SEARCH FOR PRODUCTION OF A HIGGS BOSON AND A SINGLE TOP QUARK IN MULTILEPTON FINAL STATES IN pp COLLISIONS AT $\sqrt{s} = 13$ TeV

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The exciting work in high energy physics includes not only the analysis of the data taken by the experiment but also the development of detection systems. In this thesis, the results of a search for the production of a Higgs boson in association with a single top quark (tH) are presented. This process is of particular interest due to its sensitivity to the relative sign of the top-Higgs coupling and the vector bosons-Higgs coupling. The focus is on leptonic signatures provided by the $H \to WW$, $H \to \tau\tau$, and $H \to ZZ$ decay modes.

The analysis exploits final states with two same-sign leptons or three leptons and uses the 2016 data sample collected with the Compact Muon Solenoid (CMS) detector at the Large Hadron Collider from proton-proton (pp) collisions at a center of mass-energy of 13 TeV. Multivariate techniques are used to discriminate the signal from the dominant backgrounds. The analysis yields a 95% confidence level (C.L.) upper limit on the combined $tH + t\bar{t}H$ production cross section times branching ratio of 0.64 pb, with an expected limit of 0.32 pb, for a scenario with κ_t = -1.0 and κ_{V} = 1.0. Values of κ_t outside the range of -1.25 to +1.60 are excluded at 95% C.L., assuming κ_{V} = 1.0. Sensitivity to CP mixing in the Higgs sector was investigated by considering scenarios for different values of the mixing angle α_{CP}. An upper limit on the combined $tH + t\bar{t}H$ production cross section times branching ratio of 0.6 pb is set for a scenario with $\alpha_{CP} = 180°$ which corresponds to the scenario with κ_t = -1.0 and κ_{V} = 1.0.

On the detection systems side, contributions to the construction of the CMS forward pixel detector (FPix) are presented; FPix is responsible for tracking with extreme accuracy the paths of particles emerging from the pp collisions at CMS. FPix is a modular detector composed of 672 modules built using a semiautomatic pick-and-place robotic system which integrates optical tools, pattern recognition algorithms, and glue dispensing subsystems to locate the constituent module parts on the work field and glue them together with a precision of 10 μm. Fully assembled modules were tested and characterized.