SPring-8/SACLA Advisory Council (AC) and RIKEN SPring-8 Center Advisory Council (RSAC) Report Summary

The Advisory Council (AC) is an external evaluation body unique to RIKEN, conducted twice during the seven-year Mid- to Long-Term Plan period. The AC, after consultation with the Chairman, reviews the management and research activities of the institutes through assessments by prominent scientists from both Japan and abroad. The council ensures that its reports and recommendations are appropriately incorporated into the management strategies of each institute.

In the previous AC evaluations of RSC before 2016, the review focused on RSC operations. However, as SPring-8/SACLA is jointly operated by the Japan Synchrotron Radiation Research Institute (JASRI) and the RIKEN SPring-8 Center (RSC), the 2016 evaluation committee recommended that a joint review of the SPring-8/SACLA facilities be conducted to obtain a comprehensive understanding of their operations. Following this, JASRI and RSC began joint reviews of SPring-8/SACLA operations starting in 2019, while RSC alone underwent reviews of its operations.

In 2023, the SPring-8/SACLA AC and RSAC evaluations were conducted from July 10 to 13. The 2023 committee, chaired by Professor Jerome Hastings, consisted of seven members.

The advisory topics for SPring-8/SACLA AC were as follows.

1. Comments and/or recommendations regarding the management and operation of the SPring-8/SACLA facilities.
2. Comments and/or recommendations regarding the revised accelerator/beamline upgrade plan for the SPring-8-II project (including scrap & build).
3. Comments and/or recommendations regarding the role of SPring-8 in synchrotron radiation facilities in Japan and globally.
4. Comments and/or recommendations on the progress of SPring-8/SACLA toward their mission of shaping the future of science.

The RIKEN President's consultation for the RSAC included the following.

1. Evaluate the responses to the 2019 AC recommendations.
2. Based on the results of the Center's self-analysis, evaluate operations and R&D activities for the 4th Mid- to Long- Term Plan period (FY2018–2024).
3. Evaluate the policies of the 5th Mid- to Long-Term Plan period (FY2025–2031) and recommend new directions for operations and R&D that should be implemented and promoted.

Following presentations on each advisory topic, as well as discussions and exchanges of opinions, the chair has submitted a report summarizing the recommendations. Please see below for the full report.

Report of the SPring-8/SACLA AC and RSAC

General comments

- RSAC really appreciates the organization of the review.
- RSAC recognizes the world class status of the SPring-8/SACLA complex.
- We appreciate the thoughtful response to the 2019 RSAC recommendations. We again appreciate the joint review of RSC and JASRI affording the opportunity to understand the SPring-8/SACLA facilities as a whole.
- The continuous progress in the technical areas highlighted by the Citius detector development and the world leading optics is impressive.
- The collaborative development of accelerator-based x-ray sources, NanoTerasu and SPring-8-II, is a significant step towards a coordinated approach to SR in Japan.

Terms of Reference

1. comments and/or recommendations regarding the management and operation of the SPring-8/SACLA facilities
2. comments and/or recommendations regarding the revised accelerator/beamline upgrade plan for the SPring-8-II project (including scrap & build)
3. comments and/or recommendations regarding the role of SPring-8 in synchrotron radiation facilities in Japan and around the world
4. comments and/or recommendations regarding the progress of SPring-8/SACLA toward their mission to set the direction for the future of science

● Terms of Reference (TOR1)

1. comments and/or recommendations regarding the management and operation of the SPring-8/SACLA facilities

Comments:

- RSAC is in awe of the 99.5% uptime and ~ 230 hrs. MTBF for SPring-8. This is world leading.
- The reliability and new operating modes of SACLA continues to provide new opportunities for the user community.
- The transition to the use of SACLA as the SPring-8 injector has already had significant impact, reducing electric consumption by 5 MW and demonstrating a critical capability for SPring-8-II
- The continued attention to a coherent approach to the management of the entire Harima site is important to the operations, development and growth of the x-ray

facilities. In times of fixed budgets and increases in electricity costs and inflation a shared vision and responsibility by RSC and JASRI is critical.

- RSAC recognizes steps toward a coherent management system as recommended by RSAC in 2019, but there is still more that can be accomplished.

Recommendations:

- RSAC notes that the Pohang Accelerator Laboratory in Pohang Korea has similar staffing levels, and both an FEL and a storage ring, and is providing accelerator physics support to a next generation SR source as is true for the combination of RSC and JASRI on the Harima site. RSAC recommends that RSC/JASRI consider the organizational structure at PAL as an example of how a coherent management system can optimize outcomes with very limited staff. This can become critical in times of fixed budgets and increases in electricity costs and inflation.

- Terms of Reference (TOR2)

2. comments and/or recommendations regarding the revised accelerator/beamline upgrade plan for the SPring-8-II project (including scrap & build)

Comments:

Accelerator upgrade:

- The news that SPring-8-II is slated to begin installation with the 2027 summer shutdown is wonderful news for the Japanese synchrotron user community as well as the international users of SPring-8. The design of the storage ring has optimized the use of permanent magnets to reduce electricity usage. The target emittance of 50 pm will place SPring-8-II amongst the world leading facilities, ESRF and APS.
- RSAC takes note of the 'short time' between now and the planned start of installation of the new ring components at the start of the 2027 summer shutdown.
- RSAC endorses the updated lattice for Spring-8-II reaching an emittance of 50 pm. rad thanks to the effective use of damping wigglers in two of the four 30m-long straight sections and to the use of reverse bends (shifted quadrupoles). This performance, combined with an increase of the beam current from 100 to 200 mA, will enable a very significant increase in photon brightness.

Recommendations:

- At a later stage of the project, RSAC recommends to evaluate the following detailed recommendations which are summarized at the end of this presentation (pages 23-25) to reach a step further in terms of performance and to fully exploit the potential of this

new source. In consideration of the short time before the start of installation RSAC recommends considering our detailed recommendations in a timely fashion with emphasis on the injection approach.

Comments:

Beamline upgrades:

- The transition from multi-technique beamlines to focused beamlines in a continuous way enhancing the SPring-8 capabilities with new optics, new detectors and impressive automation and the SPring-8 data center will prepare the beamline suite for the start of SPring-8-II. Further the synergy with the Fugaku Supercomputer will be critical to the Digital Transformation. Categorizing beamlines by measurement, experiment and R&D is well matched to the needs of a diverse user community.

Recommendations:

Beamline upgrades:

- The progress on the scrap and rebuild approach to beamline upgrades is going well. The definition of measurement, experiment, and R&D is a positive approach. The measurement capability will become ever more important as the domain scientists see the unique potential that SR results can deliver in answering complex questions. RSAC recognizes a missing component: the link between the domain scientist and the facility. RSAC recommends that RSC/JASRI look for a solution to this challenge. RSAC notes the discussions at NanoTerasu regarding the creation of a third party to address this need.
- The RSAC recommends a continuation of the transition of contract beamlines to RIKEN ownership. This has several advantages:
  1) RIKEN has the expertise to upgrade and manage the beamline in the SPring-8-II era
  2) Block access is afforded to the 'contract institution'
  3) Increased access for the public to SPring-8-II beamlines.

- Terms of Reference (TOR3)

3. comments and/or recommendations regarding the role of SPring-8 in synchrotron radiation facilities in Japan and around the world.

Comments:

- There are 5 sites worldwide that have both an FEL and a storage ring x-ray source with common management: Among these the combination of SPring-8 (soon to be SPring-

8-II) and SACLA is world leading. The cooperation and parallel developments of optics and detectors is of particular note and contributes to world leading capabilities on the Harima site.

- The SPring-8 accelerator team designed the NanoTerasu accelerator complex and played a critical role in its construction and the commissioning which has already shown impressive results with RF capture and stored beam in just 8 days from the initial injection into the storage ring.
- The coordination of beamline capabilities between NanoTerasu and SPring-8 has begun.We note that NanoTerasu also addresses, in part, the dark period during the installation and restart of SPring-8-II.We recognize that NanoTerasu will not provide the breadth and in particular the hard x-ray facilities available at SPring-8 but many users will have access to important capabilities.

Recommendations:

- RSAC takes note of he impending start of the user program at NanoTerasu. RSAC suggests that RSC/JASRI in collaboration with NanoTerasu consider establishing a single point of entry for users of SPring-8 and NanoTerasu. There are several advantages that RSAC sees in this approach:
  1. Remove redundancy in the facility-user interface.
  2. Users of SPring-8 are familiar with the existing system and this eliminates any barrier to proposing experiments at NanoTerasu.
- RSAC strongly supports continued developments of synchrotron technologies that are world leading such as state of the art reflecting optics. Communicating the developments beyond SPring-8 and Japan to the world community in a timely fashion is very important.

Terms of Reference (TOR4)

4. comments and/or recommendations regarding the progress of SPring-8/SACLA toward their mission to set the direction for the future of science.

- X-ray facilities have in the past, and will for the foreseeable future, provide unique information necessary to better understand forefront science problems. It has already been documented that research using accelerator-based x-ray sources has contributed to solutions addressing societal challenges. The energy, time and length scales accessible with x-rays, in combination with their elemental specificity, on the Harima site, are ideally matched to problems in chemistry, biology, medicine and materials science. Further, x-ray results guide developments of technological importance that

directly impact society as evidenced by the continued leadership in industrial use at SPring-8. Continued development of x-ray research capabilities with SPring-8-II and in the future with SACLA-II will ensure the importance of x-rays will continue.

- From Prof. John Etchemendy, Provost (2000-2017), Sanford University at the LCLS Ground Breaking: "Instruments have a life of their own. They do not merely follow theory; often they determine theory, because instruments determine what is possible, and what is possible determines to a large extent what can be thought."

Recommendation:

- RSAC urges RSC to begin now to consider all possibilities afforded by the installed infrastructure to make SACLA-II unique worldwide. With a unique tool, new science will be possible and can change the way people think about important questions in fundamental science and their impact on societal challenges.

Requested by the RIKEN President

1. Evaluate the responses to the 2019 AC recommendations.
2. Based on the results of the Center's self-analysis, evaluate operations and R&D activities for the 4th Mid- to Long- Term Plan period (FY2018-2024).
3. Evaluate the policies of the 5th Mid- to Long-Term Plan period (FY2025-2031) and recommend new directions for operations and R&D that should be implemented and promoted.

- Request of the RIKEN President (TOR1)

1. Evaluate the responses to the 2019 AC recommendations.

- RSAC is very pleased with the response to our 2019 recommendations. In particular, as a committee, we are encouraged to continue helping RSC/JASRI drive world leading science and technology with accelerator-based x-ray sources.

- Request of the RIKEN President (TOR2)

2. Based on the results of the Center's self-analysis, evaluate operations and R&D activities for the 4th Mid- to Long-Term Plan period (FY2018-2024).

- RSAC recognizes the strengths of the Center as world leading in the development of advanced beamline components that in turn lead to cutting edge research by RSC staff, JASRI staff and users.
- Both SPring-8 and SACLA are exceptionally reliable, stable, and well managed, despite

minimal staffing levels.

- RSC staff have world leading impact in several areas, highlighted, for example, by results from SACLA in non-linear x-ray science and inelastic x-ray scattering at SPring-8 and the High Energy Density science platform at SACLA.

- Request of the RIKEN President (TOR3)

3. Evaluate the policies of the 5th Mid- to Long-Term Plan period (FY2025-2031) and recommend new directions for operations and R&D that should be implemented and promoted.

- RSAC emphasizes the importance of the generation of reliable, robust data as the basis for scientific advances. The SPring-8-II Upgrade (2025-2028) is an opportunity to reach this goal as a better 'Data Creation Platform'. Generating the data is necessary but not sufficient. Analysis, visualization, and interpretation is also critical. It is the data generation aspect of TRIP that is the strength of SPring-8 (SPring-8-II) and SACLA. RSC has also established the direct link to Fugaku which provides the other components that will make TRIP successful.
- RSAC recognizes the need for top down as well as bottoms up approaches for the use of SPring-8 and SACLA. The top-down approach is well matched to use inspired research for example with the Semiconductor Device Characterization Platform and the National Resilience Platform. RSAC takes note that the existing strategy of RSC to create data, use the unique capabilities of the Fugaku supercomputer and the bioscience capabilities matches exactly the TRIP concept.
- SPring-8 has world leading use by industry and this naturally resonates with a top-down approach.
- RSAC strongly recommends RSC start considering SACLA-II with a focus on developing worldwide unique capabilities.
- There is always a need to train and develop the next generation of leaders for the RSC. This is a continuing need, not just for RSC but for large facilities in general. This will ensure a continuity of vision for the development of the capabilities on the Harima site.

- Accelerator upgrade recommendations (1)

- In addition to the reduction of the electron beam emittance, it is necessary to optimize other parameters such as the proper matching of the electron and photon phase-spaces. This will maximize the intensity of the coherent flux. A first objective could be having both horizontal and vertical beta functions of about 2m in 24 of the available 48 straight sections.

- In these straight sections, the horizontal beam-stay-clear is then reduced which will allow the installation of small vertical as well as horizontal gap insertion devices. In addition, RSAC suggests comparing the performances of the undulators (and in particular in-vacuum undulators) with variable parameters of length, gap and local beta functions.

- Accelerator upgrade recommendations (2)

- RSAC recommends evaluating the replacement of the short and normal bending magnet sources or at least a few of them by longitudinal gradient permanent magnet material bending magnets targeting a sharp peak field of about 3T as has been constructed and successfully used in operation at Sirius and planned for the SLS 2.0 and SOLEIL II projects. This will bring the critical photon energy from 22.5 keV to 71 keV which will tremendously increase the photon flux at higher photon energies. RSAC believes that with such a shape of the longitudinal magnetic field and a very small dispersion in its center, the contribution to the total energy loss per turn should be low.

- Accelerator upgrade recommendations (3)

- As is the case for Spring-8, Spring-8-II will run in Top-up mode for stable operation. A conventional scheme with pulsed bump magnets is considered for a transparent injection into Spring-8-II. RSAC believes that the ultralow emittance of the new source will enhance the sensitivity of the electron beam position and beam size to even very small errors in the injection system. RSAC recommends the team evaluate an injection scheme using a single Non-linear Kicker taking advantage of the very low emittance beam from the LINAC. The first fourth generation storage ring (MAX IV) is running with such a system and has achieved sub-micrometer levels of residual perturbations to the stored beam size, well below the nominal beam size in both horizontal and vertical planes.