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Search for pair produced top squarks decaying into a charm quark and the lightest neutralinos in pp collisions at 8 TeV with the ATLAS detector at the LHC*

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Searches for direct scalar top production in the decay channel $\tilde{t} \to c + \tilde{\chi}_1^0$ using 20.3 fb^{-1} of proton-proton collisions at $\sqrt{s} = 8$ TeV recorded by the ATLAS experiment at the LHC are presented. The analysis is carried out in different signal regions according to the final state jet multiplicity. One of the regions uses charm-flavour identification to increase the signal purity. No excess above the Standard Model background expectation is observed. Limits are set on the visible cross-section of new physics within the requirements of the search. The results are interpreted in the context of direct pair production of top squarks and presented in terms of exclusion limits in the $m_{\tilde{t}} - m_{\tilde{\chi}_1^0}$ mass plane. A top squark mass of 200 GeV is excluded at 95% confidence level for $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} < 85$ GeV. Top squark masses up to 230 GeV are excluded for a neutralino mass of 200 GeV.

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Supersymmetry (SUSY) is a theoretical favoured model for physics beyond the Standard Model (BSM) which naturally solves the hierarchy problem and provides a possible candidate for dark matter in the Universe. In scenarios for which $\Delta m = m_{\tilde{t}} - m_{\tilde{\chi}_1^0} < m_b + m_W$, the stop decay into a charm quark and the lightest supersymmetric particle, the neutralino $\tilde{\chi}_1^0$, may be the dominant decay process, $\tilde{t} \rightarrow c + \tilde{\chi}_1^0$. Depending on Δm, two different approaches to search for stop pair are followed: For small Δm, the transverse momenta of the two charm jets is too low to be reconstructed. Therefore, a monojet analysis strategy is followed, making use of the presence of initial-state radiation jets to identify signal events with an energetic jet. On the other hand, for moderate Δm the charm jets receive a large enough boost to be detected. Thus, charm tagging is used to enhance the SUSY signal.

The data sample used in this note [1] was collected with the ATLAS detector [2] in the LHC [3], and corresponds to a total integrated luminosity of 20.3 fb^{-1}. The events are collected using an inclusive $E_{\mathrm{T}}^{\mathrm{miss}}$ trigger and further required to have a reconstructed primary vertex with at least two associated tracks. Requirements on the fraction of the transverse momentum, p_{T}, of the jet carried by charged tracks, the fraction of the jet energy contained in the electromagnetic layers of the calorimeter and the η range [1] suppress jets produced by cosmic rays or beam-background muons. In order to reject events coming from the production of W or Z bosons in association with jets, the events are required to have no electrons or muons in the final state. No more than three jets with $p_{\mathrm{T}} > 30$ GeV and $|\eta| < 2.8$ are allowed for the monojet-like approach, while more than three jets with $p_{\mathrm{T}} > 30$ GeV and $|\eta| < 2.5$ are required for the charm-tagged selection. In order to suppress multijet events, the direction of the $E_{\mathrm{T}}^{\mathrm{miss}}$ of the event is required to be well separated from each jet, $\Delta\phi(E_{\mathrm{T}}^{\mathrm{miss}}, p_{\mathrm{T}}) > 0.4$. Different tagging approaches are applied to the different jets in the charm-tagged selection. Since the leading jet tends to be an ISR jet both for signal and background, no tagging requirement is applied. The second and third leading-jets are required to have a loose charm-tag and the fourth leading jet is required to pass a tighter charm-tagging requirement.

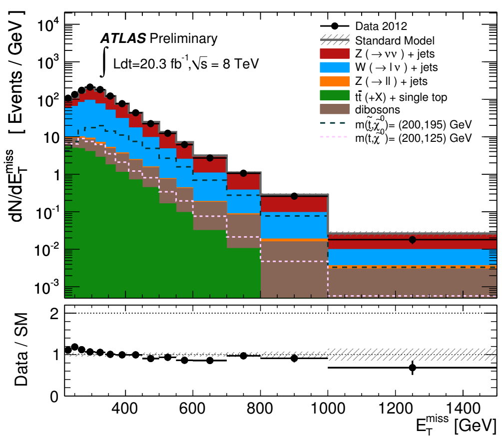

Figure 1: Measured $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution for the monojet-like selection compared to the SM predictions.

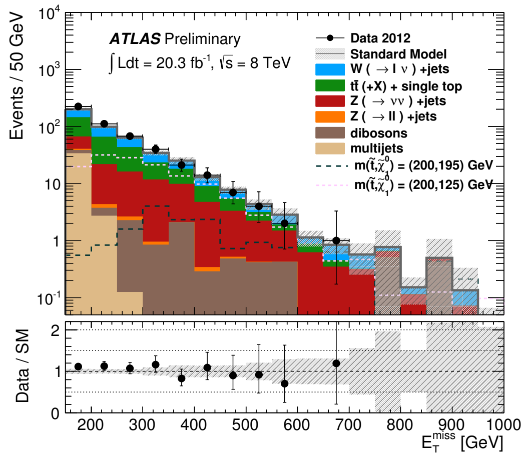

Figure 2: Measured $E_{\mathrm{T}}^{\mathrm{miss}}$for the charm-tagged selection compared to the SM predictions.

The Standard Model background contributions are dominated by the production of Z and W

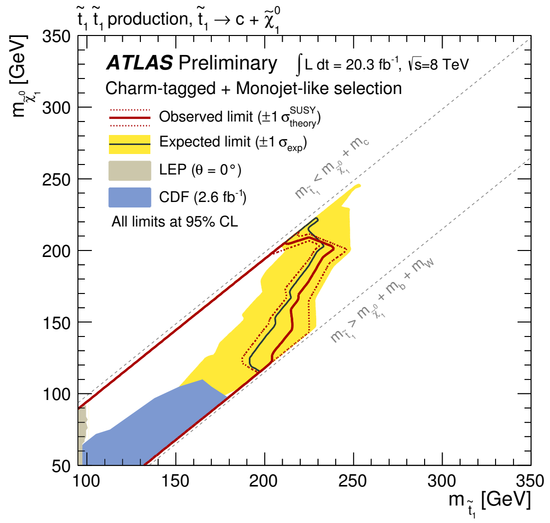

Figure 3: Exclusion plane at 95% C.L. as a function of $\tilde{t}$ and $\tilde{\chi}_1^0$ masses. The observed (red line) and expected (black line) upper limits from this analysis are compared to previous results from LEP and Tevatron experiments. The dotted lines around the observed limit indicate the range of observed limits corresponding to $\pm 1\sigma$ variations on the NLO SUSY cross section predictions. The shaded area around the expected limit indicates the expected $\pm 1\sigma$ ranges of limits in the absence of a signal.

bosons in association with jets. Its contribution to the total background is 94% and 63% for the monojet-like and charm-tagged analyses, respectively. The $W/Z+$jets backgrounds are normalised with dedicated control regions in which the presence of leptons is required. On the other hand, the top quark background in the charm-tagged analysis is estimated in a separate control region. Its contribution to the total background is 24%. In the case of the monojet-like analysis, the top quark production process is small (about 2%) and is entirely determined from MC. Other processes are considered, for example the diboson whose contribution to the total background is 3% and 7% for the monojet-like and charm-tagged analyses, respectively, and is determined from MC. The multi jet background is also considered and it is estimated in a data-driven way in both approaches. It constitutes less than 1% of the total background in the monojet-like selection and it is negligible in the charm-tagged case. Finally, the non-collision background is estimated in a data-driven way and it is found to be negligible in both selections.

Different sources of systematic uncertainties are considered in the analysis: the absolute jet p_{T} and the $E_{\mathrm{T}}^{\mathrm{miss}}$ energy scale and resolution, the pileup corrections, the lepton identification efficiencies, the modelling of parton showers and hadronization in the simulation, the jet tagging efficiencies (only in the c-tagged analysis), and the uncertainties on the control samples used to constrain the $W/Z+$jets contributions. This leads to a total systematic uncertainty of 3.2% for the monojet-like analysis and a 24% uncertainty for the c-tagged analysis. Figures 1 and 2 show the distributions of the $E_{\mathrm{T}}^{\mathrm{miss}}$ in the monojet-like and c-tagged signal regions. Good agreement is observed between the data and the Standard Model prediction.

The results are translated into 95% CL limits on the SUSY stop pair production as a function of the stop mass for different neutralino masses. Experimental uncertainties on the signal vary between 2% and 10% in the monojet-like selection, and between 8% and 29% in the charm-tagged selection, depending on the stop and neutralino masses. Theoretical uncertainties vary between 14% and 16%. Masses for the stop up to 200 GeV are excluded at 95% CL for arbitrary neutralino masses, while for neutralino masses of about 200 GeV, stop masses below 230 GeV are excluded at 95% CL.

References

[1] ATLAS Collaboration, ATLAS-CONF-2013-068, http://cds.cern.ch/record/1562880/

[2] ATLAS Collaboration, 2008 JINST 3 S08003

[3] L. Evans and P. Bryant (editors) 2008 JINST 3 S08001