Fundamentals - Computational Lab
Designing a ring with the optics code

William A. Barletta
Director, United States Particle Accelerator School
Dept. of Physics, MIT

Download the optics code

- http://uspas.fnal.gov/PCprog.html
- This program allows you to design a storage ring.
  - It calculates single particle trajectories, betatron functions, periodic betatron/dispersion functions (if there is a solution).
  - After insertion of sextupole magnets it is possible to track particle trajectories, rf-parameters are calculated as well as beam lifetimes. Insertion of vacuum pumps allows the user to calculate the pressure profile.
  - Ample parameter lists are available for cut and paste into a word processing program.
  - Many graphs are available for particle trajectories, betatron functions, rf-phase space and tracking.
  - All graphs can be directly printed or saved in *.wmf format for inclusion into a word processor.

To initialize project start with "beam line"

- Compose a magnet structure for a superperiod
  - Set of magnets and drift spaces
  - The superperiod will repeat several times to make a ring
  - If you design a beam transport line that may not be the case.
- To begin, select a set of lattice elements (all have the default length of 25cm)
  - Once you have the structure, click on each element to edit parameters
  - Click "accept" to accept your edits.
- To insert an element,
  - click the element behind the "to be inserted element",
  - choose your insertion element, edit and "accept".
- To add/insert an element at the end of the beam line click "beam line".
  - "Delete", eliminates the element clicked.
- To start from scratch, clear the whole beam line in "beam line".

Test your lattice with some beam optics

- Click "beam optics”
- The first option there is to choose "z-step size".
  - If you don't, the lattice functions are plotted only at the end of elements.
    - That's faster, but the curves look a bit unrealistic.
  - To plot in smaller steps click at "z-step size".

Choose between single particle trajectories & lattice functions

- For lattice functions, you may select "symmetric solution" as desired for storage ring superperiods
  - → However, there may be no solutions!
  - → In this case give the program some initial values for the lattice functions
    - that's what the default values are for.
  - → The display of the lattice functions will show where something goes wild
- Vary initial values, magnet parameters etc. until you get close to a symmetric solution
  - → You should be successful in getting the "symmetric solution”
- Note, for symmetric solutions you must have a symmetric magnet lattice

Now that you have a symmetric solution, you build your ring

- You have a ring when the beam gets deflected in a number of superperiods by 360 degrees.
- Click "compose ring" and the program will use a number of your superperiods which give close to 360 degrees
- To exactly make it 360 deg the program asks you if you want to change the magnet strength to make an exact ring
  - Answer YES
  - If you say NO the program asks you if you want the dipole lengths to be adjusted to make a ring
    - Answer YES
  - If you answer NO you are on your own

Write a lab report about your ring design & what you have learned

- Now you have a basic ring, magnet structure, lattice functions listed & plotted
- Save your creation in File/Save As
- You may cut & paste any listing & transport it to a WORD document.
  - In the design panel, where the lattice functions & magnet arrangements are plotted use the "print" option in the "File" menu
  - This generates a metafile with the *.wmf extension.
    - This file can be "inserted" into WORD as a picture from file. Now you have magnet listing, lattice functions and graph all in one document
  - Add text to describe what you have done and what your goals are
- You may also use any lattice file (there are a few for existing storage rings in the directory) and modify that one