Design and Optimization of the CLIC FFS at 7 TeV

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FFS Design

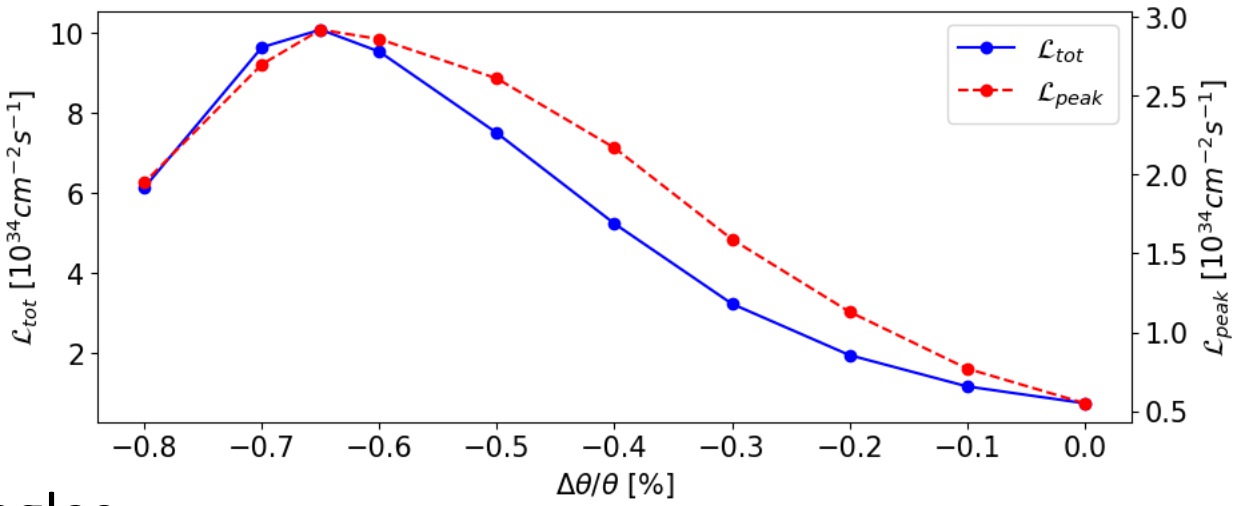
- Scaling all the BDS by a factor $(7\ \mathrm{TeV}\ /\ 3\ \mathrm{TeV})^{1/3}$.
- Same length as the 3 TeV FFS: 768 m.
- Initial beta functions (end of Collimation): $\beta_x = 86.2\ \mathrm{m},\ \beta_y = 23.8\ \mathrm{m}$.

L^* [m]	6
FFS length [m]	768
Norm. emittance $\gamma\epsilon_x/\gamma\epsilon_y$ [nm]	660/20
IP beta function β_x^*/β_y^* [mm]	9/0.12
IP beam size σ_x^*/σ_y^* [mm]	30/0.6
rms energy spread δ_p [%]	0.3

Scaling of the Bending angles

Starting luminosity:

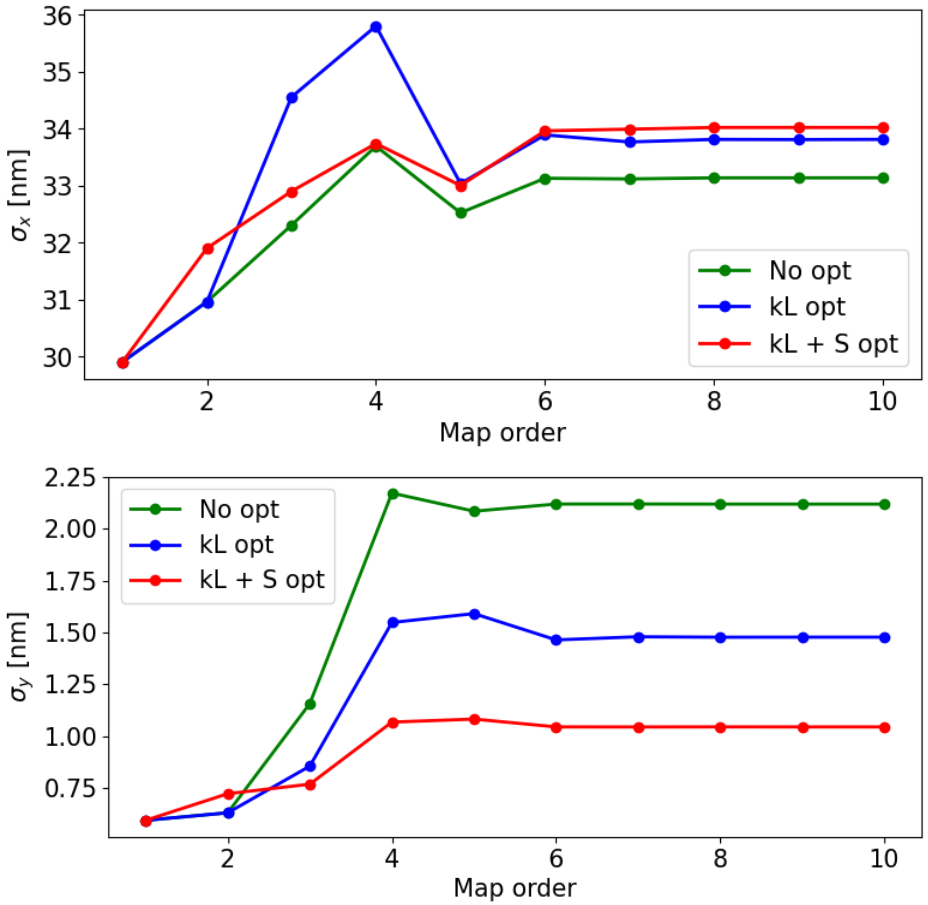
$$\mathcal{L}_{\mathrm{tot}} = 0.76 \cdot 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$$



- Reduction of the FFS bending angles.
- Compensate the dispersion reduction by scaling the sextupole strengths at each steps by a factor $\left(\frac{\Delta\theta}{\theta}\right)^{-1}$

$$\mathcal{L}_{\mathrm{tot}} = 10 \cdot 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1} \quad \text{for } \Delta\theta/\theta = -65\%$$

Beam size optimization



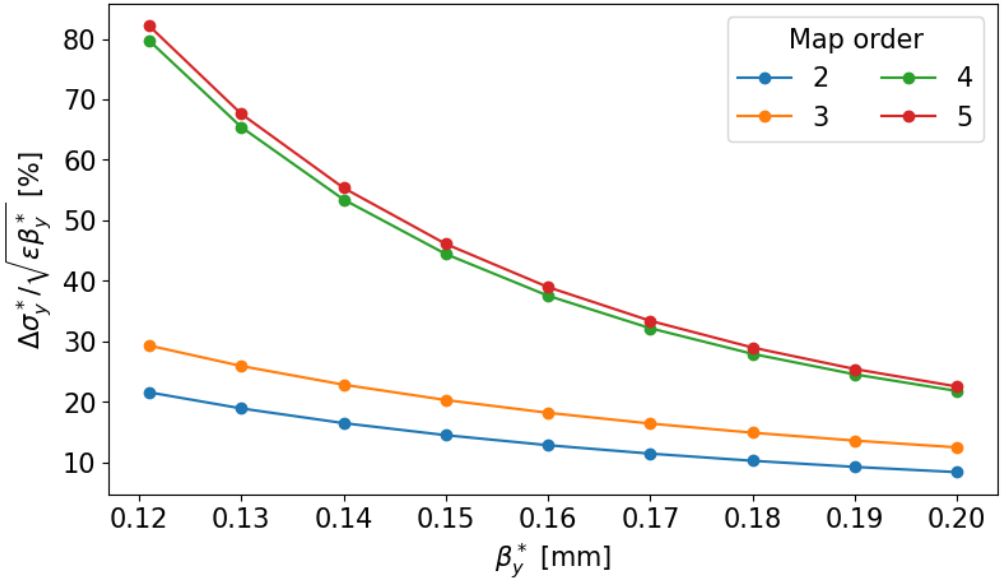
Optimization of the beam size at the IP by varying:

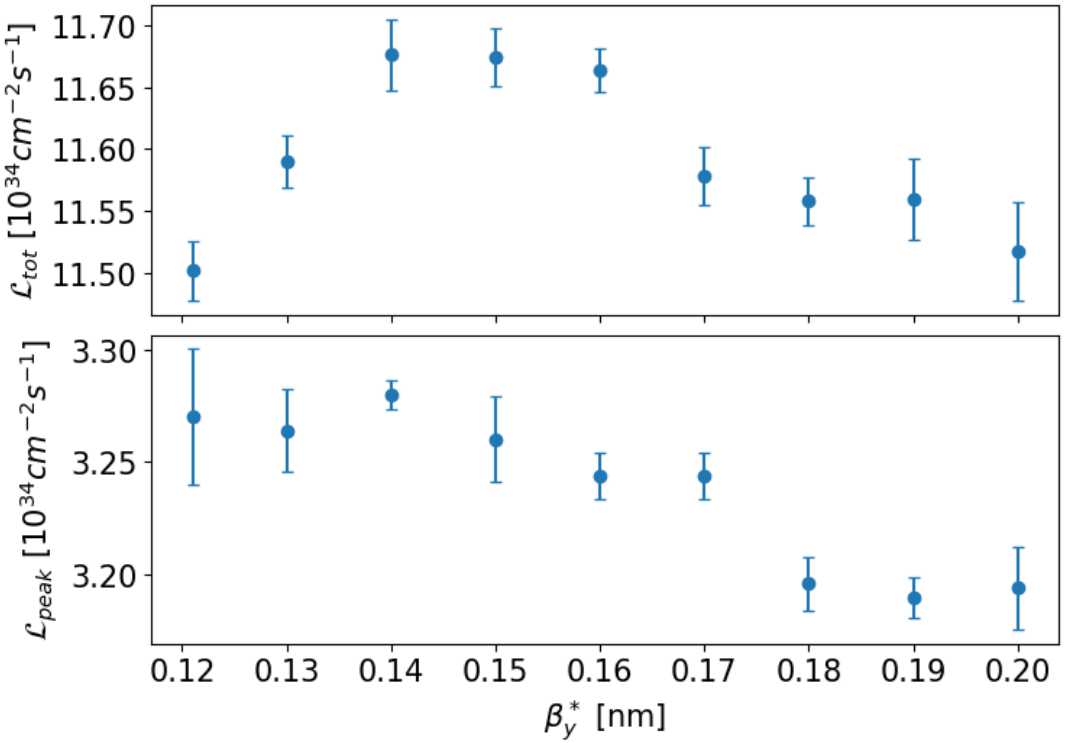
1. only the magnet strengths (blue).

2. the magnet strengths and the octupoles and decapoles positions (red).

β_y^* Scan

- Scan of β_y^* in step of 0.1 mm
- No sextupoles optimization

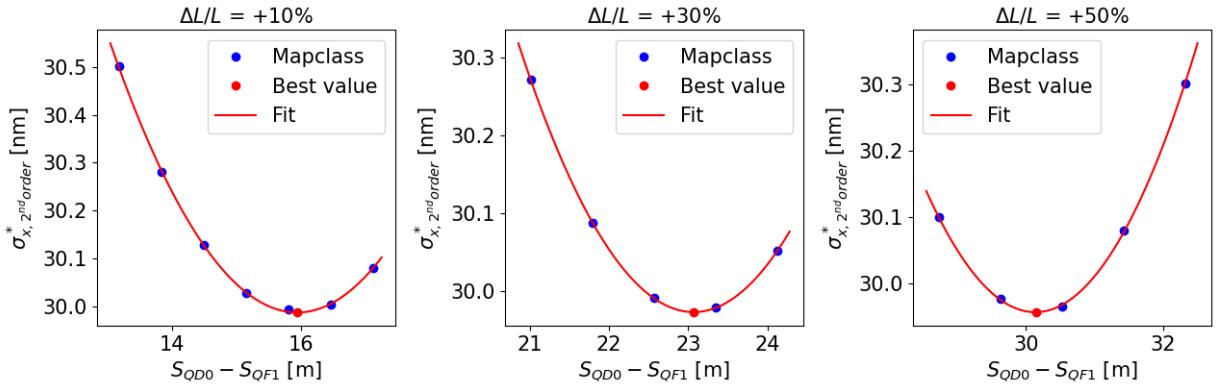


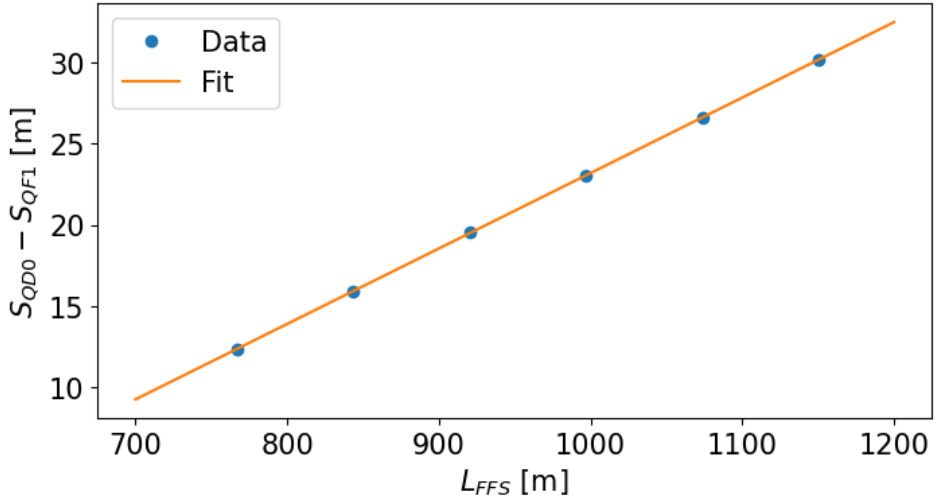


Best $\beta_y^* = 0.14$ mm

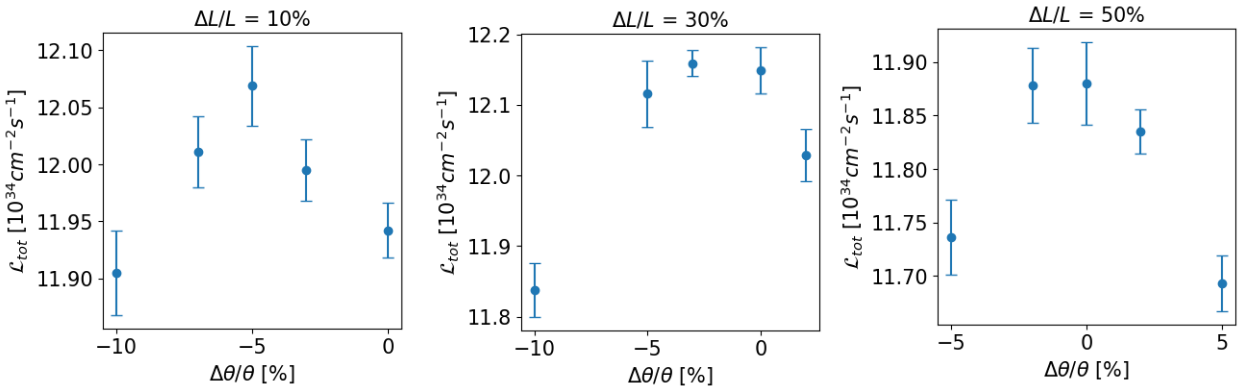
Length scaling – best QF1-QD0 distance

- Increase the length of the FFS to reduce the magnetic field into the dipoles that leads to a decrease in an energy loss by synchrotron radiation.
- FFS length increased in steps of 10%.
- Optimization of the distance between QD0 and QF1 to minimize the horizontal chromaticity.

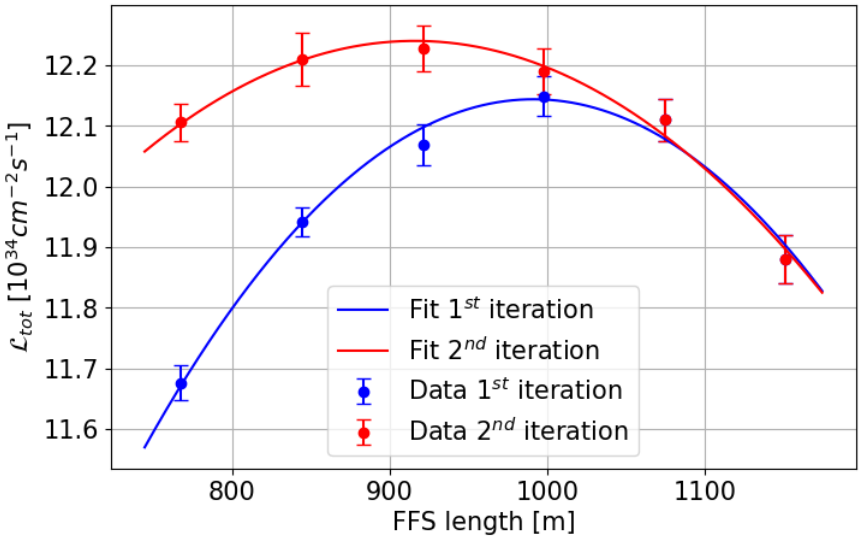




Length scaling – dispersion optimization



1. Optimization of the beam size with Mapclass (1st iteration)
2. Dispersion reduction to reduce the Synchrotron Radiation effects
3. Optimization of the beam size with Mapclass (2nd iteration)

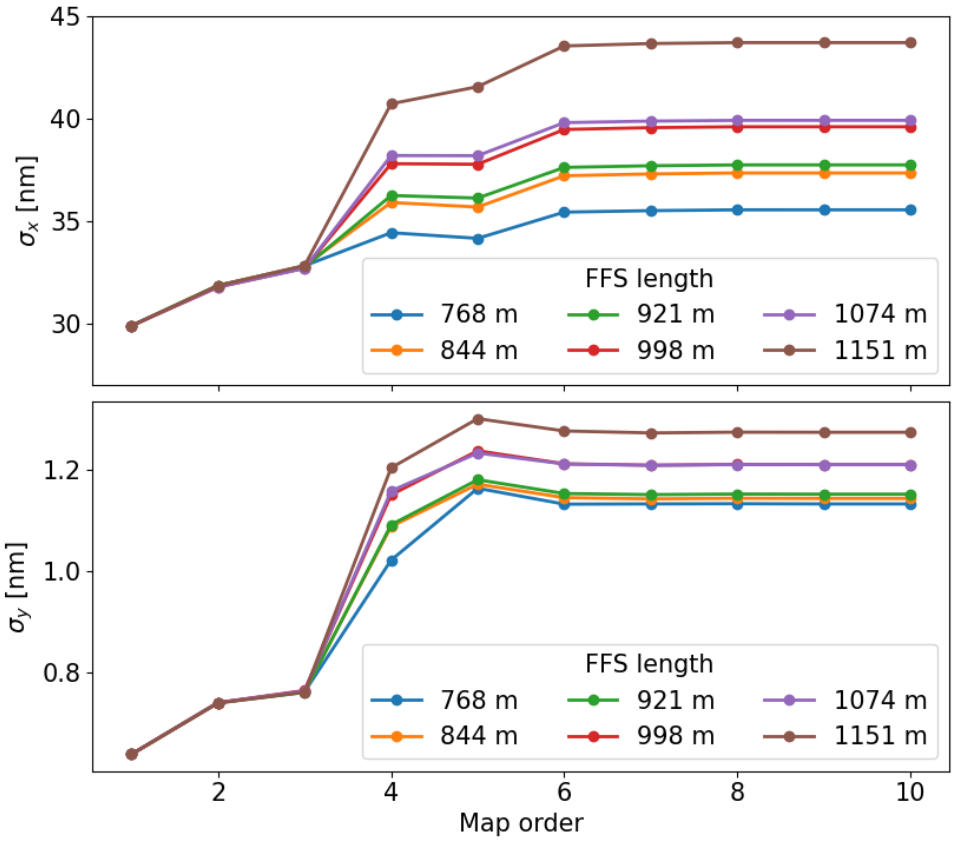


Best: $\Delta L_{FFS}/L_{FFS} = +20\%$
FFS length = 921 m

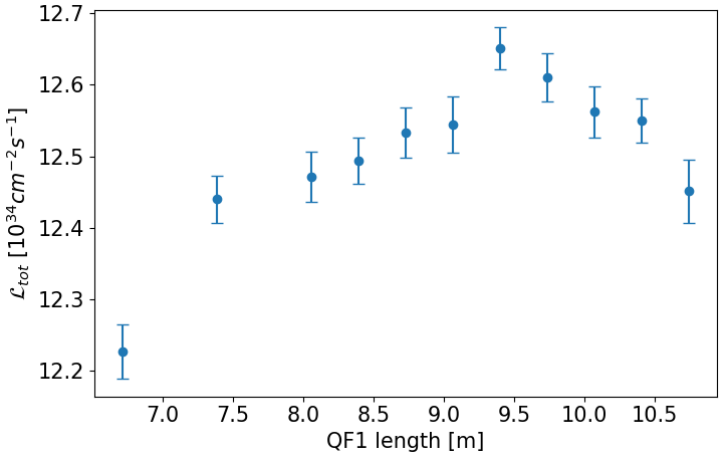
$$\mathcal{L}_{tot} = (12.23 \pm 0.04) \cdot 10^{34} cm^{-2} s^{-1}$$

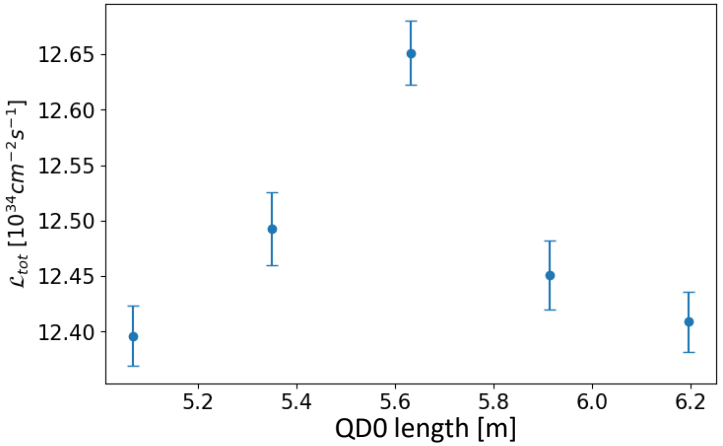
Length scaling – beam size

- At each FFS length, the beam size with Mapclass has been optimized.
- $1^{\mathrm{st}}, 2^{\mathrm{nd}}$ and 3^{rd} map orders are dominant for the luminosity calculations
- Relaxing the 4^{th} and 5^{th} orders to minimize the lower ones.



Final doublet optimization





- Variation of QF1 and QD0 length to minimize the radiation emission due to the Oide effect.
- Length variation in steps of 5% starting from QF1
- Best scaling for QF1: +40%
- No scaling for QD0

$$\mathcal{L}_{tot} = (12.65 \pm 0.03) \cdot 10^{34} cm^{-2} s^{-1}$$

Conclusions

- A first design for the FFS at 7 TeV has been proposed.
- FFS optimized and scaled differently from all the other sections of the BDS.
- Strong radiation effects have been minimized.
- An optimization of all the elements into the line has been performed to maximize the luminosity.