Transverse Impedance localization

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Transverse impedance measurements based on observed tune shift with intensity are 2 or 3 times larger than expected.

Is there a large impedance we did not account for?

If it’s just a few things we might be able to fix them.

Basic Idea

Consider a smooth focusing lattice with a single quad error.

The equation for the beta function perturbation is

$$\frac{d^2\beta_1}{d\theta^2} + 4Q^2\beta_1 = -8\pi R\Delta Q\delta_p(\theta)$$

Where ΔQ is the tune shift due to the perturbation located at $\theta=0$.

Solving one finds

$$\beta_1(\theta) = 2\pi\frac{R}{Q}\frac{\Delta Q}{\sin(2\pi Q)}\cos[2Q(\theta-\pi)], \qquad 0<\theta<2\pi$$

The variation in β leads to a variation in the phase advance,

$$\delta\psi(s) = -\int_0^s \frac{\beta_1(s)}{\beta_0^2(s)}ds$$

Implementation

Use AC dipole to measure phase advance between bpms for low and high intensity bunches. One turn map is

$$z_n = x_n - i(\beta x'_n + \alpha x_n)$$

$$z_n = \exp(i\psi) z_{n-1} + k_n, \qquad k_n = -i\beta\hat{\theta}\sin(n\psi_d)$$

$$z_n = -i\beta\hat{\theta} \lim_{\alpha \to 0^+} \sum_{m=-\infty}^{n} \sin(m\psi_d) e^{-\alpha(n-m)+i\psi(n-m)}$$

By measuring turn by turn on adjacent bpms get the phase advance between them. Careful data processing…

We will do this for low and high intensity bunches.

Might be able to do better with protons if working near a half-integer helps.