New CLIC FFS design at 380 GeV

LCWS 2019, Sendai

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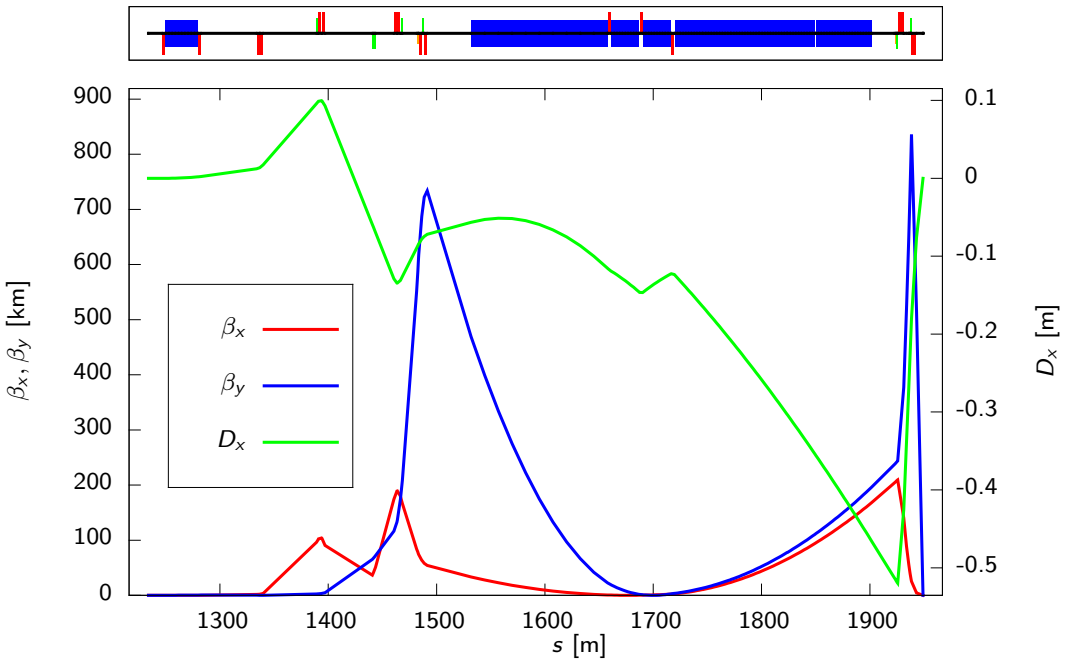
October 29, 2019

Outline

Latest FFS design of CLIC 380 GeV

In the current design of CLIC 380 GeV:

- $L^* = 6$ m is chosen to easy MDI and avoid the need to shield **QD0** (F.Plassard et al, *"CLIC 3 TeV and 380 GeV BDS design with $L^* = 6$ m"*, CLIC workshop 2018).
- IP vertical beta function was reduced from 100 μm to 70 μm. (A.Pastushenko , *"Beam optics calculations for CLIC"*, Master Thesis, 2018)

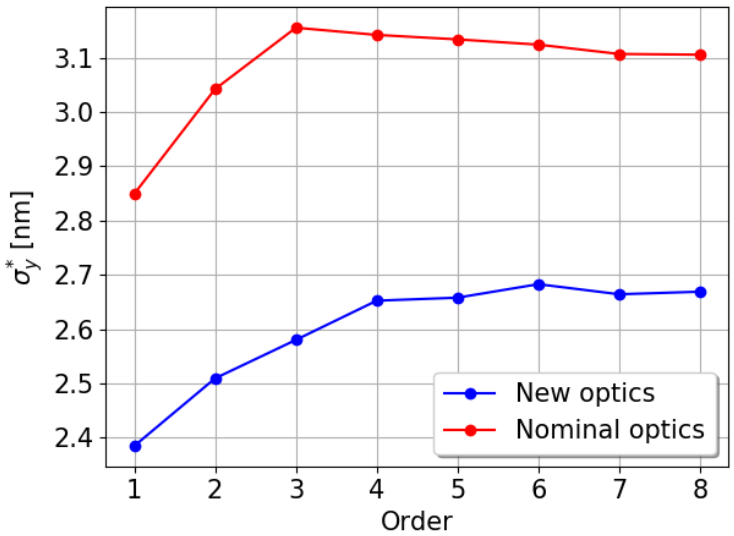


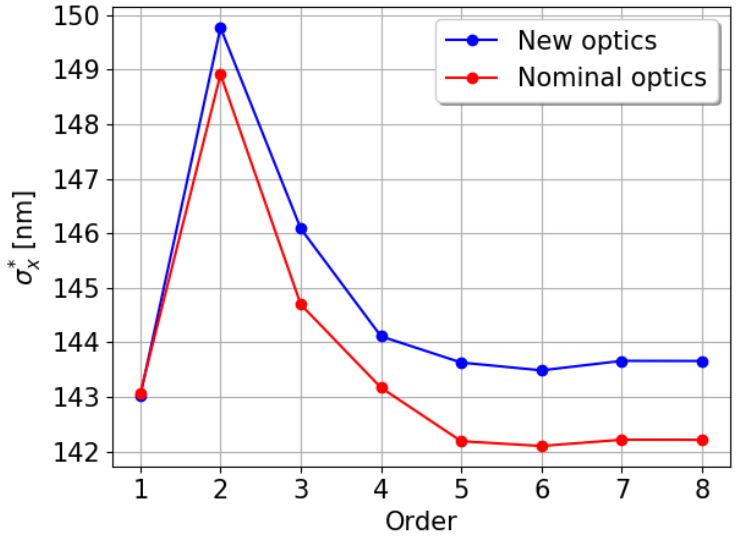
FFS length [m]	770
$\epsilon_{n,x}/\epsilon_{n,y}$ [nm]	950/30
β_x^*/β_y^* [mm]/[μm]	8/70
σ_x^*/σ_y^* [nm]	145/2.9
σ_z [μm]	70
δ_p [%]	0.35
$\mathcal{L}$ [10^{34}cm^{-2}s^{-1}]	1.5
$\mathcal{L}_{1\%}$ [10^{34}cm^{-2}s^{-1}]	0.9

Latest FFS design of CLIC 380 GeV

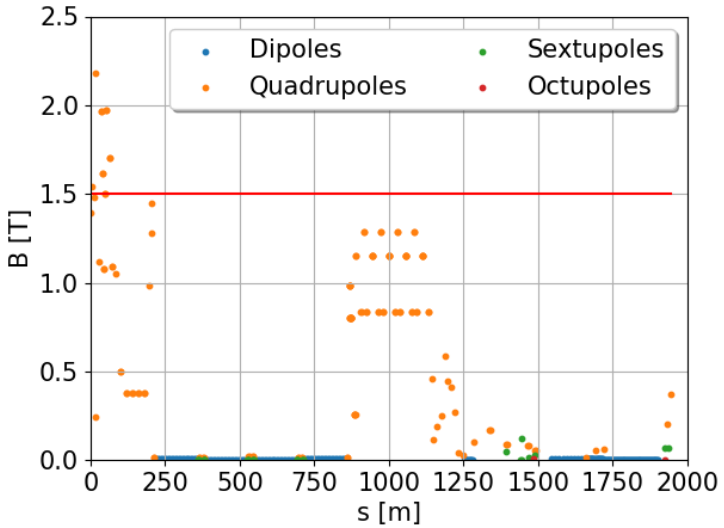
- Provides higher luminosity for on-momentum beam but has smaller momentum bandwidth.
- Higher luminosity at the optimal waist (4.5 %)
- Beam size, $\sigma_x^* \times \sigma_y^*$ [nm]:

	MAPCLASS	PLACET
$\beta_y^* = 70$	143.66×2.67	145.76×2.76
$\beta_y^* = 100$	142.22×3.11	144.22×3.14



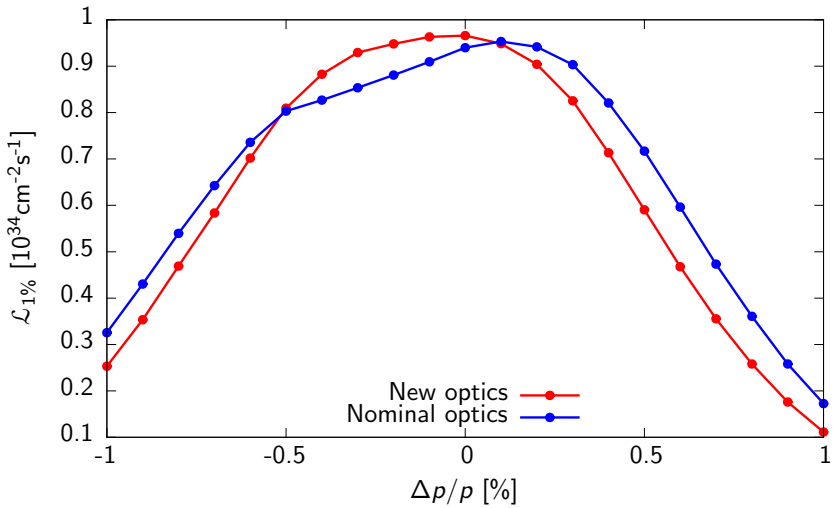


Latest FFS design of CLIC 380 GeV

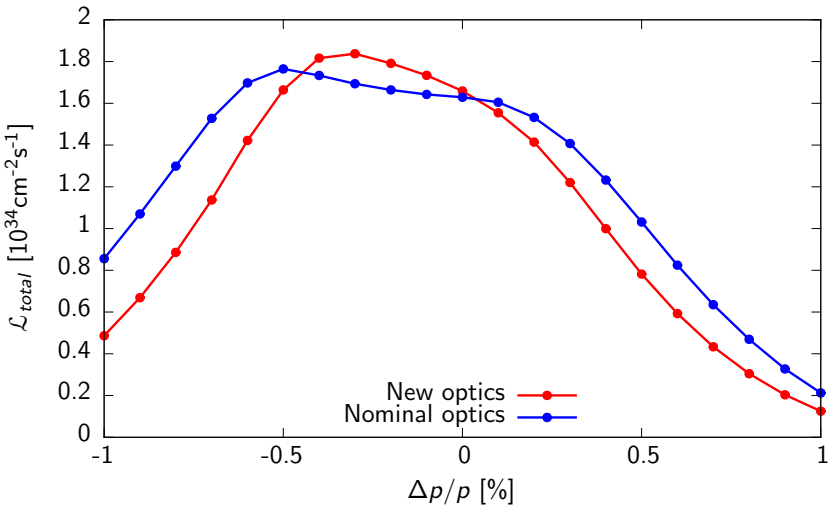


- Since the FD strength is far below the limit, it was decided to shorten the FD
- The bandwidth is small for the optics with low β_y^*, optics also has to be optimized in terms of momentum bandwidth.

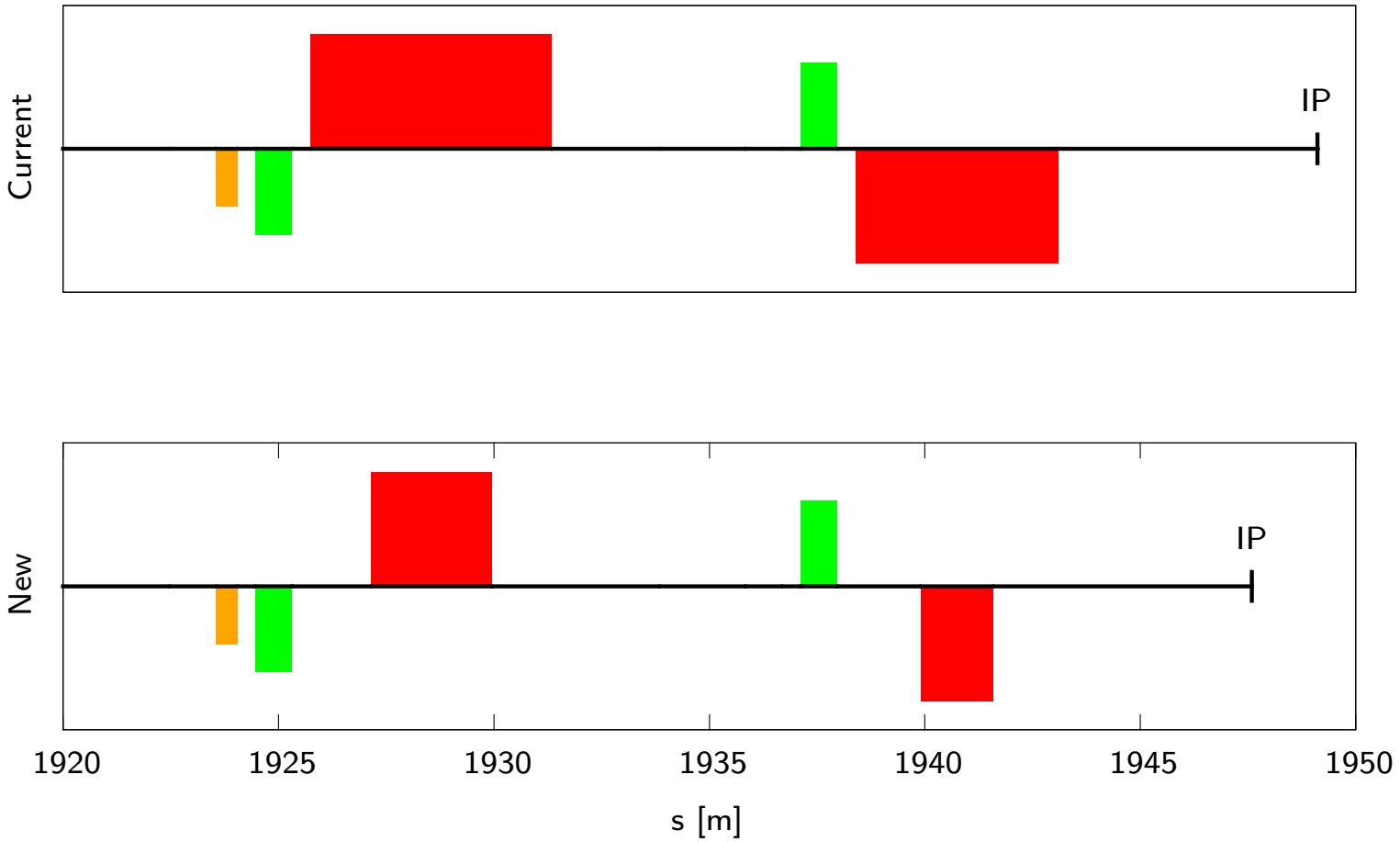
Peak luminosity



Total luminosity



FD optimization

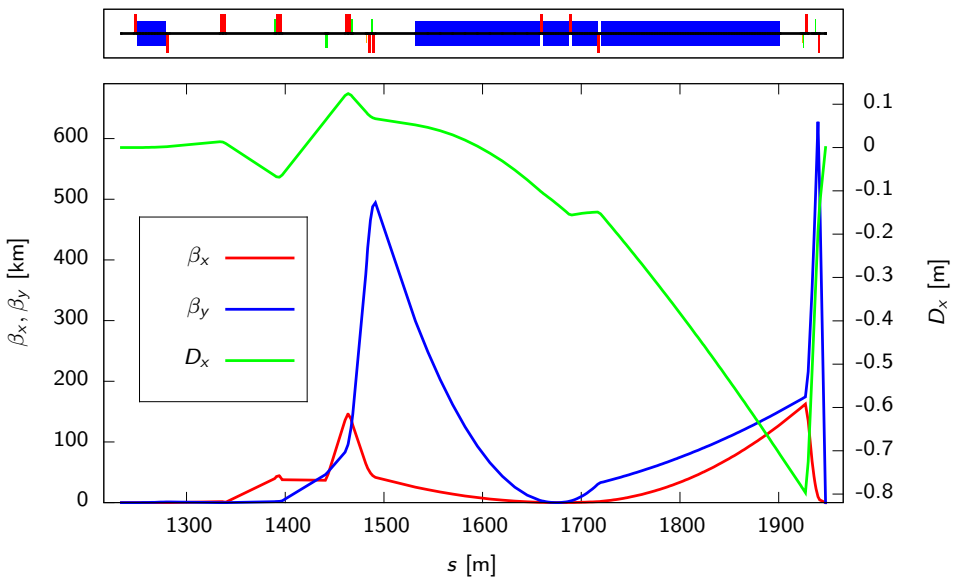


- Quadrupole
- Sextupole
- Octupole

Each magnet is shortened by 3 m. IP is moved towards the FFS to have $L^* = 6$ m. **QF1** may be shifted to balance the chromaticities.
Sextupoles are to be moved later (the closer to the quads the better).

Twiss matching

The linear optics was retrieved after shortening the FD and setting $L^* = 6$ m.

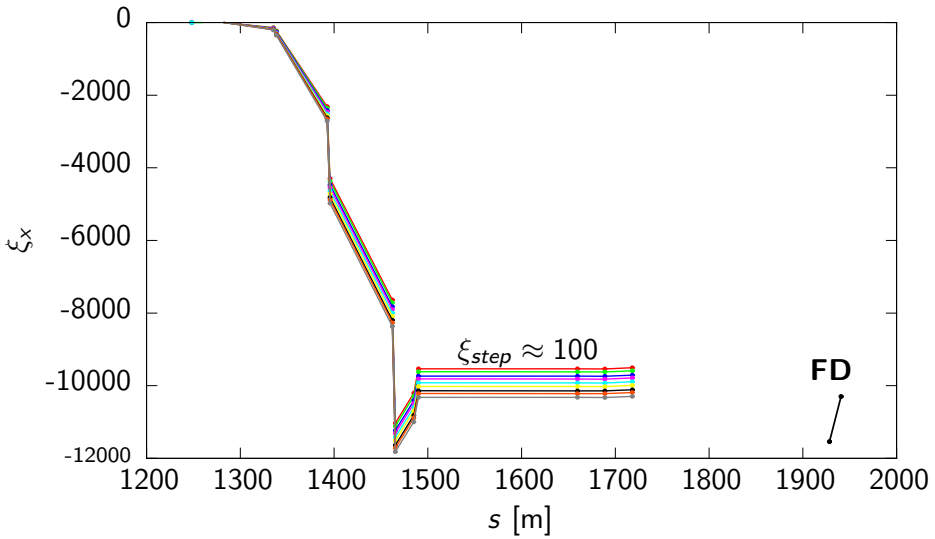


In this optics:

- Dispersion has a different profile (at the end, has a strong impact on the momentum bandwidth)
- Horizontal chromaticity is not balanced, thus not possible to reduce the horizontal IP beam size.
- An additional horizontal waist was introduced after the first bend.

Chromaticity matching

The proper upstream horizontal chromaticity was obtained by adjusting it with the constant **QF1** setting and location.

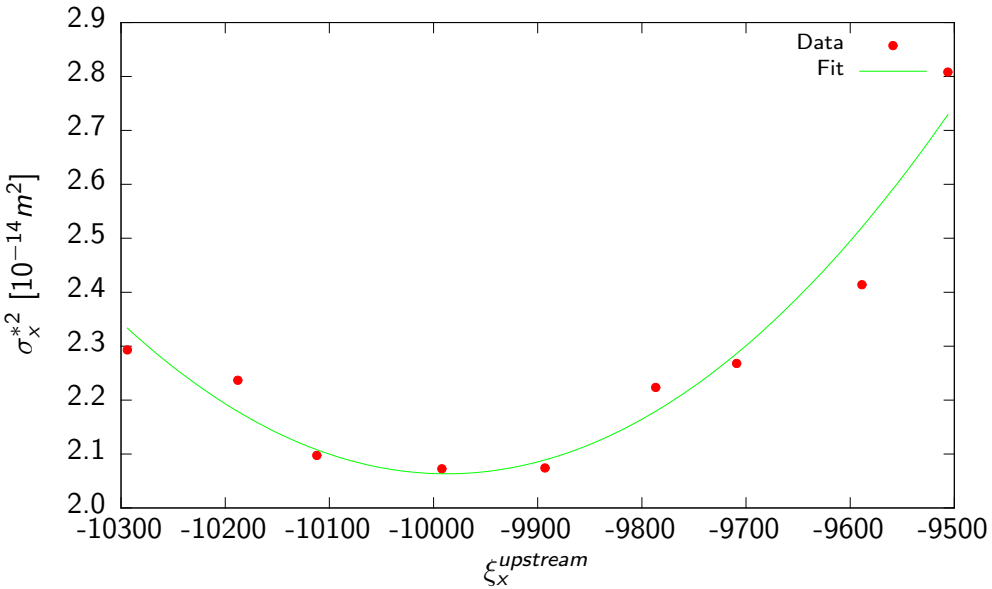


- **QF1** location was fixed
- Twiss parameters at the IP and the upstream chromaticity are matched at the same time with MadX.

The drawback of this matching method is that it is possible to disrupt the other conditions upstream of the FD.

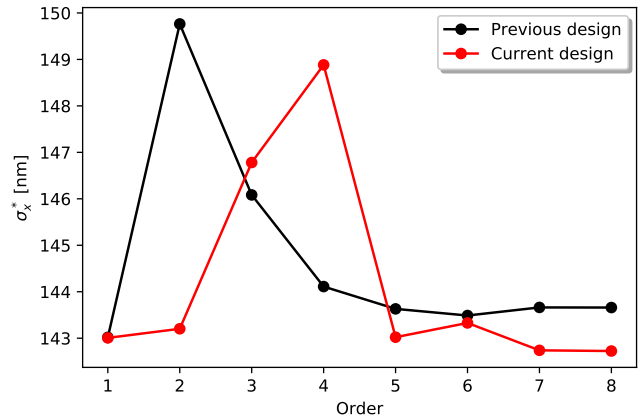
Chromaticity optimization

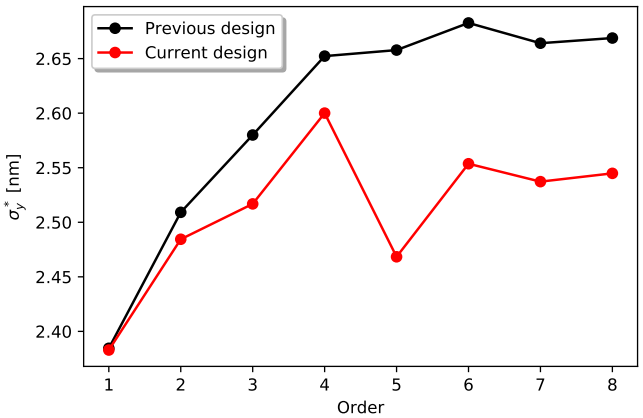
- The 2nd order beam size was matched to the linear value.
- The smallest beam size calculated was **143.9 nm** (target value is 143 nm).
- From the fit, minimum is of around **143.6 nm**.



- Setup with the smallest beam size is then checked for the luminosity and momentum bandwidth.

Beam size matched



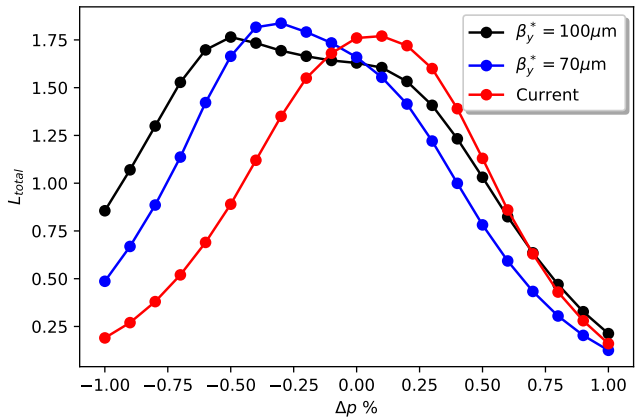


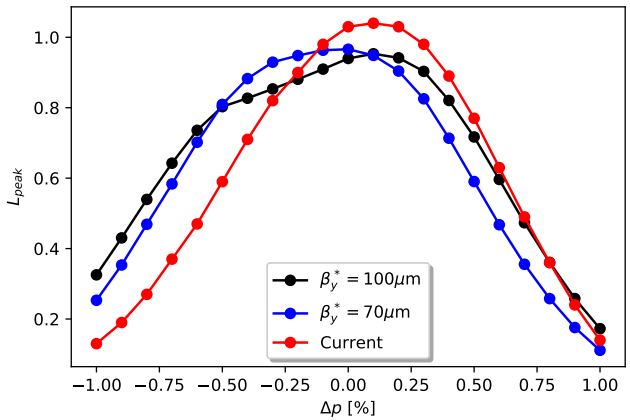
- In such a design, σ_x^* has large 3rd and 4th order aberrations.
- It has to be checked what is the source of these aberrations.

	MAPCLASS	PLACET
$\beta_y^* = 70$	143.66 × 2.67	145.76 × 2.76
$\beta_y^* = 100$	142.22 × 3.11	144.22 × 3.14
Current	**142.72 × 2.55**	**144.24 × 2.83**

Momentum bandiwdth

Although, on-momentum luminosity is larger for this design, momentum bandwidth is smaller:





	$\mathcal{L}_{total}$ $[10^{34}\text{cm}^{-2}\text{s}^{-1}]$	$\mathcal{L}_{1\%}$ $[10^{34}\text{cm}^{-2}\text{s}^{-1}]$
Optics with $\beta_y^* = 100\mu$m	1.63	0.94
Optics with $\beta_y^* = 70\mu$m	1.66	0.96
Current	**1.74**	**1.01**

Off-momentum beam size is very large:

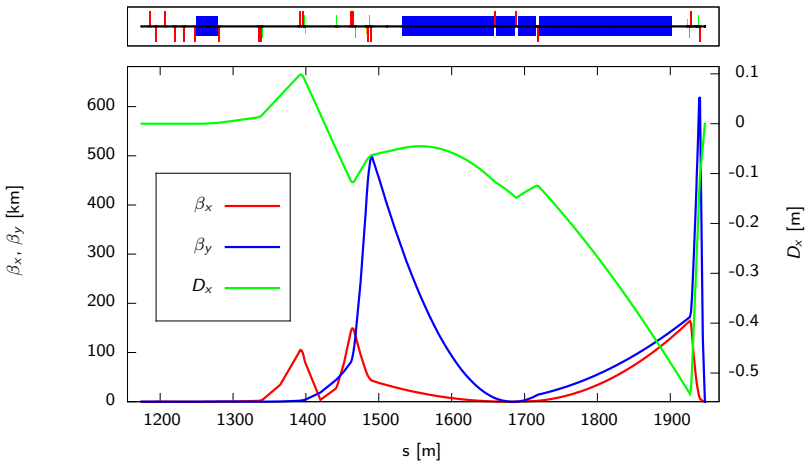
	$\sigma_x^* \times \sigma_y^*$@$^{-1.0\%}$	$\sigma_x^* \times \sigma_y^*$@$^{+1.0\%}$
Optics with $\beta_y^* = 100\mu$m	233.7 $\times$ 6.6	354.2 $\times$ 55.3
Optics with $\beta_y^* = 70\mu$m	341.0 $\times$ 9.9	502.0 $\times$ 94.6
Current	1397.5 $\times$ 21.4	1394.7 $\times$ 258.3

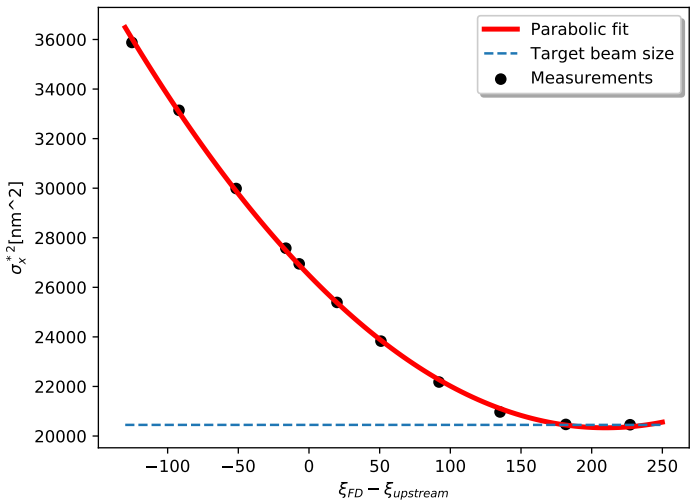
Shorter FD, original dispersion profile

Twiss and ξ_x^* matched

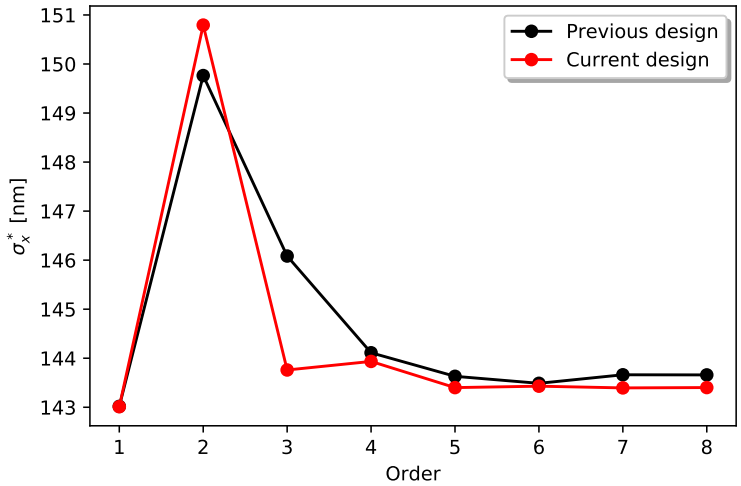
An additional constraint was put to the matching procedure to keep the same dispersion profile as in the previous designs:

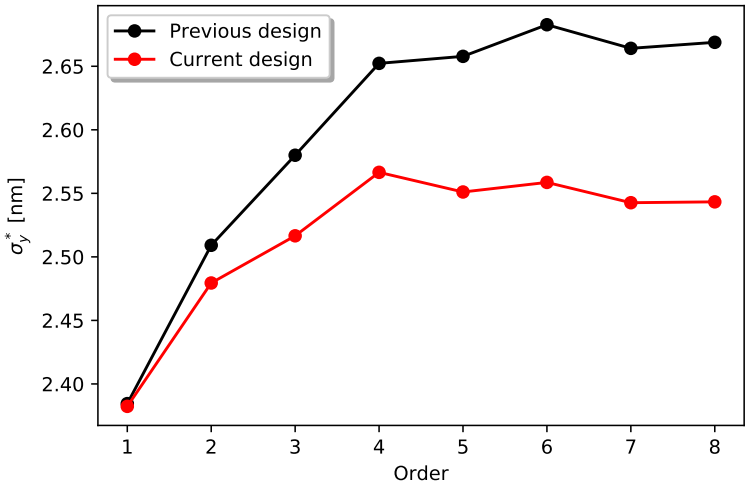
- This lattice also has unbalanced horizontal chromaticity.
- To balance it, FD was moved by some distance to adjust the chromaticity difference properly.





Beam size and momentum bandwidth





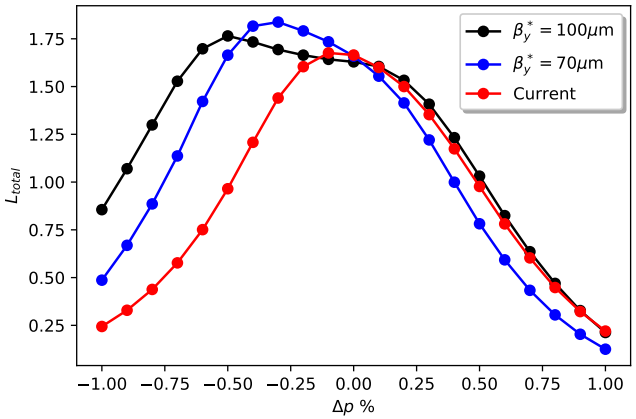
- The beam size was reduced compared to the previous design:

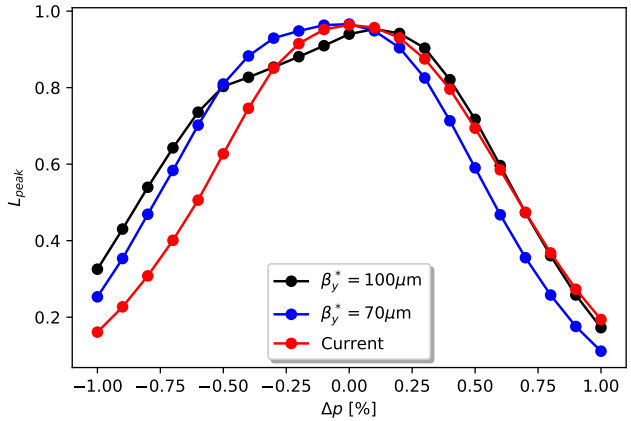
	MAPCLASS	PLACET
$\beta_y^* = 70\mu$m	143.66 × 2.67	145.76 × 2.76
$\beta_y^* = 100\mu$m	142.22 × 3.11	144.22 × 3.14
Current	**143.40 × 2.54**	**145.02 × 2.68**

- Luminosity obtained is similar to the previous design, [10^{34}cm^{-2}s^{-1}]:

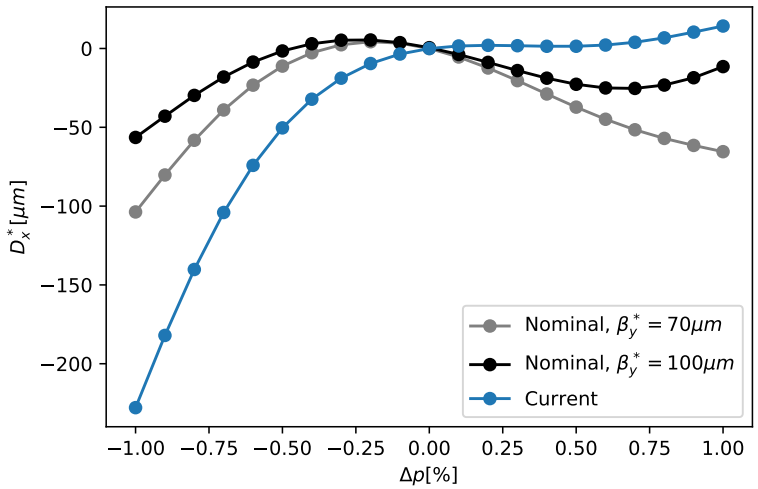
	$\mathcal{L}_{total}$	$\mathcal{L}_{1\%}$
$\beta_y^* = 100\mu$m	1.63	0.94
$\beta_y^* = 70\mu$m	1.66	0.96
Current	**1.67**	**0.97**

Beam size and momentum bandwidth



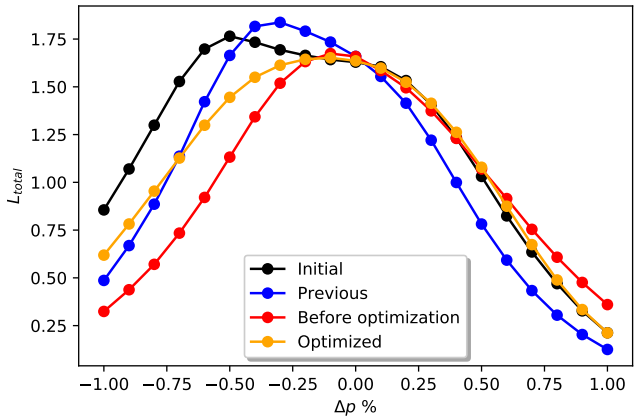


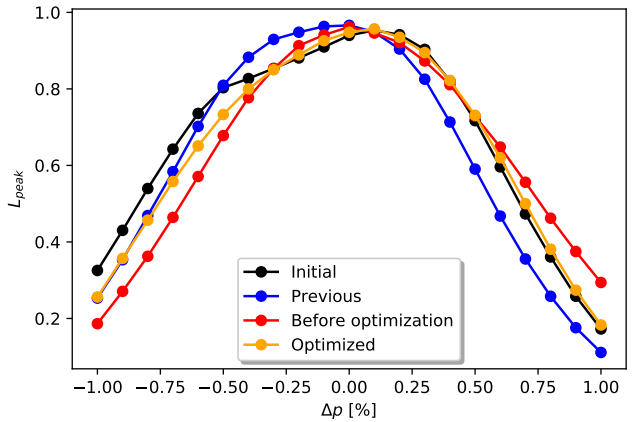
The bandwidth is smaller for this optics, mainly because D_x^* for the negative energy offset deviates too much from the target.



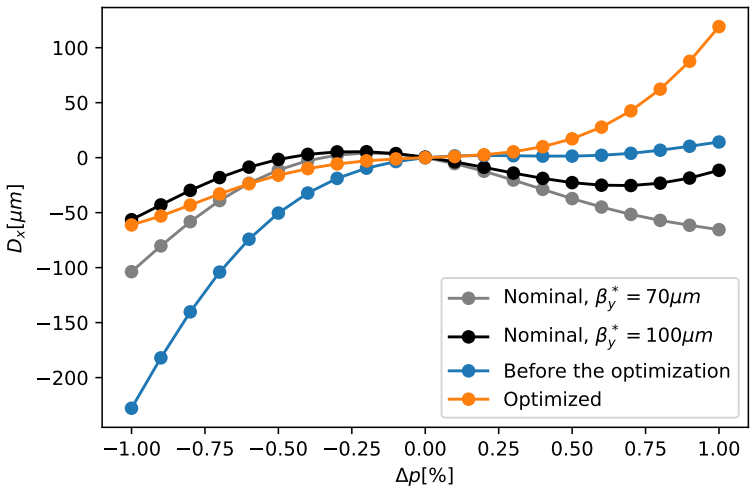
To improve the luminosity on the left side, the off-momentum dispersion was put as a constraint in the beam size matching. Also, to improve the correction, additional octupole was introduced at **SF6** location.

Momentum bandwidth optimization





D_x^* for -1.0% was reduced, giving much higher luminosity for the negative energy offset. It also impacted the luminosity for on-momentum beam.



Luminosity, $[10^{34}\text{cm}^{-2}\text{s}^{-1}]$:

	$\mathcal{L}_{total}$	$\mathcal{L}_{1\%}$
$\beta_y^* = 100\mu$m	1.63	0.94
$\beta_y^* = 70\mu$m	1.66	0.96
Before optimization	**1.67**	**0.97**
After optimization	**1.64**	**0.95**

Summary

Summary

- IP vertical beta function β_y^* was matched to 70μm.
- The FD was shortened (**QF1** and **SD0** by $\sim$ 3 m each).
- Several optics were designed for such a setup.
- Further nonlinear optimization is possible.
- The optics with different dispersion profile has to be checked.

Thank you very much for your attention!