Measurement of the top quark polarization and $t\bar{t}$ spin correlations using dilepton final states in proton-proton collisions at $\sqrt{s} = 13$ TeV

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Abstract

Measurements of the top quark polarization and top quark pair ($t\bar{t}$) spin correlations are presented using events containing two oppositely charged leptons ($e^+e^-$, $\mu^+\mu^-$, or $e^+\mu^-$) produced in proton-proton collisions at a center-of-mass energy of 13 TeV. The data were recorded by the CMS experiment at the LHC in 2016 and correspond to an integrated luminosity of 35.9 fb$^{-1}$. A set of parton-level normalized differential cross sections, sensitive to each of the independent coefficients of the spin-dependent parts of the $t\bar{t}$ production density matrix, is measured for the first time at 13 TeV. The measured distributions and extracted coefficients are compared with standard model predictions from simulations at next-to-leading-order (NLO) accuracy in quantum chromodynamics (QCD), and from NLO QCD calculations including electroweak corrections. All measurements are found to be consistent with the expectations of the standard model.

Introduction

The top quark is the heaviest fundamental particle. In the SM, the $t\bar{t}$ pairs are unpolarized but their spins are correlated. The top quark decays before hadronization and its spin information is transferred to its decay products. The precise measurement of polarization of top quark and its spin information provide insights for new physics searches.

EFT Interpretation

Several BSM models, such as 2HDM (e.g., SUSY), technicolor and top quark compositeness models predict an anomalous chromomagnetic dipole moment (CMDM), leading to modifications of the $t\bar{t}$ production rate and spin structure. The spin density matrix represents a powerful probe of the top quark CMDM and can be used to search for BSM phenomena.

Conclusion

The measured normalized differential cross sections and coefficients were compared with standard model predictions from simulations with next-to-leading order (NLO) accuracy in quantum chromodynamics (QCD) and from NLO QCD calculations including electroweak corrections. All of the measurements were found to be consistent with the expectations of the standard model. The normalized differential cross sections are used in fits to constrain the anomalous chromomagnetic and chromoelectric dipole moments of the top quark to $-0.24 < C_{\gamma}(A^1) < 0.67$ TeV$^{-2}$ and $-0.33 < C^\gamma_{\gamma} A^1 < 0.20$ TeV$^{-2}$, respectively, at 95% confidence level.

References

CMS-TOP-18-006
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