Optics and Emittance Growth in BC's

OPTIMAL BEAM OPTICS IN THE TTF-FEL BUNCH COMPRESSION SECTIONS: MINIMIZING THE EMITTANCE GROWTH

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PAC 99

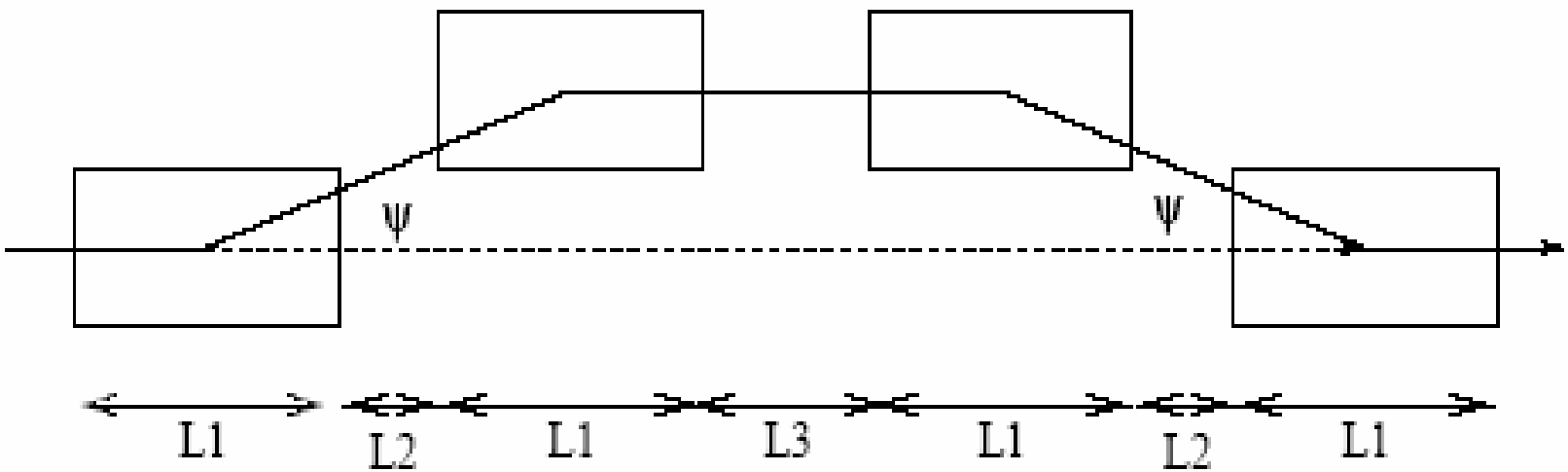
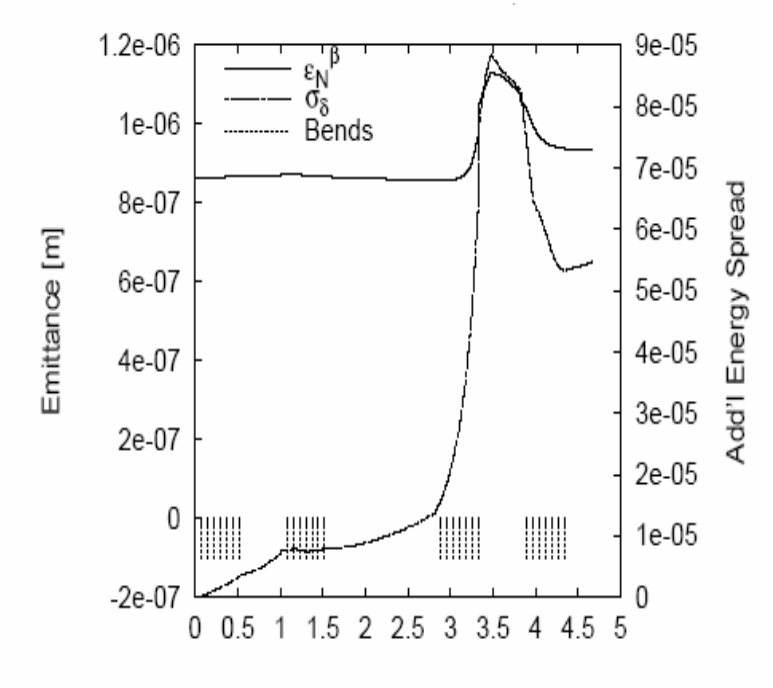
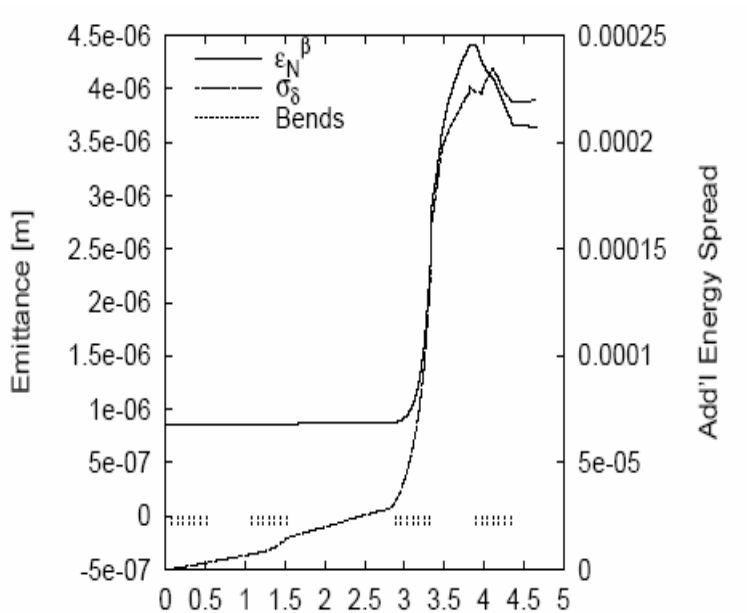


Figure 1: Geometry of BC II: $L_1 = L_2 = 0.5\text{m}, L_3 = 1.3\text{m}, \psi = 17° \ldots 21°$

Emittance and Energy Spread along Beam Line

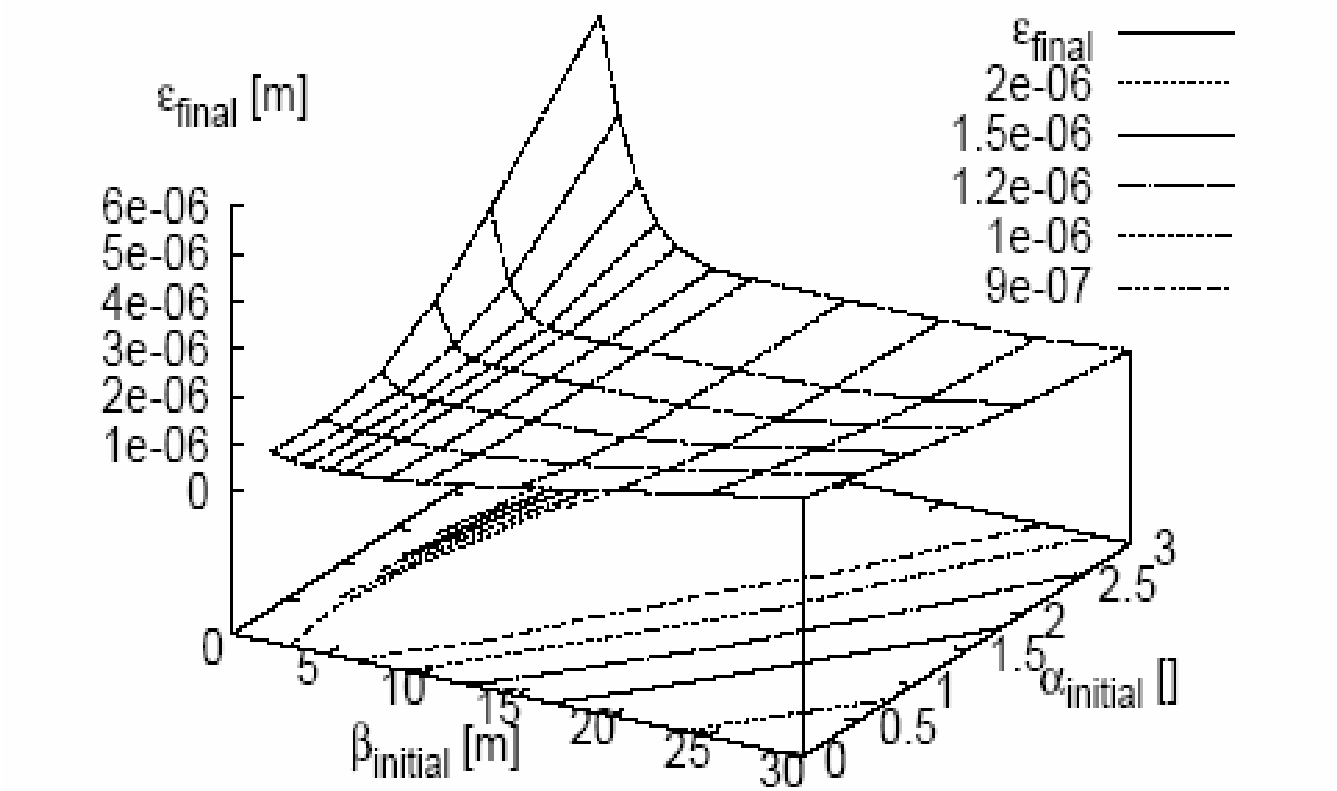


alpha=1, beta=15m

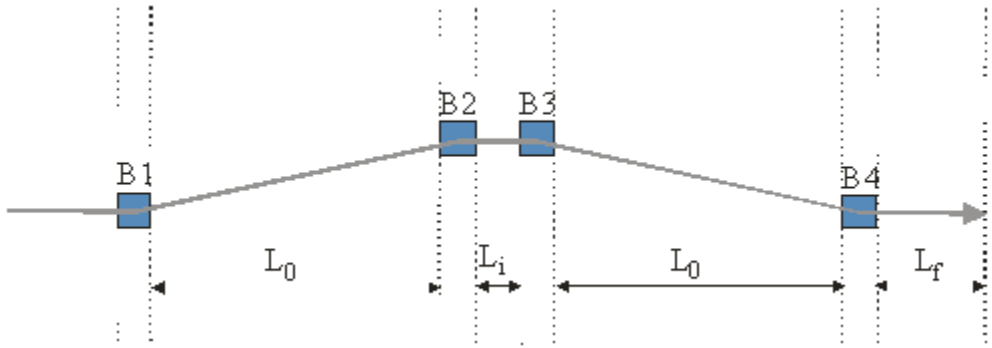


alpha=3, beta=3m

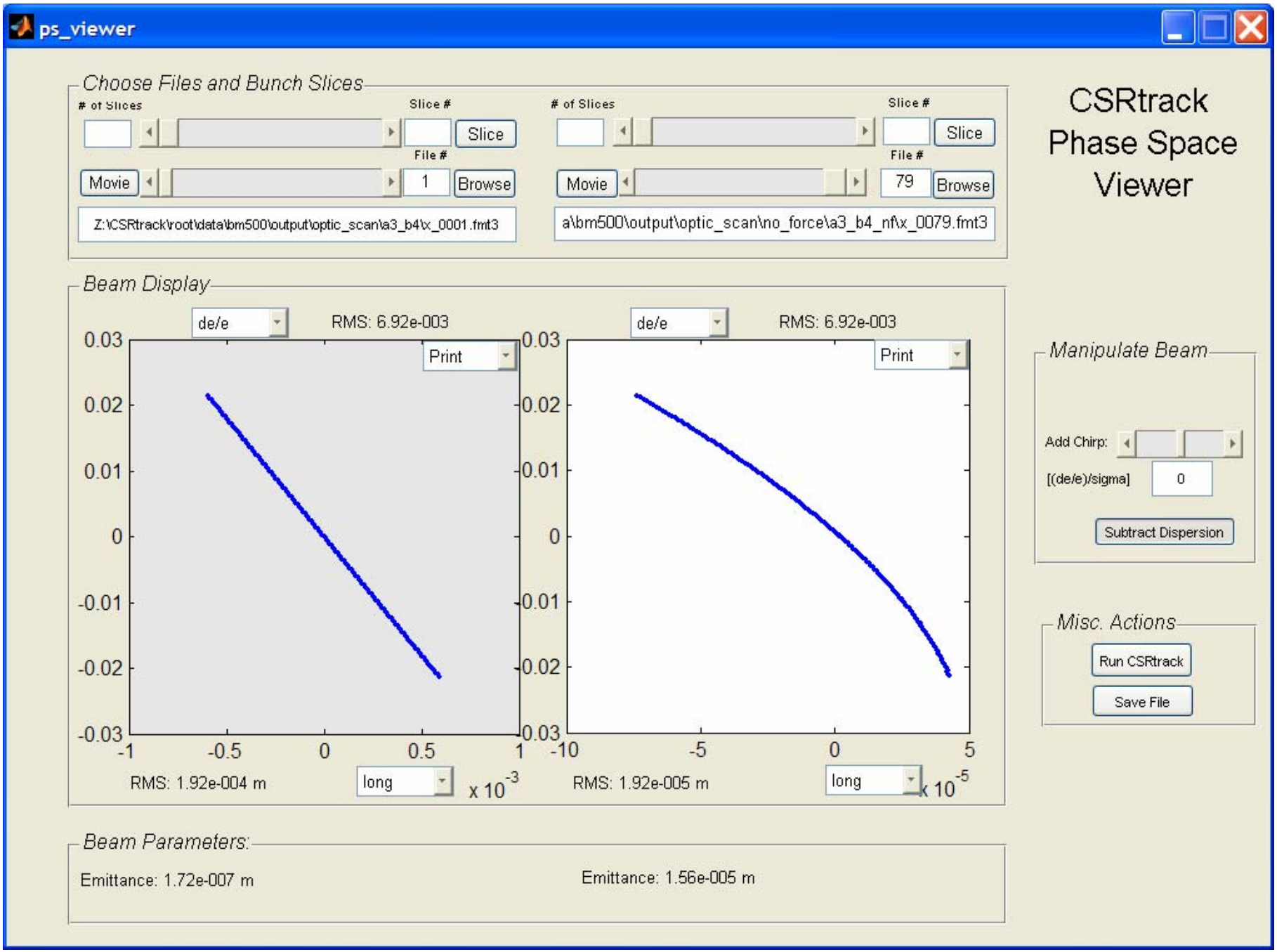
Final emittances for a scan of initial Twiss parameters

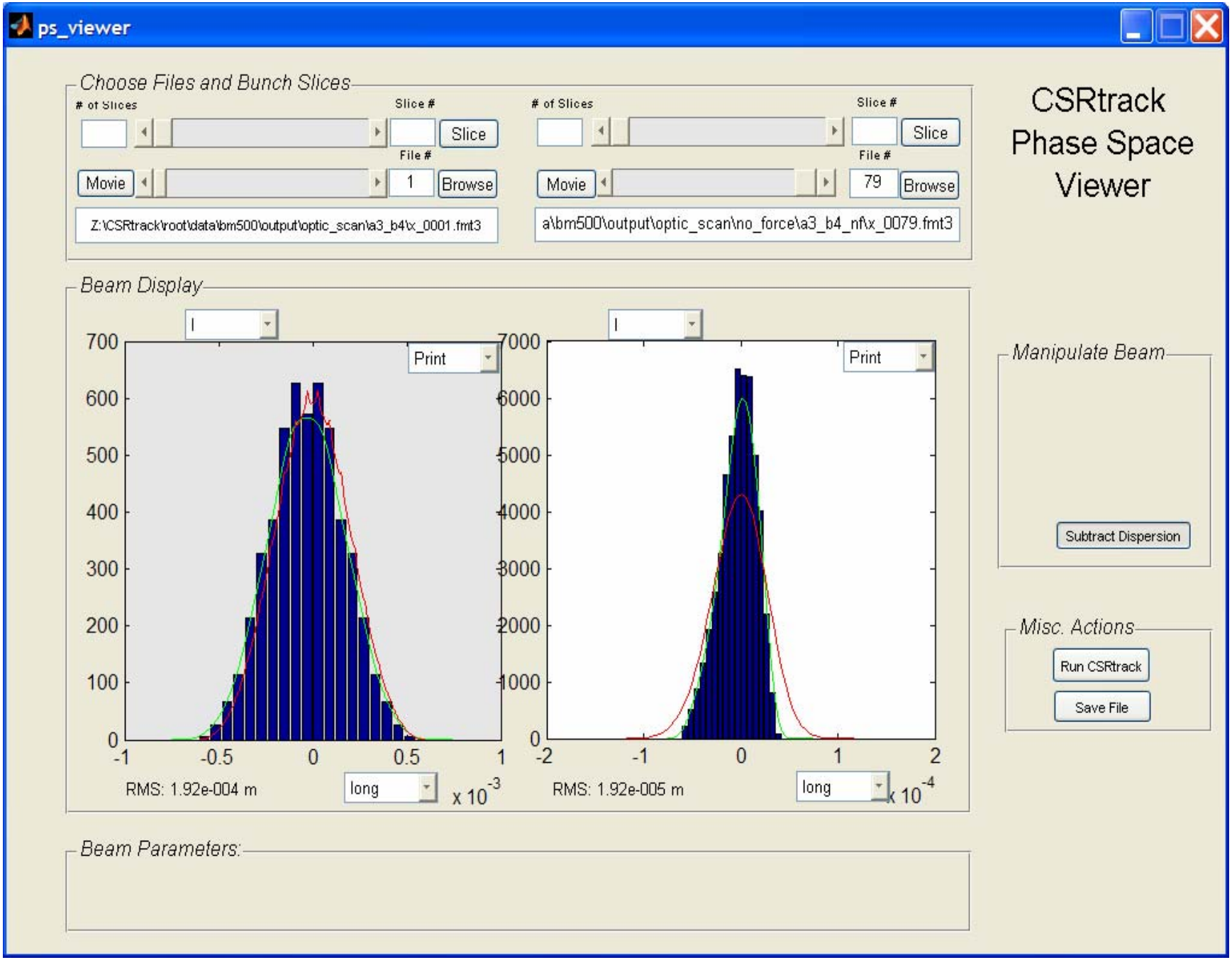


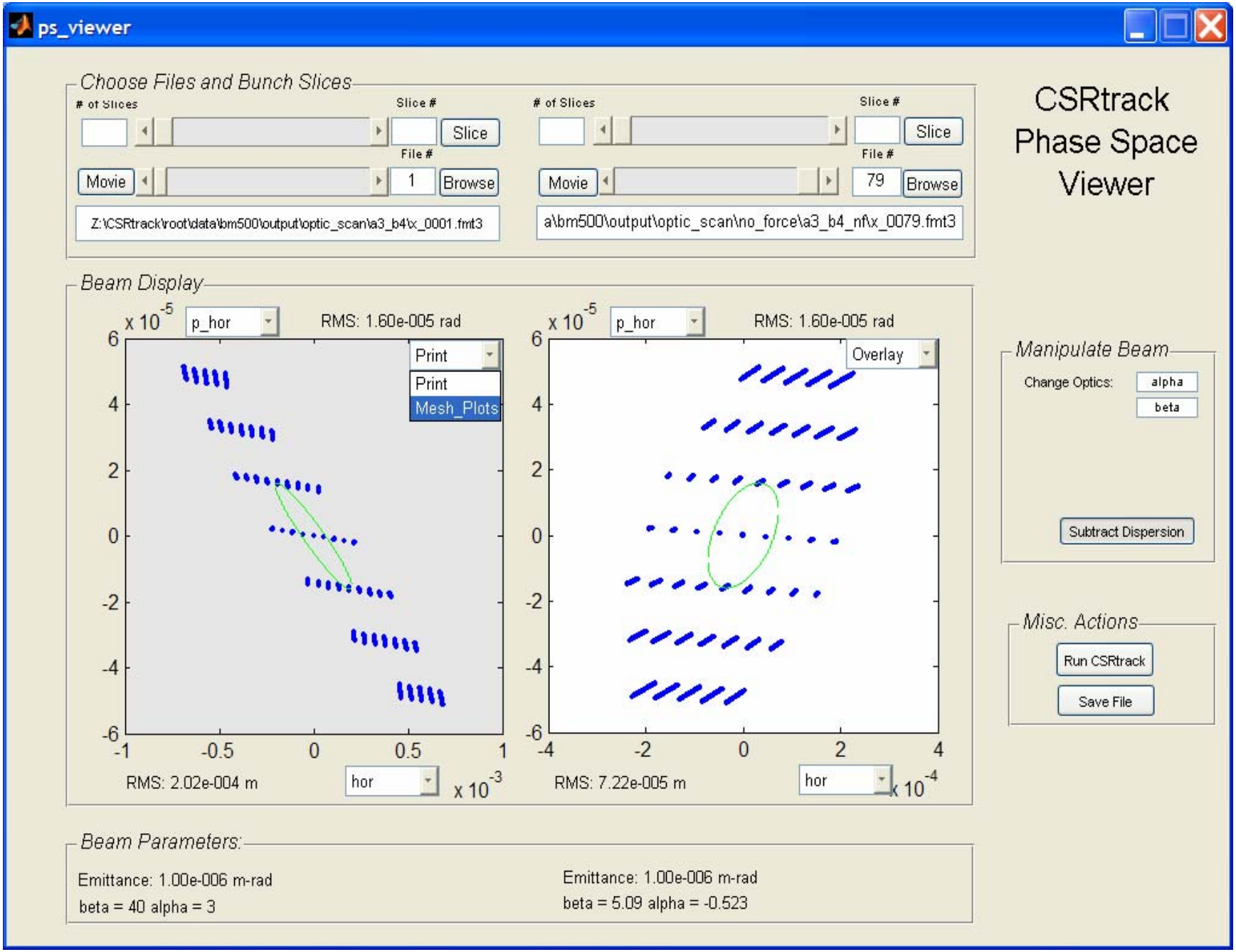
Zeuthen Benchmark Chicane

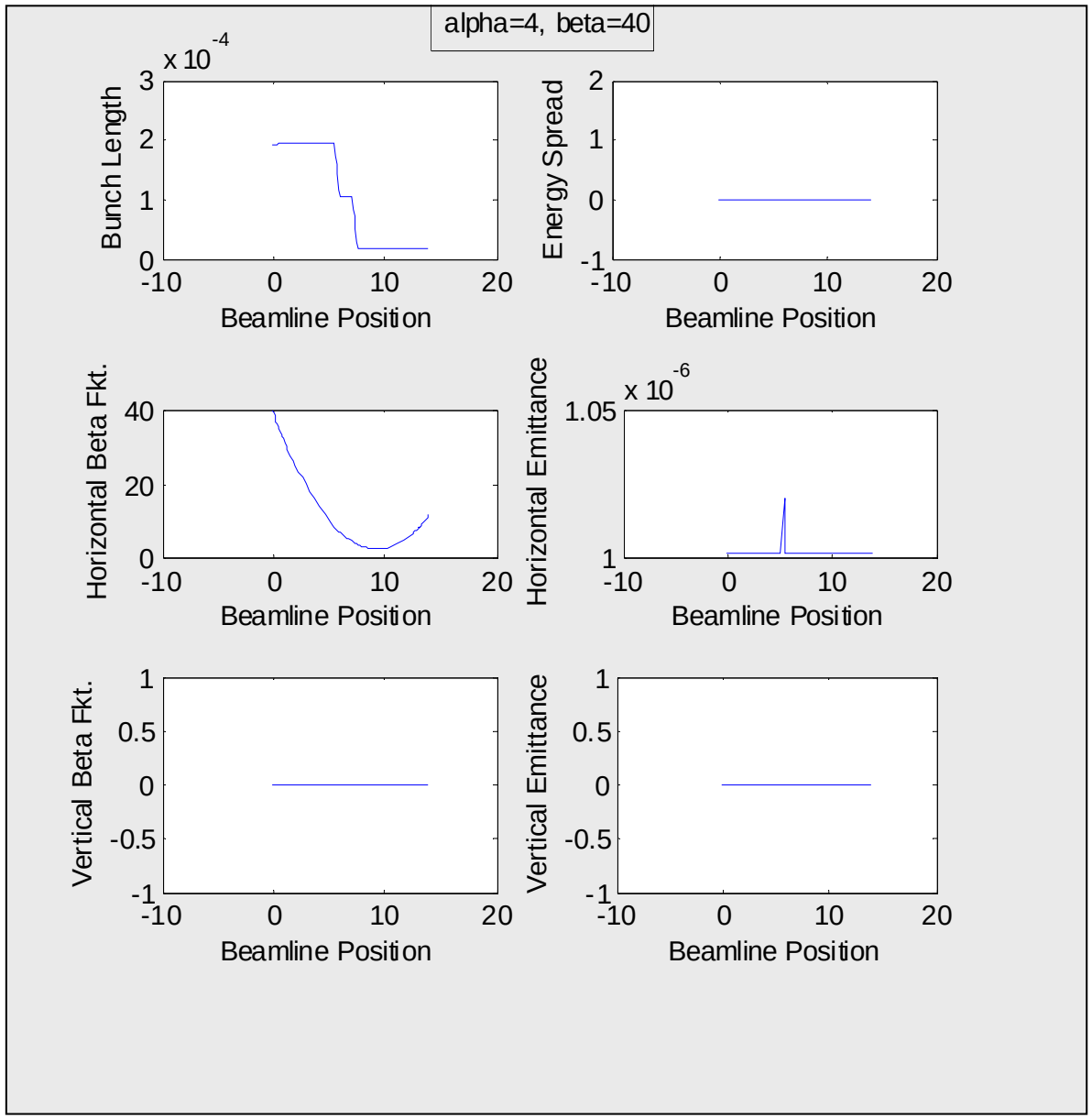


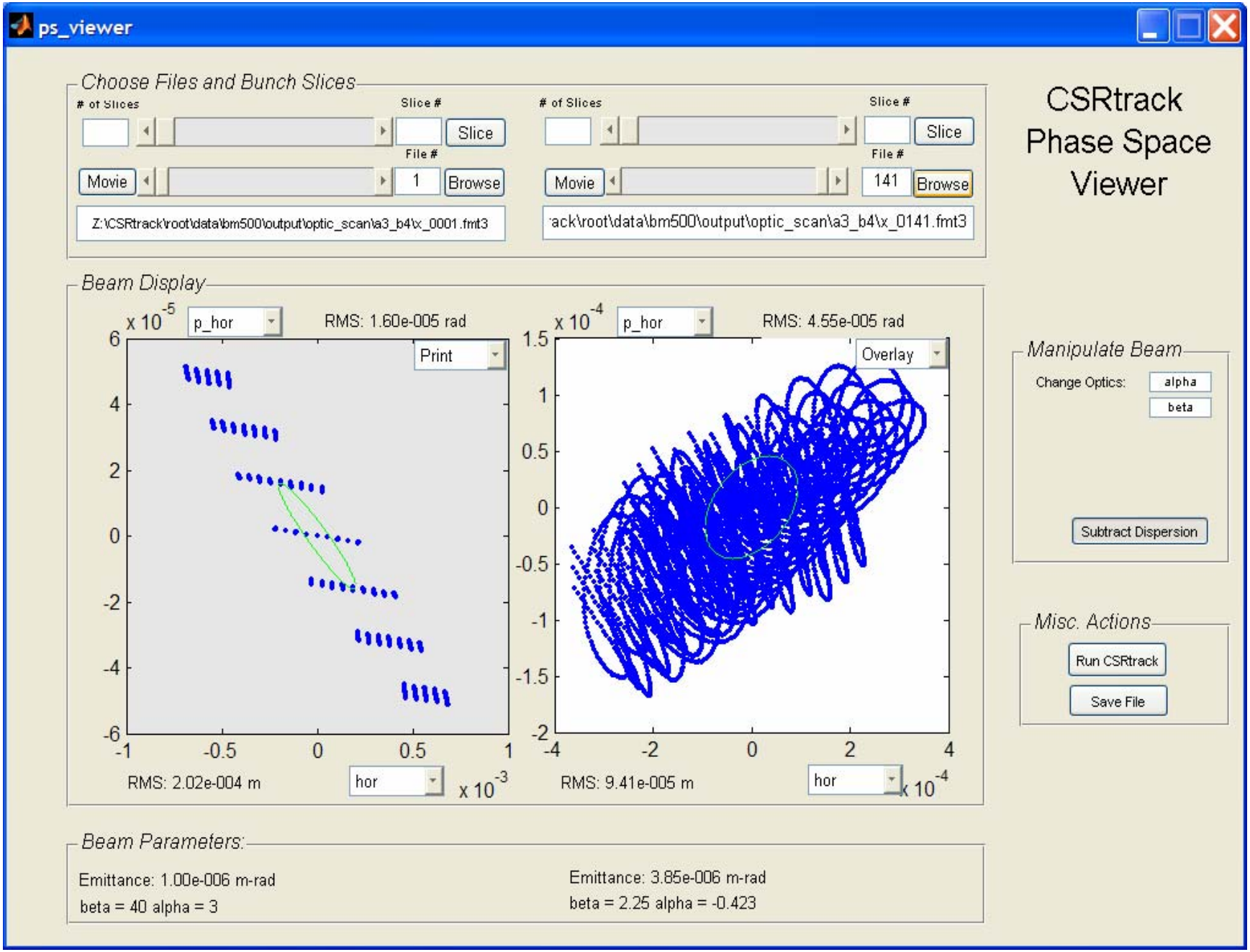
Parameters	***Symbol***	***Value***	***Unit***
Bend magnet length (projected)	L_b	0.5	m
Drift length B1->B2 and B3->B4 (projected)	L_0	5.0	m
Drift length B2->B3	L_i	1.0	m
Post chicane drift	L_f	2.0	m
Bend radius of each dipole magnet	R	10.35	m
Bending Angle	ϕ	2.77	deg
Momentum compaction	R_{56}	-25	mm
2nd order momentum compaction	T_{566}	+37.5	mm
Total projected length of chicane	L_{tot}	13.0	m

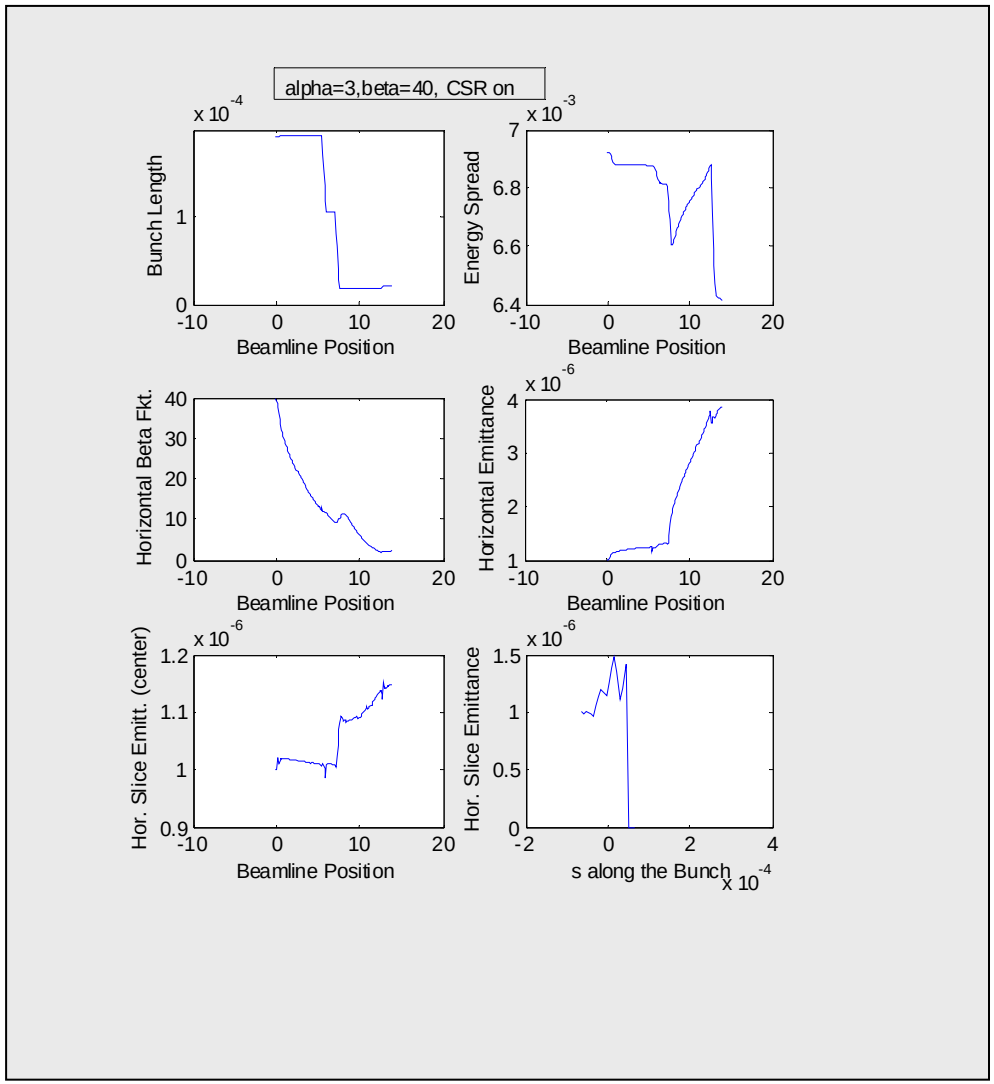

ps_viewer
Choose Files and Bunch Slices
# of Slices
Slice #
Slice
File #
Movie
1
Browse
Z:\CSRtrack\root\data\bm500\output\optic_scan\a3_b4\x_0001.fmt3
# of Slices
Slice #
Slice
File #
Movie
79
Browse
a\bm500\output\optic_scan\no_force\a3_b4_nf\x_0079.fmt3
CSRtrack
Phase Space
Viewer
Beam Display
de/e
RMS: 6.92e-003
Print
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-1
-0.5
0
0.5
1
RMS: 1.92e-004 m
long
x 10^-3
de/e
RMS: 6.92e-003
Print
-10
-5
0
5
RMS: 1.92e-005 m
long
x 10^-5
Manipulate Beam
Add Chirp:
[(de/e)/sigma]
0
Subtract Dispersion
Misc. Actions
Run CSRtrack
Save File
Beam Parameters:
Emittance: 1.72e-007 m
Emittance: 1.56e-005 m

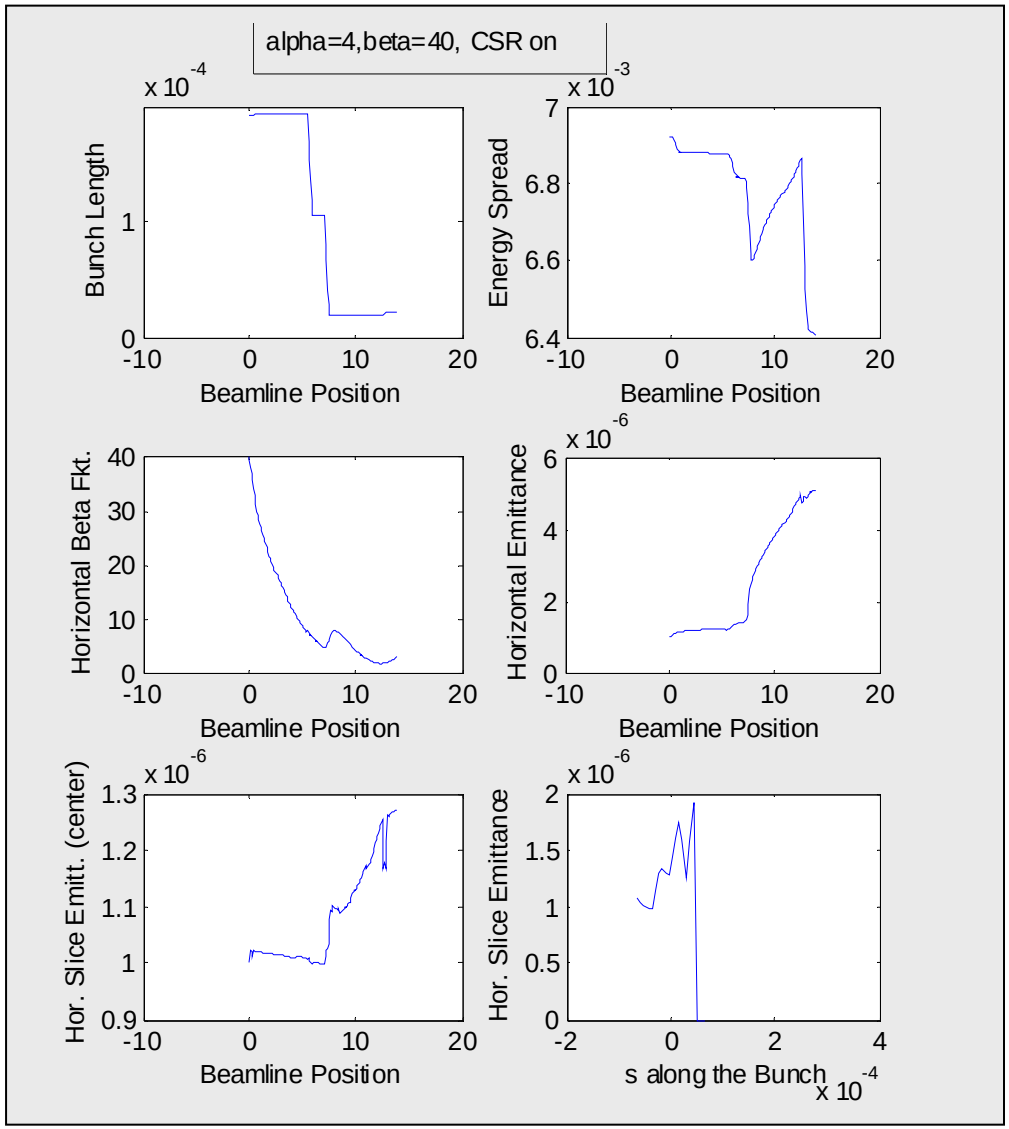

ps_viewer
Choose Files and Bunch Slices
# of Slices
Slice #
Slice
File #
Movie
1
Browse
Z:\CSRtrack\root\data\bm500\output\optic_scan\a3_b4\x_0001.fmt3
# of Slices
Slice #
Slice
File #
Movie
79
Browse
a\bm500\output\optic_scan\no_force\a3_b4_nf\x_0079.fmt3
CSRtrack
Phase Space
Viewer
Beam Display
I
Print
700
600
500
400
300
200
100
0
-1
-0.5
0
0.5
1
RMS: 1.92e-004 m
long
x 10^-3
I
Print
7000
6000
5000
4000
3000
2000
1000
0
-2
-1
0
1
2
RMS: 1.92e-005 m
long
x 10^-4
Manipulate Beam
Subtract Dispersion
Misc. Actions
Run CSRtrack
Save File
Beam Parameters:

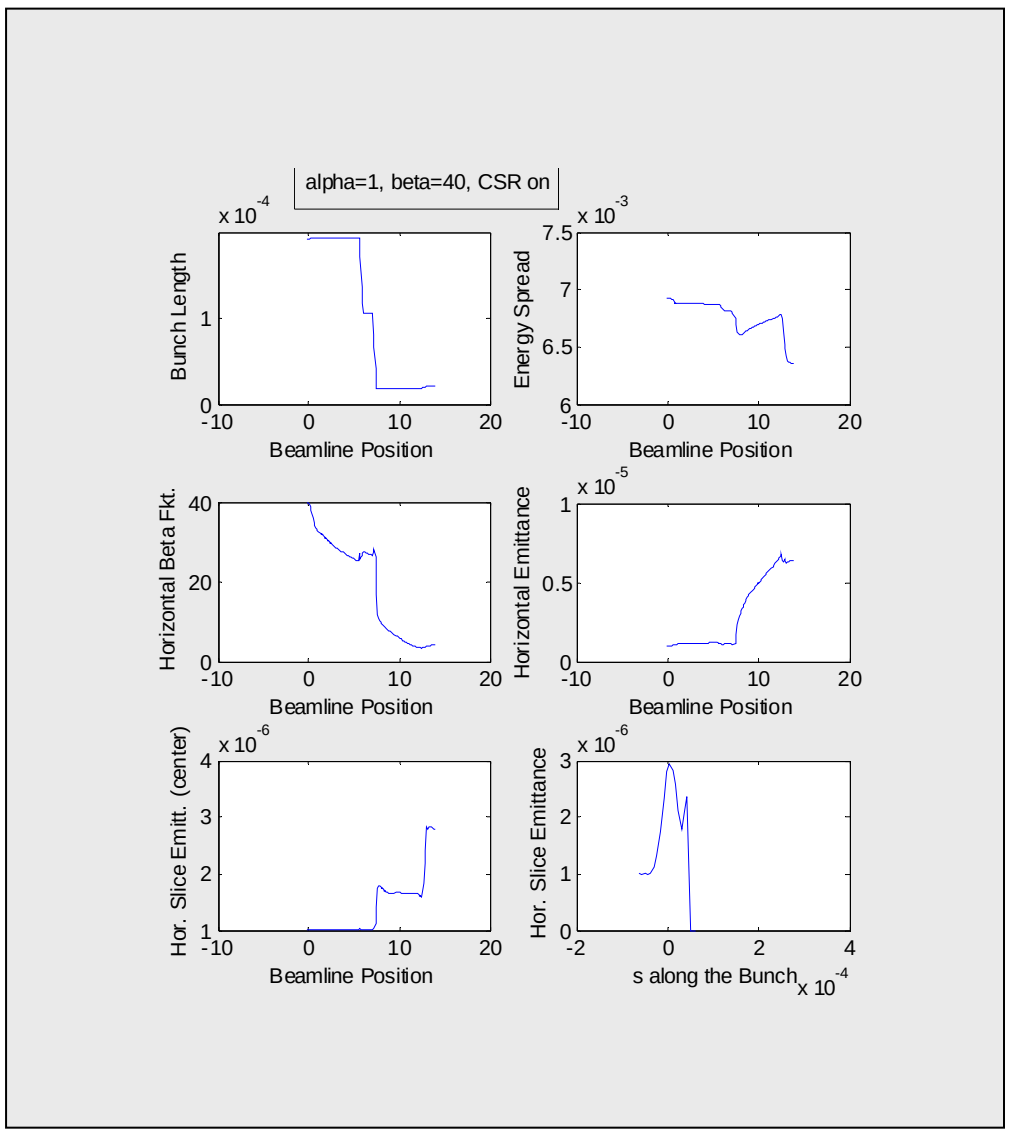

ps_viewer
Choose Files and Bunch Slices
# of Slices
Slice #
Slice
File #
Movie
1
Browse
Z:\CSRtrack\root\data\bm500\output\optic_scan\a3_b4\x_0001.fmt3
# of Slices
Slice #
Slice
File #
Movie
79
Browse
a\bm500\output\optic_scan\no_force\a3_b4_nf\x_0079.fmt3
CSRtrack
Phase Space
Viewer
Beam Display
x 10^-5
p_hor
RMS: 1.60e-005 rad
Print
Print
Mesh_Plots
RMS: 2.02e-004 m
hor
x 10^-3
x 10^-5
p_hor
RMS: 1.60e-005 rad
Overlay
RMS: 7.22e-005 m
hor
x 10^-4
Manipulate Beam
Change Optics:
alpha
beta
Subtract Dispersion
Misc. Actions
Run CSRtrack
Save File
Beam Parameters:
Emittance: 1.00e-006 m-rad
beta = 40 alpha = 3
Emittance: 1.00e-006 m-rad
beta = 5.09 alpha = -0.523


alpha=4, beta=40
x 10^-4
Bunch Length
3
2
1
0
-10
0
10
20
Beamline Position
Energy Spread
2
1
0
-1
-10
0
10
20
Beamline Position
Horizontal Beta Fkt.
40
20
0
-10
0
10
20
Beamline Position
Horizontal Emittance
x 10^-6
1.05
1
-10
0
10
20
Beamline Position
Vertical Beta Fkt.
1
0.5
0
-0.5
-1
-10
0
10
20
Beamline Position
Vertical Emittance
1
0.5
0
-0.5
-1
-10
0
10
20
Beamline Position

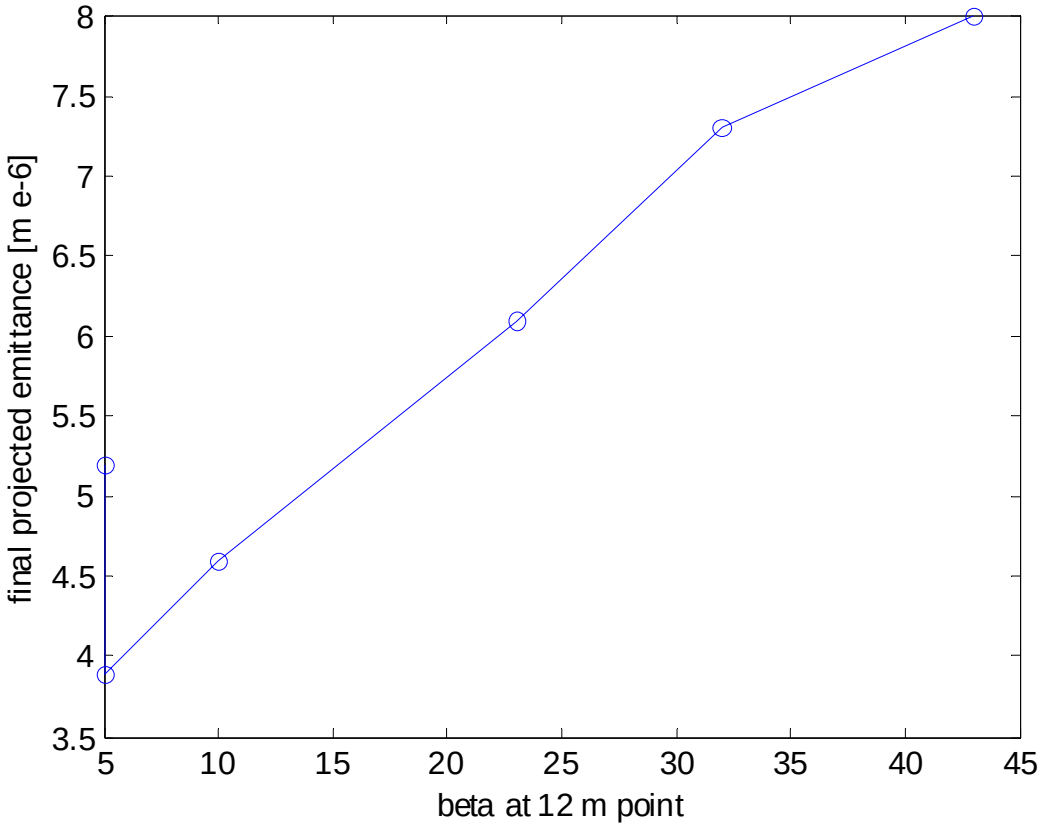

ps_viewer
Choose Files and Bunch Slices
# of Slices
Slice #
Slice
File #
Movie
1
Browse
Z:\CSRtrack\root\data\bm500\output\optic_scan\a3_b4\x_0001.fmt3
# of Slices
Slice #
Slice
File #
Movie
141
Browse
ack\root\data\bm500\output\optic_scan\a3_b4\x_0141.fmt3
CSRtrack
Phase Space
Viewer
Beam Display
x 10^-5
p_hor
RMS: 1.60e-005 rad
Print
RMS: 2.02e-004 m
hor
x 10^-3
x 10^-4
p_hor
RMS: 4.55e-005 rad
Overlay
RMS: 9.41e-005 m
hor
x 10^-4
Manipulate Beam
Change Optics:
alpha
beta
Subtract Dispersion
Misc. Actions
Run CSRtrack
Save File
Beam Parameters:
Emittance: 1.00e-006 m-rad
beta = 40 alpha = 3
Emittance: 3.85e-006 m-rad
beta = 2.25 alpha = -0.423


alpha=3,beta=40, CSR on
x 10^-4
Bunch Length
Beamline Position
x 10^-3
Energy Spread
Beamline Position
Horizontal Beta Fkt.
Beamline Position
x 10^-6
Horizontal Emittance
Beamline Position
x 10^-6
Hor. Slice Emitt. (center)
Beamline Position
x 10^-6
Hor. Slice Emittance
s along the Bunch
x 10^-4

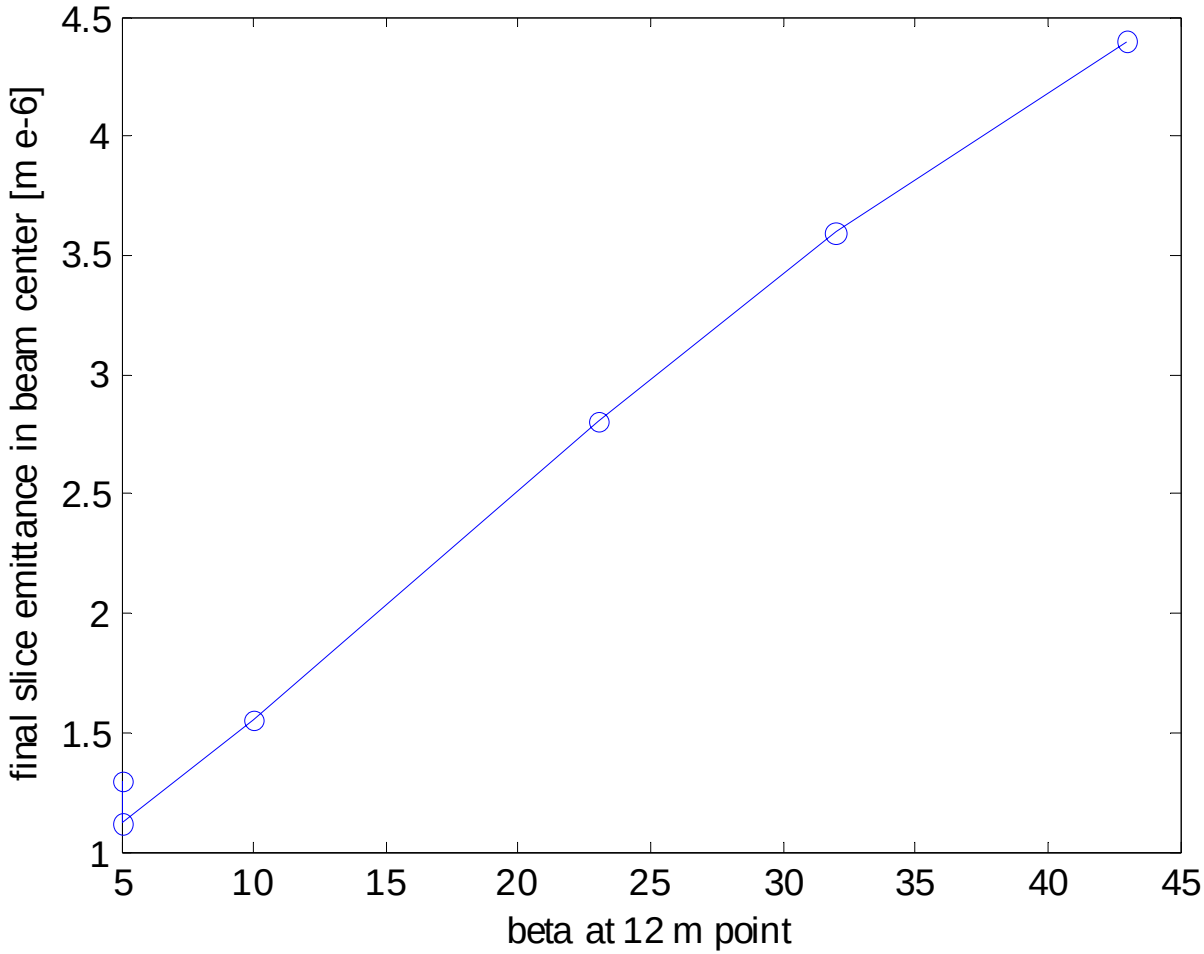

alpha=4,beta=40, CSR on
x 10^-4
Bunch Length
0
1
-10
0
10
20
Beamline Position
x 10^-3
Energy Spread
6.4
6.6
6.8
7
Beamline Position
Horizontal Beta Fkt.
0
10
20
30
40
Beamline Position
x 10^-6
Horizontal Emittance
0
2
4
6
Beamline Position
x 10^-6
Hor. Slice Emitt. (center)
0.9
1
1.1
1.2
1.3
Beamline Position
x 10^-6
Hor. Slice Emittance
0
0.5
1
1.5
2
-2
0
2
4
s along the Bunch
x 10^-4


alpha=1, beta=40, CSR on
x 10^-4
Bunch Length
0
1
-10
0
10
20
Beamline Position
x 10^-3
Energy Spread
7.5
7
6.5
6
Beamline Position
Horizontal Beta Fkt.
40
20
Beamline Position
x 10^-5
Horizontal Emittance
1
0.5
Beamline Position
x 10^-6
Hor. Slice Emitt. (center)
4
3
2
1
Beamline Position
x 10^-6
Hor. Slice Emittance
3
2
1
0
-2
2
4
s along the Bunch
x 10^-4

Keep incoming beta, vary alpha



Keep incoming beta, vary alpha



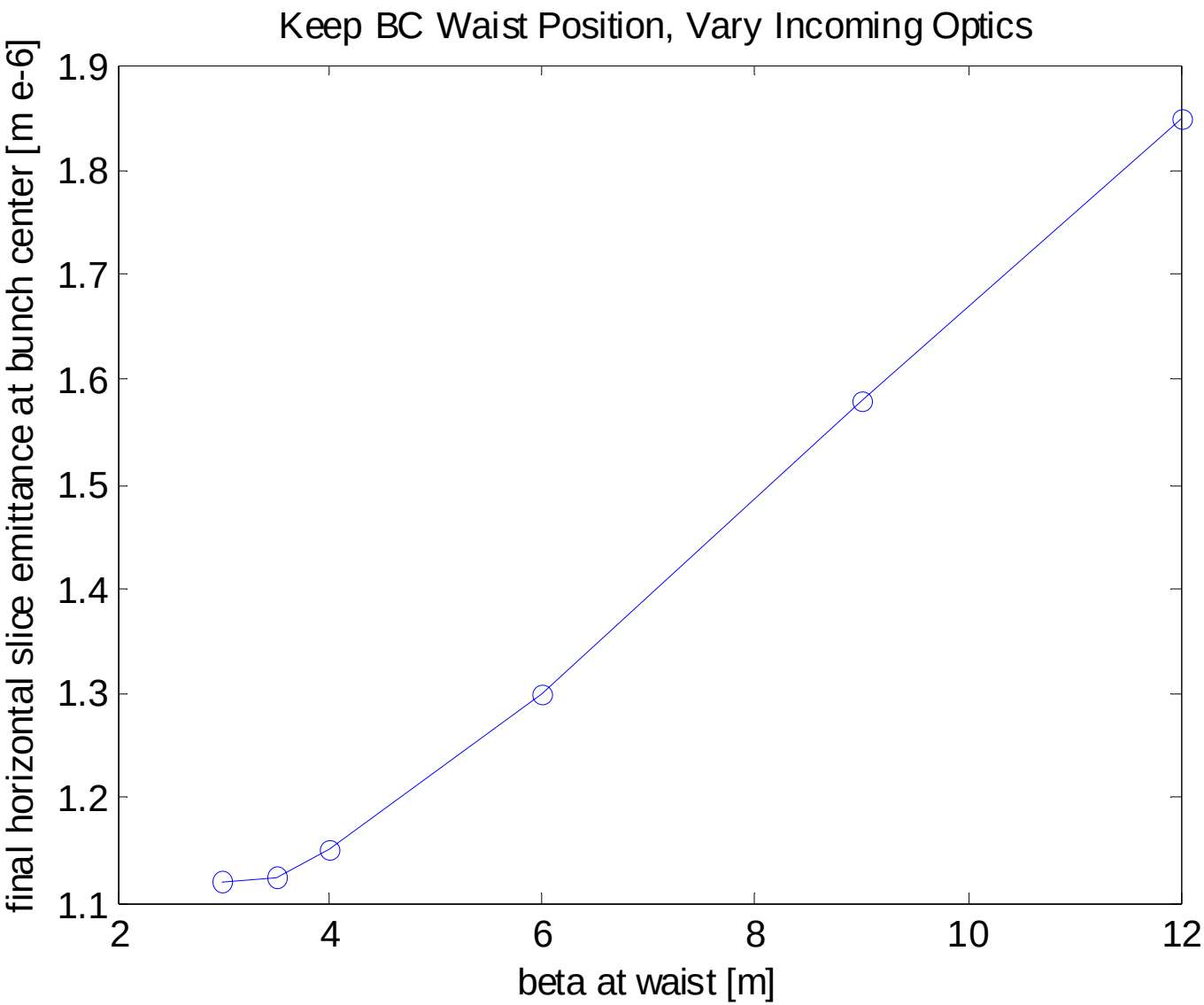
Keep Waist Position, vary incoming Optics

$\beta := 24 .. 60$ $\alpha_i := 2.7$ $s := 12$ $s_0 := 0$

$$\alpha_1(\beta) := \frac{-\beta}{2\cdot(s - s_0)} + \sqrt{\frac{\beta^2}{4\cdot(s - s_0)^2} - 1} \qquad \beta_{01}(\alpha_1, \beta) := \frac{\beta}{1 + \alpha_1(\beta)^2}$$

$$\alpha_2(\beta) := \frac{-\beta}{2\cdot(s - s_0)} - \sqrt{\frac{\beta^2}{4\cdot(s - s_0)^2} - 1} \qquad \beta_{02}(\alpha_2, \beta) := \frac{\beta}{1 + \alpha_2(\beta)^2}$$

$\beta =$	$\alpha_1(\beta) =$	$\alpha_2(\beta) =$	$\beta_{01}(\alpha_1, \beta) =$	$\beta_{02}(\alpha_2, \beta) =$
24	-1	-1	12	12
25	-0.75	-1.333	16	9
26	-0.667	-1.5	18	8
27	-0.61	-1.64	19.685	7.315
28	-0.566	-1.768	21.211	6.789
29	-0.53	-1.887	22.639	6.361
30	-0.5	-2	24	6
31	-0.474	-2.109	25.311	5.689
32	-0.451	-2.215	26.583	5.417
33	-0.431	-2.319	27.825	5.175
34	-0.413	-2.42	29.042	4.958
35	-0.397	-2.52	30.238	4.762
36	-0.382	-2.618	31.416	4.584
37	-0.368	-2.715	32.58	4.42
38	-0.356	-2.811	33.731	4.269
39	-0.344	-2.906	34.87	4.13
40	-0.333	-3	36	4
41	-0.323	-3.093	37.121	3.879
42	-0.314	-3.186	38.234	3.766
43	-0.305	-3.278	39.34	3.66
44	-0.297	-3.37	40.439	3.561
45	-0.289	-3.461	41.533	3.467
46	-0.282	-3.552	42.621	3.379
47	-0.275	-3.642	43.705	3.295
48	-0.268	-3.732	44.785	3.215
49	-0.262	-3.822	45.86	3.14
50	-0.256	-3.911	46.932	3.068
51	-0.25	-4	48	3
52	-0.245	-4.089	49.065	2.935


Keep BC Waist Position, Vary Incoming Optics
final horizontal slice emittance at bunch center [m e-6]
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
2
4
6
8
10
12
beta at waist [m]