

**Evaluation of the 5-year plan of
RIKEN Center for Advanced Photonics (RAP), Japan**

**by
RIKEN Center for Advanced Photonics Advisory Council 2014
(RAPAC 2014)**

The Advisory Council for the RIKEN Center for Advanced Photonics (RAPAC 2014) met with the RIKEN Center for Advanced Photonics (RAP) from March 2 to March 4, 2014 at the Wako campus of RIKEN in order to evaluate the 5-year plan of RAP. The overall status of RIKEN was first presented by Dr. Maki Kawai, Executive Director of RIKEN. Then the objectives, outcomes and future plans of RAP were presented by the RAP Director and the three Group Leaders. Detailed accounts of the research activities were presented by the Team Leaders in oral presentations and by the team members in poster presentations. The visits to several RAP laboratories by RAPAC were also arranged. Further exchanges between RAPAC and RAP were made at the question-and-answer sessions.

The RAPAC members have exchanged their thoughts at the closed sessions to prepare the preliminary version of the report. The final version of the report was prepared after the meeting by the e-mail exchanges between the RAPAC members. This Report is arranged in accordance with the Terms of Reference to RAPAC 2014, which reflect the Terms of Reference requested by the RIKEN President to the Advisory Council (AC) of each Center.

We would like to thank Dr. Katsumi Midorikawa, RAP Director, and all the RAP staff for making all the arrangement of this meeting with which we could carry out our work smoothly.

April 25, 2014

RAPAC 2014

Yoshiaki Kato (Chair)

Rene Beigang

Hiro-o Hamaguchi

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1. Introduction

Laser research at RIKEN dates back to 1960s when Prof. Koichi Shimoda of The University of Tokyo and Prof. Susumu Namba of Osaka University started the laboratories on quantum electronics and nanoscience, respectively, as the Chief Scientists of RIKEN. Evolving from these laboratories, Extreme Photonics Research was started in 2005 as one of the Basic Science Interdisciplinary Research Project of RIKEN Advanced Science Institute (ASI).

In accordance with the commencement of the RIKEN's third 5-year term (2013-2018), the RIKEN Center for Advanced Photonics (RAP) was inaugurated on April 1, 2013 by merging the Extreme Photonics Research Department and the Advanced Technology Support Division, both of ASI, and also recruiting two Chief Scientists as new team leaders.

The RAP research covers very broad fields from basic science to real-world applications, including laser science, atomic and molecular spectroscopy, biology, data processing, optical engineering, advanced manufacturing and neutron beam technology. These research activities are summarized by RAP as

- “Expanding the horizon of photon science”, and
- “Contributing to society by making the invisible visible”.

RAP is composed of three Research Groups, each comprising several Research Teams as below. Typical activities in these teams are described in the parentheses. The Research Groups A and C are located in Wako, whereas the Research Group B is located in Sendai.

- A. Extreme Photonics Research Group
 - 1. Attosecond Science Research Team
(high energy, high-rep, attosecond pulses for bio- imaging, spectroscopy, etc.)
 - 2. Ultrafast Spectroscopy Research Team
(ultrafast dynamics of complex molecules and interfaces)
 - 3. Live Cell Molecular Imaging Research Team
(elucidation of molecular mechanisms of life by optical imaging of living cells)
 - 4. Near-field Nanophotonics Research Team
(nm-resolution Raman imaging of various objects such as living cells and CNTs)
 - 5. Molecular Reaction Dynamics Research Team
(electron dynamics in aqueous solutions using SPring-8 and SACLA)
 - 6. Biotechnological Optics Research Team

- (observation of life in living cells by utilizing/developing fluorescent proteins)
- 7. Space-Time Engineering Research Team
 - (18-digit accuracy atomic clock for time standard and relativistic geodesy)
- 8. Image Processing Research Team
 - (development of new algorithms for scientific image processing)
- B. Terahertz-wave Research Group
 - 1. Tera-photonics Research Team
 - (high power THz source and sensitive THz detection by parametric devices)
 - 2. Terahertz Sensing and Imaging Research Team
 - (THz spectroscopy of molecular structures; detector for microwave astronomy)
 - 3. Terahertz Quantum Device Research Team
 - (GaAs- and GaN-based THz QCLs for broader freq. and room temp operation)
- C. Advanced Photonics Technology Development Group
 - 1. Photonics Control Technology Team
 - (new laser sources for scientific, industrial and medical applications)
 - 2. Ultrahigh Precision Optics Technology Team
 - (fabrication of ultrahigh precision optics for scientists in RIKEN and others)
 - 3. Neutron Beam Technology Team
 - (transportable neutron imaging instrumentation for real-world applications)
 - 4. Advanced Manufacturing Support Team
 - (manufacturing of special devices for all RIKEN and RAP)

In parallel with the scientific research, RAP stresses “contribution to society” by developing practical applications of advanced photonics, in accordance with the Noyori Initiatives and RIKEN’s Missions for the third 5-year term. RAP is now expected to take a catalytic role to stimulate cross-disciplinary activities in RIKEN.

2. RAPAC Evaluation of RIKEN Center for Advanced Photonics

The terms and reference guiding the RAPAC evaluation were as follows:

1. *Research Output and Research Plan*

Are the center’s research output and personnel up to international standards? Is the center a world-leading center in its field? Are the center’s research plan and roadmap, including personnel turnover, appropriate? Please make concrete proposals that could lead to quantum leaps.
2. *Contributions to Science, Technology and Society*

Is the research being conducted within RAP helping to expand the horizons of science and technology and contributing to the solution of issues important to society? Are the center's research plan and road map, including personnel turnover, appropriate?

3. *Budget*

Are budget allocation for research and human resources and budget acquisition from inside and outside of RIKEN well balanced?

4. *Collaboration and International Initiatives*

Is there active collaboration with groups both inside and outside of RIKEN, including international initiatives?

5. *International Human Resources*

Advice on measures for attracting top international human resources is appreciated

6. *Other Aspects*

In the following report, the RAPAC expresses its views and presents advice and recommendations on each term of reference.

1. Research Outcome and Research Plan

RAP is composed of three Research Groups each comprising several Research Teams. These Teams are lead by excellent Team Leaders, each pursuing to lead the specific field with high international competitiveness. RAP as a whole pursues a broad range of subjects that are of current importance in photonics research ranging from basic science to applications.

RAP is well structured for cross-disciplinary research that will be suitable for opening new frontier of science, as well as for "problem solving" which is listed as the first item of RIKEN's Missions. When this RAP policy is successfully implemented, it is expected that very prominent and unique research outcomes will be generated from this RAP Center.

The research outputs that have been achieved in the RAP teams are generally high and in some cases excellent by international standards. The research plans of each group and each team show the right levels of ambition and future vision. We encourage that these plans continue to be developed with **strong emphasis on key scientific problems** (of both a basic and applied nature) to be addressed.

We have discussed strategies that could best lead to the quantum leaps. **The "quantum**

leaps” will be generated from the cross-disciplinary research. We think that the quantum leaps are also generated from the basic science, as has been proven in many cases. Therefore it will be important to **keep basic science strong with the long term vision**, while vigorously pursuing applied science.

The future plans of RAP as a whole are well considered and plans are already being made to develop the portfolio of research to address future challenges. We note the coming departure of the three leaders of the established and highly successful Teams (live cell molecular imaging, near-field nanophotonics and molecular reaction dynamics). We recommend that RIKEN does everything possible to ensure continuing excellence in these areas that have been built up.

In the following, several comments to each Group are given.

A. Extreme Photonics Research Group

All the eight Teams are very active and participating in internationally competitive research. We note leading research in; attosecond technology development, ultrafast spectroscopy, imaging of living cells and biotechnical optics, nanophotonics, molecular reaction dynamics, image processing and time-space engineering. **We encourage these researches to be ambitiously driven to generate innovative results on the key issues in each field.**

Considering the three team leaders who depart in 2015 each leading excellent research team, **provision to maintain excellence in these areas must be considered.**

B. Terahertz-wave Research Group

All three teams in this group are world leading. There is excellence in non-linear generation and detection of the THz wave. **The effort in the challenging area of THz spectroscopy is impressive and should answer the basic questions of feasibility.** They have a realistic understanding of the potential and limits of THz radiation applications. The unique development of QCL THz lasers looks very promising for future applications.

C. Advanced Photonics Technology Development Group

This group comprises four rather different Research Teams all being very effective in their own right. The Photonics Control Technology team has great technical expertise and is making vital contributions to a number of scientific projects. It is important that in future planning their potential is best harnessed by a **strategic choice of projects and**

applications. The Neutron Beam Technology team has plans with high potential for impact on infrastructure safety and maintenance. The Ultrahigh Precision Optics Technology/ Advanced Manufacturing Support team is a strategic resource within RIKEN with exceptional capability; it not only provides a cost effective route to maintain research technology support at the highest level, but also bears an important role for “**realization of value through manufacturing**”.

2. Contributions to Science, Technology and Society

There is without doubt excellent basic science being pursued across the whole of RAP. We see it as very important for the future health of all RAP activities that this situation is maintained. External evidence shows that **the best applications of science can only stem from excellence in basic science**, for example it is no accident that the cluster of exceptional startups in Palo Alto arose directly from the Science and Engineering schools of Stanford University.

There are excellent prospects for contributing to solutions of issues with societal importance, for example: biomedical imaging, security applications of THz, infrastructure inspection by neutrons and the technology for lidar in environmental monitoring. More broadly **the scientific and technological programs in RAP are vital for future societal applications as well as for future research of a more basic kind.**

3. Budget

Total budget of RAP in FY 2013 was approximately 1,634 MY, with the fractions of 42% internal fund, 24% internal competitive fund and 34% external competitive fund. This budget is used with approximately equal fractions for internal funded research, external funded research and personnel.

The total number of the human resource of RAP is 337, comprising 109 research and technical staffs including 25 postdoctoral fellows, and 228 other staffs including 141 visiting researchers and 46 student trainees. The female and foreign staffs in the research and technical staffs are 11 and 12, respectively.

We sense that the current balance of budget allocation between research and human resources is appropriate judging from the health of all activities. The levels of budget

support from internal and external sources are currently well balanced and effective to maintain high standards in both basic science and technological/applications orientated research. **We hope this situation can be maintained in a sustainable way.** We encourage the continued efforts to **increase the number of female and foreign researchers** to make RIKEN better-balanced and more international institution.

4. Collaboration and International Initiatives

There is excellent potential for collaborations within RAP and with other research centers and programs in RIKEN. Positive actions are undertaken in RAP to increase interaction among the Research Teams and young researchers located in Wako and Sendai campuses; RAP annual symposium, RAP monthly seminar and participating in the lectures in Advanced Leading Science and Engineering Graduate Course for Photon Science of the University of Tokyo. **We encourage these interactions to be further strengthened since this is vital to generating new ideas,** as has been proven in many cases.

The cross team activities are already underway, such as the research between the biotechnological optics and the live cell molecular imaging research teams, and the attosecond science research team with SACLA for improving the temporal coherence of the x-ray laser beam. **Continuing efforts should be applied to ensure that the cross team activities grow.**

There is evidence of good collaboration with other Japanese institutions/universities, and we strongly encourage this to be grown. The collaboration with SIOM (Shanghai Institute of Optics and Fine Mechanics) is strategically very sensible as it accesses higher intensity lasers. We also note a number of other collaborations, and **we encourage similar international collaborations to be grown.**

5. International Human Resources

We were impressed by the number of international young researchers successfully working within RAP. The RIKEN program for Junior Scientists (International Program Associates and Foreign Postdoctoral Researchers) is an excellent vehicle to support this trend. **We hope that RIKEN will become an important international hub for the mobility of young researchers** as is implemented in Europe to foster young researchers to extend their capabilities to newer research fields.

We encourage efforts to be made to attract senior scientists for few month collaborative visits using the existing schemes. In order to attract top international human resources, **we propose the schemes to have overseas researchers attached as PIs of research teams in RAP whilst maintaining their existing overseas appointment.**

6. Other Aspects

RIKEN is considered as a candidate for the Designated National R & D Institution, which is under examination in the Government with the objective to maximize research outcomes, aiming for world-leading results based on national strategy. It is expected that RAP will take an important role for stimulating cross-disciplinary activities in this new Institute due to the coverage of broad research fields and emphasizes on cross disciplinary activities of RAP. With this regard, we note again that **the best applications of science can only stem from excellence in basic science, and basic science is driven often by the curiosities of scientists.** We therefore recommend that **the Noyori Initiative, “RIKEN that motivates researchers”, is emphasized in the new Institution and in RAP.**

RAPAC 2014:
Advisory Council for RIKEN Center for Advanced Photonics in 2014

Yoshiaki Kato (Chair)	President	The Graduate School for the Creation of New Photonics Industries (GPI)
René Beigang	Professor, Dr.	University of Kaiserslautern and Fraunhofer Institute for Physical Measurement Techniques IPM
Hiro-o Hamaguchi	Chair Professor	National Chiao Tung University
Jon Marangos	Professor	Imperial College
Yoshimi Takeuchi	Professor	Chubu University
Kenichi Ueda	Specially Appointed Professor	The University of Electro-Communications

RAPAC 2014 Program

March 2, Sun day 0 Hotel Cadenza Hikarigaoka

16:30-16:50	20	Opening remarks(Center Director & Executive Director) AC members & RAP PIs introduction
16:50-17:20	30	RIKEN's introduction (Executive Director)
17:20-17:50	30	AC member discussion about role-sharing
18:00-19:30	90	Buffet dinner (RAPAC members, RAP PIs)

March 3, Mon day 1st Wako campus, Large Meeting Room, RIBF 2nd floor

09:00 - 10:00	60	About RAP (Dr. Midorikawa)
10:00 - 10:10	10	A Extreme Photonics Research Group (Dr. Midorikawa)
	10:10 - 10:30	20 A-2 Ultrafast Spectroscopy (Dr. Tahara)
	10:30 - 10:50	20 A-5 Molecular Reaction Dynamics (Dr. Suzuki)
	10:50 - 11:10	20 A-1 Attosecond Science (Dr. Midorikawa)
11:10 - 11:30	20	Coffee break
	11:30 - 11:50	20 A-6 Biotechnological Optics (Dr. Miyawaki)
	11:50 - 12:10	20 A-4 Near-field NanoPhotonics (Dr. Kawata)
	12:10 - 12:30	20 A-7 Space-Time Engineering (Dr. Katori)
12:30 - 14:00	90	Closed Lunch (AC members only) @ small meeting room
	14:00 - 14:20	20 A-3 Live Cell Molecular Imaging (Dr. Nakano)
	14:20 - 14:40	20 A-8 Image Processing (Dr. Yokota)
14:40-14:50	10	C Advanced Photonics Tech. Development Group (Dr. Wada)
	14:50 - 15:10	20 C-1 Photonics Control Technology (Dr. Wada)
	15:10 - 15:30	20 C-3 Neutron Beam Technology (Dr. Otake)
	15:30 - 15:50	20 C-2 Ultrahigh Precision Optics / C-4 Advanced Manufacturing Support (Dr. Yamagata)
15:50-17:30	100	Lab. Tour (Otake, Midorikawa & Tahara, Katori, and Nakano)
		Dep. RIKEN, move to Hotel Cadenza by Bus
18:30-20:30	120	Working Dinner (AC members only) *Dr. Midorikawa, Dr. Otani and Dr. Wada will be in another room

March 4, Tue day 2nd Wako campus, Large Meeting Room, RIBF 2nd floor

09:00 - 09:10	10	B Terahertz-wave Research Group (Dr. Otani)
09:10 - 09:30	20	B-2 Terahertz Sensing and Imaging (Dr. Otani)
09:30 - 09:50	20	B-1 Tera-Photonics (Dr. Minamide)
09:50 - 10:10	20	B-3 Terahertz Quantum Device (Dr. Hirayama)
10:10 - 12:00	110	Poster session @ RIBF 4 th floor
12:00 - 13:30	90	Lunch (AC member, RAP PI) @ Hirosawa Club
13:30 - 14:30	60	Discussion (AC member, RAP PI)
14:30 - 16:30	120	Closed Discussion (AC member, only)
16:30 - 17:00	30	General Briefing (AC member, Executive Director & RAP PI)
17:00 -		Closing remarks

