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Multitop final states at the LHC

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Summary. — We briefly review a non-standard version of the MSSM whose phenomenology leads naturally to the study of multitop final states. Then we discuss a promising strategy to detect such final states in the early running of the LHC.

PACS `12.60.Jv` – Supersymmetric models.
PACS `14.65.Ha` – Top quarks.
PACS `13.85.Qk` – Inclusive production with identified leptons, photons, or other nonhadronic particles.
PACS `13.85.Ni` – Inclusive production with identified hadrons.

1. – A slightly uncommon SUSY spectrum

The large Yukawa couplings in the third generation of quarks may hide new physics that will manifest itself in top-rich signatures at the LHC.

It is not hard to introduce a specific model to back up this statement. If we start with a generic MSSM scenario, we can end up with a striking signature containing up to four top quarks rather easily, in particular if we invoke naturalness to constrain the s-particles spectrum.

Following [1] and [2] we take the μ parameter in the MSSM Lagrangian between 100 and 200 GeV, enough to evade the LEP bound on the chargino mass. The third generation squarks are constrained by the LEP2 bound on the Higgs boson mass and by naturalness. Their preferred mass range is around a few hundreds of GeVs. If we turn to the gluino, on the one hand the running of the squark masses favours a light gluino, because of its two-loop contribution that could drive them negative. On the other, FCNC constraints (mainly gluino-sbottom exchanges in $\Delta F = 2$ transitions) point to a heavier range for its mass. So we find it convenient to assume a gluino mass between 400 GeV and 1 TeV. The squarks of the first two generations can be as heavy as 2–3 TeV without endangering naturalness. Furthermore the lightest sfermions are higgsino-like, with masses in the neighbour of μ.

A simplified phenomenology of this model involves a single production mechanism $pp \to \tilde{g}\tilde{g}$ and a decay chain with two possible final states: $\tilde{g} \to t\bar{t}\chi^0$ and $\tilde{g} \to t\bar{b}\chi^-$. The two branching ratios will depend in general on the stop and sbottom masses, for

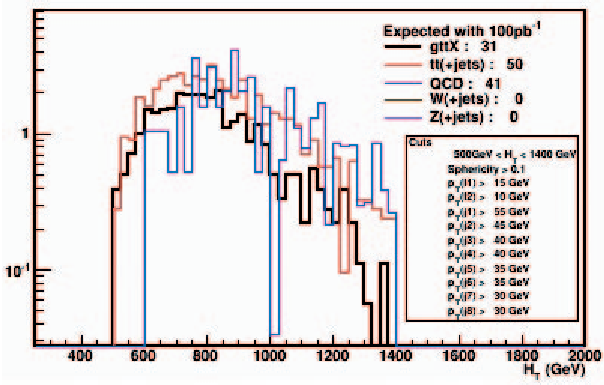

Fig. 1. – Expected events, with $L = 100\,\text{pb}^{-1}$, in H_T bins, for the signal $\tilde{g}\tilde{g} \to t\bar{t}t\bar{t}\chi^0\chi^0$ (in black) and the backgrounds: QCD, W+jets, Z+jets and $\bar{t}t$+jets, after the selection criteria indicated in the legend. Note that the first two p_T cuts pertain to the leptons while the other eight to the jets.

a detailed discussion we refer to [1]. We have neglected $\tilde{g} \to b\bar{b}\chi^0$, because it is highly suppressed with respect to the other two decay modes, since $\tilde{b} \to b\chi^0 \sim (m_b/m_t)\tan\beta$.

We are now ready to attack the experimental problem directly and we will do so by studying the case in which both gluinos decay to two tops all the time.

2. – A preliminary analysis

The signal, that we have generated with PYTHIA8 [3], is characterized by $m_{\tilde{g}} = 450\,\text{GeV}$, $m_{\tilde{t}_1} = 600\,\text{GeV}$ and $m_{\chi^0} = 100\,\text{GeV}$. The production cross section for this value of the gluino mass is $\sigma \sim 2.2\,\text{pb}$.

The big enemy is, as usual, generic QCD with a substantial help from $t\bar{t}$+jets events. We have generated the background with MADGRAPH [4], using for the QCD sample six hard partons in the initial state and including also heavy flavours.

The strategy is to get rid of the dominant dijet background with cascade cuts on up to eight of the jets p_T (see fig. 1). We also take advantage of the large H_T (the scalar sum of all the E_T in the event) of the signal and of the semileptonic top decays, requiring the presence of two same sign leptons. In this way, as can be seen in fig. 1, we are already sensitive to the signal with 100 pb^{-1}.

The main drawback of this kind of analysis is the impossibility to estimate systematic uncertainties at this stage.

In this paper we have just pointed out a direction which we find interesting to explore and which we will further study in a future paper.

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[4] `http://madgraph.hep.uiuc.edu/`.