ANNUAL REPORT

2023

BECAUSE EVOLUTION
IS UNITARY

Unitary Fund

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Make quantum technology **useful, sooner, and for more people**

To the Unitary Fund community,

Last fall, we hosted our inaugural unitaryCon, bringing together our microgrant recipients and community members for the first time in person. This event underscored the importance of our shared vision for a better future through technology and the vital role of our growing, diverse community in realizing this vision. People build quantum technology. And our focus is on nurturing that emerging community of people.

This community now spans the 100+ microgrant winners from 25+ countries, the unitaryHack participants, the thousands online on Discords, youtube, and social media, the maintainers and bug fixers on github, the unpaid and constructive peer reviewers, the graduate students going the extra mile to upload tutorial code along with their arXiv papers, and the many supporters from often competing companies who understand where and why we need to all work together. Your contributions are invaluable and recognized.

This year we have grown and expanded our programs:

- Mitiq, our quantum error mitigation compiler, surpassed 100k downloads, with contributions from 67 individuals
- unitaryHack grew to 700 participants from 80+ countries, awarding 99 bounties across 33 projects
- Our second Quantum Open Source Software Survey tracked developments in the developer ecosystem
- Metriq introduced new tools for tracking state-of-the-art metrics and resource estimates in quantum technology
- We awarded a record 23 microgrants for projects ranging from quantum error correction tools to Open Quantum Hardware, a field surveyed in our whitepaper

Our whitepaper on quantum computing's risks and benefits highlights the field's potential for economically impactful computations before cryptographically relevant ones. Let us work together towards that future.

Thanks to all of you who have joined us in this mission.

We are just getting started,

William Zeng, PhD

Gratitude, Collaboration, and **Continued Success**

Core members

IBM **Quantum**

scientifica venture capital

Supporting members

agnostiq

aws

cisco

DoraHacks

PASQAL

Quandela Cloud

qubert

Foundations

U.S. DEPARTMENT OF ENERGY

NSF

Additional supporters

- Alphabet X (formerly Google X)
- Atom Computing
- Boston Consulting Group
- Microsoft
- Cambridge Quantum Computing
- Classiq
- IQT Labs
- Rigetti
- Zapata Computing
- QCWare
- quantumcomputing.com
- QuEra
- Riverlane
- Xanadu
- Strangeworks
- PLOS
- Steve Willis & NYC Quantum Meetup
- EeroQ
- Q-CTRL
- BlueQubit
- John Hering
- Jeff Cordova
- Nima Alidoust
- Travis Humble
- George Umbrarescu
- Michał Stęchły
- Terrill Frantz
- Konstantin Vinogradov
- Jordan Rule
- Greg Ramsay
- Peter Johnson
- Guillaume Verdon
- Rishi Sreedhar
- Travis L. Scholten
- Amir Ebrahimi
- Jens Koch
- Christophe Jurczak
- Angelo Danducci II
- Will Zeng
- Wellcome Leap

Unitary Fund would like to thank all supporters for their commitment to open source quantum technology! Our community development work and research are made possible through the generosity and partnership of these foundations, companies and individuals. We are excited to work with all of them to grow the open quantum ecosystem around the world.

Ecosystem

"This is the **most inviting and friendly community** out there. Folks are extremely helpful and resourceful. People want to improve this field and want to help others to make it happen. Making the resources open source is the best move by researchers in the field. To those wondering, get involved and start contributing."

"Thank you. **Keep doing what you are doing right now.** If not for the quantum OSS community, I would not be doing research in quantum right now."

"Unitary Fund **you rock!**"

Fueling **Innovation**

Unitary Fund's **Microgrant Program** supports the growth of a diverse quantum community by investing in projects that can benefit everyone. Since we began we have distributed **93 grants** with no-strings attached across **23 countries** resulting in **17+ completed or planned publications,** welcoming **13 people** into the field, and helping to form **2 new startups** and **1 new non-profit.**

Q1

- graphix
- Optimization problems in OpenQAOA
- Timeline Debugger for the Qiskit Transpiler
- NFNet: Non-interacting Fermion Simulation Network for Large-scale Quantum Systems
- HierarQcal
- QHDOPT

Q2

- H-hat: a high abstraction level quantum programming language
- Software Developer Workshop for the Numerical Simulation of Ultracold Quantum Many-Body Systems
- Strategic partnership events in 2023 for QWorld
- Stac: A python library to work with stabilizer code circuits
- TorchQuantum
- Qutritium

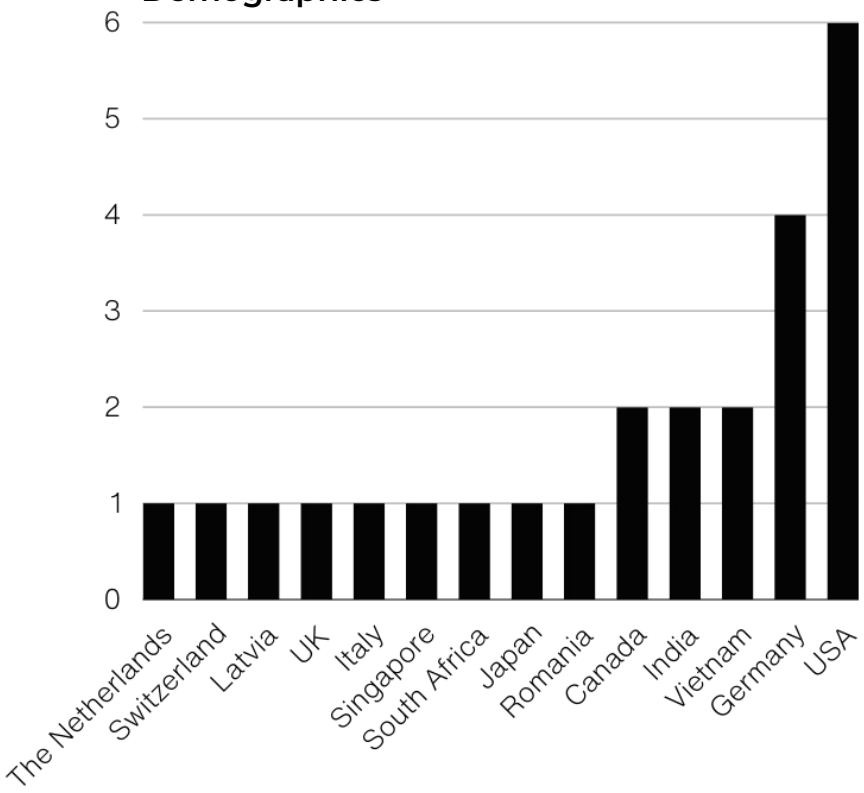
Q3

- mdopt
- lambdaQ - A functional programming language for quantum computing
- Qiskit-Qulacs
- bgls: A Unified Interface to the Gate-by-Gate Sampling Algorithm
- Sqooler fmr. Labscript-qc
- Improvements to Toqito
- QlassKit

Q4

- QAST fmr. Qasper
- Piccolo.jl
- OpenQuantum
- GA-QAS: a genetic approach to quantum compilation

Demographics



"[I have] deep gratitude to the Unitary Fund for their invaluable support. This grant has been a catalyst for significant advancements in the <Quantum|Chamitas> project, notably enabling me to develop a dedicated website for the project, launching in a few days in celebration of Women's Day. This new platform will enhance <Quantum|Chamitas>' online presence and is just the beginning of a series of follow-up activities planned. **I'm thrilled about the possibilities this support has unlocked for us.**"

- Carolina Arias Perdomo

We are thrilled that **61%** of the grants we distributed in 2023 were awarded to applicants from underrepresented groups. The up-to-date list of all grants can be found on the Unitary Fund website.

Advisory board

- Amira Abbas
- Shahnawaz Ahmed
- Tomas Babej
- Ntwali Bashige
- Amy Brown
- Stephen DiAdamo
- Mark Fingerhuth
- Cassandra Granade
- Josh Izaac
- Sonika Johri
- Sarah Kaiser
- Nathan Killoran
- Peter Karalekas
- Ryan LaRose
- Roger Luo
- Alex McCaskey
- Travis L. Scholten
- Dylan Sim
- Michał Stęchły
- Christa Zoufal

Projects

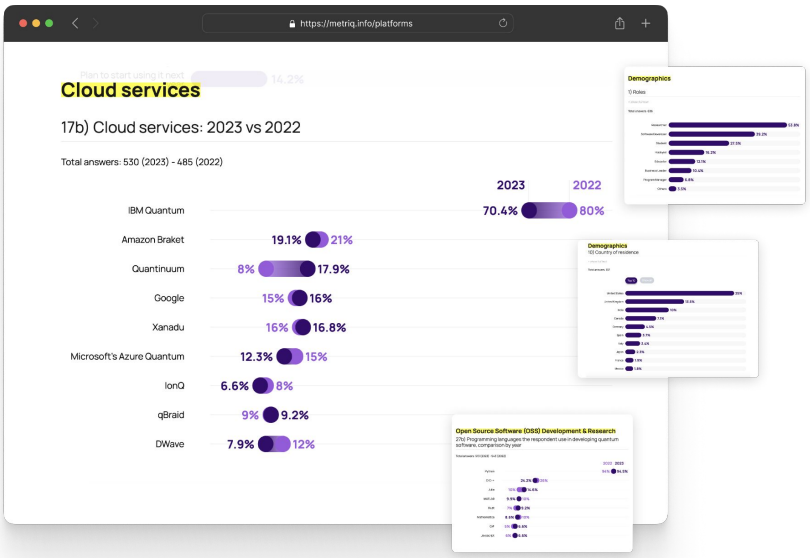
20 Open source software projects

1 Open source hardware project

2 Community education initiatives

Unveiling **Data Insights**

In 2023 we released our second annual Quantum Open Source Survey to help the many diverse stakeholders of quantum technologies get a holistic understanding of the users, tools, needs and strengths of the ecosystem today. As it was the second survey, we were also excited to provide certain comparative metrics to view how things evolved since 2022. The purpose of this survey is to gather a dataset that is inclusive and representative of current and prospective open-source software coders, for and with quantum technologies in order to better serve users of the quantum computing ecosystem.



As in 2022, the **majority** of quantum OSS users are **researchers** (53.8%), however, sizable communities identify themselves as developers (39%), students (27.5%), hobbyists (16%) and educators (12%).

This data speaks for the balanced heterogeneity of interests and sub-communities among quantum OSS users and developers. Almost 45% of respondents do not have a background in quantum research.

The **most represented country** continues to be the **United States (25%)**, with the UK making the largest leap, up to 13% from 9% last year. India (10%), Canada (7), and Germany (4.5%) round out the top five. EU countries sum up roughly 18. In all, 56 countries are represented in the survey, speaking to the continued spread of access and enthusiasm for the field.

The **most popular programming language** is **Python**, which like last year remains at 94%. The second most popular framework remains C/C++ at 24%, with Julia, MATLAB and Rust rounding out the top 5. Julia featured the largest YoY growth up 4.6% to 14.6%. Respondents also rated Python as the most promising language, with Rust, C/C++, Julia and Q# following.

Uniting **People**

unitaryHACK recap

unitaryHACK is Unitary Fund's annual hackathon - an open to all event, encouraging people to make their first, or fifth, contribution to the open source quantum ecosystem.

Taking place over the first two weeks of June, uHACK offers cash bounties to participants hailing from all over the world, and provides a diverse array of projects and issues that help to move quantum technology forward.

2023 Top level stats

700+ participants (60% YOY increase)

80+ countries

99 cash bounties

73 hackers claiming bounties

Significant **increase** in participation and involvement from prior year of **400 participants**, **63 hacks** and **27 hackers**

Top bounty closers

- Gregory Varghese, aka WingCode completed 10 bounties
- Davide Gessa, aka dakk following up with 9 bounties.
- 33 Projects featured with the help of 45 maintainers!
  Amazon Braket SDK, Bloqade, BQSKit, Covalent, Dora Factory Quantum Experiments, Error Correction Zoo, Graphix, HierarQcal, KQCircuits, lambeq, Metriq, Mitiq, OpenQAOA, pauliopt, PennyLane, Perceval, Pulser, PyClifford, PyQ, qBraid-SDK, QECFT book, Qiskit, Qiskit Aer, Qiskit Braket Provider, qrack, QuNetSim, QuTiP, scqubits, Symmer, Toqito, TorchQuantum, Yao, ZX Live

Fostering **Growth**

unitaryCON recap

In November in Rome, Italy we wrapped up our first unitaryCON, an invitation-only collaborative workshop for the extended Unitary Fund community. The workshop was an opportunity to share ongoing projects, connect with collaborators and supporters, and work with our community to advance the quantum open-source software ecosystem with the leading contributors from around the world. A huge thank you to our core member Scientifica Venture Capital, whose collaboration and support made unitaryCON possible.

On a scale of 1-10, participants gave unitaryCON an average rating of 9.3, finding the experience to be valuable and informative. The majority of participants found the interactions with other participants to be their favorite part of unitaryCON, in addition to helping them understand trends and roadmaps in open source quantum computing.

"I loved hearing about the different open source projects and ideas people have around abstracted quantum languages. I had a wonderful experience and wish we had more time to work together."

"I have a much clearer sense of the state of the quantum open source ecosystem as a whole, as well as near term developments and goals for the community.""

Empowering Partners

Community calls

19 Active project channels

20 QOSS channels

2 937 Discord members

Quantum Wednesday

29 Quantum Wednesday talks

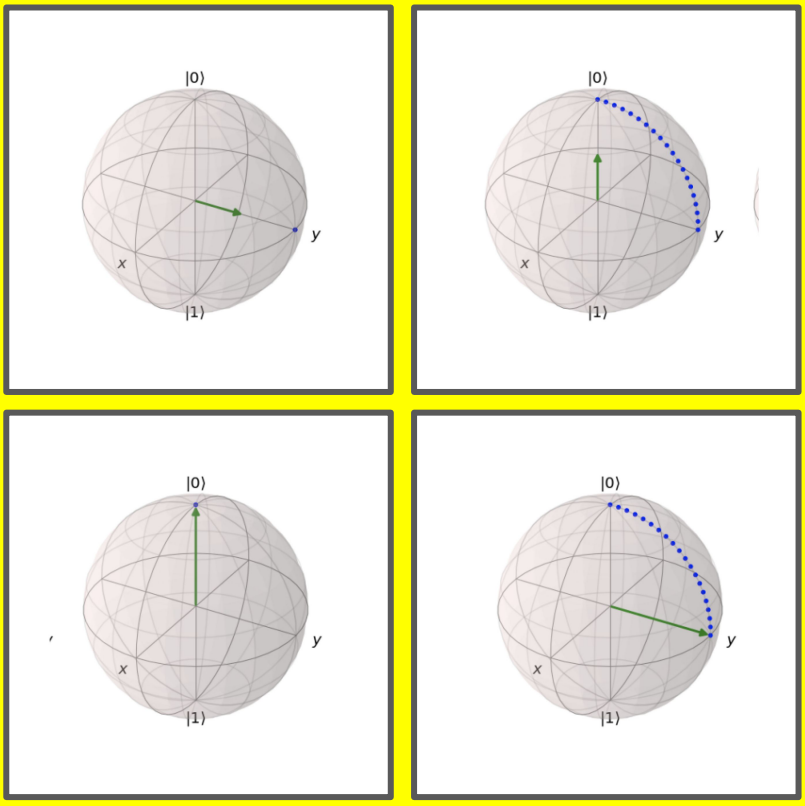
Covered a variety of quantum topics, such as error correction or mitigation, circuit knitting, and amplitude estimation

6 Guest talks

- Purva Thakra: Circuit knitting with classical communication
- Ammar Jahin, Dariel Mok, Preksha Naik, Abdulrahman Sahmoud RFC: Error Mitigation by Subspace Expansion
- Ali Gedawi: IBM recent quantum error mitigation results and related classical simulations
- Srilakshmi Palanikumar: A review of Google's Quantum Supremacy result
- Min Li: Classical Shadow and its implementation on Mitiq
- Haoran Liao: Machine Learning for Practical Quantum Error Mitigation

Unitary Labs

Envisioning tomorrow,
creating **breakthroughs**



Quantum errors, **Mitigated**

Mitiq is an open-source cross platform compiler that makes your programs robust to the error in current quantum computers.

This year, we increased Mitiq's functionality to now include the following tools and techniques:

- mitiq.qse: Quantum Subspace Expansion is an error mitigation technique which draws techniques from quantum error correction, but with a much lower overhead. Check out more in the QSE user guide.
- mitiq.shadows: The shadows module provides tools for estimating properties of unknown quantum states (e.g. the value of an expectation value). Learn more in the Shadows user guide, or one of the two shadows tutorial.
- mitiq.calibration: The calibration module was created with the goal of making error mitigation easier to use without a background in error mitigation, or the specific technique you wish to apply. Details can be found on our guide page or calibrator example.
- mitiq.pt: Mitiq now contains tools for using Pauli Twirling on quantum circuits. This is still under development, but the Pauli Twirling user guide has some more info if you want to combine these functions with an existing mitigation workflow.

2023 stats

65 contributors

135 forks

115k+ downloads

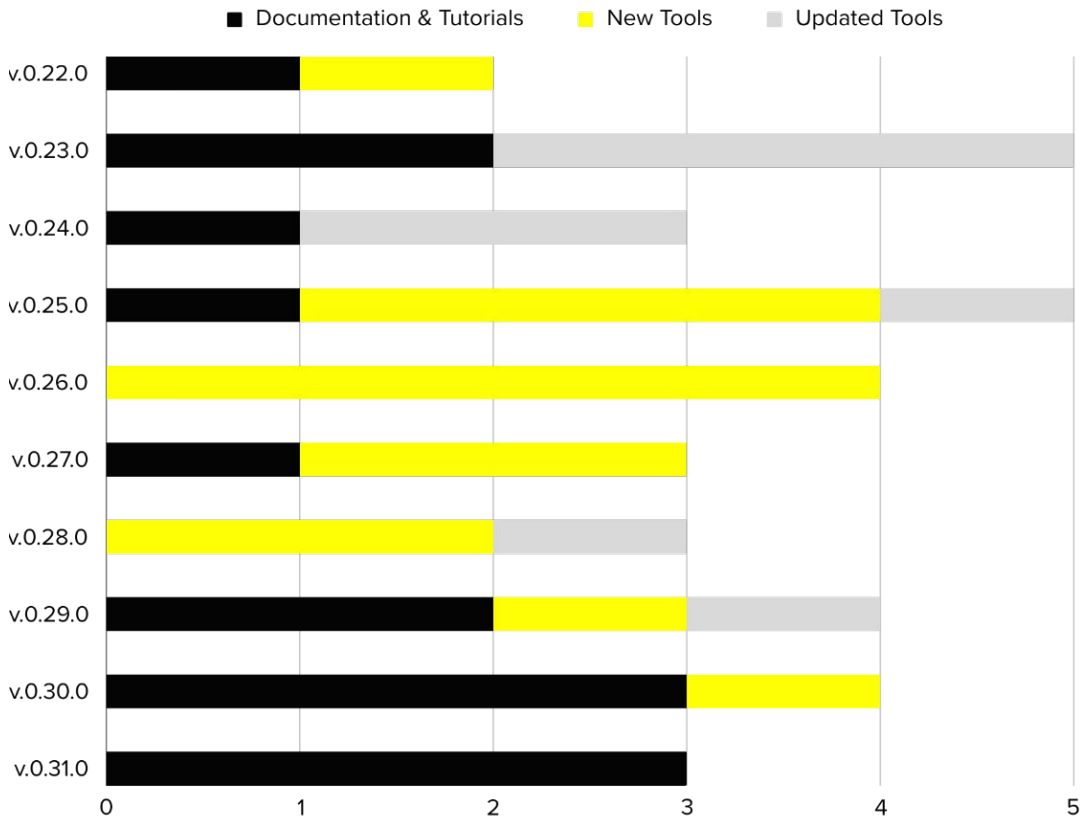
302 stars

83 paper citations

Error mitigation techniques

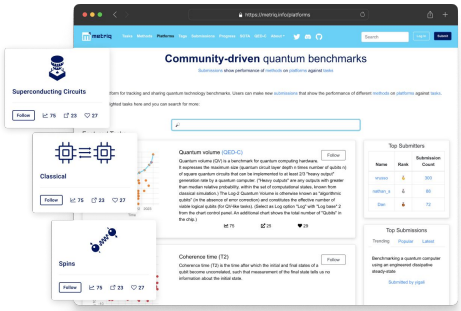
Technique	Documentation	Mitiq module	Paper references
Zero-noise extrapolation	ZNE	mitiq.zne	1611.09301 1612.02058 1805.04492
Probabilistic error cancellation	PEC	mitiq.pec	1612.02058 1712.09271 1905.10135
(Variable-noise) Clifford data regression	CDR	mitiq.cdr	2005.10189 2011.01157
Digital dynamical decoupling	DDD	mitiq.ddd	9803057 1807.08768
Readout-error mitigation	REM	mitiq.rem	1907.08518 2006.14044

Mitiq changelog



Community-driven Quantum Benchmarks

Unitary Fund built **Metriq** to provide a free, community-led platform for tracking and sharing quantum technology benchmarks. Our goal is to provide easy access to answers experts and newcomers alike might have about the field, its technical achievements, and what tools might be the right fit for their own work. On Metriq, researchers and developers in academia and industry submit results on existing benchmarks or propose new benchmarking tasks to the community. All results include sources and are openly accessible.



After debuting last year, 2023 saw key upgrades to ease of access, curation of information, and new functionality. Now with **nearly 700 submitted papers** and **over 1,200 results** Metriq provides a constantly growing, comprehensive suite of data and achievements across quantum technology.

2023 Upgrades and Accomplishments

QED-C / Metriq Integration Automated Pipeline

Metriq established a new automated pipeline that is able to run and update our submission via a fork of the QED-C benchmarking suite. This pipeline enables anyone to automatically run benchmarks for a specific algorithm, hardware provider, and quantum processor. This allows the Metriq community to continually extend the benchmarking foundation provided by QED-C to expand their results by running on further hardware providers to obtain up-to-date results. New results from the QED-C benchmark suite will continue to be uploaded in this submission. We have included functionality to subset results from the pipeline by qubit width and circuit depth.

State of the Art Page

Interested in understanding more about the overall technology-readiness level and strongest achievements of the field? In 2023, the Metriq team debuted a new, curated, page devoted to metrics showing the state of the art along with editorial context for both general and technical audiences.

Resource Estimation Guide

In 2023, we debuted a new page to give a snapshot of the technology of today, and where it will need to be in order to run quantum programs of interest. A growing resource, the page shows both successfully run quantum programs as well as what size programs would be needed for advantage across different domains.

1st ever Metriq Hackathon

We hosted our first ever hackathon in Q2 2023 which featured members of our community adding new papers and results from around the world. We hope this event will become an annual tradition and serve to grow the contributor community.

Thanks to the ongoing support and collaboration of Metriq's Partners and Supporters:

Taking **Quantum Leaps**

Talks

In person

- TERATEC/Thales workshop, Paris, France
- ARQC All Hands, Berkeley Labs, Berkeley, CA, USA
- University of Milan Bicocca, Milan, Italy
- QWorld - Quantum Science Days
- PyData Seattle
- IEEE Open Science Panel
- GE Q4Climate
- Quantum Error Correction and Mitigation Workshop, Trento, Italy
- University of Venice, Italy
- City University of Seattle, Seattle, WA, USA
- unitaryCON, Tecnopolo Roma, Italy
- Q2B Silicon Valley, CA, USA

Digital (online)

- Qiskit Demo Day
- Sandia National Labs
- Grassroot Efforts in Quantum, online event
- Silicon Valley Quantum Computing Group
- QIQT Conference, Kolkata, India

Papers

The Unitary Fund technical staff performs research in open-source quantum technology with a global network of collaborators. These are the papers we shared in 2023. Find out more on the research section of the UF site.

Open Hardware

N. Shammah, A. Saha Roy, C. G. Almudever, S. Bourdeauducq, A. Butko, G. Cancelo, S. M. Clark, J. Heinsoo, L. Henriet, G. Huang, C. Jurczak, J. Kotilahti, A. Landra, R. LaRose, A. Mari, K. Nowrouzi, C. Ockeloen-Korppi, G. Prawiroatmodjo, I. Siddiqi, W. J. Zeng, Open Hardware in Quantum Technology, arXiv (2023), [2309.17233]

Qrack

D. Strano, B. Bollay, A. Blaauw, N. Shammah, W. J. Zeng, and A. Mari, Exact and approximate simulation of large quantum circuits on a single GPU, arXiv, (2023), [2304.1469], source code

Mitiq & Error Mitigation

E. Pelofske, V. Russo, R. LaRose, A. Mari, D. Strano, A. Bärtschi, S. Eidenbenz, and W. J. Zeng Increasing the Measured Effective Quantum Volume with Zero Noise Extrapolation, arXiv (2023), [2306.15863]

M. A. Wahl, A. Mari, N. Shammah, W. J. Zeng, G. S. Ravi Zero noise extrapolation on logical qubits by scaling the error correction code distance, arxiv, (2023), [2304.14985], notebooks

Additional Research from Unitary Fund Staff

N. Johnston, V. Russo, J. Sikora Tight bounds for anti distinguishability and circulant sets of pure quantum states, arXiv (2023), [2311.17047]

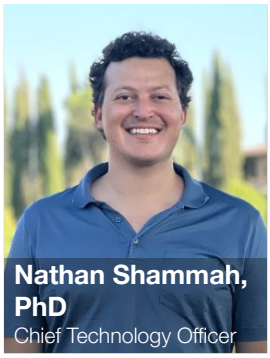
C. Paddock, V. Russo, T. Silverthorne, and W. Slofstra, Arkhipov's theorem, graph minors, and linear system nonlocal games, Algebraic Combinatorics, 6, 1119-1162, (2023), [2205.0465]

Microgrant supported research

G. Watkins, H. M. Nguyen, V. Seshadri, K. Watkins, S. Pearce, Hoi-K. Lau and A. Paler, Lattice Surgery Compiler (LSC): A High Performance Compiler for Very Large Scale Surface Code Computations, arXiv, (2023), [2302.02459]

About us

Building the open quantum technology ecosystem **together**



Our Team

Meet our skilled and dedicated team, whose expertise, passion, and collaborative efforts have been instrumental in driving our success.

Board of **Directors**

President. Partner at Quantonation. Fmr. Head of Quantum Research at Goldman Sachs and product/sw lead at Rigetti. Oxford quantum algorithms PhD.

William Zeng, PhD

CTO and Head of the Technical Staff. QuTiP admin. PhD in Physics from Univ. of Southampton.

Nathan Shammah, PhD

Secretary. Quantum Applications Architect at IBM Quantum and Policy Hackers Fellow at the Lincoln Network. PhD in quantum computing from the University of New Mexico (2018).

Travis Scholten, PhD

Treasurer. Co-founder and managing partner at Quantonation. PhD in Quantum Physics from Ecole Polytechnique.

Christophe Jurczak, PhD

COO & Co-Founder, Convergent Research, which incubates new kinds of transformative research institutions.

Anastasia Gamick

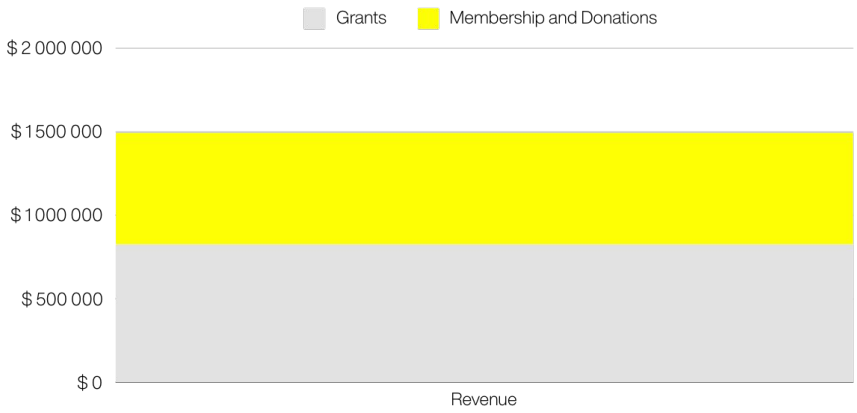
Advisor. Fmr. director and founder of the IBM Quantum and Qiskit developer ecosystem mission. BS in Electrical Engineering from NDSU, and MBA from the University of Minnesota.

Liz Durst

Financial Report

Revenue

We forecast about **$ 1.5M revenue** in 2023
Unitary Labs Grants $ 826 042
Membership & Donations $ 669 150.



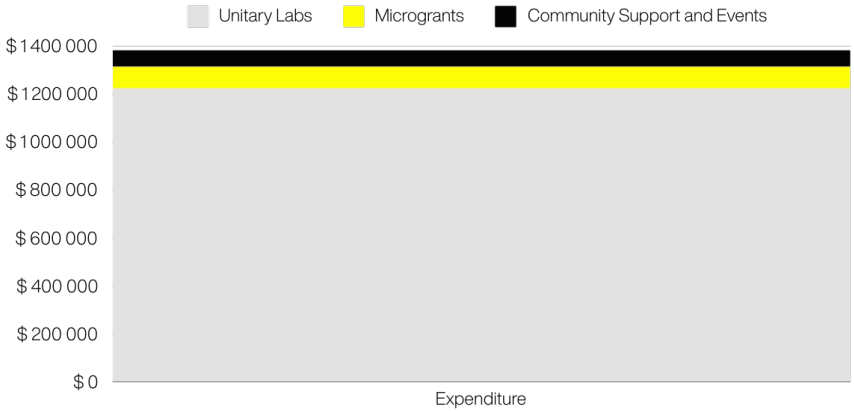
Expenditures

We forecast about **$ 1.4M expenditures** in 2023.

Unitary Labs $ 1 225 038

Microgrants & Bounties $ 90 103

Community Support and Events $ 68 735



Unitary Fund

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