Beam-based Diagnostics USPAS East Brunswick, New Jersey, June 2015

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Motivation

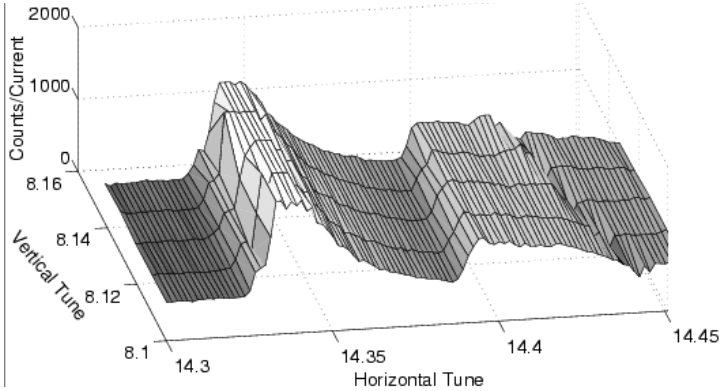
Charged particle storage rings are used for a variety of science and technology applications --- for example as synchrotron radiation light sources for biology, chemistry, and materials science, as colliders for high-energy physics or as damping rings to reduce the beam emittance for linear colliders.

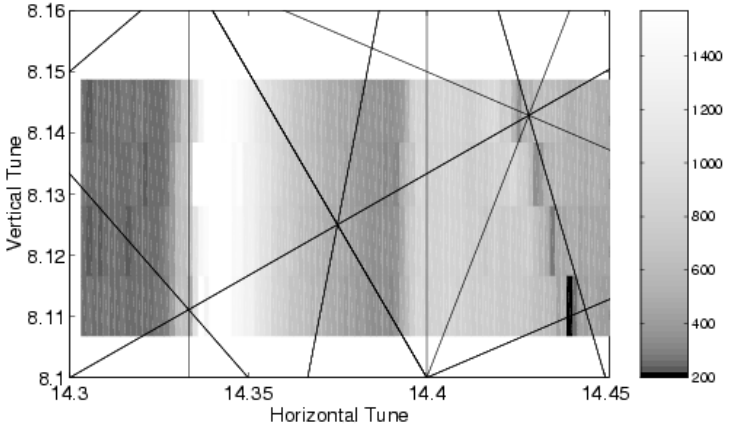
To achieve small equilibrium emittances or to minimize the beamsize at the interaction points, strong quadrupoles are necessary to focus the beam, resulting in large chromatic aberrations. The correction of those aberrations requires strong sextupoles creating non-linearities, which can cause the particle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

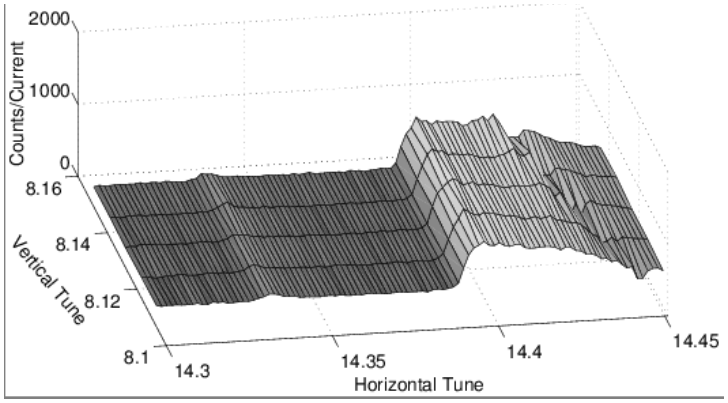
Tune scans (with and without large beta beating)

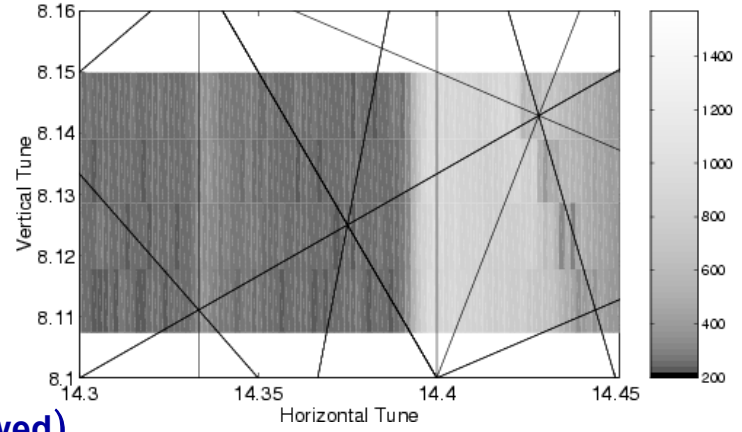
Uncorrected lattice





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 9-11:30 and 13-17 daily
- Computer labs
  - Mo-Thu 13-15 (might not use full time)
- 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).

Draft Lecture Schedule*

- **Monday (Accelerator Physics Fundamentals, Basic Measurements):**
  - Course Introduction/Organization/Outline
  - Introduction to main concepts of accelerator physics (Christoph Steier)
  - Introduction to the Matlab Middle Layer and computer class (Xiaobiao Huang)
  - Review of basic measurements (James Safranek)
- **Tuesday (Linear Lattice):**
  - Orbit Stability, Orbit Correction, Feedback (Christoph Steier)
  - Orbit Response Matrix Analysis - LOCO (James Safranek)
  - Phase Advance Measurements / Model Independent Analysis (Xiaobiao Huang)
- **Wednesday (Beamsize, Coupling, Nonlinear Dynamics):**
  - Beamsize/Emittance measurements (James Safranek)
  - Coupling (global/local), Vertical Dispersion, Measurement and Correction (Christoph Steier)
  - Nonlinear Dynamics, Dynamic Aperture, Lifetime, Frequency Maps (Christoph Steier)
- **Thursday (Beam Based Optimization, Undulators/Wigglers):**
  - Beam Based Optimization (Xiaobiao Huang)
  - Insertion Devices (nonlinear dynamics of wigglers/undulators) (James Safranek)
  - Nonlinear Lattice Calibration: Resonance Driving Term Analysis (Christoph Steier)
- **Friday (Higher order modes, Impedances, Energy Calibration):**
  - Instabilities, Higher Order Modes - Beam Based Measurements (Christoph Steier)
  - Top-off Transients (James Safranek)
  - Spin Dynamics, Energy Calibration (Christoph Steier)

*Might adjust schedule based on interest/progress

Website

- There is a website for this class
  - http://als.lbl.gov/als_physics/csteier/uspas15/
  - Will be updated as we go along
- Do not plan to hand out paper copies of talks (unless strong objection) – but will post ahead of actual lecture
- If you are curious and want to read ahead: there also are earlier versions of this class (uspas03/, uspas06/, uspas08/, uspas12/). We will change and update several aspects but keep many things.