

Homework 3

- 1) Deuterons, the nuclei of heavy hydrogen, are accelerated in a cyclotron. Determine the frequency of the voltage source, if the value of magnetic field strength in the cyclotron is 1.5 T. Determine the cyclotron radius for particles, which leave the cyclotron with a kinetic energy of 16 MeV. How many times does the deuteron cross between the “D” electrodes (also called “dees”), if the electrical potential difference between the two dees is 50 kV?
- 2) In a linear collider the bunches are dumped after each collision, while in LHC bunches circulate and collide many times. The bunch collision rate in a linear collider is therefore relatively low, in order to be able to operate without a too high wall plug power consumption. Assume a linear collider with a bunch collision repetition rate of 50 Hz. Compared to the LHC bunch crossing rate of 40 MHz. The LHC beam size at the interaction point is estimated to be $\sigma_x = \sigma_y = 17 \mu\text{m}$ (similar transverse dimensions, thus a “round” beam). If we require the same order of magnitude for the luminosity as for the LHC ($10^{34}/\text{cm}^2/\text{s}$), estimate the corresponding beam size required at the interaction point at a linear collider. Assume here for simplicity that the beam has the same transverse size in both planes (in reality the vertical beam size at the interaction point is much smaller than the horizontal size).
- 3) The vacuum chamber has a diameter of 40 mm. At $s=s_1$ there is a focusing quadrupole. The beta function is $\beta(s_1)=100$ m. Find the maximum acceptable value of the emittance. If in $z=z_2$ there is a defocusing quadrupole and $\beta=20$ m, which is the minimum value of the vacuum pipe diameter?
- 4) For an electron beam the normalized emittance value is 1 mm-mrad. Being $\beta=100$ m which is the value of the beam size if the energy is 50 MeV? Recalculate the value for 1 GeV
- 5) During nominal 25 ns operations the LHC circulates 2808 bunches per beam, though the theoretical maximum of bunches is 3564. Why do we have empty bunch positions (even though this choice decreases the instantaneous luminosity of the accelerator?)