4. BEAMLINES AND EXPERIMENTAL APPARATUSES

4.1 Overview

To demonstrate the way in which the beamlines have evolved over the past decade, the beamlines operating in 1995, 2001 and 2005 are listed in Tables 1 - 3 (inserted between p. 34 and p. 35). It can be seen that the Photon Factory has been making an effort to improve beamlines and experimental stations every year within the constraints of a limited budget. As shown also in Fig. 1 there are currently 12 insertion device based beamlines, at which 21 experimental stations are operational. Several periodic insertion devices which can be used as either multi-pole wigglers or as undulators were installed in the early stages of the Photon Factory in the 1980s. Beamlines based on such insertion devices consist of one X-ray branch beamline using the multi-pole wiggler mode and one VUV-SX branch using the undulator mode. The undulator radiation is transported to the VUV-SX branch by inserting a focusing mirror with a horizontal deviation angle of ~4°, providing reasonable space for both X-ray and VUV-SX experimental stations. At the Photon Factory we also utilize 17 bending magnets, from which synchrotron radiation is extracted and delivered to a further 48 experimental stations. For each bending magnet, there are on average three branch beamlines, some of which have been further extended to tandem branches. This approach helps to avoid the frequent switching of experimental setups and consequently to ensure more efficient operation of the relevant experimental stations. In total, there are 69 experimental stations with 29 beam ports, 59 at the 2.5 GeV PF ring and 10 at the PF-AR. Among the 69 stations, synchrotron radiation is available at 56 stations simultaneously making use of the hybrid and tandem configuration of branch beamlines. It should be noted that the super-conducting wiggler of 5T is not counted as a periodic insertion device beamline in the statistics on Table 4.

Table 4 Statistics of experimental stations.

		ID source stations		BM source stations
X-ray	full time	6	5A, 17A, NE3A, NW2A, NW12A, NW14A	26
	part time	7	13A/B1/B2, 16A1/A2, NE1A1/A2	8
VUV/SX	full time	1	28A	14
	part time	7	2A/C, 13C, 16B, 19A/B,NE1B	0

The Photon Factory has only 80 permanent staff members. This number includes the scientists and technicians in the Light Source Division and the Synchrotron Radiation Science Divisions I and II. The average number of scientific staff who belong to either Synchrotron Radiation Science Division I or II and who partially or fully support scientific activities at beamlines is only 0.5 per experimental station. This number is extremely small compared to the ESRF (≈4) and SPring-8 (≈1.5). Thus it is unfortunately not practical to provide optimum support for all the experimental stations. In order to compensate somehow for such a very low index, twelve contract personnel are employed to assist in the operation of the light source, general user support, and safety

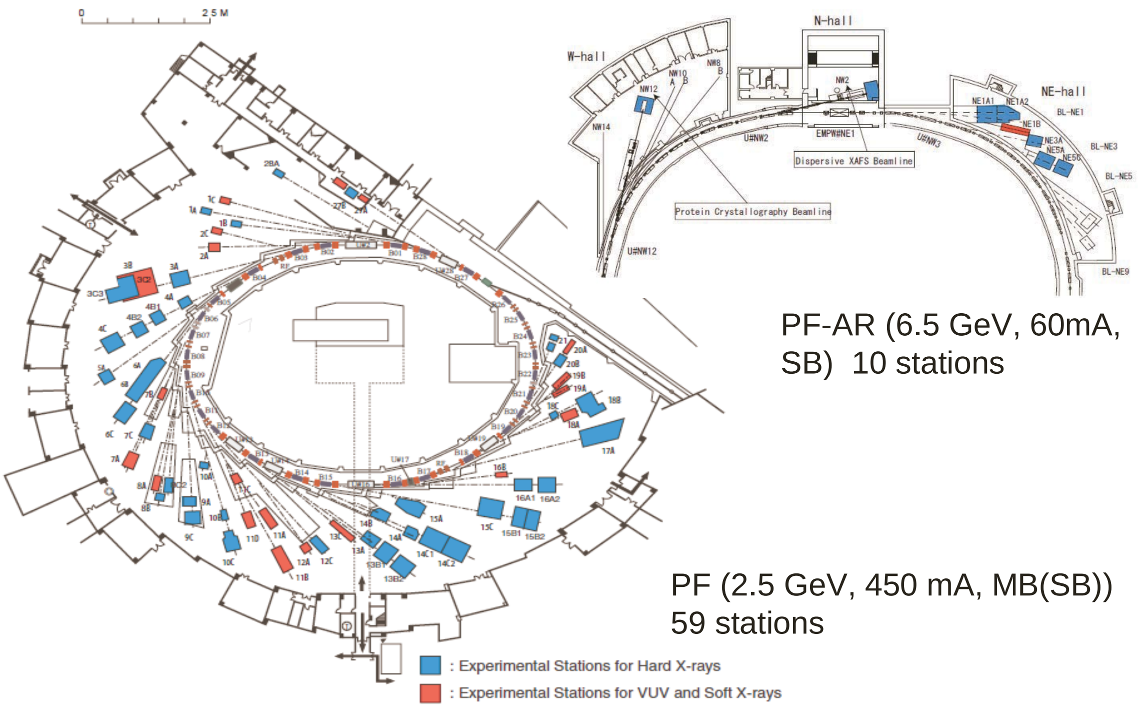

Figure 1
Plan view of experimental halls. There are 69 experimental stations and 56 stations can be operated simultaneously.

control. However the present situation is far from adequate for an organization dedicated to supplying a high standard of user support. In the future it may become unavoidable to concentrate the manpower of the PF staff members on certain high-performance beamlines, where they can provide high quality user support and carry out forefront research.

The budget situation at the Photon Factory was quite unsatisfactory in 2000 in the presence of some big science projects carried out at KEK including KEKB, the neutrino oscillation experiment, and the J-PARC project. After KEK became an agency independent of MEXT in 2004 (the Inter-University Research Institute Corporation, High Energy Accelerator Research Organization), the reduction of all budget categories by 1% every fiscal year was mandated by the government. Considering the present budget situation, the overall investment and manpower available must be concentrated on certain beamlines.

4-1-1 Categorization of the beamlines

Over the past several years the PF has strongly promoted the straight sections upgrade project in the 2.5 GeV PF ring, as mentioned in the previous section. Four new short straight sections have been produced and 10 existing long or medium straight sections lengthened (one of these sections must be used for injection). It was decided to use the four new short straight sections for X-ray experiments and 5 of the long/medium straight sections for VUV/SX experiments. The beam ports at the four short straight sections of BL-1, BL-3, BL-15, and BL-17 all currently support three branch beamlines which all maintain a certain level of scientific activities. These activities should be transferred elsewhere in order to propel new activities with short gap undulators. In 2002, we decided to construct a multipole wiggler beamline for structural biology research at the last free beam port of the PF ring. For the PF-AR was constructed originally as a booster of the TRISTAN main ring and is unfortunately located underground, a new experimental hall is needed for any new beamline. The decommissioning of existing beamlines is required to construct a new beamline.

Furthermore, as mentioned above, it is desirable to concentrate financial and manpower investment on certain beamlines and scientific activities which the PF would like to support. We thought it very important to review and categorize the existing beamlines in order to establish a strategy for the construction of new beamlines and/or the amelioration of existing ones, taking into account the concentration of staff manpower. The last external review committee held in 2001 also suggested a decrease in the number of beamlines and the gradation of the level of support available at each beamline. The committee expected the PF to provide high-level support for specified beamlines, maintaining the high-quality hardware neccessary to produce leading scientific results.

Consequently, the construction of new beamlines forces us to decommission some existing beamlines. Careful consideration is required in selecting the beamlines to be upgraded. To this end we made an effort to categorize all the beamlines at the PF. A working group consisting of several PF staff members carried out this categorization taking into account the evaluation and comments of the most recent external review for each beamline. The first draft was presented to the Photon Factory Program Advisory Committee (PF-PAC) and the users' community. Table 5 (inserted between p. 34 and p. 35) gives the categorization list as revised in 2003 including the commentsby the PF-PAC and the community. The decommissioning, amelioration and building of new beamlines has been carried out based on this categorization list. The beamlines are classified into four categories as described below.

Category S implies a high level of support for the beamline/experimental station and significant capital investment. Most beamlines under construction or major improvement belong to this category.

Category A implies a fairly high level of support for the beamline and experimental station and sufficient capital investment to support experiments in the short term .

Category B implies modest support and minimal or external investment.

Category C implies limited support and an investment level sufficient only to maintain safety or to maintain beamline operations until future plans are settled. These beamlines will be closed if significant investments become necessary for their continued operation.

The following factors were taken into account during beamline categorization:

- Scientific research activity, demand for beamtime, number and quality of publications.
- Hardware performance of beamlines and experimental apparatuses if equipped. Criteria include photonflux, resolution, beam size, stability.
- Organization of user support systems if there are users requiring such support.
- Estimation of investment for beamline/instruments over the next few years.
- Consequences of the beamline decommissioning.

In the following sections, we will describe the beamlines which have been newly constructed at the 2.5 GeV PF ring and at the PF-AR. Most of the new beamlines are associated with the results of the categorization described above. For example both BL-28A and BL-28B are categorized as C in Table 5. They were constructed in the early 1990s for research using circularly and/or elliptically polarized light which is supplied by a periodic insertion device. For several years following commissioning scientific activities at these two beamlines were relatively high thanks to their unique performance characteristics; BL-28A supplied circular polarization in the photon energy region 20-200 eV and BL-28B elliptical polarization over 2-10 keV. However, the numbers of active proposals and users became unsatisfactory towards the late 1990s. This was partly because newly developed phase-retarders gave a better degree of circular polarization and polarization-tunability in the hard X-ray regime, and undulator based beamlines dedicated to circular dichroism (CD) experiments were constructed at SPring-8 by the turn of the century. The beamlines at SPring-8 cover the range 300-2000 eV, corresponding to the resonance photoabsorption region of the transition metals, where sum rules can be applied to absorption spectra. BL-28B was still competitive in the soft X-ray region (2-4 keV) where phase-retarders are not available. However, the demand for beamtime in this energy region was not very high. In 2003, we decided to close BL-28A and BL-28B and construct in their place a spectroscopy beamline dedicated to the VUV-SX region and in particular to promote high-resolution angle-resolved photoelectron spectroscopic studies on high-Tc superconductors and nanomaterials.

4-1-2 Structural Biology Beamlines at the 2.5 GeV PF ring and the PF-AR

To support the scientific activities in structural biology, Prof. Soichi Wakatsuki was appointed as leader of the Structural Biology Group in 2000. The PF strongly supports the Structural Biology Group which evolved into the Structural Biology Research Center in May 2003 and promotes the construction of new beamlines dedicated to research in structural biology. A new beamline AR-NW12A was completed in 2002 in the northwest experimental hall of the PF-AR which was itself newly built in 2001. AR-NW12A is the first structural biology beamline at the Photon Factory equipped with an undulator as its light source. The optical system of AR-NW12A consists of a collimating mirror and a double crystal monochromator equipped with a cryogenically cooling system as well as a focusing mirror. The beamline covers the photon energy region 7-17 keV, and is optimized for high-throughput multi-wavelength anomalous diffraction (MAD) experiments. The available intensity is 2×10^{11} photons/s through a 0.2 mm square slit with 0.5 mrad beam divergence. It takes 20 minutes to obtain one dataset at AR-NW12A using the new ADSC Q210 wide-area CCD detector, compared to a few hours at a beamline which uses a bending magnet source.

Two more new structural biology beamlines were constructed at the 2.5-GeV PF ring: BL-5A with a multipole wiggler source and BL-17A with an in-vacuum short-gap undulator (SGU). Both of these beamlines were constructed with external funds brought in by Prof. Wakatsuki. BL-5A was constructed in 2003-2004 using the last remaining straight section of the 2.5-GeV PF ring. The beamline optics is similar to that of AR-NW12A except that a micro-channel water-cooling system is used, and the beamline covers the photon energy region of 6.5-17 keV. BL-17A was constructed in 2004-2006 at a newly secured short straight section with the aim of studying sample crystals as small as 20 µm. Its optics consists of a double crystal monochromator equipped with a cryogenically cooling system and a K-B mirror system. In addition to MAD experiments in the 1 Å region (11-13 keV), single-wavelength anomalous diffraction (SAD) experiments can be done in the lower photon energy region 6-8 keV, making it possible to study S-atom containing proteins without substitution by Se atoms. The commissioning of BL-17A started in October 2005 and is now in progress. Detailed beamline performance and typical research outputs are described in sections 4-2-2, 3 and 7, respectively for BL-5A, BL-17A and AR-NW12A.

4-1-3 New insertion device based beamlines at the 2.5-GeV PF ring for fields other than structural biology

The University of Tokyo has been proposing to construct a third generation VUV/SX synchrotron radiation facility, the Super-SOR project, for almost twenty years. The Photon Factory and the synchrotron radiation community feared that positive support of the development of undulator-based beamlines in the VSX region at the Photon Factory might undermine the Super-SOR project since the funding source would be the same for both the PF and the proposed Super-SOR project. This is why the PF did not invest heavily into VUV/SX undulator beamlines during the 1990s. It came to light however that many important samples fabricated in Japan were being taken abroad for high-resolution photoelectron spectroscopic measurements at facilities outside of Japan. We thought it very important to avoid such a severe situation continuing for a long time, and decided to shut down the old beamlines and construct a new one dedicated to high-resolution angle-resolved photoelectron spectroscopy (ARPES) of solid materials. In 2003, we decommissioned the old BL-28 and built the new BL-28A for this purpose. The new BL-28A has shown excellent performance, comparable to that of beamlines installed at third generation synchrotron light sources. The high flux of 10^{12} ph/s was realized at the ultimate photon energy resolution with a small focus size of $0.35 \times 0.05 mm^2$. A detailed description of the new beamline can be found in sections 4-2-4 and 4-2-9.

A second branch beamline, BL-28B, is currently under construction. This will help reduce the time losses due to apparatus changeovers and vacuum conditioning. By sharing most of the beamline optics upstream of the grating with BL-28A, the construction cost of BL-28B was significantly reduced. The construction cost was partly provided by the funds of Prof. Masaharu Oshima at the University of Tokyo. Replacement of the present undulator is required for the full utilization of the medium straight section in future.

A new BL-3A employing an in-vacuum SGU is currently under construction. The new beamline will be used for the X-ray diffraction experiments which are now carried out at BL-16A and also for studies under extreme conditions such as high pressure, low temperature and high magnetic field. Until the end of June 2006 BL-16A (4 – 25 keV) will continue to share beamtime with BL-16B, a soft X-ray beamline (40 – 550 eV) on the same undulator/multi-pole wiggler. The construction of the new beamline BL-3A equipped with a SGU makes it possible to supply the highly collimated beam which is essential for small size samples, and to increase the amount of beamtime available for X-ray diffraction experiments. The activities of the old bending-magnet beamline BL-3A will be moved to BL-6C during the summer shutdown of 2006. This reallocation will allow BL-16B to operate as a dedicated VSX beamline.

Studies of magnetic circular dichroism, magnetic linear dichroism, and natural circular dichroism are important not only in fundamental science but also in industrial applications to explore magnetic materials. Fast switching of the polarization (10 Hz) is essential to extract faint CD signals by using a lock-in amplifier, and can be realized with a pair of APPLE-II type undulators and a set of kicker magnets to deviate the electron orbit in the storage ring. One of the 9-m straight sections between bending magnets B1-B2 or B15-B16 is absolutely necessary to install this insertion device complex, and the design of new beamlines is now in progress. Preliminary estimates indicate that 10^{12} photons/s will be obtained with $E/\Delta E$ = 6000 between 250 and 1500 eV. We expect to build two new beamlines (BL-16A and 16B) over a 2-3 year period. The new BL-16A/B will take over the activities now pursued at AR-NE1B (250 – 1800 eV).

There still remain two untouched short straight sections at BL-1 and BL-15, one long straight section at BL-2, and two medium straight sections at BL-13 and BL-19. BL-1 and BL-15 will be used for structural biology and small angle scattering/micro-beam applications. There are also some other proposals for these beamlines such as X-ray reflectivity measurements, X-ray emission spectroscopy, and soft X-ray utilization. BL-2, BL-13 and BL-19 will be dedicated to VUV-SX experiments such as PEEM, soft X-ray emission spectroscopy, surface chemical reactions, and imaging microscopy. These beamlines and undulators need to be renovated, and we have been requesting funds for this from MEXT. In late 2005, the University of Tokyo abandoned its Super-SOR light source project, and decided to build beamlines at the PF and SPring-8 to carry out the research activities in the VSX region which should have been realized at the Super-SOR project. Some of the beamlines mentioned above may be constructed as joint projects between the University of Tokyo and the PF.

4-1-4 Beamlines using bending magnet sources at the 2.5 GeV PF ring

In addition to the insertion device beamlines, some of the bending magnet beamlines have also been constructed and/or upgraded. Most of this work was funded by external grants or donations.

BL-1A is a standard X-ray beamline equipped with a seven-circle diffractometer and an imaging plate diffractometer. It was constructed as a joint project between two proposals; for the study of correlated electron systems by a new research network and for crystal structure analysis of strongly correlated electron systems. A double crystal monochromator and a focusing mirror are employed to cover the photon energy region 5-20 keV. The "Collaboratory" system was developed and installed at BL-1A with the aim to share information between the experimental station and external locations at universities, and to proceed with experiments through inter-facility discussions and remote control of the system. Details of BL-1A can be found in section 4-2-1.

BL-9C used to be employed for X-ray diffraction and XAFS experiments by the NEC Corporation. They kindly donated the beamline and experimental setups to the Photon Factory in 2000, and X-ray diffraction and energy dispersive XAFS experiments could be carried out without any modification. BL-9C was subsequently improved to meet the high demand for small angle X-ray scattering (SAXS) experiments. The beryllium window installed originally at the end of the beamline was moved upstream, and an apparatus for SAXS experiments was constructed mainly by the relevant user group. Detailed information can be found in section 4-3-2.

In order to realize the upgrade of the straight sections, some of the front-ends were renovated together with the modification of the storage ring. In addition, the vertical wiggler beamline BL-14 was modified in 2004. At the same time, major optical components were overhauled and beam sharing between BL-14B and 14C was modified in order to realize a larger beam size at BL-14C.

Two other beamlines constructed by Hitachi at BL-8 and by Fujitsu at BL-17 were donated to the Photon Factory in 2005. These beamlines were constructed in the early 1980s to carry out basic research related to X-ray lithography, photo-stimulated CVD and the characterization of materials. Industrial consortiums including Hitachi and Fujitsu have since built new beamlines at SPring-8. BL-17A has been rebuilt as a structural biology beamline using an in-vacuum SGU, as described in 4-1-2 of this document.

Some beamlines that have completed their roles have recently been decommissioned. As described earlier, BL-17A, 17B, 17C, 18B, 28A and 28B were shut down in order to construct new insertion device beamlines. BL-12B (6VOPE), constructed in 1983 for high resolution VUV spectroscopy with an $E/\Delta E$ of 250,000, was closed in 2005 since beamtime applications were becoming rather limited due to the low flux compared to similar beamlines at undulator sources newly built in the US and France. The oldest yet very productive workhorse XAFS beamline BL-10B was also closed in 2005, even though there were still many users. There was no focusing system and the available energy range was limited using the radiation from a bending magnet in the 2.5-GeV PF ring. More than 1,020 papers have been published at BL-10B since 1982. In order to promote high-energy XAFS, we decided to construct a new XAFS beamline, AR-NW10A. Despite the high demand and output, continued operation of BL-10B was precluded due to manpower and budget constraints.

The structural biology beamlines which use bending magnet sources at BL-6B and BL-6C are scheduled to be closed in 2006. Some other beamlines that have lost their competitiveness, have low demand for beamtime and no significant research output will be closed in the near future.

4-1-5 Beamlines at the PF-AR for fields other than structural biology

The PF-AR, initially constructed as the booster ring for the TRISTAN project, has been converted to a storage ring dedicated to synchrotron radiation usage. Upgrades have led to significant improvements in the stability of the stored electron beam and a greatly increased lifetime. The most prominent feature of the PF-AR is that it employs full-time single-bunch operation with the rather high stored current of 60 mA. Synchrotron pulses of 130 ps duration are produced every 1.26 μs. Two beamlines have been constructed to utilize this single-bunch property: AR-NW2A and AR-NW14A.

The undulator beamline AR-NW2A was constructed in 2000-2001, and initially designed for time-resolved XAFS and time-resolved protein structure analysis using the Laue method. For this purpose, the undulator at AR-NW2A has a tapering capability to provide a wider band-pass. As the activities in structural biology were moved to AR-NW12A and time-resolved X-ray diffraction experiments to AR-NW14A, AR-NW2A is now dedicated to time-resolved XAFS experiments. The beamline consists of a cryogenically cooled double crystal monochromator, focusing mirrors, and a pair of mirrors for higher-order light reduction and provides monochromatic X-rays between 5 and 25 keV. AR-NW2A was the first beamline at the PF to use a double crystal monochromator with a cryogenic cooling system, and its detailed description can be found in section 4-2-5.

A beamline dedicated to time-resolved X-ray diffraction, AR-NW14A was constructed in 2004-2005 with the ERATO budget organized by Prof. Shinya Koshihara of the Tokyo Institute of Technology. There are two undulators with 36 mm (U36) and 20 mm (U20) periods. U36 covers the photon energy region 5-25 keV and is used as an intense ($\approx 10^{12}$ photons/s) and tunable monochromatic X-ray source. U20 is to be installed in 2006 and will provide 10^{15} photons/s at 13 keV with 1-10% bandwidths. The beamline consists of a double crystal monochromator with a cryogenic cooling system, a focusing mirror and mirrors for higher-order light reduction. A Ti-sapphire and regenerative amplifier laser system was installed for studies of the structural changes initiated by photo-illuminated phase transitions. A detailed description of AR-NW14A can be found in section 4-2-8.

Beamline AR-NW10A, dedicated to XAFS and X-ray anomalous scattering was constructed in 2005-2006 as a replacement of the old BL-10B. Prof. Kiyotaka Asakura of Hokkaido Univ. and Prof. Eiichiro Matsubara of Kyoto Univ. provided a significant part of the construction cost. To minimize construction costs, the experimental setup was relocated to the new beamline AR-NW10A. The new beamline consists of a water-cooled Si(311) double crystal monochromator and a focusing mirror and supplies X-rays in the photon energy region 8-42 keV. Since the critical energy of the PF-AR is 26 keV and a focusing system was introduced, the photon flux of AR-NW10A above 20 keV can be expected to be higher by 2-3 orders of magnitude than that of the old BL-10B. Details of AR-NW10A are given in section 4-3-6.

4-1-6 Slow Positron Facility

The Photon Factory is also responsible for the operation of the slow positron facility, which was developed by the Linac Division of the Accelerator Laboratory. An experimental station for positronium time of flight studies was opened for users a few years ago, and a second beamline for a positron microscope is currently under construction, based on external funds brought in by Prof. Fujinami of Chiba University. A detailed description can be found in section 4-2-11.

4-1-7 Experimental apparatuses

Besides the beamlines, limited but steady development efforts and investments have continued for the experimental apparatuses. Only a few examples are described here.

An apparatus for XAFS measurements in the soft X-ray region under He atmosphere was developed in a joint research program with Nippon Oil Corporation, and was actually applied to XAFS studies of P, S and Cl containing materials. Sulfur species in tribofilms generated from continuous variable transmission fluids were intensively studied (see section 4-3-1). An individual cell irradiation system using a microbeam system was developed for the study of bystander effects, which occur when a cell is irradiated by X-rays (see section 4-2-10). Besides these developments, the old and rather unreliable diffractometer at BL-1B was replaced with a new one in 2004. We should also mention here the remarkable developments in experimental systems and technology for high throughput protein crystallography realized by the Structural Biology Research Center, of which detailed descriptions can be found in section 5-7 Part B.

The detection of intense and short X-ray pulses is one of the most difficult problems currently faced by researchers in several fields. The avalanche photodiode detector (APD) developed at the Photon Factory attracts attention for its high performance, such as its high counting rate and fairly high energy resolution. However, detection efficiency becomes lower with increasing photon energy. A stacked avalanche photodiode system was developed to solve this problem and showed a detection efficiency of about 55% at 16.5 keV. The APDs are used in various situations including Mössbauer spectroscopy and time-resolved XAFS. X-ray CCD systems have also been introduced for X-ray imaging experiments, and a flat-panel detection system has replaced the old imaging tube for medical applications at AR-NE1A2. A significant improvement in the dynamic range has been confirmed, reducing the necessary exposure time. Improvements in time resolution for energy dispersive XAFS experiments also continue, for example due to the use of the X-ray CCD in kinetics mode whereby one line is used for the detector and the others for charge memory. Another even more promising method is to use the silicon microstrip detector XSRTP, which was developed by the Daresbury Laboratory and will be installed soon at AR-NW2A with the help of financial support brought in by Prof. Yasuhiro Iwasawa of the University of Tokyo. A high-speed X-ray area detector based on a visible light HARP (High-gain Avalanche Rushing amorphous Photoconductor) camera is being developed by the Structural Biology Research Center in collaboration with NHK Engineering System, as described in section 5-3 Part B-3.

4-1-8 Future prospects

At the PF we believe that the highest priority over the next few years should be the continued construction of new insertion device beamlines, taking full advantage of the straight-sections upgrade at the 2.5 GeV PF ring. Two ≈9 m and three ≈5 m straight sections will be dedicated to research activities in the VUV/SX region. Following the renewal of BL-28, we will support the construction of the new beamlines BL-16A/B, planned for FY 2006-2007. For this project one of the 9 m straight sections is an absolute neccessity in order to install a pair of APPLE-II type undulators and a kicker magnet system to realize fast (≈10 Hz) polarization switching system in the VSX region with world class competitiveness.

The next candidates in the VUV/SX region are BL-2, making use of the other 9 m straight section, and BL-13 and BL-19, which require renovation along with their respective insertion devices. Furthermore, the insertion device for the newly constructed BL-28 will require replacement within a few years.

For the X-ray region, in-vacuum SGUs will be installed to obtain high intensity with a well-collimated beam spot at the sample position. The construction of BL-3 is now in progress and we expect to observe the first photon beam in autumn 2006. BL-1 and BL-15, which each have three bending magnet beamlines, will be replaced by SGUs after in-depth consideration on the possibilities of the transfer or decommissioning of

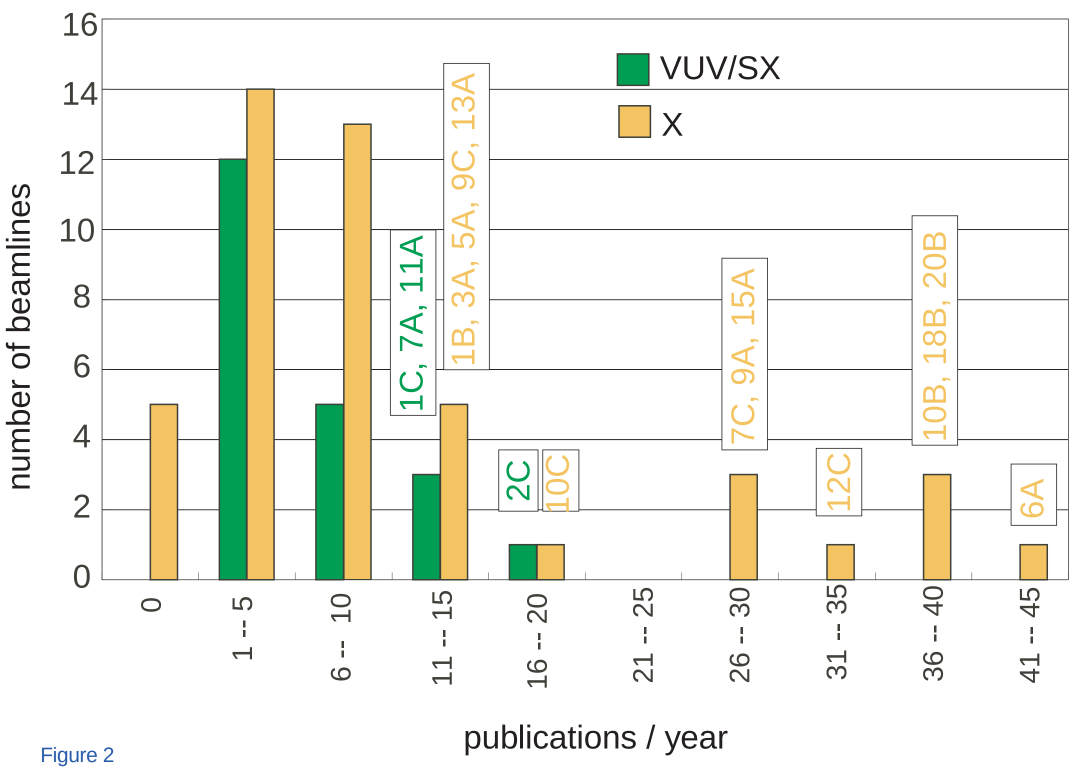

Figure 2
Distribution of publications by beamline over the period 2003-2005. The total number of publications from each beamline per year is shown. The structural biology beamlines (BL-6A and 18B), XAFS (BL-10B) and Australian Beamline (BL-20B) show high publication rates.

Table 6 Experimental fields with very few scientific staff members.

	beamlines	beamline scientists
Structural biology	4	3
SAXS	2.5	0
XAFS	5.5	2
PES	3	2

the existing beamlines.

As well as the renovation of beamlines associated with the upgrade of the straight sections at the 2.5 GeV PF ring, the proper re-assignment of beamline scientists is also important. Figure 2 shows the number of publications per year from each beamline over the period 2003-2005. It can be seen that a large number of papers were published from the structural biology beamlines BL-6A, and18B, the XAFS beamlines BL-7C, 9A, 10B and 12C, Australian Beamline (BL-20B) and the small-angle X-ray scattering (SAXS) beamline BL-15A. In the VUV/SX region, the photoelectron spectroscopy (PES) beamlines BL-1C and 2C show high publication rates. However, as can be seen from Table 6, there are very few beamline scientists attached to these very productive beamlines. While the number of publications does not always give a good measure of the importance of research at a beamline, low publication scores will be taken into account when we consider the re-assignment of beamline scientists over the course of the construction of new beamlines and the amelioration and decommissioning of the existing beamlines.

Table 1 Status of Beamlines in 1995.

X-ray Beamlines

beamline		source	purpose	energy range	spectrometer	constructed	improved/ re-constructed	age
BL-3A			X-ray diffraction and scattering	4 -25 keV	bent plane mirror + SF-DXM + bent plane mirror	1989		6
BL-3C2			X-ray topography in mK region	4 - 30 keV	white	1989		6
BL-4A			trace element analysis, X-ray microprobe	4 - 20 keV	SF-DXM	1983	1987	8
BL-4B			powder diffraction, microcrystal structure analysis	4 - 35 keV	DXM	1983	1986	9
BL-4C			X-ray diffuse scattering, fluorescent XAFS	4 - 20 keV	SF-DXM	1983	1984	11
BL-6A			macromolecular crystallography	5 - 25 keV	bent plane mirror + SXM	1986		9
BL-6B			X-ray spectroscopy and diffraction	4 - 25 keV	SF-DXM	1986		9
BL-6C1			X-ray diffraction at low temperatures	4 - 25 keV	SF-DXM	1986		9
BL-6C2			accurate lattice parameter measurement			1986		9
BL-7C			X-ray spectroscopy and diffraction	4 - 20 keV	SF-DXM	1985	1989	6
BL-8B	Hitachi		EXAFS	1.7 - 14 keV	DXM	1985		10
BL-8C1	Hitachi		X-ray lithography	5 - 40 keV	channel-cut	1985		10
BL-8C2	Hitachi		X-ray tomography and microscopy			1985		10
BL-9A	NEC		X-ray lithography	1.2 - 3.1 keV	oscillating mirror	1986		9
BL-9C	NEC		EXAFS, X-ray topography and diffraction	5 - 25 keV	SF-DXM	1986		9
BL-10A			crystal structure analysis	5 - 25 keV	bent SXM	1982		13
BL-10B			XAFS	6 - 30 keV	channel-cut DXM	1982		13
BL-10C			small angle X-ray scattering/ suraface diffraction	4 - 10 keV	DXM + bent cylindrical mirror	1982		13
BL-12C			XAFS	6 - 23 keV	DXM + bent cylindrical mirror	1982	1994	1
BL-13B1	RTAM	MPW	suraface XAFS, X-ray diffraction	4 - 30 keV	SF-DXM	1987		8
BL-13B2	RTAM	MPW	high pressure,high temperature X-ray diffraction			1987		8
BL-14A		VW	crystal structure analysis, XAFS	5 - 85 keV	DXM + bent cylindrical mirror	1984		11
BL-14B		VW	X-ray diffraction under high pressure	5 - 57 keV	DXM	1984		11
BL-14C		VW	general purpose	5 - 69 keV	DXM	1984		11
BL-15A			small angle X-ray scattering	5 - 12 keV	bent plane mirror + bent SXM	1982		13
BL-15B			X-ray topography, magnetic scattering	3 - 34 keV	white	1982		13
BL-15C			high precision X-ray diffraction	4 - 30 keV	DXM	1982	1986	9
BL-16A		MPW	general purpose	4 - 25 keV	bent plane Mirror + SF-DXM + bent plane mirror	1987	1995	0
BL-17A	Fujitsu		XAFS	5 - 13 keV	DXM	1988		7
BL-17C	Fujitsu		grazing incidence X-ray diffraction, X-ray fluorescence analysis	5 -13 keV	DXM	1988		7
BL-18B			macromolecular crystallography	6 - 30 keV	bent cylindrical mirror + DXM	1993		2
BL-18C			X-ray powder diffraction under non-ambient conditions		*under construction*	1995		0
BL-20B	Australia		general purpose	4 - 25 keV	channel-cut DXM/ white	1993		2
BL-27B			radiation biology, X-ray diffuse scattering	4 - 20 keV	DXM	1992		3
BL-28B		EMPW	spectroscopy and scattering with polarized X-rays	2 -10 keV	bent cylindrical mirror + DXM + bent plane mirror	1993		2
NE1A1		EMPW	Compton and magnetic Compton scattering	40 - 180 keV	doubly bent crystal monochromator	1989	1994	1
NE1A2		EMPW	spectroscopy and scattering with polarized X-rays	6 -28 keV	SF-DXM + bent plane mirror	1989		6
NE3A1		U	nuclear resonant scattering	5 - 25 keV	DXM + fine monochromator	1990		5
NE3A2		U	surface and interface diffraction			1990		5
NE5A			angiography and X-ray computed tomography	20 - 60 keV	SXM/ DXM	1990		5
NE5C			high pressure,high temperature X-ray diffraction	30 - 100 keV	DXM	1990		5

VUV and Soft X-ray Beamlines

beamline		source	purpose	energy range	monochromator	constructed	improved/ re-constructed	age
BL-1A	NTT		solid surface analysis	50-900eV	GCM	1983	1988	7
BL-1B	NTT		lithography	white		1983	1992	3
BL-1C	NTT		photochemical reaction	<250 eV	PGM	1983	1992	3
BL-2A		U	soft X-ray spectroscopy	1.8 - 5 keV	DXM	1983	1991	4
BL-2B1		U	soft X-ray micorscopy	400 - 830 eV	FZP	1985		10
BL-2B2		U	soft X-ray spectroscopy	250 - 1600 eV	grazing incidence	1984	1988	7
BL-3B			VUV and soft X-ray spectroscopy	10 -280 eV	SGM	1989	1992	3
BL-7A	RCS		soft X-ray photoelectron spectroscopy	10 - 1000 eV	PGM	1985		10
BL-7B	RCS		suraface photochemical reaction , angle resolved photoelectron spectroscopy	5 - 50 eV	Seya-Namioka	1985		10
BL-9B	NEC		SR-induced photochemical reaction	<300 eV		1988		7
BL-8A	Hitachi		soft X-ray spectroscopy	40 - 1800 eV	VLSPG	1985		10
BL-11A			soft X-ray spectroscopy	40 - 1000 eV	Grasshopper	1982		13
BL-11B			surface XAFS, soft X-ray spectroscopy	1.8 - 4 keV	bent cylindrical mirror + DXM	1982	1994	1
BL-11C			VUV spectroscopy	4 - 35 eV	Seya-Namioka	1982		13
BL-11D			angle-resolved photoelectron spectroscopy	20 - 150 eV	CDM	1982		13
BL-12A			soft X-ray spectroscopy	30 - 1000 eV	grazing incidence	1982	1993	2
BL-12B			VUV high-resolution spectroscopy	5 - 30 eV	6VOPE	1983		12
BL-13C	RTAM	U	soft X-ray photoemission spectroscopy/ XAFS	140 -1000 eV	grazing incidence	1992	1993	2
BL-16B		U	soft X-ray spectroscopy	40 - 600 eV	grazing incidence	1987		8
BL-17B	Fujitsu		photochemical vapor deposition	white	toroidal mirror	1989		6
BL-18A	ISSP		angle resolved photoelectron spectroscopy of surafaces and interfaces	7 -150 eV	CDM	1989		6
BL-19A	ISSP	revolver-U	spin-resolved photoelectron spectroscopy	12 - 250 eV	grazing incidence	1990		5
BL-19B	ISSP	revolver-U	spin-resolved photoelectron spectroscopy	10 - 1200 eV	VLSPG	1991		4
BL-20A			VUV spectroscopy	5 - 40 eV	normal incidence	1991		4
BL-27A			radiation biology, soft X-ray photoelectron spectroscopy	1.8 - 6 keV	DXM	1992		3
BL-28A		HU	VUV and soft X-ray spectroscopy with circularly polarized undulator radiataion	15 - 250 eV	grazing incidence	1990		5
NE1B		HU	spectroscopy and microscopy with circularly polarized soft X-rays	250 - 1800 eV	grazing incidence	1993		2

Table 2 List of beamlines at the PF Storage Ring and PF-AR in 2001.

X-ray Beamlines

Beamline		Source	Purpose	Energy range	Beamline optics	Constructed	Improved/ re-constructed	Age
BL-1A			X-ray powder diffraction	6 - 21 keV	DXM + bent cylindrical mirror	1983	2001	0
BL-1B			X-ray powder diffraction under extreme condition	6 - 21 keV	DXM + bent cylindrical mirror	1983	1998	3
BL-3A			X-ray diffraction and scattering	4 -25 keV	Bent plane mirror + SF-DXM + bent plane mirror	1989		12
BL-3C2			Accurate lattice parameter measurement	4 - 30 keV	DXM	1998		3
BL-3C3			X-ray magnetic Bragg scattering	4 - 30 keV	White/ DXM	1989	1997	4
BL-4A			Trace element analysis, X-ray microprobe	4 - 20 keV	SF-DXM + (K-B mirrors)	1983	1987	14
BL-4B1			Micro-crystal and area structure analysis	4 - 35 keV	SF-DXM	1983	1995	6
BL-4B2			Powder diffraction	6 - 20 keV	SF-DXM + bent cylindrical	1983	1995	
BL-4C			X-ray diffraction and scattering	6 - 21 keV	DXM + bent cylindrical mirror	1983	1995	6
BL-6A			Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM	1986		15
BL-6B	TARA		Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM	1986	1995	6
BL-6C	TARA		Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM	1986	1998	3
BL-7C			X-ray spectroscopy and diffraction	4 - 20 keV	SF-DXM + double mirror	1985	1989	12
BL-8B	Hitachi		EXAFS	1.7 - 14 keV	DXM + bent cylindlical mirror	1985		16
BL-8C1	Hitachi		X-ray lithography	5 - 40 keV	Channel-cut	1985		16
BL-8C2	Hitachi		X-ray tomography and microscopy			1985		16
BL-9A			XAFS	2.2 - 15 keV	Bent conical mirror + DXM + bent conical mirror + double mirror	1986	1999	2
BL-9C			General purpose	5 - 23 keV	DXM + bent cylindrical mirror	1986	2001	0
BL-10A			Crystal structure analysis	5 - 25 keV	Bent SXM	1982	1997	4
BL-10B			XAFS	6 - 30 keV	Channel-cut DXM	1982		19
BL-10C			Small angle X-ray scattering	4 - 10 keV	DXM + bent cylindrical mirror	1982	1996	5
BL-12C			XAFS	6 - 23 keV	DXM + bent cylindrical mirror	1982	1994	7
BL-13A		MPW	High pressure, high temperature X-ray diffraction	30keV	DXM + K-B mirrors	1987	2000	1
BL-13B1		MPW	Suraface XAFS, X-ray diffraction	4 - 30 keV	SF-DXM + bent plane mirror	1987		14
BL-13B2		MPW	High pressure, high temperature X-ray diffraction	4 - 30 keV	Doubly bent crystal monochromator	1987	1996	5
BL-14A		VW	Crystal structure analysis, XAFS	5 - 85 keV	DXM + bent cylindrical mirror	1984		17
BL-14B		VW	X-ray diffraction under high pressure	10 - 57 keV	DXM	1984		17
BL-14C1		VW	Medical applications and general purpose	5 -100 keV	DXM	1984	1999	2
BL-14C2		VW	High pressure, high temperature X-ray diffraction			1984	1999	2
BL-15A			Small angle X-ray scattering	5 - 12 keV	Bent plane mirror + bent SXM	1982	1997	4
BL-15B1			X-ray topography, magnetic scattering	5 - 20 keV	DXM + bent cylindrical mirror/ white	1982	1997	4
BL-15B2			Surface and interface diffraction			1997	1997	4
BL-15C			High precision X-ray diffraction	4 - 30 keV	DXM	1982	1986	15
BL-16A1		MPW	General purpose	4 - 25 keV	Bent plane Mirror + SF-DXM + bent plane mirror	1987	1995	6
BL-16A2			X-ray diffraction and scattering					
BL-17A	Fujitsu		XAFS	5 - 13 keV	DXM	1988		13
BL-17C	Fujitsu		Grazing incidence X-ray diffraction, X-ray fluorescence analysis	5 -13 keV	DXM	1988		13
BL-18B			Macromolecular crystallography	6 - 30 keV	Bent cylindrical mirror + DXM	1993		8
BL-18C			X-ray powder diffraction under non-ambient conditions		Under construction	1995		6
BL-20B	Australia		General purpose	4 - 25 keV	Channel-cut DXM/ white	1993		8
BL-27B			Radiation biology, X-ray diffuse scattering	4 - 20 keV	DXM	1992		9
BL-28B		EMPW	Spectroscopy and scattering with elliptically polarized X-rays	2 -10 keV	Bent cylindrical mirror + DXM + bent plane mirror	1993		8
NE1A1		EMPW	Compton and magnetic Compton scattering	40 - 180 keV	Doubly bent crystal monochromator	1989	1994	7
NE1A2		EMPW	Medical application of angiography	33 keV	Singel crystal monochromator	1989	2000	1
NE3A1		U	Nuclear resonant scattering	5 - 25 keV	DXM + fine monochromator	1990		11
NE5A			Angiography and X-ray computed tomography	20 - 60 keV	SXM/ DXM	1990		11
NE5C			High pressure, high temperature X-ray diffraction	30 - 100 keV	DXM	1990		11

VUV and Soft X-ray Beamlines

Beamline		Source	Purpose	Energy range	Monochromator	Typical Resolving Power(E/DE) and Photon Flux(/s)	Constructed	Improved/ re-constructed	Age
BL-1C			Soft X-ray photoelectron spectroscopy	20 - 250 eV	VLSPGM	5000 - 10000 10^{11}at E/DE=2000	1983	1998	3
BL-2A		U	Soft X-ray spectroscopy	1.8 - 5 keV	DXM	2000-8000 10^{11}	1983	1997	4
BL-2C		U	Soft X-ray spectroscopy	250 - 1400 eV	VLSPGM	5000 - 10000 10^{11} - 10^{10}	1996		5
BL-3B			VUV and soft X-ray spectroscopy	10 -280 eV	SGM	200 - 3000 10^{12} -	1989	1992	9
BL-7A	RCS		Soft X-ray photoelectron spectroscopy	10 - 1000 eV	VLSPGM	5000 - 10000	1985	2000	1
BL-7B	RCS		Suraface photochemical reaction , angle resolved photoelectron spectroscopy	5 - 50 eV	Seya-Namioka	1000	1985		16
BL-8A	Hitachi		Soft X-ray spectroscopy	40 - 1800 eV	SX-700	2000 10^{10}	1985	1996	5
BL-11A			Soft X-ray spectroscopy	70 - 1900 eV	VLSPGM	500 - 5000 10^{12} -	1982	1996	5
BL-11B			Surface XAFS, soft X-ray spectroscopy	1.8 - 4 keV	Bent cylindrical mirror + DXM	2000 10^{10}	1982	1994	7
BL-11C			VUV spectroscopy	4 - 35 eV	Seya-Namioka	1000	1982		19
BL-11D			Angle-resolved photoelectron spectroscopy	20 - 1200 eV	Grazing incidence	2000 - 5000 10^{11} - 10^{10}	1982	1997	4
BL-12A			Soft X-ray spectroscopy	30 - 1000 eV	Grazing incidence	1000 10^{9}	1982	1993	8
BL-12B			VUV high-resolution spectroscopy	5 - 30 eV	6VOPE	2.5×10^{5} 10^{4}	1983		18
BL-13C		U	Soft X-ray photoemission spectroscopy/ XAFS	70 -1000 eV	Grazing incidence	1000 - 6000 10^{12} - 10^{10}	1992	1993	8
BL-16B		U	Soft X-ray spectroscopy	40 - 550 eV	SGM	1000 - 10000 10^{12} - 10^{10}	1987	1995	6
BL-17B	Fujitsu		Photochemical vapor deposition	white	Toroidal mirror	——	1989		12
BL-18A	ISSP		Angle resolved photoelectron spectroscopy of surfaces and interfaces	7 -150 eV	CDM	1000 - 2000 10^{11} - 9	1989		12
BL-19A	ISSP	revolver-U	Spin-resolved photoelectron spectroscopy, soft X-ray emission spectroscopy	12 - 250 eV	Grazing incidence	1000 10^{12}	1990		11
BL-19B	ISSP	revolver-U	Spin-resolved photoelectron spectroscopy	10 - 1200 eV	VLSPG	400 - 4000 10^{12} - 10^{11}	1991		10
BL-20A			VUV spectroscopy	5 - 40 eV	Normal incidence	300 - 30000 10^{12} -	1991		10
BL-27A			Radiation biology, soft X-ray photoelectron spectroscopy	1.8 - 6 keV	DXM	2000	1992		9
BL-28A		HU	VUV and soft X-ray spectroscopy with circularly polarized undulator radiataion	30 - 250 eV	Grazing incidence	1000 10^{10}	1990		11
NE1B		HU	Spectroscopy with circularly polarized soft X-rays	250 - 1800 eV	Grazing incidence	1000 - 5000 10^{11} -	1993		8

Table 3 List of beamlines at the PF Storage Ring and PF-AR in 2005.

X-ray Beamlines

Beamline	Source	Purpose	Energy range	Beamline optics	remarks	Constructed	Improved/ re-constructed	Age
BL-1A		X-ray powder diffraction	6 - 21 keV	DXM + bent cylindrical mirror		1983	2001	4
BL-1B		X-ray powder diffraction under extreme condition	6 - 21 keV	DXM + bent cylindrical mirror		1983	1998	7
BL-3A		X-ray diffraction and scattering	4 -25 keV	Bent plane mirror + SF-DXM + bent plane mirror	to be moved to BL-6C in 2006	1989		16
BL-3C2		Accurate lattice parameter measurement	4 - 30 keV	DXM		1998		7
BL-3C3		X-ray magnetic Bragg scattering	4 - 30 keV	White/ DXM		1989	1997	8
BL-4A		Trace element analysis, X-ray microprobe	4 - 20 keV	SF-DXM + (K-B mirrors)		1983	1987	18
BL-4B1		Micro-crystal and area structure analysis	4 - 35 keV	SF-DXM		1983	1995	10
BL-4B2		Powder diffraction	6 - 20 keV	SF-DXM + bent cylindrical		1983	1995	
BL-4C		X-ray diffraction and scattering	6 - 21 keV	DXM + bent cylindrical mirror		1983	1995	10
BL-5A	MPW	Strucutural biology	6 - 18 keV	bent flat mirror + DXM + bent cylindrical	external fund	2003		2
BL-6A		Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM		1986		19
BL-6B		Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM	to be closed in 2006	1986	1995	10
BL-6C		Macromolecular crystallography	5 - 25 keV	Bent plane mirror + SXM	to be closed in 2006	1986	1998	7
BL-7C		X-ray spectroscopy and diffraction	4 - 20 keV	SF-DXM + double mirror		1985	1989	16
BL-8B		EXAFS	1.7 - 14 keV	DXM + bent cylindlical mirror		1985		20
BL-8C1		X-ray lithography	5 - 40 keV	Channel-cut		1985		20
BL-8C2		X-ray tomography and microscopy				1985		20
BL-9A		XAFS	2.2 - 15 keV	Bent conical mirror + DXM + bent conical mirror + double mirror		1986	1999	6
BL-9C		General purpose	5 - 23 keV	DXM + bent cylindrical mirror		1986	2001	4
BL-10A		Crystal structure analysis	5 - 25 keV	Bent SXM		1982	1997	8
BL-10B		XAFS	6 - 30 keV	Channel-cut DXM	closed at the end of 2005	1982		23
BL-10C		Small angle X-ray scattering	4 - 10 keV	DXM + bent cylindrical mirror		1982	1996	9
BL-12C		XAFS	6 - 23 keV	DXM + bent cylindrical mirror		1982	1994	11
BL-13A	MPW	High pressure, high temperature X-ray diffraction	30keV	DXM + K-B mirrors		1987	2000	5
BL-13B1	MPW	Suraface XAFS, X-ray diffraction	4 - 30 keV	SF-DXM + bent plane mirror		1987		18
BL-13B2	MPW	High pressure, high temperature X-ray diffraction	4 - 30 keV	Doubly bent crystal monochromator		1987	1996	9
BL-14A	VW	Crystal structure analysis, XAFS	5 - 85 keV	DXM + bent cylindrical mirror		1984	2004	1
BL-14B	VW	X-ray diffraction under high pressure	10 - 57 keV	DXM		1984	2004	1
BL-14C1	VW	Medical applications and general purpose	5 -100 keV	DXM		1984	2004	1
BL-14C2	VW	High pressure, high temperature X-ray diffraction				1984	2004	1
BL-15A		Small angle X-ray scattering	5 - 12 keV	Bent plane mirror + bent SXM		1982	1997	8
BL-15B1		X-ray topography, magnetic scattering	5 - 20 keV	DXM + bent cylindrical mirror/ white		1982	1997	8
BL-15B2		Surface and interface diffraction				1997	1997	8
BL-15C		High precision X-ray diffraction	4 - 30 keV	DXM		1982	1986	19
BL-16A1	MPW	General purpose	4 - 25 keV	Bent plane Mirror + SF-DXM + bent plane mirror	to be moved to BL-3A in 2006	1987	1995	10
BL-16A2		X-ray diffraction and scattering						
BL-17A	SGU	Strucutural biology	6 - 13 keV	DXM + K-B mirrors	external fund	2005		0
BL-18B		General purpose	6 - 23 keV	Bent cylindrical mirror + DXM		1993	2005	0
BL-18C		X-ray powder diffraction under non-ambient conditions	6 - 25 keV	DXM + K-B mirrors		1995		10
BL-20B Australia		General purpose	4 - 25 keV	Channel-cut DXM/ white		1993		12
BL-27B		Radiation biology, X-ray diffuse scattering	4 - 20 keV	DXM		1992		13
NE1A1	EMPW	Compton and magnetic Compton scattering	40 - 180 keV	Doubly bent crystal monochromator		1989	1994	7
NE1A2	EMPW	Medical application of angiography	33 keV	Singel crystal monochromator		1989	2000	1
NE3A1	U	Nuclear resonant scattering	5 - 25 keV	DXM + fine monochromator		1990		11
NE5A		Angiography and X-ray computed tomography	20 - 60 keV	SXM/ DXM		1990		11
NE5C		High pressure, high temperature X-ray diffraction	30 - 100 keV	DXM		1990		11
NW2A	U	time-resolved XAFS	5 -20 keV	DXM + bent cylindrical/flat mirror + double mirror		2001		4
NW10A		high energy XAFS/AXS	8 -42 keV	DXM + bent cylindrical mirror	under commissioning, partly external fund	2006		0
NW12A	U	Strucutural biology	6 - 18 keV	bent flat mirror + DXM + bent cylindrical mirror		2002		3
NW14A	U	time-resolved X-ray diffraction	5 - 25 keV	DXM + bent cylindrical mirror + double flat mirrors	under commissioning, external fund	2005		0

VUV and Soft X-ray Beamlines

Beamline	Source	Purpose	Energy range	Monochromator	Typical Resolving Power(E/DE)	and Photon Flux(/s)	Constructed	Improved/ re-constructed	Age
BL-1C		Soft X-ray photoelectron spectroscopy	20 - 250 eV	VLSPGM	5000 - 10000	10^{11}at E/DE=2000	1983	1998	7
BL-2A	U	Soft X-ray spectroscopy	1.8 - 5 keV	DXM	2000-8000	10^{11}	1983	1997	8
BL-2C	U	Soft X-ray spectroscopy	250 - 1400 eV	VLSPGM	5000 - 10000	10^{11} - 10^{10}	1996		9
BL-3B		VUV and soft X-ray spectroscopy	10 -280 eV	SGM	200 - 3000	10^{12} - 10^{9}	1989	1992	13
BL-7A RCS		Soft X-ray photoelectron spectroscopy	10 - 1000 eV	VLSPGM	5000 - 10000		1985	2000	5
BL-7B RCS		Suraface photochemical reaction , angle resolved photoelectron spectroscopy	5 - 50 eV	Seya-Namioka	1000		1985		21
BL-8A		Soft X-ray spectroscopy	40 - 1800 eV	SX-700	2000	10^{10}	1985	1996	9
BL-11A		Soft X-ray spectroscopy	70 - 1900 eV	VLSPGM	500 - 5000	10^{12} - 10^{9}	1982	1996	9
BL-11B		Surface XAFS, soft X-ray spectroscopy	1.8 - 4 keV	Bent cylindrical mirror + DXM	2000	10^{10}	1982	1994	11
BL-11C		VUV spectroscopy	4 - 35 eV	Seya-Namioka	1000		1982		23
BL-11D		Angle-resolved photoelectron spectroscopy	20 - 1200 eV	Grazing incidence	2000 - 5000	10^{11} - 10^{10}	1982	1997	8
BL-12A		Soft X-ray spectroscopy	30 - 1000 eV	Grazing incidence	1000	10^{9}	1982	1993	12
BL-13C	U	Soft X-ray photoemission spectroscopy/ XAFS	70 -1000 eV	Grazing incidence	1000 - 6000	10^{12} - 10^{10}	1992	1993	12
BL-16B	U	Soft X-ray spectroscopy	40 - 550 eV	SGM	1000 - 10000	10^{12} - 10^{10}	1987	1995	10
BL-18A ISSP		Angle resolved photoelectron spectroscopy of surfaces and interfaces	7 -150 eV	CDM	1000 - 2000	10^{11} - 10^{9}	1989		16
BL-19A ISSP	revolver-U	Spin-resolved photoelectron spectroscopy, soft X-ray emission spectroscopy	12 - 250 eV	Grazing incidence	1000	10^{12}	1990		15
BL-19B ISSP	revolver-U	Spin-resolved photoelectron spectroscopy	10 - 1200 eV	VLSPG	400 - 4000	10^{12} - 10^{11}	1991		14
BL-20A		VUV spectroscopy	5 - 40 eV	Normal incidence	300 - 30000	10^{12} - 10^{8}	1991		14
BL-27A		Radiation biology, soft X-ray photoelectron spectroscopy	1.8 - 6 keV	DXM	2000		1992		13
BL-28A	HU	high resolution ARPES	30 - 300 eV	VLSPG	30000	10^{12}	2004		1
NE1B	HU	Spectroscopy with circularly polarized soft X-rays	250 - 1800 eV	Grazing incidence	1000 - 5000	10^{11} - 10^{9}	1993		12

Table 5 Beamline Categorization List.

BL	light source	E	comments at the last review	Future plan proposed by the corresponding beamline scientist (F) and plan to response the review.	publications 97	98	99	00	01	02	97〜'02	Act. Rep. 99	00	01	demand 10-12	2002. 1-3	2002. 4-7	10-12	2003. 1-2	2003. 5-6	award	invited talks	management	category	comments in categorization
1A	B	X	under construction		2	5	6	2	0	1	16	-	-	-										S	Proceed the colaboratory system. However, the beamline is requested to move when SGU beamline is installed.
1B	B	X	Proper measures are required for the trouble of the diffractometer	(F) fit for low temperature and high pressure environment. (F) Prepare the data analysis system. The control system of the equipment has some technical problems.	0	0	7	11	4	4	26	6	3	2	120%	108%	97%	108%	151%	177%	1	8			
1C	B	GIM	Prepare the users manual. The organization after S1 project is finished should be clarified. Increase the number of users.	Prepare the filter system to reduce higher orders. Prepare the sliding system of ARPES-10 to make the replacement of equipments easier.	0	0	10	17	10	1	38	3	0	1			61%	92%	70%	86%		8		S	Proceed the material evaluation with high resolution photoelectron spectroscopy. However, the beamline is requested to move when SGU beamline is installed.
2A	U	SX	Proper measure for the heat load problem is required. Short-gap undulator may be useful if the in-house scientist pay much power for it. It should be analyzed why there are many users at 2C and only a few at 2A. Scientific purpose of 2A should be clarified and equip proper system for it.	(F) A beamline with short-gap undulator is required to solve the heat load and lack of beam time. Grating spectrometer is better solution below 2keV.	4	2	4	1	1	0	12	1	0	0		100%	109%	120%	113%	180%	1	2		B-C	Discussion on the future of beamlines using soft X-ray DXM , BL-2A, 11B and 28B, is required including the future of science and estimation of demand. Apparent demand is high since the most of beam time is used at 2C. No positive proposals from surface chemistry-UG, XAFS-UG.
2C	U	GIM	Proper measure for the heat load problem is required. The focus is too large. Prepare the users manual.	(F) Experiment those require high energy resolution. Because of the lack of beam time, another one is required.	2	2	1	6	4	6	21	0	5	1	133%	138%	170%	122%	162%	158%		6		A	Focus power to solve the drift or enlarge of the focus size by the heat load or its variation.
3A	B	X	The control system is getting old and it is hard to handle. Prepare the users manual.	(F) The renewal of the control system is required. The diffractometer has been overhauled in 2001. Prepare a users manual until May. Equip an area detector system.	1	18	11	19	17	10	76	9	9	6	136%	129%	103%	131%	123%	172%	4	5			The beamline is requested to move when SGU beamline is installed.
3B	B	GIM	Contamination of the beamline optics. Prepare the users manual.	(F) Consider the utilization of circular polarization.	11	9	15	8	2	4	49	3	3	2	100%	100%	91%	116%	81%	119%		1			The beamline is requested to move when SGU beamline is installed.
3C1	B	X			0	0	0	0	0	0	0	0	0	0	0%	0%	0%	0%	0%					C	Practically closed. It is better to make working space for BL-4A.
3C2	B	X	The X-ray optics with the proposed resolution has been made already. Thus the target of the research is not proper.	(F) Specialized for X-ray microscopy experiments.	0	0	1	0	0	0	1	2	3	2								1			
3C3	B	X	The users are limited and do not change. Too few papers. Prepare a magnet and control system.	(F) Extend to low temperature, high magnetic field. (F) Faster signal processing system is required. Preparing a new control system. PF is still competitive in the magnetic diffraction using white X-rays. Cryogenic cooler and it positioning system is required.	2	1	1	0	2	1	7	4	2	1	91%	88%	91%	74%	86%	98%				B	Leave as it is until the reconstruction of BL-3 is required.
4A	B	X	Improve the user interface of the sagittal focusing system. Prepare a users manual for microbeam diffraction. Develop new users. More user support is required.	(F) Improve the X-ray microbeam system. Improve the goniometer and prepare a proper detection system. Users manual for XFA is prepared. Although improving the control software, it is not possible to realize the user interface similar to the commercial products.	15	20	18	13	9	3	78	7	9	5	109%	100%	109%	119%	150%	123%		1			
4B1	B	X	More supporting man-power is required. Or should be automated. It is better to do in a 3-rd generation facility.	(F) Proper microbeam optics or undulator source is required.	4	3	1	0	0	1	9	1	1	6							1	5			
4B2	B	X	Prepare a furnace. Develop to prevent the contamination of the mirror. Analyze the reason that the number of users doesn't increase.	(F) Dedicated beamline with an undulator is required. (F) Temperature control between 80 and 1300K. High temperature equipment is to be made until 2002. Prepare a users manual. It costs much to improve the control software.	9	8	9	4	14	2	46	2	3	4	123%	131%	123%	134%	161%	−		5	users group	not fixed	It is requested to make strategy for powder diffraction including carried out at other stations.
4C	B	X	Lack of man power. Prepare the experimental environment under extreme conditions.	(F) Introduce a phase retarder and improve the data analysis software. Prepare a mirror system for higher order reduction.	6	7	11	12	6	11	53	4	9	6	224%	106%	111%	128%	101%	135%	2	30			
5	MPW	X	under construction																					S	Under construction with the help of external fund.
6A	B	X	User the same control system as BL-18B. It is important to develop facility own technology.	Replace the mirror. Improve the data analysis environment.	40	37	62	36	38	19	232	16	19	16	89%	88%	91%	86%	123%	92%	?	?			
6B	B	X	Improve the user interface and efficiency.		29	19	38	17	6	5	114	2	1	2									SBSP		
6C	B	X	Recent commercially available IP system has similar performance. It should be discussed on the possibility and importance.	(F) time-resolved experiments	4	6	1	3	1	0	15	0	0	0									SBSP		
7A	B	GIM	Too large beam size. Prepare a users manual.	(F) energy dispersive surface XAFS	1	3	1	2	6	8	21	5	6	5		112%		100%					Univ. of Tokyo	B	Since this is an externally constructed beamline, thus PF will not invest now.
7B	B	NIM	Although the flux is sufficient, there are a few papers. What is the reason of the problem; management or instrumental? It should be discussed to construct a new beamline dedicated for ARPES by using VLSG optics rather than improve the present beamline.	(F) Improve the energy resolution by replacing to VLSF.	0	5	5	3	4	0	17	1	2	0		22%		32%					Univ.of Tokyo	B	Since this is an externally constructed beamline, thus PF will not invest now. It is better to merge the functions of BL-11C and 7B.
7C	B	X	This optics is suited for RIXS or AXS rather than XAFS. Prepare a collimation mirror system with paying attention to the total reflection XAFS experiments on the liquid surface.	(F) Prepare a collimation mirror system.	68	48	57	40	35	22	270	30	15	8	Summed in 9A						9	28		B	Leave as it is until the new plan is settled.
8A	B	GIM			0	1	0	0	0	0	1	0	0	1									Hitachi	C	Discussion on the future of this beam line is required.
8B	B	SX/X			0	0	1	1	1	0	3	0	0	0									Hitachi	C	
8C	B	X			1	3	2	2	0	0	8	0	0	2									Hitachi	C	
9A	B	X	Prepare multi-element SSD system. Extend to lower energy region. More manpower is required.	(F) A multi-element SSD system is prepared with the help of Prof. Iwasawa. Extend to soft X-ray region (realized to S and P). More man-power is required.	0	0	2	9	24	22	57	6	21	20	111%	87%	102%	112%	120%	131%				A	
9C	B	X	Low necessity. Prepare a higher order reduction mirror system.	Mirror system should be prepared at BL-4C since it is dedicated for diffraction experiments.	1	1	3	4	7	4	20	0	2	7	113%	110%	143%	87%	133%	77%	1				
10A	B	X	The optics does not fit for VDC method. Need renewal. Prepare an area detector, improve the energy resolution and reduce the higher orders.	(F) Prepare a 4-circle diffractometer with VW of SGU source. Tandem alignment of camera system with IP and diffractometer is planned. Upgrade the software.	6	10	6	9	7	4	42	5	3	3	110%	106%	91%	81%	116%	119%	1	4		B	Focus on BL-14A that has higher energy resolution, has focusing system and faster diffractometer.
10B	B	X	Increase the specialized staff and prepare to develop the system to carry out challenging research. Construct a beamline for high energy regime in PF-AR. Prepare data analysis system. Future plan should be made by the facility not by the users.	(F) Increase man-power (F) construct succeeding beamline in PF-AR. Planning to construct a beamline for 15 to 40 keV region. Owing to the lack of man-power, it is not possible to prepare data analysis system.	74	43	56	46	41	36	296	40	31	26	109%	64%	100%	106%	79%	99%	4	72?		B	Construct more sophisticated beamline for XAFS.
10C	B	X	Prepare user manual. Another detection system is required. The optics is not suited for 2-D experiments. Prepare the future vision of SAX'S with BL-15A.	(F) Prepare an area detector. Users manual is already prepared.	15	25	24	16	20	14	114	25	20	12	143%	142%	116%	132%	126%	150%		9	users group	not fixed	Global discussion on the future of SAXS at PF is required.
11A	B	GIM	Should be solved the contamination of the optical elements. Prepare a dedicated equipment.	No good way to solve the contamination problem and the beamline is crowded. Assign beam time, including other line's).	5	7	9	7	7	5	40	5	6	6	114%	120%	109%	95%	50%	93%		3		A	Recover the competitive power by improving the performance such as the measure for contamination and management of the beam line.
11B	B	SX	focus is too large(5*2) Proper measure is required for heat load problem. Focus on a research field and make outputs. Develop new users.		22	11	17	6	5	2	63	4	3	5	96%	29%	66%	48%	25%	44%				B	Rapid decrease of the demand. The number of published papers is decreasing simultaneously. Discussion on the future of beamlines using soft X-ray DXM , BL-2A, 11B and 28B, is required including the future of science and estimation of demand. Some proposals are made by surface chemistry and
11C	B	NIM	Scrap ARPES-I and shift to ARPES-II, ARUPS-10.	(F) Normal Incidence monochromator with undulator source is required. Scrap ARPES-I and shift to ARPES-II, ARUPS-10.	1	6	9	6	6	5	33	3	1	0	33%	48%	100%	74%	91%	44%				C	Low demand and unattractive performance It is better to close it, rather than improve. Should consider to merge with BL-7B.
11D	B	GIM	Improve the energy resolution. Realize the initially designed performance.	Modify the optics using VLSG. Install dedicated Scienta 2002.	2	6	7	1	0	5	21	0	3	1	59%	65%	39%	25%	28%	19%		2		S	Encourage the improvement progressing now.
12A	B	GIM	Old fashioned beamline optics. Evaluation of optical element is important.	(F) Technical staff for optical element evaluation.	3	2	4	2	4	7	22	5	5	2	40%	18%	25%	40%	30%	23%		3		C	Low demand and unattractive performance It is better to close it, rather than improve.

BL	light source	E	comments at the last review	Future plan proposed by the corresponding beamline scientist (F) and plan to response the review.	publications							Act. Rep.			demand						award	invited talks	management	category	comments in categorization
					97	98	99	00	01	02	97~ '02	99	00	01	10-12	2002. 1-3	2002. 4-7	10-12	2003. 1-2	2003. 5-6					
12B	B	NIM	No needs are expected. BL-12B has finished its role.		3	2	0	5	2	3	15	4	1	0	0%	0%	0%	0%	0%	0%		2		C	Low demand and unattractive performance It is better to close it, rather than improve.
12C	B	X	Prepare a mirror system for higher-order reduction.	(F) DXM that can reach higher energy region, higher order reduction mirror . Bent conical mirror for better focus. Only the financial problem.	11	16	30	19	27	14	117	16	17	17	Summed in 9A							1		A	
13A	MPW	X	Prepare a users manual.	(F) Install X-CCD in place of IP.	0	1	0	4	4	6	15	0	0	0	129%	106%	115%	117%	202%	156%	2	10		B	Scientific output from the present beamline and equipment is required.
13B	MPW	X	Only a few users. Scrap and build of 13B should be planned, watching the activity of the fluorescent XAFS.		7	6	9	8	4	7	41	2	2	0	92%	106%	78%	80%	179%	144%				C	The present activity will be included in the present XAFS beamlines. Optimize under the straight section upgrade.
13C	U	GIM	Simultaneous scanning of the spectrometer and undulator gap is required. Too large focus size(5*1) Proper measure is required for heat load and vibration. Optimize the undulator.	(F) Replace the insertion device. Prepare the users manual in 2002.	8	3	4	4	6	2	27	3	5	4	183%	229%	205%	113%	175%	257%		2	users group	A	Should solve the heat load problem.
14A	VW	X	Getting old. Merge with BL-10A.	(F) Prepare a new high speed, high precision four circle diffractometer. Revise the control software and users manual.	10	15	14	17	10	3	69	9	7	8	89%	100%	100%	92%	96%	91%	1	3			Focus on BL-14A that has higher energy resolution, has focusing system and faster diffractometer.
14B	VW	X	Prepare a users manual. Improve the monochromator.	(F) renewal of the monochromator and control system.	7	8	9	11	8	5	48	4	2	5	100%	100%	80%	95%	96%	100%	3	9		S	Should be modified to realize the straight section upgrade.
14C1	VW	X	Improve the stability of the monochromator.		13	16	7	9	11	15	71	3	6	1	167%	180%	163%	123%	158%	160%					
14C2	VW	X	Prepare a users manual.									6	3	4							1		users group		
15A	B	X	Improve the user interface and prepare a users manual. Assign a beamline scientist.	(F) Proper measure is required for the aging of the beamline. Improve the user interface. Realize the measurement by changing multi-parameters.	26	24	27	17	18	17	129	37	29	26	121%	141%	102%	117%	142%	159%		5	users group	not fixed	Global discussion on the future of SAX'S at PF is required. The beamline is requested to move when SGU beamline is installed.
15B1	B	X	Replace the topography control system. But the number of users is decreasing. It is better to do X-ray magnetic scattering experiment at SPring-8. Introduce high-resolution CCD.	(F) Renewal of the control system is required.	2	8	10	10	8	6	44	5	2	2	81%	102%	89%	87%	95%	102%					
15B2	B	X	Increase the users. Assign a beamline scientist and introduce industrial application.	(F) Install a manipulator for low temperatures. Increase of users is not expected since it needs long beam time.									1	2								1			
15C	B	X		(F) Renewal of the control system is progressing.	8	13	8	12	17	7	65	2	4	11	96%	96%	100%	116%	96%	102%		1			
16A	MPW	X	Optimize the beamline optics. Realize the multi-extreme sample environment.	(F) Introduce a phase retarder.	3	7	5	4	5	6	30	2	2	4	121%	103%	162%	122%	108%	157%	2	27		B	Scientific output from the present beamline and equipment is required.
16B	U	GIM	Make easier the optical alignment. Prepare photon position monitor. Prepare simultaneous scanning of the spectrometer and undulator gap.	(F) Prevent the contamination of the optical elements and introduce VLSG.	2	3	4	6	3	7	25	5	6	5	126%	109%	256%	169%	119%	123%				A	Should solve the heat load problem.
17A	B	X	Prepare a users manual.		4	1	2	2	3	0	12	3	3	3									Fujitsu		installed.
17B	B				0	0	0	0	0	0	0	0	0	0							1		Fujitsu	C	Practically closed.
17C	B	X	Prepare a users manual.		1	2	3	0	0	0	6	2	2	1									Fujitsu		
18A	B	GIM	Below the international level; low energy resolution, intense higher order. Not good wavelength reproducibility.		9	9	9	3	4	11	45	5	10	3							1		ISSP, Univ. Of Tokyo		
18B	B	X	Should be specialized for MAD. Make the control software same as BL-6A.	(F) MAD beamline with an insertion device.	23	18	48	28	24	25	166	20	15	15	117%	84%	80%	72%	70%	Summed in 6A	2	7			
18C	B	X	Prepare a users manual.		10	12	10	9	16	10	67	7	6	2	69%	82%	64%	55%	60%	79%	1	1			
19A	U	GIM	The spectrometer is old.		6	9	4	1	7	8	35	0	1	2								6	ISSP, Univ. Of Tokyo	B	Since this is an externally constructed beamline, thus PF will not invest now.
19B	U	GIM	There is a problem in the reproducibility of energy, left more than 10 years.		9	10	2	6	7	3	37	2	4	2									ISSP, Univ. Of Tokyo	B	Since this is an externally constructed beamline, thus PF will not invest now.
20A	B	NIM	Move the undulator source beamline. Improve the energy resolution by improving the scanning mechanism.	(F) Construct a new NIM beamline with an undulator source. It need more than 10M yen, thus it is better to user undulator.	5	4	7	1	2	5	24	3	6	5	121%	106%	100%	83%	113%	135%		8		B	Functioning well as a beamline with a bending magnet source. Thus we don't have to invest much for the improvement.
20B	B	X	No focusing system.		0	0	1	0	0	0	1	1	0	0									Australia		Papers are not registered.
27A	B	SX	Supporting man power.	(F) Re-coat the focusing mirror.	8	7	10	10	9	5	49	8	5	4	89%	96%	86%	94%	81%	93%		6			
27B	B	X	Although there are some papers on XAFS, but only a few from radiation biology or diffraction experiments. Increase the number of users. Supporting man-power.		3	6	10	5	6	6	36	6	8	4	99%	104%	103%	81%	96%	123%		6			
28A	EU	GIM	Cool down the sample to liquid He temperature. Development of new users is required.	(F) Simultaneous scanning of the spectrometer and undulator gap. Construct a new variable polarization beamline.	2	7	4	5	3	5	26	6	0	2	89%	100%	2%	89%	57%	76%	1	6		C	A few users. Future plan should be discussed. Now considering the the construction of beamline dedicated for high resolution photoelectron spectroscopy.
28B	EMPW	X/SX	No competitive power to SPring-8 above 6keV. Few papers.	Few users who plan to use below 6keV.	5	3	5	5	4	4	26	4	2	2	94%	100%	13%	100%	100%	113%		1		C	A few users. Future plan should be discussed. Discussion on the future of beamlines using soft X-ray DXM , BL-2A, 11B and 28B, is required including the future of science and estimation of demand. No attractive proposals are made by surface chemistry and XAFS -UG. Now requesting the opinion for the spokespersons of resent proposals.
NE1A1	EMPW	X	Develop new users. Prepare a users manual.		6	7	7	4	6	0	30	4	2	2			153%	105%	128%	174%		4		B	
NE1A2	EMPW	X										1	0	0										B	
NE1B	EU	GIM	Getting less competitive.		3	3	3	3	2	0	14	2	0	1			162%	96%	156%	133%		2		B	Save the investment until the plan of straight section upgrade is settled.
NE3	U	X	reconsider the strategy of this beam line.	(F) Prepare a focusing system.	1	4	0	3	0	0	8	3	2	0			117%	109%	97%	102%		2		not fixed	Discussion on the future of Mossbauer spectroscopy and the coexisting instruments. Nuclear resonance-UG made proposals.
NE5A	B	X	Only a few proposals. Install a versatile area detector.		10	8	4	5	6	1	34	6	4	0			87%	100%	109%	100%		4			
NE5C	B	X			5	9	1	2	6	7	30	6	6	3			75%	79%	106%	90%	2		users group		
NW2	U	X																						S	Proceed the time-resolved experiments by using the single bunch property.
NW12	U	X																		add to 6A				S	Proceed the structural biology.
BL	source	E	comments at the last review	Future plan proposed by the corresponding beamline scientist (F) and plan to response the review.	97	98	99	00	01	02	97~ '02	99	00	01	2001. 10-	2002. 1-3	2002. 4-7	2002. 10-	2003. 1-2	2003. 5-6	award	invited talkd	management	category	comments in categorization
					publications							Act. Rep.			demand										

2003.6.11

less the 3 per year

less than 5 per year

Papers, Activity Report: Published from the beamline (multiply counted when some stations were used)

Demand: requested beam time / available beam time

less than 70%

less than 80%

more than 105%