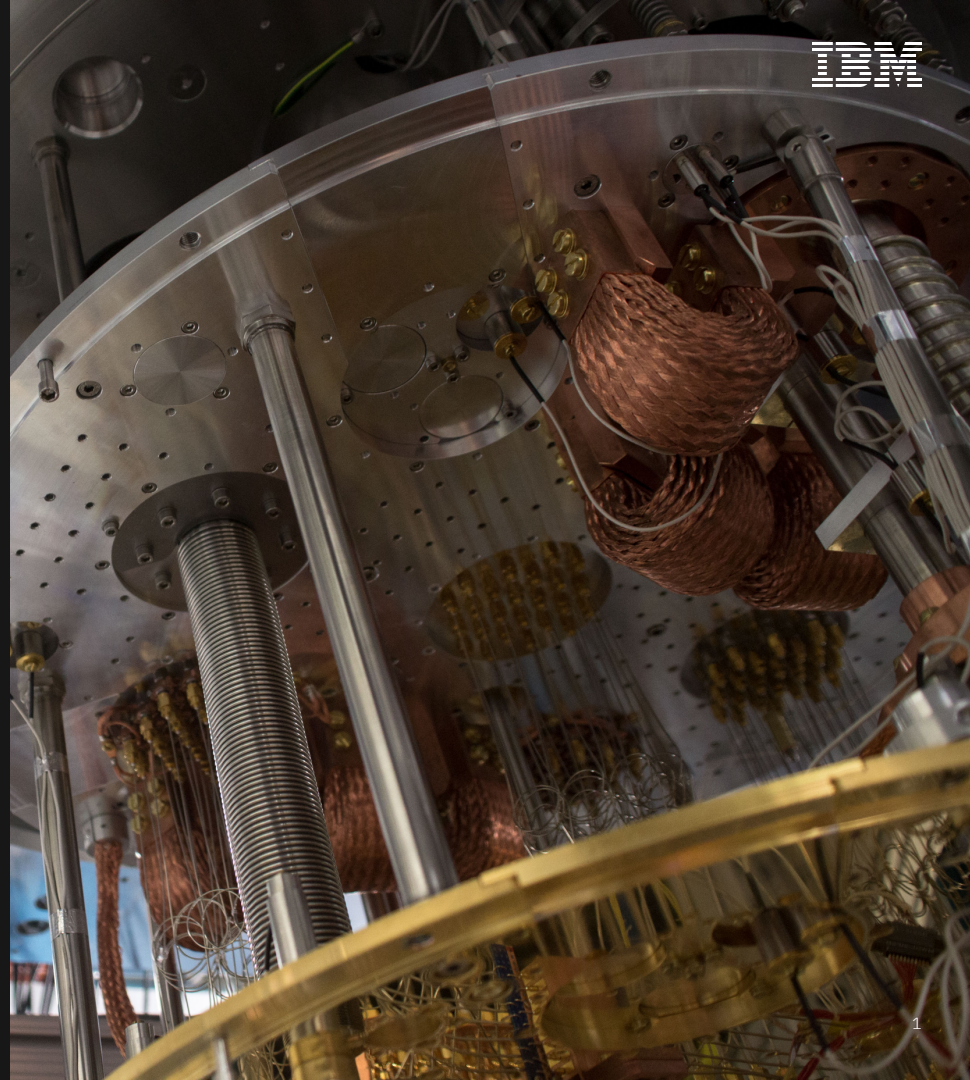


Quantum Computing

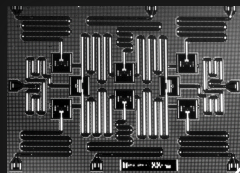
—
Federico Mattei

IBM Quantum Ambassador

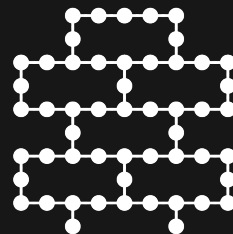
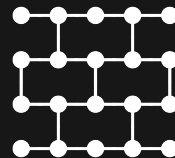
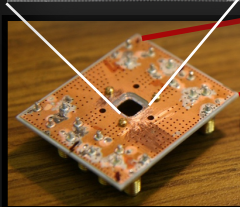


Inside an IBM Q quantum computing system

Qubits on chip



Circuit board



Development of quantum systems since 2016

Advanced programming tools for quantum developers



Over 155k users
200 third-party papers
29 million experiments

Graphically build, debug, and run quantum circuits on IBM Q hardware systems and simulators.

Programming with Qiskit is seamlessly integrated into the platform – work is saved in the cloud and tools are automatically updated.

Two screenshots of the IBM Q Experience web interface. The left screenshot shows the 'Rainy Day Experiment' circuit composer, displaying a quantum circuit diagram with qubits q[0] through q[4] and a classical register c5. The right screenshot shows the 'Quantum Algorithms with Qiskit' guide, featuring a histogram of probabilities for different measurement outcomes.

Quantum Algorithms with Qiskit

Note that the results on the x-axis in the histogram above are ordered as $c_2c_1c_0$. We can see that only results where $c_2 = 0$ appear, indicating that the teleportation protocol has worked.

2. Teleportation on a real quantum computer

You will now see how the teleportation algorithm works on a real quantum computer. Recall that we need one qubit for $|\psi\rangle$, one qubit for Alice, and one qubit for Bob, for a total of three qubits.

```
# get the least-busy backend at IBM and run the quantum circuit there
IBMQ.load_account()
from qiskit.providers.ibmq import least_busy
backend = least_busy(IBMQ.backends(simulator=False))
```


With quantum computers, we can tackle problems in entirely new ways

1. Model physical **processes** of nature
2. Perform significantly **more scenario** simulations
3. Obtain **better optimization** solutions
4. Find **better patterns** within AI/ML processes



Thank you

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IBM Q publications and websites

IBM Q and the IBM Q Experience

<http://ibm.com/quantum-computing>

Qiskit

<https://qiskit.org>

Quantum Volume advancement

<https://newsroom.ibm.com/2019-03-04-IBM-Achieves-Highest-Quantum-Volume-to-Date-Establishes-Roadmap-for-Reaching-Quantum-Advantage>

Open Pulse Development

<https://arxiv.org/pdf/1809.03452.pdf>

Error Mitigation

<https://www.nature.com/articles/s41586-019-1040-7>

IBM Q publications (Chemistry/ML/AI/Finance)

Quantum Chemistry

<https://www.nature.com/articles/nature23879>

<https://arxiv.org/abs/1906.10675>. (IBM, Keio, and Mitsubishi Chemical)

Quantum Machine Learning

<https://www.nature.com/articles/s41586-019-0980-2>

Quantum AI

<https://arxiv.org/abs/1906.10467> (Keio, Mitsubishi Chemical, MIZUHO, MUFG)

Quantum Finance: Risk analysis

<https://www.nature.com/articles/s41534-019-0130-6>

Quantum Finance: Generative adversarial networks

<https://arxiv.org/abs/1904.00043>

Quantum Finance: Amplitude estimation w/o QPE (IBM, Keio Univ, MUFG and Mizuho joint paper)

<https://arxiv.org/abs/1904.10246>

Quantum Finance: Credit risk analysis

<https://arxiv.org/abs/1907.03044>

Quantum Finance: Option pricing (IBM and JP Morgan Chase joint paper)

<https://arxiv.org/abs/1905.02666>

Quantum Finance: Portfolio optimization

<https://arxiv.org/abs/1907.04769>

Quantum Finance: Qiskit finance

<https://github.com/Qiskit/qiskit-tutorials/blob/master/qiskit/finance/index.ipynb>

IBM Q Expert Insights

“Exploring quantum computing use cases for manufacturing” — June 2019

<https://www.ibm.com/thought-leadership/institute-business-value/report/quantum-manufacturing>

“Getting your financial institution ready for the quantum computing revolution” — April 2019

<https://www.ibm.com/downloads/cas/MBZYGRKY>

“Building your quantum capability: The case for joining an ecosystem” — Feb 2019

<https://ibm.co/quantumeco>

“Coming soon to your business: quantum computing - Five strategies to prepare for the paradigm-shifting technology”

ibm.biz/quantumstrategy

“Wielding a double-edged sword: Preparing cybersecurity now for a quantum world” — July 2018

ibm.biz/quantumsecurity

“Taking the Quantum Leap: Why now?” — February 2018

<https://www-935.ibm.com/services/us/gbs/thoughtleadership/quantumleap/>