Beam Dynamic Effects of Experimenal Solenoid

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Thanks to A. Latina, H. Garcia, B. Dalena, J. Snuverink, M. Modena, A. Bartalesi, H. Gerwig

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Introduction

- Reminder ECFA talks
- Studies for CLIC
- Preliminary studies for ILC

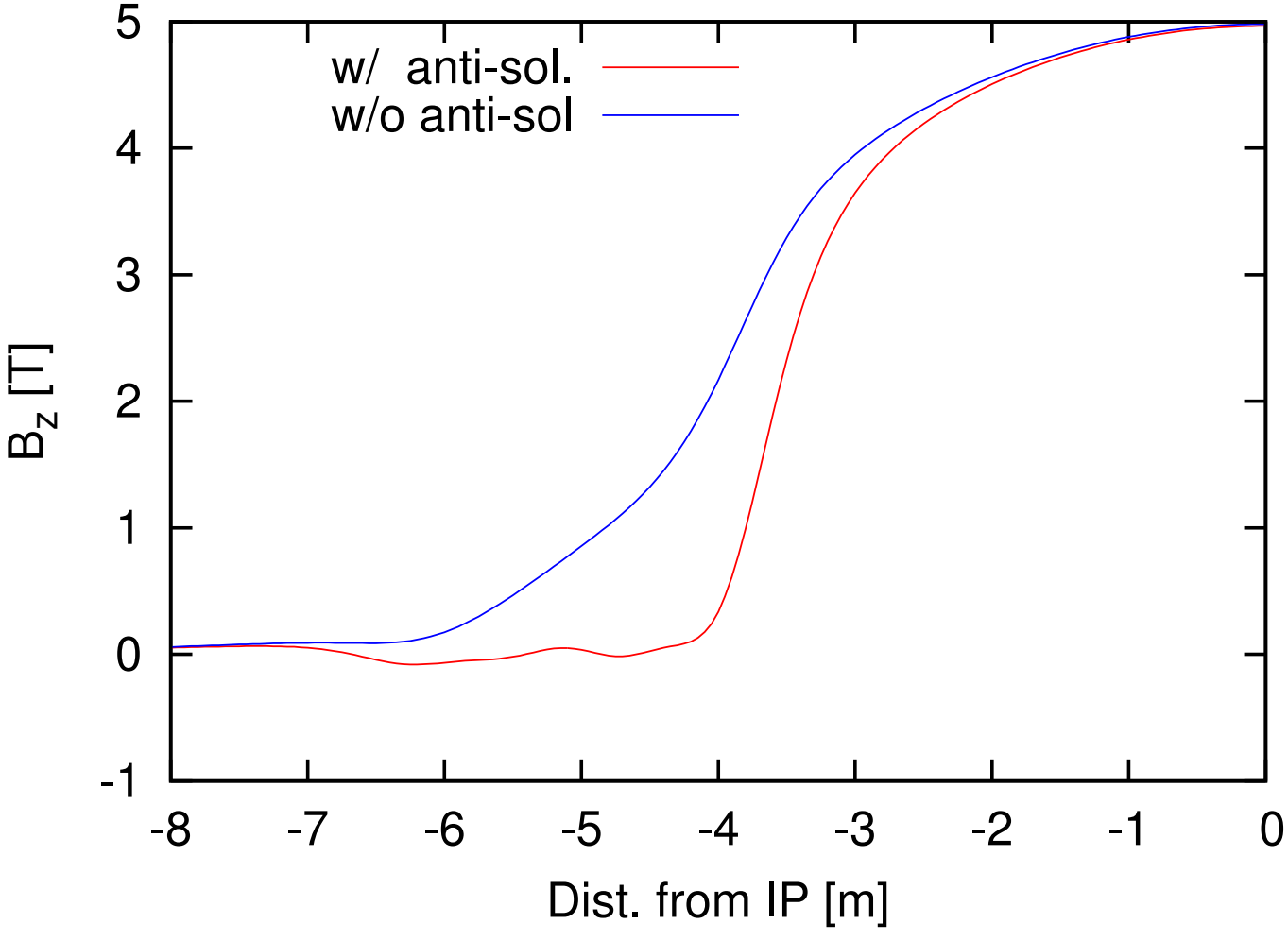
FF Magnet Multipoles

- All FF magnets in CLIC checked + ILC QF1.
- Compared to QD0 prototype, only b_3 and a_3 above margins.
- For ILC, higher orders play a more important role.
- URL

Solenoid Studies

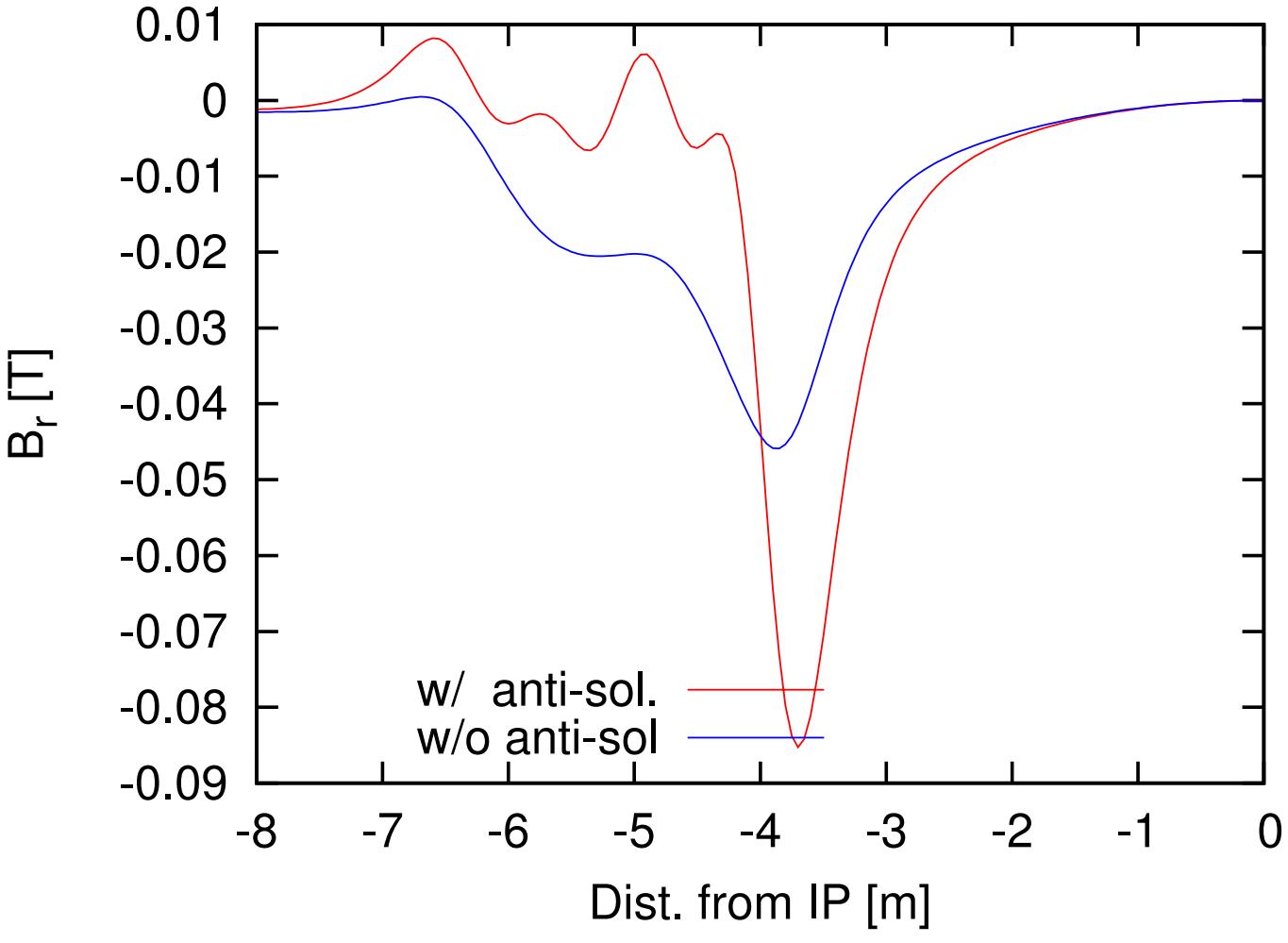
- Integration into PLACET finished.
- New solenoid field map produce similar results as before.
- Preliminary tuning studies with anti-solenoid presented.
- URL

Field Map



Longitudinal field

Field Map

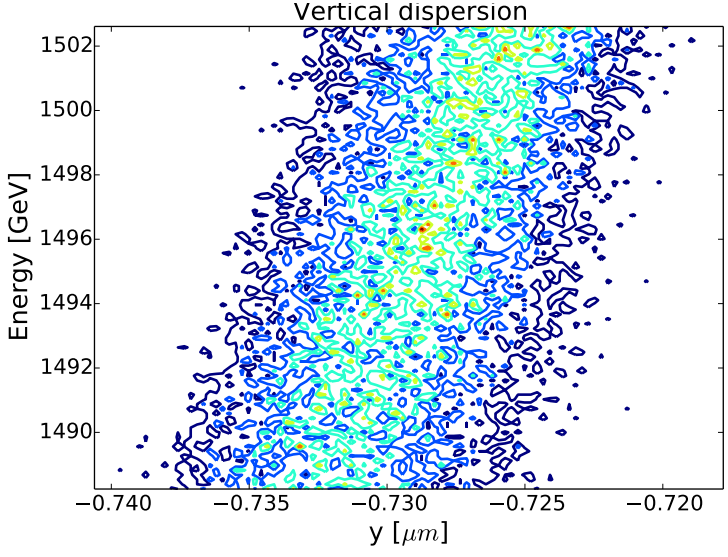


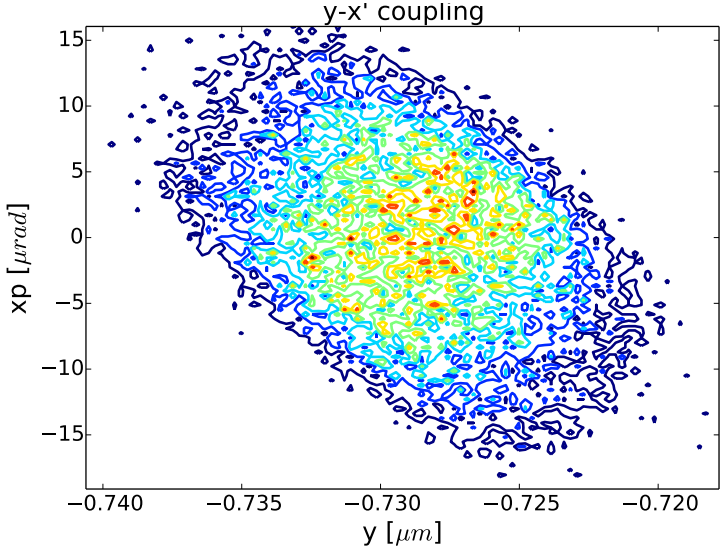
Radial field

Field Map

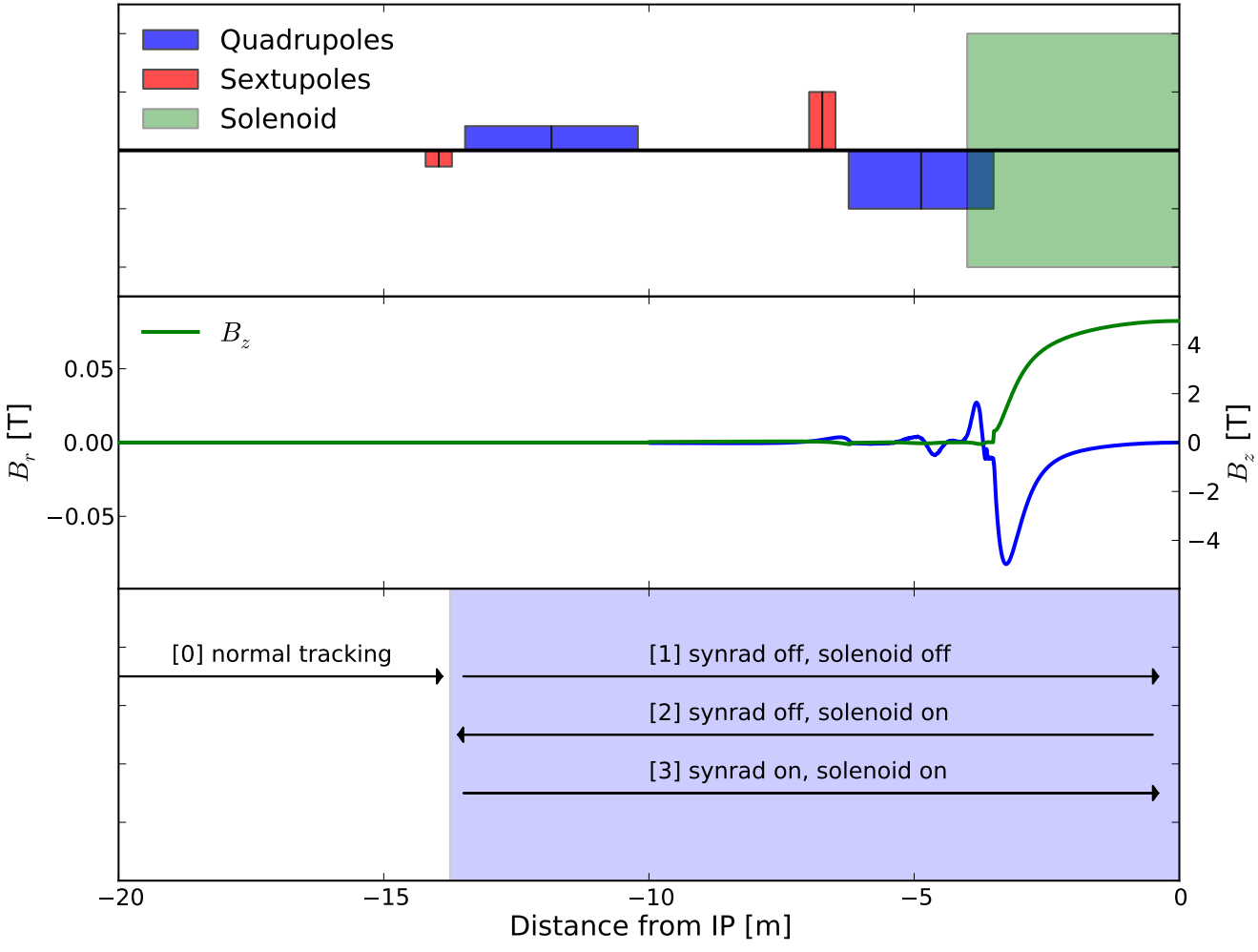
- FEM simulation including a realistic solenoid design.
- Anti-solenoid designed to minimise field inside QD0/protect the magnet.
- The QD0 itself is not included in these FEM simulations.
- Courtesy H. Gerwig.

Main Effects (w/ anti-solenoid)





Deterministic Simulation



Deterministic Simulation

	w/o anti-solenoid [%]	w anti-solenoid [%]
Relative loss	5	4

- Experimental solenoid cause about 4 % luminosity loss due to ISR.
- About 1 % additional losses w/o anti-solenoid.
- Newer FEM simulations including the QD0 (A. Bartalesi) show similar results in deterministic simulation (see ECFA talk).

Tuning Simulation

Should be able to end up with **same luminosity** as deterministic simulations if we find the ideal correction?

- 5 sextupoles in BDS -> 5 horizontal and 5 vertical knobs.
- QD0 vertical displacement provide one additional knob.
- See e.g. PRSTAB 15, 051006 for details about these knobs.
- Algorithm: Iterate over knobs and do a parabola fit for each.

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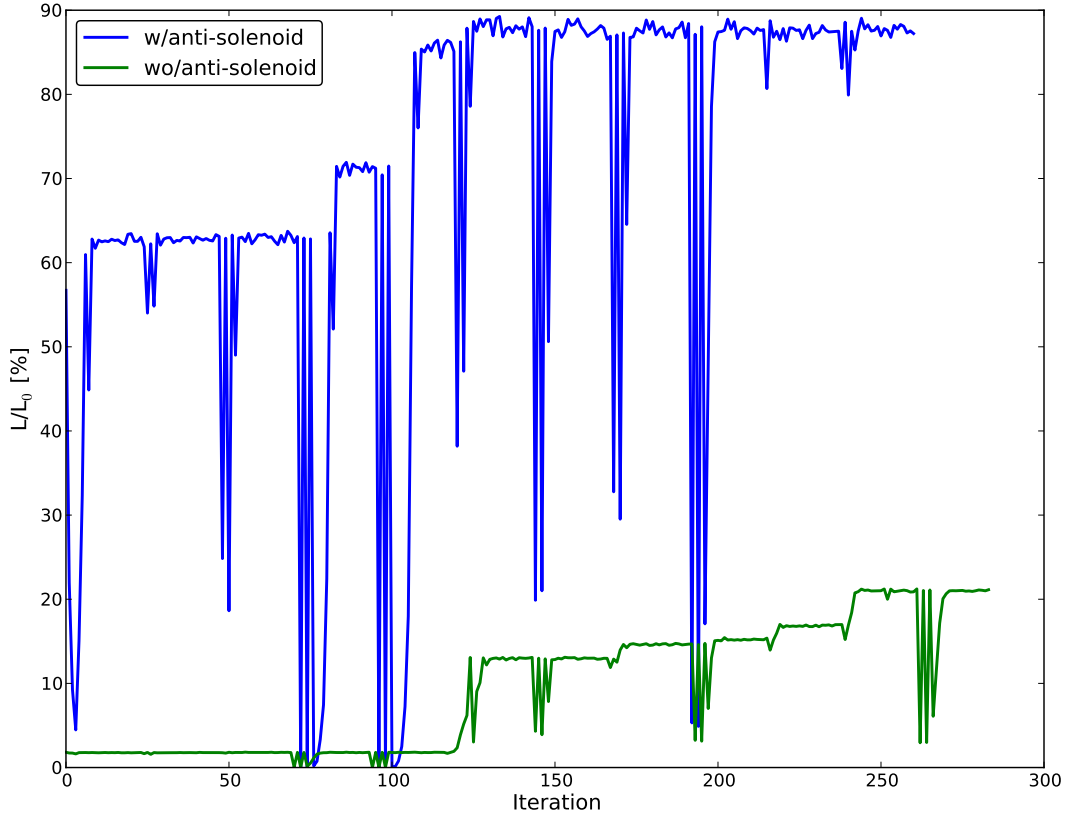
First tuning results



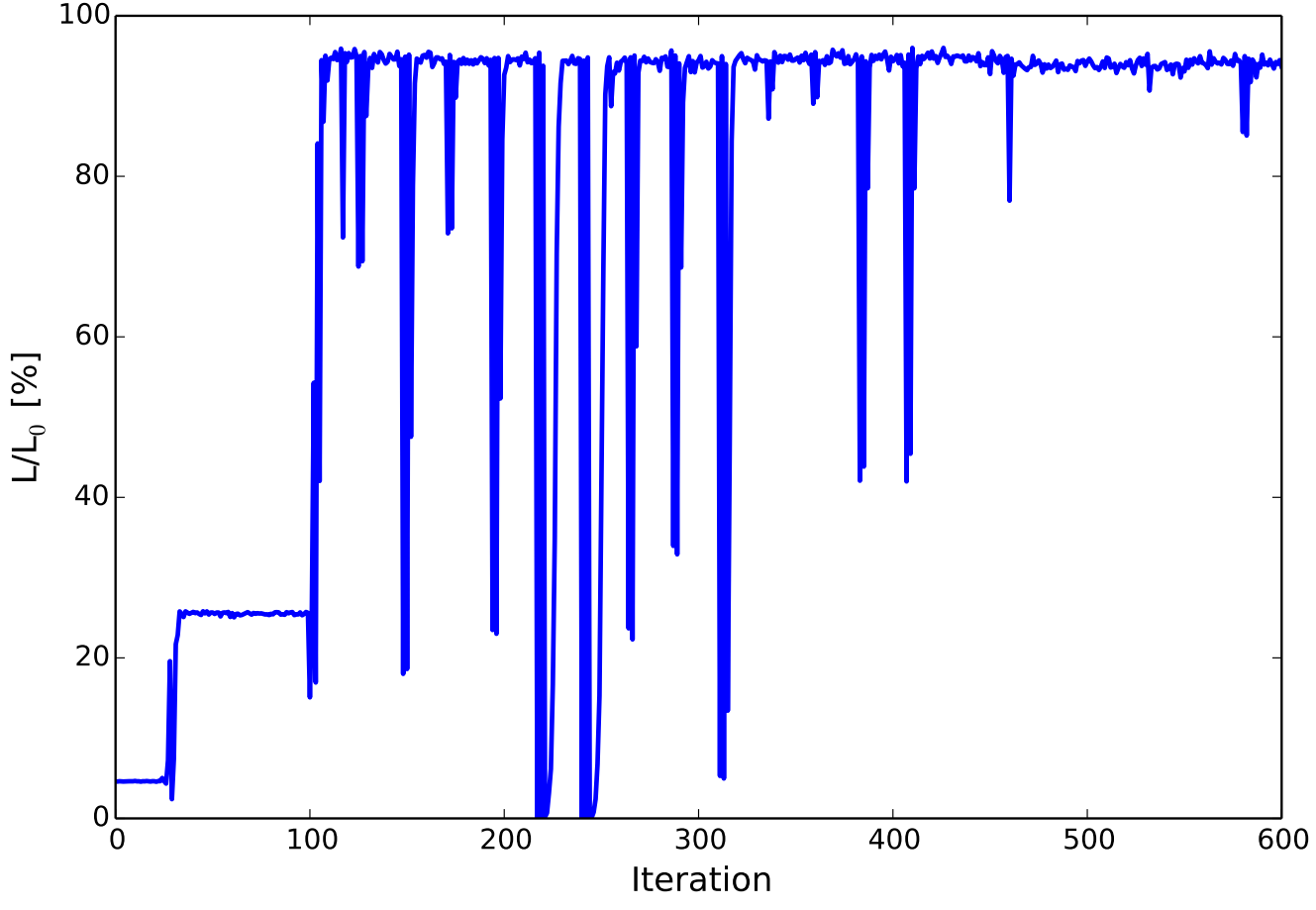
- Map w/ anti-solenoid easier to tune.
- Around 90 % optimum achieved (compared to 96 %).
- Map w/o anti-solenoid very hard to correct, probably due to strong field inside the QD0.

Additional tuning knobs

Five additional knobs

- We already used vertical movement of the QD0. Added horizontal movement, and roll.
- Added the same three knobs for QF1.

Additional tuning knobs



Additional tuning knobs

Five additional knobs

- We already used vertical movement of the QD0. Added horizontal movement, and roll.
- Added the same three knobs for QF1.
- Optimal luminosity increased from 90 % to around 94-95 %
- Modulating sextupole strengths as well might get us closer to the 96 %..

Summary CLIC tuning

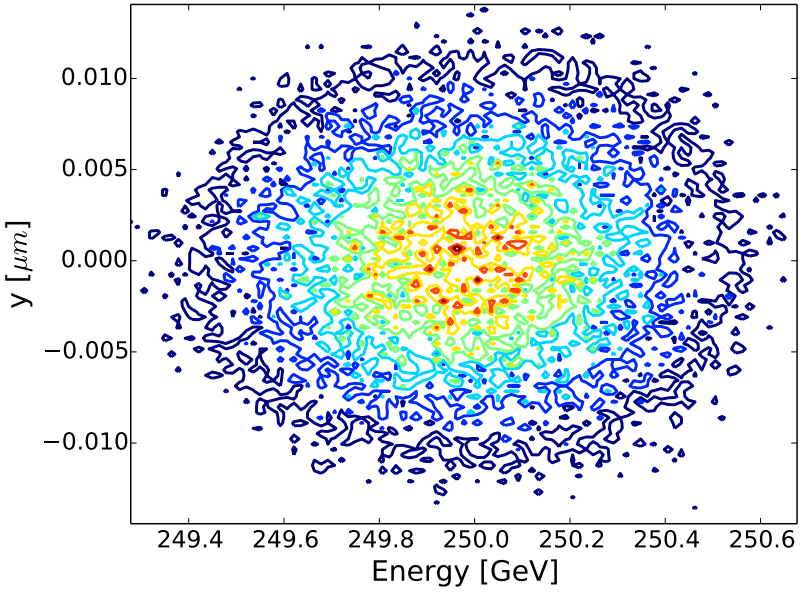
- Deterministic simulation suggest around 4-5 % luminosity loss from ISR for the SiD design.
- Full tuning study including QD0/QF1 knobs obtain quite consistent results within error-bars.
- Nonlinear knobs might be needed to fully perfectly correct the optics.

ILC Solenoid Studies

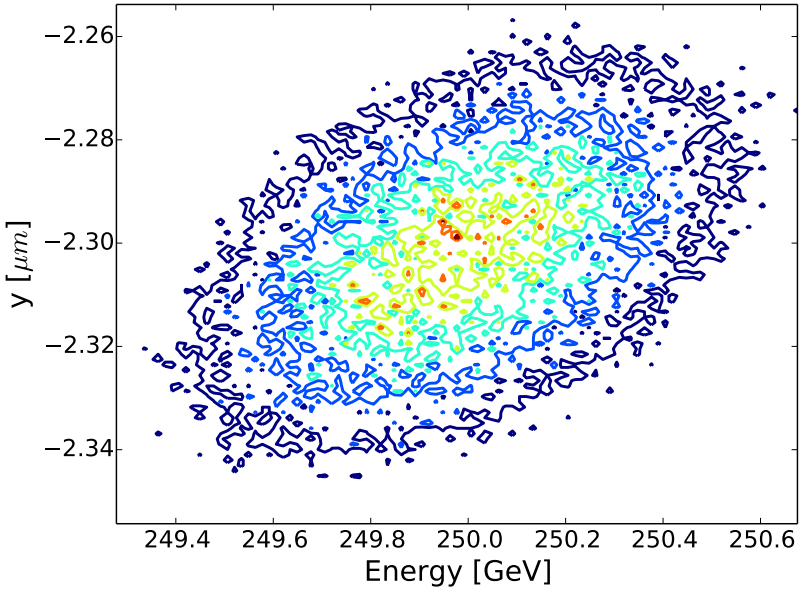
- The SiD design for CLIC is not too far away from the ILC SiD design.
- As first iteration, using SiD field map w/o anti-solenoid to study the ILC lattice.
- Expect lower losses from deterministic simulation, more trouble tuning (stronger optical distortions).
- The SC QD0 should give a good amount of shielding itself -> results expected to be overly pessimistic.
- References for ILC solenoid effect: Seryi et al., PRSTAB, 2005 [1, 2], PhD by R. Versteegen, 2011 [3].

Vertical Dispersion

No solenoid

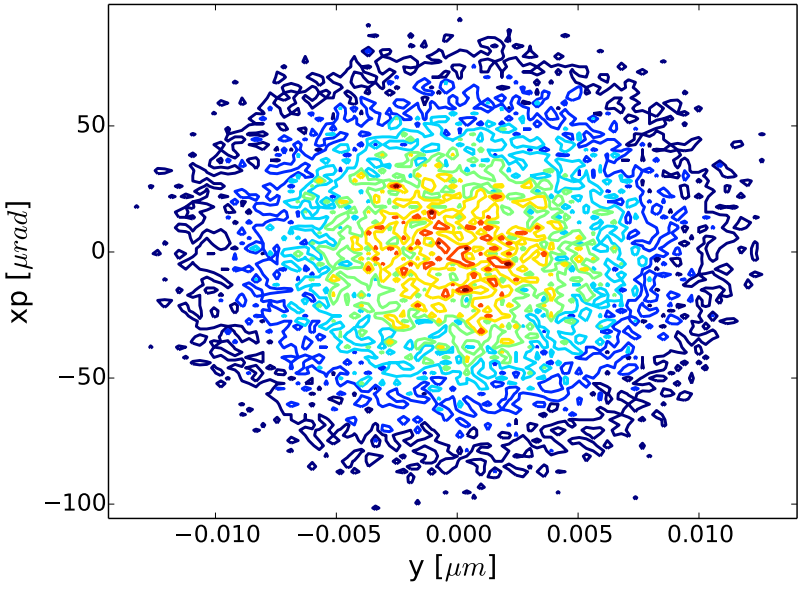


With solenoid

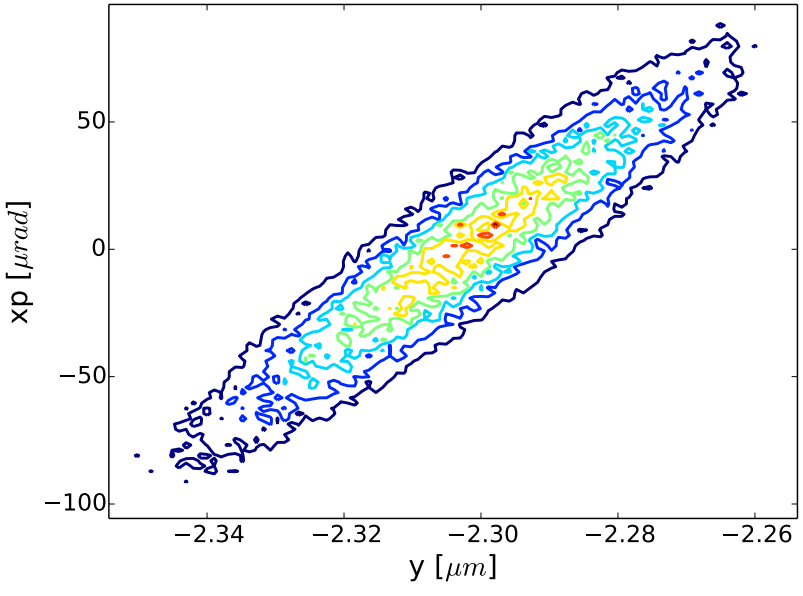


y-x' coupling

No solenoid



With solenoid



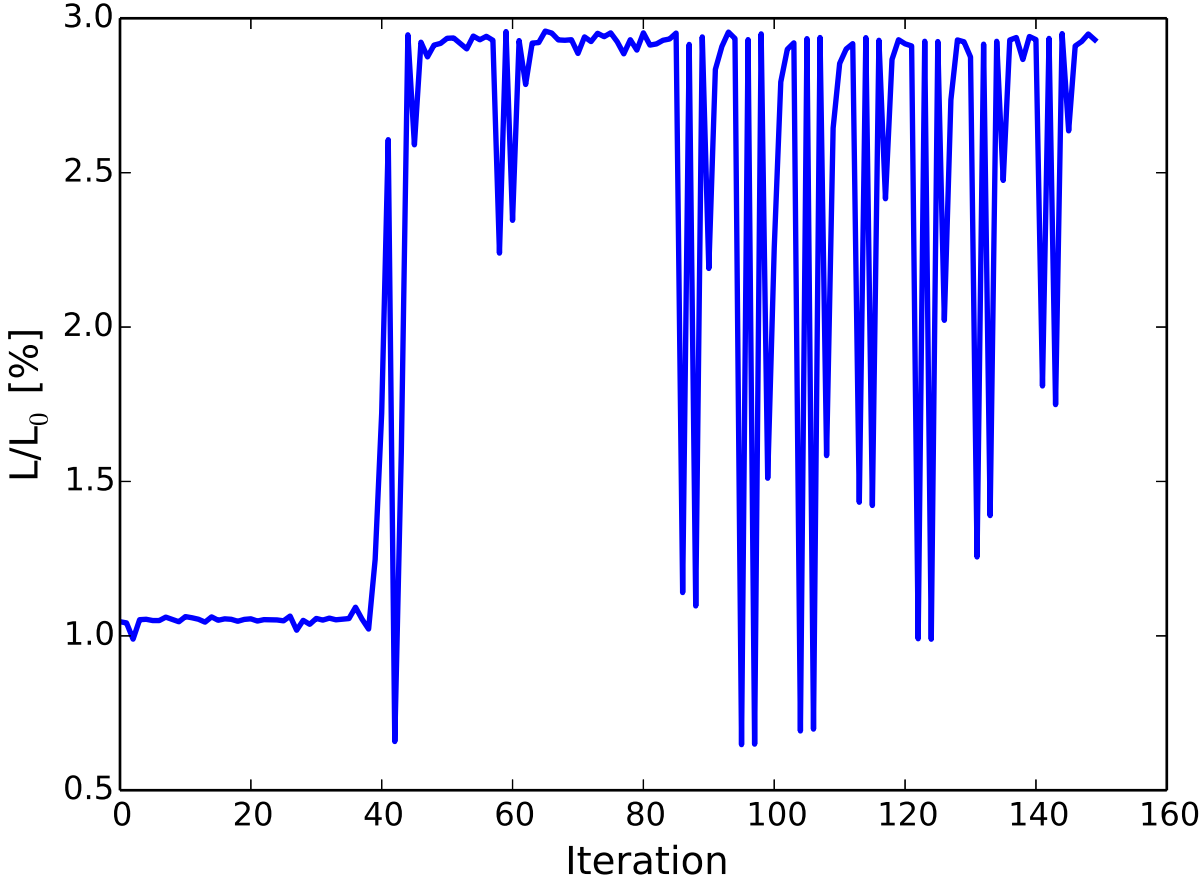
Calculating new knobs

- For each sextupole, vary with $\pm\Delta x$ and track the beam.
- Calculate the covariance matrix, using the variation of the variables E, x, y, xp, yp.
- Use SVD decomposition to calculate orthogonal knobs.

ILC Solenoid Studies

- Deterministic simulation showed only 1 % luminosity loss from ISR.
- Tuning the optical part expected to be more challenging.

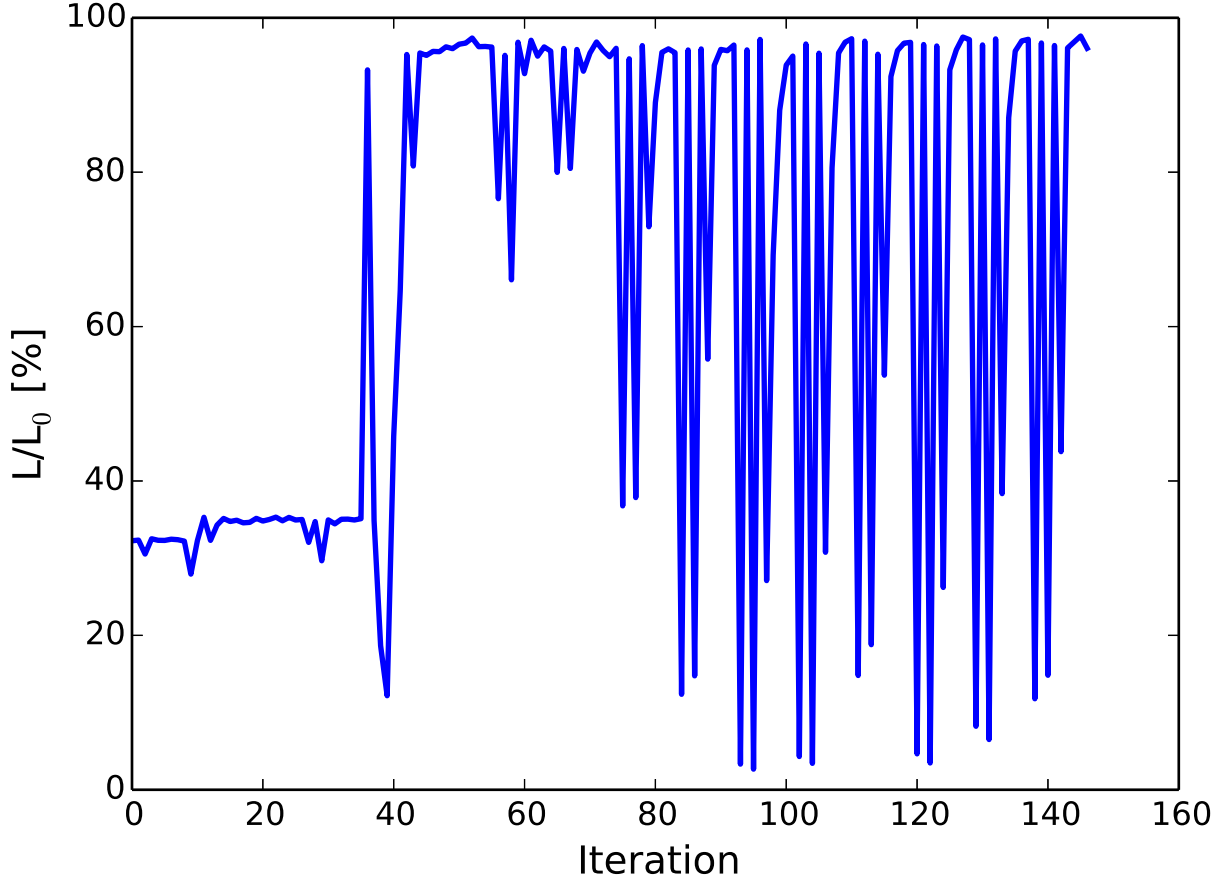
First try at tuning



Using the same list of knobs we use for CLIC..

Tuning - Improvements

First, reduce the absolute strength of the solenoid a factor 20 to see if the algorithm/knobs work as expected..



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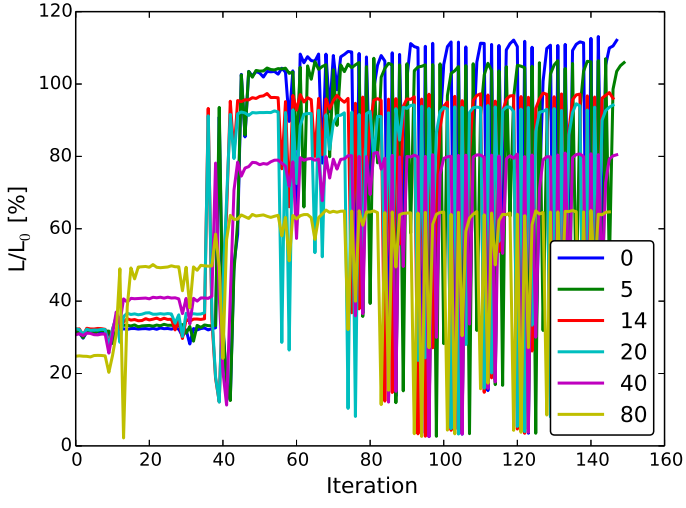
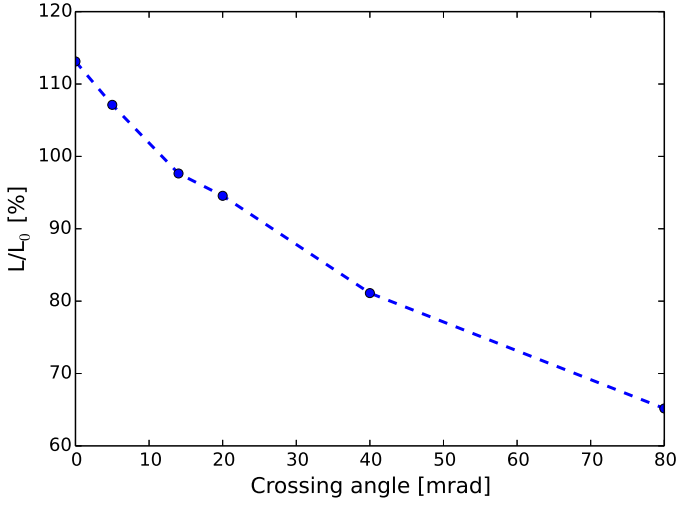
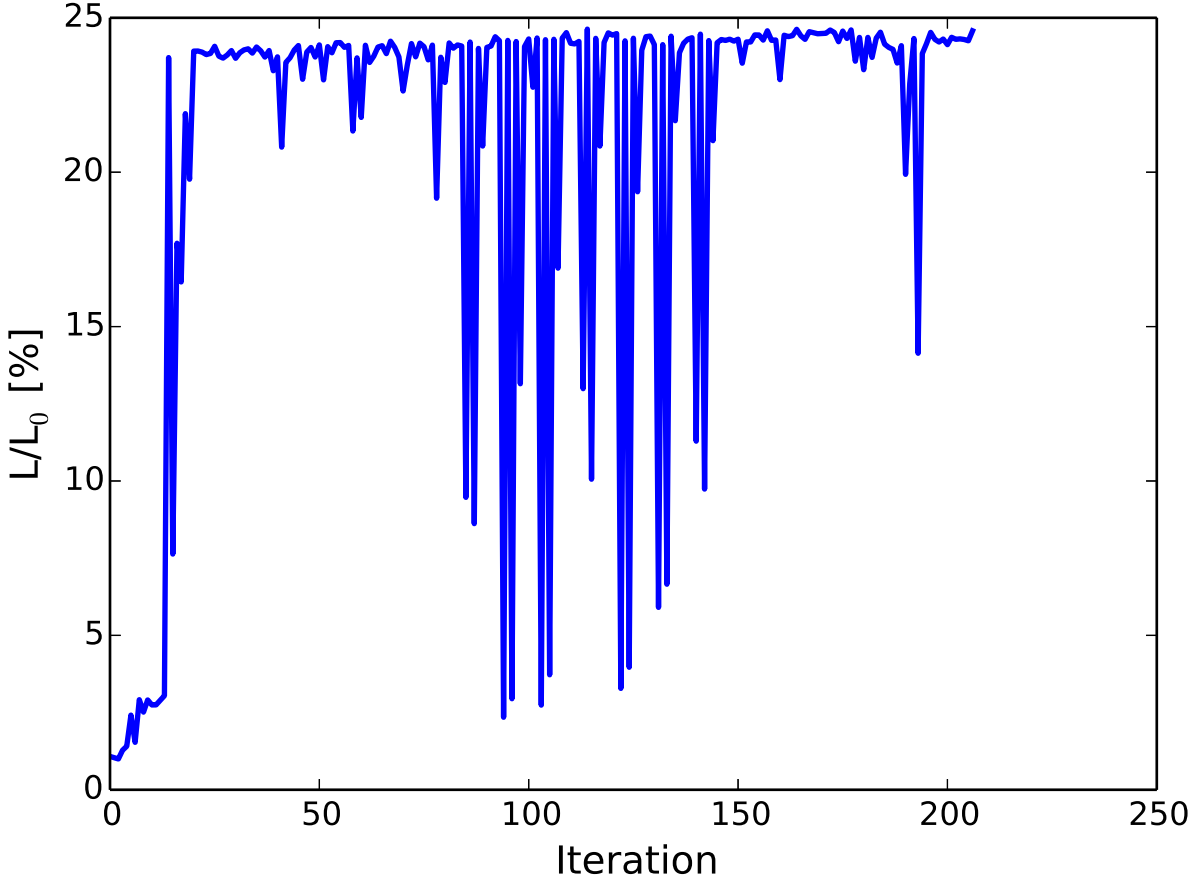




Give an idea of how much impact increasing the crossing angle will have on the tuning performance.

Tuning - Improvements

Order of knobs could improve things?
Going twice over the QD0/QF1 vertical and roll knobs.



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- Order of knobs important -> non-linear optimisation.
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  - Certain probability for mutation.
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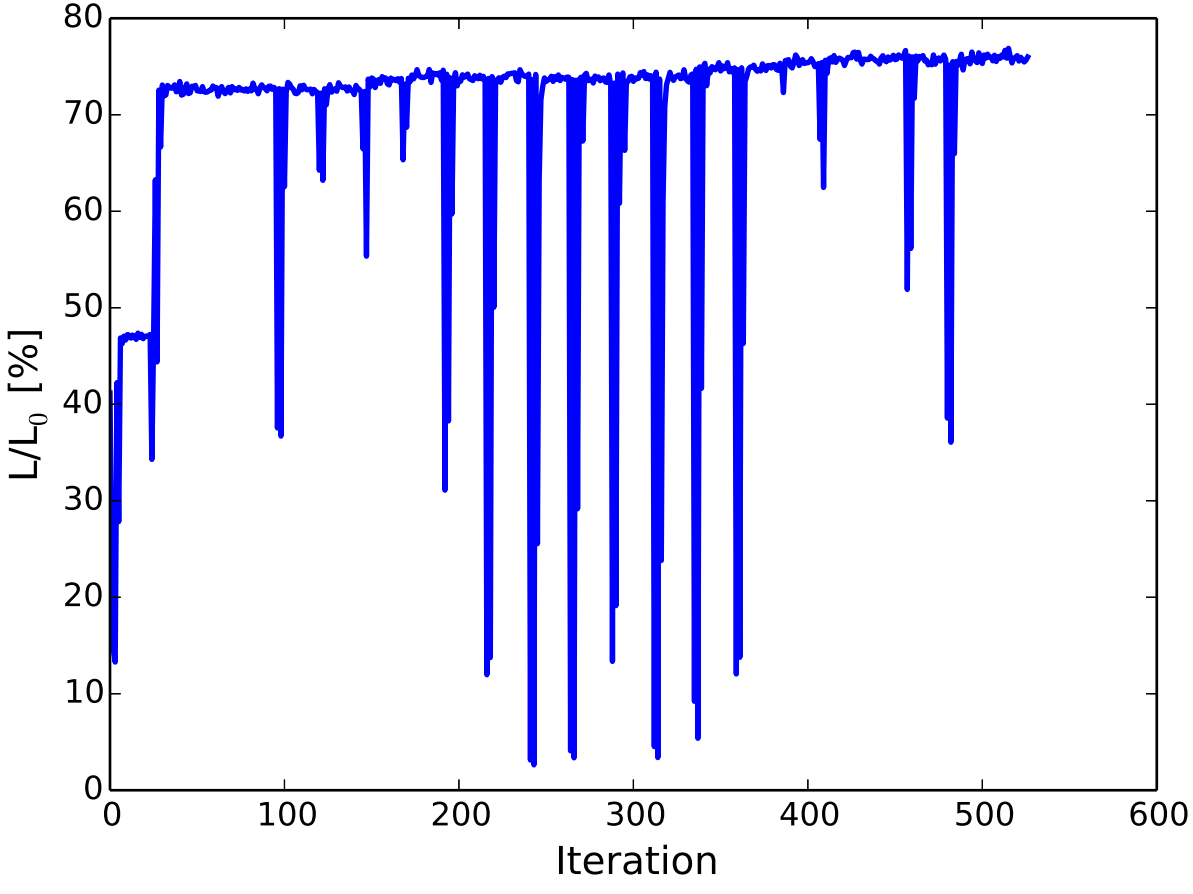
The Simplex algorithm could be an alternative approach.

Tuning - with anti-solenoid

- The SC QD0 should provide significant shielding not included in these simulations.
  - And comprises an anti-solenoid we learned today.
- The anti-solenoid was found to remove $\sim$ 90 % of the optical distortions by Versteegen, similar has been found for CLIC.

Tuning - with anti-solenoid



Using the same knob order which gave 25 % L/L_0 before.

Summary ILC tuning

- About 99 % should be recovered if we manage perfect compensation.
- Optical distortions stronger than for CLIC.
- Preliminary, about 25 % recovery without anti-solenoid, 75 % with anti-solenoid.
- Anti-DID and shielding effect of QD0 not included.

References

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