Homework Problems for:
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Chapter 9

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Homework Problems for Chapter 9

1. Collimator Parameters. Determine the optimum taper angle $\theta \approx b/L_T$, which minimizes the deflection by the taper, Eq. (16). As an example, consider Titanium ($\lambda = 1.2$ nm), a gap g of 1 mm, and bunch length $\sigma_z = 100$ μm, and compute the value of the optimum angle, as well as the taper length for a beam pipe radius $b = 5$ mm.

Rewrite the explicit formula for the total kick, Eq. (17), using the optimized taper angle. Then, describe the incoming jitter as $\Delta y = t\sigma_y$ (t dimensionless), normalize the resulting deflection angle as $t' = \delta y'/\sigma'_y$, and derive an expression for the *jitter amplification factor* t'/t. Reveal its dependence on the gap size g using $\beta = \sigma_y/\sigma'_y = g^2/(\epsilon_y n_y^2)$ where n is the number of σ at which the collimation should occur (ϵ_y is the vertical emittance and β the beta function at the collimator). Show that there is an optimum gap size g for which the deflection is minimized. Evaluate this gap size for a Ti spoiler of 1 cm flat length L_F.

2. Beam Dispersion. Conceive a scheme by which the horizontal energy-position correlation $< x\delta >$ or $< x'\delta >$ in the bunch can be measured. Hint: one possibility is to use two horizontal wire scanners [1], separated by a $-I$ optical transform with bending magnets as in Section 3.3 (see Eq. (35), with $R_{16} = 2D_x$, where D_x is the nominal value of the dispersion at the two wires). Assume that the beam energy spread $\sigma_\delta =< \delta^2 >^{1/2}$ is either known or can be measured independently.

Why could it be important to minimize correlations in the beam distribution?

[1] A wire scanner is a device that measures the horizontal (or vertical or diagonal) beam size. It is equipped with thin filaments of, *e.g.*, W or C, which are moved in small steps through the beam. Recording the scattering rate as a function of wire position and correcting for the finite size of the wire, one can determine the rms beam size at the wire location in the direction orthogonal to the wire filament.