Title: Measurements of inclusive and differential cross sections for vector boson productions with the ATLAS detector at the LHC

Abstract: Precision measurements of the vector boson ($W^{\pm}$ and Z-bosons) properties are crucial for understanding the electroweak sector of the Standard Model. As the mediators of the weak force, such measurements provide an excellent probe of perturbative quantum chromodynamics (pQCD) and of the proton structure and may also reveal deviations from theoretical predictions, potentially indicating new physics beyond the Standard Model, for example, measuring $W^{\pm}$ and Z-boson production across various energy regimes could uncover potential contributions from new particles or interactions that are observable at higher energies but undetectable at lower energies.

In this thesis, two measurements of the $W^{\pm} \to \ell\nu$ and $Z \to \ell\ell$ (where ℓ refers to electron or muon) production cross sections are presented using two datasets collected with the ATLAS detector at the Large Hadron Collider (LHC).

The measurement of the inclusive fiducial and total $W^{\pm}$- and Z-boson production cross sections and their ratios are performed on the data collected in 2022 in proton–proton collisions at a centre-mass-of-energy of $\sqrt{s}$ =13.6 TeV, corresponding to an integrated luminosity of 29 fb^{-1}. It is the first measurement of the production rate of $W^{\pm}$ and Z-boson using LHC Run-3 data taken in 2022 at the unprecedented high energy. Moreover, the first measurement of the ratio of top–antitop quark ($t\bar{t}$) pair to $W^{\pm}$-boson production cross section using the same data sample is also performed in this study, which probe different parton densities within the proton. The measurements are compared with Standard-Model predictions calculated at next-to-next-to-leading-order (NNLO) in α_s, next-to-next-to-leading logarithmic accuracy in QCD plus next-to-leading-order (NLO) electroweak accuracy. Good agreement is observed between measured cross sections and the predictions in $W^{\pm}$ and Z cross sections whereas the $t\bar{t}$ over $W^{\pm}$ cross section ratio is slightly lower than some predictions.

The second analysis involved in this thesis is the measurement of the differential $W^{\pm} \to \ell\nu$ production cross section using the data collected in 2017 and 2018 in proton–proton collisions at centre-mass-of-energies of $\sqrt{s}$ =5.02 and 13 TeV. This datasets are taken from special runs during Run-2 at the LHC, which are also called low pile-up runs characterized by a low number of interactions per bunch crossing, $\langle\mu\rangle \sim 2$. The precise measurement on the $W^{\pm}$ differential cross sections with low systematic uncertainties improves the knowledge on the proton structure and is used to place constraints on the PDFs by performing the Hessian reweighting on the existing PDF sets, resulting in significant constraints on the quark distribution functions.