Accelerator Homework, Part 2

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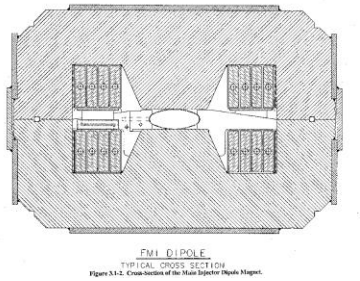
1. Below is an example of a simple dipole magnet.



   It has a pole face width *w* (ignore the beveling near the coils), a gap *g*, a length *l* and is wound with *N* turns of conductor. Assuming the permeable laminations have $\mu >> \mu_0$, show that the magnetic field in the gap is

   $$B = \frac{\mu_0 N I}{g}$$

   and calculate the inductance.
2. In order to extract the beam from the8 GeV Fermilab Booster , one needs to bend it by about 50 mrad to clear the nearest downstream magnet. Let's assume we want to do this with a single two meter long magnet. Use:
   a. A single turn (*N*=1)
   b. *g*=*w*=6 cm to provide the required beam aperture

   Calculate the magnetic field and current required. Also calculate the inductive voltage to ramp to this field with the present rise time of 40 ns.
3. Fun with antimatter… The Fermilab antiproton source holds the record for antiproton production, by a good margin. Its record average stacking rate over 1 week is 2.5×10^{11} pBar/hour. At this rate
   a. How long would it take to make enough antiprotons to fill the LHC to the nominal intensity (slide 21); ie use one beam pipe and run it as a p-pBar collider with the same luminosity?
   b. How long would it take to make the "half gram" of antimatter in Dan Brown's Angels and Demons?
   c. How long would it take to do this, assuming we could magically turn the entire design LHC beam energy into antimatter like they apparently did in the book, optimistically assuming one fill every 2 hours?
4. Consider the SLAC B-Factory, which collides electrons and positrons asymmetrically with energies of 9 and 3.1 GeV respectively.
   a. Show that the center of mass energy is, to this accuracy, equal to the Υ_{4S} resonance.
   b. How fast is the center of mass moving?
   c. On average, how far will a B_d meson travel before decaying?
   d. How far would the same meson travel a symmetric machine, assuming it was also produced at the Υ_{4S} resonance?