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Parasitic Mode Losses in the Damping Ring

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The two major sources of parasitic mode loss impedance in the damping ring will be the RF cavities (higher order modes) and the injection/ejection kickers. Treating the latter component first, we assume that the kicker chamber is a ceramic tube boated on the inside with kovar (1.3 ohms/square), as designed for CESR ^{1}.

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SINGLE PASS COLLIDER MEMO | CN- 35

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TITLE: Parasitic Mode Losses in the Damping Ring

The two major sources of parasitic mode loss impedance in the damping ring will be the RF cavities (higher order modes) and the injection/ejection kickers. Treating the latter component first, we assume that the kicker chamber is a ceramic tube coated on the inside with kovar (1.3 ohms/square), as designed for CESR[1]. For a chamber of this type, it has been found that the energy loss per pulse is just the resistive loss given by

$$W = R \int I^2(t)\, dt$$

where I(t) is the instantaneous current in the beam pulse and R is the dc resistance of the coating, given by

$$R = R_s\, L/2\pi a.$$

Here R_s is the surface resistance of the coating, L is the length of the chamber and a is its radius. Carrying out the integration for a gaussian pulse, the loss parameter becomes

$$k = \frac{W}{q^2} = \frac{R}{2\sqrt{\pi}\,\sigma_t} . \qquad (1)$$

Assuming R_s = 1.5 ohms, L = 30 cm and a = 1 cm, we compute R = 7Ω. For σ_t = 17 ps (corresponding to a damped bunch length of 5 mm), k = 0.12.

Turning to the RF cavities, we can estimate the loss parameter starting from computed values for higher modes in the PEP cavities. For example, the PEP cell with a = 3.8 cm has k = 1.2 V/pC for σ_z = 0. This scales to 2.4 V/pC at 714 MHz, with a = 1.9 cm. Using other cavity data, we estimate k = 2.0 at σ_z = 1 mm and k = 1.0 at σ_z = 5 mm for a cavity with a = 2.0 cm at 714 MHz. This variation of k with σ_z can be represented approximately by

$$k/\text{cell} = 2.4 \exp\,[-0.17\, \sigma_z(\text{mm})] \quad \text{V/pC} \qquad (2)$$

1. R. Dixon, F. Messing, D. Morse and A. Sadoff, IEEE Trans. Nucl. Sci. NS-24, 1337 (1977)

For four cells at σ_z = 5 mm, k = 4.1 V/pC. Adding k = 0.24 for two kickers and including k = 0.16 for miscellaneous losses, we have a total loss parameter of 4.5 V/pC for the damping ring at σ_z = 5 mm. Multiplying by the time between bunches (55 ns) we obtain a loss impedance of 2.5 x 10^5 ohms. For a circulating current of 142 mA, the energy loss per turn per particle is 35 keV. Values at other bunch lengths are readily computed from Eqs. (1) and (2).