Super-FOFO + Dipole Simulations:
A Status Report

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Emittanace Exchange with Super FOFO Lattice

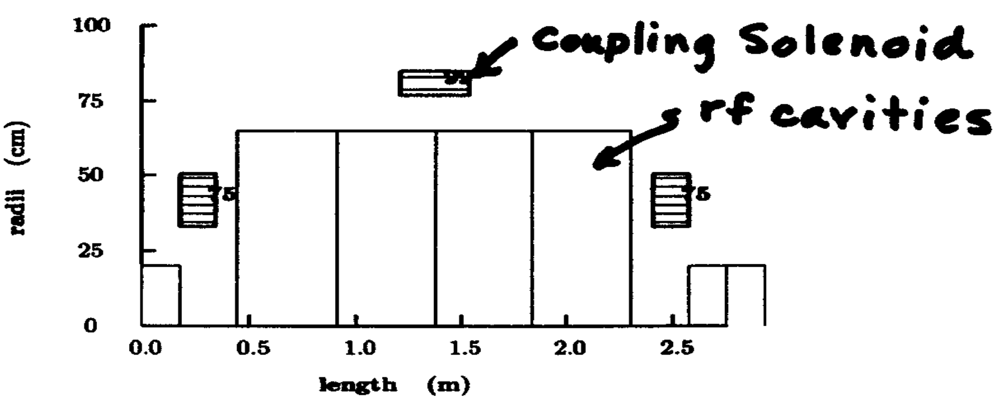
DRAFT

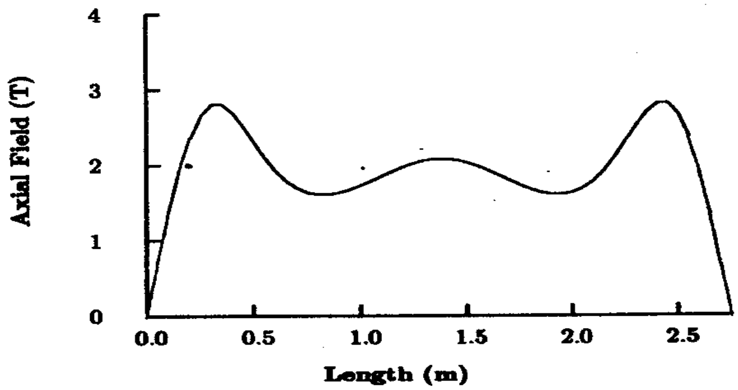
R.B. Palmer 8/17/00

0.1 Super FOFO

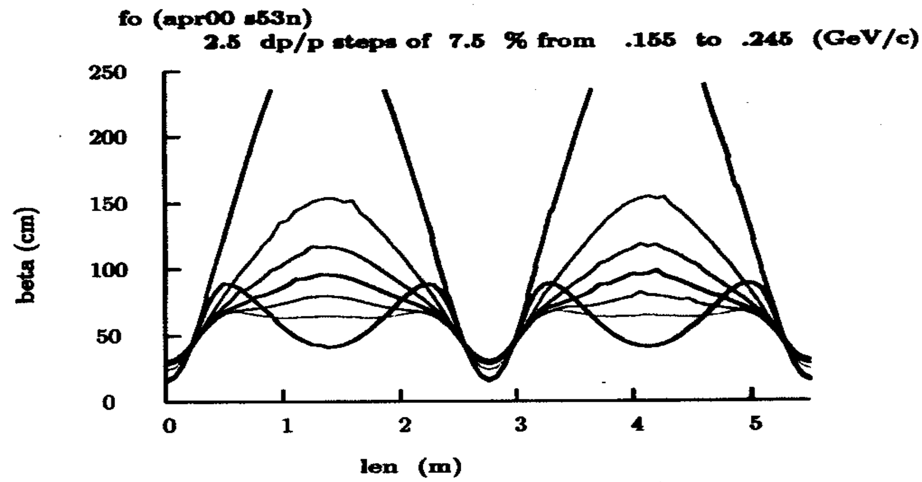
Consider modifying the initial super FOFO lattice as used now in the Study 2 simulations. The cell length is 2.75 m, the β at the absorber is $\approx$ .3 m and it accepts an emittance ($\epsilon_n \approx 10$ mm rad), and a momentum spread of +/− 22 %.

Figs (a) and (b) show the coils and axial field. Fig (c) shows the beta functions for a range of momenta, as a function of position down the cell. Fib (d) shows the phase advance per cell vs momentum (it is realtively linear between limits at π and 2 π where there are resonaces), and the maximum and minimum β's. It is seen that the beta at the absorber (red) is realtively flat, but the β at the center is strongly mometum dependent, rising from about .4 m at one limit and 3 m at the other (this will turn out ot be important).

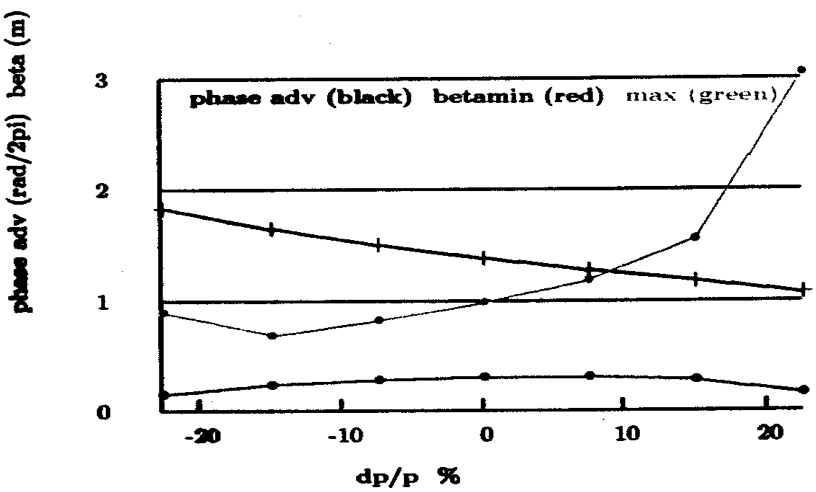




Axial Field (T)
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
2.5
Length (m)

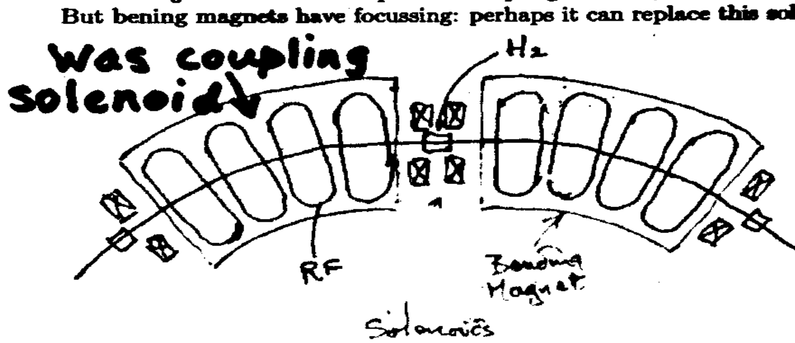


fo (apr00 s53n)
2.5 dp/p steps of 7.5 % from .155 to .245 (GeV/c)
beta (cm)
0
50
100
150
200
250
0
1
2
3
4
5
len (m)



0.2 Add a Bend

In order to use this lattice for emittance exchange we must add some bending to generate dispersion at the absorber. The absorber can then be made wedge like and the required exchange obtained. Consider putting the bend in the center of the cell¿ It now falls on top of the coupling solenoid, which is uncomfortable. But bening magnets have focussing: perhaps it can replace this solenoid.



Started with Study 2 Design A ICOOL files. However, these were for ICOOL v2.06, and ICOOL had gone to v2.08. (Rick fixed the files – there are many SHEET files.)

Meanwhile Rick made ICOOL v2.10 to take care of the bend in the dipole (BSOL Model 3). This required new files with

z B_z (r=0) B_y grad

Wrote output files with magnetic fields from SHEET files.

Translated these to new files for BSOL Model 3. (Needed to write a small program to do this.)

Test: Reproduce old v2.08 results using v2.11 and BSOL Model 3 with $B_y = 0$. This required commenting out some code in ICOOL because $B_y = 0$ was a failure mode in BSOL Model 3.

→→ Finally reproduced v2.08 results: 22/100 particles transmitted vs. 20/100.

- Find if there is sufficient space inside the smaller coils for the harmonic RF, and redesign the lattice with larger inside radii, if needed.

2.11 Cooling Latices

2.11.1 Introduction

The cooling is done in six sections with steadily decreasing β's. This is done to maximize the cooling rate. Too small a β at a given emittance results in too large divergence angles and particle loss. Too large a β gives small divergence angles and a greater relative emittance growth from coulomb scattering. The best β scales down with the emittance and is always such as to give a certain constant divergence angles ($\sigma_{x'} = \sigma_{y'} \approx 0.1$).

The six sections are made from two different physical lattices [(1) and (2)], with three different current setting in each: 1,1 1,2 1,3 in the first lattice, and 2,1 2,2 2,3, in the second. The final cooling section (2,3) is further broken into 2 parts (2,3a) and (2,3b) that differ only in their window sizes and thicknesses.

The lengths of the sections are:

	length m	from target m
cool 1,1	$6 \times 2.75 = 16.5$	444.9
cool 1,2	$6 \times 2.75 = 16.5$	461.4
cool 1,3	$6 \times 2.75 = 16.5$	477.9
cool 2,1	$14 \times 1.65 = 23.1$	501
cool 2,2	$10 \times 1.65 = 16.5$	517.5
cool 2,3a	$16 \times 1.65 = 26.4$	543.9
cool 2,3b	$16 \times 1.65 = 26.4$	570.3

The lattices used have been named "Super FOFO". The "FOFO" refers to the basic sequence of alternating solenoids, that focus the beam and generate β, and thus beam size, minima between the solenoids. The "Super" part, proposed by A. Sessler, is the replacement of the simple alternating solenoids with alternating, but more complex, solenoid systems. In this case the systems consist of strong short "focusing" solenoids at either end, and a weaker "coupling" fields between them.

An example of the fields (for the last part) is given below

```
125e-6    1    10e-6
1 0        0.2
NONE
  0  0  0  0  0   0  0  0  0  0    0  0  0  0  0
VAC
CBLOCK
  0  0  0  0  0    0  0  0  0  0
OUTPUT
SREGION          !  free
2.75       1     5e-3
1  0.   0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
ENDCELL
CELL
1
.true.
SHEET
3 29  0.02  0.02   2.76      0.65   5.0    2    0. 1.     0. 0. 0. 0. 0.
OUTPUT
SREGION          !================ 3ND DRIFT
2.75       1     5e-3
1  0.   0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
ENDCELL
REFP
2   0.2   0.   0  3
CELL
6
.true.
SHEET            !  ======================== cool t53
3.  29  0.01  0.01  2.751  0.4  5.      2. 80. 0.  0. 0. 0. 0. 0.
SREGION          !  dummy
0.001       1  1e-3
1  0.     0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
SREGION          ! 1/2 HYDROGEN
0.175       1     3e-3
1  0.  0.18
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
LH
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
SREGION          !Hydrogen  window
200e-6   1   100e-6
1 0      0.18
NONE
  0  0  0  0  0   0  0  0  0  0    0  0  0  0  0
```

11316

		z	r	Bz	Br
1	1	0.0000E+00	0.0000E+00	0.2339E-01	0.0000E+00
1	2	0.0000E+00	0.1000E-01	0.2339E-01	0.6996E-01
1	3	0.0000E+00	0.2000E-01	0.2339E-01	0.1400E+00
1	4	0.0000E+00	0.3000E-01	0.2339E-01	0.2102E+00
1	5	0.0000E+00	0.4000E-01	0.2338E-01	0.2808E+00
1	6	0.0000E+00	0.5000E-01	0.2338E-01	0.3518E+00
1	7	0.0000E+00	0.6000E-01	0.2337E-01	0.4234E+00
1	8	0.0000E+00	0.7000E-01	0.2337E-01	0.4955E+00
1	9	0.0000E+00	0.8000E-01	0.2336E-01	0.5684E+00
1	10	0.0000E+00	0.9000E-01	0.2335E-01	0.6421E+00
1	11	0.0000E+00	0.1000E+00	0.2334E-01	0.7167E+00
1	12	0.0000E+00	0.1100E+00	0.2333E-01	0.7923E+00
1	13	0.0000E+00	0.1200E+00	0.2332E-01	0.8689E+00
1	14	0.0000E+00	0.1300E+00	0.2331E-01	0.9466E+00
1	15	0.0000E+00	0.1400E+00	0.2329E-01	0.1025E+01
1	16	0.0000E+00	0.1500E+00	0.2328E-01	0.1105E+01
1	17	0.0000E+00	0.1600E+00	0.2326E-01	0.1187E+01
1	18	0.0000E+00	0.1700E+00	0.2324E-01	0.1269E+01
1	19	0.0000E+00	0.1800E+00	0.2323E-01	0.1352E+01
1	20	0.0000E+00	0.1900E+00	0.2321E-01	0.1436E+01
1	21	0.0000E+00	0.2000E+00	0.2319E-01	0.1522E+01
1	22	0.0000E+00	0.2100E+00	0.2317E-01	0.1607E+01
1	23	0.0000E+00	0.2200E+00	0.2315E-01	0.1694E+01
1	24	0.0000E+00	0.2300E+00	0.2312E-01	0.1780E+01
1	25	0.0000E+00	0.2400E+00	0.2310E-01	0.1867E+01
1	26	0.0000E+00	0.2500E+00	0.2307E-01	0.1953E+01
1	27	0.0000E+00	0.2600E+00	0.2305E-01	0.2038E+01
1	28	0.0000E+00	0.2700E+00	0.2302E-01	0.2122E+01
1	29	0.0000E+00	0.2800E+00	0.2299E-01	0.2203E+01
1	30	0.0000E+00	0.2900E+00	0.2297E-01	0.2282E+01
1	31	0.0000E+00	0.3000E+00	0.2293E-01	0.2358E+01
1	32	0.0000E+00	0.3100E+00	0.2290E-01	0.2430E+01
1	33	0.0000E+00	0.3200E+00	0.2287E-01	0.2497E+01
1	34	0.0000E+00	0.3300E+00	0.2284E-01	0.2559E+01
1	35	0.0000E+00	0.3400E+00	0.2281E-01	0.2614E+01
1	36	0.0000E+00	0.3500E+00	0.2277E-01	0.2663E+01
1	37	0.0000E+00	0.3600E+00	0.2274E-01	0.2705E+01
1	38	0.0000E+00	0.3700E+00	0.2270E-01	0.2739E+01
1	39	0.0000E+00	0.3800E+00	0.2266E-01	0.2764E+01
1	40	0.0000E+00	0.3900E+00	0.2262E-01	0.2781E+01
1	41	0.0000E+00	0.4000E+00	0.2259E-01	0.2789E+01
2	1	0.1000E-01	0.0000E+00	-0.1164E+00	0.0000E+00
2	2	0.1000E-01	0.1000E-01	-0.1165E+00	0.6983E-01
2	3	0.1000E-01	0.2000E-01	-0.1167E+00	0.1398E+00
2	4	0.1000E-01	0.3000E-01	-0.1170E+00	0.2100E+00
2	5	0.1000E-01	0.4000E-01	-0.1176E+00	0.2805E+00
2	6	0.1000E-01	0.5000E-01	-0.1182E+00	0.3515E+00
2	7	0.1000E-01	0.6000E-01	-0.1190E+00	0.4229E+00
2	8	0.1000E-01	0.7000E-01	-0.1199E+00	0.4951E+00
2	9	0.1000E-01	0.8000E-01	-0.1209E+00	0.5679E+00
2	10	0.1000E-01	0.9000E-01	-0.1221E+00	0.6415E+00
2	11	0.1000E-01	0.1000E+00	-0.1234E+00	0.7161E+00
2	12	0.1000E-01	0.1100E+00	-0.1247E+00	0.7916E+00
2	13	0.1000E-01	0.1200E+00	-0.1262E+00	0.8682E+00
2	14	0.1000E-01	0.1300E+00	-0.1277E+00	0.9458E+00
2	15	0.1000E-01	0.1400E+00	-0.1293E+00	0.1025E+01
2	16	0.1000E-01	0.1500E+00	-0.1309E+00	0.1105E+01
2	17	0.1000E-01	0.1600E+00	-0.1326E+00	0.1186E+01
2	18	0.1000E-01	0.1700E+00	-0.1342E+00	0.1268E+01

cool 1,1 v2.11
250

z	Bz	By	grad
0.0000E+00	0.2339E-01	0.0000E+00	0.0000E+00
0.1000E-01	-0.1164E+00	0.0000E+00	0.0000E+00
0.2000E-01	-0.2559E+00	0.0000E+00	0.0000E+00
0.3000E-01	-0.3948E+00	0.0000E+00	0.0000E+00
0.4000E-01	-0.5328E+00	0.0000E+00	0.0000E+00
0.5000E-01	-0.6697E+00	0.0000E+00	0.0000E+00
0.6000E-01	-0.8051E+00	0.0000E+00	0.0000E+00
0.7000E-01	-0.9387E+00	0.0000E+00	0.0000E+00
0.8000E-01	-0.1070E+01	0.0000E+00	0.0000E+00
0.9000E-01	-0.1199E+01	0.0000E+00	0.0000E+00
0.1000E+00	-0.1325E+01	0.0000E+00	0.0000E+00
0.1100E+00	-0.1449E+01	0.0000E+00	0.0000E+00
0.1200E+00	-0.1568E+01	0.0000E+00	0.0000E+00
0.1300E+00	-0.1684E+01	0.0000E+00	0.0000E+00
0.1400E+00	-0.1796E+01	0.0000E+00	0.0000E+00
0.1500E+00	-0.1903E+01	0.0000E+00	0.0000E+00
0.1600E+00	-0.2004E+01	0.0000E+00	0.0000E+00
0.1700E+00	-0.2102E+01	0.0000E+00	0.0000E+00
0.1800E+00	-0.2194E+01	0.0000E+00	0.0000E+00
0.1900E+00	-0.2280E+01	0.0000E+00	0.0000E+00
0.2000E+00	-0.2360E+01	0.0000E+00	0.0000E+00
0.2100E+00	-0.2435E+01	0.0000E+00	0.0000E+00
0.2200E+00	-0.2503E+01	0.0000E+00	0.0000E+00
0.2300E+00	-0.2564E+01	0.0000E+00	0.0000E+00
0.2400E+00	-0.2619E+01	0.0000E+00	0.0000E+00
0.2500E+00	-0.2667E+01	0.0000E+00	0.0000E+00
0.2600E+00	-0.2709E+01	0.0000E+00	0.0000E+00
0.2700E+00	-0.2744E+01	0.0000E+00	0.0000E+00
0.2800E+00	-0.2772E+01	0.0000E+00	0.0000E+00
0.2900E+00	-0.2794E+01	0.0000E+00	0.0000E+00
0.3000E+00	-0.2810E+01	0.0000E+00	0.0000E+00
0.3200E+00	-0.2823E+01	0.0000E+00	0.0000E+00
0.3400E+00	-0.2814E+01	0.0000E+00	0.0000E+00
0.3500E+00	-0.2802E+01	0.0000E+00	0.0000E+00
0.3600E+00	-0.2786E+01	0.0000E+00	0.0000E+00
0.3700E+00	-0.2765E+01	0.0000E+00	0.0000E+00
0.3800E+00	-0.2741E+01	0.0000E+00	0.0000E+00
0.3900E+00	-0.2713E+01	0.0000E+00	0.0000E+00
0.4000E+00	-0.2682E+01	0.0000E+00	0.0000E+00
0.4100E+00	-0.2648E+01	0.0000E+00	0.0000E+00
0.4200E+00	-0.2613E+01	0.0000E+00	0.0000E+00
0.4300E+00	-0.2575E+01	0.0000E+00	0.0000E+00
0.4400E+00	-0.2536E+01	0.0000E+00	0.0000E+00
0.4500E+00	-0.2496E+01	0.0000E+00	0.0000E+00
0.4600E+00	-0.2454E+01	0.0000E+00	0.0000E+00
0.4700E+00	-0.2413E+01	0.0000E+00	0.0000E+00
0.4800E+00	-0.2371E+01	0.0000E+00	0.0000E+00
0.4900E+00	-0.2329E+01	0.0000E+00	0.0000E+00
0.5000E+00	-0.2287E+01	0.0000E+00	0.0000E+00
0.5100E+00	-0.2245E+01	0.0000E+00	0.0000E+00
0.5200E+00	-0.2205E+01	0.0000E+00	0.0000E+00
0.5300E+00	-0.2165E+01	0.0000E+00	0.0000E+00
0.5400E+00	-0.2126E+01	0.0000E+00	0.0000E+00
0.5500E+00	-0.2088E+01	0.0000E+00	0.0000E+00
0.5600E+00	-0.2051E+01	0.0000E+00	0.0000E+00
0.5700E+00	-0.2016E+01	0.0000E+00	0.0000E+00
0.5800E+00	-0.1982E+01	0.0000E+00	0.0000E+00
0.5900E+00	-0.1949E+01	0.0000E+00	0.0000E+00

```
125e-6    1    10e-6
1 0         0.2
NONE
  0  0  0  0  0   0  0  0  0  0    0  0  0  0  0
VAC
CBLOCK
  0  0  0  0  0    0  0  0  0  0
OUTPUT
SREGION          !  free
2.75       1     5e-3
1  0.    0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
ENDCELL
CELL
1
.true.
SHEET
3 29  0.02  0.02   2.76      0.65   5.0    2    0. 1.     0. 0. 0. 0. 0.
OUTPUT
SREGION          !================= 3ND DRIFT
2.75       1     5e-3
1  0.    0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
ENDCELL
REFP
2   0.2    0.  0  3
CELL
6
.true.
BSOL              !   ======================== cool 1,1
3.  70.   0.200  2. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
SREGION           !   dummy
0.001        1  1e-3
1  0.     0.5
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.  0. 0. 0. 0. 0.
VAC
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
SREGION          ! 1/2 HYDROGEN
0.175       1     3e-3
1  0.   0.18
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
LH
CBLOCK
   0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
SREGION          !Hydrogen  window
200e-6    1   100e-6
1 0       0.18
NONE
  0  0  0  0  0   0  0  0  0  0    0  0  0  0  0
```

TO DO

So far accomplished only Step 0.

1. Put in diagnostics (dispersions, emittances, etc.) at the right places.

2. Turn on dipole.

3. Remove coupling solenoid?

4. Put in wedges.

5. Go to RFOFO. (This is what Bob is already doing now.)

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(Lots of knobs!)