4.1/9.1m L* Optics & Performance

Glen White, SLAC

SiD Meeting, SLAC

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Overview

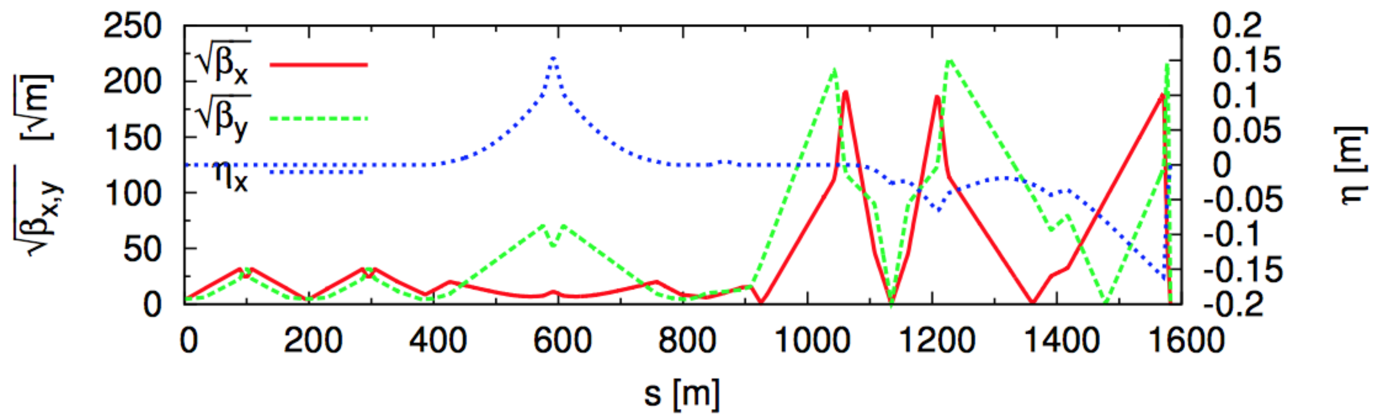
- Assessing impact of changes RDR->TDR
- FFS optics
  - Single L* @ 4.1m (QF1 L*=9.1m)
  - Optimal lattice configuration
- MDI-related studies
  - BDS collimation
  - IR detector solenoid compensation
  - IR diagnostics

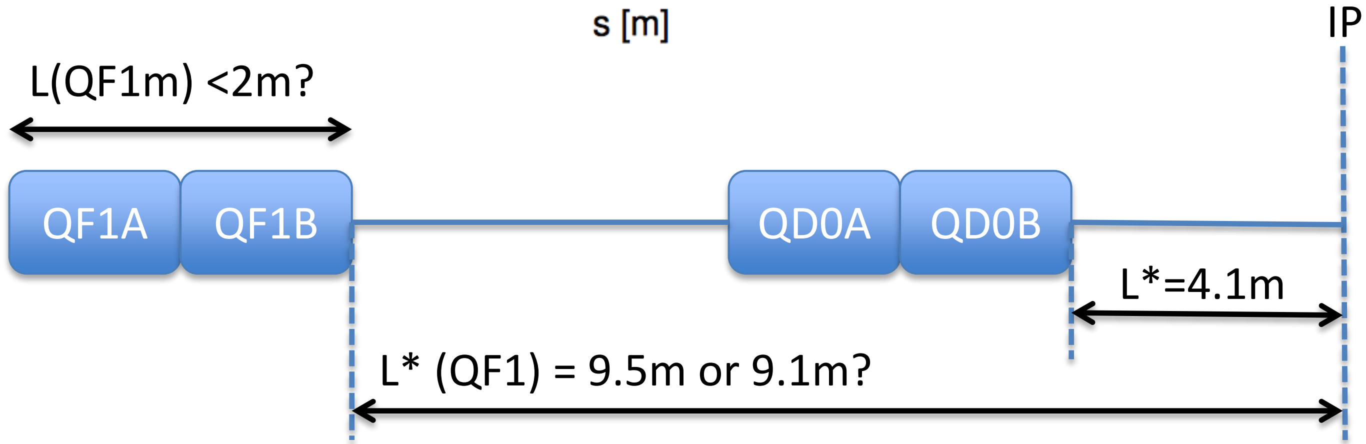
RDR->TDR BDS Challenges

- Detailed studies of RDR configuration concluded BDS can deliver design lumi given 6nm emittance growth budget.
  - Including impact of all static & dynamic error sources, inter & intra-bunch timescales.
  - This level of study not yet complete for TDR changes.
- Changes from RDR make BDS tuning more challenging
  - 40 -> 35nm ε_y delivered emittance assumption
  - Increased IP β_x
    - Tighter BDS magnet tolerances (poorer tuning performance)
    - ATF2 experience has shown poorer performance with larger β_x^*
  - Larger QF1-QD0 separation
    - Tighter BDS magnet tolerances (poorer tuning performance)
  - 2 IR optics solutions (2 L* configs)
    - Poorer tuning performance (tuning time & collimation optimisation etc.)
  - No overhead from "waist shift"
    - Baseline lumi now includes vertical waist-shift effect, RDR did not.

L*=4.1m Optics

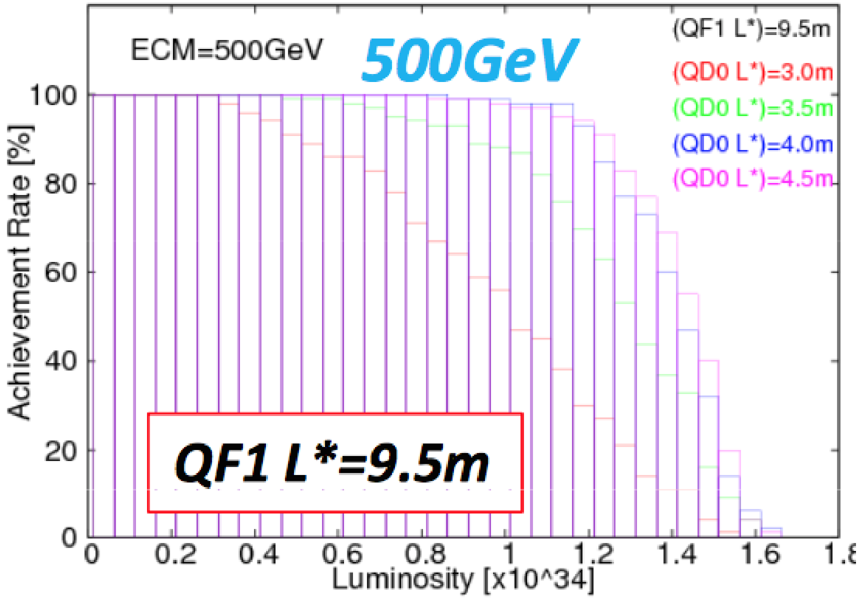
Tools: *MADX, MAPCLASS, SAD, Lucretia*

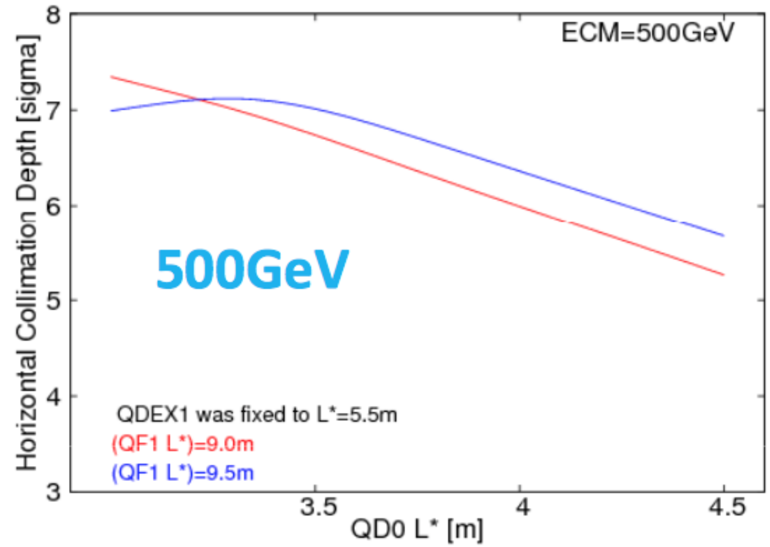


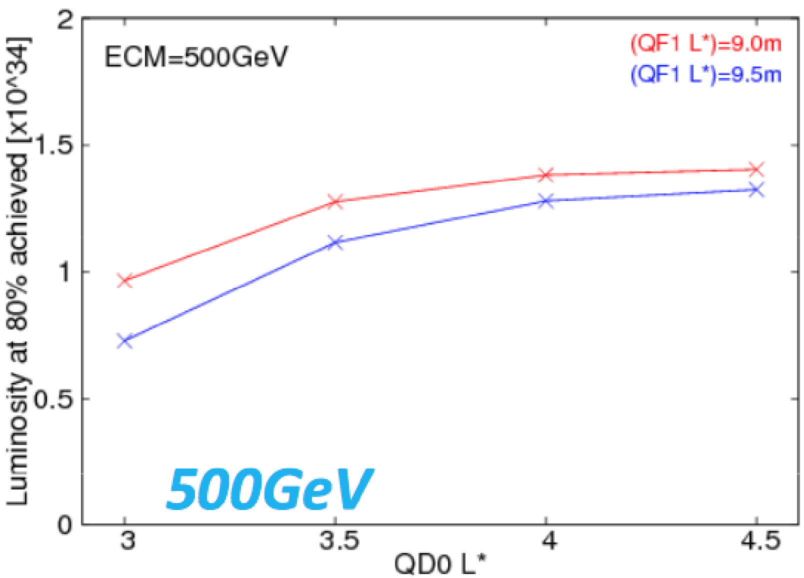


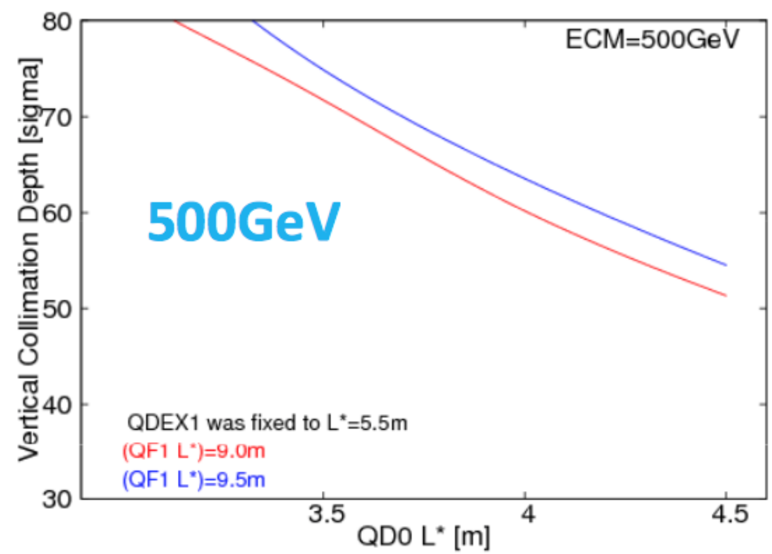
- Have optics solutions for E_{CM} = 250 GeV with improved collimation performance by powering front halves of QF1 & QD0 magnets only.
- Tuning performance driven by QD0->QF1 distance
  - Prefer QF1 closer to QD0, also shorter QF1

Collimation depth & beam tuning simulation For different L* *(T. Okugi, KEK)*

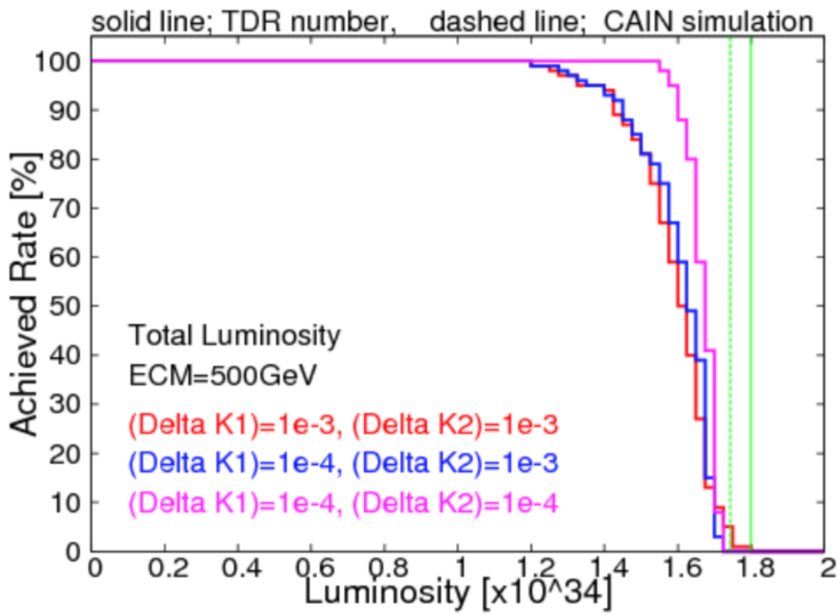


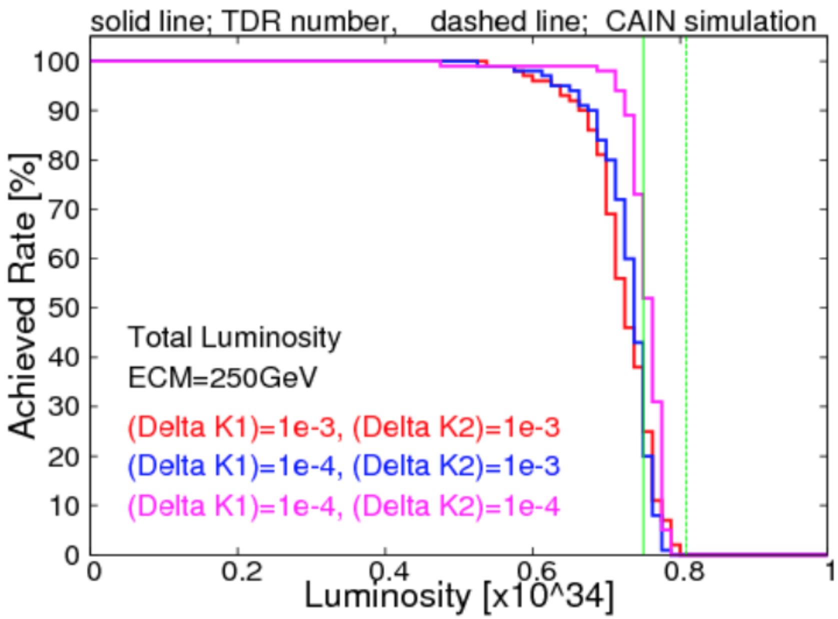






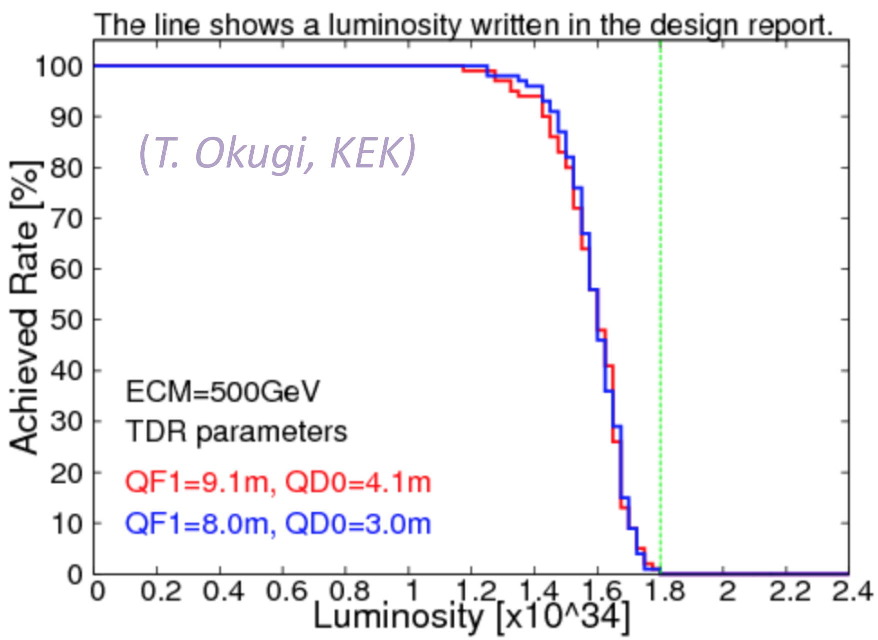
MC Tuning Simulations (*T. Okugi, KEK*) – *SAD + CAIN*





- Tuning simulation results for E_{CM}=250,500 GeV
  - *Compare magenta lines to outer green lines depicting design lumi*
- 4.1, 9.1m QD0, QF1 L* configuration
- Standard tuning algorithms no longer sufficient to deliver design luminosirty, more work required in the future to specify a tuning system and/or improved assumption of BDS delivered beam quality.

Recover Tuning Performance @ Smaller L* by Moving in QF1

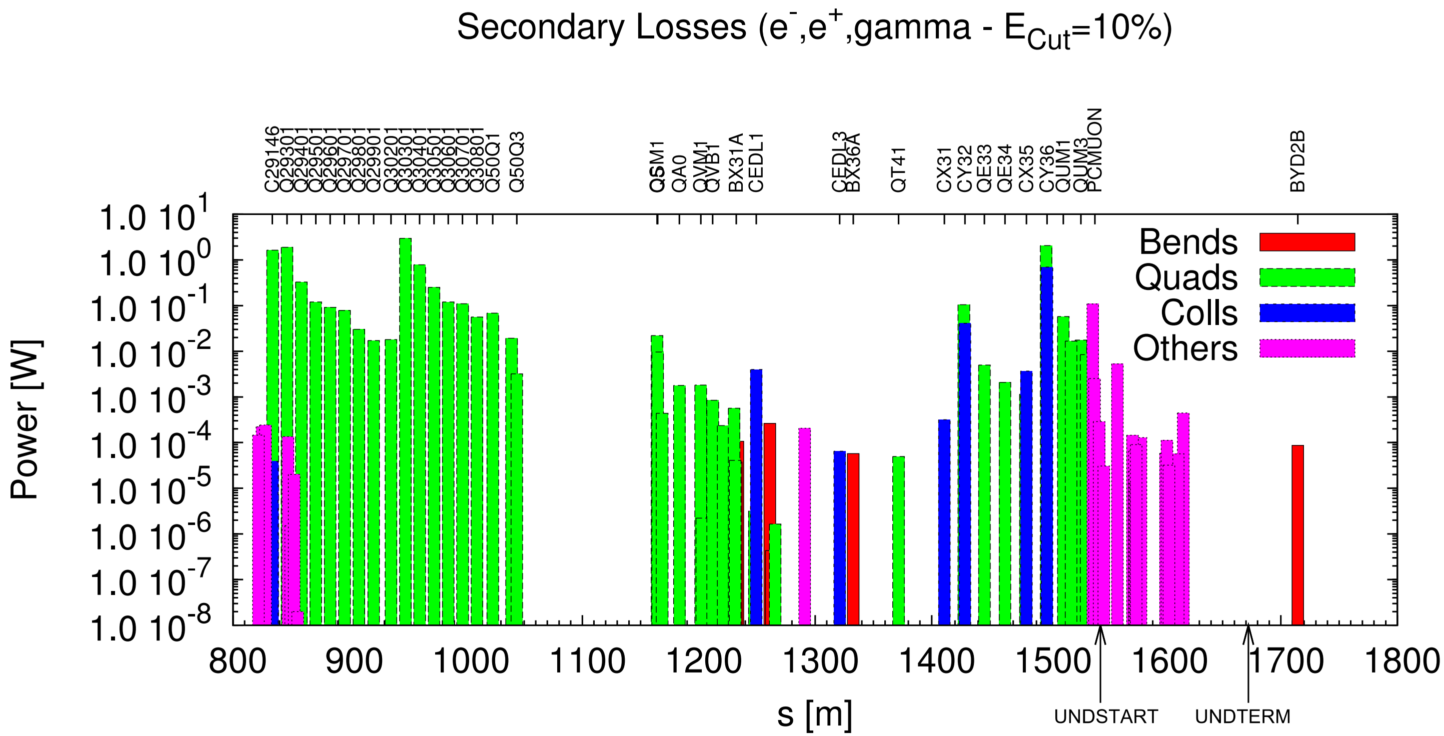


- Can recover lumi performance at small L* by moving QF1 closer to IP.
  - Improved collimation depth
- Would require moveable QF1 to be compatible with push-pull operations…

Software Improvements for Backgrounds & IR Studies

- 2 “new” tools, merging standard accelerator tracking options with GEANT-4 for RK style tracking through complex fields and/or materials.
- G4 interface added to Lucretia (supported by SLAC)
  - Control of G4 materials, fields and tracking through Lucretia Matlab data structures.
- BDSIM (supported by RHUL)
  - Standard accelerator tracking added within G4 framework
  - Writing ability to call BDSIM from within Lucretia.
- Collaboration: SLAC & RHUL
- In-use or planned for ILC BDS work:
  - Collimation system design
  - Muon flux calculations and collimation design
  - Detector solenoid tracking and compensation design

Lucretia + G4



- Developed to study collimation system for LCLS-II
- Currently studying losses in LCLS to verify modeling and possible improve LCLS collimation system.
- Will be useful for ILC BDS collimation modeling.

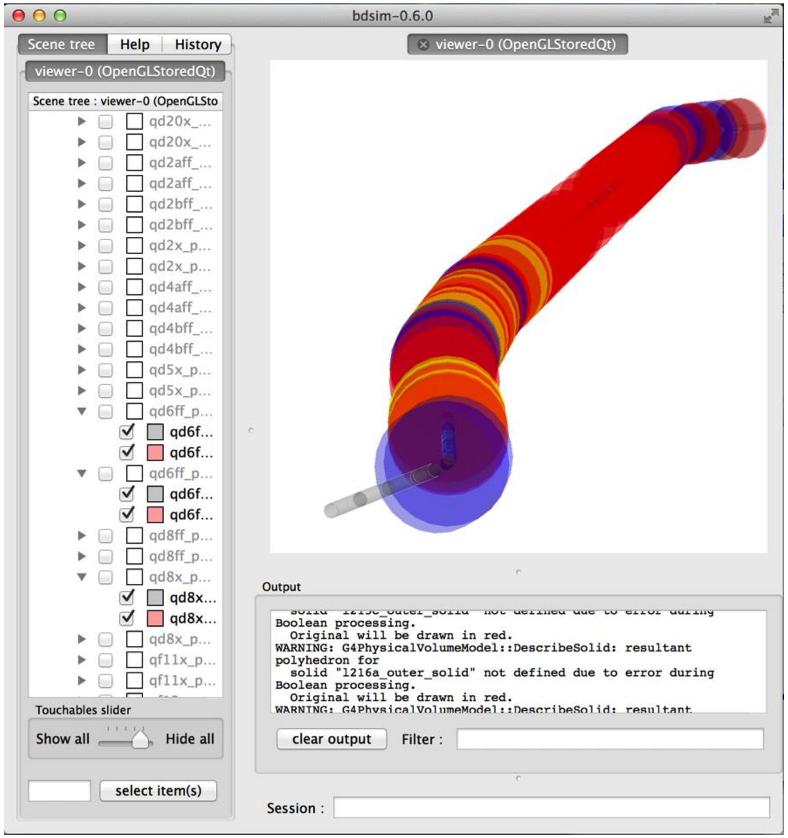
A BDSIM Accelerator Model

<u>L. Nevay</u>, S. Boogert, H. Garcia-Morales,

S. Gibson, R. Kwee-Hinzmann, J. Snuverink

- Beamline built from ASCII input
- Geant4 model of accelerator automatically created
- Generic geometry created by default
  - typically cylinders of iron
  - more specific geometry can be specified or imported
- Normal Geant4 Runge-Kutta steppers are replaced
  - vacuum steppers replaced by maps for specific magnet types
  - much faster and more accurate for known fields – ie quadrupolar
- Hits on accelerator recorded
- Integrated analysis for energy loss histograms
  - both ASCII and ROOT output supported

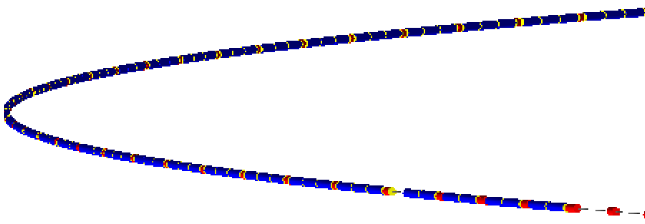
ATF2 example

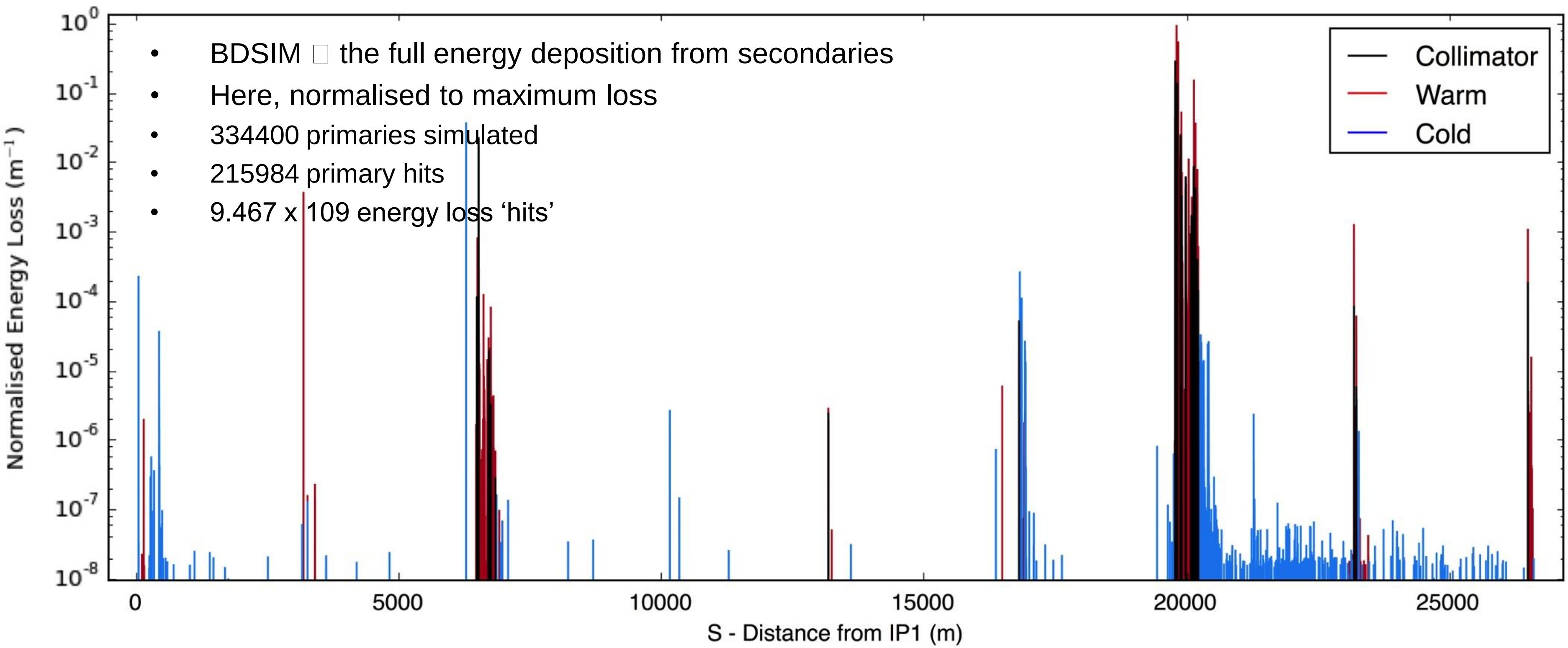


BDSIM LHC Model

- Created model of existing LHC for comparison
  - before using for HL-LHC simulations
- 3.5 TeV 2011 & 4TeV 2012 physics run lattices
- pybdsim – python tools used to prepare inputs
  - supplied with BDSIM
  - allows easy conversion of inputs
  - can easily aggregate input information from various sources

NB no perspective

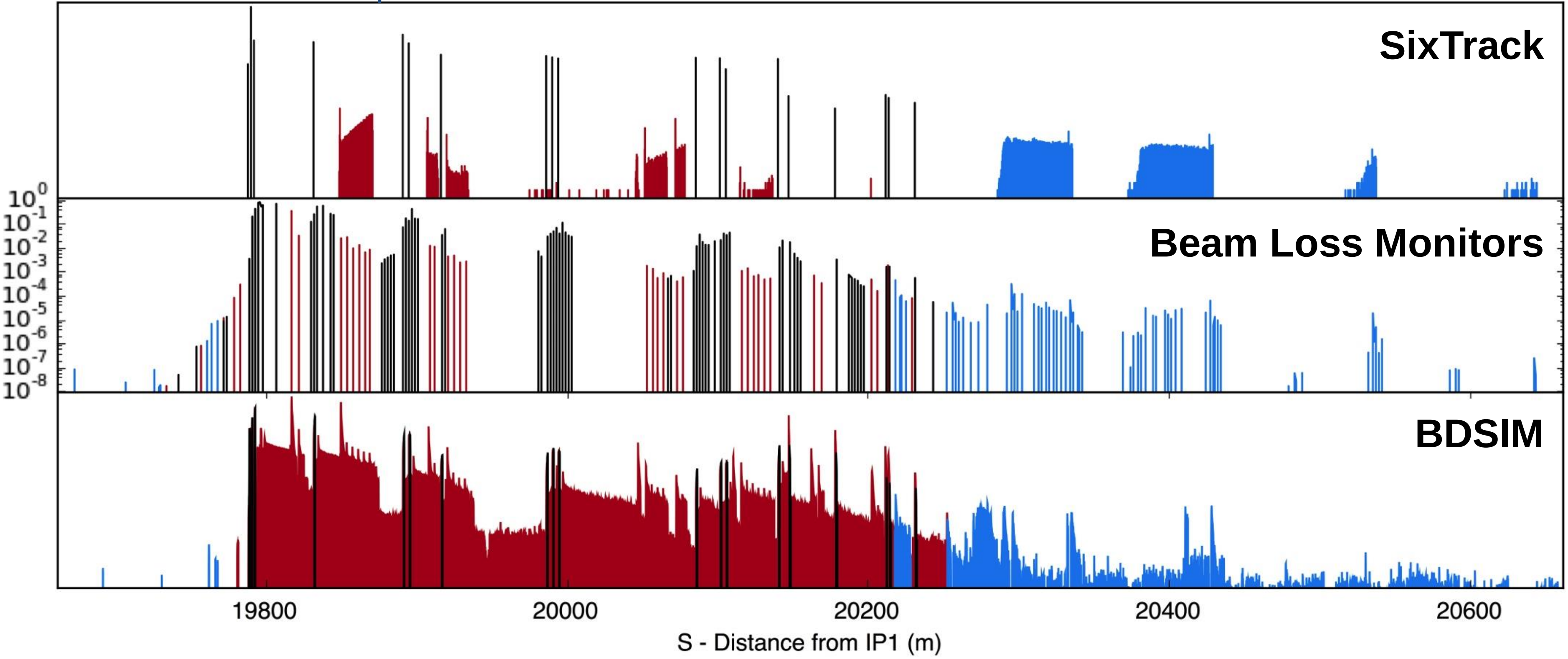




- BDSIM □ the full energy deposition from secondaries
- Here, normalised to maximum loss
- 334400 primaries simulated
- 215984 primary hits
- 9.467 x 109 energy loss ‘hits’

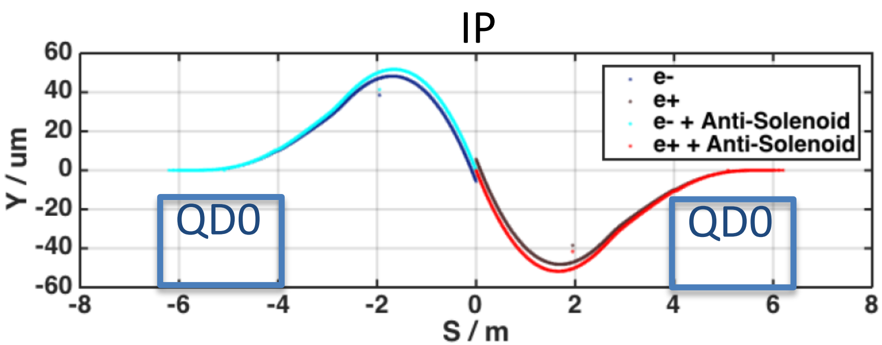
Comparison with LHC BLM Data

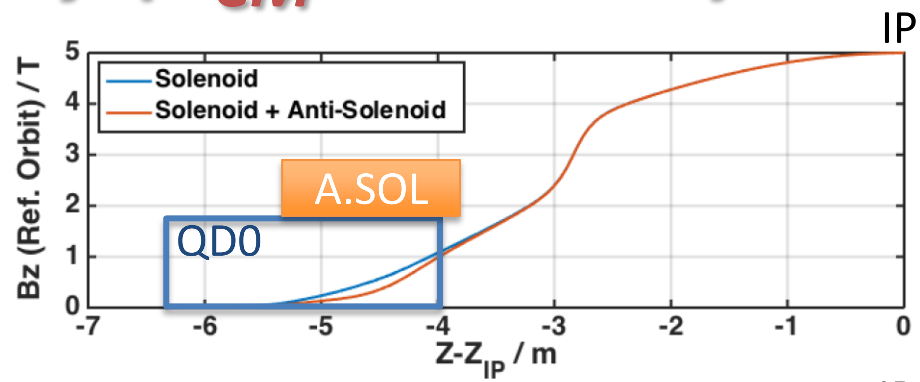
- Data from R. Bruce et al, Phys. Rev. ST Accel. Beams 17, 081004 (2014)
- Favorable comparison with Beam loss monitor data

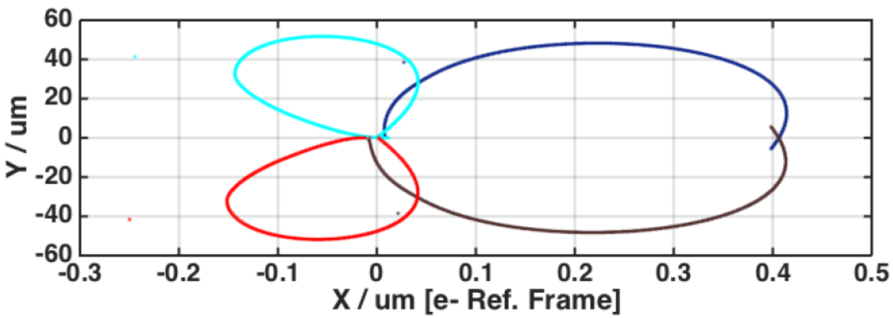


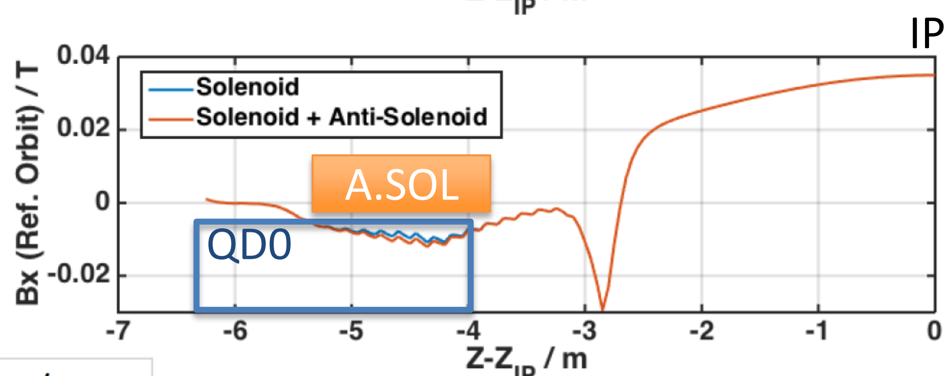
Detector Solenoid Compensation

SiD – Solenoid Only (E_{CM}=500GeV)









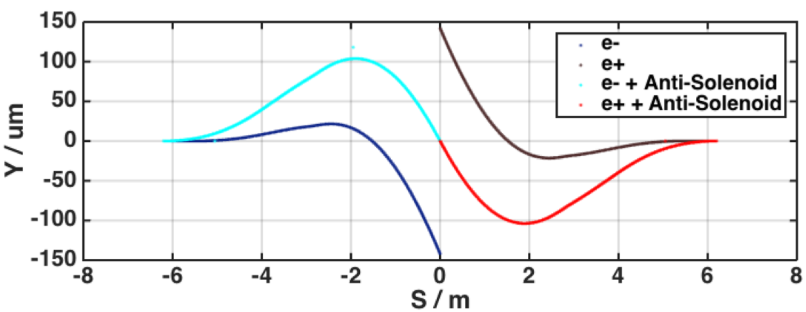
Detector	Y^* (um)	Y'^* (urad)	X^* (um)	X'^* (urad)	σ_y^* (nm)	σ_y/σ_{y0}
SiD (e-)	-5.6 (0)	-65.9 (-64.7)	0.4 (0)	-1.1 (-0.2)	63.1 (9.7)	10.7 (1.6)
SiD (e+)	5.7 (0)	66.1 (64.9)	-0.4 (0)	-0.5 (-0.7)	69.1 (9.2)	11.7 (1.6)

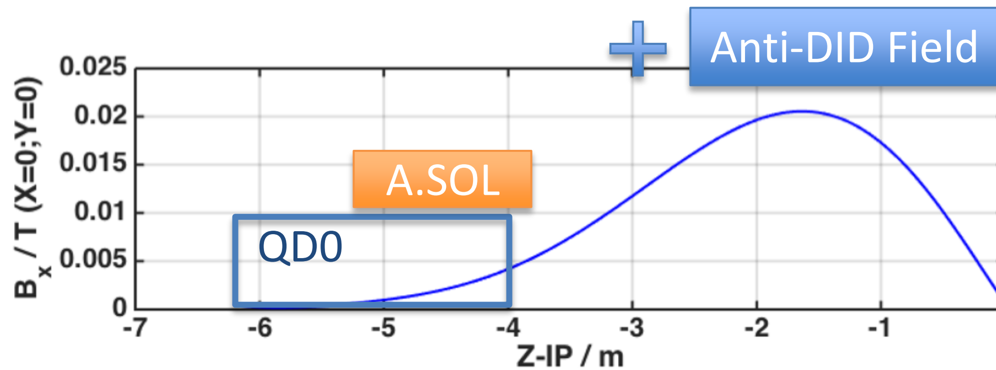
- Parentheses show values after anti-solenoid + QD0 dipole correction

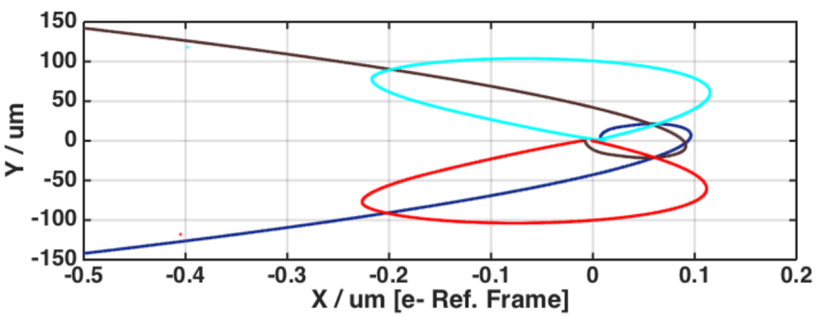
Reduces to design 5.9nm
After applying <x'y>, <xy> & <Ey>
Linear correction knobs

Detector	A.sol Length (m)	A.Sol Pos (m) *(u/s QD0 d/s face)*	A.Sol I (A.turns) *X 10^5*	A.Sol |Bz| (max) / T	Dipole Bx / By (T) *X 10^{-4}*
SiD (e-)	0.662	0.439	-1.337	0.283	-0.626 / -0.294
SiD (e+)	0.704	0.610	1.264	0.278	-0.739 / -0.297

Detector Solenoid Compensation
SiD – Solenoid + Anti-DID (E_{CM}=500GeV)







Detector	A.sol Length (m)	A.Sol Pos (m) *(u/s QD0 d/s face)*	A.Sol I (A.turns) *X 10^5*	A.Sol |Bz| (max) / T	Dipole Bx / By (T)
SiD (e-)	0.609	0.448	-1.35	0.243	-0.011 / -0.526E-4
SiD (e+)	"	"	1.35	"	"

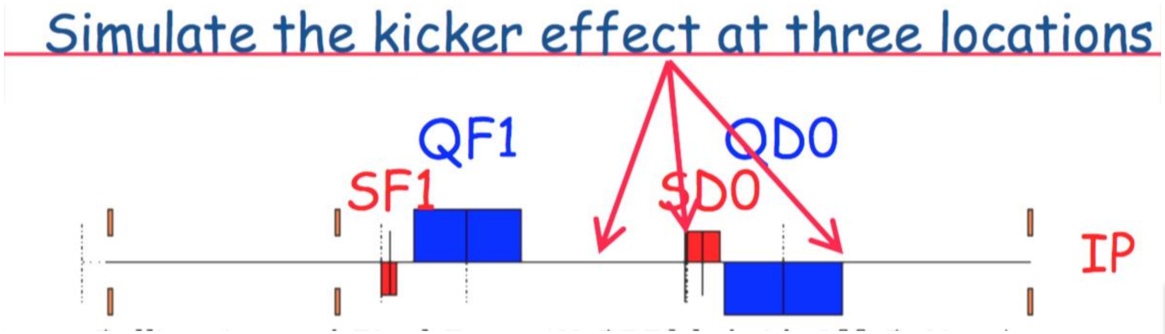
Detector	Y^* (um)	Y'^* (urad)	X^* (um)	X'^* (urad)	σ_y^* (nm)	σ_y/σ_{y0}
SiD (e-)	-141.9 (0)	-133.2 (-105.2)	-0.5 (0)	-1.4 (0.17)	171.5 (23.0)	29.1 (3.9)
SiD (e+)	141.9 (0)	132.3 (105.2)	-0.5 (0)	-1.4 (-0.79)	202.6 (23.0)	34.3 (3.9)

- Parentheses show values after anti-solenoid + QD0 dipole correction

Reduces to design 5.9nm
After applying <x’y>, <xy> & <Ey>
Linear correction knobs

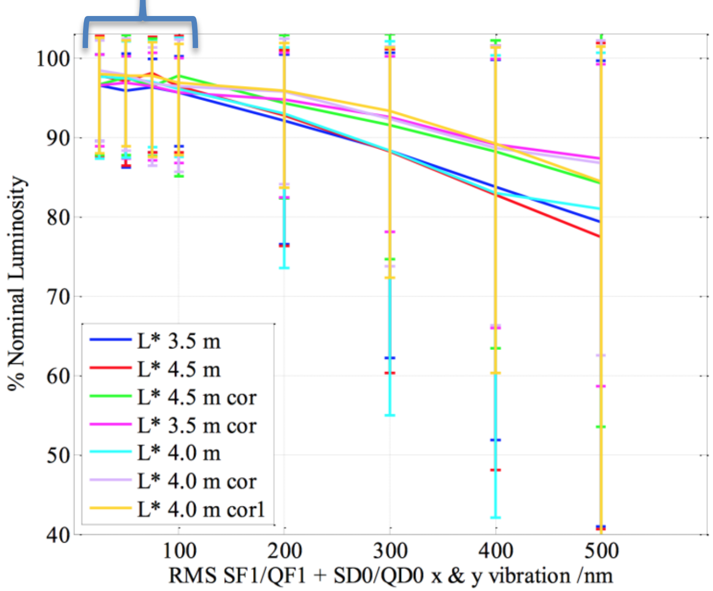
IP Feedback Tolerances / IP Diagnostics

M. Wang, SLAC



- No significant improvement for moving IP kicker to u/s QD0 location
- Jitter tolerance similar to RDR estimates
  - ~<100nm
- **Still consider d/s QD0 location for BPM to determine IP beam position**

Negligible impact for rms jitter ~<100nm



Summary

- FD configuration studies
  - Smaller L* better for vertical collimation depth
  - Larger L* (smaller QF1-QD0 distance) better for tolerances and lumi tuning performance
  - L* ~ 4m seems optimal, 4.1m proposed
  - Prefer smaller QF1-QD0 distance, and shorter QF1 magnet would also be benefical
    - Proposed QF1 L*=9.1m (0.4m closer to IP than baseline)
  - http://atf.kek.jp/twiki/bin/view/Main/ILCBDSOpticsStorage
- More work required on tuning algorithms to realize design luminosity
- IP diagnostics, FB kicker
  - Happy with FB kicker location between QF1 & QD0
  - Still would like to consider BPM option d/s QD0 for IP position information.
- New software tools for backgrounds & IR studies
  - Work started to specify collimation configuration & study backgrounds.
  - Study muon flux and consider more compact collimation system
  - Tools constructed to design IR solenoid compensation system
- More detailed report on these activities @ Asian LC workshop in April (KEK).