New flavor physics in di- and tri-lepton events from single or couple of top quark/quarks at the LHC

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Abstract

the feeblest signal of Flavor-Changing Neutral Currents (FCNC [1], [2]) effects in the top sector, either direct or indirect, may be an indicator of new flavor physics beyond the Standard Model (SM). In this research, we will look for FCNC such as $t \to u$ and $t \to c$ which are absent at tree-level in the SM. This fact has led to a lot of theoretical as well as experimental activity in understanding and searching for top FCNC within model-independent approaches, as well as within specific popular models beyond the SM.

Research Context

We will consider the di-lepton and tri-lepton signals with a pair of opposite-sign same-flavor (OSSF) leptons such as $pp \to l^+l^- + j + l^{'} + \nu$, where a selection of a single b-tagged jet is used with the last equation and, in general, $l = e, \mu$ or τ, and $l^{'} = l$ and/or $l^{'} \neq l$ can be considered in the tri-lepton channels. Indeed, the presence of two-three high p_T charged leptons and b-tagged jet allows to have an efficient trigger strategy (lepton trigger) on such final states. The main backgrounds in the SM for this analysis are top quark pair production the production of single-top quark via s- or t-channel, single-top production in association with a gauge-boson such as Z or W boson. The events used in this analysis are carried out by Monte Carlo event generators, the MADGRAPH5 [3] to simulate Matrix Elements (ME) of signal and background samples, and PYTHIA to simulate parton shower and underlying events. The final truth events are processed through DELPHES [4] which simulates the detector effects, applies simplified reconstruction algorithms to reconstruct electrons, muons and hadronic jets.

To isolate the signal events from the SM backgrounds, we can use either an inclusive di-lepton selection criteria or a tri-lepton signature with an additional

selection of a single b-tagged jet. To reduce the potential SM background to the level that it can be neglected and gain higher signal efficiency, lower cut on the di-lepton invariant mass (m_{ll}), inclusive variables like effective mass (m_{eff}) and Machine Learning weights could be applied. There is also a possibility to define separate signal regions for scalar-, vector, and tensor-like signal scenarios.

Results and Discovery Potential

In the last step, the p-value for each signal and background hypothesis need to be computed by RooFit package and then CL_s test determines the 95% confidence level (CL) exclusion values for the New Physics (NP) mass scale Λ. The discovery potential can be inferred from the expected Z-values (computed by BinomialExpZ function in RooStat); in particular $Z = 5$ corresponds to a 5σ discovery. We know from Quantum Field Theory (QFT) that the larger the quark mass, the more significant the FCNC effects (m/Λ). For this reason, searching for new FC dynamics in the top-sector was and is one of the major goals of past, current and future colliders. Any potential discovery in this project could have a huge impact on our understanding of flavor physics and the results can be used in other beyond the SM analyses.

References

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