National Insurance Conference of Canada

Montreal, Quebec | Sept 26th-28th

2023

THE RAPIDLY APPROACHING COMPUTING TSUNAMI - ARE WE READY?

Moderator

LINDA VAN DEN BRINK

AVP, Counsel Bond & Specialty Insurance Claim at Travelers

PETER TYSOWSKI

Quantum Consulting Leader, Insurance, IBM

MICHELE MOSCA

CEO & Co-Founder, evolutionQ

NICC

2023

NATIONAL INSURANCE CONFERENCE OF CANADA

PLEASE TAKE YOUR SEATS

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IBM Quantum

Quantum Computing in Insurance

National Insurance Conference of Canada

September 27, 2023

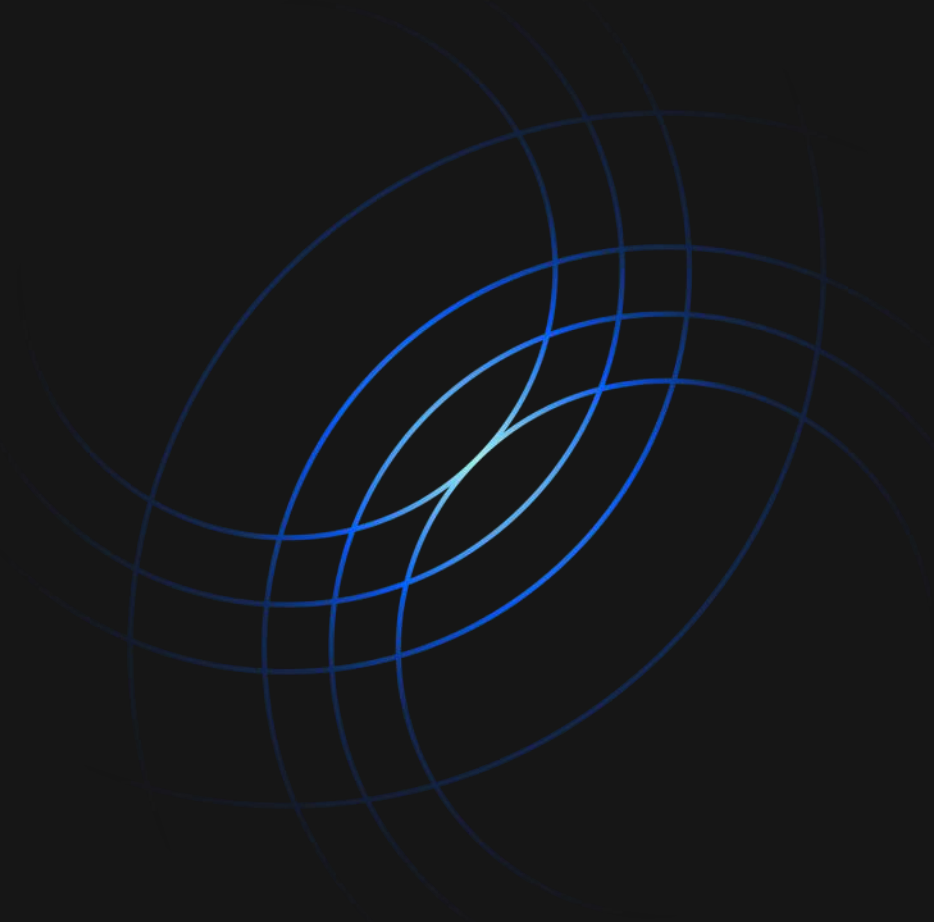
Dr. Peter Tysowski

Insurance Industry Applications Consultant

peter.tysowski@ibm.com

Introduction to Quantum Computing

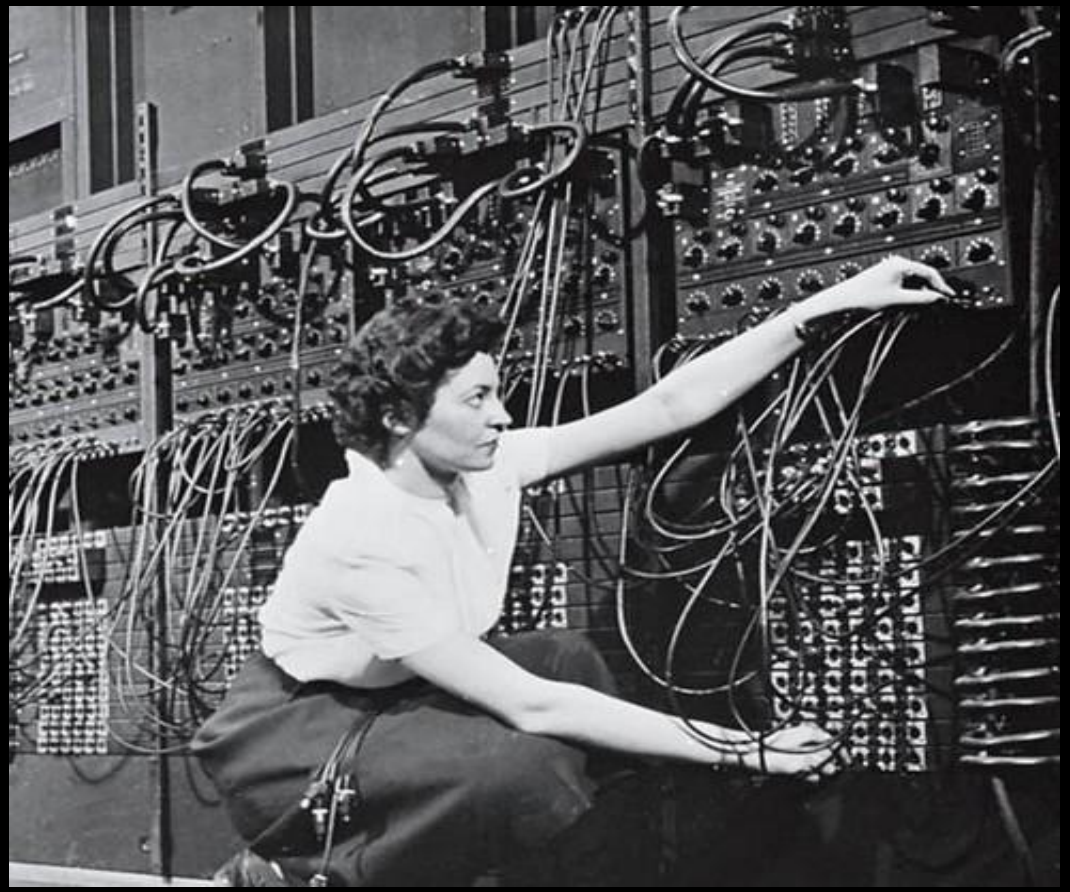
IBM **Quantum**



We are at beginning of a new age of computation

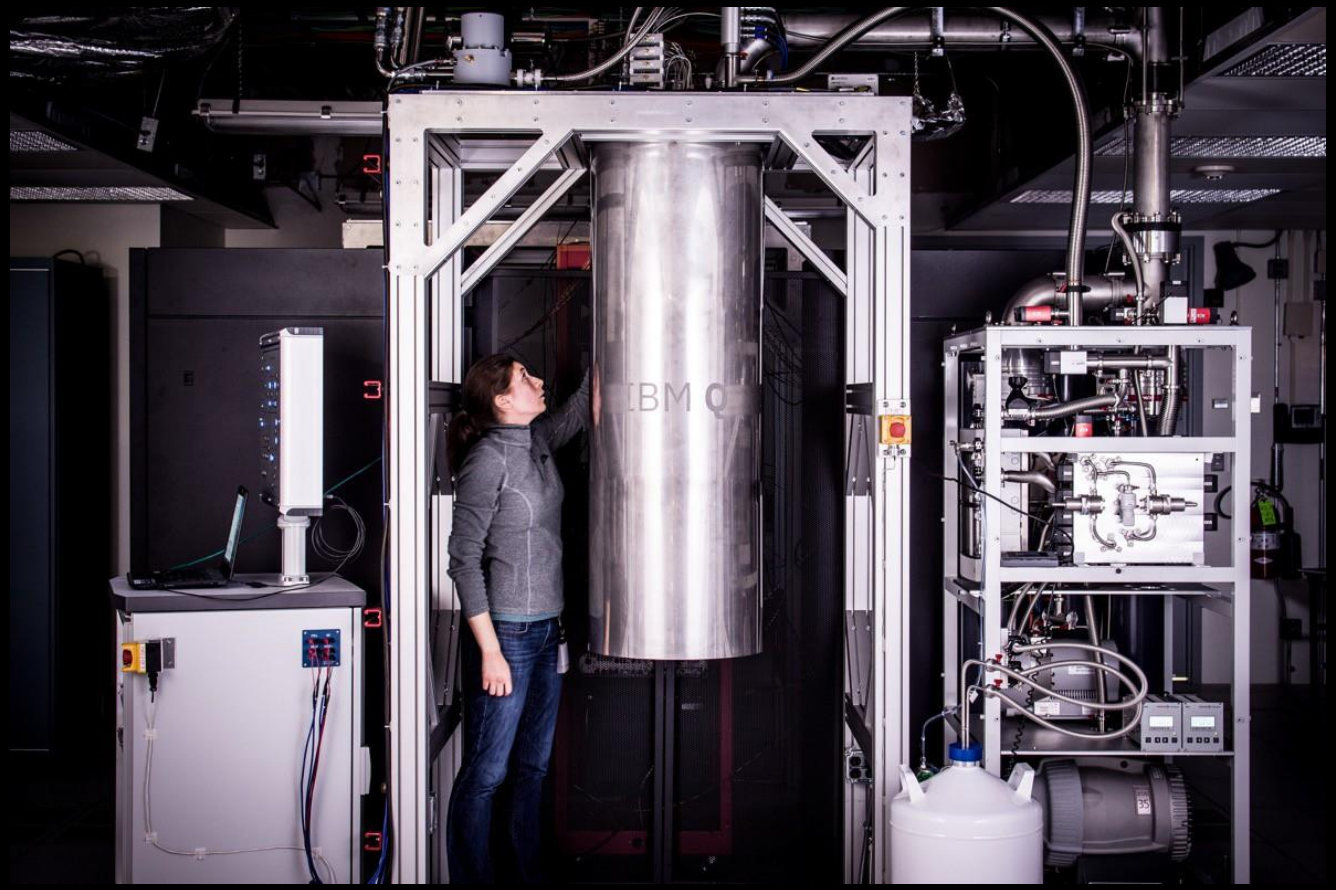
Colossus

First electronic digital programmable computing device



IBM Quantum

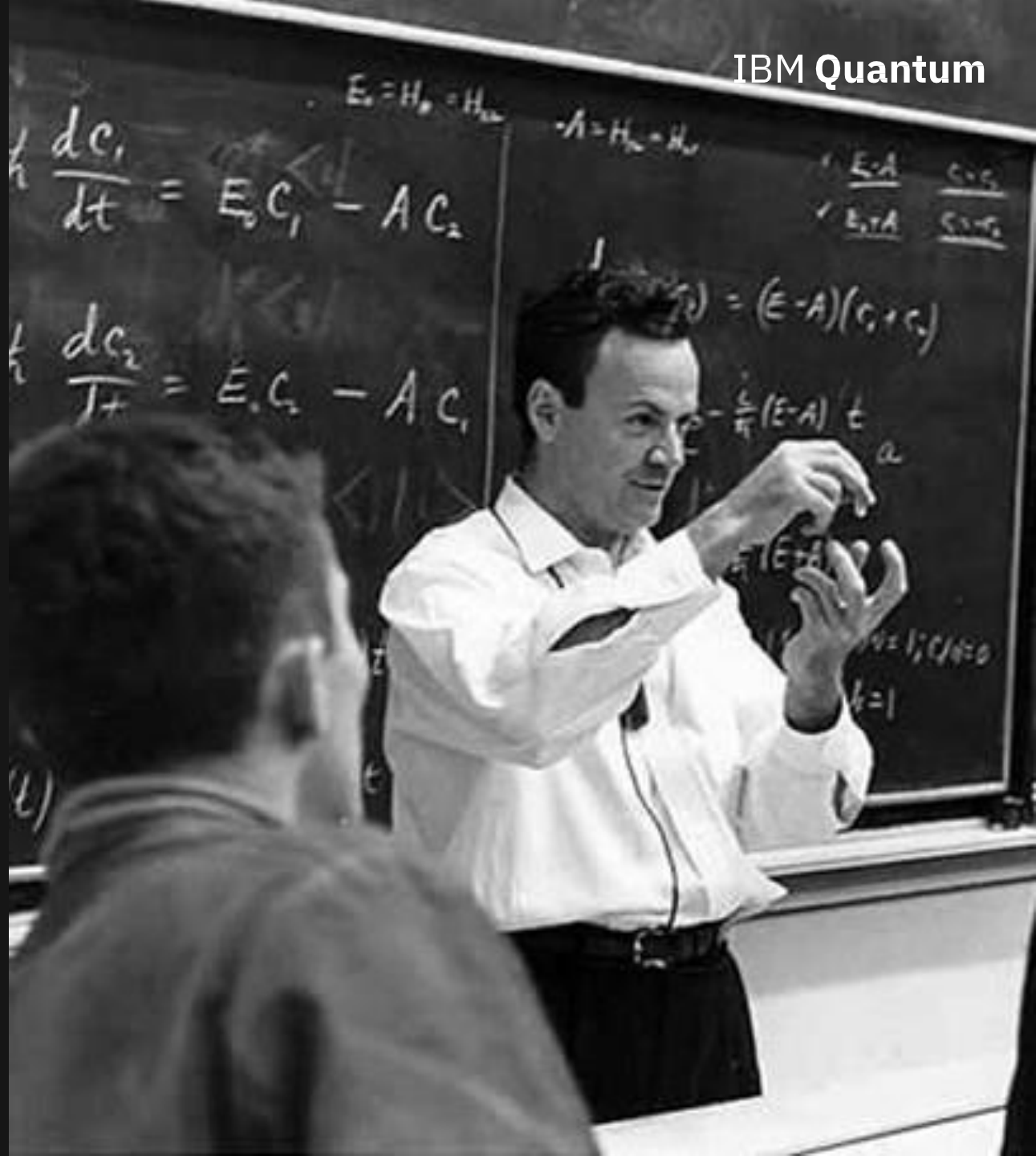
First universal quantum computing device made available to public



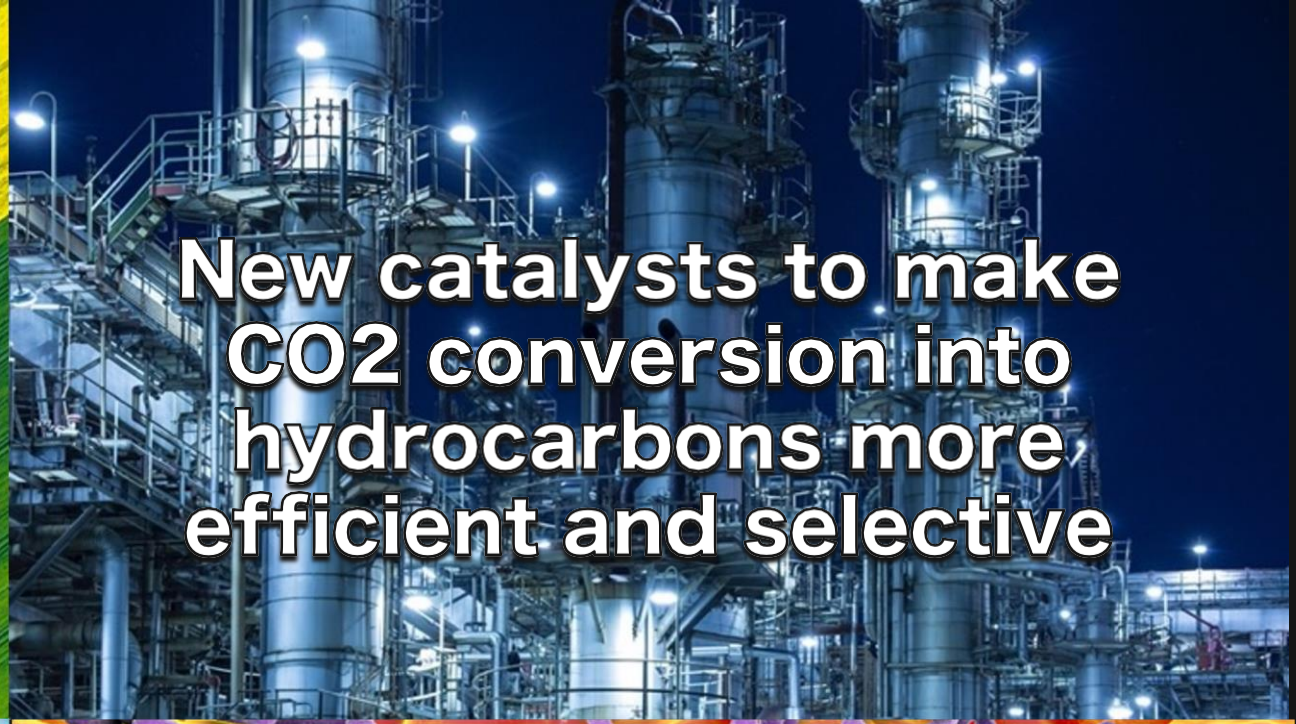
“I’m not happy with all the analyses that go with just the classical theory, because nature isn’t classical, dammit, and if you want to make a simulation of nature, you’d better make it quantum mechanical …”

Richard P. Feynman
Department of Physics,
California Institute of Technology

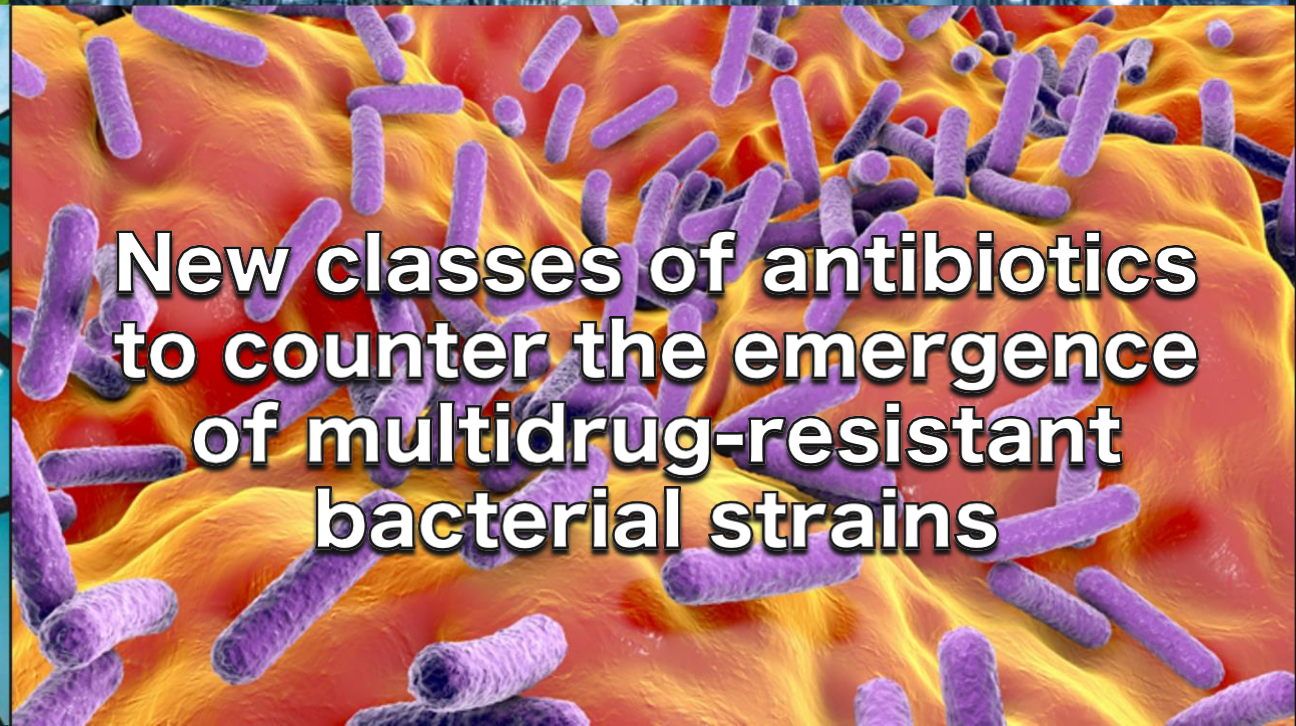
International Journal of Theoretical Physics,
Vol 21, Nos. 6/7, 1982



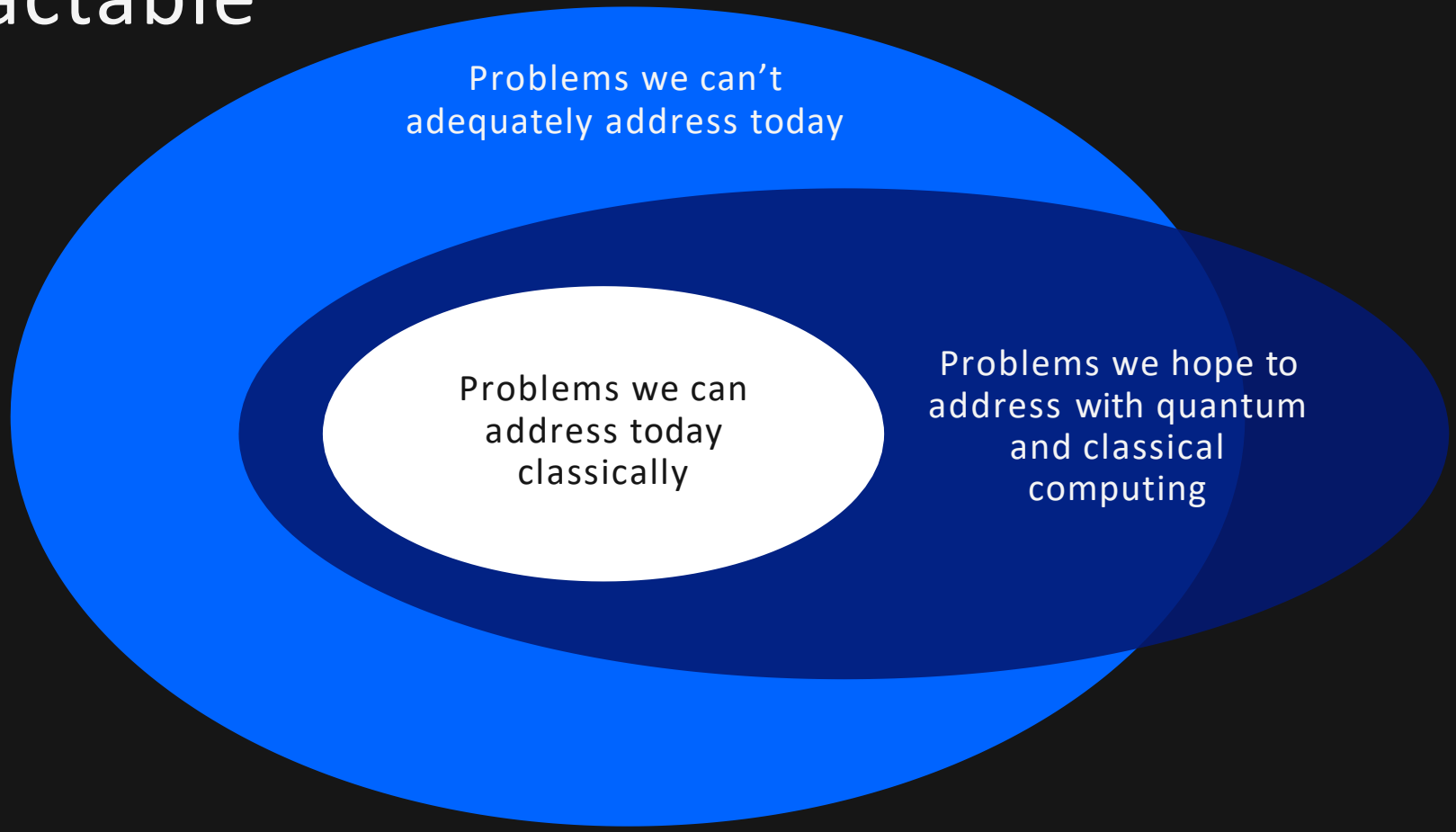

Improved nitrogen-fixation process for creating ammonia-based fertilizer


New catalysts to make CO2 conversion into hydrocarbons more efficient and selective


Better financial models to improve stability, predictability and growth of world economies
IBM Quantum / © 2023 IBM Corporation


New classes of antibiotics to counter the emergence of multidrug-resistant bacterial strains

Quantum can help us tackle intractable problems



Despite how sophisticated digital "classical " computing has become, there are many scientific and business problems for which we've barely scratched the surface.

First we had bits and classical logic circuits…

IBM **Quantum**

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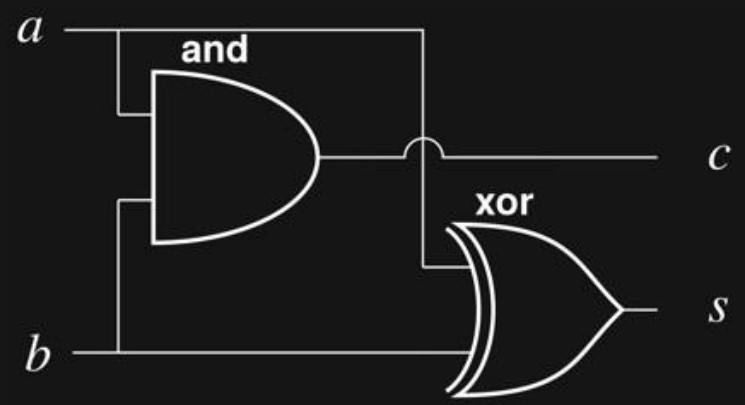
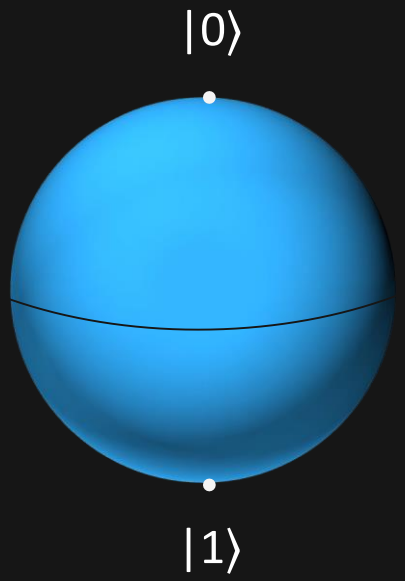
A bit is a controllable classical object that is the unit of information



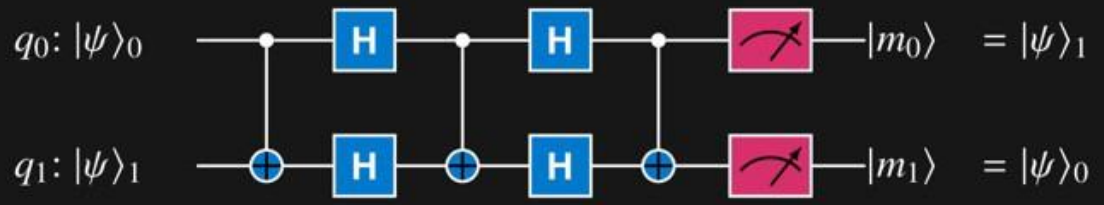
A classical logic circuit is a set of gate operations on bits and is the unit of computation

…and now we have qubits and quantum circuits

IBM **Quantum**



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



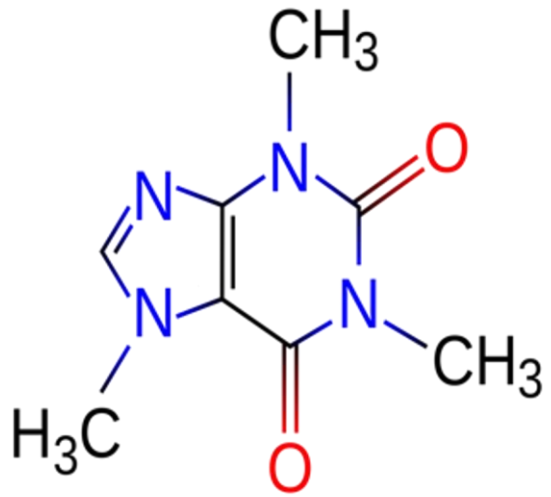
A quantum circuit is a set of quantum gate operations on qubits and is the unit of computation

Computing with caffeine

If our best classical computers are so powerful, shouldn’t we be able to perfectly simulate molecules and chemical reactions?

This would allow us to accelerate discovery of new compounds and processes for healthcare, materials, alloys, and sustainable energy creation.

Let’s consider caffeine …



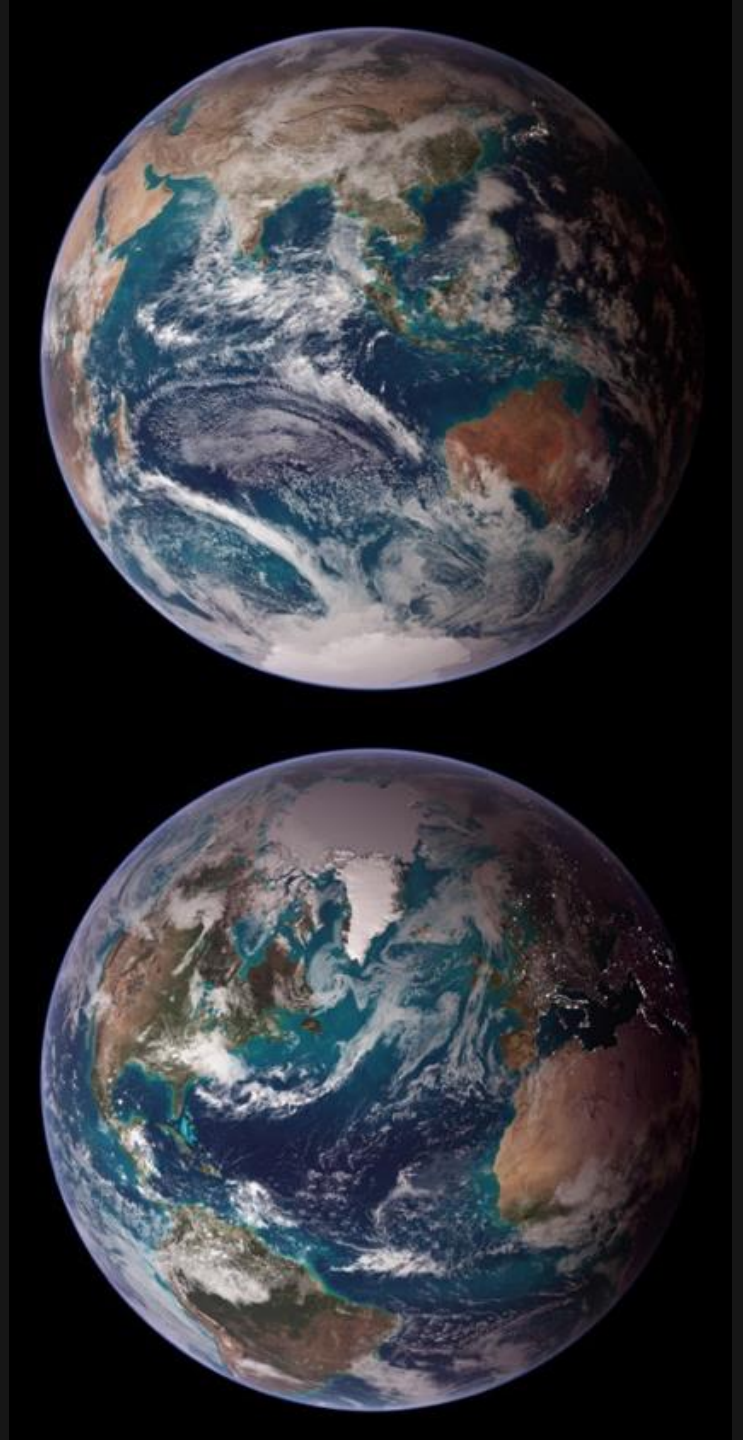
Computing with caffeine

We would need approximately 10^{48} bits to represent the energy configuration of a single caffeine molecule at a single instant in a classical computer.

This is 1 to 10% of the total number of atoms in the Earth.

10^{48} =

1,000,000,000,000,000,
000,000,000,000,000,000,
000,000,000,000,000



IBM **Quantum**

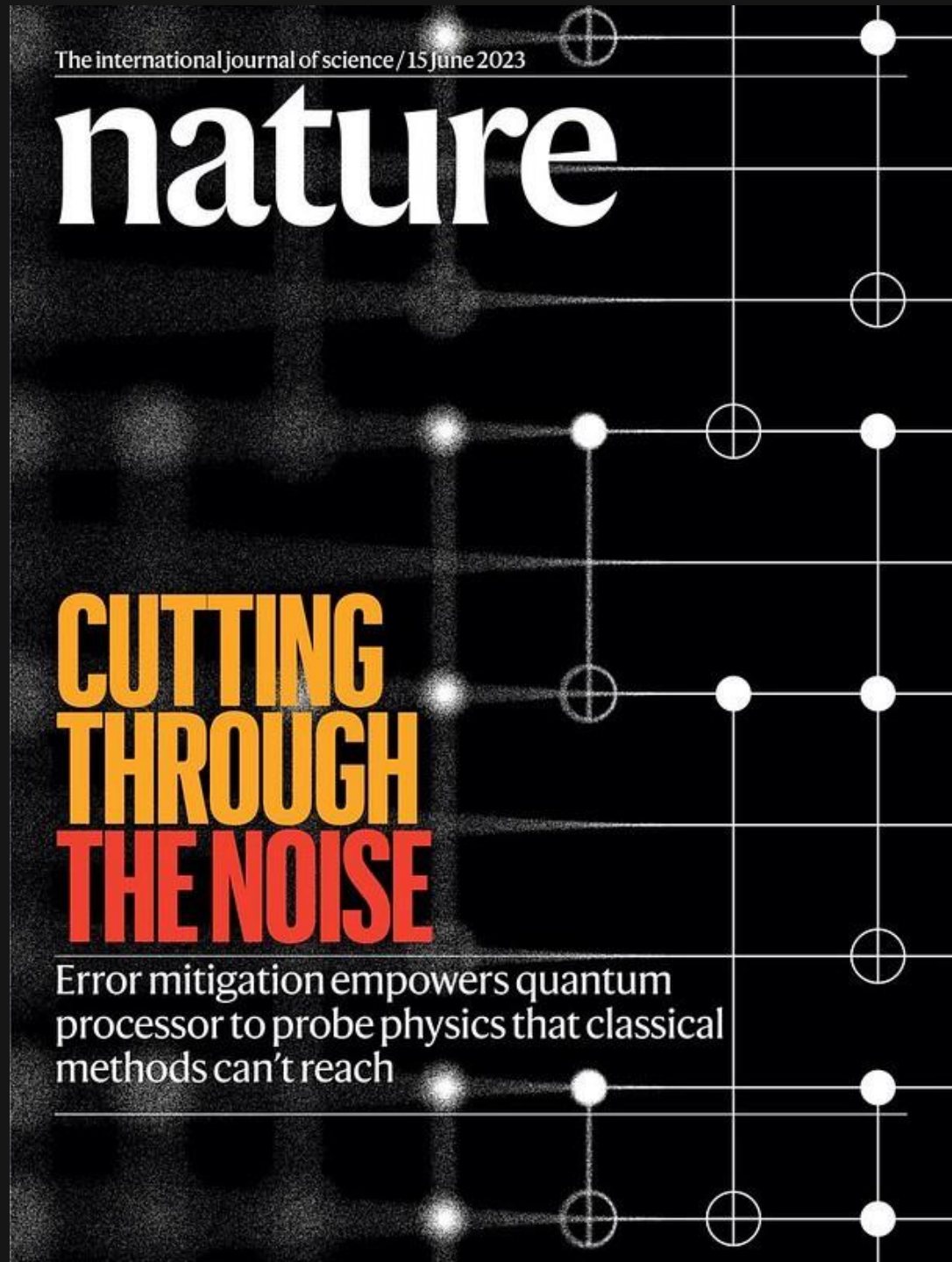
Computing with caffeine

Though it’s impossible to completely represent the molecular configuration of caffeine on today’s most powerful super computers, but we could represent it using 160 logical qubits.

Nature 2023: Quantum Utility

A noisy quantum computer is able to produce accurate expectation values in regimes beyond brute force computation and where leading classical approximations struggle

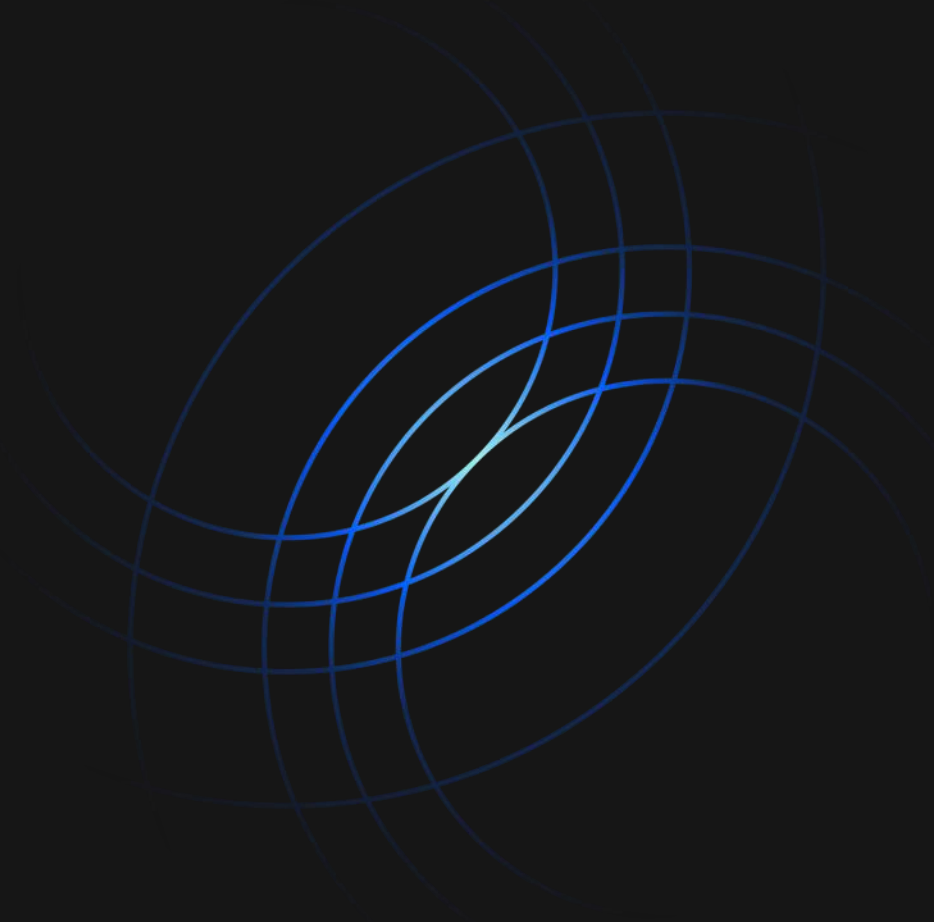
This serves as evidence for the utility of quantum computing before fault tolerance



https://www.nature.com/articles/s41586-023-06096-3

The IBM Quantum Network and Roadmap

IBM **Quantum**



IBM Quantum – On the cloud since May 2016

Over 460,000 registered users have run …

over 2 TRILLION hardware quantum circuits in total, and users run …

over 4 BILLION hardware quantum circuits on a typical day on …

more than 25 quantum computing systems on the IBM Cloud, and written over

1750+ scientific and research papers.

A Sample of Recent Collaborations with IBM Quantum

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, and developing new machine learning models for fraud detection and credit-worthiness determination.

WELLS FARGO

Using quantum computing to to exploring how advances in artificial intelligence and quantum computing can help make banking faster, easier, smarter, and safer.

HSBC

Exploring the use of quantum computing for pricing and portfolio optimization, to advance net zero goals, and to mitigate risks, including identifying and addressing fraudulent activity.

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.

A large Property, Casualty, and Auto Insurer in the U.S.

Exploring how quantum computing can help the business make better decisions within the underwriting process.

2019
Falcon
27 Qubits

2020
Hummingbird
65 Qubits

2021
Eagle
127 Qubits

2022
Osprey
433 Qubits

System Two is the next evolution in Quantum designed for greater scale and computational power

IBM Quantum System One

Designed for up to 200 Qubits

Pre-eminent system for quantum research and development

Platform for first practical quantum advantage demonstration

IBM Quantum System Two

Designed for 400 to 4000+ Qubits

Parallelization to speed up workflows and scale applications

Designed for early quantum advantage workflows with modularity to scale

IBM Quantum System Two

https://www.youtube.com/watch?v=AQjKUN8PORM&t=1s

Performance =

Scale — Number of qubits

\+ Quality — Circuit fidelity

\+ Speed — Circuit execution speed

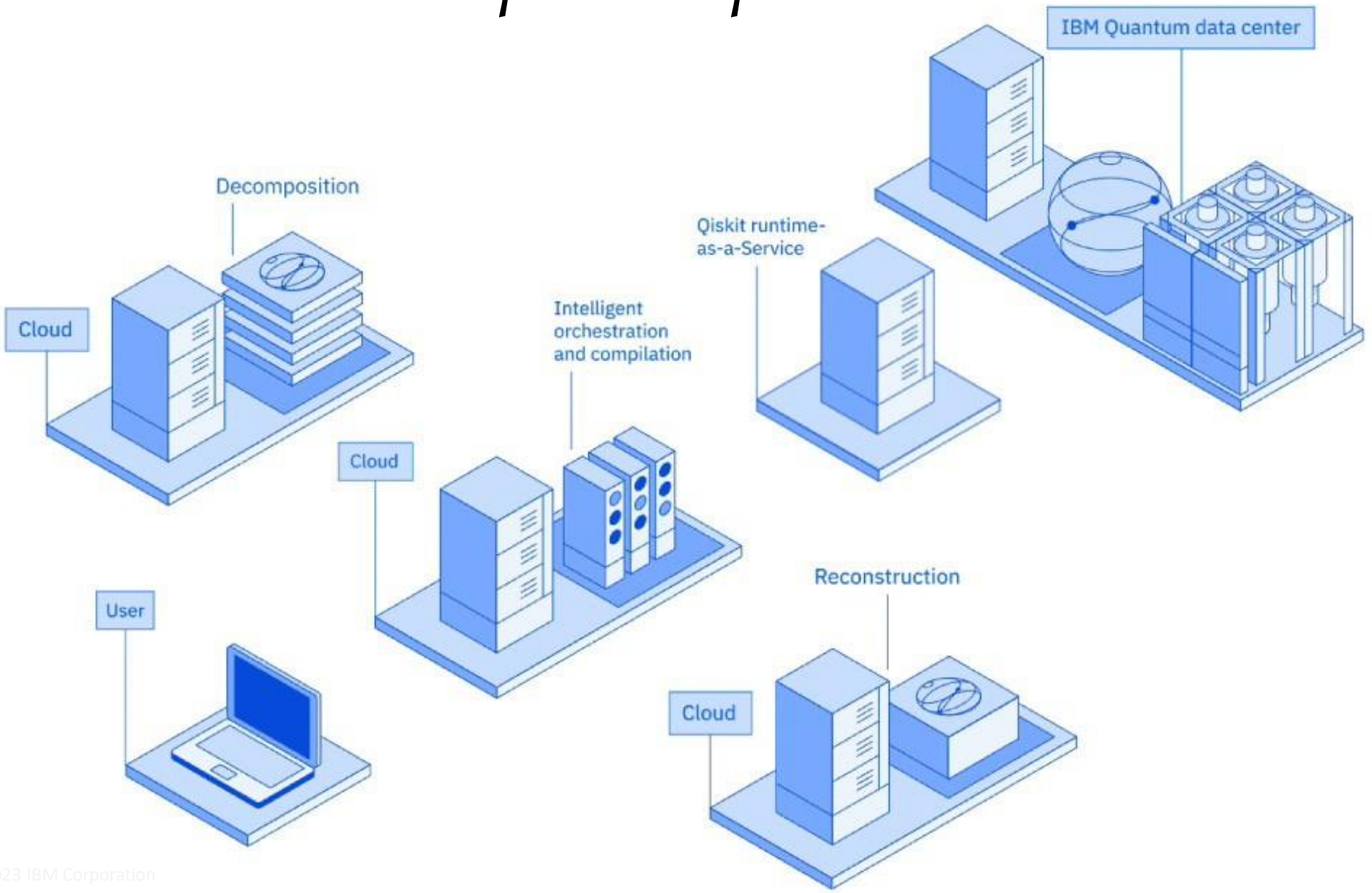
Development Roadmap

Executed by IBM
On target

IBM Quantum

	2019	2020	2021	2022	2023	2024	2025	2026+
	Run quantum circuits on the IBM cloud	Demonstrate and prototype quantum algorithms and applications	Run quantum programs 100x faster with Qiskit Runtime	Bring dynamic circuits to Qiskit Runtime to unlock more computations	Enhancing applications with elastic computing and parallelization of Qiskit Runtime	Improve accuracy of Qiskit Runtime with scalable error mitigation	Scale quantum applications with circuit knitting toolbox controlling Qiskit Runtime	Increase accuracy and speed of quantum workflows with integration of error correction into Qiskit Runtime
Model Developers					Prototype quantum software applications →		Quantum software applications Machine learning | Natural science | Optimization	
Algorithm Developers		Quantum algorithm and application modules Machine learning | Natural science | Optimization			Quantum Serverless	Intelligent orchestration	Circuit Knitting Toolbox	Circuit libraries
Kernel Developers	Circuits		Qiskit Runtime	Dynamic circuits	Threaded primitives	Error suppression and mitigation		Error correction
System Modularity	Falcon 27 qubits	Hummingbird 65 qubits	Eagle 127 qubits	Osprey 433 qubits	Condor 1,121 qubits Heron 133 qubits x p	Flamingo 1,386+ qubits Crossbill 408 qubits	Kookaburra 4,158+ qubits	Scaling to 10K-100K qubits with classical and quantum communication

Quantum-centric *supercomputer*



IBM Quantum Computation Centers (QCC)

IBM **Quantum**

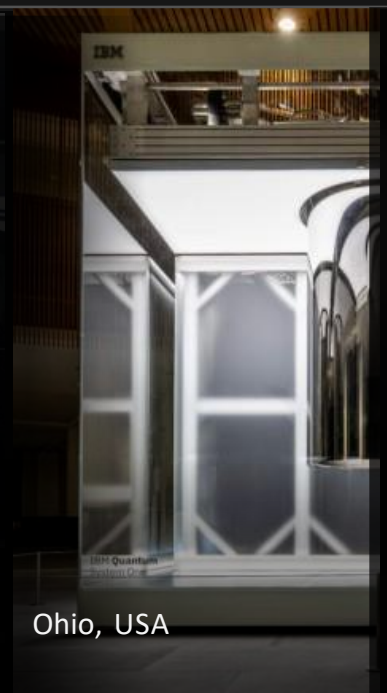
Centers with dedicated Quantum Systems committed to advancing industry-specific initiatives or regional quantum ecosystems

IBM Quantum datacenter in NY	Fraunhofer	University of Tokyo	Cleveland Clinic	PINQ²	Yonsei	BasQ
	Dec 2020	Jun 2021	Mar 2023	Projected 2023	Projected 2023	Projected 2025

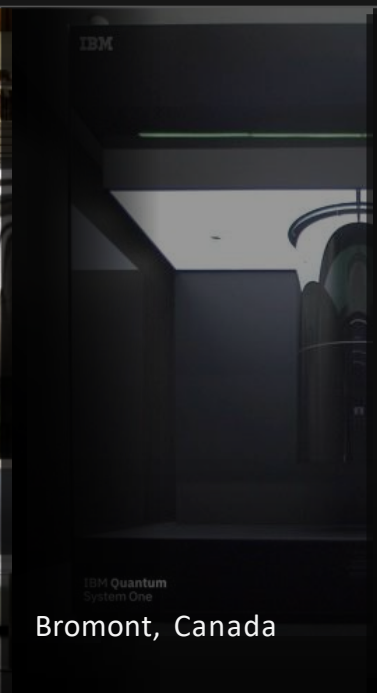
New York, USA

Ehningen, Germany

Shin-Kawasaki, Japan



Ohio, USA



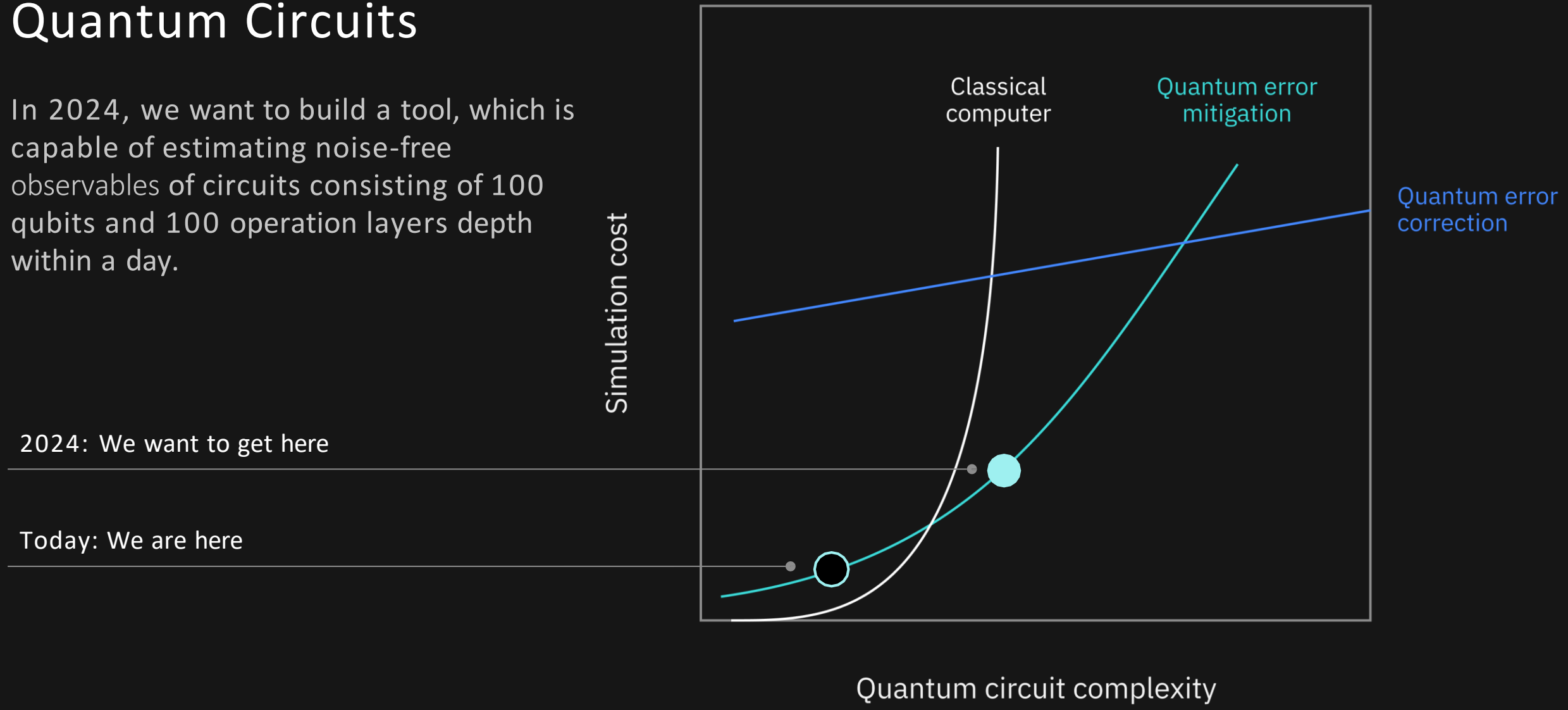
Bromont, Canada

Seoul, South Korea

Basque Country, Spain

100 x 100 Quantum Circuits

In 2024, we want to build a tool, which is capable of estimating noise-free observables of circuits consisting of 100 qubits and 100 operation layers depth within a day.



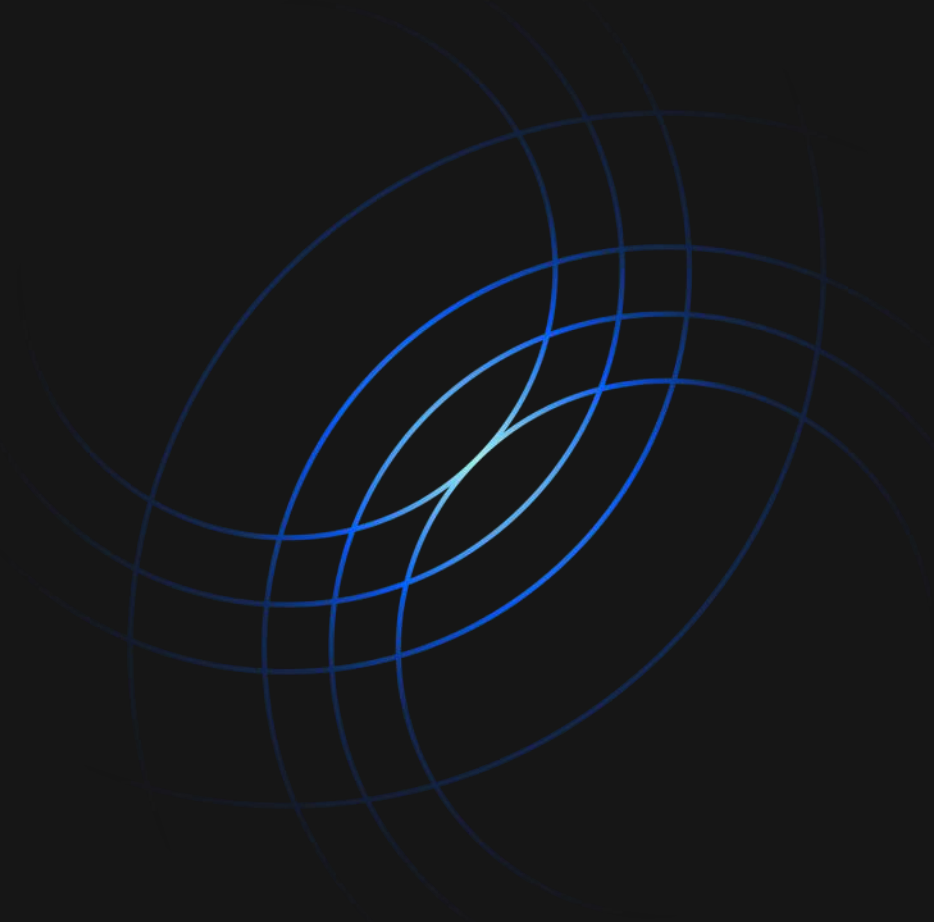
Bring useful quantum computing to the world

A path towards quantum computing

IBM's point of view and goal is a computational quantum advantage, where a computational task of business or ***scientific*** *relevance can be performed more efficiently, cost-effectively, or accurately using a quantum computer than with classical computations alone.*

Quantum Use Cases for Insurance

IBM Quantum



Quantum is expected to perform insurance tasks more efficiently, cost-effectively, or accurately…

Improved Underwriting

Segment customers into risk categories more precisely and reduce the overall risk in the portfolio.

Improved Pricing

Create policies with greater customization that differentiate in the marketplace.

Improved Risk Analysis & Loss Reserving

More completely predict the likelihood and consequences of catastrophic events and provide quicker response and better risk management.

Improved Claims Processing

Detect fraudulent claims more quickly and precisely, by considering more factors, and process claims more quickly and with less risk.

Quantum Problem Domains

Machine Learning

We can find more complex relations in data sets and build better training models resulting in greater precision.

Quantum higher-dimensional feature spaces can provide an exponential advantage over classical methods.

Simulation

We can replace Monte Carlo simulation by quantum techniques that require fewer trials for the same accuracy.

We can achieve quadratic speed-up in performance with Quantum Amplitude Estimation.

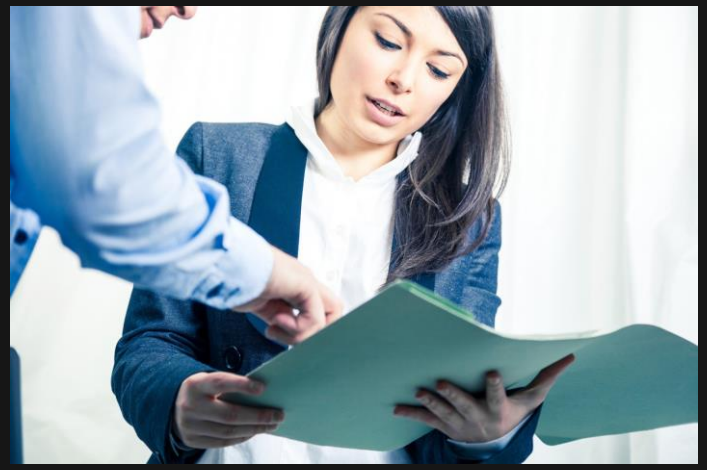
Optimization

We can address combinatorial optimization problems that consider more realistic constraints.

Finding optimal solutions to QUBO and black-box objective functions can yield new insights.

Customer and Risk Classification
using Quantum Machine Learning

IBM Quantum



The Problem with Underwriting, Pricing, and Marketing for Commercial Businesses Today (and similarly for Personal, Life)

A new application is filed… does it pose an acceptable level of risk?
The insurer must cover expected claim payments adequately. For example, determining Property and Casualty (P&C) insurance risk categories for private small-to-medium commercial businesses is challenging due to incomplete data and micro-segmentation.

Businesses that are on the boundaries of risk levels are especially of interest, as well as new risk categories that other insurers have not yet considered.

High-Level Underwriting Process

The Machine Learning (ML) Approach

Applying Machine Learning (ML) to risk assessment could result in:

Higher Automation	Higher Throughput	Higher Accuracy	Higher Case Acceptance
Competitive Pricing	More Effective Marketing	Higher Up-Sell	Better Sales Incentives

Classical Constraints

- Insights from data mined from diverse sources can help complete the risk picture. However, it is difficult to compute the increased number of factors.

Risk Concentration Analysis
using Quantum Optimization

IBM **Quantum**

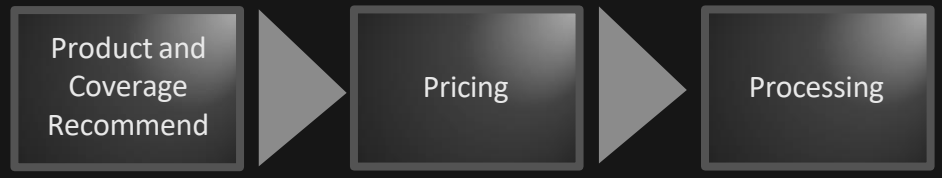
The Problem with Product Design and Sales Today

Customers are searching today for personalized policies that can meet their needs today and tomorrow. Insurers sell policies that need to be matched to both the insured's needs and their emotional framework (need-to-buy).

By offering sale and product configurations that can satisfy individual needs, customers are more likely to decide to purchase.

Contract design is challenging due to limitations of questionnaires and many possible combinations of riders.

High-Level Product Development Process



The Optimization Approach

Applying optimization to product design and marketing could result in:

Higher Differentiation | Higher Sales | Higher Profits | Higher Retention

Common efficacy measures employed can include the bind rate (converting quotes to binding policies), sales growth, and retention rate.

Classical Constraints

- Contract templates tend to lack choice and flexibility.
  Contracts are priced based on limited historical claims information.
  Products are sold in a standardized way versus appealing to the customer.

Catastrophe and Mortality Projection
using Quantum Estimation

IBM Quantum

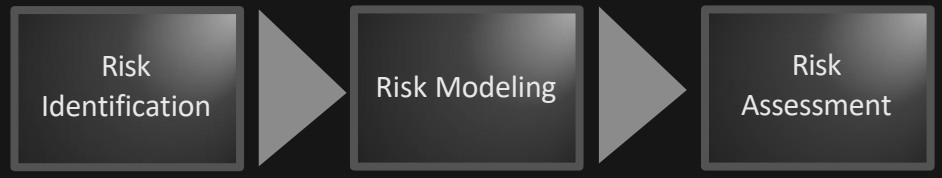
The Problem with Risk Management Today

Insurers need to confidently ascertain the total risk exposure of their book of business and forecast the likelihood and consequences of catastrophic loss. They must assess changes in underlying risk, the litigation environment, and emerging health risks.

The ability to accurately perform reserving will inform the strategies for underwriting, re-balancing of the contract portfolio, and re-insurance.

Traditional analysis relies on historical models, but it involves complex processes where the probabilities of risk can change quickly.

High-Level Risk Management Process



The Simulation Approach

Applying improved simulation could result in:

- More Efficient Capital Allocation
- Higher Optimization of Total Portfolio Risk
- Confidence in Meeting Regulatory Thresholds

Basic risk metrics and control techniques can be employed such as underwriting limits, evolution of reserves, and probabilities of ruin.

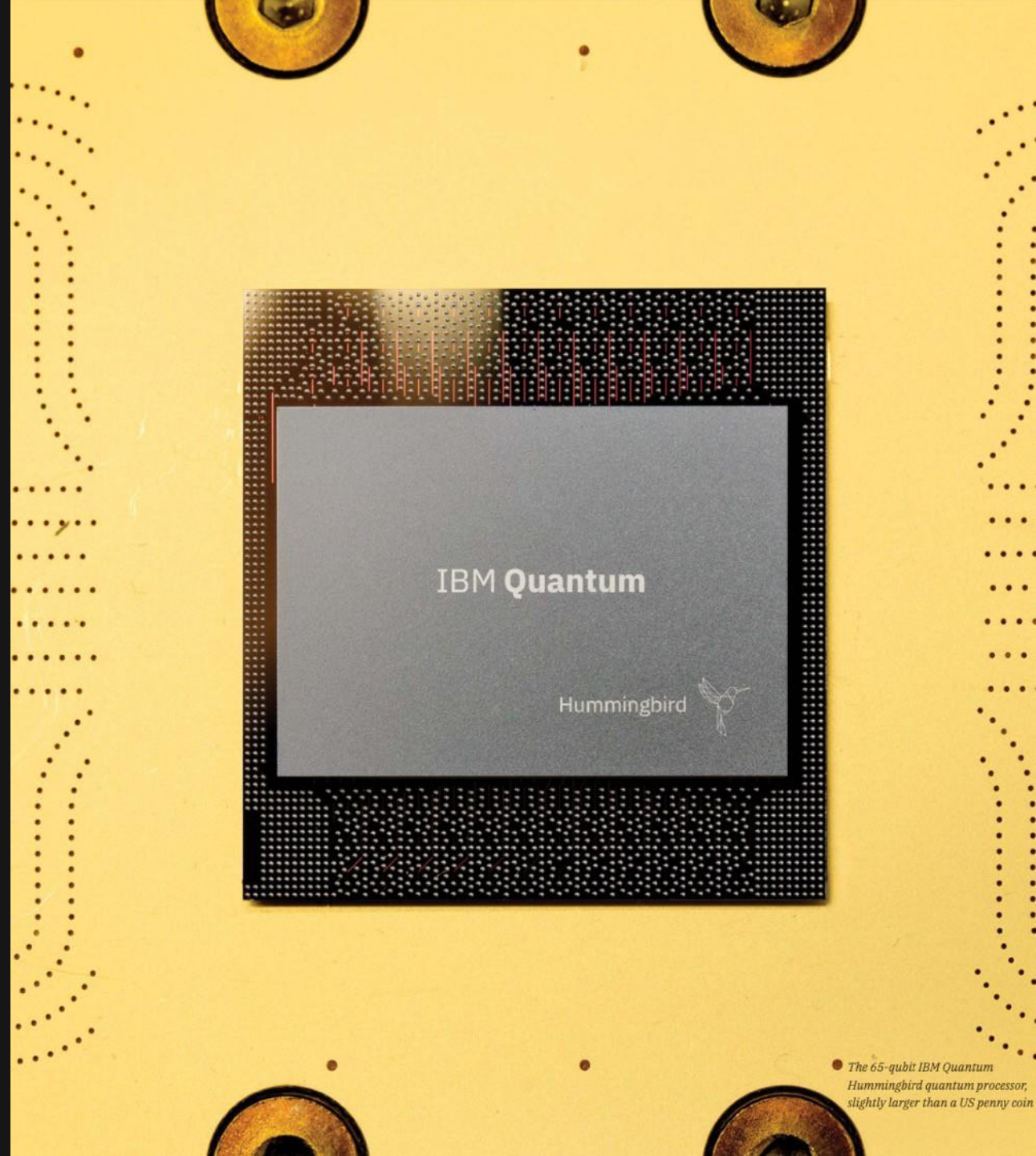
Classical Constraints

- A limited number of scenarios with corresponding risk factors can be executed today, and simulations can take days to complete.
- The effects of climate change cannot be feasibly modeled.

Quantum-Readiness

Quantum computing readiness is a continuously evolving state that depends on your general approach to, and investment in, innovation, as well as new talent and skills, and overall digital maturity.

This readiness includes your adoption of enabling technologies such as automation, AI, and hybrid multi-cloud; your willingness to analyze, experiment, and iterate with evolving computing capabilities; the sophistication of your workflows; and your organizational skillset.



The 65-qubit IBM Quantum Hummingbird quantum processor, slightly larger than a US penny coin

A quantum team spans multiple skill areas

IBM Quantum

Quantum development is a collaborative effort with development roles contributing at various levels of technical abstraction and quantum knowledge

Business and Architecture Focus

Quantum Architect

Integrates a quantum model into business workflows to satisfy the functional requirements of a business solution.

Quantum Data Engineer

Creates the data requirements for the model and ensures that the data is optimally stored, manipulated, and read. Builds efficient ETL pipelines between quantum and classical devices.

Quantum and Optimization Focus

Quantum Model Developer

Selects the most appropriate quantum algorithm to apply to the ML task and configures it for optimal execution within a business context.

Quantum Algorithm Developer

Creates or adapts new QML algorithms using basic building blocks of quantum circuits and more fundamental quantum algorithms.

Quantum Kernel Developer

Optimizes the quantum algorithm for execution on near-term quantum systems.

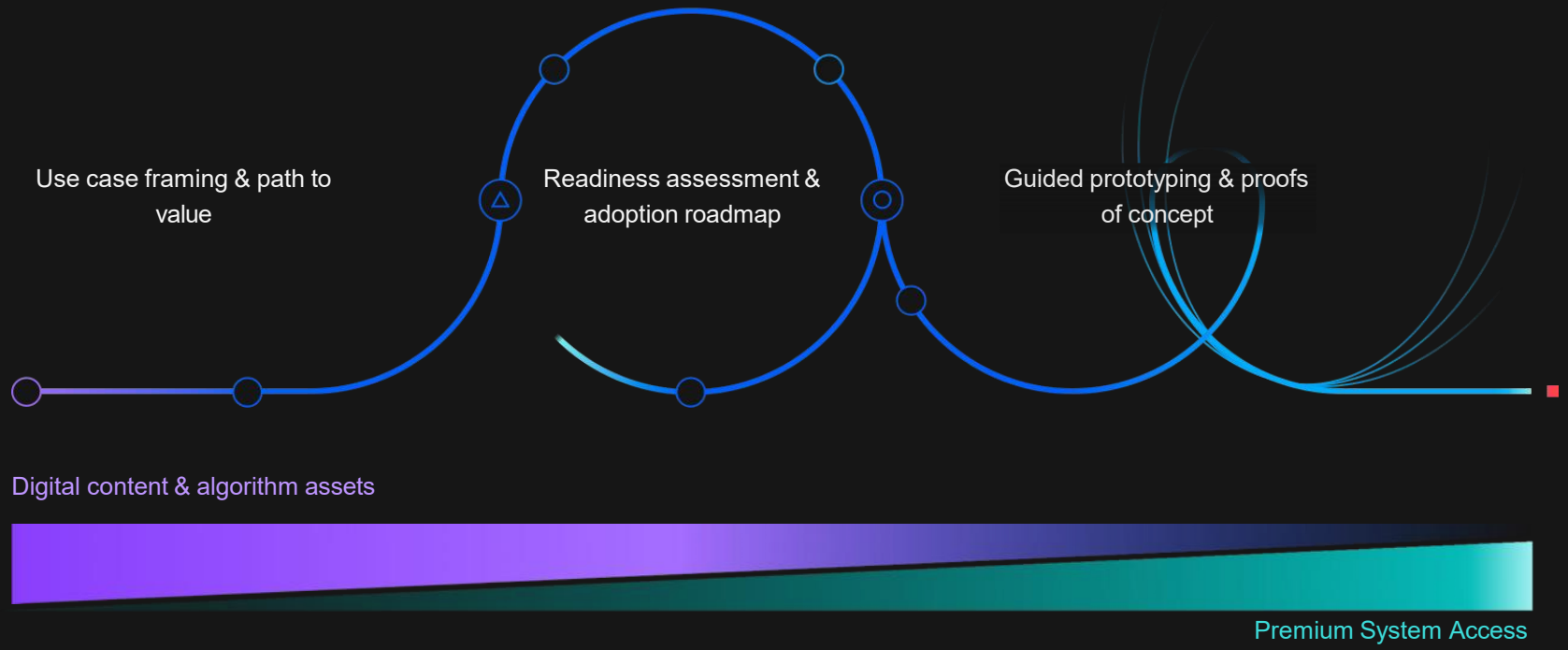
IBM Quantum

Preparing your organization for quantum advantage...

Business readiness:
Define your company's compelling case for quantum. Set priorities to capture new opportunities and minimize risk of competitive threats. Develop early proofs of concept with experts in industry quantum computing.

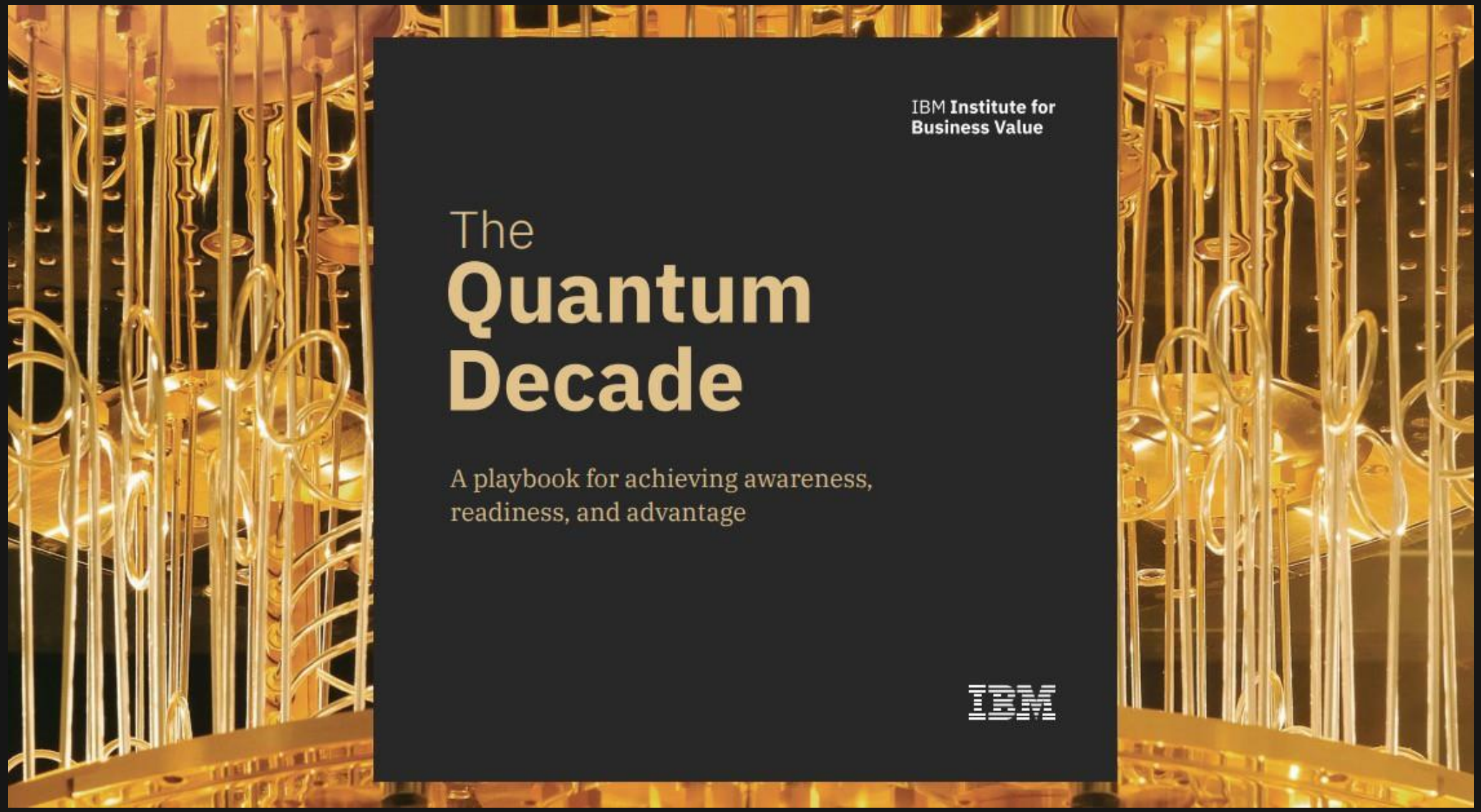
Technical readiness:
Build quantum fluency across your organization and engage technical teams in learning experiences with hands-on applications of quantum algorithms through guided prototyping.

Premium access:
Direct access to premium quantum services and support for the world's most advanced fleet of quantum systems.



Why Start the Journey Now?

- We are on track for business advantage soon.
- Quantum talent is hard to find and retain.
- It takes time to train up on quantum.
- There are no off-the-shelf solutions.
- Ideas are already being protected as IP.
- Readiness can take years to implement.
- Readiness investments are without regret.
- Even current techniques can be improved.
- Your competition is likely engaged, already.



https://www.ibm.com/thought-leadership/institute-business-value/report/quantum-decade

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IBM **Quantum**