

### III. RESEARCH DIVISIONS AND LABORATORIES (2014.6.1)

#### 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

TAKAHASHI, Sentaro, Ph. D. (Kyoto Univ.),  
Radiation Health Sciences  
YAMANA, Hajimu, D. Eng. (Tohoku Univ.),  
Radiochemistry  
MORI, Yoshiharu, D. Eng. (Kyushu Univ.),  
Accelerator Physics  
NAKAJIMA, Ken, D. Eng. (Hokkaido Univ.),  
Nuclear Engineering  
UNESAKI, Hironobu, D. Energy Sc. (Kyoto Univ.),  
Reactor Physics and Engineering  
MORIYAMA, Hirotake, D. Eng. (Kyoto Univ.),  
Nuclear Material  
MISAWA, Tsuyoshi, D. Eng. (Kyoto Univ.),  
Reactor Physics and Engineering  
SAITO, Yasushi, D. Eng. (Kyoto Univ.),  
Thermal and Fluid Engineering  
OHTSUKI, Tsutomu, D. Sc. (Tokyo Metropolitan Univ.), Nuclear Chemistry

###### 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  
TAKAMIYA, Koichi, D. Sc. (Osaka Univ.),  
Nuclear Chemistry  
TAKAHASHI, Tomoyuki, D. Eng. (Kyoto Univ.),  
Environmental Health Physics  
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  
FUKUTANI, Satoshi, D. Eng. (Kyoto Univ.),  
Environmental and Sanitary Engineering  
PYEON, Cheol Ho, D. Energy Sc. (Kyoto Univ.),  
Nuclear 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  
SHEN, Xiu-Zhong, D. Eng. (Shanghai Jiao-Tong Univ.), Nuclear Reactor Safety Engineering  
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  
UEHARA, Akihiro, D. Eng. (Kyoto Inst. of Tech.)  
Analytical Chemistry  
UESUGI, Tomonori, D. Sc. (Univ. of Tokyo),  
Accelerator Science and 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  
NAKAMURA, Hidehito, Ph.D. (Osaka Univ.),  
Radiation Measurements  
YAGI, Takahiro, D. Energy Sc. (Kyoto Univ.),  
Radiation Detection and Measurement  
SHIBAHARA, Yuji, D.Eng. (Osaka Univ.),  
Analytical Chemistry  
SHIGA, Hiroshi, (Kyoto Univ.),  
Radiation Control  
IKEGAMI, Maiko, Ph. D. (Kyoto Univ.),  
Environmental Engineering

###### Researcher

MUTO, Masayuki, D. SC. (Hiroshima Univ.),  
Accelerator Physics

###### Guest Researcher

###### Professor

OIGAWA, Hiroyuki, Nuclear Transmutation, Host laboratory: Research Reactor Safety

## **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 materials saving.
- ii) Study on energy policy issues, with special emphasis on the role of nuclear energy to enhance energy security.
- iii) Study on nuclear security issues, including safeguards, physical protection, proliferation resistance evaluation and nuclear material detection technology.

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, several types of research are carried out with relation to the safe and reliable control of radiation 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) Development of an advanced radiation safety management system and control procedures, with using experiences with KUR and KUCA.
- ii) Behavior and kinetic of radio-nuclides originating from nuclear waste in soil and plants, especially the modeling of transfer of radio-carbon and radio-caesium.
- iii) Measurement and control of radioactivity induced by neutron and charged particles in nuclear plants and accelerators.
- iv) Health effects and risks of radiation and radioactive materials, with relation to the nuclear industries and boron neutron capture therapy.

#### **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) Study on mechanism of nuclear reaction using research reactor and accelerator
- ii) Production mechanism of radioactive aerosol and its characteristics
- iii) Neutron activation analysis of extraterrestrial and terrestrial materials
- iv) Study on half-life change in radioisotopes and nuclear transmutations

#### **III-1-1- (6) Nuclear System**

To realize an innovative 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 system (ADS).
- ii) Nuclear characteristics of next generation reactors including thorium fueled reactors and high performance research reactors.
- 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 wire-mesh sensors and multi-sensor probes to measurement of characteristics of gas-liquid two-phase flow.
- ii) Thermal-hydraulic characteristics of liquid-metal two-phase flow by using potential probes.
- iii) Heat transfer enhancement due to radiation induced surface activation (RISA) by using gamma-ray and proton beam.
- iv) Application of neutron radiography to flow visualization and measurement.
- v) Direct contact phase change of water droplets in a molten metal pool.

#### **III-1-1- (8) Materials Radiation 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 technologies for on-site remediation of water bodies contaminated with refractory organic compounds, toxic trace elements and radionuclides. The mechanisms of the removal of contaminants are investigated using X-ray absorption spectroscopy. Analytical methodologies for on-site analyses of trace elements using highly sensitive portable voltammetry instrument are studied. Also under way is PIXE/PIGE analysis of fluorine in unstable degradation products of perfluorinated chemicals.

The ongoing research topics are as follows:

- i) The adsorption of radionuclides with bentonite, zeolite, and activated carbon was investigated. Of the radionuclide tracers used, 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.
- ii) 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.

- iii) The remediation technologies for environmental water contaminated with humic substances and estrogens were investigated. An actual treatment system using soil filtration technique was constructed after laboratory experiments and pilot studies in Japan. More recent research is focused on the degradation of recalcitrant perfluorinated compounds by electrolysis as well as gamma-ray irradiation.
- iv) The biological filtration system for simultaneous removal of Fe, As, Mn and  $\text{NH}_4^+$  from groundwater was developed. After 7 years of pilot study and an X-ray absorption fine structure spectroscopic study to clarify the mechanisms of arsenic removal, an actual treatment unit for potable water was constructed and is currently in operation in Vietnam. The ANAMMOX process for removal of ammonium is now investigated.
- v) Co-precipitation of radioactive cesium from the extracts of municipal wastes is investigated by producing various metal-ferrocyanide compounds *in-situ*. After laboratory experiments, on-site test is now conducted to establish the method for actual contaminated wastes.

### 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

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

#### Professors

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

#### Associate Professor

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

UEBAYASHI, Hirotoishi, 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  
ITO, Daisuke, D. Eng. (Tokyo Inst. of Tech.),  
Thermal Hydraulics  
OBA, Yojiro, D. Eng. (Keio Univ.), Magnetic and  
Metallic Materials Science  
ONODERA, Yohei, D. Eng. (Kyoto Univ.),  
Material Structure Science  
AMANOV, Auezhan, Ph.D. (Sun Moon Univ.),  
Tribology

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  $\gamma$ -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. Deuterium treated protein complexes are produced by a minimum medium cultivation system in our institute.
- 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: 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-equilibrium and crystalline materials are investigated by complementary use of neutron and x-ray scatterings. Recently, the subject of our group is focused on getting structural information of functional materials: rechargeable batteries, hydrogen storage materials, etc. In particular, three dimensional locations of light atoms, lithium and hydrogen, in the condensed matter can be precisely determined by the Rietveld and pair distribution function (PDF) analyses, and the reverse Monte Carlo (RMC) modeling based on neutron and X-ray diffraction data.

#### III-2-1- (3) Neutron Optics

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

- i) Development and construction of new type neutron spin echo spectrometer which is called "VINROSE" at BL06 at J-PARC/MLF. It consists of two spectrometers, NRSE and MIEZE .
- ii) Development of new neutron optical devices including spin control devices, such as various tspin flippers.
- iii) Utilization of thermal neutron imaging for wide field, such as engineering, agriculture, archeology.

We are not only managing neutron beam lines with supermirror guides CN3 and B4 at KURRI, but also "MINE" beam lines at C3-1-2 at JRR-3. The MINE has two beam lines, monochromatic and wide-band ones. The prototype of the VIN ROSE (MIEZE and NRSE) had

been successfully developed in the MINE beam line and CN3 at KURRI. Furthermore, we had designed and provided all neutron supermirrors for the VIN ROSE beam lines. These supermirrors were fabricated by ion beam sputtering machine at KURRI. The installation of the VIN-ROSE is in progress.

#### **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) Condensed matter physics and chemistry using the time-differential 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) Structure and Dynamics of protein complex with Neutron and X-ray scattering methods
- 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  $\gamma$ -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  $\gamma$ -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.),  
Biochemistry, Protein Chemistry

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

##### **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

SANADA, Yu, D. Sc. (Kyoto Univ.)  
Molecular 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 modifications of lens proteins induced by aging, UV, gamma and neutron irradiation.
- ii) Study of mechanism of D-amino acid formation in protein. Racemization of Asp residues triggers the aggregation of 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) Particle 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 the environmental stress factors, such as radiation, hyperthermia, and pressure, and have been studying on the following topics.

- i) Mechanism of carcinogenesis and aging.
- ii) Mechanism of stress response.

In addition, in order to contribute to the development of cancer treatment, we are carrying out basic research in biology, bioscience and medical science focusing on BNCT (Boron Neutron Capture Therapy) that have been conducted at KURRI.

Our current research topics are:

- i) DNA repair and intracellular mechanism.
- ii) Evaluation of cancer treatment by detecting the susceptibility of solid tumor cells.
- iii) Influence on distant metastases by treatment of local tumor, screening for new <sup>10</sup>B-compounds for BNCT.

Some researchers in the field of engineering or chemistry are carrying out the study of biological matter at KURRI, we are working positively to collaborate them to launch a new project.

### III-3-2. Particle Radiation Oncology Research Center

#### Director

TAKAHASHI, Sentaro, Ph.D. (Kyoto Univ.),  
Radiation Health Sciences

#### Professor

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

#### Associate Professor

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

#### Assistant Professors

KONDO, Natsuko, M. D., D. Med. Sc. (Nara Medical  
Univ.), Neuro-surgery  
NARABAYASHI, Masaru, M.D., Radiation Oncology  
FUJIMOTO, Nozomi,  
Medical Physics and Engineering  
NAKAGAWA, Yosuke, D.D.S., D.Med.Sc. (Nara  
Medical Univ.)

### 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 epithermal 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 adenocarcinoma. 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. Using this system, a clinical trial of BNCT

for recurrent malignant brain tumors has been started since October in 2012. Development of the AB-BNCT system is an important first step for a future in which BNCT will be available in the hospital.

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 practical and research subjects are as follows;

- 1) Clinical trial using AB-BNCT system.
- 2) Pioneering RB-BNCT for common cancer
- 3) Research on effect of BNCT for normal organs or tissues.

### III-3-2-(2) Advanced Neutron Therapy

Boron neutron capture therapy (BNCT) is a radiation therapy that makes use of the  $^{10}\text{B}(n, ^4\text{He})^7\text{Li}$  reaction to selectively kill tumor cells. The ranges of lithium nuclei and alpha particles that are emitted following the  $^{10}\text{B}(n, ^4\text{He})^7\text{Li}$  reaction are 5  $\mu\text{m}$  and 9  $\mu\text{m}$ , respectively, corresponding to the diameter of a representative tumor cell. If  $^{10}\text{B}$  compound selectively accumulates with higher concentration in tumor cells than normal cells, BNCT can selectively destroy the tumors without damage for the normal tissues. However, if  $^{10}\text{B}$  compound dose not sufficiently accumulate in tumor cells, the advanced malignant tumor cells will increase. Another weak point of BNCT is that the treatable depth is limited to about 7cm because of the attenuation of epithermal neutrons in a human body. It is the object of our research to overcome these problems of BNCT.

To advance the present situation of BNCT, we decided to develop a new accelerator based neutron source. An accelerator based neutron source was installed in a medical research laboratory as one division of the innovation research laboratory on April 2009. This accelerator can continuously supply 30MeV proton beam with the constant current of 1mA over 1 hour. At present, the characteristics of neutron field were examined by means of physical (dosimetry of mixed radiation fields for neutron and gamma-ray) and biomedical (radiation effect and radiation safety) methods. Furthermore, the clinical trials already started on October 2012.

## III-4. HEAD OFFICE FOR SAFETY MANAGEMENT

Safety operation of the facilities is the most important issue. The Head Office for Safety Management was established in 2002 to supervise the safety management in the Institute, especially in the nuclear and radiation facilities. At present, three divisions, i.e., Quality Control, Nuclear Fuel Management, and Safety Control Center are operated under the supervising of this Head Office. This head office also administrates a safety control in the working environment at KURRI.



### 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

KOBORI, Hiroshige  
(Concurrent) Group Chief

#### Group Chiefs

MINAMI, Kaoru  
(Concurrent) Subgroup Chief  
TSUCHIYAMA, Tatsuo  
YOSHINO, Hirofumi

#### Subgroup Chiefs

OONO, Kazuomi  
ZHANG, Jian  
YAMAMOTO, Hiroshi  
OKUMURA, Ryo  
KAKIHANA, Eiko

#### Senior Staff Members

ABE, Naoya  
HASEGAWA, Kiyoshi  
FUJIHARA, Yasuyuki  
TAKESHITA, Tomoyoshi  
HIRAI, Yasuhiro  
YOSHINAGA, Hisao  
FUJIWARA, Keiko  
ITAMI, Teppei  
KURIHARA, Kouta  
SAKAMOTO, Masaaki

### Technical Staff Members

IINUMA, Yuto  
INO, Yuta  
IMOTO, Haruka  
OGINO, Shinya  
KANAYAMA, Masaya  
KOBAYASHI, Norika  
TANAKA, Yoshiaki  
NAKAMORI, Akira  
MARUYAMA, Naoya  
MIYAKE, Tomohiro  
YAMADA, Tatsuya

### III-7. ADMINISTRATION OFFICE

Head: KOBAYASHI, Eiji  
Assistant Head (General): NAGATA, Toshiyuki  
Assistant Head (Finance): IWASE, Tomohiro  
General Affairs Section  
Section Chief: KAWAHARA, Eiji  
SUZUKI, Michiyo  
IIJIMA, Yuuichi  
YAMAMOTO, Yuka (nurse)  
Joint Use Program Section:  
Section Chief: NAKAYAMA, Chiyoko  
SUGANO, Takahito  
Library Section:  
Section Chief: NAKATSUKA, Hiroto  
Accounting Section  
Section Chief: WAKABAYASHI, Junichiro  
MAEYAMA, Shiori  
Contract Section:  
Section Chief: ADACHI, Kenji  
HAYASHI, Yuusaku  
MORITA, Masaya  
Building Work Section:  
Section Chief: FUJIKAWA, Sinichi  
HIGASHINO, Keita  
Electricity Work Section:  
Section Chief: MORI, Tetsuya  
NAKATANI, Daisuke  
TOKUDA, Yuichi  
Other Utility Work Session:  
Section Chief: HAYASHI, Yasuhiko  
OKADA, Tomohiro  
Travel Expenses and Rewards Section  
Section Chief: WAKABAYASHI, Junichiro  
OMOTANI, Sanae