

USPAS Graduate Accelerator Physics Homework 5

Due date: Wednesday January 23, 2013

1 Simple DBA Light Source

A light source ring has eight equal double achromat bends (16 dipoles). Each dipole is 2.7 m long and the circumference is 176 m. The energy of the beam is 2.5 GeV.

- (3 points) Calculate the critical energy of photons radiated in the dipoles.
- (3 points) Calculate the total energy lost per turn.
- (3 points) Calculate the momentum compaction of the ring.
- (3 points) Calculate the damping times τ_x , τ_y , and τ_u .
- (3 points) Calculate the approximate equilibrium emittance of the electron beam.

2 LHC Synchrotron Radiation Losses

The LHC will be capable of accelerating protons to 7 TeV in each of its two counter-rotating rings at full energy. The circumference is 26.7 km and the arc dipole field at 7 TeV will be 8.33 T.

- (3 points) Calculate the critical energy of photons radiated in the dipoles.
- (3 points) Calculate the total energy lost per turn per proton.
- (4 points) Calculate the total power radiated by synchrotron radiation for an LHC proton beam of average current 0.56 A.

3 Touschek Lifetime

(10 points) Calculate a rough estimate of the Touschek lifetime for a flat electron beam in a ring, using the following lattice parameters. Assume that the lattice parameters are constant and ignore dispersive contributions to the horizontal beam divergence $\sigma'_{x,RMS}$.

Table 1: Touschek Lifetime Parameters

Parameter	Variable	Unit	Value
Beam energy	E	GeV	9
Path length	L	m	1000
Equilibrium horizontal emittance	ϵ_x	m	4×10^{-9}
Vertical emittance	ϵ_y	m	$\epsilon_x/6$
Bunch length	σ_s	m	5×10^{-3}
Number of electrons	N_0		3×10^{10}
Effective $\beta_{x,y}$	$\beta_{x,y}$	m	3
Momentum acceptance	$\delta_{\text{acceptance}}$		0.001