World Premier International Research Center Initiative (WPI)
Executive Summary (For Interim Evaluation)

Host Institution	High Energy Accelerator Research Organization (KEK)	Host Institution Head	Shoji Asai
Research Center	International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP)		
Acting Director	Kazunori Hanagaki	Administrative Director	Katsuo Tokushuku

Instruction:
Summarize the Self-Evaluation Report for Interim Evaluation (**within 4 pages** including this page).

I. Summary

The International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP) was founded at KEK in December 2021 under the guiding vision of "Bringing new eyes to humanity." We aimed to discover new measurement principles, invent new measurement techniques based on those principles, and use them to create scientific results.

Several new projects are emerging from the QUP, but progress has not been as rapid as it should have been. QUP and KEK directorates discussed and made major changes to follow the recommendations of the WPI committees. This resulted in the director's change and withdrawal from the flagship project. With tight communication between QUP and KEK, a revised vision of QUP is being proposed by scrutinizing the current projects and adding new projects focused on quantum sensors and devices.

II. Items

1. Overall Image of Your Center

QUP was founded at KEK in December 2021, as the 14th WPI center. QUP started with Prof. Masashi Hazumi as the director and with 12 other Principal Investigators (PIs). QUP set up three satellites at the University of California, Berkeley, the Institute of Space and Astronautical Science (ISAS)/JAXA, and Toyota Central R&D Labs. (TCRDL). Guided by the vision of "Bringing new eyes to humanity," QUP initially aimed to develop new measurement principles, devise innovative techniques based on those principles, and apply them to advance fundamental science.

As pointed out by the WPI committee in recent years, progress has not been satisfactory. New ideas are discussed at the theoretical level, and some new experimental proposals were made, but the pace of experimental realization remained below expectations. In response to the severe recommendations from the WPI Program Committee, a committee was formed in June 2024, under the leadership of KEK Director General Shoji Asai, to conduct a thorough evaluation of QUP's structure and research portfolio. The committee recommended that a drastic revision be made regarding the organization and research projects of the QUP. **Hazumi stepped down as Director and PI**, and after consulting with the WPI and MEXT, **Dr. Kazunori Hanagaki was appointed Acting QUP Director in December 2024.** The process of proposing a new director is currently underway.

While critically evaluating the results of projects launched under the previous concept, we are creating a new concept under the leadership of the acting director and the candidate for the new center director, **Dr. Toshiyuki Azuma** of RIKEN, who joined QUP as Deputy Director in April 2025 with 40% FTE.

Currently, QUP is under the restructuring process. Following intensive discussions on a fundamental restructuring of QUP operations, we have decided to launch five new active research groups focused on quantum sensors and devices, and one group dedicated to broad interdisciplinary applications. At the same time, selected ongoing projects will be retained. The details of the restructured research strategy will be described in **the revised "Research Center Project" Document**, to be submitted in May 2025.

2. World-Leading Scientific Excellence and Recognition

Over the initial two years and four months of its operation, QUP has cultivated several novel research directions. These are the results of fusions between researchers from different fields in the QUP experimental groups, with a significant contribution from the QUP theory group. The QUP Synergy Summit (QSS) was also launched as a new platform for industry-academia collaboration.

New Eyes for light neutral quantum field:
One of the key outcomes has been the identification of quantum sensor-based techniques as promising tools for exploring new fields in fundamental physics, such as dark matter and axions. Precision magnetic field measurements and Casimir force studies—initiated through interdisciplinary exchanges—have emerged as novel approaches to probe the new quantum field. These ideas originated within QUP and are now being realized for real measurements.
The transition edge sensor (TES) is a key technology in QUP that helps achieve high-precision measurements in various scientific areas where QUP PIs are working. Three PIs started a joint project to search for low-mass DM in the mass range well below the proton mass. Optical TES, a "new eye" developed for other applications, is critical in this Light Dark Matter Search Project at Kamioka mine. TES technology is also integral to a separate solar axion detection effort at QUP.
Through such convergence of expertise and instrumentation, **QUP is emerging as a center of excellence for precision measurement targeting light neutral quantum fields**. Advanced tools including TES, NV centers in diamond and specially designed Casimir force materials are being incorporated into new experimental platforms.

Hard and Clear Eyes for the extreme environment:
QUP has also promoted the development of detectors suitable for extreme environments. For example, technologies originally designed for solar cell applications are being adapted into radiation-hard particle detectors. The data acquisition (DAQ) group is contributing to the creation of robust measurement systems.
QUP is advancing cryogenic electronics capable of operating at liquid helium temperatures—an essential capability for scaling up quantum devices.
The center also supports machine learning initiatives that address the challenge of extracting faint signals originating from a new quantum field from large backgrounds. These methods are currently applied to heavy flavor tagging and rare event searches in the ATLAS experiment at CERN.

Termination of the flagship project:
QUP's original flagship project, SpaceTES, a detector development initiative for measuring cosmic microwave background (CMB) polarization aboard the LiteBIRD satellite, was terminated following the identification of significant technical and financial challenges, which was also pointed out by an internal KEK review committee. The systemology section was also closed by the end of FY2024. Instead, QUP has created an engineering support section to strengthen the technical support needed to accelerate the projects.

In the restructuring process of QUP, we will add more projects related to quantum devices.

QUP Cryo Facility and the next:
Recognizing the importance of shared experimental infrastructure, QUP launched a cryogenic detector facility at KEK's Fuji experimental hall in March 2023. The facility, which currently hosts four operational dilution refrigerators, supports TES development and will play a key role in the center's next phase of quantum device research.

The next plan to facilitate fused research among QUP researchers is to set up a large-volume, clean environment to pursue reliable measurements. In connection with the building of a new/renovated building complex, a large-volume anechoic room against a wide range of radio waves and a large-volume cold room with ~4K degrees are planned.

3. Global Research Environment and System Reform

QUPosium and QUP colloquium:
QUP holds an annual international symposium named QUPosium. The first one was held in December 2022 as an anniversary event. We invited well-known key researchers to each meeting, including Dmitry Budker (Mainz), Suzanne Staggs (Princeton) in 2022, Adam Riess (Johns Hopkins U. / STSI, Nobel laureate) in 2023, and Marianna Safronova (U. Delaware) in 2024.
Since April 2022, QUP has been organizing QUP colloquium almost every month, inviting prominent researchers. We have had 34 QUP colloquia by April 2025, with 20 foreign speakers.

Open call to postdoctoral fellow position: All job advertisements for the QUP postdoctoral fellow were made on a public call using the well-known worldwide system. QUP postdoctoral fellows are for three years with the possibility of a 2-year renewal based on satisfactory job performance. For outstanding candidates, we can offer an assistant professor position for five years with the possibility of a 2-year renewal and treat them as QUP senior scientists. This option was found to be effective in attracting excellent early-career researchers.

Unique recruitment/salary scheme: QUP's recruitment scheme enables quick decisions in the recruitment process. The QUP director negotiates with the individuals to determine their salary. The scheme is a significant factor that makes the QUP competitive with the world's top institutes in attracting excellent researchers. We have set up a rule to update the annual salary with the evaluation, including one-on-one interviews with the QUP director, giving an incentive to the fixed-term researchers. The conditions of the fixed-term researchers at KEK are lower than those of the permanent researchers, but QUP is trying to close the gaps.

QUP unique job rank: QUP established Principal Engineer as a new QUP job rank, and by implementing the above-mentioned salary negotiation system, it has become possible to improve the labor conditions of technical staff, which helps to attract talented engineers.

Reform on the KEK rules on accepting international graduate students: QUP created an original internship program named QUPIP. In 2024, we set up the QUP international fellowship program to support graduate students by accepting and employing them long-term. This opened the door to hiring graduate students from other countries.

4. Values for the Future

QUP became active in the human resource building and outreach.

We started an internship program, QUPIP, to invite graduate students or postdocs to stay at the QUP institute for 1-3 months or longer. In two years, we accepted 32 QUPIP fellows. Seventy-five percent are from abroad, including students from Harvard, Rome "La Sapienza," and l'Ecole Normale, Paris. Several papers were published from this communication.

We set up the QUP International Fellowship program to support graduate students by accepting and employing them long-term. Under current KEK regulations, only domestic graduate students are eligible to be hired as special researchers, but QUP has established internal rules that also allow acceptance from overseas.

QUP gave two public lectures in 2023-2024 aimed at high school students. Since mere lectures tend to be one-way communication, time was set aside for dialogue between participants and QUP researchers. This attempt was a success. The high school students asked many questions about the research and their future career paths.

5. Future Prospects

Currently, QUP is under the restructuring process for the future. While critically evaluating the results of projects launched under the previous concept, we are creating a new concept under the leadership of the candidate for the new center director.

To realize the QUP's vision as "bringing new eyes to humanity", we will establish three research domains: **quantum sensors**, **quantum devices**, and **non-quantum devices**, each of which will be led by newly appointed Principal Investigators (PIs), aiming to deepen and expand the research. From these domains, we will build a framework that simultaneously aspires to reach the summits of fundamental research and to expand broadly into applied fields. While maintaining close interconnections among the three domains, the center will focus on exploring undiscovered particles, detecting ultra-weak gravitational signals, and discovering new laws of nature by developing state-of-the-art measurement techniques and detectors based on quantum sensing technologies for high-precision measurements, while also promoting their application across a wide range of disciplines.

Although QUP aimed initially to promote interdisciplinary research when it was established, sufficient activities were not implemented toward that goal. Within the vertically segmented research structure, researchers devoted to specific objectives have limited opportunities to recognize potential applications in other fields. Therefore, to achieve this goal, we introduce "mechanisms" along with coordinator-type researchers to support them.

6. Host Institution's Concrete Plan toward Making its center an autonomous research institute in the second half of the grant period (from the 6th year of the center's operation)

KEK established QUP as an autonomous research institute, in contrast to KEK's nature as one of the inter-university research institute corporations, where the opinions of the user community are strongly reflected in the lab's operation.

KEK will continue to position this center as a unique organization that contributes to shaping global research activities and as an independent research entity distinct from other research organizations within KEK. KEK views the center's activities as a foundation for fostering interdisciplinary integration and promoting organizational reform within KEK itself. By establishing the center as an interdisciplinary research hub, new research fields are anticipated to emerge, further enhancing KEK's overall capabilities. QUP fits seamlessly with KEK's strategic plan to build an International Research Center at the Quantum Frontier.

At the same time, KEK hopes that QUP will foster synergy across its laboratories by, for example, sharing detector development infrastructure and interface platforms. Through the multi-institutional efforts, QUP will serve as a catalyst for strengthening KEK's overall research ecosystem and securing sustainable external support.

7. Others None

8. Center's Response to Results of FY2024 Follow-up (including Site Visit Results)

KEK and QUP took the recommendations seriously. KEK formed the review to improve the QUP and took the initiative to reform it. After the former QUP director Masashi Hazumi resigned, the acting director, Kazunori Hanagaki, had a close discussion with the KEK director Shoji Asai. Dr. Toshiyuki Azuma has been nominated as the director candidate, who has joined QUP since April 2025 as the deputy director. The QUP directorate has started restructuring the organization and has been in close contact with the KEK directorate.

Following intensive discussions on the fundamental restructuring of QUP operations, we have decided to launch five new active research groups focused on quantum sensors and devices, and one group dedicated to broad interdisciplinary applications. At the same time, the ongoing projects are being critically evaluated, and some will be retained. The details of the new projects will be described in **the revised "Research Center Project" Document**, which will be submitted in May 2025.

World Premier International Research Center Initiative (WPI) Self-Evaluation Report for Interim Evaluation

Host Institution	High Energy Accelerator Research Organization (KEK)	Host Institution Head	Shoji Asai
Research Center	International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP)		
Acting Director	Kazunori Hanagaki	Administrative Director	Katsuo Tokushuku

Common Instructions:

* Unless otherwise specified, prepare this report based on the current (31 March 2025) situation of your WPI center.

* As a rule, keep the length of your report within the specified number of pages. (The attached forms are not included to this page count.)

* Use yen (¥) when writing monetary amounts in the report. If an exchange rate is used to calculate the yen amount, give the rate.

1. Overall Image of Your Center (write within 2 pages including this page)

Give an overview of the center's identity and describe the center's progress in achieving its set goals.

・ List the Principal Investigators in Appendix 2, enter the number of center personnel in Appendix 3-1 and 3-2, make a diagram the center's management system in Appendix 3-3, draw a campus map in Appendix 3-4, and enter project funding in Appendix 3-5 and 3-6.

The International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP) was founded at KEK in December 2021, as the 14th WPI center. QUP started with Prof. Masashi Hazumi as the director and with 12 other Principal Investigators (PIs). QUP set up three satellites at the University of California, Berkeley, the Institute of Space and Astronautical Science (ISAS)/JAXA, and Toyota Central R&D Labs. (TCRDL). Guided by the vision of "Bringing new eyes to humanity," QUP initially aimed to develop new measurement principles, devise innovative techniques based on those principles, and apply them to advance fundamental science.

As pointed out by the WPI committee in recent years, progress has not been satisfactory. New ideas are discussed at the theoretical level, and some new experimental proposals were made, but the actual experimental implementation is not as fast as the pace of experimental realization remained below expectations. In response to the severe recommendations from the WPI Program Committee, a committee was formed in June 2024, under the leadership of KEK Director General Shoji Asai, to scrutinize the activities of QUP. The committee recommended that a drastic revision be made regarding the organization and research projects of the QUP.

Hazumi stepped down as Director and PI, and after consulting with the WPI and MEXT, **Dr. Kazunori Hanagaki was appointed Acting QUP Director in December 2024.** The process of proposing a new director is currently underway.

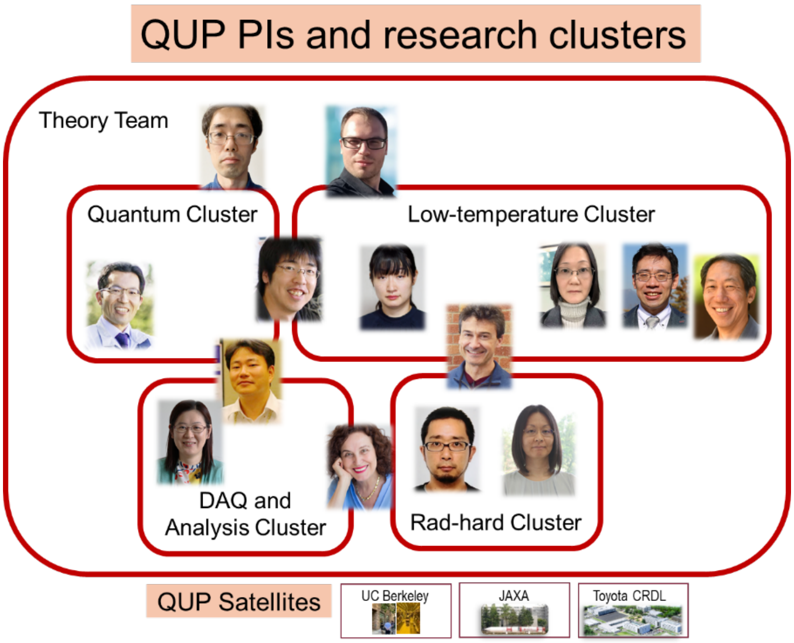
While critically evaluating the results of projects launched under the previous concept, we are creating a new concept under the leadership of the acting director and the candidate for the new center director, **Dr. Toshiyuki Azuma** of RIKEN, who joined QUP as Deputy Director in April 2025 with 40% FTE. Following intensive discussions on a fundamental restructuring of QUP operations, we have decided to launch five new active research groups focused on quantum sensors and devices, along with one group dedicated to broad interdisciplinary applications in FY2025. At the same time, the ongoing projects described below will be retained. The details of the restructured research strategy will be described in **the revised "Research Center Project" Document** to be submitted in May 2025.

Until FY2024, **Four experimental research clusters and a theory group** formed the QUP activities, as shown in the plot on the next page. New ideas have emerged, which are briefly described below. More details will be provided in the next section. These are the results of fusions between researchers from different fields in the QUP clusters, with a significant contribution from the QUP theory group. As a new platform for industry-academia collaboration, the QUP Synergy Summit (QSS) was also launched.

The study of precise magnetic field measurement and the analysis of Casimir force in the application area were realized to be good "eyes" for the new field search in fundamental physics, such as Dark Matter or

Axion. These are newly born ideas at QUP, and QUP is preparing to make the actual measurements. These are the main activities in the Quantum cluster.

The transition edge sensor (TES) is a key technology in QUP to achieve high-precision measurements in various scientific areas where QUP PIs are working. The activity of the low-temperature cluster is focused on this device. Three PIs started a joint project to search for low-mass DM in the mass range well below the proton mass. Optical TES, a "new eye" developed for other applications, is critical in this Kamioka Light Dark Matter Project.



The radiation-hard cluster converts the "eye" developed for the solar cells into particle detectors in a high-radiation environment.

The DAQ cluster is engaged for measurement tools for the new "eye". The study of cryo-electronics and activity in machine learning is in progress.

QUP had a flagship project, SpaceTES, which developed detectors for measuring the cosmic microwave background (CMB) polarization in space at the LiteBIRD satellite, but the project was stopped after finding significant technical and financial problems pointed out by a review committee formed by KEK. The systemology section was also closed by the end of FY2024. Instead, QUP has created the engineering support section to strengthen the technical support needed to accelerate the projects.

QUP has used the 4th floor of the KEK building #4 for its headquarters and newly hired researchers. The QUP members who have been at KEK remain in their original office. In FY2024, we started using another building as the number of members increased. The main experimental area is in the Fuji hall of KEK, where we set up the QUP cryo-facility. A new building complex with offices and an experimental area next door is under construction and will be ready for use in the summer of 2025.

QUP became active on the human resource building and outreach:

We started an internship program, QUPIP, to invite graduate students or postdocs to stay at the QUP institute for 1-3 months or longer. In two years, we accepted 32 QUPIP fellows. Seventy-five percent are from abroad, including students from Harvard, Rome "La Sapienza," and l'Ecole Normale, Paris. Several papers were published from this communication.

QUP gave two public lectures in 2023-2024 aimed at high school students. Since mere lectures tend to be one-way communication, time was set aside for dialogue between participants and QUP researchers. This attempt was a success. The high school students asked many questions about the research and their future career paths.

In summary, several new projects are emerging from the QUP, but progress toward realizing them to the experimental stage was not as rapid as it should have been. A drastic change occurred in FY2024, including the change of director and withdrawal from the flagship project. With tight communication between QUP and the host institute, a revised vision is being proposed and will be submitted to the WPI committee in May 2025.

2. World-Leading Scientific Excellence and Recognition

2-1. Advancing Research of the Highest Global level (within 10 pages)

2-1-1. Research results to date

Give an overall picture of the Center's research activities. Select 10 representative research results achieved during the period from 2021 through March 2025. Number them [1] to [10] and provide a description of each.

- In Appendix 1-1, list the papers underscoring each research achievement (up to 20 papers) and provide a description of each of their significance.
- Appendix 1-3 lists the center's research papers published in 2024.

[1] Light dark matter search via nitrogen-vacancy (NV) centers in diamond

PIs, Nakayama, Iizuka, and Hazumi have presented two approaches of magnetometry using nitrogen-vacancy (NV) centers in diamond for axion dark matter search; electron spin coupling (JHEP **2025** (2025) 83) **(App1-1:1)** and nuclear spin coupling (PRD **111** (2025), 075028) **(App1-1:2)**(Fig. 1a). These two are complementary. Based on our approaches, we have set the target to reach a coupling of 10^{-12} using cryogenic ensemble NV centers. We have developed a robust measurement technique and verified it using a single NV center at room temperature [3]. We have installed the cryogenic optically detected magnetic resonance (ODMR) experimental setup in KEK. We have checked that the temperature of a diamond sample in the cryogenic chamber decreases to 4K from its photoluminescence spectra (Fig. 1b).

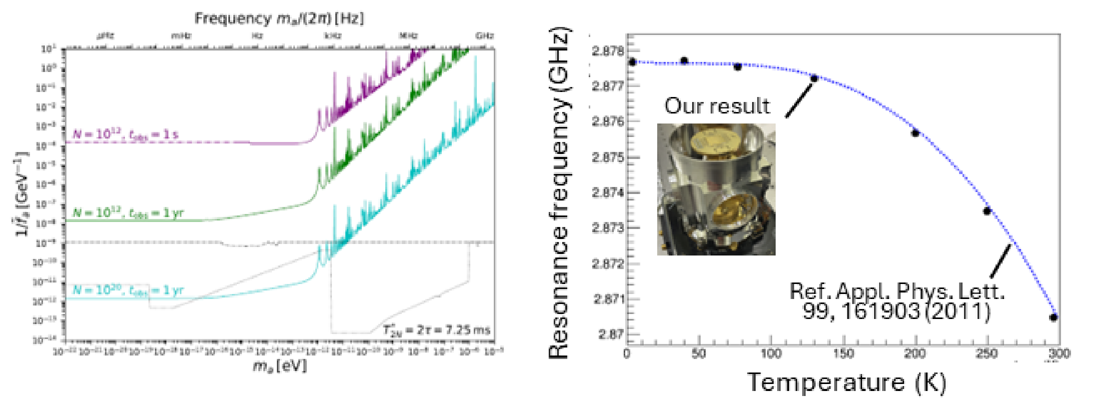


Fig. 1: (a) Sensitivity projection of axion-neutron coupling from NV centers in diamond (**App1-1:2**). (b) Measured resonance frequency as a function of temperature.

[2] New force search via Casimir forces

PIs Nakayama, Iizuka and Hazumi have presented an idea of new force search via a Casimir force setup where the Casimir force can be vanished by introducing Weyl semimetals (PRD **108** (2023) 016009)**(App1-1:3)** (Fig. 2a). Considering a typical measurement setup of Casimir forces in a sphere-plate configuration together with recent signal-to-noise ratio improvement methods, we have set the target to reach an sensitivity around $|a|=10^{15}$ and $l = 0.3\times10^{-7}$ in Yukawa type model $V(r) = -Gm_1m_2/r(1+ae^{-r/l})$, which is new constraint. We have installed the measurement setup of Casimir forces in a sphere-plate configuration in the QUP satellite of Toyota Central R&D Labs. We have checked that the optical apparatus works, and the pressure in the chamber reaches 10^{-7} Torr.

[3] Development of a new radiation-hard detector with CIGS

The $Cu(In,Ga)Se_2$ (CIGS) semiconductor is well-known in solar cell applications for its self-repair mechanism against radiation damage. **PI Togawa** and his group aim for this attractive material for applications in particle detectors and cameras in high-radiation environments. The group has

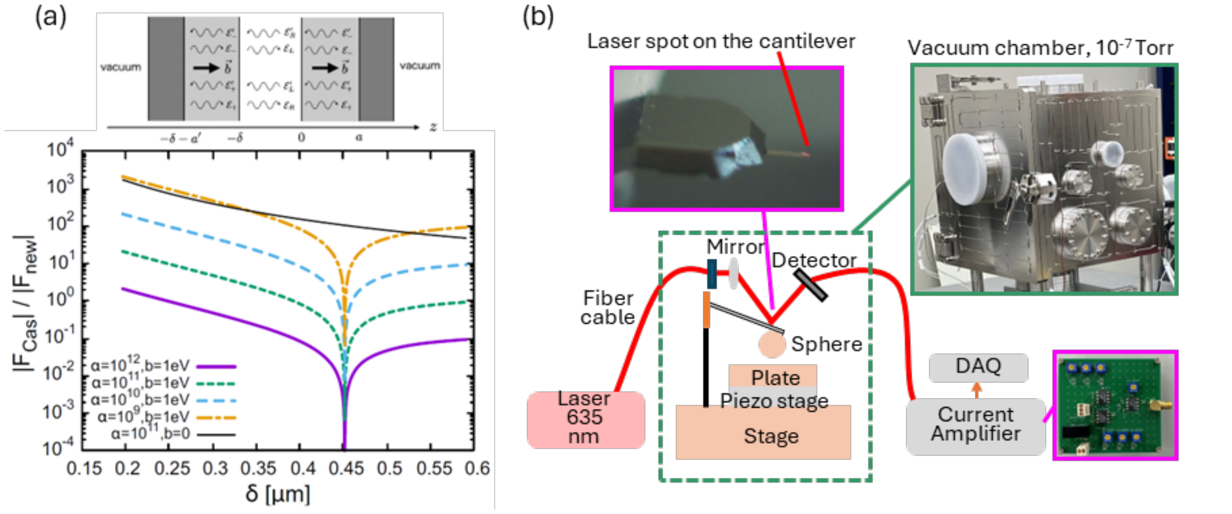


Fig. 2: (a) New force search by vanishing Casimir force. (b) An experimental setup of Casimir forces is in a sphere-plate configuration.

succeeded in detecting Xe ions with the fabricated CIGS detector. This is the first detection of a single particle beam using CIGS semiconductors worldwide. They have also confirmed that the detector recovers from radiation damage by heat treatment.

They investigated the temperature dependence of the recovery of solar cells and confirmed the strong dependence between 90 and 130 °C. Based on the Arrhenius function, $\ln(k) = -E_a/(k_b T) + \ln(A)$, where k is the difference of output current with heat annealing, Ea is excitation energy and A is a constant, Fig. 3 is obtained for 1 hour annealing (JINST **19** (2024) C05042) **(App1-1:4)**[4]. The excitation energy of 1.0 eV is extracted, and only Cu can be free within this energy by creating Cu and Cu-vacancy, which needs 0.6 eV. We also performed defect measurements by Deep Level Transient Spectroscopy (DLTS). For the sample irradiated with 10^{16} 1 MeV n_{eq}/cm^2, Indium-vacancy and Copper-site-Indium are found in the DLTS temperature range of 70 – 300 K, which were not seen before irradiation. With the heat annealing at 130 °C for 1 hour, both defects are (almost) vanished. It can be explained that both defects are neutralized by Cu or Cu-vacancy, which can be generated by heat annealing(NIMA **1067** (2024) 169637) **(App1-1:5)**[5].

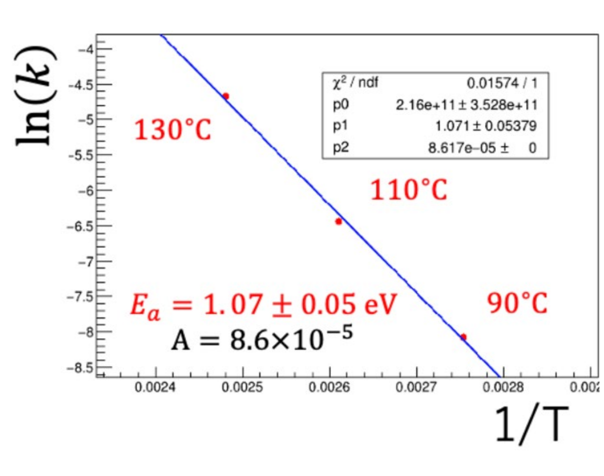


Fig. 3: Temperature dependence of recovery for irradiated solar cells.

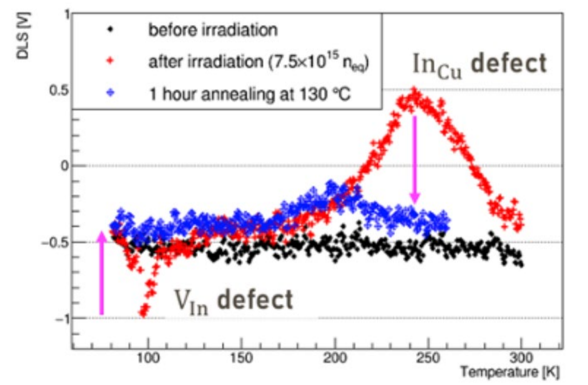


Fig. 4: DLTS results of the CIGS detector. Two main defects are observed after irradiation, and they almost disappear with heat annealing.

[4] Kamioka Light Dark Matter project

The Kamioka-LDM project aims to search for dark matter (DM) particles well below the proton mass. These particle's interactions with regular matter would be too low energy to produce ionization or even promote charge carriers in semiconductors. Therefore, such signals are invisible to traditional detectors like the large WIMP search experiments, which rely on ionization. However, the possible existence of such DM particles has a solid theoretical motivation. The Kamioka-LDM project uses the "new eyes" of quasiparticle detectors, which can sense non-ionizing energy deposits, to search for low-mass DM particles. The project was started in 2021 with a QUP initiative to form a joint project of **three PIs, Garcia-Sciveres, Hasegawa, and Hattori**. A US-Japan award that served to establish a collaboration between QUP and Tohoku U. for operation at the Kamioka underground facility, which is necessary for having an extremely quiet environment where such faint DM signals could be distinguished from cosmic rays and natural radioactivity. Additionally, the signals must be distinguished from intrinsic material relaxation backgrounds, which are peculiar to quasiparticle detectors and invisible to traditional detectors that rely on ionization.

To solve the many challenges of building a new world-class low-background experiment based on a new detection method (one not relying on ionization), we defined a 2-phase approach. Phase 1 is based on a partnership with the TESSERACT collaboration(PRD **110** (2024) 072006) **(App1-1:6)**[6]. to operate a superfluid helium target, called HeRALD, as the fastest path to establish a working, underground cryogenic experiment capability within QUP (a clear benefit to QUP), while at the same time achieving the first underground deployment of a HeRALD target (a clear benefit to TESSERACT). Phase 2 will deploy QUP-developed superconducting aluminum targets with multiplexed transition edge sensor (TES) readout, as described in the next topic **(App1-1:8).**

Fig. 5: Dilution refrigerator placed in Kamioka.

A Bluefors XLD-400 dilution refrigerator placed in the QUP cryo-facility was assigned to this project. This fridge was successfully relocated to the new Cryolab space at the Kamioka underground facility in November 2024 (Fig. 5). The refrigerator is fully operational with the same performance as at KEK. The necessary SQUID readout for carrying out dark matter searches is being commissioned, with the final elements recently shipped from the Berkeley Satellite/LBNL to Japan in 2025.

The cavern radioactivity at the fridge's final location has recently been measured with NaI detectors for gamma radiation and He proportional counters for neutrons. Simulation of this attenuation of these backgrounds with the final shielding configuration is in progress. The helium cell to be run at the cryolab is prepared at the Berkeley Satellite/LBNL. Some issues were found with the deposition of the Cs film used to prevent superfluid He from wetting the TES sensors in this setup, and a solution is being implemented. We project the cell to be ready in fall 2025. In parallel, the first round of QUP-designed prototype TES sensors aimed at Phase 2 has been fabricated commercially with SEEQC, Inc.

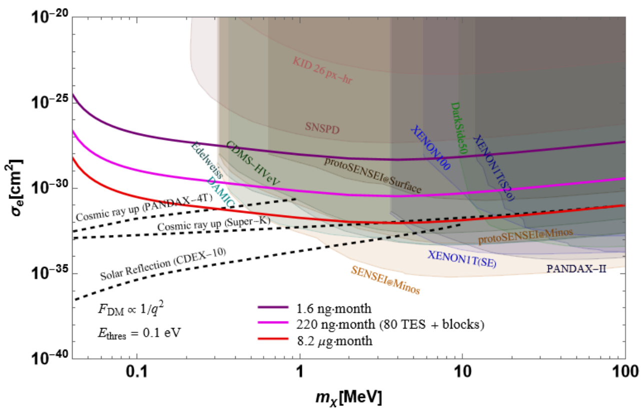


Fig 6: Sensitivity for DM-electron scattering with optical TES target.

Improved sensitivity studies are being carried out with the QUP theory group (M. Chen, V. Takhistov, K. Nakayama, and K. Hattori, paper in preparation) (Fig. 6).

Significant progress has been made by

TESSERACT with participation from QUP members in understanding and mitigating low energy excess backgrounds (LEE)(Nature C. **15** (2024) 6444) **(App1-1:7)**[7].
This is expected to be important for Phase 2. In contrast, in Phase 1, the helium quantum evaporation process is expected to allow effective rejection of LEE, which will affect individual sensors but will not generate quantum evaporation.

[5] Development of Optical TES and its readout

As mentioned in the Kamioka-LDM Project, we aim to explore light dark matter in the MeV region using superconducting detectors sensitive to sub-eV signals. We have made significant progress in developing and readout TESs. The initial work of **PI Hattori** and her group, published in (SST **35** (2022) 095002)**(App1-1:8)**, demonstrated a single-photon resolving optical TES with an energy resolution of 67 meV, among the best ever reported (Fig. 7). This resolution is sufficient to detect sub-eV signals expected in dark matter-electron scattering events.

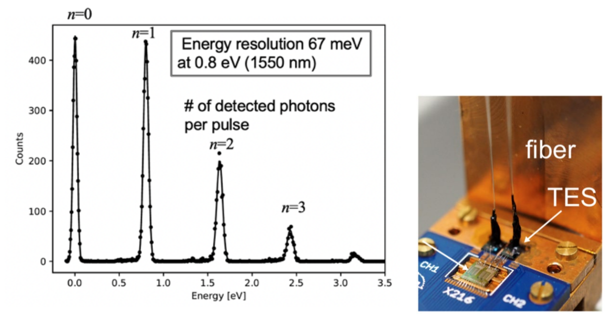


Fig. 7 TES responses to a pulsed laser at 1550 nm (0.8 eV).

To enable scalable dark matter detectors, the group also developed a microwave SQUID multiplexer (μMUX) system capable of reading multiple TESs simultaneously. This work, detailed in (JLTP **215** (2024) 170) **(App1-1:9)**[10], achieved single-photon detection in multiple pixels, demonstrating the potential of array-based TES detectors.

These advances address key challenges in dark matter detection, such as better sensitivity to MeV dark matter by detecting electron scattering and increased target mass. The technologies we developed lay the foundation for large-scale TES-based detectors to explore the sub-MeV dark matter parameter space. We have been developing TESs coupled with aluminum targets to enhance sensitivity and prepare for the Phase-2 Kamioka-LDM project scheduled in 2026.

[6] Solar axion searches

TES microcalorimeters are a new radiation detector that improves energy resolution by a factor of 20 and detection sensitivity for weak line emission and rare events. As an application of this technology, **PI Yamasaki** and her group worked out a new Solar axion detector with a ^{57}Fe absorber that can detect the 14.4 keV axion generated in the Sun by the axion-nucleon coupling at the magnetic dipole transition in ^{57}Fe. They have designed and fabricated a dedicated TES microcalorimeter in the ISAS satellite clean room **(App1-1:10-12)**[8].

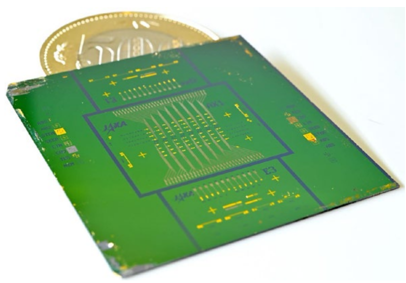


Fig. 8: A sample chip of 64-pixel TES array with ^{57}Fe absorbers**(App1-1:12)**

A test run with one sensor was conducted in the 2023-2024 winter, and the calorimeter's performance was evaluated. It worked as a radiation detector for 14.4 keV energy input from a calibration source, with an energy resolution degraded to ~ 200 eV due to small heat conductance. By 3 days of operation, no signals were detected, including background. An upper limit at ma~ 1 keV was set,

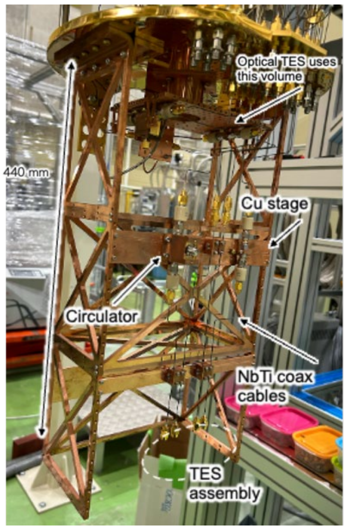


Fig. 9: Cold stage for TES multiplexed readout installed in a QUP refrigerator.

proving the concept's validity. Although the current sensitivity is an order of 3 worse than the previous experiment, it can be improved by a long exposure time and a large mass of ^{57}Fe with an array format. A new multipixel readout system utilizing GHz and rf-SQUID techniques has been installed in a QUP dilution refrigerator to obtain the large mass on the TES microcalorimeter array. The key component, cryogenic resonators between 6 and 8 GHz, were fabricated and tested. Now, a 160-pixel simultaneous readout in one readout channel is feasible.

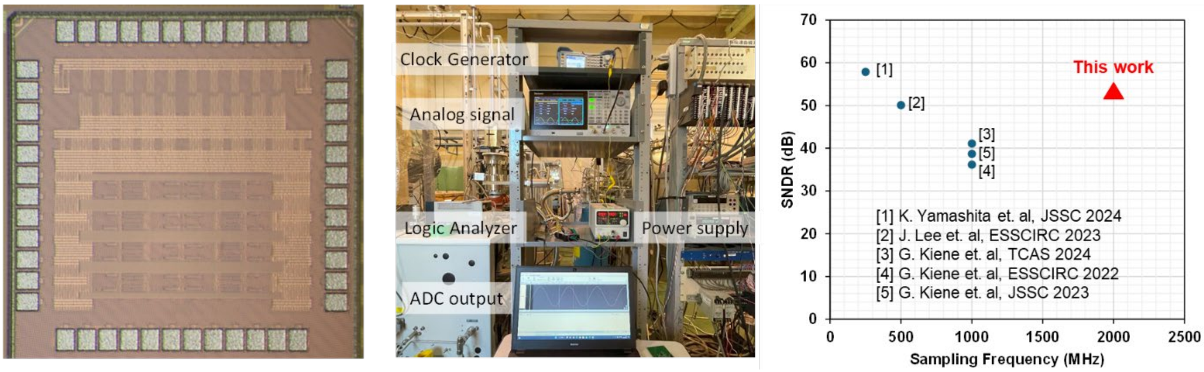
The update of the TES calorimeter design is inevitable but is being delayed by human resource limitations. Facilities in the ISAS clean room are partly renewed, and activation is expected. Also, to reduce the potential background, the group designed and fabricated a cryogenic anti-counter with a ~ 1cm square absorber and TES.

[7] Development of Cryo CMOS ASICs for Qubit Controller

In recent years, there has been intense competition to increase the number of qubits used in quantum computers. However, controlling them with coaxial cables, as with current superconducting qubits, will inevitably reach a limit in volume and cooling capacity. To address this issue, **PI Miyahara** and his collaborators are developing ASICs for qubit control that operate at cryogenic temperatures below 4 K. Specifically, we are developing a high-speed Cryo CMOS ADC to read analog signals from qubits.

Fig. 10 (a) shows a chip photo of the developed Cryo-CMOS ADC. This ADC was developed using a 22nm bulk CMOS process. It has a resolution of 10 bits and a sampling rate of 2 GS/s. Fig. 10 (b) shows the cryogenic measurement setup for the ADC cooled down with liquid helium. The sampling clock and analog signals are input to the ADC from a signal generator, and the digital data output from the ADC is captured on a laptop using a logic analyzer. The developed ADC was confirmed to operate correctly in liquid helium (4.2K). Fig. 10 (c) shows a performance comparison of state-of-the-art ADCs operating at cryogenic temperatures. The developed ADC achieved the highest sampling rate of 2GS/s and sufficient SNDR as a 10-bit ADC.

This work was supported by JST Moonshot R&D Grant Number JPMJMS226A.



(a) (b) (c)

Fig. 10 (a) Chip photo of a developed Cryo CMOS ADC. (b) Measurement setup for Cryo CMOS ADC in liquid helium. (c) Performance comparison with state-of-the-art Cryo CMOS ADCs.

[8] Theory

PI Nakayama and **PI Takhistov** have developed many novel methods and targets for discovering new fundamental quantum fields beyond the Standard Model by linking techniques from distinct fields, including cosmology, astrophysics, quantum metrology, and condensed matter. These works have already spearheaded several QUP experimental efforts. For example, this includes new quantum field searches with NV diamond and the Casimir force involving PI Nakayama, as described above.

PI Nakayama, Takhistov, and postdoctoral fellows, including **M. Chen,** have been active in estimating experimental sensitivity for new quantum field searches at QUP, such as for the Kamioka-LDM project (Fig.6). Further, utilizing their broad expertise and collaborating with QUP experimentalists, such as experts in X-ray astronomy, QUP theorists have proposed new data analyses and targets to search for new quantum fields. A good example is astrophysical X-ray studies of postdoctoral fellow **Y. Zhou, PI Takhistov, Deputy Director K. Mitsuda** described in Section 2-2-3 to search for decaying axion-like particle and sterile neutrino matter. **PI Takhistov** in collaboration with atomic theorist Prof. M. Safranova at U. Delaware (USA) is working to establish data analysis pipeline for utilizing networks of quantum sensors as new entry to multimessenger astronomy for probing new quantum fields. Hence, QUP theorists are a core for the fusion research and activities in QUP.

In addition to the research largely related to the QUP experiments, the group has also proposed research topics in a wide range of fields for the future of QUP. A few examples are listed below. Nakayama demonstrated, with validated simulations, how cosmic strings can efficiently generate dark-photon (vector) dark matter, providing a concrete target for forthcoming searches (JHEP **08** (2023) 068) **(App1-1:13)**. Nakayama and Takhistov demonstrated that quantum processes in the early Universe could emit gravitons with laboratory-detectable signatures, opening a pathway to probe Planck-scale ($\sim 10^{18}$ GeV) physics (PLB **856** (2024) 138958) [11]. Takhistov demonstrated that optical surveys and upcoming gravitational-wave detectors can reveal novel fundamental strong force (QCD) phase transitions above TeV-scale triggered by new quantum fields, and identified possible hints (PRL **130** (2023) 22 22)**(App1-1:14)**. Takhistov set leading novel limits on sub-TeV-scale magnetic monopoles from multiple experiments, considering new production from the atmosphere (PRL, **128** (2022), 20 201101). Takhistov developed a unique diffractive-lensing test for establishing mixed dark-matter scenarios involving both new quantum fields and black holes (PRL **133** (2024) 101002) **(App1-1:15)**[12]. Takhistov showed that quantum sensors, including, e.g., atomic clocks and networks in space, can probe orders of magnitude in the parameter space of novel ultralight quantum fields by capturing their transient signals (PRD **110** (2024) 075007) [13].

[9] Machine learning application

PIs Bortoletto, **Nakahama**, and their groups developed several novel methods of machine learning applications to high-energy-physics studies for accelerating discoveries of new fundamental quantum fields. New methodologies are focused on 1) new physics searches beyond the Standard Model (BSM) of particle physics, 2) measurements of the Higgs boson properties, and 3) detector development (e.g., anomaly detections during inspections).

Senior Scientist **J. Montejo Berlingen** developed the model-agnostic machine-learning algorithm passwd-abc, based on abc layers, which is suited for unsupervised learning directly on data and addresses critical limitations of current approaches in the BSM search program at the LHC (PRD **109** (2024) L011702)**(App1-1:16)**[35]. The proposed methodology was applied to the corresponding phenomenology studies in the context of R-Parity-Violating SUSY searches (JHEP **214** (2023) 215). The application for the analysis of the ATLS data is in progress

The group led the deep-learning application to the heavy-flavor jet tagging, boosted-object reconstructions, and event-selection optimizations, and demonstrated the performance in a series of related data analyses in the ATLAS collaboration at LHC. They are several key measurements of the Higgs-boson properties such as the Yukawa-couplings between the Higgs field and second-generation quarks (JHEP **2025** (2025) 75)**(App1-1:17)**, as well as the Higgs self-coupling (PRD **108** (2023) 052003), (PLB **843** (2023) 137745), (PRD **110** (2024) 032012)**(App1-1:18)**[50] and (PRD **108** (2023) 052003).

The group initiated an interdisciplinary study of image processing at detector developments. The efforts focused on visual inspection of detector components to help prevent future failures and improve fabrication processes, improving the reliability and efficiency of detector Quality Control. This framework has been demonstrated and validated at the production of pixel modules for the upgraded Inner Tracker to be deployed in the ATLAS detector for high luminosity.

[10] Sensor development of the LiteBIRD space mission

From 2021 to 2024, sensor development for the LiteBIRD space mission, named as the SpaceTES project, was one of the main activities of QUP, with the timeline shown in Fig. 11. In September 2024, technical and financial difficulties on the LiteBIRD project were pointed out by a review committee formed by KEK and, as a result, KEK and QUP have relinquished their commitment to the LiteBIRD project, and SpaceTES is no longer the flagship project of QUP. Nevertheless, considerable development had already taken place by then through a collaborative effort led by the **PIs Hasegawa, Hazumi, and Lee**.

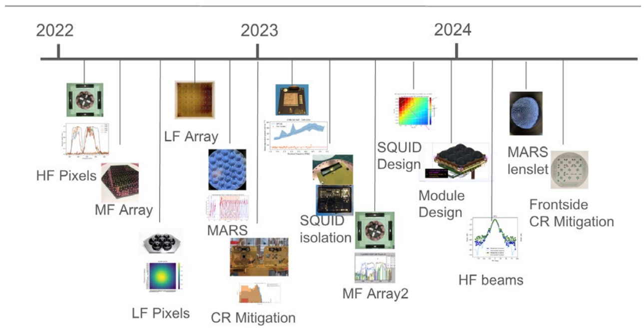


Fig. 11: Timeline of the SpaceTES project on the detector development.

Fig.12 shows the effort put into TES array development for LiteBIRD Low Frequency Telescope by QUP researchers. In the past few years, **Deputy-PI T. Ghigna** has led the work on TES arrays for LiteBIRD LFT in close collaboration with engineers and scientists in the Marvell nano lab at UC Berkeley, and the prototype sensors were produced in 2024. Design and characterization of the arrays has been published or presented in several venues (for example, JLTP **216** (2024) 254) **(App1-1:19)**. This was the first step in realizing a highly uniform and reliable array that can meet the requirements of a space mission.

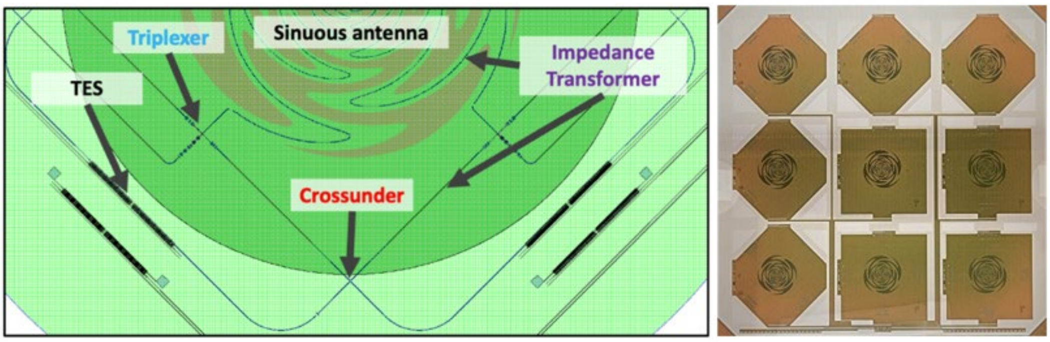


Fig. 12: Design of the sensor arrays for the LiteBIRD Low Frequency Telescope.

At QUP, we did not want to limit our contribution to LiteBIRD just to sensor development, but we want to contribute to delivering high-quality data to the collaboration and the scientific community. In this spirit, new methods were developed to characterize the sensors and the readout to improve our understanding of the physics of superconducting detectors and use this knowledge to improve our calibration strategies. A method that tracks the loop-gain of the TES sensors during observation and use the information to improve the ability to calibrate science data was developed by **T. de Haan** in collaboration with **D. Kaneko** and **Y. Zhou** (JLTP **216** (2024) 527) **(App1-1:20)**. This has been tested in the QUP lab and is now being tried for the other CMB experiment.

2-1-2. State of joint research

Describe the results of joint research conducted with other research organizations both in and outside Japan. In Appendix 1-4, describe the state of the Center's agreements concluded with these organizations.

QUP researchers have collaborated with many other research organizations in Japan and worldwide. Almost all published papers, including those we showed in the previous sections, result from joint research with various international collaborators.

Some QUP activities are tightly connected with large international collaborations, such as ATLAS and Belle-II experiments related to the rad-hard, DAQ, and analysis clusters. The host institute, KEK, made the agreements for these international collaborations, as there are also non-QUP KEK members. In this section, we report only the joint research related to the Space TES and Kamioka-LDM Projects, where QUP has a key role in the joint research.

Sensor development for the LiteBIRD: PI Lee led the development of the main sensors of the low-frequency telescope at the QUP Berkeley satellite, with close communication with QUP researchers in Japan. The outcome is shown in the previous section. QUP also had general MOUs with JAXA and WPI-Kavli-IPMU to keep tight collaboration with these major Japanese institutes in the LiteBIRD project. QUP also signed a strategic partnership project agreement with the Ernest Orlando Lawrence Berkeley National Laboratory (LBNL) to develop the sensor readout.

Kamioka Light Dark Matter Project: The phase-1 project is led by **PI Garcia-Sciveres**. To keep the low background environment for the measurement, we moved a dilution refrigerator in the Kamioka mine, in the area where the Research Center for Neutrino Science (RCNS) of Tohoku University conrols. We have an MOU with the RCNS for scientific collaboration. We appointed Prof. Ishidoshiro of RCNS as a QUP affiliate member. As the initial stage of the experiment will be performed with a helium cell provided by the TESSERACT collaboration, an MOU was concluded with the collaboration in 2024. Currently, the cell is tested at LBNL under the supervision of PL Garcia-Sciveres.

2-1-3. Appraisal by society and scientific organizations

Describe how society and/or scientific organizations in and outside Japan have recognized the Center's research achievements.
・ To substantiate the above evaluation, list the main awards received and invitational/Keynote lectures given by the Center's researchers in Appendix 1-5.

Masashi Hazumi became a member of the Copernican Academy in Poland in February 2023. **Nanae Taniguchi** received the JPS Fumiko Yonezawa Memorial Award in February 2023. **Daniela Bortoletto** was awarded OBE-Officer of the Order of the British Empire in 2024.

QUP researchers gave many presentations in the international workshop and conference; some are listed in Appendix 1-5. In addition to the presentations on our research outputs, some are invited to give talks for the wider scope and for future planning of the science community. In February 2023, **Hazum**i and **Garcia-Sciveres** had invited talks in the P5 Town Hall meeting, where the future plan of the US particle physics was discussed with its distinguished review panel and the community. Masashi input the direction of the polarization measurements of the cosmic microwave background from space, i.e., the LiteBIRD project, and Garcia-Sciveres gave the prospect on Quantum Information Science. **Bortoletto** gave an overview talk on the detector R&D at the ICFA seminar in November 2023. **Takhistov** gave an overview talk on the searches for new quantum fields with multimessenger observation, in a month-long workshop in the US in 2024.

2-1-4. Research environment, including facilities and equipment

Describe the degree to which the Center has prepared a research environment appropriate for a world premier international research center, including facilities, equipment and support systems, and describe the functionality of that environment.

Since the beginning of the QUP foundation, we have noticed the importance of having shared QUP facilities that QUP researchers can use. The first facility identified is for cryogenic detectors, which was actualized with the FY2021 and FY2022 budgets. In March 2023, we started the operation of four dilution refrigerators in the Fuji experimental hall at KEK (Fig. 13). The system is used for

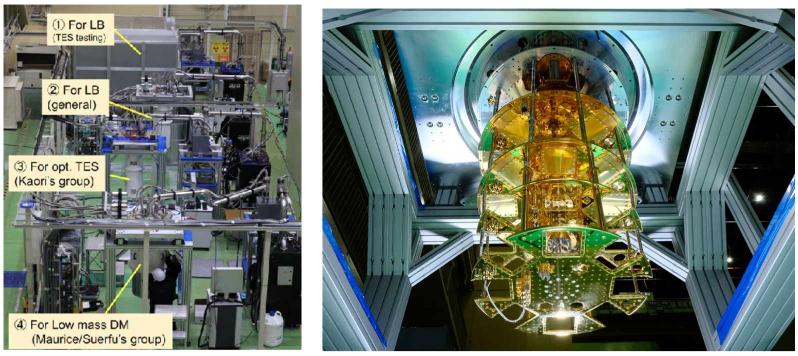


Fig. 13. Dilution refrigerators installed in Fuji experimental hall.

developing quantum detectors at low temperatures, as reported in the previous sections. Two of them were initially used for the SpaceTES project, i.e., the development of focal plane detectors for the LiteBIRD space mission, and will be used for new projects starting in FY2025. The other two are primarily used for the detectors of dark matter searches. In 2024, a dilution refrigerator was moved to Kamioka to have a facility with a low-radiation-background environment, as a part of a joint research project with RCNS, as described in Section 2-1-2.

The next plan to facilitate fused research among QUP researchers is to set up a large-volume, clean environment to pursue reliable measurements. In connection with the building of a new/renovated building complex, a large-volume anechoic room against a wide range of radio waves and a large-volume cold room with ~4K degrees are planned. They will be placed in the experimental area of the building complex in summer 2025.

2-1-5. Competitive and other funding

Describe the results of the Center's researchers to date in securing competitive and other research funding.
・ In Appendix 3-6, describe the transition in acquiring research project funding.

QUP PIs have been very competitive in obtaining competitive funding. The main source in Japan is the KAKENHI grant of JSPS, and many QUP researchers, including postdoctoral fellows, succeeded in getting the award. The high awards of 10 million yen or more per year are listed in Appendix 3-6. Hazumi received a Grant-in-Aid for Scientific Research (S) for 2022-2026, and Hasegawa has received a new Grant-in-Aid for Scientific Research (S) since FY2025.

We are also obtaining the other government funds. PI Miyahara has received the Moonshot R&D Grant from JST since 2022 for "High speed ADC for frontend" in the "Development of Scalable Highly Integrated Quantum Bit Error Correction System" project. PI Hattori has received FOREST funds from JST on "Exploration of Dark Matter with Superconducting Detector Arrays" for 2023-2026. PI Nakahama has received the JSPS core-to-core program "AI-Smart application to High Energy Physics" for 2023-2027. PI Garcia-Sciveres has received awards for "Nano-sensors on CMOS" and "Nanoscale Hybrids " from DOE in the US.

2-1-6. Applications of research results

Describe the applications created from research results, their effect in spawning innovation, intellectual properties (IPs) obtained, and joint research activities conducted with corporations, etc.

QUP Synergy Summit (QSS)

The QUP Synergy Summit, a new pivotal platform for industry-academia collaboration, was launched in FY2023. This unique initiative fosters a symbiotic relationship where the industry presents real-world problems and aims to solve them with KEK technology, a form of "deep tech" rooted in fundamental laws. The reverse pattern, where KEK's challenges are addressed with the industry's technology, is also under consideration, further enhancing the collaborative spirit of the QUP framework. The secretariat was set up at the QUP satellite at Toyota Central R&D Labs. (TCRDL). Four meetings were held by March 2025. The first collaborative theme was set to the soft error problem caused by cosmic rays.

2-2. Generating Fused Disciplines (within 3 pages)

2-2-1. State of strategic (or "top-down") undertakings toward creating new interdisciplinary domains

Describe the content of "top-down" measures taken by the Center to advance research by fusing disciplines. For example, measures strategically being taken by the Center to create fusions of interdisciplinary disciplines.

Since the start of the QUP, the director has taken the initiative to create forums called "Waigaya" and "Coffee chat" to facilitate informative discussions among QUP researchers and encourage collaborative work among PIs in different fields. As already described in section 2-1-1, the two outcomes from this activity are new field searches with very different devices, namely the NV diamond sensor and the Cashmir force.

For the NV diamond case, QUP particle physicists met with researchers in the application area of TCRDL, finding that this high-precision device for measuring magnetic fields can be a competitive detector for dark matter. As a QUP project, we first concentrate on the pure physics application, i.e., dark matter searches, with a strong collaboration with the professionals of this device, Prof. Mizuochi of Kyoto University, invited as an affiliate member of QUP.

The application of the Casimir force is a target research area since the start-up of the QUP. Initially, this was for an application area, led by **PI Iizuka** of TCRDL, toward realizing a non-contact shaft-bearing system. After the discussion in the forum, the Casimir force can be controlled by introducing Weyl semimetals, so that it is possible to extend the search area of the new force, such as the fifth force. The experiment was set up in the TCRDL satellite by TCRDL junior researchers in collaboration with Prof. Pramod Reddy, University of Michigan. The program for the new field search thus started in a fusion of different researchers who met in the QUP.

Experts on the transition edge sensor (TES) have gathered in QUP and new activities emerged. Three PIs started a joint project to search for low-mass DM in the mass range well below the proton mass. Optical TES, a "new eye" developed for other applications, is critical in this Light Dark Matter Project. TES is also a key device for the search for Axion coming from the Sun.

In this way, QUP is a place where researchers from different fields come together to start new projects. With the new tools such as NV diamonds, special materials for Casimir forces, and TES, QUP is becoming **a center for the search for light neutral quantum fields**.

2-2-2. State of "bottom-up" undertakings from the center's researchers toward creating new interdisciplinary domains

Describe the content of "bottom-up" measures taken by the Center to advance research by fusing disciplines. For example, measures that facilitate doing joint research by researchers in differing fields.

QUP researchers develop "new eyes" through communication with different fields to acquire new ideas and convert them into new applications. The examples (**NV diamonds** and **Casimir force**) we showed in the last section are examples of the director's arrangement, but various QUP researchers also work in this direction.

The CIGS detector, which is already described in the highlight section, is a well-known material in the **solar cell** application. **PI Togawa** took this device for a different application, i.e., a particle detector that can detect signals from a single charged particle, aiming for application to high-energy physics and then for the radiation camera in a high-radiation environment. A collaboration started with Dr. Nishinaga of NIMS, who became an affiliate member of QUP.

PI Nakahama was central in creating a forum of machine learning and AI for exchanging information among Japan's particle physics, accelerator physics, and astrophysics. She has organized several international workshops to make links to the global community and a school for early career researchers. **T. de Haan**, QUP senior scientist, developed a high-performance Astronomy-specialized large-language model (LLM) as shown in Section 2-2-3.

QUP is a place to meet researchers who bring new "eyes" to humanity. As shown in the next section, such encounters lead to new research activities.

2-2-3. Results of research in fused research fields

Describe the Center's record and results by interdisciplinary research activities yielded by the measures described in 2-2-1 and 2-2-2.

- In Appendix 1-2, list up to 10 of the Center's main papers on interdisciplinary research that substantiate the above record of results, and describe their content.

[1] Light dark matter searches via NV centers in diamond (**App1-2:1, App1-2:2**)
[2] New force search via Casimir forces (**App1-2:3**)

These two research projects were born in the fusion at QUP under the strong leadership of former director Masashi Hazumi. The details are already described in section 2-1-1.

[3] CIGS device for solar cells and particle detectors
PI Togawa performed irradiation tests of thicker CIGS, aiming to use the devices as detectors with single-particle sensitivity. The recovery processes were investigated, providing feedback on the application for the original solar cell development (JJAP **62** (2023) SK1014) (**App1-2:4**) .

[4] X-ray astronomy
A Theory **PI Takhistov**, with QUP postdoctoral fellow **Y. Zhou** and **Deputy Director K. Mitsuda**, who have also worked for X-ray astrophysics, identified the ultra-faint dwarf galaxy Segue 1 as the most sensitive X-ray target for discovering sterile-neutrino dark matter decays (APJ **976** (2024) 238) (**App1-2:5**) [30]. X-ray satellite data can pursue this potential theme, such as the newly JAXA-launched X-Ray Imaging and Spectroscopy Mission (XRISM). This is an example of the fusion with the bottom-up discussion in the **Coffee Chat**. Senior Scientist, **K. Sato**, was the corresponding author of one of the first papers from the observation data of XRISM, published in Nature in February 2025 (Nature **638**, 365–369 (2025)) (**App1-2:6**).

[5] TES application for XAFS
With its superb energy resolution, the TES detector has the potential for a wide range of applications. QUP researchers are working on this. An example is the work of postdoctoral fellow **R. Hayakawa** with his collaborators (Analyst **149** (2024) 2932) (**App1-2:7**) [60].

[6] AI Assistant
Senior Scientist **T. de Haan** developed a specialized AI assistant 8-Billion-Parameter LLM, "AstroSage-8B", trained on 250,000 paper preprints in astronomy, astrophysics, cosmology, and astronomical instrumentation. On the 4,425-question AstroMLab-1 benchmark, the model gets 80% of the answers right, which is GPT-4o-Level Performance while operating at roughly one thousandth the cost. This demonstrates the power of specialized AI, and is published in (Scientific Reports **15** (2025) 13751)(**App1-2:8**).

3. Global Research Environment and System Reform

3-1. Realizing an International Research Environment (within 4 pages)

3-1-1. Center's record of attracting and retaining top-world researchers from abroad

Describe the participation of top-world researchers as PIs and their stays as joint researchers at the Center.

・ In Appendix 3-2, give the number of overseas researchers among all the Center's researchers, and the yearly transition in their numbers. In Appendix 4-1, give the achievements of overseas researchers staying at the center to substantiate this fact.

QUP was launched with three foreign PIs: Daniela Bortoletto (Oxford), Maurice Garcia-Sciveres (LBNL), and Adrian Lee (UC Berkeley). To promote internationalization and the presence of foreign PIs on site, QUP made an open call for new PIs for theoretical physics in FY2023. A foreign researcher (**Volodymir Takhistov**) was hired on-site as the PI in April 2024. Four out of 14 PIs are foreign PIs, and the ratio is 28%.

The three original PIs visited QUP a few times yearly, mainly during the "**QUPweek**," when all QUP members got together. They also participated nearly weekly in the regular video meetings, such as the QUP PI meeting and the QUP seminar. To compensate for their limited on-site stay, QUP hired three deputy PIs (Christopher Betancourt, Suerfu Burkhant, and Tommaso Ghigna) who stay on the QUP KEK campus for most of the time and have close contact with the PIs.

After setting up the QUP Berkeley satellite in March 2022, **PI Lee** has operated the satellite and accelerated the development of the sensors for LiteBIRD, the QUP's flagship project for 2021-2024. He accepted one internship student from the University of Tokyo in 2023. His deputy PI, Ghigna, and other QUP researchers visited the satellites for sensor development and communicated closely with the UCB researchers, who also became QUP affiliate members.

PI Garcia-Sciveres, leading the Kamioka-LDM Project, sent one postdoc and one graduate student to QUP with the QUP and JSPS internship programs. **PI Bortoletto**, who is developing radiation-hard silicon detectors for future collider experiments, accepted one graduate student from the University of Geneva as a QUP intern.

There are two long-term visitors to the QUP, related to cosmic microwave background research: Prof. Nils Halverson (U. Colorado) and Prof. Andrew Jaffe (Imperial College London). Many guest speakers were in our annual symposium (QUPosium) and almost monthly QUP colloquium, as described in Section 3-1-3 and Appendix 4-1.

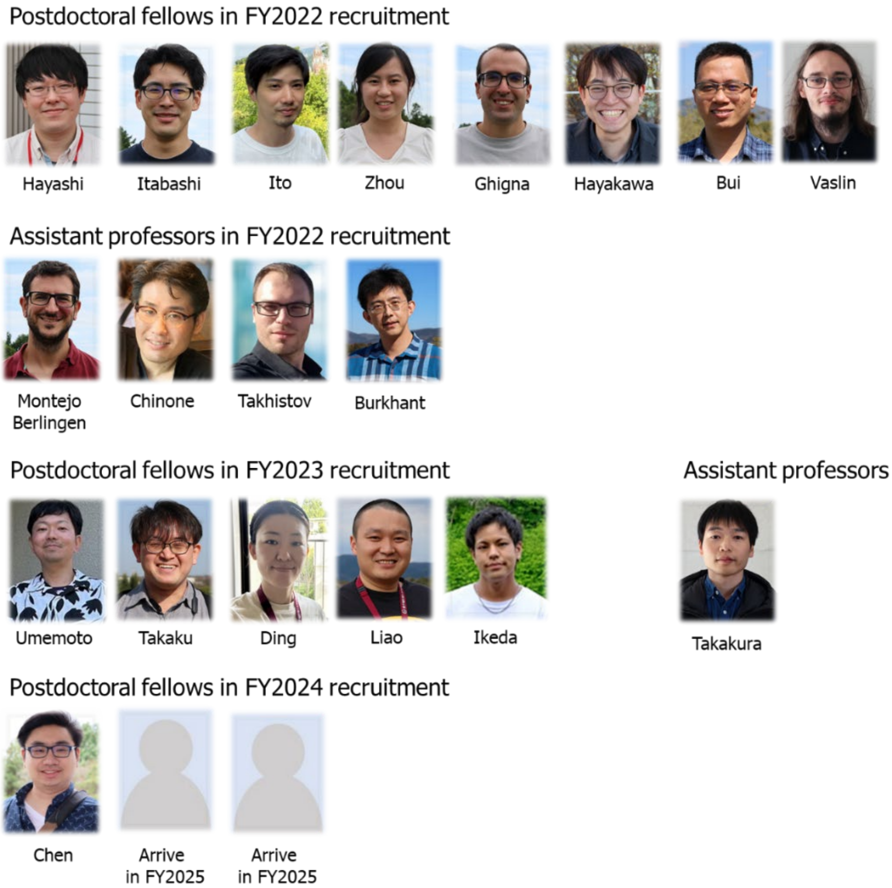
3-1-2. Employment of young researchers at the Center and their job placement after leaving the Center

Describe the Center's employment of young researchers, including postdoctoral researchers, and the positions they acquire after leaving the Center.

・ Enter the following to substantiate the facts provided above:
- In Appendix 4-2, describe the Center's state of international recruitment of postdoctoral researchers, the applications received, and selections made.
- In Appendix 3-2, give the percentage of postdoctoral researchers employed from abroad.
- In Appendix 4-3, describe the positions that postdoctoral researchers acquire upon leaving the Center.

All job advertisements for the QUP postdoctoral fellow were with the public call, using the well-known worldwide system (academic jobs online). The first call was held in February 2022, and the first foreign postdoc arrived only in August 2022; with the severe COVID-19 pandemic restrictions, we gradually increased the number of members.

QUP postdoctoral fellows are for three years with the possibility of a 2-year renewal based on satisfactory job performance. For outstanding candidates, we can offer an assistant professor position for five years with the possibility of a 2-year renewal and treat them as QUP senior scientists. Both numbers are listed in Appendix 4-2. In the FY2022 requirements, we hired eight postdocs and four senior scientists in this scheme, with 3 (2) foreign postdoctoral fellows (senior scientists). In FY2023, we hired five postdoctoral fellows and one senior scientist, with three foreign postdocs. In 2024, 3 foreign fellows were hired. (Two of them will come in FY2025).



Two (**Montejo-Berlingen, Takakura**) of the five senior scientists (assistant professors) hired with this scheme have already been promoted to faculty positions at other universities (Barcelona and Tokyo). One (**Burkhant**) was nominated as deputy PI. The other two (**Chinone** and **Takhistov**) were promoted to QUP as associate professors. Takhistov became the QUP PI as described in the previous section. These facts demonstrate the high standard of QUP recruitment and the effectiveness of our hiring scheme with the higher position option.

All postdoctoral fellows are still in the first three-year term. Nevertheless, four talented Japanese fellows have already moved to faculty positions at other Japanese universities or institutes, Tokyo, Kobe, Rikkyo University, and AIST, as shown in Appendix 4-3.

By the end of FY2024, QUP consisted of 14 PIs, 15 senior scientists, and 11 postdocs, about half of what was initially planned (See Appendix 3-2).

3-1-3. Center's record of holding international symposia, workshops, research meetings, training meetings and others

・ In Appendix 4-4, describe the main international research meetings held by the Center.

QUPosium:
Despite the difficulty with COVID-19 at the start of the center, we managed to have the first international symposium in December 2022, twelve months after our foundation. The symposium was named QUPosium, and we decided to hold it annually. We invited well-known key researchers to each meeting, including Dmitry Budker (Mainz), Suzanne Staggs (Princeton) in 2022, Adam Riess (Johns Hopkins U. / STSI, Nobel laureate) in 2023, and Marianna Safronova (U. Delaware) in 2024.

QUP colloquium:
Since April 2022, QUP has been organizing QUP colloquium almost every month, inviting prominent

researchers. We have had 34 QUP colloquia by April 2025, with 20 foreign speakers, including J. Ellis (CERN and King's College London) and Laura Baudis (U. Zurich).

PI-led workshops:
QUP PIs organized several international workshops related to their research activity. **PI Nakahama** is organizing workshops and a training meeting related to machine learning and has obtained a special JSPS fund. We also had workshops led by **PI Hasegawa** related to research on the cosmic microwave background, and a workshop on TES application organized by Akamatsu.

3-1-4. System for supporting the research activities of overseas researchers

Describe the Center's preparations to provide an environment conducive for overseas researchers to concentrate on their work, including for example living support in various languages or living support for their families.

Living Support:
A team in the QUP office supports the settlement of foreign researchers, contacting them in advance about employment. Since 2023, we have contracted an outside company for 24-hour medical and other care assistance.

Japanese language course:
In 2024, we organized a half-year Japanese language course for foreign researchers at QUP.

3-1-5. Overseas satellites and other cooperative organizations

・ In Appendix 4-5, describe the state of cooperation with overseas satellites and other cooperative organizations.

QUP Berkeley Satellite:
The MOU was signed with the University of California, Berkeley (UCB) in March 2023 to set up the QUP satellite office and for research cooperation in the particle physics and astrophysics areas. The Satellite is run by **PI Lee**. The significant activities went on in 2023-2024 to develop high-precision TES bolometers for the SpaceTES project, the flagship project, by fully utilizing the Marvell nano lab in UCB, with QUP's support on human resources. The QUP scientists visited the satellite with the coordination of the deputy-PI Ghigna, resulting in many publications as shown in Appendix 4-5. We also sent a student from the University of Tokyo in 2023 for 2 months with the QUP internship program (QUPIP). The student will be promoted to the QUP postdoctoral fellow after completing the Ph.D. thesis.

Lawrence Berkeley National Laboratory (LBNL):
PI Garcia-Sciveres, also affiliated with the UCB, is participating in the QUP satellite and leading the QUP Kamioka-LDM project. He is working at LBNL on developing the initial detector and sent one postdoc and a student to the QUP KEK site with the QUPIP and JSPS exchange programs.
To develop the cold readout for the TES bolometer, QUP made a joint project with Dr. Aritoki Suzuki, an affiliate member of QUP. The work was concluded in December 2024.

Oxford University:
In 2024, we sent a student from the University of Geneva to PI Bortoletto's laboratory for two months with our QUPIP program.

3-2. Making Organizational Reforms (within 2 pages)

3-2-1. Decision–making system in the center

Describe the strong leadership that the director is giving on the Center's operation and its effect, and the division of roles and authority between the Center and its host institution.
- In Appendix 3-3, draw a concrete diagram of the Center's management system.

QUP is a WPI institute which should be a top-down institute, while 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 foundation of QUP, there were many discussions with KEK about harmonizing the organizational structure of QUP under the foundation of KEK.

For the appointment of researchers, KEK requires a resolution from the Education and Research Council regarding faculty appointments, and the Council delegates the task to a high-level committee of the KEK institute, where the outside members selected by the community are in the majority. QUP must be independent in making the recruitment decision from such a committee with outside members. **As an exception, the Council has decided to delegate the task to the QUP director for the QUP researcher appointments**, at the foundation of QUP. KEK also delegated the other (non-researcher) appointments to the QUP director. This ensures the leadership of the QUP director. The QUP director will report QUP's human resource allocation plan regularly in the KEK's director meetings to help the mutual understanding of the scope of QUP.

The KEK has also allowed the QUP director to set a special allowance depending on the individual's excellence, allowing the director to hire world-class researchers. Specific bylaws were set up so the QUP director could negotiate with the individuals to determine their salaries.

With these arrangements, **QUP was set up as an individual institute at KEK.** The Director of QUP makes final decisions on important matters such as personnel, budget, research goals, and research policy. The center's operation is done with a top-down approach based on the director's decision. Under the leadership of the Center Director, the QUP Steering Committee was set up with members including the Director, the Deputy Director, the Administrative Director, and a PI representative to discuss critical operational matters such as personnel, budget, and research goals and policies. A "PI meeting" is held periodically, in which members of the Center Steering Committee, all PIs, and deputy PIs can participate to discuss resources needed for research, etc. An "external advisory board" consisting of five prominent researchers from Japan and abroad evaluated the center's operation from a higher perspective and provided beneficial advice.

Changes in KEK and QUP organizations:

The new KEK director general, Dr. Shoji Asai, arrived on April 1, 2024. Dr. Kazunori Hanagaki became an executive director of KEK and resigned as the deputy director of QUP. **Prof. Kazuhisa Mitsuda became the new deputy director of QUP.**

Following the severe recommendations from the WPI committees, KEK organized reviews to assess the QUP's progress. **Masashi Hazumi resigned** from his QUP director and PI position on December 1st, 2024, and the KEK DG appointed **Kazunori Hanagaki as the acting director**. The KEK DG aims to propose a new director and new QUP scopes to the WPI program committee in FY2025. **The candidate for the new director is Dr. Toshiyuki Azuma** of RIKEN. He has joined QUP as Deputy Director in April 2025 with 40% FTE. The directors are working together to restructure the QUP, with close contact with the KEK DG. More details are described in Appendix 3-3.

3-2-2. Arrangement of administrative support staff and effectiveness of support system

Describe the assignment of the Center's administrative support staff who have English language and other specialized skills, effort made in establishing the support system, and the system's effectiveness.

The QUP administrative staff who support the QUP researchers communicate in English. To maintain good coordination with KEK while maintaining QUP independence, the QUP administration office contains a newly set-up KEK administration section, the QUP management office (see the organization diagram in Appendix 3-3).

3-2-3. Achieving Gender-Balance Plan

- Describe the content of measures taken by the center to implement the center's gender-balance plan. The measures should be divided into the two categories, a) measures at the executive level, and b) measures among principal investigators and other researchers.
- Concretely describe the measures taken by the host institution to provide a support system and to work toward improving the environment for achieving gender balance.
- On the transition in the number of female researchers, enter the figures in Appendices 3-1 and 3-2.

The center's importance of diversity is clearly stated in the code of conduct, which is set at the beginning of the QUP. In selecting initial PIs, we chose researchers consistent with the center's mission, identity, and goals. Priority was given to the highest level of competence. Diversity was also considered, and the ratio of female PIs was approximately 40%.

We did not take any affirmative action in the recruitment and just encouraged diverse applicants in every recruitment announcement. At the end of FY, the female fraction of PIs was reduced to 35.7%. Among researchers, the female fraction was 17.6%, twice as large as the KEK average (8%).

To support the activities of a diverse group of researchers, the QUP has established a room that can be used when children are brought with researchers. A new utility toilet for women has been installed in the experimental area of the Fuji laboratory, which only had a toilet on the ground floor.

KEK has restructured the section on diversity, equality, and inclusion (DE&I) since April 2024. The QUP director is a member of the DE&I committee, and the deputy director is a working group member. KEK and QUP collaborate on improving diversity. The action plan for the section was made in FY2024.

3-2-4. System reforms advanced by WPI program and their ripple effects

Concisely itemize the system reforms made to the Center's research operation and administrative organization, and describe their background and results. Describe the ripple effects that these reforms have on the host institution. (If any describe the ripple effects on other institutions.)

Unique recruitment/salary scheme: QUP's recruitment scheme enables quick decisions in the recruitment process. The QUP director negotiates with the individuals to determine their salary. The scheme is a significant factor that makes the QUP competitive with the world's top institutes in attracting excellent researchers. We have set up a rule to update the annual salary with the evaluation, including one-on-one interviews with the QUP director, giving an incentive to the fixed-term researchers. The conditions of the fixed-term researchers at KEK are lower than those of the permanent researchers, but QUP is trying to close the gaps.

QUP unique job rank: Some (and many at the start of the institute) QUP researchers belong to the other institutes at KEK or outside KEK. It is essential to have the QUP job rank (such as PIs, senior scientists) and the standard job rank (such as professor, assistant professor, etc.) independent. QUP established Principal Engineer as a new QUP job rank, and by implementing the above-mentioned salary negotiation system, it has become possible to improve the labor conditions of technical staff, which helps to attract talented engineers. We hired the first Principal Engineer in May 2023.

Reform on the KEK rules on accepting graduate students: QUP created an original internship program named QUPIP. The program works well as reported in section 4-2. In 2024, we set up the QUP international fellowship program to support graduate students by accepting and employing them long-term. Under current KEK regulations, only domestic graduate students are eligible to be hired as special researchers, but QUP has established internal regulations that also allow acceptance from overseas.

4. Values for the Future (within 2 pages)

4-1. 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 during the period from 2021 through March 2025 and how they have contributed to creating the Societal Value of Basic Research. In Appendix 5-1((1) and (2)), describe concretely the contents of these outreach activities and media reports or coverage.

QUP focuses on disseminating information through public lectures, video presentations, and social media such as "X". While outreach activities should communicate QUP's ongoing research to the broad public, they should also target a specific audience at each event.

Public lectures: The 26th "Science in Japan," sponsored by the Washington office of the Japan Society for the Promotion of Science, was held in June 2023 in Washington, D.C. (Fig. 14). The theme was "Quantum Taste of the Universe," with the full cooperation of QUP. The event provided an opportunity to introduce QUP's research to science attaches from around the world in Washington, D.C., as well as local researchers from universities and companies.

Fig. 14: public lecture in 2024

QUP organized two public lectures for high school students. The first was in March 2024, entitled "Making Tools to Look into the Universe!" in Tsukuba, attracting a young audience of about 100 participants, including 28 high school students. At the end of the event, we had a tea time, when the participants had a chance to communicate directly with the Japanese and non-Japanese QUP researchers to learn about the various paths to becoming a researcher. It was a good opportunity for high school students to consider their future career paths. The second one was in December 2024. The third one is planned for July 2025. We will regularly hold this interactive type of public lecture in the future. The QUP researchers also gave public talks at the cultural centers and high schools. Junior high school students visited KEK/QUP and QUP researchers showed the labs and had an active Q&A time with them.

Social Media: We have been tweeting various topics on social media X, from QUP's scientific results to everyday life. Since FY2024, the English and Japanese have been posted separately.

QUP video: The "QUP three-minute talking" program, launched in FY2022, is a high school-level program that introduces the research and personalities of QUP researchers. So far, we have featured 9 QUP researchers. The videos were distributed on YouTube. We started with Japanese and expanded to English versions with Japanese subtitles, as we also introduced foreign researchers.

Targeting undergraduate and graduate school students, we are producing the QUP Lecture Series. PI Iizuka gave nine lectures on the Casimir effect. QUP also showed several videos to explain QUP's research in depth.

4-2. 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 your measures for fostering researchers with a view to achieving gender plans, and your measures for conducting domestic and international promotion activities to attract female researchers to the center.

We started an internship program for graduate students and postdocs to visit QUP. These early career scientists can stay for 1-3 months with the QUP researchers at the QUP site at KEK, the Berkeley satellite, and the locations of QUP PIs such as Oxford and LBNL. In FY2023 and FY2024, 32 QUPIP fellows came to QUP, including 11 PhD and 11 master's students. Fourteen students came from abroad. One Japanese PhD student visited the Berkeley satellite for 2 months.

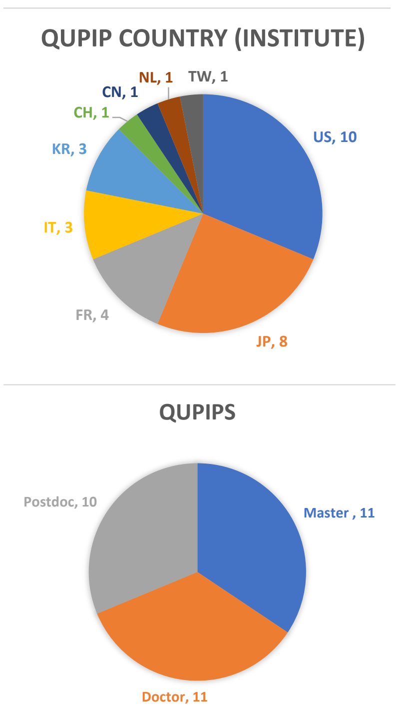


Fig. 15: QUPIP demography

The program is successful. Some collaborative papers were published with QUPIPs. So far, two QUPIP graduate students have successfully been accepted for the QUP postdoctoral fellow position and will join after completing their doctoral dissertations. One QUPIP became a QUP engineer. Some students and postdocs came repeatedly for several years. Based on this achievement, QUPIP has accepted interns for over three months since FY2024.

Based on an MOU held with SOKENDAI, most of the on-site QUP PIs and senior scientists have been affiliated with the graduate school since September 2023.

As discussed in Section 3-2-4, we set up the QUP international fellowship program by expanding KEK's special system to accept domestic graduate students so that QUP researchers can supervise both domestic and foreign visiting graduate students.

Through the various mechanisms shown above, namely from Sokendai and under the KEK's special researcher system, On-site QUP PIs supervised 7 Japanese students in 2023 and 6 in 2024. Four new Japanese students will be expected starting in April 2025.

4-3. 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.

- In Appendix 5-2 and 5-3, describe the concrete measures being taken by the host institution.
- In Appendix 5-4, excerpt the places, in the host institution's "Mid-term objectives" and/or "Mid-term plan" that clearly show the positioning of the WPI center within its organization.

QUP and KEK continue to discuss the support plans for making QUP a sustainable institute beyond the WPI funding period. QUP and KEK agreed to cooperate in creating a concrete financial plan for the permanent establishment of QUP. An estimated personnel cost of 400 million yen would be required to maintain current activities after the 10th year. This will require QUP to aggressively seek external funding of about 200 million yen for the programs it promotes, while KEK promises to cover at least 200 million yen.

By renovating the old KEK facilities, KEK offers a new research building complex for QUP (Fig. 17). The design work was completed in FY2022. The new building was to be completed by the end of FY2024, but due to a delivery problem, its completion was delayed to summer 2025.

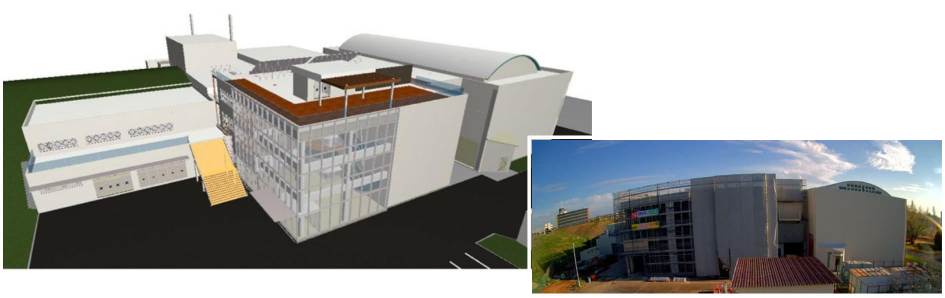


Fig. 16: Plan of QUP's new research building complex and construction status on April 5, 2025

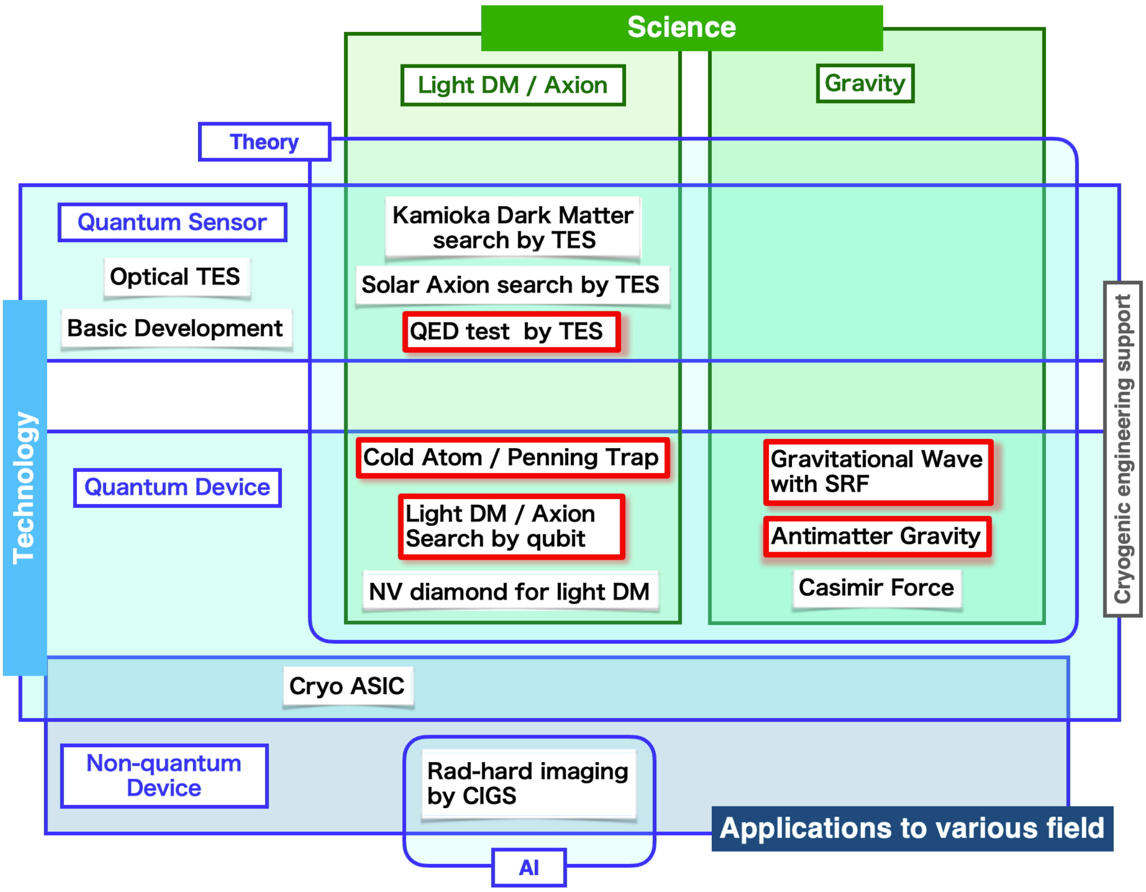
5. Future Prospects (within 2 pages)

Describe policy and plan for achieving the Center's research objectives in the future.

Currently, QUP is under the restructuring process. While critically evaluating the results of projects launched under the previous concept, we are creating a new concept under the leadership of the candidate for the new center director.

Following intensive discussions on a fundamental restructuring of QUP operations, **we have decided to launch five new active research groups focused on quantum sensors and devices**, along with **one group dedicated to broad interdisciplinary applications.** At the same time, six ongoing projects will be retained. The roles of the new groups are clearly defined; five groups are tasked with bridging quantum metrology and particle physics in an integrated framework, while one group plays a key role in horizontal applications to various fields. The six ongoing projects have been preserved because they are aligned with our new vision. We expect them to deliver substantial results within the fixed research term. The theory group plays a crucial role in enhancing synergy and collaboration. Early-stage initiatives with their potential to develop into major scientific breakthroughs are also included.

Below is a new pictorial structure of the planned new QUP research. The areas enclosed in red denote the newly established research groups.



To realize the QUP's vision as "bringing new eyes to humanity", we will establish three research domains: **quantum sensors**, **quantum devices**, and **non-quantum devices**, each of which will be led by newly appointed Principal Investigators (PIs), aiming to deepen and expand the research. From these domains, we will build a framework that simultaneously aspires to reach the summits of fundamental research and to expand broadly into applied fields. While maintaining close interconnections among the three domains, the center will focus on exploring undiscovered particles, detecting ultra-weak gravitational signals, and discovering new laws of nature by developing state-of-the-art measurement techniques and detectors based on quantum sensing technologies for high-precision measurements, while also promoting their application across a wide range of disciplines.

Although QUP originally aimed to promote interdisciplinary research at the time of its establishment, sufficient activities were not implemented toward that goal. Within the vertically segmented research structure, researchers devoted to specific objectives have limited opportunities to recognize the potential for applications in other fields. Therefore, to achieve this goal, we introduce "**mechanisms**" **along with coordinator-type researchers to support them**.

The details will be described in **the revised "Research Center Project" document** to be submitted in May 2025.

6. Host Institution's Concrete Action Plan toward Making its center an autonomous research institute in the second half of the grant period (from the 6th year of the center's operation) (within 2 pages)

Describe the Host Institution's plan for realizing a research system including the allocation of resources (e.g., personnel, infrastructure) that will sustain the Center as a "top world-level research institute" after its WPI funding period ends. To enable this, describe the assets that the Host Institution provide the Center (e.g., expected acquisition of external funding, allocation of personnel, provision of budgets).

KEK established QUP as an autonomous research institute, in contrast to KEK's nature as one of the inter-university research institute corporations, where the opinions of the user community are strongly reflected in the lab's operation.

KEK will continue to position this center as a unique organization that contributes to shaping global research activities and as an independent research entity distinct from other research organizations within KEK. KEK views the activities of the center as a foundation for fostering interdisciplinary integration and promoting organizational reform within KEK itself. By establishing the center as an interdisciplinary research hub, it is anticipated that new research fields will emerge, further enhancing KEK's overall capabilities. **QUP fits seamlessly with KEK's strategic plan to build an International Research Center at the Quantum Frontier.**

At the same time, KEK hopes that QUP will foster synergy across its laboratories. Through the multi-institutional efforts, QUP will serve as a catalyst for strengthening KEK's overall research ecosystem and securing sustainable external support.

To maximize the impact of QUP across KEK and strengthen institutional synergy, we propose the following strategic initiatives:

- **Unification and sharing of detector development infrastructure and interface (IF) platforms**, thereby enhancing the overall development capability across KEK.
- **Implementation of a systematic and integrated approach** to explore weakly coupled regimes and high-sensitivity detection. This enables comprehensive coverage of the relevant parameter space beyond previous methodologies.
- **Shared foundational technologies and coordinated development efforts** will accelerate the transfer of innovation to applied research fields.

These initiatives are designed not only to advance QUP's scientific goals but also to connect with new external funding opportunities. Specific examples include:

- The **Institute of Materials Structure Science (IMSS)** is actively pursuing collaborations on novel material and quantum matter development. QUP's progress in next-generation detection technologies can serve as a foundation for joint research and resource acquisition.
- QUP will work with the **Cryogenics Center** and **Mechanical Engineering Center** to translate foundational technologies into externally funded collaborative projects.
- The **Institute of Particle and Nuclear Studies (IPNS)** and QUP will jointly pursue new funding programs related to quantum technologies and precision measurement

Even after the completion of the WPI program, KEK is committed to providing the necessary support to ensure that the center remains a world-leading research institute. To this end, **KEK will explore optimal ways to reorganize roles, integrating QUP's functions within the broader KEK structure while preserving the center's mission and identity**. **Specifically, KEK plans to position QUP as one of its core research centers, maintaining its distinctive mission and vision**. Toward the goal of establishing the center as a permanent organization after ten years, KEK, under the leadership of its Director-General, will support QUP in building its own financial base. Along with this, KEK will develop and enhance necessary facilities and, from the sixth year onward, will sequentially grant tenure-track positions for senior researchers and technical staff.

Following advice from the Program Committee after QUP's launch, QUP and KEK engaged in extensive discussions on 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, as already described in Section 4-5.

7. Others (within 1 page)

None.

8. Center's Response to Results of FY 2024 Follow-up (including Site Visit Results)

* Describe the Center's response to results of FY 2024 follow-up. Note: If this information has already been provided, please indicate where in the report.

Overall concern with the state of progress of QUP continues this year, necessitating the Program Committee to make a similar set of comments and recommendations. The general view of the Program Committee is that QUP has not yet converged on a convincing strategy to implement its overarching vision. For this reason, in the near term, QUP needs to re-evaluate the vision it put forward at its inception ("to bring new eyes to humanity") and define it more clearly or put forth a new vision which is compelling at the world-leading level in each and all of the WPI missions required by WPI. It is good that KEK has acknowledged these comments by the Program Committee by taking the initiative to make major changes in the QUP.
The institutional strategy to enable this vision should be made clear at all levels. They must develop a new research focus that can only be achieved through fusion of different fields and points of view, so as to make major inroads toward solving some big problem that will be exciting to the world research community.
(Site visit version)
Overall concern with the state of progress of QUP continues this year, necessitating the Working Group to make a similar set of comments and recommendations. The general view of the WG is that QUP has not yet converged on a convincing strategy to implement its overarching vision.
For this reason, in the near term, QUP needs to re-evaluate the vision it put forward at its inception ("to bring new eyes to humanity"), and define it more clearly or put forth a new vision which is compelling, at the world-leading level required by WPI, and consistent with its current and planned activities. The institutional strategy to enable this vision should be made clear at all levels (institutional, cluster, working group, researchers).

KEK and QUP took the recommendations seriously. As described in section 3-2, KEK formed the review to improve the QUP and took the initiative for the reform.
After the resignation of the former QUP director Masashi Hazumi, the acting director, Kazunori Hanagaki, who is also an executive director of KEK, had a close discussion with the KEK director Shoji Asai. Dr. Toshiyuki Azuma has been nominated as the director candidate, who has joined QUP with 40% FTE since April 2025 as the deputy director. The QUP directorate has started restructuring the organization, with close contact with the KEK directorate.

QUP has decided to stop the SpaceTES project, which was the flagship project of QUP, after finding technical and financial difficulties. The systemology section was closed in FY2024, and, instead, the engineering support section was created to strengthen the technical support needed to accelerate the ongoing and new projects.

Currently, QUP is promoting the results of projects launched under the past concept and creating a new concept under the leadership of a candidate for the new center director. Following intensive discussions on a fundamental restructuring of QUP operations, we have decided to launch five new active research groups focused on quantum sensors and devices, along with one group dedicated to broad interdisciplinary applications. At the same time, the ongoing projects are being evaluated, and some of them will be retained. The details on the new projects will be described in **the revised "Research Center Project" Document** to be submitted in May 2025.

As a part of such reform, an intention was expressed by the KEK Director General to move away from the LiteBIRD project. Though this is in line with the Program Committee's comments, it should be kept in mind that any decision involves and affects the international LiteBIRD study efforts outside QUP and a larger international community of CMB scientists.
(Site Visit comment)
It is imperative that plans for the flagship "SpaceTES" project are consolidated urgently in agreement with KEK, JAXA and MEXT, taking into account realistic resource and institutional constraints of QUP and the level of the expertise of QUP staff for space development. It should be kept in mind that any decision involves and affects the international LiteBIRD study efforts outside QUP and a larger international community of CMB scientists.

The "SpaceTES" project is no longer the QUP project after technical and financial difficulties were found. A review committee that assessed the KEK contribution to the LiteBIRD project also pointed these out. The JAXA and KEK management are communicating and collaborating on the process after the QUP's retreat from the LiteBIRD project.

The QUP leadership should have a serious discourse with the KEK leadership to work out a concrete plan for improvement that will reflect the spirit as well as each and all of the requirements of the WPI Program. Moreover, the WPI center must serve as a catalyst for transforming the culture and systems of KEK. KEK should study several successful WPI centers and use that study to pro-actively implement new transformational processes.
(Site Visit comment)
The Working Group recognized in this site visit that the research program of the center does not fully align with the expectations of the host institution KEK. The QUP leadership should have a serious discourse with the KEK leadership to work out a concrete plan for improvement that is fully supported by both sides and that allows the making of significant changes necessary to ensure long-term success of QUP.

As described in the first comment, the new QUP directorate has a close communication with the KEK leadership on the reorganization of the QUP. This is discussed in more detail in the revised **"Research Center Project" Document**, but KEK positions QUP as a unique organization that contributes to shaping global research activities and as an independent research entity distinct from other research organizations within KEK. KEK views the activities of the center as a foundation for fostering interdisciplinary integration and promoting organizational reform within KEK itself. By establishing the center as an interdisciplinary research hub, it is anticipated that new research fields will emerge, further enhancing KEK's overall capabilities. **QUP fits seamlessly with KEK's strategic plan to build an International Research Center at the Quantum Frontier.**

(Site Visit comment)
It is difficult to gauge scientific success of each QUP area from the current way the list of publications is built. The Working Group suggests creating an additional list which contains only those papers where

a full member of QUP has made a significant contribution.

The category-A articles in Appendix 1-3 are papers where a full member of QUP has made a significant contribution.

(Site Visit comment)
The Working Group feels that now is time to focus on strengths and weaknesses of each group's activities and results, and to make clear what exactly is needed for QUP to succeed in a timely way.

As described in the first comment, currently, QUP is promoting the results of projects launched under the past concept and creating a new concept under the leadership of a candidate for the new center director. we have decided to launch five new active research groups focused on quantum sensors and devices, along with one group dedicated to broad interdisciplinary applications. These are described in the revised **"Research Center Project" Document.**

World Premier International Research Center Initiative (WPI)
Appendix 1-1 List of Papers Underscoring Each Research Achievement

* List papers underscoring each research achievement [1] ~ [10] listed in the item 2-1-1 "Research results to date" of 2. "World-Leading Scientific Excellence and Recognition" (up to 20 papers) and provide a description of the significance of each (within 10 lines).
* For each, write the author name(s); year of publication; journal name, volume, page(s), and article title. Any listing order may be used as long as format is the same. If a paper has many authors, underline those affiliated with the Center.
* If a paper has many authors (say, more than 10), all of their names do not need to be listed.
* Place an asterisk (*) in front of those results that could only have been achieved by a WPI center.

[1] Light dark matter search via nitrogen-vacancy (NV) centers in diamond

*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, 83 (2025), DOI:10.1007/JHEP03(2025)083 (arxiv, Feb. 24, 2023 https://arxiv.org/abs/2302.12756)
We present an approach to directly search for light dark matter, such as axion and dark photon, by using magnetometry with nitrogen-vacancy centers in diamonds. This theoretical work came from the synergy effect between particle physics theory researchers and experimental researchers in NV diamond sensing.

*2) S. Chigusa, M. Hazumi, E. D. Herbschleb, Y. Matsuzaki, N. Mizuochi, and K. Nakayama, "Nuclear spin metrology with nitrogen vacancy center in diamonds for exion dark matter detection", Physical Review D 111 (2025), 075028 DOI:10.1103/PhysRevD.111.075028 (arxiv, Aug. 24, 2024 https://arxiv.org/abs/2407.07141)
We proposed an idea to use the nuclear spin of the nitrogen atom at NV centers in diamonds for probing the axion dark matter. The usual magnetometry with the nitrogen spin is not very appealing because of the smallness of the nuclear magnetic moment compared with that of the electron spin. However, axion dark matter generally couples to the nuclear spin and electron spin with (roughly) the same coupling strength and hence nuclear spin magnetometry is beneficial for axion dark matter search. We estimated sensitivity for the axion-nucleon coupling.

[2] New force search via Casimir forces

*3) Y. Ema, M. Hazumi, H. Iizuka, K. Mukaida, and K. Nakayama, "Zero Casimir force in axion electrodynamics and the search for a new force", Physical Review D 108 (2023) 016009 DOI:10.1103/PhysRevD.108.016009
It is known that Casimir forces arise between planar bodies, which are attractive in thermal equilibrium. We theoretically show that Casimir forces can be vanished by introducing Weyl semimetal, and new force sensitivity can be sufficiently improved. This work came from the synergy effect between particle physics theory researchers and an industrial researcher.

[3] Development of new radiation hard detector with CIGS

*4) M. Togawa, S. Fujii, M. Imura, K. Itabashi, T. Isobe, M. Miyahara, J. Nishinaga and H. Okumura, "The CIGS semiconductor detector for particle physics", Journal of Instrumentation 19 (2024) C05042 DOI:10.1088/1748-0221/19/05/C05042
This paper describes beam test of the world's first Cu(In,Ga)Se2 (CIGS) particle detector. CIGS detectors (2 and 5 μm thick) were tested by Xe ion (400 MeV/u, $^{132}Xe^{54+}$) at the HIMAC, and they successfully detecting single Xe ion with a fast response. The output charge is understandable through estimation with the GEANT4 simulation. With 0.6 MGy irradiation by Xe ions, the CIGS output degraded to 50%, but it was recovered to 97% after the heat treatment under 130°C for 2 hours. This marks a significant step in confirming that CIGS semiconductors can serve as particle detectors with recovery features for radiation damage.

*5) K. Itabashi, S. Fujii, M. Imura, T. Isobe, M. Miyahara, J. Nishinaga, H. Okumura and M. Togawa, "Study of radiation tolerance of $Cu(In,Ga)Se_2$ detector", Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1067 (2024) 169637 DOI:10.1016/j.nima.2024.169637
This paper describes the radiation damage recovery mechanism though the irradiation experiments, especially the annealing temperature and time dependences are demonstrated. In the CYRIC experiment, 70 MeV protons with a fluence of 7.5×10^{15} MeV neq/cm^2 were irradiated to CIGS solar cells. After dark annealing at 130 °C for 1 h, a short circuit current density (JSC) recovered from 57% to 85% of the initial state. On the other hand, it took about 34 h for the JSC to recover from 50% to 85% at 90 °C. From these two irradiation

experiments, it appeared that the radiation damage recovery mechanism is effective for the CIGS detector, the amount of recovery having a strong dependence on annealing temperature.

[4] Kamioka Light Dark Matter project

6) R. Anthony-Petersen, … M. Garcia-Sciveres, … B. Suerfu et. al., "Demonstration of the HeRALD Detector Concept", Physical Review D 110 (2024) 072006 DOI:10.1103/PhysRevD.110.072006
This paper demonstrates the basic HeRALD concept and the detection of quantum evaporation signals.

*7) R. Anthony-Petersen,… M. Garcia-Sciveres, …B. Suerfu, et. al., "A Stress Induced Source of Phonon Bursts and Quasiparticle Poisoning," Nature Communications 15 (2024) 6444 DOI:10.1038/s41467-024-50173-8
This paper conclusively tied the low energy excess noise observed in TES detectors to the amount of mechanical stress induced in the substrate by thermal contraction forces. It has been cited by over 40 publications (counting citations of the preprint and of the published paper)

[6] Development of Optical TES and its readout
8) K. Hattori, T. Konno, Y. Miura, S. Takasu, and D. Fukuda, "An optical transition-edge sensor with high energy resolution", Superconductor Science and Technology 35 (2022) 95002 DOI:10.1088/1361-6668/ac7e7b
This paper demonstrates an optical transition-edge sensor (TES) with an outstanding energy resolution of 67 meV at 0.8 eV, achieved by lowering the superconducting transition temperature to 115 mK using an Au/Ti bilayer. Such high energy resolution is essential for detecting faint signals expected in light dark matter searches, where the interaction between dark matter and electrons can release only sub-eV energy. The work also discusses the trade-off between transition temperature and detector response speed, highlighting a path to further improvements. By identifying Johnson noise from readout components as the dominant noise source, the authors provide clear directions for noise reduction.

*9) R. Hayakawa, D. Fukuda, K. Hattori, F. Hirayama, T. Kikuchi, S. Kohjiro, A. Sato, H. Yamamori, "Demonstration of Simultaneous Optical Transition-Edge Sensors Readout Using Microwave SQUID Multiplexer with 5 MHz Flux Ramp Modulation", Journal of Low Temperature Physics 215 (2024) 170-176 DOI:10.1007/s10909-024-03080-7
This paper demonstrates a crucial advancement in the readout of transition-edge sensor (TES) arrays using a microwave SQUID multiplexer (μMUX) with 5 MHz flux ramp modulation. High-resolution, multi-pixel TES readout is essential for light dark matter searches, where detecting sub-eV energy depositions is critical. The authors successfully read out signals from multiple optical TESs simultaneously, achieving single-photon resolution down to 0.46 eV. By addressing the challenge of fast TES signal response, this work enables large-scale TES array implementation, improving both detection efficiency and spatial resolution. This technology is directly applicable to dark matter experiments requiring large sensor arrays with high energy sensitivity.

[6] Solar axion searches

*10) Ryo Ota, Keita Tanaka, Tasuku Hayashi, Rikuta Miyagawa, Yuta Yagi, Noriko Y. Yamasaki and Kazuhisa Mitsuda, "Electro-Thermal Simulation and Evaluation of Transition Edge Sensor X-ray Microcalorimeter with Mushroom-Type Absorber", Journal of Low Temperature Physics, 217, 366-373(2024) DOI:10.1007/s10909-024-03190-2
TES microcalorimeters are operated in a feedback loop that couples thermal and electrical effects on TES. We constructed a 3D FEM simulator to simulate the temperature in the sensor and pulse current as functions of time. It helps us understand the internal behavior of the TES and devise the necessary update of the heat conductance to fabricate Solar axion TES with large absorbers.

*11) Y. Yagi, R. Konno, T. Hayashi, K. Tanaka, N. Y. Yamasaki, K. Mitsuda, R. Sato, M. Saito, T. Homma, Y. Nishida, S. Mori, N. Iyomoto & T. Hara,"Performance of TES X-Ray Microcalorimeters Designed for 14.4-keV Solar Axion Search", Journal of Low Temperature Physics (2023), 211, 255-264, DOI: 10.1007/s10909-023-02942-w,
An evaluation of TES microcalorimeter for Solar axion search is reported.

*12) Yuta Yagi, Tasuku Hayashi, Keita Tanaka, Rikuta Miyagawa, Ryo Ota, Noriko Y. Yamasaki, Kazuhisa Mitsuda, Nao Yoshida, Mikiko Saito, and Takayuki Homma, "Fabrication of A 64-pixel TES Microcalorimeter Array with Iron Absorbers Uniquely Designed for 14.4-keV Solar Axion Search", IEEE Transactions on Applied Superconductivity, 33(5), Art no.2100805, pp.1-5 (2023), DOI:10.1109/TASC.2023.3254488
A fabrication method for a 64-pixel TES array for Solar axion search is described. A new electroplating

technique to attach a pure Fe absorber to the Ti/Au array is introduced.

[7] Development of Cryo CMOS ASICs for Qubit Controller

None

[8] Theory

*13) N. Kitajima, K. Nakayama, "Dark photon dark matter from cosmic strings and gravitational wave background", Journal of High Energy Physics (2023) 68 DOI:10.1007/JHEP08(2023)068
One of the well-motivated dark matter candidates is dark photon, and various experiments are searching for it. With the use of detailed lattice simulation with a super computer, we calculated cosmic abundance of dark photon in a scenario with spontaneously broken dark gauge symmetry, forming cosmic strings which emit dark photon. We find that correct dark matter abundance can be reconciled, while it may leave observable amount of stochastic gravitational waves.

*14) P. Lu, V. Takhistov and G. M. Fuller "Signatures of a High Temperature QCD Transition in the Early Universe", Physical Review Letters 130 (2023) 221002 DOI:10.1103/PhysRevLett.130.221002
While the fundamental strong (QCD) force is well probed in some regions, new quantum fields can result in quark and gluon confinement occurring well above a temperature of ~GeV and also alter the order of the QCD phase transition. The paper identifies a novel connection of such QCD transitions to black holes, enabling astrophysical telescopes to probe new regimes of QCD, which are challenging to explore in laboratories. Intriguingly, the work also identifies potential hints of such novel QCD dynamics around TeV scale. The study establishes a novel link between often unrelated fields of particle QCD physics, black holes, and gravitational waves. The work included QUPIP Lu as an author.

*15) Han Gil Choi, Sunghoon Jung, Philip Lu and Volodymyr Takhistov "Coexistence Test of Primordial Black Holes and Particle Dark Matter from Diffractive Lensing", Physical Review Letters 133 (2024) 101002 DOI:10.1103/PhysRevLett.133.101002
This paper describes an innovative approach to definitively probe scenarios in which DM is composed of a mixture of microscopic particles together with macroscopic (primordial) black holes (PBHs) by exploiting unusual gravitational wave signal patterns from diffractive gravitational lensing effects. This allows to unambiguously search for particle DM halos around PBHs in current and near future experiments. The proposed method utilizes unique frequency-dependent amplitude variations of gravitational waves generated during celestial mergers from gravitational lensing of DM objects. The effect is highly sensitive, and it allows not only directly probing the theory that PBHs coexist with new particles as DM components, but also can establish definitive support for it. The work involved 2 QUPIP interns, Choi and Lu, as authors. QUP made a press release on this paper.

[9] Machine Learning application

*16) A. Badea and J. Montejo Berlingen, "Data-driven and model-agnostic approach to solving combinatorial assignment problems in searches for new physics", Physical Review D 109 (2024) L011702 DOI:10.1103/PhysRevD.109.L011702
The paper describes a novel approach to solving combinatorial assignment problems in particle physics. The correct assignment of decay products to parent particles is achieved in a model-agnostic fashion by introducing a neural network architecture, passwd-abc, which combines a custom layer based on attention mechanisms and dual autoencoders. It is demonstrated how the network, trained purely on background events in an unsupervised setting, is capable of reconstructing correctly hypothetical new particles regardless of their mass, decay multiplicity, and substructure, and produces simultaneously an anomaly score that can be used to efficiently suppress the background.

*17) G. Aad, … D. Bortoletto, et al. (ATLAS Collaboration) "Measurements of WH and ZH production with Higgs boson decays into bottom quarks and direct constraints on the charm Yukawa coupling in 13 TeV pp collisions with the ATLAS detector", Journal of High Energy Physics 2025, 75 (2025) DOI: 10.1007/JHEP04(2025)075 (arxiv, Oct 25, 2024, https://arxiv.org/abs/2410.19611)
This paper describes a study of the Higgs boson decaying into bottom and charm quarks by the ATLAS collaboration at LHC. It is very challenging to identify the Higgs decays to charm quarks. D. Bortoletto and her group led the analysis, especially on the development of ML-based boosted H->bb/cc tagging and flavour-tagging calibration studies. The results are used to set constraints on the charm coupling modifier, resulting in $|\kappa_c| < 4.2$ at 95% confidence level.

*18) G. Aad, … D. Bortoletto, … Y. Nakahama, … M. Togawa, et al. (ATLAS Collaboration) "Search for the nonresonant production of Higgs boson pairs via gluon fusion and vector-boson fusion in the $b^{-}b\tau+\tau-$ final state in proton-proton collisions at $\sqrt{s}$ =13 TeV with the ATLAS detector", Physical Review D 110 (2024) 032012 DOI: 10.1103/PhysRevD.110.032012
This paper describes a search for the nonresonant production of Higgs boson pairs he $HH \rightarrow bb\tau^{+}\tau^{-}$ channel by the ATLAS collaboration at LHC. This decay channel is most sensitive to the search for the Higgs pair production. D. Bortoletto and Y. Nakahama's groups worked together for the analysis, by using the ML technique in the event selection.

[10] Sensor development of the LiteBIRD space mission

*19) C. Raum, B. Westbrook, S. Beckman, T. Elleflot, N. Farias, T. Ghigna, N. Halverson, J. Hubmayr, M. Hazumi, G. Jaehnig, A. T. Lee and A. Suzuki, "Fabrication Process Control to Realize High Yield, Uniform, Repeatable Low-Frequency Detector Arrays for the LiteBIRD CMB Experiment", Journal of Low Temperature Physics 216 (2024) 254-263 DOI:10.1007/s10909-024-03129-7
This paper describes the process flow developed to fabricate the LiteBIRD low frequency telescope detector arrays, covering bands from 34 to 161 GHz. The detector wafer itself has a device side and a sky side. The device side contains the trichroic polarization sensitive sinuous antennae coupled to transition-edge sensor detectors. The sky-side contains the cosmic ray mitigation structure. This paper represents an example of the collaboration between QUP researchers, who have been leading the array design optimization, and affiliated researchers (mostly based at UC Berkeley) and dives into the details of the process control to develop highly reliable TES arrays to meet the stringent requirements of a space mission improving a technology that was originally developed for ground-based applications.

*20) T. de Haan, T. Adkins, M. Hazumi, D. Kaneko, J. Montgomery, G. Smecher, A. Suzuki and Y. Zhou, "Monitoring TES Loop Gain in Frequency Multiplexed Readout", Journal of Low Temperature Physics 216 (2024) 427-435 DOI:10.1007/s10909-024-03174-2
This paper presents a new method for precise monitoring of the loop gain of transition edge sensors (TES) under electrothermal feedback. The measurement is implemented on the ICE DfMux electronics and operates simultaneously with Digital Active Nulling (DAN). It uses one additional bias sinusoid per TES and does not require any additional readout channels. The paper shows results from tests done in the QUP laboratory. Laboratory results show that it can be used to efficiently track the detector loop-gain. The next step is to show that the loop-gain monitor can be used as a reliable tracer of the detector gain during observation. The loop gain monitor has been since implemented on the POLARBEAR 2 experiment (analysis is underway) and it is under study to become an integral part of the baseline calibration strategy for the LiteBIRD satellite. This work was led by QUP researcher with the sensors developed in collaboration with affiliated members from UC Berkeley satellite. This work also involved a recipient of the QUPIP program (Adkins T.)

World Premier International Research Center Initiative (WPI)

Appendix 1-2 List of Papers of Representative of Interdisciplinary Research Activities

* List **up to 10 papers** underscoring each interdisciplinary research activity and give brief accounts (within 10 lines).
* For each, write the author name(s); year of publication; journal name, volume, page(s), and article title. Any listing order may be used as long as format is the same. If a paper has many authors, underline those affiliated with the Center.
* If a paper has many authors (say, more than 10), all of their names do not need to be listed.

1) (Same paper as **App1-1:1**) 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, 83 (2025), DOI:10.1007/JHEP03(2025)083 (arxiv, Feb. 24, 2023 https://arxiv.org/abs/2302.12756)
We present an approach to directly search for light dark matter, such as axion and dark photon, by using magnetometry with nitrogen-vacancy centers in diamonds. This theoretical work came from the synergy effect between particle physics theory researchers and experimental researchers in NV diamond sensing.

2) (Same paper as **App1-1:2**) S. Chigusa, M. Hazumi, E. D. Herbschleb, Y. Matsuzaki, N. Mizuochi, and K. Nakayama, "Nuclear spin metrology with nitrogen vacancy center in diamonds for exion dark matter detection", Physical Review D 111 (2025), 075028 DOI:10.1103/PhysRevD.111.075028 (arxiv, Aug. 24, 2024 https://arxiv.org/abs/2407.07141)
We proposed an idea to use the nuclear spin of the nitrogen atom at NV centers in diamonds for probing the axion dark matter. The usual magnetometry with the nitrogen spin is not very appealing because of the smallness of the nuclear magnetic moment compared with that of the electron spin. However, axion dark matter generally couples to the nuclear spin and electron spin with (roughly) the same coupling strength and hence nuclear spin magnetometry is beneficial for axion dark matter search. We estimated sensitivity for the axion-nucleon coupling.

3) (Same paper as **App1-1:3**) Y. Ema, M. Hazumi, H. Iizuka, K. Mukaida, and K. Nakayama, "Zero Casimir force in axion electrodynamics and the search for a new force", Physical Review D 108 (2023) 016009 DOI:10.1103/PhysRevD.108.016009
It is known that Casimir forces arise between planar bodies, which are attractive in thermal equilibrium. We theoretically show that Casimir forces can be vanished by introducing Weyl semimetal, and new force sensitivity can be sufficiently improved. This work came from the synergy effect between particle physics theory researchers and an industrial researcher.

4) Jiro Nishinaga, Manabu Togawa, Masaya Miyahara, Kosuke Itabashi, Hironori Okumura, Masataka Imura, Yukiko Kamikawa and Shogo Ishizuka, "Annealing effects on Cu(In,Ga)Se_2 solar cells irradiated by high-fluence proton beam", Japanese Journal of Applied Physics 62 (2023) SK1014 DOI:10.35848/1347-4065/acc53b
This paper describes the study of the radiation damage on Cu(In,Ga)Se_2 (CIGS) solar cells in extremely-high-radiation environments and their annealing effects. PI Togawa and his group need a thicker CIGS device to use this material for particle detectors. Results of the radiation damage and recovery of the standard and thicker devices were shown. The comparison of the two devices gave an insight into the annealing mechanism and hence feedback to the original usage: solar cell application.

5) Yu Zhou, Volodymyr Takhistov and Kazuhisa Mitsuda "Unlocking Discovery Potential for Decaying Dark Matter and Faint X-Ray Sources with XRISM" Astrophysical Journal 976 (2024) 238 DOI:10.3847/1538-4357/ad83cf
The work demonstrates that the recently JAXA-launched X-Ray Imaging and Spectroscopy Mission (XRISM) space telescope with powerful X-ray spectroscopy capabilities is particularly well suited to probe decaying DM, such as sterile neutrinos and axion-like particles, in the mass range of a few to tens of keV. The group identified Segue 1 as a remarkably promising target for XRISM/Resolve allowing to probe the underexplored DM parameter window around a few keV and testing DM couplings with a sensitivity that exceeds by two orders existing Segue 1 limits. The study outlines implications for next-generation, higher-resolution detectors. The work exemplifies synergy collaboration between QUP particle theorists and X-ray astronomers.

6) M. Audard, K. Sato *et al.* (XRISM collaboration), "The bulk motion of gas in the core of the Centaurus galaxy cluster", Nature 638, 365–369 (2025). DOI:10.1038/s41586-024-08561-z (Accepted

on December 20, 2024)
This paper describes the work done by QUP senior scientist, prof Kosuke Sato, as the corresponding author, related to the X-ray spectroscopic observations of the Centaurus galaxy cluster with the XRISM satellite. The group found that the hot gas flows along the line of sight relative to the central galaxy, with velocities from 130 km s^{-1} to 310 km s^{-1} within about 30 kpc of the center. This indicates bulk flow consistent with core gas sloshing.

7) T. Yomogida, T. Hashimoto, T. Okumura, S. Yamada, H. Tatsuno, H. Noda, R. Hayakawa, S. Okada, S. Takatori, T. Isobe, T. Hiraki, T. Sato, Y. Toyama, Y. Ichinohe, O. Sekizawa, K. Nitta, Y. Kurihara, S. Fukushima, T. Uruga, Y. Kitatsuji and Y. Takahashi, "Application of transition-edge sensors for micro-X-ray fluorescence measurements and micro-X-ray absorption near edge structure spectroscopy: a case study of uranium speciation in biotite obtained from a uranium mine", Analyst 149 (2024) 2932-2941 DOI:10.1039/d4an00059e
The paper describes an application of transition-edge sensors for micro-X-ray fluorescence measurements and micro-X-ray absorption near edge structure spectroscopy, contributed by the QUP postdoctoral fellow Ryota Hayakawa, with external researchers. The fluorescent X-rays of Uranium Lα1 and Rb K were fully separated by a TES with 50 eV energy resolution at an energy of around 13 keV.

8) T. de Haan, YS. Ting, T. Ghosal, *et al.* "Achieving GPT-4o level performance in astronomy with a specialized 8B-parameter large language model", Scientific Reports 15, 13751 (2025), DOI:10.1038/s41598-025-97131-y (arxiv, Nov. 13, 2024 https://arxiv.org/abs/2411.09012)
The paper describes the authors' development of a domain-specialized natural-language AI assistant tailored for research in astronomy, astrophysics, cosmology, and astronomical instrumentation. Trained on 250,000 paper preprints, along with millions of synthetically-generated question-answer pairs and other astronomical literature, it demonstrates remarkable proficiency on a wide range of questions, performing on par with GPT-4o. This achievement demonstrates the potential of domain specialization in AI, suggesting that focused training can yield capabilities exceeding those of much larger, general-purpose models. AstroSage-Llama-3.1-8B is freely available, enabling widespread access to advanced AI capabilities for astronomical education and research.

World Premier International Research Center Initiative (WPI)
Appendix 1-3 2024 List of Center's Research Results

Refereed Papers
- List only the Center's papers published in 2024. (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 MEXT 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), 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 20), 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.)
- These files do not need to be divided into 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 2024 with significant contributions by QUP scientists.

1. Original Articles

[1] C. Raum et al. "Fabrication Process Control to Realize High Yield, Uniform, Repeatable Low-Frequency Detector Arrays for the LiteBIRD CMB Experiment" Journal of Low Temperature Physics 216 (2024) 254-263 DOI:10.1007/s10909-024-03129-7

[2] T. de Haan et al. "Monitoring TES Loop Gain in Frequency Multiplexed Readout" Journal of Low Temperature Physics 216 (2024) 427-435 DOI:10.1007/s10909-024-03174-2

[3] E. D. Herbschleb, S. Chigusa, R. Kawase, H. Kawashima, M. Hazumi, K. Nakayama and N. Mizuochi "Robust sensing via the standard deviation with a quantum sensor" APL Quantum 1 (2024) 46106 DOI:10.1063/5.0223678

[4] M. Togawa et al. "The CIGS semiconductor detector for particle physics" Journal of Instrumentation 19 (2024) C05042 DOI:10.1088/1748-0221/19/05/C05042

[5] K. Itabashi, S. Fujii, M. Imura, T. Isobe, M. Miyahara, J. Nishinaga, H. Okumura, M. Togawa "Study of radiation tolerance of Cu(In,Ga)Se2 detector" Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1067 (2024) 169637 DOI:10.1016/j.nima.2024.169637

[6] Robin Anthony-Petersen et al. "Demonstration of the HeRALD superfluid helium detector concept" Physical Review D 110 (2024) 072006 DOI:10.1103/PhysRevD.110.072006

[7] Robin Anthony-Petersen et al. "A stress-induced source of phonon bursts and quasiparticle poisoning" Nature Communications 15 (2024) 6444 DOI:10.1038/s41467-024-50173-8

[8] R. Ota et al. "Electro-Thermal Simulation and Evaluation of Transition Edge Sensor X-ray Microcalorimeter with Mushroom-Type Absorber" Journal of Low Temperature Physics 217 (2024) 366-373 DOI:10.1007/s10909-024-03190-2

[9] T. Hayashi et al. "Design and Development of a 224-pixel TES X-Ray Microcalorimeter System for Microanalysis with STEM" Journal of Low Temperature Physics 217 (2024) 341-349 DOI:10.1007/s10909-024-03175-1

[10] R. Hayakawa, D. Fukuda, K. Hattori, F. Hirayama, T. Kikuchi, S. Kohjiro, A. Sato, and H. Yamamori "Demonstration of Simultaneous Optical Transition-Edge Sensors Readout Using Microwave SQUID Multiplexer with 5 MHz Flux Ramp Modulation" Journal of Low Temperature Physics 215 (2024) 170-176 DOI:10.1007/s10909-024-03080-7

[11] Wei-Yu Hu, Kazunori Nakayama, Volodymyr Takhistov and Yong Tang "Gravitational wave probe of Planck-scale physics after inflation" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 856 (2024) 138958 DOI:10.1016/j.physletb.2024.138958

[12] Han Gil Choi, Sunghoon Jung, Philip Lu and Volodymyr Takhistov "Coexistence Test of Primordial Black Holes and Particle Dark Matter from Diffractive Lensing" Physical Review Letters 133 (2024) 101002 DOI:10.1103/PhysRevLett.133.101002

[13] Jason Arakawa, Joshua Eby, Marianna S. Safronova, Volodymyr Takhistov and Muhammad H. Zaheer "Detection of bosenovae with quantum sensors on Earth and in space" Physical Review D 110 (2024) 075007 DOI:10.1103/PhysRevD.110.075007

[14] Taehun Kim, Philip Lu, Danny Marfatia and Volodymyr Takhistov "Regurgitated dark matter" Physical Review D 110 (2024) L051702 DOI:10.1103/PhysRevD.110.L051702

[15] Kåre Fridell, Chandan Hati and Volodymyr Takhistov "Noncanonical nucleon decays as window into light new physics" Physical Review D 110 (2024) L031701 DOI:10.1103/PhysRevD.110.L031701

[16] S. Locke et al. (Super Kamiokande Collaboration) "New methods and simulations for cosmogenic induced spallation removal in Super-Kamiokande-IV" Physical Review D (2024) 032003 DOI:10.1103/PhysRevD.110.032003

[17] Thomas Schwemberger, Volodymyr Takhistov and Tien-Tien Yu "Hunting nonstandard neutrino interactions and leptoquarks in dark matter experiments" Journal of Cosmology and Astroparticle Physics 2024 (2024) 068 DOI:10.1088/1475-7516/2024/11/068

[18] Muping Chen, Graciela B. Gelmini, Philip Lu and Volodymyr Takhistov "Primordial black hole neutrinogenesis of sterile neutrino dark matter" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 852 (2024) 138609 DOI:10.1016/j.physletb.2024.138609

[19] Kaloian D. Lozanov, Misao Sasaki and Volodymyr Takhistov "Universal gravitational waves from interacting and clustered solitons" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 848 (2024) 138392 DOI:10.1016/j.physletb.2023.138392

[20] Muping Chen, Graciela B. Gelmini, Philip Lu and Volodymyr Takhistov "Primordial black hole sterile neutrinogenesis: sterile neutrino dark matter production independent of couplings" Journal of Cosmology and Astroparticle Physics 2024 (2024) 59 DOI:10.1088/1475-7516/2024/07/059

[21] Jason Arakawa, Muhammad H. Zaheer, Joshua Eby, Volodymyr Takhistov and Marianna S.Safronova "Bosenovae with quadratically-coupled scalars in quantum sensing experiments" Journal of High Energy Physics 2024 (2024) 222 DOI:10.1007/JHEP08(2024)222

[22] Anirban Das, Tim Herbermann, Manibrata Sen and Volodymyr Takhistov "Energy-dependent boosted dark matter from diffuse supernova neutrino background" Journal of Cosmology and Astroparticle Physics 2024 (2024) 045 DOI:10.1088/1475-7516/2024/07/045

[23] Y. Kashiwagi et al. (Super-Kamiokande Collaboration) "Performance of SK-Gd’s Upgraded Real-time Supernova Monitoring System" Astrophysical Journal 970 (2024) 93 DOI:10.3847/1538-4357/ad4d8e

[24] William DeRocco, Nolan Smyth and Volodymyr Takhistov "New Light on Dark Extended Lenses with the Roman Space Telescope" Astrophysical Journal Letters 965 (2024) L3 DOI:10.3847/2041-8213/ad3644

[25] Kai Murai and Kazunori Nakayama "Revisiting the minimal Nelson-Barr model" Journal of High Energy Physics 2024 (2024) 98 DOI:10.1007/JHEP11(2024)098

[26] Soichiro Izumine and Kazunori Nakayama "Effects of gravitational particle production on Higgs portal dark matter" Journal of Cosmology and Astroparticle Physics 2024 (2024) 002 DOI:10.1088/1475-7516/2024/08/002

[27] Tomohiro Fujita, Kai Murai, Kazunori Nakayama and Wen Yin "Misalignment production of vector boson dark matter from axion-SU(2) inflation" Journal of Cosmology and Astroparticle Physics 2024 (2024) 007 DOI:10.1088/1475-7516/2024/04/007

[28] Kamil Mudrunka and Kazunori Nakayama "Probing Gauss-Bonnet-corrected inflation with gravitational waves" Journal of Cosmology and Astroparticle Physics 2024 (2024) 069 DOI:10.1088/1475-7516/2024/05/069

[29] So Chigusa, Asuka Ito, Kazunori Nakayama and Volodymyr Takhistov "Effects of finite material size on axion-magnon conversion" Journal of High Energy Physics 2024 (2024) 185 DOI:10.1007/JHEP01(2024)185

[30] Yu Zhou, Volodymyr Takhistov and Kazuhisa Mitsuda "Unlocking Discovery Potential for Decaying Dark Matter and Faint X-Ray Sources with XRISM" Astrophysical Journal 976 (2024) 238 DOI:10.3847/1538-4357/ad83cf

[31] Tran Kim Tuyet, Toshiya Sanami and Bui Tuan Khai "Evaluation of timing and pulse shape analysis method for the measurement of photoneutron energy distribution using commercially available digitizer" IEEE Transactions on Nuclear Science (2024) DOI:10.1109/TNS.2024.3518092

[32] Y. Omiya et al. "Indications of an offset merger in Abell 3667" Astronomy and Astrophysics 689 (2024) A173 DOI:10.1051/0004-6361/202449992

[33] F. Loddo et al "RD53 pixel chips for the ATLAS and CMS Phase-2 upgrades at HL-LHC" Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1067 (2024) 169682 DOI:10.1016/j.nima.2024.169682

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[141] G. Aad et al. (ATLAS collaboration) "Inclusive and differential cross-section measurements of tt¯Z production in pp collisions at s = 13 TeV with the ATLAS detector, including EFT and spin-correlation interpretations" Journal of High Energy Physics 2024 (2024) 163 DOI:10.1007/JHEP07(2024)163

[142] G. Aad et al. (ATLAS collaboration) "Search for charged-lepton-flavor violating $\mu\tau qt$ interactions in top-quark production and decay in pp collisions at $\sqrt{s}$=13 TeV with the ATLAS detector at the LHC" Physical Review D 110 (2024) 012014 DOI:10.1103/PhysRevD.110.012014

[143] G. Aad et al. (ATLAS collaboration) "Search for non-resonant Higgs boson pair production in final states with leptons, taus, and photons in pp collisions at √s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 164 DOI:10.1007/JHEP08(2024)164

[144] G. Aad et al. (ATLAS collaboration) "Measurement of differential cross-sections in tt¯ and tt¯+jets production in the lepton+jets final state in pp collisions at s = 13 TeV using 140 fb−1 of ATLAS data" Journal of High Energy Physics 2024 (2024) 182 DOI:10.1007/JHEP08(2024)182

[145] G. Aad et al. (ATLAS collaboration) "Search for pair-production of vector-like quarks in lepton+jets final states containing at least one b-tagged jet using the Run 2 data from the ATLAS experiment" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 854 (2024) 138743 DOI:10.1016/j.physletb.2024.138743

[146] G. Aad et al. (ATLAS collaboration) "Accuracy versus precision in boosted top tagging with the ATLAS detector" Journal of Instrumentation 19 (2024) P08018 DOI:10.1088/1748-0221/19/08/P08018

[147] G. Aad et al. (ATLAS collaboration) "Search for Nearly Mass-Degenerate Higgsinos Using Low-Momentum Mildly Displaced Tracks in pp Collisions at Formula Presented with the ATLAS Detector" Physical Review Letters 132 (2024) 221801 DOI:10.1103/PhysRevLett.132.221801

[148] G. Aad et al. (ATLAS collaboration) "Search for electroweak production of supersymmetric particles in final states with two τ-leptons in s = 13 TeV pp collisions with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 150 DOI:10.1007/JHEP05(2024)150

[149] G. Aad et al. (ATLAS collaboration) "Measurement of vector boson production cross sections and their ratios using pp collisions at s=13.6 TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 854 (2024) 138725 DOI:10.1016/j.physletb.2024.138725

[150] G. Aad et al. (ATLAS collaboration) "Measurement of jet substructure in boosted Formula Presented events with the ATLAS detector using Formula Presented of 13 TeV Formula Presented collisions" Physical Review D 109 (2024) 112016 DOI:10.1103/PhysRevD.109.112016

[151] G. Aad et al. (ATLAS collaboration) "Combination of searches for Higgs boson decays into a photon and a massless dark photon using pp collisions at s= 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 153 DOI:10.1007/JHEP08(2024)153

[152] G. Aad et al. (ATLAS collaboration) "Measurement of ZZ production cross-sections in the four-lepton final state in pp collisions at s=13.6TeV with the ATLAS experiment" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 855 (2024) 138764 DOI:10.1016/j.physletb.2024.138764

[153] G. Aad et al. (ATLAS collaboration) "Search for new particles in final states with a boosted top quark and missing transverse momentum in proton-proton collisions at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 263 DOI:10.1007/JHEP05(2024)263

[154] G. Aad et al. (ATLAS collaboration) "Search for flavour-changing neutral-current couplings between the top quark and the Higgs boson in multi-lepton final states in 13 TeV pp collisions with the ATLAS detector" European Physical Journal C 84 (2024) 757 DOI:10.1140/epjc/s10052-024-12994-1

[155] G. Aad et al. (ATLAS collaboration) "Observation of electroweak production of W+W− in association with jets in proton-proton collisions at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 254 DOI:10.1007/JHEP07(2024)254

[156] G. Aad et al. (ATLAS collaboration) "Searches for exclusive Higgs boson decays into D∗γ and Z boson decays into D0γ and Ks 0γ in pp collisions at s=13TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 855 (2024) 138762 DOI:10.1016/j.physletb.2024.138762

[157] G. Aad et al. (ATLAS collaboration) "Performance of the ATLAS forward proton Time-of-Flight detector in Run 2" Journal of Instrumentation 19 (2024) P05054 DOI:10.1088/1748-0221/19/05/P05054

[158] G. Aad et al. (ATLAS collaboration) "Search for pair production of higgsinos in events with two Higgs bosons and missing transverse momentum in Formula Presented Formula Presented collisions at the ATLAS experiment" Physical Review D 109 (2024) 112011 DOI:10.1103/PhysRevD.109.112011

[159] G. Aad et al. (ATLAS collaboration) "Beam-induced backgrounds measured in the ATLAS detector during local gas injection into the LHC beam vacuum" Journal of Instrumentation 19 (2024) P06014 DOI:10.1088/1748-0221/19/06/P06014

[160] G. Aad et al. (ATLAS collaboration) "Combination of searches for pair-produced leptoquarks at s=13 TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 854 (2024) 138736 DOI:10.1016/j.physletb.2024.138736

[161] G. Aad et al. (ATLAS collaboration) "Azimuthal Angle Correlations of Muons Produced via Heavy-Flavor Decays in 5.02 TeV Pb+Pb and pp Collisions with the ATLAS Detector" Physical Review Letters 132 (2024) 202301 DOI:10.1103/PhysRevLett.132.202301

[162] G. Aad et al. (ATLAS collaboration) "Improving topological cluster reconstruction using calorimeter cell timing in ATLAS" European Physical Journal C 84 (2024) 455 DOI:10.1140/epjc/s10052-024-12657-1

[163] G. Aad et al. (ATLAS collaboration) "Statistical Combination of ATLAS Run 2 Searches for Charginos and Neutralinos at the LHC" Physical Review Letters 133 (2024) 031802 DOI:10.1103/PhysRevLett.133.031802

[164] G. Aad et al. (ATLAS collaboration) "The ATLAS trigger system for LHC Run 3 and trigger performance in 2022" Journal of Instrumentation 19 (2024) P060229 DOI:10.1088/1748-0221/19/06/P06029

[165] G. Aad et al. (ATLAS collaboration) "A search for top-squark pair production, in final states containing a top quark, a charm quark and missing transverse momentum, using the 139 fb−1 of pp collision data collected by the ATLAS detector" Journal of High Energy Physics 2024 (2024) 250 DOI:10.1007/JHEP07(2024)250

[166] G. Aad et al. (ATLAS collaboration) "The ATLAS experiment at the CERN Large Hadron Collider: a description of the detector configuration for Run 3" Journal of Instrumentation 19 (2024) P05063 DOI:10.1088/1748-0221/19/05/P05063

[167] G. Aad et al. (ATLAS collaboration) "Search for quantum black hole production in lepton + jet final states using proton-proton collisions at vs = 13 TeV with the ATLAS detector" Physical Review D 109 (2024) 032010 DOI:10.1103/PhysRevD.109.032010

[168] G. Aad et al. (ATLAS collaboration) "Combination of searches for heavy spin-1 resonances using 139 fb−1 of proton-proton collision data at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 118 DOI:10.1007/JHEP04(2024)118

[169] G. Aad et al. (ATLAS collaboration) "Search for the decay of the Higgs boson to a Z boson and a light pseudoscalar particle decaying to two photons" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 850 (2024) 138536 DOI:10.1016/j.physletb.2024.138536

[170] G. Aad et al. (ATLAS collaboration) "Probing the CP nature of the top–Higgs Yukawa coupling in tt¯H and tH events with H→bb¯ decays using the ATLAS detector at the LHC" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 849 (2024) 138469 DOI:10.1016/j.physletb.2024.138469

[171] G. Aad et al. (ATLAS collaboration) "Search for a CP-odd Higgs boson decaying into a heavy CP-even Higgs boson and a Z boson in the $\ell+\ell-t\bar{t}$ and $\nu\bar{\nu}b\bar{b}$ final states using 140 fb−1 of data collected with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 197 DOI:10.1007/JHEP02(2024)197

[172] G. Aad et al. (ATLAS collaboration) "Observation of Wγγ triboson production in proton-proton collisions at s=13 TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 848 (2024) 138400 DOI:10.1016/j.physletb.2023.138400

[173] G. Aad et al. (ATLAS collaboration) "Differential cross-section measurements of the production of four charged leptons in association with two jets using the ATLAS detector" Journal of High Energy Physics 2024 (2024) 4 DOI:10.1007/JHEP01(2024)004

[174] G. Aad et al. (ATLAS collaboration) "Electron and photon energy calibration with the ATLAS detector using LHC Run 2 data" Journal of Instrumentation 19 (2024) P02009 DOI:10.1088/1748-0221/19/02/P02009

[175] G. Aad et al. (ATLAS collaboration) "Search for pair production of squarks or gluinos decaying via sleptons or weak bosons in final states with two same-sign or three leptons with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 107 DOI:10.1007/JHEP02(2024)107

[176] G. Aad et al. (ATLAS collaboration) "Studies of new Higgs boson interactions through nonresonant HH production in the $b\bar{b}\gamma\gamma$ final state in pp collisions at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 66 DOI:10.1007/JHEP01(2024)066

[177] G. Aad et al. (ATLAS collaboration) "Measurement of the Centrality Dependence of the Dijet Yield in p+Pb Collisions at √sNN=8.16 TeV with the ATLAS Detector" Physical Review Letters 132 (2024) 102301 DOI:10.1103/PhysRevLett.132.102301

[178] G. Aad et al. (ATLAS collaboration) "Performance and calibration of quark/gluon-jet taggers using 140 fb−1 of pp collisions at √s = 13 TeV with the ATLAS detector" Chinese Physics C 48 (2024) 023001 DOI:10.1088/1674-1137/acf701

[179] G. Aad et al. (ATLAS collaboration) "Search for New Phenomena in Two-Body Invariant Mass Distributions Using Unsupervised Machine Learning for Anomaly Detection at √s = 13 TeV with the ATLAS Detector" Physical Review Letters 132 (2024) 081801 DOI:10.1103/PhysRevLett.132.081801

[180] G. Aad et al. (ATLAS collaboration) "Search for top-philic heavy resonances in pp collisions at s=13 TeV with the ATLAS detector" European Physical Journal C 84 (2024) 157 DOI:10.1140/epjc/s10052-023-12318-9

[181] G. Aad et al. (ATLAS collaboration) "A precise measurement of the Z-boson double-differential transverse momentum and rapidity distributions in the full phase space of the decay leptons with the ATLAS experiment at s=8 TeV" European Physical Journal C 84 (2024) 315 DOI:10.1140/epjc/s10052-024-12438-w

[182] G. Aad et al. (ATLAS collaboration) "Search for non-resonant Higgs boson pair production in the 2b+2ℓ+ETmiss final state in pp collisions at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 37

DOI:10.1007/JHEP02(2024)037

[183] G. Aad et al. (ATLAS collaboration) "Study of High-Transverse-Momentum Higgs Boson Production in Association with a Vector Boson in the qqbb Final State with the ATLAS Detector" Physical Review Letters 132 (2024) 131802
DOI:10.1103/PhysRevLett.132.131802

[184] G. Aad et al. (ATLAS collaboration) "A search for R-parity-violating supersymmetry in final states containing many jets in pp collisions at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 3
DOI:10.1007/JHEP05(2024)003

[185] G. Aad et al. (ATLAS collaboration) "Measurement of the tt¯ cross section and its ratio to the Z production cross section using pp collisions at s=13.6 TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 848 (2024) 138376 DOI:10.1016/j.physletb.2023.138376

[186] G. Aad et al. (ATLAS collaboration) "Observation of WZγ Production in pp Collisions at sqrt[s]=13 TeV with the ATLAS Detector" Physical Review Letters 132 (2024) 021802 DOI:10.1103/PhysRevLett.132.021802

[187] G. Aad et al. (ATLAS collaboration) "Study of Z→llγ decays at s = 8 TeV with the ATLAS detector" European Physical Journal C 84 (2024) 195
DOI:10.1140/epjc/s10052-024-12471-9

[188] G. Aad et al. (ATLAS collaboration) "Evidence for the Higgs boson decay to a Z boson and a photon at the LHC" Physical Review Letters 132 (2024) 021803
DOI:10.1103/PhysRevLett.132.021803

[189] G. Aad et al. (ATLAS collaboration) "Measurement of the production cross-section of J/ψ and ψ(2S) mesons in pp collisions at s=13 TeV with the ATLAS detector" European Physical Journal C 84 (2024) 169 DOI:10.1140/epjc/s10052-024-12439-9

[190] G. Aad et al. (ATLAS collaboration) "Search for resonant production of dark quarks in the dijet final state with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 128 DOI:10.1007/JHEP02(2024)128

[191] G. Aad et al. (ATLAS collaboration) "Search for new phenomena with top-quark pairs and large missing transverse momentum using 140 fb−1 of pp collision data at s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 139
DOI:10.1007/JHEP03(2024)139

[192] G. Aad et al. (ATLAS collaboration) "Measurement and interpretation of same-sign W boson pair production in association with two jets in pp collisions at √s = 13 TeV with the ATLAS detector" Journal of High Energy Physics 2024 (2024) 26
DOI:10.1007/JHEP04(2024)026

[193] G. Aad et al. (ATLAS collaboration) "Search for non-resonant production of semi-visible jets using Run 2 data in ATLAS" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 848 (2024) 138324
DOI:10.1016/j.physletb.2023.138324

[194] G. Aad et al. (ATLAS collaboration) "Search for the Zγ decay mode of new high-mass resonances in pp collisions at s=13 TeV with the ATLAS detector" Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics 848 (2024) 138394

DOI:10.1016/j.physletb.2023.138394

[195] G. Aad et al. (ATLAS collaboration) "Measurement of the H→ γγ and H→ ZZ*→ 4 ℓ cross-sections in pp collisions at √s=13.6 TeV with the ATLAS detector" European Physical Journal C 84 (2024) 78 DOI:10.1140/epjc/s10052-023-12130-5

2. Review Articles

[196] Maurice Garcia-Sciveres "Discussion of future directions of silicon readout integrated circuits" Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1064 (2024) 169402 DOI:10.1016/j.nima.2024.169402

[197] Maurice Garcia-Sciveres "Solid State Tracking Detectors" Instrumentation and Techniques in High Energy Physics (2024) 45-70 DOI:10.1142/9789819801107_0002

[198] D.V. Berlea et al. "Depletion depth studies with the MALTA2 sensor, a depleted monolithic active pixel sensor" Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 1063 (2024) 169262 DOI:10.1016/j.nima.2024.169262

[199] ATLAS collaboration "Characterising the Higgs boson with ATLAS data from the LHC Run-2" Physics Reports (2024) DOI:10.1016/j.physrep.2024.11.001

3. Proceedings

[200] F. Haslbeck et al. "The ATLAS Alarm Helper" EPJ Web of Conferences 295 (2024) 02014 DOI:10.1051/epjconf/202429502014

[201] R. Akizawa et al. (LiteBIRD Collaboration) "Development status of the cryogenic holder mechanism for LiteBIRD LFT PMU" Proceedings of SPIE - The International Society for Optical Engineering 13102 (2024) 131021X DOI:10.1117/12.3019552

[202] M. Kusama et al. "Breadboard model assembly and characterization of a sapphire achromatic half-wave plate for LiteBIRD low-frequency telescope" Proceedings of SPIE - The International Society for Optical Engineering 13102 (2024) 131020A DOI:10.1117/12.3019752

[203] B. Prasad et al. "The Simons Observatory: Design, Fabrication and Characterization of Low Frequency Detectors" Proceedings of SPIE - The International Society for Optical Engineering 13102 (2024) 131020X DOI:10.1117/12.3020813

[204] N. Kohara et al. "Extremely large optical space telescope comprising formation-flying ultra-small satellites: proof-of-concept experiments of a diffractive optical system on the ground" Proceedings of SPIE - The International Society for Optical Engineering 13100 (2024) 1310077 DOI:10.1117/12.3018728

[205] Y. Matsuda et al. "Extremely large optical space telescope comprising formation-flying ultra-small satellites: science requirements and telescope concept" Proceedings of SPIE - The International Society for Optical Engineering 13092 (2024) 130926O DOI:10.1117/12.3018148

[206] Y. Ezoe et al. "Status of geospace X-ray imager mission (GEO-X)" Proceedings of SPIE - The International Society for Optical Engineering 13093 (2024) 130932E

DOI:10.1117/12.3018746

[207] M. Numazawa et al. "Development of ultra-lightweight X-ray telescopes fabricated with MEMS technologies for GEO-X" Proceedings of SPIE - The International Society for Optical Engineering 13093 (2024) 130937E DOI:10.1117/12.3020669

[208] R. Besuner et al. "CMB-S4 Systems Engineering" Proceedings of SPIE - The International Society for Optical Engineering 13099 (2024) 130992N DOI:10.1117/12.3017697

[209] M. Leitner et al. "Project Overview of the Stage-4 Cosmic Microwave Background Experiment (CMB-S4)" Proceedings of SPIE - The International Society for Optical Engineering 13094 (2024) 130941N DOI:10.1117/12.3018095

4. Other English articles

None

World Premier International Research Center Initiative (WPI)
Appendix1-4　List of the Cooperative Research Agreements with Overseas Institutions

*Prepare the information below during the period from the beginning of the Center through March 2025.

1. Counterpart of an Agreement: University of California, Berkeley
   Name of an Agreement: AGREEMENT FOR JOINT OPERATION OF THE QUP SATELLITE FACILITY AT UCB
   Dates of an Agreement: December 1, 2022
   Summary of an Agreement:
   QUP and the University of California, Berkeley Physics division (UCBP) coordinate the QUP satellite facility at UCBP and conduct joint interdisciplinary research to develop new methodologies by integrating particle physics, astrophysics, condensed matter physics, measurement science, and systems science.

2. Counterpart of an Agreement: Ernest Orlando Lawrence Berkeley National Laboratory
   Name of an Agreement: Strategic Partnership Project Agreement Between Lawrence Berkeley National Laboratory (LBNL) and KEK
   Dates of an Agreement: October 27, 2023
   Summary of an Agreement:
   The agreement is to design a superconducting bolometer detector with Transition Edge Sensor (TES) for Cosmic Microwave Background experiments, at LBNL
   The Agreement was terminated by the end of 2024 as QUP stopped the development of the LiteBIRD sensor.

3. Counterpart of an Agreement: Nicolaus Copernicus Academy NCA, Poland
   Name of an Agreement: Agreement on Collaborative Work between QUP and NCA
   Dates of an Agreement: December 21, 2023
   Summary of an Agreement:
   QUP and NCA share research on the observation of the cosmic microwave background (CMB) with the international satellite experiment called "LiteBIRD".

4. Counterpart of an Agreement: The TESSERACT Collaboration (International collaboration, the head contact is in UC Berkeley, USA)
   Name of an Agreement: Memorandum of Understanding between the TESSERACT Collaboration and QUP
   Dates of an Agreement: July 13, 2024
   Summary of an Agreement:
   The goal of the MOU is to operate a payload developed by the HeRALD group in the Kamioka setup, taking advantage of a window of opportunity in the development schedule of the QUP-Kamioka Light Dark Matter Project.

World Premier International Research Center Initiative (WPI)
Appendix 1-5
Major Awards, Invited Lectures, Plenary Addresses (etc.) (within 2 pages)

*Prepare the information below during the period from the start of the center through March 2025.

1. Major Awards

*List main internationally-acclaimed awards received/unofficially announced in order from the most recent.
*For each, write the recipient's name, the name of award, and the date issued.
In case of multiple recipients, underline those affiliated with the center.

Date	Recipient's name	Name of award
Jan 2024	Daniela Bortoletto	OBE -Officer of the Order of the British Empire
Feb 2023	Nanae Taniguchi	JPS Fumiko Yonezawa Memorial Award
Feb 2023	Masashi Hazumi	Member of the Copernican Academy in Poland

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

*List up to 20 main presentations in order from most recent.
*For each, write the lecturer/presenter's name, presentation title, conference name and date(s)

Date(s)	Lecturer/Presenter's name	Presentation title	Conference name
Mar 24 - 27, 2025	Volodymyr Takhistov	New Probes of Fundamental Physics in Diffuse Astrophysical Backgrounds	UCLA Dark Matter 2025
Mar 24 - 27, 2025	Maurice Garcia-Sciveres	The new Cryolab at Kamioka	UCLA Dark Matter 2025
Dec 3-5, 2024	Kaori Hattori	Development of Optical Transition-Edge Sensors	the 37th International Superconductivity Symposium, ISS 2024
Nov 18-22, 2024	Kosuke Itabashi	Development of high radiation tolerance detector with CIGS	Pixel2024
Jun 17 – Jul 19, 2024	Volodymyr Takhistov	From Neutrinos to Multimessenger Targets for Discovering New Quantum Fields	Center for Theoretical Underground Physics and Related Areas (CETUP* 2024)
Jun 5-10, 2024	Tijmen de Haan	The LiteBIRD payload module featuring state-of-the-art technologies for precision CMB measurements	SPIE Astronomical Telescopes + Instrumentation
Mar 14-15, 2024	Hideo Iizuka	Control of equilibrium and non-equilibrium Casimir forces	The 15th International Workshop on Fundamental Physics Using Atoms (FPUA2024)
Mar 4-7, 2024	Louis Vaslin	Anomaly Detection algorithms applied to the Quality Control of detector components	AISSAI Anomaly Detection Workshop
Nov 27 - Dec 1, 2023	Daniela Bortoletto	Detector R&D: tracking detectors and particle ID	The 13th ICFA seminar on "Future

			Perspectives in High Energy Physics”
Jul 23-28, 2023	Tommaso Ghigna	Design and optimization of the lowest frequency pixels of LiteBIRD Low-Frequency Telescope	The 20th International Conference on Low Temperature Detectors
Jul 23-28, 2023	Suerfu Burkhant	The TESSERACT project and progress toward light dark matter direct detection using superfluid helium-4	The 20th International Conference on Low Temperature Detectors
Jul 17-21, 2023	Yu Nakahama	Probing the nature of electroweak symmetry breaking with Higgs boson pairs in ATLAS	The 31st Lepton Photon conference
Jun 25-29, 2023	Manabu Togawa	The CIGS semiconductor detector for particle physics	24th International Workshop On Radiation Imaging Detectors
Jun 12-16, 2023	Masashi Hazumi	Primordial cosmology and fundamental physics with LiteBIRD	From the Galaxy to the Big-Bang
Mar 27-30, 2023	Masaya Hasegawa	Simons array and Simons Observatory; probing cosmic inflation and particle physics from Chile	International Conference on the Physics of the Two Infinities
Feb 22-24, 2023	Maurice Garcia-Sciveres	HEP and QIS	P5 Town Hall at LBNL
Feb 22-24, 2023	Masashi Hazumi	LiteBIRD	P5 Town Hall at LBNL
Nov 14-18, 2022	Yuji Chinone	The past, present, and future of the search for primordial gravitational waves from cosmic inflation with CMB experiments in the Atacama desert and space	The 9th Korea- Japan Workshop on Dark Energy
Oct 31 - Nov 4, 2022	Kaori Hattori	An optical transition-edge sensor with high energy resolution	Single Photon Workshop 2022
February 8, 2022	Masashi Hazumi	“QUP Overview and "Project Q”	KEK IPNS-IMSS-QUP Joint workshop

World Premier International Research Center Initiative (WPI)
Appendix 2 FY 2024 List of Principal Investigators

NOTE:

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

*In the case of researcher(s) not listed in the latest report, attach a "Biographical Sketch of a New Principal Investigator"(Appendix 2a).

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

<Results at the end of FY2024> **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
Daniela Bortoletto	66	University of Oxford, Professor, Head of Particle Physics	PhD, Physics	20	2021/10/1	Mainly at Oxford University and joins videoconference meetings (PI meeting/seminar (~every week)) and occasional meetings with the director (once a month)) . Stays in the center for 1 week each in August and December.	Regular Contributions via videoconference. Accept an internship graduate student in Oxford.
Mauricio A. Garcia-Sciveres	58	Lawrence Berkeley National Laboratory, Senior Scientist	PhD, Physics	20	2021/10/1	Mainly stays at LBNL and joins videoconference meetings (PI meeting/seminar (~every week) and occasional meetings with the director (once a month)). As the leader of the Kamioka Lite dark matter project, he visited several times a year to QUP and Kamioka.	Regular Contributions via videoconference. Operation of the QUP Berkeley satellite, where the sensor development of the SpaceTES project took place.
Masaya Hasegawa	46	KEK,IPNS, Associate Professor	PhD, Physics	70	2021/10/1	Stays at the center.	
Kaori Hattori	43	National Institute of Advanced Industrial Science and Technology (AIST), Research Institute for Physical Measurement, Senior Researcher and KEK,QUP, Associate Professor	PhD, Physics	40	2021/10/1	Stays at the center for 40% to participates in the Center's activities as PI. Joins videoconference meetings from another institution.	
Hideo Iizuka	52	Toyota Central R&D Labs., Inc., Senior Fellow and KEK,QUP, Professor	Doctor of Engineering	40	2021/10/1	Stays at the Center for ~40% to participate in the Center's activities. Stays at the Toyota Satellite time-to-time for the QUP research activities.	

Adrian Tae-Jin Lee	60	University of California, Berkeley, Professor	PhD, Physics	50	2021/10/1	Stays at the Berkeley satellite. Joins videoconference meetings (PI meeting/seminar (~every week), steering committee meeting (every month), Flagship project meeting (every week) and occasional meetings with the director (every week)) from the satellite. One week stay in December.	Regular Contributions via videoconference. Accepted an internship Phd student (QUPIP) to the Berkeley satellite for 2 months. Sent a PhD student to the center for the internship program (QUPIP) for 2 months.
Masaya Miyahara	44	KEK,IPNS, Associate Professor	Doctor of Engineering, ASIC design	70	2021/10/1	Stays at the center.	
Yu Nakahama	43	KEK,IPNS, Associate Professor	PhD, Physics	70	2021/10/1	Stays at the center.	
Kazunori Nakayama	42	Tohoku University, Graduate School of Science and Faculty of Science, Associate Professor	PhD, Physics	30	2021/10/1	Stays in Tohoku university and joins videoconference meetings (PI meeting/seminar (~every week) and occasional meetings with the director (a few in a month)) . Came to the center several times for research discussions and workshops.	
Nanae Taniguchi	45	KEK,IPNS, Associate Professor	PhD, Physics	70	2021/10/1	Stays at the center.	
Manabu Togawa	46	KEK,IPNS, Associate Professor	PhD, Physics	70	2021/10/1	Stays at the center.	
Noriko Yamasaki	58	Japan Aerospace Exploration Agency (JAXA), Institute of Space and Astronautical Science (ISAS), Professor	PhD, Physics	20	2021/10/1	Stays at the ISAS satellite and joins videoconference meetings (PI meeting/seminar (~every week) and occasional meetings with the director (once a month)). Several visits to the center.	
Volodymyr Takhistov	36	KEK,QUP, Associate Professor	PhD, Physics	100	2024/4/1	Stays at the center.	
Hiroki Akamatsu	40	KEK,QUP, Associate Professor	PhD, Physics	100	2025/3/1	Stays at the center.	

Principal investigators unable to participate in project in FY 2024

Name	Affiliation (Position title, department, organization)	Starting date of project participation	Reasons	Measures taken
Masashi Hazumi	Professor, QUP, KEK	2021 December 16	Resignition of QUP director and PI on November 30, 2024.	

Appendix 3-1 FY 2024 Records of Center Activities

1. Researchers and other center staff

1-1. 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 2024	Final goal (Date: April, 2025)
Researchers from within the host institution	6	9	8
Researchers invited from overseas	3	3	3
Researchers invited from other Japanese institutions	4	2	2
Total principal investigators	13	14	13

b) Total members

	At the beginning of project		At the end of FY 2024		Final goal (Date: April, 2025)	
	Number of persons	%	Number of persons	%	Number of persons	%
Researchers	15		40		67	
Overseas researchers	3	20	14	35	27	40
Female researchers	5	33	7	18	24	36
Principal investigators	13		14		13	
Overseas PIs	3	23	4	29	3	23
Female PIs	5	38	5	36	5	38
Other researchers	2		15		14	
Overseas researchers	0	0	4	27	4	29
Female researchers	0	0	0	0	4	29
Postdocs	0		11		40	
Overseas postdocs	0	0	6	55	20	50
Female postdocs	0	0	2	18	15	38
Research support staffs	0		10		20	
Administrative staffs	3		25		25	
Total number of people who form the "core" of the research center	18		75		112	

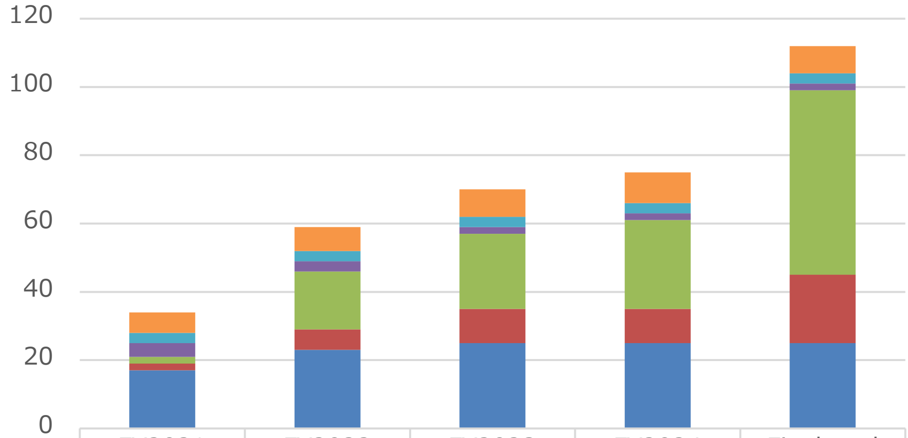
	At the beginning of project		At the end of FY 2024		Final goal (Date: April, 2025)	
	Number of persons	%	Number of persons	%	Number of persons	%
Doctoral students	0		10		15	
Employed	0	-	7	70.0	15	100.0

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

World Premier International Research Center Initiative (WPI)
Appendix 3-2　Annual Transition in the Number of Center Personnel

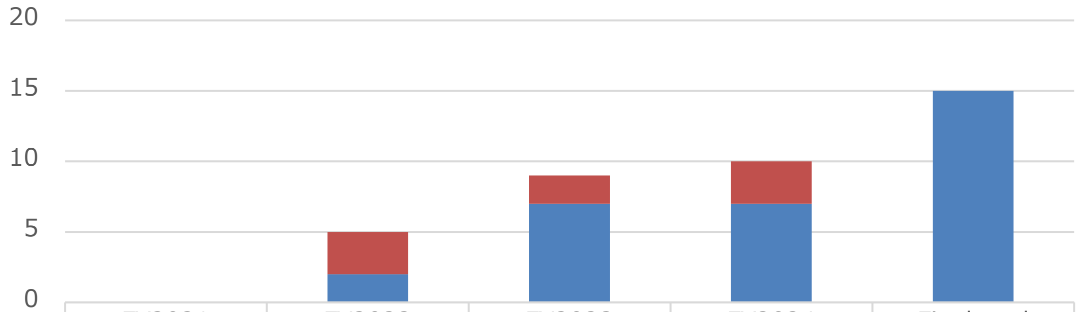
*Make a graph of the annual transition in the number of center personnel since the start of project.

Transition of Personnel



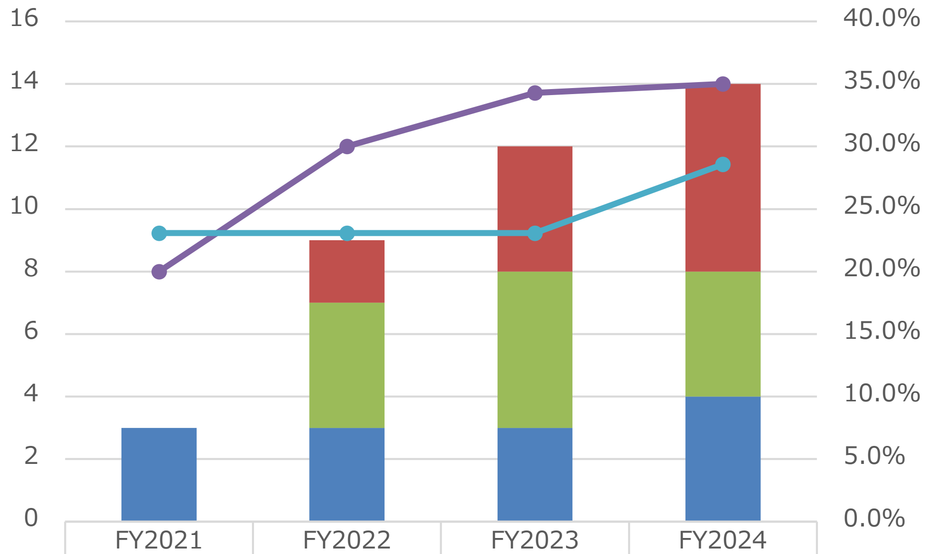
	FY2021	FY2022	FY2023	FY2024	Final goal
PI : Researchers from within host institution	6	7	8	9	8
PI : Researchers invited from abroad	3	3	3	3	3
PI : Researchers invited from other Japanese institutions	4	3	2	2	2
Other researchers (incl. postdocs)	2	17	22	26	54
Research support staffs	2	6	10	10	20
Administrative staffs	17	23	25	25	25

Doctoral students



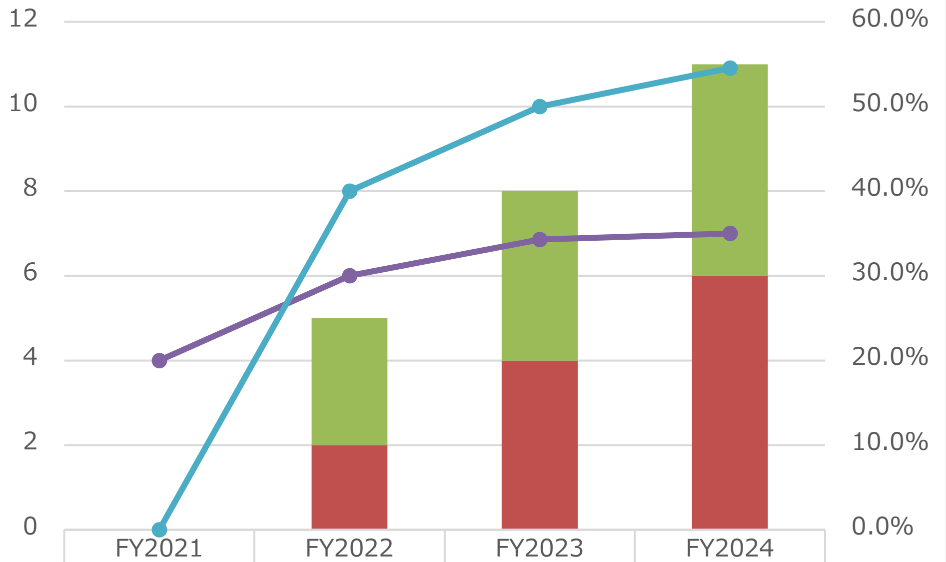
	FY2021	FY2022	FY2023	FY2024	Final goal
Not employed	0	3	2	3	0
Employed	0	2	7	7	15

Number/Ratio of Overseas Researchers



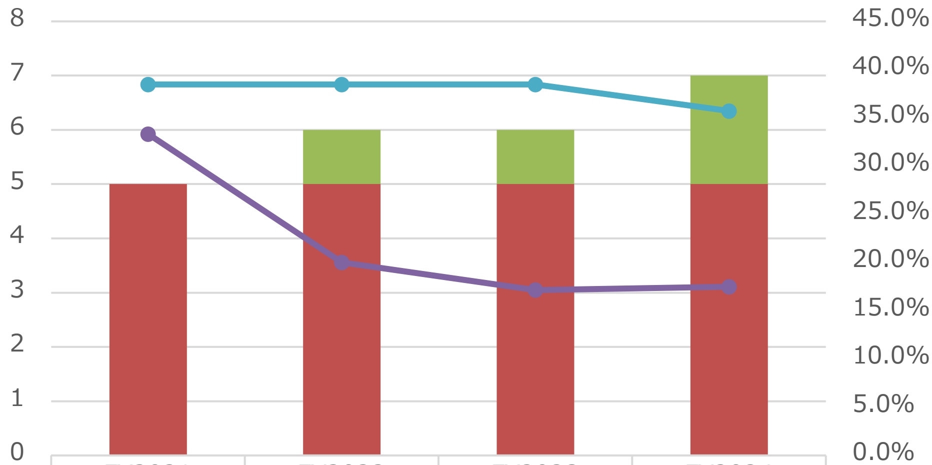
	FY2021	FY2022	FY2023	FY2024
Overseas postdocs	0	2	4	6
Overseas non-PI researchers	0	4	5	4
Overseas PIs	3	3	3	4
Ratio of oversea researchers	20.0%	30.0%	34.3%	35.0%
Ratio of oversea PIs	23.1%	23.1%	23.1%	28.6%

Number/Ratio of Overseas Postdocs



	FY2021	FY2022	FY2023	FY2024
Japanese postdocs	0	3	4	5
Overseas postdocs	0	2	4	6
Ratio of oversea researchers	20.0%	30.0%	34.3%	35.0%
Ratio of overseas postdocs	0.0%	40.0%	50.0%	54.5%

Number/Ratio of Female Researchers



	FY2021	FY2022	FY2023	FY2024
Female postdocs	0	1	1	2
Female non-PI researchers	0	0	0	0
Female PIs	5	5	5	5
Ratio of female researchers	33.3%	20.0%	17.1%	17.5%
Ratio of female PIs	38.5%	38.5%	38.5%	35.7%

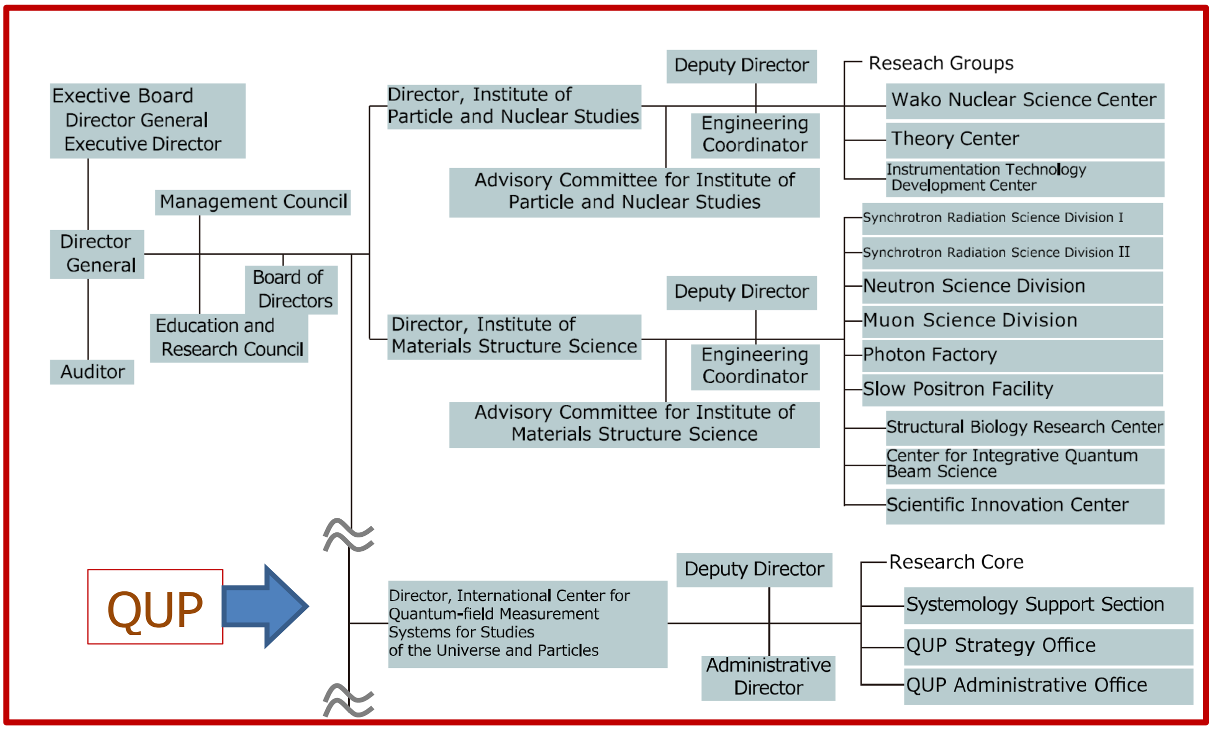
World Premier International Research Center Initiative (WPI)
Appendix 3-3 Diagram of Management System

- Diagram the center's management system and its position within the host institution in an easily understood manner.
- If any 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. The details are described in section 3-2-1.



[Changes in the KEK and QUP organization in FY2024]

There were significant changes in the QUP organization and the KEK management in FY2024.

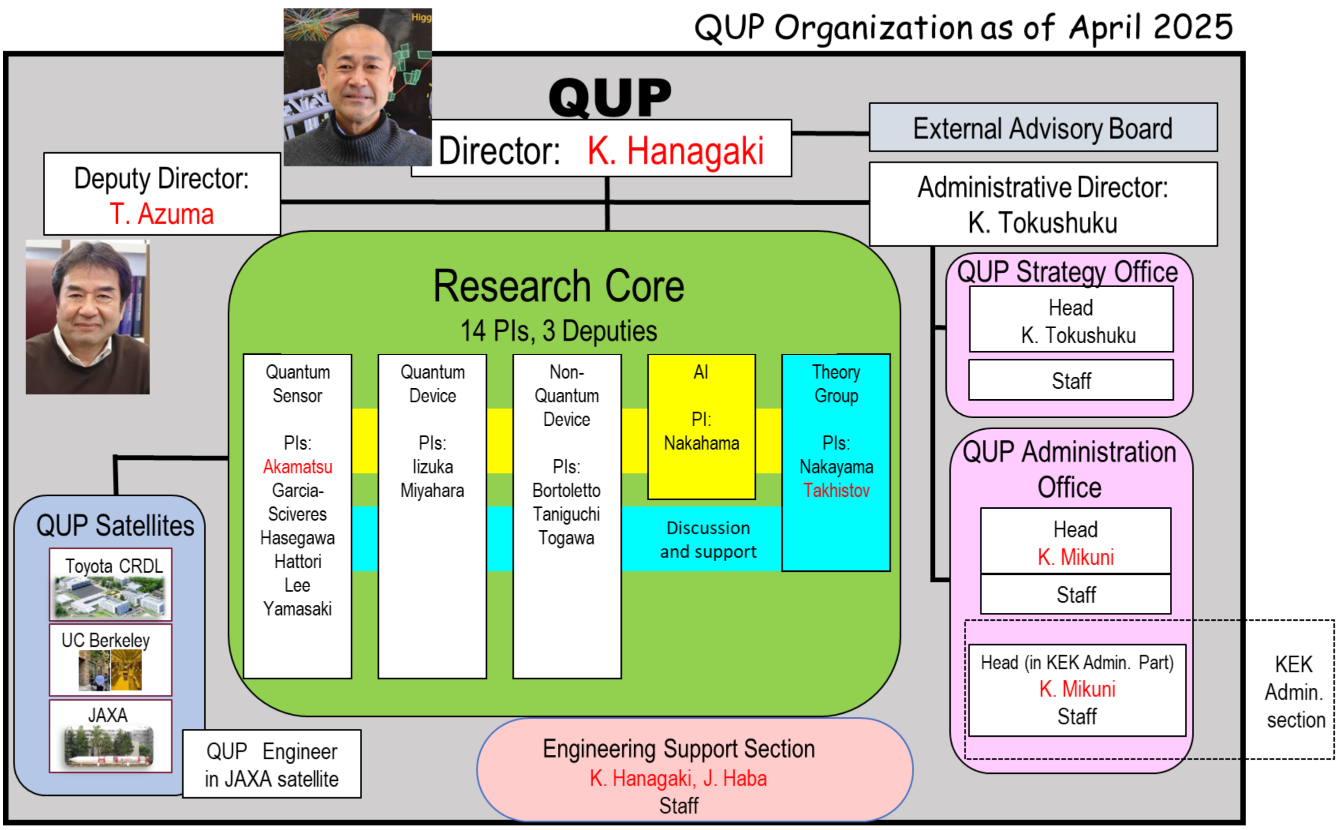
- In FY2024, **KEK started with the new director general, Dr. Shoji Asai**. He appointed the QUP deputy director, **Dr. Kazunori Hanagaki, as one of the KEK executive directors**. Dr. Hanagaki stepped down as the deputy director of QUP. The QUP director, Prof. Masashi Hazumi, appointed **Prof. Kazuhisa Mitsuda as a new deputy director of QUP**. The QUP documents of "Host institute commitment" and "Research Center Project" were updated to reflect these changes. QUP **appointed a new PI, Volodymyr Takhistov,** as one of the leaders in the QUP theory section. Later, in February 2025, **Prof. Hiroki Akamatsu** was appointed as another new PI. He is leading the low-temperature group.

KEK DG seriously took the strong recommendations from the WPI program committee and the working group on the status of QUP. He formed review committees to assess the QUP's progress and, separately, to assess the KEK's contribution to the LiteBIRD project. Following the outcome of the reviews, the QUP director, Masashi Hazumi, resigned as the director and PI of QUP on December 1. With the consultation with WPI PD, DPD, PO, and MEXT, KEK DG **appointed Kazunori Hanagaki as the acting director**. It was decided that the scope of the QUP should be drastically revised with the new director, and the proposal should be made to the program committee. The preparation started with the close contact with the KEK DG. **Dr. Toshiyuki Azuma of RIKEN is nominated as the candidate of the new QUP director.**

Following these actions, the research projects and organization of the QUP are undergoing significant changes. Already by the end of FY2024, the following decisions were made:

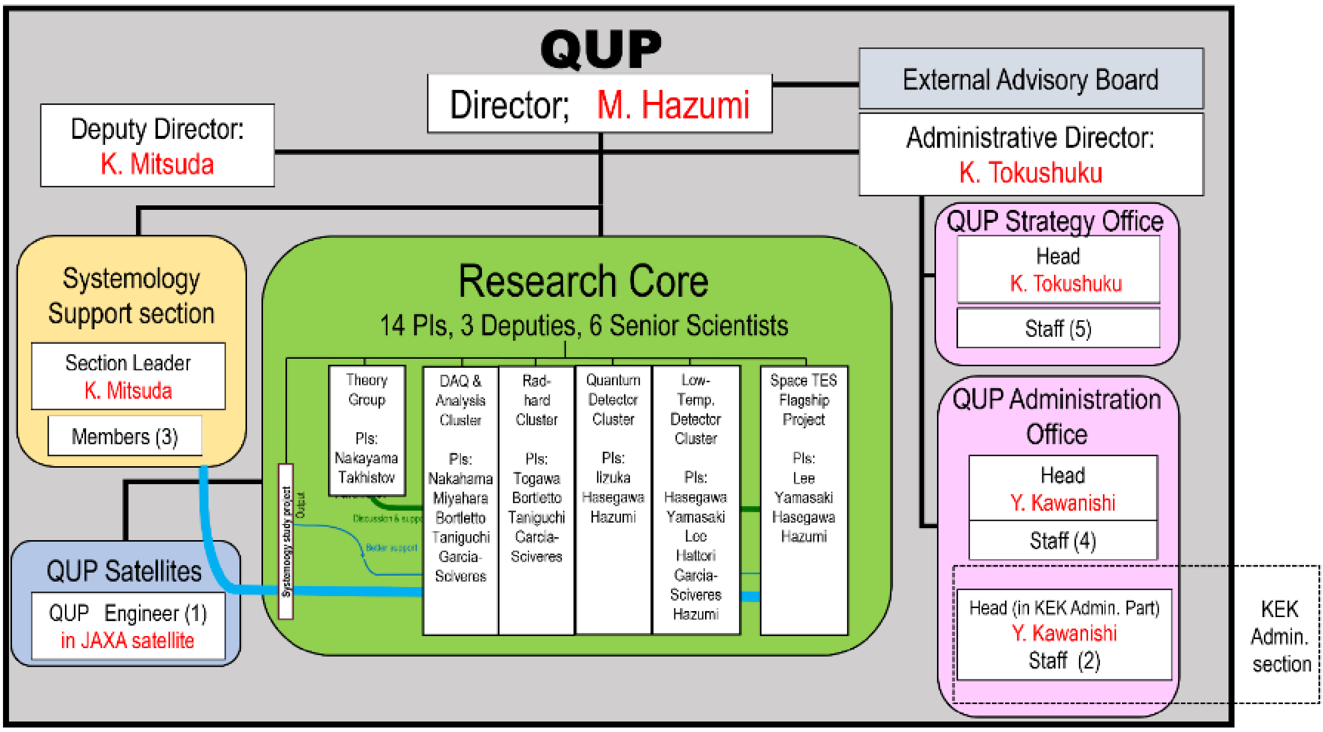
- **QUP stops the SpaceTES project** as its flagship project
- **The systemology support section is closed.** Instead, QUP has created **an engineering support section** to strengthen the technical support needed to accelerate the projects.
- The cluster structure of the research core is reorganized to prepare new PIs for new QUP projects.
- Prof. Toshiyuki Azuma has been with QUP since April 2025 with 40% FTE. He replaced Kazuhisa Mitsuda as deputy director.

Below is the organization diagram as of April 1, 2025. New members after April 1, 2024, are shown in red.



The old QUP organization diagram on April 1, 2024, is shown below for reference.

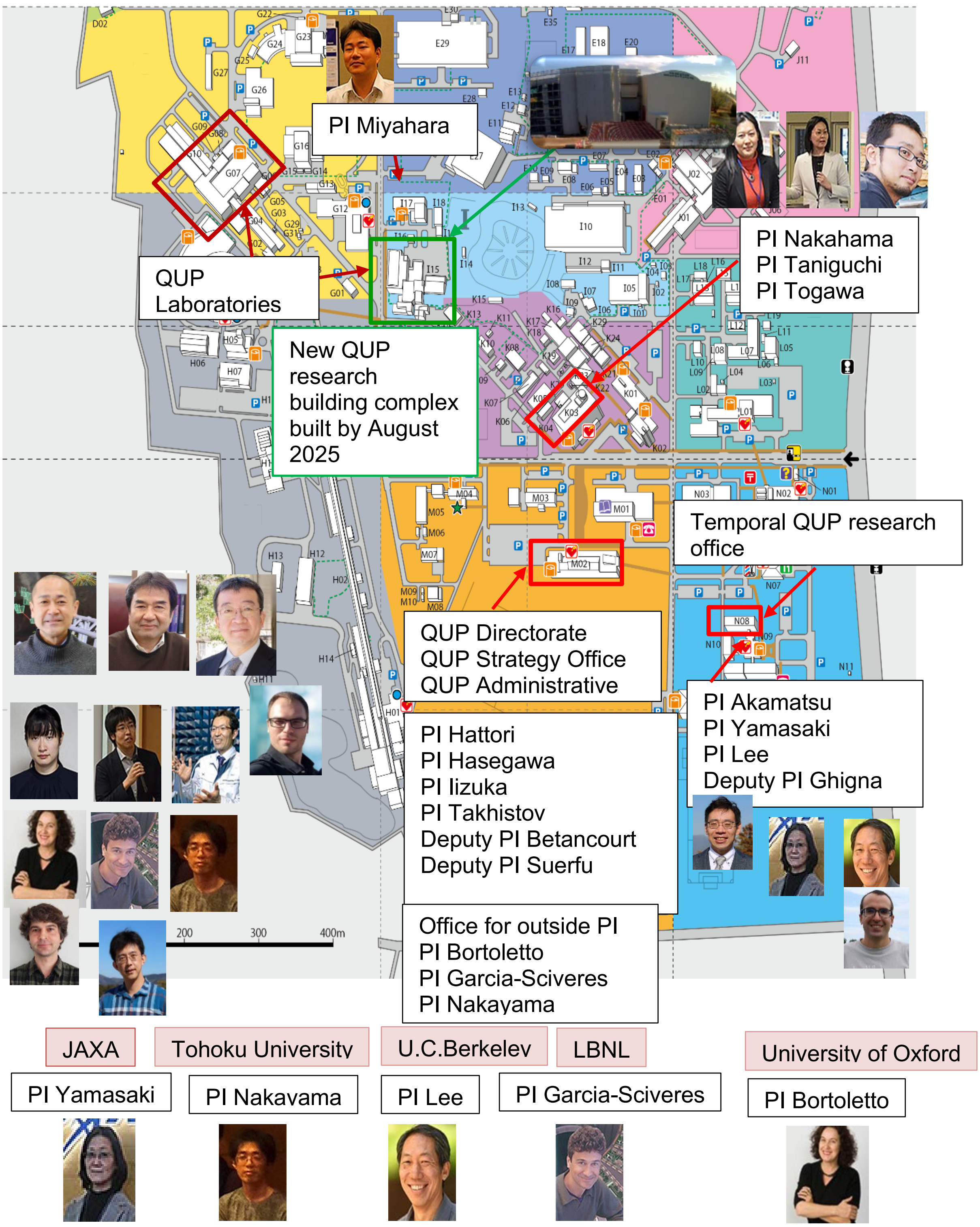
QUP Organization as of April 2024



World Premier International Research Center Initiative (WPI)
Appendix 3-4　Campus Map

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

Location of QUP PIs in KEK Campus



World Premier International Research Center Initiative (WPI) — Appendix 3-5

Appendix 3-5 Project Expenditures in FY2024

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 yens)

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	24	20
	Principal investigators (no. of persons):14	66	26
	Other researchers (no. of persons):24	188	174
	Research support staff (no. of persons):10	58	58
	Administrative staff (no. of persons):25	70	56
	RA for university students (no. of persons):6	3	0
	Subtotal	409	334
Project activities	Research startup cost (no. of persons):20	26	25
	Cost of outreach	3	3
	Gratuities and honoraria paid to resaearchers (no. of persons):2	4	4
	Cost of satellite organizations (no. of satellite organizations):3	103	93
	Cost of international symposiums (no. of symposiums):2	3	3
	Rental fees for facilities	53	0
	Other costs (Space charge, equipment relocation cost, etc.)	555	37
	Subtotal	747	165
Travel	Domestic travel costs	9	9
	Overseas travel costs	16	15
	Travel and accommodations cost for invited scientists	23	23
	(no. of domestic scientists):0		
	(no. of overseas scientists):30		
	Travel cost for scientists on transfer	1	1
	(no. of domestic scientists):0		
	(no. of overseas scientists):1		
	Subtotal	49	48
Equipment	Facility improvement costs	9	5
	Facility / equipment procuement cost	135	103
	Establishing new facility	880	0
	Subtotal	1024	108
Research projects (Detail items must be fixed)	Project supported by other government subsidies, etc. *1	21	0
	KAKENHI	117	0
	Commissioned research projects, etc.	345	0
	Joint research projects	8	0
	Ohers (donations, etc.)	0	0
	Subtotal	491	0
Total		2720	655

Costs (Million yens)

Item	Costs
WPI grant in FY2024	655
Costs of establishing and maintaining facilities	889
Establishing new facilities	880
(Number of facilities: , 3,230 m²)	
Repairing facilities	9
(Number of facilities: , 2,074 m²)	
Others	0
Costs of equipment procured	135
Laser	11
(Number of units:1)	
Cryostat positioning device	7
(Number of units:2)	
Detector	3
(Number of units:1)	
Others	114

*1. Funding sources that include government subsidies (including Enhancements promotion expenses (機能強化促進経費), subsidies (補助金), 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.

2) Costs of satellites

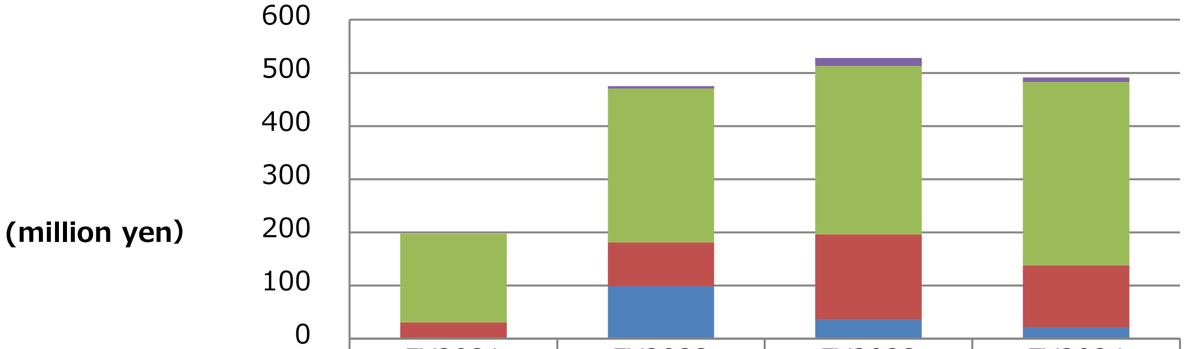
(Million yens)

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 staffs (no. of persons):0		
	Administrative staffs (no. of persons):0		
	Subtotal	0	0
Project activities	Subtotal	103	93
Travel	Subtotal	0	0
Equipment	Subtotal	0	0
Research projects	Subtotal	0	0
Total		103	93

World Premier International Research Center Initiative (WPI)
Appendix 3-6　Annual Transition in the Amounts of Project Funding

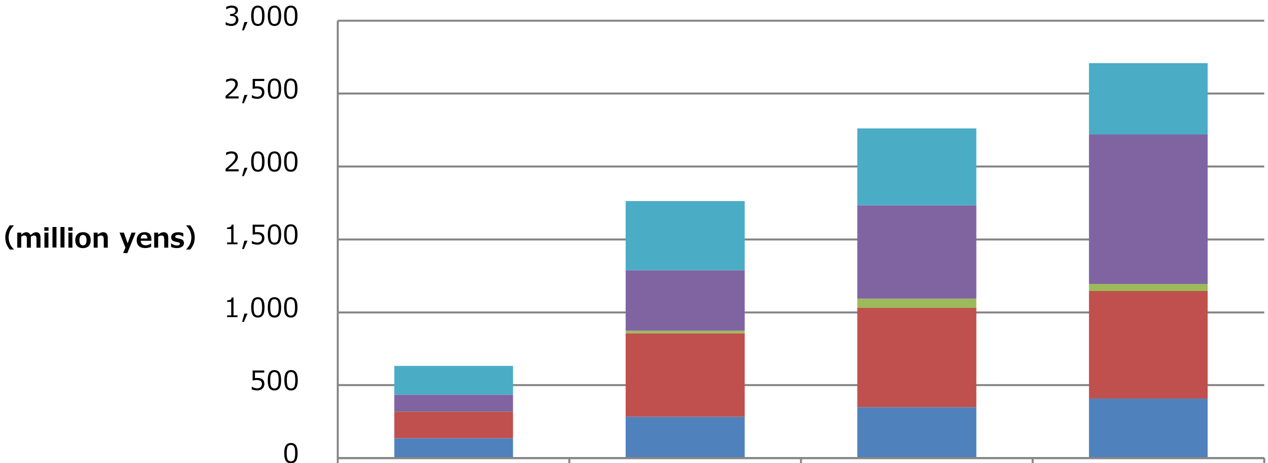
*Make a graph of the transition in the number of overall project funding.

Transition of Research Project Expenditures



	FY2021	FY2022	FY2023	FY2024
Ohers (donations, etc.)	0	0	0	0
Joint research projects	0	5	15	8
Commissioned research projects, etc.	167	289	317	345
KAKENHI	31	82	160	117
Project supported by other government subsidies, etc. *1	0	99	36	21

Transition of Project Expenditures



	FY2021	FY2022	FY2023	FY2024
Research Projects	198	475	528	491
Equipment	116	414	641	1,024
Travel	0	19	61	49
Project Activities	183	573	682	737
Personnel	137	283	350	409

*1 Definition is as shown in Appendix 3-5 (Project Expenditures)

- Describe external funding warranting special mention. Include the name and total amount of each grant.

FY2021
・ Name KAKENHI: Grant-in-Aid for Transformative Research Areas, JSPS
  Total Amount:　12,750,000 JPY (Acquired by Noriko Yamasaki)

FY2022
・ Name KAKENHI: Grant-in-Aid for Scientific Research (S), JSPS
  Total Amount:　51,110,000 JPY (Acquired by Masashi Hazumi)
・ Name KAKENHI: Grant-in-Aid for Transformative Research Areas, JSPS
  Total Amount:　15,600,000 JPY (Acquired by Noriko Yamasaki)
・ Name the Moonshot R&D Grant, JST
  Total Amount:　16,900,000 JPY (Acquired by Masaya Miyahara)

FY2023
・ Name KAKENHI: Grant-in-Aid for Scientific Research (S), JSPS
  Total Amount:　51,110,000 JPY (Acquired by Masashi Hazumi)
・ Name KAKENHI: Grant-in-Aid for Transformative Research Areas, JSPS
  Total Amount:　47,200,000 JPY (Acquired by Noriko Yamasaki)
・ Name KAKENHI: Fund for the Promotion of Joint International Research (Home-Returning Researcher Development Research), JSPS
  Total Amount:　46,500,000 JPY (Acquired by Hiroki Akamatsu)
・ Name the Moonshot R&D Grant, JST
  Total Amount:　33,000,000 JPY (Acquired by Masaya Miyahara)
・ Name FOREST, JST
  Total Amount:　10,000,000 JPY (Acquired by Kaori Hattori)
・ Name Core-to-Core Program, JSPS
  Total Amount:　14,800,000 JPY (Acquired by Yu Nakahama)

FY2024
・ Name KAKENHI: Grant-in-Aid for Scientific Research (S), JSPS
  Total Amount:　28,300,000 JPY (Acquired by Masashi Hazumi)
・ Name the Moonshot R&D Grant, JST
  Total Amount:　23,000,000 JPY (Acquired by Masaya Miyahara)
・ Name FOREST, JST
  Total Amount:　6,000,000 JPY (Acquired by Kaori Hattori)
・ Name Core-to-Core Program, JSPS
  Total Amount:　14,800,000 JPY (Acquired by Yu Nakahama)

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World Premier International Research Center Initiative (WPI)
Appendix 4-1 FY2024 Visit Records of Researchers from Abroad

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

Total: 83

	Name	Age	Affiliation		Academic degree, specialty	Record of research activities (Awards record, etc.)	Time, duration	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	Andrew H Jaffe	58	Professor, Imperial College London	UK	Ph.D. in Physics	theoretical cosmologist	2024/9/9～2024/12/7	Short-term Invited Fellow Program
2	Shaul Hanany	69	Professor, University of Minnesota Twin Cities	USA	Ph.D. in Physics	Astroparticle physics APS Fellow	2024/3/19～2024/3/19	Speaker of QUP Colloqium
3	Laura Baudis	55	Professor, University of Zurich(UZH) SWITZERLAND	Switzerland	Ph.D. in Physics	Astrophysics co-spokesperson of XENON exp. a member of the CERN Science Policy Committee	2024/12/2～2024/12/2	Speaker of QUP Colloqium
4	Jim Strait	77	Senior Scientist, LBNL	USA	Ph.D. in Physics	Particle physics CMB-S4 Project Director	2024/12/18～2024/12/19	Speaker of QUP Colloquium
5	Balantekin Akif Baha	69	Eugene P. Wigner Professor, University of Wisconsin	USA	Ph.D. in Physics	Theoretical Physics American Physical Society Hans Bethe Prize,	2024/5/28～2024/5/31	Speaker of QUP Colloquium
6	Christophe Grojean	51	Professor/Principal Investigator, Humboldt Univ. Berlin/DESY	Germany	Ph.D. in Physics	Theoretical physics	2025/2/20～2025/2/20	Speaker of QUP Colloquium
7	Matt Pyle	45	Associate Professor, University of California Berkeley	USA	Ph.D. in Physics	particle physics experiment	2021/12/7～2024/12/11	Participation as a speaker at QUPosium2024
8	Marianna Safronova	51	Professor, University of Delaware	USA	Ph.D. in Physics	Theoretical Atomic Physics APS fellow	2024/12/4～2024/12/11	Participation as a speaker at QUPosium2024
9	Graciela Gelmini	64	Professor, University of California, Los Angeles	USA	Ph.D. in Physics	Theoretical particle physics	2024/12/4～2024/12/12	Participation as a speaker at QUPosium2024
10	Andrew Sonnenschein	55	Scientist, Fermilab	USA	Ph.D. in Physics	particle physics experiment Division Director, Particle Astrophysics	2024/12/6～2024/12/13	Participation as a speaker at QUPosium2024
11	John Callas	65	Principal Investigator, NASA / JPL	USA	Ph.D. in Physics	particle physics experiment Project manager of NASA's Mars Exploration Rover project	2024/12/6～2024/12/16	Participation as a speaker at QUPosium2024
12	Dmitry Budker	61	Professor, Helmholtz Institute Mainz, Johannes Gutenberg University	GERMANY	Ph.D. in Physics	Atomic, molecular, and optical physics Norman F. Ramsey Prize, APS Fellow	2024/12/7～2024/12/12	Participation as a speaker at QUPosium2024
13	Oliver Buchmueller	54	Senior Research Fellow, Imperial College London South Kensington Campus	UK	Ph.D. in Physics	particle physics Principal Investigator of The Atom Interferometer Observatory and Network	2024/12/7～2024/12/12	Participation as a speaker at QUPosium2024
14	Pramod Reddy	47	Professor of Mechanical Engineering, University of Michigan	USA	Ph.D. in Physics	particle physics experiment	2024/12/7～2024/12/12	Participation as a speaker at QUPosium2024

15	Chiara P. Salemi	29	Dr., KIPAC, Stanford University	USA	Ph.D. in Physics	particle physics experiment	2024/12/7～ 2024/12/13	Participation as a speaker at QUPosium2024
16	Kent Irwin	59	Professor, Stanford University	USA	Ph.D. in Physics	particle and astroparticle physics	2024/12/7～ 2024/12/14	Participation as a speaker at QUPosium2024
17	Celine Boehm	50	Professor, University of Sydney / Edinburgh	AUSTRALIA	Ph.D. in Physics	astroparticle physics	2024/12/8～ 2024/12/12	Participation as a speaker at QUPosium2024
18	Joseph L. Kirschvink	71	Nico and Marilyn Van Wingen Professor of Geobiology, Caltech	USA	Ph.D.	Geobiology	2024/12/8～ 2024/12/16	Participation as a speaker at QUPosium2024
19	David Kaplan	66	Professor, Johns Hopkins University	USA	Ph.D. in Physics	Theoretical particle physics Kavli Frontiers Fellow, Alfred P. Sloan Fellow	2024/12/9～ 2024/12/11	Participation as a speaker at QUPosium2024
20	Michael Doser	64	Principal Investigator, CERN	Switzerland	Ph.D. in Physics	particle physics experiment spokesperson of the AEGIS experiment	2024/12/9～ 2024/12/11	Participation as a speaker at QUPosium2024
21	Michael Tobar	60	Professor, University of Western Australia	AUSTRALIA	Ph.D. in Physics	particle physics experiment	2024/12/9～ 2024/12/11	Participation as a speaker at QUPosium2024
22	William DeRocco	29	Postdoc, University of Maryland	USA	Ph.D. in Physics	Theoretical particle physics	2024/12/9～ 2024/12/10	Participation to QUPosium 2024
23	Qiuhong Wang	35	Postdoc, Fudan University	China	Ph.D. in Physics	particle physics experiment	2024/12/9～ 2024/12/11	Participation to QUPosium 2024
24	Jason Arakawa	28	Postdoctoral Researcher, University of Delaware	USA	Ph.D. in Physics	Theoretical particle physics	2024/12/9～ 2024/12/11	Participation to QUPosium 2024
25	Rong-Kang Zhang	25	Graduate Student, Department of Physics, Tongji University	China	Ph.D. in Physics	particle physics experiment	2024/12/9～ 2024/12/11	Participation to QUPosium 2024
26	Beige Liu	25	Ph.D. student, University of Science and Technology, China	China	Ph.D. in Physics	particle physics experiment	2024/12/9～ 2024/12/9	Participation to QUPosium 2024
27	Enrique Martínez-González	63	Professor, Instituto de Física de Cantabria, CSIC	Spain	PhD in physics	astorparticle physics	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES
28	Michele Pinchera	58	Researcher INFN	Italy	Master of Science and MEng in Space Engineering	astrophysics experiment	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES
29	Mario Zannoni	55	Professor, Physics Department, University of Milano Bicocca	Italy	PhD in astronomy	experimental cosmology Head of Cryogenics and Microwave lab in Uni Milano Bicocca	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES
30	Carlo Baccigalupi	55	Professor, Astrophysics and Cosmology, the International School for Advanced Studies	Italy	PhD in Physics	astroparticle physics experiment Gruber prize for cosmology, co-recipient (along with 45 members of the Planck team)	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES
31	Paolo Natoli	53	Full Professor, Department of Physics and Earth Sciences, University of Ferrara	Italy	Ph.D in Physics	astroparticle physics Gruber prize for cosmology, co-recipient (along with 45 members of the Planck team)	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES
32	Francesco Piacentini	52	Professor, Physics Deprtament, Sapienza University of Rome	Italy	PhD in Astronomy	astrophysics experiment	2024/6/24～ 2024/6/28	Participation to Lessons-Learned Workshop about TES

33	Giovanni Signorelli	49	Professor, Pisa University and INFN	Italy	Ph.D. in Physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
34	Ludovic Montier	47	Researcher at IRAP	France	Ph.D. in Physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
35	TARALLI Emanuele	45	Principal Investigator, NWO-I/SRON	Netherland	Ph.D. in physics	astroparticle physics experiment	2024/6/23～2024/6/29	Participation to Lessons-Learned Workshop about TES
36	Emanuele Taralli	45	Instrument Scientist, Instrument Science Group, SRON	Netherlands	Ph.D. in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
37	Jonathan Aumont	44	CNRS Researcher	France	Ph.D. in Physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
38	Luca Pagano	41	Professor, Physics and Earth Science, University of Ferrara	Italy	Ph.D. in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
39	Nicoletta Krachmalnicoff	39	Assistan Professor, Astrophysics and Cosmology, SISSA	Italy	PhD in Physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
40	Stuart Harper	35	PDRA	United Kingdom	PhD in astrophysics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
41	Matteo D'Andrea	35	Instrument Scientist, INAF/IAPS Roma	Italy	Ph.D. in Astronomy, Astropysics and Space Science	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
42	VACCARO Davide	33	Researcher, NWO-I/SRON	Netherland	Ph.D. in physics	astroparticle physics experiment	2024/6/23～2024/6/29	Participation to Lessons-Learned Workshop about TES
43	Gabriele Coppi	33	Non Tenure Assistant Professor	Italy	PhD in Astrophysics	astroparticle physics experiment	2024/6/24～2024/6/27	Participation to Lessons-Learned Workshop about TES
44	Paolo Campeti	33	Researcher Technologist, INFN Ferrara	italy	PhD in Astrophysics and Cosmology	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
45	Davide Vaccaro	33	Instrument scientist, SRON	Netherlands	Ph.D in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
46	Margherita Lembo	32	Postdoc, University of Ferrara	Italy	PhD in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
47	Fabio Columbro	32	Researcher, Physics department, Sapienza University	Italy	PhD in Astronomy, Astrophysics and Space Science	astroparticle physics experiment	2024/6/26～2024/6/26	Participation to Lessons-Learned Workshop about TES
48	Mario De Lucia	31	Postdoc	italy	PhD in physics	astroparticle physics experiment	2024/6/25～2024/6/28	Participation to Lessons-Learned Workshop about TES
49	Alessandro Carones	30	Post-Doc researcher, Physics department, SISSA	Italy	Ph.D. in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
50	Giacomo Galloni	29	Postdoc, Department of Physics and Earth Science, University of Ferrara	Italy	PhD in Astronomy, Astrophysics and Space Science	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES

51	Léo Vacher	26	Postdoc	Italy	Ph.D. in astrophysics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
52	Paolo Dal Bo	30	PhD student	Italy	Master's degree	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
53	Giulia Conenna	29	PhD student in physics and astronomy at University of Milano-Bicocca	Italy	Master in astrophysics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
54	Giulia Conenna	29	PhD student in astronomy and physics at university of Milano-Bicocca	Italy	Master bachelor	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
55	Nicole Farias	28	PhD Student	United States	PhD in Physics (in progress)	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
56	Nicolò Raffuzzi	28	PhD student - University of Ferrara - Department of Physics and Earth Science	Italy	PhD physics	astroparticle physics experiment	2024/6/26～2024/6/28	Participation to Lessons-Learned Workshop about TES
57	Christian Gimeno-Amo	25	PhD student, Instituto de Física de Cantabria (CSIC-UC)	Spain	Master in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
58	Silvia Micheli	25	PhD student - U. La Sapienza of Rome	Italy	Master degree in Astronomy and Astrophysics	astroparticle physics experiment	2024/6/26～2024/6/28	Participation to Lessons-Learned Workshop about TES
59	Emile Carinos	24	Ph.D. student, IRAP, Université Toulouse 3	France	Master degree in physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
60	Meng P. Chiao	58	Systems Engineer, Instrument/Payload Systems Engineering Branch, NASA GSFC	USA	Ph.D. in physics	astrophysics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
61	Christopher Raum	58	R&D Engineer, Physics, University of California, Berkeley	United States	PhD in electrical engineering, Silicon micromachining	astrophysics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
62	VAN WEERS Hendrikus	54	Engineer, NWO-I/SRON	The Netherlands	Engineer	astrophysics experiment	2024/6/23～2024/6/29	Participation to Lessons-Learned Workshop about TES
63	Henk van Weers	54	Mechanical System Engineer, Engineering Group, SRON	The Netherlands	Engineer	astrophysics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
64	Damien Rambaud	51	Mr, IRAP CNRS	France	Engineer	astrophysics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
65	Stephan Maestre	49	Electronic engineer, IRAP	FRANCE	Digital electronic engineer, PhD in Microelectonics	astrophysics experiment	2024/6/24～2024/6/25	Participation to Lessons-Learned Workshop about TES
66	Marcos López-Caniego	46	Support Scientist, ESAC, ESA	Spain	Ph.D. in Physics	astroparticle physics experiment	2024/6/24～2024/6/28	Participation to Lessons-Learned Workshop about TES
67	Baptitse Mot	42	Permanent, IRAP, CNRS	France	Engineer	astroparticle physics experiment	2024/6/26～2024/6/28	Participation to Lessons-Learned Workshop about TES
68	Wai Ling WU	39	Researcher, SLAC National Accelerator Laboratory	USA	Ph.D. in Physics	astroparticle physics experiment	2025/1/25～2025/1/29	Participation as a speaker at CMB-BmodeNEXT

69	Aritoki Suzuki	39	Staff Scientist, Lawrence Berkeley National Laboratory(LBL)	USA	Ph.D. in Physics	astroparticle physics experiment	2025/1/24～ 2025/1/29	Participation as a speaker at CMB-BmodeNEXT
70	Anna Suliga	31	Postdoc, University of California(UC) Berkeley	USA	Ph.D. in Physics	Particle physics theory	2024/6/20～ 2024/6/21	Discussion on Research with Takhistov PI
71	Avinash Anand	28	Ph.D Student, University of Rome "Tor Vergata", Sapienza University of ROme	ITALY		particle physics experiment	2024/10/5～ 2025/3/20	QUP Internship Program (QUPIP)
72	Lorenzo FERRARI BARUSSO	31	Postdoc, University of Genoa	ITALY	Ph.D. in Physics	astroparticle physics experiment	2024/10/6～ 2024/12/22	QUP Internship Program (QUPIP)
73	Ta-Chun Yu	23	Research Student, National Central University	Republic of China (Taiwan)		astroparticle physics experiment	2024/11/14～ 2024/12/27	QUP Internship Program (QUPIP)
74	WALTER Clément	29	Ph.D Graduate, The École normale supérieure Paris-Saclay(ENS Paris-Saclay) FRANCE Dept. of Astrophysics	FRANCE	Ph.D. in physics	astroparticle physics experiment	2024/4/1～ 2024/4/26	QUP Internship Program (QUPIP)
75	DI GIORGI Eugenia	29	Ph.D Student, Trento Univ. ITALY Dept. of Physics	ITALY		astroparticle physics experiment	2024/4/1～ 2024/4/27	QUP Internship Program (QUPIP)
76	ARAKAWA Jason	28	Postdoc, Univ. of Delawere(UD) U.S.A. Physics & Asrtonomy Dept.	USA	Ph.D. in physics	Particle physics theory	2024/4/15～ 2024/7/11	QUP Internship Program (QUPIP)
77	ERRACHDI Sabri	21	Ph.D Student, Univ. Paris Cite FRANCE UFR Physique	FRANCE		astroparticle physics experiment	2024/5/25～ 2024/8/21	QUP Internship Program (QUPIP)
78	DING Qianhang	29	Research Fellow, Institute for Basic Science(IBS) KOREA Center for Theoretical Physics of the Universe	South Korea	Ph.D. in physics	Particle physics theory	2024/5/6～ 2024/6/12	QUP Internship Program (QUPIP)
79	GUSTAFSON Robert Andrew	25	Ph.D Student, Virginia Polytechnic Institute and State University	USA		Particle physics theory	2024/7/23～ 2024/9/25	QUP Internship Program (QUPIP)
80	Andrew Caruso	24	Master Student, Virginia Polytechnic Institute and State University	USA		Particle physics theory	2024/7/8～ 2024/8/20	QUP Internship Program (QUPIP)
81	Han Gil Choi	32	Senior Researcher, Institute for Basic Science, Republic of Korea	South Korea	Ph.D. in Physics	Particle physics theory	2024/8/1～ 2024/9/3	QUP Internship Program (QUPIP)
82	Laura WINKLER	24	Master Student, University of Geneve	Switzerland		particle physics experiment	2024/8/29～ 2024/11/30	QUP Internship Program (QUPIP)
83	Antoine Cools	29	Ph.D Researcher, University of Melbourne AUSTRALIA Dept. of Physics	AUSTRALIA	Ph.D. in Physics	particle physics experiment	5/1/18～2025/3/1	QUP Internship Program (QUPIP)

World Premier International Research Center Initiative (WPI)

Appendix4-2 Postdoctoral Positions through Open International Solicitations

* In the column of number of applications and number of selection, put the total number (upper), the number and percentage of overseas researchers in the < > brackets (lower).

Fiscal year	number of applications	number of selection
FY 2021	0	0
	<0 , -%>	< 0, -%>
FY 2022	195	8 (+4 hired as assistant professor)
	< 181, 93%>	< 4,50 %> <7, 58% including ass. prof.>
FY 2023	91	5 (+1 hired as assistant professor)
	< 77, 85%>	< 2, 40%> <2, 33% including ass. prof.)
FY 2024	482	3 (2 of them will arrive in FY2025)
	<469, 97%>	<3, 100 %>

KEK

QUP

World Premier International Research Center Initiative (WPI)
Appendix 4-3 Status of Employment of Postdoctoral Researchers

Enter the information below during the period from the start of the center through the end of FY 2024.
- For each person, fill in the spaces to the right. More spaces may be added.
- Leave "Position as of April 2025" blank if unknown.
- Enter the host institution name and the center name in the footer.

Japanese Postdocs (*Employed as Assistant professor)

Employment period (Starting year. Month - Ending year. Month)	Position before employed at WPI center		Next position after WPI center		Position as of April 2025*	
	Position title, organization	Country where the organization is located	Position title, organization	Country where the organization is located	Position title, organization	Country where the organization is located
2022.6-2023.3	Research Associate, NAOJ	Japan	Assistant Professor, Rikyo University	Japan	Assistant Professor, Rikyo University	Japan
2022.10-2024.3	Postdoc,Tokyo Institute of Technology	Japan	Assistant Professor, Kobe University	Japan	Assistant Professor, Kobe University	Japan
2024.4-2025.3	JSPS postdoctoral fellow, Kyoto Universioty	Japan	Researcher, AIST	Japan	Researcher, AIST	Japan
2022.10-2024.3*	JSPS postdoctoral fellow, Kavli IPMU, Tokyo	Japan	Associate professor, QUP,KEK	Japan	Associate professor, QUP,KEK	Japan
2024.3-2024.8*	JSPS Overseas Research Fellow, Kyoto University	Japan	Assistant professor, U.Tokyo	Japan	Assistant professor, U.Tokyo	Japan

Overseas Postdocs (*Employed as assistant professor)

Employment period (Starting year. Month - Ending year. Month)	Position before employed at WPI center		Next position after WPI center		Position as of April 2025*		Nationality
	Position title, organization	Country where the organization is located	Position title, organization	Country where the organization is located	Position title, organization	Country where the organization is located	
2022.8-2023.8	Postdoc, Kavli IPMU, Tokyo	Japan	Assistant professor, QUP,KEK	Japan	Assistant professor, QUP,KEK	Japan	Italy
2022.7-2023.3*	Research fellow, CERN	Switzerland	Tenure Track Researcher, IFAE, Barcelona	Spain	Tenure Track Researcher, IFAE, Barcelona	Spain	Spain
2022.9-2024.3*	Kavli Fellow, Kavli IPMU, Tokyo	Japan	Associate professor, QUP,KEK	Japan	Associate professor, QUP,KEK	Japan	USA

World Premier International Research Center Initiative (WPI)
Appendix 4-4 Holding International Research Meetings

* Indicate up to two of most representative international research conferences or symposiums each financial year and give the number of participants using the table below.

FY2021: 1 meeting

Date	Meeting title and Place held	Number of participants
Feb 8-10, 2022	KEK IPNS-IMSS-QUP Joint workshop (video-only)	From domestic institutions: 151 From overseas institutions: 11

FY2022: 4 meetings

Date	Meeting title and Place held	Number of participants
Dec 12-15, 2022	QUPosium2022 (Epochal Tsukuba, Japan)	From domestic institutions: 117 From overseas institutions: 38
Feb 23-24 , 2023	ML at HEP workshop (QUP/KEK, Japan)	From domestic institutions: 101 From overseas institutions: 18

FY2023: 5 meetings

Date	Meeting title and Place held	Number of participants
Dec 11-13, 2023	QUPosium2023 (Epochal Tsukuba, Japan)	From domestic institutions: 101 From overseas institutions: 17
July 3-7, 2023	"International hands-on workshop of LiteBIRD simulation" (KEK/QUP, Tsukuba, Japan)	From domestic institutions: 21 From overseas institutions: 29

FY2024: 4 meetings

Date	Meeting title and Place held	Number of participants
Dec 9-11, 2024	QUPosium2024 (Epochal Tsukuba, Japan)	From domestic institutions: 81 From overseas institutions: 31
June 24-26, 2024	Lessons-Learned Workshop about TES (KEK, Japan)	From domestic institutions: 25 From overseas institutions: 15

World Premier International Research Center Initiative (WPI)
Appendix 4-5
FY 2024 Status of Collaboration with Overseas Satellites

- If satellite and partner institutions have been established, fill in required items of the form below.

1. Satellites and partner institutions
- List the satellite and partner institutions in the table below (including the domestic satellite institutes).
- Indicate newly added and deleted institutions in the "Notes" column.

<Satellite institutions>

Institution name		Principal Investigator(s), if any	Notes
1	QUP Space and Astronautical Science Satellite	Noriko Yamazaki	
2	QUP Satellite in Toyota Central R&D Labs., Inc.	Hideo Iizuka	
3	QUP Berkeley Satellite	Adrian Lee, Maurice Garcia-Sciveres	
4			

< Partner institutions>

Institution name	Principal Investigator(s), if any	Notes
Kavli IPMU	M. Hazumi*, V. Takhistov* (* affiliate members)	MOU on a general scientific collaboration
SOKENDAI	KEK's PIs (M. Hazumi, M. Hasegawa, Y. Nakahama, N. Taniguchi and M. Togawa, K. Hattori, V. Takhistov)	MOU on the education of graduate students.
Nicolaus Copernicus Academy, Poland	None	MOU on the collaboration related to the SpaceTES project
Research Center for Neutrino Science, Tohoku University	None	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

- If overseas satellite institutions have been established, fill in required items on the form below. If overseas satellite institutions have not been established, it is not necessary to complete the form.

2. Coauthored Papers
- List the refereed papers published in FY 2024 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 1-3. Italicize the names of authors affiliated with overseas satellite institutions.
- For reference, write the Appendix 1-3 item number in parentheses after the item number in the blocks below. Let it free, if the paper is published in between Jan.-Mar. 2025 and not described in Appendix 1-3.

QUP Berkeley Satellite (University of California, Berkeley) (Total: 18 papers)

[1*][1] C. Raum et al. "Fabrication Process Control to Realize High Yield, Uniform, Repeatable Low-Frequency Detector Arrays for the LiteBIRD CMB Experiment" Journal of Low Temperature Physics 216 (2024) 254-263 DOI:10.1007/s10909-024-03129-7

[2*][2] T. de Haan et al. "Monitoring TES Loop Gain in Frequency Multiplexed Readout" Journal of Low Temperature Physics 216 (2024) 427-435 DOI:10.1007/s10909-024-

03174-2

[3*][36] C. Leloup et al. "Impact of beam far side-lobe knowledge in the presence of foregrounds for LiteBIRD" Journal of Cosmology and Astroparticle Physics 2024 (2024) 011 DOI:10.1088/1475-7516/2024/06/011

[4*][37] Y. Zhou et al. "A Method of Measuring TES Complex ETF Response in Frequency-Domain Multiplexed Readout by Single Sideband Power Modulation" Journal of Low Temperature Physics 216 (2024) 73-84 DOI:10.1007/s10909-024-03107-z

[5*][39] N. Farias et al. "Understanding the Phase of Responsivity and Noise Sources in Frequency-Domain Multiplexed Readout of Transition Edge Sensor Bolometers" Journal of Low Temperature Physics 216 (2024) 352-362 DOI:10.1007/s10909-024-03143-9

[6*][42] S. Adachi et al. "Exploration of the polarization angle variability of the Crab Nebula with POLARBEAR and its application to the search for axionlike particles" Physical Review D 110 (2024) 063013 DOI:10.1103/PhysRevD.110.063013

[7*][43] D. Kaneko et al. "Design and performance of a gain calibration system for the POLARBEAR-2a receiver system at the Simons Array cosmic microwave background experiment" Journal of Astronomical Telescopes, Instruments, and Systems 10 (2024) 018003 DOI:10.1117/1.JATIS.10.1.018003

[8*][44] N. Galitzki et al. "The Simons Observatory: Design, Integration, and Testing of the Small Aperture Telescopes" Astrophysical Journal, Supplement Series 274 (2024) 33 DOI:10.3847/1538-4365/ad64c9

[9*][53] T. Ghigna et al. "Development of the Low Frequency Telescope focal plane detector arrays for LiteBIRD" Proceedings of SPIE - The International Society for Optical Engineering 13102 (2024) 131020Y DOI:10.1117/12.3019287

[10*][54] T. Ghigna "The LiteBIRD mission to explore cosmic inflation" Proceedings of SPIE - The International Society for Optical Engineering 13092 (2024) 1309228 DOI:10.1117/12.3021377

[11*][55] N. Farias et al. "Development of LiteBIRD's cold readout sub-assembly" Proceedings of SPIE - The International Society for Optical Engineering 13102 (2024) 1310214 DOI:10.1117/12.3020736

[12*][69] M. Remazeilles et al. "LiteBIRD science goals and forecasts. Mapping the hot gas in the Universe" Journal of Cosmology and Astroparticle Physics 2024 (2024) 026 DOI:10.1088/1475-7516/2024/12/026

[13*][70] Y. Takase et al. "Multi-dimensional optimisation of the scanning strategy for the LiteBIRD space mission" Journal of Cosmology and Astroparticle Physics 2024 (2024) 036 DOI:10.1088/1475-7516/2024/12/036

[14*][71] A.I. Lonappan et al. "LiteBIRD science goals and forecasts: a full-sky measurement of gravitational lensing of the CMB" Journal of Cosmology and Astroparticle Physics 2024 (2024) 009 DOI:10.1088/1475-7516/2024/06/009

[15*][72] D. Paoletti et al. "LiteBIRD science goals and forecasts: primordial magnetic fields" Journal of Cosmology and Astroparticle Physics 2024 (2024) 086 DOI:10.1088/1475-7516/2024/07/086

[16*][73] P. Campeti et al. "LiteBIRD science goals and forecasts. A case study of the origin of primordial gravitational waves using large-scale CMB polarization" Journal of Cosmology and Astroparticle Physics 2024 (2024) 008 DOI:10.1088/1475-7516/2024/06/008

[17*][74] T. Namikawa et al. "LiteBIRD science goals and forecasts: improving sensitivity to inflationary gravitational waves with multitracer delensing" Journal of Cosmology and Astroparticle Physics 2024 (2024) 010 DOI:10.1088/1475-7516/2024/06/010

[18*][75] M. Russell et al. "Deployment of POLARBEAR-2b" Journal of Low Temperature Physics 216 (2024) 237-245 DOI:10.1007/s10909-024-03127-9

3. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY 2024. Enter by institution and length of exchange.
- Write the number of principal investigators' visits in the top of each space and the number of other researchers in the bottom.

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
FY2024	0	0	0	0	0
	2	3	1	0	6

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2024	3	4	0	0	7
	4	0	0	0	4

World Premier International Research Center Initiative (WPI)
Appendix 5 (1) List of Achievements of Center's Outreach Activities between FY 2021 – 2024

* Using the table below, show the achievements of the Center's outreach activities from FY2021 through FY2024 (number of activities, times held).

*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 below, 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.

Activities	FY2021	FY2022	FY2023	FY2024
	(number of activities, times held)			
PR brochure, pamphlet	1	2	0	0
Lectures, seminars for the general public	1	4	4	5
Teaching, experiments, training for elementary, secondary and high school students	1	3	3	2
Science cafe	0	1	1	2
Open house	0	2	2	2
Participating, exhibiting in events	1	1	2	4
Press releases	2	0	0	3
Publications of the popular science books	0	0	0	0
Others (YouTube)	0	6	14	10

World Premier International Research Center Initiative (WPI)
Appendix 5 (2) List of Media Coverage of Projects Carried out between FY 2021 – 2024

* Select main articles (especially from overseas media) reported in the fiscal years 2021 to 2024 as a result of press releases, interviews, etc.

1) Japan

No.	Date	Type of the media (e.g., newspaper, magazine, television)	Description
1	May 2023	Cable TV in Tsukuba city (ACCS) and YouTube	14 minute program to introduce research insitutes in Tsukuba city title as "Tsukuba de Kagaku (Sicence in Tsukuba) No.24. QUP senior scientist, Prof. Hiroki Akamatsu gave a pulic lecture on the low temperature detector. (https://www.youtube.com/watch?v=SfRKnQoAIVk)
2	June 2023	Cable TV in Tsukuba city (ACCS) and YouTube	14 minute program to introduce research insitutes in Tsukuba city title as "Tsukuba de Kagaku (Sicence in Tsukuba) QUP researchers and facility were introduced. (https://www.youtube.com/watch?v=0bLFSntTclA&t=91s)
3	January 7, 2024	Newspaper (Nihon Keizai Shinbun)	QUP-PI's acticities on the Casimir force
4	June 27, 2025	NHK TV	"What do gravitational waves reveal?" in the Frontiers series (Masashi Hazumi) NHK-BS

2) Overseas

No.	Date	Type of the media (e.g., newspaper, magazine, television)	Description
1	December2022	Magazine	QUP Director intervied by CERN Courier
2	January 28-, 2025	Web Radio	QUP PI, Prof. Volodymyr Takhistov talked in Aspen about science with Colorado school students

World Premier International Research Center Initiative (WPI)

Appendix 5-2 Host Institution's Commitment (Fund, Personnel)

1. Contributions from host institution (Fund, Personnel)

* Regarding "Fund" entry, describe with reference to the items in the Progress Report (Jisseki-hokoku-sho) based on Article 12 of the Grant Guidelines (Kofu-yoko).

* Don't include competitive funding obtained by researchers (used as research project funding)

※ Concept of "Full-time Faculty (Tenured)"

- If researchers secure tenured positions at the host institution, they should be counted under "Full-time Faculty (Tenured).
- Foreign Principal Investigators (PIs) and host-institution researchers affiliated with the center through cross-appointments should also be included under "Full-time Faculty (Tenured)," provided that the cross-appointment arrangement is properly established within the host institution.
- Faculty members on a tenure track should also be included under "Full-time Faculty (Tenured)." However, if tenure-track faculty members are included in this category, the specific number must be indicated.

(FY 2021-2024)

<Fund>				**(million yen)**
Fiscal Year	**2021**	**2022**	**2023**	**2024**
Personnel	24.8	81.6	82.6	72.6
Principle Investigators	11.8	36.6	37.9	39.7
Full-time Faculty (Tenured)	11.8	36.6	37.9	39.7
Fixed-term Faculty	0.0	0.0	0.0	0.0
Other researchers	4.5	31.8	31.4	18.7
Full-time Faculty (Tenured)	4.5	31.8	31.4	18.7
Fixed-term Faculty	0.0	0.0	0.0	0.0
Postdocs	0.0	0.0	0.0	0.0
Research support staffs	0.0	0.0	0.0	0.0
Administrative staffs	8.5	13.2	13.3	14.2
Full-time staffs	8.5	13.2	13.3	14.2
Fixed-term staffs	0.0	0.0	0.0	0.0
Project activities	147.2	529.8	608.2	570.8
Travel	0.0	4.5	1.2	1.3
Equipment	3.1	59.8	4.8	36.0
Others	0.0	0.0	0.0	0.0
Research projects	0.0	0.0	0.0	0.0
Total	175.1	675.7	696.8	680.7

175.1

<Personnel>				**(person)**
Fiscal Year	**2021**	**2022**	**2023**	**2024**
Personnel	20	25	25	26
Principle Investigators	5	5	5	5
Full-time Faculty (Tenured)	5	5	5	5
Fixed-term Faculty	0	0	0	0
Other researchers	2	5	5	6
Full-time Faculty (Tenured)	2	5	5	6
Fixed-term Faculty	0	0	0	0
Postdocs	0	0	0	0
Research support staffs	0	0	0	0
Administrative staffs	13	15	15	15
Full-time staffs	13	15	15	15
Fixed-term staffs	0	0	0	0

World Premier International Research Center Initiative (WPI)

Appendix 5-3　Host Institution's Commitment from FY2021 to FY2024

1. Contributions from host institution (Personnel costs, Land and/or building(s), Lab space, etc (other than listed on Appendix 5-2))

The following are the major host contributions of KEK to the operation of QUP.

Director's discretionary budget (50 million yen/year)

Personnel cost (corresponding to FTE for the center) for

- Deputy director, PIs and senior scientists who are tenured at KEK,
- KEK's technician, and
- Members of KEK Administration Bureau who support the center.

Land and Buildings

- Cost for the space charge for residential and laboratory buildings
- Cost of constructing a new building complex. (see pictures).

Plan of QUP's new research building complex and construction status on April 5, 2025

2. System under which the center's director is able to make substantive personnel and budget allocation decisions

As already mentioned in 3-2-1, in establishing QUP, we had many discussions with KEK to harmonize the organizational form of QUP with that of KEK under the rules of KEK. QUP should be a top-down institute, but KEK is an Inter-University Research Institute Corporation and the user The foundations of KEK and WPI are completely different.

KEK requires a resolution from the Education and Research Council regarding faculty appointments, and the Council delegates the task to a high-level committee of the KEK institute, where the outside members selected by the community are in the majority. As an exception, the Council has decided to delegate the task to the QUP director for the QUP researcher appointments, at the foundation of QUP. KEK also delegated the other (non-researcher) appointments to the QUP director, as well. This ensured the leadership of the QUP director. The QUP director will report QUP's human resource allocation plan regularly in the KEK's director meetings to help the mutual understanding of the scope of QUP.

The KEK has also accepted the QUP director to set a special allowance depending on individual excellence, allowing the director to hire world-class researchers. Specific bylaws were established for the QUP Director to negotiate with individuals to determine their salaries.

3. Support for the center director in coordinating with other departments at host institution when recruiting researchers, while giving reasonable regard to the educational and research activities of those departments

No special support on this aspect. Negotiation was done directly with the directors of the other institutes/facilities of KEK.

4. Revamping host institution's internal systems to allow introducing of new management methods

(e.g., English-language environment, merit-based pay, cross appointment, top-down decision making unfettered by conventional modes of operation)

As mentioned in section 2**, the Education and Research Council of KEK made the exceptional decision** to allow the QUP director to appoint researchers and non-researchers working at QUP without the council's approval.

KEK rules are flexible enough so that the other unique aspects of QUP can be handled within the existing KEK rules. This includes flexible salary determination and a new scheme to change the salary according to the annual evaluation, as well as independent job ranks (such as PIs, Principal Engineers), etc., which makes QUP unique in KEK.

5. Utilities and other infrastructure support provided by host institution

(*In addition to those listed in the item 1. "Contributions from host institution")

None

6. Support for other types of assistance

None

World Premier International Research Center Initiative (WPI)
Appendix 5-4　The Host Institution's Mid-term Plan

* Excerpt the places in the host institution's "Mid-term objectives" and/or "Mid-term plan" that clearly show the positioning of the WPI center within its organization.

High Energy Accelerator Research Organization (KEK) 4th Mid-term objectives

No description about QUP.

High Energy Accelerator Research Organization (KEK) 4th Mid-term Plan

QUP is described in the first section as an institute for achieving KEK's goals related to research.

Excerpt:

I. Measures for achieving the goals concerning the improvement of the quality of education and research

1 Measures for achieving the goals related to research
[1-1]　To create world-class research results by conducting and upgrading the B-factory experiment, particle and nuclear experiments at J-PARC (including neutrino experiments such as the Hyper-Kamiokande project), and the ATLAS experiment at CERN in Europe, **and by establishing the International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP). KEK will enhance its presence as an international center of excellence by producing world-class research results.**