Report of the RIKEN SPring-8 Center Advisory Council 2009

Date: February 8 – 10, 2009

AC members:

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General statement

The RIKEN SPring-8 Center (RSC) has been playing many important roles in the frontiers of science and technology from the materials to the life science fields by providing state-of-the-art experimental facilities utilizing brilliant light sources as well as by promoting its own research activities. A rather drastic turnover of many PIs and reorganization of the RSC to a more mission-oriented structure with three divisions in response to the 1st RSAC 2006 recommendations must have been quite a challenge. But, together with the new RIKEN's mission of constructing a compact XFEL facility by the end of FY 2011, the three divisions of the RSC: Innovative Light Sources Division, responsible for the technical development of advanced SR sources including XFEL; Photon Science Research Division, carrying out cutting edge research in life, materials and physical sciences at SPring-8; and Advanced Photon Technology Division, developing technologies to make best use of SPring-8 and XFEL for users including industrial sectors, have been actively fulfilling their assigned responsibilities. Now, the XFEL facility construction is well advanced, to be completed in about two years as originally planned, and the recent achievements, present activities and future plans by the groups in each of the three divisions have proved the RSC to be one of the best institutes in the world with impressive progress and exciting potential as described by individual PIs at the RSAC 2009. It is crucial to maintain and further improve the quality and the level of R&D for the RSC to continue to be a leading figure in the world scientific community and to contribute to the future developments of industrial and medical science and technology. The task of the RSC to contribute to the benefit of human society is a formidable challenge.

Comments on the specified issues

1. **The management system for the RIKEN SPring-8 Center, especially its organizational structure and administrative systems, with the aim of making the RSC a world-leading research institute.**

The RSC has reorganized in response to the RSAC 2006 recommendations. Reorganizations are always challenging and the RSC has been up to that challenge. The new mission oriented structure is working well as can be seen from the comments below about the scientific progress and impact. That being said there is a challenge ahead: provide the scientific leadership for the use of the XFEL. This challenge is now. The XFEL will begin operation in just over two years and the recruitment of staff and the establishment of new laboratories and/or the re-direction of existing staff and laboratories needs to be done in a very short time. The approach to this challenge should engage the ultrafast science community in Japan and take best advantage of the scientific leadership already part of RIKEN, for example the independent laboratory of Dr. Midorikawa.

There is also a need to expand the role of the advanced photon technology division to include the XFEL. Only then can the value of the developments for both storage ring and FEL experiments be completely realized. There are unique opportunities but with them come unique challenges. The structure of a mission oriented organization is a good platform to meet these challenges, but it needs to be nimble and able to adapt. It will require strong leadership and cooperation, but the RSC has shown that they are up to the challenge.

To keep and maintain a vibrant research community on the SPring-8 campus it is critical to have a significant number of young scientists, students and postdoctoral researchers. RSC should make a serious effort to understand how to attract more young research staff and graduate students to the SPring-8 campus to get them involved in the world-top level research activities. The number of postdoctoral fellows and graduate students appears to be rather limited, but the potential opportunities for such young people are tremendous. Working with such young people will also stimulate the communications and discussion in the SPring-8 community, between groups of different expertise and disciplines as well as over generations. The isolated location of the campus may be making this place less attractive to young people, as some PIs mentioned. The RSC must come up with a strategy to make this place more attractive. This may require additional financial support.

2. The research programs and the collaborative activities inside and outside RIKEN that are currently being conducted or are planned for the RSC (from the viewpoints of both scientific and social/societal impacts)

Life sciences:

Structural biology is certainly one of the main RSC research activities. The RSC has been playing essential roles in providing cutting-edge SR beamline technologies to the SPring-8 user community so

that structural biology in Japan has a strong presence in the world scientific community, both in high throughput structural genomics and structural biology of membrane protein complexes, for which high-resolution structural information is important for biological as well as medical sciences but is still usually difficult to obtain. The RSC's own research activities in structural biology are also showing impressive progress and remarkable achievements in those two aspects as well. It is also important to note that the RSC has a few groups studying three-dimensional structures of large macromolecular complexes, membrane proteins and cells by electron microscopy (EM) and image analysis. Since EM is a complementary technique to X-ray diffraction and also many of the EM image analysis techniques will be useful for single-particle diffraction imaging by XFEL, the EM groups are expected to play important roles in the future research activities of the RSC as a whole.

It is, however, rather a shame that the RSAC members shared an impression that the interactions between groups involved in structural biology are not as well coordinated as they could be like those seen between the groups of material sciences by the strong leadership of Dr. Takata. It would be nice to see more cohesive interactions between the groups in structural biology, which could be promoted just by sharing more facilities and resources or may need some leading figure over-viewing and coordinating the activities of the groups.

The recent publication in *Nature* of the F-actin structure by X-ray fiber diffraction analysis was particularly impressive, not only because the scientific impact of the work is high but also because the RSC has maintained its support to this rather long-term study, which needed a specific superconducting magnet to make highly-oriented liquid-crystalline sol specimens of the F-actin filament and a specific beamline setup appropriate for high-quality fiber diffraction data collection and took more than a decade for Dr. Oda to get this work done. We expect the RSC to maintain support for such long-term, high-risk research activities.

Materials sciences:

Materials science is the other major research area of RSC in the utilization of the accelerator based light sources on the SPring-8 campus. RSC scientists are amongst the world leaders in this area. The RSC has responded to recommendations from the 2006 RSAC with specific developments that will keep the research of the RSC materials team at the forefront. In particular is the establishment of the materials dynamics laboratory headed by Dr. A. Baron and the Structural Materials Science laboratory headed by Dr. M. Takata.

The Materials Dynamics laboratory has very recently obtained funding for the development of a second beamline for inelastic x-ray scattering that will open new research opportunities. This beamline will be the world's best for the foreseeable future. Already the work of the laboratory has had important impacts on our understanding of the dynamics of novel superconductors ranging from insights in the 'classic' high T_C systems to MgB_2 to the recent Fe-As compounds. Most importantly they have very

recently begun to investigate electronic excitations in the eV energy loss regime with meV resolution.

The advances in Takata's laboratory in the use of maximum entropy methods has been similarly impressive. They have recently moved from fitting the precise charge density and then deriving the electrostatic potential to directly fitting the electrostatic potential. This is a very important step. These techniques have been applied to a wide variety of materials ranging from charge order in the manganites, important as GMR systems, to organic systems that show classic metal-insulator transitions

The RSC has been at the forefront of the manipulation of the x-ray polarization and its use for both magnetic and chiral systems. They are developing research efforts in polymers and soft matter. In general they are maintaining a leading position. In this regard they have established the quantum order research group with three sub-groups: spin order, spatial order and excitation order. Each has forefront results and the combination may be unique.

Overall the materials research is extremely strong and well integrated in the both Japanese and worldwide materials research community. Of particular note is the out reach to the industrial community and the impact of the research. An exciting example is the study of the amorphous to crystalline transformation underlying recording of DVDs. This utilizes a unique combination of x-ray optics and science capability applied to an important technological area.

It is also of note that the construction and management of the RCS material science beamlines takes the whole beamline layout at the SPring-8 into consideration, where JAEA, NIMS and other institutions are developing their activities on materials science.

3. The roles that the RSC is expected to take in the research complex (with JASRI and the XFEL) at the SPring-8 site.

The RSC has been fulfilling its responsibilities to: 1) support the activities of JASRI and 2) play a leading role in the design and construction of XFEL. It is expected that RSC will continue to fulfill these responsibilities for the future developments of the SPring-8 site. There is no doubt that the responsibility of the Riken Harima Institute, most naturally the RSC, will expand significantly once the XFEL is completed. To maintain the level of excellence that has put the RSC amongst the world leaders, the RSC will need more resources for both research and technical staff as well as a budget for equipment and supplies. It would be important for RIKEN to consider appropriate plans to support this crucial expanded role.

Recommendations

XFEL research

The XFEL is expected to begin user operations two years from now. The RSC has been very successful in carrying out world class research with the SPring-8 facility. This research role has and will continue to benefit the broad user community.

We recommend that a similar world leading science program for the use of the XFEL be started within the Riken Harima Institute. This might be best accomplished by expanding the RSC. This expanded role would take best advantage of the existing expertise and technical developments.

Innovative Light Sources Division

The innovative light source division 'gave birth' to the compact X-ray Free Electron Laser concept and the use of a pulsed DC electron gun. There will be a continued need for development of the SPring-8 XFEL and we recommend this as one role for this division. There is now an initiative for SPring-8 synchrotron source upgrade known as SPring-8 II. We take note that the new chief scientist in this division will be in the general area of accelerator physics.

We recommend that this individual take a leading role in meeting the challenges of the published goals for SPring-8 II to be the 'ultimate' storage ring.

Photon Science Research Division

1) Life Sciences

The research of the individual teams is of the highest quality. There are approximately 30 scientists and 10 post doctoral researchers. The complementary nature of the expertise of the individual teams gives the RSC the potential to become a true internationally leading center in life sciences.

We recommend the appointment of a life sciences coordinator to capture this potential. This coordination role should help to:

1) Promote closer interactions between the research teams.

2) Ensure the continued development and optimal use of the research infrastructure and resources.

This coordinator position could be rotating taking advantage of the various expertises of the RSC life science researchers.

2) Materials Science

Energy and the Environment; The Noyori Initiative 4: RIKEN that is useful to world.

We recommend that the RSC materials effort investigate the research opportunities related to energy and the environment with a focused, cross cutting approach

It is more fascinating for RSC material science group to be the world leading center in this field by more collaboration with other groups in SPring-8 such as JAEA, NIMS and so on.

New Initiatives

The Noyori Initiative 5: RIKEN that contributes to culture. The world synchrotron radiation community has begun to have impact using SR techniques as analytical tools for the study of cultural heritage artifacts and archeological finds.

We recommend that the RSC explore these opportunities using Spring-8.

Advanced Photon Technology Division

The present emphasis of the developments appears to focus on the life sciences. As with the photon science research division where both life sciences and material sciences are on an equal footing we see a similar need in the photon technology division. This will inevitably lead to cross fertilization that will benefit both areas. This will become particularly true when the XFEL begins operations and the need for advanced instrumentation to fully exploit the unique source properties becomes paramount.

We recommend that this division be strengthened and organized to meet the instrumentation challenges.

Young researchers

Young researchers are critical to the research environment. This can have significant impact at the RSC.

We recommend that the RSC look for initiatives that can increase the engagement of young scientists in the research activities at the RSC.

Budget

With the recommended expanded role of the Harima Institute in the science program on the SPring-8 campus any efforts that lead to increased resources are crucial to ensure the successful launch of the XFEL science program