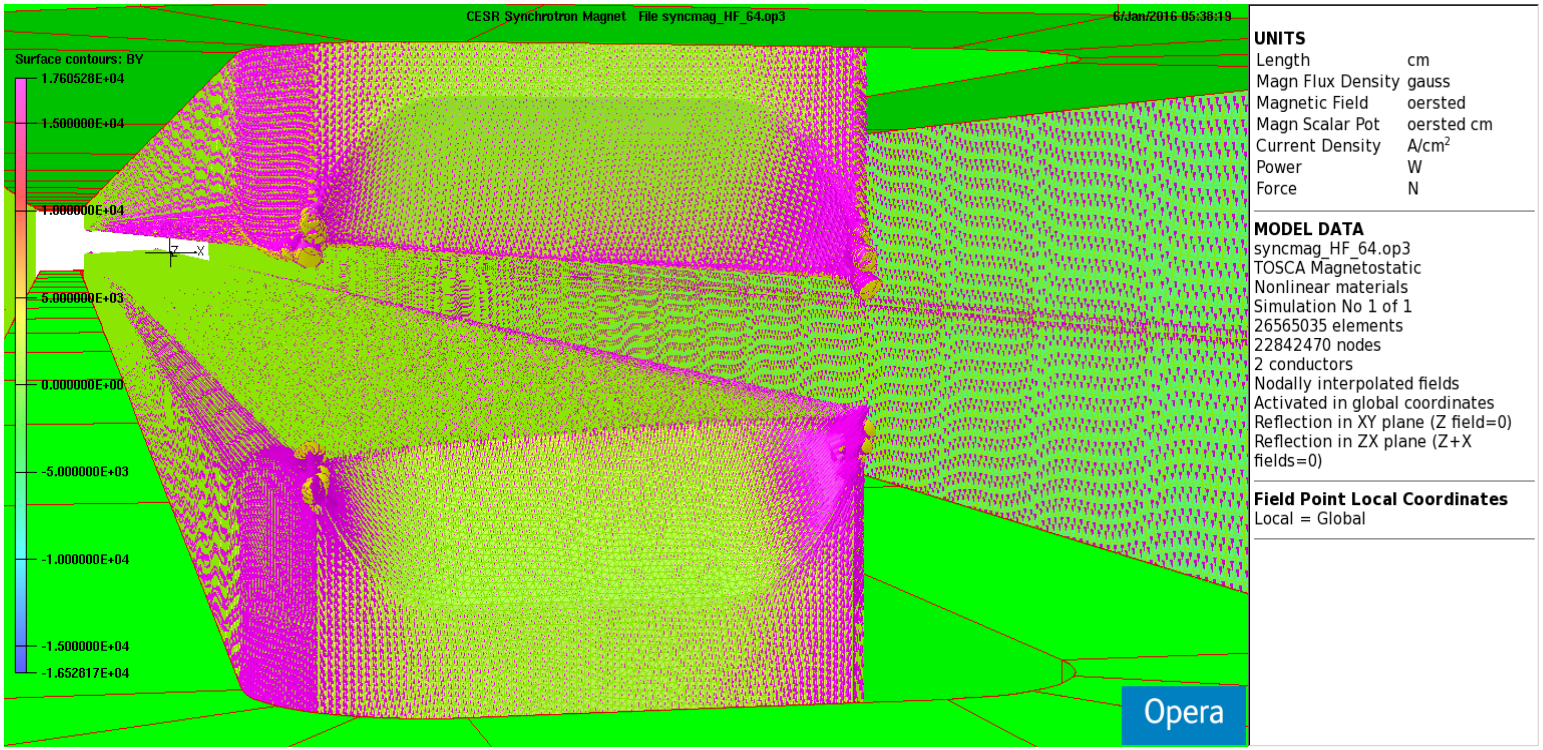
CESR Synchrotron Combined-Function Magnet Models



Jim Crittenden

29 January 2016

John Seeman dissertation (May 1979)
Figure 3.3

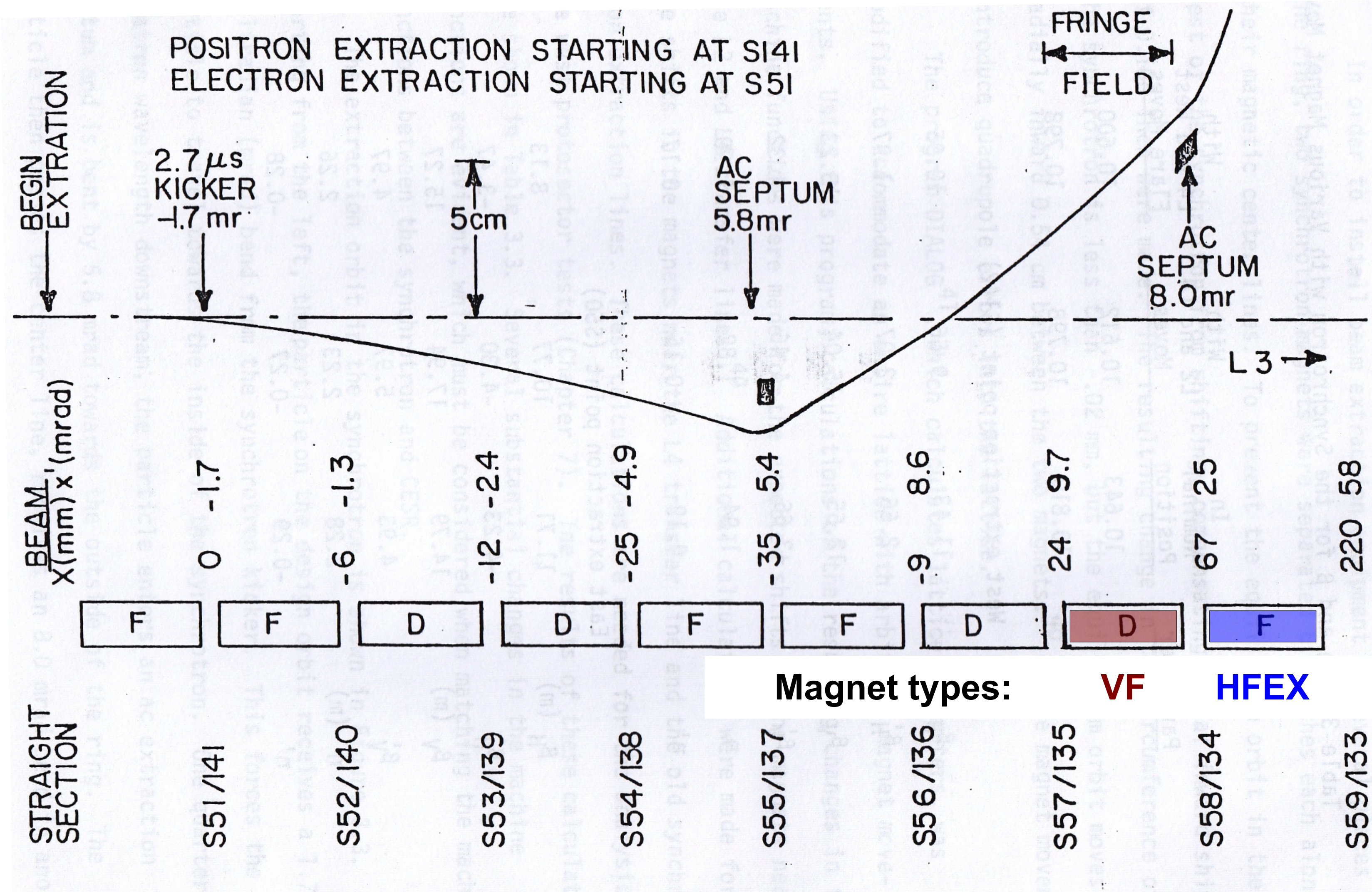


Figure 3.3 Synchrotron extraction orbit.

Entrance and exit orbit positions and angles

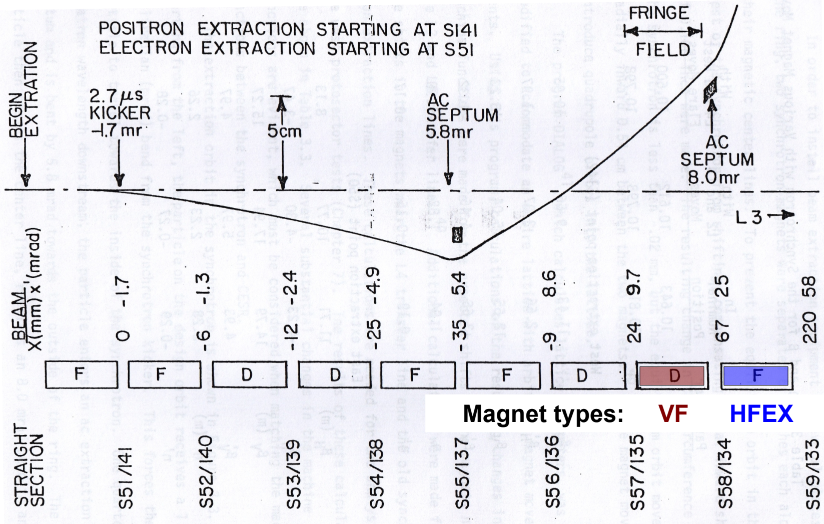


Figure 3.3 Synchrotron extraction orbit.

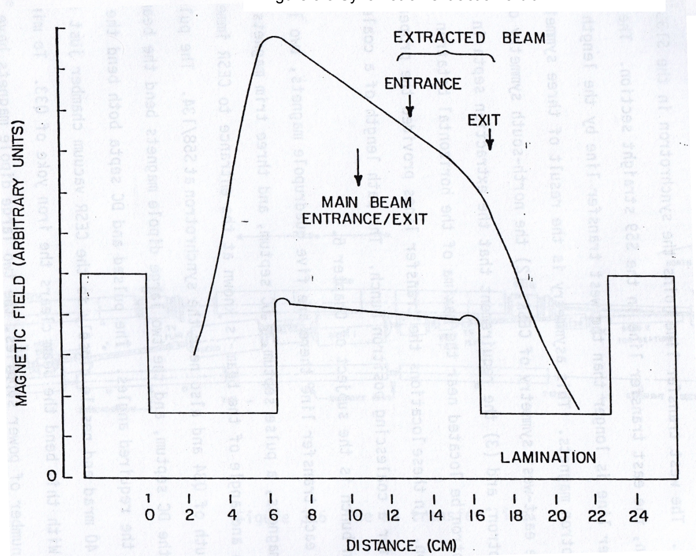


Figure 3.5 Magnetic field of a radially defocusing synchrotron magnet. The entrance and exit of the extract beam are shown.

	Design orbit		Extracted beam	
	X (mm)	X' (mrad)	X (mm)	X' (mrad)
VF (S58/134) entrance	-8.8	16.36	17.5	26.02
VF (S58/134) exit	-8.8	-16.36	5.62	0.85
HFEX (S59/135) entrance	-8.8	16.36	75.8	41.36
HFEX (S59/135) exit	-8.8	-16.36	208.6	41.36

The deflection angle of 32.72 mrad (1.875 degrees) corresponds to a transverse kick of 173.03 MeV for a 5.289 GeV beam.

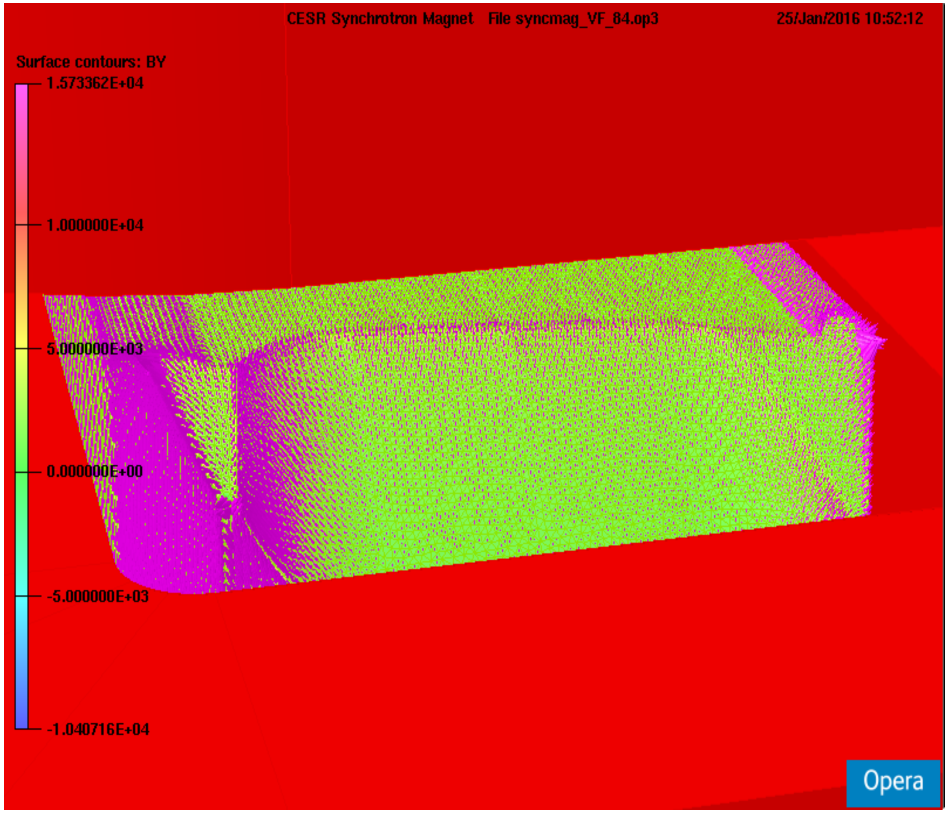
Fig 3.3 of John's thesis shows the positions and angles of the extracted beam relative to the design synch orbit. The design synch orbit enters the VF magnet at X = 10.55 cm relative to X = -4.5 inches, as shown in Fig. 3.5. On this scale, the center of the magnet is at 4.5 inches = 11.43 cm.

There is a discrepancy between the figures and the text in the thesis. The figures give a VF entrance position for the extracted beam of 15.2 mm. The text gives 17.5 mm. For this table we choose the text value.

Assuming there is no deflection in the HFEX magnet for the extracted beam, which is almost but not quite true, the exit position is at about X = 209 mm, since the magnet is about 3210 mm long.

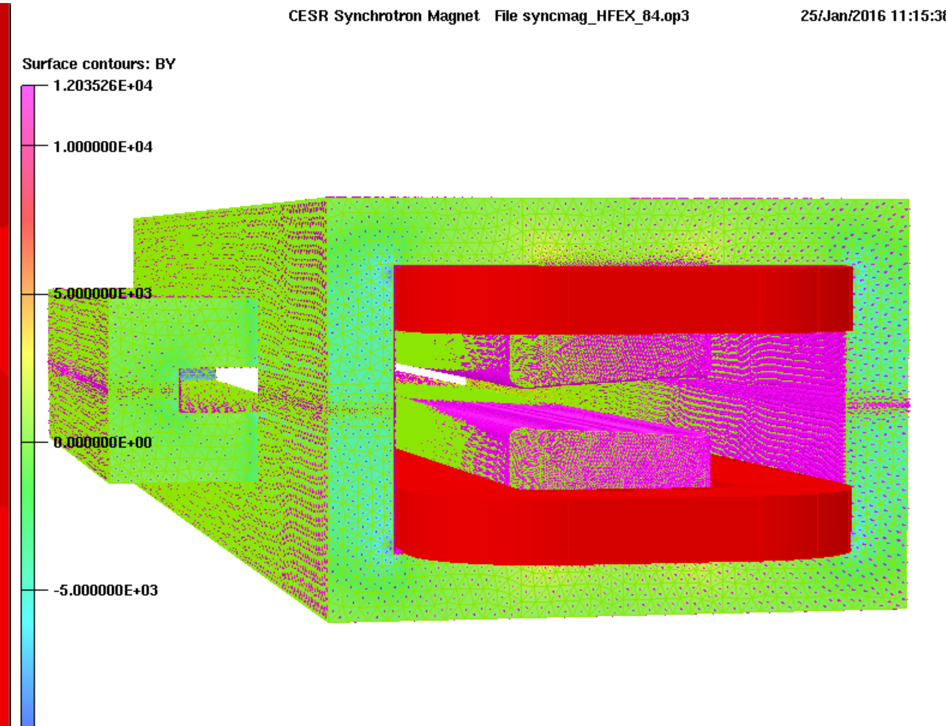
The end of the extraction channel is 24.25 inches from the end of the magnet, i.e. following a length of 2597 mm. At this point the extracted beam is at X = 183 mm, which is outside the backleg wall (X=146 mm) and inside the back wall of the extraction channel (X = 190 mm).

Vertically-focusing, wide gap magnet (VF)
Horizontally-focusing, narrow gap magnet with extraction channel on outside leg (HFEX)



VF

Wide gap (1.5 inch), vertically focusing.



HFEX

Narrow gap (1.0 inch), horizontally focusing, with extraction channel.
The extraction channel ends 27” from the end of the magnet.

Models obtained also for VFEX and HF magnets, and for the high-gradient versions HFM and VFM magnets, which are located adjacent to the L1, L2, L4, L5 straight sections.

BH3001-17B (16 June 1965): Negative lamination
Narrow gap (1.02 in), horizontally focusing

CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

-1.8125	.5879	.1875
-1.8125	.9004	.5000
1.8125	.7692	.1875

Circle Hyperbola Intersections

-1.6413	.4306
1.6912	.6262

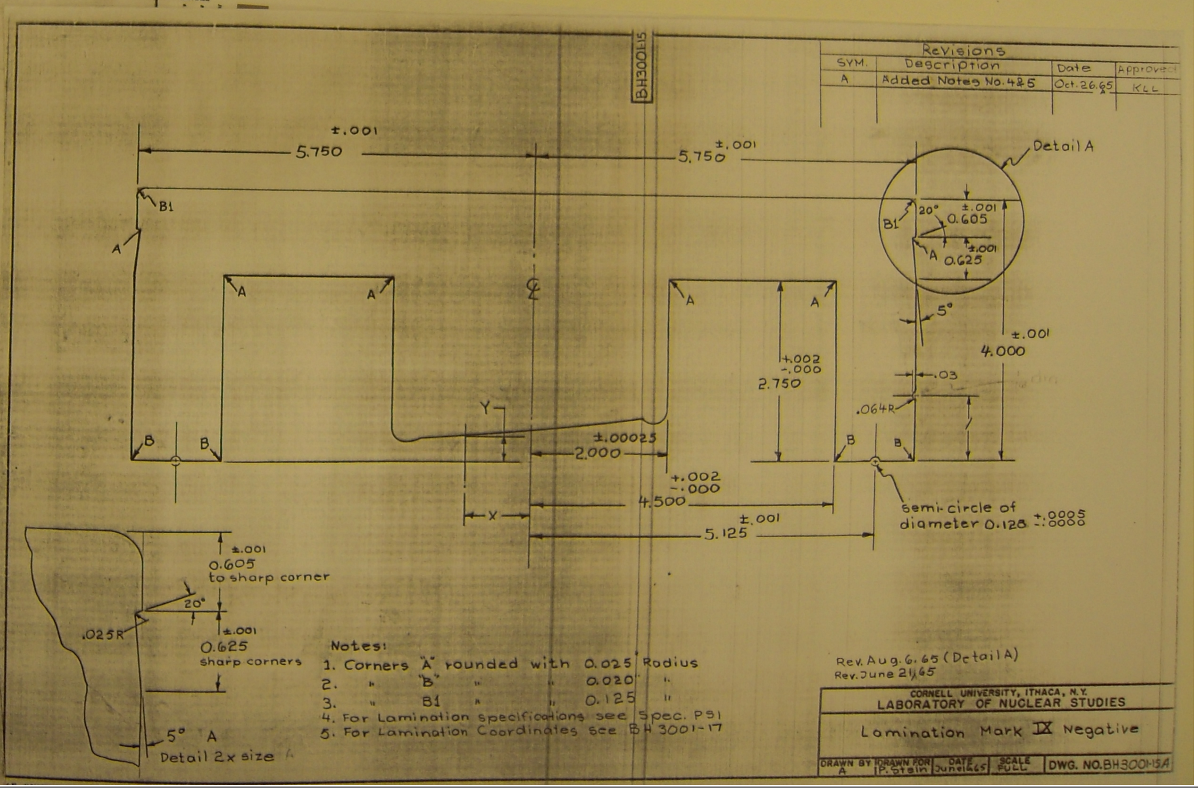
Minimal Y Values

.4004	.5817

Narrow Gap (1.0")		Narrow Gap (1.0")	
x	y	x	y
-2.0000	.5879	-.0000	.5103
-1.9500	.4605	.0500	.5131
-1.9000	.4221	.1000	.5160
-1.8500	.4042	.1500	.5189
-1.8000	.4006	.2000	.5219
-1.7500	.4044	.2500	.5248
-1.7000	.4133	.3000	.5278
-1.6500	.4276	.3500	.5309
-1.6000	.4324	.4000	.5339
-1.5500	.4345	.4500	.5370
-1.5000	.4366	.5000	.5402
-1.4500	.4387	.5500	.5433
-1.4000	.4409	.6000	.5465
-1.3500	.4431	.6500	.5498
-1.3000	.4453	.7000	.5530
-1.2500	.4475	.7500	.5564
-1.2000	.4497	.8000	.5597
-1.1500	.4520	.8500	.5631
-1.1000	.4543	.9000	.5665
-1.0500	.4566	.9500	.5700
-1.0000	.4589	1.0000	.5734
-.9500	.4612	1.0500	.5770
-.9000	.4636	1.1000	.5806
-.8500	.4660	1.1500	.5842
-.8000	.4684	1.2000	.5878
-.7500	.4708	1.2500	.5915
-.7000	.4733	1.3000	.5953
-.6500	.4757	1.3500	.5991
-.6000	.4783	1.4000	.6029
-.5500	.4808	1.4500	.6068
-.5000	.4833	1.5000	.6107
-.4500	.4859	1.5500	.6147
-.4000	.4885	1.6000	.6187
-.3500	.4911	1.6500	.6228
-.3000	.4938	1.7000	.6192
-.2500	.4965	1.7500	.5924
-.2000	.4992	1.8000	.5821
-.1500	.5019	1.8500	.5855
-.1000	.5047	1.9000	.6034
-.0500	.5075	1.9500	.6417
-.0000	.5103	2.0000	.7692

CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
TABLE OF COORDINATES
MARK IX-NARROW GAP-NEGATIVE LENS
DWG. NO. BH3001-17B

CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967



BH3001-16 (16 June 1965): Positive lamination Wide gap (1.49 in), vertically focusing

CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967

CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

-1.8125	.7727	.1875
-1.8125	1.0852	.5000
1.8125	1.0279	.1875

Circle Hyperbola Intersections

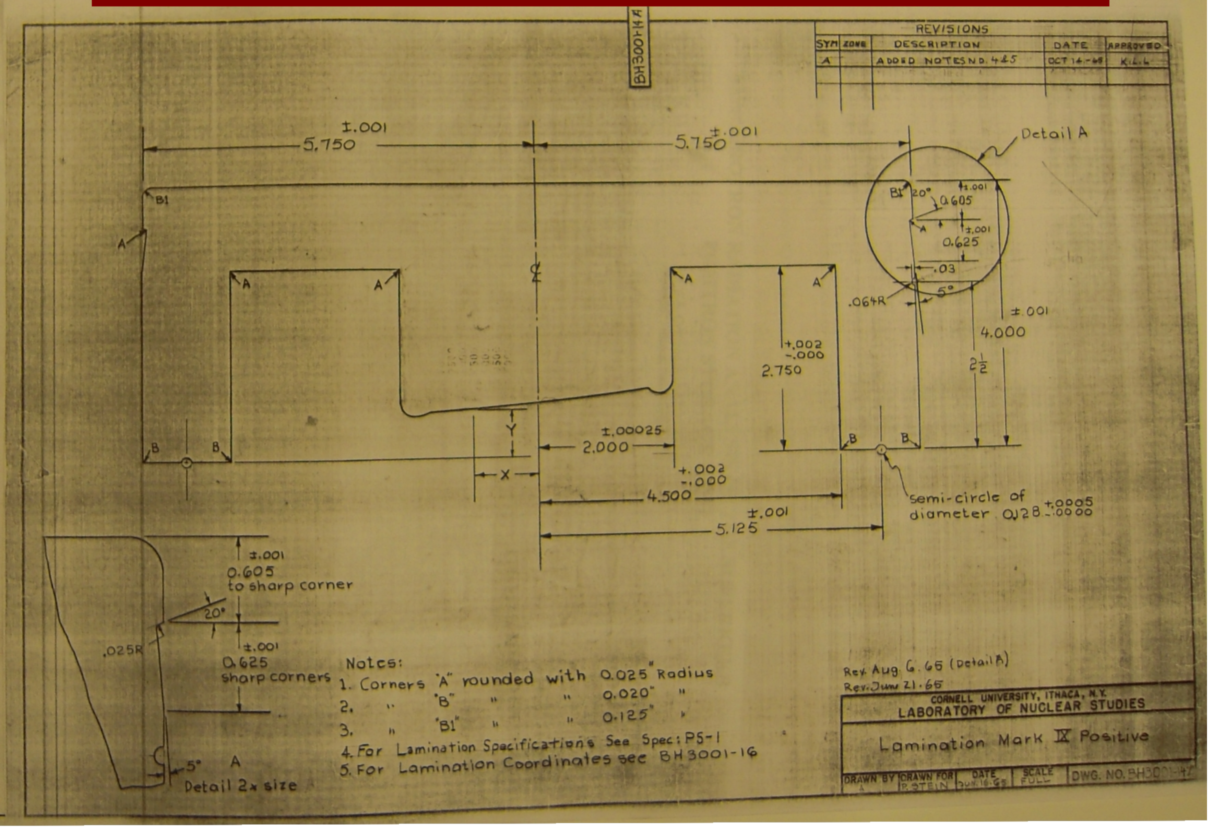
-1.5820	.6415
1.6604	.9183

Minimal Y Values

.5852	.8404

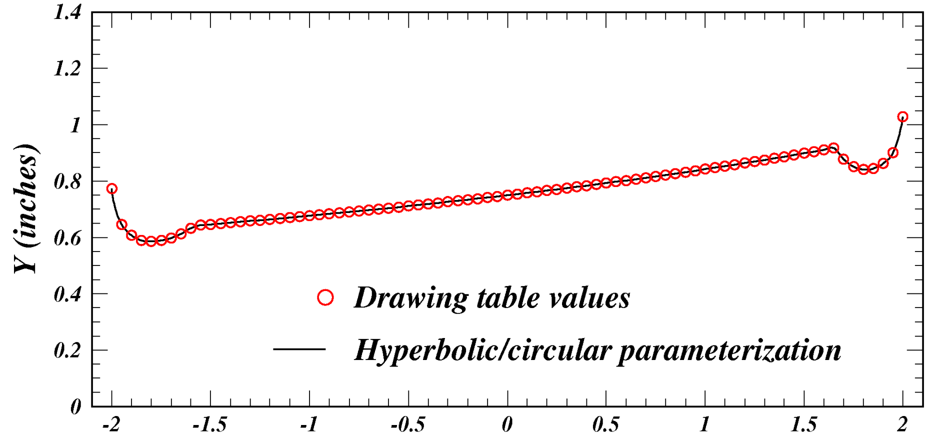
Wide Gap (1.5")		Wide Gap (1.5")	
x	y	x	y
-2.0000	.7727	-.0000	.7495
-1.9500	.6453	.0500	.7536
-1.9000	.6069	.1000	.7577
-1.8500	.5890	.1500	.7619
-1.8000	.5854	.2000	.7662
-1.7500	.5892	.2500	.7705
-1.7000	.5981	.3000	.7748
-1.6500	.6124	.3500	.7792
-1.6000	.6326	.4000	.7837
-1.5500	.6434	.4500	.7882
-1.5000	.6463	.5000	.7928
-1.4500	.6492	.5500	.7974
-1.4000	.6521	.6000	.8021
-1.3500	.6551	.6500	.8069
-1.3000	.6582	.7000	.8117
-1.2500	.6612	.7500	.8166
-1.2000	.6643	.8000	.8215
-1.1500	.6674	.8500	.8265
-1.1000	.6706	.9000	.8316
-1.0500	.6737	.9500	.8367
-1.0000	.6770	1.0000	.8420
-.9500	.6802	1.0500	.8473
-.9000	.6835	1.1000	.8526
-.8500	.6868	1.1500	.8581
-.8000	.6902	1.2000	.8636
-.7500	.6936	1.2500	.8692
-.7000	.6970	1.3000	.8749
-.6500	.7005	1.3500	.8806
-.6000	.7040	1.4000	.8865
-.5500	.7076	1.4500	.8924
-.5000	.7112	1.5000	.8984
-.4500	.7148	1.5500	.9045
-.4000	.7185	1.6000	.9107
-.3500	.7222	1.6500	.9170
-.3000	.7260	1.7000	.8779
-.2500	.7298	1.7500	.8511
-.2000	.7336	1.8000	.8408
-.1500	.7375	1.8500	.8441
-.1000	.7415	1.9000	.8620
-.0500	.7455	1.9500	.9004
-.0000	.7495	2.0000	1.0279

CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
Table of Coordinates
Mark IX - Wide Gap-Positive Lens
DRAWN BY P. Stein | DATE 6/23/65 | DWG. NO. BH 3001-16

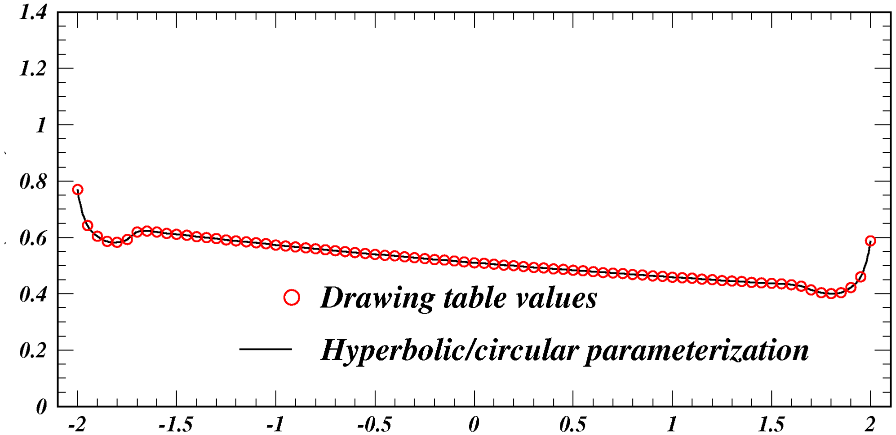


Poletip shapes from drawing tables

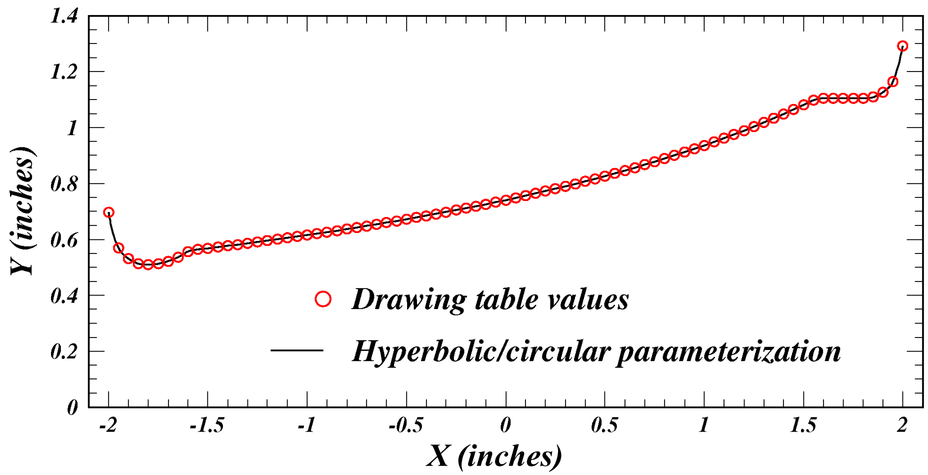
Synchrotron magnet Dwg BH3001-16 VF Wide Gap with function 19



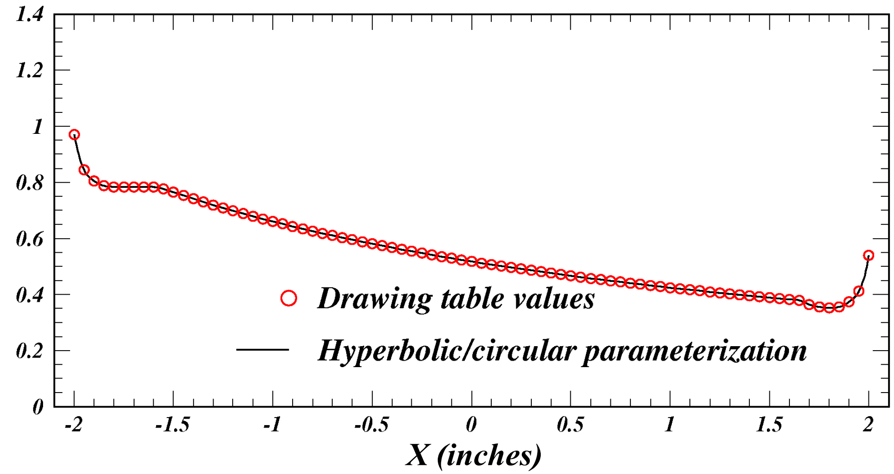
Synchrotron magnet Dwg BH3001-17B HF Narrow Gap with function 18



Synchrotron magnet Dwg BH3085 VFM Wide Gap with function 21

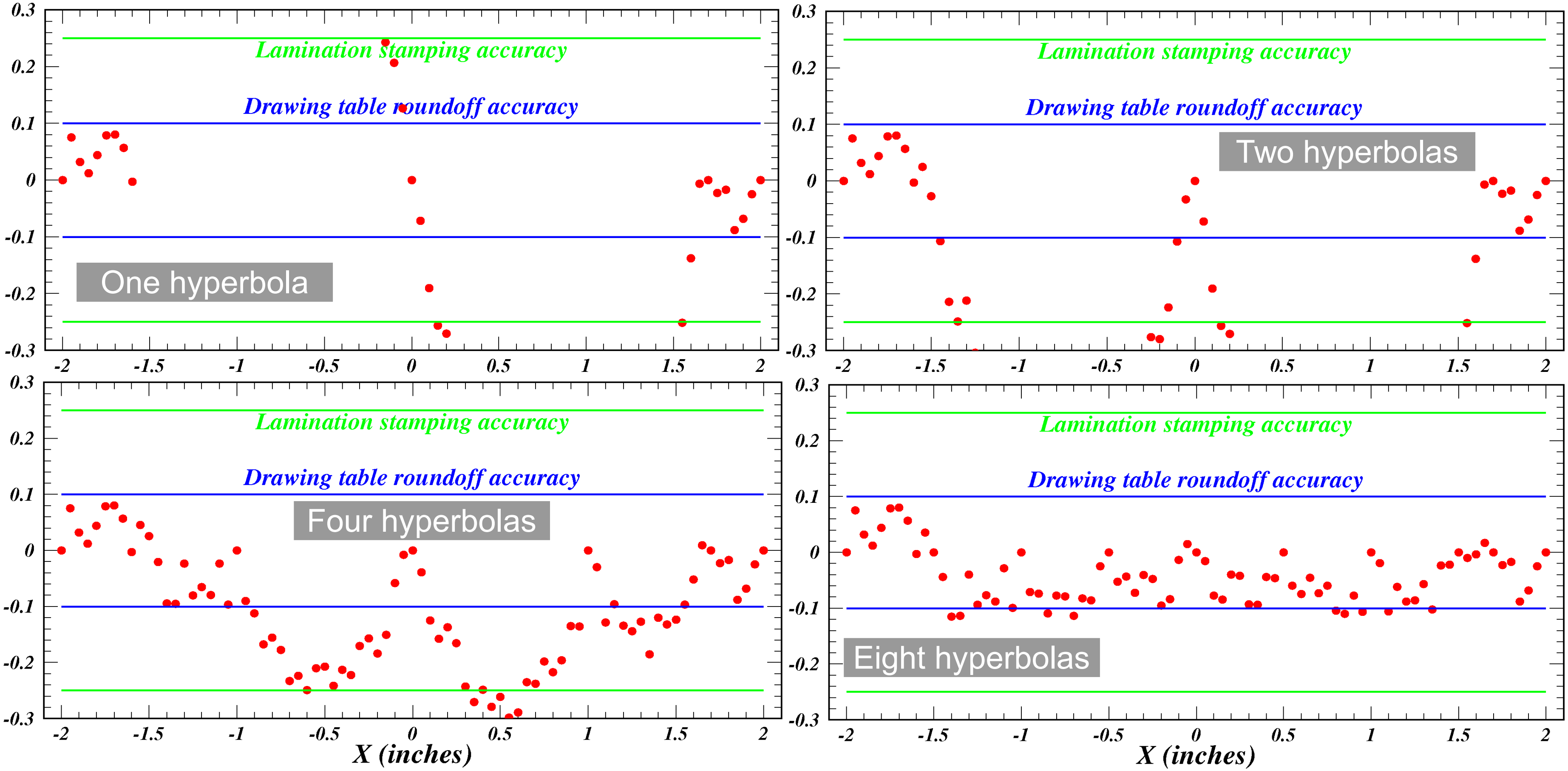


Synchrotron magnet Dwg BH3086 HFM Narrow Gap with function 20



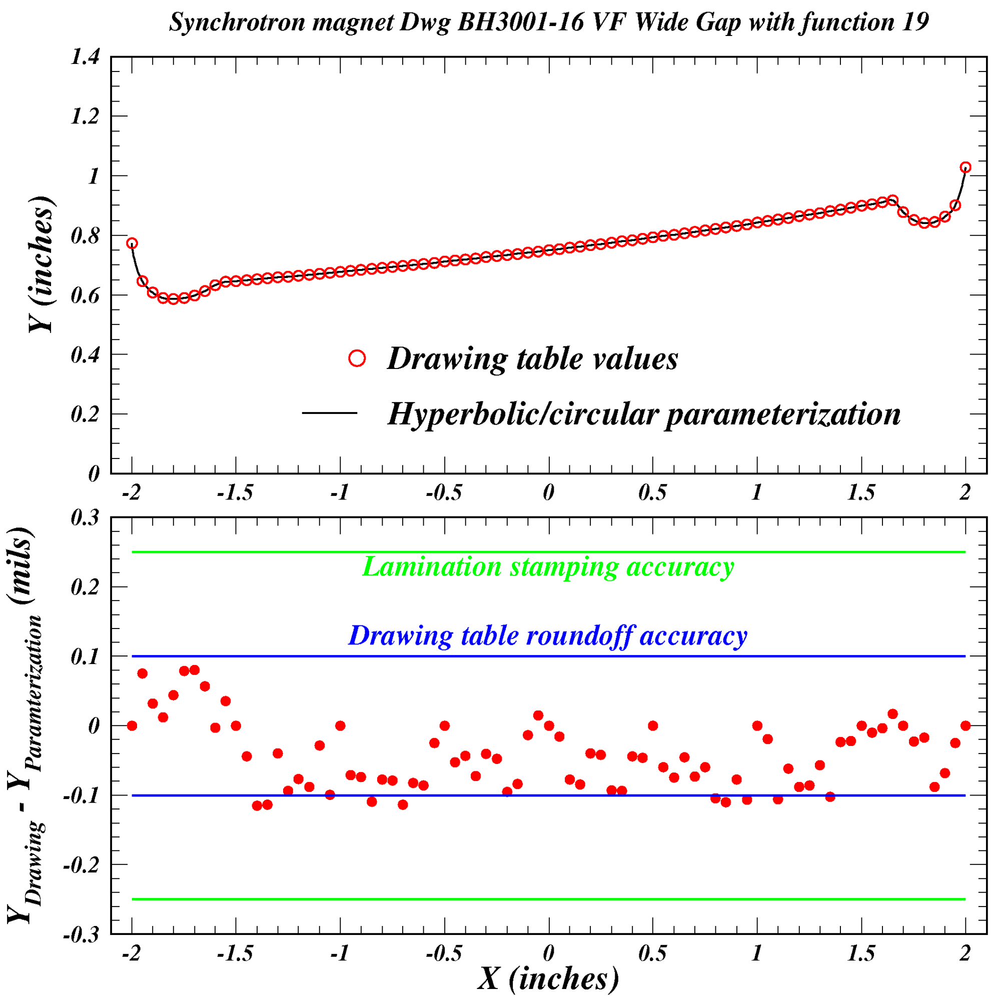
Several attempts required to figure out where the cylindrical shapes apply. Small cylinders tangential to poletip sides. Large cylinder on high-field side only on inside side of cylinder axis.

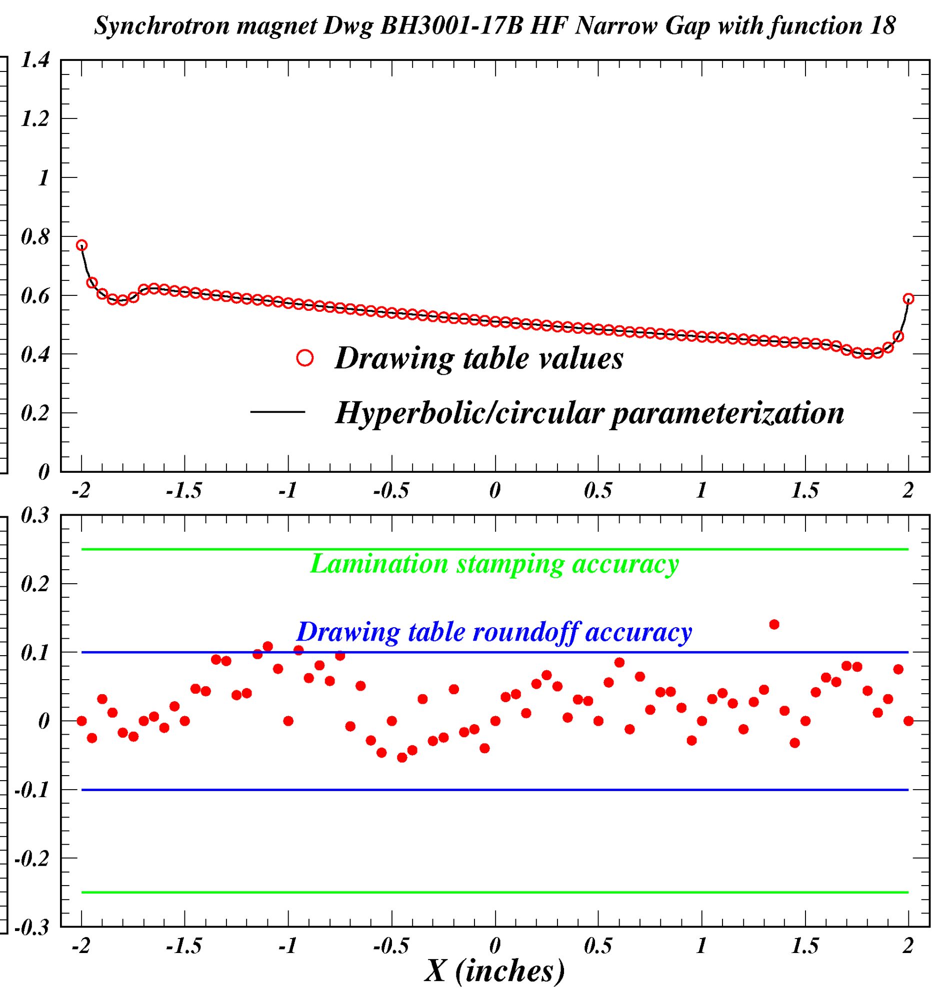
Pole shape parameterization accuracy Example: VF magnet



Drawing table accuracy 0.1 mil
CS-31: Lamination stamping accuracy 0.25 mils
Eight piecewise continuous hyperbola parameterizations required to reproduce drawing table accuracy.

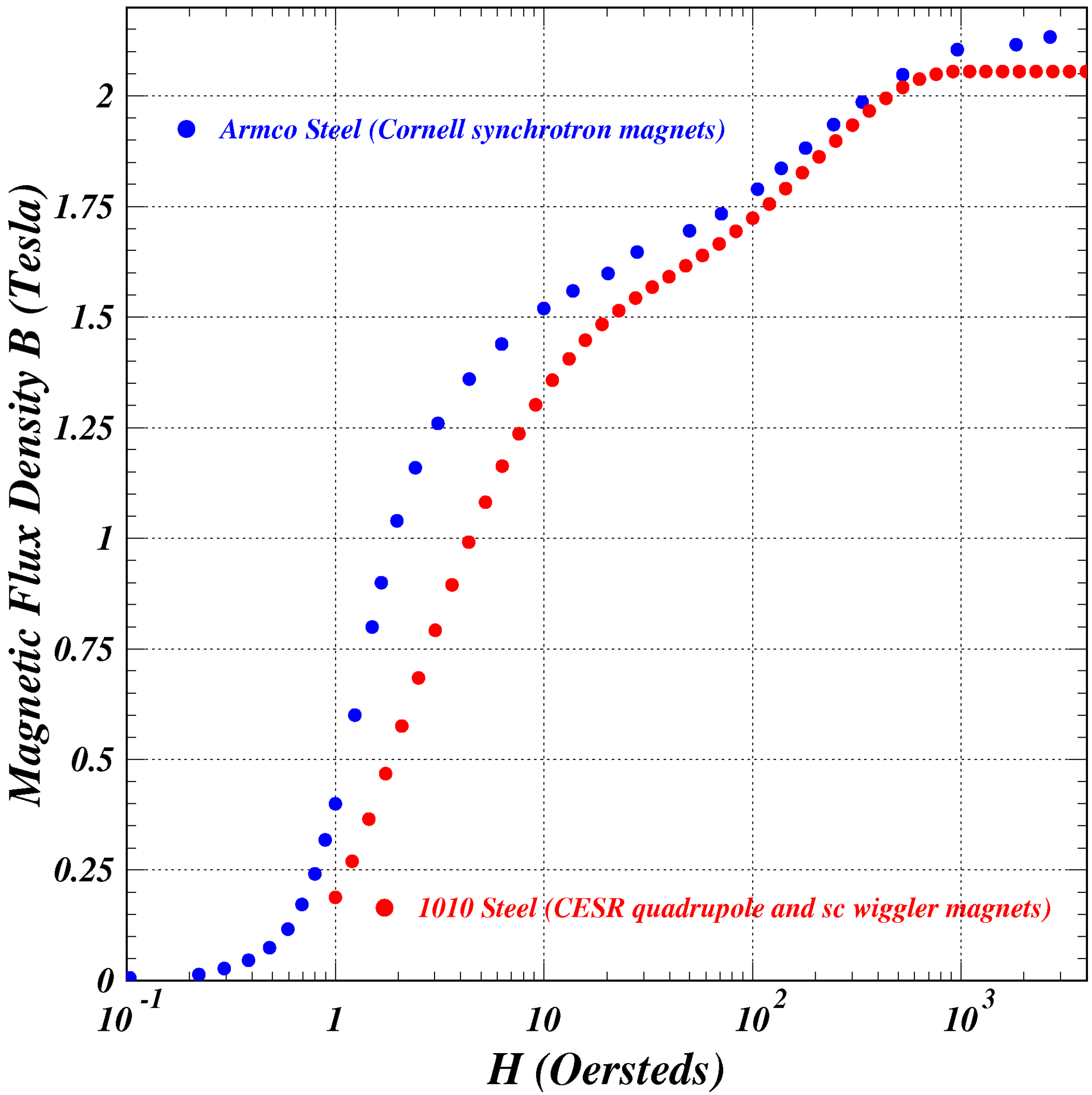
Pole shape parameterization accuracy





VF and HF magnets

Choice of B-H curve



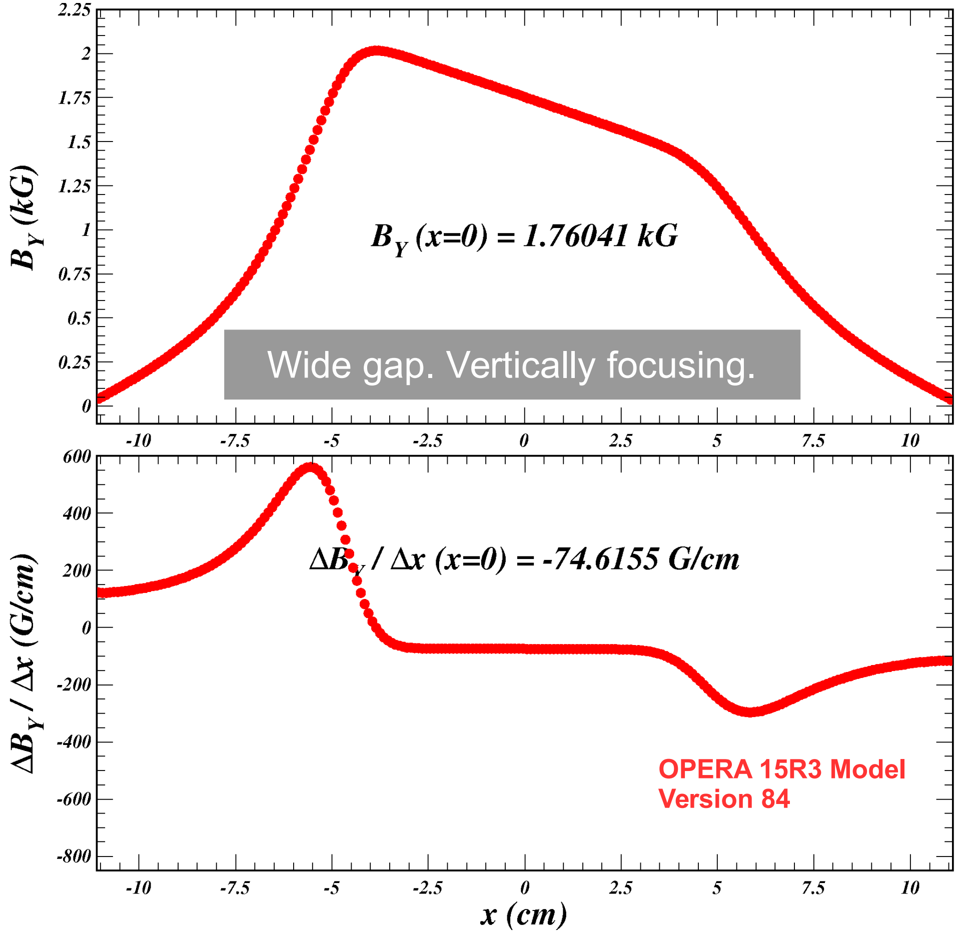
CS-33/Wilson:
"14-mil thick carlite-coated Armco A-6 from Hydro-Cam Engineering"

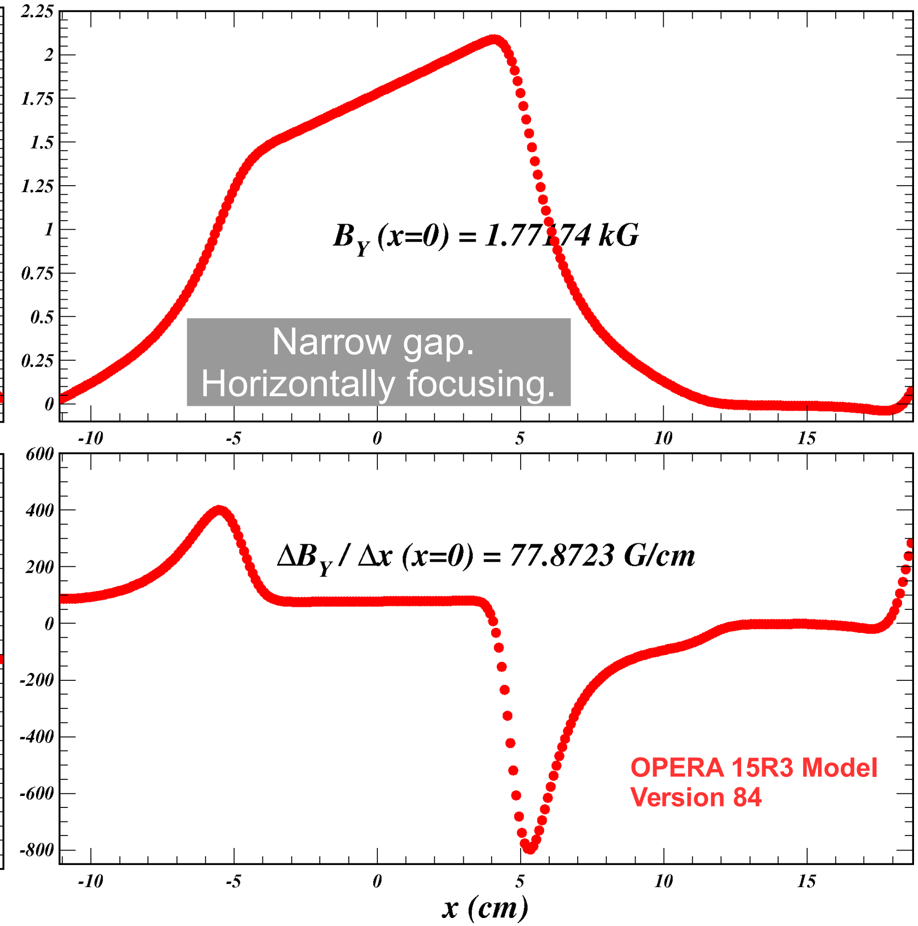
Design curve likely available in CSDS-24/Stein (11 Oct 1965), but haven't been able to find it yet. Maybe annex?

http://fieldp.com/myblog/2010/saturation-curves-for-common-soft-magnetic-materials/ has tables for Armco, 1008, 1010 steel, and other materials.
Created OPERA BH table from Armco.

Compared results with 1010 and Armco BH tables. Central field, field gradient and normalized field gradient profile showed differences less than 0.5%.

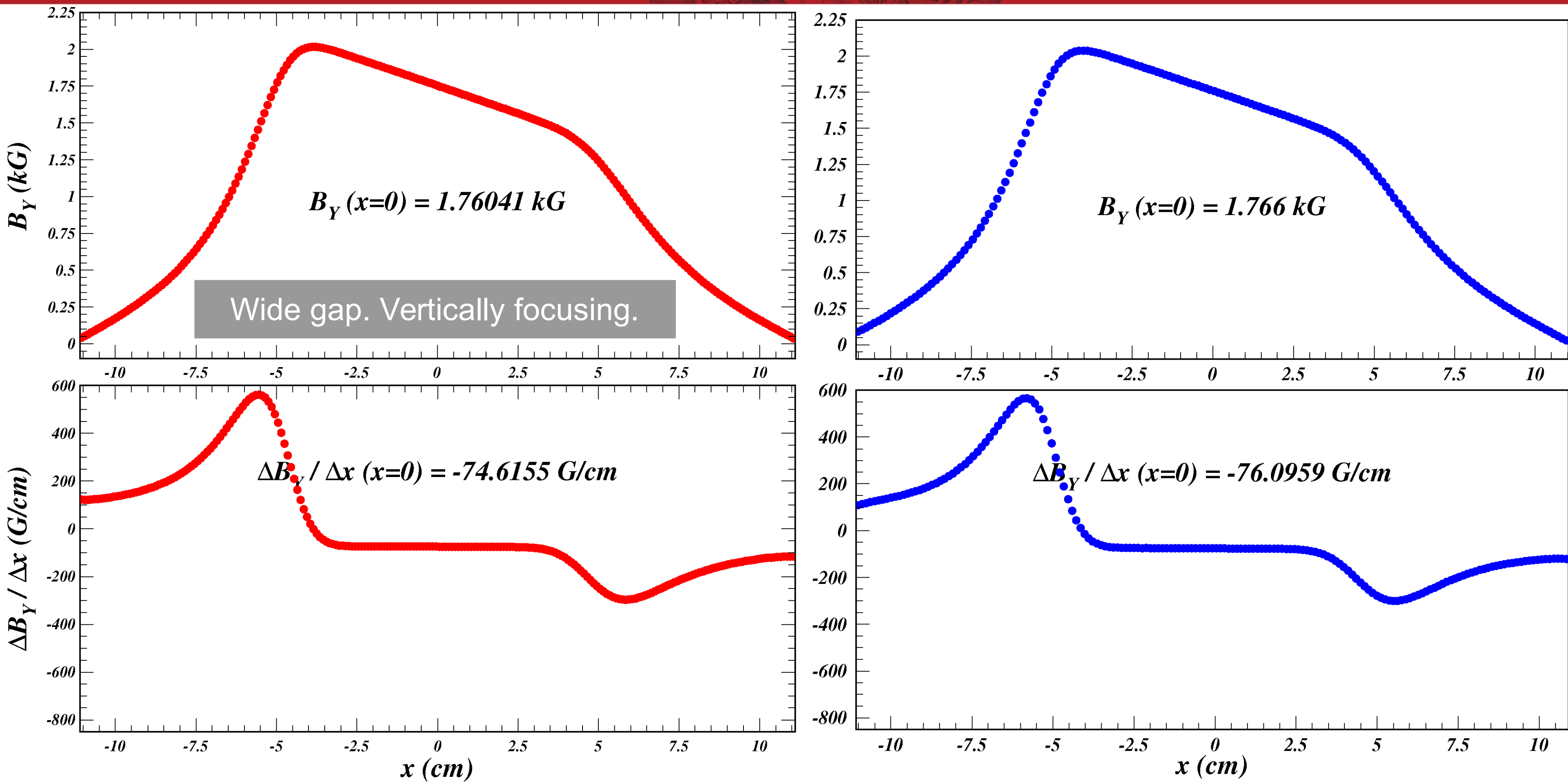
Transverse field and gradient profiles for the VF and HFEX magnets





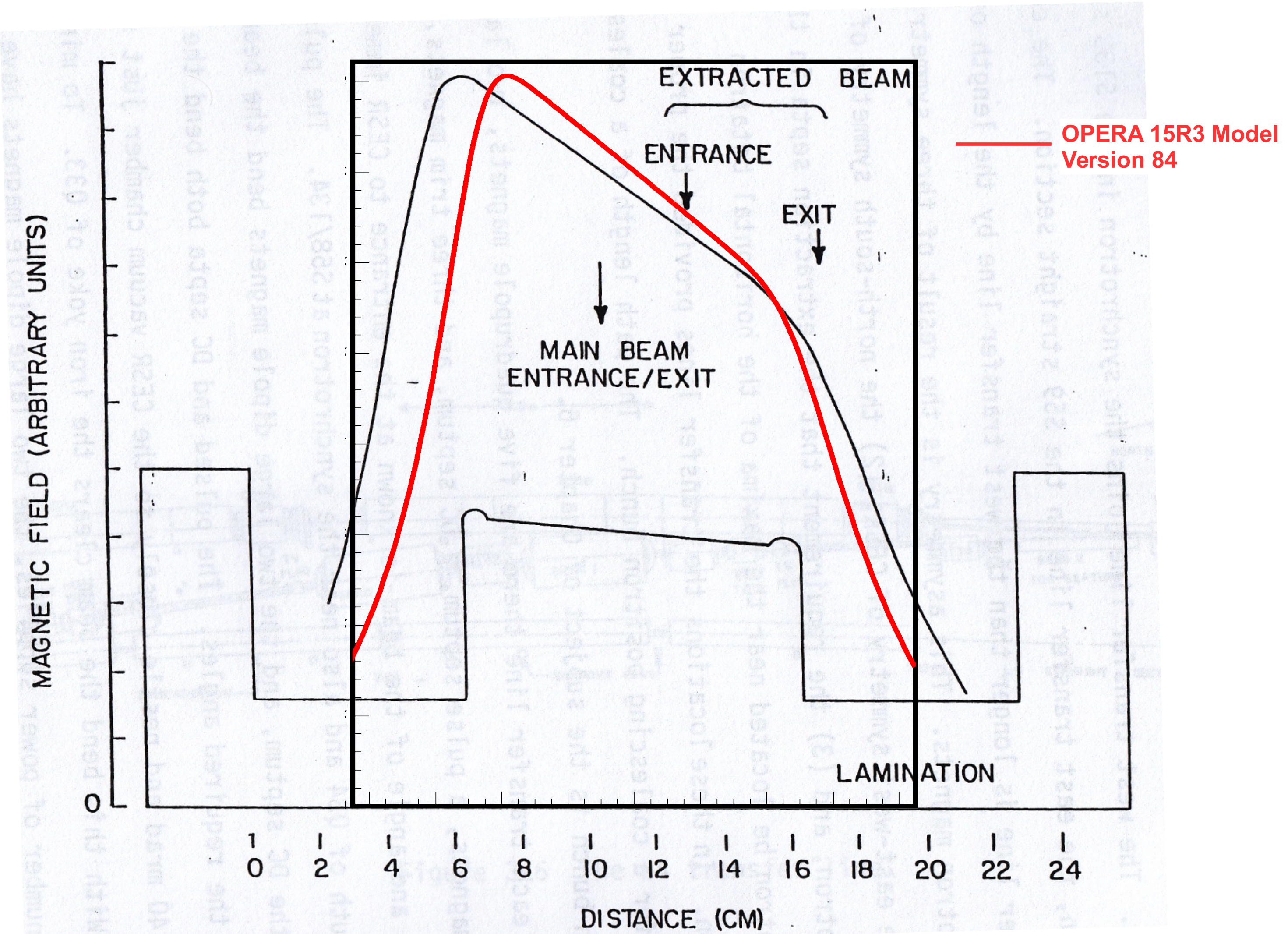
5.289 GeV: Design current 218 A.
Use fudge factor 1.064 (1.044) to get near design central field value (1.766 kG) for VF (HFEX).
Obtain central gradient value of 74.6 (77.9) G/cm, while design values are 75.5 (77.3) G/cm.

Comparison to Poisson 2D model (circa 1988) VF magnet



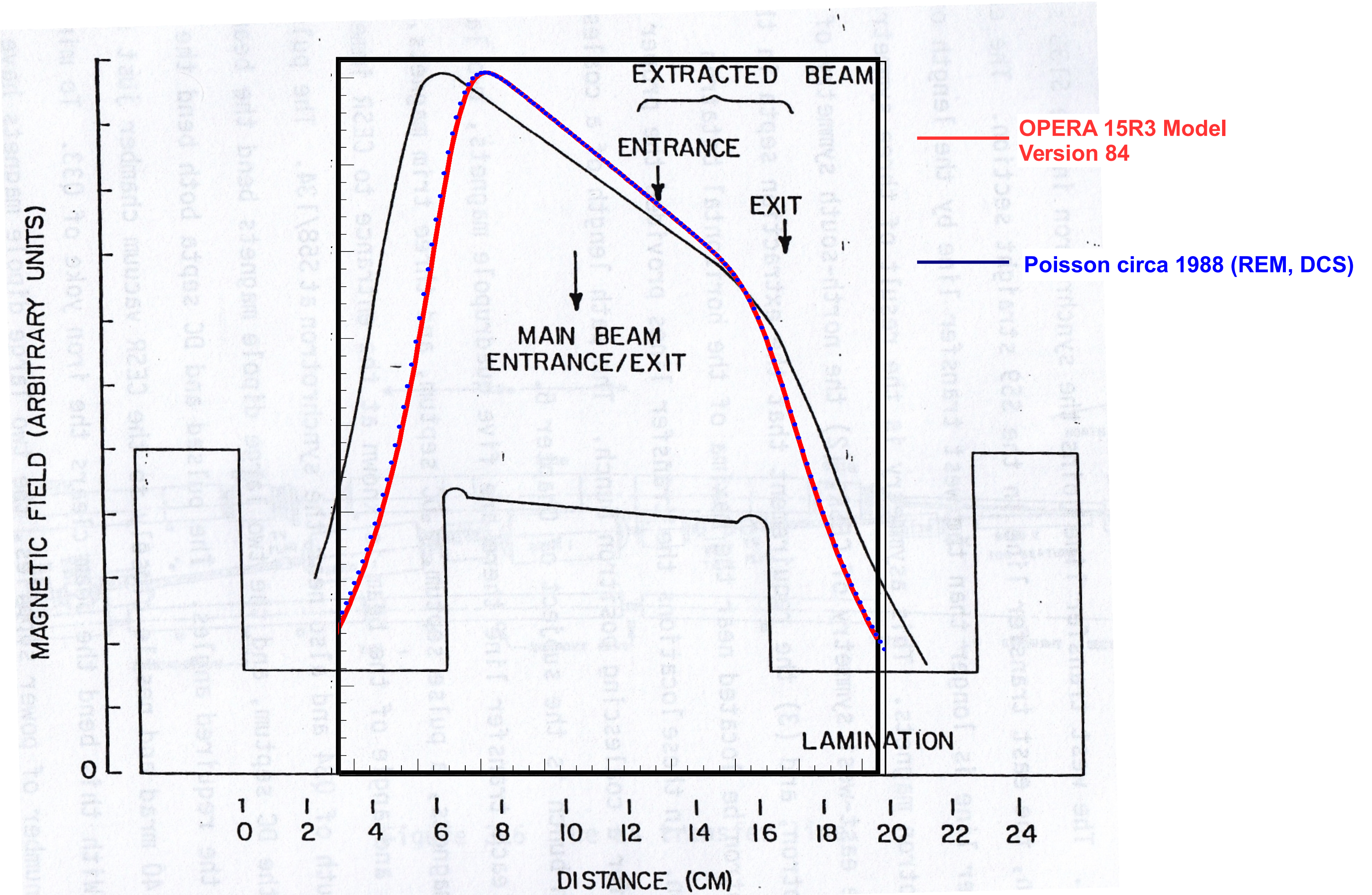
The nominal field gradient for 5.289 GeV is 75.6 G/cm.
The Poisson central field gradient is 0.7% high, while the Opera gradient is 1.3% low.

Seeman dissertation Fig 3.5
Wide gap, horizontally defocusing magnet



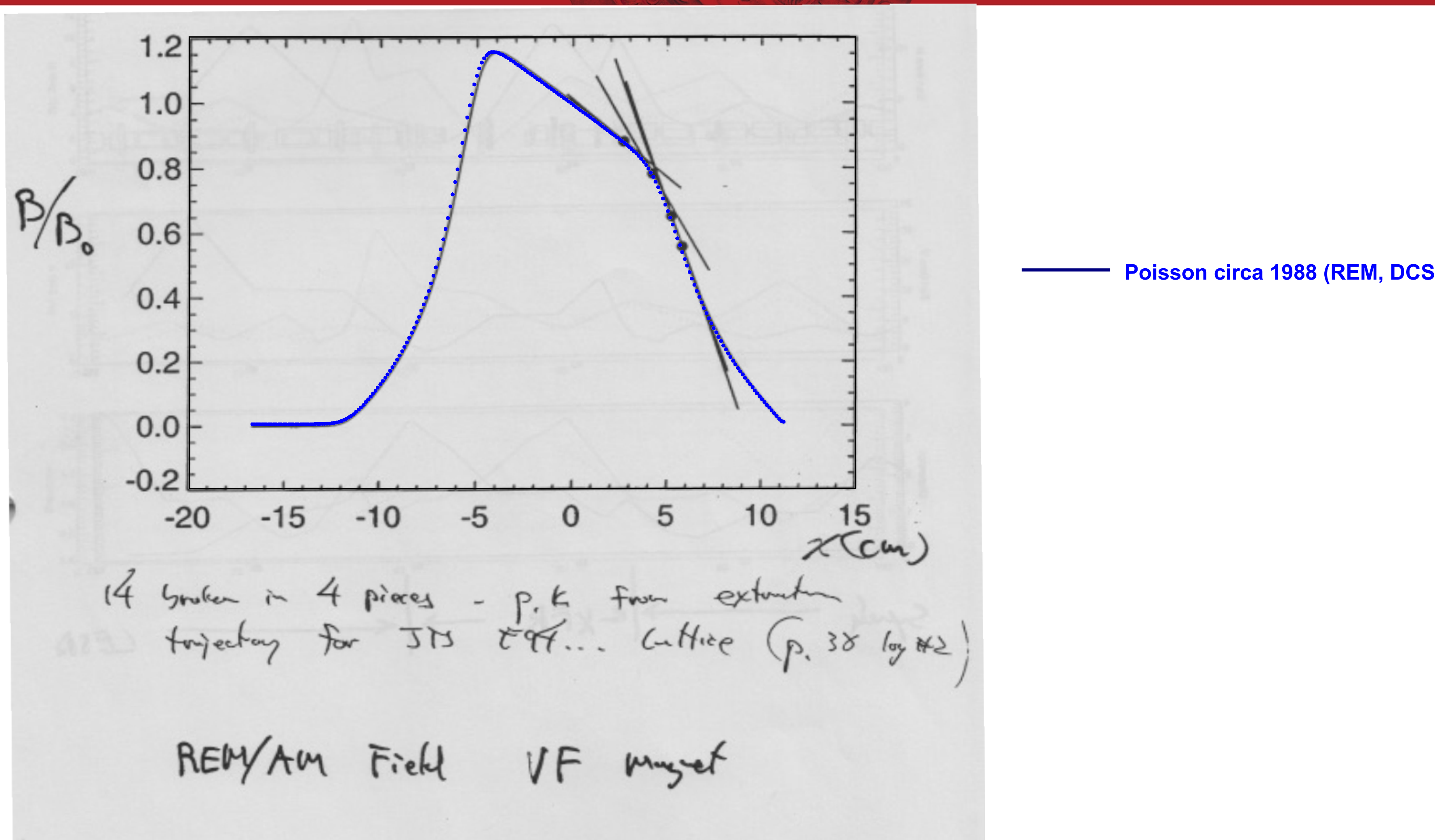
Surprised to find such a large difference. Fig 3.5 looks suspicious.

Seeman dissertation Fig 3.5
Wide gap, horizontally defocusing magnet



John's field plot is "illustrative only"

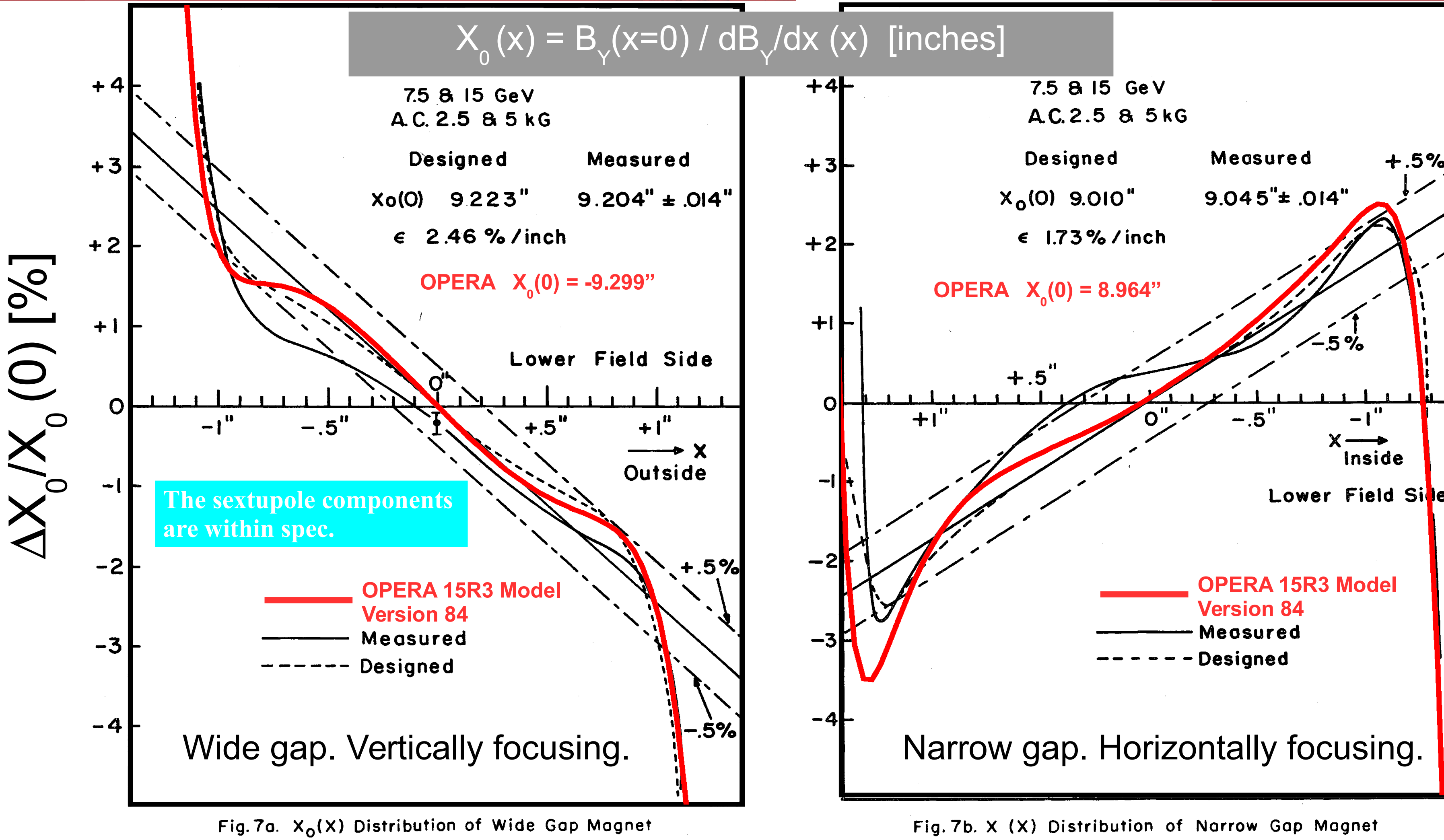
Henderson talk on injection
30 Oct 2000



This is clearly the field table used by Stu. The Opera model is a good match.

Detailed comparison of the measured and modeled field gradient profiles

$X_0(x) = B_Y(x=0) / dB_Y/dx\ (x)$ [inches]



The normalized central inverse gradients have the expected dependence on horizontal position, but are 0.8% high (0.5% low) for the VF (HF) magnet. These offsets have been subtracted in the above plots.

Detailed comparison of the measured and modeled field gradient profiles for the Poisson 2D model

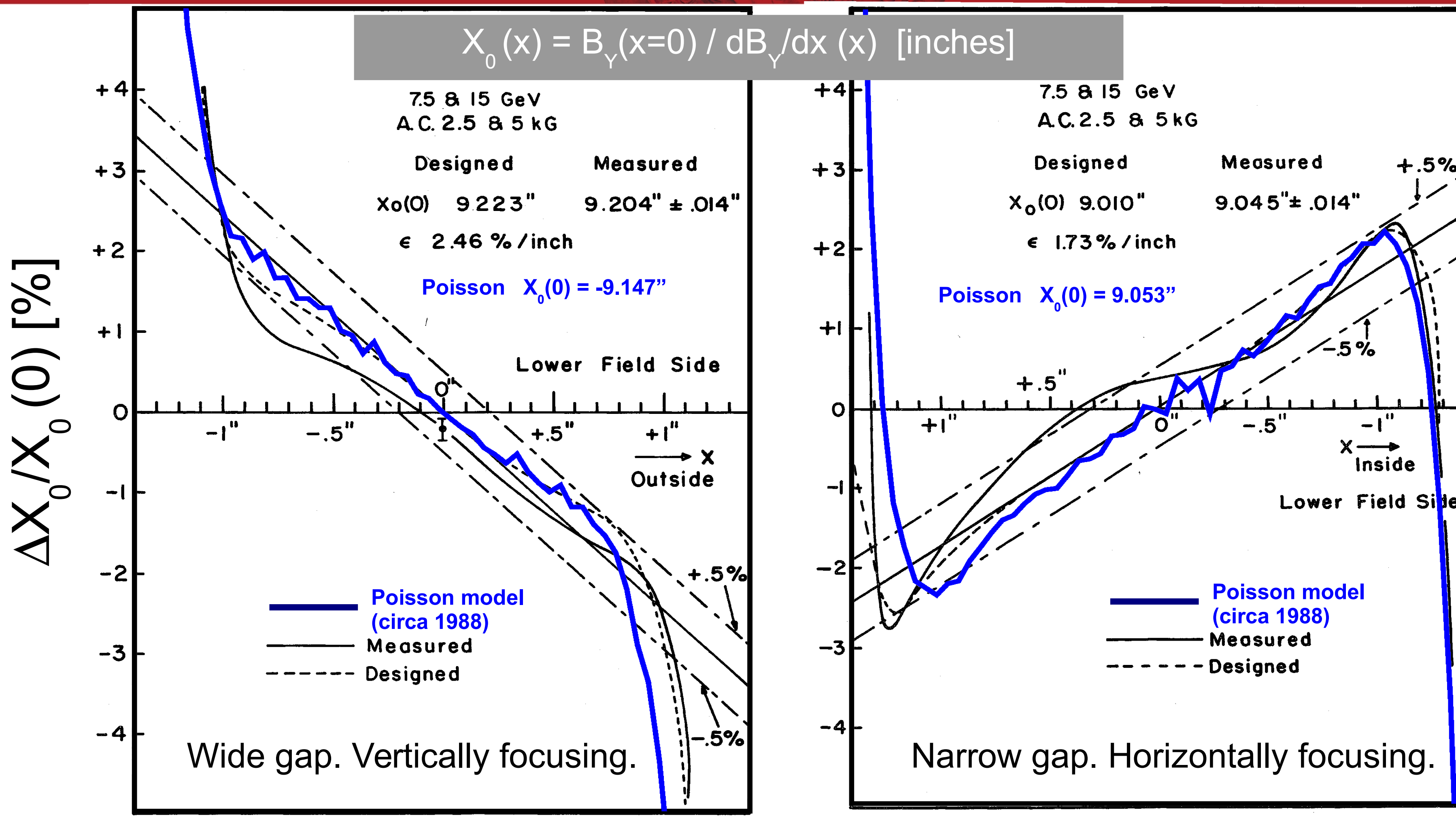


Fig. 7a. $X_0(X)$ Distribution of Wide Gap Magnet

Fig. 7b. X (X) Distribution of Narrow Gap Magnet

The normalized central inverse gradients are 0.8% low (0.5% high) for the VF (HF) magnet. These offsets have been subtracted in the above plots.

End packs for fringe field

CS-31: Magnetic field measurement I

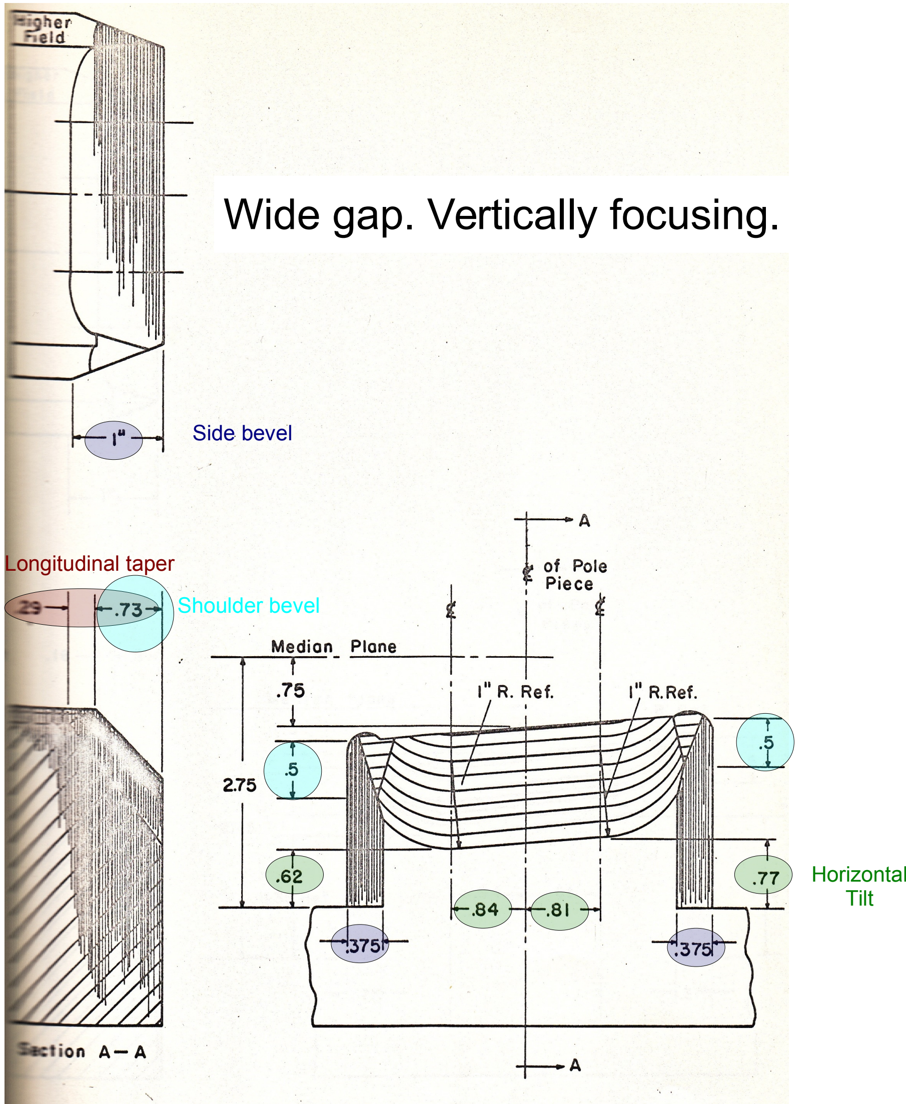


Fig. 7 Hard Pack of Wide Gap Magnet

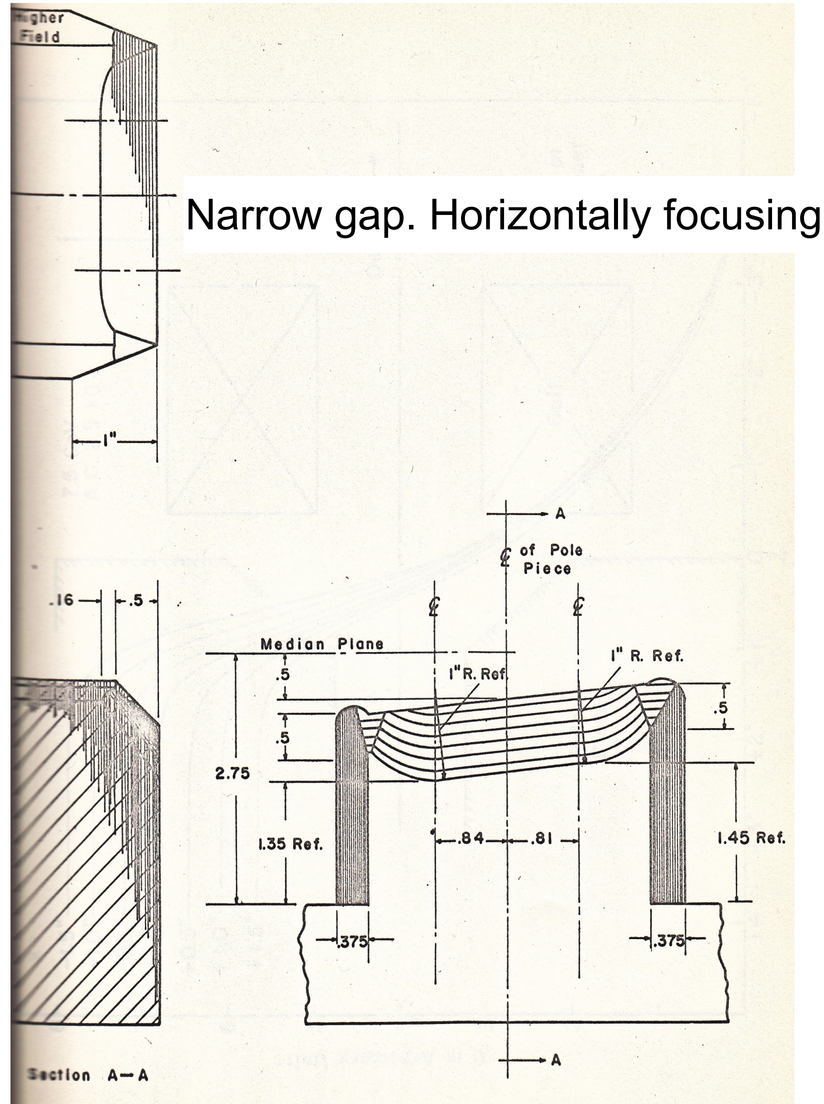


Fig. 8 Hard Pack of Narrow Gap Magnet

End packs for fringe field
CS-31: Magnetic field measurement I

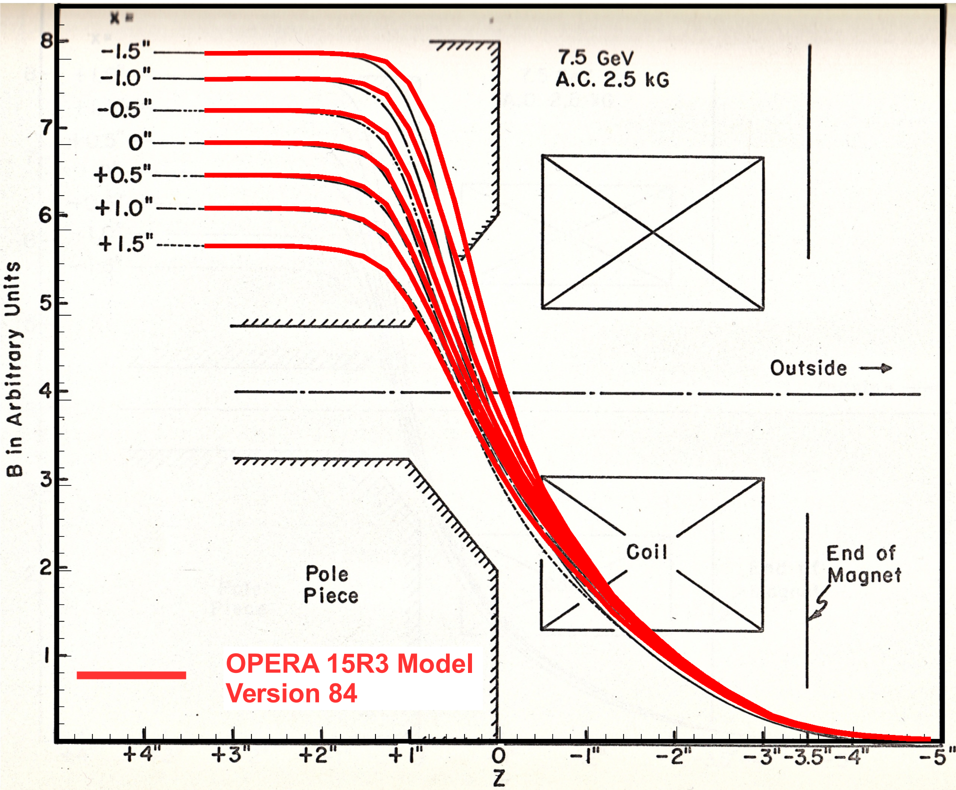


Fig. 9 Fringing Field of Wide Gap Magnet

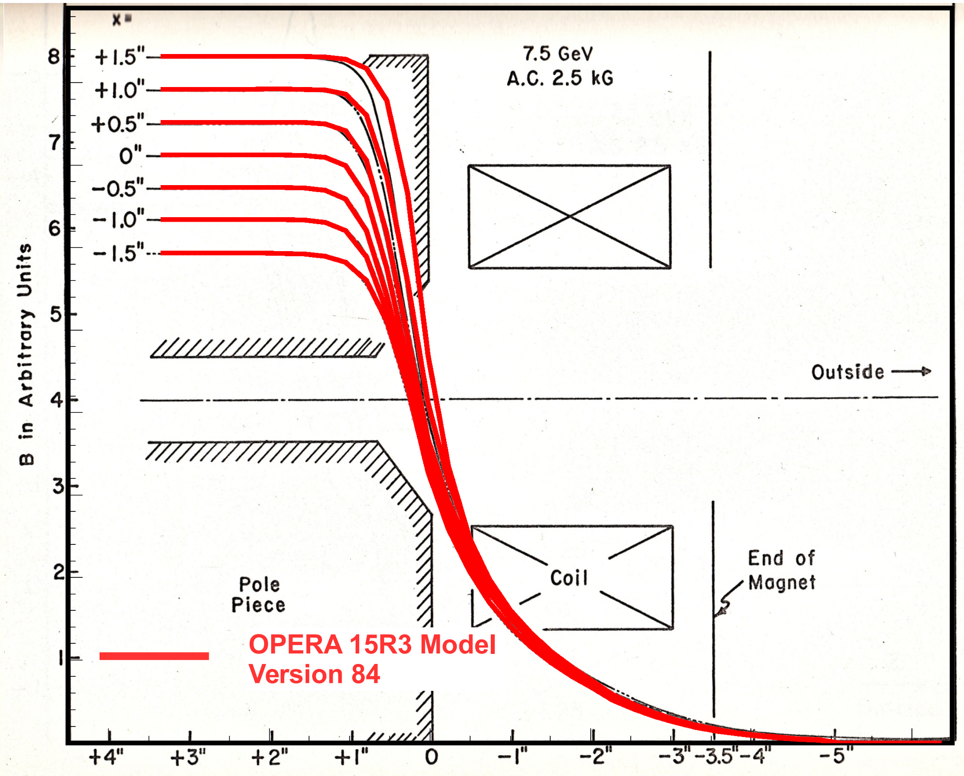
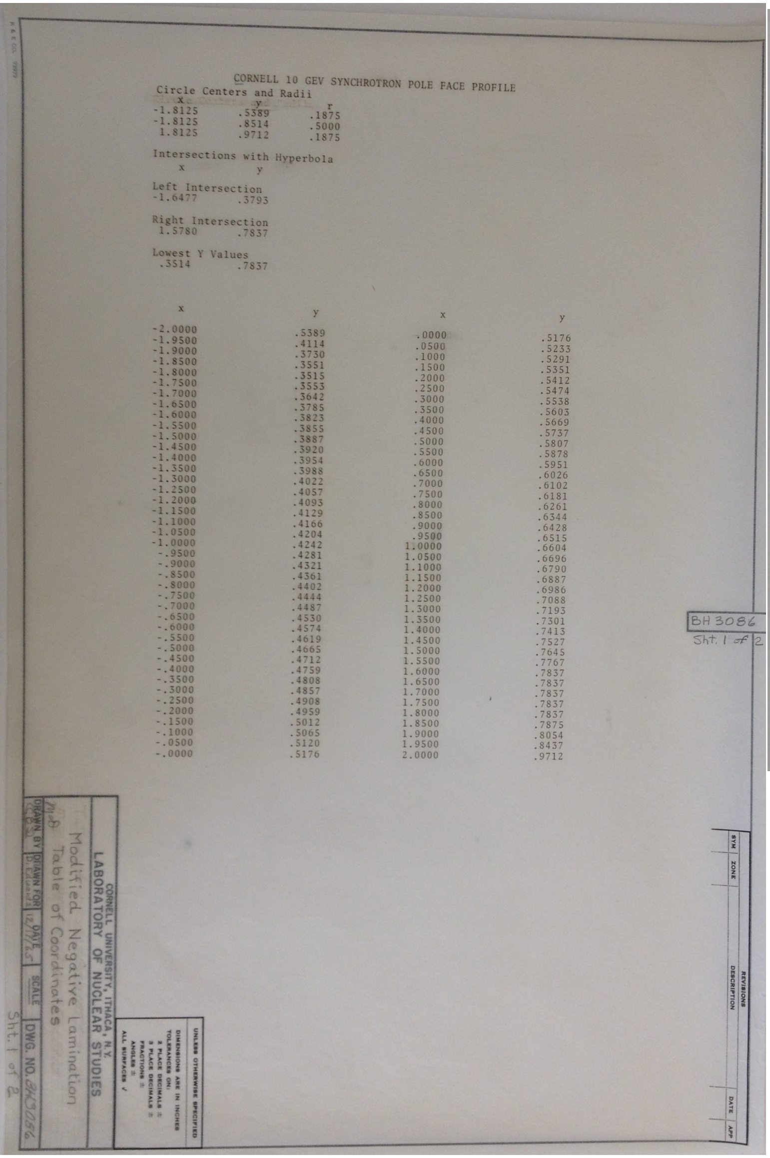


Fig. 10 Fringing Field of Narrow Gap Magnet

Wide gap. Vertically focusing.

Narrow gap. Horizontally focusing.

BH3086: High-gradient negative lamination
Narrow gap (1.035 in), horizontally focusing



CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

x	y	r
-1.8125	.5389	.1875
-1.8125	.8514	.5000
1.8125	.9712	.1875

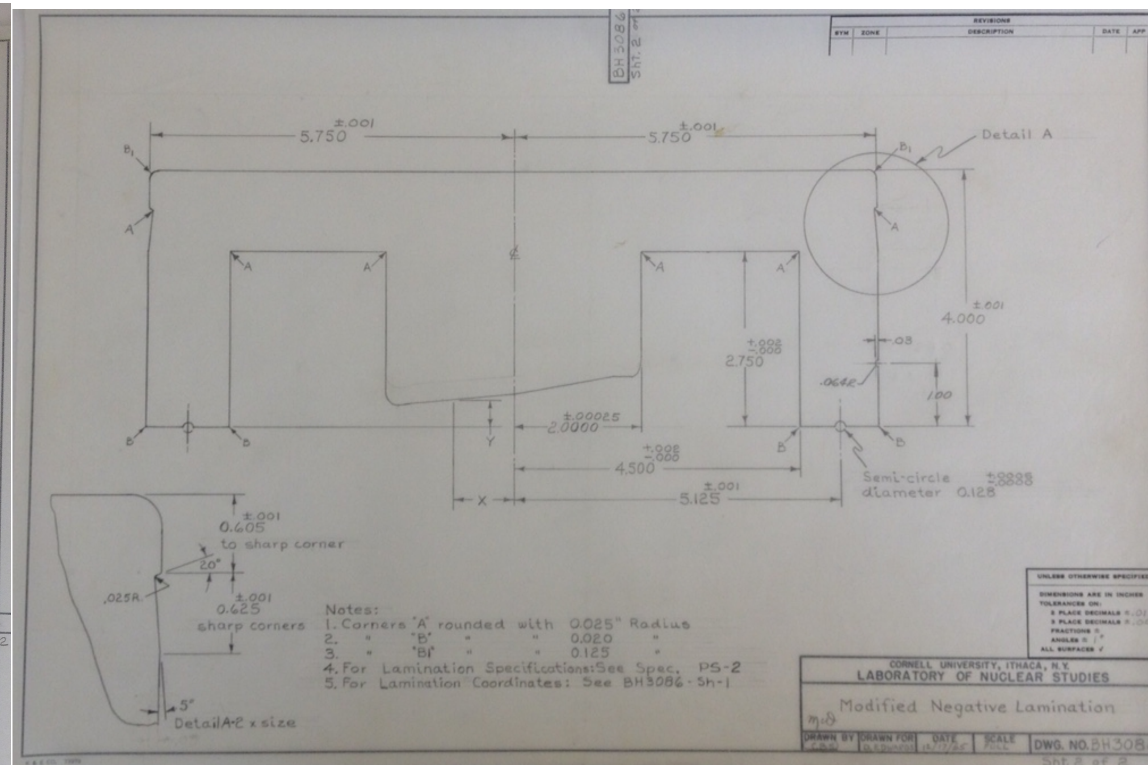
Intersections with Hyperbola

	x	y
Left Intersection	-1.6477	.3793
Right Intersection	1.5780	.7837
Lowest Y Values	.3514	.7837

x	y	x	y
-2.0000	.5389	.0000	.5176
-1.9500	.4114	.0500	.5233
-1.9000	.3730	.1000	.5291
-1.8500	.3551	.1500	.5351
-1.8000	.3515	.2000	.5412
-1.7500	.3553	.2500	.5474
-1.7000	.3642	.3000	.5538
-1.6500	.3785	.3500	.5603
-1.6000	.3823	.4000	.5669
-1.5500	.3855	.4500	.5737
-1.5000	.3887	.5000	.5807
-1.4500	.3920	.5500	.5878
-1.4000	.3954	.6000	.5951
-1.3500	.3988	.6500	.6026
-1.3000	.4022	.7000	.6102
-1.2500	.4057	.7500	.6181
-1.2000	.4093	.8000	.6261
-1.1500	.4129	.8500	.6344
-1.1000	.4166	.9000	.6428
-1.0500	.4204	.9500	.6515
-1.0000	.4242	1.0000	.6604
-.9500	.4281	1.0500	.6696
-.9000	.4321	1.1000	.6790
-.8500	.4361	1.1500	.6887
-.8000	.4402	1.2000	.6986
-.7500	.4444	1.2500	.7088
-.7000	.4487	1.3000	.7193
-.6500	.4530	1.3500	.7301
-.6000	.4574	1.4000	.7413
-.5500	.4619	1.4500	.7527
-.5000	.4665	1.5000	.7645
-.4500	.4712	1.5500	.7767
-.4000	.4759	1.6000	.7837
-.3500	.4808	1.6500	.7837
-.3000	.4857	1.7000	.7837
-.2500	.4908	1.7500	.7837
-.2000	.4959	1.8000	.7837
-.1500	.5012	1.8500	.7875
-.1000	.5065	1.9000	.8054
-.0500	.5120	1.9500	.8437
-.0000	.5176	2.0000	.9712

BH 3086
Sht. 1 of 2

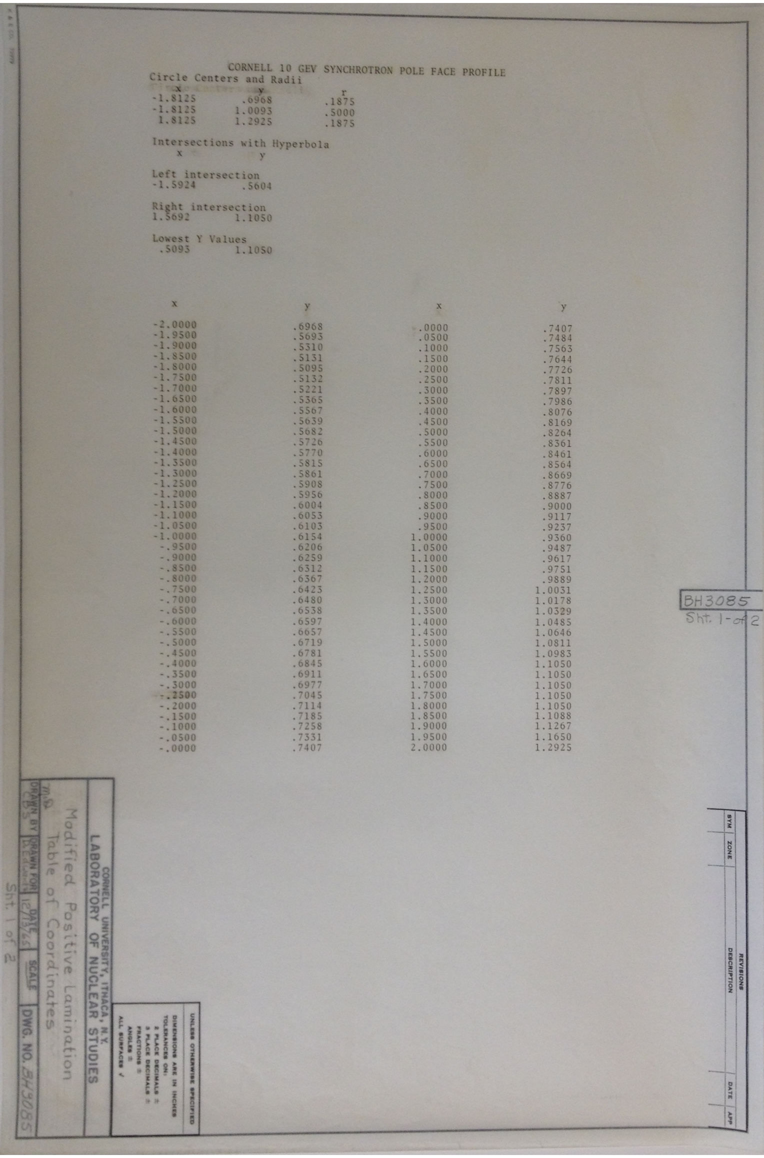
CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
Modified Negative Lamination
Table of Coordinates
DWG. NO. BH3086
Sht. 1 of 2



CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967

Length: 134.98 in

BH3085: High-gradient positive lamination
Wide gap (1.481 in), vertically focusing



CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

x	y	r
-1.8125	.6968	.1875
-1.8125	1.0093	.5000
1.8125	1.2925	.1875

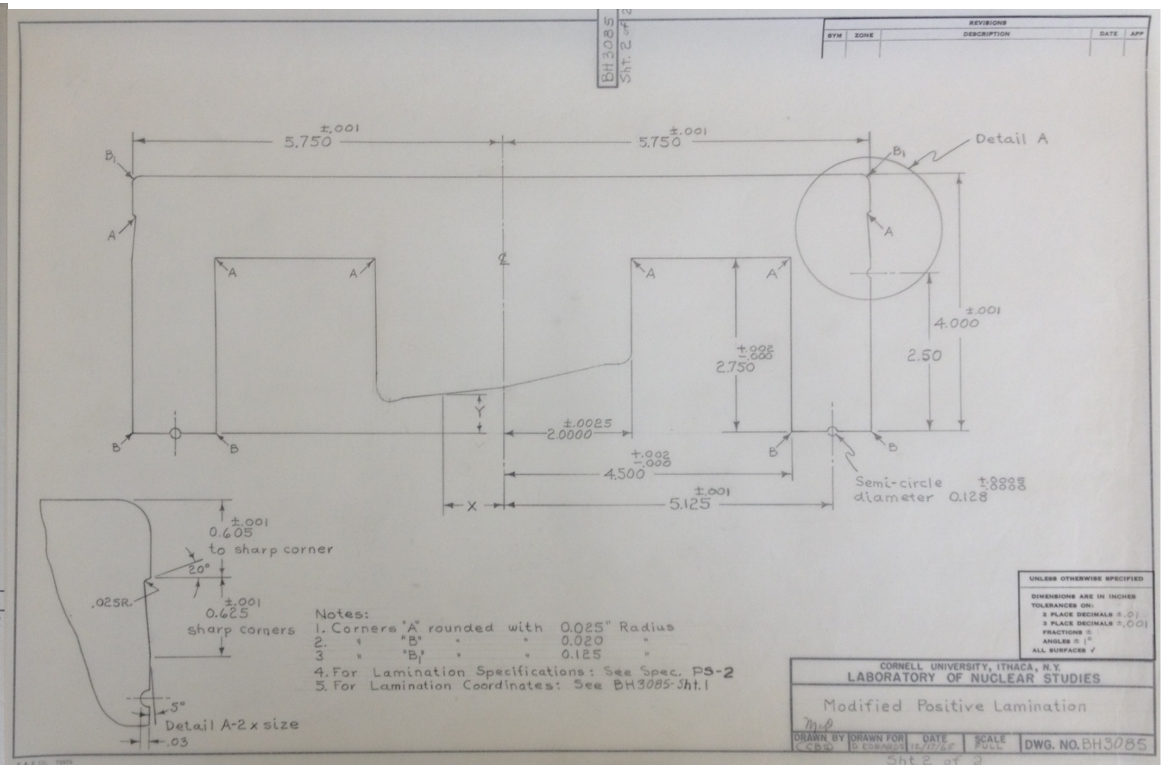
Intersections with Hyperbola

	x	y
Left intersection	-1.5924	.5604
Right intersection	1.5692	1.1050
Lowest Y Values	.5093	1.1050

x	y	x	y
-2.0000	.6968	.0000	.7407
-1.9500	.5693	.0500	.7484
-1.9000	.5310	.1000	.7563
-1.8500	.5131	.1500	.7644
-1.8000	.5095	.2000	.7726
-1.7500	.5132	.2500	.7811
-1.7000	.5221	.3000	.7897
-1.6500	.5365	.3500	.7986
-1.6000	.5567	.4000	.8076
-1.5500	.5639	.4500	.8169
-1.5000	.5682	.5000	.8264
-1.4500	.5726	.5500	.8361
-1.4000	.5770	.6000	.8461
-1.3500	.5815	.6500	.8564
-1.3000	.5861	.7000	.8669
-1.2500	.5908	.7500	.8776
-1.2000	.5956	.8000	.8887
-1.1500	.6004	.8500	.9000
-1.1000	.6053	.9000	.9117
-1.0500	.6103	.9500	.9237
-1.0000	.6154	1.0000	.9360
-.9500	.6206	1.0500	.9487
-.9000	.6259	1.1000	.9617
-.8500	.6312	1.1500	.9751
-.8000	.6367	1.2000	.9889
-.7500	.6423	1.2500	1.0031
-.7000	.6480	1.3000	1.0178
-.6500	.6538	1.3500	1.0329
-.6000	.6597	1.4000	1.0485
-.5500	.6657	1.4500	1.0646
-.5000	.6719	1.5000	1.0811
-.4500	.6781	1.5500	1.0983
-.4000	.6845	1.6000	1.1050
-.3500	.6911	1.6500	1.1050
-.3000	.6977	1.7000	1.1050
-.2500	.7045	1.7500	1.1050
-.2000	.7114	1.8000	1.1050
-.1500	.7185	1.8500	1.1088
-.1000	.7258	1.9000	1.1267
-.0500	.7331	1.9500	1.1650
-.0000	.7407	2.0000	1.2925

BH3085
Sht. 1 of 2

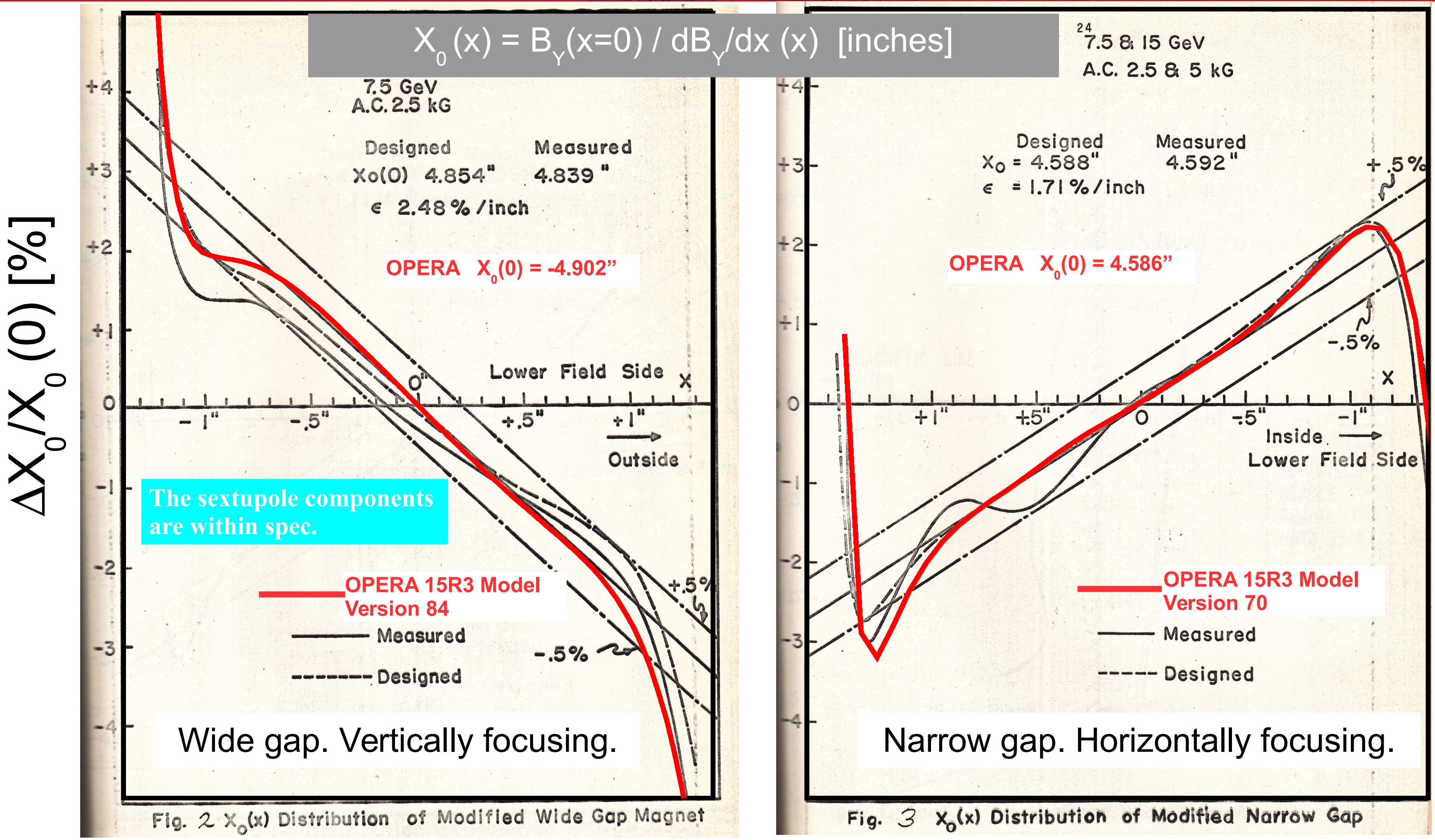
CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
Modified Positive Lamination
Table of Coordinates
DWG. NO. BH3085
Sht. 1 of 2



CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967

Length: 134.98 in

Measured and designed field gradients
Magnets modified for high gradients near straight sections



The normalized central inverse gradients have the expected dependence on horizontal position, but are 1.0% high (xx% low) for the VF (HF) magnet. These offsets have been subtracted in the above plots.

Summary

* 3D models of the Cornell synchrotron magnets have been developed.
Six models: vertically focusing VF, horizontally focusing HF , high-gradient VFM, HFM, and VFEX, HFEX with extraction channels. The models pertinent to extraction to CESR are VF and HFEX.

* The models are ¼ models (Y>0, Z>0 only) and 1/10th length. Full-length tables are written by extending the central field along the full lenth to the fringe region.

* Design specs are reproduced at the 0.2% level for the central field strength, 1% for the quadrupole moment and 0.1% for the sextupole term.

* Design versions for the six models are generated automatically in grid batch jobs, 16 hours per pair of magnets, limited by the number of Opera licenses.

* The extraction channels are approximated as continuous iron, while the magnets were built with a serious of discrete blocks of iron. Also, the channels begin 24 inches from the upstream end of the magnet and end 27 inches from the downstream end. The model has the extraction channel along the entire length of the magnet.

* The upstream 17 inches of the high-gradient magnets are opposite-sign, normal-gradient sections. These have not yet been modeled.

John Seeman dissertation (May 1979)
Figure 3.6

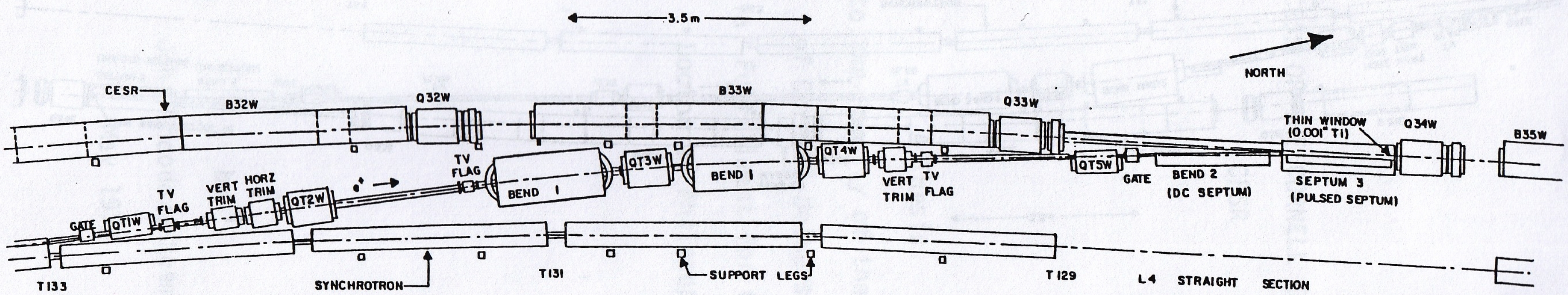


Figure 3.6 The L4 transfer line.

John Seeman dissertation (May 1979)
Figure 3.7

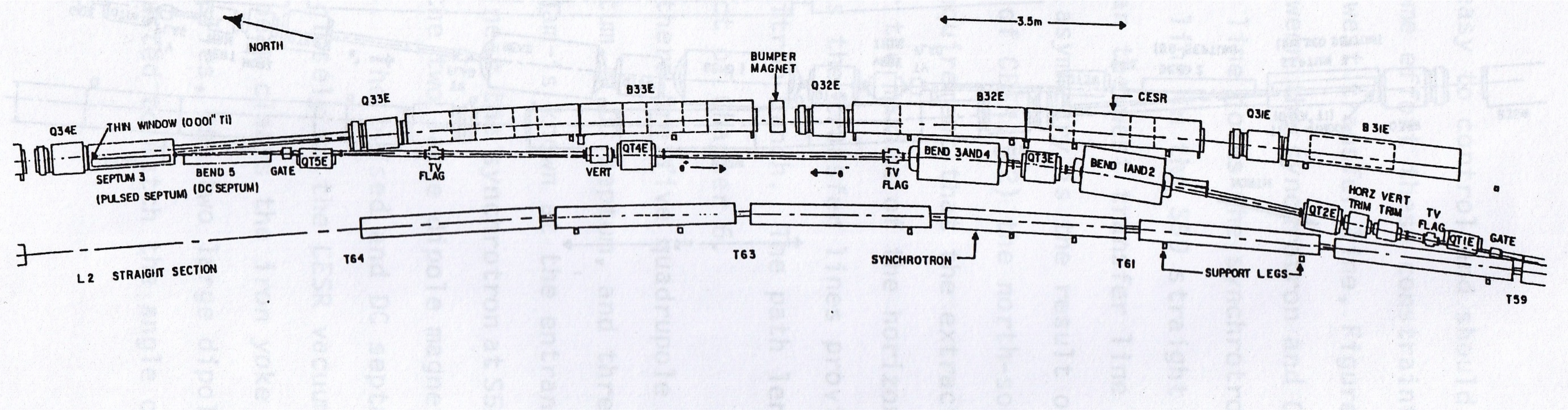
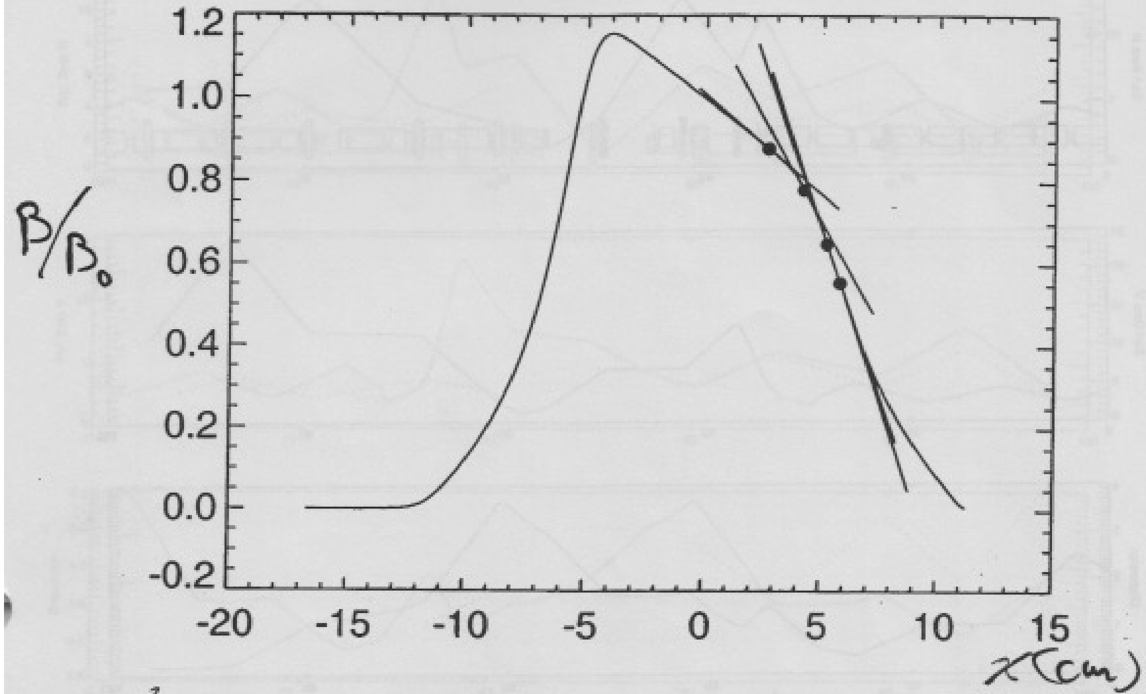


Figure 3.7 The L2 transfer line.

Henderson 30 Oct 2000



14 broken in 4 pieces - p.k from extraction trajectory for JTS E97... Lattice (p. 38 log #2)

REM/AM Field VF magnet

Synchrotron magnet modified for extraction channel

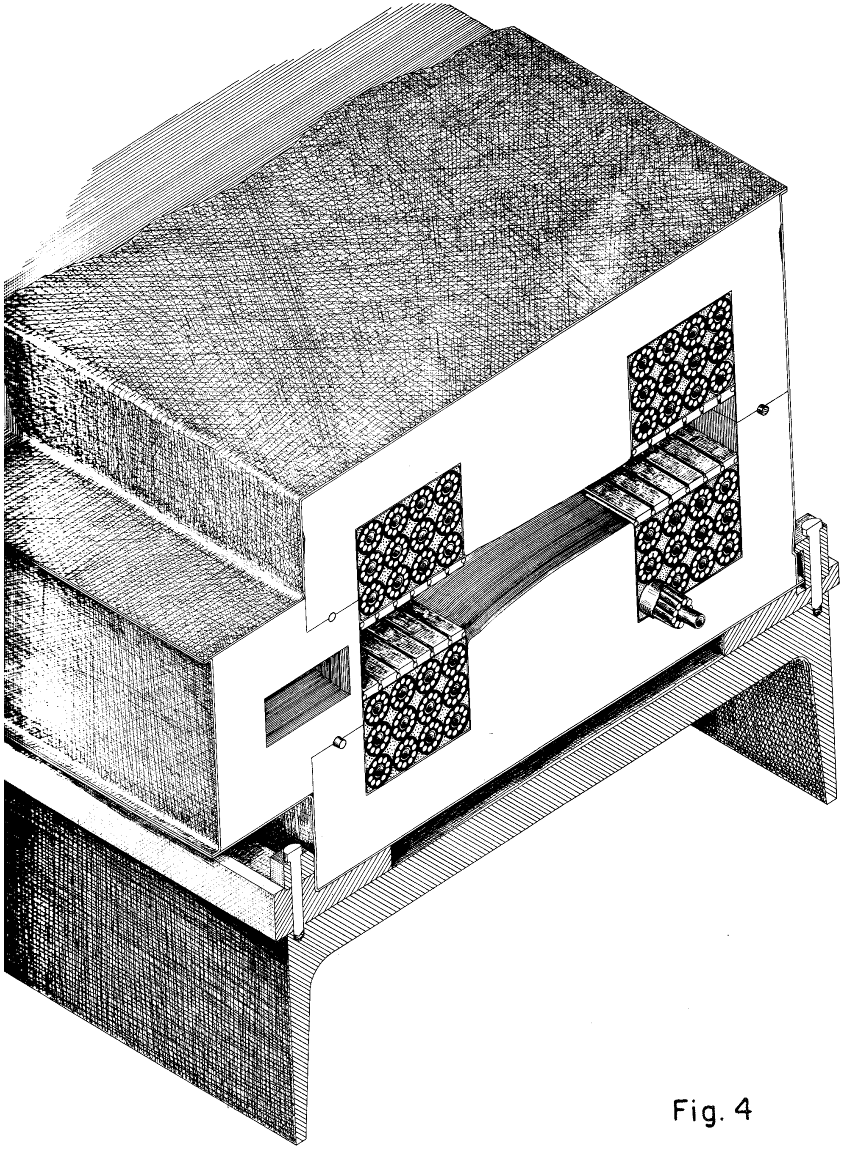


Fig. 4

Wide gap. Vertically focusing.

Weaker field on outside of ring.

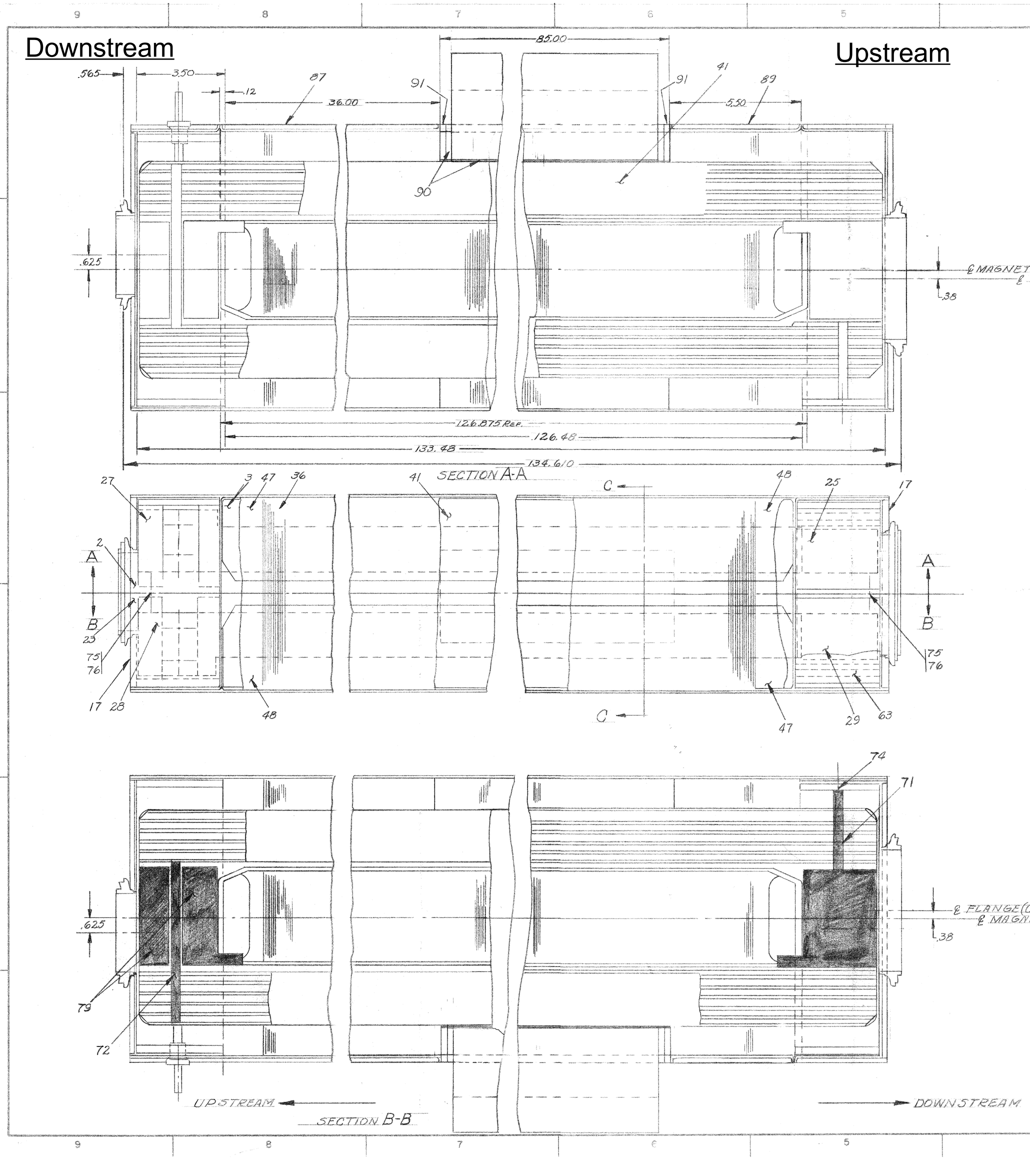
Estimated extraction channel dimensions:

Horizontal aperture: 2 in
Vertical aperture: 1 in

Aperture central position:
X= 5.7 in
Y= 0

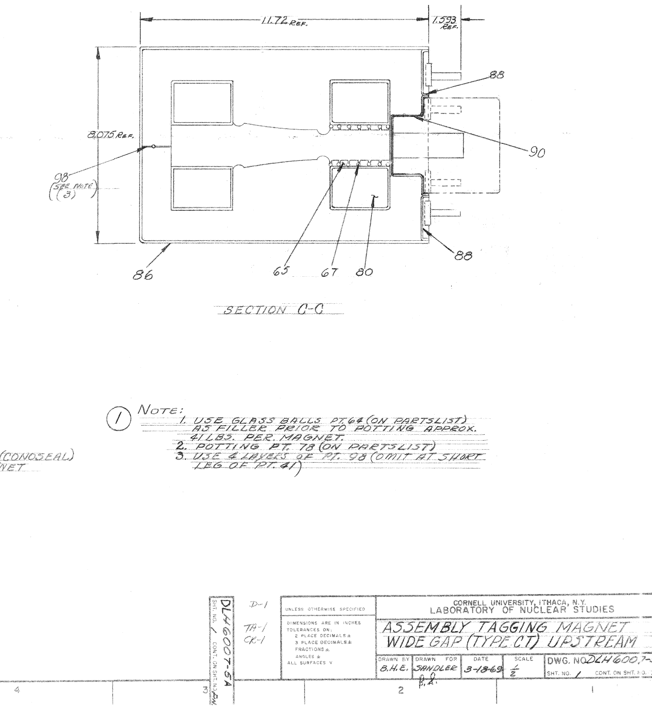
Outer steel dimensions:
X: 2.25 in
Y: 4 in

Cornell Synchrotron Tagging Magnet
Dwg DLH6007-5A_1.2

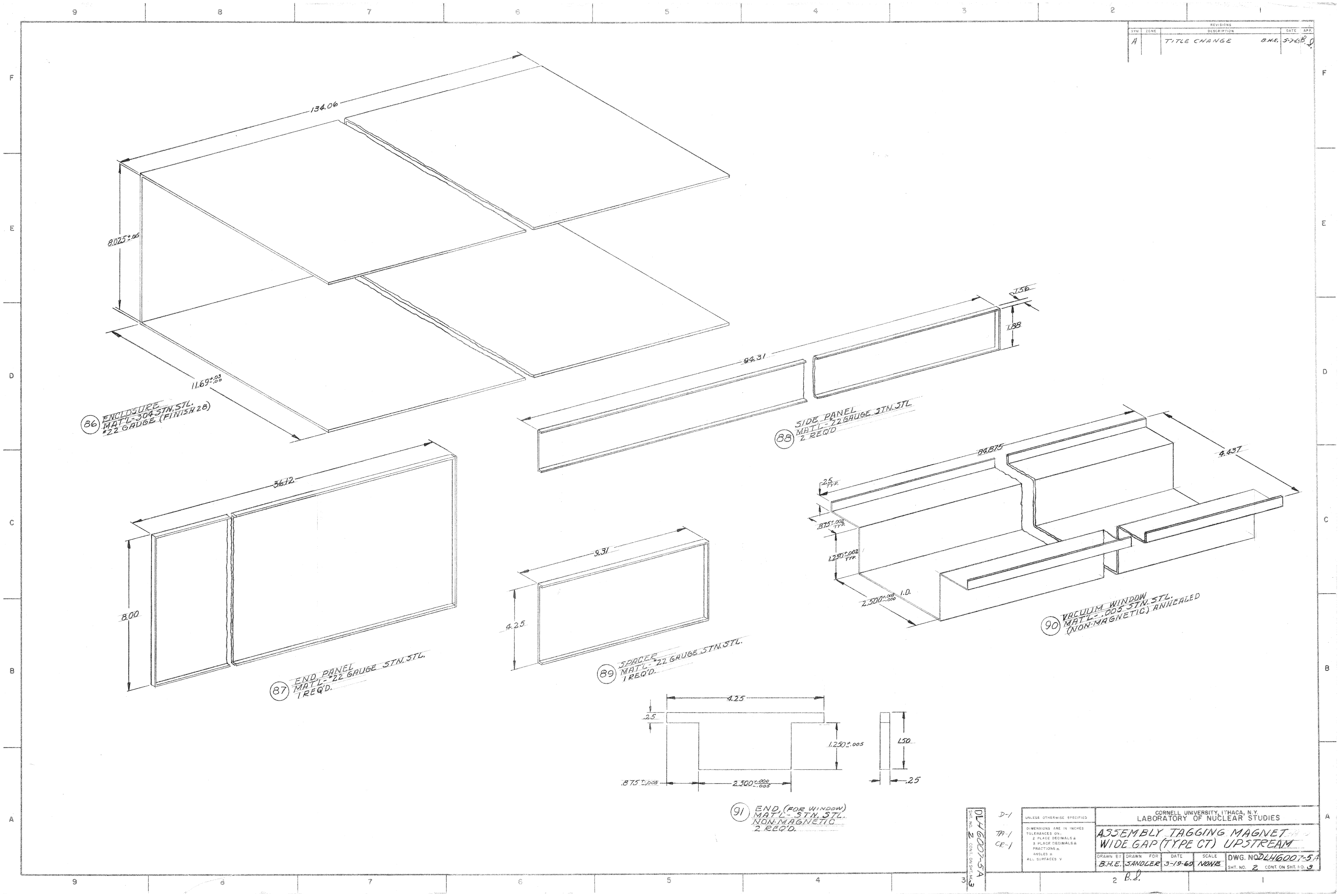


8 Dec 2015: Bar magnet test
JAC & SW

We found that the 85-inch ss extraction channel sheath is entirely full of iron. Also, we found the magnet steel to begin 3.5 inches from the ends of the ss cover (134 inches long). Unlike the drawing, the 85-inch section begins 24 inches from one end of the main ss cover, and 27 ¾ inch from the other. Assuming that the longer distance is the downstream end (39.5 inches in the drawing, then the upstream end of the cover should be 24 inches from the 85-inch section, rather than the 5.5+3.5=9 inches in the drawing. It is 20.5 inches from the upstream end of the steel. NB: the steel length of the magnet, including the endpacks, is 126.875 inches. These measurements of the extraction channel were found to be the same for EXFR and WXFR.

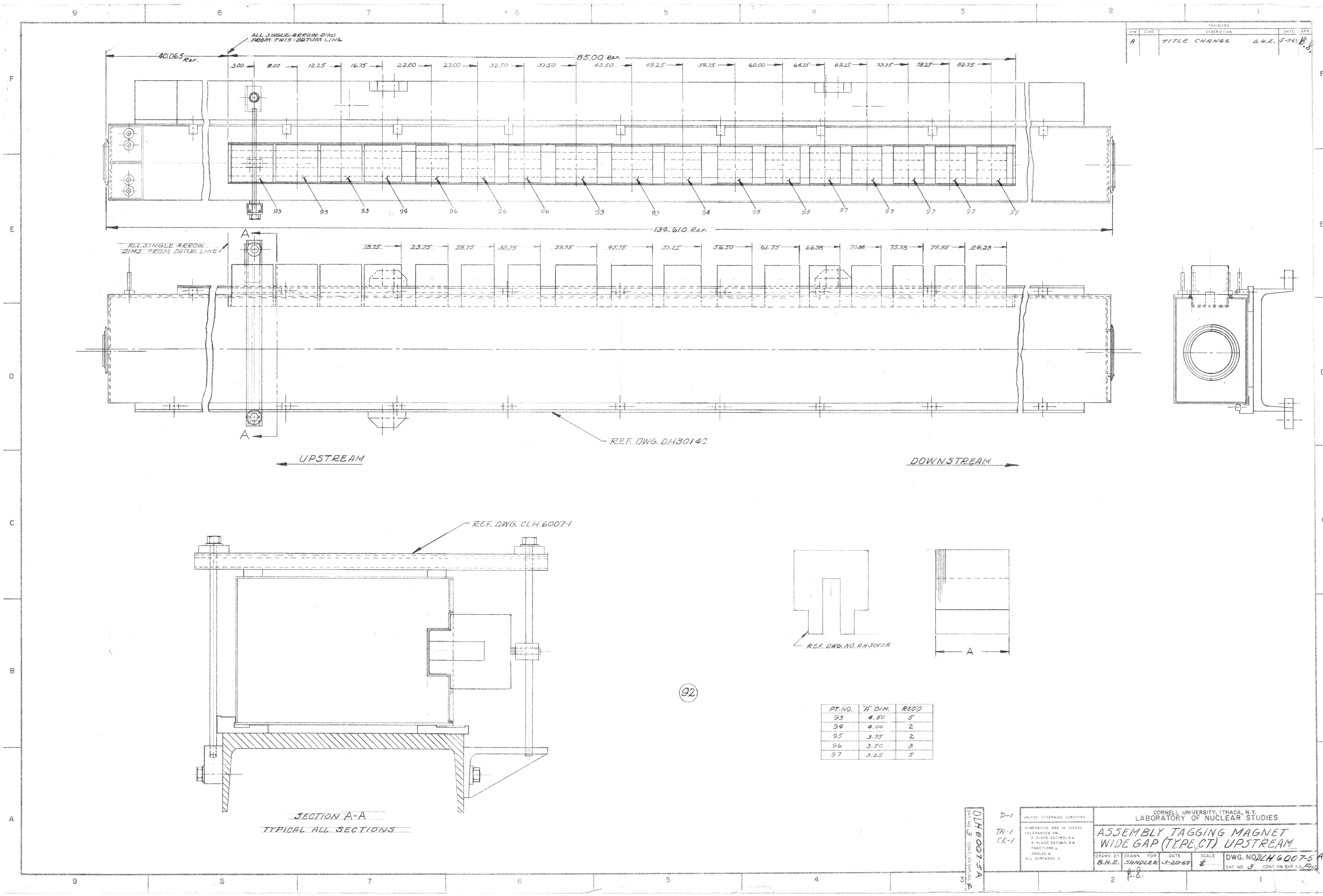


Cornell Synchrotron Tagging Magnet
Dwg DLH6007-5A_2.3

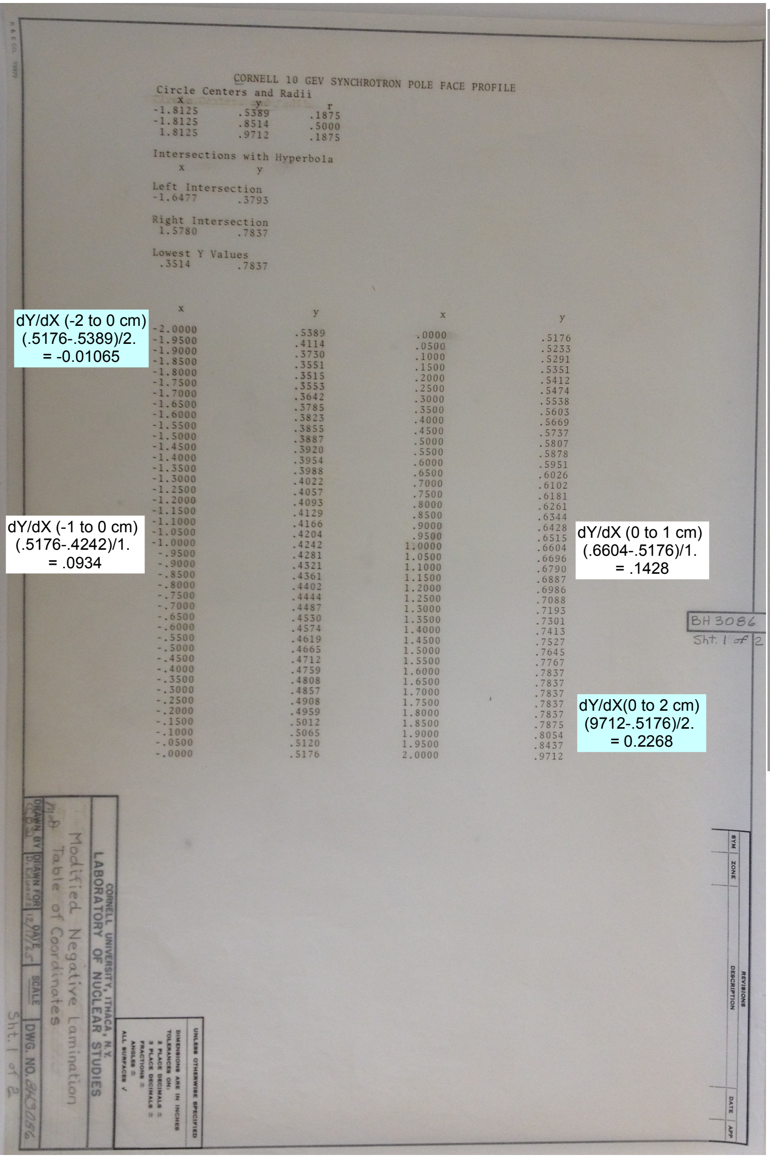


Cornell Synchrotron Tagging Magnet

Dwg DLH6007-5A_3



BH3086 - Negative lamination
Narrow gap (1.035 in), horizontally focusing



CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

x	y	r
-1.8125	.5389	.1875
-1.8125	.8514	.5000
1.8125	.9712	.1875

Intersections with Hyperbola

	x	y
Left Intersection	-1.6477	.3793
Right Intersection	1.5780	.7837
Lowest Y Values	.3514	.7837

x	y	x	y
-2.0000	.5389	.0000	.5176
-1.9500	.4114	.0500	.5233
-1.9000	.3730	.1000	.5291
-1.8500	.3551	.1500	.5351
-1.8000	.3515	.2000	.5412
-1.7500	.3553	.2500	.5474
-1.7000	.3642	.3000	.5538
-1.6500	.3785	.3500	.5603
-1.6000	.3823	.4000	.5669
-1.5500	.3855	.4500	.5737
-1.5000	.3887	.5000	.5807
-1.4500	.3920	.5500	.5878
-1.4000	.3954	.6000	.5951
-1.3500	.3988	.6500	.6026
-1.3000	.4022	.7000	.6102
-1.2500	.4057	.7500	.6181
-1.2000	.4093	.8000	.6261
-1.1500	.4129	.8500	.6344
-1.1000	.4166	.9000	.6428
-1.0500	.4204	.9500	.6515
-1.0000	.4242	1.0000	.6604
-.9500	.4281	1.0500	.6696
-.9000	.4321	1.1000	.6790
-.8500	.4361	1.1500	.6887
-.8000	.4402	1.2000	.6986
-.7500	.4444	1.2500	.7088
-.7000	.4487	1.3000	.7193
-.6500	.4530	1.3500	.7301
-.6000	.4574	1.4000	.7413
-.5500	.4619	1.4500	.7527
-.5000	.4665	1.5000	.7645
-.4500	.4712	1.5500	.7767
-.4000	.4759	1.6000	.7837
-.3500	.4808	1.6500	.7837
-.3000	.4857	1.7000	.7837
-.2500	.4908	1.7500	.7837
-.2000	.4959	1.8000	.7837
-.1500	.5012	1.8500	.7875
-.1000	.5065	1.9000	.8054
-.0500	.5120	1.9500	.8437
-.0000	.5176	2.0000	.9712

BH 3086
Sht. 1 of 2

CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
Modified Negative Lamination
Table of Coordinates

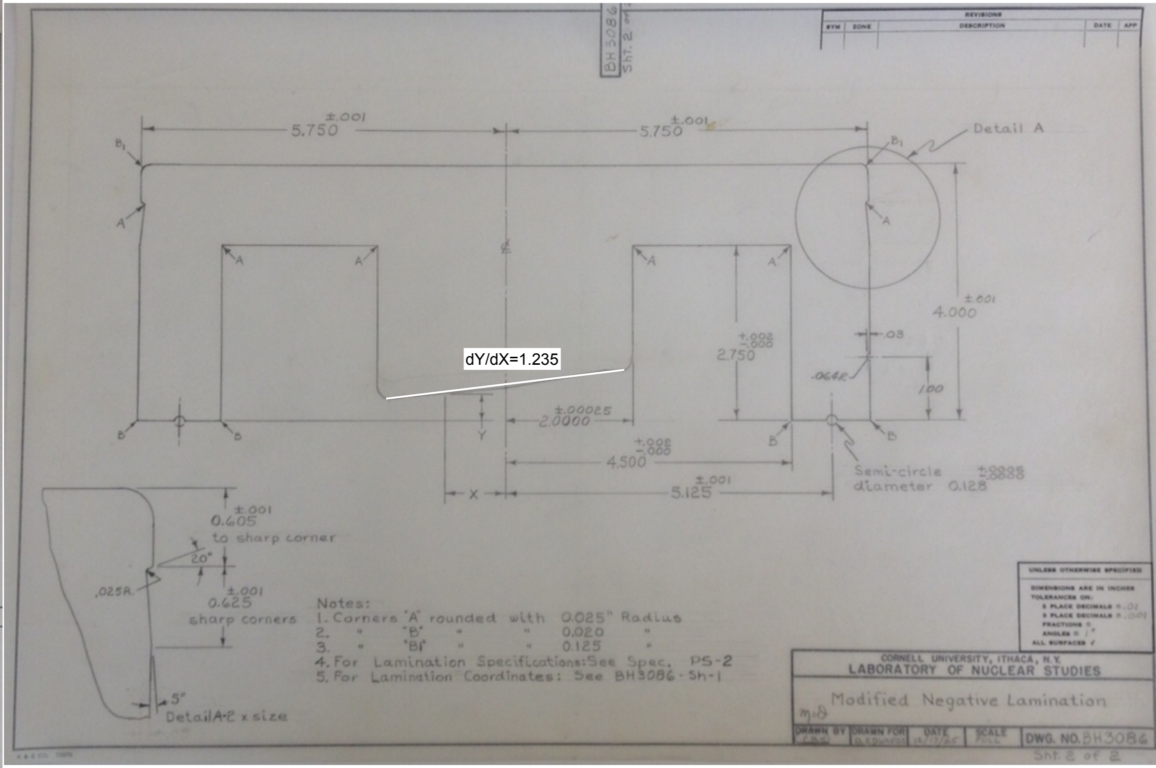
DWG. NO. BH3086
Sht. 1 of 2

dY/dX (-2 to 0 cm)
(.5176-.5389)/2.
= -0.01065

dY/dX (-1 to 0 cm)
(.5176-.4242)/1.
= .0934

dY/dX (0 to 1 cm)
(.6604-.5176)/1.
= .1428

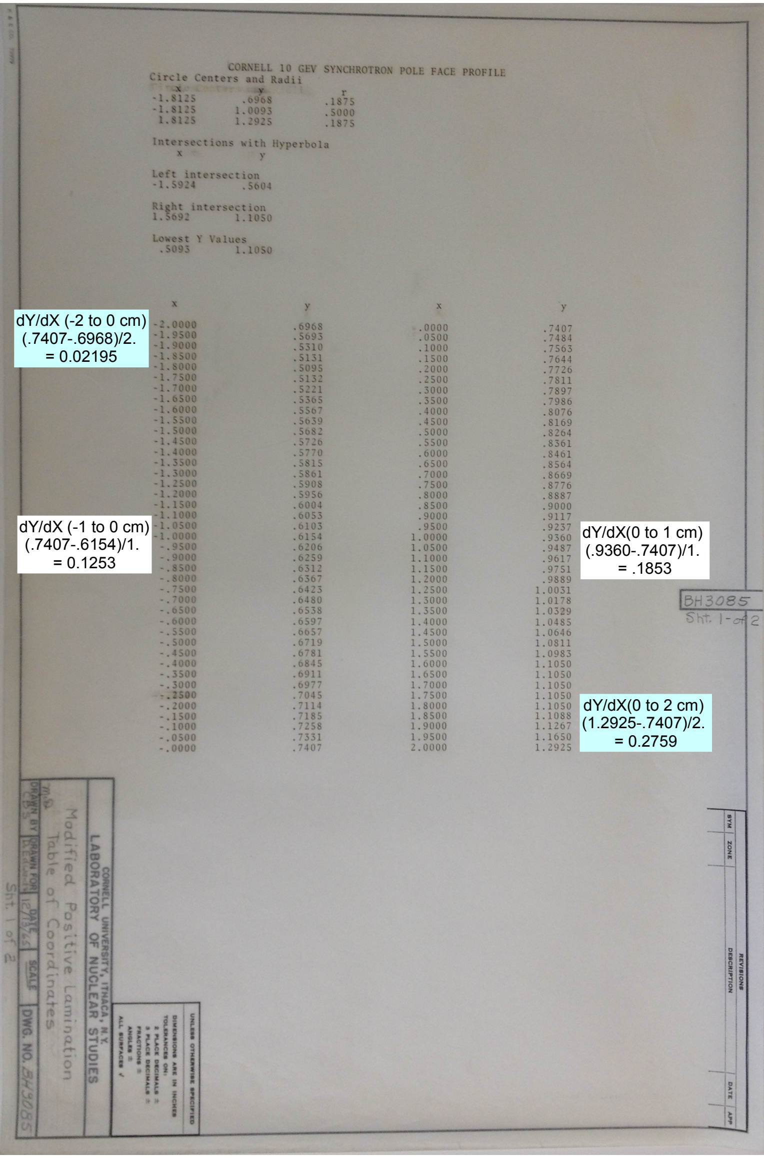
dY/dX(0 to 2 cm)
(9712-.5176)/2.
= 0.2268



CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967

Length: 134.98 in

BH3085 - Positive lamination
Wide gap (1.481 in), vertically focusing



CORNELL 10 GEV SYNCHROTRON POLE FACE PROFILE

Circle Centers and Radii

x	y	r
-1.8125	.6968	.1875
-1.8125	1.0093	.5000
1.8125	1.2925	.1875

Intersections with Hyperbola

	x	y
Left intersection	-1.5924	.5604
Right intersection	1.5692	1.1050
Lowest Y Values	.5093	1.1050

x	y	x	y
-2.0000	.6968	.0000	.7407
-1.9500	.5693	.0500	.7484
-1.9000	.5310	.1000	.7563
-1.8500	.5131	.1500	.7644
-1.8000	.5095	.2000	.7726
-1.7500	.5132	.2500	.7811
-1.7000	.5221	.3000	.7897
-1.6500	.5365	.3500	.7986
-1.6000	.5567	.4000	.8076
-1.5500	.5639	.4500	.8169
-1.5000	.5682	.5000	.8264
-1.4500	.5726	.5500	.8361
-1.4000	.5770	.6000	.8461
-1.3500	.5815	.6500	.8564
-1.3000	.5861	.7000	.8669
-1.2500	.5908	.7500	.8776
-1.2000	.5956	.8000	.8887
-1.1500	.6004	.8500	.9000
-1.1000	.6053	.9000	.9117
-1.0500	.6103	.9500	.9237
-1.0000	.6154	1.0000	.9360
-.9500	.6206	1.0500	.9487
-.9000	.6259	1.1000	.9617
-.8500	.6312	1.1500	.9751
-.8000	.6367	1.2000	.9889
-.7500	.6423	1.2500	1.0031
-.7000	.6480	1.3000	1.0178
-.6500	.6538	1.3500	1.0329
-.6000	.6597	1.4000	1.0485
-.5500	.6657	1.4500	1.0646
-.5000	.6719	1.5000	1.0811
-.4500	.6781	1.5500	1.0983
-.4000	.6845	1.6000	1.1050
-.3500	.6911	1.6500	1.1050
-.3000	.6977	1.7000	1.1050
-.2500	.7045	1.7500	1.1050
-.2000	.7114	1.8000	1.1050
-.1500	.7185	1.8500	1.1088
-.1000	.7258	1.9000	1.1267
-.0500	.7331	1.9500	1.1650
-.0000	.7407	2.0000	1.2925

BH3085
Sht. 1 of 2

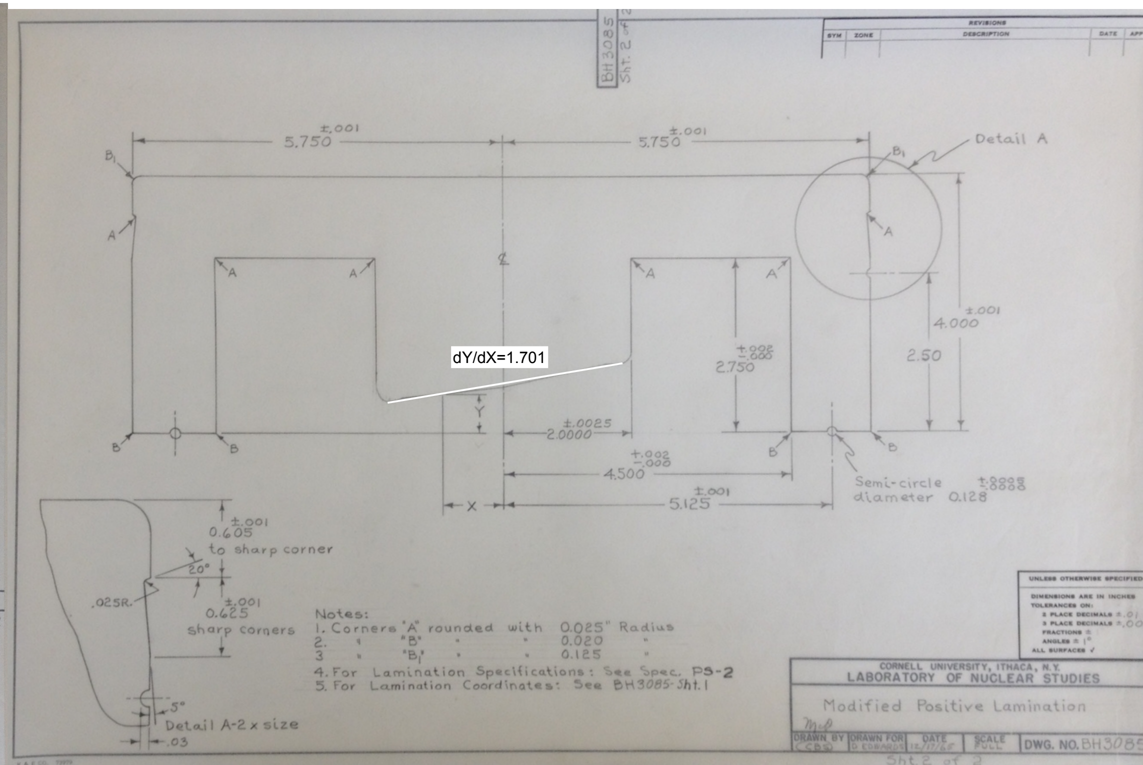
CORNELL UNIVERSITY, ITHACA, N.Y.
LABORATORY OF NUCLEAR STUDIES
Modified Positive Lamination Table of Coordinates
DWG. NO. BH3085
Sht. 1 of 2

dY/dX (-2 to 0 cm)
(.7407-.6968)/2.
= 0.02195

dY/dX (-1 to 0 cm)
(.7407-.6154)/1.
= 0.1253

dY/dX(0 to 1 cm)
(.9360-.7407)/1.
= .1853

dY/dX(0 to 2 cm)
(1.2925-.7407)/2.
= 0.2759

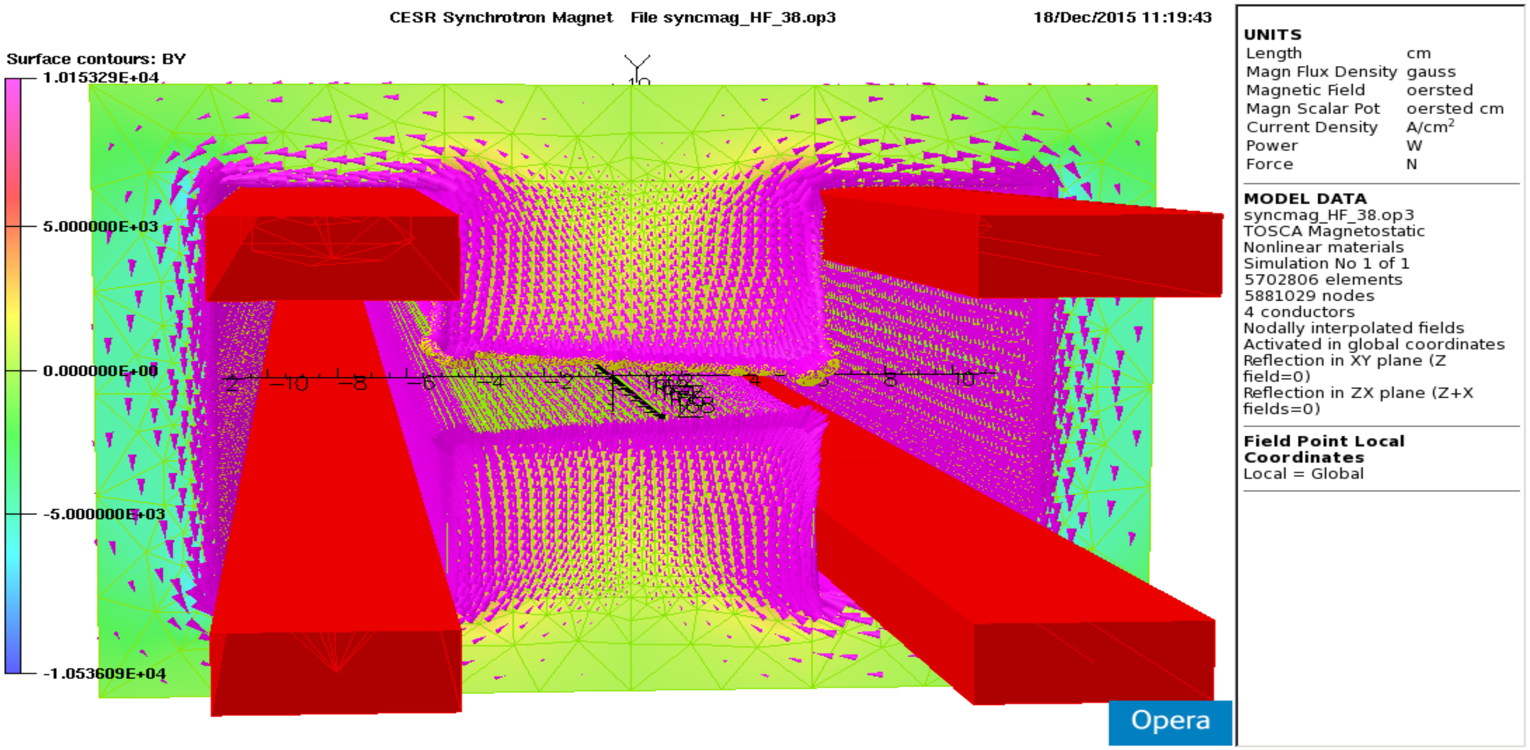


dY/dX=1.701

CS-33: The 10 to 20 GeV Cornell Electron Synchrotron
R.R. Wilson
1 May 1967

Length: 134.98 in

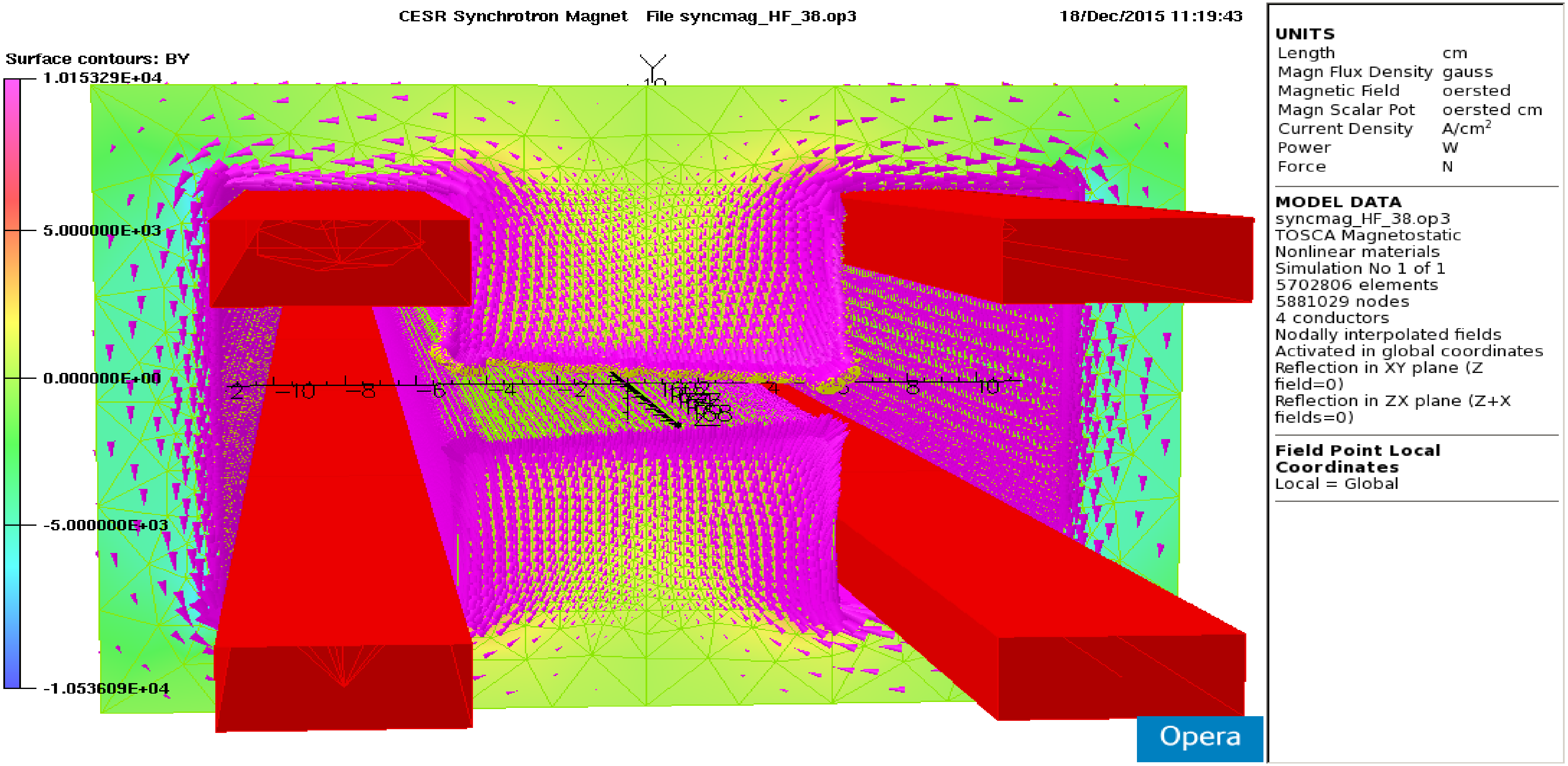
CESR Synchrotron Combined-Function Magnet Model



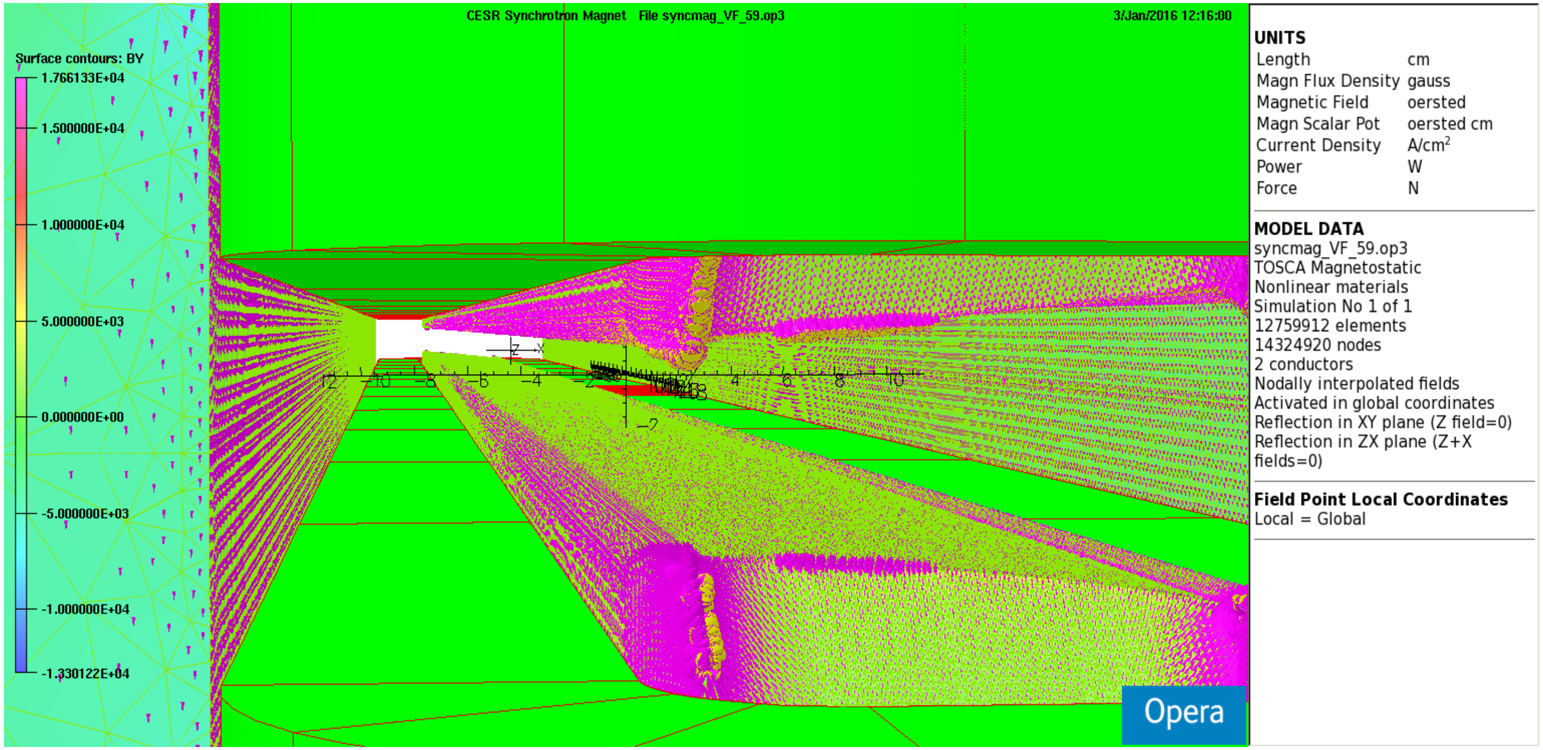
Jim Crittenden

3 January 2016

OPERA model


CESR Synchrotron Magnet File syncmag_HF_38.op3
18/Dec/2015 11:19:43
Surface contours: BY
1.015329E+04
5.000000E+03
0.000000E+00
-5.000000E+03
-1.053609E+04
Opera
UNITS
Length cm
Magn Flux Density gauss
Magnetic Field oersted
Magn Scalar Pot oersted cm
Current Density A/cm2
Power W
Force N
MODEL DATA
syncmag_HF_38.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
5702806 elements
5881029 nodes
4 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in ZX plane (Z+X fields=0)
Field Point Local Coordinates
Local = Global

CESR Synchrotron Combined-Function Magnet Model



Jim Crittenden

3 January 2016

Detailed comparisn of the measured and designed field gradient profiles

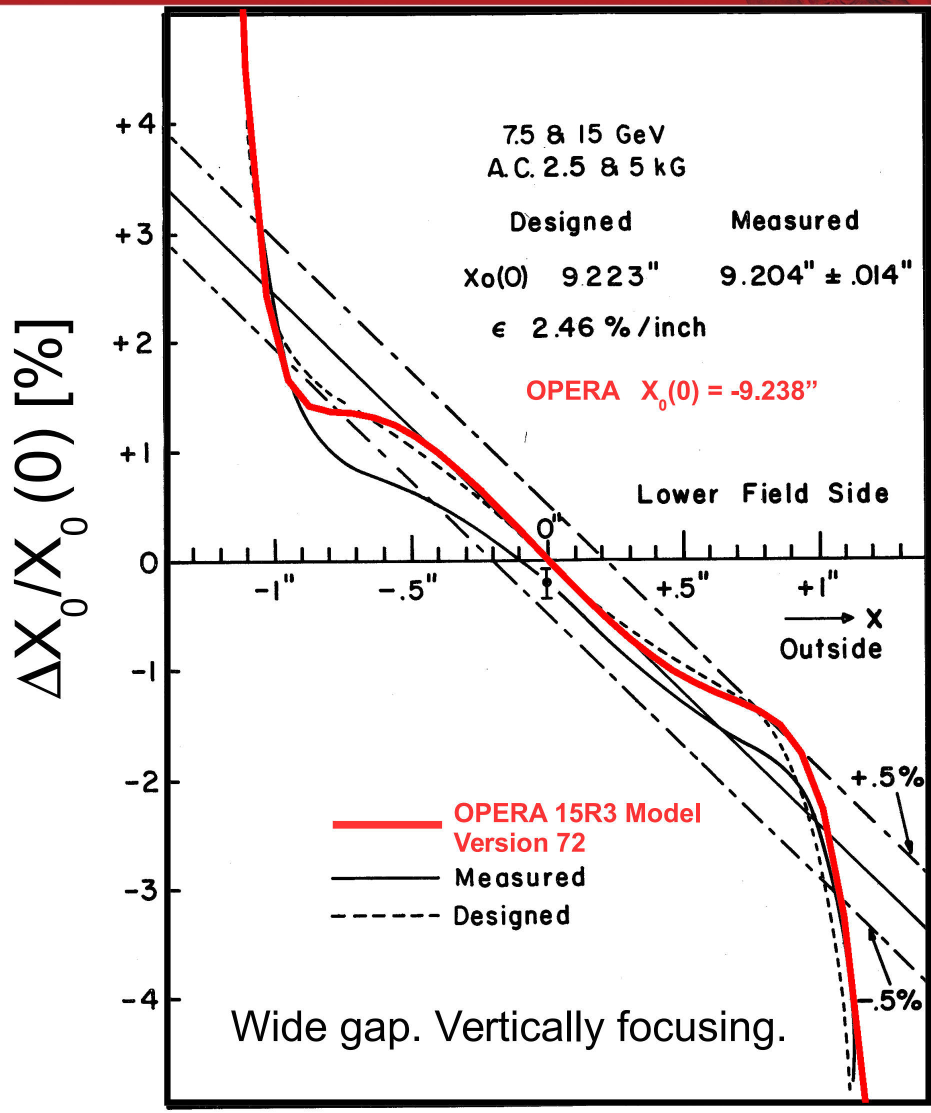


Fig. 7a. $X_0(X)$ Distribution of Wide Gap Magnet

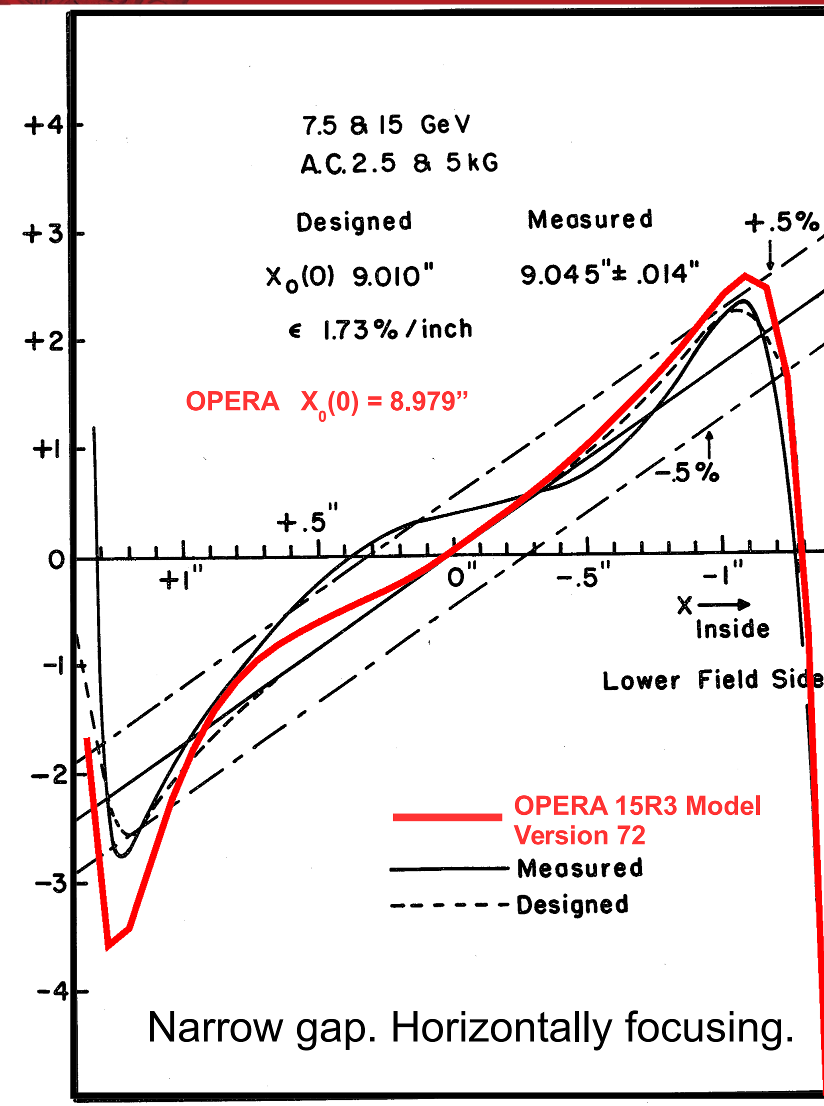


Fig. 7b. X (X) Distribution of Narrow Gap Magnet