Simulations of Balbekov's ring cooler using COSY INFINITY

(Short Solenoids)

Informal report

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Short Solenoids. Case 1: Super Imposed with +/- infinity length.

Linear Map

-0.1467136	-1.796260	0.9193886	-0.2657072	0.000000	100000
1.015304	-0.1467136	0.1788531E-10	0.9193886	0.000000	010000
-0.9193886	0.2657072	-0.1467136	-1.796260	0.000000	001000
-0.1788531E-10	-0.9193886	1.015304	-0.1467136	0.000000	000100

Symplectic error : 1.146056879226474

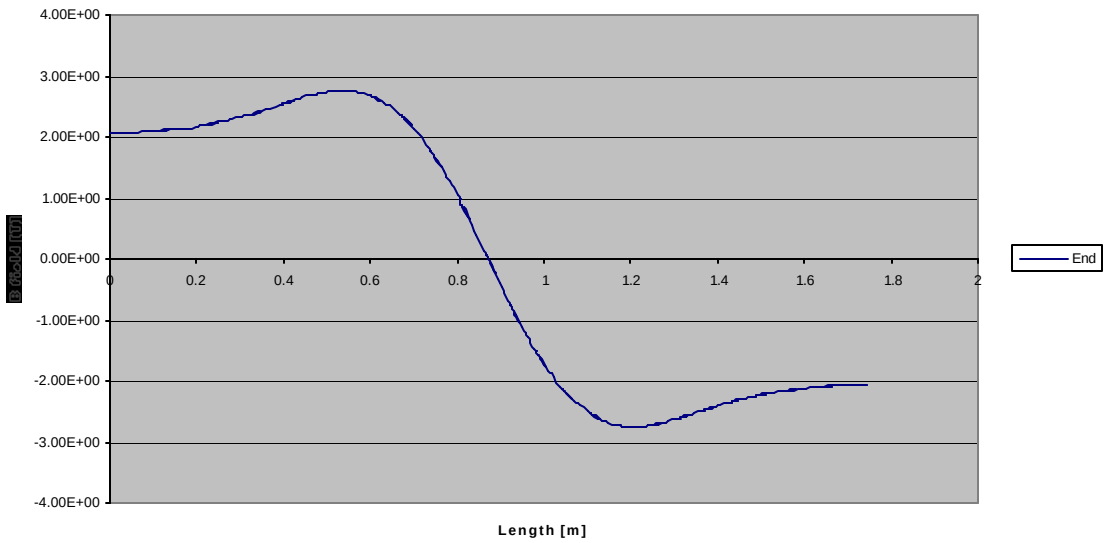
Fifth Order Map

-0.1467136	-1.796260	0.9193886	-0.2657072	0.000000	100000
1.015304	-0.1467136	0.3060451E-11	0.9193886	0.000000	010000
-0.9193886	0.2657072	-0.1467136	-1.796260	0.000000	001000
-0.3060451E-11	-0.9193886	1.015304	-0.1467136	0.000000	000100
-5.150356	1.407434	-3.471527	-10.58868	0.000000	300000
-6.411803	-5.982760	-1.425787	-8.650997	0.000000	210000
-6.063072	-2.101315	-2.173004	-8.458362	0.000000	120000
-2.226005	-3.298721	0.3628300	-2.185223	0.000000	030000
3.471527	10.58868	-5.150356	1.407434	0.000000	201000
8.867431	3.476400	1.049483	13.48336	0.000000	111000
6.099573	13.79142	-5.180687	4.906295	0.000000	021000
-7.441644	5.174597	-7.461286	-19.46612	0.000000	200100
-3.926569	-5.333063	-0.8823853	-7.007610	0.000000	110100
-0.3628300	2.185223	-2.226005	-3.298721	0.000000	020100
-5.150356	1.407434	-3.471527	-10.58868	0.000000	102000
-7.461286	-19.46612	7.441644	-5.174597	0.000000	012000
1.049483	13.48336	-8.867431	-3.476400	0.000000	101100
-0.8823853	-7.007610	3.926569	5.333063	0.000000	011100
-5.180687	4.906295	-6.099573	-13.79142	0.000000	100200
-2.226005	-3.298721	0.3628300	-2.185223	0.000000	010200
3.471527	10.58868	-5.150356	1.407434	0.000000	003000
1.425787	8.650997	-6.411803	-5.982760	0.000000	002100
2.173004	8.458362	-6.063072	-2.101315	0.000000	001200
-0.3628300	2.185223	-2.226005	-3.298721	0.000000	000300
-15.71585	27.23532	-23.72338	-33.63860	0.000000	500000
-36.02640	5.753202	-21.46530	-55.14127	0.000000	410000
-38.39075	16.29484	-33.88081	-55.16902	0.000000	320000
-33.14696	-7.116152	-14.53667	-36.65477	0.000000	230000
-14.27604	2.840011	-11.47237	-15.47623	0.000000	140000
-7.567237	-3.099152	-1.462962	-6.833978	0.000000	050000
23.72338	33.63860	-15.71585	27.23532	0.000000	401000
55.74263	-36.40506	46.08522	99.46462	0.000000	311000
93.84505	43.66483	10.39065	121.6189	0.000000	221000
46.89272	-13.36919	35.57062	65.34311	0.000000	131000
37.16991	20.41435	0.8954823	38.14645	0.000000	041000
-34.27733	91.54633	-82.11162	-93.71142	0.000000	400100
-59.96424	11.50418	-48.78140	-105.3240	0.000000	310100
-32.35605	50.02397	-68.71758	-72.45926	0.000000	220100
-25.69754	-4.938121	-15.17153	-35.30644	0.000000	130100

1.462962	6.833978	-7.567237	-3.099152	0.000000	040100
-31.43170	54.47063	-47.44675	-67.27721	0.000000	302000
-118.1380	-87.95822	12.81203	-146.6876	0.000000	212000
-78.94206	25.16981	-57.27854	-120.5226	0.000000	122000
-90.46738	-65.21267	9.060995	-97.77821	0.000000	032000
46.08522	99.46462	-55.74263	36.40506	0.000000	301100
32.32123	-123.0740	106.7597	119.2030	0.000000	211100
79.07023	50.84993	-0.3026055	108.8777	0.000000	121100
-15.17153	-35.30644	25.69754	4.938121	0.000000	031100
-30.16067	130.4938	-117.2428	-109.0184	0.000000	300200
-54.89676	0.1304368	-37.83173	-84.40901	0.000000	210200
-13.38056	40.98646	-48.64227	-35.89058	0.000000	120200
-15.13447	-6.198304	-2.925925	-13.66796	0.000000	030200
47.44675	67.27721	-31.43170	54.47063	0.000000	203000
55.74263	-36.40506	46.08522	99.46462	0.000000	113000
117.2428	109.0184	-30.16067	130.4938	0.000000	023000
-12.81203	146.6876	-118.1380	-87.95822	0.000000	202100
-106.7597	-119.2030	32.32123	-123.0740	0.000000	112100
37.83173	84.40901	-54.89676	0.1304368	0.000000	022100
57.27854	120.5226	-78.94206	25.16981	0.000000	201200
0.3026055	-108.8777	79.07023	50.84993	0.000000	111200
48.64227	35.89058	-13.38056	40.98646	0.000000	021200
-9.060995	97.77821	-90.46738	-65.21267	0.000000	200300
-25.69754	-4.938121	-15.17153	-35.30644	0.000000	110300
2.925925	13.66796	-15.13447	-6.198304	0.000000	020300
-15.71585	27.23532	-23.72338	-33.63860	0.000000	104000
-82.11162	-93.71142	34.27733	-91.54633	0.000000	014000
46.08522	99.46462	-55.74263	36.40506	0.000000	103100
-48.78140	-105.3240	59.96424	-11.50418	0.000000	013100
10.39065	121.6189	-93.84505	-43.66483	0.000000	102200
-68.71758	-72.45926	32.35605	-50.02397	0.000000	012200
35.57062	65.34311	-46.89272	13.36919	0.000000	101300
-15.17153	-35.30644	25.69754	4.938121	0.000000	011300
0.8954823	38.14645	-37.16991	-20.41435	0.000000	100400
-7.567237	-3.099152	-1.462962	-6.833978	0.000000	010400
23.72338	33.63860	-15.71585	27.23532	0.000000	005000
21.46530	55.14127	-36.02640	5.753202	0.000000	004100
33.88081	55.16902	-38.39075	16.29484	0.000000	003200
14.53667	36.65477	-33.14696	-7.116152	0.000000	002300
11.47237	15.47623	-14.27604	2.840011	0.000000	001400
1.462962	6.833978	-7.567237	-3.099152	0.000000	000500

Symplectic Error : 1.159670981749786

Short Solenoids - Case 1: Superimposed with infinity length solenoids Sharp Cut Off



Short Solenoids – Case 2: Superimposed with l1, l4 solenoids sharp-cut-off

Linear Map

0.3762572E-01	-1.146453	0.5033401	0.3468572E-01	0.000000	100000
1.092008	0.3762572E-01	0.2354971E-10	0.5033401	0.000000	010000
-0.5033401	-0.3468572E-01	0.3762572E-01	-1.146453	0.000000	001000
-0.2354971E-10	-0.5033401	1.092008	0.3762572E-01	0.000000	000100

Symplectic error : 0.4181479113771105

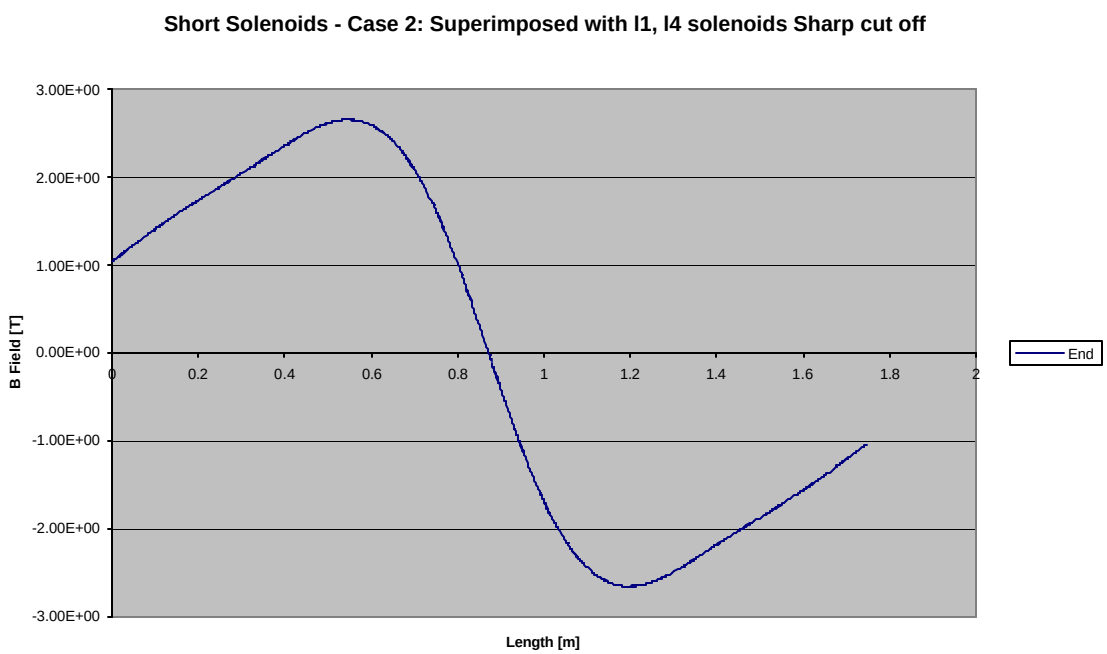
Fifth Order Map

0.3762572E-01	-1.146453	0.5033401	0.3468572E-01	0.000000	100000
1.092008	0.3762572E-01	0.1216993E-10	0.5033401	0.000000	010000
-0.5033401	-0.3468572E-01	0.3762572E-01	-1.146453	0.000000	001000
-0.1216993E-10	-0.5033401	1.092008	0.3762572E-01	0.000000	000100
-3.823132	-1.926509	-1.388275	-3.800984	0.000000	300000

-7.309344	-6.926245	-1.623955	-5.544482	0.000000	210000
-7.330362	-6.368015	-1.092651	-5.709820	0.000000	120000
-2.497266	-4.260799	0.5651303	-1.279245	0.000000	030000
1.388275	3.800984	-3.823132	-1.926509	0.000000	201000
4.536294	5.904955	-3.549300	2.046974	0.000000	111000
3.433730	9.304556	-5.091437	-0.6175929	0.000000	021000
-2.912339	-0.3604728	-3.760043	-8.973219	0.000000	200100
-2.341078	-3.594736	-2.238926	-5.750423	0.000000	110100
-0.5651303	1.279245	-2.497266	-4.260799	0.000000	020100
-3.823132	-1.926509	-1.388275	-3.800984	0.000000	102000
-3.760043	-8.973219	2.912339	0.3604728	0.000000	012000
-3.549300	2.046974	-4.536294	-5.904955	0.000000	101100
-2.238926	-5.750423	2.341078	3.594736	0.000000	011100
-5.091437	-0.6175929	-3.433730	-9.304556	0.000000	100200
-2.497266	-4.260799	0.5651303	-1.279245	0.000000	010200
1.388275	3.800984	-3.823132	-1.926509	0.000000	003000
1.623955	5.544482	-7.309344	-6.926245	0.000000	002100
1.092651	5.709820	-7.330362	-6.368015	0.000000	001200
-0.5651303	1.279245	-2.497266	-4.260799	0.000000	000300
-7.024981	3.068808	-3.212673	-5.204727	0.000000	500000
-20.85751	0.1145394E-01	-7.808336	-10.41922	0.000000	410000
-31.77869	1.148110	-16.81883	-15.72985	0.000000	320000
-31.26774	-3.142224	-16.56386	-14.27044	0.000000	230000
-20.16655	0.2965039E-02	-12.46469	-12.47953	0.000000	140000
-8.419566	-5.004937	-1.776100	-4.647193	0.000000	050000
3.212673	5.204727	-7.024981	3.068808	0.000000	401000
21.74434	1.433363	-0.2345324E-01	25.16933	0.000000	311000
45.93245	19.18062	-1.688297	40.50234	0.000000	221000
40.63174	9.860645	8.145171	38.31300	0.000000	131000
23.94901	20.39823	-3.924540	16.36480	0.000000	041000
-13.93601	8.985857	-20.83406	-25.15787	0.000000	400100
-29.11362	-3.450772	-30.09039	-39.35423	0.000000	310100
-24.06788	4.409796	-39.41291	-41.45522	0.000000	220100
-11.48432	-7.918705	-16.24201	-16.36184	0.000000	130100
1.776100	4.647193	-8.419566	-5.004937	0.000000	040100
-14.04996	6.137617	-6.425347	-10.40945	0.000000	302000
-41.69157	-25.14642	6.127670	-19.40508	0.000000	212000
-52.72772	-19.49162	-7.323765	-39.49546	0.000000	122000
-42.71906	-42.71872	10.87427	-25.34622	0.000000	032000
-0.2345324E-01	25.16933	-21.74434	-1.433363	0.000000	301100
11.80768	1.925221	10.12350	50.98200	0.000000	211100
14.75747	40.84000	-14.24453	32.01220	0.000000	121100
-16.24201	-16.36184	11.48432	7.918705	0.000000	031100
-22.63733	19.86262	-36.43739	-42.94624	0.000000	300200
-34.57389	-4.405723	-29.75746	-35.20686	0.000000	210200
-24.09109	16.36777	-36.41369	-32.87776	0.000000	120200
-16.83913	-10.00987	-3.552201	-9.294386	0.000000	030200
6.425347	10.40945	-14.04996	6.137617	0.000000	203000
21.74434	1.433363	-0.2345324E-01	25.16933	0.000000	113000
36.43739	42.94624	-22.63733	19.86262	0.000000	023000
-6.127670	19.40508	-41.69157	-25.14642	0.000000	202100
-10.12350	-50.98200	11.80768	1.925221	0.000000	112100
29.75746	35.20686	-34.57389	-4.405723	0.000000	022100
7.323765	39.49546	-52.72772	-19.49162	0.000000	201200
14.24453	-32.01220	14.75747	40.84000	0.000000	111200
36.41369	32.87776	-24.09109	16.36777	0.000000	021200
-10.87427	25.34622	-42.71906	-42.71872	0.000000	200300
-11.48432	-7.918705	-16.24201	-16.36184	0.000000	110300
3.552201	9.294386	-16.83913	-10.00987	0.000000	020300
-7.024981	3.068808	-3.212673	-5.204727	0.000000	104000
-20.83406	-25.15787	13.93601	-8.985857	0.000000	014000

-0.2345324E-01	25.16933	-21.74434	-1.433363	0.000000	103100
-30.09039	-39.35423	29.11362	3.450772	0.000000	013100
-1.688297	40.50234	-45.93245	-19.18062	0.000000	102200
-39.41291	-41.45522	24.06788	-4.409796	0.000000	012200
8.145171	38.31300	-40.63174	-9.860645	0.000000	101300
-16.24201	-16.36184	11.48432	7.918705	0.000000	011300
-3.924540	16.36480	-23.94901	-20.39823	0.000000	100400
-8.419566	-5.004937	-1.776100	-4.647193	0.000000	010400
3.212673	5.204727	-7.024981	3.068808	0.000000	005000
7.808336	10.41922	-20.85751	0.1145394E-01	0.000000	004100
16.81883	15.72985	-31.77869	1.148110	0.000000	003200
16.56386	14.27044	-31.26774	-3.142224	0.000000	002300
12.46469	12.47953	-20.16655	0.2965039E-02	0.000000	001400
1.776100	4.647193	-8.419566	-5.004937	0.000000	000500

Symplectic error : 0.4439028201745663



Short Solenoids – Case 4: Four independent solenoids

```
CMST Short solenoid 1
  0.8811626    -0.1346346    -0.3938806     0.6017603E-01  0.000000     100000
  0.4671317     0.8745263    -0.2087902    -0.3908390      0.000000     010000
  0.3938806    -0.6017603E-01 0.8811626    -0.1346346      0.000000     001000
  0.2087902     0.3908390     0.4671317     0.8745263      0.000000     000100
 ------------------------------------------------------------------------------
CMST Short Solenoid 2
  0.2232739    -0.2051047    -0.7554729     0.6926696      0.000000     100000
  0.2308405     0.1488812    -0.7803119    -0.5015582      0.000000     010000
  0.7554729    -0.6926696     0.2232739    -0.2051047      0.000000     001000
  0.7803119     0.5015582     0.2308405     0.1488812      0.000000     000100
 ------------------------------------------------------------------------------
CMST Short Solenoid 3
  0.3768410     -1.018814    -0.1684964     0.4558727      0.000000     100000
  0.8324902    -0.3890411E-01-0.3717771     0.1765701E-01  0.000000     010000
  0.1684964    -0.4558727     0.3768410     -1.018814      0.000000     001000
  0.3717771    -0.1765701E-01 0.8324902    -0.3890411E-01  0.000000     000100
 ------------------------------------------------------------------------------
CMST Short Solenoid 4
 -0.1193499     -1.138175     0.1717849E-03 0.4925782E-03  0.000000     100000
  0.8601762    -0.1756896     0.4193529E-03 0.1961648E-03  0.000000     010000
 -0.1717849E-03-0.4925782E-03-0.1193499     -1.138175      0.000000     001000
 -0.4193529E-03-0.1961648E-03 0.8601762    -0.1756896      0.000000     000100
 ------------------------------------------------------------------------------

Symplectic error :

 0.3072805981764356E-003
End of Cell 1
```

Cosy Infinity’s Parameters used in Balbekov’s Ring Cooler Simulations

```
OV order 2 0 ;
RP 250 0.11342 1 ;
{Muons...uma: 0.11342, charge: 1, muons mass: 0.1 GeV, energy 250 MeV}
SB .1 .1 0 .1 .1 0 0 0 0 0 0 ;
{Set half widths of beam .1 in x,y and .1 rad in a,b}
```

Case 1

```
  Write 30 'Short Solenoid ' ;
  CMSTP 4 NIs r1_s r2_s l_s x_s 0 1.7439 ;
   {A PIECE OF THICK MAGNETIC SOLENOIDS}
   {N: Number of Solenoids, X(IS): Starting position of the IS-th
solenoid,
    S1, S2: Beginning and end position of slice }
   PM 7 ; PM 6 ;
   Write 7 'Symplectic Error : ' ;
   Write 7 SE(Map) ;


ri_ss := 0.2847619 ; ro_ss := 0.3095238 ;

r1_s(1) := ri_ss ;
r1_s(2) := ri_ss ;
r1_s(3) := ri_ss ;
r1_s(4) := ri_ss ;

r2_s(1) := ro_ss ;
r2_s(2) := ro_ss ;
r2_s(3) := ro_ss ;
r2_s(4) := ro_ss ;

j_ss1 := 65730000 ; j_ss2 := 164594200 ;
l_s(1) := 0.4656 + 5 ; l_s(2) := 0.3816 ;
j_ss4 := -65730000 ; j_ss3 := -164594200 ;
l_s(3) := 0.3816 ; l_s(4) := 0.4656 + 5 ;

Ltot := -5 ;
x_s(1) := Ltot ;
Ltot := Ltot + l_s(1) ;
x_s(2) := Ltot ;
Ltot := Ltot + l_s(2) ;
Ltot := Ltot + L1 ;
x_s(3) := Ltot ;
Ltot := Ltot + l_s(3) ;
x_s(4) := Ltot ;

s1_s(1) := 0 ;
s2_s(1) := l_s(1) ;
```

```
NIs(1) := j_ss1 * (ro_ss - ri_ss) ;
NIs(2) := j_ss2 * (ro_ss - ri_ss) ;
NIs(3) := j_ss3 * (ro_ss - ri_ss) ;
NIs(4) := j_ss4 * (ro_ss - ri_ss) ;
```

Case 2

```
  CMSTP 4 NIs r1_s r2_s l_s x_s 0 1.7439 ;
   {A PIECE OF THICK MAGNETIC SOLENOIDS}
   {N: Number of Solenoids, X(IS): Starting position of the IS-th
solenoid,
    S1, S2: Beginning and end position of slice }

{Short Solenoids}
ri_ss := 0.2847619 ; ro_ss := 0.3095238 ;

r1_s(1) := ri_ss ;
r1_s(2) := ri_ss ;
r1_s(3) := ri_ss ;
r1_s(4) := ri_ss ;

r2_s(1) := ro_ss ;
r2_s(2) := ro_ss ;
r2_s(3) := ro_ss ;
r2_s(4) := ro_ss ;

j_ss1 := 65730000 ; j_ss2 := 164594200 ;
l_s(1) := 0.4656 ; l_s(2) := 0.3816 ;
j_ss4 := -65730000 ; j_ss3 := -164594200 ;
l_s(3) := 0.3816 ; l_s(4) := 0.4656 ;

Ltot := 0 ;
x_s(1) := Ltot ;
Ltot := Ltot + l_s(1) ;
x_s(2) := Ltot ;
Ltot := Ltot + l_s(2) ;
Ltot := Ltot + L1 ;
x_s(3) := Ltot ;
Ltot := Ltot + l_s(3) ;
x_s(4) := Ltot ;

s1_s(1) := 0 ;
s2_s(1) := l_s(1) ;


NIs(1) := j_ss1 * (ro_ss - ri_ss) ;
```

```
NIs(2) := j_ss2 * (ro_ss - ri_ss) ;
NIs(3) := j_ss3 * (ro_ss - ri_ss) ;
NIs(4) := j_ss4 * (ro_ss - ri_ss) ;
```

Case 4

```
Write 30 'Short solenoid 1' ;
  Write 7 'Short solenoid 1' ;
   CMST  In_ss1 ri_ss ro_ss 0.4656 ; PM 7 ;
  Write 30 'Short Solenoid 2' ;
  Write 7 'Short Solenoid 2' ;
   CMST In_ss2 ri_ss ro_ss 0.3816 ; PM 7 ;

  Write 30 'CMST Short Solenoid 3' ;
  Write 7 'CMST Short Solenoid 3' ;
   CMST In_ss3 ri_ss ro_ss 0.3816 ;  PM 7 ;
  Write 30 'CMST Short Solenoid 4' ;
  Write 7 'CMST Short Solenoid 4' ;
   CMST In_ss4 ri_ss ro_ss 0.4656 ; PM 7 ;

{Short Solenoids}
ri_ss := 0.2847619 ; ro_ss := 0.3095238 ;

j_ss1 := 65730000 ; j_ss2 := 164594200 ;
extention_s1 := 0.4656 ; extention_s2 := 0.3816 ;
j_ss4 := -65730000 ; j_ss3 := -164594200 ;
extention_s4 := 0.4656 ; extention_s3 := 0.3816 ;

In_ss1 := j_ss1 * (ro_ss - ri_ss) ;
In_ss2 := j_ss2 * (ro_ss - ri_ss) ;
In_ss3 := j_ss3 * (ro_ss - ri_ss) ;
In_ss4 := j_ss4 * (ro_ss - ri_ss) ;
```