Commissioning of NewSUBARU

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1 ABSTRUCT

The commissioning of NewSUBARU started in October, 1998. The exhaustive effort to store a beam in three months made clear that the aperture of the vacuum chamber should be terribly small. In the New Year shutdown, we found that all the RF contact fingers in eight bellows beside insertion devices closed almost completley the aperture. After fixing these fingers or replacing by temporal Cu plates just to prevent electric discharge in bellows, the commissioning restarted in February and an electron beam was easily stored without correction. The ring is now in operation for vacuum baking by synchrotron radiation at 1 GeV.

2 STORAGE RING

NewSUBARU [1] is the facility of a 1.5 GeV electron storage ring for the light source in the region of VUV and soft X-ray which is located at the SPring-8 site. The project team for NewSUBARU between Himeji Institute of Technology (HIT) and SPring-8 has been organized to establish the SR research complex in SPring-8.

The storage ring has six inverse bending magnets and two very long straight sections (LSS,14 m each), compared with its small circumference ($\sim$119 m). Two LSS's are initially used for a 11-m long undulator and an optical klystron(FEL), and two short straight sections (4m each) for 2.3-m undulators. The natural emittance is 67 nm at 1.5 GeV because the total number of main dipole magnets is 12.

Considering complementarity to SPring-8 : the most brilliant light source in the world, NewSUBARU aims to produce short pulses of radiation.

The ring is now operated in positive α_p mode given in Table1 and Fig.1 for easier commissioning because of small β_x and dispersion. Sextupole magnets are not excited to avoid the difficult problems of dynamic aperture.

Table 1: Present parameters of NewSUBARU storage ring

Energy	1	GeV
Circumference L	118.731	m
Revolution frequency	2.525	MHz
Harmonic number	198	
RF frequency	499.951	MHz
Betatron tunes	6.27/2.24	
α_p	0.0012	
Straight sections	4m	$\times$4
	14m	$\times$2

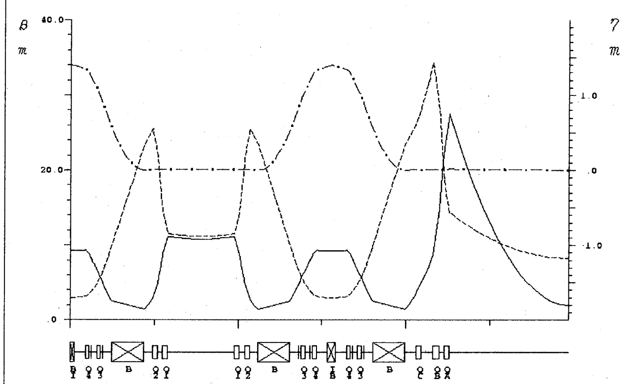

Figure 1: Twiss parameters of the quadrant for $\alpha_p \simeq 0.001$. Solid:β_x, broken:β_y, dotted:dispersion

3 PRESENT PERFORMANCE

3.1 Tune Measurement

The RF knockout system by four strip lines (length is 20cm and the maximum power is 10 W in each) is used to excite coherent betatron oscillations. The fractional parts of tunes are calculated from the sidebands of harmonics of the revolution frequency. The signal of a clearing elctrode is fed to the real time spectral analyzer (SONY Tektronix 3056). The resonances are also sometimes defined as the center of two frequencies where the blow-up of the spot size on the TV monitor of SR starts and ends. Obtained tunes are $\nu_x = 6.274$, $\nu_y = 2.230$. Simultaneously no significant linear coupling is observed.

The horizontal tune spread and energy spread are estimated as $\Delta\nu_x \simeq 0.02$, $\Delta E/E \simeq \pm 10^{-3}$ from the damping time of the coherent betatron oscillation at injection assuming the chromaticity is about -10. These are consistent with the width of the energy slit in the beam transport line.

3.2 BPM

The beam positions are measured at 18 BPM's in two mode, cod-mode and single-pass-mode. In the single-pass-mode, signals of each electrode are measured by digital oscilloscopes (8 bits, sampling rate : 4 and 5 G/s) through 0.1 pF capacitor and amplifier. The average positions of about ten turns of one turn trajectory of the stored beam in single-pass-mode consist with the values of the cod-mode within 0.5 mm. The correction by steering magnets are done by

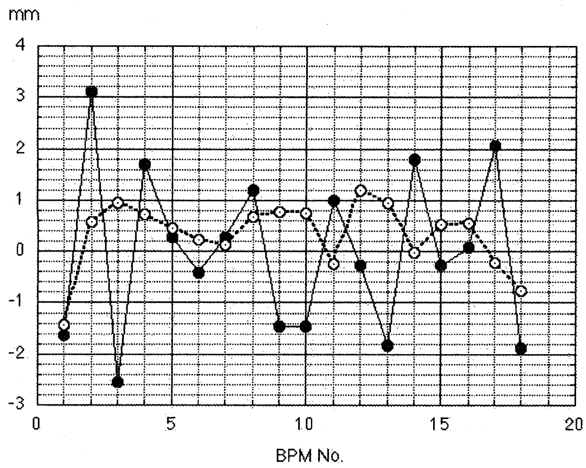

Figure 2: Closed orbit ; closed:horizontal, open:vertical

local bump, singular value decomposition or best correctors(MICAD) methods to obtain better efficiency of injection and longer beam life. The preliminary results are shown in Fig.2.

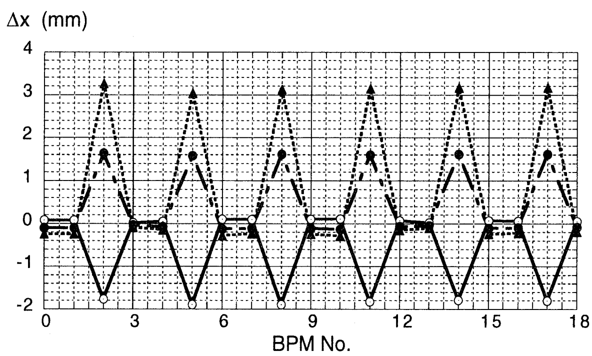

Figure 3: Horizontal orbit shift due to Δf_{RF}, open : +1kHz, closed : -1kHz, triangle : -2kHz

3.3 α_p and Dispersion

Changing the RF frequency by $\pm$1kHz, the achromaticity in straight sections are confirmed as shown in Fig.3. BPM No. 2, 5, 8, 11, 14 and 15 are located at dispersive points downstream of inverse bending magnets. The observed change of the vertical cod is less than 0.1 mm. Synchrotron oscillation is always observed as the side bands of BPM signals. The main source of this oscillation is understood as phase noise due to chopper in the high voltage of klystron. This gives ν_s=0.0014. The RF voltage is monitored as 90 kV, but there exists some ambiguity. Then α_p is estimated as,

$$\begin{aligned} \alpha_p &= 0.00077 \quad (V_{RF} = 90kV) \\ &\sim 0.0013 \quad (V_{RF} = 60kV). \end{aligned}$$

Assuming $\alpha_p = 0.0012$, the average dispersion is estimated as 0.9 m at the BPM's mentioned above (design value : 1.3 m) from Fig.3. This estimation is very rough because the relation between $\Delta f_{RF}/f_{RF}$ and $\Delta E/E$ is not linear due to higher order terms in α_p. Synchrotron oscillation is stable in the region of $\Delta f_{RF} \simeq$ -9 to +3 kHz, which is consistent with the estimation using higher order $\alpha_p' s$ calculated by SYNCH.

3.4 Beam Intensity

The beam life time and vacuum pressure increase are summarized in Fig.4 and 5. If the beam loss is dominated by Rutherford scattering, we have the following equation, $P * \tau = (2.0 \sim 2.7) \times 10^{-3} (Pa * sec)$. The base pressure without beam is almost $10^{-9} Pa$. From these the average pressure on the beam orbit would be 10 times larger than the reading value of ccg's and the curves in Fig.4 and 5 nearly lie on the theoretical ones.

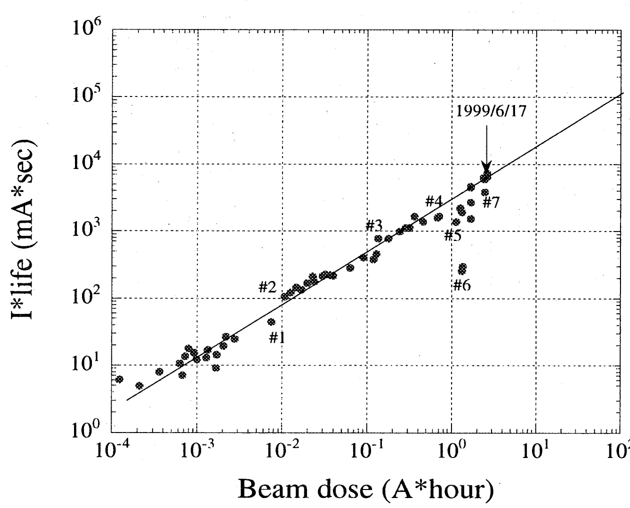

Figure 4: Beam life v.s. current dose

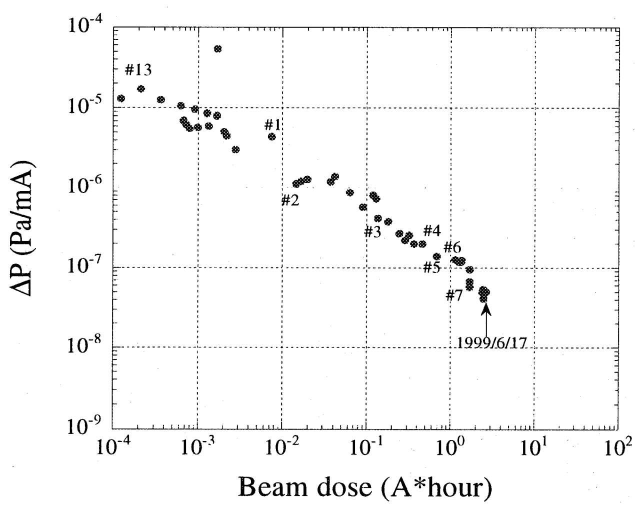

Figure 5: Increase of vacuum pressure v.s. current dose

The beam from the LINAC of SPring-8 is injected by up tol Hz and the maximum peak current of the stored beam reaches at 23 mA in either single bunch or multibunch operation and the net capture efficiency is estimated about 70 %.

3.5 Long Undulator

The effects of the 10.8-m long undulator (the longest ID in the world) given in Table 2 were roughly surveyed before this summer shutdown. In the normal operation, the gap is opened at 120 mm and the magnetic field is shielded by Fe plates. Injection and accumulation was tested at the gap of 35 mm. The net injection efficiency and the beam life were reduced to 1/30 and 1/3 of the normal values. Tunes were roughly corrected by the quardrupole magnet Q1 located at the both sides of short straight sections to avoid the linear coupling. The perturbation at K=2.5 is calculated by SYNCH, where one period is approximated as the combination of drift spaces and hard edge magnets, each length is a quadrant of one period. From this calculation, the vertical tune shift is estimated as 0.078 and β_y at the entrance/exit of bending magnets (full gap : 20 mm) and at Q1s (full gap : 28 mm) are expected to change to 28 m from 23 m and to 31 m from 20 m at K=1.4 (35-mm gap), repectively. The observed tune shift is calculated as 0.062 taking into account of Q1 correction. There is no significant changes in the horizontal betatron oscillation as expected, but when the RF shaker is turned on, there can be seen small coupling, i.e., this tune correction is not enough.

Table 2: Parameters of Long Undulator

Period	54	mm
No. of periods	200	
Total length	10.8	m
Minimum gap	25	mm
K-value	2.5	
Field strength	0.49	T
Wave length @1GeV	29	nm

4 IMPROVEMENT

In this summer shutdown the vacuum system has been improved as follows.

(1) NEG pumps are added at every TSP where absorbers exist.

(2) ID vacuum system is completely changed. Beam ducts of rectangular cross section are replaced by those with anti-chambers of 160 ϕ. SIP's of 400 l/sec and NEG's of 200 l/sec are installed altenately at almost every 1 m.

From this improvement, the average vacuum is expected to be less than 1/5 of the present value.

5 ACKNOWLEDGEMENT

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6 REFERENCES

[1] A. Ando *et al.*, " VUV and Soft X-ray Light Source New-SUBARU ", Proc. 1997 PAC (757.PDF), " Isochronous storage ring of the NewSUBARU project", J. Synchrotron Rad. (1988). **5**. 342, " NewSUBARU and Other Light Source Projects in Japan ", APAC98 (645)