



Contribution ID : 650

Type : Oral talk

Recent highlights of top-quark physics with the ATLAS detector

Tuesday, 6 October 2020 11:20 (20)

Four recent measurements in different areas of top-quark physics are presented. The cross sections for the production of top-quark pairs in association to a photon ($t\bar{t}\gamma$) or to a Z boson ($t\bar{t}Z$) are measured both inclusively and differentially as a function of kinematic variables characterizing the $t\bar{t}$ +boson system. Both sets of measurements use the full Run-2 data set corresponding to 139/fb of integrated luminosity. Final states with three and four leptons and b-jets are used to extract $t\bar{t}Z$ rates, while $t\bar{t}\gamma$ cross sections are derived from final states with one photon, one electron and one muon of opposite sign and at least two jets. The measurements are compared to predictions obtained by NLO+PS Monte Carlo generators and fixed-order NLO calculations. Based on a recent analysis the ATLAS collaboration established first evidence for the hard scattering process in which two top-quark-antiquark pairs are produced. This process is also called four-top-quarks production and is predicted to have a small cross-section of 12 fb in the standard model. Candidate events are selected if a lepton pair with the same electric charge is present or if there are at least three leptons in the event. The background is mainly given by top-quark-antiquark production in association with a W boson and heavy-flavour jets. A multivariate discriminant is used to optimize the separation between signal and background events and enhance the sensitivity. Recent measurements involving B-meson decays sparked renewed interest in testing lepton universality between tau and light leptons because of observed deviations at the four-standard-deviation level. By selecting events with two opposite sign leptons (muon pairs and electron-muon pairs) and at least two b-tagged jets, a highly pure sample of top-quark pair decays is assembled and used to extract a large unbiased sample of W bosons decaying to leptons down to low transverse momenta. A fit to the two dimensional distribution for the transverse momentum and the transverse impact parameter of the lepton is then used to differentiate between leptons originating directly from the W boson and those resulting from the W-boson-to-tau-lepton decay chain. This results into the most precise measurement of the ratio of the probability for an on-shell W-boson decay to tau to the probability for its decay to muon.

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Session Classification : High Energy Physics

Track Classification : High energy physics