MEIC Collider Ring & IR Optics Chromaticity Correction

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MEIC

- ***Outline***
- MEIC compact lattice with two IP's
- Chromaticity correction scheme
- Beta chromaticity at IP's
- Conclusion

$$\beta_x^* = 25mm$$

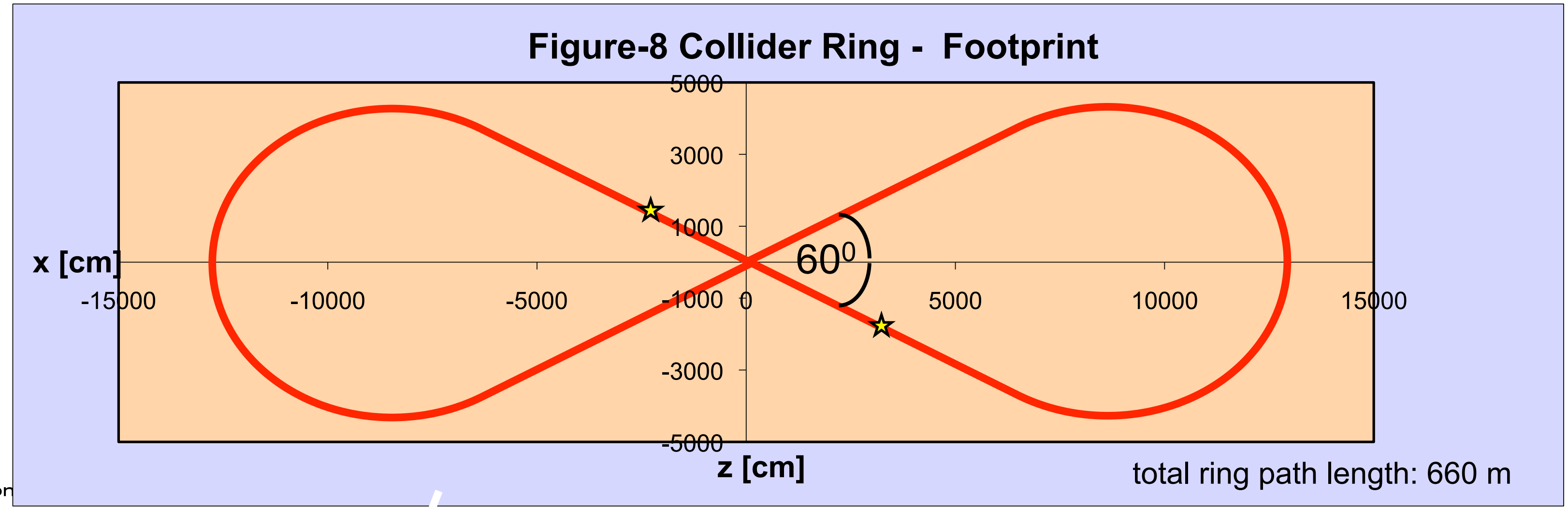
$$\beta_y^* = 5mm$$

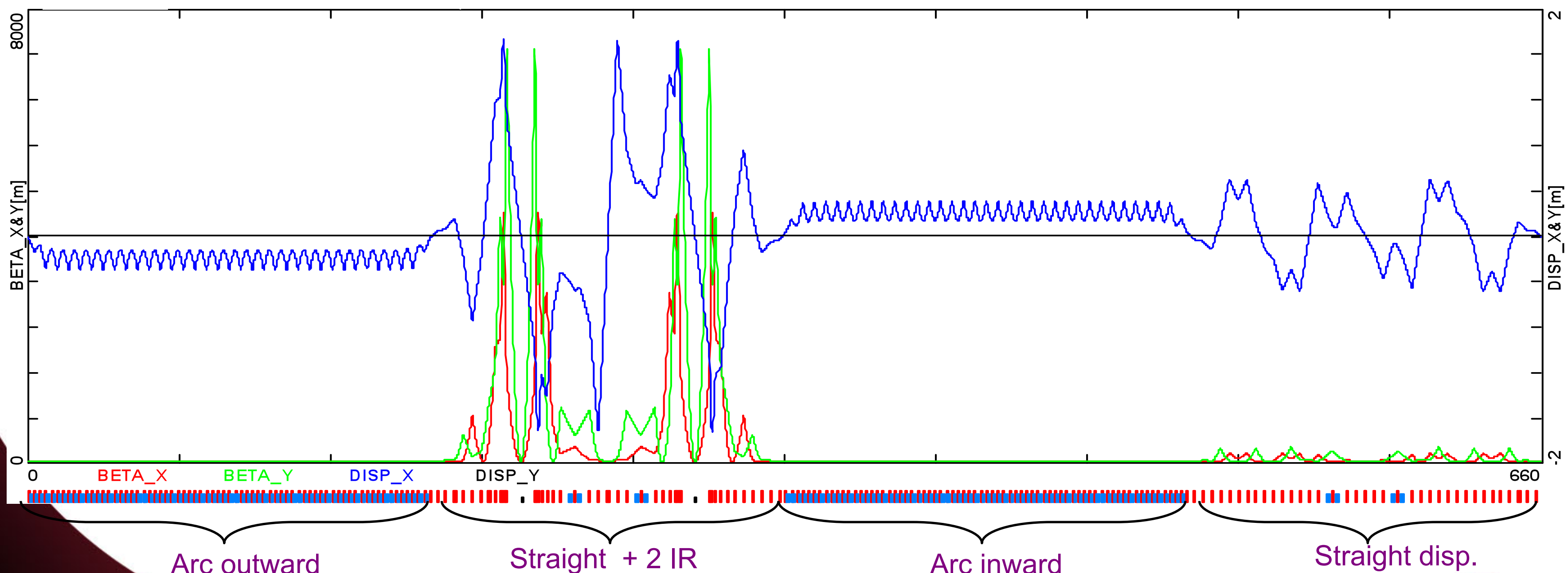
EIC@JLab Parameters

Beam Energy	GeV	12/3	60/5	60/3	250/10
Collision freq.	MHz		499		
Particles/bunch	10^{10}	0.47/2.3	0.74/2.9	1.1/6	1.1/3.1
Beam current	A	0.37/2.7	0.59/2.3	0.86/4.8	0.9/2.5
Energy spread	10^{-4}	~ 3	~ 3		
RMS bunch length	mm	50	5	5	5
Horz. emit., norm.	µm	0.18/80	0.56/85	0.8/75	0.7/51
Vert. emit. Norm.	µm	0.18/80	0.11/17	0.8/75	0.03/2
Horizontal β^*	mm	25	25	25	125
Vertical β^*	mm	5	5		
Vert. b-b tuneshift/IP		.015/.013	0.01/0.03	.015/.08	0.01/0.1
Laslett tune shift	p-beam	0.1	0.1	0.054	0.1
Peak Lumi/IP, 10^{34}	$cm^{-2}s^{-1}$	0.59	1.9	4.0	11

Low energy | Medium energy | High energy

Figure-8 Electron Ring – Optics





Collider Ring – Tune Diagram

Two Ring ‘tunes’ are being studied:

Working point above the integer:	Q_x=32.096 Q_y=29.113
Working point a la KEKB:	Q_x=32.506 Q_y=29.531

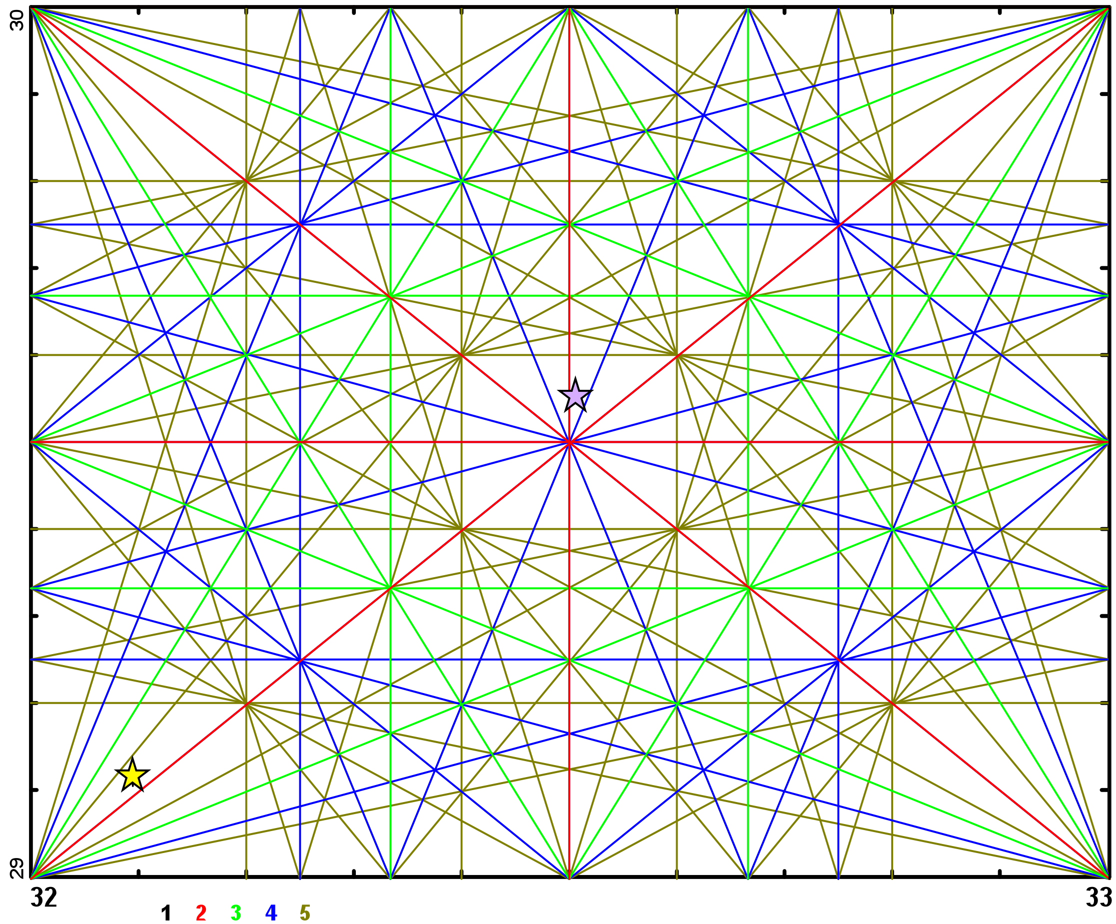
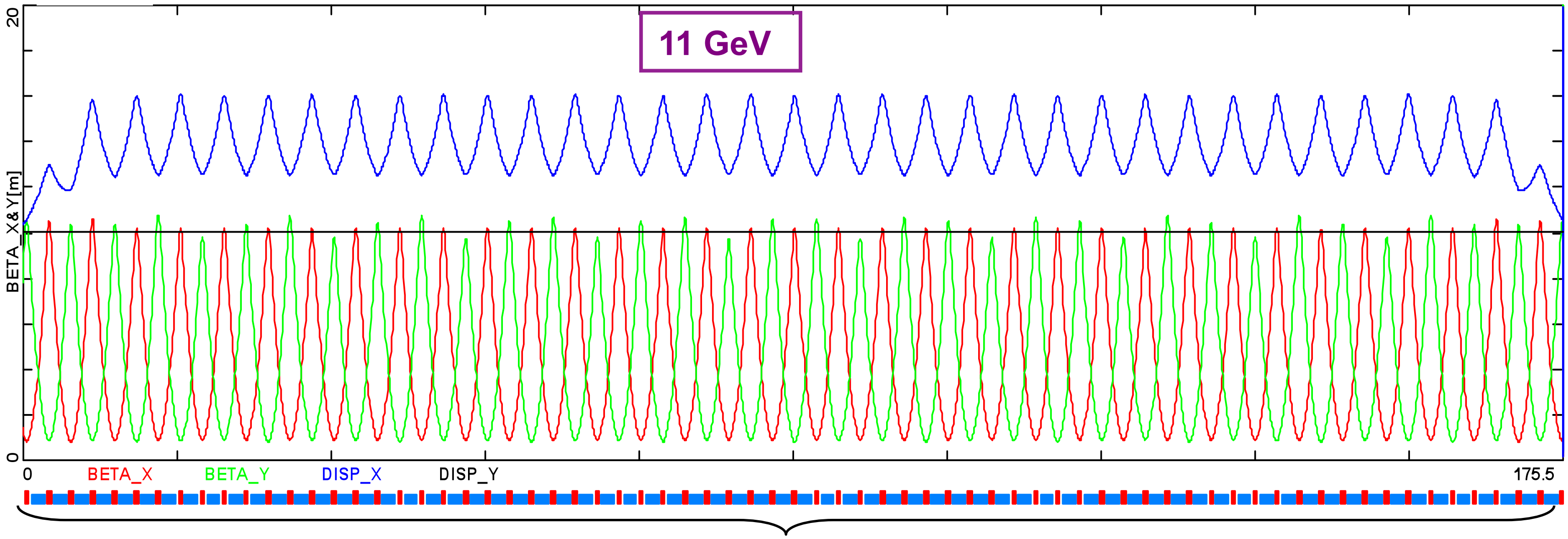


Figure-8 Collider Ring – Arc Optics



36 FODO cells, total arc length: 180 m

phase adv./cell ($\Delta\phi_{x,y}$= 120^0)

- No dispersion suppression at the end of the arc - Uncompensated dispersion leakage into the straights (by design) to facilitate chromaticity compensation with sextupoles in the straights

- Dispersion pattern not favorable for chromaticity compensation with sextupoles: small disp. and betas, large phase advance driven by mitigation of synchrotron radiation effects on emittance

Dipoles

Lb=150 cm

B=**11.6** kG.

Quadrupoles

Lq=50 cm

G= ±**4.5** kG/cm

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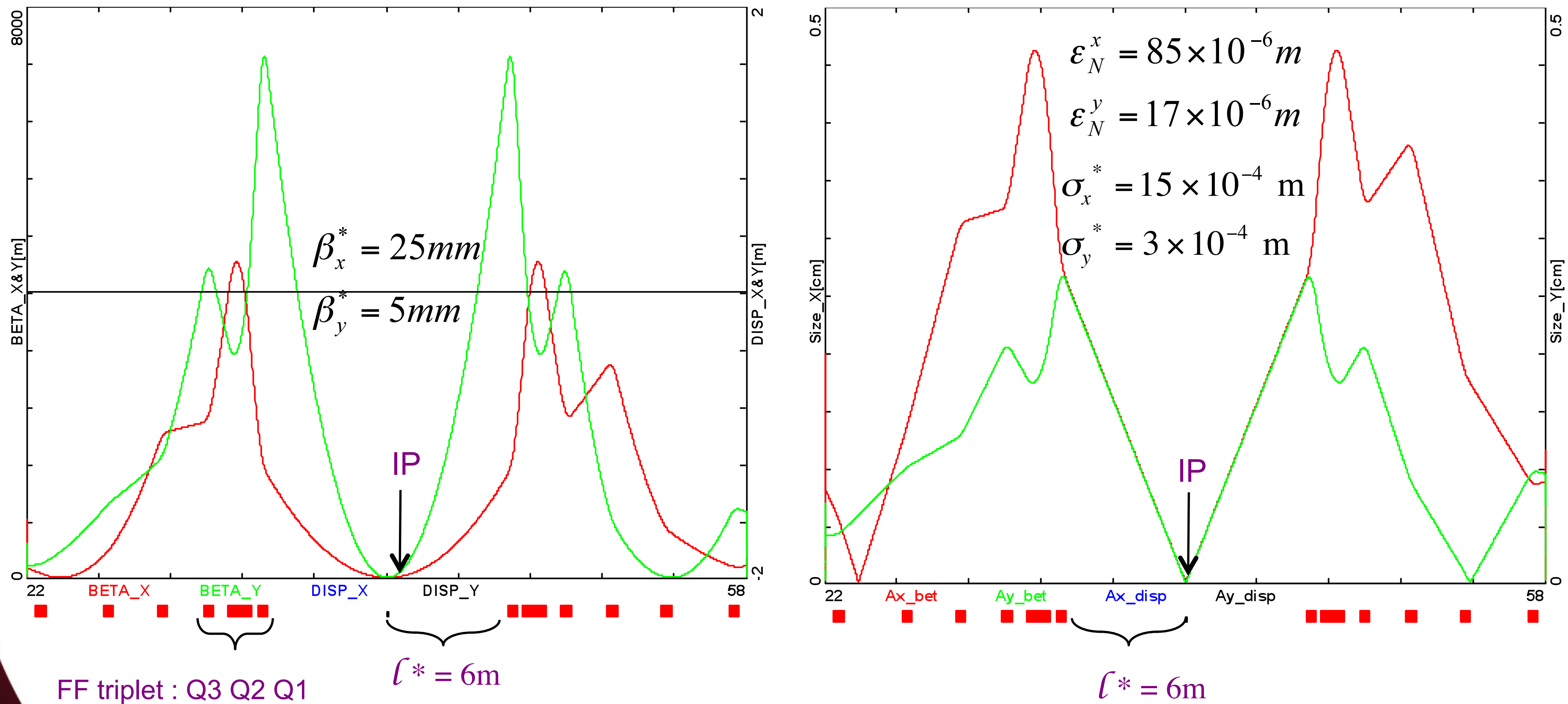
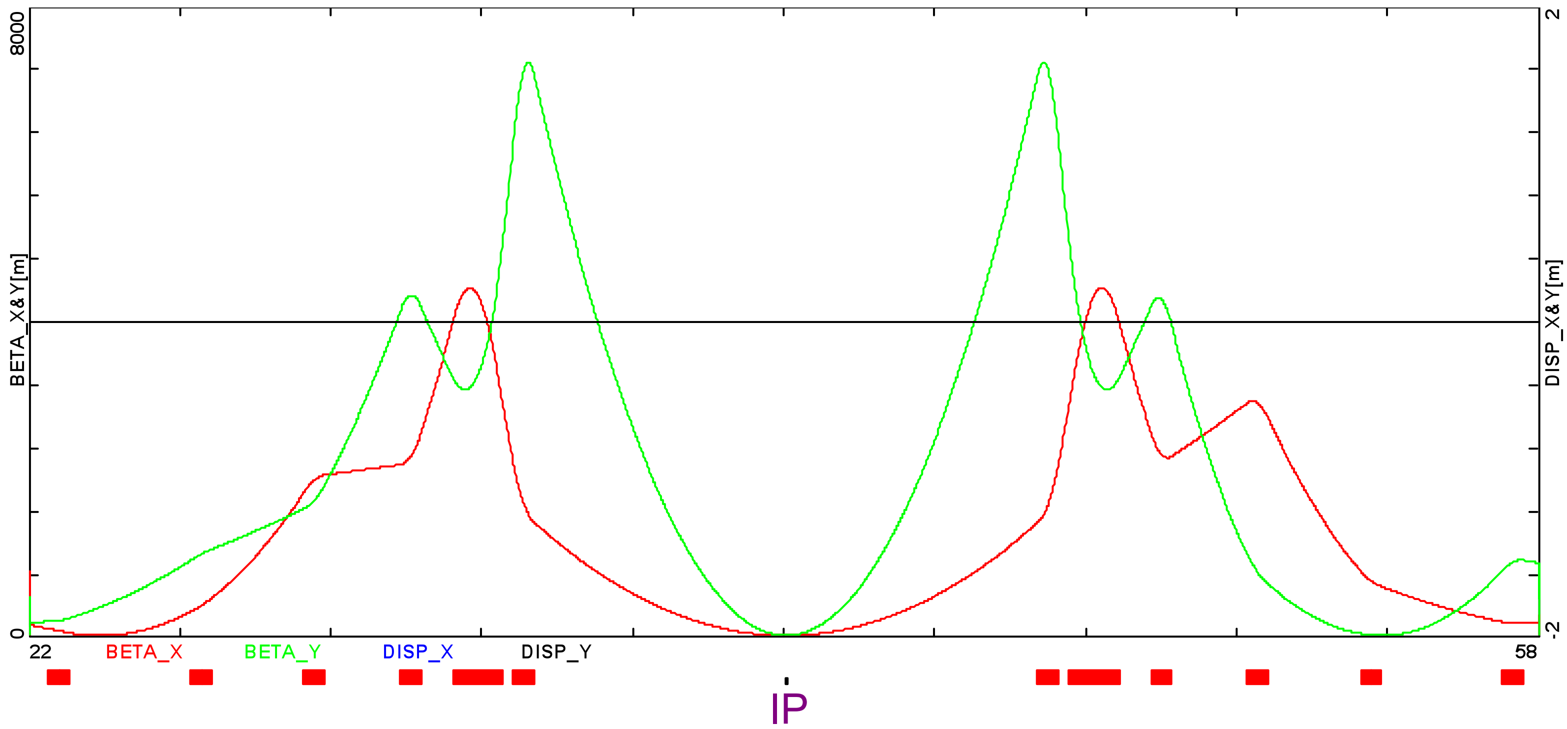
Interaction Region Optics

vertical focusing first



Q1	G[kG/cm] = -3.4
Q2	G[kG/cm] = 2.1
Q3	G[kG/cm] = -4.1

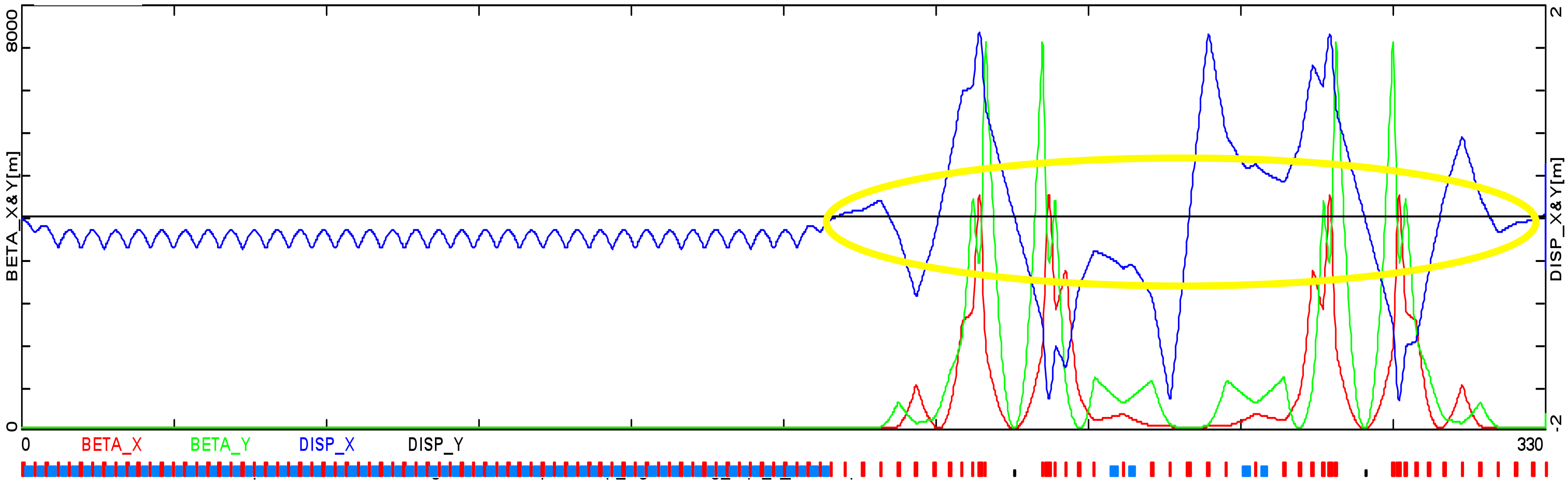
IR – Natural Chromaticity

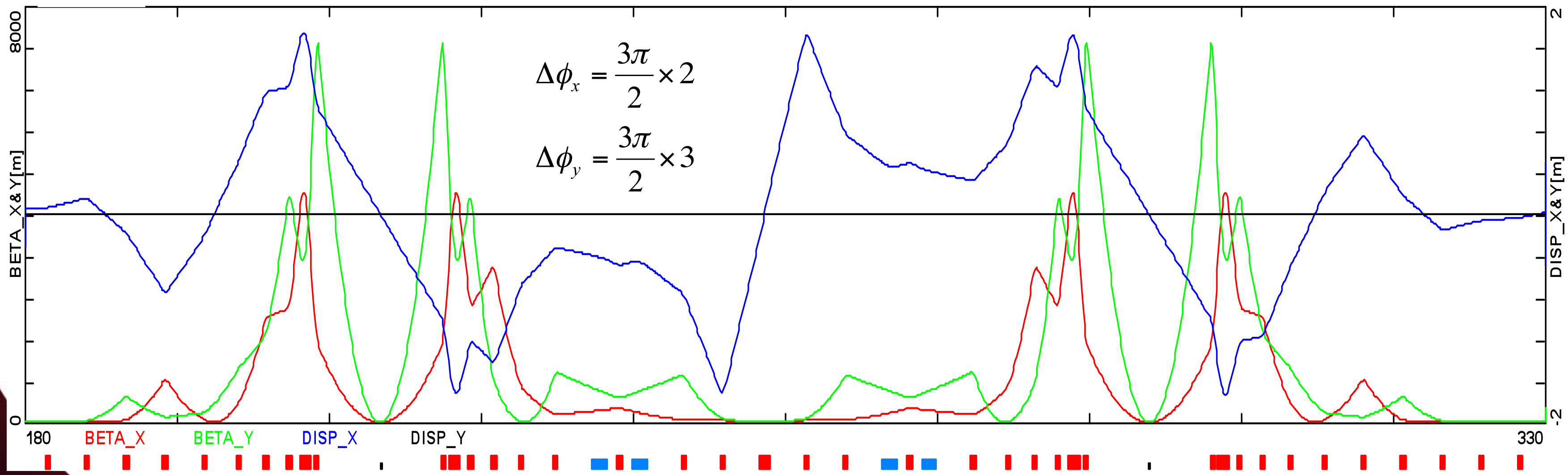


$$\zeta_{x,y}^{IR} \simeq -\tfrac{1}{4\pi}\sum_i \beta_{x,y}^i \int g_0^i ds = -\tfrac{1}{4\pi}\sum_i \beta_{x,y}^i k_1^i \qquad k_1 = \frac{1}{B\rho}\int \frac{\partial B_y}{\partial x} dl = \frac{e}{pc}\int \frac{\partial B_y}{\partial x} dl\,[m^{-1}]$$

Natural Chromaticity: ζ_x = -278 ζ_y = -473

Collider Ring - Pair of IR's Optics



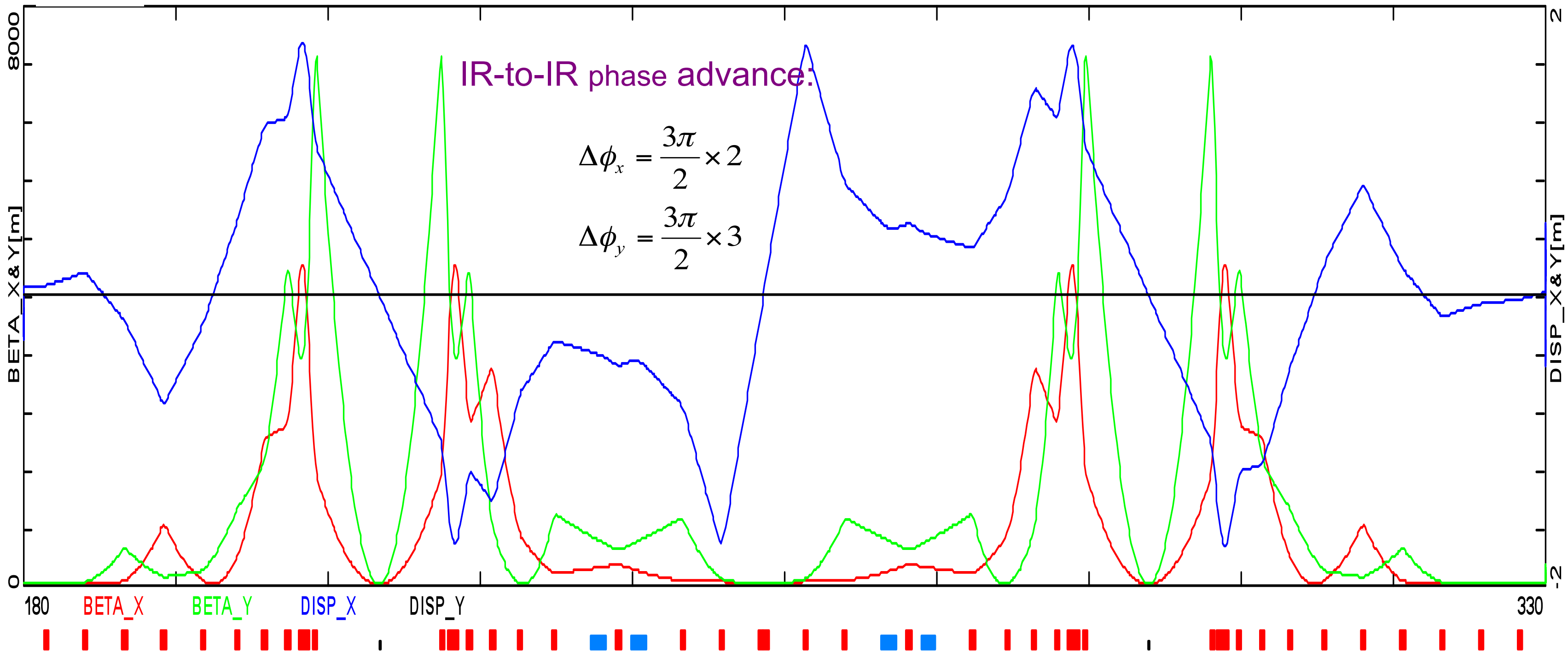


$$\Delta\phi_x = \frac{3\pi}{2} \times 2$$

$$\Delta\phi_y = \frac{3\pi}{2} \times 3$$

IR-to-IR phase advance:

Collider Ring – Pair of IRs Optics



IP IP

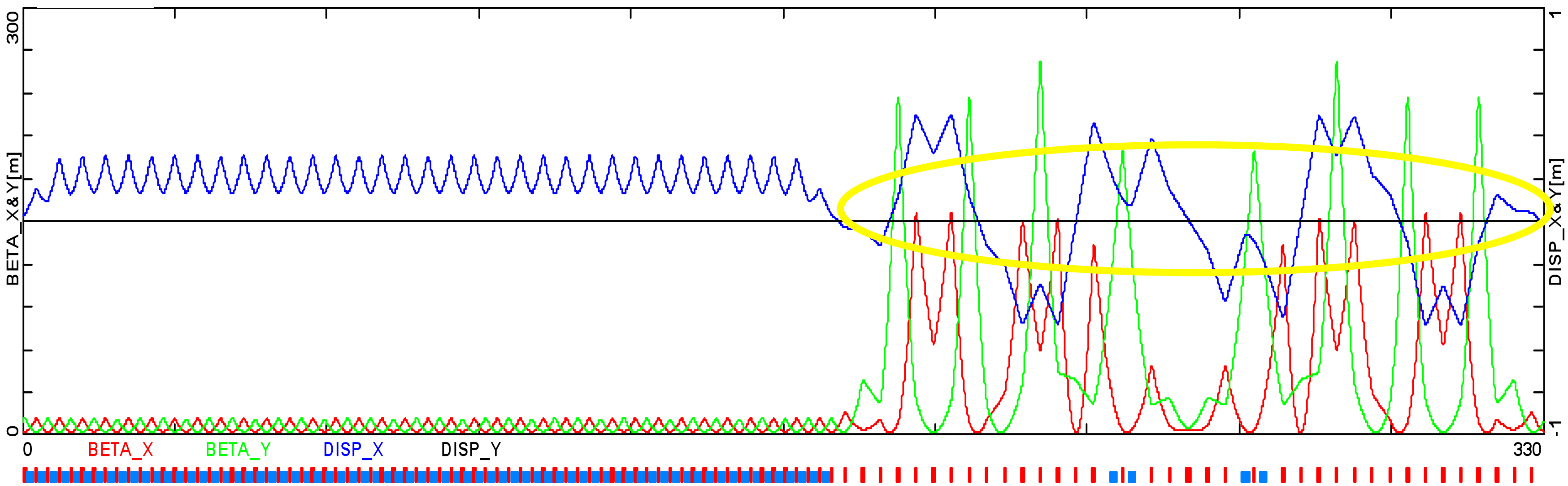
$$Q_x'' \sim \cos(\mu_x^{15})\cos(\mu_x^{15} - 2\pi Q_x) \quad *$$

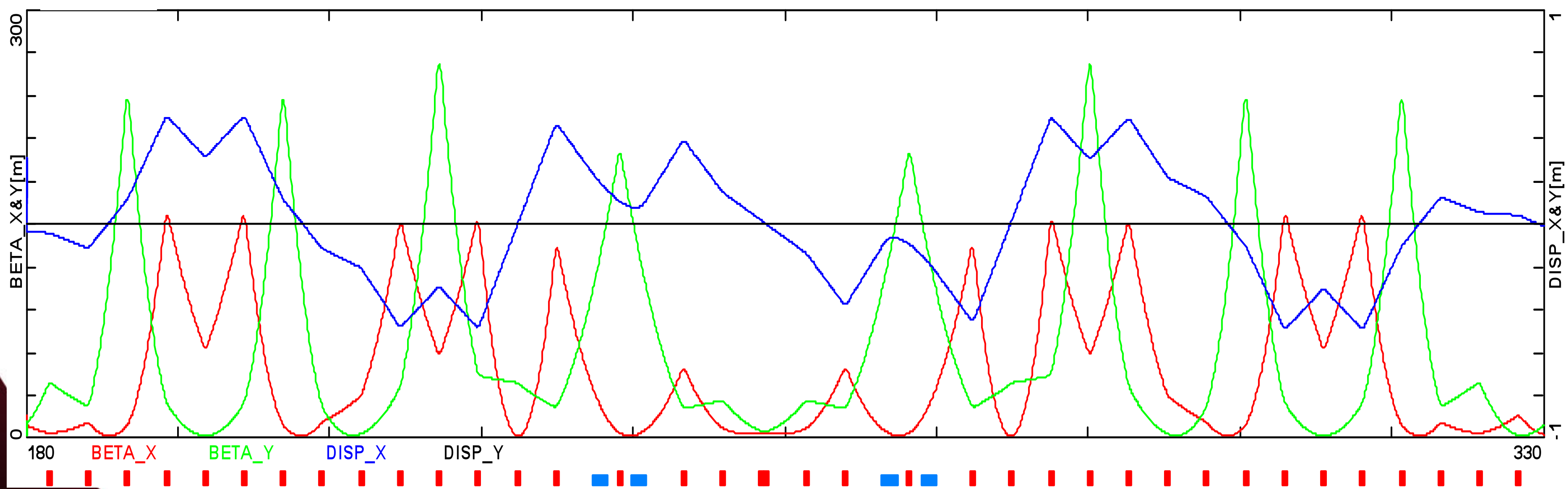
$$\mu_x \sim \frac{\pi}{2} + k\pi -> Q'' \sim 0$$

Natural Chromaticity: $\zeta_x = -557$ $\zeta_y = -946$

* Fartoukh, LHC-rep 308

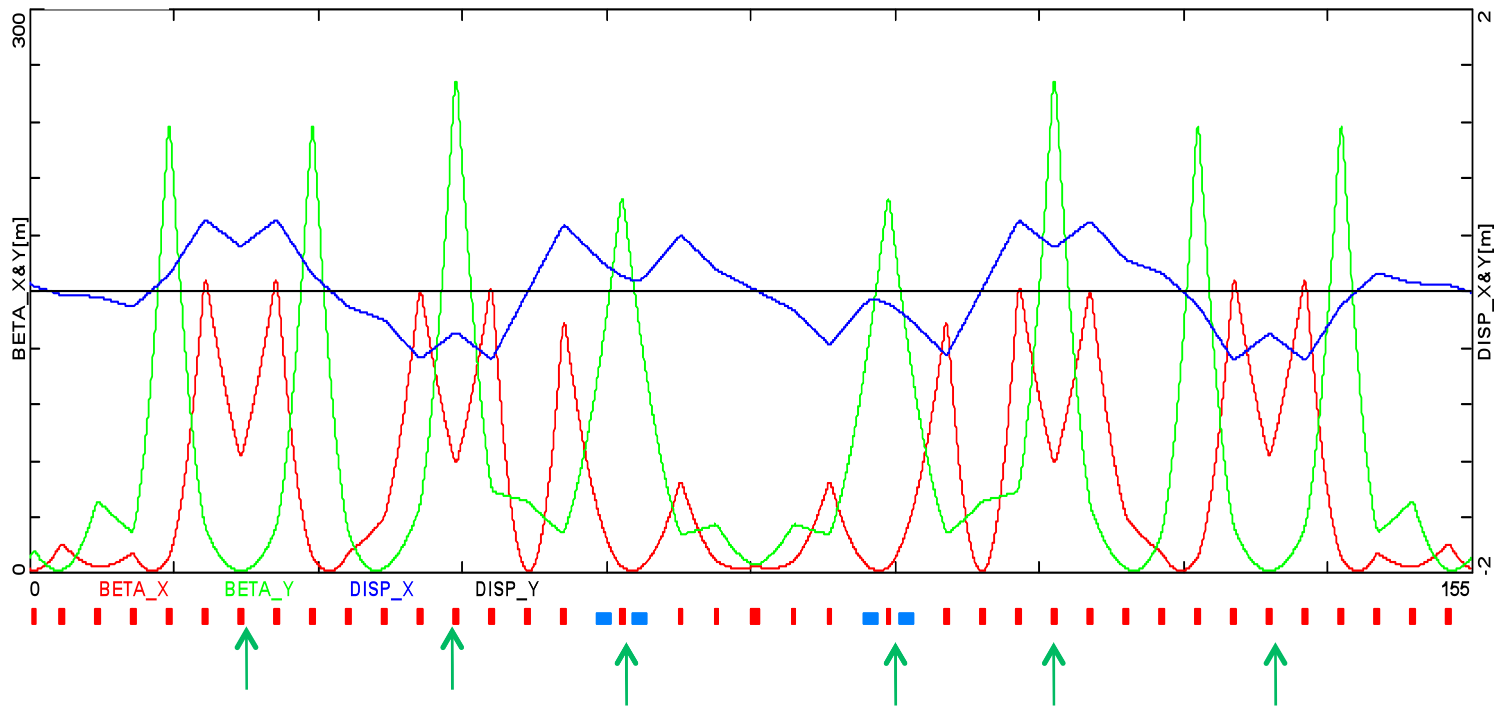
Collider Ring – Dispersive Straight





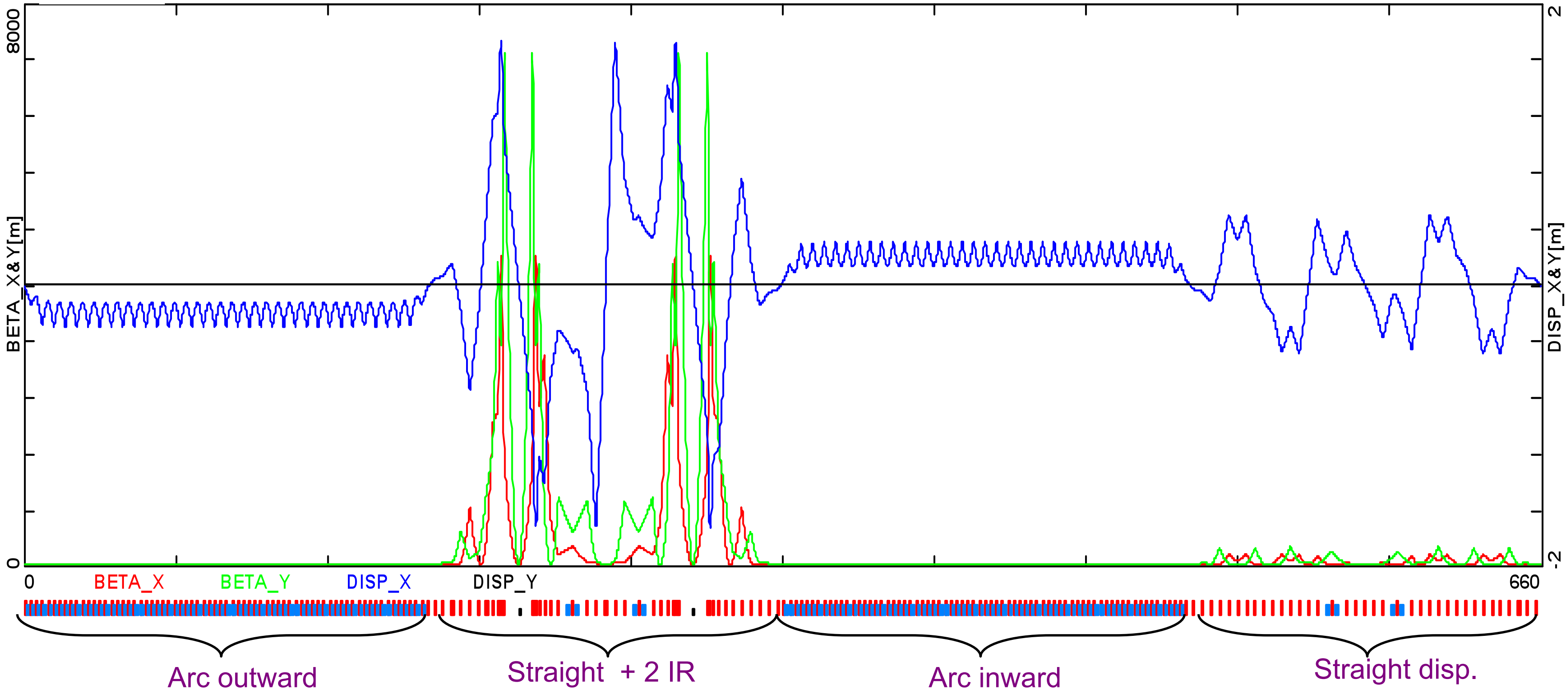
Straight – Chromaticity Compensation

Uncompensated dispersion pattern coming out of the Arc



$$\xi_{sext} = \frac{1}{4\pi}\sum_{sext} \beta\ \eta_0 g_1^{sext}$$

Collider Ring – Chromaticity



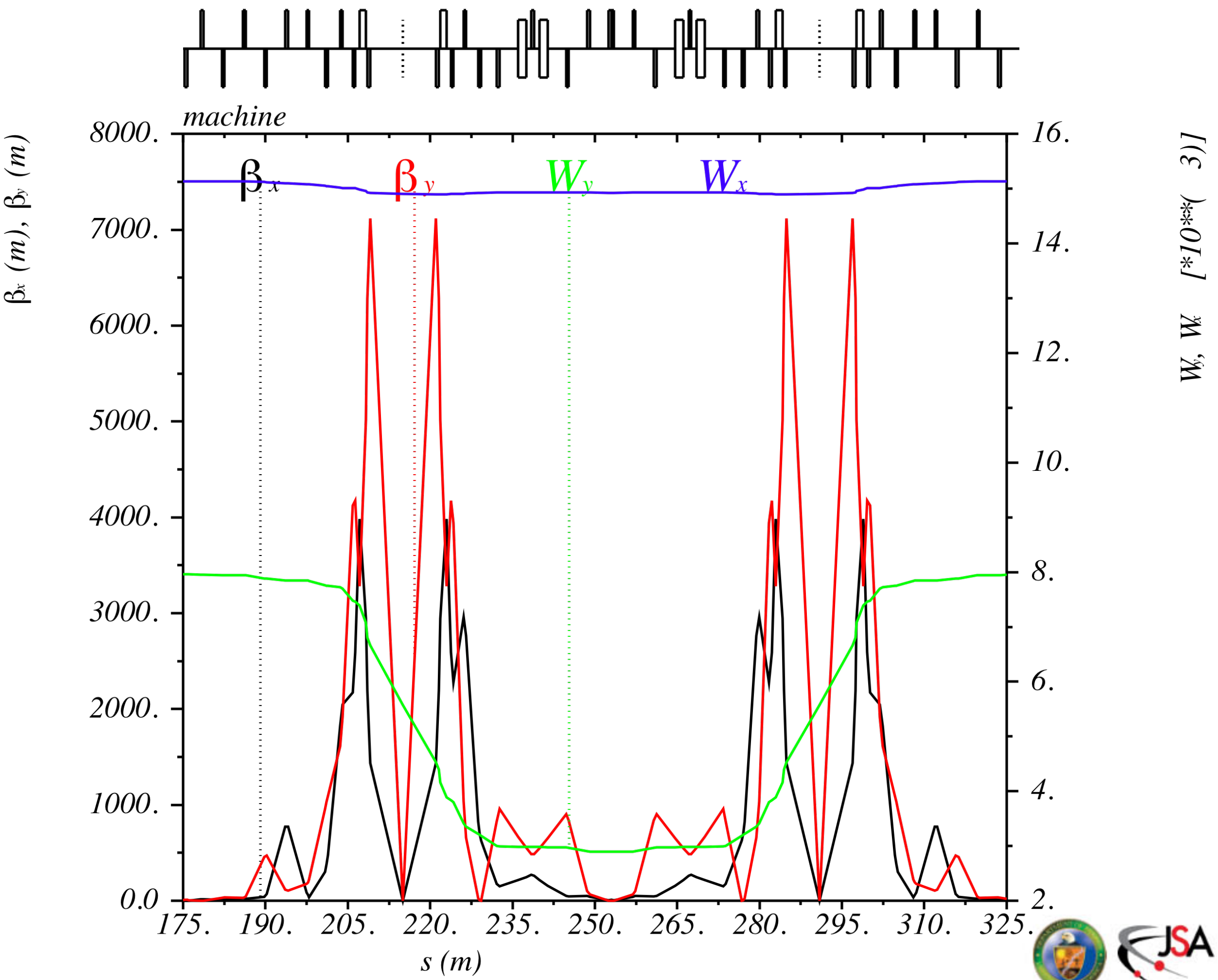
Natural Chromaticity: $\zeta_x = -628$ $\zeta_y = -1023$

Montague Chromatic function

$$w_x = \sqrt{a_x^2 + b_x^2}$$

$$b_x = \frac{1}{\beta_x} \frac{\partial}{\partial \delta_p} \beta_x$$

$$a_x = \frac{\partial}{\partial \delta_p} \alpha_x - \frac{\alpha_x}{\beta_x} \frac{\partial}{\partial \delta_p} \beta_x$$



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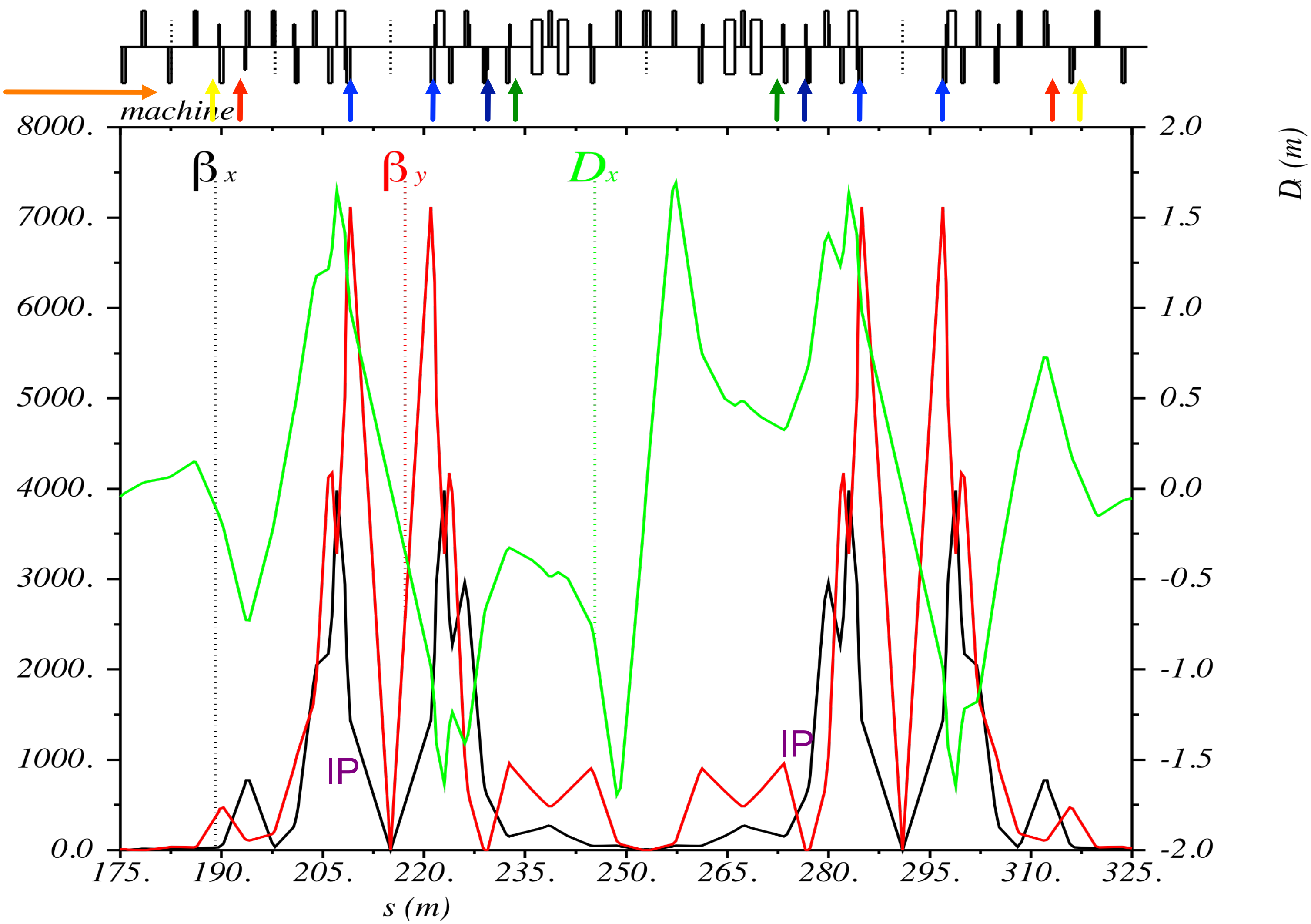
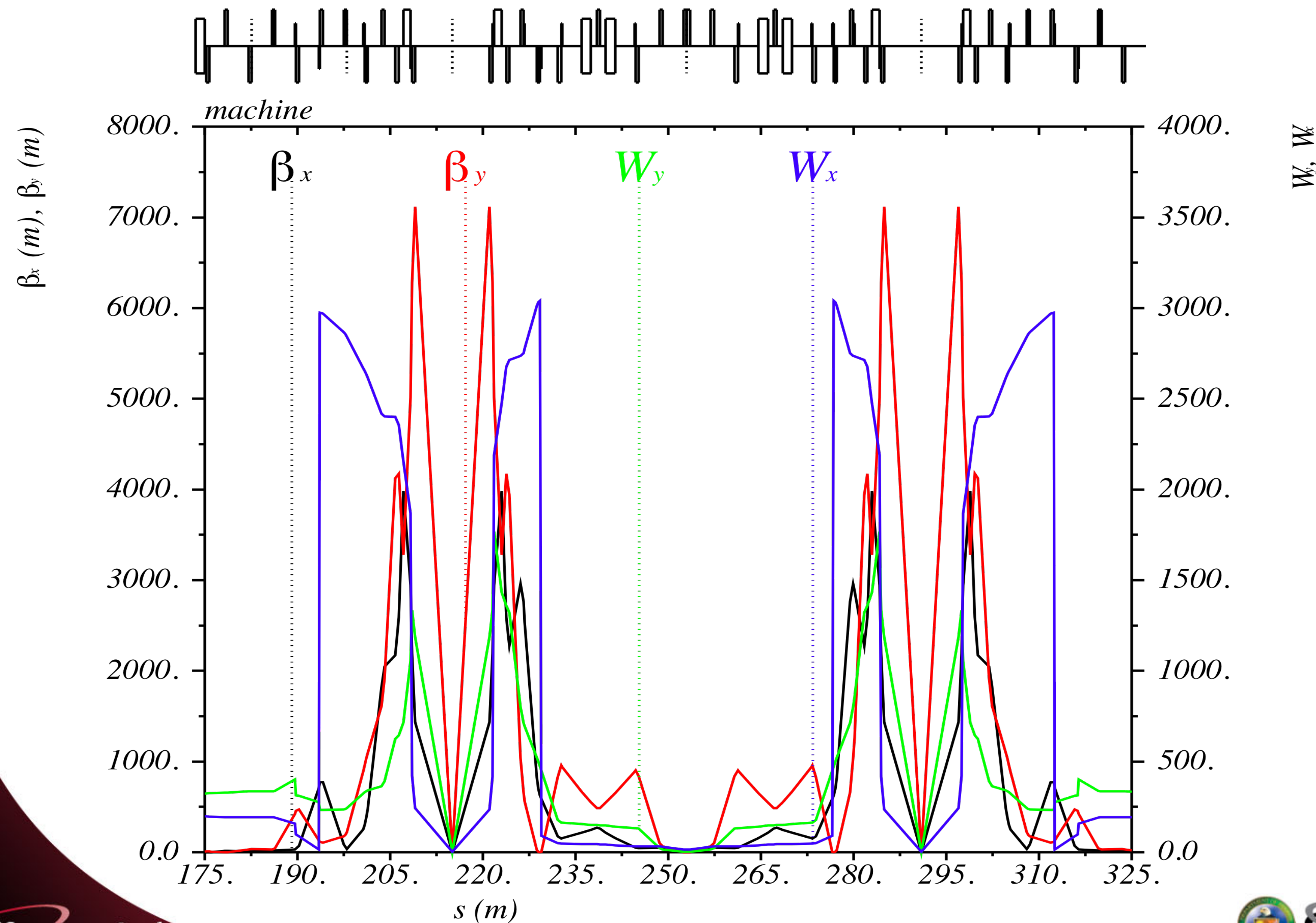
IR – Chromaticity Compensation

Uncompensated dispersion pattern coming out of the Arc

Sextupoles



$$\zeta_{sext} = \frac{1}{4\pi} \sum_{sext} \beta \, \eta_0 g_1^{sext}$$



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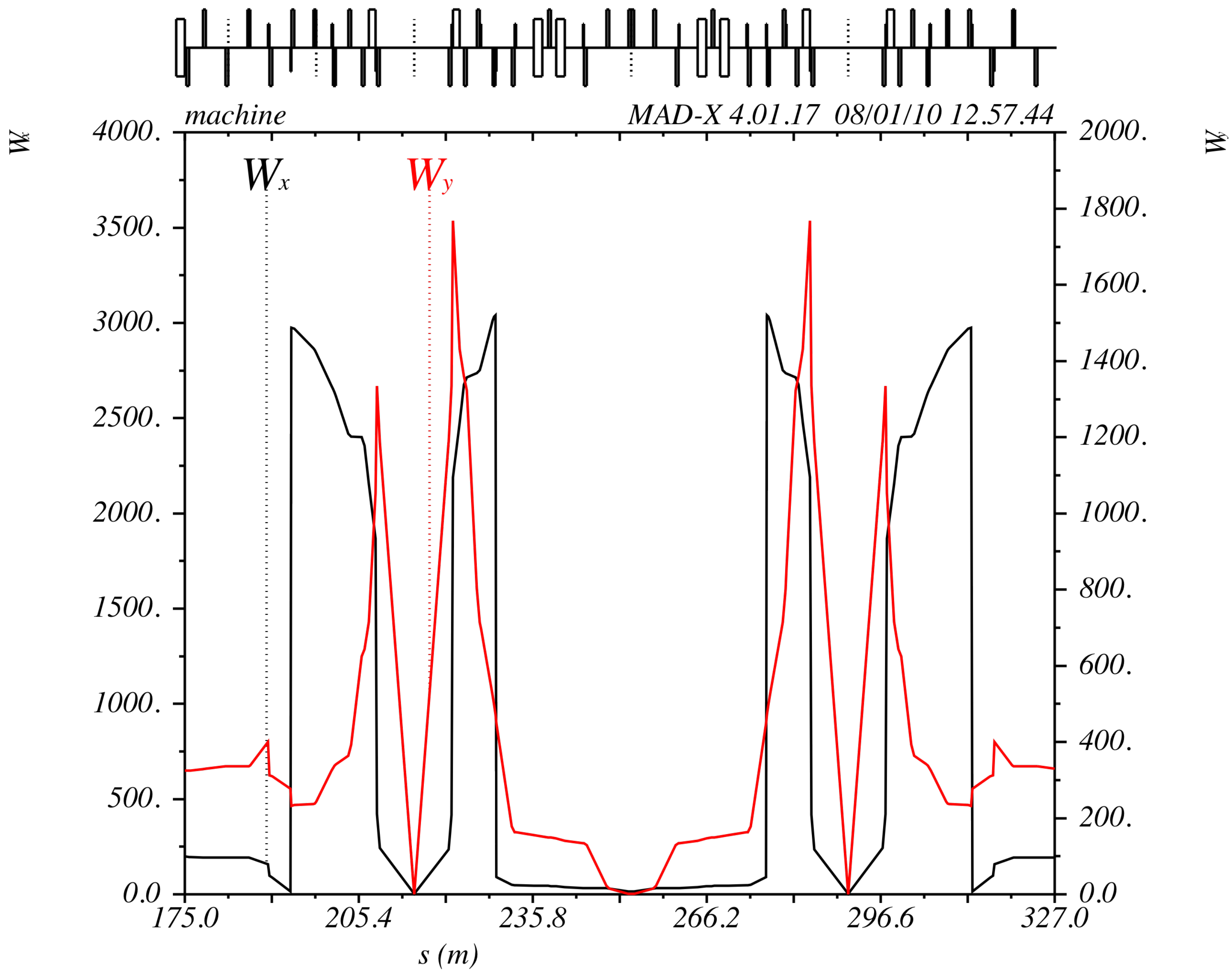
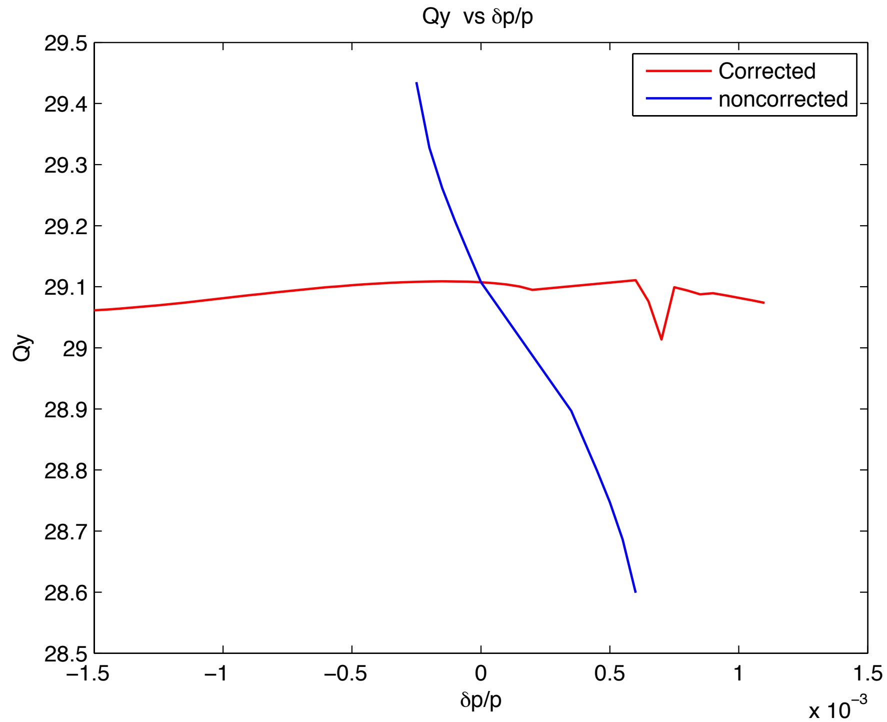


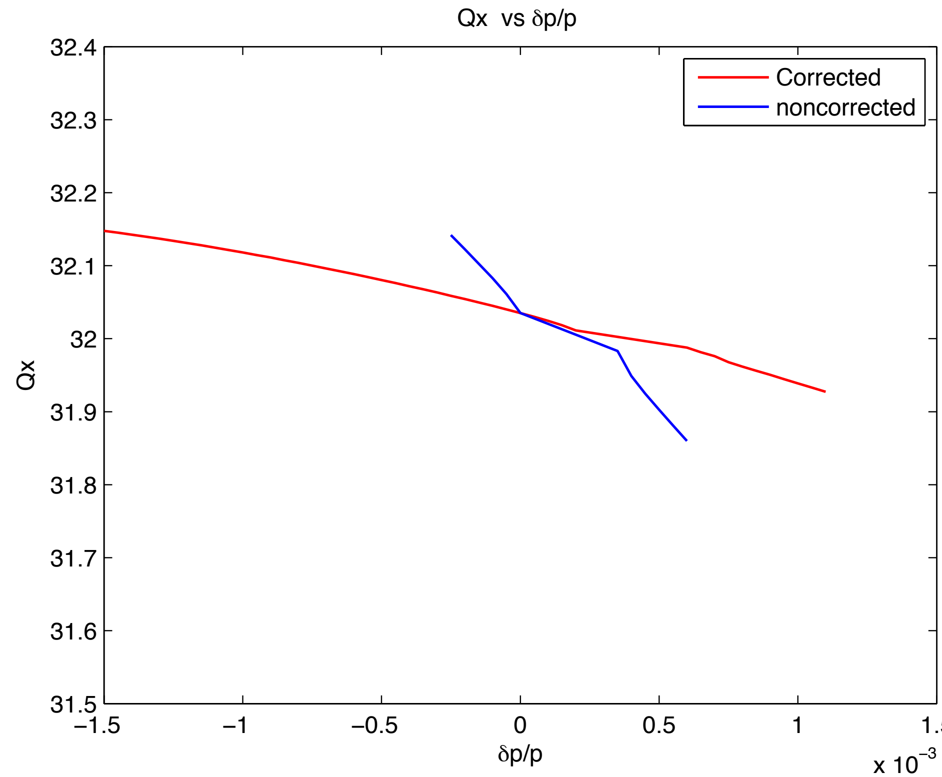
machine
MAD-X 4.01.17 08/01/10 12.57.44
W_x
W_y
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.
0.0
2000.
1800.
1600.
1400.
1200.
1000.
800.
600.
400.
200.
0.0
175.0
205.4
235.8
266.2
296.6
327.0
s (m)

Tune variation Diagram



$$\sigma_p \sim 3\times 10^{-4}$$

$$\Delta p/p(5\sigma_p) \sim 1.5\times 10^{-3}$$



Conclusions

- MEIC figure-8 compact lattice .
- Dispersive straights for chromaticity correction.
- Beta chromaticity correction for the two IP's
- Ring Tune chromaticity correction $\zeta_x^{after} \ \& \ \zeta_y^{after} < 100$
- More to be done (tune chromaticity correction in second straight, 2nd order chromaticity correction, dynamic aperture studies)
- Acknowledgement & special thanks to

Hutton, Derbenev, all CASA members ….