Status of the New SUBARU project

New SUBARU project team
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Abstract

New SUBARU project constructs an 1.5 GeV synchrotron light source ring in the SPring-8. The ring covers the region from VUV to soft X-ray, which is complemental to the SPring-8 storage ring. The ring has invert bending magnets with which the momentum compaction factor can be varied from $+0.0012$ to -0.001. Two very long straight sections (14m each) will be used for a study and a development of new light sources such as FEL. The first beam commissioning is scheduled at the end of September 1998.

1 INTRODUCTION

New SUBARU is a name of the project to construct a facility with an 1.5 GeV synchrotron light source ring in the SPring-8 site which uses the 1.0 GeV Linac as an injector. LASTI(Laboratory of Advanced Science and Technology for Industry) of Himeji Institute of Technology is in charge of the construction collaborating with SPring-8. The construction cost of the ring is borne by the local government, Hyogo prefecture. The ring covers the photon energy region from VUV to soft X-ray, and is capable of offering hard X-ray and IR using insertion devices. This energy region is suitable for industrial uses, such as X-ray micro lithography, LIGA for micromachining, material processings, etc. Besides the ring, the facility has a FEL-dedicated 15 MeV LINAC named LEENA (Laser Enhanced ElectroN Accelerator) [1]. With these all the facility covers photon energy region from 0.1eV to 50 keV. The expected brilliance and energy region is shown in Fig.1.

The ring is designed to be a complement to the 8 GeV storage ring (SR). It is not a low emittance ring, but having a high flexibility of operation and then to be convenient for R&Ds. Two main characteristics of the ring lattice are (1) variable momentum compaction factor (α) with invert dipoles and (2) two straight sections as long as 14m (11m is free for a insertion) each. A quasi-isochronism or controllable momentum compaction factor would be one of key techniques of future electron synchrotron. It would supply a short pulsed light in synchrotron light source rings, possibly high gain of ring FEL, high luminosity for colliders and low longitudinal emittance in damping rings. An operation with negative α is another important theme. It is thought to have an advantage in bunch shortening because a potential well distortion by a inductive impedance would enlarge the RF voltage gradient. The other characteristic, long straight sections, will be used for a development of new insertion light sources such as FEL.

The mission of the project is to stimulate industrial activities and supply seeds of new technology for industries in the local area. The ring will be used not only to promote industrial activities but also to develop research works of new light sources and future accelerator technology. The facility is expected to play an important role in a big research complex including SPring-8. The construction of the ring will be finished by the end of March 1998, including four insertions and two beam lines. The first beam commissioning of the ring is scheduled at the end of September 1998.

Table 1: Main parameters of new SUBARU storage ring.

Fundamentals	
Injection energy	1 GeV
Operation energy	$0.5 \sim 1.5$ GeV
Stored current (goal)	500 mA
Circumference L	118.716 m
Revolution period	0.396 μ sec
Harmonic No. n	198
RF frequency	500 MHz
Betatron Tunes	6.21/2.17
Chromaticity (ξ)	-19/-7.5
α_1	$+0.0012 \sim -0.001$
Parameters at	$E = 1.5$GeV, $\alpha = 0.0012$
Natural emittance	67 nm
Coupling	10 %
Bending field	1.55 T
Critical photon	0.53 nm = 2.33 keV
Radiation loss	176 keV/turn
Damping time X/Y	6.56/6.73 msec
Longitudinal	3.42 msec
Energy spread	0.072 %
RF voltage	250 kV
Bucket height	0.83 %
Synchrotron tune	0.0022
Bunch length ($1\sigma_t$)	27 psec
Touschek life	> 10 hrs

2 STORAGE RING

The ring has a race track shape with two fold symmetry. It has six bending cells and six dispersion free straight sections. The main parameters of the ring are summarized in Table 1. Fig.2 shows the envelope functions of two cases, positive and negative α. Two short straight sections are used for an injection and RF acceleration and the other four are used for insertion light sources. A type of the bending cell is a modified DBA with two 34 degrees bends and one -8 degrees invert bend at the middle. The cell has three

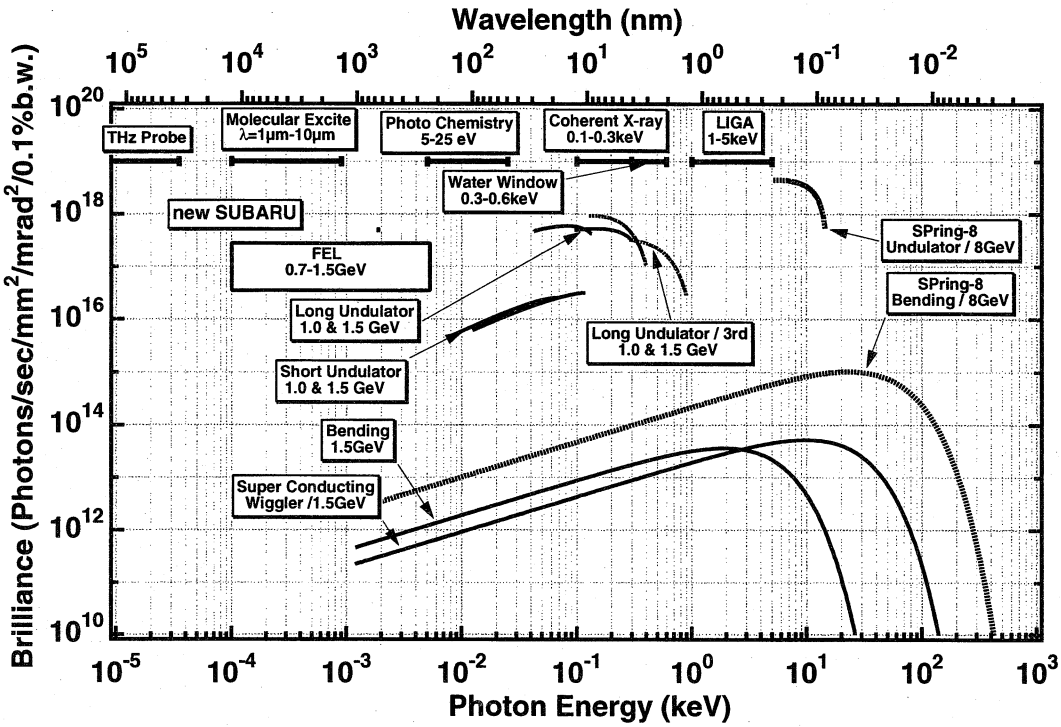

Figure 1: Expected brilliance of new SUBARU project compared with SPring-8.

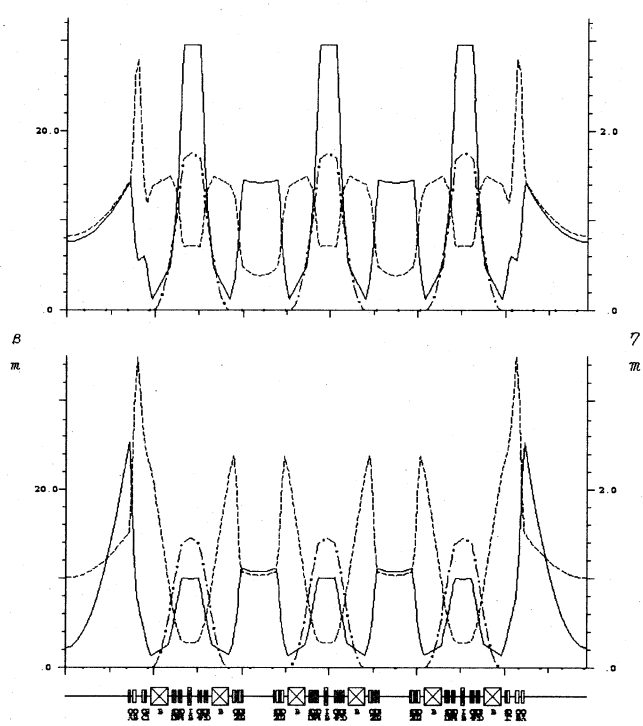

Figure 2: Twiss parameters of a half of the ring for $\alpha = -0.001$ (above) and $\alpha = +0.001$ (below). Solid lines, broken lines and dotted lines represent Real line: β_x, broken:β_y and the dispersion(η), respectively.

dipoles but its neck-tie diagram is basically that of DBA. The linear momentum compaction factor (α_1) is controlled by changing dispersion function in the invert bend keeping the achromatism. The designed emittance of the ring is roughly 70πnm, which is close to the theoretically attainable limit for that bending structure [2].

The natural energy spread is 0.072% at $E = 1.5$ GeV with $\alpha = 0.0012$ where the natural bunch length is $\sigma_t = 27$ps. Our first goal of the bunch shortening is $\sigma_t = 3$ps, or 1mm, which would be obtained at $\alpha \sim 10^{-5}$. Here the intrinsic bunch shortening limit came from the quantum fluctuation of the path length is 0.1ps [3].

The ring has three sextupole families in dispersive sections in order to control two chromaticities and the second order momentum compaction factor (α_2). This would be an essential part of the quasi-isovhronus opeartion. One family is pole-pace windings set inside the gap of each invert bend in order to minimize the coupling between the families. This enables to keep the enough dynamic aperture with additional two families at dispersion free sections [4].

One HOM damped cavity with SiC duct developed and used at INS-SOR and KEK-PF[5] is installed. The SiC absorber eliminates the resonant impedances up to $n = 800$. The DC power supply for the klystron is a newly designed crowbarless power supply using IGBT inverter unit [6], which voltage ripple is very small in low frequency region. This characteristics is very important because the synchrotron oscillation is so slow in a quasi-isochronus operation that it could be resonant with the ripple.

Main part of the vacuum chamber is made of aluminum. Its cross section at the straight section is a flat hexagon with

Table 2: Main parameters of insertion light sources of New SUBARU.

insertions	λ_u (mm)	Number of perid	gap (mm)	K	photon wave length (nm)
S-U	76	30	25~58	1.3~5.3	8.1~149
L-U	54	200	25~44.5	0.8~2.5	1.4~29
SC-W	350	1	30	262	0.1~0.23
OK (undulator)	160/320	32.5/16.5	40	1.7~12	200~12000

Table 3: Beam lines to be constructed

Purpose	Source	Energy(keV)
EUVL	BM	0.08~0.3
LIGA	BM	3
Coherenct exposure	L-U	0.08~0.3
Material processing	BM	< 1
Material analysis	BM	< 1
FEL R&D	OK	0.006
X-ray microscope	S-U	0.3~0.6
Topography	SC-W	> 2

inner height of 28mm. The structures in the vacuum chamber, such as vacuum slots or tapers, are designed according to a simple guide line; the longitudinal impedance $Z_{0,L}$ should satisfy $|Z_{0,L}/n| < 1\Omega$ for $n < 10^3$ and $|Z_{0,L}/n| < 10^{-1}\Omega$ for $n > 10^3$. The pumping system is designed to keep an averaged vacuum of 4×10^{-7}Pa when 500mA is accumulated in the ring. It guarantees a Touchek life time longer than 10 hours.

3 INSERTION LIGHT SOURCES

Table 2 summarizes the parameters of four insertions, they are the long undulator (L-U), the short undulator (S-U), the superconducting wiggler (SC-W) and the optical klystron for the FEL (OK). L-U is 10.8 m long, however it consists of separable 8 units in order that its length is changable by replacing units. SC-W is a three pole wiggler of which maximum field strength is 8 T. The undulators of OK are planner type using electric magnets. One can choose their period 160mm or 320mm. The period is changed by re-connecting the coils. The storage ring will be operated at $0.5 \sim 0.7$ GeV for FEL. The energy spread widening by the microwave instability was estimated using Keil-Shnell criteria. However the FEL would have gains more than a few thens % with peak current of 10A and the impedance of $|Z_L|/n = 0.1\Omega$. A distance between mirrors is one fourth of the ring circumference.

4 BEAM LINES

The ring has rooms for 4 beam lines from insertions and 9 beam lines from bending magnets (BM). Table 3 lists 8 beam lines scheduled to be constructed. Two beam lines will be constructed every year. In this first year, Japanese fiscal year 1997, the lines for EUVL and LIGA are under construction [7].

5 REFERENCES

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