Beam Dynamics IR Stability Issues

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September 18 2007

IRENG07

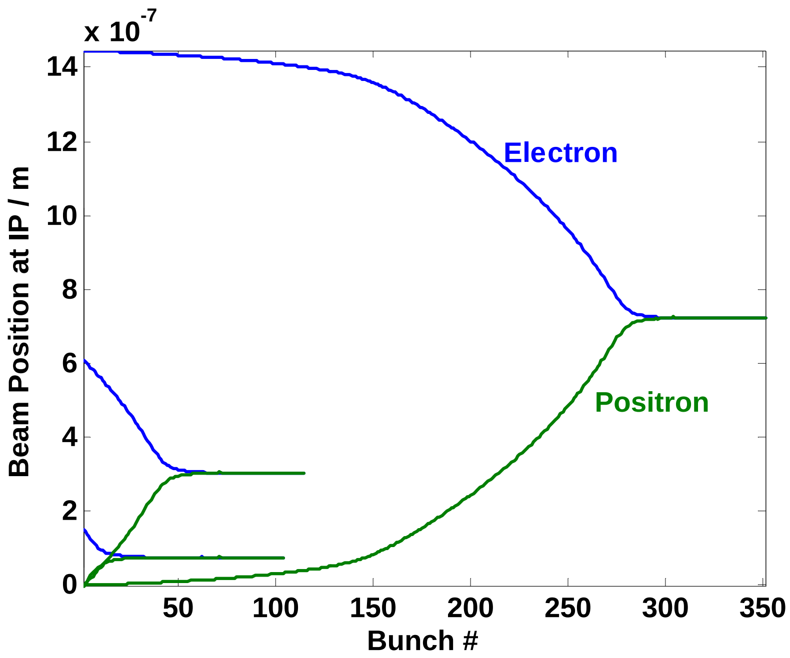
- Vibration tolerances for final doublet cryomodules
- Settlement of detector (effect of ~mm shift in desired IP)

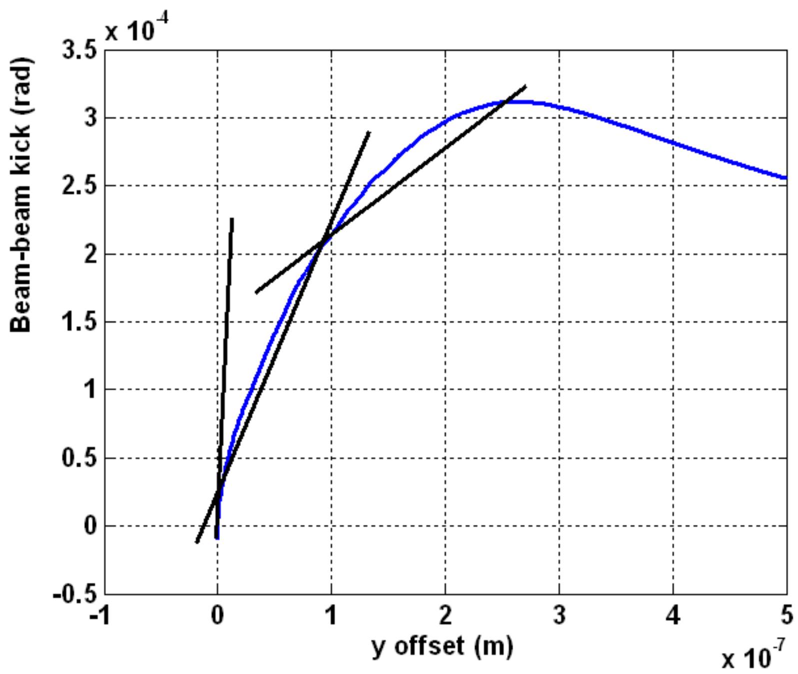
Final Doublet Stability

- Asses jitter tolerance on cryomodules containing QF1/SF1 + QD0/SD0.
- Use Lucretia + GUINEA-PIG to measure LUMI loss criteria for magnet offsets with IP fast-feedback compensating.
- Luminosity degrades with increased offset through 2 effects:
  - time required for feedbacks to converge
  - IP beam aberrations induced as a result of off-axis passage through sextupoles.

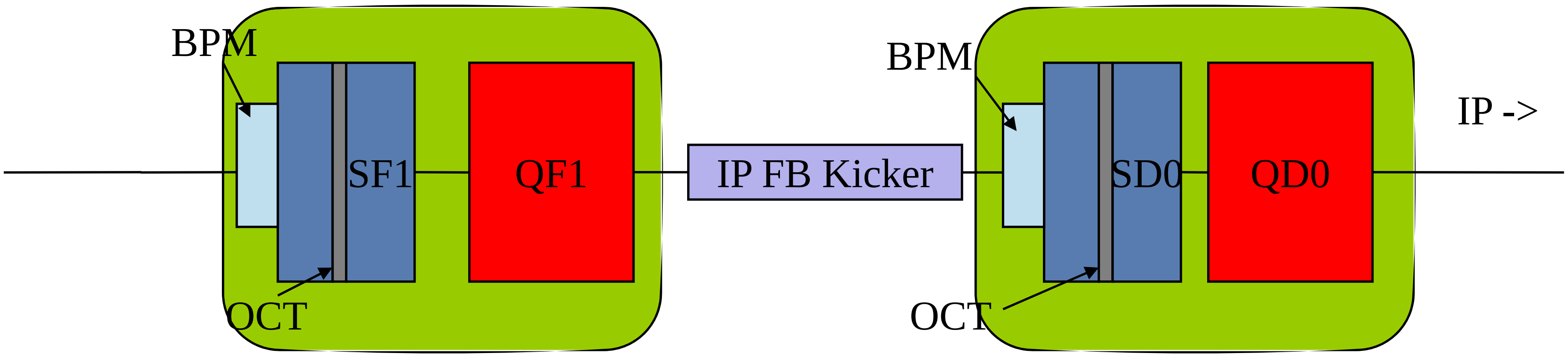
IP Fast-Feedback

- Use ILC IP FFB, tuned for ‘noisy’ conditions
  - Less than 5% lumi-loss with GM ‘K’ + 25nm component vibration (pulse-pulse) & ~ 0.1 sigma intra-bunch uncorrelated beam jitter.
- Assume BDS-entrance FFB has perfectly flattened beam train (flat trajectory into Final Doublet).
- No ‘banana’ effect on bunches.
- Calculate Luminosity from measured bunches, with mean of last 50 weighted to account for the rest of the beam train (2820 bunches).



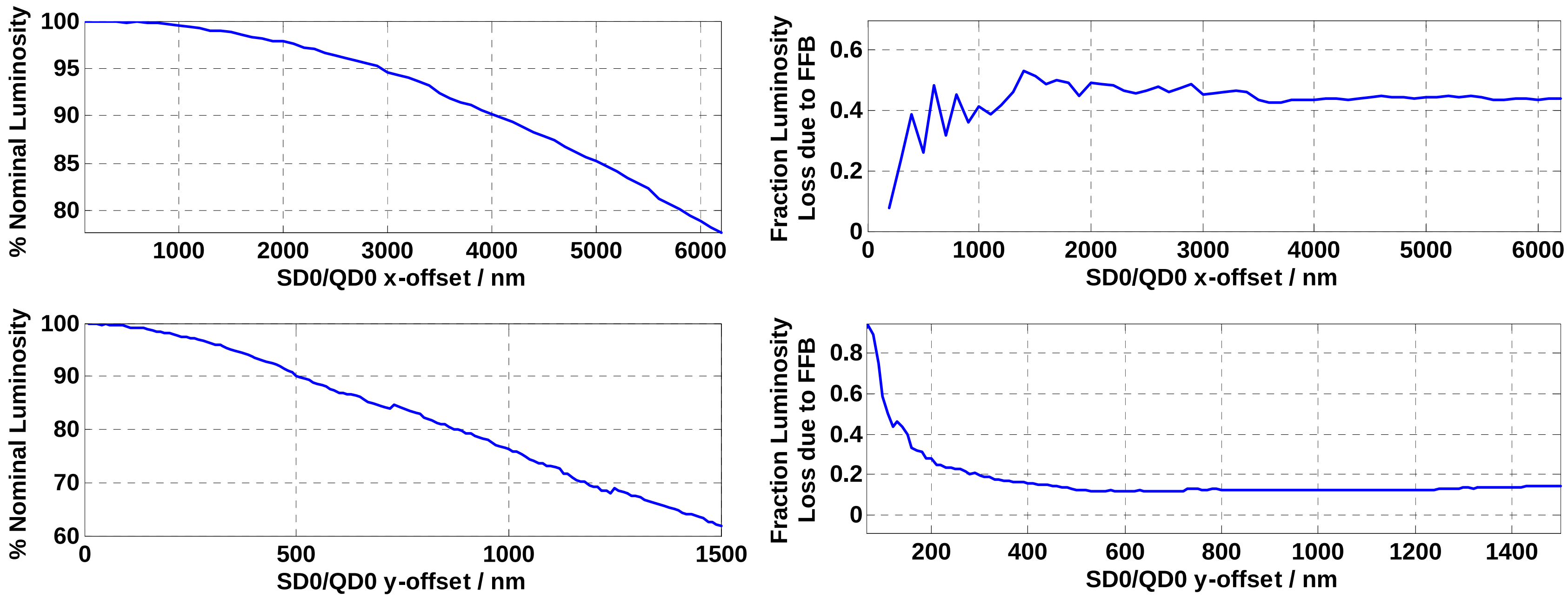


Modeled Final Doublet Layout



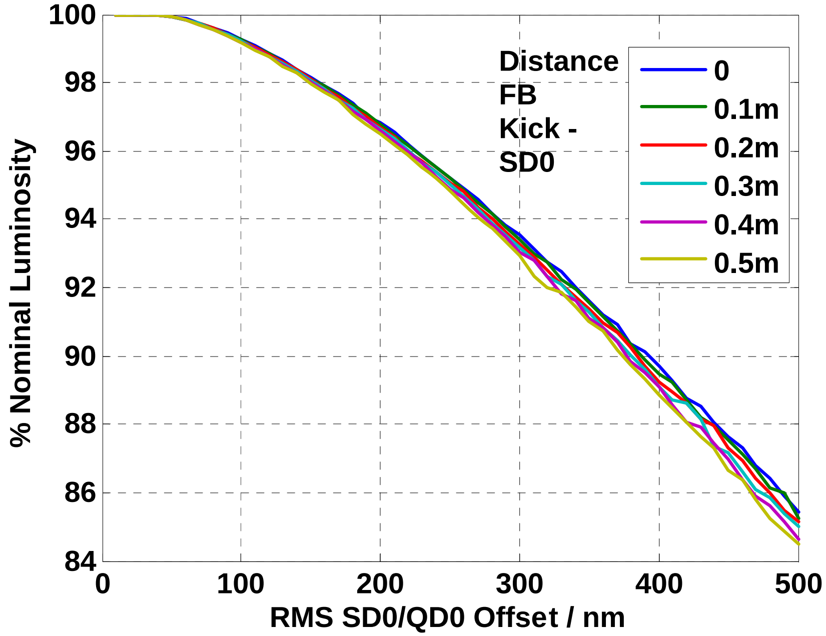
- IP FFB kicker (~1m) gap between 2 cryomodules near IP.
- Distance of kick from SD0 face affects lumi as beam is kicked off-center through SD0.
- Advantage to using shorter kicker?

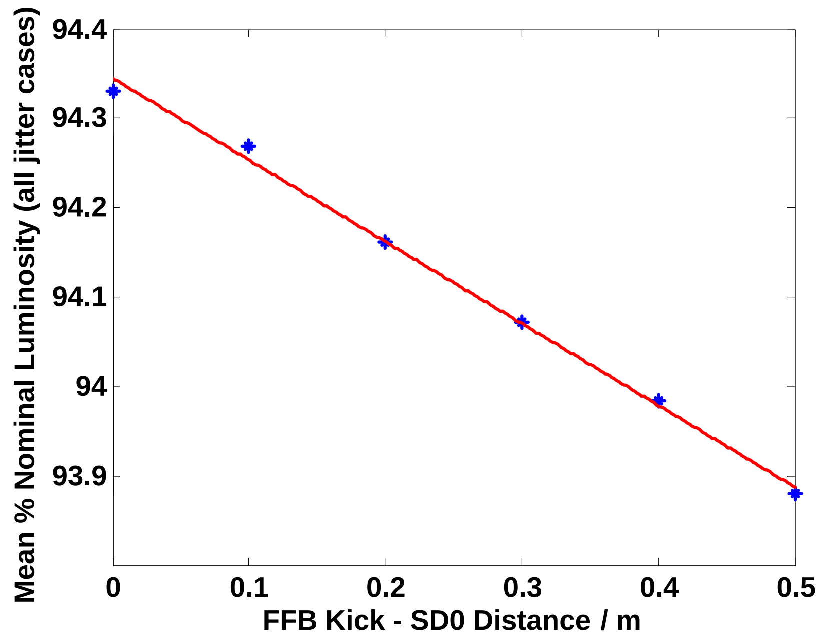
Effect of SD0/QD0 Offset



- Luminosity loss as a function of SD0/QD0 offset and relative importance of offset through SD0 vs. IP offset.
- Shows beam size growth through offset SD0 dominant over FFB beam offset conversion time (more so in vertical plane).
  - e.g. for y at 500nm offset, ~85% of luminosity loss through beamsize growth effect, 15% through conversion time of FFB system.

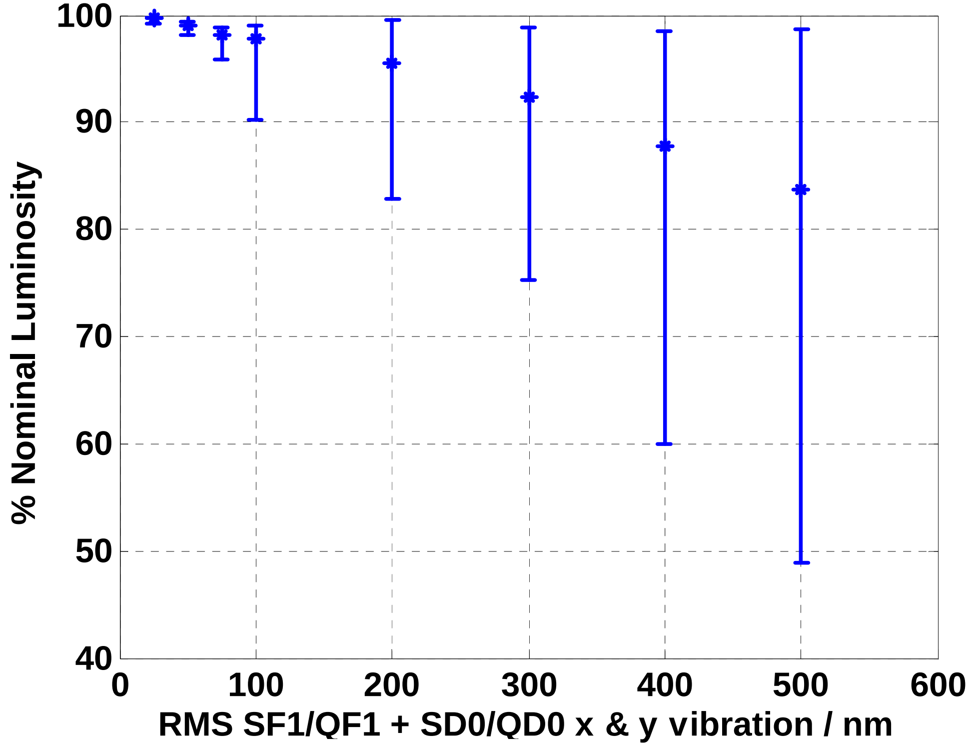
Luminosity vs. QD0/SD0 RMS Jitter and Kick Distance





- Calculate Luminosity loss for different jitter / kick distance cases using ‘SD0 lumi loss’ and ‘FFB lumi loss’ look-up tables (horizontal + vertical).
- Left plot shows % nominal luminosity with given RMS SD0/QD0 jitter and varying kick-SD0 distance.
- Right plot shows all jitter cases plotted vs. kick distance and shows the expected dependence on kick distance.

Tracking Simulation Results with RMS Offsets of both Final Doublet Cryomodules



- Track 80K macro particles (e- & e+ side) from QF1 -> IP with RMS SF1/QF1 and SD0/QD0 vibration in horizontal and vertical planes.
- Results show mean and range of luminosities from 100 consecutive pulses.

Vibration Tolerance Summary

- Added luminosity loss due to jitter of final doublet cryomodules (>5% @ ~200nm RMS) .
  - Needs to be convolved with ‘background’ environment of GM and other jitter sources.
- Results are worse-case here where everything else is perfect, other errors (e.g. non-linear train shape) will mask this effect to some degree.
- Small effect due to kicker distance from SD0, becomes more pronounced in cases with larger RMS jitter.
- Simulations of BDS tuning show something like ~10% overhead in luminosity after initial tuning. All dynamic lumi-reducing effects should total less than this.
  - Remaining luminosity overhead dictates how long ILC can run before some (online) re-tuning required (~ 3 days with current assumptions).

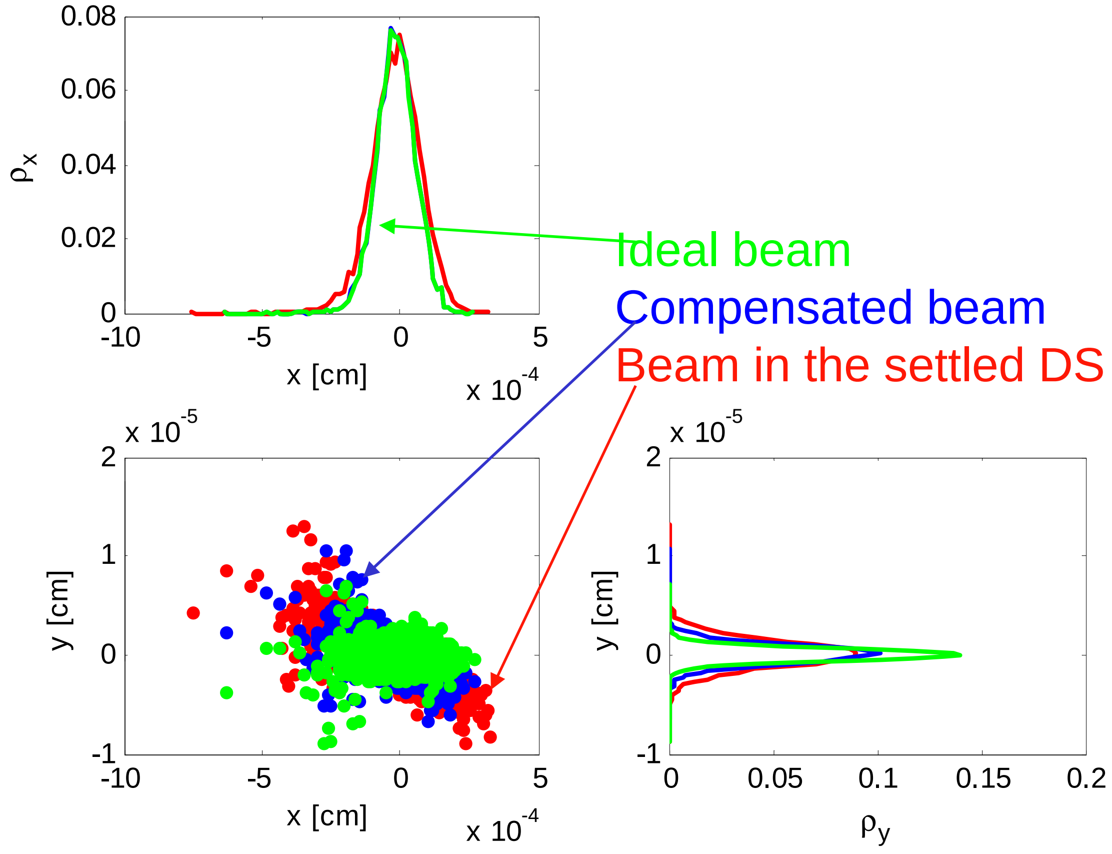
Settlement of Detector (IP)

- Effect of IP moving up or down by ~mm's per year? Assume settlement isolated to IP (+ QD0/SD0).
- If want to keep collision point at same physical location w.r.t. detector, need to periodically re-align BDS.
- How often? – What is tolerance of absolute collision position w.r.t. detectors from physics perspective?

Doing Nothing

- Can we do nothing? (Leave IP in a shifted location w.r.t. detectors)
- Would need to at least move QD0/SD0 cryomodules. Presumably get info on how far IP has shifted from detector vertex reconstruction?
- Beam offset w.r.t. detector solonoid a problem?

DS "sags" by, say, 1cm per year... (S. Seletskiy)



- In case of 1 cm sag of the DS we expect to obtain the increase of both x and y beam sizes.
  - σ_y/σ_{y0}: 1.5 => 2.2
  - σ_x/σ_{x0}: 1 => 1.3
- The trajectory in the IP will get shifted by dx=90um and dy=70nm.

- Such small changes occurring in 1 year can be easily compensated.
- PS: all simulations are done for SiD, L*=351cm.

Impact of BDS Realignment

- Rotate 2 sides of BDS starting at first quadrupole (QMBSY1) to collide beams at desired IP location using magnet movers.
  - Need range of movers ~ few mm (more closer to IP).
  - Compensate for change in IP y' offset with IP y' FFB kicker:
    - Required correction ~0.5urad per mm IP drift. Current design of kicker required to provide up to ~100urad IP y' kick.
- Degrades lumi through added IP dispersive effects due to required angle change + finite resolution of movers perturbing orbit.
- IP vertical beam spot degrades ~0.3nm (~6%) per mm IP drift (perfect mover resolution).
- Can correct with IP tuning knobs (which have to be applied every few days to combat ground motion and component jitter effects anyway).
- Following a drift rate of ~1mm / year looks bearable, something like 10mm / year may be more tricky (would need more detailed studies with simulations).
- What about beam position in outgoing beam pipe in FD cryomodules given intention to move modules ~mm's?