World Premier International Research Center Initiative (WPI)
FY2025 WPI Project Progress Report

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Research Center	International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP)		
Center Director	Toshiyuki Azuma	Administrative Director	Katsuo Tokushuku

Common instructions:
* Unless otherwise specified, prepare this report based on the current (31 March 2026) situation of your WPI center.
* So as to execute this fiscal year's follow-up review on the "last" center project plan, prepare this report based on it.
* Use yen (¥) when writing monetary amounts in the report. If an exchange rate is used to calculate the yen amount, give the rate.
- Prepare this report within 10-20 pages (excluding the appendices, and including Summary of State of WPI Center Project Progress (within 2 pages)).

Summary of State of WPI Center Project Progress (write within **2 pages**)

Under the new Director, Toshiyuki Azuma (appointed in December 2025), QUP has undergone a decisive and rapid transformation of both its scientific program and organizational structure. All projects carried over from the previous phase have been critically re-evaluated, strategically repositioned with defined goals and timelines, and integrated into three scientifically distinct and complementary pillars: Fundamental Forces and Hidden Sectors, Light Dark Matter Including Axions, and Gravity, each driven by PI-led research groups with well-defined accountability. The previous structure's ambiguity regarding project roles and the Director's engagement has been fully resolved: the Director personally leads the muonic atom QED program as a core scientific deliverable, directly demonstrating his own research agenda within the new framework. The overarching strategy, to pioneer the weak-coupling frontier through next-generation quantum sensors and devices that serve as new 'Quantum Eyes' for the universe, is already producing world-level results within a single fiscal year of restructuring.

Pillar I — Fundamental Forces and Hidden Sectors QUP successfully measured 44 keV muonic X-rays from muonic Ar (Z = 18) in FY2025, including a QED contribution of ~100 eV, using newly developed 50 keV TES detectors at KEK/J-PARC. Analysis is underway targeting $\Delta E_{QED}/E_{QED} < 1\%$, precision competitive with, and potentially superior to, the best bound-state QED results from ion storage rings worldwide. Concurrently, two landmark world-first results were achieved. The first is the state-selective observation of highly charged muonic Ar (μAr) by electronic K X-ray spectroscopy, providing a clear signature of H-like, He-like, and Li-like μAr ([5] T. Okumura *et al.*, Phys. Rev. Lett. 134 (2025) 243001). The second is the first direct and unambiguous observation of the muonic deuterium molecule ($dd\mu^+$), enabled by QUP's high-precision TES platform and rigorous three-body calculations beyond the Born–Oppenheimer approximation (Y. Toyama *et al.*, Science Advances 12 (2026) eaed3321). That the Director himself leads this group is not a formality: the program is active at KEK/J-PARC and is producing results that establish QUP as a global reference point for bound-state QED and exotic atomic physics.

Pillar II — Light Dark Matter Including Axions Three scientifically non-degenerate experiments address distinct dark matter manifestations, providing multi-dimensional coverage that no single experiment can replicate. DarQ established a fully operational end-to-end qubit measurement platform in FY2025, achieved $T_1 = 49.4$ μs coherence times, and performed the first dark photon dark matter search with a tunable qubit–cavity system, establishing a new experimental limit (K. Nakazono *et al.,* arXiv:2505.15619 (2025), submitted to Phys. Rev. Lett.), delivered within a single year of platform commissioning. Multi-qubit GHZ entangled sensor research, targeting Heisenberg-limited sensitivity, has begun at Fermilab under a newly awarded U.S.–Japan program. The NV Diamond project, of which QUP and its collaborators were among the original proposers, has generated significant publication activity: two papers on electron-spin and nuclear-spin axion detection protocols have been published ([1][2]), and a third on the hybrid electron–nuclear spin protocol has been submitted; the hybrid protocol at 77 K approaches astrophysical bounds. This work was led by E.D. Herbschleb, who joined QUP as a full-time PI in April 2026, in close collaboration with affiliated researcher N. Mizuochi (Kyoto University), formally anchoring the program within the center. The Kamioka-LDM experiment commissioned its TES readout

system at the underground facility, confirmed single-photon sensitivity consistent with a 3 eV photon, and will publish results from its GaAs dark matter search in FY2026.

Pillar III — Gravity The superconducting RF cavity project achieved the highest quality factor reported to date in the quantum millikelvin regime. QUP is the natural home for this program: KEK's decades of ILC-driven expertise in superconducting cavity technology represent a world-class asset that QUP is actively cultivating and extending toward entirely new scientific applications, miniaturizing cavities into the MHz–GHz regime, exploring millikelvin and strong-field combinations, and opening a gravitational-wave detection window inaccessible to any existing instrument. Nb_3Sn coating was successfully deposited and tested under 1 T, a critical step toward inverse Gertsenshtein-effect detection and axion searches. M. Fujiwara joined QUP as PI to lead the antimatter gravity program. Phase 1 Lyman-α laser linewidth narrowing is underway; QUP aims to realize the first hydrogen atomic fountain within the WPI funding period.

Theory The theory program has played a central role in advancing fundamental physics by tightly integrating theoretical developments with QUP's experimental programs. In FY2025, the group submitted or published more than 15 papers, alongside extensive hosting and supervision of QUPIP participants and visitors.

Technology Advancement Platform A central concern raised by the Program Committee, whether QUP has genuine in-house quantum device fabrication capacity, has been decisively addressed. A multi-node domestic TES fabrication alliance led by PI N. Yamasaki now spans QUP, JAXA/ISAS, NIMS, AIST, RIKEN, and OIST. At JAXA/ISAS, a 256-pixel TES array has been demonstrated with 27 pixels read out simultaneously via MWMUX. At NIMS, Ti/Au bilayer TES devices were first fabricated in FY2025. AlMn TES prototypes with SEEQC have resolved a residual interface issue. Superconducting qubits are fabricated in-house at the OIST shared cleanroom. A consortium kick-off workshop is planned for FY2026. The semiconductor detector group progresses across multiple areas, including: real-time diamond alpha-ray imaging (1.5 μm resolution, 97% track efficiency); an AI-based ATLAS ITk defect detection system exceeding expert human performance (97% efficiency on FE chips); a novel CMOS-Si hybrid pixel detector with Hamamatsu Photonics; and CdTe semiconductor pixel detector research with ACRORAD. A 10-bit, 2 GS/s CryoCMOS ADC verified at 4.2 K demonstrates full cryogenic signal-chain integration.

Global Research Environment and System Reform QUP's governance has been decisively restructured. The Leadership Council now holds clear authority over scientific direction, and the former Strategy Office has been replaced by the QUP Alliance and Public Relations Office with a sharper mandate. An invitation-based scientific roundtable consisting of Blaum (Heidelberg), Budker (Mainz), Cooley (SNOLAB), Doyle (Harvard), Murayama (UC Berkeley), and Ritt (PSI), has been constituted to ensure QUP's agenda is shaped by the global frontier community; its first meeting is scheduled for 2026.

The concern about satellite-heavy PI distribution has been directly addressed. Four new PIs joined in FY2025, with T. Azuma and T. Nitta fully based at KEK, T. Takahashi (Kavli IPMU), and M. Fujiwara (TRIUMF). From April 2026, E. D. Herbschleb joined as a QUP-dedicated full-time PI, formally anchoring the NV Diamond program within the center. As of April 2026, 9 of 15 PIs have appointments at KEK, with engagement levels ranging from 100% to 20%, a deliberately flexible model that keeps world-class researchers directly connected to QUP's science, and the ratio continues to improve.

The QUP building complex (experimental hall with two dilution refrigerators, 200 m^2 cleanroom, RF anechoic chamber) was completed in summer 2025 and, together with the Kamioka underground facility, positions QUP among the world's foremost institutions for end-to-end quantum measurement science. International researchers reached 42% of total staff. QUPIP hosted 15 fellows (12 from overseas, 20% female) with one progressing to a postdoctoral appointment. Q-EYES 2025 (65 participants, 25 invited speakers) and eight colloquiums sustained high international visibility. KEK has committed to tenure acquisition for at least 5 QUP researchers by FY2030 and personnel cost coverage of ≥400 million yen/year post-WPI, with QUP securing ≥200 million yen through external funding.

* Describe clearly and concisely the progress being made by the WPI center project from the following viewpoints.

1. World-Leading Scientific Excellence and Recognition

1-1. Advancing Research of the Highest Global Level

* Among the research results achieved by the center, concretely describe those that are at the world's highest level. In Appendix 1, list the center's research papers published in 2025.
* Regarding the criteria used when evaluating the world level of the center, note any updated results using your previous evaluation criteria and methods or any improvements you have made to those criteria and methods.

Overview / Research agenda

The International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP) is a World Premier International Research Center hosted by the High Energy Accelerator Research Organization (KEK), Japan. Under new leadership established in December 2025, QUP has undertaken a fundamental reassessment of its research framework guided by a core belief: that the deepest mysteries of nature, dark matter, the origin of gravity, and possible deviations from established physical laws, may not be resolved by ever-higher collision energies alone, but instead demand a qualitatively new approach grounded in extreme measurement sensitivity. Whereas conventional particle physics has advanced primarily along the energy frontier, QUP opens a complementary axis: the **weak-coupling frontier**, explored through next-generation quantum sensors and devices that serve as new "Quantum Eyes" for observing the universe. This renewed vision has reorganized QUP's scientific activities around **three major scientific pillars**, each targeting a domain of fundamental physics inaccessible to conventional accelerator-based methods, supported by a cross-cutting Technology Advancement Platform and a dedicated Theory Group (Figure 1).

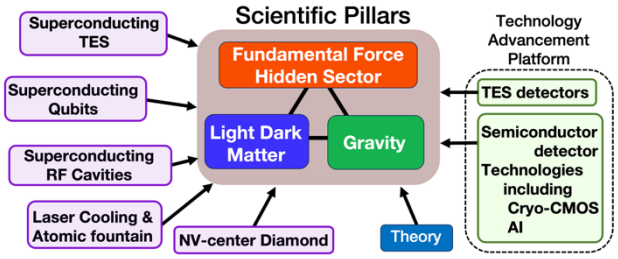

Figure 1 Research group configuration at QUP: three scientific pillars supported by a horizontal Technology Advancement Platform and Theory Group.

The scientific logic of QUP's program rests on deliberate non-redundancy: the three pillars address fundamentally distinct frontiers whose observational signatures cannot be closed by any single experiment, and each pillar naturally informs and reinforces the others toward a unified, multi-dimensional understanding of new physics. The first pillar probes **the precision frontier** of known forces and hidden sectors through X-ray spectroscopy of muonic atoms at KEK/J-PARC, targeting bound-state QED under the strongest electromagnetic fields in nature and enabling searches for dark photons and axion-like particles. The second pillar targets **the low-mass dark matter frontier** through three non-degenerate experiments, DarQ, NV Diamond, and Kamioka-LDM, spanning orthogonal coupling channels that no single detector can cover simultaneously. The third pillar opens observational windows into **gravity** that are entirely inaccessible to existing approaches, through superconducting RF cavities in the MHz–GHz regime and atom interferometry for testing the Weak Equivalence Principle with antihydrogen. A further defining strength is that QUP drives its science from first principles to final measurement: detectors are conceived and fabricated in-house with specific physics goals in view, and the cryogenic, readout, and fabrication infrastructure required is built as an integral part of the research program, creating shared technical capabilities across all pillars.

Underpinning all three pillars is a horizontal Technology Advancement Platform comprising a TES development group (end-to-end fabrication at KEK, JAXA/ISAS, other domestic facilities, and UC Berkeley) and a semiconductor detector technologies group (CdTe/Si sensors, CryoCMOS ASICs, AI-driven event reconstruction). A Theory Group provides the unifying intellectual framework by identifying target parameter spaces and guiding sensitivity studies across all experimental efforts. The following sections describe each pillar and the supporting platform in more detail.

1-1.1. Three Major Scientific Pillars

1-1.1.1. Fundamental Forces and Hidden Sectors

QED Test with Muonic Atoms:

Overview Quantum electrodynamics (QED) is the most precisely tested quantum field theory and provides the theoretical foundation for precision-frontier searches for physics beyond the Standard Model, including potential new particles. In particular, bound-state QED (BSQED) in extremely strong fields has attracted significant attention due to its large QED contributions and the theoretical challenges it poses, where conventional perturbative methods are not fully applicable.

Traditionally, BSQED has been investigated using highly charged heavy ions confined in storage rings or traps. The group led by T. Azuma at RIKEN has recently opened a complementary approach based on

muonic atoms, in which a negative muon is bound to a nucleus. Because the muon has a much smaller orbital radius than an electron, its wavefunction is localized very close to, and in some cases even overlaps with, the nucleus. This provides direct access to ultra-strong electromagnetic fields in the vicinity of the nucleus. As a proof of principle, recent experiments on muonic Ne atoms (Z = 10) demonstrated that the combination of superconducting TES detectors and the high-intensity muon beams available at KEK/J-PARC enables high-resolution spectroscopy of the 5g–4f and 5f–4d transitions around 6.3 keV, which include BSQED contributions of 2.4 and 5.2 eV, respectively (T. Okumura, *et al.* Phys. Rev. Lett. 130 (2023) 173001). T. Azuma has now joined QUP as both PI and the Director, with the aim of advancing this research program substantially by extending the measurements to heavier muonic atoms.

FY2025 Achievements In FY2025, 44 keV muonic X-rays associated with the 4–3 transition in muonic Ar atoms (Z = 18) were measured, including a QED contribution of approximately 100 eV. These measurements were performed using newly developed TES detectors with an energy coverage extending up to 50 keV. A statistically significant dataset was successfully acquired, and the analysis is currently underway, incorporating detailed modeling of the detector response to the pulsed muon beam. The expected precision (ΔE_{QED} / E_{QED} < 1%) is competitive with, and potentially superior to, that achieved in previous strong-field BSQED studies using highly charged ions in storage rings or traps. Concurrently, by electronic K x-ray spectroscopy, the state-selective observation of highly charged muonic Ar (μAr) provided a clear signature of the presence of muonic atoms with one, two, and three electrons, i.e., H-like, He-like, and Li-like μAr, and was recently published ([5] T. Okumura *et al.*, Phys. Rev. Lett. 134 (2025) 243001).

Furthermore, the first unambiguous evidence has been obtained for the formation of a muonic molecule composed of two deuterons and one negative muon (muonic deuterium molecule, ddμ⁺) (Figure 2, Y. Toyama *et al.*, Science Advances 12 (2026) eaed3321). The existence of such an exotic molecule has long been suggested through theoretical predictions and indirect methods, such as the observation of reaction products; however, no direct observation had been reported prior to this work. This achievement was enabled by high-precision X-ray spectroscopy using superconducting TES detectors, which made it possible to resolve muonic transitions for individual vibrational states. The observed spectra reflect the characteristic structure of the corresponding vibrational wavefunctions. By comparison with rigorous three-body calculations, recently developed by the theoretical group at Tohoku University and going beyond the Born–Oppenheimer approximation, the existence of the ddμ⁺ molecule has been conclusively established.

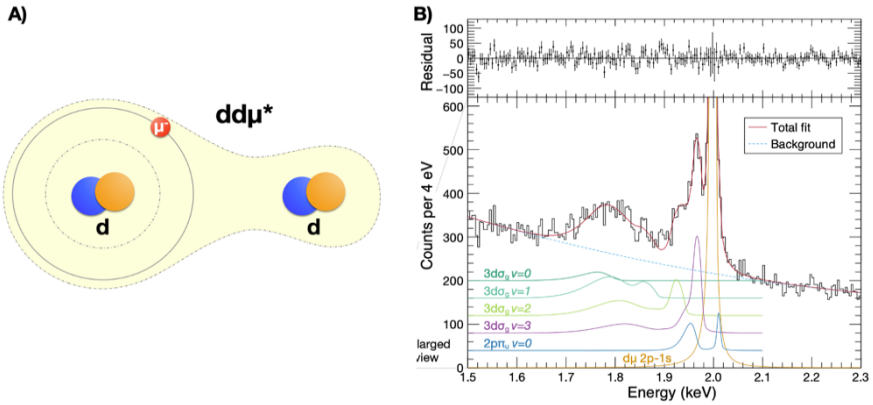

Figure 2 X-ray spectrum associated with the dissociation of resonance states in the muonic deuterium molecule. A) Schematic diagram of ddμ. B) Observed X-ray energy spectrum and the theoretical calculation.*

FY2026 Plan and Medium-Term Outlook

In 2026-2027, the QED work is planned to be extended to further heavier muonic atoms, such as muonic Kr (Z=36) and muonic Xe (Z=54) produced in rare gas targets, by updating the gamma-TES detector to cover energies up to 100 keV. The technical challenge is mitigating the temperature effects originating in the background component, including electrons accompanying the muon beam at the J-PARC H-line

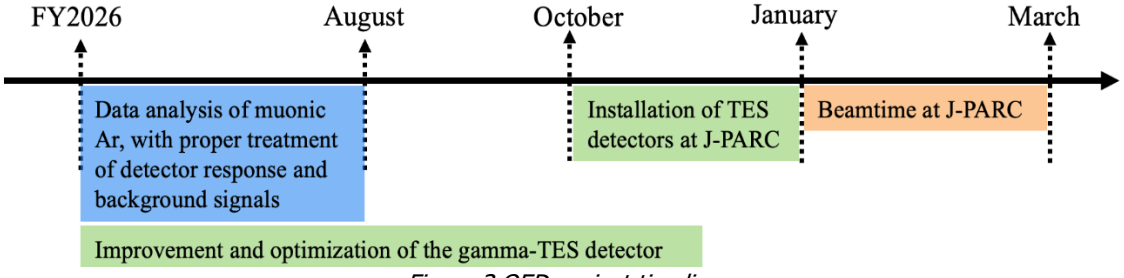

Figure 3 QED project timeline

beamline. These measurements will prove BSQED under the field of approximately $10^{18\text{-}19}$ V/m. The timeline is shown in Figure 3.

1-1.1.2. Light Dark Matter including Axions

Overview: A Coherent Strategy for the Low-Mass Frontier

Conventional WIMP searches at the GeV–TeV scale have achieved remarkable sensitivity, yet no confirmed signal has been observed. This has motivated a global shift toward the low-mass frontier, where compelling theoretical candidates, axions, dark photons, and other hidden-sector particles, remain largely unexplored over more than thirty orders of magnitude in mass. Progress requires multiple, complementary experimental approaches, and QUP has established precisely such a program specially designed to address this need.

The three experiments address fundamentally different manifestations of dark matter. DarQ and the NV Diamond project both search for wave-like dark matter through precision sensing of oscillating fields, while the Kamioka Low-mass Dark Matter (Kamioka-LDM) experiment searches for particle-like dark matter through discrete scattering events in a cryogenic target. Even within the wave-like category, DarQ targets the photon-coupling channel (axion–photon coupling $g_{a\gamma\gamma}$ and dark-photon kinetic mixing ε), whereas the NV Diamond experiment targets the spin-coupling channels (g_{aee}, g_{app}, g_{ann}). This multi-dimensional non-degeneracy is the physical basis for the irreplaceability of each experiment: measuring $g_{a\gamma\gamma}$ without g_{app} leaves the QCD axion flavor structure undetermined, and without the scattering cross-section σ, the cosmological dark matter budget cannot be closed. A signal in one channel can be independently tested in another, while null results across channels provide powerful joint constraints on theory.

Experiment 1 [DarQ — Superconducting Qubits and Cavities]: A system made of superconducting qubits and microwave cavities can act as a highly sensitive detector for GHz-frequency photons, making it one of the most promising tools for dark matter searches. DarQ belongs to the broad class of experiments that search for axion–photon conversion, a category that includes ADMX, BREAD, and SQUAD experiments. Within this class, DarQ pursues two distinct detection strategies in parallel.

The first, DarQ-Lamb, employs single-photon counting to detect individual microwave photons while avoiding measurement backaction associated with the Heisenberg uncertainty principle. Other groups, including a program at Fermilab, are pursuing similar cavity-based single-photon detection schemes. While the underlying technique is shared, DarQ-Lamb and the Fermilab approach differ in cavity modulation method, cavity material, and most critically for independent discovery potential, the frequency range being scanned. Both experiments, therefore, retain fully independent sensitivity to dark matter signals. Although cavity-based single-photon detection is among the most actively pursued directions in the axion community, previous experiments have been limited to a tuning range of only ~10 MHz, severely restricting parameter space coverage. Significantly improving this frequency tunability is therefore the central R&D goal for DarQ-Lamb.

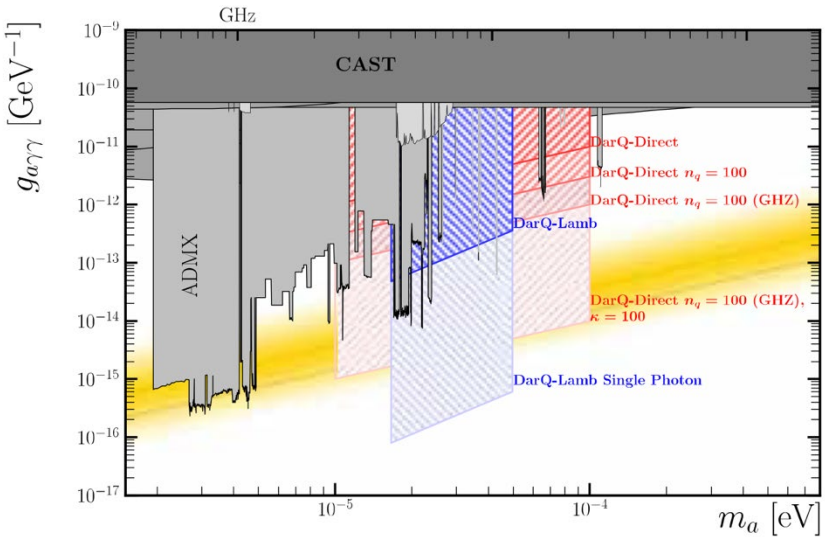

Figure 4 Sensitivity projections for DarQ in the axion–photon coupling $g_{a\gamma\gamma}$

The second approach, DarQ-Direct, is an entirely original detection concept, proposed for the first time worldwide by the DarQ collaboration (S. Chen *et al.*, Phys. Rev. Lett. 131 (2023) 211001). Unlike cavity-based schemes, DarQ-Direct detects photons by directly exciting superconducting qubits without an intervening cavity, placing it in a fundamentally different class of detector at the level of detection methodology. Established in October 2023 with QUP at its core, DarQ brings together specialists in particle physics and quantum technology. Since superconducting qubits are normally driven by RF pulses, a weak coherent RF signal from dark matter could directly excite them, requiring minimal modification of existing quantum computing hardware. No other group is currently pursuing this approach. Reaching sensitivity competitive with DarQ-Lamb requires realizing multi-qubit entanglement, a significant technical challenge;

collaboration with Fermilab on this frontier is planned.

The sensitivity projections for DarQ are shown in Figure 4. The horizontal axis represents the axion mass ma and the vertical axis represents the axion–photon coupling constant $g_{a\gamma\gamma}$, where smaller values correspond to better sensitivity. The yellow band indicates the theoretically predicted region for QCD axions under the DFSZ and KSVZ models, which constitutes the ultimate physics target. Compared to the exclusion regions of existing experiments CAST and ADMX, DarQ opens up unexplored parameter space at higher masses ($m_a \sim 10^{-5}$–10^{-4} eV) beyond the range covered by ADMX. The most ambitious scenarios, DarQ-Lamb Single Photon (darkest blue) and DarQ-Direct n_q = 100 (GHz), κ = 100 (darkest red), both reach into the QCD axion theory band, setting the goal of achieving physically meaningful sensitivity.

FY2025 Achievements

In FY2025, a basic qubit measurement platform was established at QUP. A dilution refrigerator equipped with cryogenic coaxial cables, low-noise HEMT amplifiers, microwave control electronics, and qubit readout hardware was commissioned (Figure 5a), enabling fundamental measurements of both microwave cavities and superconducting qubits. The qubit measurement system is shown in Figure 5b. Superconducting qubits fabricated in-house at the OIST shared cleanroom were installed, and reliable control and operation were demonstrated. The T_1 decay curve of the qubit is shown in Figure 5c. A fit to the data yields T_1 = 49.4 μs, which is a solid starting point for practical quantum measurements at QUP.

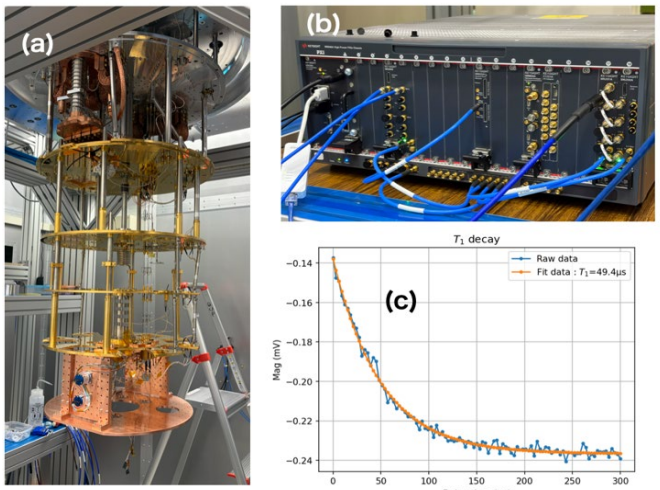

Figure 5 a) Dilution refrigerator installed at QUP. (b) Qubit measurement system. (c) The T_1 decay curve of the qubit T_1=49.4 micro sec.

Using this platform, a search for dark photon dark matter was carried out with a tunable qubit–cavity system. This work established a new experimental limit (K. Nakazono *et al.*, arXiv:2505.15619 (2025), submitted to Phys. Rev. Lett.). In March 2026, additional R&D projects were launched, including direct excitation of qubits by weak signals and development of a single microwave photon detector (SMPD). Related results were presented at the Patras Workshop on Axions, WIMPs, and WISPs 2025.

FY2026 Plan and Medium-Term Outlook

The FY2026 schedule is shown in Figure 6. For the DarQ-Lamb single-photon counting approach, the main goal in FY2026 is to extend the detector frequency bandwidth from approximately 10 MHz to around 100 MHz, dramatically increasing the rate at which new parameter space is scanned. This will be achieved by increasing the physical size of the superconducting qubits. Fabrication of DarQ-Lamb qubits began at the start of FY2026, with data-taking at the LD400 and XLD400 dilution refrigerators at the QUP cryo-facility planned from June onward. Fabrication is already underway, and performance characterization is in progress.

For the DarQ-Direct approach, the goal is to report the first dark photon search results in the 100 MHz frequency range using a single qubit in FY2026. DarQ-Direct data-taking at XLD400 begins in May, expanding to LD400 from September onward, with analysis running in parallel from June. Data taking is already underway, and since the qubit frequency has been confirmed to be tunable over more than 1 GHz, reaching the 100 MHz region is technically straightforward. The main remaining challenge is achieving stable, long-term operation during measurements, which is expected to be addressed through standard engineering improvements. Quantum amplifier testing is planned by June, alongside cabling upgrades for both the XLD and LD systems.

Looking further ahead, research on multi-qubit GHZ (Greenberger–Horne–Zeilinger) entangled sensor systems has begun in collaboration with Fermilab, supported by a newly awarded U.S.–Japan research program. With n entangled qubits, the signal rate scales as n^2 rather than n, a quantum enhancement related to the Heisenberg limit, which could significantly enhance the ability to detect extremely weak photon signals. In addition, installation of an 8 Tesla superconducting magnet at LD400 is scheduled for the end of FY2026 (Figure 6), opening the path toward QCD axion searches in the DFSZ/KSVZ band. Qubit characterization is already underway, and the goal is to begin a full axion search within approximately five years.

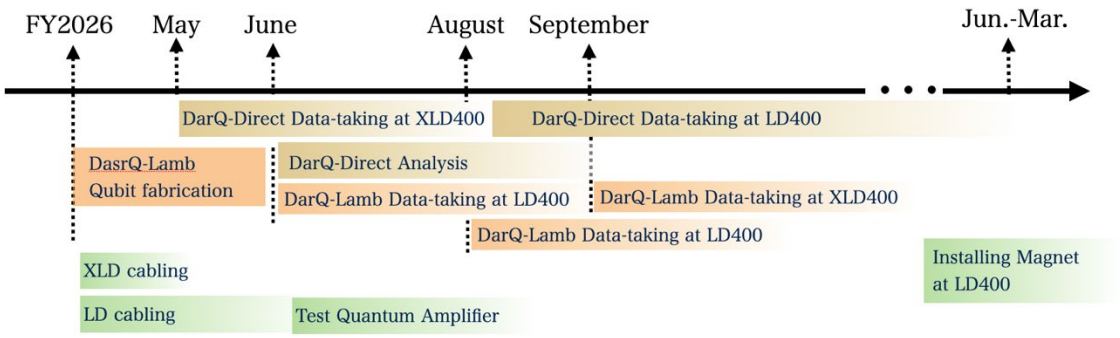

Figure 6 Schedule for the DarQ experiment in FY2026. The timeline shows data-taking, analysis, and instrumentation milestones for both the DarQ-Direct and DarQ-Lamb approaches. Installation of the superconducting magnet at LD400 is planned toward the end.

Experiment 2 [NV Diamond — Nitrogen-Vacancy Quantum Spin Sensors]: While DarQ targets the photon-coupling channel, the NV Diamond project targets the orthogonal axion–fermion spin-coupling channels, g_{aee} (electron), g_{app} (proton), and g_{ann} (neutron), which are inaccessible to any photon-based experiment. The two programs are therefore scientifically non-redundant even where their mass ranges overlap, covering 10^{-22} to 10^{-6} eV (below μ Hz to above MHz).

Nitrogen-vacancy (NV) centers in diamond are attractive sensors because they combine long quantum coherence with the robustness and scalability of a solid-state platform. QUP and collaborators at Kyoto University were among the first to propose NV centers specifically for axion dark matter searches. The experiment is led by E. D. Herbschleb (QUP PI from April 2026) and A. Umemoto (QUP Assistant Professor) in close partnership with N. Mizuochi (ICR, Kyoto University, a QUP-affiliated researcher since the center's founding). This institutional alliance, combining QUP's cryogenic quantum-sensing infrastructure with Kyoto's world-class diamond-growth expertise, is a core pillar of the project. This collaboration represents a natural evolution of QUP's earlier efforts, conducted with limited resources, to develop the theoretical foundations and establish cryogenic experimental capabilities for dark matter searches, while offering Kyoto University access to cryogenic characterization infrastructure and QUP's interdisciplinary network for extending its diamond expertise into new application domains.

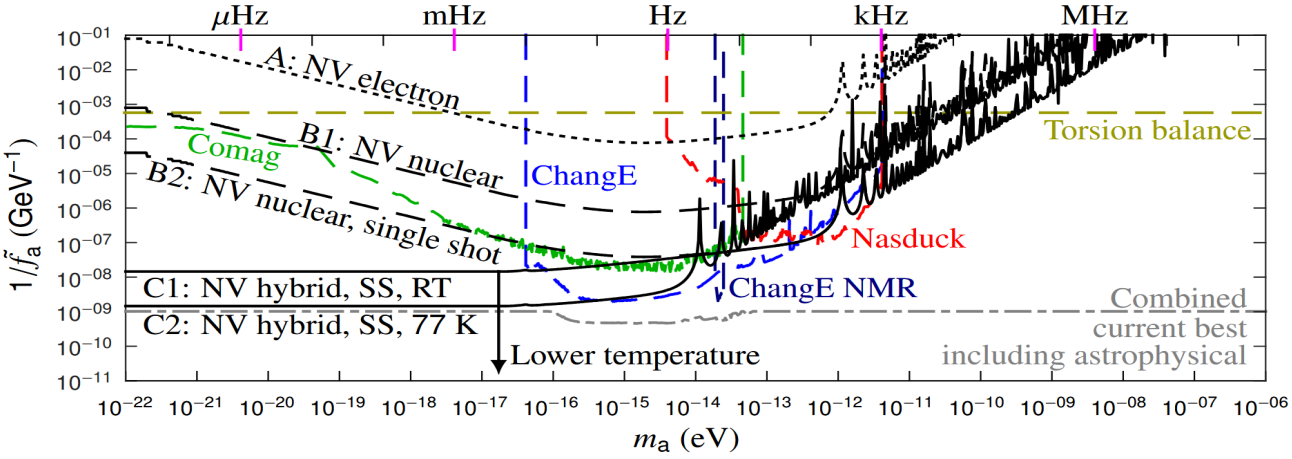

Figure 7 Projected exclusion limits for NV Diamond methods A (electron spin), B1/B2 (nuclear spin with/without single-shot readout), and C1/C2 (hybrid spin at RT/77 K), compared with leading comagnetometers. The calculations assume a realistic 10^{12} NVs (current state of the art for a 1x1x0.07 mm^3 diamond), including noise for a year of integration. Not only does this illustrate the feasibility of this project, but also the potential, as there is still much room for improvement, from improving the diamond sample, to lower temperatures, to measurement designs.

FY2025 Achievements FY2025 produced two peer-reviewed and one submitted publications that each introduced a genuinely new detection concept, progressively improving projected sensitivity. First, QUP and collaborators were the original proposers of using NV-center spins as axion detectors ([1] S. Chigusa *et al.*, JHEP (2025) 83). This foundational work showed that NV centers in solid-state diamond offer intrinsic advantages over state-of-the-art K–^{3}He comagnetometers: spin densities orders of magnitude higher (a 1×1×0.07 mm³ diamond versus a 2 cm spherical gas cell) and compatibility with cryogenic

operation. Using standard NV electron-spin sensors, a realistic bound-curve A in Figure 7 was established. Second, the team moved beyond conventional magnetic-field sensing by exploiting the ^{14}N nuclear spin embedded in each NV center ([2] S. Chigusa *et al.*, Phys. Rev. D111 (2025) 075028). The nuclear spin retains full axion sensitivity while being far less susceptible to magnetic noise, improving the projected reach by two orders of magnitude (curves B1/B2 in Figure 7); single-shot readout further reduces readout noise in a way unavailable to gas-cell comagnetometers. Third, the first hybrid electron–nuclear spin protocol was designed specifically for axion detection (S. Chigusa *et al.*, arXiv:2511.16732 (2025)). The one-to-one pairing of electron and nuclear spins within each NV center, absent in any gaseous mixture, allows dynamical cancellation of magnetic noise, suppressing 1/f magnetic noise up to ~1 kHz (versus ~1 Hz for the best comagnetometers). Decoupling sequences extend this noise-filtering frequency further while simultaneously increasing coherence time, an advantage that compounds strongly at cryogenic temperatures. Even at 77 K, the projected sensitivity (curve C2 in Figure 7) already approaches, and in parts comes close to the astrophysical bounds, while significant room for improvement remains.

FY2026 Plan and Medium-Term Outlook The FY2026 plan advances from theoretical design to coordinated dual-site operation. Nuclear-spin control capabilities will be added to the QUP system, enabling the first experimental tests of the nuclear-spin and hybrid protocols, a world first. A second setup equipped with a cryostat will be established at Kyoto, linked to the QUP system with different diamond orientation and isotopic composition (^{14}N at one site, ^{15}N at the other). This configuration enables independent sensitivity to g_{app} and g_{ann} simultaneously, a measurement with no analog in any other laboratory experiment, and allows efficient rejection of local environmental backgrounds. The next critical milestone is the dual-site demonstration scheduled for July FY2026. Over the medium term, the project aims to produce competitive terrestrial limits and establish an internationally visible platform for spin-based searches. The QUP cryogenic infrastructure at Kyoto, in addition to enabling dark matter science, provides an indispensable tool for evaluating and iterating diamond growth quality at low temperature, a direct benefit for Kyoto University's materials research program.

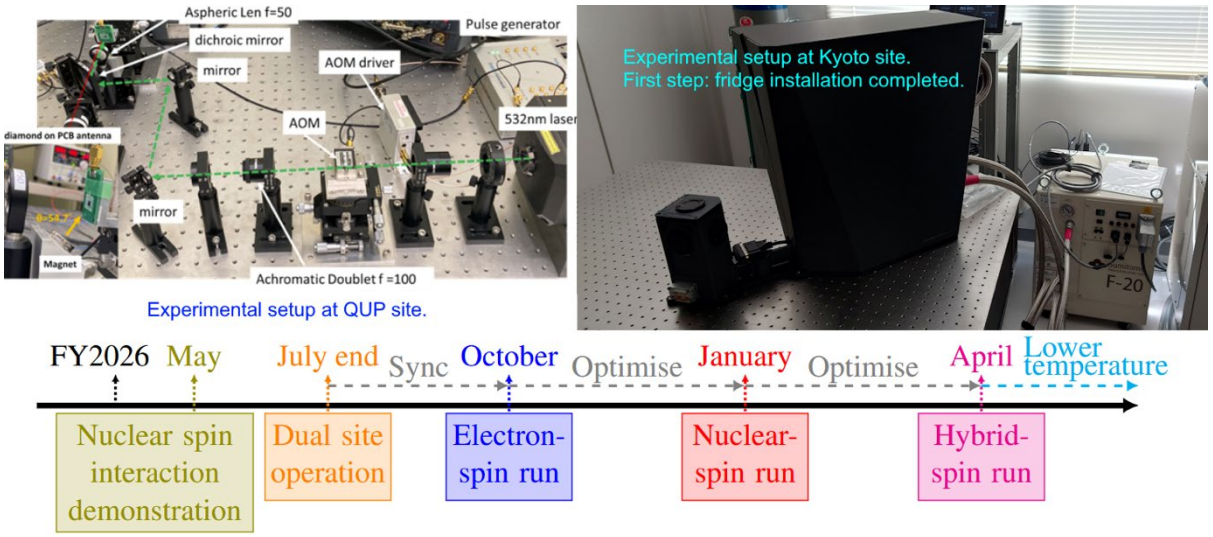

Figure 8: Electron-spin setup at QUP (top left) and initiated hybrid-spin setup at Kyoto (top right) with the cryostat already installed, important for collaboration with Kyoto. FY2026 milestones are indicated at the bottom. Adding nuclear capabilities to the setup is a world first. The FY2025 achievements serve as the starting point; the July site visit (dual-site operation) is the next critical milestone.

Experiment 3 [Kamioka-LDM — Cryogenic Underground Dark Matter Search]: Unlike DarQ and NV Diamond, which sense coherent wave-like fields, the Kamioka-LDM experiment searches for individual scattering events in which a dark matter particle deposits energy into electrons or nuclei in a cryogenic target. The experiment is led by M. Garcia-Sciveres (LBNL, QUP PI), M. Hasegawa (QUP PI), and K. Ishidoshiro (Tohoku University, QUP-affiliated researcher), with the apparatus installed at the Kamioka underground facility within the KamLAND area. The target mass regime, MeV to GeV, is precisely where conventional large noble-gas detectors lose sensitivity: nuclear recoils below the GeV scale fall below the detection threshold, and reaching the MeV frontier requires coupling to electronic excitations or collective lattice modes with sub-meV energy thresholds.

The project is organized into two phases. Phase 1 establishes underground capability and delivers first

physics results using near-term technology; Phase 2 scales up with superconducting aluminum targets and RF-multiplexed readout for a definitive search well beyond current limits (theoretical sensitivity documented in (M. Chen *et al.* Phys. Rev. D113 (2026) 036006)). Phase 1 originally centered on a joint He-4 payload run with the TESSERACT collaboration under a signed MOU, but technical delays on the TESSERACT end, outside QUP's control, led to the adoption of a scintillating GaAs crystal target with TES-based photon readout as the primary Phase 1 experiment, following advice from the WPI committee. This contingency was low-risk precisely because GaAs scintillation properties had already been under study within QUP. The photon-only GaAs readout architecture developed in Phase 1 is directly applicable to the Al target phonon readout in Phase 2, creating a continuous technology development pathway. Preparations for a TESSERACT He-4 run continue in parallel, with a decision point in Q3 FY2026.

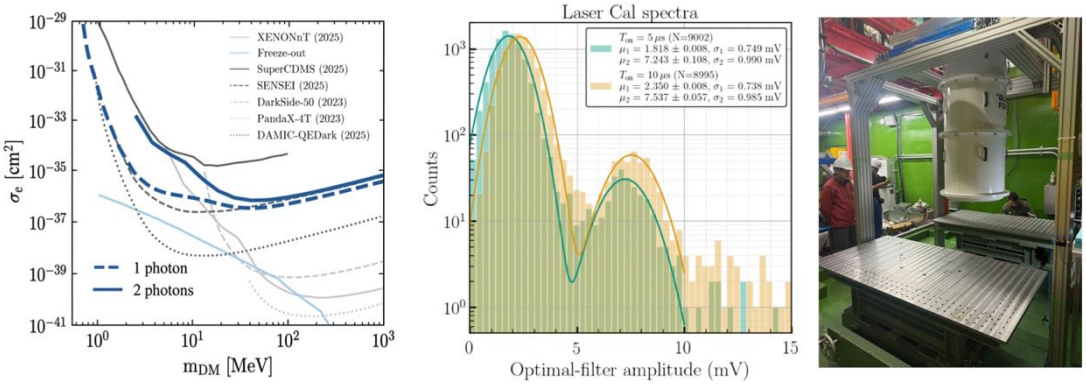

Figure 9 Left: Expected electron-recoil dark matter sensitivity for the Phase 1 GaAs run (2.3 g, 7 days), compared with XENONnT, SuperCDMS, SENSEI, and DAMIC-QEDark. Middle: Histogram of recorded pulse amplitude from a single TES with diffuse illumination. The left peak is due to phonon energy reaching the TES, and the right peak is a single 3eV photon directly hitting the TES. The rate is too low to see multi-photon direct hits. Right: Installed shield support structure at the Kamioka underground laboratory (April 23)

FY2025 Achievements Substantial progress was achieved in detector infrastructure during FY2025. The TES readout system was successfully commissioned, reaching a noise floor within a factor of five of the TESSERACT state-of-the-art, an excellent starting point for the typical site-specific noise improvement program in this field. An optical fiber calibration system was installed, confirming single-photon sensitivity consistent with a 3 eV photon at the expected resolution. The shielding support structure was completed and installed in April 2026. In response to delays in the TESSERACT He-4 payload (external to QUP), the GaAs scintillation path was accelerated and has become the leading Phase 1 approach. The GaAs detector employs an n-type GaAs crystal as an infrared scintillator at cryogenic temperature, with W–Al bi-layer photon-absorbing pixels (QETs) and a silver coating that simultaneously maximizes photon collection efficiency and suppresses Low Energy Excess (LEE) backgrounds by absorbing bulk phonons. The target pixel noise of 0.3 eV enables single infrared photon sensitivity, and the expected DM exclusion reach for a 7-day GaAs run has been calculated (Figure 9, left. Paper in preparation). The LEE mitigation strategy, silver coating, optimized geometry, and coincidence rejection, are also directly relevant to Phase 2 Al targets.

FY2026 Plan and Medium-Term Outlook The primary FY2026 milestones are a published dark matter search with the GaAs detector and dedicated LEE characterization studies that will inform both Phase 1 and Phase 2. The 8-channel TES readout system will be completed by installing the remaining SQUID channels. Device fabrication is proceeding at the Berkeley Satellite (LBNL) to QUP design specifications; Two-TES-per-absorber pixels ('banana devices') are used to calibrate photon signal collection and reject TES film LEE ('singles'). In Q3 FY2026, a decision will be made whether to proceed with a TESSERACT ^{4}He joint run or to transition directly toward Phase 2 superconducting Al targets. RF multiplexing development, shared across multiple TES-based QUP projects, will be benchmarked against existing 8-channel readout using the same GaAs devices, for an apples-to-apples noise comparison. MIT, Melbourne, and Peking U. have joined the effort with their own funding, and we anticipate transitioning to a collaboration model (with charter, spokespersons, and authorship rules) in FY2026 or FY2027.

Two complementary TES technologies are under active development, and resolving their respective merits is central to the Phase 2 roadmap. The current GaAs devices employ W-Al QET pixels, a low-Tc, low-bandwidth architecture with well-established quasiparticle collection from Al absorbers, and scaling this approach to Phase 2 follows a path of least resistance, since replacing the GaAs crystal with a Si

substrate simply removes the scintillation channel and makes dark matter interactions in the Al target itself the direct signal. The critical open question for W-Al QETs is multiplexing: Phase 2 will require an order of 1000 readout channels versus only 8 for the current GaAs run, and no demonstration of multiplexed readout with W TESes exists to date. The GaAs 8-channel system, therefore, serves a dual purpose, providing the Phase 1 science run while acting as a testbed for multiplexing development. The complementary Ti/Au bilayer TES technology, developed at NIMS as a domestic in-house fabrication capability under PI N. Yamasaki (JAXA Satellite) in collaboration with AIST and domestic partners, operates at higher T_c and broader bandwidth, has already demonstrated the initial Phase 2 resolution target before multiplexing, and has existing multiplexing heritage, though added noise still requires improvement. Its outstanding open question is the opposite of W-Al QETs: Ti/Au devices have never been coupled to Al collectors, making Ti/Au-Al QET integration the immediate next fabrication milestone. The two technologies are thus complementary in the near term, with W-TES multiplexing and Ti/Au-Al QET integration representing the respective critical R&D steps that will together determine the optimal Phase 2 device architecture.

1-1.1.3. Gravity

Gravity remains the least understood of the fundamental forces, and QUP is addressing it through two projects using advanced photon-manipulation quantum technology, including VUV laser cooling and RF cavities with high-Q, to achieve unprecedented sensitivities. Both build durable technological capabilities that remain at QUP beyond each experiment's immediate deliverables. They provide a foundation that no other group pursuing this science can readily replicate.

Antimatter Gravity Studies:

Precision comparison of the gravitational interaction of antimatter with ordinary matter represents a fundamental test of the Weak Equivalence Principle. While the sign of antimatter's gravitational acceleration has recently been measured, a precision comparison has never been achieved. This project is positioned as the development of essential enabling technologies that lay the foundation for such future measurements. The central technical challenge is the development of a narrow-linewidth (~100 MHz) Lyman-alpha (Ly-α) laser at 121 nm, a wavelength for which no commercial source exists. KEK possesses the world's highest-power Ly-α laser (30 μJ/pulse), originally developed for muon beam applications, however, its linewidth (~80 GHz) is far too broad for coherent manipulation of (anti)hydrogen. Narrowing this by a factor of ~800 while preserving sufficient power is QUP's core contribution. The project is led by PI M. Fujiwara, who joins QUP from TRIUMF, Canada, with expertise in antihydrogen production through collaboration with the ALPHA experiment at CERN. QUP develops the narrow-linewidth Ly-α laser and realizes a hydrogen atomic fountain. KEK provides the existing laser infrastructure and J-PARC beamlines. The completed system will be deployed to TRIUMF for future antihydrogen measurements in CERN. Further phases, including antihydrogen interferometry and direct gravitational measurements, will be pursued beyond the WPI funding period. The project timeline is shown in Figure 10.

In FY2025, prior to the official project start, foundational preparation was carried out. M. Fujiwara was appointed as a QUP PI, and a phased implementation strategy was developed in close coordination with QUP and KEK, leading to the identification of J-PARC U-line and H-line beamlines as key experimental platforms for Phase 1. A CW 845 nm seed laser for linewidth narrowing was procured, and construction of a gas-jet hydrogen source has begun. An experienced postdoctoral researcher is scheduled to join in July 2026.

From FY2026 onward, the project proceeds in four partially overlapping phases. In Phase 1 (FY2026-2027), a factor of ~16 narrowing (80 GHz → 500 MHz) will be demonstrated at J-PARC using the procured seed laser. Ionization of residual H gas is scheduled in 2026, and optimization with a dedicated atomic H source is targeted for 2027. Phase 2 (FY2027–2028) begins before Phase 1 completion: a dedicated ~100 MHz linewidth Ly-α laser will be constructed at QUP. In Phase 3 (FY2028–2029), the system will be

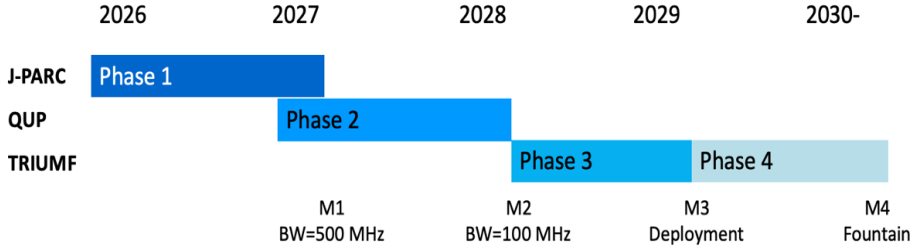

Figure 10 Antimatter gravity project timeline

deployed to TRIUMF. In Phase 4 (FY2029–), a hydrogen atomic fountain will be realized. Within the WPI funding period, the primary deliverable is the first-ever realization of a hydrogen atomic fountain, a critical step toward enabling precision gravitational measurements of antimatter.

Gravitational Wave Detection using Superconducting RF Cavities:

High-frequency gravitational waves in the MHz–GHz range, a regime entirely inaccessible to existing detectors such as LIGO and KAGRA, represent a largely unexplored frontier. Theoretical scenarios, including cosmological phase transitions, primordial black holes, and exotic compact objects, predict signals in this band, but no direct experimental constraint exists. QUP aims to establish the first detector prototype operating in this regime, providing sensitivity data in a previously unmeasured frequency window. QUP pursues two complementary detection schemes led by PI T. Nitta. The first, as stimulated by researchers at QUP and KEK, employs two identical, coupled superconducting cavities: a gravitational wave parametrically excites the normal-mode splitting via wall displacements, generating a detectable signal in the antisymmetric mode. The second exploits the inverse Gertsenshtein effect, in which a gravitational wave converts into microwave photons inside a cavity placed in a strong external magnetic field, a configuration technically related to axion dark matter searches already underway at QUP, providing direct experimental synergy. The key performance parameter for both schemes is the cavity quality factor Q. Sensitivity scales directly with Q, and achieving $Q > 10^9$ under the demanding conditions of simultaneous millikelvin temperature and tesla-scale magnetic field is the central technical challenge of this program. This is where QUP's position within KEK is essential: KEK's decades of superconducting RF cavity development for accelerators, including ILC-grade surface processing and Nb_3Sn coating techniques that would be difficult to replicate elsewhere.

In FY2025, the KEK team established baseline performance benchmarks. A niobium cavity with accelerator-grade surface treatment achieved $Q \sim 10^8$ at 10 mK. Separately, an Nb_3Sn coating was successfully deposited on a niobium substrate and characterized under a 1 T magnetic field. These results confirm the technical feasibility of the approach and provide quantitative targets for the next phase. The FY2026 goal is to measure Q of the Nb_3Sn cavity under simultaneous conditions of strong magnetic field (≥ 1 T) and millikelvin temperature, a parameter regime not previously reported in the literature. Achieving $Q \geq 10^7$ under these conditions would represent a significant result, enabling a first, sensitivity-limited physics search for high-frequency gravitational waves via the Gertsenshtein effect using a low-noise microwave readout chain.

The primary value of this program within the WPI period lies in three concrete deliverables that establish the technological foundation for future gravitational-wave detection: (1) Establishing the Q-factor performance envelope of superconducting cavities under conditions relevant to gravitational-wave detection. (2) Demonstrating a complete readout chain, i.e., cavity, amplifier, and signal-processing, at millikelvin temperatures. (3) Providing the first experimental sensitivity bound on high-frequency gravitational waves in the MHz–GHz band. These results will define the quantitative roadmap for a subsequent, dedicated detector program, a frontier that no existing instrument can access.

1-1.2. Cross-disciplinary Metrology

1-1.2.1. Theory

The theory program at QUP, co-led by PIs Nakayama and Takhistov, advances research in fundamental physics across quantum measurement, particle physics, and astrophysics, in close integration with experimental efforts at QUP. A major achievement has been the establishment of experiment-driven frameworks for new physics searches directly linked to QUP detector platforms. In particular, axion search strategies using NV diamond sensors have been developed through close collaboration between theorists and experimentalists, leading to landmark publications in 2025 ([1] S. Chigusa *et al.*, JHEP (2025) 83, [2] S. Chigusa *et al.*, Phys. Rev. D111 (2025) 075028). In parallel, pioneering approaches to quantum sensing beyond conventional two-level systems have demonstrated that multilevel (qutrit-based) platforms can enhance sensitivity to dark matter interactions by up to an order of magnitude, opening new parameter space (X. Ma *et al.*, arXiv:2510.19918 (2025)).

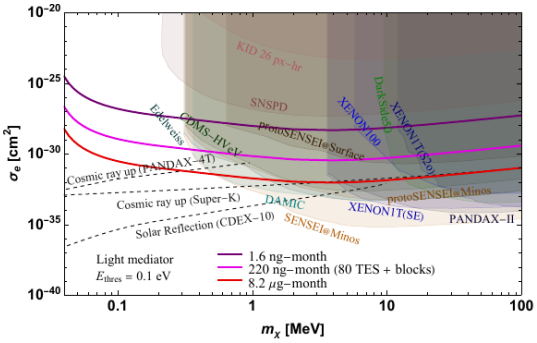

Figure 11 Representative sensitivity for TES-based detection of DM-electron scattering from the analysis

For the Kamioka light dark matter program, novel

strategies for sub-GeV dark matter detection using transition edge sensors (TES) have defined concrete sensitivity targets and significantly shaped ongoing experimental efforts (M. Chen *et al.* Phys. Rev. D113 (2026) 036006) (Figure 11).

QUP theory has also advanced a new paradigm in multimessenger physics, demonstrating that networks of quantum sensors, such as GNOME, can probe previously inaccessible fundamental messengers beyond photons, neutrinos, and gravitational waves (J. Arakawa *et al.*, JCAP 02 (2026) 026). This work establishes a bridge between laboratory-scale quantum technologies and astrophysical observations, positioning QUP at the forefront of cross-disciplinary research.

Complementary advances include the development of novel probes of axions and other light particles, world-leading constraints on short-range forces from Casimir measurements, and new astrophysical approaches to dark matter and neutrino physics in regimes inaccessible to laboratory experiments. In addition, new search directions beyond the Standard Model have been initiated for future neutrino experiments.

In FY2025, the group submitted or published more than 15 papers. Theory activities also contributed to human resource development through the supervision of international postdoctoral researchers under the QUPIP program, leading to multiple high-impact publications and sustained international collaborations.

1-1.2.2. Superconducting TES Detectors

TES detectors have been a core research priority at QUP since its inception, with major efforts focused on solar axion searches and optical TES applications for dark matter detection. As the program has progressed, it has become clear that further advances, particularly toward functionalities such as multiplexed readout, require a more integrated and coherent development strategy. Accordingly, previously separate activities have been consolidated into a unified TES research group led by PI N. Yamasaki at JAXA Satellite, while preserving the flexibility of individual research efforts by QUP members, K. Hattori, and H. Akamatsu. In FY2025, the TES detector fabrication platform, as illustrated in Figure 12, was established with substantial efforts. The achievements described below are fully consistent with, and strongly supported by, this collaborative framework under research collaboration agreements.

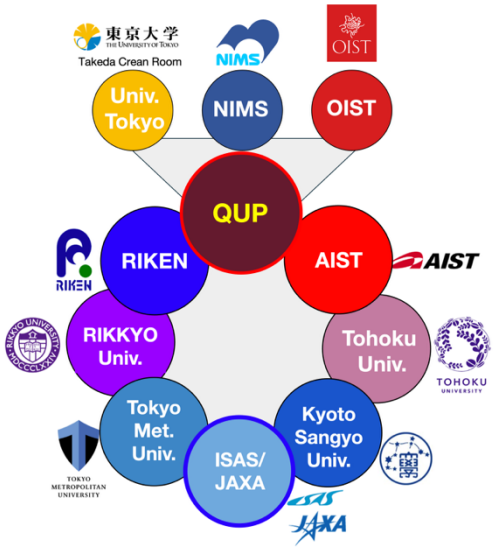

Figure 12 Organized TES fabrication alliance in Japan.

The primary goal of the platform in FY2025 was to operate the MWMUX system, a microwave multiplexed readout for TES arrays originally developed at AIST, in combination with an X-ray TES array fabricated within the QUP platform and integrated into the QUP cryostat. The TES was fabricated at the ISAS satellite, with the objective of tuning process parameters to control the transition temperature. The relationship between transition temperature and film thickness was investigated by using the latest surface-resistance formulation by T. Kubo (JJAP 64 (2025) 018001), and measured lattice parameters of TES and pure Ti films via X-ray diffraction. While the surface resistance was found to vary within roughly a factor of two, this level of control is insufficient to achieve transition-temperature precision better than 10 mK. Moreover, the dependence of transition temperature on film thickness, even within a single device, indicates non-uniformity in the evaporated crystal structure. Post-deposition annealing was observed to modify lattice parameters, suggesting that a combined approach, integrating surface-resistance control with annealing, provides a more effective route to precise transition-temperature tuning (manuscript in preparation). In parallel, a 256-pixel TES array was fabricated with 64 readout lines at the ISAS clean room. The array was integrated into the QUP MWMUX system with a 32-pixel connection, and signals from 27 pixels were successfully read out. The system enabled simultaneous measurements of resistance versus temperature and X-ray signals. However, several issues remain: limited temperature stability of the QUP cryostat

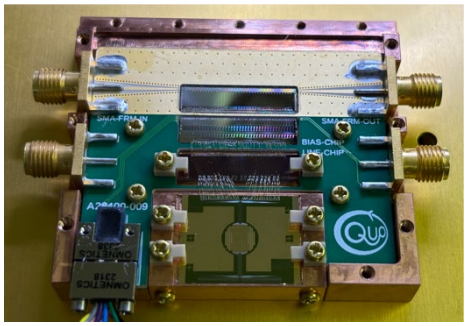

Figure 13 224-pixel array TES with the MWMUX installed in the QUP cryostat

affecting energy resolution, and a quasi-periodic gain fluctuation of ~0.2%, which requires further investigation.

The scientific objective is, under Phase 2 of the Kamioka program, to explore light dark matter in the MeV mass range using superconducting detectors with sub-eV sensitivity, recognizing that this will likely require a sustained development effort. This approach employs TES devices coupled to aluminum targets. Based on optical TES measurements, the achieved sensitivity has been reported (M. Chen *et al.* Phys. Rev. D113 (2026) 036006). To advance this direction, prototype AlMn TES devices were fabricated in collaboration with SEEQC. The first batch revealed a residual resistance issue at the Nb/AlMn interface, which was successfully resolved in the second batch by improved surface cleaning prior to Nb deposition. In parallel, an alternative TES design based on Ti/Au bilayers has been developed at the National Institute for Materials Science (NIMS). TES fabrication at the NIMS clean room is positioned as an in-house process development activity. The current focus is to establish a reproducible fabrication process for TES chips with transition temperatures in the range of 0.2–0.3 K, suitable for high-sensitivity measurements and scalable to multi-pixel arrays. Key processes include Si wafer preparation, Ti/Au deposition, photolithography, etching, and chip dicing. In FY2025, the first successful TES device was fabricated. Remaining challenges include transition-temperature reproducibility, transition sharpness, fabrication yield, and integration with cryogenic testing and multiplexed readout systems. Overall, this work represents an active effort to optimize TES-array fabrication for reliable fabrication, with clear applicability to optical TES development for light dark matter searches.

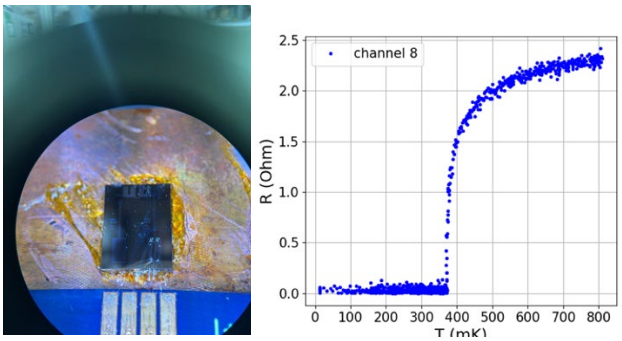

Figure 14 AlMn TESs (left) and their transition curve (right).

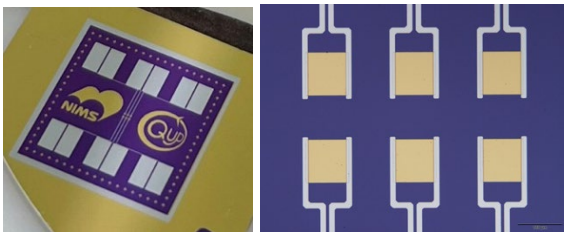

Figure 15 Fabricated Ti/Au TES sensors with Al bias line at NIMS clean room. The size of TES is 100 x 100 um^2

On the other hand, under Phase 1 of the Kamioka program, a newly hired QUP postdoc will carry out hands-on device fabrication of the TES detector with GaAs crystal, utilizing the new bidirectional platform function of the Berkeley satellite for collaboration, training, and technology transfer.

Near-term milestones:

- Early summer 2026: Dispatch of a newly recruited postdoc to LBNL for GaAs detector fabrication
- 2026–2027: Demonstration of multi-pixel TES arrays integrated with the MWMUX system on the QUP platform
- 2026: Evaluation of the single-photon response of AlMn TES devices.
- 2026: Fabrication and performance testing of TES detectors coupled to aluminum targets at NIMS.
- 2027: Deployment of these detectors at Kamioka

1-1.2.3. Semiconductor Detectors, Quantum imaging and AI

Semiconductor detectors and low-noise readout electronics form a core technological foundation for QUP's quantum measurement programs. The group operates within a strong international network across Japan, Europe, and the United States. Research activities include Si and CdTe imagers for space X-ray and gamma-ray observations led by PI T. Takahashi; Si pixel detectors for charged-particle tracking at KEK and CERN led by PI M. Togawa; novel radiation-hard materials such as CIGS and diamond; low-noise readout ASICs including CryoCMOS developed by PI M. Miyahara; and data acquisition systems and AI/ML-based detector-response modeling, drawing on expertise from large-scale experiments such as ATLAS, led by PI Y. Nakahama. PI D. Bortoletto further strengthens ties with CERN and the European detector community. Reflecting the broad societal relevance of this research, T. Takahashi and M. Togawa organized a Workshop on Radiation-Hard Semiconductors in January 2026. The workshop attracted more than 150 participants from particle physics, space engineering, materials science, and device/circuit design, including researchers from JAXA, universities, national institutes, and industry, significantly exceeding expectations. The spontaneous emergence of cross-disciplinary collaborations centered on radiation hardness highlighted the growing impact of QUP's semiconductor detector program.

Diamond, with its exceptional radiation hardness and chemical stability, is being explored as a scintillator, semiconductor detector, and bolometer in collaboration with NIMS, Tsukuba, Tohoku IMR, AIST, and Kanazawa, with access to IMR GIMRT, UVSOR, and the RIKEN Pelletron. A real-time imaging system combining a nitrogen-doped HPHT single-crystal diamond (light yield: 5.5×10^4 photons/MeV) with a custom-built EMCCD microscope achieved the first real-time imaging of alpha-ray tracks from a ^{241}Am source under ambient conditions, reaching 1.5 μm optical resolution and 97±19% track-recognition efficiency, an order-of-magnitude improvement over ZnS(Ag) scintillators ([10] A. Umemoto et al., JCAP (2025) 012, and [11] PTEP (2025) 123H01). On the theoretical side, TDDFT calculations using the Earth Simulator supercomputer showed that electronic excited states in P-doped diamond persist for more than 200 fs after alpha-ray irradiation, providing a theoretical basis for the scintillation mechanism. Additional activities included CMOS–Si hybrid and CdTe pixel detectors, both with Kavli IPMU and F-REI, CIGS-based radiation-hard pixel detectors, and GaN LGAD detectors (H. Okumura et al., JJAP 65 (2026) 016501).

QUP collaborates on radiation-hard 3D sensors with picosecond timing capability. Within the DRD3 OCTOPUS project for next-generation silicon pixel detectors, systematic TCAD transient simulations of multiple detector geometries were performed to study the effects of implant design, pitch, and layout parameters on signal formation and timing at different hit positions. Optimized configurations, achieving improved timing performance while maintaining excellent spatial response, were identified, providing guidance for future sensor design. The group is also contributing to the migration of the MALTA monolithic pixel detector from the TowerJazz 180 nm process to TPSCo 65 nm technology ([49] G. Dash *et al.*, JINST 20 (2025) P09039). In parallel, ultra-light support structures using 25 μm carbon fiber and 12 μm Kevlar are being developed to minimize material budget for future silicon detectors at Higgs factories, with demonstrations scheduled for 2026.

In CryoCMOS development, QUP made major contributions under the Moonshot R&D program to low-power mixed-signal ASICs integrating the full superconducting-qubit readout chain. A 10-bit, 2 GS/s, 13 mW time-interleaved ADC was designed and fabricated, and its correct operation at 4.2 K was verified using a temperature-tolerant bias scheme and calibration circuitry. Building on this, a mixed-signal SoC integrating a 12-bit 2 GS/s DAC, PLL, and sine-wave generator on the same chip was developed, with end-to-end signal generation and digitization demonstrated in a liquid-helium Dewar environment. Eliminating room-temperature signal sources significantly reduces wiring complexity and thermal load, an important advantage for dilution-refrigerator-based detector systems. The technology is being evaluated for transfer to QUP quantum sensor programs, including qubit-based dark matter searches. Under the renewed Moonshot program (FY2026–FY2030), development of a qubit control-and-readout SoC is planned for FY2026, followed by the installation of a dilution refrigerator and system-level demonstrations in FY2027.

In AI-related research, an unsupervised anomaly-detection method combining a denoising convolutional autoencoder with DBSCAN clustering was developed for automated inspection of Si pixel detectors, and applied to ATLAS ITk pixel-module production for the LHC Phase-II upgrade. The method achieved rare-defect detection efficiencies of 89–97% across PCBs, silicon sensors, and FE chips, exceeding human inspection performance by about 35% for FE chips. Advanced ML methods were also applied to ATLAS physics analysis: a transformer-based classifier for the Higgs-to-charm search achieved 30–40% better background rejection and about 15% higher expected signal significance than the conventional BDT approach ([46] G. Aad et al., JHEP (2025) 75, [47] G. Aad et al., Phys. Rev. Lett. 135 (2025) 231802), and is now fully integrated into the ATLAS statistical analysis framework.

1-2. Generating Fused Disciplines

* Describe the content of measures taken by the center to advance research by fusing disciplines. For example, measures that facilitate doing joint research by researchers in differing fields. If any, describe the interdisciplinary research/fused discipline that have resulted from your efforts to generate fused disciplines. You may refer to the research results described concretely in "1-1. Advancing Research of the Highest Global Level."

International Workshop to Determine the Direction of QUP

To establish a new vision for QUP, two international workshops were held to refine its three scientific pillars and strengthen interdisciplinary research. In April 2025, QUP organized a workshop on quantum and cryogenic sensors, discussing applications to high-precision tests of fundamental physics, dark matter searches, and gravity research. In January 2026, QUP hosted the Workshop on Radiation-Tolerant Semiconductors (Q-RadSemi2026), which attracted broad participation from academia and industry and explored the expansion of radiation-tolerant semiconductors into diverse research fields. These discussions formed an important basis for updating the center's vision.

QUP Synergy Summit

The QUP Synergy Summit (QSS), launched in FY2023 and led by the Toyota Central R&D Labs satellite, promotes collaboration between academia and industry and the social implementation of research outcomes. Through QSS, QUP researchers and industrial partners discuss societal and technological needs while exploring practical applications of QUP technologies, including quantum sensing and advanced measurement systems. The fifth meeting, held in November 2025, focused on quantum sensors and quantum technologies for the Internet of Things and was attended by approximately 30 industry participants.

2. Global Research Environment and System Reform

2-1. Realizing an International Research Environment

* Describe what's been accomplished in the efforts to raise the center's recognition as a genuine globally visible research institute, along with innovative efforts proactively being taken in accordance with the development stage of the center, including the following points, for example:
- Efforts being developed based on the analysis of number and state of world-leading, frontline researchers (in Appendix 2); exchanges with overseas satellites (in Appendix 4); number and state of visiting researchers from abroad (in Appendix 5-1); number and destination of overseas visits by center researchers (in Appendix 5-2, including doctoral students).
- Proactive efforts to raise the level of the center's international recognition and to obtain diversity within the center.
- Efforts to make the center into one that attracts excellent young researchers from around the world (such as efforts fostering young researchers and contributing to advancing their career paths)
- Efforts to cultivate global mindsets and foster international awareness among young center researchers

QUP Building and Experimental Facilities

In summer 2025, the QUP building complex, whose construction began in FY2023, was completed (Figure 16). The facility integrates research offices, an experimental hall, and an education wing with seminar rooms, enabling researchers and students to work closely together under one roof and strengthening QUP as a visible collaborative research hub.

In the experimental hall, relocation of QUP's cryogenic facility from the KEK Fuji experimental hall has started, and two dilution refrigerators were transferred during FY2025. The facility will support the qubit-based dark matter search program described in Section 1-1.2.2. A ~200 m² cleanroom facility divided into three rooms, together with a radio-frequency anechoic chamber, was also established to provide an integrated low-noise experimental environment. In March 2026, a ceremony was held to mark both the appointment of the new Director and the completion of the complex.

Figure 16 QUP building complex, the experimental hall area, and anechoic chamber.

Together with the underground low-noise cryogenic facility established at the Kamioka mine in collaboration with Tohoku University, where cosmic-ray and environmental radiation backgrounds are significantly suppressed, these developments mark substantial progress toward an integrated infrastructure for quantum sensor testing and searches for new particles.

International conference

The international conference "Multimessenger Astronomy Beyond the Standard Model and Quantum Sensing (Q-EYES 2025)" was held on 9–11 December 2025 at the Tsukuba International Congress Center (Figure 17). The meeting featured 25 invited speakers and 65 participants. It provided early-career QUP researchers with opportunities to engage with leading international scientists and deepen their global perspective through active discussions.

Figure 17 Group photo of QEYES 2025.

Colloquium

A series of QUP colloquiums has been held almost monthly at KEK, with remote participation available. In FY2025, a total of eight colloquiums were held, featuring distinguished speakers, seven of whom were from overseas institutions. The colloquiums were widely announced to the community.

Diversity

Diversity is of central importance to QUP and is explicitly stated in its code of conduct. Postdoctoral positions at QUP are always advertised through open international recruitment, with applications from overseas researchers accounting for nearly 90% (Appendix 3-1-1-3). As of FY2025, QUP has 14 PIs, of whom three are women and four are non-Japanese. The proportion of international researchers at QUP has steadily increased, reaching 42% by the end of FY2025 (Appendix 3-1a). While the proportion of female researchers is currently 14%, and further efforts are needed to achieve the target of 20%, this level already exceeds the average at the host institution, KEK.

QUP Internship Program (QUPIP)

QUP established the QUPIP internship program in FY2023. The program allows postdoctoral researchers and graduate students to stay at QUP and work with senior scientists for typically 1–3 months, with the possibility of extension. In FY2025, the program hosted 3 postdoctoral researchers, 7 master's students, and 5 PhD students. Twelve of the students came from abroad, including Asia, Europe, and the Americas (Figure 18). This year, we received more applications from early-career researchers in Asia, particularly those below the postdoctoral level. QUPIP recruitment is conducted through an open and gender-neutral process, without specific affirmative action measures. Nevertheless, the proportion of female participants has reached 20%, meeting QUP's target for gender balance among researchers. Some participants have joined the program more than once, leading to long-term collaborations with QUP researchers in several cases.

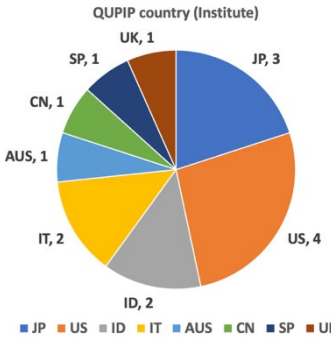

Figure 18 QUPIP demography

The Berkeley Satellite

The role of the Berkeley Satellite was redefined at the end of FY2025 following a major restructuring of QUP activities. The satellite originally supported detector R&D for the LiteBIRD satellite experiment, but its mission has now been realigned with QUP's renewed scientific strategy, shifting to a network- and training-driven model centered on TES fabrication and detector integration for the Kamioka dark matter program.

The satellite is formally established through an MOU with the University of California, Berkeley (UCB), rather than with Lawrence Berkeley National Laboratory. This distinction is practically significant: institutional agreements of this kind are far more tractable with UCB than with a national laboratory, and the satellite therefore requires a responsible UCB faculty member to serve as the institutional anchor. A. Lee (UCB) fulfills this role by virtue of his faculty appointment and expertise in sensor development and detector integration. Under this framework, the satellite operates as a bidirectional platform for collaboration, training, and technology transfer, leveraging the unique environment formed by the co-location of UCB and LBNL, one of the world's leading hubs for detector development. Concretely, QUP researchers will carry out hands-on device fabrication at two world-class facilities: the UC Berkeley Marvell Nanofabrication Laboratory and the Molecular Foundry at LBNL. The first researcher dispatch from QUP is scheduled for June 2026, with a newly hired QUP postdoc serving as the first QUP visitor to undergo this hands-on fabrication training and to produce QUP devices for the Kamioka program.

2-2. Making Organizational Reforms

* Describe the system reforms made to the center's research operation and administrative organization, along with their background and results.
* Describe the measures taken and results achieved in implementing the center's gender-balance plan.
* If innovated system reforms generated by the center have had a ripple effect on other departments of the host institutions or on other research institutions, clearly describe in what ways.
* Describe the center's operation and the host institution's commitment to the system reforms. (Include measures taken made by the host institution to provide a support system and to work toward improving the environment for achieving gender balance.)

Strategic Decision-Making Framework and Establishment of Roundtable Meetings at QUP

In response to recommendations from the WPI Committee, the framework for strategic decision-making in the management of QUP has been clarified. Key strategic issues, including research directions, are discussed within the Leadership Council, composed of the Director, the Deputy Director, Executive Assistant to the Director, and Administrative Director (Appendix 3-1-3).

The former Strategy Office has been reorganized and renamed the "QUP Alliance and Public Relations Office." This office supports the center's operations by implementing strategies formulated by the Leadership Council, including external funding acquisition, academia–industry–government collaboration, international partnerships, public relations, and outreach activities. It functions as an operational coordination unit. In particular, public relations activities are being strengthened through close coordination with KEK, including cross-appointment arrangements and the appointment of a new URA

starting in July. Strategic decisions are made under the responsibility of the Leadership Council.

The Leadership Council recognizes that defining and advancing the three pillars of QUP is a challenging task and remains an unresolved issue shared by similar institutions worldwide. It considers it essential to enable frank and constructive dialogue among leading researchers and scientific leaders across institutions, ensuring an appropriate balance between competition and collaboration. To this end, QUP has decided to convene a focused, invitation-based roundtable on future flagship scientific themes, bringing together leading researchers in quantum sensing, AMO physics, and particle physics. The external members have been selected as follows: Klaus Blaum (Heidelberg), Dmitry Budker (Mainz), Jodi Cooley (SNOLAB), John Doyle (Harvard), Hitoshi Murayama (UC Berkeley), and Stefan Ritt (PSI). The first meeting is scheduled for 2026.

Unique recruitment and salary scheme

QUP's recruitment scheme enables rapid decision-making in the hiring process. The QUP Director negotiates directly with candidates to determine their salaries, which is a significant factor in maintaining competitiveness with the world's leading institutes in attracting outstanding researchers. This scheme has also facilitated the rapid realignment of QUP under the new Director. As an example, Dr. Fujiwara of TRIUMF joined QUP as a PI in this fiscal year. To enable his more active involvement, he has been appointed under an international cross-appointment arrangement with TRIUMF, effective April 2026. This marks the first cross-appointment between KEK and a foreign institute. The streamlined recruitment process at QUP played a key role in enabling this milestone in a timely manner.

3. Values for the Future

3-1. Creating and Disseminating the Societal Value of Basic Research

* Describe the content of measures taken by the center to widely disseminate the results of its basic research to the general public.
* Describe what was accomplished in the center's outreach and other activities last year and how they have contributed to creating the Societal Value of Basic Research. In Appendix 6, describe concretely the contents of these outreach activities. In Appendix 7, describe media reports or coverage, if any, of the activities.

Public events

In FY2025, the outreach event for students was held in July at the Tsukuba International Congress Center under the title "Does an Apple Fall Down in a Reversed Universe? — Antimatter and Gravity". Following a lecture by M. Fujiwara of TRIUMF, who later became a QUP PI, QUP researchers joined students for an informal discussion, providing a valuable opportunity to share the excitement of scientific research directly with younger participants. In November, QUP hosted the WPI Symposium "Scientific Eyes to Change the Future" at the same venue, bringing together all 18 WPI institutes. The program included short talks by early-career researchers from three WPI centers and a poster session involving both high school students and WPI researchers. The high school session featured 31 posters from 12 schools across eight prefectures (Figure 19). A luncheon meeting between early-career researchers and student presenters further promoted direct interaction and discussion.

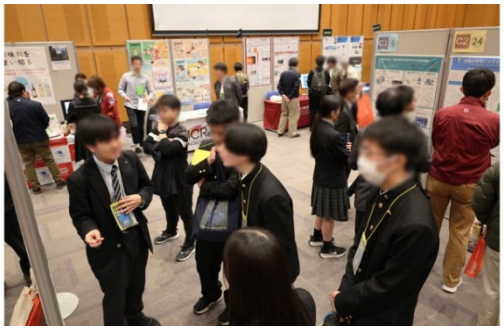

Figure 19 Poster session of high school students at WPI science symposium.

Media coverage

The appointment of the new Director, the launch of new initiatives, and the completion of the new building complex described in Section 2-1 attracted considerable media attention. The commemorative ceremony was attended by around ten media organizations and resulted in three media reports. In particular, QUP's qubit-based dark matter research drew strong interest, leading to several interview requests in April 2026.

3-2. Human Resource Building: Higher Education and Career Development

* Describe the content of measures taken by the center to foster young researchers, including doctoral students, through their participation in a research system that creates new interdisciplinary domains within a rich international environment.
* Describe measures taken for fostering researchers with a view to achieving gender plans, and measures taken for domestic and international promotion activities to attract female researchers to the center.

As described in Section 2-1, the QUPIP program was established to host postdoctoral researchers and graduate students, and in FY2025, a total of 15 QUPIP fellows were based at QUP. Numerous joint papers with QUP researchers were published, and one former QUPIP fellow joined QUP this fiscal year as a postdoctoral researcher, demonstrating the program's effectiveness in attracting and retaining young researchers.

To strengthen the educational framework beyond QUPIP, QUP also supports graduate students through long-term appointments using KEK's specialized system. In FY2025, four doctoral students were enrolled,

including one former QUPIP fellow, indicating a steady transition from QUPIP to advanced research training. Mr. Miyamaru received the JPS Student Presentation Award at the autumn meeting.

Under the MOU with SOKENDAI, most senior QUP scientists have been affiliated with the graduate school since September 2023. In FY2025, QUP researchers supervised four SOKENDAI doctoral students. Two of the eight students supported through these programs are female, meeting QUP's target for female representation.

Active outreach also contributed to recruitment. The Acting Director and Director promoted the renewed QUP through seminars, workshops, and institutional visits, including at Fermilab, IN2P3, the University of Tokyo, the KEK Open House, and the KEK Research Promotion Meeting.

3-3. Self-sufficient and Sustainable Center Development

* Describe the state of implementation of the host institution's mid-to-long term measures for supporting the center toward becoming self-sufficient and sustainable after the 10-year funding period ends, such as reforming the host institution's organization, providing personnel with priority allocation of tenured posts to the center, providing fundamental financial support, and material support including land and buildings.

With a view toward the permanent establishment of QUP after a 10-year period, KEK reaffirms its commitment to the development of a concrete and sustainable financial plan, as stipulated in the updated QUP document on the research center project and in accordance with the recommendations of the Program Committee. Under the leadership of the Director-General, KEK will provide comprehensive support to enable QUP to establish an independent financial foundation, while ensuring close alignment with KEK's strategic plan to build an international research center at the forefront of quantum research. In parallel with expanding the necessary facilities, *KEK will promote the acquisition of tenure for researchers and engineers beginning in fiscal year 2026, with the goal of securing tenure for at least five researchers by fiscal year 2030.*

KEK engaged in a support plan to sustain QUP beyond the WPI funding period. KEK recognizes QUP as a critical center for exploring new directions in future research through transformative advances in measurement science. KEK has reaffirmed its commitment to developing a concrete financial plan for QUP's permanent establishment. It is estimated that, in total, more than 600 million yen per year will be required in personnel costs to maintain the current level of activity after the completion of the WPI program. KEK will request that QUP actively secure external funding of approximately 200 million yen or more, *while committing to cover the remaining 400 million yen or more annually in personnel costs to support QUP's permanent establishment as a formal KEK research institute.*

4. Others

* In addition to the above 1-3 points, if there is anything else that deserves mention regarding the center project's progress, please note it.

None

5. Center's Response to Results of Last Year's Follow-up

* Transcribe the item from the "Actions required and recommendations" section in the site visit report and the Follow-up report, then note how the center has responded to them.
* If you have already provided this information, indicate where in the report.

QUP takes the Program Committee's concerns seriously and has undertaken concrete measures to address each of the identified issues. These include clarifying specific scientific milestones, timelines, and implementation strategies for all emerging projects, as well as making a focused effort to foster a more vibrant and interactive intellectual culture within the Center. The individual responses to the Committee's observations are described below, and in the relevant sections of this report.

1) Turnover of personnel

> The roles and positions of projects continued from the previous leadership remain unclear. The new Director should not be constrained by the former organizational structure and is expected to take proactive steps to establish a framework necessary for realizing the new progress plan. Specifically, based on the new progress plan, it is essential to re-evaluate the direction of ongoing projects carried over from the previous leadership and to review the operational structure, including the renewal of personnel. If projects from the previous leadership are to be continued, clear goals must be defined for each project within the context of the new progress plan, thereby clarifying their roles and expected outcomes.

Under the new Director, QUP has undertaken a comprehensive restructuring of both its research framework and personnel organization. The previous structure has been replaced by a coherent system based on three scientific pillars, Fundamental Forces and Hidden Sectors, Light Dark Matter, and Gravity, supported by a horizontal Technology Advancement Platform and Theory Group.

All ongoing projects from the previous phase have been critically re-evaluated and explicitly repositioned within these pillars with defined scientific objectives and timelines. The Kamioka dark matter experiment and NV-diamond program are formally integrated into the Light Dark Matter pillar. The former solar TES and optical TES groups have been consolidated into a unified TES Development Group under PI N. Yamasaki. The previous Deputy PI scheme has been discontinued in favor of PI-led research groups with clear accountability. New groups have been established in key frontier areas, superconducting qubits (DarQ), TES-based QED tests, superconducting RF cavities, and antimatter gravity, each directly driving one of the three scientific pillars. The Director himself leads the QED muonic atom program (P1-1) as a core scientific deliverable, directly demonstrating his own research agenda within the new framework.

2) Specific Research Content

The research projects to be initiated by the new plan should have clear international benchmarks of excellence, and a concrete roadmap and schedule for achieving the goals. The Program Committee expects some early milestone achievements by next year to demonstrate success of the new plan.

Finally, it remains unclear how the incoming Director will lead his own research group, which is expected to play a central role in achieving QUP's scientific goals. A clear, well-defined plan for the Director's own research agenda and its integration into the broader vision of QUP is essential for credibility and success.

Each project is defined with explicit international benchmarks and near-term milestones already demonstrating early progress. In Pillar 1, the QED test with muonic atoms (P1-1) has successfully acquired a statistically significant dataset of 44 keV muonic X-rays from muonic Ar atoms in FY2025, with analysis underway; the target precision of $\Delta E_{QED}/E_{QED} < 1\%$ is competitive with the best bound-state QED results from ion storage rings. Concurrently, two landmark world-first results were achieved. The first is the state-selective observation of highly charged muonic Ar (μAr) by electronic K X-ray spectroscopy (*Phys. Rev. Lett.* 134 (2025) 243001). The second is direct observation of a muonic deuterium molecule ($dd\mu^+$) (*Science Advances* 12, eaed3321 (2026)), representing world-first achievements enabled by QUP's TES platform.

In Pillar 2, the DarQ program has commissioned a fully operational end-to-end experimental platform in FY2025, achieving qubit coherence times of $T_1 = 49.4$ μs, exceeding the original target, and performed its first dark photon search with a tunable qubit–cavity system, establishing a new experimental limit (arXiv:2505.15619, submitted to *Phys. Rev. Lett.*). The NV Diamond project produced three peer-reviewed publications in FY2025, introducing progressively improving detection concepts, with dual-site operation at QUP and Kyoto University targeted by July 2026 as the next critical milestone. The Kamioka-LDM experiment has commissioned its TES readout system at the underground facility and confirmed single-photon sensitivity; a published dark matter search result with the GaAs detector is planned for FY2026.

In Pillar 3, the superconducting RF cavity project is advancing toward the development of higher-Q cavities, building on the recent achievement of the highest cavity quality factor ever reported in the quantum regime (Phys. Rev. Applied 25, 034076 (2026)). The antimatter gravity project has initiated core activities with Phase 1 laser linewidth narrowing (60 GHz → 500 MHz). Ionization of residual H gas is scheduled in 2026, and optimization with a dedicated atomic H source is targeted for 2027.

3) KEK's Commitment

KEK should clearly demonstrate its commitment to positioning QUP as the core initiative for quantum sensor development and continuing to support it with a sustainable number of permanent positions and adequate funding to secure core PIs and researchers even after the WPI grant ends.

KEK reaffirms its commitment to positioning QUP as the core initiative for quantum sensor development within KEK's long-term strategic plan for an International Research Center at the Quantum Frontier. Concretely, KEK will promote the acquisition of tenure for QUP researchers and engineers beginning in FY2026, with the goal of securing tenure for at least five researchers by FY2030. Financially, KEK estimates that more than 600 million yen per year in total personnel costs will be required to maintain QUP's activity level after the WPI program concludes. KEK commits to covering 400 million yen or more, while QUP is expected to secure 200 million yen or more through external funding. This commitment is made under the leadership of KEK's Director-General and is explicitly aligned with KEK's strategic plan. The newly completed QUP building complex further demonstrates KEK's commitment to securing long-term infrastructure for QUP.

4) On-site quantum device fabrication facility

The new leadership must develop more concrete and detailed plans across several critical dimensions. For example, if QUP aims to establish itself as a leading center for Transition Edge Sensor (TES) development, fabrication and applications, it must promptly define a solid foundation for this effort. Specifically, it should clarify whether QUP has the in-house capacity to develop TES detector systems—whose specifications vary by application, as noted in the new proposal—or whether it will rely on fabrication, for instance, by UC Berkeley. The answer to this question will fundamentally shape the character and identity of QUP.

QUP has made concrete progress in establishing a domestic TES fabrication capability, directly addressing the question of whether QUP can develop TES detector systems in-house. A multi-node domestic alliance for TES fabrication has been organized under the leadership of PI N. Yamasaki, spanning QUP, JAXA/ISAS, NIMS, AIST, RIKEN, OIST, and university partners. A kick-off workshop is scheduled early in FY2026. At ISAS, a 256-pixel TES array with 64 readout lines has been fabricated, integrated into the QUP MWMUX system, and signals from 27 pixels have been successfully read out. At NIMS, the first Ti/Au bilayer TES devices have been successfully fabricated in FY2025, with an active process optimization program targeting reliable T_c control in the 0.2–0.3 K range. AlMn TES prototype devices have been fabricated in collaboration with SEEQC, with a residual-resistance issue resolved in the second fabrication batch.

These advances establish that QUP is building genuine in-house capability across multiple fabrication nodes, rather than relying solely on UC Berkeley. Near-term milestones include demonstration of multi-pixel TES arrays integrated with the MWMUX system (FY2026–2027), evaluation of AlMn TES single-photon response (FY2026), and deployment of TES detectors coupled to aluminum targets at Kamioka (FY2027).

5) Future of QUP's collaboration with UC Berkeley

The future of QUP's collaboration with UC Berkeley, particularly in the post-LiteBIRD context, has not been sufficiently addressed. Clear discussions and substantiation of its future role are necessary.

The Berkeley Satellite has been strategically redefined to align with QUP's renewed scientific mission (Section 2-1). While PI A. Lee does not perform direct TES fabrication at the satellite, his extensive network at UC Berkeley and LBNL provides QUP researchers with access to state-of-the-art fabrication facilities and expertise through collaborative visits and mentorship. In 2026, the satellite will offer the necessary facilities to fabricate a GaAs sensor by QUP researchers. This bidirectional exchange is essential to accelerate QUP's research to meet scientific goals.

6) New PIs

A group of young PIs has been recruited to support the renewed vision. However, with the exception of one individual, there is concern that most of these PIs are based at satellite institutions rather than at KEK, potentially undermining their impact on the Center's core activities.

Drastic improvements have been made since the last evaluation. In 2025, QUP recruited four new PIs: T. Azuma, T. Takahashi, T. Nitta, and M. Fujiwara, including one early-career PI (T. Nitta). Among them, T. Azuma and T. Nitta are fully based at QUP, while T. Takahashi contributes one day per week on average (20% FTE), and M. Fujiwara holds a 20% cross-appointment with QUP since April 2026. An additional PI has been recruited at QUP, working at QUP since April 2026. QUP has a total of 15 PIs: 9 have appointments at KEK.

7) The role of the Strategy Office

Although QUP has established Strategy Office headed by Administrative Director and manned by University Research Administrators, its strategic role in promoting internationalization and institutional innovation has been very limited. Under the leadership of the Administrative Director, the Strategy Office should take on a more proactive role in advancing the WPI mission - particularly in building international networks, supporting structural reform, and ensuring long-term sustainability.

The framework for strategic decision-making in the management of QUP has been clarified (Section 2-2). The Leadership Council, composed of the Director, the Deputy Director, Executive Assistant to the Director, and Administrative Director (Appendix 3-1-3), has been established to deliberate on key strategic issues, including research directions. The former Strategy Office has been reorganized and renamed the "QUP Alliance and Public Relations Office," which supports the center's operations by implementing strategies formulated by the Council. The Leadership Council recognizes that defining and advancing the three pillars of QUP is a challenging task and remains an unresolved issue shared by similar institutions worldwide. A roundtable on future flagship scientific themes is formed by inviting leading researchers in quantum sensing, AMO physics, and particle physics. The first meeting is scheduled for 2026.

Appendix 1 FY 2025 List of Center's Research Results and Main Awards

1. Refereed Papers

- List only the Center's papers published in 2025. (Note: The list should be for the calendar year, not the fiscal year.)

(1) Divide the papers into two categories, A and B.
   A. WPI papers
      List papers whose author(s) can be identified as affiliated with the WPI program (e.g., that state "WPI" and the name of the WPI center (WPI-center name)). (Not including papers in which the names of persons affiliated with the WPI program are contained only in acknowledgements.)
   B. WPI-related papers
      List papers related to the WPI program but whose authors are not noted in the institutional affiliations as WPI affiliated. (Including papers whose acknowledgements contain the names of researchers affiliated with the WPI program.)

      Note: On 14 December 2011, the Basic Research Promotion Division (the Basic and Generic Research Division at present) in MEXT's Research Promotion Bureau circulated an instruction requiring paper authors to include the name or abbreviation of their WPI center among their institutional affiliations. From 2012, the authors' affiliations must be clearly noted.

(2) Method of listing paper
   - List only refereed papers. Divide them into categories (e.g., original articles, reviews, proceedings).
   - For each, write the author name(s); year of publication; journal name, volume, page(s) (or DOI number), and article title. Any listing order may be used as long as format is consistent. (The names of the center researchers do not need to be underlined.)
   - If a paper has many authors (say, more than 10), all of their names do not need to be listed.
   - Assign a serial number to each paper to be used to identify it throughout the report.
   - If the papers are written in languages other than English, underline their serial numbers.
   - Order of Listing
      A. WPI papers
         1. Original articles
         2. Review articles
         3. Proceedings
         4. Other English articles

      B. WPI-related papers
         1. Original articles
         2. Review articles
         3. Proceedings
         4. Other English articles

(3) Submission of electronic data
   - In addition to the above, provide a .csv file output from the Web of Science (e.g.) or other database giving the paper's raw data including Document ID. (Note: The Document ID is assigned by paper database.)
   - The papers should be divided into A or B categories on separate sheets, not divided by paper categories.

(4) Use in assessments
   - The lists of papers will be used in assessing the state of WPI project's progress.
   - They will be used as reference in analyzing the trends and whole states of research in the said WPI center, not to evaluate individual researcher performance.
   - The special characteristics of each research domain will be considered when conducting assessments.

(5) Additional documents
   - After all documents, including these paper listings, showing the state of research progress have been submitted, additional documents may be requested.

A. WPI papers

This section lists papers published in 2025 with significant contributions by QUP scientists.

1. Original Articles

[1] S. Chigusa, M. Hazumi, E. D. Herbschleb, N. Mizuochi and K. Nakayama "Light dark matter search with nitrogen-vacancy centers in diamonds" Journal of High Energy Physics 2025 (2025) 83 DOI:10.1007/JHEP03(2025)083

[2] S. Chigusa, M. Hazumi, E. D. Herbschleb, Y. Matsuzaki, N. Mizuochi and K. Nakayama "Nuclear spin metrology with nitrogen vacancy center in diamond for axion dark matter detection" Physical Review D 111 (2025) 075028 DOI:10.1103/PhysRevD.111.075028

[3] T. Kikuchi et al. "Array of Optical Transition-Edge Sensors Fabricated by Ion-Milling Process Evaluated with Microwave Multiplexer for 100 or More Sensors" Journal of Low Temperature Physics 221 (2025) 199-208 DOI:10.1007/s10909-025-03324-0

[4] T. Y. Saito et al. "Application of Hard X-Ray and Gamma-Ray TES Microcalorimeter at Accelerator Facility" IEEE Transactions on Applied Superconductivity 35 (2025) 2100805 DOI:10.1109/TASC.2024.3525445

[5] T. Okumura, T. Azuma et al. "Few-Electron Highly Charged Muonic Ar Atoms Verified by Electronic K X Rays" Physical Review Letters 134 (2025) 243001 DOI:10.1103/PhysRevLett.134.243001

[6] R. Anthony-Petersen et al. "Low energy backgrounds and excess noise in a two-channel low-threshold calorimeter" Applied Physics Letters 126 (2025) 102601 DOI:10.1063/5.0247343

[7] T. K. Bui et al. "First Limits on Light Dark Matter Interactions in a Low Threshold Two-Channel Athermal Phonon Detector from the TESSERACT Collaboration" Physical Review Letters 135 (2025) 161002 DOI:10.1103/hsrl-crvf

[8] C. L. Chang et al. "Spontaneous generation of athermal phonon bursts within bulk silicon causing excess noise, low energy background events, and quasiparticle poisoning in superconducting sensors" Applied Physics Letters 127 (2025) 263502 DOI:10.1063/5.0281876

[9] T. Tsuruta et al. "Development of TES Microcalorimeters with Serpentine Absorbers for Two-Dimensional Position Detection" IEEE Transactions on Applied Superconductivity 35 (2025) 2101104 DOI:10.1109/TASC.2025.3527415

[10] A. Umemoto et al. "First direction sensitive search for dark matter with a nuclear emulsion detector at a surface site" Journal of Cosmology and Astroparticle Physics 2025 (2025) 012 DOI:10.1088/1475-7516/2025/02/012

[11] A. Umemoto, M. Yoshino, T. Iida, M. Miyakawa, T. Taniguchi and S. Nomura "Real-Time Alpha-Ray Track Imaging Using a Synthetic Diamond Scintillator" Progress of Theoretical and Experimental Physics 2025 (2025) 123H01 DOI:10.1093/ptep/ptaf147

[12] K. D. Lozanov, S. Pi, M. Sasaki, V. Takhistov and A. Wang "Axion-like universal gravitational wave interpretation of pulsar timing array data" Classical and Quantum Gravity 42 (2025) 035007 DOI:10.1088/1361-6382/ad9e67

[13] Q. Ding, M. He, V. Takhistov and H.-Y. Zhu "Dark-matter-independent orbital decay bounds on ultralight bosons from OJ287" Physical Review D 112 (2025) 103051 DOI:10.1103/y5qn-rvv1

[14] Y. Bai, T.-K. Chen, J. Liu and X. Ma "Wess-Zumino-Witten Interactions of Axions" Physical Review Letters 134 (2025) 081803 DOI:10.1103/PhysRevLett.134.081803

[15] S. Pi, M. Sasaki, V. Takhistov and J. Wang "Primordial Black Hole formation from power spectrum with finite-width" Journal of Cosmology and Astroparticle Physics 2025 (2025) 045 DOI:10.1088/1475-7516/2025/09/045

[16] T. Schwemberger and V. Takhistov "Diffuse Neutrino Signals from Dark Stars Seeding Supermassive Black Holes" Astrophysical Journal Letters 989 (2025) L44

DOI:10.3847/2041-8213/ade5a9

[17] Q. Ding M. He and V. Takhistov "Primordial Black Hole Mergers as Probes of Dark Matter in the Galactic Center" Astrophysical Journal 981 (2025) 62 DOI:10.3847/1538-4357/adaeb4

[18] K. Wei et al. "Dark matter search with a resonantly-coupled hybrid spin system" Reports on Progress in Physics 88 (2025) 057801 DOI:10.1088/1361-6633/adca52

[19] S. Han et al. (SuperKamiokande collaboration) "Measurement of neutron production in atmospheric neutrino interactions at Super-Kamiokande" Physical Review D 112 (2025) 1-24 DOI:10.1103/4d71-d69k

[20] K. D. Lozanov, M. Sasaki and V. Takhistov "Universal gravitational wave signatures of cosmological solitons" Journal of Cosmology and Astroparticle Physics 2025 (2025) 094 DOI:10.1088/1475-7516/2025/01/094

[21] N. Bozorgnia, M. Chen, G. B. Gelmini, A. C. Kamaha and Y. Xu "Spin-dependent dark matter interactions at loop-level in Ar and Xe" Journal of Cosmology and Astroparticle Physics 2025 (2025) 066 DOI:10.1088/1475-7516/2025/04/066

[22] S. Iguro, V. Mathur, I. M. Shoemaker and V. Takhistov "Cosmology-independent constraints on irreducible magnetic monopole background" Journal of Cosmology and Astroparticle Physics 2025 (2025) 022 DOI:10.1088/1475-7516/2025/08/022

[23] K. Nakayama and M. Yamada "PQ-ball and its real scalar analogue in an expanding universe" Journal of Cosmology and Astroparticle Physics 2025 (2025) 082 DOI:10.1088/1475-7516/2025/09/082

[24] J. Kobayashi, K. Nakayama and M. Yamada "Decay rate of PQ-ball" Journal of Cosmology and Astroparticle Physics 2025 (2025) 057 DOI:10.1088/1475-7516/2025/07/057

[25] W.-Y. Hu, K. Nakayama, V. Takhistov and Y. Tang "Dual gravitational wave signatures of instant preheating" Journal of Cosmology and Astroparticle Physics 2025 (2025) 029 DOI:10.1088/1475-7516/2025/01/029

[26] T. Sichanugrist, H. Fukuda, T. Moroi, K. Nakayama, S. Chigusa, N. Mizuochi, M. Hazumi and Y. Matsuzaki "Entanglement-enhanced ac magnetometry in the presence of Markovian noise" Physical Review A 111 (2025) 042605 DOI:10.1103/PhysRevA.111.042605

[27] K. Murai and K. Nakayama "Domain walls in Nelson-Barr axion model" Journal of High Energy Physics 2025 (2025) 99 DOI:10.1007/JHEP09(2025)099

[28] X. M. Tong, K. Tokési, D. Kato, T. Okumura, S. Okada and T. Azuma "Orbital Collapse in Exotic Atoms and Its Effect on Dynamics" Physical Review Letters 134 (2025) 193001 DOI:10.1103/PhysRevLett.134.193001

[29] Y. Takahashi et al "Speciation of cesium in a radiocesium-bearing microparticle emitted from Unit 1 during the Fukushima nuclear accident by XANES spectroscopy using transition edge sensor" Journal of Hazardous Materials 495 (2025) 139031 DOI:10.1016/j.jhazmat.2025.139031

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2. Review Articles

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[231] G. Aad et al. "Future Circular Collider Feasibility Study Report: Volume 1 Physics, Experiments, Detectors" European Physical Journal C 85 (2025) 1468 DOI:10.1140/epjc/s10052-025-15077-x

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[237] G. Aad et al. (ATLAS collaboration) "Climbing to the Top of the ATLAS 13 TeV data" Physics Reports 1116 (2025) 127-183 DOI:10.1016/j.physrep.2024.12.004

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3. Proceedings

[242] T. Yano et al. (the Hyper-Kamiokande Collaboration) "Hyper-Kamiokande: Neutrino Astrophysics and Status" Proceedings of Science 501 (2025) 1215 DOI:10.22323/1.501.1215

[243] G. Dash et al. "Timing response characterization of MALTA monolithic pixel detectors" Journal of Instrumentation 20 (2025) C10004 DOI:10.1088/1748-0221/20/10/C10004

[244] A. Kondo et al. "Low-power test of bridge coupler in disk-and-washer structure for muon acceleration" Journal of Physics: Conference Series 3094 (2025) 012025 DOI:10.1088/1742-6596/3094/1/012025

[245] N. Kawamura, R. Kitamura, S. Kanda, S. Matoba, T. Mibe, T. Fukuyama, Y. Mimura and Y. Uesaka "A new concept of Mu − (Equation presented) conversion search" Proceedings of Science 480 (2025) 074 DOI:10.22323/1.480.0074

[246] H. Yoneda et al. "Imaging MeV Gamma-ray Lines with Advanced Image Reconstruction Framework for COSI" Proceedings of Science 501 (2025) 891 DOI:10.22323/1.501.0891

4. Other English articles

None

2. Invited Lectures, Plenary Addresses (etc.) at International Conferences and International Research Meetings

- List up to 10 main presentations during FY 2025 in order from most recent.
- For each, write the date(s), lecturer/presenter's name, presentation title, and conference name.

Date(s)	Lecturer/Presenter's name	Presentation title	Conference name
2025/12/2-3	Tatsumi Nitta	Dark matter search with superconducting qubits	ASPIRE Quantum Workshop, Chicago (USA)
2025/11/16-21	Manabu Togawa	A radiation tolerant particle detector with CIGS	The 14th international "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors (HSTD-14), Taipei (Taiwan)
2025/11/6-7	Yuji Chinone	Simons Observatory & Primordial Gravitational Waves	GW-CMB 2025 Workshop "New Frontiers in Observational Cosmology with Gravitational Waves and Cosmic Microwave Background", Taoyuan (Taiwan)
2025/10/19-24	Suerfu	Low-mass Dark Matter Searches in Kamioka Underground Laboratory	APPC16 (Asia Pacific Physics Conference), Haikou (China)
2025/10/16	Atsuhiro Umemoto	Development of high-pressure high-temperature synthetic diamond for dark matter search	MANA International Symposium 2025, Tsukuba (Japan)
2025/09/23-28	Toshiyuki Azuma	Opening a New Frontier in Precision Spectroscopy of Muonic Atoms with Superconducting X-ray Calorimeters	The 9th International Symposium on Symmetries in Subatomic Physics (SSP2025), Nara (Japan)
2025/06/23-27	Daniela Bortoletto	Semiconductor Technologies for Vertex Detector, Silicon Tracker and Timing	Open Symposium on the European Strategy for Particle Physics, Venice (Italy)
2025/06/23-27	Volodymyr Takhistov	Bridging Macroscopic and Microscopic Worlds: from Black Holes to Quantum Sensors	XVIII International Conference on Interactions Between Particle Physics and Cosmology (PPC 2025) , Deadwood (USA)
2025/06/1-6	Ryota Hayakawa	Light Dark Matter Search using Transition-Edge Sensor with sub-eV Sensitivity	The Low Temperature Detectors Conference (LTD2025), Santa Fe (USA)
2025/04/8-10	Kazunori Nakayama	Light dark matter search with quantum technology	QUP workshop, Tsukuba (Japan)

3. Major Awards

- List up to 10 main awards received during FY 2025 in order from the most recent.
- For each, write the date issued, the recipient's name, and the name of award.
- In case of multiple recipients, underline those affiliated with the center.

Date	Recipient's name	Name of award
Sep. 2025	Takafumi Miyamaru (QUPIP student)	JPS Student Presentation Awards at the autumn JPS meeting
Sep. 2025	Volodymyr Takhistov	Particle Physics Medal – Young Scientist Award in Theoretical Particle Physics, Japan Particle and Nuclear Theory Forum — 20th edition
Jul. 7 2025	Daniela Bortoletto	European Physical Society (EPS) Emmy Noether Distinction

Appendix 2　FY 2025 List of Principal Investigators

NOTE:

*Underline names of principal investigators who belong to an overseas research institution.

*Enter the host institution name and the center name in the footer.

	<Results at the end of FY2025>						Principal Investigators Total: 14
Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
Center director Toshiyuki Azuma	65	Professor/ QUP/KEK Principal Investigator/RIKEN	PhD, Physics	80	2026/3/1 as a PI	Since 2025/4/1, T. Azuma was at the center for 40%, as the deputy director . He became the director in 2025/12/8 and a PI on 2026/3/1.	
Manabu Togawa	47	Associate Professor/Institute of Particle and Nuclear Studies (IPNS)/KEK	PhD, Physics	70	2021/10/1	Stays at the center.	
Masaya Hasegawa	47	Associate Professor/IPNS/KEK	PhD, Physics	70	2021/10/1	Stays at the center.	
Masaya Miyahara	45	Associate Professor/IPNS/KEK	Doctor of Engineering	70	2021/10/1	Stays at the center.	
Adrian Tae-Jin Lee	61	Professor/Department of Physics/University of California Berkeley	PhD, Physics	20	2021/10/1	Stays at the Berkeley satellite. Joins videoconference meetings (PI meeting(~every month)). A few day stay in July.	Regular Contributions via videoconference.
Daniela Bortoletto	67	Professor/Department of Physics/University of Oxford	PhD, Physics	20	2021/10/1	Mainly at Oxford University and joins videoconference meetings (PI meeting(~every month))	Regular Contributions via videoconference.
Mauricio A. Garcia-Sciveres	59	Senior Scientist/Lawrence Berkeley National Laboratory	PhD, Physics	20	2021/10/1	Mainly stays at LBNL and joins videoconference meetings (PI meeting and Steering committee meeting (~every month). As the leader of the Kamioka Lite dark matter project, he visisted several times a year to QUP and Kamioka.	Regular Contributions via videoconference. Visits several times a year to QUP and Kamioka, for Kamioka Light Darkmatter Project. Promote sending Postdocs and students from various institutes as QUPIPs.

Noriko Y. Yamasaki	59	Professor/Institute of Space and Astronautical Science (ISAS)/Japan Aerospace Exploration Agency (JAXA)	PhD, Physics	20	2021/10/1	Stays at the ISAS satellite and joins videoconference meetings (PI meeting(~every month) and occasional meetings with the director (once a month)). Several visits to the center.	
Kazunori Nakayama	43	Associate Professor/Graduate School of Science and Faculty of Science, Tohoku University	PhD, Physics	30	2021/10/1	Stays in Tohoku university and joins videoconference meetings (PI meeting (~every month). Came to the center several times for research discussions and workshops.	
Yu Nakahama	44	Associate Professor/IPNS/KEK	PhD, Physics	70	2021/10/1	Stays at the center.	
Volodymy Takhistov	37	Associate Professor/QUP/KEK	PhD, Physics	100	2024/4/1	Stays at the center.	
Tatsumi Nitta	33	Associate Professor/QUP/KEK	PhD, Physics	100	2025/5/1	Stays at the center.	
Tadayuki Takahashi	67	Professor/Kavli-IPMU/University of Tokyo	PhD, Physics	20	2025/6/1	Stays at Kavli IPMU and comes to QUP every week on Tuesday, since May 2025.	
Makoto Fujiwara	57	Senior Scientist/Particle Physics Department/TRIUMF	PhD, Physics	20	2026/3/1	Mainly at TRIUMF and joins videoconference meetings (PI meeting(~every month) and research meeting for the start up of the project)	Regular Contributions via videoconference.

*Percentage of time that the principal investigator devotes to working for the center vis-à-vis his/her total working hours.

Principal investigators unable to participate in project in FY 2025

Name	Affiliation (Position title, department, organization)	Starting date of project participation	Reasons	Measures taken
Nanae Taniguchi	Associate Professor/IPNS/KEK	2021/10/1	Left QUP on 1 June 2025 following discussions on the revised QUP research framework and the realignment of PI responsibilities under the new project plan.	Her research activities were reviewed in the context of the new QUP research pillars, and the relevant activities were reorganized under the revised project structure.
Hideo Iizuka	Senior Fellow/Toyota Central R&D Labs., Inc., and Professor/QUP/KEK	2021/10/1	Resigned from the PI position on 28 February 2026 following discussions on the revised QUP research framework and the realignment of PI responsibilities.	From April 2026, he will continue to contribute to QUP as an affiliate member from Toyota Central R&D Labs.
Kaori Hattori	Senior Researcher/ National Institute of Advanced Industrial Science and Technology (AIST), Research Institute for Physical Measurement and Associate Professor/QUP/KEK	2021/10/1	Resigned from the PI position on 28 February 2026 following discussions on the revised QUP research framework and the consolidation of TES-related activities.	She will continue to contribute to QUP as a QUP scientist under PI N. Yamasaki.
Hiroki Akamatsu	Associate Professor/QUP/KEK	2025/3/1	Resigned from the PI position on 28 February 2026 following discussions on the revised QUP research framework and the consolidation of TES-related activities.	He will continue to contribute to QUP as a QUP scientist under PI N. Yamasaki.

Appendix 3-1 FY 2025 Records of Center Activities

1. Researchers and center staff, satellites, partner institutions

1-1. Number of researchers in the "core" established within the host institution

- Regarding the number of researchers at the Center, fill in the table in Appendix 3-1a.

Special mention

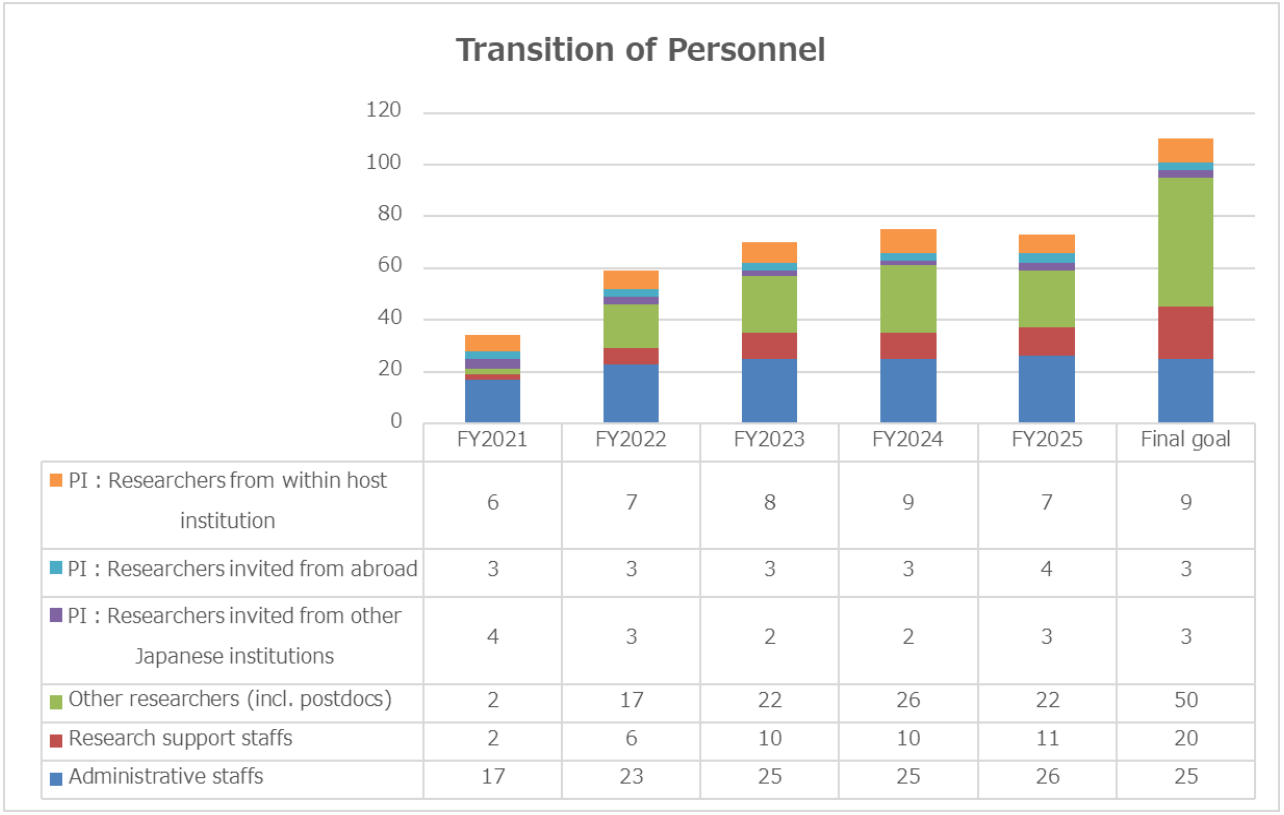
- Enter matters warranting special mention, such as concrete plans for achieving the Center's goals, established schedules for employing main researchers, particularly principal investigators.
- As background to how the Center is working on the global circulation of world's best brains, give good examples, if any, of how career paths are being established for the Center's researchers; that is, from which top-world research institutions do researchers come to the Center and to which research institutions do the Center's researchers go, and how long are their stays at those institutions.

As shown in Appendix 3-1a and in the figure below, the number of researchers, including postdoctoral fellows, as well as Research Support Staff at QUP remains below the final target. As of the end of FY2025, the total number has decreased compared to FY2024. This is partly because some postdoctoral researchers completed their three-year terms and moved on to more advanced positions, while new recruitment was temporarily suspended during the first half of FY2025 due to a major revision of the center's research plan.

However, recruitment resumed in the latter half of the fiscal year in line with the new research plan. Although not reflected in the figure, four additional postdoctoral researchers and two associate professors have already been selected and are scheduled to take up their positions in the first half of FY2026.

The status of PI appointments is as follows. An external PI from TRIUMF, Dr. Fujiwara, will be appointed as a Professor at QUP under a cross-appointment scheme starting on April 1, 2026. In addition, Ernst David Herbschleb will join from Kyoto University as an Associate Professor on April 1 and will serve as a PI leading dark matter searches using quantum sensors based on NV-diamond technology. With these appointments, **the number of PIs originally planned under the new center structure will be achieved by April 2026.** The addition of further PIs is also under consideration.

QUP will actively promote international recruitment of postdoctoral researchers in FY2026 to accelerate progress toward the final target. While it may be challenging to fully achieve the target number of on-board researchers by the end of FY2026, efforts will be made to come as close as possible, including those who have already accepted offers and are scheduled to arrive.



	FY2021	FY2022	FY2023	FY2024	FY2025	Final goal
PI : Researchers from within host institution	6	7	8	9	7	9
PI : Researchers invited from abroad	3	3	3	3	4	3
PI : Researchers invited from other Japanese institutions	4	3	2	2	3	3
Other researchers (incl. postdocs)	2	17	22	26	22	50
Research support staffs	2	6	10	10	11	20
Administrative staffs	17	23	25	25	26	25

In parallel, many postdoctoral researchers and early-career researchers initially recruited by QUP have successfully advanced to positions at other institutions. For example, in FY2026, postdoctoral researcher Yu Zhou moved to the National Astronomical Observatories, Chinese Academy of Sciences as an Associate Professor. Suerfu, formerly a Deputy PI and Assistant Professor, was appointed as a Lecturer at the University of Melbourne, and Associate Professor Kosuke Sato moved to Kyoto Sangyo University as a Professor. In addition, Atsuhiro Umemoto was promoted to Assistant Professor within QUP.

1-2. Satellites and partner institutions

- List the satellite and partner institutions in the table below.
- Indicate newly added and deleted institutions in the "Notes" column.
- If satellite institutions have been established overseas, describe by satellite the Center's achievements in coauthored papers and researcher exchanges in Appendix 4.

<Satellite institutions>

Institution name	Principal Investigator(s), if any	Notes
QUP Space and Astronautical Science Satellite	Noriko Yamazaki	
QUP Satellite in Toyota Central R&D Labs., Inc.	Hideo Iizuka	
QUP Berkeley Satellite	Adrian Lee	

< Partner institutions>

Institution name	Principal Investigator(s), if any	Notes
Kavli IPMU	T. Takahashi, V. Takhistov* (* affiliate members of IPMU)	MOU on a general scientific collaboration
SOKENDAI	KEK's PIs (M. Hasegawa, M. Miyahara, Y. Nakahama, M. Togawa, V. Takhistov*) (*affiliate members)	MOU on the education of graduate students.
Research Center for Neutrino Science, Tohoku University	None (K. Ishidoshiro is an affiliate member of QUP)	MOU on the collaboration related to the Kamioka Light Dark Matter project, since October 2023.
Tesseract Collaboration	M. Garcia-Sciveres	MOU related to the Kamioka Light Dark Matter project, since June 2024
Kyoto University	None (N. Mizuochi is an affiliate member of QUP)	Collaborative Research related NV diamond, since February 2026

1-3. Postdoctoral Positions through Open International Solicitations

- In the columns "number of applications" and "number of selections," put the total number (upper) and the number and percentage of overseas researchers in the < > brackets (lower)

Fiscal year	Number of applications	Number of selections
FY 2025	67	5
	〈 59, 88%〉	〈 2, 40%〉

2. Holding international research meetings

- Indicate the number of international research conferences or symposiums held in FY2025 and give up to three examples of the most representative ones using the table below.

FY 2025: 5 meetings

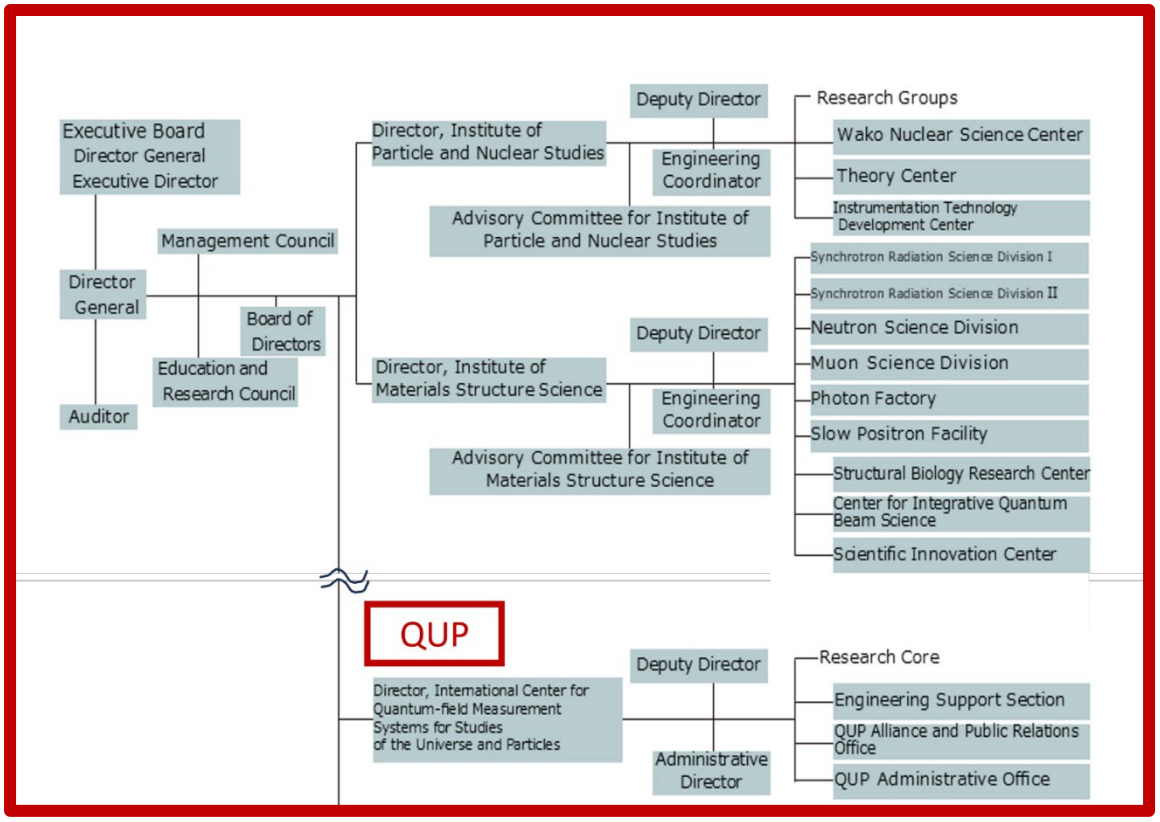
Major examples (meeting titles and places held)	Number of participants
QUP workshop (April 8-10, 2025, KEK, Tsukuba, Japan)	From domestic institutions: 95 From overseas institutions: 12
The international conference Multimessenger Astronomy Beyond the Standard Model and Quantum Sensing (Q-EYES 2025) (December 9-11, 2025, KEK, Tsukuba, Japan)	From domestic institutions: 51 From overseas institutions: 14
Q-RadSemi2026 Workshop on Radiation-Tolerant Semiconductors (January 22-23, 2026, Epochal Tsukuba, Japan)	From domestic institutions: 151 From overseas institutions: 2

3. Diagram of management system

- Diagram the center's management system and its position within the host institution in an easily understood manner.
- If any new changes have been made in the management system from that in the latest "center project" last year, describe them. Especially describe any important changes made in such as the center director, administrative director, head of host institution, and officer(s) in charge at the host institution (e.g., executive vice president for research).

[QUP position at KEK]

QUP is positioned within KEK as a research institute directly connected to KEK-HQ, like KEK's original two research institutes and two research centers, as shown in the KEK organization diagram (https://www.kek.jp/en/about/facts/organization). The relevant part is also shown below.



KEK is one of the inter-university research institute corporations where the opinions of the user community are strongly reflected in the lab operation. At the same time, the WPI QUP should be a top-down institute. At the foundation of QUP, KEK's high-level council, the Education and Research Council, ensured the leadership of the QUP director as an exception.

[Changes in the QUP organization in FY2025]

There were significant changes in the QUP organization in FY2025. QUP submitted an updated "Center Projects" document, which was approved in March 2026.

Organization Changes from the previous "Center Projects":

- **The QUP Leadership Council** was newly established. It consists of the Deputy Director, the Executive Assistant to the Director, and the Administrative Director. Strategic discussion, decision-making, and implementation, including the allocation of necessary resources, are integrated within the Leadership Council as a standing body.
- The role of the former QUP Strategy Office evolved to focus primarily on alliance-building and public relations activities. In the restructured framework, it has been reorganized as the "**QUP Alliance**

and Public Relations Office" to better align its name with its functions.

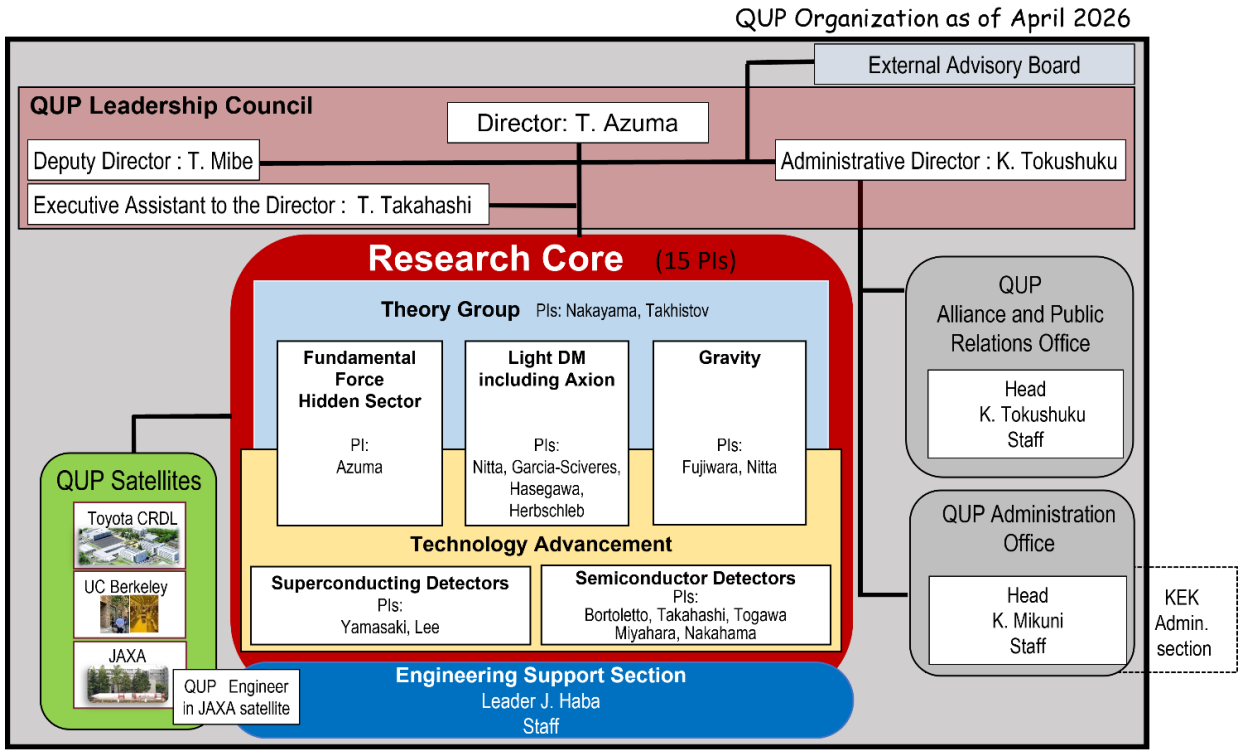
- **The Systemology Support Section** has been closed. In its place, QUP has established an **Engineering Support Section** to strengthen the technical support required to accelerate research activities.

These changes took effect by the end of FY2025.

Personal Changes:

- On December 8, following approval by MEXT and the WPI Program Committee, **Prof. Toshiyuki Azuma** was appointed as the new Director of QUP. The former Acting Director, **Dr. Kazunori Hanagaki**, left QUP and now continues to support its activities as an Executive Director of KEK.
- In line with the new direction described in the "Center Projects" document, Four PIs, N. Taniguchi, H. Akamatsu, K. Hattori, and H. Iizuka left from their positions. New PIs were appointed as follows: Tatsumi Nitta (since May), Tadayuki Takahashi (since June), and Makoto Fujiwara (since March). In addition, the QUP Director, Toshiyuki Azuma, has served as a PI since March.
- For completeness, it is noted that in April 2026, following the end of FY2025, Prof. Ernst David Herbschleb was appointed as an additional PI working on dark matter searches using NV diamond sensors. The total number of PIs is now 15, as planned in the new "Center Projects" document.
- In the new research project, we no longer appoint Deputy PIs, as these positions had been established to maintain close and continuous relationships between the center and overseas PIs.

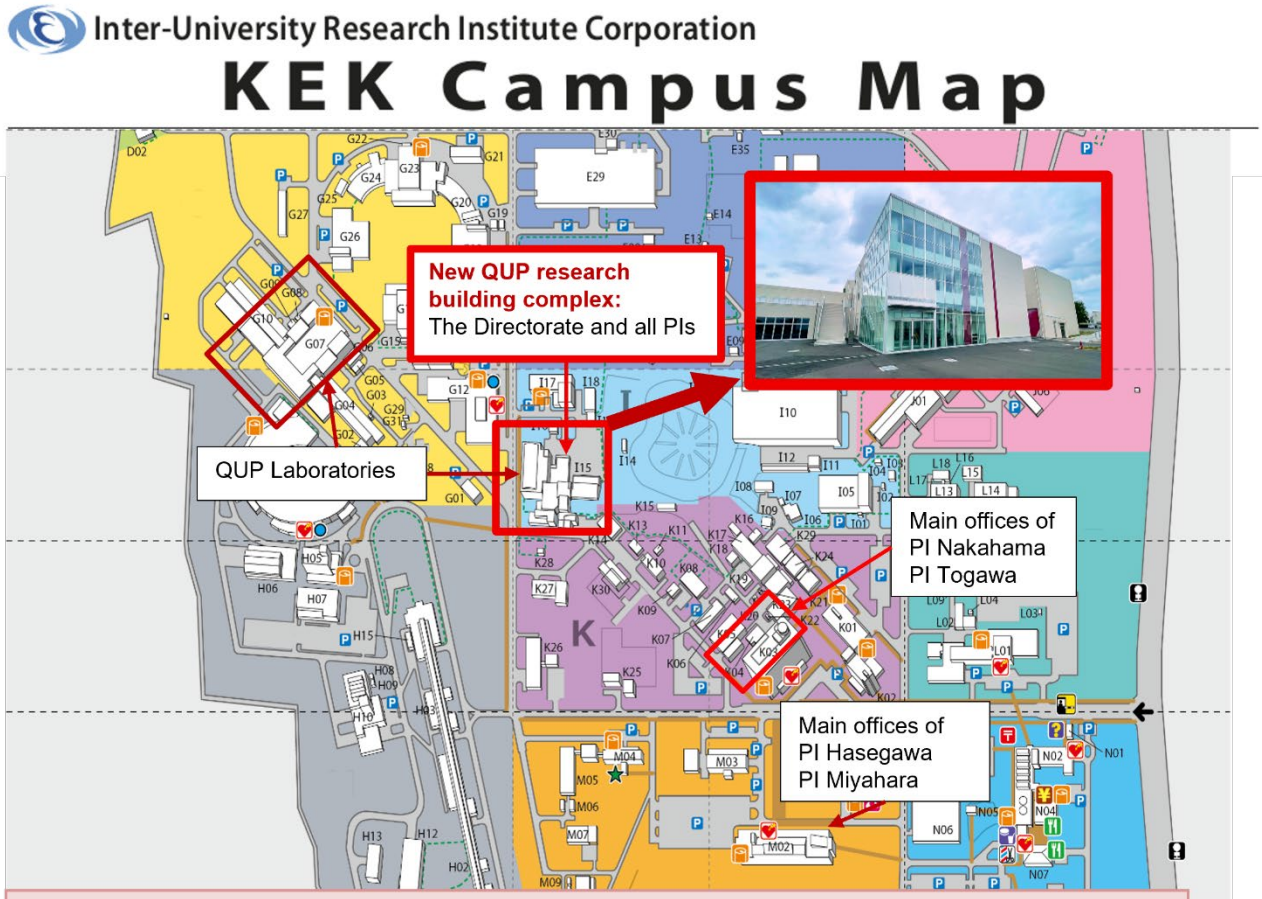
An organizational chart as of April 1, 2026, is shown below.



4. Campus Map

- Draw a simple map of the campus showing where the main office and principal investigator(s) are located.

As described in Section 2.1, the QUP Research Building Complex has been completed, and the QUP directorate, administrative office, and all PIs and researchers have relocated to the new facility. PIs who hold appointments in other divisions at KEK, as well as external PIs, are also provided with office space in the QUP Research Building Complex. For completeness, their primary office locations are indicated in the figure.



Locations of the main offices of the external PIs

JAXA	Tohoku Univ.	U.C. Berkeley	LBNL	Univ. of Oxford	TRIUMF
PI Yamasaki	PI Nakayama	PI Lee	PI Garcia-Sciveres	PI Bortletto	PI Fujiwara

5. Securing external research funding*

External research funding secured in FY2025

Total: 579,357,992 yen

- Describe external funding warranting special mention. Include the name and total amount of each grant.
* External research funding includes "KAKENHI," funding for "commissioned research projects," "joint research projects," and for others (donations, etc.) as listed under "Research projects" in Appendix 3-2, Project Expenditures.

Major External Funding Obtained in FY2024 (Direct Costs)

- **Program:** KAKENHI (Grant-in-Aid for Scientific Research (S), JSPS)
  Total Amount: JPY 57,400,000
  PI: Masaya Hasegawa

- **Program:** Moonshot R&D Program (JST)
  Total Amount: JPY 14,000,000
  PI: Masaya Miyahara

- **Program:** Research Grant for Decommissioning Science (JAEA)
  Total Amount: JPY 34,668,000
  PI: Masaya Miyahara

- **Program:** PRESTO (JST)
  Total Amount: JPY 10,000,000
  PI: Takumi Nitta

- **Program:** Core-to-Core Program (JSPS)
  Total Amount: JPY 13,372,750
  PI: Yu Nakahama

Appendix 3-1a FY 2025 Records of Center Activities

Researchers and other center staff

Number of researchers and other center staff

* Fill in the number of researchers and other center staff in the table blow.
* Describe the final goals for achieving these numbers and dates when they will be achieved described in the last "center project."

a) Principal Investigators

(full professors, associate professors or other researchers of comparable standing)

(number of persons)

	At the beginning of project	At the end of FY 2025	Final goal (Date: April, 2027)
Researchers from within the host institution	6	7	9
Researchers invited from overseas	3	4	3
Researchers invited from other Japanese institutions	4	3	3
Total principal investigators	13	14	15

b) Total members

	At the beginning of project		At the end of FY 2025		Final goal (Date: April, 2027)	
	Number of persons	%	Number of persons	%	Number of persons	%
Researchers	15		36		65	
Overseas researchers	3	20	15	42	25	38
Female researchers	5	33	5	14	13	20
Principal investigators	13		14		15	
Overseas PIs	3	23	4	29	4	27
Female PIs	5	38	3	21	3	20
Other researchers	2		11		20	
Overseas researchers	0	0	2	18	4	20
Female researchers	0	0	1	9	3	15
Postdocs	0		11		30	
Overseas postdocs	0	-	9	82	17	57
Female postdocs	0	-	1	9	7	23
Research support staffs	0		11		20	
Administrative staffs	3		26		25	
Total number of people who form the "core" of the research center	18		73		110	

	At the beginning of project		At the end of FY 2025		Final goal (Date: April, 2027)	
	Number of persons	%	Number of persons	%	Number of persons	%
Doctoral students	0		10		15	
Employed	0	-	8	80.0	15	100.0

※b) The number of doctoral students in the lower table can be duplicated in the upper table of overall composition.

Appendix 3-2 Project Expenditures

1) Overall project funding

* In the "Total costs" column, enter the total amount of funding required to implement the project, without dividing it into funding sources.
* In the "Amount covered by WPI funding" column, enter the amount covered by WPI within the total amount.
* In the "Personnel," "Project activities," "Travel," and "Equipment" blocks, the items of the "Details" column may be changed to coincide with the project's actual content.

(Million yen)

Cost items	Details (For Personnel - Equipment please fill in the breakdown of fiscal expenditure, and the income breakdown for Research projects.)	Total costs	Amount covered by WPI funding
Personnel	Center director and administrative director	20	16
	Principal investigators (no. of persons):14	79	45
	Other researchers (no. of persons):24	143	135
	Research support staff (no. of persons):7	43	43
	Administrative staff (no. of persons):26	77	60
	RA for university students (no. of persons):8	7	5
	Subtotal	369	304
Project activities	Research startup cost (no. of persons):20	11	11
	Cost of outreach	8	7
	Gratuities and honoraria paid to researchers (no. of persons):5	3	3
	Cost of satellite organizations (no. of satellite organizations):3	3	3
	Cost of international symposiums (no. of symposiums):3	1	1
	Rental fees for facilities	45	0
	Other costs (Space charge, equipment relocation cost, etc.)	513	75
	Subtotal	584	100
Travel	Domestic travel costs	9	8
	Overseas travel costs	6	5
	Travel and accommodations cost for invited scientists (no. of domestic scientists):13 (no. of overseas scientists):23	19	17
	Travel cost for scientists on transfer (no. of domestic scientists):0 (no. of overseas scientists):0	0	0
	Subtotal	34	30
Equipment	Facility improvement costs	58	31
	Facility / equipment procurement cost	195	155
	Establishing new facility	599	0
	Subtotal	852	186
Research projects (Detail items must be fixed)	Project supported by other government subsidies, etc. *1	0	0
	KAKENHI	103	0
	Commissioned research projects, etc.	472	0
	Joint research projects	5	0
	Others (donations, etc.)	0	0
	Subtotal	580	0
Total		2419	620

Costs (Million yen)

WPI grant in FY 2025	620
Costs of establishing and maintaining facilities	657
Establishing new facilities	599
(Number of facilities:1 , 3,236 m²)	
Repairing facilities	58
(Number of facilities:2 , 4,718 m²)	
Others	0
Costs of equipment procured	195
Superconducting qubit control device	28
(Number of units:1)	
Cryostat	22
(Number of units:1)	
Others	145

*1. Management Expenses Grants, subsidies, indirect funding, and allocations from the university's own resources.
*2 When personnel, travel, equipment (etc.) expenses are covered by KAKENHI or under commissioned research projects or joint research projects, the amounts should be entered in the "Research projects" block.

*1 運営費交付金、各種補助金、間接経費、その他大学独自の取組による学内リソースの配分等による財源
*2 科研費、受託研究費、共同研究費等によって人件費、旅費、設備備品等費を支出している場合も、その額は「研究プロジェクト費」として計上すること

2) Costs of satellites

(Million yen)

Cost items	Details	Total costs	Amount covered by WPI funding
Personnel	Principal investigators (no. of persons):0		
	Other researchers (no. of persons):0		
	Research support staff (no. of persons):0		
	Administrative staff (no. of persons):0		
	Subtotal	0	0
Project activities	Subtotal	3	3
Travel	Subtotal	0	0
Equipment	Subtotal	0	0
Research projects	Subtotal	0	0
Total		3	3

Appendix 4 FY 2025 Status of Collaboration with Overseas Satellites

1. Coauthored Papers

- List the refereed papers published in FY 2025 that were coauthored between the center's researcher(s) in domestic institution(s) (include satellite institutions) and overseas satellite institution(s). List them by overseas satellite institution in the below blocks.
- Transcribe data in same format as in Appendix 1. Italicize the names of authors affiliated with overseas satellite institutions.
- For reference write the Appendix 1 item number in parentheses after the item number in the blocks below. Let it free, if the paper is published in between Jan.-Mar. 2026 and not described in Appendix 1.

Overseas Satellite 1 QUP Berkeley Satellite (University of California, Berkeley) (Total: 11 papers)

[1] (6) R. Anthony-Petersen et al. "Low energy backgrounds and excess noise in a two-channel low-threshold calorimeter" Applied Physics Letters 126 (2025) 102601 DOI:10.1063/5.0247343

[2] (7) T. K. Bui et al. "First Limits on Light Dark Matter Interactions in a Low Threshold Two-Channel Athermal Phonon Detector from the TESSERACT Collaboration" Physical Review Letters 135 (2025) 161002 DOI:10.1103/hsrl-crvf

[3] (8) C. L. Chang et al. "Spontaneous generation of athermal phonon bursts within bulk silicon causing excess noise, low energy background events, and quasiparticle poisoning in superconducting sensors" Applied Physics Letters 127 (2025) 263502 DOI:10.1063/5.0281876

[4] (37) A. Foster et al. "DETECTION OF THERMAL EMISSION AT MILLIMETER WAVELENGTHS FROM LOW-EARTH ORBIT SATELLITES" Open Journal of Astrophysics 8 (2025) DOI:10.33232/001c.137526

[5] (38) F. Carralot et al. "Requirements on the gain calibration for LiteBIRD polarisation data with blind component separation" Journal of Cosmology and Astroparticle Physics 2025 (2025) 019 DOI:10.1088/1475-7516/2025/01/019

[6] (39) M. Ruiz-Granda et al. "LiteBIRD science goals and forecasts: improved full-sky reconstruction of the gravitational lensing potential through the combination of Planck and LiteBIRD data" Journal of Cosmology and Astroparticle Physics 2025 (2025) 073 DOI:10.1088/1475-7516/2025/11/073

[7] (40) E. de la Hoz et al. "LiteBIRD science goals and forecasts: constraining isotropic cosmic birefringence" Journal of Cosmology and Astroparticle Physics 2025 (2025) 083 DOI:10.1088/1475-7516/2025/07/083

[8] (41) S. Giardiello et al. "Requirements on bandpass resolution and measurement precision for LiteBIRD" Journal of Cosmology and Astroparticle Physics 2025 (2025) 038 DOI:10.1088/1475-7516/2025/10/038

[9] (42) M. Tomasi et al. "A simulation framework for the LiteBIRD instruments" Journal of Cosmology and Astroparticle Physics 2025 (2025) 040 DOI:10.1088/1475-7516/2025/11/040

[10] (43) R. Aurvik et al. "On the computational feasibility of Bayesian end-to-end analysis of LiteBIRD simulations within Cosmoglobe" Journal of Cosmology and Astroparticle Physics 2025 (2025) 041 DOI:10.1088/1475-7516/2025/11/041

[11] (44) M. Bortolami et al. "First release of LiteBIRD simulations from an end-to-end pipeline" Journal of Cosmology and Astroparticle Physics 2025 (2025) 042 DOI:10.1088/1475-7516/2025/11/042

2. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY 2025. Enter by institution and length of exchange.
- Write the number of principal investigator visits in the top of each space and the number of other researchers in the bottom.

Overseas Satellite 1: QUP Berkeley Satellite (University of California, Berkeley)

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2025	1	0	0	0	1
	0	1	0	0	1

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2025	4	1	0	0	5
	1	0	0	0	1

Appendix 5-1 FY 2025 Visit Records of Researchers from Abroad

* If researchers have visited/stayed at the Center, provide information on them in the table below.
* Enter the host institution name and the center name in the footer.

Total: 44

	Name	Age	Affiliation		Academic degree, specialty	Record of research activities (Awards record, etc.)	Date	Summary of activities during stay at center (e.g., participation as principal investigator; short-term stay for joint research; participation in symposium)
			Position title, department, organization	Country				
1	Yeongduk Kim	66	Professor, Institute for Basic Science(IBS) KOREA	Korea	Ph.D. in physics	Particle physics experiment	2025/04/13～ 2025/04/17	Speaker of QUP Colloqium
2	Aaron S. Chou	54	CASE Senior Scientist, The University of Chicago	U.S.A	Ph.D. in physics	Particle physics experiment	2025/04/06～ 2025/04/11	Participation in QUP workshop
3	Surjeet Rajendran	42	Assistant Professor, Johns Hopkins Univ.(JHU) U.S.A. Physics & Astronomy	U.S.A	Ph.D. in physics	Particle physics theory	2025/04/10～ 2025/04/10	Participation in QUP workshop
4	Paul Hamilton	47	Associate Professor, University of California, Los Angeles	U.S.A	Ph.D. in physics	Particle physics experiment	2025/05/19～ 2025/05/23	Speaker of QUP Colloqium
5	Akira Konaka	64	Professor, TRIUMF CANADA Physical Sciences Division	Canada	Ph.D. in physics	Particle physics experiment	2025/06/03～ 2025/06/04	Speaker of QUP Colloqium
6	Michael Smy	57	Researcher, University of California, Irvine	U.S.A	Ph.D. in physics	Particle physics theory	2025/08/24～ 2025/08/26	Speaker of QUP New Horizon seminar
7	Dorothea Fonnesu	40	Postdoc, The National Institute for Nuclear Physics, ITALY Laboratori Nazionali di Legnaro(LNL)	Italy	Ph.D. in physics	Accelerator physics	2025/09/18～ 2025/09/20	Speaker of QUP New Horizon seminar
8	Peter Sorensen	48	Postdoc, Lawrence Berkeley National Laboratory(LBNL)	U.S.A	Ph.D. in physics	Astroparticle physics theory	2025/09/23～ 2025/09/30	Speaker of QUP Colloqium
9	Kyouhei Yamada	32	Postdoc, Princeton University, Dept. of Physics	U.S.A	Ph.D. in physics	Particle physics experiment	2025/11/26～ 2025/11/26	Speaker of QUP New Horizon seminar
10	Andrei Derevianko	56	Professor, Univ. of Nevada Dept. of Physic	U.S.A	Ph.D. in physics	Astroparticle physics theory	2025/12/05～ 2025/12/15	Participation as a speaker at QEYE 2025 and QUP Colloquium

11	Gordan Krnjaic	42	Assistant Professor, Univ. of Chicago U.S.A. Dept. of Astronomy & Astrophysics	U.S.A	Ph.D. in physics	Particle physics theory	2025/12/07～ 2025/12/13	Participation as a speaker at QEYE 2025 and QUP Horizen Seminar
12	Arne Wickenbrook	46	Principal Researcher, Johannes Gutenberg Univ. of Mainz GERMANY	Germany	Ph.D. in physics	Particle physics theory	2025/12/05～ 2025/12/14	Participation as a speaker at QEYE 2025
13	Teppei Katori	45	Assistant Professor, King's College London(KCL) U.K. Dept. of Physics	U.K.	Ph.D. in physics	Particle physics experiment	2025/12/09～ 2025/12/11	Participation as a speaker at QEYE 2025
14	Charles Cheung	45	Scientist, University of Delaware	U.S.A	Ph.D. in physics	Atomic physics theory	2025/12/09～ 2025/12/11	Participation as a speaker at QEYE 2025
15	Joerg Jaeckel	46	Professor, Heidelberg University	Germany	Ph.D. in physics	Particle physics theory	2026/03/22～ 2026/03/26	Speaker of QUP Colloqium
16	Eric Hudson	48	Professor, UCLA Department of Physics & Astronomy	U.S.A	Ph.D. in physics	Particle physics theory	2026/03/19～ 2026/04/02	Speaker of QUP Colloqium
17	Makoto Fujiwara	57	Senior Scientist and Head, TRIUMF CANADA Particle and Nuclear Physics	Canada	Ph.D. in physics	Particle physics experiment	2025/07/15～ 2025/07/21	Speaker of QUP Science lecture
18	Makoto Fujiwara	57	Senior Scientist and Head, TRIUMF CANADA Particle and Nuclear Physics	Canada	Ph.D. in physics	Particle physics experiment	2025/04/06～ 2025/04/10	Participation in QUP workshop
19	Makoto Fujiwara	57	Senior Scientist and Head, TRIUMF CANADA Particle and Nuclear Physics	Canada	Ph.D. in physics	Particle physics experiment	2026/01/27～ 2026/01/28	Short-term stay for joint resarch
20	Aritoki Suzuki	40	Physicist Staff Scientist, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	Ph.D. in physics	Astroparticle physics experiment	2025/04/04～ 2025/04/13	Participation in QUP workshop
21	Kim Siang Khaw	27	Ph.D Student, Tsung-Dao Lee Institute	CHINA	Ph.D Student	Particle physics theory	2025/04/06～ 2025/04/11	Participation in QUP workshop
22	Guan Ming Wong	27	Ph.D Student, Tsung-Dao Lee Institute	CHINA	Ph.D Student	Particle physics theory	2025/04/06～ 2025/04/11	Participation in QUP workshop
23	Mauricio Andres Garcia-Sciveres	59	Senior Scientist, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	Ph.D. in physics	Particle physics experiment, QUP PI	2025/05/17～ 2025/05/23	Participation as principal investigator
24	Mauricio Andres Garcia-Sciveres	59	Senior Scientist, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	Ph.D. in physics	Particle physics experiment, QUP PI	2026/01/27～ 2026/02/06	Participation as principal investigator
25	Mauricio Andres Garcia-Sciveres	59	Senior Scientist, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	Ph.D. in physics	Particle physics experiment, QUP PI	2025/08/17～ 2025/08/22	Participation as principal investigator

26	Mauricio Andres Garcia-Sciveres	59	Senior Scientist, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	Ph.D. in physics	Particle physics experiment, QUP PI	2025/11/08～ 2025/11/15	Participation as principal investigator
27	Adrian T. Lee	61	Professor, University of California, Berkeley	U.S.A	Ph.D. in physics	Astroparticle physics experiment, QUP PI	2025/07/07～ 2025/07/09	Participation as principal investigator
28	Xiaolin Ma	27	Researcher, University of Beiging	China	Ph.D. in physics	Particle physics theory	2025/07/17～ 2025/07/31	Short-term stay for joint resarch
29	Thomas Schwemberger	30	Researcher, University of Oregon, Department of Physics	U.S.A	Ph.D. in physics	Particle physics theory	2025/09/08～ 2025/09/30	Short-term stay for joint resarch
30	Juan Manuel Geria	29	Researcher, Institute of Technologies in Detection and Astroparticles (ITeDA)	Algentina	Ph.D. in physics	Particle physics experiment	2026/01/31～ 2026/02/15	Short-term stay for joint resarch
31	Daniel Tobias Unger	31	Postdoc, Heidelberg Univ. GERMANY Kirchhoff Institute for Physics	Germany	Ph.D. in physics	Particle physics experiment	2026/02/17～ 2026/02/28	Short-term stay for joint resarch
32	Arturo de Giorgi	29	Postdoc, Durham University	U.K.	Ph.D. in physics	Particle physics theory	2025/04/01～ 2025/06/06	QUP Internship Program (QUPIP)
33	Jason Arakawa	30	Postdoc, Univ. of Delawere(UD) U.S.A. Physics & Asrtonomy Dept.	U.S.A	Ph.D. in physics	Particle physics theory	2025/04/01～ 2025/05/29	QUP Internship Program (QUPIP)
34	Jason Arakawa	30	Postdoc, Univ. of Delawere(UD) U.S.A. Physics & Asrtonomy Dept.	U.S.A	Ph.D. in physics	Particle physics theory	2025/10/20～ 2026/01/16	QUP Internship Program (QUPIP)
35	Nicolò Raffuzzi	29	Postdoc, Lawrence Berkeley National Laboratory	U.S.A	Ph.D. in physics	Particle physics experiment	2025/04/15～ 2025/07/10	QUP Internship Program (QUPIP)
36	Thomas Raymond Barbera	22	Ph.d. Student, Massachusetts Institute of Technology(MIT)	U.S.A	Ph.D Student	Particle physics experiment	2025/06/18～ 2025/07/25	QUP Internship Program (QUPIP)
37	Yikun Gu	32	Researcher, University of Zaragoza	Spain	Ph.D. in physics	Particle physics experiment	2025/08/13～ 2025/10/16	QUP Internship Program (QUPIP)
38	Owaise Ahmed	22	Master Student, Indian Institute of Technology Hyderabad	India	Master Student	Particle physics experiment	2025/09/14～ 2025/11/23	QUP Internship Program (QUPIP)
39	Sreedevi Vasudevan Vallivattom	23	Ph.d. Student, Malaviya National Institute of Technology Jaipur	India	Ph.D Student	Particle physics experiment	2025/09/22～ 2025/12/20	QUP Internship Program (QUPIP)
40	Marco Manno	25	Ph.d. Student, The National Institute for Nuclear Physics, University of Ferrara	Italy	Ph.D Student	Particle physics theory	2025/09/01～ 2025/11/29	QUP Internship Program (QUPIP)

41	Jiachen Yu	25	Ph.d. Student, University of Science and Technology of China	China	Ph.D Student	Particle physics experiment	2025/10/07～ 2025/12/06	QUP Internship Program (QUPIP)
42	Writasree Maitra	29	Ph.d. Student, Washington University in St. Louis(WUSTL) . Physics Dept.	U.S.A	Ph.D Student	Particle physics theory	2025/10/04～ 2025/12/23	QUP Internship Program (QUPIP)
43	Guangyong Fu	31	Ph.d. Student, The University of Melbourne	Australia	Ph.D Student	Particle physics experiment	2025/10/08～ 2025/12/20	QUP Internship Program (QUPIP)
44	Alexander Drummond	22	Master Student, Virginia Polytechnic Institute and State Univ.(Virginia Tech) Dept. of Physics	U.S.A	Master Student	Particle physics experiment	2026/01/04～ 2026/03/25	QUP Internship Program (QUPIP)

Appendix 5-2 FY 2025 Visit Records of Center Researchers to Overseas

* If center researchers including doctoral students have visited the other countries, provide information on them in the table below. (Any duration and any source of travel expenses are acceptable.)
  For multiple places to visit, list them together in one record.
* Enter the host institution name and the center name in the footer.

Total: 36

	Name	Age	Position title	Academic degree, specialty	Place to Visit		Summary of activities during visit (e.g., short-term stay for joint research; participation in conference/symposium)	Date
					Department, organization/ Venue	Country		
1	Ryota Takaku	30	QUP Postdoc	Ph.D. in physics	The University of Minnesota	U.S.A	short-term stay for joint research	2025/04/21 ～ 2025/04/27
2	Louis Vaslin	31	QUP Postdoc	Ph.D. in physics	European Organization for Nuclear Research, (CERN)	Switzerland	participation in conference/symposium	2025/05/18 ～ 2025/05/24
3	Yu Zhou	32	QUP Postdoc	Ph.D. in physics	Shanghai Tech University	CHINA	participation in conference/symposium	2025/05/22 ～ 2025/06/15
4	Hiroki Akamatsu	40	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	Santa Fe Community Convention Center	U.S.A	participation in conference/symposium	2025/06/01 ～ 2025/06/08
5	Ryota Hayakawa	30	QUP Postdoc	Ph.D. in physics	Santa Fe Community Convention Center	U.S.A	participation in conference/symposium	2025/06/01 ～ 2025/06/08
6	Christopher Alexander, Betancourt	39	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	University of Zurich	Switzerland	short-term stay for joint research	2025/06/02 ～ 2025/06/09
7	Volodymyr Takhistov	36	QUP PI (Associate Professor)	Ph.D. in physics	Fermilab	U.S.A	participation in conference/symposium	2025/06/08 ～ 2025/07/03
8	Tatsumi Nitta	32	QUP PI (Associate Professor)	Ph.D. in physics	IQM Quantum Computers' headquarters (Espoo, Finland)	Finland	short-term stay for joint research	2025/06/17 ～ 2025/06/18
9	Tommaso Ghigna	35	QUP Senior Researcher (Assistant Professor)	Ph.D. in physics	SRON	Netherlands	short-term stay for joint research	2025/06/29 ～ 2025/07/01
10	Hiroki Akamatsu	40	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	SRON	Netherlands	short-term stay for joint research	2025/06/29 ～ 2025/07/02
11	Thomas Raymond Barbera	22	Ph.D. Student, QUP Internship	Ph.D. student, Particle Physics	University of California, Barkley	U.S.A	QUP Internship Program (QUPIP)	2025/06/8 ～ 2025/06/17
12	Yuji Chinone	41	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	University of Manchester	U.K	participation in conference/symposium	2025/07/19 ～ 2025/07/27

13	Tatsumi Nitta	33	QUP PI (Associate Professor)	Ph.D. in physics	Pritzker Nanofab at University of Chicago	U.S.A	short-term stay for joint research	2025/07/31 ～ 2025/08/09
14	Louis Vaslin	31	QUP Postdoc	Ph.D. in physics	California Institute of Technology	U.S.A	participation in conference/symposium	2025/08/17 ～ 2025/08/24
15	Kazunori Hanagaki	56	QUP Acting Director	Ph.D. in physics	Brookhaven National Laboratory, Fermilab	U.S.A	short-term stay for discussion on the possibility of joint research	2025/08/20 ～ 2025/08/27
16	Tatsumi Nitta	33	QUP PI (Associate Professor)	Ph.D. in physics	Fermilab	U.S.A	short-term stay for joint research	2025/08/24 ～ 2025/08/27
17	SUERFU	37	QUP Senior Researcher (Assistant Professor)	Ph.D. in physics	Xichang Qionghai Hotel	CHINA	participation in conference/symposium	2025/08/24 ～ 2025/09/15
18	Volodymyr Takhistov	36	QUP PI (Associate Professor)	Ph.D. in physics	Jagiellonian University	Poland	participation in conference/symposium	2025/09/16 ～ 2025/09/20
19	Karin Watanabe	25	QUP Research Assistant	Ph.D. student, Particle Physics	Tenerife	Spain	Participation in Patras workshop	2025/09/21 ～ 2025/9/27
20	Kan Nakazono	26	QUP Research Assistant	Ph.D. student, Particle Physics	Tenerife	Spain	Participation in Patras workshop	2025/09/21 ～ 2025/9/27
21	Chikara Kawai	27	QUP Research Assistant	Ph.D. student, Particle Physics	Tenerife	Spain	Participation in Patras workshop	2025/09/21 ～ 2025/9/27
22	Toshiyuki Azuma	64	QUP Deputy Director (Professor)	Ph.D. in physics	Jena, Kirchhof-Inst. At Heidelberg, MPI-Heidelberg	Germany	short-term stay for joint research	2025/10/10 ～ 2025/10/18
23	SUERFU	37	QUP Senior Researcher (Assistant Professor)	Ph.D. in physics	Hilton Haikou Meilan	CHINA	participation in conference/symposium	2025/10/20 ～ 2025/10/27
24	Tadayuki Takahashi	66	QUP Executive Assistant to the Director (Professor)	Ph.D. in physics	Postdoc, Lawrence Berkeley National Laboratory (LBNL)	U.S.A	short-term stay for joint research	2025/10/6 ～ 2025/10/6
25	Yuji Chinone	42	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	National Central University	Republic of CHINA	participation in conference/symposium	2025/11/05 ～ 2025/11/11
26	SUERFU	37	QUP Senior Researcher (Assistant Professor)	Ph.D. in physics	University of Melbourne	Australia	participation in conference/symposium	2025/11/17 ～ 2025/11/28
27	Tommaso Ghigna	35	QUP Senior Researcher (Assistant Professor)	Ph.D. in physics	University of Milano Bicocca	Italy	short-term stay for joint research	2025/11/29 ～ 2025/12/15
28	Tatsumi Nitta	33	QUP PI (Associate Professor)	Ph.D. in physics	University of Chicago	U.S.A	participation in conference/symposium	2025/11/30 ～ 2025/12/07
29	Karin Watanabe	25	QUP Research Assistant	Ph.D. student, Particle Physics	University of Chicago	U.S.A	Participation in ASPIRE workshop	2025/11/30 ～ 2025/12/07
30	Kan Nakazono	26	QUP Research Assistant	Ph.D. student, Particle Physics	University of Chicago	U.S.A	Participation in ASPIRE workshop	2025/11/30 ～ 2025/12/07

31	Chikara Kawai	27	QUP Research Assistant	Ph.D. student, Particle Physics	University of Chicago	U.S.A	Participation in ASPIRE workshop	2025/11/30 ～ 2025/12/07
32	Manabu Togawa	47	QUP PI (Associate Professor)	Ph.D. in physics	Academia Sinica	Republic of CHINA	participation in HSTD 14 conference	2025/11/30 ～ 2025/12/07
33	Tatsumi Nitta	33	QUP PI (Associate Professor)	Ph.D. in physics	Fermilab	U.S.A	short-term stay for joint research	2026/02/07 ～ 2026/02/11
34	Volodymyr Takhistov	37	QUP PI (Associate Professor)	Ph.D. in physics	ASPEN CENTER FOR PHYSICS	U.S.A	participation in conference/symposium	2026/02/20 ～ 2026/03/02
35	Yuji Chinone	42	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	University of Groningen	Netherlands	participation in conference/symposium	2026/03/16 ～ 2026/03/21
36	Hiroki Akamatsu	41	QUP Senior Researcher (Associate Professor)	Ph.D. in physics	Sron	Netherlands	short-term stay for joint research	2026/03/17 ～ 2026/03/22

Appendix 6 FY2025 State of Outreach Activities

* Fill in the numbers of activities and times held during FY2025 by each activity.
* Describe the outreach activities in the "3-1. Societal Value of Basic Research" of Progress Report, including those stated below that warrant special mention.

Activities	FY2025 (number of activities, times held)
PR brochure, pamphlet	QUP general brochure minor aligned to the new project plan (English 1, Japanese 1)
Lectures, seminars for general public	QUP public lecture (1), Hosting WPI symposium in November (1) Science Lectures to the public (6),
Teaching, experiments, training for elementary, secondary and high school students	QUP Site visits by junior high school students (1), high school students (2)
Science café	Science Cafés in Tsukuba (4)
Open houses	In Collaboration with KEK Open House (2)
Participating, exhibiting in events	WPI symposium (host) (1), WPI Young Researchers Forum (1), Tsukuba Science Festival (1)
Press releases	Press release (4), Web News posting in Japanese (21) and in English (21)
Publications of the popular science books	None
Others ( )	

*If there are any rows on activities the center didn't implement, delete that (those) row(s). If you have any activities other than the items stated above, fill in the space between parentheses after "Others" on the bottom with the name of those activities and state the numbers of activities and times held in the space on the right. A row of "Others" can be added, if needed.

Outreach Activities and Their Results

List up to three of the Center's outreach activities carried out in FY2025 that have contributed to enhancing the brand or recognition of your Center and/or the brand of the overall WPI program, and describe its concrete contents and effect in narrative style. (Where possible, indicate the results in concrete numbers.)

Examples:
- As a result of using a new OO press-release method, a OO% increase in media coverage was obtained over the previous year.
- By holding seminars for the public that include people from industry, requests for joint research were received from companies.
- We changed our public relations media. As a resulting of using OO to disseminate information, a OO% increase in inquiries from researchers was obtained over the previous year.
- As a result of vigorously carrying out OO outreach activity, ¥OO in external funding was acquired.

As noted in Section 3.1, QUP hosted the WPI Symposium on 15 November 2025. Following the format adopted by WPI-ASHBi in the previous year, the program combined invited talks with poster presentations by researchers from each WPI and competitively selected high school students. A luncheon session was also organized to facilitate direct exchanges between researchers and students. In designing the program, priority was placed on maximizing the value of participation for the high school students. The following measures were introduced:

- The objective of student participation was defined not as presenting completed results, but as advancing their work through discussions with WPI researchers. Students were therefore encouraged to present interim results as well as unresolved issues.
- All student presentations were scheduled in the morning so that participants could attend the luncheon session and lectures in a more relaxed setting.

The symposium was highly successful, attracting a total of 244 participants and featuring 31 poster presentations by high school students. Although most student presenters were initially expected to come from local high schools, applications were received from a wide geographic area, including the Kansai

region. Feedback collected after the event also highlighted the effectiveness of the program. A teacher who accompanied a group of students commented:
"The researchers are taking the time to engage seriously with each student through detailed discussions, which makes this a very stimulating experience for them. Thank you very much. The students are also actively asking questions, which is wonderful to see."
QUP has consistently incorporated opportunities for direct interaction into its outreach activities, rather than limiting them to one-way lectures. The experience gained through these efforts was effectively applied to this symposium. As a result, the event attracted participants from a broader region and enhanced the visibility of both QUP and the WPI program by offering a distinctive, discussion-oriented format that provides meaningful two-way communication rarely achieved in conventional outreach events.

Appendix 7 FY 2025 List of Project's Media Coverage

* List and describe media coverage (e.g., articles published, programs aired) in FY 2025.

* Enter the host institution name and the center name in the footer.

	Date	Types of Media (e.g., newspaper, magazine, television)	Description
1	2026/2/12	Newspaper	New laboary for the quntum sensor was opened. The article was written after a QUP organised tour of the new experimental hall to the media on 16 Jaunary, 2026. (Akahata Newspaper)
2	2026/3/15	Newspaper	Report on the opening ceremony titled "Inauguration of the New Director of WPI-QUP and Completion of the New Research Building" held on 14 March 2026. (Yomiuri Newspaper, Ibaraki)
3	2026/3/17	Newspaper	Report on the opening ceremony titled "Inauguration of the New Director of WPI-QUP and Completion of the New Research Building" held on 14 March 2026. (Kyodo Press with other news papers)