



ELTE Informatikai Kar

Piquasso: fotonikus kvantumszámítások
hatékony szimulációja

Kvantuminformatika Nemzeti Laboratórium (2021.11.09.)

Kozsik Tamás (kto@elte.hu)

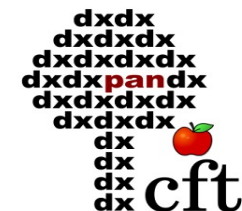




PIQUASSO



PIQUASSO



Piquasso

- Lineáris optikai szimulátor
- Univerzális optikai kvantumszámítógép szimulátora
- Gaussi bozonikus mintavételezés

Article | Published: 23 October 2019

Quantum supremacy using a programmable superconducting processor

Frank Arute, Kunal Arya, [...] John M. Martinis 

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

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Abstract

The promise of quantum computers is that certain computational tasks might be executed exponentially

Article | Published: 23 October 2019

Quantum supremacy using a programmable superconducting processor

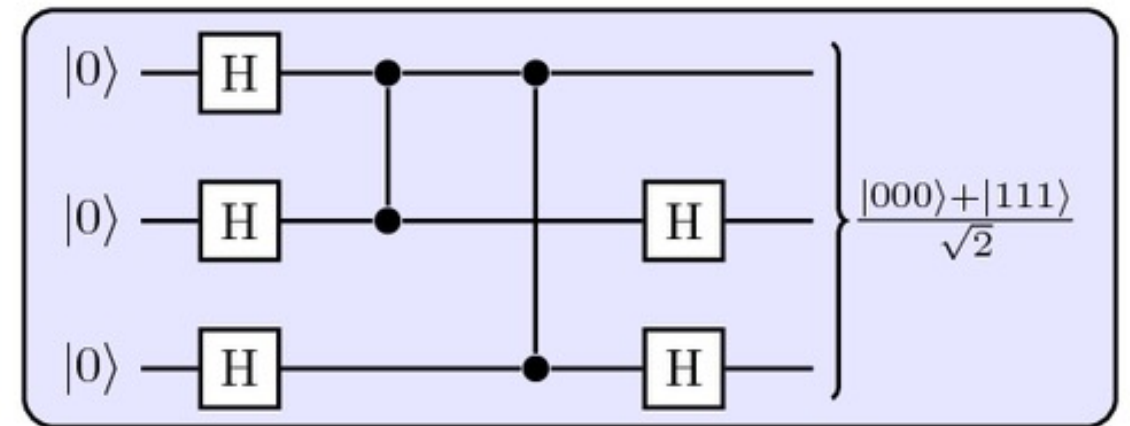
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Abstract

The promise of quantum computers is that certain computational tasks might be executed exponentially





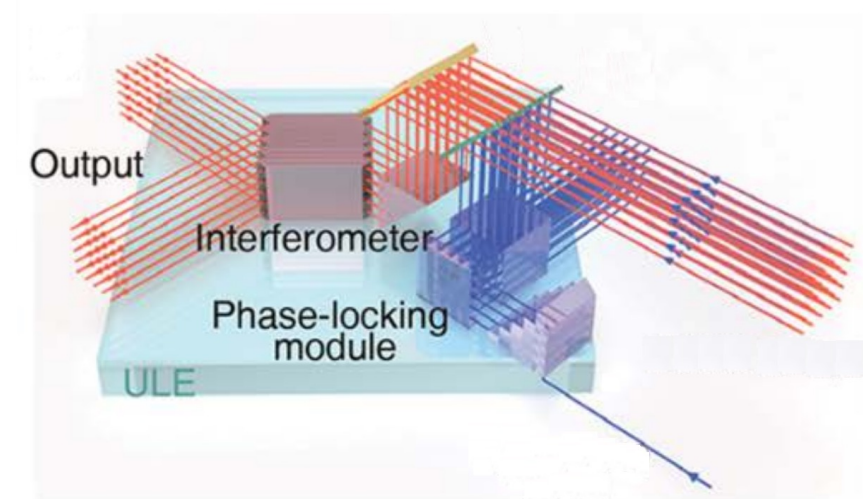
中国科学技术大学
University of Science and Technology of China

Quantum computational advantage using photons

 Han-Sen Zhong^{1,2,*},  Hui Wang^{1,2,*},  Yu-Hao Deng^{1,2,*},  Ming-Cheng Chen^{1,2,*},  Li-Chao Peng^{1,2},  Yi-Han Luo^{1,...}

+ See all authors and affiliations

Science 18 Dec 2020:
Vol. 370, Issue 6523, pp. 1460-1463
DOI: 10.1126/science.abe8770



Quantum Physics

[Submitted on 29 Jun 2021 (v1), last revised 5 Jul 2021 (this version, v2)]

Phase-Programmable Gaussian Boson Sampling Using Stimulated Squeezed Light

Han-Sen Zhong, Yu-Hao Deng, Jian Qin, Hui Wang, Ming-Cheng Chen, Li-Chao Peng, Yi-Han Luo, Dian Wu, Si-Qiu Gong, Hao Su, Yi Hu, Peng Hu, Xiao-Yan Yang, Wei-Jun Zhang, Hao Li, Yuxuan Li, Xiao Jiang, Lin Gan, Guangwen Yang, Lixing You, Zhen Wang, Li Li, Nai-Le Liu, Jelmer Renema, Chao-Yang Lu, Jian-Wei Pan

The tantalizing promise of quantum computational speedup in solving certain problems has been strongly supported by recent experimental evidence from a high-fidelity 53-qubit superconducting processor¹ and Gaussian boson sampling (GBS) with up to 76 detected photons. Analogous to the increasingly sophisticated Bell tests that continued to refute local hidden variable theories, quantum computational advantage tests are expected to provide increasingly compelling experimental evidence against the Extended Church-Turing thesis. In this direction, continued competition between upgraded quantum hardware and improved classical simulations is required. Here, we report a new GBS experiment that produces up to 113 detection events out of a 144-mode photonic circuit. We develop a new high-brightness and scalable quantum light source, exploring the idea of stimulated squeezed photons, which has simultaneously near-unity purity and efficiency. This GBS is programmable by tuning the phase of the input squeezed states. We demonstrate a new method to efficiently validate the samples by inferring from computationally friendly subsystems, which rules out hypotheses including distinguishable photons and thermal states. We show that our noisy GBS experiment passes the nonclassicality test using an inequality, and we reveal non-trivial genuine high-order correlation in the GBS samples, which are evidence of robustness against possible classical simulation schemes. The photonic quantum computer, Jiuzhang 2.0, yields a Hilbert space dimension up to 10^{43} , and a sampling rate 10^{24} faster than using brute-force simulation on supercomputers.

Comments: 23 pages, 6 figures. Comments are welcome

Subjects: **Quantum Physics (quant-ph)**; Optics (physics.optics)

DOI: [10.1103/PhysRevLett.127.180502](https://doi.org/10.1103/PhysRevLett.127.180502)

Cite as: [arXiv:2106.15534](https://arxiv.org/abs/2106.15534) [quant-ph]

(or [arXiv:2106.15534v2](https://arxiv.org/abs/2106.15534v2) [quant-ph] for this version)

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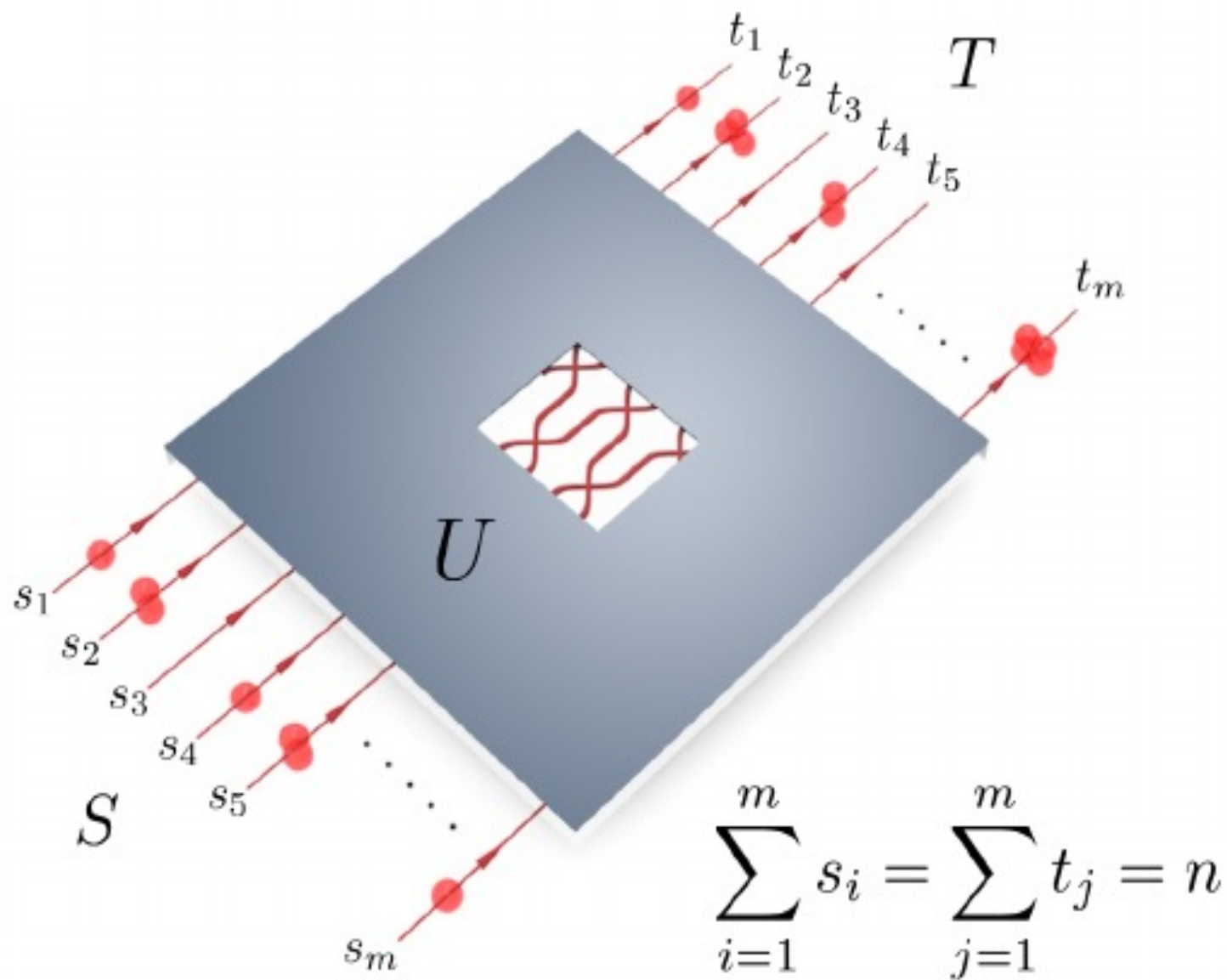
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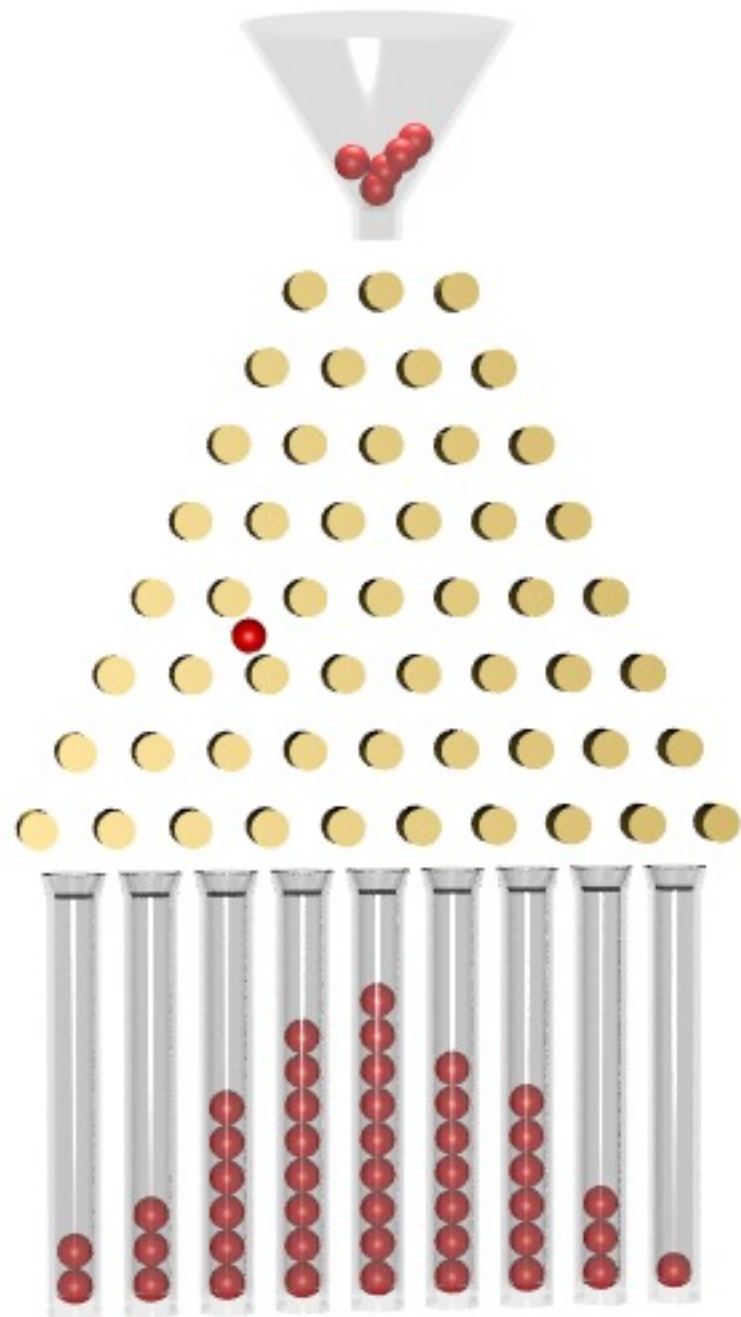
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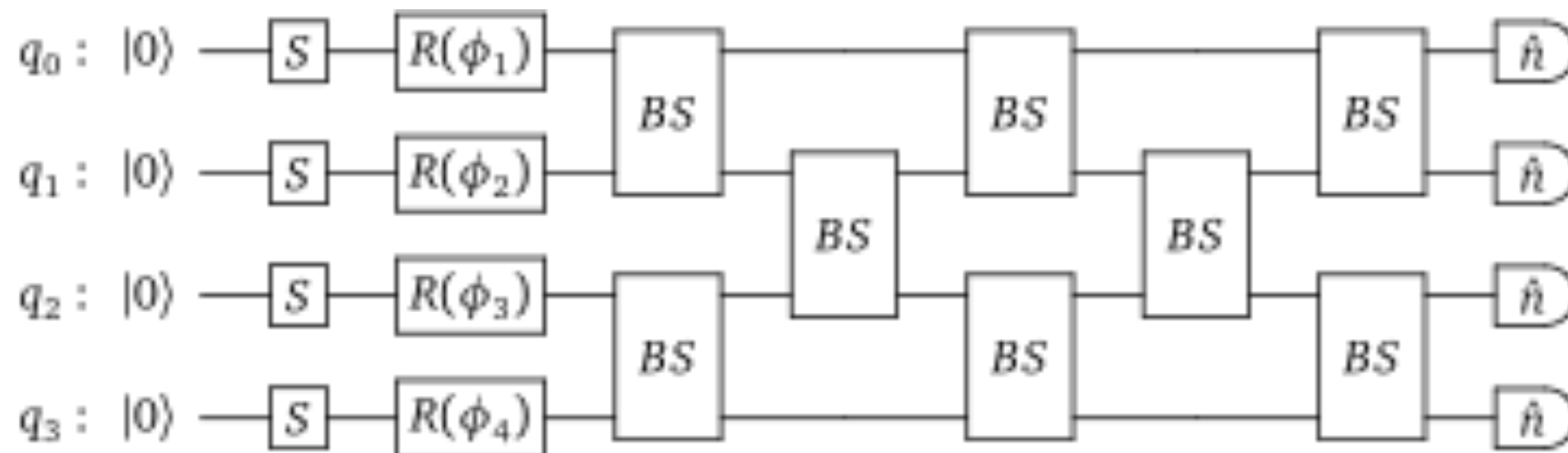
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magyar kutatók vezetésével fejlesztett
nyelv és kvantumszámítógép-szimulátor

Gaussi bozonikus mintavételezés

- Threshold detektoros (jelen kísérletei, pl. USTC)
- Részecskeszám-felbontó detektorral (jövő kísérletei, pl. Quix)

Univerzális optikai kvantumszámítógép szimulátora

- Zajmentes számolás
- Zajos számolás

```
In [1]: import piquasso as pq
import numpy as np

with pq.Program() as preparation:
    pq.Q(0, 1) | pq.Squeezing2(r=1, phi=np.pi / 4)
    pq.Q(2, 3) | pq.Squeezing2(r=2, phi=np.pi / 3)

with pq.Program() as interferometer:
    pq.Q(0, 1) | pq.Beamsplitter(theta=np.pi / 4, phi=np.pi / 3)
    pq.Q(1) | pq.Phaseshifter(phi=np.pi / 2)
    pq.Q(1, 2) | pq.Beamsplitter(theta=np.pi / 5, phi=np.pi / 6)

with pq.Program() as executable_program:
    pq.Q(all) | preparation

    pq.Q(0, 1, 2) | interferometer
    pq.Q(2, 3, 4) | interferometer

    pq.Q(3) | pq.HeterodyneMeasurement()

simulator = pq.GaussianSimulator(d=5)
result = simulator.execute(executable_program)
result
```

```
Out[1]: <Result samples=[(-1.017200627783451, 1.5609890986162434)]>
```



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Code

Kolarovszki Merge pull request #114 from Budapest-Quantum-Computi... bc87e7a 5 days ago 597 commits

.github/workflows	Run test on main branch too	last month
benchmarks	feat(api): Simulator	15 days ago
docs	feat(api): Simulator moved to separate file	5 days ago
piquasso	doc: Move TODO to comment	5 days ago
scripts	feat(api): Simulator	15 days ago
tests	update: Documentation updated	5 days ago
.codecov.yml	Display coverage results using CodeCov	2 months ago
.flake8	ci: Unit tests should run last	19 days ago
.gitignore	refactor(gaussian/state): Naming convention for bases	2 months ago
.mypy.ini	Adding type hints	2 months ago
LICENSE.txt	Fix LICENSE.txt	2 months ago

About

No description, website, or topics provided.

Readme

Apache-2.0 License

Releases

6 tags

Packages

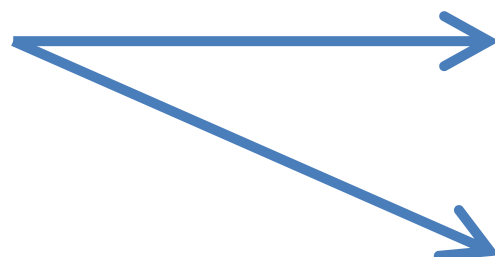
No packages published

Contributors 6

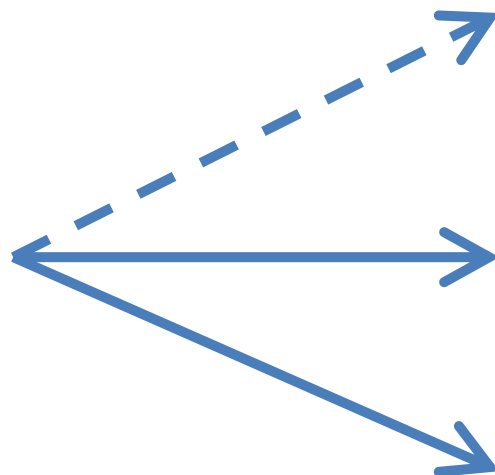


Frontend:
programozás

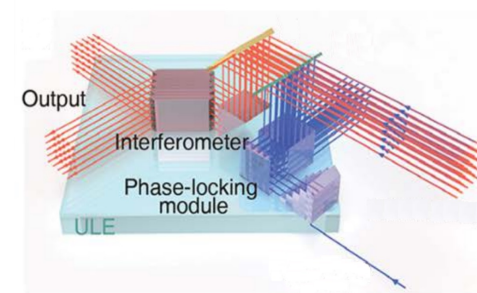
Backend



Frontend: programozás



Backend



} szimulátor

Frontend:
programozás



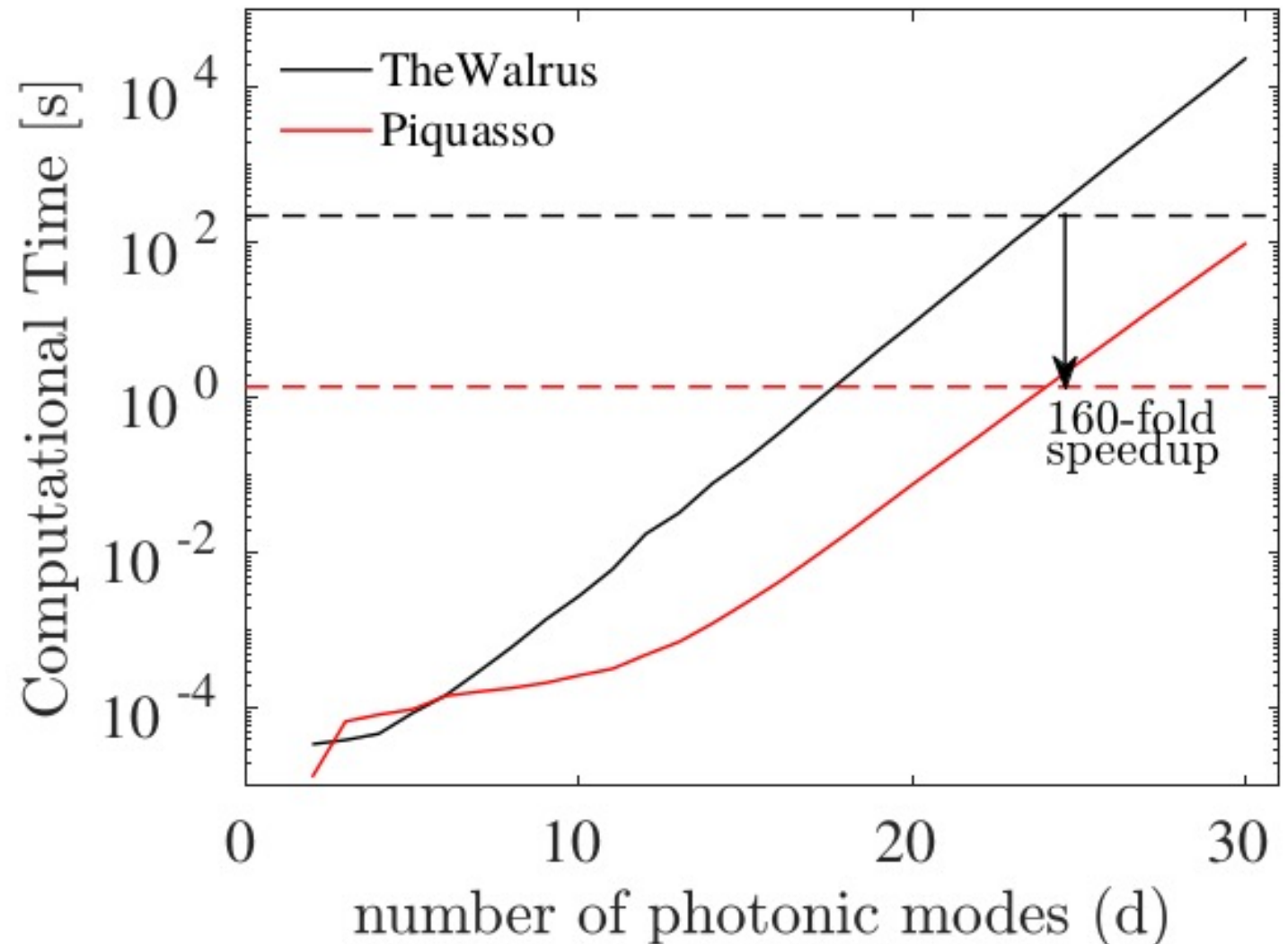
Backend



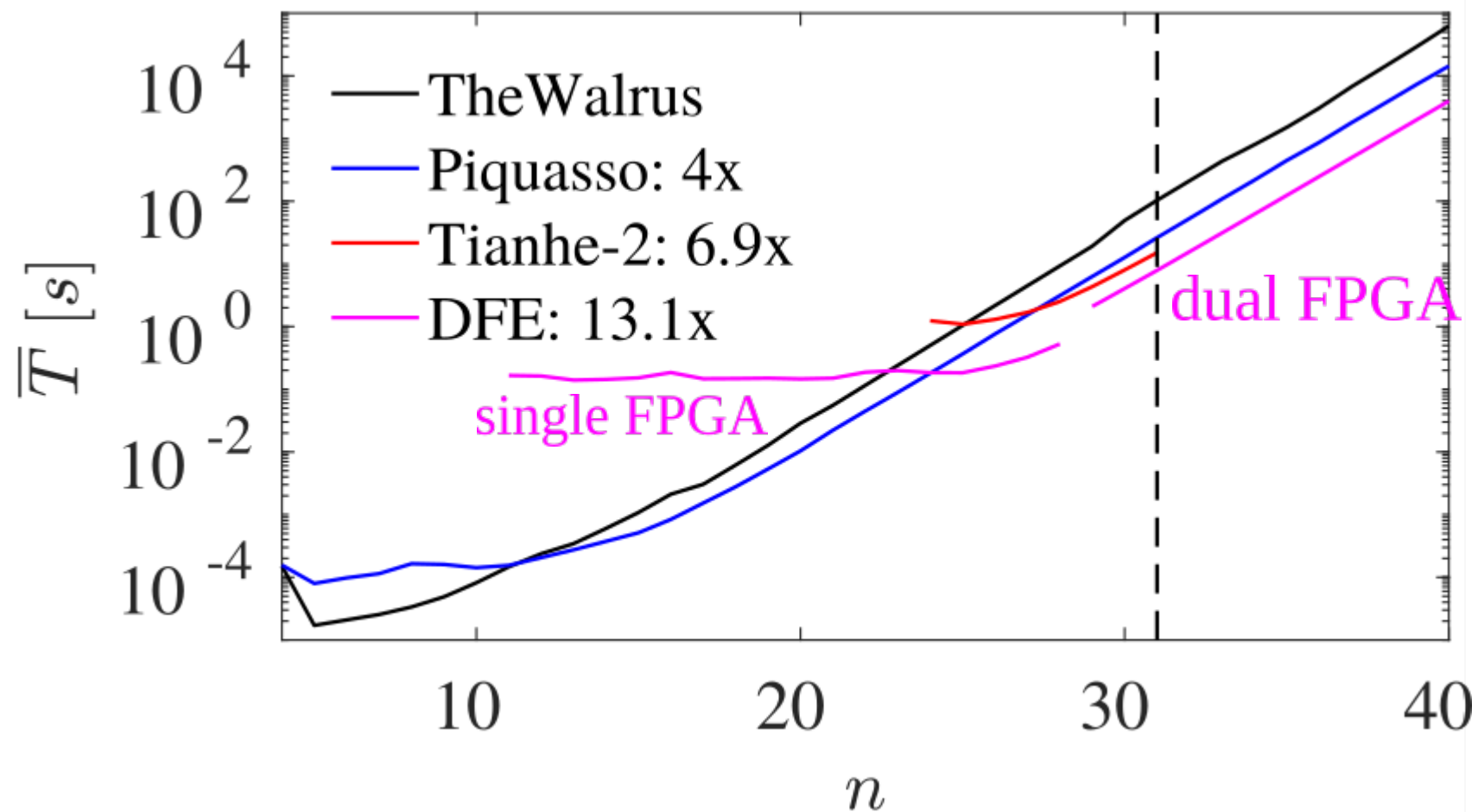


Torontonian-számolás CPU-n

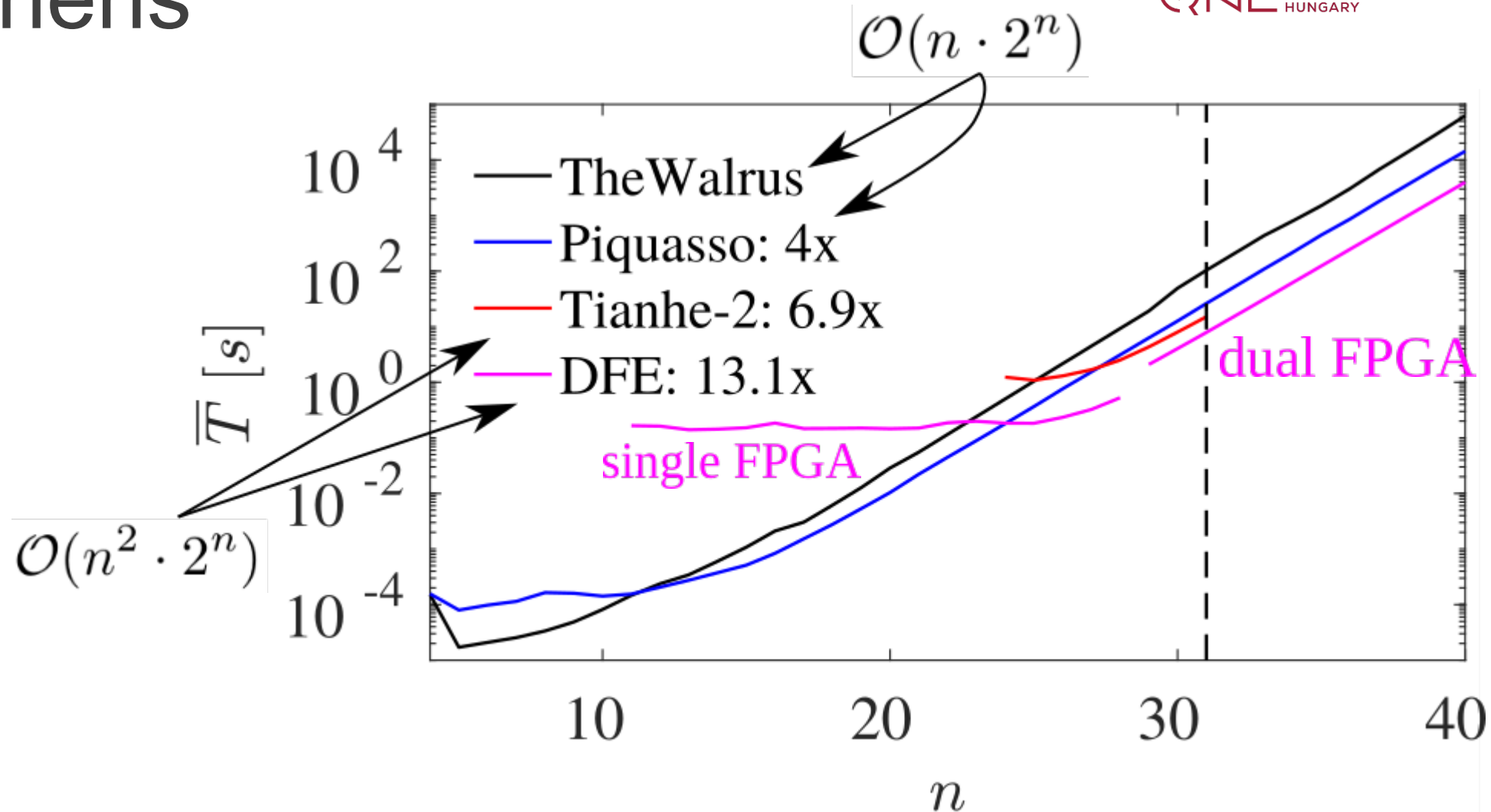
- Intel Xeon Gold 6130, 16 mag
- $(2d \times 2d)$ -s mátrixok
- The Walrus: Strawberry Fields (a jelenlegi piacvezető szimulátor, Xanadu)
- Piquasso: 50 módus



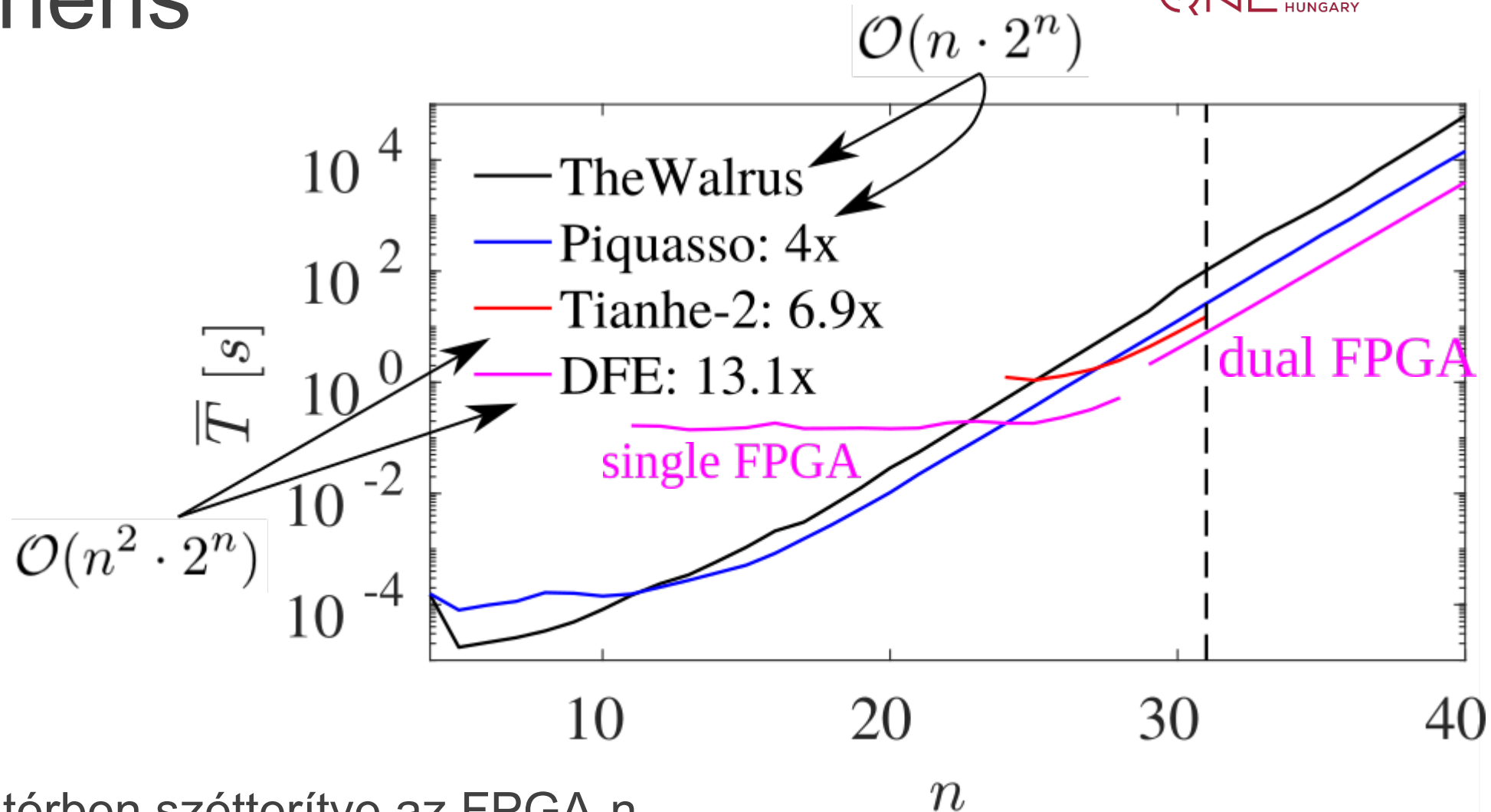
Permanens



Permanens



Permanens

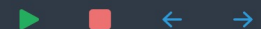


n^2 művelet térben szétterítve az FPGA-n
Időbonyolultság: $\mathcal{O}(C \cdot 2^n)$

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CONTROL

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SIMULATION

Cutoff HBar

5 2

PARAMETERS

phi 0

z 0.0001

shots 10000

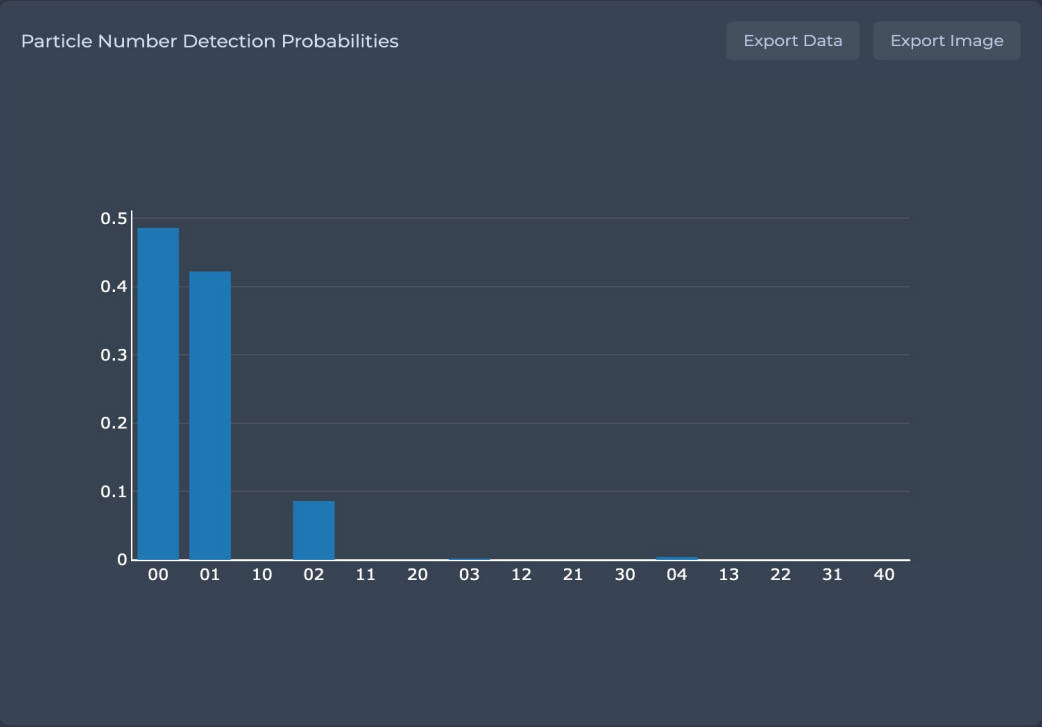
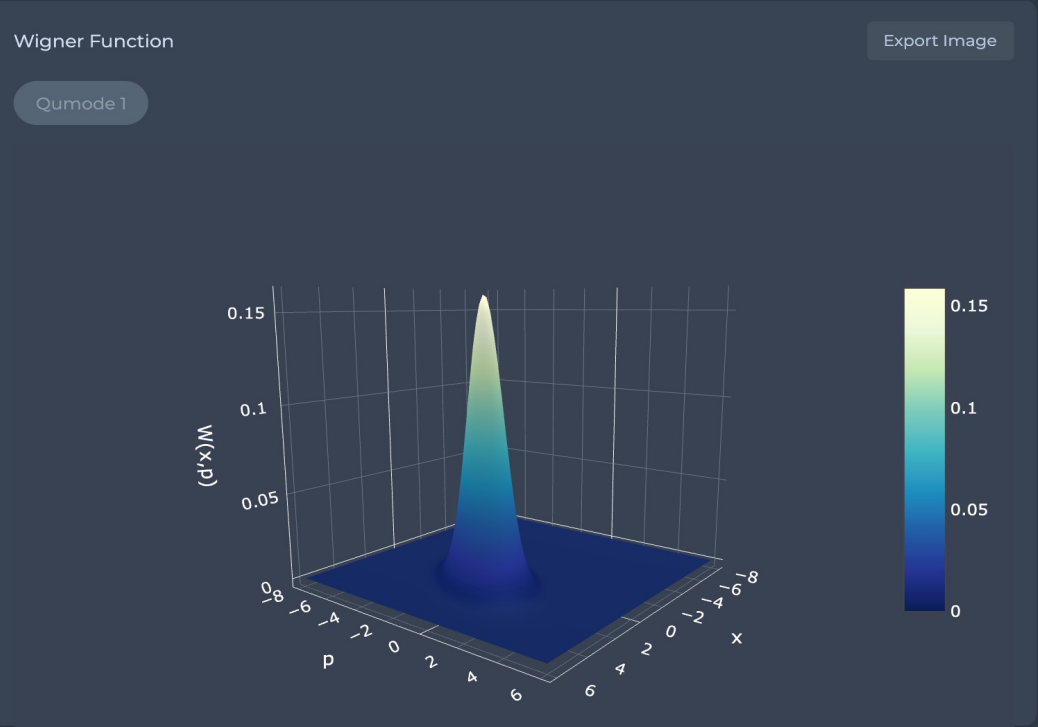
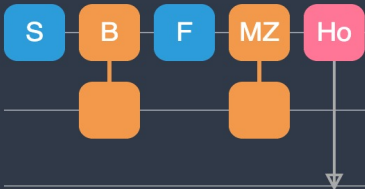
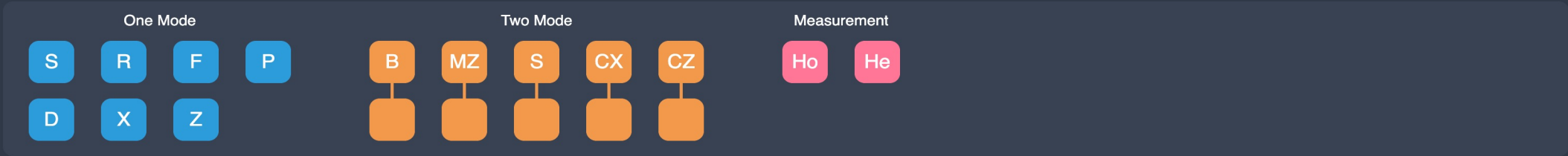
DOCUMENTATION

Beamsplitter

The matrix representation of the beamsplitter instruction is

$$B = \begin{bmatrix} t & r^* \\ -r & t \end{bmatrix},$$

where $t = \cos(\theta)$ and $r = e^{-i\phi} \sin(\theta)$.



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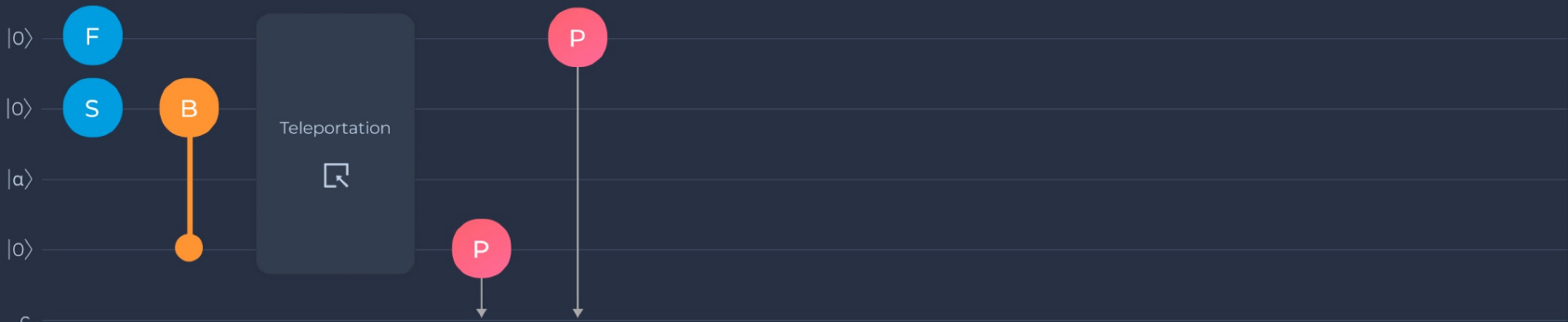
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Boson sampling	2 months ago	 joczikszabi	Public	  	Open Project



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	d7bbc131-4f30-4a99-8cfd-bba4575d2efa	 Pending	 darrellsteward	5 minutes ago
	c97ad4c1-aea9-4fce-97c2-4ccc77a08d85	 Completed	 joczikszabi	1 hour ago
	4e291239-30c4-4f0e-ac38-9c507c1f52d2	 Completed	 devonlane	3 days ago
	6b12c8a7-a52c-482c-bff8-5f6d9ad1e0f5	 Failed	 devonlane	1 week ago

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