Search for a heavy top partner decaying in $bff\prime\chi_1^0$ in final states with two leptons in proton proton collisions data collected at 13 TeV centre of mass energy

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Supersimmetry models with light partners of the top quark (top squarks or stops, $\tilde{t}$) are well motivated since they limit the dominant correction to the Higgs boson mass and thus preserve naturalness. Mass splittings $\tilde{t} - \chi_1^0$ of 1530 GeV seem preferred since they would lead to the right cosmological abundance of dark matter due to $\tilde{t}-\chi_1^0$ annihilation. For mass differences below the W-boson mass top squarks could decay either via a two-body ($\tilde{t} \to \chi_1^0$) or a four-body $\tilde{t} \to bff\prime\chi_1^0$, where $ff\prime$ represents a pair of quarks or leptons) decay with branching ratios depending on details of the model. The analysis strategy based on the presence of an ISR jet has been used to search for both decay modes by ATLAS and CMS. However, the CMS experiment[1], searching for events with the presence of a high-momentum jet from initial state radiation, high missing energy, and a low-momentum muon, either as the only lepton in the event or accompanied by an electron or muon of the opposite charge, has reached a better sensitivity for the four-body decay mode with respect to what published by ATLAS[2].

For this motivation, a new analysis on the data collected in the LHC RunII at 13 TeV centre of mass energy is on-going, targeting for the International Conference on High Energy Physics (ICHEP 2016) and searching for $\tilde{t}\tilde{t}$ production with subsequent four-body decays in events with a high p_T jet, E_T^{miss} and two soft leptons, corresponding to signal events with leptonic decays of two virtual W bosons. The two leptons (electrons or muons) must have opposite charge, and a high-momentum jet compatible with the ISR signature has to be find in the event, together with at most one additional jet of moderate to high p_T, no hard leptons, and a significant amount of E_T^{miss}. The dominant Standard Mode backgrounds to this search are: pair production of top quarks, W+jets or Z/γ+jets production, and diboson production. The contributions of these background will be estimated by using several control regions in data to correct the Monte Carlo predictions.

Muons and electrons will be required to have p_T above 6 and 7 GeV, respectively. Standard loose identification requirements will be applied to reduce the background from non-prompt leptons produced in semileptonic hadron decays, and from jets showing a lepton signature. Further background reduction will be achieved by requiring the leptons to be isolated.

The signal simulation for $\tilde{t}\tilde{t}$ production with up to two additional jets has been done with MadGraph[3], while the four-body decays, hadronization and showering have been performed by PYTHIA[4]. Top squarks with masses between 260 and 400 GeV have been generated, with differences between the stop and the first neutralino χ_1^0 masses in the range 10-80 GeV, for a total number of $\sim$ 1.5 million of events already filtered requiring $E_T^{miss} > 100\ GeV$ and 2 leptons with $p_T > 3\ GeV$. Both the filter decision and the numbers of simulated events to be requested to the central ATLAS Monte Carlo production required a careful study of the analysis efficiencies and needs. In Fig. 1 the generated grid is shown,where all signal points are represented by the blue diamonds. Benchmark points are the ones used to test the analysis sensitivity. In Fig. 2 and in Fig. 3 the E_T^{miss} and lepton p_T distributions in events generated for the signal point $m(\tilde{t}) = 300\ GeV$ and $m(\chi_1^0) = 220\ GeV$ are shown. The modelling of the detector response will be performed with the ATLAS fast simulation program. The selection on E_T^{miss} and on p_T of the ISR jet candidate will be set to be greater than 200 GeV and 150 GeV, respectively, above the trigger thresholds on data. Given the low p_T request on leptons, trigger signatures based on E_T^{miss} will be used.

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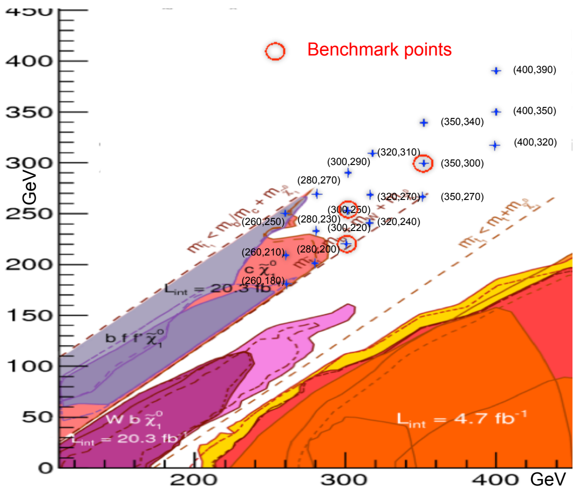

Figure 1. Generated grid of signal points (blue diamonds) for $\tilde{t}\tilde{t}$ production and decay in $bff\prime\chi_1^0$. Benchmark points are the ones used to test the analysis sensitivity.

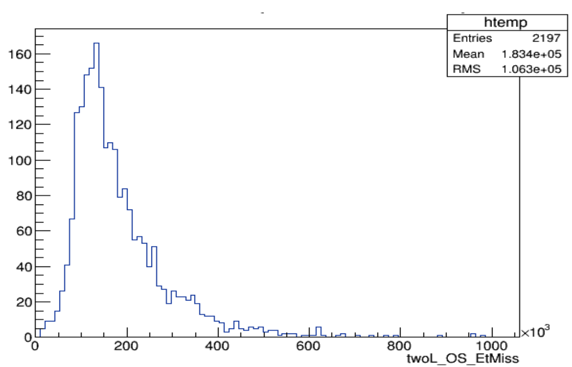

Figure 2. E_T^{miss} distribution in generated events of $\tilde{t}\tilde{t}$ production and decay in $bff\prime\chi_1^0$ in final states with two leptons, for the signal point $m(\tilde{t}) = 300\ GeV$ and $m(\chi_1^0) = 220\ GeV$.

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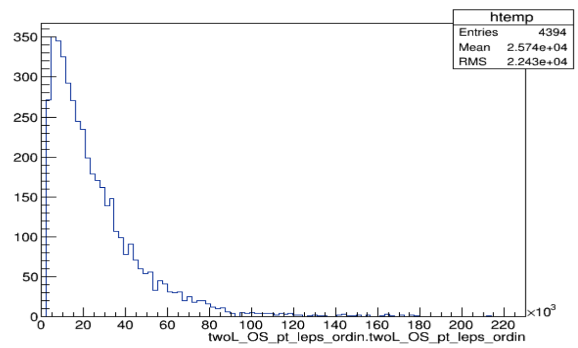

Figure 3. Lepton p_T distribution in generated events of $\tilde{t}\tilde{t}$ production and decay in $bff\prime\chi_1^0$ in final states with two leptons, for the signal point $m(\tilde{t}) = 300\ GeV$ and $m(\chi_1^0) = 220\ GeV$.