Crab waist interaction region for FCC-ee and the arc first attempt (one quarter of the ring IR: v. 6-13-2, arc: v14)

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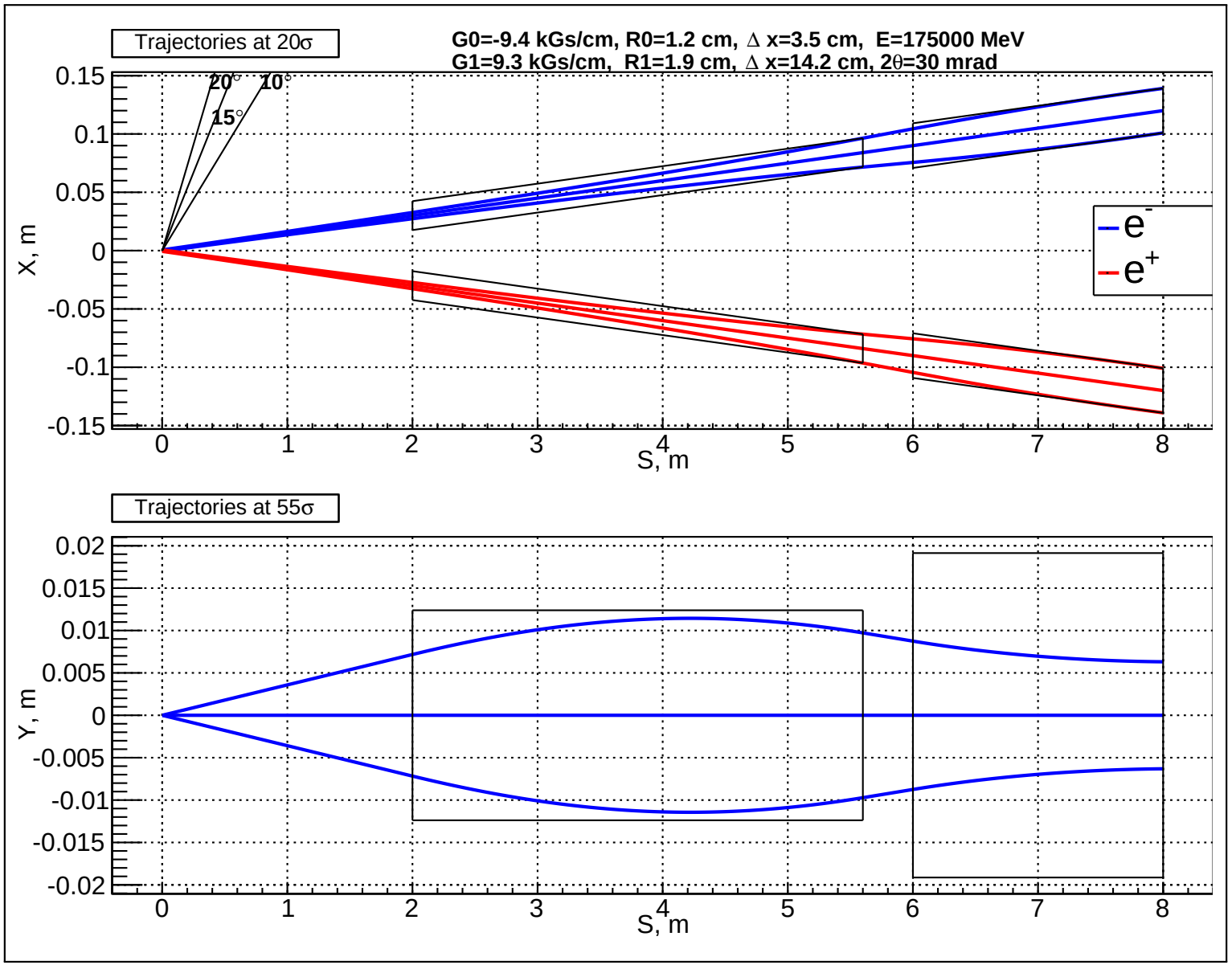
Parameters for crab waist

	Z	W	H	tt
Energy [GeV]	45	80	120	175
Perimeter [km]	100			
Crossing angle [mrad]	30			
Particles per bunch [10^{11}]	1	4	4.7	4
Number of bunches	29791	739	127	33
Energy spread [10^{-3}]	1.1	2.1	2.4	2.6
Emittance hor. [nm]	0.14	0.44	1	2.1
Emittance ver. [pm]	1	2	2	4.3
β_x^*/β_y^* [m]	0.5 / 0.001			
Luminosity / IP [$10^{34}\ cm^{-2}s^{-1}$]	212	36	9	1.3
Energy loss / turn [GeV]	0.03	0.3	1.7	7.7

Final Focus layout

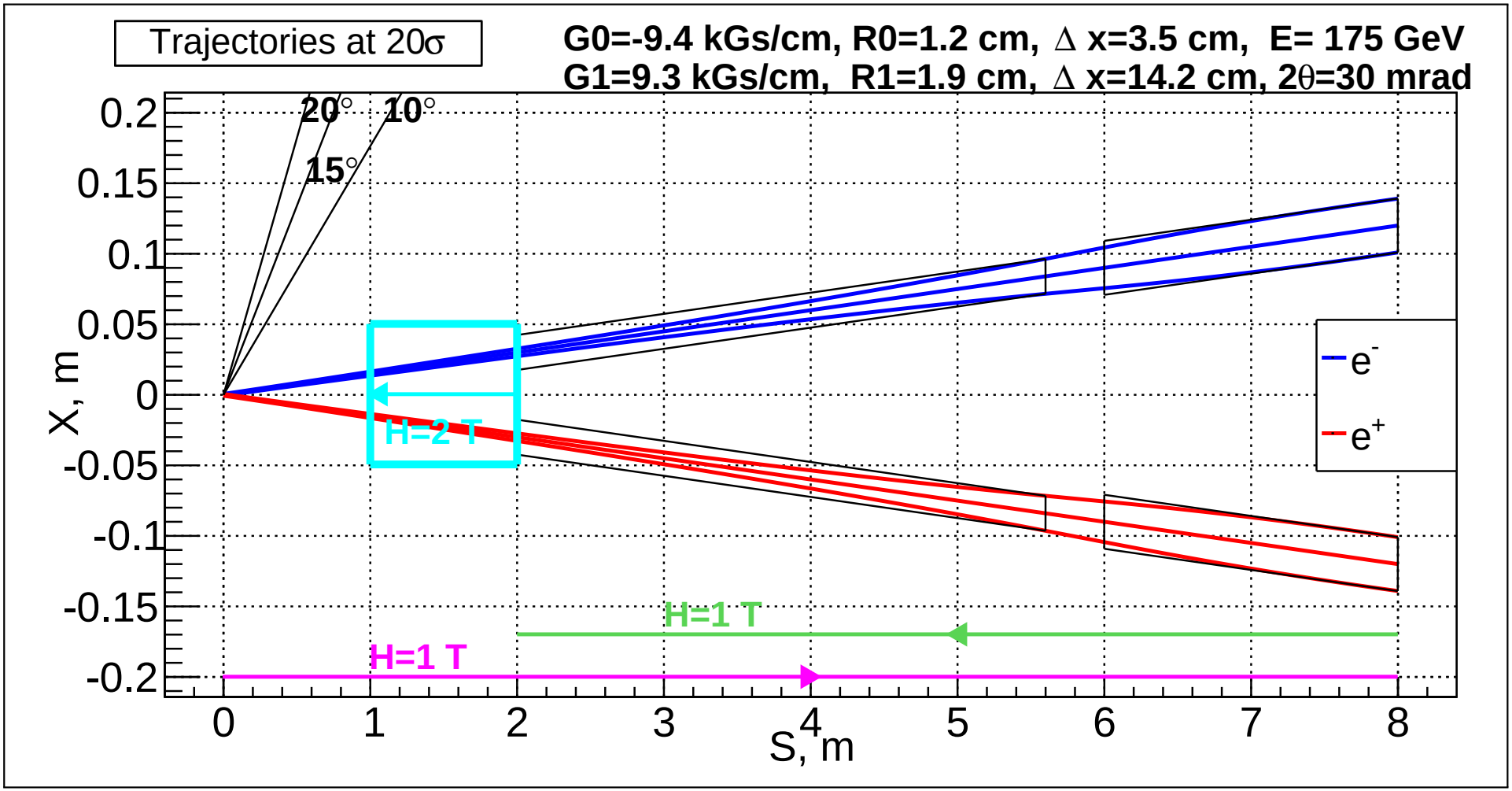


Rectangles represent bare apertures.

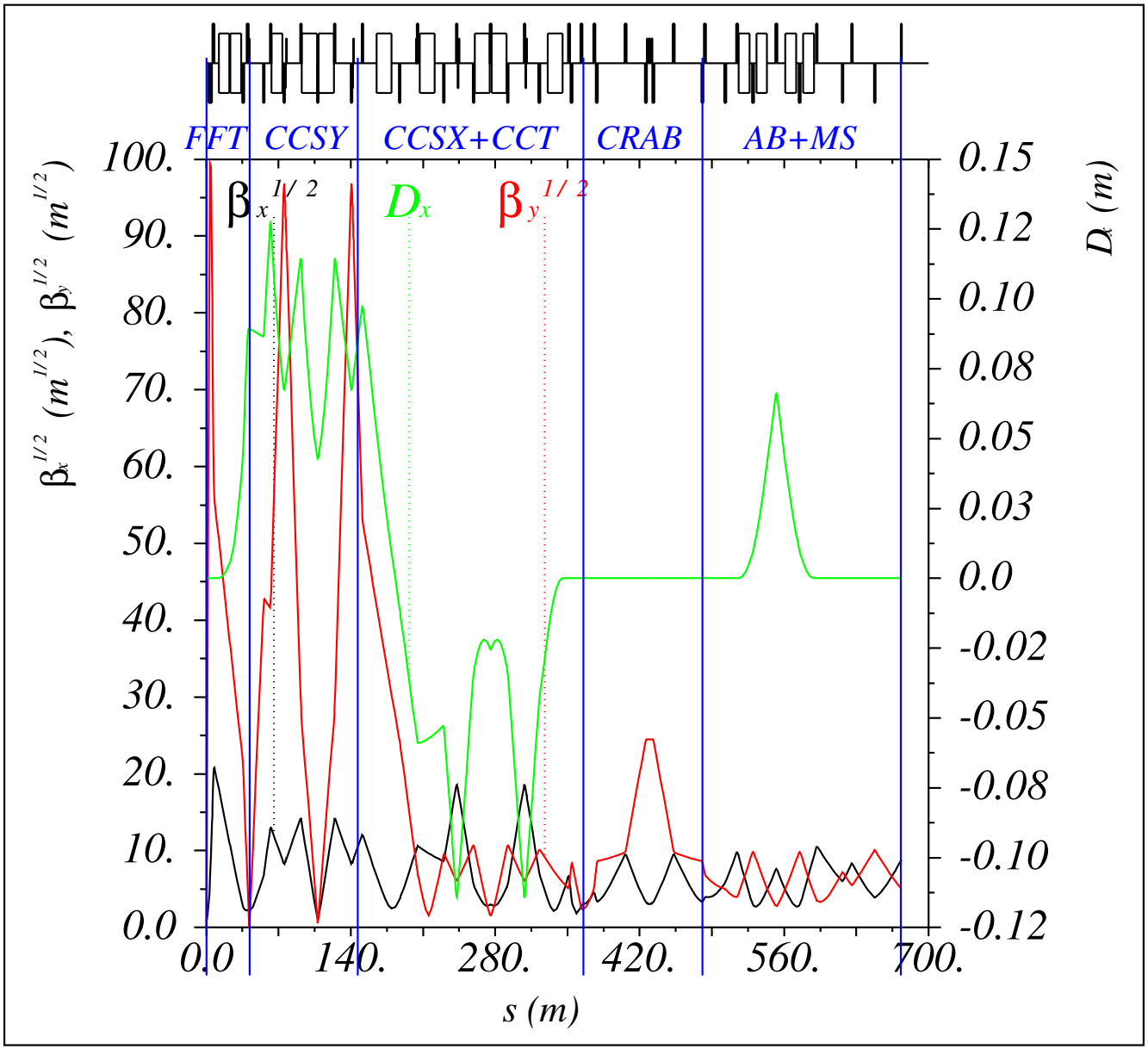
	L [m]
Q0	3.6
Q1	2

	R [m]
Q0	0.012
Q1	0.019

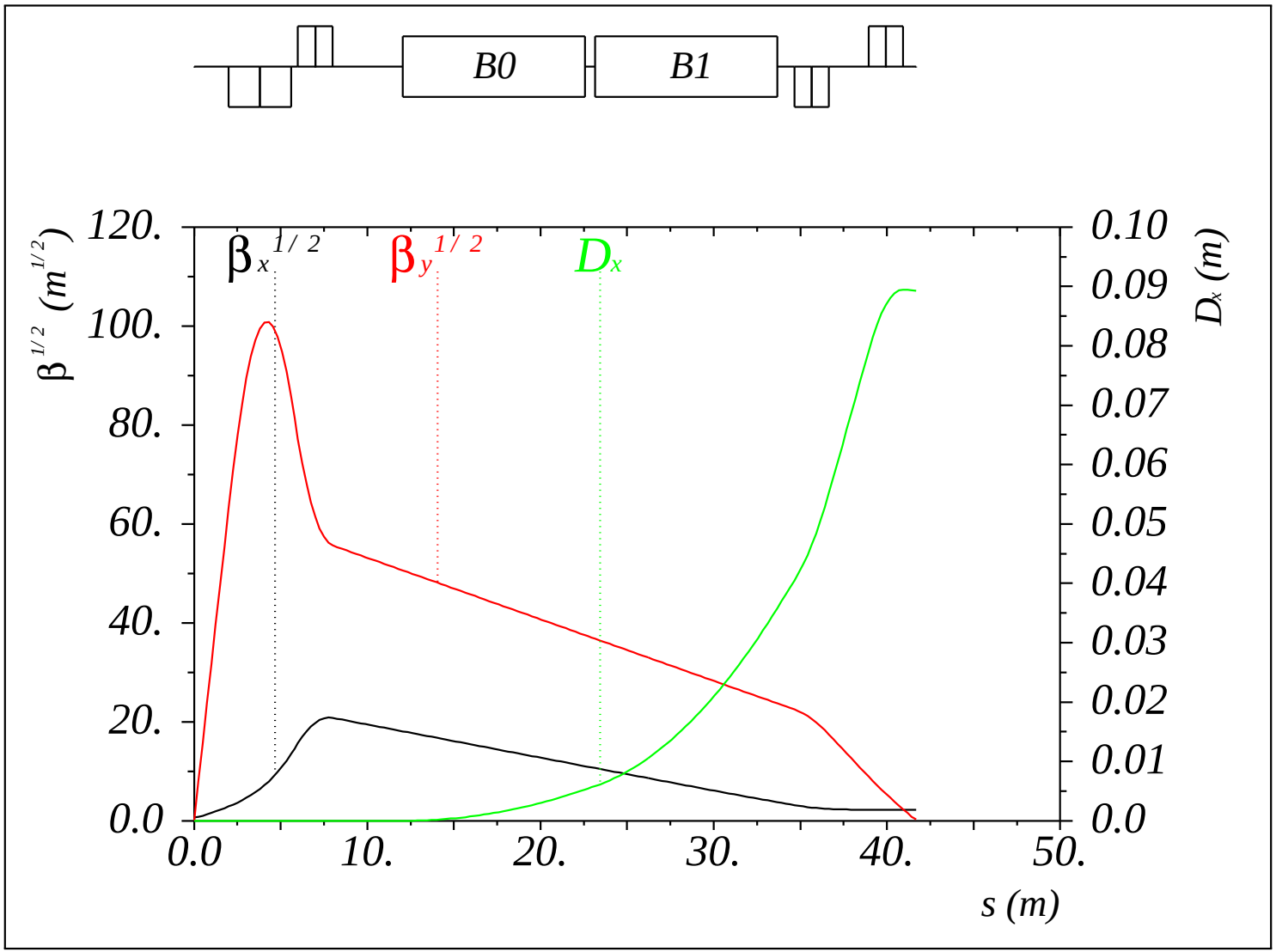
Final Focus layout: sketch of solenoids



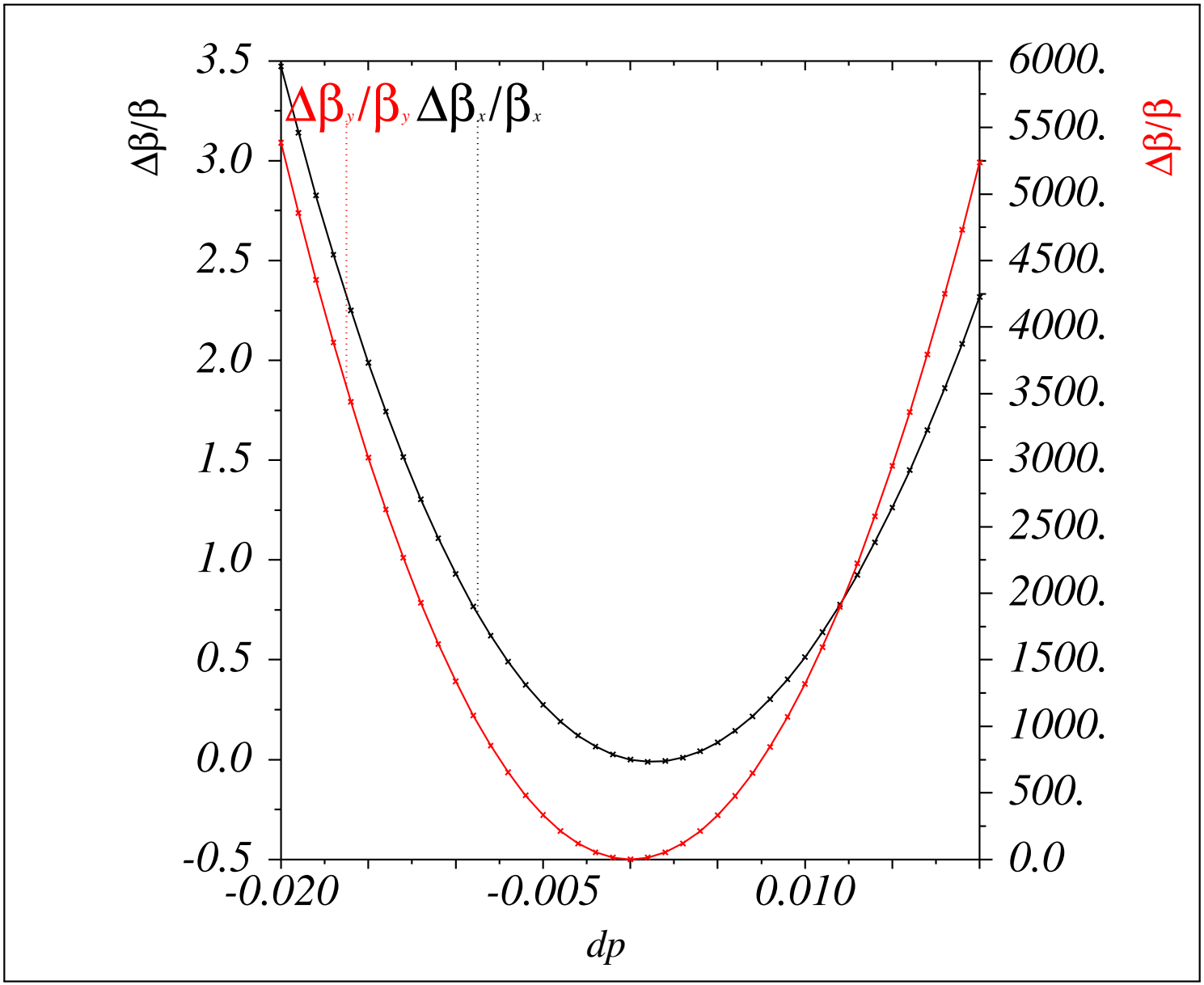
Interaction Region optical functions



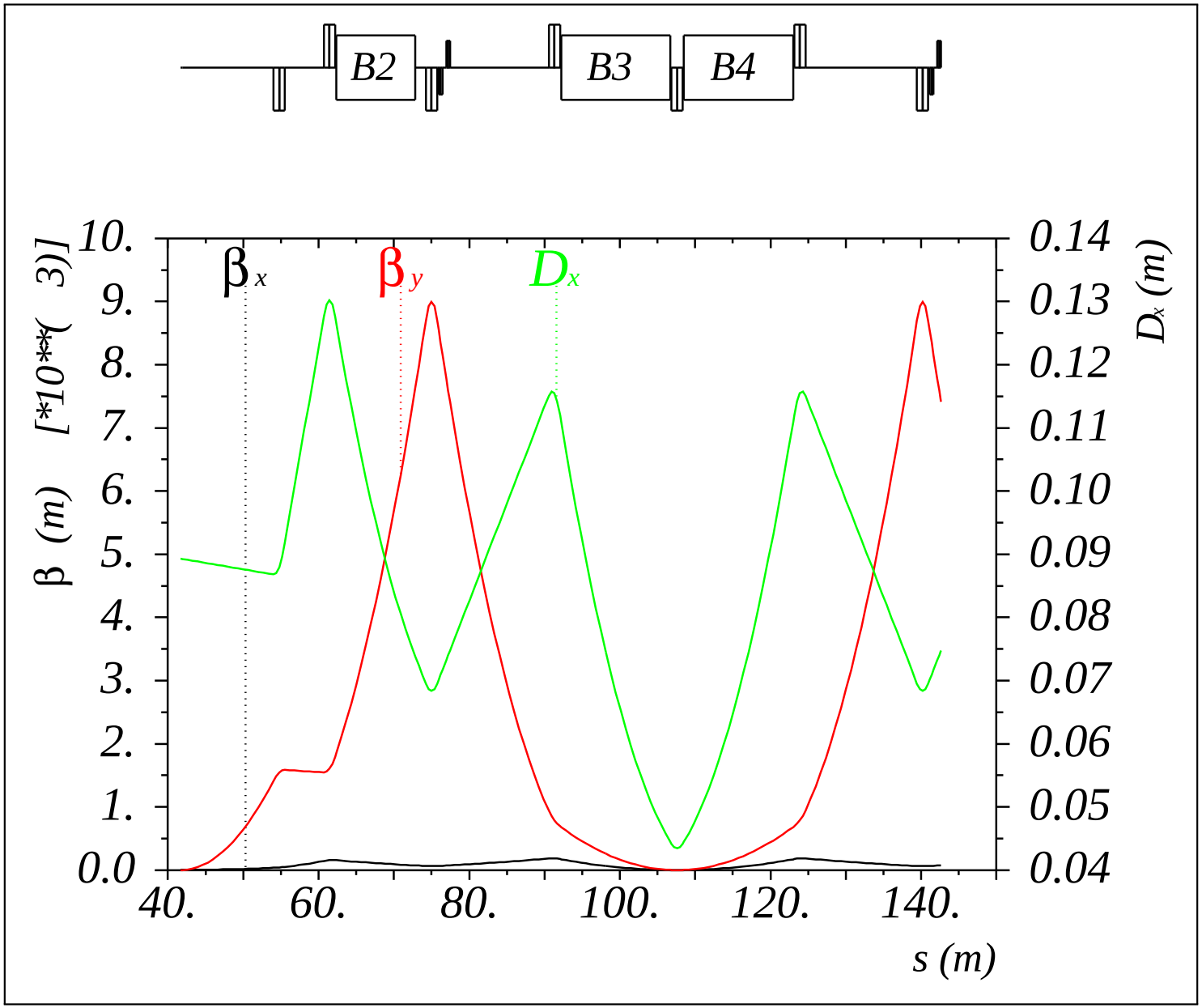
Final Focus Telescope



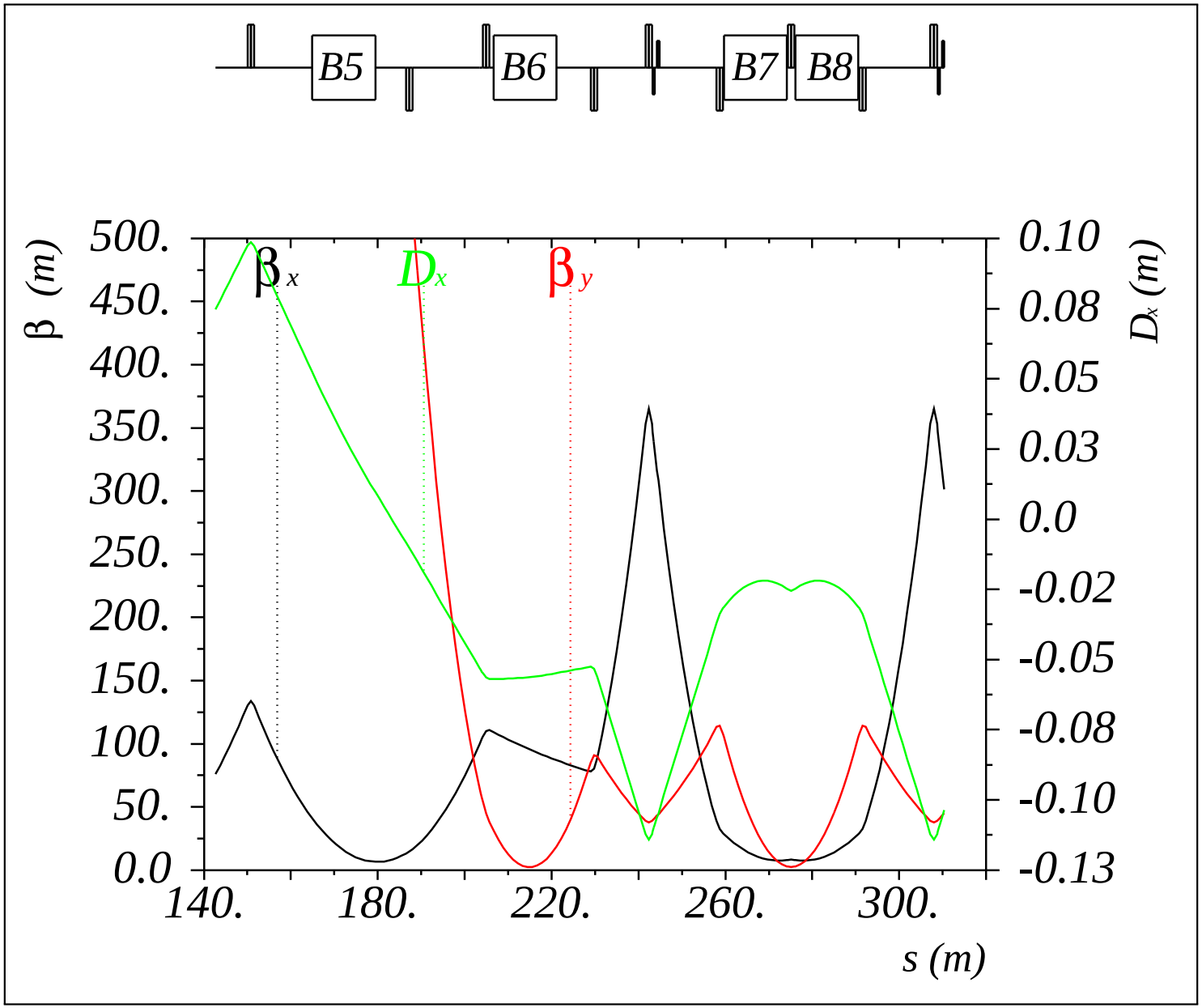
Final Focus Telescope: beta chromaticity



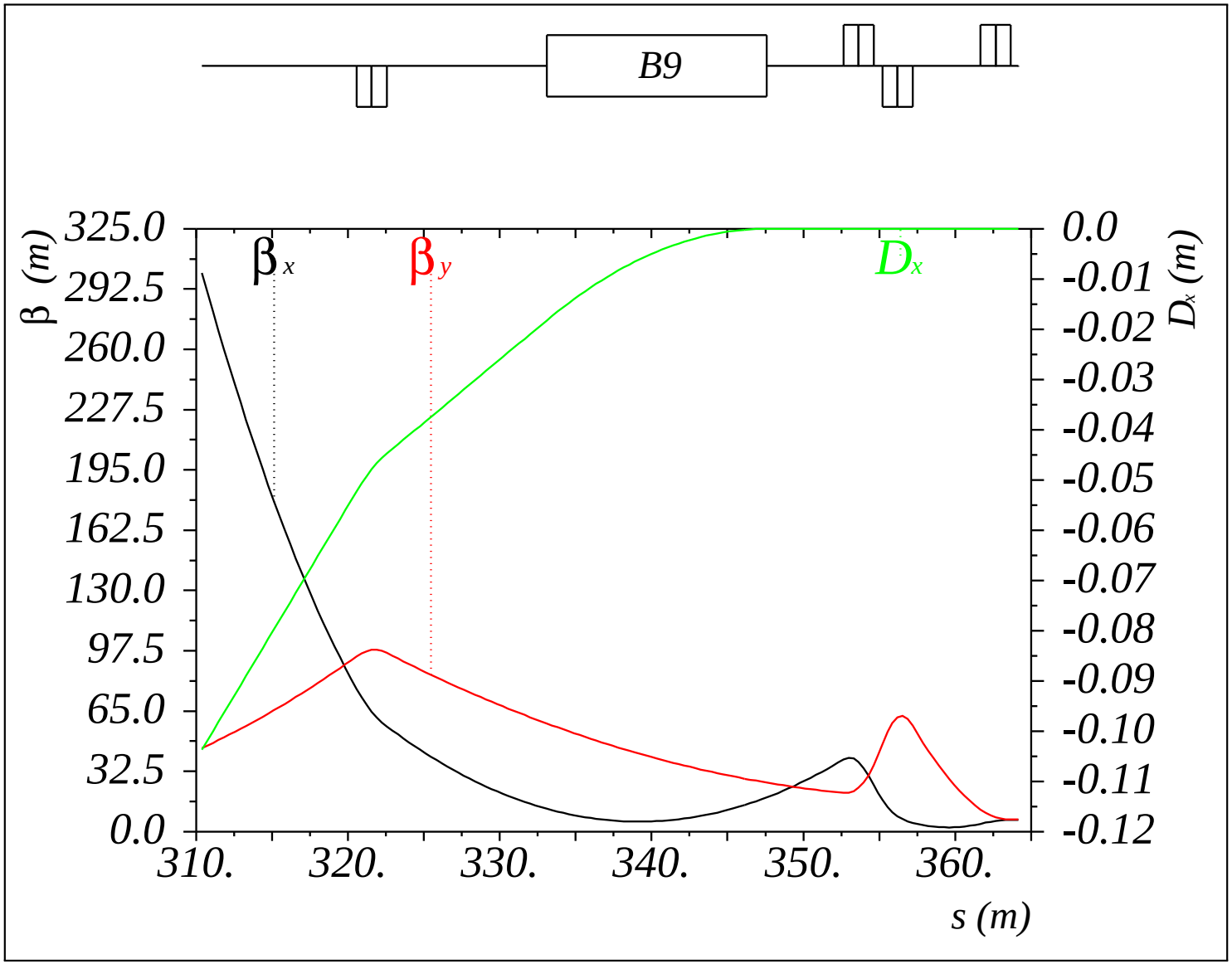
Y Chromaticity Correction Section



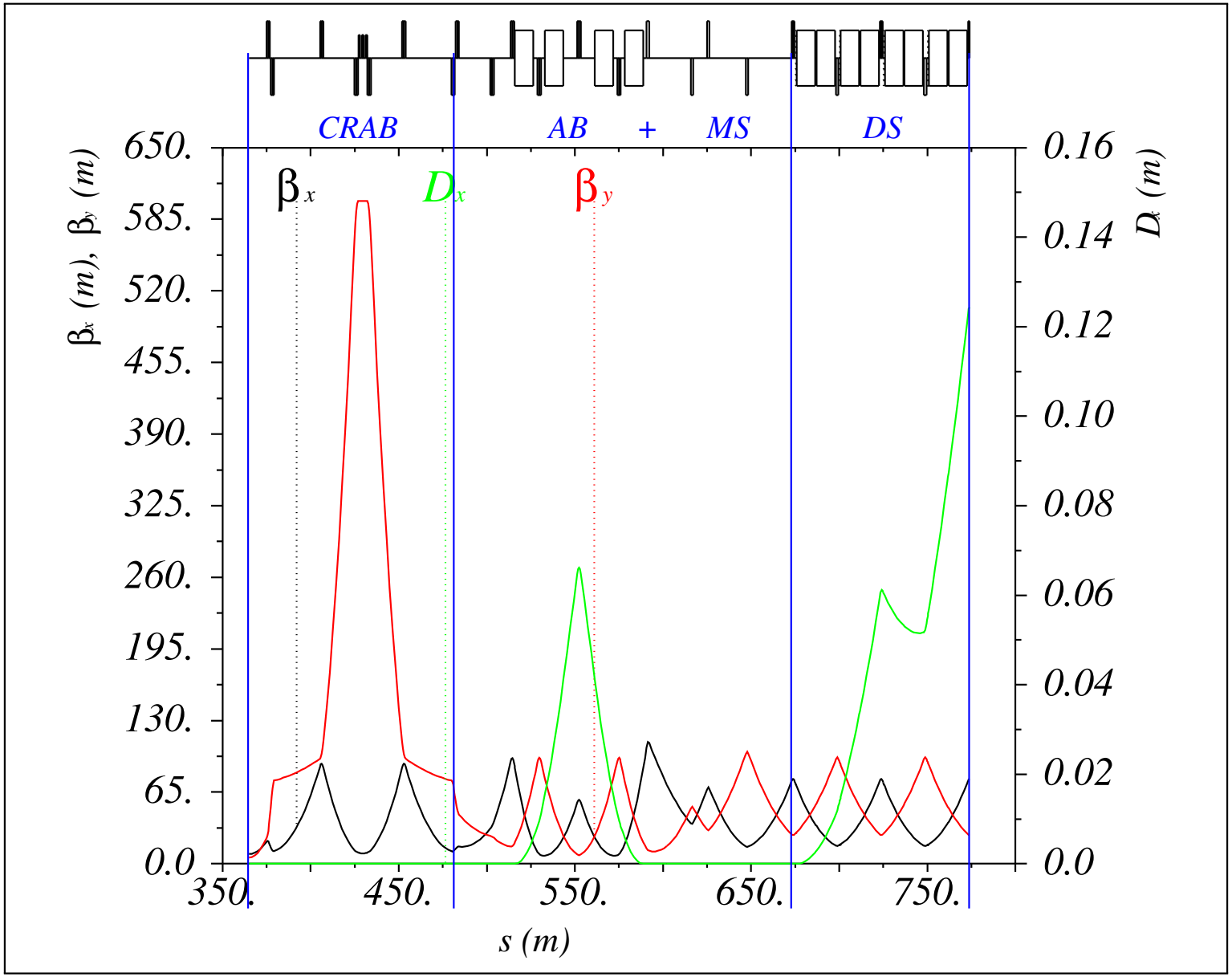
X Chromaticity Correction Section



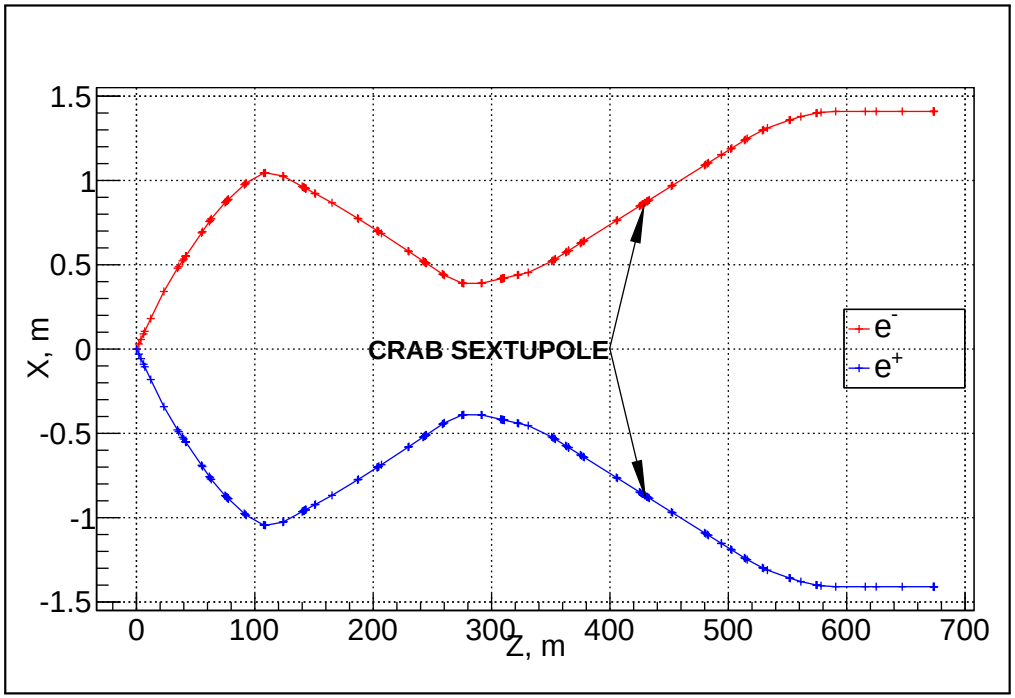
Chromaticity Correction Telescope



CRAB, AB, MS, DS sections



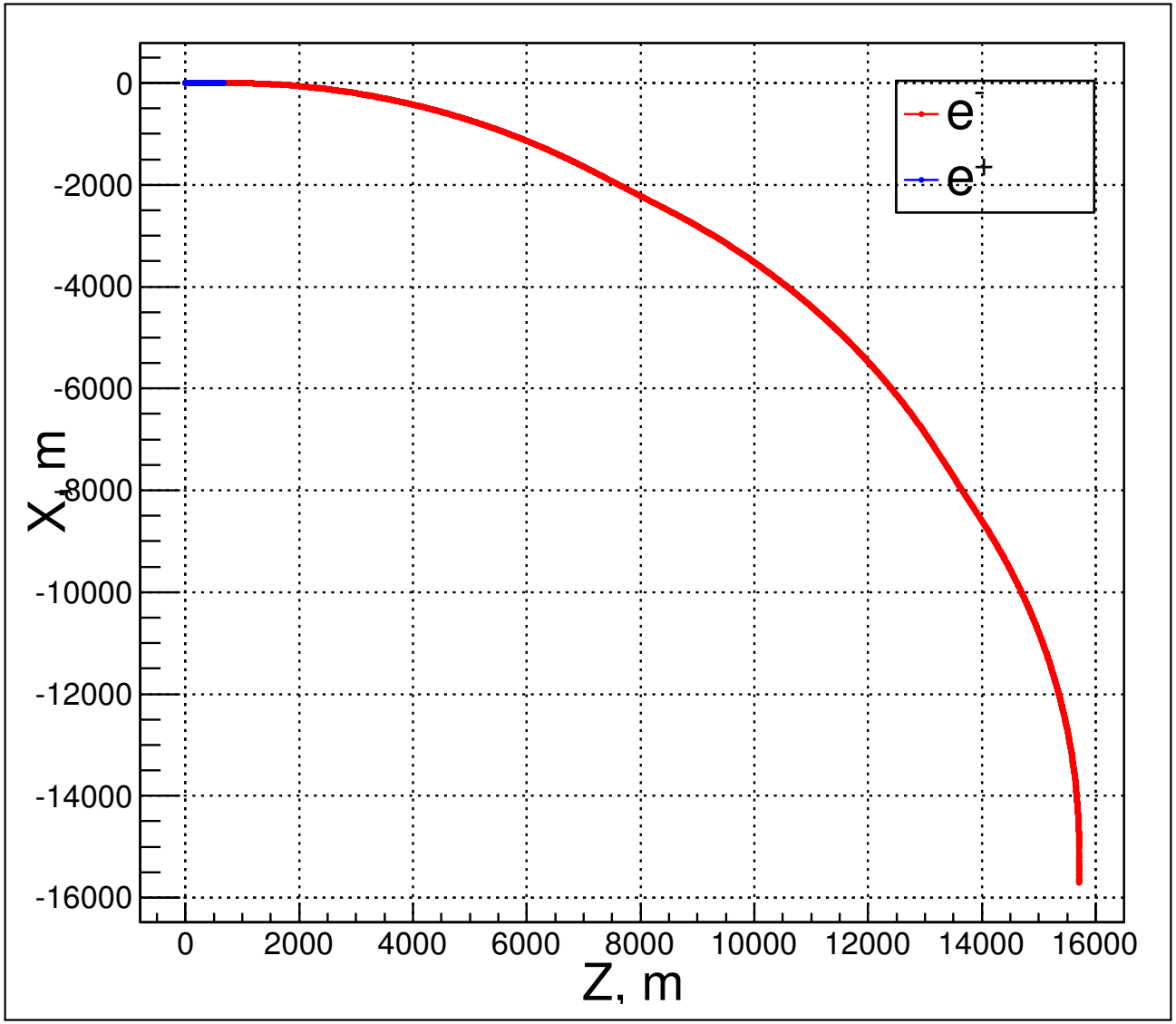
Interaction Region layout



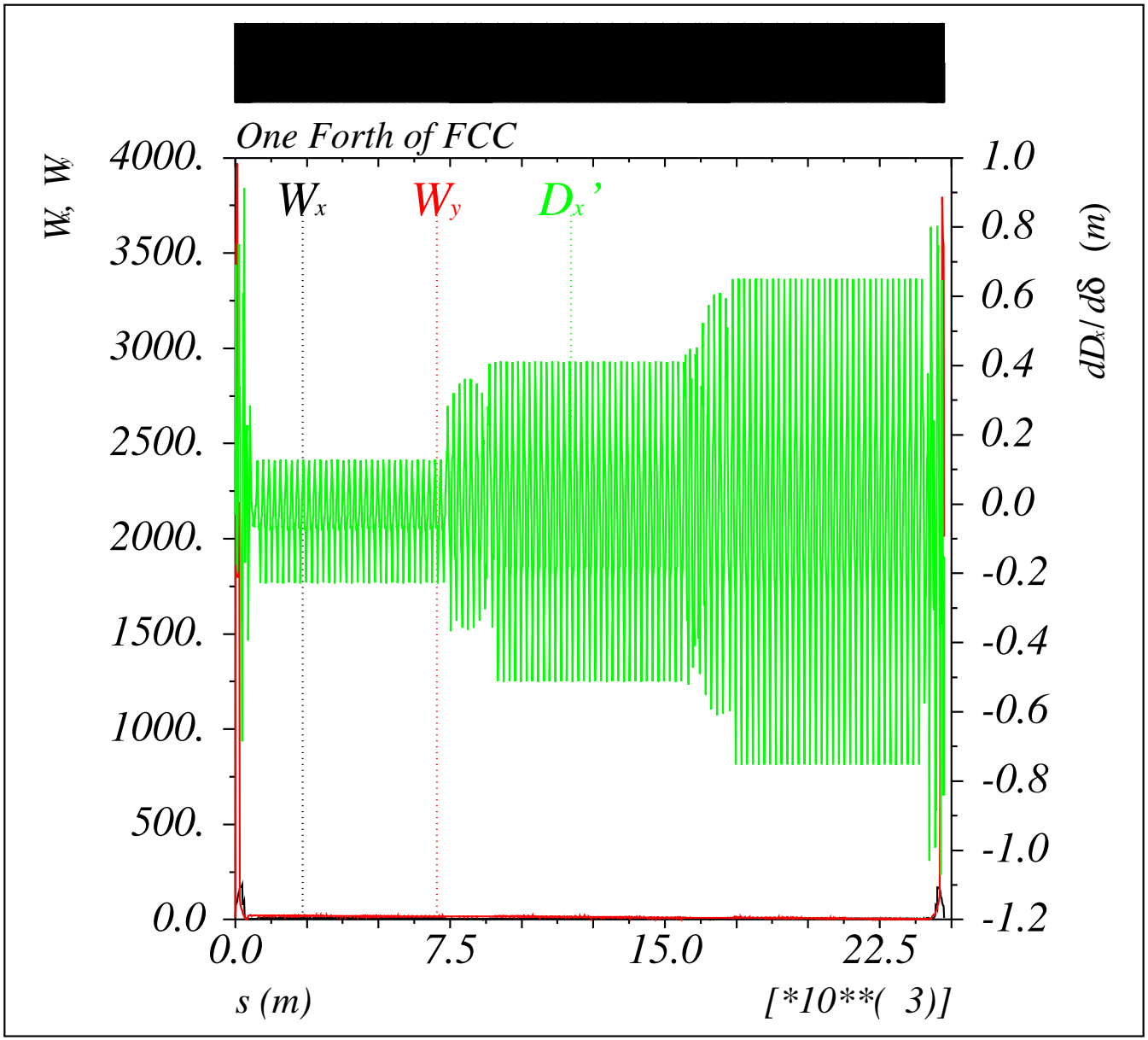
Before the achromatic bend at the crab sextupole each beam is diverging at ± 4.4 mrad.

	L [m]	B [T]	ϕ [mrad]
B0	10.5	0.06	1
B1	10.5	0.21	3.7
B2	10.5	0.21	3.8
B3	14.5	0.21	5.2
B4	14.5	0.21	5.2
B5	14.5	0.03	0.6
B6	14.5	0.01	0.2
B7	14.5	-0.13	-3.2
B8	14.5	-0.13	-3.2
B9	14.5	-0.11	-2.8
B10	10.5	0.06	1

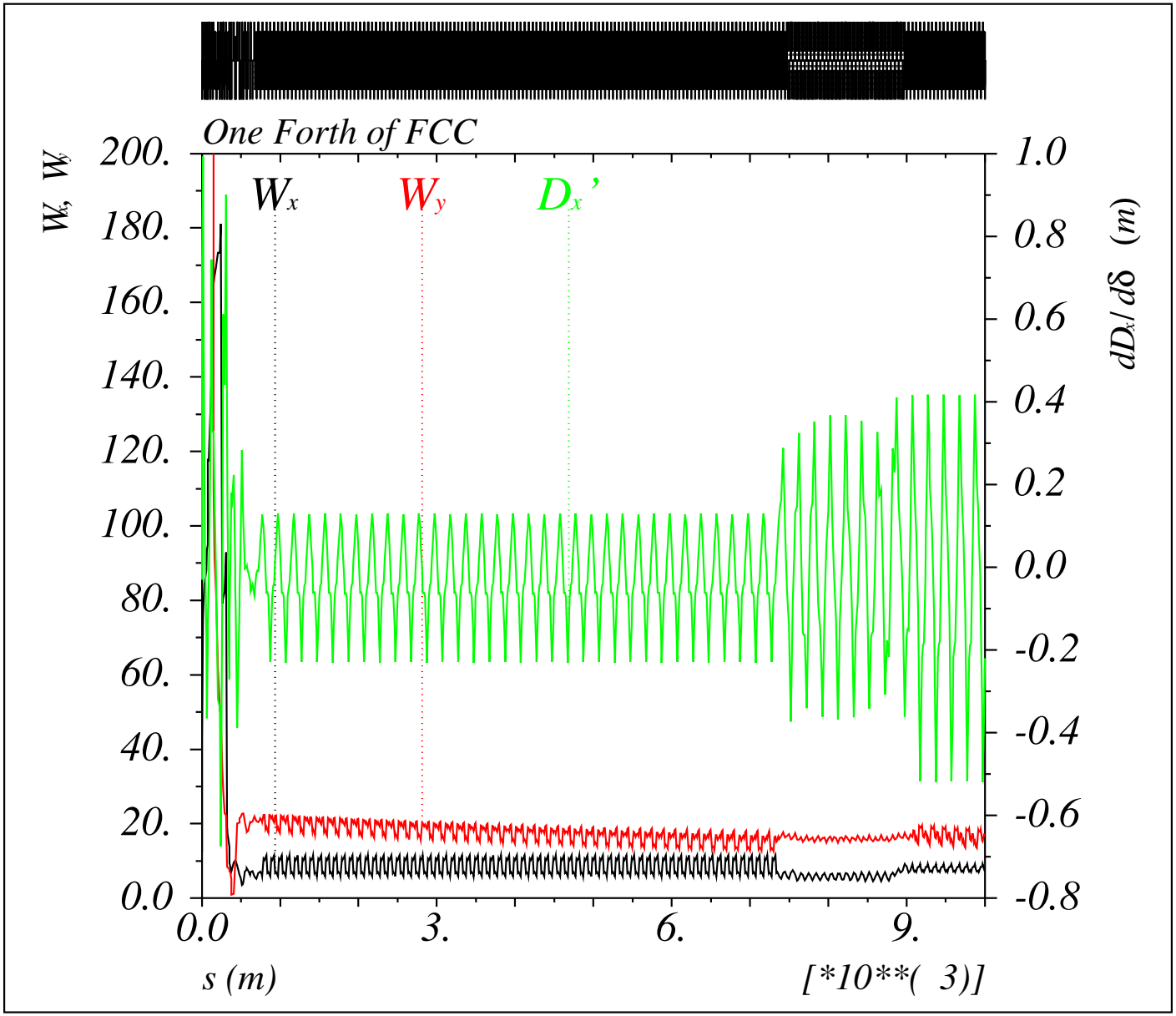
Quarter layout



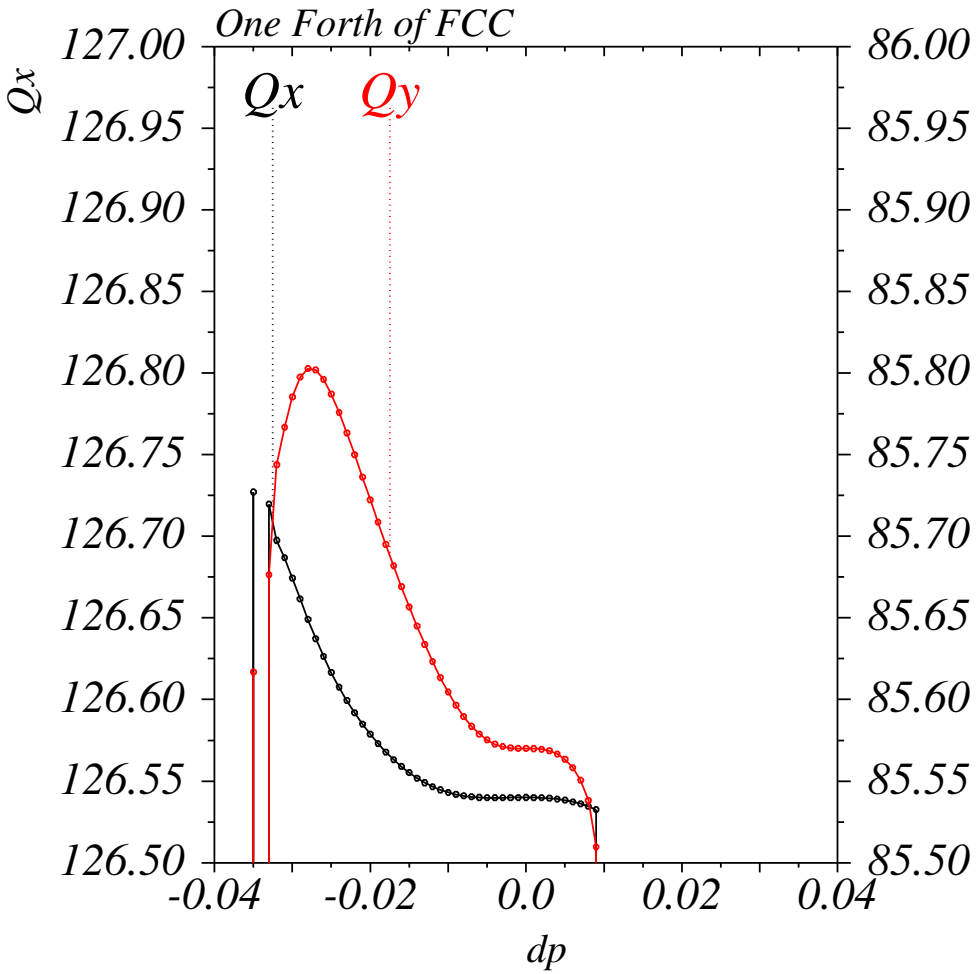
Chromaticity: Montague functions



Chromaticity: Montague functions

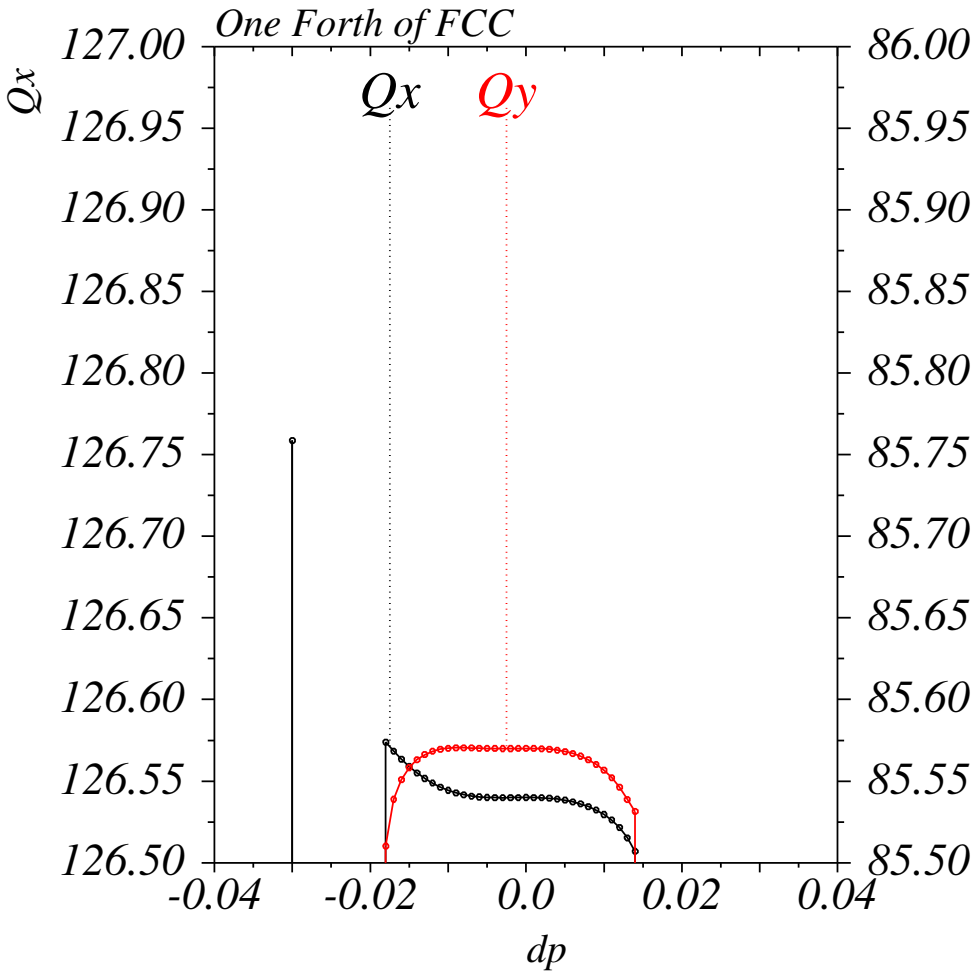


Energy acceptance I: [-3.3%;+0.9%]



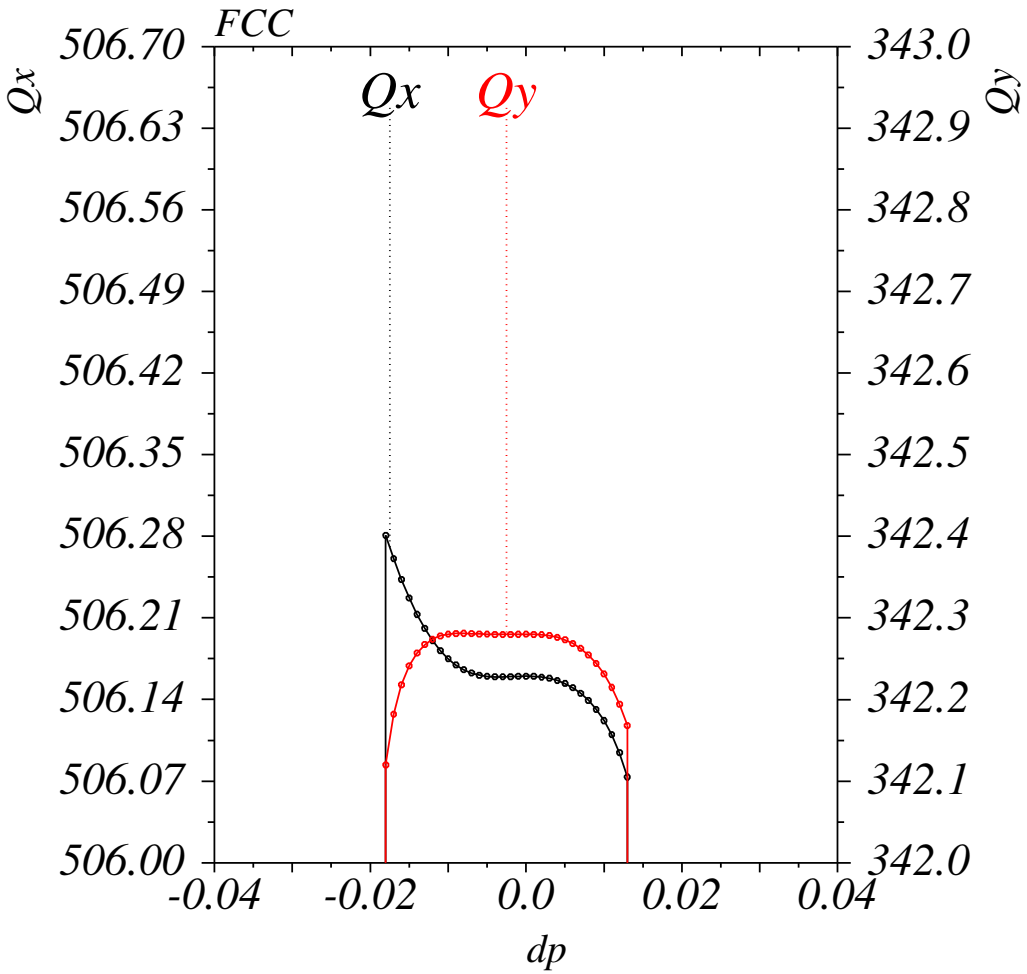
	Value	$\Delta Q(1.5\%)$
Q_x	126.54	
Q'_x	0	0
Q''_x	-81	-0.009
Q'''_x	$-3.6 \cdot 10^4$	-0.02
Q''''_x	$-2.3 \cdot 10^6$	0.005
Q_y	85.57	
Q'_y	0	0
Q''_y	-33	-0.004
Q'''_y	$-2.9 \cdot 10^5$	-0.16
Q''''_y	$-2.7 \cdot 10^6$	-0.006

Energy acceptance II: [-1.8%;+1.4%]



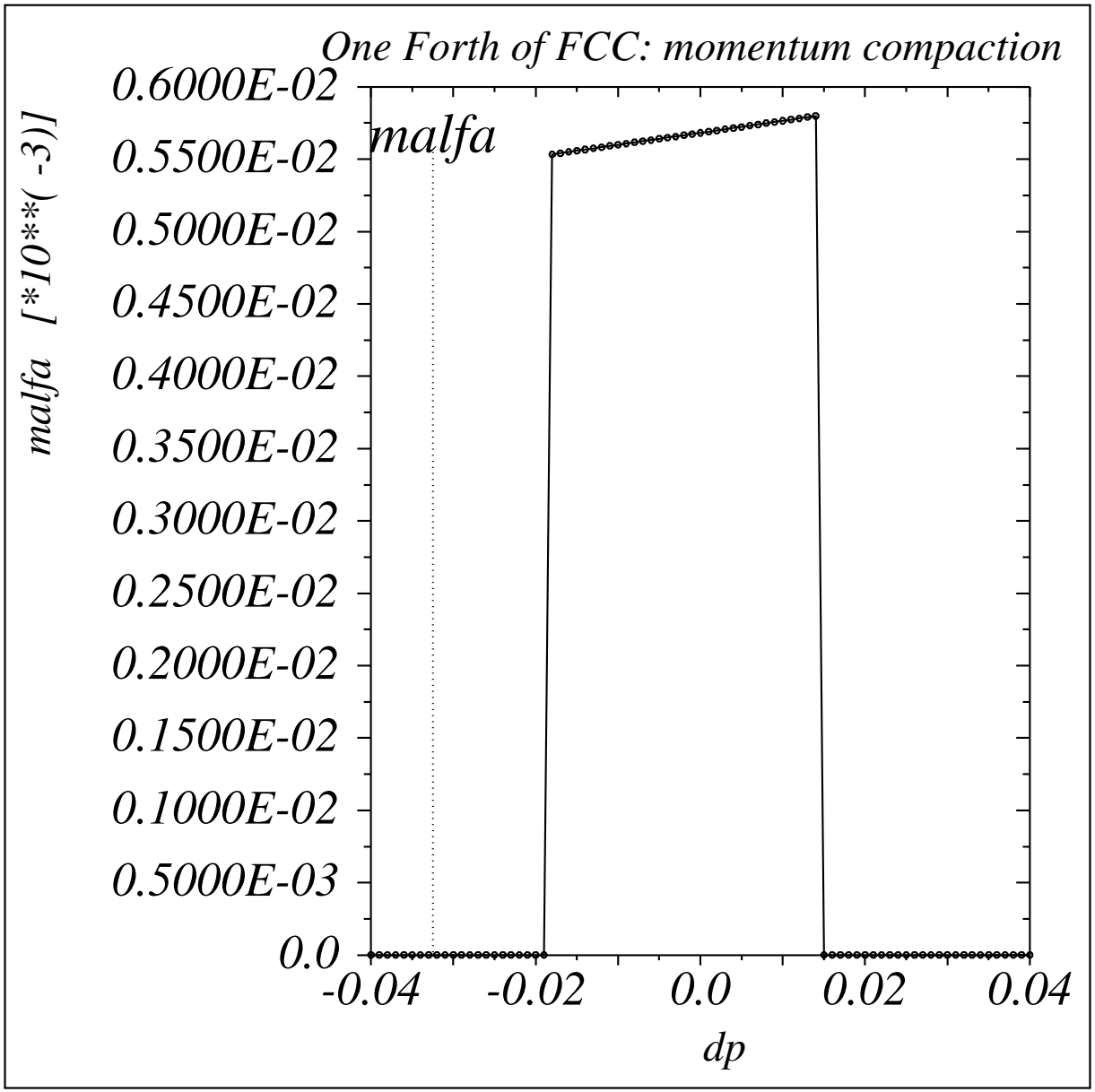
	Value	$\Delta Q(1.5\%)$
Q_x	126.54	
Q'_x	0	0
Q''_x	-73	-0.008
Q'''_x	$-4.1 \cdot 10^4$	-0.02
Q''''_x	$-2.7 \cdot 10^6$	0.006
Q_y	85.57	
Q'_y	0	0
Q''_y	-53	-0.006
Q'''_y	$-5 \cdot 10^4$	-0.028
Q''''_y	$-8 \cdot 10^6$	-0.017

Energy acceptance II: [-1.8%;+1.4%] (full ring)



	Value	$\Delta Q(1.5\%)$
Q_x	506.16	
Q'_x	0	0
Q''_x	-276	-0.03
Q'''_x	$-1.5 \cdot 10^5$	-0.08
Q''''_x	$-9.9 \cdot 10^6$	-0.02
Q_y	342.28	
Q'_y	0	0
Q''_y	-216	-0.02
Q'''_y	$-1.8 \cdot 10^5$	-0.1
Q''''_y	$-3 \cdot 10^7$	-0.06

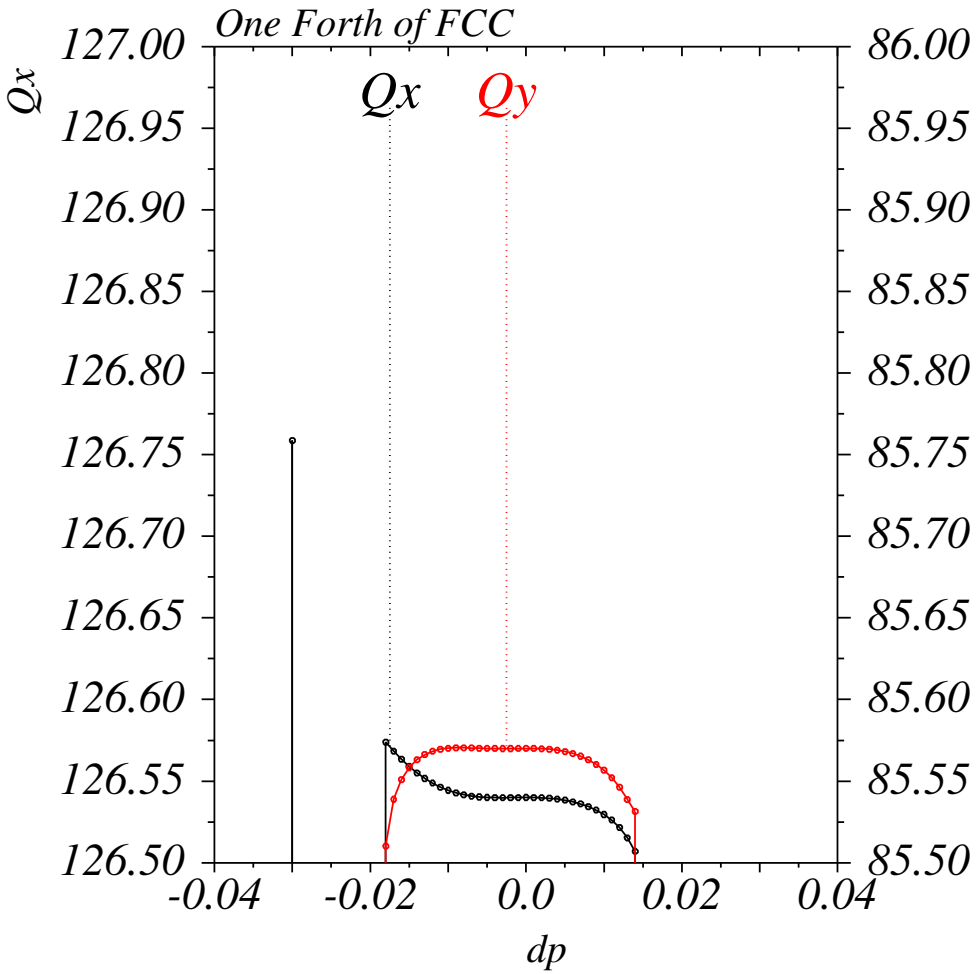
Energy acceptance III: momentum compaction



Parameters of one quarter of the ring

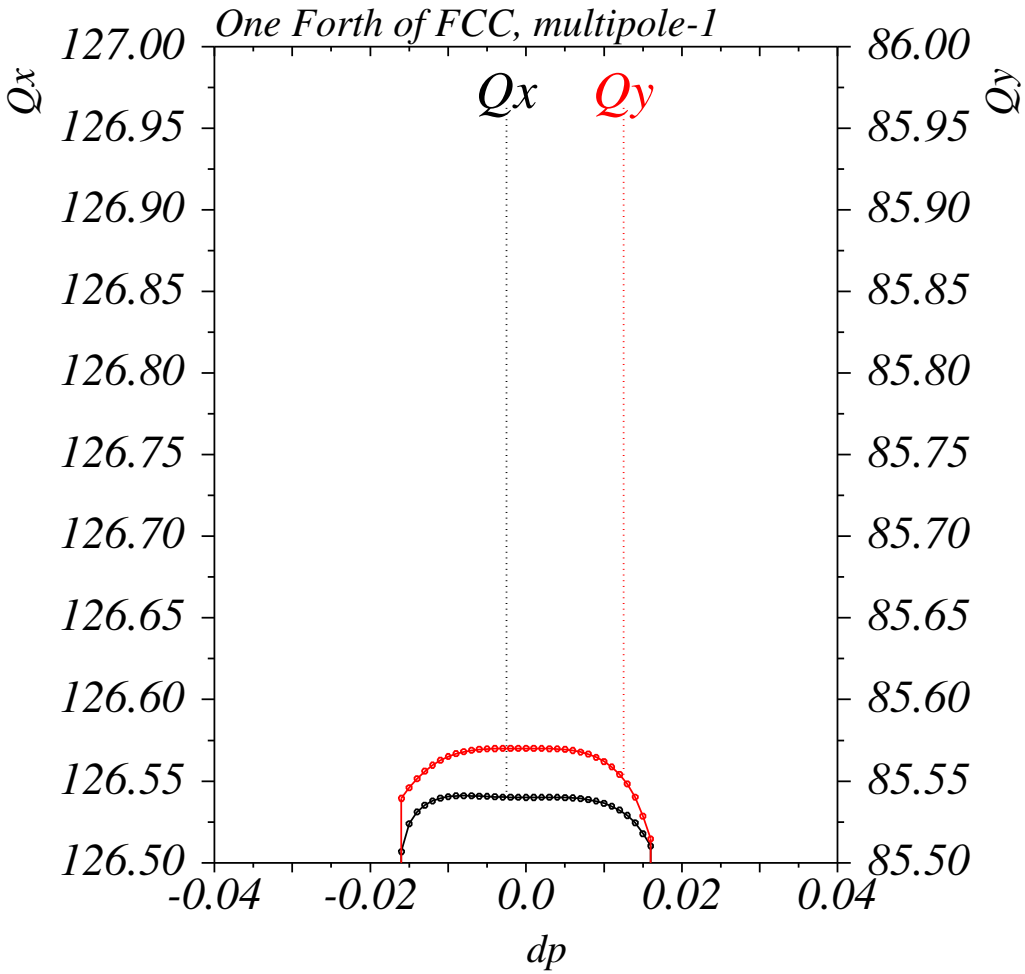
	tt
Energy [GeV]	175
Perimeter [m]	24747.6
Momentum compaction	$5.7 \cdot 10^{-6}$
Emittance hor. [nm]	1.8
Energy spread [10^{-3}]	1.6
β_x^*/β_y^* [m]	0.5 / 0.001
Energy loss / turn [GeV]	2.15

Energy acceptance II: [-1.8%;+1.4%]



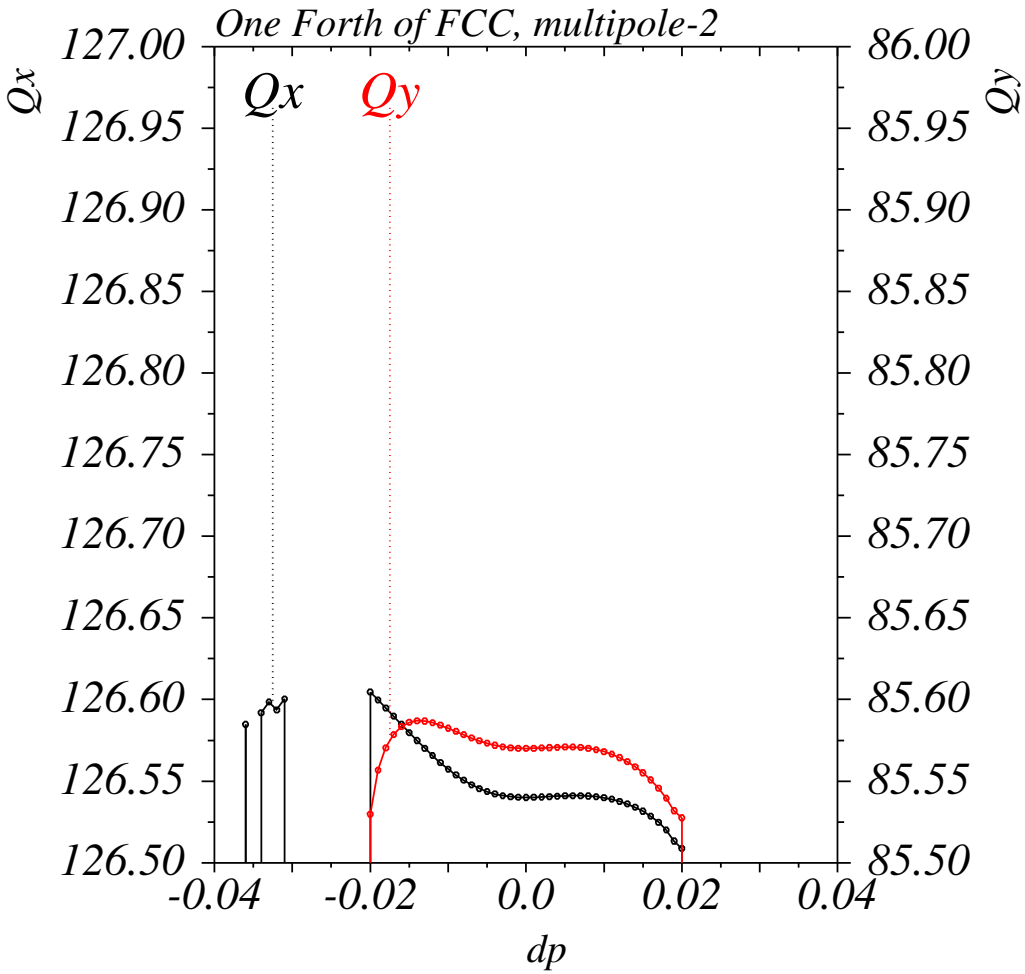
	Value	$\Delta Q(1.5\%)$
Q_x	126.54	
Q'_x	0	0
Q''_x	-73	-0.008
Q'''_x	$-4.1 \cdot 10^4$	-0.02
Q''''_x	$-2.7 \cdot 10^6$	0.006
Q_y	85.57	
Q'_y	0	0
Q''_y	-53	-0.006
Q'''_y	$-5 \cdot 10^4$	-0.028
Q''''_y	$-8 \cdot 10^6$	-0.017

Energy acceptance IV: [-1.6%;+1.6%]



	Value	$\Delta Q(2\%)$
Q_x	126.54	
Q'_x	0	0.
Q''_x	39	-0.008
Q'''_x	$-18 \cdot 10^4$	-0.02
Q''''_x	$-7.9 \cdot 10^6$	-0.05
Q_y	85.57	
Q'_y	0	0
Q''_y	1.5	0.0003
Q'''_y	$-1 \cdot 10^4$	-0.01
Q''''_y	$-1.8 \cdot 10^7$	-0.1

Energy acceptance V: [-2%;+2%]



	Value	$\Delta Q(2\%)$
Q_x	126.54	
Q'_x	0	0
Q''_x	183	0.04
Q'''_x	$-6.6 \cdot 10^4$	-0.09
Q''''_x	$1.3 \cdot 10^6$	0.009
Q_y	85.57	
Q'_y	0	0
Q''_y	180	0.04
Q'''_y	$-6 \cdot 10^4$	-0.08
Q''''_y	$-8.5 \cdot 10^6$	-0.06

Summary I

What is done?

1. Closed ring is ready, files are in /afs/cern.ch/eng/fcc/ee/TLEP_V14_IR_6-13-2
2. At the end of IR the distance between the beams is 3 m.
3. Energy acceptance [-1.8%;+1.4%].
4. Chromaticity of momentum compaction is reasonable.

What is next?

1. Redo the matching section between IR and the arc (accommodate the extra angle of IR into the arc).
2. Change phase advance per cell to odd multiple of $\pi/4$.
3. Four families of sextupoles in the arc and octupoles in IR.
4. Dynamic aperture studies, 6d tracking.

Summary II

Questions

1. Is it possible to build required final focus quadrupoles?
2. How longitudinal detector field will be compensated?
3. Is there a need to increase L^*?
4. Do positions and fields of the dipoles allow for synchrotron radiation shielding and detector background minimization?
5. How much length is needed for RF cavities in the IR?
6. Feedback, please!