New Developments in LIAR

LC02 Codes Session

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The LIAR Collaboration

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What is LIAR?

- The LInear Accerlator Research Code
- Designed to study "high-performance" linear accelerators
- Not a "design code" (a la MAD, DIMAD) but a performance simulation code
  - emphasis on implementation of misalignments, errors, and correction algorithms

LIAR's Beamline Representation

- Magnets: quads, xcors, ycors, bends
  - represented at R-matrix level
  - dynamic calc of R-matrix based on particle energy (for chromatic aberrations, dispersion)
  - xcor/ycor dispersion included, but not bend magnet (bend matrix somewhat primitive)
  - magnet movers with finite step size represented
- RF structures
  - R-matrix, energy gain sinusoidal in time
  - short- and long-range transverse wakefields
  - short range longitudinal wakefields
  - include "average loading" (loss parameter) in design optics

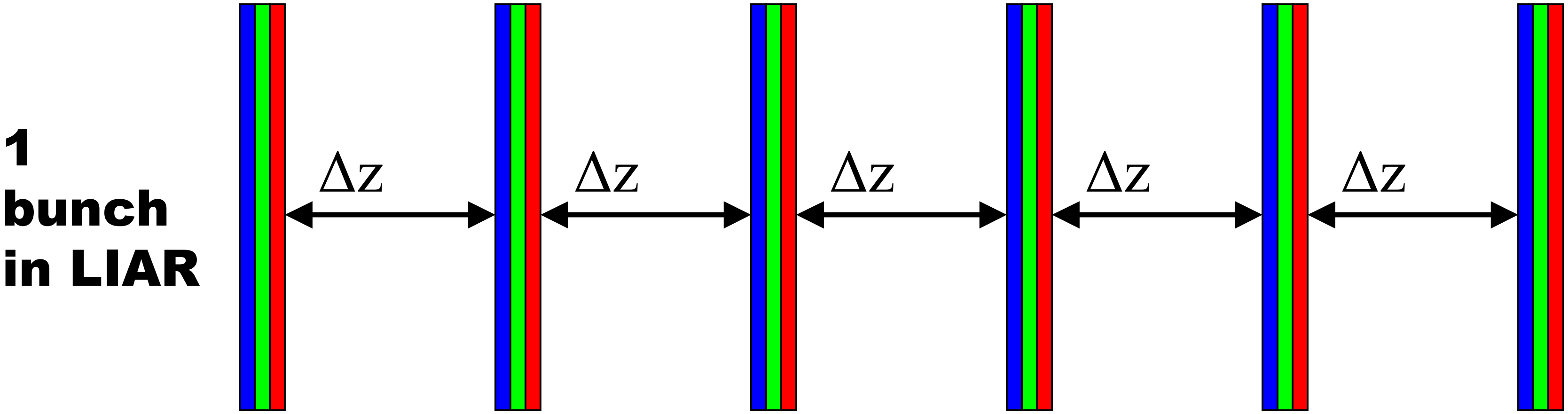
LIAR beamline (2)

- **BPMs and MARKERs**
  - single- and multi-bunch positions, 2nd momemts
  - BPM resolutions included
  - Lots of diagnostic info generated which is not normally observable
- **Element supports**
  - can have multiple RF structures/girder
  - only 1 quad/girder
  - quads can if desired share girder with RF structures

LIAR Beamline

- Representation of Beamline Imperfections
  - misalignments (x or y)
    - uncorrelated, Gaussian-distributed, by element or by girder/support
    - correlated, generated by ATL motion
  - Errors
    - quad strength or rotation
    - x/ycor strength or rotation
    - bend strength or rotation
    - RF structure amplitude or phase
  - Resolution limits of quad movers and BPMs

LIAR Representation of the Beam



- Beam is a series of "Macroparticles," each of which
  - Has 6 first moments (x,x',y,y',z,E)
  - Has 10 second moments (4x4 x/y sigma matrix)
  - Has a charge
  - Full beam with RMS length/espread represented by group of macroparticles
  - Bunch trains permitted

LIAR Diagnostic/Correction Capabilities

- Multiknobs
  - hand generated by user, can include magnet or RF structure parameters
  - Tuning algorithm deterministic (different from realistic “move it around and seek best value” approach)
- Reference Orbits
- Feedbacks
  - no time-response information
  - Implementation somewhat different from “conventional” beam-based steering feedbacks
- Assorted steering algorithms
  - 1:1 with correctors
  - assorted magnet-mover based methods
    - various tunable parameters
  - DF steering
    - designed for SLAC linac, not easy to apply in general
- Automatic loop over seeds and save end-beamline emittances, etc.

LIAR Limitations

- No multipoles above quadrupole
- Beam representation not amenable to tracking through high-order multipoles
- Bunch length fixed throughout beamline
- "Hard-coded" for all RF structures very similar
  - only 1 SRWF, loss parameter at any given time
- Management of LRWFs cumbersome
- Written in FORTRAN-90
  - has advantages and disadvantages
  - difficult to add new tuning method without modifying code – nice to be able to do "quicker" and "dirtier" (and "more private") studies

The Big Structural Changes

- MATLAB-LIAR interface
  - All of LIAR can be executed as a MATLAB subroutine
  - MATLAB has read/write access to LIAR beam/lattice data
  - Can write simulations where
    - LIAR tracking generates data (BPM readings, etc)
    - MATLAB routines read data, decide correction, apply correction to LIAR beamline
  - Example: studies of NLC steering feedbacks with time-dependent behavior included

Structural Changes (2)

- LIAR-DIMAD interface
  - allows change in beam representation from LIAR mode to DIMAD mode (zillions of point-particles)
  - Tracks using DIMAD tracking engine
  - Permits use of high-order multipoles
  - Can be converted between different representations at will
  - Complete beamline information interfacing between 2 tracking engines – “transparent to the user”
  - Allows bunch compression
  - NB: DIMAD mode does not permit change in design energy or wakefields (switch back to LIAR mode for RF structures)

Structural Changes (3)

- Vast improvements in RF structure management
  - up to 10 different short-range wakes permitted
  - up to 10 different long-range wakes permitted
  - much-improved management of loss parameters and long-range transverse wakefields (inc. error wakes)
- Can have interleaved structures, vastly different structure types (L-, S-, X-band) in one beamline

New Features

- Bend magnets
  - all those parameters (K1, K2, H1, H2, fringe field integrals) allowed
  - Dispersion handled better
  - Improved (?) R-matrix and field-error handling
  - Gradient bends
- Ground Motion models
  - The entire Seryi GM model now included in LIAR
    - wavelike motion – P(ω,k) parameters
    - diffusive (ATL) motion
    - Systematic (ATTL) motion
    - Can represent 2 beamlines pointing at each other and properly represent the correlated motion!

New Features (2)

- Correlation plots
  - scan multiknob, measure beam size at a marker, look for the best value
- Generation of closed orbit bumps
- More general DF Steering algorithm
- Effects of tilted (yawed/pitched) RF structure or support

Still To Come

- More GM features
  - resonant girders, FD stabilization
- LRWF angle wakes (maybe!)
- Debugging, debugging, debugging
- Documentation, documentation, documentation

Do We Need It?

- Incoherent Synchrotron Radiation
- Detector Solenoid
- Definition of girders/supports/movers in beamline definition file
  - presently done inferrentially in LIAR