Author: R. Fernow and G. Morgan

Date: March 7, 1984

No.: 52-1

Title: Coil Design for the BNL SSC Prototype Dipole (SSC-P7)

Task Force: Coil Geometry Analysis

M. Anerella
F. Atkinson
G. Bagley
A. Bertsche
E. Bleser
D. Brown
V. Buchanan
J. Cottingham
J. Cullen
P. Dahl
Y. Elisman
A. Feltman
R. Fernow
G. Ganetis
D. Gardner
A. Ghosh
C. Goodzeit
D. Gough
A. Greene
H. Hahn
W. Harrison
J. Herrera
R. Hogue
S. Kahn
E. Kelly
H. Kirk
J. Koehler
R. Louttit
R. LeRoy
W. McGahern
G. Morgan
R. Palmer
S. Plate
I. Polk
A. Prodell
K. Robins
R. Rosenka
W. Sampson
W. Schneider
M. Shapiro
R. Shutt
J. Skaritka
A. Stevens
C. Sylvester
P. Thompson
P. Wanderer
T. Wild
E. Willen

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The first BNL SSC prototype dipole will use CBA NbTi cable. This cable has a mean thickness including insulation of 55 mils and an 11 mil keystone. Unfortunately the keystone does not match the required angle for the small diameter SSC coils. For this reason we have considered a partial keystoned SSC design. An important constraint on the design was that the pole angles had to match those for the SSC-43 design in order to minimize any changes to existing magnet components and tooling.

The best design (SSC-P7) we were able to obtain is shown in Fig. 1. The first turns of the midplane blocks lie flat on a 3 mil thick piece of midplane insulation, while the last turns of the post blocks lie flat against the 30 mil thick piece of G-10 at the post. The coil geometry is summarized in Table 1:

Table 1 Coil Geometry

N	r_i (cm)	r_o (cm)	ϕ_{min}	ϕ_{max}	Δr_{max} (mils)
10	1.610	2.393	0.18°	45.14	28
5	1.610	2.393	53.90	76.20	9
8	2.449	3.231	0.13	23.75	2
10	2.449	3.231	25.02	54.46	2

The quantities r_i and r_o are the reference radii which bound the conductor turns. Φ_{min} and Φ_{max} are the minimum and maximum angles subtended to a conductor corner in the block. Δr_{max} is the maximum deviation of a conductor corner from its reference radius. The x,y coordinates of the corners of each turn are shown in Fig. 2.

Table 2 Current Margins at 4.5K (Bo = 5.81 T)

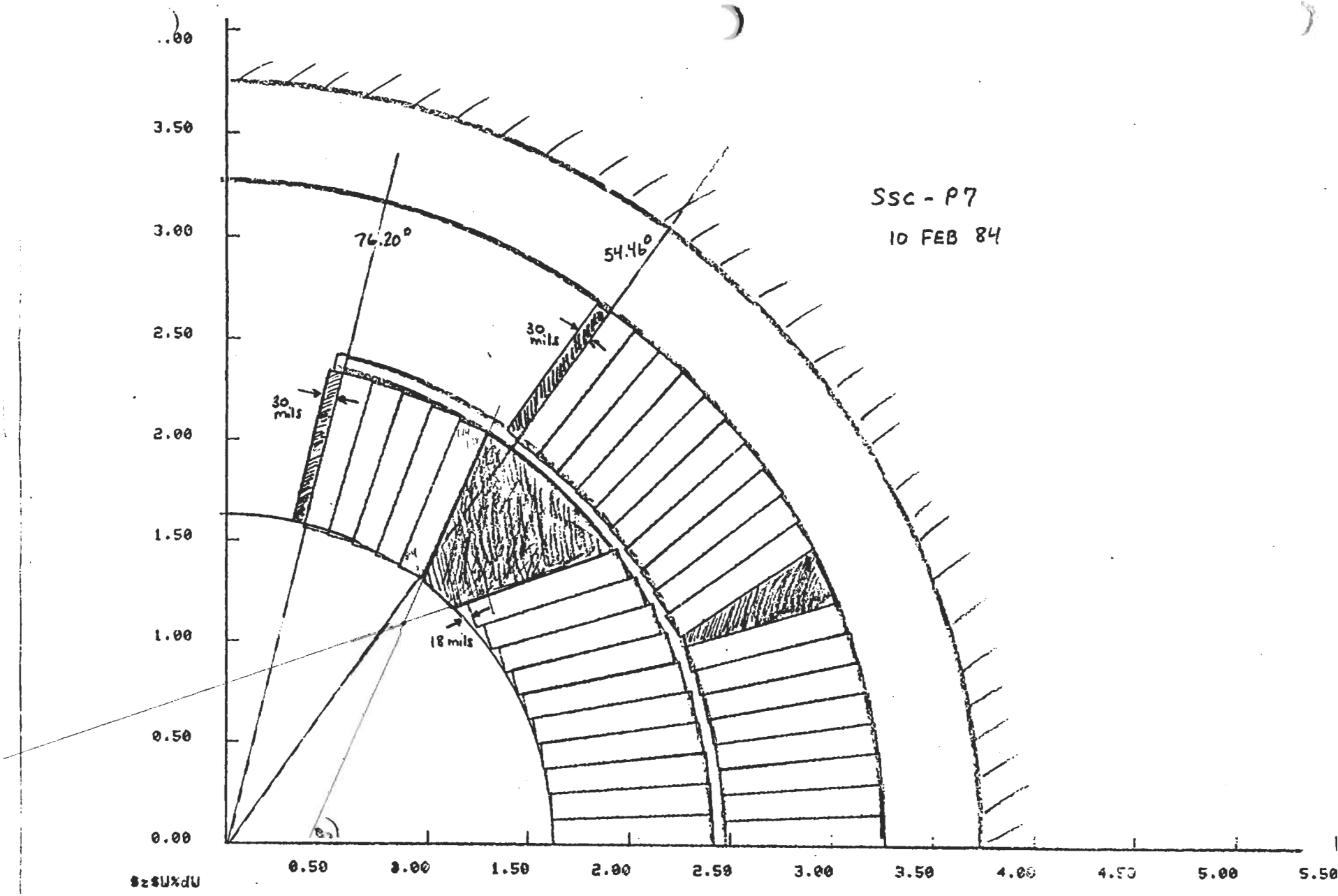
Block	I (A)	B_p (T)	I_{cr} (A)	Margin (%)
1	4000	4.44	6235	56
2	4000	6.07	4160	4
3	5400	3.25	8220	52
4	5400	4.96	5520	2

The current margins at 4.5K are given in Table 2 for the case when the inner coil is operated at 4000 A and the outer coil at 5400 A. The peak fields are calculated at the upper, inside corners of the block. The 2-in-1 iron configuration is shown in Fig. 3. This produces a central field of 58.1 KG with a 2% safety margin. The critical currents were taken from measured CBA coil data.

The multipoles are shown in Table 3. The coil arrangement produces a large b_4 term because of the post angle constraint mentioned above.

Table 3 Multipoles $b_n \times 10^4$ @ 1 cm

I_1	TF	b_1	b_2	b_3	b_4	b_5	b_6
$\infty\mu$	15.010	0.0	8.3	0.0	34.7	0.0	-11.7
1KA (MDP)	14.950	4.0	3.6	0.0	35.1	-0.1	-11.7
4KA (MDP)	14.519	-0.4	22.6	-0.1	36.6	0.0	- 2.0


Ssc - P7
10 FEB 84
76.20°
54.46°
30 mils
30 mils
18 mils
..00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50

zU%dU

... 65

EQ FUNCTION = 11.973381

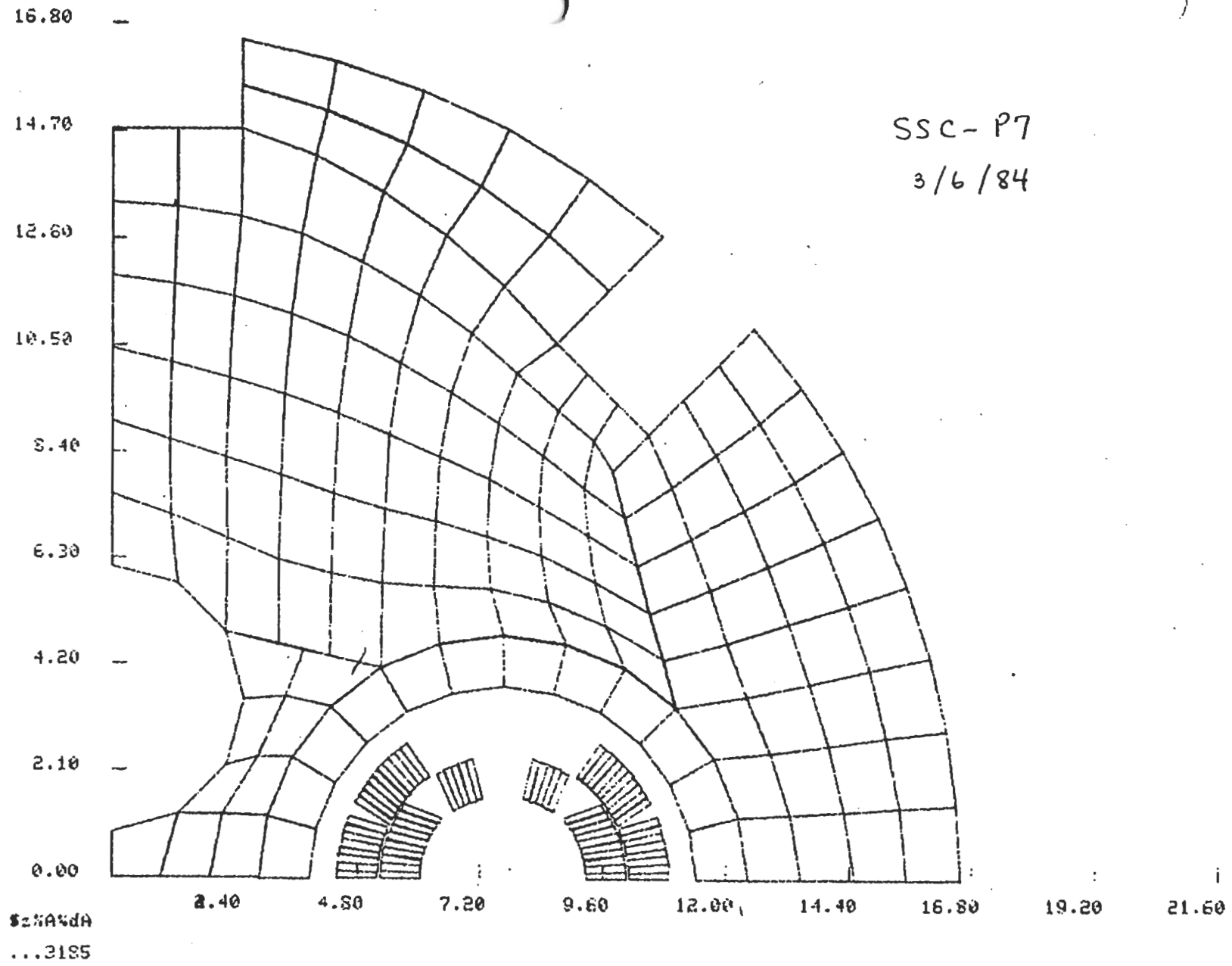
MINIMIZATION 1

	x (cm)	y	x	y	x	y	x	y
C,CXY 1 1 1	1.6098	.0076	1.6075	.1333	2.3901	.1613	2.3929	.0076
C,CXY 1 1 2	1.6026	.1332	1.5959	.2587	2.3770	.3145	2.3853	.1611
C,CXY 1 1 3	1.5867	.2580	1.5755	.3833	2.3541	.4669	2.3678	.3139
C,CXY 1 1 4	1.5618	.3818	1.5461	.5066	2.3213	.6179	2.3404	.4655
C,CXY 1 1 5	1.5281	.5040	1.5080	.6281	2.2787	.7670	2.3033	.6154
C,CXY 1 1 6	1.4856	.6240	1.4611	.7474	2.2264	.9137	2.2563	.7630
C,CXY 1 1 7	1.4343	.7415	1.4054	.8639	2.1643	1.0575	2.1996	.9079
C,CXY 1 1 8	1.3743	.8560	1.3410	.9772	2.0925	1.1977	2.1331	1.0495
C,CXY 1 1 9	1.3055	.9668	1.2680	1.0868	2.0111	1.3340	2.0570	1.1873
C,CXY 1 1 10	1.2281	1.0735	1.1863	1.1921	1.9201	1.4656	1.9712	1.3207
II2,RI,RO=	41.1576	45.1396	1.6555	2.3930				
C,CXY 1 3 1	.5057	1.5313	.3841	1.5635	.5709	2.3240	.7195	2.2847
C,CXY 1 3 2	.6247	1.4907	.5044	1.5271	.7182	2.2805	.8653	2.2359
C,CXY 1 3 3	.7408	1.4416	.6218	1.4824	.8624	2.2276	1.0078	2.1778
C,CXY 1 3 4	.8534	1.3844	.7360	1.4294	1.0029	2.1656	1.1464	2.1106
C,CXY 1 3 5	.9620	1.3192	.8463	1.3683	1.1394	2.0945	1.2808	2.0345
II2,RI,RO=	53.8979	58.2632	1.6196	2.3930				
C,CXY 2 1 1	2.4491	.0076	2.4469	.1333	3.2285	.1613	3.2312	.0076
C,CXY 2 1 2	2.4445	.1332	2.4378	.2588	3.2179	.3146	3.2261	.1612
C,CXY 2 1 3	2.4335	.2585	2.4223	.3837	3.1999	.4674	3.2136	.3143
C,CXY 2 1 4	2.4160	.3830	2.4003	.5078	3.1745	.6192	3.1936	.4667
C,CXY 2 1 5	2.3921	.5066	2.3720	.6307	3.1417	.7697	3.1663	.6180
C,CXY 2 1 6	2.3619	.6289	2.3374	.7522	3.1016	.9186	3.1316	.7679
C,CXY 2 1 7	2.3254	.7496	2.2964	.8720	3.0542	1.0655	3.0896	.9160
C,CXY 2 1 8	2.2826	.8684	2.2493	.9897	2.9997	1.2102	3.0404	1.0620
II2,RI,RO=	20.8295	23.7489	2.4490	3.2207				
C,CXY 2 3 1	1.5248	1.9181	1.4238	1.9930	1.8784	2.6294	2.0018	2.5379
C,CXY 2 3 2	1.6218	1.8381	1.5236	1.9165	2.0006	2.5363	2.1207	2.4404
C,CXY 2 3 3	1.7146	1.7532	1.6193	1.8351	2.1182	2.4374	2.2347	2.3373
C,CXY 2 3 4	1.8030	1.6636	1.7106	1.7488	2.2307	2.3330	2.3437	2.2288
C,CXY 2 3 5	1.8867	1.5695	1.7975	1.6580	2.3381	2.2232	2.4472	2.1150
C,CXY 2 3 6	1.9656	1.4712	1.8795	1.5629	2.4400	2.1084	2.5452	1.9964
C,CXY 2 3 7	2.0394	1.3689	1.9566	1.4635	2.5362	1.9887	2.6373	1.8730
C,CXY 2 3 8	2.1079	1.2627	2.0286	1.3603	2.6265	1.8644	2.7235	1.7452
C,CXY 2 3 9	2.1709	1.1531	2.0951	1.2534	2.7108	1.7358	2.8034	1.6132
C,CXY 2 3 10	2.2284	1.0401	2.1562	1.1430	2.7887	1.6032	2.8768	1.4773
I2,RI,RO=	25.0206	27.9289	2.4490	3.2244				

TED Y ARRAY

PHIST	TURNS	RIN	ROUT	I/L	THICK	PHIEND	
3.0000	3.0000	1.6100	2.3930	1.0000	55.0000	11.0000	0.0000
3.0000	3.0000	2.4490	3.2310	1.0000	55.0000	11.0000	0.0000

Fig 2


16.80
14.70
12.60
10.50
8.40
6.30
4.20
2.10
0.00
2.40
4.80
7.20
9.60
12.00
14.40
16.80
19.20
21.60
$z%A%dA
...3185

SSC-P7
3/6/84