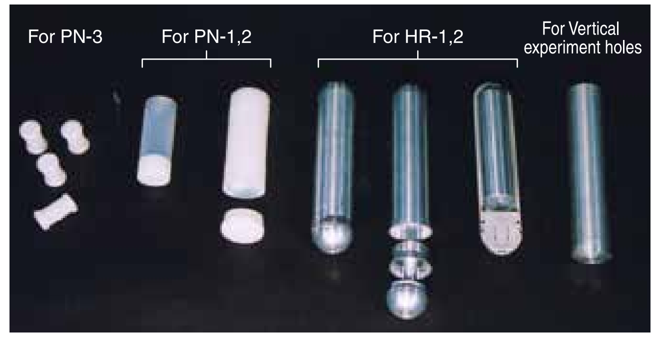
Utilization facilities of JRR-3

View of the reactor room

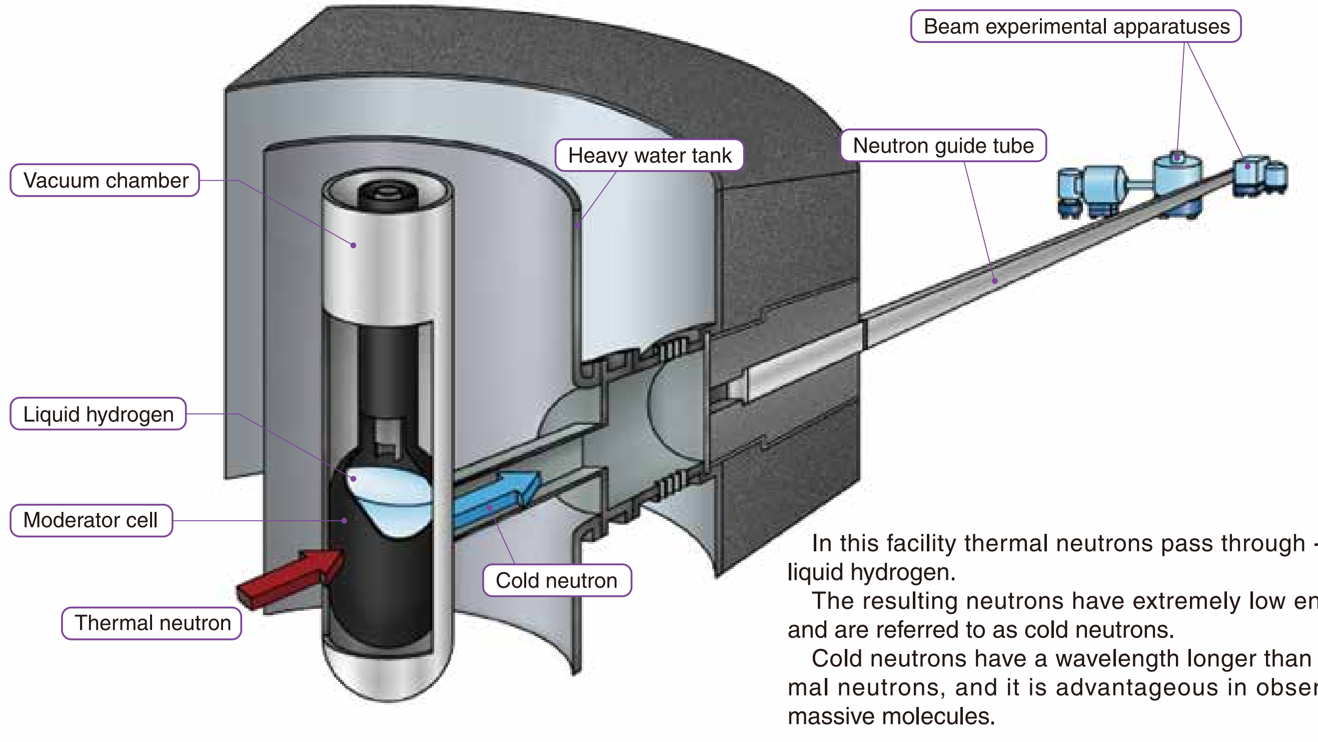
Neutron beam experimental apparatuses in the beam hall

Experiments in the neutron activation analysis laboratory



JRR-3 irradiation capsules

Cold Neutron Source (CNS)



In this facility thermal neutrons pass through -250 liquid hydrogen.

The resulting neutrons have extremely low energy and are referred to as cold neutrons.

Cold neutrons have a wavelength longer than thermal neutrons, and it is advantageous in observing massive molecules.

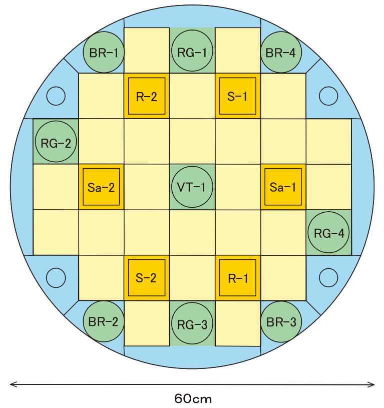
Utilization facilities of JRR-3

	Equipment name	Installation place	Purposes
VT-1	Vertical irradiation facility	Reactor core	Irradiation test, RI production
RG-1～4	Vertical irradiation facility	Reactor core	Irradiation test, RI production
BR-1～4	Vertical irradiation facility	Reactor core	Irradiation test, RI production
HR-1、2	Hydraulic irradiation facility	Heavy water tank	RI production, activation analysis
PN-1、2	Pneumatic irradiation facility	Heavy water tank	RI production, activation analysis
PN-3	Irradiation facility for activation analysis	Heavy water tank	Activation analysis
SH-1	Vertical irradiation facility	Heavy water tank	Irradiation test, RI production
DR-1	Rotating irradiation facility	Heavy water tank	Rotating irradiation
SI-1	Uniform irradiation facility	Heavy water tank	Production of silicon semiconductor

Installation beam port	name of Instruments	
1G	HRPD	High Resolution Powder Diffractometer
1G-A	BIX-3	Diffractometer for Biological Crystallography (QST*)
1G-B	BIX-4	Single Crystal Diffractometer for Biological Macromolecules (QST*)
2G	TAS-1	Triple-Axis Spectrometer
3G	PNO	Apparatus for Precise Neutron Optics and Neutron Diffraction Topography
4G	GPTAS	Triple-Axis Spectrometer (University of Tokyo)
5G	PONTA	Polarized Neutron Triple-Axis Spectrometer (University of Tokyo)
6G	TOPAN	Tohoku-University Polarization Analysis Neutron Spectrometer (Tohoku University)
7R	TNRF	Thermal Neutron Radiography Facility
T1-1	HQR	High Q-Resolution Triple-Axis Spectrometer (University of Tokyo)
T1-2	AKANE	Advanced Kinken Neutron Spectrometer (Tohoku University)
T1-3	HERMES	Kinken Powder Diffractometer for High Efficiency and High Resolution Measurements (Tohoku University)
T1-4-1	PGA	Prompt Gamma-ray Analysis System
T2-1	RESA	Diffractometer for Residual Stress Analysis
T2-2	FONDER	Four-Circle Off-Center-Type Neutron Diffractometer (University of Tokyo)
T2-3-1	MUSASI	Multi-Purpose Thermal Neutron Application and Science
T2-4	TAS- 2	Triple-Axis Spectrometer
C1-1	HER	High E-Resolution Triple-Axis Spectrometer (University of Tokyo)
C1-2	SANS-U	Small-Angle Neutron Scattering Instrument (University of Tokyo)
C2-1	LTAS	Low energy Triple-Axis Spectrometer
C2-2	SUIREN	Apparatus for Surface and Interface Investigations with Reflection of Neutrons
C2-3-1	NSE	Neutron Spin Echo Spectrometer (University of Tokyo)
C2-3-2-1	MPGA	Multiple Prompt Gamma-ray Analysis
C2-3-3-1	CNRF	Cold Neutron Radiography Facility
C2-3-3-2	CHOP	(Test Port with Chopper)
C3-1-1	AGNES	Angle Focusing Cold Neutron Spectrometer (University of Tokyo)
C3-1-2-1	NOP	Apparatus for Neutron Optics
C3-1-2-2	MINE	Multilayer Interferometer for Neutrons (Kyoto University)
C3-2	SANS-J	Small-Angle Neutron Scattering Instrument

* QST: National Institutes for Quantum and Radiological Science and Technology

Specifications of fuel elements



The reactor core is composed of 26 standard fuel elements, 6 control rods with follower fuel, beryllium reflectors, and vertical irradiation holes.

Standard fuel element

Control rod with follower fuel

Vertical irradiation hole

Beryllium reflector

	Standard fuel element	Follower fuel element
Enrichment of U-235	Approx. 20wt%	Approx. 20wt%
Fuel core material	Uranium-Silicon dispersion alloy (U_3Si_2Al)	
Cladding material	Aluminum alloy	
Number of fuel plate	21 plates/element	21 plates/element

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JRR-3

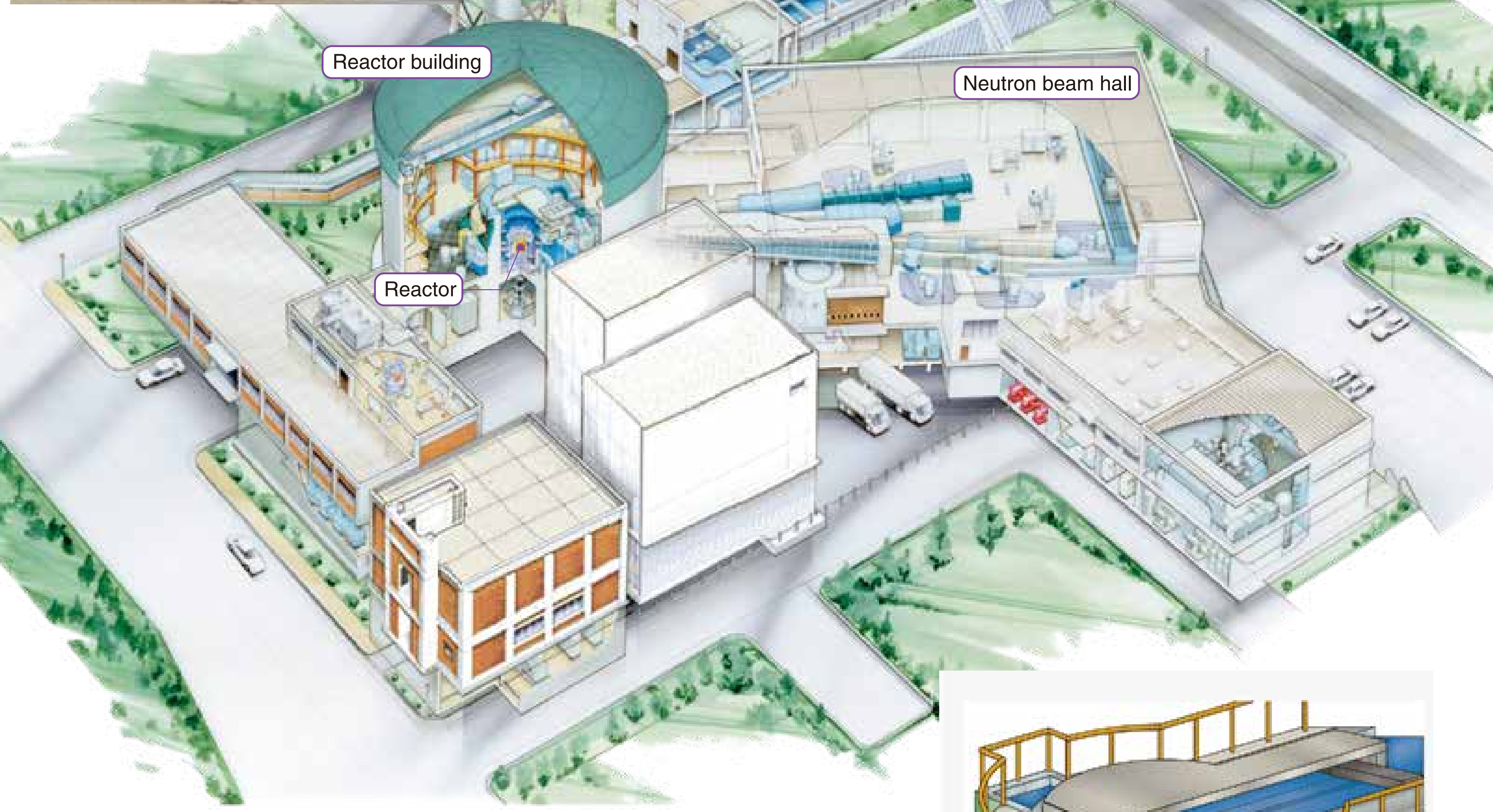
Japan Reseach Reactor No.3

JRR-3 achieved the first criticality in 1962 as the first research reactor constructed with the homegrown technology and had been utilized in a lot of researches from the dawn of nuclear research and industry. In 1990,JRR-3 was modified for upgrade and resumed its operation as a high performance and multi purpose research reactor with thermal power of 20MW.

JRR-3 has several utilization facilities for neutron beam experiments, irradiation tests for nuclear fuel and material and production of RI.Cold neutron (very low energy neutron) beams are available and utilized for clarification of life phenomena by analyzing structure of polymer molecules, for example.

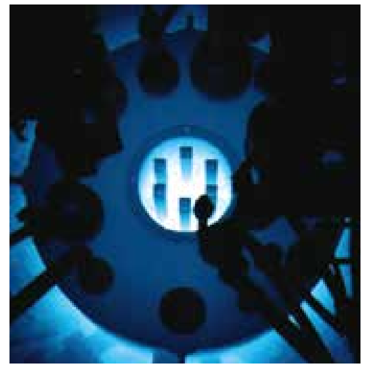
Bird's eye view of JRR-3 reactor building

Outside view of JRR-3

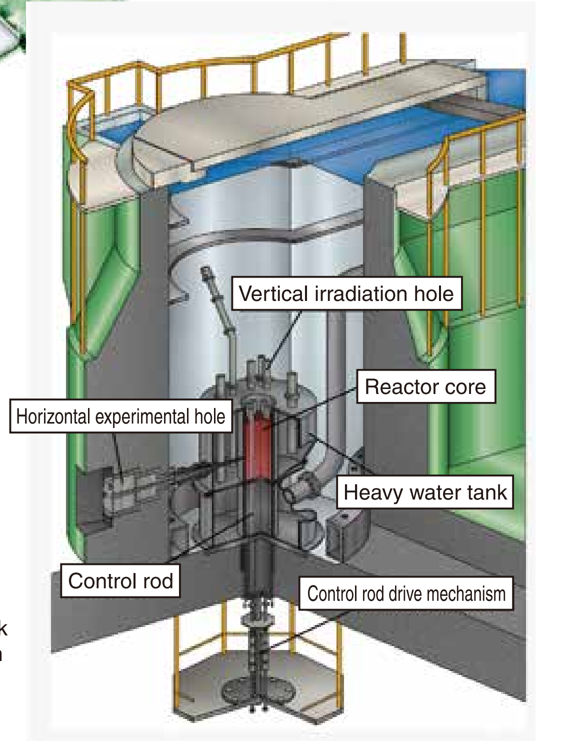


Specifications of JRR-3

Purpose	Beam experiments, Irradiation tests of fuels and materials, RI production, Activation analysis
Type	Light water moderated and cooled, pool type reactor with low-enriched uranium
Maximum thermal power	20MW
Maximum thermal neutron flux	Approx. 3×10^{18} m^{-2} s^{-1}



Reactor core (center) and heavy water tank glowed pale-blue with Cherenkov radiation



Utilization of JRR-3

JRR-3 has been utilized as a world-class high-performance research reactor for beam experiments (neutron radiography, neutron scattering experiments, prompt gamma-ray analysis) and neutron irradiation (RI production, neutron activation analysis), etc.

Contribution to the medical and industrial fields

Medical Isotope Irradiations

JRR-3 produces medical RIs for use in brachytherapy (internal radiotherapy), which can significantly improve the quality of life (QOL) after treatment with as little loss of function and form as possible.

Au-198 grains are used in the treatment of cancers in the mouth or at the entrance to the throat, and is implanted inside or next to the area requiring treatment.

Nuclear reaction of gold

$^{197}Au(n,)^{198}Au$

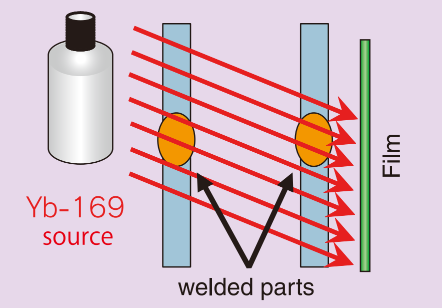
(half life: 2.694 days)

Image of brachytherapy using Au-198 grains

Industrial Isotope Irradiations

JRR-3 is routinely used to develop and produce RIs for science, agriculture and industry.

Sealed radioactive ß sources are used in industrial radiography, gauging applications, and calibration sources for measurement instruments.



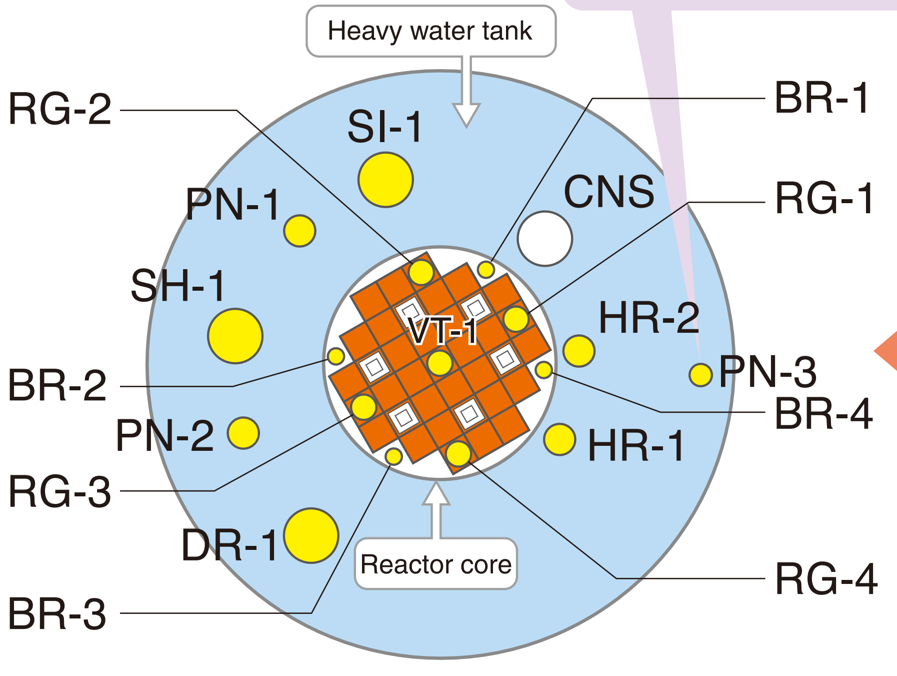
Nondestructive inspection of welded parts

Nondestructive and multi element simultaneous analysis of sample

Neutron activation analysis

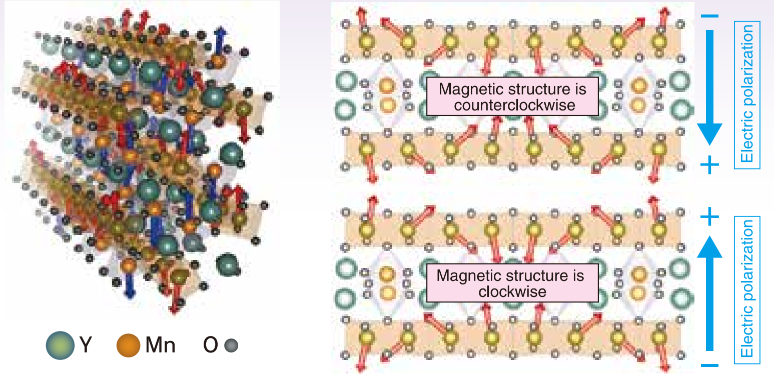
When a material is irradiated by neutrons, characteristic rays are emitted from the material. Neutron activation analysis allows us to analyze the composition of the material or a trace amount of impurities which have been taken in the material.

Capsules(back) and irradiation samples(front)

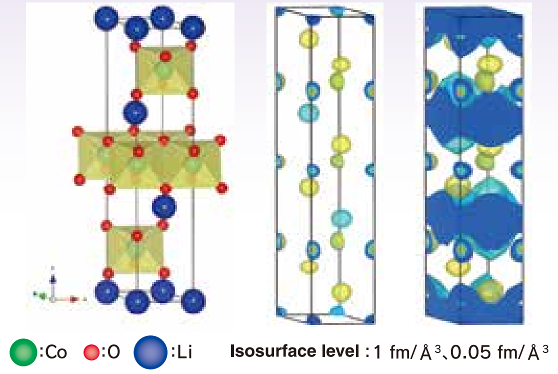


Fuel element · Vertical experiment hole · Control rod

Contributing to the elucidation of the structure of functional materials responsible for the next generation and study of new material synthesis

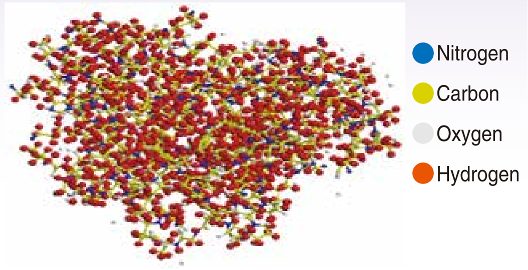


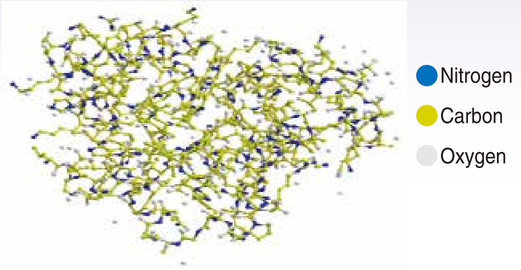
Elucidation of the relationship between crystal or magnetic structure and polarization of multiferroic magnetic materials



Analyses of crystal structure and nuclear density distribution of lithium-ion battery materials

Contributions to the function clarification of protein and the research and development of new drugs



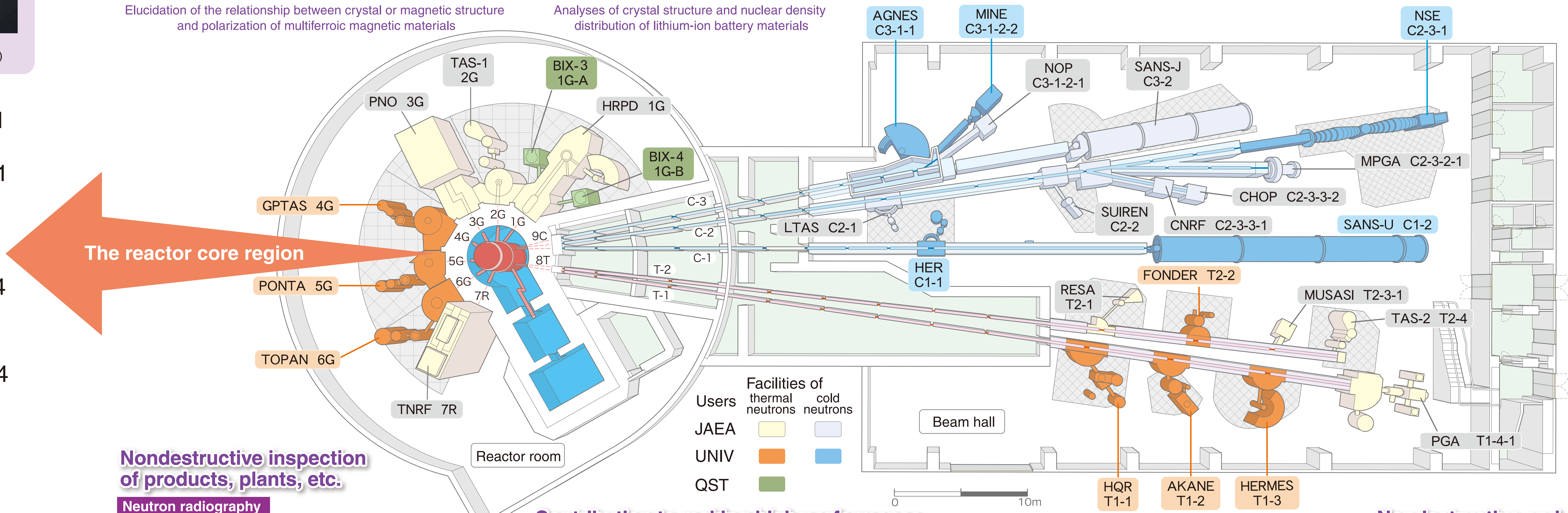


Observation of water molecules surrounding protein by neutron diffraction

Neutron scattering experiment

Examining how neutrons are scattered by the target material allows us to observe the ordering of atoms that compose the material, the force that acts on molecules, their induced movements, etc.

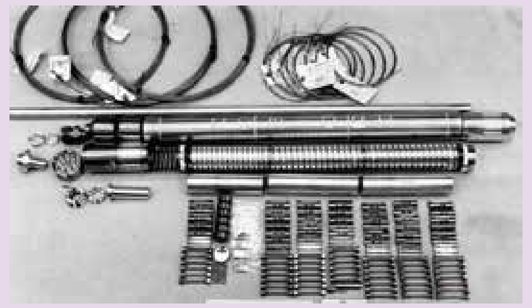
Especially, cold neutrons with long wavelength allow us to observe the material with a big molecular structure more clearly, and to carry out a new field research such as development of polymeric material and clarification of life phenomena, etc.



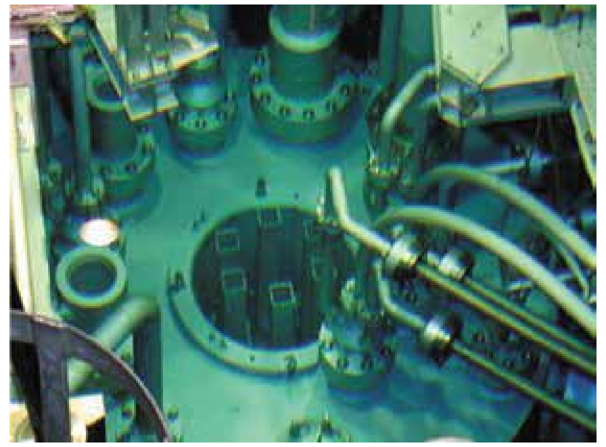
Contributions to the development of nuclear fuels and materials

Irradiation to fuels and materials

Fuels and materials for light-water nuclear reactors, fast breeder reactors and fusion reactors are irradiated by neutrons. After the irradiation, their conditions are examined in a hot laboratory, and the results are utilized for the development and research of future fast breeder reactors, fusion reactors, etc.



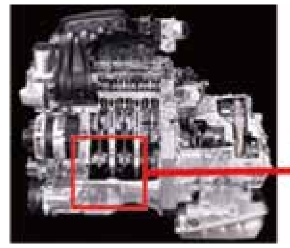
Irradiation capsules(back) and irradiation test pieces(front)



Reactor core region

Nondestructive inspection of products, plants, etc.

Neutron radiography



Oil movement inside the engine
Cooperation: Nissan Motor Co., Ltd.

Neutron imaging with high material permeability is used as one of the nondestructive inspection methods, and it is effective for visualization of the inside of metals that are difficult to detect with X-rays.

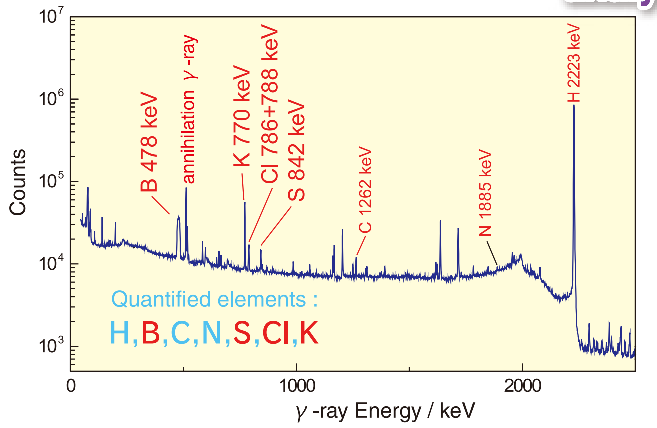
On the other hand, since some light materials such as hydrogen and water will absorb and scatter neutrons, the movement of water and oil inside the product can be observed.

Contribution to making high performance and high reliability materials

Residual stress analysis with neutrons

This is a method of measuring a change of crystal lattice plane distance (atomic arrangement) in the material and taking it as a change of strain, by making use of the neutron diffraction phenomenon. Because neutron has high material penetration property, the stress and strain in a metallic machine part can be measured without destruction nor contact. This method has been actively utilized to inspect the material strength design, integrity and reliability of industrial products (auto parts, power generation plant material, etc.) .

Nondestructive and multi element analysis for light elements etc.



Neutron induced prompt gamma-ray analysis (PGA)

PGA is a high sensitive method of analysis for trace elements which are included in a sample, by measuring prompt gamma-rays which are immediately emitted after neutron irradiation. This method is effective for various element analyses from light elements, such as hydrogen, boron and sulfur which are difficult to analyze in neutron activation analysis, to heavy elements. This method has been chiefly utilized to analyze environmental samples, meteorite, industrial materials and archaeology samples.