QEst Hack 2026

Introduction to Quantum Computing

Teppo Seesto
IBM Quantum Ambassador



IBM Quantum mission

Bring useful quantum computing to the world



© 2026 IBM Corporation

What is quantum computing?

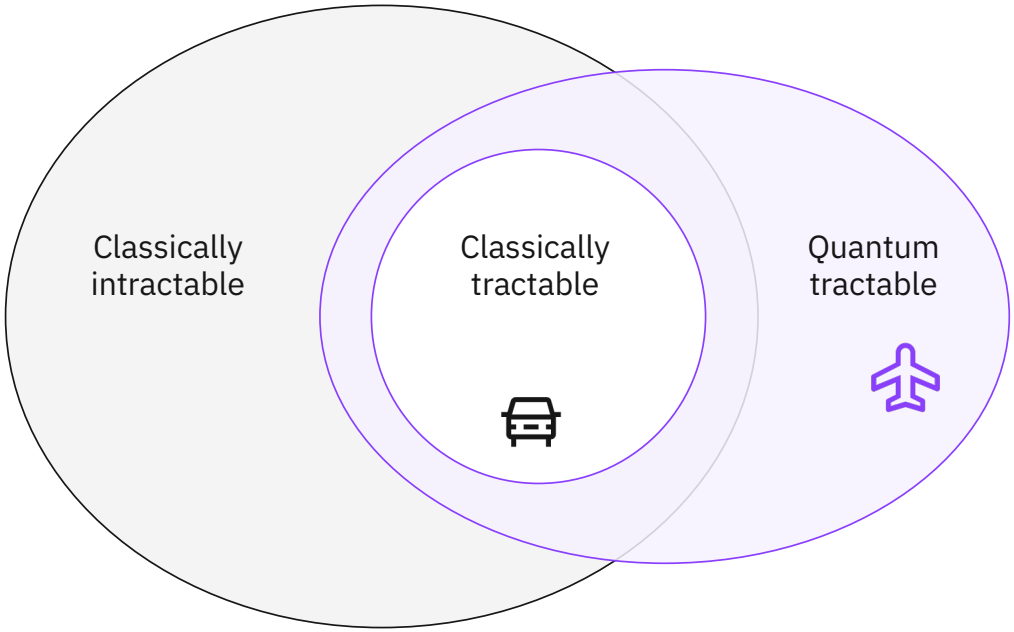


IBM Quantum / © 2024 IBM Corporation

Unlock discovery with quantum computing

Harnesses the capacity to advance conceptual and tools-based discovery

Quantum computers are exponentially more powerful than classical computers



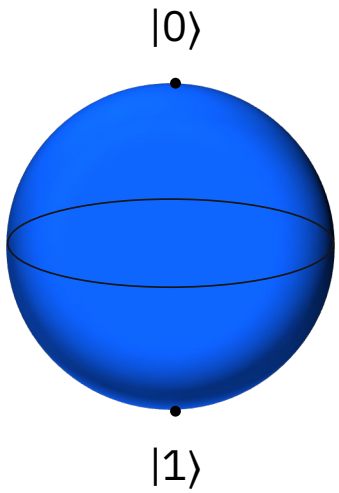
1. A new way of computing
   New paradigm of problem-solving and thinking
2. Solving new problems
   Unlock classically unsolvable problems, cutting computation time down from hours to minutes
3. Discovery of new use cases
   Expand discovery into new computational spaces

© 2026 IBM Corporation

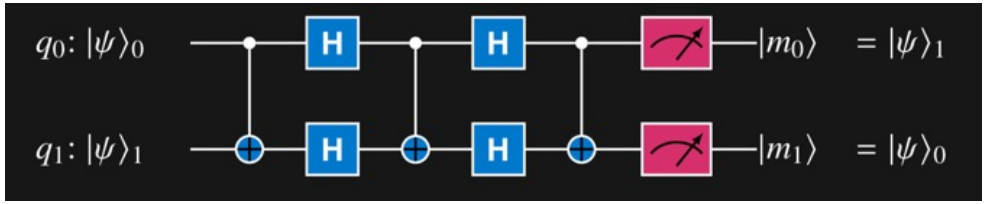
Source: https://matt-rickard.com/dyson-tool-driven-scientific-revolutions

Quantum bits (qubits) and quantum circuits

IBM **Quantum**



A quantum bit or qubit is a controllable quantum object that is the unit of information



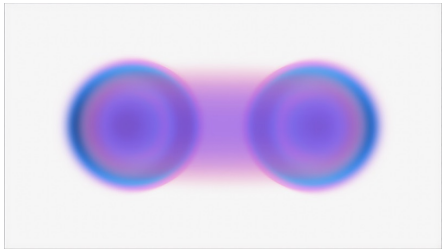
A quantum circuit is a set of quantum gate operations on qubits and is the unit of computation

Uniquely quantum

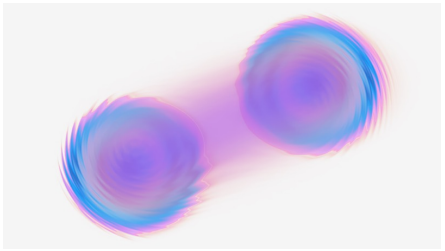
Some problems are classically intractable and will never be solvable with traditional computers



Superposition
A quantum system existing in a complex linear combination of two states until it is measured



Entanglement
Information shared jointly between entangled pairs or groups



Interference
Interaction that affects likelihood of solutions

Moore's law: the number of transistors in a classical integrated circuit doubles about every two years
... but we are approaching the end due to physical limitations

Approaching the physical limit: IBM created the world's first 2 nm node chip in 2021, with transistors as small as 10 silicon atoms

These Quantum concepts can reduce the number of computational steps required for certain algorithms
&
At a ~100 qubit scale, with sufficient circuit depth and complexity, classical computers can no longer simulate exactly

© 2026 IBM Corporation

Use cases



IBM Quantum / © 2024 IBM Corporation

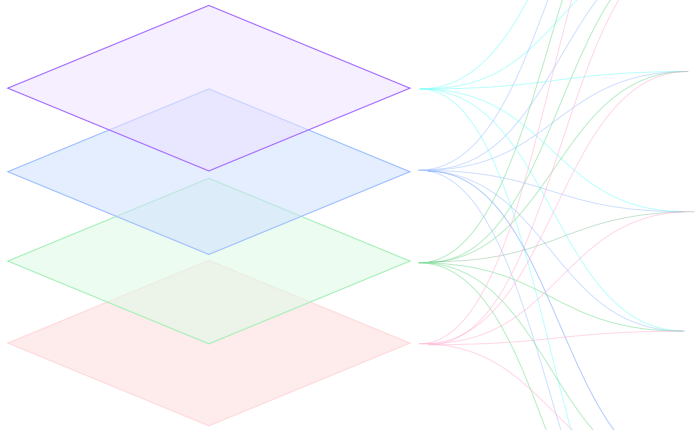
Quantum computing is expected to have impact across industries

Hamiltonian simulation

Optimization

Quantum machine learning

Partial differential equations (PDEs)



Aerospace	• High strength-to-weight materials development • Wing ply-composite design optimization • Aircraft computational fluid dynamics
Automotive	• Advanced batteries • Multi-objective vehicle routing optimization • Auto design and simulation
Chemicals	• Lower energy fertilizer manufacturing • Efficient catalysts • Accelerated product development
Electronics & semiconductors	• Placement and routing optimization • Deposition/etch process modeling • Multi-domain simulation
Energy	• Grid management • Grid optimization with EVs • Carbon sequestration
Financial services	• Portfolio optimization • Derivatives/options pricing • Anti-money laundering
Healthcare & life sciences	• Drug discovery and drug design optimization • mRNA & protein structure predictions • Disease target & biomarker discovery

© 2026 IBM Corporation

Battery design and development

Business imperative

Accelerating the discovery of higher performance and lower cost batteries is essential for the manufacturing of more efficient and more profitable electric vehicles (EV).

Current state

Battery development relies on labor- and time-intensive empirical techniques. The order of magnitude time to develop new materials is ~10 years.

Business value exploration

Quantum chemistry simulations may help shorten the battery cycles by conducting the material and design exploration computationally. The potential benefits include higher-capacity, lighter-weight, lower-cost batteries and faster time to market.



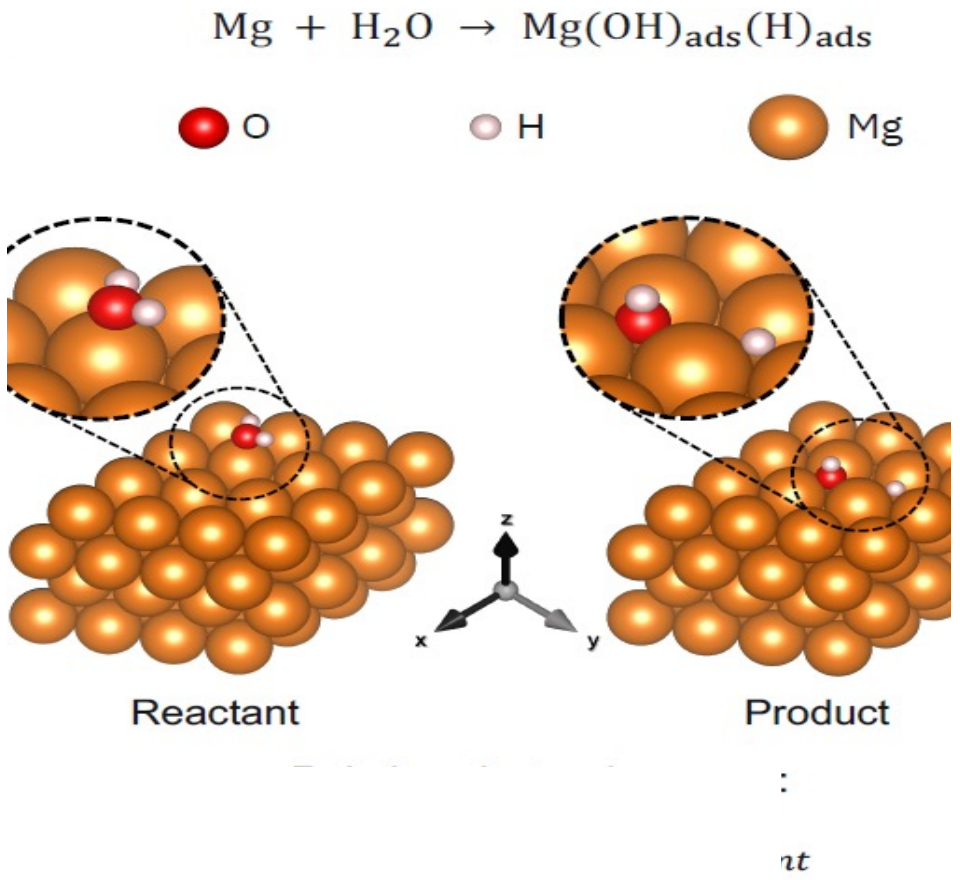
Boeing

New materials qualification

IBM and Boeing model corrosion reactions for magnesium, the lightest structural metal

Magnesium has the potential to improve the weight of critical aerospace structures. However, magnesium reacts with water and corrodes readily.

IBM simulated the reaction of water with magnesium to better understand its reaction mechanisms to explore the possibility of lighter, higher-performance aerospace structures.



arXiv:2203.07536

© 2026 IBM Corporation

Virtual screening in drug discovery

Business imperative

Machine learning (ML) is used in virtual screening for discovering drug candidates in a faster and more cost-effective manner.

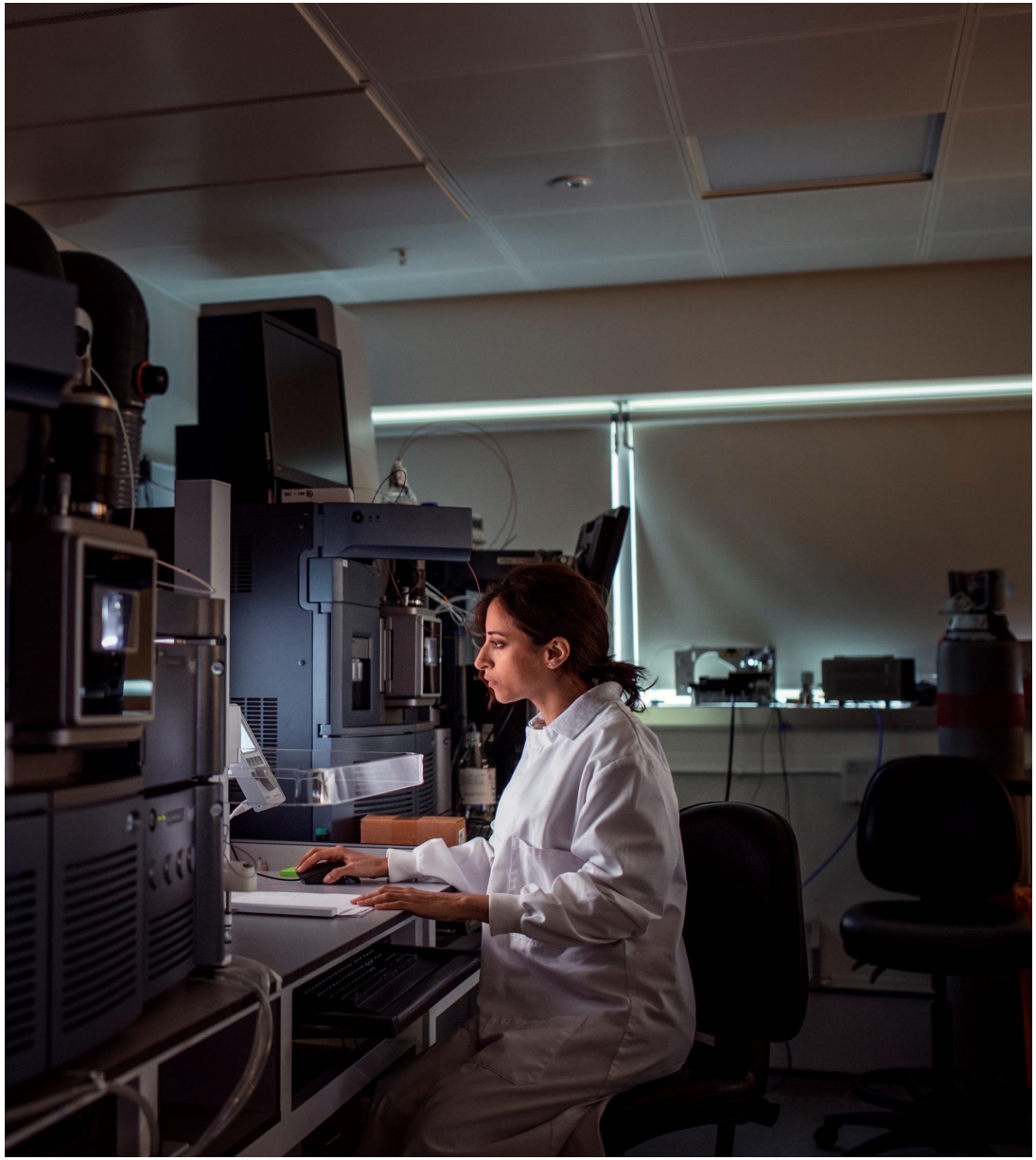
Current state

A conventional ligand-based virtual screening strategy consists of using ML algorithms to train a classifier that can identify potential drug candidates from a digitalized library of compounds. To achieve accuracy, ML models require a lot of high-quality data. However, when dealing with rare or new diseases such as COVID-19, the limited amount of training data can be challenging.

Business value exploration

In POC studies with limited data, quantum machine learning (QML) has shown increased accuracy compared to classical ML and deep learning algorithms.

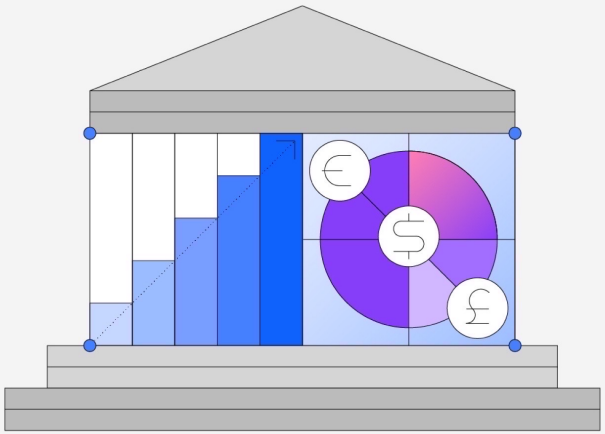
© 2026 IBM Corporation



Voice of our first adopters

HSBC

- → Pricing and portfolio optimization
- → Sustainability
- → Risk management



“This technology has the potential to transform how we run areas of the bank by addressing challenges which classical computers may never be able to solve, alone. Our work with IBM, a leading provider of quantum computing, is essential to harnessing this potentially game-changing technology for financial services.”

Colin Bell, CEO of HSBC Bank and HSBC Europe

© 2026 IBM Corporation

ExxonMobil

Routing optimization

In 2021, more than 500 liquified natural gas (LNG) ships were used to transport critical fuel supplies across the oceans. Together, they make thousands of journeys per year to destination ports where the LNG is deployed to power critical infrastructure.

Finding optimal routes for a fleet of such ships can be a mind-bendingly complex optimization problem.

https://www.ibm.com/case-studies/exxonmobil/
IEEE Trans Quantum Engineering, vol. 2, p. 1



Quantum computers take a new approach to addressing this sort of complexity, with the potential to find solutions that classical supercomputers alone cannot handle. Industry leaders like ExxonMobil are getting involved now to explore how blending classical and quantum computing techniques might solve big, complex, pressing global challenges.

© 2026 IBM Corporation

Factory scheduling optimization

Business imperative

Maximizing equipment utilization in production processes is important to optimizing manufacturing throughput and increasing revenue.

Current state

Production scheduling currently requires the solution of classically intractable computational problems (for example, combinatorial problems like car sequencing, job-shop scheduling). Dispatch rules are generally used to find feasible solutions that may be far from optimal.

Business value exploration

Quantum scheduling optimization has the potential to identify more optimal solutions and lead to more efficient production schedules.



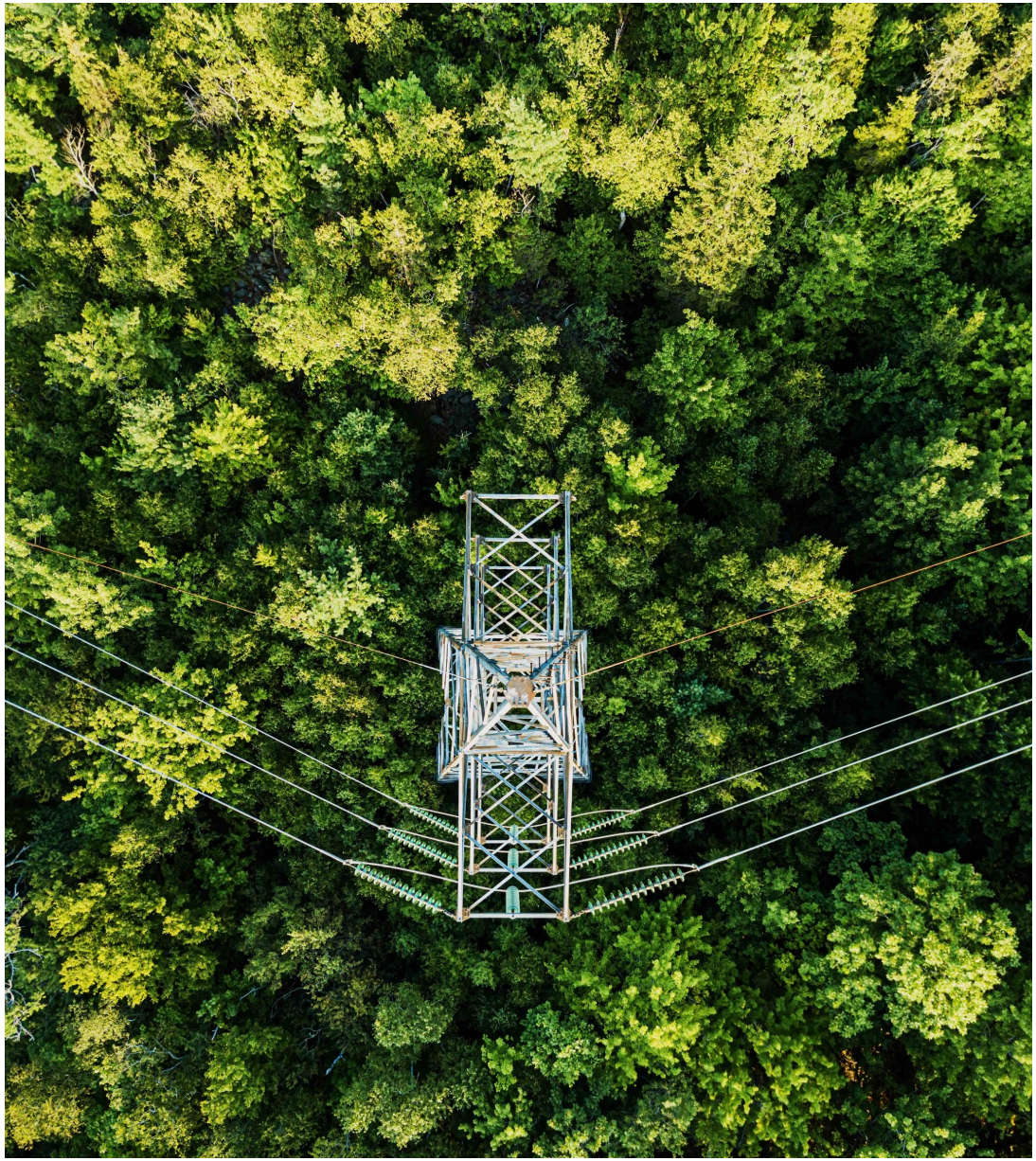
© 2026 IBM Corporation

E.ON

E.ON is partnering with IBM to drive the transformation of the energy industry with quantum computing.

Their goal is to explore the potential of quantum computing to optimize the world’s rapidly decentralized energy infrastructure.

Some areas under consideration are whether quantum computing could be used to help control grid-connected renewable energy systems and to optimize electric car charging processes.



© 2026 IBM Corporation

Cleveland Clinic

Modeling biologically-relevant molecules with quantum-centric supercomputing.

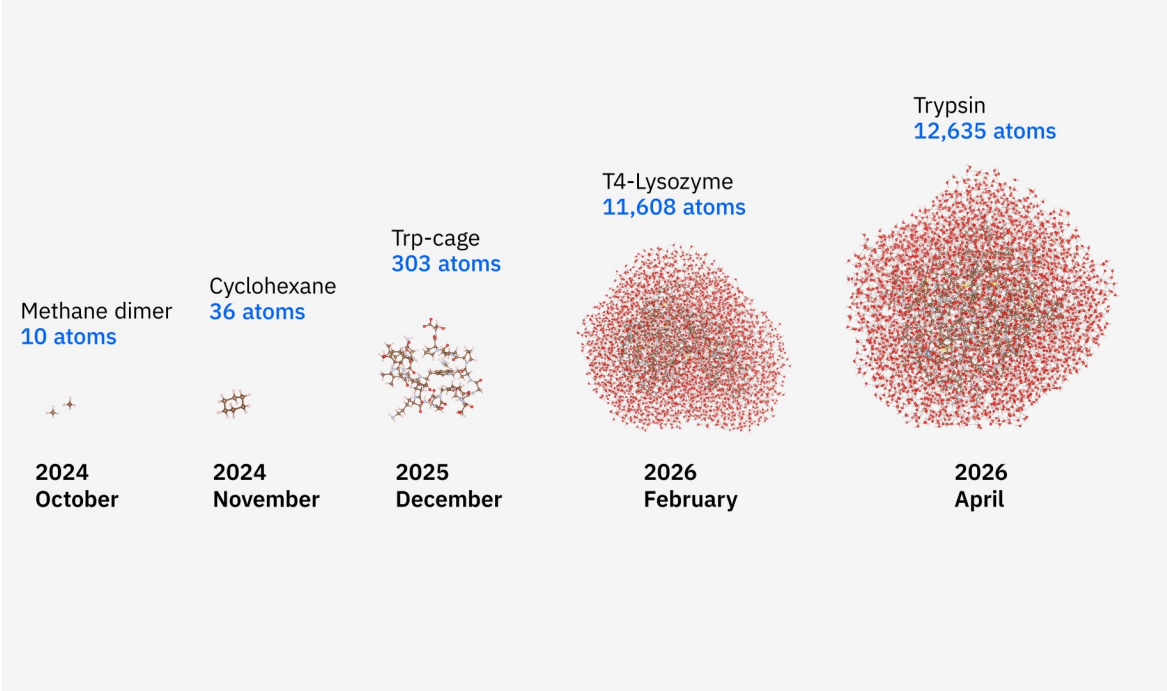
Molecular simulation

Scientists at Cleveland Clinic, RIKEN, and IBM used two IBM quantum computers and two supercomputers to simulate two molecules relevant to drug development, reaching a scale of 12,635 atoms in the largest simulation.

The result is the largest-known simulation of biologically meaningful molecules ever performed using quantum hardware, and a signal that quantum computers are maturing into useful scientific tools.

"Better chemistry workflows really mean ways to help you and future generations lead better, healthier lives."

Dr. Kenneth Merz, PhD
Kenneth Merz Laboratory
Cleveland Clinic

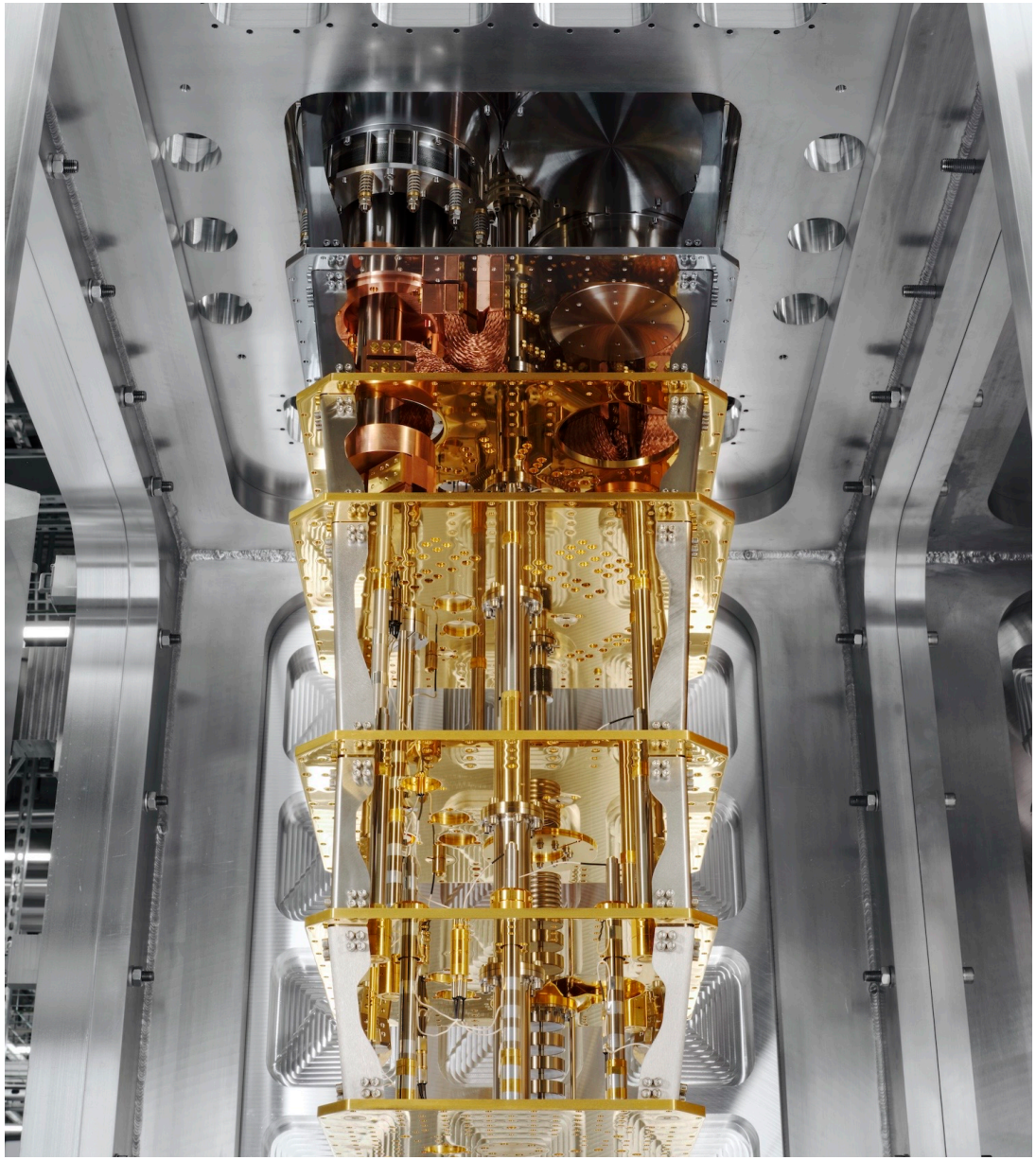


- This illustration shows how quickly the scale of quantum chemistry simulations has grown in recent months.

Read the paper: https://arxiv.org/abs/2605.01138
Read the blog: https://www.ibm.com/quantum/blog/cleveland-clinic-riken-chemistry

© 2026 IBM Corporation

Quantum Hardware



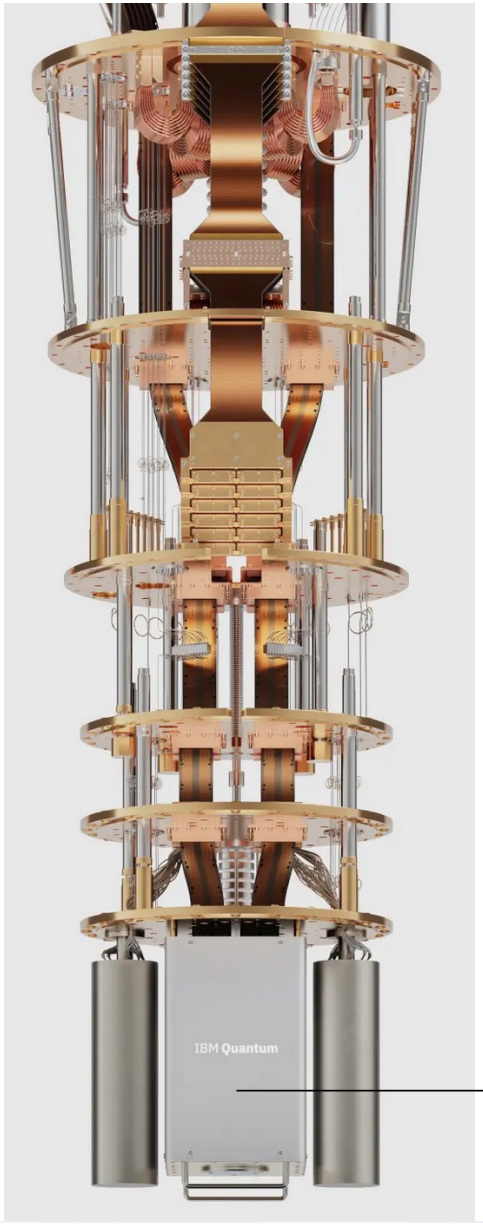
IBM Quantum / © 2024 IBM Corporation

Quantum chips

Superconductive qubits



Chandelier

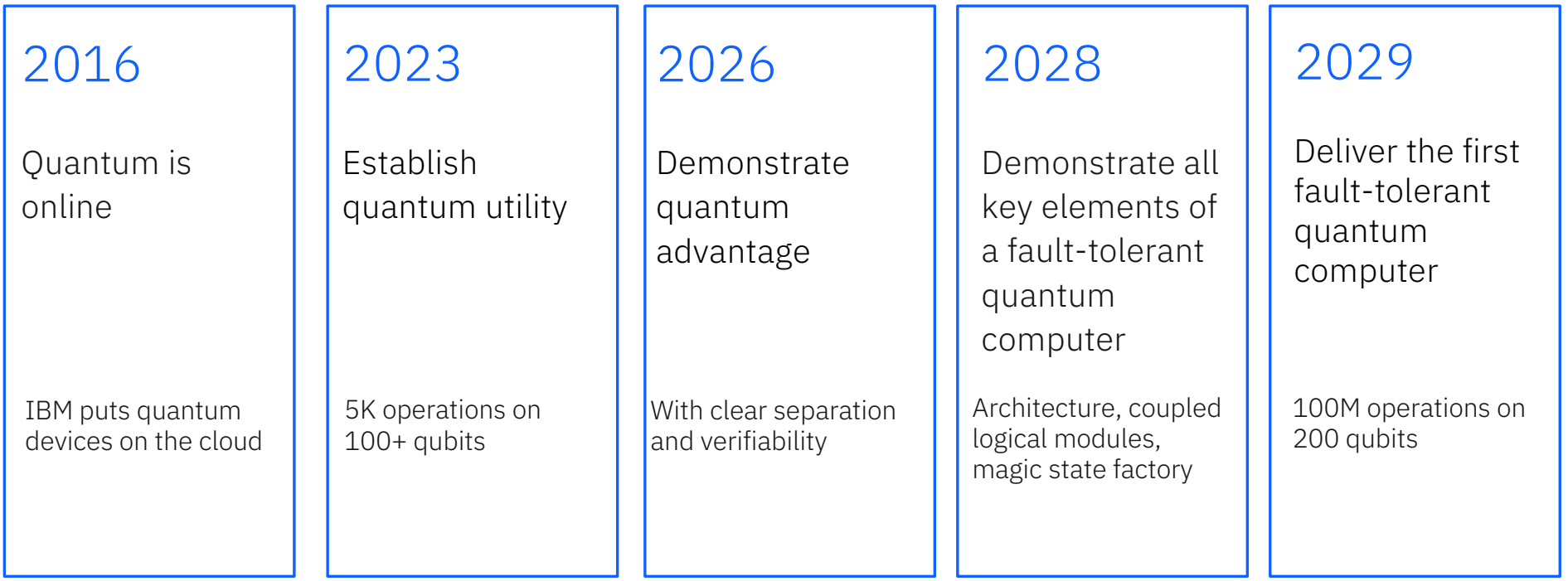


Quantum chip

IBM Quantum Systems

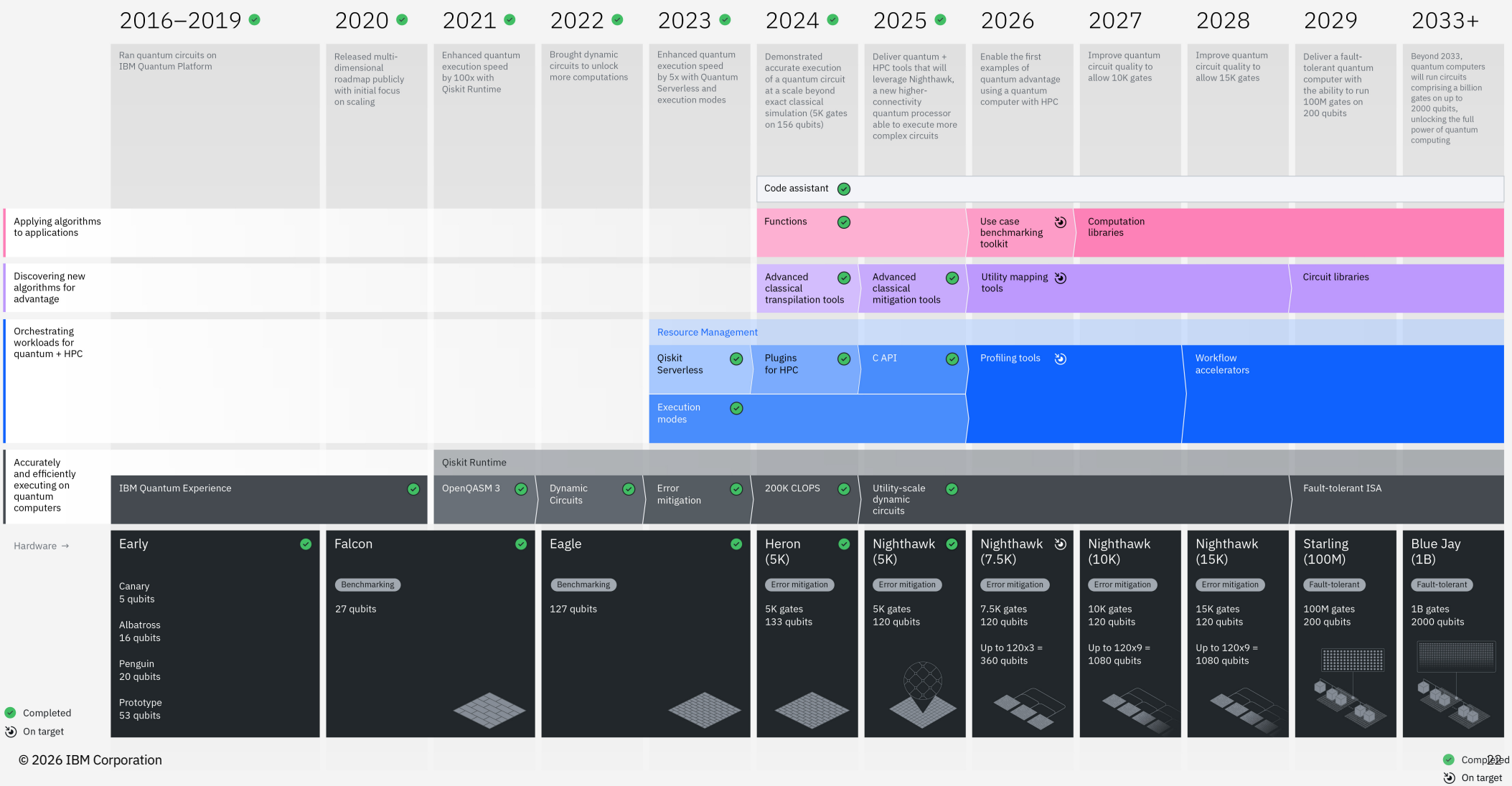


Key milestones in bringing useful quantum computing to the world



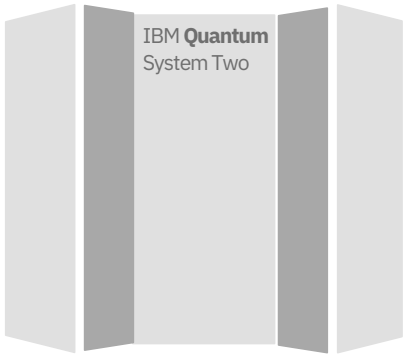
© 2026 IBM Corporation

Development Roadmap



© 2026 IBM Corporation

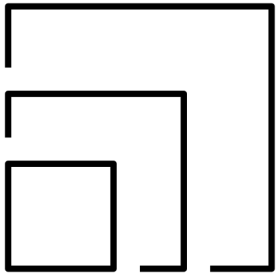
Completed
On target



\+



\+



=



QPUs

Qiskit

Quantum Software
(powered by Qiskit addons and Qiskit Functions)

Useful Work

IBM Quantum Platform unlocks research with quantum

© 2026 IBM Corporation

IBM Quantum in numbers

The IBM Quantum ecosystem is a thriving, rich community driving innovation.

340+

IBM Quantum Network members
The largest ecosystem

600K+

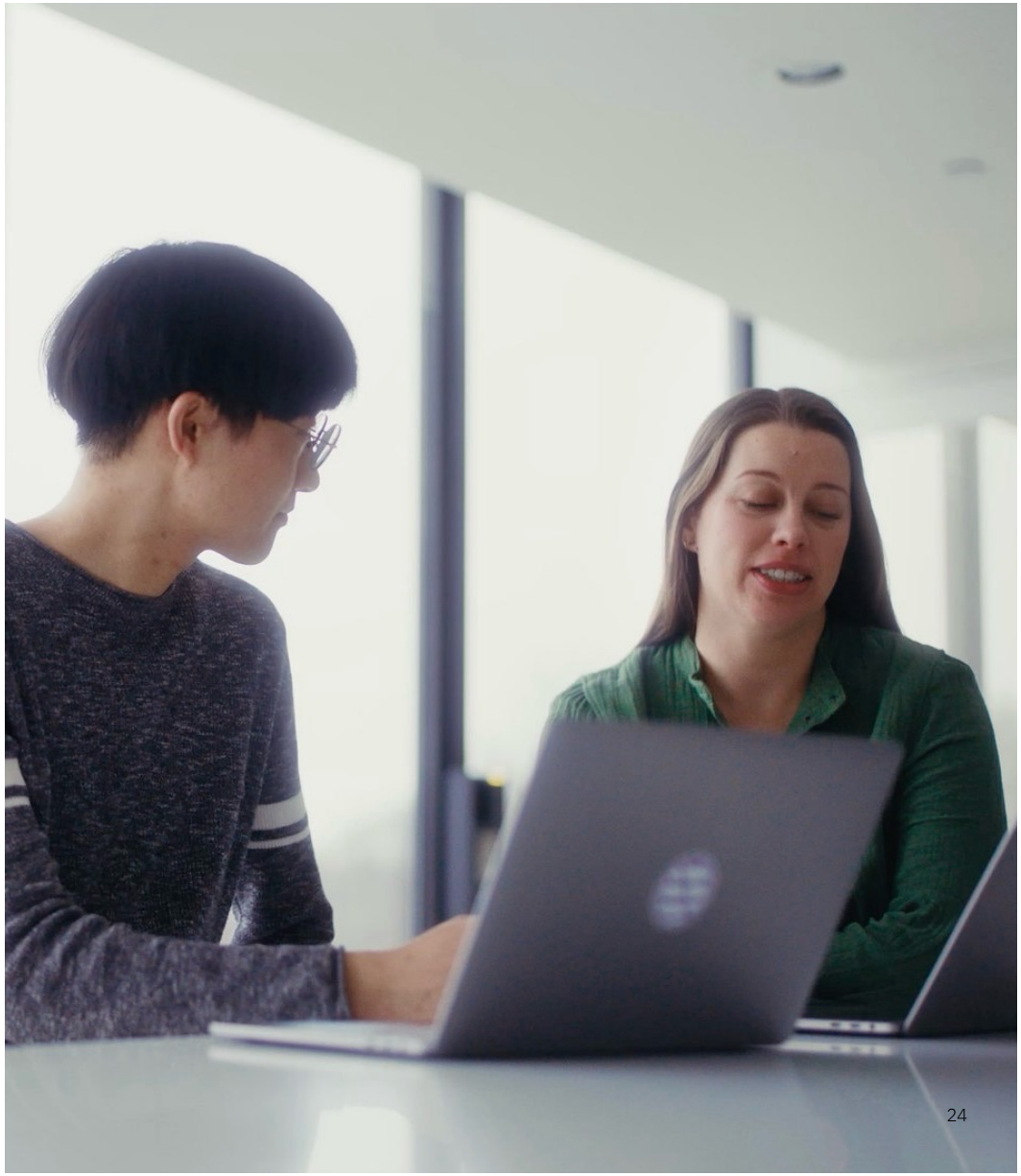
Users
The largest user base

5,000+

Papers
The most innovative ecosystem

11+

Quantum computers
The largest fleet



Begin exploring quantum today with the Open Plan

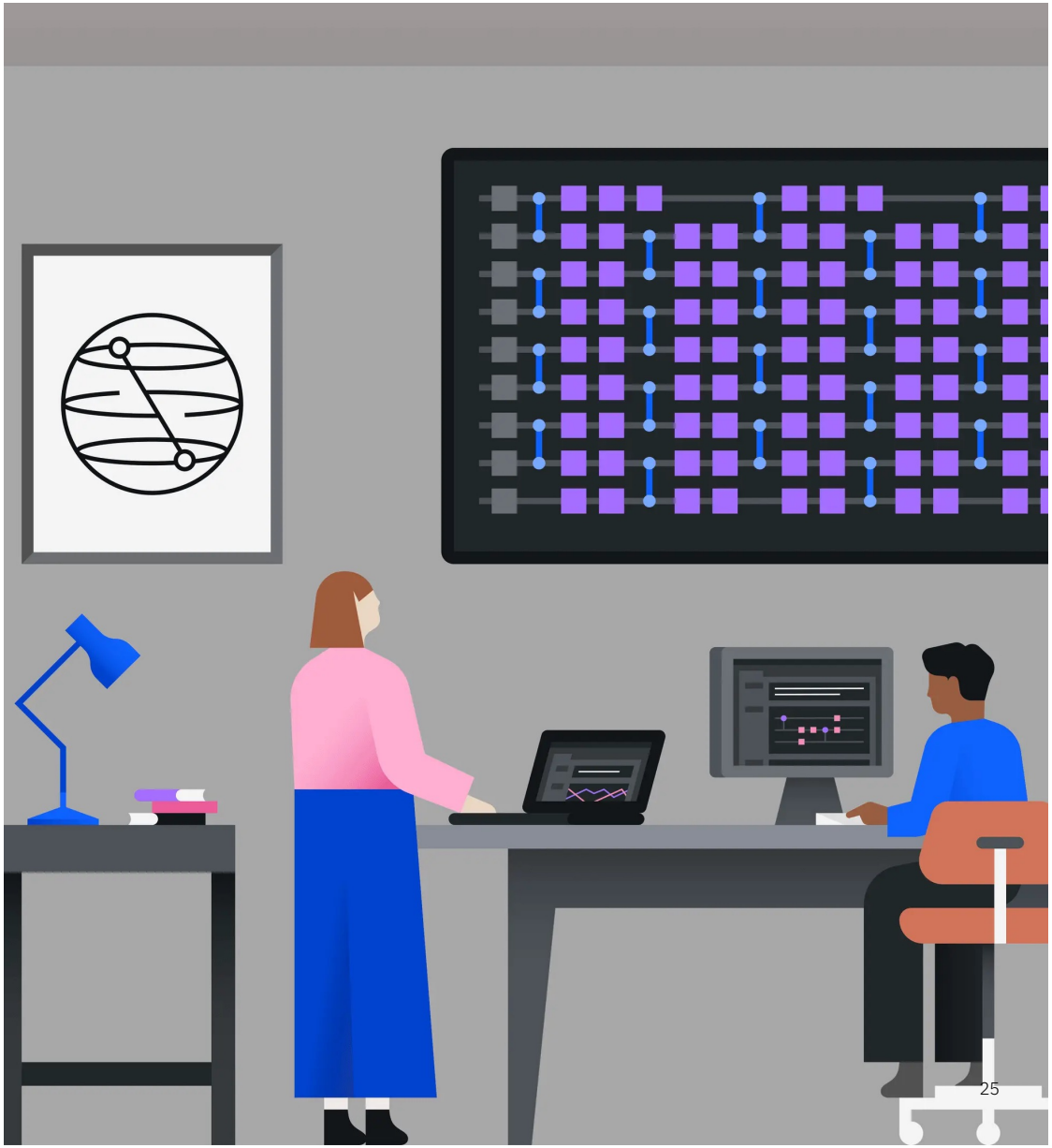
Get up to 10 minutes of runtime per month free.

- ✓ Access to IBM Quantum Compute service
- ✓ Access to 100+ qubit quantum computers

Create your own account on IBM Quantum Platform and start using 100+ qubit IBM quantum computers

← Register here

https://quantum.ibm.com



© 2026 IBM Corporation

Qiskit

With increased performance, stability, and reliability.

Qiskit SDK

arXiv:2405.08810

The lingua franca of quantum computing; write once and execute quantum circuits on 10+ different hardware providers

- IBM Quantum
- AQT
- IQM
- Azure Quantum
- Alice & Bob
- IonQ
- Amazon Braket
- Superstaq
- Quantinuum
- Rigetti

Quantum SDK Preferred
(2025 Unitary Foundation Survey)

69%

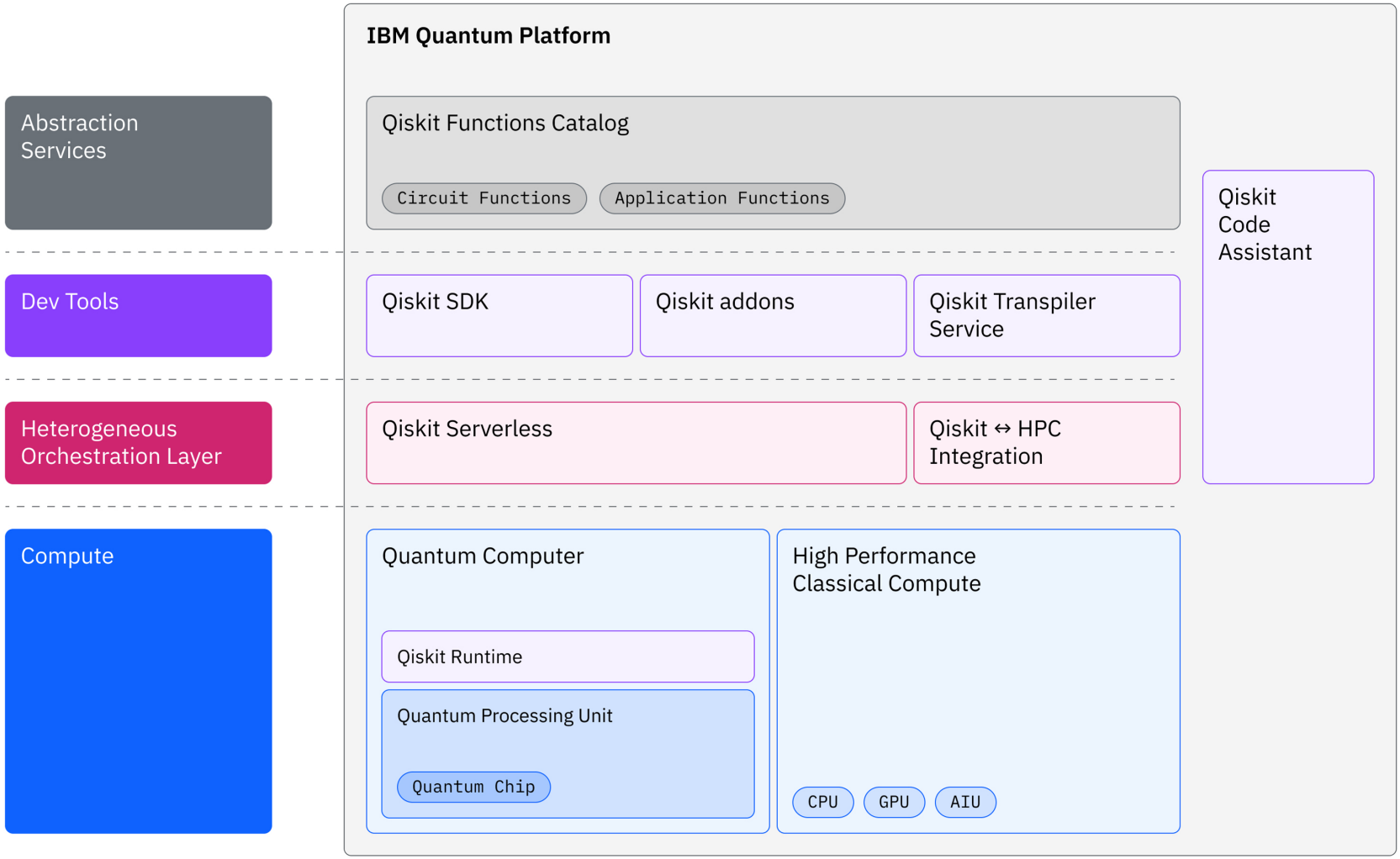
Qiskit contributors that are external to IBM

74%

Dependent Qiskit projects

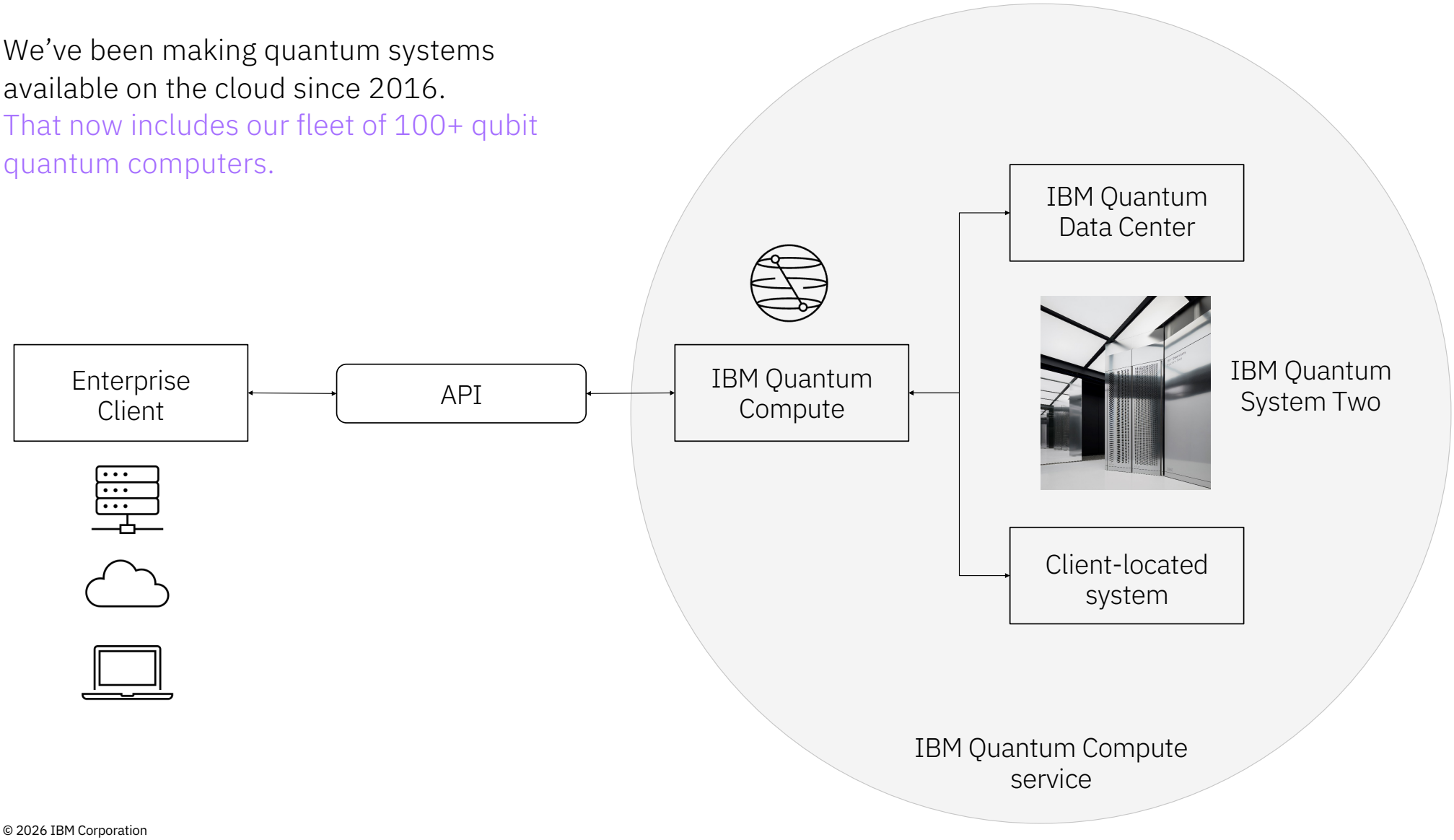
7400+

© 2026 IBM Corporation



© 2026 IBM Corporation

We've been making quantum systems available on the cloud since 2016.
That now includes our fleet of 100+ qubit quantum computers.



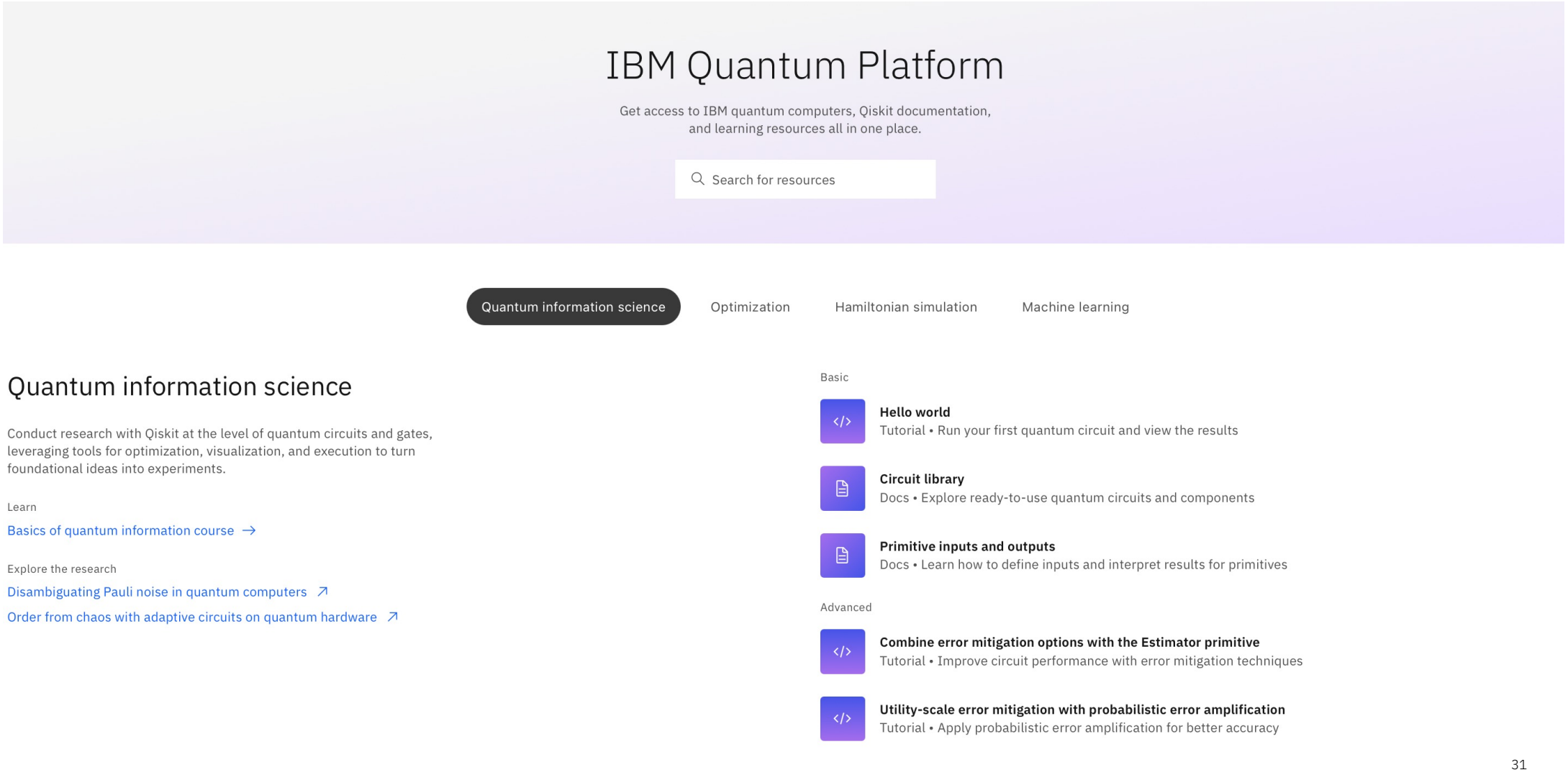
© 2026 IBM Corporation

Some links for materials



© 2025 IBM Corporation

https://quantum.ibm.com



https://learning.quantum.ibm.com

IBM **Quantum Platform** Search Sign in

Learning Courses Modules

Learn quantum computing

Start learning and applying quantum computing with Qiskit through our library of 10+ courses from leading experts.

View all courses →



Featured courses

Start with the fundamentals

Course:
Basics of Quantum Information
with John Watrous

Start this course



Start using a quantum computer

Course:
Use a quantum computer today
with Olivia Lanes

Start this course



Multi-resource learning paths

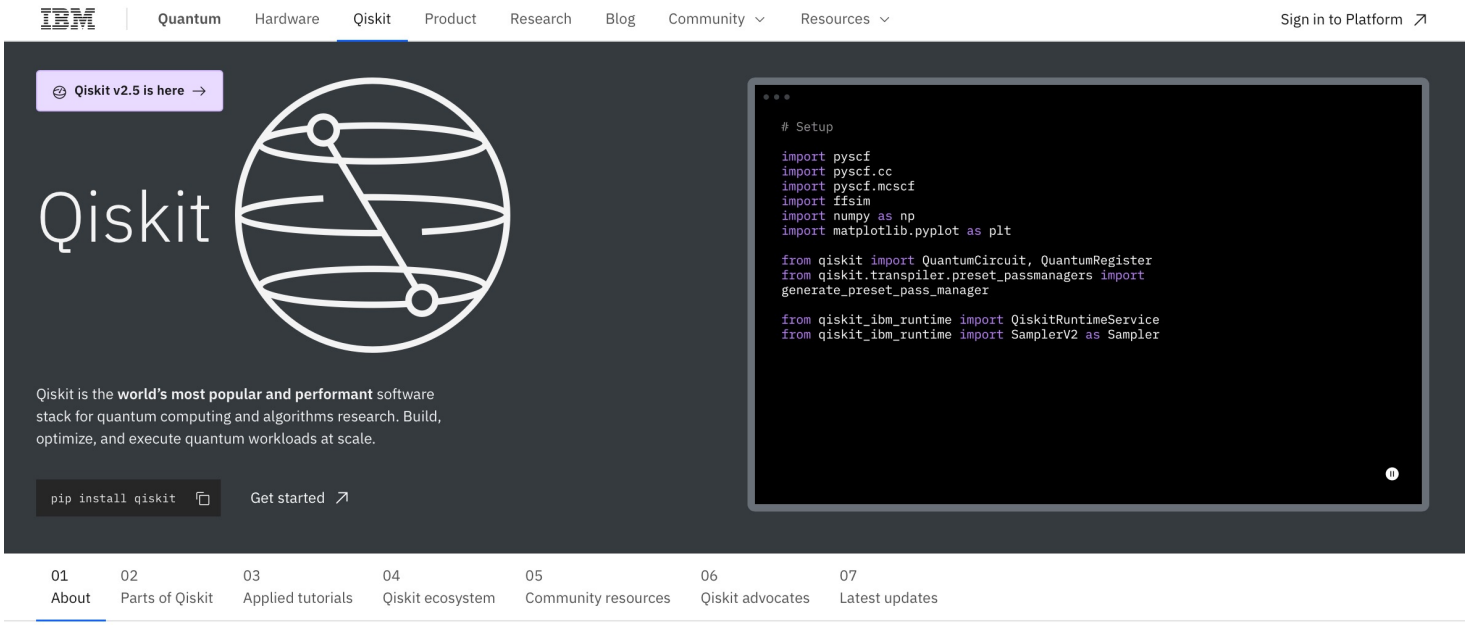
Sequences of content designed to facilitate learning and skill-building in specific interest areas.

- Introduction to quantum →
- Optimization →
- Data science →
- Physics and chemistry →
- Quantum algorithm development →
- QISE →

Qiskit

https://www.ibm.com/quantum/qiskit

- Open-source quantum software for large-scale execution
- Tools for quantum information science
- Tools for HPC orchestration
- Tools for algorithm development
- Pre-built code templates
- Addons to build algorithms
- Apply quantum computing to your use case
- Extend Qiskit with projects from the community



Open-source quantum software for large-scale execution

13M
Qiskit downloads

69%
Developers prefer Qiskit as primary SDK, according to the Unitary Foundation

83x
Faster transpilation time, according to Benchpress toolkit

7K+
Dependent projects

Qiskit is the software of choice for the era of advantage because it offers the most comprehensive suite

https://docs.quantum.ibm.com

IBM **Quantum Platform**

Documentation Tutorials API references

Get started

Introduction

Quickstart

IBM Quantum Composer

Changelogs

Qiskit

Introduction to Qiskit

Install

Circuits and operators

Transpilation

Primitives

Debugging

Advanced techniques - Qiskit addons

Integrate external quantum resources with Qiskit

Integrations

Qiskit Code Assistant

IBM Quantum services

Introduction to IBM Quantum services

Install

Run your first circuit on hardware

IBM Quantum Platform

Execute with primitives

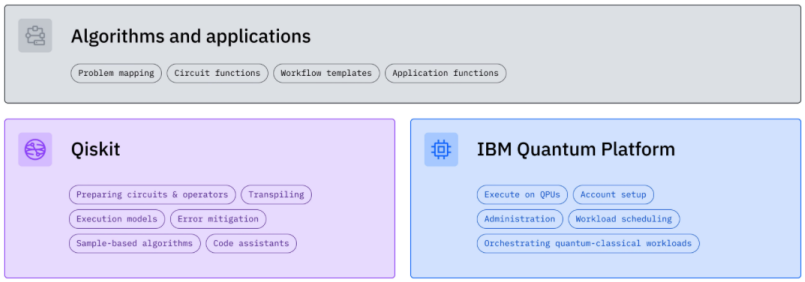
Advanced execution features

IBM quantum computers

Manage workload execution

Execution modes

Qiskit Serverless



Beyond Qiskit and its related packages is the Qiskit ecosystem ↗, a catalog of open-source projects that interface with Qiskit to extend its functionality.

Get started

Quickstart

Build a quantum circuit in under two minutes - no sign-in or API key required.

Start building →

Tutorials

Try end-to-end examples that apply Qiskit to common quantum computing use cases.

Browse tutorials →

Learning

Explore our free learning offerings, such as full courses and classroom modules.

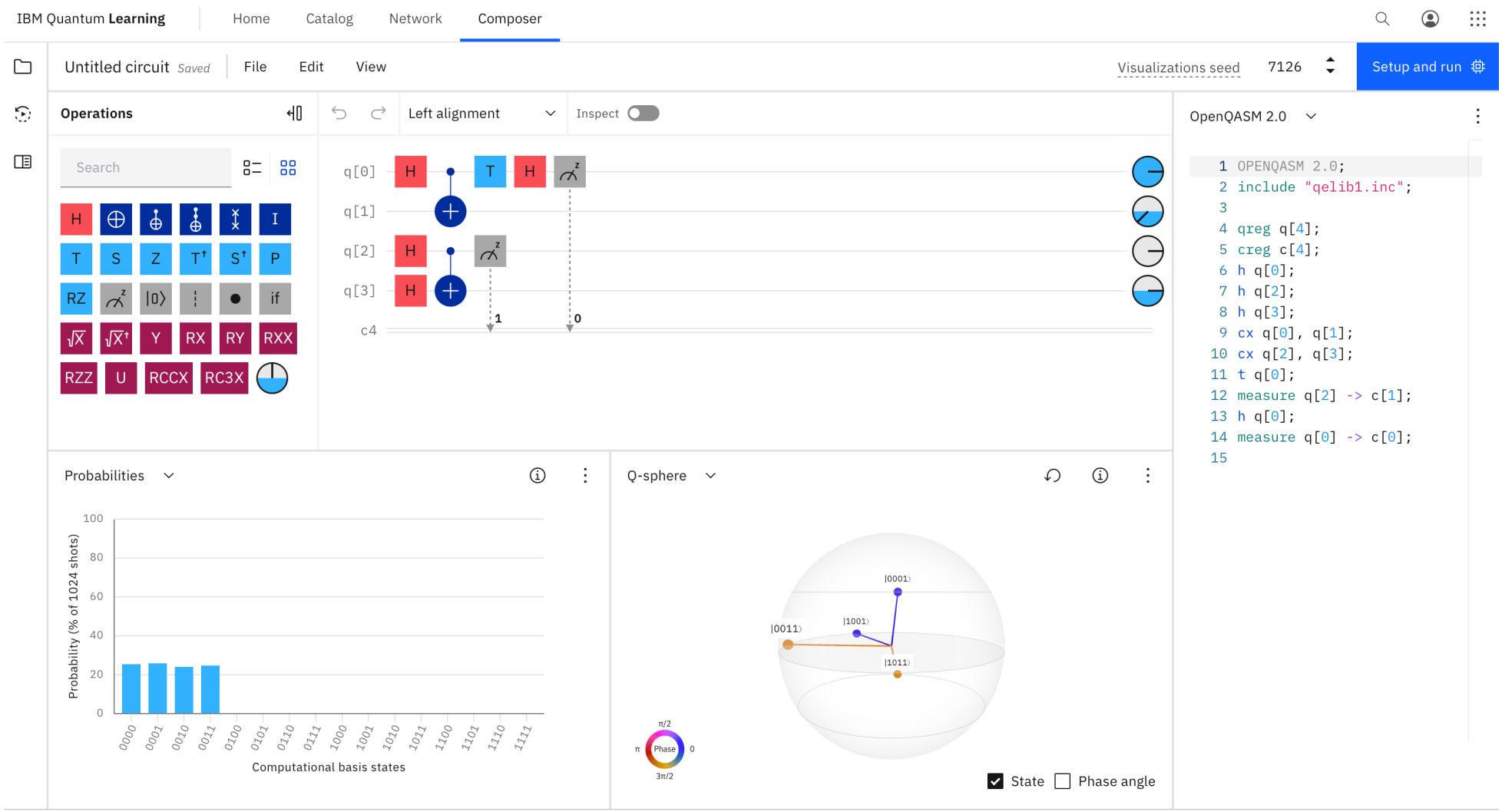
Visit IBM Quantum Learning →

Learning paths

Explore curated sequences of learning, documentation, and tutorial content designed to facilitate knowledge and skill-building in specific interest areas.

Explore learning paths →

https://quantum.ibm.com/composer/



IBM **Quantum**