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Measuring Quantum Interference in the Off-shell Higgs to 4 Leptons by Learning the Likelihood Ratio

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The traditional methods of training a classifier to separate signal and background events for measurement of a theory parameter break down in the context of quantum interference between signal and background processes. How can we train a Machine Learning model without the concept of labels?
A first feasibility study is performed to bringing the recently developed Likelihood-free inference based Madminer methods to ATLAS for the off-shell Higgs to four leptons signal strength measurement. Advantages of this method might include an optimal method for various values of the signal strength, training without class labels, as well as the possibility to have a machine learning method be aware of certain systematic uncertainties. We show that a machine learning algorithm that is aware of the physics at the full range of the theory parameter performs better at constraining the measurement compared to an algorithm only aware of the physics near the Standard Model.

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