

Abstract

The top quark represents an important elementary particle of the Standard Model because of its extraordinary properties. Due to its large mass, and consequently its short mean lifetime, it decays before the formation of bound states, what makes it an ideal particle for studying properties of the pseudo-bare quark and offers the possibility for precise tests of internal consistency of the Standard Model. This thesis is focused on the study of the associated production of top-antitop-quark pair and Z boson ($t\bar{t}Z$). Although this process is considered very rare in the Standard Model, the large center-of-mass energy and luminosity achieved by the Large Hadron Collider enable its precise analysis.

The first part of this thesis is devoted to the first ever differential cross section measurement of $t\bar{t}Z$ process performed on data detected by the ATLAS detector. The full dataset of Run 2 of the Large Hadron Collider operation, corresponding to integrated luminosity of 139 fb^{-1} obtained in pp collisions at center-of-mass energy of 13 TeV, is employed for measurements in $t\bar{t}Z$ decay channels featuring three or four charged leptons in the final state. The resulting distributions of the differential cross section, measured as a function of nine variables using the method of iterative Bayesian unfolding, are found to be in consistency with the Standard Model predictions.

The second part of this dissertation is focused on the inclusive cross section measurement using the same data as for the differential part, but performed in the final state with only two charged leptons from the Z boson decay. The inclusive cross section is measured by the profile likelihood fitting technique that is used for the extraction of signal strength, representing the ratio between the measured cross section and its corresponding Standard Model prediction. Only the expected signal strength using Monte Carlo simulations is measured, yielding the following result:

$$\mu_{t\bar{t}Z}^{2\ell} = 1.000_{-0.116}^{+0.124} = 1.000_{-0.089}^{+0.100}(\text{syst.}) \pm 0.074(\text{stat.}). \quad (2)$$

Keywords: top quark, Z boson, $t\bar{t}Z$, inclusive cross section, differential cross section