IBM **Q**: quantum computers for research and business

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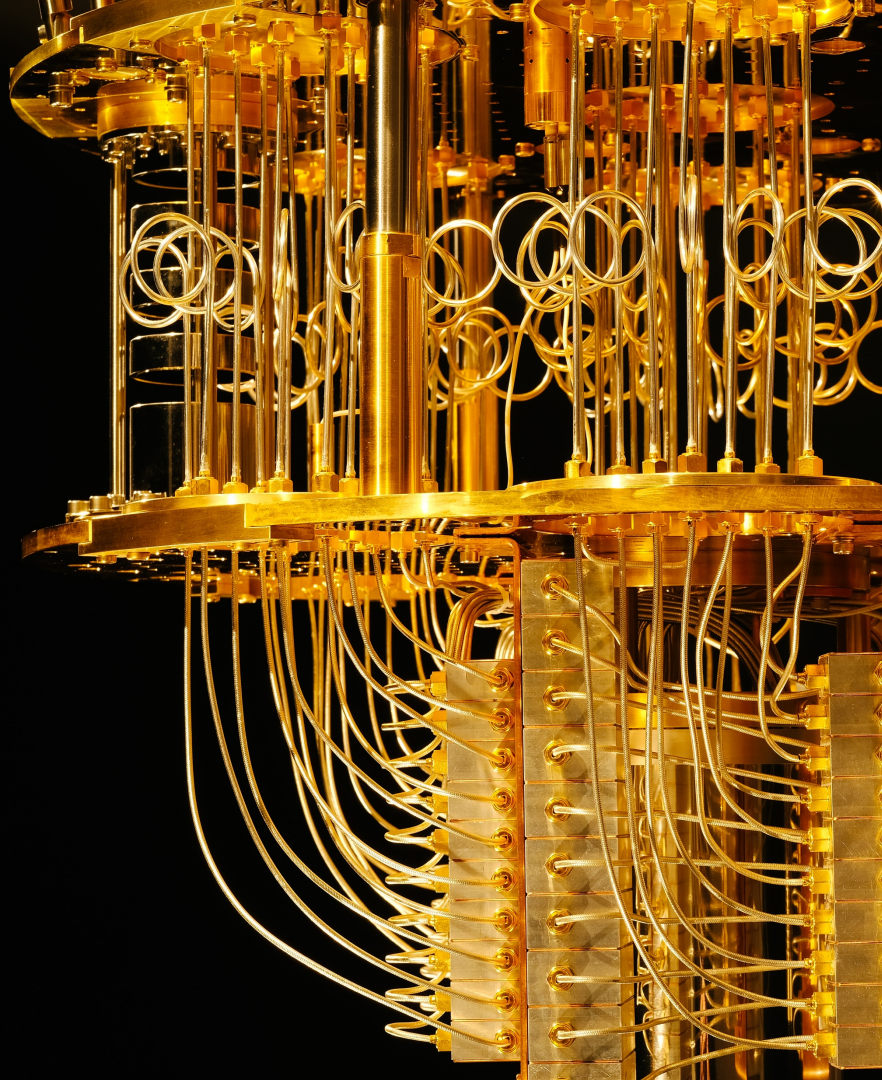
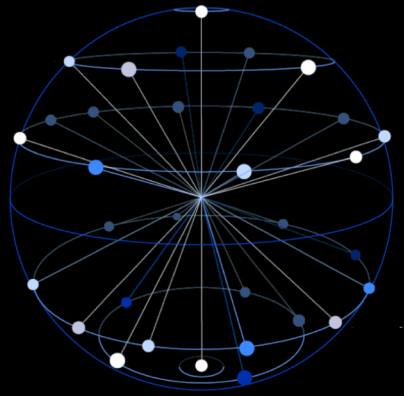


In May of 1981, IBM and MIT hosted the Physics of Computation Conference

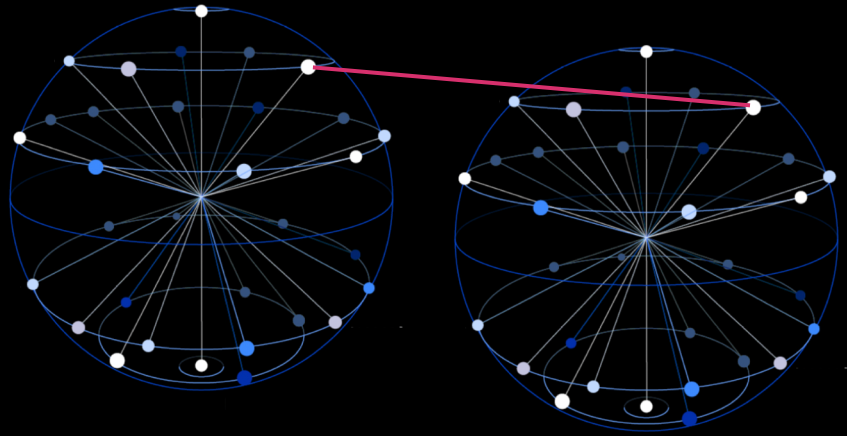
How do quantum computers work?

Universal quantum computers leverage quantum mechanical properties of superposition and entanglement to create states that scale exponentially with number of qubits, or quantum bits.



Superposition

A single quantum bit can exist in a superposition of 0 and 1, and N qubits allow for a superposition of all possible 2^N combinations.



Entanglement

The states of entangled qubits cannot be described independently of each other.

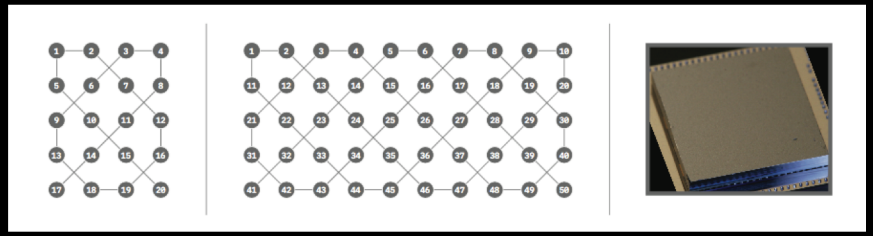
There are several kinds of quantum computing

Universal fault-tolerant quantum computer

The holy grail of quantum information science. Allows one to run useful quantum algorithms which achieve exponential speed ups over their classical counterparts. However the over head of quantum error correction estimates **1M-5M qubits**

Approximate quantum computer (NISQ)

A quantum device which does not have fault tolerance, with the goal of demonstrating a useful application by interacting with a classical computing system, e.g. quantum chemistry, optimization. **Estimate 1K-5K qubits.**



Analog / quantum-inspired / quantum annealer

A specially built system which may use quantum effects to solve/emulate a specific problem.

Where are we on the road to Quantum Advantage?

Quantum Foundations

Fundamentals of quantum information science

Create and scale qubits with increasing coherence

Create error detection and mitigation schemes

Quantum Ready

Core algorithm development

Increase quantum volume

Standardize performance benchmarks

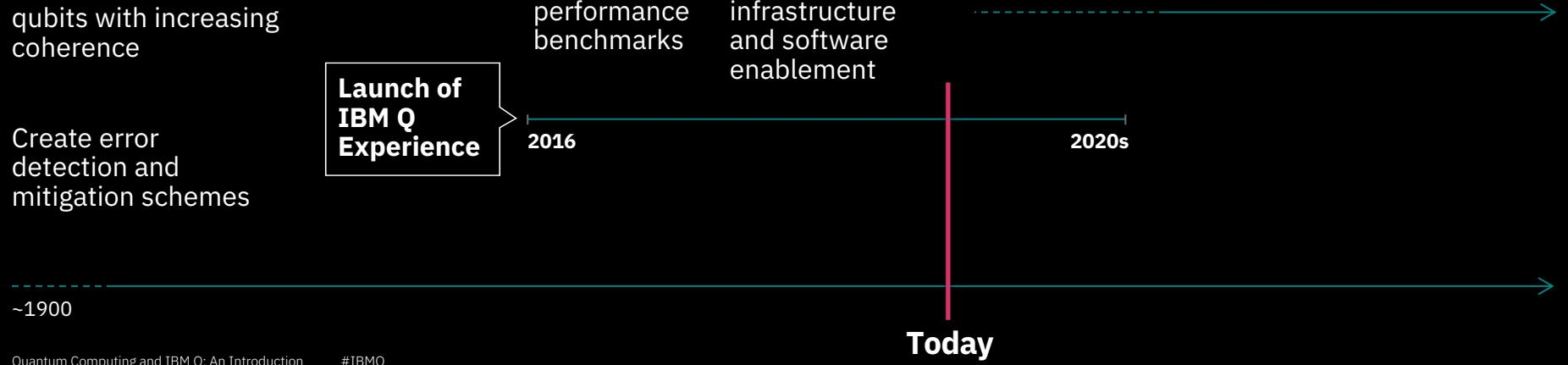
System infrastructure and software enablement

Quantum Advantage

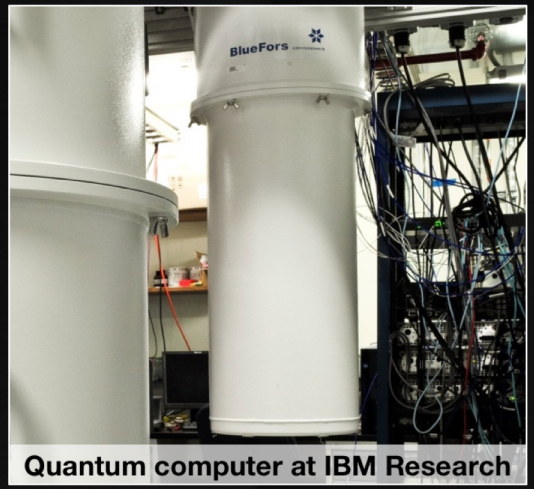
Demonstrate an advantage to using QC for real problems of interest

Extract Commercial Value

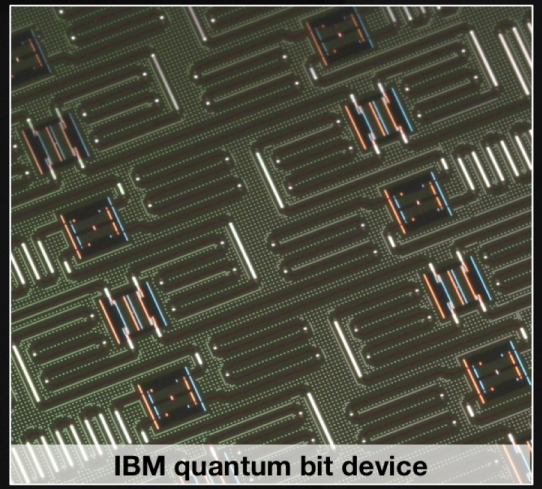
Enable scientific discovery



IBM released the IBM **Q** Experience in 2016



Quantum computer at IBM Research

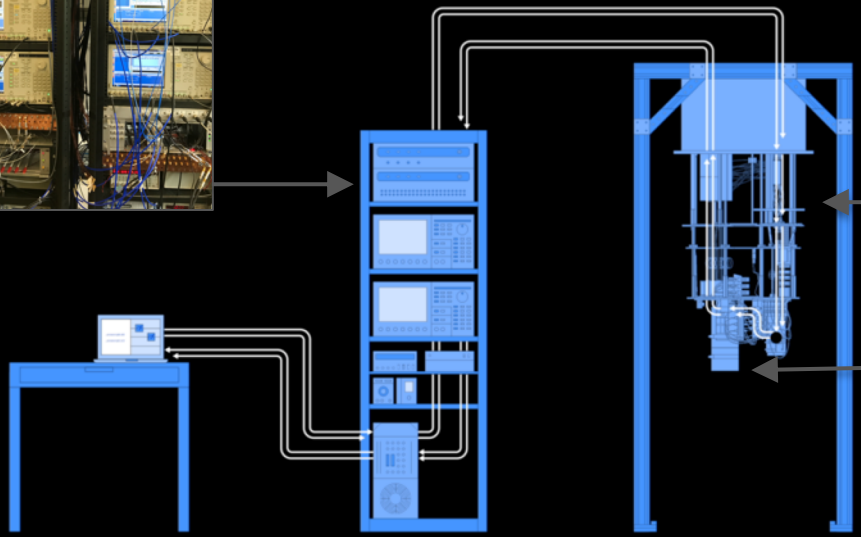

IBM quantum bit device


IBM Quantum Experience

In May 2016, IBM made a quantum computing platform available via the IBM Cloud, giving students, scientists and enthusiasts hands-on access to run algorithms and experiments

Inside an IBM Q quantum computing system

Microwave electronics



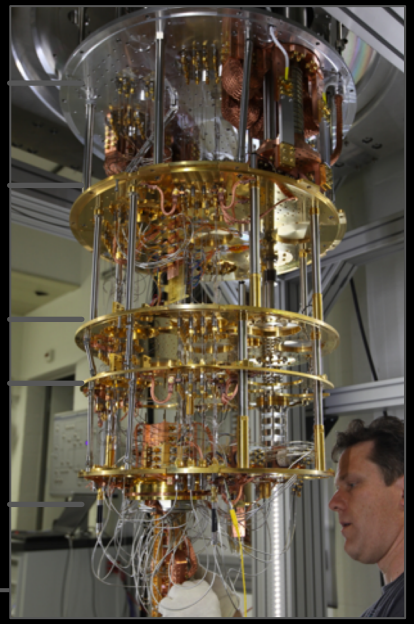
40K

3K

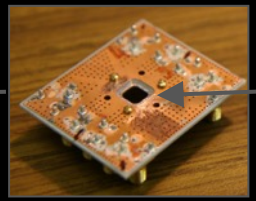
0.9K

0.1K

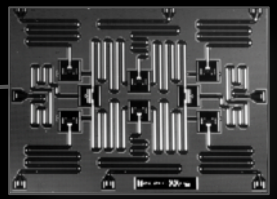
0.015K



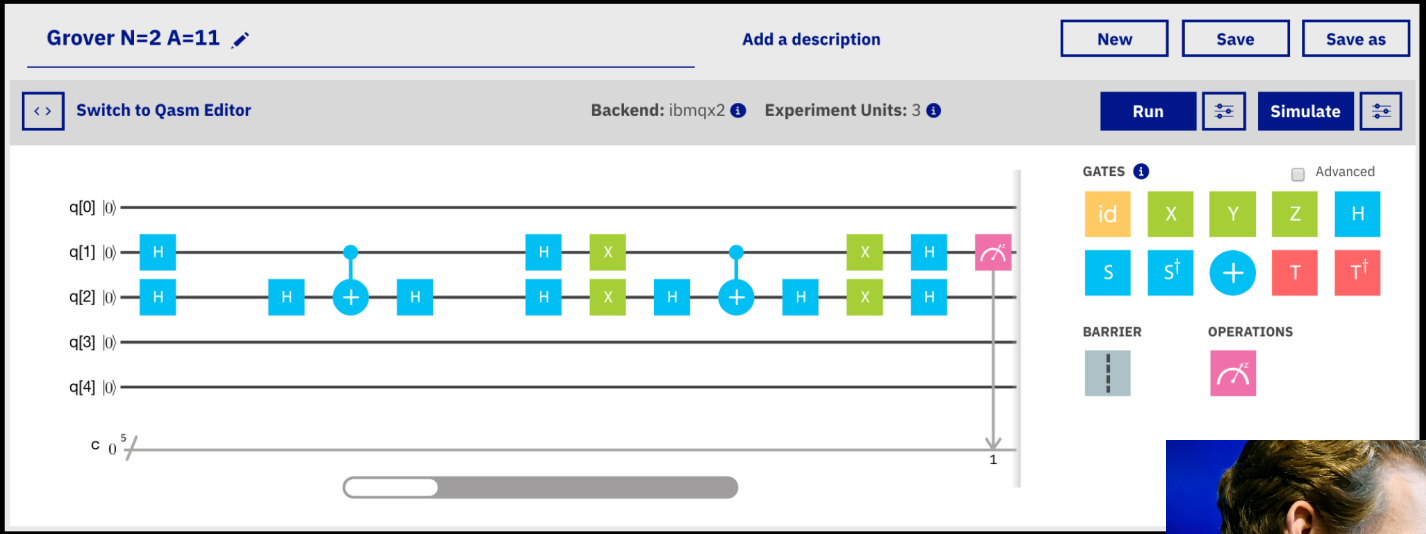
Refrigerator to cool qubits to 10 - 15 mK with a mixture of ^{3}He and ^{4}He



PCB with the qubit chip at 15 mK protected from the environment by multiple shields



Chip with superconducting qubits and resonators



Quantum programs for the 5 qubit machine can be constructed visually and then either simulated or run on the hardware.

Qiskit

An open-source quantum computing framework for leveraging today's quantum processors and conducting research

GitHub | Join the Slack community | Try it out

Our vision

Qiskit is an open-source framework for quantum computing whose goal is to be accessible to people with many backgrounds: quantum researchers, other scientists, teachers, developers, and general tech enthusiasts. Our vision for Qiskit consists of four foundational elements: Terra (the code foundation, for composing quantum programs at the level of circuits and pulses), Aqua (for building algorithms and applications), Ignis (for addressing noise and errors), and Aer (for accelerating development via simulators, emulators and debuggers). Today, we bring you Terra and Aqua, and a commitment to deliver Ignis and Aer in the near future.

More information

The IBM Q Experience has seen extraordinary adoption

First quantum computer on the cloud

> 100,000 users

All 7 continents

> 6.7 Million experiments run

> 120 papers

> 1500 colleges and universities, 300 high schools, 300 private institutions

The IBM **Q** Network

In December, 2017, IBM launched the **IBM Q Network**, a collaboration with leading Fortune 500 companies and research institutions with a shared mission to …

Accelerate Research

Collaborate with the most advanced academic and research organizations to advance quantum computing technology.

Launch Commercial Applications

Engage industry leaders to combine IBM's quantum computing expertise with industry specific expertise to accelerate development of the first commercial use cases.

Educate and Prepare

Expand and train the ecosystem of users, developers, and application specialists that will be essential to the adoption and scaling of quantum computing.

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