FF Optics studies with large beta optics and IP waist scan

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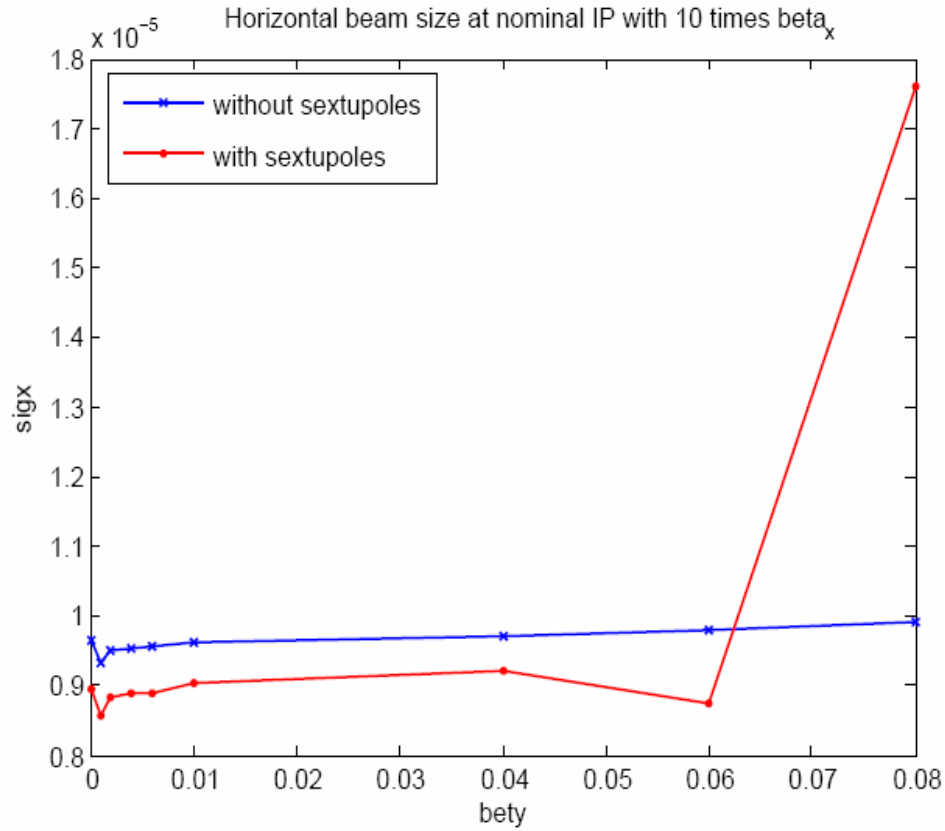
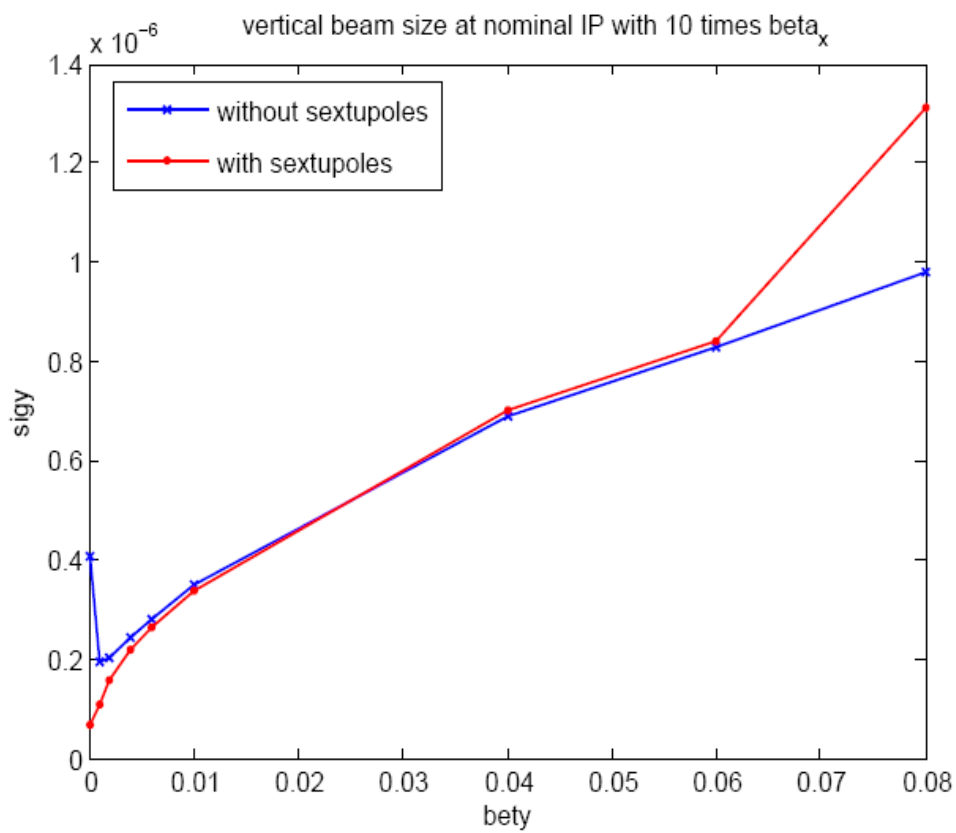
Motivation

- Choose a beta function large enough at IP such that the chromaticity is small and doesn't need to be corrected. Sextupoles can then be turned off, providing an easier beam for commissioning work, especially for newly installed diagnostic instruments (Shintake, wire-scanners, cavity BPMs,…) and for the initial alignment of magnets with beam.
- orthogonal waist scans can be expected to imply at different IP locations which can get waist in both planes.

At nominal IP, beta_y can be increased to 800times, if beta_x increased to 10times.



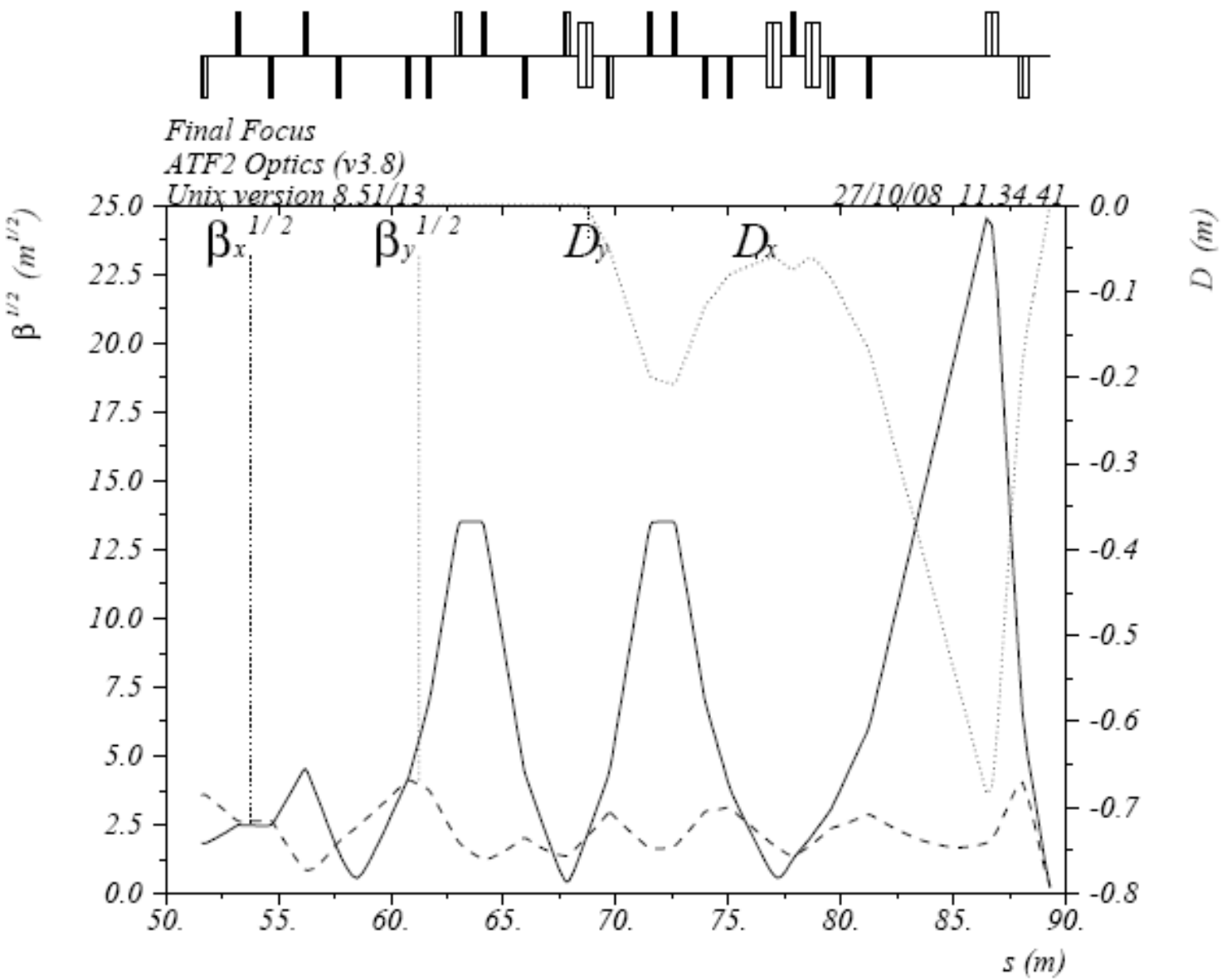


10timesbetx_closextupoles

beta_y(m)	sigy(m)	sigx(m)
0.0001	4.08e-07	9.66e-06
0.001	1.93e-07	9.34e-06
0.002	2.02e-07	9.50e-06
0.004	2.44e-07	9.53e-06
0.006	2.82e-07	9.55e-06
0.01	3.50e-07	9.63e-06
0.04	6.89e-07	9.71e-06
0.05	7.76e-07	9.75e-06
0.06	8.30e-07	9.80e-06
0.08	9.82e-07	9.91e-06

10timesbetx_withsextupoles

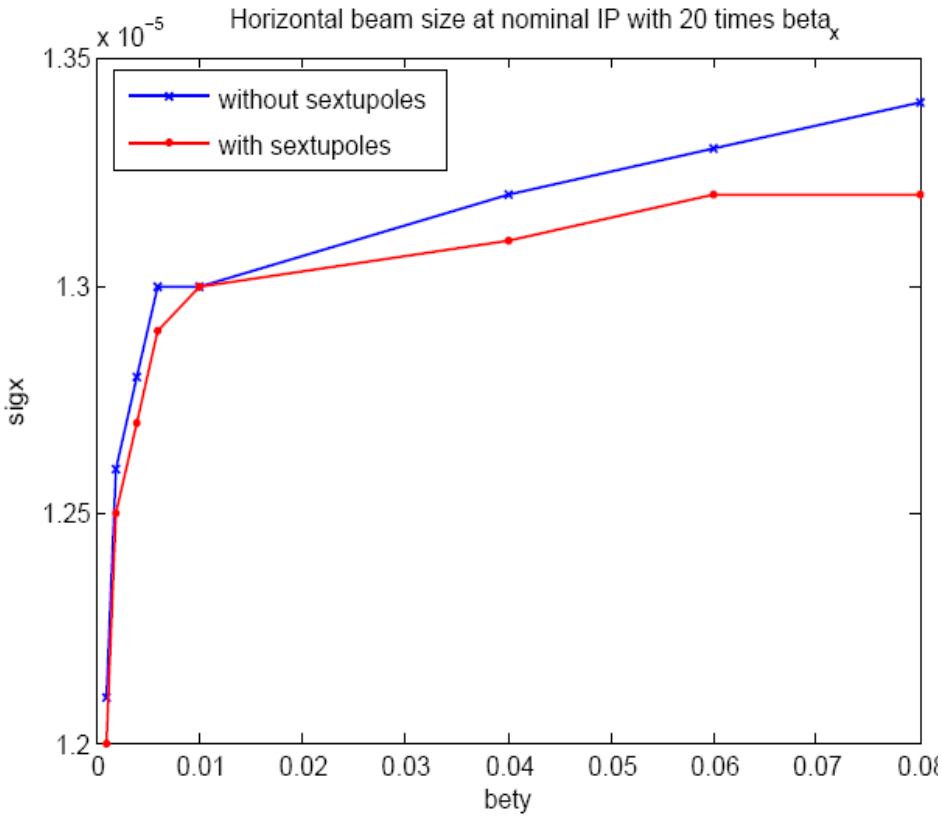
beta_y(m)	sigy(m)	sigx(m)
0.0001	6.63e－08	8.96e-06
0.001	1.09E-07	8.56E-06
0.002	1.57e-07	8.84e-06
0.004	2.17e-07	8.88e-06
0.006	2.65E-07	8.90E-06
0.01	3.37E-07	9.05E-06
0.04	7.01E-07	9.21E-06
0.06	8.42E-07	8.75E-06
0.08	13.1e-07	17.6e-06

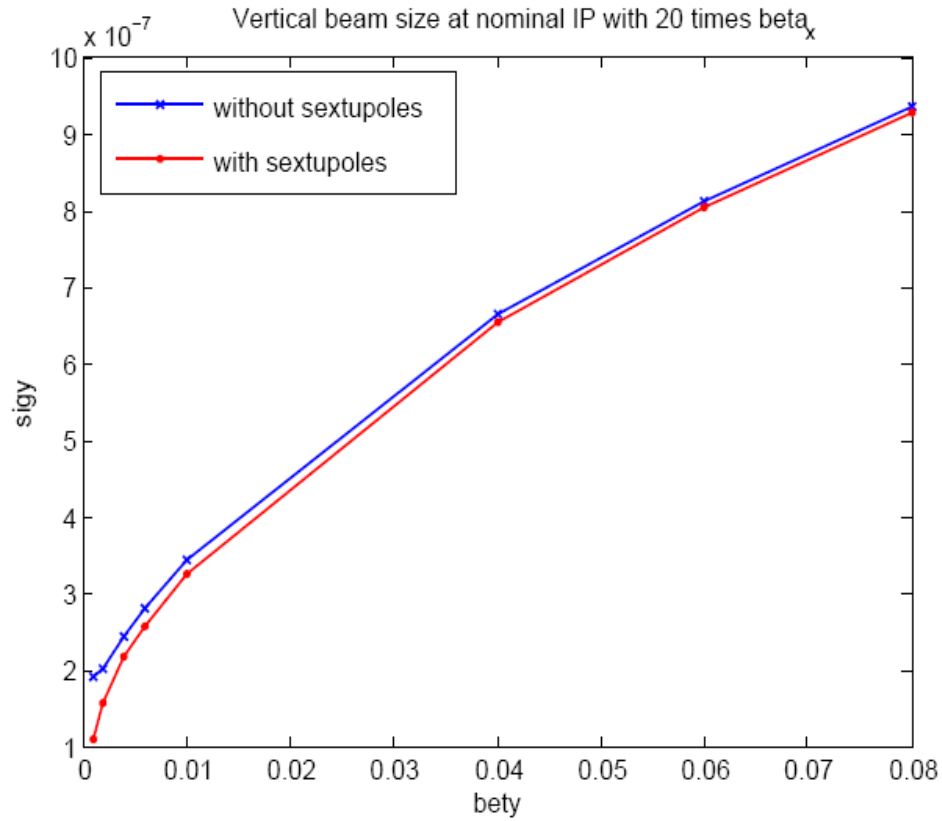


$\delta_E / p_0 c = 0.000000E+00$

Table name = TWISS

At nominal IP, beta_y can be increased to 800times, if beta_x increased to 20times.



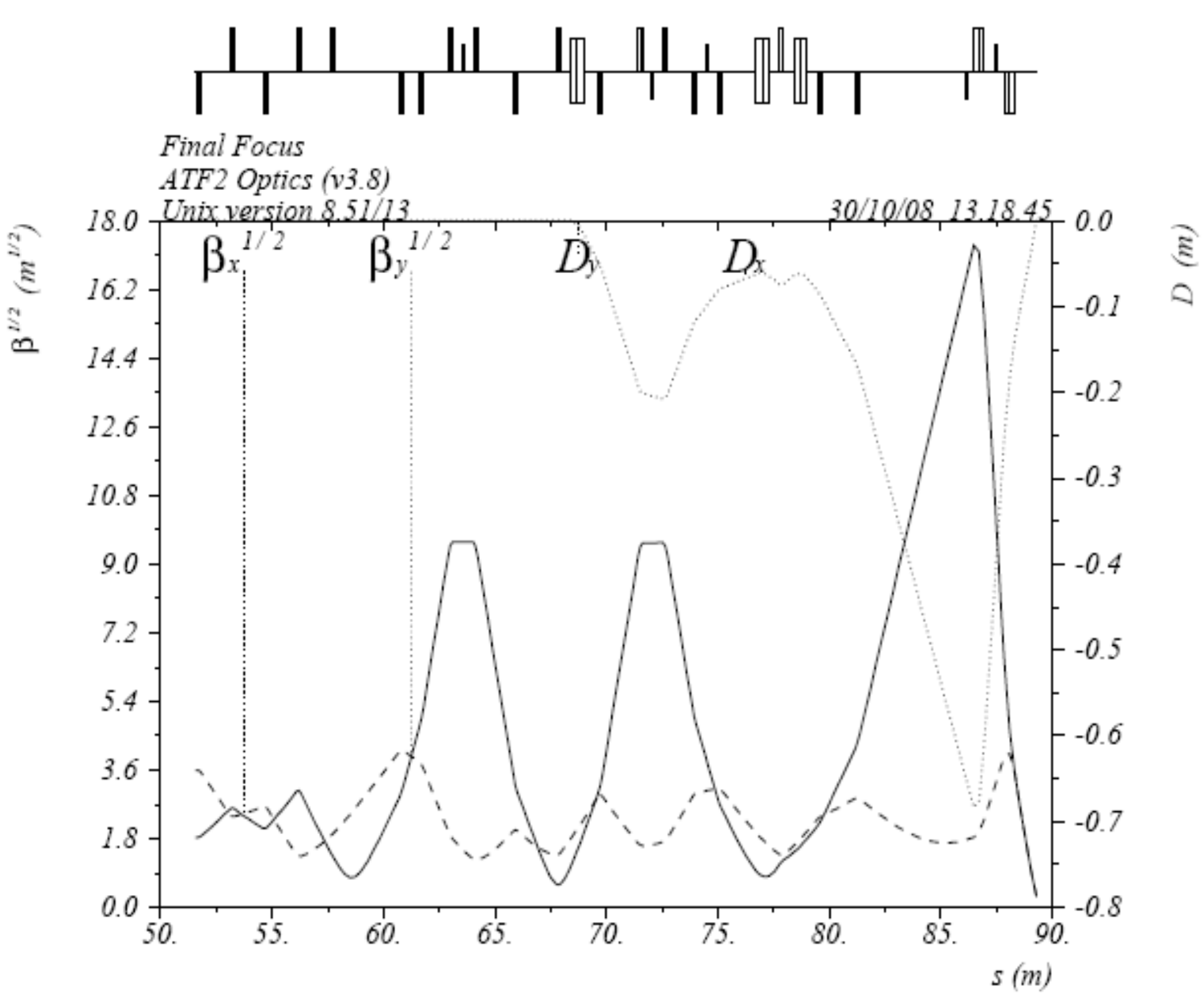


20timesbetx_closextupoles

beta_y(m)	sigy(m)	sigx(m)
0.001	1.91E-07	1.21E-05
0.002	2.02E-07	1.26E-05
0.004	2.43E-07	1.28E-05
0.006	2.80E-07	1.30E-05
0.01	3.44E-07	1.30E-05
0.04	6.65E-07	1.32E-05
0.06	8.11E-07	1.33E-05
0.08	9.35E-07	1.34E-05

20timesbetx_withsextupoles

beta_y(m)	sigy(m)	sigx(m)
0.001	1.10E-07	1.20E-05
0.002	1.57E-07	1.25E-05
0.004	2.18E-07	1.27E-05
0.006	2.57E-07	1.29E-05
0.01	3.26E-07	1.30E-05
0.04	6.53E-07	1.31E-05
0.06	8.04E-07	1.32E-05
0.08	9.27E-07	1.32E-05



$\delta_E / p_0 c = 0.000000E+00$

Table name = TWISS

Orthogonal waist scans:

$$\begin{pmatrix} \Delta f_x \\ \Delta f_y \end{pmatrix} = \begin{pmatrix} a\,b \\ c\,d \end{pmatrix} \begin{pmatrix} \delta_{QD} \\ \delta_{QF} \end{pmatrix}$$

$$M$$

$$\rightarrow \qquad \begin{pmatrix} \delta_{QD} \\ \delta_{QF} \end{pmatrix} = M^{-1} \begin{pmatrix} \Delta f_x \\ \Delta f_y \end{pmatrix}$$

Nominal IP:

$$M = \begin{pmatrix} 2.57 & -16.8 \\ -1.68 & 0.24 \end{pmatrix} \quad \rightarrow \quad M^{-1} = \begin{pmatrix} -0.0087 & -0.6085 \\ -0.0609 & -0.0931 \end{pmatrix}$$

IP+39cm:

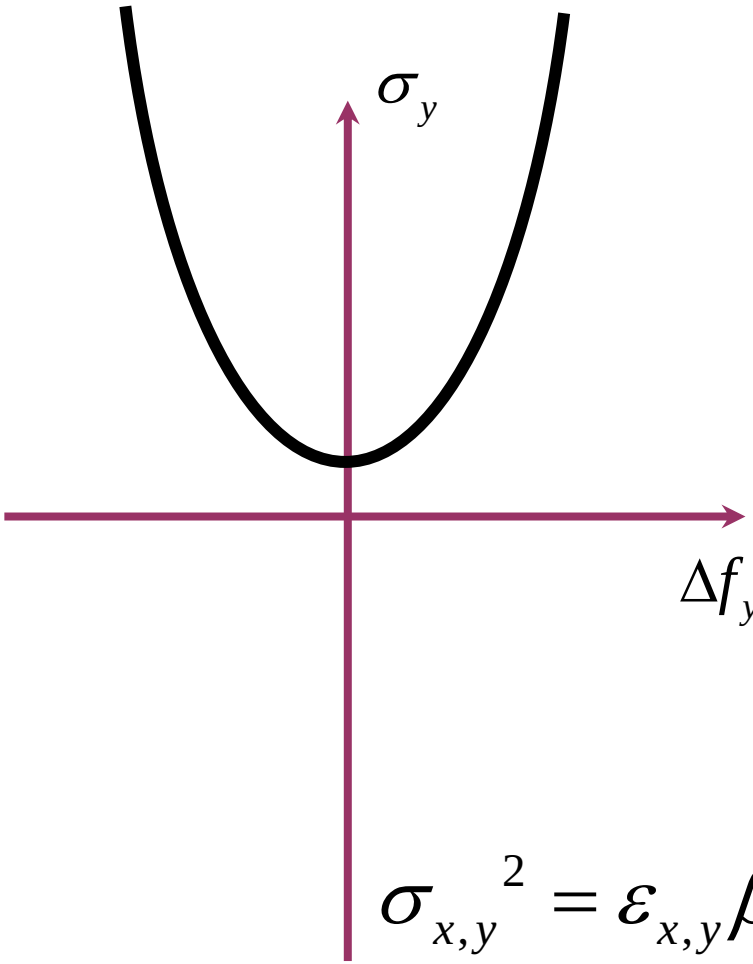
$$M^{-1} = \begin{pmatrix} -0.0087 & -0.418 \\ -0.0522 & -0.0741 \end{pmatrix}$$

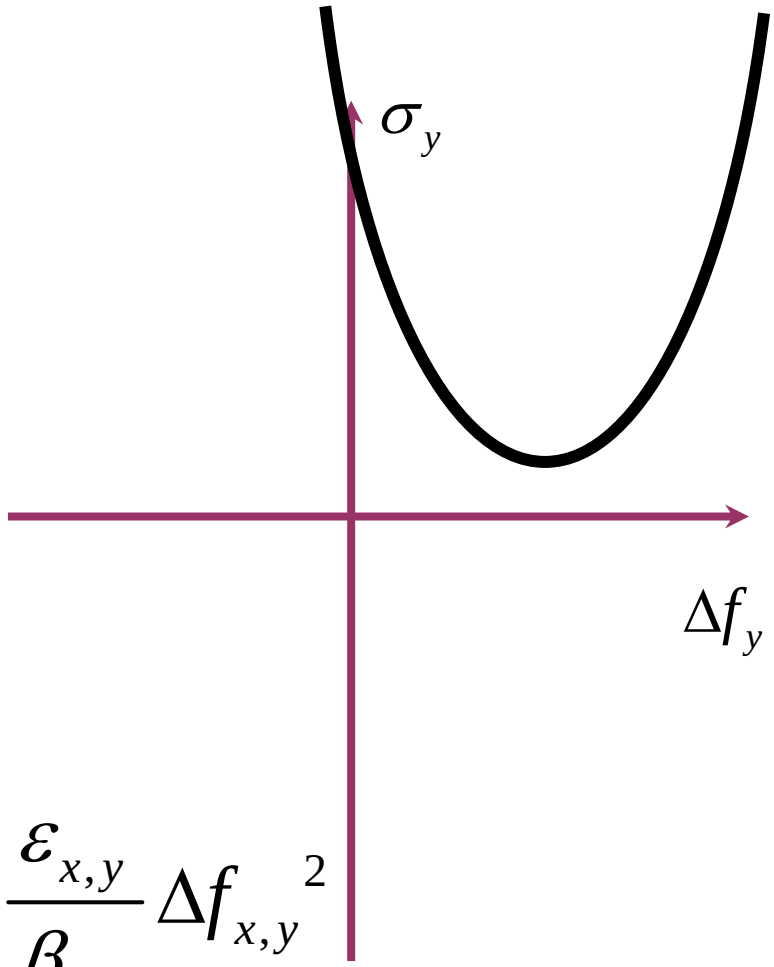
IP-54cm:

$$M^{-1} = \begin{pmatrix} -0.0076 & -1.3027 \\ -0.0746 & -0.1438 \end{pmatrix}$$

For different β , M remains the same.

The fractional quadrupole strength $\delta_{QD,QF}$ are in parts per thousand, and the longitudinal waist motions $\Delta f_{x,y}$ are in meters.



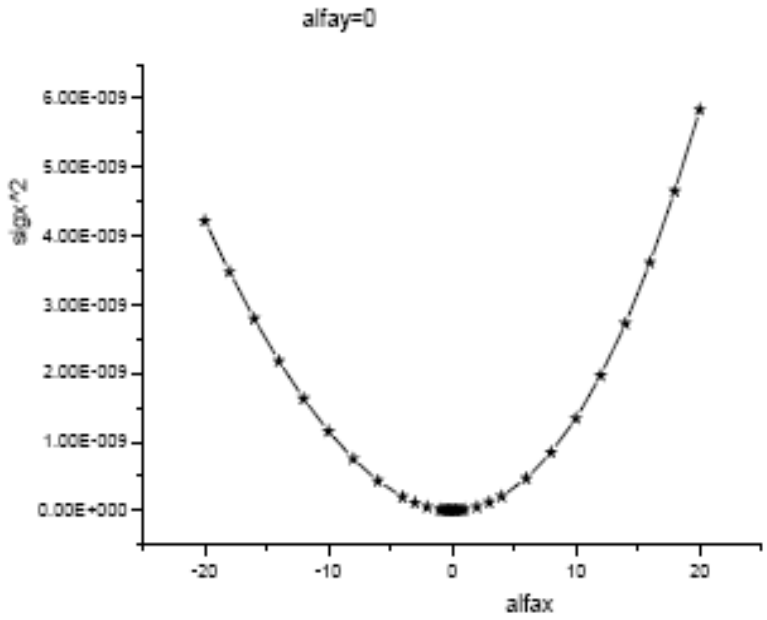


$$\sigma_{x,y}^{\,2} = \varepsilon_{x,y}\beta_{x,y} + \frac{\varepsilon_{x,y}}{\beta_{x,y}}\Delta f_{x,y}^{\,2}$$

Without errors

With errors

The same for X !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5.00E-009
4.00E-009
3.00E-009
2.00E-009
1.00E-009
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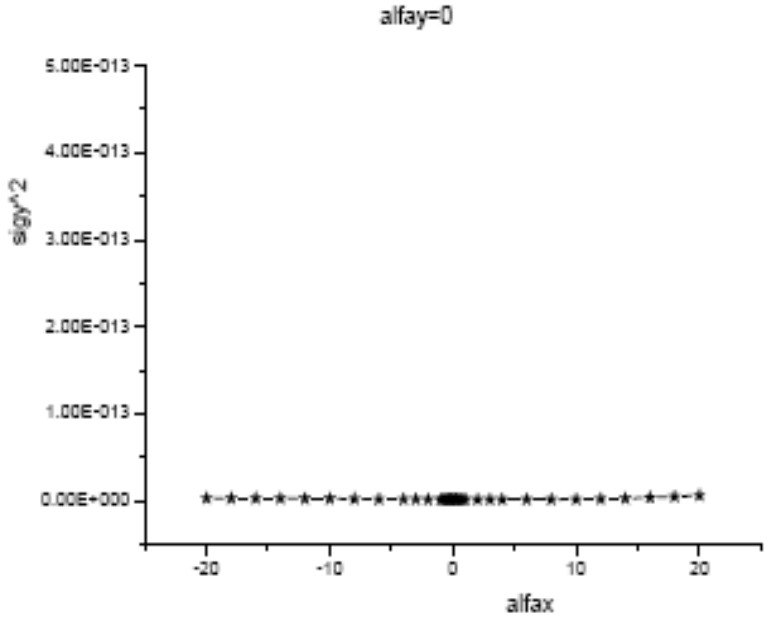
-20
-10
0
10
20
alfax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sigy^2
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4.00E-013
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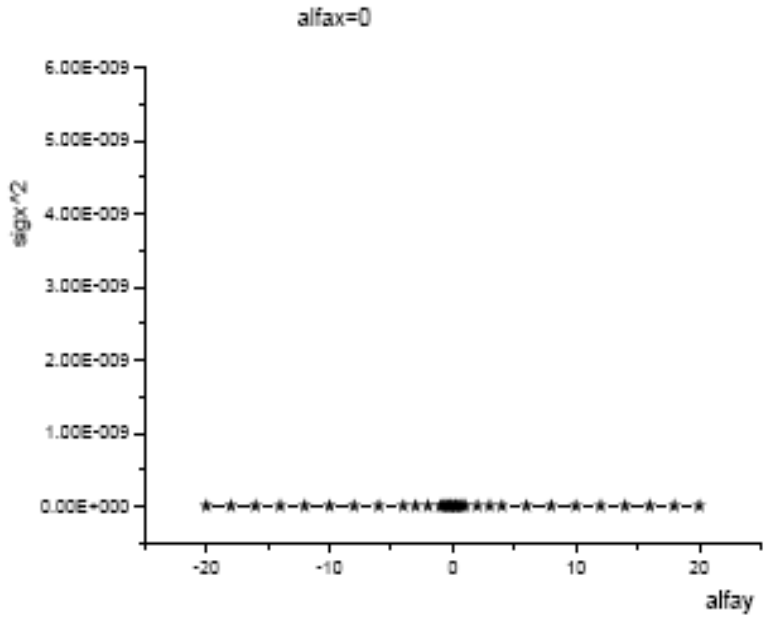
20
alfax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sigx^2
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5.00E-009
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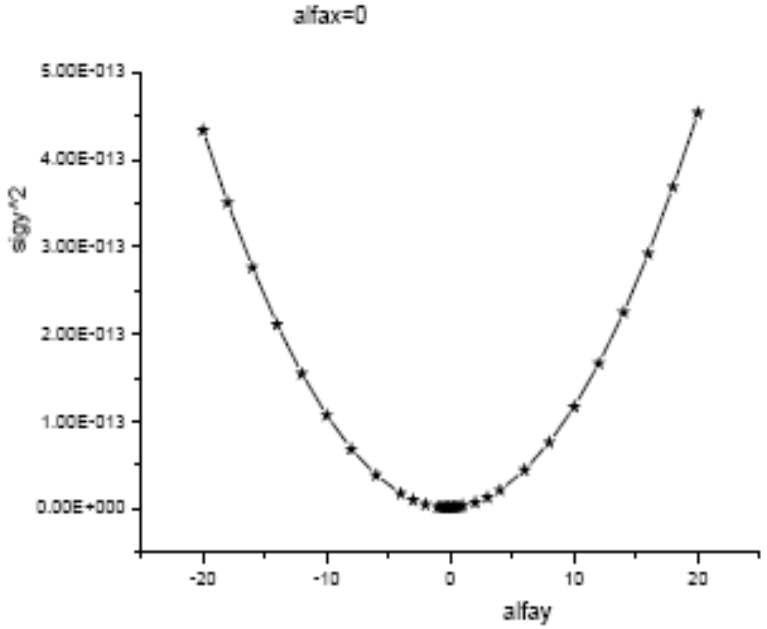
-20
-10
0
10
20
alfay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4.00E-013
3.00E-013
2.00E-013
1.00E-013
0.00E+000
-20
-10
0
10
20
alfay

Conclusion & prospects

- As we can see, for the 10 times beta_x case, beta_y in a range of 100~600times, no need for sextupoles. Check also with larger emittance.
- Procedure to tune-up the beam at displaced IP with wire-scanner prior to shifting it back to the nominal IP.
- Study alignments of magnetic elements with beam and optical corrections at the IP with gradually reduced beta functions down to nominal value.