A dual CLIC BDS system for two detectors

Vera Cilento and Rogelio Tomás
Many thanks to Fabien Plassard

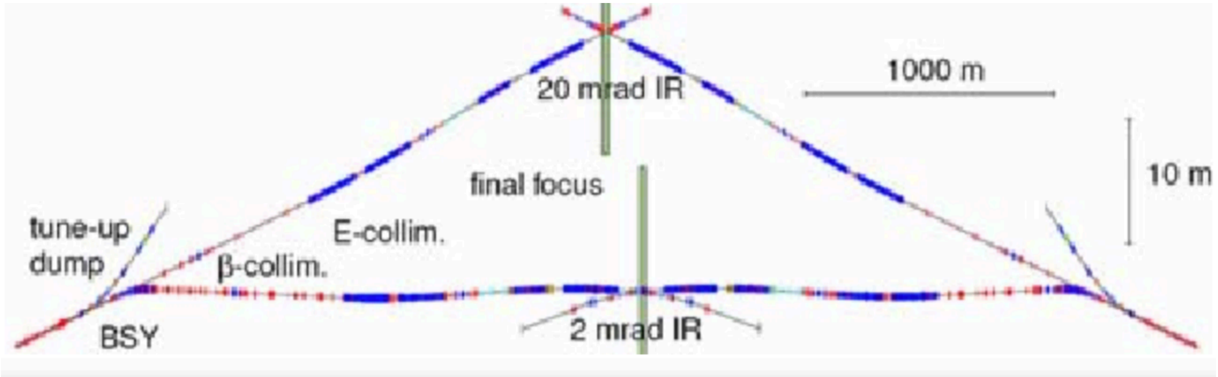
Outline

- Motivation of the study
- Introduction
- Optics Design of the new BDS (2nd BDS)
  - Twiss functions and the horizontal dispersion
- 2nd BDS studied with different bending angles → θ=0 mrad, 4.83 mrad, -4.83 mrad, 9.66 mrad, -9.66 mrad
- Comparison between 1st BDS and 2nd BDS
  - In terms of beam sizes
  - In terms of luminosity
- Conclusions
- Future Works

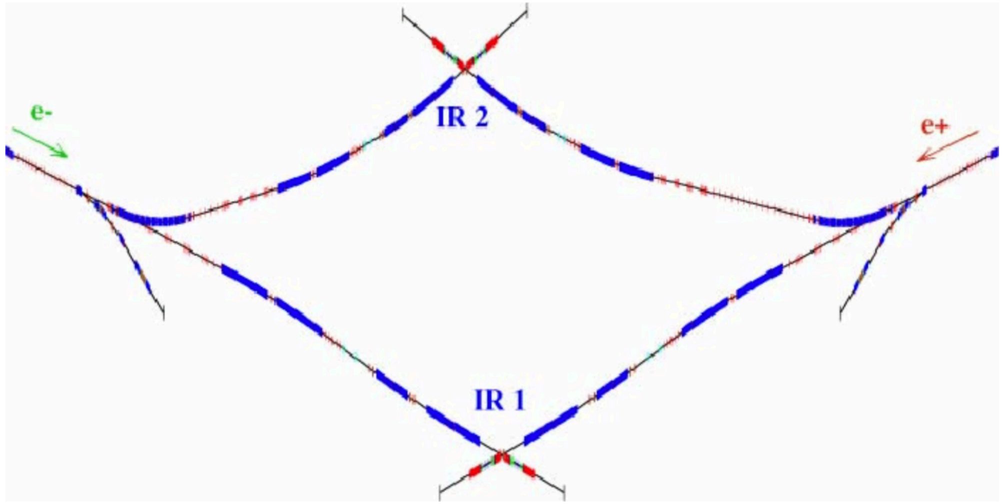
Motivation of the study

- Two Interaction Regions (IRs) would make CLIC design more comparable with other future accelerator projects
- The two IRs possibility was studied already in ILC* and NLC*

- ILC:



- NLC:

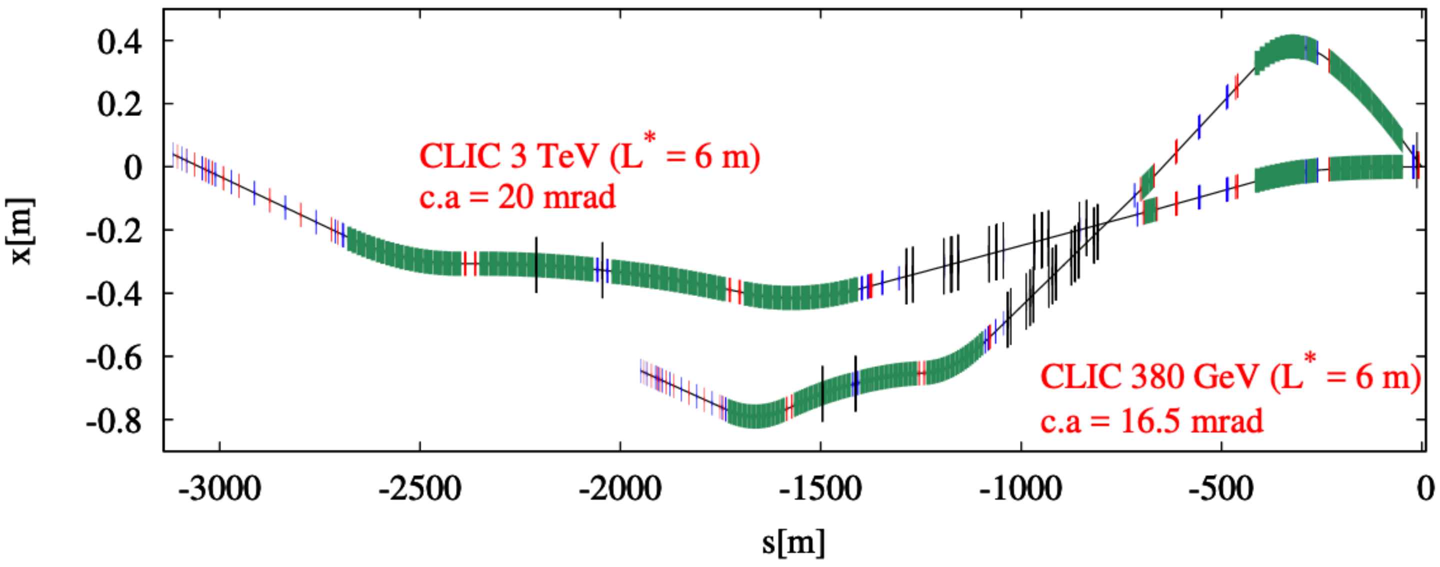


* BEAM DELIVERY SYSTEM IN ILC. G. A. Blair# , John Adams Institute at RHUL, London. TW20 0EX. UK. Proceedings of EPAC 2006, Edinburgh, Scotland.
* BEAM DELIVERY LAYOUT FOR THE NEXT LINEAR COLLIDER. Andrei Seryi , Yuri Nosochkov, Mark Woodley SLAC, Stanford, CA 94309, USA. Proceedings of EPAC 2004, Lucerne, Switzerland.

Introduction

- The BDS* design taken into account is the one for CLIC 380 GeV with L*= 6 m

L* [m]	4.3	6
FFS length [m]	550	770
Norm. emittance (end of linacs) $\gamma\epsilon_x/\gamma\epsilon_y$ [nm]	920 / 20	920 / 20
Norm. emittance (IP) $\gamma\epsilon_x/\gamma\epsilon_y$ [nm]	950 / 30	950 / 30
Beta function (IP) β^*_x/β^*_y [mm]	8 / 0.1	8 / 0.1
IP beam size σ^*_x/σ^*_y [nm]	144 / 2.9	144 / 2.9
Bunch length σ_z [μm]	70	70
rms energy spread δ_p [%]	0.3	0.3
Bunch population N_e [10^9]	5.2	5.2
Number of bunches n_b	352	352
Repetition rate f_{rep} [Hz]	50	50
Luminosity $\mathcal{L}_{total}$ [10^{34}cm^{-2}s^{-1}]	1.5	1.5
Peak luminosity $\mathcal{L}_{1\%}$ [10^{34}cm^{-2}s^{-1}]	0.9	0.9



* Optics optimization of longer L* Beam Delivery System designs for CLIC and tuning of the ATF2 final focus system at ultra-low β* using octupoles. Fabien Plassard. CERN-THESIS-2018-223. PhD : U. Paris-Saclay : 2018-06-06.

Introduction

- The BDS* design taken into account is the one for CLIC 380 GeV with L*= 6 m
- A preliminary design of a new Diagnostics Section for the 2nd BDS will be proposed

L* [m]	4.3	6
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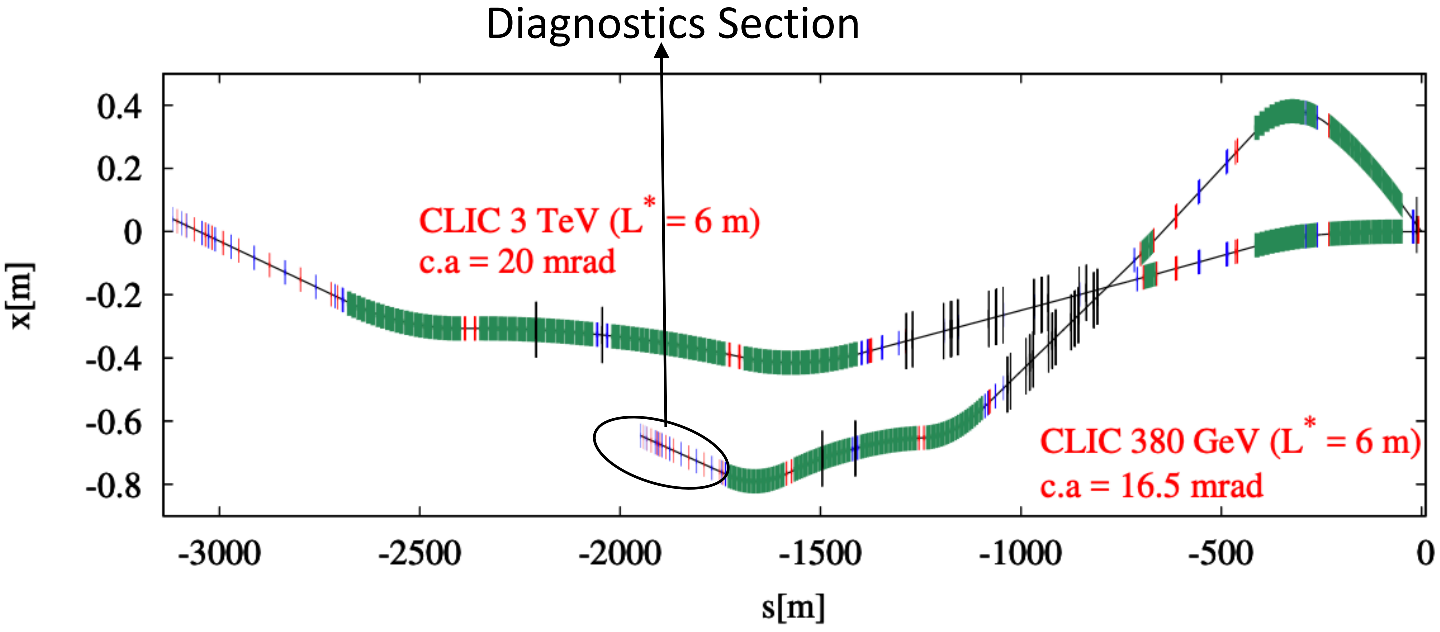


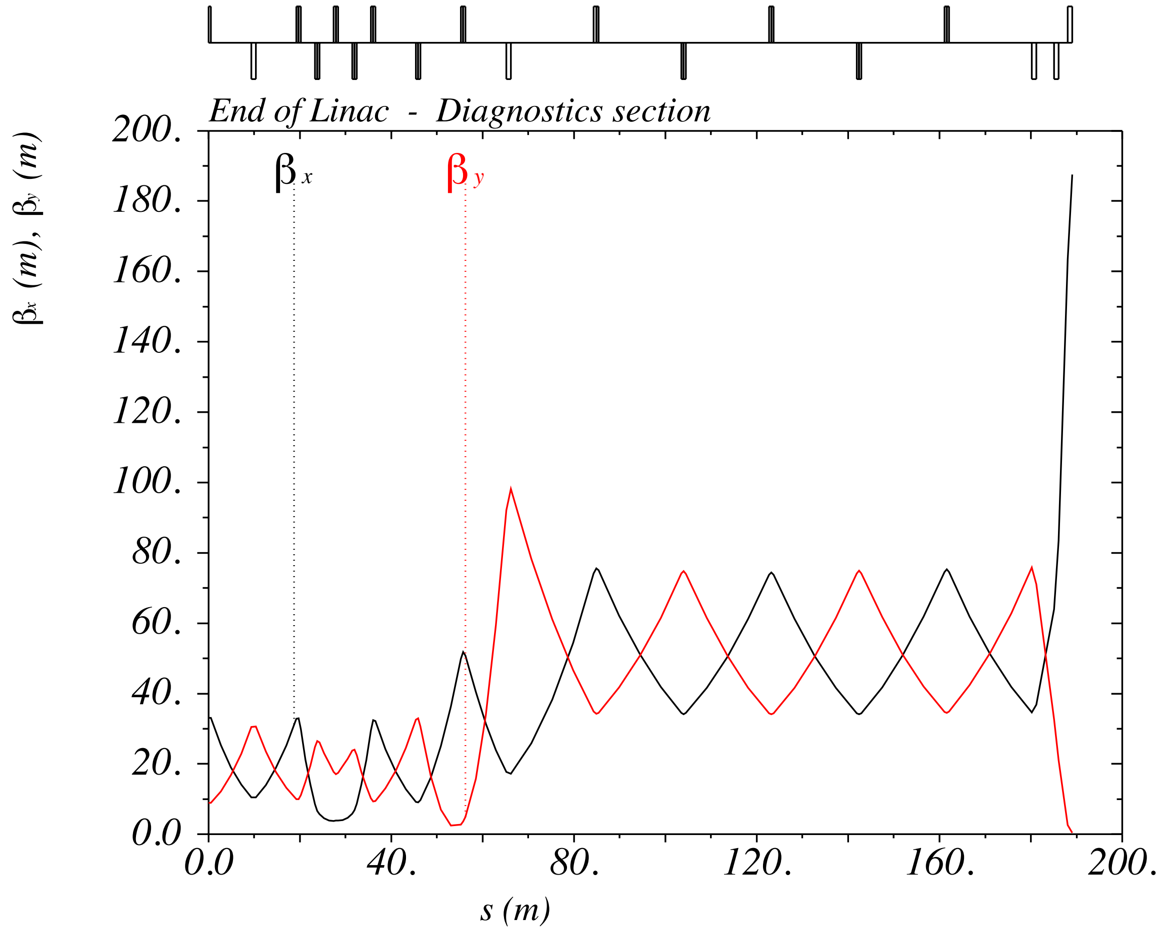
* Optics optimization of longer L* Beam Delivery System designs for CLIC and tuning of the ATF2 final focus system at ultra-low β* using octupoles. Fabien Plassard. CERN-THESIS-2018-223. PhD : U. Paris-Saclay : 2018-06-06.

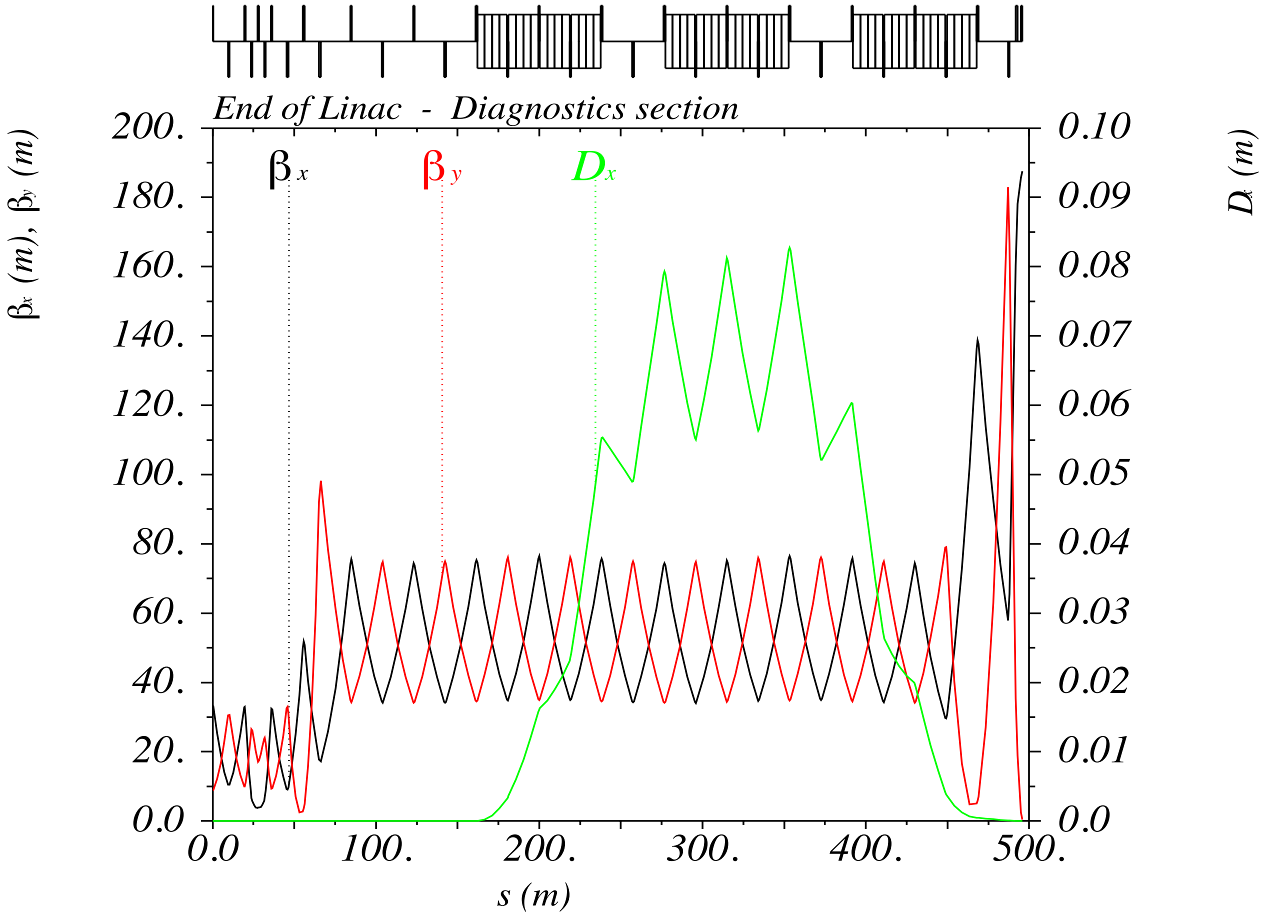
Optics Design of the new BDS (2nd BDS)

- The 2nd BDS includes a new Big Bend to separate the two beam lines with a beam siwtchyard
- The Design of the 2nd BDS has been done starting from the Diagnostics Section
- The FODO cell structure of the Diagnostics Section has been increased with 8 more cells with a μ of 45°
- The total additional length of the 2nd BDS is 300 m
- The FODO cells have been filled with a Dipole + Dispersion Suppressor for the separation of the two BDS
- The Twiss functions and the horizontal Dispersion have been matched at the design values
- The new Diagnostic Section has been connected with the old BDS (the two BDS are exactly the same in terms of $\beta^*_{x,y}$)

Optics Design of the new BDS (2nd BDS)

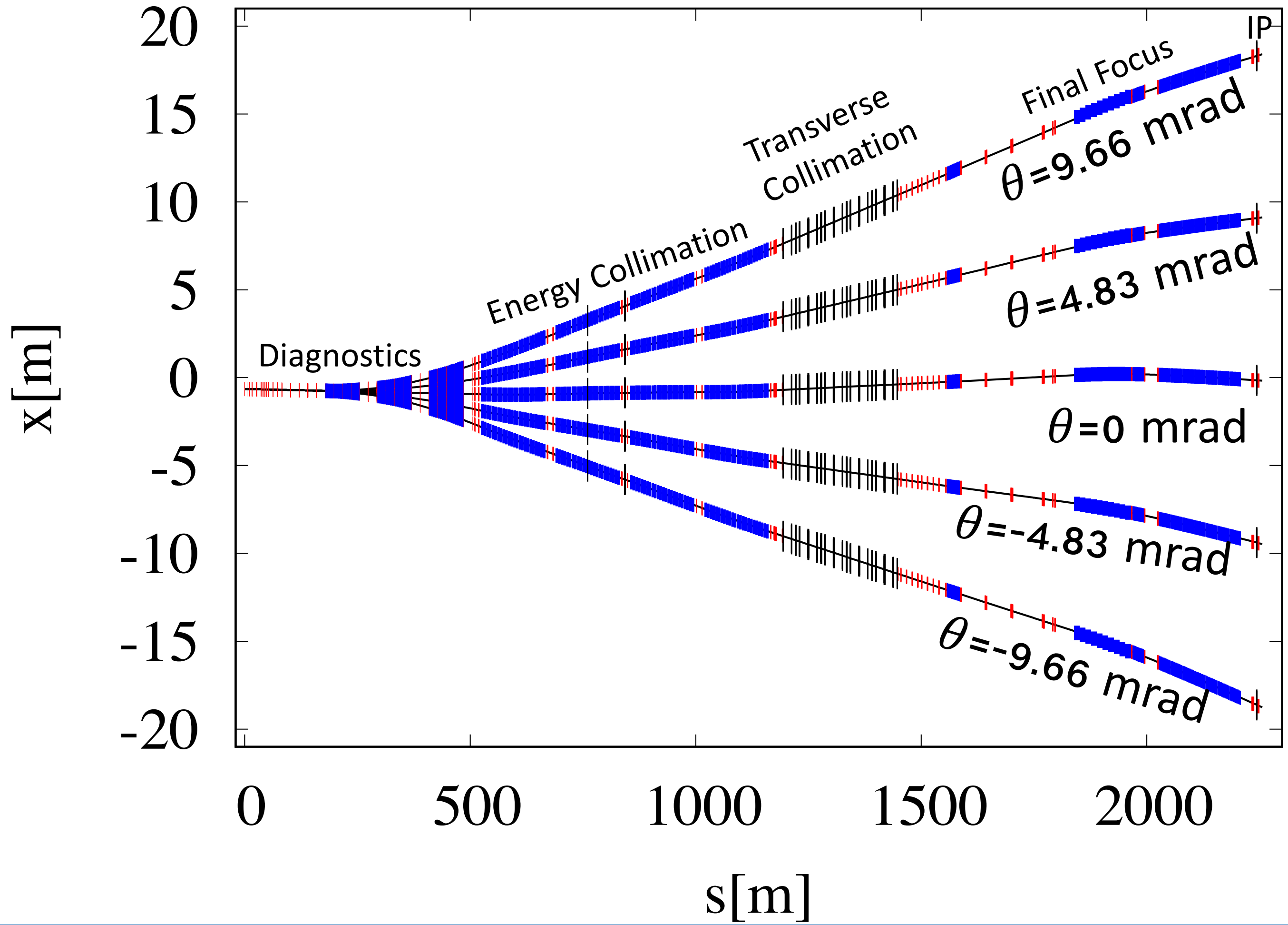
- Twiss Functions and Horizontal Dispersion

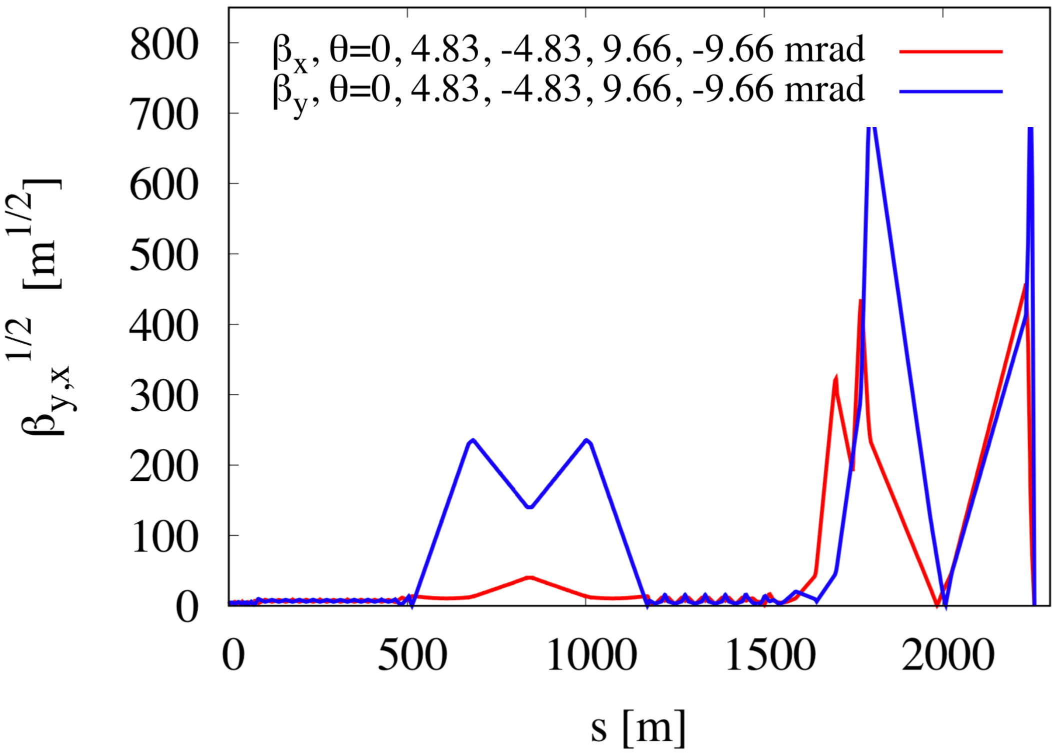




2^{nd} BDS with different bending angles

- The 2^{nd} BDS has been studied for six different options: θ=0 mrad, 4.83 mrad, -4.83 mrad, 9.66 mrad, -9.66 mrad





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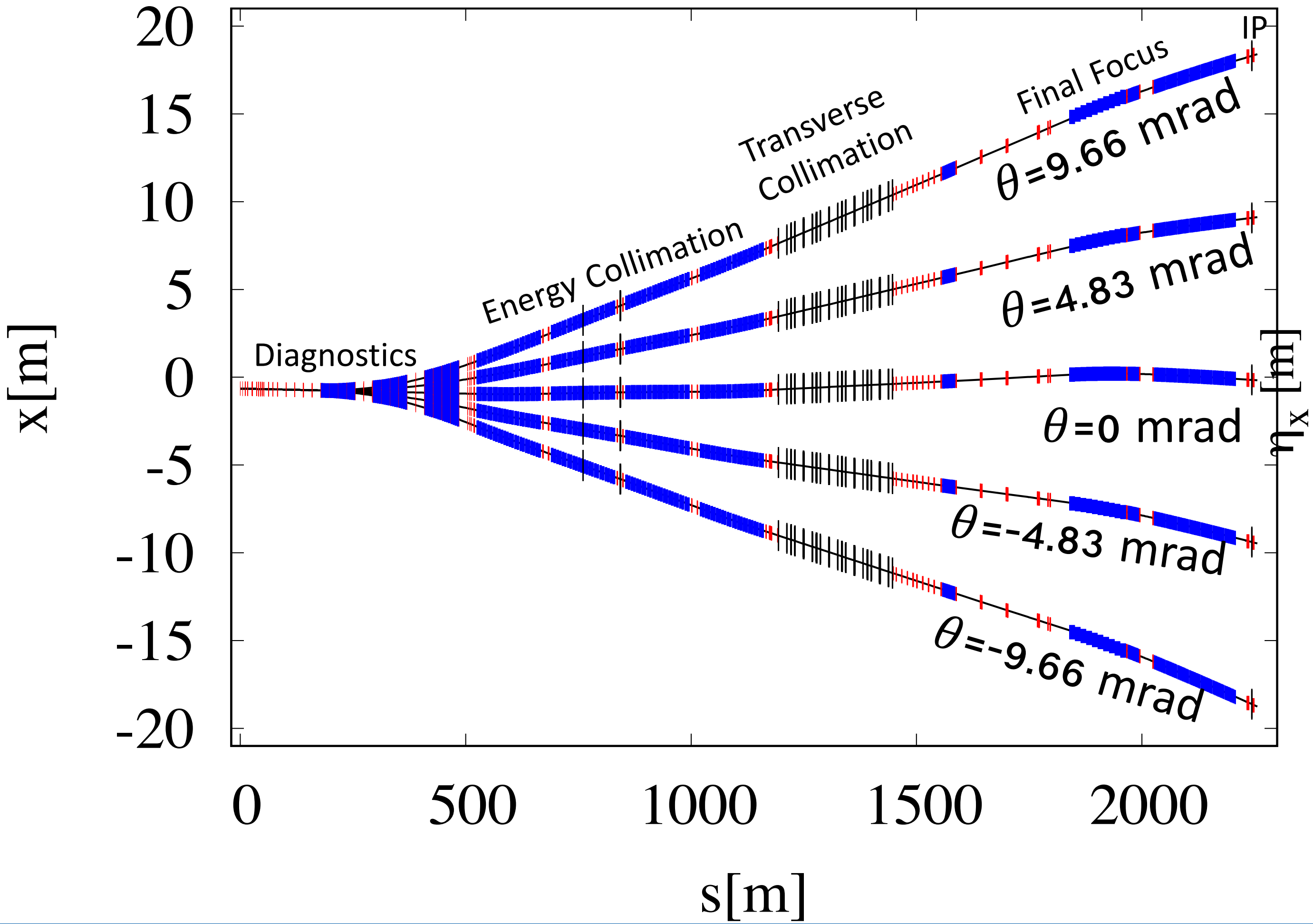

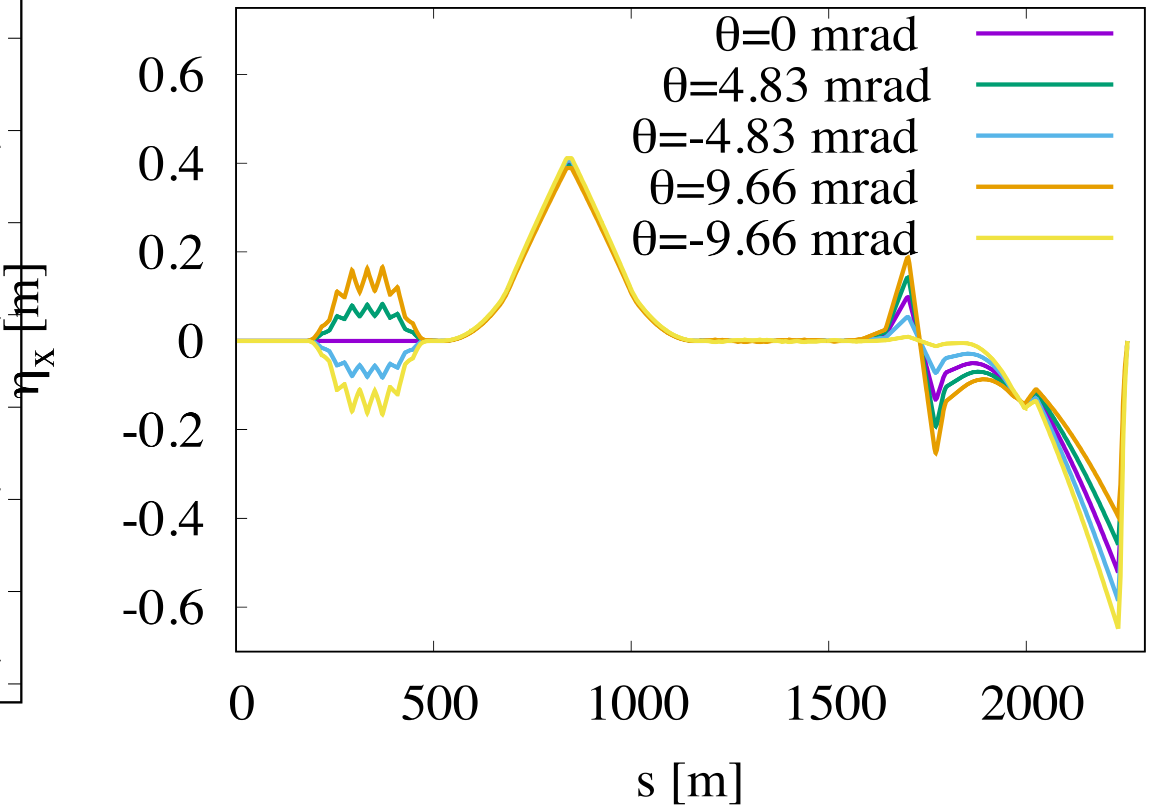

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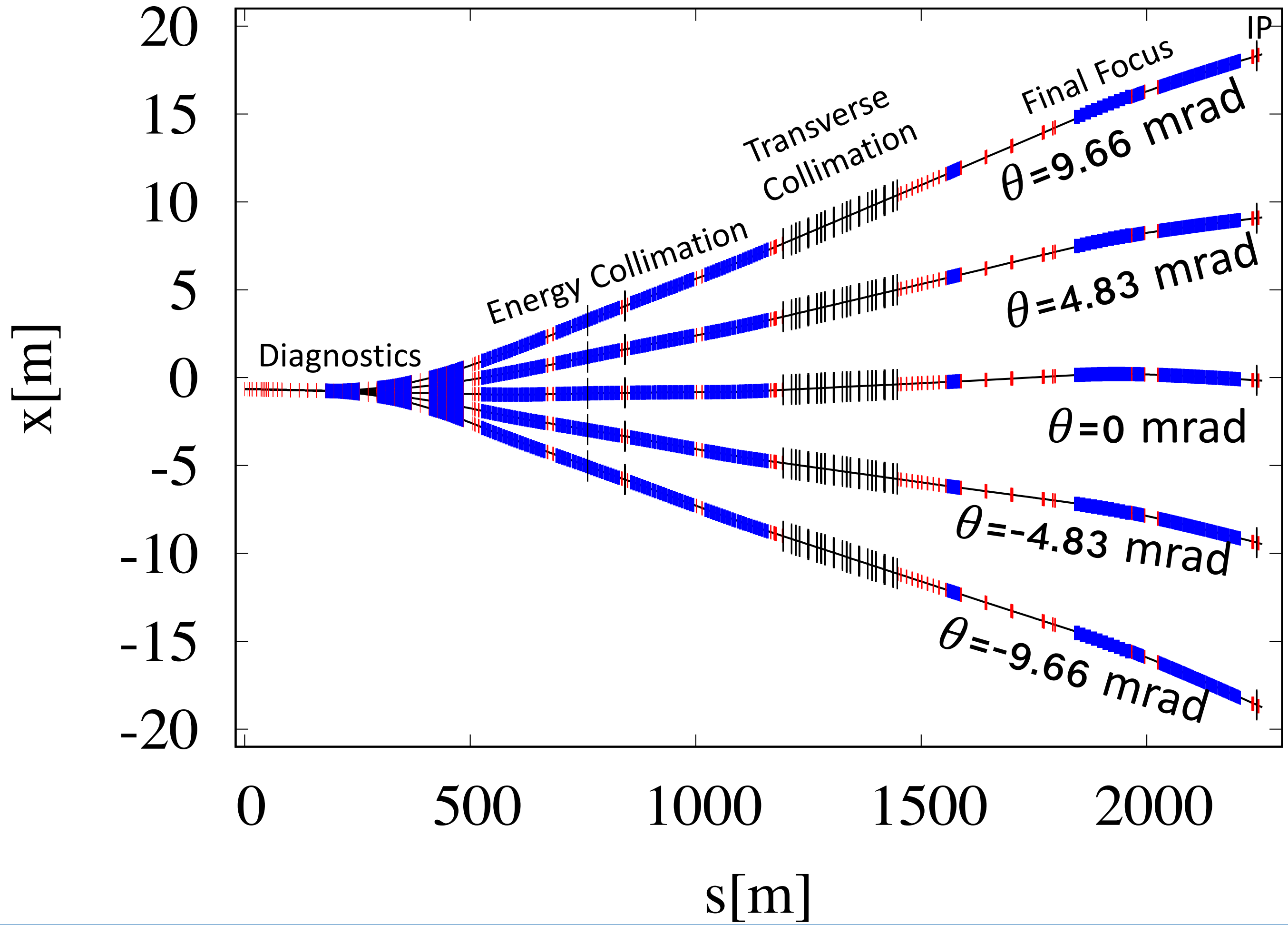
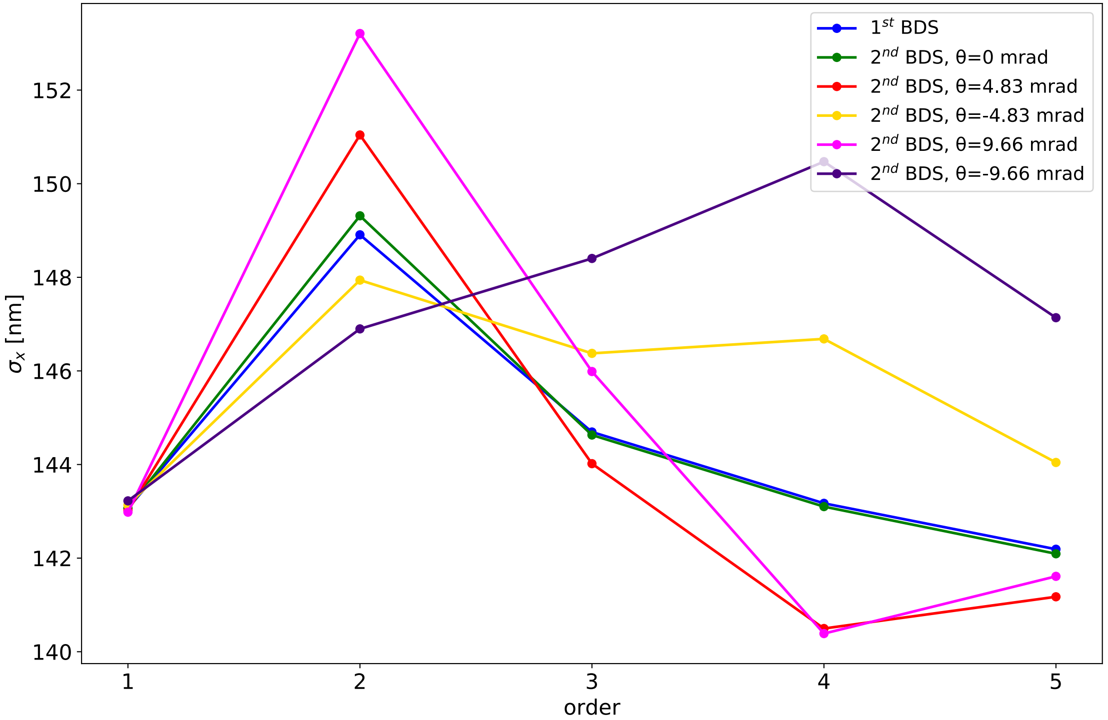
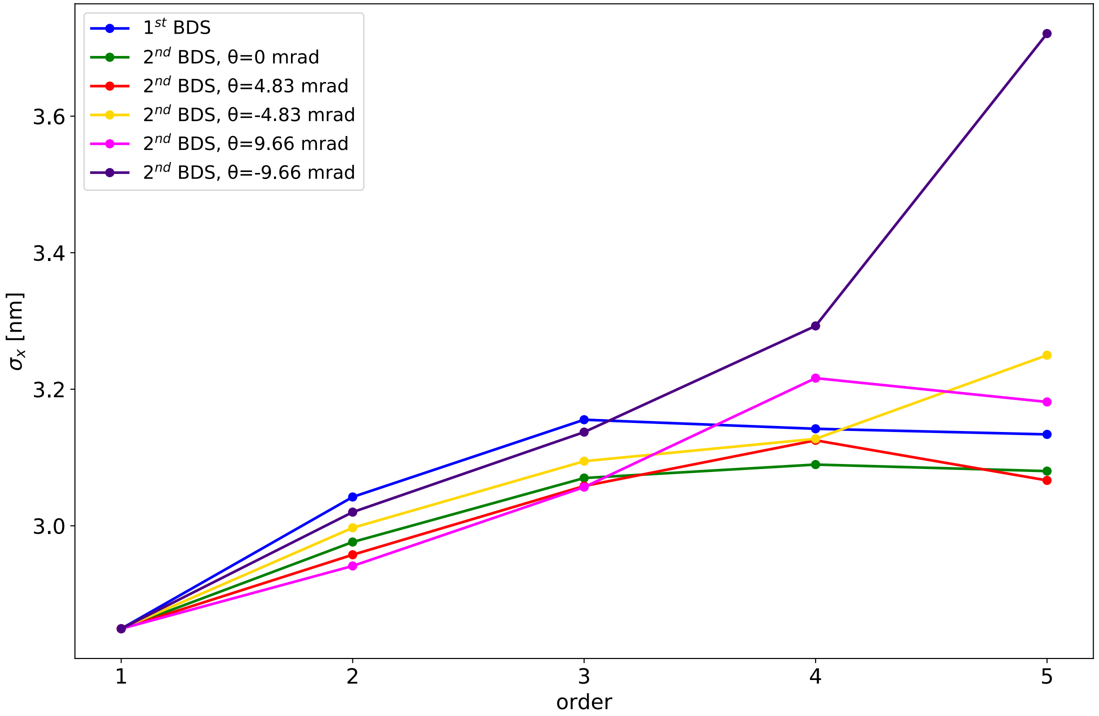


θ [mrad]	θ_c[mrad]
0	16.5
4.83	26.2
-4.83	6.8
9.66	35.8
-9.66	-2. 8

Comparison between 1st BDS and 2nd BDS

- Beam Sizes with MAPCLASS Simulations and with chromatic corrections

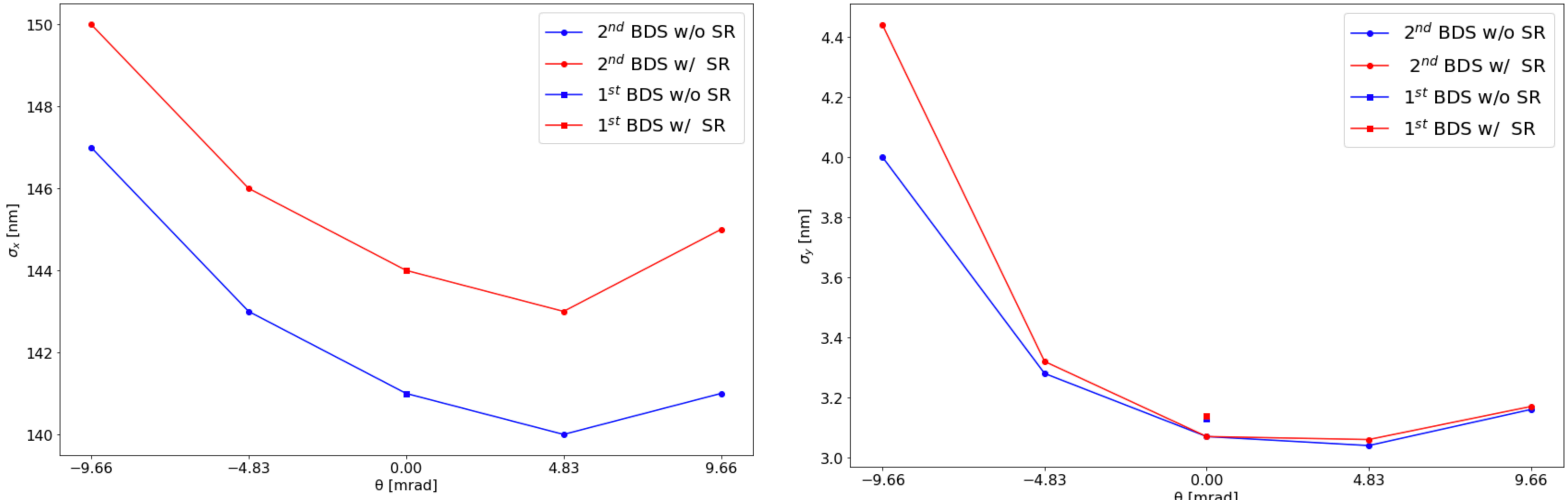




- Chromatic corrections have been done using the FFS sextupoles and octupoles to be fast, but this might not be the best solution, so dedicated sextupoles could be installed in the diagnostics section for local correction in the future

Comparison between 1st BDS and 2nd BDS

- Beam Sizes with PLACET Simulations and with chromatic corrections



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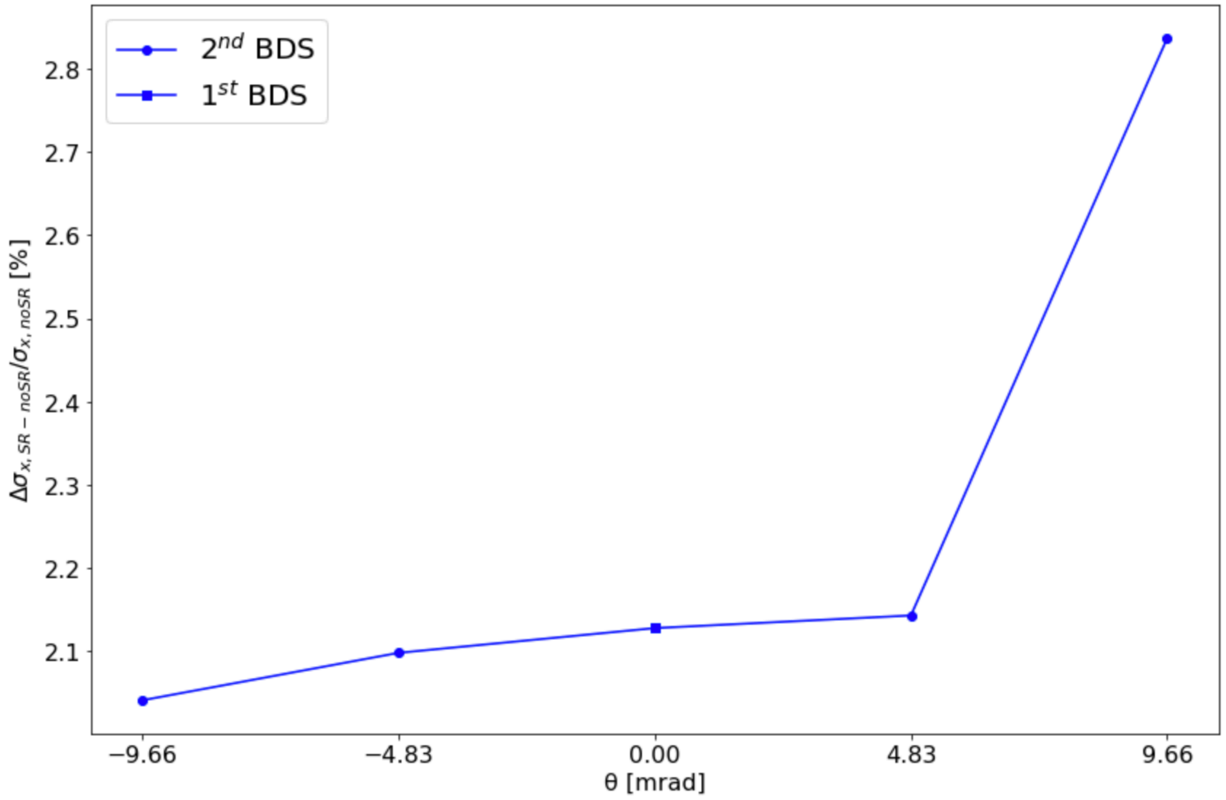
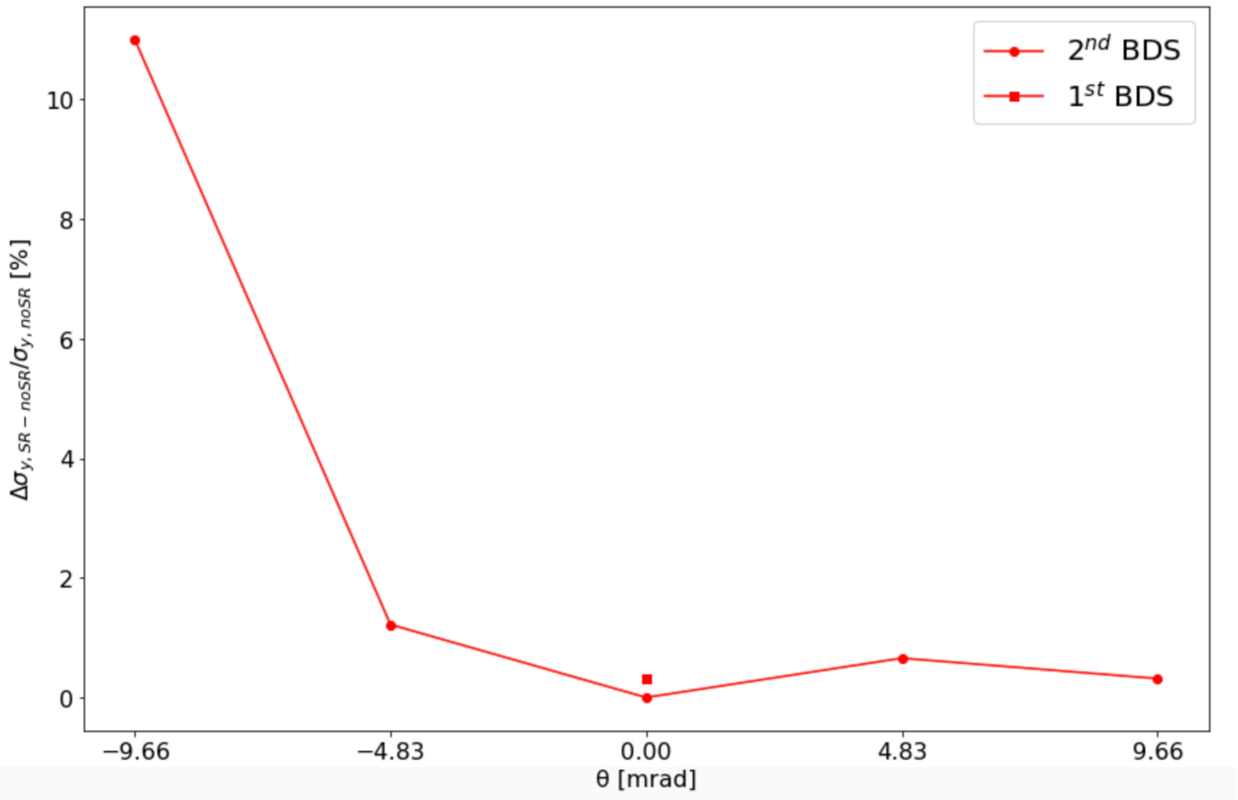
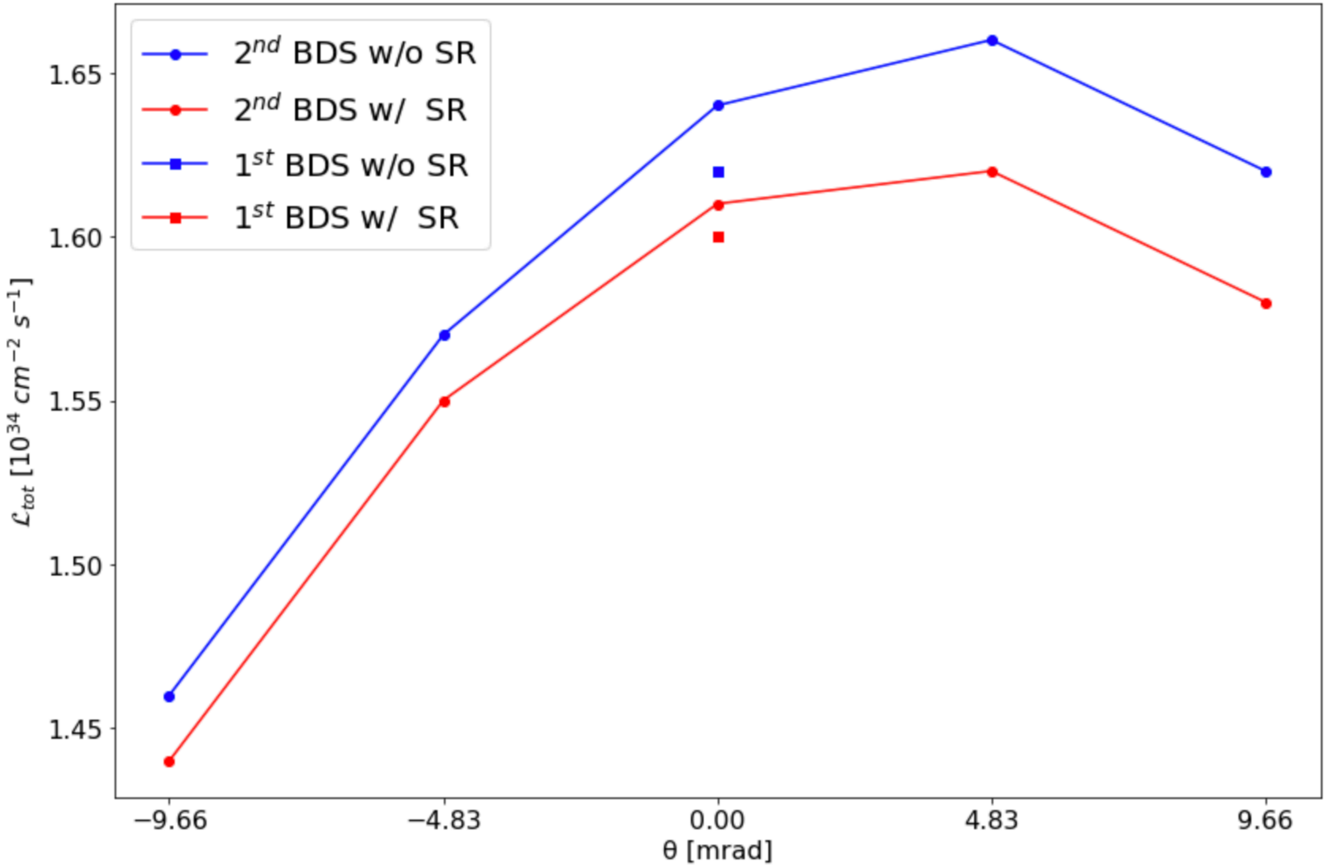




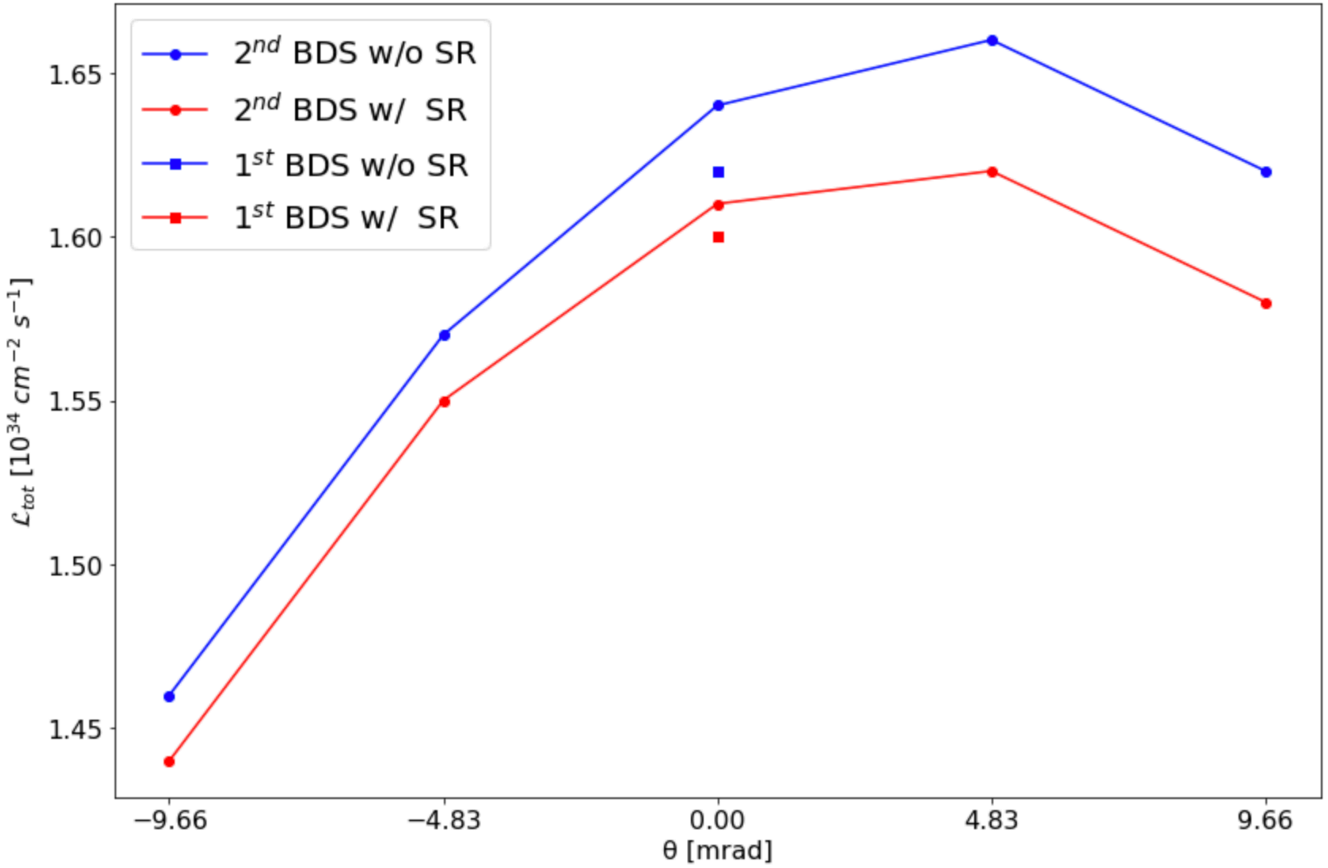
Comparison between 1st BDS and 2nd BDS

- Luminosity after chromatic corrections



Comparison between 1st BDS and 2nd BDS

- Luminosity after chromatic corrections



- Both MAPCLASS and PLACET simulations confirm the same beam sizes reachable for all the 6 different bending angles lattice options
- ~2% of luminosity loss comes from the SR itself
- From this first simulations, it is possible to say that the most comparable option in terms of Luminosity in respect with the 1st BDS is the one with θ=4.83 mrad

Comparison between 1st BDS and 2nd BDS

- Luminosity (Summary Table)

always optimized w/ sext. and octupoles

	1st BDS θ_c=16.5 mrad	2nd BDS θ=0 mrad θ_c=16.5 mrad	2nd BDS θ=4.83 mrad θ_c=26.2 mrad	2nd BDS θ=-4.83 mrad θ_c=6.8 mrad	2nd BDS θ=9.66mrad θ_c=35.8 mrad	2nd BDS θ=-9.66 mrad θ_c=-2.8 mrad
$\mathcal{L}_{TOT}$ [10^{34} cm^{-2} s^{-1}] SR off (w/o sext.)	1.62	1.54	1.55	1.51	1.48	1.42
$\mathcal{L}_{TOT}$ [10^{34} cm^{-2} s^{-1}] SR on (w/o sext.)	1.6	1.51	1.53	1.49	1.43	1.39
$\mathcal{L}_{TOT}$ [10^{34} cm^{-2} s^{-1}] SR off (w/ sext.)	1.62	1.64	1.66	1.57	1.62	1.46
$\mathcal{L}_{TOT}$ [10^{34} cm^{-2} s^{-1}] SR on (w/ sext.)	1.6	1.61	1.62	1.55	1.58	1.44

Conclusions and Future Works

- It is clear that an improvement in terms of horizontal dispersion at the IP should be done with a MAD-X re-matching
- The optimal solution is not far from this first design (for 380GeV) → explore other designs to have smaller β_x and η_x in the dipoles:
    - A better phase advance (60° or 90°) would allow a more efficient use of space for bending
    - A triplet lattice with three quads in between long dipole sections
    - TME lattice
- The total Luminosity achievable with a θ=4.83 mrad is comparable with the one of the 1st BDS
- Increasing the crossing angle at the IP would come with a luminosity penalty*
- Very important is to compute the emittance growth analytically and compare with PLACET and MAPCLASS simulations
- It is important to specify that this is only valid for CLIC with c.o.m of 380 GeV → The BDS required for CLIC 3TeV will be 1 km longer or above in order to not have too much Luminosity loss
- The next important problem is the crossing angle → with only one bend it is not possible to have the same crossing angle at both IPs → keep the large crossing of 25mrad to be compatible with g-g collider?
- What will be the required transverse and longitudinal displacements? I explored the options with 10-20m transverse → generating longitudinal shift between detectors is easy optics-wise but gives issues with train synchronizations

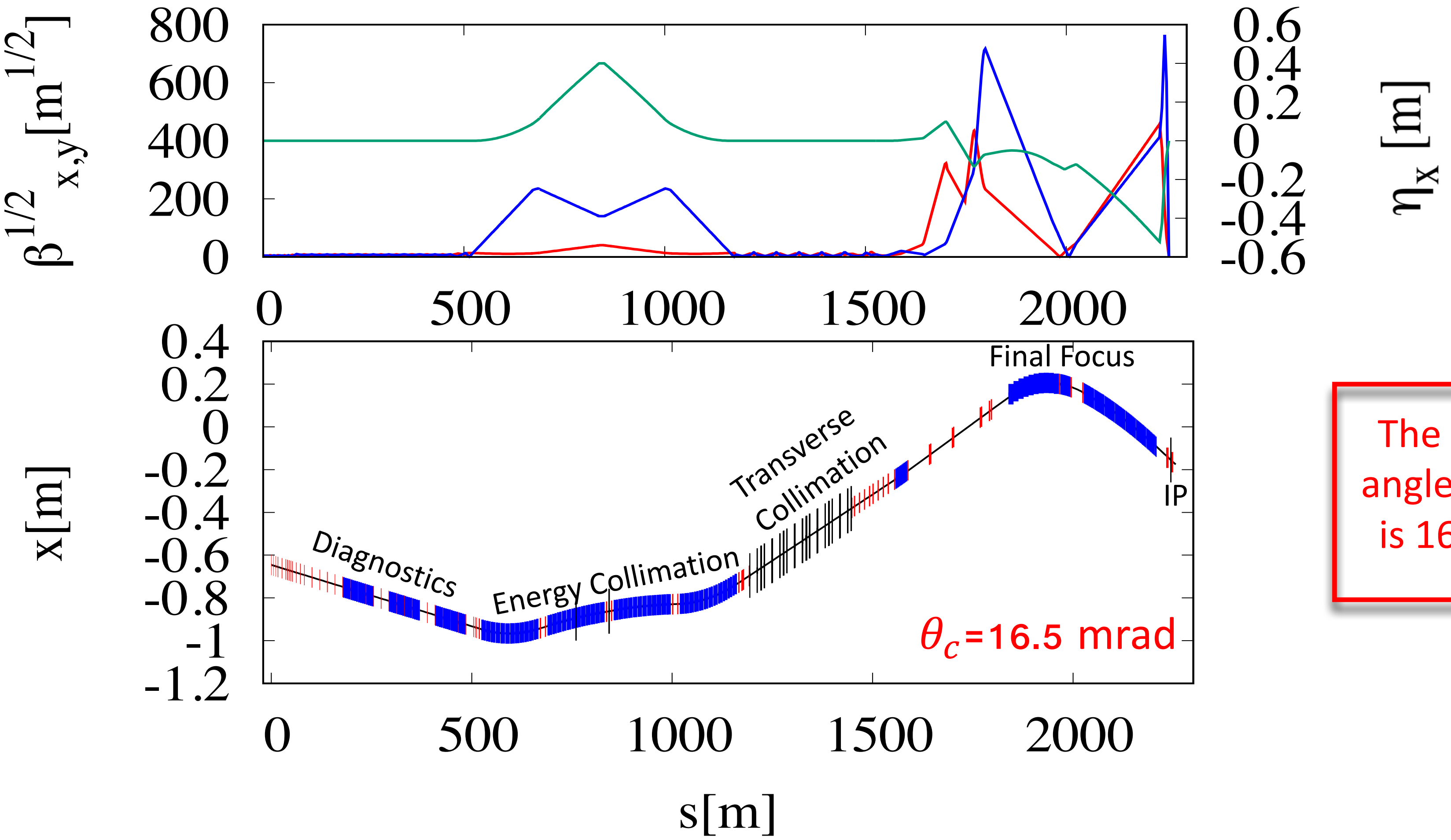
* THE CROSSING ANGLE IN CLIC. D. Schulte, F. Zimmermann, CERN, Geneva, Switzerland. Proceedings of the 2001 Particle Accelerator Conference, Chicago

Thank you for the attention!

Back-up Slides

2nd BDS with different bending angles

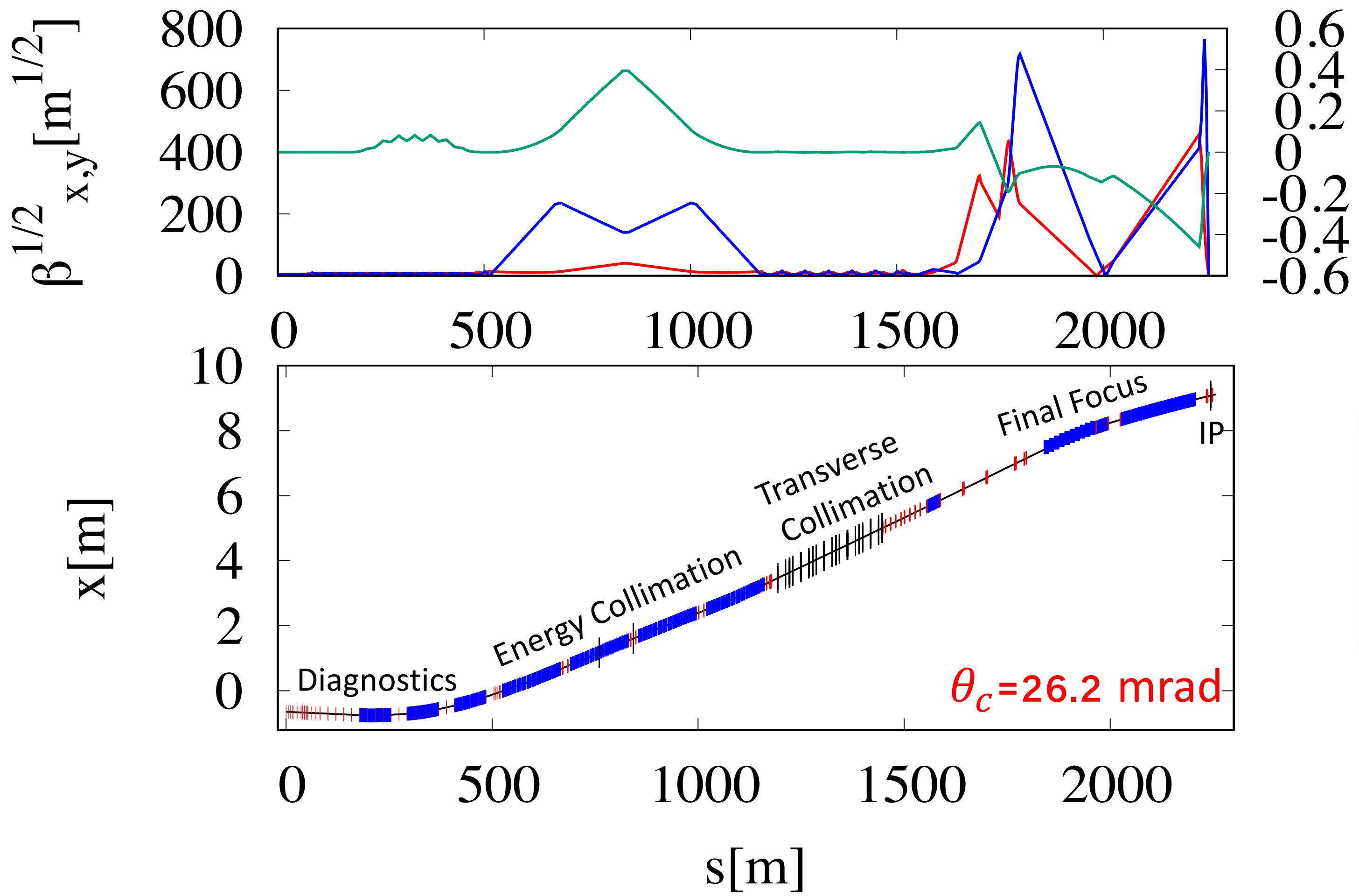
- Case θ=0 mrad



The crossing angle at the IP is 16.5 mrad

2nd BDS with different bending angles

- Case θ=4.83 mrad

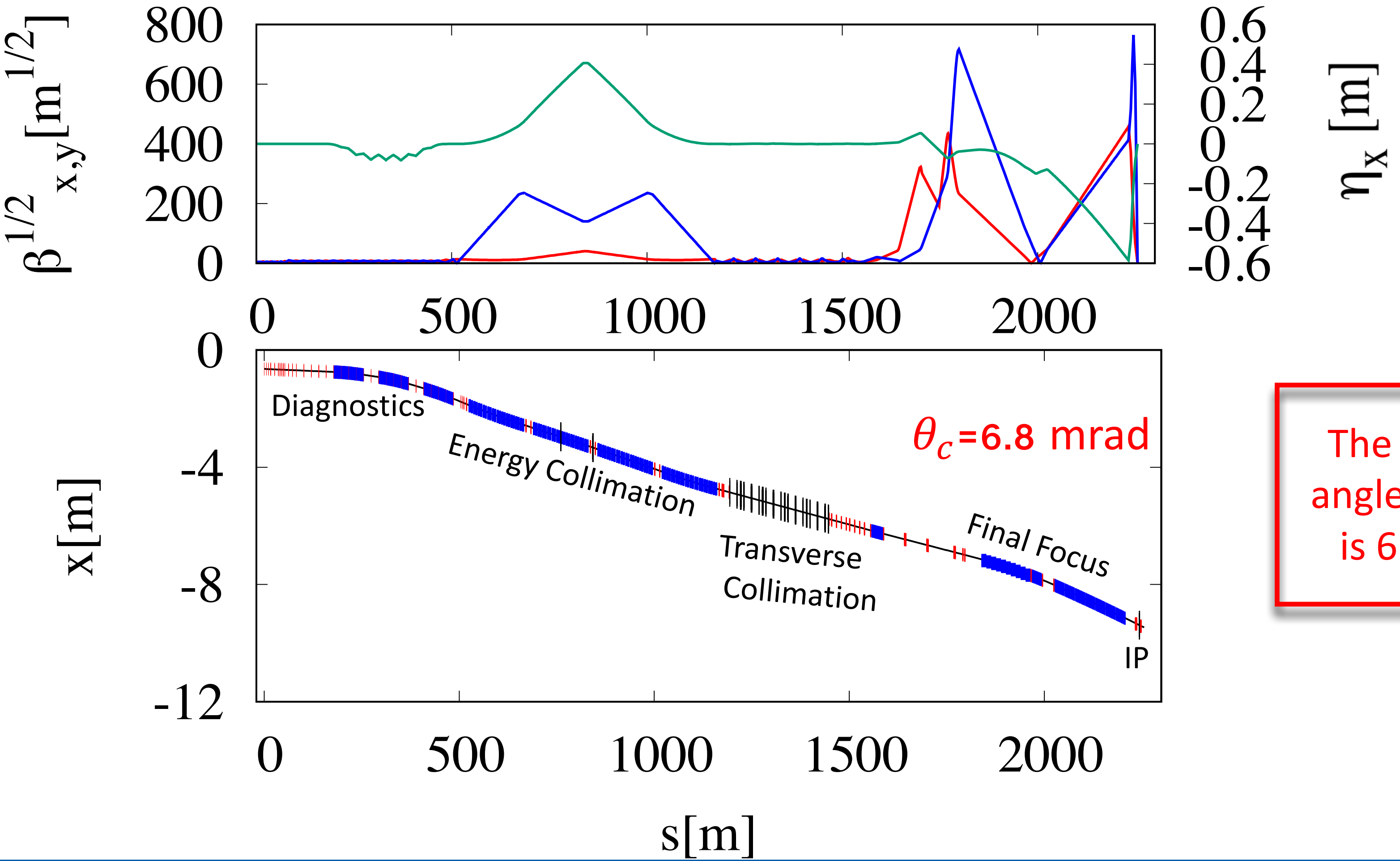


• Case θ=4.83 mrad

The crossing angle at the IP is 26.2 mrad

2^{nd} BDS with different bending angles

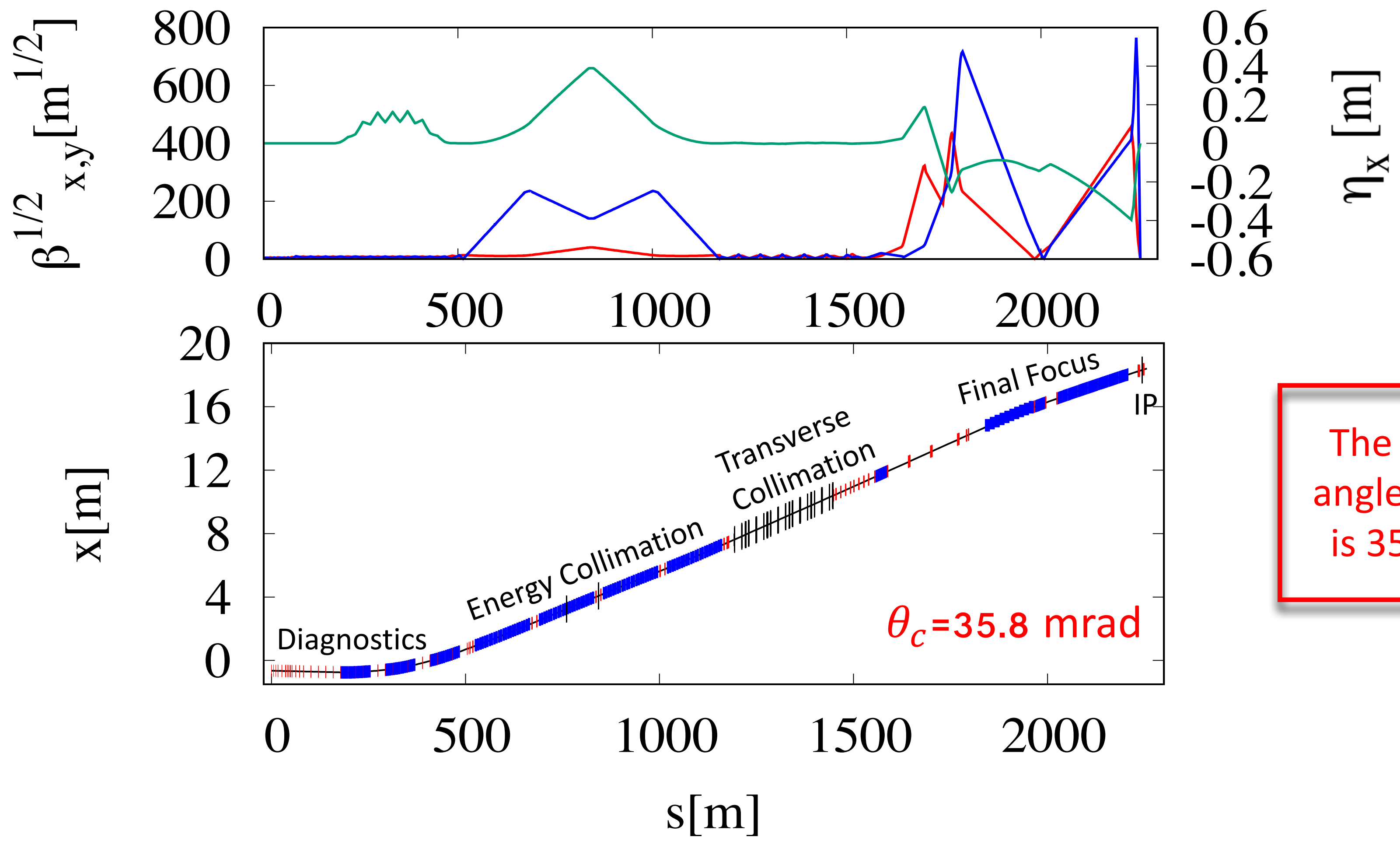
- Case θ=-4.83 mrad



The crossing angle at the IP is 6.8 mrad

2nd BDS with different bending angles

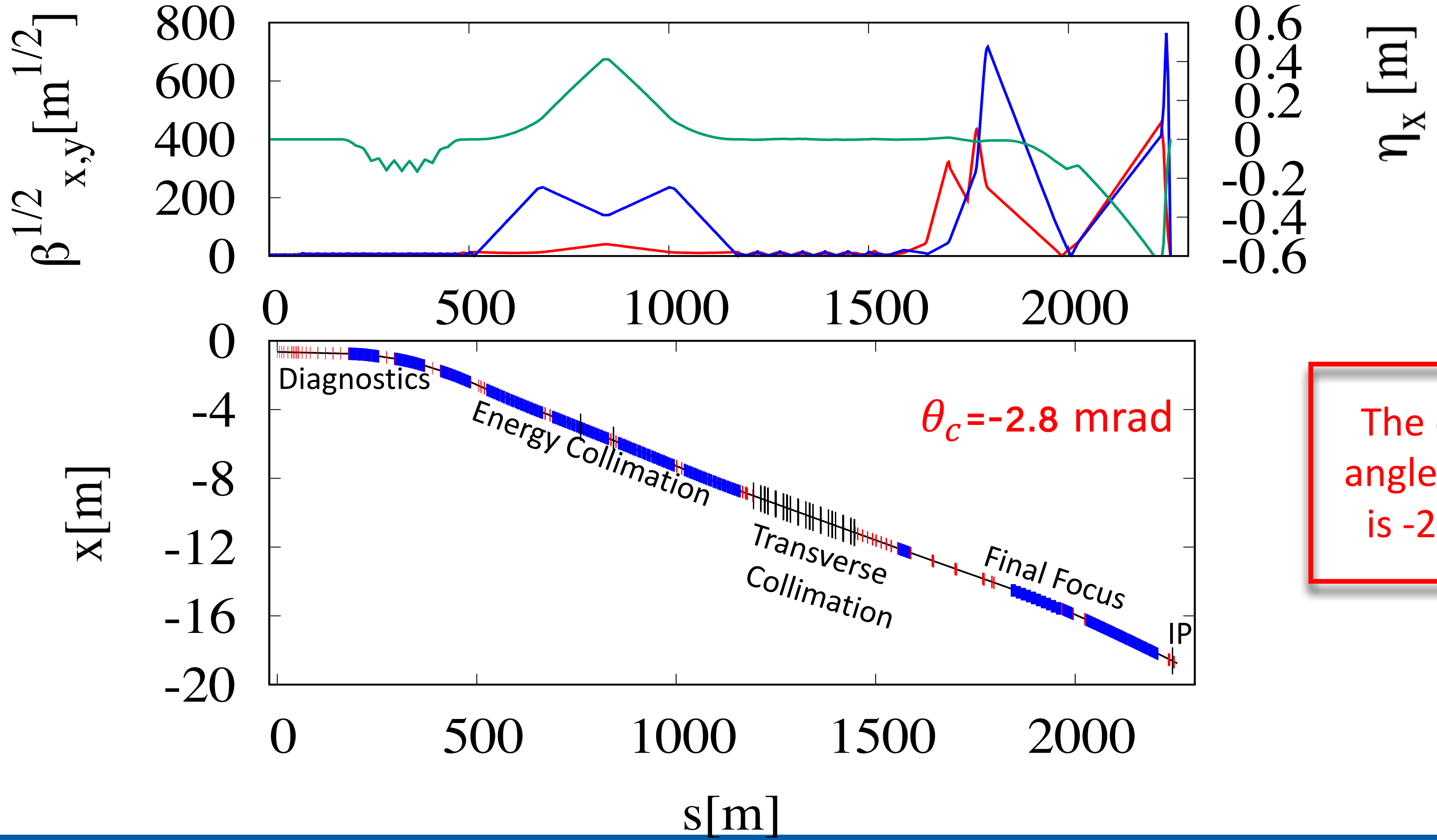
- Case θ=9.66 mrad



The crossing angle at the IP is 35.8 mrad

2nd BDS with different bending angles

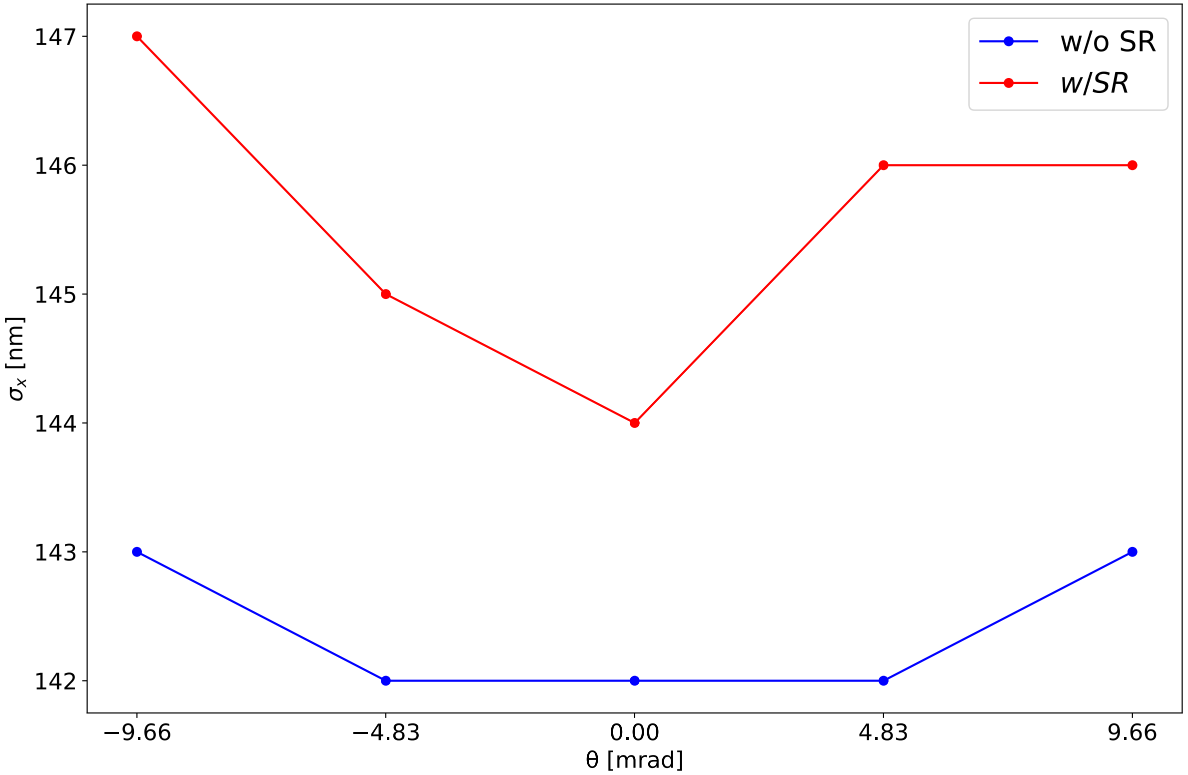
- Case θ=-9.66 mrad

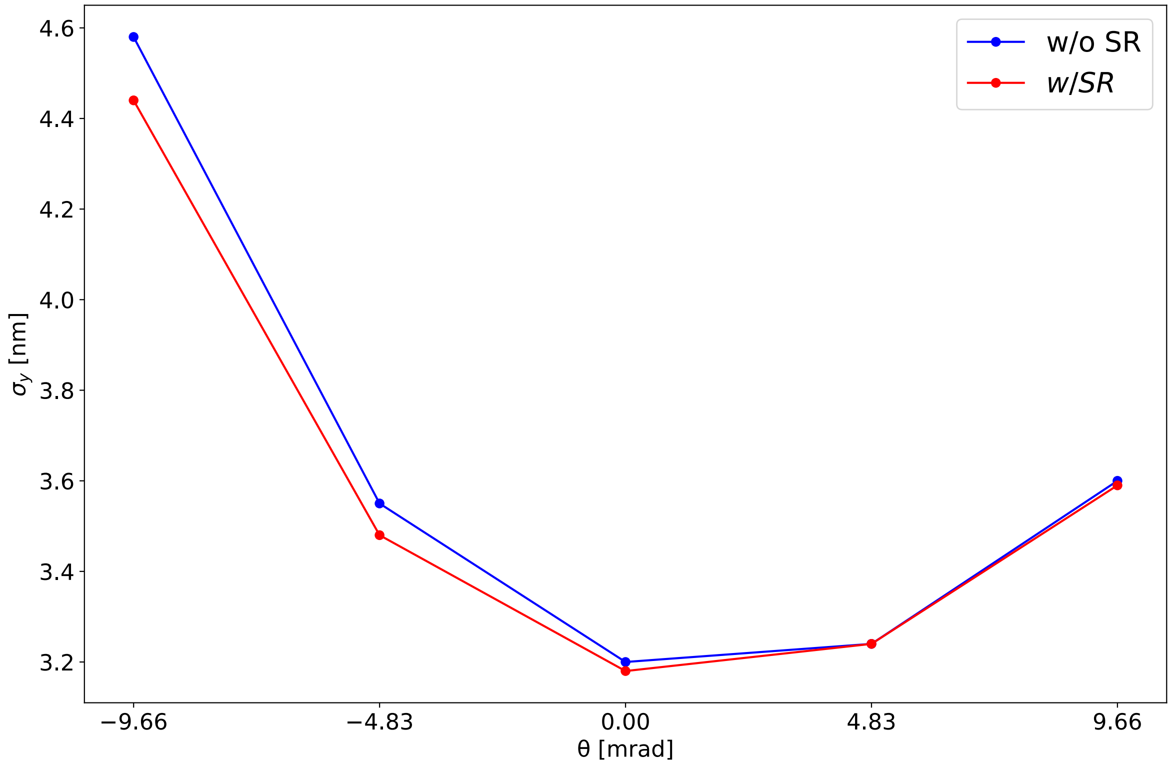


The crossing angle at the IP is -2.8 mrad

Comparison between 1st BDS and 2nd BDS

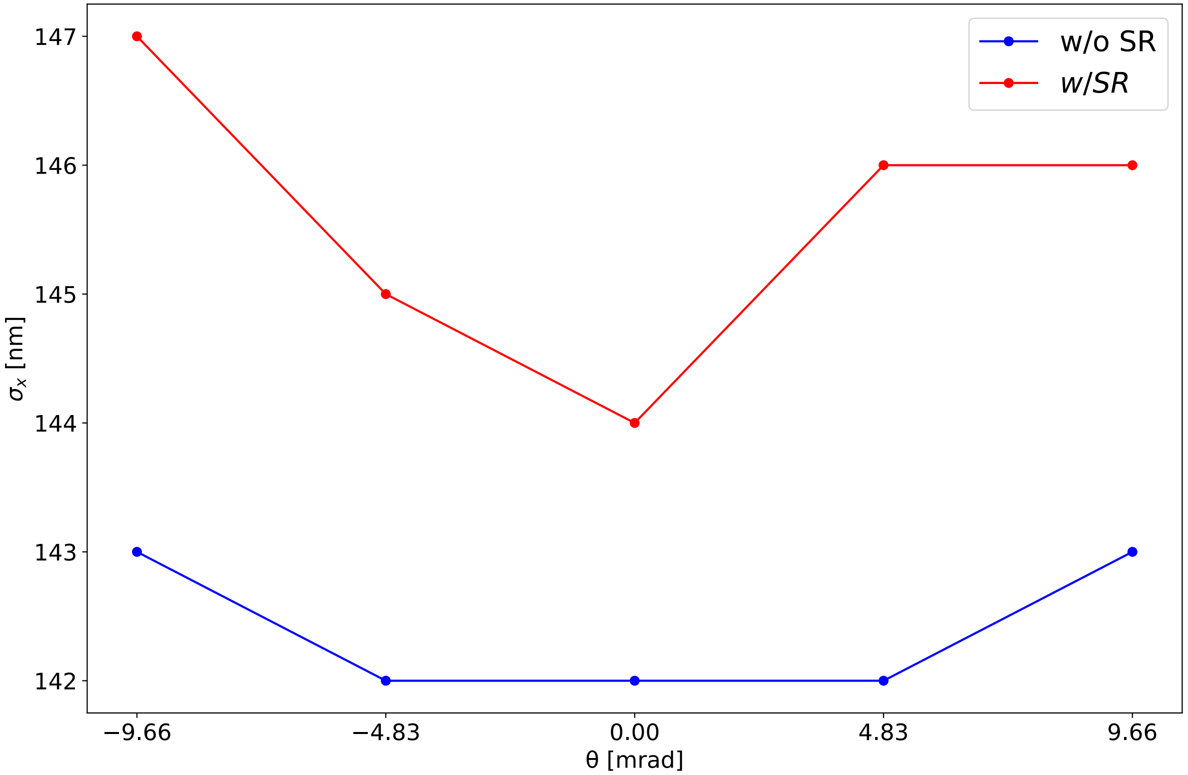
- Beam Sizes with PLACET Simulations before chromatic corrections

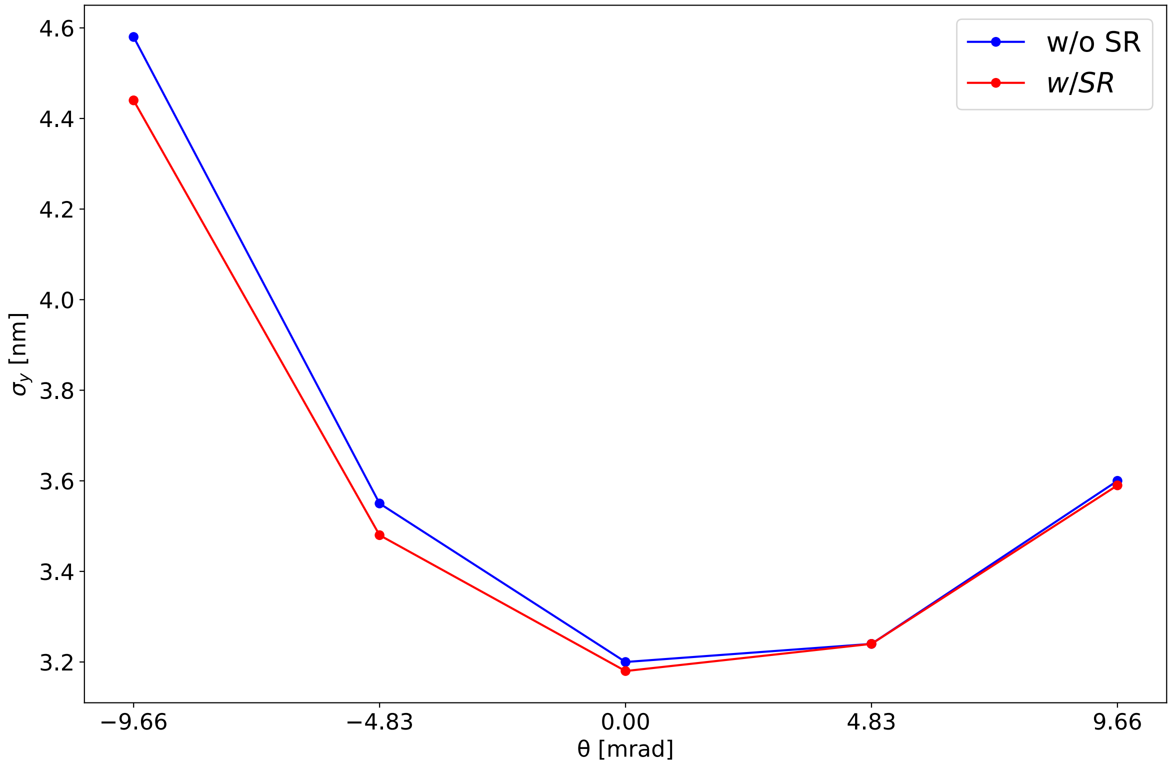




Comparison between 1st BDS and 2nd BDS

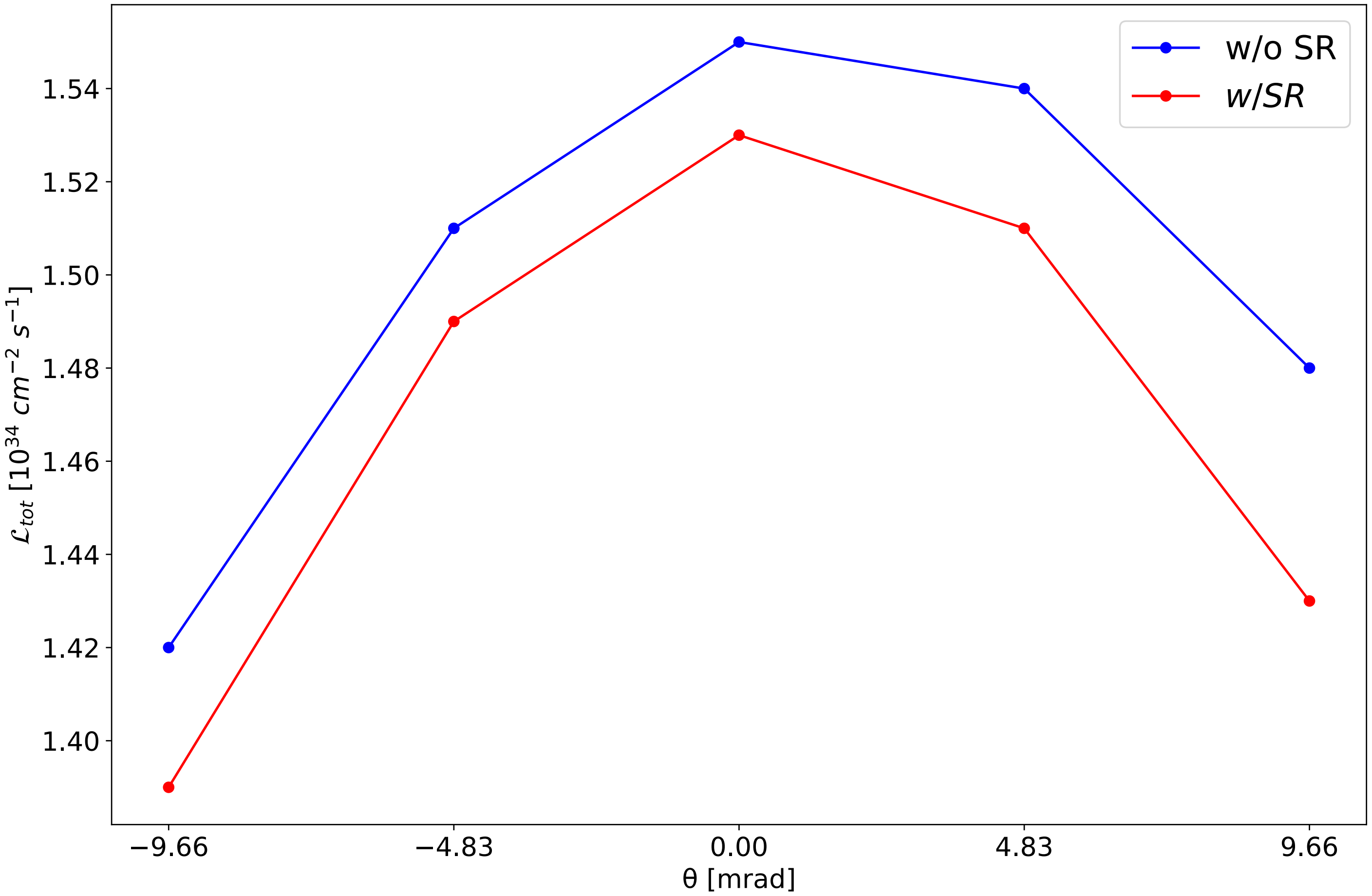
- Beam Sizes with PLACET Simulations before chromatic corrections





Comparison between 1st BDS and 2nd BDS

- Luminosity before chromatic corrections



- The chromatic aberrations in the vertical plane could be a source of Luminosity loss
- To fix this aberrations we could use the sextupoles in the FFS region or add new ones
- ~1% of luminosity loss comes from the SR itself

Comparison between 1st BDS and 2nd BDS

- Beam Sizes with PLACET Simulations before correcting chromatic aberrations

SR off	1st BDS	2nd BDS θ=0 mrad	2nd BDS θ=4.83 mrad	2nd BDS θ=-4.83 mrad	2nd BDS θ=9.66 mrad	2nd BDS θ=-9.66 mrad
σ_x^* [nm]	141	142	142	142	143	143
σ_y^* [nm]	3.1	3.2	3.2	3.5	3.6	4.6

- The chromatic aberrations in the vertical plane could be a higher source of Luminosity loss
- To fix this aberrations we could use the sextupoles in the FFS region or add new ones before

Comparison between 1st BDS and 2nd BDS

- Beam Sizes with PLACET Simulations

SR on	1st BDS	2nd BDS θ=0 mrad	2nd BDS θ=4.83 mrad	2nd BDS θ=-4.83 mrad	2nd BDS θ=9.66 mrad	2nd BDS θ=-9.66 mrad
σ_x^* [nm]	144	144	144	145	146	147
σ_y^* [nm]	3.1	3.2	3.2	3.5	3.6	4.4

- The chromatic aberrations in the vertical plane could be a higher source of Luminosity loss
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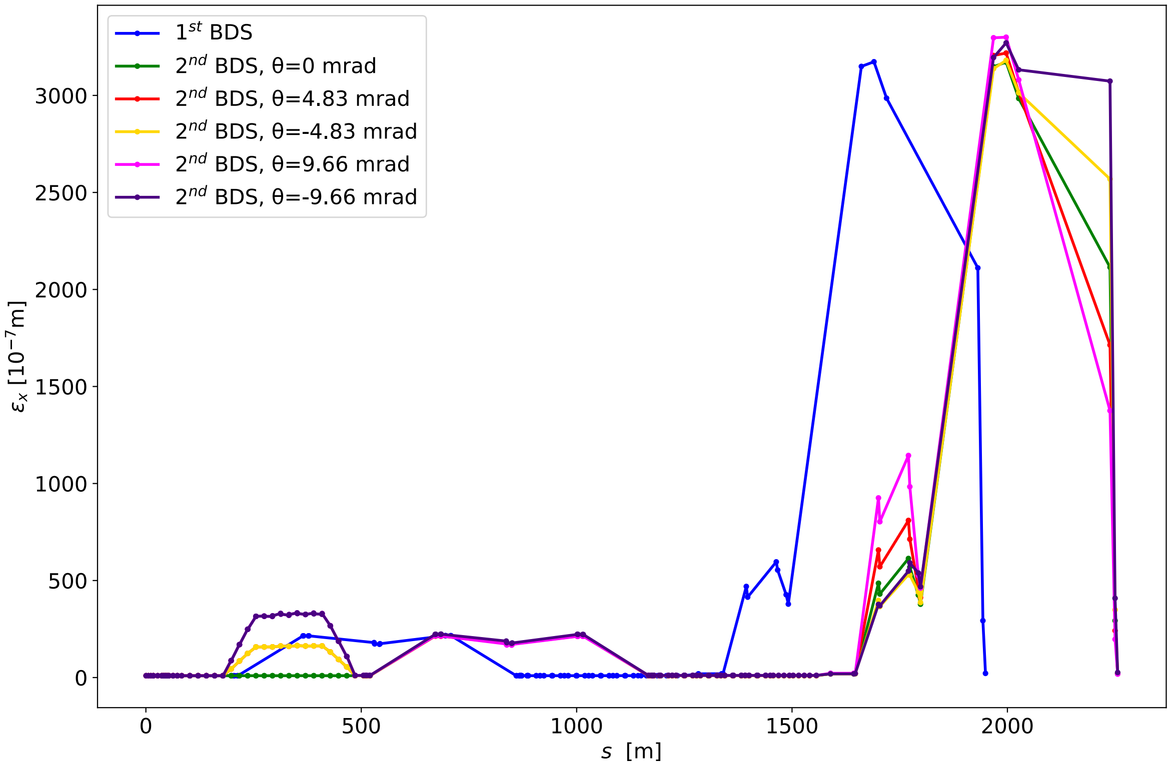
Comparison between 1st BDS and 2nd BDS

- Emittance growth

- W/o SR



- W/ SR