Kansai Photon Science Institute

National Institutes for
Quantum Science and Technology

Quantum Beam Science Research Directorate

National Institutes for Quantum Science and Technology
Quantum Beam Science Research Directorate

Kansai Photon Science Institute

Opening up a bright future with powerful light

Based on technological developments such as the world's top class high-intensity laser and high-brightness synchrotron, we are promoting state-of-the-art academic research and industrial and medical applications for the creation of innovation using them.

Development of light source facilities and equipment as well as underlying technology as a research infrastructure

Laser

High-intensity laser (J-KAREN-P)
X-ray laser
High average power short-pulse laser

Synchrotron radiation

SPring-8 contract beamlines
Leading-edge applications of brilliant hard X-rays
X-ray utilization for materials science

Computer simulation

Various utilization studies by taking advantage of the features of light

Applications to a wide variety of fields such as physics, chemistry, life science, engineering, medical treatment

State-of-the-art academic research

Quantum optics
Quantum functional material science
Quantum life science

Industrial and medical applications for innovation

Concrete defect detection
Next-generation devices and materials development
Blood glucose level sensor
others

Open laboratory

Institutional cooperation
Joint research
Facility for common use
Kid's Science Museum
others

The creation of innovative results and seeds ⇒ Contributing to science and technology, industrial development

Kizu District (Kyoto Prefecture)

Keihanna Science City

Harima District (Hyogo Prefecture)

Harima Science Garden City

SPring-8

Provided by: RIKEN

Photon Science

~With state-of-the-art laser technology, pioneering new scientific fields, creating new industries~

Having developed laser technology ourselves with the world‘s highest performance, we are opening up new scientific fields by performing academic research which has become possible for the first time using it. In addition, aggressively taking advantage of the new technology born from this, we are facilitating industry and medical treatment. To this end, we are researching high-intensity laser science, laser-driven particle acceleration, X-ray laser, ultrafast optics, and industrial applications of laser technologies.

Development of the world’s top-class high-intensity lasers (J-KAREN-P)

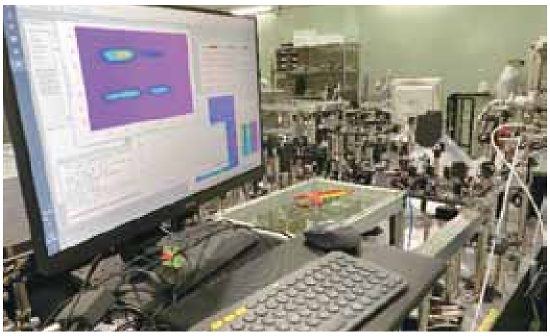
We are engaged in the development of the world’s top class high-intensity laser. We have been able to achieve an ultra-high power of 1000 trillion watts by confining a laser energy of 30 J within the time of 30 femtoseconds (1 femtosecond=a 1000 trillionth’s of a second).
(The photo shows glowing green in the light of a strong excitation laser.)

1000 trillion watts of light is focused to the size of a few microns and can be used to generate a very strong optical field in the laboratory.

Development of heavy ion acceleration technology by use of high intensity lasers

We are developing laser-driven high-purity carbon accelerator for radiotherapy (cancer therapy) that is compact in size and that offers exceptional strength and stability by using laser-driven ion-acceleration technology with intense lasers.

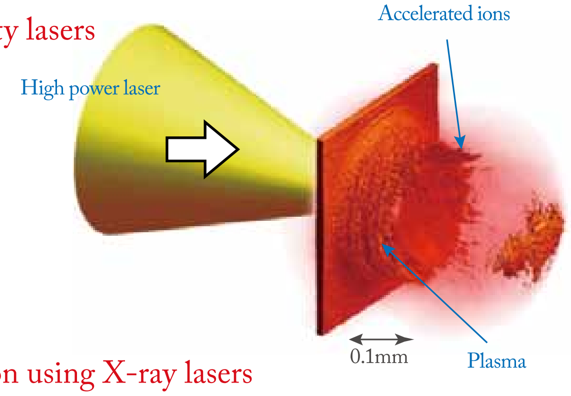
Research on ultrafast optics



We use intense femtosecond laser pulses to study the fundamental principles of atomic, molecular, and solid state electronic dynamics and their control.

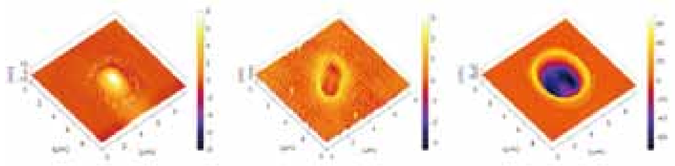
Development of new scientific fields by high-intensity lasers

With high-intensity lasers we are conducting research on compact accelerators of the future. It is possible to realize compact accelerators with the possibility for applications and also particle beam cancer therapy equipment with high-intensity lasers (J-KAREN-P) by the development of new acceleration methods "laser acceleration technology".



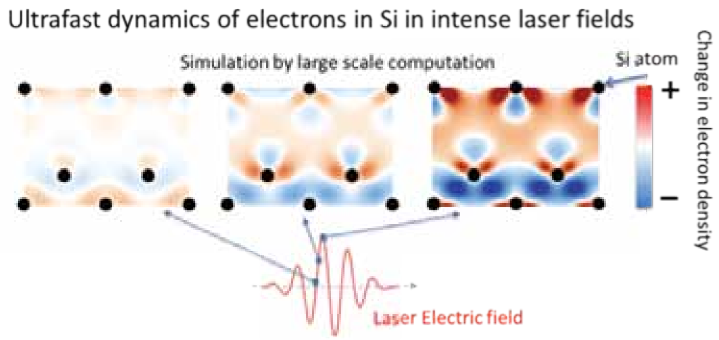
Nano-scaled resolved observation and nanofabrication using X-ray lasers

Nano-scale fabrication technology using soft X-ray lasers with short wavelengths is expected to become a fundamental technology that will be indispensable to the manufacture of information and communications devices to support a smart society.



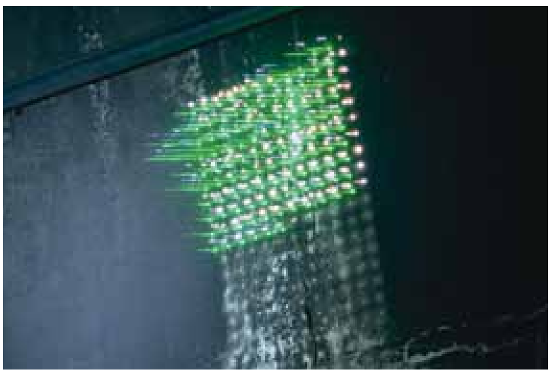
Femtosecond X-ray laser processing at nanoscale depths

Pursuit of real-time and real-space tracking of electronic dynamics



The basis of the manipulation of all materials such as particle acceleration by high-intensity lasers, laser processing, and others, is the ultra-fast excitation and energy transfer of the electrons present in the material. We are carrying out the elucidation of this and establishing the foundation of new applied research.

Creation of new industries with high-intensity lasers



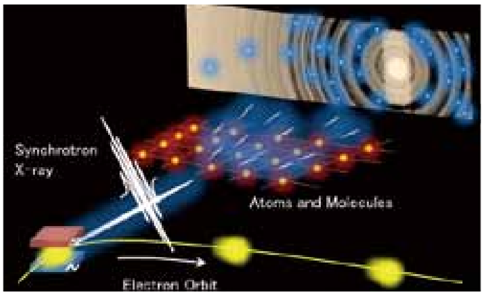
We are developing technology to use lasers to quickly detect internal defects in concrete. In Japan, which has a large number of tunnels, aging of tunnels has become a societal problem. Using lasers, engineers can detect internal defects in concrete quickly, remotely, and in a contact-free manner.
Our technology is being introduced in performance catalogs showcasing inspection-support technologies for road tunnels and bridges for use in future robotic inspections.

Synchrotron Radiation Science

～Revealing the quantum nature of materials using super-high-intensity X-rays～

What is synchrotron radiation?

Synchrotron radiation is the highly-directional light produced when electrons or positrons are accelerated to nearly the speed of light in a particle accelerator. Synchrotron radiation contains very powerful X-rays, more than 100 million times brighter than those used in medicine. Since X-rays have wavelengths comparable to the size of an atom, they are excellent probes of the quantum world on the nano- and atomic scales.



Intense X-rays made by accelerating electrons are used to explore material microstructures with sizes less than 10 millionths of a millimetre

Development of Advanced Synchrotron Radiation Application Technologies: BL11XU (QST Quantum Dynamics Beamline I)

X-ray Energy Width

Electron Spectroscopy — Nuclear Spectroscopy

1 eV — 10 meV — 1 neV

X-ray Diffraction 【Structural Change】

Resonant X-ray Inelastic Scattering 【Electron Motion】

Energy-Domain Mössbauer Spectroscopy 【Electronic・Magnetic State】

Nuclear Resonance X-ray Inelastic Scattering 【Atomic Motion】

Surface X-ray Diffractometer

Resonant X-ray Inelastic Scattering Apparatus

Synchrotron Rediation Mössbauer Station

By selecting X-rays of well-defined energy, it is possible to study individual electronic and nuclear states. We are developing technology to extract X-rays with energy distribution spreads of only one hundred thousandth of the X-ray energy, and even as narrow as one trillionth of the X-ray energy.

Materials science using synchrotron radiation BL14B1 (QST Quantum Dynamics Beamline II)

This beamline allows the use of both monochromatic X-rays, and also broadband X-rays for diffraction and spectroscopy. This allows fast time-resolved measurements under special conditions, such as high-temperature, high-pressure and gas atmosphere.

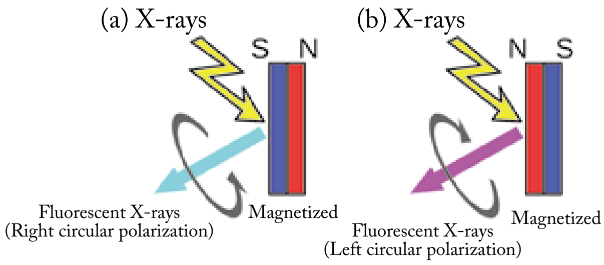
This cubic-type multi-anvil high-pressure and high-temperature apparatus enables us to monitor the hydrogen absorption into materials such as alloys.

Discovery of new phenomena and development of ultimate observation technologies for materials and devices

Powerful synchrotron radiation X-rays enable us to discover previously unknown phenomena and apply ultimate observation techniques. We utilize new phenomena and technology for the development of new materials and devices.

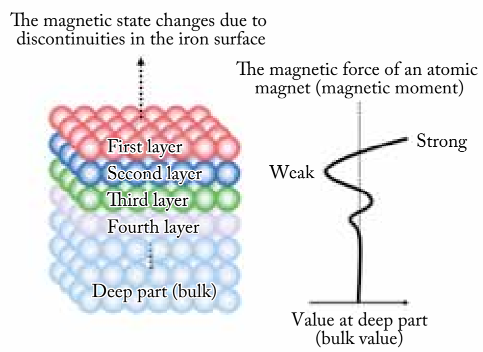
Discovery of a new magneto-optical effect

Fluorescent X-rays generated when irradiating a magnet with X-rays have a characteristic oscillation (polarization). We discovered that the oscillation changes according to the direction of the magnet. It is possible to use this phenomenon that appears in the case of X-rays, which have high penetrating power, to observe the inside of magnets, and it is expected to contribute to the development of magnets with higher performance.



Solving the "surface mystery" of iron magnets

We developed an innovative technology for magnetic exploration with atomic layer resolution. This technology uses embedded iron isotopes, which exhibit the Mössbauer effect, in each layer and irradiates the iron isotopes with synchrotron radiation X-rays that has a very narrow energy bandwidth. With this technology, we have succeeded in observing changes in the magnetic force at the iron surface. It is possible to use this technology to develop new high-speed and energy-saving magnetic devices.

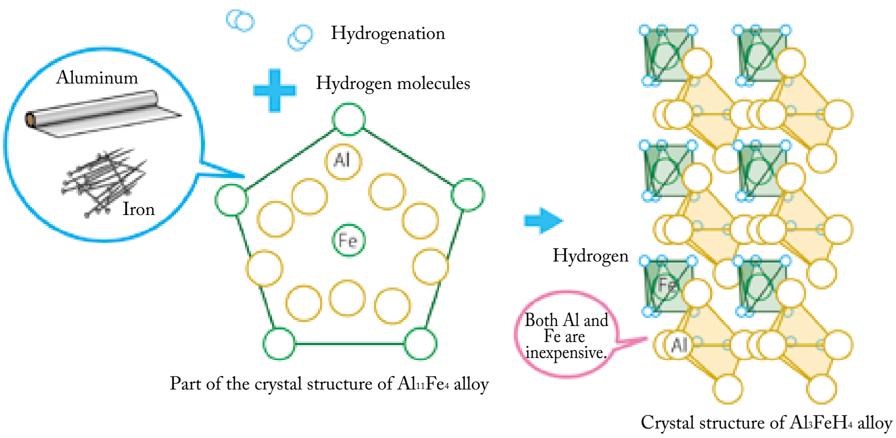


Development of environmental and energy materials that support our daily lives

Using powerful synchrotron radiation X-rays makes it possible to observe the synthesis process of materials at atomic and molecular levels. By taking advantage of this capability, we will promote the development of substances and materials that will help solve environmental and energy problems.

Synthesis and observation of hydrogen storage materials at high temperature and high pressure

Based on a new concept of synthesis, we have discovered that hydrogen can be stored in an alloy of aluminum and iron, which are abundant elements on the earth, through in-situ X-ray diffraction experiments at high temperature and high pressure. We're conducting research to develop inexpensive hydrogen-storage alloys that can store enormous amounts of hydrogen.



A new concept of combining metals that do not react easily with hydrogen

We have discovered that hydrogen is stored in alloys of aluminum and iron, which are resource-rich materials.

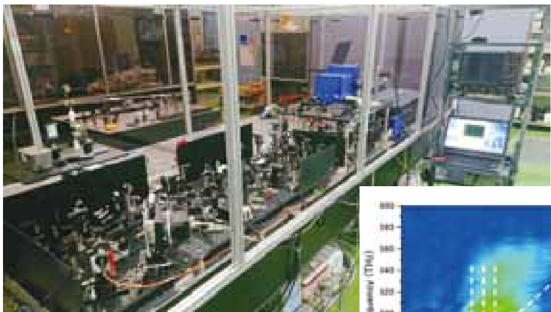
Applications in Medicine and Life Sciences

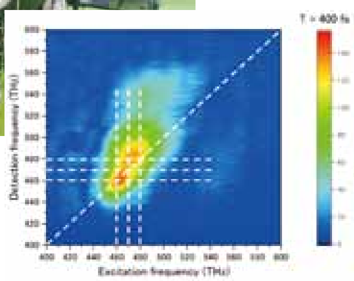
～Approaching the source of life with the power of quantum beams～

We use quantum beams that enable us to observe and analyze swift reactions or tiny areas and conduct basic research that contributes to the development of life sciences and practical research valuable to society, such as medical treatment. That way, we aim to develop quantum life and medical research using laser technology.

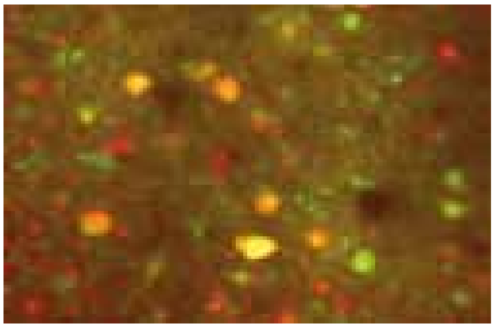
Collaboration with quantum life science research

We are developing a device to observe the movement of excited electrons in materials using ultra-short laser pulses of 10 femtoseconds or less and a laser light source with an optimum wavelength that can be applied to microscopes to elucidate the brain functions of small animals.





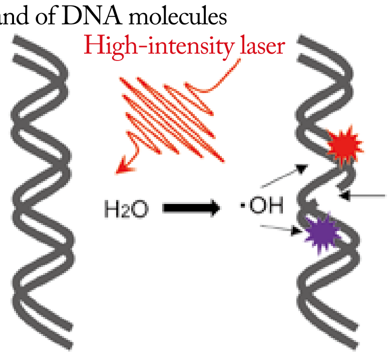
Two-dimensional electron spectrometer and two-dimensional spectra



Mouse brain chart showing inhibitory neurons (red) and neural activity (green).

It is known that intense laser irradiation can produce hydroxyl radicals (expressed as " · OH") from water molecules with extreme chemical reactivity. We use DNA molecules to study the effect of the characteristic · OH generated by lasers. This laser-employed research will contribute to intense laser chemistry and the development of biomedical research.

A strand of DNA molecules

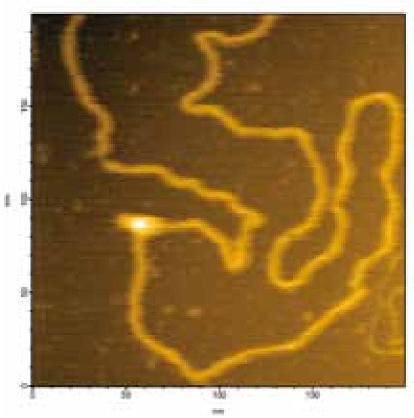


Chemical changes and chain breaks occur.

Laser light during irradiation and after transmission

DNA damage repair research

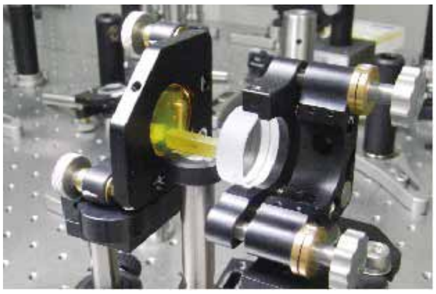
We are carrying out a computer-employed investigation of the detailed mechanism by which quantum beams impart energy to DNA. We are also researching the process of DNA damage, its shape and structure, and the repair process by making full use of optical science and other technologies. Furthermore, we are trying to understand the mechanism and types of DNA damage likely to cause mutations. The results obtained from these studies are expected to help treat and prevent cancer.



DNA damage observed with an atomic force microscope (the area indicated by the arrow in the figure; the length of one side: 2/10,000 of a millimeter)

Medical laser applications research

By combining an advanced solid-state laser with optical parametric oscillation technology, we have succeeded in generating a mid-infrared laser with a peak power a billion times stronger than that of conventional blackbody radiation. We use this laser and develop a palm-sized, non-invasive blood glucose level sensor and various non-invasive bio-sensing devices for social implementation. This development may enable an estimated 420 million diabetics worldwide to manage their daily blood glucose levels without pain. In that case, it will help improve their quality of life.



Optical parametric oscillator

Non-invasive blood glucose level sensor
There is no need to prick a needle and draw blood. Blood glucose levels can be measured with just a touch of a finger.

Collaborative Activities

~We strive for coexistence with industry, academia, government and the local community~

Joint research

In the Kansai Photon Science Institute, we have been conducting joint research with outside people. We accept the proposals for academic research and industrial technology development using advanced laser facilities and synchrotron radiation facilities. (as a general rule the results are made public.)

Facility for common use

In order for outside people to use the cutting-edge research facilities owned by the Kansai Photon Science Institute, we have established a "facility for common use system". Under this system, external users such as for research and development and/or industrial use themselves, according to the purpose are entitled to use the facilities for a fee. We recruit research topics related to facility use twice a year. (For general industrial use and some facilities proposals are accepted at any time.)
In the Harima area, outside researchers have been entrusted with the Nanotechnology Platform Project by the Ministry of Education, Culture, Sports, Science and Technology (Advanced Research Infrastructure for Materials Science Project from FY2022) and provided with research support using the SPring-8-dedicated beamlines. For more information, please visit the following website.
https://www.qst.go.jp/site/kansai-harima-fs/

Communication with the local community

To take advantage of the adjacent Science Museum at the Kansai Photon Science Institute, which is intended for the general public for the purpose of promoting interest and understanding in science and technology starting from light, we are actively performing public information and public relations activities .
Also, to further deepen exchanges with the local community, we have been promoting communication activities such as opening the facilities to the general public (open house) and participating in local events. With the aim of an "open laboratory" which can contribute to society through light, we are promoting a variety of initiatives while obtaining everyone's understanding and cooperation.

Open house (Harima)

Open house (Kizu)

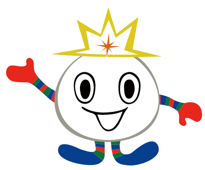
Beautification campaign around the Institute (Kizu)

きっづ光科学館ふぉとん
The Kids' Science Museum of Photons

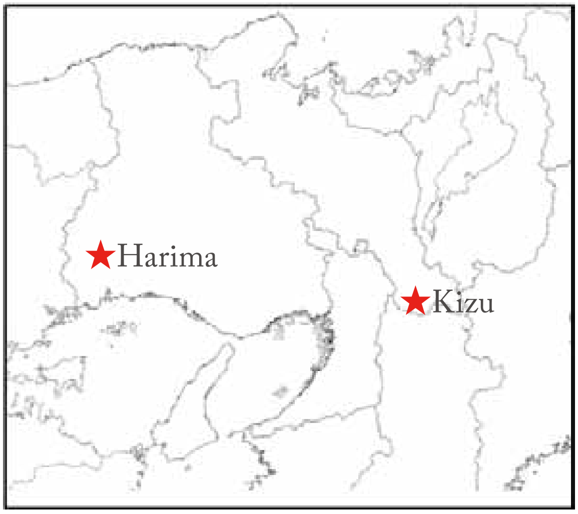
At the “Kids‘ Science Museum of Photons”, you can learn about the wonders of light from the basic nature of light to state-of-the-art light-use technology while having a fun experience. It provides one the experience of coming in contact with the mystery of light via the three exhibition zones, a full dome video projection hall and a variety of experimental events.

Adjacent to the Kansai Photon Science Institute (Kizu District)

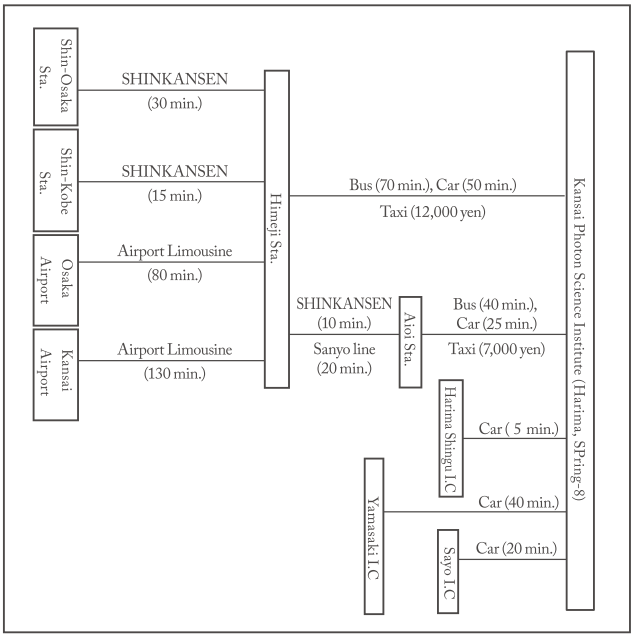
TEL：(+81-774)71-3180　FAX：(+81-774)71-3190
https://www.qst.go.jp/site/kids-photon/



Please scan the QR code and subscribe to the Kids’ Science Museum of Photons’ YouTube channel.

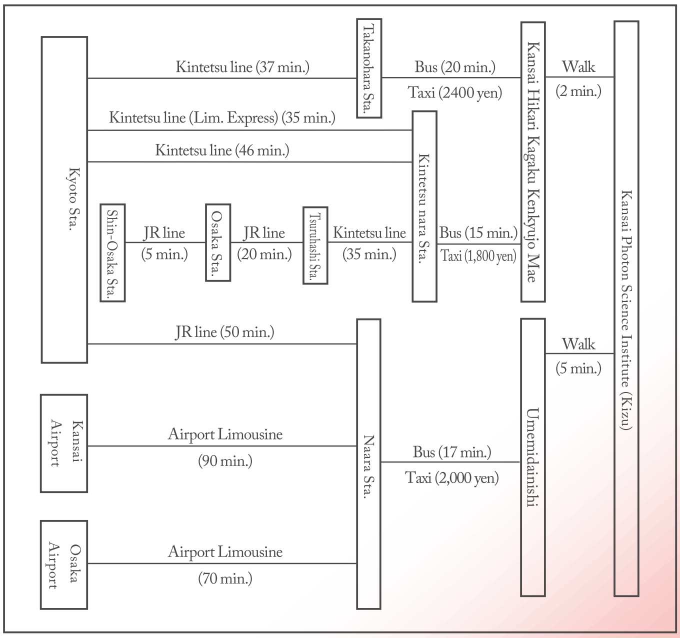


Harima(Harima Science Garden City)



〒679-5148　1-1-1 Kouto Sayo Hyogo
TEL : (+81-791)58-0922　FAX : (+81-791)58-0311

Kizu(Keihanna Science City)



〒619-0215　8-1-7 Umemidai Kizugawa Kyoto
TEL : (+81-774)71-3000　FAX : (+81-774)71-3072

Kansai Photon Science Institute
https://www.qst.go.jp/site/kansai/

Please scan the QR code and subscribe to the Kansai Photon Science Institute's YouTube channel.

KPSI
Kansai Photon Science Institute

This logo is designed keeping in the mind the sharpness of laser light and the broad light of synchrotron radiation.

Published: Kansai Photon Science Institute