Karlsruhe Institute of Technology

Institute for Beam Physics and Technology (IBPT)
Bastian Härer, Axel Bernhard, Bennet Krasch, Nathan Ray, Anke-Susanne Müller

Accelerator Physics WS24/25

Exercise sheet 4 (Submission: 03.12.2024)

Exercise 1: Emittance (3 points)

Consider a proton beam inside a FODO lattice with a geometric emittance of $\epsilon = 2\,\mu\text{m}\,\text{rad}$.

(a) Calculate the RMS width (1 σ) of the beam inside an F quadrupole with $\beta = 108\,\text{m}$. (1)

(b) What is the normalized emittance of this beam if we assume $\epsilon = 2\,\mu\text{m}\,\text{rad}$ and $10\,\text{GeV/c}$? (1)

(c) What is the RMS beam width inside an F quadrupole ($\beta = 108\,\text{m}$),
if a beam with the normalized emittance of b) is accelerated to $400\,\text{GeV/c}$ (1)

Exercise 2: KARA Electron Bunches (4 points)

On one afternoon, we have all 184 buckets of the KARA storage ring($f_{\text{rev}} = 2.7\,\text{MHz}$) filled with the same amount of electrons. A current monitor measures an average current of $I = 100\,\text{mA}$. The bunches have a bunch length of $t_b = 300\,\text{ps}$.

(a) What charge Q_b and how many electrons N_b are in one bunch? (1)

(b) If we would have a fast current monitor, what peak current would it measure?
Assume a rectangular bunch shape. (1)

(c) After one hour, the current in the ring drops to $I = 97.6\,\text{mA}$.
How many electrons are lost per turn? (2)

Exercise 3: Dispersion and Chromaticity (4 points)

(a) Describe in your own words the terms dispersion and chromaticity in context of accelerator physics. (2)

(b) Sextupoles feature a non-linear magnetic field. How are they used in particle accelerators?
What negative effects could they have, if not used carefully? (1)

(c) What is the momentum compaction factor? Can it be smaller than zero and what would that imply? (1)