Appendix for supplementary baseline circuits

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1 Supplementary baseline circuits (SAT and 2-qubit sanity check)

When we implemented the circuits for Lights Out on IQM devices, the measured distributions were close to uniform. To contextualize this result, we include two supplementary diagnostic baselines based on Grover's Search – a small circuit for SAT and a smaller 2-qubit Grover's Search instance. These baselines test whether the effects of Grover's search are observable on IQM in the case of small circuits.
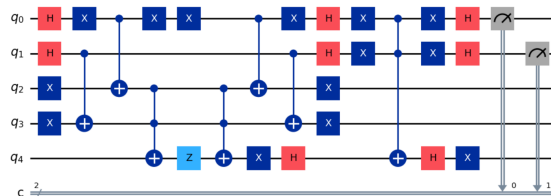

Fig. 1: Implementation of Grover's Search for a small SAT problem.

The circuit that we prepared is shown in Fig. 1. Here, q_0 and q_1 serve as the formula variables, and the SAT formula to solve is $(q_0) \wedge (\neg q_1)$. q_2 and q_3 store the calculated values for clauses, and q_4 is used to perform phase change. The expected output of the circuit is state 01 with probability 1.

In our experiments, one of the IQM devices provided output probabilities close to random output, so we decided to run an even smaller circuit with Grover's Search, just to verify that everything works properly (see Fig. 2). The circuit uses just two qubits and has only two two-qubit operations. The expected output is state 10 with probability 1.
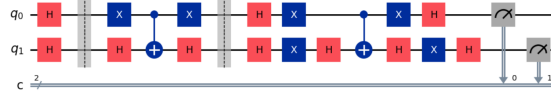
Fig. 2: Implementation of a small imitation of Grover's Search.

Table 1: Measured output distributions (1000 `shots` each) for the SAT baseline circuit. The first line contains the number of counts for the correct state `01`, together with relative frequency, and the second line contains the remaining counts. The data is shown for Sampler mode with *optimization_level* 3 and 0.

Device	opt=3	opt=0
Emerald	**01: 409 (0.409)**	**01: 241 (0.241)**
	00: 148 10: 135 11: 308	00: 210 10: 264 11: 285
Garnet	**01: 630 (0.630)**	**01: 509 (0.509)**
	00: 105 10: 68 11: 197	00: 128 10: 190 11: 173
Sirius	**01: 258 (0.258)**	**01: 260 (0.260)**
	00: 250 10: 237 11: 255	00: 263 10: 255 11: 222

2   Results for supplementary baseline circuits (SAT and 2-qubit sanity check)

To contextualize the near-uniform Lights Out results on IQM, we summarize the results of running the SAT circuit in Table 1 and small Grover's Search circuit in Fig. 3 on IQM devices, and on IBM devices in Table 2.
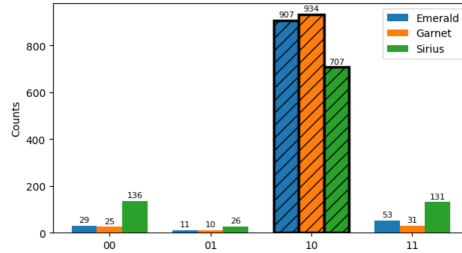

Fig. 3: Measured output distributions (1000 `shots` each) on IQM devices for supplementary diagnostic baseline 2-qubit circuit. Expected output is state `10`.

Table 2: Measured output distributions (4000 `shots` each) for the SAT baseline circuit. The first line contains the number of counts for the correct state `01`, together with relative frequency, and the second line contains the remaining counts. The data is shown for Sampler mode with *optimization_level* 3 and 0.

Device	opt=3	opt=0
ibm_marrakesh	**01: 3438 (0.860)**	**01: 1935 (0.484)**
	00: 201 10: 123 11: 238	00: 1084 10: 352 11: 629
ibm_fez	**01: 3161 (0.790)**	**01: 966 (0.242)**
	00: 310 10: 191 11: 338	00: 1791 10: 686 11: 557
ibm_torino	**01: 3339 (0.835)**	**01: 2193 (0.548)**
	00: 259 10: 157 11: 245	00: 735 10: 414 11: 658