Non-interleaved FFS design

Oscar BLANCO[1,2]
LAL[1], CERN[2]

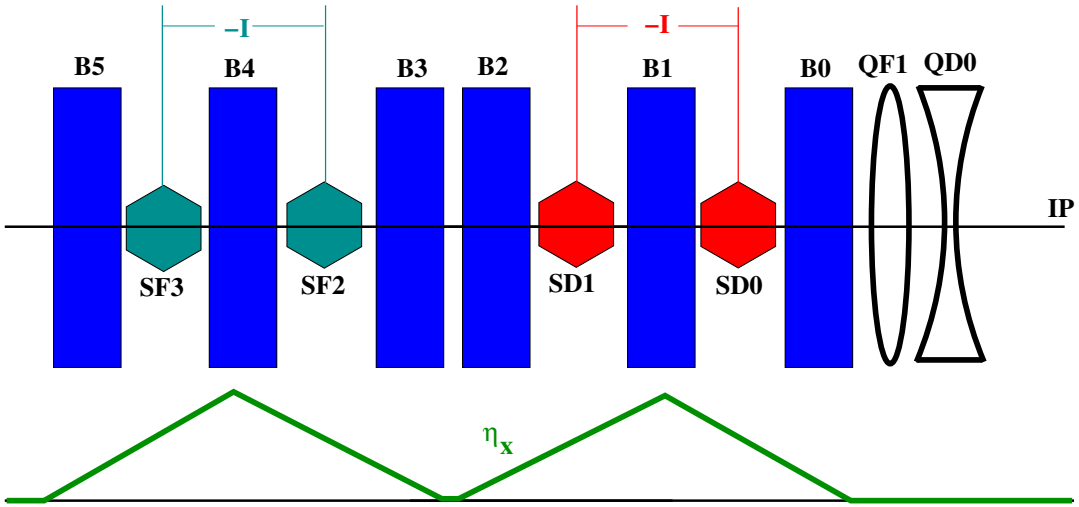
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

CERN

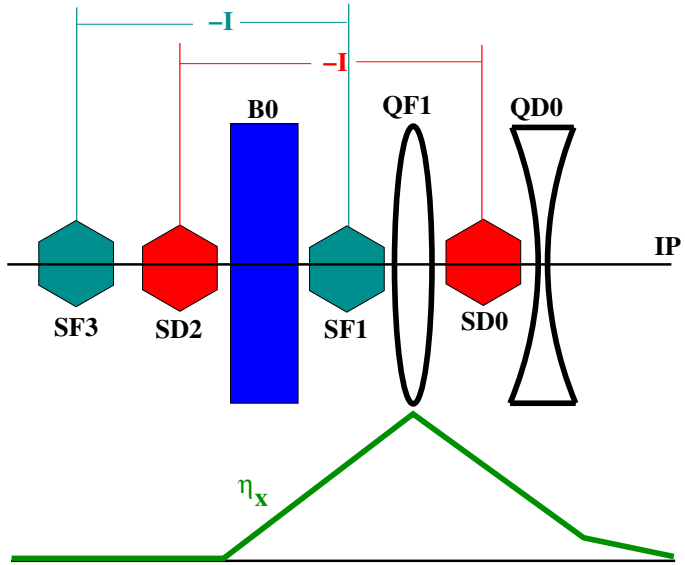
Table of contents

Chromaticity correction

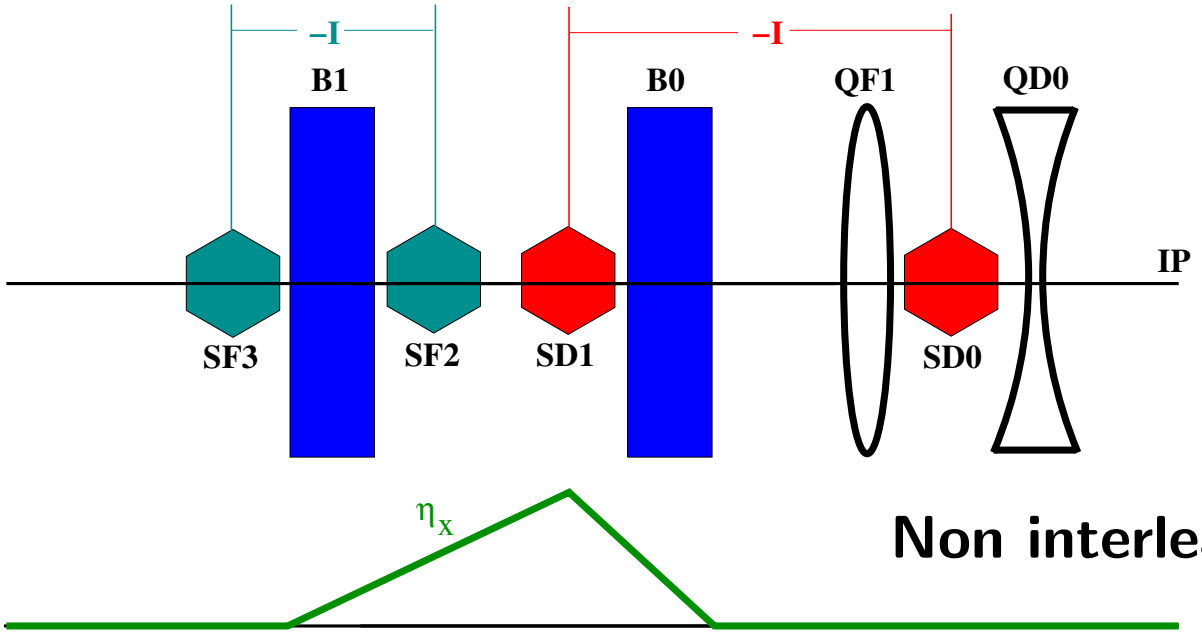
Local, Non-local and Non-interleaved correction



Non-local



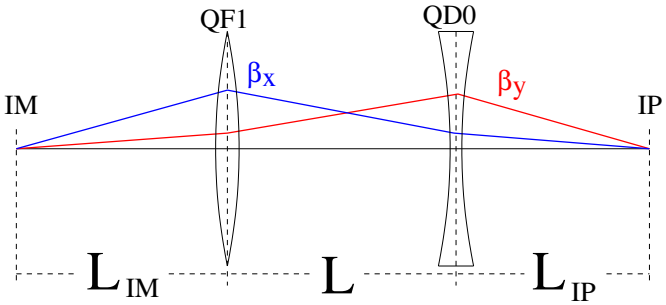
Local

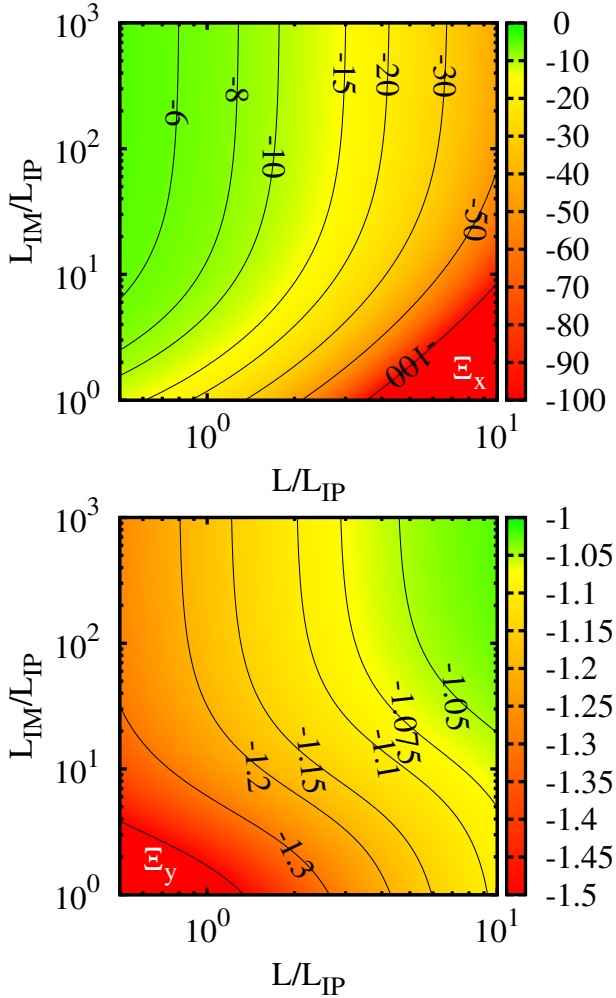


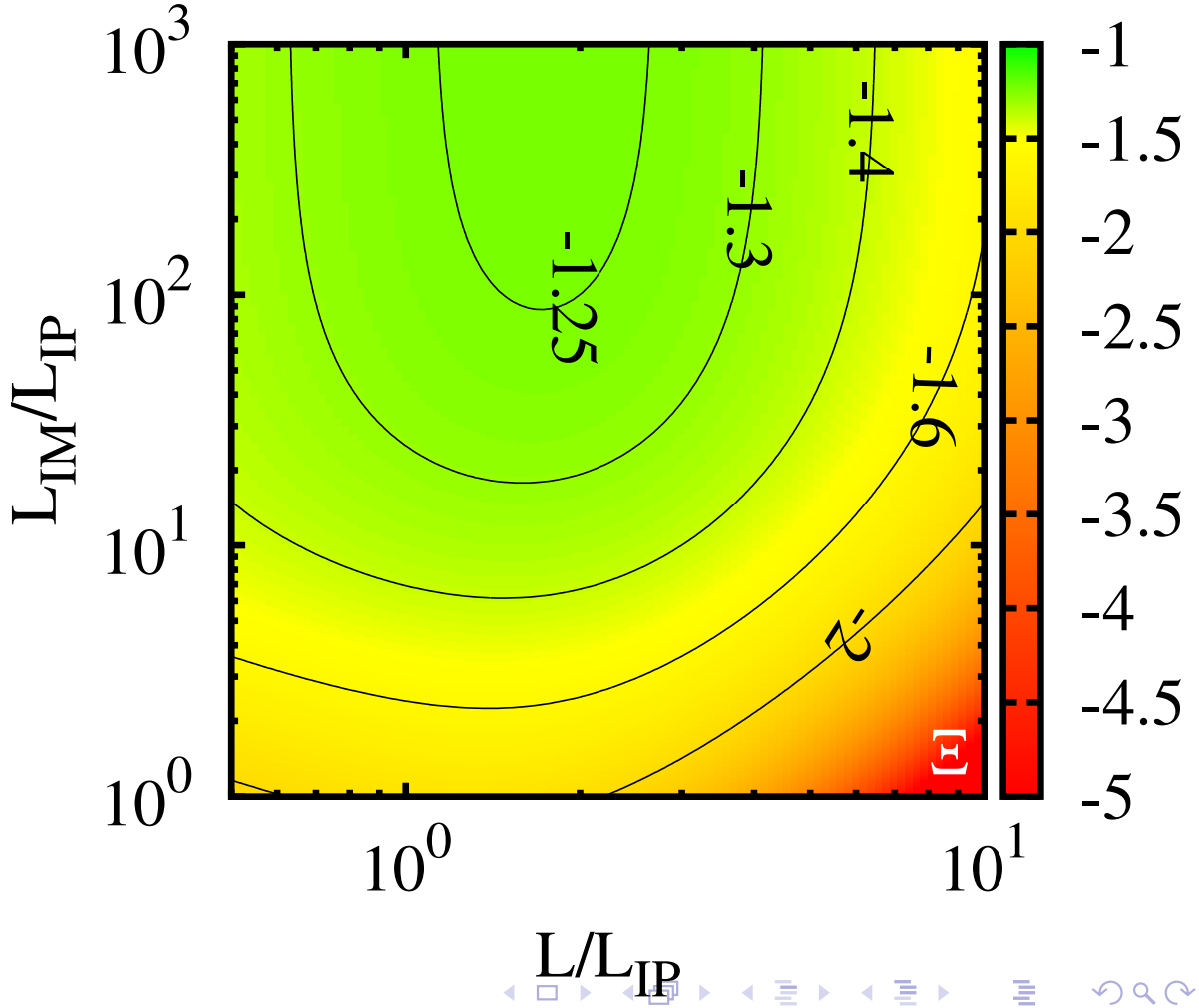
Non interleaved

Some design criteria

Chromaticity minimization







Chromaticity of a doublet in units of L_{IP}/β_y^*

Oide effect

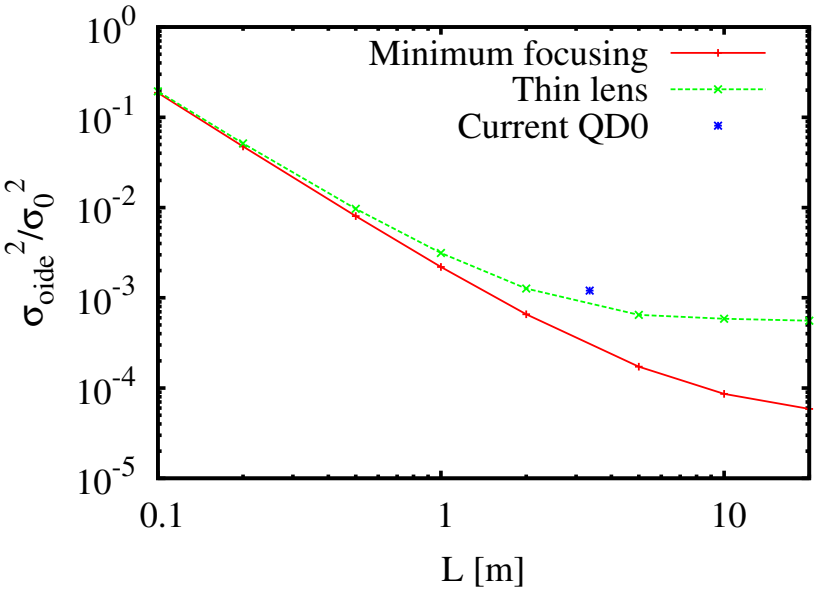
For the vertical plane,

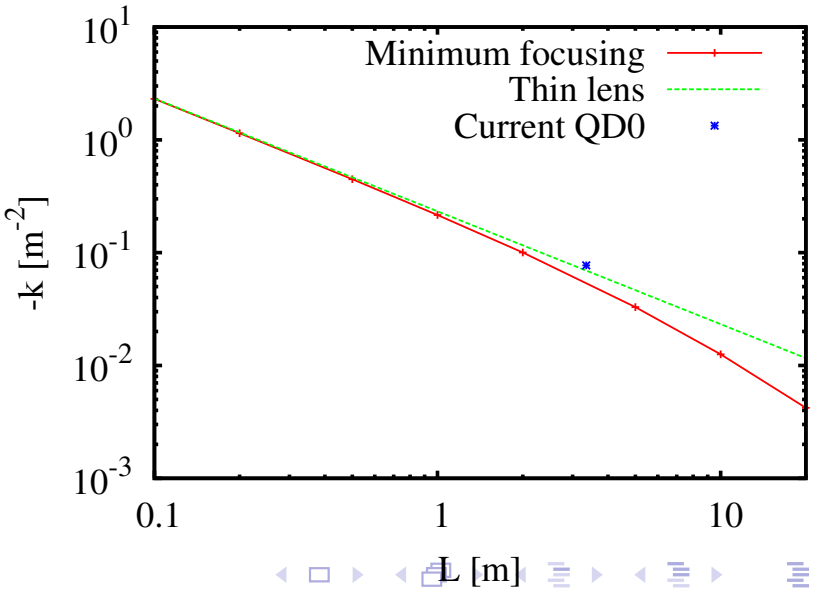
$$\sigma_{oide}^2 = \frac{110}{3\sqrt{6\pi}} r_e \frac{\lambda_e}{2\pi} \gamma^5 F(\sqrt{k}L, \sqrt{k}l^*) \left(\frac{\epsilon}{\beta^*}\right)^{5/2} \quad (1)$$

where

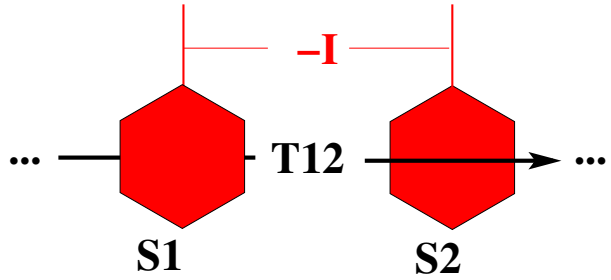
$$F(\sqrt{k}L, \sqrt{k}l^*) = \int_0^{\sqrt{k}L} |\sin\phi + \sqrt{k}l^* \cos\phi|^3 \left[\int_0^{\phi} (\sin\phi' + \sqrt{k}l^* \cos\phi')^2 d\phi'\right]^2 d\phi \quad (2)$$

Oide effect at the Final Doublet is negligible for 500 GeV





$-I$ transformation (geometrical terms cancelled)



$$T_{12} = \begin{pmatrix} t_{11} & t_{12} & 0 & 0 \\ t_{21} & t_{22} & 0 & 0 \\ 0 & 0 & t_{33} & t_{34} \\ 0 & 0 & t_{43} & t_{44} \end{pmatrix}$$ Ideally the phase advance is π. $$\rightarrow \begin{pmatrix} M_x & 0 & 0 & 0 \\ t_{21} & 1/M_x & 0 & 0 \\ 0 & 0 & M_y & 0 \\ 0 & 0 & t_{43} & 1/M_y \end{pmatrix}$$

$\Delta\phi$ represents the phase advance error.

$$\begin{aligned} t_{11}t_{22} &= 1 - (\alpha_{x2} - \alpha_{x1})\Delta\phi_x \\ t_{33}t_{44} &= 1 - (\alpha_{y2} - \alpha_{y1})\Delta\phi_y \\ t_{12} &= \sqrt{\beta_{x1}\beta_{x2}}\Delta\phi_x \\ t_{34} &= \sqrt{\beta_{y1}\beta_{y2}}\Delta\phi_y \end{aligned}$$

and

$$0 = \beta_{y2}/\beta_{y1} - \beta_{x2}/\beta_{x1}$$

$\alpha\Delta\phi \ll 1$
$M > 1, \beta\Delta\phi < 1$
$M_x - M_y \ll 1$, it will set a limit to the cancellation of geometrical terms in both planes at the same time, when matching the sextupoles.

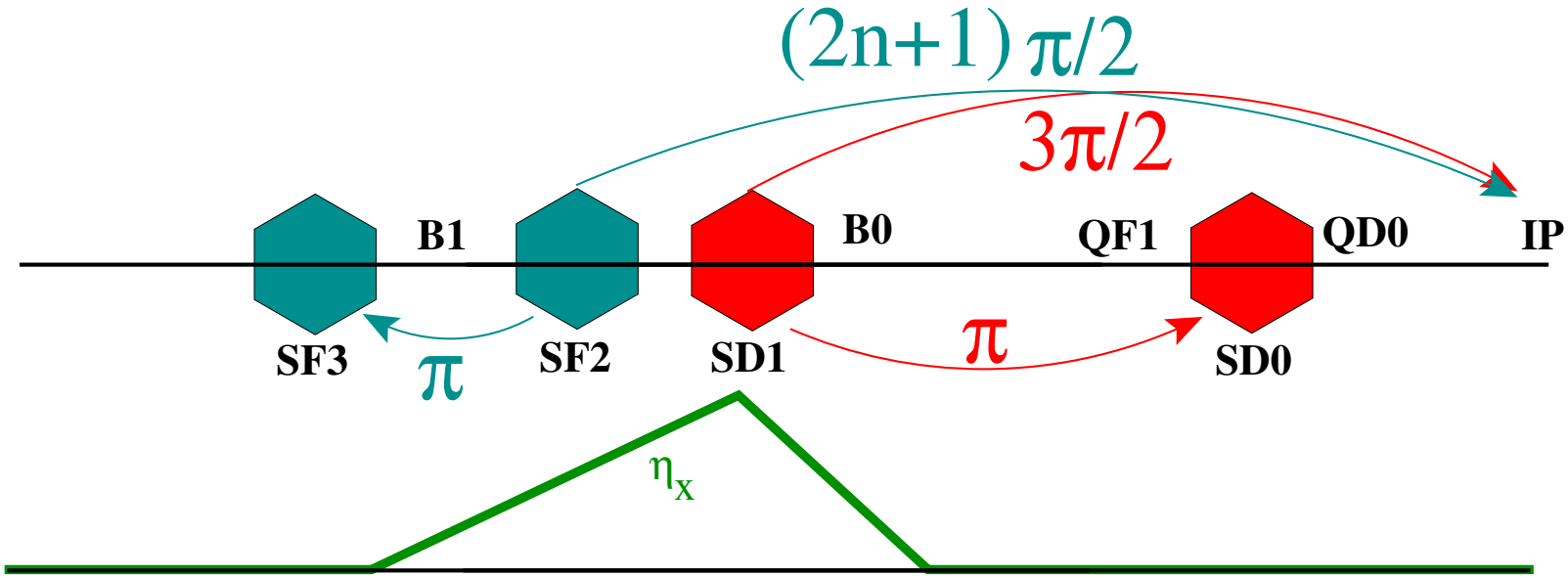
Second order terms, T116, T166,...

One of the paired sextupoles is in a horizontal dispersive region ($\eta_x \neq 0$).

The kick there will be

$$x_2' \propto (x_1 + \eta_x \delta)^2 \rightarrow \qquad T111, T116, T166$$

$$y_2' \propto (x_1 + \eta_x \delta) y \rightarrow \qquad T313, T336$$



Radiation in bending magnets

$$\sigma_{bend}^2 \propto \int_0^{IP} \frac{E^5}{\rho^3} t_{16}(s, IP)^2 ds$$

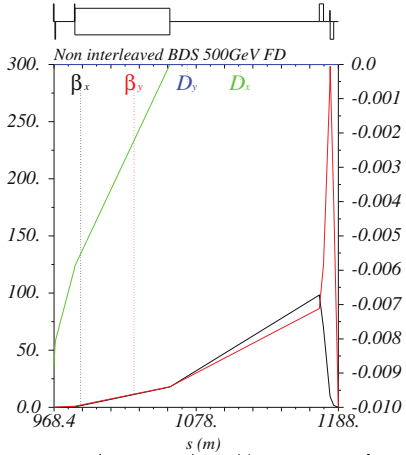
Enough dispersion to cancel chromaticity but not to much due to radiation.

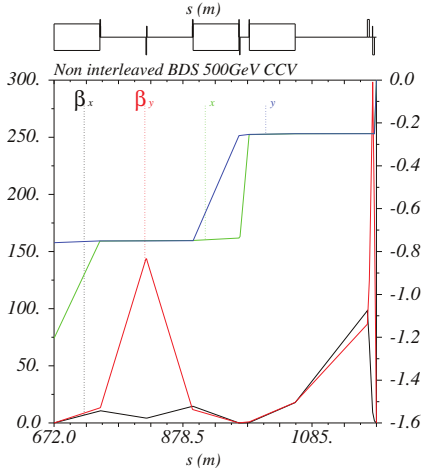
500GeV Non-interleaved Lattice

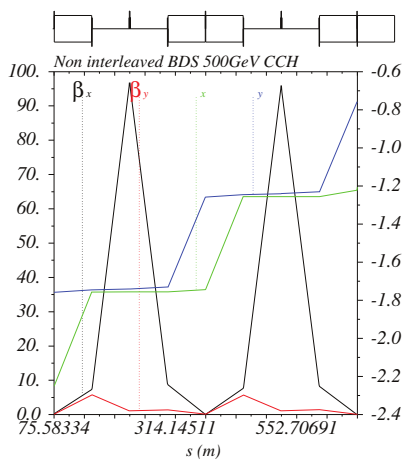
Current 500 GeV Lattice Parameters (from CDR)

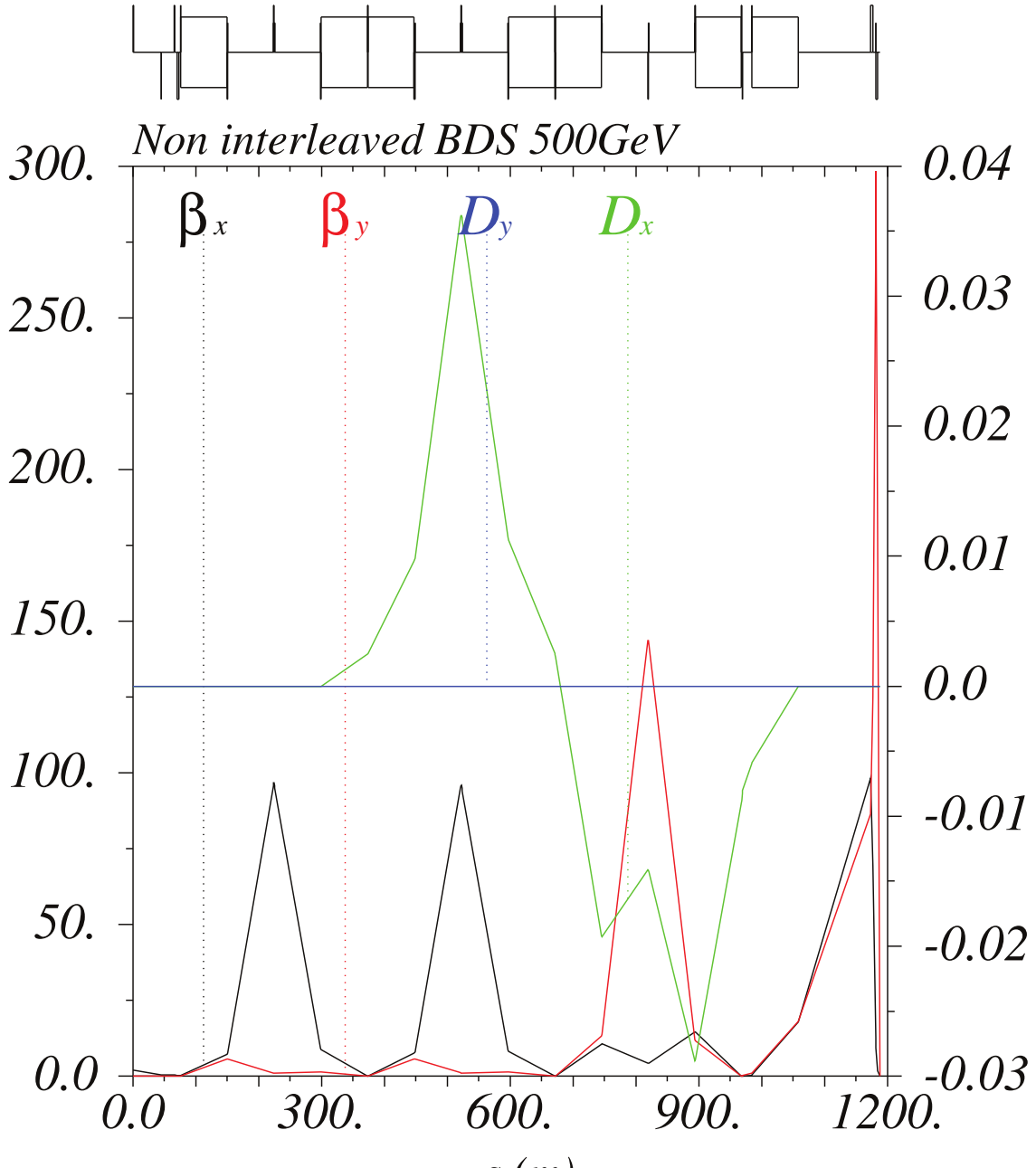
Parameter [Units]	**Value**
Length (linac exit to IP distance/side [m])	1750
Maximum energy/beam [TeV]	0.25
Distance from IP to first quad, L^* [m]	4.3
Crossing angle at the IP [mrad]	18.6
Nominal core beam size at IP, σ^*, x/y [nm]	202/2.3
Nominal beam divergence at IP, θ^*, x/y [μrad]	25/23
Nominal beta-function at IP, β^*, x/y [mm]	8/0.1
Nominal bunch length, σ_z [μm]	72
Nominal disruption parameters, D, x/y	0.1/12
Nominal bunch population, N	6.8×10^9
Beam power in each beam [MW]	4.9
Preferred entrance train to train jitter [σ]	< 0.2
Typical nominal collimation aperture, x/y [σ_x/σ_y]	10/55
Vacuum pressure level, near/far from IP [10^{-9} mbar]	100/10

Non-interleaved CLIC 500 GeV





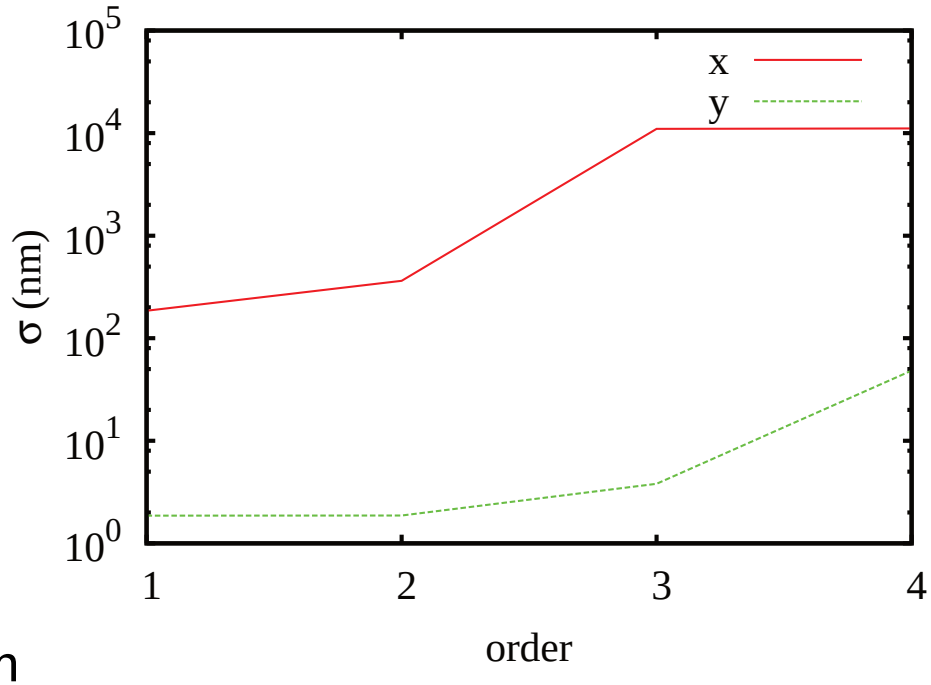




Non-interleaved CLIC 500 GeV (cont.)

The lattice desing gives linear (order=1) beam size of :

$\sigma_x = 1.9\text{nm}$, $\sigma_y = 186\text{nm}$



$\sigma_{bends} = 0.2\text{nm}$

For the moment the biggest component in the horizontal plane is second order dispersion T166.

Conclusions

- The distance between the quadrupoles in the FD should be around one and two times the L^*.
- Phase advance and beta ratios should be matched with enough precision to allow the geometrical terms cancellation.
- Sextupoles position should be placed to get a phase advance as close to $(2n+1)\pi/2$ as possible.
- A non-interleaved line latice has been created from previous lattice designs and matched to these requirements. As a result, second order components in the vertical beam size were corrected and 25% horizontal beam size increase was obtained.
- Lattice length reduction, magnets optimization and tunning evaluation is foreseen.