



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. Brando, 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 Lovioie 

Nature 606, 75–81 (2022) | [Cite this article](#)

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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

Download 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

USTC - 56 Qubits



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

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

USTC - 113 Photons



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

Development Roadmap

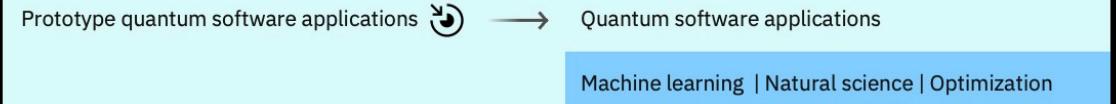
Executed by IBM ✓
On target ⏱

IBM Quantum

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

Perspectiva

Model Developers



Algorithm Developers

Quantum algorithm and application modules

Quantum Serverless

Machine learning | Natural science | Optimization

Intelligent orchestration

Circuit Knitting Toolbox

Circuit libraries

Kernel Developers

Circuits	Qiskit Runtime	Dynamic circuits	Threaded primitives	Error suppression and mitigation	Error correction
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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
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algorithms that harness these indicators to estimate a person's 'biological age', which can be higher or lower than their chronological age³.

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 individuals⁴. But the link between epigenetic changes and ageing is unclear, says Matt Kaeberlein, a specialist in the biology of

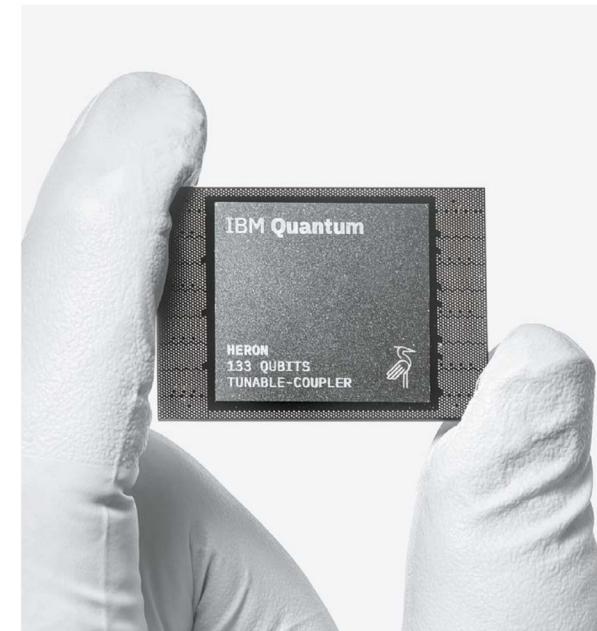
IBM RELEASES FIRST-EVER 1,000-QUBIT QUANTUM CHIP

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.



IBM's Heron quantum processor.

RYAN LAVINE FOR IBM

Precisamos de + Qubits e — Ruido

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

Craig Gidney¹ and Martin Ekerå^{2,3}

¹Google Inc., Santa Barbara, California 93117, USA

²KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden

³Swedish 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



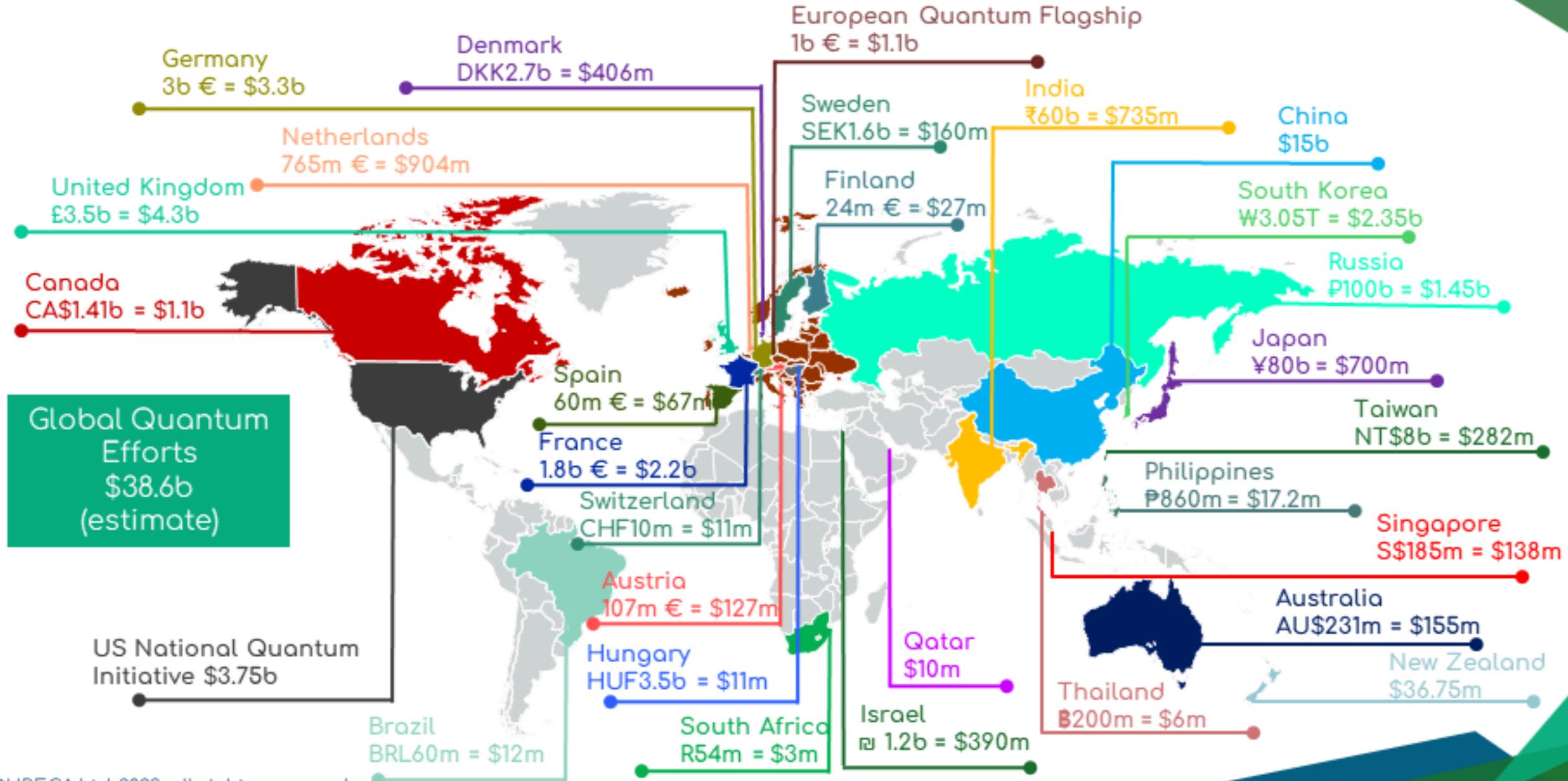
Expert Panel® Forbes Councils Member

Forbes Technology Council **COUNCIL POST** | Membership (Fee-Based)

Sep 30, 2022, 08:15am EDT

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8. Segurança Nacional
9. **Novos Materiais**
10. E-Sports/Jogos
11. Mercado Imobiliário
12. Petróleo e Gás

Quantum effort worldwide



Características da Computação Quântica

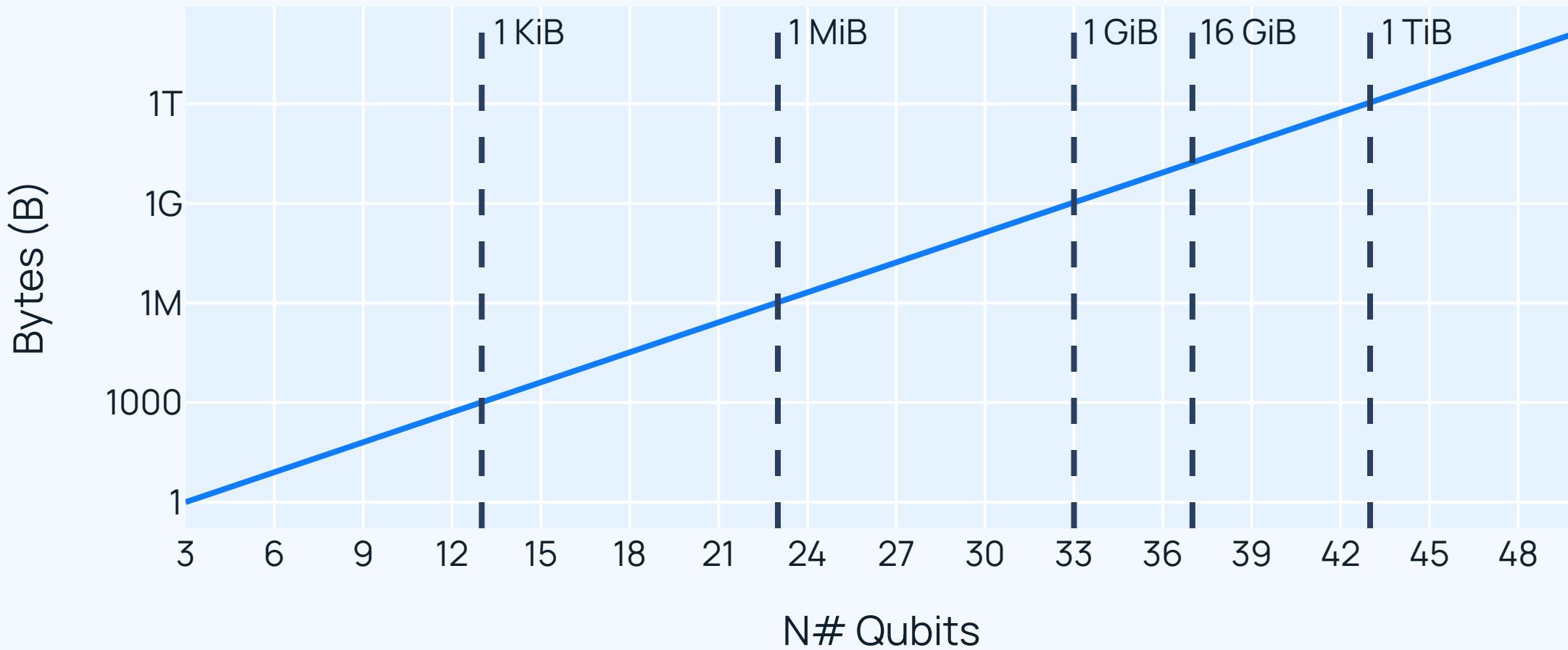


Superposição ◊ Entrelaçamento ◊ Medida 

Artista Mark Ryde

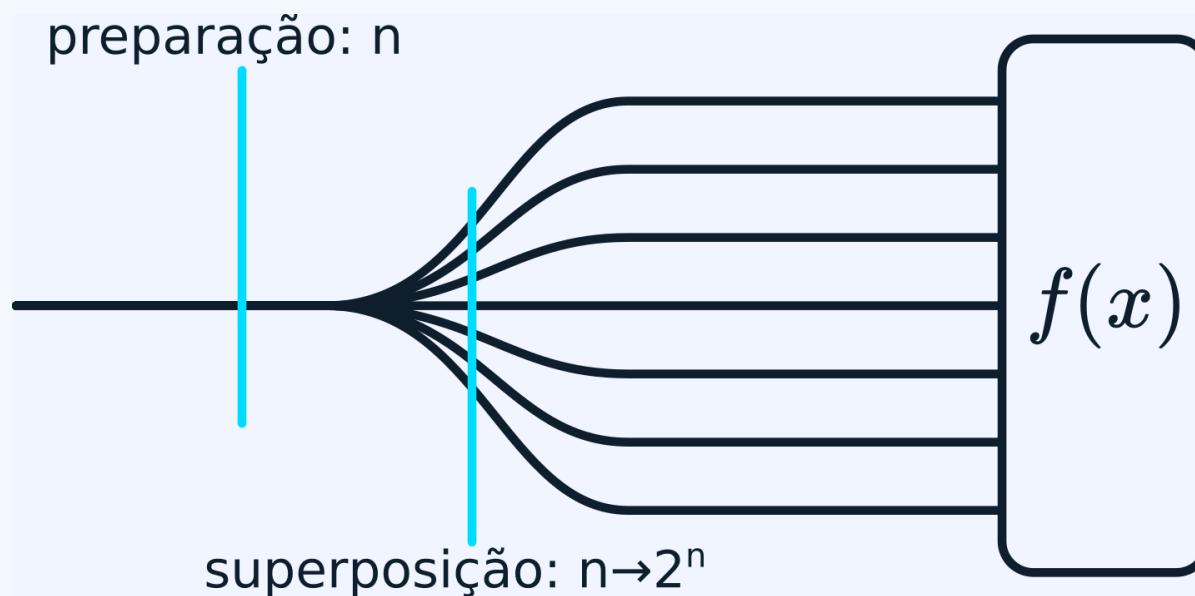
Bits por Qubits

Superposição



Entrelaçamento

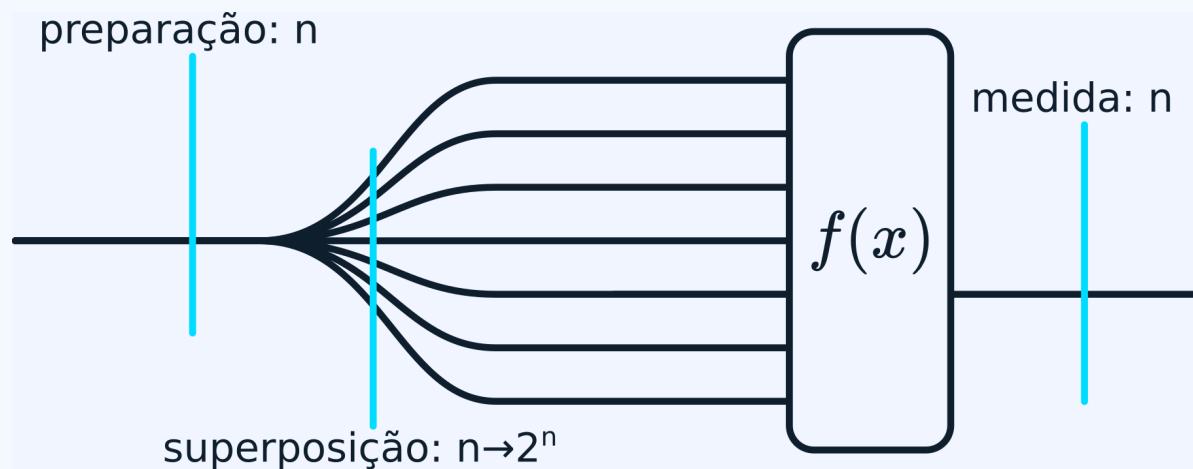
$$\sum_{x=0}^{2^n-1} \alpha_x |x\rangle |0\rangle \xrightarrow{U_f} \sum_{x=0}^{2^n-1} \alpha_x |x\rangle |f(x)\rangle$$



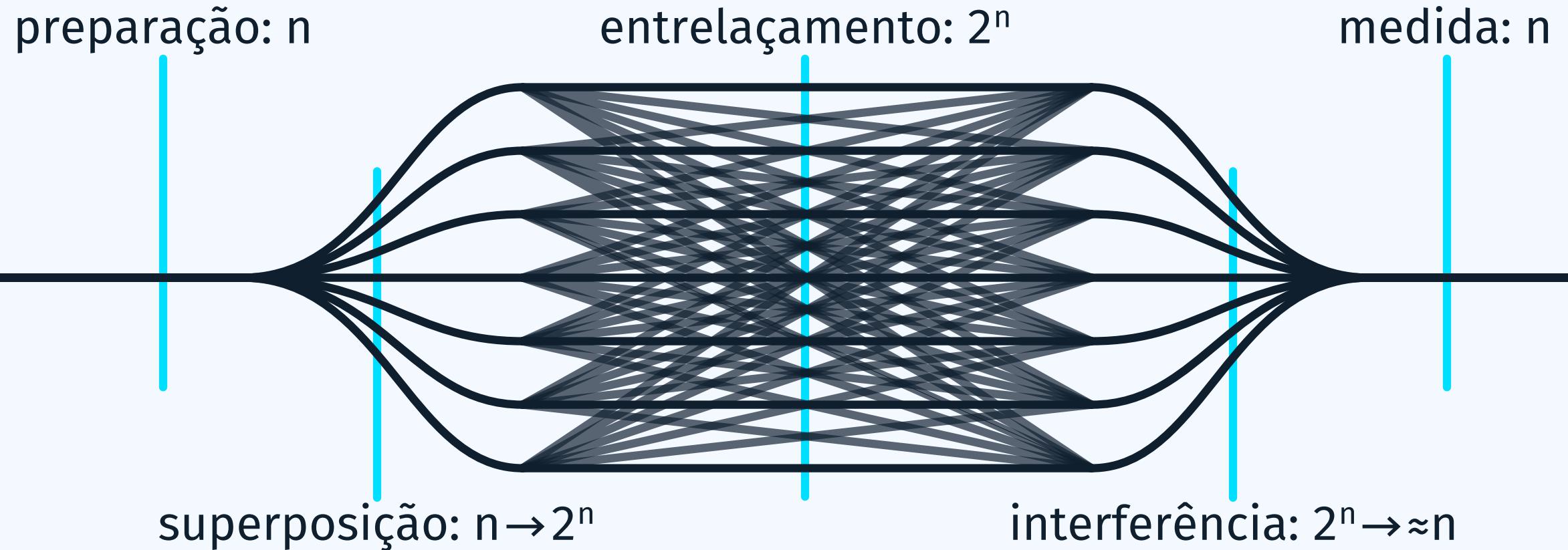
Paralelismo Quântico

Medida

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



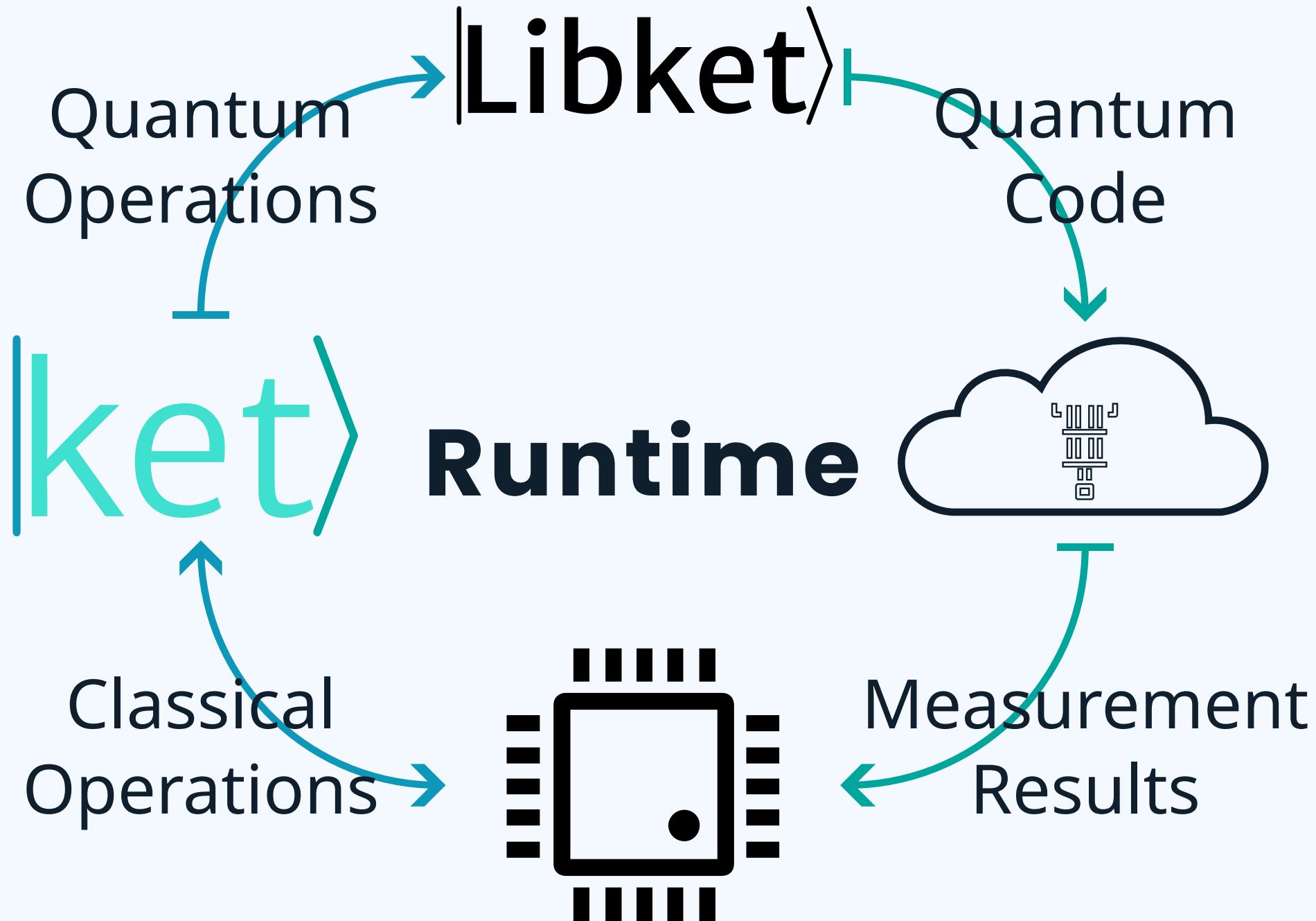
Algoritmo Quântico



`|ket>`

Plataforma da Programação Quântica

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



Superposição

```
from ket import *

p = Process()

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

Entrelaçamento

```
p = Process()

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

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

$$\begin{aligned} |0_a\rangle|0_b\rangle &\xrightarrow{H_a} \frac{1}{\sqrt{2}}(|0_a\rangle + |1_a\rangle)|0_b\rangle \\ &\xrightarrow{\text{CNOT}} \frac{1}{\sqrt{2}}(|0_a0_b\rangle + |1_a1_b\rangle) \end{aligned}$$

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
```

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

Simulador Quântico

Testar aplicações quânticas em
um computador clássico

Ket Bitwise Simulator

```
01001011 01100101 01110100  
00100000 01000010 01101001  
01110100 01110111 01101001  
01110011 01100101 00100000  
01010011 01101001 01101101  
01110101 01101100 01100001  
01110100 01101111 01110010
```

Padrão do Ket (CPU)

Similador QuBOX–UFSC

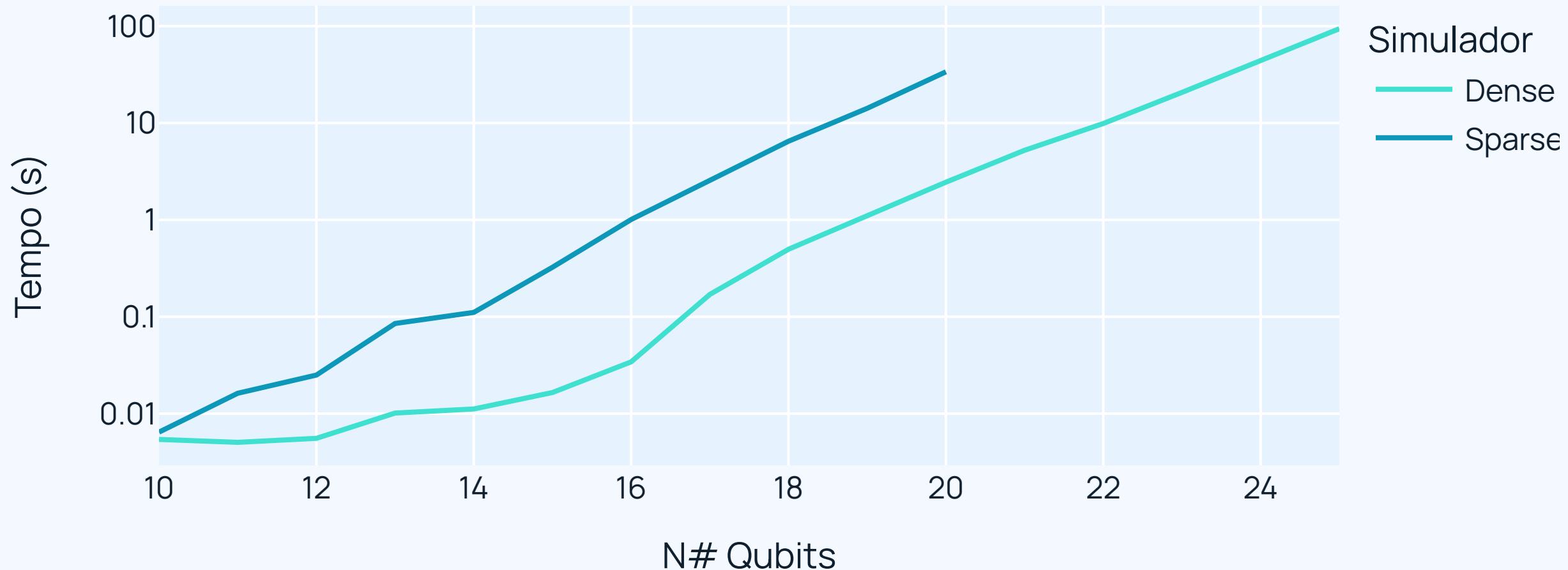


Acesso Remoto (GPU)

 **quantuloop**
Quantum Simulator Suite for HPC

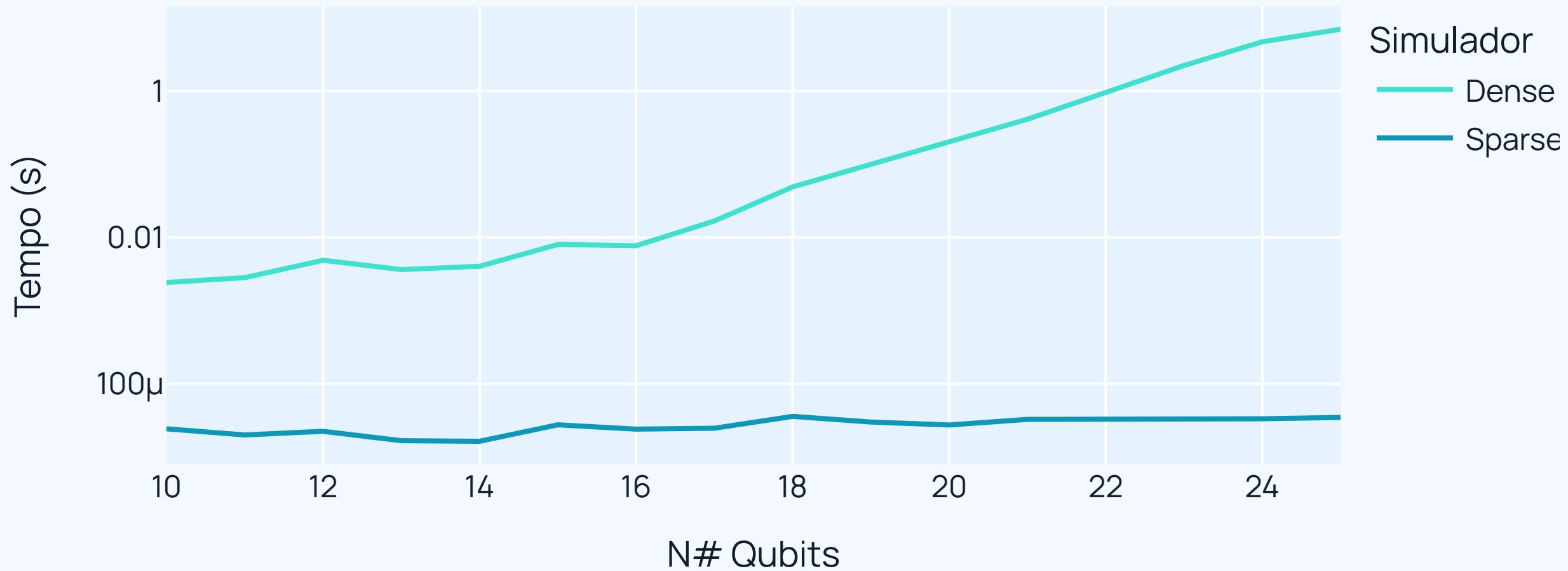
AWS Cloud ou Local (Multi GPU)

KBW - Algoritmo Quântico de Estimação de Fase



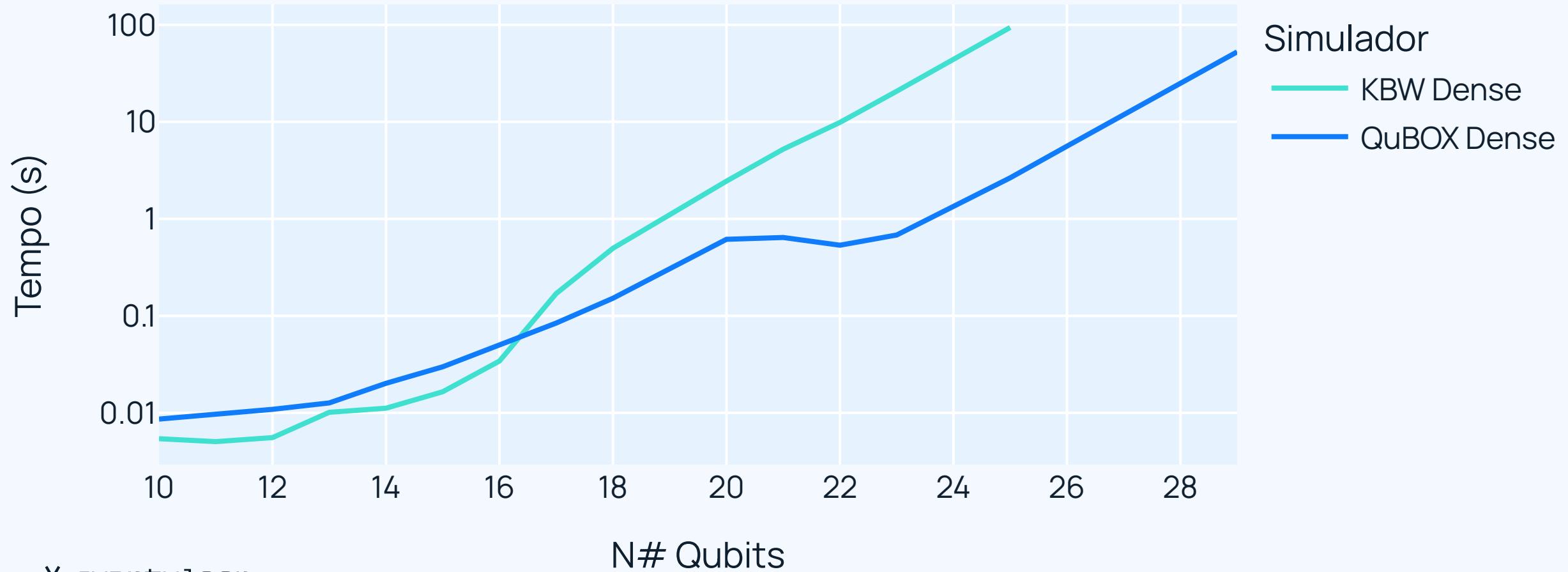
Ket 0.5.3; Python 3.11.4; Linux 6.4.7; Intel Core i7-8565U

KBW - Preparação do Estado Quântico W



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



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>

@gcq_ufsc

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Tube @gcqufsc

Projeto Computação Quântica na Região Sul do Brasil



UFSC ◊ UFSM ◊ UDESC ◊ UFPR ◊ SENAI(ISE-SE)



Parallel Bitwise - Multi-GPU Simulator



12.2021 03.2022 09.2022 12.2022 04.2023 07.2023 11.2023



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



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Introdução à Programação Quântica com Ket

Hoje as 21h20 na Sala Q201

Evandro Chagas Ribeiro da Rosa