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Inclusive search for supersymmetry using razor variables in pp collisions at $\sqrt{s} = 13$ TeV

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An inclusive search for supersymmetry using razor variables is performed in events with four or more jets and no more than one lepton. The results are based on a sample of proton-proton collisions corresponding to an integrated luminosity of 2.3 fb^{-1} collected with the CMS experiment at a center-of-mass energy of $\sqrt{s} = 13$ TeV. No significant excess over the background prediction is observed in data, and 95% confidence level exclusion limits are placed on the masses of new heavy particles in a variety of simplified models. Assuming that pair-produced gluinos decay only via three-body processes involving third-generation quarks plus a neutralino, and that the neutralino is the lightest supersymmetric particle with a mass of 200 GeV, gluino masses below 1.6 TeV are excluded for any branching fractions for the individual gluino decay modes. For some specific decay mode scenarios, gluino masses up to 1.65 TeV are excluded. For decays to first- and second-generation quarks and a neutralino with a mass of 200 GeV, gluinos with masses up to 1.4 TeV are excluded. Pair production of top squarks decaying to a top quark and a neutralino with a mass of 100 GeV is excluded for top squark masses up to 750 GeV.

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I. INTRODUCTION

Supersymmetry (SUSY) is a proposed extended space-time symmetry that introduces a bosonic (fermionic) partner for every fermion (boson) in the standard model (SM) [1–9]. Supersymmetric extensions of the SM are particularly compelling because they yield solutions to the gauge hierarchy problem without the need for large fine-tuning of fundamental parameters [10–15], exhibit gauge coupling unification [16–21], and can provide weakly interacting particle candidates for dark matter [22,23]. For SUSY to provide a "natural" solution to the gauge hierarchy problem, the three Higgsinos, two neutral and one charged, must be light, and two top squarks, one bottom squark, and the gluino must have masses below a few TeV, making them potentially accessible at the CERN LHC. Previous searches for SUSY by the CMS [24–30] and ATLAS [31–37] collaborations have probed SUSY particle masses near the TeV scale, and the increase in the center-of-mass energy of the LHC from 8 to 13 TeV provides an opportunity to significantly extend the sensitivity to higher SUSY particle masses [38–51].

In R-parity [52] conserving SUSY scenarios, the lightest SUSY particle (LSP) is stable and assumed to be weakly interacting. For many of these models, the experimental signatures at the LHC are characterized by an abundance of jets and a large transverse momentum imbalance, but the exact form of the final state can vary significantly, depending on the values of the unconstrained model parameters. To ensure sensitivity to a broad range of SUSY parameter space, we adopt an inclusive search strategy, categorizing events according to the number of identified leptons and b-tagged jets. The razor kinematic variables M_{R} and R^2 [53,54] are used as search variables and are generically sensitive to pair production of massive particles with subsequent direct or cascading decays to weakly interacting stable particles. Searches for SUSY and other beyond the SM phenomena using razor variables have been performed by both the CMS [53–58] and ATLAS [59,60] collaborations in the past.

We interpret the results of the inclusive search using simplified SUSY scenarios for pair production of gluinos and top squarks. First, we consider models in which the gluino undergoes three-body decay, either to a bottom or top quark-antiquark pair and the lightest neutralino $\tilde{\chi}_1^0$, assumed to be the lightest SUSY particle, or to a bottom quark (antiquark), a top antiquark (quark), and the lightest chargino $\tilde{\chi}_1^{\pm}$, assumed to be the next-to-lightest SUSY particle (NLSP). The NLSP is assumed to have a mass that is 5 GeV larger than the mass of the LSP, motivated by the fact that in many natural SUSY scenarios the lightest chargino and the two lightest neutralinos are Higgsino-like and quasidegenerate [61]. The NLSP decays to an LSP and an off-shell W boson, the decay products of which mostly have too low momentum to be identifiable. The specific choice of the NLSP-LSP mass splitting does not have a large impact on the results of the interpretation. The full range of branching fractions to the three possible decay

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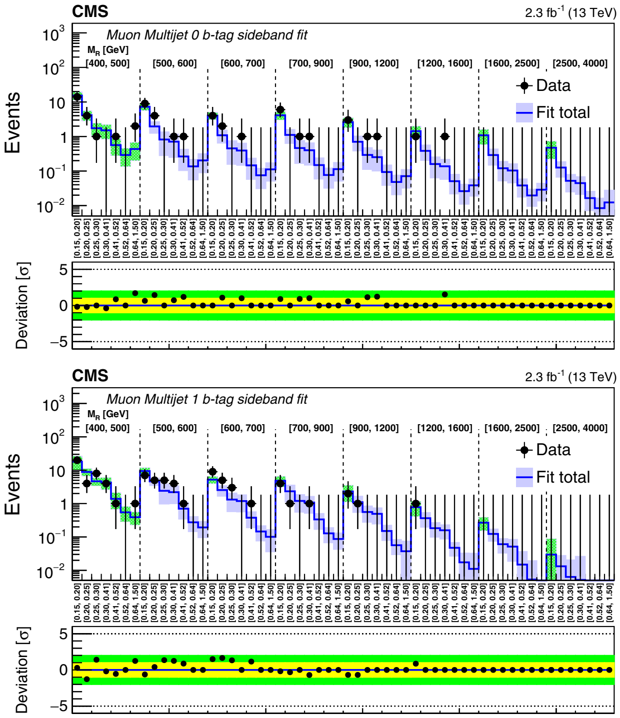

FIG. 19. Comparison of the predicted background with the observed data in bins of M_R and R^2 variables in the Muon Multijet category for the zero b-tag (upper) and 1 b-tag (lower) bins. A detailed explanation of the panels is given in the caption of Fig. 7.

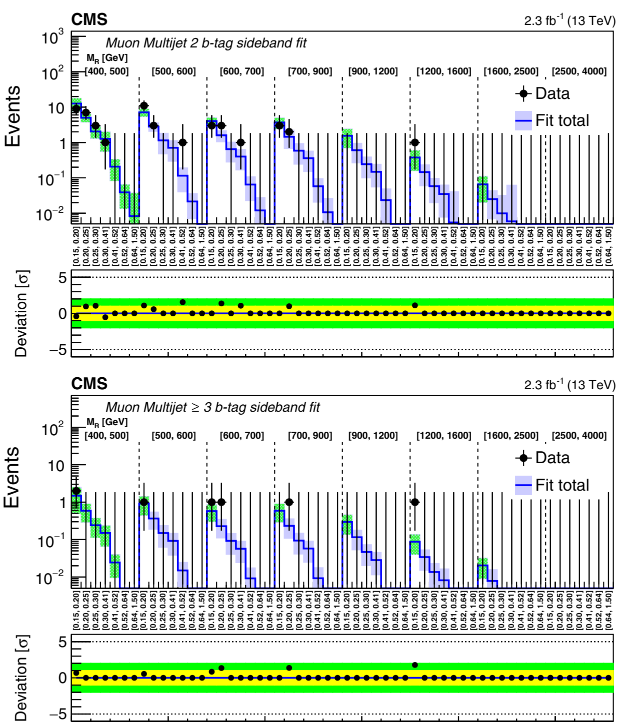

FIG. 20. Comparison of the predicted background with the observed data in bins of M_R and R^2 variables in the Muon Multijet category for the 2 b-tag (upper) and ≥ 3 b-tag (lower) bins. A detailed explanation of the panels is given in the caption of Fig. 7.

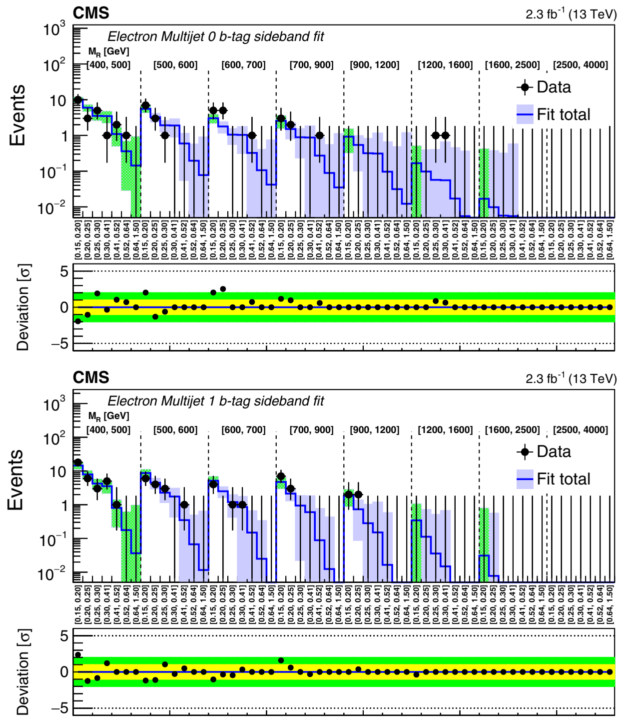

FIG. 21. Comparison of the predicted background with the observed data in bins of M_R and R^2 variables in the Electron Multijet category for the zero b-tag (upper) and 1 b-tag (lower) bins. A detailed explanation of the panels is given in the caption of Fig. 7.

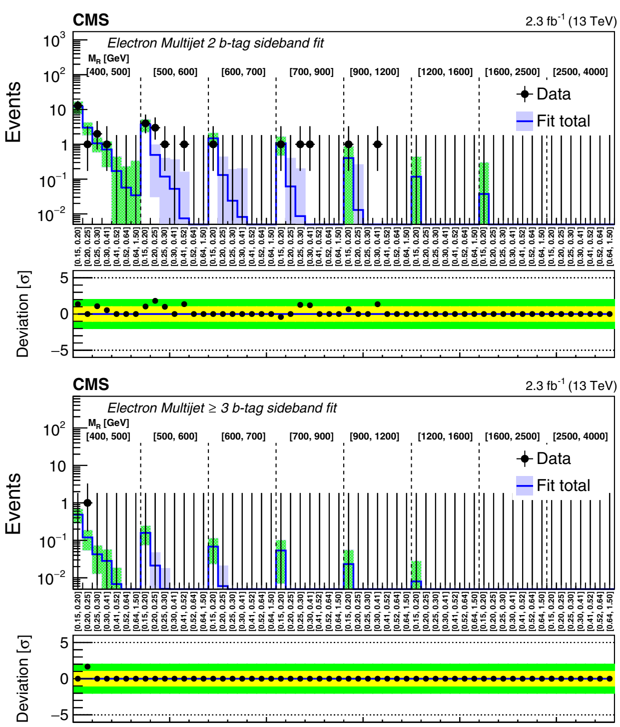

FIG. 22. Comparison of the predicted background with the observed data in bins of M_R and R^2 variables in the Electron Multijet category for the 2 b-tag (upper) and ≥ 3 b-tag (lower) bins. A detailed explanation of the panels is given in the caption of Fig. 7.

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