Introduction to Particle Accelerators

Homeworks II

1 Synchrocyclotron

The CERN synchrocyclotron (SC) accelerates protons up to 600 MeV. Compute the maximum orbit radius, considering a constant magnetic field of 1.9 T. Compute the revolution frequency as a function of the radius. Is it possible to change the radial profile of the field to obtain a constant revolution frequency as a function of the radius?

2 Circular accelerator

Consider a proton synchrotron with a maximum energy of 10 GeV with a magnetic field ramping to 1.5 T in 1 second.

1. What is the proton momentum (GeV/c) when the field reaches 1.5 T?
2. What is the value of $B\rho$ at top energy?
3. If 2/3 of the circumference are filled with bending magnets, what are ρ and R?
4. What is the revolution frequency at 1 GeV? At 10 GeV?
5. What are the consequences of (4) for the rf system?
6. What is the energy gain per turn necessary to accelerate to 10 GeV in 0.9 s?
7. If ϕ_s is set to 45 degrees, what is the peak cavity voltage?

3 Transition energy

η is defined as

$$\frac{\Delta f}{f} = -\eta \frac{\Delta p}{p} \tag{1}$$

where Δ represents the deviation with respect to the reference particle.

1. What is the physical meaning of η?
2. Using $\frac{\Delta R}{R} = \alpha \frac{\Delta p}{p}$; compute η as a function of α and γ;

3. γ_{tr} is the value of γ at which $\eta = 0$. What is the physical interpretation of γ_{tr}?

4. We consider three machines: the Bevatron, the CERN PS and LEAR with the values of α being respectively 2.42, 0.026 and -0.046. Discuss the three cases.