Summary of the LHC Beams 1 & 2 Parameters Between Separation/Recombination Dipoles D1/D2 at IR's 1 & 5

J.A. Johnstone
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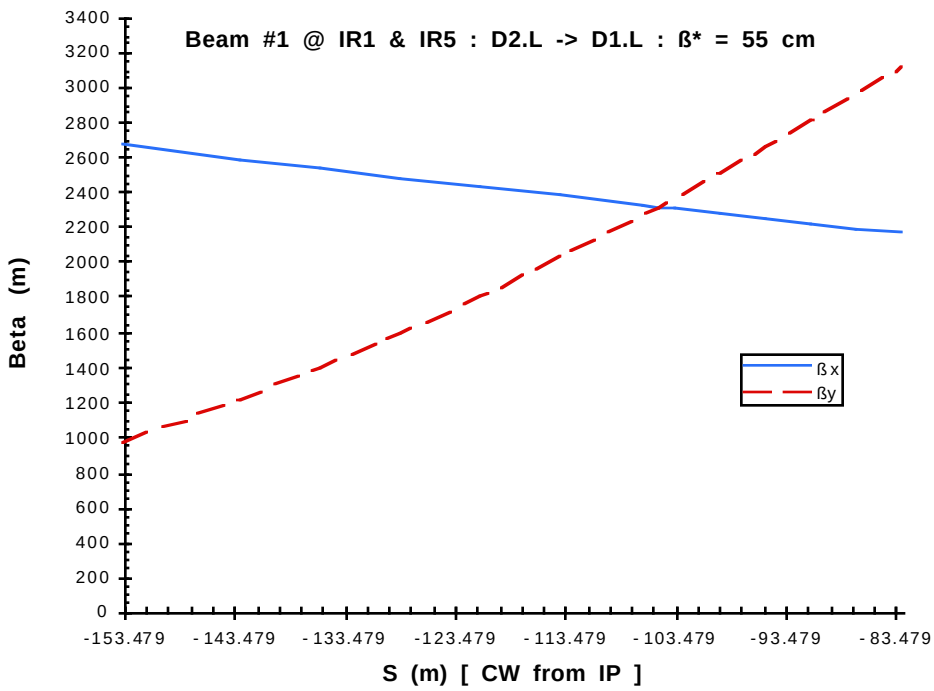
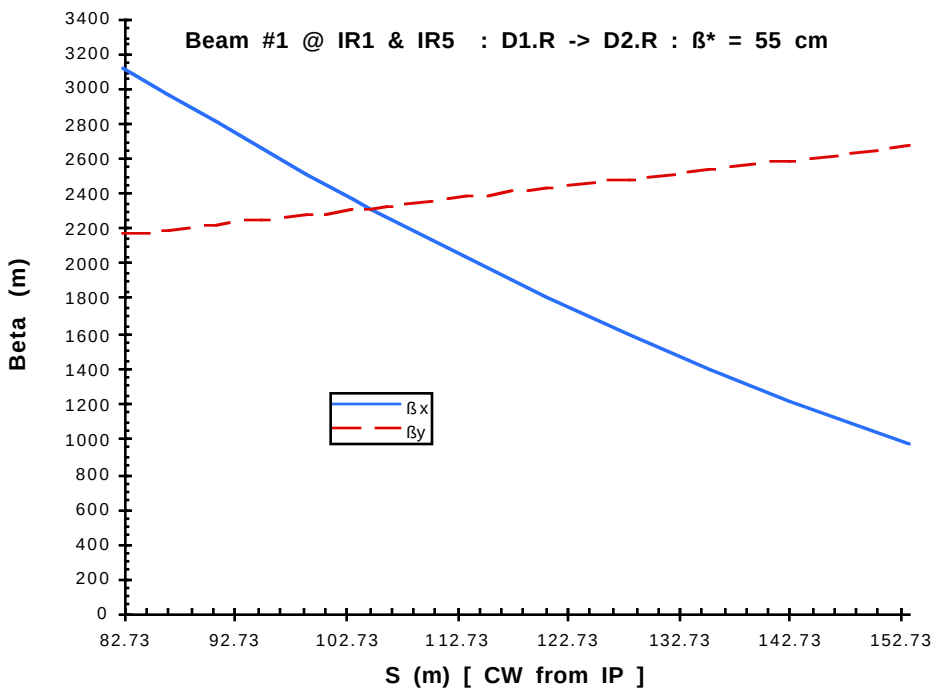
The accompanying graphs, tables and analytic equations describe the behavior of beams 1 & 2 through the 70.75 m drifts separating the D1 & D2 dipoles for colliding beams with β^*'s = 55 cm and 25 cm. Following the LHC design report the one-σ normalized emittance is taken to be 3.75 μm, and half-crossing angles are chosen to give ~9.4σ beam separation at the parasitic crossings. Also following the convention used in the LHC design report, the reference co-ordinate system advances longitudinally clockwise around the ring. This implies that the positive X direction is towards the outside of the ring — *even for beam #2*. Some care should be taken, therefore, in interpreting trajectory offsets Δx from beamline center, and the horizontal dispersion function η.

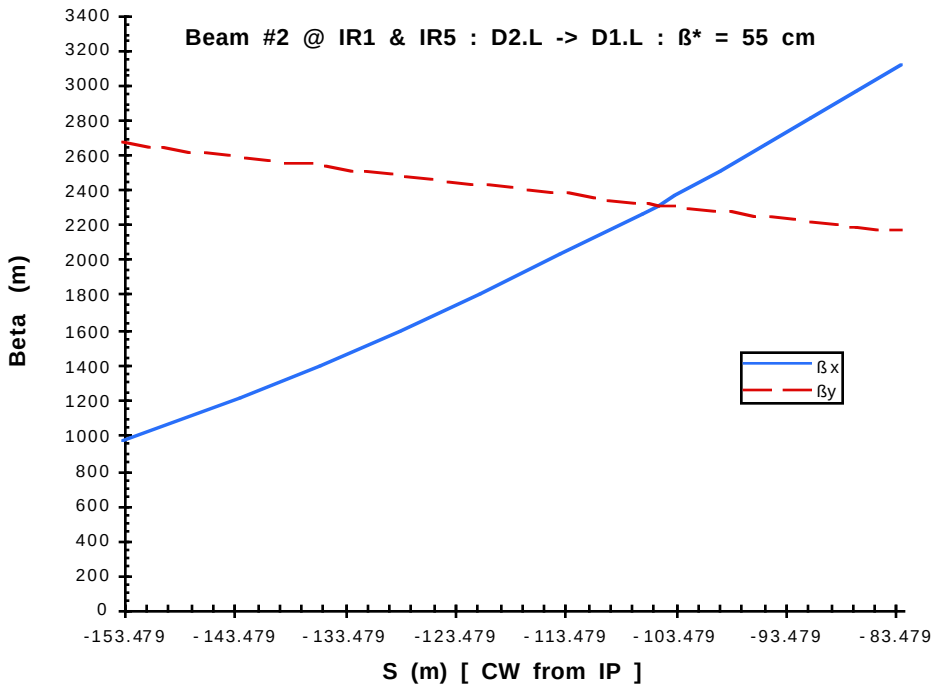
Hopefully this information will prove useful in determing locations for BB compensation hardware & instrumentation; thereby making the exceedingly boring task of compiling it a worthwhile undertaking.

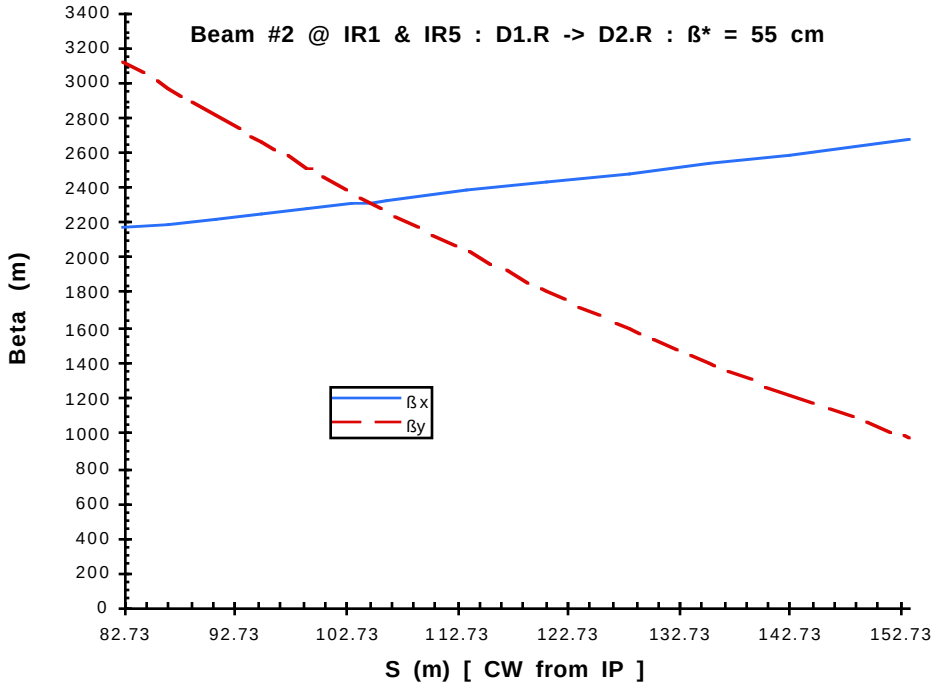
β* = 55 cm : Beam 1


Beam #1 @ IR1 & IR5 : D2.L -> D1.L : ß* = 55 cm
Beta (m)
S (m) [CW from IP]
ßx
ßy
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-153.479
-143.479
-133.479
-123.479
-113.479
-103.479
-93.479
-83.479


Beam #1 @ IR1 & IR5 : D1.R -> D2.R : ß* = 55 cm
Beta (m)
S (m) [CW from IP]
ßx
ßy
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
82.73
92.73
102.73
112.73
122.73
132.73
142.73
152.73

β* = 55 cm : Beam 2


Beam #2 @ IR1 & IR5 : D2.L -> D1.L : ß* = 55 cm
Beta (m)
S (m) [CW from IP]
ß x
ßy
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-153.479
-143.479
-133.479
-123.479
-113.479
-103.479
-93.479
-83.479


Beam #2 @ IR1 & IR5 : D1.R -> D2.R : ß* = 55 cm
Beta (m)
S (m) [CW from IP]
ß x
ßy
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
82.73
92.73
102.73
112.73
122.73
132.73
142.73
152.73

Beam #1 @ IR1 : $\beta^* = 55$ cm ; $\alpha = +142.5$ μrad (V)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	2663.3	9.18	0.0	961.7	-2.08	-3.27
BBC (End)	-106.43	2320.1	3.96	0.0	2259.2	-0.88	-5.02
BBC	-104.93	2309.6	3.79	0.0	2309.6	-0.85	-5.08
BBC (End)	-103.43	2299.1	3.62	0.0	2360.6	-0.81	-5.13
D1.L	-82.73	2156.9	1.33	0.0	3120.7	-0.28	-5.90
IP5	0.0	0.55	0.0	0.0	0.55	0.0	0.0
D1.R	82.73	3120.7	-1.33	0.0	2156.9	1.15	4.91
BBC (End)	103.43	2360.6	-3.62	0.0	2299.1	1.96	5.07
BBC	104.93	2309.6	-3.79	0.0	2309.6	2.02	5.08
BBC (End)	106.43	2259.2	-3.96	0.0	2320.1	2.08	5.09
D2.R	153.48	961.7	-9.18	0.0	2663.3	3.92	5.45

Beam #2 @ IR1 : $\beta^* = 55$ cm ; $\alpha = -142.5$ μrad (V)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	961.7	-9.18	0.0	2663.3	3.92	5.45
BBC (End)	-106.43	2259.2	-3.96	0.0	2320.1	2.08	5.09
BBC	-104.93	2309.6	-3.79	0.0	2309.6	2.02	5.08
BBC (End)	-103.43	2360.6	-3.62	0.0	2299.1	1.96	5.07
D1.L	-82.73	3120.7	-1.33	0.0	2156.9	1.15	4.91
IP5	0.0	0.55	0.0	0.0	0.55	0.0	0.0
D1.R	82.73	2156.9	1.33	0.0	3120.7	-0.28	-5.90
BBC (End)	103.43	2299.1	3.62	0.0	2360.6	-0.81	-5.13
BBC	104.93	2309.6	3.79	0.0	2309.6	-0.85	-5.08
BBC (End)	106.43	2320.1	3.96	0.0	2259.2	-0.88	-5.02
D2.R	153.48	2663.3	9.18	0.0	961.7	-2.08	-3.27

Beam #1 @ IR1 : β* = 55 cm : α = +142.5 μrad (V)

Left Side of IP

$$\beta_{x1}(s) = 2663.3 - 7.564(s + 153.48) + 0.00575(s + 153.48)^2$$
$$\eta_{x1}(s) = 9.176 - 0.1110(s + 153.48)$$

$$\beta_{y1}(s) = 961.7 + 21.746(s + 153.48) + 0.1240(s + 153.48)^2$$
$$\eta_{y1}(s) = -2.083 + 0.0255(s + 153.48)$$
$$\Delta y_1(s) = -3.274 - 0.0372(s + 153.48)$$

Right Side of IP

$$\beta_{x1}(s) = 3120.7 - 39.286(s - 82.73) + 0.1240(s - 82.73)^2$$
$$\eta_{x1}(s) = -1.326 - 0.1110(s - 82.73)$$

$$\beta_{y1}(s) = 2156.9 + 6.752(s - 82.73) + 0.00575(s - 82.73)^2$$
$$\eta_{y1}(s) = 1.152 + 0.0392(s - 82.73)$$
$$\Delta y_1(s) = 4.908 + 0.0077(s - 82.73)$$

Beam #2 @ IR1 : β* = 55 cm : α = -142.5 μrad (V)

Left Side of IP

$$\beta_{x2}(s) = 961.7 + 21.746(s + 153.48) + 0.1240(s + 153.48)^2$$
$$\eta_{x2}(s) = -9.176 + 0.1110(s + 153.48)$$

$$\beta_{y2}(s) = 2663.3 - 7.564(s + 153.48) + 0.00575(s + 153.48)^2$$
$$\eta_{y2}(s) = 3.922 - 0.0554(s + 153.48)$$
$$\Delta y_2(s) = 5.451 - 0.00767(s + 153.48)$$

Right Side of IP

$$\beta_{x2}(s) = 2156.9 + 6.752(s - 82.73) + 0.00575(s - 82.73)^2$$
$$\eta_{x2}(s) = 1.326 + 0.1110(s - 82.73)$$

$$\beta_{y2}(s) = 3120.7 - 39.286(s - 82.73) + 0.1240(s - 82.73)^2$$
$$\eta_{y2}(s) = -0.280 - 0.0263(s - 82.73)$$
$$\Delta y_2(s) = -5.904 + 0.0372(s - 82.73)$$

Beam #1 @ IR5 : $\beta^* = 55$ cm ; $\alpha = +142.5$ μrad (H)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	2663.3	5.25	-5.45	961.7	0.0	0.0
BBC (End)	-106.43	2320.1	1.88	-5.09	2259.2	0.0	0.0
BBC	-104.93	2309.6	1.77	-5.08	2309.6	0.0	0.0
BBC (End)	-103.43	2299.1	1.66	-5.07	2360.6	0.0	0.0
D1.L	-82.73	2156.9	0.17	-4.91	3120.7	0.0	0.0
IP5	0.0	0.55	0.0	0.0	0.55	0.0	0.0
D1.R	82.73	3120.7	-1.05	5.90	2156.9	0.0	0.0
BBC (End)	103.43	2360.6	-2.82	5.13	2299.1	0.0	0.0
BBC	104.93	2309.6	-2.94	5.08	2309.6	0.0	0.0
BBC (End)	106.43	2259.2	-3.07	5.02	2320.1	0.0	0.0
D2.R	153.48	961.7	-7.09	3.27	2663.3	0.0	0.0

Beam #2 @ IR5 : $\beta^* = 55$ cm ; $\alpha = -142.5$ μrad (H)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	961.7	-7.09	3.27	2663.3	0.0	0.0
BBC (End)	-106.43	2259.2	-3.07	5.02	2320.1	0.0	0.0
BBC	-104.93	2309.6	-2.94	5.08	2309.6	0.0	0.0
BBC (End)	-103.43	2360.6	-2.82	5.13	2299.1	0.0	0.0
D1.L	-82.73	3120.7	-1.05	5.90	2156.9	0.0	0.0
IP5	0.0	0.55	0.0	0.0	0.55	0.0	0.0
D1.R	82.73	2156.9	0.17	-4.91	3120.7	0.0	0.0
BBC (End)	103.43	2299.1	1.66	-5.07	2360.6	0.0	0.0
BBC	104.93	2309.6	1.77	-5.08	2309.6	0.0	0.0
BBC (End)	106.43	2320.1	1.88	-5.09	2259.2	0.0	0.0
D2.R	153.48	2663.3	5.25	-5.45	961.7	0.0	0.0

Beam #1 @ IR5 : β* = 55 cm : α = +142.5 μrad (H)

Left Side of IP

$$\beta_{x1}(s) = 2663.3 - 7.564(s + 153.48) + 0.00575(s + 153.48)^2$$
$$\eta_{x1}(s) = 5.254 - 0.0178(s + 153.48)$$
$$\Delta x_1(s) = -5.451 + 0.00767(s + 153.48)$$

$$\beta_{y1}(s) = 961.7 + 21.746(s + 153.48) + 0.1240(s + 153.48)^2$$

Right Side of IP

$$\beta_{x1}(s) = 3120.7 - 39.286(s - 82.73) + 0.1240(s - 82.73)^2$$
$$\eta_{x1}(s) = -1.045 - 0.0855(s - 82.73)$$
$$\Delta x_1(s) = 5.904 - 0.0372(s - 82.73)$$

$$\beta_{y1}(s) = 2156.9 + 6.752(s - 82.73) + 0.00575(s - 82.73)^2$$

Beam #2 @ IR5 : β* = 55 cm : α = -142.5 μrad (H)

Left Side of IP

$$\beta_{x2}(s) = 961.7 + 21.746(s + 153.48) + 0.1240(s + 153.48)^2$$
$$\eta_{x2}(s) = -7.093 + 0.0855(s + 153.48)$$
$$\Delta x_2(s) = 3.274 + 0.0372(s + 153.48)$$

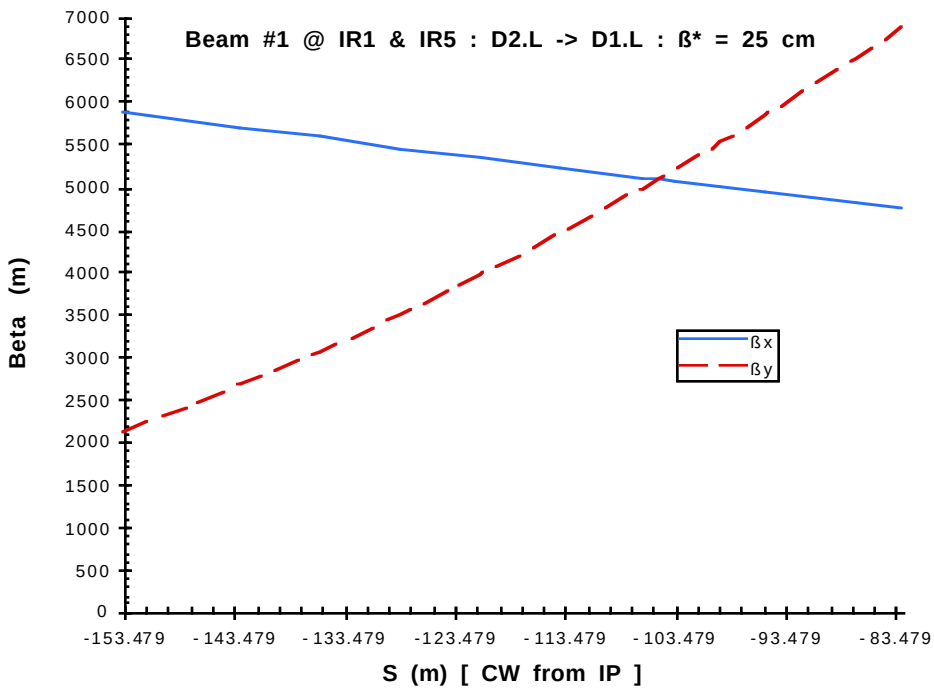
$$\beta_{y2}(s) = 2663.3 - 7.564(s + 153.48) + 0.00575(s + 153.48)^2$$

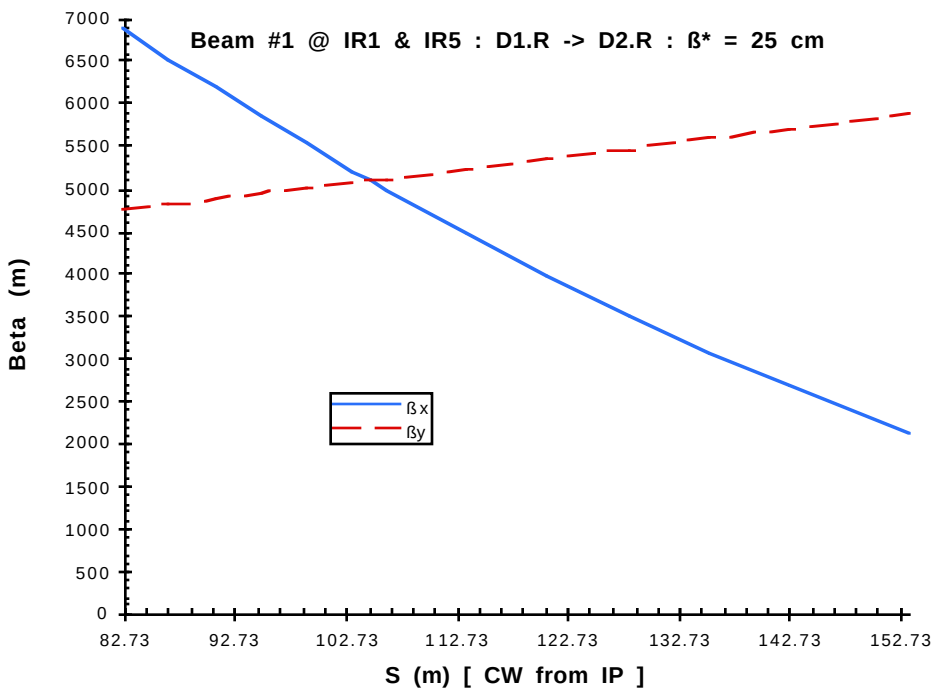
Right Side of IP

$$\beta_{x2}(s) = 2156.9 + 6.752(s - 82.73) + 0.00575(s - 82.73)^2$$
$$\eta_{x2}(s) = 0.174 + 0.0718(s - 82.73)$$
$$\Delta x_2(s) = -4.908 - 0.00767(s - 82.73)$$

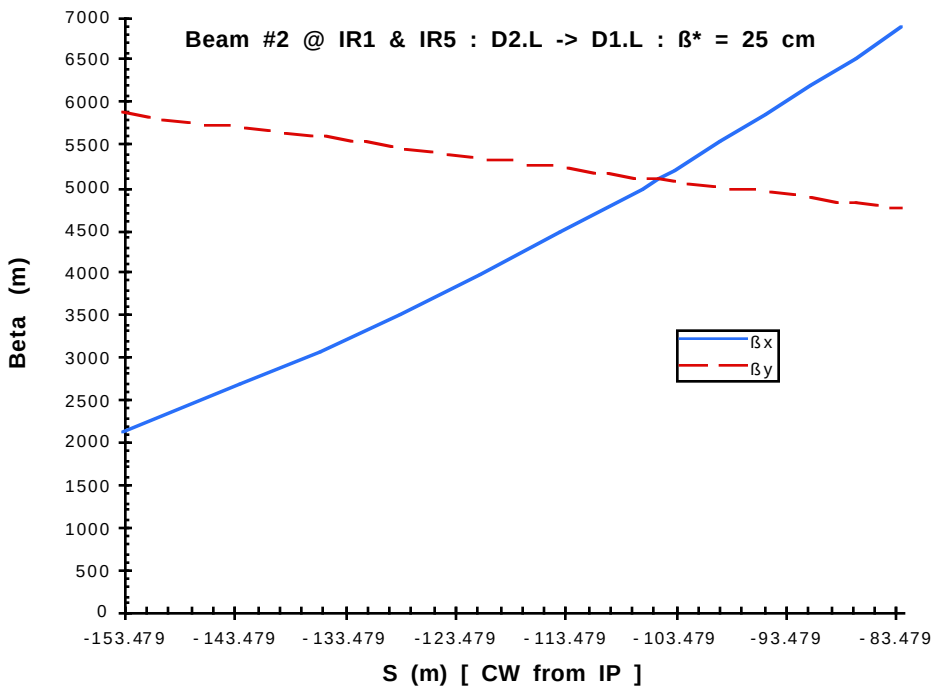
$$\beta_{y2}(s) = 3120.7 - 39.286(s - 82.73) + 0.1240(s - 82.73)^2$$

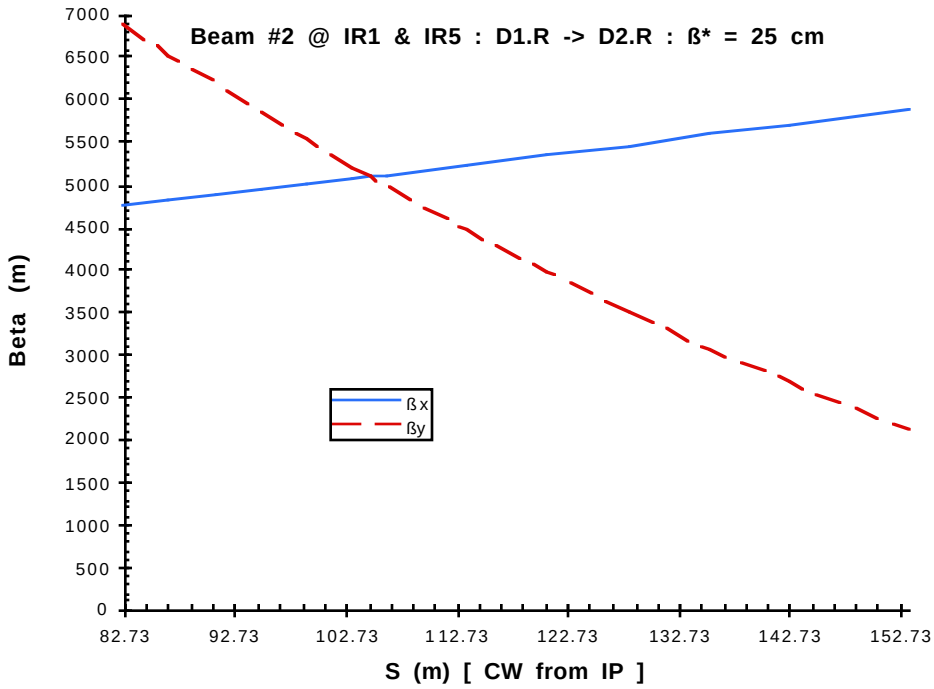
β* = 25 cm : Beam 1


Beam #1 @ IR1 & IR5 : D2.L -> D1.L : ß* = 25 cm
Beta (m)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-153.479
-143.479
-133.479
-123.479
-113.479
-103.479
-93.479
-83.479
S (m) [CW from IP]
ßx
ßy


Beam #1 @ IR1 & IR5 : D1.R -> D2.R : ß* = 25 cm
Beta (m)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
82.73
92.73
102.73
112.73
122.73
132.73
142.73
152.73
S (m) [CW from IP]
ßx
ßy

β* = 25 cm : Beam 2


Beam #2 @ IR1 & IR5 : D2.L -> D1.L : ß* = 25 cm
Beta (m)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-153.479
-143.479
-133.479
-123.479
-113.479
-103.479
-93.479
-83.479
S (m) [CW from IP]
ßx
ßy


Beam #2 @ IR1 & IR5 : D1.R -> D2.R : ß* = 25 cm
Beta (m)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
82.73
92.73
102.73
112.73
122.73
132.73
142.73
152.73
S (m) [CW from IP]
ßx
ßy

Beam #1 @ IR5 : β^* = 25 cm ; α =+211.0 μrad (H)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	5854.3	3.37	-8.07	2112.4	0.0	0.0
BBC (End)	-106.43	5103.5	0.88	-7.54	4969.6	0.0	0.0
BBC	-104.93	5080.5	0.80	-7.52	5080.5	0.0	0.0
BBC (End)	-103.43	5057.4	0.72	-7.50	5192.7	0.0	0.0
D1.L	-82.73	4745.1	-0.38	-7.27	6865.5	0.0	0.0
IP5	0.0	0.25	0.0	0.0	0.25	0.0	0.0
D1.R	82.73	6865.5	-0.91	8.74	4745.1	0.0	0.0
BBC (End)	103.43	5192.7	-2.43	7.60	5057.4	0.0	0.0
BBC	104.93	5080.6	-2.54	7.52	5080.5	0.0	0.0
BBC (End)	106.43	4969.6	-2.65	7.44	5103.5	0.0	0.0
D2.R	153.48	2112.4	-6.09	4.84	5854.3	0.0	0.0

Beam #2 @ IR5 : β^* = 25 cm ; α = –211.0 μrad (H)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	2112.4	-6.09	4.85	5854.3	0.0	0.0
BBC (End)	-106.43	4969.6	-2.65	7.44	5103.5	0.0	0.0
BBC	-104.93	5080.5	-2.54	7.52	5080.5	0.0	0.0
BBC (End)	-103.43	5192.7	-2.43	7.60	5057.4	0.0	0.0
D1.L	-82.73	6865.5	-0.91	8.74	4745.1	0.0	0.0
IP5	0.0	0.25	0.0	0.0	0.25	0.0	0.0
D1.R	82.73	4745.1	-0.38	-7.27	6865.5	0.0	0.0
BBC (End)	103.43	5057.4	0.72	-7.50	5192.7	0.0	0.0
BBC	104.93	5080.5	0.80	-7.52	5080.6	0.0	0.0
BBC (End)	106.43	5103.5	0.88	-7.54	4969.6	0.0	0.0
D2.R	153.48	5854.3	3.37	-8.07	2112.4	0.0	0.0

Beam #1 @ IR1 : β* = 25 cm : α = +211.0 μrad (V)

Left Side of IP

$$\beta_{x1}(s) = 5854.3 - 16.514(s + 153.48) + 0.01182(s + 153.48)^2$$
$$\eta_{x1}(s) = 9.176 - 0.1110(s + 153.48)$$

$$\beta_{y1}(s) = 2112.4 + 47.920(s + 153.48) + 0.2722(s + 153.48)^2$$
$$\eta_{y1}(s) = -3.084 + 0.0377(s + 153.48)$$
$$\Delta y_1(s) = -4.848 - 0.0550(s + 153.48)$$

Right Side of IP

$$\beta_{x1}(s) = 6865.5 - 86.444(s - 82.73) + 0.2723(s - 82.73)^2$$
$$\eta_{x1}(s) = -1.326 - 0.1110(s - 82.73)$$

$$\beta_{y1}(s) = 4745.1 + 14.842(s - 82.73) + 0.01182(s - 82.73)^2$$
$$\eta_{y1}(s) = 1.705 + 0.0580(s - 82.73)$$
$$\Delta y_1(s) = 7.267 + 0.0114(s - 82.73)$$

Beam #2 @ IR1 : β* = 25 cm : α = -211.0 μrad (V)

Left Side of IP

$$\beta_{x2}(s) = 2112.4 + 47.920(s + 153.48) + 0.2722(s + 153.48)^2$$
$$\eta_{x2}(s) = -9.176 + 0.1110(s + 153.48)$$

$$\beta_{y2}(s) = 5854.3 - 16.514(s + 153.48) + 0.01182(s + 153.48)^2$$
$$\eta_{y2}(s) = 5.808 - 0.0580(s + 153.48)$$
$$\Delta y_2(s) = 8.071 - 0.0114(s + 153.48)$$

Right Side of IP

$$\beta_{x2}(s) = 4745.1 + 14.842(s - 82.73) + 0.01182(s - 82.73)^2$$
$$\eta_{x2}(s) = 1.326 + 0.1110(s - 82.73)$$

$$\beta_{y2}(s) = 6865.5 - 86.444(s - 82.73) + 0.2723(s - 82.73)^2$$
$$\eta_{y2}(s) = -0.415 - 0.0377(s - 82.73)$$
$$\Delta y_2(s) = -8.742 + 0.0550(s - 82.73)$$

Beam #1 @ IR1 : $\beta^* = 25$ cm ; $\alpha = +211.0$ μrad (V)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	5854.3	9.18	0.0	2112.4	-3.08	-4.85
BBC (End)	-106.43	5103.5	3.96	0.0	4969.6	-1.31	-7.44
BBC	-104.93	5080.5	3.79	0.0	5080.5	-1.25	-7.52
BBC (End)	-103.43	5057.4	3.62	0.0	5192.7	-1.20	-7.60
D1.L	-82.73	4745.1	1.33	0.0	6865.5	-0.42	-8.74
IP5	0.0	0.25	0.0	0.0	0.25	0.0	0.0
D1.R	82.73	6865.5	-1.33	0.0	4745.1	1.71	7.27
BBC (End)	103.43	5192.7	-3.62	0.0	5057.4	2.91	7.50
BBC	104.93	5080.6	-3.79	0.0	5080.5	2.99	7.52
BBC (End)	106.43	4969.6	-3.96	0.0	5103.5	3.08	7.54
D2.R	153.48	2112.4	-9.18	0.0	5854.3	5.81	8.07

Beam #2 @ IR1 : $\beta^* = 25$ cm ; $\alpha = -211.0$ μrad (V)							
Location	S (m)	βx (m)	ηx (cm)	Δx_o (mm)	βy (m)	ηy (cm)	Δy_o (mm)
D2.L	-153.48	2112.4	-9.18	0.0	5854.3	5.81	8.07
BBC (End)	-106.43	4969.6	-3.96	0.0	5103.5	3.08	7.54
BBC	-104.93	5080.5	-3.79	0.0	5080.5	2.99	7.52
BBC (End)	-103.43	5192.7	-3.62	0.0	5057.4	2.91	7.50
D1.L	-82.73	6865.5	-1.33	0.0	4745.1	1.71	7.27
IP5	0.0	0.25	0.0	0.0	0.25	0.0	0.0
D1.R	82.73	4745.1	1.33	0.0	6865.5	-0.42	-8.74
BBC (End)	103.43	5057.4	3.62	0.0	5192.7	-1.20	-7.60
BBC	104.93	5080.5	3.79	0.0	5080.6	-1.25	-7.52
BBC (End)	106.43	5103.5	3.96	0.0	4969.6	-1.31	-7.44
D2.R	153.48	5854.3	9.18	0.0	2112.4	-3.08	-4.85

Beam #1 @ IR5 : β* = 25 cm : α = +211.0 μrad (H)

Left Side of IP

$$\beta_{x1}(s) = 5854.3 - 16.514(s + 153.48) + 0.01182(s + 153.48)^2$$
$$\eta_{x1}(s) = 3.368 - 0.0422(s + 153.48)$$
$$\Delta x_1(s) = -8.071 + 0.0114(s + 153.48)$$

$$\beta_{y1}(s) = 2112.4 + 47.920(s + 153.48) + 0.2722(s + 153.48)^2$$

Right Side of IP

$$\beta_{x1}(s) = 6865.5 - 86.444(s - 82.73) + 0.2723(s - 82.73)^2$$
$$\eta_{x1}(s) = -0.911 - 0.0732(s - 82.73)$$
$$\Delta x_1(s) = 8.742 - 0.0550(s - 82.73)$$

$$\beta_{y1}(s) = 4745.1 + 14.842(s - 82.73) + 0.01182(s - 82.73)^2$$

Beam #2 @ IR5 : β* = 25 cm : α = -211.0 μrad (H)

Left Side of IP

$$\beta_{x2}(s) = 2112.4 + 47.920(s + 153.48) + 0.2722(s + 153.48)^2$$
$$\eta_{x2}(s) = -6.092 + 0.0732(s + 153.48)$$
$$\Delta x_2(s) = 4.848 + 0.0550(s + 153.48)$$

$$\beta_{y2}(s) = 5854.3 - 16.514(s + 153.48) + 0.01182(s + 153.48)^2$$

Right Side of IP

$$\beta_{x2}(s) = 4745.1 + 14.842(s - 82.73) + 0.01182(s - 82.73)^2$$
$$\eta_{x2}(s) = -0.379 + 0.0530(s - 82.73)$$
$$\Delta x_2(s) = -7.267 - 0.0114(s - 82.73)$$

$$\beta_{y2}(s) = 6865.5 - 86.444(s - 82.73) + 0.2723(s - 82.73)^2$$

Ω