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Machine learning for polarization measurement in Vector Boson Scattering at the LHC

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Vector Boson Scattering (VBS) is a rare and complex process that occurs during high-energy proton-proton collisions at the Large Hadron Collider (LHC), observed with the ATLAS detector. Polarization, an intrinsic property related to the spin of the particles, can be observed by analyzing the characteristic of the decay products of the Vector Bosons. This plays a crucial role in better understanding the Higgs Mechanism, the longitudinal polarization is directly linked to the electroweak spontaneous symmetry breaking and arise from the mass obtained by the boson. This phenomenon is highly constrained by the Standard Model (SM), precise measurement could lead to hints of new physics beyond our current model. Machine Learning (ML), and particularly Deep Neural Networks (DNNs), enhance our ability to better handle the discrimination of this kind of process and the polarization states. The usage of high dimensional input parameters that cover various crucial aspects for the initial particles or their decay products help to probe the VBS process. Consequent Monte-Carlo generated samples are used to train those DNNs and are made to mimic the data produced at the LHC and collects by ATLAS. Those novel techniques were used to make observation of gauge boson joint-polarisation states in W^\pm Z production from pp collisions at \sqrt{s} = 13 TeV with the ATLAS detector and the very first observation of both a W and a Z boson simultaneously polarised longitudinally. This achievement also includes the measurement of joint helicity fractions and both the inclusive and differential cross sections with good agreement with the Standard Model predictions.

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