An Open Platform for Accelerated Quantum Supercomputing

Monica VanDieren | IQuHack, Jan 30, 2026

What sparked your interest to participate in this hackathon?

menti.com
Code: 2114 8418

Agenda

Industry Challenges
What stands in the way of useful quantum computing?
How is the industry working on these challenges?
What are the NVIDIA quantum-related technologies?

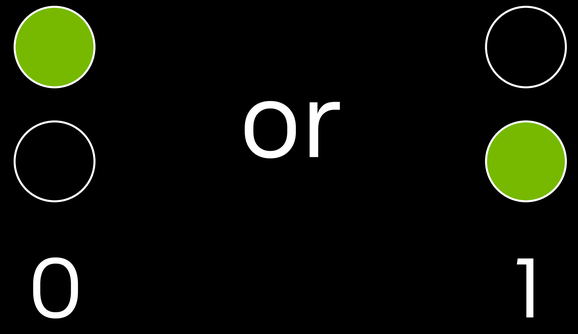
Your Challenges at iQuHack
Industry-inspired
GPU-accelerated
AI-assisted
Role-driven engineering

What you can do to prepare for tomorrow
Form a team
Create accounts on qbraid, brev, and coda
Brush up on CUDA-Q
Read the arxiv paper

What is a Quantum Computer?

Conventional computer

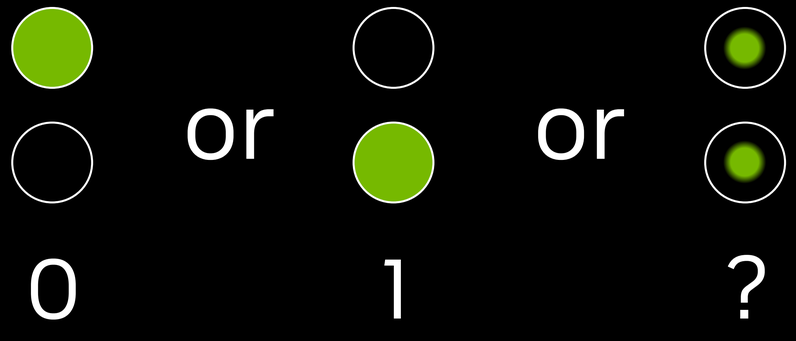
Bit



Transistor

Quantum computer

Qubit



- Superconducting qubits
- Trapped ions
- Neutral atoms
- Photonic qubits
- ...

NVIDIA is not building
Qubits

NVIDIA is building all
Accelerated Quantum
Supercomputers

Quantum HPC Integration

Three Domains

Offline

Simulations for
- Algorithms research
- Application discovery
- Processor design
- Synthetic Data Generation

AI training for
- QEC
- Calibration
- Control

Near-Time

- Hybrid Algorithms and Applications
- Preprocessing and postprocessing
- Calibration

Real-Time

- Quantum Error Correction
- Real-time Optimal Control

CUDA-Q is SW for Quantum Accelerated Supercomputing

A New Heterogenous Architecture

Programming model and compiler for heterogenous supercomputer

Low-latency interconnects for real-time hybrid computing

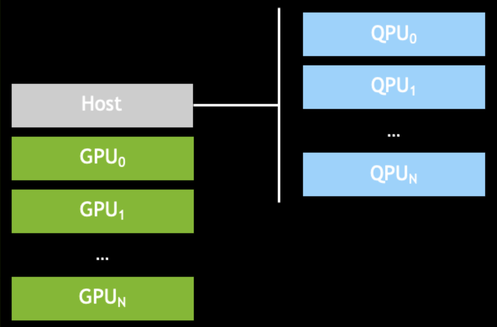
Libraries to enable domain scientists

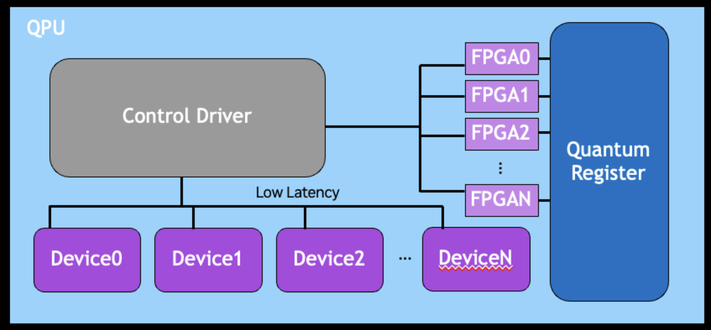
Open source and qubit-agnostic

Libraries, Applications, Frameworks

CUDA-Q

Platform for Programming Accelerated Quantum Supercomputers





NVIDIA

The NVIDIA Quantum Platform

Bringing AI Supercomputing to Enable Useful Quantum Computing

CUDA-Q
Open-Source Software Platform for Accelerated Quantum Supercomputers

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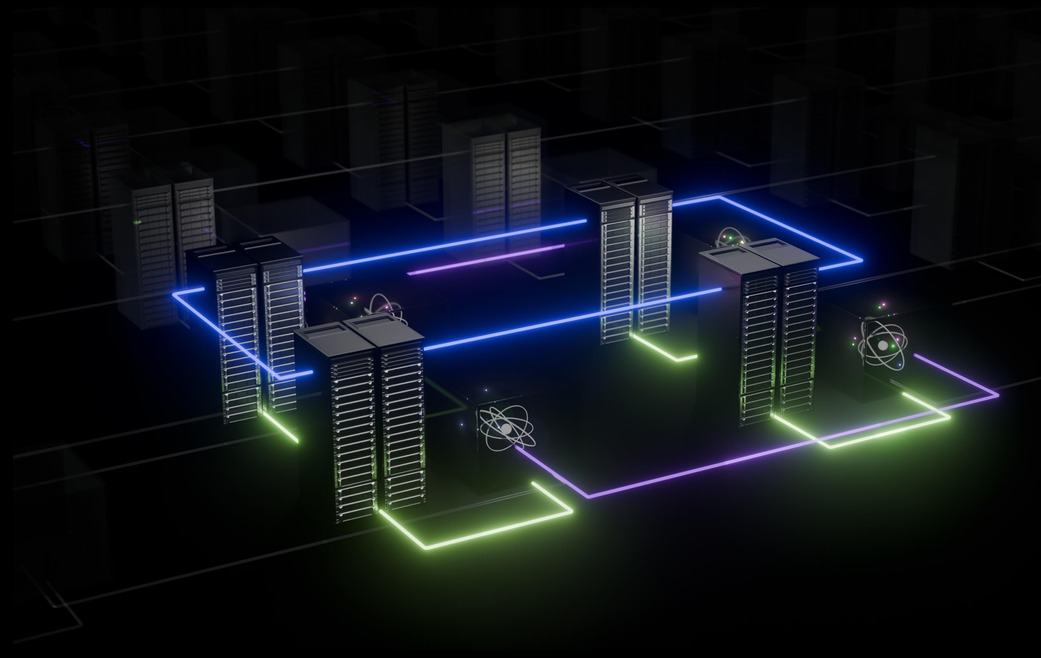
Open-Source Software Platform for Accelerated Quantum Supercomputers

cuQuantum
Accelerated Quantum Simulations

Cirq
PENNYLANE
QIBO
Qiskit
Quest
Qulacs
TKET™
Torch Quantum

NVIDIA

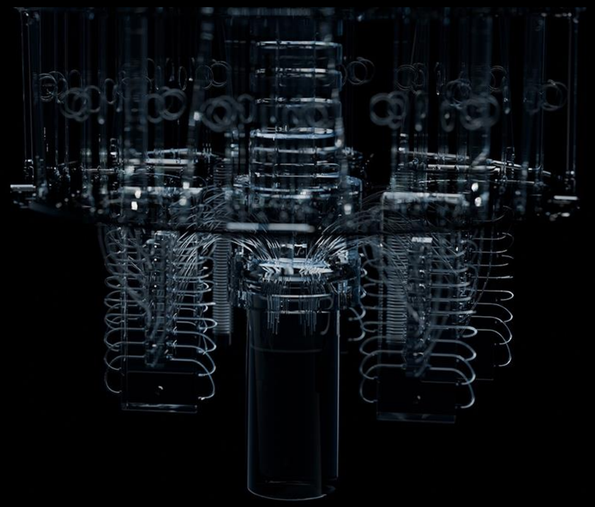
Accelerating the Journey From Qubits to Supercomputers

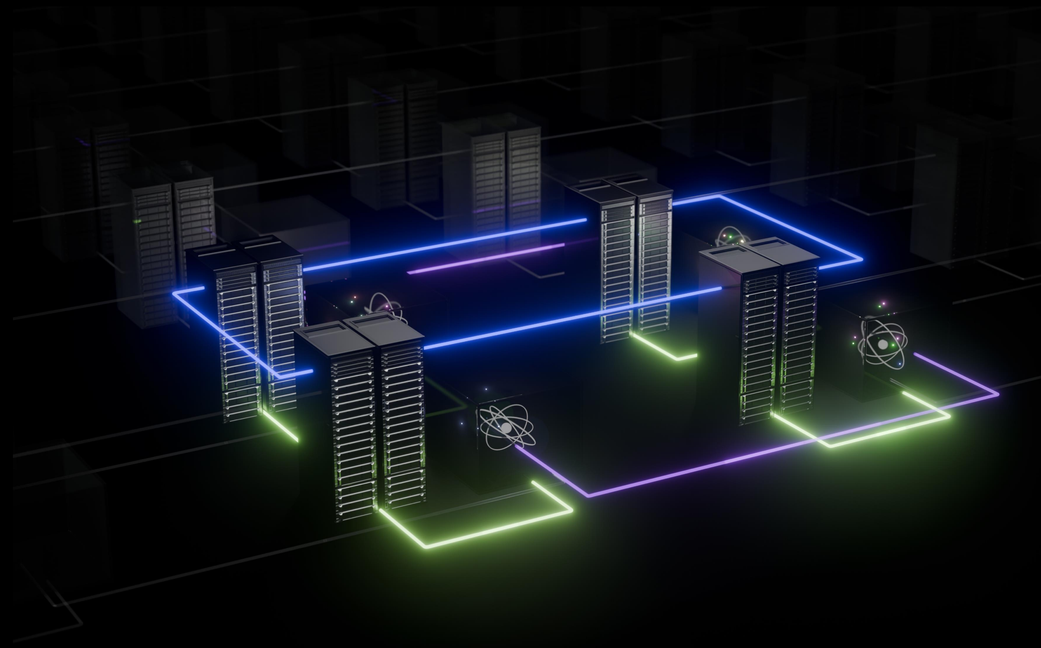


Accelerated Quantum Supercomputers

NVIDIA

Accelerating the Journey From Qubits to Supercomputers





Qubits

Accelerated Quantum Supercomputers

In one or two words, what is the biggest bottleneck in quantum computing today?

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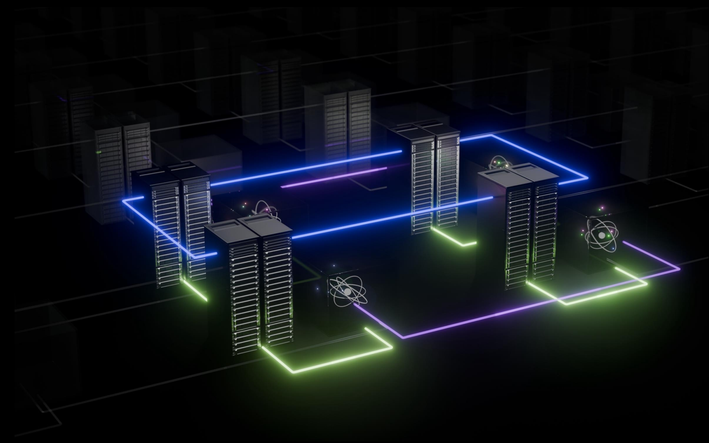
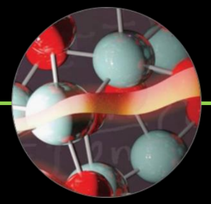
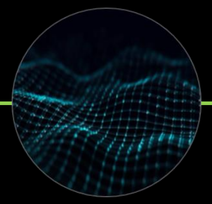
The Journey From Qubits to Supercomputers



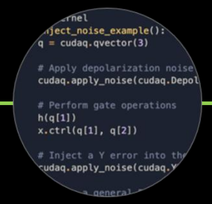
Today's Systems



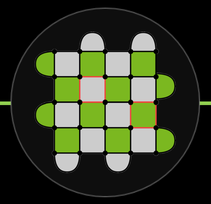
Quantum Algorithm and Hybrid Application Development



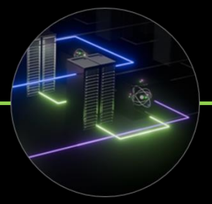
Qubit Design EDA



Quantum Data Generation



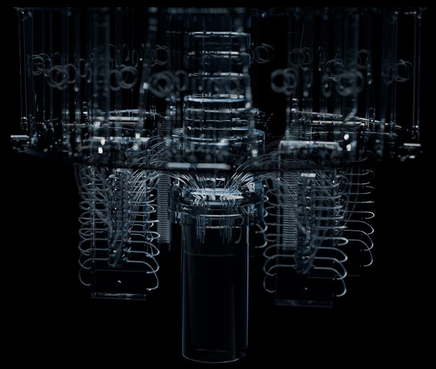
Quantum Error Correction

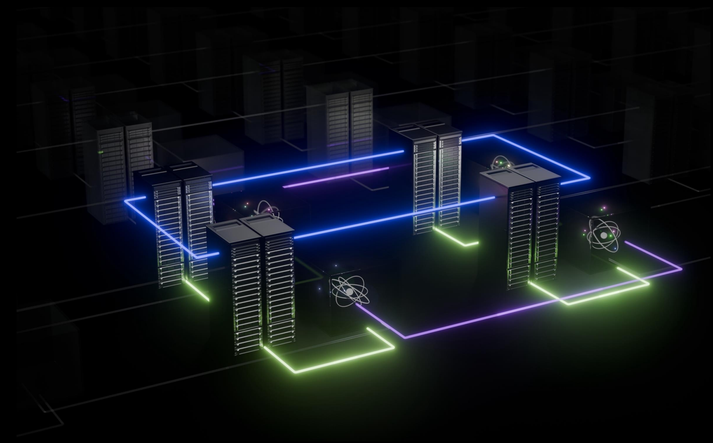


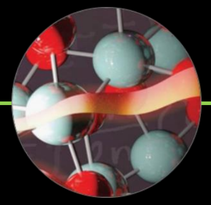
Quantum Computing Deployments

Accelerated Quantum Supercomputers

The Journey From Qubits to Supercomputers







Today's Systems

Quantum Algorithm and Hybrid Application Development

Accelerated Quantum Supercomputers

The Generative Quantum Eigensolver

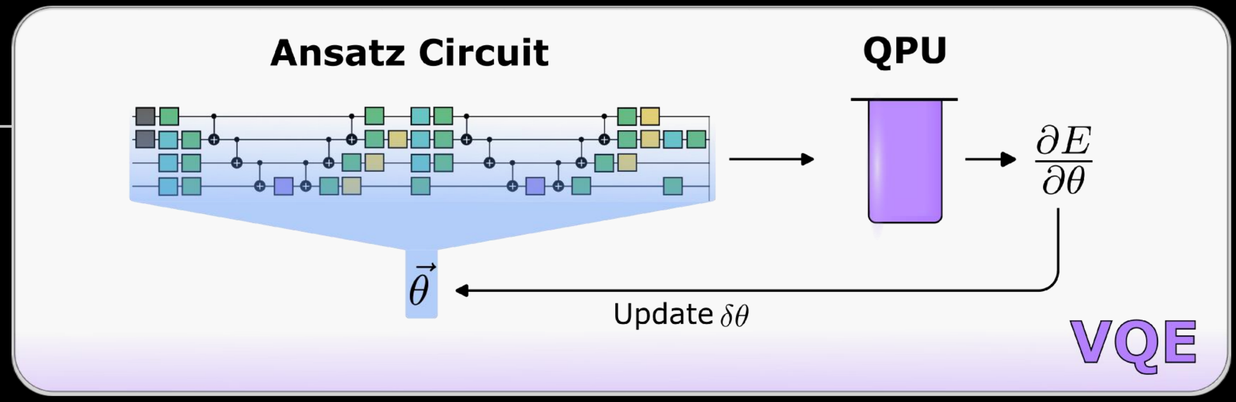
First demonstration of GPT-generated circuits in the literature

Goal: Find a circuit producing e.g. ground state
Optimization of some possible space of circuits for desired output

VQE

Optimization parameters are *part of quantum circuit*

- Leads to issues with local minima and barren plateaus



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https://arxiv.org/pdf/2401.09253.pdf

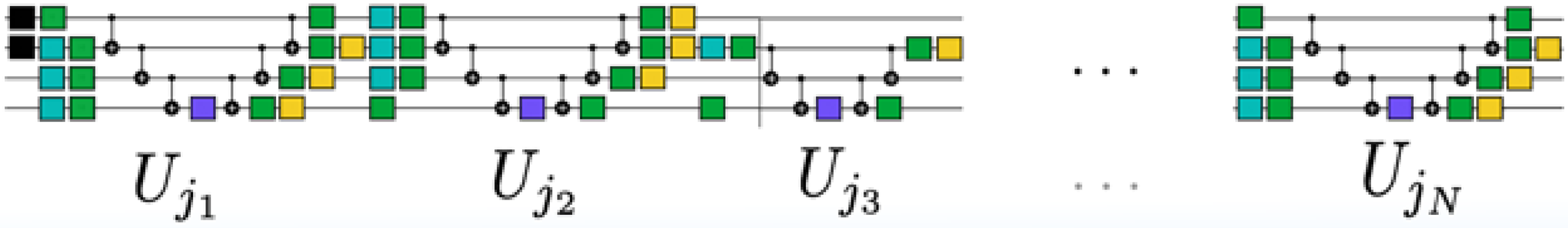
NVIDIA

NVIDIA Quantum

$$\vec{j} \sim \underset{\text{word}_{j_1}}{\text{"Once}} \ \underset{\text{word}_{j_2}}{\text{upon}} \ \underset{\text{word}_{j_3}}{\text{a}} \ \underset{\text{word}_{j_4}}{\text{time}} \ \cdots \ \underset{\text{word}_{j_{N-2}}}{\text{happily}} \ \underset{\text{word}_{j_{N-1}}}{\text{ever}} \ \underset{\text{word}_{j_N}}{\text{after"}}$$

LLM

$$\vec{j} \sim$$



GPT-QE

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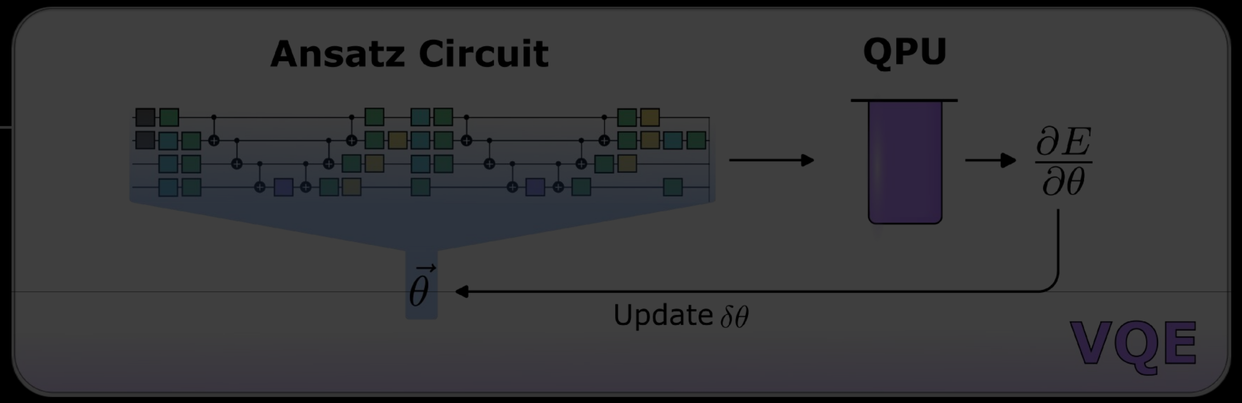
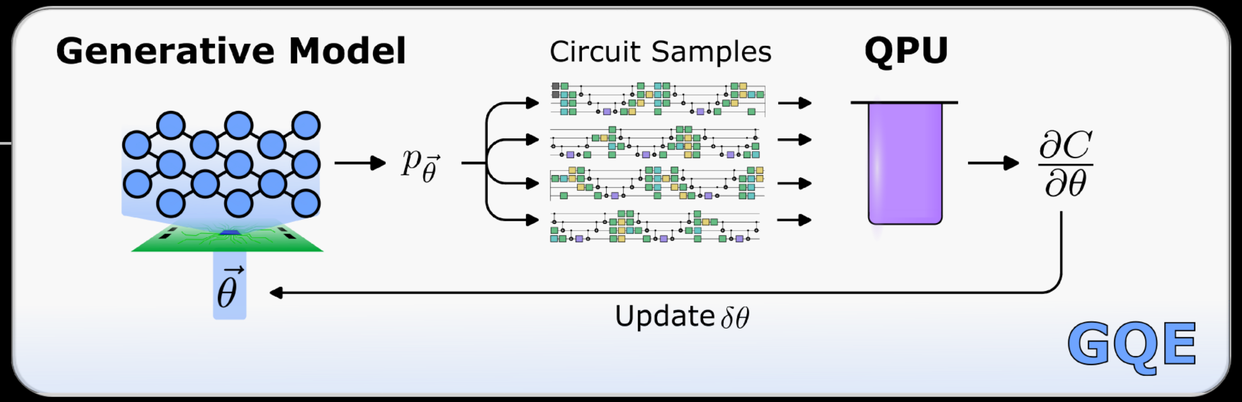
GQE

Move cost-function *to DNN landscape*

- Training capabilities and scalability of classical models can overcome these limitations

- **GQE also allows potential of pretraining from database of circuit results**
  - Each training epoch creates more accurate circuits





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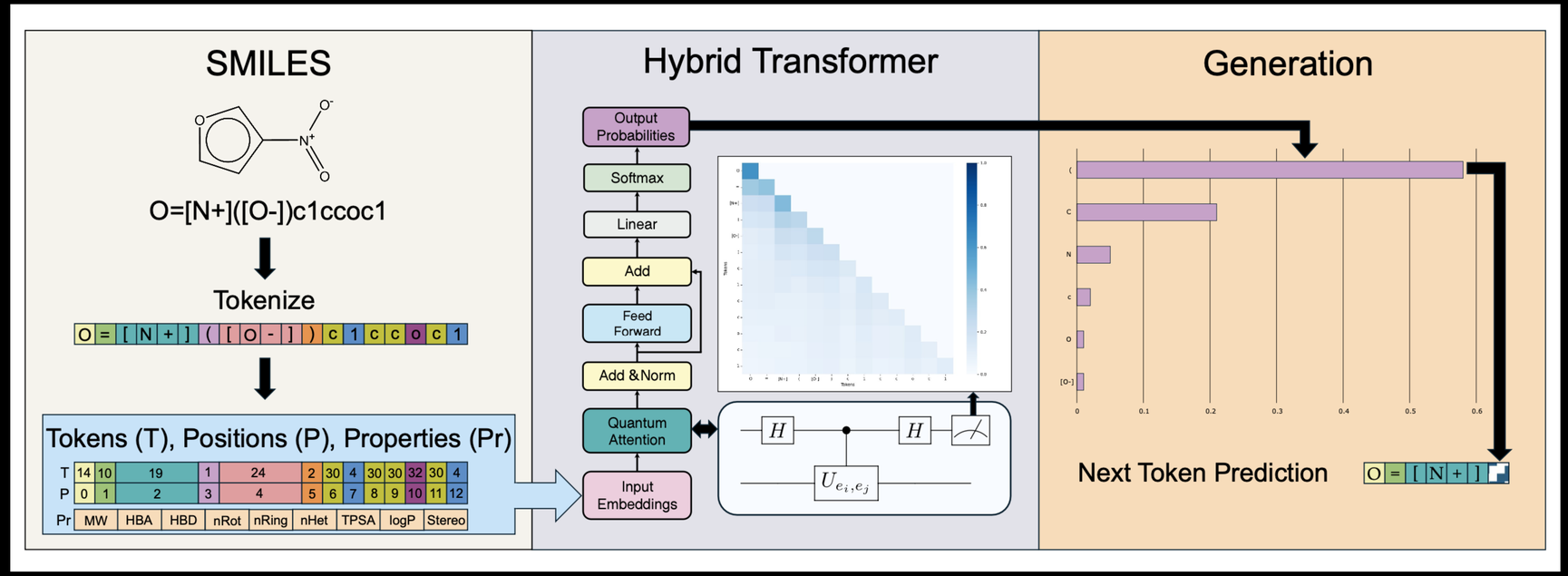
NVIDIA

Quantum GPT Architecture

Hybrid quantum-classical transformer architecture for conditional molecular generation, arXiv:2502.19214



NISQ friendly

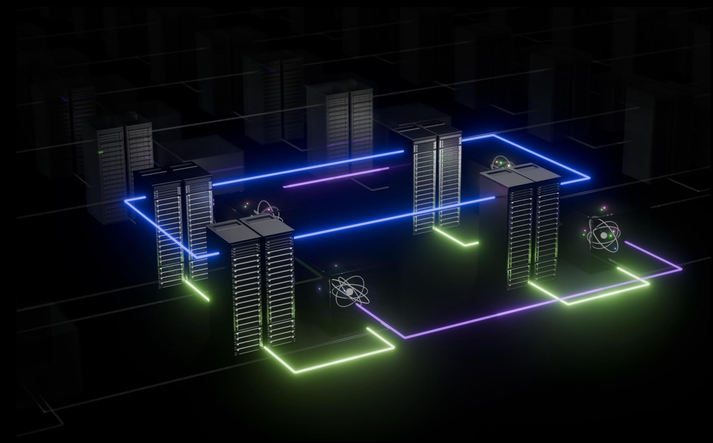
Hybrid and classical models learn different features better

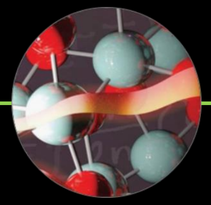
80%

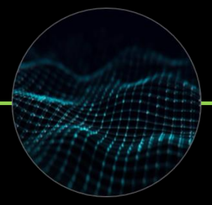
Speedup over CPU when running on 4 GPU

A. Smaldone, et. al., arXiv: 2502.19214

The Journey From Qubits to Supercomputers







Today's Systems

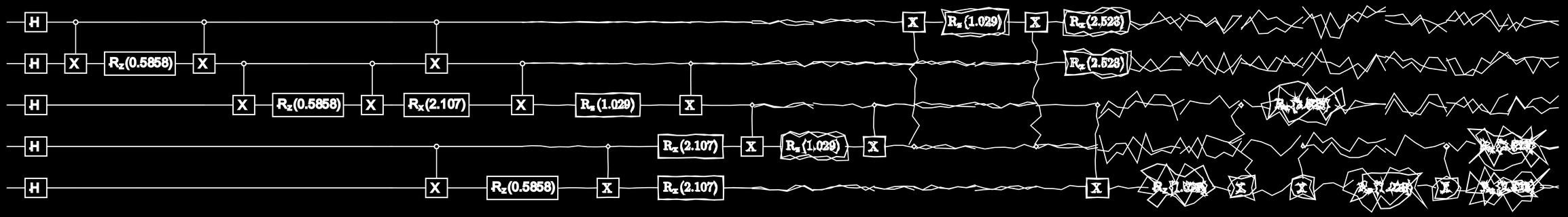
Quantum Algorithm and Hybrid Application Development

Qubit Design EDA

Accelerated Quantum Supercomputers

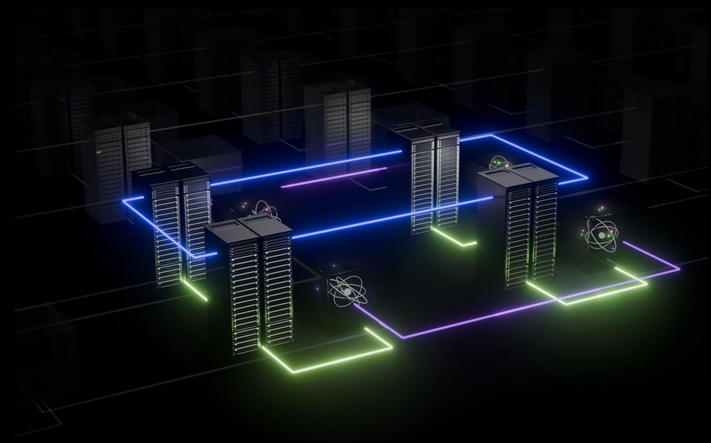
Noise Limits Today’s Quantum Hardware

Current noisy quantum hardware is limited to just hundreds of operations

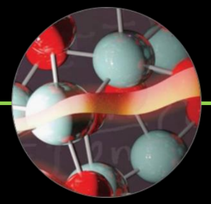


Quantum
Processor

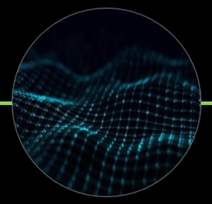
The Journey From Qubits to Supercomputers



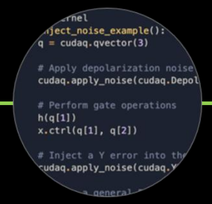
Today's Systems



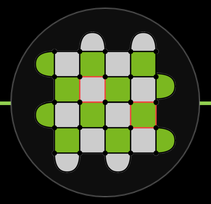
Quantum Algorithm and Hybrid Application Development



Qubit Design EDA



Quantum Data Generation



Quantum Error Correction

Accelerated Quantum Supercomputers

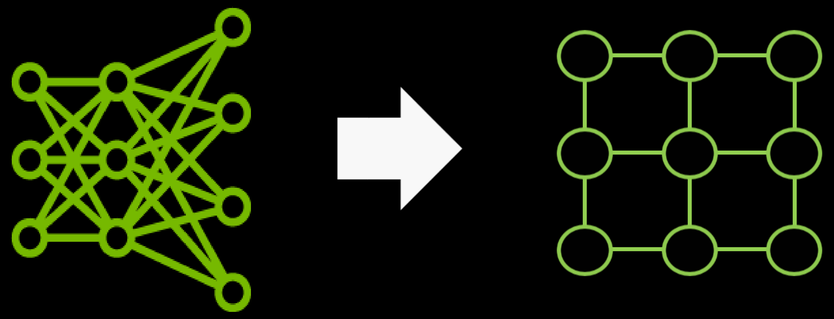
NVIDIA

AI for Error Correction

AI-driven code generation and decoding

AI for code generation

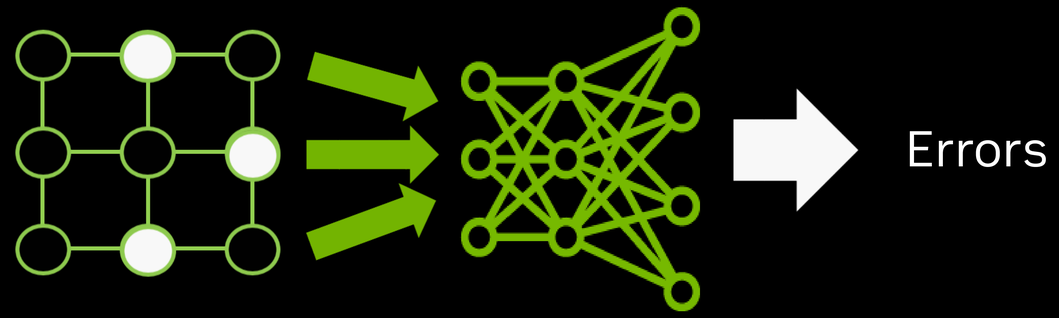
Error correcting code with specific properties are generated by the reinforcement learning (e.g., [1])



Error correcting code

AI for decoders

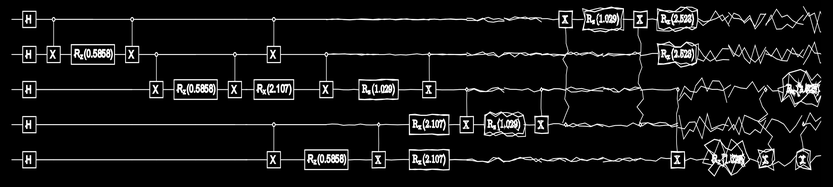
The result of syndrome measurements are decoded by machine learning models (e.g., [2])



1. J. Olle et al., *npj Quantum Information* 10.1, 1-17, (2024).
2. Bausch et al. ,*Nature* **635**, 834–840 (2024)

Building an AI Decoder

Custom Noise Model



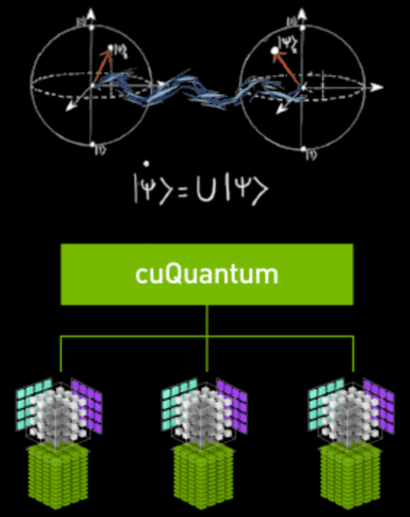
\+

Sampling Algorithm

Strategic Kraus Operator Sets

$\{K_0, \ldots, K_N\}$
$\{K_0, \ldots, K_N\}$
$\{K_0, \ldots, K_N\}$

Accelerated Simulators



Synthetic Training Data

On DGX H100 Supercomputer with 576 nodes:

- Emulated 85 qubit system – ***1 million shots*** generated in > 6 hours
- Emulated 35 qubit system – ***1 trillion shots*** generated in > 2 hours

Released open source in CUDA-Q 0.10

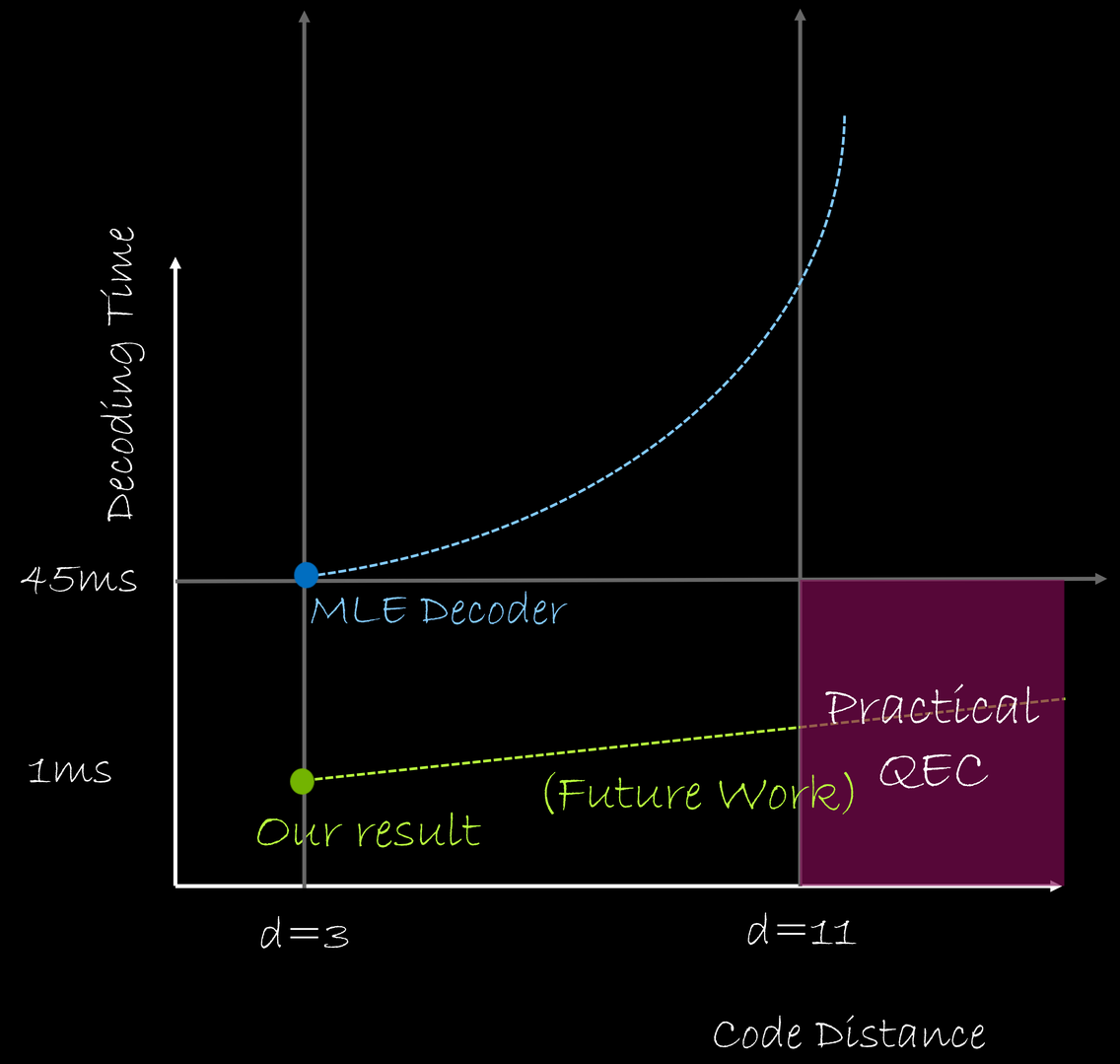
Trained with open source PhysicsNemo AI-physics framework

Decoding QuEra's QPU with AI

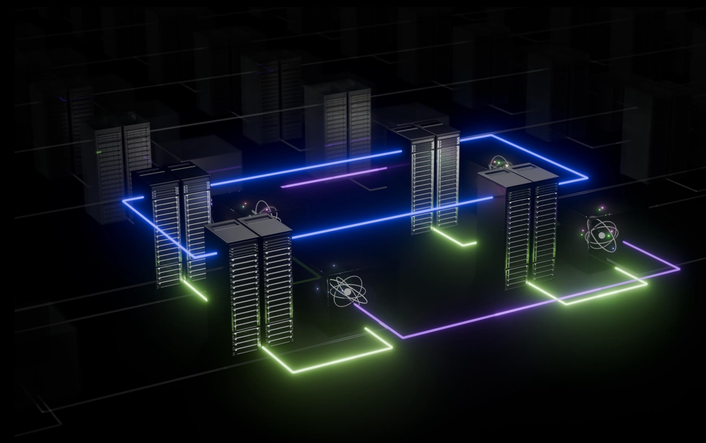
Transformer-based decoder

Future Work

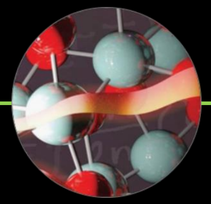
- Larger codes – much more training data needed
- Fine-tune on QPU data for higher accuracy
- Deploy for real-time decoding



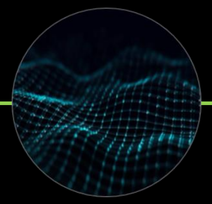
The Journey From Qubits to Supercomputers



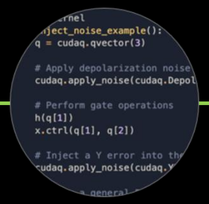
Today's Systems



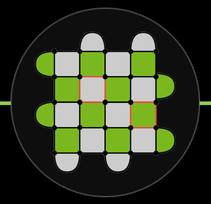
Quantum Algorithm and Hybrid Application Development



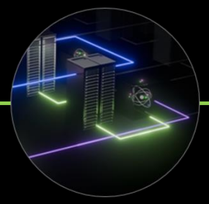
Qubit Design EDA



Quantum Data Generation



Quantum Error Correction

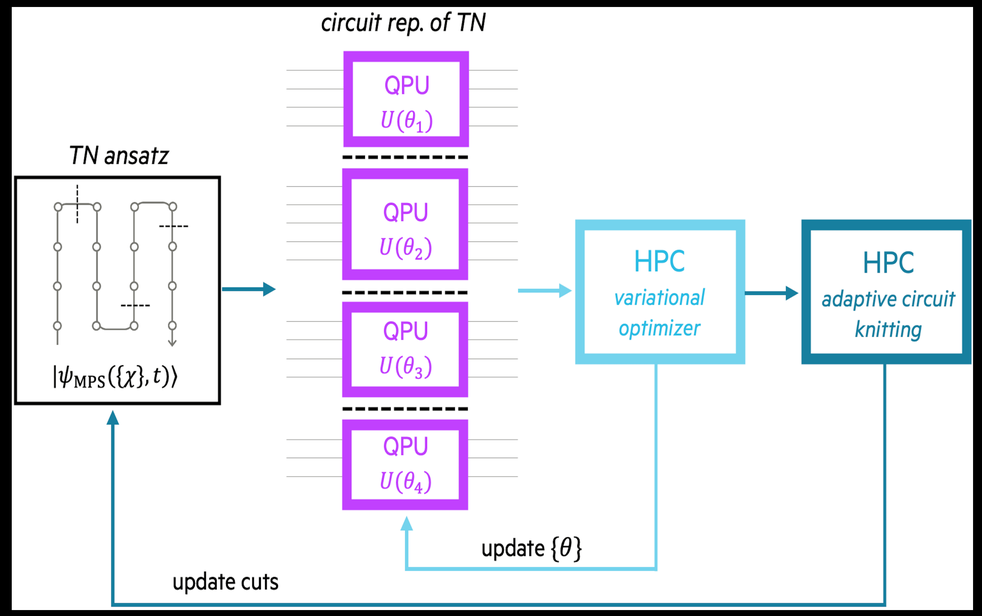


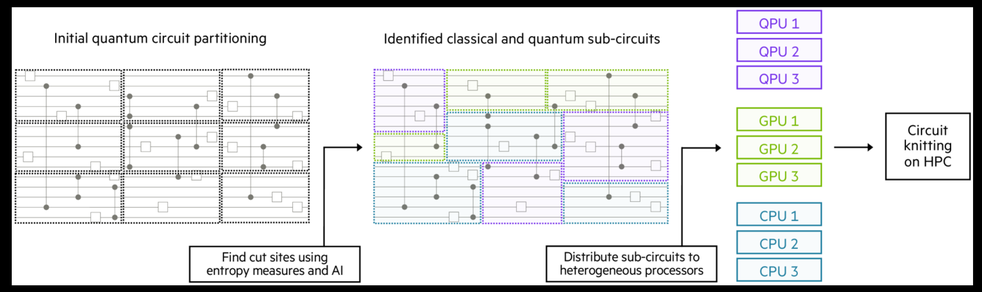
Quantum Computing Deployments

Accelerated Quantum Supercomputers

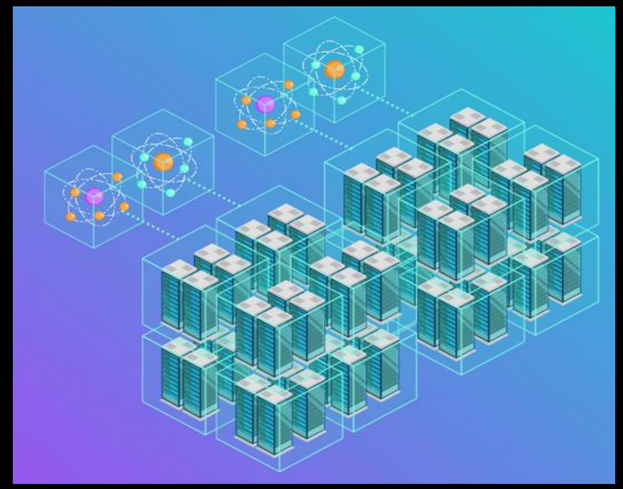
Distributed Quantum Computing with Adaptive Circuit Knitting

Adaptive Circuit Knitting





Distributed Quantum Computing



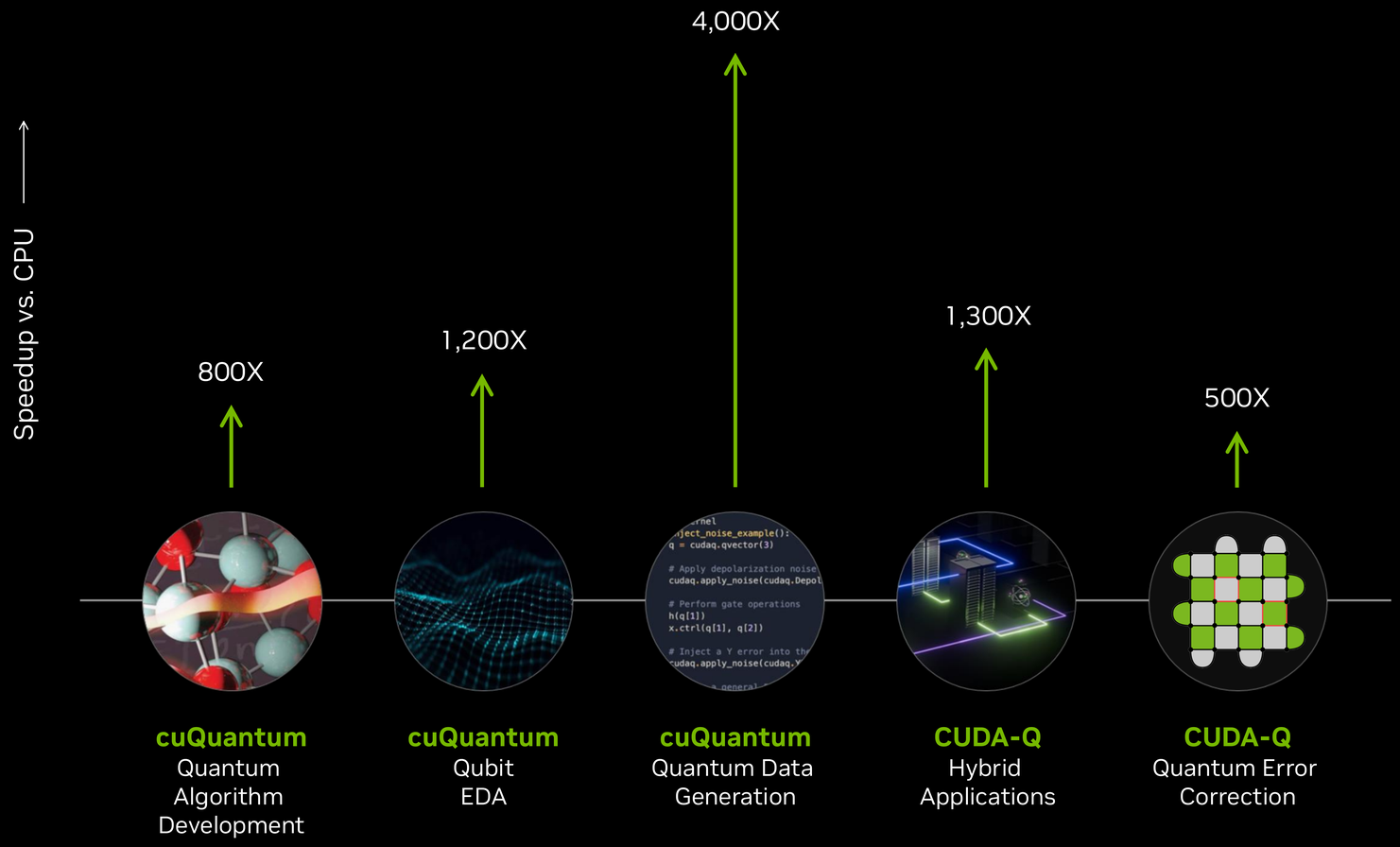
Up to 2 orders of magnitude reduction in classical overhead

40q simulation on Perlmutter using 1024 NVIDIA GPUs over 256 nodes

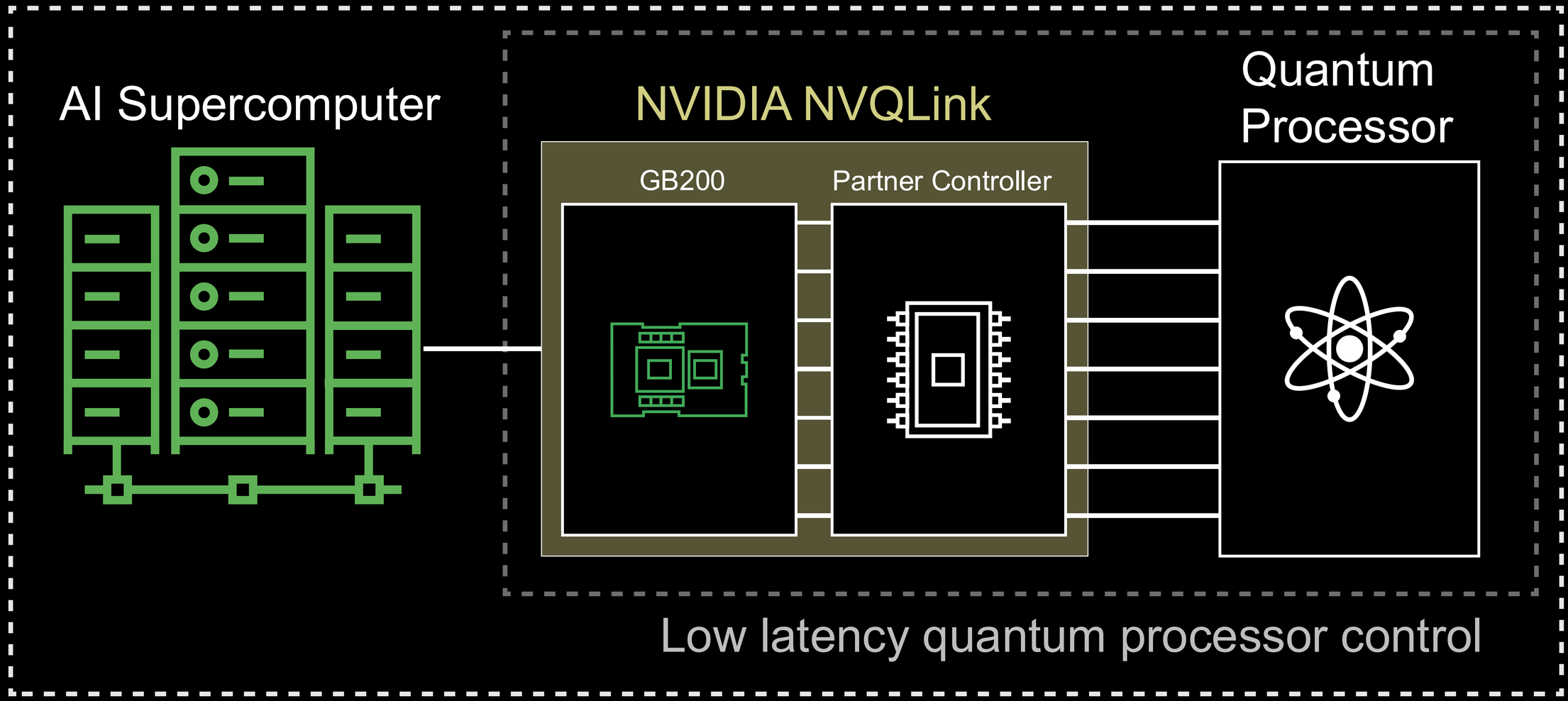
M. Mohseni, et. al., How to Build a Quantum Supercomputer: Scaling from Hundreds to Millions of Qubits, arXiv: 2411.10406
https://www.hpe.com/us/en/newsroom/blog-post/2025/03/scaling-quantum-computers-hewlett-packard-enterprise-and-nvidia-tackle-distributed-quantum-computation.html

NVIDIA GB200 NVL72 Powers Quantum

State of the art accelerated computing provides speedups across quantum workloads



NVIDIA NVQLink



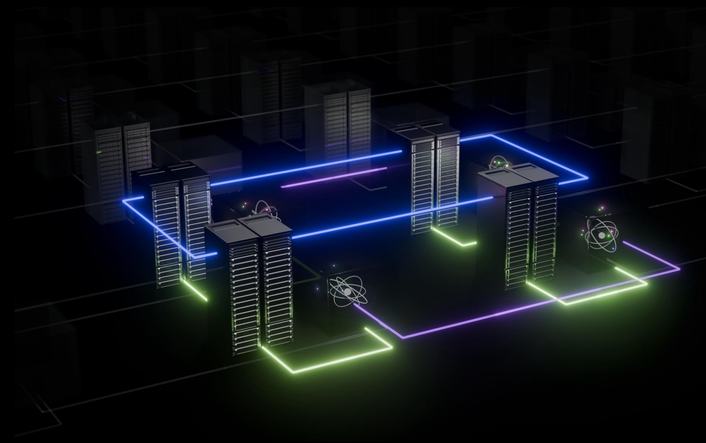
Agenda

Industry Challenges
What stands in the way of useful quantum computing?
How is the industry working on these challenges?
What are the NVIDIA quantum-related technologies?

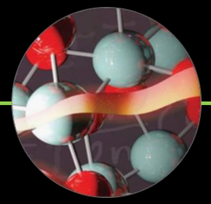
Your Challenges at iQuHack
Industry-inspired
GPU-accelerated
AI-assisted
Role-driven engineering

What you can do to prepare for tomorrow
Form a team
Create accounts on qbraid, brev, and coda
Brush up on CUDA-Q
Read the arxiv paper

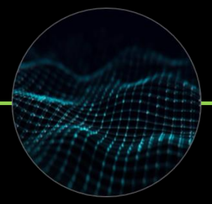
The Journey From Qubits to Supercomputers



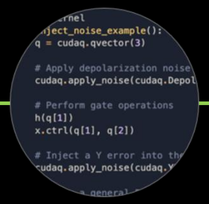
Today's Systems



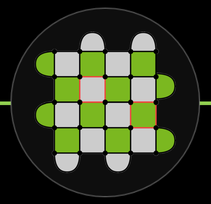
Quantum Algorithm and Hybrid Application Development



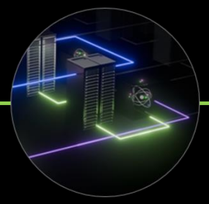
Qubit Design EDA



Quantum Data Generation



Quantum Error Correction

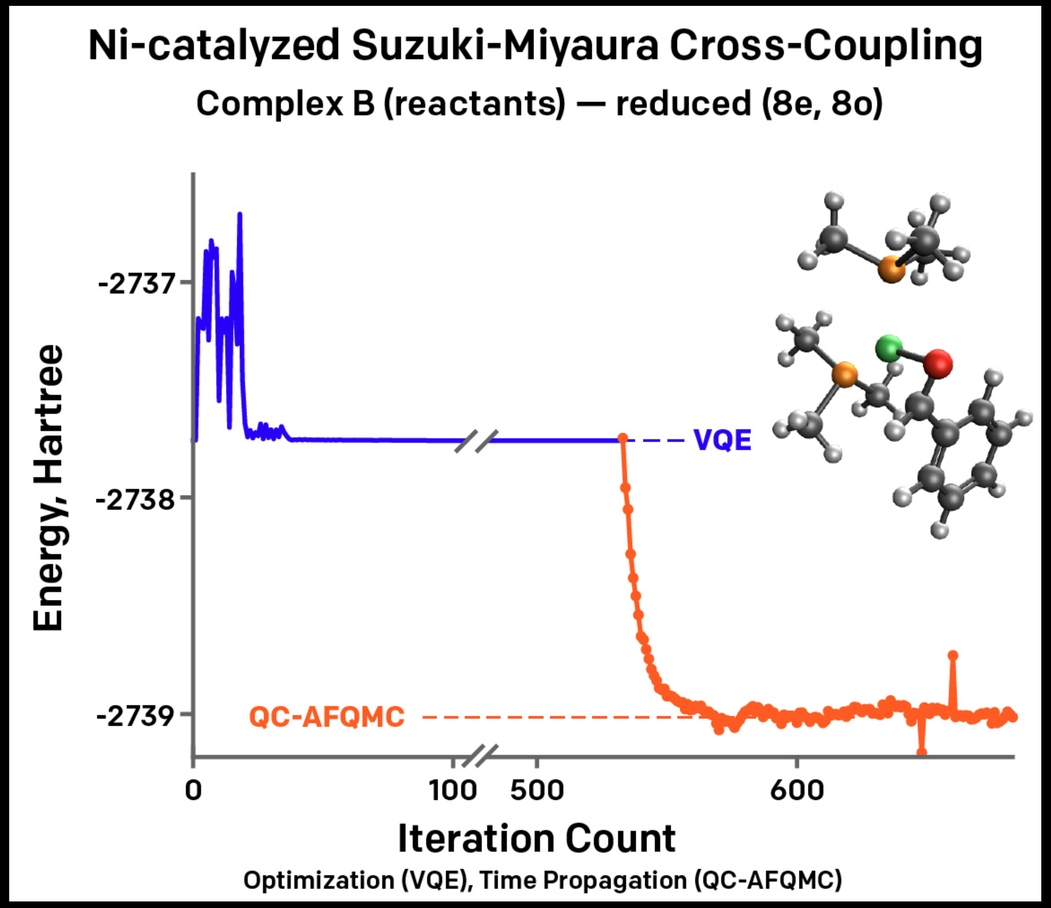


Quantum Computing Deployments

Accelerated Quantum Supercomputers

Drug Design & Computational Chemistry

Largest demonstration of its kind combining hardware, platforms, and accelerated computing



- Simulate a key catalytic reaction
- E2e accelerated workflow CUDA-Q executed within the Braket environment:
  - Seamless access to IonQ QPU **executing ~200k circuits**
  - Circuit transmission speed **improved by 3x**
  - **960 H200 GPUs** for postprocessing QPU data with libraries built on top of CUDA

20x faster time to solution

End-to-end accelerated hybrid workflow

https://ionq.com/news/ionq-speeds-quantum-accelerated-drug-development-application-with

Powering the Quantum Ecosystem

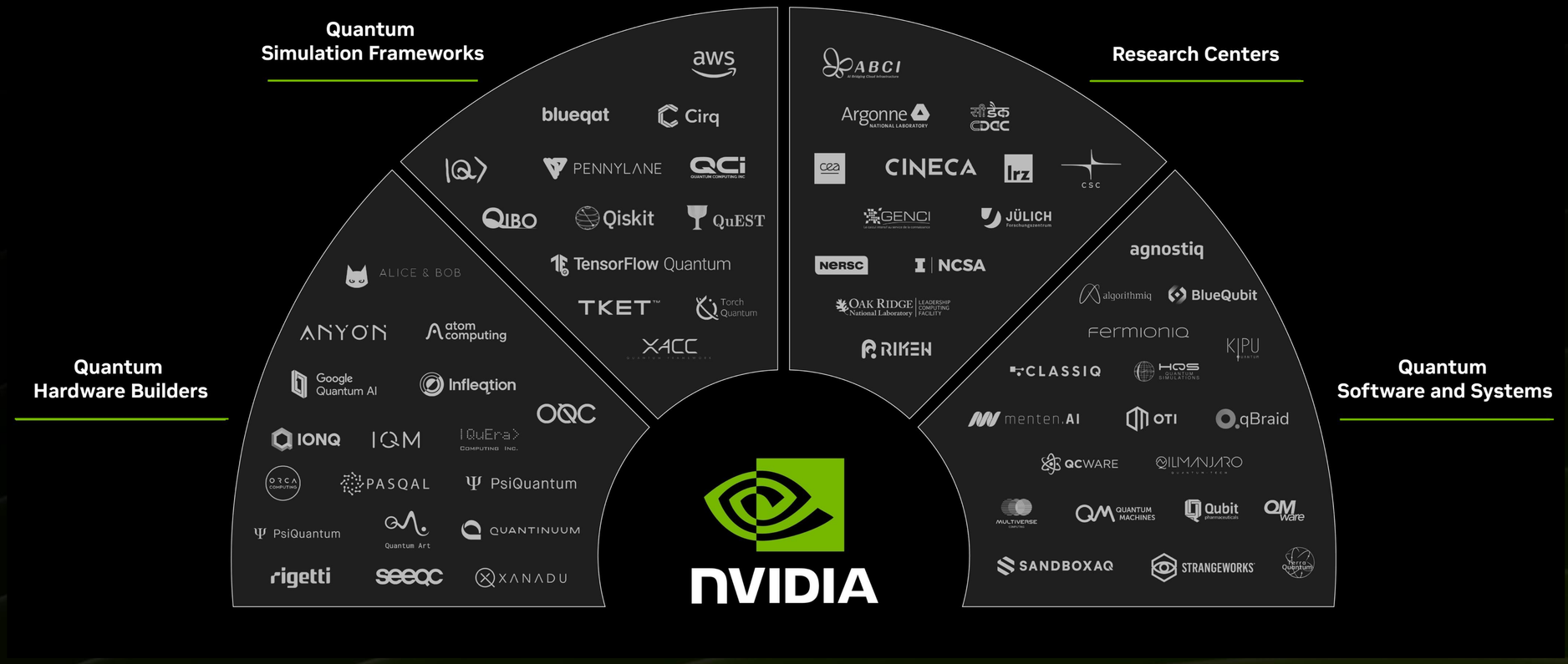
The only quantum company that works with every other quantum company

200+
NVIDIA Quantum Partners

>90%
Largest Startups Working with NVIDIA

>80%
QPUs Integrating NVIDIA Software

100%
Leading Quantum Development Frameworks Accelerated



NVIDIA Challenge
Vibe coding encouraged!

- Generate a sequence of 1s and -1s with low autocorrelation
- Relevant for radar and telecommunications
- State of the art classical heuristic algorithm is the memetic tabu search
- Quantum approaches like QAOA have been studied
- This challenge examines the combination of the quantum and classical approaches, inspired by a team of researchers at Kipu Quantum GmbH and NVIDIA https://arxiv.org/html/2511.04553v1

Try to generate a low autcorrelation sequence yourself

Low Autocorrelation Binary Sequence

Interactive visualization

Submit your answer

LABS Challenge Timeline

Phase 1 = Milestone 1 and 2
Phase 2 = Milestone 3 and 4

Form Team - collaborate

Project Lead

GPU Acceleration Person in Charge (PIC)

Quality Assurance PIC

Technical Marketing PIC

Milestone 1 - learn

complete a warmup lesson to understand the problem and build an implementation in qbraid based on a recent research paper

Vibe coding encouraged!

Milestone 2 - plan and unlock credits

Plan your own solution to unlock GPU and AI credits

Create strategies for use of AI, code verification, GPU acceleration, and measuring success

Milestone 3 - build

Implement your solution in CUDA-Q and accelerate it with GPUs on brev.nvidia.com

Use CODA and other AI agents

Milestone 4 - communicate

Present results and retrospective

Awards Ceremony -celebrate

In our challenge, you will be operating as an R&D start-up. Teamwork is key. Which role fits your strengths and interests?

menti.com
Code: 2114 8418

NVIDIA prizes for the MIT IQuHack

Four ways to win!

NVIDIA Challenge Awards

Eligibility: complete the NVIDIA challenge

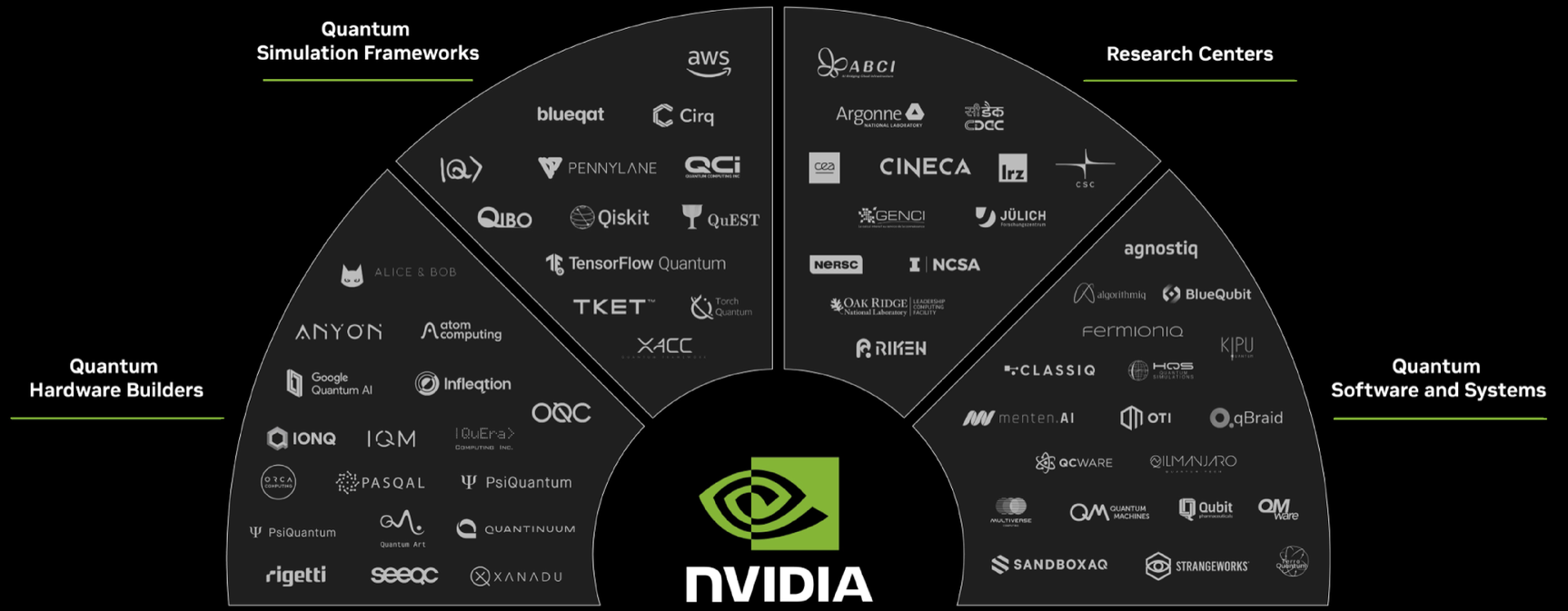
- 1st Prize 400 brev credits /person*
- 2nd Prize 300 brev credits/person*
- 3rd Prize 100/ brev credits person*

NVIDIA Ecosystem Award

Eligibility: Use CUDA-Q or NVIDIA tech in one of the other challenges (e.g., IQM, Quantum Rings, IonQ, Blue Qubit).

Submit your code, a short description of your project, and use of NVIDIA tech to the NVIDIA ecosystem award discord channel

- One prize: 200 brev credits/person*
- Other challenges where CUDA-Q or NVIDIA tech may*be useful: IQM, Quantum Rings



* Max 5 people per team

Agenda

Industry Challenges
What stands in the way of useful quantum computing?
How is the industry working on these challenges?
What are the NVIDIA quantum-related technologies?

Your Challenges at iQuHack
Industry-inspired
GPU-accelerated
AI-assisted
Role-driven engineering

What you can do to prepare for tomorrow
Form a team
Create accounts on qbraid, brev, and coda
Brush up on CUDA-Q
Read the arxiv paper

Resources for the hackathon

CUDA-Q “Hello World” visualization tool

CUDA-Q documentation

Scaling advantage with quantum-enhanced memetic tabu search for LABS paper

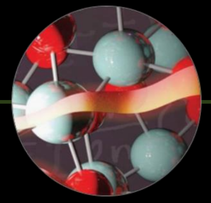
brev.nvidia.com

coda.conductorquantum.com

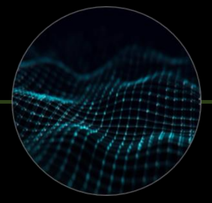
CUDA-Q Academic

Resources for Learning to Program Accelerated Quantum Supercomputers

Today's Systems



Quantum Algorithm and Hybrid Application Development



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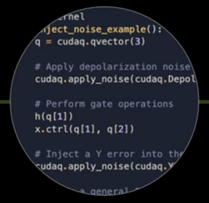
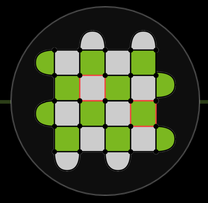


GPU Simulations to Generate Quantum Data



Quantum Error Correction

Quantum Computing Deployments

Accelerated Quantum Supercomputers

CUDA-Q Academic Modules

- **Quantum Applications to Finance and Chemistry**
- **Dynamics 101**
- **Large-Scale Simulation of Quantum Systems**
- **QEC 101**
- **Divide and Conquer for Max Cut**

NVIDIA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