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Quantum in Finance

Quantum Computing Meets Wall Street

Real Portfolio Optimization
Executable on IonQ Production Systems

The Challenge: Cardinality-constrained portfolio selection (choosing exactly k assets for optimal risk/return) is an NP-hard problem. At S&P 500 scale, classical solvers hit a computational wall.

The Solution: An end-to-end hybrid pipeline utilizing IonQ hardware and Kipu Quantum's BF-DCQO* algorithm to process real market data without relying on pure classical heuristics.

**Bias-Field Digitized Counterdiabatic Quantum Optimization*



Raw Market Data

(Classical)
250 S&P 500 historical asset returns.



Data Denoising

(Classical)
Applies Random Matrix Theory (RMT) to strip out noise eigenmodes, isolating true structural market correlations.



100% of assets are analyzed.

Hardware-Capped Partitioning

(Classical)
Assets are dynamically clustered via Louvain to perfectly match the exact hardware qubit budget.



BF-DCQO Execution

(Quantum)
Solves Ising subproblems natively on IonQ hardware using non-variational BF-DCQO. Highly resilient to near term noise.



Hybrid Refinement

(Classical)
Recombines solutions and enforces exact cardinality through global local-search swap moves.



The Optimized Global Portfolio

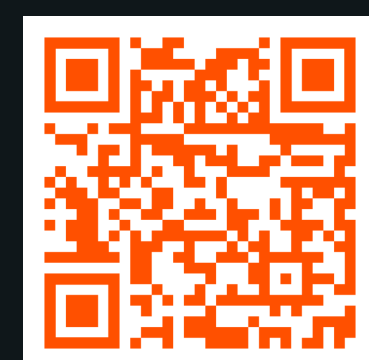
Executing Large-Scale Portfolio Optimization on Near-Term IonQ Quantum Hardware

250

Asset Universe Optimized

End-to-end execution of fixed-cardinality portfolio selection with real market data from S&P 500.

Publication



64

Qubits

Powered by the joint Kipu Quantum and IonQ pipeline on the IonQ 64-qubit dev system.

99.99999%

Single-Qubit Gate Fidelity

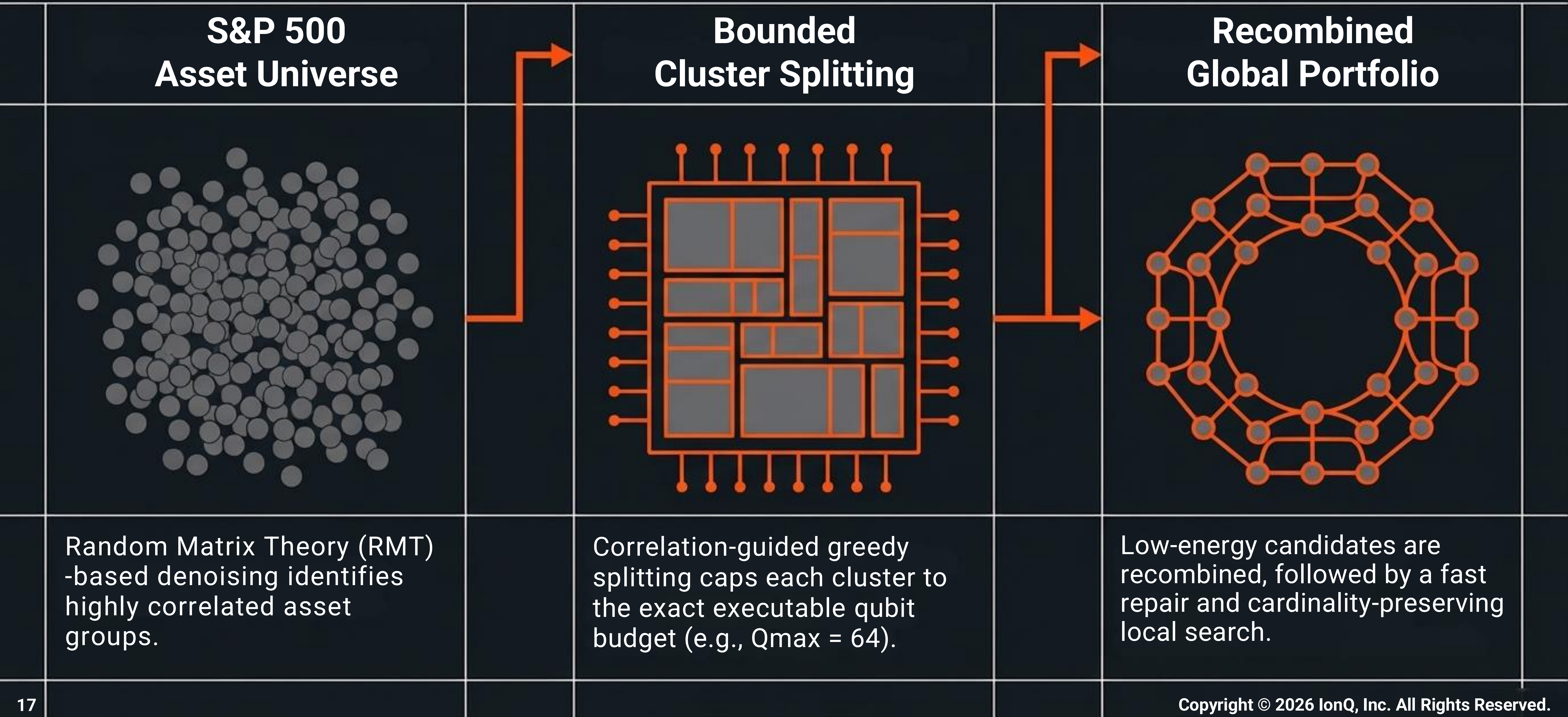
99.99%

Two-Qubit Gate Fidelity

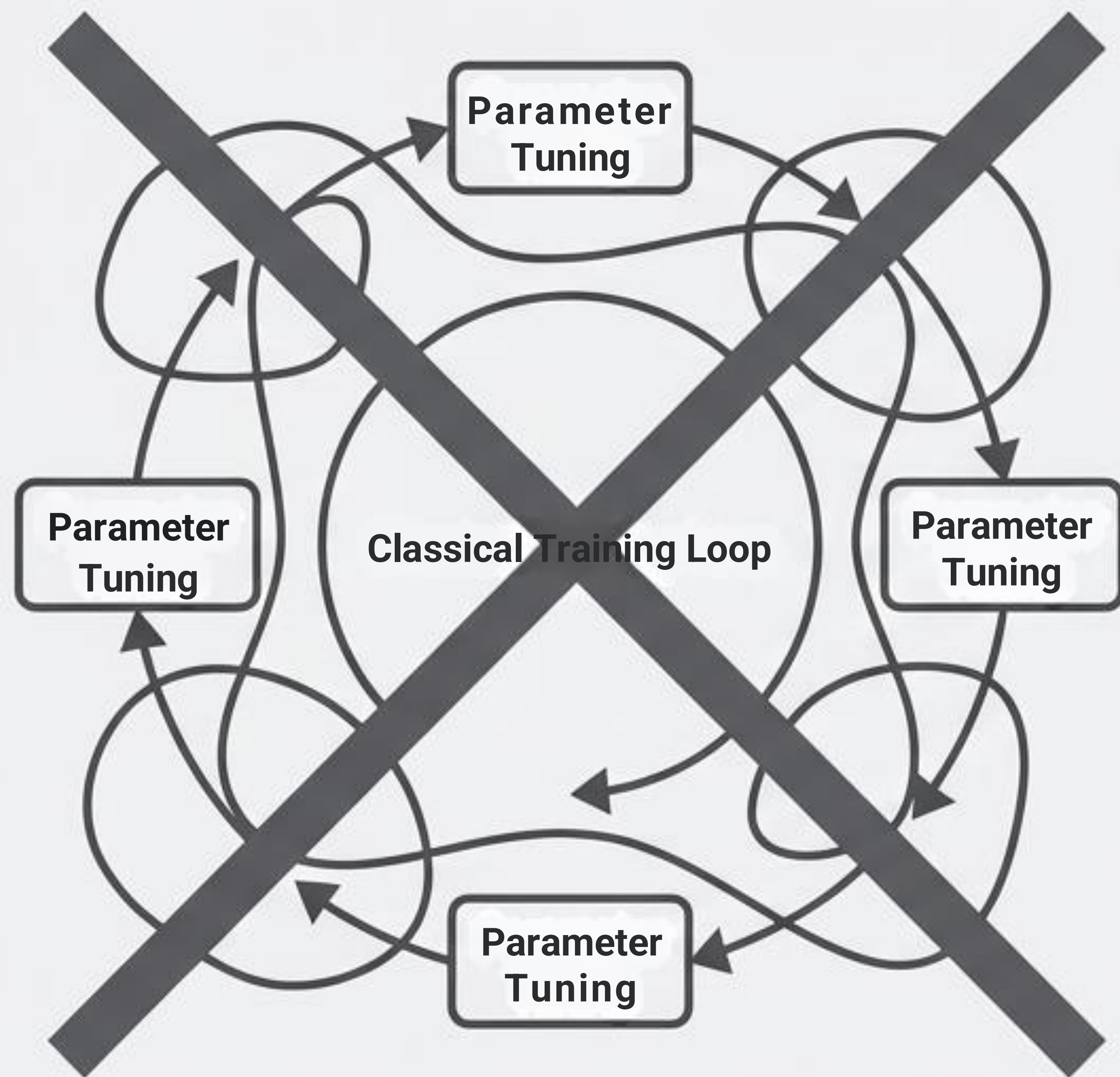
The world-record commercial hardware performance enabling deep-circuit financial modeling.

A hardware-tested route for scaling financial optimization,
balancing **executable problem size and circuit cost against resulting solution quality.**

The Hardware-Aware Decomposition Pipeline



Escaping the Variational Trap: BF-DCQO



Bias-Field Digitized Counterdiabatic Quantum Optimization



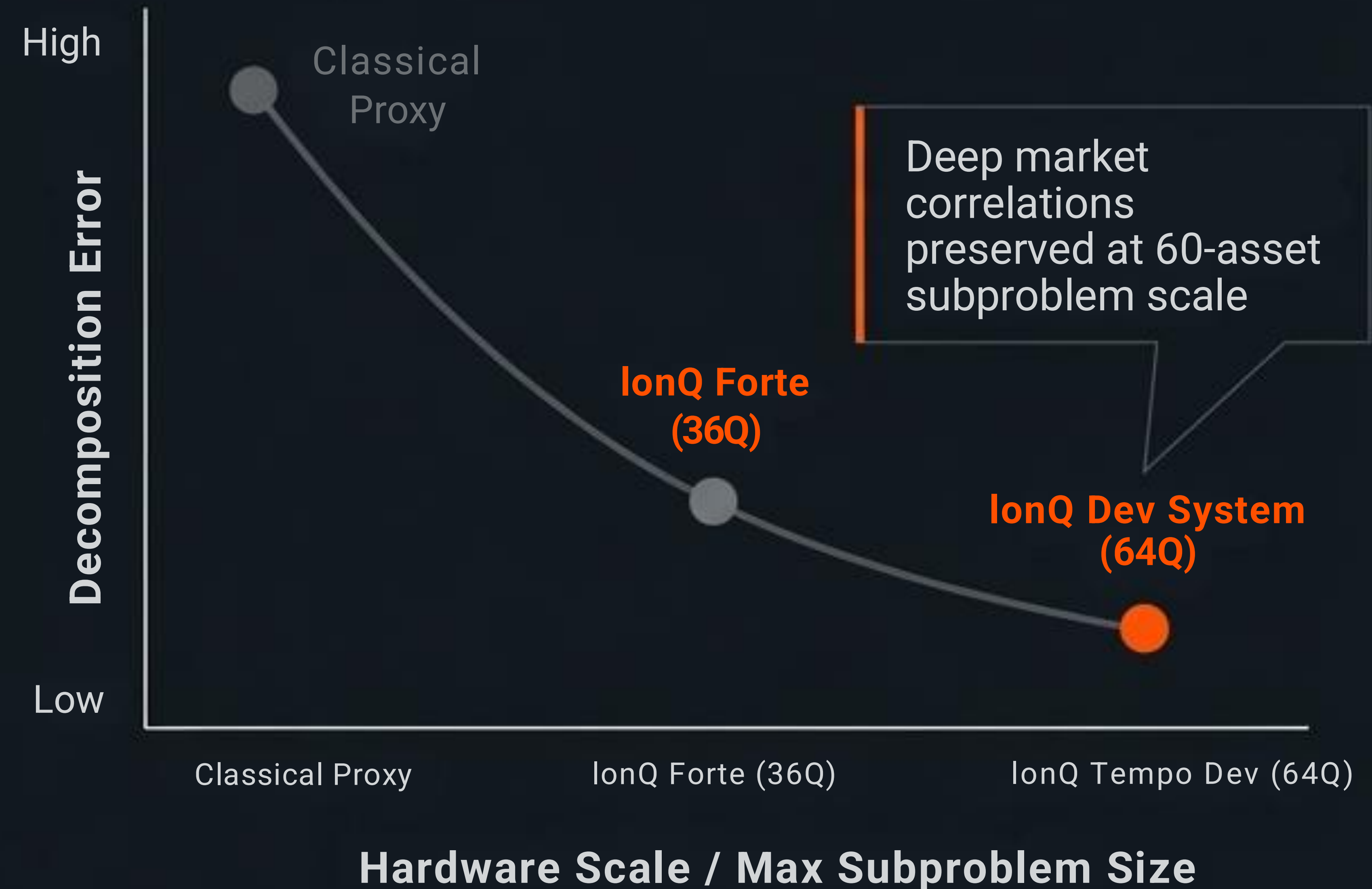
- **Non-Variational:** Circuit parameters are derived analytically straight from the problem Hamiltonian. Zero classical training loops required.
- **Iterative Concentration:** Progressively concentrates samples toward favorable solutions using lowest-energy measurement outcomes.
- **Resource Efficient:** Gate pruning controls circuit depth without discarding dominant cost structure.

Traditional quantum financial models rely on slow, noise-sensitive classical loops to train circuit parameters.

Scaling Qubits Preserves Deep Market Correlations

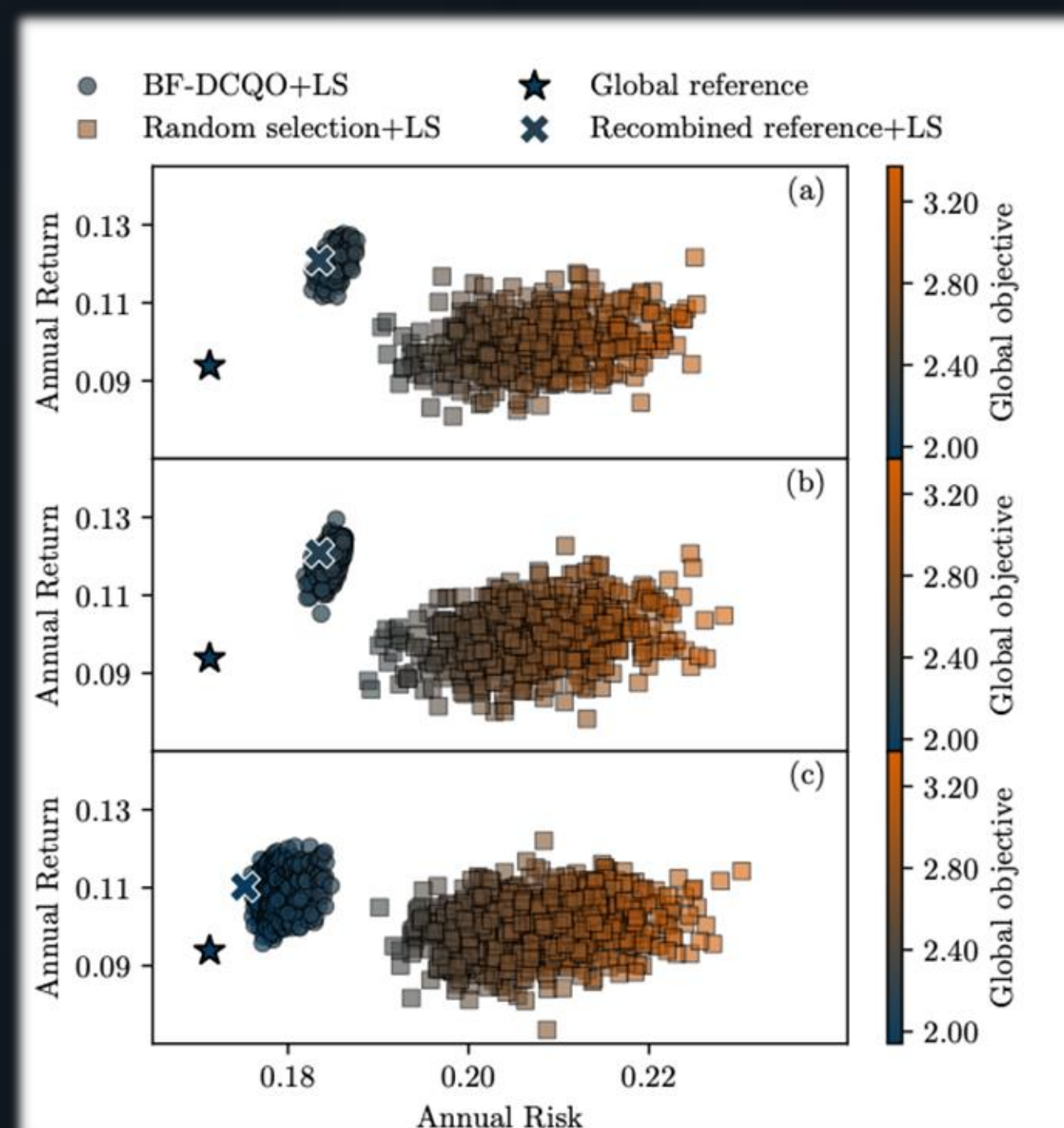
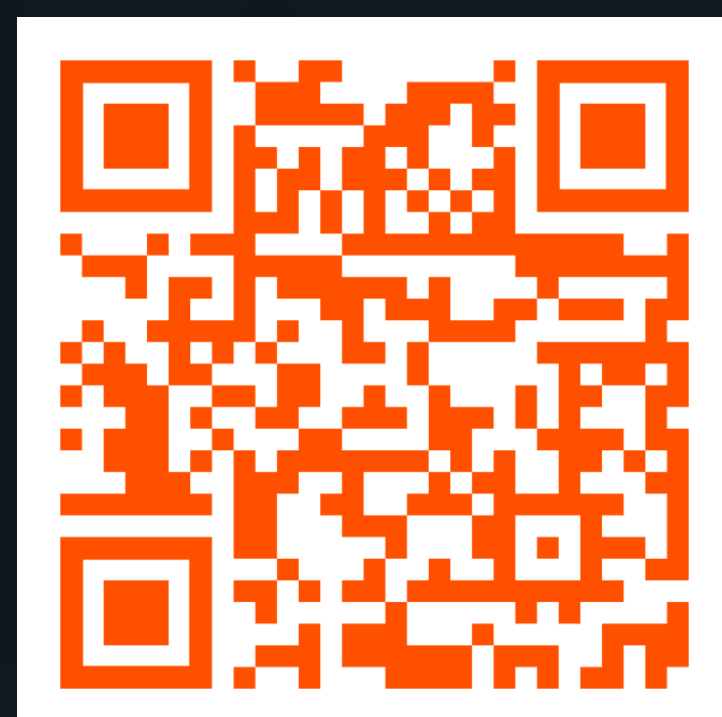
Fewer clusters at larger hardware sizes means fewer severed cross-asset correlations-directly reducing decomposition-induced error

	Classical Approach	IonQ Forte (36Q)	IonQ Dev System (64Q)
Total Clusters	1 Cluster	14 Clusters	11 Clusters
Max Subproblem	250 Assets	36 Assets	60 Assets
Decomposition Error	Very High (Due to heavy classical approximations)	High (More cross-asset correlations severed)	Low (Preserves deep market correlations)

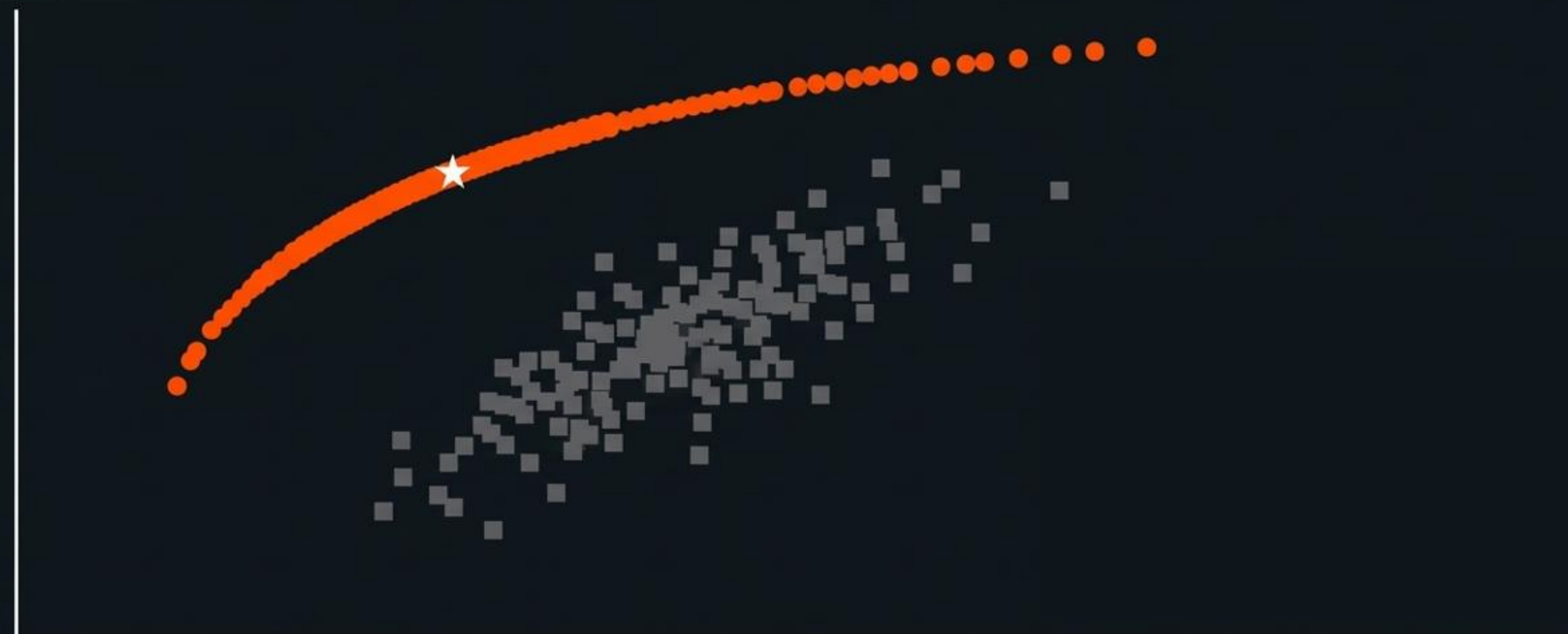


The Hardware Scaling Advantage

Publication



Annual Return



Annual Risk



Direct ROI on Qubits

Moving from 36 to 64 qubits strictly improves the objective value. Larger executable subproblems preserve more of the asset correlation structure that drives financial return.



Algorithmically Future-Proof

The hybrid pipeline dynamically adapts to the available qubit limit. As IonQ hardware scales, portfolio quality mathematically improves without rewriting the software.



Beyond Classical Limits

Quantum BF-DCQO initializations consistently outperform random classical baselines, concentrating samples in low-energy regions to unlock optimal risk-return frontiers that per-cluster solvers cannot access.

Quantum is Now



Important Information and Where to Find it

In connection with IonQ, Inc.'s ("IonQ") proposed acquisition of SkyWater Technology, Inc. ("SkyWater") (the "Transaction"), IonQ has filed with the SEC a Registration Statement on Form S-4 (the "Registration Statement") which includes a prospectus with respect to the shares of IonQ common stock (the "IonQ Shares") to be issued in the Transaction and a proxy statement (the "Proxy Statement/Prospectus") for stockholders of SkyWater and SkyWater has filed with the SEC the proxy statement (the "Proxy Statement"). The definitive Proxy Statement has been mailed to stockholders of SkyWater. Each of IonQ and SkyWater may also file with or furnish to the SEC other relevant documents regarding the Transaction. This presentation is not a substitute for the Registration Statement, the Proxy Statement/Prospectus or any other document that IonQ or SkyWater may file with the SEC or mail to SkyWater's stockholders in connection with the Transaction.

INVESTORS AND SECURITY HOLDERS OF IONQ AND SKYWATER ARE URGED TO READ THE REGISTRATION STATEMENT, THE PROXY STATEMENT/PROSPECTUS INCLUDED WITHIN THE REGISTRATION STATEMENT, THE PROXY STATEMENT AS WELL AS ANY OTHER RELEVANT DOCUMENTS FILED WITH THE SEC IN CONNECTION WITH THE TRANSACTION OR INCORPORATED BY REFERENCE INTO THE REGISTRATION STATEMENT, THE PROXY STATEMENT/PROSPECTUS AND THE PROXY STATEMENT (INCLUDING ANY AMENDMENTS OR SUPPLEMENTS THERETO), BECAUSE THEY CONTAIN IMPORTANT INFORMATION REGARDING IONQ, SKYWATER, THE TRANSACTION AND RELATED MATTERS.

The documents filed by IonQ with the SEC also may be obtained free of charge at IonQ's website at investors.ionq.com. The documents filed by SkyWater with the SEC also may be obtained free of charge at SkyWater's website at ir.skywatertechnology.com.

Participants in the Solicitation; No Offer or Solicitation

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This presentation contains forward-looking statements. All statements contained in this presentation other than statements of historical fact are forward-looking statements, including, without limitation, statements regarding the timing of Q-Day, the future state of cybersecurity, our technical computing and interconnect roadmap. In some cases, you can identify these statements by forward-looking words such as “build,” “strengthen,” “transformative,” “scale,” “unlock,” “win,” “pending,” “roadmap,” “solve(ing),” “look forward,” “accelerate,” “anticipate,” “expect,” “suggest,” “plan,” “believe,” “intend,” “estimate,” “target,” “project,” “should,” “could,” “would,” “may,” “will,” “forecast,” “confident” and other similar expressions. These statements are only predictions based on our expectations and projections about future events as of the date of this presentation and are subject to a number of risks, uncertainties and assumptions that may prove incorrect, any of which could cause actual results to differ materially from those expressed or implied by such statements, including, among others, those described under the heading “Risk Factors” in our most recent filings with the Securities and Exchange Commission (the “SEC”). New risks emerge from time to time, and it is not possible for our management to predict all risks, nor can management assess the impact of all factors on our business or the extent to which any factor, or combination of factors, may cause actual results to differ materially from those contained in any forward-looking statement we make. Investors are cautioned not to place undue reliance on any such forward-looking statements, which speak only as of the date they are made. Except as otherwise required by law, we undertake no obligation to update any forward-looking statement, whether as a result of new information, future events or otherwise.