Nishina School 2019

H. Ishiyama,[*1] T. Motobayashi,[*1] and H. Ueno[*2]

Nishina School aims at introducing nuclear physics research to Asian university students who are choosing their future field of study. In 2019, the 13th Nishina School was held from July 30 to August 9. This period was made slightly later than usual to make it easier for Japanese students to participate after their term-end examinations. Students and supervisors from Peking University (PKU), the University of Hong Kong (HKU), Seoul National University, Rikkyo University, and Tohoku University joined Nishina School this year. High-school students from Philips Exeter Academy, USA, along with their teacher, participated in most of the School programs. Figure 1 shows all 22 students and School staff members.

The School began with self-introductions of the students. The first week was dedicated mostly to lectures and training on a few subjects related to a nuclear reaction experiment that was performed in the second week of the School. The lectures were on a few basic topics for research, including overviews of nuclear physics and nuclear astrophysics, as well as methods of radiation measurements. Another lecture was dedicated to radiation safety. The training subjects were electronic-pulse propagation and radiation detection. The training covered the detectors, electronics, and data acquisition system to be used in the experiment in the following week.

The program in the second week focused on a reaction experiment using proton beams from the Pelletron accelerator at RIKEN Nishina Center. The students were divided into six groups, which oversaw six different types of measurements. They started to design the experiment by evaluating the feasibility of measurements (*i.e.*, estimation of γ-ray yields, etc.), following which they set the detectors around the reaction target and determined the conditions of beam exposure based on their considerations. After the experiment, they analyzed the experimental data obtained and finally made presentations on their results. They studied the low-energy ^{12}C$(p,\gamma)^{13}$N or ^{10}B$(p,\alpha)^{7}$Be reaction, which are related to nucleosynthesis in stars.

Fig. 1. Participants of Nishina School 2019.

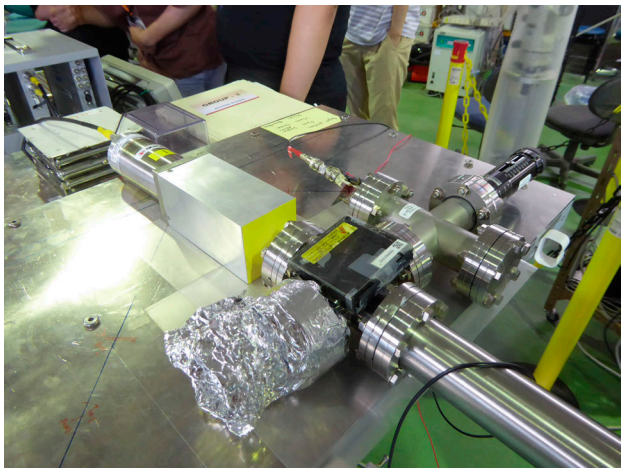

Fig. 2. Photograph of the experimental apparatus. The ^{12}C or BN target in the vacuum pipe at the center of photograph was irradiated with proton beams from the Pelletron accelerator. The NaI detector at upper side of the photograph detected γ-rays generated by the reactions.

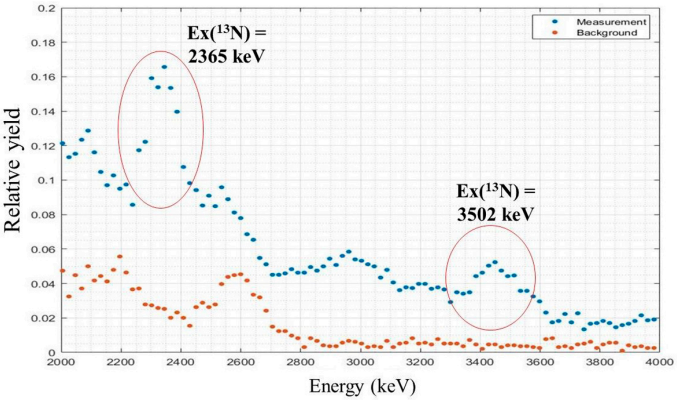

Fig. 3. Example of the γ-ray spectra obtained for the "in-beam" measurement of the ^{12}C$(p,\gamma)^{13}$N reaction with a 2-MeV proton beam.

Figure 2 shows the experimental apparatus. Proton beams with an energy of 1 or 2 MeV bombarded a carbon or boron nitride target, which stopped the protons to provide a so-called thick target yield of those reactions. Two methods were employed to determine the resonance yield: the detection of "in-beam" γ-rays from ^{13}N or ^{7}Be excited states and the detection of 511-keV γ-rays from the β^+ decay of ^{13}N or ^{7}Be activities, which is known as the "activation" technique. Figure 3 shows an example of the obtained γ-ray spectrum for the "in-beam" measurement of the ^{12}C$(p,\gamma)^{13}$N reaction. Two distinct peaks of relevance in the experiment are clearly observed. The six teams could finally extract the reaction cross sections.

We thank all the staff members of the Nishina Center who participated and helped in Nishina School 2019.

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Creation of superheavy elements highlighted at the closing ceremony of IYPT 2019†

H. En'yo,*1

The year, 2019 was the International Year of the Periodic Table (IYPT). It marked the celebration of the 150th anniversary of Mendeleev's periodic table and the completion of the 7th row of the table. The opening ceremony took place on January 29th at the UNESCO HQ in Paris, and the closing ceremony took place on December 5th at the Tokyo Prince Hotel. The closing ceremony was hosted by the Chemical Society of Japan, Science Council of Japan, and RIKEN on behalf of UNESCO, IUPAC, and IUPAP.

The closing ceremony included an impressive list of exhibitions and sessions; it started with an opening session, followed by sessions titled "Introduction of IYPT activities" and "Discoveries and Creation of elements," and ended with a session titled "Periodic Table for Next Generations." The event also had musical performances, including one by an orchestra comprised of Japanese chemists. The entire program was recorded and can be viewed on the web page of IYPT of Japan.[1)]

An important session for Nishina Center was the "Creation of Superheavy Elements," which started with the piano fantasy "Nihonium" played by a high school student Honoka Motai. Miss Motai is so devoted to the periodic table that the discovery of nihonium inspired her to compose the music she performed. Her beautiful music was accompanied by a screen showing the landscape of Nihonium Avenue stretching from Wako City Station to RIKEN.[2)] This avenue is a "walk of fame" of about 15 min for the 118 elements from hydrogen to oganesson, which are displayed in paving stones and lead to the entrance of RIKEN, where a large monument dedicated to nihonium is installed.

After the piano performance, celebrated speeches were given with institutional introductory movies. This included Victor Matveev for the Joint Institute for Nuclear Research, Karlheinz Langanke for GSI Helmholtzzentrum für Schwerionenforschung, Roderick Clark for Lawrence Berkeley National Laboratory, Mark Stoyer for Lawrence Livermore National Laboratory, Krzysztof Rykaczewski for Oak Ridge National Laboratory, Kosuke Morita for RIKEN Nishina Center, and a final speech given by Yuri Oganessian representing all the discoverers. Lastly, the boards of 15 superheavy elements from Rf ($Z = 104$) to Og ($Z = 118$) are shown in line by M. Itkis (JINR), V. Matveev (JINR), R. Clark (LBNL), A. Yakushev (GSI), C. Duellmann (GSI, JGUM), M. Block (GSI, JGUM), K. Langanke (GSI), D. Ackermann (GANIL), J. Khuyagbaatar (GSI), M. Honoka (Tokyo Gakugei University Senior High School) with K. Morimoto (RIKEN), S. Dmitriev (FLNR, JINR), V. Utyonkov (FLNR, JINR), M. Stoyer (LLNL), K. Rykaczewski (ORNL), and A. Karpov (FLNR, JINR), respectively.

These scientists had participated in both this ceremony and the 4th International Symposium on Superheavy Elements (SHE2019), held from 1–5 December at Hakone. H. Haba (RIKEN) and K. Morita (Kyushu-U, RIKEN) jointly chaired the symposium.

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1) https://iypt.jp/.
2) The video was created by N. Miya-uchi, RIKEN Nishina Center, and can be obtained upon request.

Fig. 1. The boards of 15 superheavy elements from Rf to Og displayed by discoverers.

† Condensed from the article in Nucl. Phys. News **30**, 1 (2020)

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The 3rd "Hodan-kai" meeting for the future of exotic nuclear physics

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The third "Hodan-kai" meeting by young researchers was held from February 19 to 21, 2020 at the Integrated Innovation Building in Kobe campus of RIKEN, which is the same venue as for the previous Hodan-kai meetings. This Hodan-kai was the third in the meeting series organized by RIBF Theory Forum and RIKEN Nishina Center, and supported by RIKEN iTHEMS and JICFuS. The style of Hodan-kai is different from that of an ordinary workshop in which recent research works are presented by the respective research groups. This meeting aims to facilitate the exchange of new ideas among young researchers, including unmatured ideas and dreams that are not feasible at present. Given the spirit of the meeting, the presentation files are disclosed to the public. Furthermore, the venue is located in a rather isolated place, which enables participants to concentrate on physics discussions. The meeting always exceeds the scheduled time owing to passionate discussions among the participants.

The first Hodan-kai was held from July 21 to August 2, 2017, and focused mainly on the latest theoretical research on nuclear physics. The number of participants was 49 with 23 presentations. The second meeting was held from February 18 to 20, 2019 and had 42 participants. While limiting the number of presentations to 25, the topic was extended: 6 presentations were made by theoretical nuclear physicists, 7 presentations by experimental nuclear physicists, and 12 presentations by researchers in other fields that may closely be related to nuclear physics. The program and summary of the first and second Hodan-kai were shared on their respective websites.[1,2)]

Fig. 1. Group photograph of the 3rd "Hodan-kai" meeting.

Fig. 2. Photograph of a panel discussion.

In the third Hodan-kai, we had 43 participants and 17 presentations by young researchers including 6 and 7 presentations by theoretical and experimental nuclear physicists, respectively, and 4 presentations by researchers in other fields. In addition to these talks given in the regular Hodan-kai style, we newly organized two "panel discussion" sections to facilitate interaction among the participants. In the panel discussions, introductory talks on "New textbook for nuclear physics" and "What is cooling?" were given by the organizers, and 5–7 short talks were given by invited panelists. Though, as always, these exciting discussions easily exceeded the scheduled time, the meeting ended sucessfully while keeping the spirit of Hodan-kai. The full program and summary of the third Hodan-kai can be found on its website.[3)] Figures 1 and 2 show some snapshots of the 3rd Hodan-kai. Attracting more students to this meeting is one of the key ingredients for the success of "Hodan-kai." We plan to hold the next Hodan-kai in February 2021 and look forward to having more participants.

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1) 1st Hodan-kai: https://indico2.riken.jp/event/2509/.
2) 2nd Hodan-kai: https://indico2.riken.jp/event/2864/.
3) 3rd Hodan-kai: https://indico2.riken.jp/event/3157/.

SHE2019—The 4th International Symposium on Superheavy Elements

H. Haba on behalf of the SHE2019 Local Organizing Committee*1

The 4th International Symposium on Superheavy Elements (SHE2019) was held on December 1–5, 2019 at The Prince Hakone Lake Ashinoko in Hakone, Japan. Hakone is close to Tokyo, situated at the foot of Mount Fuji, and one of the most popular travel destinations among Japanese and foreign tourists. SHE2019 followed the previous symposiums at Texas A&M University, USA in 2013 and 2015 and Kazimierz Dolny, Poland in 2017. This symposium was jointly organized by the RIKEN Nishina Center, Research Center for Superheavy Elements, Kyushu University, and Advanced Science Research Center, Japan Atomic Energy Agency. It had 130 registrants from 16 countries. There were 2 plenary, 33 invited, and 27 oral talks, as well as 14 poster presentations.

SHE2019 covered all theoretical and experimental aspects of superheavy nuclei and atoms. SHE2019 started with two plenary talks titled "SHE2019 Symposium: experimental challenges" by Y. Oganessian and "Superheavy elements: theoretical challenge" by W. Nazarewicz of Michigan State University, USA on the evening of December 1. From the morning of December 2 till the evening of December 4, the following scientific sessions were conducted: 1) Reaction of Synthesis of the Heaviest and Neutron-rich Nuclei; 2) Status and Short-term Plans at SHE Facilities; 3) Nucleosynthesis of SHE and Search in Nature; 4) Properties and Structure of the SHN; and Decays, 5) Heavy Atoms and Chemistry of SHE; 6) New Approaches and Setups; and 7) New Facilities, Setups, and Instrumentations. On the evening of December 2–4, Young Scientists sessions were held to give young scientists as many opportunities for oral presentation as possible.

The excursion of SHE2019 was conducted in the afternoon on December 4. The participants visited Hakone Lake to enjoy the scenery, Hakone Sekisho (checkpoint) to experience the history, and Hakone Shrine to explore the local culture and religion.

The year 2019 marked the 150th anniversary of the discovery of the periodicity of chemical elements by Dmitrij Ivanovich Mendelejev. Thus, the United Nations and UNESCO proclaimed 2019 as the "International Year of the Periodic Table of Chemical Elements (IYPT2019)." The Closing Ceremony of IYPT was held at The Tokyo Prince Hotel in Tokyo, Japan on December 5th, immediately after SHE2019. Most of the SHE2019 participants joined the Closing Ceremony of IYPT and celebrated the discoveries of elements 113, 115, 117, and 118—nihonium (Nh), moscovium (Mc), tennessine (Ts), and oganesson (Og), respectively—and the completion of the 7th period of the periodic table.

Fig. 1. Conference photo taken at a garden of The Prince Hakone Lake Ashinoko on December 4, 2019 (©Hideto En'yo).

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RIKEN Symposium "Trends in ion-beam breeding over the last two decades and future research"

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The RIKEN Symposium on "Trends in ion-beam breeding over the last two decades and future research" was held on 23–24 Jan. 2020 at the RIKEN Wako Campus. It was the 9th RARF/RIBF User's Meeting on Biology, which is held once every two years. The Beam Mutagenesis Group promotes various life-science applications of ion beams from the RI Beam Factory. In particular, this group develops new techniques to breed plants and microbes with the use of heavy-ion irradiation. We started collaborations with flower companies and public agricultural experimental stations in 1996 to investigate the potential uses of heavy-ion beams in applied plant breeding. As a result, two new flower varieties were obtained from irradiated samples in 1998. The former is a dahlia having large flowers and a novel color, and it has been sold in Hiroshima City since the autumn of 2001.[1] The latter is a verbena, which is sterile, generating no seeds; produces flowers with a prolonged lifespan; and has been marketed since the spring of 2002.[2] We formed a consortium for ion-beam breeding. In 2019, it consisted of 184 domestic and 20 overseas user institutions. We have already produced 34 new plant varieties. This meeting was first convened in Jan. 2003 to spread ion-beam breeding technology, and it consisted of practical research, biology, and special lectures. Practical research is classified into research on flowers, food crops, microbes, and environmental-improving plants such as trees and moss depending on the irradiation samples. Figure 1 shows the change in the numbers of participants categorized by their specialization. The number of flower breeders has decreased since the early meetings. We found that ions with higher LETs, such as Fe, are effective for the mutation breeding of microbes.[3] Two new yeast strains created in 2010 are currently used by over 20 breweries to produce high-quality sake in Japan.[4] The number of microbe breeders has increased since 2011. NEXT and SIP programs were started from 2010 and 2014, respectively. We have been investigating the effects of LETs ranging from 23 to 640 keV/μm on mutation induction. The highest mutation rate was observed at an LET of 30 keV/μm (LETmax) in *Arabidopsis thaliana*[5] and rice.[6] The majority of mutations caused by LETmax irradiation were small deletions that were sufficient to disrupt a single gene.[7] We have been using high- throughput DNA sequencing technologies to analyze gene mutations. An increasing number of biologists have shown that mutants induced by LETmax irradiation have become more useful and important in modern genetic studies, enabling the discovery of genes.[8,9]

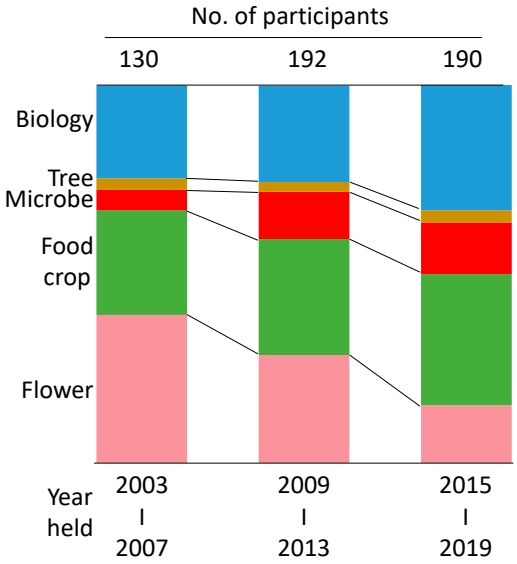

Fig. 1. Changes in the specializations of symposium participants from 2003 to 2019.

The symposium began with the history over the last two decades of biology and practical research on flowers and food crops. In a special issue, Dr. Kang, who belongs to ARTI and KAERI and is the President of the Korean Society of Breeding Science, introduced "Current status and future prospect of mutation breeding research in Korea." The next session was on the results of breeding microbe such as *Tricholoma matsutake*, baker's yeast, and microalgae. Finally, we discussed avenues for research on biology and ion-beam breeding in the next decade. The targets of heavy-ion breeding have extended from flowers to crops such as grains and beans, which will contribute to solving the global problems of food supply and environmental stress. The next meeting will be held in Jan. 2022.

*1 RIKEN Nishina Center

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RIKEN Open Day 2019

H. Haba*1 and K. Takahashi*1

RIKEN Open Day, on which many laboratories showcase their research activities and attractive experimental devices to the public, was held in the RIKEN Wako campus on April 20, 2019. In the Nishina Center, 17 research groups comprising more than 200 researchers participated in the event, as listed in Table 1. The cover page of the leaflet that introduced the exhibition content in the Nishina Center is shown in Fig. 1. The radiation controlled area in the RIBF building was opened to the public to display the world's largest superconducting cyclotron SRC, the in-flight RI separator BigRIPS, and other powerful experimental devices, along with the exhibition laboratories.

The year 2019 marked the 150th anniversary of the discovery of the periodicity of chemical elements by Dimitry Mendeleev. Thus, the United Nations and UNESCO proclaimed 2019 as the "International Year of the Periodic Table of Chemical Elements." Dr. Kosuke Morita, the director of the Superheavy Element Research Group, gave a scientific lecture titled "In search of further new elements" at the Suzuki Umetaro Hall. He presented the discovery of element 113, nihonium, and the research plan for the next new element, element 119, at RIBF. The weather on the open day was very pleasant. A total of 8,253 visitors came to the RIKEN Wako Campus. Among them, 3,013 visited RIBF.

Fig. 1. Cover of the leaflet provided by the Nishina Center for RIKEN Open Day 2019.

Table 1. List of the Nishina Center exhibitions on RIKEN Open Day 2019.

Laboratory / Group / Team	Exhibition theme	Number of staff
Accelerator Group	The World's Strongest Superconducting Ring Cyclotron	35
SLOWRI Team	Ion Trap and Ultra-Slow RI Production	4
BigRIPS Team	Superconducting RI Beam Separator BigRIPS	11
Rare RI-Ring Team	Precision Mass Measurement in 1 ms	8
Spin isospin Laboratory	Microscopes for Unstable Nuclei	13
SAMURAI Team	SAMURAI Magnetic Spectrometer	6
Nuclear Spectroscopy Laboratory	Tiny Magnets in Materials	12
Radioactive Isotope Physics Laboratory	Study on Origin of Elements at RIBF	9
	Glass Marble Shooting	10
Nishina Center	Nuclear Chart with LEGO Block	7
Nuclear Chemistry Research Team	Familiar RI and Useful RI	6
Ion Beam Breeding Team	Creating Amazing Plants	15
Superheavy Element Research Group	The Discovery of the New Element "Nihonium"	12
User Liaison Group	Let's Make Your Nihonium	7
SCRIT Team	Handmade Spectrometer	7
Radiation Laboratory	See Radiation with Diffusion Cloud Chamber	11
	Enjoy Spinning a Variety of Tops	
	Research Activities in the Experimental Hadron Physics	
Quantum Hadron Physics Laboratory	Elementary Particles, Nuclei and the Universe	13
High Energy Astrophysics Laboratory	In Space Now	40

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Outreach activities outside the Wako campus

N. Miyauchi*1

The year 2019 marks the 150th anniversary of the discovery of Mendeleev's periodic law. Further, in 2016, the names of the four elements up to the 118th, including the 113th element nihonium, were finalized, and the 7th period of the periodic table was completed. To commemorate these events, the United Nations General Assembly and UNESCO declared 2019 as the International Year of Periodic Table (IYPT2019). Accordingly, various events related to the periodic table were held globally. In Japan, "the Japan Chemical Society, International Year of Periodic Table 2019 Executive Committee" organized special traveling exhibitions at about 20 locations across the country to familiarize people with the periodic table. The User Liaison Group held workshops at two locations in these traveling exhibitions.

JST Science Agora in Daiba, Tokyo on Nov. 16–17

The workshop aimed to build a model of the 113th element, nihonium. The first workshop was held at a traveling exhibition booth organized by the Executive Committee of the International Periodic Table at the Science Agora[1] venue on November 16 and 17, 2019 (the Science Agora itself was held for three days, from November 15 to 17). Specifically, we asked participants to make a three-dimensional nihonium model using small beads, which are a children's toy, and helped them gain an understanding of the nucleus and how nihonium was discovered. Although the nucleus is never visible to the naked eye, the workshop was an attempt to make people feel the existence of the nucleus by making a model using the actual number of protons and neutrons.

This time, owing to the limited size of our booth, only a few participants could be taught by a researcher. As a result, the total number of participants was only 44 over two days. Although the workshop had the disadvantage of not being able to handle a large number of people, it was well received because the participants were able to talk with actual researchers owing to the face-to-face seating style.

Ehime Prefectural Science Museum on Jan. 18–19

The next nihonium workshop was held at another traveling exhibition booth organized by the Executive Committee at the Ehime Prefectural Science Museum[2] on January 18 and 19, 2020 (we were invited for two days to the traveling exhibition that was conducted from December 14, 2019 to January 26, 2020). The workshop was a great success because Mr. Yoji Hisamatsu (of this Science Museum), who directed all the traveling exhibitions, took care of us. More than 100 participants made their own models of nihonium over the two days of the workshop.

Fig. 1. Workshop to make a nihonium model using small beads.

Fig. 2. Brief lecture on atomic nuclei and nihonium.

RIKEN Osaka Campus Open Day 2019

Apart from the above two traveling exhibitions, we participated in the open house of RIKEN's Osaka campus on November 23, 2019. Various RIKEN Centers from all over Japan also participated in the event to introduce their research to people in the Osaka area. We introduced research at the RNC by using a small 3D nuclear chart produced by a 3D printer, in addition to poster panels. We had a large audience including children. The exhibition was very successful.

References

1) https://www.jst.go.jp/sis/scienceagora/en/reports/2019/.
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*1 RIKEN Nishina Center