XY Orbit Correctors

CLS DESIGN NOTE – 2.1.48

Date: 2000-05-30

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1. Introduction

The preliminary design of the synchrotron radiation source (SR1) orbit corrector magnets has been completed. The orbit correction scheme has been described in previous technical notes[1,2]. The magnetic properties of these elements have been modeled using POISSON. From these analyses the power requirements were determined.

2. XY Orbit Corrector Magnets

The XY orbit corrector magnets are dual purpose horizontal and vertical dipole magnets capable of kicking the SR1 beam 1.4 mrad at the nominal beam energy of 2.9 GeV. Using a corrector length of 0.2 m, a magnetic field of 0.0822 T is required in each dimension. For dynamic orbit correction[2] the magnetic field will be diminished due to Eddy current effects which increase with frequency. At higher frequencies the required kicks are small (see ref. 2) and these correctors will be adequate up to 100 Hz operation.

Each corrector is built in a "C" configuration to allow the radiated photons to leave the magnet unimpeded by iron. Four coils are used to produce a horizontal field (vertical kick) and two coils are used to produce a vertical field (horizontal kick). A cross sectional view of the magnet is shown in Figures 1 and 2.

As shown in Figure 1 for half the corrector, a total of two coils are required for the vertical field (B_y). As shown in Figure 2 for half the magnet, the horizontal field (B_x) is produced with a total of four coils of two different sizes. For the horizontal field the coil sizes are chosen so that they can be run in series. The ratio of turns on the coils is 39/36 (right/left).   For the horizontal field the coil sizes and locations are chosen to minimize the quadrupole and sextupole content of the corrector field.

The orbit corrector design was developed using POISSON. The results of these calculations are given in Table 1. Details of the dimensions for the yoke and the dimensions and location of the coils are given in Appendices 1 and 2.

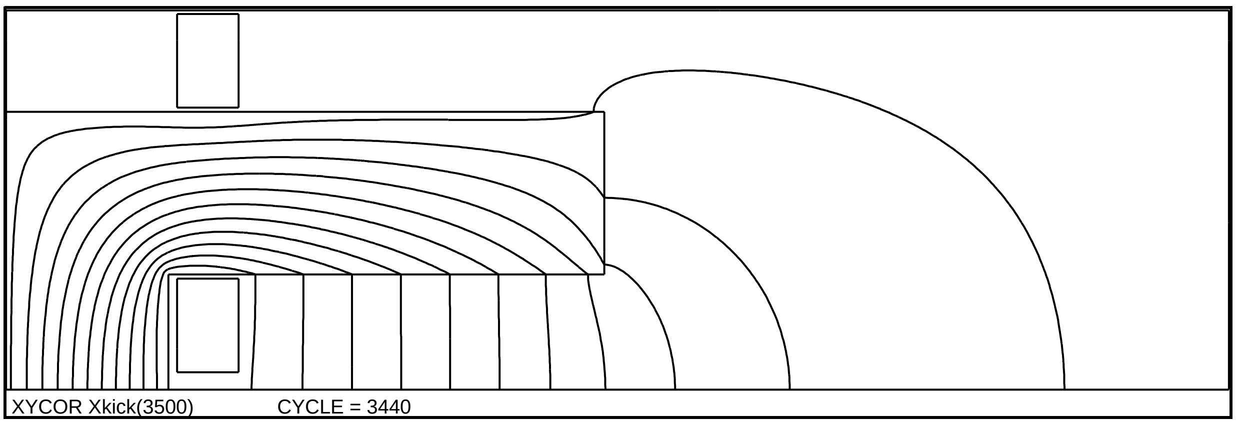

Figure 1. Corrector with vertical field (B_y) for X kicks.

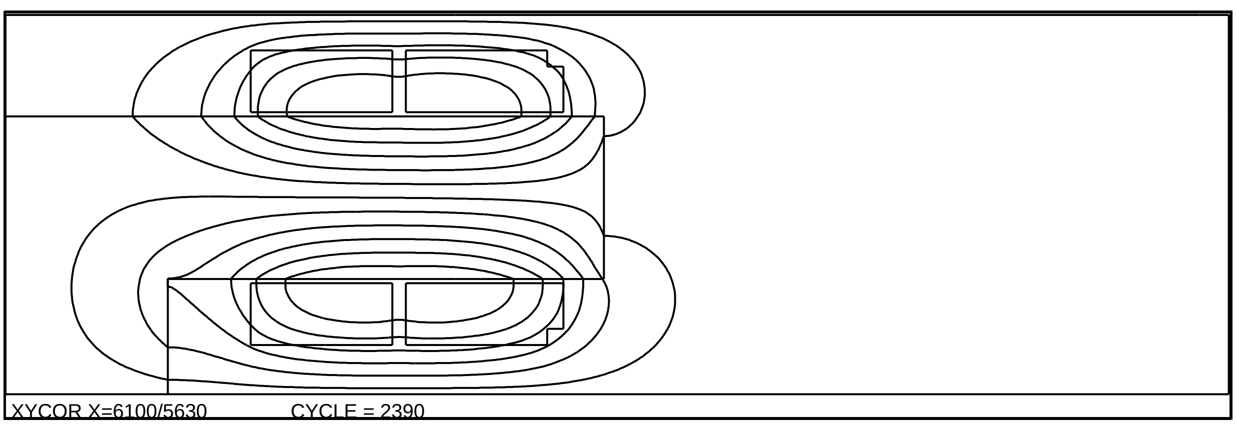

Figure 2. Corrector with horizontal field (B_x) for Y kicks.

Table 1.. Corrector Excitation.

Ampere-turns	B T	B' T/m	B'' T/m^2	B''' T/m^3	B'''' T/m^4
3500 (B_y)	0.0811	- 0.0014	- 0.27	- 0.18	- 7.7E1
6100/5630 (B_x)	0.0855	0.0005	0.049	4.7	-6.3E3

For these calculations the magnet iron permeability of AISI 1010 steel was used. The magnet field strengths were calculated at X=0., Y=0. as described in Appendix 1. The field multipoles were calculated on an arc of 20 mm from this centre.

The coil dimensions are given in Appendix 1. All the coils use 6.48 mm square conductor with a 3.12 mm diameter cooling channel. This size of conductor allows for 24 turns in the coil shown in Figure 1. and allows for 39 and 36 turns in the right and left coils of Figure 2. Scaling from the results in Table 1, the Ampere-turns required for a vertical field (B_y) of 0.0822 T is 3550 and for a horizontal field (B_x) are 5865/5414. Details of the XY corrector parameters are given in Table 2.

Table 2. XY Orbit Corrector Parameters at 2.9 GeV.

Number of magnets	24	
X or Y kick**	1.40	mrad
X or Y kick at 3.2 GeV	1.27	mrad
Maximum Field strengths (B_y and B_x)	0.090	T
Length (physical)	0.15	m
Magnet gap (yoke)	108	mm
Magnet gap (between coils)	44	mm
Good field width (1%)(B_y)	> 80	mm
Good field width (1%)(B_x)	40	mm
Number of coils (B_y)	2	
Number of coils (B_x)	4	
Ampere-turns (B_y)	3884	
Ampere-turns (B_x)	6421/5926	
Number of windings per coil (B_y)	24	
Number of windings per coil (B_x)	39/36	
Current (B_y)	162	A
Current (B_x)	165	A
Conductor area (less cooling channel)	34.3	mm^2
Conductor length per magnet (B_y)	34.6	m
Conductor length per magnet (B_x)	96.3	m
Resistance per magnet (copper)* (B_y)	0.018	Ω
Resistance per magnet (copper)* (B_x)	0.050	Ω
Voltage drop per magnet (B_y)	2.92	V
Voltage drop per magnet (B_x)	8.25	V
Power per magnet (B_y)	473	W
Power per magnet (B_x)	1361	W

*resistivity = 1.79 E-8 Ω m **assumes magnetic length = physical length

The quality of the good field region of the orbit corrector is shown in Figures 3. The figure shows ΔB/B, on the horizontal (X) axis, with respect to the magnet center. ΔB is given by

$$\Delta B = B(x) - B(0) .$$

where B(x) is the field value calculated by POISSON on the transverse horizontal axis and B(0) is the value of the field at the center (0.,0.). Two curves are shown: one for B_y and one for B_x. As expected from the geometry of the yoke, the field quality of the vertical field (B_y) is much better than the horizontal field (B_x). Both field deviate by less than 1% over a range of ±20 mm.

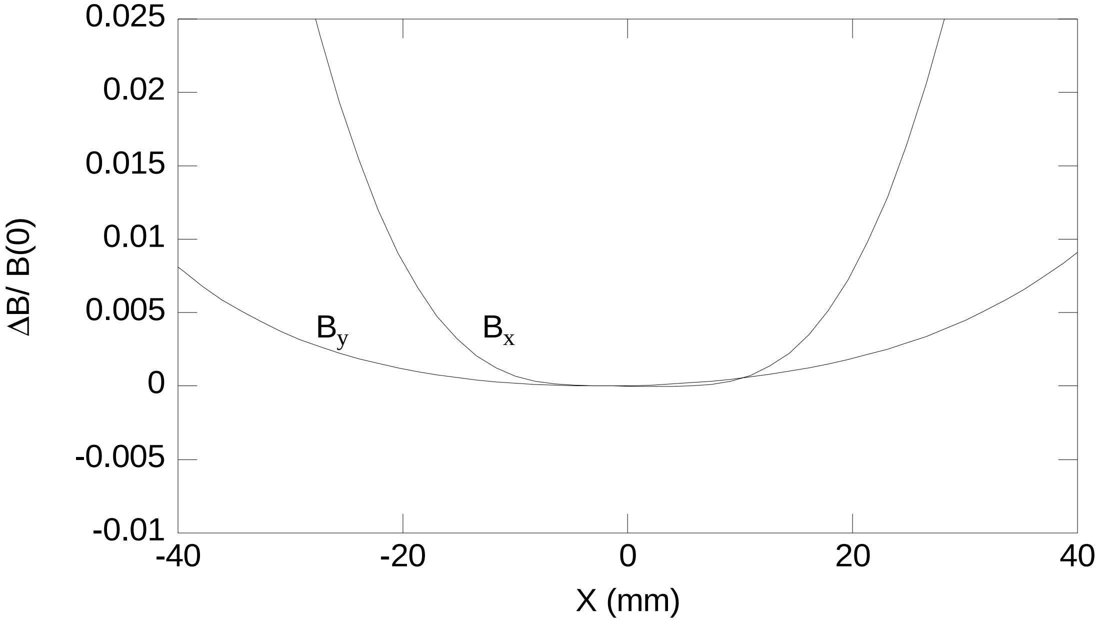

Figure 3. Remnant fields for the XY orbit corrector.

3. References

1) Technical Design Note 2.1.20B, "CLS Lattice Performance Analyses", L. O. Dallin, November 1999.

2) Technical Design Note 2.1.47, "SR1 Dynamic Orbit Correction", L. O. Dallin, May 2000.

4. Appendix 1.

The POISSON (Automesh) input file for the XY orbit corrector is given below.

```
XYCOR
$REG NREG=8,DX=.174,DY=.178,XMIN=-18.4,XMAX=38.85,YMAX=17.75,NPOINT=5,KMAX=330
$REG LMAX=100,MAT=1$
$PO X=-18.4,Y=0. $
$PO X=38.85,Y=0. $
$PO X=38.85,Y=17.75 $
$PO X=-18.4,Y=17.75 $
$PO X=-18.4,Y=0. $
$REG MAT=3,CUR=0.,NPOINT=7$
$PO X=-18.4,Y=0. $
$PO X=-10.8,Y=0. $
$PO X=-10.8,Y=5.4 $
$PO X=9.6,Y=5.4 $
$PO X=9.6,Y=13. $
$PO X=-18.4,Y=13. $
$PO X=-18.4,Y=0. $
$REG MAT=1,CUR=3500.,NPOINT=5$
$PO X=-10.4,Y=.8138 $
$PO X=-7.5092,Y=.8138 $
$PO X=-7.5092,Y=5.2 $
$PO X=-10.4,Y=5.2 $
$PO X=-10.4,Y=.8138 $
$REG MAT=1,CUR=-3500.,NPOINT=5$
$PO X=-10.4,Y=13.2 $
$PO X=-7.5092,Y=13.2 $
$PO X=-7.5092,Y=17.5862 $
$PO X=-10.4,Y=17.5862 $
$PO X=-10.4,Y=13.2 $
$REG MAT=1,CUR=6100,NPOINT=7$
$PO X=7.707,Y=5.2 $
$PO X=7.707,Y=3.0569 $
$PO X=6.9593,Y=3.0569 $
$po X=6.9593,Y=2.3092 $
$PO X=.33,Y=2.3092 $
```

```
$PO X=.33,Y=5.2 $
$PO X=7.707,Y=5.2 $
$REG MAT=1,CUR=-6100.,NPOINT=7$
$PO X=7.707,Y=13.2 $
$PO X=7.707,Y=15.3431 $
$PO X=6.9593,Y=15.3431 $
$PO X=6.9593,Y=16.0908 $
$PO X=.33,Y=16.0908 $
$PO X=.33,Y=13.2 $
$PO X=7.707,Y=13.2 $
$REG MAT=1,CUR=5630,NPOINT=5$
$PO X=-6.9193,Y=5.2 $
$PO X=-6.9193,Y=2.3092 $
$PO X=-.29,Y=2.3092 $
$PO X=-.29,Y=5.2 $
$PO X=-6.9193,Y=5.2 $
$REG MAT=1,CUR=-5630.,NPOINT=7$
$PO X=-6.9193,Y=13.2 $
$PO X=-6.9193,Y=16.0908 $
$PO X=-.29,Y=16.0908 $
$PO X=-.29,Y=13.2 $
$PO X=-6.9193,Y=13.2 $
```

5. Appendix 2.

A detailed cross sectional drawing of the XY orbit corrector is shown in Figure 4.

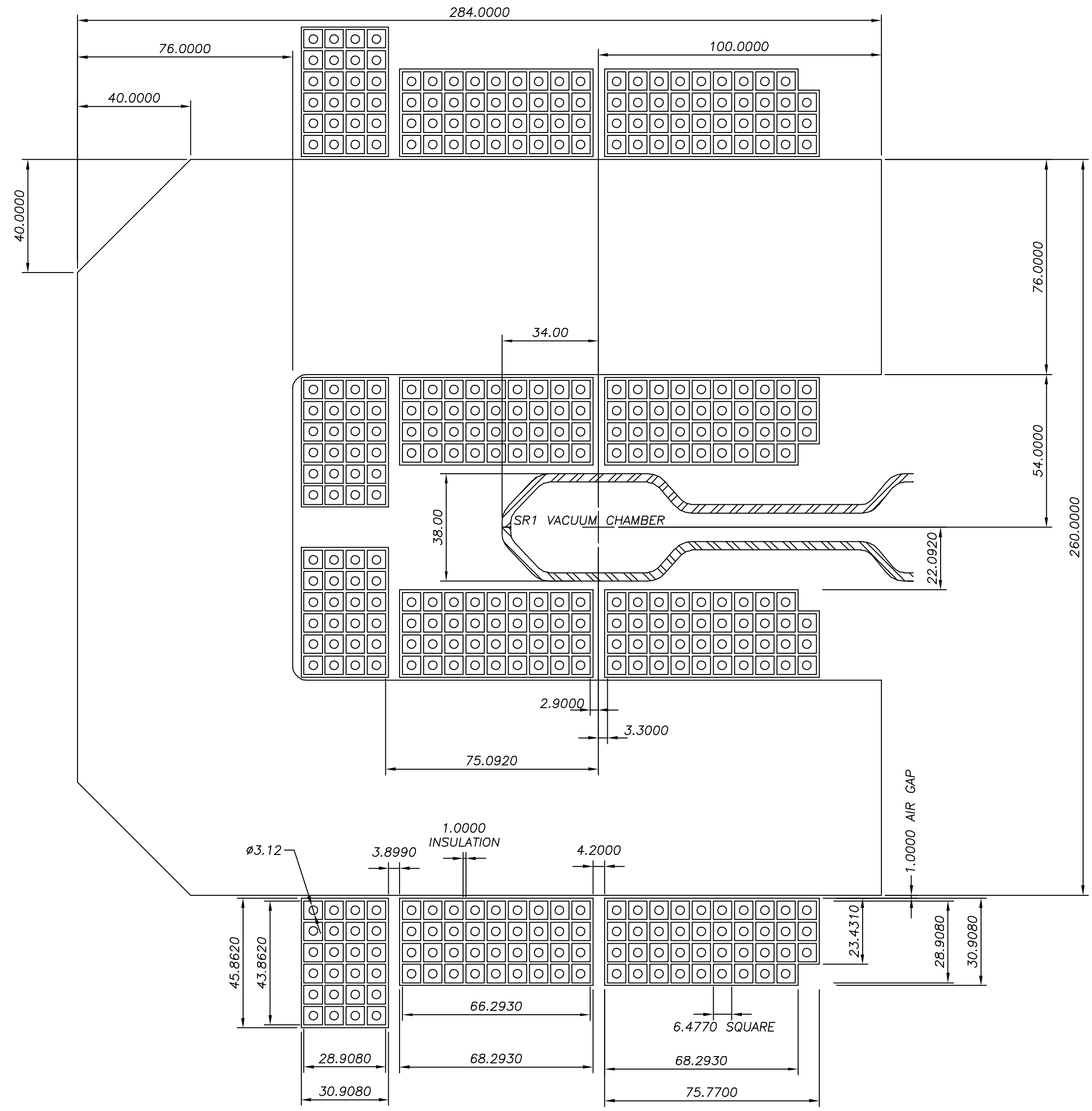

Figure 4. Details of XY orbit corrector.