Search for $t\bar{t}$ quark resonances with the CMS detector

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The Standard Model (SM) of elementary particles is the cornerstone of our understanding of the fundamental forces and particles that constitute the universe. It has been rigorously tested and repeatedly confirmed by numerous experiments, providing a coherent explanation for a wide range of phenomena on the smallest scales. However, the SM is not without its limitations - it does not account for gravity, dark matter, or the matter-antimatter asymmetry observed in the universe. These gaps in the theory have spurred theorists to propose various extensions to the SM, igniting a continual pursuit for new physics beyond the current paradigm.

This talk presents a search for new physics effects within the top-antitop quark invariant mass spectrum in proton-proton collisions, with data recorded by the CMS experiment. The focus is on heavy resonances decaying into top-antitop quark pairs. The analysis targets final states featuring one electron or muon, alongside missing transverse energy and a minimum of two jets. Both well-separated as well as highly collimated decay products are considered.

In addition to the primary analysis, the talk will briefly explore some of the techniques involved in jet reconstruction and classification. By analyzing the substructure of jets, insights into the identity of the mother particles can be gained. This process, known as jet tagging, is particularly valuable in studies involving jets from heavy-flavored quarks, offering a powerful tool to enhance the sensitivity of searches for new physics.

To prepare for Run 3 data analysis, an existing analysis is reproduced using the new columnar-based analysis framework `Columnflow` and the 2017 dataset, corresponding to an integrated luminosity of $41.48\,\mathrm{fb}^{-1}$. The approach involves corrections, event selection, reconstruction of the top-antitop quark pair system, a machine learning-based process classification, and a the statistical inference model, which have all been implemented in the framework.

As a proof of principle and a base for the upcoming Run 3 data analysis, the analysis is implemented and improved. Furthermore, expected limits on the production cross section times branching ratio of the production and decay of a topcolor leptophobic Z' in a mass range of $0.4\,\mathrm{TeV}$ bis $9\,\mathrm{TeV}$ at 95% confidence level are derived using Run 2 data, serving as a proof of principle for the implementation of the analysis in the new framework.