Luminosity Issues for LC BDS

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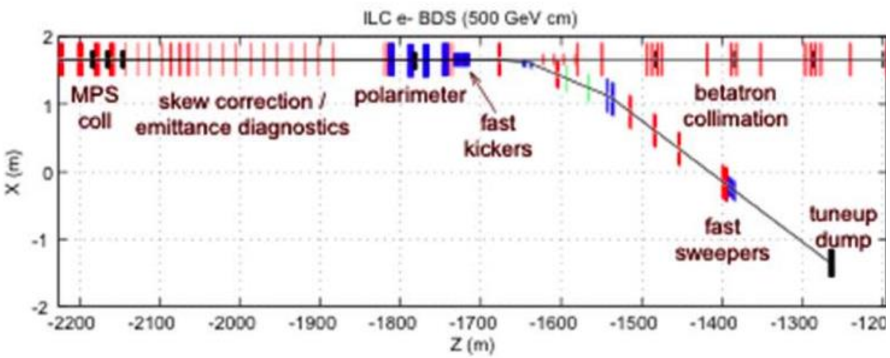
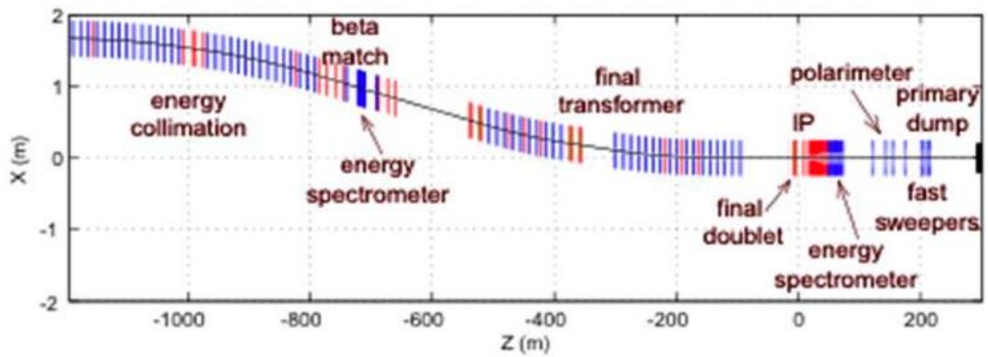
Overview

- Consider luminosity issues for the Beam Delivery system of LC (ILC & CLIC)
- List of issues, where is further effort warranted? Experimental tests?
- A list for consideration and some (personally) highlighted topics…

BDS Layout





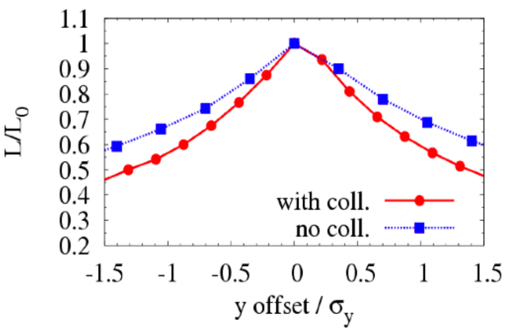
- FFS injection
  - Buffer FFS from linac changes
    - dispersion, coupling, matching
    - Need to specify dynamic range of corrections acceptable to FFS from integrated tuning simulations
  - Collimation
    - Wakefields
- FFS <- ***most issues here***

Low-emittance matching into a FFS experience ongoing (ATF2, FACET)

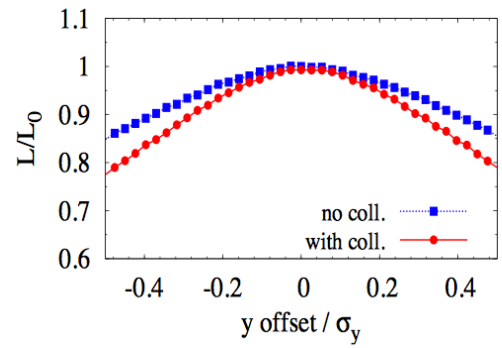
Collimator Wakes

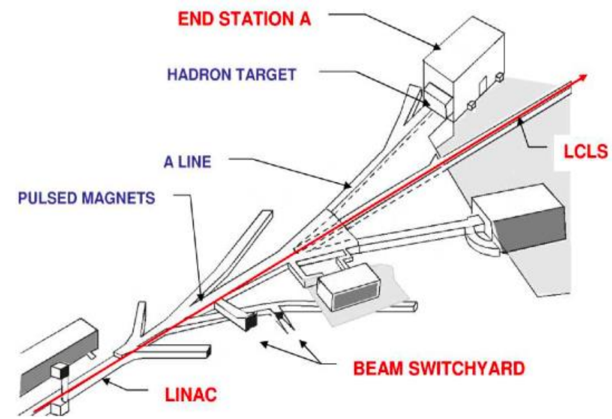
J. R-Lopez et. al. (IFIC) – ILC/CLIC wakefield collaboration

ILC (nominal)

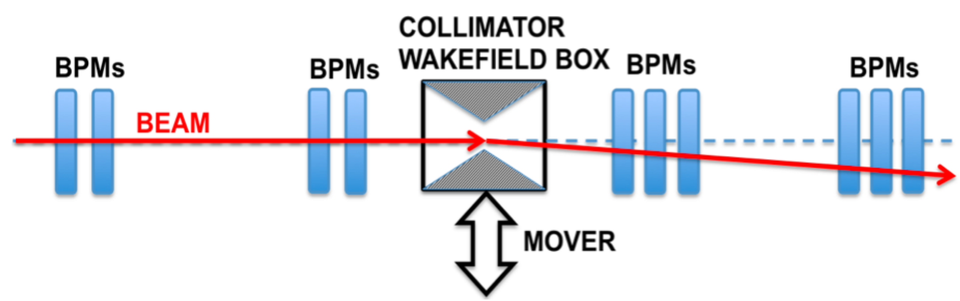


CLIC (nominal)



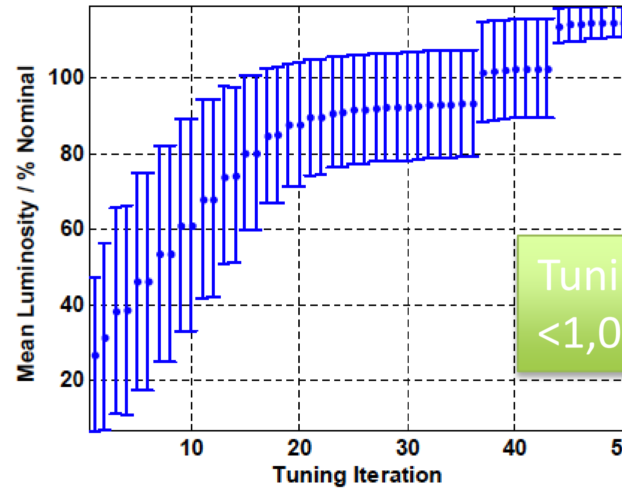


- Collimator wakes are important luminosity loss source
  - Tightens tolerances on orbit control in BDS
  - Present assumptions included in tuning simulations -> seems OK
- Important to verify wakefield calculations
  - Past and future test plans @ SLAC ESA with ILC & CLIC bunch length profiles ~15GeV ??
  - Also possible future halo collimation studies @ ATF2

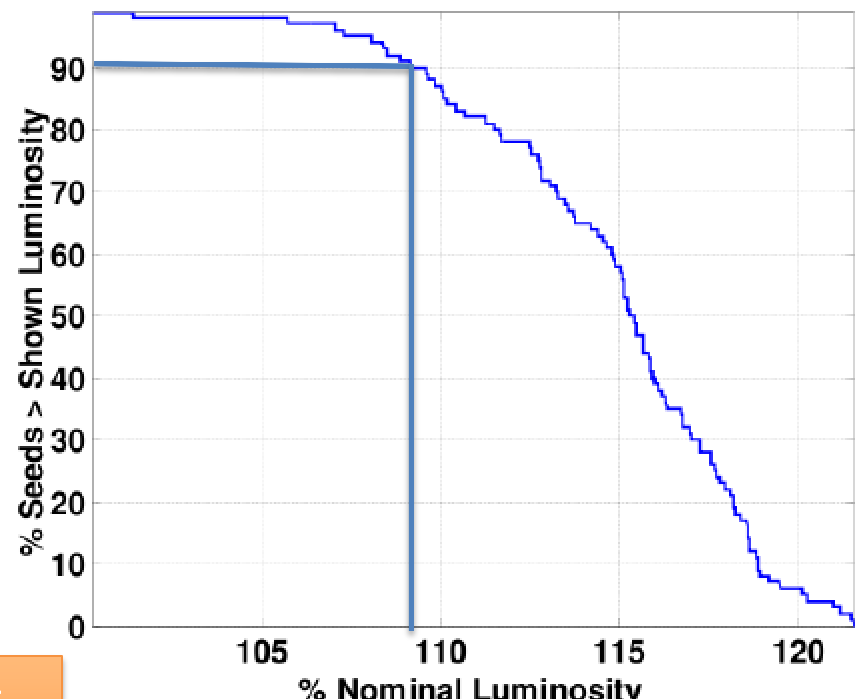


"Start-end" Simulations *(ILC)*

- ILC RDR parameters
- Start-end tuning procedure
- 90% seeds tune with 8% overhead
  - Includes pulse-pulse dynamics + FB's
  - Excludes "fast effects" @ IP
- Expect ~90% seeds to provide nominal luminosity
  - Including IP high-bandwidth feedback for worst possible conditions
- Need to update for TDR parameter sets
- 2-sided simulations
  - ILC RDR 2-sided sim: 90% seeds @ 85% lumi
    - Needed to expand sim time



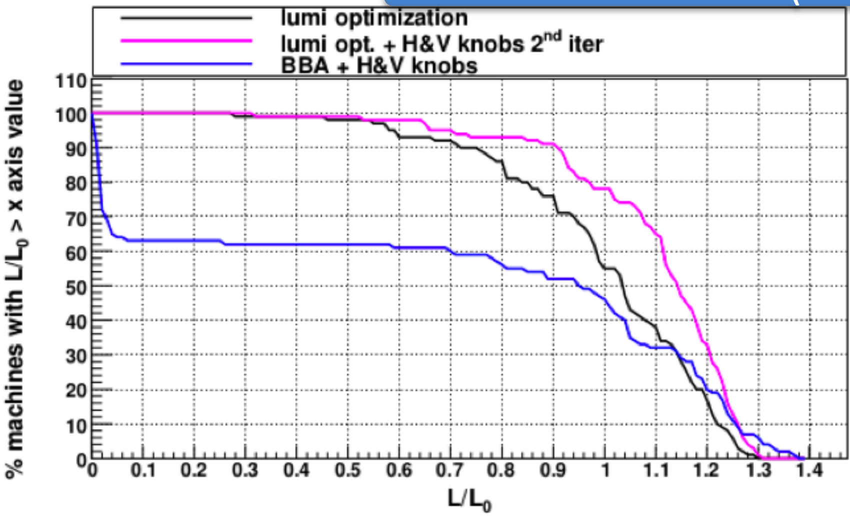
Tuning time <1,000 pulses

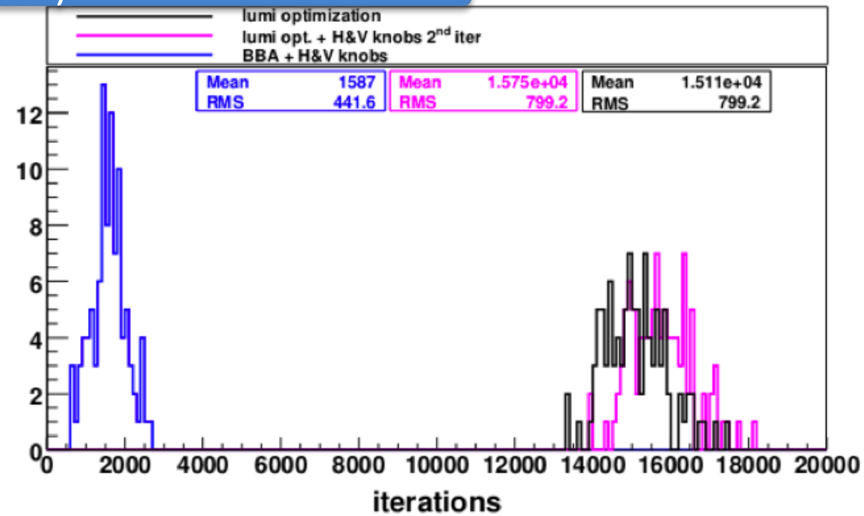


Tunable with worst-case GM, pessimistic linac behaviour & simplistic correction techniques

“Start-end” Simulations *(CLIC)*

(CLIC CDR)



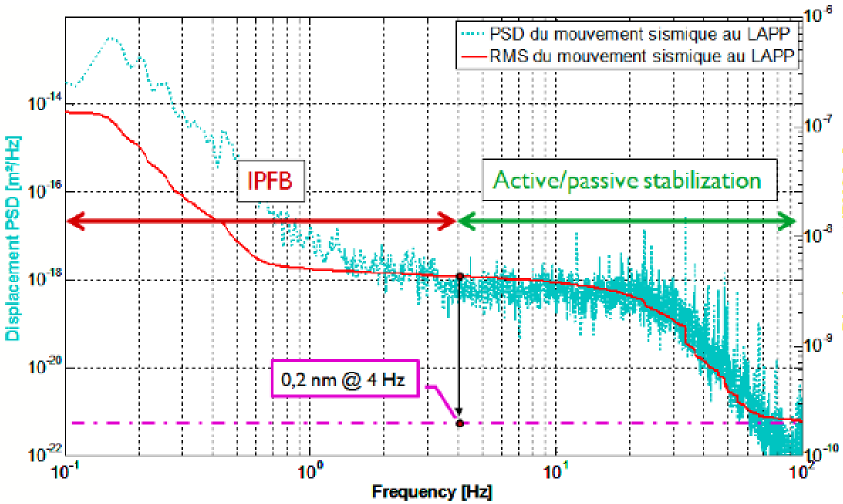


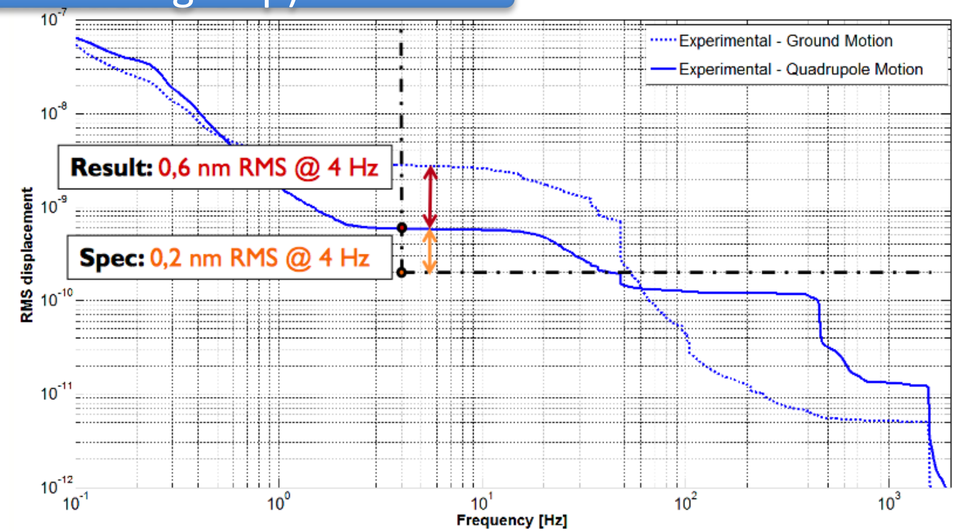
- Convergence to 90% lumi for 90% seeds with 18,000 iterations
  - About 1 hour if fully automated and fault-free
- Expect to improve >100% lumi if include non-linear knobs

- Important to demonstrate tunability to >100% to allow overhead for additional effects
- Desirable to gain experience fully automating beam-based tuning procedures (ATF2?)

Combined Feedbacks…

(CLIC QD0 Stabilization group)



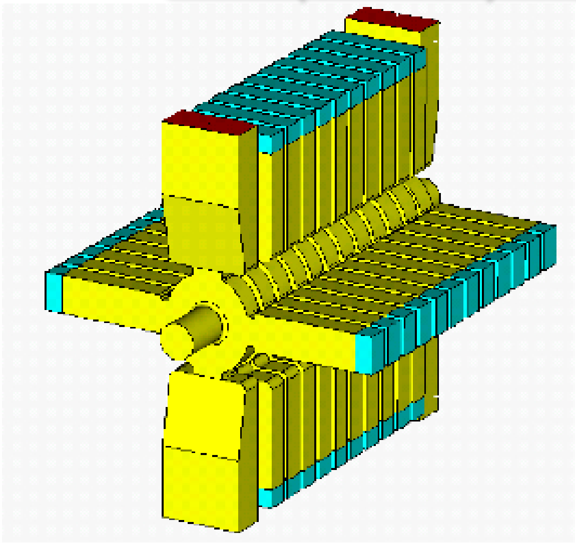


- CLIC
  - 0.2nm > 4Hz Quad stabilization
  - Orbit feedbacks stabilize < 4Hz
  - Beam-based test of feedback combination? (ATF2?)
  - Optimized orbit control by adapting FB with GM information (ATF2 test planned)
- ILC
  - Rely on intrabunch + inter-pulse orbit feedback systems
  - No jitter test of prototype QD0 SC magnet yet however…

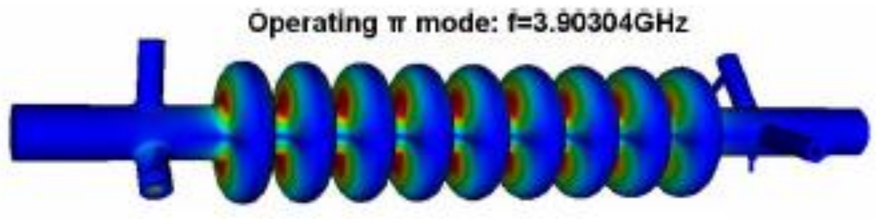
- Demonstration of complex GM + stabilization + orbit co-ordinated feedbacks (ATF2?)

Crab-Cavity

(CLIC CDR)

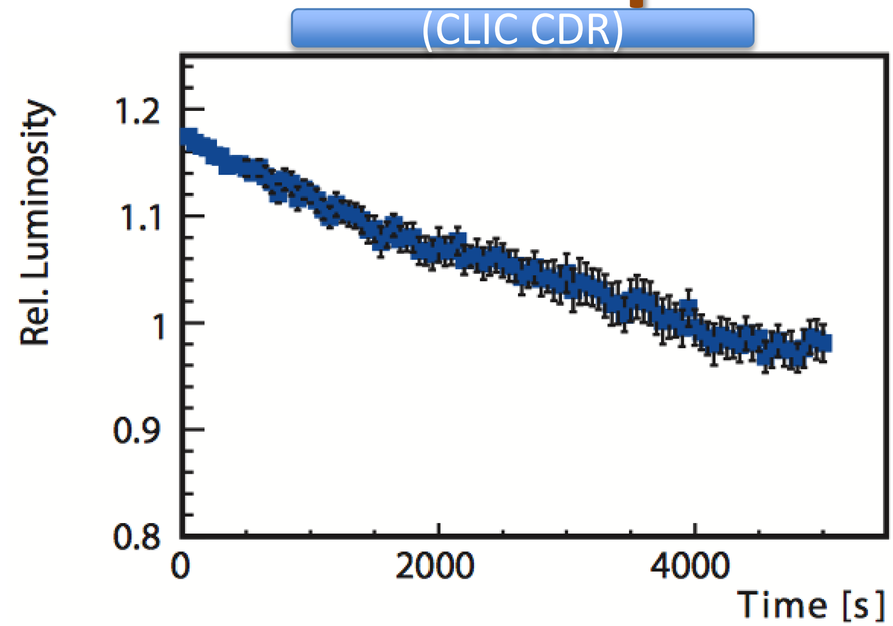


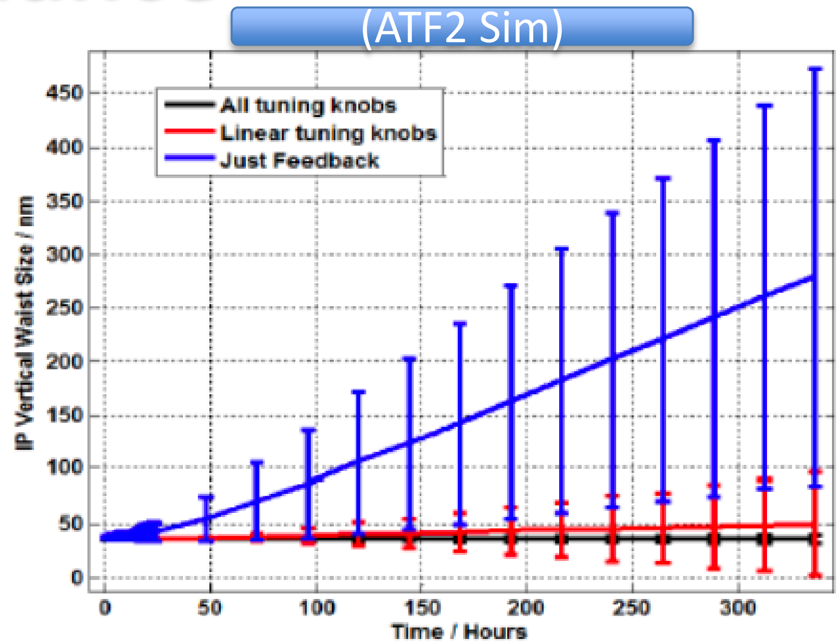
(ILC TDR)



- Crab-cavities essential for max (head-on) lumi with horizontal IP crossing-angle.
- Main lumi preservation issue: relative RF phase between e- and e+ sides (dynamic)
  - ILC relative timing requirement = 61 fs [TDR]
    - J-lab demo 37 fsec
  - CLIC requirement = 2 fs (0.01 degree @ 12 GHz) [CDR]
    - Challenging to demonstrate…
    - **What dynamic solution is possible and how does this perform when merged with other feedbacks ?**

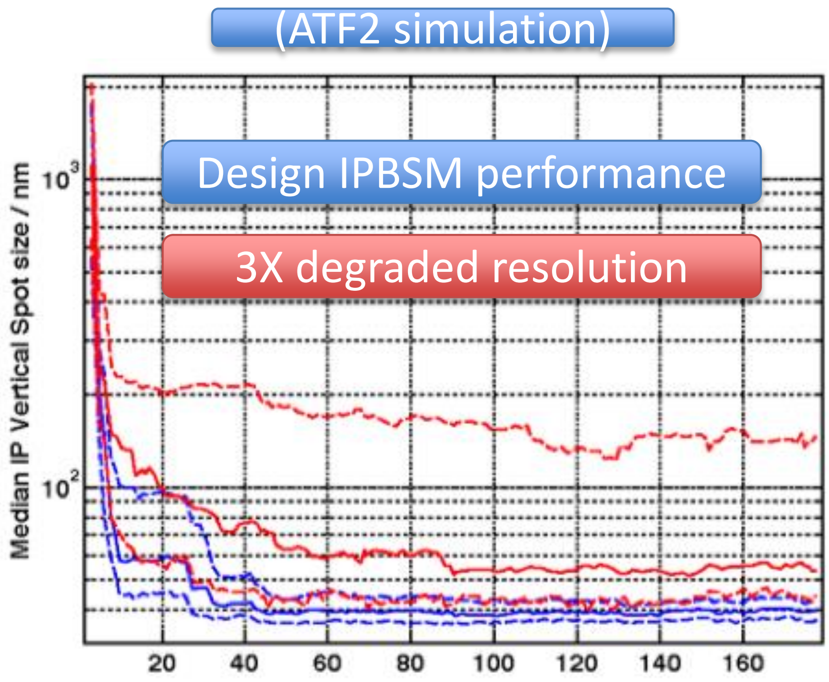
Integrated, long-timescale performance





- Even with orbit feedbacks, lumi degrades on multi-hour timescale
- Should be able to fix with periodic application of tuning multiknobs
- Can test this at ATF2…

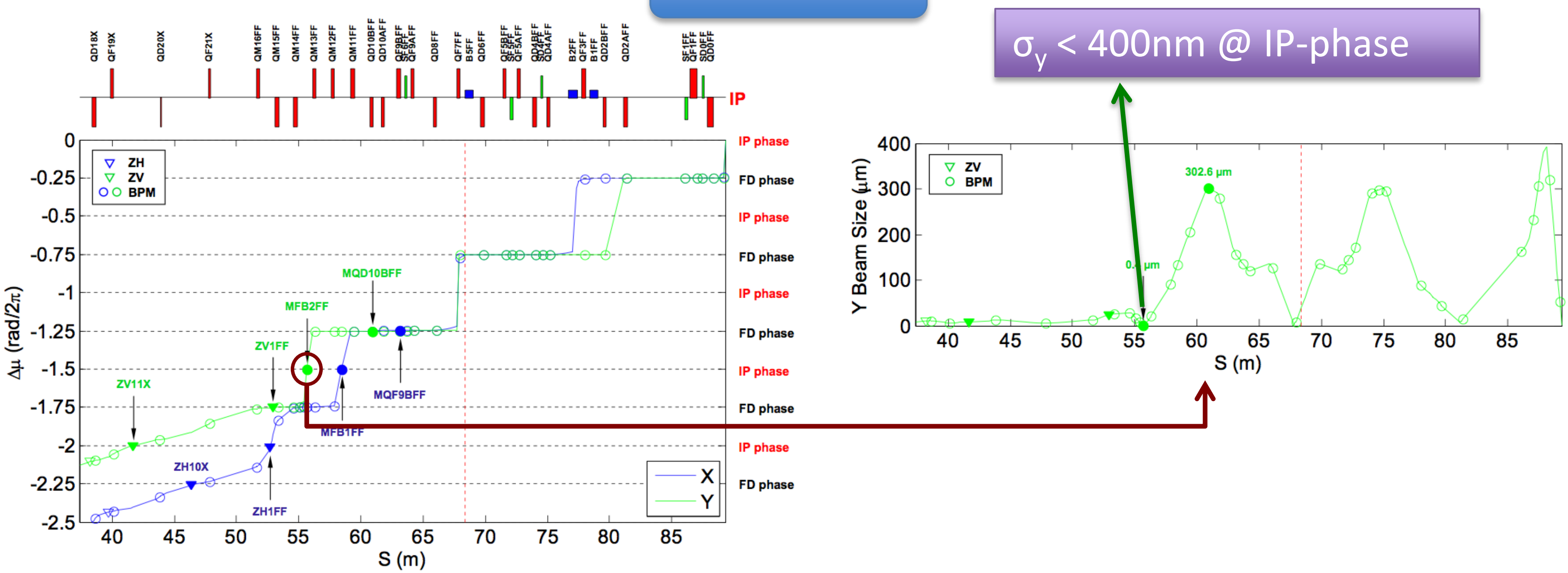
Luminosity monitoring performance



- LC tuning assumes availability of fast lumi-dependent signal to optimize on
- ILC
  - Sufficient to use incoherent beamstrahlung pair signal with some angle cut
- CLIC
  - Complicated by larger contribution from other beamstrahlung + physics sources
  - Studies done to also use hadronic background detection
- Impact of varying detector performance on tuning process…
  - Utterly critical diagnostic system for achieving and maintaining lumi
- Spare no expense on this system!
- Can also use more complex event-shape analysis to deduce information on specific collision parameters
  - Important to keep up development work on this…

Orbit Control in FFS

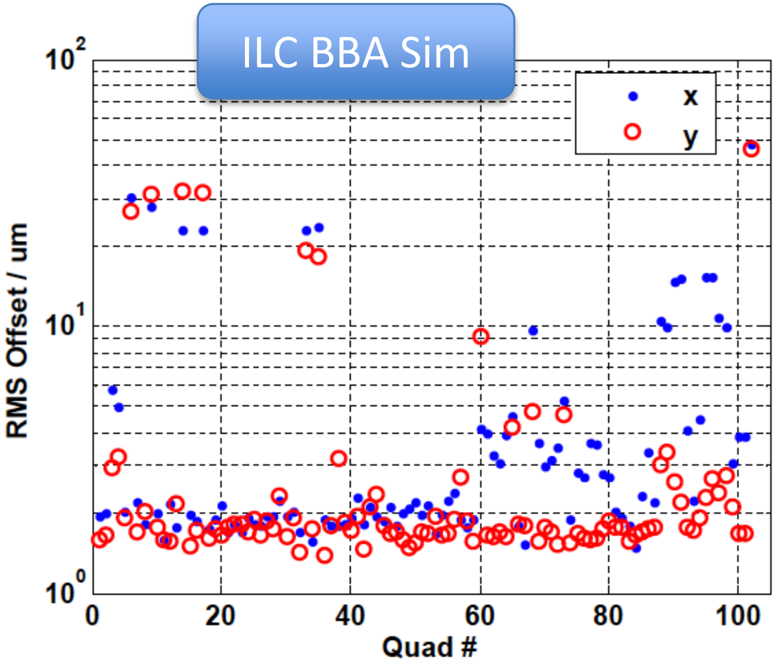
ATF2



- FFS optics requirements lead to unusual situation for beam diagnostics
- All phase changes occur inside magnetic elements, only sample FD-phase
- 1 location for IP-phase sampling at IP vertical image point (waist) with small beam size
  - Critical for FFS feedback
  - Need high-performance BPM
- Consider splitting QF7FF quad to access IP phase in x & y simultaneously?

- Correct phasing and operation of 2-phase FFS feedback still to be demonstrated at ATF2

BBA



- ILC
  - Relaxed requirements
    - few 100 um initial alignment, 1um BPM resolution
    - Fits ATF2 experience
    - 1-1 steering OK
- CLIC
  - More challenging
    - 10um initial alignment
    - 10nm BPM resolution
    - Dispersion-matched steering

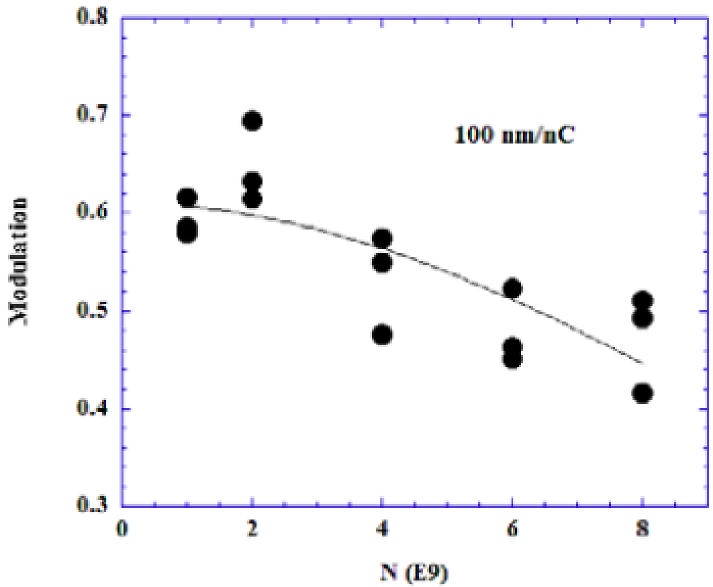
- CLIC requirements need to be experimentally demonstrated

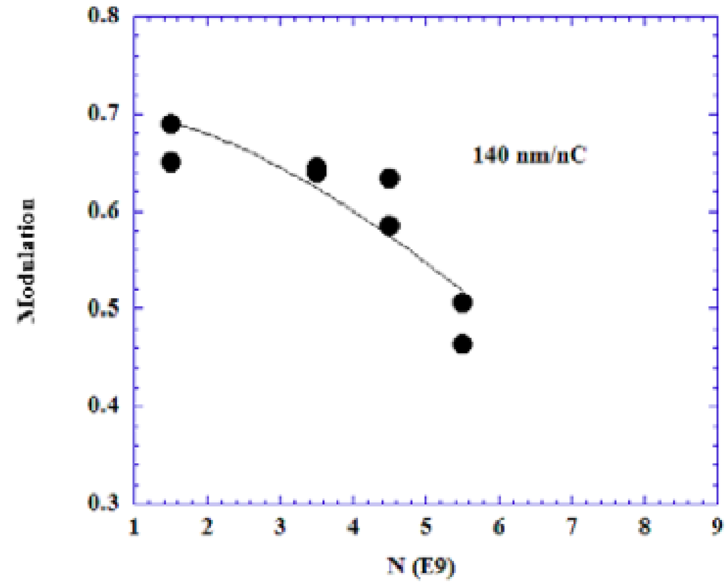
Understanding Luminosity performance scaling with Chromaticity

- CLIC pushed to focusing limit of FFS design
  - Need to verify with ATF2 pushed beta option
- ILC more relaxed, higher than most-pushed-possible IP betas chosen
  - Pushing harder allows relaxing of beam power, recovery of unexpected luminosity loss elsewhere
  - Important to understand limitations
    - Pushed beta config study @ ATF2 also important here
- Also test alternative options
  - e.g. reduced sextupole configuration
  - More variety of multipole correction devices desirable?
    - e.g. skew-sextupoles @ ATF2

- Important to continue FFS design studies @ ATF2

Wakefields





- Recent calculations and studies by K.Kubo et. al for ATF2 FFS & ILC BDS
  - Seems to be no issues for all considered transverse and longitudinal wake sources
- BUT, strong apparent wake dependence seen at ATF2 FFS
  - Larger than can currently be accounted for
  - Identified as additional study item for ATF2 in recent GDE review

Other issues…

- Orbit steering / alignment
  - BBA (DMS)
- Push-pull detector implications
  - Ground deformation impact, re-tuning (time) with varying L* configurations
- Tolerances
  - int. mag. fields, multipoles
  - Alignment
- QD0 magnet technology
  - Warm -> crossing angle, multipoles
  - Cold -> vibration
- Inclusion of realistic solenoid field in tuning simulations
- “Realism”/failure-mode analysis
  - Going beyond idealized tuning simulations to consider impact to operations with reduced performance or disabled diagnostics & worse than expected error conditions