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BUNCH SEPARATION IN A DAMPING RING

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ABSTRACT

A method of RF manipulation is described by which a bunch may be separated longitudinally from the other bunches before being ejected. This allows the use of a higher bunch frequency and therefore a smaller ring diameter in damping rings for high energy e^+e^- colliders

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INTRODUCTION

The size of damping rings for future linear colliders will depend on various parameters of the collider. It appears that for many plausible parameter sets the damping rings will have to be quite large. The reason is that the number of bunches in the ring at any time must be at least fT_d , where f is the linac repetition rate and T_d the total time needed for a bunch to be damped sufficiently. Since these bunches must be separated longitudinally by at least the time T_k needed for the rise and/or fall of the ejection kicker, the circumference will have to satisfy¹

$$C > fT_dT_k \quad (1)$$

There is nothing very fundamental in this limitation. T_k is a technical parameter that could in principle be made small. However, in practice this may not be so easy.

Condition (1) is valid if the bunches are equidistant. This is not strictly necessary; there is a great deal of empty space between successive bunches. A manipulation by means of RF could in principle temporarily separate the bunch that has to be ejected (or injected) from the other bunches. This appears to be possible with a scheme that bears some resemblance to the "harmonic-number changing" method proposed by Garoby for an entirely different purpose.² The extra bunch separation would, of course, allow us to choose a higher bunch repetition rate and therefore a smaller ring diameter.

DESCRIPTION OF THE METHOD

We shall assume that in addition to the normal RF system of the ring we have a second system of roughly equal voltage, but with a slightly higher frequency. The frequency ratio may be chosen within limits; for the present description we shall assume that it is 5:4. The amplitudes of the two systems must be continuously adjustable.

Figure 1 shows the waveform seen by the beam if the second system (amplitude A_5) is turned up, followed by a turn-down of the original component A_4 . The bunches are indicated by small circles around the stable fixed points; the small offset needed for compensating the radiation losses is neglected since it does not change the

Fig. 1

argument in a significant way. As may be seen, if the changes are adiabatic, the bunches are shifted longitudinally and an empty bucket appears, repeated in this example after every 4 full buckets.

Figure 2 shows how we may exploit this in a damping ring. We leave a gap of 3 missing bunches in one place around the azimuthal bunch distribution (Fig. 2a). Then, we create the empty buckets as described above (Fig. 2b) so that the bunch to be ejected is separated from the others. We now eject this bunch and inject a fresh one,

Fig. 2

also separated (Fig. 2c). Then, we invert the process of Fig. 1 so that the empty buckets disappear (Fig. 2d). The gap has now shifted by one period, compared to Fig. 2a, and we can repeat the same process on the next cycle after an appropriate phase shift between the two RF systems.

The adiabaticity requirement probably means that the entire cycle should take at least one or two synchrotron periods. It may be possible to arrange some compensation between the excitation of synchrotron oscillations by the process that creates the empty buckets and its reverse. More exact calculations will certainly be needed for a proper design. The synchrotron period should obviously be smaller than the collider's repetition period multiplied by the number of damping rings used.

Saving a factor 2 in ring circumference at the cost of doubling the RF system may well be worth while. In principle, additional RF systems could increase the bunch separation and so allow a further reduction in ring size.

REFERENCES

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