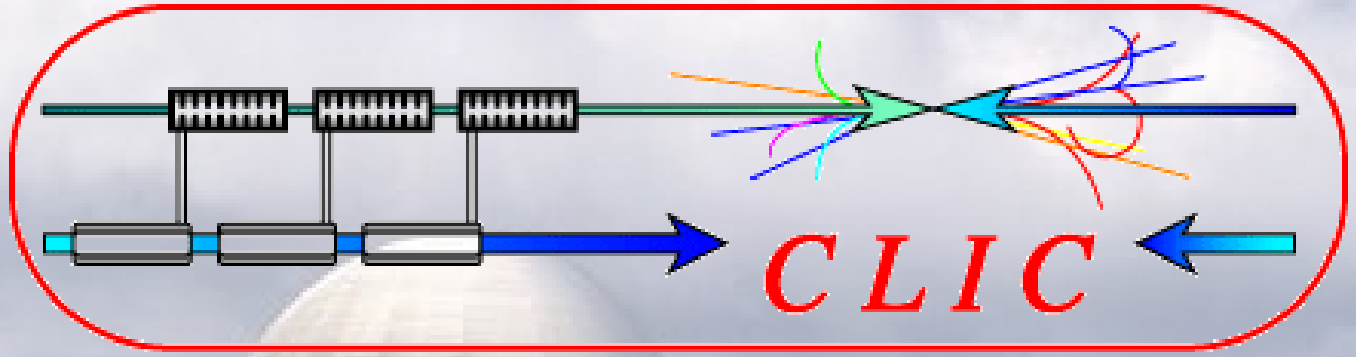
Optimization of the 500 GeV Beam Delivery System

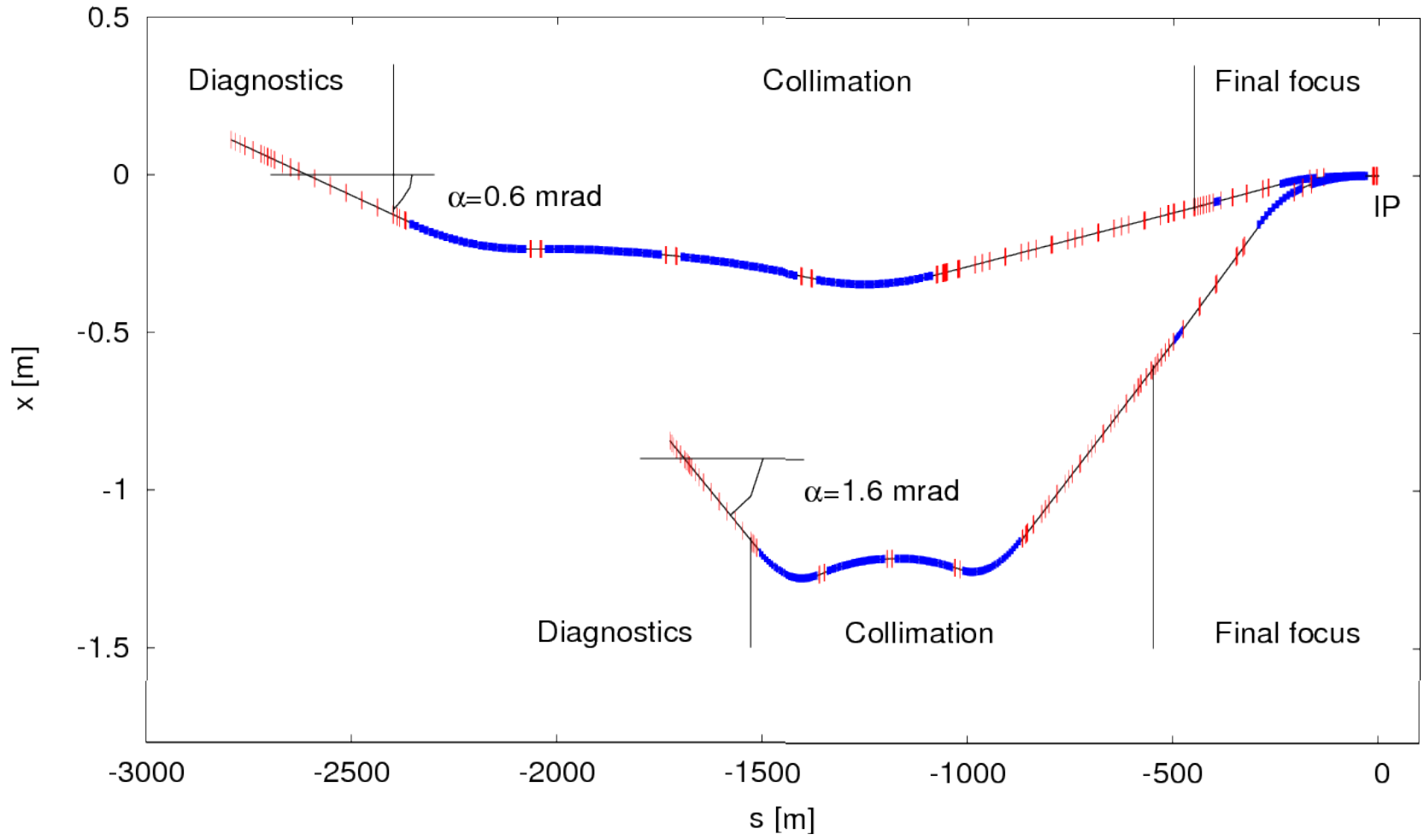


Guillermo Zamudio

Outline

- The BDS status a year ago & Conservative and nominal parameters.
- High order aberration reduction.
- Tunnel problem & solution.
- Lattice for the Nominal requirements.
- Summary

BDS footprint a year ago.

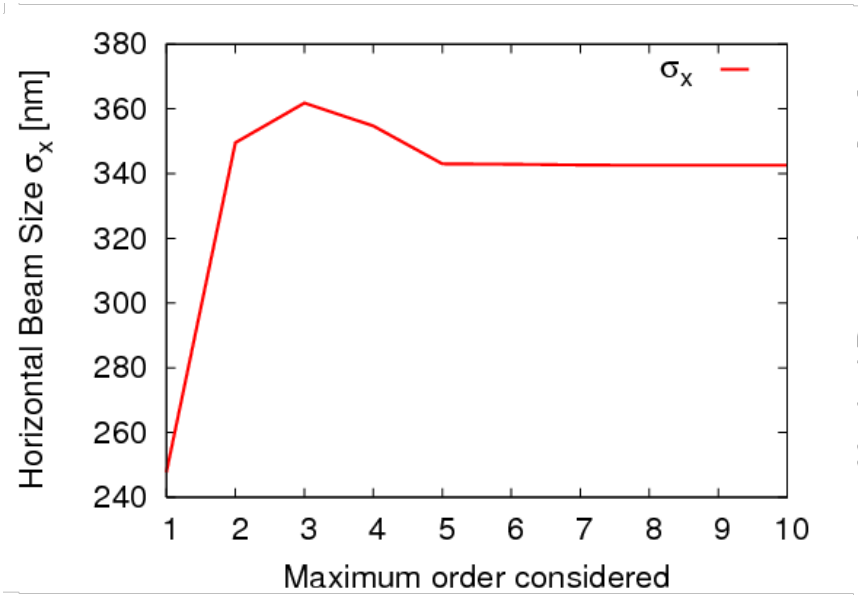


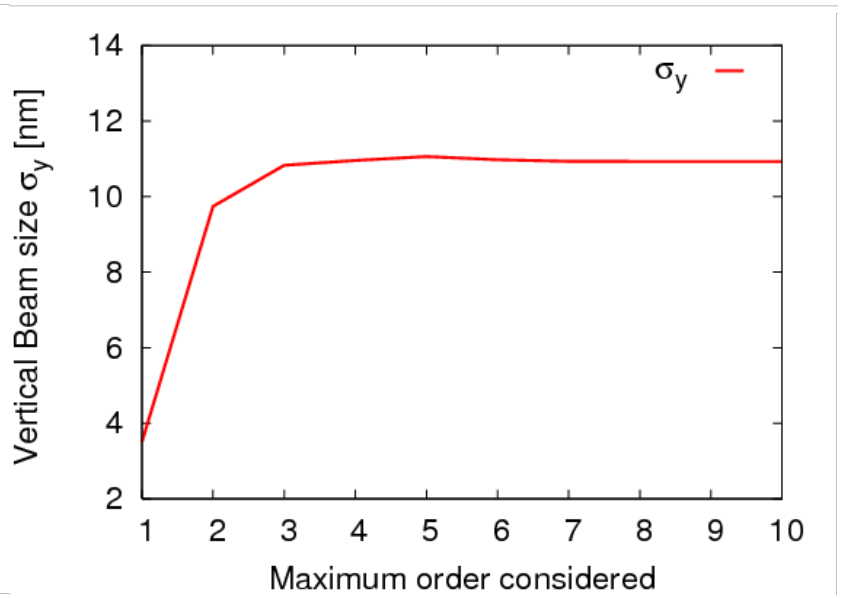
- Crossing angle is 20 mrad.
- 500 GeV BDS needs to be connected with the LINAC.

Parameters at 500 GeV

	Conservative	Nominal
Center-of-mass energy	500 GeV	
Total (Peak 1%) luminosity [$cm^{-2}s^{-1}$]	0.9 (0.6) 10^{34}	2.3 (1.4) 10^{34}
Repetition rate (Hz)	50	
Bunch charge (10^9)	6.8	
Bunch separation (ns)	0.5	
Beam pulse duration (ns)	177	
Number of bunches	354	
Bunch length (ns) σ_z	44	
Hor./vert. norm. emittance ($10^{-6}/10^{-9}$ rad)	3/40	2.4/25
Hor./vert. final focusing β_x^*/β_y^* (mm)	10/0.4	8/0.1
Hor./vert. IP beam size σ_x^*/σ_y^* (nm)	248/5.7	202/2.3

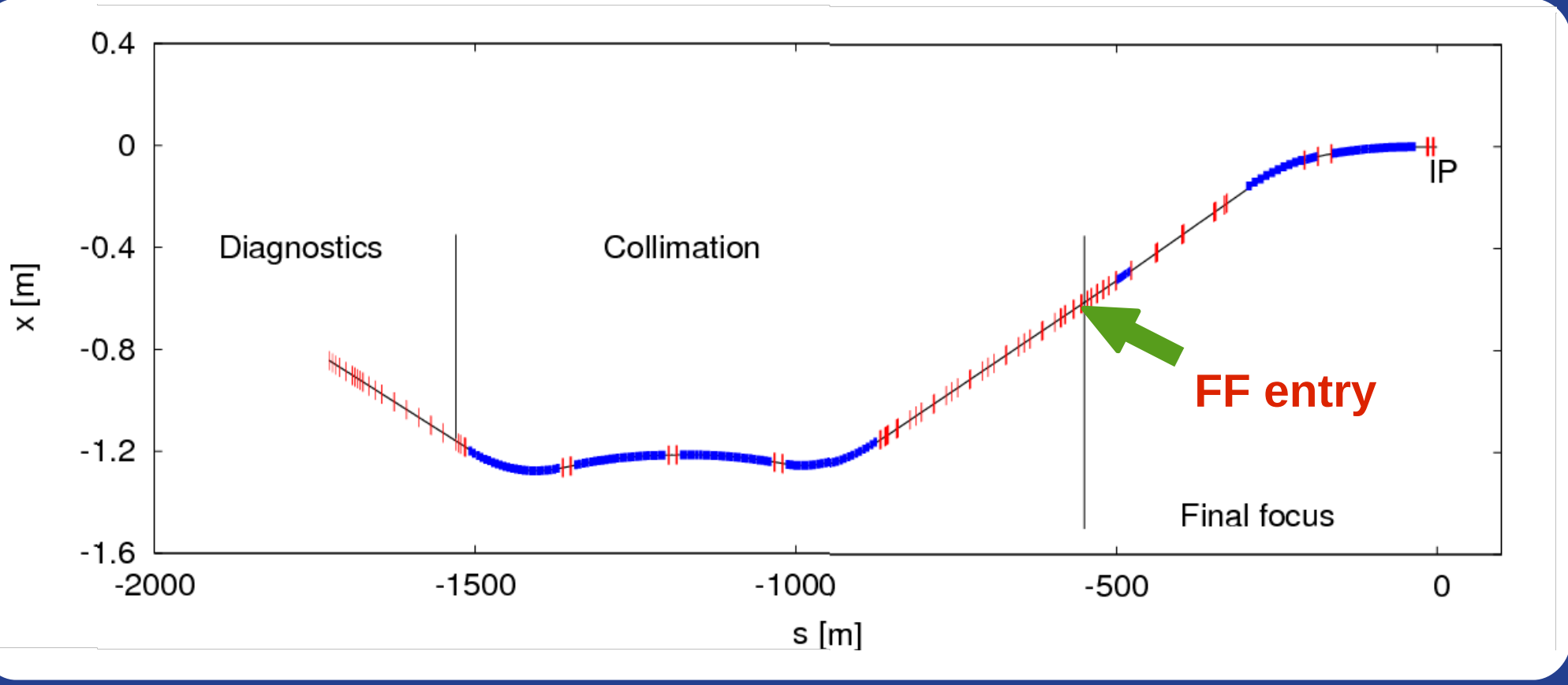
Beam size at the IP in 2009





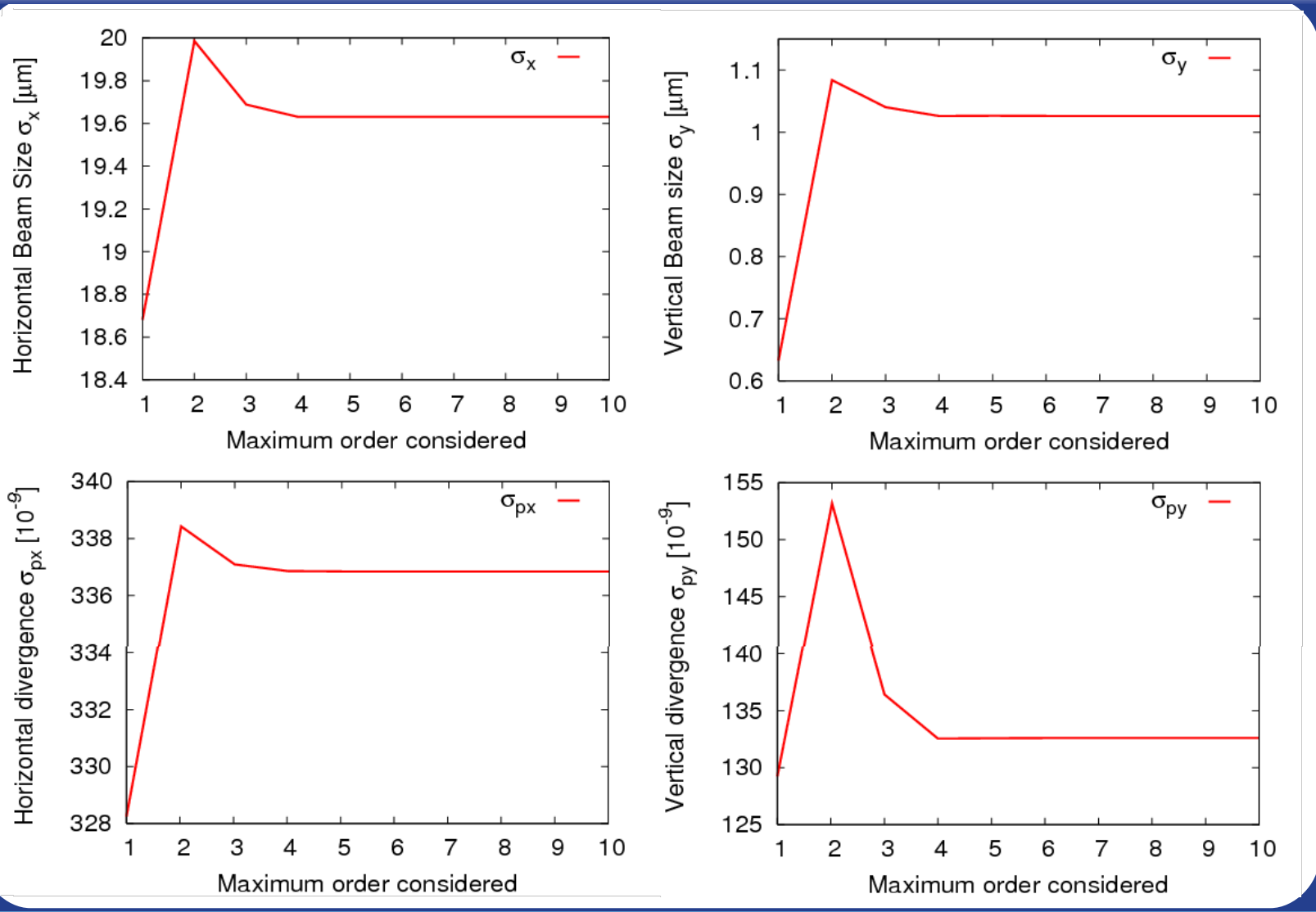
- High order aberrations increase the beam size = reduced luminosity.
- Required beam size is 248 / 5.7 nm.
- Optimization of the FFS is done using MAD-X , PTC, MAPCLASS and the Simplex algorithm.

Any errors coming from the Collimation?



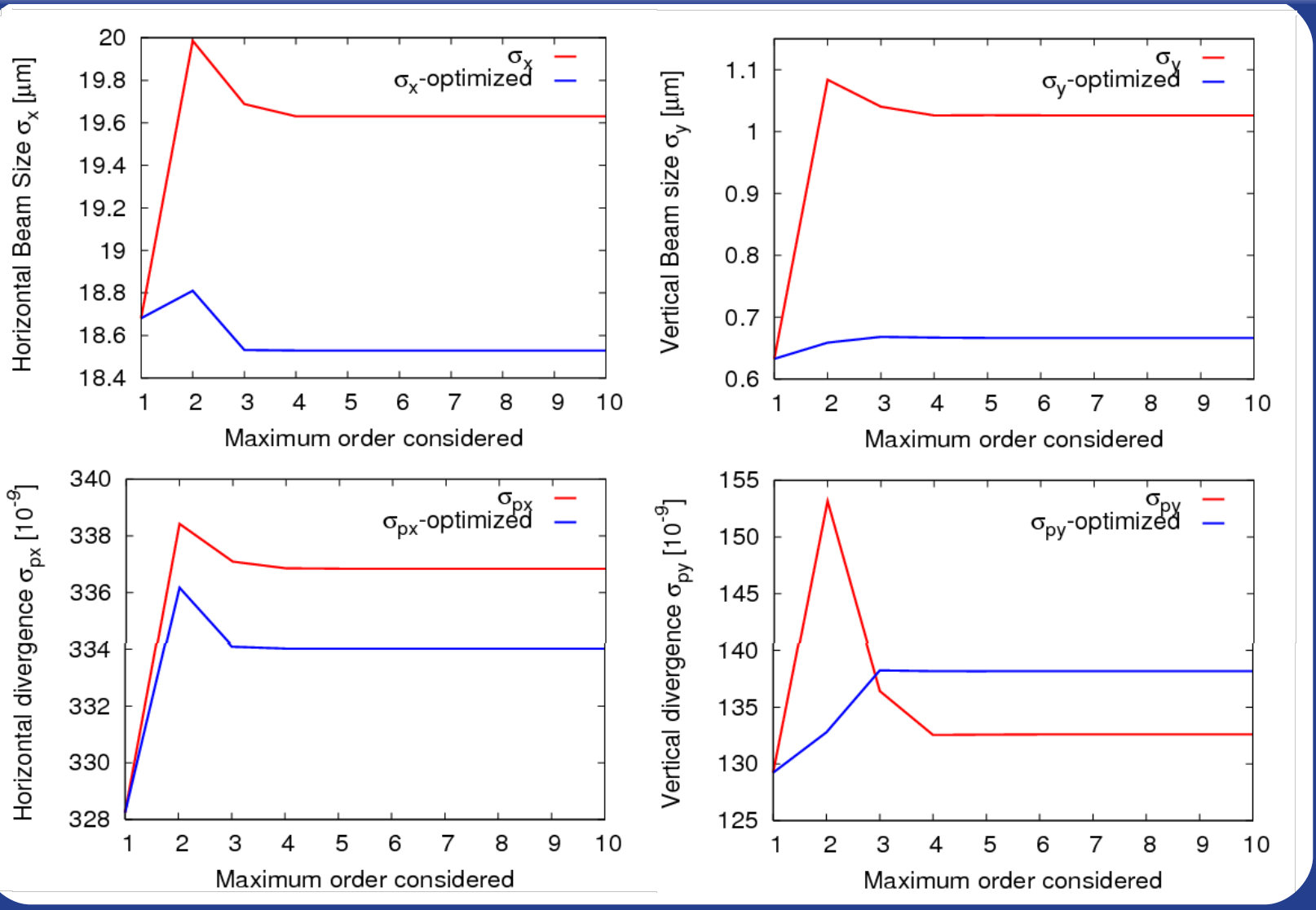
- Reduce high order aberrations present at the FF entry using sextupoles in the Collimation section.

Beam size and divergence at FF entry.



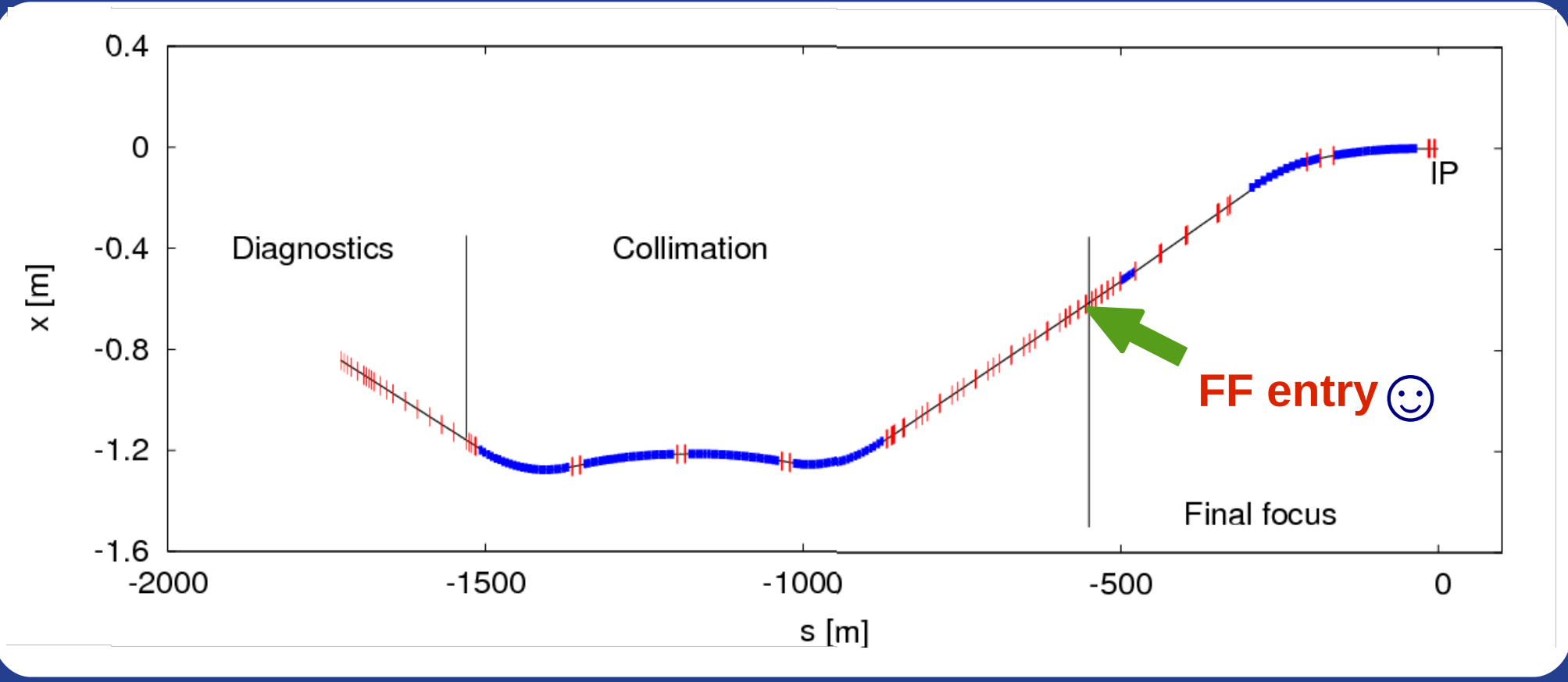
- Aberrations in the vertical beam size need to be reduced.
- Sextupoles in the Collimation are used as correctors.

Beam size and divergence at FF entry.



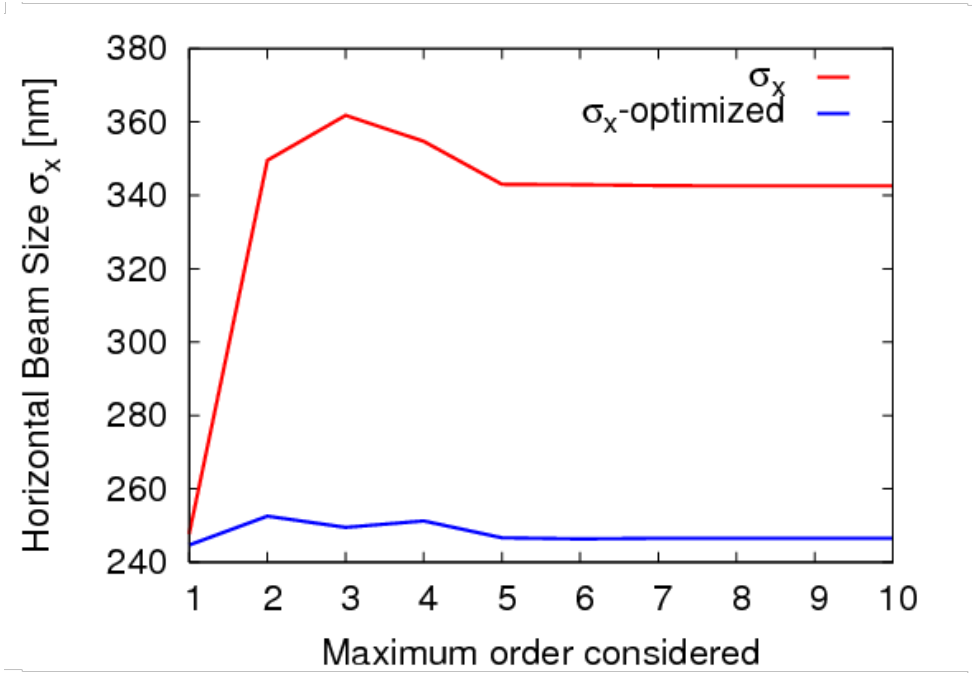
- Aberrations have been reduced.
- Vertical divergence increased with ~ 3%.

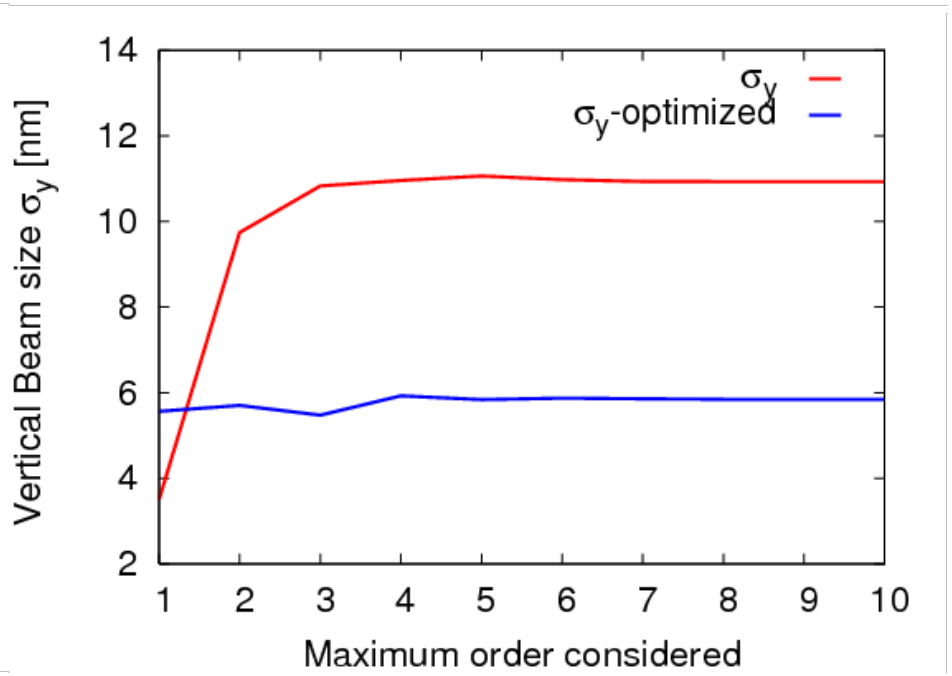
Optimization of the FFS



- Beam size and divergence at the FF entry: OK.
- Next step: Reduce remaining errors by optimizing the FFS.

Beam size at the IP after optimization





- Quadrupole and sextupole strength are used as variables.
- The required beam size at the IP is 248 / 5.7 nm.
- The high order aberrations have been reduced notoriously.

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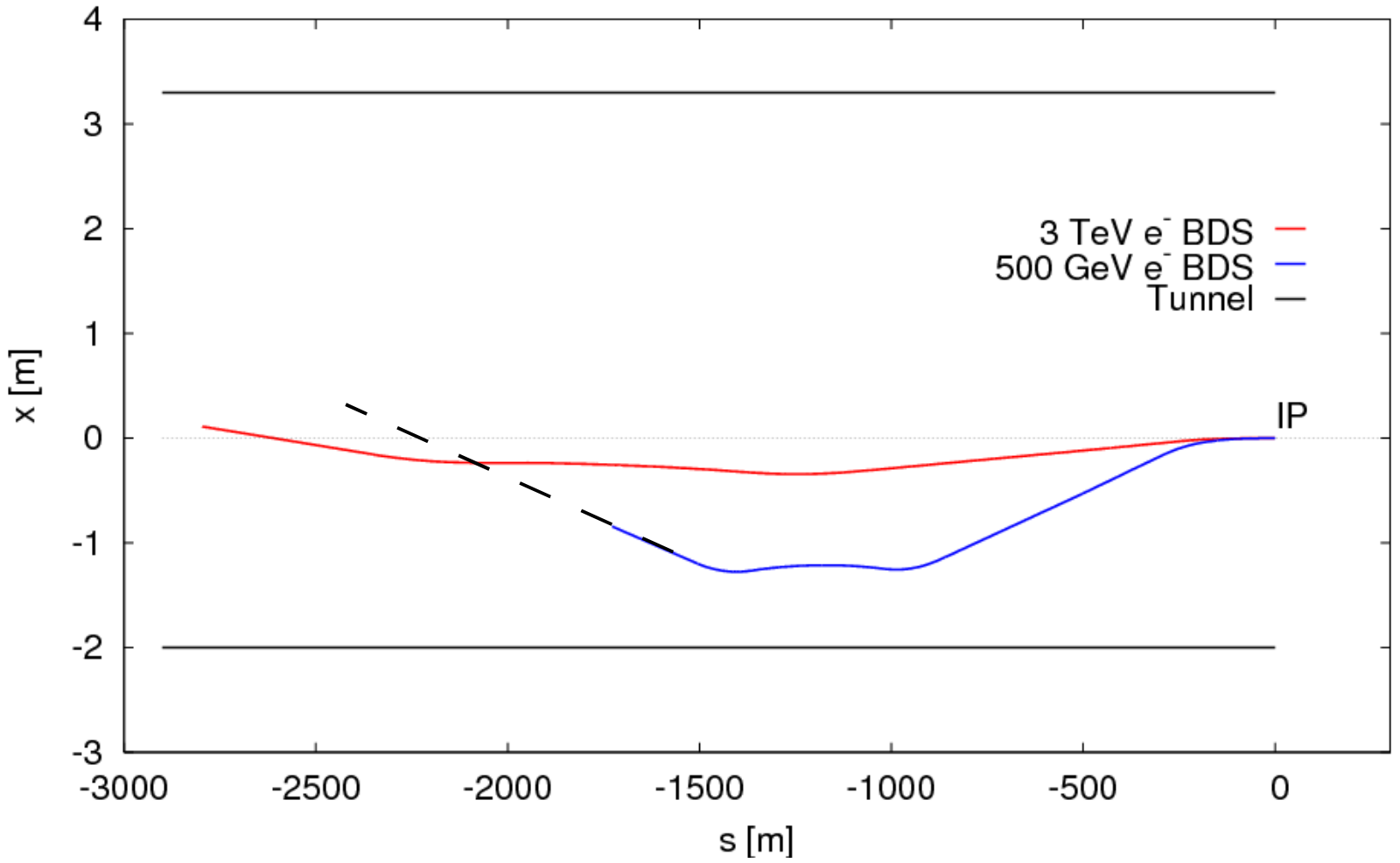
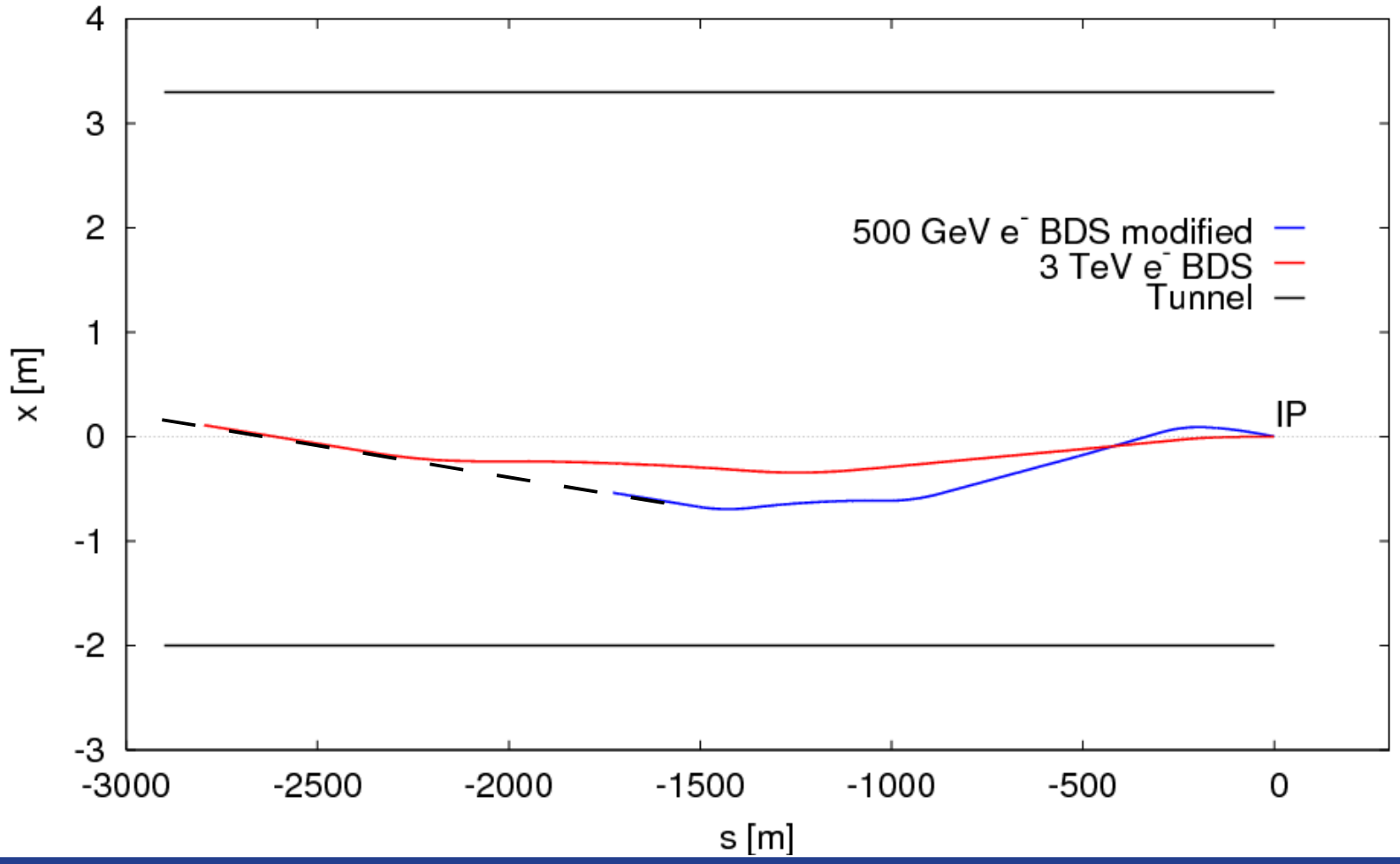
Tunnel fitting problem



- The 500 GeV BDS needs to be modified in order to give enough space for instruments

Tunnel fitting solution



- Rotate the BDS 0.7 mrad around the IP for better fitting.
- Modify dipoles in the Collimation to align the Diagnostics and LINAC.
- Crossing angle reduced from 20 mrad to 18.6 mrad.

Re-optimizing the BDS

		Original	New (Rotated)
FFS entry	Horizontal Beam size [um]	18.53	18.53
	Vertical Beam size [um]	0.666	0.666
	Horizontal Divergence [10^{-9}]	334.0	333.7
	Vertical Divergence [10^{-9}]	138.16	135.83
IP	Horizontal Beam size [nm]	246.52	246.35
	Vertical Beam size [nm]	5.84	5.92
Luminosity	[10^{34} $cm^{-2}s^{-1}$]	1.04	1.02

- The previously optimized FFS has been modified to fit in the tunnel. Re-optimization needed.
- Matching of sextupoles in the Collimation has proven to be enough.
- The rotated design still meets the luminosity and beam size requirements, (248 / 5.7 nm ,0.9 10^{-34} $cm^{-2}s^{-1}$).

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Beam parameter at 500 GeV

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Hor./vert. IP beam size σ_x^*/σ_y^* (nm)	248/5.7	202/2.3

DONE!

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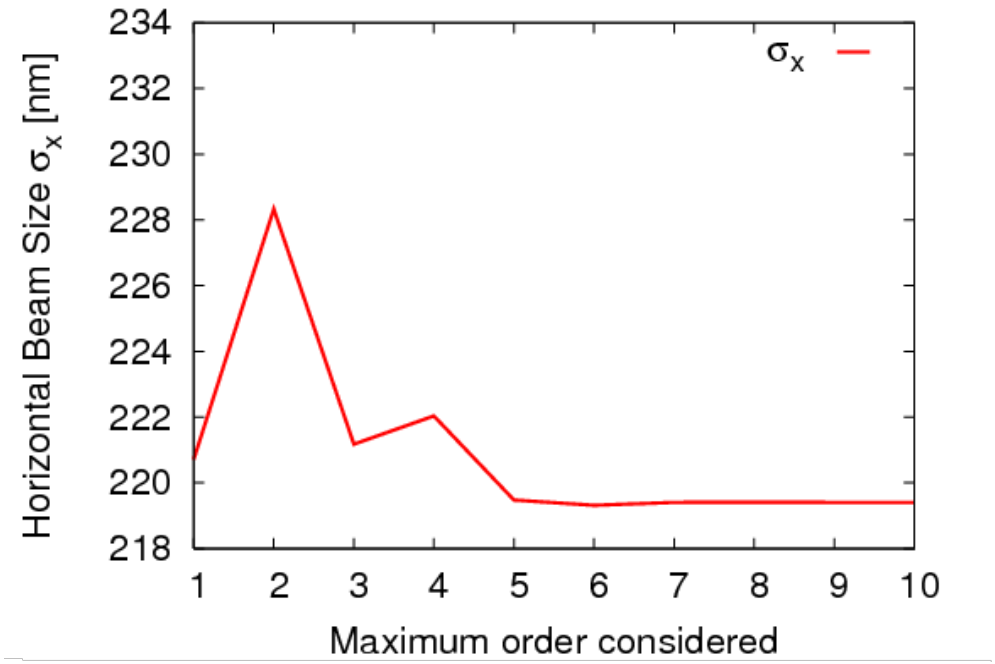
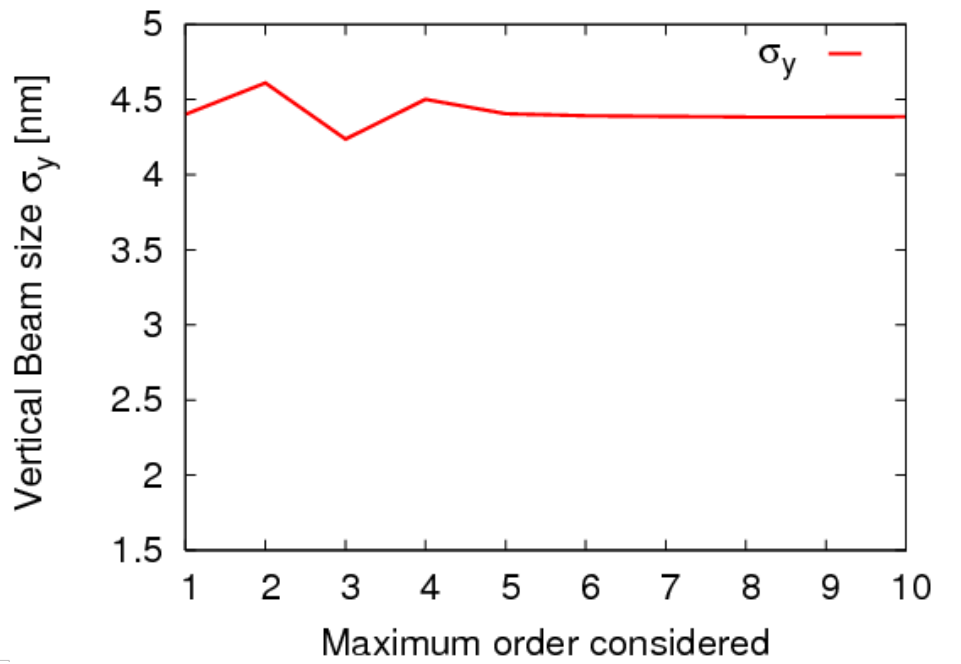
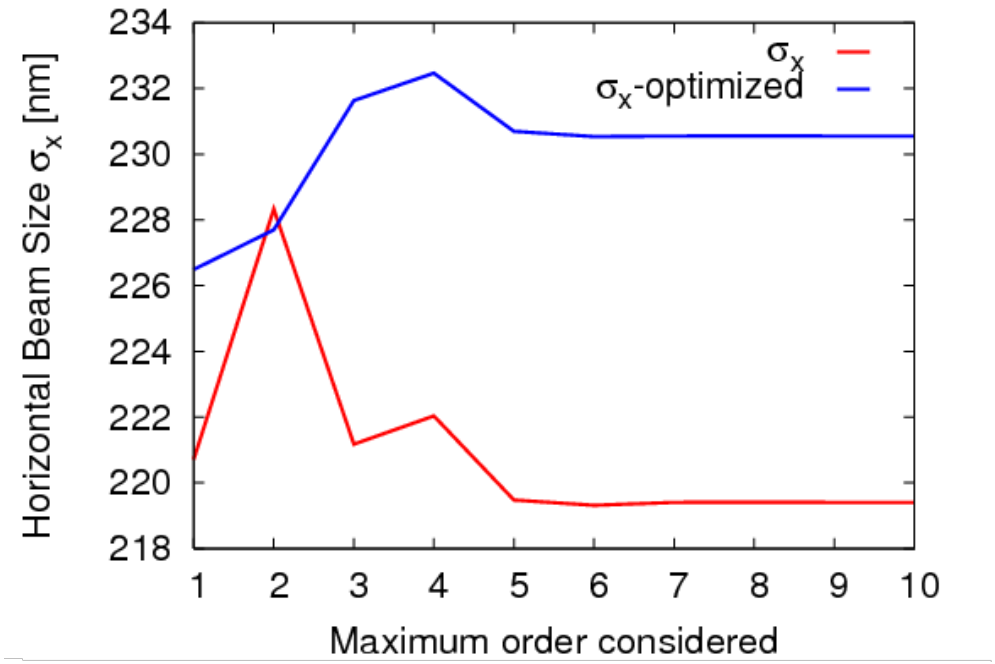
500 GeV Nominal lattice

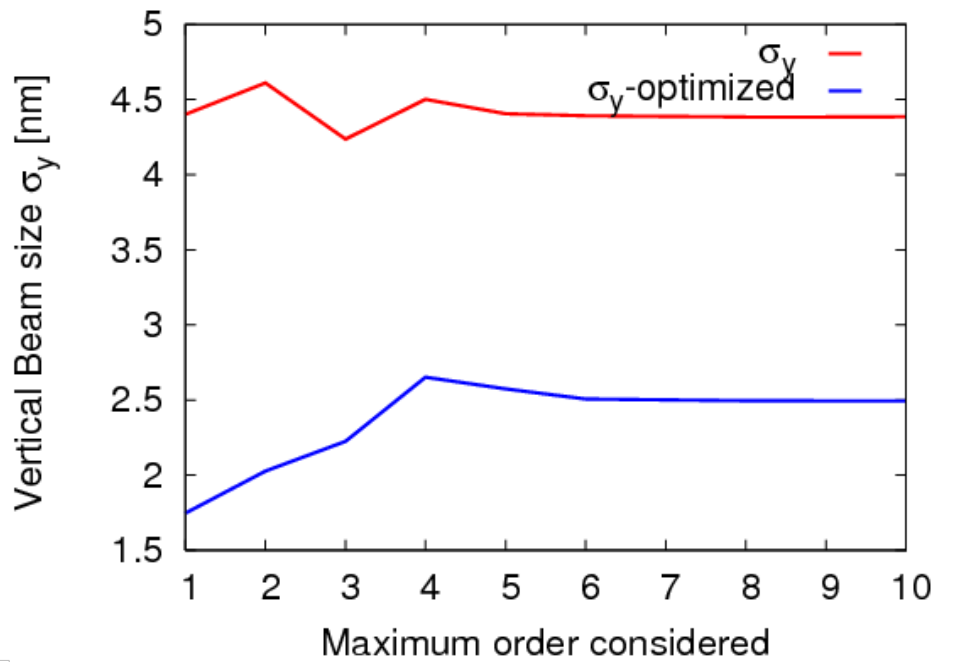




- Required beam size is 202 / 2.3 nm.
- The conservative lattice used with the nominal parameters yields neglectable aberrations but the beam size is not small enough.
- Match the FFS quadrupoles and sextupoles.

500 GeV Nominal lattice





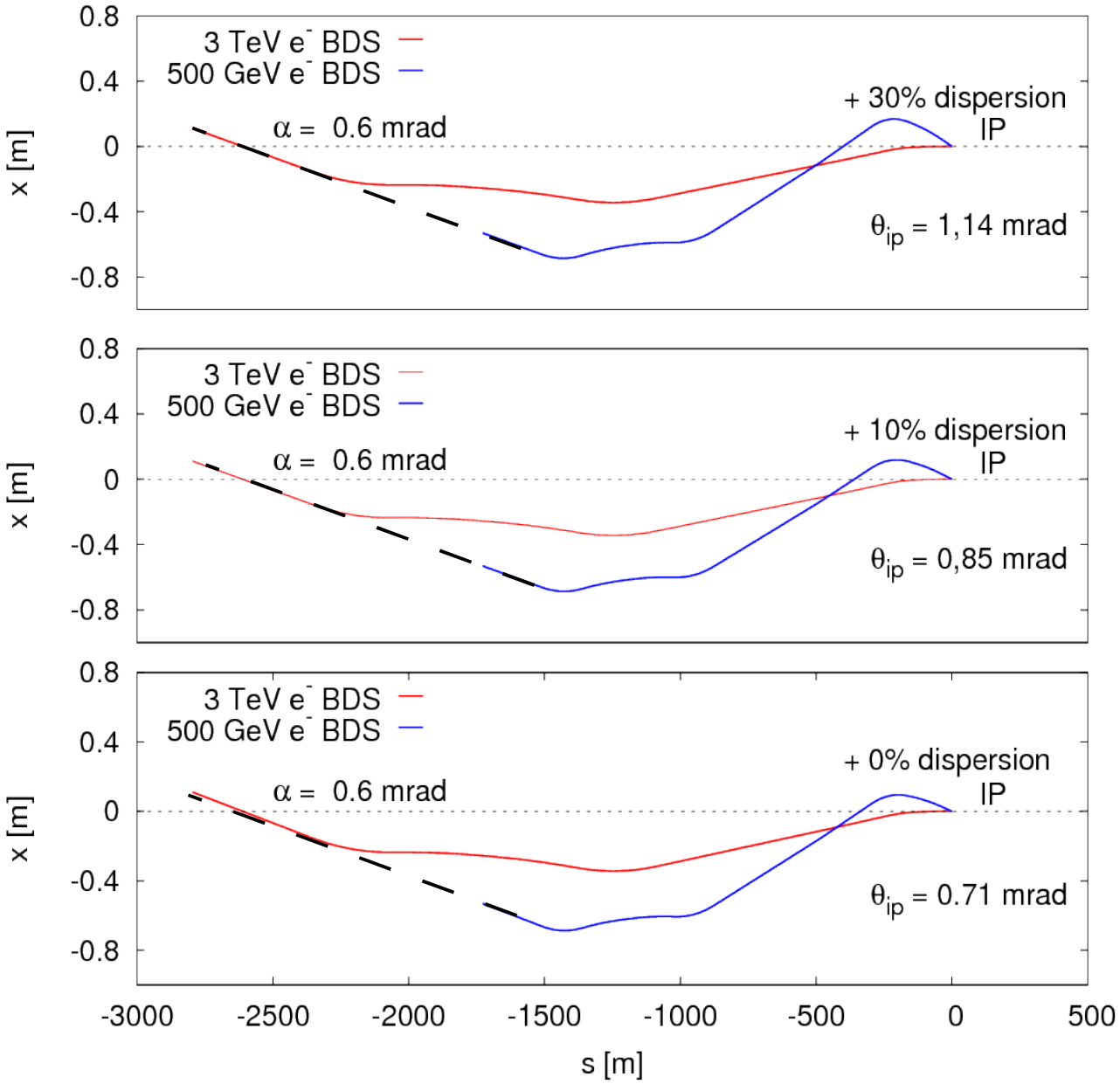
- Required beam size is 202 / 2.3 nm.
- The matching increases σ_x (~ 5%) while σ_y is reduced (~50 %).
- Increasing dispersion in the FFS is tested as a solution.

500 GeV Nominal lattice

Dispersion increment %	Beam size σ_x [nm]	Beam size σ_y [nm]	Total (Peak) Luminosity $[10^{34}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}]$
Required	202	2.3	2.3 (1.4)
0	230	2.5	2.18 (1.39)
10	221	2.4	2.28 (1.47)
20	210	2.4	2.47 (1.56)
30	203	2.3	2.52 (1.54)

- Quadrupoles and sextupoles are matched for each case.
- Peak luminosity requirement is reached with a dispersion increment of 10%.

Diagnostic section alignment



To maintain the Diagnostics section aligned with the LINAC the rotation angle around the IP increases as the dispersion is increased.

Conclusions

- The current 500 GeV BDS for the conservative parameters has now neglectable high order aberrations and satisfy the luminosity requirements.
- The 500 GeV BDS fits now in the tunnel.
- The Diagnostics section is now aligned with the LINAC,

- A lattice for the nominal requirements can now be chosen from the four proposed.


Thank you!