Report of

The 2nd RIKEN Center for Advanced Photonics Advisory Council

(RAPAC2016)

August 2016

Committee Members

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I. General aspects

The RIKEN Center for Advanced Photonics (RAP) is a very active research center, covering broad fields from science to engineering with focus on photonics and biology. RAP has been producing many excellent research outcomes since its establishment in 2013. In the Second term (FY2018-2022), we think that it is better for RAP to continue and strengthen the present structure so that the high-level research that is being formed in RAP is further developed to the world's highest level. Since RAP is directed towards strengthening interdisciplinary activities, it will take important roles in RIKEN to develop new fields.

II. Report on RAPAC2016 Terms of Reference

1. Does RAP possess research achievements and human resources that meet international standards, produce world-leading research in its field, and engage in research that contributes to society?
Also, elucidate RAP's standing within its field, and strengths and weakness with respect to its areas of focus (sub-themes). Please also advise on RAP's future plans for RIKEN's fourth 5-year term.

- The research activity of RAP is focused on pushing the frontier of science in photonics and biology, and also on contribution to society through advanced engineering in photonics. RAP is unique among other institutions on laser science worldwide, covering very broad fields, from photon source development to applications in science, engineering and industry.
- The scientific research at RAP meets international standards, and actually lead the world in several research fields as described in 2-2), with high fraction of highly cited papers: 20 and 18 % for top 10% and 2.4 and 1.8 % for top 1%, in 2014 and 2015, respectively.
- RAP attaches importance to contribution to society, especially at the engineering-oriented research teams. For example, various methods developed at the Image Processing Research Team are used in many projects in RAP, RIKEN, other institutions and industry in Japan. Also the Advanced Photonics Technology Development Group is making vital contributions to important scientific projects as described in 3.
- The scientific and technical staffs at RAP, which have accomplished high level scientific and engineering developments, well meet international standards.
- The strength of RAP is that unique outcome will be created through close collaboration between the research teams working on different fields at very high levels, with good

mixing of science and technology. In this respect, RAP has been successful in forming very competitive teams, by recruiting active scientists in RIKEN and from other organizations. Collaboration between the RAP teams is taking place on several subjects, and it is expected that collaborations within RAP, RIKEN and other organizations will expand since the team leaders are very much aware of the importance of this approach.

- The weakness of this approach is that it is difficult to expand the teams to larger scales, even if the research outcome and social impact of a RAP team are very high, limiting them from intensively competing with major institutes worldwide which are more focused on specific subjects. We think, in this case, it is necessary to make a decision for RAP to support the team for expanding in RIKEN and/or forming consortium with other organizations in order to take a lead on the important subject.
- RAP proposes for its Second term (FY2018-FY2022) to form a new group "Advanced Bioimaging Research Group" by combining the existing 4 teams in the Extreme Photonics Research Group. We think this plan to be very timely, since the core members of this new Group are already working with other teams in RIKEN on "4-D Measurements for Multilayered Cellular Dynamics" as the RIKEN President's Fund Project 2013-2018, and this new Group will become the core organization in RIKEN to further strengthen this important research field.
- RAP also proposes to start 2 new teams on "Quantum Optoelectronics" and "Ultrafast Laser Manufacturing" in the Extreme Photonics Research Group. (The latter is reorganized from the existing team.) This action will help broadening the scope and updating the RAP research fields.
- We think that it is important for RIKEN to continue the medium size laboratories in order to distinguish RIKEN from universities. In this respect, it is better to make the active research teams stronger, rather than starting new research groups and teams.

2. Are RAP's undertakings in line with the initiatives noted below and the intended results being achieved? Does the AC have recommendations on any new strategies that RAP should implement?

2-1) Pioneer a research management model for maximizing research and development results.

- The RAP center is managed by the Director without putting much pressure on the researchers for short term outcome, considering that the researchers are driven internally by the curiosity on new scientific and/or technical fields. Smooth communication within RAP is stressed to manage the teams with diverse directions, by holding the PI meetings frequently and the whole RAP gathering at Sendai every year. This management style, which is in accordance with the good RIKEN tradition, appears working quite well, with the Director receiving respect from the PIs who are aware of the responsibility for producing outcomes by their own initiatives. We hope that truly innovative findings will emerge from this free environment.

- The RAP budget is composed of 36 % internal and 64 % external funds. Although this appears to be a good situation from financial aspect, extensive dependence on external funds should be moderated since it may lead to weakening the research with long term scopes. Also the active researchers are exhausted in many paper works associated with the application and implementation. It is necessary on the management side to seriously think of the ways to reduce these works in order to maximize the productivities of the researchers. It is important to increase the internal fund in order to keep the stability of the research by hiring the research staffs with this stable fund.

2-2) Lead the world in preeminent research and development achieved through scientific excellence.

- The Attosecond Science Research Team is one of the major groups in the world on ultrafast science with their state-of-the-art work on producing intense attosecond pulses, demonstrating the attosecond pump – attosecond probe spectroscopy for the first time. The team is further extending their approach to produce single-period light pulses and arbitrary shaped light fields, allowing them to control the very fast processes that they initiate.
- The Space-Time Engineering Research Team is at the forefront of the optical clock development in the world. They have demonstrated that the cryogenic optical lattice clocks they have developed have an accuracy of 5×10^{-18}, making the optical lattice clocks as one of the promising candidates for the future redefinition of SI second. This team is developing optical lattice clocks with even higher precision and accuracy, with the objective to make these clocks useful to monitor gravitational potential that might lead to predicting earthquakes in future. Dr. Katori, the team leader, is making a big effort to disseminate information and knowledge with strong vision for the future.
- The Ultrafast Spectroscopy Research Team has developed innovative spectroscopic techniques and revealed ultrafast dynamics in various environments, making RIKEN visible internationally in the ultrafast spectroscopy community. We hope the team will encounter a new unexpected finding that will lead to a real breakthrough by continuing to challenge new observations.
- The two RAP research teams in biology are engaged in world standard works. The Live Cell

Super-Resolution Imaging Research Team and Biotechnological Optics Research Team have made remarkable advances on technology development and scientific research in super-resolution live imaging microscopy and genetically encoded probes, respectively. They will take even more important roles in bio-photonics, which is a rapidly expanding field as shown by the Nobel Prize in Chemistry in 2014.

- The Terahertz-wave Research Group in Sendai is working at the forefront of THz research since its beginning, and is respected by the THz community. The realization of widely tunable and high power pulsed THz sources as well as the investigation of sensitive THz detection methods using nonlinear optical methods are very competitive on an international level. The GaAs-based and GaN-based QCLs developed at the Terahertz Quantum Device Research Team by overcoming various technical difficulties are world leading and very promising for the future of THz application in the real world.

2-3) Become a hub for science and technology innovation.

- RAP is collaborating with many Centers in the RIKEN President's Fund Project "4D Measurements for Multilayered Cellular Dynamics", with the RAP members acting as the Leader and the Vice Leader. Since RAP has many leading specialists in this rapidly advancing field of optical technology in biology, the new "Advanced Bioimaging Research Group" in RAP will make significant contribution to RIKEN for strengthening the biology and medical research in RIKEN.
- The RAP-Topcon Collaborative Program is a very important action for transforming RIKEN into a hub for S&T innovation, since this program is based on the strong trust of the company in RIKEN on developing R&D of advanced technologies in the company. This program is important as a new scheme to foster young scientists and engineers in industry to make them backbone leaders in the companies, and also for hiring post-docs of academic scopes with company funds.
- RAP is taking part in the RIKEN-AIST Joint Research Program "Innovation Core for Quantum Technology" started in 2015. It is hoped that this joint program will contribute to forming collaboration with universities, government laboratories and industry on R&D of nation-wide important issues.

2-4) Serve as a focal point for global brain circulation

- The numbers and fractions of the females (18, ~11 %) and foreigners (19, ~12 %) in the research and technical staffs, which have not changed significantly in these 3 years, may be slightly higher than other government affiliated research institutes. It will be necessary, however, to increase the fraction of foreign researchers in order to serve as a focal point for global brain circulation.

- We think that the research environment of RAP meets the international standards, since the research level is very high and communication can be made in English in research. Probably it is better to encourage foreign researchers to communicate in Japanese in order to enjoy the daily life of Japan.

2-5) Foster world-class leaders in scientific research

- RAP has been taking positive actions to foster and train young researchers, by providing them, for example, to organize the RAP seminars themselves to interact with accomplished scholars, such as Nobel Prize Laureate Prof. Kajita. Since RAP offers a very good platform for education, we think that it is better to have more graduate students and post-docs to take part in the research. This will contribute not only to foster young researchers but also for trying high risk subjects.
- In these 3 years, 17 researchers have taken academic positions after being trained in RAP, including 1 at a foreign university. Still there are possibilities for RAP to contribute to global brain circulation, considering its high level research activities. This situation could be improved by closely collaborating with world leading scientists, not only on research but also on exchanges of senior and young researchers.

3. Evaluate how appropriate and effective the Center's activities are towards maximizing RIKEN's achievements as a whole, including collaboration between centers.

Considering that photonics is very interdisciplinary in nature, RAP is attaching much importance to work with other Centers towards maximizing the achievements of RIKEN as a whole. Several activities are in progress at present, in addition to the contribution to the RIKEN President's Fund Project "4D Measurements for Multilayered Cellular Dynamics" as described in 2-3).

- In collaboration with RSC, RAP has succeeded in seeding soft x-ray laser SCSS with high-order harmonics, dramatically improving the spectral and temporal properties of SCSS. It is expected that harmonics seeding of SACLA will result in achieving full temporal coherence in the x-ray region for the first time.
- In order to generate ultra-slow muons with high efficiency at RIKEN-RAL muon source and at J-PARC, the laser team in RAP has succeeded in developing a new Lyman-α laser system with the energy 20 x higher than the present Lyman-α source. Since significantly higher slow muons are being generated with this source at J-PARC, this work will

contribute to RIKEN-KEK-JAEA joint project on ultra precision measurement of anomalous magnetic moment of muon and for development of the ultra-slow muon microscope.

- The Advanced Manufacturing Support Team of RAP is engaged in design of the experimental apparatus and machining of various parts upon request of the RIKEN scientists, significantly contributing to rapid progress of the experimental research of RIKEN as a whole. By developing, for example, optical components for astronomical instruments, high power coherent Lyman-α radiation for high-efficiency generation of ultra-slow muons at J-PARC LMF, and compact neutron source for industry uses and future on-site inspection of infrastructures.

4. Other comments and advices

- The Advanced Manufacturing Support Team is working very effectively to support the research activities of whole RIKEN. It is necessary to hire younger technology staffs in this team in order to keep motivation of the technical staffs and to succeed the skills and craftsmanship of the present staffs who will retire in ~10 years. It is better to strengthen this team by collecting the RIKEN technical staffs, for maximizing the efficiency of the supporting activities.
- RAP is taking much effort to increase the research staffs by internal as well as external funds in order to improve the research activities. At present RAP is composed of 57 staff scientists, with 22 permanent and 35 fixed term positions. Because of the long-term nature of some of the research, there is a need for a larger proportion of the permanent staffs.

III. Report on Research Activities

A. Extreme Photonics Research Group

This research group pursues realization of extremes of novel light sources such as intense attosecond pulses and extremely accurate optical clocks, and optical technologies such as ultrafast spectroscopy, live cell imaging and image processing, in order to expand science horizon and developing new applications in science and industry.

A-1 Attosecond Science Research Team

Attosecond science deals with the time-scale on which electrons function. Every attosecond research group in the world is striving to measure how quickly electrons can respond to a change in their environment. Measuring any fast response requires one pulse to initiate the dynamics to be measured, and a second pulse to monitor its progress. Since attosecond pulses lie in the XUV spectral region, the cross-section for making a transition is extremely small, and consequently the pulses must be very intense to have an effect. To make progress, all of the world's attosecond groups (with the exception of the RIKEN Attosecond Science Research Team), compromise by using a single visible pulse as either the pump or the probe. Since the speciality of the Attosecond Science Research Team is to produce intense pulses, the team had a head start to be the first group to perform attosecond pump -- attosecond probe spectroscopy.

Under team leader Dr. Midorikawa, they have developed two beam lines for attosecond science and they have enabled them to perform be the world's first attosecond pump – attosecond probe experiments.

Two experiments stand out: Both observe electronic response.

- In the first experiment, the team studied the simplest molecule, hydrogen. They have shown that it takes time for the molecule to realize it has been ionized. If the pump pulse ionizes the molecule, they can measure that the ion only begins to vibrate after a delay of about 1 fs. *This is the first proposed and proven measurement of such a delay.* The delay arises from the time it takes for the newly ionized electron to leave its companion molecule.
- The second experiment involved irradiating molecular nitrogen with a train that consisted of a few attosecond pulses. They probed the response of N_2 with a second, very precisely delayed pulse. The group found that an electronic wave packet is created in the excited state manifold of the ion. The highest oscillation frequency that they measured is 500 attoseconds. *This is the first direct measurement of such a fast electronic wave packet.*

Over the next few years, the team plans to produce single-period light pulses. These electric field transients will allow them to control the very fast processes that they initiate.

A-2 Ultrafast Spectroscopy Research Team

The Ultrafast Spectroscopy Research Team excels in its developments of new spectroscopic techniques in the ultrafast regime of picosecond and femtosecond. The two techniques, femtosecond time-resolved stimulated Raman spectroscopy and heterodyne-detected sum frequency generation spectroscopy, reported by Dr. Tahara, are truly world-leading. The name RIKEN is now well known in the ultrafast spectroscopy community because of the several novel spectroscopies including the above two that have been developed by the team.

Dr. Tahara has significantly contributed to make RIKEN visible internationally. A big discovery tends to come out from an unexpected result. If the Ultrafast Spectroscopy Research Team continues to challenge new observations, it will encounter, hopefully in the next ten years, a new unexpected finding that will lead to a real breakthrough.

Dr. Tahara reported a new finding that the coherence detected by spectroscopy has nothing to do with the proton transfer reaction in the excited electronic state. This unexpected result is of great interest and should be studied in further details for other ultrafast photochemical systems.

A-3 Live Cell Super-Resolution Imaging Research Team

The team developed super-resolution confocal live imaging microscopy (SCLIM). The system consists of a spinning-disk confocal scanner and a high-sensitivity camera system. Using SCLIM, the team studied the molecular mechanisms of membrane trafficking, specifically dynamic processes of protein sorting through the Golgi apparatus. The team proposed "hug-and kiss" mechanism and settled the long-standing debates regarding cisternal maturation. This achievement is highly appreciated in the field of cell biology.

SCLIM is applicable to numerous studies in life sciences such as real-time observation of drug delivery within living cells and tissues. The next generation of SCLIM, SCLIM-2 is now under construction. Techniques to realize super-resolution using spinning-disk are expected to be improved with the new system.

The team is collaborating with other teams in RAP to develop novel technologies such as spinning-disk two-photon excitation and quantifying parameters of cellular dynamics. It will bring about the next breakthrough in life sciences.

A-4 Biotechnological Optics Research Team

The team has developed numerous genetically encoded probes to better understand the spatio-temporal regulation of biological functions inside cells and tissues.

Research achievements which are highly evaluated in the field of life sciences are as follows. (1) The team developed "Fucci" probes which repot the cell cycle. The probes are commercially available and they are used by many researches in the field of cell biology. (2) The team developed UnaG, a novel fluorescent protein from vertebrate eel. It can be used as a diagnostic probe to determine serum levels of unconjugated bilirubin from human. (3) The team developed the tissue clearing method called Sca*le*S which is a reliable system for high-resolution 3D microscopy. Quantitative 3D imaging of the brain in Alzheimer's disease patients was performed using Sca*le*S.

These achievements are highly appreciated in the field of life sciences. The team is expected to continue developing new fluorescent proteins which will be useful tools for life sciences.

A-5 Space-Time Engineering Research Team

The world currently maintains time using a microwave transition in Cesium atoms. However, this standard will change over the next decade or two to allow much greater precision. While international research on the best new standard has concentrated on trapping and observing a single atom, Dr. Katori, the team leader of the Space-Time Engineering Research Team, has already proposed using many atoms simultaneously, with the atoms trapped in a periodic lattice formed by light. Dr. Katori's proposal offers the major advantage of having many more atoms to observe.

By using Strontium atoms because of their intrinsic accuracy as an oscillator; cryogenic cavities to minimize thermal noise; carefully tuned trapping lasers to minimize the Stark shifts; and two clocks so one can be compared with the other, the team has demonstrated accuracy $\Delta\nu/\nu < 5 \times 10^{-17}$. *This accuracy is so great that one can observe the changes in time caused by gravity if the clocks are separated by a vertical distance of only 4 cm.*

To demonstrate the potential for applications, the team places one clock at RIKEN and another at the University of Tokyo, linking them with a fiber optical cable. As expected, the clocks ticked at different rates consistent with their different vertical separation of 15.19 $\pm$0.04 meters.

Looking forward, other atoms may be even more accurate, but already the team can see an important new technology that will impact the world. Imagine, for example a clock constantly monitoring the gravitational potential for changes that might predict a future earthquake. The value of forewarning would be immeasurable.

A-6 Image Processing Research Team

The team developed novel image acquisition and processing techniques.

Research achievements which are highly be evaluated in the field of image processing are as follows. (1) The team developed new 3D internal structure microscopes (3D-ISMs). They are used by many experimental research groups, and research results were published in top journals. (2) The team developed an image processing software (VCAT5) which is provided through internet. Compared with other imaging software which is only distributed to customers, the image platform is interactive and the software continues to be improved by many users. The reputation of the image platform by collaborators will make it a global standard in the fields of image science and technology.

A-7 Innovative Photon Manipulation Research Team

Metamaterial science is a challenging field which gives us a potential of full control of optical properties of material parameters by artificial structure inside the material. The real understanding of the relation between the performance and nano-structure is not clear yet. Tanaka team demonstrated several important steps on this way. Publications and research level are good enough.

Metamaterials research is still at a new stage. It is not bad to go into this area. This team is still young, so maybe we should not judge on the same scale. He should focus more on the metamaterials. For the next stage, Dr. Tanaka should expand the scope to the possible real application. In this case the other materials like transition metal oxide and semiconductor might be within a scope. How to make breakthrough works is most critical for the next 5 years.

A-8 Cloud-Based Eye Disease Diagnosis Joint Research Team

The team is developing an image evaluation system for retinal OCT imaging for diagnosis. Imaging processing technology is provided by team A-6, and this joint research will be a good example for collaboration of a company and RIKEN. Cloud based diagnosis system for eye-screening will be a pioneer in telemedicine.

A-9 RIKEN-SIOM Joint Research Unit

The two research results were presented from RIKEN-SIOM Joint Research Unit. One is 3D Glass Microfluidics, especially microchannel fabrication, and the other is laser long-hole drilling. Both researches are very interesting from the viewpoint of μ-TAS and of 3D Silicon LSI. 3D Glass Microfluidics with more complex fluidic paths should be further developed so that they can be widely utilized at cheaper cost. Laser long-hole drilling has good properties of short processing time, compared with mechanical drilling, but there is still problem to be solved in terms of form accuracy and surface quality with regard to the laser drilling hole.

B. Terahertz-wave Research Group

Terahertz is still a developing field with possible applications in pure and applied science up to real world applications, although not all expectations have been fulfilled so far. The group in Sendai is working at the forefront since the beginning and is well known and respected by the THz community. After what has been reported this will not change and continue. In Sendai both very fundamental as well as real world applications are performed.

B-1 Tera-Photonics Research Team

The objective of the research activities in this team is the realization of widely tunable and high power pulsed THz sources as well as the investigation of sensitive THz detection methods using nonlinear optical methods.

The team has made remarkable advances in both areas. By detailed investigation of injection seeded parametric generation in Lithiumniobate a record high output power of 100 kW peak power around 2 THz was obtained using a compact table top pump laser.

On the detection side pulses with energies as low as 80 aJ have been measured using nonlinear upconversion in Lithiumniobate. With an improved phasematching scheme in periodically poled Lithiumniobate a compact fiber coupled detection system was designed. In both fields the team in Sendai is the worldwide leading group, the quality of their research is very competitive on an international level.

The use of organic nonlinear materials for THz generation and detection which was also pioneered in this team allows for real time imaging in the THz frequency range. These materials are also used for the generation of widely tunable THz radiation.

B-2 Terahertz Sensing and Imaging Research Team

The team works both in applied areas as well as in very basic science and has achieved a number of highlights.

Following spectroscopic investigations of large helical molecules and the theoretical identification of the origin of spectral features, the team started to investigate the possibility to actively control the molecular structure of large molecules using powerful THz pulses. The final goal is to control and modify the structure of biomolecules. In a first experiment the crystallization of a plural polymer was changed by irradiation with strong THz pulses. Although the origin of the change was not yet explained these experiments can, in principle, be of great interest for real applications.

The spectroscopy of $\{Li^+@C_{60}\}(PF_6)^-$ is an interesting combination of basic spectroscopy and application. The spectroscopy in the THz range should reveal the motion of the Li^+ ion in the C_{60} cage. All experiments are supported by calculations. The material itself is interesting for fast switching devices and quantum computing. Both projects are done in collaboration with a company.

The third experiment is certainly the most fundamental oriented project in the THz-wave Research Group. It supports an experiment in the field of inflation cosmology where the very early stages of our cosmos before the big bang are investigated. The team designs and realizes a cryogenic detector for 145 µm and 240 µm with a sensitivity of better than 10^{-18} W/sqrt(Hz). This project is very ambitious and shows that the team is well recognized in the world.

B-3 Terahertz Quantum Device Research Team

Quantum cascade lasers are widely used laser systems for a number of applications. In the THz region it is difficult to get laser action, in particular at higher temperatures. The team followed two different directions to obtain laser action in the THz range.

Using GaAs based QCLs a new design with an indirect injection scheme -comparable to a 4-level system- led to high temperature laser operation at 1.9 THz. The operating temperature of 160 K is the highest temperature for low frequency QCLs. With this design a liquid nitrogen dewar type QCL was designed which can be used for practical applications. With the same injection method a high power QCL operating at 4 K produces an output power of up to 250 mW at a frequency of 4.2 THz.

In order to cover the frequency range between 5 and 7 THz a GaN based QCL was realized. The QCL uses a new pure 3-level design with indirect injection into the upper laser level. The team has succeeded to get laser action at 5.4 THz. This is a very promising result for the future of THz applications in the real world.

C. Advanced Photonics Technology Development Group

The objective of this group is to develop laser and neutron beam technology for solving important social issues. Engineering and manufacturing support of all RIKEN research is also an important mission of this group.

C-1 Photonics Control Technology Team

All solid state lasers for wide variety of scientific applications have been developed with high quality and high efficiency. The laser devices developed by this team satisfied the collaborating research groups in and out of RIKEN, for example, National Observatory, Space Agency, High Energy Physics Laboratory, and even medical and agriculture applications. The technical support and contribution to the national-wide research programs is significant. This is a clear evidence of high level technical potential of this team.

The balance of core technology and application science has been well managed. The technical levels of these laser systems are high enough as non-commercial, custom-made experimental laser systems. Such an activity is quite important for RIKEN because this team keeps a high level effort to develop new laser techniques available for today and near future with strong internal motivation of technical development and scientific application simultaneously.

Dr. Wada has made a big effort to organize the external collaboration network. It is important because the lasers developed by this team meets real applications over the world and gives this team a feedback channel to hear the voice of scientific front and technological requirement.

We recommend they keep such style of activities constantly. This team might become a bridge between internal groups and outside community by widely available laser technology.

C-2 Ultrahigh Precision Optics Technology Team

The team reported on the neutron focusing mirror with metallic substrate as an example, which must be highly evaluated. In addition to it, they have been contributing to the manufacturing of a variety of experimental equipments and devices with very high accuracy. We are convinced that the team is indispensable to support the research activities of RIKEN. As a future plan, there is still a room for further development with regard to the neutron focusing mirrors.

C-3 Neutron Beam Technology Team

Although neutron beam is a very powerful tool for non-destructive measurements of various materials due to its high penetration power and high sensitivities to light elements and magnetic moments, its use has been limited since large facilities are required to generate neutron beams.

The RAP Neutron Beam Technology Team is making a drastic change to this situation by developing a compact neutron source named RANS (RIKEN Accelerator-driven compact Neutron Source). With RANS, this team is focused on developing the neutron beam technology for industrial applications, especially for practical use on site.

So far this team has demonstrated, through collaboration with industry, the usefulness of RANS for applications to R&D of steel materials by diffraction and imaging of thermal neutrons and to infrastructure inspection by fast neutron imaging of thick concrete slabs.

It is expected that the on-site industrial use of compact neutron sources will be started in near future based on the results of RANS demonstrations. Furthermore, nondestructive on-site inspection of social infrastructures may become realistic in several years when the RAP project of developing a more compact, transportable neutron system is implemented as planned.

C-4 Advanced Manufacturing Support Team

This team plays a very important role to manufacture experimental equipments and devices not only in RAP group but also in all RIKEN. Without their enthusiastic support, most of experimental equipments and devices cannot be created inside RIKEN. Otherwise, scientists in RIKEN have to pay 10 times more cost to provide them from outside RIKEN.

In addition, RIKEN has to continue to keep and maintain manufacturing capability inside. To do so, RIKEN had better employ young staffs who have good manufacturing skill as soon as possible.

RAPAC2016 Program

Venue: Hilton Tokyo, 3rd Floor, Yamato

July 31, Sun day 1st

16：30-16：50	20	Opening remarks (Center Director & Dr. Matsumoto, Executive Director) AC members & RAP PIs' introduction
16：50-17：20	30	RIKEN's introduction (Dr. Matsumoto, Executive Director)
17：20-17：30	10	RAP's response to the 1st RAPAC recommendations
17：30-17：35	5	RAPAC Terms of Reference
17：35-17：40	5	RAPAC Program/Schedule announcement
17：40-18：00	20	AC member discussion about role-sharing

August 1, Mon day 2nd

09：00 - 09：30		30	About RAP (Dr. Midorikawa)
09：30 - 09：40		10	A Extreme Photonics Research Group (Dr. Midorikawa)
	09：40 - 10：10	30	A-2 Ultrafast Spectroscopy (Dr. Tahara)
	10：10 - 10：40	30	A-1 Attosecond Science (Dr. Midorikawa)
10：40 - 11：00		20	Coffee break
	11：00 - 11：30	30	A-5 Space-Time Engineering (Dr. Katori)
	11：30 - 12：00	30	A-6 Image Processing (Dr. Yokota)
	12：00 - 12：30	30	A-3 Live Cell Super-Resolution Imaging (Dr. Nakano)
12：30 - 13：30		60	Closed lunch (AC members only) @ Kotobuki
	13：30 - 14：00	30	A-4 Biotechnological Optics (Dr. Miyawaki)
	14：00 - 14：30	30	A-7 Innovative Photon Manipulation (Dr. Tanaka)
	14：30 - 15：00	30	A-8 Cloud-Based Eye Disease Diagnosis (Dr. Akiba)
	15：00 - 15：30	30	A-9 RIKEN-SIOM Joint Research Unit (Dr. Sugioka)
15：30 - 16：00		30	Brief discussion
16：00 - 16：20		20	Coffee break
16：20 - 16：30		10	C Advanced Photonics Technology Development Group (Dr. Wada)
	16：30 - 17：00	30	C-1 Photonics Control Technology (Dr. Wada)
	17：00 - 17：30	30	C-3 Neutron Beam Technology (Dr. Otake)

	17：30 - 18：00	30	C-2&4 Ultrahigh Precision Optics Technology & Advanced Manufacturing Support (Dr. Yamagata)
18：00 - 18：30	30	Brief discussion	
18：30 - 20：30	120	Working dinner (AC members only)	

August 2, Tue day 3rd

09：00 - 09：10	10	B Terahertz-wave Research Group (Dr. Otani)	
	09：10 - 09：40	30	B-2 Terahertz Sensing and Imaging (Dr. Otani）
	09：40 - 10：10	30	B-1 Tera-Photonics (Dr. Minamide)
	10：10 - 10：40	30	B-3 Terahertz Quantum Device (Dr. Hirayama)
10：40 - 11：10	30	Brief discussion	
11：10 - 11：30	20	Coffee break	
11：30 - 12：30	60	Discussion (AC members, RAP PIs)	
12：30 - 14：00	90	Closed Lunch (AC members, only) @ Kotobuki	
14：00 - 15：30	90	Poster session	
15：30 - 16：00	30	Discussion (AC members, RAP GDs)	
16：00 - 17：30	90	Closed discussion (AC members, only)	
17：30 - 18：00	30	General briefing (AC members, Dr. Koyasu, Executive Director, and RAP PIs)	
18：00 -		Closing remarks