22/04/2024

UTFPR

SEMANA ACADÊMICA DE INFORMÁTICA

Como Programar um Computador Quântico

Tecnologias Quânticas

- **Computação quântica**
- Comunicação quântica
- Sensores quânticos
- Simulação quântica

Relacionados

- Criptografia pós-quântica
- Computação inspirada

Fonte da image: IBM

Computadores Quânticos Hoje

Article | Published: 23 October 2019

Quantum supremacy using a programmable superconducting processor

Frank Arute, Kunal Arya, Ryan Babbush, Dave Bacon, Joseph C. Bardin, Rami Barends, Rupak Biswas, Sergio Boixo, Fernando G. S. L. Brandao, David A. Buell, Brian Burkett, Yu Chen, Zijun Chen, Ben Chiaro, Roberto Collins, William Courtney, Andrew Dunsworth, Edward Farhi, Brooks Foxen, Austin Fowler, Craig Gidney, Marissa Giustina, Rob Graff, Keith Guerin, … John M. Martinis + Show authors

Nature **574**, 505–510 (2019) | Cite this article

1.00m Accesses | **3295** Citations | **6319** Altmetric | Metrics

Google - 53 Qubits

Article | Open Access | Published: 01 June 2022

Quantum computational advantage with a programmable photonic processor

Lars S. Madsen, Fabian Laudenbach, Mohsen Falamarzi. Askarani, Fabien Rortais, Trevor Vincent, Jacob F. F. Bulmer, Filippo M. Miatto, Leonhard Neuhaus, Lukas G. Helt, Matthew J. Collins, Adriana E. Lita, Thomas Gerrits, Sae Woo Nam, Varun D. Vaidya, Matteo Menotti, Ish Dhand, Zachary Vernon, Nicolás Quesada & Jonathan Lavoie

Nature **606**, 75–81 (2022) | Cite this article

111k Accesses | **146** Citations | **1279** Altmetric | Metrics

Xanadu - 125 Photons

REPORT

Quantum computational advantage using photons

HAN-SEN ZHONG, HUI WANG, YU-HAO DENG, MING-CHENG CHEN, LI-CHAO PENG, YI-HAN LUO, JIAN QIN, DIAN WU, XING DING, [...], AND JIAN-WEI PAN +14 authors Authors Info & Affiliations

SCIENCE • 3 Dec 2020 • Vol 370, Issue 6523 • pp. 1460-1463 • DOI: 10.1126/science.abe8770

22,683 761

USTC - 76 Photons

Featured in Physics Editors' Suggestion

Strong Quantum Computational Advantage Using a Superconducting Quantum Processor

Yulin Wu *et al.*
Phys. Rev. Lett. **127**, 180501 – Published 25 October 2021

Physics See Viewpoint: Quantum Leap for Quantum Primacy

895 More

Article | References | Citing Articles (311) | Supplemental Material | PDF | HTML | Export Citation

USTC - 56 Qubits

Featured in Physics Editors' Suggestion

Phase-Programmable Gaussian Boson Sampling Using Stimulated Squeezed Light

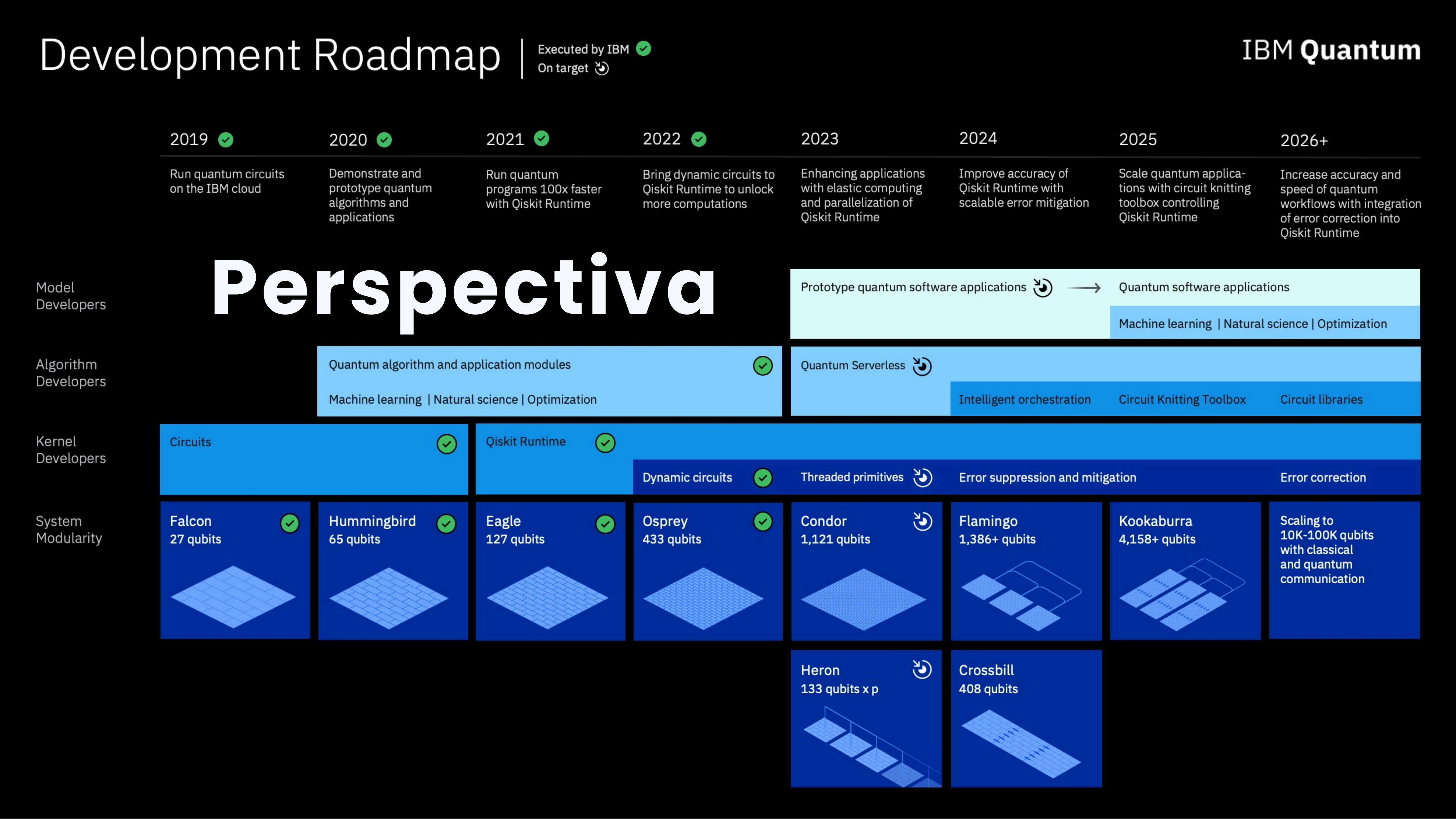
Han-Sen Zhong *et al.*
Phys. Rev. Lett. **127**, 180502 – Published 25 October 2021

Physics See Viewpoint: Quantum Leap for Quantum Primacy

410 More

Article | References | Citing Articles (150) | Supplemental Material | PDF | HTML | Export Citation

USTC - 113 Photons



Development Roadmap
Executed by IBM
On target
IBM Quantum
Perspectiva
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 applica-tions 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

algorithms that harness these indicators to estimate a person's 'biological age', which can be higher or lower than their chronological age[3].

Another hallmark of ageing is a shift in the proteins that the body produces. To explore how organs age, Oh and his colleagues first analysed nearly 5,000 proteins in blood samples from 1,398 healthy adults. They identified about 850 proteins that originated mainly from a single organ and trained a machine-learning algorithm to predict a person's age on the basis of the levels of these proteins. They validated their model using blood samples from more than 4,000 other people.

The results showed that an organ's biological age is linked to disease risk. For example, roughly 2% of participants had accelerated heart ageing — that is, their levels of blood proteins relating to heart ageing differed substantially from those of other people of the same age. Having a prematurely old heart was linked to a 250% increased risk of heart failure, the authors found.

Marking time

Researchers have used epigenetic markers to show that the pace of organ ageing varies between individuals[4]. But the link between epigenetic changes and ageing is unclear, says Matt Kaeberlein, a specialist in the biology of

IBM RELEASES FIRST-EVER 1,000-QUBIT QUANTUM CHIP

The company will now focus on developing smaller, more reliable processors.

By Davide Castelvecchi

IBM has unveiled the first quantum computer with more than 1,000 qubits — the equivalent of the digital bits in an ordinary computer. But the company says that it will now shift gears and focus on making its machines more error-resistant rather than larger.

For years, IBM has been following a quantum-computing road map that roughly doubled the number of qubits every year. The chip unveiled on 4 December, called Condor, has 1,121 superconducting qubits arranged in a honeycomb pattern. It follows on from IBM's other record-setting, bird-named machines, including a 127-qubit chip called Eagle, released in 2021 and a 433-qubit one called Osprey, announced last year.

RYAN LAVINE FOR IBM

IBM's Heron quantum processor.

Precisamos de
+ Qubits e − Ruido

How to factor 2048 bit RSA integers in 8 hours using 20 million noisy qubits

Craig Gidney[1] and Martin Ekerå[2,3]

[1]Google Inc., Santa Barbara, California 93117, USA
[2]KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden
[3]Swedish NCSA, Swedish Armed Forces, SE-107 85 Stockholm, Sweden

Published:	2021-04-15, volume 5, page 433
Eprint:	arXiv:1905.09749v3
Doi:	https://doi.org/10.22331/q-2021-04-15-433
Citation:	Quantum 5, 433 (2021).

FORBES > INNOVATION

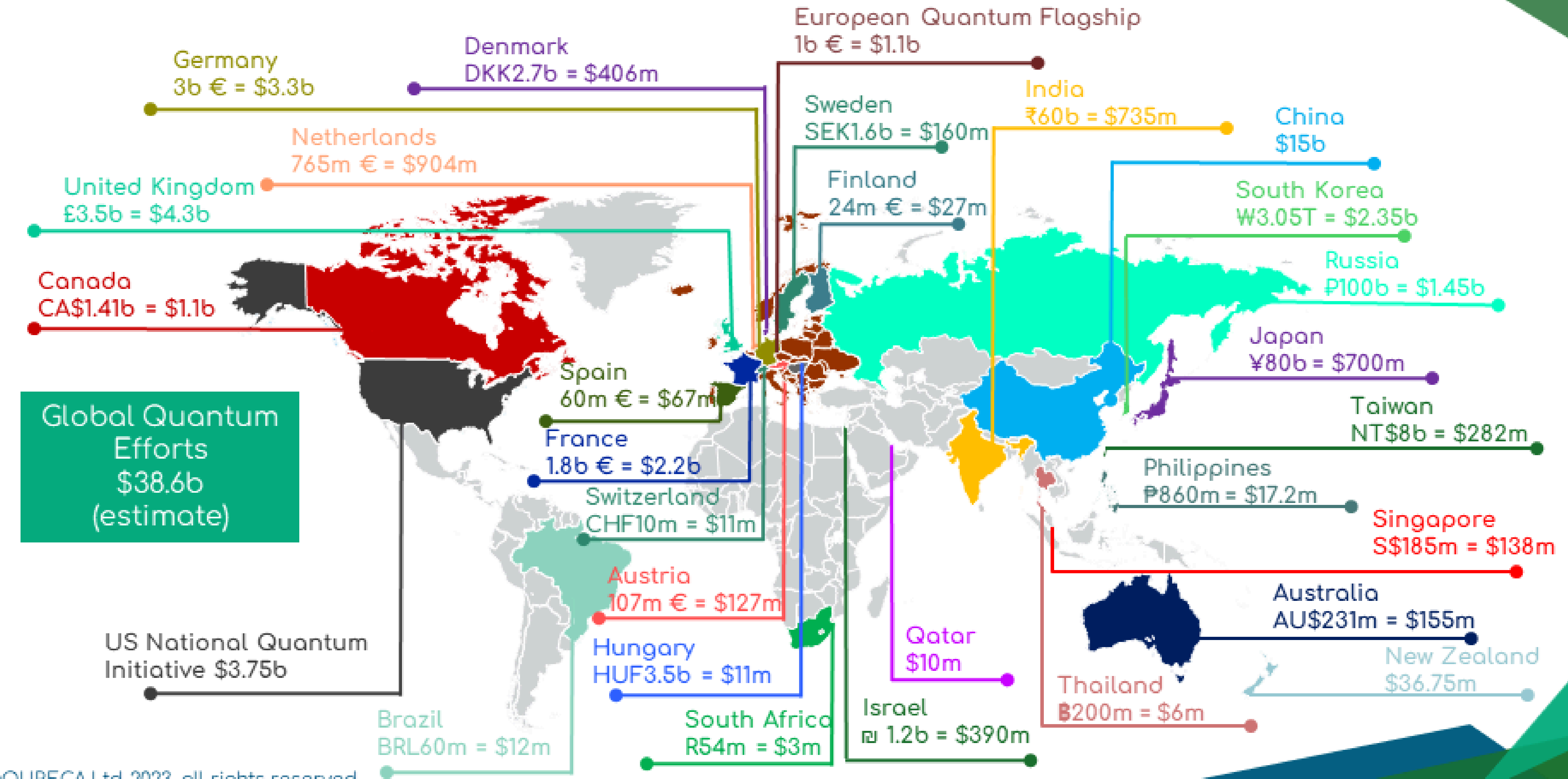
12 Industries And Focuses Set To Be Revolutionized By Quantum Computing

Expert Panel® Forbes Councils Member
Forbes Technology Council COUNCIL POST | Membership (Fee-Based)

Sep 30, 2022, 08:15am EDT

1. **Produtos Farmacêuticos**
2. Cibersegurança
3. Marketing e Publicidade
4. **Treinamento de IA**
5. **Serviços Financeiros**
6. **Logística**
7. Assistência Médica
8. Segurança Nacional
9. **Novos Materiais**
10. E-Sports/Jogos
11. Mercado Imobiliário
12. Petróleo e Gás

Quantum effort worldwide



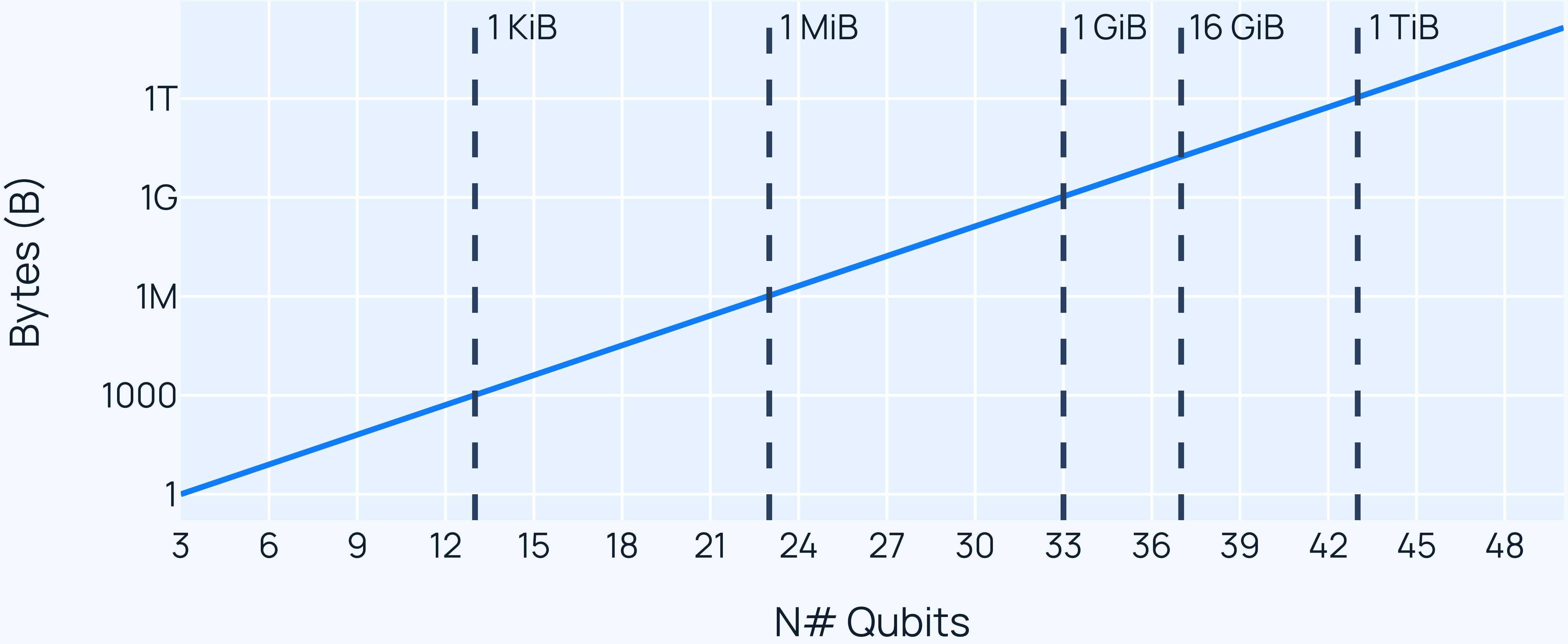
Características da Computação Quântica

Superposição ◇ Entrelaçamento ◇ Medida 👀

Artista Mark Ryde

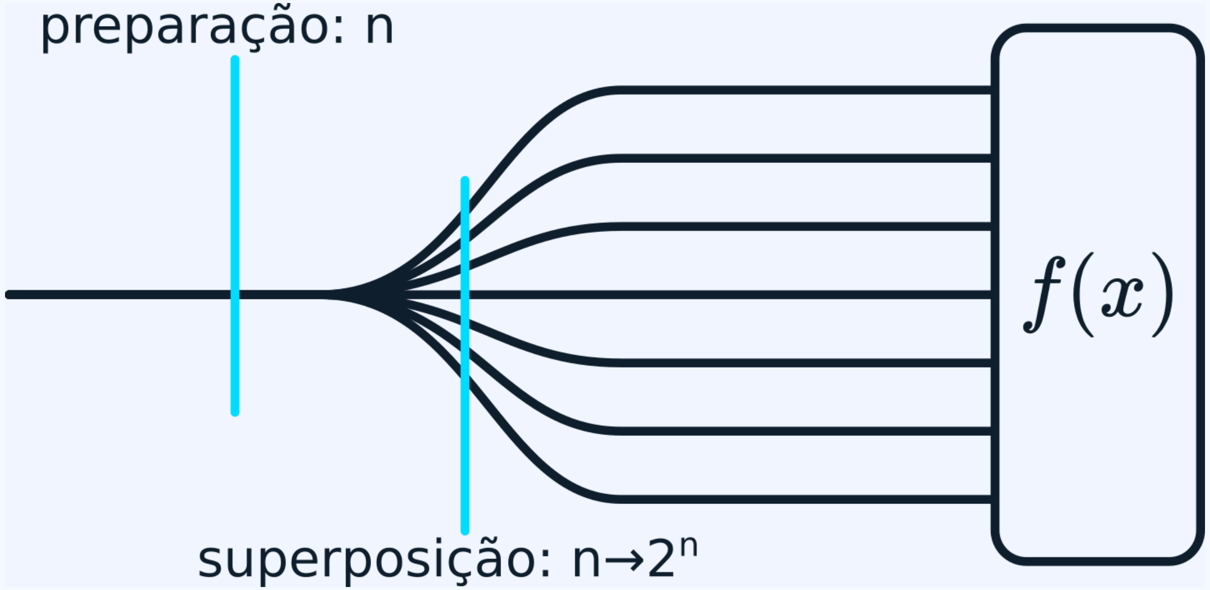
Bits por Qubits

Superposição



Entrelaçamento

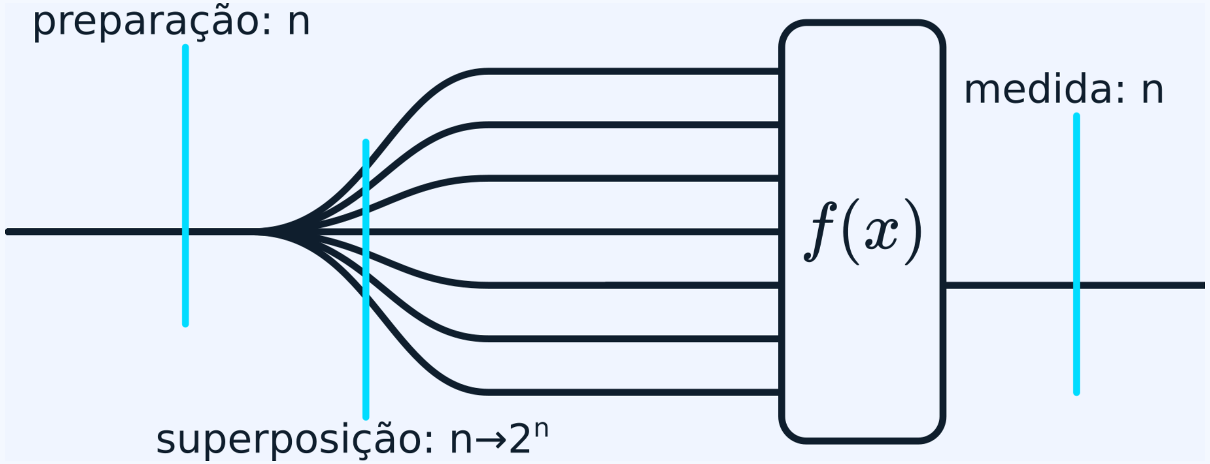
$$\sum_{x=0}^{2^n-1} \alpha_x |x\rangle|0\rangle \xrightarrow{U_f} \sum_{x=0}^{2^n-1} \alpha_x |x\rangle|f(x)\rangle$$



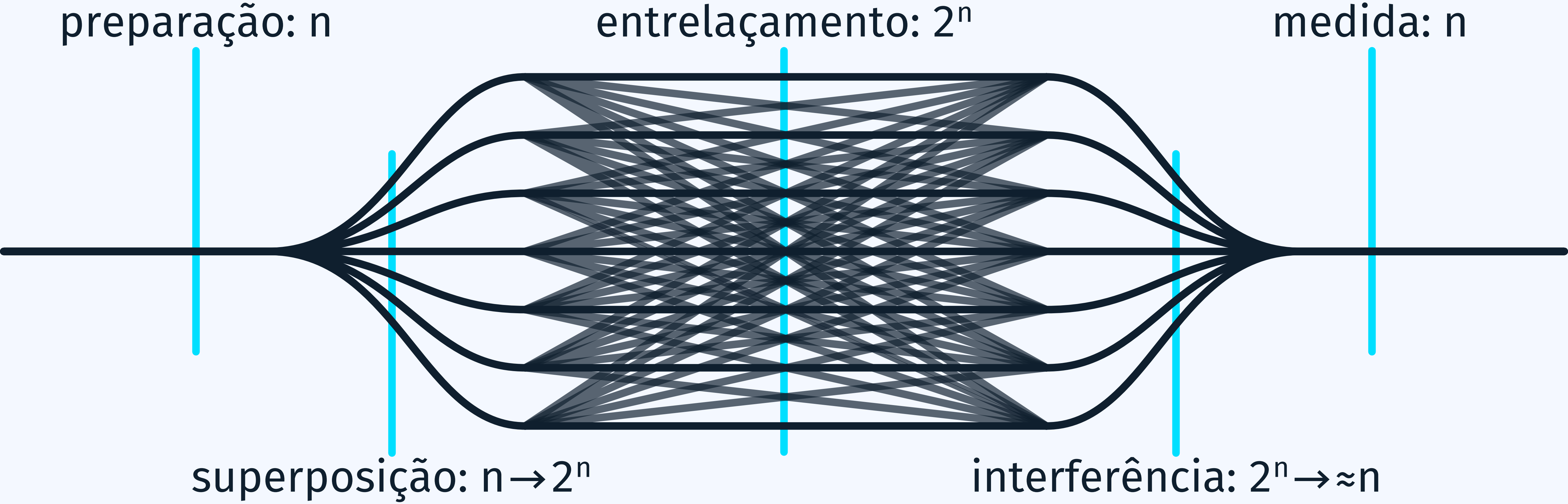
Paralelismo Quântico

Medida

$$\sum_{x=0}^{2^n-1} \alpha_x |x\rangle |f(x)\rangle \Rightarrow \sum_{x' \mid f(x')=y}^{2^n-1} \alpha_{x'} |x'\rangle |y\rangle$$



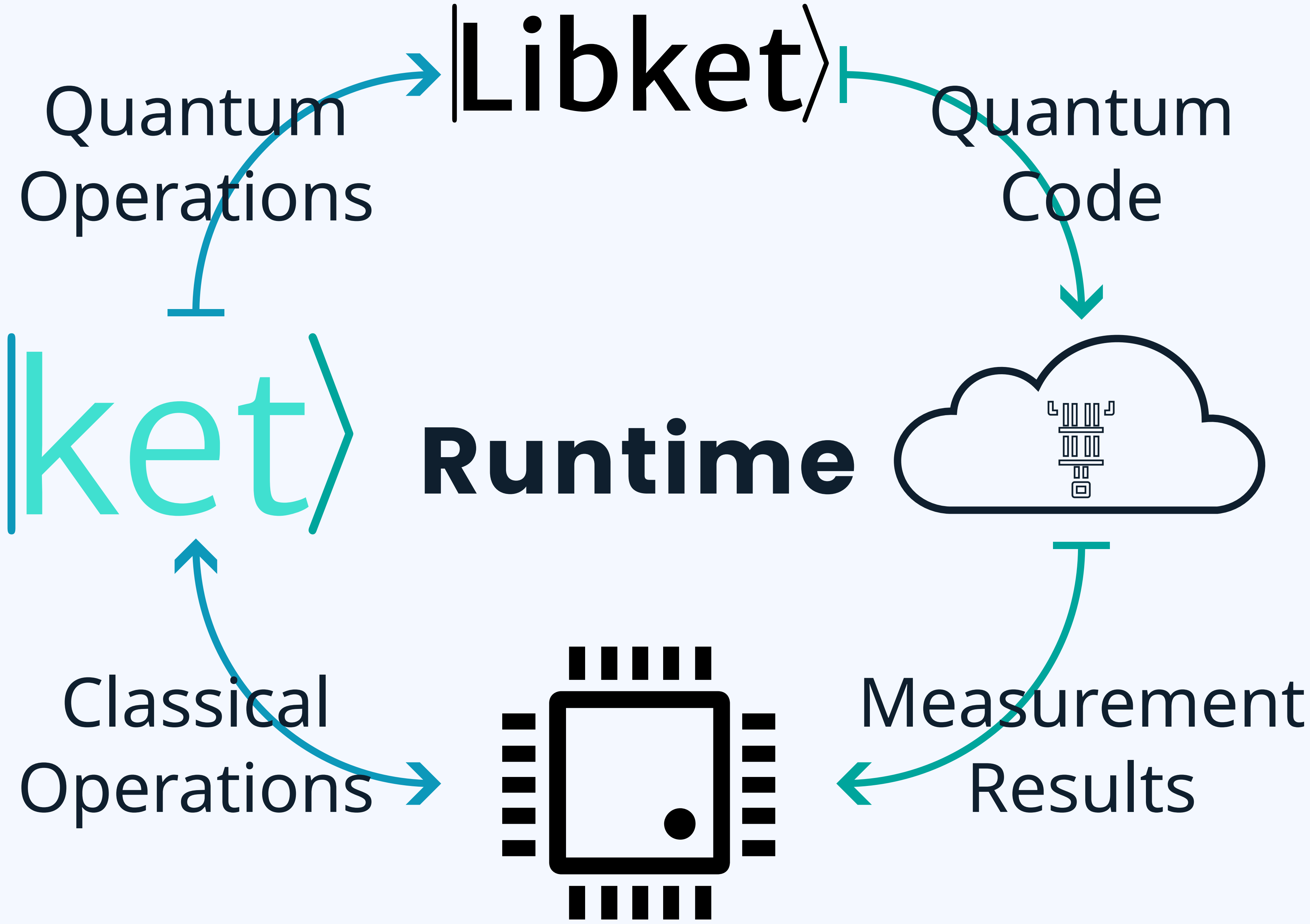
Algoritmo Quântico



|ket⟩

Plataforma da Programação Quântica

```
$ pip install ket-lang
```



|Libket⟩
Quantum Operations
Quantum Code
|ket⟩
Runtime
Classical Operations
Measurement Results

Superposição

```python
from ket import *

p = Process()

qubits = p.alloc(n)
H(qubits)
```

$$|0\cdots 0\rangle \xrightarrow{H^{\otimes n}} \sum_{k=0}^{2^n-1} \frac{1}{\sqrt{2^n}} |k\rangle$$

Entrelaçamento

```python
p = Process()

a, b = p.alloc(2)
H(a)
with control(a):
    X(b)
```

$$|0_a\rangle|0_b\rangle \xrightarrow{H_a} \frac{1}{\sqrt{2}}(|0_a\rangle + |1_a\rangle)|0_b\rangle$$

$$\xrightarrow{\text{CNOT}} \frac{1}{\sqrt{2}}(|0_a 0_b\rangle + |1_a 1_b\rangle)$$

Medida

```
>>> from ket import *
>>> p = Process()
>>> qubits = p.alloc(n)
>>> H(qubits)
>>> measure(qubits).value
14
```

$$\sum_{k=0}^{2^n-1} \frac{1}{\sqrt{2^n}} |k\rangle \Rightarrow p(k) = \frac{1}{2^n}$$

```
>>> p = Process()
>>> a, b = p.alloc(2)
>>> H(a)
>>> with control(a):
...     X(b)
...
>>> ma = measure(a)
>>> mb = measure(b)
>>> assert ma.value == mb.value
```

$$\frac{1}{\sqrt{2}}(|0_a0_b\rangle + |1_a1_b\rangle) \quad \Rightarrow \quad p(0_a0_b) = 0.5$$

$$\Rightarrow \quad p(1_a1_b) = 0.5$$

Simulador Quântico

Testar **aplicações quânticas** em um **computador clássico**

Ket Bitwise Simulator

Padrão do Ket (CPU)

Similador QuBOX–UFSC

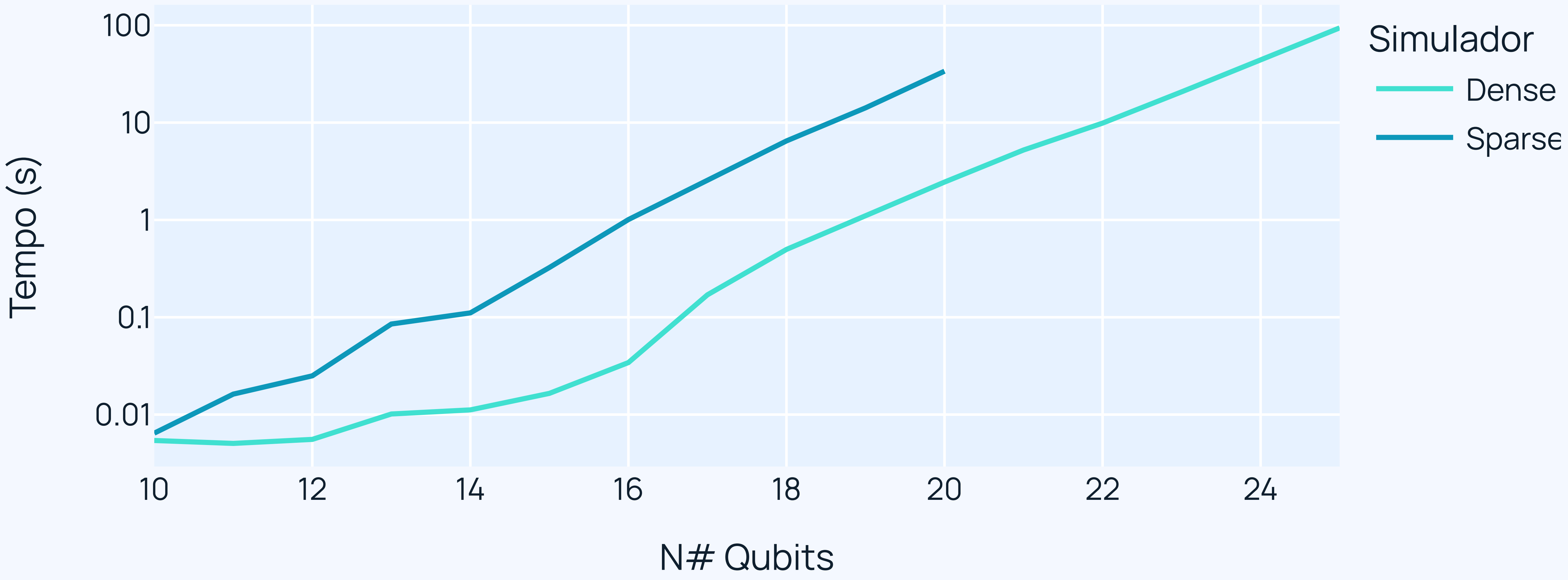
Acesso Remoto (GPU)

quantuloop

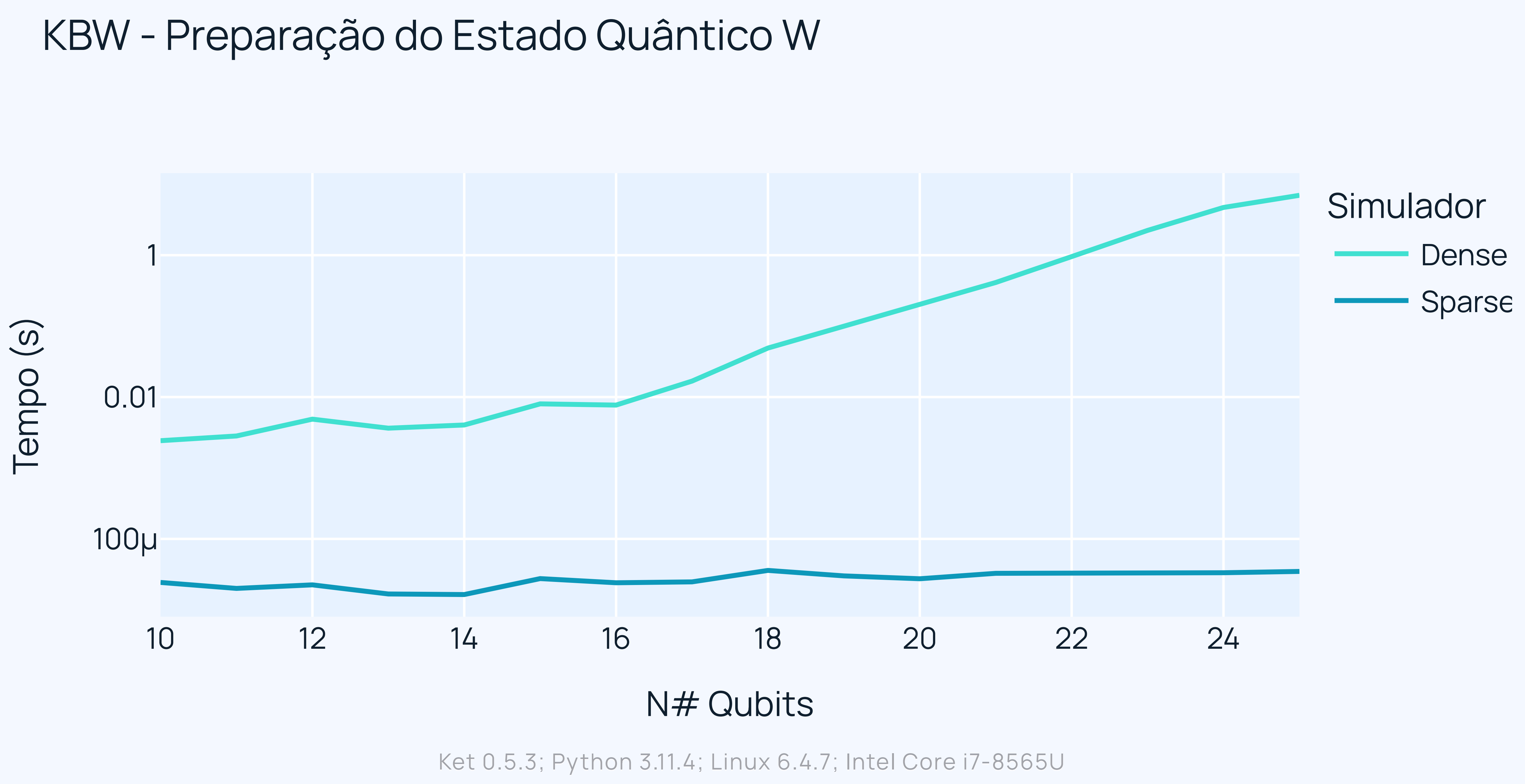
Quantum Simulator Suite for HPC

AWS Cloud ou Local (Multi GPU)

KBW - Algoritmo Quântico de Estimação de Fase

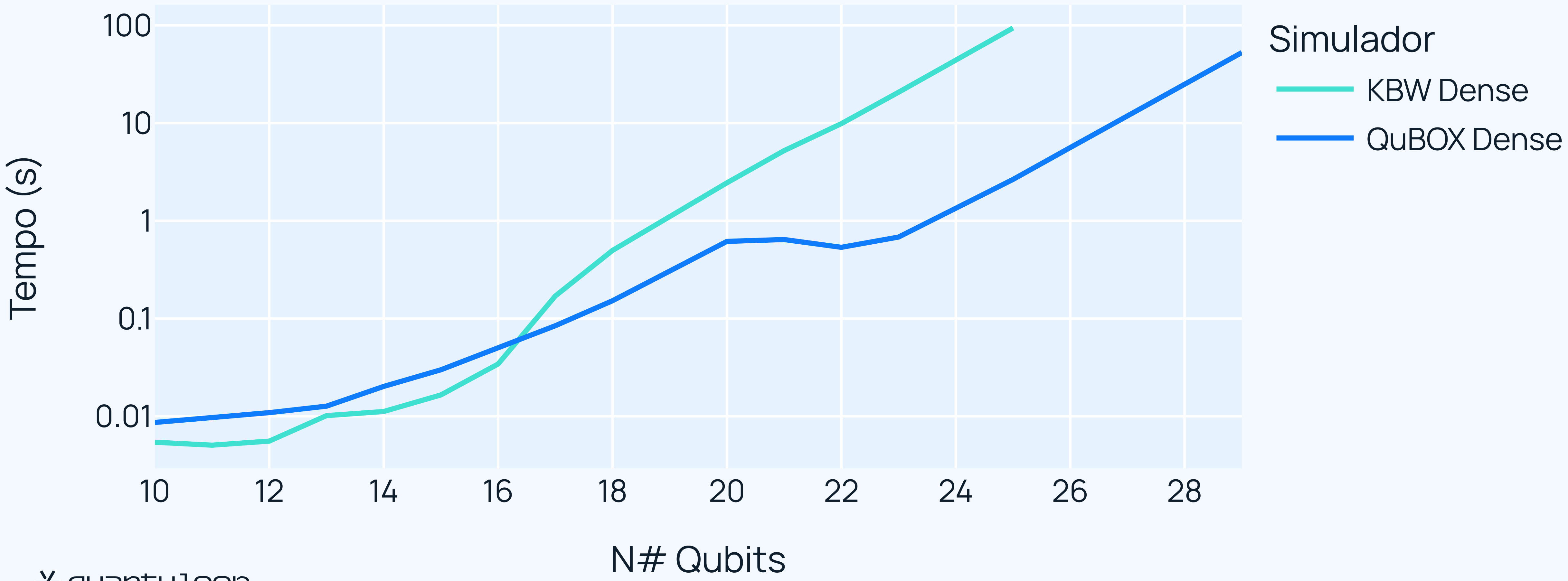


Ket 0.5.3; Python 3.11.4; Linux 6.4.7; Intel Core i7-8565U



KBW - Preparação do Estado Quântico W
Simulador
Dense
Sparse
Tempo (s)
1
0.01
100µ
10
12
14
16
18
20
22
24
N# Qubits
Ket 0.5.3; Python 3.11.4; Linux 6.4.7; Intel Core i7-8565U

KBW vs. QuBOX - Algoritmo Quântico de Estimação de Fase



quantuloop

Ket 0.5.3; Python 3.11.4; Linux 6.4.7; Intel Core i7-8565U

GCQ-UFSC

- QuBOX-UFSC
  https://qubox.ufsc.br
- Projeto Ket
  https://quantumket.org
- Curso: Computação Quântica I
  https://aprenda.quantumket.org
- Workshop de Computação Quântica
  https://workshop-cq.ufsc.br

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Projeto Computação Quântica na Região Sul do Brasil

UFSC ◇ UFSM ◇ UDESC ◇ UFPR ◇ SENAI(ISE-SE) quantuloop

QuBOX UFSC

WORLD QUANTUM DAY APRIL 14

Parallel Bitwise - Multi-GPU Simulator

SENAI CIMATEC HPC

IEEE QUANTUM WEEK

Tutorial presenter at IEEE International Conference on Quantum Computing and Engineering - QCE22

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Showcased in the NVIDIA Catalog

NVIDIA AI Accelerated

quantuloop Quantum Simulator Suite for HPC

awsmarketplace

aws Qualified Software

Featured in AWS Article

HPC wire

Quantuloop at AWS Booth

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12.2021 03.2022 09.2022 12.2022 04.2023 07.2023 11.2023

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SEMANA ACADÊMICA DE INFORMÁTICA

Introdução à Programação Quântica com Ket

Hoje as 21h20 na Sala Q201

Evandro Chagas Ribeiro da Rosa