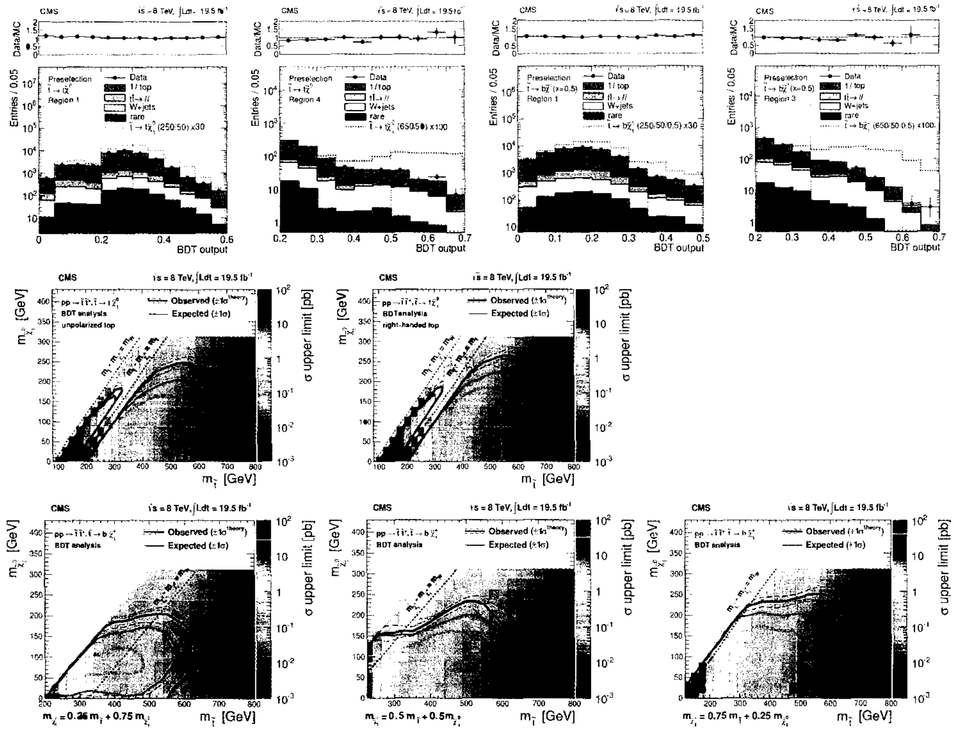

Figure 6 – Results of the CMS stop search in the single lepton final state. First row: BDT output distributions for data, SM background and signal points with Δm = 200 and 400 GeV/c^2 in the $t\tilde{\chi}_1^0$ (left) and $b\tilde{\chi}_1^{\pm}$ (right) decay mode. Second row: $t^{(*)}\tilde{\chi}_1^0$ decay mode: Sensitivity of the single lepton stop search as function of the stop and LSP masses for an unpolarized (center) and right-handed (right) top. Third row: $b\tilde{\chi}_1^{\pm}$ decay mode: Sensitivity of the single lepton stop search as function of the stop and LSP masses for $m(\tilde{\chi}_1^{\pm}) = 0.25m(\tilde{t}_1) + 0.75m(\tilde{\chi}_1^0)$, $0.5m(\tilde{t}_1) + 0.5m(\tilde{\chi}_1^0)$ and $0.75m(\tilde{t}_1) + 0.25m(\tilde{\chi}_1^0)$.

signal and background. The variation of the kinematics of a large variety of $(\tilde{t}_1, \tilde{\chi}_1^0)$ signal points is taken into account by training different BDTs for signal with different $\Delta m = m(\tilde{t}_1) - m(\tilde{\chi}_1^0)$. In figure 6 we report the output of the BDT for both decay modes, and for each decay mode for signals with different Δm; for each decay mode, we can observe that signal points with a high Δm is better separated from the SM background. The observed absence of data versus the SM background for the different BDT trainings is interpreted as 95% CL exclusion of signal as a function of the mass of the lightest stop and LSP, this for the two decay modes (see figure 6). In the $b\tilde{\chi}_1^{\pm}$ decay mode, three different hypothesis are made about the mass of the lightest chargino (figure 6), while in the $t^{(*)}\tilde{\chi}_1^0$ decay mode, the case for unpolarized and right-handed tops are considered in the interpretation of the results. Across the different hypothesis on the decay mode, and within them, different kinematic configurations, stop masses below $\sim$ 650 GeV/c^2 are excluded for LSP masses below $\sim$ 230 GeV/c^2. It has to be noted that in the case of the $t^{(*)}\tilde{\chi}_1^0$ decay mode, there is a loss of sensitivity along the $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) = m(t)$ line below which the top is virtual. The details about the selection of the ATLAS search for stop in the single lepton final state are provided in Ref. [10]. The reach of this search, interpreted in the $b\tilde{\chi}_1^{\pm}$ and $t\tilde{\chi}_1^0$ decay modes is shown in figure 7.

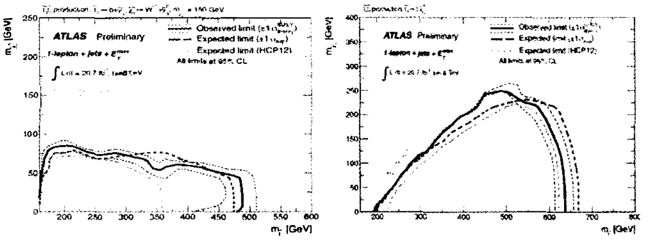

Figure 7 – Results of the ATLAS stop search in the single lepton final state: Expected and observed sensitivity of the search in the $(m(\tilde{t}_1),m(\tilde{\chi}_1^0))$ plan. Left: Interpretation of the results in the $b\tilde{\chi}_1^{\pm}$ decay mode for a constant value of the lightest chargino mass. Right: Interpretation of the results in the $t\tilde{\chi}_1^0$ decay mode.

Search for direct stop production in the $c\tilde{\chi}_1^0$ decay mode

We report in this section the results of the ATLAS search for stop pair production where the lightest stop $\tilde{t}_1$ decays through the $c\tilde{\chi}_1^0$ mode [11] (see figure 2). This search is characterized by the presence of jets stemming out of the hadronization of two c quarks, and E_T^{miss} due to the presence of two $\tilde{\chi}_1^0$. The pre-selection is based on the requirement of at least one jet with $p_T >$ 120 GeV/c, and $E_T^{miss} >$ 150 GeV. Then, in order to get the best sensitivity to kinematically different regions, two selections are performed as follows:

- **Low Δm:**
  - Like for the signal selection at low Δm in the stop search with 0 lepton, advantage is taken from the ISR jet which is harder; it is therefore required that the leading jet has a p_T greater than 280 GeV/c: $p_T(j_1) >$ 280 GeV/c.
  - Since the phase space is limited, it is required that the number of jets with $p_T >$ 30 GeV/c to be less or equal to three: N(jet)$\leq$3.
  - $E_T^{miss} >$ 220 GeV.
- **Medium Δm:**
  - In order to increase the signal purity of the selected data, charm-tagging [11] is performed
  - $p_T(j_1) >$ 270 GeV/c.
  - Since the phase space is less limited, at least two jets from the hard-scatter plus additional jets from ISR can be expected; it is therefore required to have at least three jets with $p_T >$ 30 GeV/c: N(jet)$\geq$3.
  - $E_T^{miss} >$ 410 GeV.

On figure 8 we can observe the E_T^{miss} distribution in data compared with the total predicted SM background, whose composition differs across the low and medium Δm signal regions; are also represented the distribution of benchmark signal points in each case. The absence of excess in data events is interpreted as 95 % CL exclusion of signal in the $(m(\tilde{t}_1),m(\tilde{\chi}_1^0))$ plan, see figure 8: The lightest stop $\tilde{t}_1$ is excluded up to ~230 GeV/c^2 for a mass of $\tilde{\chi}_1^0$ up to ~200 GeV/c^2.

Summary of stop searches at $\sqrt{s}$ = 8 TeV

Figure 9 presents the summary of all searches of the lightest stop pair production across different decay modes and final states, as performed by ATLAS, the CMS experiment having overall a comparable sensitivity across the $(m(\tilde{t}_1),m(\tilde{\chi}_1^0))$ plan. For the two-body $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$ decay mode, ATLAS excludes stop up to ~500 GeV/c^2 for LSP mass up to ~200 GeV/c^2 through the

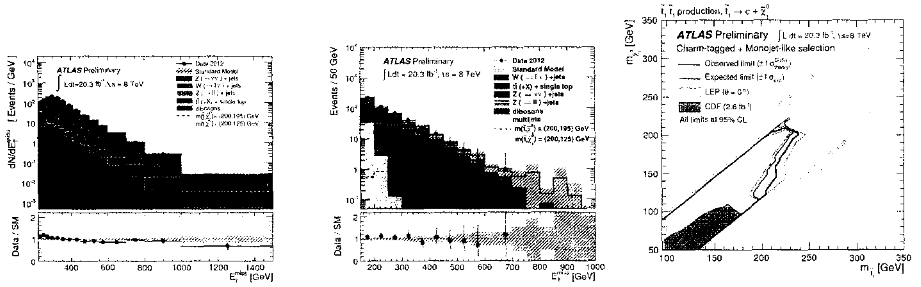

Figure 8 – ATLAS stop pair production search in the $c\tilde{\chi}_1^0$ decay mode. Left and centre: E_T^{miss} spectrum in the low and medium Δm signal regions respectively. Right: Expected and observed sensitivity of the search in the $(m(\tilde{t}_1),m(\tilde{\chi}_1^0))$ plan.

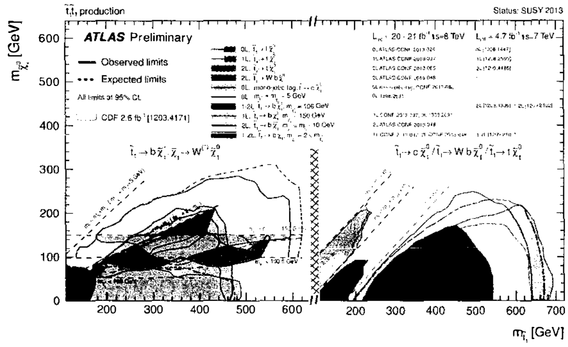

Figure 9 – Summary of all searches of stop pair production, across different final states, and different decay modes, as pursued by ATLAS. Left: Searches in the $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm} \to bW^{\pm}\tilde{\chi}_1^0$ decay mode. Right: $\tilde{t}_1 \to t^{(*)}\tilde{\chi}_1^0 \to bW^{\pm}\tilde{\chi}_1^0$ and $\tilde{t}_1 \to c\tilde{\chi}_1^0$ decay modes.

searches in the single and dilepton final states, with specific hypothesis about the mass of the lightest chargino $\tilde{\chi}_1^{\pm}$; the sensitivity is further extended through the search in the hadronic final state with the hypothesis of the lightest chargino being almost degenerate with the LSP, thus maximally opening the phase space for the b jets stemming directly out of the decays of the stop. CMS reaches sensitivity to a stop mass up to ~600 GeV/c^2 for an LSP mass up to ~200 GeV/c^2 through the search in the single lepton final state, where the mass of the lightest chargino is varied as function of the mass of the stop and of the LSP. For the two-body $\tilde{t}_1 \to t\tilde{\chi}_1^0$ decay mode with an on-shell top quark, both experiments exclude a stop mass up to ≥600 GeV/c^2 for an LSP mass up to ~250 GeV/c^2. For the three-body $\tilde{t}_1 \to bW^{\pm}\tilde{\chi}_1^0$ decay mode, which dominates in the $m(b)+m(W^{\pm})+m(\tilde{\chi}_1^0)<m(\tilde{t}_1)<m(t)+m(\tilde{\chi}_1^0)$ region, CMS excludes a stop mass up to ~300 GeV/c^2 for an LSP mass up to ~180 GeV/c^2.

3.2 Sbottom searches

The interpretation of the ATLAS search [8] in the hadronic final state (see section 3.1) for pair production of the lightest sbottom $\tilde{b}_1$ in $\tilde{b}_1 \to b\tilde{\chi}_1^0$ decays is provided in figure 10: In the high Δm region, sensitivity to sbottom mass of up to ≥600 GeV/c^2 is reached for LSP mass up to ~260 GeV/c^2 thank to the differential cuts on m_{CT}; at low Δm a sensitivity down to $m(\tilde{b}_1)$-$m(b)$-$m(\tilde{\chi}_1^0)$~40 GeV/c^2 is reached thank to the specific selection for signal with low phase space which takes advantage from the presence of an ISR jet. The CMS search for sbottom pair

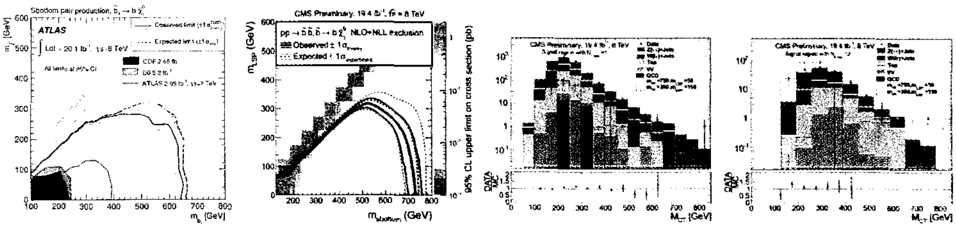

Figure 10 – Two left plots: Sensitivity of the ATLAS and CMS respective searches for the lightest sbottom $\tilde{b}_1$. Two right plots: CMS sbottom search: Distribution of the m_{CT} variable in the N(b)=1 and 2 regions respectively.

production in the $\tilde{b}_1 \to b\tilde{\chi}_1^0$ decay mode [12] is based on the requirement of at least two jets with $p_T > 70$ GeV/c, where at least one jet should be b-tagged, the scalar sum H_T of the p_T of all jets (with $p_T > 30$ GeV/c) to be larger than 250 GeV, E_T^{miss} larger than 175 GeV, and the transverse invariant mass $M_T(j_2,E_T^{miss})$ to be larger than 200 GeV. Then the final selection is performed in exclusive bins of number of b-tagged jets N(b) and m_{CT} to increase the sensitivity of the search across the (m($\tilde{b}_1$),m($\tilde{\chi}_1^0$)) plan. In figure 10 the distribution of the m_{CT} variable is shown for N(b)=1 and 2: The distribution of data is well reproduced by the SM background, up to regions where signal points with different Δm could be expected. Thank to the exclusive binning of the signal regions, this search excludes sbottom masses up to ~700 GeV/c^2 for LSP masses up to ~300 GeV/c^2; having not yet a specific selection for the low Δm region, this search doesn't yet have sensitivity to signal below m($\tilde{b}_1$)-m(b)-m($\tilde{\chi}_1^0$) ~100 GeV/c^2.

3.3 Naturalness

As mentioned in section 3, the masses of the two stops $\tilde{t}_{1,2}$ are the ones most sensitive, among the squarks, to the mass of the Higgs. Furthermore, when the parameters of the Susy model are not unduly contrived, the measure of the Higgs boson mass at ~125 GeV/c^2 gives a hint, if Susy is realized, that the lightest stop can have a mass of the order of 1 TeV/c^2 [5]; this suggests a 'natural', i.e. O(TeV/c^2) realization of Susy where the masses of the Higgs and the lightest stop are rather close, the mass of the latter being enough to stabilize the mass of the Higgs boson. CMS has searched for the experimental signature of a 'natural' Susy, where the lightest stop $\tilde{t}_1$ and higgsinos are light, and where the lightest chargino $\tilde{\chi}_1^{\pm}$ and the two lightest neutralinos $\tilde{\chi}_{1,2}^0$ are almost pure higgsinos, therefore degenerate in mass [13]. Two modes are considered for the production of the higgsino: The direct electro-weak production, and via the strong production $\tilde{t}_R\tilde{t}_R$ (see figure 11). Concerning the decay modes (see figure 11):

- For the strong production, two two-body decays of the stop are considered: $\tilde{t}_R \to b\tilde{\chi}_1^{\pm}, t\tilde{\chi}_{1,2}^0$.
- For the decays of the degenerate lightest chargino and two lightest neutralinos, the following is considered: $\tilde{\chi}_1^{\pm}, \tilde{\chi}_{1,2}^0 \to W^*, Z^*\tilde{\chi}_1^0$.
- Finally, within the context of Gauge Mediated Susy Breaking (GMSB), the lightest neutralino decays into the higgs and gravitino, this latter being considered as the LSP.

Two higgs particles plus E_T^{miss} and two b quarks (in the case of the strong production) are expected as signatures of this search. The selection takes the advantage of the known Higgs mass by requiring at least one $H \to \gamma\gamma$ decay; at least two jets are required, either stemming from higgs of stop decays; finally, two jets are required to be b-tagged. Then three signal regions are defined to optimize the signal selection across different kinematic regions: Region (a) where at least three b-tagged jets are required, for the large Δm=m($\tilde{t}_R$)-m($\tilde{\chi}_1^0$) region. Region (b) with two b-tagged jets and m(bb)∈[95,155] GeV/c^2 for the small m($\tilde{t}_R$)-m(H) region. Region

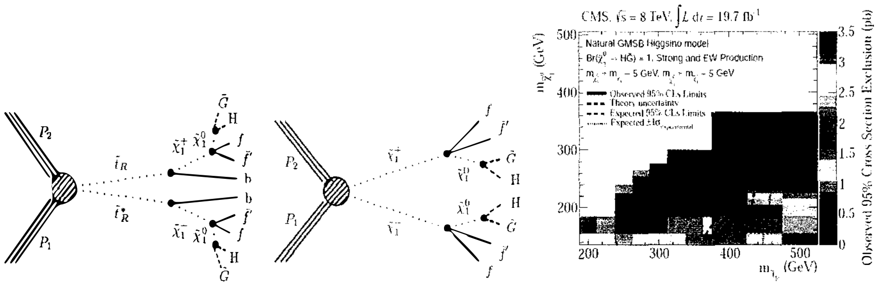

Figure 11 – CMS Susy search in 'natural' scenario. and Higgs. Left and centre: Production of higgsinos via the strong and electro-weak production modes, and subsequent decays. Right: Expected and observed sensitivity of the search in the $(m(\tilde{t}_R), m(\tilde{\chi}_1^0))$ plan.

(c) with two b-tagged jets and m(bb) off from the Higgs mass for the larger $m(\tilde{t}_R)$-$m(H)$ region. Assuming $m(\tilde{\chi}_2^0)=m(\tilde{\chi}_1^\pm)+5$ GeV/c^2, $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0)+5$ GeV/c^2, and $Br(\tilde{\chi}_1^0 \rightarrow H\tilde{G})=1$, this search excludes stop masses up to $\sim$400 GeV/c^2 for the LSP masses up to $\sim$340 GeV/c^2.

4 Conclusions

During the year 2012, the ATLAS and CMS collaborations have pursued an extensive search program through many final states, with sensitivity to many Susy particles. General searches exclude the gluino with a mass $\leq$ 1.3 TeV/c^2 for LSP mass $\leq$ 700 GeV/c^2. The amount of collected data allowed exclusive searches for the direct production of third generation squarks which might be the only supersymmetric particles produced at the LHC, and are well motivated searches in regard of measurements of the CDM [6]. These searches are however challenging because of their lower production cross section and their kinematic signature being very entangled with the one of SM processes. Searches for the lightest stop have been pursued across a variety of final states and four decay modes. The general mass domain of exclusion of third generation searches extends to $\sim$700 and $\sim$300 GeV/c^2 for the squarks and LSP respectively. Given the strong motivations for this type of searches, they are to be actively pursued at the next period of LHC's data taking at a center of mass energy of 13 TeV.

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