To Widely Utilize Quantum Beam Technologies of Our Institute

**Technology Transfer**
You can use our intellectual property rights and technologies in various fields such as medicine, industry, agriculture and energy. Examples of products developed in collaboration between our institute and companies/public institutes are shown below.

![Continuous Silicon Carbide Fiber “Hi-Nicalon®”](image1)
![Air Cleaning Filter](image2)
![Radioactive Cesium Adsorbent “KranCsair®”](image3)
![Hydrogels for Wound Dressing “Viewgel®, Gel Protector®”](image4)
![Polymer Electrolyte Membrane for Next Generation Fuel Cells](image5)
![“Ryuujin”, a chrysanthemum cultivar blooming earlier in low temperature](image6)
![“Uruwashi-no-Kaori”, a new color variety of fragrant Cyclamen](image7)
![“KNOX”, green wall plants with high NO₂ absorption](image8)
![Novel sake yeast “Gunma227” with high ethyl caproate production](image9)
![Sake “Hoō Seioku Maikaze” brewed using the yeast “Gunma227”](image10)
![Low cadmium rice “Koshihikari Kan No.1” (right); parent rice “Koshihikari” (left)](image11)

**Facilities Sharing**
You can use our quantum beam facilities and equipment.

<table>
<thead>
<tr>
<th>Main Facilities, Equipment and Devices</th>
<th>Examples of Usage</th>
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</thead>
<tbody>
<tr>
<td>AVF Cyclotron</td>
<td>It is possible to supply heavy ions and light ions with a wide range of energy and to use them in combination. Research and development on space environment, biotechnology and medical applications, creation of functional materials, synthesis and utilization of short-lived isotopes.</td>
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<tr>
<td>Tandem Accelerator</td>
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<td>Single-ended Accelerator</td>
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<tr>
<td>Ion Implanter</td>
<td></td>
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<tr>
<td>Electron Beam Irradiation Facility</td>
<td>Development of polymer processing technology, irradiation effects of semiconductor-related materials, radiation resistance evaluation of materials and equipment.</td>
</tr>
<tr>
<td>Co-60 Irradiation Facilities</td>
<td></td>
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**Food Irradiation Database**
http://foodirra.taka.qst.go.jp/

Food irradiation is a technology for controlling spoilage and eliminating foodborne pathogens. In Japan, gamma-ray irradiation has been used for sprout inhibition of potatoes since 1974.

**Outreach Activities**
We focus on activities that make our research activities widely known to local residents, junior and senior high school students, and university students.

- Open House
- Science and Technology Education and Support for Workplace Experience

**Research Exchange**
We strengthen our network through collaboration with universities and overseas research institutions.

- Collaborations with Universities
- International Cooperation

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Takasaki Advanced Radiation Research Institute is a core institute to conduct R&D of quantum-beam science and quantum technology which are the main missions of the National Institutes for Quantum and Radiological Science and Technology (QST) established on April 1 of 2016. We are conducting this R&D on the basis of knowledge and technology accumulated over more than 50 years of radiation/quantum-beam application research at our predecessor institutes, i.e., Takasaki Radiation Chemistry Research Establishment of the Japan Atomic Energy Research Institute (April 1963 to September 2005) and Takasaki Advanced Radiation Research Institute of the Japan Atomic Energy Agency (from October 2005 to March 2016).

We have an ion-beam irradiation facility named TIARA (Takasaki Ion Accelerators for Advanced Radiation Application), which is one of the most advanced facilities in the world, as well as electron-beam and gamma-ray irradiation facilities. These facilities provide many kinds of quantum-beams: ions, electrons, positrons, neutrons, and gamma-rays. Based on these facilities, we are developing leading-edge technologies of generation and control of quantum-beams as well as highly precise material processing and observation technologies using quantum-beams. Through effective use of such technologies, we are also performing advanced R&D of materials science, life science, and quantum technology to find solutions for important issues of each research field as well as to create innovative outcomes. By conducting the R&D mentioned above, we are aiming to contribute to the development of science and technology and the promotion of industry.

Finally we express our appreciation for your continued interest in and warm support for our activities at Takasaki Advanced Radiation Research Institute.
Aiming to lead the super smart society, quantum-functional materials such as quantum sensors, innovative electronic devices, and advanced functional polymer materials have been developed by utilizing quantum beams combined with our understanding of materials at the nano-size level.

**Quantum Sensing and Information Materials**

Formation of luminescent centers expected to be applied to quantum bits and quantum sensors “Nitrogen-Vacancy (NV) center in diamond” and “Silicon Vacancy (VSi) in silicon carbide (SiC)” by controlling their concentration and position

Development of technology to manipulate the electron spin direction and control the flow of spin current in graphene, which are essential for the realization of high-performance spintronics devices based on graphene

**EUV Ultra-Fine Fabrication Technology**

Development of materials and processes for nanofabrication to realize ultra-miniaturization and low power consumption of semiconductors, which are essential for IoT, AI (artificial intelligence), big data, and 5th-generation mobile technologies (5G)

**Advanced Biodevices**

Development of a high-performance culture substrate that reproduces the in vivo environment and controls cell functions through new technology that gels proteins while maintaining their biocompatibility and controls their hardness and shape

**Advanced Functional Polymer Materials Alliance**

Promoting efficient and rapid product development by collaborating with multiple companies in material development using materials informatics

**Positron Beam Microstructural Analysis**

Development of technology to analyze atomic vacancies, surface atomic arrangements, and electron spins of materials by using positrons, the antimatter of electrons
Development of Quantum Beam Technology

Lead the research and development of "Quantum Science, Quantum Life Science, and Quantum Beam Technology" and aim to build a quantum beam science platform.

Ion Microbeam Elemental Analysis

- Elemental distribution analysis in rice leaves
  - Red: Zinc
  - Blue: Silicon
  - Green: Calcium

Generation and Utilization of Cluster-Ion Beams

- Development of a highly-intense ion source as a basis for highly-sensitive mass spectrometry using cluster-ion beams

Generation of X-ray Atto (10^{-18}) second Pulses

- Development of X-ray attosecond pulse generation technology that makes it possible to stop the movement of electrons for viewing by phase-controlled free-electron laser (FEL) and high harmonic generation technology
Quantum Beam Biological Application Research

Explore the interaction between radiation/quantum beams and organisms to achieve innovative results by comprehensively utilizing the "watch", "create", and "cure" functions of quantum beams. Promote a paradigm shift in biology from the molecular level to the quantum level.

Ion Beam Breeding

Photos Courtesy of Aichi Agricultural Research Center

New chrysanthemum cultivars with elegant petals created by ion beams.

Radiotracer Imaging for Agriculture

Movement of photoassimilate into strawberry fruits by RI imaging using $^{14}$C produced by our cyclotron accelerator.

3-Dimensional Visualization of Single-Cell Dose

Development of a technology that can evaluate the radiation dose distribution in one cell, which is important in the targeted alpha therapy.

Microbeam Irradiation of Cells

Analysis of the biological effects of heavy ions by target irradiation of the cells. The cells were automatically detected by an irradiation microscope, and irradiated with a heavy-ion microbeam smaller than those cells.

Cancer Therapy with Accelerator Produced RI

Development of cancer treatment drugs using astatine (At)-211, which accumulates in the tumor and destroys it by alpha-irradiation.

Microfluidic Chip for Biological Samples

Heavy-ion microbeam irradiation targeted to the central nervous system (CNS) of the nematode C. elegans enclosed in a PDMS microfluidic chip (Worm Sheet), which we have developed for immobilization of biological samples without the use of anesthesia.
Our ultimate goal is to build a platform for the conduct of world class quantum science and technology research towards the improvement of human health and the overall well being of mankind through the creation of a harmonious diversity.

The National Institutes for Quantum and Radiological Science and Technology (QST) was established on April 1, 2016. The Institute was created by a government decree announced on July 8th, 2015 to merge the National Institute of Radiological Sciences and the Quantum Beam Directorate and the Nuclear Fusion Directorate of the Japan Atomic Energy Agency, resulting in the establishment of QST. The institute is bestowed with the mission to conduct high quality research and development related to quantum science and technologies, nuclear fusion, and radiological science and its application in medicine. QST plays a leadership role in molding the future direction of Japan's radiological science field and is Japan's collaborating partner for international organizations including the ITER and BA projects.

QST combines the research and development abilities of seven Japanese institutes nationwide in the fields of radiology, quantum beams and nuclear fusion to form a world class institution in quantum science and technologies research. QST takes an unparalleled, pathfinding role in technology research and to promote exploratory studies and translational research that integrate quantum science and technology with medicine and life sciences. QST also serves as a platform to foster collaboration between industry, government, and universities, through activities such as personnel exchanges and joint research. Such efforts repay society on multiple levels that include increase economic output, technological advancement, and education and training opportunities for the next generation of engineers and scientists. Finally, QST actively promotes the creation of harmonious diversity in society by fostering intellectual creativity and understanding and respect for other cultures around the world. This kind of activity contributes to the progress of a peaceful and spiritually rich human society.

We hope to continue to benefit from everyone's advice, support, and guidance.

President Toshio Hirano
M.D., Ph.D.