Design of a Vertically Split Yoke and Associated Collar for the 50 mm SSC Collider Dipole: Collar Interior Dimensions

Jim Strait
Fermilab
25 June 1990

In a companion note[1] I described the design of the outer surface of the collar for the vertically split yoke collider dipole magnet. I describe here the specification of the interior shape which determines the conductor placement. The method of determining the shape is similar but not identical to that used for the 40 mm vertically split dipole[2].

The combination of collar deflections due to coil prestress, assembly into the yoke and cooldown must result in a coil of the design shape: round, at the correct radius and with the correct pole angles. Prestress causes the vertical radius to increase, assembly causes the horizontal radius to decrease and the vertical radius to increase and cooldown causes both to decrease with the vertical decreasing somewhat more. The undeflected room temperature collar must have a horizontal radius larger and a vertical radius smaller than nominal to arrive at the correct shape cold.

The ''target shape'' for the coils, fully assembled at 4 K and zero field, is the shape specified by the magnetic design shrunk according to the thermal contraction of stainless steel. This would be the shape of the coils if the collars were infinitely rigid. Finite element calculations[3] were done to determine the net deflection of the collar interior due to assembly and cooldown. In these calculations both the inner and the outer coil prestresses were 10 kpsi and the horizontal yoke-collar interference was 6.5 mils. The results are shown in Table I.

Table I[3]
Collar displacements due to assembly and cooldown

Position #	Location	dx(inches)	dy(inches)
1	Outer Midplane	-0.0103	0.0000
2	Outer Pole Outer Edge	-0.0049	-0.0010
3	Outer Pole Inner Edge	-0.0035	0.0012
4	Inner Pole Outer Edge	-0.0014	0.0004
5	Inner Pole Inner Edge	-0.0008	0.0020

The deflections in Table I must be corrected for the fact that the design calls for 5.5 mils of inteference, not the 6.5 mils assumed here. In addition, the thermal contraction of stainless steel must be subtracted. These are done in Table II. The nominal collar dimensions are taken from the cable coordinates for the W6733 cross section[4] with the ground wrap

and collaring shoe added. These dimensions are for the collar version that does not include collaring shims. The integrated thermal contraction is taken to be -0.0030 inch. The dimensions columns labelled "Deflection rel. to free collar at 4K" are the difference between the dimensions in Table I and the thermal contraction. The actual design has 1 mils less horizontal interference than assumed in the finite element calculation. The x deflections relative to the free collar are corrected by adding 0.0010 inch to the value at the horizontal mid-plane and assuming that the other x deflections are decreased by the same proportion. The y deflection nearest the pole is assumed to decrease by 0.0005 inch and the other y deflections are assumed to decrease by the same proportion. The columns labelled "Coordinates rel. to nominal" are minus one times the corrected deflections.

Table II
Corrected Collar Deflections

(all dimensions are inches)

	Nominal Dimensions			Thermal Contraction		Deflection rel. to free collar at 4K		Coordinates rel. to nominal	
Pos#	r	x	y	dx	dy	dx	dy	dx	dy
1	1.998	1.998	0.000	-.0060	0.0000	-.0043	0.0000	0.0033	0.0000
2	1.998	1.3445	1.4779	-.0040	-.0044	-.0009	0.0034	0.0007	-.0030
3	1.490	0.941	1.1553	-.0028	-.0035	-.0007	0.0047	0.0005	-.0042
4	1.490	0.389	1.4383	-.0012	-.0043	-.0002	0.0047	0.0002	-.0042
5	0.976	0.2305	0.9484	-.0007	-.0028	-.0001	0.0048	0.0001	-.0043

To generate the actual collar interior all radii are increase by 3 mils (to generate the 3 mils increase in x at the horizontal mid-plane) and the centers of curvature are offset by -7 mils relative the horizontal center line of the collar system. The offset was chosen to give the best fit to the design values of y+dy at the design values of x+dx from Table II. In the collar drawing (Figure 1, from a preliminary version of drawing 102-ME-292059) the values of r, offset, and 2x are specified. In Table III these values are given along with the value of y that follows from these. The deviation of y from the design value from Table II is also given.

Table III
Design Collar Dimensions

(all dimensions are inches)

Pos#	r	offset	x	y	y-deviation
1	2.001	-.007	2.001	0.0000	0.0000
2	2.001	-.007	1.345	1.4745	-.0004
3	1.493	-.007	0.9415	1.1517	0.0006
4	1.493	-.007	0.389	1.4344	0.0003
5	0.979	-.007	0.2305	0.9445	0.0004

The coil cavity arc lengths in the design collar are about 2.4 mils smaller than in the nominal collar. (Details of the calculation are in Figure 2.) This is because the sum of the various collar deflections results in a coil cavity that is larger than the nominal one specified by the magnetic design.

Footnotes

[1] J. Strait, Design of a Vertically Split Yoke and Associated Collar for the 50 mm SSC Collider Dipole: Yoke-Collar Interface, TS-SSC-90-033, 6/25/90.

[2] J. Strait, Design of a Vertically-Split Yoke and Associatted Collar for the 40 mm Dipole, TS-SSC-90-029, 6/11/90.

[3] J. Kerby, private communication.

[4] G. Morgan, private communication.

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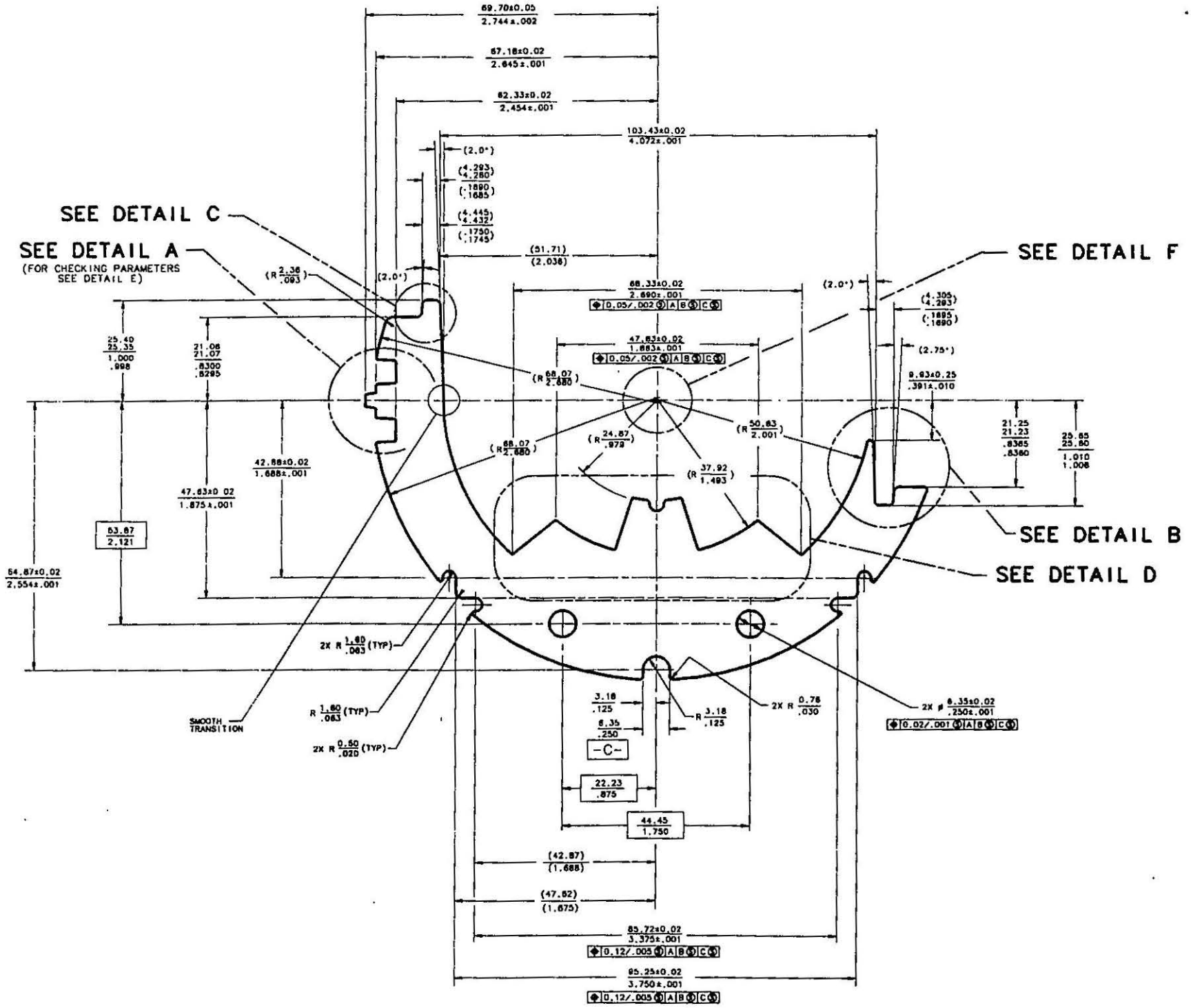
SEE DETAIL C
SEE DETAIL A
(FOR CHECKING PARAMETERS SEE DETAIL E)
SEE DETAIL F
SEE DETAIL B
SEE DETAIL D
69.70±0.05
2.744±.002
67.18±0.02
2.645±.001
82.33±0.02
2.454±.001
103.43±0.02
4.072±.001
(2.0°)
(51.71)
(2.036)
68.33±0.02
2.690±.001
0.05/.002 Ⓢ A B Ⓢ C Ⓢ
47.63±0.02
1.883±.001
0.05/.002 Ⓢ A B Ⓢ C Ⓢ
(2.75°)
9.93±0.25
.391±.010
25.40
25.35
1.000
.998
21.06
21.07
.8300
.8295
42.88±0.02
1.688±.001
47.63±0.02
1.875±.001
63.87
2.121
64.87±0.02
2.554±.001
21.25
21.23
.8385
.8380
25.65
25.60
1.010
1.008
2X R 1.60 .063 (TYP)
R 1.60 .063 (TYP)
2X R 0.50 .020 (TYP)
SMOOTH TRANSITION
3.18
.125
6.35
.250
-C-
R 3.18 .125
2X R 0.76 .030
2X ⌀ 6.35±0.02 .250±.001
0.02/.001 Ⓢ A B Ⓢ C Ⓢ
22.23
.875
44.45
1.750
(42.87)
(1.688)
(47.62)
(1.875)
85.72±0.02
3.375±.001
0.12/.005 Ⓢ A B Ⓢ C Ⓢ
95.25±0.02
3.750±.001
0.12/.005 Ⓢ A B Ⓢ C Ⓢ

Figure 1a

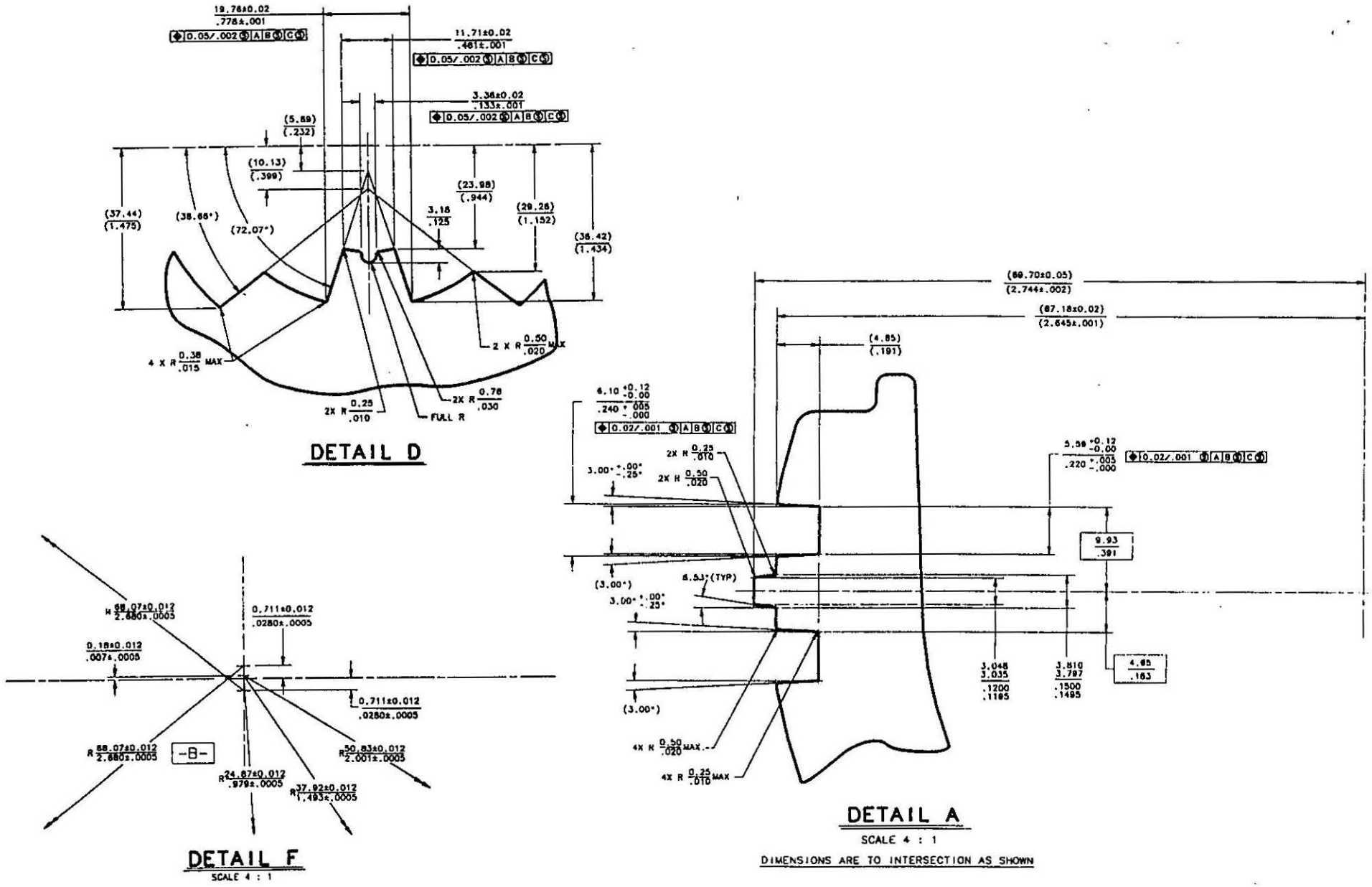
DETAIL D
DETAIL F
SCALE 4 : 1
DETAIL A
SCALE 4 : 1
DIMENSIONS ARE TO INTERSECTION AS SHOWN

Figure 1b

Compare Arc Lengths Between Nominal (Round) and Actual (Elliptical) Collar Interior

Outer Coil Outer Radius (2)

Round	Elliptical
$\theta = 47.71° = 0.8326$	$\theta = 47.77° = 0.8337$
$s = 1.6636$	$\tilde{s} = 1.6682$
	$s = 1.6612$ (-0.0024)

Outer Coil Inner Radius (3)

$\theta = 50.84° = 0.8873$	$\theta = 50.90° = 0.8885$
$s = 1.3220$	$\tilde{s} = 1.3265$
	$s = 1.3195$ (-0.0025)

Inner Coil Outer Radius (4)

$\theta = 74.87° = 1.3067$	$\theta = 74.90° = 1.3072$
$s = 1.9469$	$\tilde{s} = 1.9517$
	$s = 1.9447$ (-0.0022)

Inner Coil Inner Radius (5)

$\theta = 76.34° = 1.3324$	$\theta = 76.38° = 1.3331$
$s = 1.3004$	$\tilde{s} = 1.3051$
	$s = 1.2981$ (-0.0023)

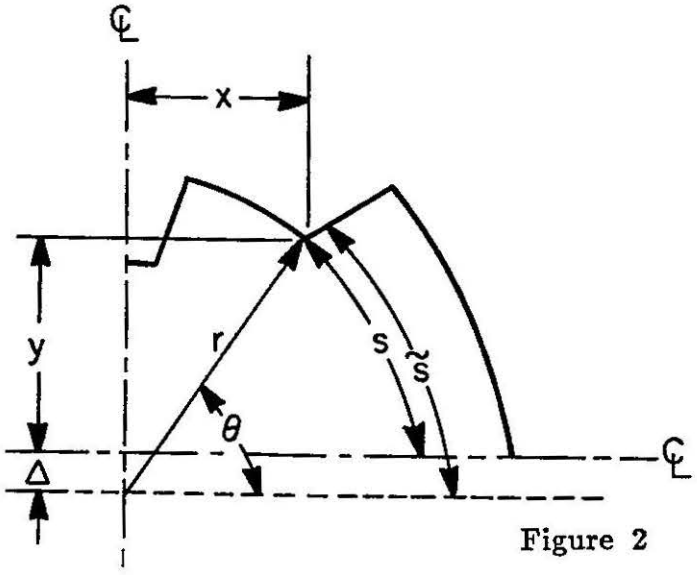

Figure 2

$\theta = \cos^{-1}(x/r)$

$\tilde{s} = r\theta$

$s \cong \tilde{s} - \Delta$