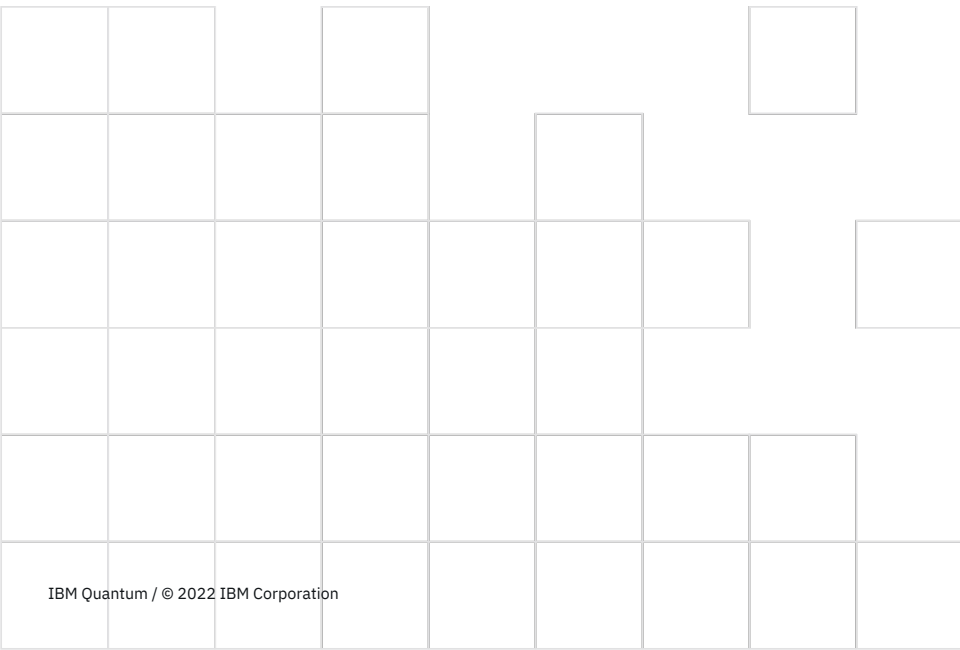


Qiskit Quantum Software Stack

Junye Huang

Quantum Developer Advocate



What is Qiskit?

What can you use Qiskit for?

Qiskit SDK Architecture

High level applications

Qiskit Nature

For applications relating to simulating quantum mechanical systems and natural phenomena.

Qiskit Finance

For applications relating to financial modeling.

Qiskit Optimization

For applications relating to optimization problems.

Qiskit Machine Learning

For applications relating to machine learning.

Low level applications

Qiskit Metal

For designing quantum hardware and processors.

Qiskit Dynamics

For building, transforming, and solving time-dependent models of quantum systems.

Qiskit Experiments

For running quantum experiments with a library of characterization, calibration, and verification experiments.



Core Capabilities

Qiskit Terra

For building and transforming quantum circuits and operators at the level of gates or pulses.

Simulator

Qiskit Aer

For simulating quantum circuits on classical hardware.

Hardware providers

IBM

IBM Quantum systems

AQT

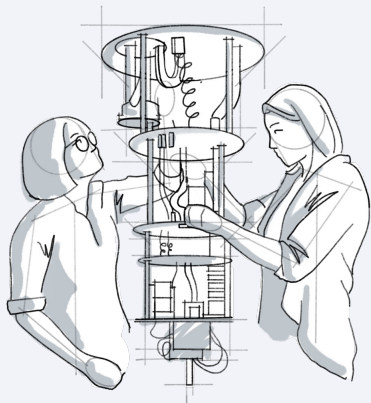
AQT systems

IonQ

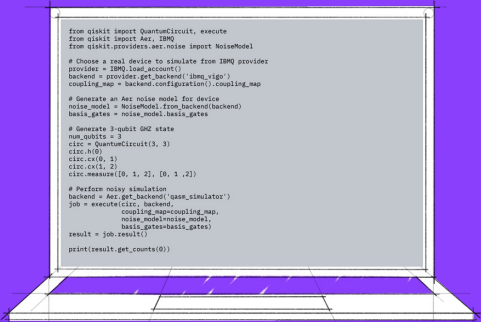
IonQ systems

Qiskit can connect to many other systems

Qiskit for



Research

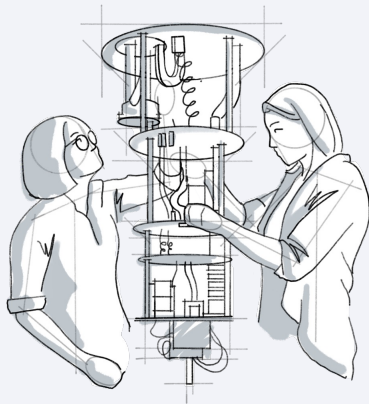


Development

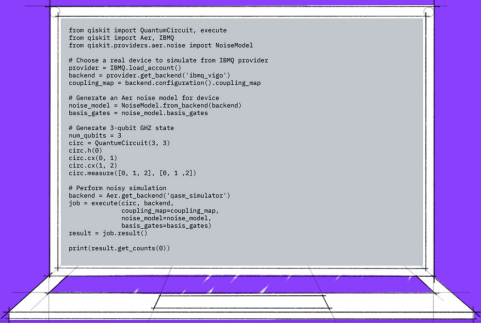


Learning

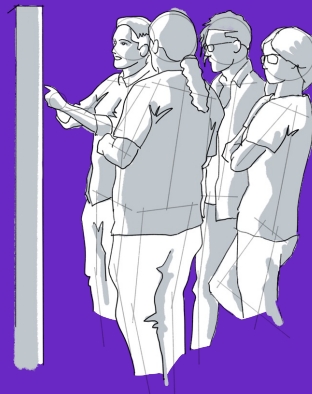
Qiskit for



Research



Development



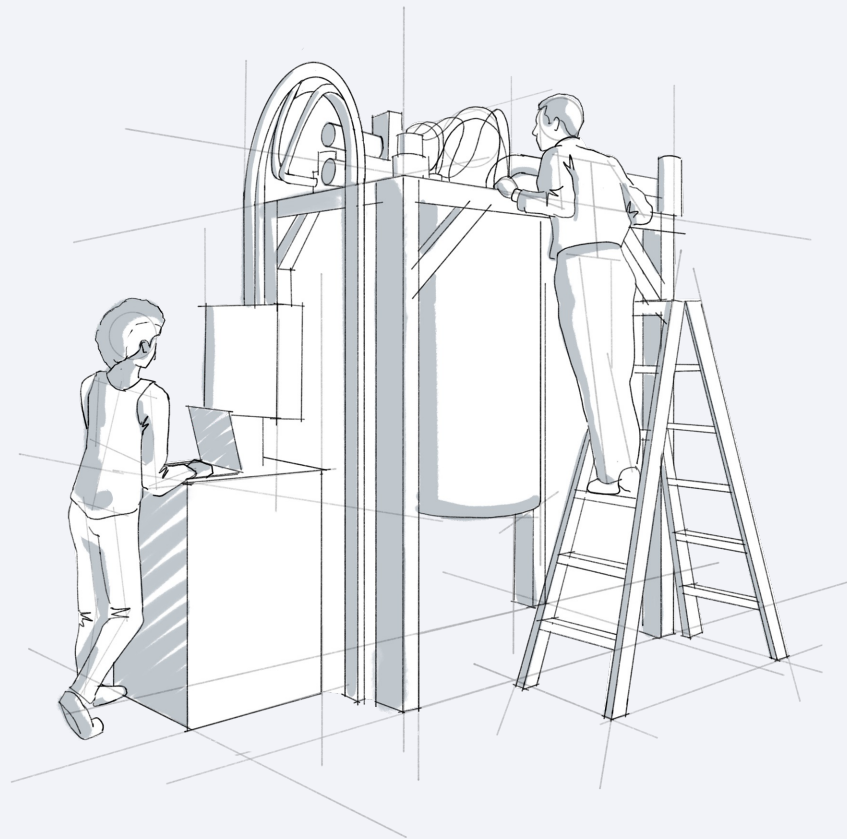
Learning

Since launching in Mar 2017



Qiskit has enabled

**1400+
research
papers***



*based on the usage of IBM Quantum systems

Access to a wide range of quantum systems



The screenshot shows the IBM Quantum Services interface. At the top, there's a 'Services' header with a description: 'View the availability and details of IBM Quantum programs, systems, and simulators.' Below this are tabs for 'Programs', 'Systems' (selected), and 'Simulators'. A search bar is present with the text 'Search by system name'. A filter indicates 'All systems (22)'. The main content is a grid of 16 system cards, each representing a different quantum system. Each card includes the system name, status (Online or Offline), processor type, and a table of metrics: Qubits, QV, and CLOPS. Some cards also show a 'Queue paused maintenance' status.

System Name	Status	Processor Type	Qubits	QV	CLOPS
ibmq_washington	Online	Eagle v1	127	64	850
ibmq_brooklyn	Online	Hummingbird v2	65	32	1.5K
ibmq_kolkata	Online	Falcon v5.11	27	128	2K
ibmq_montreal	Online	Falcon v4	27	128	2K
ibmq_mumbai	Online	Falcon v5.1	27	128	1.8K
ibmq_cairo	Online - Queue paused maintenance	Falcon v5.11	27	64	2.4K
ibmq_auckland	Online	Falcon v5.11	27	64	2.4K
ibmq_hanoi	Online	Falcon v5.11	27	64	2.3K
ibmq_toronto	Online	Falcon v4	27	32	1.8K
ibmq_peekskill	Online	Falcon v5	27		
ibmq_guadalajara	Online - Queue paused maintenance	Falcon v4P	16	32	2.4K
ibmq_perth	Online	Falcon v5.11H	7	32	2.9K
ibmq_lagos	Online	Falcon v5.11H	7	32	2.7K
ibmq_nairobi	Online	Falcon v5.11H	7	32	2.6K
ibmq_jakarta	Online	Falcon v5.11H	7	16	2.4K
ibmq_manila	Online	Falcon v5.11L	5	32	2.8K
ibmq_bogota	Online	Falcon v4L	5	32	2.3K
ibmq_santiago	Online	Falcon v4L	5	32	
ibmq_quito	Online	Falcon v4T	5	16	2.5K
ibmq_belem	Online	Falcon v4T	5	16	2.5K
ibmq_lima	Online	Falcon v4T	5	8	2.7K
ibmq_armonk	Online	Canary v1.2	1	1	

Hardware providers

IBM

IBM Quantum systems

AQT

AQT systems

IonQ

IonQ systems

Qiskit can connect to many other systems

Cross-platform support

- **Superconducting:** IBM Quantum, Rigetti
- **Trapped ions:** AQT, IonQ, Quantinuum
- **Spin qubits:** Quantum Inspire
- **Cold atoms:** Qiskit Cold Atom provider
- **Platform:** Azure Quantum, AWS Braket
- **Simulator:** cuQuantum (NVIDIA)

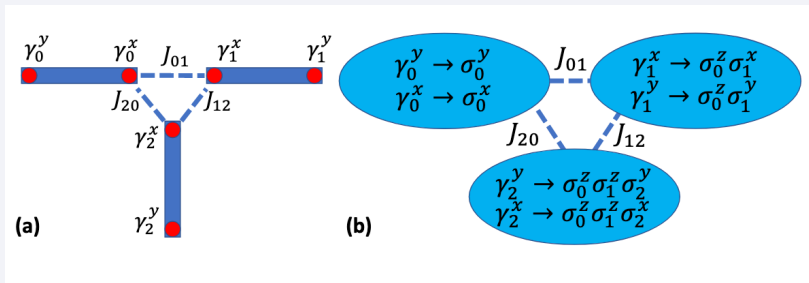
Qiskit Pulse for pulse-level control



With pulses, you can dig deep into the heart of a quantum device and study the system as if you were physically present in the lab.

Highlight

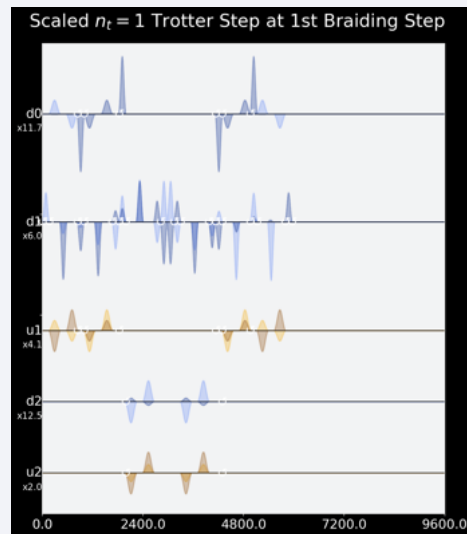
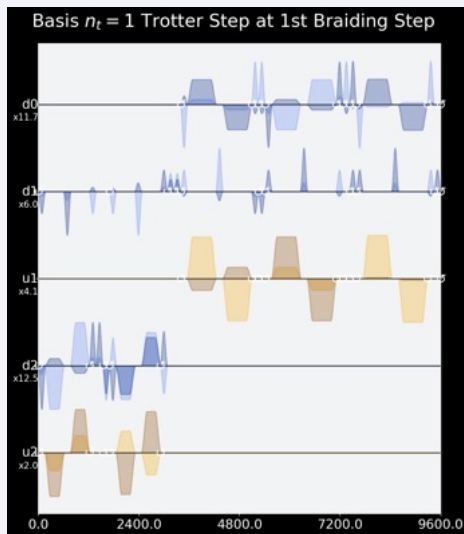
- Simulating the dynamics of braiding of Majorana zero modes using an IBM Quantum computer with Qiskit Pulse [arXiv:2012.11660](https://arxiv.org/abs/2012.11660)
- Qiskit Pulse allowed the authors to overcome the device's noise with specially-crafted controlled gates.



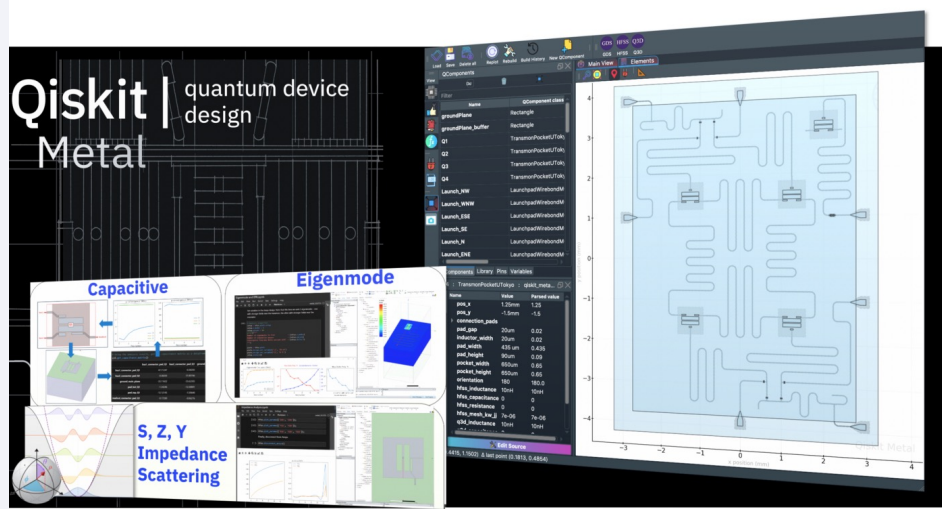
Core Capabilities

Qiskit Terra

For building and transforming quantum circuits and operators at the level of gates or pulses.



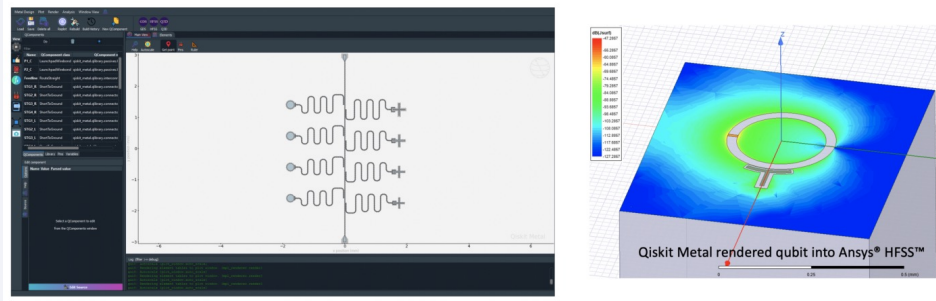
Qiskit Metal for designing quantum processors



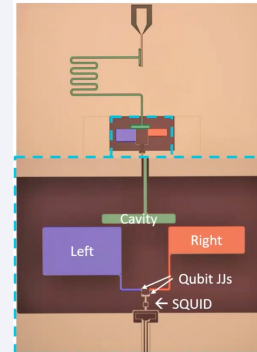
Qiskit Metal is the first EDA tool specifically for quantum computers used for designing, modelling and analyzing performance of quantum processors.

Community driven and experimentally tested by IBM Quantum and the community

Promote more knowledge sharing in the quantum hardware community



An 8-qubit chip designed by C. Warren, Amr Osman, and team (Chalmers) with Qiskit Metal.

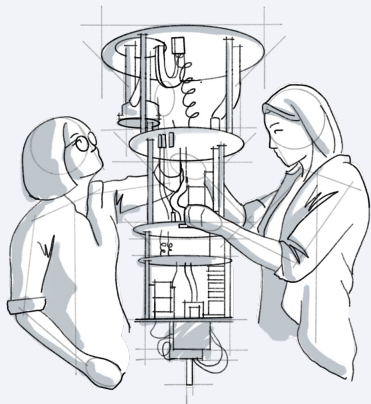


Two transmon qubits with a SQUID coupler designed by Zachary Parrott (UCB & NIST) with Qiskit Metal.

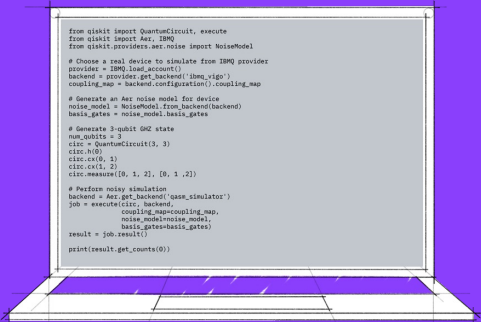
Qiskit Metal

For designing quantum hardware and processors.

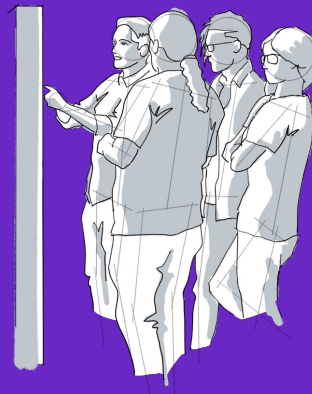
Qiskit for



Research











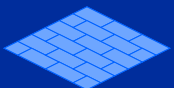

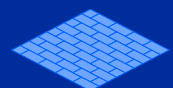

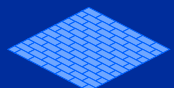

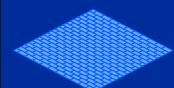
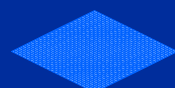
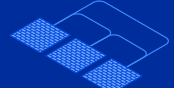
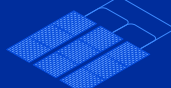
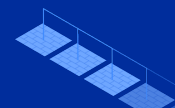
Development



Learning

Development Roadmap | Executed by IBM On target

2019 	2020 	2021 	2022	2023	2024	2025	Beyond 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 	Flamingo 1,386+ qubits 	Kookaburra 4,158+ qubits 	Scaling to 10K-100K qubits with classical and quantum communication
					Heron 133 qubits x p 	Crossbill 408 qubits 