Prof. Dr. Albin F. Wrulich EPFL, Winter Term 2005/2006

Introduction to Particle Accelerator Physics

Tutorial 5 - Problems

Discussion: 31.1.2006 Hand in: 7.2.2006 Solutions: 7.2.2006

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1. Apertures, Dispersion, and Acceptance

Assume a simple ideal light source lattice, composed of identical arcs and identical dispersion free straight sections. The maximum beta functions occur somewhere in the arcs: $\beta_{x,\max} = \beta_{y,\max} = 25$ m/rad. The ideal machine will be flat, i.e. it has no vertical bending magnet fields and thus dispersion will be purely horizontal. The maximum horizontal dispersion is $D_{\max} = 0.5$ m and occurs at the same location as $\beta_{x,\max}$. In the center of all straights, there is a horizontal and vertical focus with $\beta_{x,0} = 9$ m/rad and $\beta_{y,0} = 1$ m/rad. The vacuum chamber has a constant cross section around the machine with an inner full width $w = 60$ mm and full height $h = 30$ mm. In one of the straight sections a (short) septum will be installed for injection, but we will place it 15 mm away from the beam axis in order to not introduce an additional aperture limitation.

a) What is the vertical acceptance A_y of the ring?

b) It is planned to install undulators centered in the straight sections. The undulators have a length $L = 4$ m and a full gap (vacuum chamber inner height) $g_u = 6$ mm. What is the vertical acceptance after the installation of the undulators?

c) What are the horizontal and vertical betatron phase advances ϕ_x and ϕ_y along the undulator?

d) We would of course like to have maximum vertical acceptance in order to minimize beam losses. What would the optimum choice of $\beta_{y,0}$ be?

e) The bending magnets in the arcs are equipped with gradients in order to achieve vertical focussing. Due to the thickness of the vacuum chamber (2×4 mm) the resulting magnetic gap will be $g_m = 38$ mm. Since after the installation of the undulators the vertical acceptance is restricted anyway, we may ask if the large magnetic gap leads to a waste of electric power. Assume the optimum $\beta_{y,0}$ from above and calculate the minimum magnetic gap height required in order not to further restrict the vertical acceptance.

f) How much power can be saved this way?

2. Chromaticity Correction with Sextupoles in a Collider

In a circular collider the largest contribution to chromaticity comes from the interaction region due to high betatron values and strong quadrupole strengths. Would it be a good idea to install sextupoles there to compensate chromaticity locally?

3. Chromaticity in Linacs

The general structure of a linear accelerator consists only of straight sections. Therefor, can such a linac have chromaticity at all? And if so, how can it be corrected?

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