Beam-based Diagnostics USPAS Michigan, June 2012

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Motivation

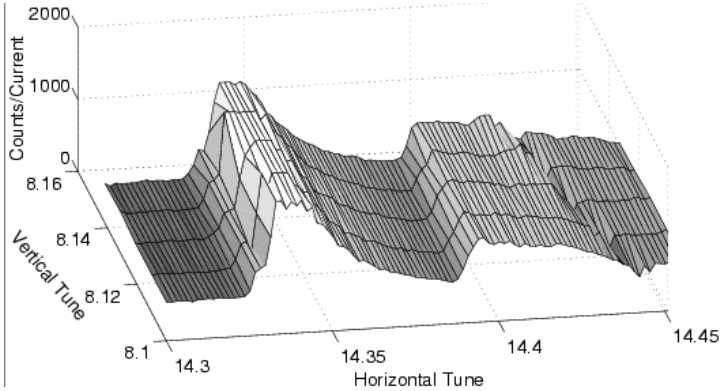
Charged particle storage rings are used for a variety of science and technology applications --- for example as synchrotron radiation light sources for biology, chemistry, and materials science, as colliders for high-energy physics or as damping rings to reduce the beam emittance for linear colliders.

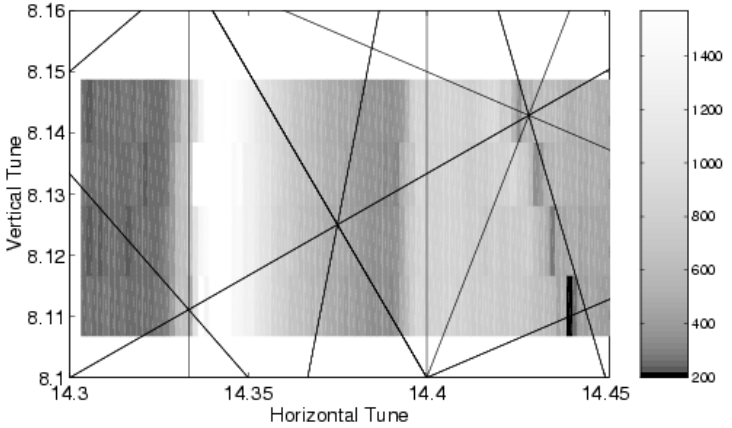
To achieve small equilibrium emittances or to minimize the beamsize at the interaction points, strong quadrupoles are necessary to focus the beam, resulting in large chromatic aberrations. The correction of those aberrations requires strong sextupoles creating non-linearities, which can cause the particle motion at large amplitudes to become unstable (dynamic aperture).

The dynamic aperture limits the performance in many current accelerators. To optimize the performance a good knowledge of the machine model is required. To achieve the required accuracy of the machine model, beam based measurements have proven to be essential.

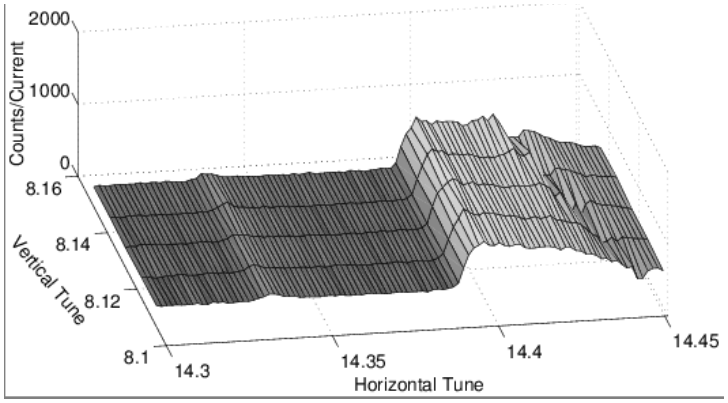
Tune scans (with and without large beta beating)

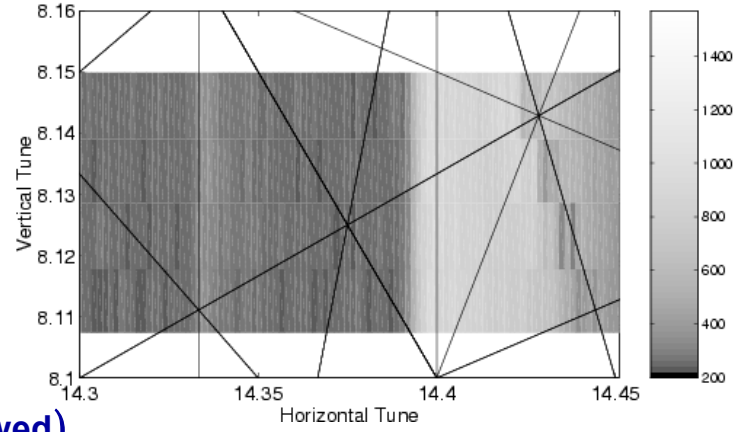
Uncorrected lattice





Corrected lattice





Three resonances:

$5\nu_x = 72$ **(allowed)**

$3\nu_x = 43$ **(unallowed)**

$2\nu_x - \nu_y = 37$ **(unallowed)**

Schedule*

- Class meets from 9-12 and 14-17 daily
- Computer labs
  - Mo-Thu 15-17 (probably will not use full time)
  - (Fri 9-10 – depending on progress)
- Not all time in class-room will be lectures, (hopefully) some time will be available for discussion, further computer tutorials, …
- Lecturers will at least be available from 21:00-22:00 in computer room and/or study room

*Friday all USPAS classes end at noon

Problem sets

- Distributed in the afternoon: Monday-Thursday
  - Some written problems and mostly computer problems
- Due following day: Tuesday-Friday
  - Computer problems can be handed in late if computer room availability should be insufficient

Grades

- Based on problem sets, class participation, computer class, (and final exam).

Lectures

- Monday:
  - o Introduction to main concepts of accelerator physics (CS)
  - o Review of basic measurements (JS)
  - o Introduction to computer lab (XH)

- Tuesday:
  - o Closed orbit, orbit stability, orbit feedbacks, beam-based alignment (CS)
  - o LOCO: Determining gradient errors using response matrix analysis (JS)
  - o Betatron phase advance measurements (CS)
  - o MIA: Model Independent Analysis (XH)

- Wednesday:
  - o Beam size and emittance measurements (JS)
  - o Introduction to coupling, Coupling diagnostics/correction (CS)
  - o Energy calibration (CS)

- Thursday:
  - o Lifetime, injection efficiency, frequency analysis (CS)
  - o Effects of insertion devices (JS)
  - o Resonance driving term analysis (CS)
  - o Orbit bump analysis of nonlinearities (JS)

- Friday:
  - o Instabilities/Higher Order Modes (CS)
  - o Broadband impedances (phase advance, bumps, ORM) (JS)

Website

- There is a website for this class
  - http://als.lbl.gov/als_physics/csteier/uspas12/
  - Will be updated as we go along
- Will also hand out copies of all talks (if at all possible before the lectures).
- If you are curious and want to read ahead: there also are three earlier versions of this class on the web (uspas03/, uspas06/, uspas08/). We will change and update several aspects but keep many things.