ILC BDS MEETING

Optics Design and Beam Dynamics Modeling Status

Long L^* option for ILC at 500 GeV Alternate FFS configuration Status & Plans

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December 4th

LINEAR COLLIDER COLLABORATION

OUTLINE

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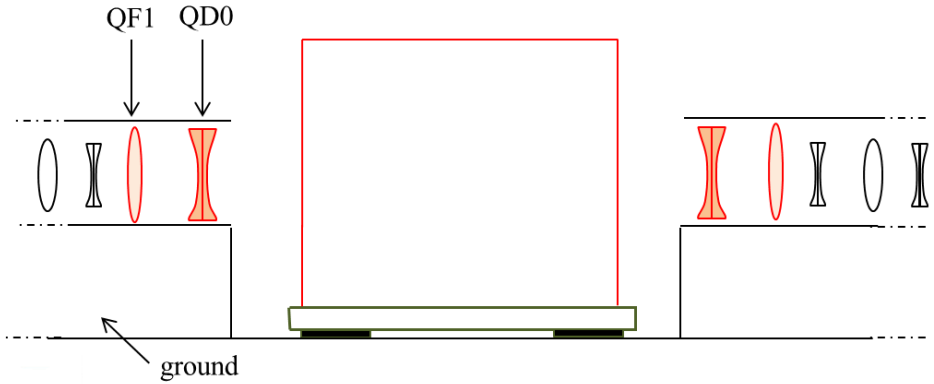
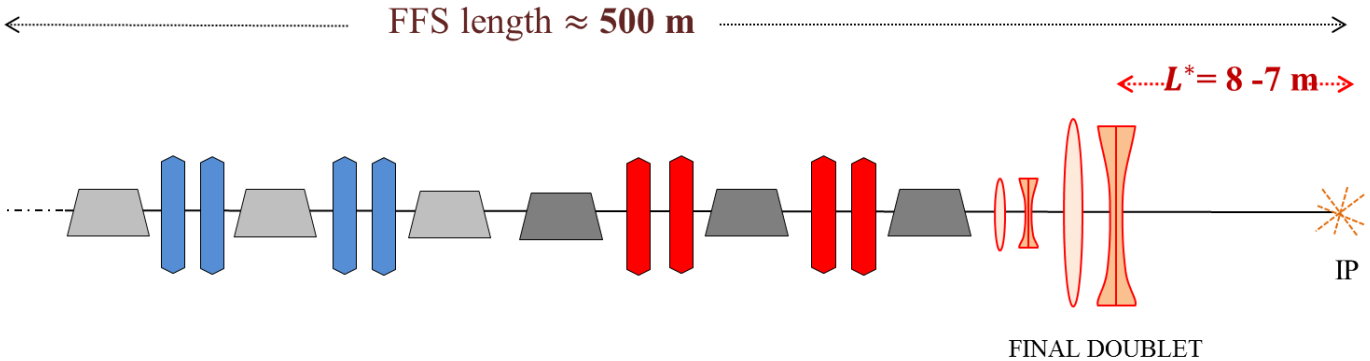
Objectives and FFS design strategy

- Long L^* to allow the location of the FD outside of the detector on the stable ground
- Small FD magnets vibration
- Same magnets for all the detectors
- common L* for both SiD and ILD



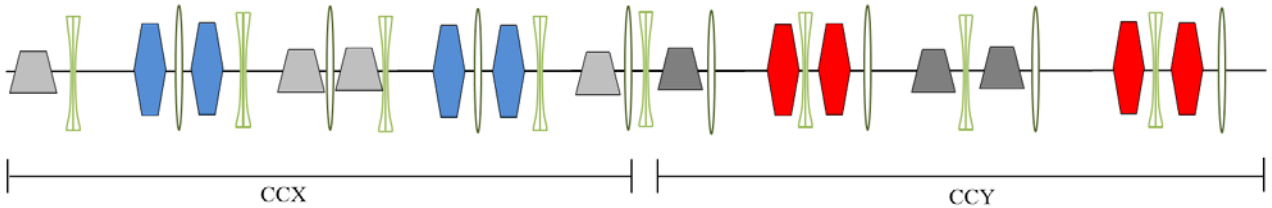


- Final Focus design based on the traditional scheme with dedicated chromatic correction sections
- First study based on a Last Drift of 8 meters and according to the size of the detectors a new study based on L^* = 7 m has started

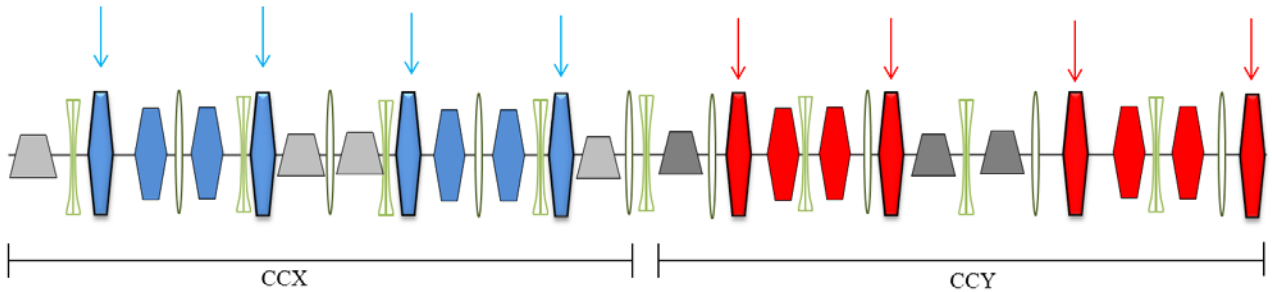
Goal : Check the feasibility in terms of luminosity and tuning performances

A Summary of the optics optimization and performances

Original traditional design



New traditonal using 8 extra sextupoles

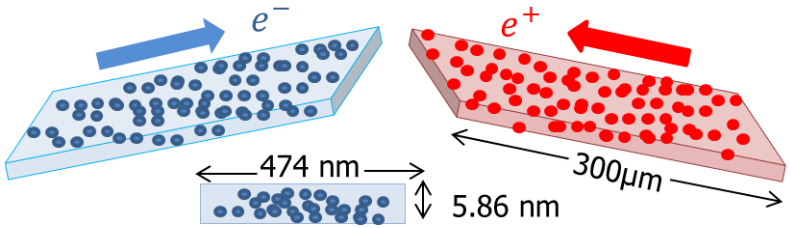


For the L^*= 8 m option, taking into account higher order aberrations and SR:

Current performances :

goal : L_{total}= 1.5 × $10^{34} cm^{-2} s^{-1}$

$\sigma_x{}^*$ [nm]	$\sigma_y{}^*$ [nm]	L_{total} [$\times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	L_{peak} [$\times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]
498.1	**6.46**	**1.36**	**0.84**

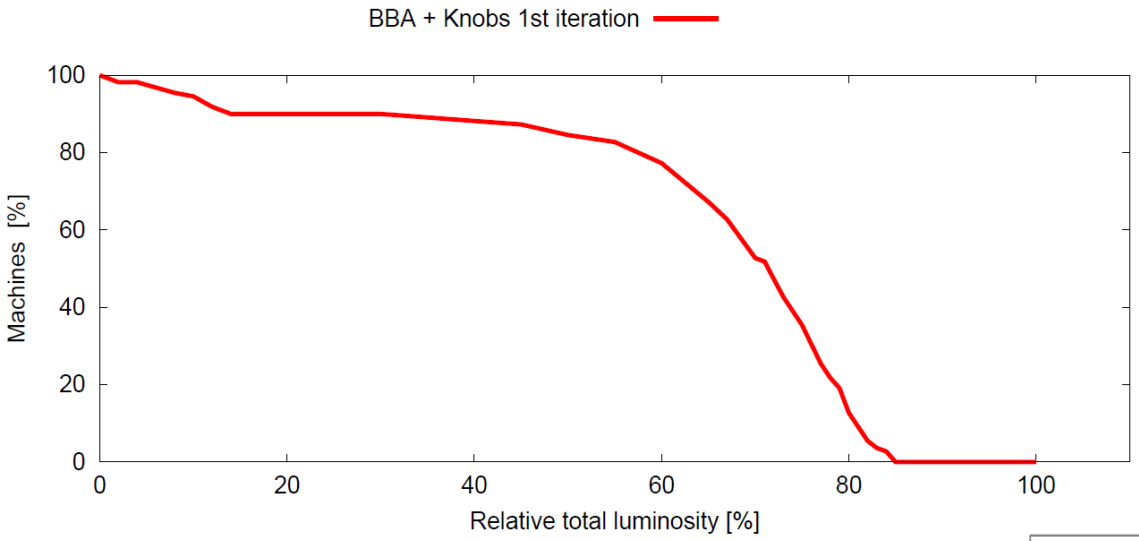


(Δp/p = 0.125%)

B

Tuning status: BBA optimization (L^*=8m)

Previous status of the tuning study for the new design:



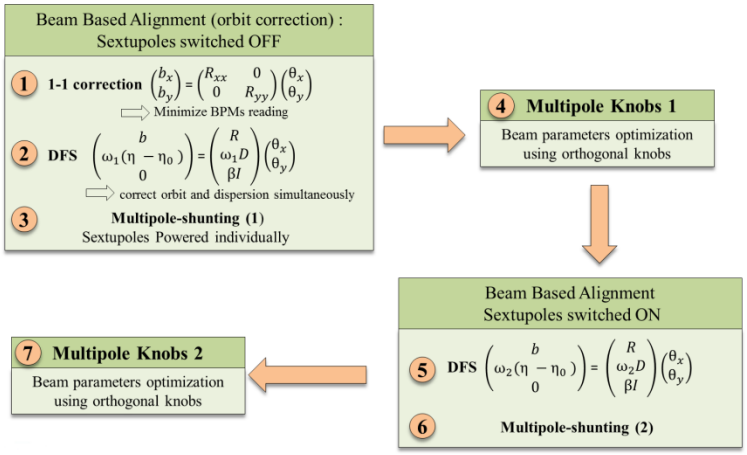
Tuning set up:

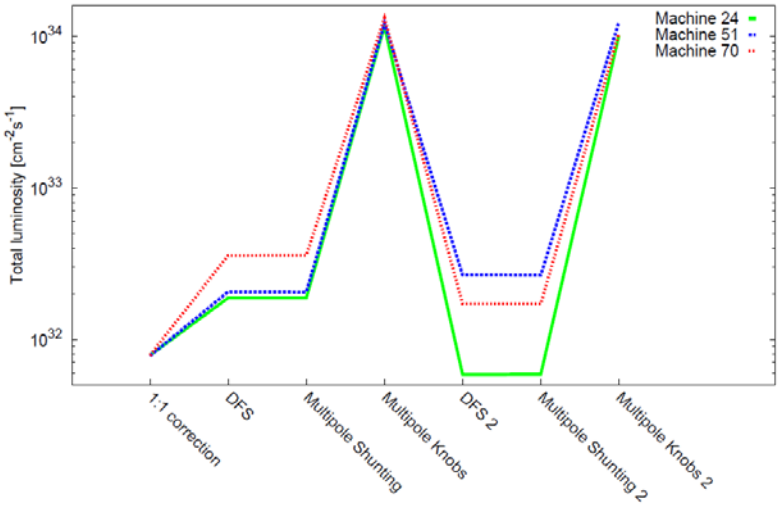
- Initial misalignment: **10 µm** RMS in transverse plane
- Elements misaligned : **Quads, Sextupoles and BPMs**
- BPM resolution : **10 nm**
- L_{T0} = **1.5** $\times 10^{34} cm^{-2} s^{-1}$

⇨ 70% machines reach 65% of L_{T0}

⇨ No significant improvement after iterations

⇨ DFS weights must be optimized

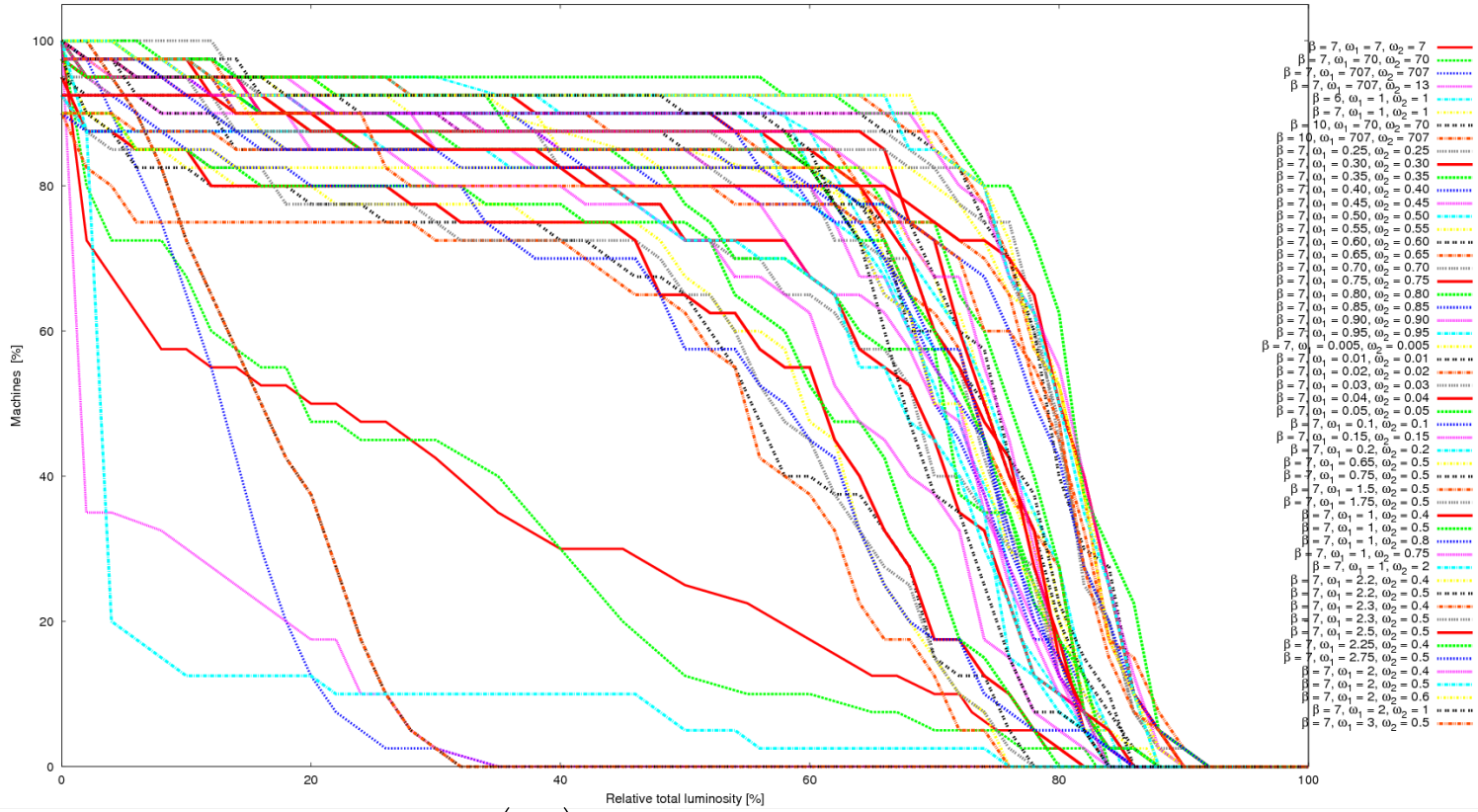




B Tuning status: BBA optimization (L^*=8m)

Optimization of the DFS weight factors β, ω 1, ω 2 :

- Several weights combinaisons were performed for 40 seeds each
- Optimal weights found for the new design with L^*=8m: **β = 7 , ω 1 = 2.25 , ω 2 = 0.4**



DFS1 $\begin{pmatrix} b \\ \omega_1(\eta - \eta_0) \\ 0 \end{pmatrix} = \begin{pmatrix} R \\ \omega_1 D \\ \beta I \end{pmatrix} \begin{pmatrix} \theta_x \\ \theta_y \end{pmatrix}$

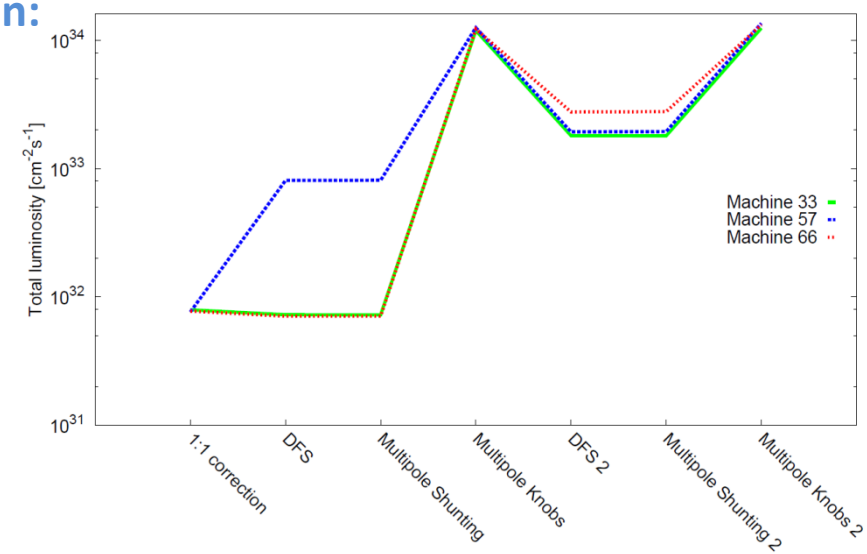
DFS2 $\begin{pmatrix} b \\ \omega_2(\eta - \eta_0) \\ 0 \end{pmatrix} = \begin{pmatrix} R \\ \omega_2 D \\ \beta I \end{pmatrix} \begin{pmatrix} \theta_x \\ \theta_y \end{pmatrix}$

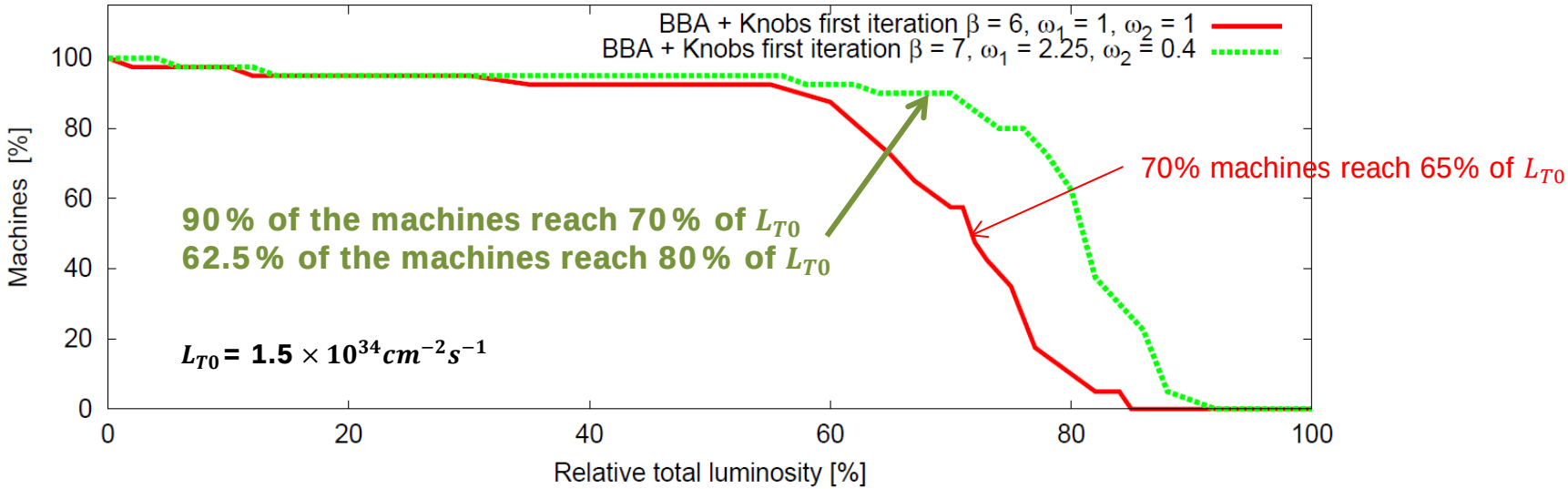
B

Tuning status: BBA optimization (L^*=8m)

Tuning performance after weights optimization:

- Optimization of the DFS weights improve the alignment process especially for the DFS2
- With optimized β, ω_1, ω_2 luminosity at the 2nd multipole knobs is increased from the 1st
- New tuning (BBA+Knobs): 90% of the 110 machines reach 70% of L_{T0}



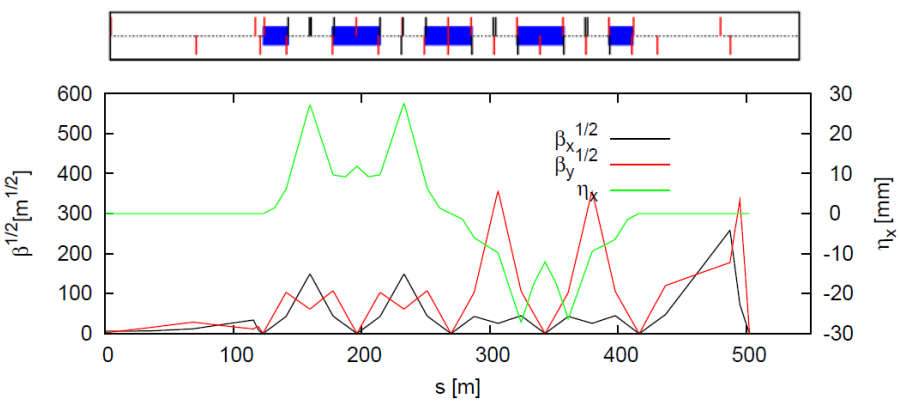


A

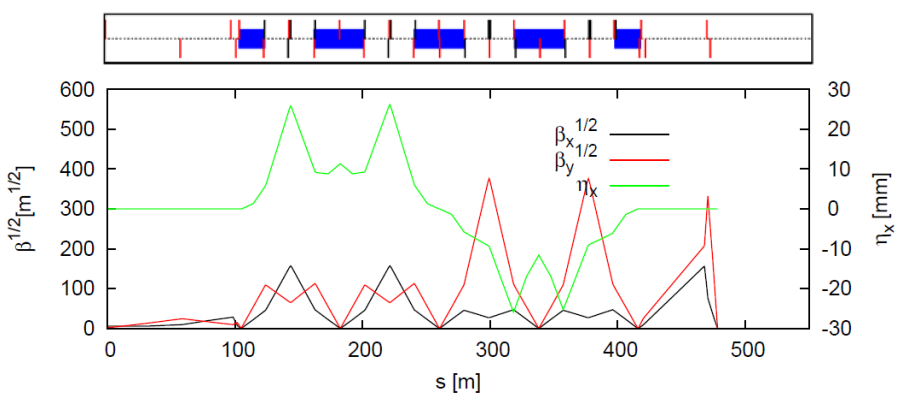
Lattices designed for L^* = 7 m

- A last drift of 7 meters is a possible option to remove the FD from the detector area
- The space (D1) between QD0 and QF1 can impact on chromaticity minimization, it must be considered in the case of the traditional scheme and different lengths between the FD were optimized for the L^* = 7 m option

Lattice for D1 = L = 7 m*



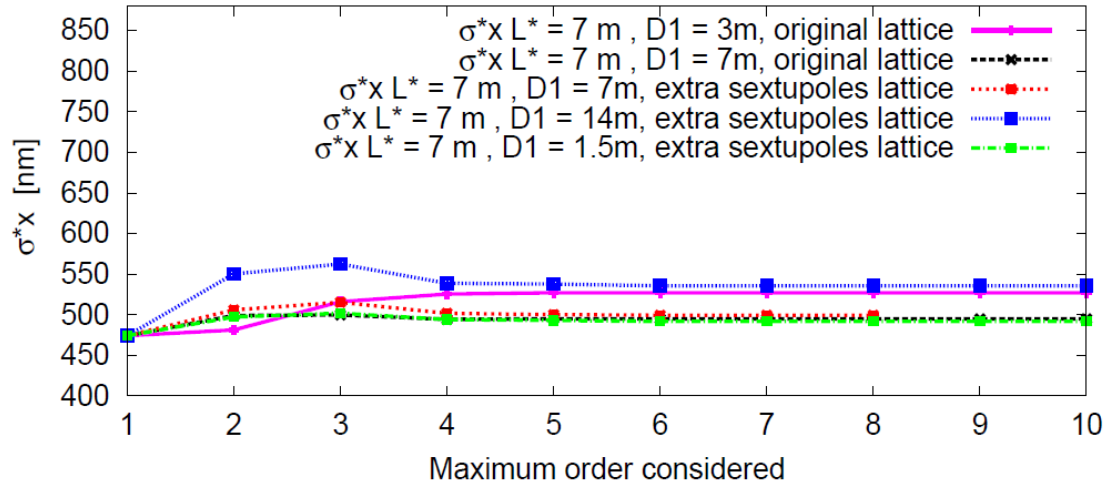
Lattice for D1 = 1.5 m

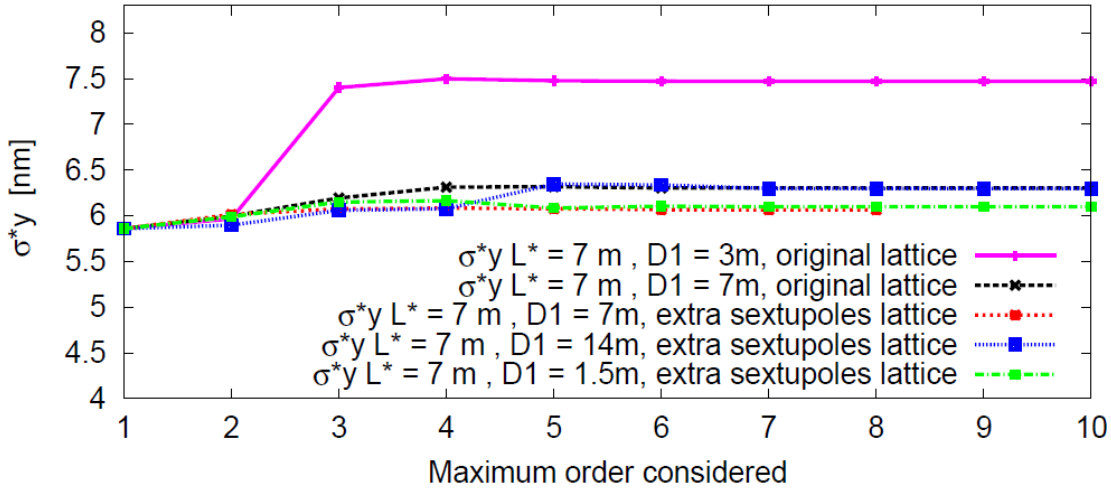


B

Beam sizes and bandwidth

- Considering higher order aberrations the deviation is very small in vertical plane (4% and 5% for extra sextupoles lattice D1 = 1.5 m and D1 = 7 m respectively)
- For D1 = 1.5 m : $\sigma_x(10)$ = **491.7 nm**
- For D1 = 7 m : $\sigma_x(10)$ = **499.3 nm**



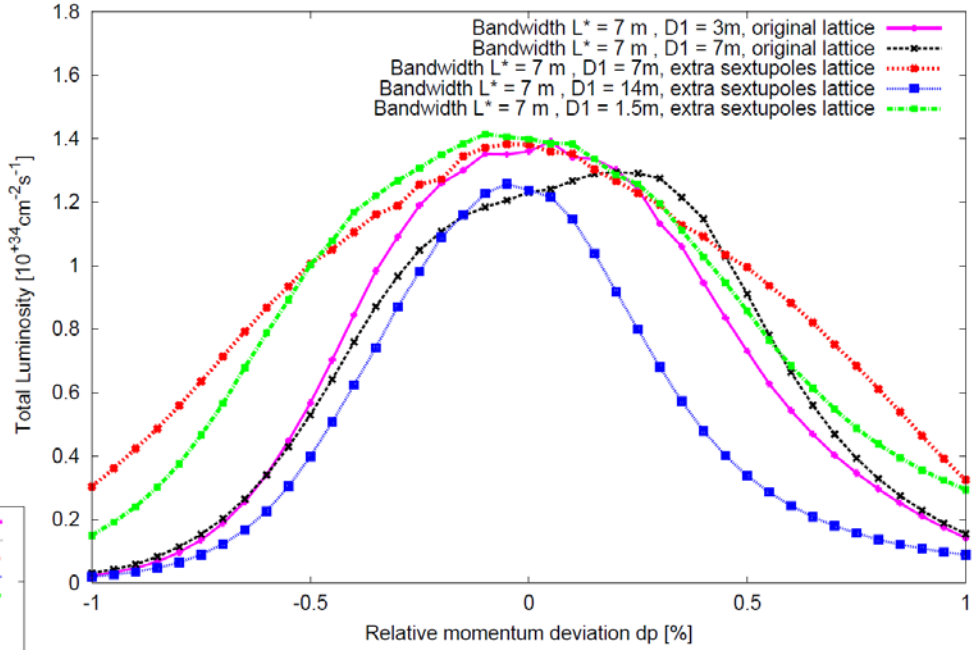


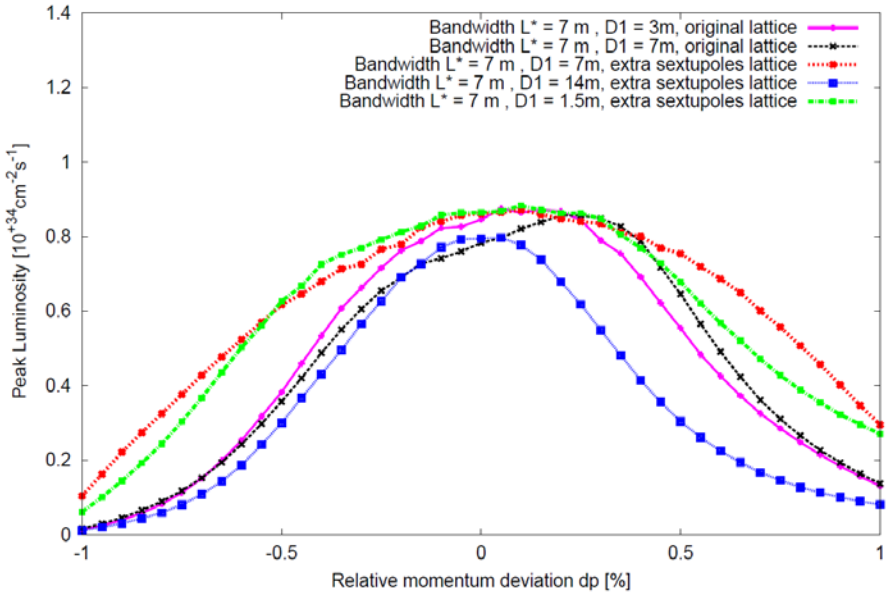
- Considering higher order aberrations the deviation is very small in horizontal plane (4% and 3% for extra sextupoles lattice D1 = 1.5 m and D1 = 7 m respectively)
- For D1 = 1.5 m : $\sigma_y(10)$ = **6.1 nm**
- For D1 = 7 m : $\sigma_y(10)$ = **6.07 nm**

B

Beam sizes and bandwidth

- For D1 = 1.5 m : $L_{TOT} = 1.41 \times 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- For D1 = 7 m : : $L_{TOT} = 1.38 \times 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$



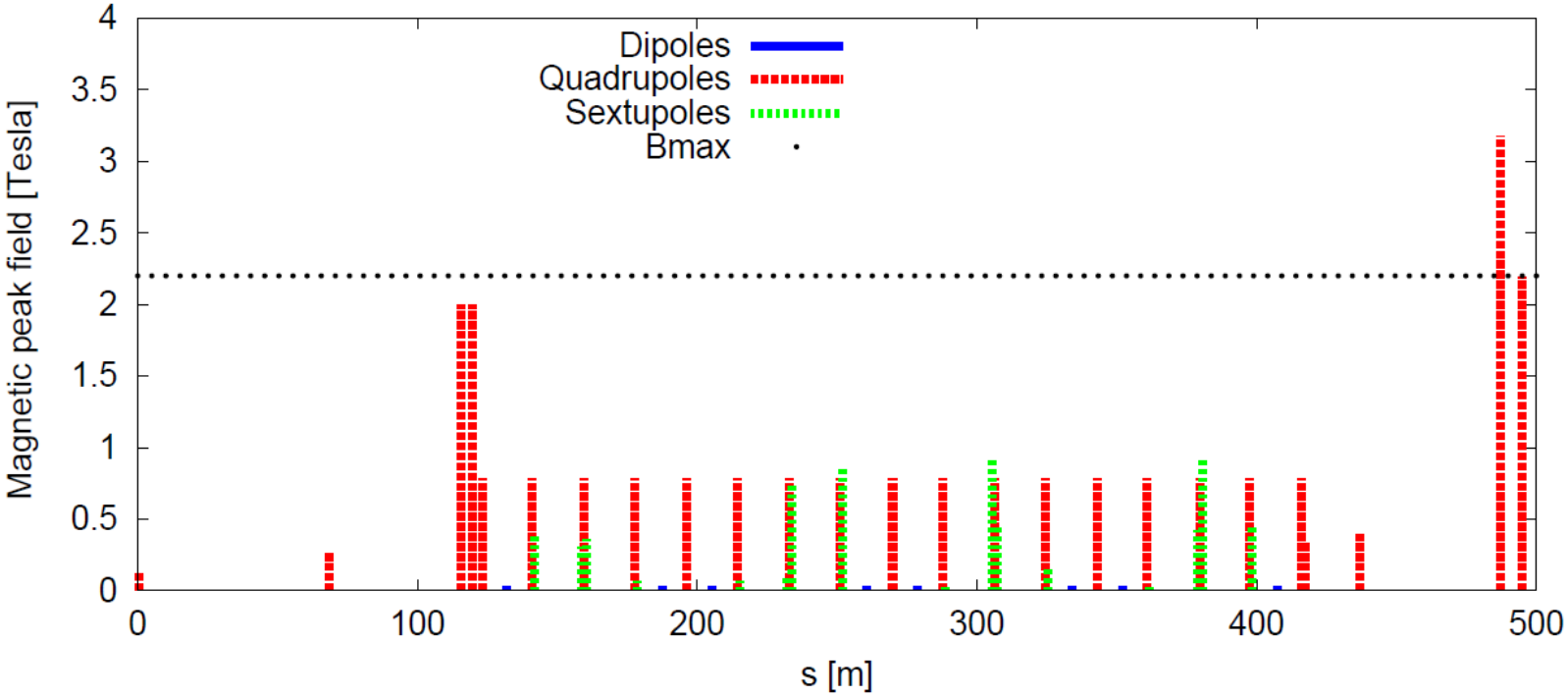


- For D1 = 1.5 m : $L_{peak} = 0.88 \times 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- For D1 = 7 m : : $L_{peak} = 0.87 \times 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

C

Magnetic peak field checking

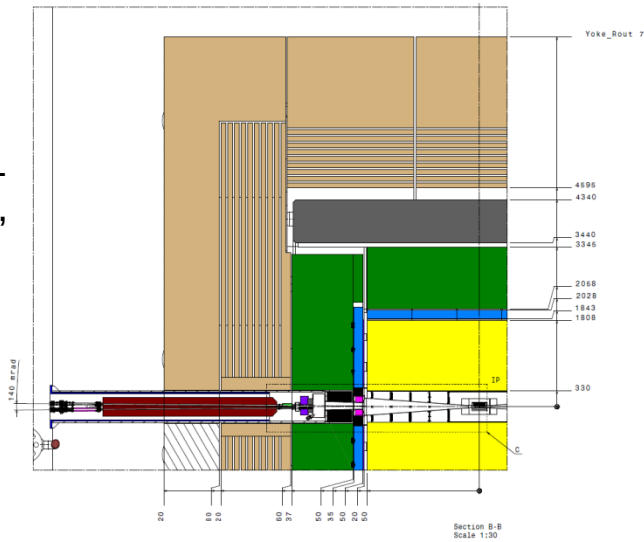
- Due to the short length of this traditional scheme the two last quadrupoles show high magnetic field (2 Tesla) to match the β-functions in CCX and CCY
- QF1 and QD0 show a high magnetic field for the current lattice and should be reduce in further optimization according to the technology available

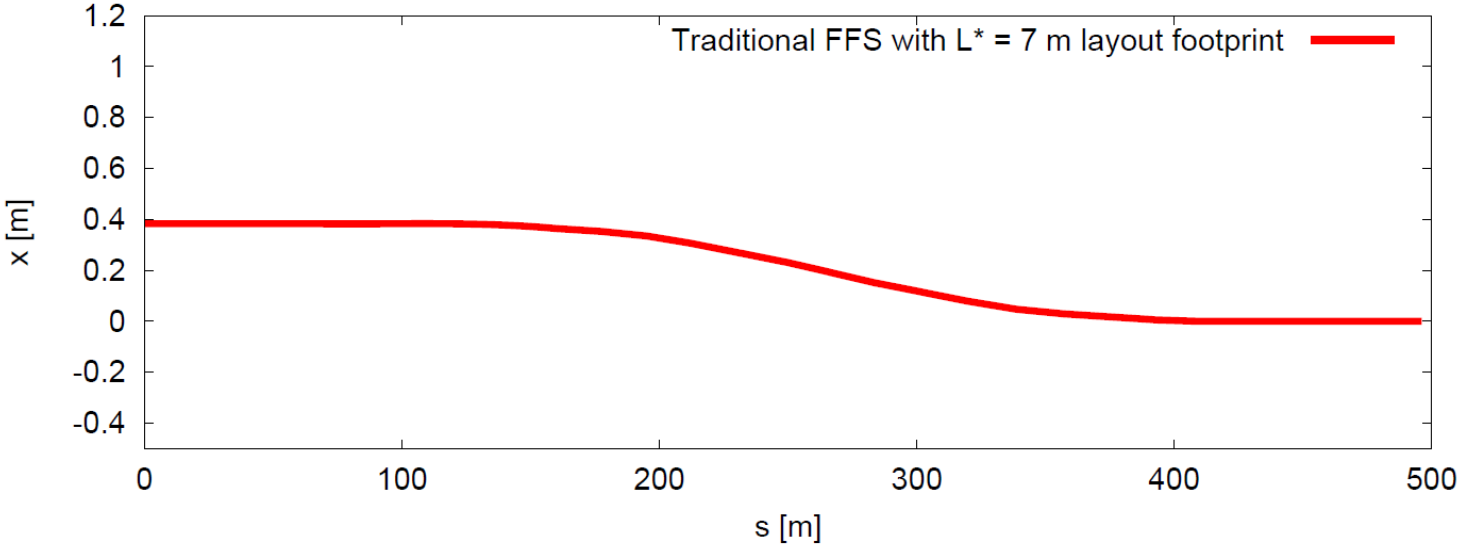


A

Engineering constraints

- ILD & SiD detector region designs must be rethought for the Long L^* option
- Find optimum position, length and strength of the Final Doublet QF1 and QD0 to increase luminosity and bandwidth, reduced tolerences, simpler tuning and wider collimation depth
- Optimal L^* lattice should have a compatible layout with the baseline design from the detector group
- Consider the ILC tunnel according to this alternate FFS design





B

Further studies and simulations

FFS design :

- Optimization of the traditional design using the minimal L^* according the final size of the detector
- Optimization of the space between QF1 and QD0 for the chromaticity minimization
- Reduce FD magnetic peak field especially for QF1 (currently > 3 T)
- Optimize bending magnet strenght, according to the ILC tunnel, can improve chromaticity correction in CCX and CCY but limited by synchrotron radiation
- Optimization and tuning simulation of the long L^* option based on the Local scheme

FFS tuning :

- Iterate BBA+knobs simulations for L^* = 8 m with the optimized weights and apply Simplex algorithm
- Weights optimization with realistic errors condition for ILC (initial misalignment, BPM resolution...)
- Start tuning on L^* = 7 m options , investigate an easier lattice for the tuning (strength and length of the magnets, less sextupoles for beam parameters procedures, etc.)

5 Summary and Conclusions

- L^* = 8 m design tuning shows promising results with the optimized DFS weights **with 90% of the machines reaching 70% of L_{T0}**
- Weights optimization for tuning takes a long time and is **needed for each different lattice** (different L^* or tuning set up)
- With less optimistic tuning set up (200 µm initial transverse misalignment and 100nm BPM resolution) the **tuning performance drop**
- The space between QF1 and QD0 has a significant impact on final beam sizes at the maximum order considered: need to be more investigate
- Current best FFS configuration for L^* =7m is the extra sextupole lattice with 1.5 meters between the FD: $\boldsymbol{\sigma_x}$ **= 491.7 nm** , $\boldsymbol{\sigma_y}$ **= 6.1 nm** , $\boldsymbol{L_{TOT}}$ **= 1.41** $\times 10^{34} cm^{-2} s^{-1}$
- From L^* = 8 m to L^* = 7 m the luminosity is slightly improved (from 10% to 6% of luminosity loss with L_{T0} = 1.5 $\times 10^{34} cm^{-2} s^{-1}$)
- **Design and technology constraints will be integrated to the future FFS design** optimization with long L^* options (Tunnel, studying details from the detector side, maximum FD peak field, etc.)