Improvement of the loose kinematic reconstruction method of $t\bar{t}$ using CMS open data

M. V. Spitsyn[1], V. E. Aushev[1], O. I. Zenaiev[1,2]

[1]Taras Shevchenko National University of Kyiv

[2]Hamburg University

This report presents the results of improving the loose kinematic reconstruction (LKR) method [1] for the $t\bar{t}$ quark system in the dilepton decay channel ($t\bar{t} \to l^+\nu_l b l^-\bar{\nu}_l\bar{b}$). The study uses open data from the CMS experiment collected at a centre-of-mass energy of $\sqrt{s} = 7$ TeV [2].

The standard LKR method is insufficiently kinematically constrained due to the presence of two undetected neutrinos. To solve this problem, two modifications of the algorithm were developed and implemented. The first modification, LKRv2, introduces an event veto procedure to prevent the duplication of physical objects and, like the standard version, applies an invariant mass constraint to the lepton-b-jet system ($m_{lb} < 180$ GeV). The second modification, LKRv3, replaces the assumption of equal neutrino and lepton momenta with an analytical calculation of neutrino kinematics based on transverse mass (M_T) and the hypothesis of rapidity equality ($y_{\nu\bar{\nu}} = y_{l\bar{l}}$).

The characteristics of the reconstruction methods were studied using data generated by Monte Carlo simulations (MadGraph and Pythia6 generators) [3, 4]. A comparative analysis shows that the proposed LKRv3 method significantly improves the resolution of the reconstructed variables. In particular, the integral resolution for the invariant mass of the system $t\bar{t}$ improved by 6.83%, and for the transverse momentum by 7.19% compared to the baseline method. However, there is a slight decrease in reconstruction efficiency (1–3%) due to more stringent kinematic constraints. Nevertheless, the increase in accuracy justifies this compromise.

Obtained results confirm the potential of the developed methods for accurate measurements of differential cross sections and the possibility of high-precision data analysis based on open CMS data.

Bibliography

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