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Studies of the energy dependence of diboson polarization fractions and the Radiation Amplitude Zero effect in WZ production with the ATLAS detector

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In the standard model of particle physics, the spontaneous symmetry breaking of the complex Higgs field gives rise to the massive Higgs boson and three Goldstone bosons. These Goldstone bosons give the longitudinal degree of freedom to the W and Z bosons. This analysis studies diboson polarization states, in a phase space where the longitudinal-longitudinal contribution is enhanced, with WZ production from proton-proton collision in the ATLAS experiment of the Large Hadron Collider at $\sqrt{s} = 13$ TeV. The dominant contribution of both bosons being transversely polarized nearly vanishes at tree-level if the bosons are produced centrally, which effectively enhances the longitudinal-longitudinal WZ contribution. As high jet multiplicity skews this Radiation Amplitude Zero (RAZ) effect, only events with lower p_T^{WZ} ($< 20, 40, 70$ GeV) are selected. We measure RAZ as the depth in the central region of the distributions of the rapidity differences between the W lepton and the Z boson and between the W boson and the Z boson. A high p_T^Z cut also enhances the W_0Z_0 contribution. A BDT variable is trained to distinguish different diboson polarization states in two high p_T^Z exclusive regions: $100 < p_T^Z \leq 200$ GeV and $p_T^Z > 200$ GeV. A maximum log-likelihood fit is then executed, yielding an observation of a non-zero longitudinal-longitudinal polarization fraction (f_{00}). Notably, this analysis marks the first observations of the Radiation Amplitude Zero Effect and of the longitudinal-longitudinal WZ production in the high-p_T^Z phase space.

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