Since re-organization as an independent administrative institution in April 2001, researchers at the National Institute of Radiological Sciences (NIRS) have been performing studies according to mid-term plans that have been revised every 5 years. The first mid-term plan was started in April 2001; the second, in April 2006; and the third, in April 2011. NIRS has five fields of research activities: heavy charged particle therapy, molecular imaging, radiation protection, radiation emergency medicine, and radiation technology.

The third mid-term plan has been carried out by four research centers and one fundamental technology center. In May 2012, the program for recovery from the Fukushima Daiichi Nuclear Power Plant (NPP) accident was started as a new center. In March 2013, a new department was also established; the Radiation Emergency Medical Assistant Team (REMAT) now plays an important part in medical response to accidents including the after effects of the Fukushima NPP accident. In this report, the research activities at NIRS during the third year of the third mid-term plan (April 2013 to March 2014) are presented.

The Great East Japan Earthquake triggered tsunami with over 10 meter-high waves that damaged facilities of the Fukushima Daiichi NPP of Tokyo Electric Power Company (TEPCO) and led to the nuclear accident. Since NIRS is designated as the national core center for radiation emergency medicine, many NIRS researchers continue to be involved in response activities to the accident, though almost 3 years have passed. Besides these activities many others are also being carried out and 356 original papers were published in FY 2013, in both international and domestic journals of high reputation. Furthermore, more than 60 proceedings were published for international and domestic scientific meetings, and 460 oral presentations and 55 patent applications were made. Collaborative studies and exchanges of researchers were also actively carried out: 134 collaborative studies were done, 345 researchers worked as visiting staff, and 134 students were accepted as trainees.

The Research Center for Charged Particle Therapy, as a leading research organization in this field, has been conducting clinical, biological and physics research studies using heavy ions generated from the heavy ion medical accelerator in Chiba (HIMAC). In FY 2013, 888 patients were treated. In FY 2013, the clinical trial team treated 7 tumor types of cancers: prostate, lung, head and neck, bone and soft tissue, liver, pancreas and post-operative pelvic recurrence of rectal cancer. Highlights of research progress are shown in detail in other sections.

The Molecular Imaging Research Center, consisting of four groups, has long experience with medical imaging technologies including positron emission tomography (PET), single photon emission tomography (SPECT), and magnetic resonance imaging (MRI). The Center conducts basic science and technology studies for molecular imaging and also application studies for diagnosis and pathophysiology of oncology and psychiatry. Current projects include the development of molecular probes and radio-pharmaceutical production techniques and the investigation of measurement techniques for PET and MRI, in addition to preclinical and clinical applications in oncology and psychiatric and neurological diseases. One of the

Outline of Research Activities

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most important topics in 2013 was determining the structure of new tau ligand PBB3 and labeling it with C-11.

The Research Center for Radiation Protection has been providing a scientific basis for establishing regulations with global standards for radiation protection, security and safety, focusing on effects of low-dose radiation derived from human activities and from natural environmental radiation. For this purpose, the results of basic radiobiological research have been provided to promote understanding of radiation effects and to encourage enactment of more reasonable regulations for the safe and secure use of radiation in our daily life. On March 5-7, 2014, the 6th International Systems Radiation Biology Workshop was held as a Research Center Symposium, jointly with DoReMi (Low Dose Research towards Multidisciplinary Integration, supported by the EC).

NIRS has been designated as the national center for radiation emergency medicine in Japan, providing direct or consultative services to local governments and hospitals in the event of a radiation incident. Since REMAT has been established, the Research Center for Radiation Emergency Medicine is now responsible for basic research studies; the Center is focusing its efforts on three projects: developing and modifying the most appropriate methodologies for evaluating radiation exposure, exploring and supplying effective drugs to reduce the radiotoxicity and metallic toxicity of internal actinide contamination, and applying mesenchymal stem cells (MSCs) as regenerative medicine to treat radiation exposure injuries.

Services provided by REMAT include providing exposed victims (patients) with the most advanced radiation emergency medicine treatments possible and making dose assessments. REMAT especially is playing an important role in medical response to the Fukushima NPP accident. REMAT also carries out activities to maintain and strengthen the emergency preparedness system and has worked to establish three nation-wide network councils for medicine, bio-dosimetry with chromosome analysis, and physical dosimetry. REMAT has also introduced several courses at NIRS on radiation emergency medical preparedness for medical professionals of the Asian region. In September 2013, NIRS was designated as a collaborating Center of the World Health Organization (WHO); the terms of reference are: strengthening preparedness to radiation emergencies and REMAPAN activities; providing medical and technical assistance to WHO in response to radiation emergencies; carrying out biodosimetry and BioDoseNet (cytogenetics and internal contamination monitoring); analyzing radiation protection for indoor radon exposure; and promoting radioprotection in the field of medical exposure to ionizing radiation, with the focus on risks assessment and risk management.

Together, the Research Center for Radiation Protection and REMAT also acted as a national hub in collaboration with international organizations including the International Atomic Energy Agency (IAEA), International Commission on Radiological Protection (ICRP), and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

The Fundamental Technology Center, which was established to support various studies performed in NIRS using advanced fundamental technologies, has been carrying out maintenance and quality control of institute accelerators including the single particle irradiation system to cell (SPICE), the particle induced X-ray emission (PIXE) analysis and tandem accelerator (PASTA), and the neutron exposure accelerator system for biological effects experiments (NASBEE), as well as radiation measurement apparatuses for cosmic rays. Efforts have also been extended to establish and support experimental animal laboratories for internal and external researchers.

In May 2012, the program for recovery from the Fukushima Daiichi NPP accident was started. This program includes four research projects and a system of cooperation. Research projects are the study for long-term and environmental effects of radiation, the health effect survey for emergency workers at the NPP, and the study of environmental dynamics of radionuclides and radiation in the ecosystems in Fukushima Prefecture. The system of cooperation is for collaboration with researchers at the Fukushima Medical University (FMU).

The second-term of the International Open Laboratory (IOL) began in April 2011 and was concluded in March 2014. Four units were approved, including the Particle Therapy Molecular Target Unit, the Particle Beam Quality Unit, the Space Radiation Research Unit, and the Radiation Response Model Unit. During the three years of operation, the IOL conducted top level research by collaborating with distinguished scientists from leading research institutes world-wide and promoted further internationalization at NIRS by actively supporting research collaborations with foreign scientists.

Some other research programs have also been continued or were newly started with the support of funding agencies including the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Economy, Trade and Industry (METI), the Ministry of the Environment, and the Nuclear Regulation Authority (NRA).

In this report readers will be able to learn about the substantial research that was performed in the 3rd year of the third mid-term plan. I would like to conclude with heartfelt thanks for the cooperation and advice generously provided to us by all parties concerned.