RF PHASE SHAKE AND RF VOLTAGE MODULATION AT PHASE TRANSITION

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1. Introduction

The KEK 12 GeV Main Ring synchrotron has long suffered from obstinate beam loss at the transition energy. In the early operations, beam loss appeared even when the beam intensity was far below 1×10^{12} ppp. The loss at such low intensity has been almost eliminated by the improvements of beam feedback circuits. However, as the beam intensity goes up above 1×10^{12} ppp the transition beam loss has again become noticeable. Since this beam loss increases with the beam intensity, we can well assume the excitation of some kind of instability, which has the threshold local beam current density as given by the impedance criterion.

We can expect the suppression of instabilities by lowering the local beam current density even when we have not found and removed the cause of instabilities. Therefore, an artificial emittance blow-up of beam bunch is well worth considering. At the same time, longitudinal beam dilution which does not involve emittance growth has also the possibility of instability suppression. With these anticipations in mind, two RF manipulations have been tested for the Main Ring transition crossing.

2. Phase Shake

Sinusoidal phase modulation of RF voltage (phase shake) has been tested with the scheme shown in Fig. 1 for the possible emittance blow-up. When the phase shake voltage is applied on the phase shifter (PS-A), characteristic responce appears in the radial position signal (dr). Typical responces are observed in the following conditions; (1) $f_m \ll f_s$, (2) $f_m \simeq f_s$, $2f_s$ and (3) $f_m \gg f_s$, where f_m is the frequency of the phase shake and f_s is the synchrotron frequency.

In the third case ($f_m \gg f_s$), the position feedback cannot follow the phase shake and we can realize random voltage kick in each revolution. We have observed negative (inward) shift of the radial position during the shaking operation. We have found the decrease of transition beam loss when the phase shake is turned on several tens of millisecond before the transition and turned off just at the transition. Fig. 2 shows the effect of the phase shake. The increase of beam pulse width has been observed during the shaking as was expected. However, this pulse broadening has not come from emittance blow-up because the beam shape becomes sharp again at the end of shaking. Therefore, phase shake produces only longitudinal dilution by the effective voltage reduction which is indicated by the negative radial position shift.

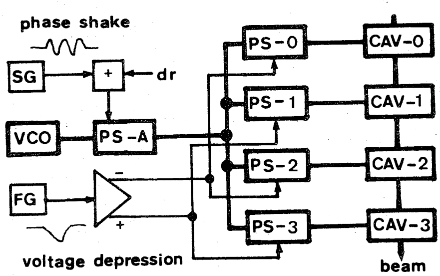
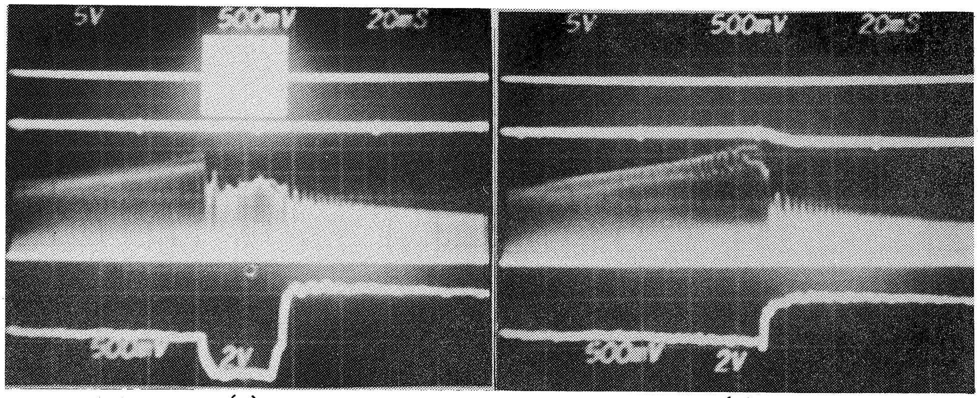


Fig. 1 Scheme of two RF manipulations at the transition



(a) (b)

Fig. 2 Performance of phase shake at two-bunch operation, (a) with phase shake and (b) without phase shake. Traces are: 1. Phase shake voltage, 2. Beam current, 3. Bunch signal, 4. Radial position signal

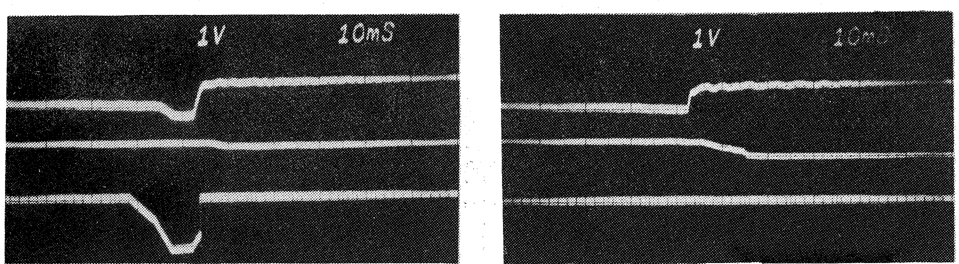
3. <u>Voltage Depression</u>

Longitudinal bunch dilution can be also made by the amplitude modulation of the accelerating RF voltage. Counterphasing method of Fig. 1 has been adopted to get effective voltage reduction. After a number of trials, several adequate patterns of phasing function have been obtained. An example is shown in Fig. 3. The effect is similar to that by the phase shake.

4. <u>Discussions</u>

In the present machine operation, nine bunches of the Main Ring reach the transition with different emittances. Therefore, the longitudinal dilution processes are affected in the multibunch operation mode in the following way; the best dilution operation for the smallest emittance bunch will drive some part of the other larger emittance bunches out of RF bucket; on the other hand, the best dilution for the largest emittance bunch will not have sufficient effect on the smaller emittance bunches.

Contradictory situation occurs in the overall Main Ring operation; when the beam loss is saved at the transition by the longitudinal dilution, beam loss increases at the final slow extraction process. Several solutions are conceivable to accommodate these problems.



(a) (b)

Fig. 3 Performance of voltage modulation at nine-bunch operation, (a) with counterphasing and (b) without counterphasing. Traces are: 1. Radial position, 2. Beam current, 3. Phasing voltage