

# Long-lived particle Anomaly detection with parameterized quantum circuits

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We present a study on the possibility to apply quantum machine learning techniques for the detection of anomalous patterns in a typical high energy physics detector. To approach this task we propose an anomaly detection algorithm based on a parameterized quantum circuit. The algorithm has been trained on a classical computer and tested with simulations as well as on real quantum hardware. Tests on NISQ devices have been performed with IBM quantum computers. For the execution on quantum hardware some hardware driven adaptations have been implemented. The quantum anomaly detection algorithm is able to detect simple anomalies like different characters in handwritten digits as well as more complex structures, like anomalies in the particle distributions due to displaced tracks inside a typical muon detector at a collider experiment. For this latter case, while we prove that it is possible to perform anomaly detection with a quantum algorithm, the required quantum circuit is not simple enough to be executed with the quantum hardware that was available for the study. In particular we show that, due to the necessary amplitude encoding of classical data, the quantum algorithm is not able to outperform classic anomaly detection algorithms on the available quantum hardware.

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