III. RESEARCH DIVISIONS AND LABORATORIES

III. RESEARCH DIVISIONS AND LABORATORIES (2012.6.1)

III-1. DEPARTMENT OF NUCLEAR SCIENCE AND ENGINEERING

By the reorganization of the Institute in 2003, this department, which consists of Division of Nuclear Engineering Science and Research Center for Safe Nuclear System, was formed. This department covers a wide research field such as the reactor safety, the management of radioactive materials, the development and effective use of nuclear energy, the studies on the recycling of nuclear fuels, and research reactor utilization.

III-1-1. Division of Nuclear Engineering Science

Professors

YOSHIIE, Toshimasa, D. Eng. (Osaka Univ.),
Radiation Effects in Solids
SHIBATA, Seiichi, D. Sc. (Kyushu Univ.),
Nuclear Chemistry and Radiochemistry
YAMANA, Hajimu, D. Eng. (Tohoku Univ.),
Radiochemistry
MORI, Yoshiharu, D. Eng. (Kyushu Univ.),
Accelerator Physics
KOYAMA, Akio, D. Eng. (Kyoto Univ.),
Sanitary Engineering
NAKAJIMA, Ken, D. Eng. (Hokkaido Univ.),
Nuclear Engineering
TAKAHASHI, Sentaro, Ph.D. (Kyoto Univ.),
Radiation Health Sciences
UNESAKI, Hironobu, D. Energy Sc. (Kyoto Univ.),
Reactor Physics and Engineering
MISAWA, Tsuyoshi, D. Eng. (Kyoto Univ.),
Reactor Physics and Engineering
MORIYAMA, Hirotake, D. Eng. (Kyoto Univ.),
Nuclear Material

Associate Professors

FUJIKAWA, Yoko, D. Eng. (Kyoto Univ.),
Environmental Science
OKI, Yuichi, D. Sc. (Univ. of Tsukuba),
Nuclear Chemistry, Health Physics
XU, Qiu, D. Eng. (Kyushu Univ.),
Radiation Damage in Metals
FUJII, Toshiyuki, D. Eng. (Osaka Univ.),
Physical Chemistry
FUKUTANI, Satoshi, D. Eng. (Kyoto Univ.),
Environmental and Sanitary Engineering
TAKAHASHI, Tomoyuki, D. Eng. (Kyoto Univ.),
Environmental Health Physics
SAITO, Yasushi, D. Eng. (Kyoto Univ.),
Thermal and Fluid Engineering
TAKAMIYA, Koichi, D. Sc. (Osaka Univ.),
Nuclear Chemistry
ISHI, Yoshihiro, Ph.D. (Niigata Univ.),
Accelerator Physics
TAKAHASHI, Toshiharu, D. Sc. (Tohoku Univ.),
Solid State Physics
KINASHI, Yuko, M.D., D. Med. Sc. (Kyoto Univ.),
Radiation Oncology
YAMAMOTO, Toshihiro, D. Eng. (Osaka Univ.),
Reactor Physics

Assistant Professors

KOIDE, Hiroaki, Nuclear Engineering
IMANAKA, Tetsuji, Nuclear Engineering
KUBOTA, Takumi, D. Eng. (Tohoku Univ.),
Radiochemistry
KAWABE, Hidenori, D. Eng. (Kobe Univ.),
Earthquake Engineering
PYEON, Cheol Ho, D. Energy Sc. (Kyoto Univ.),
Nuclear Reactor Physics
SHEN, Xiu-Zhong, D. Eng. (Shanghai Jiao-Tong Univ.), Nuclear Reactor Safety Engineering
YAGI, Takahiro, D. Energy Sc. (Kyoto Univ.),
Radiation Detection and Measurement
HORI, Jun-ichi, D. Eng. (Tokyo Inst. of Tech.),
Nuclear Engineering
SATO, Koichi, D. Eng. (Kyoto Univ.),
Radiation Effects in Solids
YASHIMA, Hiroshi, D. Eng. (Tohoku Univ.),
Radiation Control
NAKAMURA, Hidehito, Ph.D. (Osaka Univ.),
Radiation measurements
UEHARA, Akihiro, D. Eng. (Kyoto Inst. of Tech.)
Analytical Chemistry
UESUGI, Tomonori, D. Sc. (Univ. of Tokyo),
Accelerator Science and Engineering
OKUMURA, Kiyoshi , Reactor Engineering
SEKIMOTO, Shun, D. Eng. (Kyoto Univ.),
Radiochemistry and Geochemistry
SANO, Tadafumi, D. Eng. (Osaka Univ.),
Reactor Physics
KURIYAMA, Yasutoshi, D. Sci. (Osaka Univ.),
Accelerator Physics
TAKAHASHI, Yoshiyuki, D. Eng. (Kyoto Univ.),
Reactor Physics and Engineering

Guest Researcher

Professors

NAGASAWA, Hideko, Particle Radiation Oncology,
Host laboratory: Particle Radiation Oncology Research Center

Associate Professor

NISHIHARA, Kenji, Nuclear Transmutation,
Host laboratory: Research Reactor Safety

This division, which consists of eleven research laboratories from the previous research divisions of Nuclear Safety Research, Nuclear Energy Science and Fuel Cycle and Environment, was formed in 2003. This division covers a wide research field as follows.

III-1-1-(1) Research Reactor Safety

The Kyoto University Research Reactor (KUR) is a light water moderated, tank-type nuclear reactor, to utilize for general nuclear researches cooperated by all Japanese university researchers. It is used as a strong neutron source, which is applicable for a broad range of research fields. Besides the KUR, a 46 MeV electron linear accelerator (LINAC) is also used as a neutron source. Also, a new type of Fixed Field Alternating Gradient (FFAG) proton accelerator is under construction for the study of accelerator driven sub-critical nuclear reactor.

Using these three facilities, we are conducting the following research works:

i) Experimental Research on Advanced Utilization of Neutron Sources, Neutron Behavior and Nuclear Reactions
The experimental researches on nuclear reaction data (cross sections) are conducted for the utilization of various neutron sources, such as research reactors, accelerators, and nuclear fusion reactors. The cross sections of minor actinides and long-lived fission products are being measured.

ii) Research and development of future accelerators based on FFAG principle and their applications
The accelerator based on FFAG principle has a unique feature to utilize non-linear electric and magnetic fields efficiently, which is quite different from the ordinary accelerators. Non-linear beam dynamics, thus, is one of the most interesting subject in this type of accelerator. Various noble accelerator technologies based on FFAG principle such as ionization beam cooling, which could be useful for intense neutron source, are also under development.

iii) Integral Tests for Nuclear Data Evaluation and Validation
The evaluation and validation of cross sections through the analysis of integral experiments such as critical experiments (Integral Tests) are conducted.

iv) Research on safety of nuclear facilities
Researches on dynamic analysis and seismic safety evaluation of nuclear facilities are conducted. Prediction of strong ground motion for large earthquake is being conducted as well as the development of analysis methods.

III-1-1- (2) Nuclear Material Control

The activities of this laboratory are focused on optimum control and use of nuclear materials and development of innovative nuclear energy system to solve future energy issues. The current research subjects include:

i) Study on innovative nuclear energy system with high potential on non-proliferation and nuclear material saving.
ii) Study on energy policy issues, with special emphasis on the role of nuclear energy.
iii) Study on nuclear material transportation, safeguards and physical protection methodology.

This laboratory is related to the Department of Socio-Environmental Energy Science (Energy Policy), Graduate School of Energy Science, Kyoto University.

The studies conducted in this laboratory are made by merging both the technical and sociological aspects of nuclear energy, which is inevitable for discussing the role of nuclear materials as energy resource today and in the future.

III-1-1- (3) Radioactive Waste Management

The research activities of this laboratory are focused on radioactive waste management experimentally and theoretically. Studies on nuclear safety are also important themes. The current subjects are as follows:

i) Fundamental research on treatment and disposal of radioactive waste
ii) Technical aspects of radioactive waste treatment facilities
iii) Decommissioning of nuclear facilities
iv) Distribution and migration of radionuclides in the ground
v) Measurement of environmental radioactivity
vi) Radiation protection from environmental radioactive pollution

III-1-1- (4) Radiation Safety and Control

In the laboratory of Radiation Safety and Control, a wide variety of researches are carried out, with relation to the safe and reliable control of radiation use in the nuclear industries and several radiation facilities. At present, following subjects are carried out with collaboration of multi-disciplinary researchers, including engineering, technology, biology, medicine and environmental science:

i) Radiation safety in and surrounding the nuclear plants, in order to develop an advanced radiation safety management system and control procedures, with using experiences with KUR and KUCA.

ii) The level and movement of radioactive gas and aerosols generated by the accelerators, from the view point of radiation safety assessment.
iii) Behavior and kinetic of radio-nuclides originating from nuclear waste in soil and plants, especially the modeling of transfer of radio-carbon and radio-cesium.
iv) Measurement and control of radioactivity induced by neutron and charged particles in nuclear plants and accelerators.
v) Health effects and risks of radiation and radioactive materials, with relation to the nuclear industries and boron neutron capture therapy, as well as biological effects of radiation on human and non-human biota.

III-1-1- (5) Isotope Production and Application

This laboratory is focusing on studies concerning the production of isotopes using KUR and their various applications. The current research subjects are as follows:

i) Multitracer preparation and its application
ii) Trace element analysis by neutron activation method
iii) Study on nuclear decay of actinide elements
iv) Study on neutron energy spectrum induced by the Hiroshima atomic bomb using fast neutron product of ^{63}Ni
v) Environmental science study using long-lived nuclides
vi) Production mechanism of radioactive aerosol and its characteristics

III-1-1- (6) Nuclear System

To realize an emergent nuclear system with enhanced safety and high efficiency, this laboratory is performing basic studies on the nuclear characteristics of nuclear systems, which are subject to neutron transport and nuclear reactions, mainly based on reactor physics experiments using the Kyoto University Critical Assembly (KUCA). The current research subjects of this laboratory are as follows:

i) Development of accelerator driven subcritical reactors.
ii) Nuclear characteristics of next generation reactors including (a) thorium fueled reactors, (b) reactors for incinerating long-lived radioactive elements, (c) high performance research reactors, and so on.
iii) Research on reactor physics experimental technique based on reactor noise analysis or higher mode analysis.
iv) Development of neutron detectors and innovative experimental techniques for various reactor physics experiments and for hidden illicit material detection system by radiation detecting techniques.

III-1-1- (7) Heat Transport

Research activity of this laboratory covers (a) thermal-hydraulics of nuclear energy, (b) fundamental aspects of multiphase flows, (c) boiling heat transfer, and (d) flow visualization and measurement using neutron radiography. Current research subjects include:

i) Application of multi-sensor probes to measurement of characteristics of gas-liquid two-phase flow in a large diameter pipe.
ii) Direct contact phase change of water droplets in a molten metal pool.
iii) Heat transfer enhancement due to radiation induced surface activation (RISA).
iv) Thermal-hydraulic characteristics of two-phase flow in mini-channels.
v) Application of neutron radiography to flow visualization and measurement.

III-1-1- (8) Materials Irradiation Effects

The purpose of this research laboratory is to understand the fundamental aspects of irradiation effects in solids by high energy particles. It crosslinks with nuclear energy technology as well as solid state physics. The current research subjects are as follows:

i) Irradiation damage in metals, ceramics and semiconductors from low to high temperatures.
ii) Development of materials for advanced nuclear energy system.
iii) Computer simulation of irradiation effects in solids.
iv) Safety assessment of materials for nuclear power plants.
v) Development of materials for accelerator-driven subcritical reactors

III-1-1- (9) Environmental Radionuclide Science & Engineering

Current studies in this laboratory have been focusing on transport, redistribution and remediation of trace elements and radionuclides released in the environment through anthropogenic activities and natural phenomena. We have developed the environmental tracer technique that can be applied to the site characterization and the safety assessment for high-level radioactive waste disposal, and to exploit new water resources. Also developed are the technologies for on-site remediation of water bodies contaminated with refractory organic compounds and toxic trace elements. The mechanisms of the removal of contaminants are investigated using x-ray absorption spectroscopy. Analytical methodologies for on-site analyses of trace elements are also developed using highly sensitive portable voltammetry instrument.

The ongoing research topics are as follows:

i) The distribution of iodine ratio of $^{129}I/^{127}I$ and iodine concentration was surveyed in the Kanto plain for estimation of the origin of iodine and a mobility of deep brine.
ii) The adsorption of radionuclides with bentonite, zeolite, and activated carbon was investigated. Cs-134, Sr-85, and I-131 were produced at the KUR. Cs-134 and Sr-85 was removed with bentonite and zeolite. I-131 was hardly removed with bentonite, zeolite, and activated carbon.
iii) Soil contaminated with heavy metals was treated using a solution of natural organic matter extracted from plant wastes. The decontaminating ability of the extract was equivalent to 10^{-3} M EDTA.
iv) Remediation of groundwater, farm effluents and river water using natural filtration technique was investigated. After the laboratory experiments and the 3 to 8 years of pilot study, actual treatment systems were built and started to operate in Japan and Vietnam. The performance of the actual systems is now monitored.
v) Co-precipitation of radioactive cesium (extracted from municipal wastes using acid solutions, etc.) with various ferrocyanides is investigated. The examination of coagulation - precipitation characteristics, elemental composition and crystal structure of the precipitates, and the removal of rad-cesium is now under way to clarify the effects of matrix components peculiar to such extracts.

III-1-1- (10) Nuclear Recycle Chemistry

This laboratory investigates the basic chemical characteristics of lanthanide and actinide in various liquids, which is essential for developing advanced chemical processing techniques for the recycle of radioactive substances. Specially focused technological targets of this chemical research are reprocessing of spent nuclear fuels, partitioning and transmutation, and radioactive waste management.

Current research subjects are:

i) Coordination properties and separation characteristics of f-elements in high temperature melts and highly concentrated electrolyte solutions
ii) Chemistry for the advancement of the processing of nuclear fuels and radioactive wastes
iii) Mass-independent isotope effects in chemical exchange reactions
iv) Radiochemical and analytical chemistry of elements related to nuclear fuel cycle.

III-1-1- (11) Quantum Beam System (Visiting Research Laboratory)

In order to promote research systematically and synthetically by inviting active researchers who cover the field of quantum beam source development or nuclear safety, this laboratory has been prepared.

III-1-2. Research Center for Safe Nuclear System

Director

FUKUNAGA, Toshiharu, D. Eng. (Tohoku Univ.), Neutron Scattering

Professors

KAMAE, Katsuhiro, D. Eng. (Nagoya Inst. of Tech.) Earthquake Engineering

MORI, Yoshiharu, D. Eng. (Kyusyu Univ.) (Concurrently) Accelerator Physics

Associate Professor

ISHI, Yoshihiro, PhD (Niigata Univ.), (Concurrently) Accelerator Physics

UEBAYASHI, Hirotoshi, D. Eng. (Osaka Inst. of Tech.), Earthquake Engineering

Assistant Professors

KAWABE, Hidenori, D. Eng. (Kobe Univ.) (Concurrently) Earthquake Engineering

UESUGI, Tomonori, D. Sci. (Univ. of Tokyo) (Concurrently) Accelerator Physics

KURIYAMA, Yasutoshi, D. Sci. (Osaka Univ.) (Concurrently) Accelerator Physics

The Research Center for Nuclear Safety System was established originally to promote social understanding of safety of nuclear facilities and research activities at the Research Reactor Institute. It has two research laboratories which are Nuclear Disaster Prevention System and Hybrid Nuclear System.

III-1-2-(1) Nuclear Disaster Prevention System

Social consensus regarding energy problems is essential to the sustaining development of humankind. In this laboratory, the strategy of disaster prevention in electricity sources is studied to construct safe and stable energy system focusing upon human disaster as well as natural disaster, especially by earthquake.

The current main research subjects are as follows:

i) Study on the formation of public consensus on matters of energy in society.
ii) Study on the systematization of disaster prevention system focusing upon human disaster as well as natural disaster, especially by earthquake.
iii) Study on the strong ground motion prediction to mitigate earthquake disaster.
iv) Study on the strategy of earthquake disaster reduction in collaboration with local government.

III-1-2-(2) Hybrid Nuclear System

Novel nuclear power system such as ADS(Accelerator Driven System), intense neutron source and their applications using FFAG accelerators are studied. The FFAG(Fixed Field Alternating Gradient) accelerator has a unique feature compared with accelerators, which can utilize nonlinear beam optics effectively to realize a zero chromaticity in beam behavior providing the large dynamic apertures, and is conceived as one of the most suitable accelerators for intense hadron and muon accelerations and also for an intense secondary particle source using ERIT (Emittance Recovery Internal Target) with ionization cooling.

III-2. DEPARTMENT OF MATERIAL SCIENCE

In the department our attention is focused on material science with devices and facilities developed uniquely and on the creation of highly-qualified quantum beams such as neutrons, nuclei and high-energy photons.

III-2-1. Division of Quantum Beam Material Science

Professors

FUKUNAGA, Toshiharu, D. Eng. (Tohoku Univ.), Neutron Scattering

KAWABATA, Yuji, D. Eng. (Kyoto Univ.), Neutron Physics and Engineering

OHKUBO, Yoshitaka, Ph. D. (Purdue Univ.), Applied Nuclear Physics

MORIMOTO, Yukio, D. Sc. (Osaka Univ.), Protein Crystallography

SETO, Makoto, D. Sc. (Kyoto Univ.), Solid State Physics

SUGIYAMA, Masaaki, D.Sc.(Kyoto Univ.), Radiation Physics

Associate Professors

TANIGUCHI, Akihiro, D. Eng. (Nagoya Univ.), Nuclear Physics

HINO, Masahiro, D. Sc. (Kyushu Univ.), Neutron Optics

CHATAKE, Toshiyuki, D. Sc. (Tokyo Inst. of Tech.), Neutron Structural Biology

KITAO, Shinji, D. Sc. (Kyoto Univ.), Solid State Physics

MORI, Kazuhiro, D. Sc. (Grad. Univ. Advanced Studies), Materials Structure Science

Assistant Professors

KAWAGUCHI, Akio, D. Sc. (Kyoto Univ.), Polymer Physics

KOBAYASHI, Yasuhiro, D. Eng. (Osaka Univ.), Solid State Physics

SATO, Nobuhiro, D. Eng. (Kyoto Univ.), Polymer Chemistry

TANIGAKI, Minoru, D. Sc. (Osaka Univ.), Nuclear Physics

KITA, Akiko, D. Sc. (Tokyo Inst. of Tech.), Structural Biology

KITAGUCHI, Masaaki, D. Sc. (Kyoto Univ.), Neutron Coherence Optics

ITO, Daisuke, D. Eng. (Tokyo Inst. of Tech.), Thermal Hydraulics

OBA, Yojiro, D. Eng. (Keio Univ.), Magnetic and Metallic Materials Science

Program-Specific Assistant Professor
(Industry - Government - Academia Collaboration)

NUMOTO, Nobutaka, Ph. D. (Kyoto Univ.), Structural Biology

This Division has six laboratories collaborating each other. In this division, the research projects are promoted especially on material science with particle beams of neutron, RI, electron and γ-ray. In the projects, the division also directs its effort to creating and characterizing highly qualified particle beams and to development of new facilities and devices for the advanced uses of them. The current research projects in the laboratories are described below.

III-2-1- (1) Neutron Scattering Science

Neutron, the best partner of the X-ray, scattering and diffraction method are the most powerful technique to investigate and clarify the relationship between structure and function of widely distributed materials. Our laboratory concentrates on quantum beam studies of:

i) Structural biology of the macromolecule from the term of proton or protonation in a biological pathway. It is a very popular mechanism as a catalytic material. Three-dimensional structures at the atomic resolution and quaternary structures of proteins will deeply give us an information for understanding the physiological biophysics by use of the neutron and synchrotron radiation sources.
ii) The structure of various kinds of amorphous materials and protein complexes or aggregates by the method of X-ray or neutron scattering in order to clarify the quaternary structure and highly expressing functions.

Also we have actively collaborated with other high-flux facilities: KENS, JRR-3M, J-PARC and synchrotron radiation facilities PF and SPring-8.

III-2-1- (2) Neutron Material Science

In this laboratory, static and dynamical structures of disordered (amorphous, glass and gel), non-equilibirum and crystalline materials are investigated by complementary use of neutron and x-ray scatterings. The obtained results are returned for production of intelligent and functional materials. Therefore, several subjects in the laboratory are focused to get structural information of functional, energy storage and high temperature materials.

III-2-1- (3) Neutron Optics

The main research filed of this laboratory is the development of neutron optical devices and its utilization. The current subjects are as follows:

i) Development of VIN-ROSE which is a set of neutron resonance spin echo（NRSE） and MIEZE spectrometers for a pulse neutron source.
ii) Development of neutron optical devices including multilayer mirrors, supermirrors, monochromators, polarizers, analysers, and spin control devices, such as various type of spin flippers.

iii) Utilization of thermal neutron imaging for engineering, agriculture, archeology and so on.

After the successful development of MIEZE and NRSE in C3-1-2(JRR-3), BL-10 and BL-05(J-PARC), the construction of the beam line of VIN-ROSE has started in BL-06, J-PARC.

III-2-1- (4) Nuclear Beam Material Science

This laboratory is mainly concerned with the development of production methods of radioactive nuclear beams and their applications. The current research subjects are as follows:

i) Development of on-line isotope separation system for fission products.
ii) Nuclear structure studies of neutron-rich nuclei around mass number $A = 150$.
iii) Research and development of nuclear radiation techniques.
iv) Solid state physics and chemistry using gamma-ray perturbed angular correlation technique.

III-2-1- (5) Nuclear Radiation Physics

Research subjects of this laboratory are focused on the followings:

i) Condensed matter physics with nuclear methods, such as the study on the electronic states of synthetic metals and superconductors using Mössbauer spectroscopy.
ii) Fundamental studies of nuclear resonant excitation using synchrotron radiation and its application for materials and biological sciences.
iii) Fundamental studies of X-ray radiation with charged particle beams.

III-2-1- (6) Radiation Material Science

It is well known that a material structure and its dynamical character are deeply related. In the case of a functional material with a nano-scale structure, it is essential to reveal a mechanism of function to understand its dynamical character based on the structure. Along this line, this research group studies the nano-scale static and dynamical structures of functional materials such as supercritical fluid, polymer aggregates, gel and protein, with neutron, X-ray scattering methods.

The current research topics are as follows:

i) Kinetics of quaterny structure of protein with SANS and SAXS
ii) Size distribution of nano precipitates in metal alloy with SANS and SAXS.
iii) Development of analyzing method for SANS and SAXS.
iv) Application of γ-ray-induced reaction for developing nanomaterials, such as chemical modification of nanoparticles and simultaneous cross-linking and decomposing of multi-component polymer systems.
v) Exploration of the environmentally-friendly material synthesis process with γ-ray irradiation by taking advantage of their reaction free from chemical initiators or catalysts.

III-3. DEPARTMENT OF RADIATION LIFE SCIENCE AND RADIATION MEDICAL SCIENCE

This department consists of one division and one center, that is, division of radiation life science and particle radiation oncology research center. In particle radiation oncology research center, advanced neutron therapy session, which is financially maintained by private donations, was established since 2008.

Five research groups are collaborating for the research on physics, biology, chemistry and medicine using photon radiations and neutrons.

III-3-1. Division of Radiation Life Science

Professors

FUJII, Noriko, D. Med. Sc. (Tokyo Med. Den. Univ.), Radiation Biochemistry and Biological Function

Associate Professors

KOBAYASHI, Tooru, D. Eng. (Tokyo Inst. of Tech.), Medical Physics and Engineering

SAKURAI, Yoshinori, D. Eng., (Kyoto Univ.) Medical Physics and Engineering

TANO, Keizo, D. Med. Sc. (Nara Medical Univ.), Molecular Biology

Senior Lecturer

KINOUCHI, Tadatoshi, Ph. D. (Univ. of Tokyo), Biochemistry, Gerontology

Assistant Professors

TANAKA, Hiroki, D. Eng. (Kyushu Univ.), Medical Physics and Engineering

SAITO, Takeshi, D. Sc. (Hiroshima Univ.), Radiation Physical Chemistry, Radiation Biology

This division is composed of three laboratories: Radiation Medical Physics, Radiation Biochemistry and Biological Function, and Radiation Biology.

The current research projects are as follows:

III-3-1- (1) Radiation Medical Physics

Medical physics is the general term for the physics and technology which are supporting medicine, especially radiation therapy and particle therapy. As it covers many different fields, the important subjects are “promotion for the advance of radiation therapy” and “quality assurance for radiation therapy”. Our group is focusing on “boron neutron capture therapy (BNCT)”, which is one kind of particle therapies.We are studying for the advance of BNCT as follows:

i) Advance of the BNCT irradiation fields: We are studying about the improvement of the irradiation field at the Heavy Water Neutron Irradiation Facility of KUR. We are also performing the design studies for accelerator-based irradiation system.
ii) Development of dose estimation methods: We are developing the separative estimation methods for four components such as thermal (<0.5 eV), epi-thermal (0.5 eV to 10 keV) and fast neutrons (>10 keV), and gamma ray. Our final goal is the completion of the real-time estimation system for 3D dose distribution under BNCT.
iii) Establishment of quality assurance (QA): We are studying about the QA program for BNCT, such as the standard dosimetry for the irradiation field, the dose estimations for pre- and post-treatment, the exposure estimation for patient, *etc.*.

III-3-1- (2) Radiation Biochemistry and Biological Function

Our study is focused on various post-translational modifications, such as: deamidation, racemization, stereoinversion, isomerization, truncation, phosphorylation, oxidation and an increase in intramolecular disulfide bonding of inert proteins, such as lens, brain and skin. These post-translational modifications generate during aging process spontaneously and also are increased by UV (ultraviolet), gamma and neutron irradiation.

Our aim is to elucidate the post-translational modifications which can induce the partial unfolding of the protein, resulting in a reduction of the protein functions, followed by the related diseases. The current research includes the following projects:

i) Study of post-translational modification of lens proteins induced by aging, UV, gamma and neutron irradiation.
ii) Study of mechanism of D-amino acid formation in protein. The aggregation of protein induced by racemization of Asp residues in protein.
iii) The identification of D-beta-Asp containing protein in UV-irradiated skin from elderly human donors.
iv) Study of the radioresistant mechanisms in the radioresistant bacteria.
v) Study of a specific enzyme that degrades D-Asp-containing protein.

III-3-1- (3) Radiation Biology

After the life was born on the earth 3,600 million years ago, the life has not been separated from various environmental stresses, such as radiation, temperature and pressure. And the life built cell structure to distinguish it from the surrounded environment. Recently, it has been made clear that a cell is using basic mechanism of biological reaction for replying to various stresses. Therefore, basic biological reaction may be clarified by discovering stress response mechanism. Dysfunction of stress response in cell may be a cause of carcinogenesis and acceleration of aging. If so, it is also expected that a disease is cured by fixing a stress response function normally.

Along such a working hypothesis, we choose four environmental stress factors, such as radiation, hyperthermia, and pressure, and are doing the study focused on the following topics.

i) Mechanism of carcinogenesis and aging
ii) Mechanism of stress response
iii) Development of new cancer therapy by hyperthermia and radiation
iv) A search of cancer and aging prevention natural material

A last aim of our research activities is prevention and a treatment of cancer and aging.

As topics of our recent research in 2006, we found that nongenetic damage induced by long-lived radicals played an important role in an initial process of cellular malignant transformation. This new radical attacked centrosome, and destroyed its structure. In those cell culture, structural aberration of chromosome did not occur, but aneuploid was seen in high frequency. From these results, we speculated that a main target of radiation carcinogenesis is not DNA, but is centrosome, which are the proteins to constitute chromosomal homeostasis maintenance mechanism. If our experiment results are right, mutation theory of carcinogenesis is to be wrong.
Therefore, we propose a new hypothesis of radiation carcinogenesis. This result was presented at International Congress of Radiation Research 2011 in Warsaw as an invited speaker.

III-3-2. Particle Radiation Oncology Research Center

Professor and Director

ONO, Koji, M. D., D. Med. Sc. (Kyoto Univ.), Radiation Oncology

Professor

MARUHASHI, Akira, D. Eng. (Kyoto Univ.) Medical Physics, Radiation Basic Medicine, Radiation Oncology

Associate Professor

MASUNAGA, Shin-ichiro, M. D., D. Med. Sc. (Kyoto Univ.), Radiation Oncology

SUZUKI, Minoru, M. D., D. Med. Sc. (Kyoto Univ.), Radiation Oncology

Assistant Professors

KONDO, Natsuko, M. D., D. Med. Sc. (Nara Medical Univ.), Neuro-surgery

NARABAYASHI, Masaru, M.D., Radiation Oncology

III-3-2-(1) Particle Radiation Oncology

The research project of Boron Neutron Capture Therapy (BNCT) at KURRI was re-started in 1990. Over 400 times BNCT for malignant tumors, that are refractory to standard treatment, have been performed by BNCT researchers of KURRI and their collaborators. They consist of many cases of malignant brain tumors (mainly malignant glioma), melanoma of the skin, H & N cancers, and more than 5 cases of lung (including malignant pleural mesothelioma) and liver cancers, respectively. The 5-year survival rate of malignant melanoma of the skin is 55%. The first BPA-BNCT for malignant glioma in the world and first clinical trial using epithrermal neutron beam without craniotomy in Asia were performed in KURRI at the beginning of 1994 and 2002, respectively. According to the paper that reported the effectiveness of Temozolomide (TMZ) on newly diagnosed glioblastoma (GBM), X-ray therapy with or without TMZ achieved MSTs of 12.1 and 14.6 months, respectively. On the other hand, the median survival time (MST) after BNCT to this tumor is over 24 months. Only quite small number of patients received TMZ medication. So, we consider that BNCT is more effective than TMZ+X-ray therapy. For recurrent GBM, BNCT looks superior treatment than standard supportive therapy. From the previous report on TMZ+X-ray therapy trial, we can estimate MST of 7-8 months for recurrent GBM cases. BNCT for this disease elongated the MST to 11.8 months. Hazard ratio is around 1.5-1.7. In December of 2001, the first patient of recurrent H & N tumor in the world was treated by BNCT. An analysis was also performed on all recurrent H & N tumors. BNCT showed excellent effects on the cases of histological type of adenocarcioma. All patients of this pathology are surviving after BNCT. Malignant melanoma is also good in clinical course after BNCT, however, that of squamous cell carcinoma patients is not good. Although the reason is not clear, far advanced many cases might be included in this histological type group. In total, about 25% of the patients without treatment option except BNCT survived over 5 years after BNCT. Lung cancer, especially malignant pleural mesothelioma, and primary or secondary liver tumors are other new targets of clinical study. BNCT gave an excellent effect to some of them. New interesting tumor is Paget disease besides a breast. Large disease is completely resolved with surgical resection by BNCT.

Based on these data, the center is developing an accelerator neutron source in collaboration with two companies. The neutron intensity at the exit of collimator and thermal neutron production at 5 cm depth are 1.8 and 2.0 times larger than those of KUR. At present physical and radiobiological studies of neutrons have been completed and we are concentrated on the preparation in order to start clinical test to get an official approval of cyclotron neutron generator and BPA as a medical device and medical drug, respectively. We are expecting it in this summer.

Mission of the center is organization and enforcement of clinical study of BNCT for cancers, and the center is nucleus of BNCT and related researches in whole Japan.

The main research subjects are as follows:

i) Radiology research for NCT.
ii) Development of radio-medical techniques.
iii) Radiation dosimetry in living systems and micro-dosimetry.
iv) Clinical BNCT for cancer patients.

III-3-2−(2) Advanced Neutron Therapy

As a result of ^{10}B-thermal neutron reaction, energetic particles of ^{4}He and ^{7}Li, and gamma rays are emitted. Energies (ranges, LETs) of each particle, ^{4}He and ^{7}Li, are 1.47MeV (8.9μm, 165keV/μm) and 0.84MeV, (4.8μm, 175keV/μm) and 0.04% of those are 1.68MeV (9.8μm, 170keV/μm) and 1.01MeV (5.3μm, 190keV/μm) corresponding to the nuclear energy state of ^{7}Li generated in ^{10}B (n, ^{4}He) ^{7}Li reactions, respectively. All of these particles possess most effective potential for giving damage to cells. If ^{10}B compound accumulates selectively at higher concentration in all tumor cells than surrounding normal cells, we can completely destroy the tumor without damage to the normal tissues by BNCT. There exist the tumor cells in which ^{10}B compound is low in concentration. Although the proportion of such cells is not so large, however, it is inevitable in the advanced malignant tumor. Another weak point of BNCT is that curable depth of tumor is limited to about 7cm by attenuation of epi-thermal neutron in a body. It is the object of our research program to overcome these problems of BNCT.

To advance the BNCT of the present situation, we decided to develop a new system of an accelerator and a moderator, and to achieve the neutron field the most suitable for BNCT. An accelerator-moderator system was installed in a medical research lab as one division of the innovation research laboratory on Apr. 2009. This accelerator is able to supply 30MeV proton beam of the constant intensity of 1mA over 1hour continuously. At present, characteristics of neutron field of an irradiation port achieved by this system were examined by means of physical (dosimetry of mixed radiation fields of neutron and gamma-ray) and biomedical (radiation effect and radiation safety) methods.

III-4. HEAD OFFICE FOR SAFETY MANAGEMENT

Recently, safety management is becoming more and more important in view of public acceptance of nuclear facilities. Therefore, the Head Office for Safety Management was established in 2002 to supervise the safety management in the Institute, especially in the nuclear facilities. In FY 2011, three divisions, i.e., Quality Control, Nuclear Fuel Management, and Safety Control Center were operated in this Head Office.

III-5. HEAD OFFICE OF ACADEMIC INFORMATION

This office supports the institute in information-related aspects. It has mainly three duties interrelated with each other.

i) Network operation: The office maintains the network system and operates servers for e-mail and homepage.
ii) Support of research and education: The library is a constituent unit of the office. Meeting the multidisciplinary character of the institute, it possesses a wide variety of research journals, books, and other documents, especially, related to nuclear science and engineering. Through the network, electronic journals and databases subscribed by Kyoto University are also available. The office transmits lectures given in the institute to other campuses of Kyoto University and other universities via internet TV-systems.
iii) Public relations: The office introduces to the public activities of the institute through the homepage, by issuing brochures and progress reports, and by holding an open lecture meeting and open campus.

III-6. TECHNICAL STAFF OFFICE

The technical staff office takes charge of the technical works for the operation of a reactor, maintenance of the experimental facilities, safety control of radiation and radioactive waste disposal. It consists of four groups and each group has two subgroups.

General Manager

IKEGAWA, Ryusho
(Concurrent) Group Chief

Group Chiefs

MINAMI, Kaoru
(Concurrent) Subgroup Chief
TSUCHIYAMA, Tatsuo
KOBORI, Hiroshige
(Concurrent) Subgroup Chief

Subgroup Chiefs

OONO, Kazuomi
ZHANG, Jian
YAMAMOTO, Hiroshi
YOSHINO, Hirofumi
KAKIHANA, Eiko

Senior Staff Members

ABE, Naoya
HASEGAWA, Kiyoshi
FUJIHARA, Yasuyuki
TAKESHITA, Tomoyoshi
HIRAI, Yasuhiro
OKUMURA, Ryou
YOSHINAGA, Hisao
FUJIWARA, Keiko
ITAMI, Teppei

Technical Staff Members

IINUMA, Yuto
INO, Yuta
IMOTO, Haruka
OGINO, Shinya
KANAYAMA, Masaya
KURIHARA, Kouta
SAKAMOTO, Masaaki
TANAKA, Yoshiaki
NAKAMORI, Akira
MARUYAMA, Naoya
MIYAKE, Tomohiro
YAMADA, Tatsuya

III-7. ADMINISTRATION OFFICE

Director :	NAGATA Toshiyuki
General Affairs Division:	
Director :	HIKITA Satoru
Assistant Director :	IZUMORI Yoshihiro
General Affairs Section	
Section Chief :	HASHI Masahiro
	SUZUKI Michiyo
	YAMAMOTO Yuka (nurse)
Joint Use Program Section:	
Section Chief :	NAKAYAMA Chiyoko
Library Section :	
Section Chief :	NAKATSUKA Hiroto
Financial Affairs Division	
Diretor :	ASAI Masahiko
Accounting Section	
Section Chief:	IWASE Tomohiro
	WAKABAYASHI Junichiro
Supplies Section :	
Section Chief :	ADACHI Kenji
	ISETO Motoko
	OGAWA Sachiko
	FUJINAGA Sumio
Building Work Section :	
Section Chief :	FUJIKAWA Sinichi
Electricity Work Section :	
Section Chief :	MORI Tetsuya
	TANIGUCHI Masaru
	FUJIWARA Kenji
Other Utility Work Session :	
Section Chief :	HAYASHI Yasuhiko
	OKADA Tomohiro