Introduction

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On behalf of the staff of the Photon Factory (PF) we are pleased to present Photon Factory Activity Report 2014. This report covers the research activities carried out in fiscal year 2014 (April 2014 – March 2015). Using the PF and PF-AR we have been conducting a variety of synchrotron radiation experiments including slow positron experiments in material and life sciences as an Inter-University Research Corporation. The PF is promoting inter-university collaboration to activate joint research projects. In FY2014 we had about 940 active approved proposals, 3,100 registered users and more than 600 publications. The inter-university research program has been going well and the activities are becoming increasingly important. The PF is also participating in large national projects of the Ministry of Education, Culture, Sports, Science and Technology (MEXT): “Elements Strategy Initiative to Form Core Research Center”, “Platform for Drug Discovery, Informatics, and Structural Life Science”, “Photon and Quantum Basic Research Coordinated Development Program”, “Cross-ministerial Strategic Innovation Promotion Program”, and “Impulsing Paradigm Change through Disruptive Technologies Program”. The PF is also serving as an administrative facility in the Photon Beam Platform to open new research fields of industrial use. Thus, the PF is working to solve a variety of challenges for sustainable human development as well as fundamental scientific problems.

Operation and upgrades of the PF and the PF-AR

The PF has actively been upgrading the beamlines to focus on important scientific areas over the past decade. We are operating two storage rings, the 2.5 GeV PF ring and the 6.5 GeV PF-AR. The PF ring has strong photon intensities in energy regions of vacuum ultraviolet (VUV) and soft X-ray (SX), while the PF-AR has a great advantage in the hard X-ray region. In the long straight sections of the PF ring we have installed new undulators and reconstructed the VUV and SX beamlines to capitalize on the PF ring’s strengths: BL-2A/B for surface and interface science, BL-13A/B for surface chemistry, BL-16A for surface spectroscopy with polarization switching, and BL-28A/B for strongly correlated electron science. Meanwhile, we have upgraded the hard X-ray beamlines to support the large number of X-ray users and gain long-term competitiveness in the field of X-ray science by installing short-gap undulators in the short straight sections of the PF ring: BL-1A for protein crystallography, BL-3A for structural science, BL-15A for XAFS and small-angle scattering, and BL-17A for protein crystallography. In the PF-AR we are focusing on hard X-ray activities such as high-pressure, time-resolved experiments. In the PF and PF-AR, competitive bending beamlines have been supported generously while beamlines with low productivity have been closed. We had almost reconstructed these beamlines successfully by the end of FY2014. Thanks to the systematic reconstruction of beamlines we succeeded in reducing the number of stations from 72 (FY2005) to 39 (FY2014) in the PF ring with no loss of productivity. The scrapping and building of beamlines has had a significant positive effect on manpower and budget shortages. Our user community has also played an important role in these improvements: six stations are managed by user groups and one station by a university.

In FY2014 we suffered a serious budget cut and an increase in electricity rates. As a result it was very difficult to secure the operating time of the PF and PF-AR. Finally, the user times of the PF and PF-AR were 2328 hours and 1992 hours, respectively, which are approximately half of the pre-quake level. It is most unfortunate that users’ research activities and graduate school education were seriously affected by this shortage of user time. In order to overcome the difficult situation, the PF cooperated with the PF user association (PF-UA) and communicated the difficulty to KEK and MEXT. At the request of the PF-UA, 28 chairpersons of scientific associations, 21 representatives of companies and eleven leaders of national projects gave their approval on a document requesting the securing of user time and submitted a formal request to KEK and MEXT. Thanks to this powerful appeal, we were able to promptly recapture budget for operating rings in FY2015, though it is still not sufficient. To overcome the crisis of beamtime shortage we are also developing ways for effectively using user time, including time-sharing by two groups.

We have been promoting the project for a direct injection path to the PF-AR. In this project we are constructing a tunnel for the injection path to achieve a good balance between the injections to PF-AR and Super KEKB. In future we will acquire the ability of top-up operation in the PF-AR with the completion of this tunnel. We have already completed building the tunnel, and construction of the accelerator and some facilities. We are planning to install the accelerator in early autumn 2016 and start the PF-AR again in winter.

The PF is conducting inter-university research programs using slow positron as well as synchrotron radiation. Recently, a technique to determine atomic positions on the top surface of a crystal using slow positrons was

developed in collaboration with the Japan Atomic Energy Agency and Nagoya University. They have refined the reflection high-energy positron diffraction (RHEPD) method to develop the total-reflection high-energy positron diffraction (TRHEPD) method, which have provided good evidence of the effectiveness of determining surface structure by observations of the reconstructed structure of a silicon surface and silicon structure on silver and so on.

Inter-university research program

The PF welcomes applications for research proposals from all over the world. There are various proposal categories: type G for general experiments, type P for preliminary experiments by novice users or feasibility studies for new types of experiments, Type S1 and S2 for high-level research projects, and type U for urgent and important experiments. In FY2014 we launched a new type of research proposal, type T, in collaboration with the PF-UA. This proposal supports research by PhD students for three years until they complete their doctoral course. The proposal is rigorously judged by documentary examination and interview. The PhD students have to make the proposal by themselves, conduct the experiments, and sometimes learn from their failure. Finally they are expected to mature as scientists who can make excellent use of synchrotron radiation. The corresponding PF staff member becomes a mentor of the student and leads various experiments in collaboration with a supervisor in a university.

The Institute of Materials Structure Science (IMSS), KEK started planning a new inter-university research program, called multi-probe experimental proposals, to promote researches using multiple quantum beams such as synchrotron light, neutron, muon, and slow positron beams. The proposals must be experimental ones using multi-probes. The proposals are expected to be a high-level research project, which requires the full use of multi-probes, with a validity period of three years. The proposals are also judged by documentary examination and interview by an ad hoc committee. We hope the projects will produce flagship science of the IMSS.

Collaboration among universities and institutes

The 32nd PF symposium, which is an annual meeting to communicate the present status of the PF to PF users, was held on March 18th, 2015. The PF symposium has joined in the IMSS Science Festa since 2012. On the first day we discuss quantum beam science with neutron, muon, and slow positron users, and on the second day specific issues are separately discussed by each side. The IMSS Science Festa has given PF users a valuable opportunity for communication with many researchers of different fields. 2015 in the PF symposium, after some reports from facilities and centers, we frankly discussed various issues about the operation, management, and future direction of the PF as well as photon science. In particular, there was serious discussion about the future plan. This issue has long been under discussion and is slowly but surely being resolved as described below.

The IMSS launched a special symposium to address the IMSS's identity or raison d'etre. In the past four symposiums we discussed various issues of the IMSS and tried to find solutions. We began with the mission and the installation purpose of the IMSS and then proceeded to the present status and future challenges. Finally we were trying to find solutions and make proposals in various directions such as communities, KEK, and government. The issues discussed include the IMSS's place in KEK and future plans for quantum beams and facilities. The final report will be written up this fiscal year.

We strongly support nanotechnology research and education in the Tsukuba area, namely the Tsukuba Innovation Arena for Nanotechnology (TIA-nano), which has been led by the National Institute of Advanced Industrial Science and Technology, the National Institute for Materials Science, University of Tsukuba, and KEK. In FY2014, TIA-nano and Kyoto University's Nanotechnology Hub established the Nanotech Career-up Alliance (Nanotech CUPAL) based on subsidized projects for fostering science and technology personnel. We aim to enhance the careers of nanotech researchers in Japan and to improve their mobility by conducting two projects: Nanotech Research Professional and Nanotech Innovation Professional projects.

Future plan of the PF

The KEK Roadmap 2013 was published in May 2013. In the Photon Science section of the Roadmap, it is described that KEK will construct and then operate the compact energy recovery linac (cERL) and will work toward construction of a 3 GeV ERL facility. After that, based on the opinions and discussions from the PF-UA, the Japanese Society for Synchrotron Radiation Research, and the international review committee of the Roadmap, KEK made the following additional statement in October 2013: While KEK is engaged in a long-term effort toward the construction of a 3 GeV ERL facility, KEK will play a leading role in the realization of a low-emittance storage ring as a high-brilliance light source in the mid-term. KEK is now beginning specific studies on this possibility with an eye on the value of the nationwide effort.

The IMSS Steering Committee established the "Committee for Future Plans of the PF" to consider carefully the relation between the low-emittance storage ring and the 3 GeV ERL project in the PF future plan. The Committee for Future Plans submitted the mid-term summary to the IMSS Steering Committee in July 2015. On the basis of discussions in the Steering Committee, the Committee for Future Plans will summarize a final report and submit it before the end of FY2015.

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