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Application of Quantum Machine Learning to High Energy Physics Analysis at LHC using IBM Quantum Computer Simulators and IBM Quantum Computer Hardware

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Using IBM Quantum Computer Simulators and Quantum Computer Hardware, we have successfully employed the Quantum Support Vector Machine Method (QSVM) for a ttH (H to two photons), Higgs production in association with a top quark pair analysis at the LHC.

We will present our experiences and results of a study on LHC high energy physics data analysis with IBM Quantum Computer Simulators and IBM Quantum Computer Hardware using IBM Qiskit. The work is in the context of a Qubit platform. Taking into account the limitation of a low number of qubits, the result using the Quantum Computer Simulators expressed in a ROC curve is comparable with the results using classical machine learning methods (BDT and classical SVM). This study is applied to a ttH physics analysis, one of the flagship physics channels at the LHC, with 5 qubits, 100 training events and 100 test events. Here the ROC curve is defined as the Receiver Operating Characteristics curve in the plane of background rejection versus signal efficiency.

In addition, we have employed the IBM QSVM Variational quantum machine learning algorithm using 5 qubits on the IBM Quantum Computer Hardware of 20 qubits ("IBM Boeblingen"), with 100 training events and 100 test events, again for a ttH (H to two photons) analysis at the LHC. The present result from the IBM Quantum Hardware is about 10% in performance below the Quantum Simulation.

The work is performed by an international and interdisciplinary collaboration with Department of Physics and Department of Computer Sciences of University of Wisconsin, CERN Openlab of IT Division, IBM Research Zurich and Fermilab Quantum Institute.

This work pioneers a close collaboration of academic institutions with industrial corporations in a High Energy Physics analysis effort.

Secondary track (number)

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