Welcome, and Happy IYQ!!!

Natalie Hawkins
Qiskit Advocate
Seattle Quantum Computing Meetup, Founder

IBM Quantum

'Quantum' should

Seattle Quantum Computing Meetup
Knowledge Share, Network

QISKIT 2025 2025 FALL FEST

$\Delta x \, \Delta p \geq \frac{\hbar}{2}$

$\Delta p \geq \frac{\hbar}{2}$

100
Years of Quantum Mechanics

Sat, Oct 4, 2025, 12:30pm-2:00pm

Today's Agenda

Qiskit Fall Fest 2025

What is it?
Who are the hosts?
SQCM FF25 Schedule

IBM Quantum, and others

IBM Hardware
IBM Roadmap
Quantum Computers
Quantum Programming

Qiskit

How to use it?

SQCM Fall Fest 2025 Activities

Coding Challenges
Hackathon Prompts
Open-Your-Choice Project
Quantum Games
Free Time

Qiskit Fall Fest – What is it?

Qiskit Fall Fest 2025

Qiskit Fall Fest is a collection of quantum computing events created and planned by university students and volunteer hosts, with support from IBM Quantum.

    54 Sponsored Events
+ 89 Extension Events __
  143 Total Events

https://www.ibm.com/quantum/events/fall-fest-2025

The Seattle Quantum Computing Meetup was selected as one of 150 universities or organizations to host a FF25, out of 600 applications.

https://github.com/SeattleQuantumComputingMeetup/qiskit_fall_fest_2025/tree/main
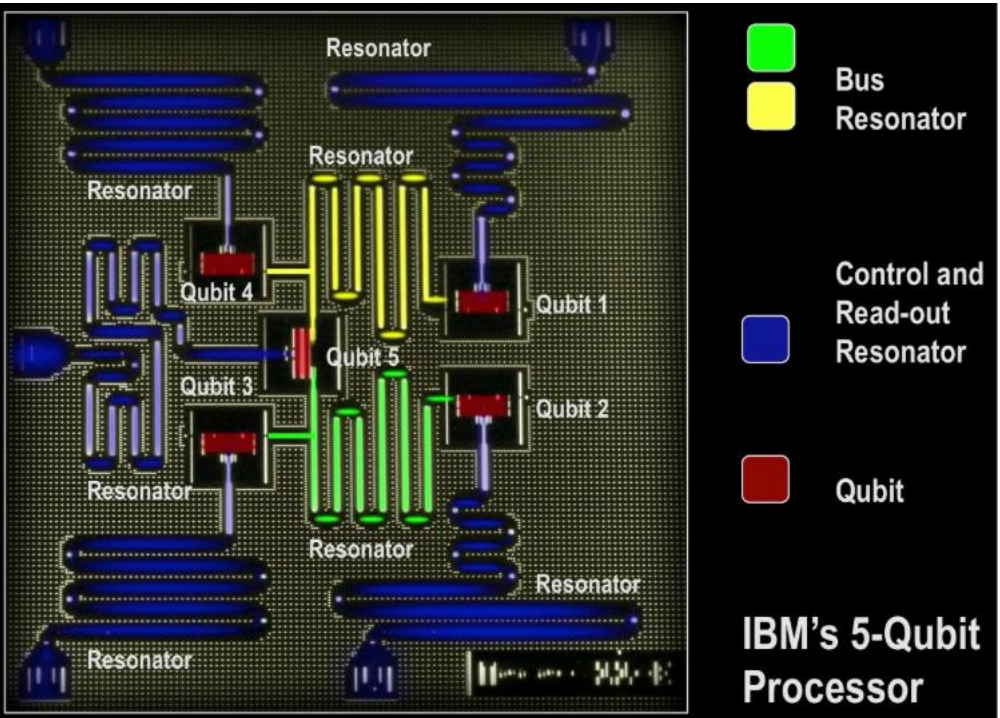
SQCM FF25 Schedule

Date	Time	Activity	Location
Sep 30	6-7:30pm PT	<u>Fall Fest 2025 Prep - Qiskit and Quantum Computing 101</u>	Northgate Branch, Seattle Public Library
Oct 4	12:30-2:00pm PT	<u>Qiskit Coding Challenges, Hackathon Prompts, Game Day</u>	Montlake Branch, Seattle Public Library
Nov 3	10:00 am PT	Deadline for Coding Challenges and Hackathon Work	submit online
By Dec 1	11:59 pm PT	Participation and Winner Certificates Will Be Awarded	delivered online

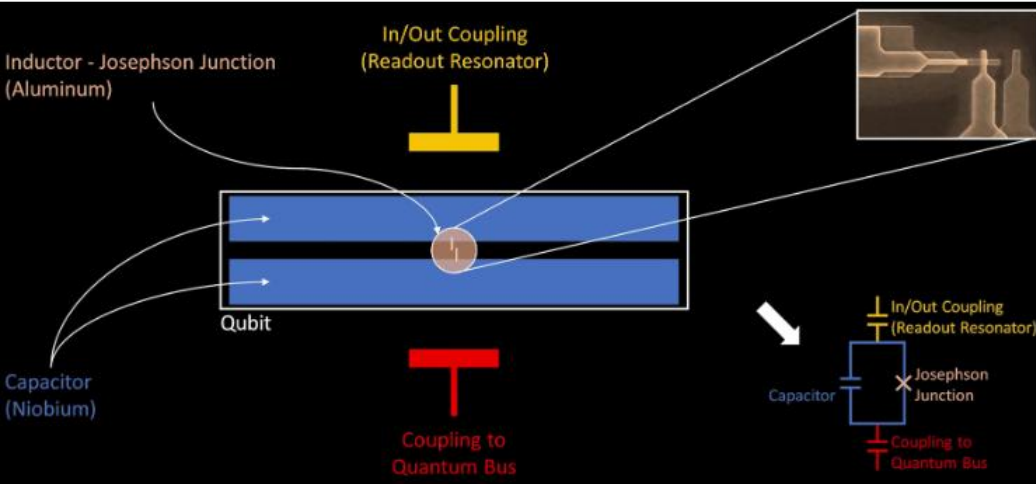# IBM Quantum and Others – hardware and software

IBM Quantum, Hardware

The IBM Quantum Experience went live on May 4, 2016:

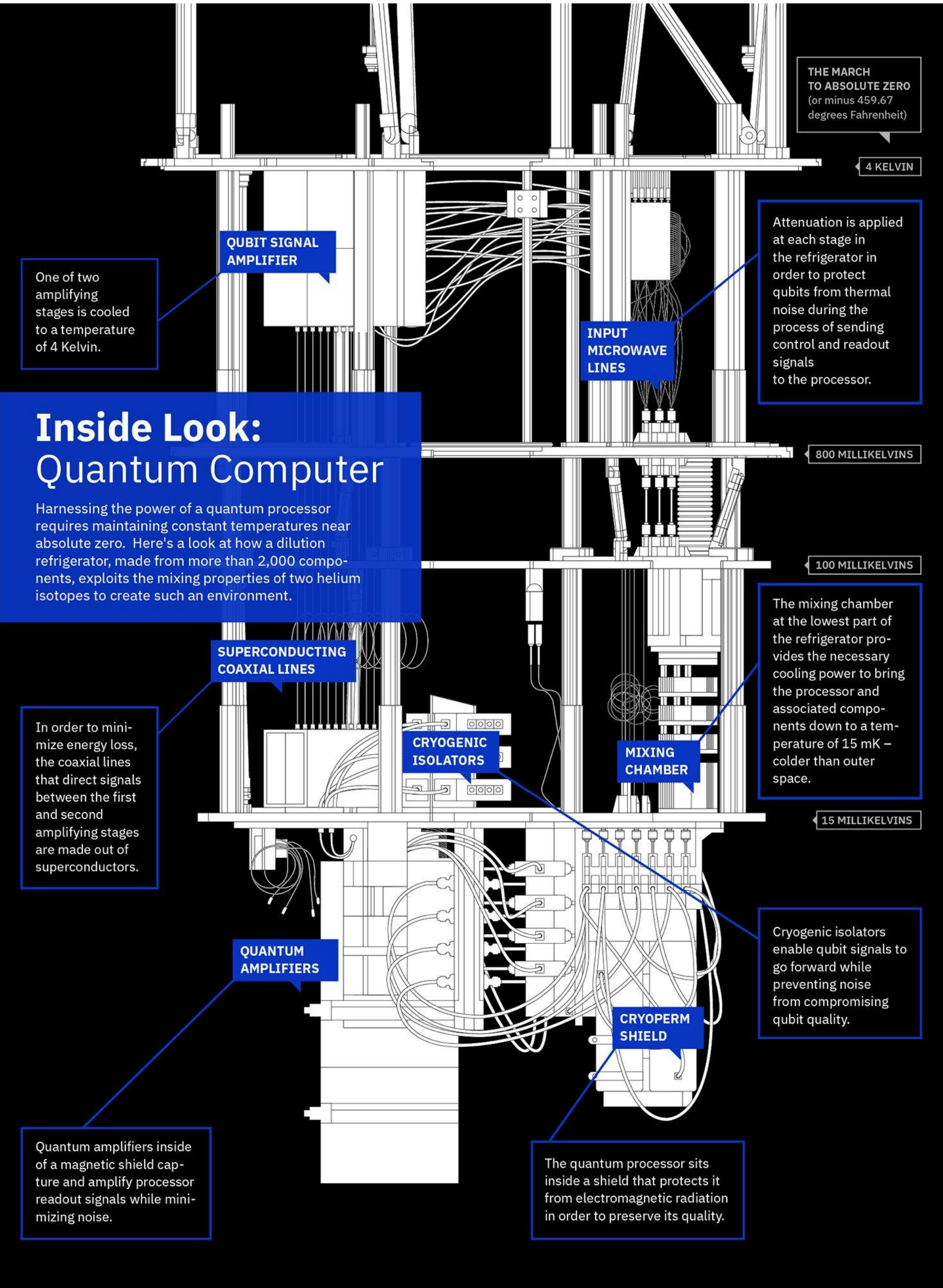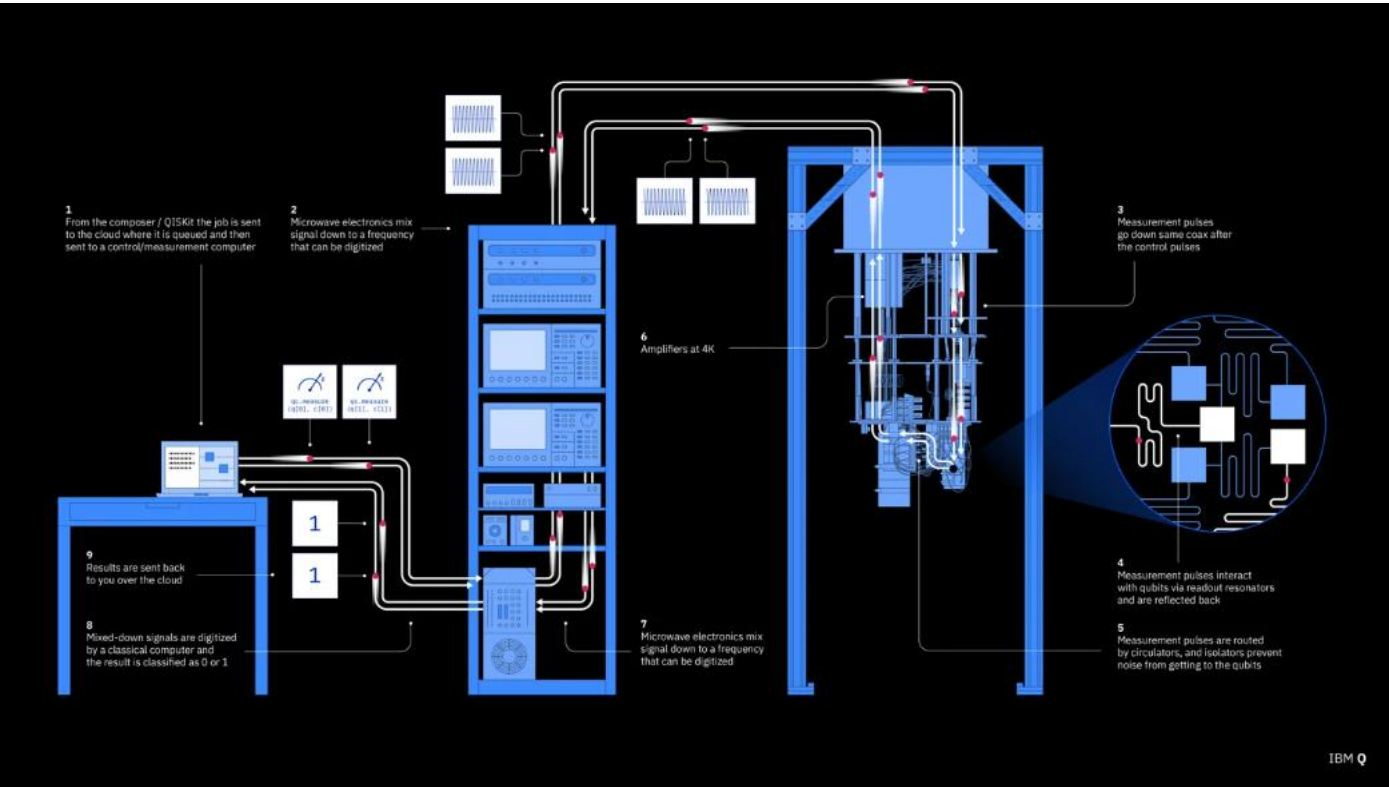Superconducting Qubit with Josephson Junction (JJ):

QPU: size like CPU

Qubit: millimeters

JJ: microscopic
(<= micrometers)

Inside Look: Quantum Computer

Harnessing the power of a quantum processor requires maintaining constant temperatures near absolute zero. Here's a look at how a dilution refrigerator, made from more than 2,000 components, exploits the mixing properties of two helium isotopes to create such an environment.

THE MARCH TO ABSOLUTE ZERO
(or minus 459.67 degrees Fahrenheit)

4 KELVIN

800 MILLIKELVINS

100 MILLIKELVINS

15 MILLIKELVINS

QUBIT SIGNAL AMPLIFIER

INPUT MICROWAVE LINES

One of two amplifying stages is cooled to a temperature of 4 Kelvin.

Attenuation is applied at each stage in the refrigerator in order to protect qubits from thermal noise during the process of sending control and readout signals to the processor.

SUPERCONDUCTING COAXIAL LINES

In order to minimize energy loss, the coaxial lines that direct signals between the first and second amplifying stages are made out of superconductors.

CRYOGENIC ISOLATORS

MIXING CHAMBER

The mixing chamber at the lowest part of the refrigerator provides the necessary cooling power to bring the processor and associated components down to a temperature of 15 mK – colder than outer space.

Cryogenic isolators enable qubit signals to go forward while preventing noise from compromising qubit quality.

QUANTUM AMPLIFIERS

CRYOPERM SHIELD

Quantum amplifiers inside of a magnetic shield capture and amplify processor readout signals while minimizing noise.

The quantum processor sits inside a shield that protects it from electromagnetic radiation in order to preserve its quality.

https://electronics360.globalspec.com/article/13553/how-quantum-computers-work

IBM Quantum, Roadmap

Diagram:

https://www.ibm.com/roadmaps/quantum/

Video:

https://www.ibm.com/quantum/technology#roadmap

	2016–2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2033+
Development Roadmap ↓	Ran quantum circuits on IBM Quantum Platform	Released multi-dimensional roadmap publicly with initial focus on scaling	Enhanced quantum execution speed by 100x with Qiskit Runtime	Brought dynamic circuits to unlock more computations	Enhanced quantum execution speed by 5x with Quantum Serverless and execution modes	Demonstrated accurate execution of a quantum circuit at a scale beyond exact classical simulation (5K gates on 156 qubits)	Deliver quantum + HPC tools that will leverage Nighthawk, a new higher-connectivity quantum processor able to execute more complex circuits	Enable the first examples of quantum advantage using a quantum computer with HPC	Improve quantum circuit quality to allow 10K gates	Improve quantum circuit quality to allow 15K gates	Deliver a fault-tolerant quantum computer with the ability to run 100M gates on 200 logical qubits	Beyond 2033, quantum computers will run circuits comprising a billion gates on up to 2000 logical qubits, unlocking the full power of quantum computing

Code assistant ✓

Applying algorithms to applications
- Functions ✓
- Use case benchmarking toolkit
- Computation libraries

Discovering new algorithms for advantage
- Advanced classical transpilation tools ✓
- Advanced classical mitigation tools ◷
- Utility mapping tools
- Circuit libraries

Orchestrating workloads for quantum + HPC
- Resource Management
- Qiskit Serverless ✓
- Plugins for HPC ✓
- C API ◷
- Profiling tools
- Workflow accelerators
- Execution modes ✓

Accurately and efficiently executing on quantum computers
- Qiskit Runtime
- IBM Quantum Experience ✓
- OpenQASM 3 ✓
- Dynamic Circuits ✓
- Error mitigation ✓
- 200K CLOPS ✓
- Utility-scale dynamic circuits ◷
- Fault-tolerant ISA

	Early ✓	Falcon ✓	Eagle ✓	Heron (5K) ✓	Nighthawk (5K) ◷	Nighthawk (7.5K) ◷	Nighthawk (10K) ◷	Nighthawk (15K) ◷	Starling (100M)	Blue Jay (1B)
	Benchmarking	Benchmarking		Error mitigation	Error mitigation	Error mitigation	Error mitigation	Error mitigation	Fault-tolerant	Fault-tolerant
	Canary 5 qubits / Albatross 16 qubits / Penguin 20 qubits / Prototype 53 qubits	27 qubits	127 qubits	5K gates | 133 qubits	5K gates | 120 qubits	7.5K gates | 120 qubits / Up to 120x3 = 360 qubits	10K gates | 120 qubits / Up to 120x9 = 1080 qubits	15K gates | 120 qubits / Up to 120x9 = 1080 qubits	100M gates / 200 logical qubits	1B gates / 2000 logical qubits

Innovation Roadmap ↓

Software innovation

IBM Quantum Experience ✓	Qiskit ✓	Application modules ✓	Qiskit Runtime ✓	Quantum Serverless ✓	AI-enhanced quantum ✓	HPC-Quantum integration ✓	Advantage candidates ◷	Error correction decoder	Workflow accelerator	Fault-tolerant ISA
	Open-source SDK for building and compiling circuits for quantum hardware	Modules for domain specific application and algorithm workflows	Performance and abstraction through primitives	Demonstrate concepts of managing quantum and cloud classical compute for an end to end workflow	Prototype demonstrations of AI-enhanced circuit transpilation	Realize an integration of classical HPC and a quantum computer at utility scale	Define problem types for advantage in 2026	Demonstrate a real-time error correction decoder	Demonstrate a workflow accelerator that streamlines execution for a known advantage workflow	Demonstrate a complete instruction set architecture including magic state distillation for FTQC

Hardware innovation

Early ✓	Falcon ✓	Hummingbird ✓	Eagle ✓	Osprey ✓	Condor ✓	Flamingo ✓	Loon ◷	Kookaburra	Cockatoo	Starling
Canary 5 qubits / Albatross 16 qubits / Penguin 20 qubits / Prototype 53 qubits	Demonstrate scaling with I/O routing with bump bonds	Demonstrate scaling with multiplexing readout	Demonstrate scaling with MLW and TSV	Enabling scaling with high density signal delivery	Single-system scaling and fridge capacity	Demonstrate scaling with l-couplers	Demonstrate c-couplers and next-generation packaging for FTQC	Demonstrate a complete module consisting of a logical processing unit and quantum memory	Demonstrate entanglement of modules using a universal adapter	Demonstrate multiple modules and magic state distillation
			Egret ✓ — Tunable coupler demonstration		Heron ✓ — Architecture based on tunable-couplers	Crossbill ✓ — Demonstrate m-couplers				

✓ Completed   ◷ On target

IBM Quantum
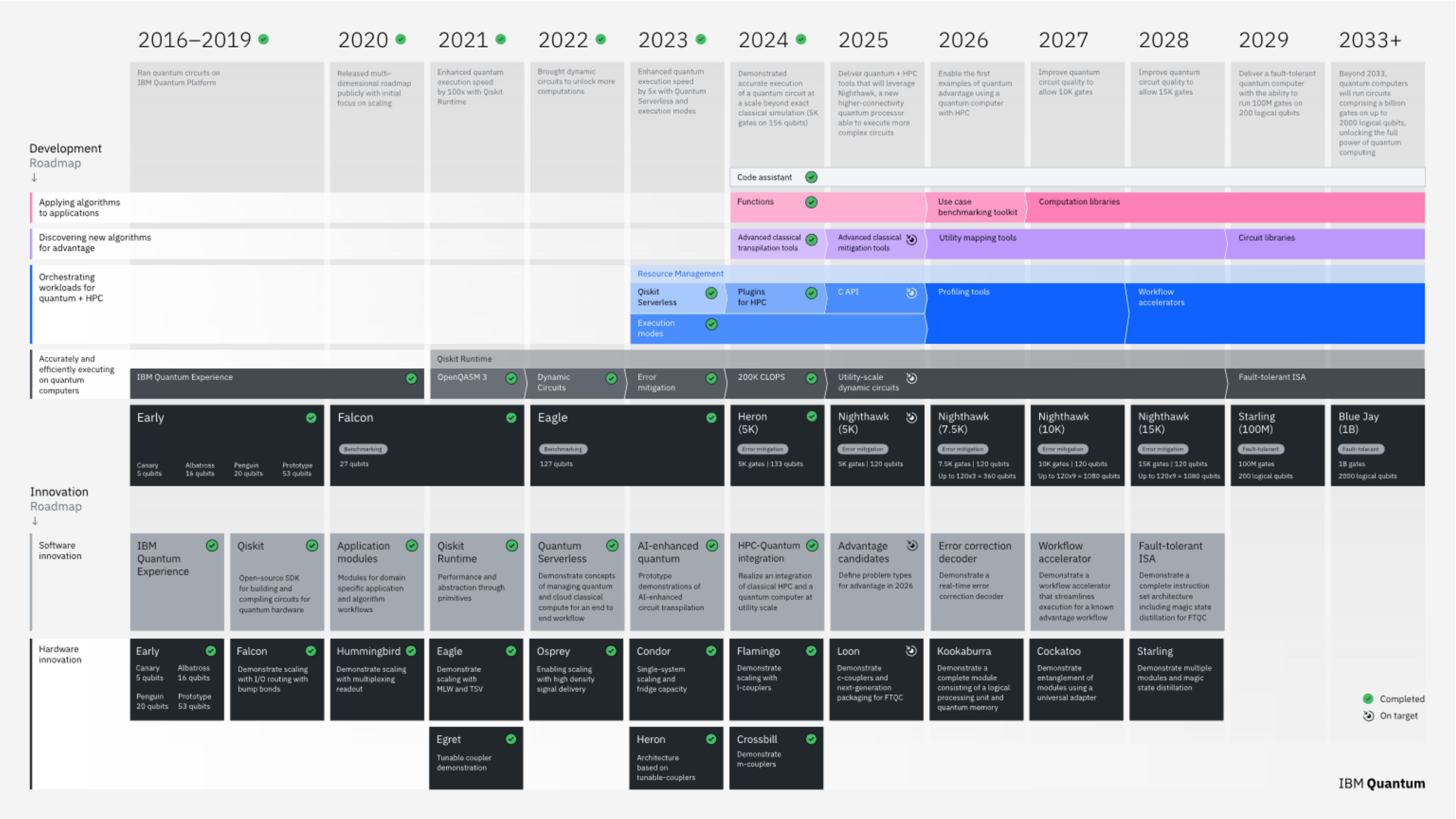
What's Out There?

"The development of quantum software has been strongly influenced by the open-source community, with many toolkits and frameworks—such as Qiskit, Cirq, PennyLane, and qBraid SDK—available under open licenses," Wikipedia, Quantum Programming.

https://unitary.foundation/posts/2024_surveyresults/

Quantum Processors

There are different types of quantum processors:

❑ Circuit-based quantum processors - QPUs are based on the quantum circuit and quantum logic gate-based model of computing. (e.g. IBM and others)

❑ Annealing quantum processors - QPUs are based on quantum annealing, not to be confused with digital annealing. (e.g. D-Wave)

❑ Analog quantum processors - These QPUs are based on analog Hamiltonian simulation. (e.g. QuEra)

https://en.wikipedia.org/wiki/List_of_quantum_processors

Quantum Programming

Quantum programming refers to the process of designing and implementing algorithms that operate on quantum systems, typically using quantum circuits composed of quantum gates, measurements, and classical control logic.

These circuits are developed to manipulate quantum states for specific computational tasks or experimental outcomes.

Quantum programs may be executed on quantum processors, simulated on classical hardware, or implemented through laboratory instrumentation for research purposes.

There are:
▪ Quantum instruction sets (e.g. OpenQASM)
▪ Quantum software development kits (e.g. Qiskit and others)
▪ Quantum programming languages

https://en.wikipedia.org/wiki/Quantum_programming

Qiskit

Tools and Documentation

How do I write and run Qiskit code?

Online Lab Environments

- Google Colab is the easiest
- qBraid is another option

https://quantum.cloud.ibm.com/docs/en/guides/online-lab-environments

Install Locally in a Python environment

You can run your Qiskit code on your own computer.

https://quantum.cloud.ibm.com/docs/en/guides/install-qiskit

Jupyter Notebooks

This is the most common way to get started with Qiskit code.

You can upload your notebook, or start a new one, in Google Colab, for the easiest path as a Beginner.

Qiskit Documentation

The IBM Quantum Platform has Guides, an API Reference, Tutorials, and other Documentation.

https://quantum.cloud.ibm.com/docs/en/guides

Qiskit Pattern:

The anatomy of a quantum algorithm – when ready to run on a backend

Map problem to quantum circuits & operators

- Circuit library
- Quantum info library
- And more...

Optimize for target hardware

- Transpiler
- AI-enhanced transpiler
- And more...

Execute on target hardware

- Runtime primitives
- Execution modes
- And more...

Post-process results

- Quantum info library
- Visualization module
- And more...
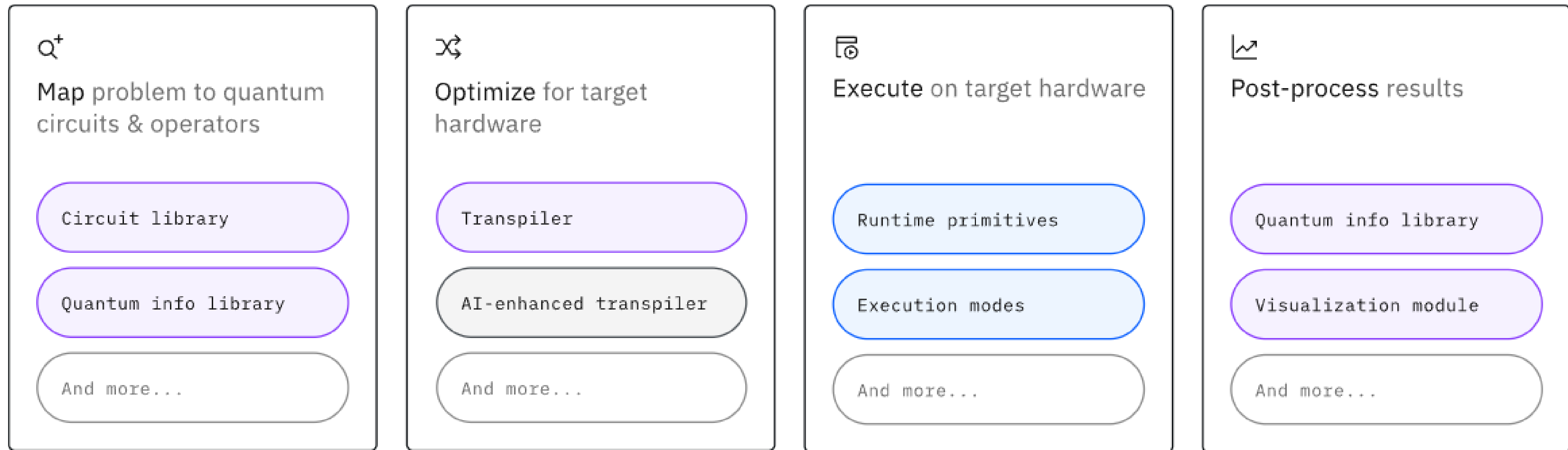
■ Qiskit SDK ■ Qiskit Runtime Service ■ Qiskit Transpiler Service

Qiskit Pattern:

The anatomy of a quantum algorithm – when ready to run on a backend

How will you encode your data in a quantum state (angle, amplitude)? What qalg or subroutines will you use? ↓↓

Create an Instruction Set Architecture (ISA) circuit (native gates + SWAPs) ↓↓

Use the Sampler() or Estimator() Primitive to run a job ↓↓

Egs. result = job.result(), plot_histogram(counts) ↓↓

⌕⁺ Map problem to quantum circuits & operators

Circuit library

Quantum info library

And more...

⤭ Optimize for target hardware

Transpiler

AI-enhanced transpiler

And more...

▣ Execute on target hardware

Runtime primitives

Execution modes

And more...

⭧ Post-process results

Quantum info library

Visualization module

And more...

☐ Qiskit SDK   ☐ Qiskit Runtime Service   ☐ Qiskit Transpiler Service

Example Backends: ↑↑
AerSimulator(), FakeTorino(), ibm_torino (Heron 133 QBs)

How will you test the code↑↑ that is producing these results?

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Edu Resources

How do I learn more?

Qiskit Channel on YouTube

- Topic videos – short and long
- Seminar videos
- Qiskit Global Summer School presentations and panels
- Lab tours

https://www.youtube.com/qiskit

Qiskit-Community GitHub repos

- qgss-2025
- qiskit-machine-learning
- qiskit-experiments
- qiskit-optimization
- qiskit-metal

https://github.com/qiskit-community

Qiskit Guides / API Reference

- Introduction to Qiskit
- Install Qiskit
- Qiskit Tools - such as Circuits and Operators, Transpiler, Debugging Tools, Primitives, Execution Modes, Manage jobs, IBM Quantum Computers

https://quantum.cloud.ibm.com/docs/en/guides

IBM Quantum Platform Learning

Free Online Classes, work at your own pace – Foundations, Focused topics, QC for business, Qiskit in classroom

https://quantum.cloud.ibm.com/learning/en

IBM Quantum Platform Tutorials

- Hello world
- Shor's Alg
- Grover's Alg
- QAOA Alg
- Quantum kernel training

https://quantum.cloud.ibm.com/docs/en/tutorials

Qiskit v2.0 Developer Certification Study Guide and Sample Test

Useful materials – whether or not you actually take the test

https://www.ibm.com/training/certification/ibm-certified-quantum-computation-using-qiskit-v2x-developer-associate-C9008400

SQCM Fall Fest 2025 Activities

Where are you on your Quantum journey?

0   Beginner - Intermediate   5   10

What's
Quantum?

Reading, Videos,
Science, math or
hands-on coding

Papers, Active
Research and
development

What are the project options?

Qiskit Coding Challenges

➢ **Beginner Notebook** – *Qiskit 2 Fundamentals Lab*, This notebook is designed to help you get up to speed on Qiskit 2 fundamentals by providing hands-on exercises for 18 core concepts. As a bonus, in the last cell, you can run code on real IBM quantum hardware!

➢ **Intermediate Notebook** – *Hands-On Introduction to DiVincenzo Criteria with Qiskit 2,* Physicist David DiVincenzo outlined five key requirements for any physical implementation of a quantum computer, plus two additional criteria for quantum communication. In this notebook, we will **experience each DiVincenzo criterion through practical Qiskit demonstrations**. You will get to run circuits on simulators and real IBM Quantum devices to **explore each principle hands-on**.

https://github.com/SeattleQuantumComputingMeetup/qiskit_fall_fest_2025/tree/main/coding_challenges

Hackathon Prompts

❖ Cleveland Clinic – protein structure prediction

❖ BasQ – quantum Battleship/BombTester game

❖ Mila – financial application, options pricing

❖ Rensselaer PTI – cryptography/Quantum Key Distribution

https://github.com/SeattleQuantumComputingMeetup/qiskit_fall_fest_2025/tree/main/hackathon_prompts

How do I earn a certificate from IBM Quantum?

Submit your work by sending a direct message in Discord (nhawkins), Meetup (Natalie Hawkins), or LinkedIn (natalie-hawkins-seattle) with ONE of the following, as well as indicating your full name as you wish it to appear on the certificate:

- a link to a github repo or other storage location, like Box, containing your work

- attach your file(s) to the message

- Or maybe I can create a public Box for you to drop it into, in which case make sure you label it with your full name, if the above aren't working out for you

Participation Certificate

Do one of the following:

- Attend at least one in-person SQCM FF25 event

- Complete the Beginner or Intermediate Notebook

Winner Certificate

Do one of the following:

- Complete both the Beginner and Intermediate Notebooks

- Submit work on one of the Hackathon prompts

- Submit work on a topic of your own choosing related to Quantum Computing. This could be a hackathon-like prompt, an idea for a start-up, an article or essay or piece of creative writing, an idea for a game, a type of art of any form, or any other suggestion you might have; the sky's the limit! Have fun!

How do spend the rest of my time today at the SQCM FF25 Kickoff?

1

Start working on the Beginner Notebook. Choose a path of uploading the notebook to an online lab environment or create a Python environment on your own machine and install Qiskit.

2

Join the SQCM Discord. Network with others, to see what they're interested in.

Find the Discord invite link under the About tab on: https://www.meetup.com/seattle-quantum-computing-meetup/

3

Read through the Hackathon Prompts, if that path interests you, or brainstorm on a topic of your own choice.

4

Try out the board game Entanglion, created by IBM Quantum Researchers, or the digital QC game, Qpong, created by Junye Huang, Technical Integrations Engineer at IBM Quantum.

https://kirais.itch.io/qpong

Thanks for Joining the SQCM Qiskit Fall Fest!!

IBM **Quantum**

'Quantum' should

Seattle Quantum
Computing Meetup
—
Knowledge Share, Network

Century of Quantum

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