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Applying benchmarking protocols to encoded qubits with non-Markovian errors

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An essential goal for any quantum information processing platform is to develop the tools necessary to validate high-fidelity quantum gates. This effort has produced a suite of benchmarking and tomographic protocols that have been applied to a wide variety of physical implementations. All these protocols, however, were designed with strict error assumptions that can and will be violated by physical errors, especially as we push to lower and lower error rates. In this talk we look at randomized benchmarking with encoded states (from which leakage errors may occur) in the presence of non-Markovian noise and under the influence of sequence-length dependent filtering errors. These circumstances may apply to a variety of physical systems, but are particularly pertinent for 1/f charge noise and hyperfine leakage noise in electrically controlled quantum dot qubits. We demonstrate how these errors affect the outcome of randomized benchmarking, including the signatures of said errors and the confidence with which we can report an average gate fidelity.