

The Era of Quantum Utility

IBM Quantum

Ginés Carrascal de las Heras

IBM Quantum Computational Scientist



**Financiado por
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SECRETARÍA DE ESTADO
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E INTELIGENCIA ARTIFICIAL



**Plan de
Recuperación,
Transformación
y Resiliencia**



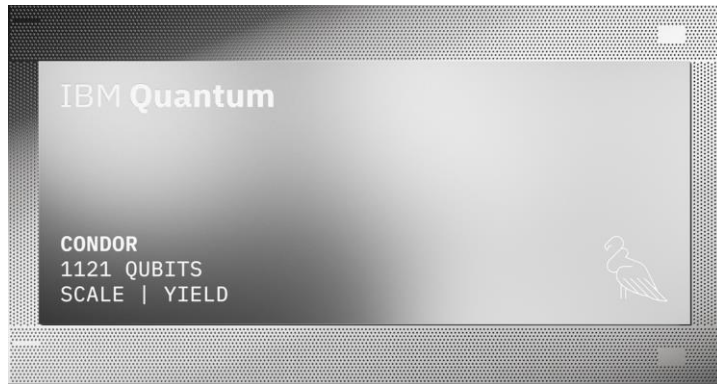
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Quantum Summit 2023 announcements

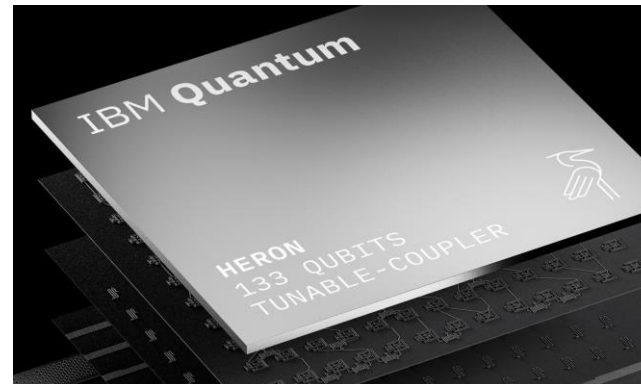
Condor

- 1,121-qubit processor
- 50% increase in qubit density
- 1 mile+ of flex cabling



Heron

- 133-qubit processor
- Tunable coupler architecture



IBM Quantum System Two



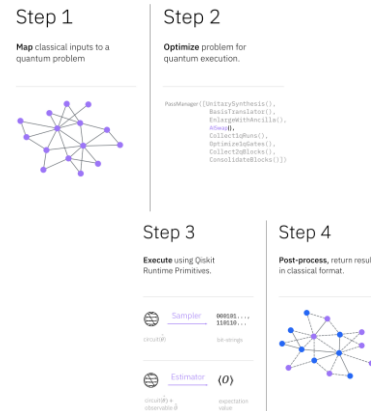
Quantum Summit 2023 announcements

Qiskit 1.0 (Feb 2024)

- 55% decrease in memory usage
- 16x faster binding & Transpiling
- 23% fewer 2Q gates

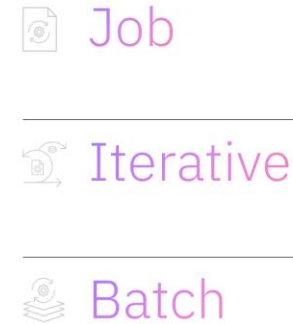
Qiskit
1.0

Qiskit Patterns & Quantum Serverless



Execution Modes

- Yields a 5x improvement in execution time.



AI Transpilation Alpha & Generative AI for watsonx

- ```
graph TD; 01[01 Code assistant] --- 02[02 Optimize circuits]; 01 --- 03[03 Resource Management]; 02 --- 04[04 Minimize errors]; 03 --- 04;
```

01 Code assistant

02 Optimize circuits

03 Resource Management

04 Minimize errors

Quantum Summit 2023 announcements (cont'd)

Quantum Utility scale use cases

- Demonstration of utility-scale quantum computing use cases

Simulating large-size quantum spin chains on cloud-based superconducting quantum computers

102 qubits / 3186 CX gates

arXiv:2207.09994

Uncovering local integrability in quantum many-body dynamics

124 qubits / 2641 CX gates

arXiv:2307.07552

Realizing the Nishimori transition across the error threshold for constant-depth quantum circuits

125 qubits / 429 gates + meas.

arXiv:2309.02863

Scalable circuits for preparing ground states on digital quantum computers: The Schwinger model vacuum on 100 qubits

100 qubits / 788 CX gates

arXiv:2308.04481

Efficient long-range entanglement using dynamic circuits

101 qubits / 504 gates + meas.

arXiv:2308.13065

Updating access plans to utility-scale

Open, Pay-Go, Premium



Quantum Accelerator v3.0

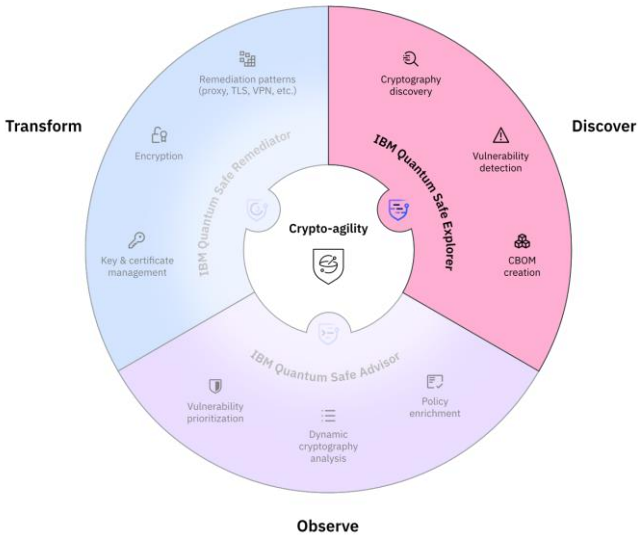
- Utility-scale access to systems  
Network benefits and support

Offering Evolution

| QA 1.0                                                                                                                                              | QA 2.0                                                                                                                                                                     | QA 3.0                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| A single offering to prepare you for quantum advantage through business readiness, education and technical skill building and premium system access | A single offering to prepare you for quantum advantage through joint hands-on proof of concept development for a selected use case to ensure adoption of quantum computing | A single offering to prepare you for quantum advantage through opportunity evaluation, utility demonstrations and enterprise workflow integration |
| 2021                                                                                                                                                | 2023                                                                                                                                                                       | 2024+                                                                                                                                             |

IBM Quantum Safe

- 1. Quantum Safe Explorer
- 2. Quantum Safe Advisor
- 3. Quantum Safe Remediator



**means** we're going to  
need a bigger roadmap



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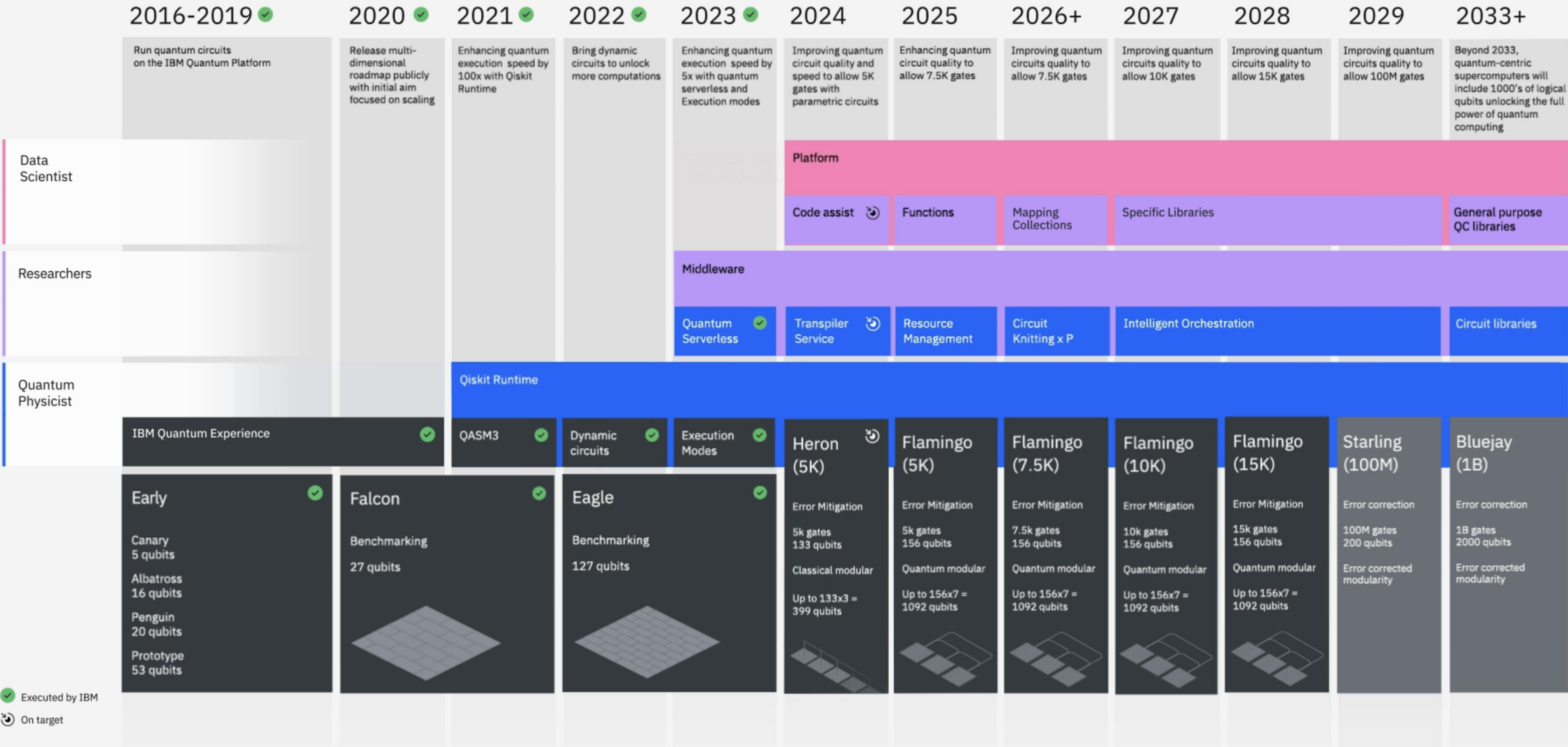


Development Roadmap

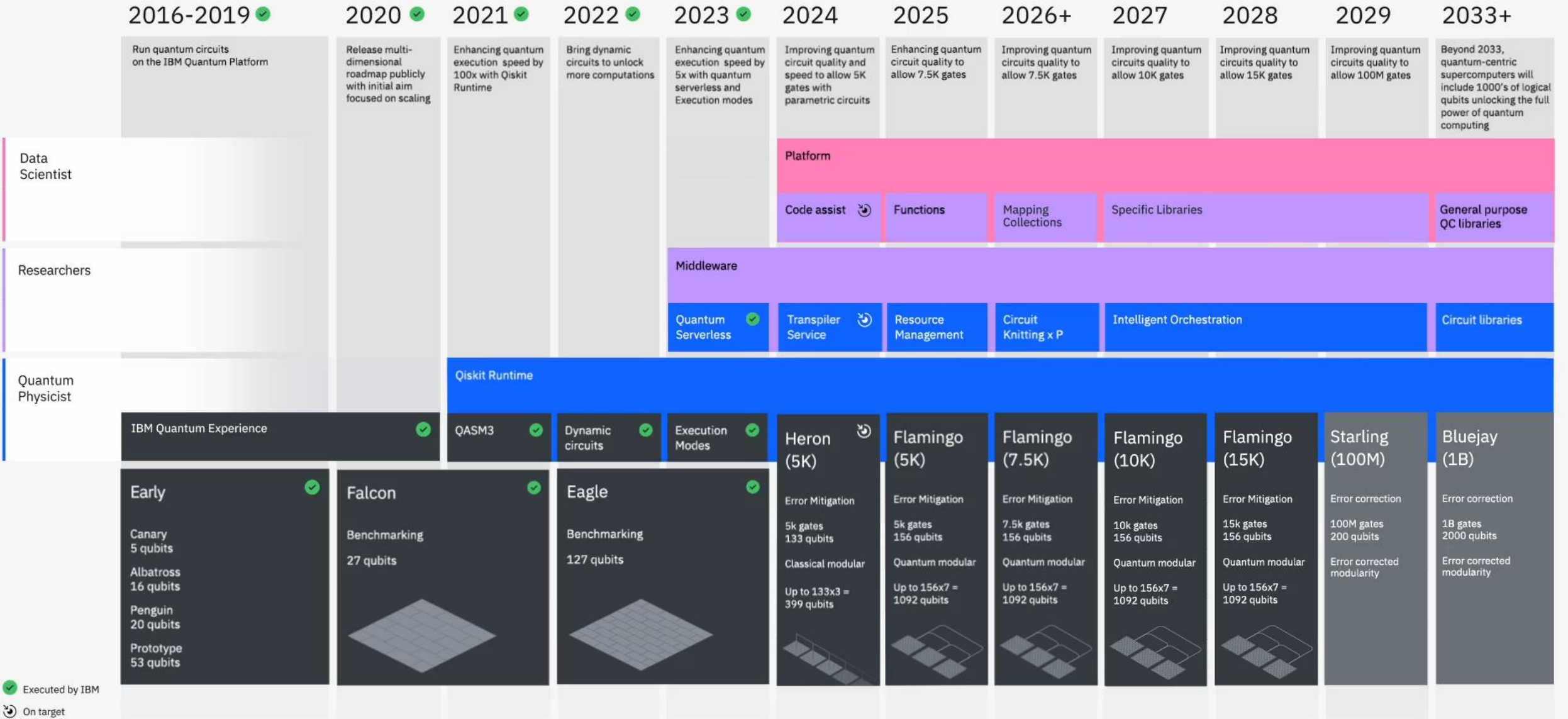
|                   | 2019                                  | 2020                                                          | 2021                                                 | 2022                                                                 | 2023                                                                                | 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 |
| Data Scientist    |                                       |                                                               |                                                      |                                                                      | Prototype quantum software functions                                                | Quantum software applications                                     |                                                                                     |                                                                                                           |
|                   |                                       |                                                               |                                                      |                                                                      |                                                                                     |                                                                   | Machine learning   Natural science   Optimization                                   |                                                                                                           |
| Researchers       |                                       | Quantum algorithm & application modules                       |                                                      |                                                                      | Middleware for Quantum                                                              |                                                                   |                                                                                     |                                                                                                           |
|                   |                                       | Machine learning   Natural science   Optimization             |                                                      |                                                                      | Quantum Serverless                                                                  | Intelligent orchestration                                         | Circuit Knitting Toolbox                                                            | Circuit libraries                                                                                         |
| Quantum Physicist | Circuits                              |                                                               | Qiskit Runtime                                       |                                                                      |                                                                                     |                                                                   |                                                                                     |                                                                                                           |
|                   |                                       |                                                               | QSAM3                                                | Dynamic circuits                                                     | Execution Modes                                                                     | Error suppression and mitigation                                  |                                                                                     | Error correction                                                                                          |
|                   | Falcon<br>27 qubits                   | Hummingbird<br>65 qubits                                      | Eagle<br>127 qubits                                  | Osprey<br>433 qubits                                                 | Condor<br>1,121 qubits                                                              | Flamingo<br>1,386+ qubits                                         | Kookaburra<br>4,158+ qubits                                                         | Scaling to 10K-100K qubits with classical and quantum communication                                       |
|                   |                                       |                                                               |                                                      |                                                                      | Heron<br>133 qubits x p                                                             | Crossbill<br>408 qubits                                           |                                                                                     |                                                                                                           |



Development Roadmap



Development Roadmap





Flamingo  
(5K)

Error Mitigation

10k gates  
156 qubits

Quantum modular

Up to  $156 \times 7 = 1092$  qubits



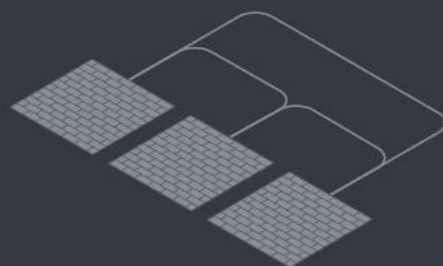
Flamingo  
(10K)

Error Mitigation

10k gates  
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Quantum modular

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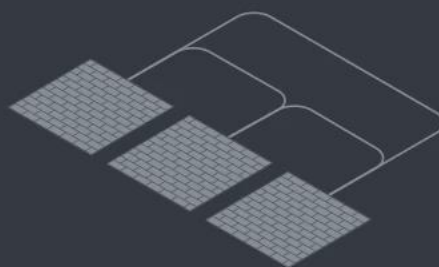
Flamingo  
(15K)

Error Mitigation

15k gates  
156 qubits

Quantum modular

Up to  $156 \times 7 = 1092$  qubits



Starling  
(100M)

Error correction

100M gates  
200 qubits

Error corrected  
modularity

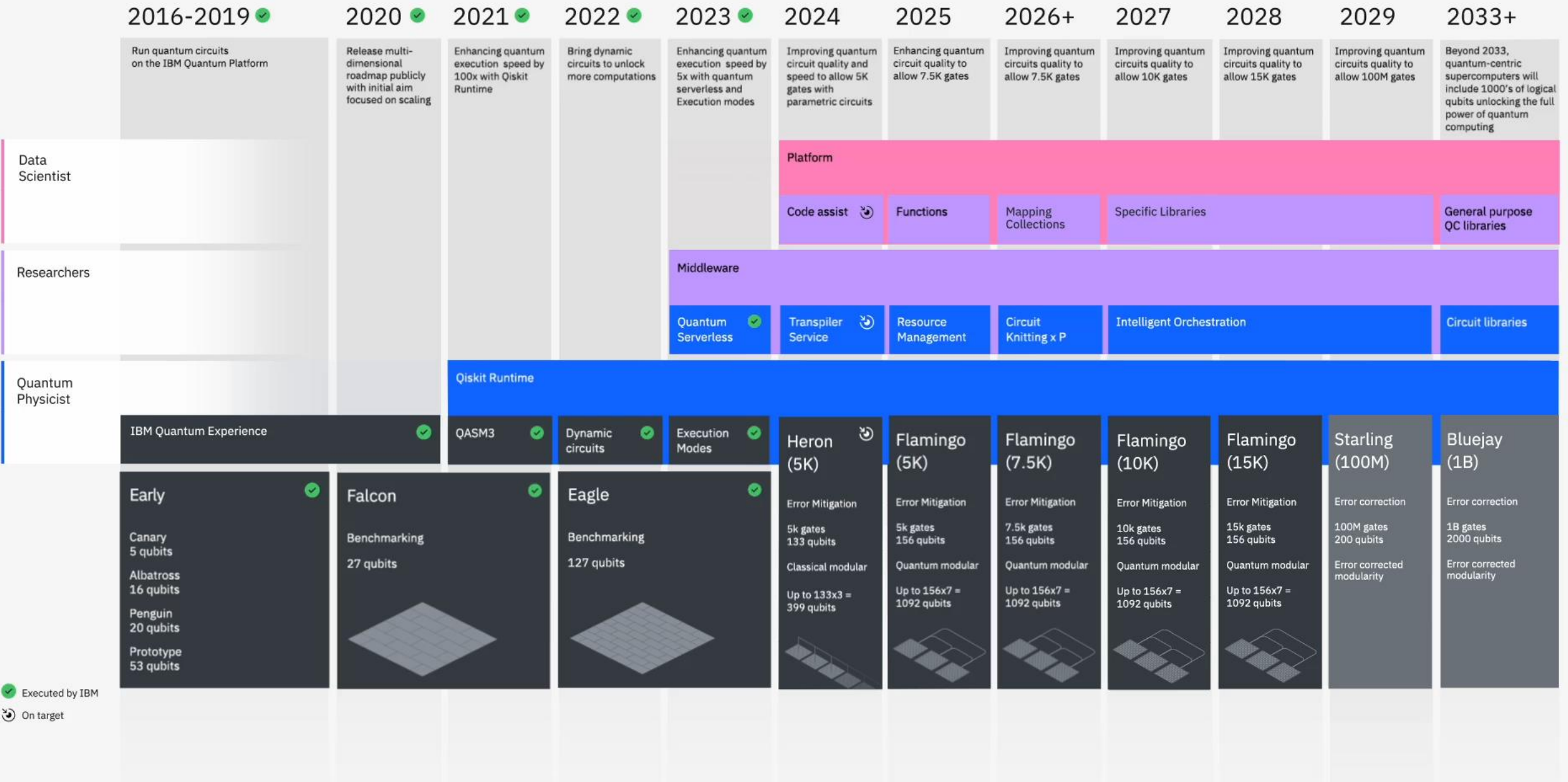
Bluejay  
(1B)

Error correction

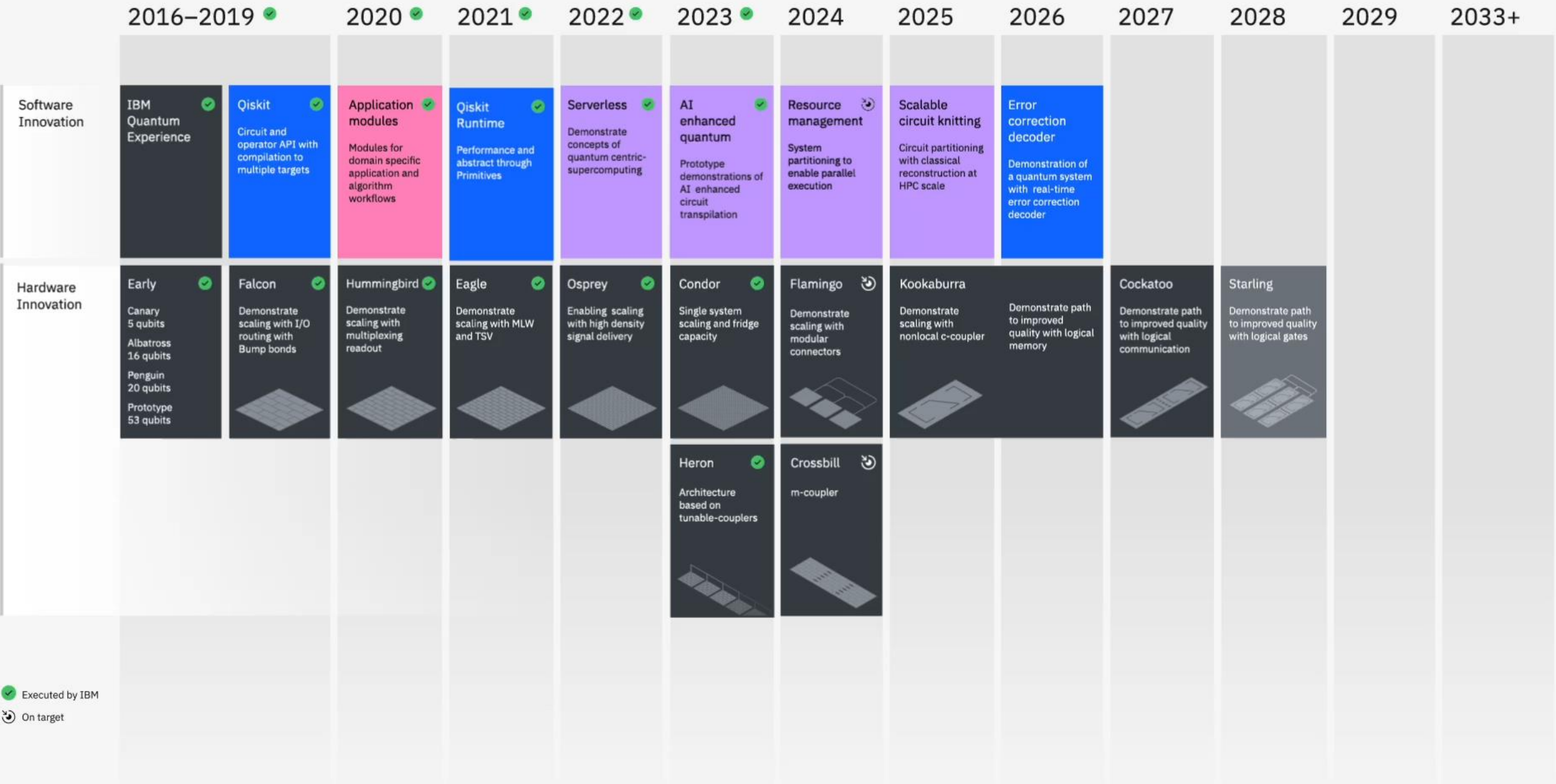
1B gates  
2000 qubits

Error corrected  
modularity

Development Roadmap



Innovation Roadmap





[www.ceste.es](http://www.ceste.es)