PRESENT STATUS OF A COMPACT ELECTRON STORAGE RING NIJI-IV FOR UV FEL EXPERIMENT

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ABSTRACT

A compact electron storage ring NIJI-IV for UV FEL experiment has been constructed in December 1990 at ETL in Tsukuba. NIJI-IV has the triple bend achromatic lattice. The circumference is 29.6m which has two long straight sections with a length of 7.25m where the dispersion is free. A insertion device with a length of 6.3m can be installed in this section. The electron beam is supplied by the linac TELL with an injection energy of about 300MeV. The first storage of electrons has been achieved in February 1991. At the present a stored beam current is higher than 70mA.

INTRODUCTION

The free electron laser(FEL) is expected as a high quality and wide tunability light source for many fields such as nuclear fusion, medical, photochemistry and so on. The first FEL oscilation by using storage has been achieved in the visible wavelength range (650nm) using ACO storage ring at Orsay, France in 1988.[1] In the UV range (240nm) using VEPP-III storage ring at Novosibrisk ,USSR in 1988[2] and in the visible range (630nm) using Super-ACO storage ring at Orsay in 1989.[3] At Electrotechnical Laboratory (ETL) in Japan it has been accomplished in the visible range(598nm) using TERAS storage ring in 1991.[4] A compact electron storage ring NIJI-IV for the UV FEL experiment has been constructed in the ETL linac facility in December 1990.[5] The schematic diagram of NIJI-IV is shown in Figure 1. The proposal and the design works of NIJI-IV have reported.[6][7] Table 1 shows fundamental parameters of NIJI- IV. The features of NIJI-IV are low emittance and small energy spread and having 7.25m long straight section where the dispersion can be free. A 6.3m transverse optical klystron(TOK) is going to be installed.[8]

In this paper, the betatron tunes which the electrons can be stored and the beam lifetime of NIJI-IV are described.

Table 1 Fundamental parameters of NIJI-IV

Beam Energy	300 MeV (Max.500 MeV)
Circumference	29.6 m
Lattice Type	Triple Bend Achromat
Periodicity	2
L_s/C_r	0.245
Bending Angle	60°
Bending Radius	1.2 m
Max. Bending Field	1.4 T
Field Index	0
Edge Angle	16.1°
Harmonic Number	16
Radio Frequency	162.1 MHz
Max. RF Power	2.5 kW

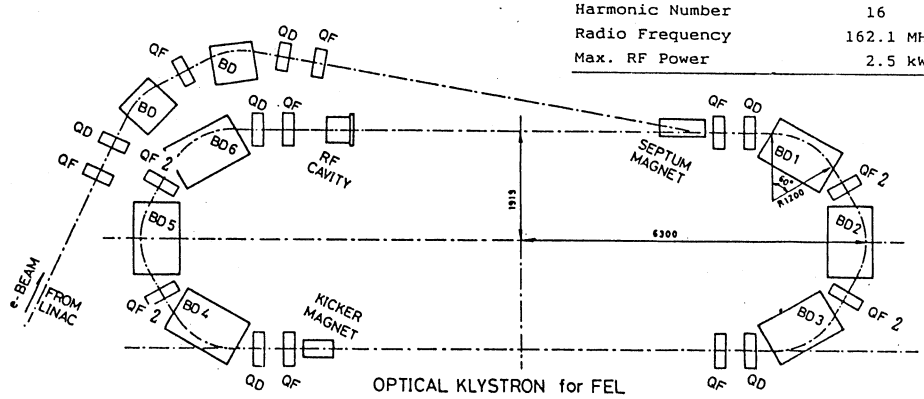


Fig.1 The schematic diagram of NIJI-IV

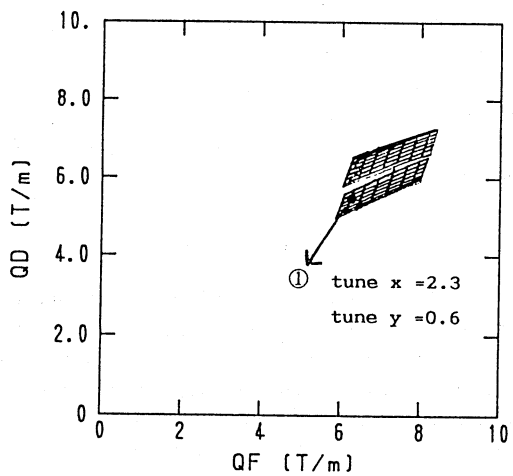
INJECTION AND STORAGE

NIJI-IV has one septum magnet and one kicker magnet for the injection and storage of the electron beam. The kicker magnet is located at the opposite position to the septum magnet as shown in the Fig.1. The bump orbit is generated in the whole ring. In order to survy the injection characteristic the orbit of the electron injected through about 10 turns must be checked up.

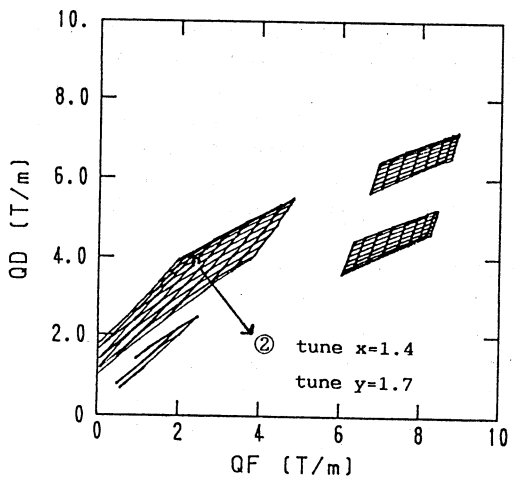
Example of the necktie diagrams are shown in Figures 2(a), (b) and (c). In this experiment the betatron tunes as ①, ② and ③ were chosen. The stored beam current of 70mA is obtained at tune ③ as shown in Fig.2(c).

Figure 3 shows a time evolution of the beam current during the injection and storage at the electron energy of 300MeV. It is possible to accumulate up to 50mA within 20 minutes. For example the beam lifetime is discussed at tune ③.

a) QF2=9.7T/m The dispersion is free.



b) QF2=5.0T/m



c) QF2=2.5T/m

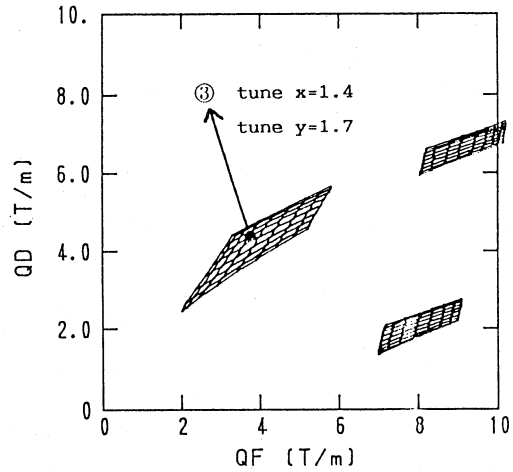


Fig.2 The necktie diagram for 3 types of NIJI-IV (At the beam energy 500MeV)

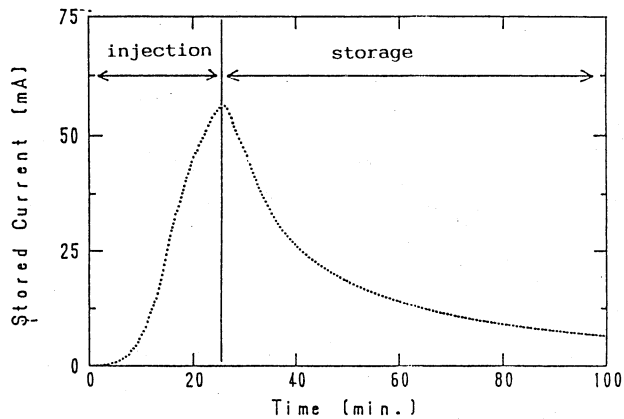


Fig.3 Time evolution of the beam current

BEAM LIFETIME

The lifetime of the electron beam stored in a storage ring depends mainly on scattering by gas molecules and electron-electron scattering in the bunches called "Touschek effect" at energy lower than 1GeV. The decay rate of the stored beam is written as

$$-dI/dt = \alpha I^2 + \beta I + f(I), \qquad (1)$$

where αI^2 is due to the pressure increased by the gas desorption from the chamber being proportional to the stored current I, βI due to the residual gas pressure and f(I) due to Touschek effect .[9] The lifetime of NIJI-IV was estimated by measuring the stored current and the pressure. The stored current and the pressure are measured by DCCT and the ionization gauge respectively. A personal computer PC9801 is used for the record of thease data, the

sampling time is five seconds. The Figure 4 shows the relations between the stored current and the pressure at 300MeV. It is shown that the pressure is proportional to the stored beam current and the pressure rising rate decreases. Figure 5 shows that $|dI/dt|/I$ is also proportional to the stored current and α in the equation (1) decreases. We consider that the decrease of slope in Fig.5 does not depend on Tauschek effect. Because the operating tune, the stored energy and RF power supplied in the ring are the same in these experiments. The lifetime increases due to decrease in the gas desorption caused by synchrotron radiation. The beam decay rate due to Tauschek effect is much smaller than one due to scattering by gas morlecules. Figure 6 shows decrease in pressure rising rate due to increase in the dose (the time integration of the stored beam current).

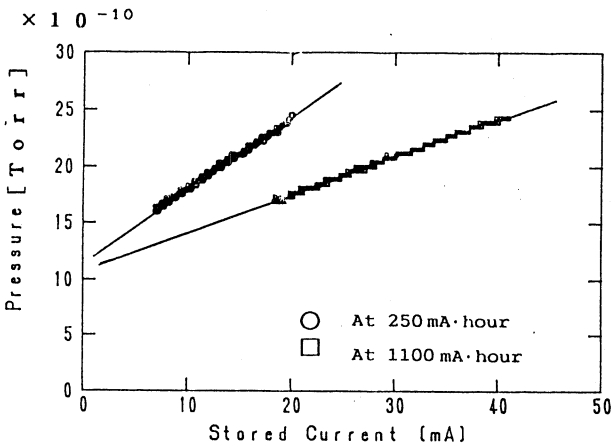


Fig.4 Variation of the pressure whith the beam current

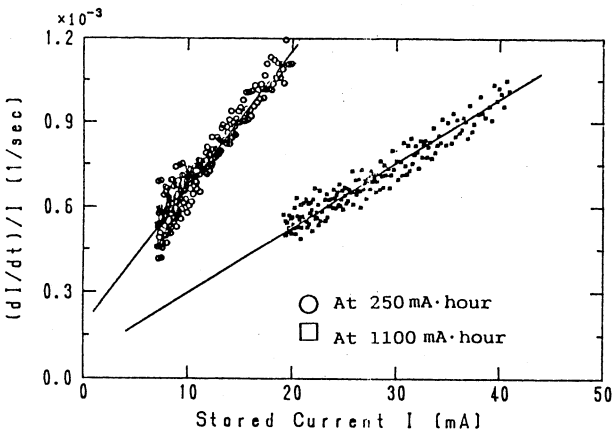


Fig.5 Variation of $|dI/dt|/I$ with the beam current

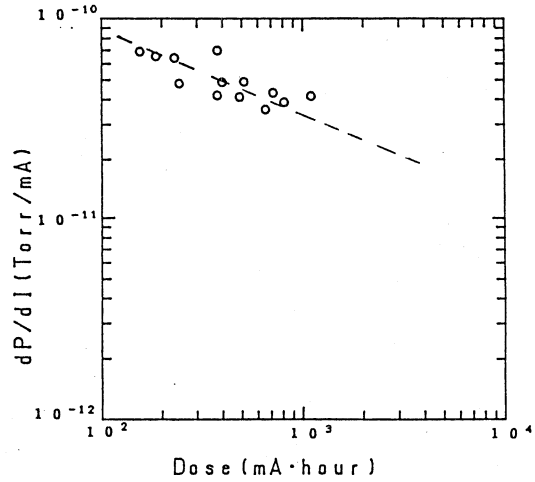


Fig.6 Decrease in the pressure rising rate dp/dI due to increase in the dose

CONCLUSION

A compact electron storage ring NIJI-IV for UV experiment has been constructed in December 1990. The tunes which the electrons can be stored and the beam lifetime are described. The stored current of 70mA is obtained. The lifetime is mainly determined by the scattering whith gas molecules. We expect that the stored current improve by the closed orbit distortion correction.

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