BDS Change Request: Support of Single L* Optics Configuration Shared by both Detectors

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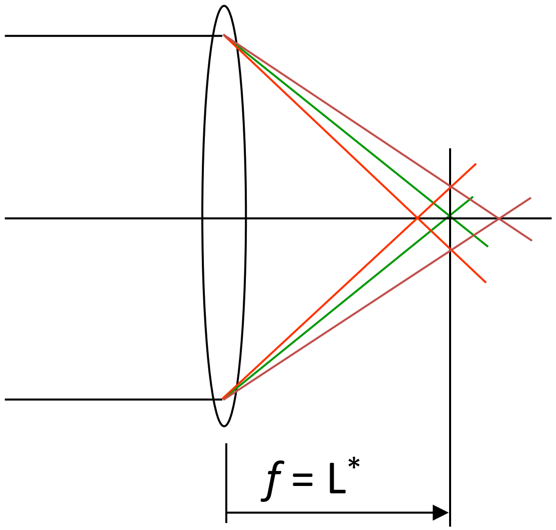
General Considerations / Comments

- Unequal L* is not a *fundamental design or cost issue*
  - We have feasible optics solutions!
- Primary issue is operational lumi performance and risk mitigation
  - harder to quantify, so arguments tend to be more fuzzy
- L* is a fundamental parameter that drives many critical design features of the BDS. As L* gets longer
  - Chromatic (and geometric) corrections become more challenging
  - Overall larger beta functions drive tolerances (field and alignment) become more demanding
  - Shielding IR from SR fan becomes harder
    - collimation depth becomes tighter for fixed IR apertures
    - tighter collimation tighter jitter tolerances from wakefields etc.
- Bottom line: for the accelerator, shorter is better, and
- Having different L* will cause significant tuning differences between detectors
  - both lumi and background
  - negative impact on push-pull recovery times
  - difficult to guarantee equal luminosity performance!

Effects of L*



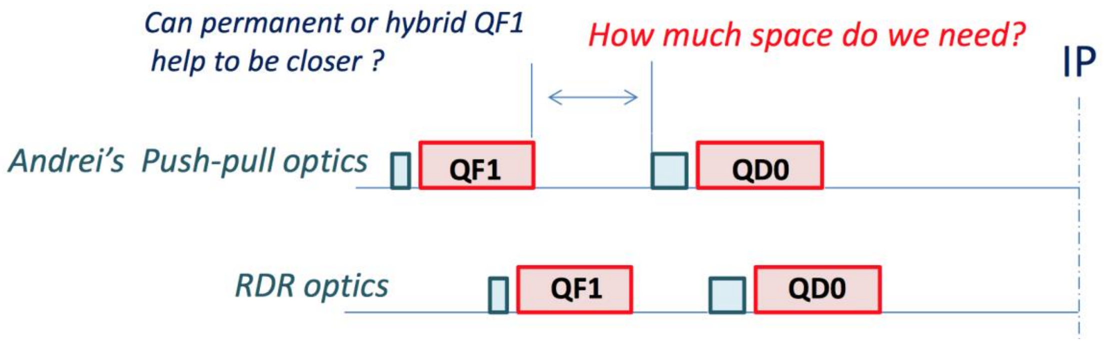
$\xi_y^* \equiv L^*_y / \beta^*_y$

$\Delta\sigma/\sigma \sim \sigma_E . L^*/\beta^*$

(9.0-11.6) *for ILC baseline*

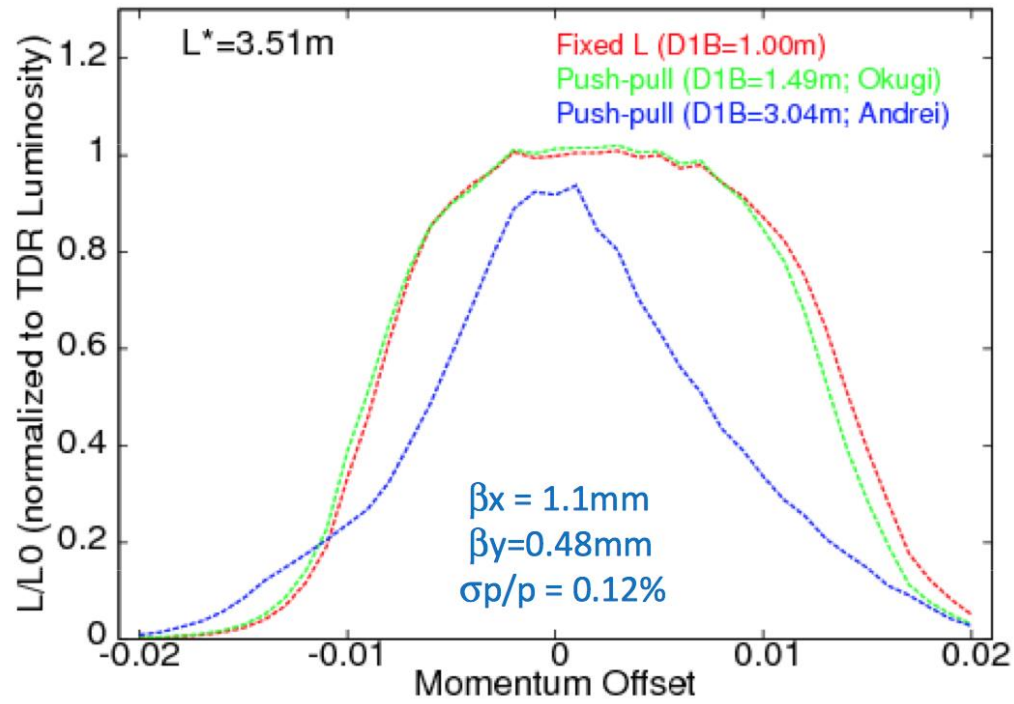
- Larger L* -> less (uncorrected) lumi through chromatic dilution of beam size
- Compensate with FFS optics design using high order magnets
  - Sextupoles, Octupoles
- Correction involves "balancing act" using quads, sextuples, octupoles to very precisely cancel chromaticity as well as up to 3rd or 4th order geometric & chromo-geometric terms introduced by the correction itself.
- Errors are introduced into lattice in real machine (alignment, finite accuracy magnet fields, unwanted higher-order field components in magnets, orbit errors etc) and must be compensated using pre-defined tuning algorithms based on experimentally observable parameters.
- In general terms, smaller L* = better expected luminosity performance.

QD0-QF1 Distance Consraint



T.Okugi

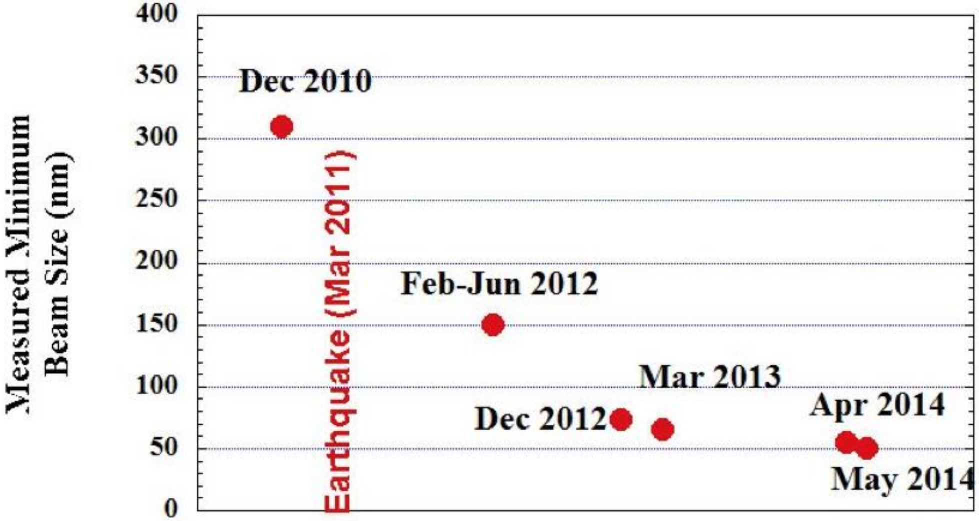
- Constraint of fixed QF1 position complicates "minimize L*" argument.
- Increased D1 distance degrades lattice performance
  - More detailed lattice studies required to determine optimum L*

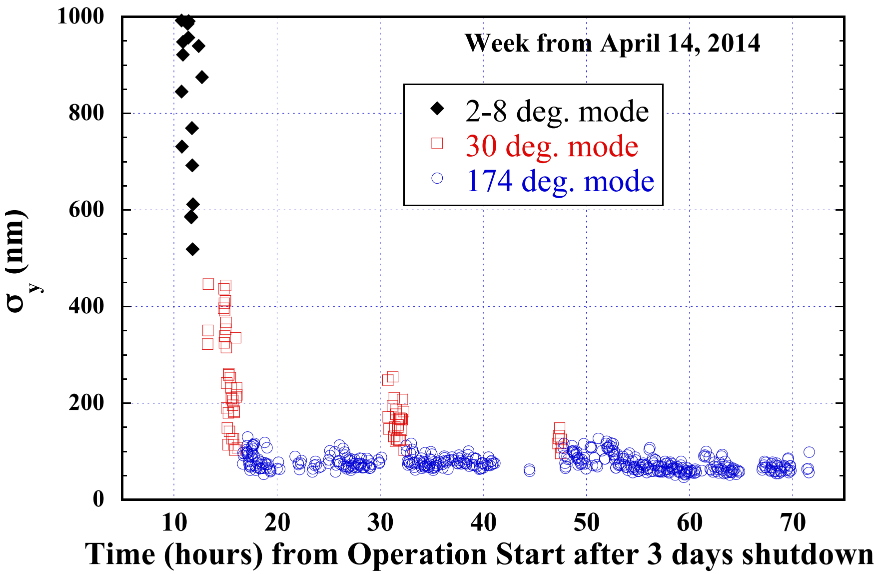


Impact of Changing L* Optics

- Errors (mis-alignemnt and field errors) within the FFS lead to a specific set of first and higher-order aberrations at the IP specific to the lattice configuration
- Tuning can be considered on 2 timescales:
  - (1) the few-hour (and then periodic to counter ground motion) application of multiknobs etc to maximise luminosity after some period of beam-off condition
  - (2) longer timescale period where the result of tuning iteratively gets better (ATF2 & FFTB experience has shown this behaviour).
- Change between L* configurations on periodic basis can be understood to be harmful in terms of losing the iterative work earned from (2).
- Impact will be measured as function of:
  - Function of (2)
  - Push-pull duration
  - Push-pull frequency
  - Luminosity tuning curve associated with (1)

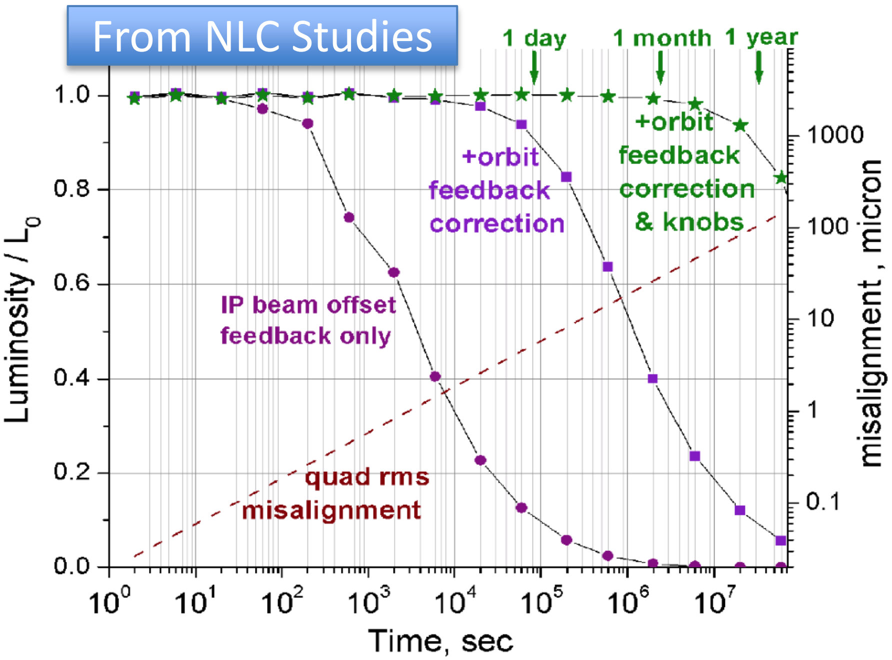
ATF2 Experience

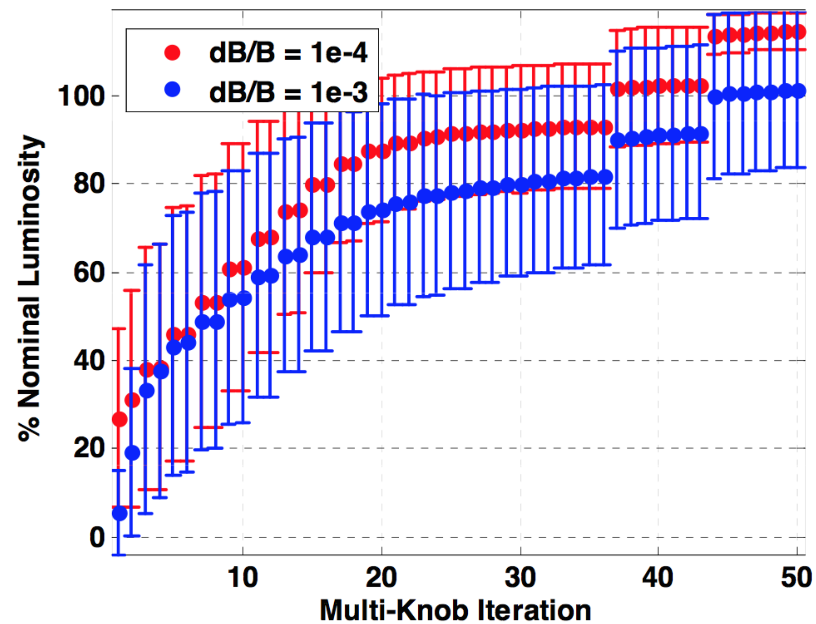




- Effects of “long-term” tuning efforts shown as beam size improvement over time (left plot)
- Time to re-tune after multi-day shutdown shown on right (~20 hours).
- Useful further information would be right plot with different chromaticity configuration (β_y^* optics)

ILC Simulations





- After O(1 day), orbit control no longer sufficient to regain luminosity, need complex tuning algorithms (using sextupole movers etc).
- Tuning very sensitive to lattice errors (e.g. magnet strength settings)
  - Expect degraded performance from changed lattice in recovery from push-pull operations.

Summary

- For least risk / optimal expected lumi from accelerator tuning, prefer single L* optics solution.
- Hard to quantify exactly
  - Can be done but requires a lot of resources on detailed lumi calculations from Monte Carlo beam dynamics simulations.
- Need swift decision to enable focusing of limited resources to fully develop BDS solution across existing TDR parameter sets.