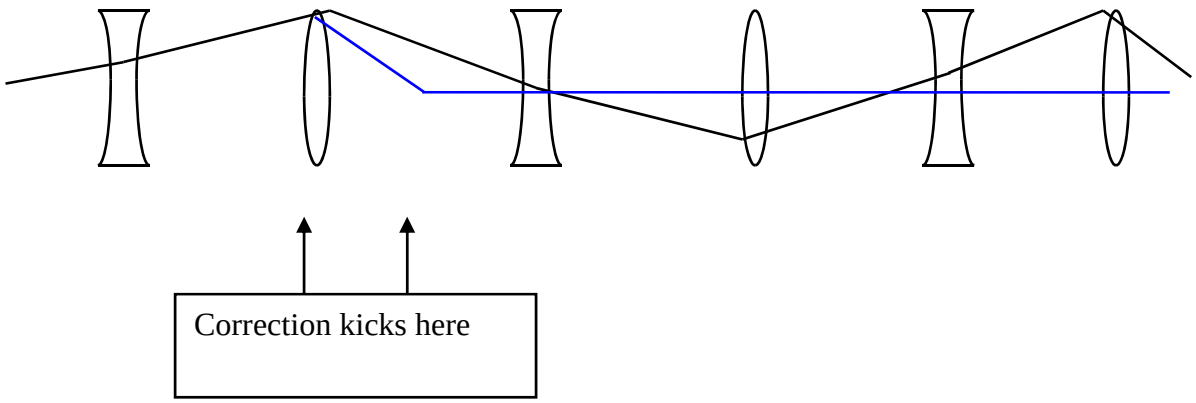
Control Room Accelerator Physics

Trajectory Correction

Steering Fundamentals

- The beam oscillates as it passes down a beamline
  - Non-ideal initial position and/or angle
  - Offset quadrupole centers
- Beam Position Monitors (BPMs) are the primary means of measuring the beam position
  - BPMs can be installed with offsets
- Dipole correctors are the primary means used to correct the trajectory (or orbit in a ring)

Trajectory Correction I



- Without special effort, the beam path is not on the ideal reference defined by the middle of the quadrupoles
- In general 2 dipole correctors/plane are required to remove a wave
- Be careful where you place BPMs (avoid 180 degree phase advance!)

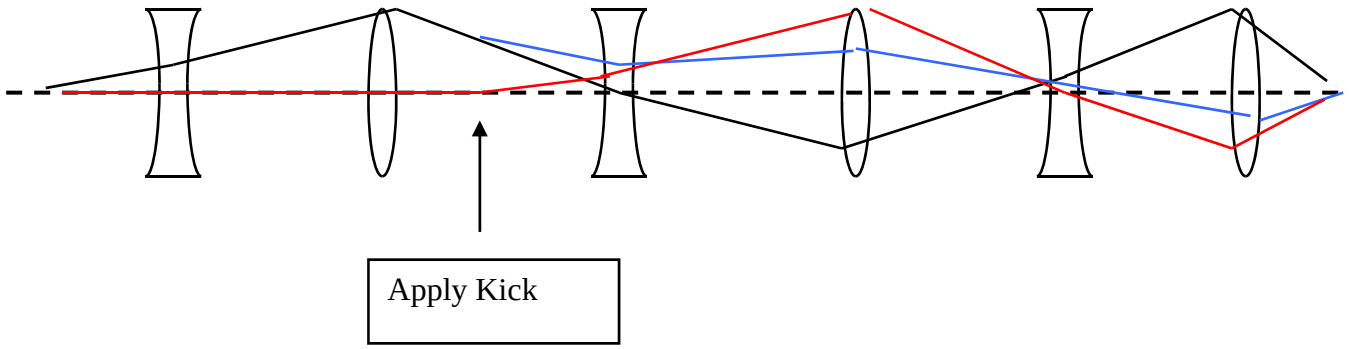
Orbit Correction

- Model based prediction:
  - Use a model to calculate the response of BPMs to dipole corrector changes
  - Need an accurate B(I) for the quadrupole and kickers
  - Need good knowledge of magnet and BPM offsets (beam-based techniques are required to refine these much below 1 mm)
  - Fast
- Beam based response matrix methods
  - Slow – need to create a BPM response vector for each kicker
  - Need to provide large kick and average to get clean responses
  - Also needs input for BPM offsets

XAL – Orbit Correction Application

- Provides options for both model and beam response matrix methods
- Can select the plane(s) to control, BPM, and correctors to use
- Can save orbits as reference and flatten to a saved orbit

Orbit Difference



- Black = original beam trajectory
- Blue = trajectory after a kick is applied
- Red = difference orbit (black – red)

Orbit Difference

- Perturb the trajectory of the beam at some point (i.e. change a dipole corrector)
- Compare the difference between the model predictions of before/after with the observed difference (BPM readings) before/after
  - There should be no change in model or BPM upstream of the perturbation (independent of initial conditions)
  - Downstream of the perturbation the model and BPM changes should agree
    - If a BPM polarity is reversed, it's observed change will have a minus sign error
    - If all observed BPM changes are off by -1, the dipole corrector likely has a polarity problem
    - If all BPMs and dipole corectors both have a polarity problem, you need another beam measurement (e.g.. Wire scanner with a known orientation)

Orbit Difference

- Standard technique for commissioning new beam-lines
- One of the first tasks once beam is well transmitted
- If you cannot get good agreement between the model and observation in an Orbit-difference test, model based orbit correction will not work