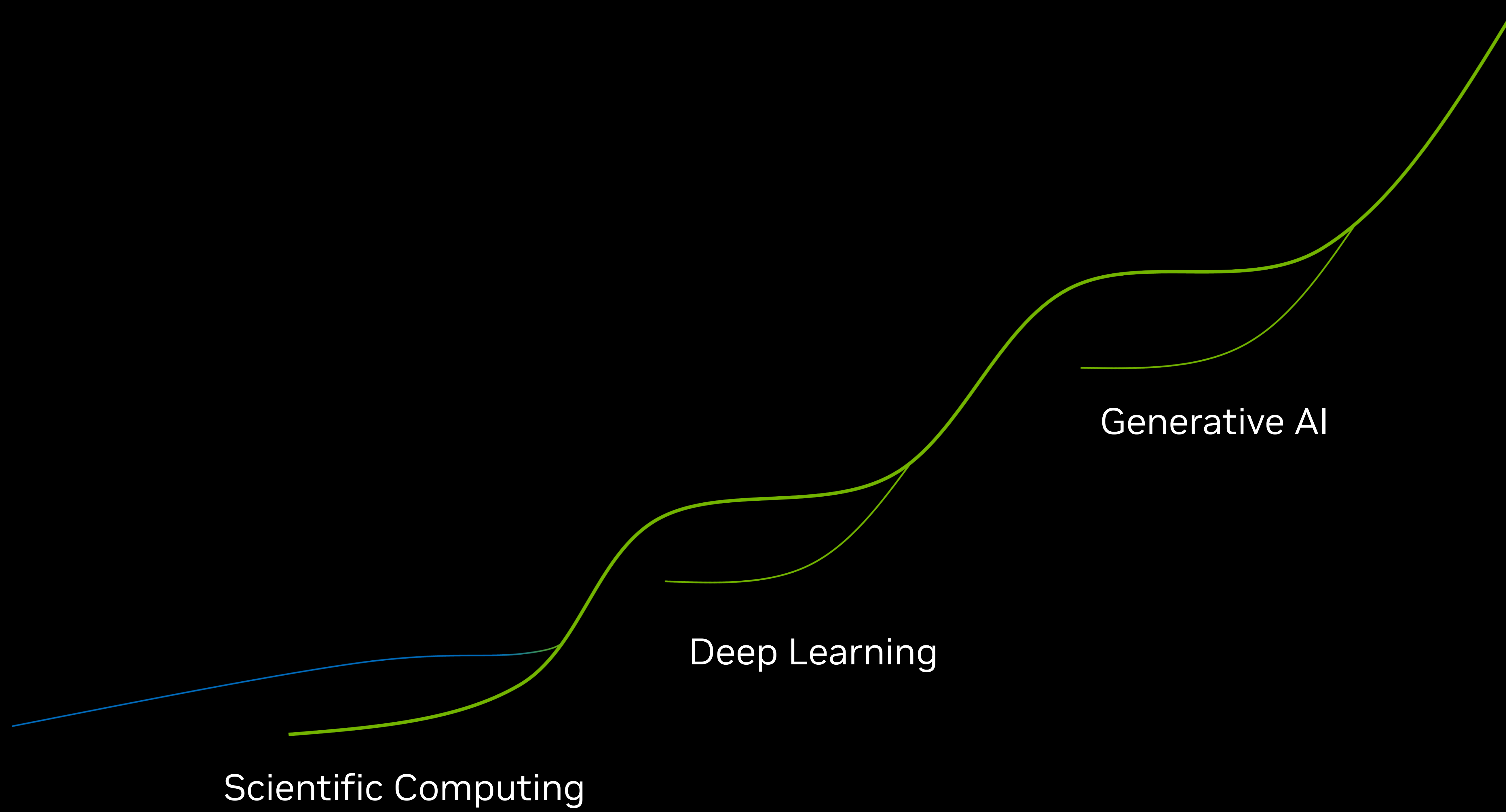


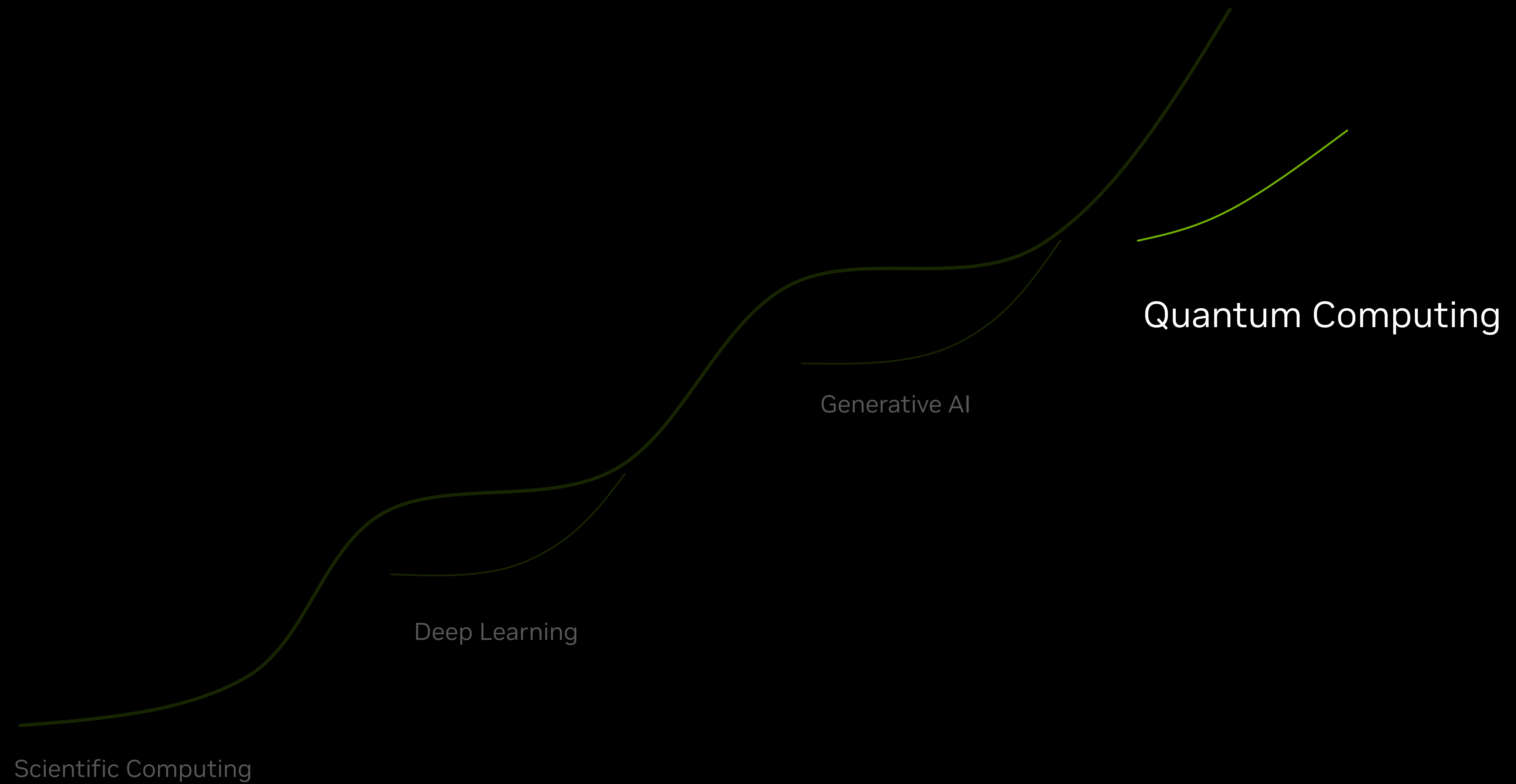
Accelerated Quantum Supercomputing using CUDA-Q

Esperanza Cuenca-Gomez, Developer Relations Manager, Quantum Computing

NVIDIA's History of Enabling Computing Revolutions



NVIDIA's History of Enabling Computing Revolutions

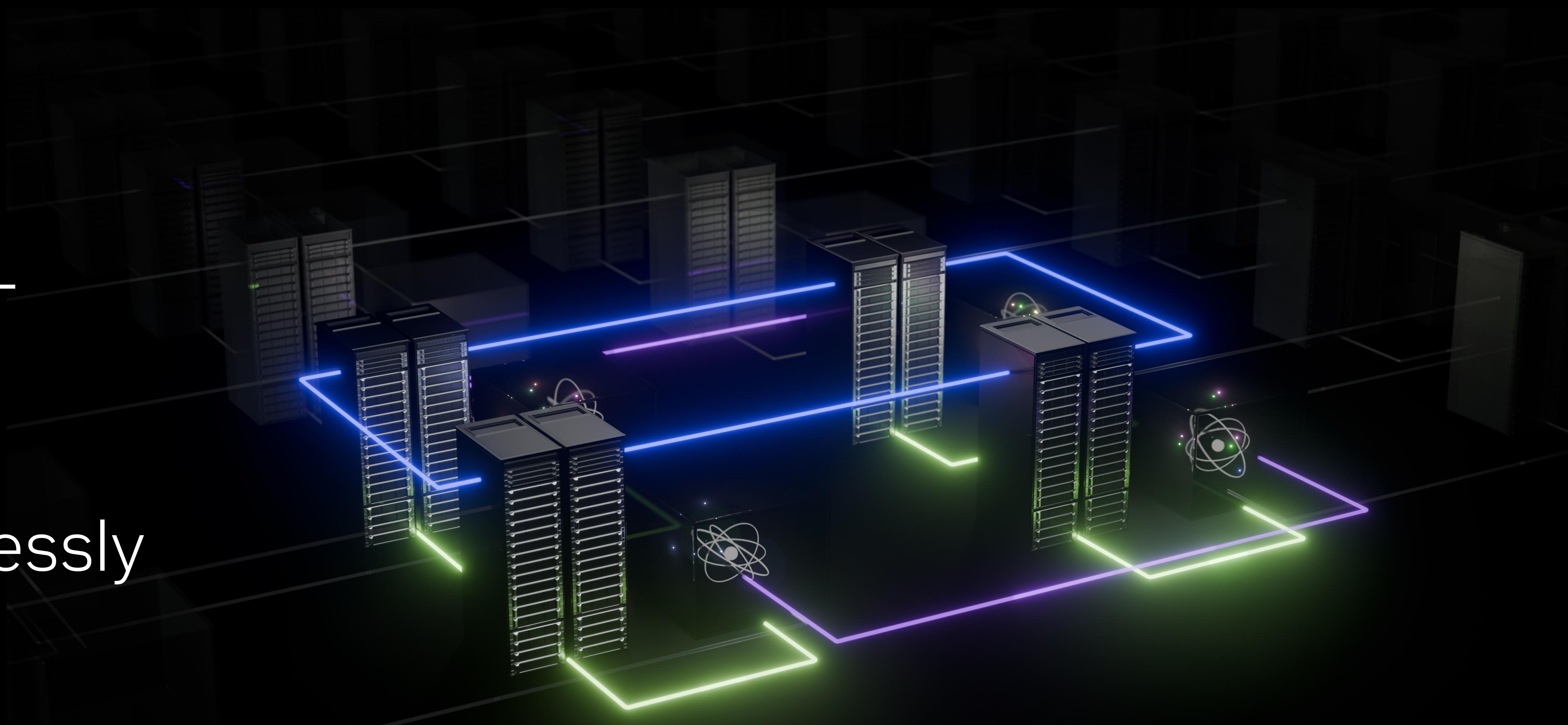


NVIDIA is not building
Qubits

NVIDIA is building all
Accelerated Quantum
Supercomputers

The Accelerated Quantum Supercomputer

- Supercomputing architecture **connecting quantum hardware**
- Ability to run **hybrid algorithms** – using GPUs and QPUs
- A **software platform** that seamlessly connects hybrid applications
- The ability to perform **qubit-agnostic** development of control and error correction



Quantum Computing Needs Accelerated Computing

AI SC for QC Deployments



Quantum Error Correction

Hybrid algorithms and applications

AI for

- Calibration
- Control
- Readout

AI SC for QC Development



Accelerated application development

AI assisted circuit design

Dynamical simulations

Noise modeling

Practical Post Quantum Cryptography

Powering the Quantum Ecosystem

The only quantum company that works with every other quantum company

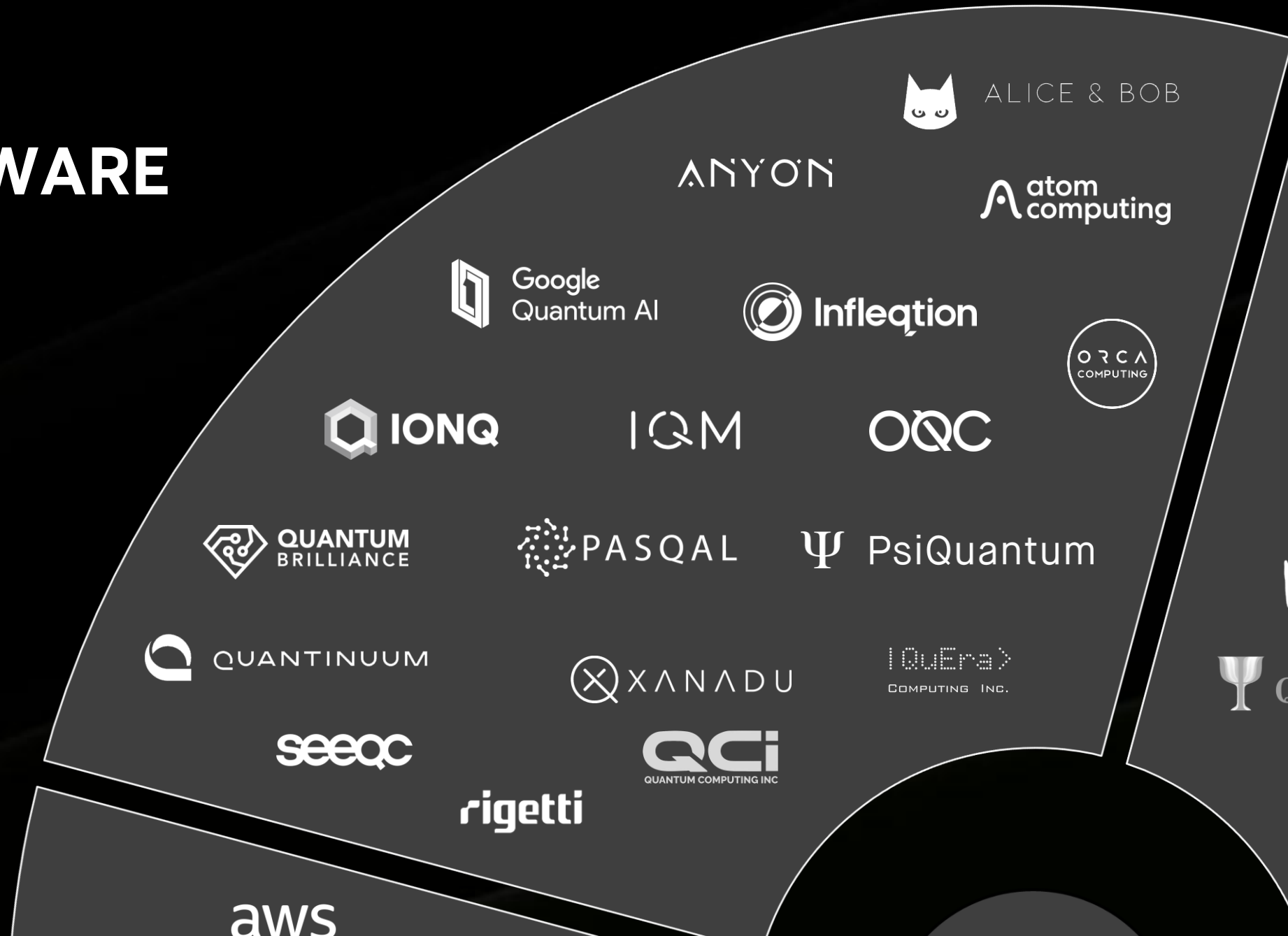
200+
NVIDIA Quantum Partners

>90%
Largest Startups Working with NVIDIA

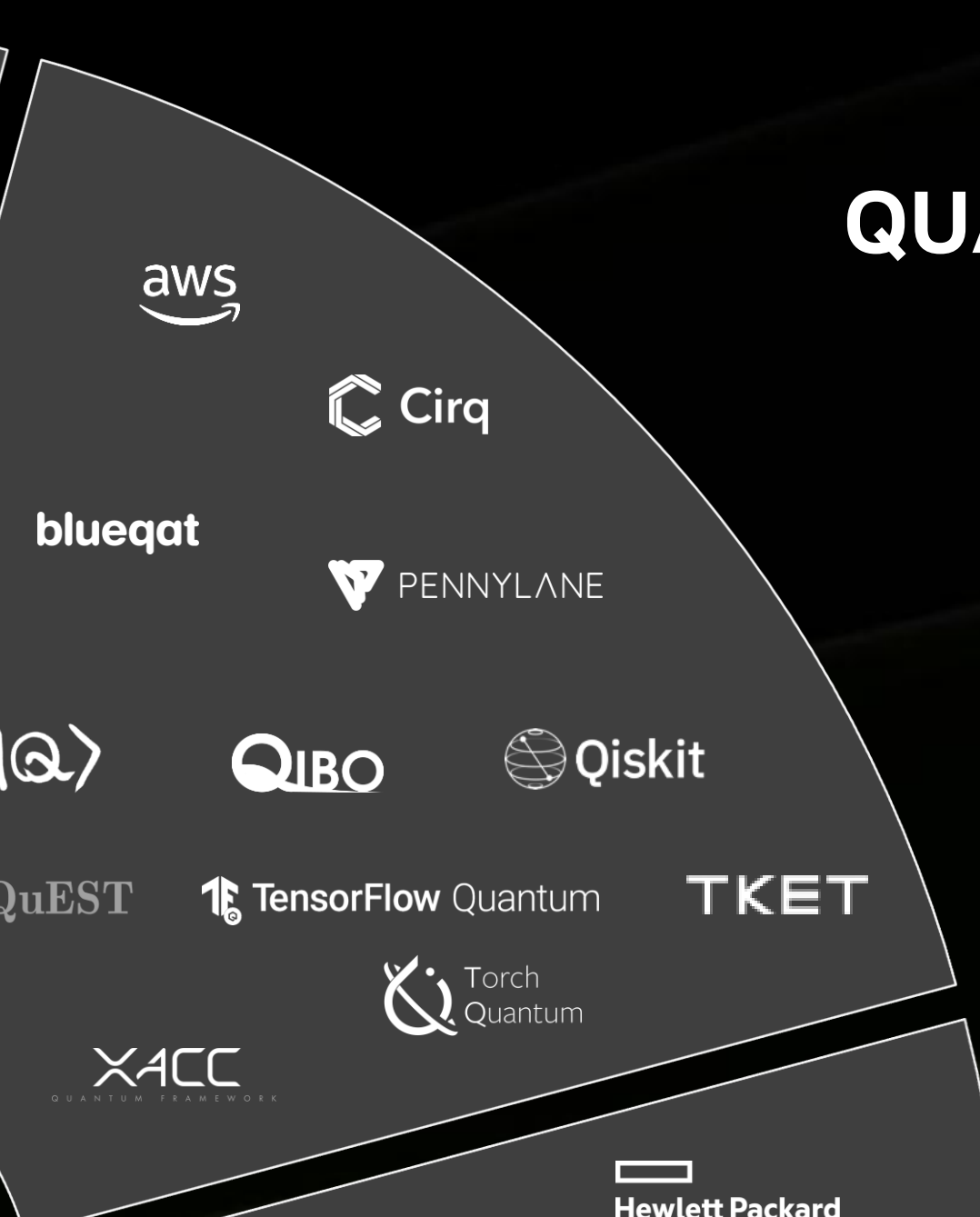
>80%
QPUs Integrating NVIDIA Software

100%
Leading Quantum Development Frameworks Accelerated

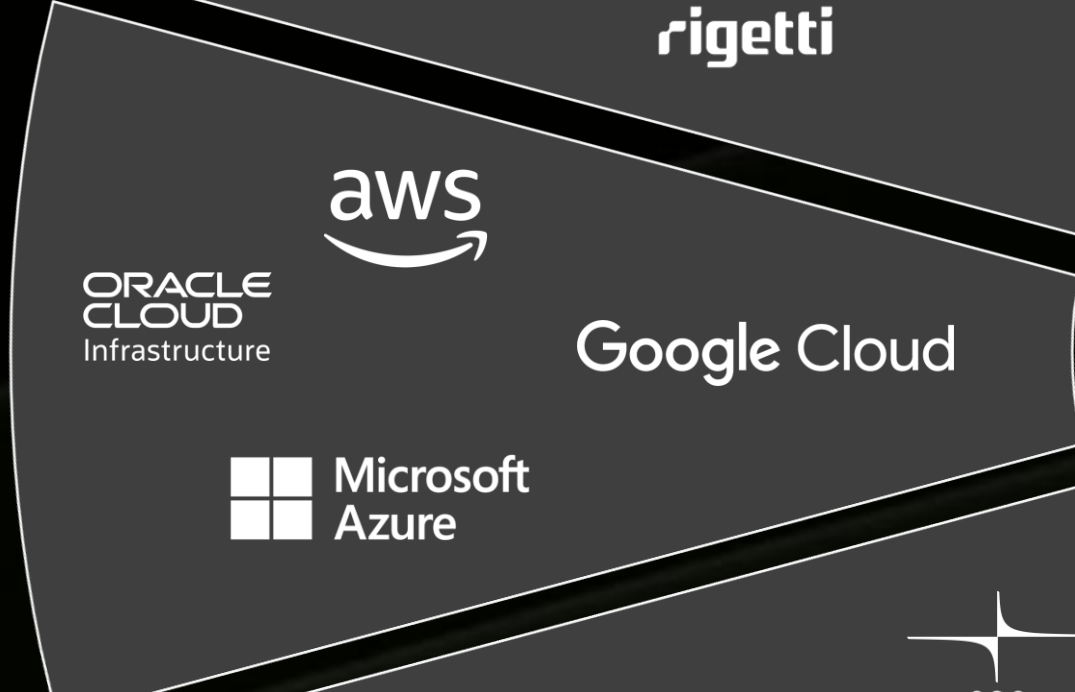
QUANTUM HARDWARE BUILDERS



QUANTUM SIMULATION FRAMEWORKS



CLOUD SERVICE PROVIDERS



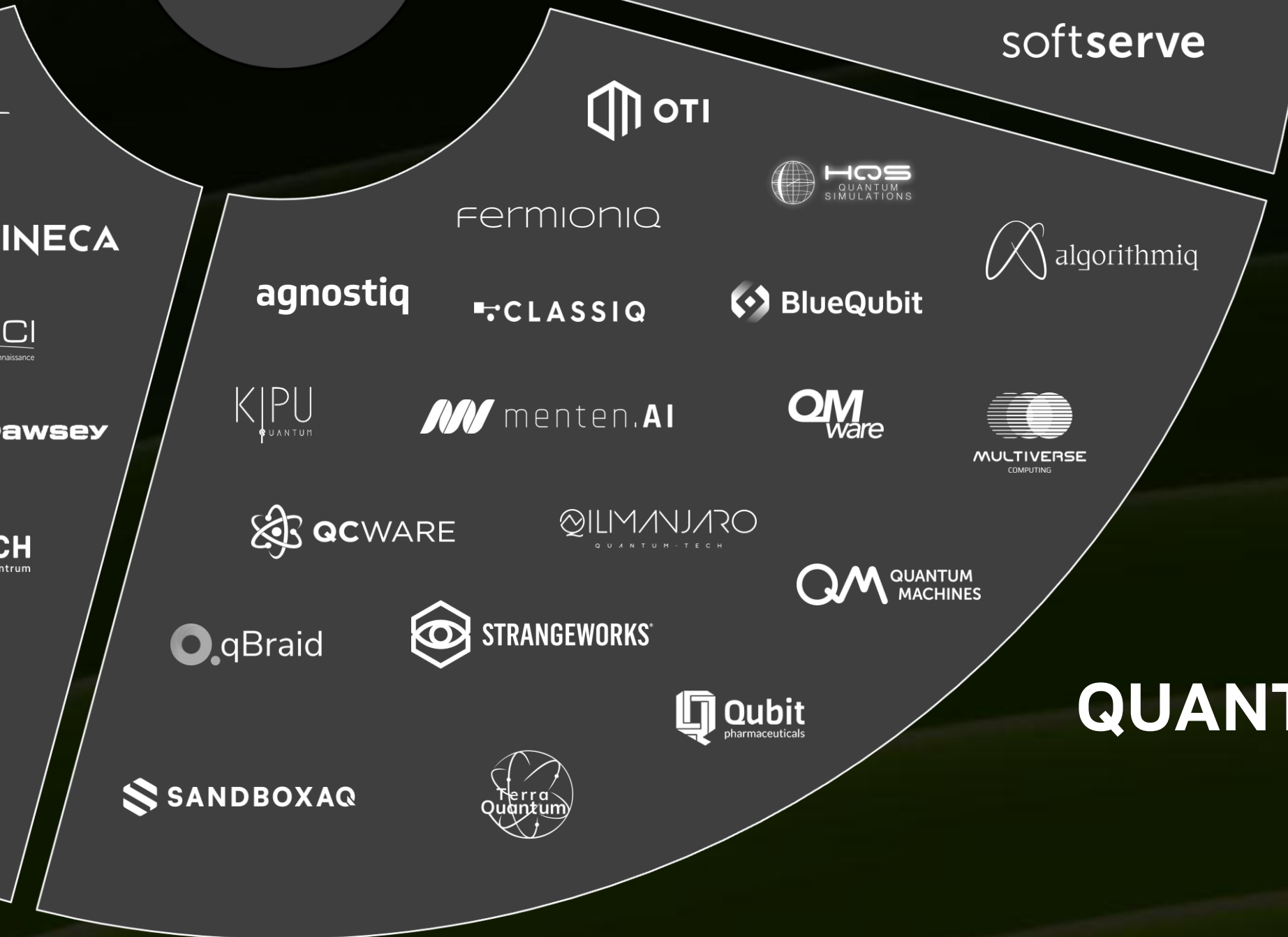
SYSTEMS BUILDERS & INTEGRATORS



RESEARCH CENTERS



QUANTUM SOFTWARE AND SYSTEMS



The NVIDIA Quantum Ecosystem

Accelerating the Quantum World

agnostiq

algorithmiq

ALICE & BOB

Amazon Braket

ANYON

Anyon Technologies

ATLANTIC QUANTUM

atom computing

blueqat

BlueQubit

CLASSIQ

diraq

D:WAVE

Entropica Labs

equal1

fermioniq

Google Quantum AI

HQS QUANTUM SIMULATIONS

horizon quantum

Infleqtion

IQ>

IQM

IONQ

Kipu

menten.AI

Microsoft

Nord Quantique

ORCA COMPUTING

OQC

OTI

Pasqal

PENNYLANE

.PLANQ

PsiQuantum

qBraid

QCDESIGN

QCI QUANTUM COMPUTING INC.

QCWARE

QIBO

QILIMANJARO

Qiskit

QM QUANTUM MACHINES

QMware

QUANDELA

QUANTINUUM

Quantum Art

QUANTUM BRILLIANCE

QUANTUM ELEMENTS

Quantum Rings

Qubit PHARMACEUTICALS

IQEra>

QUDORA TECHNOLOGIES

QuEST

quobly

rigetti

seeqc

STRANGWORKS

SANDBOXAQ

Ferra Quantum

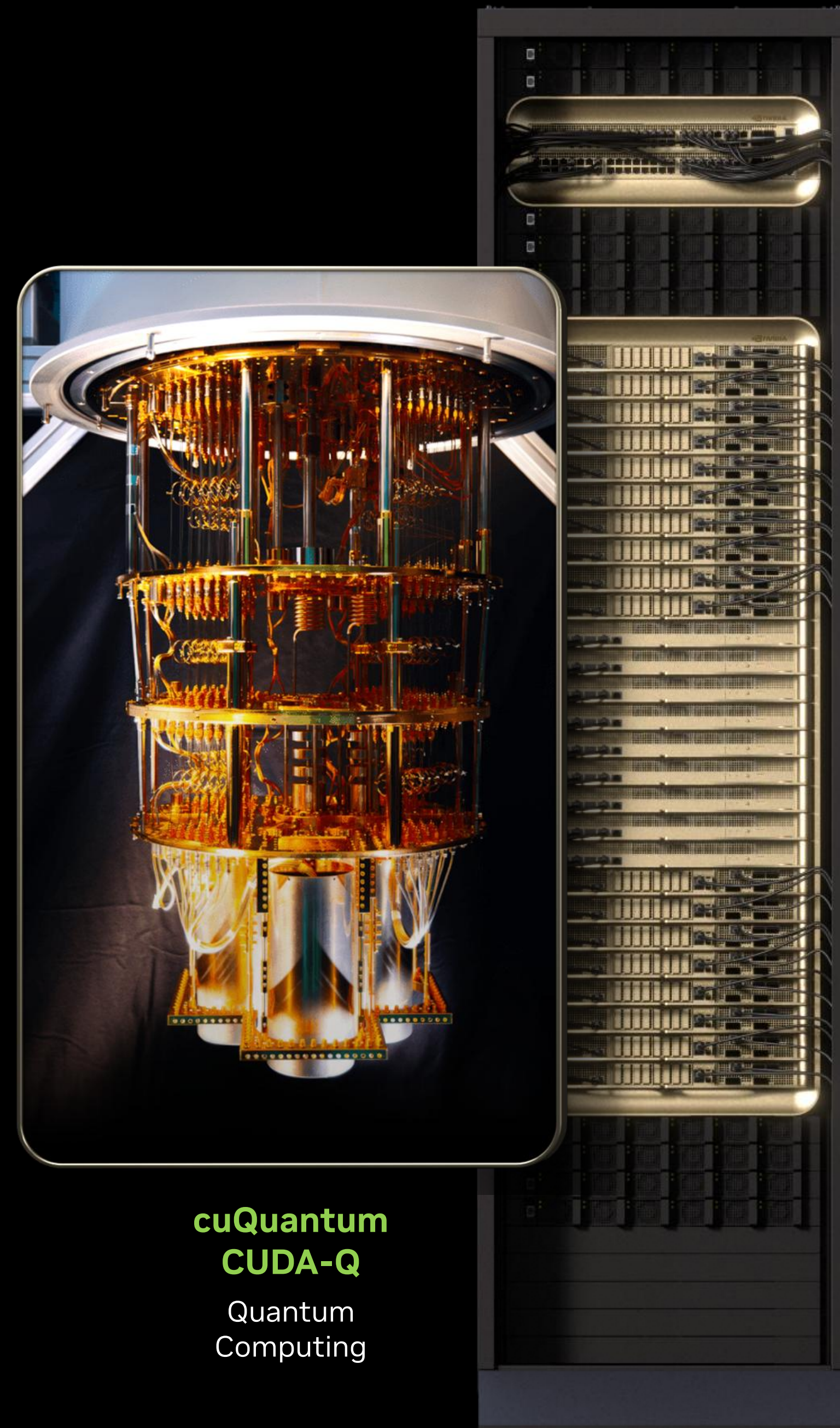
TKET

Torch Quantum

XACC QUANTUM FRAMEWORK

XANADU

NVIDIA and Europe Building Quantum-GPU Computing



Accelerating Quantum Workloads Across Europe

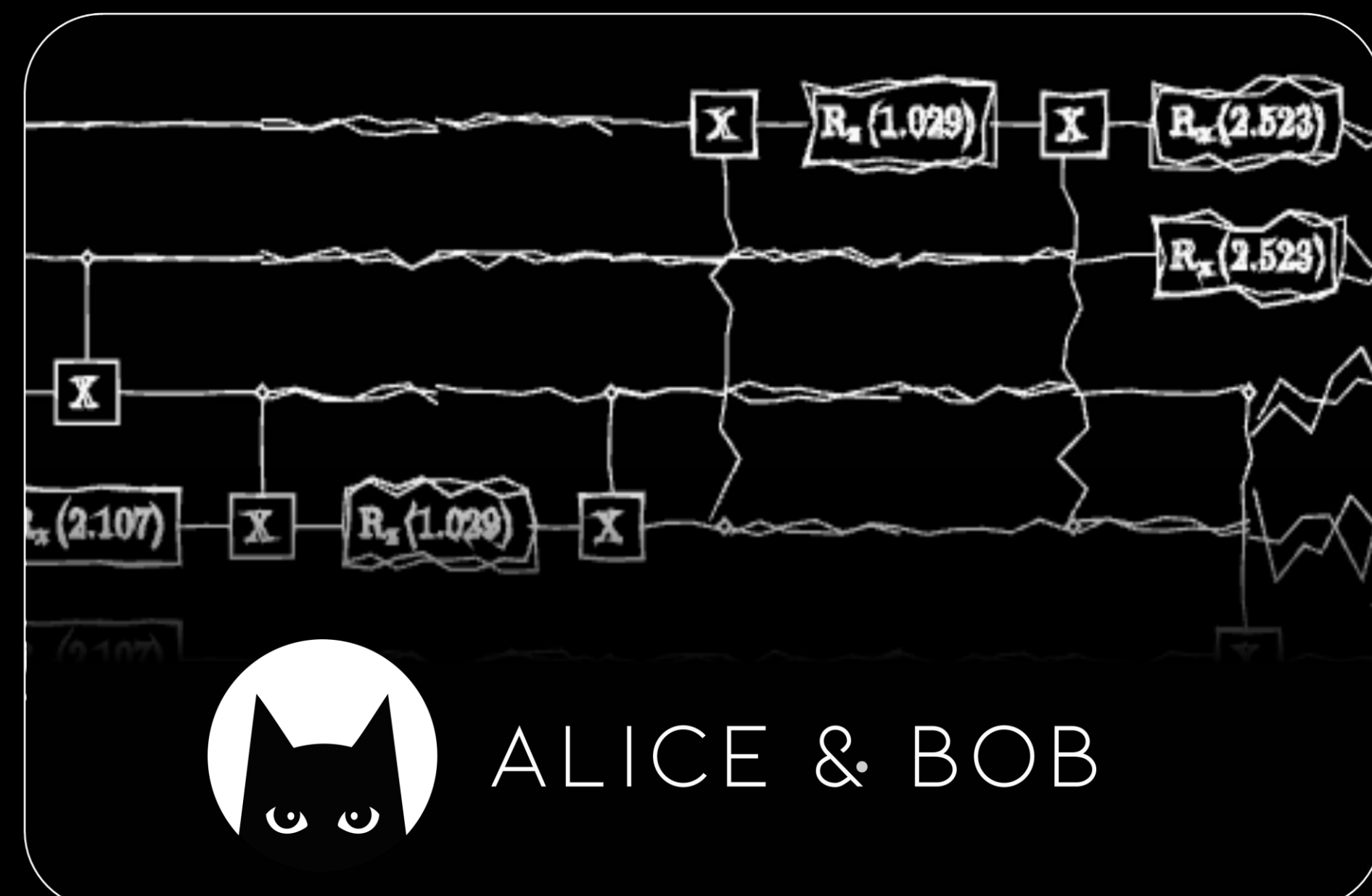
Quantum Algorithm Development



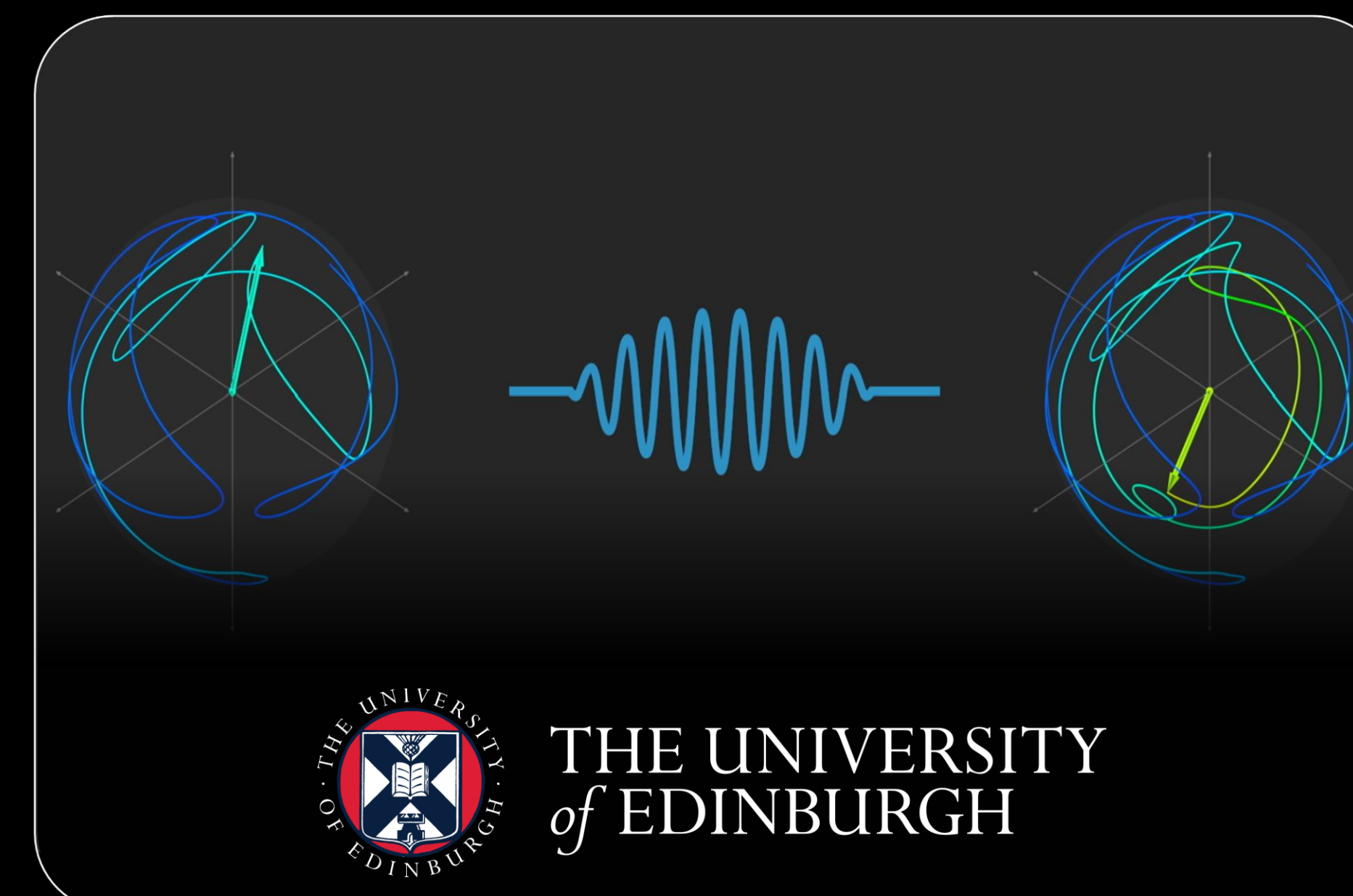
Quantum Data Generation



Quantum EDA



Quantum Error Correction



The NVIDIA Quantum Platform

Bringing AI Supercomputing to Enable Useful Quantum Computing

CUDA-QEC and CUDA-Q Solvers

Turnkey Quantum Research and Application Development

CUDA-Q

Open-Source Software Platform for Accelerated Quantum Supercomputers

cuQuantum

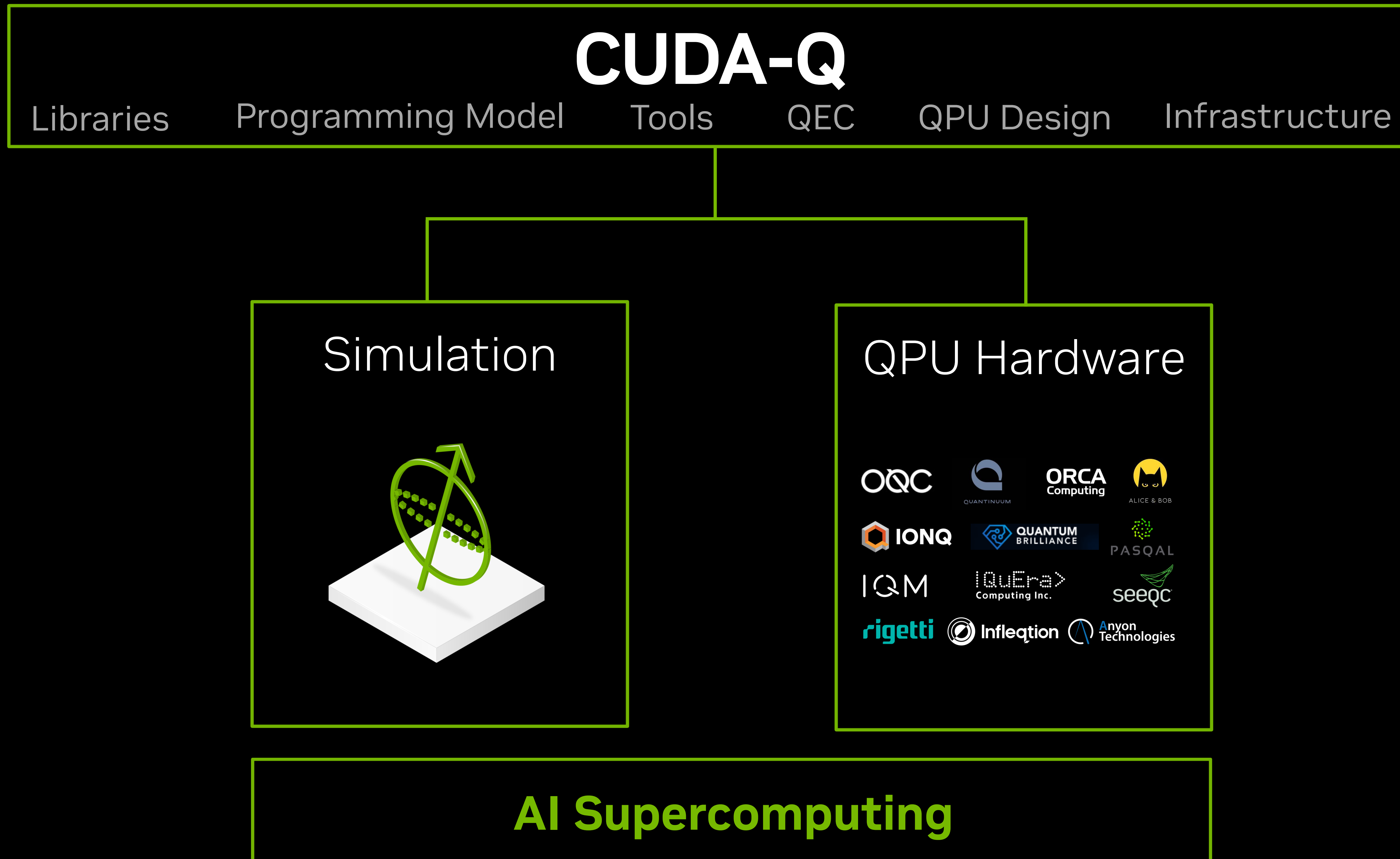
Accelerated Quantum Simulation/Emulation on GPU

NVQLink

Reference Architecture for Low Latency Integration

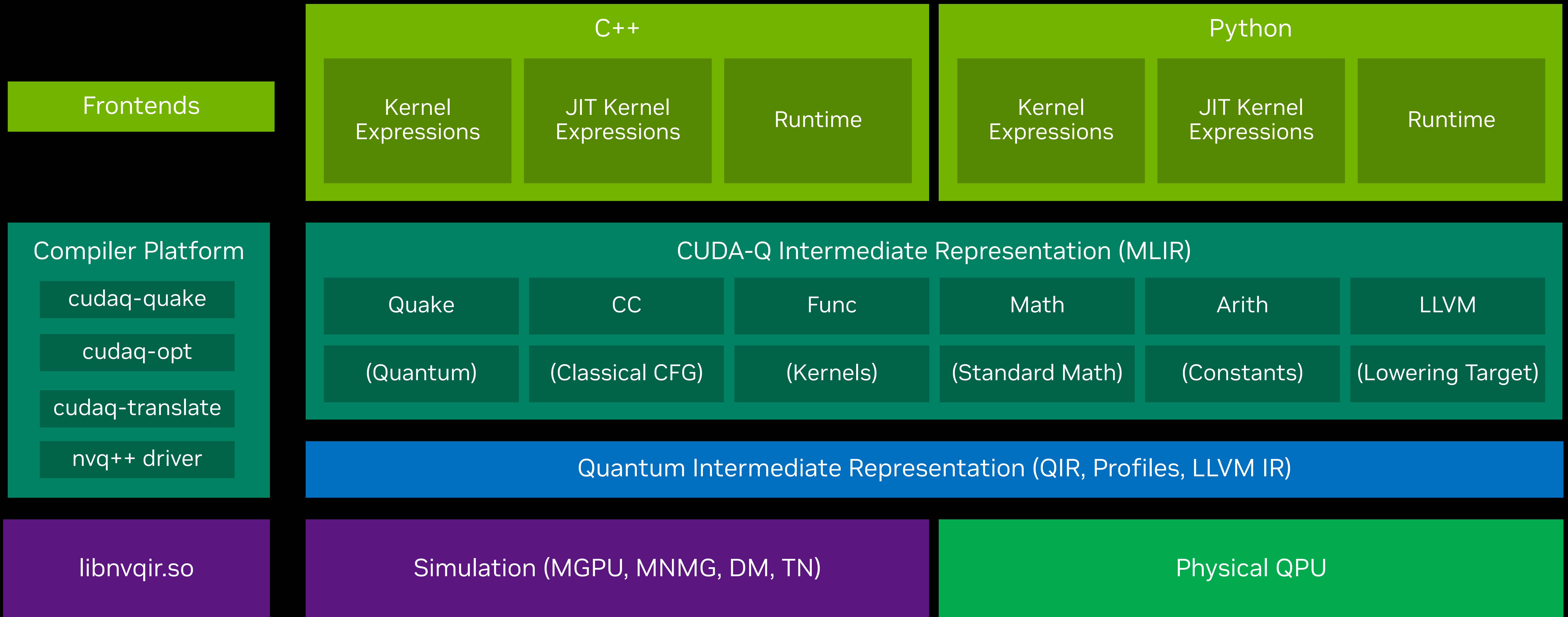
CUDA-Q

The platform for accelerated quantum computing



CUDA-Q

The CUDA-Q stack



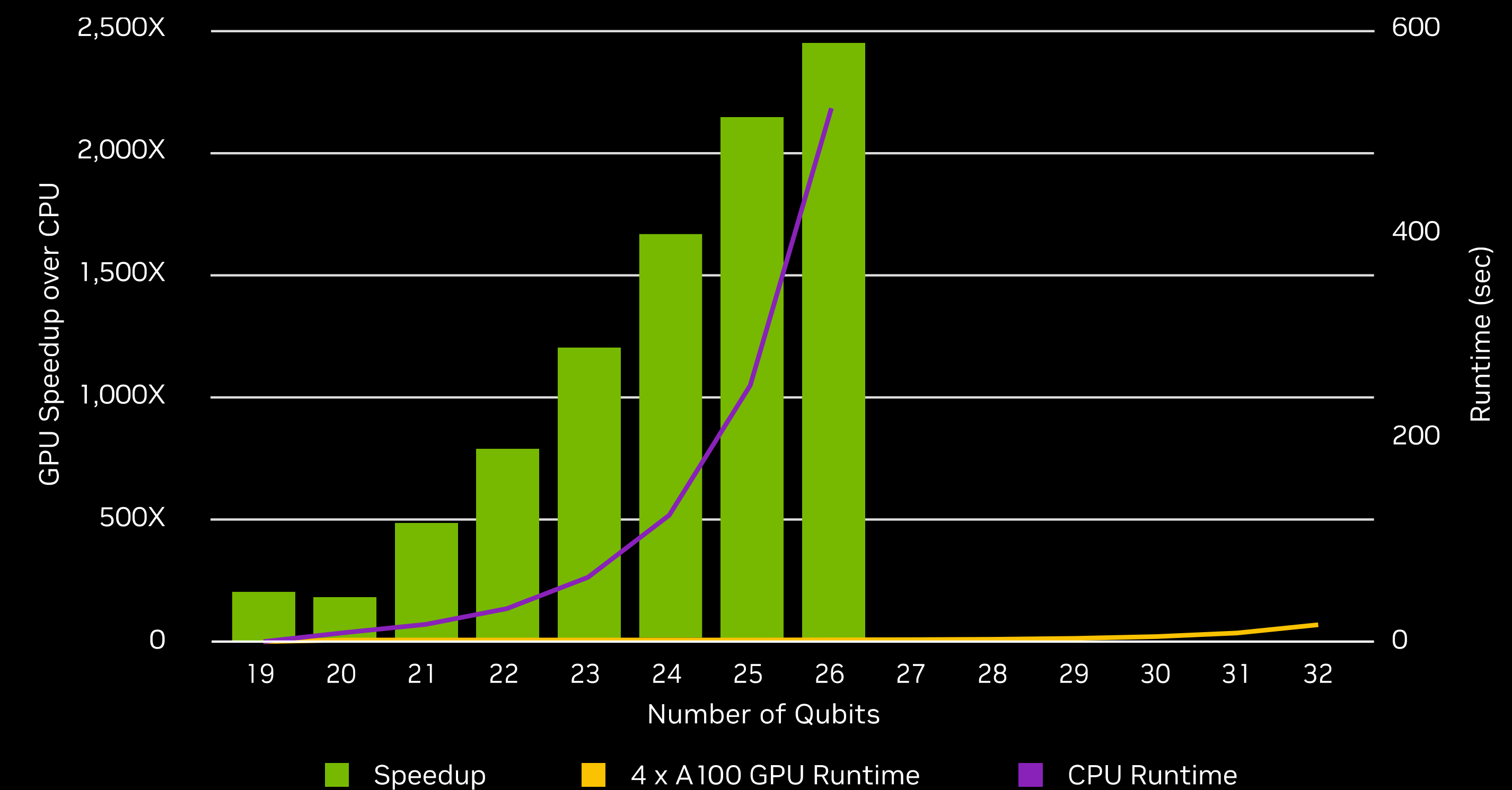
CUDA-Q

The platform for accelerated quantum computing

Features

- **Python and C++**
 - Access via familiar & powerful languages
- **QPU agnostic**
 - Supports backends from all major QPU vendors and qubit types
- **GPU-accelerated** simulation
 - Quantum simulators that scale to large-scale quantum computers
- Fully **kernel system for hybrid computing interface**
 - Seamlessly combine GPU and QPU resources
- Supports **QEC HW development**
 - DGX-Quantum reference architecture allows decoder and calibration development
- Access to classical **CUDA-X libraries**
 - Conventional parts of hybrid algorithms can draw on fastest implementations
- Comprehensive **educational tools**
 - CUDA-Q Academic onboards users to accelerated quantum supercomputing

Performance



QML workflow in CUDA-Q using **multithreaded CPU** versus **NVIDIA A100 Tensor Core GPUs**

Getting started with CUDA-Q

CUDA-Q Overview

<https://developer.nvidia.com/cuda-q>

CUDA-Q Academic

<https://github.com/NVIDIA/cuda-q-academic>

CUDA-Q Docs

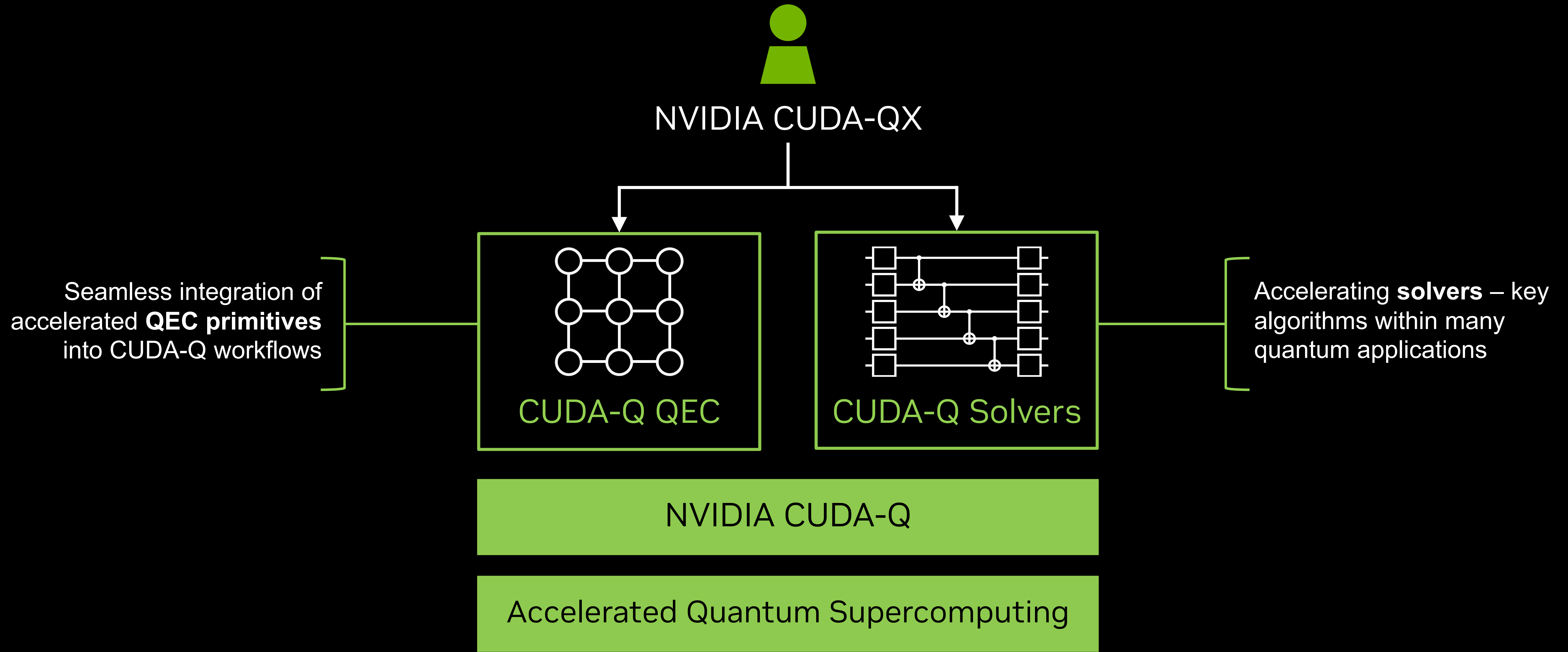
<https://nvidia.github.io/cuda-quantum/latest/index.html>

CUDA-Q Apps

<https://nvidia.github.io/cuda-quantum/latest/using/tutorials.html>

CUDA-Q Libraries

Bringing the power of CUDA-Q directly to quantum computing research problems



NVIDIA NVQLink

ALICE & BOB Anyon Technologies atom computing
diraq Infleqtion IONQ OQC
ORCA COMPUTING Pasqal QUANDELA QUANTUM MOTION
|QuEra> rigetti seeqc Silicon Quantum Computing

Quantum Processors

BERKELEY LAB KEYSIGHT QUANTINUUM
QM QUANTUM MACHINES QBLOX Zurich Instruments

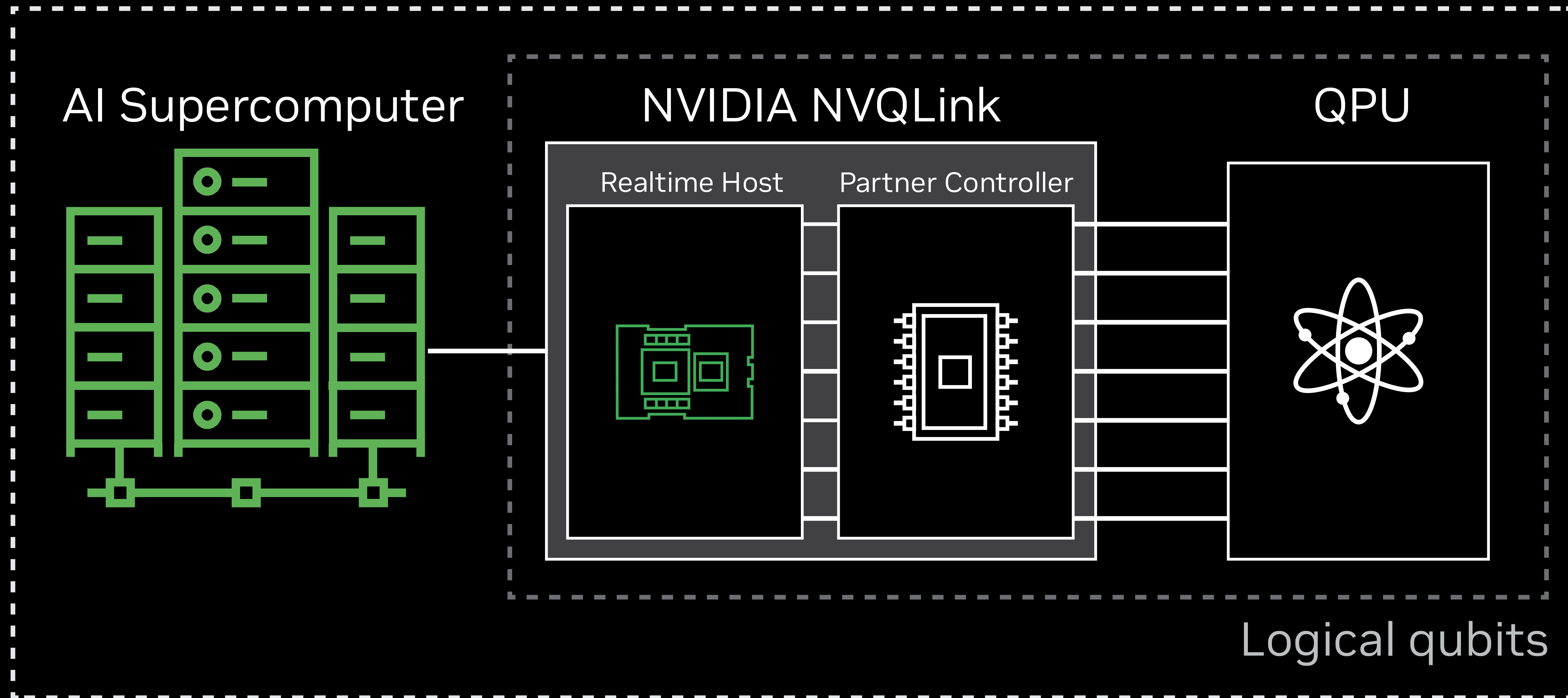
NVIDIA NVQLink

AIST Brookhaven National Laboratory CINECA DCAI
Fermilab GENCI IT4INNOVATIONS NATIONAL SUPERCOMPUTING CENTER
JÜLICH Forschungszentrum KAUST KISTI
LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY Los Alamos NATIONAL LABORATORY NCHC
NERSC National Quantum Computing Centre NATIONAL QUANTUM COMPUTING HUB SINGAPORE
OAK RIDGE National Laboratory Pacific Northwest NATIONAL LABORATORY pawsey
PCSS Sandia National Laboratories TII Technology Innovation Institute

GPU Supercomputers

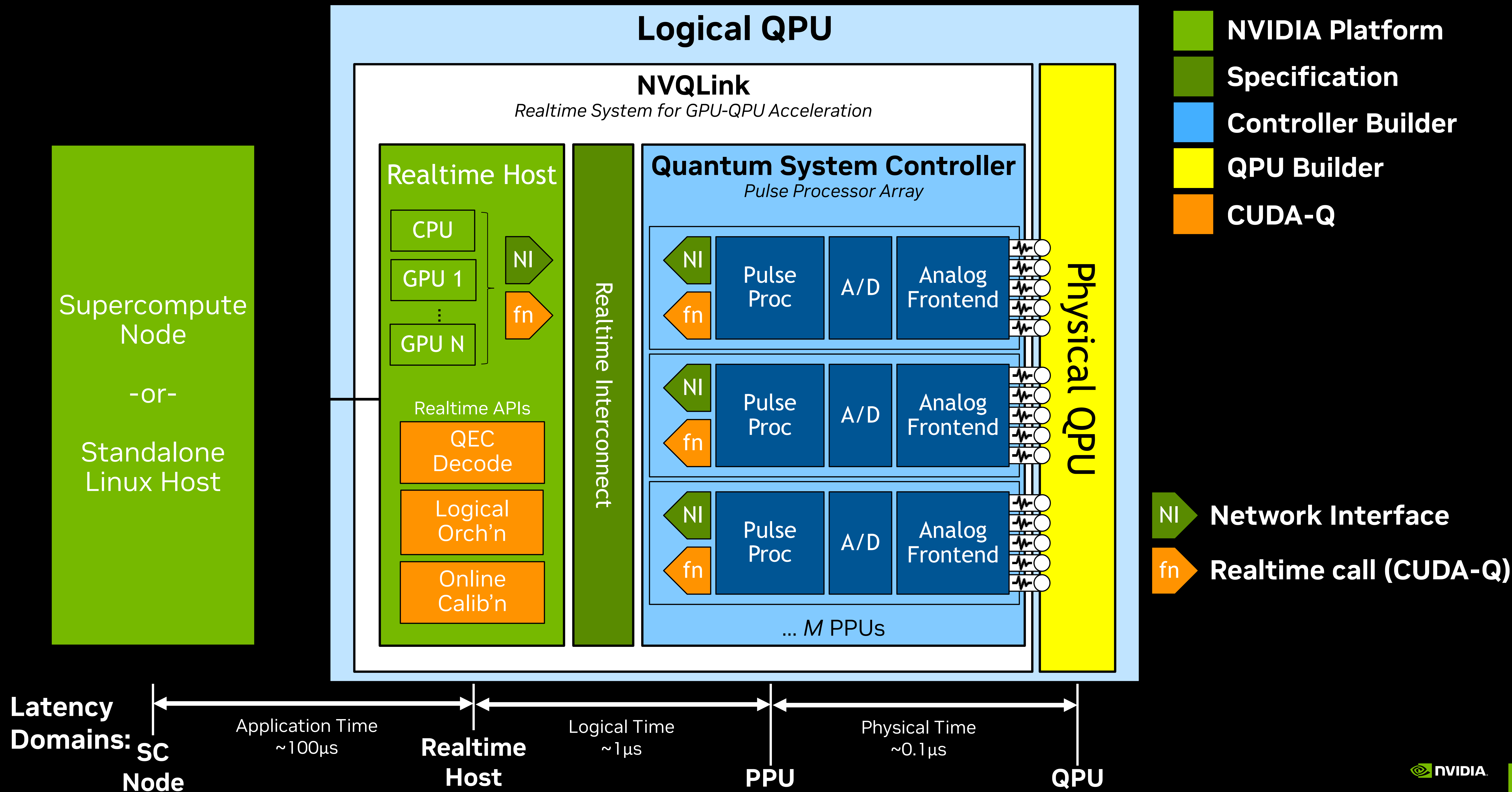
NVQLink

The Rosetta stone for Quantum-GPU supercomputing



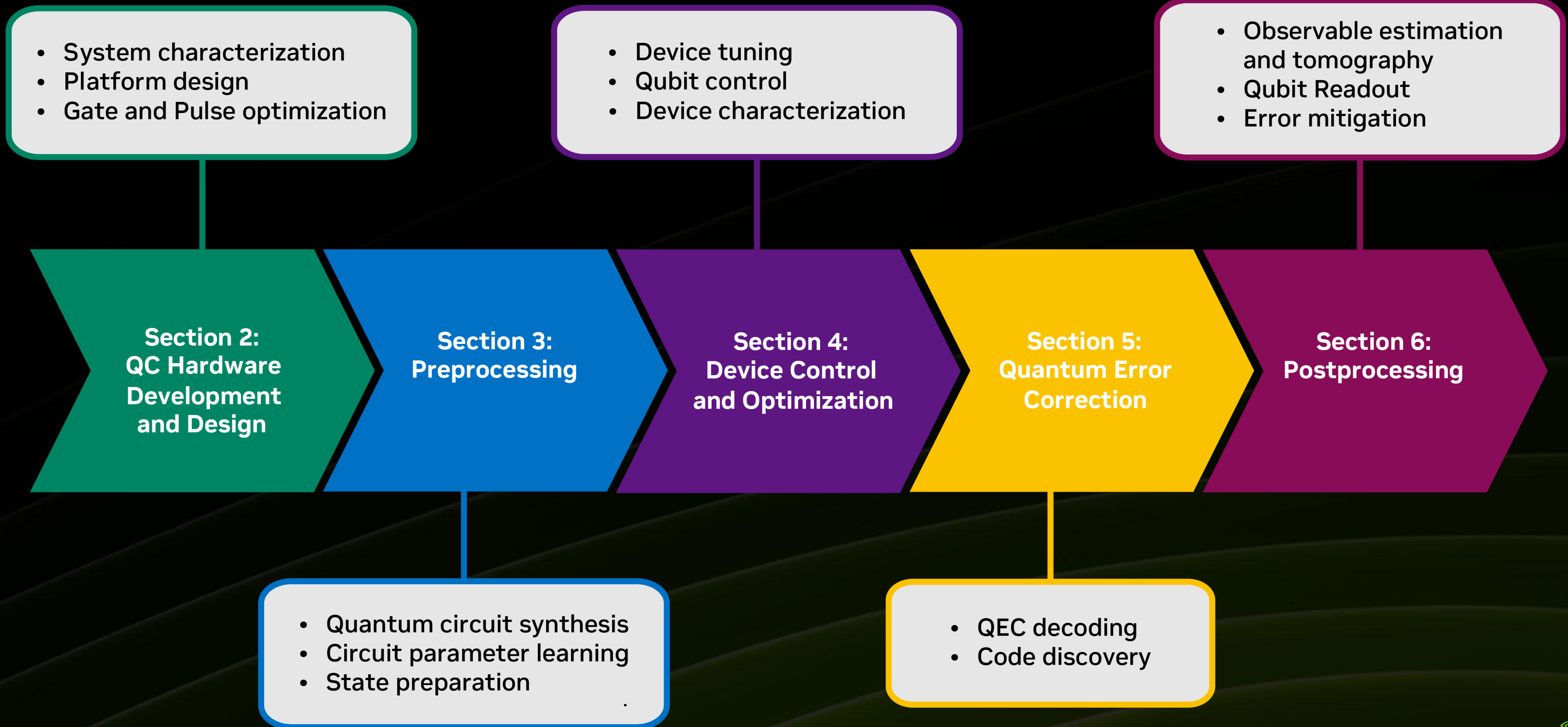
Hybrid quantum-classical computing

NVIDIA NVQLink



AI for QC

Review paper - <https://arxiv.org/abs/2411.09131>





NVIDIA Quantum

NVIDIA Quantum

<https://www.nvidia.com/en-us/solutions/quantum-computing/>

CUDA-Q v0.12 Now Available

Python – `> pip install cudaq`

C++ – <https://github.com/NVIDIA/cuda-quantum/releases>



