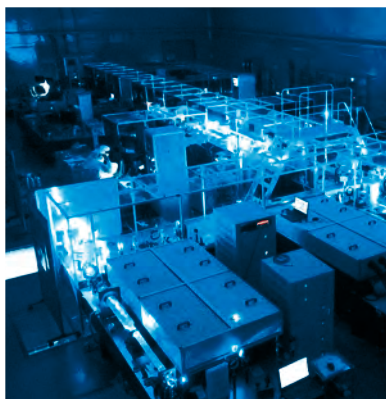
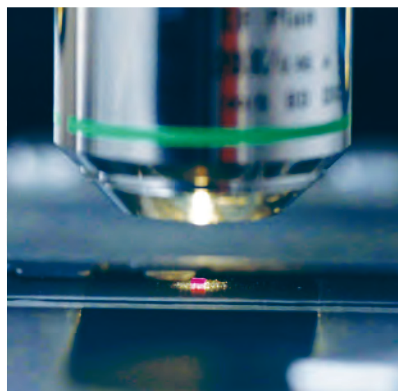
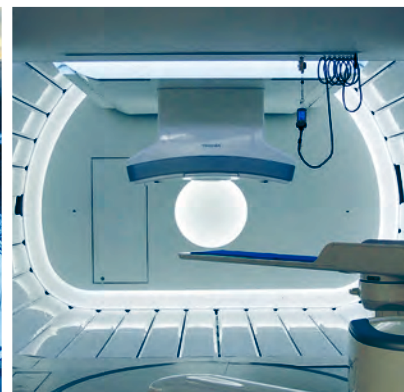
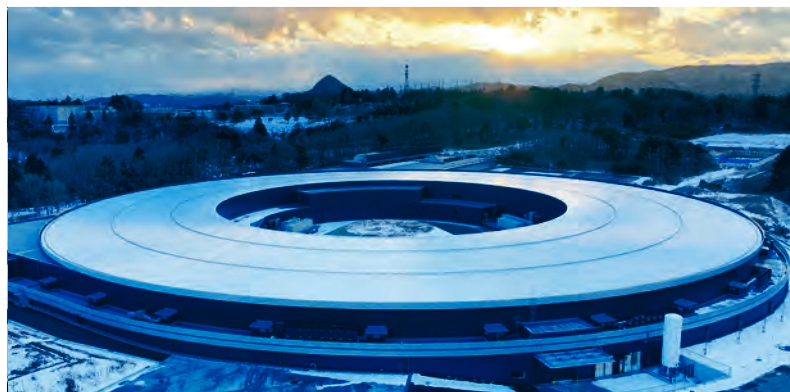


QST



PURPOSE

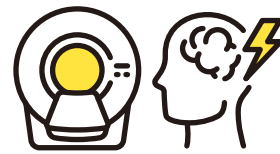
Realizing dreams and pioneering the future

Creating a new Japan,
and bringing happiness to the world with
Quantum Science and Technology



Harnessing Nature's Wisdom for a Prosperous Future

Quantum Life Science reveals the remarkable mechanisms of living systems through the lens of quantum science, driving advances in medicine and drug discovery while inspiring new technologies based on phenomena such as photosynthesis and bird migration. These insights will contribute to solutions for environmental and energy challenges and foster innovation in emerging industries.



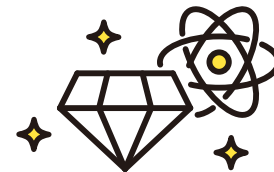
Advancing Healthy Longevity through Carbon-ion Radiotherapy and Dementia Research

By tackling major challenges such as cancer and dementia, we are helping build a future where diseases can be detected earlier, treated more effectively, and people can live longer, healthier lives. Helping build a society of healthy longevity where everyone can live longer, healthier, and more fulfilling lives as they age.



Fusion Energy for a Sustainable Future

Building on the progress of JT-60SA, ITER, and other fusion research initiatives, we are advancing toward a fusion DEMO reactor and the realization of fusion energy to support a sustainable future. Creating a sustainable energy foundation in harmony with the environment and helping build a greener future.



Making the Invisible Visible for Industrial Innovation

Quantum sensing reveals previously invisible changes in devices during operation, helping drive innovation in manufacturing and the advancement of social infrastructure. Creating new value that addresses challenges in healthcare, industry, and the environment while driving innovation and productivity growth.



Building a Resilient Society through Radiation Protection and Emergency Medical Care

By deepening our understanding of the effects of radiation, we enhance health risk assessment and develop advanced technologies for radiation protection. By enhancing radiation emergency medicine and support systems, we help protect people and communities, from everyday safety and reassurance to emergency preparedness.



Transforming Discoveries into Everyday Impact

Discoveries made at large-scale research facilities such as NanoTerasu are transformed into innovations that advance manufacturing, healthcare, energy, and solutions to societal challenges. We transform cutting-edge research into technologies and systems that benefit society.

Vision for the future

Introduction

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Aiming to be a research institution that meets the expectations of society and the nation.

The National Institutes for Quantum Science and Technology (QST) is committed to contributing to the realization of a sustainable future society in which the economy, society, and the environment are harmonized. We pursue this goal by creating and delivering new value through research and development in the field of quantum science and technology.

With our purpose “Realizing dreams and pioneering the future ~ Creating a new Japan, and bringing happiness to the world with Quantum Science and Technology ~”, QST promotes a broad range of research and development activities, from fusion energy development to lifescience and medical science, with quantum science and technology. Leveraging its unique strengths, including a diverse portfolio of large-scale research facilities such as quantum beam facilities, fusion energy facilities, and a research hospital, QST strives to advance world-leading research and development and generate innovative outcomes that contribute to society.

Quantum science and technology research and development is currently one of the most attractive research fields both in Japan and overseas. In 2025, marking the 100th anniversary of quantum mechanics, Japan further strengthened its commitment to the advancement of quantum technologies by formulating the Vision of Quantum Future Society and the Strategy of Quantum Future Industry Development, following the earlier Quantum Technology and Innovation Strategy. Designated as both the “Foundational Quantum Technology Hub” and the “Quantum Life R&D Hub” under Japan’s Vision of Quantum Future Society, Strategy of Quantum Future Industry Development, and Quantum Technology and Innovation Strategy, QST plays a leading role in advancing quantum innovation. QST promotes research and development of quantum materials—the foundational materials for quantum devices—and advances quantum life science and technology that bridges quantum technologies with life sciences and medicine. Furthermore, under Japan’s Fusion Energy Innovation Strategy, QST has been designated as the Fusion Technology Innovation Hub. With the vision of “Bringing the Sun to the Earth,” QST is advancing research and development toward the realization of fusion power generation, helping to pave the way for a sustainable energy future. In the field of medicine and healthcare, QST plays a key role in AMED’s Neuroscience Integration Program as one of the research and development hubs advancing next-generation technologies for the diagnosis and treatment of brain disorders. As part of this effort, QST leads research on the imaging and theranostics of brain lesions and neural circuits. Furthermore, QST aims to contribute to the realization of a healthy and long-lived society through the development and application of advanced medical technologies, including carbon-ion radiotherapy, targeted radionuclide therapy, and imaging technologies for the diagnosis of dementia and other diseases. Furthermore, QST has been designated as the Core Advanced Radiation Emergency Medical Support Center and plays a leading role in the development of technologies and human resources related to radiation emergency medicine and the research of radiation effects. At NanoTerasu Synchrotron Light Source developed and constructed by leveraging QST’s expertise in quantum beam generation technologies, operation of the public beamlines commenced in March 2025. Since then, NanoTerasu has contributed to the creation of a wide range of valuable outcomes, including those generated through collaborations with industry.

Building on these achievements, we will further enhance our world-leading, high-performance large-scale research facilities and the foundational science and technologies that support them, “Quantum Science and Technology Platform”. Through collaboration with researchers in Japan and abroad and the shared use of its facilities, QST will promote innovative research and development and strive to lead the world not only in quantum science and technology but also across a broad range of scientific and technological fields.

- At our nationally designated research and development centers—including the Foundational Quantum Technology Hub, the Quantum Life R&D Hub, the Fusion Technology Innovation Hub, the Core Advanced Radiation Emergency Medical Support Center, and NanoTerasu—we will further strengthen human resources, intellectual property, and research infrastructure as the core foundation of Japan’s quantum science and technology capabilities.
- Based on our “Quantum Science and Technology Platform”, we will advance cutting-edge and original research and development centered on four research fields, Quantum Technology Innovation, Quantum Medicine and Healthcare, Quantum Energy, and Quantum Beam Science.
- We have established a system for developing, maintaining, and providing access to a unique set of large-scale research and development facilities, offering a one-stop service that enables efficient use by researchers in Japan and abroad.
- QST plays an important role in national strategies and policies, has been designated as hubs for various national initiatives, and is engaged in research and development. Through steady and continuous efforts, we will continue to meet the strong expectations placed on us by the government and society.



National Institutes for Quantum Science and Technology

President
KOYASU Shigeo

QST Research Institutes and Major Quantum Science and Technology Facilities

Takasaki Institute for Advanced Quantum Science



Ion Irradiation Research Facility TIARA (in service)



Electron-beam Irradiation Facility (in service)



Cobalt 60 Gamma-ray Irradiation Facilities (in service)

Kansai Institute for Photon Science (Kizu site)



Laser Experiment Facility J-KAREN-P (in service)



QUADRA-T (in service)

Kansai Institute for Photon Science (Harima site)

QST Contract Beamlines at the Large Synchrotron Radiation Facility SPRing-8



BL11XU (in service)



BL14B1 (in service)

QST Headquarters

Institute for Quantum Life Science

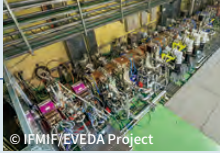


Quantum Life Science Research Building

QST Hospital



Rokkasho Institute for Fusion Energy



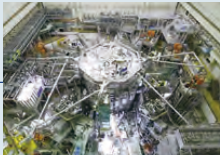
International Fusion Materials Irradiation Facility (IFMIF) Prototype Accelerator (under development)

NanoTerasu Center



NanoTerasu Synchrotron Light Source (for sharing according to the Act on the Promotion of Public Utilization of the Specific Advanced Large Research Facilities)

Naka Institute for Fusion Science and Technology



Tokamak-type Superconducting Plasma Experimental Device JT-60SA

Institute for Quantum Medical Science



Carbon-ion Radiotherapy System HIMAC (in service)

Institute for Radiological Science



Dose Assessment Building for Advanced Radiation Emergency Medicine

- **Headquarters** 4-9-1 Anagawa, Inage-ku, Chiba-shi, Chiba 263-8555, Japan Tel. +81-43-382-8001
- **Institute for Quantum Life Science/Institute for Quantum Medical Science/QST Hospital/Institute for Radiological Science** 4-9-1 Anagawa, Inage-ku, Chiba-shi, Chiba 263-8555, Japan Tel. +81-43-251-2111
- **Takasaki Institute for Advanced Quantum Science** 1233 Watanukimachi, Takasaki-shi, Gunma 370-1292, Japan Tel. +81-27-346-9232
- **Kansai Institute for Photon Science (Kizu)/The Kids' Science Museum of Photons** 8-1-7 Umemidai, Kizugawa-shi, Kyoto 619-0215, Japan Tel. +81-774-71-3000
- **Kansai Institute for Photon Science (Harima)** 1-1-1 Kouto, Sayo-cho, Sayo-gun, Hyogo 679-5148, Japan Tel. +81-791-27-2111
- **NanoTerasu Center** 6-6-11-901 Aoba, Aramaki, Aoba-ku, Sendai-shi, Miyagi 980-8579, Japan Tel. +81-22-785-9480
- **Naka Institute for Fusion Science and Technology** 801-1 Mukoyama, Naka-shi, Ibaraki 311-0193, Japan Tel. +81-29-270-7213
- **Rokkasho Institute for Fusion Energy** 2-166 Omotedate, Obuchi, Rokkasho-mura, Kamikita-gun, Aomori 039-3212, Japan Tel. +81-175-71-6500
- **Tokyo Office** 22nd Floor, Fukoku Seimei Building, 2-2-2 Uchisaiwaicho, Chiyoda-ku, Tokyo 100-0011, Japan Tel. +81-3-6852-8165

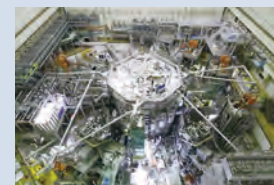


Research and development for creating the future

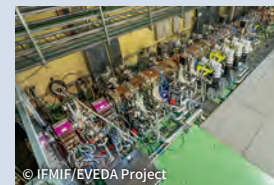
- QST promotes advanced and creative research and development in four research areas based on our quantum science and technology platform: quantum technology innovation research, quantum medical science, quantum energy research, and quantum beam science.
- By utilizing the world's most advanced and high-performance large-scale research and development facilities and their fundamental technologies, QST contributes to "maximizing research achievements" through collaborative creation and facility sharing between ourselves and domestic and overseas researchers, and leads the world not only in quantum science and technology but also in a wide range of other fields.
- As a core role in the national strategy, etc., the center will serve as a hub connecting universities and companies, accepting students, professional researchers, and engineers to foster human resources in the field of quantum science and technology, and will also focus on fostering industries by providing testbeds and startup support.



TIARA



JT-60SA



IFMIF Prototype Accelerator

Shared Use and Strategic Utilization of Advanced Research Facilities

Strengthening the Foundation for Innovation through Collaboration and Talent Development



HIMAC



SPring-8



J-KAREN-P



NanoTerasu

Quantum Technology Innovation

Nanomaterials, Quantum Devices, and Sensors

Quantum Medical Science

Carbon-ion Radiotherapy, Diagnosis and Treatment of Brain Disorders

Quantum Energy

Realization of Fusion Energy

Quantum Beam Science

Quantum Beam Processing and Analysis Technologies

Four Research Areas

The four areas are interconnected through a shared quantum technology platform, enabling innovations in healthcare, energy, materials development, and other fields.

Unlocking the Invisible World to Transform Society



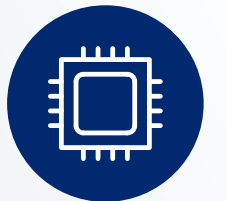
Assessing Dementia Risk with a Simple Blood Test



Dramatically Improving Battery Performance



Exploring Life at the Nanoscale



Advanced Analysis of Semiconductor Microstructures



Non-Surgical Cancer Treatment with Carbon-ion Radiotherapy



Enhancing Radiation Emergency Medical Preparedness



Generating Electricity by Fusion Energy

R&D Hubs designated by the government



Foundational Quantum Technology Hub

Vision of Quantum Future Society/Strategy of Quantum Future Industry Development



Quantum Materials and Applications Research Center Building (scheduled for completion in 2027)

Quantum Life R&D Hub

Quantum Technology Innovation Strategy



Quantum Life Science Research Building

Research and Development Center for Neuropsychiatric Disorders Diagnosis and Treatment Technologies

AMED Large Research Project Aimed at Fundamental Treatment of Dementia



Exploratory Research Building

Radiation Emergency Medicine Hub

Designated as Core Advanced Radiation Emergency Medical Support Center by the Nuclear Regulatory Commission



Dose Assessment Building for Advanced Radiation Emergency Medicine

Fusion Technology Innovation Hub

Fusion Energy Innovation Strategy



Blanket Test Facility Building

NanoTerasu Synchrotron Light Source

The Specific Advanced Large Research Facility



View of NanoTerasu

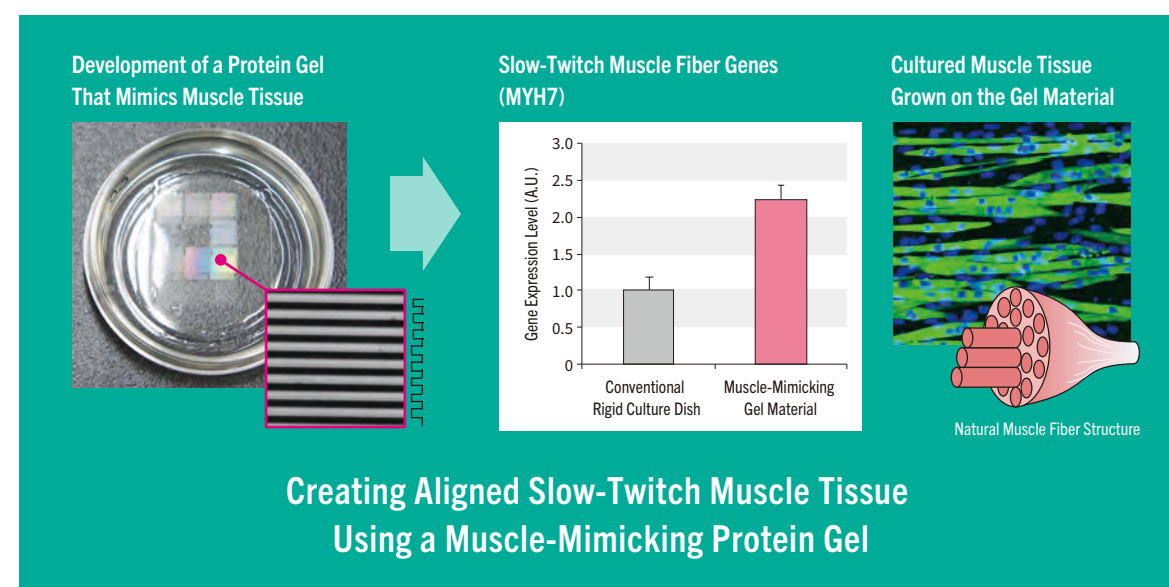


First Successful Cultivation of Slow-Twitch Muscle Fibers

Enabled by QST's Proprietary Gel Technology That Mimics the Softness and Structure of Living Tissues

Researchers from QST and Tokyo Metropolitan University achieved the first successful cultivation of slow-twitch muscle tissue using QST's unique gel materials and processing technologies, which replicate the softness and fiber alignment of natural muscle. Slow-twitch muscles are essential for daily activities and sustained physical performance. However, despite the need for cultured muscle tissue in studies of frailty prevention and muscle function recovery, reproducing slow-twitch muscle in vitro has remained a major challenge. Noting that muscle tissue in the body is soft and fibrous, whereas conventional culture dishes are hard and flat, the research team proposed that this environmental mismatch could

be preventing the formation of slow-twitch muscle fibers. Using QST's proprietary radiation processing technology, the researchers developed a gel that replicates both the softness of natural muscle tissue and the fine structure of muscle fibers. This enabled the successful formation of aligned cultured muscle tissue with the characteristics of slow-twitch muscle fibers. This breakthrough is expected to support research on preventing muscle decline and promoting muscle regeneration. Furthermore, by enabling the replication of the softness and architecture of various biological tissues, QST's gel technology may open new possibilities for the cultivation of a wide range of tissues.



Read More →

<https://www.qst.go.jp/site/news/slow-twitch-muscles.html>

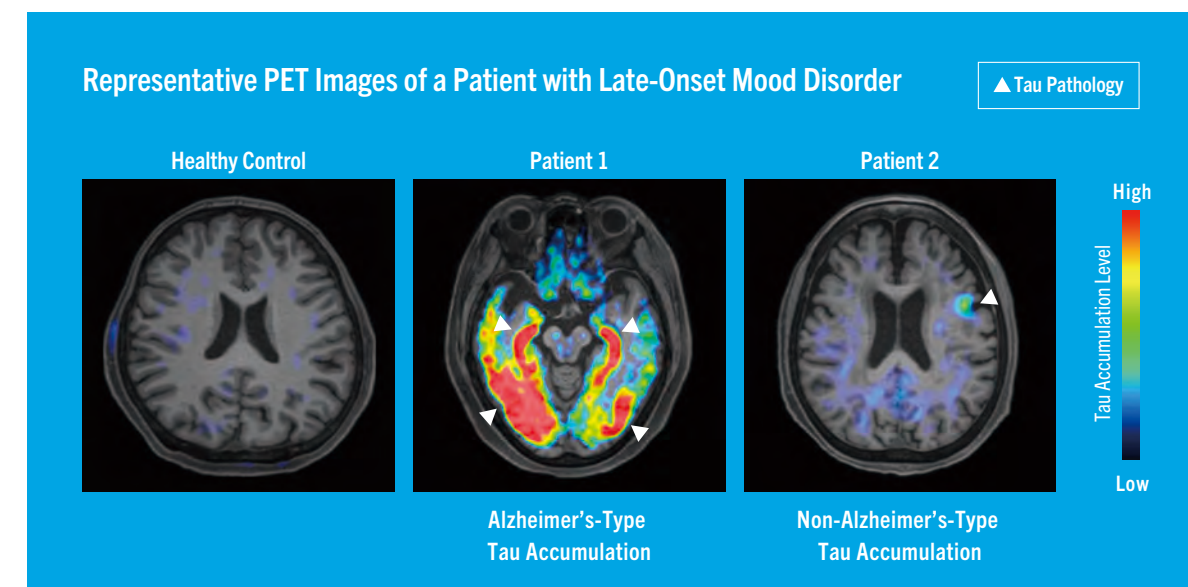


Brain Imaging Reveals the Involvement of Dementia-Related Proteins in Late-Onset Mood Disorders

Visualizing Tau Pathology with QST's Proprietary Technology for Objective Diagnosis and Treatment

Using PET brain imaging and postmortem brain analyses, a QST-led research team revealed that abnormal tau protein accumulation associated with dementia may play a role in late-onset mood disorders, including depression and bipolar disorder. Using QST's proprietary tau PET tracer, [¹⁸F] Florzotau, the team found that tau pathology was approximately 4.8 times more prevalent in patients with late-onset mood disorders than in healthy individuals. Furthermore, the study showed that mood symptoms

appeared an average of approximately seven years before the onset of cognitive impairment, suggesting that mood disorders may represent a prodromal stage of dementia. These findings open a new path toward understanding late-onset mood disorders not only as mental health conditions, but also as disorders associated with underlying changes in the brain. They are expected to contribute to earlier diagnosis and the development of more effective disease-modifying therapies.



Read More →

<https://www.qst.go.jp/site/news/mood-disorders.html>





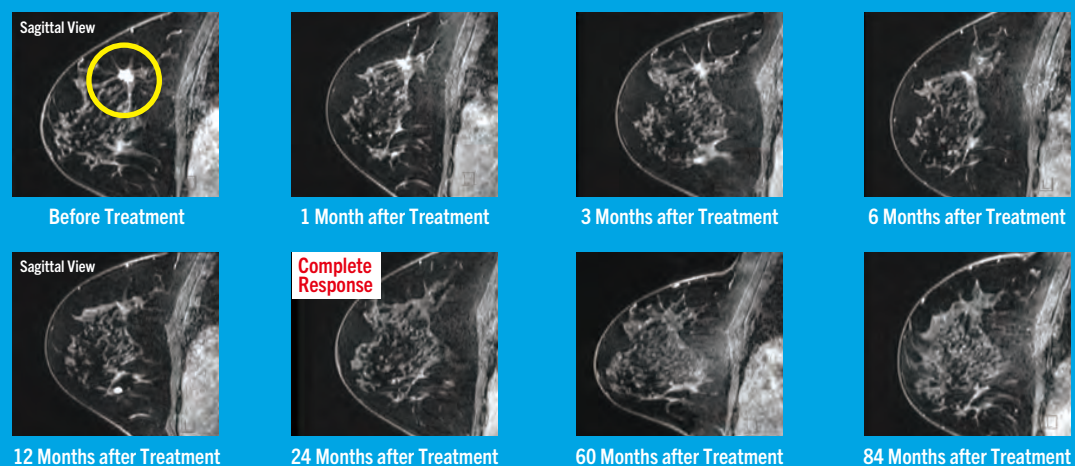
Demonstrating the Efficacy and Clinical Utility of Non-Surgical Carbon-ion Radiotherapy for Early-Stage Breast Cancer

A Promising New Treatment Option for Patients with Early-Stage Breast Cancer Who Prefer to Avoid Surgery

QST conducted a Phase II clinical trial of carbon-ion radiotherapy as a non-surgical treatment for early-stage breast cancer and confirmed its efficacy and clinical utility. The study enrolled 12 patients aged 60 years or older with Stage I, low-risk early-stage breast cancer, all of whom received carbon-ion radiotherapy over a four-day treatment course. The outcomes were highly favorable, with a 100% 5-year overall survival rate and 92% rates for both local control and disease-free survival at five years. Recurrence was observed in only one patient. Furthermore, no severe adverse events were observed, and good cosmetic outcomes were maintained in all patients except

for the one patient who underwent a mastectomy due to recurrence. A key advantage of carbon-ion radiotherapy is its ability to deliver a powerful, targeted dose to tumors while minimizing exposure to surrounding healthy tissue. These findings suggest that carbon-ion radiotherapy could become a new treatment option for patients who are not suitable candidates for surgery or who wish to avoid mastectomy, offering the potential to achieve both curative outcomes and improved quality of life. QST is currently advancing new clinical trials aimed at expanding patient eligibility and further reducing treatment burden through single-fraction carbon-ion radiotherapy.

Clinical Course of Carbon-ion Radiotherapy for Breast Cancer: A Case Study



Major Advantages for Realizing a Fusion DEMO Reactor in Japan

Japanese Technologies Developed Through ITER Pave the Way for a Fusion DEMO Reactor

QST has made significant contributions to the ITER project, showcasing Japan's world-leading fusion technologies. First, QST achieved a major milestone toward ITER's first plasma by installing the first gyrotron, a high-power microwave source for plasma generation and heating, ahead of all other ITER members at the ITER site in southern France. Furthermore, QST's advanced remote maintenance technologies have earned international recognition, resulting in the adoption of Japanese technology for the fabrication of tools used in the initial assembly of ITER blanket modules, a critical stage of the project. These achievements not only support the construction and startup of ITER, but also highlight how advanced technologies, including high-precision installation, remote handling of heavy equipment, and welding and fastening in confined spaces, will play a vital

role in the construction and maintenance of future fusion DEMO reactors. Japanese technologies pioneered through ITER are expected to accelerate the realization of fusion energy while providing a major advantage for the development of Japan's future fusion DEMO reactors.



Blanket Shield Block Cooling Pipe Cutting Tool (Left) and Gyrotron (Right)



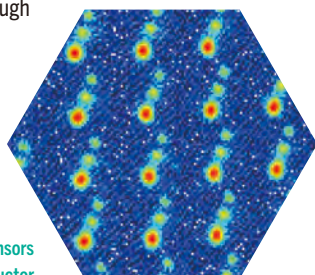
Dream Big,

Shape the Future

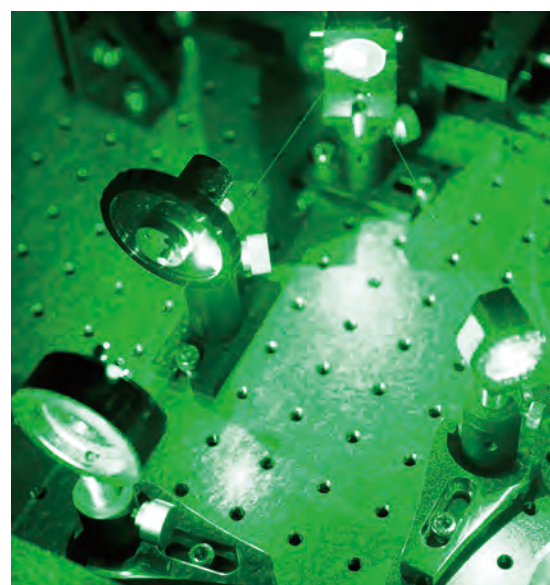
Creating with Quantum, Shaping the Future

(1) Toward a Failure-Free Society

Wouldn't it be reassuring if products could tell us when they are about to fail before a breakdown occurs? Leveraging expertise gained through quantum technology and advanced materials and device research, we are developing quantum sensors that can be embedded within equipment to detect early signs of failure. These sensors will enable the detection of extremely subtle anomalies in semiconductors and other devices, allowing their condition to be monitored in real time while in operation. Through the early detection and prevention of failures, we aim to build a safer, more reliable society where people can live free from worry. Beyond advancing research in the laboratory, we strive to connect innovation with real-world applications through industry-academia collaboration, creating reliable social infrastructure that allows everyone to live safely and with confidence.



Light emission from quantum sensors embedded in a semiconductor



Laser light for precise quantum control

Spin Photonics Opens the Door to a New Society: Energy-Efficient, High-Speed Memory

Recent advances in spin photonics research have led to the development of a novel magnetic memory material that enables information to be rewritten simply by illuminating it with laser light to reverse its spin state. In theory, this technology could enable memory devices that consume just one-thousandth the power of conventional technologies while operating up to 1,000 times faster. This research required the fabrication of artificial ferrimagnets consisting of ultra-thin magnetic layers with varying thicknesses and the evaluation of their spin states. Leveraging the advanced performance of NanoTerasu, Japan's newest synchrotron radiation facility, these measurements were conducted rapidly and with high sensitivity. The project also demonstrates the power of collaboration across research sites and facilities.



Read More →

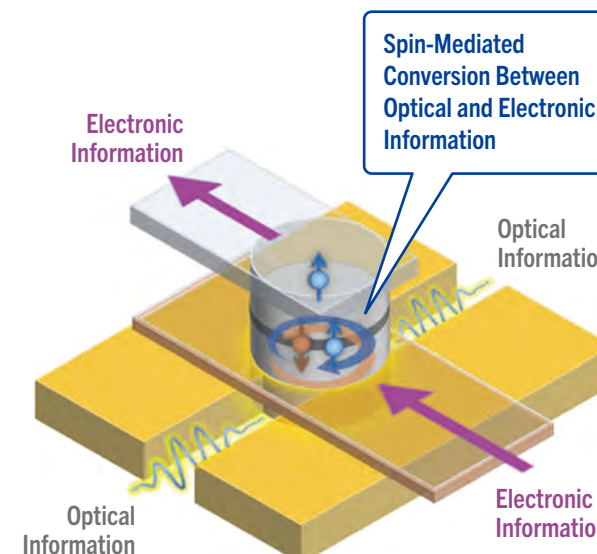


(2) Creating New Functions

Spin photonics, a technology that enables precise control of light and electron spins, is attracting growing attention as a promising field of research. This technology harnesses light (photons) to precisely control electron spins, enabling breakthrough functionalities in materials beyond what was previously possible. This technology has the potential to enable ultra-low-power devices that redefine what is possible, ultimately transforming our daily lives and society as a whole. We are also actively engaged in the research and development of devices and materials that support next-generation energy technologies, including catalysts and membrane materials for advanced batteries, as well as hydrogen storage materials for the efficient utilization of hydrogen, contributing to the realization of a carbon-neutral society. Through these multidisciplinary research activities, we are creating a stream of innovative materials that will help build a sustainable future.



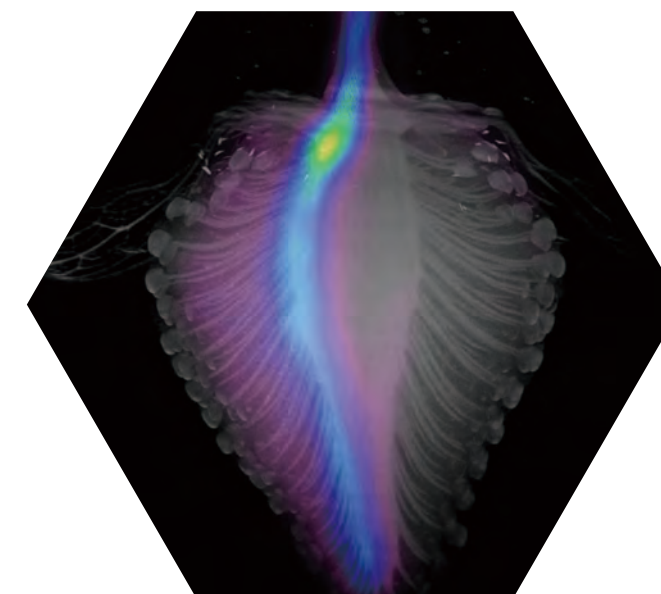
Membrane materials for batteries



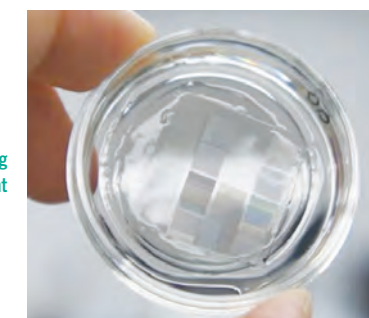
Next-generation memory technologies transforming our future

(3) Seeing the Unseen

We realize our "seeing the unseen" technologies by harnessing quantum beam technologies and the unique materials they enable. In the medical field, we develop advanced bio-devices that mimic the human body's environment and create tissue and organ models, enabling the study of cellular functions that are difficult to observe in vivo and advancing medical and drug discovery research. In the agricultural field, we use radioisotope (RI) imaging technology to track in real time how plants absorb and transport water and nutrients. The power to "seeing the unseen" is helping build a better future, driving innovations that enhance our lives in fields ranging from healthcare to food production.



Visualizing nutrient flow inside a strawberry



Gel scaffold replicating the in vivo environment



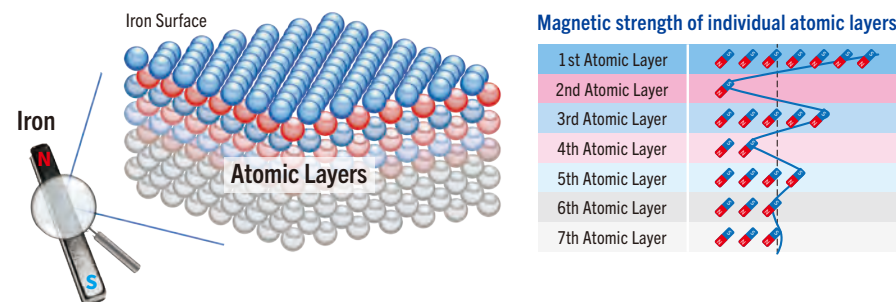
Dream Big,

Shape the Future

Creating New Knowledge with Photons, and Opening Up the Future for People and Society

(1) Unveiling the Invisible World of Nanoscience and Quantum Phenomena: Cutting-Edge Technologies Powered by Synchrotron X-rays

Using powerful synchrotron X-rays, we are developing advanced measurement technologies that reveal the behavior of quantum phenomena hidden within the nanoscale world. Recently, we refined a technique for probing the magnetic properties of nanoscale materials, achieving the world's first measurements capable of resolving magnetism one atomic layer at a time. As a result, we uncovered a quantum phenomenon in which magnetism changes from one atomic layer to the next. For example, in iron, a well-known magnetic material, the outermost atomic layer is strongly magnetic, the second layer only weakly so, and the third layer intermediate between the two. This world-first achievement provides a new window into the quantum world hidden at the atomic scale. By making the invisible visible, we are helping drive the development of next-generation devices, including advanced memory technologies, that will underpin the smart societies of the future.

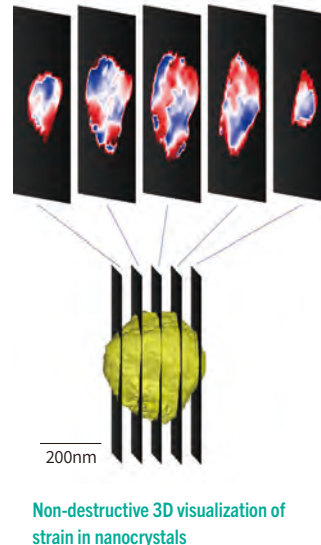
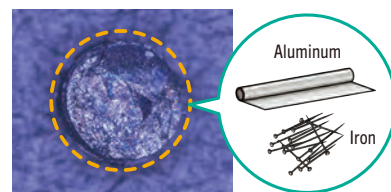


Unveiling the hidden quantum world of magnetism, one atomic layer at a time

(2) Addressing Society's Challenges through Advanced Measurement Technologies

Through advanced measurement technologies utilizing synchrotron X-rays, we are meeting diverse societal needs and helping build a better future. Using non-destructive nanoscale imaging technology, we can visualize nanoscale defects and the earliest stages of degradation in electronic devices while keeping the devices intact. Through these efforts, we contribute to the development of highly reliable, high-performance products. We have also developed technologies for real-time observation of semiconductor growth processes, paving the way for the realization of high-quality quantum-grade CVD diamonds and other advanced materials for next-generation quantum technologies. We are also working to develop low-cost hydrogen storage materials that eliminate the need for rare and expensive metals by utilizing advanced technologies capable of directly observing reactions in high-pressure hydrogen environments in real time.

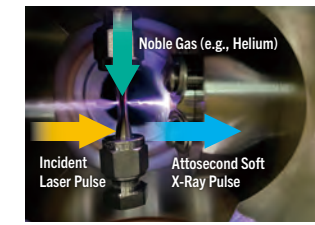
Aluminum × iron: An unexpected new hydrogen storage material



Non-destructive 3D visualization of strain in nanocrystals

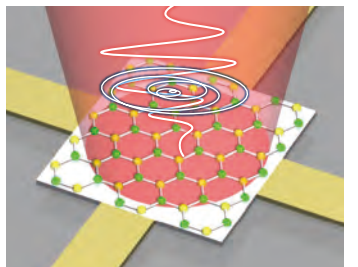
(3) Visualizing and Controlling the Quantum World with Ultrafast Lasers

Inside materials, the motion of quantum particles such as electrons governs chemical reactions and the operation of electronic devices. Ultrashort-pulse lasers allow us to observe the world of quantum motion on timescales ranging from femtoseconds (10^{-15} seconds), where atoms move, to attoseconds (10^{-18} seconds), where electrons move. At the Kansai Institute for Photon Science, we are conducting pioneering research on attosecond light generation, a breakthrough field honored by the 2023 Nobel Prize in Physics, and have successfully generated attosecond pulses in the soft X-ray region. By revealing electron dynamics in processes such as photosynthesis and semiconductor operation, this research aims to create new technologies for understanding and controlling material properties at the quantum level.



Generation of attosecond soft X-ray pulses

Ultrafast control of electronic devices with advanced laser technology



Short-pulse mid-infrared light
Short-pulse circularly polarized visible light

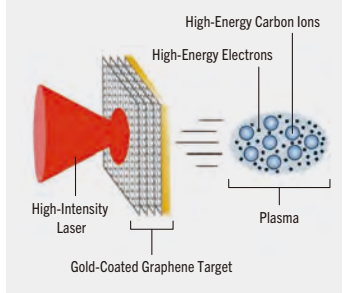
(4) Accelerating Particles with Powerful Lasers: Toward Compact Accelerators

Using high-intensity lasers, charged particles such as electrons and ions can be rapidly accelerated to high energies within a state of matter called plasma. This makes it possible to generate powerful particle beams over much shorter distances than conventional accelerators, paving the way for more compact accelerator systems. Developed at the Kansai Institute for Photon Science, the high-intensity laser system J-KAREN-P delivers light pulses with a peak power of one quadrillion watts, enabling cutting-edge research on the generation and acceleration of electrons and ions. To date, we have successfully accelerated carbon ions to 1 GeV, marking an important step toward compact next-generation particle accelerators. This technology could enable compact cancer treatment systems, including the "Quantum Scalpel," and is expected to open new possibilities for applications in medicine and industry.



Laser-driven ion injector under development

Conceptual Illustration of Carbon-Ion Acceleration Using a High-Intensity Laser



Nanometer-precision target control technology for ultra-precise laser-driven ion acceleration

(5) Developing Non-Invasive Glucose Sensors and Contact-Free Infrastructure Inspection Technologies

More than 500 million people worldwide live with diabetes and must monitor their blood glucose levels through blood sampling several times a day, facing challenges such as pain, emotional stress, and the risk of infection. To address these challenges, we have established a needle-free blood glucose monitoring technology using a high-brightness mid-infrared laser. We are also developing contact-free inspection technologies that use lasers to remotely digitize hammer-sounding tests for detecting defects inside concrete structures. This technology is helping advance the mechanization and automation of infrastructure inspections for structures such as tunnels and bridges. Recognized in the Ministry of Land, Infrastructure, Transport and Tourism's Performance Catalog of Inspection Support Technologies, this technology is already being deployed in practical infrastructure inspections.



Needle-free blood glucose sensor: Conceptual illustration
Photo courtesy of Light Touch Technology Inc.



Laser-based hammering inspection inside a tunnel



Dream Big,

Shape the Future

Understanding Life through Quantum Science, Making the World Happy with Quantum Technology

(1) Observing Life as It Is through Quantum Techniques

Biological nano-quantum sensors visualize minute biological information — such as temperature, pH, molecular dynamics, viscosity, and oxygen concentration inside cells — in real time with ultra-high sensitivity and high resolution. It enables everything from precise measurement at the single-cell level to simultaneous analysis of information spread across many cells, spatiotemporally unravelling the dynamics of life phenomena that were previously invisible. Such insights create new foundations for early disease detection, evaluation of treatment efficacy, and innovations in drug discovery and regenerative medicine. By capturing the essence of life through quantum technology, we open up a future society that supports people's health.

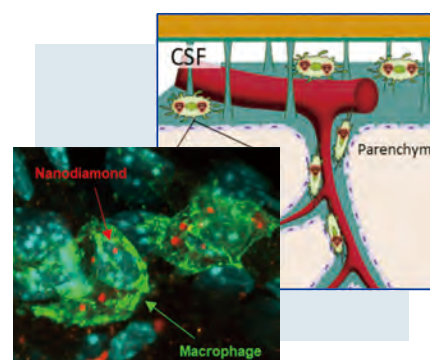
CSF: Cerebrospinal fluid

Macrophage: A type of immune cell that engulfs and digests foreign substances, dead cells, and cellular debris

A phagocyte that engulfs and digests foreign material, dead cells, and degenerated substances

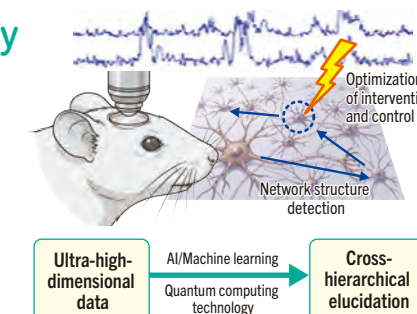
Parenchyma: The functional tissue of an organ

Schematic diagram of a macrophage incorporating nanodiamonds present in the mouse brain border region (brain surface)



(2) Understanding Life through Quantum Technology

By understanding the most microscopic layers of life phenomena through quantum theory and mimicking their principles, we promote research that leads to new drug discoveries, bio-production, and biomimetics. We observe the electronic properties of biomolecules to clarify their functions, states, and movements using NanoTerasu's synchrotron radiation. Using neutron beams, we directly observe hydrogen atoms with isotope replacement to determine the complete atomic structures of biomolecules with high precision. Based on these structural information, we analyze biomolecular dynamics and interactions at the atomic and electronic levels through molecular dynamics simulations and quantum chemical calculations, providing insights for drug target design. We also leverage a suite of instruments that simultaneously capture brain activity and body movements, and apply quantum probability models to analyze the resulting data, with the goal of elucidating the brain's cognitive and neural mechanisms.



By combining AI technology with quantum computing, we are developing new methods that efficiently analyze high-dimensional time-series data such as neural activity, aiming to elucidate various brain functions and the mechanisms underlying diseases.

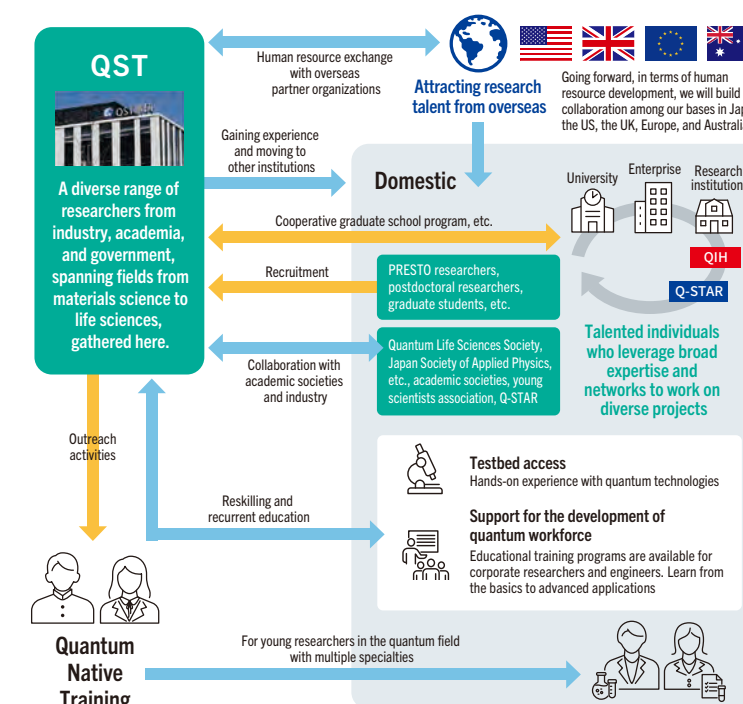
(3) Examining What Is Invisible with Quantum Technology

Hyperpolarized MRI/NMR is an innovative measurement technology that visualizes metabolism and chemical reactions within the body with far higher sensitivity than conventional methods. By detecting even the slightest movements and changes in trace amounts of substances, we can identify abnormalities developing in cells and organs at an early stage, helping us detect the early signs of disease. Additionally, since it allows real-time monitoring of internal changes resulting from treatment, it is useful for evaluating treatment effects and making optimal treatment choices. With the power of quantum technology, we visualize previously invisible aspects of life, realize precision medicine that is close to each individual, and open up a future society where people can live with peace of mind.



(4) Designing Future Society with Quantum Life Technology

The Institute for Quantum Life Science, QST is committed to promoting internationally competitive research and development and fostering people who bridge connect research outcomes to society. Outstanding researchers and engineers from both Japan and abroad gather here. The Institute serves as the core facility among domestic hubs, not only creating innovation through the fusion of quantum technology and life sciences but also advance the industrialization and commercialization of results. In addition, through educational activities for young people, we create learning opportunities that connect to the next generation and nurture the future of quantum life sciences by cultivating "quantum native" talent who can master future quantum life science.



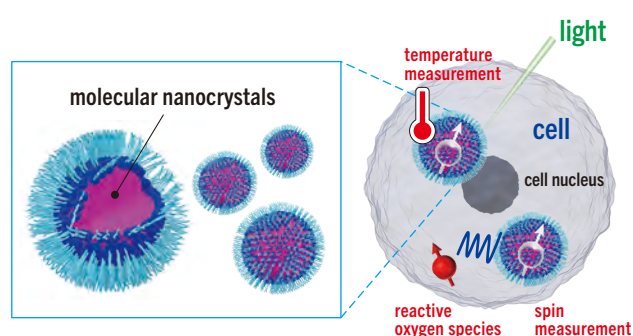
Turning the "Molecule" Itself into a Biological Nano-Quantum Sensor —Visualizing Temperature Distributions within Cells—

Internal cell temperature is crucial information related to cell function and disease progression, but measuring its distribution within tiny cells has been difficult. The Institute for Quantum Life Science, QST has developed a "molecular nano quantum sensor" that uses molecules themselves as sensors, successfully visualizing the fine temperature distributions in the cytoplasm and nucleus within living cells with high precision. This technology can be applied not only to temperature but also to intracellular spin measurement of species such as reactive oxygen, and can be deployed to multi-parameter measurements that can simultaneously measure multiple types of biological information. This deepens understanding of life phenomena, and is expected to be applied in future disease diagnosis and drug discovery.

Read More→



Quantum sensing of absolute intracellular temperature of radicals using molecular nano-quantum sensors





Dream Big,

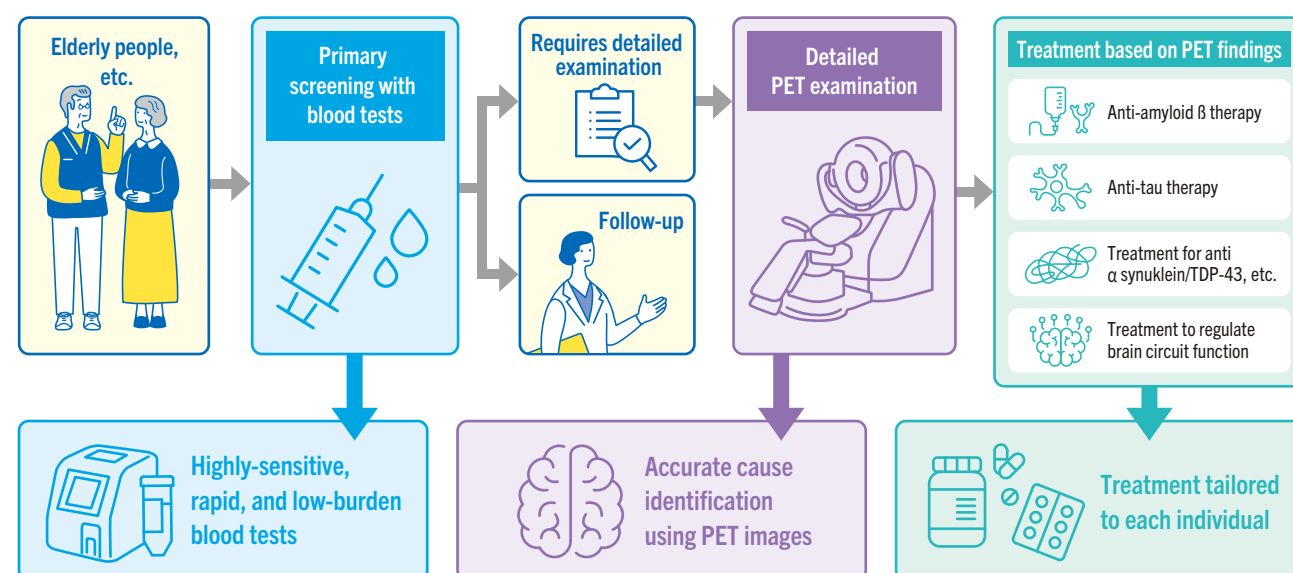
Shape the Future

Realizing a Healthy and Long-Lived Society by Overcoming Cancer and Dementia

(1) Establish Diagnostic and Treatment Methods to Overcome Dementia and Depression

Due to aging and increasing social stress, mental and brain diseases such as dementia and depression are on the rise every year. Overcoming these issues is an important challenge for realizing a healthy and long-lived society. To understand the function of brain neural circuits and the causes of diseases, we are advancing research that combines technologies to improve the precision of blood tests and PET scans with the development of therapeutic drugs under an alliance project in collaboration with universities and companies. We aim to evaluate the results obtained through global clinical research and to apply them in medical settings as quickly as possible.

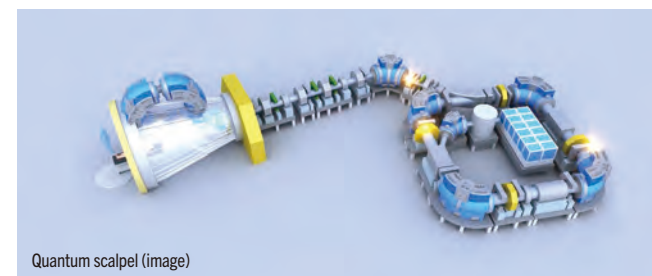
A “next-generation medical workflow” that combines mass screenings using blood tests and detailed brain imaging examinations, using proteins accumulated in the dementia brain as indicators



From left:
Blood biomarker measurement system (SIMOA),
Helmet PET, and PM-PBB3 tau PET image of
an Alzheimer's disease patient

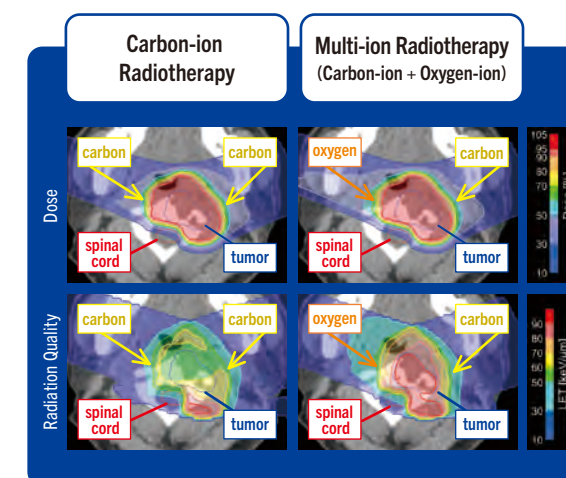
(2) Establishing Patient-Friendly Treatments to Overcome Cancer I (Quantum Scalpel)

There are two types of cancer: “solid tumors” formed by cancer cells gathering together, and cancers that spread throughout the body. Carbon-ion radiotherapy can precisely target cancer without the need for surgery, making it a minimally invasive treatment particularly suited for solid tumors while helping patients maintain their quality of life (QOL). We are developing a “quantum scalpel” that miniaturizes the device to a size suitable for hospital installation, so that more people can receive this treatment. Furthermore, we conduct research on the latest treatment technologies and high-performance imaging diagnostics, aiming to realize and promote more accurate and effective cancer treatments.



Quantum scalpel (image)

Increase in intratumoral LET with combined oxygen-ion radiotherapy (Enhanced antitumor effects)

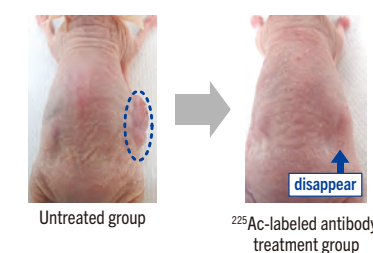
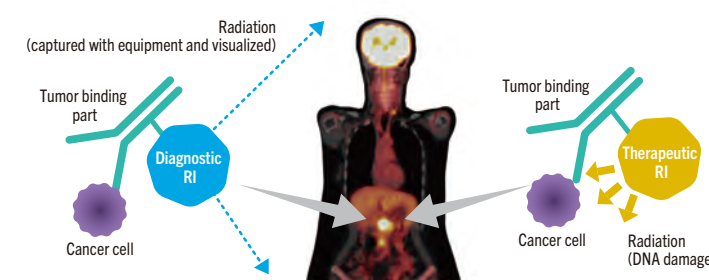


By using multi-ion radiotherapy technology that ensures high and uniform tissue irradiation throughout the tumor, the killing effect of cancer cells is enhanced.

(3) Establishing Patient-Friendly Treatments to Overcome Cancer II (Radiotheranostics)

We are advancing the clinical use of radiotheranostics, an innovative medical technology that combines diagnosis and treatment using radiopharmaceuticals for cancers that have spread throughout the body and are often difficult to detect with conventional imaging techniques such as CT. By visualizing the accumulation of the radiopharmaceutical in each patient's tumor before treatment, this approach helps ensure that the drug reaches the tumor, enabling safe and personalized radiation therapy guided by imaging. Because the dosage is extremely small, compared to chemotherapy and similar drugs, it places less burden on the body and allows treatment while maintaining quality of life (QOL). In particular, we are conducting clinical research on drugs that emit α particles (α -rays) with strong therapeutic effects in collaboration with hospitals. Furthermore, by combining multiple imaging technologies such as PET and MRI, we are conducting research to clearly understand the state and changes of cancer and predict treatment outcomes in advance.

The parts that bind to cancer are common, and by replacing the radioactive isotopes, diagnosis and treatment are integrated



Therapeutic efficacy of an α -emitting
radiopharmaceutical in a tumor-bearing
mouse model



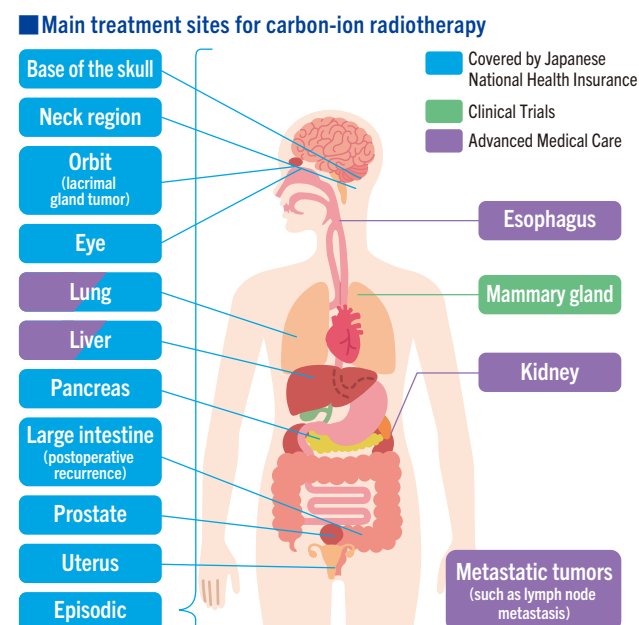
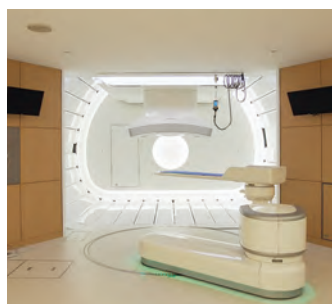
Dream Big,

Shape the Future

Creating Innovative Medicine Together and Bringing a Hopeful Future to the World

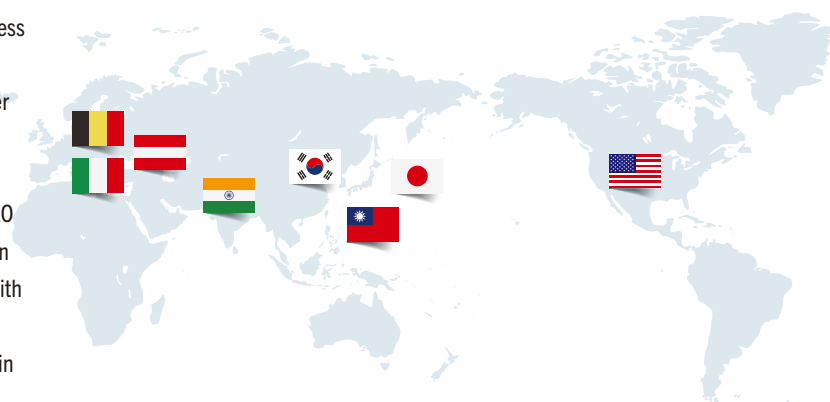
(1) Creating Innovative Medicine Together and Bringing a Hopeful Future to the World

Carbon-ion radiotherapy, pioneered at our hospital in 1994, has gained public health insurance coverage for a growing range of cancers, including difficult-to-treat cancers such as pancreatic cancer. The cumulative number of patients treated exceeds 17,000, and approximately 1,000 patients are treated annually. In April 2026, our hospital set a goal to “create innovative medicine together and deliver a hopeful future to the world.” Treatment using the next-generation device called the “Quantum Scalpel,” which reduces the HIMAC previously used for patient treatment to about one-sixth the size, is scheduled to begin in 2028. We will continue to advance medical care and research and development so that Japan’s cutting-edge cancer treatment technologies can be delivered to patients worldwide.



(2) Global Expansion of QST-Developed Carbon-ion Radiotherapy

Carbon-ion radiotherapy developed at QST has evolved into an advanced cancer treatment that combines high therapeutic effectiveness with reduced burden on patients. Our future goal is to spread these achievements worldwide and realize them as a leading option for cancer treatment in each country. We provide technical support during device implementation to institutions such as Seoul National University Hospital, Yonsei Cancer Center, Taipei Veterans General Hospital, CNAO Foundation, MedAustron, and Mayo Clinic, while also working on human resource development and understanding promotion in collaboration with the IAEA. Through these efforts, we promote the international standardization of carbon-ion radiotherapy and contribute to a society in which people around the world can live with greater peace of mind.

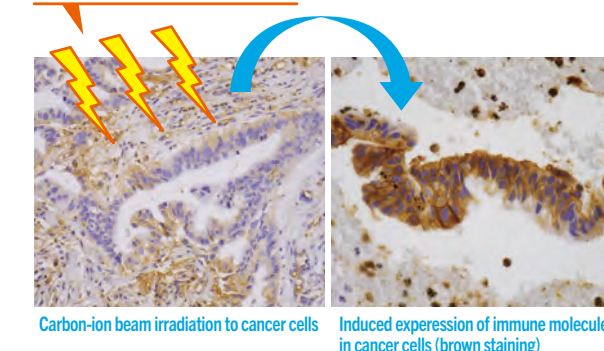


(3) Aiming for Zero Cancer Deaths through Carbon-ion Radiotherapy and Immunotherapy

Recent studies have shown that carbon-ion radiotherapy can enhance the body’s immune response against cancer in treated patients. In addition to conventional cancer treatments such as surgery, drug therapy, and radiation therapy, we are conducting research and development to establish combination therapy using immunotherapy and carbon-ion radiotherapy. Immunotherapy is attracting attention as a fourth major approach to cancer treatment.

■ Activation of immune molecules in cancer cells
by carbon-ion radiotherapy

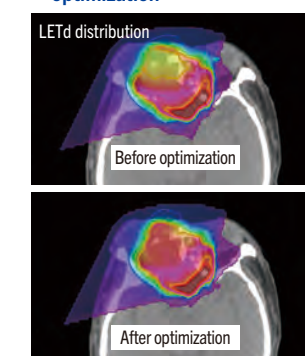
Carbon-ion Radiotherapy



(4) Next-Generation Therapy through Multi-ion Irradiation and LET Optimization

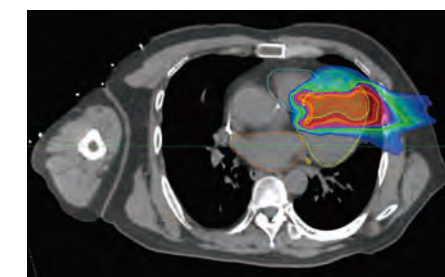
In addition to conventional carbon-ion irradiation, we are advancing research and development on multi-ion irradiation, which selectively utilizes multiple ion species. By leveraging the unique physical and biological properties of each ion species, we select and combine the optimal ion species according to the nature and location of the cancer, optimizing the distribution of LET (linear energy transfer), aiming for treatments that are stronger against cancer and minimize the burden on surrounding normal tissues. Additionally, by optimizing LET, we are making efforts to deliver effective results to the entire cancer system. The figure on the right shows how this optimization enables the effect to spread more efficiently and effectively inside the cancer.

■ Comparison before and after
LET (linear energy transfer)
optimization

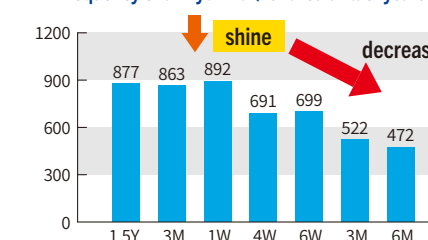


(5) Expanding Carbon-ion Radiotherapy to New Diseases

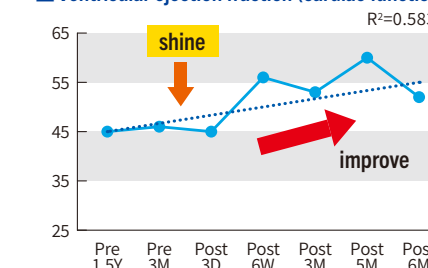
Since carbon-ion radiotherapy was launched at QST Hospital (formerly the National Institute of Radiological Sciences) in 1994, research and development has consistently focused on neoplastic diseases such as cancer and sarcoma. To expand its clinical applications, research and development has begun on carbon-ion radiotherapy for functional brain disorders such as epilepsy and hippocampal sclerosis, as well as life-threatening arrhythmias. The world’s first carbon-ion radiotherapy for life-threatening ventricular tachycardia has already been performed. We will continue basic and clinical research and development toward the practical application of carbon-ion radiotherapy for non-neoplastic diseases.



■ Frequency of arrhythmia (ventricular tachycardia)



■ Ventricular ejection fraction (cardiac function)





Dream Big,

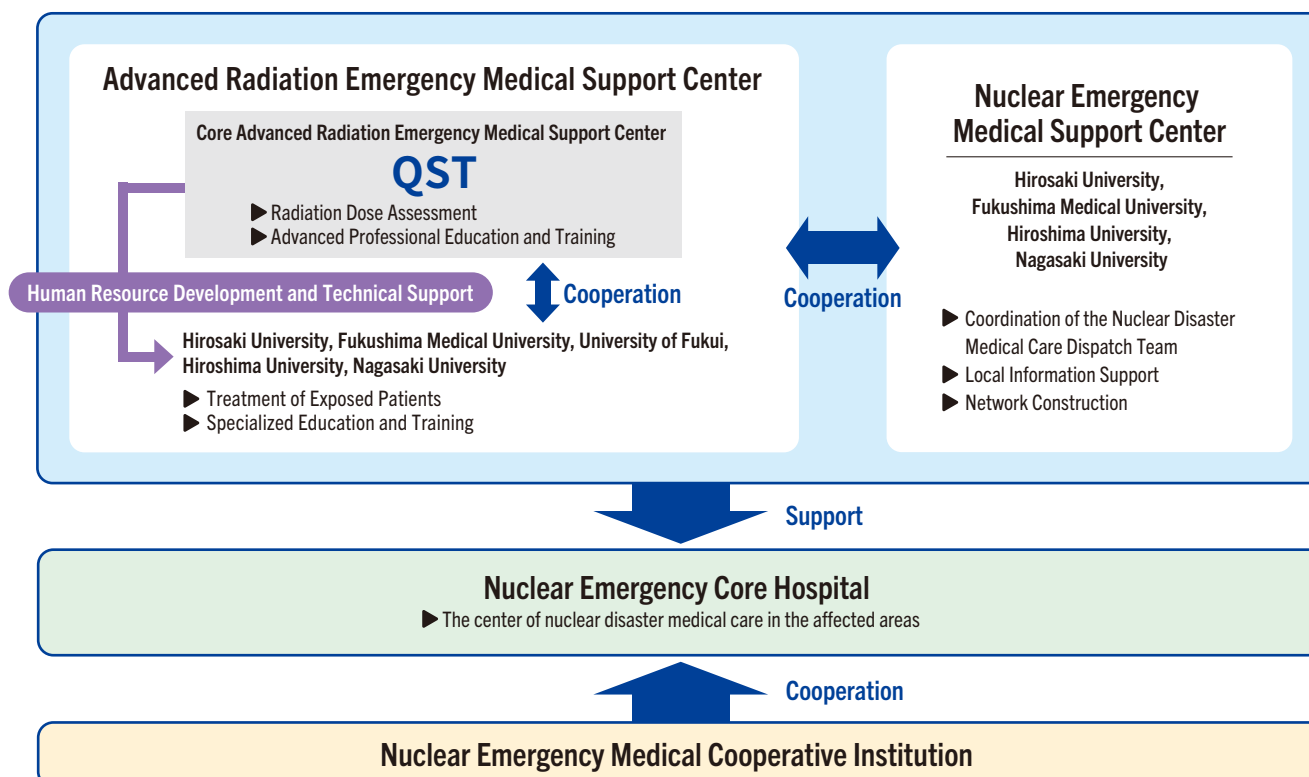
Shape the Future

Facing “Invisible” Radiation and Building “Visible” Peace of Mind

(1) Strengthen the Radiation Exposure Medical System and Build a Resilient Society against Nuclear Disasters and Radiation Accidents

In Japan, six “Advanced Radiation Emergency Medical Support Centers” have been established nationwide as bases responsible for advanced radiation exposure medical care during nuclear disasters. QST (Institute of Radiological Sciences) is designated as a “Core Advanced Radiation Emergency Medical Support Center,” playing a central and leading role within this center. As a core advanced support center, it is engaged in developing technologies related to radiation exposure medicine, providing technical support to other advanced support centers, and training specialists. Through these initiatives, we will cooperate with relevant organizations such as the Nuclear Regulation Authority to develop and strengthen systems that can fulfill their roles in nuclear disasters and radiation accidents, contributing to the construction of a safe and secure society.

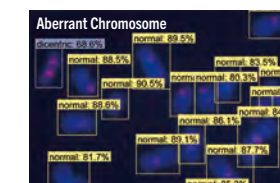
Domestic medical system during a nuclear disaster



QST is designated as a Technical Support Organization (TSO) of the Nuclear Regulation Authority, and centered around the Institute for Radiological Science, is responsible for responding to radiation exposure in nuclear disasters and related research.

(2) Developing Advanced Diagnostic Technologies for Rapid and Accurate Radiation Emergency Medicine

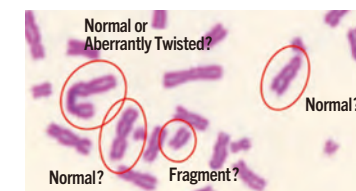
To develop treatment plans for radiation-exposed patients, it is necessary to perform dose assessments and estimate the types of radioactive materials involved, as well as the type and extent of radiation exposure. Due to nuclear disasters and radiation accidents, the forms of radiation exposure are diverse, and in particular, dose evaluation when radioactive substances are ingested into the body requires advanced technology. At QST, we are advancing research and development of biodosimetry techniques using Dose Assessment Building for Advanced Radiation Emergency Medicine, including internal dose assessment methods based on bioassays and in vivo measurements, as well as dose assessment technologies utilizing chromosome aberration analysis enhanced by machine learning.



Automatic detection of chromosomal abnormalities using AI



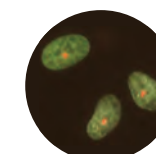
Appearance of the integrated in vitro measurement device



Visual inspection of chromosome aberrations

(3) Deepen and Bridge Knowledge on Exposure Effects to Support the Safety and Security of Radiation Utilization

To use radiation safely and securely, it is important to regulate and manage radiation handling based on scientific evidence. To obtain scientific evidence, QST conducts basic research to elucidate the mechanisms of biological responses to low-dose effects and radiation, epidemiological studies on medical and occupational exposure, and studies on radiation and its effects not only in terrestrial and marine environments but also in space. In addition to the insights gained from QST in these fields, we are also engaged in research and investigation in collaboration with international organizations to bridge the latest global findings with regulations and policy measures.



Microbeam irradiation of cells



Genome analysis of cancers related to radiation exposure



Radiation measurements on the space station

(4) Cultivating Experts in Radiation Emergency Medicine and Radiation Effects Research to Build Lasting Confidence Through Visibility

At QST, as a Core Advanced Radiation Emergency Medical Support Center, we mainly train specialists such as doctors, nurses, and technicians for these centers. In the event of a nuclear emergency or radiation accident, initial response efforts involve not only medical personnel but also organizations such as fire departments and police agencies. Accordingly, we provide training and emergency preparedness exercises for these organizations. In addition, our experts participate in drills conducted by local governments, offering technical guidance and advice to strengthen emergency response capabilities. In collaboration with researchers and engineers both domestically and internationally, we are developing and advancing dose evaluation technologies necessary for formulating treatment plans for exposed patients, deepening research on exposure effects, enhancing knowledge related to health risk assessment, and working on human resource development.



Core personnel training for nuclear disaster medical care



Initial radiation accident response seminar



Dream Big,

Shape the Future

Continuing to Move toward Realizing Fusion Energy

(1) Participation in the International Fusion Energy Project “ITER,” Involving Seven Members Worldwide

ITER: Pioneering the Future of Fusion Energy

QST participates in the “ITER Project,” a research and development project in southern France conducted through international cooperation among 34 countries to demonstrate the scientific and engineering feasibility of fusion energy. Designated by the Ministry of Education, Culture, Sports, Science and Technology as the Japan Domestic Agency (JADA) for the ITER Project, QST has been steadily promoting the design, manufacturing, transportation, assembly, and installation of superconducting coils and radio frequency heating systems, which Japan shares in cooperation with industry, making significant contributions to the construction of ITER. Through participation in ITER, QST aims to contribute to acquiring cutting-edge fusion energy core technologies, promoting international cooperation, energy security, and fostering and developing domestic industries, thereby opening a future where humanity can live safely and prosperously.



Inside the tokamak pit where a total of five sector modules are installed



Installation of the gyrotron RF heating device procured by QST/JADA

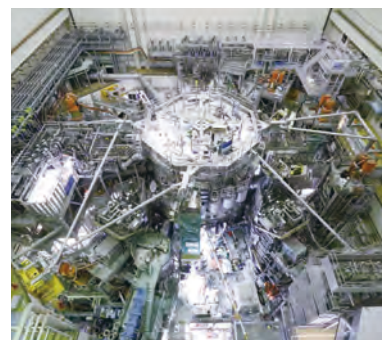
(2) Participation in the Japan-Europe International Project “JT-60SA”

Gathering the World’s Wisdom in JT-60SA to Open the Future of Fusion Energy

JT-60SA programme, which is being advanced as part of the Broader Approach activities between Japan and Europe, has achieved its long-awaited first plasma and is moving toward full-scale plasma heating experiments. JT-60SA is the world’s largest tokamak device, equipped with state-of-the-art tokamak equipment including superconducting coils, a variety of heating devices, and advanced measurement and control devices. Thanks to this unique research environment, in addition to Japan and Europe, the two major research institutes in the United States have recently officially joined the programme. Naka Institute, centered on JT-60SA, will steadily advance research and development aimed at the early realization of fusion energy, bringing together the world’s wisdom.



JT-60SA: A collaborative fusion energy project between Japan and Europe

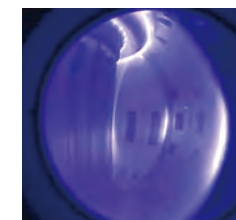


JT-60SA: The world’s largest superconducting tokamak plasma experimental device

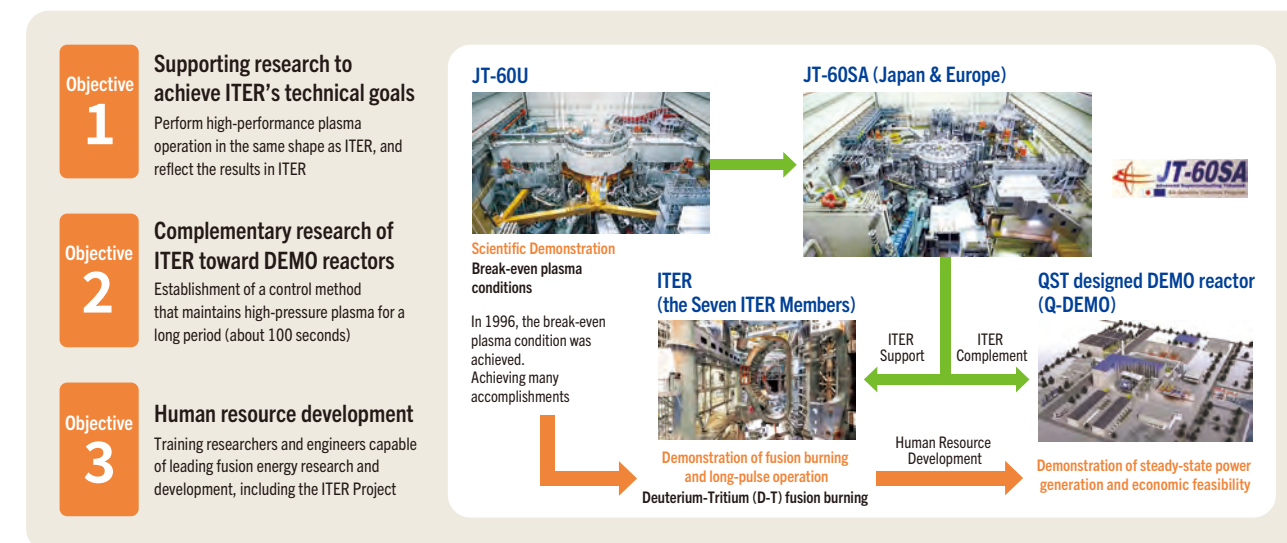
(3) Realization of Fusion Energy Pioneered by a Group of Plasma Experts

Stable Control of High-Pressure Plasma to Realize Fusion Energy Early!

The higher the pressure of the core plasma that generates fusion energy, the more rapidly the fusion energy output can be increased. However, control and operation methods to maintain high pressure are challenging, making it a major challenge worldwide to solve for the early realization of fusion energy. Leveraging the expertise gained from sustaining high-performance, high-pressure plasmas in JT-60U, JT-60SA was designed to support ITER while complementing its research program. Through JT-60SA, QST aims to accelerate the realization of a fusion DEMO reactor and the early realization of fusion energy. QST also fosters the next generation of scientists, engineers, and other highly skilled professionals who will help accelerate the realization of fusion energy.

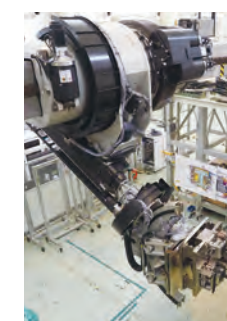


JT-60SA plasma image

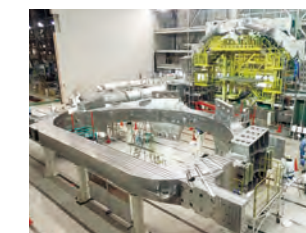


(4) Realizing Fusion Energy through the Expertise of a World-Class Fusion Reactor Engineering Team

The Naka Fusion Science and Technology Research Institute boasts a group of engineers and researchers who have played a central role in the design, manufacturing, and construction of world-leading fusion equipment such as the JT-60SA and ITER projects, in the field of reactor engineering, including superconducting magnets, remote maintenance, tokamak system development, plasma facing components, neutral beam heating, radio frequency heating systems, radiation safety, and power system development. Each group is equipped with testing equipment for research and development, enabling experiments ranging from ultra-low temperatures to ultra-high temperatures. By incorporating extensive project experience, collaboration with industry, and joint research with universities and companies, QST is working on R&D and strengthening experimental equipment to realize fusion energy as soon as possible.



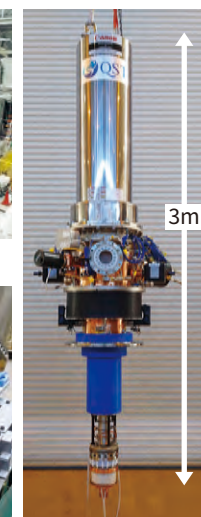
Remote maintenance system



Toroidal magnetic field coil



ITER divertor target



Gyrotron heating device



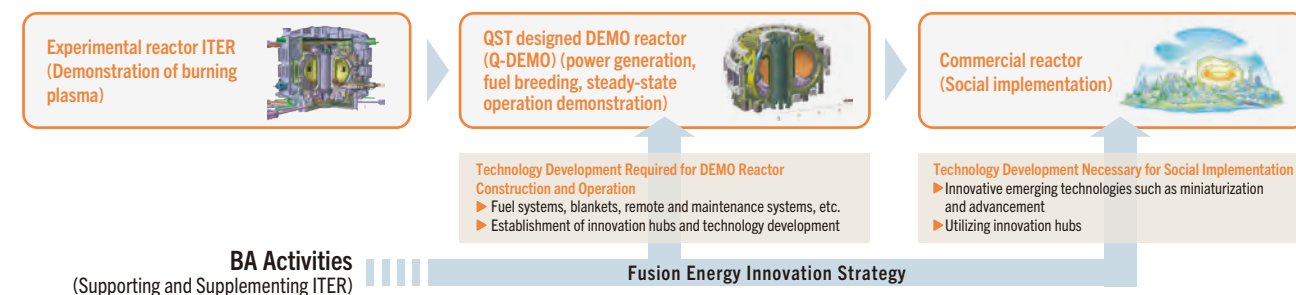
Dream Big,

Shape the Future

Early Realization of Fusion Energy through Enhancing Fusion Technologies and Accumulating Knowledge and Experience

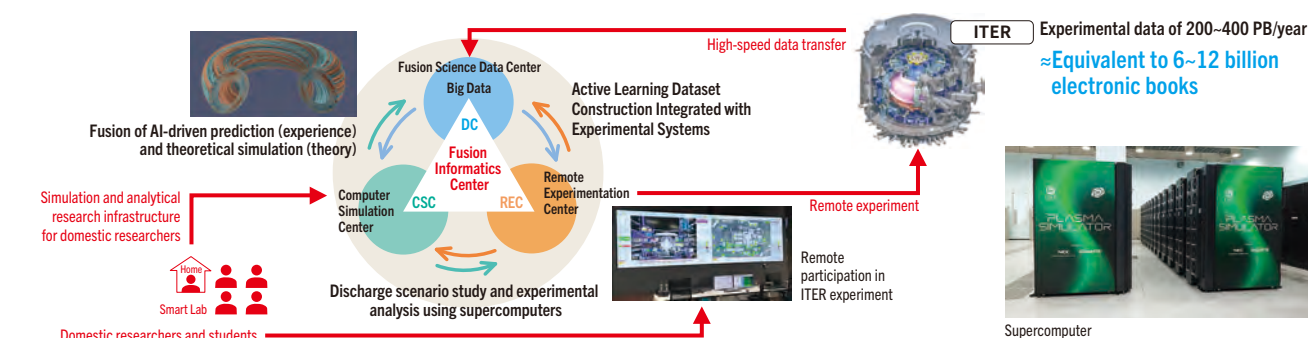
(1) Aiming to Demonstrate Power Generation in the 2030s: Q-DEMO

In line with its Fusion Energy Innovation Strategy, QST will complete the conceptual design of an ITER-sized DEMO reactor to demonstrate power generation in the 2030s by March 2026, naming it "Q-DEMO." Q-DEMO adopts core equipment equivalent to the experimental reactor ITER, such as superconducting coils and vacuum vessels, greatly simplifying design, R&D, and prototyping, enabling construction to start with low risk and the shortest possible time. As a scientifically and technologically significant milestone toward power generation, the plan is to demonstrate net electricity production (net electric power ≥ 0) by sustaining a high-temperature core plasma with energy generated from fusion reactions and achieving electrical output at the power plant terminal that exceeds the electricity consumed for power generation. Furthermore, by gradually improving the performance of core plasma and key equipment, QST will sequentially demonstrate the three main goals of the DEMO reactor—power generation, fuel breeding, and steady-state operation—and connect them to practical implementation in society.



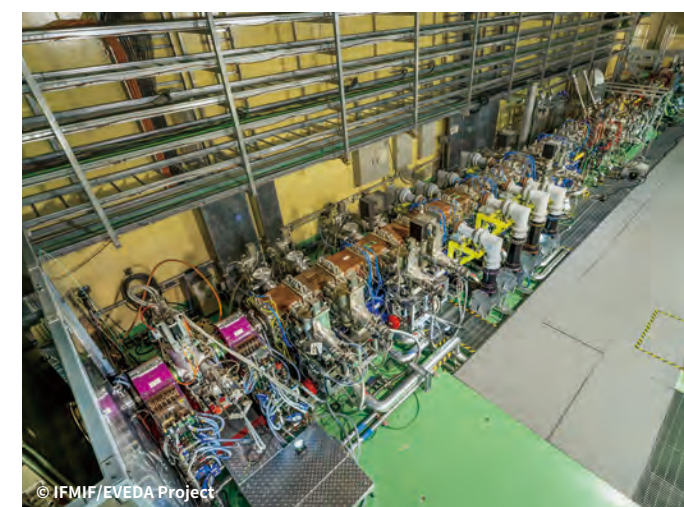
(2) Advanced Control of Core Plasma Using AI

Advanced predictive control technologies leveraging digital twins and AI are essential for controlling the highly autonomous core plasmas envisioned for the Q-DEMO and future fusion power plants. Their development is centered on supercomputing and makes use of experimental data from JT-60SA and ITER, large-scale simulation data, and data-driven science. QST is advancing a plan to integrate the Fusion Science Data Center with the Computational Simulation Center and the ITER Remote Experiment Center established under the Broader Approach (BA) activities, a wide-ranging collaboration between Japan and Europe. The third supercomputer system, which began its operation in July 2025, provides approximately ten times larger capability in processing power than that of the previous system.



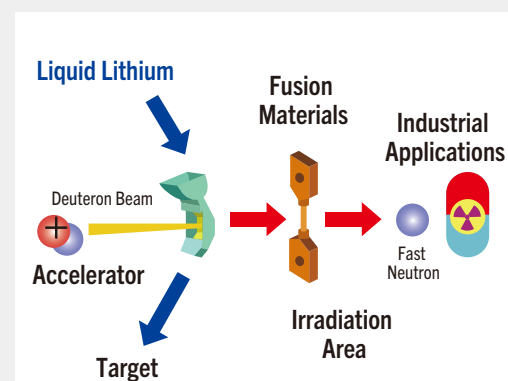
(3) Creating the Neutron Field Equivalent inside the Fusion Reactor to Develop Fusion Materials

Based on broad approach (BA) activities promoted through Japan-EU cooperation, we are developing the world's largest deuteron accelerator (IFMIF prototype accelerator: LIPAc) and a target system that generates 14 MeV fusion neutrons, as well as a neutron source system. LIPAc aims to demonstrate the world's highest-current continuous-wave accelerator. Building on its achievements, QST is also advancing, through international collaboration, a fusion materials irradiation facility project that will simulate the neutron irradiation environment inside fusion reactors, with potential industrial applications in mind. For Q-DEMO and subsequent commercial reactors, QST acquires high-energy neutron irradiation data from fusion materials and build a fusion materials database.



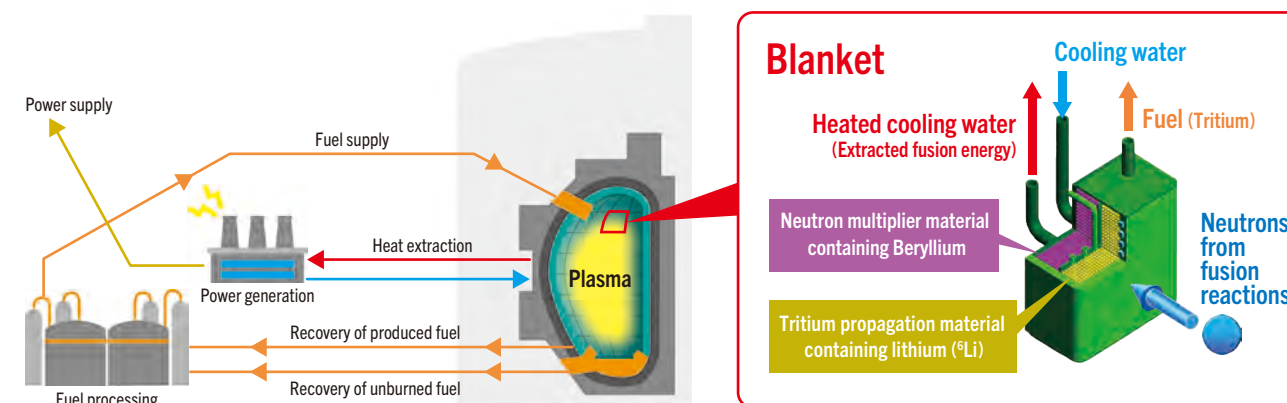
IFMIF prototype accelerator, LIPAc

The concept of neutron irradiation



(4) Generating Fusion Energy: Blankets

The fusion reactor blanket is a key technology for fusion power generation, responsible for recovering fusion energy, shielding generated neutrons, and generating fuel (tritium). QST is focusing on developing structural materials that can withstand extreme environments such as high temperature, strong magnetic field, and high-energy neutron irradiation, as well as functional materials that support fuel generation and recovery. Through demonstrations in real-world conditions with ITER, QST is enhancing design technology and further promoting the industrial application of new technologies such as lithium recovery and low-temperature refining. QST is also advancing research and development on fuel cycle systems for efficient use of fusion reactor fuel and on safe handling of tritium.





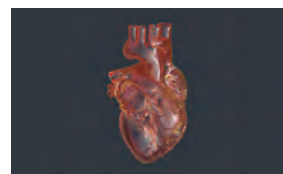
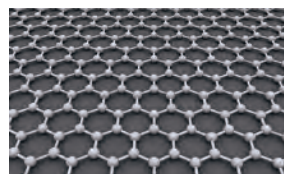
Dream Big,

Shape the Future

Opening the Future with Cutting-Edge Light, Creating Value for Society

(1) Continuously Advancing Society with Cutting-Edge Light

Synchrotron radiation is a highly brilliant X-ray source generated by advanced accelerator technologies. At NanoTerasu, high-energy electrons accelerated by a state-of-the-art linear accelerator circulate in an ultra-stable storage ring, producing exceptionally bright and high-quality synchrotron radiation. This cutting-edge light is reliably provided to users from diverse scientific, industrial, and technological fields for more than 5,000 hours each year (as of 2026). As a platform for research, innovation, and industrial competitiveness, NanoTerasu continuously delivers cutting-edge light that enables new discoveries and technological breakthroughs.

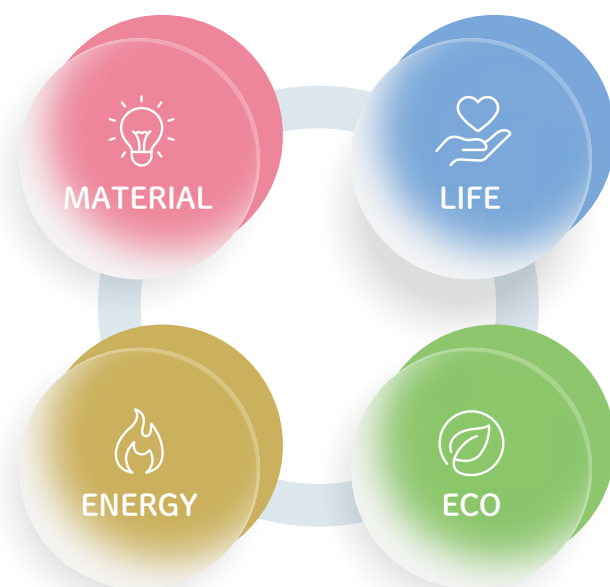


Unlocking New Possibilities in Materials

By enabling detailed observation of the nanoscale structures and electronic states of materials, we contribute to the development of novel materials with unprecedented functions and performance.

Realizing a Sustainable Energy Society

By elucidating how materials such as batteries and catalysts function, we contribute to the development of highly efficient, environmentally friendly energy technologies.

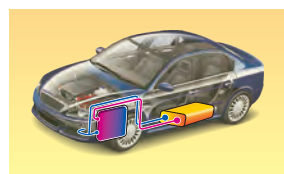


Understanding Life for a Healthier Future

By revealing the functions of proteins and other biomolecules that sustain life, we contribute to the development of innovative diagnostic technologies and pharmaceuticals.

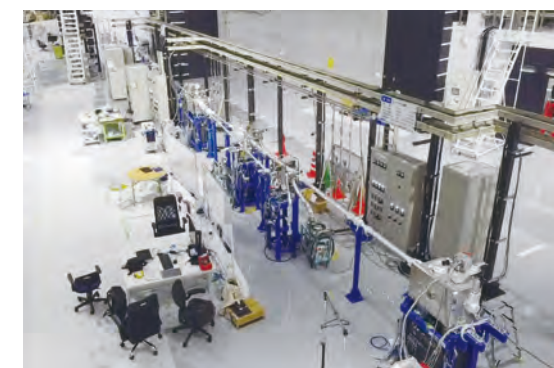
Supporting a Prosperous Future in Harmony with the Environment

By revealing the mechanisms of materials and chemical reactions, we contribute to the development of resource-efficient, energy-saving, and environmentally friendly materials and technologies.



(2) Bringing State-of-the-Art Light to Practical Use

To utilize synchrotron radiation generated by NanoTerasu for research, it must be properly shaped according to the intended purpose. The device that plays this role is the “beamline,” an essential system for maximizing the performance of synchrotron radiation. In beamlines, light is monochromatized, focused, irradiated onto samples, the responses generated are detected, and ultimately obtained as experimental data. We are developing beamlines that utilize world-class light, featuring world-class energy resolution, nano concentration in the soft X-ray range, and ultra-fast polarization switching.



BL13U: Nanoscale soft X-ray absorption spectroscopy



BL02U: Experimental equipment (end station)

(3) Pursuing Safety and Ease of Use to Accelerate Cutting-Edge Research

NanoTerasu is a facility that generates and utilizes radiation, so ensuring safety is of utmost importance. Japan's radiation management is conducted under some of the world's most stringent standards. In compliance with these standards, we are creating an environment where users can focus on their research with peace of mind, such as designating the experimental halls as a non-radiation-controlled area. In addition to safety management and continuous technological development related to radiation protection, we strive to balance safety, reliability, and convenience through stable operation of information and communication networks. Additionally, by establishing data centers, we will enable AI-driven synchrotron radiation experiments. Based on this foundation, NanoTerasu aims to remain a research hub where researchers worldwide can confidently utilize cutting-edge synchrotron radiation.



Accelerator maintenance work

(4) Advancing NanoTerasu for the Future

NanoTerasu is one of the world's leading synchrotron radiation facilities, providing highly brilliant soft X-rays for cutting-edge research and innovation. As scientific challenges become increasingly complex, users are seeking even higher brightness, greater coherence, and new capabilities for exploring matter in unprecedented detail. To meet these demands and continue expanding research frontiers, the continuous evolution of the facility is essential. In addition, we are pursuing the development of X-ray free-electron lasers to enable the observation of ultrafast phenomena and dynamic processes with femtosecond time resolution.



BL06U: Devices under development and enhancement



QST boasts a collection of world-leading, high-performance large-scale research and development facilities, along with their underlying beam technology. QST named this collective “Q-BEAMS” and will continue to support quantum science and technology by utilizing it more interdisciplinarily, synergistically, and efficiently with domestic and international researchers than ever before, while also contributing to a wide range of scientific and technological fields.



NanoTerasu

(3GeV High-Brilliance Synchrotron Radiation Facility)

The World’s Most Advanced Light Illuminating the Future

This facility began operation in 2024 through a public-private regional partnership. With world-class light source performance, it supports research and development across a wide range of fields, from cutting-edge scientific research to industrial use and even solving social

issues. NanoTerasu has the capacity to accommodate up to 28 beamlines. At present, three shared beamlines dedicated to cutting-edge academic research, including the world’s highest-resolution soft X-ray resonant inelastic scattering beamline, are being actively used by researchers from Japan and around the world. In addition, industrial utilization is being promoted through a new coalition-use program at seven beamlines operated by private regional sectors. To meet the expanding and diversified research needs, QST plans to sequentially expand its lineup of shared beamlines. As part of this, development of new X-ray diffraction beamlines has already begun, and in parallel, we are advancing the development of advanced research environments such as automation and remote utilization. Aiming to be a leading research facility in the world’s synchrotron radiation science, NanoTerasu continues to evolve.



J-KAREN-P

(Ultra-Short Pulse Petawatt Laser Device)

Towards the Frontiers of Laser Science

This is the highest output ultra-short pulse (femtosecond) petawatt laser device in Japan, capable of irradiation experiments with world-class concentration intensity. It is used in research on laser-driven ion acceleration, quantum beam source development such as high-intensity, high-energy X-ray generation, and high-intensity field science research through international collaborative experiments aimed at understanding high-energy cosmic materials.

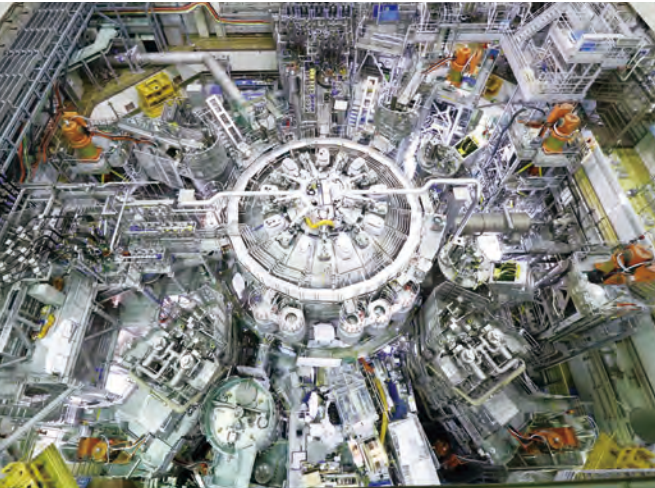


TIARA

(Ionization Research Facility)

Pushing the Limits of Manufacturing with Ion Beams

With four types of ion accelerators (AVF cyclotron, tandem accelerator, single-ended accelerator, ion implantation device), we provide a wide range of ion types and energy ranges for research and development, from quantum materials, environmental and energy material creation, to RI manufacturing and ion beam breeding. In recent years, it has become an essential facility for establishing a quantum technology foundation, such as forming single photon sources for quantum sensing and quantum computers.



JT-60SA

Neutral Beam Injection Device
(Tokamak-type Superconducting Plasma Experimental Device/
Plasma Heating Device)

Sustainable Energy for the Next Generation

JT-60SA is a tokamak-type superconducting plasma experimental device built at Naka Institute for Fusion Science and Technology, and has been developed as a joint project combining the Satellite Tokamak Project and Japan’s Domestic Program, which is being jointly advanced by Japan and Europe. In October 2023, QST achieved the long-awaited first plasma test, and also achieved the world’s largest plasma volumes and the largest plasma currents in superconducting tokamaks, demonstrating fundamental plasma control performance using superconducting coils. Currently, preparations are underway for heating devices such as neutral beam injectors that heat the plasma, which are necessary for experiments aiming to increase plasma density and temperature.



HIMAC

(Heavy Ion Medical Accelerator in Chiba)

Beams That Protect Lives and Open the Future

HIMAC at the Institute for Quantum Medical Science supports insured carbon-ion radiotherapy and clinical research at QST Hospital, while supplying high-energy heavy ion beams of various nuclides to researchers at universities, research institutions, and private companies in Japan and abroad.



SPRing-8

QST Contract Beamlines

Unveiling the Invisible World with Cutting-Edge Light

QST’s beamlines host a series of advanced measurement devices that utilize high-intensity synchrotron light hard X-rays for nanostructure observation and precise magnetic-electronic state analysis. We realize magnetic measurement of each atomic layer using advanced synchrotron radiation technology, and are promoting research on quantum materials and environmental energy materials (hydrogen storage materials), such as in-situ observation of semiconductor crystal growth and non-destructive operando measurement.

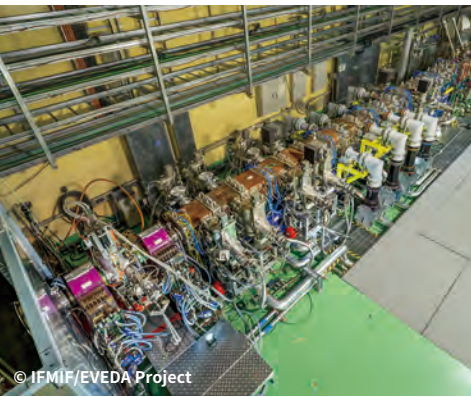


IFMIF

Prototype Accelerator

Developing Materials for Future Fusion Reactors

It is the core facility of the Japan-EU joint project aimed at realizing fusion energy. Using world-leading accelerator technology, QST is developing neutron source technology necessary for evaluating the performance of fusion reactor materials, and are promoting research and development that supports its realization.



Introducing the Students (Emerging Quantum Talent)

QST offers various programs for students (trainee, collaborative college student, student researcher, research assistant), and you can combine these to build your career.



To showcase QST’s efforts in cultivating the next generation of quantum talent, we present two research laboratories as examples.

1

CASE

Quantum Life Medical Engineering Group,
Institute for Quantum Life Science
2 postdocs, 6 graduate students,
3 support staff



Advisor: **TAKUWA Hiroyuki**

Team Research Overview

We are taking on new research challenges by applying cutting-edge quantum technologies, including nano-quantum sensors, to measuring cellular information inside living animals. In particular, by clarifying in detail the functions and roles of immune cells and nerve cells inside and outside the brain, we aim to deepen our understanding of life phenomena and contribute to disease diagnosis and treatment.

► Lab atmosphere

Aiming to create a warm, collaborative, and approachable environment

We believe that close cooperation among members is essential for conducting research efficiently and swiftly. That’s why my team values building good relationships where people can naturally help each other.

► Guiding students

I am amazed by their fresh ideas and learn a lot from them

Conversations and experiments with students are genuinely enjoyable. If our students go on to become quantum leaders who contribute to Japan’s scientific and technological future, I would be delighted to know that I was able to play even a small role in their growth.

► Expanding students’ potential

Strive to provide instruction tailored to individuality and characteristics

My hobby is home gardening, and I feel that the guidance for graduate students is very similar to this. Just as vegetables like potatoes, carrots, and onions each have their own suitable growth environments, students also need environments suited to their individuality and characteristics. Some plants require more sunlight, water, and fertilizer, while others perform best in modest environments, so the appropriate conditions vary from person to person. As an instructor, I pay special attention to taking enough time to assess students’ personalities, abilities, and potential, and to create an environment that suits them. In other words, it is important not to try to grow onions like potatoes, and accurately assessing students is where a coach’s experience and ability are tested.

Trainee

Both technical college and undergraduate students can be accepted, and research activities utilizing QST facilities can be conducted. Research durations and on-site participation frequency can be tailored to meet the needs of individual students.

Collaborating Graduate Students

QST and partner universities have signed a collaborative graduate school agreement, with QST researchers serving as supervisors to provide research guidance. You can earn a degree based on the results of QST research activities.

QST Student Researcher

We welcome outstanding graduate students from across the country and provide opportunities for them to devote themselves proactively to research with free thinking. We also provide incentives that do not restrict usage.

QST Research Assistant

We hire domestic graduate students as young researchers and engage in R&D activities funded by competitive funding, allowing them to participate in and contribute to QST’s research and development efforts.

Emerging Quantum Talent

01

Fixed-Term Researcher

H.M.
First-Year Doctoral Student,
Quantum Life Science Course, Graduate School of Science and Engineering, Chiba University

Daily Schedule	
8:30	Working hours (staggered working hours allowed)
9:00	
10:00	
10:00	Experiment
11:00	Analysis of experimental results Preparation of academic materials Paper writing Equipment checks, etc.
12:00	
13:00	
14:00	
15:00	
16:00	
17:00	
◆ Works four days per week	
◆ Every Friday at 1:00 p.m., all group members meet to share research progress and discuss approximately four research papers	

Motivation ► I want to build a career as a researcher

Since I was interested in neuroscience research, I emailed Professor Takuwa directly and asked for an opportunity to tour the lab. Since I was at a regional national university, the research I could do was limited, and I wanted to test how far I could go as a researcher at a large research institution. When given the opportunity, I initially joined as an intern, then worked as a QST research assistant, and now I am conducting research as a fixed-term QST researcher while enrolled in a doctoral program.

The Appeal of QST ► Diverse role models close to you

At QST, you will have senior researchers with diverse backgrounds and careers close to you. Having the opportunity to learn about career plans as a researcher when considering a doctoral path is a major attraction that university career offices do not offer.

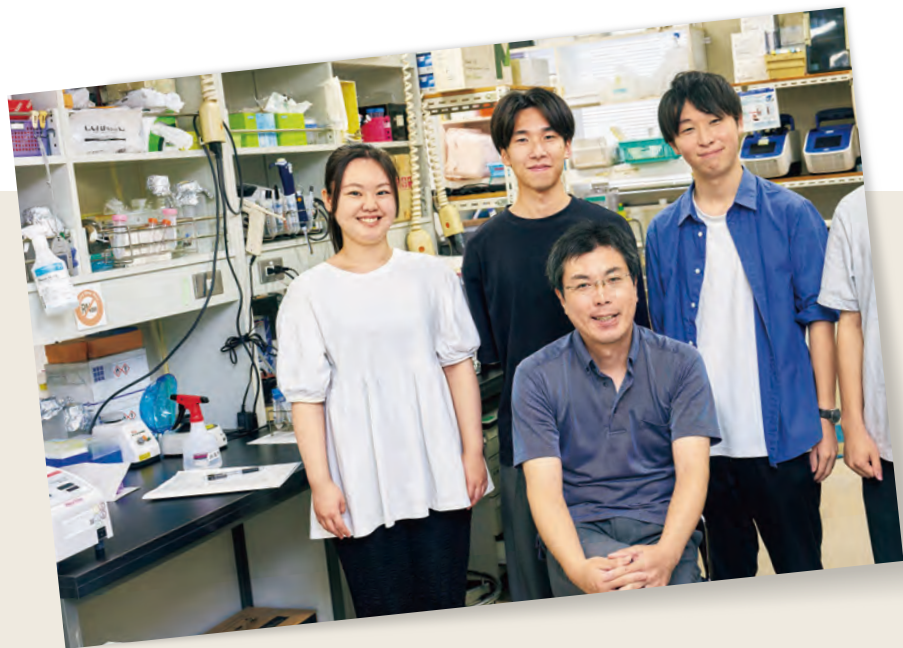
Goals ► Career as a researcher

Seeing Professor Takuwa always enjoying his research up close made me want to aim to be a “researcher who can enjoy research.” In the future, even if I gain experience in a private company, returning to QST is one of the options I consider.



Awards

March 2025: Dean’s Award (top-ranked student in the course)
October 2024: In Vivo Imaging Forum “Best Poster Award”
September 2024: 33rd Japan Bioimaging Society “Scholarship Award”
November 2023: 32nd Japan Bioimaging Society “Best Graphical Abstract Award”



CASE 2

Biomarker Research Group,
Department of Radiation Effects
Research, Institute for
Radiological Science
4 students, 4 staff members



Advisor: **DAINO Kazuhiro**

Group Research Overview

By identifying biomarkers of cancer caused by radiation exposure, we are conducting research aimed at evaluating cancer risk caused by radiation. To date, we have demonstrated in various animal models that a genetic alteration known as an interstitial chromosomal deletion may serve as a biomarker for cancers that develop following radiation exposure. We are advancing the development of other biomarkers such as fusion genes and their application to humans.

► Lab atmosphere

Opportunities for cross-disciplinary interaction

The research department consists of four research groups, bringing together researchers from various fields and backgrounds such as physics, veterinary medicine, and pathology, working on radiation and cancer studies. One of the group's features is the ability to expand networks among researchers through cross-disciplinary exchanges. Students also participate from various universities and faculties. We set research topics tailored to each student's interests and collaborate with other research staff from other groups to advance our research together.

► Guiding students

Experiencing life as a researcher

Research on the effects of radiation is a field where results can be achieved through long-term, steady study, but it carries the extremely important mission of "protecting people." As we use cutting-edge science and analytical instruments to clarify the effects of radiation exposure, we hope that students will become even more interested in this field through their research discoveries. Additionally, with the aim of becoming future researchers, we encourage them to actively participate in conference presentations and outreach activities, helping them learn about their roles as researchers.

► Expanding students' potential

I want them to take on challenges without fear of failure

I want to convey to students the importance of freely engaging in research and taking on challenges without fear of failure. Sometimes, new discoveries can arise from failure. I hope you value the spirit of taking on challenges without fear. I believe that learning ideas and coping strategies to overcome difficulties through failure leads to personal growth. I myself have learned from many failures and learned the importance of those experiences from my seniors. I want to share this idea with my students.

Emerging
Quantum
Talent
02
Research
Assistant



Y.R.
Second-Year Master's Student,
Graduate School of Human Health Sciences,
Tokyo Metropolitan University

Motivation

► Focus on research activities

I became very interested after hearing about research on the effects of radiation and genetic mutations, which led me to apply to this laboratory. Also, since I was thinking of entering graduate school on my own, I was attracted to the paid QST Research Assistant position. I am very pleased to be able to devote myself to research activities at a top-tier research institution in this field.

The Appeal of QST

► Cutting-edge equipment and diversity

I am able to conduct research in a well-equipped environment equipped with cutting-edge equipment and experimental instruments, and I also find joy in learning new experiments. One of the great attractions is that I can broaden my knowledge through interactions with Professor Taino, who has always supported me, other teachers, and students.

Goals

► Radiological technologists with extensive knowledge of radiology

After completing the master's program, I hope to utilize my radiological technologist license and apply the knowledge and experience I gained through QST in the medical field.

Emerging
Quantum
Talent
04
Student
Researcher



H.S.
First-year Master's Student,
Graduate School of Pharmaceutical Sciences,
Keio University

Motivation ► Deepening cancer research

I am working on cancer research on DNA damage repair in a university lab. I wanted to deeply study radiation, one of the factors that cause DNA damage, so I was introduced by a professor and decided to conduct research at QST.

The Appeal of QST ► Researchers from diverse fields

Interacting with professors from various specialties such as pathology and molecular biology is extremely beneficial for broadening the scope of experiments and conducting high-quality analyses. I also thought it was wonderful that they put great emphasis on nurturing students and young researchers, such as student support programs.

Goals ► Researchers creating cancer treatments

I hope to become a researcher who can succeed internationally in the future and wish to pursue a doctoral program. Currently, I have a strong interest in drug discovery for cancer treatments and aim to work for a pharmaceutical company.

Emerging
Quantum
Talent
03
Intern



M.K.
Fifth-Year Student, School of Pharmacy,
Nihon University

Motivation

► For my graduation research

Currently, I am working on my graduation research, and through studying various diseases, I became interested in cancer. To deepen my research, the professor introduced me to several research institutions, and upon learning that I could conduct research related to radiation, I decided to pursue QST.

The Appeal of QST

► Inspiration from peers

At first, I was nervous, but Professor Taino and everyone in the lab warmly welcomed me. I was able to participate in a wide range of experiments that I couldn't experience at university, and I'm truly glad I chose QST. Also, while working on research together with peers of similar age, I am constantly inspired by their sincere attitudes toward their research.

Goals

► Pharmacists familiar with chemotherapy

When patients receiving radiation therapy consult about medications, I want to be able to respond as a pharmacist knowledgeable about chemotherapy.



Daily Schedule

8:30	Going to work
9:00	Email confirmation Care for laboratory animals
10:00	
11:00	
12:00	Experiment Preparation of experimental materials Preparation of presentation materials Research papers (Reading)
13:00	
14:00	
15:00	
16:00	
17:00	

◆ Works 3-5 days per week
(Including days spent at QST as a student
in a cooperative graduate school program)

Opening the Future with Quantum Science and Technology

We introduce job content, career paths, and senior interviews at QST by job type.



01 Clerical Position

Laying the foundation for advancing research.

S.K.(Joined in 2021)



Please tell us about your usual work

The Planning Division I belong to serves as the liaison point with the Ministry of Education, Culture, Sports, Science and Technology, which oversees QST. We handle everything from important communications from the Ministry of Education, Culture, Sports, Science and Technology regarding corporate operations to various questions, while collaborating and consulting with relevant departments and executives within the organization. Additionally, we are responsible for organizing meetings and committees to receive evaluations from external experts regarding corporate operations such as QST research and development and overall management. There are various meetings, but recently we have been coordinating for an international conference inviting foreign experts.

What do you find rewarding about working at QST?

I find it rewarding to work in collaboration with various departments. For example, for the international conference we are currently preparing, we need to consult not only within the department but also with stakeholders from other departments—for preparing materials on the day, for preparing materials for the day, for the HR department; and for contracts and document processing with contractors, the finance department. The process of collaborating with people with different positions and expertise to seek better forms is what gives me a great sense of fulfillment.

Is there a future you are aiming for at QST?

I want to be an employee who can propose the necessary systems for QST to conduct even more effective and efficient research and development. I still feel I lack sufficient knowledge, so I want to deepen my learning by drawing on experiences in various departments and examples from both domestic and international sources.



Message to job seekers

QST administrative positions are a job where you can gain broad experience related to corporate management while working hand in hand with the research and development field. Since you are required to take a generalist-like approach that considers the entire organization, I think this is perfect for those who want to broaden their expertise with a broad perspective. Not only within your own department but also with other departments, job types, and external parties, you are expected to collaborate with a diverse range of partners to seek win-win solutions for both sides, so I would love to work with someone who can solve problems in cooperation with those around you.

02 Technical Positions

Achieving research through technology.

F.K.(Joined in 2024)



Please tell us about your usual work

My main responsibility is quality control of HIMAC, the carbon-ion radiotherapy system at QST Hospital. HIMAC has provided treatment to many patients since its launch in 1994, but there is a possibility that equipment issues may occur due to aging and other factors. While handling these issues and coordinating with manufacturers, we maintain daily quality control to ensure stable treatment is provided. Additionally, our clinic also performs general photon therapy, and our department is responsible for treatment planning and dose verification for high-precision treatments. Additionally, commissioning new medical devices, quality control, and building operational workflows are carried out in collaboration with other departments.

What do you find rewarding about working at QST?

QST has one of Japan's few carbon-ion radiotherapy facilities as well as conventional photon therapy equipment, providing an environment for comprehensive learning in radiation therapy. Additionally, as a leading figure in this field, I am greatly attracted to the opportunity to gain valuable experience such as participating in large-scale projects and auditing other facilities, which I cannot gain elsewhere, and I am greatly attracted to the opportunity to contribute to the advancement of healthcare while deepening my expertise.



Is there a future you are aiming for at QST?

Patients receiving treatment at QST have high expectations for cutting-edge medical care. In this era where one in two people is diagnosed with cancer, I want to strive to become a core member of quality control so that patients can receive better treatment with peace of mind. In addition to my specialized technical duties, I actively engage in research activities, applying the insights gained in clinical settings to research and contributing to the advancement of medical technology.

Message to job seekers

QST's greatest asset as a technical position is its own technology. That's why we want people who clearly understand what they want to do and how they want to grow at QST to join us. I myself started out as a medical professional, but from the very beginning, I aimed for my current technical position and continued learning alongside my work. QST offers plenty of opportunities to build your career while learning like this, so I encourage you to set goals and take on challenges. Let's hone our skills together and expand our possibilities at QST.

03 Research Positions

Mastering the cutting edge of quantum science and technology.

K.T. (Joined in 2018)



Please tell us about your usual work

We are engaged in basic research aimed at elucidating the mechanisms of action in targeted isotope therapy, ultra-high dose cancer therapy, and radiation sensitizers such as gold nanoparticles. The ultimate goal is to elucidate phenomena that span a wide range of fields, including radiation physics, radiochemistry, and radiation biology. A distinctive feature of QST's research positions is participation in IAEA CRP (International Atomic Energy Agency Collaborative Research Program), and we conduct joint research not only domestically but also internationally.



What do you find rewarding about working at QST?

I'd be happy if someone would say, "I read that paper~" at international conferences and similar events. When I see the author of a paper I read, I feel as if I have met a historical figure. Being able to feel that we are getting even a little closer to such great predecessors is a rewarding aspect of being a researcher.

Is there a future you are aiming for at QST?

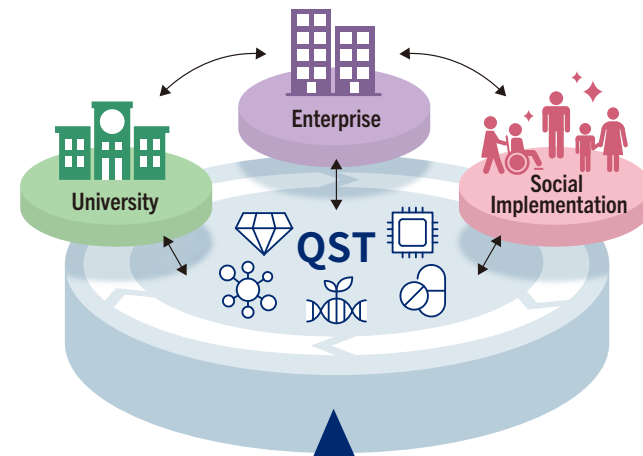
I believe the field of basic research is quite challenging, but even so, I want to contribute to the development of my specialized field. I want to write papers that all future young researchers will read, and become someone who makes people think, "Someday, I want to see the author in person."

Message to job seekers

The ideal of working with QST researchers is someone who can build complementary relationships with those around them. Even though the people I work with may have areas of expertise that overlap in some areas, I think it's good to make the most of each other's strengths while working together. Also, I believe the most important thing for a researcher is to write a paper. I want you to prioritize how to raise the metrics that demonstrate that value. Whether a paper is good is naturally evaluated five or ten years after publication, so I hope you will keep a long-term perspective and diligently engage in daily research.

Co-creating the Future with Quantum Science and Technology

Leveraging world-class research facilities and a network of researchers, we support companies in their challenges, from research and development to social implementation.



Value Created by Partnering with QST

Access cutting-edge technology, equipment, and specialized personnel to accelerate research and development, commercialize and implement in society, and form new networks.

Integration menu with QST

1. Collaborative Research

We promote joint research by linking QST's cutting-edge research infrastructure with corporate technologies and needs. We aim to create new value and solve technical challenges across a wide range of fields, from quantum technology to medicine, energy, and materials.

2. Facility Use

You can utilize quantum beam facilities and advanced research equipment. Through advanced measurement, analysis, prototyping, and evaluation, we support solving research challenges and advancing technologies that are difficult to achieve through in-house development alone.

3. Technical Consultation

Our specialized staff will assist with consultations regarding technology transfer and the possibility of joint research. We match companies with the best researchers, seeds, and systems according to their challenges and needs.

4. Talent Network

Through exchanges among researchers, engineers, and students, new collaborations and networking will be fostered. Through research guidance, human resource development, and collaborative activities, we contribute to the creation of innovation.

one-stop QST Consultation Desk ✉ q-consult@qst.go.jp

Please feel free to contact us first

More Details →



Bringing QST-originated innovation to society

Quantum Technology Innovation Hub

Through the Foundational Quantum Technology Hub and the Quantum Life R&D Hub, we accelerate the social implementation of quantum technologies, life sciences, and advanced materials by promoting industry-academia collaboration, talent development, and outreach activities.

Alliance Business

QST and companies form alliances to tackle technical challenges common to the industry. Through an open innovation system, we support everything from research and development to the creation of new services and industries.

QST Certified Venture System

We support the creation and growth of venture companies that leverage QST research results. Through the utilization of intellectual property, technical support, and commercialization assistance, we promote the return of research results to society and contribute to the creation of new industries.

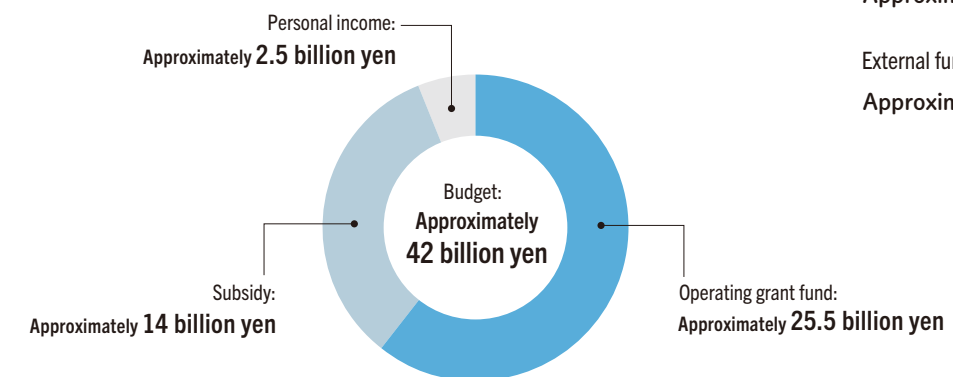
More Details →



Budget



Fiscal Year 2025 Budget: Approximately **42 billion yen**



Facility improvement subsidy:
Approximately **1.6 billion yen**

External funds such as competitive funds:
Approximately **5.5 billion yen**

Personnel



Fiscal Year 2025 Number of full-time employees: Approximately **1,300**
(of which foreign nationals approximately 4.0%, female employees approximately 28.5%)

Collaboration with universities and overseas institutions



Fiscal Year 2025 Number of international agreements signed: **81**
(including 8 in the United States, 28 in Europe, 32 in Asia, 1 other, and 12 by international organizations)

Number of joint research contracts with universities: **194** (56 paid, 138 free)

**National Institutes for
Quantum Science and Technology**

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Realizing dreams and pioneering the future

Creating a new Japan,
and bringing happiness to the world with
Quantum Science and Technology



**National Institutes for
Quantum Science and Technology**

International Affairs and Public Relations Section,
Department of International Affairs and Public Relations
4-9-1 Anagawa, Inage-ku, Chiba-shi, Chiba 263-8555, Japan
TEL +81-43-206-3026 (direct)
E-mail: info@qst.go.jp
<https://www.qst.go.jp/site/qst-english/>



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