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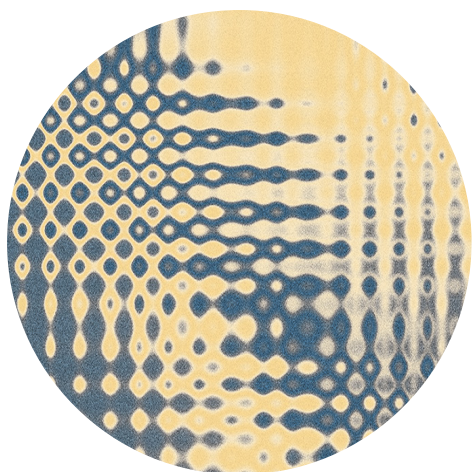
Research Council
of Finland



The Finnish Quantum Flagship

Interim Report

JANUARY 2024 — FEBRUARY 2026



Introduction

The Finnish Quantum Flagship is the spearhead of national research activities in quantum science and technology (QST) and the first initiative of its kind in Finland at this scale, bringing diverse expertise under one coordinated framework. The support of the Research Council of Finland for creating such a unique environment was exceptionally timely: QST is receiving increasing attention from governments, industries, and the general public across the national, European, and global landscapes. As an unprecedented multi-partner project, FQF has ensured the delivery of a significant impact that matches the level of promised synergy. Therefore, rather than functioning as one of many funding instruments for “business-as-usual”, FQF positioned itself as a strategic framework to ignite collaborations that did not previously exist. A concrete example is the emergence of the QMAT Centre of Excellence, built upon the collaborations developed within Program 1 of the flagship.

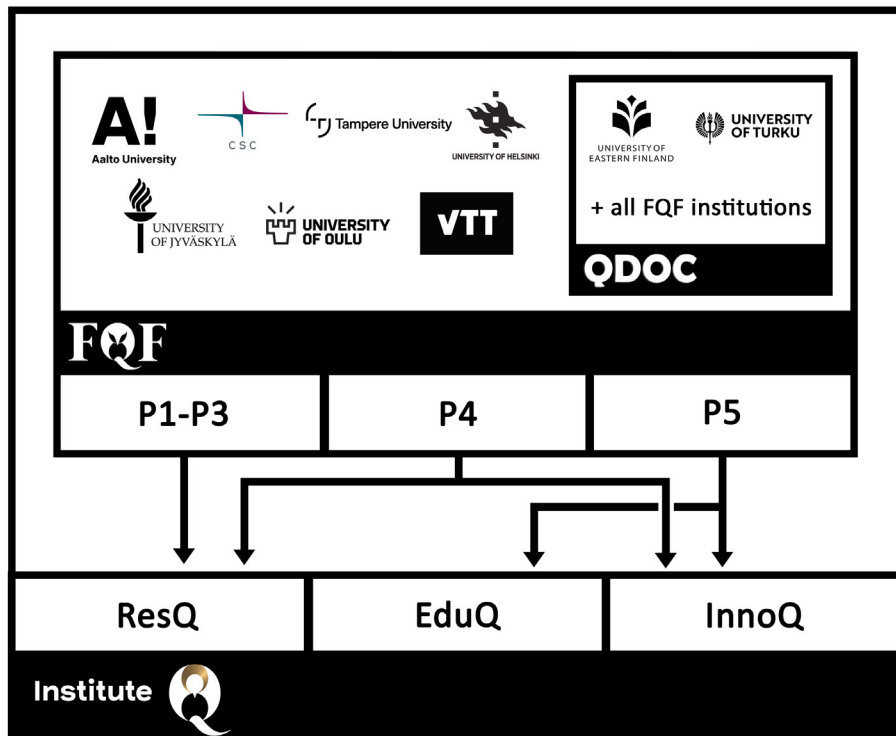
The rapidly growing interest in quantum science and technology created an urgent need for coordinated policy development. In this context, beyond advancing scientific excellence and educating the future workforce, FQF played a vital role in shaping the framework for quantum science and technology policy in Finland. Its scientific and impact personnel have directly and significantly contributed to the preparation of the Finnish quantum technology strategy and Finnish quantum technology roadmap published in 2025 and 2026, respectively.

Additionally, FQF catalyzed the development of the Finnish quantum ecosystem. In 2024, it brought together two additional members to its original seven-partner structure to form QDOC, the largest consortium for quantum doctoral education in Finland, comprising nine national members. Subsequently, in 2025, FQF successfully supported the inclusion of all these members into InstituteQ, the national quantum institute of Finland. FQF, which initially emerged from a smaller InstituteQ, effectively strengthened and expanded its parent institution. Notably, FQF also evolved into a focal point within its host institutions, leading to the creation of local quantum communities. JYUQuantum is a representative example, bringing together 27 research groups across multiple faculties at the University of Jyväskylä, strategically supporting the flagship.

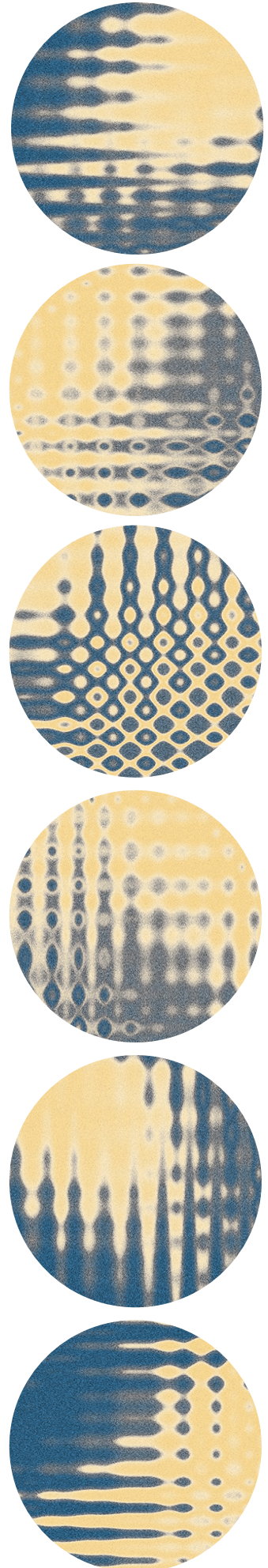
Policy making and ecosystem development, alongside scientific excellence, have therefore become defining pillars of FQF's impact. If not equally, they constitute a substantial share of the flagship's overall contribution to the national quantum landscape.

Peter Liljeroth, FQF Director
Mahdi Moghaddam, FQF Manager

FQF Ecosystem



50+ international companies
~250 international networks
~500 international universities and research institutes



FQF Programs

Program 1: Quantum Materials

Quantum materials display quantum phenomena at the macroscopic scale, bringing them to the scales required for quantum devices.

Program sub themes:

- Quantum-geometry-boosted superconducting quantum materials
- Scalable topological qubits based on fractional quantum materials
- Spinorbitronic protected transport in van der Waals quantum materials
- Controllable hybrid quantum materials by engineered out-of-equilibrium driving
- Machine-learning enabled design of quantum materials

Program 2: Quantum Devices

In this program, the goal is to harness inherently quantum effects to create novel devices with functionalities that are otherwise unattainable in a standard classical framework.

Program sub themes:

- Superconducting qubits and control for scalable processors
- Hybrid quantum devices: optomechanical, optoelectrical, and spin-mechanical interfaces
- Parametric devices—amplification, squeezing, and continuous-variable entanglement
- NIS, TES, ferro/super, and graphene bolometers
- Quantum thermodynamics and quasiparticle physics

Program 3: Quantum Algorithms, Software and Information

Progress in quantum error correction and in hybrid classical-quantum architectures is steadily expanding the frontier of near-term capability. This program addresses this evolving landscape through tightly integrated research spanning theory, algorithm design, and application-driven development.

Program sub themes:

- Scalable algorithms for near-term quantum computers
- Algorithms for fault-tolerant quantum computers
- Use cases and applications
- Quantum information theory and applications to fault tolerance, quantum sensing and metrology

Program 4: Quantum Future

The key objective of the program is to facilitate impact generation and evolution of the field. The rapid pace of development in the quantum technologies field necessitates the reservation of resources to tackle emerging topics that cross the Programs 1-3 of the flagship.

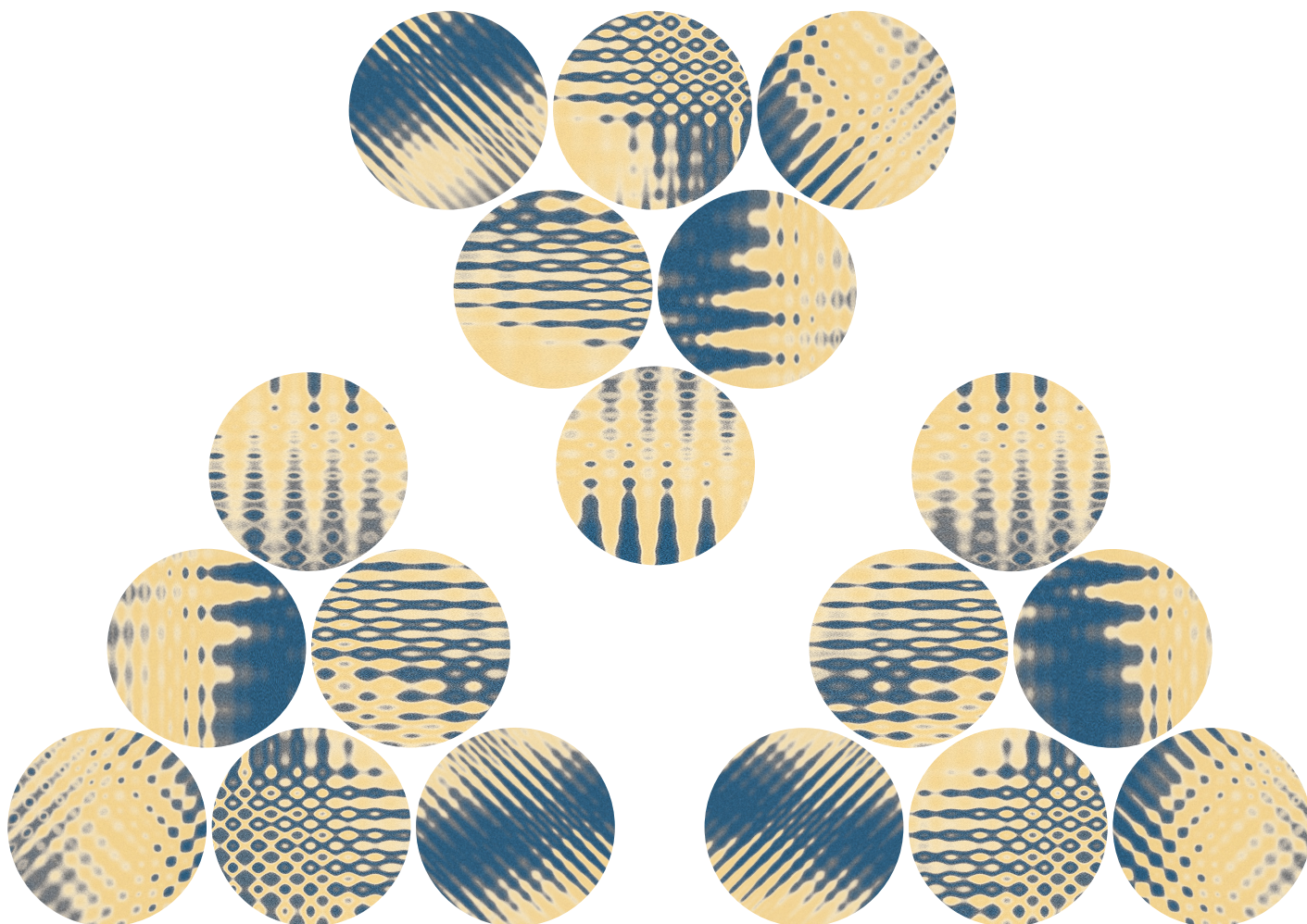
During the first term of FQF, Program 4 hosted targeted calls towards Lighthouse and smaller-scale Exploratory projects. During the second term, Program 4 will expand on this funding mechanism by merging Anchor projects with the Exploratory project concept, now with a progressive funding scheme based on synergy and the possibility to incorporate external PIs. Lighthouse projects will be even more strongly targeted to fund ideas that contribute to new technologies emerging from our ongoing work that require resources and cross-program collaboration to reach maturity.

Program 5: Quantum Ecosystem Development

The Finnish quantum ecosystem consists of universities, RTOs, companies, governmental funding agencies and regulators, and private investors (VCs). The ecosystem also affects the public and society. The goal of the Quantum Ecosystem Development program is to intensify inter-sectoral knowledge transfer to strengthen the ecosystem and speed up innovation.

Program sub themes:

- Ecosystem growth and accelerating innovation
- Societal impact
- Training and Outreach



FQF PIs & Leadership

P1: Quantum Materials		P2: Quantum Devices		P3: Quantum Algorithms, Software and Information		P4: Quantum Future		P5: Quantum Ecosystem Development	
Jose Lado (lead)	Aalto	Sorin Paraoanu (lead)	Aalto	Zoltan Zimboras (lead)	UH	Peter Liljeroth (lead)	Aalto	Eija Tuominen (lead)	VTT
Teemu Ojanen (deputy lead)	TAU	Juha Muhonen (deputy lead)	JYU	Esko Keski-Vakkuri (deputy lead)	UH	Jose Lado	Aalto	Mikael Johansson (deputy lead)	CSC
Peter Liljeroth	Aalto	Ilari Maasilta	JYU	Alexandru Paler	Aalto	Sorin Paraoanu	Aalto	Kimmo Tuominen	UH
Pertti Hakonen	Aalto	Antti Kemppinen	VTT	Jukka K. Nurminen	UH	Zoltan Zimboras	UH	Nina Granqvist	Aalto
Päivi Törmä	Aalto	Jukka Pekola	Aalto	Lauri Oksanen	UH	Eija Tuominen	VTT	Tiina Apilo	VTT
Sebastiaan van Dijken	Aalto	Laure Mercier de Lepinay	Aalto	Matti Lassas	UH			Joel Mero	JYU
Shawulienu Kezilebieke	JYU	Mika Sillanpää	Aalto	Matti Silveri	UO			Paavo Pyökkänen	UH
Christian Flindt	Aalto	Mikko Möttönen	Aalto	Tommi Mikkonen	JYU			Ismo Koponen	UH
Tero Heikkilä	JYU	Paolo Muratore-Ginanneschi	UH	Susi Lehtola	UH			Teiko Heinosaari	JYU
Zhipai Sun	Aalto	Jorden Senior	VTT	Francesco Cosco	VTT				
Riku Tuovinen	JYU	Anton Zasedatelev	Aalto						

FQF Leadership

Peter Liljeroth

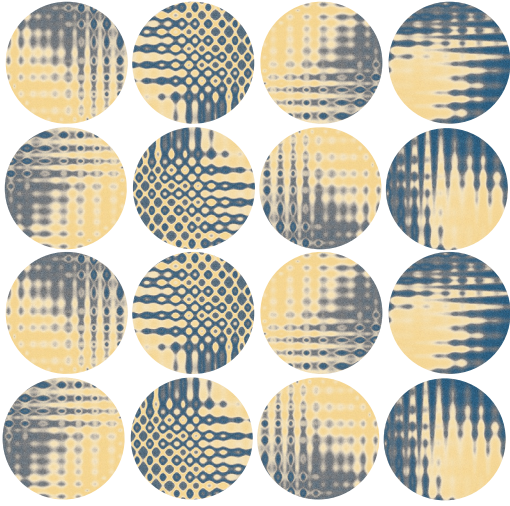
Flagship Director | Aalto University

Eija Tuominen

Flagship Vice-Director | VTT

Mahdi Moghaddam

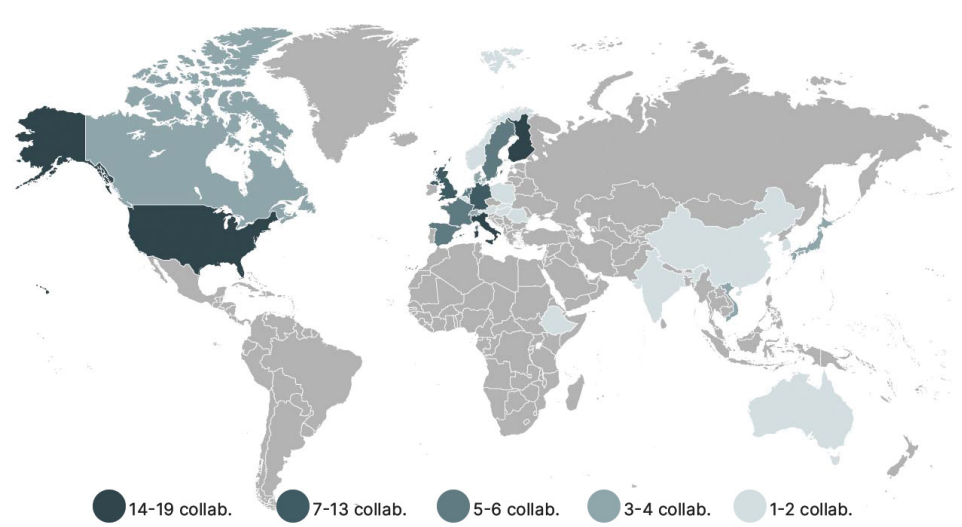
Flagship Manager | Aalto University



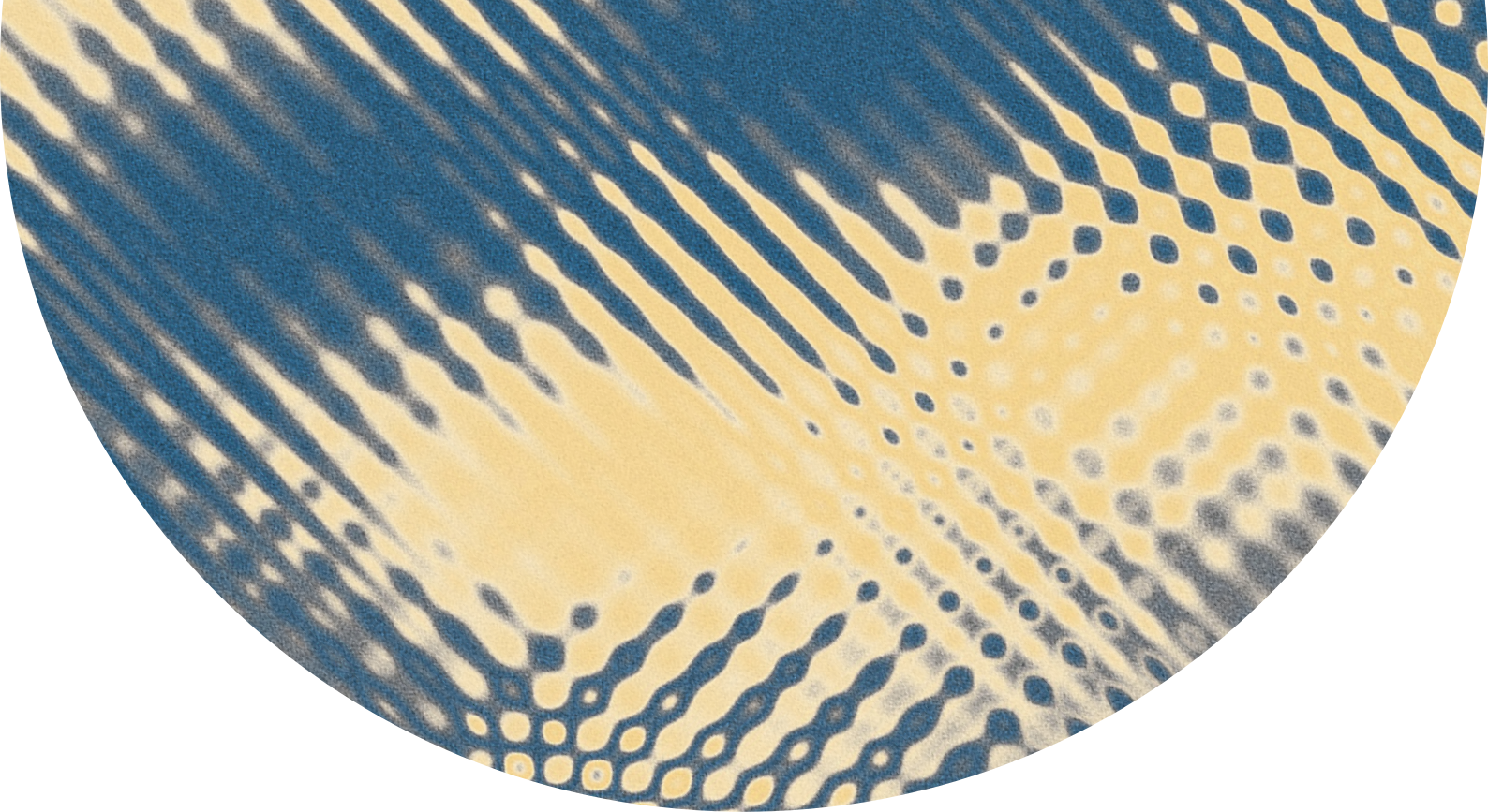
Business Development	
Juho Pirinen	Aalto
Irma Ylikangas	VTT
Sandeep Shah	UH
Santtu von Bruun	UH
Government Relations	
Ilona Lundström	Aalto

Key performance indicators

Collaborator type	Quantity (Jan. 2024- Feb. 2026)
Research organisations:	85
Industry (companies):	18
Civil society actors (e.g. nongovernmental organisations, societies, clubs):	13
Public administrative actors (e.g. officials, policy-makers):	4



Indicator	Quantity (Jan. 2024-Feb. 2026)	Additional details
Publications: peer-reviewed	374	
Publications: popular	60	These publications include (but are not limited to) webpage articles, newsletters, reports, a technology roadmap, scientific lectures, and printed handouts.
New ERC projects	3	Three ERC funding grants were awarded to FQF PIs, all from Aalto University: 1. Prof. Peter Liljeroth, Advanced Grant, GETREAL, Realizing designer quantum matter in van der Waals heterostructures. 2. Prof. Jose Lado, Consolidator Grant, ULTRATWISTROI CS, Engineering ultra-quantum materials with multiferroic super- moiré heterostructures. 3. Prof. Sorin Paraoanu, Synergy Grant, DarkQuantum, (2024-2030, GA 101118911).
New startups	3	1. Agate Sensors Oy, a spin-off from the research group of Zhipei Sun (FQF PI, Aalto), delivering ultra-miniaturized and scalable hyperspectral intelligence solutions. 2. QMill Oy, co-founded by Mikko Möttönen (FQF PI, Aalto) together with Ville Kotovirta (former FQF PI, VTT) to develop practical quantum algorithms for the NISQ era, targeting near-term industrial advantage in areas such as finance, logistics, and energy. 3. Arctic Instruments, co-founded by Visa Vesterinen (former FQF PI, VTT) providing plug-and-play microwave readout solutions and near quantum limited parametric amplifiers for quantum computing.
New company collaborators	20	
Patents	38	Flagship PIs collectively have 38 items in the innovation pipeline, including 29 patents and patent applications (granted and pending) and 9 invention disclosures.
Degrees: PhD	63	FQF PIs have supervised a total of 63 doctoral students, including 55 completed and 8 ongoing
Degrees: Master	77	
New international recruits	82	A substantial portion of the 166 new positions created within FQF have been filled by international recruits across all levels, from doctoral researchers to professorial appointments.
New tenure track positions	6	From JYU: Vlad Stirbu (IT), Majid Haghparsat, (IT) and Paolo Mognini (Physics). From Aalto; recruitments related to quantum science and Tech: Sorin Paraoanu (Experimental Quantum Physics) and Anton Zasedatelev (Experimental Quantum Physics). University of Helsinki recruited a TT in quantum algorithms, Zoltan Zimboras (Quantum Algorithms).
Social media followers	2300	
Jobs created	166	These include 100 doctoral researchers, 35 postdoctoral researchers, 6 professorial-level positions (partial support), 7 impact personnel (coordination, management, communications, corporate/business relations), and 18 other/uncategorized roles.



Internal funding structure and operational principles

Despite the locally distributed funding model, from the outset of the flagship, the FQF Management Group (MG) reached a consensus that, in order to achieve higher impact, planning must be pursued jointly. A shared internal platform was therefore established for documentation, evaluation, and funding of projects across the flagship. Representatives from each partner institution had full visibility of active nationwide projects. As a result, this transparency rather than creating formal binding commitment between partners, reduced fragmentation and improved the efficient flow of critical information across all partners and the identification of scientific synergies and impact overlaps at national level.

Within this coordinated structure, PIs across the flagship were invited to apply for funding for two main types of research projects, primarily aimed at recruiting postdoctoral researchers:

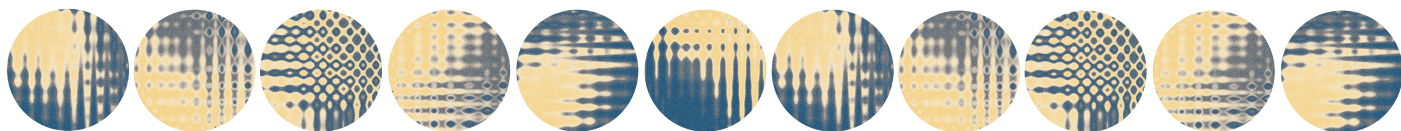
- Anchor Projects: Foundational topics aligned with PIs' and flagship's research agendas, with encouraged internal synergy between different flagship groups.
- Lighthouse / Exploratory Projects: Significant scientific breakthroughs with clear commercial prospects (Lighthouse) and high-risk, high-reward ideas (Exploratory), both requiring internal synergy across flagship partners.

The first term of the flagship is divided into two internal phases: Phase I (January 2024 – January 2026) and Phase II (February 2026 – April 2028). This interim report covers activities and outcomes of Phase I.

Across all FQF scientific programs in Phase I, 1 Lighthouse (150k€), 2 exploratory projects (75k€ each), and around 30 Anchors were funded (postdoc costs for 1.5-2 years). On top of external collaborations with groups outside of FQF existing in almost all projects, 30% of all funded projects had strong internal collaborations between FQF PIs. In addition to scientific projects, various initiatives and activities contributed to promoting impact in quantum policy and ecosystem development.

Results

With 40 official scientific principal investigators and a dedicated group of impact personnel, this report focuses not on detailing every individual activity, but on highlighting initiatives that represent the impact from a holistic view.



Ecosystem Development

FQF strengthened national and international interactions across academia, industry, policy, and also general public.

Developing quantum policy

Through multiple conventions, meetings, and email iterations, FQF MG continuously collected and compiled expert opinions from all PIs and extended personnel of partner institutions. With rich national vision, FQF represented the quantum community in various national and international policy and ecosystem development circles and co-created strategic guidelines:

- Directly contributed to the preparation of Finnish quantum tech strategy; chaired 3/4 subgroup and overall held 8/40 seats in the working group.
- Co-created the Finnish Quantum Technology Roadmap 2035, led by its RTO member VTT, providing strategic guidance for national development in quantum technology. The roadmap also shaped societal dialogue through “what if” scenarios.
- Submitted official statements to European Calls for Evidence on quantum policy documents (e.g. EU Quantum Strategy and EU Quantum Act)
- Has held 2/50 seats in OECD GFTech Quantum Focus Group, an international forum for regular in-depth dialogue and guideline publication on opportunities and risks of quantum technology (e.g. A Quantum Technology Policy Primer)
- Participated in and hosted multiple international industrial, academic, and political delegations related to QST to/from Canada, USA, Africa, Australia, and EU (ref. to Collaborations section of the report)

- Led InstituteQ’s expansion process to include all FQF host institutions. InstituteQ expanded in 2025 from three co-founder members to 9 national members.

Developing educational modules

- JYU released in 2024 the first Finnish Massive Open Online Course (MOOC) ABC of Quantum Computing (both in Finnish and English), on quantum computing. Its different parts A, B and C, educates, free of charge, different-level target groups on quantum computing, including general public.
- Aalto established Quantum Inventors Program in 2026 to train national postdocs and doctoral students how to turn scientific breakthroughs into innovation.
- UH developed two courses for physics teacher education in collaboration with upper secondary schools, implementing into the agenda concepts of quantum information and technology, and quantum optics experiments.
- Aalto developed a new doctoral level course in 2025 in Quantum machine learning.

Organizing or co-organizing events and workshops

The following gatherings in various scales and environments enhanced the visibility of the national and regional quantum ecosystem and also created societal engagements (excluding smaller PI-driven events):

See events on the following page →

Research-education events

JQUEST Workshops 2024 & 2025	Workshops strengthening national collaboration in quantum engineering and software. (90)
International Workshop on Optical Integration of Cryogenic Quantum Technologies 2025	First international workshop on optical integration for cryogenic quantum systems. (40)
Quantum Resource Estimation Workshop 2024 & 2025	Workshop focused on quantum software and hardware-aware algorithm design.
PREIN + FQF Quantum Research and Technology Workshop 2024	Joint photonics and quantum technology collaboration workshop. (50)
FQF General Meetings 2024 & 2025	Flagship-wide meetings for strategy alignment and research exchange. (50)

General public events

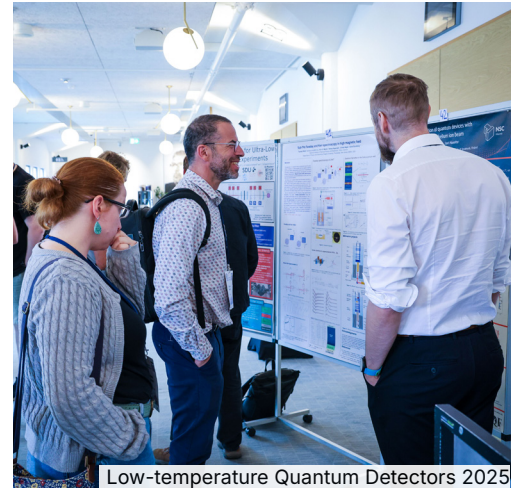
Designs for a Cooler Planet: Quantum Technology Strategy	Public outreach event introducing Finland's national quantum technology strategy to broader audiences. (+100)
3MT Pitching Competition 2024 & 2025	Doctoral researchers present quantum research in concise public-facing pitches. (50)
Five o'clock Quantum Tea (Kello viiden kvanttitee)	Monthly public discussion forum on quantum technologies in Jyväskylä.
Quantum Computer – Big Promises to Deliver?	Public expert panel on practical quantum computing applications and future impact.

Multi-sectoral events

Finnish Quantum Days 2024 & 2025	National flagship event connecting academia, industry, and policymakers. (200–300 participants)
Europe's First 50-Qubit Quantum Computer Launch	Launch of Europe's first 50-qubit system by VTT and IQM; milestone for European quantum hardware. (+100)

Research-industry events

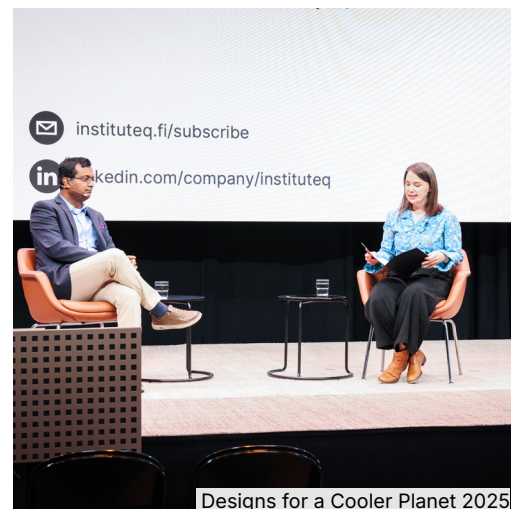
Quantum Software Days 2025 & 2026	Forum on quantum software, applications, and industry collaboration (+120).
QDOC Doctoral Students Seminar 2025	National seminar for quantum doctoral researchers; networking and professional development. (100)
Industry-Connect Matchmaking 2024, 2025 & 2026	Annual academia–industry networking and career event for doctoral researchers and companies. (+50)
Hanken Quantum Hackathon 2024 & 2025	Student and industry hackathon focused on quantum computing and sustainable finance.
Low Temperature Quantum Detectors 2025	International conference on advanced low-temperature quantum detector technologies. (150)



Low-temperature Quantum Detectors 2025



QDOC kickoff event



Designs for a Cooler Planet 2025



Finnish Quantum Days 2025

Scientific advancements

Quantum Materials

Program 1 has delivered, combining theory and experiment, significant advances in quantum materials, covering superconducting flat-band materials, van der Waals heterostructures, and driven quantum systems.

Superconducting and engineered quantum materials

Tero Heikkilä and Päivi Törmä's (ref. [here](#)) established the critical role of quantum geometry in enabling supercurrent in twisted-bilayer graphene and rhombohedral graphite, demonstrating controllable superconducting phenomena in engineered materials. Pertti Hakonen's group identified epitaxial CoSi_2 as an exceptionally low-noise and high-kinetic-inductance platform for superconducting circuits ([here](#)), investigated Cooper pair splitting ([here](#)) and quantum Hall states in graphene, and observed non-trivial topological states in superconducting nanowire devices.

Van der Waals quantum materials and topological systems

Shawulienu Kezilebieke, Peter Liljeroth and Jose Lado's groups realized a two-dimensional topological crystalline insulator, previously thought unattainable, providing a tunable platform for spintronics and nanoelectronics ([here](#)). Their collaboration additionally realized doped Mott regime with correlated charge order in monolayer 1T-NbSe_2 ([here](#)), direct real-space visualization of multiferroicity in monolayer NiI_2 ([here](#)), and demonstration of the emergence of nontrivial spin textures in supramolecular metal complexes coupled to a two-dimensional superconductor ([here](#)). Collectively, these results define a materials-by-design approach that strengthens the Flagship's core capability in discovering, characterizing, and controlling emergent quantum phases in low-dimensional materials.

Driven quantum systems

Shawulienu Kezilebieke demonstrated single-molecule optical switching by repositioning a single atom, opening pathways for nanoscale optoelectronic devices. Sebastiaan van Dijken demonstrated long-distance spin-wave propagation at cryogenic temperatures for the first time ([here](#)), addressing a key bottleneck of increased magnetic damping at low temperatures and setting the stage for studies on quantum magnonics. He additionally established high-quality growth of Er-substituted YIG films, which will be exploited in studies on microwave-to-optical quantum transduction. Päivi Törmä's group explored plasmonic lattices with active media, demonstrating lasing and Bose-Einstein condensation phenomena ([here](#)).

Quantum Devices

Superconducting Qubits and Circuit Architectures

Mikko Möttönen's team demonstrated and analyzed device-and-process strategies enabling near millisecond energy relaxation and dephasing in transmons, developed decay-protected qubit concepts with fast control via integrated on-chip filtering, and advanced design/optimization of novel qubit modalities (unimon) ([here](#)). Teams at JYU demonstrated the possibility of using Andreev bound states in Josephson junctions providing the non-reciprocity for on-chip circulators necessary for processing quantum signals, and identified superconducting ac response as a mechanism of identifying altermagnetism in hybrid altermagnet-superconductor structures ([here](#)).

Hybrid and Parametric Quantum Systems

Mika Sillanpää's group have discovered low energy losses of phonons in crystalline materials at mK temperatures, and used these materials to realize devices with synthetic phonon dimensions. They have achieved for the first time feedback cooling of a microacoustic system to the quantum regime, by combining the Josephson traveling-wave parametric amplifier technology developed at VTT with a microwave optomechanical setup ([here](#)). Quantum Computing Hardware group (A. Kemppinen and J. Senior) has focused on the optical integration of cryogenic quantum technologies. They have developed optically controlled Josephson Arbitrary Waveform Synthesizers for energy-efficient, quantum-accurate signal generation at cryogenic temperatures. In addition, record-high critical temperatures were achieved in disordered ALD-grown NbCN films ([here](#)). Möttönen's work on single-shot qubit readout, multiplexed bolometric detection, and single-quantum microwave-field characterization demonstrated scalable, low-overhead measurement approaches.

Hybrid and Parametric Quantum Systems

Laure Mercier de Lepinay group in a new collaboration with Sebastiaan van Dijken developed a Faraday material that shows near-record sensitivity for magneto-optical detection. The material is to be tested in dilution cryostats temperatures for potential magneto-optical vortex detection, which will then be applied to quantum devices.

Jukka Pekola's group have developed a qubit thermometer ([here](#)) and a thermal spectrometer ([here](#)), both unique achievements globally. The thermal spectrometer has potential to become a practical instrument, and its advantage in studying quantum dynamics has been demonstrated in a subsequent work where the group measured quantum interference thermally as the first ever observation of coherent quantum effects

in thermal transport ([here](#)). It is a prerequisite of developing a quantum refrigerator whose properties are influenced by quantum dynamics.

Cristian Flindt provided theoretical and experimental frameworks to quantify dissipation, work, heat, and noise in driven circuits, supporting device stabilization. Additionally, his group advanced single-electron and hybrid superconducting devices through real-time control of correlated charge tunneling, Wigner-function descriptions of Andreev-reflected charge pulses, interference-induced transport in Fabry-Pérot cavities, and on-demand Andreev conversion of single-electron pulses. A key milestone was developing a Floquet-Nambu scattering framework for electron quantum optics with superconductors ([here](#) and [here](#)).

Quantum Algorithms, Software, and Information

Scalable Algorithms for Near-Term Quantum Computers

Matti Silveri's team has focused on developing efficient and scalable variational quantum eigensolvers (VQE), and explored quantum sampling-assisted full configuration interaction methods. They benchmarked quantum error mitigation methods and performed experiments using IBM and VTT Q50 quantum computers. Francesco Cosco's group investigated pulse-level optimization for variational quantum algorithms, replacing parametrized quantum circuits with optimized pulse sequences. This approach allows shorter circuit durations and reduced coherence demands, significantly outperforming circuit-level approaches on

VTT Q5 quantum computer. Teemu Ojanen's group investigated noise resilience in monitored quantum circuits, showing that symmetry-enforced many-body phases can persist in noisy intermediate-scale quantum (NISQ) devices. They further demonstrated that corrective feedback and postselected measurements can mitigate noise effects and proposed a symmetry-based method for noise and gate fidelity characterization ([here](#)). Susi Lehtola's developed reusable open-source software for quantum chemistry, including second-order trust region minimization methods for high-dimensional problems ([here](#)), and engaged in industrial collaboration with Algorithmiq.

Algorithms for Fault-Tolerant Quantum Computers

Alexandru Paler's team implemented scalable quantum software for compiling and decoding fault tolerant computations. Matti Silveri's group studied bosonic quantum error correction and developed a novel gate-based repeater that utilizes grid-state encoding, advancing methods for distributed quantum computing. Paolo Muratore's team proved a longstanding conjecture concerning a universal constraint on the relaxation rates of completely positive semigroups, providing the first evidence of spectral properties that distinguish different classes of dynamical maps ([here](#)). Additionally, they are developing algorithmic methods for the exact unraveling of dynamical maps of systems coupled to Gaussian (boson or fermion) baths. Zoltan Zimboras's team advanced compilation and gate decomposition techniques, and error mitigation and correction strategies. They deployed their novel error mitigation techniques on IBM quantum computers to execute 91-qubit circuits with 91 layers and accurately measure the target correlation functions ([here](#)).

Acknowledgements

The preparation of this report was led by Mahdi Moghaddam, with contributions from across the FQF community (see members on page 6). Design and layout provided by Gavin Pugh.

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FQF is hosted within InstituteQ, Finland's National Quantum Institute.

