Study of electroweak production of $W(\ell\nu)Z(\ell\ell)\gamma$ events in the Run-2 and Run-3 proton-proton collision data of the ATLAS detector

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A key feature of the Standard Model (SM) of particle physics is its symmetry under $SU(2)_L \otimes U(1)_Y$ gauge transformations. This property results in the prediction of not only interactions of gauge bosons with fermions but also self-interactions between the gauge bosons. These include triple gauge couplings as well as quartic gauge couplings, whose structure and strength are fully determined by the electroweak gauge symmetry. Measurements of electroweak multiboson production therefore provide an important test of the gauge structure of the SM and offer a way to investigate possible deviations caused by physics beyond the Standard Model.

A particularly interesting process for probing the EW gauge structure is the production of $WZ\gamma$ events, since it is sensitive to the quartic coupling involving two W bosons, a Z boson, and a photon (γ), as can be seen in fig. 1. Due to this sensitivity, $WZ\gamma$ production

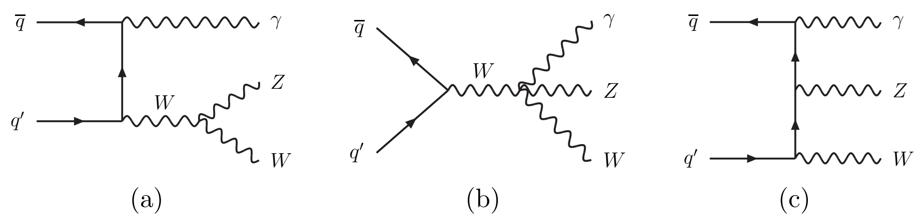

Figure 1: Feynman diagrams contributing to $WZ\gamma$ production. Figure 1b shows the diagram that is sensitive to the quartic coupling.

has been already investigated: the ATLAS experiment has observed the process in Run 2 using $140\,\text{fb}^{-1}$ of data at a center-of-mass energy of $13\,\text{TeV}$, with a significance of 6.3σ (expected 5.0σ). This measurement is limited by statistical uncertainties, primarily due to the small cross section of $WZ\gamma$ production, so the inclusion of Run 3 data is expected to significantly improve the precision of the measurement.

For that reason, my PhD project aims to measure $WZ\gamma$ production using Run 2 and Run 3 data recorded at the ATLAS detector. In addition to the fiducial cross section, a differential cross-section measurement will be performed, in which kinematic distributions sensitive to the quartic gauge coupling are probed. Possible deviations from the Standard Model are quantified using effective field theories (EFTs), where constraints are set on the Wilson coefficients of dimension-eight operators contributing to anomalous quartic gauge couplings (aQGCs), following the Eboli model. Of the 21 CP-conserving operators in this framework, 13 contribute to the $WW\gamma Z$ vertex probed in $WZ\gamma$ production. Dedicated Monte Carlo samples are produced for each of these operators in order to identify the regions of phase space with enhanced sensitivity to aQGCs.

The constraints on the Wilson coefficients that are obtained by that measurement can then be reinterpreted in the context of composite Higgs models, in which the Higgs boson is described as a composite pseudo-Goldstone boson of a new strongly interacting sector and generates deviations in the electroweak gauge boson self-couplings. In that way, the measurement of $WZ\gamma$ production allows us both to precisely test the electroweak gauge structure of the Standard Model and to probe possible new physics in the electroweak sector.