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Title: A Possible Cross Section for the LBL SSC Dipole

Task Force: LBL SSC

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A POSSIBLE CROSS SECTION FOR THE LBL SSC DIPOLE

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At the request of LBL we have been considering the design of an SSC dipole using the proposed LBL conductors with partial keystone and with a small number of thick wedges. In order to accomplish this we have written a program using MINUIT that optimizes the number of turns in conductor blocks and the thicknesses of the wedges. The optimization program utilizes a subroutine (TRAP) provided by G. Morgan, which provides the coordinates of the corners of a trapezoid with arbitrary mean thickness and keystone.[1] For a given conductor distribution the coordinates of each conductor turn are fed into another subroutine (MULQUAD), which calculates the contribution of that turn to the multipoles.

Figure 1 illustrates several aspects of the conductor geometry. It is assumed that there is a 2 mil midplane insulation cap. The starting edge of the first midplane turn is horizontal. The midpoint of the outer edge of the inner coil and the midpoint of the inner edge of the outer coil are assumed to lie on reference radii. The other edge of each layer tends to deviate more and more from constant r as more conductors are added to the block. It follows then that the beginning angle of the wedge is not along a radius. However, it is assumed that the end angle of the wedge (and the start angle of the next block of conductors) is on a radius.

Table I gives the LBL conductor thicknesses and the assumed keystone. Table II and Figure 2 shows the proposed solution consisting of 6 conductor blocks and 4 wedges. The actual coordinates of every turn are given in Figure 3. The quantity Δr is the maximum deviation from the reference radii. The start angles for the midplane blocks correspond to the 2 mil flat insulation that was actually used. The end angle corresponds to the corner point at the maximum angle. Table III gives the wedge geometry. Two points are specified for the starting edge since it does not lie on a radius. $\bar{r}$ is the mean reference radius.

The multipoles at 2/3 aperture are given in Table IV. The multipoles are all $\lesssim 10^{-4}$. The transfer function is 12.94 G/A. One possible flaw with this procedure is that MULQUAD assumes a constant current density in the conductor. The error in not using the 1/r distribution in an SSC geometry has been calculated by Morgan to be ~ 5 sextupole units and negigible for the higher moments. It would thus appear that this design would have acceptable field quality.

1. G. Morgan, Geometry of partially keystoned cables, Analysis Section Note No. 47, (1983).

TABLE I
LBL Conductors

	t (mils)	Keystone (mils)
inner	58.5	12
outer	48.2	10

TABLE II
SSCB-1 Dipole Cross Section

Block	Turns	ϕ_{st}	ϕ_{end}	r_i (cm)	r_o (cm)	Δr (mils)
1	8	0.12°	30.74	1.999	2.936	9
2	6	31.67	54.59	1.999	2.936	4
3	4	59.71	74.98	1.999	2.936	2
4	5	0.08	10.59	2.997	3.861	0
5	9	13.66	32.55	2.997	3.861	1
6	7	34.76	49.45	2.997	3.861	0

TABLE III
SSCB-1 Wedges

Wedge	ϕ_{st}(°)	$\phi_c(r_c)$	r_c (cm)	ϕ_{end}(°)
1	27.94	30.74	2.021	31.67
2	52.45	54.59	2.010	59.71
3	10.31	10.59	2.997	13.66
4	32.08	32.55	2.997	34.76

TABLE IV
Multipoles, $b_n \times 10^4$ @ 1.33 cm

n	b_n
2	-0.3
4	0.1
6	0.4
8	0.6
10	1.2
12	-1.2
TF	12.94 G/A

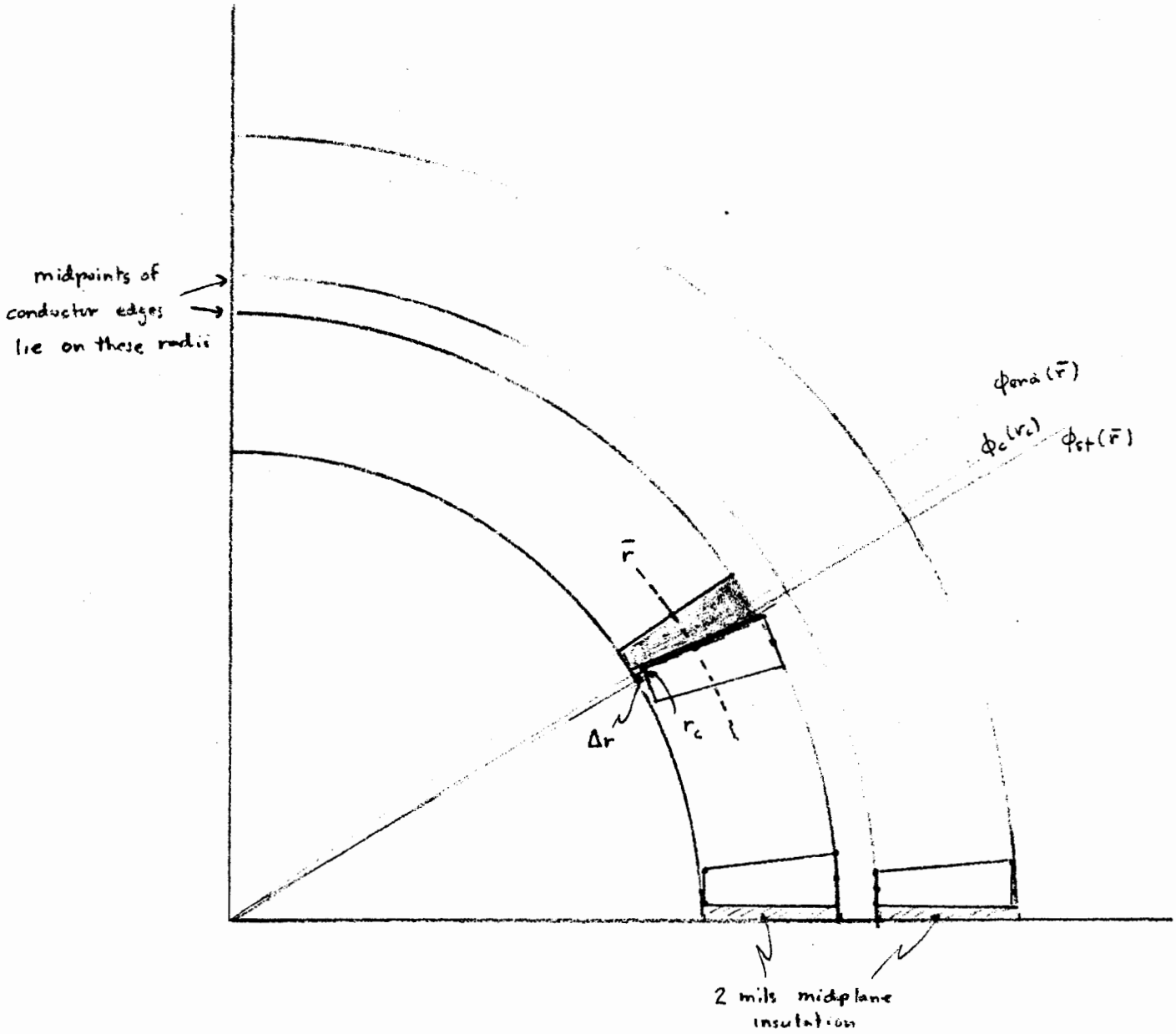
midpoints of
conductor edges
lie on these radii
$\phi_{ord}(\bar{r})$
$\phi_c(r_c)$
$\phi_{st}(\bar{r})$
$\bar{r}$
Δr
r_c
2 mils midplane
insulation

Figure 1

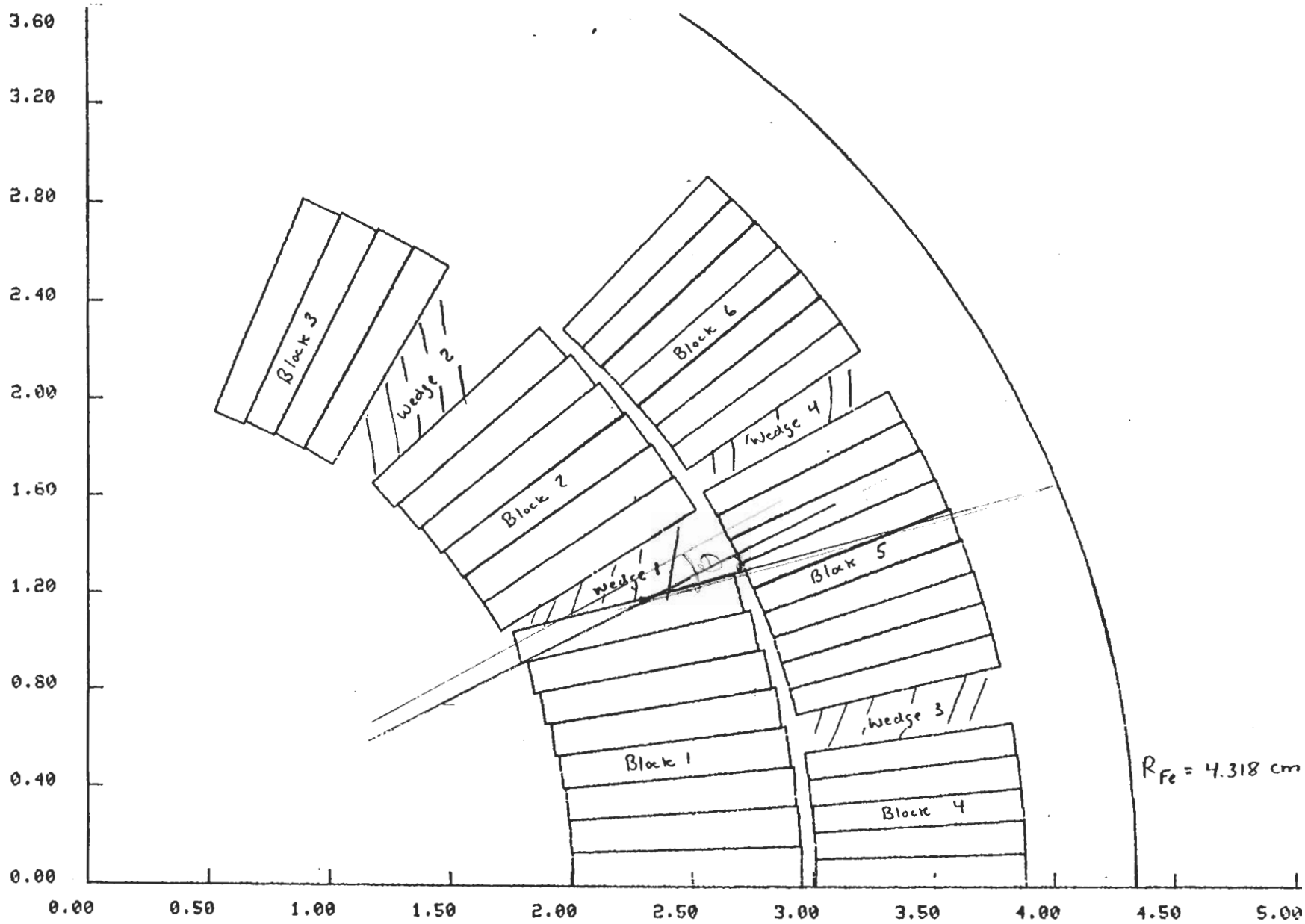

Figure 2

...3120

				x	y	x	y	x	y	x	y
,CXY	1	1	1	1.9989	.0051	1.9968	.1384	2.9334	.1689	2.9360	.0051
,CXY	1	1	2	1.9927	.1383	1.9862	.2715	2.9213	.3324	2.9293	.1688
,CXY	1	1	3	1.9782	.2710	1.9674	.4039	2.9001	.4952	2.9134	.3319
,CXY	1	1	4	1.9557	.4027	1.9406	.5352	2.8698	.6568	2.8884	.4940
,CXY	1	1	5	1.9250	.5332	1.9056	.6651	2.8304	.8168	2.8543	.6548
,CXY	1	1	6	1.8863	.6619	1.8626	.7932	2.7819	.9749	2.8111	.8137
,CXY	1	1	7	1.8395	.7886	1.8115	.9190	2.7245	1.1305	2.7589	.9703
,CXY	1	1	8	1.7847	.9128	1.7525	1.0422	2.6581	1.2833	2.6977	1.1243
,RO=				30.7389	2.0208	2.9360					
,PHTST		1	2	.2794E+02	.3167E+02						
,CXY	1	3	1	1.7014 3167	1.0494	1.6296	1.1618	2.4108	1.6794	2.4991 3147	1.5414
,CXY	1	3	2	1.6264	1.1597	1.5510	1.2696	2.3149	1.8124	2.4076	1.6773
,CXY	1	3	3	1.5447	1.2652	1.4658	1.3726	2.2116	1.9400	2.3087	1.8080
,CXY	1	3	4	1.4566	1.3657	1.3742	1.4705	2.1012	2.0618	2.2025	1.9330
,CXY	1	3	5	1.3623	1.4608	1.2765	1.5629	1.9839	2.1775	2.0893	2.0521
,CXY	1	3	6	1.2619	1.5503	1.1728	1.6495	1.8599	2.2868	1.9694	2.1649
,RO=				54.5860	2.0104	2.9360					
,PHTST		1	4	.5245E+02	.5971E+02						
,CXY	1	5	1	1.0082	1.7262	.8920	1.7916	1.3381	2.6157	1.4809	2.5354
,CXY	1	5	2	.8902	1.7892	.7719	1.8498	1.1910	2.6880	1.3363	2.6123
,CXY	1	5	3	.7685	1.8429	.6483	1.9006	1.0398	2.7520	1.1875	2.6811
,CXY	1	5	4	.6435	1.8902	.5214	1.9439	.8851	2.8076	1.0350	2.7416
,RO=				74.9846	2.0036	2.9360					
,CXY	2	1	1	2.9972	.0051	2.9956	.1148	3.8593	.1402	3.8613	.0051
,CXY	2	1	2	2.9946	.1148	2.9898	.2244	3.8524	.2752	3.8583	.1402
,CXY	2	1	3	2.9880	.2243	2.9800	.3337	3.8407	.4098	3.8506	.2751
,CXY	2	1	4	2.9774	.3335	2.9661	.4426	3.8243	.5440	3.8381	.4096
,CXY	2	1	5	2.9628	.4422	2.9483	.5510	3.8031	.6776	3.8209	.5436
,RO=				10.5859	2.9970	3.8606					
,PHTST		2	2	.1031E+02	.1366E+02						
,CXY	2	3	1	2.9125	.7078	2.8851	.8140	3.7184	1.0427	3.7522	.9118
,CXY	2	3	2	2.8843	.8138	2.8537	.9192	3.6799	1.1722	3.7176	1.0425
,CXY	2	3	3	2.8522	.9187	2.8185	1.0232	3.6369	1.3004	3.6784	1.1718
,CXY	2	3	4	2.8163	1.0224	2.7795	1.1258	3.5895	1.4269	3.6347	1.2996
,CXY	2	3	5	2.7766	1.1247	2.7368	1.2270	3.5375	1.5518	3.5865	1.4258
,CXY	2	3	6	2.7332	1.2255	2.6904	1.3265	3.4812	1.6748	3.5339	1.5503
,CXY	2	3	7	2.6861	1.3246	2.6404	1.4244	3.4206	1.7957	3.4769	1.6728
,CXY	2	3	8	2.6354	1.4220	2.5868	1.5204	3.3558	1.9145	3.4156	1.7933
,CXY	2	3	9	2.5811	1.5175	2.5296	1.6144	3.2867	2.0309	3.3501	1.9116
,RO=				32.5457	2.9970	3.8597					
,PHTST		2	4	.3208E+02	.3476E+02						
,CXY	2	5	1	2.4623	1.7091	2.3984	1.7983	3.0935	2.3116	3.1721	2.2018
,CXY	2	5	2	2.3978	1.7978	2.3313	1.8851	3.0110	2.4187	3.0928	2.3112
,CXY	2	5	3	2.3300	1.8841	2.2610	1.9694	2.9247	2.5228	3.0097	2.4177
,CXY	2	5	4	2.2592	1.9679	2.1877	2.0512	2.8349	2.6237	2.9229	2.5212
,CXY	2	5	5	2.1853	2.0491	2.1114	2.1302	2.7415	2.7215	2.8325	2.6216
,CXY	2	5	6	2.1085	2.1274	2.0323	2.2063	2.6447	2.8160	2.7386	2.7188
,CXY	2	5	7	2.0289	2.2030	1.9504	2.2796	2.5446	2.9070	2.6413	2.8126

Figure 3