November 5, 2012 **Questions for Tutorial**
Monday

Synchrotron Radiation and Electron Dynamics

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Introduction to Accelerator Physics Course

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1. Synchrotron radiation in LHC: spectrum and dynamics

The Large Hadron Collider (LHC) will collide 7 TeV protons in the same tunnel (circumference 27 km) where the Large Electron Project (LEP) operated with 100 GeV electrons. Assuming for simplicity the same bending radius in dipole magnets of 2900 m, calculate the following synchrotron radiation parameters for the three cases: for protons at the injection energy of 450 GeV, at the design energy of 7 TeV and for the electrons at 100 GeV:

- typical ('critical') photon energy of emitted synchrotron radiation
- energy loss per turn
- the damping times for energy and transverse oscillations

The rest mass of protons is 0.938 GeV and is 0.511 MeV for electrons.

2. High Energy option for LHC

New superconducting materials like Nb_3Sb may allow in the future to build 20 Tesla dipole magnets for the LHC.
To what maximum energy will LHC be able to accelerate the protons?
What will be the typical photon energy emitted by protons and what will be the energy loss per turn?
Estimate the damping time and the equilibrium emittance of the protons stored at the top energy

3. Synchrotron light source that never was: LEP at 5 GeV

The equilibrium electron beam emittance at 100 GeV at LEP was about 0.06 mm·mrad. If we tried to operate LEP at 5 GeV, how small an emittance could one hope to achieve using the same lattice? What would be the damping time at this energy (a few milliseconds at 100 GeV). Find the length of wiggler magnets you would need to install in the straight sections of the ring (assume wiggler field of 2 Tesla), in order to reduce the damping times at 5 GeV by a factor of 1000?