Institute for Radiation Sciences

ANNUAL REPORT
2022

Volume 4

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IRS ANNUAL REPORT 2022 Volume 4

Preface

It is our pleasure to present the Annual Report 2022 of the Institute for Radiation Sciences (IRS), Osaka University.

The IRS was established in 2018 in Osaka University, and it brings together all the radiation facilities at Osaka University to optimize their resources and advantages in developing and realizing advancements in radiation science.

The missions of the IRS are to reinforce education, research, and safety management relating to radiation sciences, to solve global issues for the future, and to develop human resources by pioneering novel research fields. The IRS is a unique department utilizing the open-minded advantages of Osaka University by consolidating all of the radiation facilities at the university.

The IRS is developing the Targeted Alpha Therapy in collaboration with fundamental science groups (the Graduate School of Science, etc.), an accelerator facility (the Research Center for Nuclear Physics), groups of nuclear medicine, tracer kinetics, diagnostic and interventional radiology (the Graduate School of Medicine), and Osaka University Hospital, under the research and development project, "Promotion of nuclear-medicine innovation by the establishment of Institute for Radiation Sciences" (FYs 2018-2022). At the same time, we are improving radiation safety education for students including those from countries in Southeast Asia and are building new cross-disciplinary research and a radiation safety management education program for the whole university.

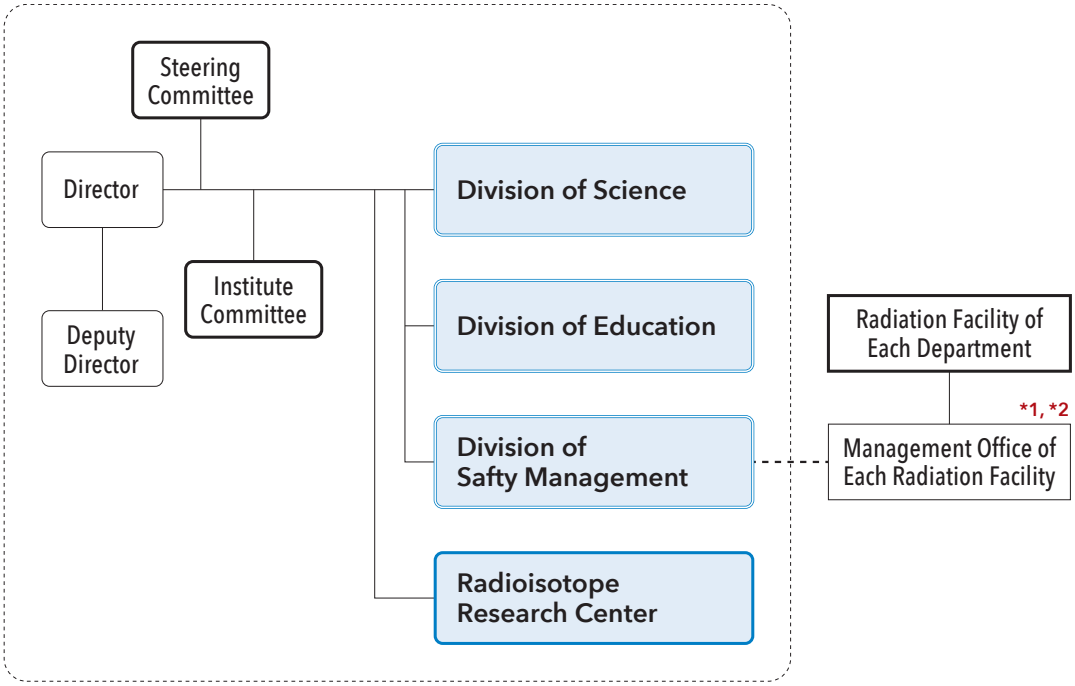
This annual report summarizes our scientific achievements in 2022. I sincerely hope that these achievements will inspire further advances, promote worldwide collaborations with our scientists in the IRS, and ultimately, produce invaluable outcomes and values that can only be attributed to the unified efforts of the radiation facilities of Osaka University.

October 2023

TOMIYAMA, Noriyuki, M.D., Ph.D.

Director
Institute for Radiation Sciences
Osaka University

Organization



*1 Radiation-related facilities

(1) Radio Isotope Experiment Laboratory, Graduate School of Science * Note1
(2) Radiation Science Experiment Laboratory, Graduate School of Science * Note1
(3) Radioisotope Usage Facility, Graduate School of Medicine * Note2
(4) Radioisotope Usage Facility, Division of Health Science, Graduate School of Medicine
(5) Radioisotope Medical Care Facility, Osaka University Hospital
(6) Radioisotope Medical Care Facility, Osaka University Dental Hospital
(7) Radioisotope Usage Facility, Graduate School of Engineering
(8) Radiation Generator Usage Facility, Institute of Free Electron Laser, Graduate School of Engineering
(9) Radioisotope Usage Facility, Graduate School of Frontier Biosciences
(10) Radio Isotope Experiment Laboratory, Research Institute for Microbial Diseases
(11) Radioisotope Usage Facility, The Institute of Scientific and Industrial Research
(12) Radioisotope Usage Facility, Institute for Protein Research
(13) Radioisotope Usage Facility, Institute of Laser Engineering Usage Facility of Ultra-high Voltage Electron Microscope Selective
(14) Radiation Generator
(15) Radioisotope Usage Facility, Radioisotope Research Center (Suita branch)
(16) Radioisotope Usage Facility, Radioisotope Research Center (Toyonaka branch)
(17) Radioisotope Usage Facility, Nuclear Physics Research Center

*2 Nuclear Fuel Usage Facility

(1) Department of Sustainable Energy and Environmental Engineering, School of Engineering
(2) Radiation Science Experiment Laboratory, Graduate School of Science

Note1 : Integrated with RI Radioisotope Research Center (Toyonaka branch) from April 1, 2018
Note2 : Integrated with RI Radioisotope Research Center Suita from April 1, 2021

Division of Science

Members *and 49 concurrent post members*

Professor
FUKASE, Koichi

Professor
TOYOSHIMA, Atsushi

Specially Appointed Prof.
YONEKURA, Yoshiharu

Spec. App. Assoc. Prof.
SHIRAKAMI, Yoshifumi

Spec. App. Assoc. Prof.
TERAMOTO, Takahiro

Goals and Objectives 2022

Targeted alpha-particle therapy has been investigated for the development of new therapies for refractory cancer through collaboration with the Graduate School of Science, Graduate School of Medicine, and Research Center for Nuclear Physics. The joint research with the Graduate School of Dentistry was newly initiated. In April 2022, a joint research laboratory, "Astatine Drug Discovery and Practical Application Joint Research Division" was established in partnership with Alpha Fusion Co., Ltd. Comprehensive studies including clinical trials, non-clinical studies, and development researches were conducted with the support of Alpha Fusion's human resources and funding.

Achievements 2022

1. **Physician-initiated clinical trial of [^{211}At]NaAt for refractory thyroid cancer**
   A Phase I investigator-initiated clinical trial using [^{211}At]NaAt was conducted in collaboration with the School of Medicine and the Osaka University Hospital.

2. **Non-clinical studies of ^{211}At-PSMA in prostate cancer**
   Lead optimization studies were conducted on prostate cancer drugs targeting prostate-specific membrane antigen (PSMA) to select a candidate compound for the non-clinical studies, which were initiated in collaboration with the School of Medicine and the Osaka University Hospital. A PCT application was filed: PCT/JP2022-29283, application date: July 29, 2022.

3. **Studies on ^{211}At-FAPI**
   A series of ^{211}At-FAPI compounds targeting fibroblast activating protein (FAP) in cancer stroma were synthesized and their anti-tumor effects were evaluated. Further optimization is still needed. A PCT application was filed: PCT/JP2023-00610, application date: February 21, 2023.

https://www.irs.osaka-u.ac.jp/department/science_mission.html

4. **Studies on ^{211}At-gold nanoparticles**
   Cancer treatments with ^{211}At-gold nanoparticles by direct tumor administration, tail vein administration, or intraperitoneal administration were investigated. Local administration to C6 glioma-implanted rats and PANC1-implanted mice showed marked tumor growth inhibition. A novel study on tongue cancer was initiated with the School of Dentistry.

5. **Studies targeting L-type amino acid transporter (LAT1)**
   LAT1 is an amino acid transporter that exhibits selective expression in diverse tumor types. Research endeavors have focused on the development of LAT1 substrates with enhanced accumulation and retention characteristics compared to ^{211}At-AAMT. In an animal model utilizing cells derived from a drug-resistant strain of pancreatic cancer (gemcitabine-resistant), the ^{211}At-L-α-methyl-O-methyl-tyrosine (L-^{211}At-AAMT-OMe) demonstrated remarkable therapeutic efficacy. Other backup compounds were also developed. Patent Application 2022-150608, application Date: September 22, 2022.

6. **New ^{211}At labeling methods using anodic oxidation or photo-irradiation**

7. **Studies on ^{211}At-labeled antibodies**
   PCT/JP2022/035783

8. **Research on various novel modalities**
   Several new drug candidates of novel modalities (mid-sized molecules, peptides) with excellent tumor delivery and cell internalization capabilities were investigated.

9. **Novel beta-ray therapeutic nuclide ^{47}Sc**
   The novel beta-ray therapeutics using ^{47}Sc have been investigated by the collaboration with Research Center for ELectron PHoton Science (ELPH), Tohoku University.

10. **Others**
    Production and supply of ^{211}At using the AVF cyclotron at the Research Center for Nuclear Physics were re-started.

Selected Publications 2022

1) Watabe T, Liu Y, Kaneda-Nakashima K, Sato T, Shirakami Y, Ooe K, Toyoshima A, Shimosegawa E, Wang Y, Haba H, Nakano T, Shinohara A, Hatazawa J. Comparison of the Therapeutic Effects of [^{211}At] NaAt and [^{131}I] NaI in an NIS-Expressing Thyroid Cancer Mouse Model. *Int. J. Mol. Sci.* **2022**, 23(16), 9434; https://doi.org/10.3390/ijms23169434

2) Kaneda-Nakashima K, Shirakami Y, Watabe T, Ooe K, Yoshimura T, Toyoshima A, Wang Y, Haba H, Fukase K. Effect to Therapy of Sodium-Iodine Symporter Expression by Alpha-Ray Therapeutic Agent via Sodium/Iodine Symporter. *Int. J. Mol. Sci.* **2022**, 23(24), 15509; https://doi.org/10.3390/ijms232415509

3) Yonekura Y, Toki H, Watabe T, Kaneda-Nakashima K, Shirakami Y, Ooe K, Toyoshima A, Nakajima H, Tomiyama N, Bando M. Mathematical Model for Evaluation of Tumor Response in Targeted Radionuclide Therapy with ^{211}At Using Implanted Mouse Tumor. Int J Mol Sci. **2022** Dec 15;23(24):15966.

4) Hertz B, Watabe T, Baum RP. Celebrating 80 years anniversary of radioiodine for use in thyroid cancer and perspectives for theranostics. Ann Nucl Med. **2022** Dec;36(12):1007-1009.

5) Suzuki K, Iwai H, Utsunomiya K, Kono Y, Watabe T, Kobayashi Y, Bui DV, Sawada S, Yun Y, Mitani A, Fukui K, Sakai H, Chu HH, Linh NM, Tanigawa N, Kanda A. Efficacy of Combination Therapy with Lenvatinib and Radioactive Iodine in Thyroid Cancer Preclinical Model. Int J Mol Sci. **2022** Aug 30;23(17):9872.

6) Watabe T, Kaneda-Nakashima K, Shirakami Y, Kadonaga Y, Ooe K, Wang Y, Haba H, Toyoshima A, Cardinale J, Giesel FL, Tomiyama N, Fukase K. Targeted α-therapy using astatine (^{211}At)-labeled PSMA1, 5, and 6: a preclinical evaluation as a novel compound. *Eur J Nucl Med Mol Imaging*. **2022** Nov 8. doi: 10.1007/s00259-022-06016-z.

7) Kaneda-Nakashima K, Shirakami Y, Kadonaga Y, Watabe T. Fibroblast activation protein inhibitor theranostics: Pleclinical Considerations. *PET Clinics* **2023**, https://doi.org/10.1016/j.cpet.2023/02/005

8) Aso A, Kaneda-Nakashima K, Nabetani H, Kadonaga Y, Shirakami Y, Watabe T, Yoshiya T, Mochizuki M, Koshino Y, Ooe K, Kawakami A, Jinno N, Toyoshima A, Haba H, Wang Y, Cardinale J, Giesel FL, Shimoyama A, Fukase K. Substrate Study for Dihydroxyboryl Astatine Substitution Reaction with Fibroblast Activation Protein Inhibitor (FAPI). *Chem Lett.* **2022**; 51(11): 1091-1094. https://doi.org/10.1246/cl.220391

9) Huang X, Kaneda-Nakashima K, Kadonaga Y, Kabayama K, Shimoyama A, Ooe K, Kato H, Toyoshima A, Shinohara A, Haba H, Wang Y, Fukase K. Astatine-211-Labeled Gold Nanoparticles for Targeted Alpha-Particle Therapy via Intravenous Injection. *Pharmaceutics* **2022**, 14(12), 2705; https://doi.org/10.3390/pharmaceutics14122705

Division of Education

Members *and 23 concurrent post members*

Professor
OKADA, Michio

Specially Appointed Prof.
NOMACHI, Masaharu

Associate Professor
NAKAJIMA, Hiroo

Specially Appointed Researcher
ISHIKAWA-FUJIWARA, Tomoko

Goals and Objectives 2022

Division of Education promotes the education of radiation sciences across the University. Combining campus wide activities on human resource development, various radiation-education programs can be proceeded more efficiently and effectively. We also intend to construct high-level radiation education programs and the related international programs.

Achievements 2022

Osaka University set up “Graduate Programs for Advanced Interdisciplinary Studies” that could provide motivated students with an opportunity to master the basics in a wide range of fields while focusing on an advanced. “Radiation science” has been implemented as a program by our Institute from this fiscal year with the cooperation of Research Center for Nuclear Physics, Graduate School of Science, and Graduate School of Medicine. In the future, with the cooperation of even more departments, we plan to expand the educational program into a cross-disciplinary program. We rename the program as “Co-creative Radiation Education Programme (CREPE)”, where some courses are newly offered by the Graduate School of Engineering. CREPE for graduate students has been adopted for the 2023 academic year.

We carried out the Nuclear Regulatory Human Resources Development Project in this fiscal year, the project title of “Nuclear Regulatory Human Resources Development Program by Co-creation with Society”. This project is the 5-years project where the radiation-education program for the undergraduate students, organized around the FUKUSHIMA Environmental Radiation Workshop, is expected to be developed. Continuing from the previous year, the

"Co-creative Radiation Education Programme (CREPE)" was held. In the fiscal year 2022, 30 students were registered for the course, and 7 of them completed the program in March 2023. We have revised a homepage (https://www.rcnp.osaka-u.ac.jp/crepe/) and a pamphlet to publicize this CREPE program. CREPE students held a poster exhibition at Osaka University Co-creation DAY@EXPOCITY on June 11. At this event, CREPE students introduced their activities in Fukushima to the general public. In addition, we participated in the Fukushima Prefecture Hamadohri District Environmental Radiation Workshop, which is the main subject of CREPE, as a radiation education division. On Saturday, July, a pre-lecture will be held for 3 days ahead of the on-site training of environmental radiation, and from August 21st to 26th (5 nights and 6 days) and September 18th to 23rd, the training of environmental radiation was held in the Hamadohri district of Fukushima prefecture. The number of participating students increased to 123, including those from other universities. The results of this workshop were presented by the students at the final discussion of the workshop held on August 29th and September 26th at Toyonaka Campus, Osaka University. At the workshop held in August, Director Tanaka, who was in charge of education, visited the facility and received a high evaluation.

Division of Radiation Education provided "Natural Sciences, Sociology, and Humanities Related to Radiation" as a basic liberal arts subject of general education in Osaka University. This subject is open to all faculties and grades and offers cross-disciplinary study of radiation-related physics, chemistry, biology, medicine, law, economics, and social psychology. The science and humanities students were educated so that they could understand radiation from various angles and become facilitators for risk communication. There were 20 students registered, and 14 passed. This time, there were students who were able to take courses for graduate students. In 2022, we invited a lecturer from the Nuclear Regulation Authority to give a lecture, which was very well received by the students.

The door to learning (Gakumon heno Tobira) "Science of radiation around us" was implemented as a mechanism. The number of registered students was 17. One graduate student conducted TA for this program.

In FY2022, JST Sakura Science Program September was held in conjunction with the Hamadori District Environmental Radiation Workshop in Fukushima Prefecture.

In February, an international symposium was held at the University of Groningen by sending two undergraduate students studying CREPE. (https://www.osaka-u.ac.jp/ja/news/topics/2023/04/03001)

Division of Safety Management

Members *and 24 concurrent post members*

Professor
YOSHIMURA, Takashi

Assistant Professor
SUZUKI, Tomokazu

Technical Staff
KON, Yukiyoshi

Technical Staff
KOKI, Ryoichi

Division of safety management works together with radiation facilities and nuclear fuel facilities with respect to radiation safety management and sums up radiation safety management in our university. Radioisotope research center undertakes a role of the center of the division and liaises closely with staffs of the facilities. The risk management system is constructed that the staffs of the institute cooperate and support to settle an emergency and accident and to provide information of the situation.

https://www.irs.osaka-u.ac.jp/department/management.html

Achievements 2022

1) Assistance to obtain the license of Radiation Protection Supervisor

In order to encourage to obtain the license of Radiation Protection Supervisor, we aided tuition and travel expenses for obtaining the license to two persons who plan to become the supervisor or its deputy supervisor in the radiation facilities in the university.

2) Cooperation in safety and management inspection activities for radiation facilities on the campuses

In this year, a self-inspection in each radiation facility and inspection from the members of this division and radioisotope research center (the inspection committee members) were conducted. After each facility conducted its self-inspection, a meeting was held in October (the first meeting) with inspection committee members. At the meeting, details of inspection were confirmed. The inspection committee members visited each facility and conducted inspections from November to December. A second meeting was held in February to share the results of the inspections at each facility. The reports of these inspections were compiled into a booklet and distributed to the university headquarters, related departments, and related parties.

RadioIsotope Research Center

Members *and 16 concurrent post members*

Director
MURATA, Isao

Co-Director
KAWABATA, Takahiro

Professor
YOSHIMURA, Takashi

Associate Professor
NINOMIYA, Kazuhiro

Associate Professor
OOE, Kazuhiro

Assistant Professor
NAGATA, Kojiro

Radioisotope Research Center (RI center) has buildings in Suita and Toyonaka campuses. RI center Suita is a main building, and this building is a core facility of Institute for Radiation Sciences. RI center Toyonaka is a branch. In RI center Suita, the research of alpha-particle nuclear therapy project has conducted. ^{211}At produced in RIKEN and QST Takasaki transported to RI center Suita, and then separation from an irradiated target material, purification of ^{211}At, syntheses of labelled compounds, and animal experiments were performed in the center. The purpose of RI center is to provide education and training of radiation safety to radiation workers in the university, to maintain and provide the facilities and experimental equipment in Suita and Toyonaka Campuses to the radiation workers, and to conduct radiation safety management and related research.

https://www.irs.osaka-u.ac.jp/department/ri_mission.html

Achievements 2022

1) Radiation safety management, and education and training for radiation workers

Environment measurements in the radiation facilities were carried out for 179 working rooms of 13 facilities on Suita and Toyonaka campuses. We managed and operated the system for management of radiation workers (the number of registered users: 3,444). Fifteen times of education and training to radiation workers (total participants: 1,921) were held using the CLE system, Osaka University.

2) Radiation education

As the safety education, we encouraged students to take the Radiation Protection Supervisor Examination and conducted the online preparatory lecture using CLE (participants: 32). Application forms for the examination were distributed.

3) Use of radiation facilities in RI center

The number of applications for joint use of RI center facilities was 53, and the number of users were 616.

Selected Publications 2022

1) K. Baba, K. Nagata, T. Yajima, T. Yoshimura, Synthesis, Structures, and Equilibrium Reactions of La(III) and Ba(II) Complexes Pyridine Phosphonate Pendant Arms on a Diaza-18-crown-6 Ether, Bull. Chem. Soc. Jpn. **95**, 466-475 (2022).

Research Activity I

Genome analysis of radiosensitive and cancer-prone Medaka *rev3l* mutants: Unraveling the mechanisms of high cancer susceptibility

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Genome homeostasis is fundamental to life, and all organisms have strict genome maintenance mechanisms. Genome maintenance is an extremely complex system involving many factors and pathways. The phenotype caused by disruption of each factor provides valuable information for understanding the overall picture of complex mechanism. In order to establish a model system for analyzing the genome maintenance mechanism, we have comprehensively generated mutants of genes involved in genome maintenance in medaka fish. As a result, we obtained a very unique mutant that spontaneously develops intestinal tumor in all individuals in an age-dependent manner under normal breeding conditions. In the culture cell established from this mutant we have detected multiple double-strand breaks (DSBs), and also found frequent induction of chromosomal aberrations. In addition, we have detected genomic structural variants in cancer cells at an extremely high level. DSB is a representative radiation damage and one of the main factors of radiation carcinogenesis. This mutant not only provides an excellent *in vivo* system for mechanism analysis from DSB to carcinogenesis, but is also considered to be a suitable model system for analyzing the biological effects of radiation. We are planning to conduct histological analysis of carcinogenic individuals at their early stages. To search for molecular markers for the histological analysis, this year we performed gene expression analysis of cancer tissues by RNA-seq. This intestinal cancer is characterized by infiltration of cancer cells into surrounding tissues such as the liver and ovaries and dissemination into the peritoneal cavity in almost all carcinogenic individuals. Epithelial-mesenchymal transition (EMT) plays an important role in cancer cell invasion and metastasis. As a result of RNA-seq, most of the retrieved EMT-related genes were found to be abnormally expressed in tumor-bearing intestinal tissue. Human colorectal cancer is classified into four molecular subtypes (CMS1-4) according to gene expression patterns. Among them, CMS4 is characterized by frequent invasion and metastasis, and abnormal expression of EMT-related genes was observed in this subtype. Our results indicate that this mutant has a phenotype very similar to the CMS4 subtype of human colorectal cancer. We would like to proceed with histological analysis using EMT-related gene expression abnormalities as indicators.

Investigation of novel drug for alpha-emitting nuclear medicine targeting to cancer specific amino acid transporter, LAT1

KANEDA-NAKASHIMA, Kazuko;[1,2] MANABE, Yoshiyuki;[1,2,3] SHIMOYAMA, Atsushi ;[1,2,3] KABAYAMA, Kazuya;[1,2,3] WATABE, Tadashi;[1,2,5] KANAI, Yoshikatsu;[1,2,6]OOE, Kazuhiro;[1,2,5] TOYOSHIMA, Atsushi;[1,2] SHIRAKAMI, Yoshifumi;[1,2,5] YOSHIMURA, Takashi;[1,2,7] FUKUDA, Mitsuhiro;[1,2,8] NAKANO, Takashi[2,8] and FUKASE, Koichi[1,2,3]

[1] *MS-CORE, FRC, Graduate School of Science, Osaka University*
[2] *Division of Science, Institute for Radiation Sciences, Osaka University*
[3] *Laboratory for Natural Product Chemistry, Graduate School of Science, Osaka University*
[4] *Laboratory for Radiochemistry, Graduate School of Science, Osaka University*
[5] *Department of Nuclear Medicine and Tracer Kinetics, Graduate School of Medicine, Osaka University*
[6] *Department of Bio-System Pharmacology, Graduate School of Medicine, Osaka University*
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[8] *Research Center for Nuclear Physics, Osaka University*

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Targeted alpha therapy (TAT) is receiving much attention in the field of "Theranostics" because of its high cytotoxic effect to the targeting cancer. However, physiological uptakes in non-targeted organs are also observed in the TAT, which might lead to the severe side effects. We should consider about both maximizing the treatment effect in the tumor and minimizing the side effects in the organs at risk. From this viewpoint, decision of targeting molecule was most important. We selected LAT1 as molecular target. LAT1 is one of the amino acid transporters, which has highly specificity to cancer tissues. We developed next-generation internal radiotherapy using chemicals targeting LAT1. First, we synthesized alpha-methyl-L-tylosine labeled with ^{211}At. ^{211}At was produced by the cyclotron, and then quickly purified and labeled (^{211}At-AAMT). Next, we performed its cytotoxicity evaluation using some cancer cell lines. As a result, cell death and specificity were confirmed. We also confirmed the specificity *in vivo*. We examined that the effects of ^{211}At-AAMT using several kinds of tumor-bearing models. Furthermore, we established the labeling technique without using mercury. From these facts, ^{211}At-AAMT has the potential to be a safe and versatile drug for several cancers.

In this year's study, we were able to confirm its efficacy in the models with lung cancer and osteosarcoma cell lines. Thus, we applied for one patent this year (Japanese Patent Application No. 2022-150608). It also obtained four private grants and one grant from Advanced Research and Development Programs for Medical Innovation (AMED). We developed the structure of a better compound and proceeded with preliminary studies for non-clinical trials. In the next year, we plan to prepare for non-clinical studies, including consulting with Pharmaceuticals and Medical Devices Agency (PMDA).

Reference

[1] KANEDA-NAKASHIMA, K.; SHIAKAMI, Y.; WATABE, T.; OOE, K.; YOSHIMURA, T.; TOYOSHIMA, A.; WANG, Y.; HABA, H.; FUKASE, K. *International Journal of Molecular Sciences*, **2022**, *23(24)*, 15509

Development of rare-gas matrix-isolation apparatus for γ-ray measurment of ^{229m}Th

MASUDA, Ryoutarou;[1,2] YASUDA, Yuki;[1] SAWAMURA, Kei;[1] SHIGEKAWA, Yudai;[3] MIYAMOTO, Yuki;[4] YOSHIMURA, Koji;[4] SHINOHARA, Atsushi[2,5] and KASAMATSU, Yoshitaka[1,2,3]

[1] *Graduate School of Science, Osaka University*
[2] *Institute for Radiation Sciences, Osaka University*
[3] *RIKEN Nishina Center for Accelerator-Based Science*
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The first excited state in the ^{229}Th nucleus, ^{229m}Th, has an extremely low excitation energy of 8.30±0.92 eV, which is 3-6 orders of magnitude smaller than those of other isomers. Therefore, the decay path of ^{229m}Th is reported to change depending on its chemical state. We have developed a new rare-gas matrix isolation apparatus to directly observe γ rays from ^{229m}Th, which leads to the determination of the accurate excitation energy and in the observation of the changes of the nuclear decay depending on the chemical state.

To observe γ ray from ^{229m}Th, it is required to stably maintain its chemical state in which ^{229m}Th is expected to emit the γ ray, and to detect the vacuum ultraviolet (VUV) photons from a ^{229m}Th sample. By the rare-gas matrix isolation method, ^{229m}Th is surrounded by rare gases which are inert atoms and intermolecular interactions are negligible. If the high valence ^{229m}Th ions recoiled from ^{233}U by α decay are trapped in the rare gas solid, the implanted ^{229m}Th ions would be isolated.

We developed the rare-gas matrix isolation apparatus in which the detection efficiency for VUV photons is ~7.4 %. The half-life of ^{229m}Th for the γ transition is estimated to be 5000 s. The γ ray emission counting rate from ^{229m}Th is expected to be 100-2000 counts per second (cps) by using a 10000 Bq ^{233}U source. We used Ar (99.99994 % purity) gas for producing noble gas solids. The substrate was cooled to about 10 K by a Gifford-McMahon refrigerator, and the Ar gas was blown onto the substrate. The flow rate of the Ar gas was adjusted by a mass flow controller to 30 cc/min. The stable and low noise photon detection conditions for a long time were determined for the observation of photons from ^{229m}Th. In the background measurements, stable photon counting rate for longer than 24 h was implemented. The average count rate was 0.28 cps, which is well below the estimated count rate for ^{229m}Th photons. We measured Cherenkov photons from ^{137}Cs and ^{228}Th sources and thereby estimated that the Cherenkov backgrounds from the ^{233}U source are negligibly small. Under these conditions, we plan to observe ^{229m}Th γ ray.

Stability Evaluation of a Series of the Lanthanide Complexes with Tripod-type Nonadentate Ligand Having Picolinic Acid Arms

NAGATA, Kojiro;[*1] ISHIDA, Yohta;[2] YAJIMA Tatsuo[3] and YOSHIMURA, Takashi[2]

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[2] *Department of Chemistry, Graduate School of Science, Osaka University*
[3] *Department of Chemistry and Materials Engineering, Faculty of Chemistry, Materials and Bioengineering, Kansai University*

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^{153}Sm, ^{161}Tb, and ^{177}Lu are candidate nuclides with half-lives of several hours to several days and emit low-energy beta particles, which have potential applications in nuclear medicine therapy. In order to apply these nuclides in medicine, it is necessary to form thermodynamically and kinetically stable metal complexes. Therefore, we have synthesized a new tripod-type ligand H_3L with picolinate moiety. Since hydrated complexes of lanthanide(Ln) ions form a nine-coordinated tri-capped trigonal prismatic (TPP) geometry, we designed this ligand to form the similar coordination geometry. In this study, a series of lanthanide complexes were synthesized by using H_3L, and the thermodynamic stability and acid decomposition reactions of the obtained complexes were evaluated.

The Ln complexes were isolated by reacting each Ln triflate [Ln = La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, (Y)] with H_3L at room temperature in water. The ^{1}H NMR signals of La, Y, and Lu complexes without unpaired electrons in the obtained complexes were observed to have C_3 symmetry, but all of them changed to more complicated C_3 symmetric signal than H_3L. In addition, elemental analysis revealed that all of these complexes form a 1:1 complex between the ligand and the Ln^{3+} ion. From the results of single crystal X-ray analysis, it was found that all of the Ce~Lu complexes, except for the La complex, have the nine-coordinated TPP geometry. As the ionic radius of the lanthanides decreased from La to Ln, the bonding distances of each M-N and M-O gradually shortened. The results of potentiometric titration showed that the log K_{ML} values of the thermodynamic stability constants of these complexes ranged from 12 to 16. These values are comparable to those of the previously reported complexes with picolinic acid moieties.

Finally, the rate constant k_{obs} for the acid decomposition reaction in perchloric acid was unexpectedly found to be minimal for the HoL complex. In other words, from LaL to HoL, k_{obs} tended to decrease with decreasing ionic radius, while from HoL to LuL, k_{obs} conversely tended to increase. This may be due to the fact that protonation of the secondary amine moiety is more likely to occur for Ln ions with smaller ionic radii than Ho^{3+}.

Physiological, genomic effects in descendant mice after the every generational low dose-rate internal ^{137}Cs radiation exposure

NAKAJIMA, Hiroo;[1*] OHNO, Mizuki[2] and TOKI, Hiroshi[3]

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Concerns about internal exposure to low-dose radiation, which came to the fore immediately after the Fukushima nuclear power plant accident that occurred following the Great East Japan Earthquake, became a social issue. This concern ultimately boils down to the existence or non-existence of carcinogenesis in the exposed generation and hereditary effects on the next generation. In this context, genetic effects have not been observed in the vast amount of research conducted to date on the effects on the children of second-generation A-bomb survivors (LSS and AHS) and Chernobyl nuclear power plant accident decontamination workers, not only in phenotypic effects but also in DNA-level effects. Nonetheless, there continues to be concern about heritable effects on second-generation A-bomb survivors and residents of the Fukushima nuclear power plant accident. This is a worrisome situation that could lead to a major trend toward genetic discrimination if concerns about genetic effects are socially accepted. It is an urgent issue to minimize such concerns as much as possible.

The purpose of this study is to present statistically tolerable values of the radiation exposure effects per generation due to internal exposure to Cesium-137 by whole DNA sequencing of liver cells of mice that have been drinking Cesium-137 (100 Bq/ml) water for multiple generations. Note that although the experimental subjects are mice, the spontaneous mutation rate of the next generation is almost the same as that of humans, and it is hoped that it will be possible to predict in a short period of time what would take several hundred years in humans.

DNA was extracted from frozen samples of A/J mouse strains that were allowed to change generations while drinking Cesium-137 water (100q/ml) for whole genome analysis. A total of six samples from the 25th generation (F20→F45), three each from the Cs-137 group and the control group, were sent to RIKEN GENESIS for whole genome analysis using the Illumina NovaSeq6000 with read length: 150, Paired-end, Multiplex method. The genomes were statistically processed and compared with the previous 1, 2, 5, and 18 generations (n=1 for each). The average testis dose was calculated to be 301 μGy/day using the PHITS code with a mouse voxel phantom. The average dose per generation was calculated to be 32.5 mGy, and the accumulated dose over a period of 25 generations was 812.5 mGy.

The correlation between the control and Cs-137 groups for each single nucleotide mutation rate per 2,483,169,483 bases at generations 1, 2, 5, 18, and 25 was determined. The results showed that the respective slopes were 0.167 and 0.167, the correlation coefficients were 0.977 and 0.979, and the coefficients of determination were 0.955 and 0.958. The frequency of DNA single nucleotide variations between the two groups was almost the same over the generations.

Non-destructive Determination of Bulk elemental composition for asteroid Ryugu by muon elemental analysis method

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A muon can make muon atomic orbit around nucleus due to its negative charge and form a muonic atom. After formation of a muonic atom, characteristic muonic X-rays (muonic X-rays) are emitted by muon interorbital transition. Because the mass of the muon is approximately 207 times higher than that of an electron, the energies of muonic X-rays are much higher than these of electrons'. Such high energy X-rays can penetrate bulk material without absorption. In recent, using muonic X-rays, non-destructive elemental analysis method has been developed [1]. This can identify elements including light ones such as carbon, nitrogen and oxygen, for bulk material non-destructively. This method has already been applied to analysis of precious meteorites and cultural heritage samples.

In this study, we applied muon elemental analysis method for the grains recovered from the asteroid Ryugu [2]. Asteroid Ryugu is a primitive asteroid classified as a C-type asteroid, which retains information on the early solar system. The composition of carbon, nitrogen, and oxygen, which are the most important materials for life, are attracting attention in such primitive material. However, it is difficult to identify these light elements for bulk sample without sample destruction except for muon elemental analysis method due to low energies of fluorescence X-rays from these elements.

The muon experiment was conducted at the D2 experimental area in the muon science facility (MUSE) of J-PARC (Japan Proton Accelerator Research Complex, Ibraraki Pref.). A low background muonic X-ray measuring system was developed for this study. We prepared 123 mg of Ryugu sample for the analysis. Muonic X-rays emitted after muon irradiation on the sample were measured by high-purity germanium detectors. For quantitative elemental analysis, we also performed muon irradiation experiment under the same conditions for the carbonaceous meteorites of Orgueil.

Figure 1 shows muonic X-ray spectra for Ryugu and Orgueil samples. The signals derived from C, N, O, Na, Mg, Si, S, Fe, and Ni were identified, which means the main components of Ryugu were these elements. The spectra obtained from the Ryugu and Orgueil samples were very similar to each other. On the other hand, there were clear differences between the Ryugu and Orgueil samples; the intensity of O was clearly lower for Ryugu than that of Orgueil. The results of this study suggests that Orgueil may have been contaminated by the Earth's material such as water in the atmosphere.

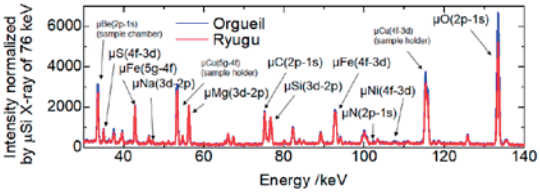

Figure 1: Muonic X-ray spectra for Ryugu and Orgueil together with assigns of principle peaks.

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Oxidation of Cu-Au Alloy Surface by Oxygen Molecular Beam

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Activation of molecular oxygen (O_2) constitutes an important step in oxidative processes, including heterogeneous catalysis, electrocatalysis, and corrosion of metals. The interaction of O_2 with various metal surfaces induces changes in its chemical stability and reactivity. It follows that the ability to control such processes bears on the chemical economic world. Alloying of pristine metals provides one of the simplest ways to do so. Understanding the microscopic mechanism behind O_2 chemisorption entails unraveling the stereochemistry of the processes involved.

We report the stereochemistry of oxidation. The orientation and motion of reactants play important roles in reactions. The small rotational excitations involved render the reactants susceptible to dynamical steering, making direct comparison between experiments and theory rather challenging. Using space-quantized molecular beams, we directly probed the (polar and azimuthal) orientation dependence of O_2 chemisorption on Cu(110) and Cu_3Au(110). We observed polar and azimuthal anisotropies on both surfaces. Chemisorption proceeded rather favorably with the O–O bond axis oriented parallel (vs perpendicular) to the surface and rather favorably with the O–O bond axis oriented along [001] (vs along [1-10]). The presence of Au hindered the surface from further oxidation, introducing a higher activation barrier to chemisorption and rendering an almost negligible azimuthal anisotropy. The presence of Au also prevented the cartwheel-like rotations of O_2.

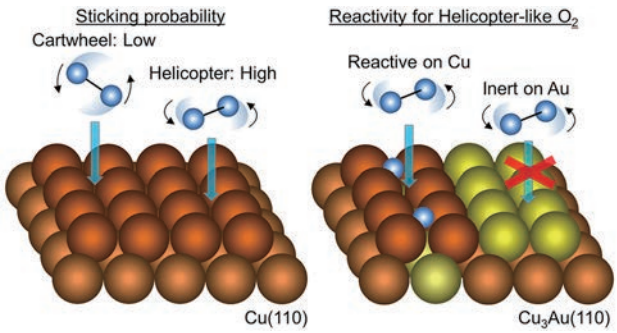

Fig.1. Oxidation of alloy surface by quantum controlled O_2

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Investigation of chemical purification method for Ce-141 as candidate nuclide for radiotheranostics

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One of the candidate radionuclides for theranostics (therapeutics + diagnosis) is cerium-141 (^{141}Ce, $T_{1/2}$ = 32.5 d). This nuclide emits β-particles (maximum β energy: 580.7 keV), which can be used for tumor therapy, and emits γ-rays with an energy of 145.4 keV, which can be used for imaging by single photon emission computed tomography (SPECT). In addition, ^{141}Ce can be produced in the ^{138}Ba(α,n)^{141}Ce reaction using accelerators, leading to a stable domestic supply in Japan. However, in nuclear medicine, ^{141}Ce has rarely been used. In this study, we investigated the chemical purification method for ^{141}Ce from the irradiated Ba target.

^{141}Ce was produced in the ^{nat}Ba(α, *xn*)^{141}Ce reaction with a 29-MeV alpha beam using the RIKEN K70 AVF Cyclotron. A ^{nat}BaO pellet was used as a target material. The irradiated ^{nat}BaO target (approximately 100 mg) was dissolved in 3 mL of 1 M HCl. After evaporation to dryness, the residue was dissolved in 10 mL of 0.03 M HCl solution. The solution was filled into a 10 mL syringe and then injected into the Ln resin cartridge column (extraction chromatographic resin with di(2-ethylhexyl) phosphoric acid) at a flow rate of 1 drop per 1–2 seconds. Each 1 mL of the eluents was corrected with sample tubes. The ^{nat}Ba was washed out from the cartridge with 0.03 M HCl, and then ^{141}Ce was eluted with 1 M HCl solution. Each eluted sample was subjected to γ-ray spectrometry with a Ge detector for the determination of ^{141}Ce radioactivity. After measurement with the Ge detector, the concentration of ^{nat}Ba in each sample was measured by ICP-MS.

The time required for the separation of ^{141}Ce with the Ln resin cartridge was less than 1 hour. Most of ^{nat}Ba was eluted at elution volume of around 15 mL with 0.03 M HCl. After elution of ^{nat}Ba, ^{141}Ce was recovered by elution with 1 M HCl. The recovery yield for ^{141}Ce was as high as 96%. The contamination of ^{nat}Ba in the ^{141}Ce fractions was calculated to be approximately 0.6 μg in the ICP-MS measurement. The separation factor of ^{141}Ce for Ba is estimated to be approximately 10^5. In the next study, the radiopharmaceutical labeling of ^{141}Ce using DOTA (1,4,7,10-Tetraazacyclododecane- 1,4,7,10-tetraacetic Acid), which is widely used for chelate labeling of therapeutic radionuclides, will be investigated.

Synthesis and preclinical evaluation of PSMA derivatives labeled with astatine-211

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It is well known that prostate specific membrane antigen (PSMA) is an excellent target for PET imaging and radiotherapy. Astatine-211 (^{211}At) is one of the promising radionuclides for alpha-particle targeted therapy. ^{211}At-labeled products can be manufactured on site and on demand. We synthesized an novel PSMA derivative labelled with ^{211}At, [^{211}At]PSMA5, for the targeted alpha therapy of metastatic prostate cancer (Fig.1).

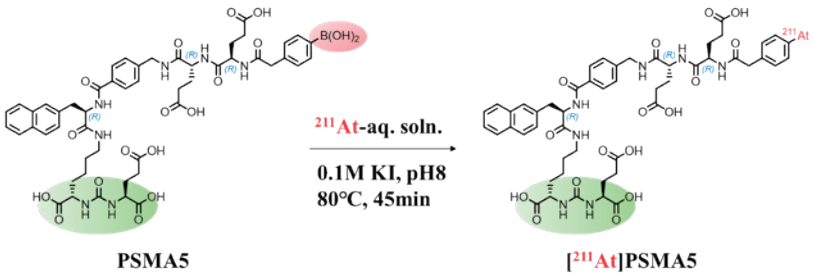

Fig. 1 Chemical structure and radiolabeling scheme of [^{211}At]PSMA5

A PSMA precursor coupled with boronic acid, PSMA5, was synthesized and reacted with aqueous solutions of ^{211}At in the presence of KI at 80℃ for 45 minutes. The reaction mixtures were purified by a solid-phase extraction (SPE) method with Oasis HLB cartridges (Waters). Radiochemical yields (RCY) and radiochemical purities (RCP) of the product were 84.7% and 99.7%. The boron-astatine substitution reaction is the efficient method for ^{211}At labeling of the PSMA ligand. [^{211}At]PSMA-5 are promising agent for the treatment of prostate cancer.

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Project to collect accidents and incidents for the creation of educational and training materials

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Act on the Regulation of Radioisotopes, etc. requires safety culture building activities in response to the IAEA's GSR Part 2, "Leadership and Management for Safety". Specifically, Article 38-4 of the Act stipulates that a user who holds the permission and a user who has notified is responsible for improving duties, enhancing education and training, and taking other measures. Heinrich's Law states that behind one major accident there are 29 minor accidental disasters and thousands more potential troubles. Therefore, the collection of near-miss information is an effective means of preventing major accidents by eliminating minor accidents and potential problems one by one before they lead to a major accident.

In radiation control, "major accidents" in Heinrich's Law are defined here as reportable accidents as defined in Article 28-3 of the enforcement regulations. The number of major accidents is very small, averaging about 4.5 per year from JFY2006 to JFY2020, and since the number of near-misses collected at a single RI site is very small, it is difficult to evaluate and improve safety without obtaining information on near-misses that have occurred at other sites. Therefore, sharing near-miss information among RI facilities would enable efficient safety improvement activities. In the field of nuclear power, information on problems is made public through NUCIA [1], an information disclosure library, but in the field of radiation application, there is no database or even a mechanism.

With the support of Grant-in-Aid for Scientific Research from JFY2022, we launched a project to collect information on near-misses in the field of radiation application in order to create educational materials for sharing information on near-misses. In JFY2022, we conducted a questionnaire survey and obtained information on about 75 near-miss events.

This work is supported by JSPS KAKENHI Grant Number JP22K029440.

Reference

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Direct Detection of Gamma-Rays from Laser Plasma

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The project's primary goal is to develop a technology for directly measuring emitted gamma-rays above 10 MeV from laser plasma using nuclear emulsion, that has not been achieved yet. This research, aimed at understanding laser plasma dynamics and detecting nuclear reactions, is essential for global research on laser plasma diagnostic techniques.

Data analysis from a development experiment using the J-KAREN-P laser at the Kansai Photon Science Institute in 2021 was advanced, primarily led by a graduate student at Osaka University. A high-brilliance pulse-laser with an intensity of 10^{21} W/cm^2 was fired on a 5 μm silver thin-film target. An emulsion detector, one meter from the target, was set up for capturing gamma-rays. After the irradiation, the emulsion was developed and digitized at Gifu and Nagoya University, respectively.

Through analysis, we confirmed four tracks of electron-positron pair generation linked to gamma rays, with detected energy estimated at 39,45,46 and 76MeV. Simulation work is ongoing to estimate the noises from gamma rays generated in the vacuum chamber. Preliminary results were presented at OPTO2020, and a research paper is in progress.

In 2023, we aim to establish clearer evidence of gamma-ray detection from laser plasma using an emulsion placed inside the vacuum chamber.

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Revealing ultrafast vibronic dynamics of tetracene molecules with sub-8 fs UV impulsive Raman spectroscopy

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Ultrafast dynamics of tetracene molecules in THF solution were investigated using sub-8 fs ultraviolet pulse lasers and ab initio calculations. The time trace of absorbance changes exhibited ultrafast decay with a time constant of 165 ± 10 fs because of the relaxation from a vibronically hot excited state to the potential minimum in the S1 state. From the signals of absorbance changes in the negative time region, we obtained the electronic dephasing time of 31.27 ± 1.63 fs. Inverse Fourier transform of stationary absorption spectra exhibited rapid decay with 2.1 ± 0.08 fs. From these data, we estimated the ratio of total dephasing time to homogenous and inhomogeneous broadening as 6.7% and 93.3%, respectively. Impulsive Raman spectra reflect the wave packet dynamics of vibrational modes. Although inhomogeneous broadening blurred the phase jump across the resonance peak in the spectral range, 1156 and 1680 cm−1 vibrational modes exhibited a phase jump from −π to ~π and −0.5π to ~0.5π, respectively. The amplitude profiles of these vibrational modes agree with simulated vibronic progressions of combination bands. Time–frequency analysis revealed coupling dynamics between low- and high-frequency modes, where high-frequency modes are in-plane motions and low-frequency modes are out-of-plane motions. Therefore, these coupling dynamics induce symmetry-breaking of the molecular framework, which fastens the singlet fission process.

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Targeted α-therapy using astatine (^{211}At)-labeled PSMA: a preclinical evaluation as a novel compound

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Prostate cancer is currently the most prevalent cancer among men in the world. Hormone therapy is performed for recurrent lesions after surgery and radiation therapy, but the prognosis is poor if hormone therapy become resistant with multiple metastases.

In recent years, attention has been paid to prostate-specific membrane antigen (PSMA), which is a membrane marker expressed in prostate cancer. PSMA is expressed in more than 90% of prostate cancers. We have succeeded in developing a new innovative therapeutic drug [^{211}At]PSMA5 targeting PSMA using the accelerator-manufacturable alpha-ray nuclide astatine (^{211}At).

Preclinical evaluation using a prostate cancer model showed markedly high accumulation in the tumor (30.6 ± 17.8 %ID/g at 3 h and 40.7 ± 2.6 %ID/g at 24 h, respectively). An excellent tumor growth suppression was observed after [^{211}At]PSMA5 administration (Fig.1). Currently, attention is focused on PSMA treatment using another alpha-ray nuclide, actinium (^{225}Ac), but its production requires nuclear fuel material or rare radioisotopes, and its supply is extremely limited. Targeted alpha therapy using [^{211}At]PSMA5 resulted in excellent treatment effect on tumor growth with minimal side effects in the normal organs. [^{211}At]PSMA5 can be a new innovative therapy for metastatic castration-resistant prostate cancer.

This project was adopted for AMED translational research (seeds-F) during FY 2022-2026. We have performed preclinical examinations to evaluate toxicity and biodistribution of [^{211}At]PSMA5 in rodents and non-rodents according to the PMDA consultation. Phase-I investigator initiated clinical trial will start in 2024.

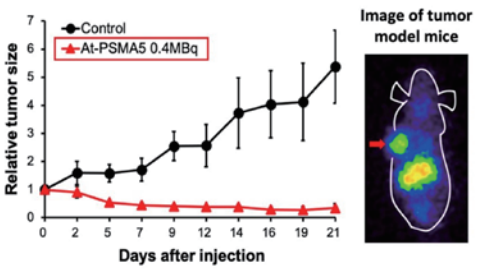

fig.1. Antitumor effect of [^{211}At]PSMA5 after single administration in prostate cancer model mouse (left) and biodistribution in tumor-bearing model (right): High accumulation in tumor (arrow) can be confirmed.

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Enrichment of ^{48}Ca by Laser Isotope Separation for the Study of Double Beta Decay

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CANDLES project searches for neutrino-less double beta(ββ) decay using ^{48}Ca, which has the highest Q-value of 4.27 MeV among the ββ decay nuclides. In the recent study by the CANDLES III system, consisting of 96 ^{nat}.CaF_2 scintillator crystals (0.35 kg of ^{48}Ca), the lower limit of the half-life of neutrino-less ββ decay of 5.6×10^{22} year (90% C.L.) was obtained by 21 selected high-purity crystals.[1] CANDLES III used natural calcium, which contains only 0.187% of ^{48}Ca. The isotope enrichment of ^{48}Ca is required to improve the detector sensitivity. However, calcium has no gaseous compound, and industrial-scale isotope separation methods such as gas diffusion and gas centrifuge are inapplicable. The only currently available method is the electromagnetic separator, which has a low production yield and is much expensive (~1 M$/g).

We focus on the development of laser isotope separation (LIS). We conducted the proof-of-principle experiment. [2,3] The deflection laser was irradiated perpendicular to the calcium atomic beam. The target calcium isotope absorbed the momentum of the incoming laser photon, which has a stable (less than 2 MHz rms) continuous wave oscillation at a calcium absorption wavelength of 422.792 nm and was deflected from the original atomic beam. The separation of ^{48}Ca and the calcium recovery were up to 5.5% and 19.6% at the deflection angle of 12.5 mrad, respectively. Toward the mass production of enriched ^{48}Ca, the intense atomic beam generator is being developed. The effect of the length of the single-tube collimator on the atomic beam shape was reported in Ref.[3]. The recovery system is also being developed to find the most applicable material to be used as a collection plate. The small chamber was introduced to expose the material to the calcium atomic beam. For future development, we installed the new irradiation chamber consisting of 6 irradiation ports aiming to produce up to 2 mol/year of ^{48}Ca by the full operation of six ports. The first step is to get stable operation from one of the six ports with the 2 W laser power. The atomic beam intensity and isotope fractionation were measured by the time of flight (TOF) system. The collection system is designed to be automated for 24-hour operation via the conveyor belt and the collection plate at the center of the chamber.

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Synthesis of Octahedral Hexanuclear Rhenium Complexes as a Molecular Targeted Agent

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Photodynamic therapy (PDT) is the method to damage cells using reactive oxygen species generated by excitation of the chromophore and energy transfer to oxygen molecules. The octahedral hexanuclear rhenium complex is known to show photoluminescence from the excited triplet state with lifetime of microseconds. In addition, the complex shows high thermal stability and low toxicity. Therefore, the complex has potential as a drug for PDT. In practice, the previous study has reported that the toxicity of the octahedral hexanuclear complex was examined when the complex was incorporated to cells and photo-irradiated.[1] There is no study for the rhenium complexes actually being injected into cancer model mice to examine accumulation in cancer tissue. In the present study, we synthesized the new complex with 4-(pyridyl)triazole-L-phenylalanine (ptph) which is potentially expectable to accumulate in cancer cells.

The complex $(n\text{-Bu}_4\text{N})_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{tepy})]$ (tepy = 4-trimethylsilylethynylpyridine) was synthesized and structurally characterized by single-crystal X-ray analysis. The L-phenylalanine moiety was introduced in the rhenium complex by the reaction of *N*-Boc-4-azido-L-phenylalanine methyl ester with $(n\text{-Bu}_4\text{N})_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{tepy})]$ in the presence of copper catalyst to give $(n\text{-Bu}_4\text{N})_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph}^{\text{MB}})]$ (ptph^{MB} = *N*-Boc-4-(pyridinetriazole)-L-phenylalanine methyl ester). The complex, $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$ was synthesized by the metathesis and deprotection of ptph^{MB} in $[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph}^{\text{MB}})]^{3-}$.

The complexes were characterized by ^{1}H NMR and IR spectra. Two types of photoluminescences were observed for the complexes, originating from the cluster core-centered excited triplet state (^{3}CC) for $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$, and from the metal-to-ligand charge-transfer excited triplet state (^{3}MLCT) for $(n\text{-Bu}_4\text{N})_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{tepy})]$ and $(n\text{-Bu}_4\text{N})_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph}^{\text{MB}})]$. The emission intensity and emission quantum yield and emission lifetime of $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$ was decreased in the presence of oxygen, indicating that the energy transfer from the excited complex to oxygen molecules was occurred to generate oxygen molecules with spin singlet states.

The LD_{50} values of $\text{Cs}_4[\text{Re}_6\text{S}_8\text{Cl}_6]\cdot\text{CsCl}$ and $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$ were similar to those of the complexes previously reported. The cell viability in dark and under irradiation of visible light was investigated. The cell viabilities under irradiation of light were lowered than those in dark for both $\text{Cs}_4[\text{Re}_6\text{S}_8\text{Cl}_6]\cdot\text{CsCl}$ and $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$. When the $\text{Cs}_4[\text{Re}_6\text{S}_8\text{Cl}_6]\cdot\text{CsCl}$ and $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$ were injected into cancer model mice, the %ID values of $\text{Cs}_4[\text{Re}_6\text{S}_8\text{Cl}_6]\cdot\text{CsCl}$ and $\text{Na}_3[\text{Re}_6\text{S}_8\text{Cl}_5(\text{ptph})]$ were 4.5±2.8% and 9.0±8.3%, respectively, after 3 h from injection of the complexes.

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II

Achievements

Original Papers

O-1 Boron Delivery to Brain Cells via Cerebrospinal Fluid (CSF) Circulation in BNCT of Brain-Tumor-Model Rats-Ex Vivo Imaging of BPA Using MALDI Mass Spectrometry Imaging

Sachie Kusaka, Yumi Miyake, Yugo Tokumaru, Yuri Morizane, Shingo Tamaki, Yoko Akiyama, Fuminobu Sato, Isao Murata
Life **12** 1786 (2022)

O-2 Cerebrospinal fluid-based boron delivery system may help increase the uptake boron for boron neutron capture therapy in veterinary medicine: A preliminary study with normal rat brain cells

Sachie Kusaka, Yuri Morizane, Yugo Tokumaru, Shingo Tamaki, Indah Rosidah Maemunah, Yoko Akiyama, Fuminobu Sato, Isao Murata
Research in Veterinary Science **148** 1-6 (2022)

O-3 Study on irradiation effect of insulating materials for fusion superconducting magnets-interlaminar shear strength at liquid helium temperature

Yoko Akiyama, Nobuto Akazawa, Yuta Kunitoku, Yuichiro Manabe, Fuminobu Sato, Akifumi Iwamoto, Shinsaku Imagawa, Shigehiro Nishijima
RADIATION PHYSICS AND CHEMISTRY **199** 110372 (2022)

O-4 Study on Irradiation Effect of Insulating Materials for Fusion Superconducting Magnet: Effect of Low-temperature Irradiation

Y Kunitoku, Y Akiyama, Y Manabe, F Sato
IOP Conference Series: Materials Science and Engineering **1241** 12004 (2022)

O-5 Boron Delivery to Brain Cells via Cerebrospinal Fluid (CSF) Circulation for BNCT in a Rat Melanoma Model

Sachie Kusaka, Yuri Morizane, Yugo Tokumaru, Shingo Tamaki, Indah Rosidah Maemunah, Yoko Akiyama, Fuminobu Sato, Isao Murata
Life **12** 1786 (2022)

O-6 Radioactivation Analysis of Concrete Wall in OKTAVIAN Facility

Shingo Tamaki, Fajar Panuntun, Kazumichi Uedoi, Wang Haidong, Sachie Kusaka, Yuichiro Manabe, Yoko Akiyama, Teruya Tanaka, Fuminobu Sato, Isao Murata
Plasma and Fusion Research **17** 1450001 (2022)

O-7 Triplet–Triplet Annihilation via the Triplet Channel in Crystalline 9,10-Diphenylanthracene

Tomoaki Yago, Manami Tashiro, Kiichi Hasegawa, Masao Gohdo, Syuta Tsuchiya, Tadaaki Ikoma,Masanobu Wakasa
The Journal of Physical Chemistry Letters **13** 8768-8774 (2022)

O-8 Direct ionization-driven observational approaches for radical cation formation insolution for pulse radiolysis

Masao Gohdo, Seiichi Tagawa,Koichi Kan, Jinfeng Yang, Yoichi Yoshida
Radiation Physics and Chemistry **196** 110105 (2022)

O-9 3D reconstructed brain images reveal the possibility of the ogg1 gene to suppress the irradiation-induced apoptosis in embryonic brain in medaka (Oryzias latipes)

Takako Yasuda, Duolin Li, Erge Sha, Fumitaka Kakimoto, Hiroshi Mitani, Hiroshi Yamamoto, Tomoko Ishikawa-Fujiwara, Takeshi Todo, Shoji Oda
Journal of radiation research **63** 319-330 (2022)

O-10 Astatine-211-Labeled Gold Nanoparticles for Targeted Alpha-Particle Therapy via Intravenous Injection

Xuhao Huang, Kazuko Kaneda-Nakashima, Yuichiro Kadonaga, Kazuya Kabayama, Atsushi Shimoyama, Kazuhiro Ooe, Hiroki Kato, Atsushi Toyoshima, Atsushi Shinohara, Hiromitsu Haba, Yang Wang, Koichi Fukase
Pharmaceutics **14** 2705 (2022)

O-11 Limonoids with anti-inflammatory activity: A review.

Erina Hilmayanti, Nurlelasari, Unang Supratman, Kazuya Kabayama, Atsushi Shimoyama, Koichi Fukase
Phytochemistry **204** 113469 (2022)

O-12 Mechanistic Studies for the Rational Design of Multivalent Glycodendrimers

Yoshiyuki Manabe, Masato Tsutsui, Kohtaro Hirao, Risako Kobayashi, Hiroshi Inaba, Kazunori Matsuura, Daisuke Yoshidome, Kazuya Kabayama, Koichi Fukase
Chemistry – A European Journal **28** e202201848 (2022)

O-13 Precise immunological evaluation rationalizes the design of a self-adjuvanting vaccine composed of glycan antigen, TLR1/2 ligand, and T-helper cell epitope
Tsung Che Chang, Yoshiyuki Manabe, Keita Ito, Ryuku Yamamoto, Kazuya Kabayama, Shino Ohshima, Yoshie Kametani, Yukari Fujimoto, Chun Cheng Lin, Koichi Fukase
RSC Advances **12** 18985-18993 (2022)

O-14 核医学装置における精度管理と性能評価のためのファントムスタディ
神谷 貴史, 佐々木 秀隆
日本放射線技術学会誌 **78** 753-759

O-15 SPECT画像における洗い出し率算出
— ^{123}I-BMIPP を用いた中性脂肪蓄積心筋血管症の診断基準 —
神谷 貴史
日本心臓核医学学会誌 **25** 18985-18993 (2022)

O-16 Mathematical Model for Evaluation of Tumor Response in Targeted Radionuclide Therapy with ^{211}At Using Implanted Mouse Tumor
Yoshiharu Yonekura, Hiroshi Toki, Tadashi Watabe, Kazuko Kaneda-Nakashima, Yoshifumi Shirakami, Kazuhiro Ooe, Atsushi Toyoshima, Hiroo Nakajima, Noriyuki Tomiyama, Masako Bando
International Journal of Molecular Sciences **23** 15966 (2022)

O-17 Effect to Therapy of Sodium-Iodine Symporter Expression by Alpha-Ray Therapeutic Agent via Sodium/Iodine Symporter
Kazuko Kaneda-Nakashima, Yoshifumi Shirakami, Tadashi Watabe, Kazuhiro Ooe, Takashi Yoshimura, Atsushi Toyoshima, Yang Wang, Hiromitsu Haba, Koichi Fukase
International journal of molecular sciences **23** 15509 (2022)

O-18 Substrate Study for Dihydroxyboryl Astatine Substitution Reaction with Fibroblast Activation Protein Inhibitor (FAPI)
Ayaka Aso, Kazuko Kaneda-Nakashima, Hinako Nabetani, Yuichiro Kadonaga, Yoshifumi Shirakami, Tadashi Watabe, Taku Yoshiya, Masayoshi Mochizuki, Yuki Koshino, Kazuhiro Ooe, Atsuko Kawakami, Naoya Jinno, Atsushi Toyoshima, Hiromitsu Haba, Yang Wang, Jens Cardinale, Frederik L. Giesel, Atsushi Shimoyama, Koichi Fukase
Chemistry Letters **51** 1091 1094 (2022)

O-19 Targeted α-therapy using astatine (^{211}At)-labeled PSMA1, 5, and 6: a preclinical evaluation as a novel compound
Tadashi Watabe, Kazuko Kaneda-Nakashima, Yoshifumi Shirakami, Yuichiro Kadonaga, Kazuhiro Ooe, Yang Wang, Hiromitsu Haba, Atsushi Toyoshima, Jens Cardinale, Frederik L Giesel, Noriyuki Tomiyama, Koichi Fukase
Eur J Nucl Med Mol Imaging **50** 849-858 (2022)

O-20 Dioxetane derivative containing carboxy group as a chemiluminophore-introducing reagent
Yukie Nohara, Shun Masuda, Kazuko Kaneda-Nakashima, Yoshifumi Shirakami, Masakatsu Matsumoto, Taku Yoshiya
Chembiochem : a European journal of chemical biology **23** e202200556 (2022)

O-21 Comparison of the Therapeutic Effects of [^{211}At]NaAt and [^{131}I]NaI in an NIS-Expressing Thyroid Cancer Mouse Model
Tadashi Watabe, Yuwei Liu, Kazuko Kaneda-Nakashima, Tatsuhiko Sato, Yoshifumi Shirakami, Kazuhiro Ooe, Atsushi Toyoshima, Eku Shimosegawa, Yang Wang, Hiromitsu Haba, Takashi Nakano, Atsushi Shinohara, Jun Hatazawa
International Journal of Molecular Sciences **23** 9434 (2022)

O-22 Effects of film thickness and alkaline concentration on dissolution kinetics of poly (4-hydroxystyrene) in alkaline aqueous solution
Naoki Tanaka, Kyoko Matsuoka, Takahiro Kozawa , Takuya Ikeda, Yoshitaka Komuro and Daisuke Kawana
Jpn. J. Appl. Phys. **61** SD1016 (2022)

O-23 Effect of surface free energy of organic underlayer on dissolution kinetics of poly (4-hydroxystyrene) film in tetramethylammonium hydroxide aqueous developer
Tomoe Otsuka, Yuqing Jin, Naoki Tanaka, and Takahiro KOZAWA
Jpn. J. Appl. Phys. **61** 056503 (2022)

O-24 Interdomain Electron Transfer in Flavohemoglobin from Candida norvegensis with Antibiotic Azole Compounds
Kazuo Kobayashi, Jotaro Igarashi, and Takahiro Kozawa
FEBS Letters **596** 938-946 (2022)

O-25 Classification of lines, spaces, and edges of resist patterns in scanning electron microscopy images using unsupervised machine learning
Yuqing Jin and Takahiro Kozawa
Jpn. J. Appl. Phys. **61** 56505 (2022)

O-26 Estimation of effective reaction radius for catalytic chain reaction of chemically amplified resist by Bayesian optimization
Yuqing Jin and Takahiro Kozawa
Jpn. J. Appl. Phys. **61** 66504 (2022)

O-27 Study on deprotonation from radiation-induced ionized acrylate polymers including acid-generation promoters for improving chemically amplified resists
Kazumasa Okamoto, Akihiro Konda, Yuki Ishimaru, Takahiro Kozawa, Yasunobu Nakagawa and Masamichi Nishimura
Jpn. J. Appl. Phys. **61** 66505 (2022)

O-28 Sensitization mechanism of metal oxide nanocluster resists with carboxylic acid ligands
Tomoe Otsuka, Yusa Muroya, Takuya Ikeda, Yoshitaka Komuro, Daisuke Kawana and Takahiro Kozawa
Jpn. J. Appl. Phys. **61** 86508 (2022)

O-29 Interfacial effects on sensitization of chemically amplified extreme ultraviolet resists
Takahiro Kozawa
Jpn. J. Appl. Phys. **61** 116501 (2022)

O-30 Extended X-ray absorption fine structure spectroscopy measurements and ab initio molecular dynamics simulations reveal the hydration structure of the radium(II) ion
Akiko Yamaguchi, Kojiro Nagata, Keita Kobayashi, Kazuya Tanaka, Tohru Kobayashi, Hajime Tanida, Kojiro Shimojo, Tetsuhiro Sekiguchi, Yui Kaneta, Shohei Matsuda, Keiichi Yokoyama, Tsuyoshi Yaita, Takashi Yoshimura, Masahiko Okumura, Yoshio Takahashi
iScience **25** 104763 (2022)

O-31 Tuning the Ground- and Excited-State Redox Potentials of Octahedral Hexanuclear Rhenium(III) Complexes by the Combination of Terminal Halide and N-Heteroaromatic Ligands
Takashi Yoshimura, Hayato Nishizawa, Kojiro Nagata, Akitaka Ito, Eri Sakuda, Shoji Ishizaka, Noboru Kitamura, Atsushi Shinohara
ACS Omega **7** 26965-26982 (2022)

O-32 Development of Nondestructive Elemental Analysis System for Hayabusa2 Samples Using Muonic X-rays
Takahito Osawa, Shunsaku Nagasawa, Kazuhiko Ninomiya, Tadayuki Takahashi, Tomoki Nakamura, Taiga Wada, Akihiro Taniguchi, Izumi Umegaki, Kenya M. Kubo, Kentaro Terada, I-Huan Chiu, Shinichiro Takeda, Miho Katsuragawa, Takahiro Minami, Shin Watanabe, Toshiyuki Azuma, Kazumi Mizumoto, Go Yoshida, Soshi Takeshita, Motonobu Tampo, Koichiro Shimomura, Yasuhiro Miyake
ACS Earth and Space Chemistry **7** 699-711 (2023)

O-33 The non-destructive investigation ofa late antique knob bow fibula (Bügelknopffibel) from Kaiseraugst/CH using Muon Induced X-ray Emission (MIXE)
Sayani Biswas, Isabel Megatli-Niebel, Lilian Raselli, Ronald Simke, Thomas Elias Cocolios, Nilesh Deokar, Matthias Elender, Lars Gerchow, Herbert Hess, Rustem Khasanov, Andreas Knecht, Hubertus Luetkens, Kazuhiko Ninomiya, Angela Papa, Thomas Prokscha, Peter Reiter, Akira Sato, Nathal Severijns, Toni Shiroka, Michael Seidlitz, Stergiani Marina Vogiatzi, Chennan Wang, Frederik Wauters, Nigel Warr, Alex Amato
Heritage Science **11**:**43** (2023)

O-34 Negative muon spin rotation and relaxation on Li metal
Jun Sugiyama, Izumi Umegaki, Soshi Takeshita, Takehito Nakano, Kazuhiko Ninomiya, Koichiro Shimomura, M. Kenya Kubo
Journal of Physics: Conference Series **2462** 12045 (2023)

O-35 Formation and evolution of carbonaceous asteroid Ryugu: Direct evidence from returned samples

T. Nakamura, M. Matsumoto, K. Amano, Y. Enokido, M. E. Zolensky, T. Mikouchi, H. Genda, S. Tanaka, M. Y. Zolotov, K. Kurosawa, S. Wakita, R. Hyodo, H. Nagano, D. Nakashima, Y. Takahashi, Y. Fujioka, M. Kikuiri, E. Kagawa, M. Matsuoka, A. J. Brearley, A. Tsuchiyama, M. Uesugi, J. Matsuno, Y. Kimura, M. Sato, R. E. Milliken, E. Tatsumi, S. Sugita, T. Hiroi, K. Kitazato, D. Brownlee, D. J. Joswiak, M. Takahashi, K. Ninomiya, T. Takahashi, T. Osawa, K. Terada, F. E. Brenker, B. J. Tkalcec, L. Vincze, R. Brunetto, A. Aléon-Toppani, Q. H. S. Chan, M. Roskosz, J.-C. Viennet, P. Beck, E. E. Alp, T. Michikami, Y. Nagaashi, T. Tsuji, Y. Ino, J. Martinez, J. Han, A. Dolocan, R. J. Bodnar, M. Tanaka, H. Yoshida, K. Sugiyama, A. J. King, K. Fukushi, H. Suga, S. Yamashita, T. Kawai, K. Inoue, A. Nakato, T. Noguchi, F. Vilas, A. R. Hendrix, C. Jaramillo-Correa, D. L. Domingue, G. Dominguez, Z. Gainsforth, C. Engrand, J. Duprat, S. S. Russell, E. Bonato, C. Ma, T. Kawamoto, T. Wada, S. Watanabe, R. Endo, S. Enju, L. Riu, S. Rubino, P. Tack, S. Takeshita, Y. Takeichi, A. Takeuchi, A. Takigawa, D. Takir, T. Tanigaki, A. Taniguchi, K. Tsukamoto, T. Yagi, S. Yamada, K. Yamamoto, Y. Yamashita, M. Yasutake, K. Uesugi, I. Umegaki, I. Chiu, T. Ishizaki, S. Okumura, E. Palomba, C. Pilorget, S. M. Potin, A. Alasli, S. Anada, Y. Araki, N. Sakatani, C. Schultz, O. Sekizawa, S. D. Sitzman, K. Sugiura, M. Sun, E. Dartois, E. De Pauw, Z. Dionnet, Z. Djouadi, G. Falkenberg, R. Fujita, T. Fukuma, I. R. Gearba, K. Hagiya, M. Y. Hu, T. Kato, T. Kawamura, M. Kimura, M. K. Kubo, F. Langenhorst, C. Lantz, B. Lavina, M. Lindner, J. Zhao, B. Vekemans, D. Baklouti, B. Bazi, F. Borondics, S. Nagasawa, G. Nishiyama, K. Nitta, J. Mathurin, T. Matsumoto, I. Mitsukawa, H. Miura, A. Miyake, Y. Miyake, H. Yurimoto, R. Okazaki, H. Yabuta, H. Naraoka, K. Sakamoto, S. Tachibana, H. C. Connolly, D. S. Lauretta, M. Yoshitake, M. Yoshikawa, K. Yoshikawa, K. Yoshihara, Y. Yokota, K. Yogata, H. Yano, Y. Yamamoto, D. Yamamoto, M. Yamada, T. Yamada, T. Yada, K. Wada, T. Usui, R. Tsukizaki, F. Terui, H. Takeuchi, Y. Takei, A. Iwamae, H. Soejima, K. Shirai, Y. Shimaki, H. Senshu, H. Sawada, T. Saiki, M. Ozaki, G. Ono, T. Okada, N. Ogawa, K. Ogawa, R. Noguchi, H. Noda, M. Nishimura, N. Namiki, S. Nakazawa, T. Morota, A. Miyazaki, A. Miura, Y. Mimasu, K. Matsumoto, K. Kumagai, T. Kouyama, S. Kikuchi, K. Kawahara, S. Kameda, T. Iwata, Y. Ishihara, M. Ishiguro, H. Ikeda, S. Hosoda, R. Honda, C. Honda, Y. Hitomi, N. Hirata, N. Hirata, T. Hayashi, M. Hayakawa, K. Hatakeda, S. Furuya, R. Fukai, A. Fujii, Y. Cho, M. Arakawa, M. Abe, S. Watanabe, Y. Tsuda
Science **379** eabn8671 (2022)

O-36 Non-Destructive Composition Identification for Mixtures of Iron Compounds Using a Chemical Environmental Effect on a Muon Capture Process

Kazuhiko Ninomiya, Meito Kajino, Akihiro Nambu, Makoto Inagaki, Takuto Kudo, Akira Sato, Kentaro Terada, Atsushi Shinohara, Dai Tomono, Yoshitaka Kawashima, Yoichi Sakai, Tsutomu Takayama
Bulletin of the Chemical Society of Japan **95** 1769-1774 (2022)

O-37 Negative Muon Spin Rotation and Relaxation Study on Battery Anode Material, Spinel $Li_4Ti_5O_{12}$

Izumi Umegaki, Kazuki Ohishi, Takehito Nakano, Shoichiro Nishimura, Soshi Takeshita, Akihiro Koda, Kazuhiko Ninomiya, M. Kenya Kubo, Jun Sugiyama
The Journal of Physical Chemistry C **126** 10506-10514 (2022)

O-38 VEGF (vascular endothelial growth factor) provides antimicrobial effects via autophagy and lysosomal empowerment in endothelial cells

Shiou-Ling Lu, Takeshi Noda
Autophagy Reports **1** 218 (2022)

O-39 VEGF-Mediated Augmentation of Autophagic and Lysosomal Activity in Endothelial Cells Defends against Intracellular Streptococcus pyogenes

Shiou-Ling Lu, Hiroko Omori, Yi Zhou, Yee-Shin Lin, Ching-Chuan Liu, Jiunn-Jong Wu, Takeshi Noda
mBio **13** e0123322 (2022)

O-40 Probing Copper and Copper–Gold Alloy Surfaces with Space-Quantized Oxygen Molecular Beam

Yasutaka Tsuda, Jessiel Siaron Gueriba, Hirokazu Ueta, Wilson Agerico Diño, Mitsunori Kurahashi, Michio Okada
JACS Au **2** 1839-1847 (2022)

O-41 Microstructure and Solute Segregation around the Melt-Pool Boundary of Orientation-Controlled 316L Austenitic Stainless Steel Produced by Laser Powder Bed Fusion

Kazuhisa Sato, Shunya Takagi, Satoshi Ichikawa, Takuya Ishimoto, Takayoshi Nakano
Materials **16** 218 (2022)

O-42 Structural Defects and Ferromagnetic Signature ofV-Doped Sb_2Te_3 Thin Films Grown on $SrTiO_3$ (001) Produced by RF-Magnetron Sputtering

Kazuhisa Sato
ACS Omega **7** 40480-40484 (2022)

O-43 Comparison of magnetic anisotropy and structural properties in chemically ordered CoPt and FePt nanoparticles

A. Tamion, F. Tournus, N. Blanc, A. Hillion, O. Proux, A. Rogalev, F. Wilhelm, J. Gutiérrez Valdés, L. E. Díaz-Sánchez, K. Sato, G. M. Pastor, V. Dupuis
Physical Review B **106** 104420 (2022)

O-44 Stacking Faults and Intercalants in $(Ta_{1-x}Ti_x)Se_2$ Revealed by Cross-Sectional Transmission Electron Microscopy

Kazuhisa Sato,Toshiya Matsushita
The Journal of Physical Chemistry C **126** 14290 (2022)

O-45 Excellent strength–ductility balance of Sc-Zr-modified Al–Mg alloy by tuning bimodal microstructure via hatch spacing in laser powder bed fusion

Yusufu Ekubaru, Ozkan Gokcekaya, Takuya Ishimoto, Kazuhisa Sato, Koki Manabe, Pan Wang, Takayoshi Nakano
Materials & Design **221** 110976 (2022)

O-46 Damping of the isovector giant dipole resonance in Ca-40,Ca-48

J. Carter, L. M. Donaldson, H. Fujita, Y. Fujita, M. Jingo, C. O. Kureba, M. B. Latif, E. Litvinova, F. Nemulodi, P. Von Neumann-Cosel, R. Neveling, P. Papakonstantinou, P. Papka, L. Pellegri, V. Yu Ponomarev, A. Richter, R. Roth, E. Sideras-Haddad, F. D. Smit, J. A. Swartz, A. Tamii, R. Trippel, I. T. Usman, and H. Wibowo
Physics Letters B **833** 137374 (2022)

O-47 Fast Heavy-Ion-Induced Anion–Molecule Reactions on the Methanol Droplet Surface

Takuya Majima, Yuki Mizunami, Takahiro Teramoto, Hidetsugu Tsuchida, Manabu Saito
The Journal of Physical Chemistry A **126** 8988-8996 (2022)

O-48 Revealing ultrafast vibronic dynamics of tetracene molecules with sub-8 fs UV impulsive Raman spectroscopy

Takahiro Teramoto, Jun Liu, Juan Du, Takayoshi Kobayashi
Physical Chemistry Chemical Physics **24** 27783-27792 (2022)

O-49 Wide-band X-ray and gamma-ray imaging of living mouse toreveal pharmacokinetics of At-211

M. Masubuchi, A. Omata, N. Koshikawa, J. Kataoka, H. Kato, A. Toyoshima, K. Ooe, D. Katayama, T. Teramoto, K. Matsunaga, T. Kamiya, T. Watabe, E. Shimosegawa, J. Hatazawa
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **1045** 167581 (2023)

O-50 Ultrafast X-ray photoelectron diffraction from free molecules: Simulations of diffraction profiles from transient intermediates in the elimination reaction of $C_2H_4I_2$

S. Minemoto, J.H. Mun, T. Teramoto, A. Yagishita, S. Tsuru
Journal of Electron Spectroscopy and Related Phenomena **258** 147221 (2022)

O-51 Ultrafast Excited State Dynamics of Forward and Reverse trans-cis Photoisomerization of Red-Light-Absorbing Indigo Derivatives

Yu Kihara, Shuntaro Tani, Yamato Higashi, Takahiro Teramoto, Yutaka Nagasawa
The Journal of Physical Chemistry B **126** 3539-3550 (2022)

O-52 Basic studies toward ultrafast soft x-ray photoelectron diffraction its application to probing local structure in iodobenzene molecules

T. Teramoto, S. Minemoto, T. Majima, T. Mizuno, J. H. Mun, A. Yagishita, P. Decleva, S. Tsuru
Structural Dynamics **9** 24303 (2022)

O-53 Advantages of FBPA PET in evaluating early response of anti-PD-1 immunotherapy in B16F10 melanoma-bearing mice: Comparison to FDG PET

Mitsuaki Tatsumi, Fumihiko Soeda, Sadahiro Naka, Kenta Kurimoto, Kazuhiro Ooe, Hideyuki Fukui, Daisuke Katayama, Tadashi Watabe, Hiroki Kato, Noriyuki Tomiyama
Frontiers in Oncology **12** (2022)

O-54 Celebrating 80 years anniversary of radioiodine for use in thyroid cancer and perspectives for theranostics

Hertz B, Watabe T, Baum RP
Annals of nuclear medicine **36** 1007-1009 (2022)

O-55 Diagnostic and prognostic significance of tartrate-resistant acid phosphatase type 5b in newly diagnosed prostate cancer with bone metastasis: A real-world multi-institutional study

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P-88 Data analysis for reduction of ^{208}Tl background events in CANDLES system
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P-96 In vitro で形成させたヒドロキシアパタイトに吸着した Ra-226 の局所構造解析
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P-97 ^{59}Co のミュオン原子核捕獲反応生成物の測定
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山本 康平, 吉村 崇, 二宮 和彦
日本放射化学会第66回討論会(2022), 2022年9月

P-100 分子レベルの情報に基づいたラジウムの環境挙動解明
山口 瑛子, 永田 光知郎, 小林 恵太, 田中 万也, 小林 徹, 谷田 肇, 矢板 毅, 吉村 崇, 奥村 雅彦, 高橋 嘉夫
日本放射化学会第66回討論会(2022), 2022年9月

Awards

A-1 Poster Award (Second Place) - Oncology, Basic, and Translational
Tadashi Watabe, Kazuko Kaneda-Nakashima, Yoshifumi Shirakami, Yuichiro Kadonaga, Kazuhiro Ooe, Yang Wang, Hiromitsu Haba, Atsushi Toyoshima, Jens Cardinale, Frederik L. Giesel, Koichi Fukase
米国核医学会(SNMMI), 2022年6月

A-2 2022 ERF SNMMI-TS Professional Development Grant Award for the SNMMI Annual Meeting
Takashi Kamiya, Tadashi Watabe, Rie Ikeda, Reina Hagura, Hidetaka Sasaki, Sadahiro Naka, Koichi Fujino, Keiko Matsunaga, Eku Shimosegawa, Mitsuaki Tatsumi and Hiroki Kato
SNMMI 2022 AnnualMeeting, 2022年6月

A-3 久田賞（Annals of Nuclear Medicine論文賞）銅賞
渡部 直史
日本核医学会, 2022年9月

A-4 日本放射線安全管理学会 令和3年度技術賞
Kazuko Kaneda-Nakashima, Zijian Zhang, Kojiro Nagata, Kenji Shirasaki, Hidetoshi, Kikunaga, Tomoo Yamamura, Kazuhiro Ooe, Tadashi Watabe, Atsushi, Toyoshima, Takashi Yoshimura, Atsushi Shinohara
一般社団法人日本放射線安全管理学会, 2022年9月

A-5 最優秀ポスター賞
鈴木 智和, 桧垣 正吾, 髙橋 賢臣
公益社団法人日本アイソトープ協会令和4年度安全取扱部会年次大会, 2022年10月

Social and Academic Contributions

S-1 オートファジーの発見、そしてその発展
野田 健司
西宮市

S-2 直弟子からみたノーベル賞の大隅良典博士
野田 健司
かわさき市民アカデミー

S-3 厚生労働科学研究（細野班）研究協力者
渡部 直史
厚生労働省

S-4 IAEA CUIJ コンソーシアム事務局
渡部 直史
国際原子力機関

S-5 大阪府立生野高等学校出張講義「宇宙は明るく光っているのか？」
吉田 斉
出張講義

S-6 医師主導治験（難治性甲状腺がんに対するアスタチン治験）
渡部 直史
治験責任医師

Patents

I-1 放射標識されたチロシン誘導体およびその用途
兼田 加珠子, 白神 宜史, 角永 悠一郎, 豊嶋 厚史, 深瀬 浩一, 長田 宏
特願2022-150608

I-2 甲状腺がんの核医学治療薬
渡部 直史, 白神 宜史
特願2022-202483

I-3 電解酸化反応による放射標識アリール化合物の製造方法
深瀬 浩一, 豊嶋 厚史, 篠原 厚, 白神 宜史, 兼田 加珠子, 下山 敦史, 角永 悠一郎
特願2022-035169

I-4 放射標識されたFAP α 親和性化合物およびその用途
白神 宜史, 角永 悠一郎, 兼田 加珠子, 渡部 直史, 深瀬 浩一, 下山 敦史, 麻生 彩佳, 吉矢 拓
特願2022-26194

Fund for Preparation of New Education and Research Projects

新規教育研究プロジェクト準備経費

現在、放射線科学基盤機構では、放射線の生物学的影響、福島関連研究、大規模RI製造法など、アルファ線核医学治療に続く新たな教育研究プロジェクトの立ち上げに取り組んでいる。これらを遂行するためには、理学研究科や医学系研究科の部局単位や大阪大学内に留まらない分野横断的な意見の交流が重要である。特にプロジェクトの計画段階で、各分野の専門家の意見を集約、精査することでプロジェクトを取り巻く環境を把握し、科学的かつ社会的に有意義な計画の立案が必要となる。そのため、本機構では、専任教員ならびに兼任教員が新たな教育研究プロジェクトの立上げを行うための準備活動を積極的に支援しており、2019年度から計画立案者に対する支援を行うために「新規教育研究プロジェクト準備経費」を策定し、公募を行っている。2022年度は以下の4件の課題を採択し、支援を行なった。

- 高度ミューオンX線分析による文理協力型新学術創出プロジェクト
- 量子ビーム治療における照射領域可視化システム構築の研究開発準備
- FAP（線維芽細胞活性化タンパク質）を標的とした新たな臨床研究プロジェクトの立ち上げに向けて
- 固体標的への超高強度レーザー照射による放射ガンマ線の計測技術の開発

本年度も大阪大学の部局間に限らず、理化学研究所、近畿大学、京都橘大学、量子科学技術研究開発機構、富山高等専門学校、福井県立病院、岐阜大学、東京大学と、研究所や病院からも技術者が参画しプロジェクトが推進された。

本取り組みは、放射線科学基盤機構の発展に留まらず、放射線科学関連分野の活性化に資する重要な活動の一つとして位置付け、今後も継続的な支援を行う予定である。次ページ以降に、採択された4件の課題の活動成果報告を載せる。

Fund for Preparation of New Education and Research Projects

高度ミューオンX線分析による文理協力型新学術創出プロジェクト

代表者 佐藤 朗（助教）[1]

参画研究者 二宮 和彦（准教授）[2], 寺田 健太郎（教授）[1], 中野 貴志（教授）[3], 友野 大（特任助教（常勤））[3], 上田 直弥（助教）[4], 髙橋 京子（招へい教授）[5], 新倉 潤（協力研究員）[6], 高浦 佳代子（講師）[7], 南 健太郎（准教授）[8]

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実績額 300,000 円

本学は、連続状ミューオンビーム施設「核物理研究センター MuSIC」を有し、研究代表者の佐藤、二宮を中心に連続状ミューオンを使った新しい学術領域の開拓を牽引する位置にあります。特にミューオンX線の分光測定については、本学の連続状ミューオンにより高精度かつ詳細な研究が実現可能で、様々な分野から発展が期待されています。非破壊かつ非接触で物質内部の元素組成や同位体比を分析出来るこの手法は、地球宇宙科学や考古学・文化財科学など破壊を伴う分析が許可されないような超貴重資料を扱う学術分野にも化学分析による研究手法を提供し、従来実現不可能であった客観的科学データによる新しい研究の創出へつながると注目を集めています。本プロジェクトでは、このような本学のミューオン科学の優位性を活かして、学術のみならず産業界も含めた文理協力の元に、大阪大学がリーダーシップを取って高度ミューオンX線分析を推し進める体制を構築して、新しい学術研究の創成を目指します。

本年度は、国内外ミューオン施設との連携体制の構築、ミューオンX線分析国際会議の開催、国内におけるミューオンX線分析の啓蒙と組織作りなどを進めました。

茨城県にあるパルスミューオン施設J-PARC-MUSEやスイスの連続ミューオン施設PSIにおいて、ミューオンを利用した元素分析法の基礎研究を実施し、特に元素の化学状態分析と同位体分析法の開発について成果がありました。小惑星探査機「はやぶさ2」がリュウグウから持ち帰った地球外サンプルに対するミューオン元素分析を2021年度にJ-PARC-MUSEで実施しましたが、そのデータ解析が完了し、結果を他の初期分析結果と共に科学雑誌Science上で発表しました。さらに、ミューオン位置測定装置とX線検出器を組み合わせたミューオンX線分析による3次元元素マッピング装置の開発を進めました。開発した装置をスイスPSIのミューオンビームラインに設置し、サンプル資料や隕石の3次元元素分布測定を実施しました。スイスPSIでは、博物資料、産業試料など様々なサンプルのミューオン元素分析を、我々阪大を中心としたグループとスイスグループが協力して進めています。この連携が発展し、阪大-KEKとスイスPSIグループが協力して応募した国際共同研究プログラム（JRPs）が採択され、2023年よりリチウムイオン電池や全固体電池などを対象とした高度ミューオン元素分析法を共同開発することとなりました。また、2023年3月には世界初のミューオンX線分析国際ワークショップを企画・開催し、国際的な研究協力体制の構築を進めました。

リュウグウサンプル初期分析の成果はプレスリリースを行い、マスコミでも大きく取り上げられました。この分析結果やミューオン元素分析の応用などについて、学会やセミナーでの専門家向けの講演を行っただけでなく、様々な形で一般向けのアウトリーチ活動を行い、ミューオン科学の啓蒙を進めました。

Fund for Preparation of New Education and Research Projects

量子ビーム治療における照射領域可視化システム構築の研究開発準備

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参画研究者 坂田 洞察（准教授）[1]，稲庭 拓（グループリーダー）[2]，増田 孝充（研究員）[2]，
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実績額 300,000 円

本研究では、粒子線を利用した量子ビーム治療における照射領域の観える化を目指したテーマにおいて、体内照射領域可視化画像を高品質で取得するシステムの構築を行うことである。患者体内の照射領域内で僅かに起こる原子核破砕反応より生成されるポジトロン放出核を情報因子とすることで体内の量子ビーム照射領域の可視化を行う。

2022年度の研究では、研究グループが開発した照射ターゲット中での生成ポジトロン放出核の強度分布（Activity分布）を計測することが可能なBeam ON-LINE PET system（BOLPs）を利用し、名古屋陽子線治療センターで供給可能な治療用エネルギーの陽子線を利用した実験を実施した。人体構成要素である炭素、酸素、カルシウムを含むゼラチン質の水、ポリエチレン、ウレタン、酸化カルシウムの照射ターゲットへの照射実験を行い、BOLPsによる計測データから、陽子線照射による炭素、酸素、カルシウム核からの陽電子放出核生成反応率の相関及び反応断面積の導出を実施した。また、モンテカルロ・シミュレーションコードであるPHITSを利用したBOLPsの陽子線照射実験場の数値シミュレーションを行った。実験データ及び解析より得られた成果の一つとして、陽子線治療において、人体中に含まれる炭素核とがん治療用の入射陽子の飛程近傍での反応が顕著となる、^{12}C(p,n)^{12}N反応による照射ターゲット中での^{12}Nの生成量分布の実験データを取得できた点である。この反応により生成される^{12}Nは、陽子線治療における可視化に伴う体内飛程推定に活用できるのではとの報告があったが、この^{12}Nの生成量分布を実験的に示したのでは世界初である。現在、専門の国際雑誌への投稿準備を進めているところである。また、2022年10月より、本研究を含んだテーマで大阪大学と住友重機械工業との共同研究を開始することができた。

今後は、2023年度から開始する科研費基盤Aを活用するなどして、陽子線を中心とした研究を遂行予定である。

Fund for Preparation of New Education and Research Projects

FAP（線維芽細胞活性化タンパク質）を標的とした新たな臨床研究プロジェクトの立ち上げに向けて

代表者 渡部 直史（助教）[1]

参画研究者 巽 光朗（准教授）[2], 白神 宜史（特任准教授）[3], 仲 定弘（薬剤師）[4]

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配分額 300,000 円

実績額 300,000 円

がんの浸潤・転移においては、がん細胞自身の性質に加えて、がん細胞と周囲組織（間質）との間で構成される微小環境が重要である。がんの間質は腫瘍全体の大部分を占めており、特にがん関連線維芽細胞（CAF: cancer associated fibroblast）はがんの増殖・進展に重要な役割を果たしていることがわかっている。CAFには膜タンパクである線維芽細胞活性化タンパク質（fibroblast activation protein：FAP）が発現しており、乳がん・大腸がん・膵がん・卵巣がん・肝細胞がん等の幅広いがん種での発現が確認されている。

今回、研究代表者と分担者の間で、FAPI-PETの実施および対象患者について、打ち合わせを行い、大型研究プロジェクトの応募のための予備的データの取得のために2022年6月よりFAPI-PET臨床研究を開始した。本臨床研究のデータを根拠データとして、今後の大型研究プロジェクトの計画を考える上での予備的データにすると共に、根拠データとして、大型研究プロジェクトへの応募を行った。

【活動内容】

1) 研究代表者と分担者の間で、FAPI-PETの実施および対象患者について、打ち合わせを行った。
2) 医学部附属病院 倫理審査委員会の承認を得て、阪大病院 核医学診療科において、患者より同意を取得し、FAPI-PET検査を実施した。
3) 肺癌や乳癌の患者を中心にFAPI-PET検査を実施し、既存のFDG-PETやCT検査と比べて、病変への集積程度や検出能について評価を行い、今後の大型研究プロジェクトの計画を考える上での予備的データにすると共に、予算申請を行う上での根拠データとした。
4) 研究代表者と分担者の間で打ち合わせを行い、大型研究プロジェクト（科研費基盤B、AMED次世代がん）への応募を行った。

Fund for Preparation of New Education and Research Projects

固体標的への超高強度レーザー照射による放射ガンマ線の計測技術の開発

代表者 民井 淳（教授）[1]

参画研究者 大田 晋輔（准教授）[1], 小林 信之（准教授）[1], 新名 嶺偉（博士前期課程２年）[1], 仲澤 和馬（招へい教員）[2], 西内 満美子（上席研究員）[3], 榊 泰直（上席研究員）[3], 川畑 貴裕（教授）[4], 古野 達也（助教）[4] 新倉 潤（助教）[5], 六條 宏紀（特任助教）[6]

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配分額 300,000 円

実績額 0 円

レーザープラズマの動的機構を理解するための診断技術開発およびレーザープラズマ内での原子核反応の証拠を得ることを目的に、これまでに測定されたことがないレーザープラズマからの放出ガンマ線の直接測定を可能にする技術を、原子核乾板（エマルション）を用いることで確立することが目的である。レーザープラズマの診断技術は世界的に活発に研究開発が進められている対象であるが、これまで放出ガンマ線が計測された例はない。また、レーザー照射場中の核反応の検出はレーザー爆縮核融合などごく一部の特殊条件下の例が存在するのみである。ガンマ線計測は、今後拡大が見込まれる超高集光エネルギー下でおきる粒子加速を調べるために重要な診断技術であり、核反応の定量的測定につながる。ガンマ線計測技術の確立は、今後の世界標準の技術を生み出すことになりインパクトが大きい。

本年度は2021年度に関西光科学研究所のJ-KAREN-Pレーザーを用いて行った開発実験のデータ解析を進める作業を行った。解析は大阪大学大学院に進学予定の学生（岩崎遼太）を中心として行っている。集光強度10^{21}W/cm^{2}で時間間隔30fsの高輝度パルスレーザーを厚さ5 μ mの銀薄膜標的に1ショット照射した。45度に傾けた標的の下流でビーム進行方向から10度の方向において、標的から1mの距離の真空槽外にエマルション検出器を設置した。エマルションは30 × 40mm^{2}を30枚重ねたスタックに、ビーム照射時のみさらに2枚を加えた構成とした。設置位置として、1枚スタックのエマルションを複数設置した予備実験によって放射線量が測定に適していると判断した位置を用いている。照射後のエマルションを岐阜大学に移送して、現像および顕微鏡による予備解析を行い、その後名古屋大学未来材料システム研究所の自動スキャンニング装置を用いてスキャンニングによりデータ化した。得られたデータの解析により、ガンマ線を起因とする電子・陽電子対生成の飛跡を4例確認している。発見された電子・陽電子の飛跡ゆらぎ解析により、検出したガンマ線のエネルギーを39,45,46,76MeVと推定している。ガンマ線の入射方向は、測定角度精度程度でおよそ標的方向を向いている。レーザープラズマからの放射ガンマ線の世界初の直接測定の可能性がある。真空槽において生成されたガンマ線である可能性を排除するためのシミュレーション作業を進めている。この成果の一部を、OPTO2020会議においてポスター（オンライン）発表した。現在投稿論文の作成を進めている。また、2023年度には観測状況をより明確にするために、エマルションを真空槽内に設置する測定を行う予定で準備作業を進めている。2022年度に関西光科学研究所にて実験を行う計画であったが、ビームタイムを実施できなかったため2023年度に行う方針とし、実験旅費として使用する予定であった採択予算全額を機構に返却した。

Division Summary

各部門の年度計画と活動実績の概要

大阪大学放射線科学基盤機構には、3つの部門と附属ラジオアイソトープ総合センターがあります。3つの部門は、放射線科学部門、放射線教育部門、放射線管理部門です。これらが役割分担しながら、放射線を用いる全部局と連携し、大阪大学全体の放射線科学を推進しています。この「アニュアルレポート2022」には、2022年度の活動実績の概要を部門ごとに載せ、活動実態をオープンにすることで、ご意見を承る資料とすることにしました。日本語での記載ですが、参考になれば幸いです。

放射線科学基盤機構
機構長　富山 憲幸

活動実績

放射線科学部門
Division of Science

部門概要

理学研究科、医学研究科、核物理研究センターとの部局間連携によりアルファ線核医学治療法開発プロジェクトを推進しています。2022年4月には、アルファフュージョン株式会社と共同研究講座「アスタチン創薬実用化共同研究部門」を設置し、アルファフュージョン社の人的リソースおよび資金の支援を得て、臨床研究、非臨床研究、開発研究を実施しました。また新たに歯学研究科との部局間連携研究を開始しました。

2022年度の活動報告

1. 難治性甲状腺がんを対象とする ^{211}At-NaAtの医師主導治験

医学部、医学部附属病院と連携して[^{211}At]NaAtを用いた第Ⅰ相医師主導治験を実施しました。大阪大学医学部附属病院核医学診療科において、治験薬GMP基準下でアスタチン化ナトリウム注射液（^{211}At-NaAt）の安定製造を行いました。第Ⅰ相医師主導治験について、5例目までの治験薬投与ならびに安全性評価を実施しました。

2. 前立腺がんを対象とする ^{211}At-PSMAの非臨床研究

前立腺特異的膜抗原（PSMA）を標的とする前立腺がん治療薬のスクリーニング研究を2021年度に続き実施し、開発候補化合物を選択しました。PMDA対面助言を行い、本化合物の非臨床試験のデータパッケージにつきPMDAの合意が得られました。医学部、医学部附属病院と連携して非臨床研究を開始しました。本技術の特許をPCT出願しました（PCT/JP2022-29283, 出願日：2022年7月29日、出願人：大阪大学）。

3. ^{211}At-FAPIに関する研究

がん間質に発現している線維芽細胞活性化たんぱく質 (FAP) を標的とする新規がん治療薬^{211}At-FAPIの合成を行い、抗腫瘍効果の評価を行いました。その結果、腫瘍の成長抑制が認められました。本技術は2023年2月21日にPCT出願しました（PCT/JP2023-00610）。

4. ^{211}At-金ナノ粒子の合成と抗腫瘍効果の評価

^{211}At-金ナノ粒子の腫瘍への直接投与、尾静脈投与、もしくは腹腔内投与によるがん治療について検討しました。C6 glioma移植ラットおよびPANC1移植マウスへの局所投与では、著しい腫瘍増殖抑制効果を示しました。歯学研究科と連携し、舌癌を対象にした研究を開始しました。がんモデルマウスにおいて、^{211}At-金ナノ粒子の尾静脈投与によっても、優れた抗腫瘍効果を示すことを確認しました。

5. L型アミノ酸トランスポーター（LAT1）基質を用いたα線核医学治療研究

腫瘍に選択的に発現するLAT1を標的とし、^{211}At-AAMTに次ぐ薬剤候補として、集積性・滞留性により優れたLAT1基質の開発研究を行い、製造・品質・生物試験を実施しました。

^{211}At標識-L-アルファメチル-O-メチルチロシン(L-^{211}At-AAMT-OMe)について、抗がん剤耐性株（ゲムシタビン耐性膵がん細胞）を用いた細胞を用いた動物モデルにおいて、優れた治療効果を認めました。

特許出願：発明の名称：放射標識されたチロシン誘導体およびその用途（特願2022-150608、出願日：2022年9月22日）

その他、バックアップ化合物について開発を行いました。

6. ^{211}Atの電解酸化標識法に関する研究

チロシンなどのハロゲン化フェノール含有化合物に対する、電解酸化によるAt標識法について検討しました。フロー電解装置を用い、N-アセチル-3-ヨードチロシンに^{211}Atを電解標識して^{211}At標識化チロシン誘導体を得ました。

7. ^{211}Atの光標識法に関する研究

ハロゲン化フェノール含有化合物に対する紫外光によるAt標識法について検討しました。

8. ^{211}At標識抗体に関する研究

^{211}At標識抗体の細胞傷害活性ならびに抗腫瘍活性について検討しました。^{211}Atリンカー核移行型の抗体の創成に成功し、従来のリンカーと比較してDNA二重鎖切断(DSB)活性の向上を確認しました。また、金ナノ粒子を導入した抗体について、DSB活性ならびに腫瘍集積性を評価しました。^{211}Atの部位特異的標識抗体についてはPCT出願を実施しました。(PCT/JP2022/035783)

9. 様々な新規モダリティーに関する研究

腫瘍への送達および細胞内在化能が優れた新規モダリティー(中分子・ペプチドなどの様々な化合物群)について、フローサイトメトリーおよびライブセルイメージングによる内在化解析、DSB活性を行い、複数の新規標的医薬候補を見出しました。

10. 新規ベータ線治療核種^{47}Scの研究開発

新規ベータ線治療核種^{47}Scについて、東北大学電子光理学研究センターで^{47}Scの製造と分離精製を実施し、いくつかの標識化合物について標識条件の検討を行いました。

11. その他

令和4年度から核物理研究センターの更新したAVFサイクロトロンを用いて^{211}At製造供給を開始しました。

活動実績

放射線教育部門
Division of Education

部門概要

本部門では、全学の放射線教育ならびに人材育成を進めています。学部および大学院での部局横断的な放射線教育プログラムの開発を行い、展開していくことにより、大学初年次からの放射線教育を充実させ、様々な分野で活躍できる人材育成を目指しています。また、国際交流を通じて、国際的な放射線教育ならびに人材育成の拠点を構築していきます。

2022 年度の活動報告

以下、本部門が行った2022年度の活動について報告をします。

1. 部局を跨がる教育プログラムとして大学院等高度副プログラムを提供しました。当機構が主体となり、核物理研究センター、医学研究科および理学研究科の協力のもと実施している「放射線科学」です。今後、更に多くの部局の協力を得て、分野横断的な教育プログラムへと充実させていく予定で2023年度開講のための科目の編成見直しを行い、プログラム名も「共創的放射線教育プログラム（CREPE）」に変更しました。工学研究科からも科目が提供されています。大学院生用のCREPEは2023年度開講予定で採択をされました。

2. 2020年度に採択された原子力規制人材育成事業「社会との共創による原子力規制人材育成プログラム」（2020年度～ 2024年度）について、2022年度分の事業を行いました。本事業では、核物理研究センター、安全衛生管理部ならびに全学教育推進機構の協力を得て、福島県浜通り地区での環境放射線研修会を中心とした共創的放射線教育プログラム（CREPE）を前年度に引き続き開講しました。2022年度には履修者は30名になり、うち7名が2023年3月にプログラムを修了しました。修了者の発表状況から鑑みますと、大変優秀な学生が育っている印象です。このCREPEプログラムの広報のため、ホームページ（https://www.rcnp.osaka-u.ac.jp/crepe/）並びにパンフレットを改訂・作成をしました。6月11日に開催された

「大阪大学共創DAY@EXPOCITY」にて、CREPE履修生がポスター展示を行いました。このイベントではCREPE履修学生が福島での活動について一般の方に紹介しました。また、CREPEの中心的な科目である福島県浜通り地区環境放射線研修会に放射線教育部門として参画しました。7月の土曜日を利用して、環境放射線の現地研修を控えた事前講義を3日に渡り行い、8月21日～26日（5泊6日）と9月18～23日（5泊6日）の2回に分けて、福島県浜通り地区において環境放射線の現地研修を行いました。参加者学生が他大学含めて123名に増えました。本研修会の成果は8月29日と9月26日に大阪大学豊中キャンパスにおいて開催された研修の最終討論会において学生により発表されました。8月の研修会では、教育担当の田中理事に視察をいただき、高い評価を得ることができました。

3. 2022年度も、全学共通教育科目として「【総合】放射線の自然科学、社会学、人文学」を開講しました。20名の履修登録があり、そのうち14名が合格しました。今回は大学院生の履修も可能とし、1名が履修しました。また、2022年度も、原子力規制庁から講師を招き講義を行ってもらい、履修学生に大変好評でした。

4. 学問への扉「身の回りの放射線の科学」を機構として実施しました。履修登録者数は17名でした。本プログラムに関して1名の大学院生がTAを行いました。

5. 2022年度は、JSTさくらサイエンスプログラム9月を福島県浜通り地区環境放射線研修会に合わせて実施しました。

6. 2月にグローニンゲン大学にCREPE履修の学部学生2名を派遣して国際シンポジウムを開催しました。（https://www.osaka-u.ac.jp/ja/news/topics/2023/04/03001）

7. 「多様な知の協奏による先導的量子ビーム応用卓越大学院プログラム」に、放射線教育部門として参画しました。また、理工情報系オナー大学院プログラムや次世代挑戦的研究者育成プロジェクトにも教育部門として、運営の面で貢献しました。

活動実績

放射線管理部門
Division of Safety Management

部門概要

本部門では、学内の放射線施設及び核燃料物質使用施設と連携、放射線安全管理に関する事項を総合調整し、全学の放射線管理を総括する業務を行っています。また、緊急時、事故時には、本機構に属する教職員が事態収拾やその際の情報提供に対して応援及び協力することで、学内の放射線施設が一体となってリスク管理を行う体制を構築しています。

2022 年度の活動報告

以下、本部門が行った今年度の活動について報告をします。

1. 放射線取扱主任者の免状取得への援助

放射線取扱主任者の免状取得奨励のために、2022年度に学内放射線施設の主任者又は主任者の代理者になる予定の者を対象に、第1種放射線取扱主任者講習の受講料と旅費の援助を募集し、計2名に援助しました。

2. 学内放射線施設自主安全・管理点検活動への協力

原子力研究・安全委員会放射線安全管理部会が行う学内放射線施設自主安全・管理点検活動では、各放射線施設が自己点検を行う年度、及び自己点検に加えて点検委員が各施設を点検する年度を交互におこなっています。2022年度は、点検委員が各施設を点検する年度でした。各施設が自己点検をした後、10月に点検委員及び各施設の管理担当者による会議(第1回)を開催し点検内容を確認しました。11月～12月にかけて点検委員が各施設を訪問し点検を実施しました。各施設の点検結果については、2月に会議(第2回)を行い、各施設で情報共有しました。これらの点検の報告については冊子にとりまとめ、年度末に安全衛生管理室を通じて大学本部及び関係部局、関係者に配付しました。

活動実績

ラジオアイソトープ総合センター
Radioisotope Research Center

部門概要

ラジオアイソトープ総合センター（RI総合センター）は、放射線業務従事者への安全教育を行うとともに各種放射線実験設備を整備し、各部局の共同利用に供すること、全学的放射線安全管理とこれに関連した研究を実施することを目的としています。

2022年度の活動報告

以下、本センターが行った今年度の活動について報告をします。

1. 安全管理・放射線教育訓練に関する業務

学内13の非密封放射性同位元素を使用する施設の179作業室の作業環境測定を計画通りに実施しました。また、放射線総合管理システム（登録者数: 3,444名、抹消者を含んだ登録者数：27,091名）の管理運用を行いました。放射性同位元素等の規制に関する法律で規定されている放射線教育訓練について、今年度は授業支援システム（CLE）を活用し、配信によって計15回（1,921名）を開催しました。

2. 放射線教育に関する業務

安全教育事業の一つとして、放射線取扱主任者試験の受験を奨励し、対策講座についてCLEを利用してオンラインで7回実施し、受験申込書を配付しました。対策講座を受講した者は32名でした。豊中消防局への放射線教育の一環として、消防局職員15名に豊中分館の見学を実施しました。

3. RIセンター施設の共同利用

共同利用については、利用状況に応じて実験室等の専有状況を随時見直し、効率的に共同利用に供しています。今年度の共同利用申請件数は53件、利用者数は616名でした。

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