Lecture 1: Miscellaneous Problems

***Q1**: The earth's radius is approximately 6400 km. Pretend we can build a storage ring collider around the planet which sits in geostationary orbit. Assuming that the earth's magnetic field has a constant value of 0.5 Gauss (= 5 μT) around our machine, and that it is perfectly perpendicular to the equatorial plane, calculate (a) the centre of mass energy of the machine, and (b) the average power radiated per electron.*

***Q2**: For a fixed beam power and centre of mass energy, show that the luminosity scaling for a round beam ($\sigma_x = \sigma_y = \sigma$) at the IP can be expressed as*

$$L \propto \frac{\sigma_z}{N_b}\delta_{SB}$$

Comment on this result.

***Q3**: Keeping all other parameters in our final luminosity scaling law constant, how does the beamstrahlung scale with centre of mass energy?*

***Q4**: The luminosity scaling law tells us that we can always increase the luminosity by 'cranking up the beam power' (providing AC power is not an issue). We can do this by*

1. *increasing the repetition rate of the machine*
2. *increasing the bunch charge*
3. *increasing the number of bunches per train*

Dividing the machine up into source, damping ring, main linac, final focus (including beam-beam effects), briefly comment on the issues associated with each of the above approaches for each sub-system.

***Q5**: LEP as a damping ring. Calculate the damping time for LEP with a beam energy of 90 GeV and a radius of 4.3 km.*

***Q6**: A damping ring at 2 GeV produces a bunch that is 5 mm long and has an relative energy spread of 0.1%. Assuming an L band compressor at 1.3 GHz, estimate the RF voltage required to compress the bunch to 0.1 mm. What is the required R_{56}?*

***Q7**: The final energy spread from the compressor in Q6 is 5% which is very large and will cause problems for chromatic emittance growth. One way around this is to use a two stage compressor, with some acceleration between the two to adiabatically damp the energy spread from the first compression before performing the second. Perform the following steps:*

a) *Repeat Q6 for a compression ration of 10.*
b) *assuming the beam is then accelerated to 8 GeV, calculate the bunch compressor parameters for the final compression to 0.1 mm. What is the final energy spread? (For this example, you may assume the 6 GeV acceleration is on crest and is uniformly applied to the entire bunch).*

What is the total longitudinal phase space rotation of the complete system. What implications does this have for damping ring ejection phase errors?

***Q8**: For a normalised emittance of 30 nm, calculate the Oide limit.*