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Light stop cornered

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Summary. — Electro-weak scale supersymmetry (SUSY) is the most promising extension of the Standard Model, allowing the solution of the naturalness problem and offering a dark matter candidate. Within this scenario the search for the top quark supersymmetric partner, the stop, plays a key role. Despite the fact that ATLAS analyses have excluded large portions of the stop phase space, there are uncovered corners at low mass that may hide a light stop. Several ATLAS searches are actually addressing these regions. These new results, obtained using the complete 2012 statistics from the Large Hadron Collider (LHC) operating at $\sqrt{s} = 8\,\text{TeV}$, will be presented.

1. – Introduction

In a broken supersymmetric theory the mass scale of SUSY partners is undetermined. However a constraint on the sparticle masses can be defined requiring a small Higgs boson mass fine-tuning. This request leads to a minimal light SUSY spectrum containing the superpartners of the top quark ($\tilde{t}_1$ and $\tilde{t}_2$), the left-handed sbottom $\tilde{b}_L$, the gluinos and the Higgsinos (fig. 1 left). Despite the large effort from ATLAS [1] and CMS [2] experiments at the LHC, no signals of new physics beyond the Standard Model have been found yet. Sparticles could be within the LHC reach but have low couplings or branching ratio, otherwise SUSY particles could be abundantly produced but with a kinematic very similar to a major background or with complex decays. Several ATLAS searches recently focus on the uncovered corners at low mass in fig. 1 (right), as the three analyses reported in the following.

2. – Light stop searches

2˙1. *Spin correlation measurements.* – Since top squarks have zero spin, it is possible to discriminate between top pair production and $\tilde{t}_1\tilde{t}_1$ events measuring angular correlations

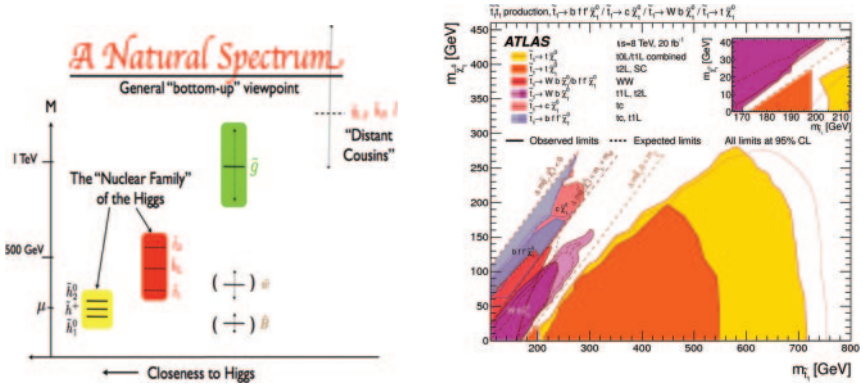

Fig. 1. – Minimal supersymmetric spectrum [3] (left plot). Summary of the 95% CL exclusion limits in the $m(\tilde{t}_1)$, $m(\tilde{\chi}_1^0)$ plane for various ATLAS analyses [4] (right plot).

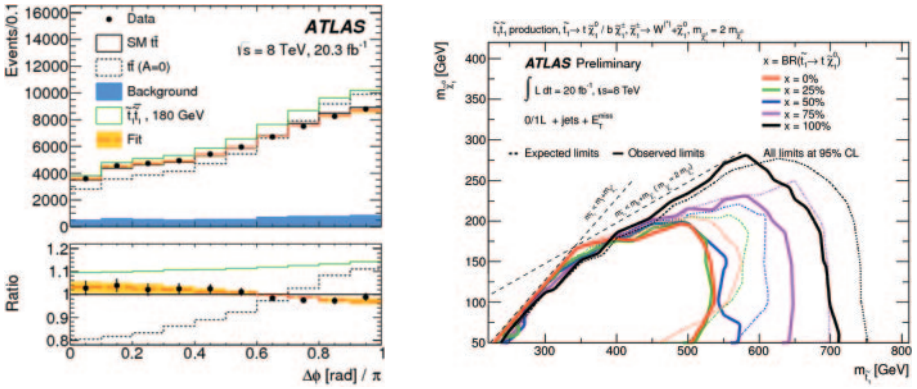

Fig. 2. – $\Delta\phi(l^+, l^-)$ distribution for experimental data, background only, background fit to data and signal predictions [5] (left plot). Combined exclusion limits assuming the decay $\tilde{t} \to t\tilde{\chi}_1^0$ with branching ratio x and $\tilde{t} \to t\tilde{\chi}_1^\pm$ with BR $1-x$ i the scenario $m_{\tilde{\chi}_1^\pm} = 2m_{\tilde{\chi}_1^0}$ [6] (right plot).

sensitive to spin difference [5]. In this analysis the correlation between the top and anti-top spins is extracted from events with 2 leptons in the final state using the difference in azimuthal angle between the two leptons. A $\tilde{t}_1\tilde{t}_1$ production with $m_{\tilde{t}_1} = 180\,\text{GeV}$ decaying to the top quark and the neutralino ($m_{\tilde{\chi}_1^0} = 1\,\text{GeV}$, supposed to be the lightest supersymmetric particle) has been simulated and compared to experimental data, as showed in fig. 2 (left) for the $\Delta\phi(l^+, l^-)$ distribution. Stop squarks with masses between the top quark mass and 191 GeV are excluded at 95% confidence level.

2˙2. *WW-like analysis.* – This analysis [4] addresses the stop pair production and subsequent decay into a final state with two different flavour leptons. The first scenario, similar to the WW production, focuses on the decay $\tilde{t}_1 \to b + \tilde{\chi}_1^\pm$ with a stop mass $\simeq 200\,\text{GeV}$, approximately degenerate with the chargino. This final state kinematics is very similar to the 3-body $\tilde{t}_1 \to b + W + \tilde{\chi}_1^0$ and 4-body $\tilde{t}_1 \to b + l + \nu + \tilde{\chi}_1^0$ stop decays. The results of this search, reported in fig. 1 (right), gives a good coverage of the interface region between the 3-body and 4-body decays up to 200 GeV.

2˙3. *Branching-Ratio–dependent limits*. – The statistical combination between the stop pair production decaying in fully hadronic final states and final states containing one lepton is proposed in [6]. The first scenario considers the decay $\tilde{t}_1 \to \tilde{\chi}_1^0 + t$ with $m_{\tilde{t}_1} < 400\,\text{GeV}$ and $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} < 250\,\text{GeV}$. A second scenario addresses the mixed decay of the stop in $\tilde{\chi}_1^0 + t$ with branching ratio x or $\tilde{\chi}_1^\pm + b$ with branching ratio $1 - x$. The expected and observed 95% CL exclusion limits are reported in fig. 2 (right) for the various x values considered.

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