Low-Autocorrelation Functions with QE-MTS

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AutoQurelation

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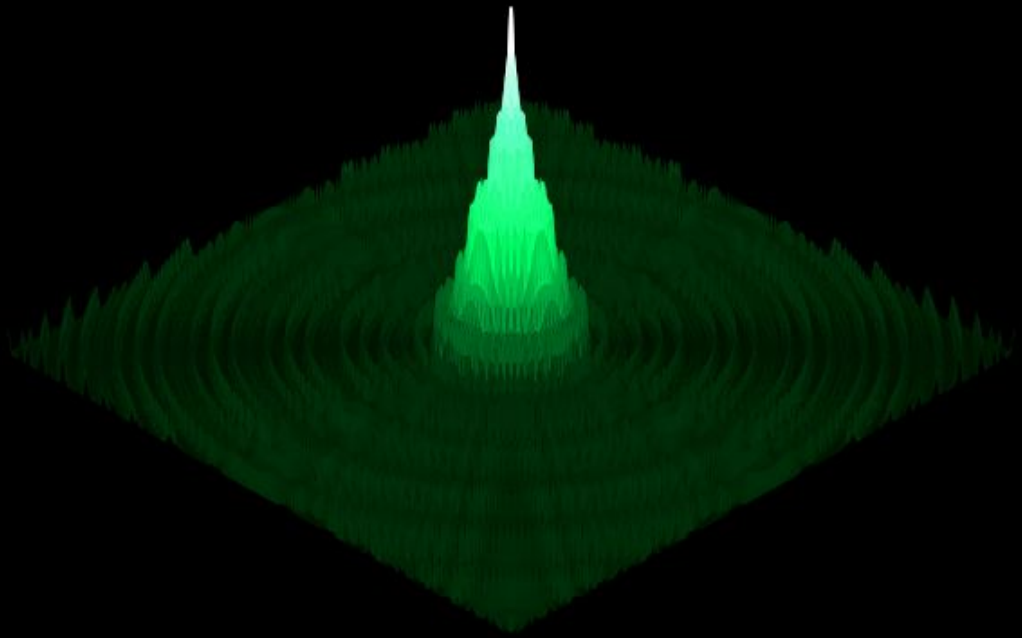
Why we should care?



Workflow

Phase 1

Milestone 1
The Ramp Up
(Scaffolded Tutorial)

DONE

Milestone 2
Research and Plan

DONE

Section 1
The Artifact (What is a PRD?)

DONE

Section 2
Assign Your Technical Roles

DONE

Section 3
Define Your Verification Strategy

DONE

Section 4
The Research Requirement

DONE

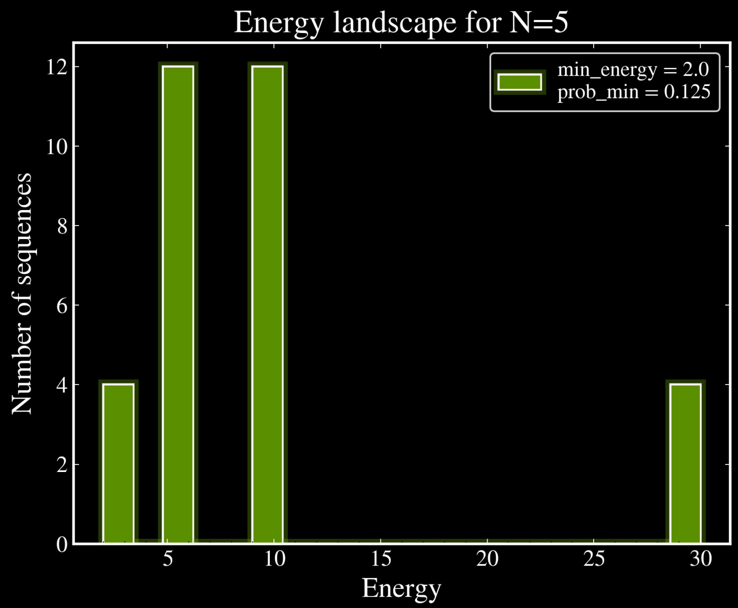
Section 5
Define Execution Tactics

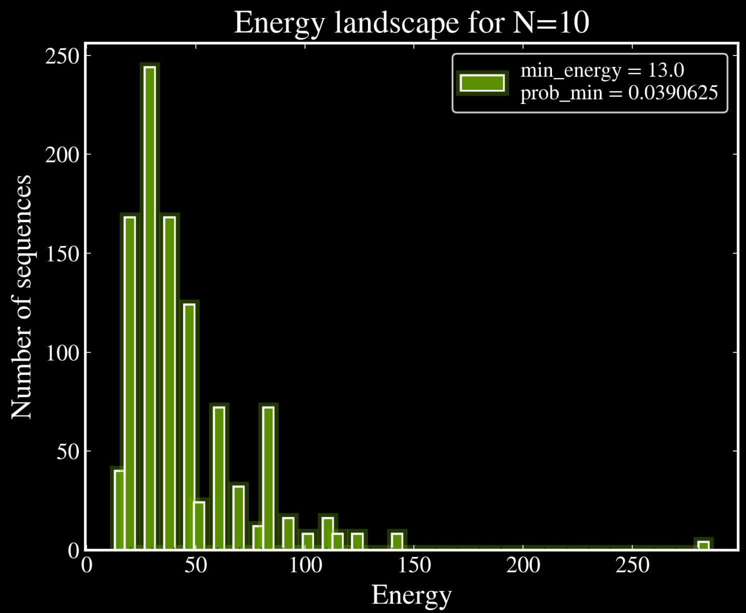
DONE

Milestone 1
The Ramp Up
(Scaffolded Tutorial)

DONE

Brute Force Testing for the LABS Problem

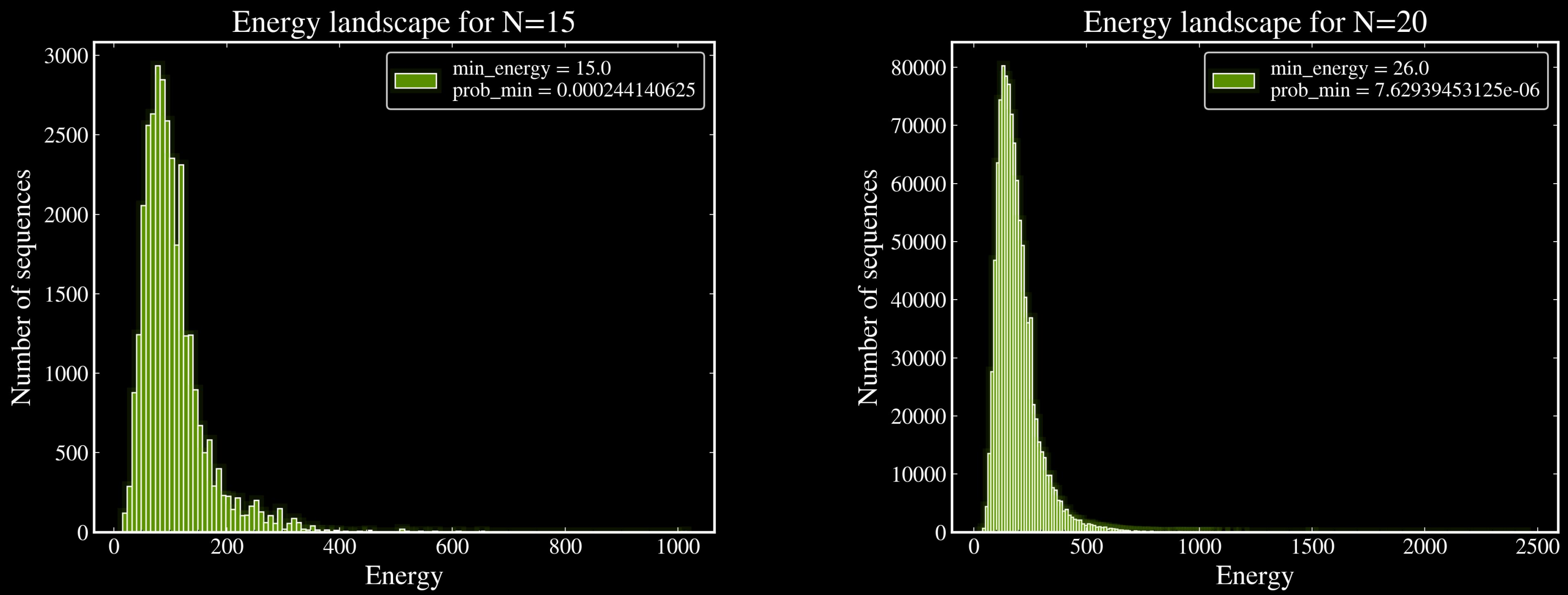




Milestone 1
The Ramp Up
(Scaffolded Tutorial)

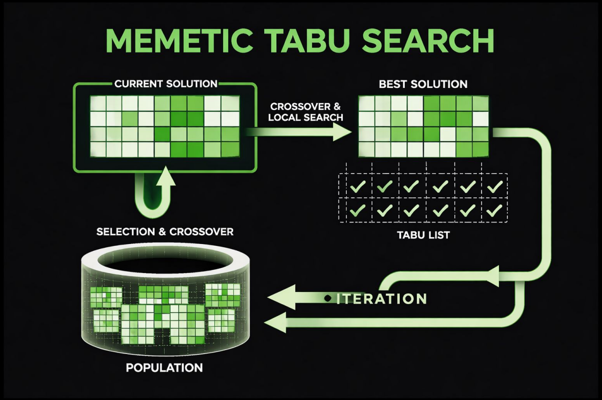
DONE

Brute Force Testing for the LABS Problem



The Memetic Tabu Search (MTS) Algorithm

Main idea: Calculated once, and change when is better.



N	Energy
19	29
25	36
30	59
39	99
45	118
55	171

Validation: From well study research paper..

T. Packebusch and S. Mertens (2016), Low Autocorrelation Binary Sequences, arXiv:1512.02475v2

The Quantum-Classical Workflow

Quantum Helpers

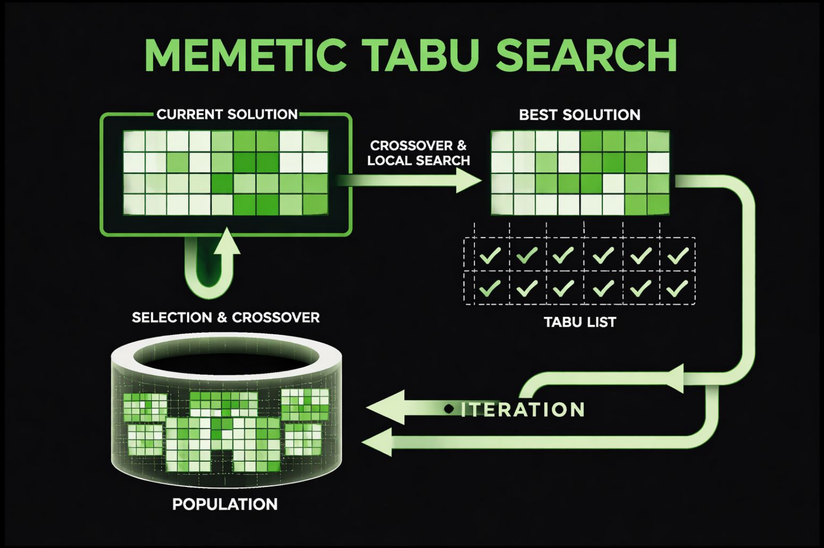
Digitized Counter Adiabatic Quantum Algorithms

Variational Quantum Algorithms

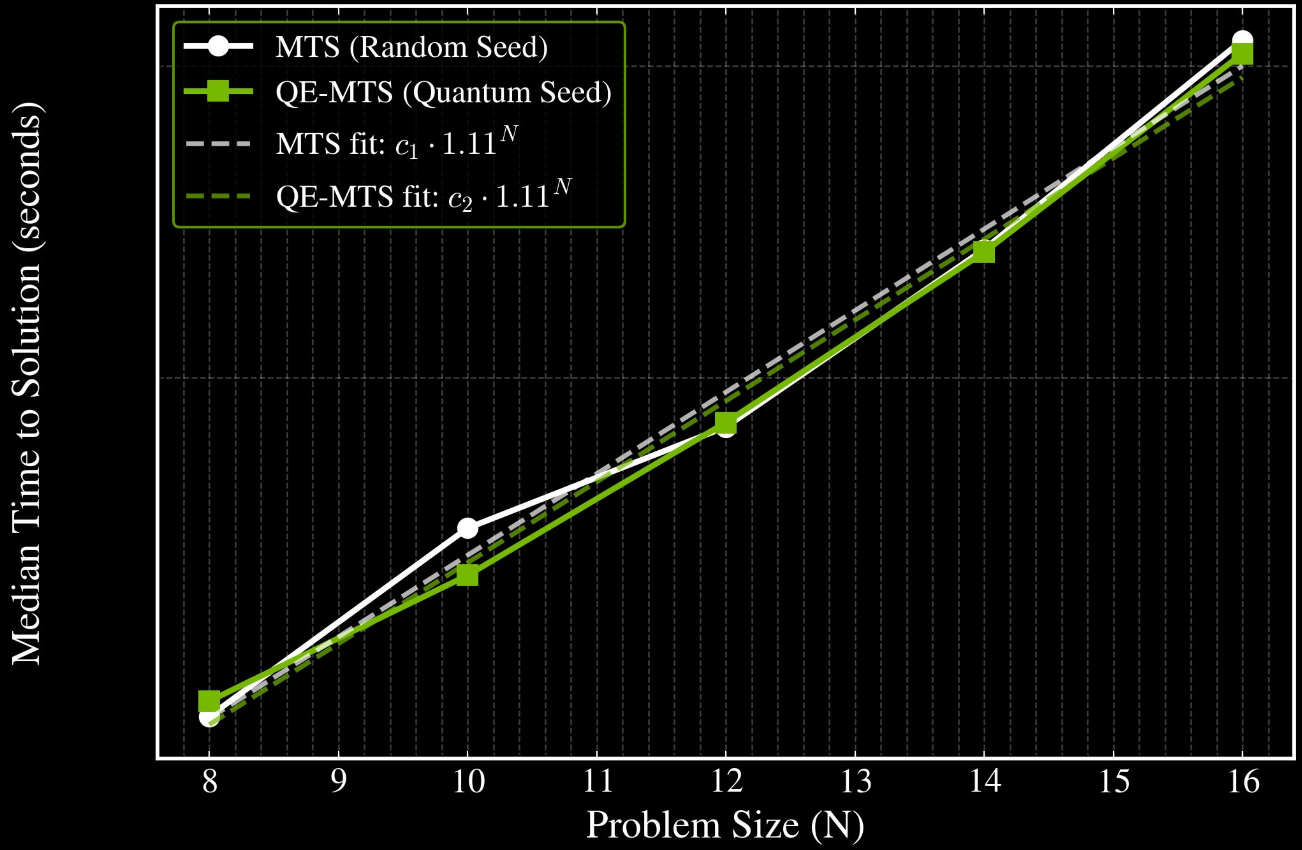
Quantum Monte Carlo Simulations

Improved Technique from DAQC

Classical High Processing



MTS vs Quantum-Enhanced MTS Scaling



Exploring the Workflow

Quantum Helpers

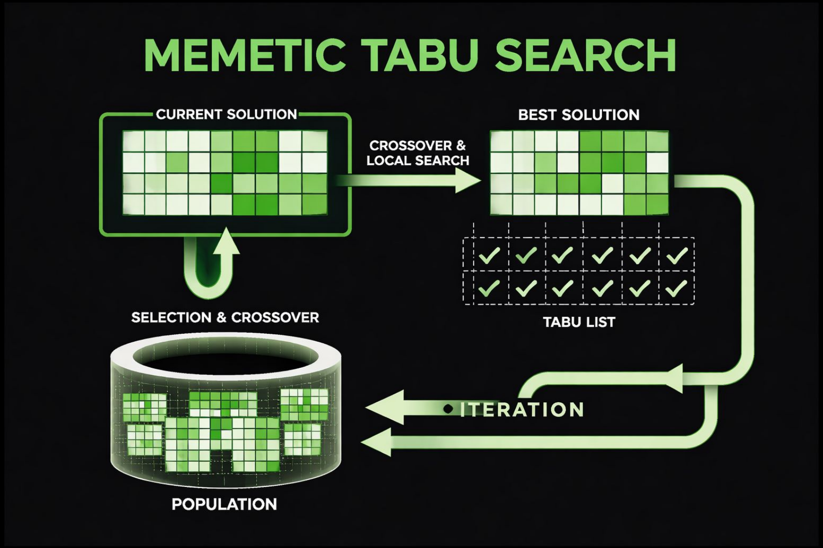
Digitized Counter Adiabatic Quantum Algorithms

Variational Quantum Algorithms

Quantum Monte Carlo Simulations

Improved Technique from DAQC

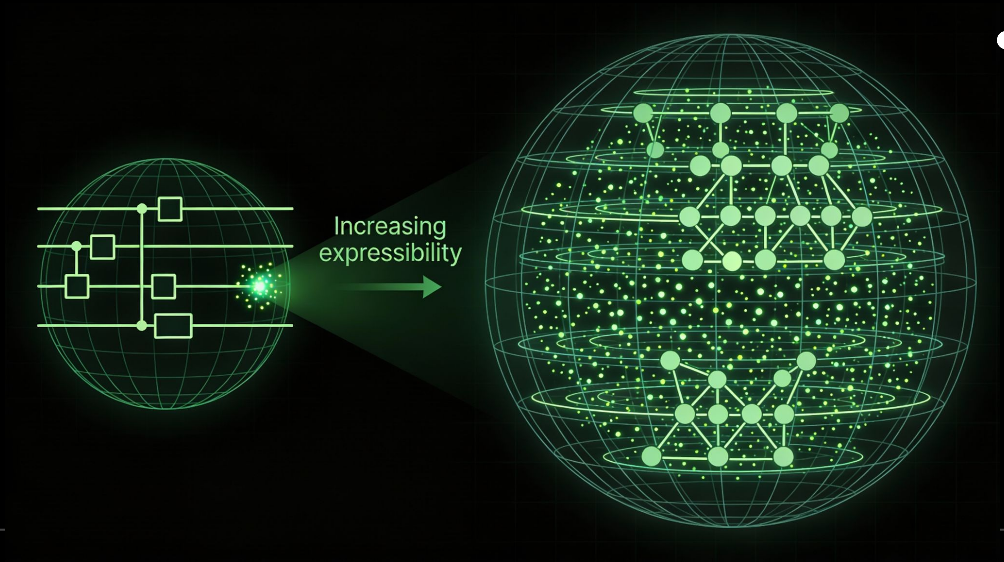
Classical High Processing



Akshay, V., Philathong, H., Morales, M. E. S., & Biamonte, J. D. (2020). Reachability deficits in quantum approximate optimization. Physical Review Letters, 124(9), 090504.

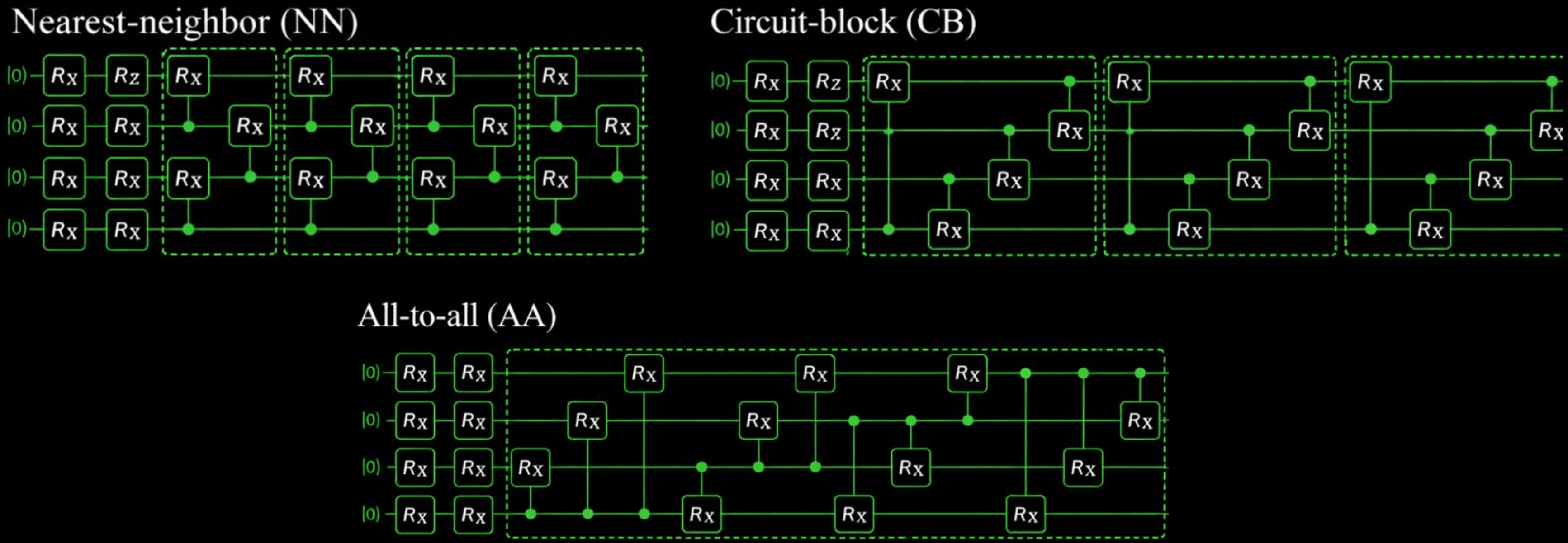
What is Expressibility?

How well a parameterized quantum circuit can represent a wide range of quantum states or unitaries.

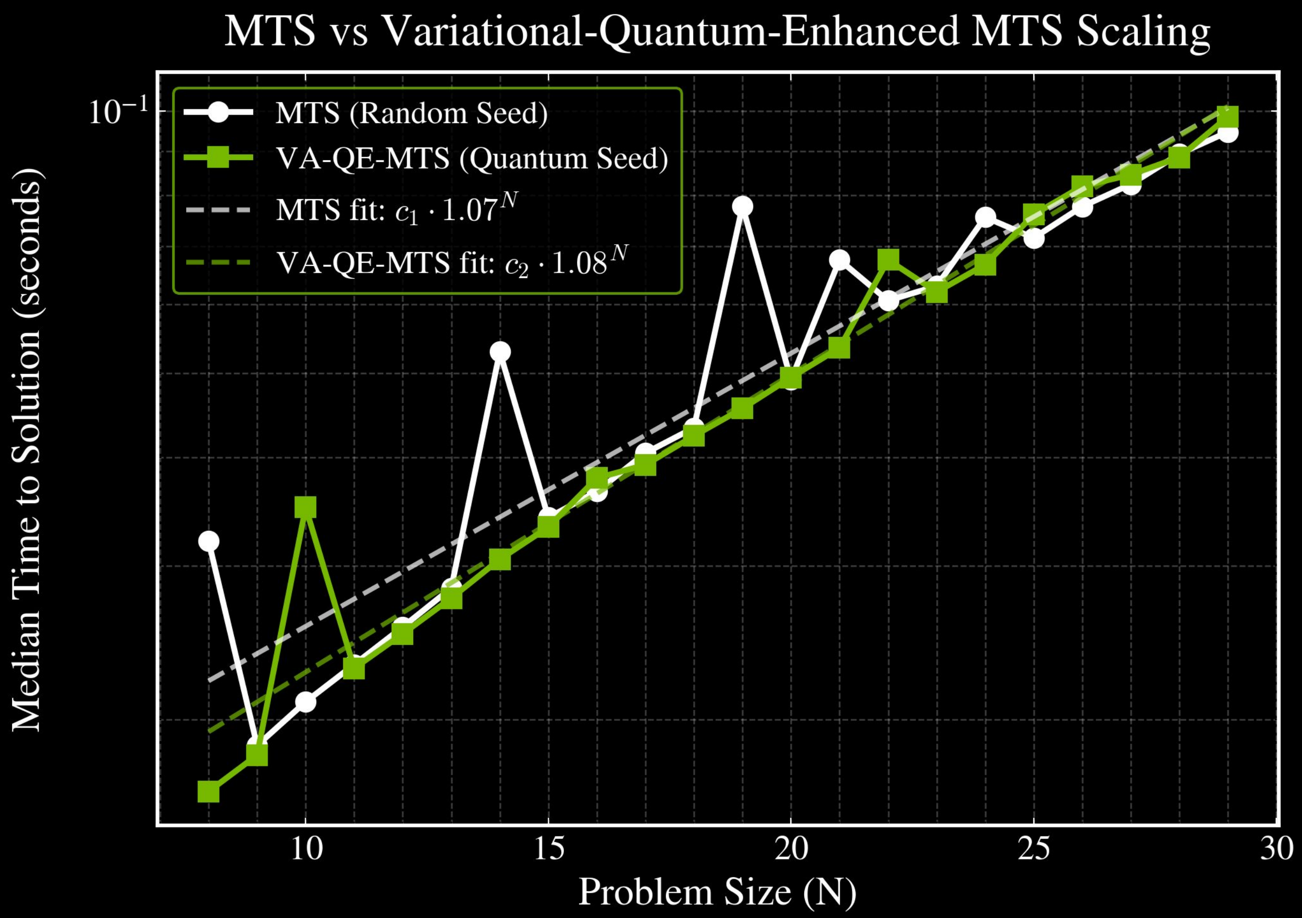


- Our chosen ansatz is proven to have more expressibility and less gates compare to the QAOA approach.

Expressibility on Variational Quantum Algorithms



Sim, S., Johnson, P. D., & Aspuru-Guzik, A. (2019). Expressibility and entangling capability of parameterized quantum circuits for hybrid quantum-classical algorithms. Advanced Quantum Technologies, 2(12)


MTS vs Variational-Quantum-Enhanced MTS Scaling
MTS (Random Seed)
VA-QE-MTS (Quantum Seed)
MTS fit: $c_1 \cdot 1.07^N$
VA-QE-MTS fit: $c_2 \cdot 1.08^N$
Median Time to Solution (seconds)
10^{-1}
10
15
20
25
30
Problem Size (N)

The Quantumness

Section 2
Assign Your
Technical Roles

The Quantumless

Technical Marketing PIC

Project Lead

Quality Assurance PIC

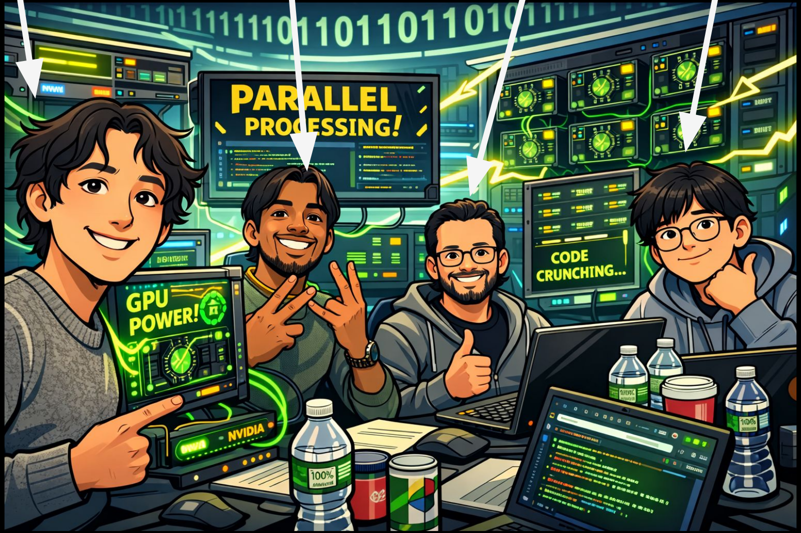
GPU Acceleration PIC

Normal Hacker 1

Normal Hacker 3

Normal Hacker 2

Normal Hacker 4



Phase 2

Milestone 3
Build

DONE

Step A:
CPU Validation

Step B:
GPU Acceleration and Hardware Migration

Step C:
GPU Acceleration of the classical algorithm

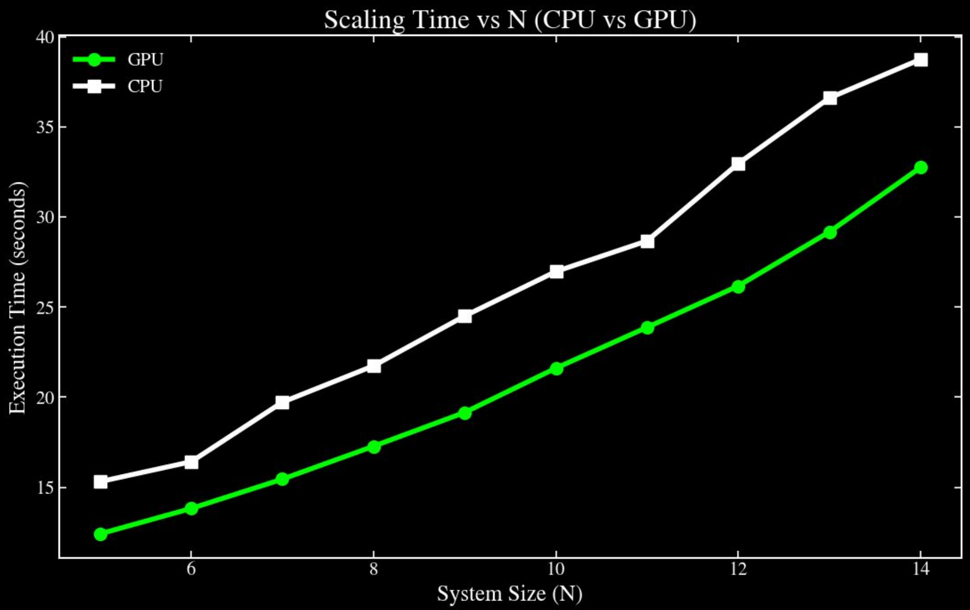
Milestone 4
Showcase & Retrospective

DONE

Step A:
The AI Post-Mortem Report

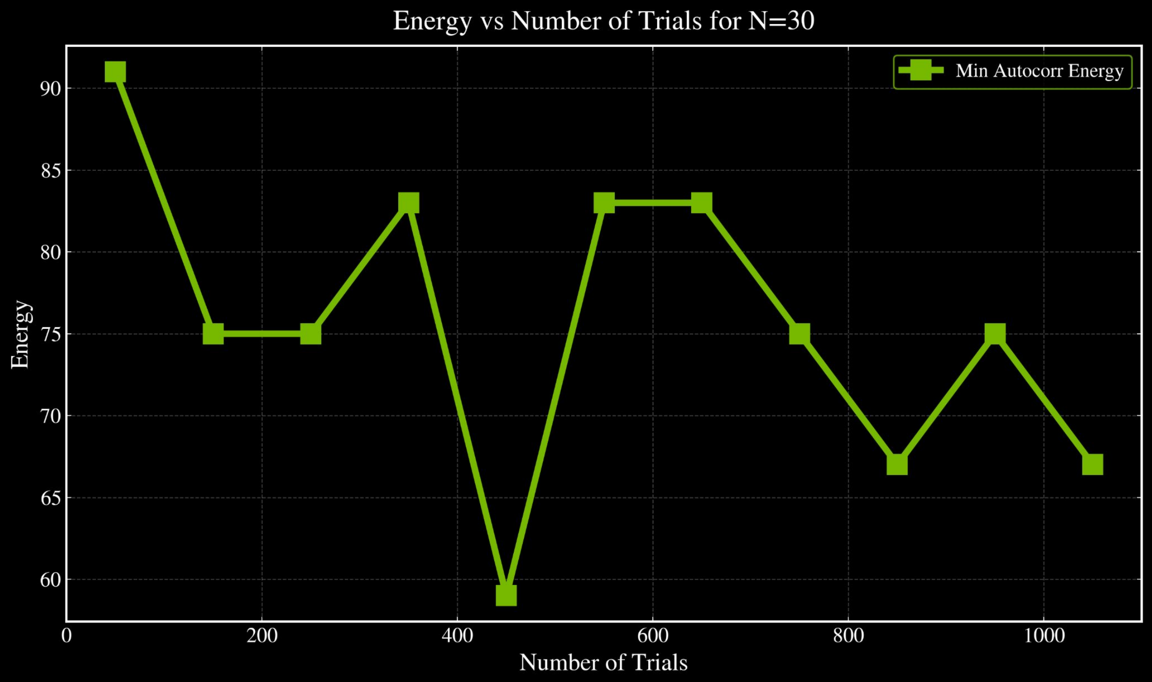
Step B:
The Presentation

GPU Acceleration - Variational Quantum Algorithm - Brev L4



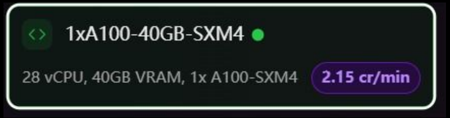
We compared CPU (Google Colab) vs GPU (L4). While the different is small, changing the GPU and for bigger sizes (N) they will be a big difference.

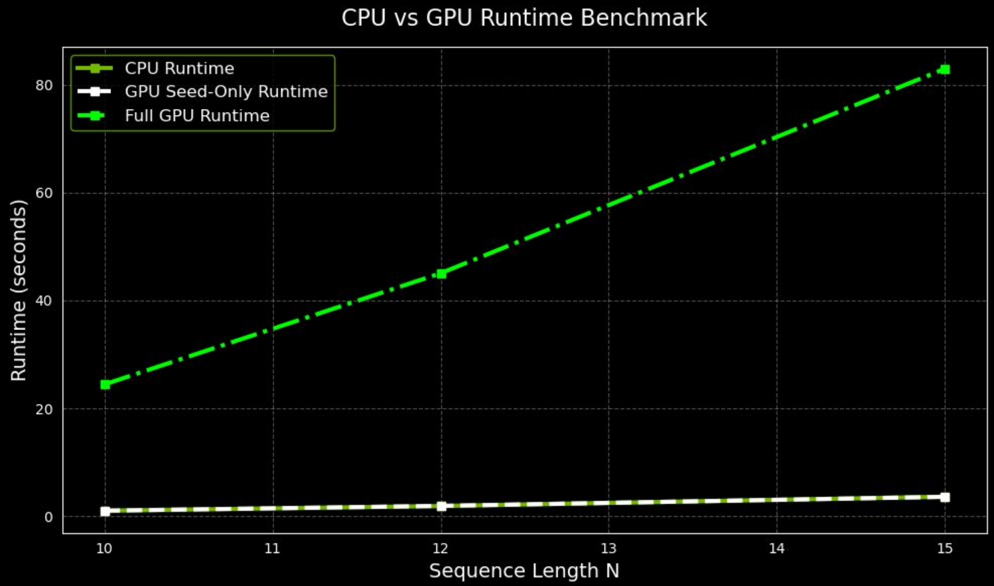
GPU Acceleration - Variational Quantum Algorithm - Brev L4



We tested also for different number of trials for the GPU for a big N (30). Simulation that crashed for us during tutorial phase before. The result should be 59 from literature and we get to it. Thus, we trust our results. This is scaled to N=30, which is 2^(30)=1073741824 dimensional configuration space!!! Nice.

GPU Acceleration - Classical MTS - qBraid 1xA100



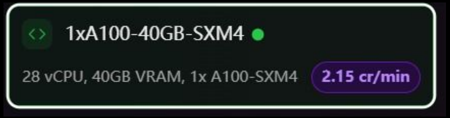


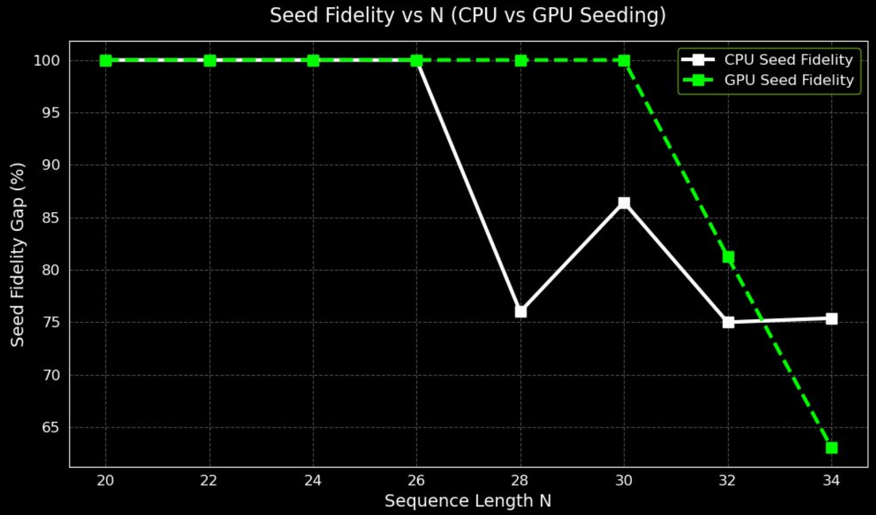
Kernel-launch overhead
+
Python loop granularity

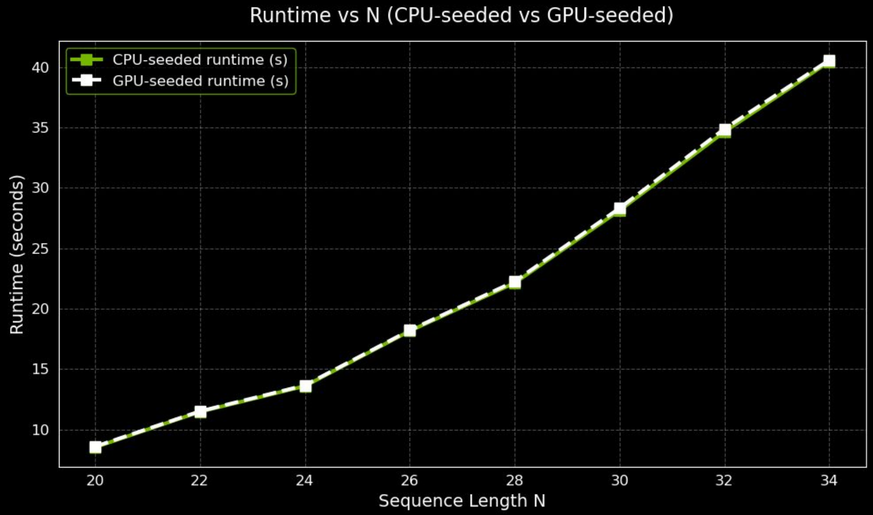
GPU Seed Only
+
CPU Classical MTS

Initial GPU verus CPU runtime shows significant disadvantage

GPU Acceleration - Classical MTS - qBraid 1xA100





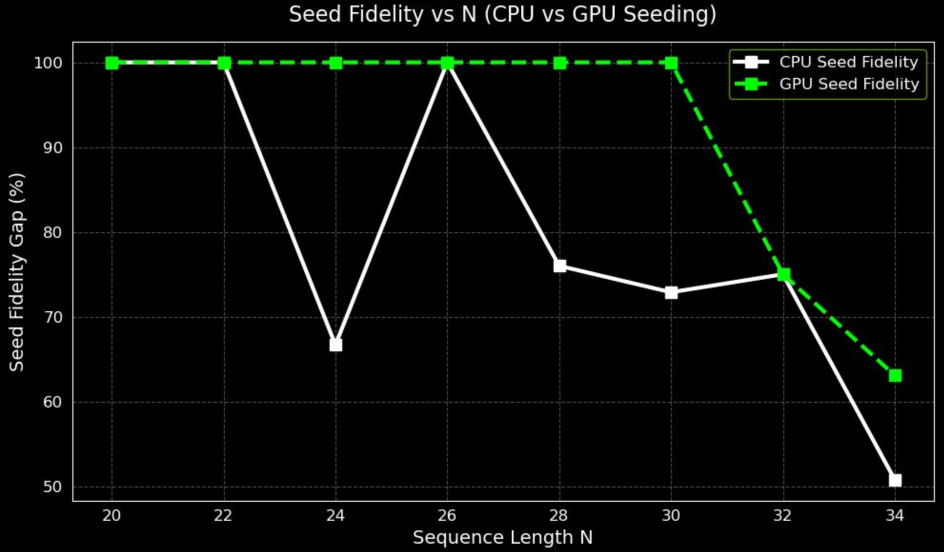


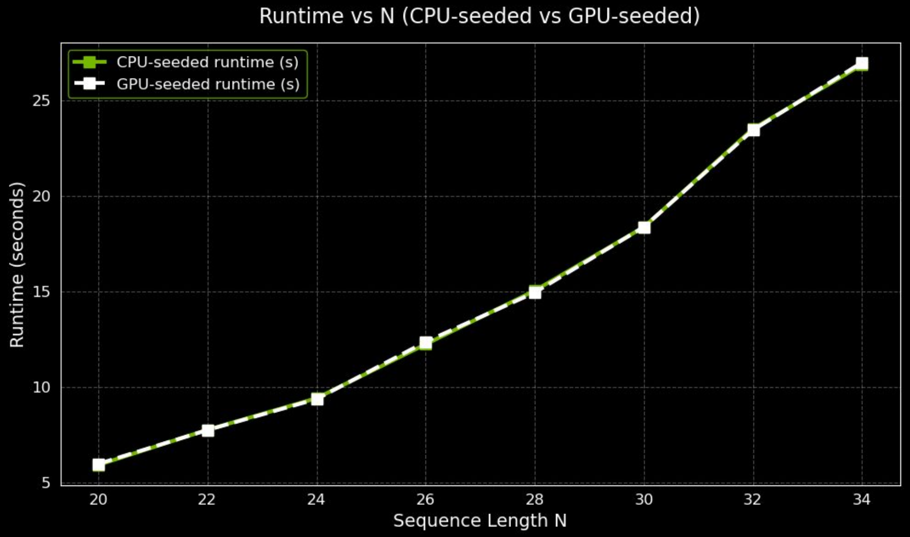
Higher Fidelity under fixed 1000 trials of MTS collapses the seed energy to primal energy, lower fails.

GPU Acceleration - Classical MTS - qBraid 8xA100

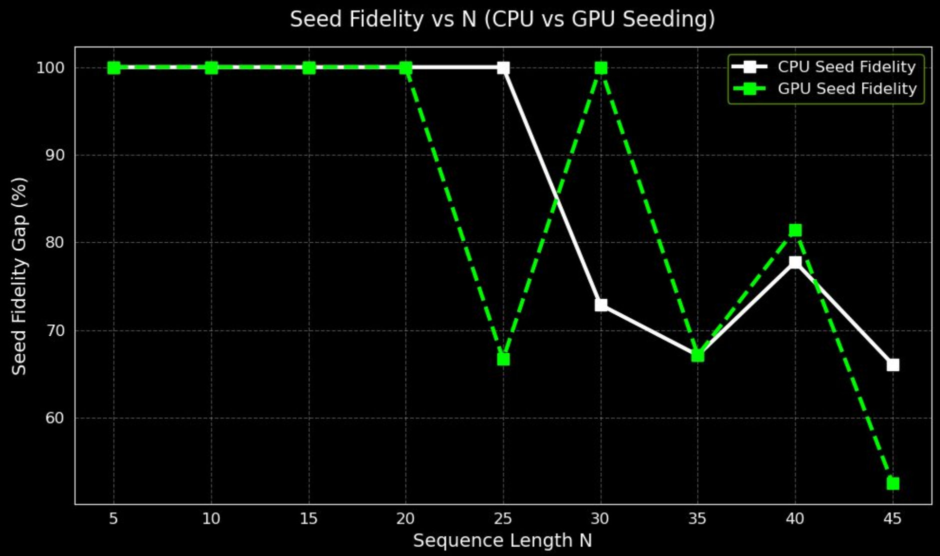
8xA100-80GB-SXM4

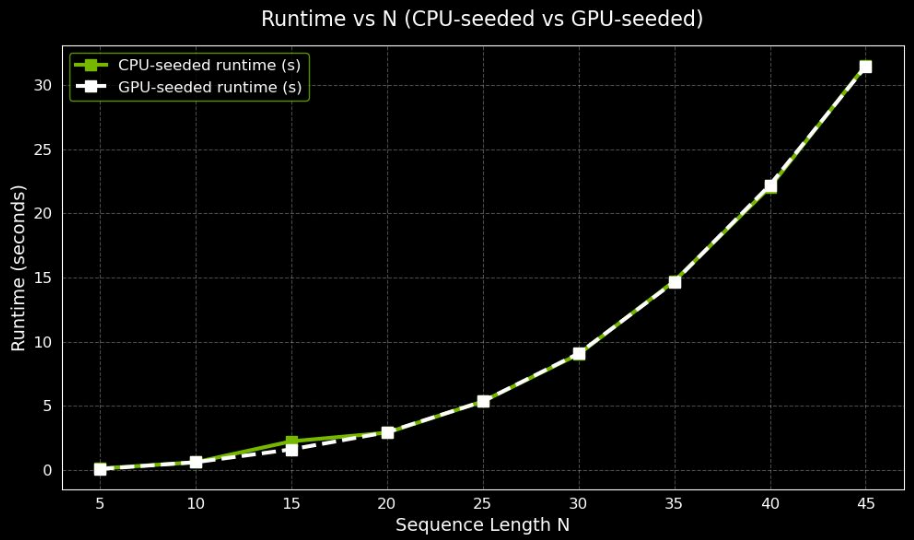
235 vCPU, 640GB VRAM, 8x A100-8... **23.87 cr/min**





GPU Acceleration - Classical MTS - qBraid 1xH100





What we learned

- It is highly important to familiarize with the platform and environment that you are doing.
- N=30 was inaccessible without GPU parallelization. We used L4 GPU. Achieving the correct energy value and compared with literature.
- Time is money, and machines in idle are more expensive. We forgot to shutdown the machine and it stay consuming some credits ~ 4 dollars, (split it equally as no one remember to turn in off - Project lead will pay twice).

Thank you! ❤️

See you in iQuHack 2027, Keep Qurelating!