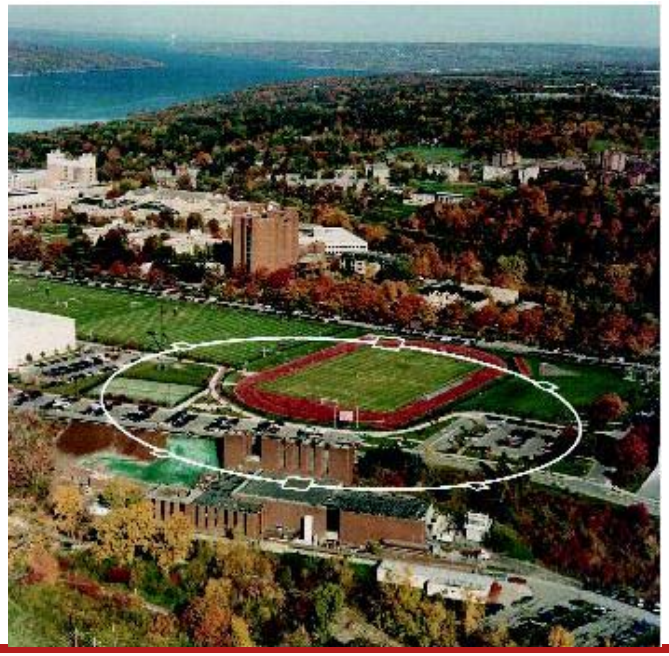
Cornell University
Laboratory for Elementary-Particle Physics

Low Emittance Tuning Working Group Summary

David Rubin

Cornell Laboratory for

Accelerator-Based Sciences and Education



LET Working Group

- Optics correction
  - Measurements
  - Analysis
  - Experience
- Instrumentation
  - Beam size monitor
    - Characterization
  - Beam position monitors
- Lattice characterization
  - NSLSII
  - ILC baseline design

Optics Correction

- Measurements
  - Closed orbits -> ORM analysis
  - Resonance excitation of normal modes and measurement of
    - Phase/amplitude data
    - Turn by turn data

Optics Correction

- Analysis of closed orbit data
  - ORM - Fit everything at once?
    - Large data set (>100 closed orbit differences)
      - ATF, Australian synchrotron, light sources
    - Fit measured to modeled response matrix

      Software provides for flexibility to include parameters as you like

      (quad, skew quad k, steering strengths, BPM tilts and gains, quad tilts, …)
    - Or with smaller data set (~12 orbits) (KEKB)

      Correct coupling - remeasure and

      Correct Dispersion - remeasure

      Correct Beta-function
- Analysis of phase/amplitude or turn by turn data
  - Fit measured betatron phase to model using quad/skew k (CESR)
    - Fit dispersion to phase/amplitude data
  - Model independent analysis of turn by turn data (PEPII)

Optics Correction

- Experience
  - KEKB (limited closed orbit data - ORM)
    - Correct coupling with vertical orbit bumps in sextupoles (and skew quads)
    - Residual dispersion <10mm horizontal and <8mm vertical
      - Correct with antisymmetric bumps in sextupoles
    - $\Delta\beta/\beta$ ~6%
      - Relatively few quad correctors?

    Each iteration ~5minutes, Convergence in 30-60 minutes
  - Australian synchrotron (extensive closed orbit data - ORM)
    - Collect orbit data in 10-15 minutes? (> 100 orbits)
    - Correct optics, coupling, BPM calibration (tilt and gain)
    - <0.07% emittance coupling
    - Vertical emittance ~6pm ? (limited by resolution of beam size monitor)

Optics Correction

- Experience

–ATF (extensive closed orbit data - ORM)

•2-3 hours to collect data

•Consecutive (same day) measurement, correction and measurement

Show good consistency in BPM tilts, skew quad correction,

Measurements done a few weeks apart are not so consistent

Model to be extended to include closed orbit errors (and/or) orbit to be carefully corrected in advance of measurements

<5pm 2004

CESR (amplitude/phase measurement)

Collect data, analyze and implement corrections in a few minutes (allows easy iteration)

- $\Delta\beta/\beta$ <1% (correct beta error with all 100 quadrupoles)
- < 0.05% emittance coupling (correct coupling error with 14 skew quads)

Compliment phase amplitude data with closed orbit data (under development)

ORM analysis to characterize BPM (after phase/coupling correction)

Include phase, dispersion data in ORM analysis

PEPII

Correction of beta beat permits approach to half integer

BPM characterization

- BPM characterization
  - ATF
    - High resolution BPM's (echotek) ->

      Sub micron resolution (30nm)

      30 micron offsets
  - KEKB
    - Offsets 75-250 microns
    - Gain mapping to measure relative gains of BPM electrodes
  - CESR
    - ORM analysis indicates BPM tilts ~30mrad (very preliminary)

Instrumentation

- Beam size measurement
  - ATF - Xray beam size monitor
    - High spatial resolution especially for 1pm vertical emittance
    - Non-destructive measurement
    - 2-dimensional (x,y) beam profiling
    - Real time beam profile measurement (<1ms)
    - <1 μm has been achieved
  - CesrTA Xray beam size monitor (under development)
    - Fast emittance determination (bunch by bunch/turn by turn) 4ns

      Based on photo diode detector
    - 2-3 μm resolution (goal)

Observations

- Big rings and small rings
  - KEKB - (3km circumference)
    - Optics correction based on “small” data set (18 orbits)
    - Sequential correction of coupling, then dispersion, then beta
  - Australian synchrotron (216 m)
    - Optics correction based on “large” data set (100 orbits)
    - Correct beta- coupling in one step, fit BPM tilts,gains with ORM
  - CESR (768m)
    - Optics correction based on phase/coupling data
      - Correct beta-coupling in one step
      - Then measure and correct dispersion
      - Then ORM analysis of large data set for BPM characterization

      Iterate ?

Observations

- Alignment
  - Alignment and stability of that alignment is crucial
    - Australian synchrotron, SLS, LBNL have all achieved <10pm emittance - with survey alignment <50 microns (and ORM correction schemes)
- BPM resolution and stability is essential
    - (ATF experience with echotek electronics)
- Fast turn around for measurement and correction of optical errors is essential
- ? How many BPM's and correctors are required
  - Study of ILC baseline lattice quantifies relationship between emittance that can be achieved vs number of BPM's
  - Extend the study to correctors?
  - Experience from existing machines is varied