NewSUBARU Storage Ring

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Storage Ring Parameters

The machine parameters of the 1.5 GeV storage ring remain the same as those of the previous year. They are listed in Table I.

Table I Main parameters of the NewSUBARU storage ring in FY2008.

Circumference	118.73 m	
Bending lattice type	modified DBA	
Number of bending cells	6	
Straight sections	4m X 4,	15m X 2
Bending radius	3.22 m	
Injection energy	1.0 GeV	
Maximum energy	1.5 GeV	
RF frequency	499.955 MHz	
Betatron tune	6.30 (H),	2.21 (V)
Momentum compaction factor	0.0014	
Electron energy	1.0 GeV	1.5 GeV
RF voltage	140 kV	260 kV
Natural energy spread	0.047%	0.072 %
Natural emittance	38 nm	67 nm
Maximum beam current	500 mA	

Operation Status

The ring has two user-time operation modes, 1.0 GeV top-up operation mode and 1.5 GeV operation mode. Basic operation time is 9:00 - 21:00 of weekdays. Monday is for machine R&D, Tuesday is for 1.5 GeV user time, Wednesday and Thursday are for 1.0 GeV top-up user time, Friday is for 1.0 GeV or 1.5 GeV user time. Night period or weekend is used for machine study and user time with the special mode, single bunch operation and Laser-Compton Gamma ray, if necessary.

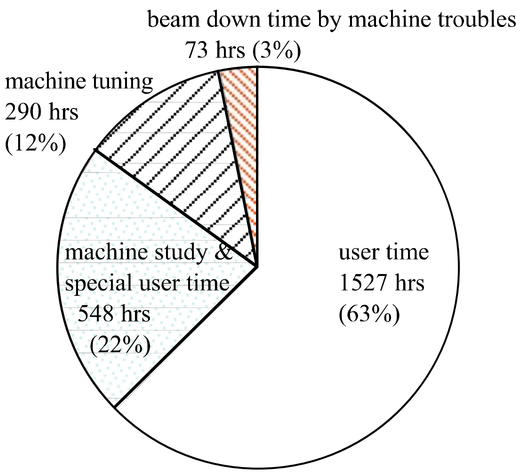

Fig. 1 Machine time in FY2008.

The total machine time in FY2008 was 2438 hrs, 81% of that of FY2007, including the beam down time. Fig. 1 shows the breakdown. The beam down time includes not only the down by a failure, but also off-beam periods by a beam abort or others due to the beam instability. The normal user time in this FY, 1527 hrs, was about 94% of that in FY2007 and 119% of that in FY2006. Time for machine study and special users was 51% of that in FY2007.

Operators – New Supporting Staff

In addition to the accelerator group members, two resident machine operators became to be in charge of the machine operation. They worked also for some machine improvements, such as the revision of GUI (graphic user interface). For example, the failure and the miss-operation of the automatic starting up process were much reduced by the improvement of the corresponding GUI.

Following the restructuring of JASRI organization, another engineer from the SPring-8 control group started full-time working for the maintenance and the improvements of the radiation safety system of NewSUBARU. The complicated hard wares and deficiency of documents were improved.

Hardware Replacements

It has been almost 10 years since the construction of the facility and some system needed replacements.

After the replacement of the main control OS, from HP-UNIX to SUSE-Linux in FY 2007, the control system became more stable. Before the replacements, some GUIs were sometimes frozen by an unidentified reason, however after the replacement it did not happen. Small software bugs were eliminated when the programs were translated.

Replacement of the OS used in the local cpu, VME board, with Solaris from HP-RT took place in FY2008.

Most of the water flow switches were replaced by more reliable new ones. It reduced the down-time by a miss-firing of the water flow interlock.

Machine Troubles

The machine troubles in FY2008 are listed in Table II. Many of sources of the failures in FY2007 were eliminated but new trouble sources appeared. The most frequent failure in FY2008, which happened 11 times, was the beam abort by the interlock of the klystron vacuum. It happened on Aug. 2 for the first time and always at the special machine condition, electron energy of 1.5 GeV and the stored beam current of around 200 mA, where the klystron power was about 58 kW. The reason is still not clear.

Machine Study and Special User Time

Table III shows the list of machine studies in FY 2008. One special theme, a research related to a production of Laser-Compton backscattering γ-ray and its use, took about 1/3 of the machine study time.

Most of the study reports are open to the public on the home page of NewSUBARU.

Accelerator Improvements

It was found that the air temperature control of the ring tunnel, which had been renewed in FY 2006, was not working well. Sometimes too strong feed-back made temperature oscillation and electron beam orbit drift in 10 min range. Re-optimization of the feed-back parameters (PID) was required to eliminate the temperature oscillation. PC control system for the feed-back parameters was added for further investigations and optimization.

In summer shut down of 2008 three visible light extraction ports were added in #1 bending cell, referred as SR4, SR5, and SR6. The vacuum chambers of the two bending cells, #1 and #6 were exposed to the air. It took about a month of beam operation for the recovery of the vacuum. The ports will be used for electron beam diagnostics and accelerator R&Ds.

The shield curtains were set at the service entrances of the experimental hall (Fig. 2), which prevented the uncontrolled air-flow from the outside. They are expected to stabilize the temperature of the facility.

Bunch current monitor was installed. It is necessary for the sophisticated bucket-selected injection, which is scheduled in FY2009.

The beam abort procedure at the end of the operation time, was changed. Previously the skew-quadrupole magnet was used but now the rf system aborts the beam. This eliminated the failure of high radiation by the beam abort.

The magnet initialization process for one special case, for the injection at 1.0 GeV after the operation at 1.5 GeV, was simplified. The excitation pattern of the bending magnets from the beam abort to the start of the injection was changed as shown in Fig. 3. The time for the initialization was reduced to about 5 min. from about 30 min.

Fig.2 Shield curtain set at the service entrance.

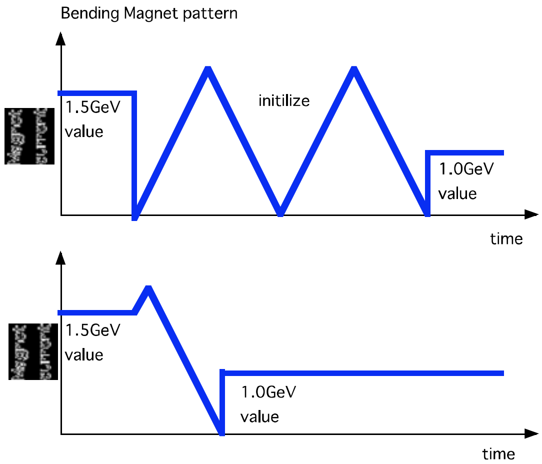

Fig. 3 Initialization pattern of bending magnet from the beam abort at 1.5 GeV to the start of injection at 1.0 GeV. The above is the old and the below is the new pattern.

Table II Machine trouble in FY2008.

Group	Failure/trouble	beam down time (hr)
Operation	miss-operation	3.5
	beam loss by a beam instabilities	0
Control	software bug	3
	VME system	6.5
RF	interlock of circulator arc	0.5
	interlock of klystron vacuum	21.5
	interlock of coupler temperature	1.5
	klystron window chiller	7
	power supply failure by a thunder	17
	breaker off (human error)	2
Timing system	trouble in cable connector	2
Monitor	miss connection of BPM (human error)	1.5
Magnet	miss firing of water-flow interlock	2.5
	failure of automatic turning on	0.5
Beam transport	orbit feed-back	1
Radiation safety	PLC stop	3

Table III List of machine studies in FY2008. The unit of study time is counted by shifts (typically 12 hrs).

R＆D theme and special user mode	responsible person	study shift
Tuning of the beam profile monitor (SR2)	S. Hashimoto	3
Optimization of bucket filling (Ion trapping)	S. Hashimoto	3
Parameter tuning for 1.5 GeV acceleration	S. Hashimoto	1
Optimization of PID parameters of the tunnel air temperature control	S. Hashimoto	2
Negative alpha-p operation	S. Hashimoto	3
Laser-Compton backscattering γ-rays (incl. Nuclear Transmutation)	S. Miyamoto	21
Test operation of new control system with Linux	S. Miyamoto	2
Spectrum measurement of SR from LU	S. Miyamoto	1
Beam abort process and radiation level	S. Miyamoto	2
Stability of SR from LU	M. Niibe	1
Vertical beam oscillation at the beam injection	Y. Shoji	4
Injection profile monitor (SR5)	Y. Shoji	4
CSR under RF modulation	Y. Shoji	2
Commissioning of sextupole windings in the invert bends	Y. Shoji	9
Long term stability of horizontal COD correction current	Y. Shoji	1
Beam based search for electron beam position at Q magnets	Y. Shoji	1
Beam instability suppression by AC sextupole magnet	T. Nakamura	1
SR-Laser synchronization	Y.Takagi	4

Beamlines

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1. Beamline Construction

Seven beamlines are operating in the NewSUBARU synchrotron facility. Four beamlines of BL01, BL03, BL06 and BL11 were constructed until 1999. Three beamlines of BL07, BL09 and BL10 were started the operation from 2000. BL03B beamline branched from the BL03 beamline propose for the usage of the EUVL (extreme ultraviolet lithography) microscope for the EUVL finished mask inspection. BL09B beamline branched from BL09 beamline propose for the usage of the advanced point diffraction interferometry for the test alignment of the EUVL imaging optics for practice use. Furthermore, BL09C beamline branched from BL09B for the usage of the EUV interference lithography to evaluate and develop EUV resist. BL02 beamline was constructed for the usage of LIGA in 2003. BL05 beamline was constracted in response to a demand in the industrial world, that is enhancement of the analysis ability in the soft X-ray region with the development of nanotechnology.

The arrangement of the beamlines in the NewSUBARU synchrotron radiation facility is shown in Fig.1.

2. BL01

BL1 is a beamline for research and developing new light sources. This beamline is one of two long straight section on NewSUBARU. Optical klystron was installed at this straight section. Upstream side of this beamline (BL01B) is intended to be used for visible and infrared light generated from FEL or SR. Downstream side of this beamline (BL01A) is used for laser Compton scattering gamma-rays source. Gamma-ray beamline hutch just outside of the storage ring tunnel was constructed in 2004 for gamma-ray irradiation experiments. Specifications of this gamma-ray source are listed in Table 1.

Table 1. Specification of BL01 gamma beam.

CO_2 laser 10.52 μm 5 W	Gamma energy : 1.7 - 4 MeV Gamma flux* : 9 x10^6 γ/s : 6 x10^5 γ/s (1.5-1.7 MeV) (with 3mmφ collimator)
Nd laser 1.064 μm 0.532 μm 5 W	Gamma energy : 17 - 40 MeV Gamma flux* : 7.5 x10^6 γ/s : 3 x10^5 γ/s (15-17 MeV) (with 3mmφ collimator)

*Electron beam energy : 1-1.5 GeV
*Electron beam current : 250 mA
gamma-ray beam divergence : 0.5 mrad

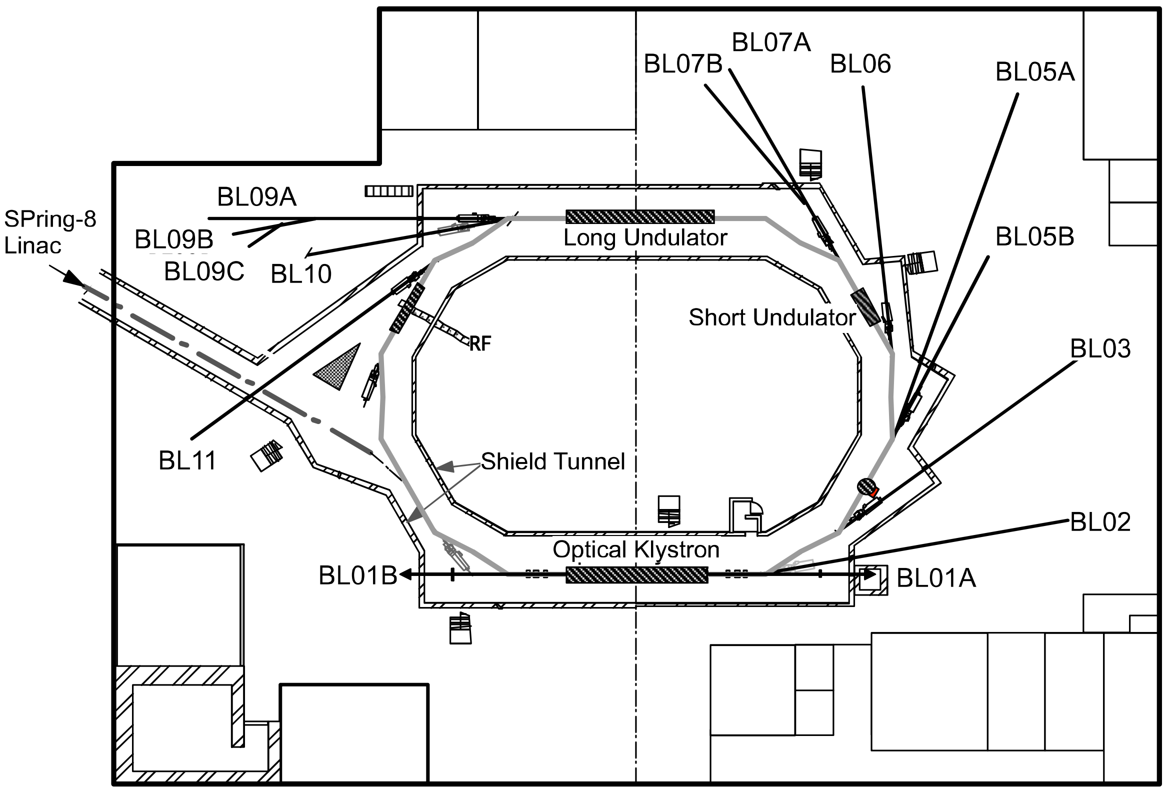

Fig. 1 Beamline arrangement in NewSUBARU.

2. BL02

The LIGA (abbreviated name of Lithogaphic, Galvanoformung and Abformung) process which consists from deep x-ray lithography, electroforming, and molding process is one of the promising candidates for such 3D micofabrication. More than hundreds aspect ratio for microstructure can be attained by the usa of the higher energy x-rays (4-15 keV) from synchrotron radiation (SR) with deeper penetration depth to the photosensitive resist. In this system we have succeeded to enlarged the exposure area up to A4 size and the fabrication dimension from submicron to millimeter by varying the energy of the x-ray source in accordance with the size of desired microparts. Micostructure with high aspect ratio over several hundreds will bi achieved using the x-rays over 10 keV since high energy x-ray has deep penetration depth to the photo-sensitive resist materials. Whereas, in the case of lithography for low energy x-rays from 1 keV to 2 keV, submicron structures with high aspect ratio will be achieved using the x-rays mask with precise line-width and thinner absorber, since low energy x-rays has low penetration depth. Based on this principle, the beamilne for x-ray exposure have constructed with continuous selectivity of x-rays frpm 100 eV to 15 keV by using the x-ray mirrors (plane and cylindrical mirror) and Be film filters. The horizontal angle of the outgoing SR could be obtained up to 12.5 mrad, which corresponds to the horizontal size of 220 mm (A4 horizontal size) at the exposure position. The second characteristic performance of the beamline is the high efficiency differential pumping system. This was necessary for maintain the vacuum difference between the storage ring ($<10^{-9}$ Pa) and the end-station ($<10^{-9}$ Pa) at which gasses for substrate cooling will be introduced in the exposure apparatus.

The flexibility for the shapes and functions of microstructure will be enlarged by achieving 3D microfabrication process using multi step exposure at various configuration between x-ray mask and substrates. The relative positions between x-ray mask and substrates, tilt and rotation angle to the SR incident direction can be moved simultaneously during SR exposure using 5 axis stages. The movement of each axis is controlled by the PC in terms of the scanning speeds, scanning length, and repetition number. In order to decrease the heat load of sample substrate suffered during SR irradiation helium introduction and substrate cooling mechanism were alse equipped. Specification of spectrometer is listed in Table 2.

Table 2. Specification of the BL02 LIGA exposure system

Optics	Plane and cylindrical mirror, Be filters
Exposure energy	100 - 2 keV, and 4 – 15 keV
Exposure method	Proximity and multi step exposure
Wafer size	A4 or 8 inch
Exposure area	230 mm(H) ×300 mm(V)
Exposure environment	< 1 atm (He-gas)

3. BL03

BL03 is a beamline for the developing the next generation lithographic technology so called extreme ultraviolet lithography (EUVL). The exposure tool is installed at the end station. Using this exposure tool, the research and development of the next generation lithography such as the less than 70 nm node is going on process. The exposure wavelength is 13.5 nm.

The semiconductor industry plays a very important role in the information technology (IT). In 2006, 256 Gbit DRAM with a gate length of 70 nm will be demanded in the IT industry. The extreme ultraviolet lithography (EUVL) is a promise technology for fabricating a fine pattern less than 70 nm. To meet this schedule, this technology has to be developed in the pilot line until 2004. As for the practical use, it is very important that both to achieve large exposure area and to fabricate fine patterns. Therefore, at Himeji Institute of Technology, large exposure field EUV camera consists of three aspherical mirrors was developed. First in the world, we fabricated 60 nm line and space pattern in the large exposure area of 10 mm × 10 mm on a wafer. Furthermore, BL03B beamline branches from the BL03 beamline propose for the usage of the EUVL microscope for the EUVL finished mask inspection.

4. BL05

BL05 was constructed in response to a demand in the industrial world, that is enhancement of the analysis ability in the soft X-ray region with the development of nanotechnology. BL05 consists of two branch lines for use in the wide range from 50 eV to 4000 eV. BL05A and BL05B are designed to cover the energy range of 1300-4000 eV and 50-1300 eV, respectively. The incident beam from the bending magnet is provided for two branch lines through different windows of a mask. Therefore, these two branch lines can be employed simultaneously.

Table 3. Specification of the BL03 exposure tool (ETS-1)

Imaging optics	Three aspherical mirrors
Exposure wavelength	13.5 nm
Numerical aperture	0.1
Demagnification	1/5
Resolution	60 nm
Depth of focus	0.9 µm
Exposure area (static)	30 mm×1 mm
Exposure area (scan)	30 mm×28 mm
Mask size	4, 8 inch, and ULE 6025
Wafer size	8 inch
Exposure environment	In vacuum

1) The double crystal monochromator was installed at the BL05A. InSb crystals and Si crystals are prepared for a double-crystal monochromator. Toroidal mirrors are used as a pre-mirror and a focusing mirror of BL05A. XAFS measurement in the total electron yield mode and fluorescence XAFS measurement using SSD (SII Vortex) can be performed. The fluorescence XAFS spectra can be measured for samples at the end station filled with He gas.

Table 4. BL05 double crystal monochromator specification

Monochromator	Double crystal monochromator
Monochromator crystals	InSb(111), Si(111)
Energy range	1300-4000 eV
Resolution	E/⊿E=3000

2) The constant-deviation monochromator consisting of a demagnifying spherical mirror and a varied-line-spacing plane grating (VLSPG), which can provide high resolution, simple wavelength scanning with fixed slits, was mounted on BL-5B. The optical system consists of a first mirror (M0), a second mirror (M1), an entrance slit (S1), a pre-mirror (M2), and three kinds of plane grating (G), an exit slit (S2) and a focusing mirror (M3). The including angle of the monochromator is 175°. Two measurement chambers are prepared at the end station of BL-5B. The XAFS spectra in the total electron yield mode and fluorescence XAFS spectra using SDD (EDAX) can be measured in a high vacuum chamber. In addition, the photoelectron spectrum can be measured using spherical electron analyzer (VG Sienta, R3000) in an ultra high-vacuum chamber. The chambers can be replaced by each other within 1 hour.

Table 5. BL05 constant-deviation monochromator specification

Monochromator	Varied-line-spacing plane grating monochromator
Grating	100 l/mm, 300 l/mm, 800 mm/l
Energy range	50-1300 eV
Resolution	E/⊿E=3000

5. BL06

BL06 has been mainly developed for irradiation experiments such as photochemical reaction, SR-CVD, photo-etching, surface modification. The white radiation beam from bending magnet is introduced to the sample stage using a pair of mirror, whose incident angle was 3°. The SR at BL-6 sample stage had a continuous spectrum from IR to soft x-ray, which was lower than 1 keV. A differential pumping system can be utilized for experiments in a gas atmosphere, which is difficult in the soft x-ray region. A sample holder can install four pieces of samples at a time. By using heater set in the sample holder, the sample can be heated from room temperature to 220°C. The temperature of sample is monitored using a Cr-Al thermocouple mounted on the sample holder

6. BL07A and BL07B

This beamline was designed for the development of new materials by SR technology. This beamline consists of two branch lines, which are provided with an incident beam from a 3-m undulator by switching the first mirror. One of them is a high photon-flux beamline with a multilayered-mirror monochromator for the study of SR-process (BL07A) and another is a high-resolution beamline with a varied line spacing grating monochromator for the evaluation of nano-structure characteristics by SR-spectroscopy (BL07B). The useful range of emitted photons from 50 to 800 eV is covered at both beamlines. The light source of BL07 is a 3-m length planar undulator, which consists of 29 sets of permanent magnets, a period length of which is 76 mm. The incident beam from the undulator is provided for two branch lines by translational switching of first mirror.

1) **BL07A**

The multilayered-mirror (MLM) monochromator, which has high reflectivity in the soft X-ray region, was installed at the BL07A. It consists of a switching mirror chamber, a slit chamber, a MLM monochromator, a filter chamber and a reaction chamber. To obtain a large photon flux, we decided to use only first mirror (switching mirror), M0, for focusing. The MLM monochromator is designed to cover an energy range of up to about 800 eV by combination of three kinds of mirror pairs with 4 kinds of filter. The flux deliver by this design is estimated to be between a maximum of 10^{17} photons/s at 95 eV and a minimum 2×10^{14} photons/s at 300 eV for a 500 mA ring current.

2) **BL07B**

The constant-deviation monochromator consisting of a demagnifying spherical mirror and varied line spacing plane grating (VLSPG), which can provide to high resolution, simple wavelength scanning with fixed slits, was mounted on BL07B. The optical system consists of a first mirror (M0), a entrance slit (S1), a premirror (M1), and three kinds of plane grating (G), an exit slit (S2) and a focusing mirror (M2). The monochromator is designed to cover the energy range 50-800 eV with three gratings, of which including angle are 168°. The VLSPG has been well known to obtain high resolution in extreme ultraviolet region by diminishing various kinds of aberration. The total resolving power about 3000 can be realized in the whole energy region.

Table 6. Specification of BL07A.

Energy range (eV)	Multilayer mirror					Filter	
	Material	Spacing	Thickness Ratio	Number of layers	ΔE/E %	Material	Thickness
50-60	Mo/Si	20 nm	0.8	20	6.2	Al	100 nm
60-95						None	—
90-140	Mo/B_4C	11 nm	0.5	25	3.3		
140-194						Ag	100 nm
190-400	Ni/C	5 nm	0.5	60	2.5		
400-560						Cr	500 nm
550-800						Ni	500 nm

Table 7. BL07B monocromator specification

Mount type	Hettrick-Underwood type
Grating G1, G2, G3	Plane VLS (600 l/mm, 1200 l/mm, 2400 l/mm)
Energy range	50-150 eV, 150 – 300 eV, 300-800 eV
Resolving power (E/ΔE)	~3000

7. BL09

A purpose of this beamline is studies on a soft X-ray interferometry or a holographic exposure experiment with making use of highly brilliant and coherent photon beams radiated from 11 m long undulator in NewSUBARU.

BL09 consists of M0 mirror, M1 mirror, G grating and M2 and M3 mirror. M0 and M3 mirrors are used for horizontal deflection and beam convergence, M1 is used for vertical beam convergence at the exit slit, and M2 is used for vertical deflection and beam convergence. A monochromator is constructed by M1 and a plane grating. The maximum acceptance of the undulator beam is 0.64 mrad in horizontal and 0.27 mrad in vertical. The acceptance can be restricted by 4-jaw slits equipped at upstream of the M0 mirror.

BL09B beamline branched from BL09 beamline for the usage of the advanced point diffraction interferometry for the test alignment of the EUVL imaging optics for practice use.

BL09C beamline branched from BL09B beamline for the usage of the EUV interference lithography for the evaluation of the exposure characteristics of EUV resist. Coherence length of 1 mm at the resist exposure position was achieved using BL09C beamilne.

Table 8. BL09 monochromator specification

Function	Extreme ultra-violet (EUV) point diffraction interferometry
Sample	EUV imaging optics. Presently, Schwarzschild optics.
Beam size	80(w) x 120(h) μm
Degree of Vacuum	5×10^{-4} Pa (differential evacuation system, upstream)
Photon number	1.2×10^{13} photons/sec, at 95 eV, Ie=40mA

Table 9. Specification of the BL09 end station

Mount type	Hettrick-Underwood type
Grating	Plane VLS (900 l/mm)
Energy range	50 – 600 eV
Resolving power (E/ΔE)	~3000

8. BL10

BL10 is for the global use in the Himeji Institute of Technology. M0 mirror is used for horizontal deflection and beam convergence, M1 is used for vertical beam convergence at the exit slit, and M2 is used for vertical deflection and beam convergence. A monochromator is constructed by M1 and a plane grating. At the beginning, the multiplayers reflectiveity measurement was carried out at this beamline. The characteristics of this beamline and the result of the Mo/Si multiplayers measurement are carried out for the development of the EUVL mask techmology.

BL10 utilizes a monochromator of the varied line spacing plane grating monochromator (VLS-PGM). The line density of the monochromator in central region of the grating is 600 lines/mm. The reflectometer is a two axis vacuum goniometer using two Huber goniometers. One axis carries the sample, which may for examplee be a mirror at the center of the reflectometer vacuum tank (θ-motion). The other (φ-motion) carries the detector on a rotating arm. In addition there are through-cacuum linear motions to translate the sample in two orthogonal directions (x,y). All motors are controlled by computer. The sample itself is mounted on a kinematic holder. The controlstage monochromator rotation, and data analysis were program using LABVIEW software. The reflectivity result obtained at BL10 has a good agreement with that at LBNL.

Table 10. BL10 monochromator specification

Mount type	Hettrick-Underwood type
Grating	Plane VLS (600 l/mm)
Energy range	50 – 600 eV
Resolving power (E/ΔE)	~1000

9. BL11

A beam line BL11 is constructed for exposure Hard X-ray Lithography (DXL) in the LIGA (German acronym for Lithographite Galvanoformung and Abformung) process. LIGA process, that utilizes a useful industrial application of SR, is one of the promising technologies for fabrication of extremely tall three-dimensional microstructures with a large aspect ratio. This process was invented at the Institut Fur Mikrostrukturtechnik (IMT) of the Karlstuhe Nuclear Center (KfK) in 1980. Microstructures with height of over a few hundreds μm have been widely applied to various fields such as micro-mechanics, micro-optics, sensor and actuator technology, chemical, medical and biological engineering, and so on. This beam line was designed by the criteria ; photon energy range 4 keV to 6 keV, a beam spot size on the exposure stage ≥ 50×5 mm^2, a density of total irradiated photons ≥ 10^{11} $photons/cm^2$. BL11 of an absorber chamber, a first-mirror chamber (M1), a second-mirror chamber (M2), a 4-way slit chamber, a Be window chamber, and an exposure chamber. The second pre-mirror is bent elliptically using a bending mechanism. Fine bending adjustment of the M2 mirror can be made in the UHV by the pulse motor. The LIGA process needs the photon energies of 3 keV to 6 keV, the optics of a LIGA beam line generally employ a Pt monolayered-mirror and a Be window, which cuts off low-energy photons. The reflectivity of a Pt-coated mirror is about 55 % in the range of photon energy from 2 keV to 4 keV, however, it drops to 30 % at the photon energy of 6 keV. Therefore, new materials with a high reflectivity must to be found for Deep X-ray lithography (DXL) in this energy range. We propose the use of a Ni/W/C multilayered-mirror with a graded d-spacing in the range of photon energy from 3 eV to 6 keV. The calculated reflectivity of the Ni/W/C multilayered-mirror is higher than 56 % at the photon energy of 6 keV with a glazing incident angle of 0.8 degrees, and photons that have higher photon energy than 6 keV can be removed A 200 μ m-thick beryllium (Be) window in a Be window chamber is used to separate the ultra-high vacuum part from the low vacuum part and to cut off low-energy photons.

Table 11. Specification of theBL11 LIGA exposure system

Exposure method	Proximity exposure
Wafer size	4 inch
Exposure area	50 mm(H)×80 mm(V)
Exposure environment	< 1atm (He-gas)

Upgrade of control system of the NewSUBARU accelerator

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Abstract

In order to maintain the NewSUBARU synchrotron radiation facility, it is important to upgrade not only its hardware but also software. Because of the recent great progresses in information technologies and the increase of manpower in our facility, some troubles have been resolved and the facility became somewhat easy to use. In this paper we report the recent upgrades of the control system of the NewSUBARU accelerator.

Introduction

For the operation of a large machine such as synchrotron radiation source, the control system is one of the most important issues. The recent rapid progress in information technologies can improve the performance of the machine still more.

Owing to the increased manpower, the control system of the NewSUBARU ring has been greatly improved since 2007. In this paper we report the system upgrades performed in 2008.

Replacement of VME CPU boards

Equipments necessary for the storage ring, such as magnet, RF, monitor and vacuum, are controlled via VME. New CPU boards replaced old-fashioned ones in VME chassis and OS was also replaced from HP-RT to Solaris. Software called EM (equipment manager) is running on the CPU board and controls equipments. All EM software was re-compiled and ported to Solaris.

Update of GUI for operating the accelerator

After porting all GUI (graphical user interface) software, which is required for operating the accelerator, to Linux in 2007 [1], some GUIs were updated or newly introduced. By updating these GUI, the accelerator became somewhat easy to use.

Automatic COD (closed orbit distortion) correction program was developed and has been used during user-time since 2008. This program measures electron beam positions by BPM (beam position monitor) every one minutes and, if the orbit is larger than the target figure, COD is corrected by steering magnets. By introducing this program, the stabilities of electron beam position and optical axis of synchrotron radiation were drastically improved and the performance as the radiation source was steadily improved [2].

Bunch current monitor system was ported from SPrinig-8 to our ring. The system measures beam current per bunch and can display filling patterns of stored electron beams in detail.

Energy saving program was upgraded so that it is easy to use. By clicking one button in the front panel, an operator can easily shutdown and automatically restart the ring for energy saving [3].

In the case of the operation at 1.5 GeV, the stored beam energy is ramped up after beam accumulation at 1.0 GeV. If stored beams are accidently aborted after ramping, the former operation GUI re-initialized all magnets for the re-injection of beams at 1.0 GeV. Facility users had to wait about one hour for beam injection to be restarted. In order for quick recovery, the updated GUI uses an another quick-pattern for initializing magnets and the waiting time was greatly shortened.

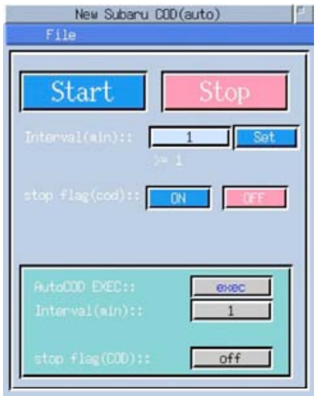

Fig.1. Front panel of the auto COD correction GUI

Connection of LabVIEW systems to MADOCA

Many kinds of monitor systems based on National Instruments LabVIEW have been developed at the NewSUBARU. However, these systems were independent from MADOCA (the control system of the SPring-8 and NewSUBARU accelerators).

By connecting our LabVIEW systems to MADOCA as shown in Fig.2, we became be able to archive the data acquired by LabVIEW systems to the database system of the SPring-8. Various kinds of data, including air temperature, temperatures of cooling water and equipments, analog voltage and current, output of thermocouples, are acquired and archived in the database. We can see trend graphs of these items in long term using the archived data. This system is useful for stabilization of the storage ring [2].

In near future, betatron tunes and beam size measured by a visibility monitor, that are analyzed in real-time using LabVIEW, would be archived to the database. The connection between LabVIEW systems and MADOCA can make more flexible tuning of the accelerator possible. And this system can also be used as an infrastructure for improving the performance of beam-lines.

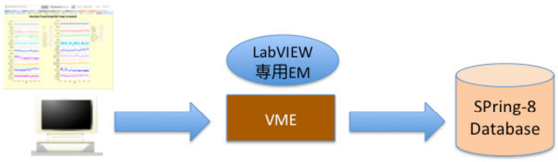

Fig.2. Connection of the LabVIEW-based systems to the SPring-8 database via VME and EM for LabVIEW.

Overhaul of the private network system for beam-lines

The beam current stored in the ring accelerator is measured by DCCT (Direct-Current Current Transformer), whose output is measured by DVM (digital volt meter). DVM is controlled by a server PC through GPIB interface. Client PCs at each beam-lines receive the information of a stored beam current from the server PC through a private LAN using TCP (Transmission Control Protocol). As the number of client PCs has been increased recently, the delivery of the stored beam current was delayed by a few minutes due to heavy network traffic.

In order to resolve this problem, we overhauled the system. 100 Mbps switching hubs replaced old-fashioned 10 Mbps dumb hubs. The outdated server PC was replaced by a new one with new operating system and new version of LabVIEW application software. The main cause of network traffic was the collisions of TCP packets. Instead of TCP communication, we used UDP (User Datagram Protocol) to reduce network collisions.

By the overhaul, beam-line users became to be able to successfully receive the real-time data of the beam current, which is updated every 200 ms.

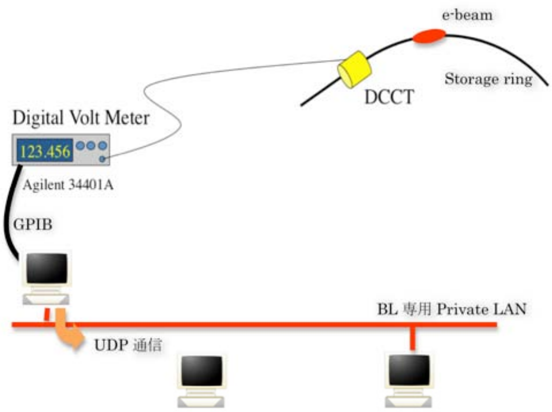

Fig. 3 Private LAN for data deliver to beam-line users.

Conclusion

By the upgrades of the control systems for the NewSUBARU accelerator, a few difficulties were resolved and it became somewhat easy to use for both machine operators and users. Further efforts to improve the performance of the facility would be continued.

Acknowledgement

We gratefully thank to Dr. T. Hirono, Dr. T. Masuda, and Dr. T.Matsumonoto of JASRI for their cooperation in making connection between our LabVIEW systems and MADOCA. Especially, Dr. T.Hirono kindly offered the software necessary for linking our system to MADOCA. We also thank to the other members of Controls and Computing Division of JASRI for their support to our facility.

References

[1] S.Hashimoto *et al.*, LASTI Annual Report vol.9, pp.22

[2] S.Hashimoto *et al.*, “Stabilization of NewSUBARU synchrotron radiation source”, LASTI Annual Report vol.10

[3] S.Hashimoto *et al.*, “Energy saving activity at the NewSUBARU synchrotron radiation facility”, LASTI Annual Report vol.10

Energy saving activities at the NewSUBARU synchrotron radiation facility

S.Hashimoto, Y.Minagawa[#], T.Shinomoto[#], I.Sasaki[#], S.Miyamoto
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Abstract

Synchrotron radiation facilities, generally speaking, need a huge quantity of electric power for their operations. Thus energy saving is important as both environmental and financial issues. We report the activity for grappling with energy saving in the NewSUBARU synchrotron radiation facility.

Introduction

In the NewSUBARU facility the quantity of electric power is limited by a contract (present contracted power is 1450 kW). Exceeding this value, we are forced to pay for breach of contract. On the other hand, contracting at the larger quantity of power means an increase of an electricity charge. Thus we have to operate the facility within the electric power of contracted value.

The electric charge for operating the facility amounts to 70 million yen a year. The ratio of electric charge to the total budget of the facility is about 35 percent. The energy saving is very important to share the budget for necessary costs of operation, safety, machine repair, maintenance and also required improvement of performance of synchrotron radiation.

Grappling with power saving in NewSUBARU

In order to saving electric power in our facility, we made some monitor systems and go by some operation rules as follows.

Watching the demand power by web camera

Using a web camera, we are watching the demand value of the total electric power of the facility, that is, the power of the near future estimated from past 30 minutes. This value is a rough yardstick and should not be exceeded 1450 kW.

The machine operators can watch the quantity using a web browser in the control room. When the value reaches the limit, they take actions for energy saving, i.e., shutdown of non-essential equipments and stop of air conditioner.

Development of data logging system for electric power

In order to monitor a breakdown of electric power in the facility in detail, we have developed a data logging system using the network distributed data logger (National Instruments Fieldpoint). The total electric power is classified into eleven small groups such as light, building, machine, etc. Each item can be individually monitored as an analogue output signal. The front panel of the data acquisition software is shown in Fig.1. A rough breakdown of the electric power in the facility is shown in Table. I.

Fig. 1. Front panel of software acquiring electric power in the facility.

(kW)	**1.0GeV**	**1.5GeV**
Building	250-300	250-300
Light	<100	<100
Ring Magnet	~350	~650
BT Magnet	~50	-
RF klystron	~300	~300
Total	~1100	~1400

Table. I. Rough breakdown of electric power in the facility

Nighttime power-off and automatic power-on of power supplies for magnets and RF klystron

In our facility, usually, beam injection starts at 9 AM o'clock and, after machine tuning, user-time starts at 10 AM and ends at 9 PM o'clock as shown in Fig.2. In case of no operation at night, all power supplies for the accelerator magnets and RF klystron are shutdown to reduce the amount of nighttime electricity consumption.

Fig. 3 shows front panel of the energy saving software. Once only one button is clicked, all power supplies can be shutdown. In case of on-beam, off course, this button disappears and can't be clicked. By setting start timer, all magnets and RF klystron automatically start up in the early morning. All magnets are automatically initialized.

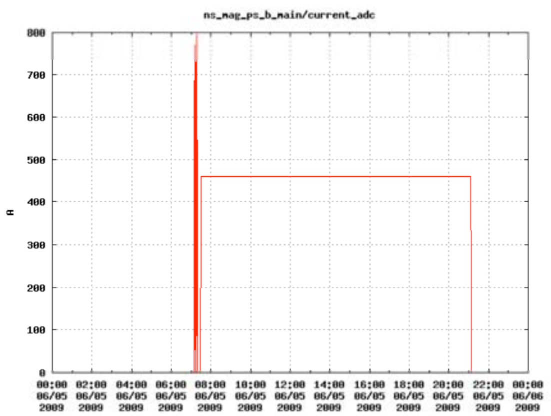

Fig. 2. Current for the bending magnet in one day. At seven o'clock, magnets are automatically initialized. At nine PM o'clock power supplies are shutdown.

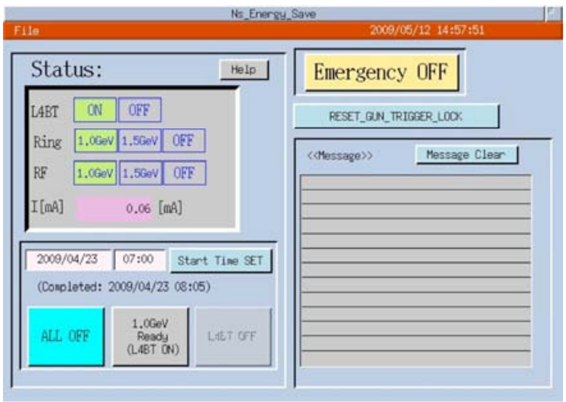

Fig. 3. Panel of the energy saving software.

Power-off of beam-transport magnets at 1.5GeV operation

The electron beams are injected at the energy of 1.0GeV from SPring-8 Linac. During user-time at 1.0 GeV, the stored beam current is almost kept at constant by the top-up operation. In case of 1.5GeV operation, the stored beam energy is ramped up after beam accumulation.

The electron beam at the energy of 1.0GeV can't be injected into the ring operated at 1.5GeV. The power supplies for magnets at beam transport can be turned off during 1.5 GeV operations. By turning off these power supplies, we can save a quantity of electric power of 50kW.

Time-shift of 1.5GeV operation in summer season

The quantity of electric power during 1.0 GeV operation is almost 1100 kW, and at 1.5 GeV it reaches to 1450 kW as shown in Table. I. In summer, especially, the total power of the facility is often larger than 1450 kW, because the contribution of air conditioner is very large.

Thus we decided that 1.5 GeV operation starts at 5 PM o'clock and ends at 9 AM of the next day. The 1.5 GeV operations for user-time have been done at night since 2008.

Energy saving and stability of the radiation source

Once power supplies are turned off, it takes about over 10 hours for magnets to reach a constant temperature. As far as the stability of temperatures are concerned, it prefers to power-on magnets whole day.

Large amount of drift in electron beam position and optical axis were observed. And this is because of variations of various kinds of temperatures such as cooling water, air in the shielded tunnel, equipments, etc [1]. Although the stored current is almost constant during top-up operation, temperatures of air, water, equipments and so on, varies in one day. These variations occur drifts in orbit of electron beams and variations of axis of synchrotron radiation.

In order to reduce these drifts, automatic COD (closed orbit distortion) correction was made a concrete reality [1,2]. With automatic COD correction during user-time, variations of axis of synchrotron radiation could be diminished [1].

Considerations

In the NewSUBARU synchrotron radiation facility, we are grappling with energy saving as both environmental and financial issues and a large amount of electric power could be successfully saved.

Energy saving occurs a large variation of temperatures in one day and affects the stability of the radiation source. By realizing automatic COD correction, we could reduced these instabilities.

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Stabilization of NewSUBARU synchrotron radiation source

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Abstract

The periodic fluctuations and drifts in optical axis of synchrotron radiation have been observed in the NewSUBARU. Measuring temperatures of air, water, equipments, building and so on, we found that temperature fluctuations in both air in the shielded tunnel and cooling water mainly affect the stabilities of electron beam orbit and optical axis. By optimizing PID parameters of temperature controllers for air and water, the periodic fluctuations almost disappeared. By realizing automatic COD correction, moreover, the drift in electron beam position could be suppressed. The fluctuations of radiation intensity observed at beam-lines became smaller than they used to be.

Introduction

In the NewSUBARU facility, both periodic fluctuation and drift in an electron beam position have been observed as shown in Fig.1. The measured intensity of synchrotron radiation was in synchronism with this variation. Its main cause was fluctuations in temperature. Although we have dealt with this problem, it has not been completely resolved.

Now we have reinforced the measurement system for temperatures and developed the network system that makes it easy to optimize PID parameters of temperature controllers.

In this paper we report the stabilization of optical axis by reducing temperature fluctuations and realizing the automatic COD (closed orbit distortion) correction.

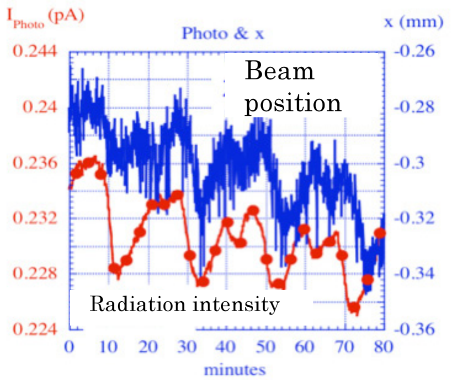

Fig. 1. Horizontal position of an electron beam and the measured radiation intensity. Drift and periodic fluctuations can be observed.

Enhancement of data logger

We have reinforced the network-distributed data logger using National Instruments Fieldpoint and increased the number of measurement points, including temperatures of air, cooling water, floor, and equipments. 60 points of data can be acquired and saved to the SPring-8 database system [1].

Stabilization of air temperature in tunnel

From the analysis of measured temperatures, it was found that the main cause of variations of electron orbit and optical axis of synchrotron radiation is the change of air temperature in a shielded tunnel for the storage ring. The range of fluctuation was about one degree.

The air temperature in the tunnel is controlled using fan coil units with two controllers (Yamatake SD35). We connected a PC to these via USB. The PC can be controlled from a remote PC through a network. Thus we can easily optimize PID parameters of the temperature controllers from our own room.

By the optimization of PID parameters, the periodic fluctuations disappeared and we could successfully maintain a constant temperature within 0.1 degree in one hour as shown in Fig. 2. PID parameters should be frequently optimized in accordance with the season, because of a change in circumference temperature.

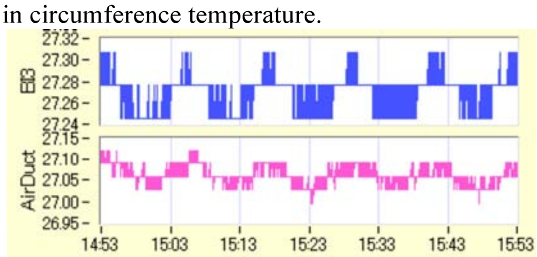

Fig.2. Air temperature in the shielded tunnel after optimization of PID parameters for temperature control. The range of temperature fluctuations in one hour is less than 0.1 degree.

Stabilization of temperature of cooling water

After the optimization of air temperature, the next major issue was fluctuations in temperature of cooling water. Using the similar way to air, PID parameters for cooling water were optimized and the range of temperature fluctuation is less than 0.2 degree. The more precise control of water temperature may be required for further stabilization of optical axis.

Stabilization of air temperature in the experimental hall

The change in temperature at the experimental hall is larger than that in the tunnel. In winter there was about a four-degree difference in temperature between daytime and nighttime. Such a large change may have a great influence on the beam-line equipments and the optical axis of synchrotron radiation.

To reduce the difference in temperature, we set up the thermal insulated curtain near a carrying door with a slight opening around it. Looking with a thermal view camera, the curtain was obviously effective for thermal insulation.

Fig. 3. A thermal insulated curtain at a carrying door in the experimental hall.

Realizing of automatic COD correction

Although periodic variations of electron beam position and optical axis almost disappeared by optimizing PID parameters of temperature controllers, slow drifts were still observed. The cause of the drifts is slow change of temperatures of vacuum chamber, magnet yoke, beam-line equipments, floor, building and so on.

To suppress these drifts, the automatic COD correction has been realized [1]. By correcting COD every one minutes, electron beam position measured by BPM (beam position monitor) became almost constant as shown in Fig.5.

Optical axis stability measured at BL10

We measured the intensity of synchrotron radiation at BL10, which is the most sensitive to the stability of optical axis in our facility. The radiation intensity normalized by a stored beam current without the COD correction is shown in Fig. 4. The periodic fluctuation with small amplitude is due to fluctuations in cooling water temperature. The slow drift comes from both the drift of electron beam position and the fluctuation in temperatures of equipments for beam-lines.

The radiation intensity with the automatic COD correction is shown in Fig. 5, where no drifts are observed in both the radiation intensity and horizontal beam position.

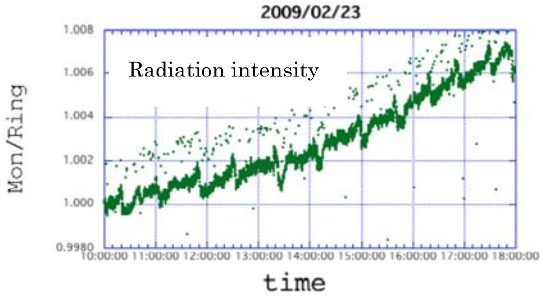

Fig. 4. Intensity of radiation observed at BL10 before the automatic COD correction.

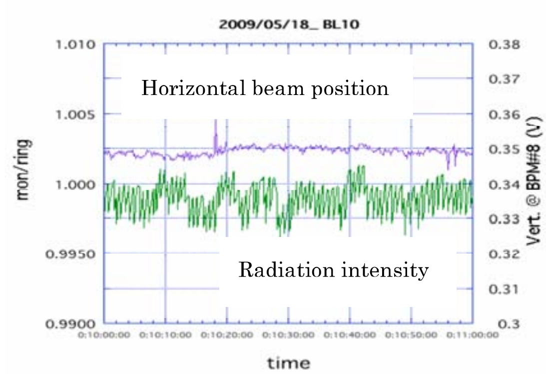

Fig. 5. Intensity of radiation observed at BL10 and horizontal position of electron beams with the automatic COD correction.

Conclusion

We have measured various temperatures in the NewSUBARU facility using a network distributed data logger and found that fluctuation of optical axis of synchrotron radiation was mainly caused by the fluctuations in temperatures of air and cooling water.

By optimizing PID parameters of temperature controllers, the range of temperature fluctuations became very small and the periodic variations of optical axis have almost disappeared.

Slow drifts of electron beams and optical axis, which may be caused by slow changes in temperatures of equipments, could be suppressed by the automatic COD correction. The fluctuation of radiation intensity observed at beam-lines became smaller than they used to be.

Acknowledgement

We greatly thank to Dr. T.Uno of Asahi Glass Corp. for his experimental data at BL10. Also the authors thank to the members of the working group for the stabilization of optical axis at the NewSUBARU.

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Bunch Current Monitor

Y. Minagawa and Y. Shoji

Abstract

We introduced a bunch current monitor for the better bucket filling control scheduled in FY2009.

Bucket filling at NewSUBARU

At the present, the single bucket injection proceeds as follows. Each of the 198 rf buckets has its own address. The target address for the injection is changed according to a programmed order. On the other hand the new system will measure the each bunch current and select the best address for the next injection in order to realize the ideal filling.

On problem of the filling control is the dummy trigger for the electron gun, which fires at after the mode change of the linac, from the Synchrotron injection to the NewSUBARU injection. The dummy trigger changes the address and makes an injection-missed bucket. With 'steady injection mode', the control software keeps the address by checking if the trigger is dummy, however it takes time. We do not use this mode at the beam accumulation because we had to reduce the injection rate from 1 Hz to 0.5 Hz. The new system will not solve this problem but fix it soon during the top-up operation.

The other problem is that the beam lifetime depends on the beam current. The main part of the ideal filling for the user time is 2 bunch trains of successive 70 bunches each, while the spaces (198-70-70=58 buckets) are filled with weak bunches. Without these weak filling the beam injection becomes worse with high stored current. With the present address control, the beam current at the spaces became stronger with time than the ideal one, because of the longer lifetime.

Bunch current monitor

The installation of the bunch current monitor was the first step to realize the new filling control. Figure 1 shows a block diagram of the system. The bunch current data is recorded in a database of the accelerator control system. Figure 2 shows GUI (Graphical User Interface) to display the data.

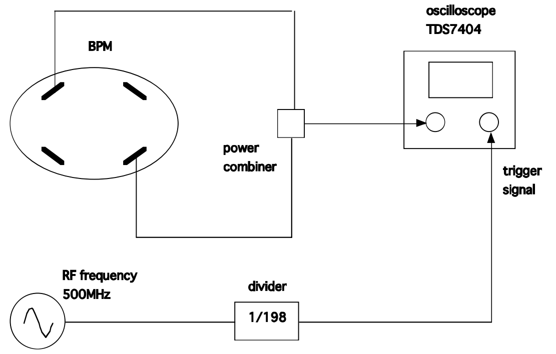

Fig. 1 Block diagram of the bunch current monitor system.

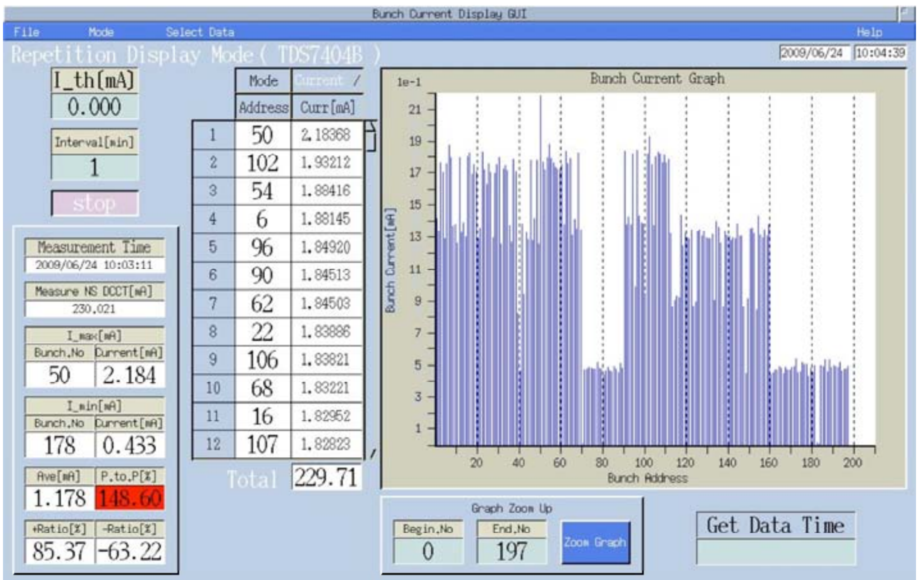

Fig.2 GUI(Graphic User Interface) pannel of the bucket filling.

New Visible Light Extraction Ports for Beam Diagnostics

Y. Shoji, K. Takeda, Y. Minagawa and T. Shinomoto

Abstract

Three synchrotron light extraction ports were added at NewSUBARU in 2008. They were for the electron beam diagnostics and R&Ds.

Three visible light extraction ports

Fig.1 shows the layout of the new three ports set at the bending sell #1, downstream of the injection straight section. The new ports are SR4, SR5, and SR6.

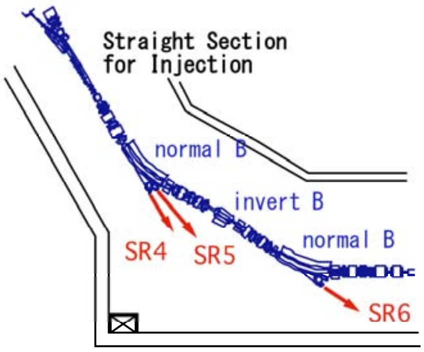

Fig. 1. Layout of three new light extraction ports.

SR5

The SR5 is the port of the normal bending magnet light. Its initial mirror is a large acceptance (H: 36.8mrad×V:11.5mrad), high quality Be mirror [1] based on the design by T. Mitsuhashi, KEK (Fig. 2). At the present, the fast-gated ICCD camera is set to observe the transverse quadrupole injection mismatch of the linac beam. The same light will be used for a double-sweep streak camera to observe the longitudinal injection mismatch [2]. A deformation of the mirror by a radiation heating will be measured using pin-hole array mask [3].

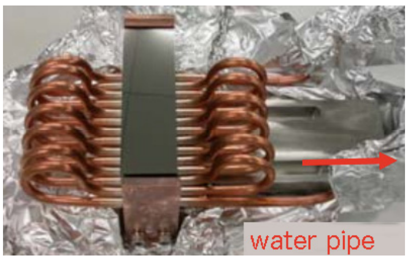

Fig.2. Flat Be mirror (96mm×27mm.)

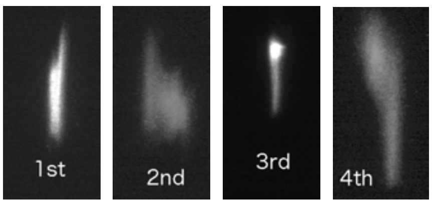

Fig. 3. Example of turn-by-turn beam profile image (initial 4 turns of the injected linac beam in the storage ring).

Transverse quadrupole mismatch at the beam injection was clearly observed using the fast-gated ICCD camera as shown in Fig. 3.

SR4

The SR4 is the light port from the dispersion-free straight section. In a special research of a short electron bunch production, the light from SR4 would be shorter than that from SR6. The beam would not have an elongation by a horizontal-longitudinal coupling [4] at SR4. With the same reason, when we observe a coherent THz radiation, the light from SR4 would have more short wavelength component than that from SR6.

SR6

The SR6 is the light port from the dispersive straight section including the invert bending magnet. We expect edge radiation at both of SR4 and SR6. However the difference between these two is not only the electron bunch size. Lienard-Wiecherd potential produced by an electron should be uni-polar at SR4 and bi-polar at SR6 as schematically shown in Fig. 4. We expect a vey special interference pattern of long wavelength radiation, similar to a single period wiggler, at SR6.

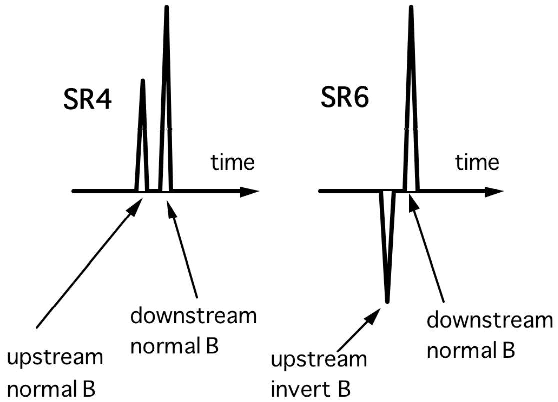

Fig. 4. Schematic view of the radiation potential at SR4 and SR6.

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Injection bump waveform monitor at the NewSUBARU

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Abstract

One of the important issues for the stable top-up operation of a storage ring is the stable beam injection with high efficiency. In order to achieve this purpose, waveforms of injection bump magnets have to be stable. We have developed the bump waveform monitor, where acquired bump waveforms are inspected in real-time and saved in a PC. We also performed statistical research in the stability of bump waveforms. In this paper we report the bump waveform monitor and the stability of bump magnets in the NewSUBARU synchrotron radiation facility.

Introduction

In the NewSUBARU facility the top-up operation has been performed in the 1.0 GeV user time. The efficiency of beam injection has to be stably high for keeping the stored current constant. To realize this purpose, many kinds of stabilities are required, that is, stabilities of injection beam from linac, pulse septum magnet, and injection bump magnets and so on.

In general, electron beams are injected to a storage ring using four pulse magnets called “bump” magnets, which make closed orbit of circulating beams at the injection point to shift horizontally for a very short period so that a beam from linac or synchrotron can be successfully injected.

In the past, there were a few times short period stops of top-up operation due to failure of injection bump magnets.

We have developed bump waveform monitor [1] to watch the operation of bump magnets. In the NewSUBARU, electron beams can be injected at the speed of 1 Hz at maximum. Data acquisition, real-time inspection and data save of four bump waveforms are required to be completed within one second.

Injection bump waveform monitor system

The outline of bump waveform monitor is shown in Fig.1. To get bump waveforms, an oscilloscope (Agilent TDS3054B) acquires monitor outputs of power supplies for bump magnets. Signals are externally triggered with beam injection pre-trigger signal. The oscilloscope is connected to a GPIB-Ethernet converter. A PC in the control room can communicate with the oscilloscope through local area network as shown in Fig.2.

Software of this system is consists of two programs. One is a program that acquires waveforms, inspects in real-time and saves these data. Another is that analyzes each waveforms saved in PC and makes statistical analysis.

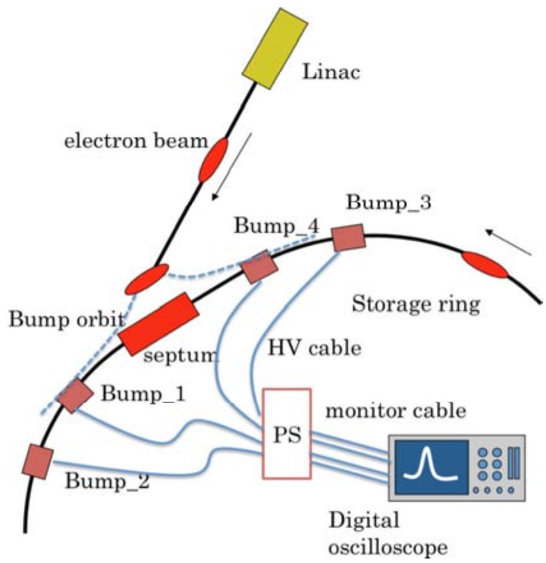

Fig.1. Electron beam injection from the SPring-8 linac to the NewSUBARU storage ring using four bump magnets.

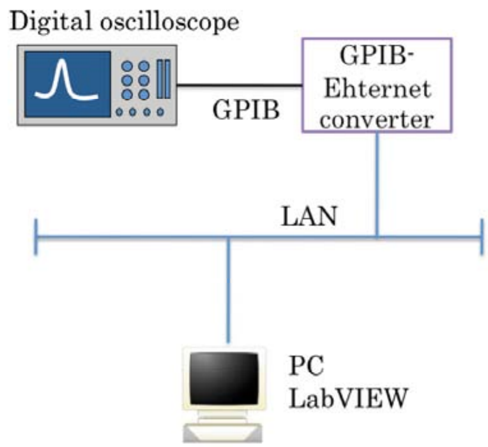

Fig.2. Bump waveforms acquired by a digital oscilloscope are transferred to the PC via a local area network.

Program for acquisition, real-time inspection and save of bump waveform

This program watches the status of oscilloscope and, if triggered, transfers waveform data from the oscilloscope to the PC. The front panel is shown in Fig. 3.

The transferred waveform data, in which the number of sampled point per channel is 10000, is inspected in real-time and is automatically decided passes and fails. The program checks whether or not the acquired waveform is between pre-defined upper and lower limits of waveform as shown in Fig. 4. If the acquired waveform is exceeded an upper limit or below a lower limit, the alarm is given. The transferred data is also saved in a hard disk of the PC.

This application was developed using National Instruments LabVIEW, where parallel-processing programs can be easily written. Thus the above-mentioned all processing can be completed within one second and is capable to acquire waveform data at 1 Hz.

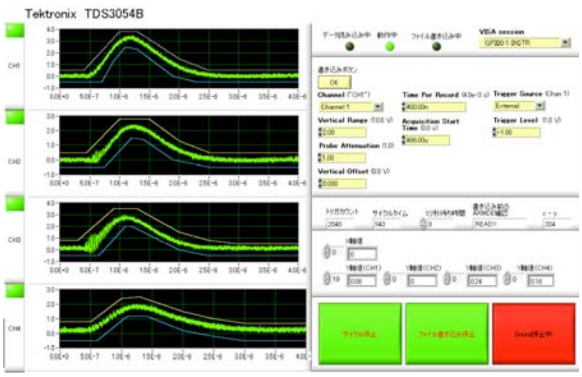

Fig.3. Front panel of the program for data acquisition, real-time inspection and data save.

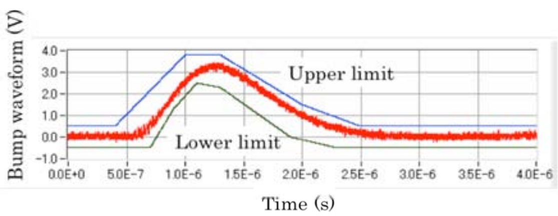

Fig.4. Real-time inspection of waveforms. If acquired waveform is between upper and lower limits, it passes.

Program for statistical analysis of saved data

In the NewSUBARU, the number of beam injection exceeds over one thousand a day. Looking at these data in detail, little discrepancies in waveforms can be found. In order to analyze these discrepancies, we have made the application program (Fig.5.) that reads a large number of data files, analyzes each waveform and make statistical analysis in the stability of bump waveforms.

This program can calculate a rise time (10-90%), peak-height, peak-position of each wavelength and show these distributions. Because bump is a high-voltage and pulsed magnet, acquired signals may be noisy. For noise reduction, data smoothing can be used before waveform analyzing.

Fig.5. Statistical analysis program for bump waveforms.

Statistical research in stability of injection bump waveform

Typical distributions of discrepancies of bump waveform are shown in Fig. 6, where rise time, peak position and peak height in 42 shots are shown. Means and standard deviations of these are shown in Table I. Detailed statistical analysis using huge amounts of stored data and research on relation between the waveform stability and the beam injection efficiency are progressing.

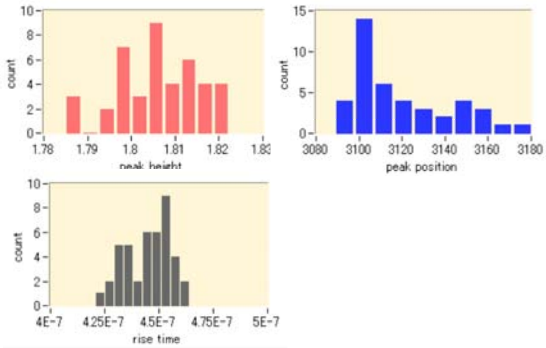

Fig.6. Discrepancies of bump waveforms in one day.

	mean	σ	σ (%)
peak position (ns)	3120	23.8	0.76
peak height (V)	1.81	0.0092	0.5
rise time (ns)	444	10.4	2.3

Table I. Mean and standard deviation of peak position, peak height and rise time of bump waveform.

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Development of knowledge systems for operating NewSUBARU accelerator

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Abstract

An electron storage ring is composed from many kinds of equipments. Sharing knowledge on the machine among an operation and maintenance staff is very important for the stable operation and adequate maintenance of the NewSUBARU. We have developed knowledge management systems for the effective operation of the NewSUBARU accelerator; an operation trouble database and a wiki server.

Introduction

In general, an electron storage ring for synchrotron radiation is composed many kinds of equipments, that is, vacuum, magnet, RF, monitor, computer, network, etc, and a large amount of knowledge and experiences are required for its stable operation.

The NewSUBARU electron storage ring, the fourth largest synchrotron radiation source in Japan, has been operated for about ten years by the accelerator staff of only three. Since 2008 three operators have been newly assigned from JASRI and been permanently stationing in our facility.

It is important to share knowledge on the machine among the operation staff in order to achieve the stable operation and the quick recovery from machine troubles. Knowledge management systems are useful for sharing and arranging information. It is noted that these knowledge systems should be developed and maintained with lower cost and manpower.

We have developed two kinds of knowledge management systems for the stable operation of the NewSUBARU storage ring; an accelerator operation trouble database and a wiki server.

NewSUBARU accelerator operation trouble database

In operating the NewSUBARU ring, there have been some troubles such as an accidental abort of stored beams, failure of beam injection or

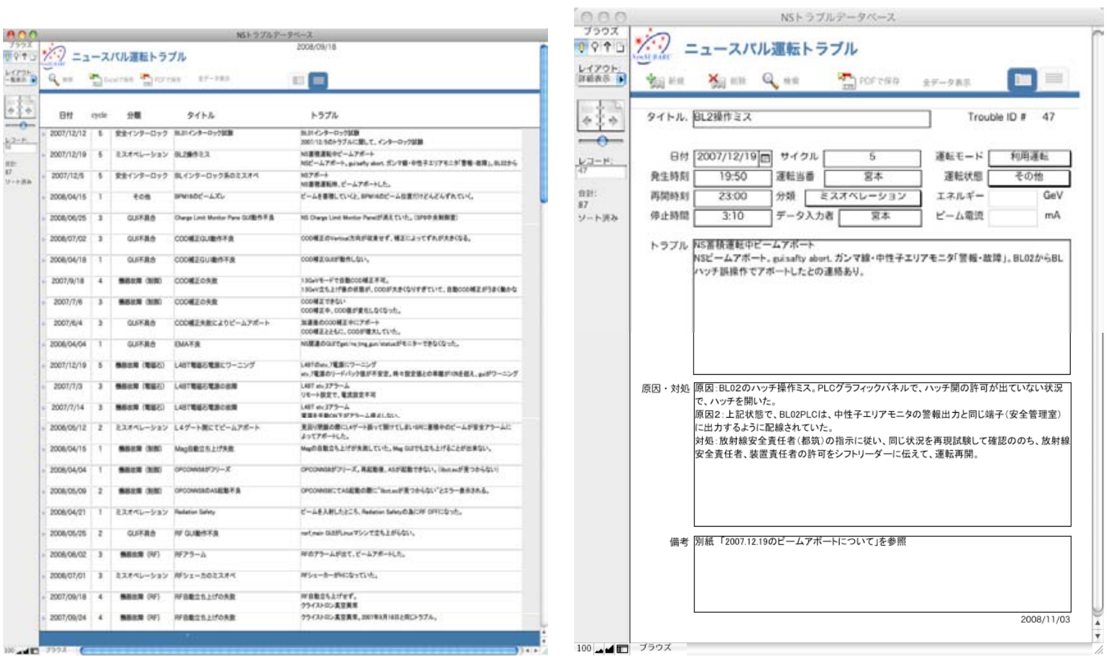

Fig. 1. NewSUBARU operation trouble database system that is made with Filemaker Pro and Apple Mac mini.

accumulation. These failures come from various causes such as fault of various equipments, beam instabilities, miss-operation and so on.

In order to record and arrange the information on operation troubles of the NewSUBARU accelerator, we have developed the small database system, where date and time of troubles, cause of failure, both temporal and permanent treatment against failure, and any notations are recorded. The database application was developed using Filemaker Pro and running on Apple Mac mini with OSX.

By data retrieval with a keyword, we can quickly search similar events that previously happened. It is possible for a non-expert to make a temporal treatment against the failure, even if an expert is absent. It also means a quick recovery from machine trouble.

Wiki server for the machine operation

A wiki is a web site that uses wiki software, allowing the easy creation and editing any number of interlinked web pages using a simplified markup language [1]. Wikis are often used to create collaborative websites, because anyone can create or edit contents via a network.

We made a wiki server for the NewSUBARU accelerator with Apple Xserve and OSX server.

Almost all kinds of information on the accelerator such as various kinds of data, operation manual, repair of equipments, documents and memorandums are included in this server. Most members of the accelerator staff actively create and edit contents, and these contents are open for not only the accelerator staff but also the beam-line users. By using the wiki server, everyone can quickly access the information necessary for the operation of the machine.

Considerations

We have developed two knowledge systems for the stable operation of the NewSUBARU ring. These systems are very useful and necessary for operating the large machine with a small number of staff.

References

[1] http://en.wikipedia.org/wiki/Wiki

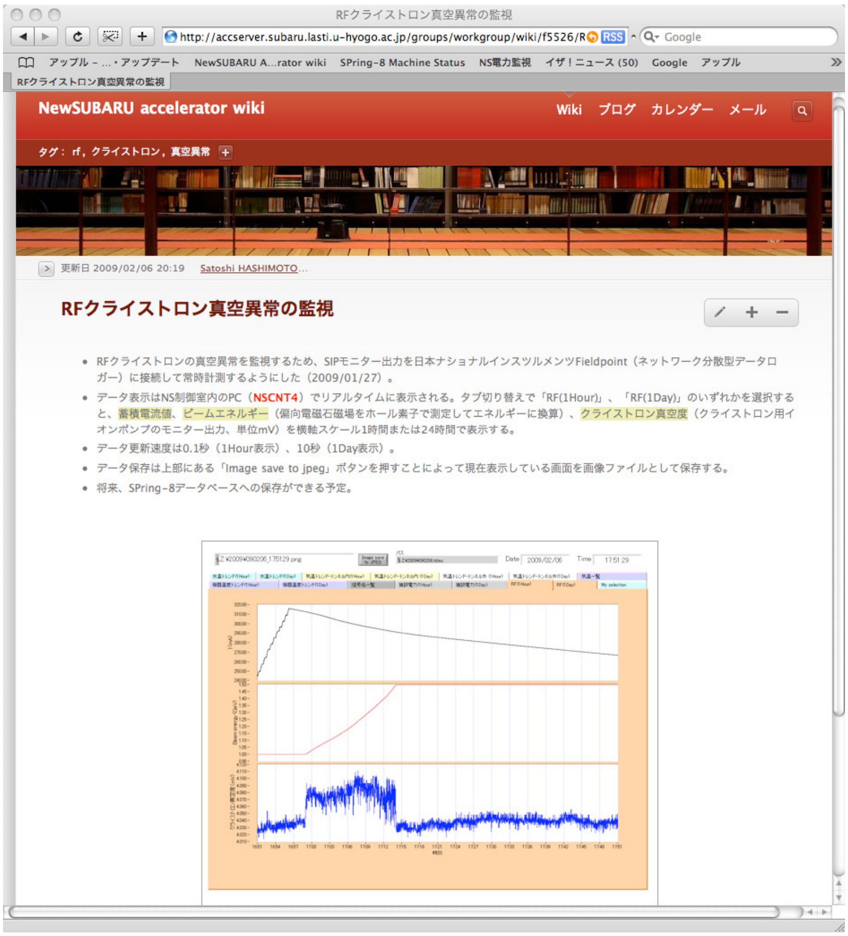

Fig. 2. NewSUBARU wiki server