NewSUBARU STORAGE RING : OPERATIONAL PROGRESS IN THESE THREE YEARS

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Abstract

The NewSUBARU has been in a phase of rapid development since 2001. We report some developments and improvements of storage ring performance at NewSUBARU in these three years. The vacuum system was upgraded and the averaged vacuum pressure for the same out-gassing was reduced. New operational parameters of an RF system enabled the accumulation of the beam to 500mA. Improvement of a water-cooling system of the facility contributed to the stability of the beam orbit. The timing synchronization between the injector linac and the storage ring made a beam injection more stable. By careful magnetic field adjustments, the 11 m long undulator emitted light with a designed spectral line width. At the present the ring is operated either at 1.0 GeV top-up mode, during which the stored beam current is typically kept at 250 $\pm$0.3mA, or at accelerated 1.5 GeV mode, during which the beam current decays from about 300 mA to about 100 mA.

INTRODUCTION

The 1.5 GeV electron storage ring NewSUBARU [1] has been constructed in the SPring-8 site in 1998. It shares the 1.0 GeV linac of SPring-8 [2] with the Synchrotron as an injector. The ring is a racetrack type with the circumference of 119 m and has two 14 m long (LSS) and four 4 m long (SSS) straight sections. In the long straight sections the 11 m long undulator (LU) and an optical klystron FEL (OK) have been installed. The main parameters of the ring are summarized in Table 1.

The ring has two operation modes for users. In 1.0 GeV user mode, a top-up injection started in June of 2003. The stored beam current is kept at 250$\pm$0.3mA by an occasional injection as shown in Fig. 1 (b) with the gaps of undulators closed. In 1.5 GeV mode, started in October of 2002, the beam is accelerated to 1.5 GeV and stored for user experiments. The user time starts with the stored beam current of 300 mA and ended at about 9 hours later with the stored beam current of about 100 mA.

After the beam commissioning the user experiments started in February 2000. Two of the main problems at that time were (1) a short lifetime because of the dynamic gas load due to the synchrotron-radiation–induced desorption (2) a reduction of the beam lifetime and the injection efficiency when the gap of LU was closed. Fig. 1 (a) shows the typical stored beam current in user time in April of 2001. The stored beam current was about 50mA at where the injected beam and the lost beam according to the lifetime were balanced. After three years, at the present, the stored beam current at the user time had been improved to that shown in Fig. 1 (b).

In the following sections we explain operational improvements to overcome many problems, including the above two, year by year.

Table 1: Main parameters of the NewSUBARU

Electron Energy	0.5 - 1.5 GeV
Injection Energy	1.0 GeV
Circumference	118.731 m
Type of Bending cell	modified DBA
Number of Bending Cell	6
RF Frequency	499.956 MHz
Harmonic Number	198
Maximum Stored Current	500 mA/ring
Betatron Tune ν_x / ν_y	6.30 / 2.23
Chromaticity ξ_x / ξ_y	3.2 / 5.8
Natural Emittance at 1 GeV	38 nm
Natural Energy Spread at 1 GeV	0.047%

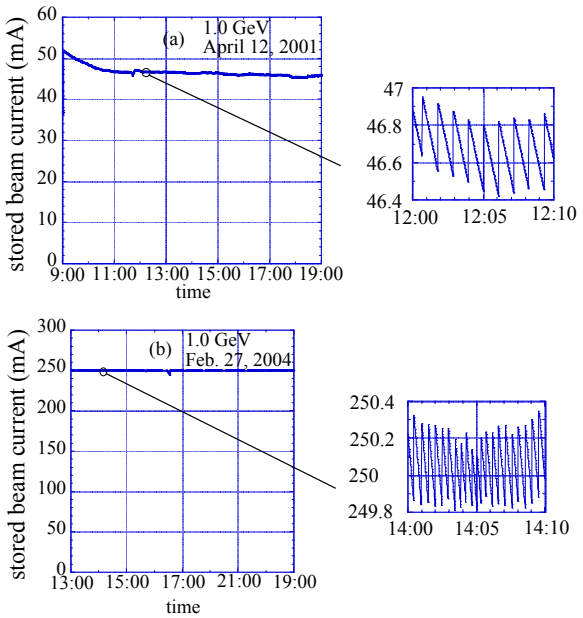

Figure 1: Stored beam current during the typical user time at 1.0 GeV, (a) in 2001 and (b) in 2004.

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IMPROVEMENTS IN 2001

Adjustment of Magnetic Field of LU

The magnetic field of LU was adjusted from April to September [3] using the bench at SPring-8. The main parameters of LU are listed in Table 2. The injection efficiency and the beam lifetime with the gap closed (35mm) had been about 60% of those with the gap opened (120mm). They were improved to about 80% after the adjustment [4]. We observed the undulator light (Fig. 2), which line width agreed with the calculation [5].

Table 2: Main parameters of the LU.

Type	planner, out of vacuum
Magnet	permanent Nd-Fe-B
Number of Periods	200
Period Length: λ_u	54mm
Total Length: L	10.8m
Gap	119-30mm
K	0.3 - 2.5

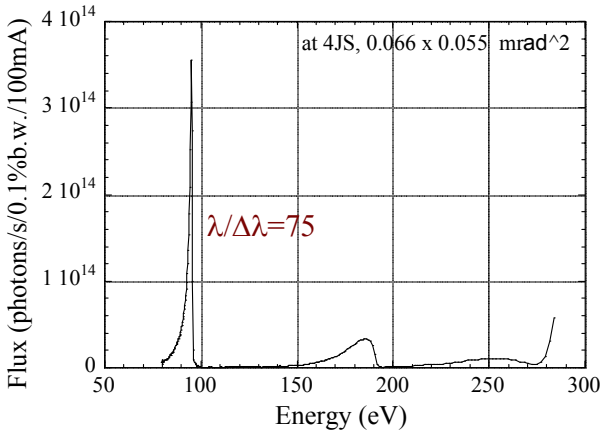

Figure 2: Photon spectrum of LU.

Upgrading of Vacuum System

In the summer of the same year the vacuum system was upgraded. It improved the beam lifetime by about a factor of two. The details are explained in the other contribution to this conference [6].

New Formal Approval of Radiation Safety

A formal approval of a new operation condition was given in November. It enabled an injection of 7.5 times more electrons and the beam storage of 500 mA (previously 100 mA). It pushed up the stored beam current at the user time and enabled a faster beam self-cleaning of the vacuum chambers [7]. The stored beam current at the user time reached to 100 mA in January of 2002 and to 250mA in June of 2002 (Fig. 3).

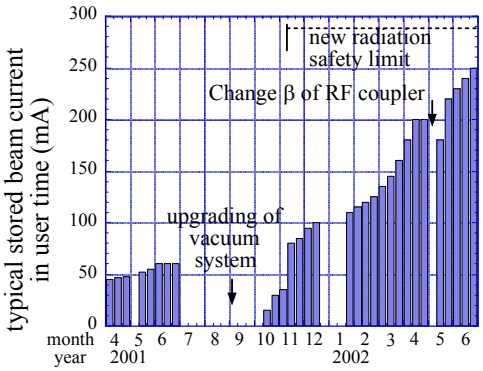

Figure 3: Increase of the typical stored beam current during the user time.

IMPROVEMENTS IN 2002

Optimisation for Large Vertical Acceptance

An optimisation of the beam orbit and a correction of the modulation of beta function maximized the vertical acceptance of the ring. The beam lifetime was improved by about 50% [8].

Before the optimisation, the radiation level at the 3rd bending section had been higher than the other sections. However the high radiation point disappeared after the optimisation.

Maximum Stored Beam Current

The maximum stored beam current was rapidly improved under the new radiation safety limit. The adjustment of the chromaticities pushed up the maximum to above 200 mA. The adjustments of harmonic sextupoles (two families set at the dispersion free straight sections), which controlled the amplitude dependent tune shifts, was also important.

With some changes of RF parameters, described in the other contribution to this conference [9], the maximum current reached to 500 mA in July. Fig. 4 shows the events for the improvements.

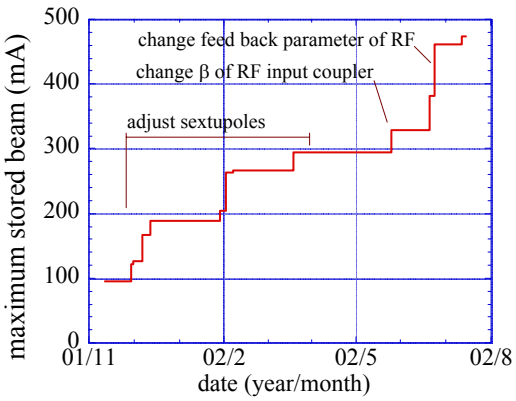

Figure 4: Improvement of the maximum stored beam current. The maximum current was limited to 500mA by the radiation safety condition at the presernt.

Acceleration to 1.5 GeV

A formal approval of acceleration of electron beam from 1GeV to 1.5GeV was given in July of 2001. In the summer of 2002 the horizontal steering system was upgraded so that to enable a correction of COD at the top energy. The user time at 1.5 GeV started in October of 2002. The RMS of the COD can be adjusted to less than 6 μm in horizontal and 8 μm in vertical direction.

IMPROVEMENTS IN 2003

HOM of RF cavity

A search of RF parameters to avoid instabilities of HOM made the beam more stable. In April we could stably accelerate the high current (370mA) beam to 1.5 GeV as is shown in Fig.5 [9].

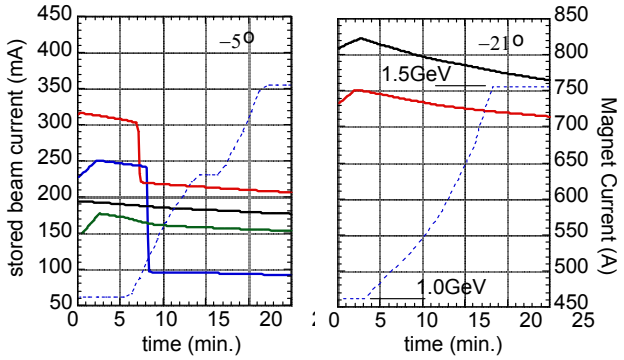

Figure 5: The stored beam current with the tuning angle of -5° (left plot) and -21° (right plot). The broken lines are current of bending magnet (right axis). The solid lines are examples of stored beam current (left axis) during the acceleration. The beam had been lost by the horizontal TM110 HOM.

Stabilization of Water Temperature

In 2001, feedback parameters of the water temperature control of the facility had been optimised. It improved the temperature fluctuation from ±1.5 degrees to ±0.5 degrees. The fluctuation of the horizontal beam position at the dispersive section was improved as is shown in Fig. 6.

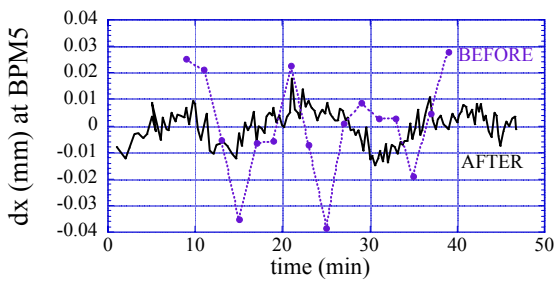

Figure 6: Improvement of the drift of the horizontal beam position by the stabilization of the cooling water temperature from ±1.5 degrees to ±0.5 degrees. The BPM15 is one of beam position monitors set at the dispersive sections.

In 2003, the cooling water system of the facility was replaced by the one with an inverter. It reduced the fluctuation down to ±0.1 degrees and we could hardly observe a shift of beam position due to the fluctuation of the water temperature.

We observe a similar orbit shift by a fluctuation of air temperature in the machine tunnel. We can turn off the cooling fans to stop the rapid fluctuation of the air temperature.

RF Synchronized Injection

The new COD correction program was developed. It stabilized the RF frequency of the ring against the hidden COD [10]. This enabled the RF synchronized buckets to bucket injection from the linac to NewSUBARU [11]. The synchronized injection has been used since September of 2003. It realized a stable injection.

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