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**PITTSBURGH QUANTUM INSTITUTE**

www.pqi.org

# Annual Report

# 2023

PQI brings together scientists and faculty from Carnegie Mellon University, Duquesne University and the University of Pittsburgh as well as industry researchers to further quantum information science and engineering education, research and commercialization for the Greater Pittsburgh Area.

# Forward

This has been a year of remarkable change for the Pittsburgh Quantum Institute, in terms of the people: leadership and governance; programs: new initiatives and efforts; and in our purpose: updated vision and mission statements. PQI is engaging with faculty, staff and students across the University of Pittsburgh (Pitt), Carnegie Mellon University (CMU) and Duquesne University (DUQ) and is forging new connections with local industry and government labs.

We therefore have many people to thank. First among these is our founding director, **Jeremy Levy**, who stepped down at the end of last year. His vision was instrumental in forming PQI and in forming our community. Next are the many faculty and staff that supported PQI over its first decade. While too many to list here, please know that your contributions are appreciated and were deeply important to getting us to where we are today.

Let us thank this year's staff. **Krista Zottola** has been instrumental in getting many of our programs up and running after COVID shut down PQI. She has served as the first contact point for many interacting with PQI, and has managed many visits, our annual event, and the new professional education program. We thank her for her dedication to PQI, and for her outstanding work over the last year. **Jesse Adams** helped write many of our materials and start some of our industry collaborations – we thank him for his help getting this important new area started.

Next, we would like to thank our many volunteers who help our many programs and initiatives run. At the start of the year, our executive board included **Theodore Corcovilos** (Duquesne), **Andrew Daley** (University of Strathclyde), **Elizabeth Dickey** (CMU), **Susan Fullerton** (Pitt), **Peyman Givi** (Pitt), **Benjamin Hunt (**CMU), **Ken Jordan** (Pitt), **David Pekker** (Pitt), **Thomas Purdy** (Pitt), **Sridhar Tayur** (CMU), **David Waldeck** (Pitt). These faculty helped us organize and run the PQI 2022 Event, and we thank them for all of their help and support. They also reviewed and approved our new governance documents and provided useful insight and thoughts for reimagining PQI for 2023 and beyond.

In January of 2023, we re-established our boards and committees. We wish to thank our steering committee first. Thank you to our faculty members: **Theodore Corcovilos** (Duquesne), **Elizabeth Dickey** (CMU), **Susan Fullerton** (Pitt), **Ken Jordan** (Pitt), **Vladyslav Kozii** (CMU), **Tom Purdy** (Pitt), **Kaushik Seshadreesan** (Pitt), **Simranjeet Singh** (CMU), **Sridhar Tayur** (CMU), and **David Waldeck** (Pitt). We also wish to thank our student and postdoc members: **Melanie Dieterlen** (Pitt) and **Dmitry Shcherbakov** (CMU).

Thanks also to our external advisory committee: **Andrew Daley** (Chair, U. of Strathclyde); **David Awschalom** (U. of Chicago), **Pedro Espina** (IARPA), **Pedram Roushan** (Google), **Jacob Taylor** (Joint Quantum Institute), and **Huili Grace Xing** (Cornell). This committee will have its first meeting next year, reviewing our programs and offering advice.

Next, we thank our seminar series committee: **Hrvoje Petek** (Chair, Pitt), **Daniel Justice** (CMU), **Jyoti Katoch** (CMU), **Prashant Krishnamurthy** (Pitt), **Jill Milstone** (Pitt), **Elias Towe** (CMU). We successfully rebooted our seminar series and regularly had approximately 75 attendees from our members. Similarly, we thank our student and postdoc seminar committee: **Melanie Dieterlen** (Co-Chair, Pitt), **Dmitry Shcherbakov** (Co-Chair, CMU), **Shubham Awate** (Pitt), **Yingheng Li** (Pitt), **Turki Alturaifi** (Pitt), **Siddarth Krishnan** (Pitt), **Hassan Alnatah** (Pitt).

Our social media committee developed our website – we thank **Atreyie Ghosh** (Pitt), **Brianna Greenstein** (Pitt), **Yingheng Li** (Pitt), and **Hassan Alnatah** (Pitt). And finally, we thank our industry outreach committee **Elizabeth Dickey** (co-chair, CMU), Rob Cunningham (co-chair, Pitt), **Shubham Awate** (Pitt) and **Brianna Greenstein** (Pitt).

Signed,

Adam Leibovich
Director, Pittsburgh Quantum Institute

Robert Cunningham
Executive Director, Pittsburgh Quantum Institute

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# Executive Summary

Over the last decade, the Pittsburgh Quantum Institute (PQI) has sought to unite quantum science and engineering throughout the Pittsburgh region. Although the University of Pittsburgh served as the sole funding source of PQI for that time, this year we've broadened our funding base to include CMU and industry in this important research and engineering field.

We arrange the annual report around the following three focus areas:
1. Our People – How are we enabling students, faculty, and staff to thrive?
2. Our Program – How are we achieving excellence in academic and research programs?
3. Our Purpose – How are we changing lives for the better?

For each of these foci, we pursue PQI's new Vision and Mission, as drafted and approved by the PQI Executive Board.

## Vision
Be a leading collaborative interdisciplinary organization that advances research, education, and training in quantum science and engineering.

## Mission
- Energize, unify, and promote quantum science and engineering in our region through camaraderie, inclusivity, and a shared vision
  - Inspire and support members to grow their research in new directions
  - Host scholars and experts to pursue ideas, techniques, and applications on the leading edge
- Advance research and technology in quantum science and engineering
  - Attract outstanding faculty and trainees to quantum research in our region
  - Support collaborative research through workshops, seminars and center-scale proposals
- Train future leaders in quantum science and engineering
  - Educate and train students to have a deep understanding of quantum science and broad understanding of sensing, communication, and computing applications
  - Develop a diverse interdisciplinary cadre of researchers by offering formal and informal learning opportunities
- Develop outside partnerships that extend and expand our community
  - Connect with team-based science initiatives and shared facilities to expand our capabilities
  - Communicate innovations and research perspectives to scientists and the general public

These were approved by the PQI Executive Board during the November 29th, 2022 meeting.

## People and Governance

In academic year 2022-23, a new leadership team was established, with Director Adam Leibovich, Executive Director Robert K. Cunningham. This team is supported by our center administrator, Krista Zottola.

This year, we focused on re-establishing our community, as described in our first mission statement: We are energizing, unifying, and promoting quantum science and engineering in Pittsburgh. To do that, we reorganized our boards and committees to become more actively engaged in running PQI and to engage more of our community.

During the past year, we formed or re-formed all of the following committees. Chairs and members are identified, and their contributions acknowledged in the Forward to this annual report.

Our *Steering Committee* advises the Director and Executive Director on activities and finances, including, but not limited to, awarding visiting scholar and postdoctoral fellowship positions, research awards and travel grants, and projects originating within PQI. It works with the Director and Executive Director to stand up external committees and supports the primary initiatives of the organization.

Our *External Advisory Committee* aims to increase the national and international awareness of PQI, its activities and its strengths, foster connections to other major centers in quantum science and technologies, and provide advice on future directions, including opportunities for new interdisciplinary research directions and education programs. Another goal of this committee is to engage relevant visitors/speakers/external contacts, and further enhance the scientific standing of PQI and impact of PQI activities through well-respected advice from industry stakeholders.

Our *Seminar Series Committee* raises awareness of important new results by established and rising quantum science and engineering experts, encouraging information sharing and establishing new connections. Speakers come from the local region as well as national and international organizations, and speakers are encouraged to meet and discuss new ideas and potential for new collaborations. Seminars occur weekly during the fall and spring semesters.

Our *Industry Outreach Committee* connects professionals in industry with leading experts in the field of quantum technology, bridging the gap between academia and industry. Local industry can partner with PQI and become an Industrial Sponsor. These partnerships allow for collaborative research, networking opportunities, visibility and recognition, and access to cutting-edge research.

Our *Student and Postdoc Seminar Committee* energizes, unifies, and promotes quantum science and engineering across PQI's member universities.  Students present their work to each other, ensuring broad awareness of research being carried out in our region.  We also set aside some time to network with friends and colleagues, so that new research ideas will be developed and explored across schools and universities.

Our *Social Media Coordination Committee* contributes to PQI's social media presence through channels including LinkedIn, Twitter and YouTube. News about PQI events and seminars are updated on these online social platforms. It also serves as a first destination for developing PQI website materials, giving followers the inside scoop on PQI discoveries, including local research, opportunities and information about joining PQI. These efforts enhance PQI's visibility and recognition, as well as the networking opportunities and quality of programming for PQI members.

## Program Directions and Communication

In Academic Year 2021-22, PQI shifted from its home within the Kenneth P. Dietrich School of Arts and Sciences to its new home under the Office of the Senior Vice Chancellor of Research (SVCR). After 10 years of leadership under Jeremy Levy, the directorship transferred to Adam Leibovich. Given these fundamental changes, it was a good time to review and update the vision, mission, bylaws and many of the opportunities that PQI offers to our members. With the PQI Executive board, the new Vision and Mission statements shown above were drafted and approved.

### Bylaws

Working with the PQI Executive Board, new bylaws were drafted and approved. The main changes from the original bylaws are:

- The Director is now appointed by the SVCR, as opposed to the Dean of the Dietrich School.
- The PQI Executive Board was replaced by the Steering Committee.
- The structure of the Steering Committee was specified, with a minimum of six faculty members and two graduate students/postdocs. Term lengths of three years were established.
- The leadership team instituted the ability to include members from local industry or research laboratories working in quantum science or engineering.
- The bylaws are written so that it will be easy to modify them to incorporate a co-director into the leadership team in the future.

The new bylaws were approved by the PQI Executive Board during the November 29th, 2022 meeting.

## Website

This year we updated PQI's web site, seeking to highlight the renewed energy behind the organization, and addressing the need to replace the aging (and soon unsupported) infrastructure of the 2012-2022 PQI website.

In particular, the following changes were made:
- Software infrastructure has been updated to the latest versions.
- Templates and plug-ins are selected from the latest set supported by Pitt's Web Communications team.  In addition, support for multiple platforms, including phones, tablets and desktop computers was added or enhanced.
- Website accessibility was improved using templates and implementing alt-text protocols that could be used by software for reading websites for those with visual impairments.
- Highlighted the institutions and individuals that help unify PQI in the Greater Pittsburgh area.
- Made it easier for faculty, postdocs, and students to find resources by reorganizing the website so that information is available through fewer clicks while searching.
- Directly connected into Pitt and CMU's calendaring systems, enabling faculty to pull PQI seminars directly into their calendaring tools.

The pqi.org website launched at the end of April 2023.

## PQI Fellowship and Discretionary Funding Awards

PQI offered 9 Graduate Student Assistant fellowships this year thanks to funding from the Pitt Dietrich School of Arts and Sciences (6), the Pitt Swanson School of Engineering (2), and the Pitt School of Computing and Information (1 of 2 possible). These positions enable students to pursue research, with the requirement that they also spend a few hours a week on activities that advance PQI. These fellows greatly contributed to the creation and development of the committees discussed above.

CMU also offered its students a best poster award for its students, increasing participation and awareness for the PQI conference poster session.

# Purpose, Events and Interaction

## PQI 2022 Annual Conference

The 2022 Annual conference combined successful elements from prior conferences with new elements for this year.  As before, faculty from CMU, Pitt, and Duquesne universities came together to share their research.  (See Figure 1.). This year, faculty from West Virginia University were also invited to participate.

*Figure 1. Faculty from CMU and Pitt gather at the PQI 2022 Conference.  Left to right: Susan Fullerton, Tom Purdy, Michael Hatridge, Beth Dickey, and Jeremy Levy.*

Faculty and students had time to interact over meals and during breaks.  Several new proposals were discussed, including several related to quantum computing and quantum sensing.  Students attended tours of both Pitt and CMU facilities and had opportunities to learn from faculty.  (See Figure 2.)



*Figure 2. Left: Faculty and students discuss research during collaboration time built into the schedule. Right: Faculty offer tours of their Labs to students from CMU, Pitt and Duquesne.*

Three public lectures were presented as part of the conference.  (See Figure 3.) The first talk is accessible to faculty and students intrigued by working in QISE.  Nicole Yunger Halpern shared the whimsy and excitement of her book: *Quantum Steampunk: The Physics of Yesterday's Tomorrow.*  Margaret Martonosi shared her view on how to connect algorithms and devices in

*Mind the Gap!  Challenges and Opportunities in Closing the Algorithms-to-Devices Gap in Quantum Computing*.  Charlie Tahan then looked to the future with his talk: Quantum 2028.



*Figure 3. Three Public Lectures were offered.  Top left: Nicole Yunger Halpern summarized her new book: Quantum Steampunk: The Physics of Yesterday's Tomorrow. Top right: Charlie Tahan spoke about the future of quantum information science and engineering and identified existing and future US Government initiatives.  Bottom: Margaret Martonosi spoke about her research in quantum computing, and in the NSF's plans to support new research.*

New this year was the first PQI panel dedicated to Industry collaboration. (See Figure 4.) Panel participants explored industry interaction.  Moderator and CMU Professor Dickey asked a distinguished panel about challenges currently being faced by their industries and their plans in Quantum Information Science and Engineering.  Panelists included:
- Sridhar Tayur from CMU's Tepper School of Business
- Jonathan Wormald, Senior Engineer, Naval Nuclear Laboratory
- Blake Johnson, Ph.D., Quantum Platform Lead, IBM Quantum
- Joshua Smith, President OPeTechnologies, and
- David Esteban Bernal Neira, Associate Scientist in Quantum Computing, NASA.

*Figure 4. Industry engagement was an important theme for this year's event. Industry explored important questions related to the future of quantum information science and engineering, and interest from regional companies. Left: Prof. Dickey asks the industry panel about the challenges they are facing. Right: Prof. Tayur explains how CMU's Tepper School works with businesses to solve problems using quantum-inspired algorithms.*

Attendance was primarily from Pitt and CMU, with other universities represented by individual faculty members or postdocs. See Figure 5 and Figure 6.
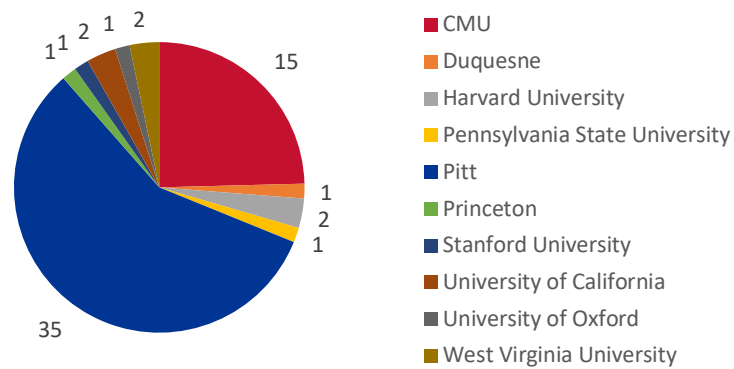


*Figure 5. University affiliation of pre-registered faculty attendees at the PQI 2022 conference.*
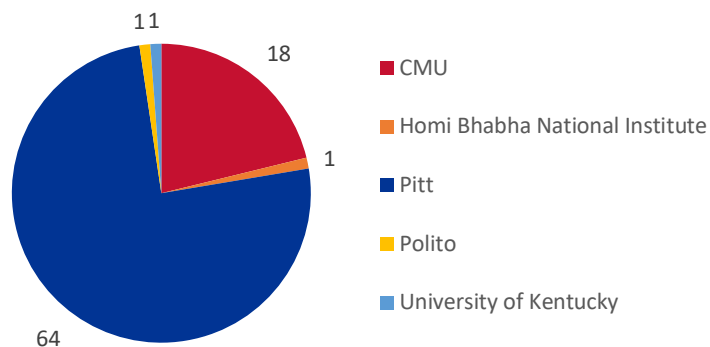


*Figure 6. University Affiliation of pre-registered student attendees. Some students decided to join us for sessions on the last day that are not recorded. We are aware of approximately 10 additional members attending from a CMU course and six more from Duquesne University.*

## PQI Professional Education Program

Also new this year was a one-day workshop tutorial on *Quantum Information Science for Professionals,* hosted by CMU's Tepper Business School.  (See Figure 7.) Instructors included Kaushik Seshandreesan, Sridhar Tayur, Robert Cunningham, Michael Hatridge, and Tom Purdy.
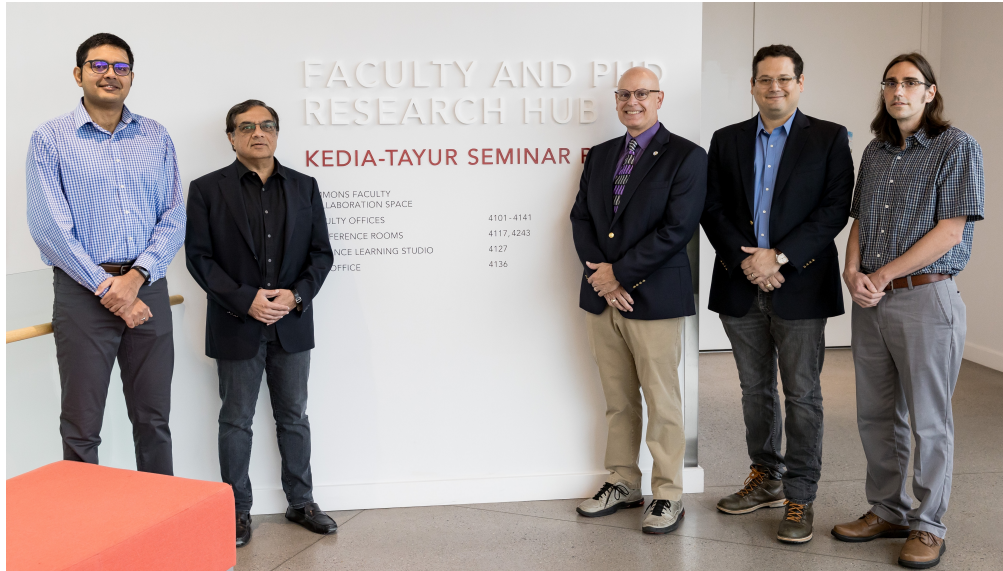




*Figure 7. Top: Instructors from the first PQI Professional Education Program.  Bottom: Students participating in the course, reviewing handouts and other material.*

Attendance was good, with participation from a variety of types of positions and organizations. The Naval Nuclear Laboratory represented the largest cohort.  See Figure 8.
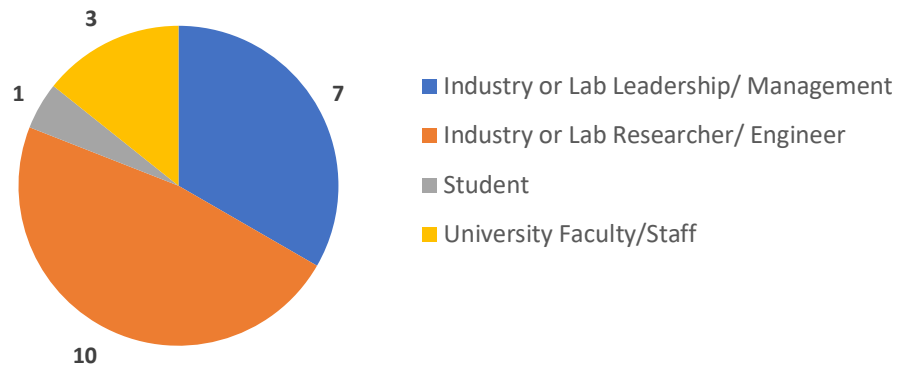
*Figure 8. Position of attendees of the PQI Professional Education Program.*

## Industry Membership

New this year is a form and plan for industry membership. PQI developed a two-tiered sponsorship agreement – an introductory membership, and a full membership. Benefits are wide ranging, and include attendance at the annual event, research engagement opportunities, access to webcast seminars and guaranteed seats in executive offerings. In addition, full members receive reduced costs for certain benefits and support for additional attendance at PQI events.

## NSF-OSTP Workshop on the Cybersecurity of Quantum Computing

Also this past year, PQI hosted a joint National Science Foundation and Office of Science and Technology Policy invitation-only event to catalyze new cybersecurity research, consisting of selected experts in quantum computing and cybersecurity. (See Figure 9.)
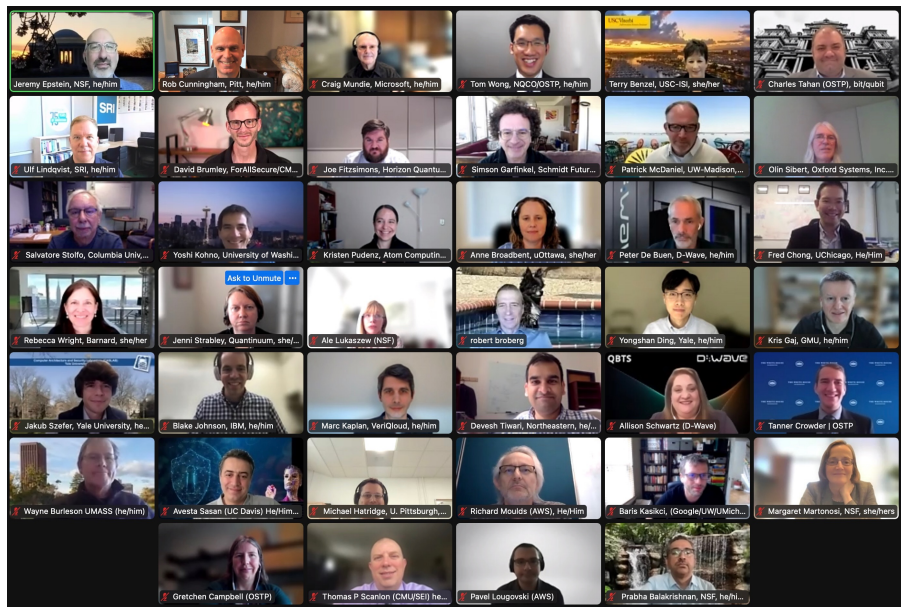


*Figure 9. Attendees of the online NSF-OSTP Cybersecurity of Quantum Computing event.*

## Distinguished Seminar Series

Revamped and rebooted, 2023 marked the restart of our Distinguished Seminar Series.  (See Figure 10.)



*Figure 10. Spring 2023 marked the restart of our Distinguished Seminar Series.  Top left: Prof. Tony Heinz of Stanford University. Top right: Prof. Andrea Alu, City University of New York. Bottom Left: Prof. Brenda Rubenstein of Brown University. Bottom Right: Prof. Ken Jordan of the University of Pittsburgh.*

## Postdoc and Student Seminar Series

We also restarted the Postdoc and Student Seminar series.  Students in the region shared their research with each other, helping attendees make connections across disciplines at the early stages of their careers.

# Budget and Finances

PQI began the academic Fiscal Year 2023 with $157,832 of funding from the University of Pittsburgh for PQI operations. We are budgeted to spend all this funding, projecting to end the year with only a few hundred dollars remaining.

In addition, three schools within Pitt contributed Graduate Student Assistant support to our students. Exact values of these are a combination of graduate student stipends, fringe benefits, and tuition.  These differ by school and degree (stipend and fringe) and by where the student is in the degree program – students still working on classes need to have their full tuition covered, whereas students that have completed their classes and are in the "full-time dissertation only" portion of their studies cost less. Carnegie Mellon University donated $2,000 for a winning poster as well as the cost of meals and use of facilities for the professional education program. Winners of the PQI 2022 Poster Competition won either CMU discretionary funding or GSA support. The winners included: Sid Achar, Paige Moncure, Nazifa Tabassum, Mihir Khanna, and Mohammad Babar.

PQI also generated $50,000 of external funding through the PQI Membership program. (See Table 1 for a summary of funding.)

| FY23 Funding Sources | |
|---|---|
| Pitt - PQI Operations | $  157,832 |
| Pitt - Dietrich School of Arts & Sciences (8 GSAs) | $  495,188 |
| Pitt – Swanson School of Engineering (2 GSAs) | $   56,699 |
| Pitt - School of Computing and Information (2 GSAs offered, 1 used) | $   42,751 |
| CMU – Student Discretionary Funding | $    2,000 |
| External Contributions | $   50,000 |
| **Total Funding** | **$  804,470** |

*Table 1.* Fiscal year 23 funding sources separated by University of Pittsburgh, Graduate Student Assistant (GSA) support by the schools of: Arts & Sciences, Engineering, and Computing and Information, Carnegie Mellon's discretionary funding support in addition to donations covering meals and the use of facilities, and external contributions. External contributions included revenue received from outside entities for the PQI Membership.

Fiscal year 2023 expenditures are forecasted to be $754,057. Spending is categorized into 4 areas aligned with each top-level mission statement. (See Table 2 and Figure 11.) Most spending went to "Train Future Leaders", primarily in the form of Graduate Student Assistant Support. Next most funding was spent to "Energize, Unify, and Promote Quantum Science" via supporting the PQI Annual Conference. The third largest area of spending was "Develop Outside Partnerships." Spending for this category included professional memberships and in-house support. Finally, "Advance Research and Technology" was the 4th largest area of spending which includes the Seminar Series and a Workshop.

| Mission Statement Areas of Alignment | Total Forecasted FY23 Expenditures |
|---|---|
| Energize, Unify, and Promote Quantum Science | $ 80,396 |
| Advance Research and Technology | $ 25,146 |
| Train Future Leaders | $ 617,328 |
| Develop Outside Partnerships | $ 33,541 |
| Total | $ 754,057 |

*Table 2. Fiscal year 23 forecasted expenditures separated into areas aligned with the four mission statements above. The largest number of expenses came from the "Train Future Leaders" area.*
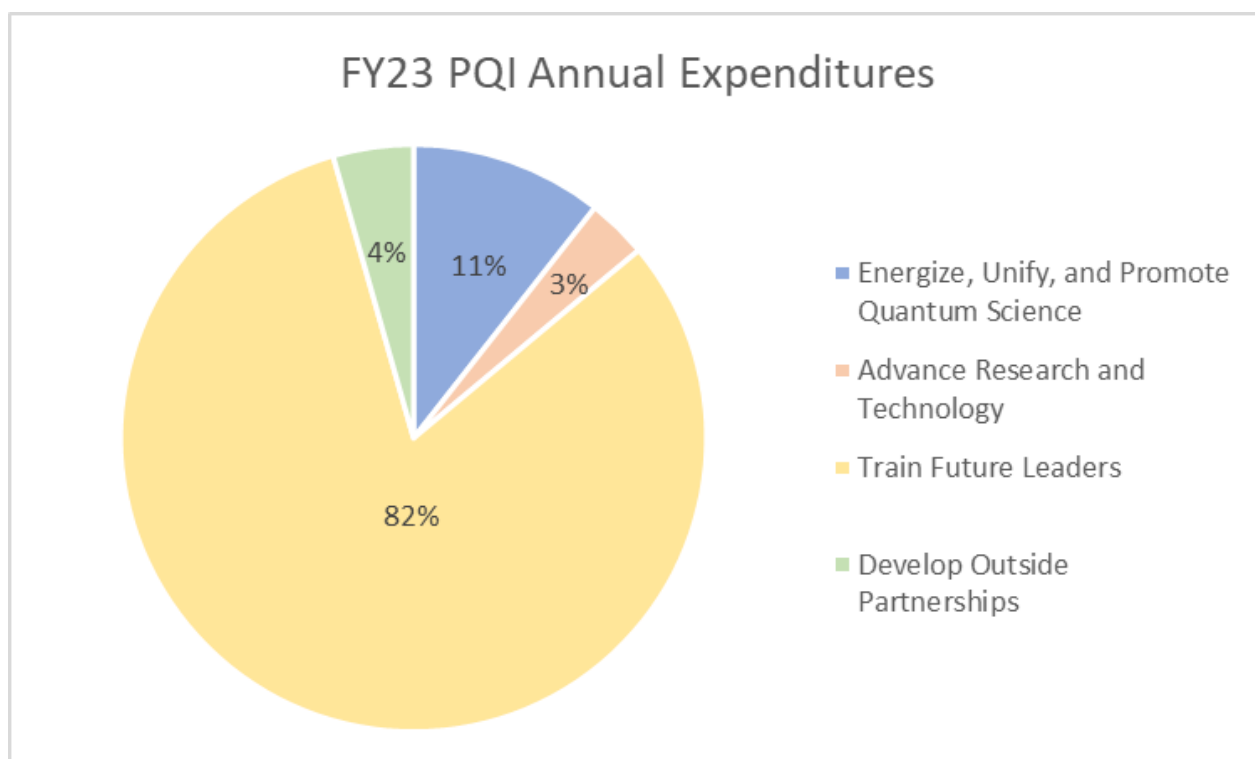


*Figure 11. Fiscal year 2023 expenditures categorized by mission area and depicting spending percentages.*

## Plans for 2023-2024 Academic Year

In the next academic year, PQI will continue to develop new ways to accomplish our mission, by sustaining our current programs and developing new initiatives, in alignment with the three strategic pillars guiding PQI into the next decade and beyond.

### Plans for Our People

As the flexible working options continue with new hires and returning to more in-person meetings, we feel it is important to have in-person meet-and-greets to foster interconnections between PQI members. We will develop a series of smaller events to forge these connections.

The PQI Postdoc and Student Seminar Series has been very successful in promoting the research of graduate student members of PQI. We plan on continuing this series, including more

outreach opportunities with CMU to achieve broader student participation and stimulate engaging discussions with attendees and speakers.

## Plans for Our Program

The PQI Distinguished Seminar Series launched in January 2023, and we were gratified that we were able to schedule an impressive lineup for the spring semester. Further, we already have a few speakers booked for next year. The Seminar Series Committee will continue to fill out the speaker list for the next academic year.

In consultation with the Steering Committee, we will move the annual PQI conference back to Spring 2024. We will begin planning the next event in the summer, seeking input on timing and content from our External Advisory Committee.

In the interim, we plan to host a small workshop or two on quantum-specific topics throughout the year also. These workshops will be focused on topics ranging from sensing to computing, bringing together local and a small number of national and international researchers. By soliciting ideas from our members, we hope to facilitate innovative research that will lead to new proposals and new projects in each of the themes.

## Plans for Our Purpose

We will continue to reach out to local laboratories and industry to forge new connections to PQI. PQI has always envisioned bringing together local researchers in quantum science and engineering in the Pittsburgh area. With increased media coverage and funding activity in the technology industry in the region, creating these connections is an important extension of our mission.

The *Quantum Information Science for Professionals* course last fall was a successful test project to balance affordability with accessibility. As such we did not charge a large fee for the course. We will run the course again and investigate the interest in repeating and extending this program.

Finally, over the past few years, federal funding in quantum information science has grown to over $800 million. Researchers in the Pittsburgh area are applying for these funds, but as a community we can always try to capture more funding. We will continue to leverage the smaller, more personalized workshops to prepare for new solicitations and then apply once they are released.