A few topics after Rome on FCC-ee Optics

FCC-ee MDI Meeting
18 July 2016

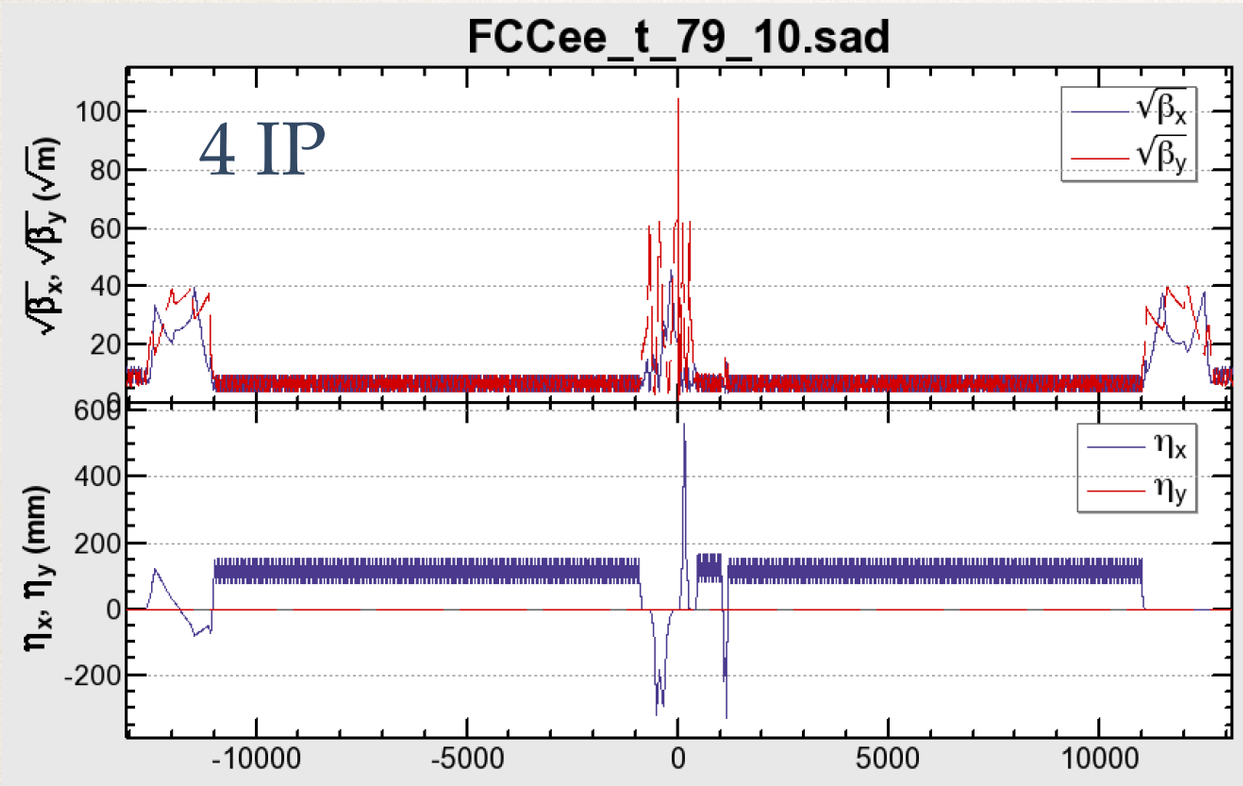
K. Oide (KEK)

- A short try for 4 IP
- Effect of radiation fluctuation on dynamic aperture
- Low emittance tuning (S. Aumon)
- An IR optics with a new location for crab sextupole (A. Bogomyagkov)

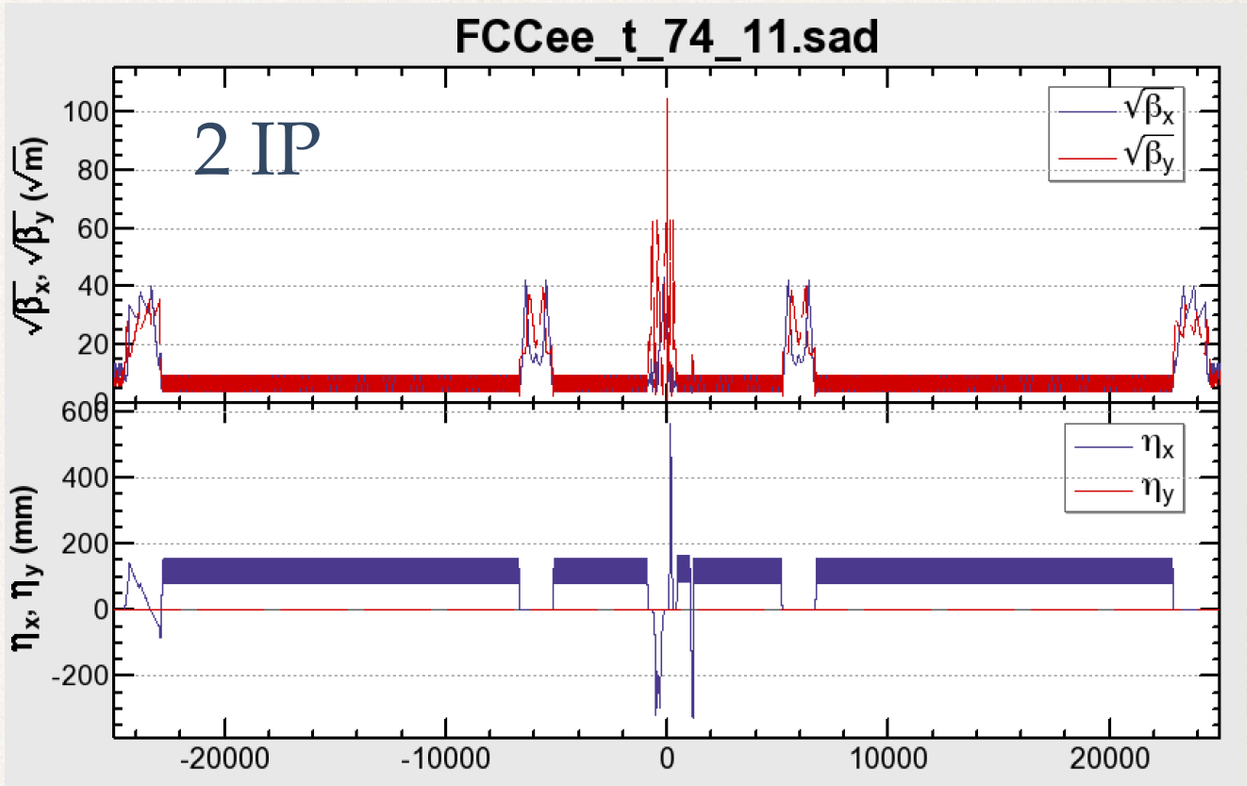
Ideal case: perfect period 4, RF at 45°

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)

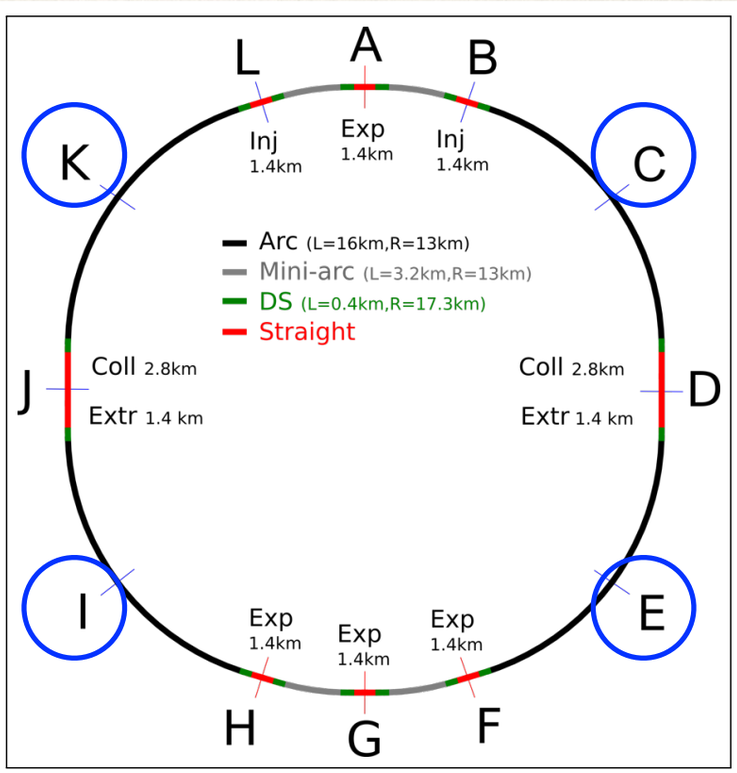
Period 4, 1/4 ring



Period 2, 1/2 ring

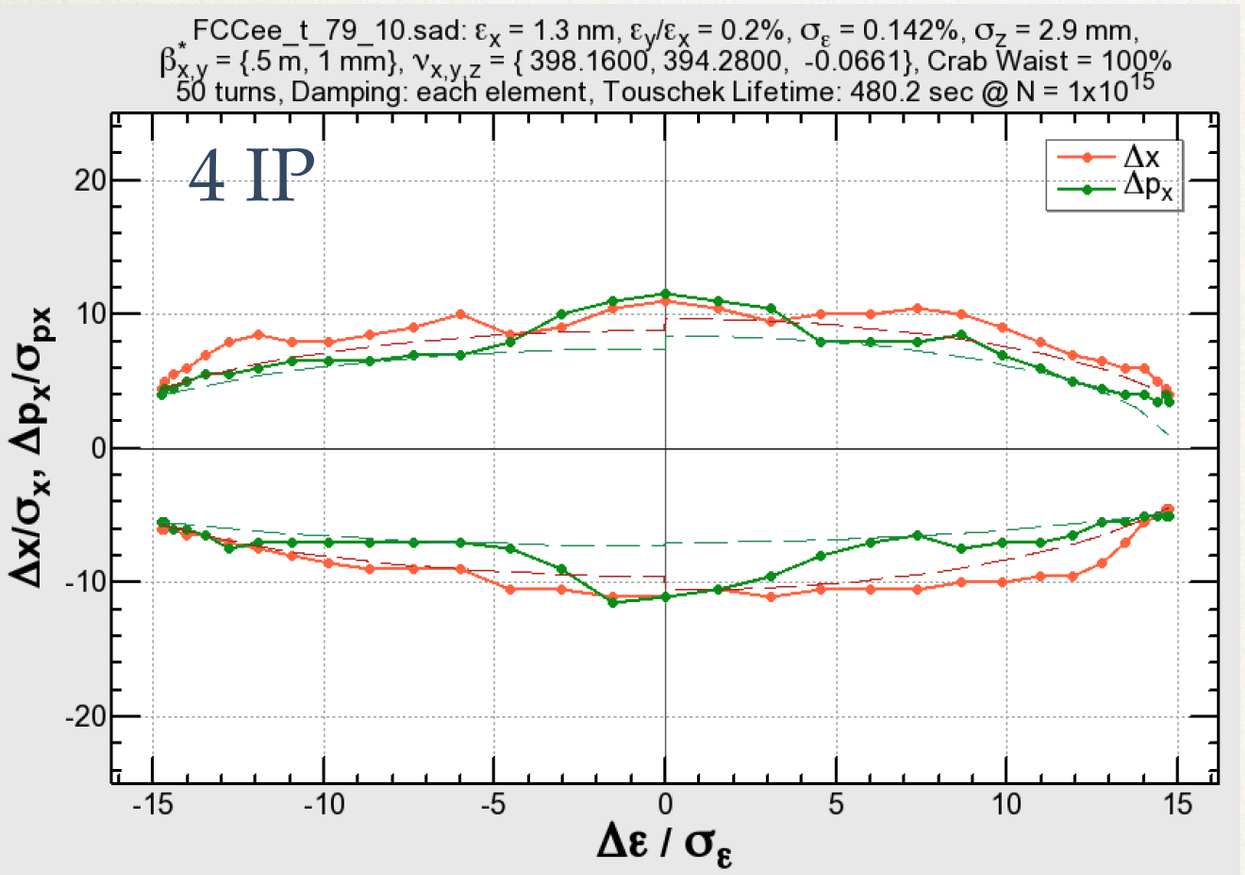


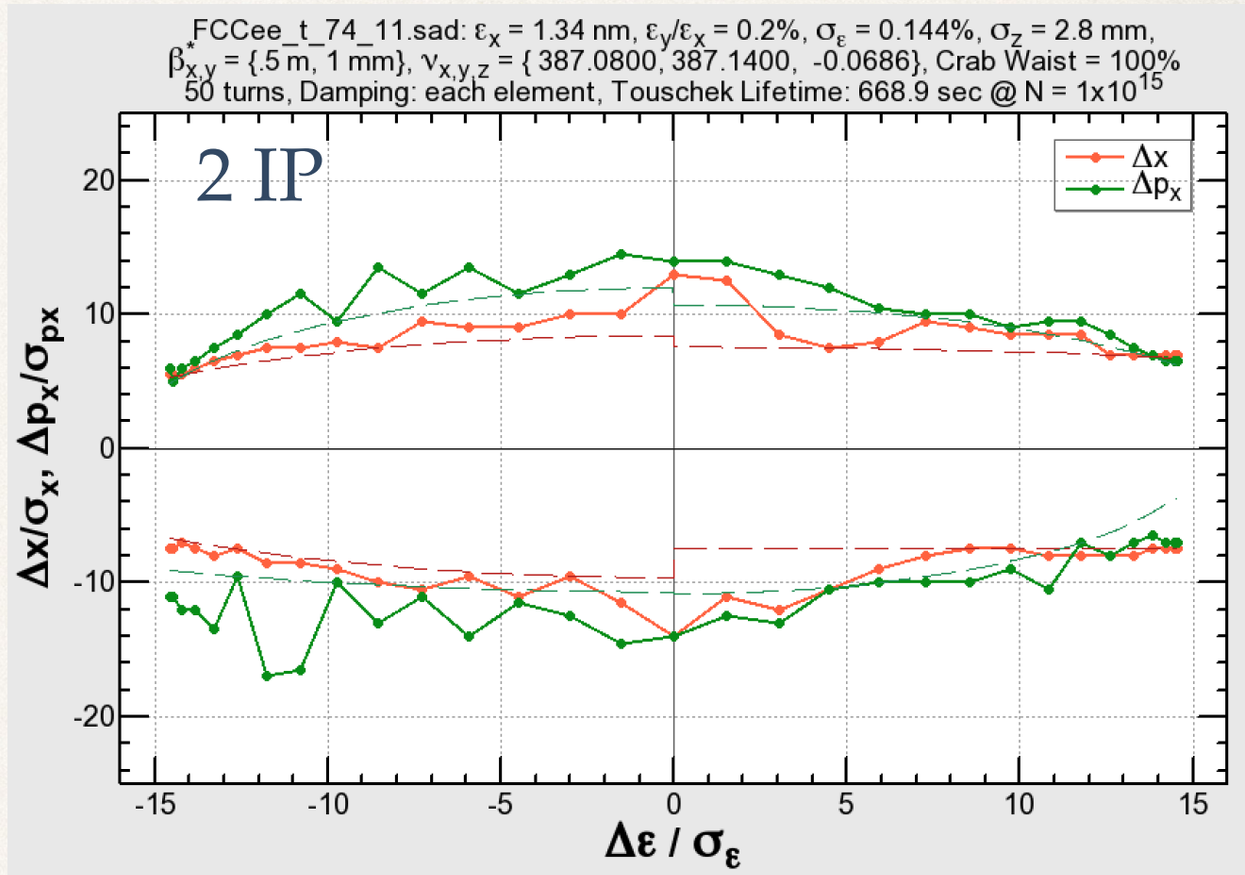
- First a perfect period 4 ring is tried as a nearly ideal case.
- RF is placed at 45°, in the midpoint of arc (CEIK of FCC-hh).
- IR and RF sections, and the arc unit cell are identical to the 2 IP optics.
- The beam line does not match the FCC-hh tunnel.



Ideal case: perfect period 4, RF at 45° (2)

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)



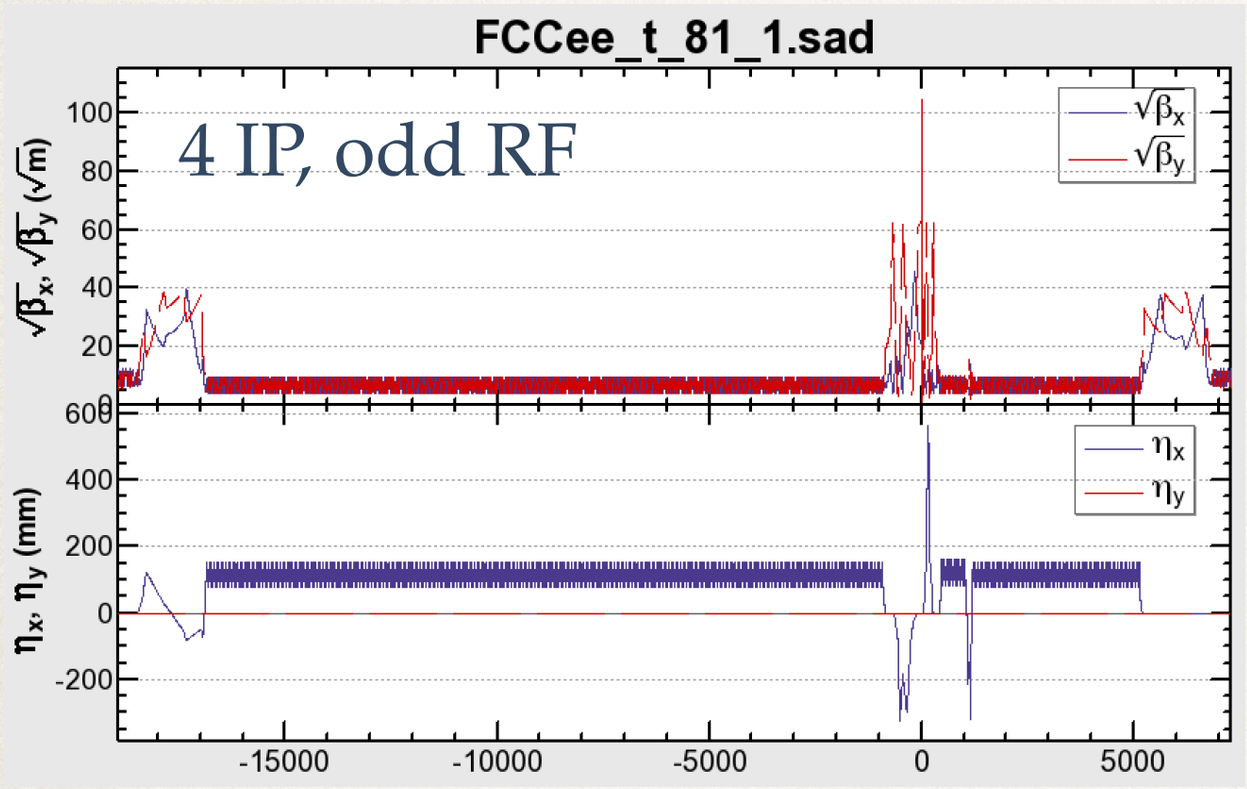


- The effect on the dynamic aperture is small.
- ±2% momentum acceptance is maintained.

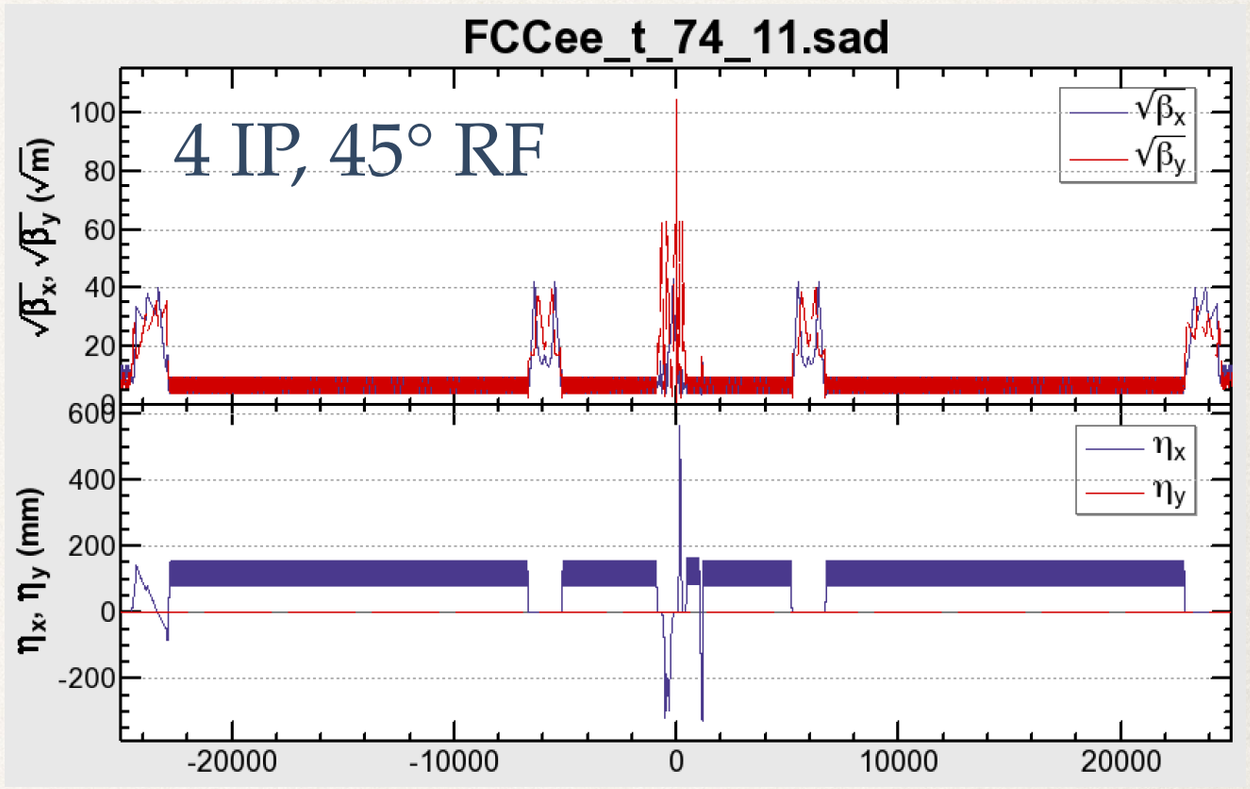
RF at the odd straight: perfect period 4

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)

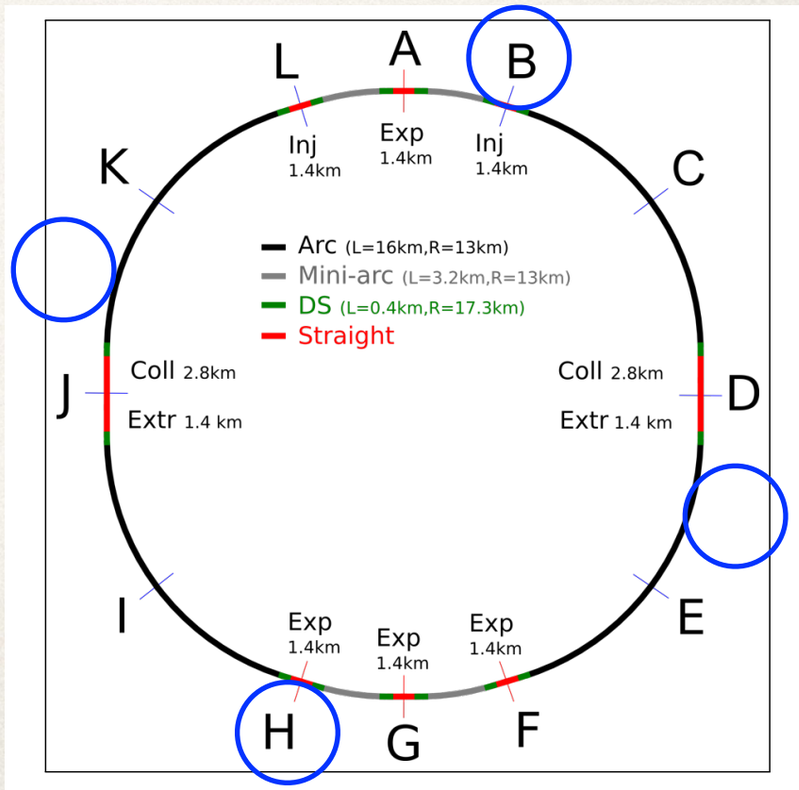
Period 4, 1/4 ring



Period 4, 1/4 ring

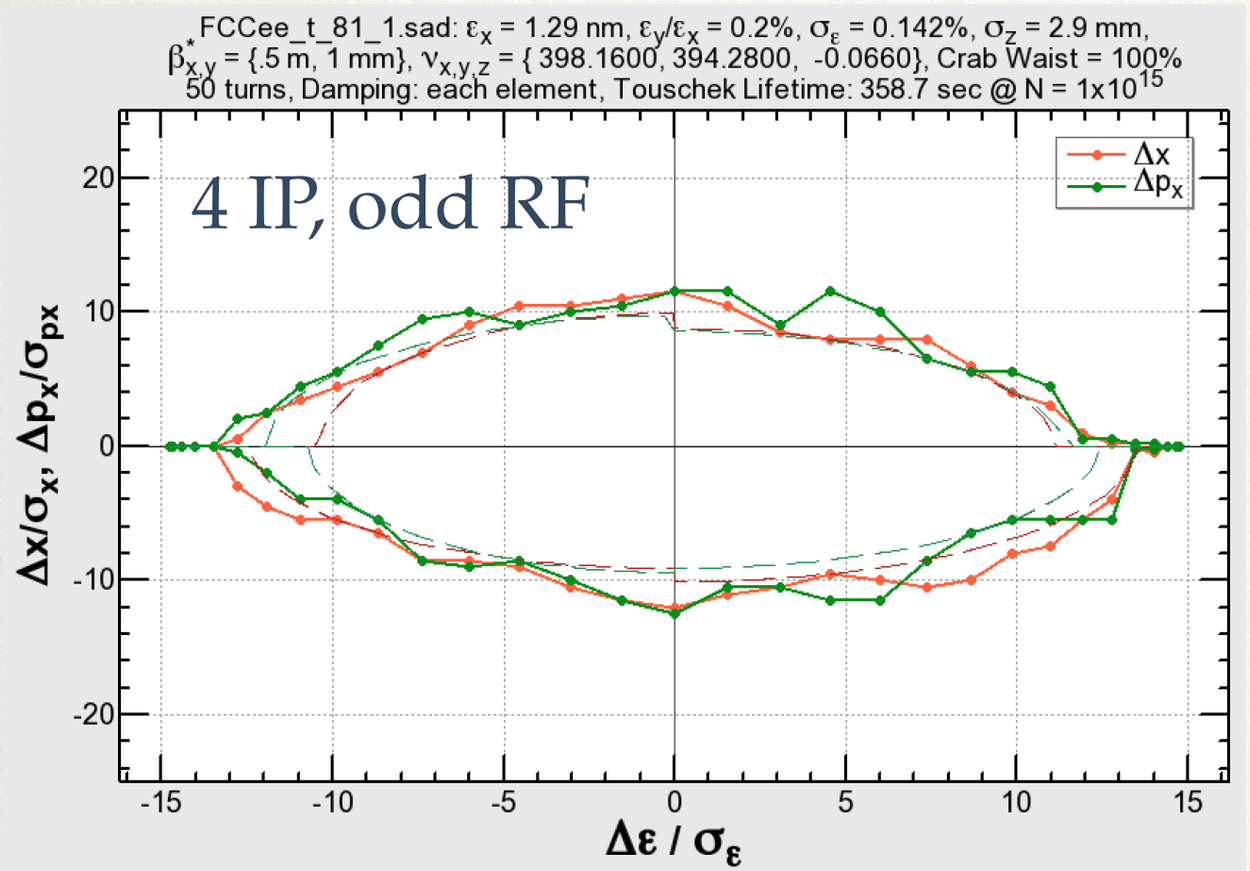


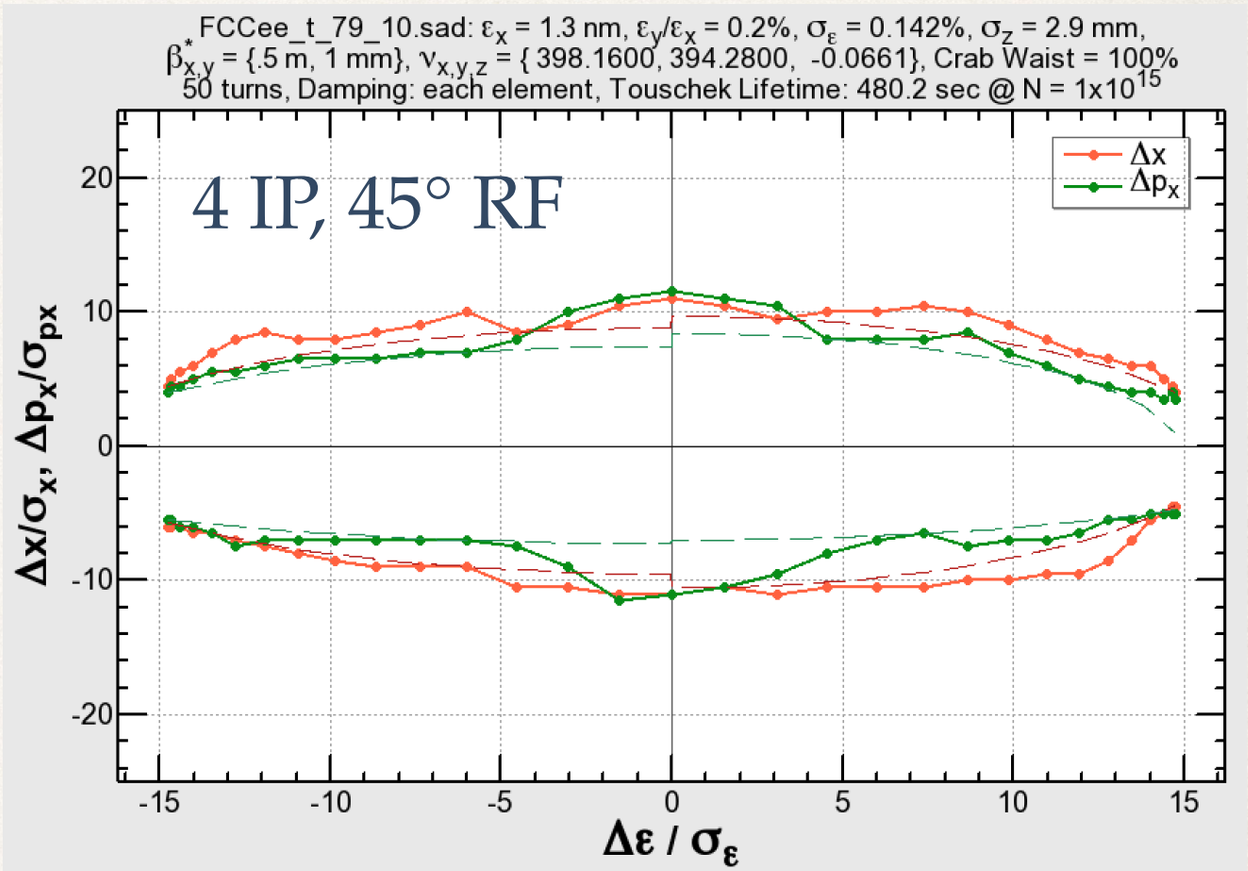
- As the RF should be placed at the short straights (B_H_) to utilize the FCC-hh layout.
- Still assume a complete period 4.
- The geometry is not yet close to FCC-hh.



RF at the odd straight: perfect period 4 (2)

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)



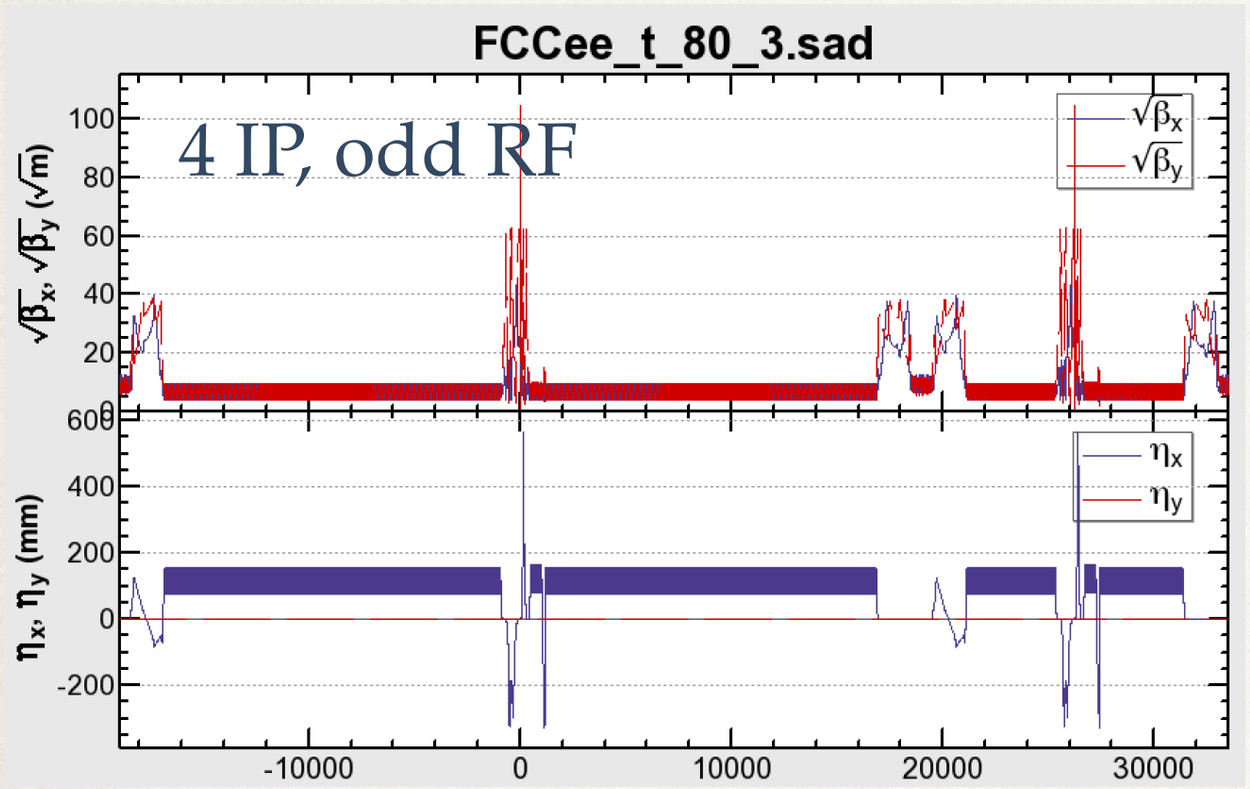


- The dynamic aperture has shrunk a little.
- The momentum acceptance has reduced to ±1.7%.

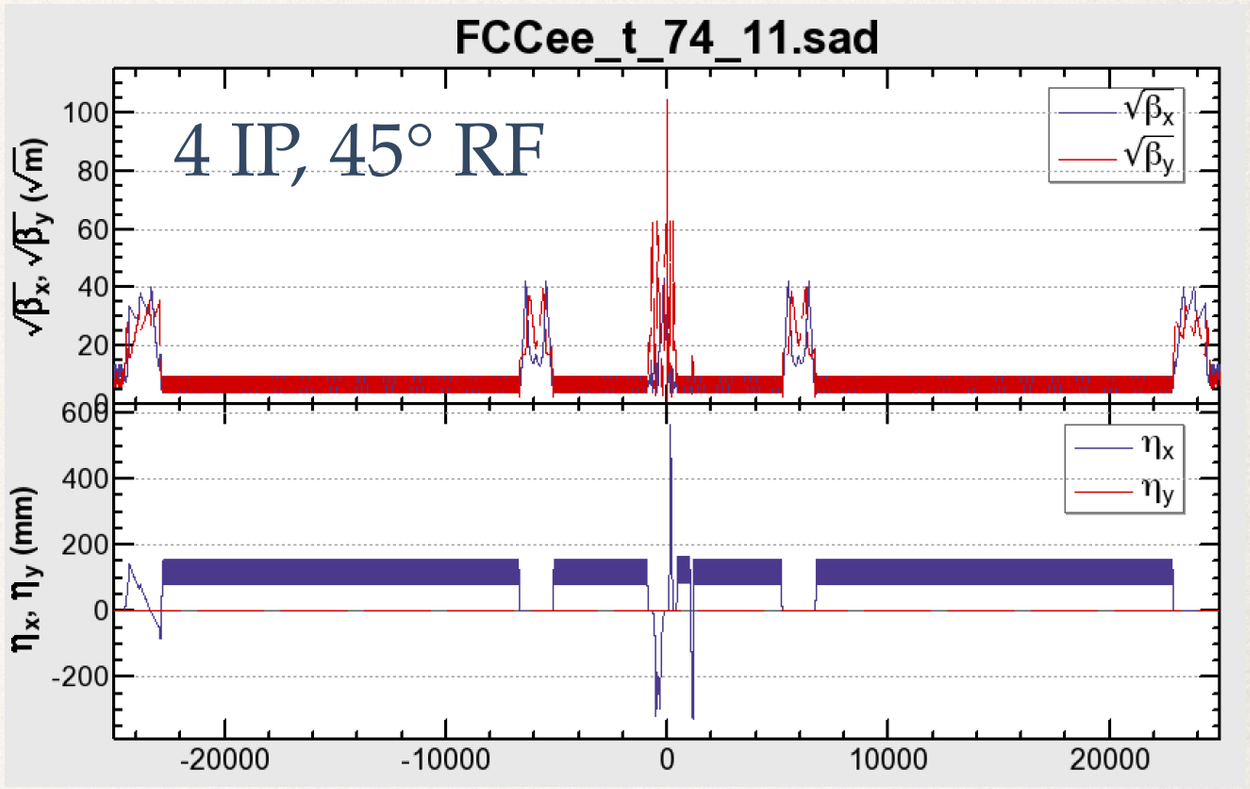
RF at the odd straight, symmetric: period 2

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)

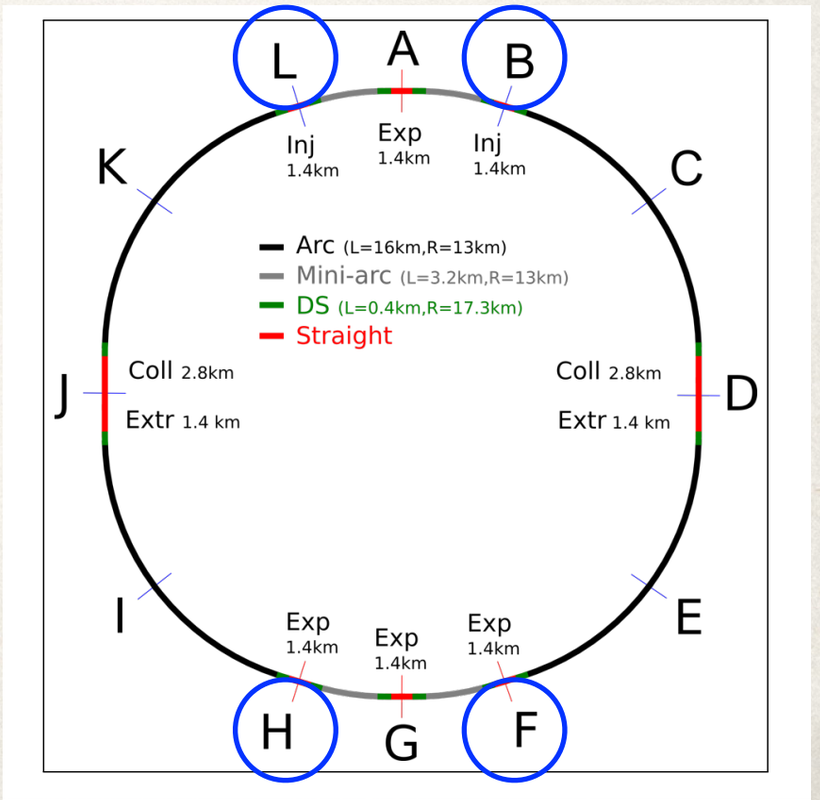
Period 2, 1/2 ring



Period 4, 1/4 ring

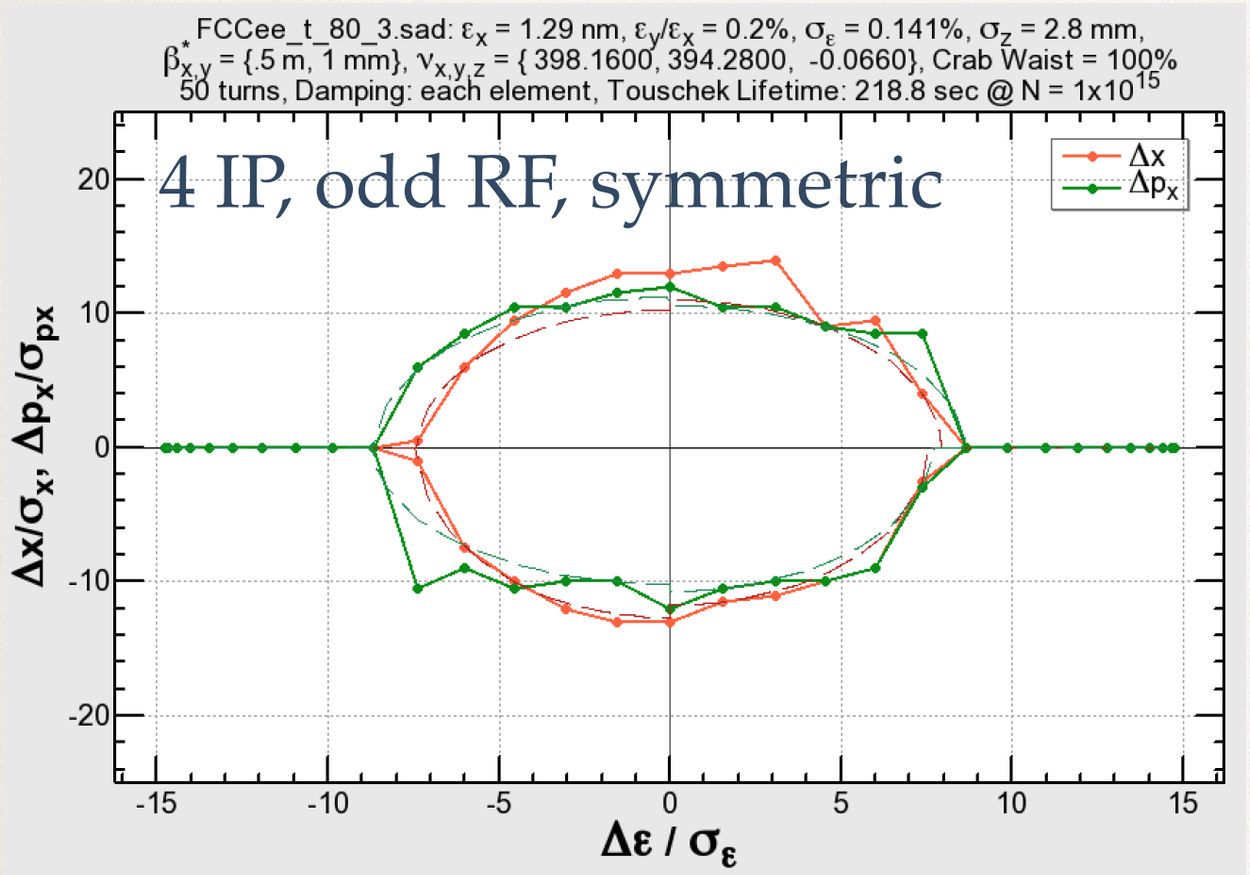


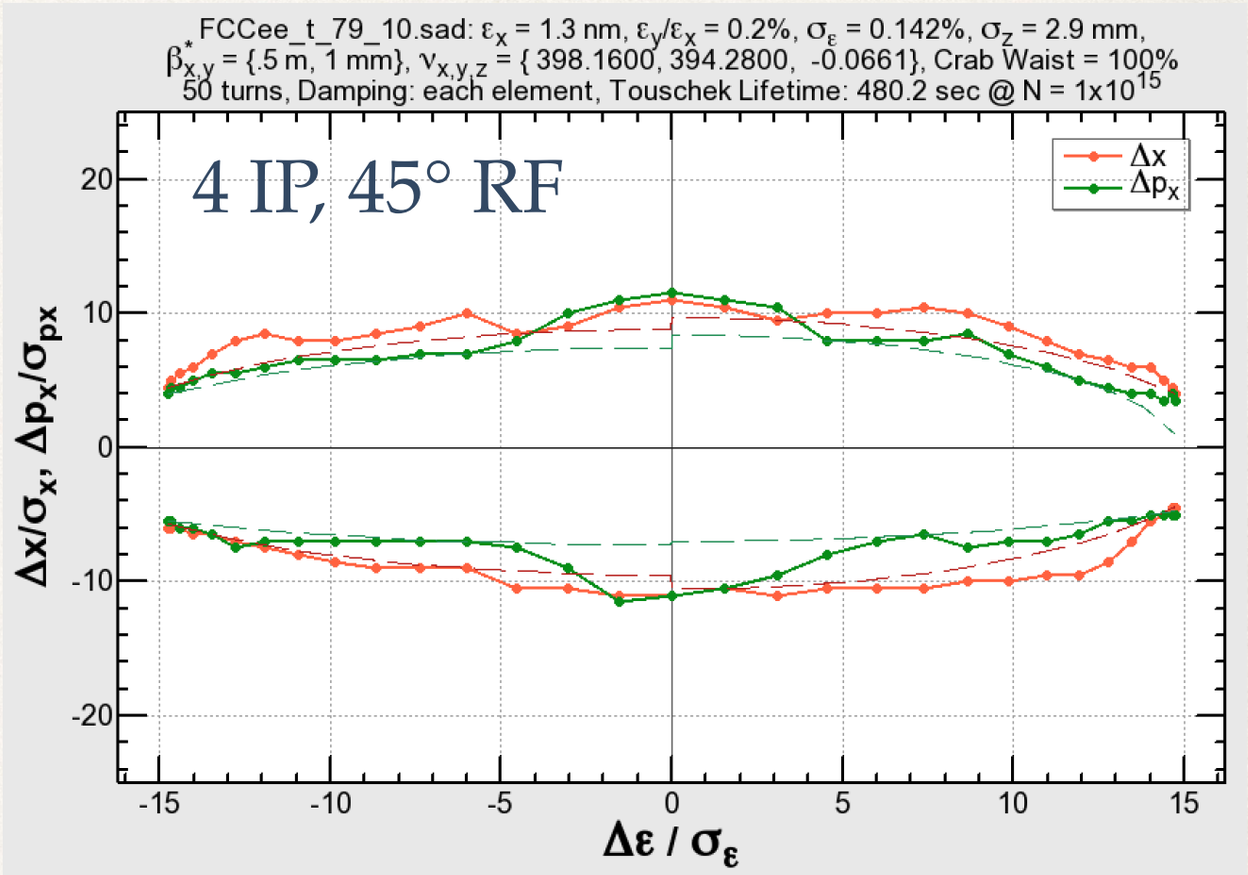
- Now place the RF symmetric, at sections BFHL.
- Then the periodicity is reduced to 2.
- The layout becomes closer to FCC-hh, but not perfect, since the length of the RF section is not correct, and the 4 IPs are still identical.



RF at the odd straight, symmetric: period 2 (2)

175 GeV, $\beta^*_{x,y}$ = (0.5 m, 1 mm)





- The dynamic aperture has shrunk.
- The momentum acceptance has reduced to ±1.0%.
- If we put more conditions on the geometry & IR, it will be even worse.

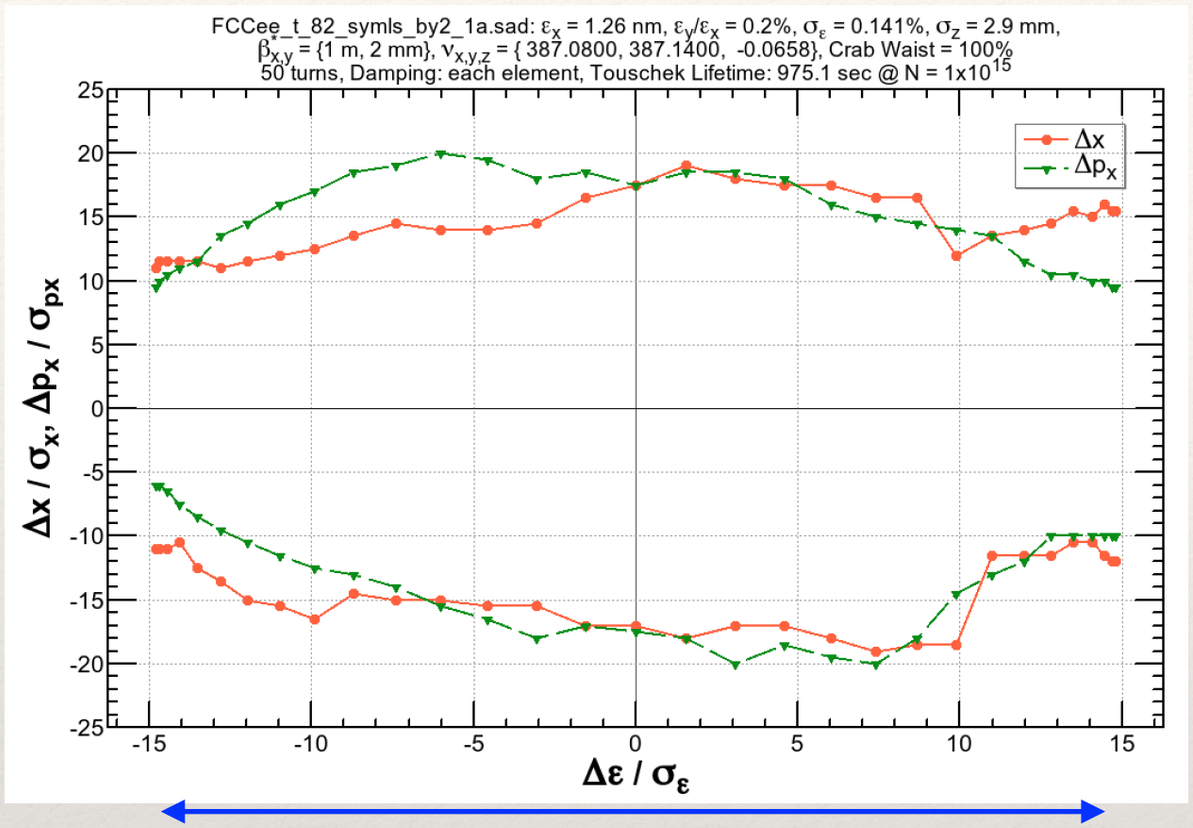
Summary for 4IP

- A preliminary design for optics with 4 IP is tried.
- Usable optics will be possible by locating the RF at 45° at the arc.
- Placing the RF at the short straights of FCC-hh reduces the dynamic aperture drastically.
- More investigation/ideas are needed for 4 IP with the geometry of FCC-hh.

Effect of Radiation Fluctuation

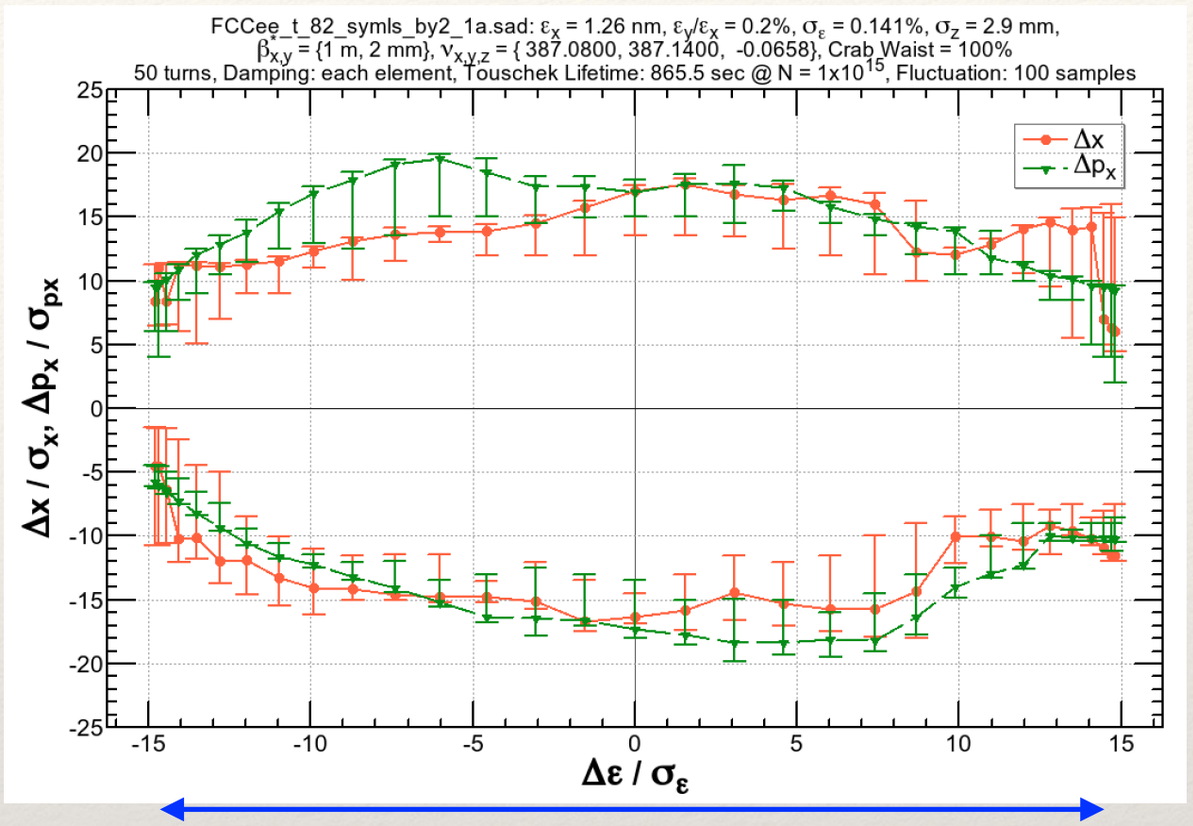
E = 175 GeV, $\beta_{x,y}$ = (1 m, 2 mm)

Radiation damping only



±2%

Radiation damping + fluctuation



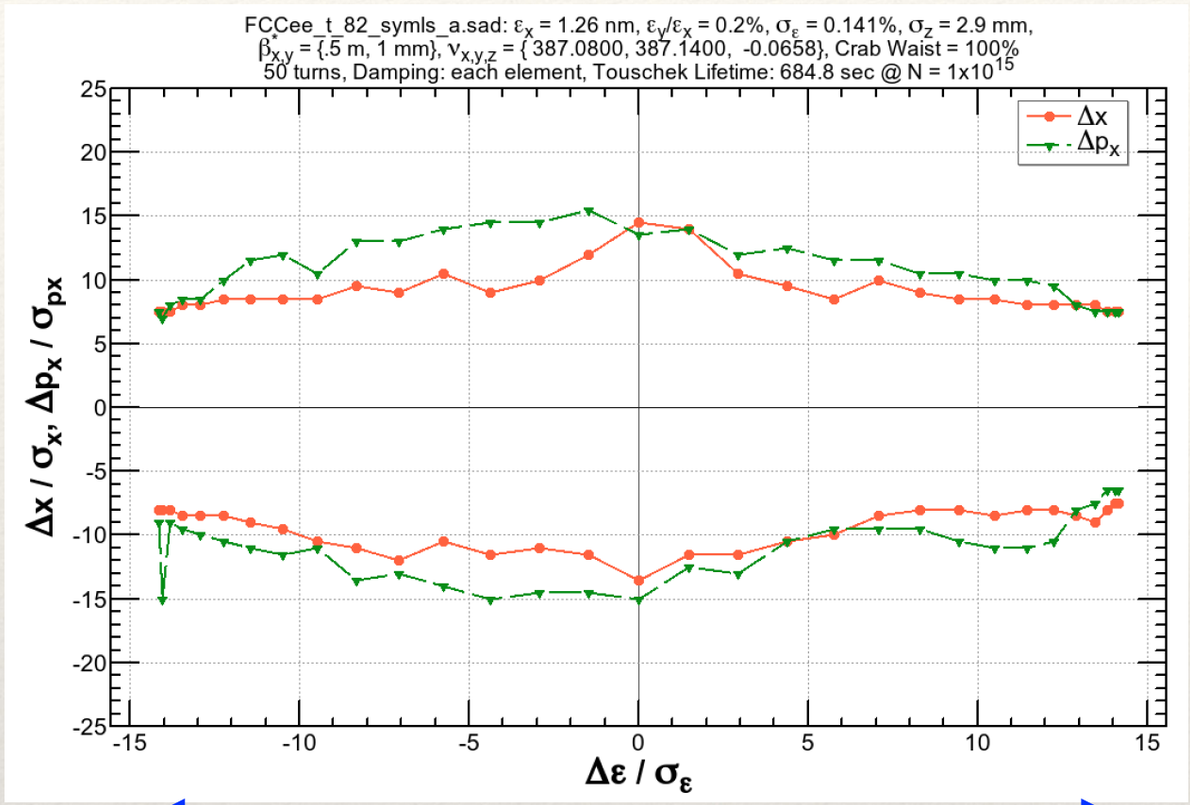
±2%

- (Right figure) 100 samples are taken to evaluate the dynamic aperture with radiation fluctuation.
  - Within the lines: particles of 75% of the samples survive.
  - Error bars correspond to the range of survival between 50% and 100% of the samples.

Effect of Radiation Fluctuation (2)

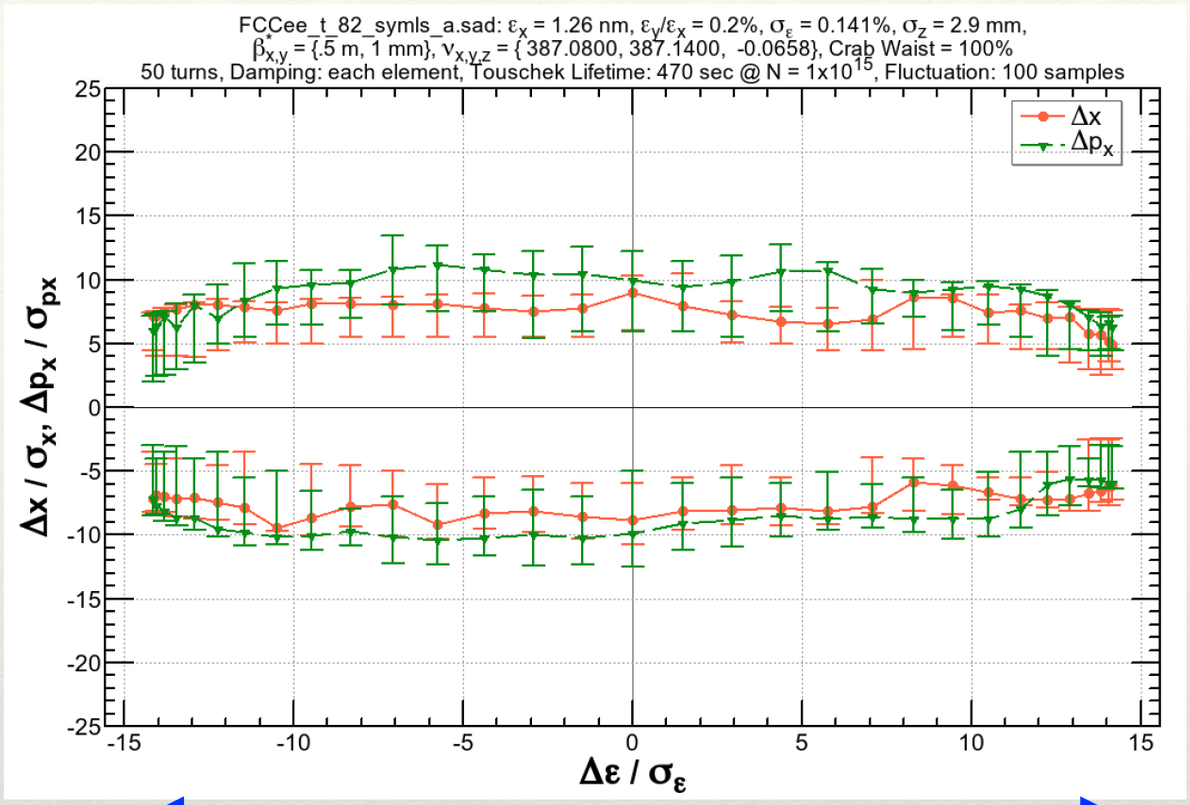
E = 175 GeV, βx,y = (0.5 m, 1 mm)

Radiation damping only



±2%

Radiation damping + fluctuation



±2%

- (Right figure) 100 samples are taken to evaluate the dynamic aperture with radiation fluctuation.
  - Within the lines: particles of 75% of the samples survive.
  - Error bars correspond to the range of survival between 50% and 100% of the samples.

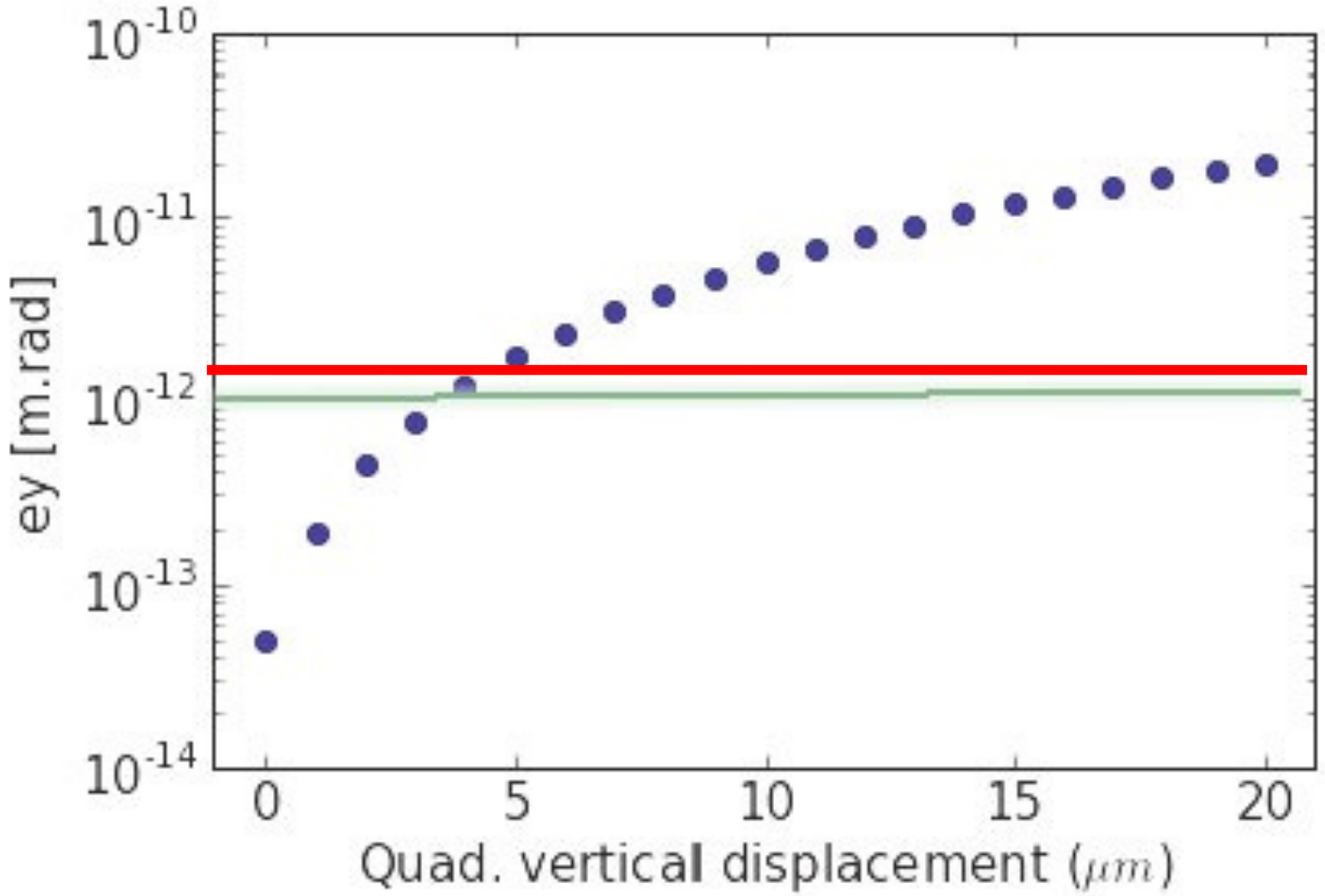
Summary for Radiation Fluctuation

- The radiation fluctuation has some impact on the dynamic aperture to reduce the transverse aperture by ~5 σ_x (at 175 GeV, 100% survival).
- The resulting DA for 100% survival still looks OK with $\beta_y^* = 2$ mm.
- A synchrotron injection now seems necessary for $\beta_y^* = 1$ mm.

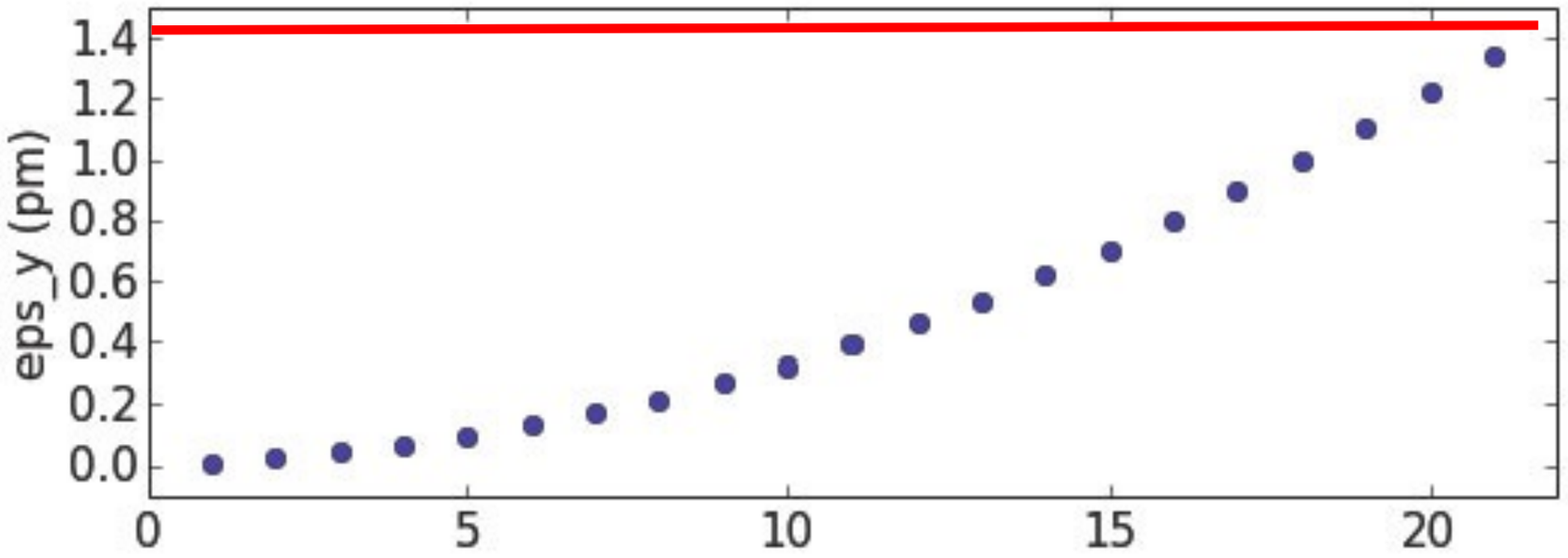
errors and vertical emittance tuning

FCC week in Rome
(no sextupole fields;
only global DFS)_

alignment
tolerance
5→20 μm

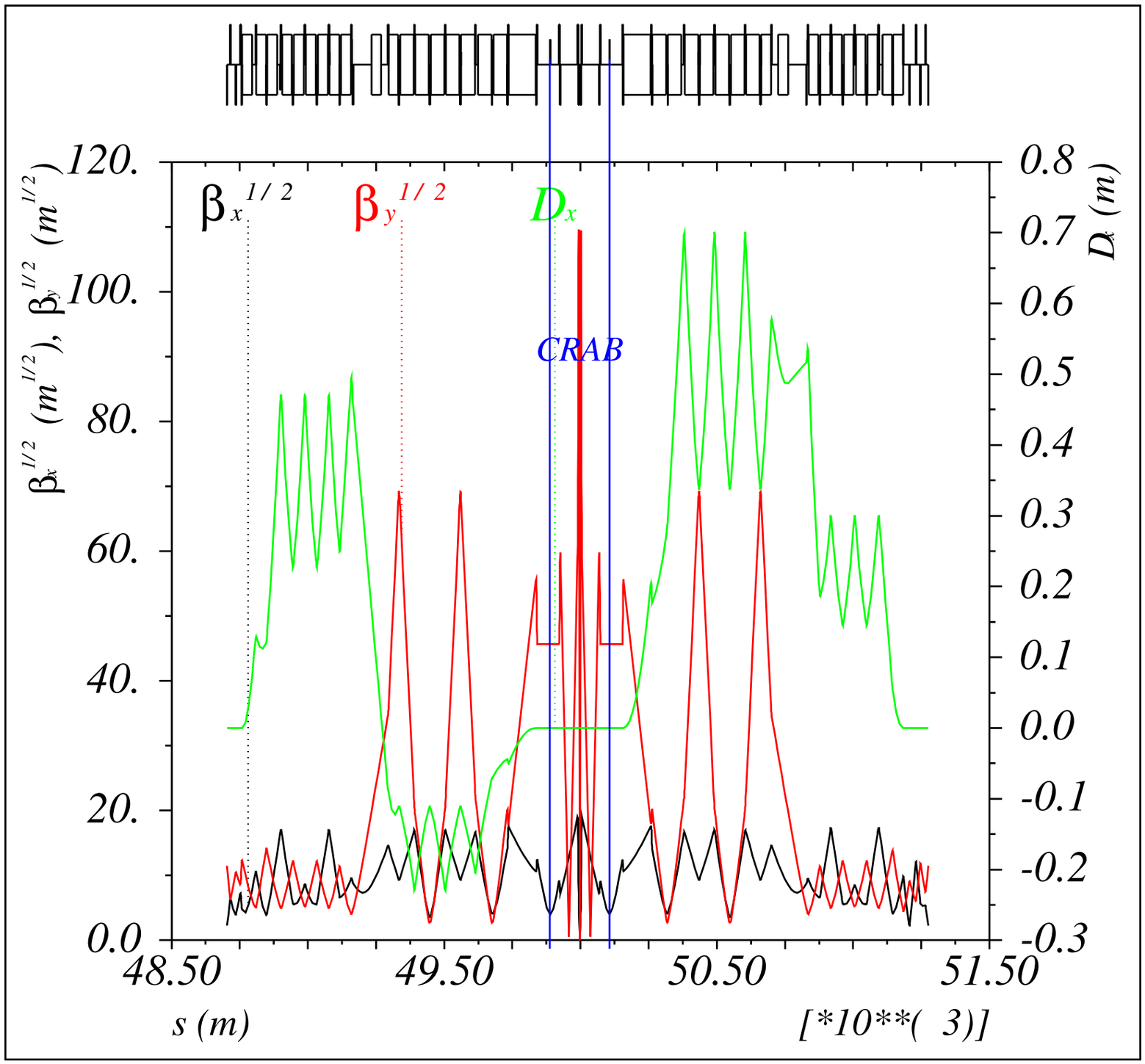


DFS without + with
sextupoles +
local dispersion
correction in IR



S. Aumon

Interaction Region optical functions: FCC-2



- A new location of the crab-waist sextupole will reduce the nonlinearity caused by the interference between final quads, and save the space for them.

	FCC-1	FCC-2
$\beta_x[m]$	42	16
$\beta_y[m]$	835	2086
$L^*[m]$	2	2.9
$L_q[m]$	3.6	1.8
$V_{11133}[m^{-3}]$	$-4076 + 45840 \cdot K3L$	$-1076 + 4620 \cdot K3L$
$V_{13333}[m^{-3}]$	$4070 - 45680 \cdot K3L$	$991 - 4518 \cdot K3L$
$V_{11133}[m^{-3}]$(PTC)		-2622
$V_{13333}[m^{-3}]$(PTC)		2887