

### Homework 13. Due October 30

#### Problem 1. 15 points. Turning the beam around – ultimate storage rings

Let's consider that we build a storage ring (magnets only), where ultra-relativistic charged particles traveling in circle of constant radius  $R$  while radiating synchrotron radiation. It means that the magnetic field is adjusted to the loss of its energy.

- (a) Find the energy of the particle as function of the traveled distance  $s$  or angle  $s/R$ ;
- (b) Find the distance when the particle's energy is reduced by a factor 2.
- (c) Losing half of the energy is considered to be "dead-end" for recirculating the beams – than linear accelerators have to do the job. For  $R$  being 6,371 kilometers – that of the Earth, find critical energy of electrons, muons and protons when particles are losing  $\frac{1}{2}$  of the energy in a single turn.

#### Problem 2. 10 points. Circulating particle in magnetic field

Consider ultra-relativistic charged particle with initial energy circulating in an uniform constant magnetic field  $\mathbf{B}_y$ .

- (a) Find energy of the particle as function of time.
- (b) What will be its trajectory?

Note: Neglect non-relativistic effects