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Gate-set tomography and beyond

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Four years ago, there was no reliable way to characterize and debug quantum gates. Process tomography required perfectly pre-calibrated gates, while randomized benchmarking only yielded an overall error rate. Gate-set tomography (GST) emerged around 2012-13 in several variants (most notably at IBM; see PRA 87, 062119) to address this need, providing complete and calibration-free characterization of gates. At Sandia, we have pushed the capabilities of GST well beyond these initial goals. In this talk, I'll demonstrate our open web interface, show how we characterize gates with accuracy at the Heisenberg limit, discuss how we put error bars on the results, and present experimental GST estimates with $1e-5$ error bars. I'll also present preliminary results of GST on 2-qubit gates, including a brief survey of the tricks we use to make it possible. I'll conclude with an analysis of GST's limitations (e.g., it scales poorly), and the techniques under development for characterizing and debugging larger (3+ qubit) systems.