# A Top-down Algorithmic Test for Comparing Imperfect Quantum Computers

**Thomas G. Draper**

Center for Communications Research - La Jolla
4320 Westerra Court, San Diego, CA 92121, US

tdraper@ccr-lajolla.org

## Abstract

*We present a new top-down algorithmic test for quantum computers based on an unsolved math problem first posed by Gauss: finding quadratic nonresidues [1]. We report the results of running this new test on current quantum computers from IBM, IonQ, Honeywell.*

No known classical algorithm finds quadratic nonresidues in polynomial time [2], but a new quantum algorithm does [3]. A quantum computer that finds quadratic nonresidues at a rate surpassing the maximal classical success rate provides evidence of quantum computation. Tests of different sizes can be constructed from primes congruent to $1$ modulo $8$. The smallest test (for $p = 17$) requires only four qubits to run. Arbitrarily large tests can be created from larger primes.

Results of the $p = 17$ test indicate that current quantum computers range from barely escaping the noise floor to providing promising evidence in the best cases. This math based test provides an agnostic comparison between different quantum architectures.

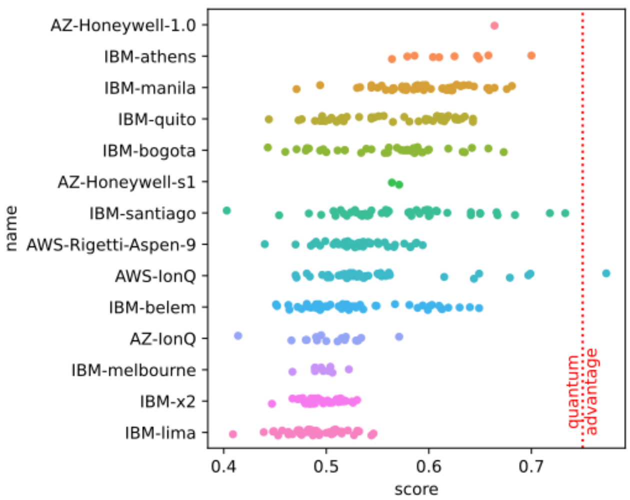


**Figure 1.** Average success rate of 1000 shot runs. Higher is better.

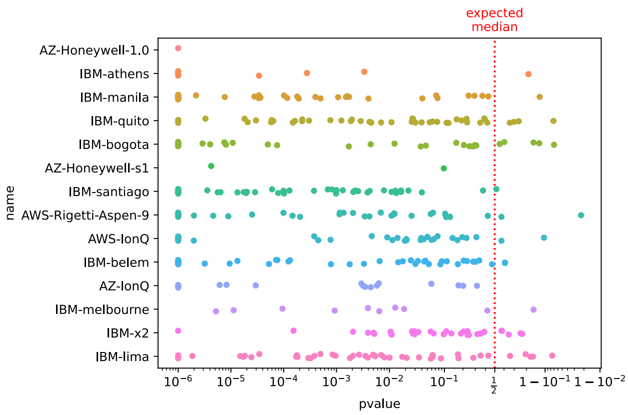


**Figure 2.** Uniformity score of 1000 shot runs. Higher is better

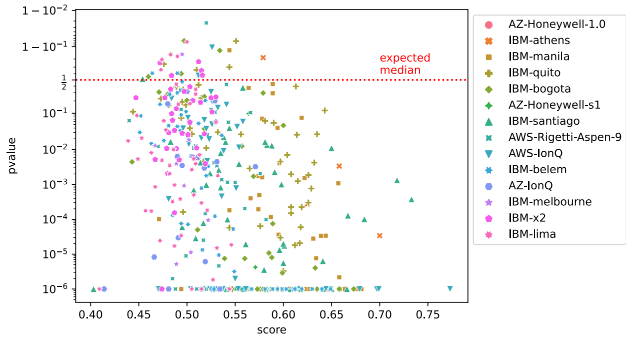


**Figure 3.** Success and uniformity score for 1000 shot runs. Upper right corner is better.

## References

[1] C. F. Gauss, "Disquisitones arithmeticae," 1801.

[2] H. Cohen, *A course in computational algebraic number theory*, ser. Graduate Texts in Mathematics. Spinger-Verlag, Berlin, 1993, vol. 138.

[3] T. G. Draper, "Evaluating NISQ Devices with Quadratic Nonresidues," 2021. [Online]. Available: https://arxiv.org/abs/2110.09483