

Crab waist interaction region for FCC-ee (one quarter of the ring IR: v. 7, arc: v16)

A. Bogomyagkov

Budker Institute of Nuclear Physics
Novosibirsk

10 July, 2015

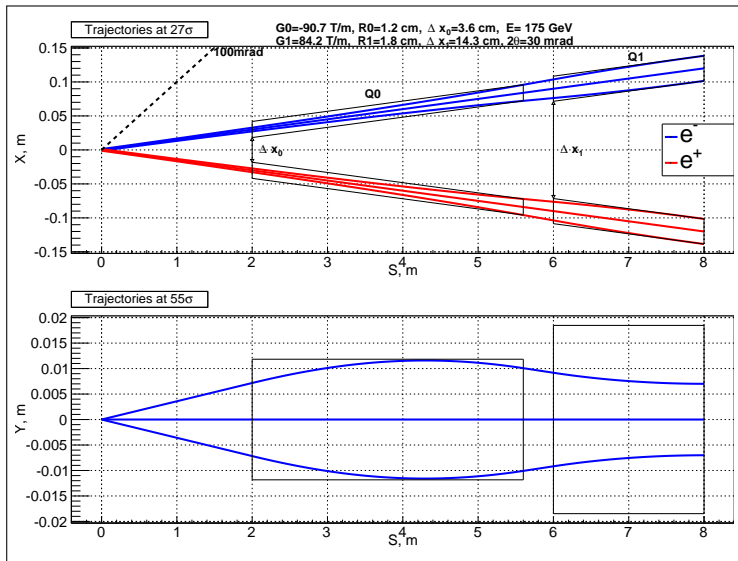
Parameters for crab waist

	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. [μm]	1	2	2	4.3
β_x^*/β_y^* [m]	0.5 / 0.001			
Luminosity / IP [$10^{34} \text{ cm}^{-2} \text{ s}^{-1}$]	212	36	9	1.3
Energy loss / turn [GeV]	0.03	0.3	1.7	7.7

PHYS. REV. S.T. - AB 17, 041004 (2014)

Change β_x : 0.5 \rightarrow 1 m

Final Focus layout



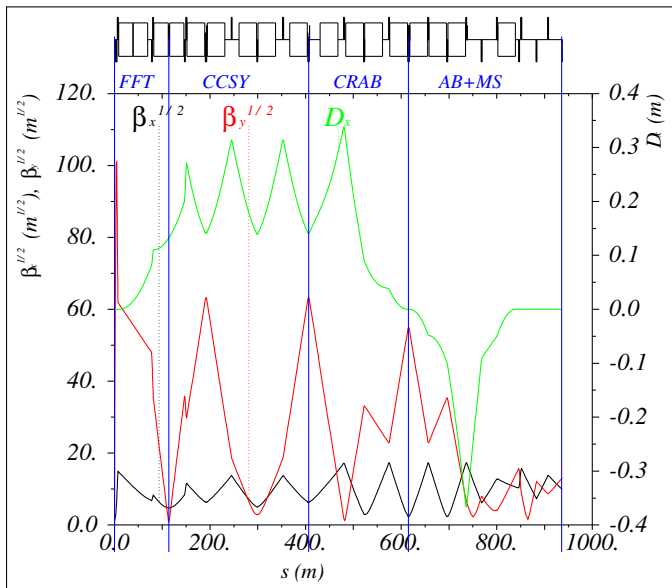
Rectangles are bare apertures.

	L [m]
Q0	3.6
Q1	2

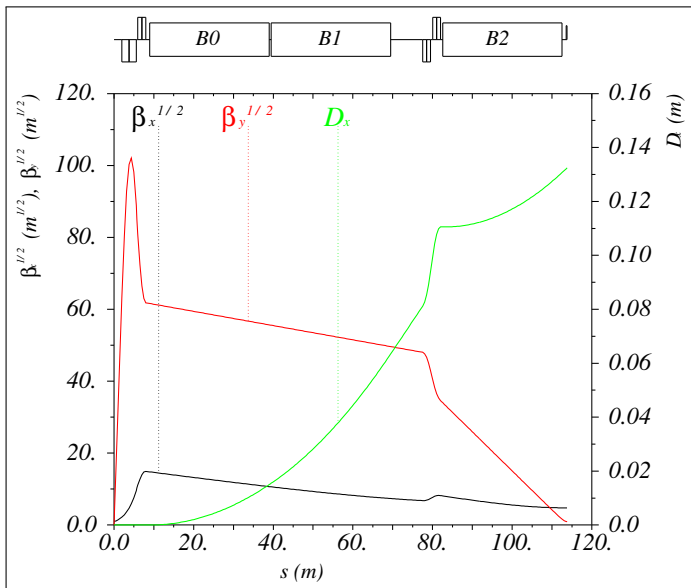
	R [m]
Q0	0.012
Q1	0.019

	B [T]
Q0	1.1
Q1	1.6

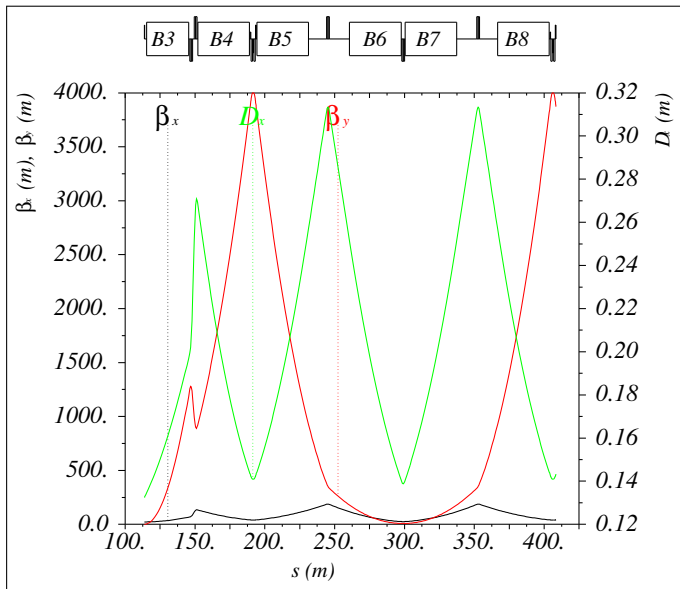
Interaction Region optical functions



Final Focus Telescope

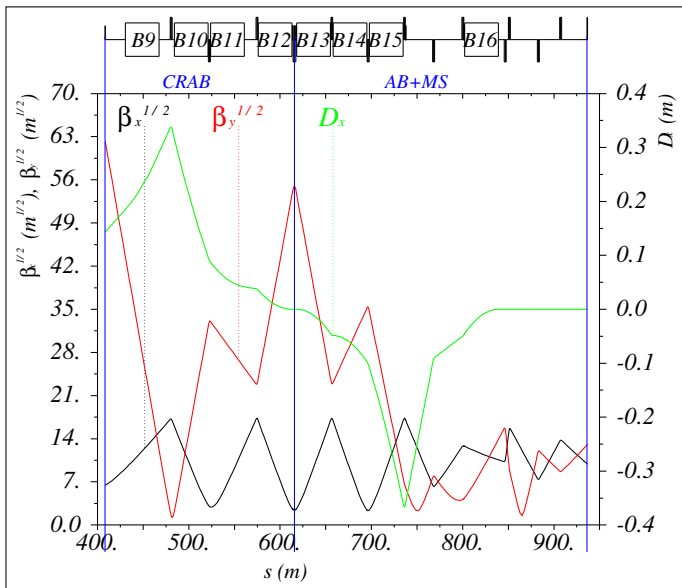


Y Chromaticity Correction Section

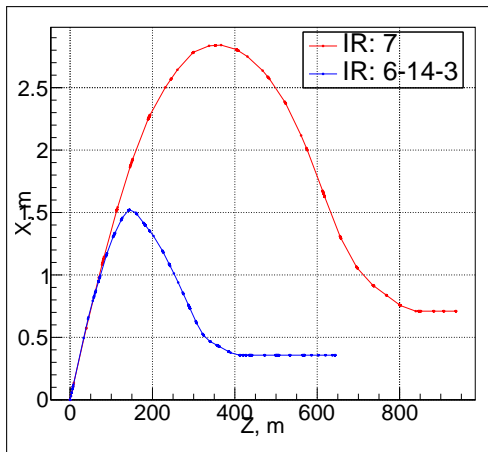


$\beta_y : 7 \rightarrow 4 \text{ km}$
 $\eta_x : 8.47 \rightarrow 14 \text{ cm}$

CRAB, MS, DS sections



Interaction Region layout



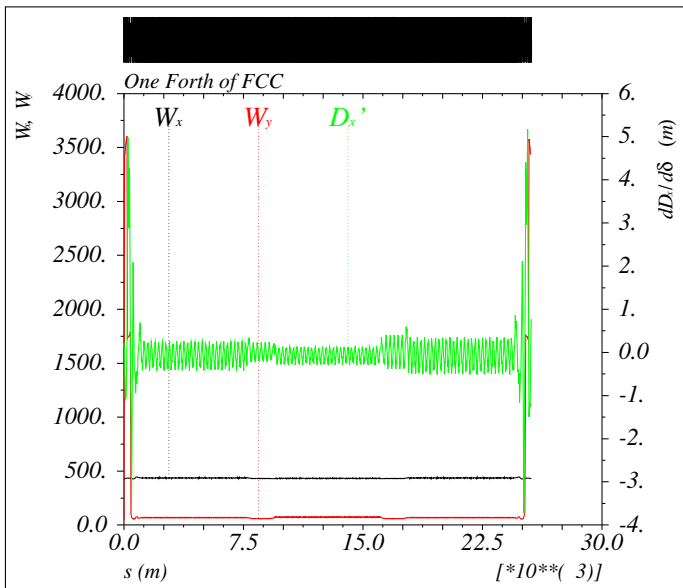
Energy loss $\Delta U = 0.03$ GeV

	L [m]	B [T]	E_γ [keV]
B0	30	0.019	396
B1	30	0.023	475
B2-3	30	0.027	555
B4	37	0.046	932
B5-8	37	0.036	739
B9-12	37	0.030	611
B13-16	37	-0.038	779

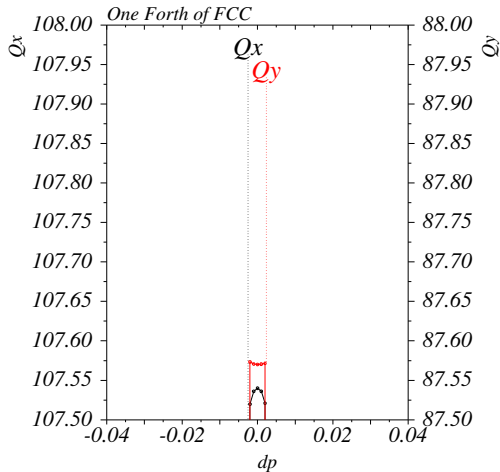
Requirement

The tunnel should be straight in order to accommodate IR for FCC-pp!

Chromaticity I: Montague functions, {107.54; 87.57}

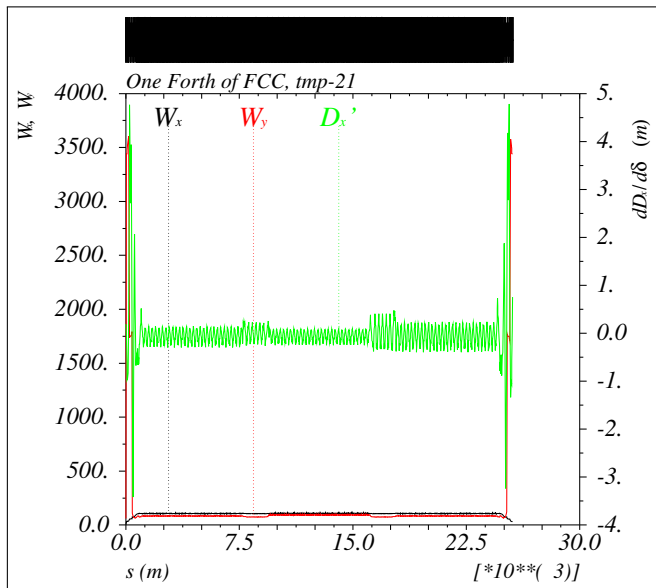


Energy acceptance I: [-0.2%;+0.2%]

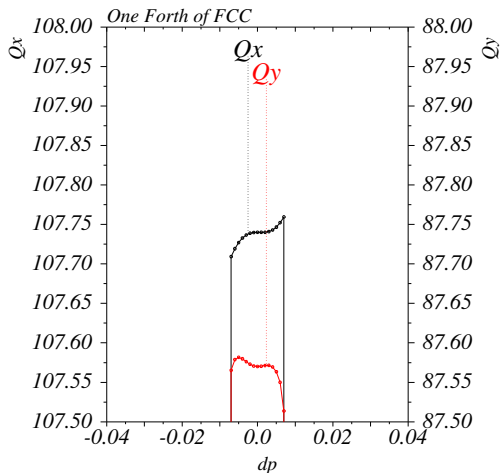


	Value	$\Delta Q(2\%)$
Q_x	107.54	
Q'_x	0	0
Q''_x	-7600	-1.5
Q'''_x	$24 \cdot 10^4$	0.3
Q''''_x	$-4 \cdot 10^9$	-25
Q_y	87.57	
Q'_y	0	0
Q''_y	1300	0.26
Q'''_y	$-75 \cdot 10^4$	-1
Q''''_y	$-4 \cdot 10^8$	-2.6

Chromaticity II: Montague functions, {107.74; 87.57}

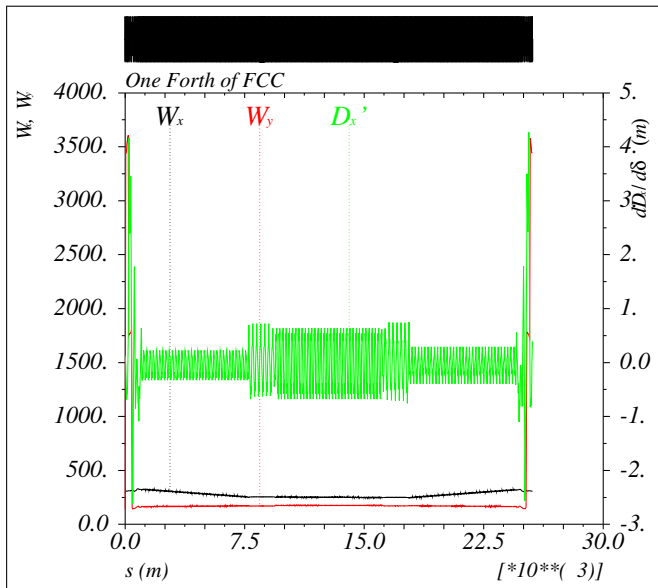


Energy acceptance II: [-0.7%;+0.7%]



	Value	$\Delta Q(2\%)$
Q_x	107.74	
Q'_x	0	0
Q''_x	-295	-0.06
Q'''_x	$49 \cdot 10^4$	0.66
Q''''_x	$21 \cdot 10^6$	0.14
Q_y	87.57	
Q'_y	0	0
Q''_y	1200	0.24
Q'''_y	$-62 \cdot 10^4$	-0.8
Q''''_y	$-4.8 \cdot 10^8$	-3.2

Chromaticity III: Montague functions, {121.54; 121.57}



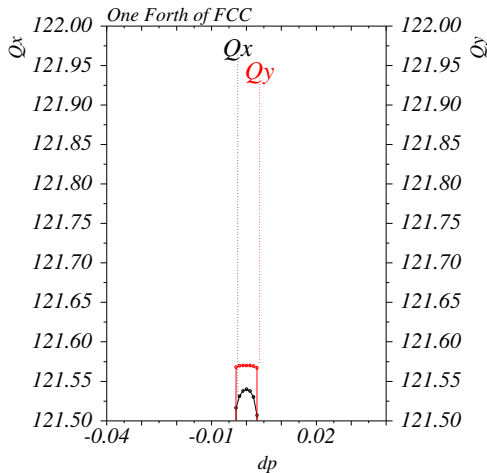
Cell:

$$\mu_x = 0.25$$

$$\mu_y = 0.25.$$

Two families of horizontal sextupoles in each arc.

Energy acceptance III: [-0.3%;+0.3%]



	Value	$\Delta Q(2\%)$
Q_x	121.54	
Q'_x	0	0
Q''_x	-4196	-0.8
Q'''_x	$32 \cdot 10^4$	-0.43
Q''''_x	$-1 \cdot 10^9$	-7
Q_y	121.57	
Q'_y	0	0
Q''_y	10	-0.002
Q'''_y	$-16 \cdot 10^4$	-0.21
Q''''_y	$-7 \cdot 10^8$	-4.8

What is done?

- 1 Decreased fields in the dipoles, introduced new dipoles.
- 2 Interaction region matched to arc ν -16.
- 3 CCSX is eliminated.
- 4 Energy acceptance $[-0.2\%;+0.2\%]$ limited by the forth and the second order horizontal chromaticities.
- 5 Geometry of the IR provides straight tunnel 6 m wide.

Plans

- 1 Install back CCSX.
- 2 Phase advance per cell of $3\pi/4$ and four families of sextupoles.
- 3 Obtain reasonable geometry of the IR.