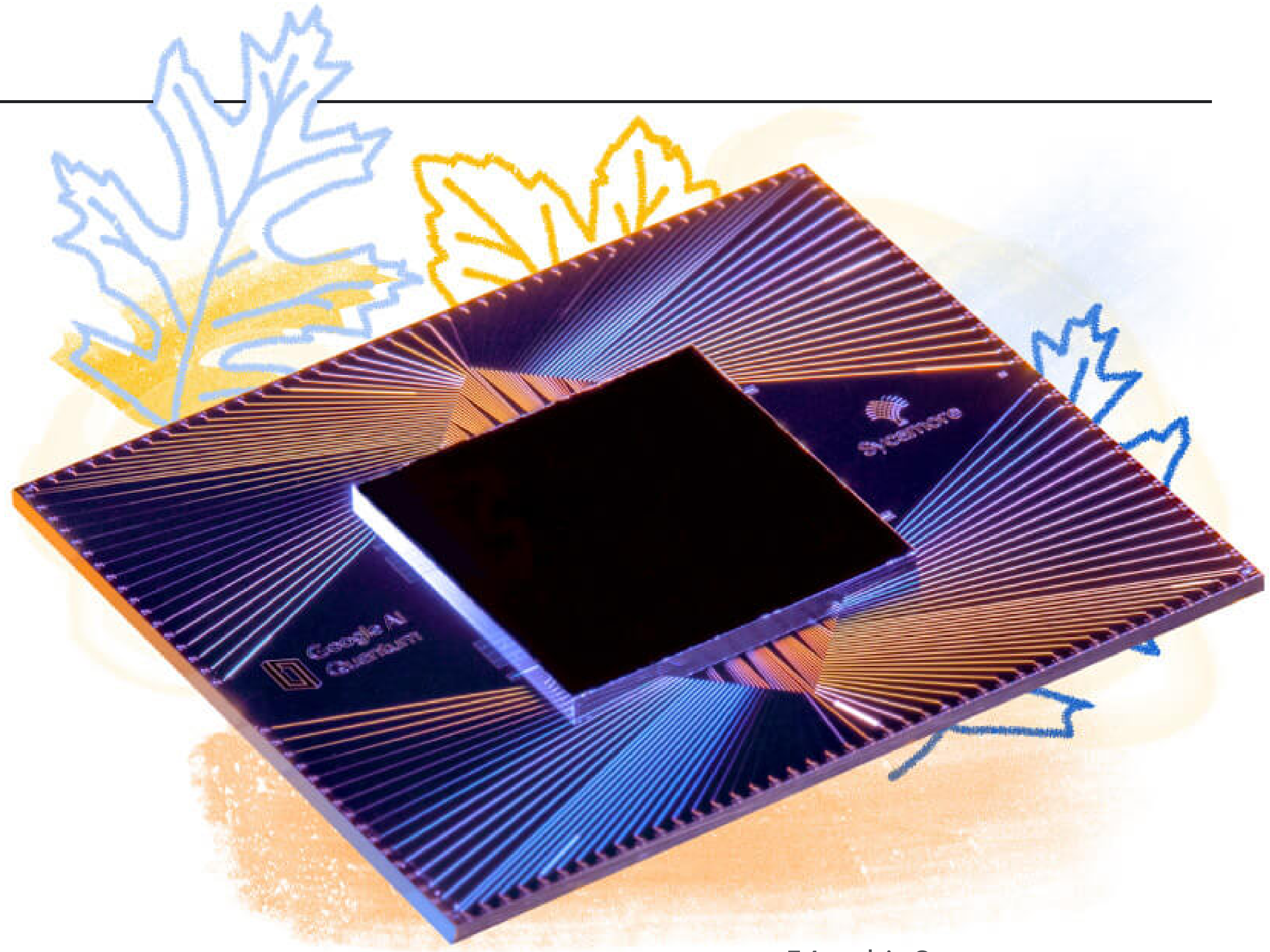
Quantum AI

Quantum Computer Datasheet

Published May 14, 2021

Description

At the core of Google's Quantum Computing Service is the Sycamore processor. It has up to 54 superconducting qubits in a square grid lattice suitable for general Noisy Intermediate Scale Quantum (NISQ) algorithms like Hartree-Fock (chemistry), QAOA (optimization), and machine learning. Standard single- and two-qubit gates are calibrated, and both individual and simultaneous readout are supported.



54-qubit Sycamore processor

Features

Qubits	Up to 54
Grid	Square lattice
Type	Universal gate-based quantum processor
User sessions	Open swim OR dedicated reservations
Single Qubit gates	Standard + arbitrary XY rotations
Two Qubit gates	$\sqrt{\text{iSWAP}}$ and Sycamore
Readout	Isolated or simultaneous
Repetition Rate	1-5 kHz typically, up to 15 kHz

General Service Specifications

Qubit Operations

Type	Gate	Duration[1]	Matrix
Single Qubit Gates	Phased XZ	25 ns	$\begin{bmatrix} \cos(\pi x/2) & -i\sin(\pi x/2)e^{i\pi a} \\ -i\sin(\pi x/2)e^{i\pi(a+z)} & \cos(\pi x/2)e^{i\pi z} \end{bmatrix}$
	Virtual Z	0 ns	$\begin{bmatrix} 1 & 0 \\ 0 & e^{i\pi t} \end{bmatrix}$
	Physical Z	20 ns	$\begin{bmatrix} 1 & 0 \\ 0 & e^{i\pi t} \end{bmatrix}$
Two Qubit Gates	Sycamore	12 ns	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -i & 0 \\ 0 & -i & 0 & 0 \\ 0 & 0 & 0 & e^{-i\pi/6} \end{bmatrix}$
	√iSWAP	32 ns	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \pm 1/\sqrt{2} & \pm i/\sqrt{2} & 0 \\ 0 & \pm i/\sqrt{2} & \pm 1/\sqrt{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
	CZ	In development	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$

Readout

	Integration	1 μs
	Ringdown	3 μs
	Total	**4 μs**

System Timing

Type	Condition	Low[2]	Typical[3]	High[4]	Unit
Repetition Rate	Single circuit, 2k reps	0.2	0.3	0.3	kHz
	Single circuit, 20k reps	1.9	2.1	2.1	kHz
	25 sweeps, 2k reps each	1.1	1.1	1.1	kHz
	25 sweeps, 20k reps each	4.0	4.1	4.1	kHz
Latency		1.6	2.3	2.8	seconds

[1] All gates in a cirq.Moment will happen simultaneously and will have the duration of the longest gate.

[2] 10th percentile value from the combined distribution of all post-calibration characterizations of all qubits from Jan - Mar 2021

[3] Median value from the 90-day distribution of median values of all qubits from Jan - Mar 2021

[4] 90th percentile value from the combined distribution of all post-calibration characterizations of all qubits from Jan - Mar 2021

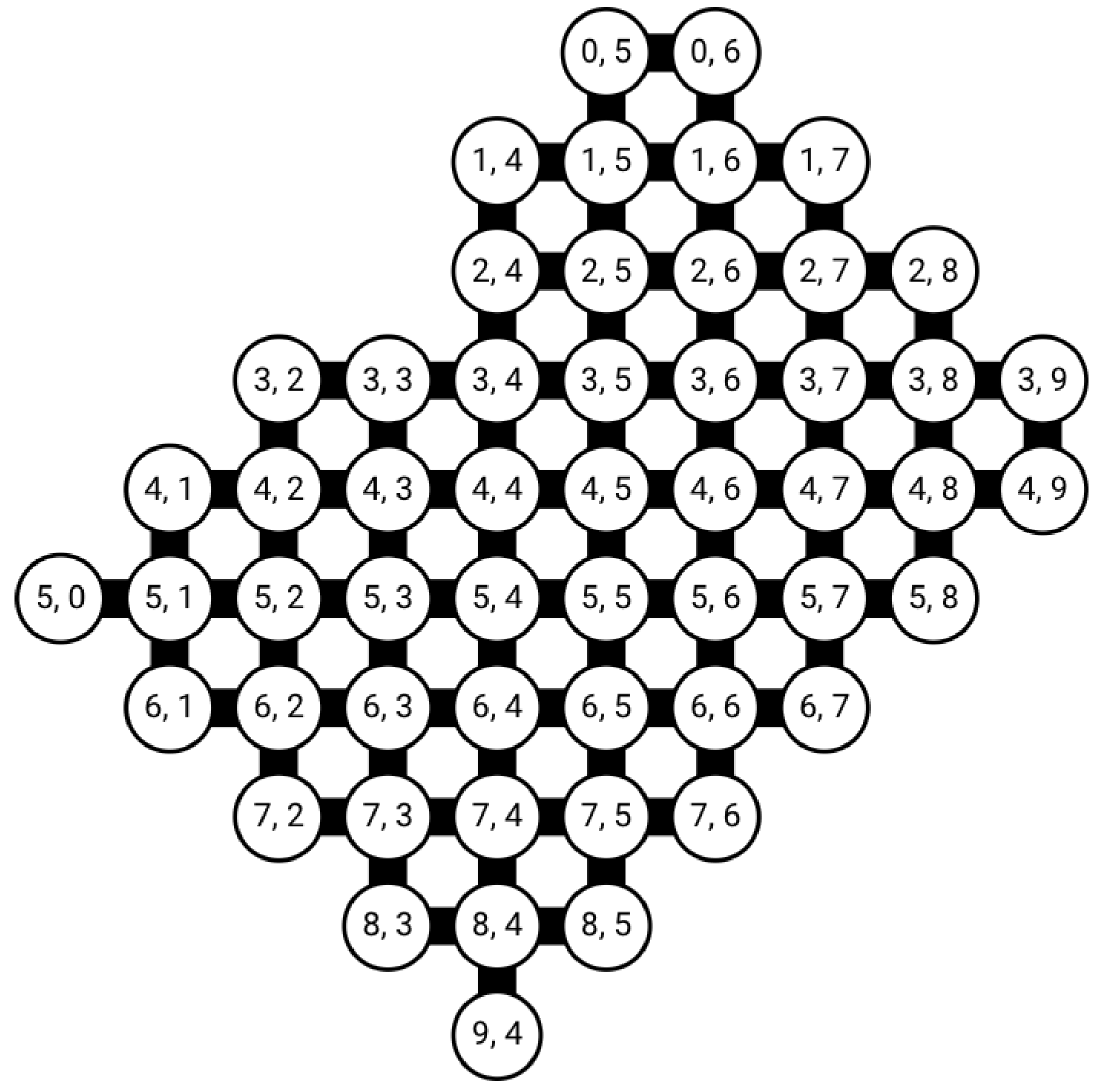
Weber Quantum Computer

Qubit Grid

processor_id	Weber
Family	Sycamore
Supported two-qubit gates	√iSWAP, Sycamore
Number of qubits in the grid	53

Qubit Layout

Example grid for Weber. Use QCS Console for up-to-date layout.



Performance

Metric	Symbol	Condition	Low [1]	Typ [2]	High [3]	Units	Description
Single-qubit gate error rate	e_1	Isolated	0.1	0.1	0.2	% error per gate	Randomized benchmarking
Two-qubit gate error rate (√iSWAP)	e_2 (√iSWAP)	Isolated	0.7	0.9	1.9	% error per gate	Cross-entropy benchmarking (XEB)
		Parallel	0.8	1.4	3.3	% error per gate	Cross-entropy benchmarking
Readout error $\lvert 0\rangle$	e_{r0}	Isolated	0.5	1.1	2.6	% error	Confusion matrix: prepare $\lvert 0\rangle$ and observe $\lvert 1\rangle$; includes state prep error
		Simultaneous	1	2	3	% error	Confusion matrix: prepare $\lvert 0\rangle$ and observe $\lvert 1\rangle$; includes state prep error
Readout error $\lvert 1\rangle$	e_{r1}	Isolated	3	5	9	% error	Confusion matrix: prepare $\lvert 1\rangle$ and observe $\lvert 0\rangle$; includes state prep error
		Simultaneous	3	7	9	% error	Confusion matrix: prepare $\lvert 1\rangle$ and observe $\lvert 0\rangle$; includes state prep error
Relaxation	T_1	Isolated	11	15	21	µs	Direct measurement of $\lvert 1\rangle$ population relaxation

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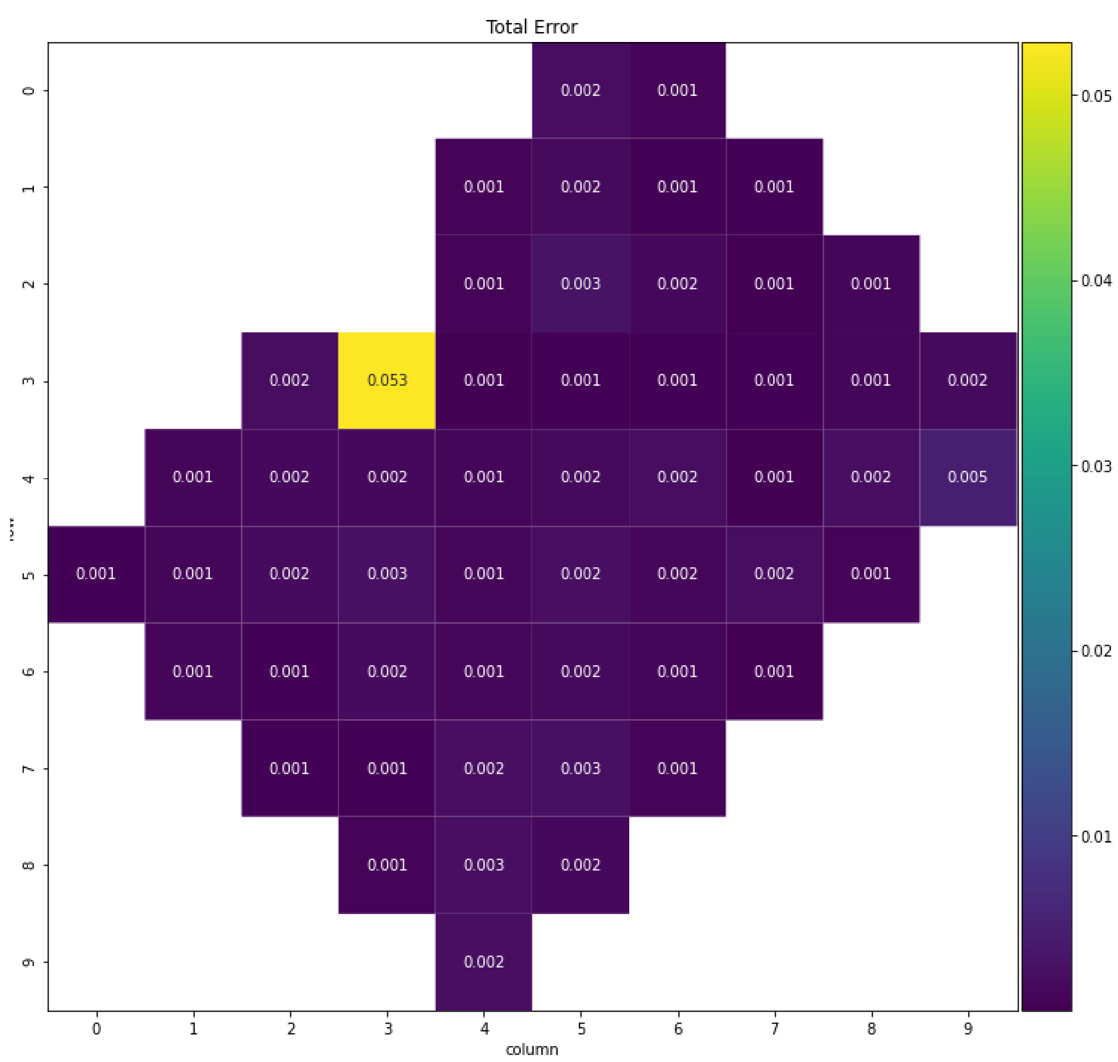
[3] 90th percentile value from the combined distribution of all post-calibration characterizations of all qubits from Jan - Mar 2021

Performance Heat Maps: Gates

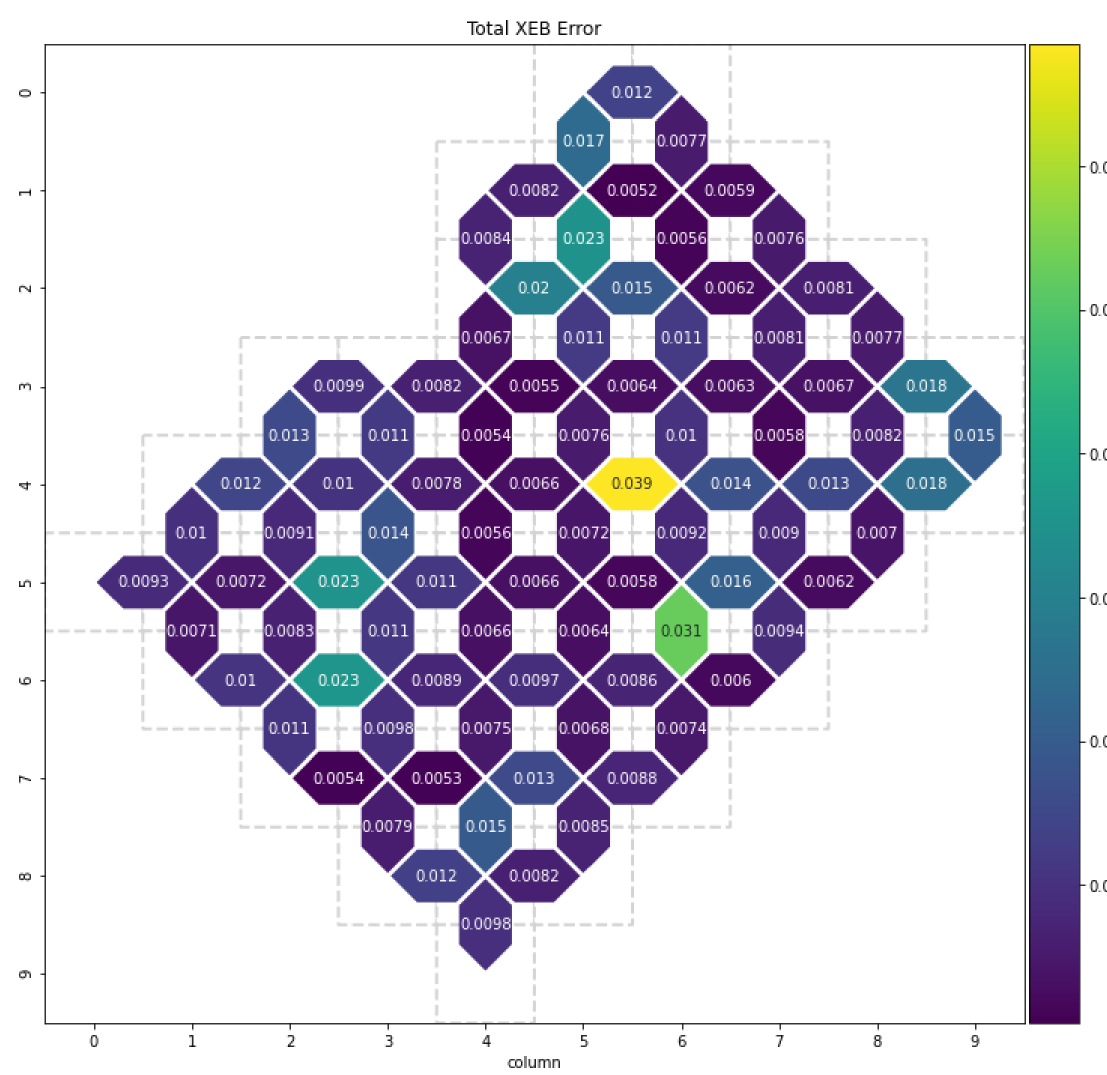
Reminder to users: check the [latest characterization report in the GCS Console](#).

Representative Characterization Metrics [1]

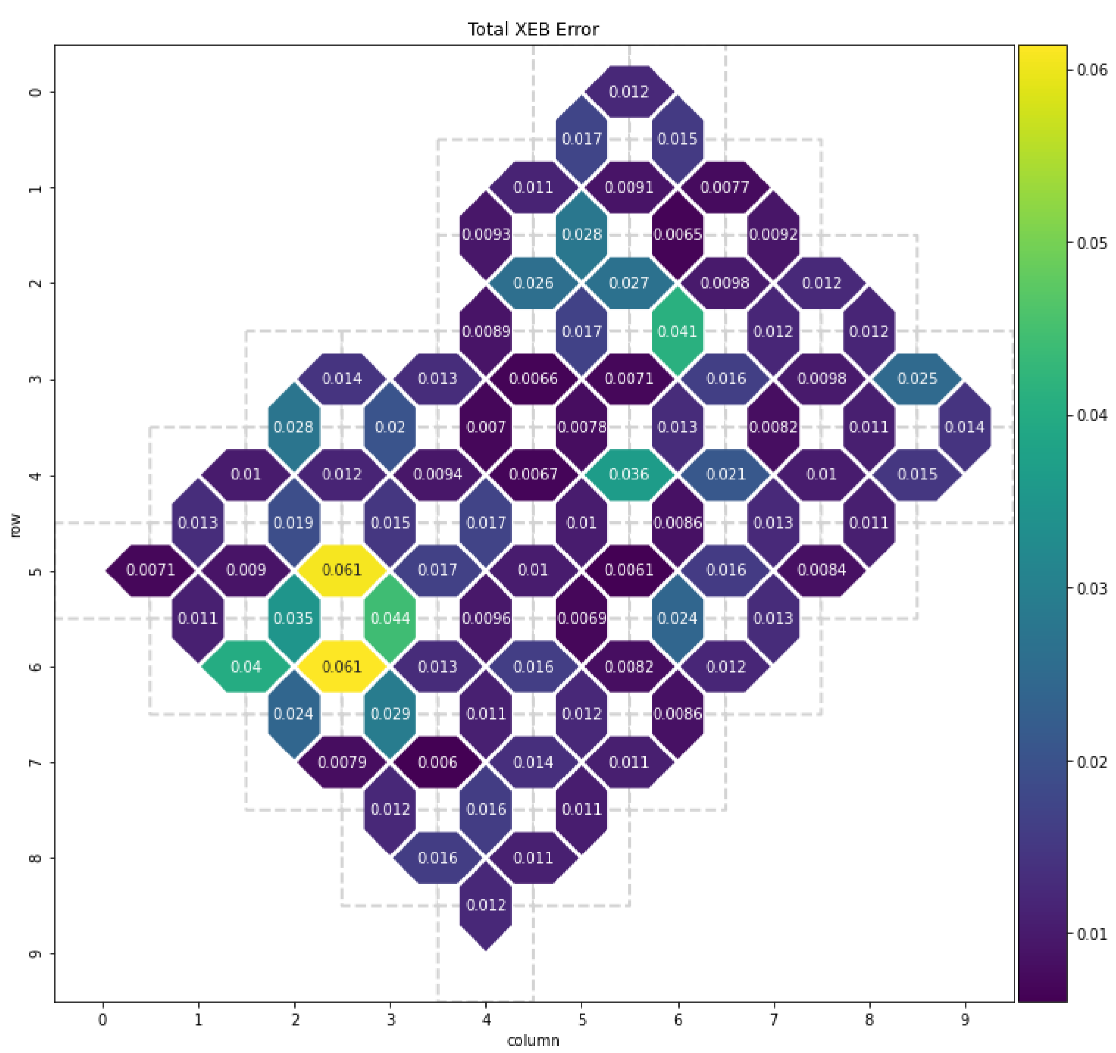
Single Qubit Total Randomized Benchmarking (RB) Error



Two Qubit Isolated Pairs Total XEB Error √iSWAP gate



Two Qubit Parallel Total XEB Error √iSWAP gate



[1] These characterization metrics were taken on 04/23/2021, and the average performance over all qubits (or pairs) is close to the typical performance metrics.

Performance Heat Maps: Readout

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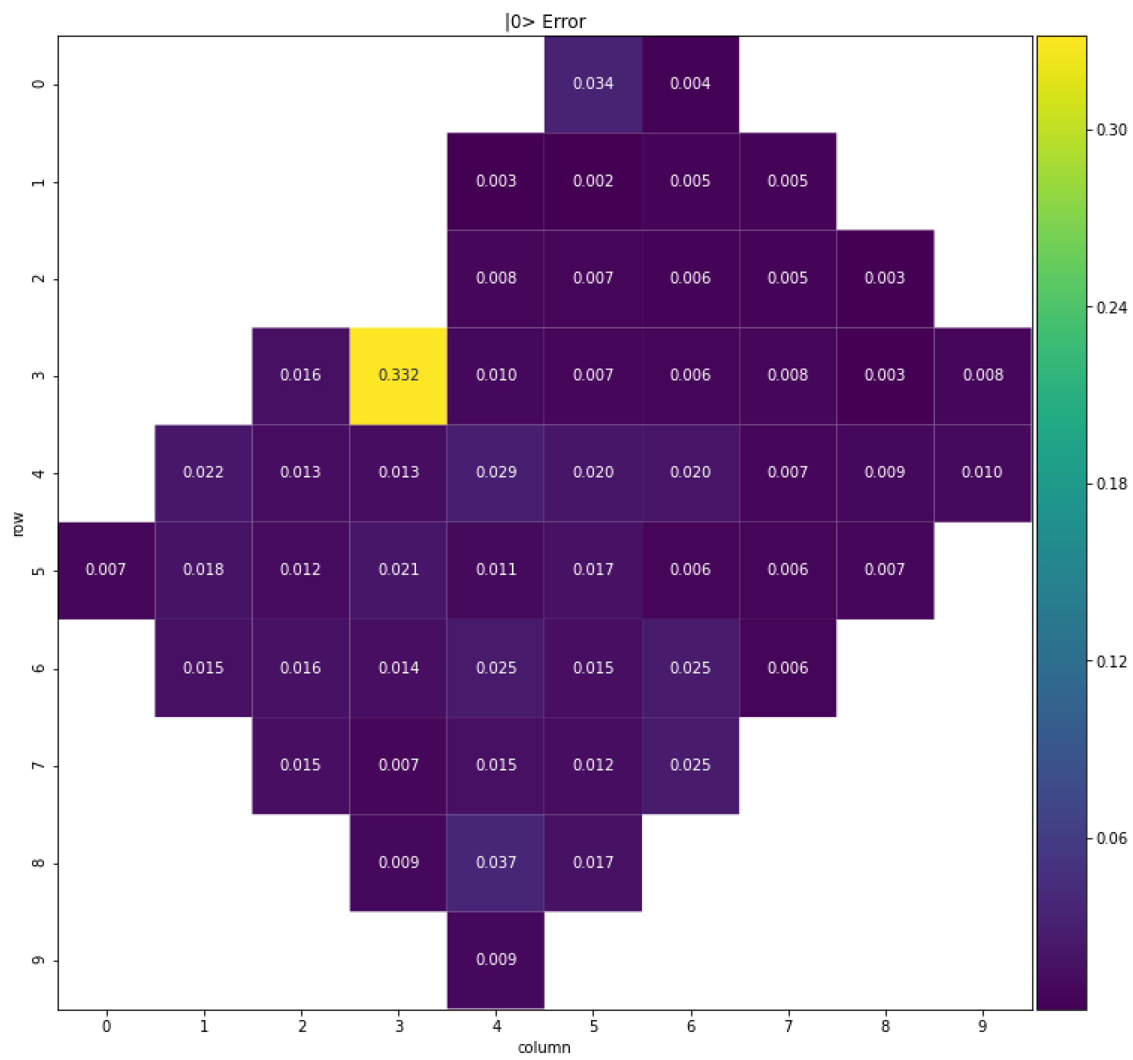
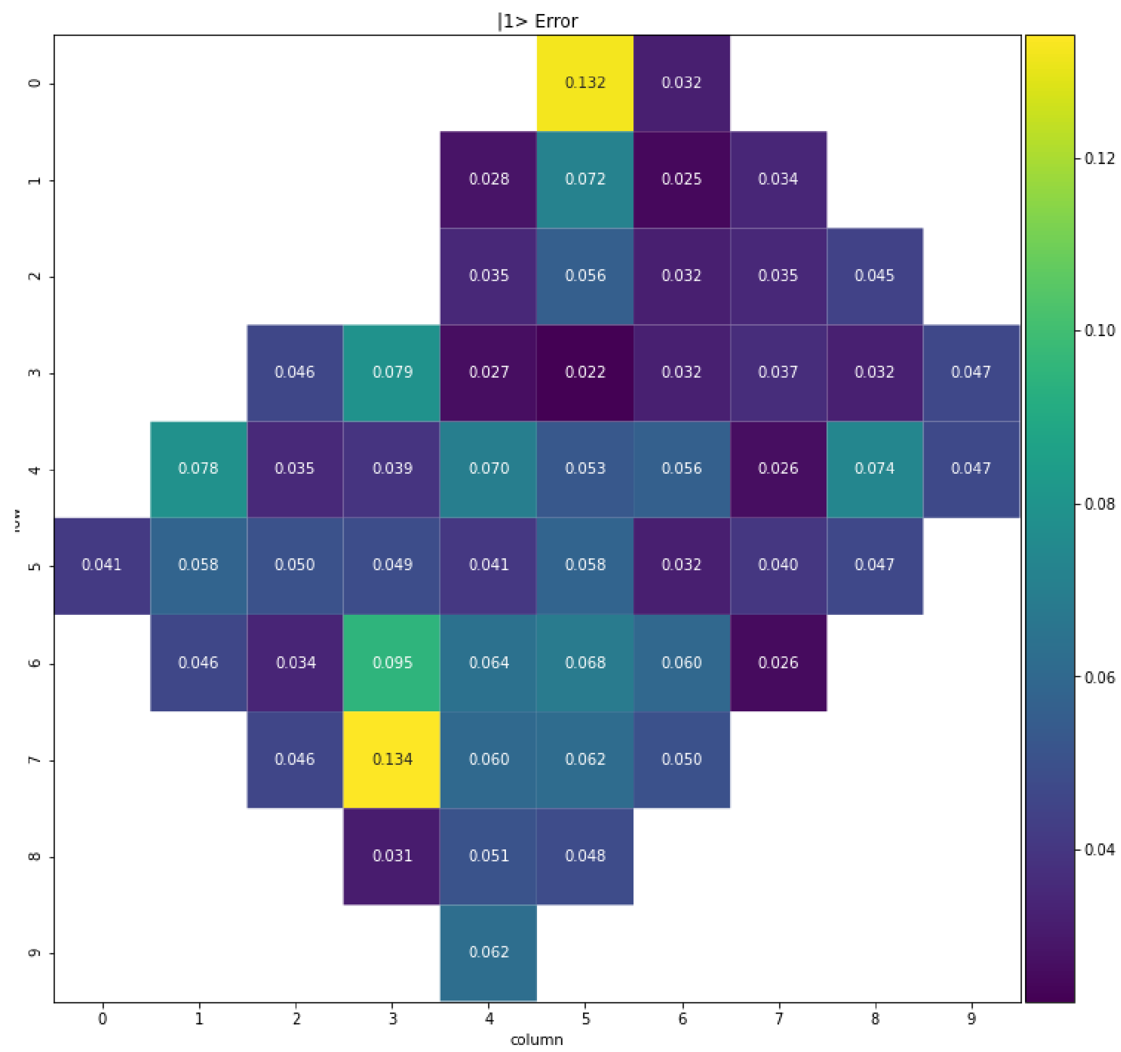
Representative Characterization Metrics [1]

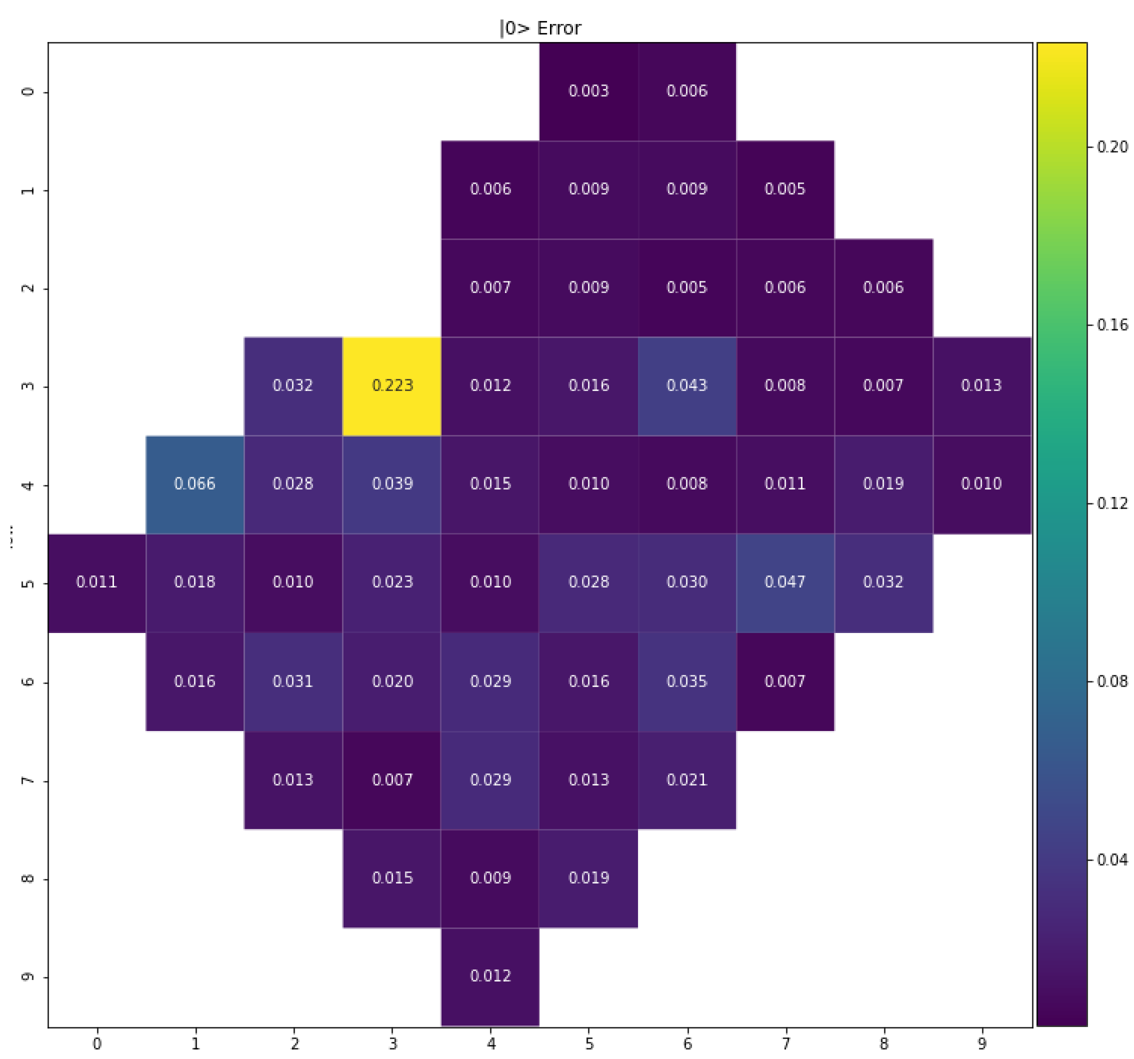
Isolated |0⟩ Readout Error



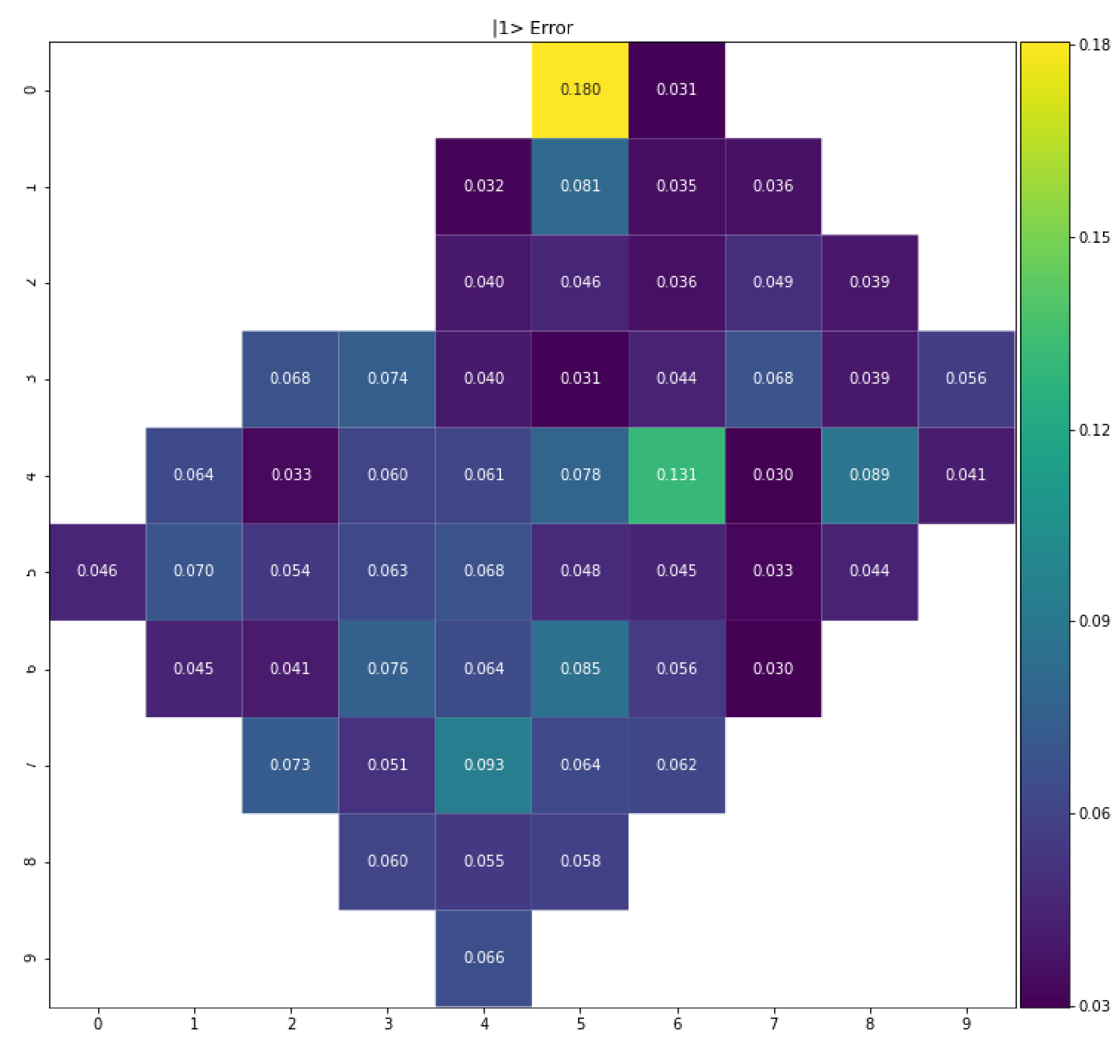
Isolated |1⟩ Readout Error



Simultaneous All Qubits |0⟩ Readout Error



Simultaneous All Qubits |1⟩ Readout Error



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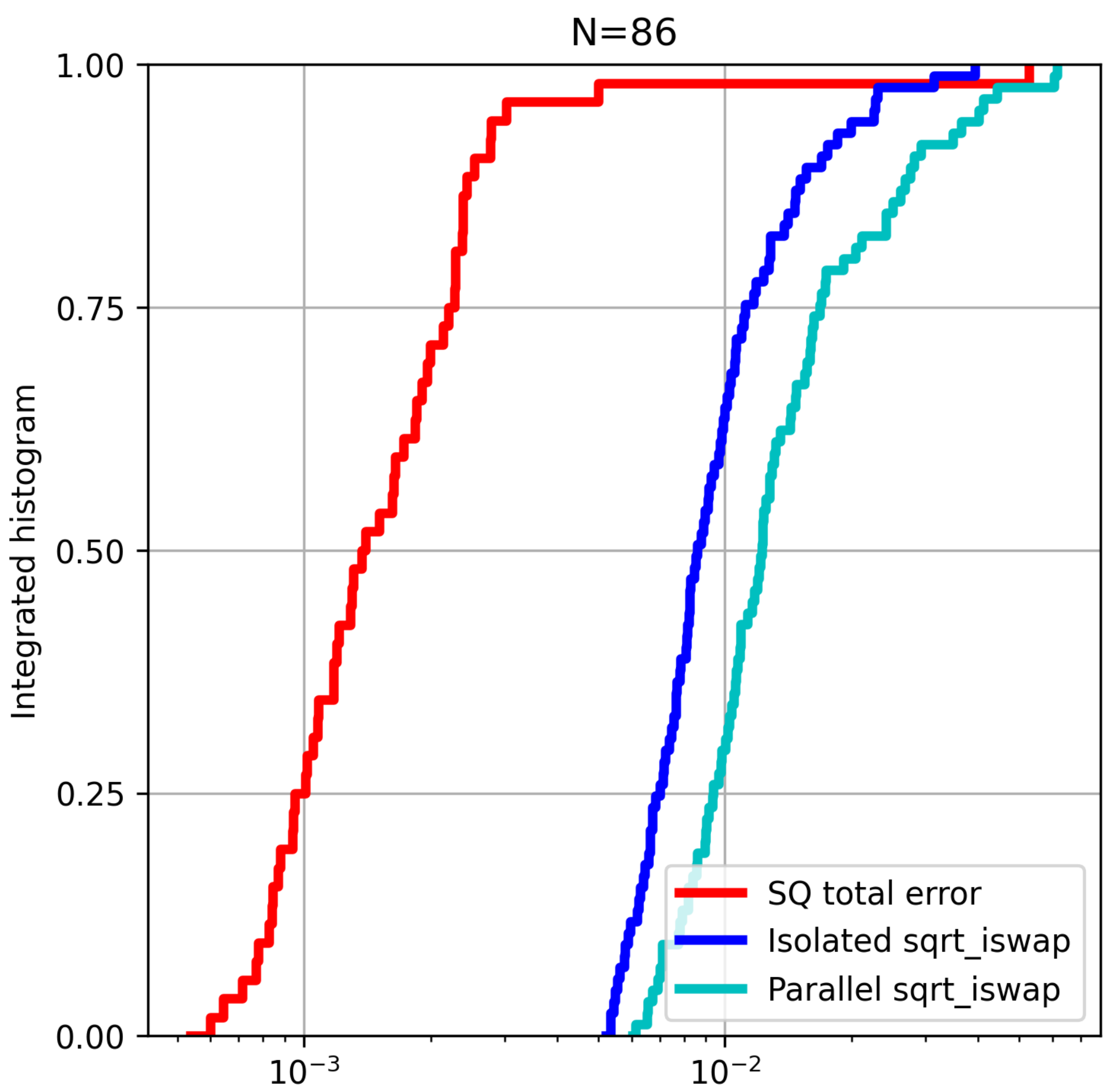
Performance Histograms

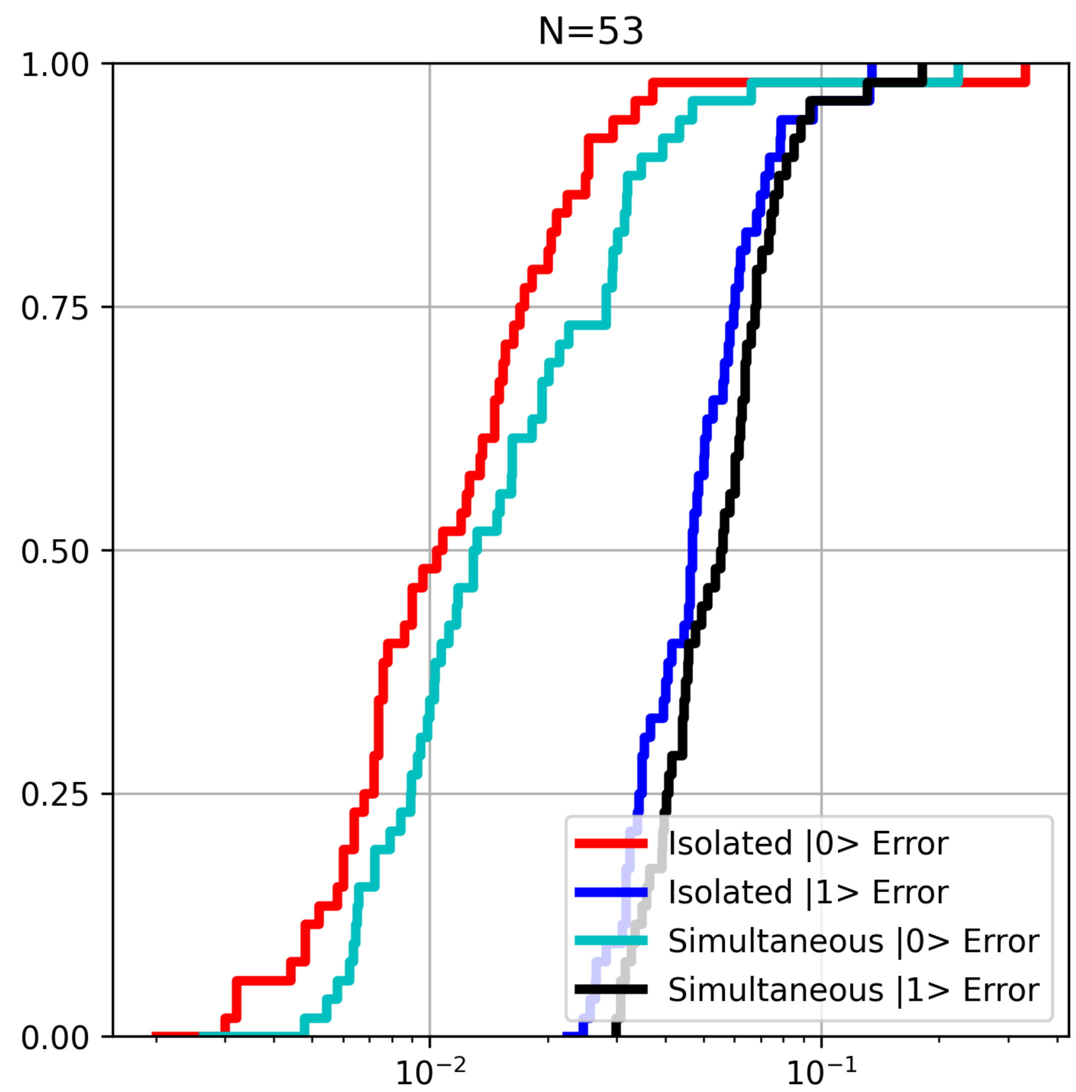
Reminder to users: check the [latest characterization report in the GCS Console]

Representative Characterization Metrics [1]

Gate Errors



Readout Errors



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