A First Look at MPS Issues in the NLC BDS

PT
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1. Introduction to NLC BDS Optics

The beam delivery system of the NLC includes the Collimation section, IP Switch, Big Bend, and Final Focus, as well as some diagnostic and tuning regions

- Collimation Region: 2 phases x 2 planes x 2 times; tightest apertures in entire machine after DRs; enormous $R_{34}$ terms (41 km), but also large $\beta$ functions

- IP Switch, Big Bend, diagnostic regions: more normal beta functions and $R_{34}$ terms

- Final Focus: large beta functions but normal $R_{34}$ terms (almost all quads are in the FD phase); contains final FD-phase collimation/absorbers (at CCX and CCY sextupoles)
NLG BDS betatron functions

\[ \beta_x', \text{ meters} \]

\[ \beta_y', \text{ meters} \]

\[ z, \text{ meters} \]
SQRT(beta functions), NLC BDS

\[ \beta_x^{1/2}, \text{meters}^{1/2} \]

\[ \beta_y^{1/2}, \text{meters}^{1/2} \]

\( z, \text{meters} \)
Original design called for large number of MPS spoilers, similar to original Linac MPS concept. Due to large energy spread from longitudinal wakes, these were abandoned.

Present system is basically all-active, relies on having large enough MAIDs to avoid trouble.

Assumptions made in this study:

- A full train striking anything other than a Collimation system spoiler will cause damage

- Primary object of MPS is to avoid beam striking a magnet (here, quad or sextupole) head-on; avoiding glancing-angle impact or protecting absorbers secondary issues

- Some number of quasi-sacrificial absorbers can be used
2. Quadrupole misalignments

Misalignments can be due to a magnet mover or a turn-to-turn short problem.

Goal: have a system wherein any changes which endanger quads occur slowly enough to be caught by MAID system (BPMs or ion chambers).

How bad are shorts? M. GYR of CERN concludes that a 1-turn short on an N-turn per pole quad will shift the neutral axis along the “u” or “v” axis of the quad by an amount:

$$du = \frac{a}{(4N-1)} \times (\frac{2}{\pi})^{1/2}$$

For a complete failure of a pole (“tripole” failure):
- For a layer-to-layer short: $du \sim \frac{a}{4}$ (N = 1)
- For a turn-to-turn short within a layer: $du \sim \frac{a}{9}$ (N = 2)
- $du \sim \frac{a}{120}$ (N = 24)

The BDS contains quads with a=5 mm, a=6 mm, and a= .5 mm (final focus).
BDS quad horizontal position MAID

MAID, m

z, m

0 1000 2000 3000 4000 5000 6000

10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}
Note that a quad is not constrained to move by exactly 1 MAID when it fails.

What happens if a quad moves several times the offset to hit a quad or collimator?

When the next pulse arrives, some element upstream of the “expected” target will get hit.

==> Need to protect every possible target from excursions of every quad, up to the point where the excursions are larger than any possible inter-pulse movement of the quad.

This requires “wake-free PC’s” -- PC’s which do not extend into the vacuum system past the ID of the vacuum pipes...
BDS quad horizontal position MAID, beams hitting quads

Solution with 18 round PC's
BDS quad vertical position MAID, beams hitting quads

Solution with 18 round PC's
3. Bend Magnet Strength errors

The bends in the BDS are weak due to synchrotron radiation concerns. Consequently, we expect that small bend errors will not lead to unacceptable oscillations.

Two types of errors are considered:

---> Single-magnet failures (due to shorts, etc)

---> Magnet string failures (due to PS problem, operational error, etc)
MAID in bend strength, individual bend magnets
MAID in bend strength, individual bend magnets

MAID, fraction of bend strength

- Hits spoiler
- Hits absorber
- Hits quad

z, m
MAID in bend strength, individual bend magnets, beam striking quads
4. Conclusions

- Quadrupole misalignment MAID is intimidatingly small (microns in some cases)

- By adding 18 round PC's inside bore of quads, MAID can be increased to ~100 microns or more for all quads

- Probably need a 2-tiered system: beam oscillations to detect small shorts or errant mover, ohmic detection of large shorts on the TS before the beam arrives

- Bend magnets are much less frightening: few bends have a MAID of <1%, bend strings are typically >10%

Future work:

- Determination of \( \rho \) limit for BDS

- Strategies for startup and recovery from MPS trips, SBD issues