PRESENT STATUS OF JSR

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ABSTRACT

JSR has been in operation since April 1989. Some quantities were measured at 135MeV that was an injection beam energy. A beam current is accumulated up to 5.6mA. A beam lifetime is observed to be ~30min at 300MeV, which is mainly determined by a collision with residual gas and slightly depends on the beam current. Tunes and natural chromaticities were measured as ν_x=2.23, ν_y=0.84 and ξ_x=-1.82, ξ_y=-1.28. The tunes agree with ones calculated by SYNCH code.

INTRODUCTION

JSR is an electron acceleration/ storage ring which is located in the linac building as shown in Fig.1. Principle parameters of the linac and JSR are given in Table 1. JSR takes the Chasman-Green lattice with a superperiodicity of three. There are long straight sections of ~1.5m even in the small ring (see Fig.2). Each cell is composed of two bending, a single quadrupole and two pairs of doublet quadrupole magnets. A dispersion function is variable by changing the single quadrupole magnet. It is possible not only to suppress the dispersion but also to leave it on the long straight section. The tunes can be selected by changing the field strength of doublet quadrupole magnets. The linac beam energy is available from several 10MeV to 150MeV. The injection energy is chosen at 135MeV because the linac is able to supply a high intensity beam at this energy. After the electrons are accumulated sufficiently in the ring the beam energy is increased up to 300MeV.

The linac was used for several experiments beside JSR. The machine-time for JSR is dedicated only one or two weeks a month. The experiment is performed in daytime.

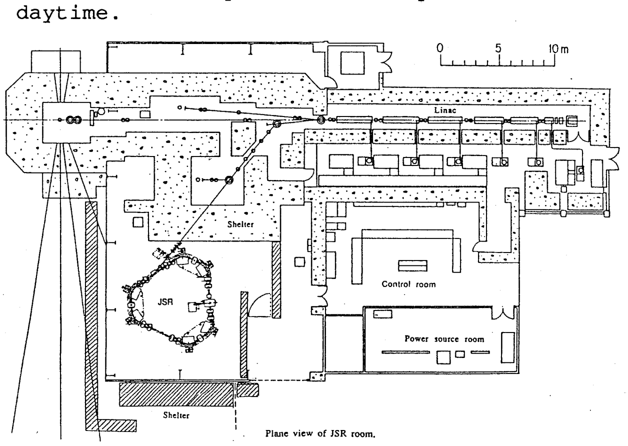

Fig.1 Plane view of linac building

Table 1 Principle parameters of Linac and JSR.

Linac			
Energy		135MeV	150MeV
Repetition rate		0.5Hz	1Hz
Peak current		~80mA	~1mA
Pulse width		1μsec	
JSR			
Stored energy		300MeV	
Injection energy		150MeV or less	
Circumference		20.546m	
Bending radius		0.835m	
Tune	x	2.23	
	y	0.83	
Energy loss		0.86keV/turn at 300MeV	
RF frequency		116.7MHz	
Peak RF voltage		30kV	

The description of design, construction and performance of components, for example magnets or rf cavity, are given in the previous papers [1)2)3)4)].

EXPERIMENTAL SET UP

The actual operating point of the betatron tune is chosen around ν_x=2.23 and ν_y=0.83. The betatron functions and dispersion function is shown in Fig.3.

The beam current stored in JSR is measured by DCCT(D.C. Current Transformer). The tunes are measured by RF-KO(Radio Frequency Knock Out electrode) and the CCD camera which observes the synchrotron

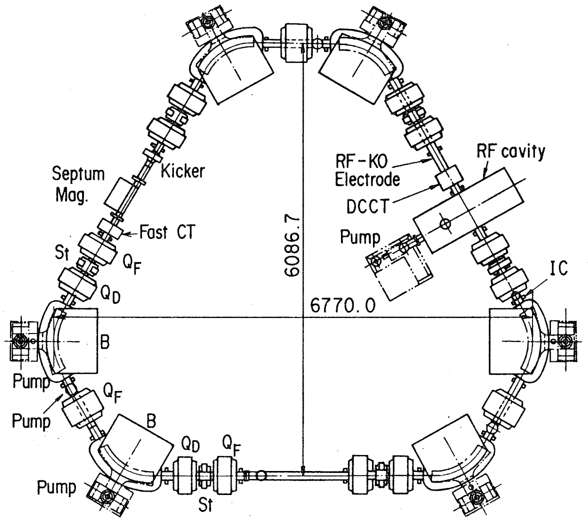

Fig.2 Plane view of JSR

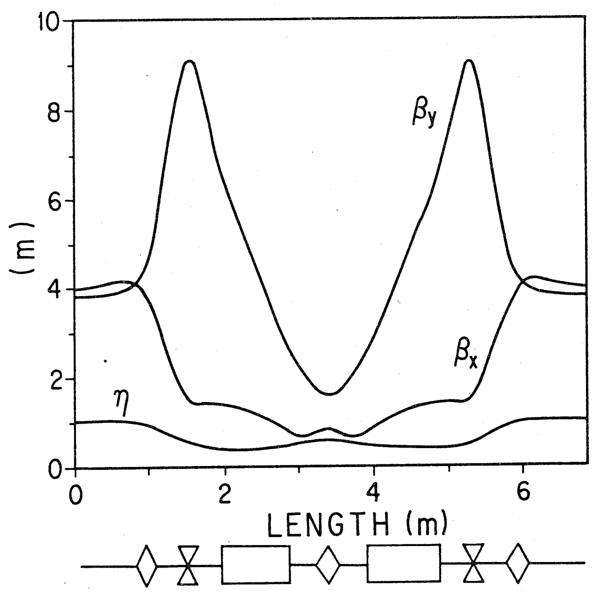

Fig.3 Betatron and dispersion functions

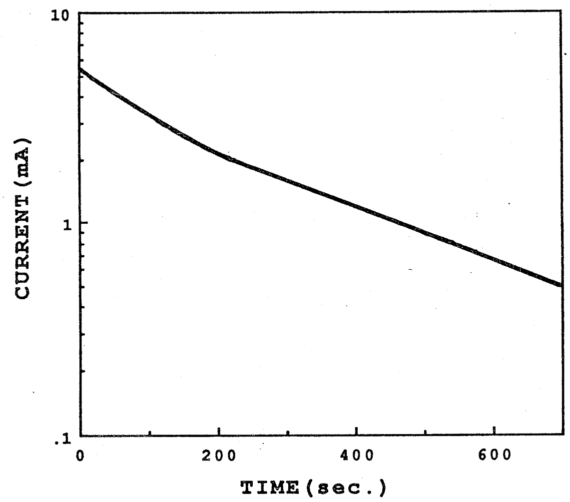

Fig.4 Time evolution of beam current at 135MeV

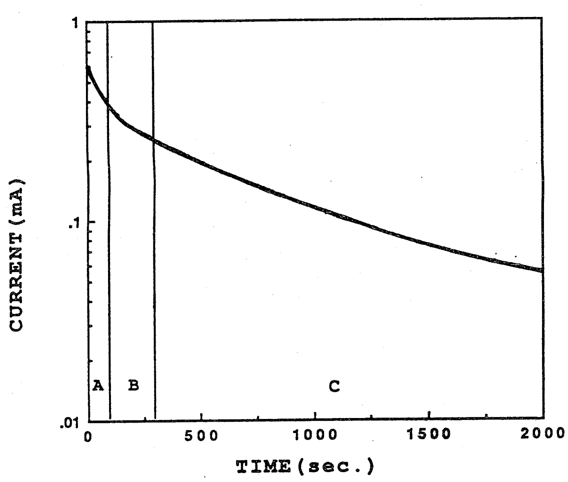

Fig.5 Time evolution of beam current
Beam energy is increased up to 300MeV.

radiation light. RF-KO gives a periodic perturbation either horizontally or vertically to the beam. The resonance will occurs if the frequency of RF-KO f_{KO} follows $f_{KO}=(m\pm\nu)f_{rev}$ where m is some integer. Here is taken m=-2 for ν_x and m=1 for ν_y. f_{rev} is the revolution frequency. The magnitude of resonance is observed as an increase of transverse beam width on the TV monitor.

The chromaticity is measured by the conventional method like that the rf frequency f_{rf} is changed to measure the tune shifts $\Delta\nu$. The relation is $\Delta\nu=-\xi df_{rf}/f_{rf}\alpha$. α is a momentum compaction factor calculated as α=0.12 by SYNCH.

The acceleration of the stored electron is slowly carried out with a time period of 5 min, because all magnet are made of iron block type. The characteristics of the eddy current are different in the bending magnets and quadrupole magnets. After the characteristics are well studied, it is able to reduce the time for ramping.

EXPERIMENT

Fig.4 shows a time evolution of the beam current just after stopping injection. Here the beam energy is 135MeV. The decay rate of the beam current is slightly depending on the beam current. Below 2mA the lifetime becomes constant and it is 8min. This value is deduced to be explained by the collision with residual gas. At a better vacuum condition, the lifetime becomes longer around 10min. Fig.5 also shows the time evolution of the beam current at three different mode; storage at 135MeV denoted A, acceleration denoted B and storage at 300MeV denoted C. The lifetime at 300MeV is observed to be ~20min. In a better vacuum condition the lifetime is obtained to be ~30 min.

In order to evaluate the lifetime of beam current two effects are considered. One is the Touschek effect. The Touschek lifetime τ_T is calculated at 135MeV by ZAP. They are τ_T=900sec without the effect of the intra-beam scattering and $\tau_T=1.1\times10^4$ sec with this effect. It is reported[5] that the effect of the intra-beam scattering appears especially in the low energy and low natural emittance ring. The Touschek lifetime is supposed to be longer than 900sec. Other is the photodesorption effect. A vacuum chamber is not sufficiently aged by synchrotron radiations. The photodesorption effect may affect the beam lifetime especially at 300MeV. To study these phenomena, further experiment and analysis are necessary. It is especially important to measure the beam size, bunch length, momentum spread, betatron function, and vacuum pressure at different conditions.

The synchro-betatron resonance is observed horizontally and vertically. Fig.6 shows the normalized beam width when the resonance tune is changed. The tune with the maximum width is regarded as the betatron tune. The interval between the resonances are measured to be $\sim 1.0 \times 10^{-3}$ and the synchrotron tune is calculated as 0.996×10^{-3}. The satellite resonance appears away the betatron tune by $m\nu_s$, where m is an integer. If there is the instability due to the ion trapping or other effects, the tunes of satellite resonance shift toward the betatron tune. It is thought any instability is not observed in this experiment with the current of ~0.3mA.

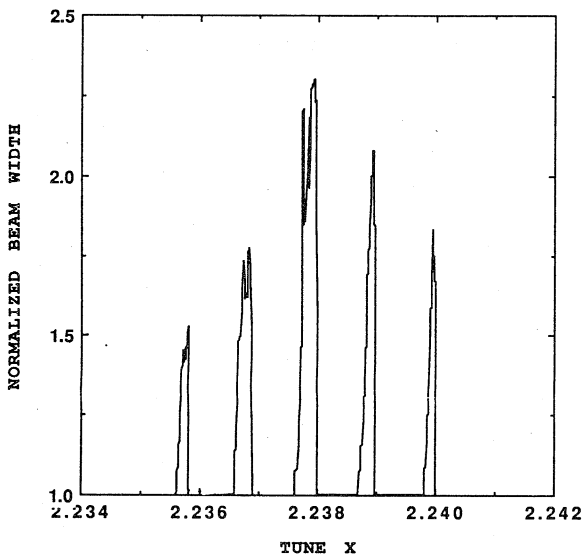

Fig.6 Synchro-betatron resonance

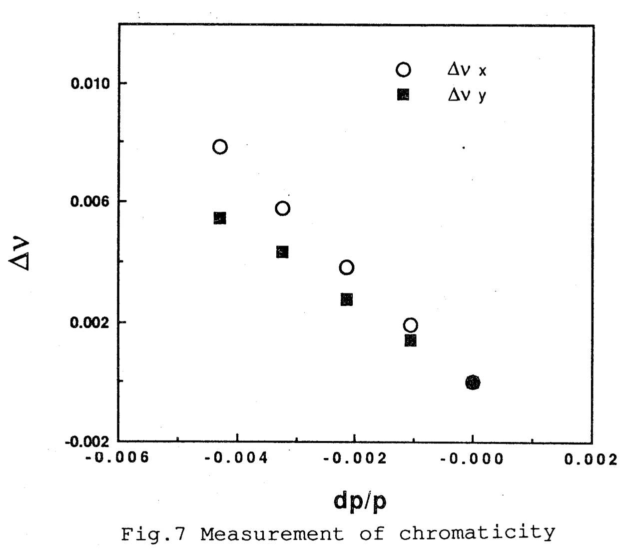

Fig.7 Measurement of chromaticity

Fig.7 shows the tune shift $\Delta\nu$ when momentum is changed by scanning the rf frequency. Then the chromaticities are measured $\xi_x=-1.82$ and $\xi_y=-1.28$. The chromaticities calculated by SYNCH are $\xi_x=-1.42$ and $\xi_y=-2.20$. It is reported that the value of chromaticity does not agree with one calculated by SYNCH in the case of a small ring[7]. It is needed to calculate by anther code or method. While the tunes at dp/p=0 are $\nu_x=2.23$ and $\nu_y=0.84$. They reasonably agree with expected value calculated by SYNCH; $\nu_x=2.26$ and $\nu_y=0.86$. This means all the magnetic components work correctly as they are designed.

CONCLUSION

Through the experiments with low current JSR and its components are proved to work correctly. Here is described the experiments at the typical operating point; $\nu_x=2.23$, $\nu_y=0.83$ and the dispersion remains on the long straight section. Other operating point was surveyed for example with double achromatic.

The lifetime of the beam current is observed to be ~10min and ~30min at the energy of 135MeV, 300MeV respectively. The lifetime seems to be mainly determined by the vacuum condition, and slightly depends on the beam current above 2mA.

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