PRESENT STATUS OF NEWSUBARU

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Abstract

Present status of the NewSUBARU storage ring is summarized. The machine performance is now in the better level than those of the designed. The efforts for this achievement will be described in another activity reports.

1 INTRODUCTION

NewSUBARU [1] is a 1.5 GeV synchrotron radiation ring at the SPring-8 site. Laboratory of Advanced Science and Technology for Industry (LASTI) at the Himeji Institute of Technology is in charge of its operation, collaborating with SPring-8. The main parameters of the storage ring are listed in Table 1.

The ring has two operation modes for users. In the 1.5 GeV mode, the beam is accelerated to 1.5 GeV and stored. The user time starts at the stored beam current of 300mA as shown in Fig.1. In another mode, 1.0 GeV top-up mode, the beam current is kept at 250$\pm$0.15 mA by an occasional injection as shown in Fig.2, with the gaps of undulators closed.

The design goal of the beam current and the beam lifetime were successfully achieved as shown in Table 1. The RMS of the closed orbit distortion (COD) can be adjusted to less than 6 μm in horizontal and 8 μm in vertical at both 1.0 GeV and 1.5 GeV.

Table 1: Main Parameters

Energy	0.5 ~ 1.5 GeV
Circumference	118.731 m
RF frequency	499.956 MHz
Natural emittance	38 nm @ 1 GeV
Filling pattern	Successive80+80 bunches
Maximum current	50 mA/bunch 500 mA /ring @ 1 GeV
Lifetime	14 hours @ 100 mA & 1.5 GeV
Tune ν_x / ν_y	6.30 / 2.23
Chromaticity ξ_x / ξ_y	3.2 / 5.8
Linear coupling constant	1 %
RMS -COD x / y	6 / 8 μm

2 EFFORTS FOR IMPROVEMENT

The beam physics and accelerator physic group paid many efforts day by day to improve the storage ring performance. Figure 3 shows the achieved maximum stored current and corresponding typical efforts. The followings are the main improvements and their results.

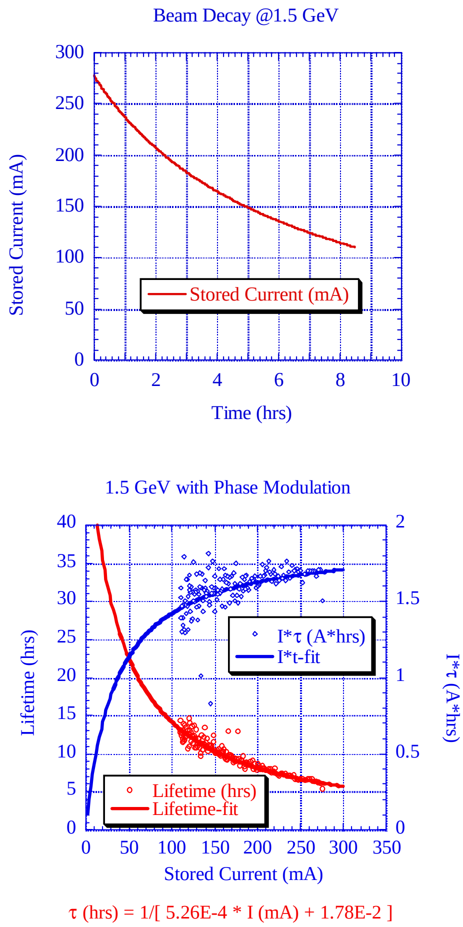

Figure 1: Stored beam current and and lifetime during the 1.5GeV user time.

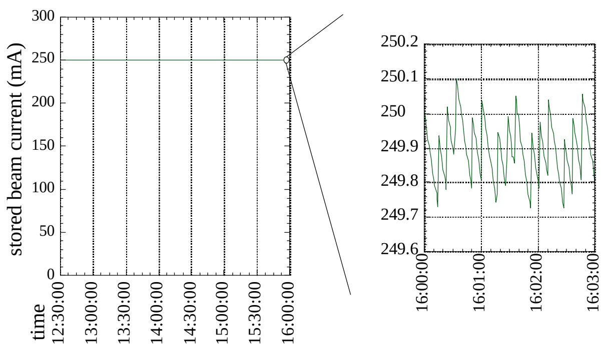

Figure 2: Stored beam current during the top-up operation at 1.0GeV.

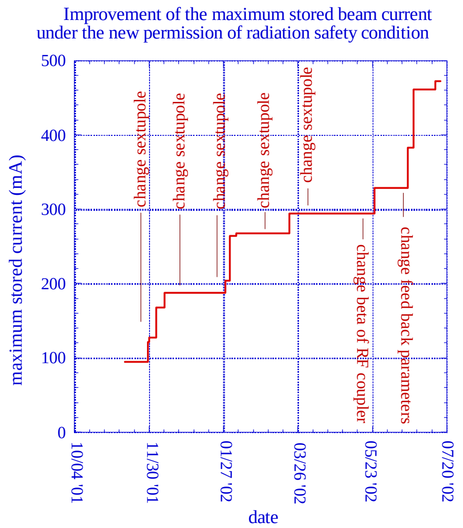

Figure 3: Maximum stored beam current and the typical events. The maximum current was limited to 500mA by a new radiation safety condition.

2.1 RF system

a) HOM (Higher Order Mode of cavity) suppression by temperature and detuning angle

The transverse HOM near 792 MHz excites the horizontal coupled bunch instability with the ordinal setting of sextupole magnets and limits the maximum stored current at ~ 80 mA. Also ~990 MHz HOM becomes very strong and causes abrupt beam loss when the RF voltage is ~ 300 kV before 1.5 GeV acceleration. The temperature of cooling water for cavity was carefully adjusted to avoid these HOM's. Now the operation frequency of the cavity is a little bit lowered by changing the detuning angle (-5 degree to - 20 degree) and almost HOM free operation is achieved.

b) Adjustment of the klystron power supply

The analogue signal for interlock of the klystron power supply was very noisy and fault turn off of the power supply occurred very often. No fault turn off is achieved after careful adjustments.

c) Double PLL feedback

The feedback circuits of amplitude stabilization both for the cavity and the klystron work very stably, in particular, at very high beam current (more than ~ 300 mA).

d) Optimise the input coupling constant to the cavity

The storage ring is now often operated at the stored current of ~ 300 mA. The initial coupling constant (β) was ~ 2.6 supposing the beam current of ~ 100 mA. This constant was changed to ~ 5.6 to realize more stable operation of the RF system for higher beam current.

e) Phase modulation in PLL feedback

The Touschek effect becomes not negligible at ~1 mA / bunch. The reduction of the line density is the key to enlarge the beam lifetime against this effect. The phase modulation in the phase lock loop is the most effective way for this purpose and results in the ~ 30 % increase of beam lifetime at 1 GeV.

f) Installation of new HOM tuner.

The fixed tuner was just replaced by a SPring-8 type movable tuner. Its commissioning will start this fall for more stable operation.

2.2 COD optimisation and Correction of Beta function

a) The aperture survey by steering magnets found a kind of the golden orbit and resulted in the ~ 40 % increase of beam lifetime.

b) The β_x and β_y correction by trim windings of quadrupole magnets

The careful analysis of the COD generated by a steering magnet and the insertion devices suggest the significant distortion of β_y caused by the systematic error in the one family of quadrupole magnet (QB). The correcting pole windings were added and then the beam lifetimes was increased by ~ 5 %.

2.3 Optimisation of correcting sextupoles magnets

The adjustment of chromaticity was very important and sensitive to keep higher current than ~ 300 mA. The harmonic sextupoles were also adjusted to avoid transverse instabilities. This adjust controls the amplitude dependent tune shifts. Both the optimisation of sextupole magnets and the HOM control are the key for the stable operation with high beam current.

2.4 Acceleration and Deceleration

A precise parameter search of tracking quadrupole magnets took place for the acceleration up to 1.5 GeV, and deceleration down to 0.5GeV. The ring is operated with 0.5GeV during the R&D of FEL. The upgrading of the horizontal steering system in the summer of 2002 enabled a COD control at 1.5GeV.

2.5 COD shift

The horizontal COD shift due to the temperature change of the cooling water was ~ 60 µm at the dispersive BPM (~ 50 mm/°C; Fig.4). The control parameters of the water cooling are optimised so as to the temperature change is less than ±0.1°C, then the horizontal COD shift is almost negligible in taking account of the accuracy as seen in Fig.3 The observed vertical COD shows typical behaviour due to random kicks as seen in the figure. This is understood at present by the reading errors or accuracy of the vertical position.

The high frequency components of the orbit oscillation were measured by spectrally analysing of the SR monitor (visible light of SR). There is no significant oscillation due to the ripples of the magnet power supplies (Fig.5).

The inverter system for the water cooling was installed in summer of 2003 for more stable operation.

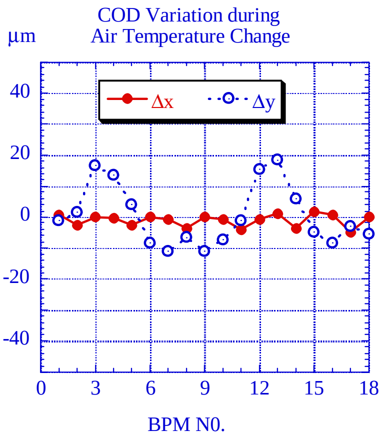

Figure 4: COD shift against room temperature.

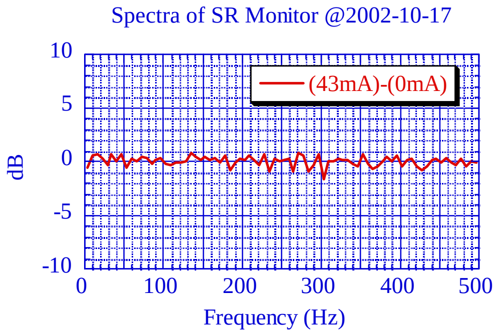

Figure 5: Spectral of SR Monitor.

2.6 Control system

a) Automatic COD correction

The COD are easily realize to keep 6~ 8 μm in rms just by one button operation. This is very useful for the user time to keep the SR axes stable.

b) Simultaneous observation of air and water temperature

The systematic analysis of the drifts in COD and SR axes became possible. The sign of the beam energy drift due to the air temperature change was observed even when there was no COD drift. The more accurate orbit control is going to be implanted.

c) Improvement of the database of the storage ring

The model machine in the database should be the same as the real storage ring. This is the key to realize a very small and/or negative α_p lattice to obtain a very short bunch. The database has been updated mainly by adjusting the effective lengths of magnets comparing measured Twiss parameters with calculated ones.

3 R&D

3.1 Very Short Bunch

Toward generating the coherent radiation in mm wavelength region, the very short bunch operation has been tested by reducing the momentum compaction factor. The preliminary result is shown in Fig.6. The bunch current is very weak and almost 1/10,000 of those of normal operation. Even the number electrons in a bunch is only 3×10^5, The strength of the coherent radiation is corresponds to those of incoherent one from 10^{11} electrons. The obtained rms bunch length is 1.7 psec and this is the world shortest bunch in a storage ring.

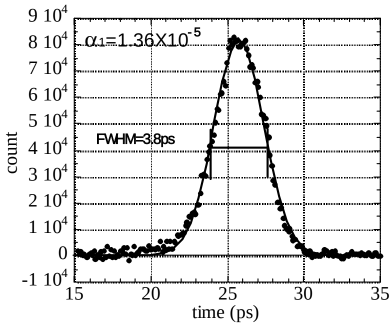

Figure 6: Preliminary result of short bunch.

3.2 Negative α_p

The operation of α_p = -1×10^{-3} has successfully performed with the injection efficiency of ~70 % (without beam centre correction in the beam transform line). The appearance of energy widening, bunch lengthening and head-tail instabilities are completely different from those at positive α_p. The quantitative research is possible only at NewSUBARU in the world and our analysis will contribute the development of beam physics.

4 ACKNOWLEDGEMENT

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5 REFERENCES

[1] A. Ando, et al., J. Synchrotron Rad. 5, 342-344 (19