NLC - The Next Linear Collider Project

"Now Bliss is Everywhere..."

Static Tuning Simulations

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Motivations

• Interest in performing beam tuning simulations on all of LC design
  – historically concentrated on main linac
  – some activity in BDS, BC regions
  – Helpful to have a single “tuning” code for the job

• Seek to study interaction between tuning algorithm and other effects
  – “Does a tuned-up beamline respond to ground motion the same way as a nominally perfect one?”
  – Small beam distortions have big lumi impact – “Banana Instability”
Motivations (2)

• Some problems can only be studied properly with an integrated beamline
  – example: ground motion – actually need 2 beamlines pointing at each other!

• Technical Review Committee (TRC)
  – Luminosity WG, Low-Emittance Transport (LET) sub-WG: considering BC-to-IP performance in unified manner
  – “...members of this group...should set common standards and use common computer codes to predict emittances...” (from the charge)
Historical Note:

SAD FFTB study from 1989 -- K. Oide

Same general idea -- all errors included, tuning simulated
The Codes Issue

- Codes typically used for LC work @ SLAC:
  - LIAR
    - Designed for simulation of tuning & errors
    - Can’t handle bunch compression, sextupoles, or higher multipoles
  - DIMAD
    - Good at high-order optics, includes bunch compression
    - Poor linear accelerator code (no transverse wakes), poor for tuning simulations
  - GUINEAPIG
    - Commonly-used beam-beam code
    - doesn’t do any other beam dynamics!
The Grand Synthesis

- **Assimilate DIMAD tracking engine into LIAR**
  - use DIMAD for bunch compressor bends, beam delivery
  - use LIAR for BC RF, linacs
  - “seamless integration”

- **Use GUINEAPIG to compute luminosity from LIAR/DIMAD runs**

- **Run everything under MATLAB**
  - take advantage of MATLAB graphics, scripting, etc.
  - “LIAR is the accelerator and MATLAB is the control system”
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The Grand Synthesis -- Example

- NLC run – DR exit to IP

- Uses LIAR with DIMAD tracking options
  - Bunch is compressed
    - $R_{56}$ properly represented
  - Energy spread is right
    - wakefields properly handled
  - Beam sizes are right
    - chromatic correction works
Single-Bunch Static Tuning: Plans

- Complete first iteration of region-by-region algorithm tests
  - compare results to NLC Emittance Budget
  - Iterate as needed
- Assemble “end to end” tuning simulation
  - concatenate regional tuning sims, with appropriate adjustments

- Test-drive the TESLA tuning algorithms

- Compare NLC and TESLA tuning sims with same by other TRC Members / Codes
A Few Words on TRC’ing

- **TESLA, NLC, CLIC groups** working feverishly to perform tuning studies
  - some more feverishly than others

- **First step: tune up the linac**
  - realistic and documented initial errors
  - documented instrumentation performance
  - documented algorithms

- **Nobody is there yet!**
  - **NLC:** Tuning 250 GeV/beam linac to “LTB” point, got \(<\Delta\gamma\varepsilon_y>\) ~ 21% w/o emittance bumps!
  - **TESLA:** tuning 250 GeV/beam linac to end, got \(<\Delta\gamma\varepsilon_y>\) ~ 70% w/o emittance bumps
What is the “NLC Linac?”

- 7.87 GeV $\rightarrow$ 250.0 GeV acceleration
- 6 km bypass line + injection/extraction
  - “full-length tunnel, half full of structures”
- Diagnostic section ("EBSY", technically considered part of BDS)
  - contains end-line wire scanners – very useful!
“Realistic” Errors

- **Quads**
  - 0.25% RMS strength
  - 200 urad RMS roll
  - 150 x 50 um RMS offset from survey line

- **Structures**
  - 25 um RMS y offset
  - 33 urad RMS pitch
  - $x$ errors = 3 $\times$ $y$ errors

- **Girders**
  - 50 um RMS y offset
  - 15 urad RMS pitch
  - $x$ errors = 3 $\times$ $y$ errors

- **Q-BPMs**
  - resolution: 0.4 um for 0.75x10$^{10}$, linac-style Q-BPMs
  - scales with BPM aperture
  - 5-25 um offset to quad center (EM or PM)

- **S-BPMs**
  - 5 um resolution

- **Sexts**
  - 150 x 50 um offsets
  - 0.7% strength
  - 200 urad tilt
  - 15 um center position uncertainty
Tuning the Linac

- **Techniques:** mover steer to zero BPMs, then DF steering
  - vary linac energy gain
  - do all variation upstream of region to be DF steered – steered region is at nominal conditions (except for incoming beam energy)
  - Tested on 1st half linac only (accelerating half)

- **Got down to** $<\Delta \gamma \varepsilon_y> \sim 21\%$ w/o emittance bumps!
• **TESLA also requires BBA in main linac**
• **Sensitive to:**
  - beam-to-quad offsets
  - structure tilts
  - structure offsets
• **Using “every trick in the book,” got to**\( <\Delta \gamma \varepsilon_y> \sim 97\% \)
• **Simple bumps not helpful (odd...)**
TRC: Next Steps

- **NLC**: complete linac tuning
  - tune LTB, bypass, BTL, EBSY lines
  - include emittance bumps

- **TESLA**: understand poor results