ILC BDS / ATF2 Alignment and Tuning Simulations

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Overview

- Starting from post-survey alignment tolerances:
- Dynamic simulation of complete ILC BDS alignment and tuning with feedbacks.
- Confirm ILC nominal luminosity performance possible and sustainable.
- Lucretia modeling environment in Matlab used.
- Apply similar strategy to ATF2 lattice.

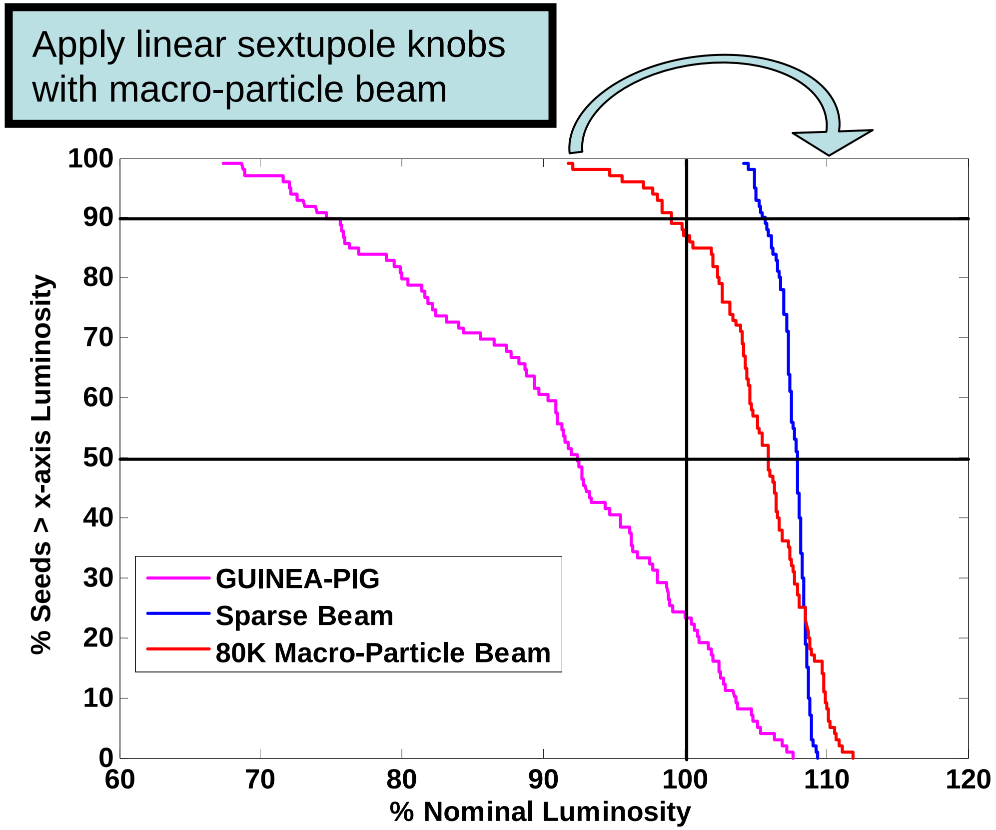
ILC Alignment and Tuning

- Switch off Sextupoles and Octupoles.
- Perform initial BBA using Quad movers and BPMs -> beam through to IP.
- Quadrupole BPM alignment.
- Perform Quadrupole BBA (DFS-like algorithm).
- Align Sextupole BPMs.
- Move FCMS to minimize FCMS BPM readings.
- Align Octupole BPMs.
- Activate sextupole and octupole magnets.
- Rotate whole BDS about first quadrupole to pass beam through nominal IP position or iteratively move FCMS and re-apply DFS BBA.
- Set reference orbit for 5 Hz feedback.
- Apply sextupole multiknobs to tune out IP aberrations and maximise luminosity.
- 5-Hz feedback system used throughout to maintain orbit whilst tuning. Errors are from finite BPM res. + lumi measurement, no GM or magnet jitter yet.

Error Parameters

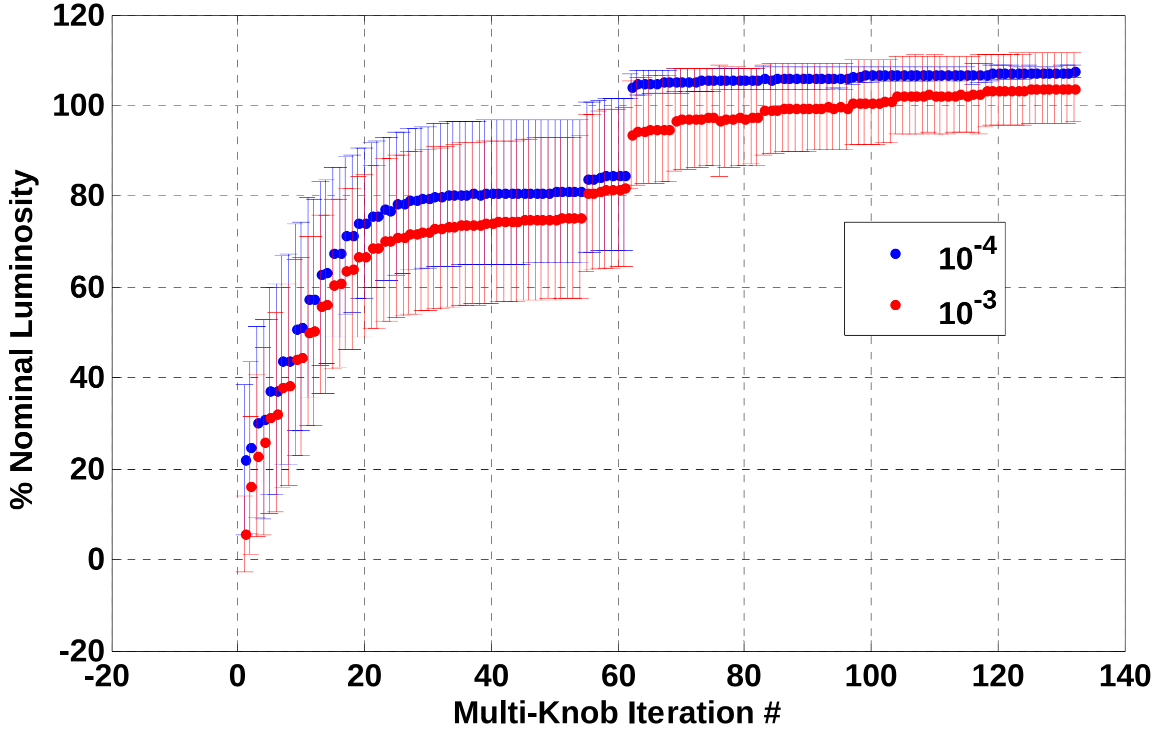
Quad, Sext, Oct x/y transverse alignment	200 um
Quad, Sext, Oct x/y roll alignment	300 urad
Initial BPM-magnet field center alignment	30 um
dB/B for Quad, Sext, Octs	1e-4
Mover resolution (x & y)	50 nm
BPM resolutions (Quads)	1 um
BPM resolutions (Sexts, Octs)	100 nm
Power supply resolution	14 - bit
FCMS: Assembly alignment	200 um / 300urad
FCMS: Relative internal magnet alignment	10um / 100 urad
FCMS: BPM-magnet initial alignment (i.e. BPM-FCMS Sext field centers)	30 um
FCMS: Oct – Sext co-wound field center relative offsets and rotations	10um / 100urad
Corrector magnet field stability (x & y)	0.1 %
Luminosity (pairs measurement or x/y IP sigma measurements)	0.1 %

Post-tuning luminosity results (100 random seeds)



- Geometric lumi calculated from final beam distribution after tuning with sparse beam representation for sparse and macro-particle beam and calculated with GP using macro-particle beam.
- Applying linear knobs to worst 80K-beam seed takes lumi to ~110%.

Comparison of 10^{-3} / 10^{-4} Magnet Strength Errors

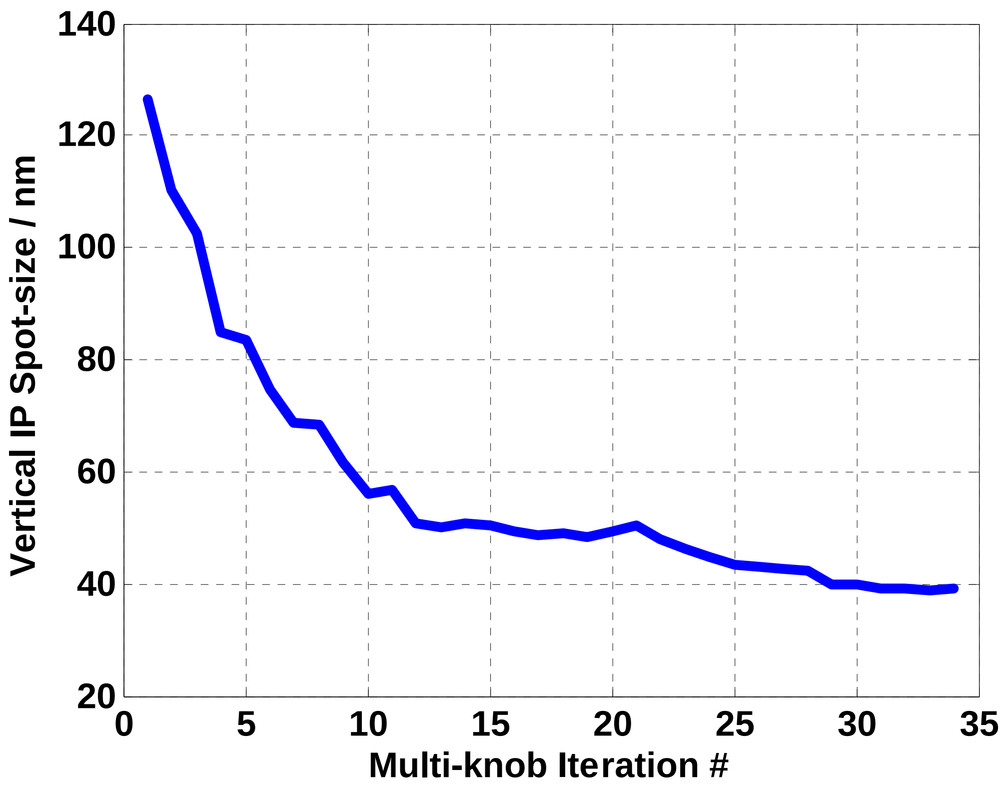


- Larger spread of initial + final errors and slower convergence rate for case of 1e-3 magnet strength errors.
- Only 75% of 1e-3 seeds exceed nominal lumi after tuning.
- For one seed, lumi increased beyond 100% nominal by extending number of linear tuning iterations.

ATF2

- For ILC, tuning performed using signal from IP luminosity monitor.
- For ATF2, one possibility: use Shintake-monitor and tune on vertical spot-size.
  - Recent presentation by Suehara- goal of 2nm precision using 90 bunches @ 1.5Hz = 1 min.
- See if the tuning can be done on a realistic timescale and required beam size achievable.

ATF2 Simulation (1 seed)



- Using ILC initial error parameters and initial normalized emittances, 6um (x), 30nm (y). Apply initial magnet-BPM alignment & BBA.
- Apply tuning steps, ignoring horizontal spot size- apply vertical dispersion and waist + coupling knobs (<x'y> using Sextupole moves, <xy> with orthogonalised skew-quad scan) + Sextupole tilt & dK scans.
- Final result ~10% larger than with perfect lattice (35nm).

ATF2 Results

- <40nm vertical spot size achieved in ~35 knob iterations.
- Each iteration requires a number of IP waist scans as the knob is scanned (~6).
- If 1 min. per scan => ~3 ½ hours to tune (if completely automated).
- No GM or magnet jitter added yet
  - will degrade accuracy of IP spot-size measurement increasing # of knob iterations.
- Also need to run multiple seeds.