Report from the Meeting of the Photon Factory ISAC Light Source Subcommittee

February 25-26, 2010

Introduction, ISAC Light Source Subcommittee Process and Report Organization

The Photon Factory ISAC Light Source Subcommittee (LSS) was chartered by the Photon Factory (PF) and the Accelerator Division VII (AD-VII) of the Accelerator Laboratory of the High Energy Accelerator Research Organization (KEK) with providing advice on the accelerator operations and developments of new light sources at KEK. The ISAC LSS meeting was held at KEK on February 25-26, 2010. In advance of the February meeting, The LSS was provided with copies of several presentations and a list of six questions that it was asked to specifically consider during the meeting (the list is included in the Appendix as item 3. The LSS heard a series of technical presentations that provided the information and background for its discussions and recommendations. Following questions and discussion, the LSS met in closed session and formulated its observations, conclusions and recommendations.

In the closeout session held on February 26, the LSS presented to the management of the PF and the Accelerator Laboratory the Executive Summary of the meeting and closing remarks. This written report details the LS Subcommittee's findings and recommendations as presented in that closeout.

In order to maintain the consistency with the PF ISAC reporting approach, the organization of this report is as follows: Following this Introduction is an Executive Summary and Perspective. Each of the next six sections gives more details and elaboration of the questions in the same order that they were presented in the verbal closeout with PF and Accelerator Laboratory management. The last section offers Other Conclusions and Comments. The Appendix contains a list of the ISAC LSS members, the Agenda of the LSS meeting, and the list of six questions provided by PF and AD VII management.

Executive Summary and Perspective

First, the LSS wishes to emphasize the remarkable performance of accelerator systems at the PF - one of the world first dedicated synchrotron radiation (SR) sources. The record high and very consistent mean time between failures (MTBF), around 300 hours, is the trademark of the PF and is the gold standard for all SR sources around the world. The staff of the Accelerator Division VII should be complimented for the diligence and dedication to their duties that result in the supreme reliability of the PF accelerators. Recent full implementation of the top-up mode strongly benefits the PF user community by significant improvements of the x-ray source stability. The AD VII has developed and operates high-quality insertion devices. It continues to introduce novel radiation sources such as the 10 Hz polarization switching double undulator.

The LSS is extremely impressed with the progress of the compact energy recovery linac (cERL) project. Particularly the Subcommittee wants to compliment the collaborative effort of multiple institutions in the development of the DC gun and congratulate the team with the recent record performance results of this gun. Also, this success is the direct result of the integration of the PF accelerator division into the KEK Accelerator Laboratory.

The 5-GeV ERL x-ray source is a very attractive option for the PF future, and, as

presented, is in the early stage of design. The Accelerator Laboratory and AD-VII are collaborating with several institutions and considering an innovative expansion of the design that would incorporate a x-ray free electron laser – oscillator type (XFELO).

The KEK-X is another very desirable and attractive option for a future x-ray source at the KEK. Both 4-GeV and 7-GeV storage rings of the Super KEKB factory are being considered for the x-ray source, which would bring the PF in line with the best performance of upgraded third-generation x-ray sources around the world. The LSS recognizes this visionary idea and brings attention to several very significant and exciting challenges in the design and integration of accelerator systems that would perform at the state-of-the-art level for high-energy physics and SR experiments.

1. Question 1 – Is the machine operation of 2.5 GeV PF ring and PF-AR at the expected level of modern synchrotron radiation facilities?

The LSS recognizes that the operational performance of PF accelerator systems and particularly the 2.5-GeV ring is at a record high level. The MTBF value of 300 hours--one of the most important characteristics of the performance--is the highest for all SR facilities around the world, or at least of those that the Subcommittee is aware of. Furthermore, the average recovery time from the beam loss is relatively short, and, as a result, the x-ray beam availability is higher than 98%. Overall operation of the PF accelerator systems could be considered as one of the best in the world.

The full implementation of the top-up mode has been a success that was definitely welcomed by the PF user community. This mode of operation, as at all other SR facilities around the world, creates a strong foundation for improvements in the stability of electron and x-ray beams.

2. Question 2 – Are improvements of storage rings and developments of IDs conducted in appropriate way?

Based on the content of presentations and interactions with the AD VII staff, the LSS concludes that PF and AD VII management have clear understanding of the tasks and developments needed to support sustainable operation and future improvements. Main areas of improvements are: beam stability and novel insertion devices (IDs). The most effective way to achieve tangible results in the beam stability area is to concentrate on the improvements of beam position monitors and fast feedback systems. The AD VII staff has good expertise and experience in the design and operation of IDs. It should continue improvements of the ID feed-forward system to achieve better beam stability--few percents of the electron beam size--while changing ID operational parameters.

3. Question 3 – How is the progress of the development of the ERL key technologies? Are they focused enough and progressing reasonably fast? Is the construction plan of the cERL reasonable? Are they pointing in the right directions?

Excellent progress has been made in the study and development of the cERL, which will serve as a test bed for a future 5-GeV ERL light source. The cERL project greatly benefits from the new Accelerator Laboratory organizational structure. The AD VII staff, as the part of team formed by the Accelerator Laboratory, was able to utilize for the cERL construction a large hall already equipped with much of the infrastructure needed for the facility. The cERL has well-defined and ambitious goals to reach in 2012 an energy of 35 MeV with a 10-mA beam current, then 125 MeV with 2-pass operation in 2016, and finally--245 MeV with another two cryomodules. The LSS concludes that the cERL project goals and the construction plan are quite adequate.

Aggressive and very successful R&D efforts by the highly skilled team are in progress for the DC gun, gun drive laser, superconducting cavities for the injector and main linac, and the high-power rf source. The LSS commends the team for the recent record achievement in the DC gun performance.

Increasing the current beyond 10 mA is expected with future development of the DC gun and with the ultimate goal of 100 mA for the future 2-pass 5-GeV ERL light source. The LSS one more time emphasizes the vital importance of the fruitful collaboration on development of the DC gun development established by KEK with other institutions in Japan.

Studies of the 5-GeV ERL are in the preliminary stage. Modeling and analytical analysis of the beam dynamics proceeds well. Significantly more effort would be required in order to accomplish a detailed conceptual design. The accelerator physics group benefits from the interaction with the team from Cornell University.

The team is also investigating the highly attractive option of using the high-brightness, ultrashort bunches available from the 5-GeV ERL machine to drive one or more XFELOs. The LSS strongly encourages the PF and AD VII staff to collaborate on that subject with different institutions in Japan and around the world.

4. Question 4 – We consider that the KEK-X project, if it realizes the concurrent operation with the Super KEKB for high-energy physics, would be very attractive for the SR users. How do you evaluate the KEK-X project in the context of the global SR advancements? Any pitfalls to watch out?

The KEK-wide accelerator strategy is based on a long-term plan that will deliver world-leading capabilities for high-energy physics ***and*** synchrotron science over the coming decade and beyond. Part of such a plan based on the KEK-X project has been presented to the LSS. The KEK-X with its potential to deliver the brightness of x-ray beams on a level comparable with most advanced third-generation SR sources could become another premier SR facility in Japan.

But in order to succeed, the KEK Accelerator Laboratory has to meet major technical and, in the future, operational challenges. Super KEKB rings should achieve record high luminosity for high-energy physics experiments and at the same time deliver x-ray beams

that are competitive with existing dedicated third-generation SR sources. The LSS recognizes that as yet there is no such a machine built in the world, and the KEK Accelerator Laboratory has to come up with innovative solutions for that exciting task. One of the top challenges is the compatibility of the high-luminosity lattice with multi-ID operations for both high-energy and low-energy rings. The KEK team is working toward addressing this challenge and investigating several others. Significantly more effort would be required to produce a viable technical option for the KEK-X project. Nevertheless, it is clear to the LSS that the KEK Accelerator Laboratory has all the necessary expertise and resources to achieve such an ambitious goal, and whether they are successful is just a question of priorities within the KEK Laboratory.

5. Question 5 – Considering the constraints in both financial and human resources, is the present scenario of the cERL/KEK-X/ERL reasonable?

As has been pointed out by the PF ISAC in the last report, the cERL/KEK-X/ERL strategy is very interesting and has significant potential. Based on the information presented at the meeting, the LSS concludes that the timeline for development and potential construction of the KEK-X and 5-GeV ERL is reasonable. As the LSS stated in the answer to the previous question, the necessary requirement to launch the KEK-X project is a successful series of innovative accelerator developments for both Super KEKB storage rings. But the LSS also states that if the Accelerator Laboratory will continue to execute this plan with the current level of effort and financial resources, it is not clear how such a plan would be accomplished even in the next 15 years.

6. Question 6 – The light source division is making every effort to balance between the maintenance of the user facility and the development work for the future light source. In light of this, are there any suggestions how to improve the efficiency to manage the existing storage rings?

Once again the LSS commends the dedication and expertise of AD VII management and staff that resulted in the remarkable performance of the PF storage rings. In order to maintain this record high level of performance, the Subcommittee encourages AD VII management to continue the delicate balancing of priorities between PF rings proactive maintenance, R&D and new source developments.

One of the ways to improve the efficiency of operations is to continue to advance the automation of all possible tasks executed by the control room. Also, the advancement of the beam position monitoring and correction should lead to more effective x-ray beam delivery to PF users.

In conclusion, the Subcommittee requests the PF ISAC to convey to the KEK/PF management our strong recommendation of preserving adequate allocations of resources to preserve and, in some cases, continue to improve the performance of the PF accelerator systems.

7. Other Conclusions and Comments

Accelerator Physics:

• It is important to study in detail the beam dynamics for the ERL double-loop design. As a very attractive option for future ERLs and the XFELO, the double-loop design must also be benchmarked at the cERL when it becomes operational. 5 GeV ERL could be also considered as a source of the SASE FEL under a special configuration.

• Concurrent operation of the Super KEKB and KEK-X would be possible if several accelerator challenges will be addressed. One such challenge is the optimized dynamic aperture of the storage rings. The Subcommittee notes that modern methods of multi-objective lattice optimization using genetic algorithms, which have proven successful for other difficult lattices, might lead to a solution to this problem, if they have not already been tried. A solution that relaxes constraints on the ID straight lattice properties might be found. The LSS suggests to the AD VII staff to collaborate on that matter with other institutions where such optimization algorithms are being developed.

Instrumentation:

• The BPM electronics for PF rings is going to be upgraded. It could be beneficial to investigate the use of BPM processors currently chosen for the NSLS-II.

• Improvements in the orbit feedback system should lead to orbit stabilization within at least 5% of the beam size, and this stability should be preserved during ID gap changes.

• The AD VII staff has good expertise in the area of IDs. It would be very useful and interesting for the SR community if fast switching (faster than 10Hz) of polarization would succeed.

Lastly, we thank the Light Source Subcommittee PF and AD VII staff for their excellent help and organizational support to enable a most successful meeting. We also thank you for a delightful evening with KEK colleagues and a wonderful dinner.

Appendix – Contained in the Appendix to this LS Subcommittee Report are the following:

1. **List of the LS Subcommittee members**

2. **Agenda of the LS Subcommittee Meeting– February 25-26, 2010**

3. **List of Questions provided to the LS Subcommittee by PF and AD VII Management**

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1. List of the Members of the LS Subcommittee:

Efim Gluskin – Advance Photon Source, Chairperson of Subcommittee

Robert Hettel – Stanford Linear Accelerator Laboratory

Toshitada Hori – RIKEN

Haruo Ohkuma – Spring-8

Joachim Pflueger – European X-ray FEL

2. Agenda of the LS Subcommittee Meeting

Date: February 25-26, 2010

Place: Room 244, Building No.4, KEK

09:00 – 09:20 Executive session (Closed) 20 min

09:20 – 09:25 Welcome O. Shimomura 5 min

09:25 – 09:30 Welcome K. Oide 5 min

09:30 – 09:45 Charge to the subcommittee S. Wakatsuki 15 min

09:45 – 10:00 Introduction of light source division Y. Kobayashi 15 min (10 min + 5 min)

PF ring and PF-AR

10:00 – 10:50 Operation status T. Honda 50 min (40 min + 10 min)

10:50 – 11:10 Coffee break

11:10 – 11:40 Development of beam diagnostics T. Obina 30 min (20 min + 10 min)

11:40 – 12:10 Development of insertion devices K. Tsuchiya 30 min (20 min + 10 min)

12:10 – 13:30 Lunch

ERL & KEK-X

13:30 – 13:50 Introduction H. Kawata 20 min (15 min + 5 min)

13:50 – 14:40 Overview of cERL and ERL project S. Sakanaka 50 min (40 min + 10 min)

14:40 – 15:20 Development of electron gun M. Yamamoto 40 min (30 min + 10 min)

15:20 – 16:00 Development of SC cavity K. Umemori 40 min (30 min + 10 min)

16:00 – 16:20 Coffee break

16:20 – 17:00 Beam dynamics of injector T. Miyajima 40 min (30 min + 10 min)

17:00 – 17:40 Beam dynamics of return loop K. Harada 40 min (30 min + 10 min)

17:30 – 18:00 Introduction of KEK-X project Y. Kobayashi 20 min (15 min + 5 min)

18:00 – 18:30 Discussion 30 min

19:00 Dinner

09:00 – 11:00 Executive session (Closed) 120 min

11:00 – 11:30 Summary presentation 30 min

11:30 – 13:00 Lunch

13:00 – 15:00 Tour (South AR, East Counter Hall, STF) 120 min

3. List of Questions provided to the LS Subcommittee by PF and AD VII Management

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Question 2 – Are improvements of storage rings and developments of IDs conducted in appropriate way?

Question 3 – How is the progress of the development of the ERL key technologies? Are they focused enough and progressing reasonably fast? Is the construction plan of the cERL reasonable? Are they pointing in the right directions?

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