IBM Quantum:
It's time
to get *started*

Kenneth Wood
Global Business Development Director
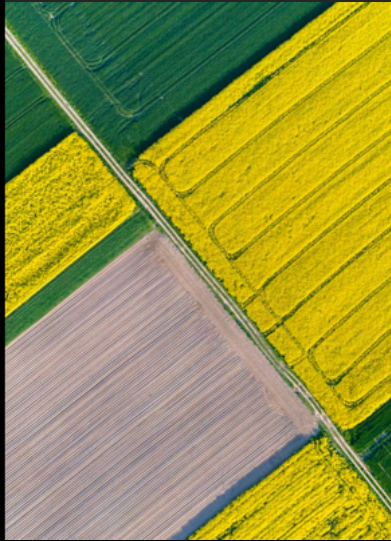IBM Quantum
kawood@us.ibm.com

IBM Quantum

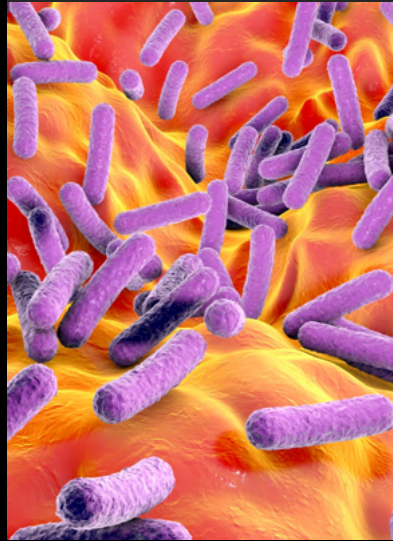# Hard Problems

Improved nitrogen-fixation process

New catalysts

Better financial models

New classes of antibiotics

DAIMLER

Pursing the next generation of battery technology by advancing the development of new materials, improving automotive manufacturing techniques, and enhancing the product experience.

JPMorgan Chase & Co.

Developing improved methodologies for financial modeling including option pricing and risk analysis.

woodside

Improve petrophysical analysis and gain better insights on oil exploration and rock type predictions

Cleveland Clinic

Creating a new quantum computing ecosystem in Ohio focused on advancing skills in the region and fundamentally advancing the pace of discovery in healthcare and life sciences.

ExxonMobil

Exploring more accurate thermodynamical and chemical simulations, and ways to optimize logistics in resource and energy distribution.

Goldman Sachs

Investigating quantum computing to gain advantage and unlock efficiencies in pricing sophisticated financial instruments.

BOEING

Exploring quantum computing's potential to deliver the advanced computation and communications increasingly at the heart of aerospace innovation.

## U.S. DEPARTMENT OF ENERGY — Office of Science / AFRL

Providing access to real quantum computing hardware to accelerate the development of DOE and DOD mission-critical applications and drive transformational advancements in science and research.

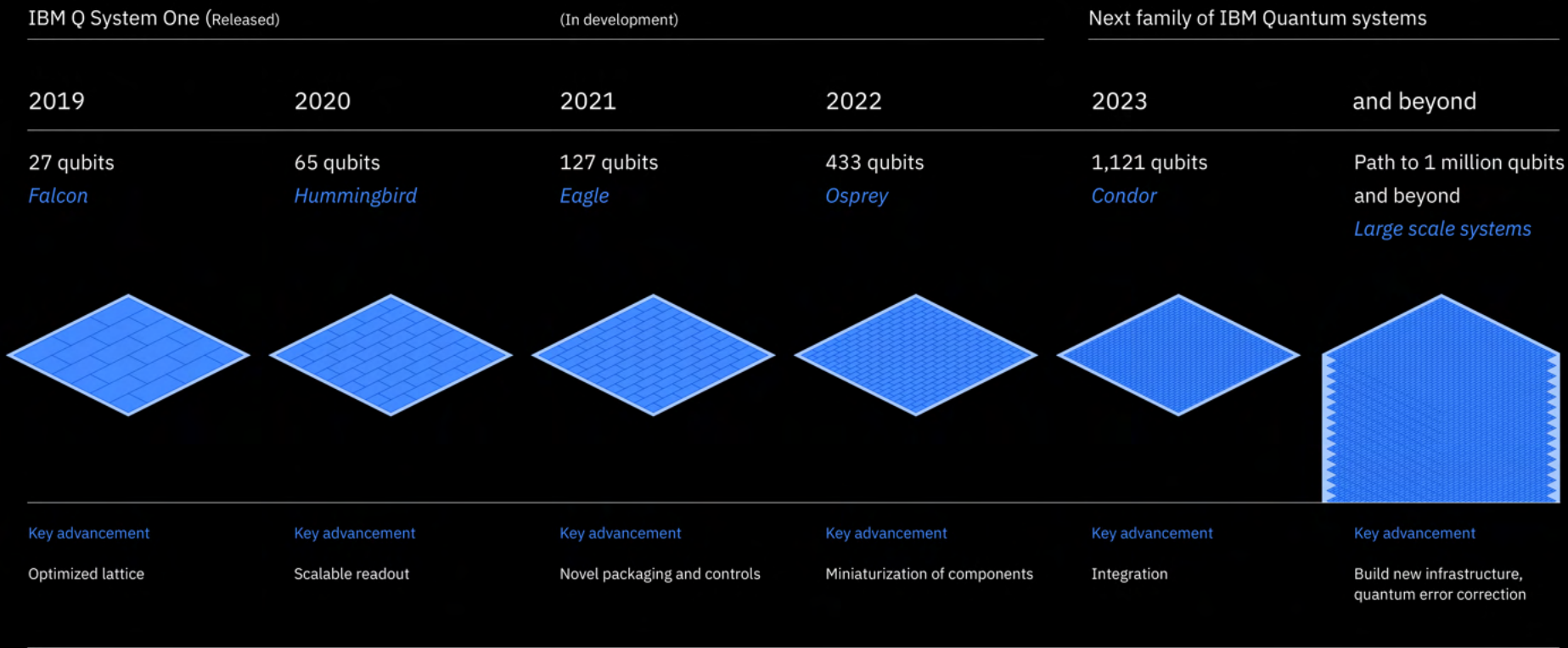# Quantum Bits and Quantum Circuits
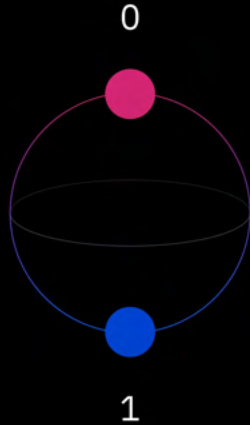
A quantum bit or qubit is a controllable quantum object that is the unit of information
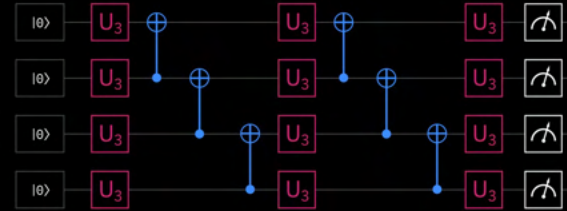
A quantum circuit is a set of quantum gate operations on qubits and is the unit of computation

Scaling Hardware: IBM's Quantum Technology Roadmap

IBM Q System One (Released)		(In development)		Next family of IBM Quantum systems	
2019	**2020**	**2021**	**2022**	**2023**	**and beyond**
27 qubits	65 qubits	127 qubits	433 qubits	1,121 qubits	Path to 1 million qubits and beyond
Falcon	*Hummingbird*	*Eagle*	*Osprey*	*Condor*	*Large scale systems*

Key advancement	Key advancement	Key advancement	Key advancement	Key advancement	Key advancement
Optimized lattice	Scalable readout	Novel packaging and controls	Miniaturization of components	Integration	Build new infrastructure, quantum error correction

Qiskit

– Qiskit is the most **Feature-Rich** quantum computing software design kit (SDK)

– Qiskit is the most **Open** quantum computing SDK

– Qiskit is the most **Modular** quantum computing SDK

– Qiskit is the most **Widely Used** quantum computing SDK.

Platform Development Roadmap

	2019	2020	2021	2022	2023	2024	2025	2026+
	Run quantum circuits on the IBM cloud	Demonstrate and prototype quantum applications	Run quantum applications 100x faster on the IBM Cloud	Increase circuit possibilities with dynamic circuits	Frictionless development with quantum workflows built in the cloud	Call 1K+ qubit services from Cloud API and investigate error correction	Enhance quantum workflows through HPC and quantum resources	

Quantum application modules

Quantum application services

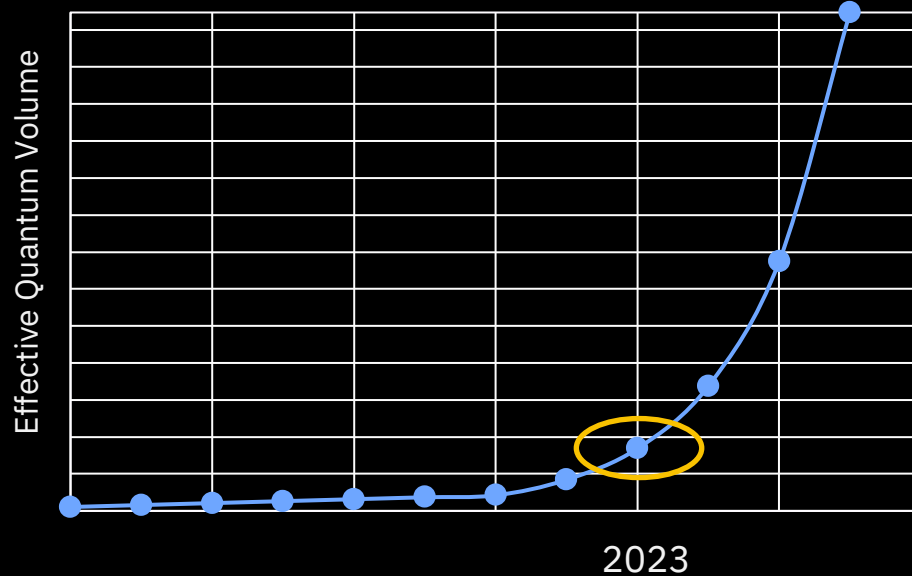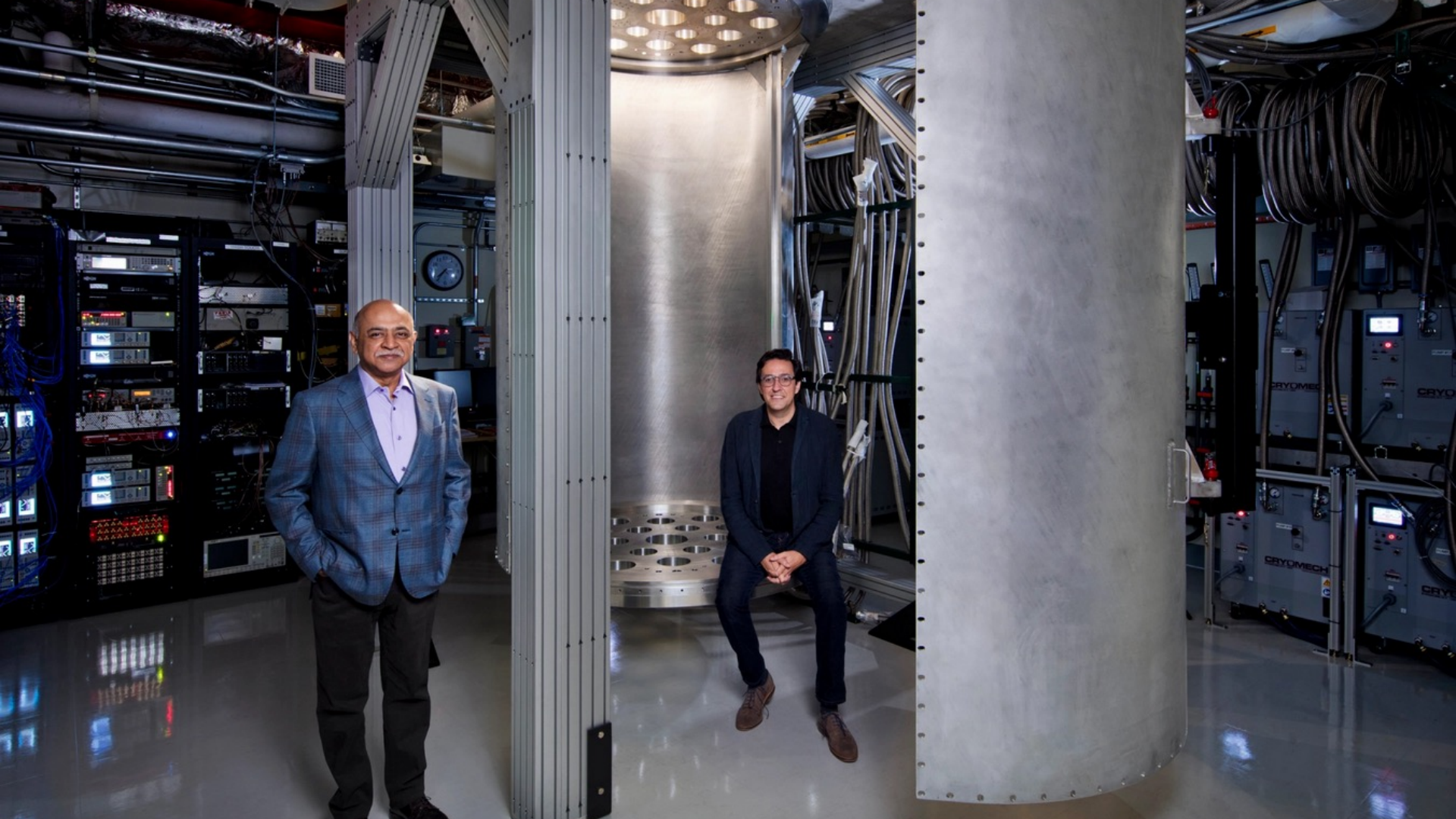|								
Model developers						Natural Sciences · Finance · Optimization · Machine Learning		
Algorithm developers		Natural Sciences · Finance · Optimization · Machine Learning			Prebuilt quantum runtimes		Prebuilt quantum + classical runtimes	
Kernel developers	Circuits		Quantum runtime	Dynamic circuits	Circuit libraries		Circuits at scale (Cryo CMOS, HPC-quantum integration)	
Quantum systems	**Falcon** 27 qubits	**Hummingbird** 65 qubits	**Eagle** 127 qubits	**Osprey** 433 qubits	**Condor** 1121 qubits	**Beyond** 1K - 1M+ qubits		
IBM Cloud	Circuits		Programs		Applications			
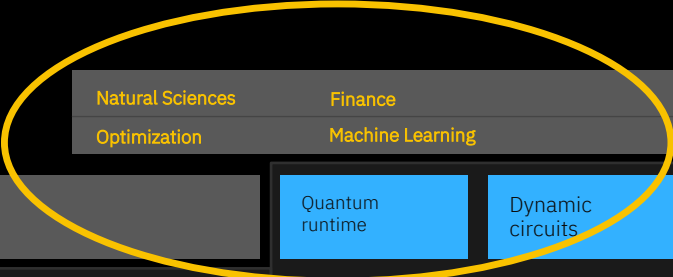
An Inflection Point

Quantum volume will continue to scale as we advance key building blocks of systems.
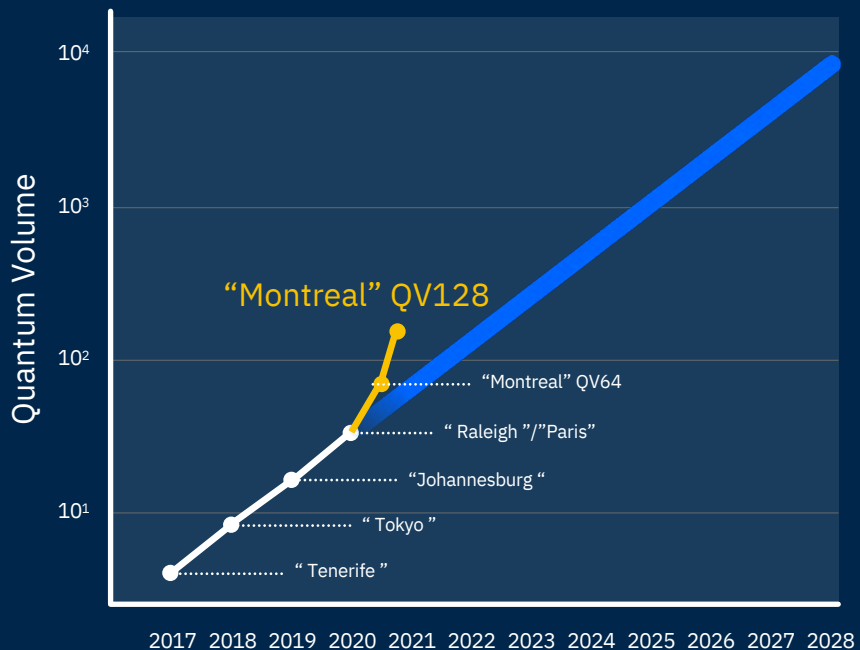
At 1000+ qubits in 2023 on our roadmap, there will be an inflection point to software (encoded) scaling.

"Montreal" QV128

"Montreal" QV64

" Raleigh "/"Paris"

"Johannesburg "

" Tokyo "

" Tenerife "

Quantum Volume

2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028
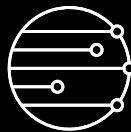
Effective Quantum Volume

2023

IBM Quantum Network
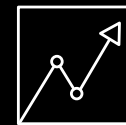## A collaborative community of discovery

Educate and Train

Over 300,000 users have run over 700 Billion quantum circuits on 20+ quantum computers

Accelerate Research

145+ Clients and partners

Over 400 scientific papers

Develop Applications

Collaborating on 30+ applications

IBM Quantum Network Today

IBM Q Network Today

147 members

- 12 industry partners
- 19 hubs
- 37 members
- 38 startups
- 41 academic members and partners

Partners

JP Morgan Chase & Co.

ExxonMobil

Samsung

Daimler

JSR Corp

Accenture

Goldman Sachs

Woodside Energy

BP

Amgen

Boeing

Paypal

Hubs

University of Tokyo
Fraunhofer
Cleveland Clinic
US Air Force Research Lab
Oak Ridge National Lab
Keio University
NC State Univ.
Munich Hub at U. Bundeswehr
National Taiwan University
Iberian Nanotech Lab
CSIC Spain
Los Alamos National Laboratory
Pacific Northwest National Lab
Brookhaven National Lab
U. Melbourne
U. Oxford
U. Sherbrooke
SKK University
CERN

Members

Delta
Anthem
Wells Fargo
Barclays
Mizuho
MUFG
Mitsubishi Chem
Argonne Lab
Fermilab
Berkeley Lab
US Naval Res Lab
ITRI
III Taiwan
Quemix
Flight Profiler
SVA
Archer
A*Quantum
Tradeteq
Grid
CMC
Lockheed Martin
Sandia National Lab
DIC
Toyota
Hitachi
Toshiba
Yokogawa Electric
General Atomics
SuMiTB
Sony
AIS
CMU-SEI
GE Research
Deloitte
Keysight
Molecular Forecaster

Startups

CQC
QC Ware
1QBit
Zapata
Strangeworks
Q-CTRL
Quantum Benchmark
Blueqat
Qu&Co
JoS Quantum
SolidStateAI
ProteinQure
MaxKelsen
Netramark
Entropica
Boxcat
Rahko
Qunasys
QuantFi
Agnostiq
AIQTech
Zurich Instruments
BEIT
Quantum Machines
Aliro
Xanadu
Apply Science
Multiverse
Equal1
Miraex
SoftwareQ Inc.
Super.tech
Nordic Quantum
Opacity
Phasecraft
ColdQuanta
Qedma
Horizon

Academic

MIT
EDX.org
Virginia Tech
U. Montpellier
Notre Dame
Harvard
Princeton
Florida State
U. Stony Brook
U. Chicago
Duke
CU Boulder
U. Waterloo
U. Illinois
Northwestern
NYU
Wits
Aalto University
U. of Turku
U. Basque Country
U. of Innsbruck
EPFL
Chalmers University
ETH Zurich
Saarland University
Johns Hopkins
Boston University
U. Autonoma Madrid
Stanford
Georgia Tech
U. New Mexico
National U. Singapore
U. Georgia
U. Minho
U. Tennessee
Cornell
Purdue
KAIST
New Mexico State Univ.
Northeastern University
Univ of Southern California

Founding a core team for Quantum requires an investment in upskilling in-house resources

The IBM Quantum Network is designed to transform classically trained computational resources into Quantum Practitioners able to independently engage and conduct experimentation.

What roles align to Quantum upskilling?

– Research scientist
– Computer scientist
– Data scientist
– Development engineer

IBM Quantum Network Program

Quantum Systems on IBM Cloud

– Access to quantum systems and software services
– Shared or dedicated systems, direct partner or hub

Enablement

– Workshops, tutorials, and consultation
– Dedicated team to train, support and guide users

IBM Quantum Network Community

– Membership in the premier network of collaborators
– Member-only events, resources, and content

Engagement Models

1. Quantum Hub Member
2. Quantum Accelerator
3. Industry Partner

June 2020

University of Sherbrooke joins IBM Q Network

IBM Q Hub – L'Institut Quantique At Université De Sherbrooke Joins IBM Q Network: First IBM Q Hub In Canada

(Newswire.ca) L'Institut quantique (IQ) at Université de Sherbrooke (UdeS) has agreed to join the IBM Q Network as an IBM Q Hub, the first in Canada. With the financial support from the government of Québec, UdeS will greatly expand its quantum computing capacity as an IBM Q Hub, which will give its members exclusive cloud-based access to IBM's most advanced quantum computing systems and software, including a 53-qubit system, currently the largest universal one available in the industry. "The IBM Q Hub at IQ is a tool for both fundamental research and the development of practical applications, explains Alexandre Blais, IQ Scientific Director. We want to build a quantum community of users where academia, private companies and startups meet and connect."

Pioneering Quantum Information Technology with Partners

IBM, Fraunhofer partner on German-backed quantum computing research push

Douglas Busvine

3 MIN READ

FRANKFURT (Reuters) - IBM is joining forces with a German research institute to explore the potential of quantum computing, backed by a government plan to invest 650 million euros ($717 million) over two years in wider research in the field.

IBM News Room

IBM and the University of Tokyo Unveil the Quantum Innovation Initiative Consortium to Accelerate Japan's Quantum Research and Development Leadership
Keio University, Toshiba, Hitachi, Mizuho, MUFG, JSR, DIC, Toyota, Mitsubishi Chemicals and IBM to expand the country-wide quantum computing research, development and education ecosystem


IBM News Room

Cleveland Clinic and IBM Unveil Landmark 10-Year Partnership to Accelerate Discovery in Healthcare and Life Sciences
IBM Hybrid Cloud, High Performance Computing, Artificial Intelligence, and Quantum Computing technologies to serve as foundation for newly launched Cleveland Clinic Global Center for Pathogen Research & Human Health
IBM plans to install its first private-sector, on premises quantum computing system in the U.S. at Cleveland Clinic. Cleveland Clinic also plans to receive first, next-generation IBM 1,000+ qubit quantum system in the coming years

What are the next steps?

1. Log in and try our real quantum systems
   https://quantum-computing.ibm.com/

2. Attend one of our free Qiskit training series

3. Join the IBM Quantum Network and get started!
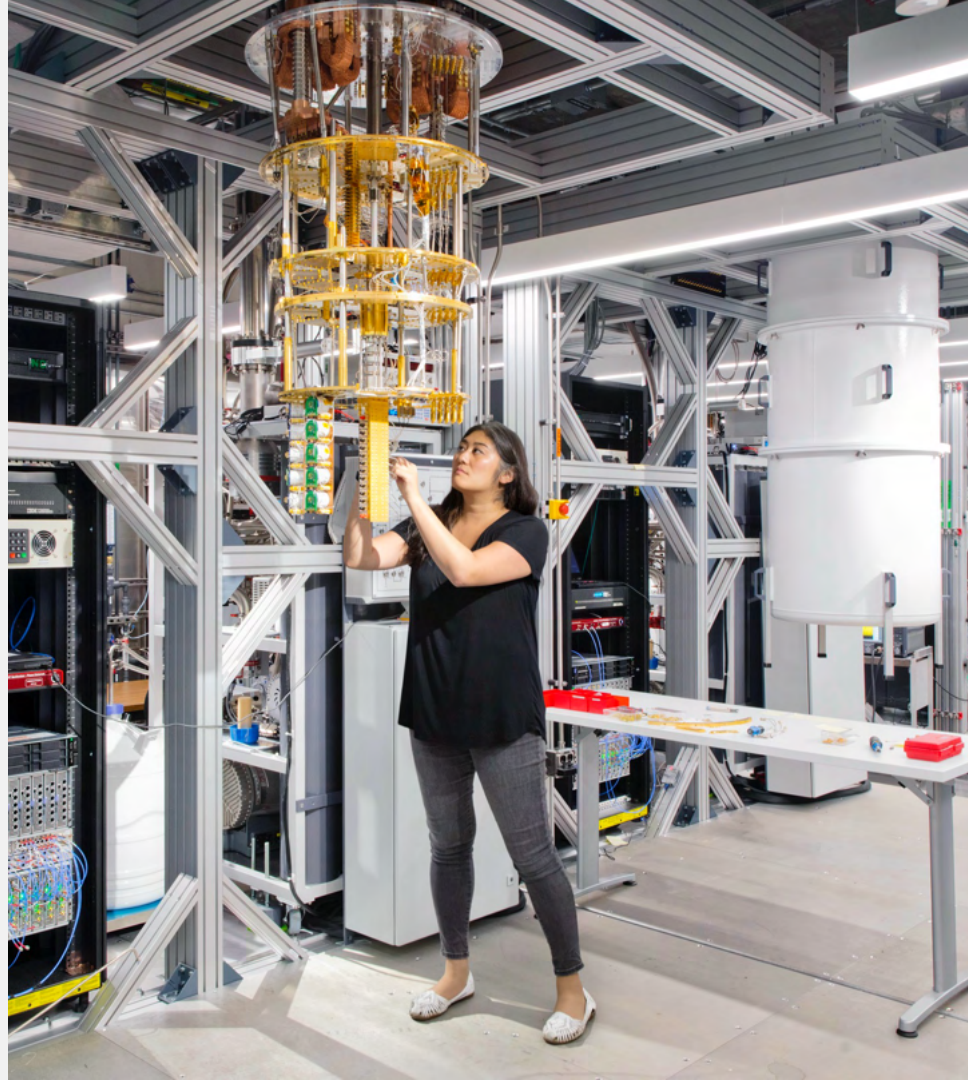
IBM **Quantum**

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IBM Q Network Useful Links

The Quantum Era of Accelerated Discovery - Dr. Dario Gil *(Video 30mins) - Excellent summary, well worth the time to watch*	https://www.youtube.com/watch?v=zOGNoDO7mcU#action=share
Technical Papers from IBM and IBM Q Network Members on Chemistry, AI/ML, Optimization, Finance. (Airtable)	https://ibm.biz/q-network-arxiv
IBM Q and IBM Q Experience (access link to IBM Q Open Systems)	https://quantum-computing.ibm.com/
Qiskit	https://qiskit.org
Qiskit for Educators	https://qiskit.org/education/
IBM Quantum Text Book	https://qiskit.org/education/#textbook
Coding with Qiskit Video Series, Seminar Series, Circuit Sessions, Superposition Talk Show, 1 Minute Qiskit	https://www.youtube.com/qiskit
Video: The State of Quantum Computing in 2019 (1 hour - IBM Panel with ExxonMobil, JPMC, Daimler)	https://www.ibm.com/events/think/watch/playlist/472902/replay/120181736/
Demo: A Quantum Finance Simulator for Option Pricing	https://ibm-q-financial-demo.mybluemix.net/
Demo: Protein Folding	https://protein-folding-demo.mybluemix.net/
Demo: Test a Quantum Classifier	https://ibm-q4ai.mybluemix.net/
Quantum Conversations for Business Class	https://w3.ibm.com/w3publisher/ibm-q-training/quantum-conversations
Jay Gambetta's Blog, VP of Quantum	https://www.ibm.com/blogs/research/author/jaygambetta/

IBM Institute for Business Value Reports

Quantum Computing Focus

Exploring quantum computing use cases for financial services	https://www.ibm.com/thought-leadership/institute-business-value/report/exploring-quantum-financial
Getting your financial institution ready for the quantum computing revolution	https://www.ibm.com/thought-leadership/institute-business-value/report/quantumfinancial
Prioritizing quantum computing applications for business advantage (financial services examples)	https://www.ibm.com/thought-leadership/institute-business-value/report/prioritizing-quantum-apps
Exploring quantum computing use cases for healthcare	https://www.ibm.com/downloads/cas/8QDGKDZJ
Exploring quantum computing use cases for life sciences	https://www.ibm.com/thought-leadership/institute-business-value/report/quantum-life-sciences
Exploring quantum use cases for chemicals and petroleum	https://www.ibm.com/thought-leadership/institute-business-value/report/quantum-chemical-petroleum
Exploring quantum computing use cases for airlines	https://www.ibm.com/thought-leadership/institute-business-value/report/quantum-airlines
Building your quantum capability: The case for joining an "ecosystem"	https://www.ibm.com/thought-leadership/institute-business-value/report/quantumeco
Coming soon to your business: quantum computing - Five strategies to prepare for the paradigm-shifting technology	https://www.ibm.com/thought-leadership/institute-business-value/report/quantumstrategy
Taking the Quantum Leap: Why Now?	https://www.ibm.com/thought-leadership/institute-business-value/report/quantumleap