

Quantum Computing for

19.12.2019

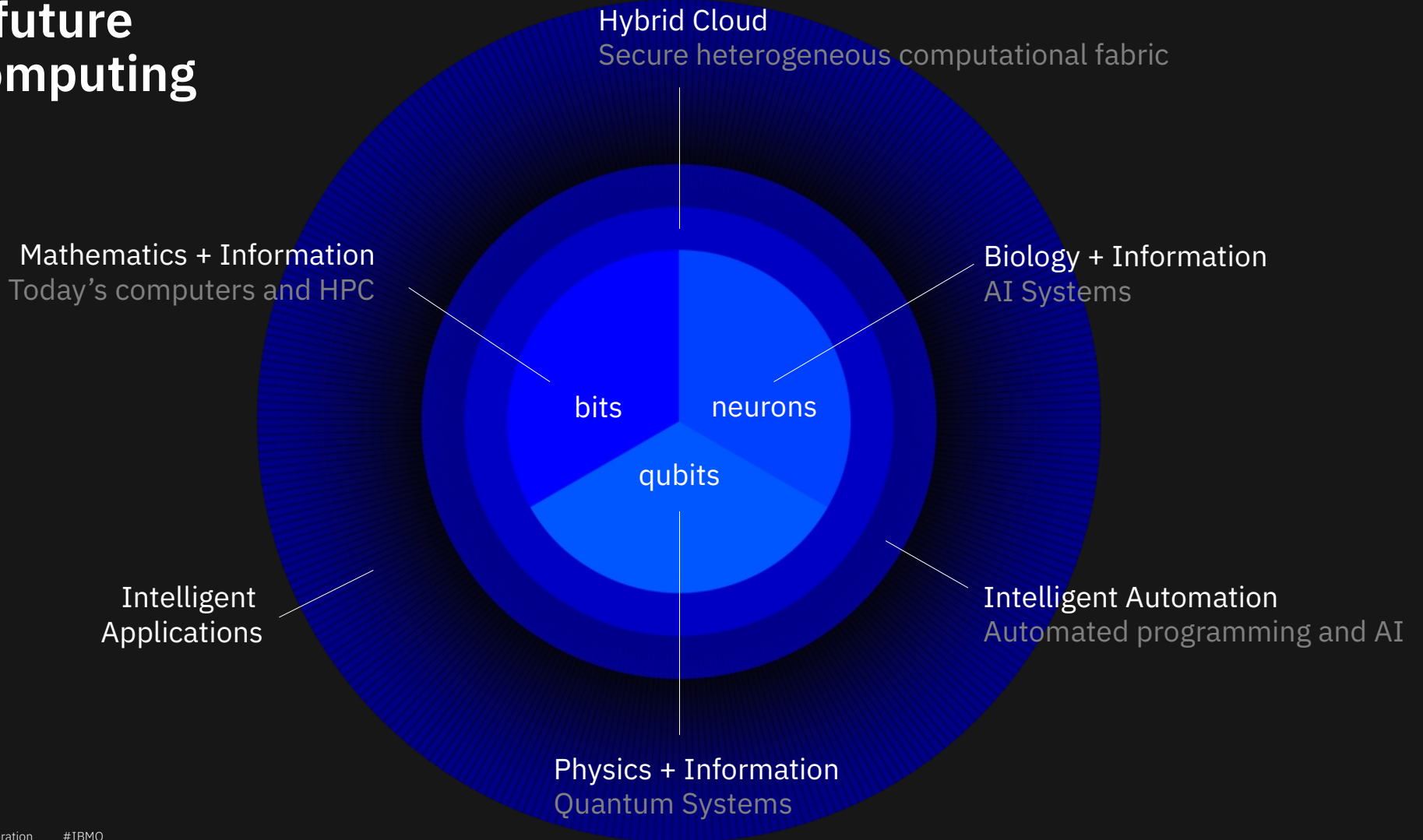


Ingolf Wittmann

Technical Director
IBM Q Ambassador Leader Global
CTO & Leader of HPC Europe



The future of computing



The world's most powerful “bits + neurons” system

Oak Ridge National Laboratory
US Department of Energy

Summit supercomputer specs

200,000
trillion calculations
per second

9216
IBM Power 9 processors

27,648
NVIDIA GPUs

250 PB
File System

IBM Red Hat Enterprise Linux (RHEL) v 7.4
Operating System



Potential Use Cases for Quantum Computing

		Chemicals and Petroleum	Distribution and Logistics	Financial Services	Health Care and Life Sciences	Manufacturing
	Chemical Simulation	Chemical product design			Drug Discovery	Materials Discovery
		Surfactants, Catalysts				Quantum Chemistry
■	Scenario Simulation		Disruption Management	Derivatives Pricing	Disease Risk Predictions	
				Investment Risk Analysis		
▲	Optimization	Feedstock To Product	Distribution Supply Chain		Medical/Drug Supply Chain	Fabrication Optimization
		Oil Shipping / Trucking	Network Optimization	Portfolio Management		Manufacturing Supply Chain
			Vehicle Routing	Transaction Settlement		Process Planning
		Refining Processes				
◆	AI/ML	Drilling Locations	Consumer Offer Recommender	Finance Offer Recommender	Accelerated Diagnosis	Quality Control
		Seismic imaging	Freight Forecasting	Credit/Asset Scoring	Genomic Analysis	Structural Design & Fluid Dynamics
			Irregular Behaviors (ops)	Irregular Behaviors (fraud)	Clinical Trial Enhancements	

The road to Quantum Advantage

Quantum Science

Create the fundamental theoretical and physical building blocks of quantum computing.

Quantum Ready

Engage the world to prepare for the quantum computing era.

Quantum Advantage

Commercial advantage to solving real world problems with quantum computing systems.

Launch of the IBM Q Network

1900s

2016

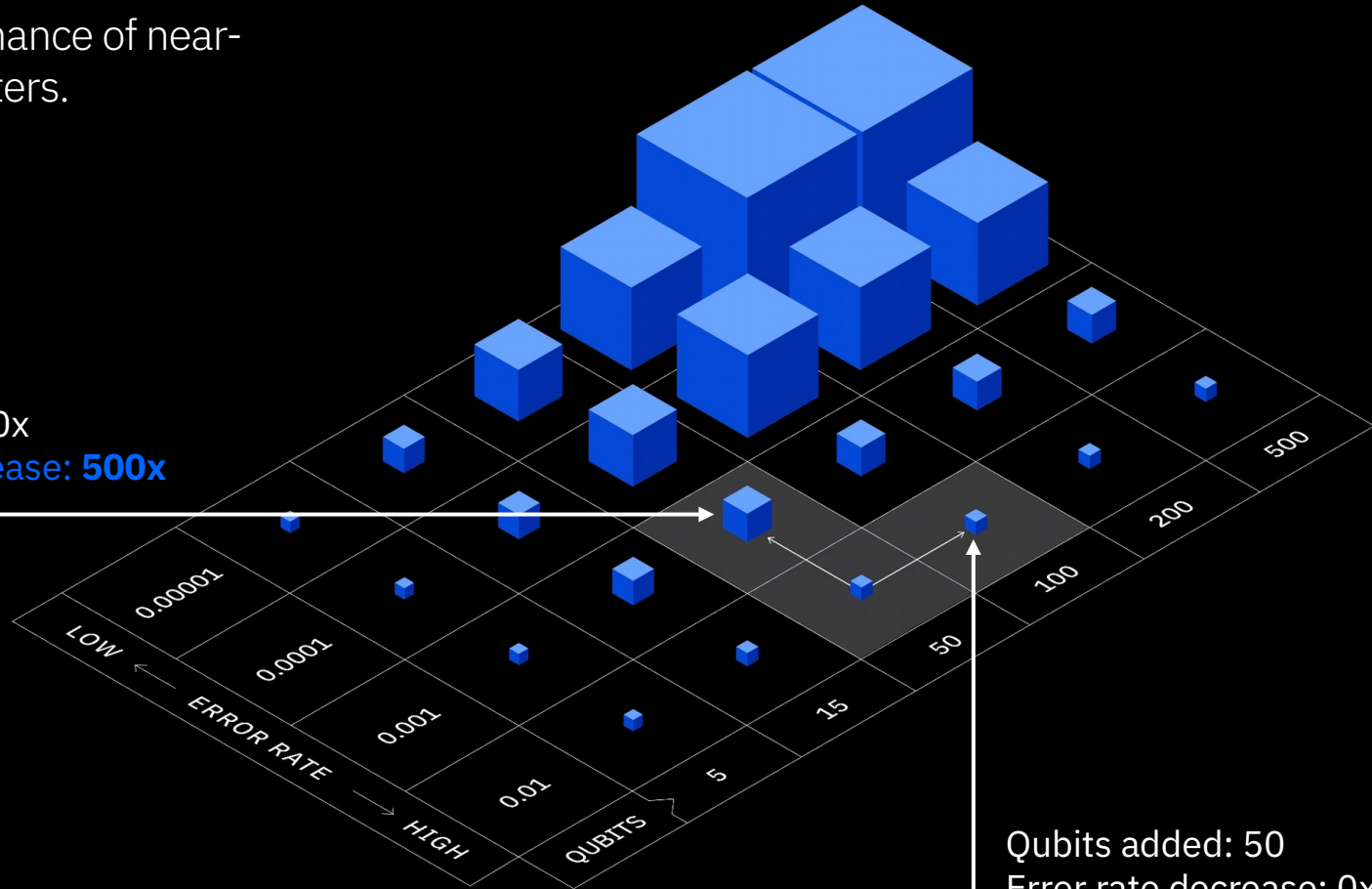
~2020s

2050+

Quantum Volume

Measuring the performance of near-term quantum computers.

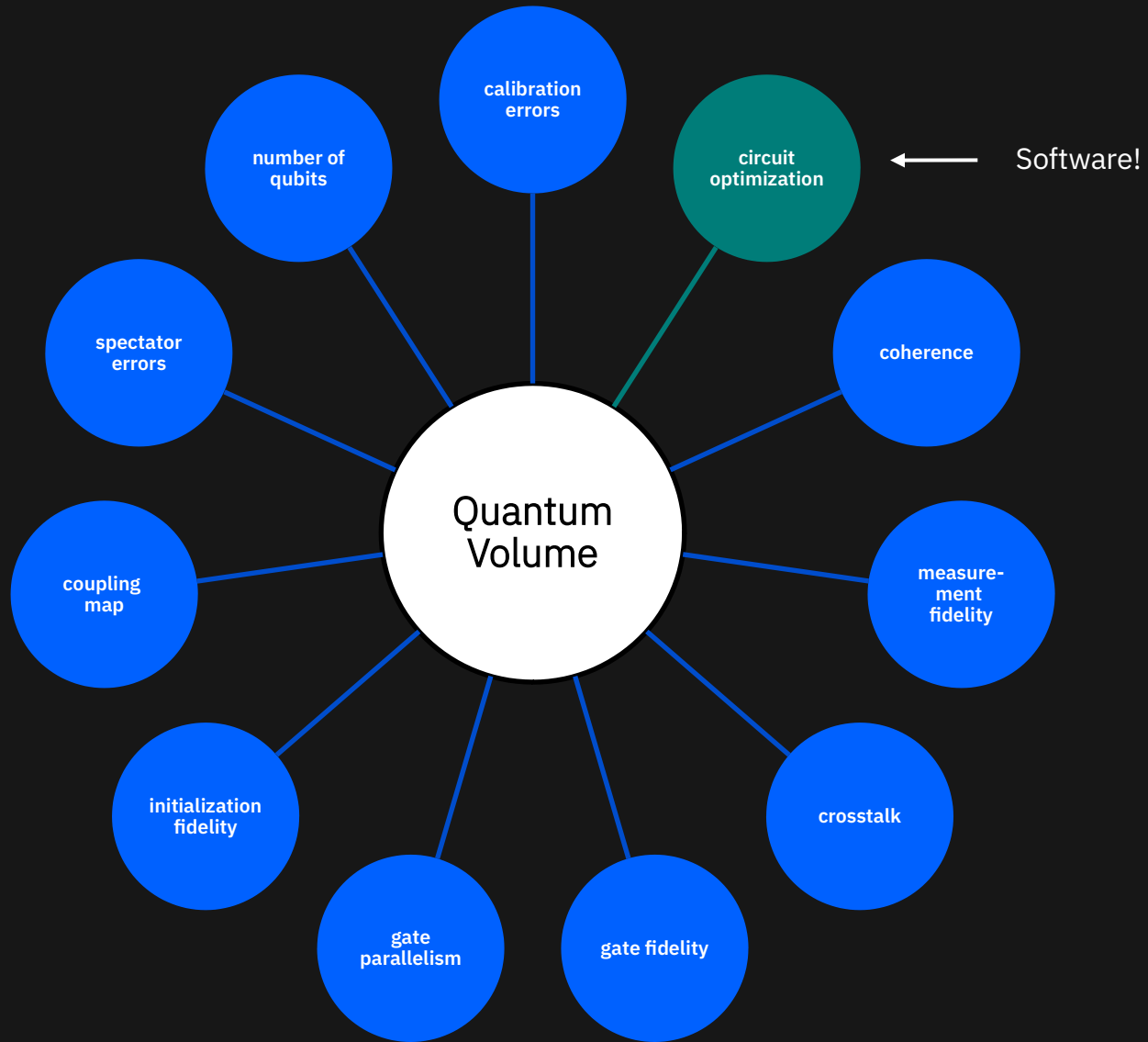
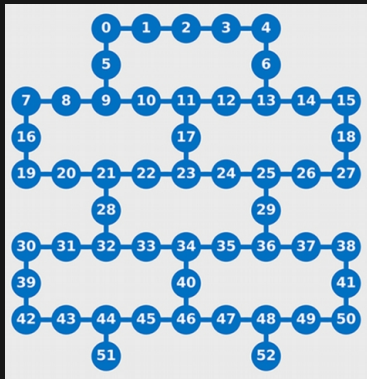
Qubits added: 0
Error rate decrease: 10x
Quantum volume increase: **500x**



Qubits added: 50
Error rate decrease: 0x
Quantum volume increase: **0x**

Quantum volume

Many factors contribute to the performance of the overall system



Quantum volume

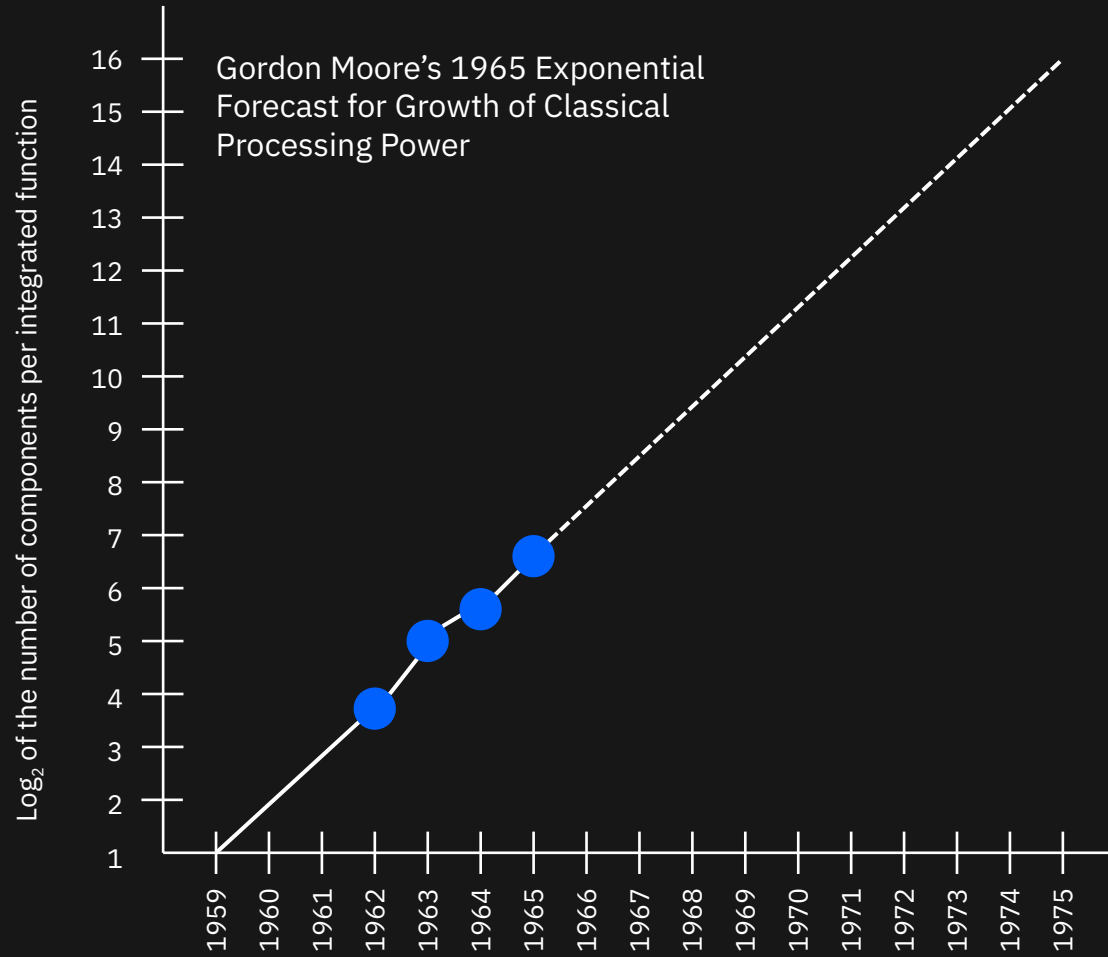
IBM Achieves Highest Quantum Volume to Date,
Establishes Roadmap for Reaching Quantum Advantage
For significant improvement over classical systems, the power of
quantum computers must double every year

Quantum Volume is a fundamental performance metric that measures progress in the pursuit of Quantum Advantage, the point at which quantum applications deliver a significant, practical benefit beyond what classical computers alone are capable.

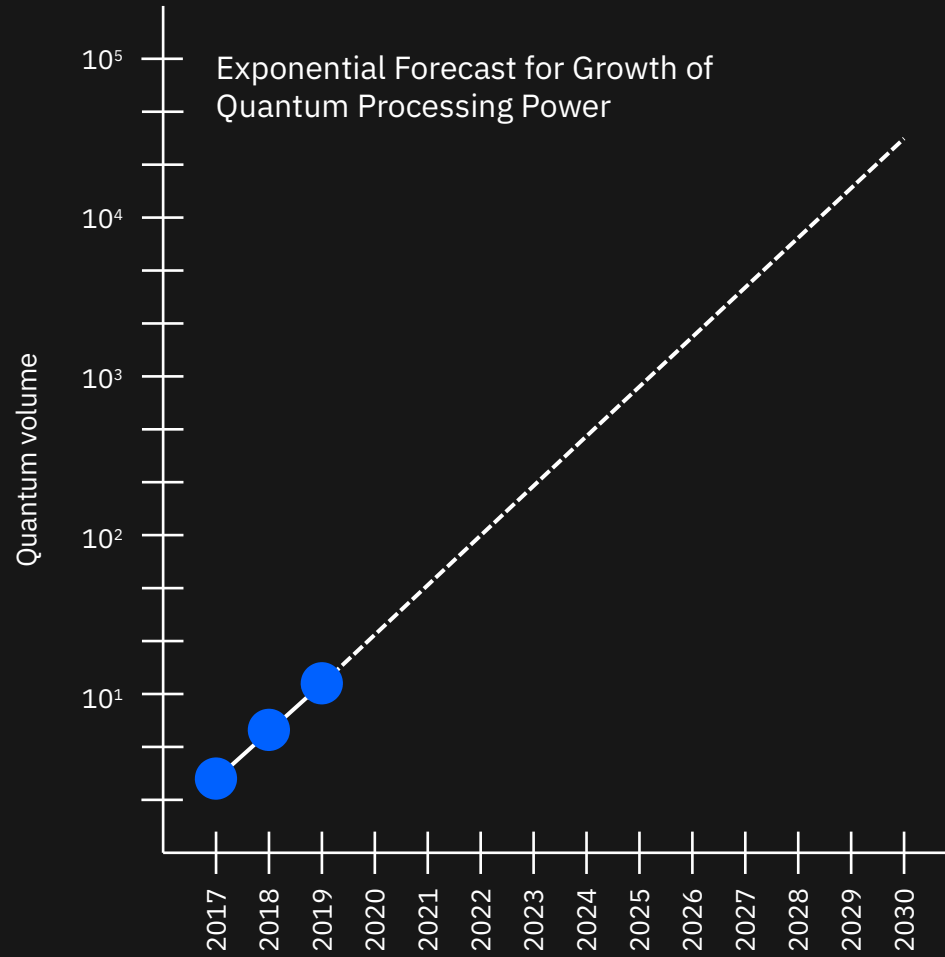
Quantum Volume is a measurement that determines how powerful a quantum computing system is, accounting for both [gate and measurement errors](#), [device cross talk](#), as well as [device connectivity and circuit compiler efficiency](#).

Quantum Volume is usable for [any gate and circuit-based](#) NISQ quantum computing system.

Classical Moore's law



Quantum volume



COMPUTERS

IBM's new 53-qubit quantum computer is its biggest yet

The system will go online in October.

BY STEPHEN SHANKLAND | SEPTEMBER 18, 2019 5:00 AM PDT

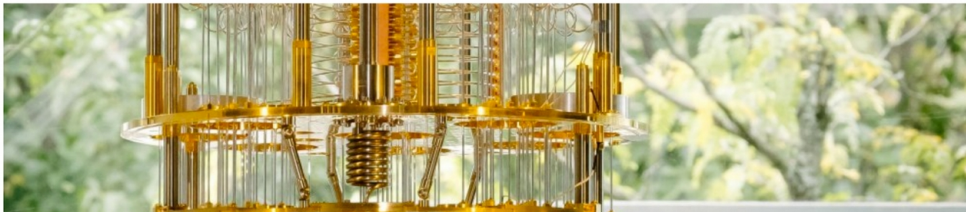


IBM will soon launch a 53-qubit quantum computer



Frederic Lardinois @fredericl / 8:00 am EDT • September 18, 2019

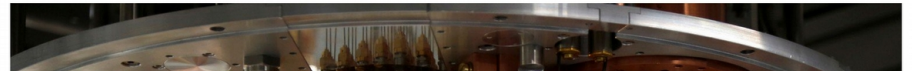
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MIT Technology Review

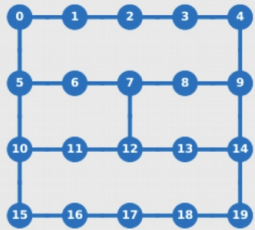
Computing Sep 18

IBM's new 53-qubit quantum computer is the most powerful machine you can use

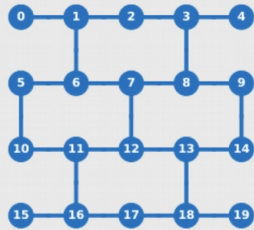


IBM Q quantum devices

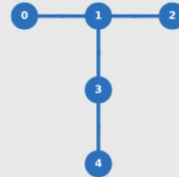
IBM's 10 Quantum Device Lineup



Johannesburg
Poughkeepsie



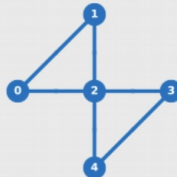
Almaden
Boeblingen
Singapore



Ourense
Valencia
Vigo

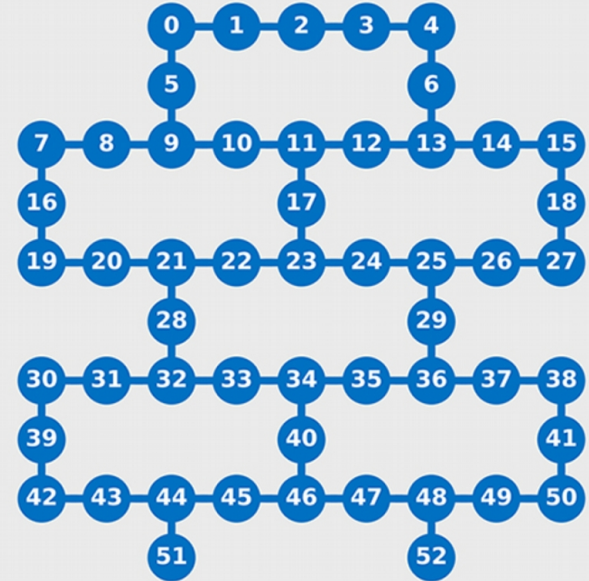


Melbourne



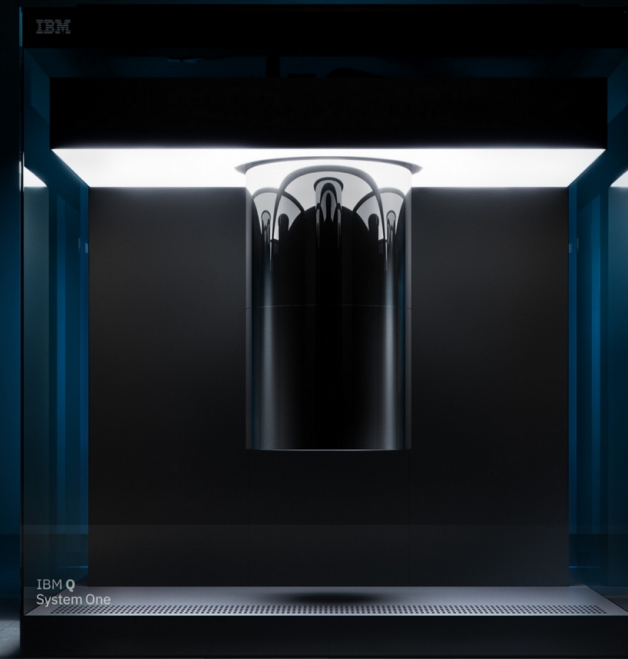
Yorktown

53 Qubit Rochester Device



We are building the quantum computation centers of the future with the IBM Q System One

Designed by IBM scientists, systems engineers, and industrial designers, IBM Q System One has a sophisticated, modular, and compact design optimized for stability, reliability, and continuous commercial use.



The IBM Q Experience has been the most widely used and accessible quantum cloud service for business and science

1

First quantum computing system on the cloud in **2016**. Several IBM Q systems are available to clients and the public. **Over 155k users**.

2

Release of open specifications for quantum cloud APIs has enabled the growth of Qiskit with over **240k downloads** to date.

3

Real research is happening with the IBM Q Experience. Quantum community published **200 third-party papers** testing fundamentals of science citing access to IBM Q tools.

4

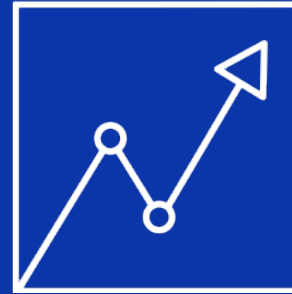
An inflection point - users see more value in working with hardware than simulators as measured by the number of executions on each. **Over 29 million experiments** have run on IBM Q Experience.

IBM Q Network

Accelerate
quantum research



Develop
commercial
applications



Promote education
and prepare



Fraunhofer & IBM quantum cooperation

- Fraunhofer Member and Hub in the WW IBM Q Network
- Physical IBM Q System in Germany
- Fraunhofer competence center for quantum computing
- Collaboration of German federal and state governments with academia and industry to developing various fields of application for quantum computing and to develop quantum skills and expertise in Germany and Europe

PRESS RELEASE

PRESS RELEASE

September 12, 2019 || Page 1 | 2

First installation of an IBM quantum computer on European soil

IBM and Fraunhofer team up to promote quantum computing in Europe

Berlin, September 10, 2019 – IBM (NYSE: IBM) and the Fraunhofer-Gesellschaft, Europe's leading organization for applied research, have today announced an agreement to set up a partnership that will advance research in the field of quantum computing. The aim of this cooperation is to develop expertise and new strategies for the use of quantum computing in industry and for applied processes.

Under the terms of the joint initiative, an IBM Q System One quantum computer is to be installed at a German location. It will be the first facility of its kind in Europe. The IBM Q System One is designed to perform multi-qubit operations to an extremely high level of quality, stability, reliability and reproducibility. These factors and the resultant large quantum volume – a measure of the power of a quantum computer – mean that the IBM Q System One is the ideal platform for state-of-the-art research into concrete quantum computing applications in science and industry.

Quantum computing promises to deliver the power required to analyze the complex systems of business and industry, to disentangle the convoluted interdependencies in molecular and chemical reactions, to master complex optimization problems and to significantly increase the performance of artificial intelligence. Such advances could open the door to new scientific discoveries and deliver enormous improvements in supply-chain management, logistics and the modeling of financial data and data for classic engineering problems.

The German federal government is to invest 650 million euros over the next two years to promote the advance of quantum technology from basic research to market-ready applications. The establishment of the Fraunhofer Center for Quantum Computing is in accordance with the objectives of the federal government's framework program. At the same time, it will provide the IBM Q Network with a major European hub for quantum computing. The focus here will be on achieving a unique concentration of quantum skills in Germany and building a community of researchers, developers, IT profes-

Meet the IBM Q Network

91 Members

- 8 industry partners
- 11 hubs
- 19 members
- 23 startups
- 30 academic partners

Partners

JP Morgan
Chase & Co.

ExxonMobil

Samsung

Daimler

Goldman
Sachs

Woodside
Energy

JSR
Corporation

Accenture

Hubs

German National
Hub at Fraunhofer

Keio University

Oak Ridge
National
Laboratory

NC State

U. Melbourne

U. Oxford

U. Bundeswehr
Munich

National Taiwan
University

Iberian
Nanotechnology
Laboratory

CSIC Spain

US Air Force
Research Lab

Members

Wells Fargo

Barclays

Mizuho

MUFG

Mitsubishi
Chemical

Argonne Lab

Fermilab

Berkeley Lab

Brookhaven Lab

Naval Research
Lab

Flightprofiler at
Purdue

U. Automata
Madrid

ITRI

III Taiwan

CERN

Univ of Minho

Honda

Hitachi Metals

Nagase

Startups

QC Ware

Grid

Quemix

CQC

1QBit

Zapata

Strange Works

Q-CTRL

Quantum
Benchmark

MDR

Qu&Co

JoS Quantum

SolidStateAI

ProteinQure

Labber Quantum

MaxKelsen

Netramark

Entropica

Boxcat

Rahko

Qunasys

QuantFI

Agnostiq

Academic

MIT

EDX.org

Virginia Tech

U. Montpellier

University of Minho

Notre Dame

Harvard

Princeton

Florida State

U. Stony Brook

U. Chicago

U. Tokyo

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

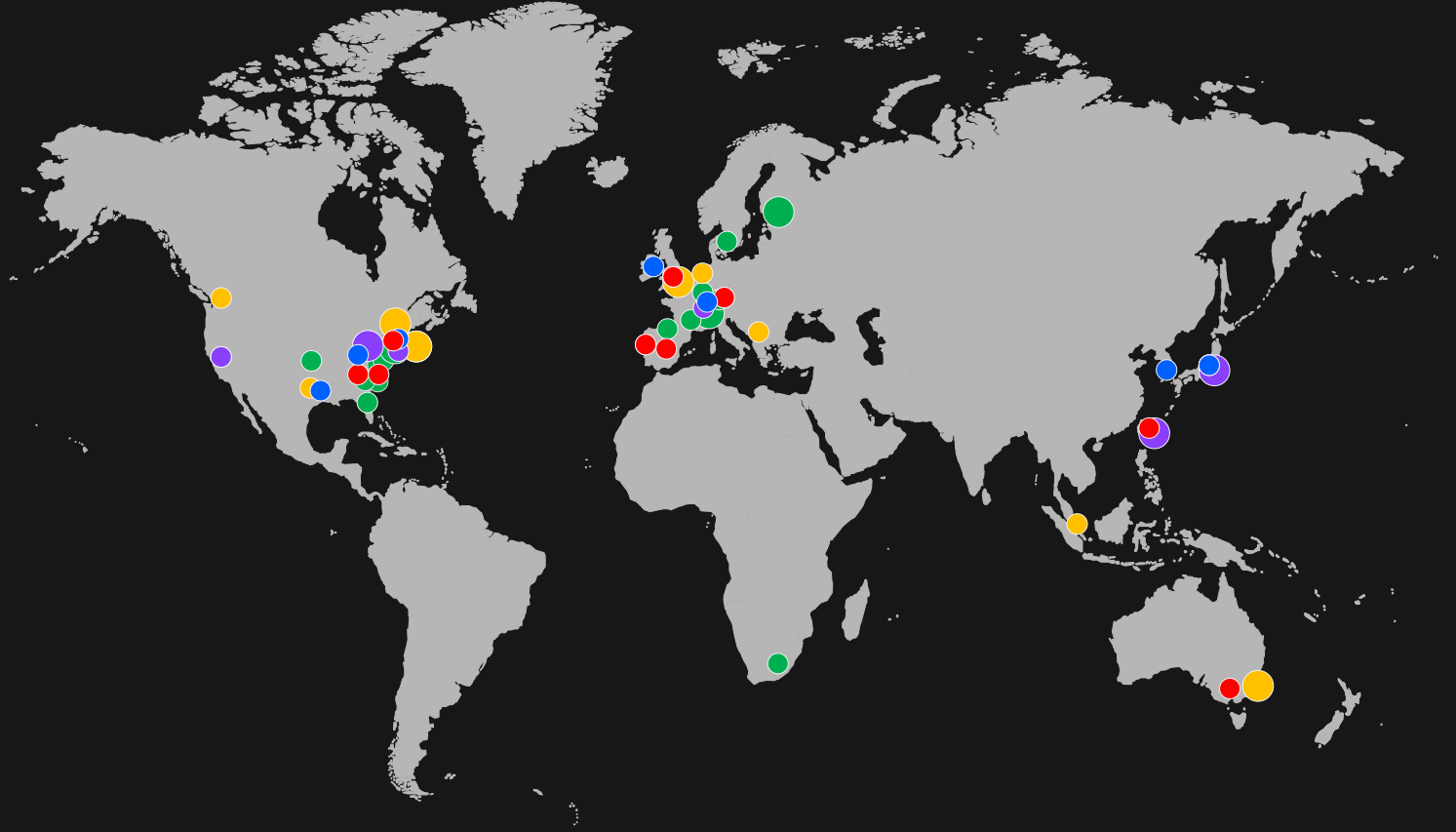
Johns Hopkins

Boston University

Stanford Univ

IBM Q Network

- Industry Partners
- Hubs
- Members
- Startups
- Academic Partners





A showcase for the **work we have begun and early results** in the IBM Q Network

IBM Q Summit

Yorktown Heights, NY
May 8-9, 2019

A forum to share ideas, and help **make the IBM Q Network as effective as possible** in our mission to advance research, education, and commercial application development

Gave all attendees a chance to **get to know and collaborate** with their fellow IBM Q Network members



Start your quantum journey today with IBM Q

IBM Q

Discover quantum computing with IBM Q, IBM's quantum computing initiative

IBM Q Experience

Explore IBM's quantum cloud services platform, start using real quantum computing systems today

Qiskit

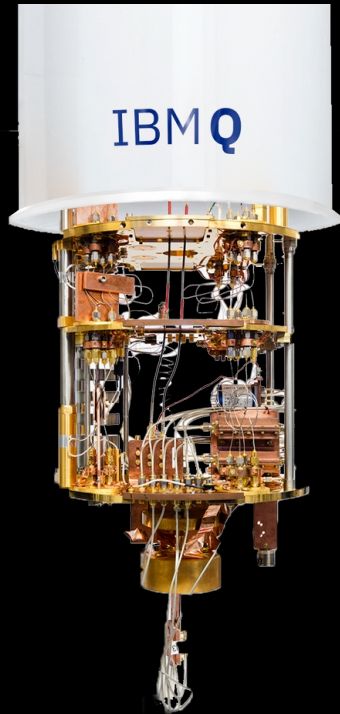
Learn about and start using Qiskit software development framework

IBM Q Network

Collaborate, research, and explore quantum computing applications

IBM Q Network

Program for members



Commercial-grade Quantum Technology on the Cloud

Access to the most advanced systems and software
Shared or dedicated systems

Training, Support and Consulting

Workshops, tutorials, foundational code and expertise
Dedicated team to support and guide users

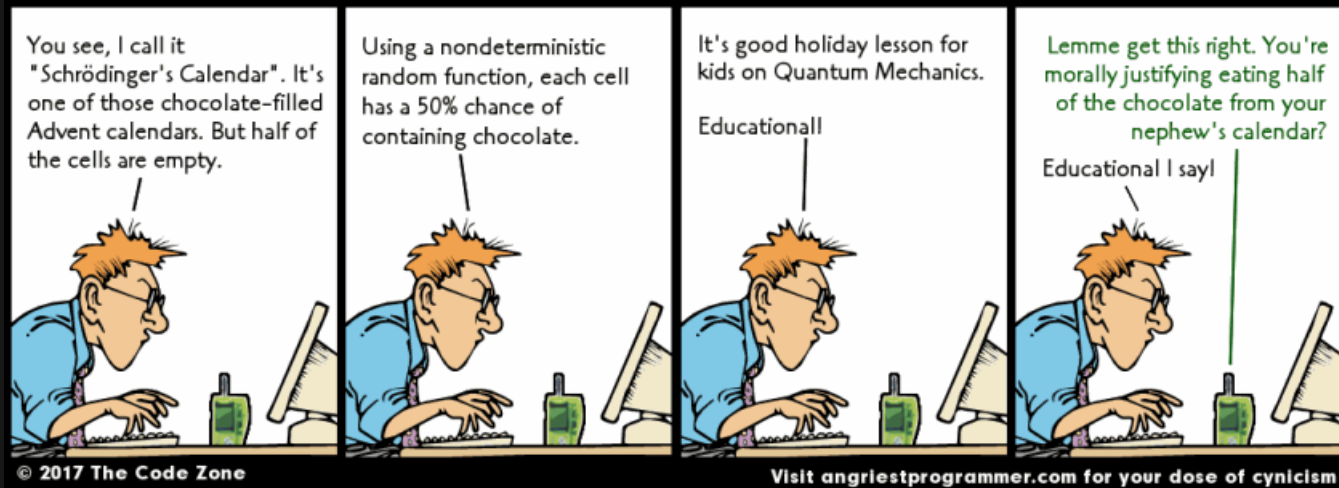
Collaborative Use Case R&D and Business Strategy

Collaborative research on quantum applications
Direct with IBM or through an IBM Q Hub

Part of the IBM Q Network Community

Membership in the world's premier network of partners
Collaborating to advance quantum computing

Quantum starts here.



Happy Holidays ... ibm.com/ibmq





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