Report of the Third and Final Meeting of the GEM Magnet Technical Panel

SSC Laboratory
Dallas, Texas
October 10-11, 1991

SUMMARY

The GEM Magnet Technical Panel convened three times to study issues related to the technical credibility of the GEM solenoidal magnet concept, the cost estimate, proposed schedule, and operational issues. The meetings were held on September 4-6, September 25-27, and October 10-11, 1991. Individual reports were written for each of the first two meetings. The third and final report of the Panel summarizes the findings of all three meetings. The charge to the Panel was to determine whether a baseline magnet concept consisting of a large superconducting solenoid, in either single or double coil version, is feasible and to estimate the cost, manpower requirement and schedule.

The Technical Panel considered four magnet design options: an unshielded single-coil solenoid, a single-coil solenoid shielded with a surface iron plate, a single-coil solenoid shielded with a barrel-shaped iron flux return, and a double-coil solenoid. All four of these options had iron poles.

In response to the charge, the panel finds:

1. Although all four of the options considered are technically feasible, the unshielded single-coil solenoid is the preferred magnet configuration for the GEM Detector. Should the field at the surface be unacceptable, surface shielding iron could be added as a backup, at an approximate cost of $5-10M.

2. The initial design, manufacturing, and operational concepts for the unshielded solenoid magnet conductor, coil, cryostat, and supports all appear to be feasible. The estimated cost of $95M, the required manpower, and the proposed schedule appear credible.

3. Relative to the unshielded single solenoid, cost for the iron barrel shielded system is a factor of 1.5-2 larger and the schedule impact is 3.5-6 months. The relative cost for the double solenoid is a factor of 2 larger and the schedule impact is 6-8 months. Design and manufacturing requirements and installation schedule are different for various options. The manpower requirements are reflected in the cost estimates.

4. The unshielded solenoid can be operated within all known regulations.

5. The permanent surface facilities for the unshielded solenoid concept can be substantially reduced in scale from the proposed initial concept; however, several less costly temporary structures are required. Either shielded concept requires additions to the surface facilities, especially the dual coil concept, which requires additional winding space.

6. A procurement strategy is currently not defined, and must be selected and implemented to avoid schedule delays. We recommend that early and intensive discussions between the SSCL and the Department of Energy be initiated.

7. Rapid commencement of conductor development is recommended to support the schedule requirements.

8. Magnetic forces on structural steel in the underground hall due to the unshielded magnet do not impose significant constraints on the conventional structural design.

Report of the Meeting

Introduction

The third meeting of the Panel was held to respond to the recommendations of the PAC and to deal with any loose ends left over from the previous meetings.

The Panel considered the cost and schedule impact of various shielded magnet configurations, since the PAC stated that the case for an unshielded magnet was not convincing. The impact of building a shielded magnet, with regard to cost and schedule, was made more quantitative so that a decision to proceed with any one of these options could be made on an informed basis. The Panel also heard from experts that passages exist in the Environmental Impact Statement that might inhibit the construction of an unshielded solenoid. This also prompted further study of shielded solenoid configurations.

An action item from the second meeting was to carry out calculations to determine the magnetic forces that might affect structural members in the detector hall. The Panel also felt that the above-ground testing requirements needed further explanation. These issues are also recorded in this report.

Double Versus Single Solenoid

An estimate was made of the cost increase for the double coil relative to the single coil solenoid. The three factors used to define the expected differences:

1. Stored Energy Ratio = (4.23 GJ/1.84 GJ) = 2.3
2. Amp Turn Ratio = (34.7 AT/10.7 AT) = 3.2
3. Coil Diameter Ratio = (11.9 M/8.9 M) = 1.3

For the items in Table 1 that are not thought to be related to these factors the cost increases shown in the table are based on engineering judgments made by a number of panel members.

In summary, the cost increase that results from choosing a double coil for shielding over a single unshielded coil is on the order of $100M.

Table 1
Cost Comparison Between
Single and Double Coil Versions

MAGNET SYSTEM	$Sgl	$Dbl/$Sgl	$Dbl
SUBSYSTEM DESIGN	11.7	1.8	21.0
COIL FORMS	7.0	2.2	15.4
CONDUCTOR	7.7	3.2	24.6
WINDING (INCL TOOLING)	12.0	3.0	36.0
THERMAL RADIATION SHIELDS	2.3	1.3	3.0
VACUUM VESSELS	8.2	1.3	10.6
COLD MASS SUPPORTS	7.4	3.2	24.0
COIL ASSEMBLY	6.4	2.0	12.8
POLES	11.1	1.8	20.0
POWER/PROTECTION SYSTEM	5.7	2.0	11.4
CRYOGENICS & VACUUM	11.2	1.1	12.3
INSTALLATION	2.1	2.0	4.2
MANAGEMENT/INTEGRATION	1.3	1.0	1.3
TOTALS	$94.1M		$196.6M

The panel identified two aspects of the double-coil concept that represent significant technological and schedule risk:

1. The two coils must be supported in such a way as to prevent mechanical instabilities due to the forces between them, however, this is not unlike problems arising between coil and poles or coil and shield in any design.

2. To adhere to the schedule, it may be necessary to increase the number of winding stations. Also, the internal and external coil sections may require different tooling. Therefore, a significant increase in building space may be required.

Iron Barrel Shielded System

The panel has compared the iron barrel shielded system with the unshielded single solenoid in respect to cost and schedule. Two different versions for the barrel shielded concept are considered: Version 1 limits the stray field at the surface to below 10 gauss, and Version 2 limits it to the minimum practical field, which is considered to be about 1.0 gauss. A distance of 50 m from the surface to the magnet center is assumed. The 10 gauss figure was chosen for the first case because it is considered the safe limit for fields in public areas, to which people with cardiac pacemakers may be exposed. An unshielded solenoid would result in approximately 40 gauss fields at 50 m.

Parameters of the two versions are shown in Appendix B, and the cost evaluation is given below:

- Version 1. (1.3 m thick barrel.)
  Cost of the extra 20 ktonnes of iron $55.5M

- Version 2. (2.0 m thick barrel)
  Cost of the extra 36 ktonnes of iron $99.0M

The version 1 concept with the addition of some surface shielding may be an alternative to version 2, if the field has to be reduced to the 1.0 gauss level.

The addition of the extra iron will lengthen the schedule relative to that of the unshielded single-coil solenoid. The overall estimated difference is 3.5 months, assuming that only large pieces of steel

are handled. If this assumption is incorrect, the overall difference could be as much as 6 months.

It may be possible to reduce the schedule increase by adding another construction shaft in the underground hall and carrying out parallel installations. This solution would have an extra cost impact on the experimental facilities

It should be noted that iron shielding may eliminate the possibility of increasing the resolution of the detector by adding muon chambers around the exterior of the magnet barrel in a future upgrade, as the collaboration has proposed.

Iron Shielding and the Impact on Hall Parameters

Magnetic shielding for the GEM solenoid may affect the hall parameters for the GEM detector. The shielding will increase the magnet diameter by about 2.6-4.0 m, and will add about 23 to 37 kilotonnes to the weight of the magnet.

The increase in magnet diameter may not necessitate a change in the width of the hall. The hall width is nearly the same as for the full-scale L* detector with iron shielding; therefore, in principle, a fully shielded GEM solenoid should be able to fit into the same hall. However, the Collaboration will lose space in the area next to the solenoid, where it has contemplated installing electronics rooms.

The construction schedule proposed for the iron barrel shielded solenoid assumes two access shafts, which would increase the complexity of the hall design.

Forces on Magnetizable Objects and Structures Within the Hall

Small objects and sections of larger objects that are made of magnetically permeable material, and located in the vicinity of the detector, can experience a torque and net force due to the interaction with the field and its local gradient. The forces vary from 0.1 to about 2.5 g at distances corresponding to crane, crane rail, and rock bolt locations. For installed structural components, these forces are likely to be a small portion of the total load-carrying requirements for such elements.

The elevation view in Figure 1 shows contours of constant body force density (in units of g) for small objects. The location of the solenoid, pole, and crane rail, and the outline of the hall are indicated. Most of the hall volume has contour values below 1g.

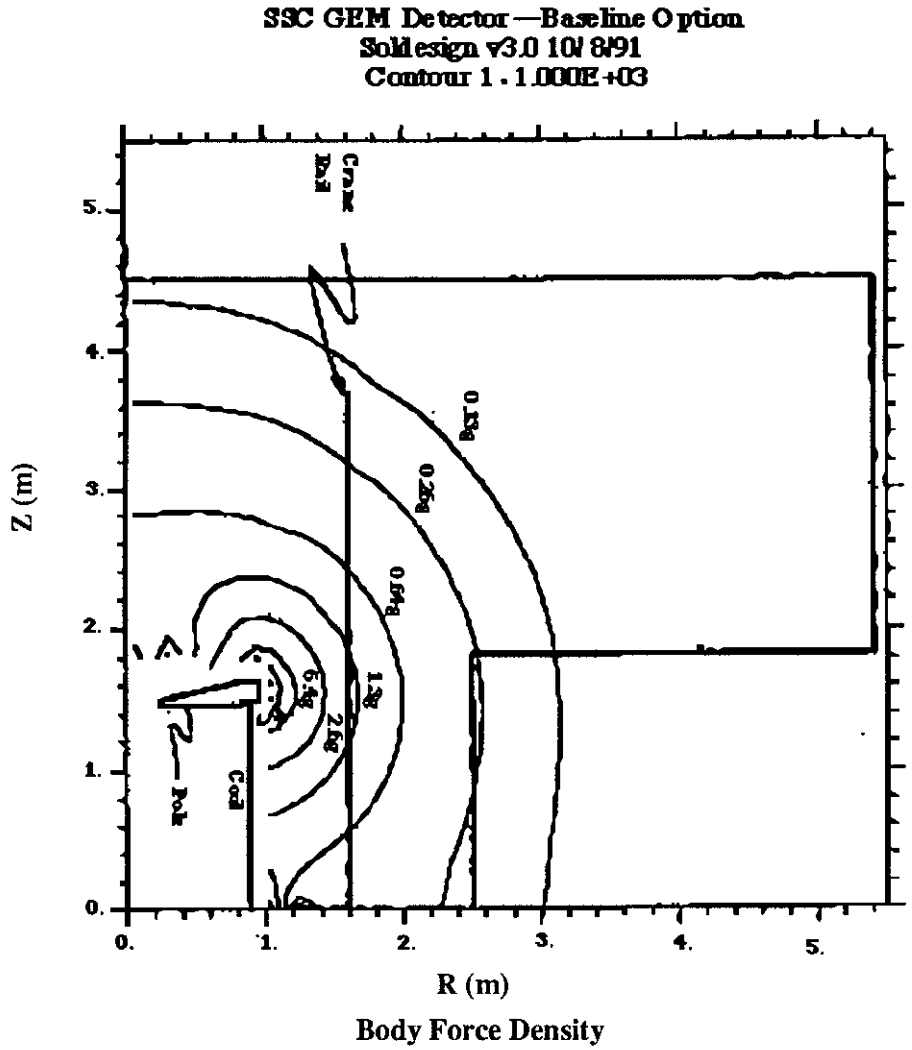

Figure 1 Contours of Constant Body Force Density Expressed in g's

Local force directions are illustrated in Figure 2. Forces on objects are generally oriented toward the poles. The forces can approach 10-20 g close to the poles, but they decrease rapidly with distance. At about 5 m from the poles, they decrease to about 1g. Control of magnetizable objects near the poles and throughout significant segments of the hall volume is essential, but this is viewed as a tractable problem from the standpoint of design and operational procedure.

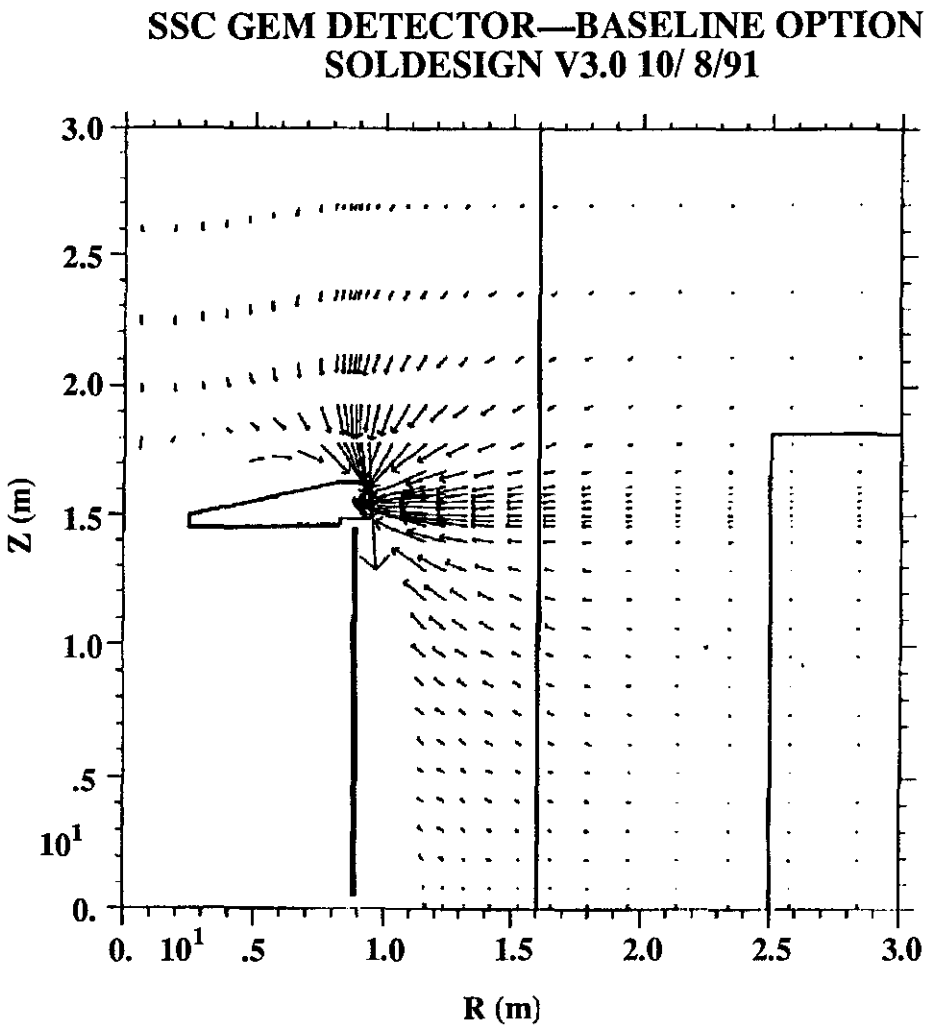

Figure 2 Local Force Directions

Forces on the crane will be toward the poles, hence the crane will tend to be pulled along the rail toward the nearest pole regardless of its location. There is an unstable null force point at the midplane of the magnet and two stable null points, one over each pole.

For shielded magnet systems, forces on objects will be reduced by about a factor of 20 for comparable locations relative to the magnet. However, large local forces will exist near regions of high field gradients (e.g. near gaps and openings in the shield).

Further estimates of the effects of residual magnetization and attraction between nearby magnetized objects will be done, but are not likely to impact the system conceptual design.

Final Environmental Impact Statement

At the third meeting, the Panel was made aware that at hearings about the Final Environmental Impact Statement (FEIS), the SSCL stated that there will be no measurable magnetic fields at the surface of the Laboratory. Nevertheless, the Woolley Report contains extensive research into the existence of any regulations that might prohibit running the GEM magnet in an unshielded mode, and this research has uncovered no regulation that prohibits such operation. Consequently, the Panel reiterated its previous position that the unshielded single-coil solenoid is the best option.

As mentioned in the report of the first meeting of the Panel, surface shielding may be feasible with a minimum impact on cost and schedule. For example, a reinforced concrete pad of about 160 x 200m, carrying the equivalent of about 12 cm of solid steel in the central region, tapering toward the edges, could reduce the surface field to the 10 gauss level. The pad would cost about $5-10 million.

Above-Ground Magnet Testing

As stated in the first report, the panel does not recommend testing the completed magnet halves above ground with current. The cost and time associated with providing all the necessary services for full testing with current would be large, and the stresses this would place on the coils would be significantly different from the actual operational loads. This testing can best be performed in place in the experimental hall.

The panel recommends that above-ground cold leak testing be performed. The following aspects should be considered when deciding whether such testing will be advantageous:

a. Verification testing of the components and assemblies within the magnets will be required to eliminate defects before final assembly of the magnet halves. Since problems will be very difficult to repair after the closure of the vacuum vessel, every effort should be made to test components individually before assembly. A "progressive" testing program, in which components are tested at each level of assembly, is the best way to minimize the probability of defects in the final assembly.

b. The key element in deciding on above-ground testing should be a detailed consideration of possible failure modes and consequences. In addition, as potential failure modes are identified, access to the more likely failure points should be included in the design.

c. The objective of the above-ground tests of the magnet halves will be to identify and repair any cryogenic problems, insulation problems, or cold leaks that occur during final assembly, or which were not identified during earlier assembly/testing stages.

d. Following assembly of the coils into the vacuum vessels, three types of tests should be considered, in the following order, as

funds, time, and risk dictate: i) pressurize the cryogenics passages, and test for leaks (with or without evacuating the vessels); ii) cool the cold mass to LN temperature and leak check again; and finally, iii) cool the cold mass to operating temperature and leak check again.

e. Above-ground cold testing may be costly, in terms of both time and effort required. Unique components, which must be designed, fabricated, and installed, may be required just for testing. In addition, there is some small technical risk associated with performing the tests.

f. In evaluating the benefits of the proposed testing, the panel noted examples of both: i) cases where such testing did not prevent later difficult internal problems, and ii) cases where problems were found and corrected during such testing and then later operation was relatively trouble-free.

Additional Appendices

Appendix C contains additional material given to the Panel on the cost of shielding electrical components in the detector hall. In Appendix D, John Stekly provides additional material on operations related to safety in magnetic fields, and further data on MRI installations.

Conclusions

The Panel's final conclusions are given in the Summary at the beginning of this report. Over the course of the three meetings, the Panel made progress in several areas including conductor design, the manufacturing process, the facility requirements for the construction of the solenoid, and the procurement process. A great deal remains to be done, and it is clear that the GEM collaboration has a big job ahead.

Appendix A

Panel Members and Participants

GEM Magnet Review Panel Members and Participants

September 3-4, 1991
September 25-27, 1991
October 25-27, 1991

Members

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Mike Harris, SSC Laboratory
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Darrell Langlinais, Chicago Bridge & Iron, Inc.
Bob Schwendman, Pitt-Des Moines, Inc.

Appendix B

Spreadsheets for the Iron Barrel

Table B1
Spreadsheet for 1.3 Meter Iron Shield

250	Rhole		cm	Radius of hole in door
8.30	Recran		m	Internal free radius
8.90	Rwindin		m	Mean radius of winding
29.00	Dpole		m	Internal free length
.80	B		T	Magnetic induction
130	Spcond		cm	Space for coil from screen to barrel
2.37	BsatPol		T	Induction in pole
	BsatMan	2.37	T	Induction in barrel

3.65	PriceIP		$/kg	Price of iron for pole fully erected
2.57	PriceIB		$/kg	Price of iron for barrel fully erected
	Price_B	48.89	M$	Price of Barrel fully erected
	Price_P	12.32	M$	Price of one Pole fully erected
	Price_T	73.54	M$	Total price of iron fully erected

	W_I_T	25776	t	Optimized weight of iron
	W_B	19025	t	Weight of barrel
	W_Door	1533	t	Weight of mobile part
	W_Cro	1842	t	Weight of one crown
	W_P	3376	t	Weight of one pole
	Rinman	9.60	m	Internal radius of barrel
	Rexman	10.90	m	Outside radius of barrel
	Dextpol	32.15	m	External length of magnet
130.00	T_B		cm	Thickness of barrel
	T_door1	44.30	cm	Thickness of door near hole
	T_door2	147.09	cm	Thickness of door near free aperture
	T_P	157.72	cm	Thickness of pole at Rwinding
	T_P_Bxt	122.09	cm	Thickness of pole on barrel outside di
	H	636620	Oe	Magnetic field
	At	19.94	MAt	Needed ampere-turns
	Flux	199.08	Wb	Flux
	Sman	88.31	m^2	Cross section of barrel
	IronSpC	7.43	t/m^3	Specific mass of iron with packing
	tpsn	.41421356	-	Tangente(pi/N)
8	N		-	Number of sides of barrel
1.05	FoisIro		-	Packing factor for iron
7.80	IronSp		t/m^3	Specific mass of iron
1.08	FactAt		-	Factor for ampere-turns
	Energy	1.84	GJ	Stored energy
	μ0	1.2566E-6	A/m	Vacuum permeability
50000.00	Current		A	Current
	Induct	1.47	H	Coil inductance
	Nturn	398.78	-	Number of turns

Table B2
Spreadsheet for 2.0 Meter Iron Shield

250	Rhole		cm	Radius of hole in door
8.30	Recran		m	Internal free radius
8.90	Rwindin		m	Mean radius of winding
29.00	Dpole		m	Internal free length
.80	B		T	Magnetic induction
130	Spcond		cm	Space for coil from thermal screen to barrel
	BsatPol	1.87	T	Induction in pole
	BsatMan	1.49	T	Induction in barrel

3.65	PriceIP		$/kg	Price of iron for pole fully erected
2.57	PriceIB		$/kg	Price of iron for barrel fully erected
	Price_B	77.79	M$	Price of Barrel fully erected
	Price_P	17.84	M$	Price of one Pole fully erected
	Price_T	113.48	M$	Total price of iron fully erected

	W_I_T	40046	t	Optimized weight of iron
	W_B	30268	t	Weight of barrel
	W_Door	1944	t	Weight of mobile part
	W_Cro	2945	t	Weight of one crown
	W_P	4889	t	Weight of one pole
	Rinman	9.60	m	Internal radius of barrel
	Rexman	11.60	m	Outside radius of barrel
	Dextpol	33.00	m	External length of magnet
200.00	T_B		cm	Thickness of barrel
	T_door1	56.18	cm	Thickness of door near hole
	T_door2	186.52	cm	Thickness of door near free aperture
200.00	T_P		cm	Thickness of pole at Rwinding
	T_P_Bxt	145.48	cm	Thickness of pole on barrel outside diameter
	H	636620	Oe	Magnetic field
	At	19.94	MAt	Needed ampere-turns
	Flux	199.08	Wb	Flux
	Sman	140.50	m^2	Cross section of barrel
	IronSpC	7.43	t/m^3	Specific mass of iron with packing
	tpsn	.41421356	-	Tangente(pi/N)
8	N		-	Number of sides of barrel
1.05	FoisIro		-	Packing factor for iron
7.80	IronSp		t/m^3	Specific mass of iron
1.08	FactAt		-	Factor for ampere-turns
	Energy	1.84	GJ	Stored energy
	μ0	1.2566E-6	A/m	Vacuum permeability
50000.00	Current		A	Current
	Induct	1.47	H	Coil inductance
	Nturn	398.78	-	Number of turns

Appendix C

Costs Associated with Shielding the Electrical Components

For the electrical components in the detector hall, Warren Kampmeier made a study of the costs associated with dealing with the stray magnetic fields. The SDC hall was used as a model, because more is known about the electrical equipment required for that detector. A field distribution comparable to the GEM unshielded solenoid was assumed. Two methods for dealing with the stray fields were developed: Electrical devices could either be shielded, or oversized to compensate for saturation losses. Of the two, the latter is probably the least expensive, the former is a better solution.

The enclosed spreadsheet assumes that either one or the other method is used for each device depending on cost and effectiveness. For switch-gear and panel boards, the breaker sizes were increased by 20%. The use of larger breakers requires an increase in wire size, thereby leading to an increase in wire cost. Transformers were priced to incorporate special core construction (cast iron) and shielding. Motors in the larger sizes were increased in Hp ratings, and in the smaller sizes double shielded enclosures were added. For lighting fixtures, an added cost was included for remote mounting of high energy discharge lamp ballast transformers.

As shown in the spreadsheet, for a hall comparable to the SDC hall, the stray field would lead to an increase of about $55K for electrical equipment.

POWER DISTRIBUTION ELECTRICAL DEVICE TAKEOFF-Material Only						
Magneticaly Operated Equipment- SDC Hall Area						
Quant	Description	Base Price	Cost	Spcl Price	Cost	Remarks
60Hz in	input conv					
5	75KVA Trans	1675	8375	2300	11500	
5	200A 208V panels	1440	7200	1440	7200	
2	200A 480V panels	1793	3586	1793	3586	
2	400A 480V panels	1800	3600	1800	3600	6 CBs inc typ
35000	wire			0.06	2100	
2	100Hp motors	3670	7340	4950	9900	
10	25Hp motors	875	8750	956	9560	
Emergency System						
1	200A 208panel	1440	1440	1440	1440	
1	75KVA trans	1675	1675	2300	2300	
1	400A 480V panels	1800	1800	1800	1800	
15000	wire			0.06	900	
Lighting						
1	200A 208panel	1440	1440	1440	1440	
1	75KVA trans	1675	1675	2300	2300	
20	Fixtures Hi Bay	403	8060	903	18060	
20	Fixtures Flour	70	1400	235	4700	
15	Exit	130	1950	340	5100	
HVAC						
3	25 Hp motors	875	2625	956	2868	
1	10Hp butane	363	363	518	518	
22000	wire			0.06	1320	
Special Electronics						
3	400A 480V panels	1800	5400	1800	5400	
9	75KVA Trans	1675	15075	2300	20700	
9	200A 208V panels	1440	12960	1440	12960	
17000	wire			0.06	1020	
Clean Electronics						
3	400A 480V panels	1800	5400	1800	5400	
9	75KVA Trans	1675	15075	2300	20700	
9	200A 208V panels	730	6570	1440	12960	
17000	wire			0.06	1020	
Jacking						
1	Motor Contrl Cntr	9025	9025	9800	9800	
4	100Hp motors	3670	14680	4950	19800	
10000	wire			0.06	600	
	Totals		145464		200552	
	Difference	55088				

Appendix D

Data Provided by John Stekly

FAX: 214 - 708-0006

10/8/91

To: Ray Stefanski

Superconducting Super Collider

As we discussed, I am sending you the following:

1. Two pages from IGC instructions relating to magnetic field sensitivity of 33 items likely to be encountered in MRI installations.

2. Additional pages relating to safety of operation in a magnetic field.

3. A tabular estimate of radial and axial distances to various external field levels for the GEM unshielded magnet. These are "far field" estimates and becomes less accurate closer to the magnet.

4. A tabular estimate of the radial and axial distances to various levels of magnetic force to weight ratios - as expected there does not appear to be any regions of high magnetic g forces in the "far field" external to magnet. Hazards due to forces between two or more magnetized ferromagnetic masses can still be a problem.

5. An estimate of the minimum weight of iron necessary to shield the GEM magnet - either as a plate on the surface, or as a return path cylinder surrounding the windings.

   This appears to agree with the MIT 3D finite element calculations.

   Magnitudes of external fields with shielding in either flat or cylinder configuration depend strongly on the B H curve. At 1.5T or below, choice of material is important [μ can range from 4000 to 200 with attendant variation of external field].

Z J J Stekly

Table V-1 Maximum magnetic induction (B-field in Gauss) expected for acceptable operation of sensitive devices. 1 gauss = 0.1 mT

Device	Informational Source (See Reference List)								Recommended (Best Estimate) Maximum Field
	#1	#2	#3	#4	#5	#6	#7	#8	
1) Scintillation Camera	1	1	1	1.5	-	1	0.5	2	1
2) Rotating ECAT	0.6	-	0.6	-	-	-	-	-	0.6
3) CT Scanner Utilizing PMT's	1-2	1	-	1.5		1	0.5	2	1
4) CT Scanner Non PMT	-	-	-	-	-	1	-	-	5
5) Shielded PMT's	10	10	-	-	-	-	-	-	10
6) Cyclotron	1	-	1	-	-	-	-	-	1
7) Image Intensifier	1	1	1	-	-	1	0.5	2	1
8) Electron Microscope	1	-	-	-	-	-	0.01	-	1
9) LINAC	-	-	-	-	-	-	-	1	1
10) Ultrasound	3	-	-	-	-	-	-	-	3
11) Analytical Balance	-	-	-	-	-	-	-	-	2
12) Color TV	1.5	-	-	-	-	-	-	-	1.5
13) EEG	-	-	-	-	-	-	-	-	1*
14) Mass Spect	1	-	-	-	-	-	-	-	1
15) Video Camera - Unshielded	3	10	10	2	-	10	-	5	3
16) Video Camera - Steel Case	10	10	-	-	-	-	-	-	10
17) B&W Monitor - Non-Critical	10-20	-	-	-	-	-	-	-	15
18) Cardiac Pacemaker	5-15	5	3	10	5	5	5	15	5-15

* More sensitive to changing field (gradient fields) than B_o.

(Continued)

Table V-1 Maximum magnetic induction (B-field in gauss) expected for acceptable operation of sensitive devices

Device	Informational Source (See Reference List)								Recommended (Best Estimate) Maximum Field	
	#1	#2	#3	#4	#5	#6	#7	#8		
19) ECG	-	-	-	-	-	-	-	-	- *	
20) Neuro-Stimulator	-	-	-	-	-	-	-	-	5	
21) Mechanical Watches	10	-	-	10	-	30	-	15	10	X
22) High Density Magnetic Storage	1-10	10	10	5	-	10	5	15	5	X
23) Magnetic Credit Cards	10-200	20	-	10	-	30	-	15	20	
24) Disc & Tape Drives	-	-	-	-	-	10	-	15	10	X
25) Computers	1-10	-	-	5	-	10	-	-	10	X
26) X-ray Tube	10	-	-	-	-	-	-	-	10	
27) Operator Console	-	-	<50	-	-	-	-	-	15	
28) MRI Power Supplies, etc.	-	-	-	-	-	-	-	-	-	
29) Resucusitation Equipment	-	-	-	-	-	-	-	-	-	
30) Hearing Aids	-	-	-	10	-	-	-	-	10	
31) Electric Motors	-	-	-	10	-	30	-	-	20	
32) Photographic Equipment	-	-	-	-	-	30	-	-	30	
33) Metal Detector	-	-	-	-	-	-	-	-	-	

* More sensitive to changing field (gradient fields) than B_o.

SAFETY

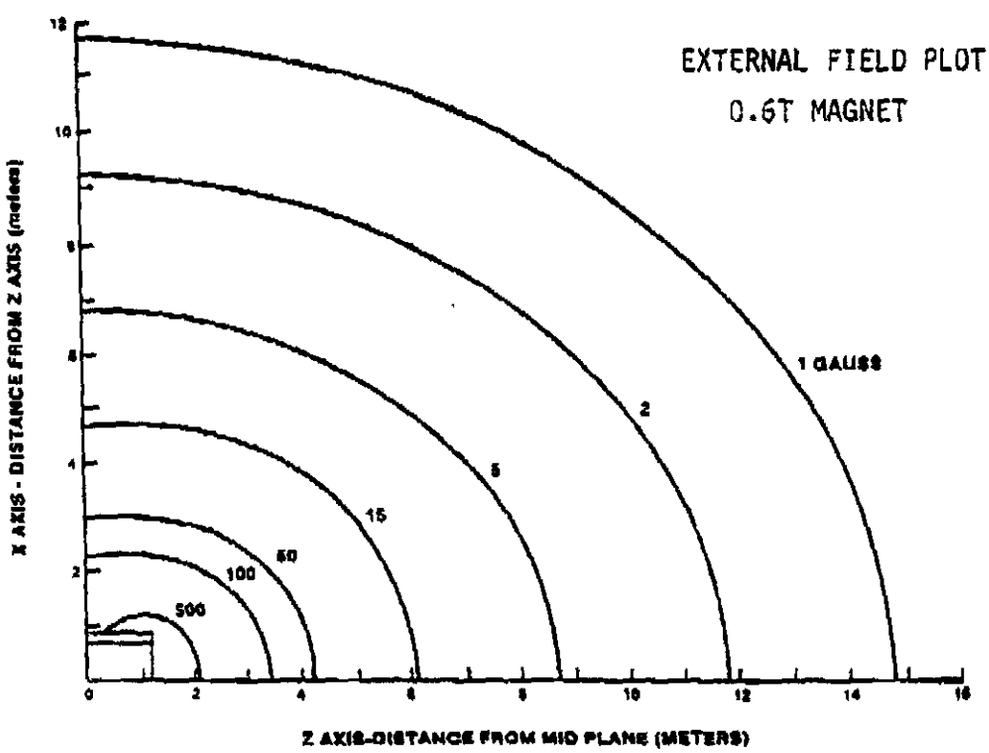
- HIGH VOLTAGE PROTECTION

The fundamental hazard to be avoided in the use of this system is a high voltage. Although redundant protection schemes are used in this system, correct operating procedures should be observed. To ensure absolute safety, electrician quality rubber gloves should be worn when handling main coil current leads, even though protection within the magnet has been provided.

- MAGNETIC FORCE/FIELD EFFECTS

The magnetic field beyond the cryostat is extremely strong. The field will attract ferrous objects toward the magnet with a force proportional to the mass of the object. Moreover, objects brought to within 1 g acceleration line become "missiles", attracted to the center of the magnet with a force that increases as the magnet isocenter is approached.

Proper labeling and positioning of equipment, as well as safe personnel practices, must be maintained at all times. The diagram below illustrates the external magnetic field distribution (Gauss) as a function of distance from the magnet isocenter.



A910952

DISTANCE TO VARIOUS VALUES OF

EXTERNAL FIELD

UNSHIELDED

FIELD G	AXIAL DISTANCE m	RADIAL DISTANCE m
200	34.5	27.4
100	43.5	34.6
50	54.9	43.6
20	74.5	59.1
10	93.9	74.5
5	118	93.9
2	160	127
1	202	160

SAFETY

IGC recommends that all operating personnel be thoroughly trained in safe practices, particularly related to metal objects near the magnet.

NOTE: The IGC Magnet System is provided with an emergency field dump system. This system should always be connected and readily available to assure rapid de-energization of the magnet in case of emergency.

The warning notices below summarize the major safety considerations which must be observed on site.

WARNING

ASPHYXIANT/EXTREME COLD/STRONG MAGNETIC FIELD

NITROGEN (N_2) AND HELIUM (He) PRESENT IN LIQUID AND GASEOUS FORM

POWERFUL MAGNETIC FIELD PRESENT

PERSONS WEARING ELECTRONIC MEDICAL DEVICES SHOULD

STAY CLEAR OF AREA

NITROGEN OR HELIUM GAS reduces oxygen available for breathing in confined, poorly-ventilated areas.

Nitrogen and helium are inert, odorless, colorless, and tasteless gases.

MAY CAUSE UNCONSCIOUSNESS OR DEATH WITHOUT WARNING !

LIQUID NITROGEN OR LIQUID HELIUM is extremely cold and the liquid or cold gas from the liquid can cause severe frostbite to the eyes and skin. Do not touch frosted pipes or valves.

STRONG MAGNETIC FIELD HAZARD magnetic objects such as iron tools, parts, and tanks may be pulled toward magnet by strong magnetic field present. Injury to personnel and damage to equipment may result. Keep all magnetic material more than 20 feet away. Personal electronic medical devices may be affected by strong magnetic field.

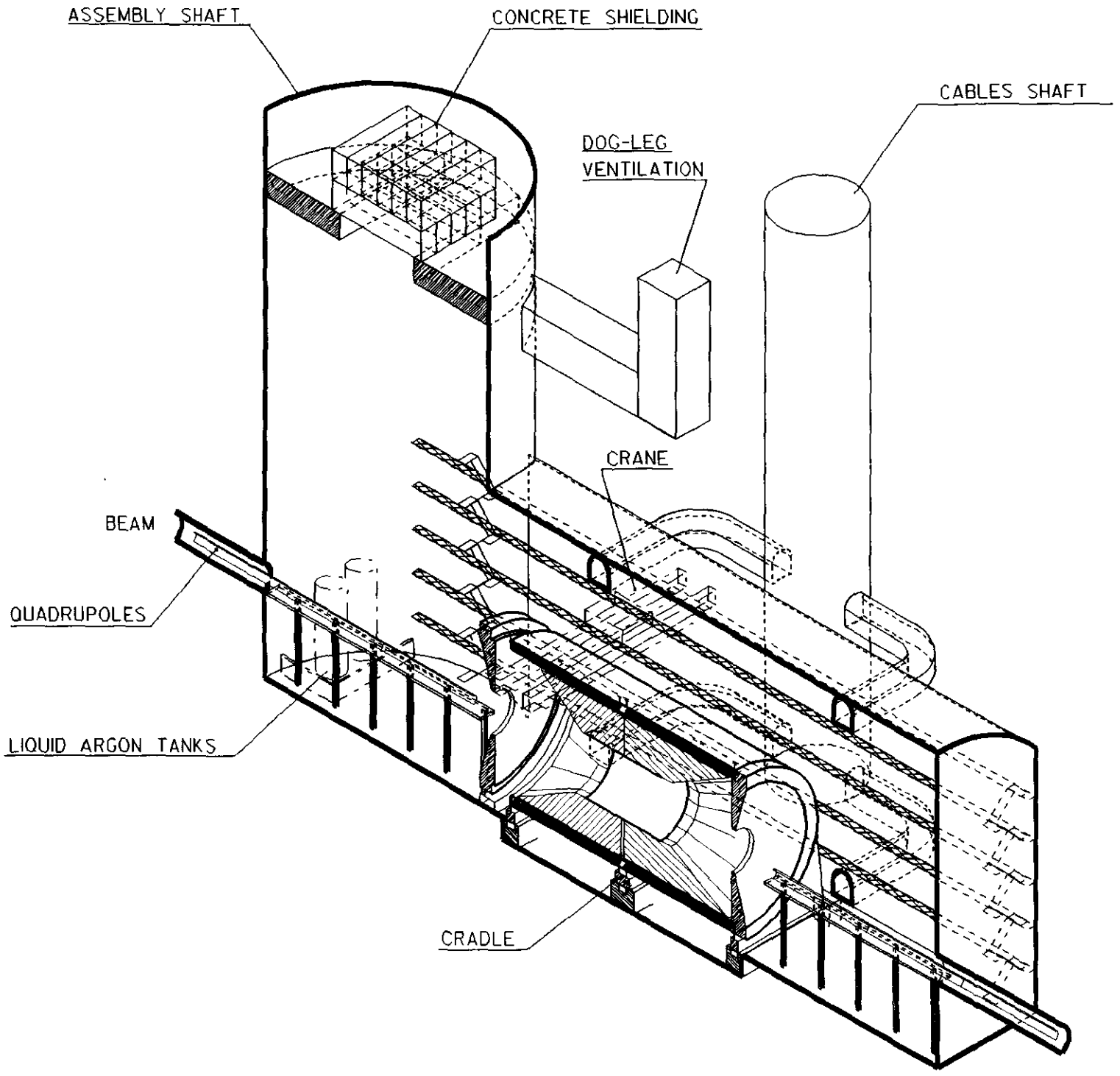
DISTANCE TO VARIOUS LEVEL OF "g": $\frac{\text{MAGNETIC FORCE}}{\text{WEIGHT}}$

MAGNETIC FORCE IS PROPORTIONAL TO WEIGHT
OF FERROMAGNETIC MATERIAL

MAGNETIC "g" DIRECTED TOWARD MAGNET CENTER	AXIAL DISTANCE (m)	RADIAL DISTANCE (m)
.01	47.4	39.9
.02	39.9	33.5
.05	31.7	26.7
.1	26.7	22.4
.2	22.4	18.9
.5	17.8	15

WEIGHT OF AXIALLY MAGNETIZED IRON
NECESSARY FOR EFFECTIVE SHIELDING
- SIDE PLATE, OR
- AXIAL CYLINDER

FIELD IN IRON (T)	WEIGHT K (kg)
2T	20,400
1.5T	27,200
1.0T	40,800


ASSEMBLY SHAFT
CONCRETE SHIELDING
CABLES SHAFT
DOG-LEG
VENTILATION
CRANE
BEAM
QUADRUPOLES
LIQUID ARGON TANKS
CRADLE

Forces on Magnetizable Objects & Structures Within the Hall

Small objects and sections of larger objects that are made of magnetically permeable material and located in the vicinity of the detector, can experience a torque and a net force due to the interaction with the field and its local gradient. The forces vary from about 0.1 to about 2.5 g's at distances corresponding to crane, crane rail, and rock bolt locations. For installed structural components, these forces are likely to be a small portion of the total load carrying requirements for such elements.

Figure 1 shows contours of constant body force density for small objects and is expressed in number of g's. This is an elevation view and the location of the solenoid, pole, crane rail, and outline of the hall are indicated. The vast majority of the hall volume has contour values below 1g.

Forces on objects are generally oriented toward the poles and local force directions are illustrated in Figure 2. In close proximity to the poles the forces can approach 10-20 g's, but decrease rapidly with distance. At about 5m away from the poles, they decrease to about 1g. Control of magnetizable objects near the poles and throughout significant segments of the hall volume is essential, but this is viewed as a tractable problem from the standpoint of design and operational procedure.

Forces on the crane will be toward the poles, hence the crane will tend to be pulled along the rail toward the nearest pole regardless of its location. There is an unstable null force point at the midplane of the magnet and two stable null points, one over each pole.

For shielded magnet systems, forces on objects will be reduced by about a factor of 20 for comparable locations relative to the magnet. However, large local forces will exist near regions of high field gradients (eg- near gaps and openings in the shield).

Further estimates involving effects of residual magnetization and attraction between nearby magnetized objects are to be done, but are not likely to impact the system conceptual design.

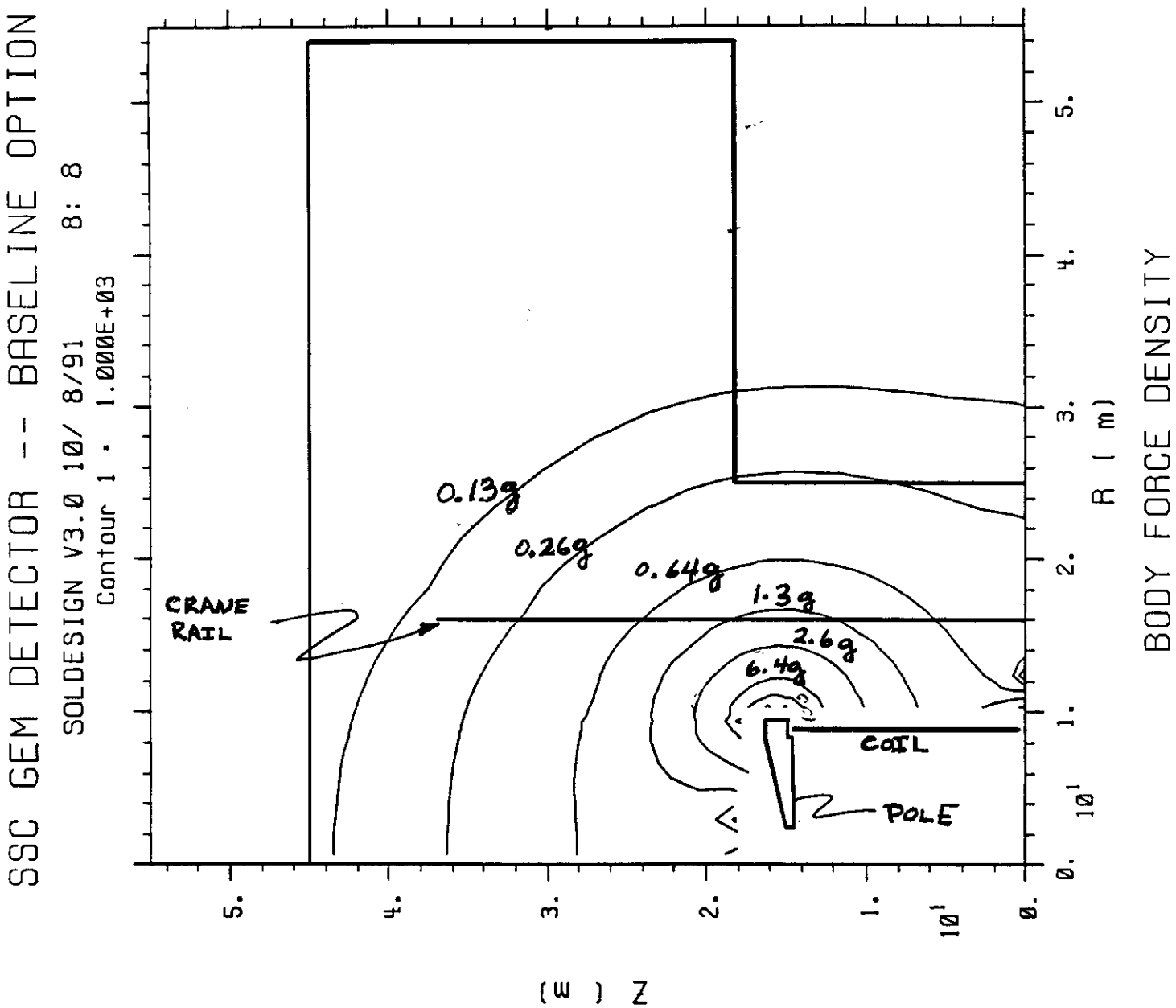


FIG. 1. CONTOURS OF CONSTANT BODY FORCE DENSITY EXPRESSED IN g'S

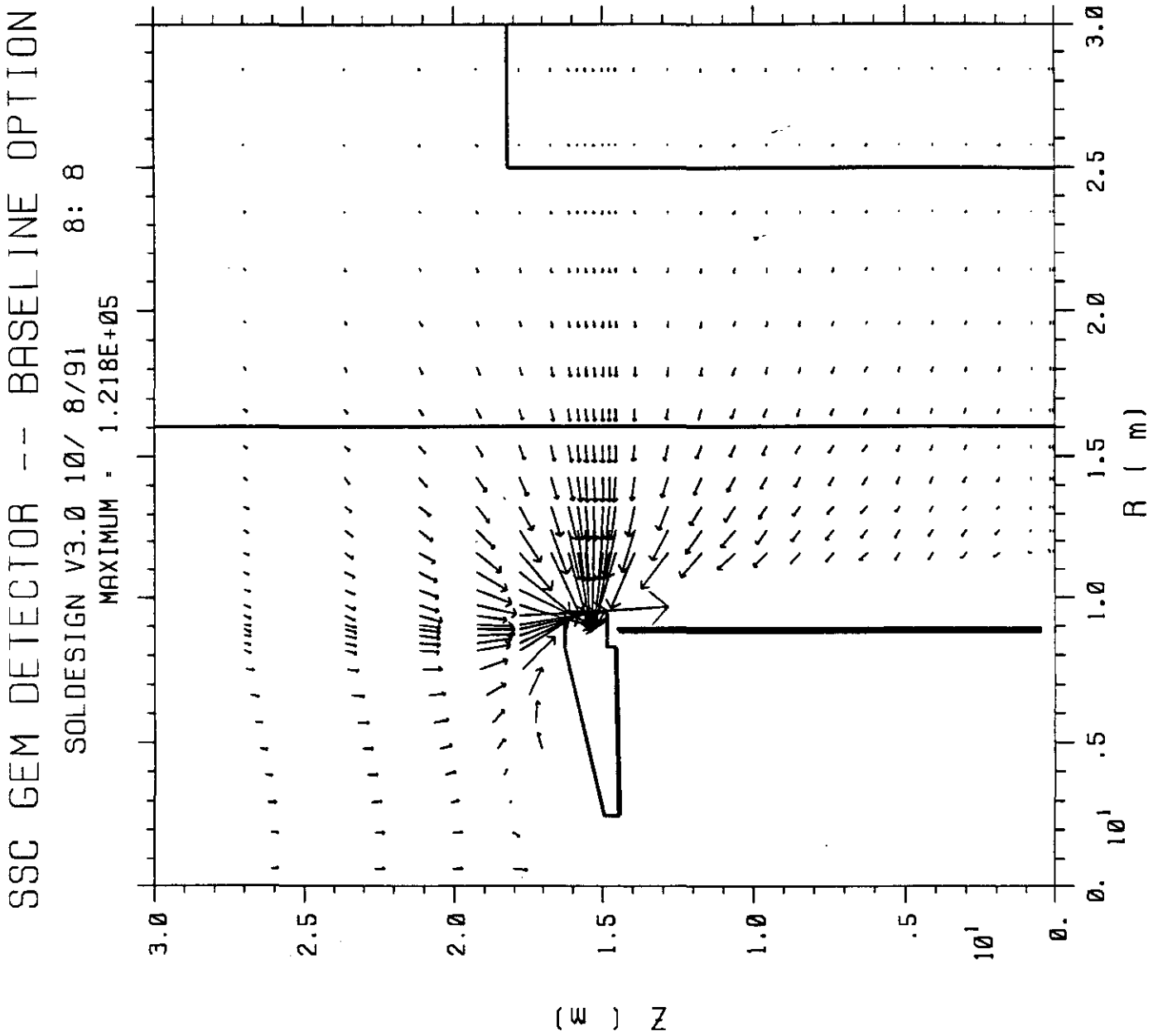


FIG. 2. LOCAL DIRECTIONS & MAGNITUDES OF BODY FORCE DENSITIES

EG&G

INTEROFFICE CORRESPONDENCE

Date: December 5, 1991

To: Phil Shelley

From: Biff Corning

Subject: NEPA Compliance Issues raised by the GEM Magnet Safety Proposal; November 12, 1991 Memo on

The major concern I have with the proposal outlined in the subject memo is that it is outside the scope of the EIS. Below are some of my reactions that you may find useful in adding lively discussion at your meeting.

- The memo quotes the DEIS accurately, so reading is not a problem. Section 10.1.3.2.A.2 states "at a point next to the tunnel wall, the magnetic field from *any* of the superconducting [used in the SSC operation and experiments] or conventional magnets will be about the same magnitude as the earth's magnetic filed. Thus, *no* magnetic field source term would be present at the surface of the SSC site or at it's boundaries."

  Yet the single-coil solenoidal magnet, as it would exist if located IR-5, would produce a *surface field directly above the interaction point of approximately 40 gauss*. Quite simply put, the EIS commits to one half gauss and anything beyond that is **beyond the scope of the EIS**. Proposing elevated levels detectable at the surface will surely require an EA.

- Any discussion of warning towers, significant amounts of protective fencing, or other surface changes based on changes in surface magnet field elevations will also trigger NEPA, and if we are lucky, only an EA.

- While the health effects of exposure is inconclusive, the public concern over elevated exposure will insure re-opening public hearings.

Superconducting Super Collider Laboratory
2550 Beckleymeade Avenue, Mail Stop 2000
Dallas TX 75237-3946
(214) 708–6178
Fax: (214) 708-6174

Physics Research Division

Memorandum

To: Ray Stefanski
From: Warren Kampmeier
Subject: Flux Cost Considerations
Date: October 9, 1991

I have attached the memo that I wrote to Mike back when for your information.

In talking with various manufactures and with Age Visser before writing that note, it seemed that the flux problem might be solved in two ways. The device could be shielded or the device be oversized to compensate for saturation losses. Of the two, the latter is probably least expensive, the former a better solution.

The spreadsheet enclosed uses both methods. For switch and panelboards, the breaker sizes were increased 20%. This had no cost impact on breakers since breakers are priced in ranges, however, the wire sizes would have to increase, thus the wire addition.

Transformers were priced to incorporate special core construction (cast core) and shielding.

Motors in the larger sizes were increased in Hp ratings and in the smaller sizes a cost factor for double shielded enclosures was added.

I have yet to receive a satisfactory answer from lighting fixture manufactures so I have estimated the cost of remote mounting the high energy discharge lamp ballast transformers. The lamps themselves should not be a problem.

Please note that this estimate only covers the electrical distribution in the Hall and the quantities were taken from the SDC design. No quantity scaling was done.

POWER DISTRIBUTION ELECTRICAL DEVICE TAKEOFF-Material Only						
Magneticaly Operated Equipment- SDC Hall Area						
Quant	Description	Base Price	Cost	Spcl Price	Cost	Remarks
60Hz ir	input conv					
5	75KVA Trans	1675	8375	2300	11500	
5	200A 208V panels	1440	7200	1440	7200	
2	200A 480V panels	1793	3586	1793	3586	
2	400A 480V panels	1800	3600	1800	3600	6 CBs inc typ
35000	wire			0.06	2100	
2	100Hp motors	3670	7340	4950	9900	
10	25Hp motors	875	8750	956	9560	
Emergency System						
1	200A 208panel	1440	1440	1440	1440	
1	75KVA trans	1675	1675	2300	2300	
1	400A 480V panels	1800	1800	1800	1800	
15000	wire			0.06	900	
Lighting						
1	200A 208panel	1440	1440	1440	1440	
1	75KVA trans	1675	1675	2300	2300	
20	Fixtures Hi Bay	403	8060	903	18060	
20	Fixtures Flour	70	1400	235	4700	
15	Exit	130	1950	340	5100	
HVAC						
3	25 Hp motors	875	2625	956	2868	
1	10Hp butane	363	363	518	518	
22000	wire			0.06	1320	
Special Electronics						
3	400A 480V panels	1800	5400	1800	5400	
9	75KVA Trans	1675	15075	2300	20700	
9	200A 208V panels	1440	12960	1440	12960	
17000	wire			0.06	1020	
Clean Electronics						
3	400A 480V panels	1800	5400	1800	5400	
9	75KVA Trans	1675	15075	2300	20700	
9	200A 208V panels	730	6570	1440	12960	
17000	wire			0.06	1020	
Jacking						
1	Motor Contrl Cntr	9025	9025	9800	9800	
4	100Hp motors	3670	14680	4950	19800	
10000	wire			0.06	600	
	Totals		145464		200552	
	Difference	55088				

MIT-GEM-EM-02

Shielding of the Magnetic Fields from the GEM Magnet

7 November 1991

R. D. Pillsbury, Jr.
L. Myatt
J. Sullivan

This document and all reports and memoranda in this series are intended as a record of MIT work in progress. They are for use in informal discussions of design and fabrication alternatives. This material is subject to change and should not, therefore, be published or referred to in the open literature. Conclusions are preliminary and distribution should be strictly limited.

Plasma Fusion Center
Massachusetts Institute of Technology
Cambridge, MA 02139

TO: Distribution

FROM: R. D. Pillsbury, Jr.
L. Myatt
J. Sullivan

DATE: November 5, 1991

SUBJECT: Shielding of the Magnetic Fields from the GEM Magnet

INTRODUCTION AND SUMMARY

The present baseline design for the GEM magnet system is comprised of a single layer superconducting solenoid and a thin iron pole piece at either end. The magnetic flux density at the center of the solenoid is 0.8 T. Such a design produces significant magnetic field levels outside of the bore of the solenoid. At the surface of the earth, assumed to be 51 m above the centerline of the magnet, the field is less than 40 Gauss. The flux density at points outside the magnet system, but inside the experimental hall, varies from 2 kG to 100 G. Forces produced by the interaction of these magnetic fields with small volumes of magnetized material are discussed in a previous memorandum [1]. Field levels of this order may require the shielding of electronics and other magnet systems near the detector.

The shielding of the magnetic fields produced by the GEM magnet are described in this memorandum. Shielding requirements are investigated for two different regimes. In the first, local shielding of a region of space that sees approximately 50 G of flux density is investigated in order to assess the requirements for shielding the fields from a counting room. In the second case, the impact of shielding on the fringe fields at the surface of the earth is assessed.

For the first case, a uniform 50 G flux density is assumed and the thickness of iron necessary to reduce the flux density inside the volume of the counting room to a few Gauss is calculated. Typical results indicate that thicknesses from 50 to 10 cm will reduce the flux density to the range of 1 to 3 Gauss for the room size of 20 x 20 x 4 m assumed in the analysis.

In the second case of surface shielding, three concepts are investigated. They are:

(1) The baseline thin pole design with no iron return frame and a surface plate of iron;

(2) A thick pole design with iron return frame; and

(3) A double solenoid with a thin pole.

The fringe field distributions for each of the design options will be presented. Along with the first option, several cases of a large flat iron plate at or below the surface are analyzed. The second and third options are basically self-shielding.

The fringe field distribution from a thick pole configuration with no return frame was also calculated. As will be seen, the differences in the fringe field distributions between the thin and thick pole designs are very small except in the immediate neighborhood of the pole pieces. Therefore, minor configuration changes of the coil and pole pieces will not have a major impact on the surface or counting room shielding concepts results presented in this memo.

FRINGE FIELD DISTRIBUTIONS

Figure 1 shows an elevation view of one half of the hall, solenoid, and pole piece. A section from the magnet centerline outward is shown. Superimposed on the figure are contours of constant flux density in Gauss. As seen, in the vicinity of the pole piece, the flux density is on the order of 2 kG and falls rapidly to 0.5 kG or less over a large fraction of the hall. These axisymmetric analysis were performed using the two-dimensional, nonlinear, finite element program MITMAP [2].

Figure 2 shows a similar plot for the thick pole case. As can be seen, there are only minor differences in the fringe field in the hall except in the immediate vicinity of the pole piece. Therefore the conclusions reached concerning the shielding requirements both for the counting room and for the surface are valid for both pole piece configurations.

Figure 3 shows a similar view for a system with a thick pole and a 2.0 m thick iron return frame. As can been seen the fringe field levels are reduced everywhere. For example, the surface field has dropped from 40 G to 1 G. An alternate consisting of a 1.3 m return frame was also analyzed. The fields outside the coil bore are, of course, larger than the 2 m case, but still less than the no return frame case. For example, the flux density at the surface is 9 G.

Figure 4 shows the dual solenoid with thin pole option. This also is a self-shielded design in that the fringe fields are greatly reduced. The surface flux density is approximately 1 G.

As mentioned previously, there are several areas that may require shielding, such as the

reinforces the statements made about similarity in fringe fields from the thin and thick pole cases.

Figure 8 shows the surface fringe field plot for the case of a thick pole and a 2 m thick iron return frame. As can be seen the field level is 1 G. If a 10 G field level is allowed, a thick pole and 1.3 m thick return frame is sufficient as is shown in Figure 9. Finally, Figure 10 shows the surface plot for the thin pole and a double solenoid. As can be seen, the maximum flux density is 2 G and considerably reduced in axial extent.

These figures show that surface fringe field levels of 1 to 10 G are attainable with the self-shielding options. However, there are significant cost and schedule impacts for such systems.

One alternative to full self-shielding is to install an iron plate or a sequence of plates between the coil and surface in order to shield the fringe fields. Figure 11 shows an example of such a plate. In this example, a quarter of the solenoid (with the pole piece omitted) and plate are shown. The planes of symmetry are called out. Also shown is a lip on the far end of the plate.

A range of plate locations, sizes, thickness and lips were analyzed using ANSYS. The optional lip was added to redirect the fringing of the field lines as they enter (or leave) the plate at the ends and, therefore, reduce the fields at the surface.

Table 1 lists some of the cases run, the plate geometry, the plate depth below the surface, the size of the lip, the flux density on the surface in the geometric center of the plate and the value at the edge of the plate (the fringing effect), and the iron required.

Several conclusions can be drawn from this table. They are:

(1) A plate closer to the surface will produce a higher amount of fringing over the edges of the plate at the surface. For example, runs 13, 16, and 17 show essentially the same flux density magnitude at the surface over the center of the plate but the lower plates produce between 20% and 40% of the fringing at the surface.

(2) Plates close to the surface need a lip to reduce the fringing field to a value equal to or below the level of the field at the center of the plate. For example, runs 18 and 19 show that a 5 m lip, 0.5 m thick reduces the maximum field on the surface from 11 G to 5.6 G – the flux density in the plate is well below saturation. Plates further from the surface may not require a lip at all.

(3) A 160 x 140 x 0.5 m plate with a 5 m lip that is 1.5 m below the surface shields the surface to 1.4 G except in the neighborhood of the edge where it rises to 5.6 G.

counting room and the surface of the earth. The shielding requirements for the first case is discussed in the next section and the surface shielding is discussed in a separate section.

LOCAL SHIELDING

In order to asses the shielding requirements for regions near the magnet such as the counting room, an axisymmetric analysis was performed using ANSYS [3]. A cylindrical volume equivalent to the proposed 20 x 20 x 4 m counting room was placed in a uniform flux density of 50 G. The thicknesses of the walls and the floor and ceiling were varied independently.

Figure 5 shows a plot of the maximum flux density in the enclosed volume as a function of the floor and ceiling thickness for several different wall thicknesses. The dashed curves represent lines of constant iron volume in cubic meters. As can be seen, a 2 G field level is attainable with approximately 200 cubic meters of iron or 1560 tonnes using a 0.2 m thick wall and a 0.175 m thick floor and ceiling.

If a 1 G flux density level is required, approximately 430 cubic meters of iron or 3380 tonnes is necessary using 0.45 thick floor and ceiling and 0.30 m thick walls. Shielding to a higher level of 5 – 10 G is significantly easier and such analyses can be made when allowable flux density levels are specified.

A lower ambient flux density would allow reduced thickness with basically a linear dependence, since the iron is in unsaturated regime where the relative permeability is quite high. For example, shielding an ambient field of 5 G would require 338 tonnes of iron. However, an increase in the flux density would not scale linearly since the iron would approach saturation and the lower permeability regime is more nonlinear.

SURFACE SHIELDING

The fringe field produced by the GEM magnet at the surface of the earth has been calculated and presented in elevation views of the hall and magnet for the options discussed above.

Figure 6 shows a plan view 50 meters above the magnet with contours of constant flux density produced by the thin pole baseline. This distance corresponds approximately to the surface of the earth. The magnet is 50 meters below the surface and centered with its axis parallel to the z-axis in the figure. As can be seen, the maximum fringe field is approximately 40 G (Note: the 10^1 label).

Figure 7 shows a similar plot for the thick pole case. A comparison of figures 6 and 7

Figure 12 shows the flux density magnitude at the surface versus position along the surface at the plane of symmetry. The extent of the plate (which is 1.5 m below the surface) is indicated. As can be seen, the flux density is 1.4 G at the center and falls to 0.5 G near the edge, but the fringing of the field is evident as the magnitude rises to 5.6 Gauss at the edge. It is felt that the fringing may be further reduced to the 1.4 G level by varying the depth and thickness of the lip. This case may be compared to the 2 m thick iron return frame as shown in Table 2.

(4) A 120 x 100 x 0.15 m plate with a 5 m lip that is 1.5 m below the surface shields the surface to 8 G or less. This case can be compared with the 1.3m thick iron return frame case – see Table 2.

(5) Finally, it appears surface shielding is possible if the maximum flux density is in the 1 to 10 G range. Optimization of the plate thickness with position and of the lip may allow a reduction in the weights shown.

Table 1: Surface Shielding With Iron Plates

Plate Size (m)	Depth Below Surface	Plate Lip to Control Fringing	Peak Surface Fields		tonnes of Iron
			Over Coil	Plate Edge	
160Lx140W 0.25 thk (Run #16)	1.5 m	No Lip	2.7 G	8.2 G	43,700
160Lx140W 0.50 thk (Run #18)	1.5 m	No Lip	1.4 G	11 G	87,400
160Lx140W 0.50 thk (Run #19)	1.5 m	5 m Lip	1.4 G	5.6 G	90,100
160Lx140W 0.25 thk (Run #21)	1.5 m	5 m Lip	2.7 G	4.5 G	46,400
160Lx140W 0.15 thk (Run #23)	1.5 m	5 m Lip	5.8 G	4.1 G	28,900
120Lx100W 0.15 thk (Run #24)	1.5 m	5 m Lip	8.1 G	7.7 G	16,800
160Lx140W 0.25 thk (Run #13)	9.5 m	No Lip	3.3 G	3.6 G	43,700
160Lx140W 0.25 thk (Run #14)	9.5 m	5 m Lip	3.4 G	2.7 G	46,400
160Lx140W 0.25 thk (Run #15)	9.5 m	15 m Lip	3.5 G	2.0 G	51,900
160Lx140W 0.25 thk (Run #17)	15.5 m	No Lip	4.2 G	2.5 G	46,400

Table 2: Comparison of Return Frame and Plate Shielding Options

Shielding Hardware Description	Peak Field at Ground Elevation	tonnes of Iron
160Lx140Wx0.50 thk Plate 5 m Lip, 1.5 m Below Ground (Run #19)	1.4 G	90,100
2 m Thick Iron Return Frame	1.0 G	30,100
120Lx100Wx0.15 thk Plate 5 m Lip, 1.5 m Below Ground (Run #24)	8.1 G	16,800
1.3 m Thick Iron Return Frame	8.8 G	19,100

REFERENCES

[1] R. D. Pillsbury, Jr., "Fringe Field Dipole-dipole Force Interactions," Internal memorandum MIT-GEMEM-01, October, 1991

[2] R. D. Pillsbury, Jr., "MITMAP - MAP User's Manual,",PFC/RR-91-4, February, 1991

[3] ANSYS Revision 4.4A, Swanson Analysis Systems, Inc., Houston, PA.

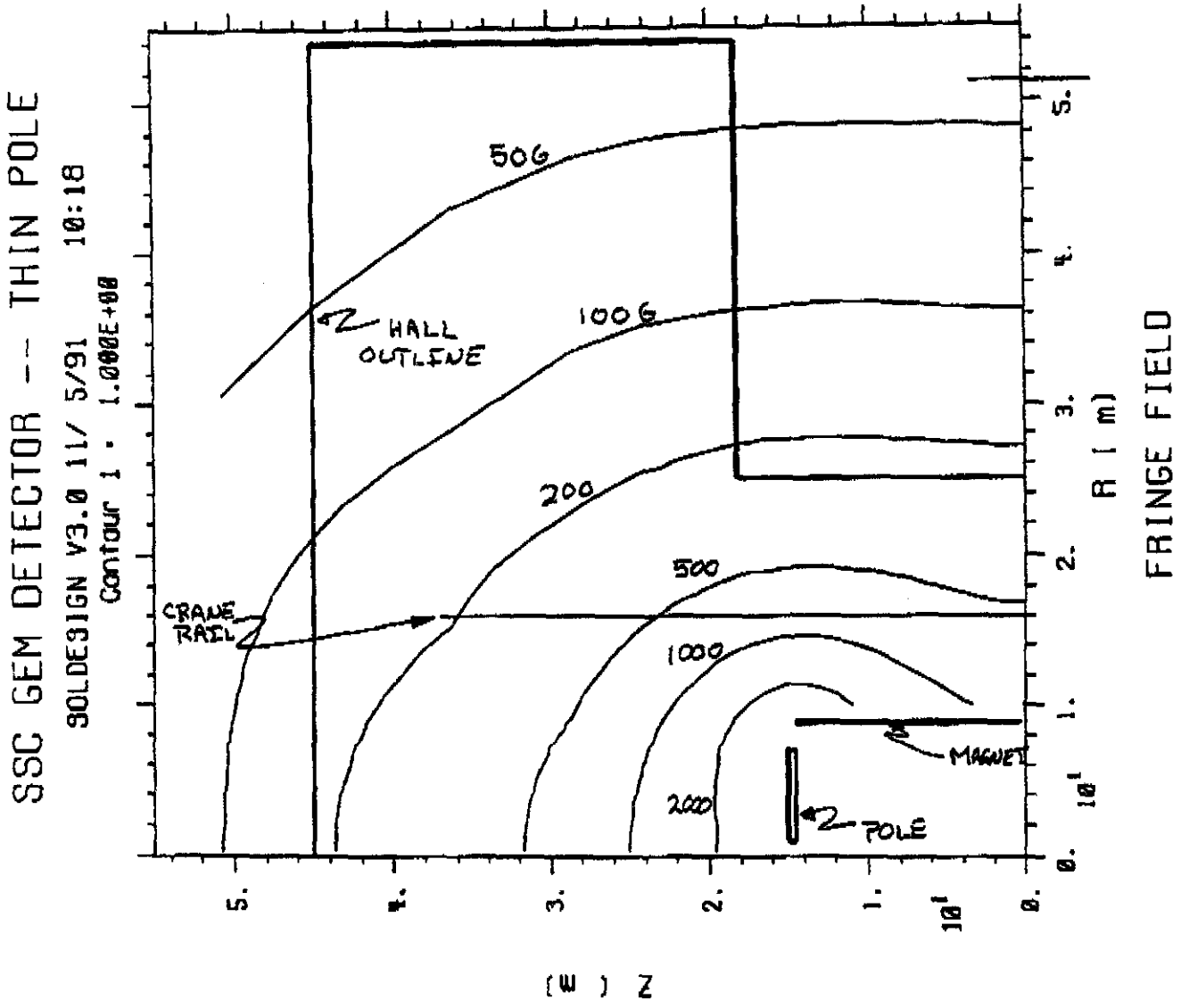


Fig. 1 – Contours of constant flux density for the thin pole baseline design for GEM superimposed on an elevation view of the experimental hall.

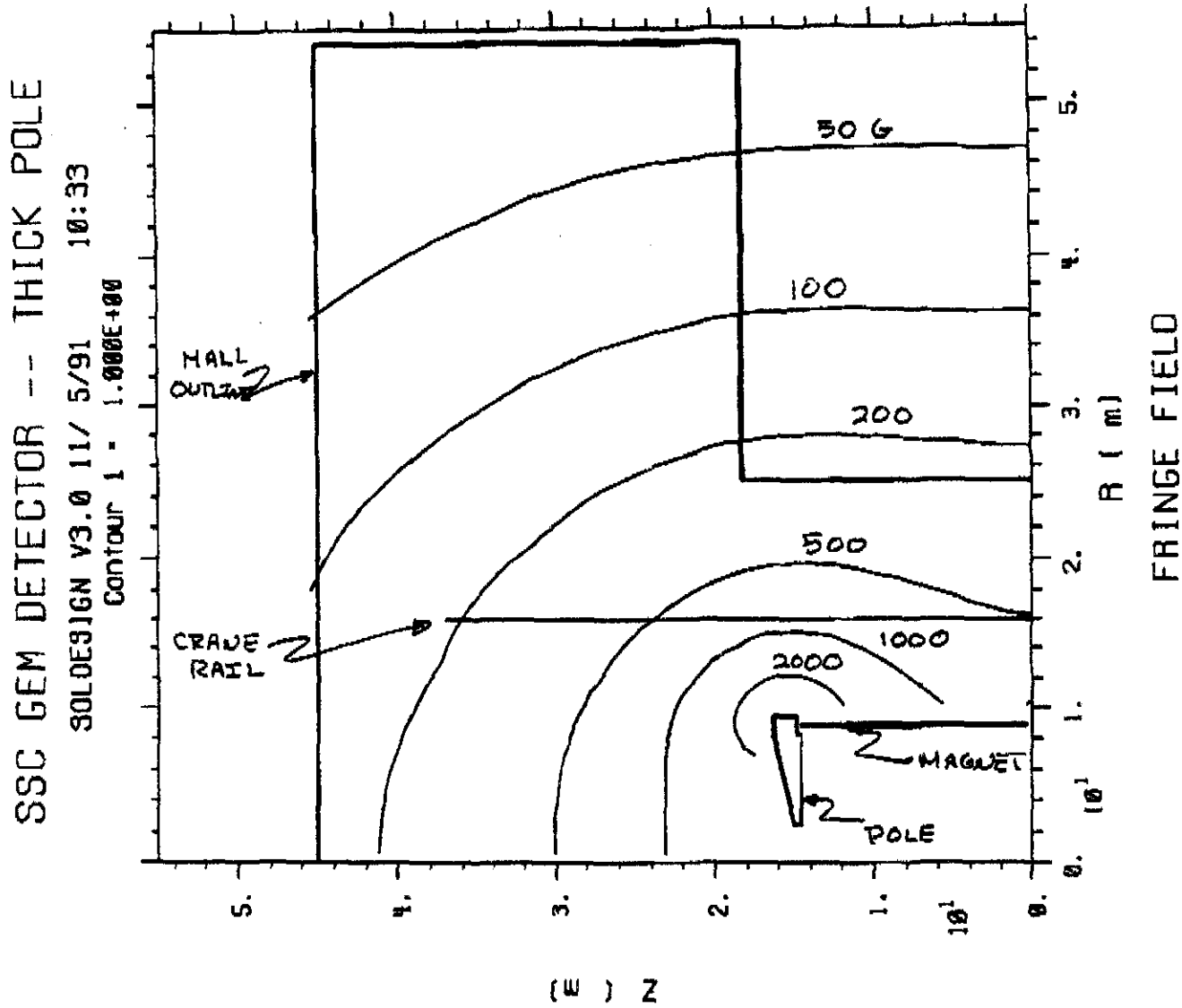


Fig. 2 – Contours of constant flux density for the thick pole design for GEM superimposed on an elevation view of the experimental hall.

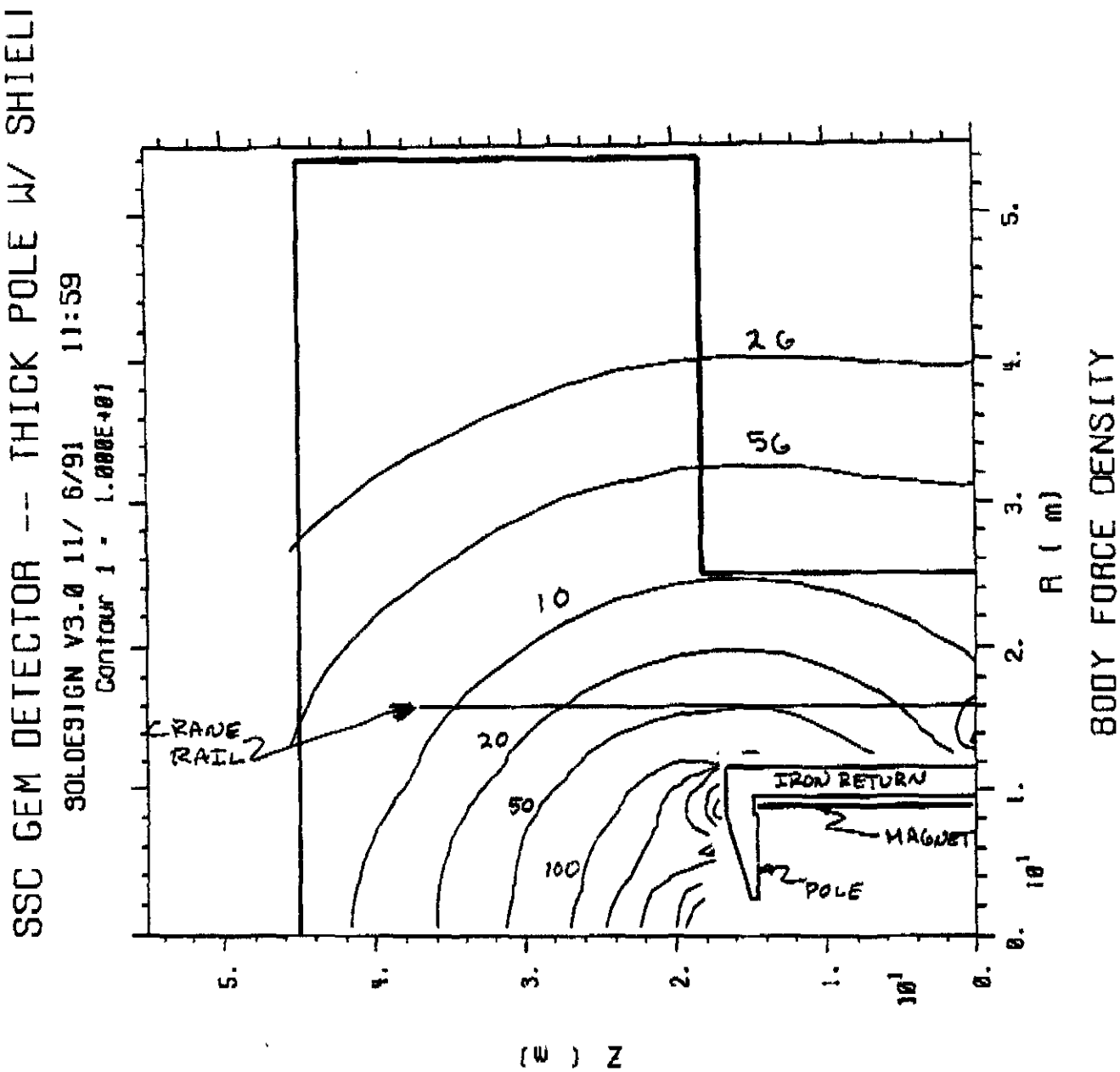


Fig. 3 – Contours of constant flux density for the thick pole and 2 m thick iron return frame design for GEM superimposed on an elevation view of the experimental hall.

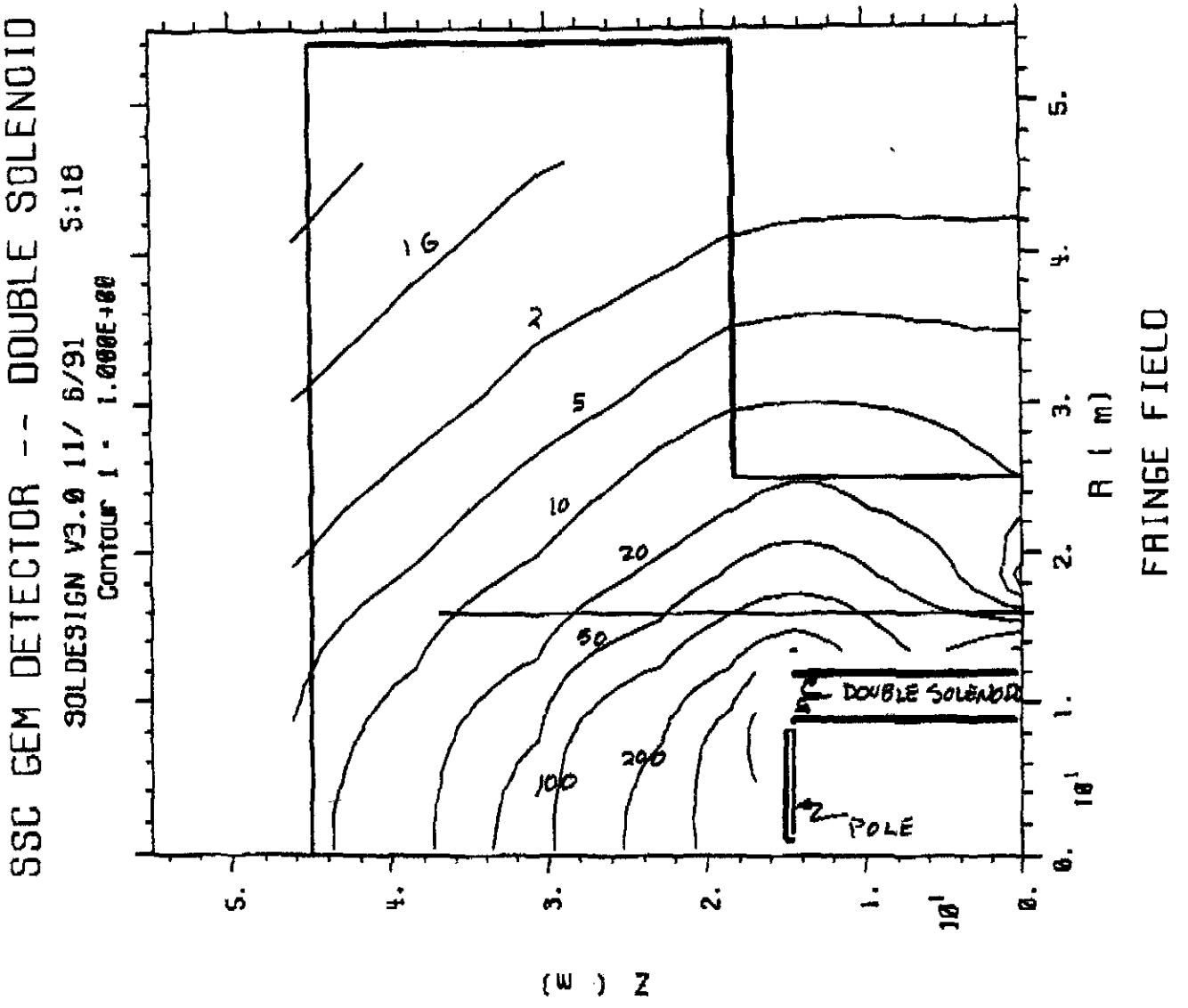


Fig. 4 – Contours of constant flux density for the thin pole and double solenoid design for GEM superimposed on an elevation view of the experimental hall.

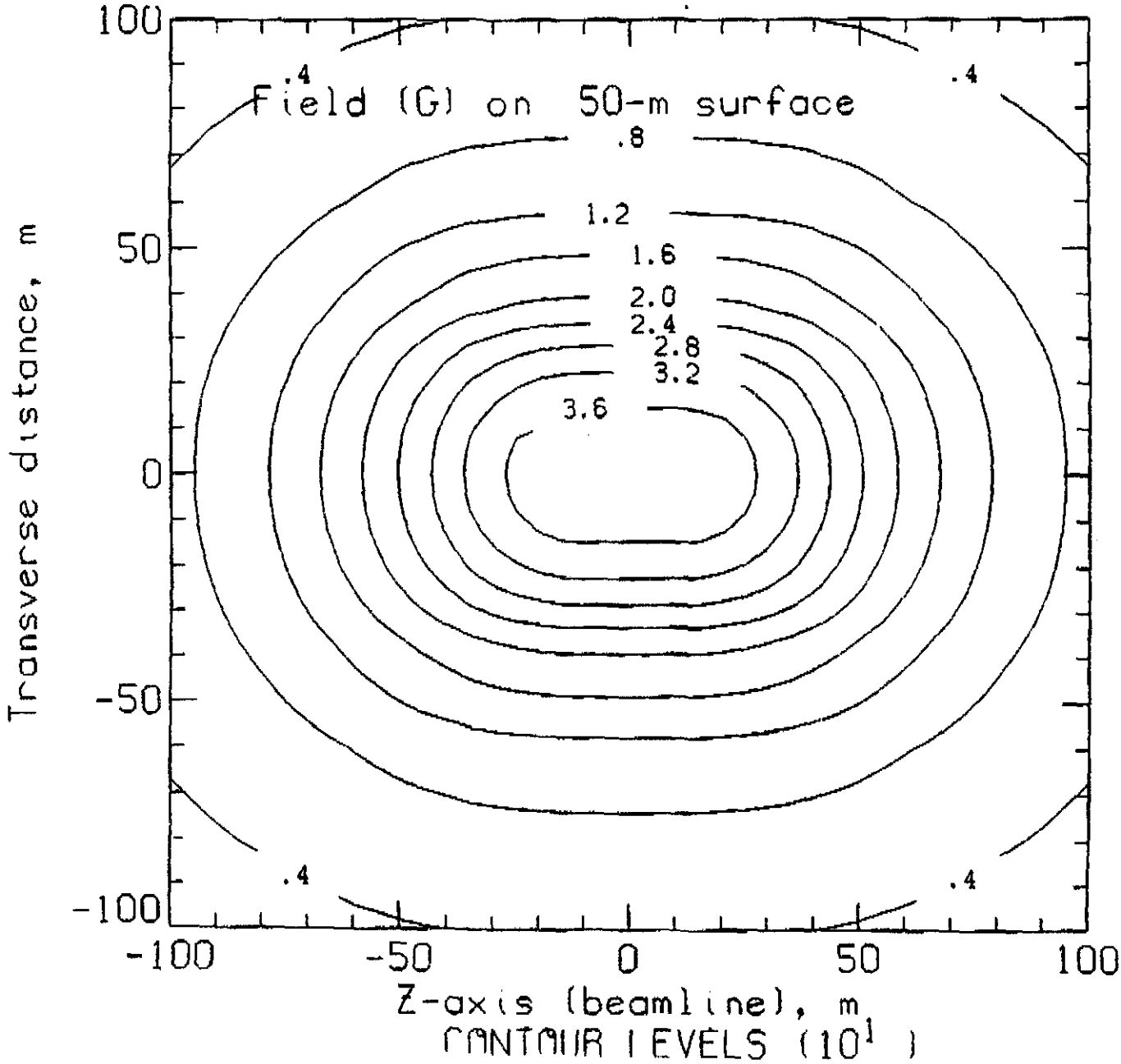


Fig. 6 – Contours of constant flux density at the surface of the earth for the thin pole baseline design for GEM.

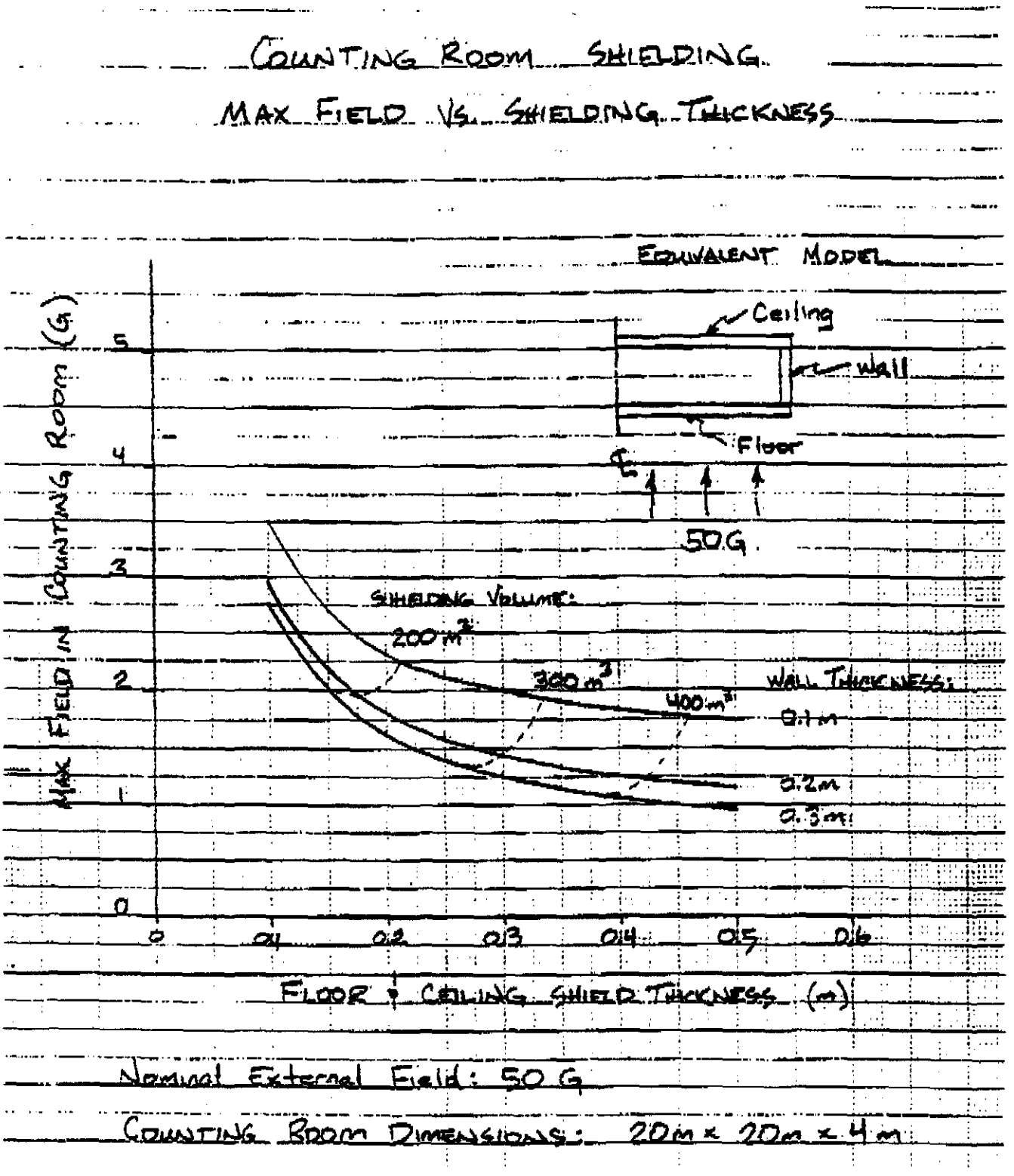


Fig. 5 – Flux density level inside a 20 x 20 x 4 m volume in a uniform 50 G field as a function of floor, ceiling and wall thicknesses.

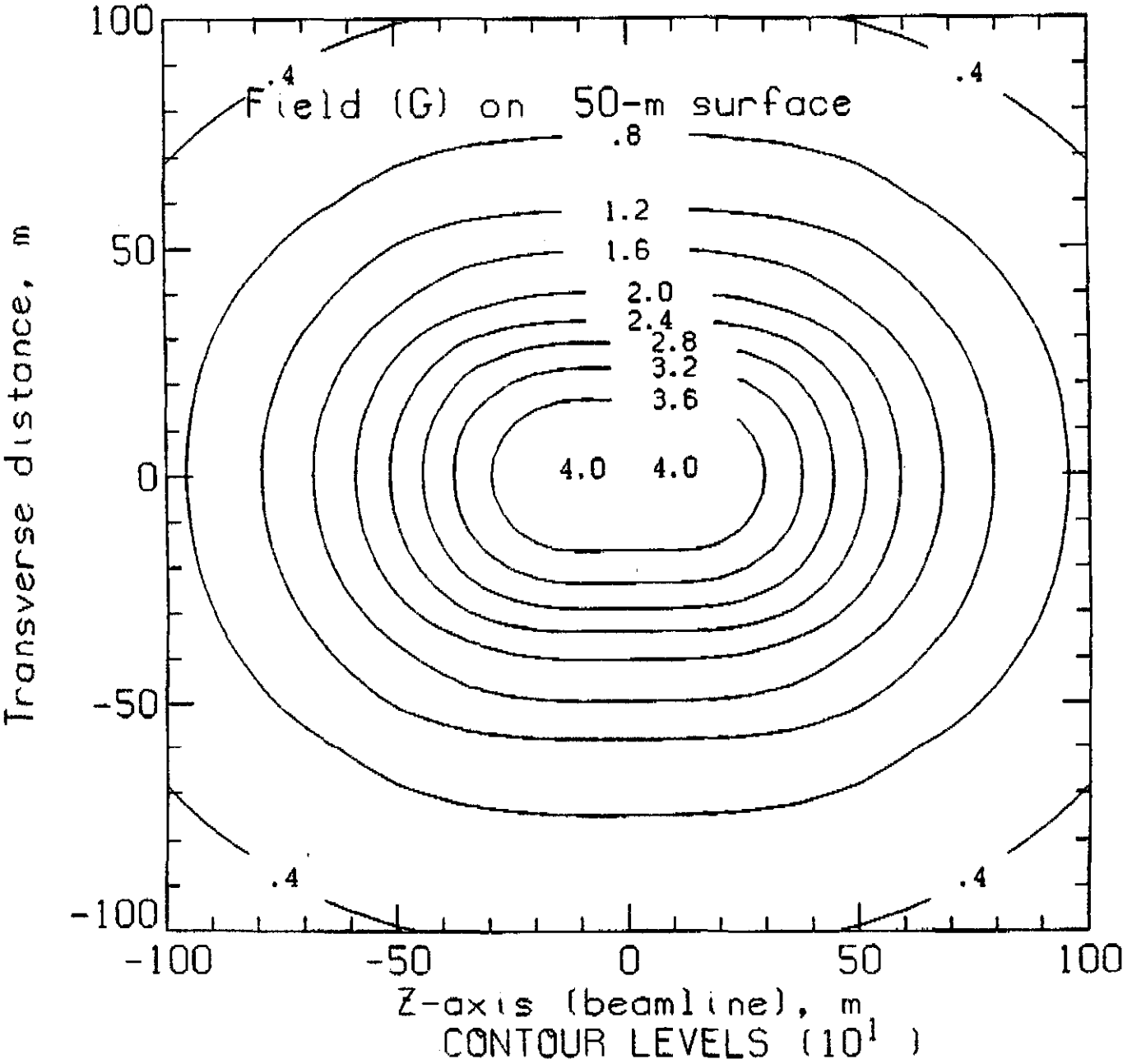


Fig. 7 – Contours of constant flux density at the surface of the earth for the thick pole design for GEM.

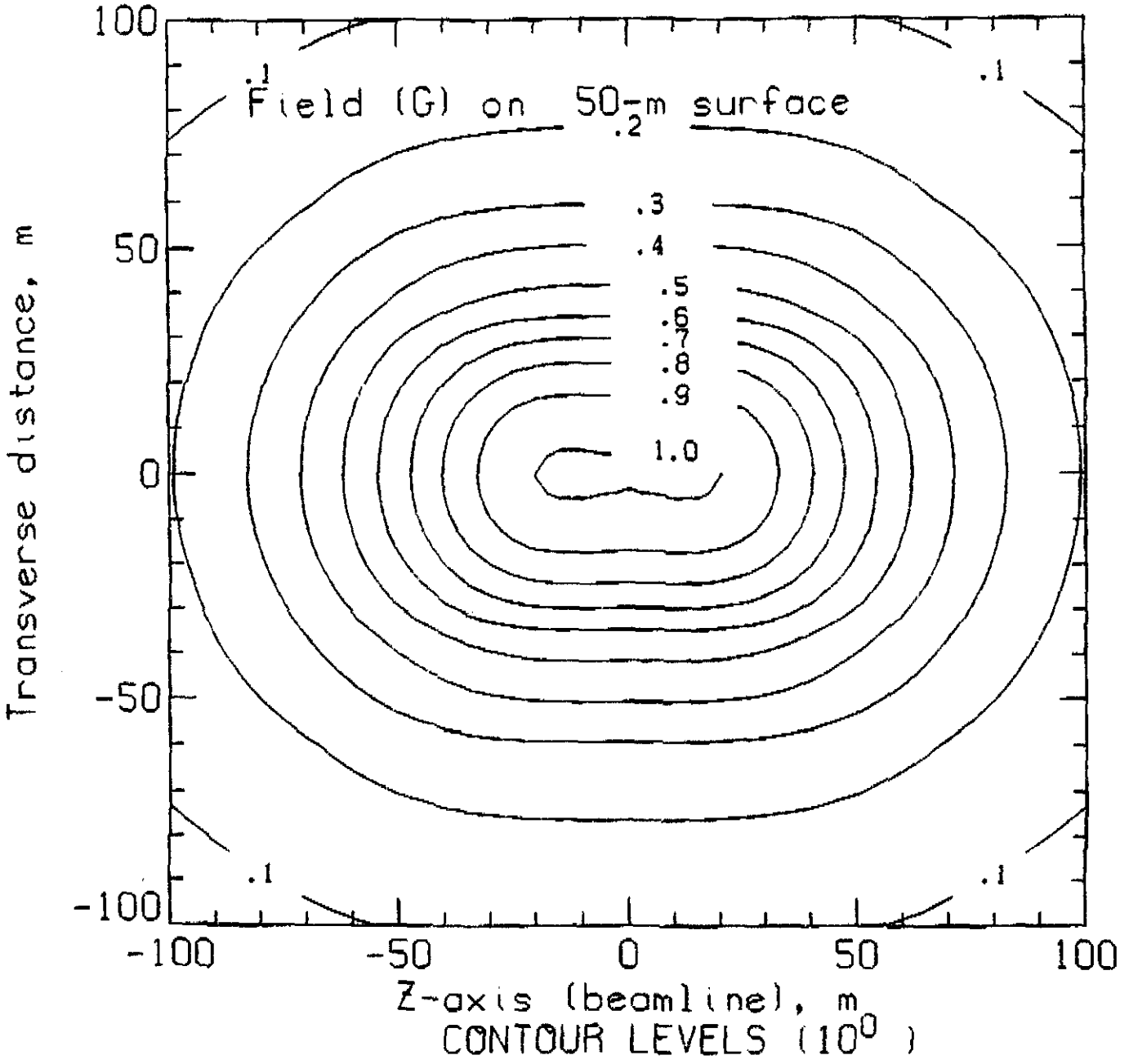


Fig. 8 – Contours of constant flux density at the surface of the earth for the thick pole and 2 m thick iron return frame design for GEM.

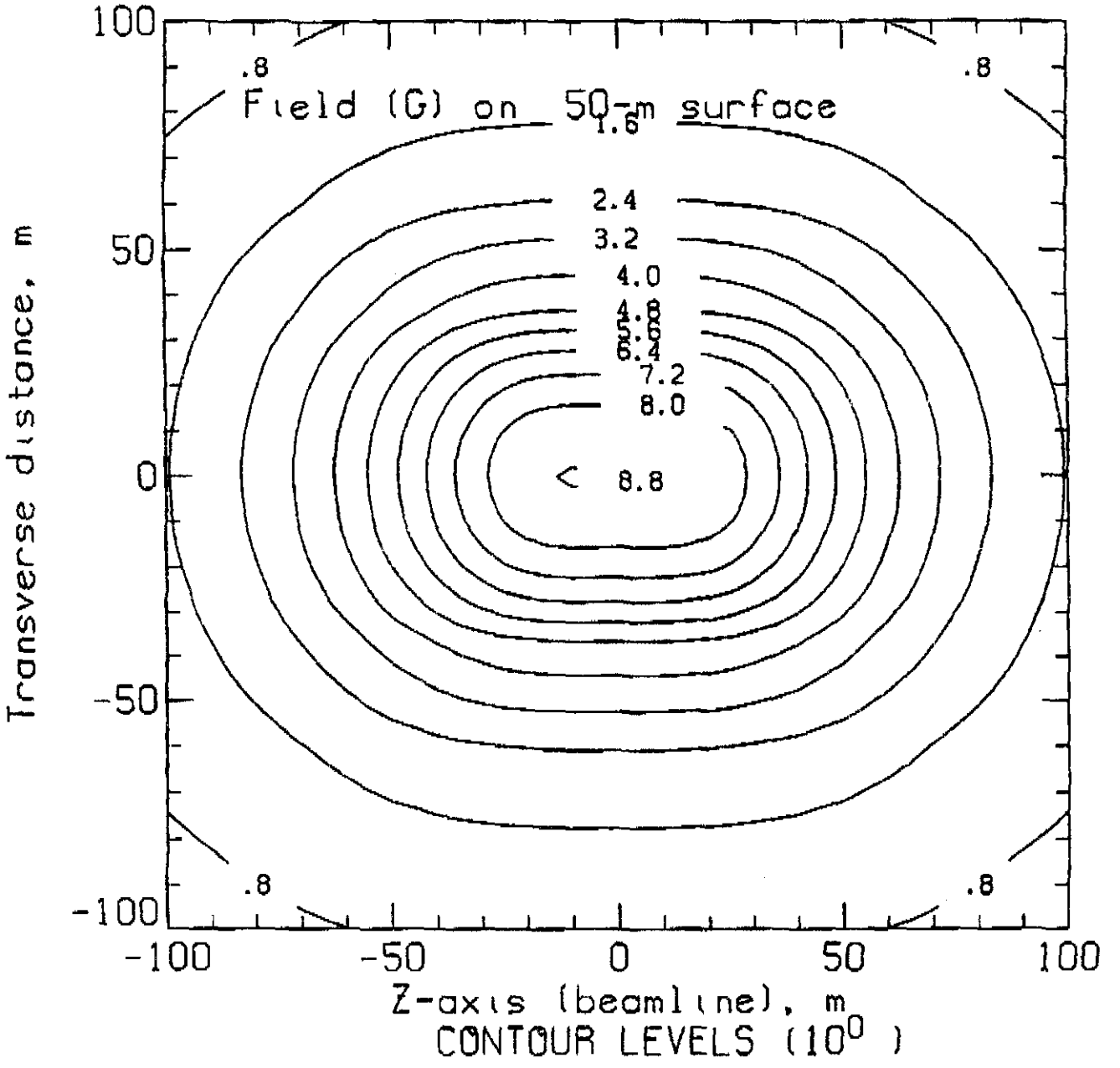


Fig. 9 – Contours of constant flux density at the surface of the earth for the thick pole and 1.3 m thick iron return frame design for GEM.

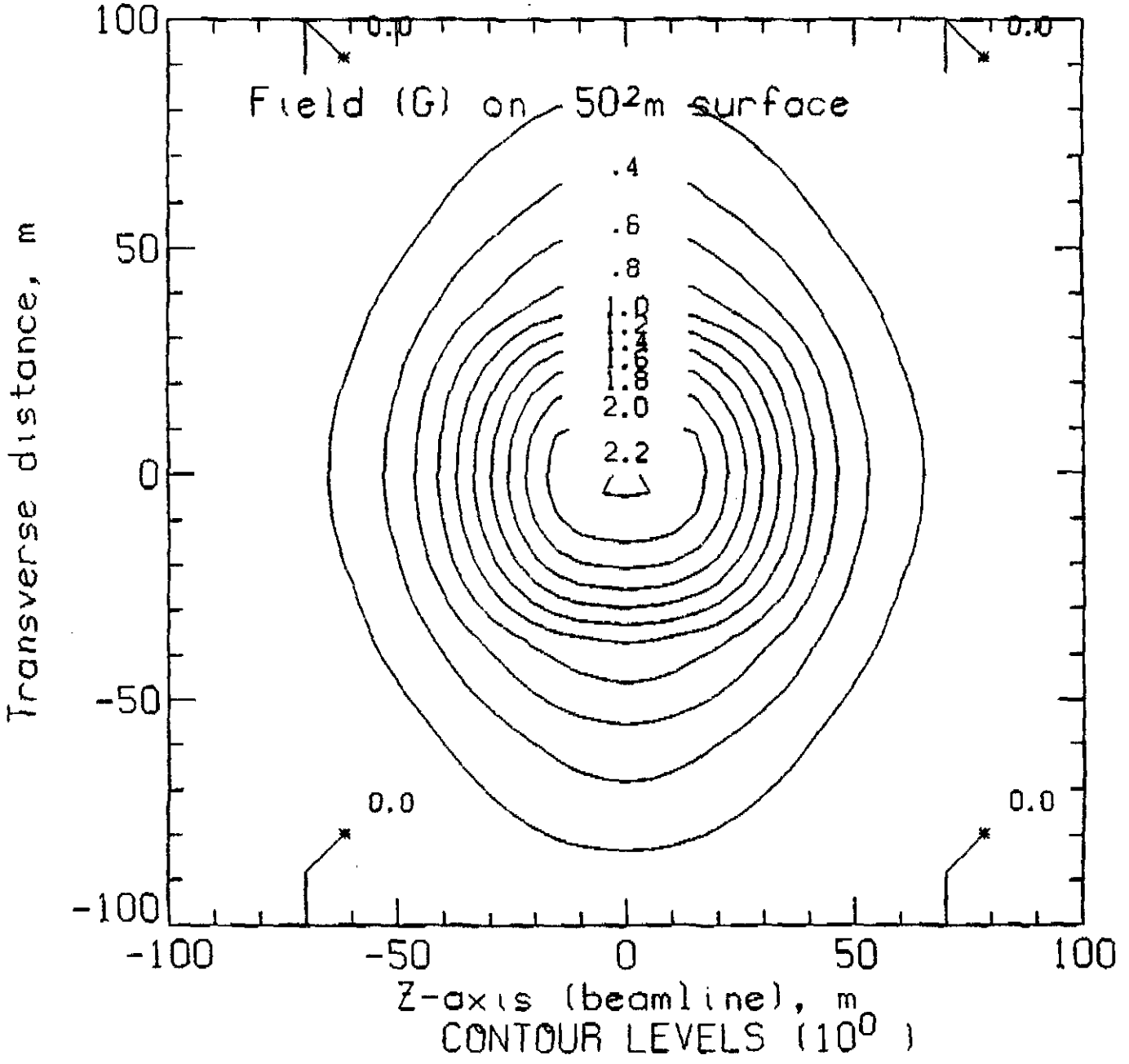


Fig. 10 – Contours of constant flux density at the surface of the earth for the thin pole and double solenoid design for GEM.

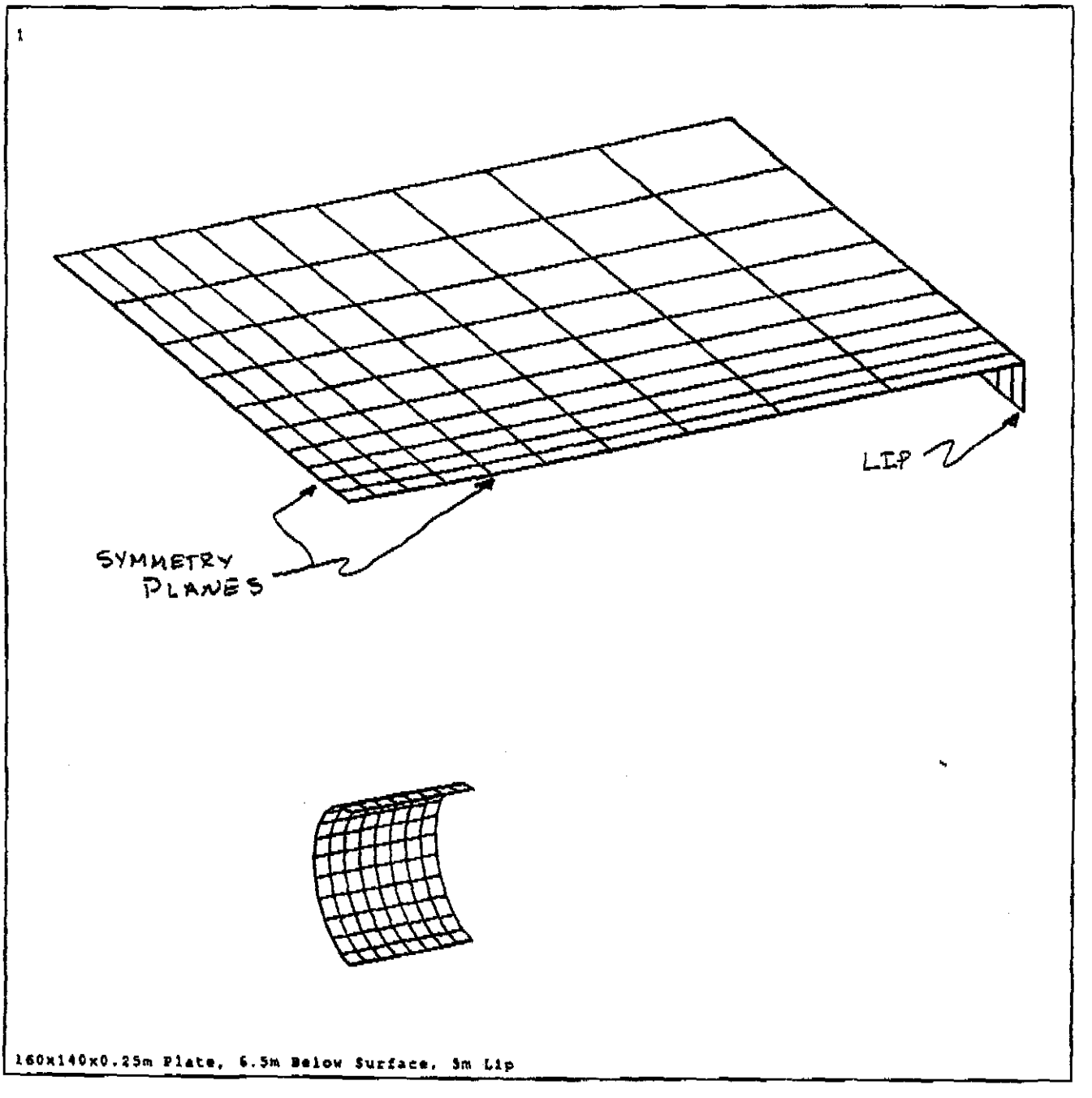


Fig. 11 – Surface plate geometry for shielding surface fields.

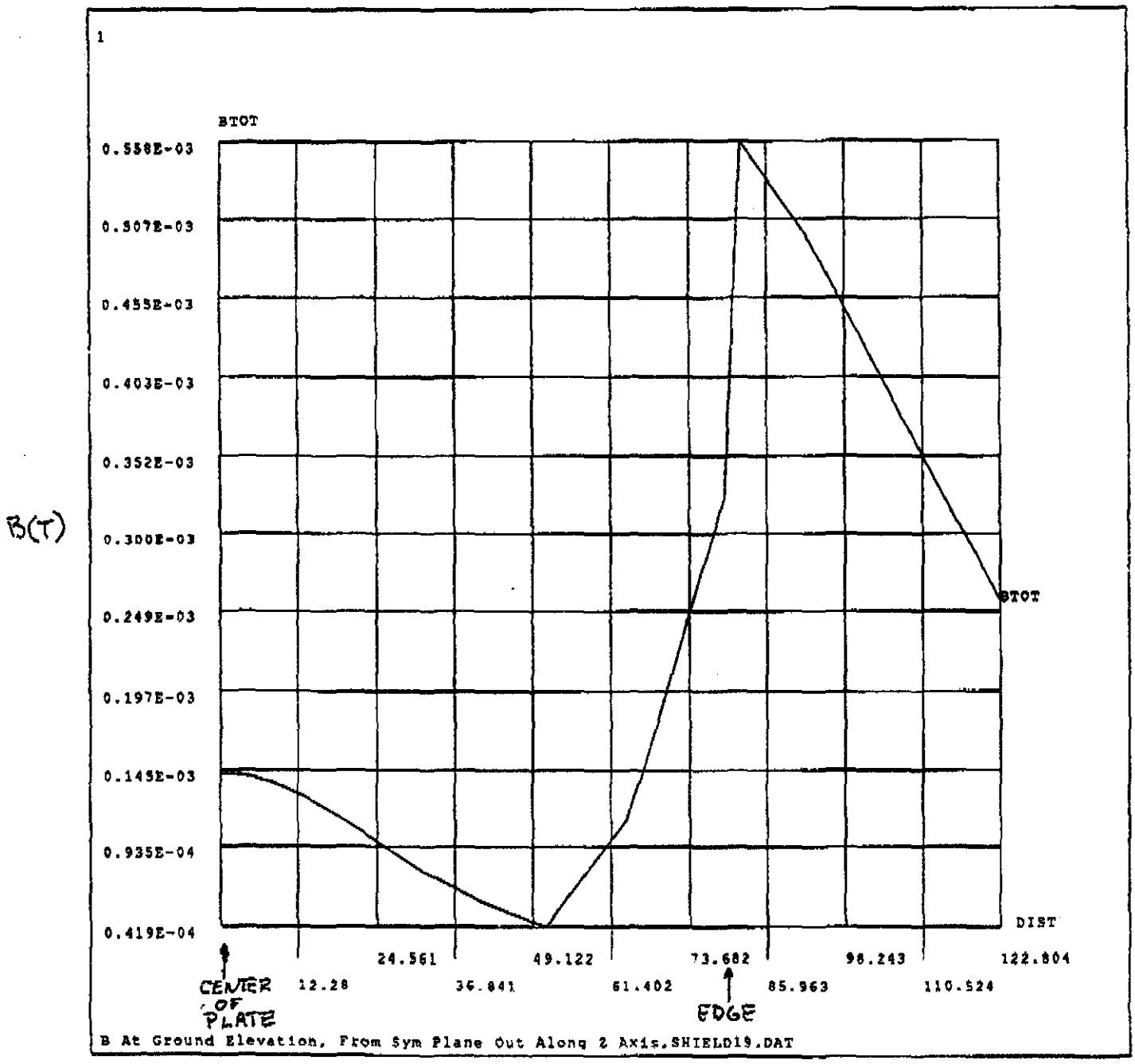


Fig. 12 – Flux density magnitude versus position at the surface.

SERC

Rutherford Appleton Laboratory

TECHNOLOGY DEPARTMENT
R65, Rm 1.08

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6 November 1991

Dear Ray,

FINAL GEM REPORT

I only received the Report today so have had little time to study it in detail.

However a quick scan it certainly appears to reflect and include all the major points discussed. I am pleased you have included the Russian's comments on the conductor as they mostly reflect my views and I was a little concerned that I appeared to be out on a limb in relation to the American Panel Members' views. I also still believe that an indirectly cooled only conductor should not be rejected at this stage.

Kind regards

Peter Clee

pc054

From: "ch%\"francois_wittgenstein@mac (11/13/91)
To: Ray Stefanski
GatorMail-Q 3rd GEM magnet report
Received: by qmail.ssc.gov; 13 Nov 91 17:34:25
Date: Fri, 8 Nov 1991 11:34:31 CST
From: "ch%\"francois_wittgenstein@macmail.cern.ch\""@SSCVX1.SSC.GOV (Francois Wittgenstein)
Message-Id: <911108113431.2520c760@SSCVX1.SSC.GOV>
Subject: 3rd GEM magnet report
To: Ray_Stefanski.physics@qmail.ssc.gov
X-Vmsmail-To: stefanski@sscvx1

Received: From CEARN(MAILER) by SSCVX1 with Jnet id 5638
for STEFANSKI@SSCVX1; Fri, 8 Nov 91 11:34 CDT
Received: from CEARN by CEARN.cern.ch (Mailer R2.07B) with BSMTP id 5637; Fri, 08 Nov 91 18:36:18 GVA
Received: from dxmint.cern.ch by CEARN.cern.ch (IBM VM SMTP V2R1) with TCP; Fri, 08 Nov 91 18:36:16 GVA
Received: by dxmint.cern.ch (cernvax) (5.57/3.14) id AA11335; Fri, 8 Nov 91 18:31:32 +0100
Message-Id: <9111081731.AA11335@dxmint.cern.ch>
Date: 8 Nov 91 18:28:06 U
From: "Francois Wittgenstein" <francois_wittgenstein@macmail.cern.ch>
Subject: 3rd GEM magnet report
To: stefanski@sscvx1
Cc: harris@sscvx1, alain_herve@macmail.cern.ch

	Subject:	Time:5:52 PM
OFFICE MEMO	3rd GEM magnet report	Date:11/8/91

Dear Ray,

Many thanks for the report and congratulations for having finalized this difficult job . It is clear that some additional cost should be considered for the implication of the stray field on the sensitive monitoring equipment and a figure of 40% as mentioned in Appendix C could be convenient but should be applied to a basis of several M$ (installed equipment) as noted by Alain Herve. I am convinced that the basic version, without shielding, could be operated safely if the operating team is ready to impose some discipline. The operating of the BEBC magnet demonstrated that this constraint is feasible. It is just a question of willingness !

The screwdrivers transformed in " missile " could exist of course but the BEBC patrols discovered this "terrible " guns in due time. Therefore this type of anti-argumentation should be kept on the correct level.

Concerning the parameters of the conductor I see that I could already convinced our russian colleagues to be less rash with the discharge voltage but some additional effort should be undertaken concerning the discharge time constant which should be increased by a factor 2. Quick discharges are mortal for S. C magnets and the engineer's nerves should accept a relaxed discharge.....also under severe random conditions !

I am personaly not too much convinced by the design of the Kurchatov conductor and I see more interest in the conductor shape d.

As we intend to organize in the immediate future a conductor development for the LHC detectors, I am interested to know what happens with item 7 of page 3.

I wish you and your collaborators good luck for continuing your program and would appreciate to be informed on the issue of this interesting (for all of us) project.

Kind regards. Francois Wittgenstein.

From: "ch%\"alain_herve@macmail.cern. (11/5/91)
To: Ray Stefanski
GatorMail-Q GEM report
Received: by qmail.ssc.gov; 5 Nov 91 02:26:19
Date: Tue, 5 Nov 1991 2:22:53 CST
From: "ch%\"alain_herve@macmail.cern.ch\""@SSCVX1.SSC.GOV (Alain Herve)
Message-Id: <911105022253.25206f0f@SSCVX1.SSC.GOV>
Subject: GEM report
To: Ray_Stefanski.physics@qmail.ssc.gov
X-Vmsmail-To: STEFANSKI@sscvx1

Received: From CEARN(MAILER) by SSCVX1 with Jnet id 6957
for STEFANSKI@SSCVX1; Tue, 5 Nov 91 02:22 CDT
Received: from CEARN by CEARN.cern.ch (Mailer R2.07B) with BSMTP id 6956; Tue,
05 Nov 91 09:24:37 GVA
Received: from dxmint.cern.ch by CEARN.cern.ch (IBM VM SMTP V2R1) with TCP;
Tue, 05 Nov 91 09:24:34 GVA
Received: by dxmint.cern.ch (cernvax) (5.57/3.14)
id AA00364; Tue, 5 Nov 91 09:20:01 +0100
Message-Id: <9111050820.AA00364@dxmint.cern.ch>
Date: 5 Nov 91 09:18:30 U
From: "Alain Herve" <alain_herve@macmail.cern.ch>
Subject: GEM report
To: STEFANSKI@sscvx1
Cc: HARRIS@sscvx1, francois_wittgenstein@macmail.cern.ch

	Subject:	Time:9:13
OFFICE MEMO	GEM report	Date:11/5/91

I just received the draft report. It is conformed to the meeting conclusions on technical matters. Just for the record, but it is not important at this stage, the 5-10 M$ for the surface shielding is misleadingly low as well as the 55 k$ for the electrical hall modifications.

==========

Superconducting Super Collider Laboratory
2550 Beckleymeade, Building 4, MS-2011
Dallas, Texas 75237-3946
(214) 708-4028
Fax: (214) 708-4099

Conventional Construction Division

TO: Ray Stefanski
FROM: Jon Ives
DATE: Nov 9, 1991
SUBJECT: Report of 3rd Meeting of GEM Magnet Technical Panel

- Tks for a copy of the report.
- As you know, we in CCD have been concerned about the implications of the unshielded magnet from two perspectives:

  — Impacts on conventional construction materials and costs and for long term corrosion due to induced stray currents.

  — Consistency with SEIS commitments regarding levels of magnetic field. (I understand you are working with Phil Shelley on this.)

cc: Etheridge, Crumpley, Torlig, Shelley, Wiebe

Superconducting Super Collider Laboratory
Physics Research Division
2550 Beckleymeade Avenue
Mail Stop 2001
Suite 215
Dallas, TX 75237-3946
(214) 708-6018• FAX (214) 708-0006
91 5840 M P _____

Wednesday, October 30, 1991

Ronn Woolley
SSC Laboratory
2550 Beckleymeade, MS 1001
Dallas, Texas 75237

Dear Ronn:

Please find enclosed a draft of the Report of the Third Meeting of the GEM Magnet Technical Panel. Send comments and corrections to me by November 6, 1991. The reprot will be made available to the PAC and for general distribution.

We're also including comments prepared by Klimenko and Martovetsky. They made several suggestions in their papers, including a recommendation to design for lower current densities.

Thank you for your participation in the work of the Panel. At the very least, it's been an interesting experience.

Sincerely,

Ray

Ray Stefanski
Physics Research Division

Magnet

The physics goals of the GEM experiment include, among others, high resolution measurements of the muons emitted at large transverse momentum in proton - proton collisions. The aim of the design concept is to have 5% momentum resolution for 500 GeV muons at 90 degrees assuming 100 micron measurement errors and no vertex constraint. Such resolution should be achieved over a broad central region of rapidity in order to provide sufficient acceptance for multimuon events. These requirements lead to our concept of a large aperture solenoidal magnet with muon tracking stations inside the uniform magnetic field.

The GEM Collaboration is proposing a large superconducting solenoid with field shaping iron end poles and field of 0.8 Tesla. The proposed magnet will have an outside diameter of 20.4 m, an inner diameter available for tracking and calorimetry of 16.6 m, and a pole-to-pole inside length of 29 m. Other relevant parameters are: total stored energy of 2.04 GJ, operating current of 52.5 kA, discharge time of about 2 hours and an emergency discharge time of about 5 min. A of parameters is given in Table 1, the schematic drawing of the magnet is shown in Fig.1 and the corrsponding resolution of the muon measurement is shown in Fig.2.

Table 1. Major Parameters List

1.	Central induction	0.80	T
2.	Mean radius of windings	8.9	m
3.	Outer radius of outer cryostat vessel	9.45	m
4.	Inner radius of inner cryostat vessel	8.40	m
5.	Coil length, end-to-end (per half)	14.44	m
6.	Cryostat vessel length	30.0	m
7.	Conductor length (total)	24	km
8.	Number of turns	408	
9.	Total mass of coil windings (per half)	238	t
10.	Total mass of cryostat vessel (each half)	717	t
11.	Total mass of iron end pole (each)	2950	t
12.	Radial pressure on windings	255	kPa
13.	Inductance	1.47	H
14.	Number of ribs per coil assembly	3	
15.	Central membrane maximum z	0.025	m
16.	Winding minimum z	0.25	m
17.	Axial force on poles	63.5e6	N
18.	Axial force on conductor	27.9e6	N
19.	Magnet axis height above hall floor	13.0	m

The design team comprises magnet designers and engineers from the MIT Plasma Fusion Center, Lawrence Livermore National Laboratory and National High Magnetic Field Laboratory (Florida). In addition all aspects of the design have been scrutinized by the GEM Magnet Technical Panel convened by the SSCL to study issues related to the feasibility of technical concept, the cost estimate, proposed schedule and operational issues. The membership of the panel included national and international magnet design experts as well as representatives of major industrial firms. The Panel found the concept of GEM magnet to be feasible, the cost estimate to be credible and costraction schedule tight but possible. All present recommendations of the panel are incorporated in present design.

The magnet will be constructed from two independent sets of single layer windings. The coil will be wound on the inner side of the bobbin and each winding will be surrounded by a liquid nitrogen radiation shield. Details of the assembly are shown in Fig.3. The mechanical structure will have a central support membrane sandwiched between the two halves. The membrane will provide structural support for the coil and the cryostat as well as a support for the muon chambers and a tube containing calorimeters and the central tracker.

The cooling for the magnet coil will be obtained by the natural convection

flow provided by the thermal syphon method. The tubing attached to the outside of the coil bobbin will be connected to headers on the top and bottom to promote free convection. The system can handle all heat loads including thermal radiation, cold mass support conduction and heating in the area of conductor joints. The refrigeration system will be patterned on that of the accelerator.

There are several proposed conductor designs. All af them include standard niobium-titanium conductor with either copper or aluminium stabilizer. The designs differ in the liquid helium cooling arrangements ranging from passive to forced flow scheme. The choice of the conductor will be made based on its stability and the manufacturing scheme. High priority R&D program of conductor development and test will be initiated in the next few month. The design and costing is based at present on a high stability "cable-in-conduit" conductor with copper stabilizer.

The total cost of the magnet and its mechanical support system is estimated to be $95.1 M including 25% contingency. Major individual components of the cost estimate include engineering for subsystem design, coil bobbins, conductor, winding and tooling development, vacuum vessels, iron poles, power protection and control systems, and cryogenics and vacuum systems.

The iron magnet poles serve as field shaping components and not as a flux return. In the proposed design, there will be an unconstrained magnetic field in the experimental hall, access shafts and on the earth surface immediately above the interaction region. The fringe field and the corresponding forces on ferromagnetic forces has been calculated at all point in the hall, acess shafts and on the surface. using full 3-D modelling programs developped for plasma fusion confinement calculations. The field in the underground area will range from about 2 kgauss close to the magnet poles to a few hundred gauss at the end of the experimental hall. All the forces on the structural components of the hall, including crane rails and supporting structure appears to be small except in immediate vicinity of the poles. The surface field will have a maximum of about 40 gauss immediately above the detector and the 5 gauss perimeter will extend over the oval area of about 200 by 180 m. This field will require local shielding of operation and control areas on the surface and institution of special operational procedures for the GEM experiment. These procedures will be based on experiences gained at other large magnet facilities with unconstrained fields (MRI hospital installations, plasma fusion facilities, FNAL 15′ Bubble Chamber etc.). They will include restricted access to the detector with magnet on, securing ferromagnetic objects in the hall, etc. Local shielding of specialized equipment may be needed, although most of the problems associated with equipment working in a magnetic field can be minimized by the choice of less sensitive components, alignment with respect to the field lineds. The surface area affected by the magnetic field will be inaccessible to the public. A proposal to shield the surface with a 15 cm thick iron plate appears to be a possible and cost effective backup scheme.

The magnet represents a critical path item in the GEM detector construction schedule. The experiment has to be completed at the beam turn-on time. The construction schedule derived with this constraint, requires that the magnet should be manufactured, assembled and tested in the experimental hall before the end of April 1997. Rapid progress mandated by such an aggressive construction schedule requires timely completion of the engineering design studies and an early decision on the manufacturing scheme. In particular, intensive studies of the conductor and its stabilizer and of the winding scheme and the associated tooling are part of the FY92 R&D proposal. The manufacturing scheme requires also availability of the surface fabrication hall in 1993 and early definition and implementation of procurement strategy.

Additional design work on the improvement of the momentum resolution at larger values of rapidity is also initiated. Here,the most promissing option is a modification of the shape of the iron pole to concentrate magnetic field flux at small angles.

Fig.1 Schematic drawing of the magnet.
Fig.2 Momentum resolution of muons with p_t= 500 GeV as function of the pseudorapidity.
Fig.3 Details of the magnet coil assembly.

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Fig.1 Schematic drawing of the magnet.
Fig.2 Momentum resolution of muons with p_t= 500 GeV as function of the pseudorapidity.
Fig.3 Details of the magnet coil assembly.

Superconducting Super Collider Laboratory
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Dallas TX 75237-3946
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Physics Research Division

Memorandum

91 5840 M P _ _ _ _

To: Roy Schwitters
From: Fred Gilman
Subject: Report of the GEM Magnet Panel
Date: October 31, 1991

Attached to this memo is the report of the third meeting of the GEM Magnet Panel that occurred on October 10 - 11, 1991. It constitutes the final report of the Panel and summarizes the results of all three meetings.

In the course of its meetings the Panel considered four options for the baseline magnet concept: a single-coil solenoid without iron flux return; a single-coil solenoid with an iron plate on the surface of the earth; a single-coil solenoid with a barrel-shaped iron flux return; and a double-coil solenoid.

The single-coil solenoid without iron flux return is the preferred option recommended by the Panel because of cost, schedule, and technical risk. The estimated total cost for this option is about $94M; they find that the associated manpower and schedule are credible and that the magnetic forces on the structural steel elements in the hall do not impose significant constraints.

The iron plate at the surface could be considered as a back-up if a magnetic field at the surface (about 35 Gauss directly above the center of the magnet 50 meters below) proves to be unacceptable. Its cost is estimated at $5M to $10M for covering an area of about 160 meters by 200 meters with a tapered plate that reduces the field below 10 Gauss.

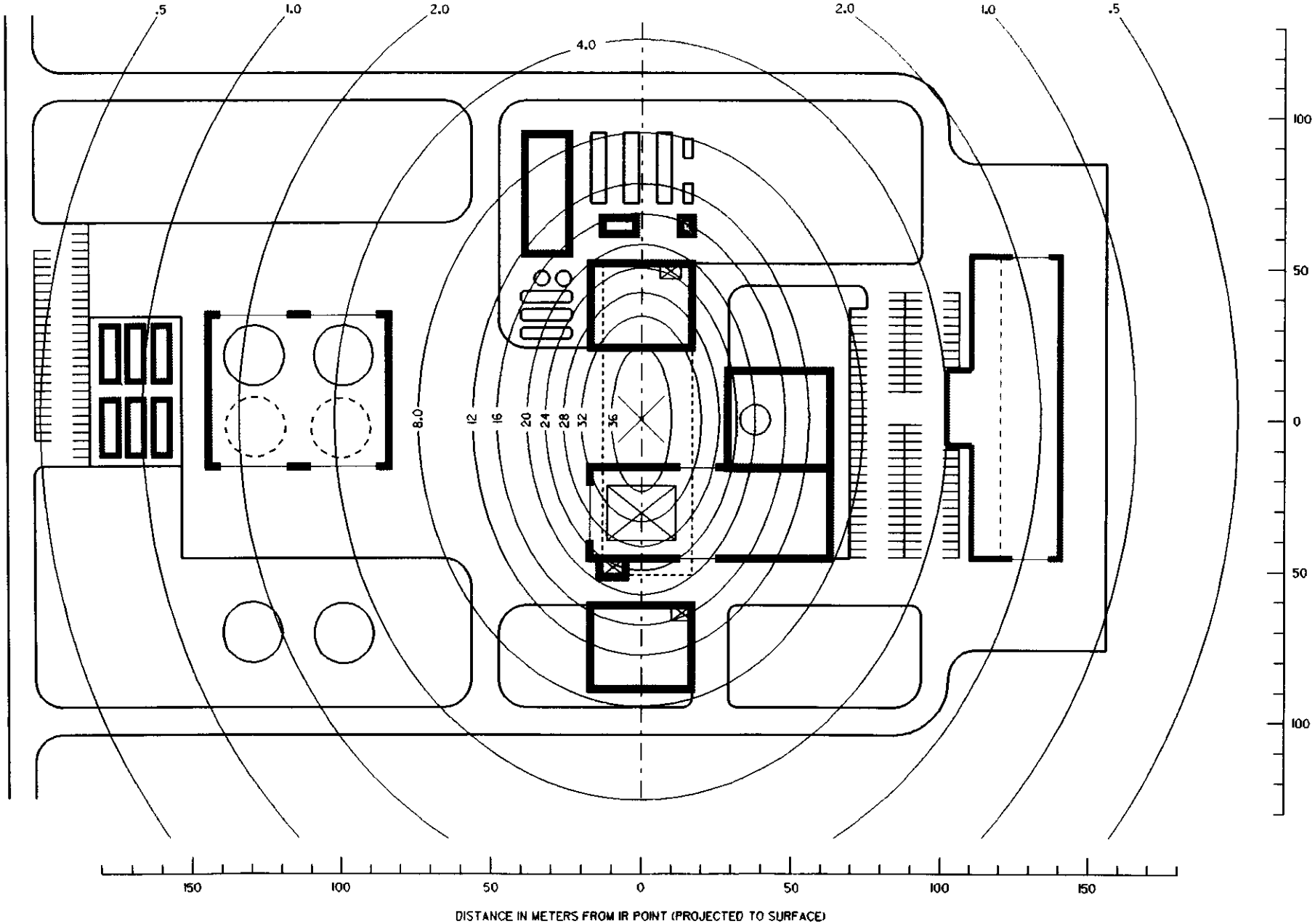
The double-coil solenoid would cost about $197M on the same basis, take 6 to 8 months longer to construct, and have significantly greater technical risk. Within the option of having a barrel-shaped iron flux return, two versions were considered: 1.3 meters thickness (an extra 20 kilotonnes, limiting the surface field to less than 10 Gauss) and 2.0 meters (an extra 36 kilotonnes, limiting the surface field to less than 1 Gauss). The first version would cost an extra $55M and the second version an extra $99M. The schedule impact is estimated at 3.5 to 6 months. Aside from cost and schedule impact, the presence of the iron flux return would reduce the capabilities for obtaining better muon momentum resolution in a potential future upgrade that adds additional chambers outside the magnet.

The Laboratory will now have to make a decision as to whether to proceed on the recommended path. To do so, a statement is needed of the Laboratory's position on the magnitude of the magnetic field permitted at the surface. It appears that the single coil solenoid without flux return can be operated within all known regulations. Other large magnet facilities without flux returns have operated, including those with magnets at the earth's surface, and they have done so within existing ES&H regulations and in a safe manner.

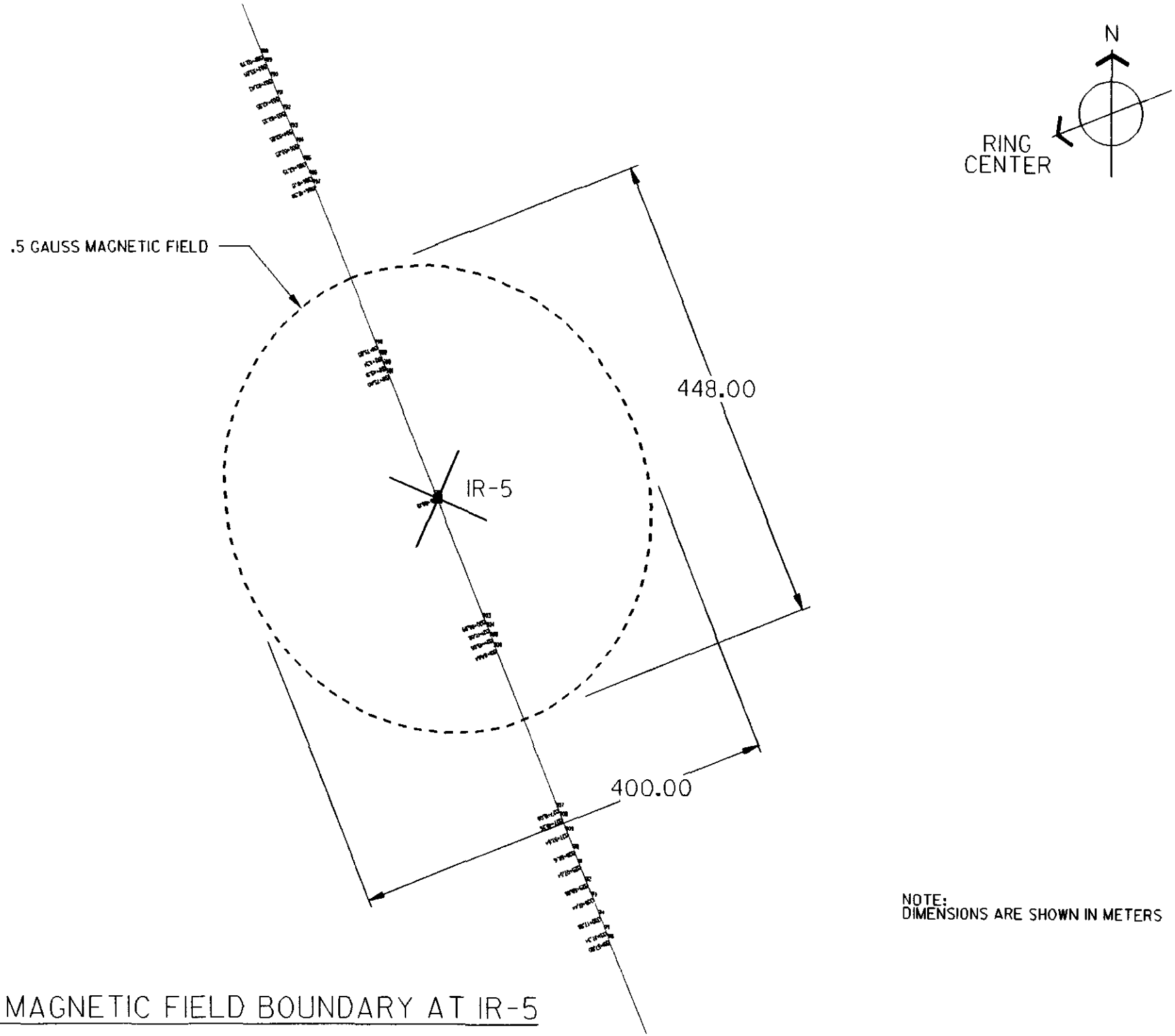
If the single coil solenoid with or without a surface plate is given the go-ahead, we will have to move quickly. To meet the GEM schedule, the design of the coil-winding/assembly building should start already this calendar year, and within FY1992 we need to carry out substantial engineering design/R&D for the magnet and the associated conductor.

Attachment: Report of the GEM Magnet Panel

cc: E. Siskin
P. Reardon
R. Stefanski
Central Files

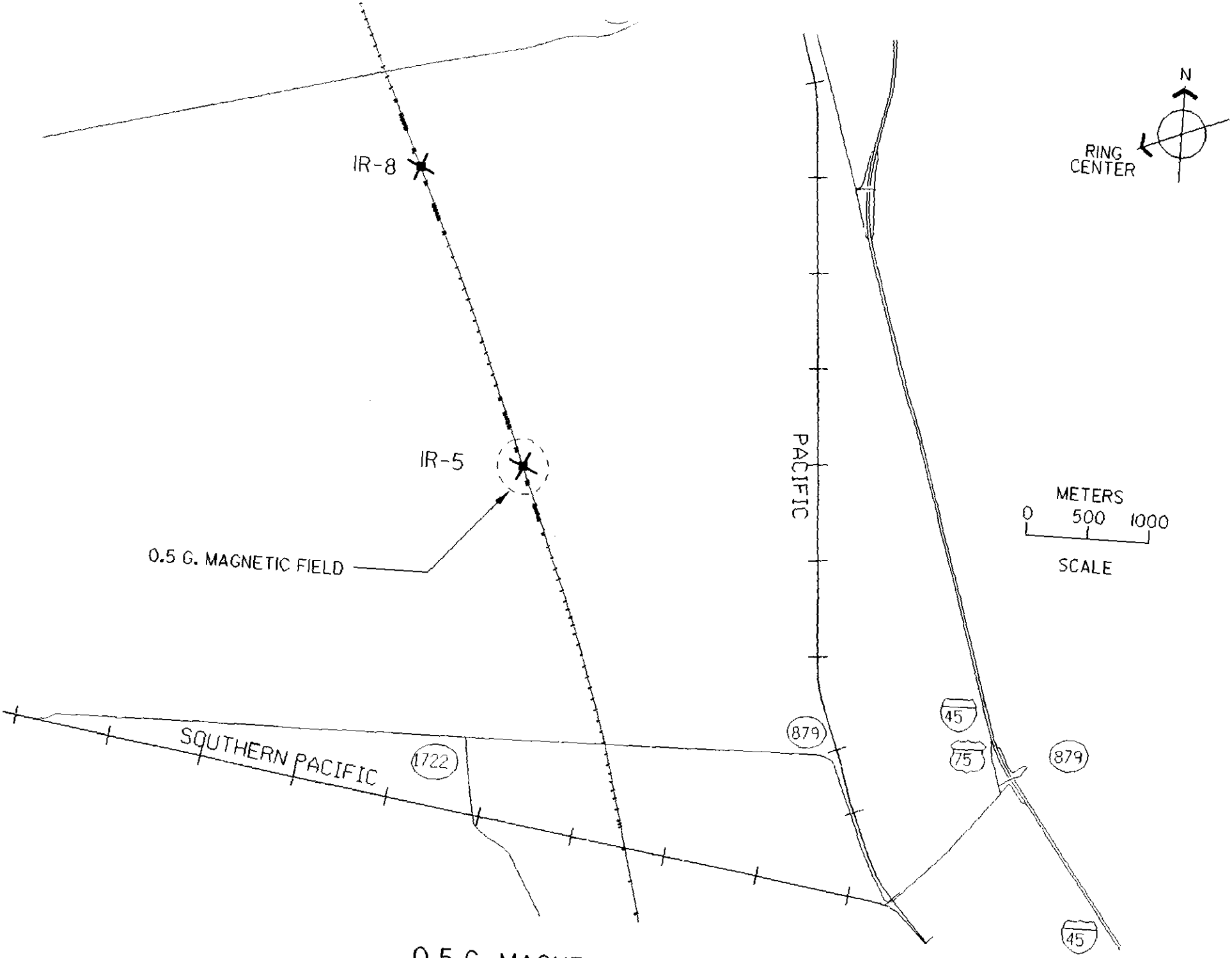


MAGNETIC FIELD PATTERN AT GEM SURFACE FACILITIES



NOTE:
DIMENSIONS ARE SHOWN IN METERS

.5 G. MAGNETIC FIELD BOUNDARY AT IR-5



0.5 G. MAGNETIC FIELD AT IR-5

FRINGE FIELD CALCULATIONS FOR THE GEM DETECTOR FOR SSC

R. D. Pillsbury, Jr.

Plasma Fusion Center
Massachusetts Institute of Technology
Cambridge, MA 02139

maximum
force on coils
coil = 1.5 g

SUMMARY

- **Fringe Fields**

- **Electromagnetic Forces**

  - **Lorentz Forces** – $\vec{I} \times \vec{B}$
  - **Forces Iron – Pole Pieces, etc**
  - **Fringe Field Interactions – Aligned Dipoles**
  - **Fringe Field Interactions – Arbitrary Dipoles**
  - **Eddy Current Forces** – $\frac{\partial \vec{B}}{\partial t}$

FORCE AND TORQUE ON A DIPOLE

$$\vec{F} = (\vec{m}_m \cdot \vec{\nabla})\vec{B}$$

$$\vec{T} = \vec{m}_m \times \vec{B}$$

where for a uniformly magnetized body

$$\vec{m} = \frac{\vec{M}}{Vol}$$

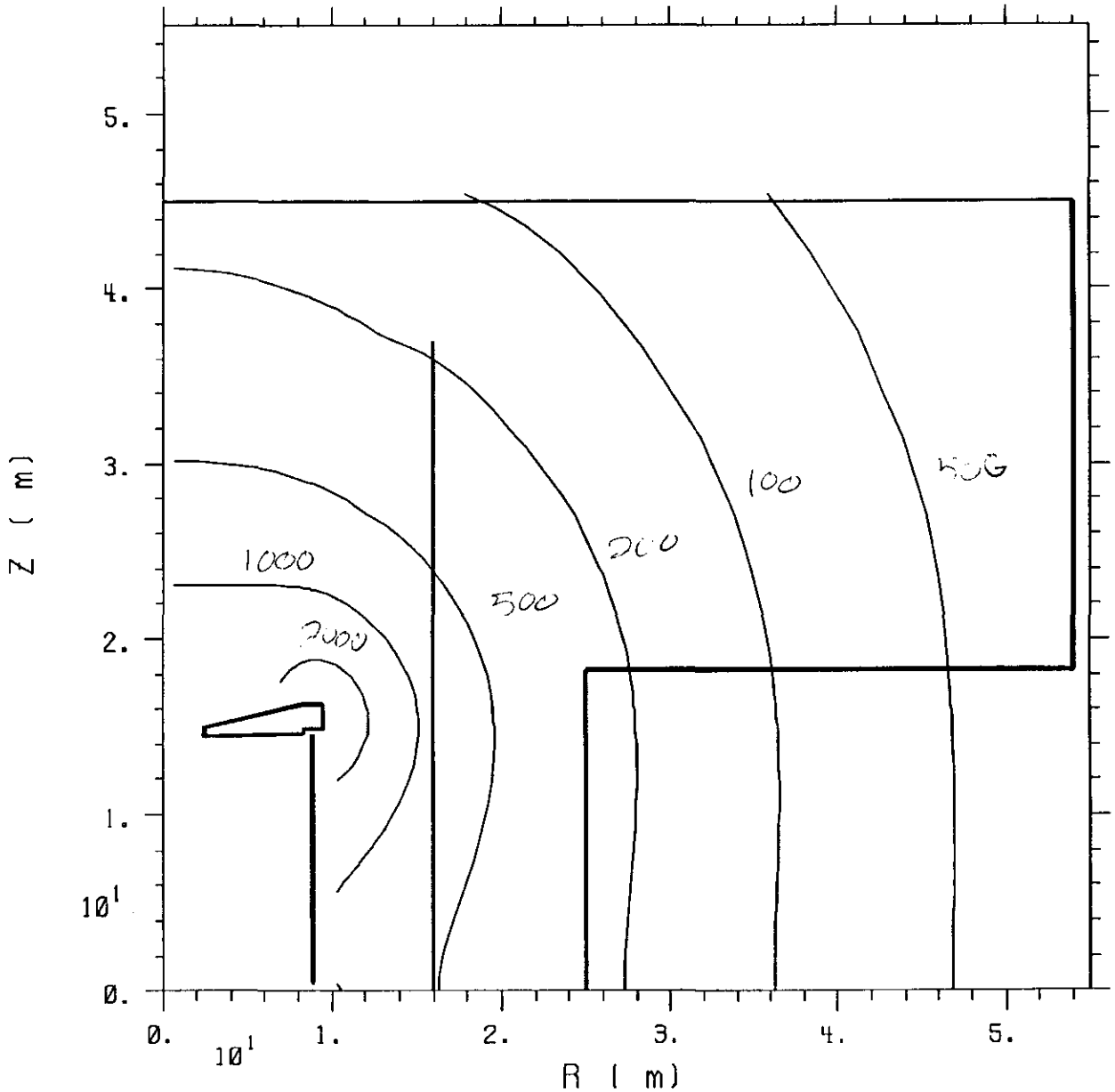
If magnitization direction is known then

$$\vec{M} = \frac{\vec{B}_{sat}}{\mu_o}$$

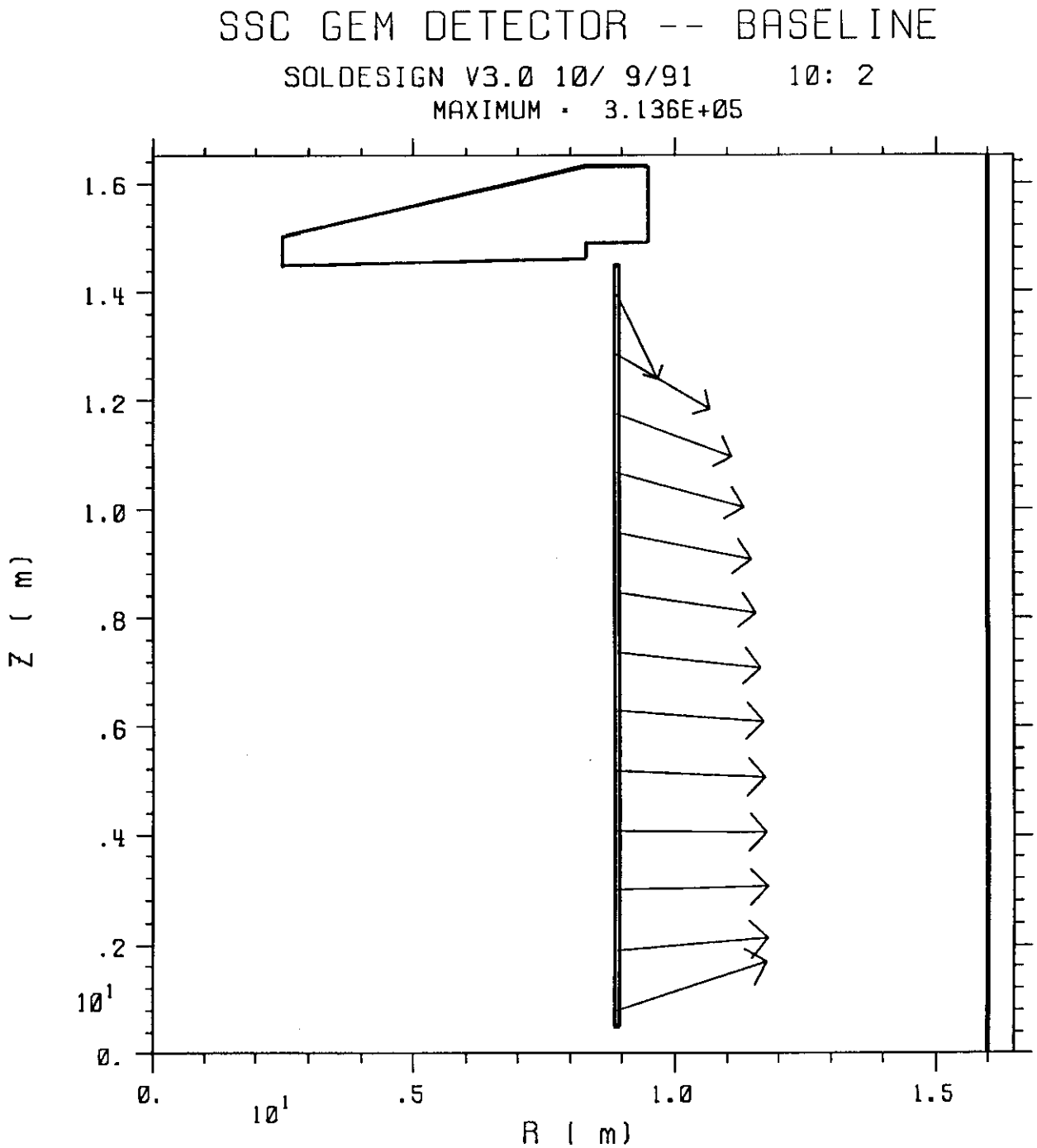
SSC GEM DETECTOR -- BASELINE OPTION

SOLDESIGN V3.0 10/ 8/91 8: 8

Contour 1 = 1.000E+00



FRINGE FIELD


SSC GEM DETECTOR -- BASELINE
SOLDESIGN V3.0 10/ 9/91 10: 2
MAXIMUM = 3.136E+05
1.6
1.4
1.2
1.0
.8
.6
.4
.2
10¹
0.
Z (m)
0.
10¹
.5
1.0
1.5
R (m)

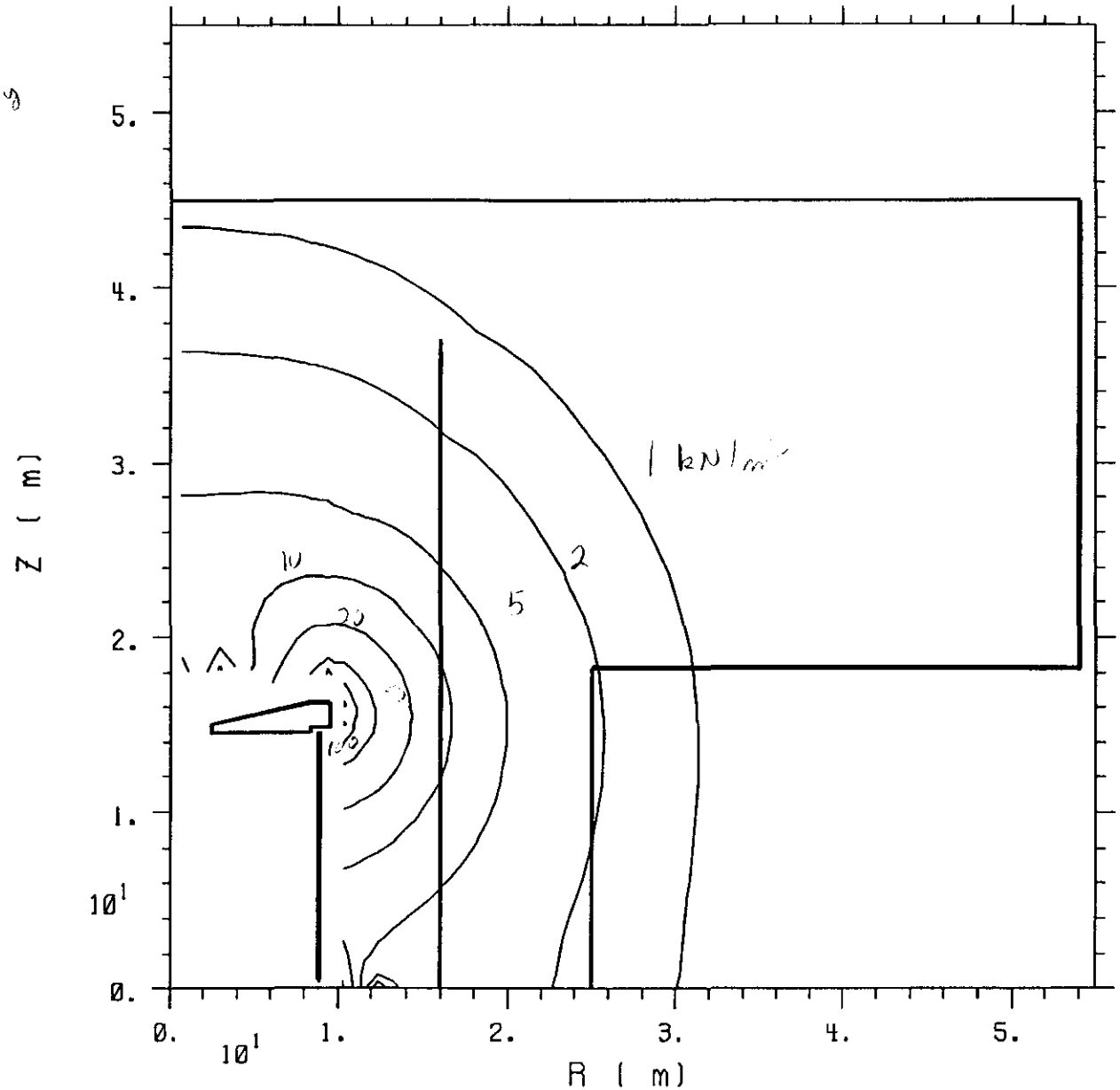
SSC GEM DETECTOR -- BASELINE OPTION

SOLDESIGN V3.0 10/ 8/91 8: 8

Contour 1 = 1.000E+03

g = acc of gravity

10 kNt/m² = 1.2g

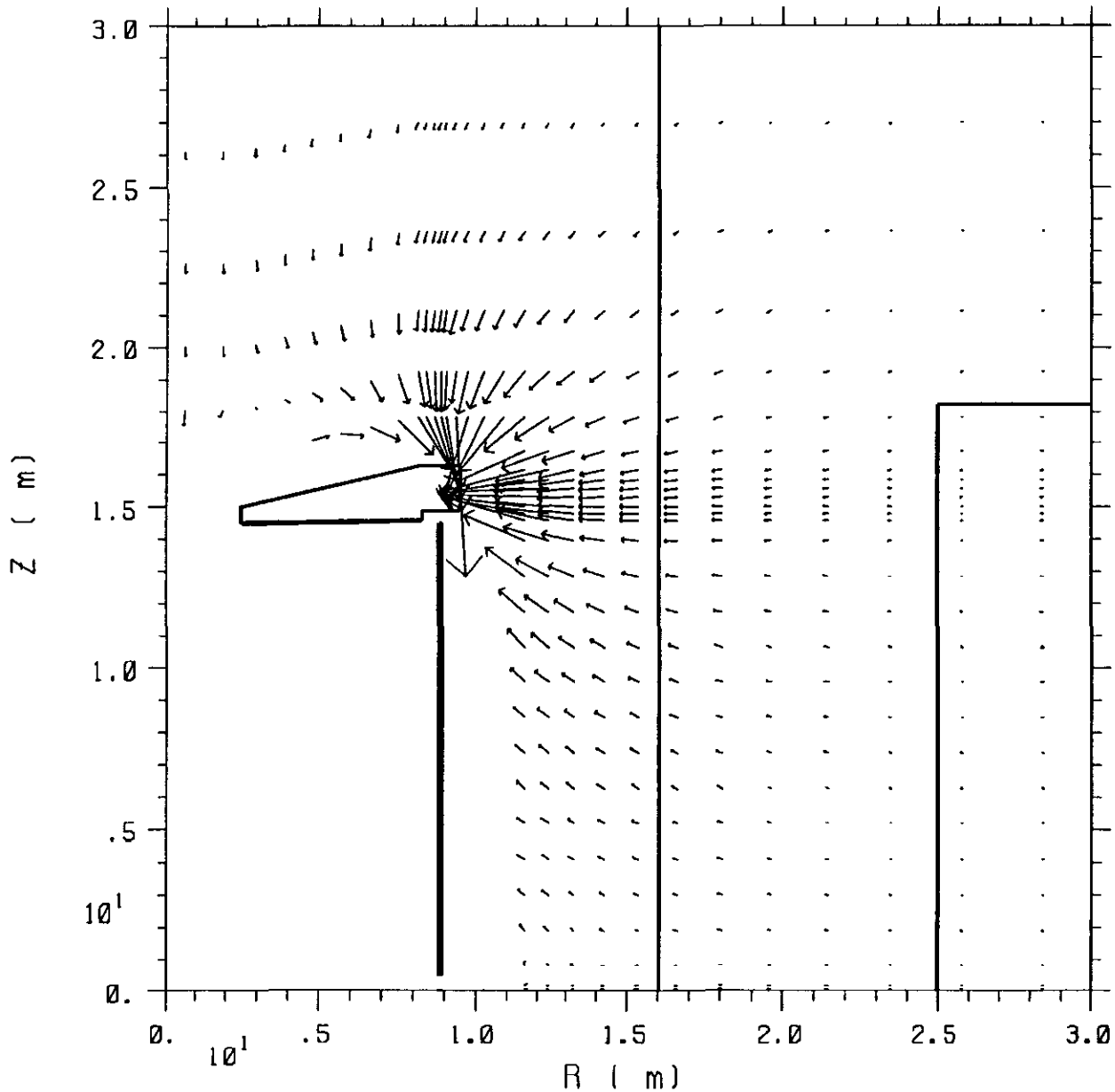


BODY FORCE DENSITY

SSC GEM DETECTOR -- BASELINE OPTION

SOLDESIGN V3.0 10/ 8/91 8: 8

MAXIMUM = 1.218E+05



SSC GEM DETECTOR -- BASELINE

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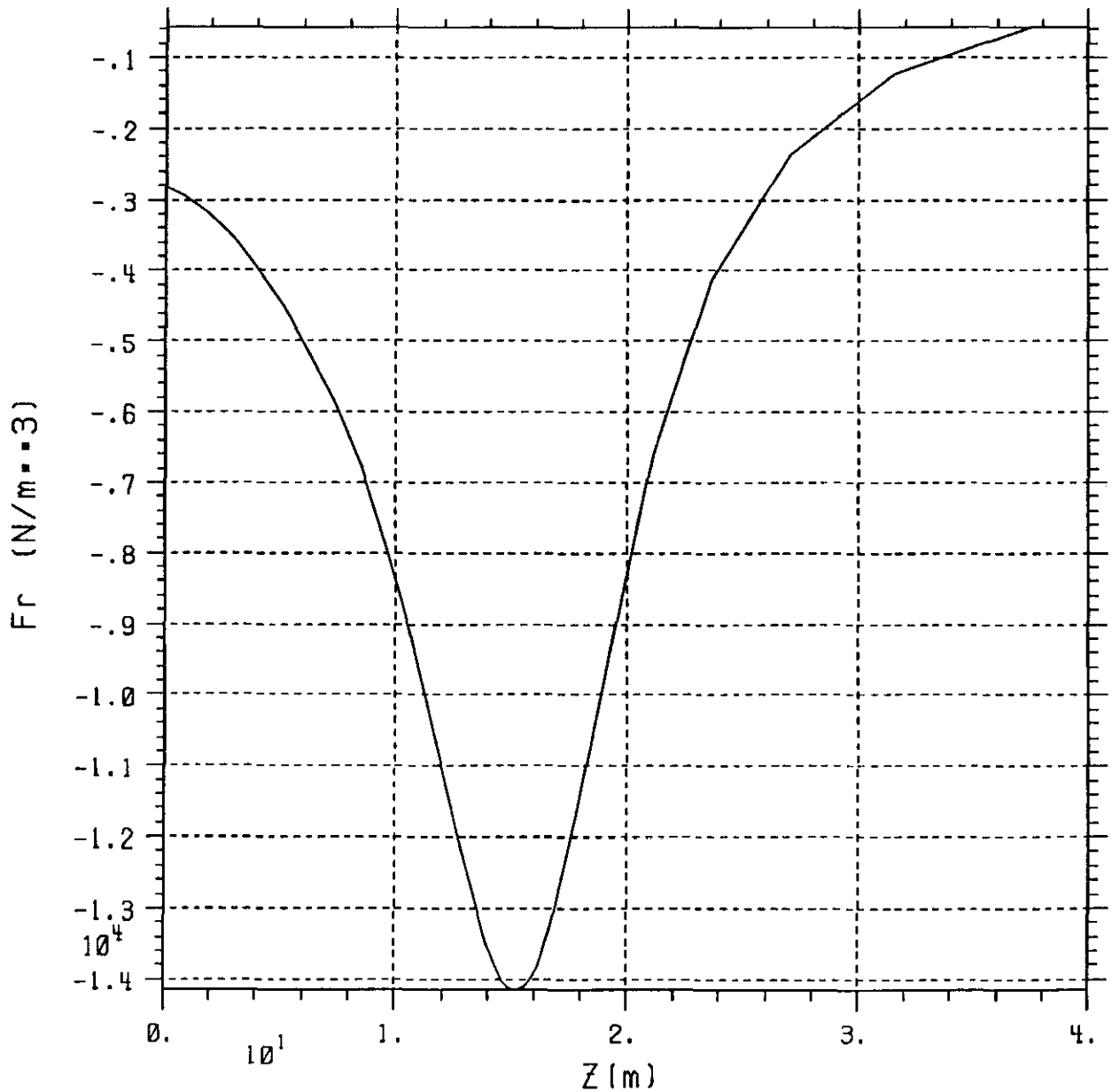
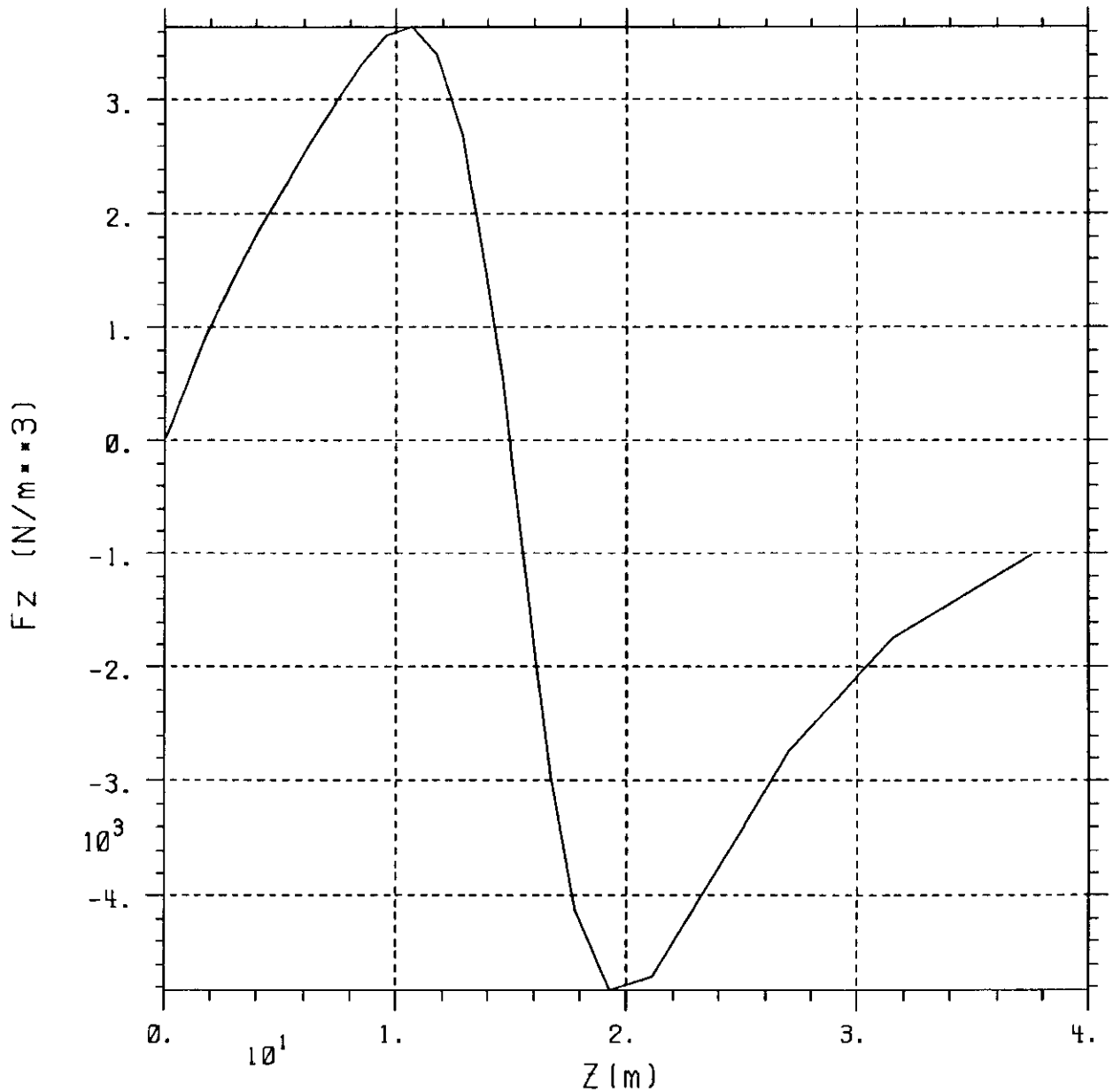


SSC GEM DETECTOR -- BASELINE

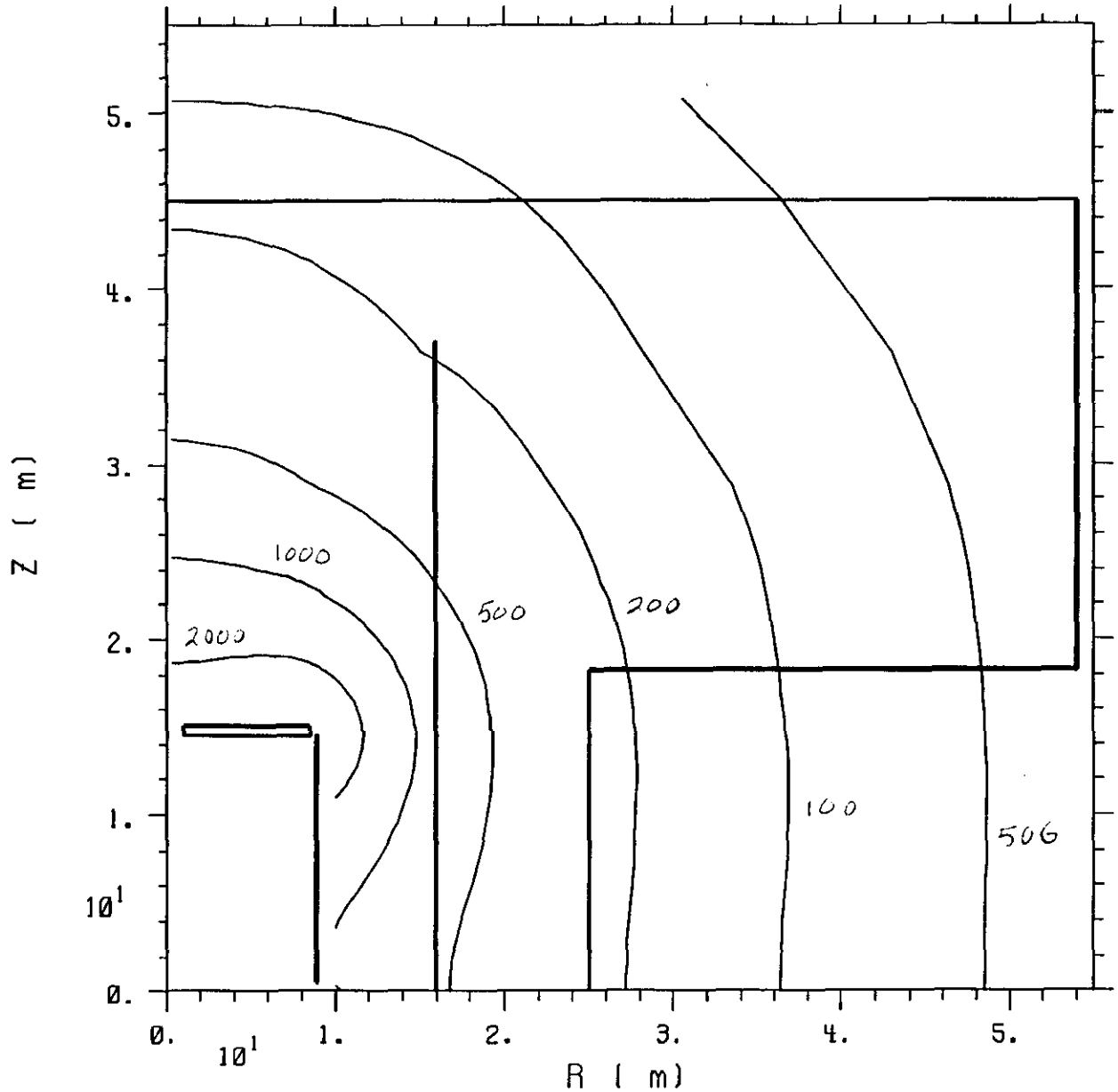
SOLDESIGN V3.0 10/ 8/91 15:46



SSC GEM DETECTOR -- THIN OPTION

SOLDESIGN V3.0 10/ 7/91 15:59

Contour 1 • 1.000E+00

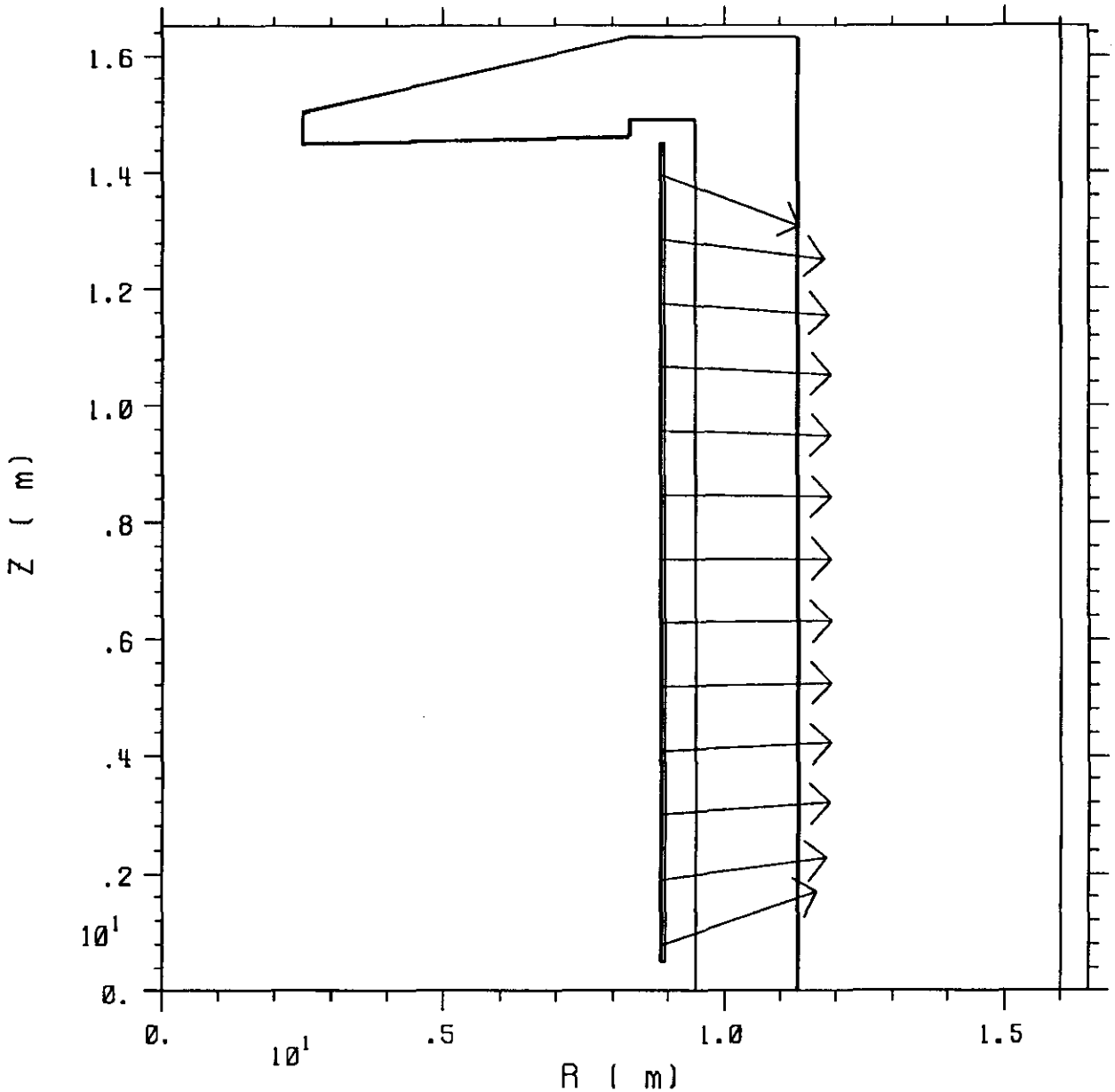


FRINGE FIELD

SSC GEM DEECTOR -- BASELINE W/ SHIELD

SOLDESIGN V3.0 10/ 9/91 10: 5

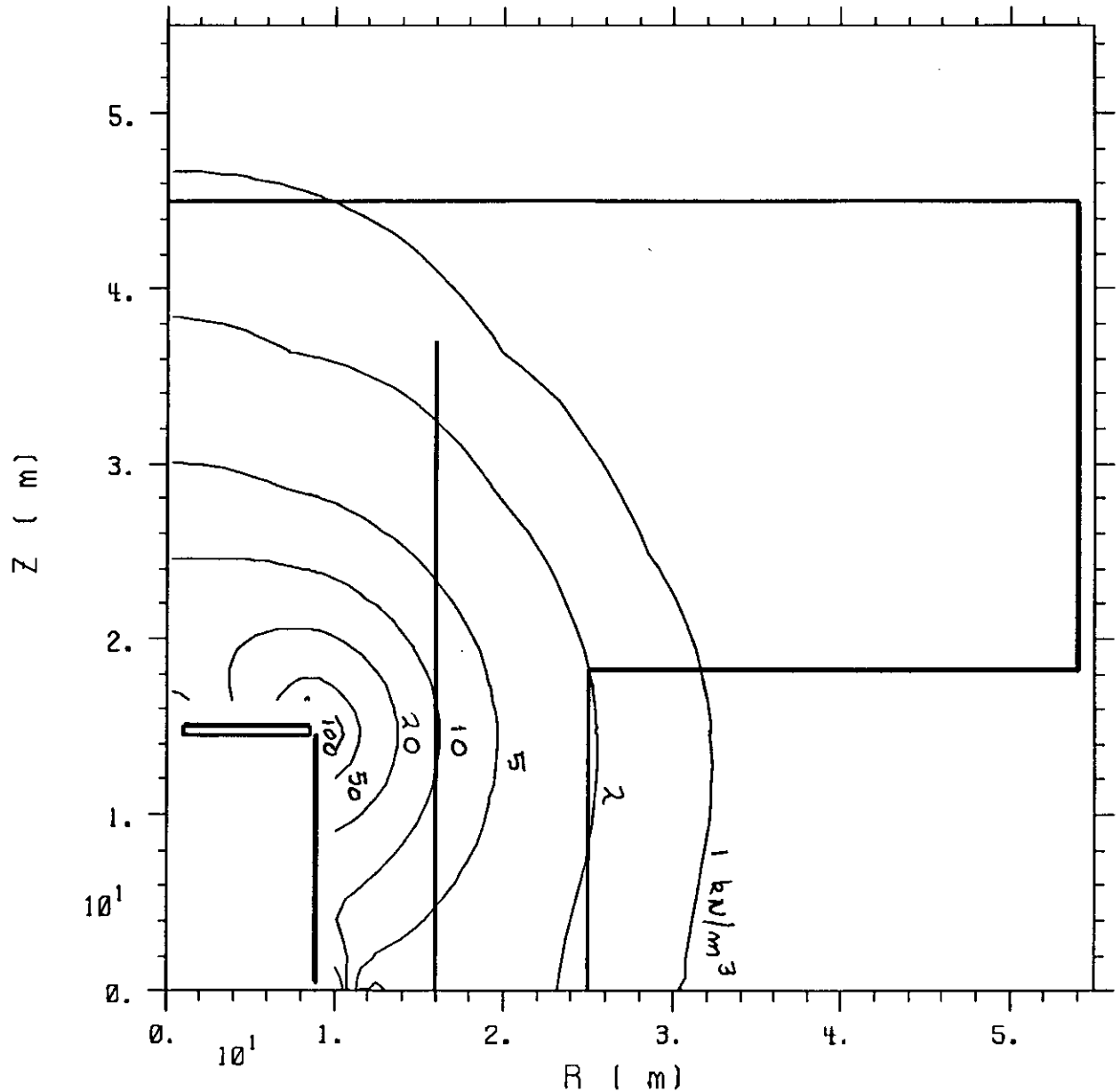
MAXIMUM = 3.008E+05



SSC GEM DETECTOR -- THIN OPTION

SOLDESIGN V3.0 10/ 7/91 14:47

Contour 1 : 1.000E+03

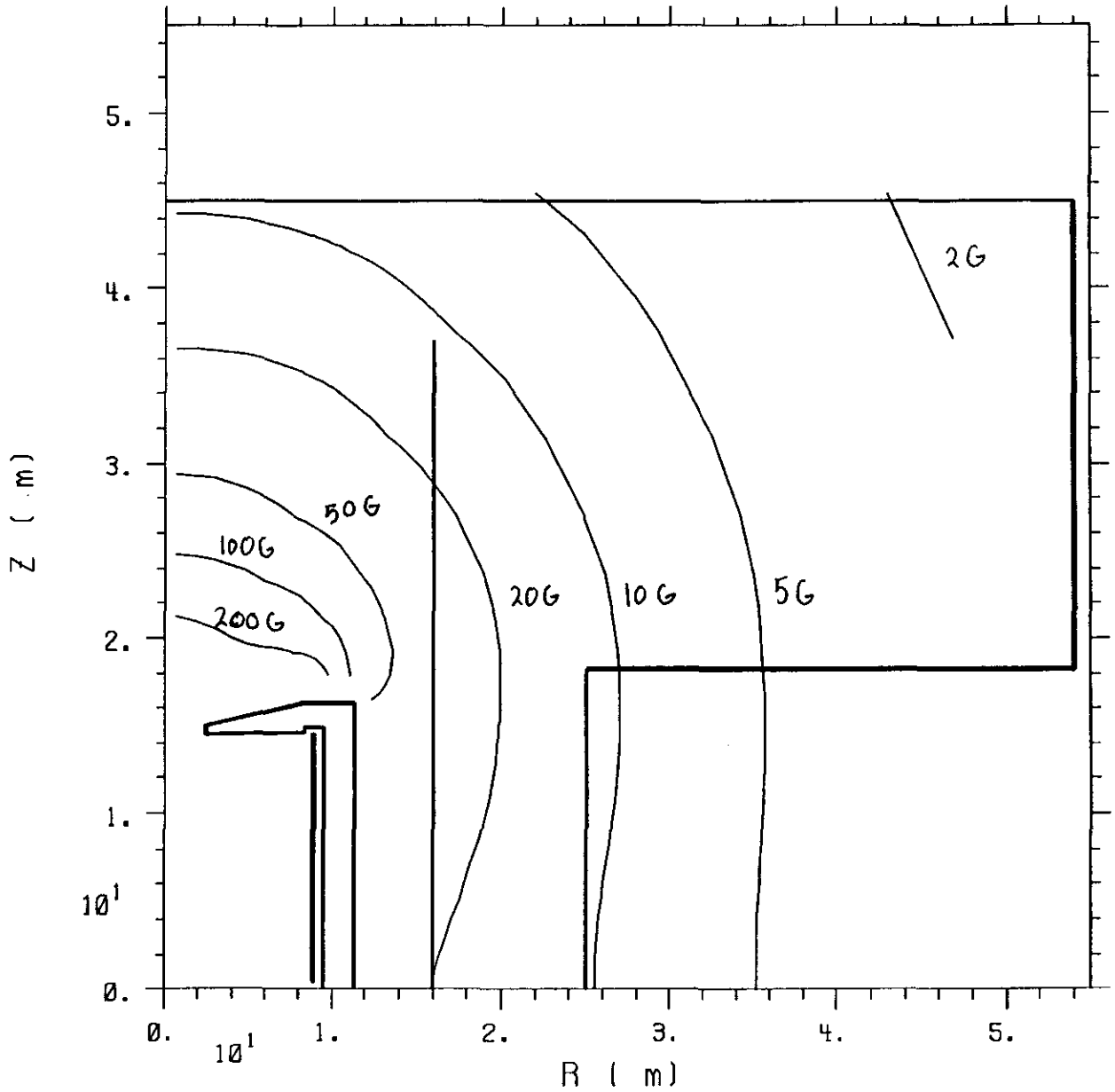


BODY FORCE DENSITY

SSC GEM DETECTOR -- BASELINE W/ SHIELD

SOLDESIGN V3.0 10/ 8/91 17:24

Contour 1 = 1.000E+00

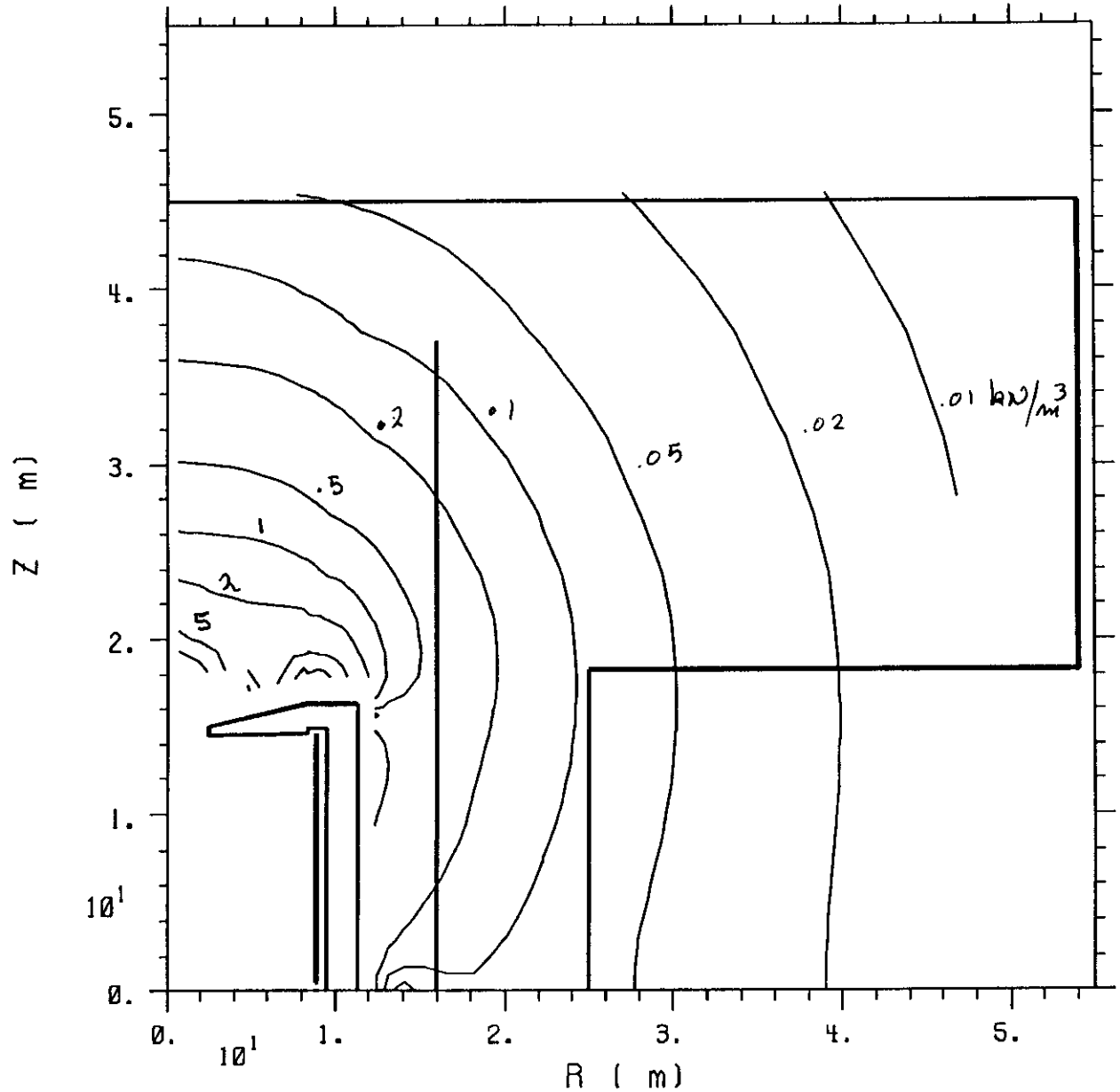


FRINGE FIELD

SSC GEM DETECTOR -- BASELINE W/ SHIELD

SOLDESIGN V3.0 10/ 8/91 17:24

Contour 1 = 1.000E+01

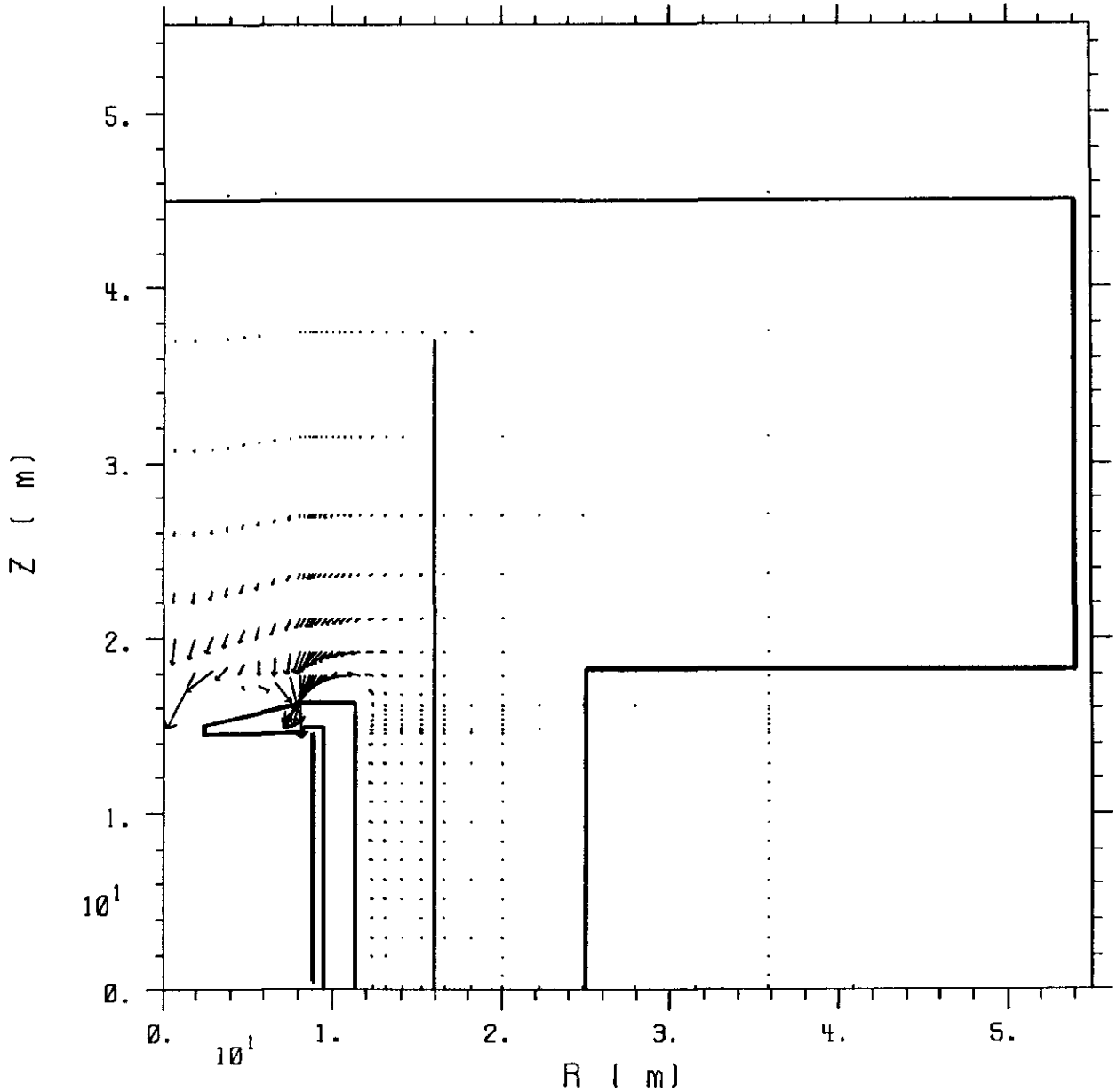


BODY FORCE DENSITY

SSC GEM DETECTOR -- BASELINE W/ SHIELD

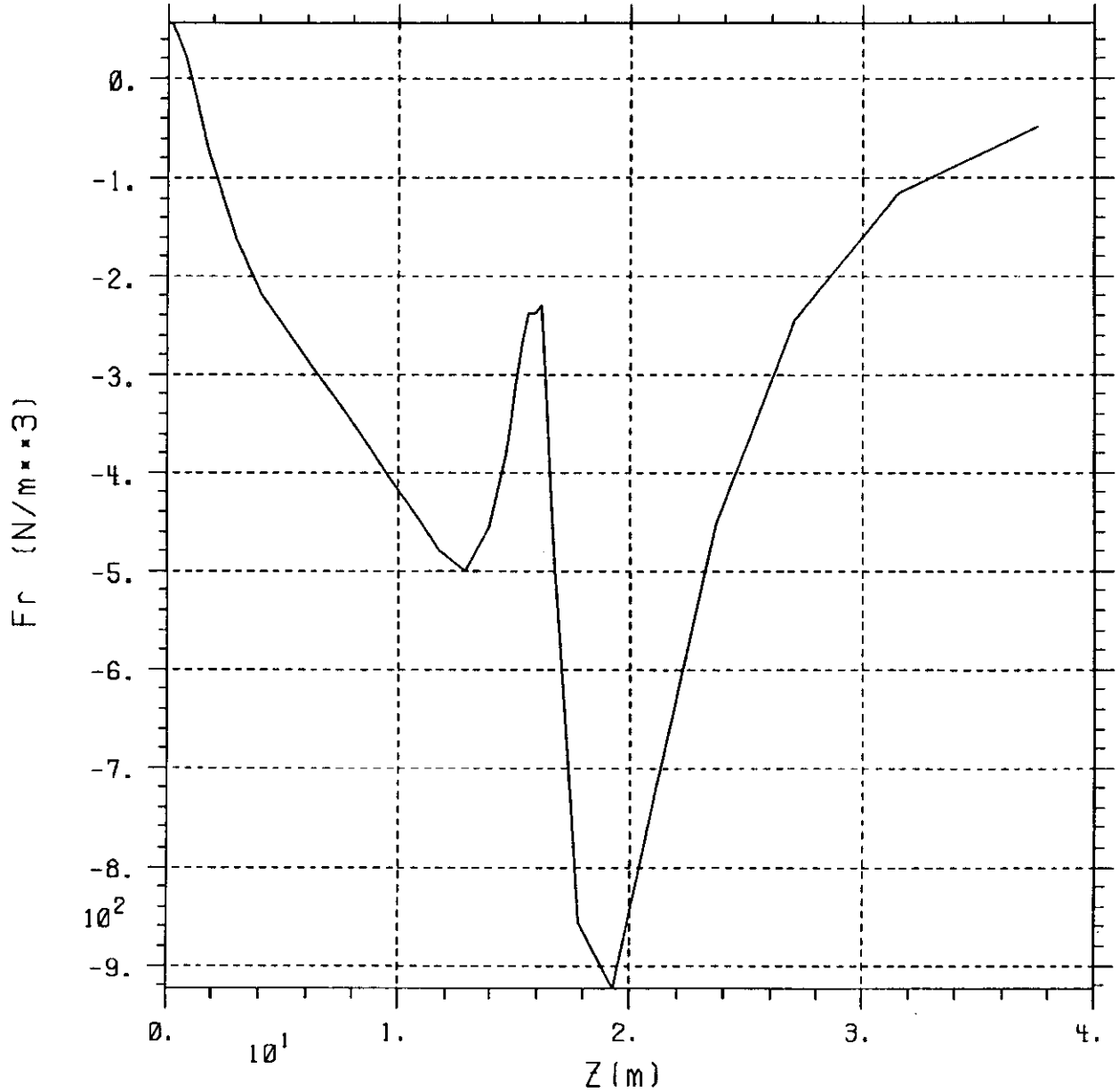
SOLDESIGN V3.0 10/ 8/91 17:24

MAXIMUM = 1.823E+04



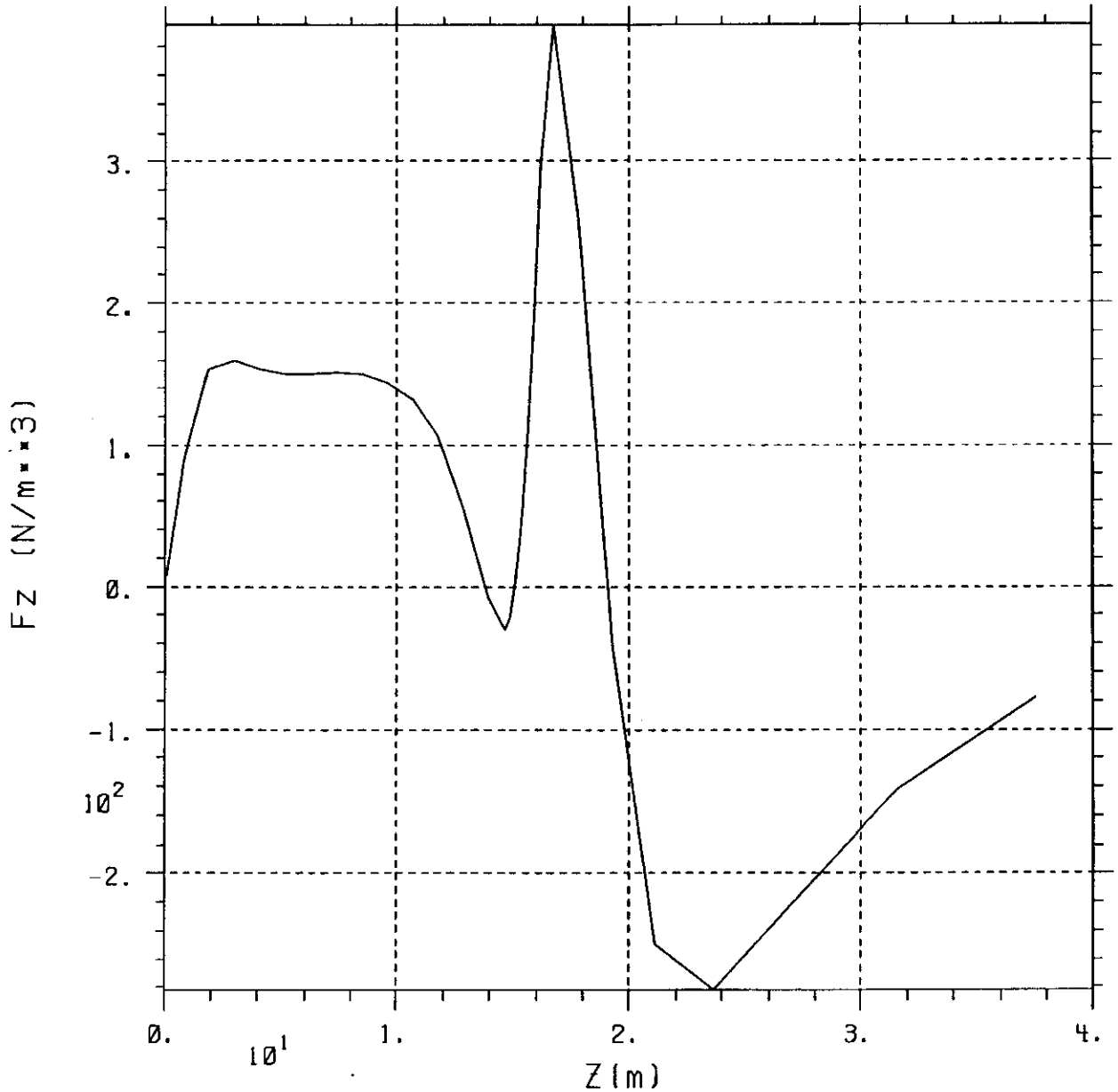
SSC GEM DETECTOR -- BASELINE W/ SHIELD

SOLDESIGN V3.0 10/ 8/91 17:24



SSC GEM DETECTOR -- BASELINE W/ SHIELD

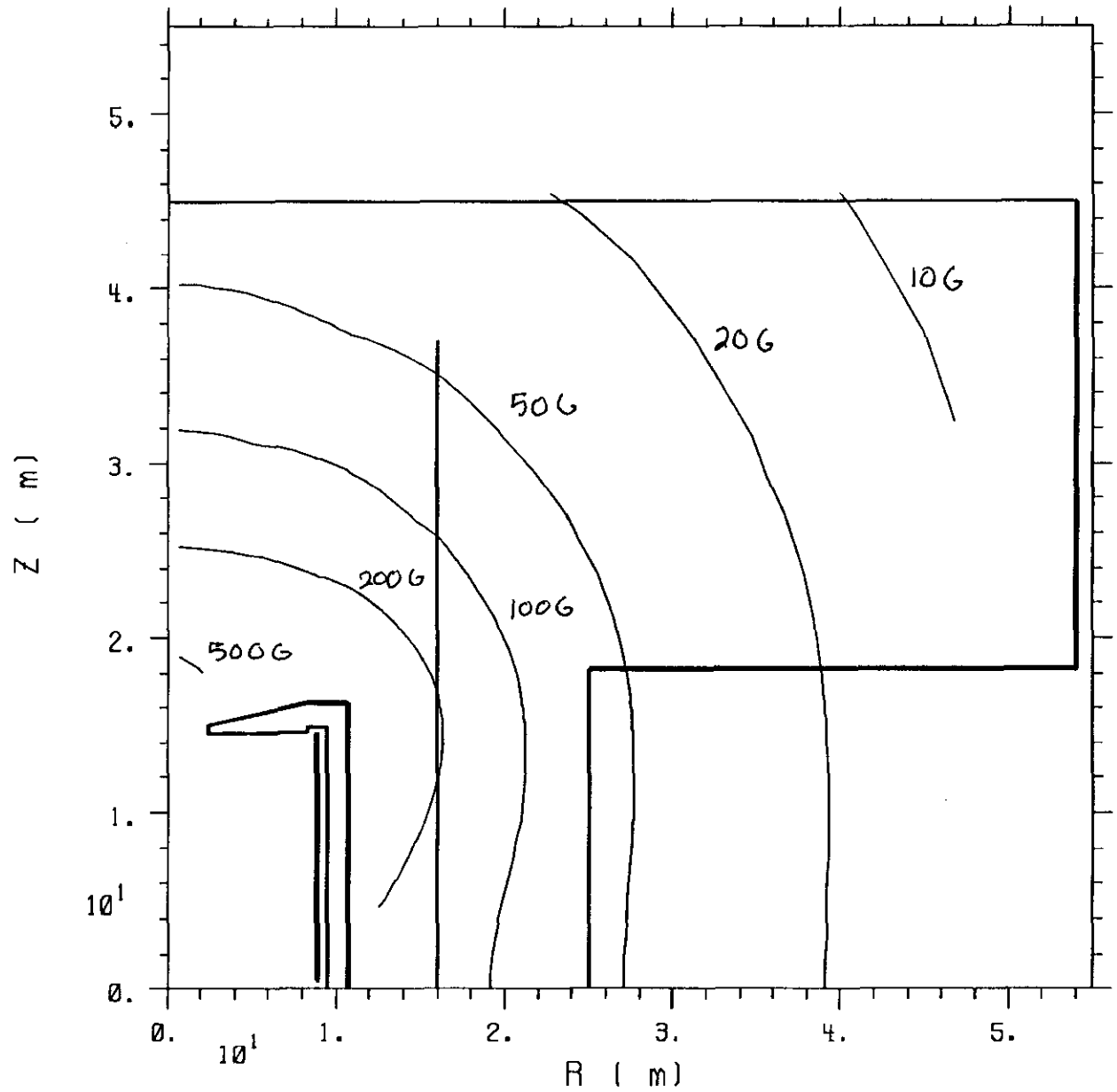
SOLDESIGN V3.0 10/ 8/91 17:24



SSC GEM DETECTOR -- BASELINE 1.2m SHIELI

SOLDESIGN V3.0 10/ 9/91 13:31

Contour 1 = 1.000E+00

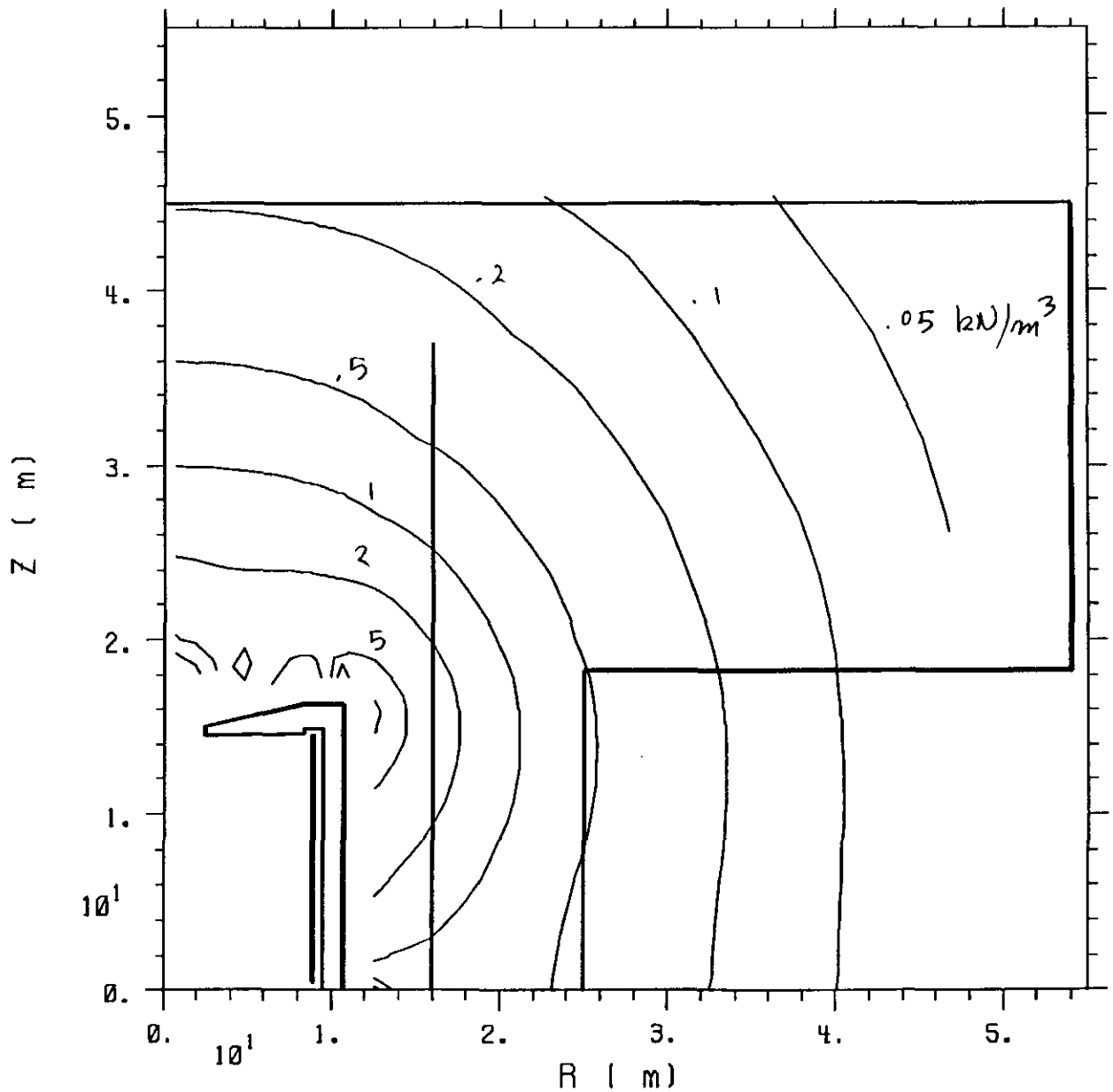


FRINGE FIELD

SSC GEM DETECTOR -- BASELINE 1.2m SHIELI

SOLDESIGN V3.0 10/ 9/91 13:31

Contour 1 · 1.000E+01

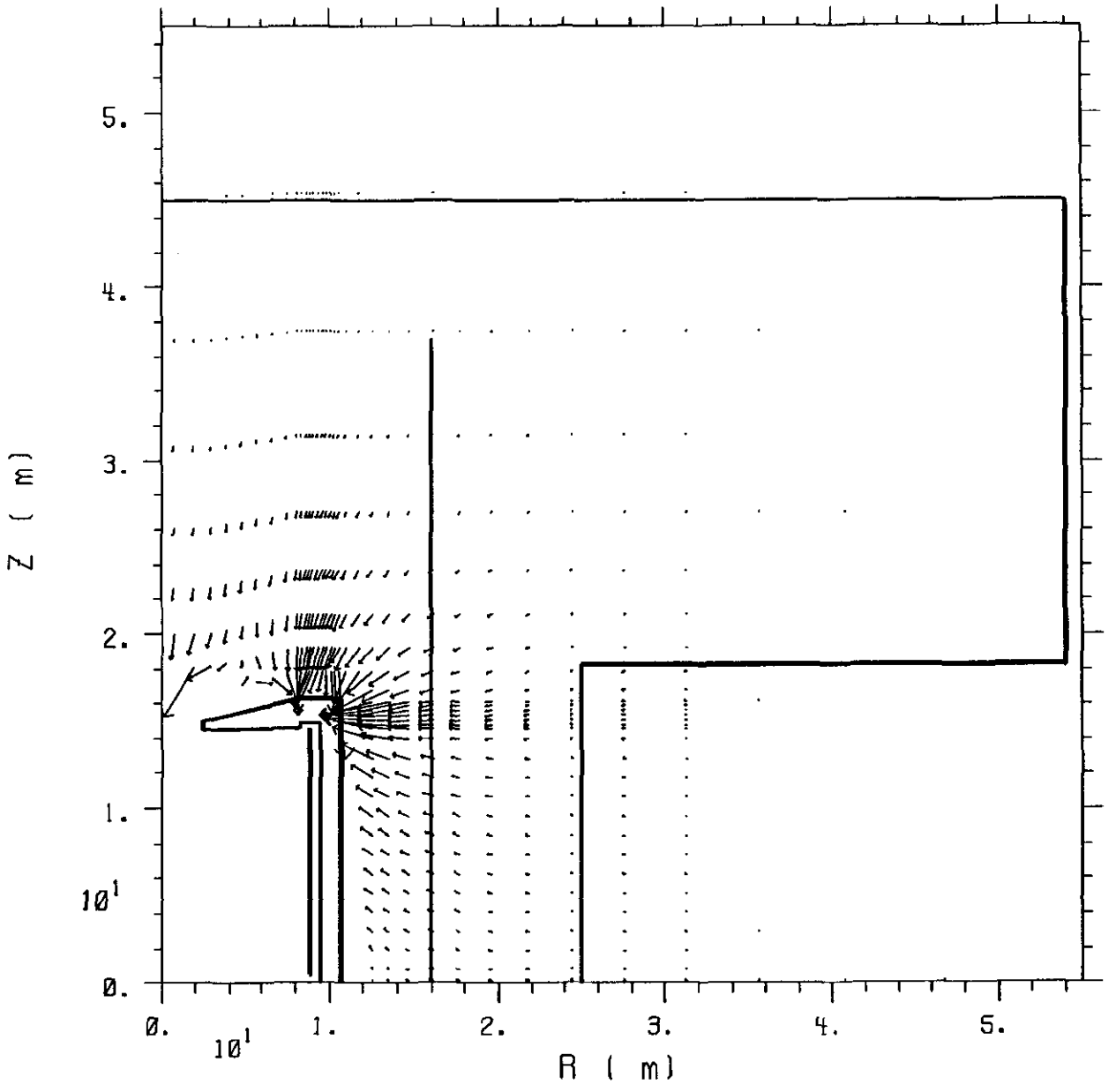


BODY FORCE DENSITY

SSC GEM DETECTOR -- BASELINE 1.2m SHIEI

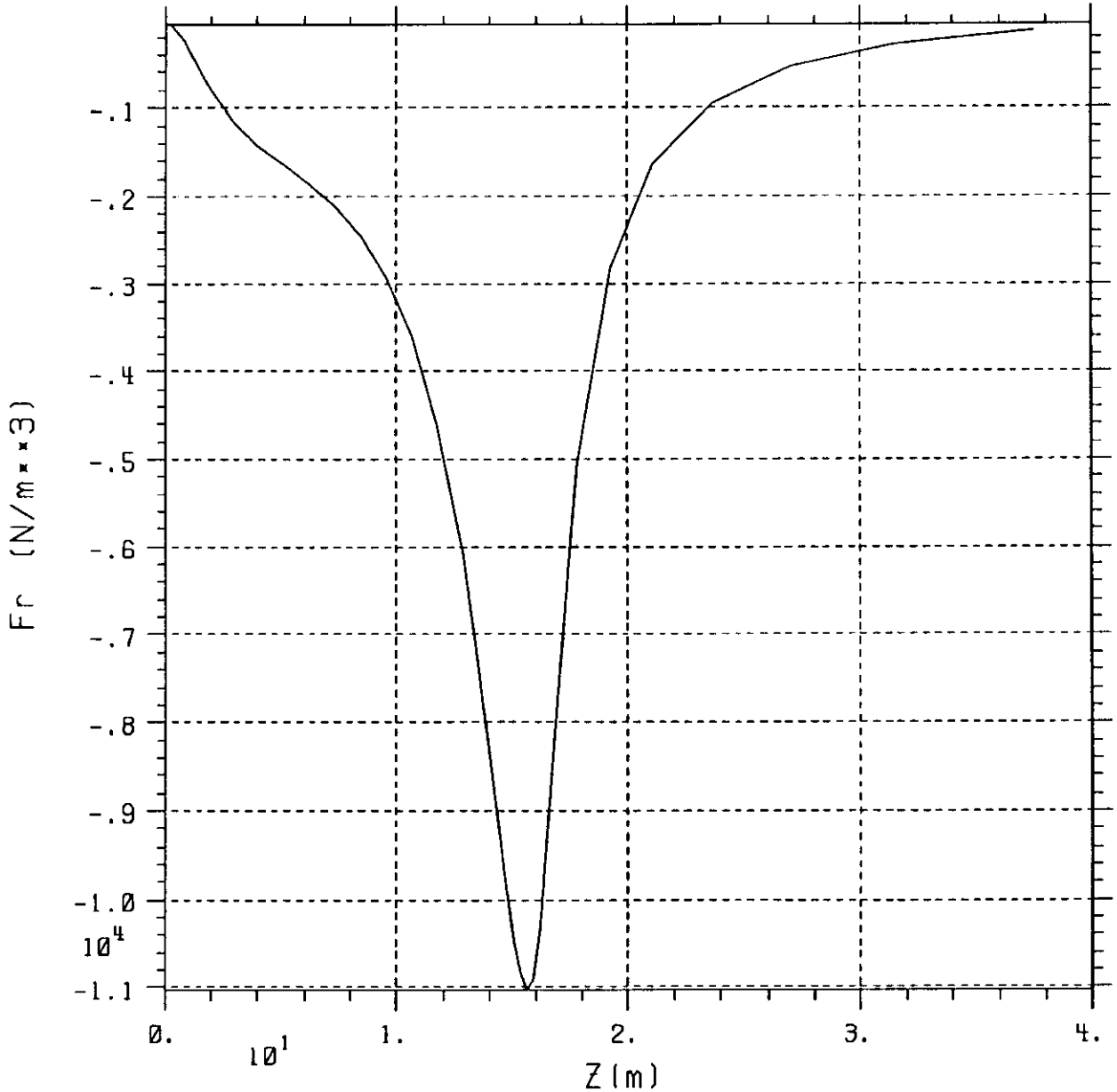
SOLDESIGN V3.0 10/ 9/91 13:31

MAXIMUM = 1.764E+04



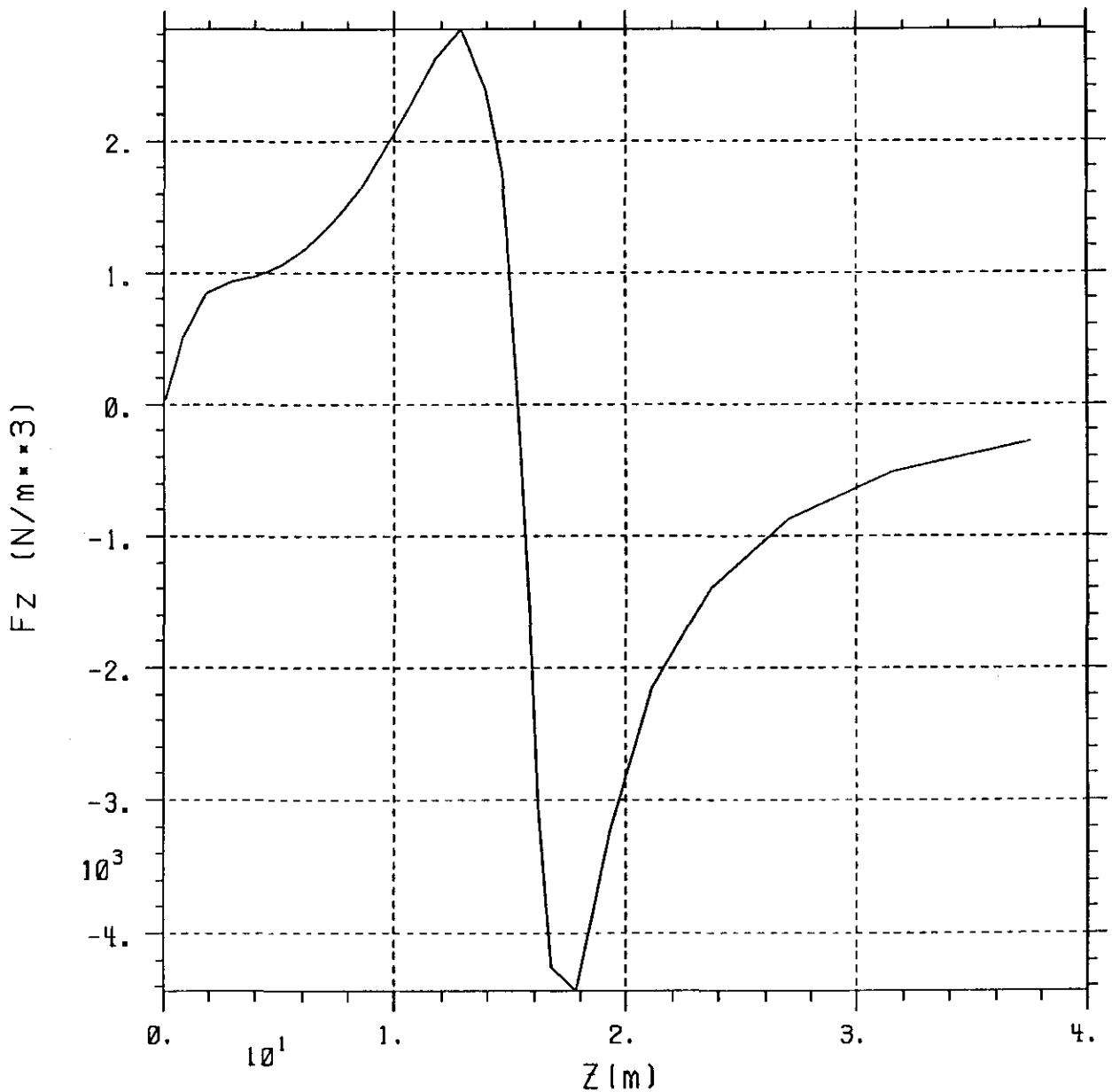
SSC GEM DETECTOR -- BASELINE 1.2m SHIEI

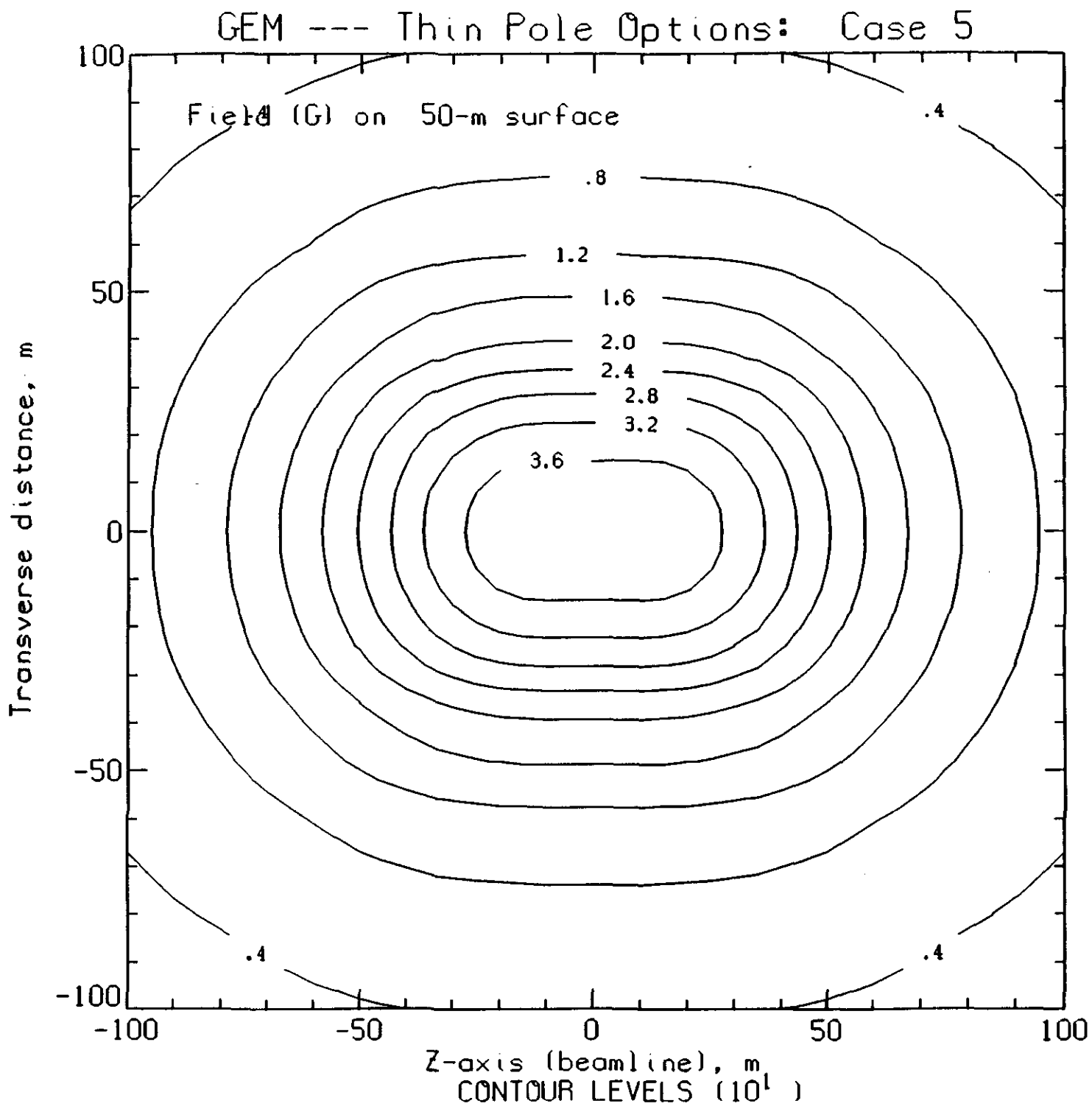
SOLDESIGN V3.0 10/ 9/91 13:31



SSC GEM DETECTOR -- BASELINE 1.2m SHIEI

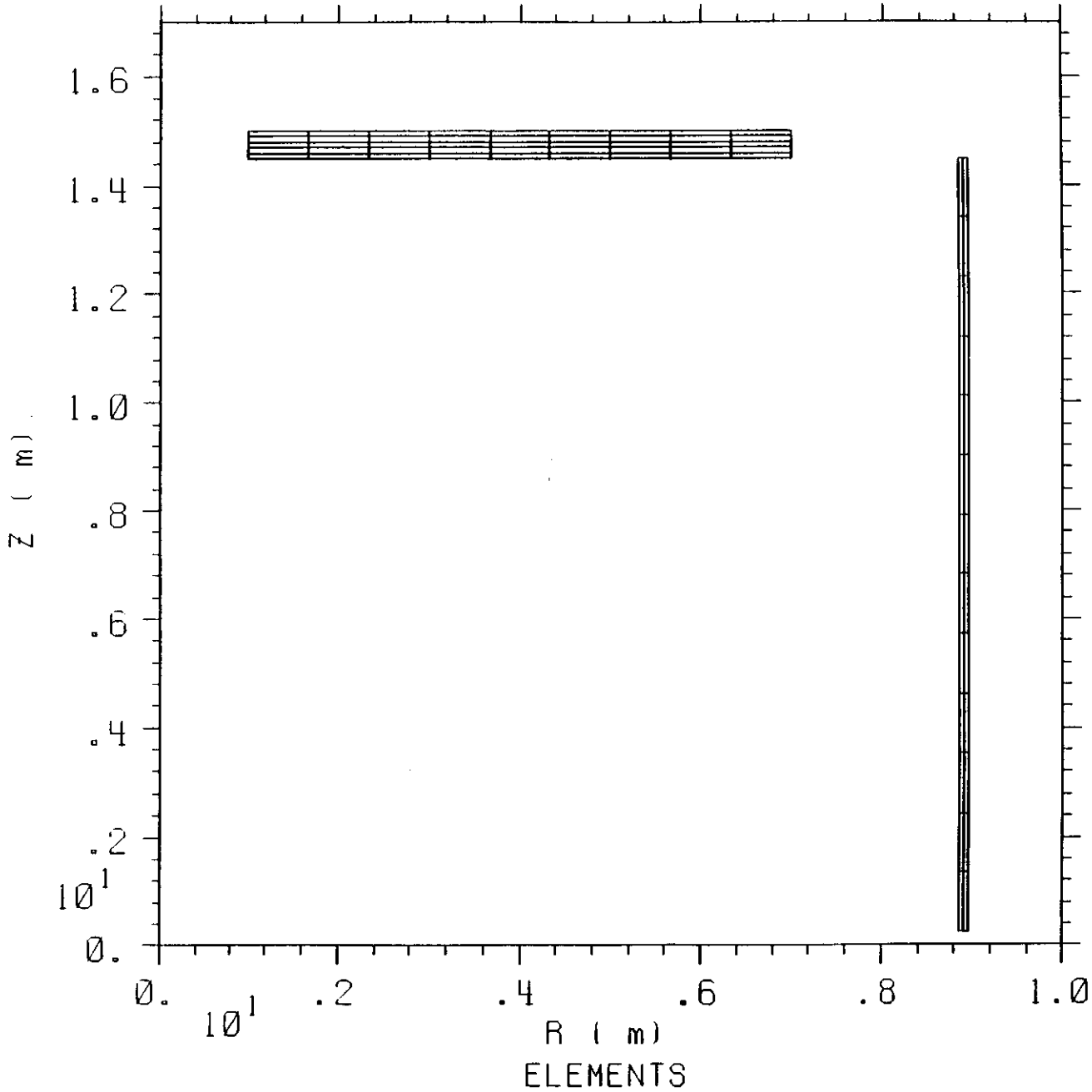
SOLDESIGN V3.0 10/ 9/91 13:31



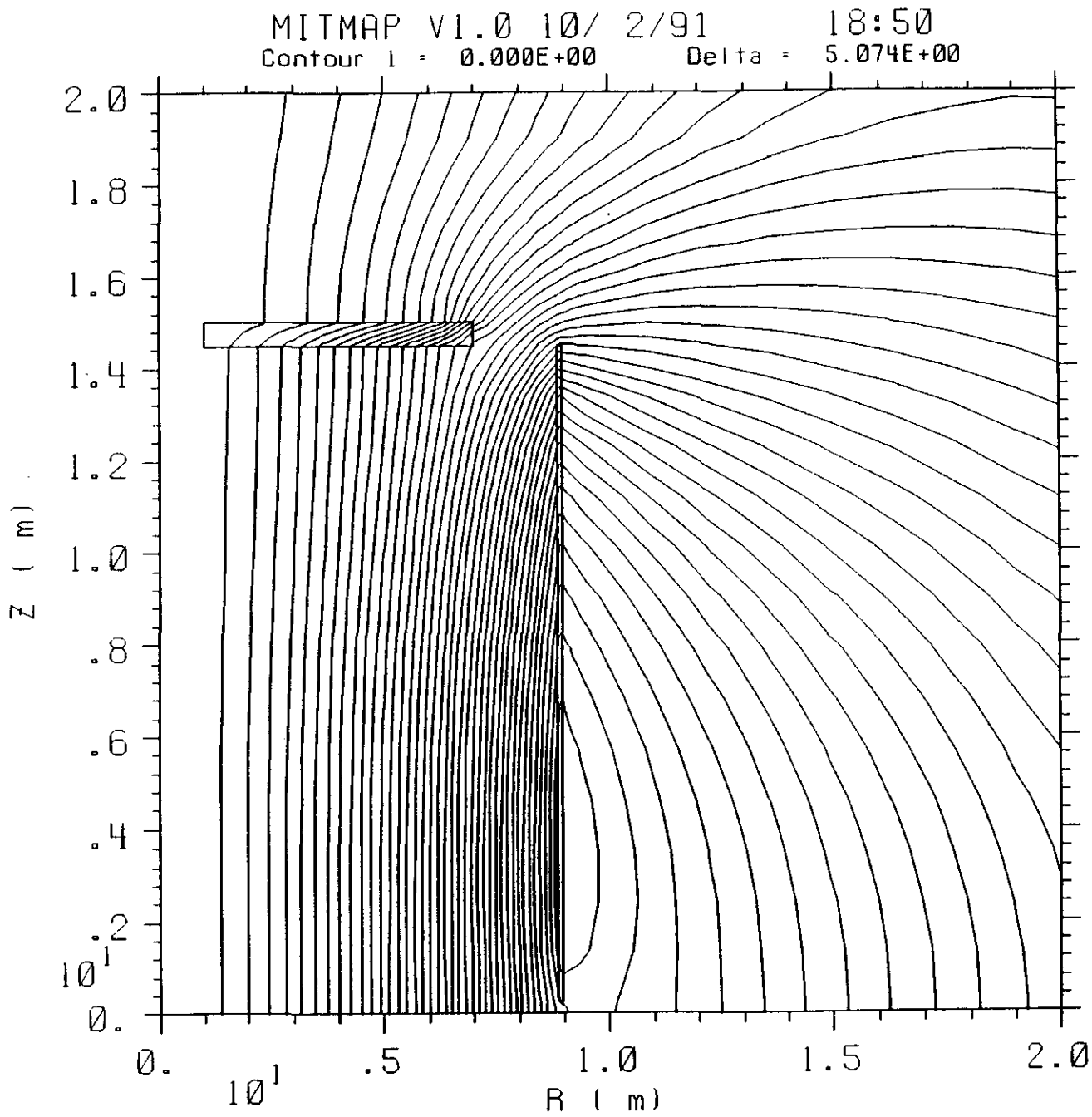

GEM --- Thin Pole Options: Case 5
Field (G) on 50-m surface
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
.4
.4
100
50
0
-50
-100
-100
-50
0
50
100
Transverse distance, m
Z-axis (beamline), m
CONTOUR LEVELS (10^1)

GEM --- Thin Pole Options: Case 5

MITMAP V1.0 10/ 2/91 18:28

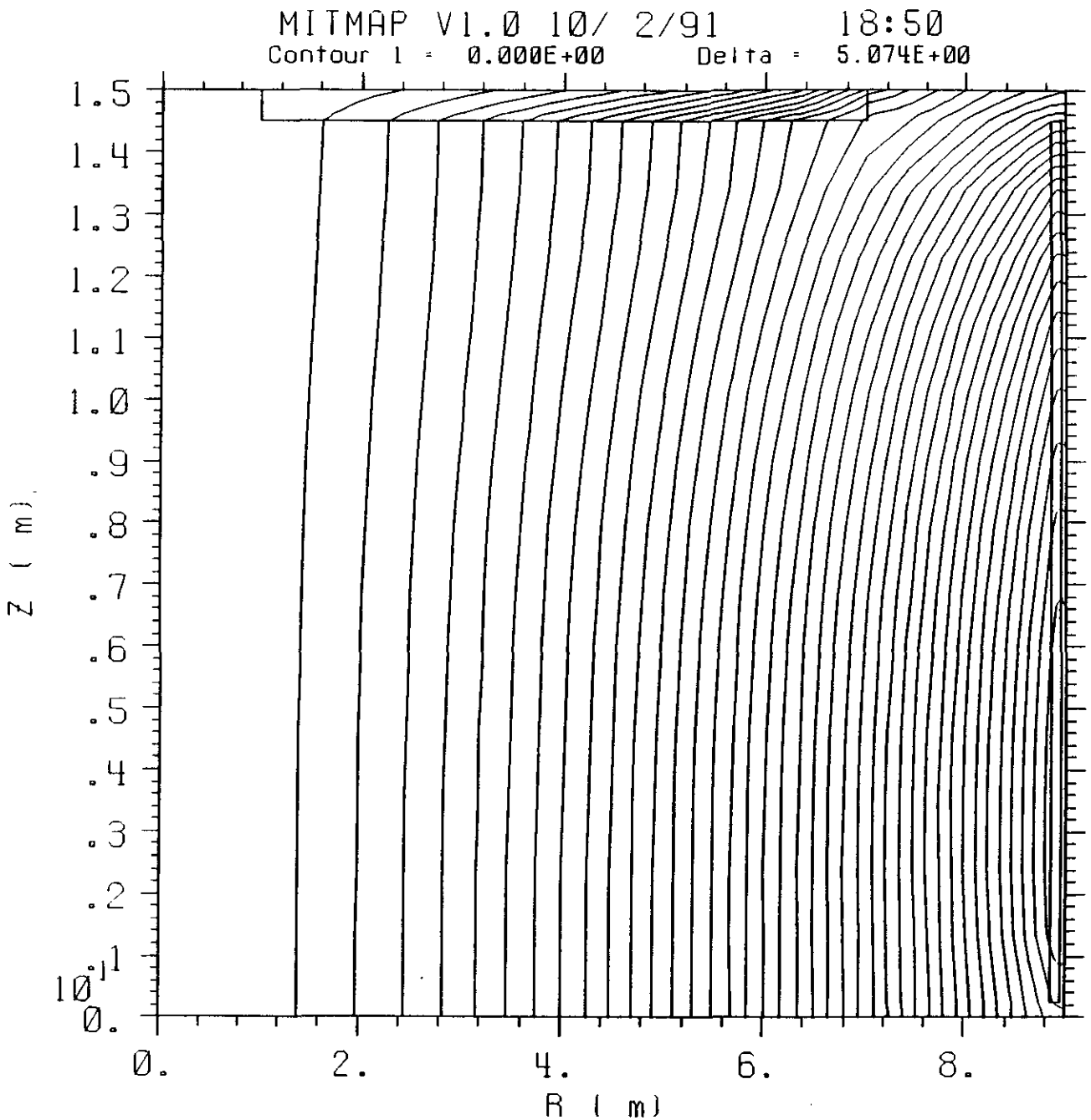


GEM --- Thin Pole Options: Case 5



CONTOURS OF CONSTANT FLUX

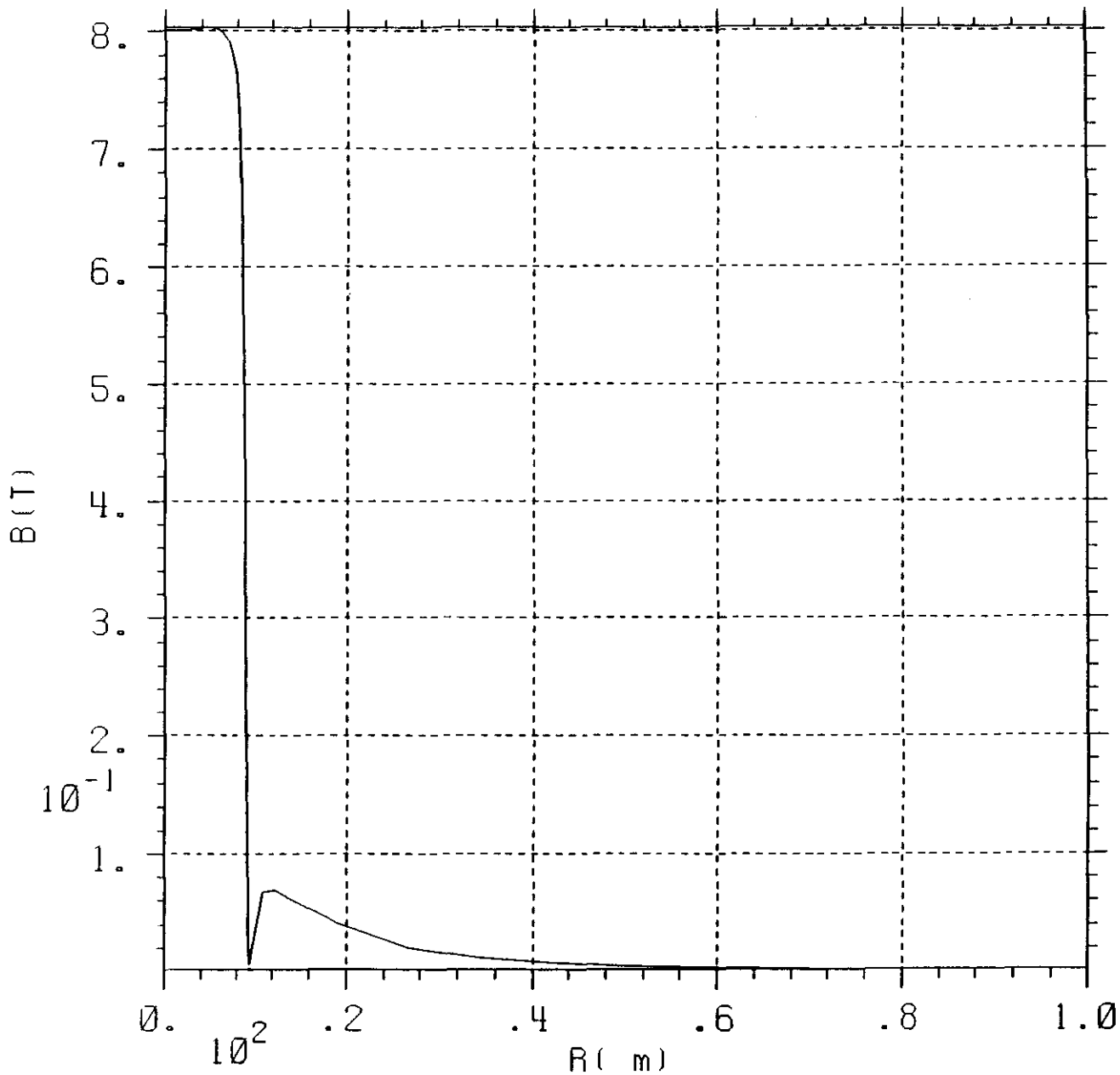
GEM --- Thin Pol Options: Case 5



CONTOURS OF CONSTANT FLUX

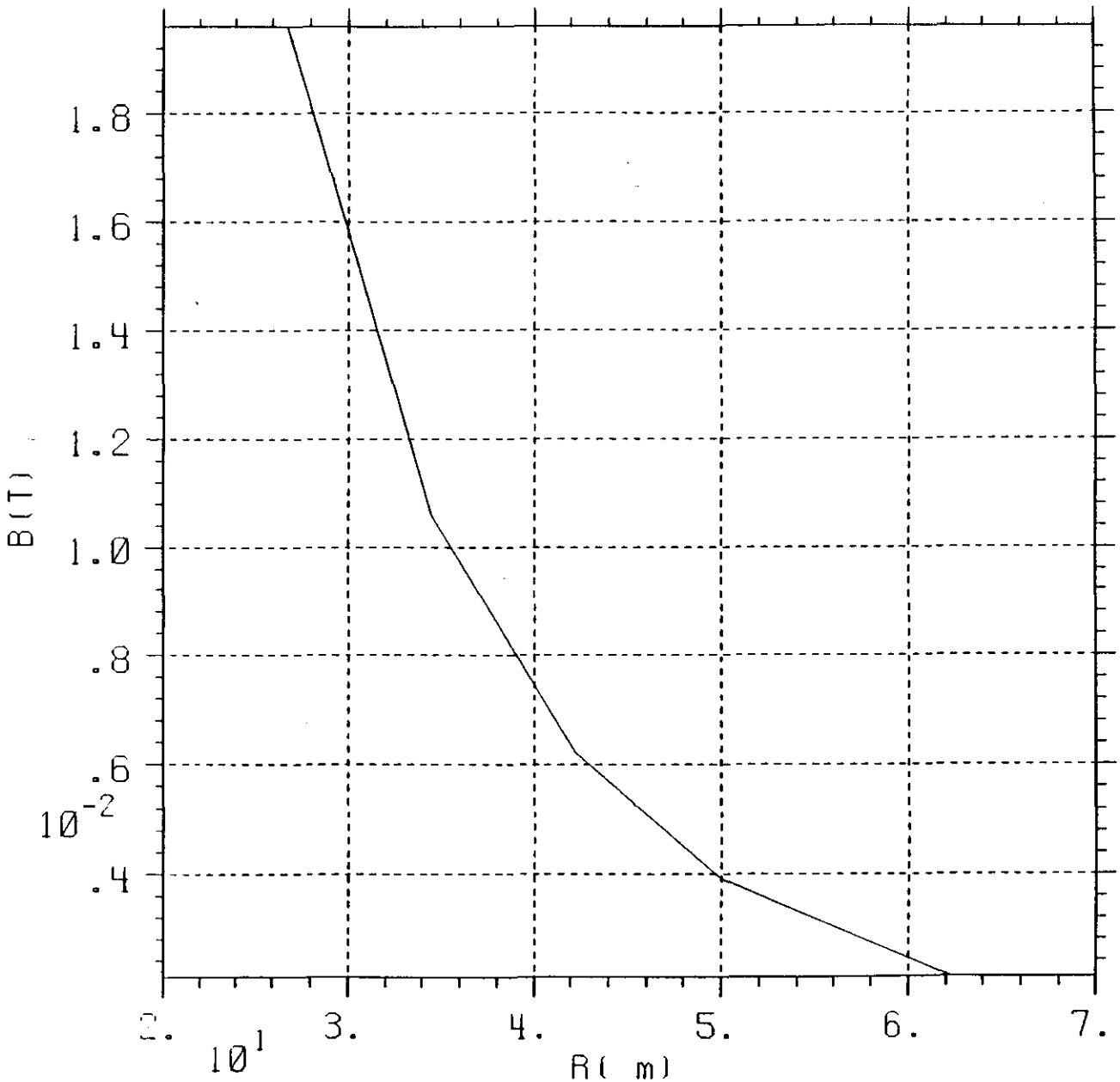
GEM --- Thin Pol Options: Case 5

MITMAP V1.0 10/ 2/91 18:50



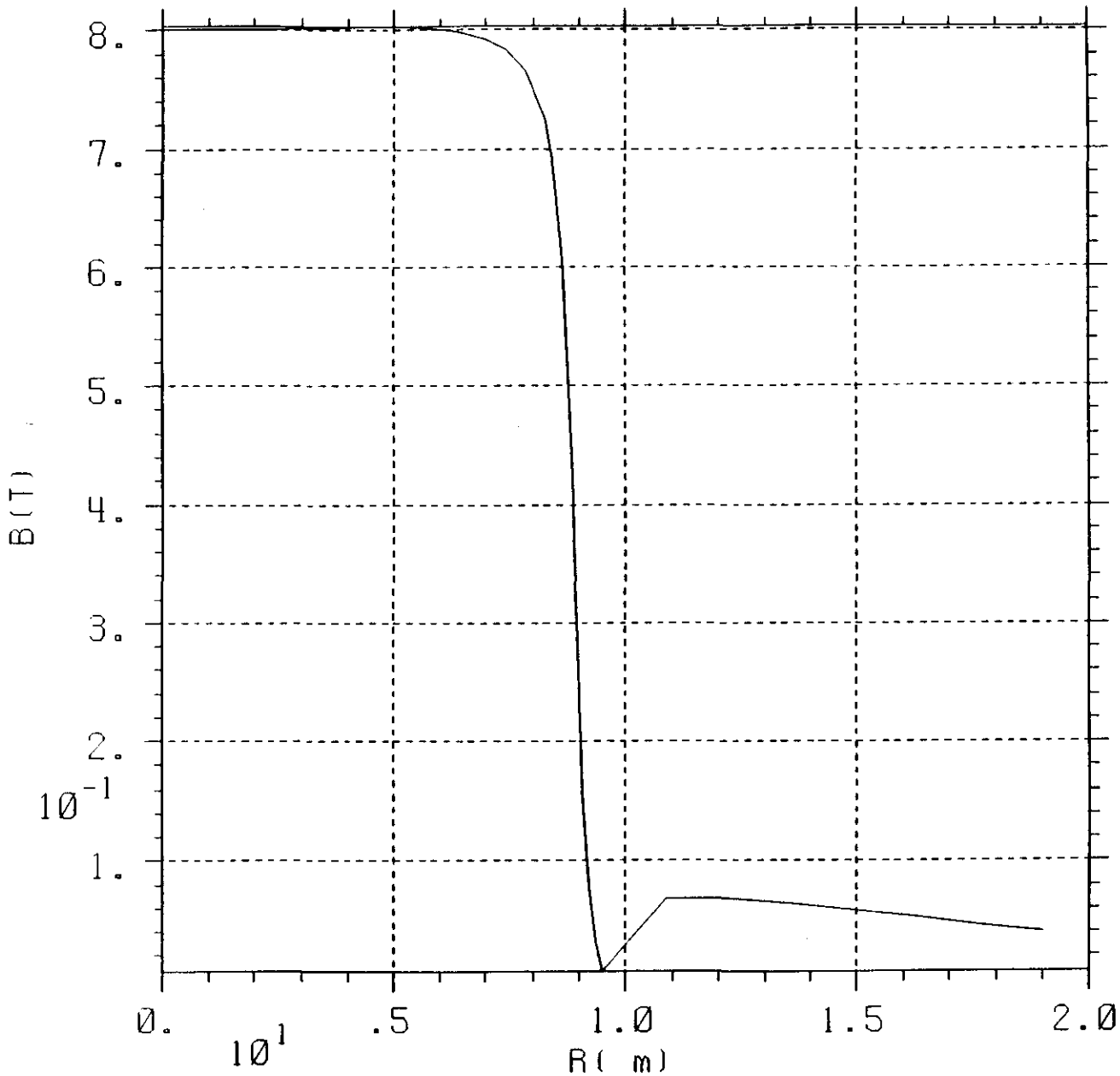
GEM --- Thin Poi Options: Case 5

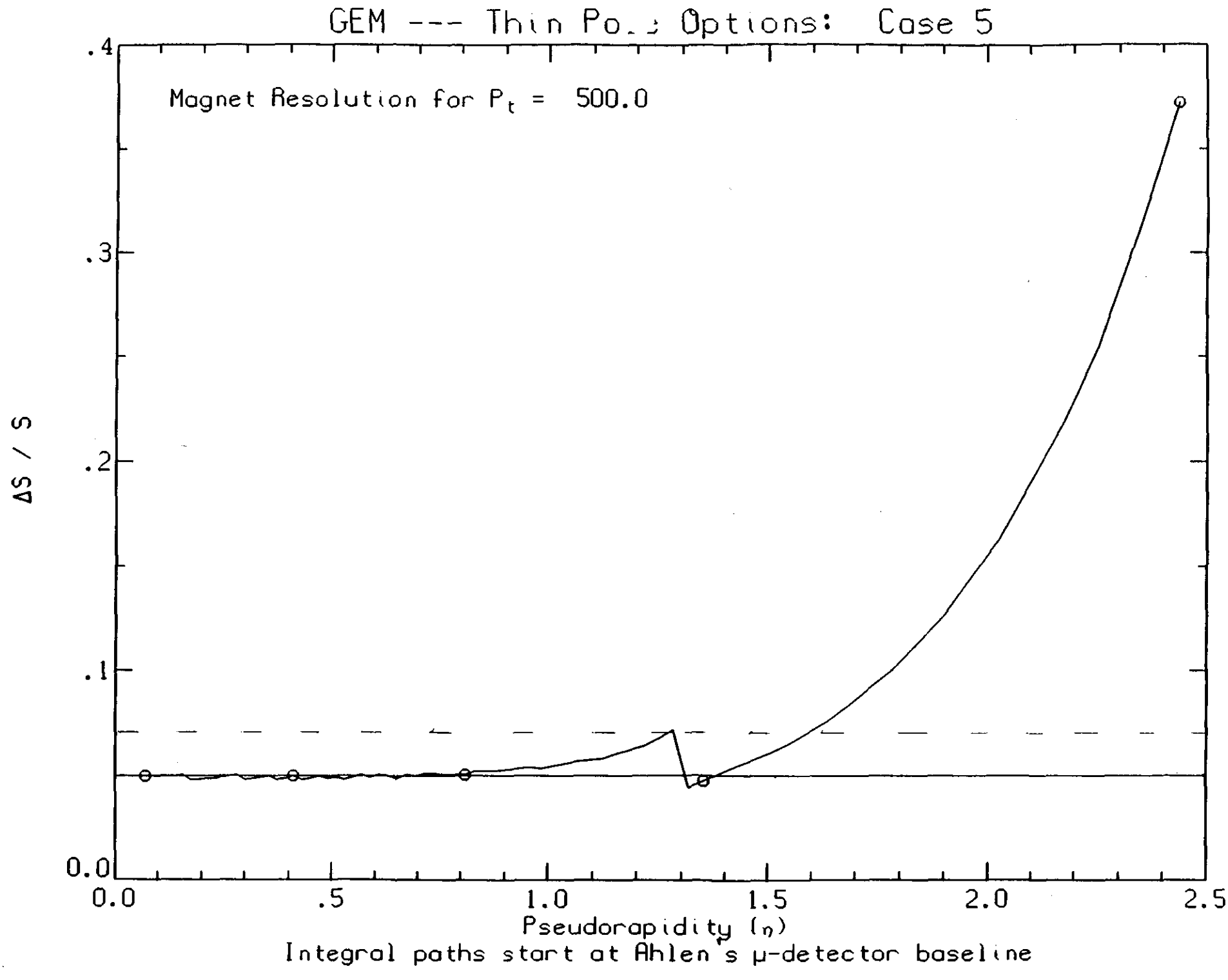
MITMAP V1.0 10/ 2/91 18:51

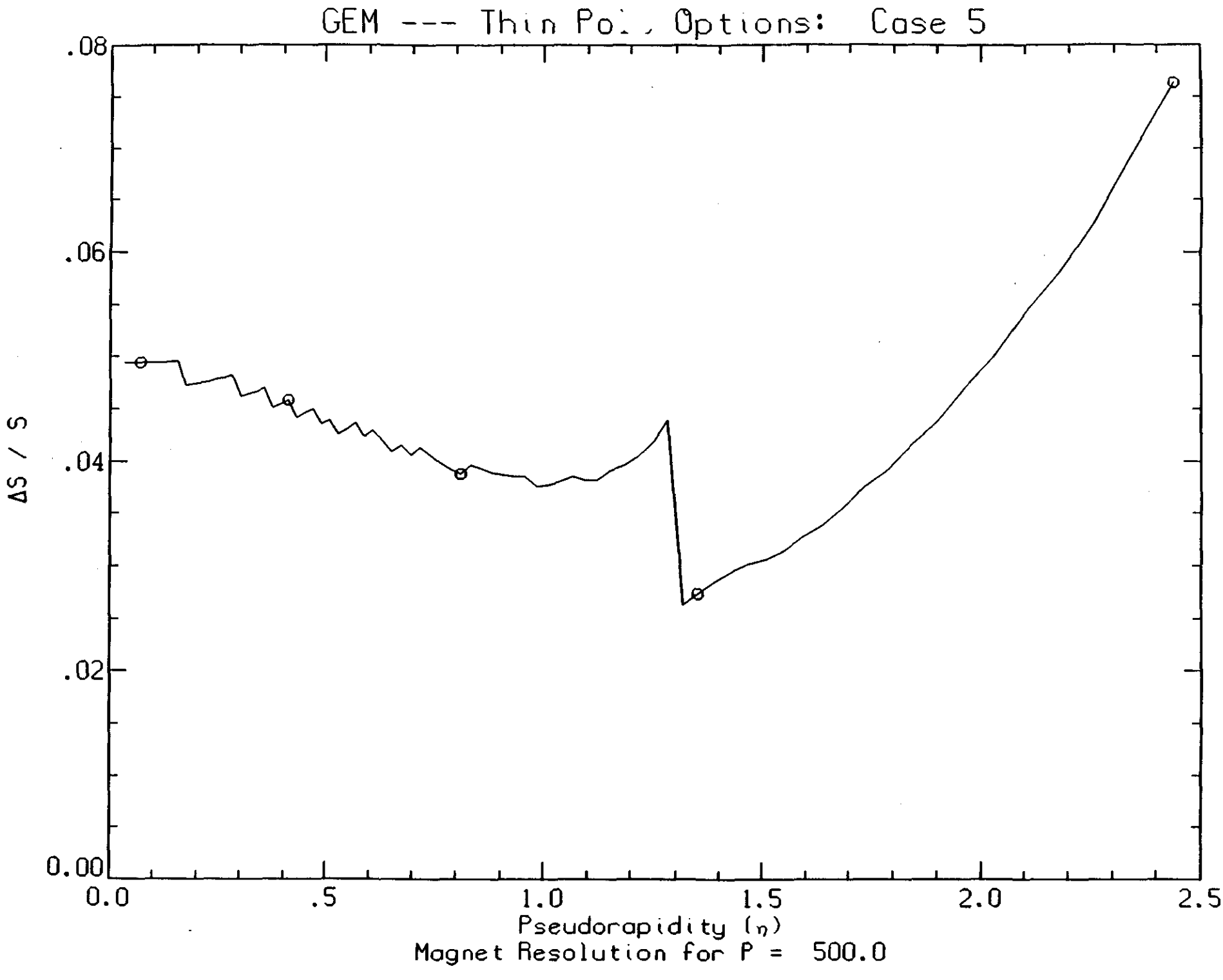


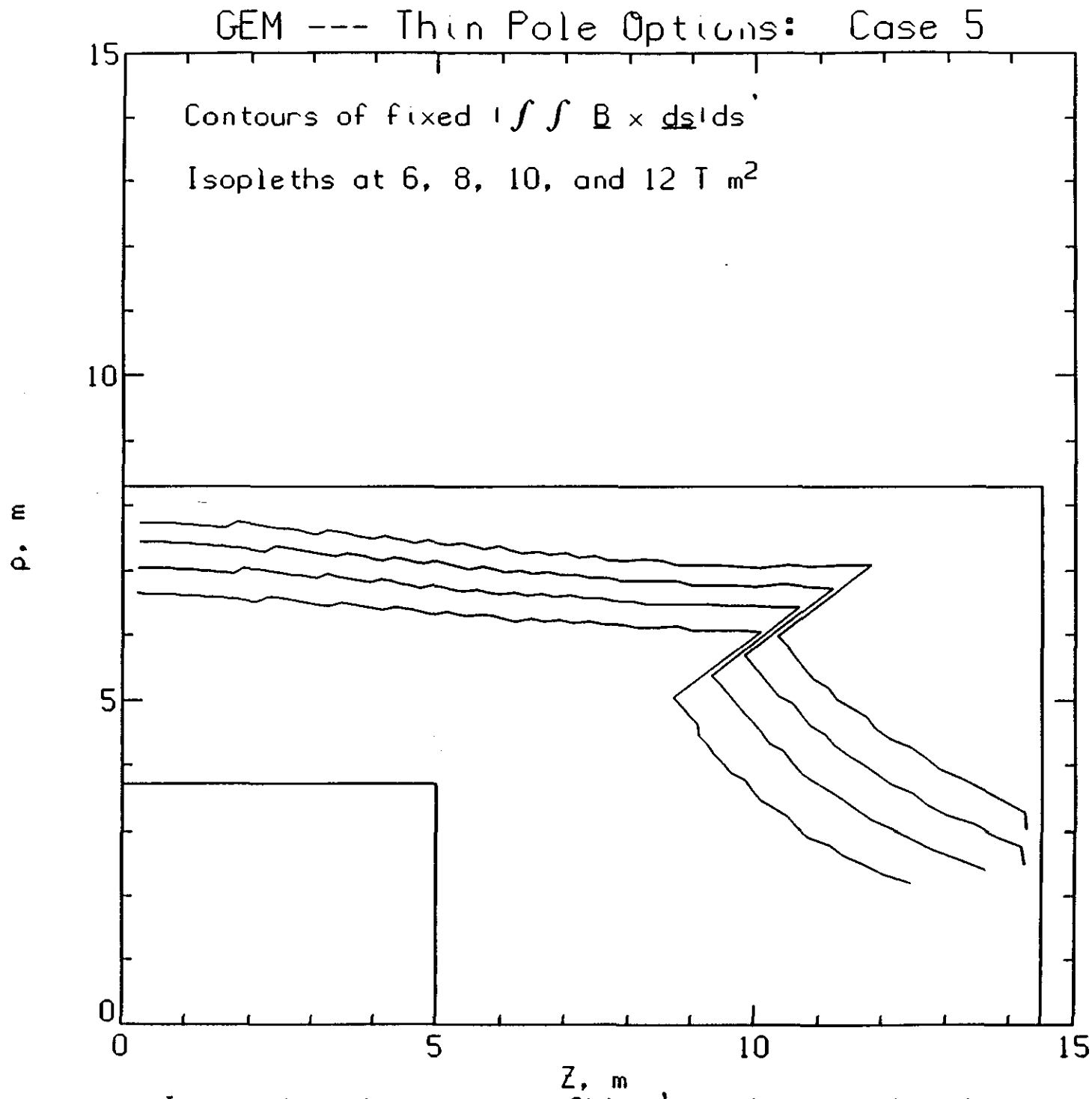
GEM --- Thin Pole Options: Case 5

MITMAP V1.0 10/ 2/91 18:51




GEM --- Thin Po.: Options: Case 5
Magnet Resolution for P_t = 500.0
ΔS / S
.4
.3
.2
.1
0.0
0.0
.5
1.0
1.5
2.0
2.5
Pseudorapidity (η)
Integral paths start at Ahlen's μ-detector baseline

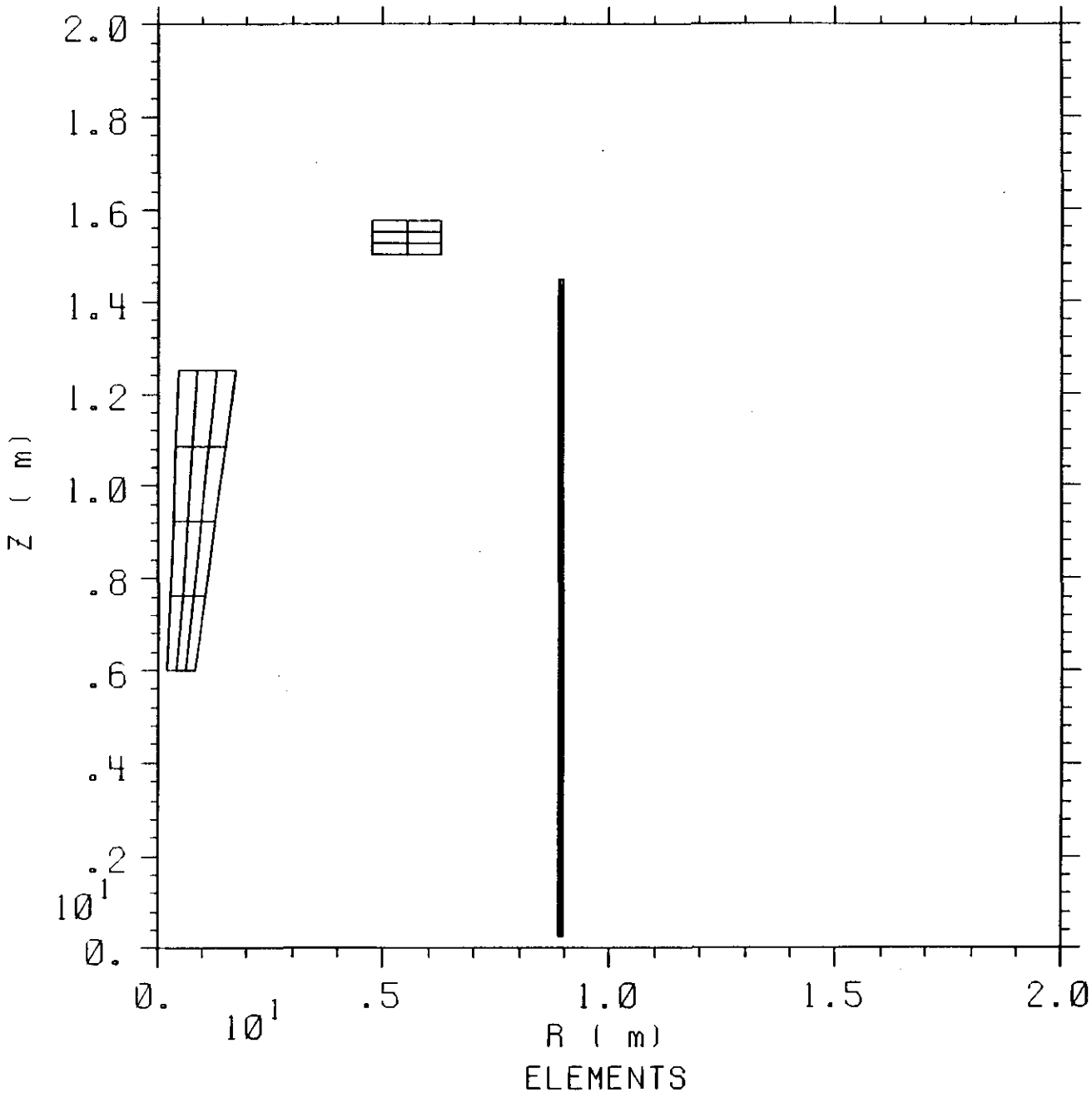

GEM --- Thin Pol, Options: Case 5
.08
.06
.04
.02
0.00
ΔS / S
0.0
.5
1.0
1.5
2.0
2.5
Pseudorapidity (η)
Magnet Resolution for P = 500.0



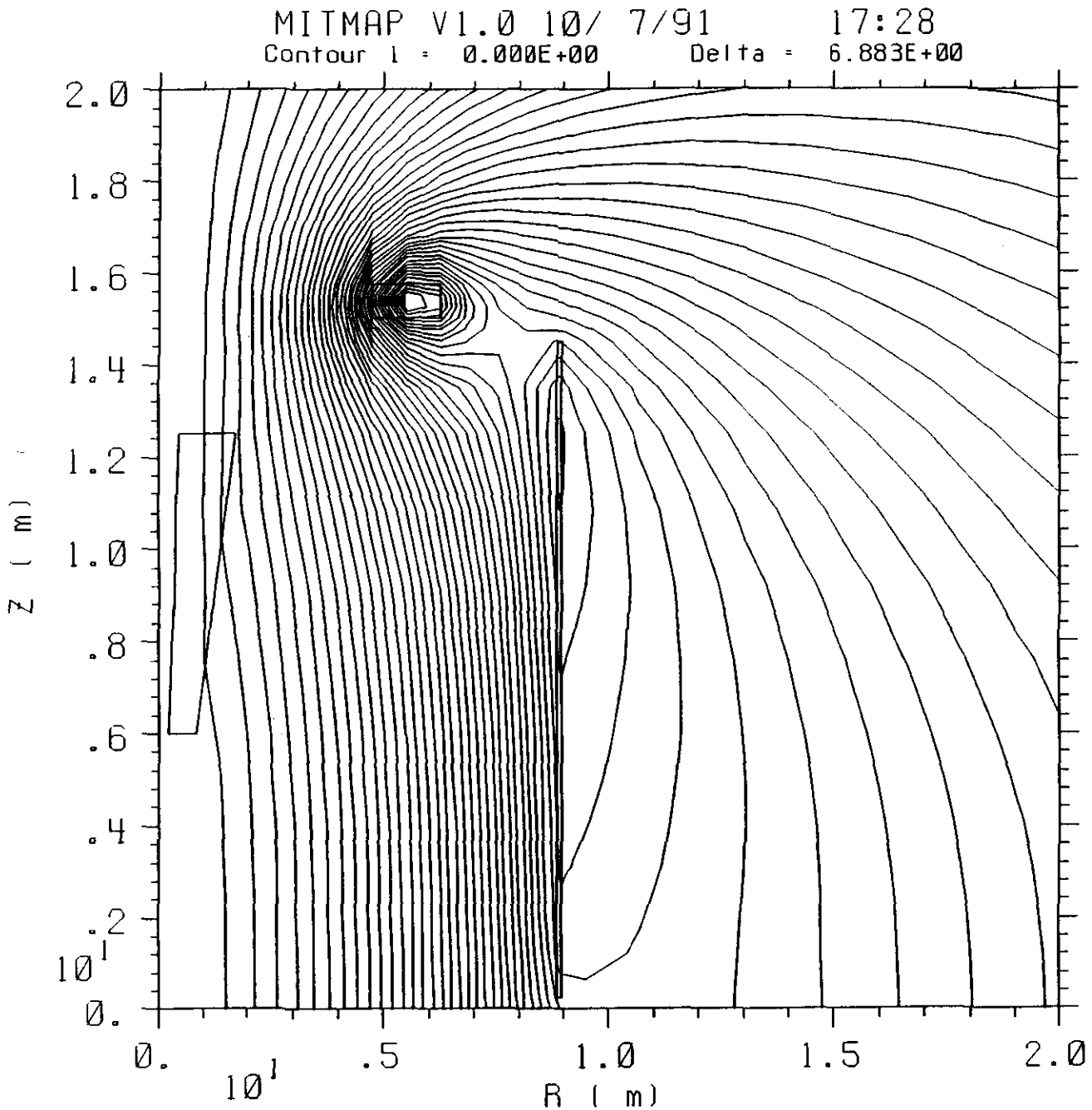
Integral paths start at Ahlen's μ-detector baseline

GEM --- Base and "Bottle 2a Solenoids plus Forward HC

MITMAP V1.0 10/ 7/91 16: 2

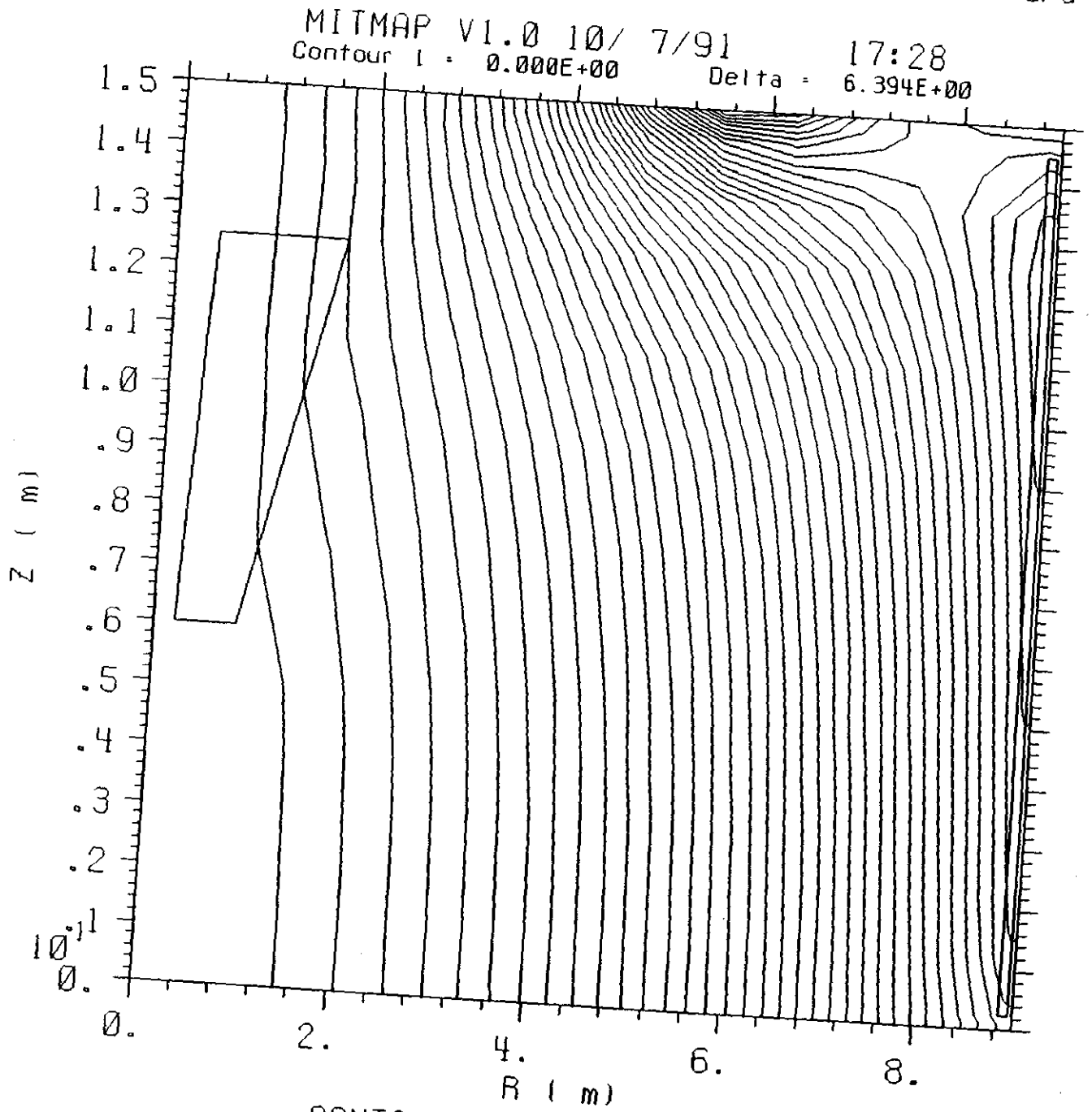


GEM --- Base and "Bottle 2a" Solenoids plus Forward HC



CONTOURS OF CONSTANT FLUX

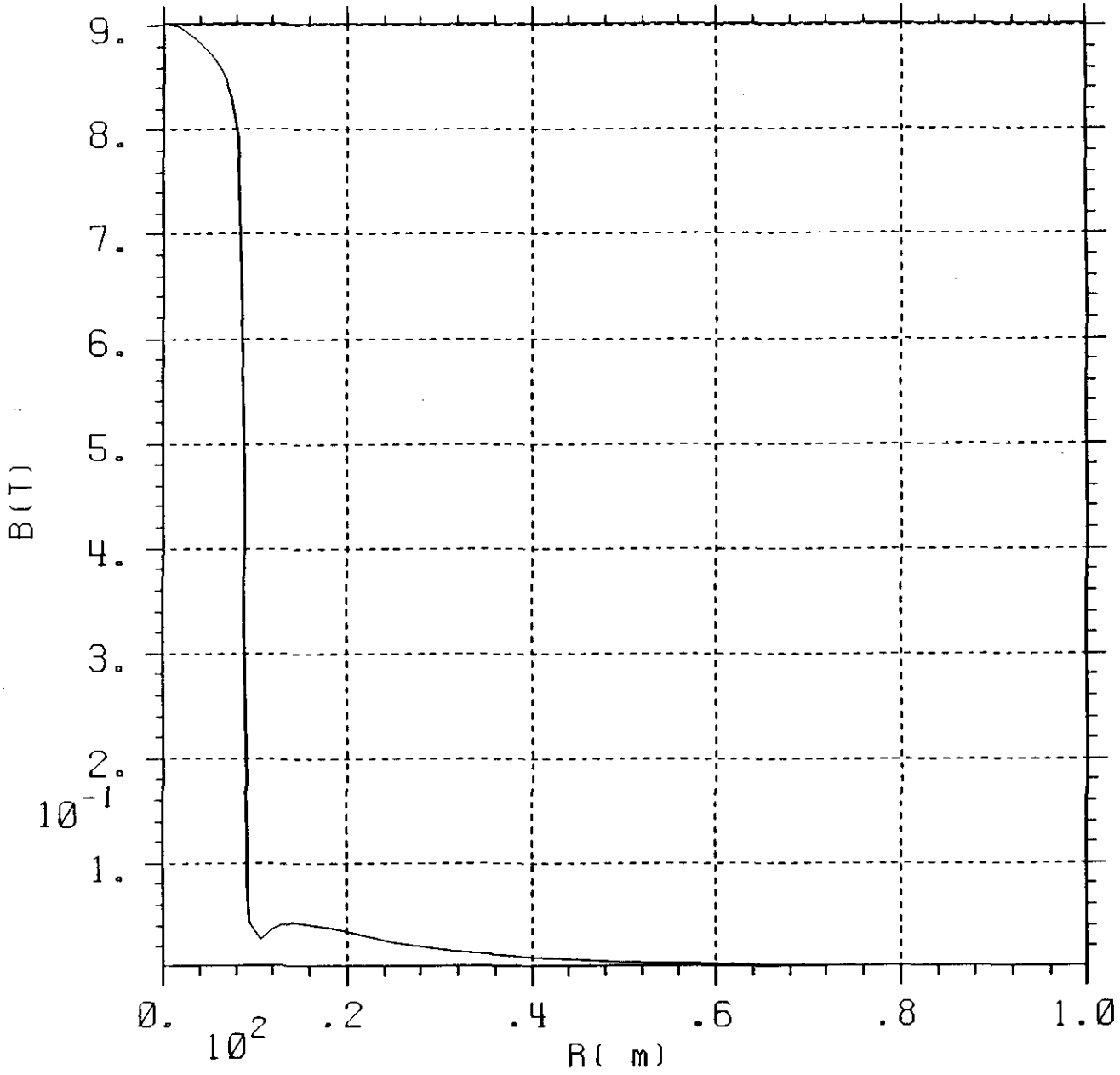
GEM --- Base and "Bottle 2a Solenoids plus Forward HC



CONTOURS OF CONSTANT FLUX

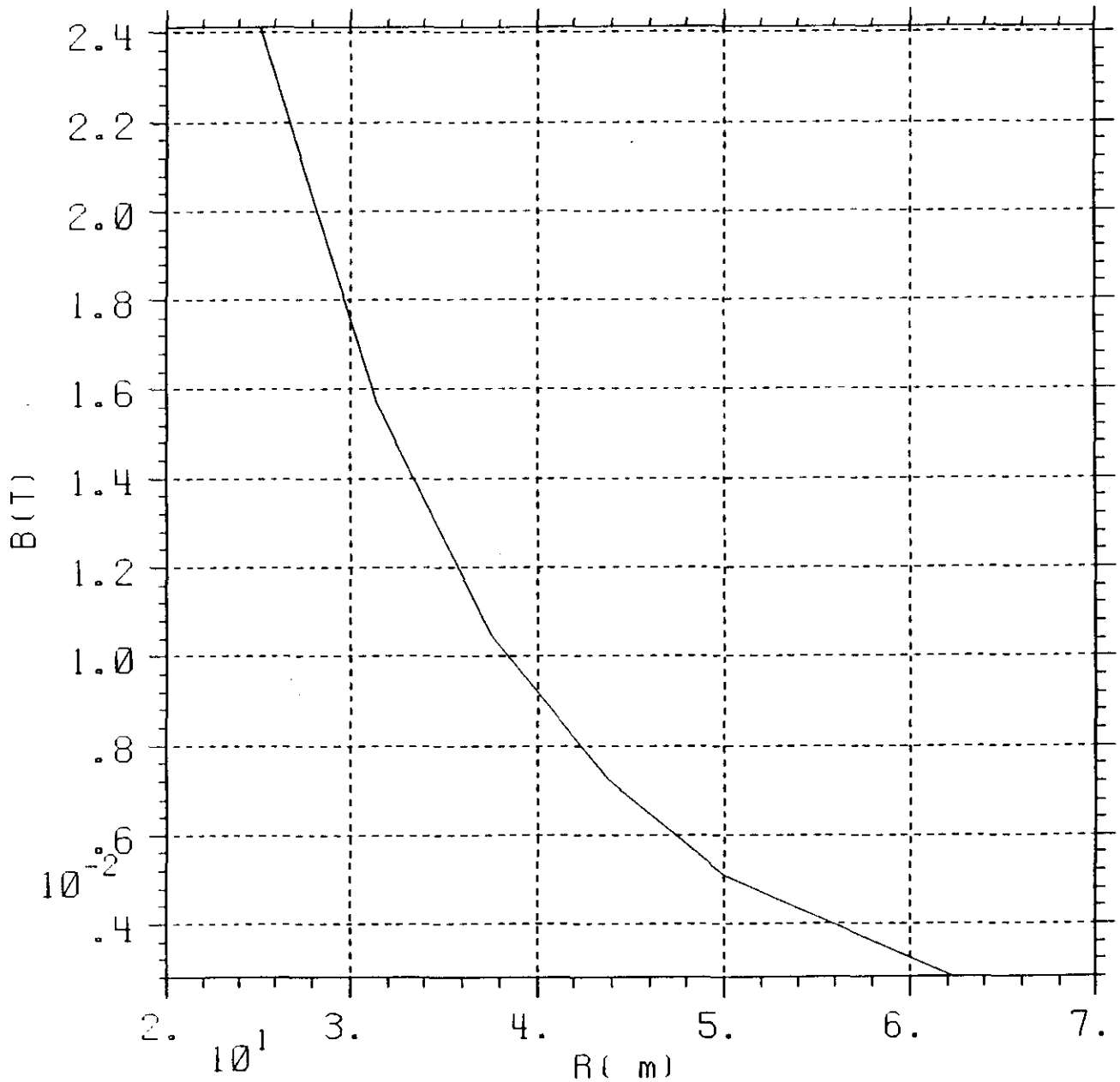
GEM --- Base and "Bottle 2a' Solenoids plus Forward HC

MITMAP V1.0 10/ 7/91 17:29



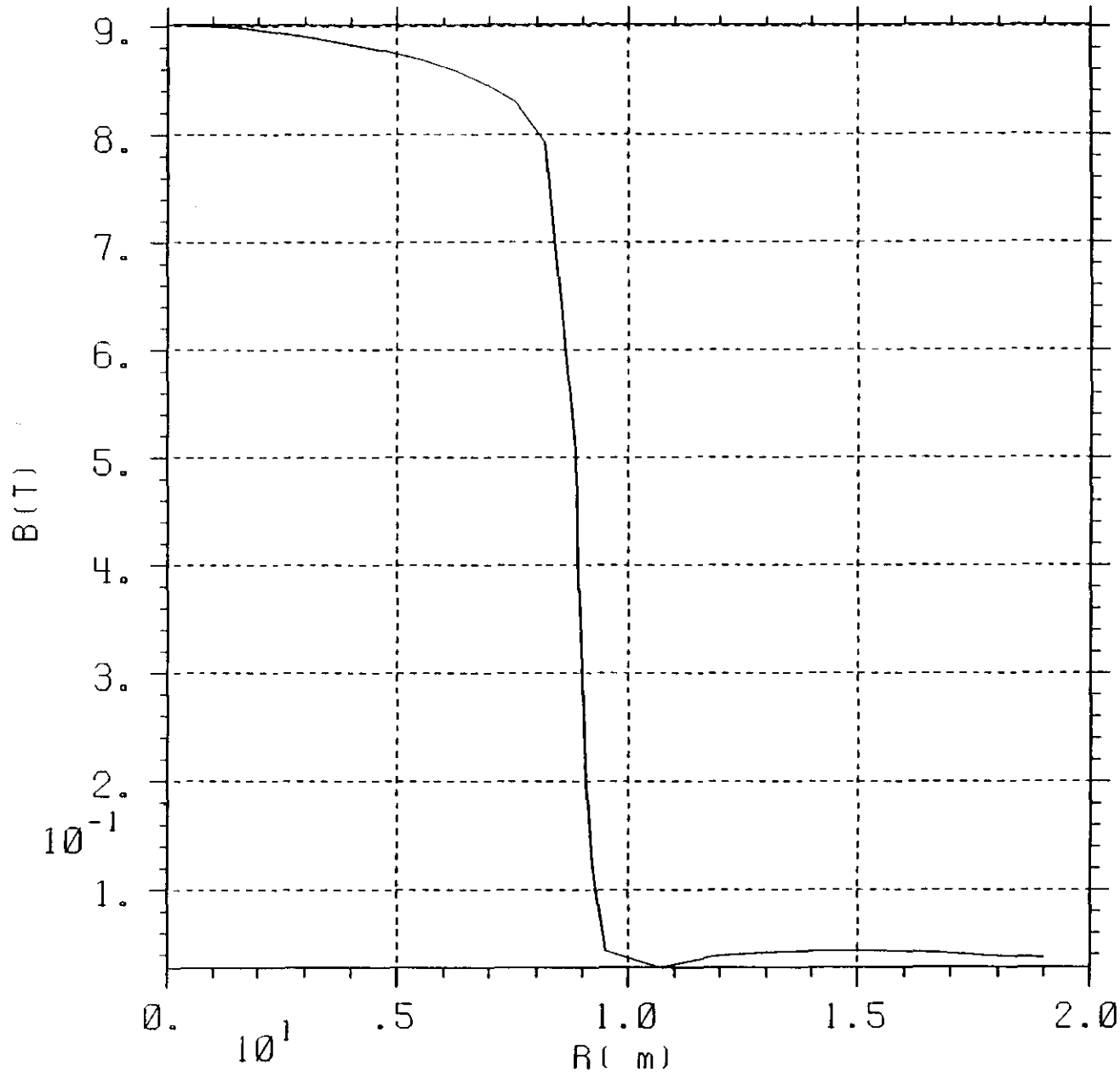
GEM --- Base and "Bottle 2a" Solenoids plus Forward HC

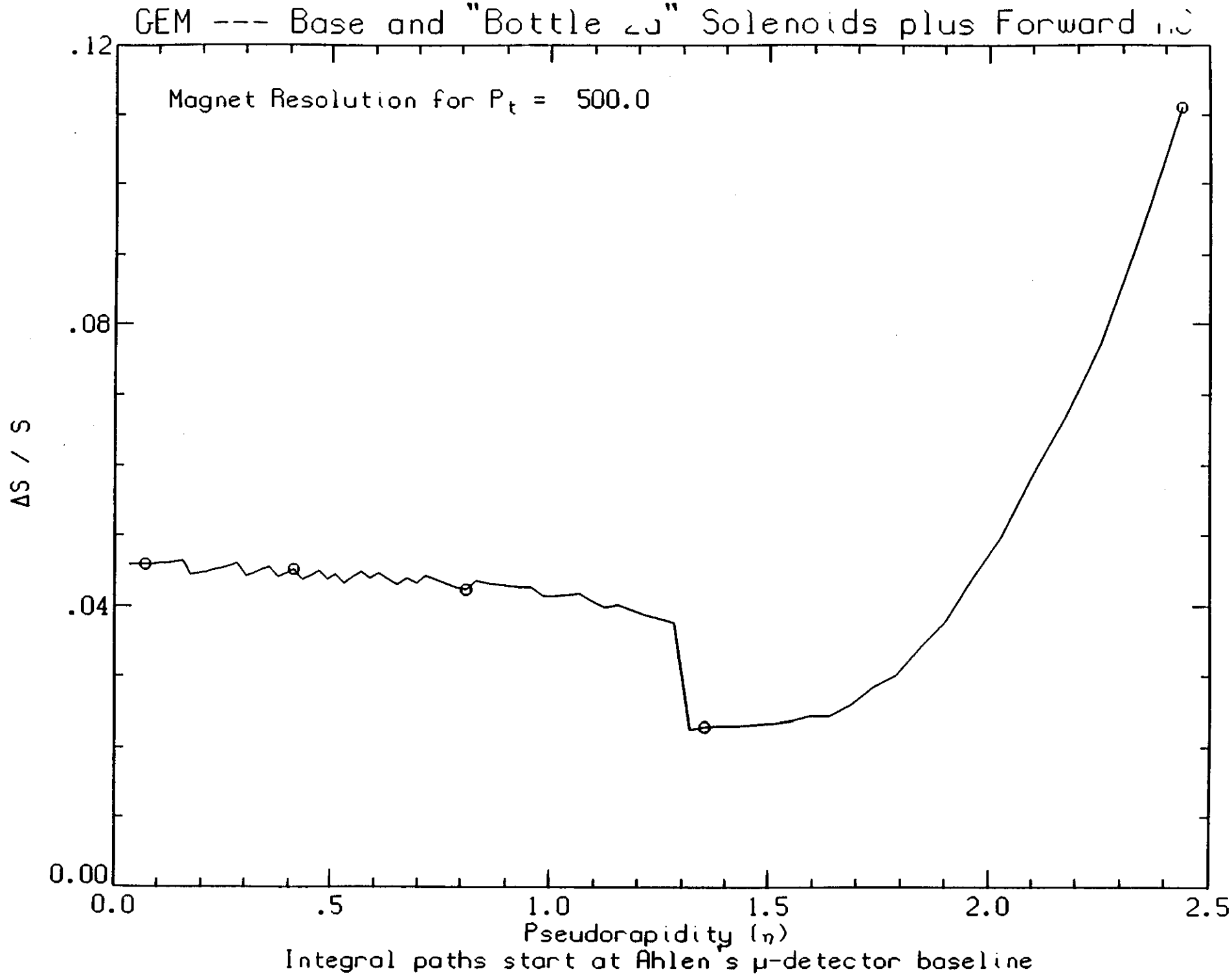
MITMAP V1.0 10/ 7/91 17:29

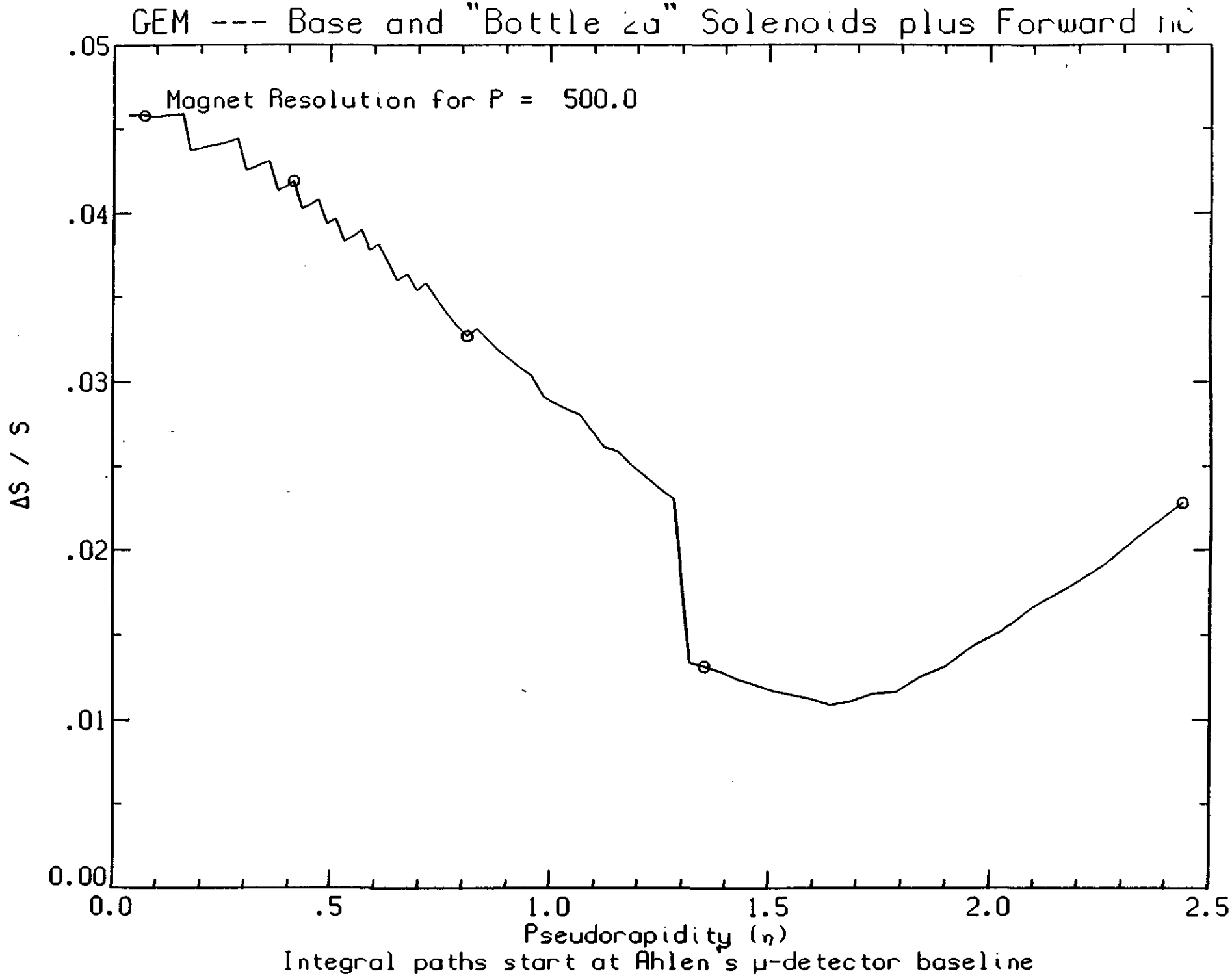


GEM --- Base and "Bottle 2a Solenoids plus Forward HC

MITMAP V1.0 10/ 7/91 17:29




GEM --- Base and "Bottle
Solenoids plus Forward
Magnet Resolution for P_t = 500.0
.12
.08
.04
0.00
ΔS / S
0.0
.5
1.0
1.5
2.0
2.5
Pseudorapidity (η)
Integral paths start at Ahlen's μ-detector baseline


GEM --- Base and "Bottle 2a" Solenoids plus Forward MC
Magnet Resolution for P = 500.0
ΔS / S
.05
.04
.03
.02
.01
0.00
0.0
.5
1.0
1.5
2.0
2.5
Pseudorapidity (η)
Integral paths start at Ahlen's μ-detector baseline

From: "ch%\"alain_herve@macmail.cern. (10/22/91)
To: Ray Stefanski
GatorMail-Q GEM magnet
Received: by qmail.ssc.gov; 22 Oct 91 10:03:38
Date: Tue, 22 Oct 1991 9:53:36 CDT
From: "ch%\"alain_herve@macmail.cern.ch\""@SSCVX1.SSC.GOV (Alain Herve)
Message-Id: <911022095336.23e00224@SSCVX1.SSC.GOV>
Subject: GEM magnet
To: Ray_Stefanski.physics@qmail.ssc.gov
X-Vmsmail-To: STEFANSKI@sscvx1

Received: From CEARN(MAILER) by SSCVX1 with Jnet id 4208
for STEFANSKI@SSCVX1; Tue, 22 Oct 91 09:53 CDT
Received: from CEARN by CEARN.cern.ch (Mailer R2.07B) with BSMTP id 4207; Tue,
22 Oct 91 14:42:34 GVA
Received: from dxmint.cern.ch by CEARN.cern.ch (IBM VM SMTP V2R1) with TCP;
Tue, 22 Oct 91 14:42:32 GVA
Received: by dxmint.cern.ch (cernvax) (5.57/3.14)
id AA20899; Tue, 22 Oct 91 14:39:58 +0100
Message-Id: <9110221339.AA20899@dxmint.cern.ch>
Date: 22 Oct 91 14:37:48 U
From: "Alain Herve" <alain_herve@macmail.cern.ch>
Subject: GEM magnet
To: STEFANSKI@sscvx1
Cc: HARRIS@sscvx1, francois_wittgenstein@macmail.cern.ch

	Subject:	Time:14:24
OFFICE MEMO	GEM magnet	Date:10/22/91

Last week I did some independant computations to check what was said during last meeting. I confirm that:

- Without barrel stray field is around 40 Gauss at 50 m and extend as plotted by PFC.
- With the 130 cm barrel, and the same induction in poles (our base solution adding 55 M$), the same stray field is below the10 Gauss level.
- With just the same poles as above, but no barrel, the stray field at 50 m is only 13 Gauss, showing that shielding effect is mainly due to barrel and confirming PFC results that poles are useful only to better the field map inside.
- With poles only and a surface shielding at 50 m, the radial component on the beam line (so called dipole effect) is negligible (2 to 3 Gauss maximum).

In addition I had the stray field around L3 measured. In all counting rooms where people stay it is lower than 4 Gauss. This create problems only for color screens. In rooms with accessible electronics it is 10 G in the "small blockhaus" and 17 G in the "main blockhaus". These last values are sufficient to create problems with scopes and all screens but not to normal electronics and power supplies neither to paging systems or bank cards.

==========

From: "ch%\"alain_herve@macmail.cern. (10/23/91)
To: Ray Stefanski
GatorMail-Q GEM magnet addendum
Received: by qmail.ssc.gov; 23 Oct 91 03:09:48
Date: Wed, 23 Oct 1991 2:59:53 CDT
From: "ch%\"alain_herve@macmail.cern.ch\""@SSCVX1.SSC.GOV (Alain Herve)
Message-Id: <911023025953.23e00224@SSCVX1.SSC.GOV>
Subject: GEM magnet addendum
To: Ray_Stefanski.physics@qmail.ssc.gov
X-Vmsmail-To: HARRIS@sscvx1, STEFANSKI@sscvx1

Received: From CEARN(MAILER) by SSCVX1 with Jnet id 6012
for STEFANSKI@SSCVX1; Wed, 23 Oct 91 02:59 CDT
Received: from CEARN by CEARN.cern.ch (Mailer R2.07B) with BSMTP id 6010; Wed,
23 Oct 91 08:58:10 GVA
Received: from dxmint.cern.ch by CEARN.cern.ch (IBM VM SMTP V2R1) with TCP;
Wed, 23 Oct 91 08:58:07 GVA
Received: by dxmint.cern.ch (cernvax) (5.57/3.14)
id AA04041; Wed, 23 Oct 91 08:55:29 +0100
Message-Id: <9110230755.AA04041@dxmint.cern.ch>
Date: 23 Oct 91 08:53:19 U
From: "Alain Herve" <alain_herve@macmail.cern.ch>
Subject: GEM magnet addendum
To: HARRIS@sscvx1, STEFANSKI@sscvx1
Cc: francois_wittgenstein@macmail.cern.ch

	Subject:	Time:8:53
OFFICE MEMO	GEM magnet addendum	Date:10/23/91

Please read:

.....stray fiel in "small blockhaus".... 10 to 15 Gauss....
.....stray field in "large blockhaus"..... 17 to 30 Gauss...

Regards

A.H.

==========

MEMO

91-5840-E-P

To: Mike Harris
From: Richard Stroynowski
Subject: Conductor development

The GEM Magnet Technical Panel concluded its three meetings with an unresolved question of the suggested choice of the magnet conductor, stabilizer and its manufacturing process. It has been recognized that the conductor development represents a critical path item in the magnet design and construction schedule.

In order not to lose momentum and remain on the proposed schedule, the GEM Collaboration proposes that three members of the GEM Magnet Technical Panel form a task force charged with developing a consensus conceptual design of the conductor supported by the necessary calculations of its stability and cost so that a comparison may be made with any alternative concepts proposed by industry. The task force would include Peter Marston of MIT Plasma Fusion Laboratory, John Miller of National High Magnetic Field Laboratory working in conjunction with Livermore National Laboratory and Peter Clee of the Rutherford National Laboratory.

MEMO

91-5840-E-P

To: Mike Harris
From: Richard Stroynowski
Subject: Experimental Hall

The GEM Collaboraton is pursuing for the LOI the design of the unshielded solenoid magnet. This magnet has an outer diameter of about 19m and fits comfortably in the base-line hall design of 26m width. The GEM Magnet Technical Panel has studied alternatives to the unshielded magnet option and discussed iron shielding and the two-coil options. Among these the iron shielded option is somewhat less expensive. If the collaboration proposal for the unshielded magnet would not be approved, the the iron shielded alternatives may be considered. Since the iron shielding would add between 1.3 to 2.0 meters to the radius of the magnet, the collaboration requests that study of the correspondingly larger experimental hall shall be undertaken by the civil construction engineering firm.

Brandeis High Energy Physics Group

Telefax Cover Sheet

Panafax UF-600AT
(617) 736 - 2915
Verification Number
(617) 736 - 2800

Facsimile # 214-708-0006

Verification #

Date: October 21, 1991

To: Ray Stefanski
Physics Research Division
SSCL

From: Jim Bensinger

High Energy Physics Group
Department of Physics
Brandeis University
Waltham, Mass.
U.S.A., 02254

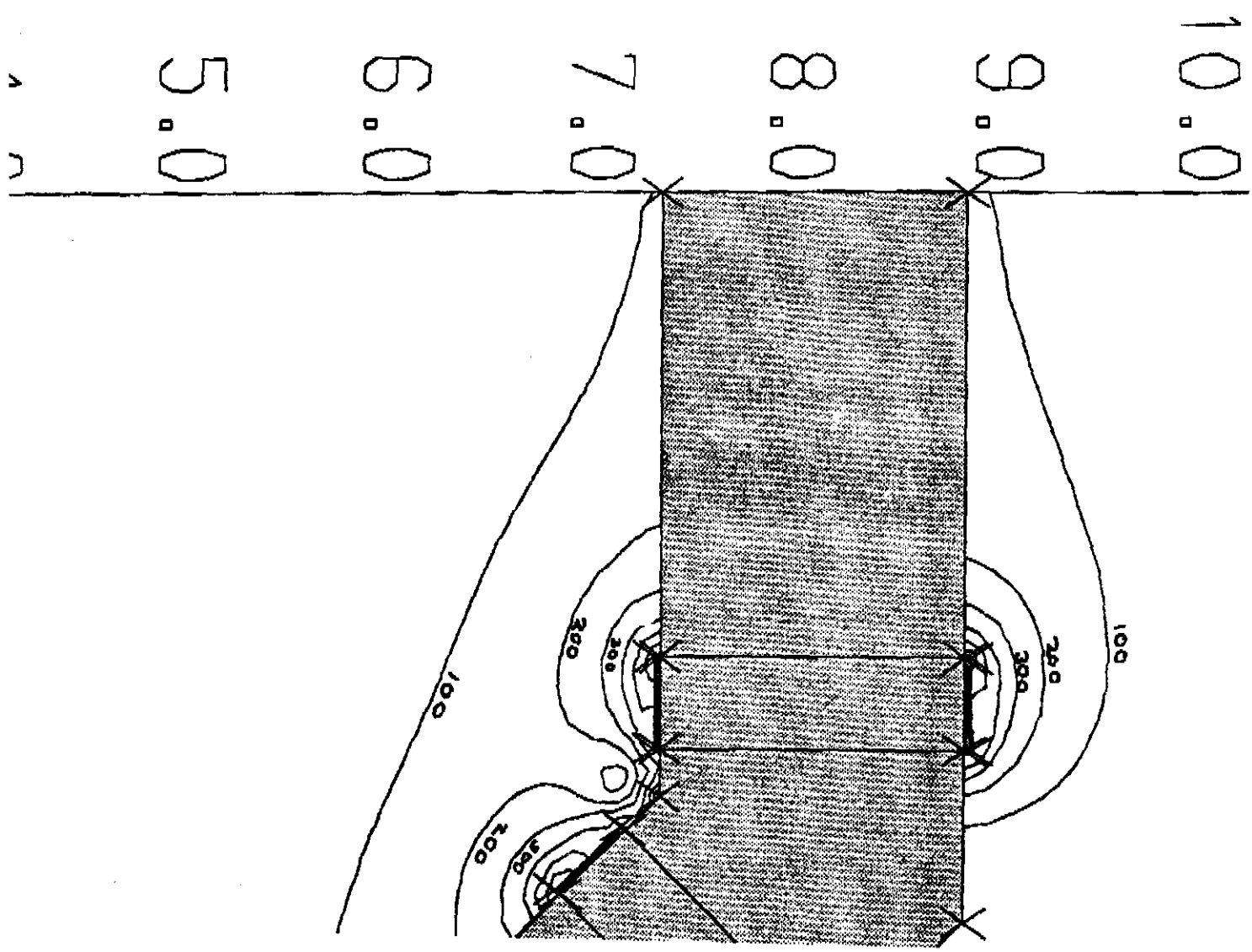
Comments: Ray - The field map you requested.

This transmission consists of 2 pages, including this cover sheet.

Date sent:

Time sent:

Operator's Initials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200
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200
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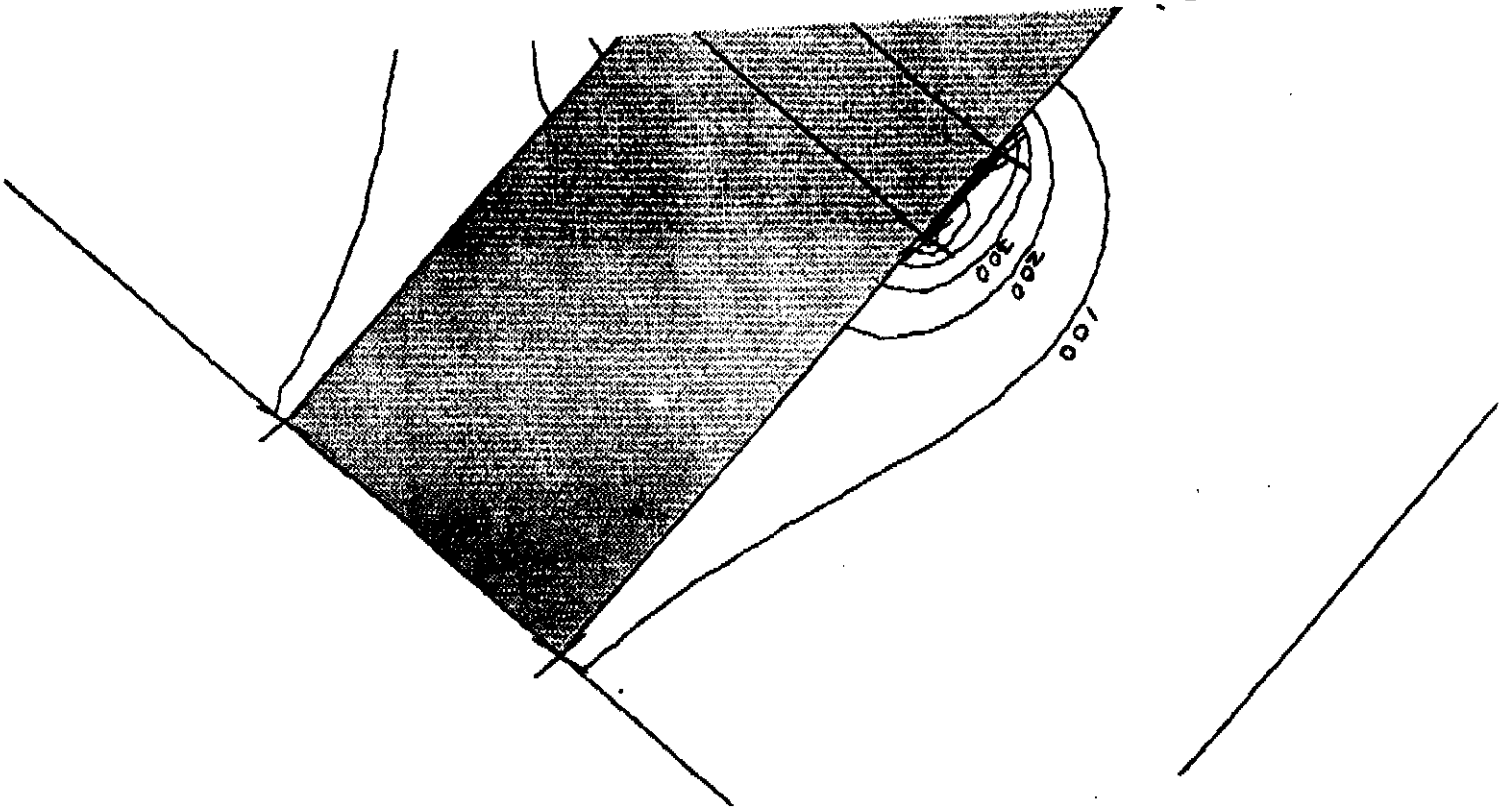

100
200
300

DOE F 1325.8
(10-89)

United States Government **Department of Energy**

memorandum

DATE: August 19, 1991

REPLY TO ATTN OF: William Watson, PD3

SUBJECT: Collider magnetic fields near O'Brien Airport

TO: Nat Brown, Tony Robledo, PD5

To determine whether the SSC collider ring's magnetic field will disrupt the normal operation of aircraft instruments at O'Brien Airport, at least three things need to be compared:

(1) the strength of the collider's magnetic field at the airport,
(2) the average strength of the earth's own magnetic field, and
(3) the normal fluctuations of the earth's magnetic field.

Both the second and third items are important in determining the effect of the collider's magnetism on aircraft. The earth's magnetic field is the environment in which aircraft and their instruments function. In the Dallas area, this field has a nominal overall strength of 550 milligauss and a direction 66° below the horizontal, with the horizontal component of the field being about 6° east of true north and having a strength of 225 milligauss. However, the field deviates with geomagnetic activity about 2% from these values for a few hours or even a few days each year--about ±11 milligauss for the total field strength and ±4.5 milligauss for the horizontal component.

In contrast, the magnetic field at the surface 50 meters above the SSC's collider ring will be no greater than 2 milligauss. This strength, itself smaller than the size of a natural fluctuation of the earth's field, is what the collider's field would be due to the presence of the magnets alone, in the absence of any shielding whatsoever from the steel cryostats encasing the magnets. However, the cryostats would screen almost all of the magnets' fields from the environment. Ferromagnetic materials in the earth itself would screen much of the remainder leaving the collider's contribution to the magnetic field at the surface to be nearly zero.

This remaining magnetic field would not only be much smaller than the earth's average field in this area, but is less than the normal fluctuations in the earth's field (which would be the case even without the screening). Thus, nature itself frequently makes bigger changes in the local magnetic field than the SSC would. So even with the SSC's magnetic field being added to the earth's, the net magnetic field near the earth's surface would be of a normal strength. Since aircraft instruments already function properly in the geomagnetic field's natural fluctuations, they should continue to with the SSC running.

FILE NO. _____

ARCHIVED
Log No. _____

Superconducting Super Collider Laboratory
2550 Beckleymeade Ave., Suite 210
Dallas, TX 75237-3946

Magnet Engineering

RECEIVED
JUL 24 1991
U.S. DEPT OF ENERGY
SSC PROJECT OFFICE

MEMO: July 23, 1991

TO: Bill Watson

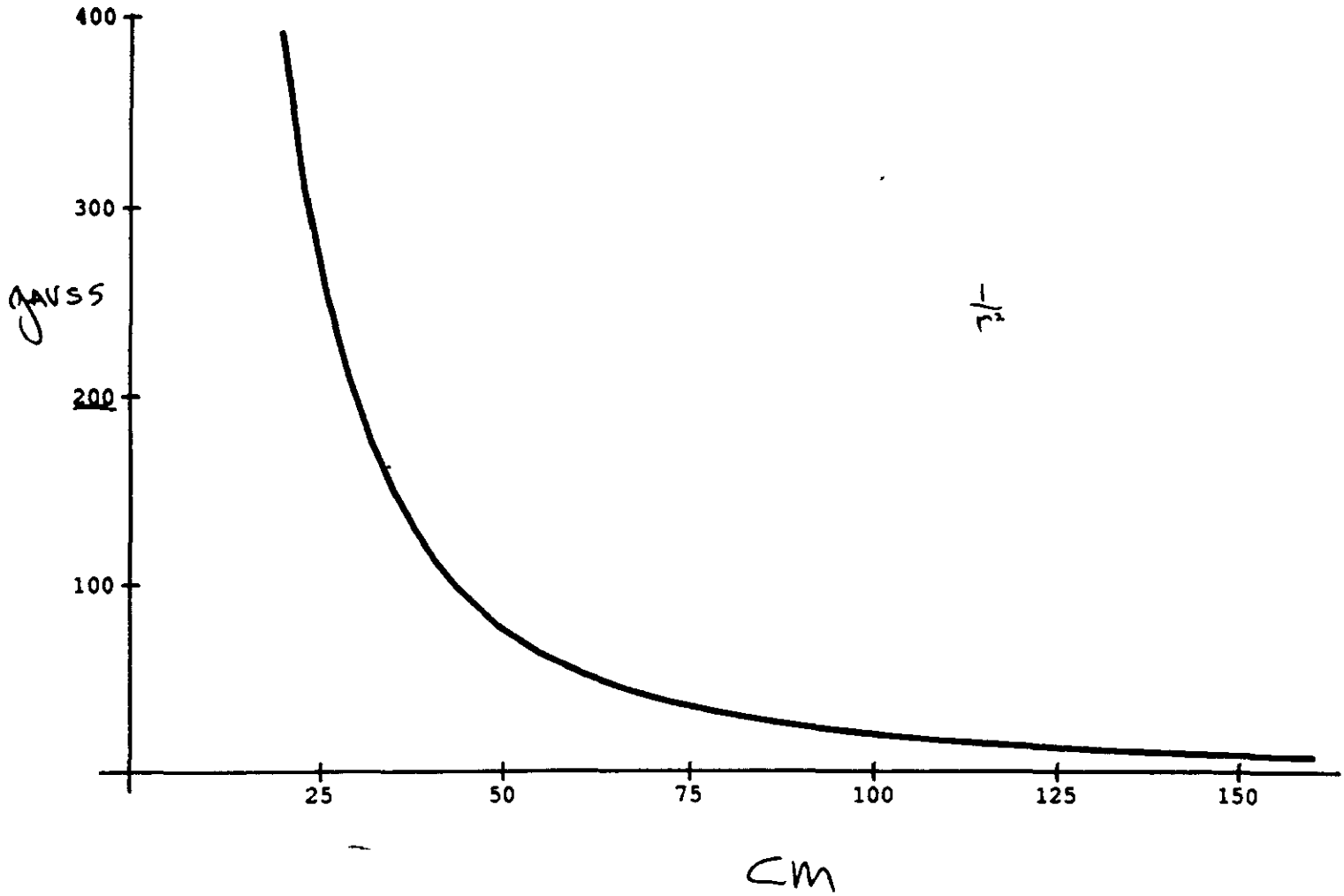
FROM: Greg Snitchler

RE: Field leakage at 50 meters distance

CC: J. Jayakumar

The fringe field in the horizontal plan at 50 meters is 8 milligauss. The fringe field in the vertial plan are approximately a factor of 7 lower or at 50 meters the field is 2 milligauss.This is a high estimate because there is shielding due the cryostat. Enclosed are the results of an electromagnetic finite element model used for scaling the fringe fields at 5% above operational current. The distant fringe field goes as $\frac{1}{r^2}$.

Horizontal B-Field



50 m away - no magnetic shielding

Department of Energy
SSC Project Office
2550 Beckleymeade, Mail Stop 1020
Dallas, Texas 75237-3946

Dr. Ted Kozman
SSC Laboratory
2550 Beckleymeade, MS 1044
Dallas, Texas 75237

Dear Dr. Kozman:

Mr. Fred Shannon, Manager of the O'Brien Airpark which is near the collider ring footprint, has expressed great concern about the collider's magnetic field and its effect on magnetic and other instruments on aircraft using the Airpark.
Dr. William Watson of our office has put together some information that includes theoretical calculations provided by the Superconducting Super Collider (SSC) Lab which indicates that the collider magnetic field outside the cryostats should be practically nil. We plan to convey this information to Mr. Shannon within the next few days. However, we would like to collect, as soon as possible, some experimental data to support our theoretical calculations. The test data would be kept on file for future use in responding to concerns of a similar nature.

Please investigate the feasibility for conducting some straight forward tests with the ER string at Fermilab to show the change in the local magnetic field due to the magnets being switched on. If it is determined that the tests are feasible, please arrange for the test to be conducted and provide the Department of Energy (DOE) with the results. Dr. Watson will be point of contact for DOE and he can be reached at (214) 708-2541.

Thanks for your attention to this request.

Sincerely,

Nat Brown

Nat Brown
Director, SSCPO
Compliance Division

DOE F 1325.8
(10-89)

United States Government **Department of Energy**

memorandum

DATE: August 19, 1991

REPLY TO ATTN OF: William Watson, PD3

SUBJECT: Collider magnetic fields near O'Brien Airport

TO: Nat Brown, Tony Robledo, PD5

To determine whether the SSC collider ring's magnetic field will disrupt the normal operation of aircraft instruments at O'Brien Airport, at least three things need to be compared:

(1) the strength of the collider's magnetic field at the airport,
(2) the average strength of the earth's own magnetic field, and
(3) the normal fluctuations of the earth's magnetic field.

Both the second and third items are important in determining the effect of the collider's magnetism on aircraft. The earth's magnetic field is the environment in which aircraft and their instruments function. In the Dallas area, this field has a nominal overall strength of 550 milligauss and a direction 66° below the horizontal, with the horizontal component of the field being about 6° east of true north and having a strength of 225 milligauss. However, the field deviates with geomagnetic activity about 2% from these values for a few hours or even a few days each year--about ±11 milligauss for the total field strength and ±4.5 milligauss for the horizontal component.

In contrast, the magnetic field at the surface 50 meters above the SSC's collider ring will be no greater than 2 milligauss. This strength, itself smaller than the size of a natural fluctuation of the earth's field, is what the collider's field would be due to the presence of the magnets alone, in the absence of any shielding whatsoever from the steel cryostats encasing the magnets. However, the cryostats would screen almost all of the magnets' fields from the environment. Ferromagnetic materials in the earth itself would screen much of the remainder leaving the collider's contribution to the magnetic field at the surface to be nearly zero.

This remaining magnetic field would not only be much smaller than the earth's average field in this area, but is less than the normal fluctuations in the earth's field (which would be the case even without the screening). Thus, nature itself frequently makes bigger changes in the local magnetic field than the SSC would. So even with the SSC's magnetic field being added to the earth's, the net magnetic field near the earth's surface would be of a normal strength. Since aircraft instruments already function properly in the geomagnetic field's natural fluctuations, they should continue to with the SSC running.

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Superconducting Super Collider Laboratory
2550 Beckleymeade Ave., Suite 210
Dallas, TX 75237-3946

Magnet Engineering

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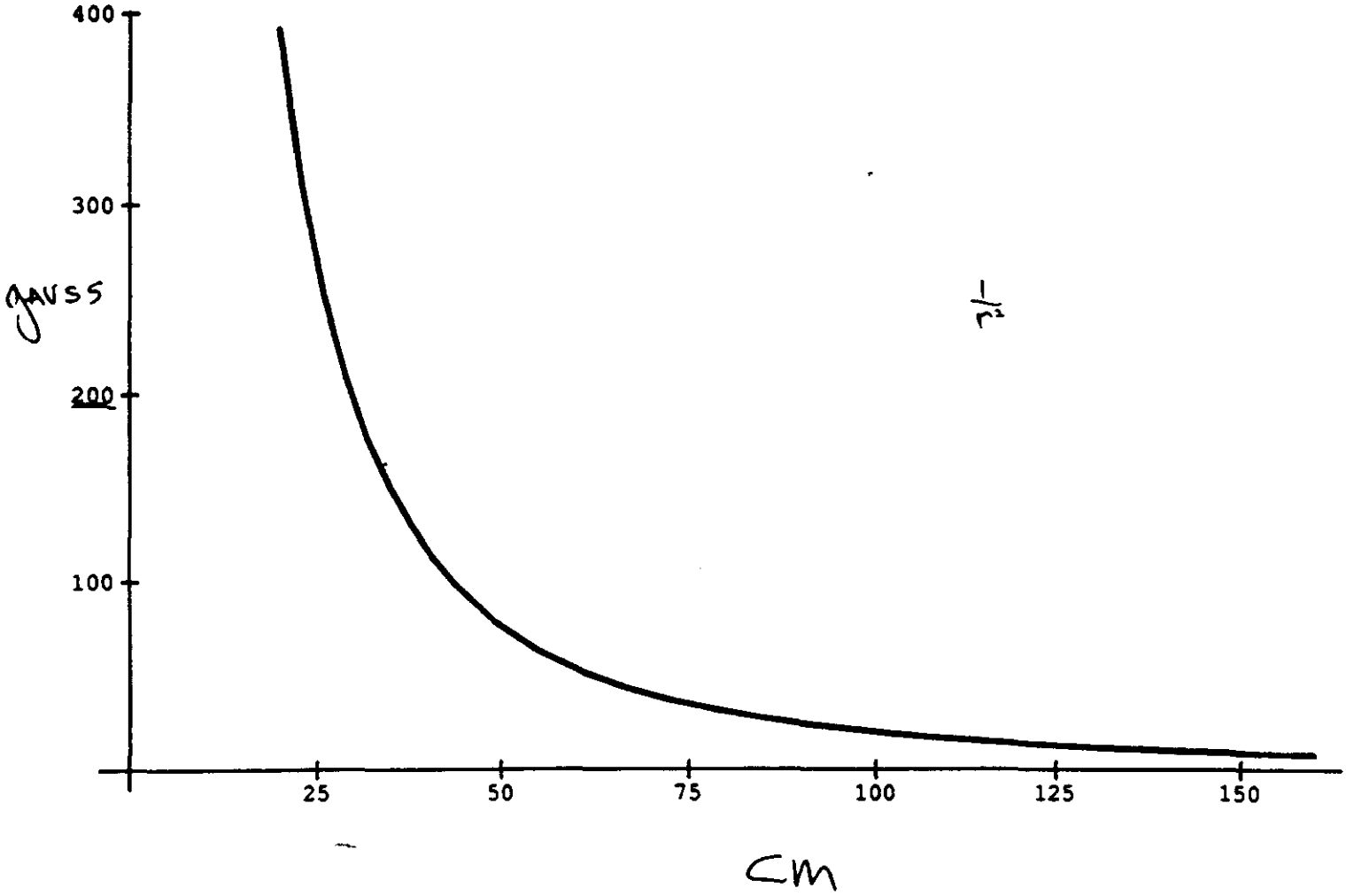
//

Horizontal B-Field

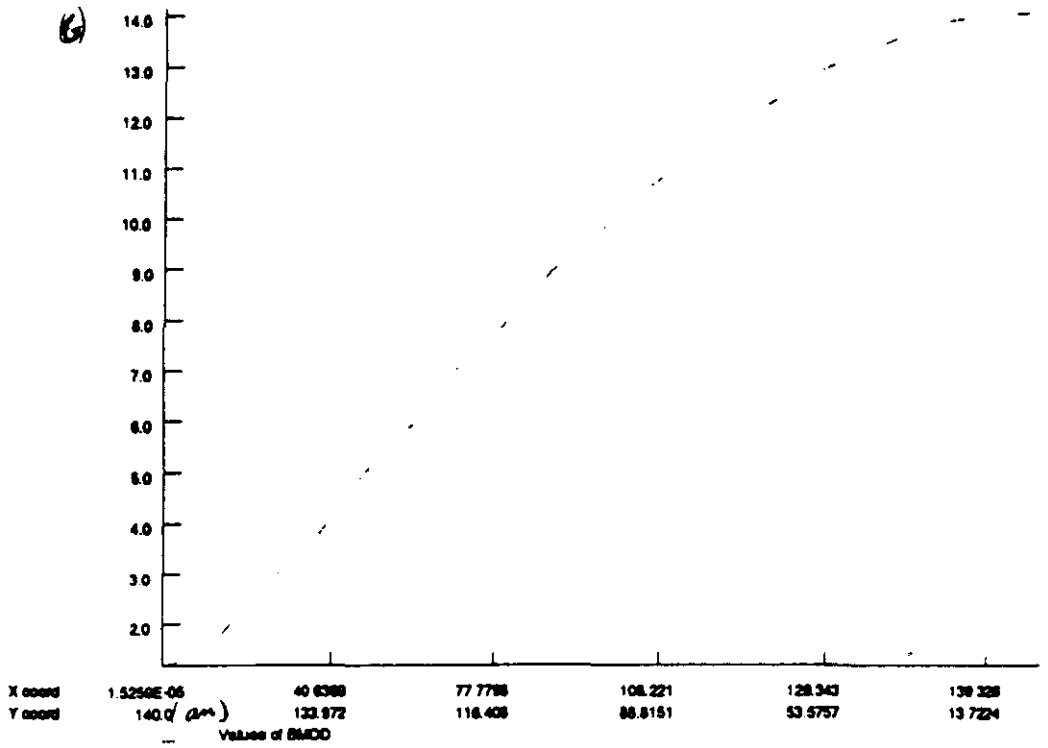


50 m away - magnetic shielding

```
In[18]:= a={{40, 115}, {60, 50}, {80, 30}, {100, 21}, {120, 17},
    {140, 14}}

Out[18]= {{40, 115}, {60, 50}, {80, 30}, {100, 21}, {120, 17}, {140, 14}}

In[19]:= fcn=Fit[a, {x^-1,x^-2,x^-3}, x]

                    6
         4.61343 10      1828.93    1672.31
Out[19]= ----------- + ------- + -------
              3            2          x
             x            x

In[20]:= fcn=Fit[a, {x^-2,x^-3}, x]

                    6
         -1.05516 10      209167.
Out[20]= ------------ + -------
              3            2
             x            x

In[21]:= plots:=Show[Plot[fcn, {x,20, 160}], ListPlot[a]]

In[22]:= plots

Out[22]= -Graphics-

In[23]:= fcn /. x->5000

Out[23]= 0.00835826

In[24]:= fcn=Fit[a, {x^-3}, x]

                    6
         7.83769 10
Out[24]= -----------
              3
             x

In[25]:= plots

Out[25]= -Graphics-

In[26]:= fcn=Fit[a, {x^-2,x^-3}, x]

                    6
         -1.05516 10      209167.
Out[26]= ------------ + -------
              3            2
             x            x

In[27]:= plots

Out[27]= -Graphics-

In[28]:= fcn=Fit[a, {x^-3}, x]

                    6
         7.83769 10
Out[28]= -----------
              3
             x

In[29]:= plots
```

```
Out[29]= -Graphics-

In[30]:=
```

FRINGE PIC
23JUL91 10:05 [illegible] Page 14 LINE 0 140 140 0 CUs 1/1-40 NP=32 COMP=BMOD

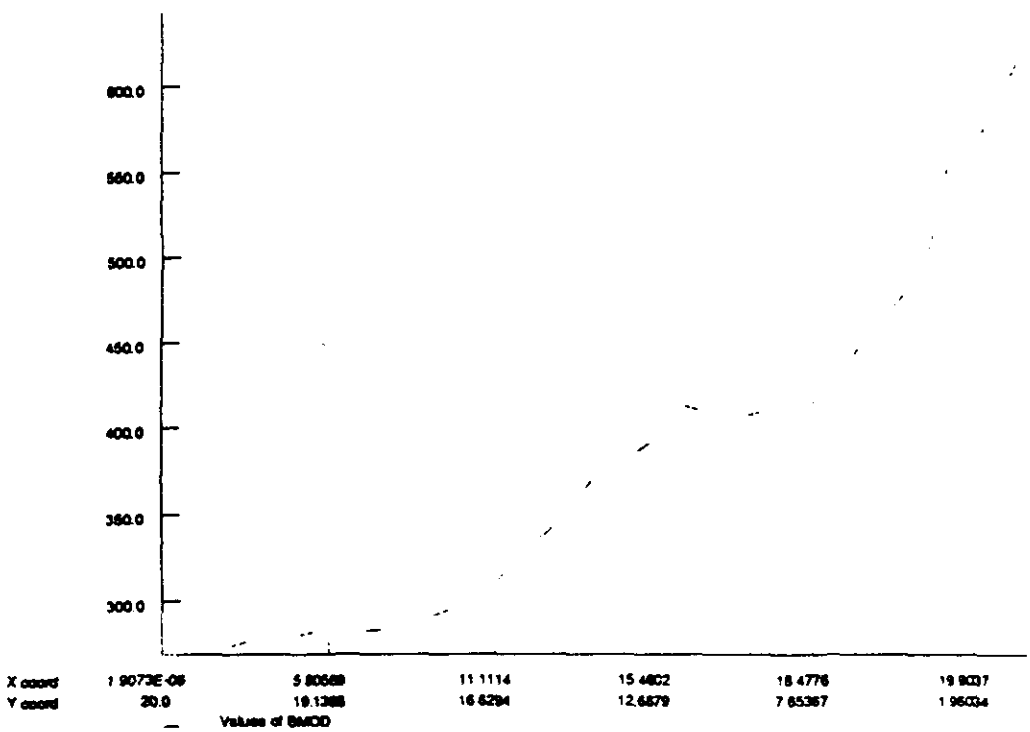


VF/PE2D.8

FRINGE.PIC
23JUL91 10:02:23 Page 6 100

VF/PE2D.8

FRINGE.PIC
23JUL91 10:02:48 Page 7 : LINE 0 20 20 0 CUs1/20 NP=32 COMP=BMOD



VF/PE2D.8

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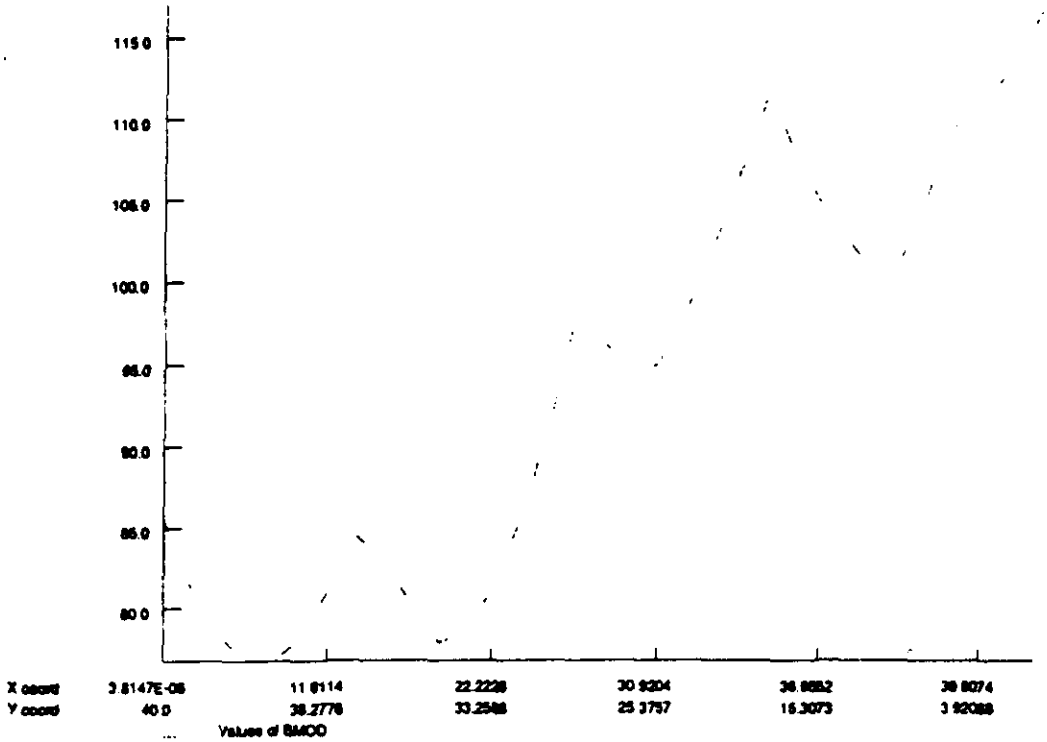
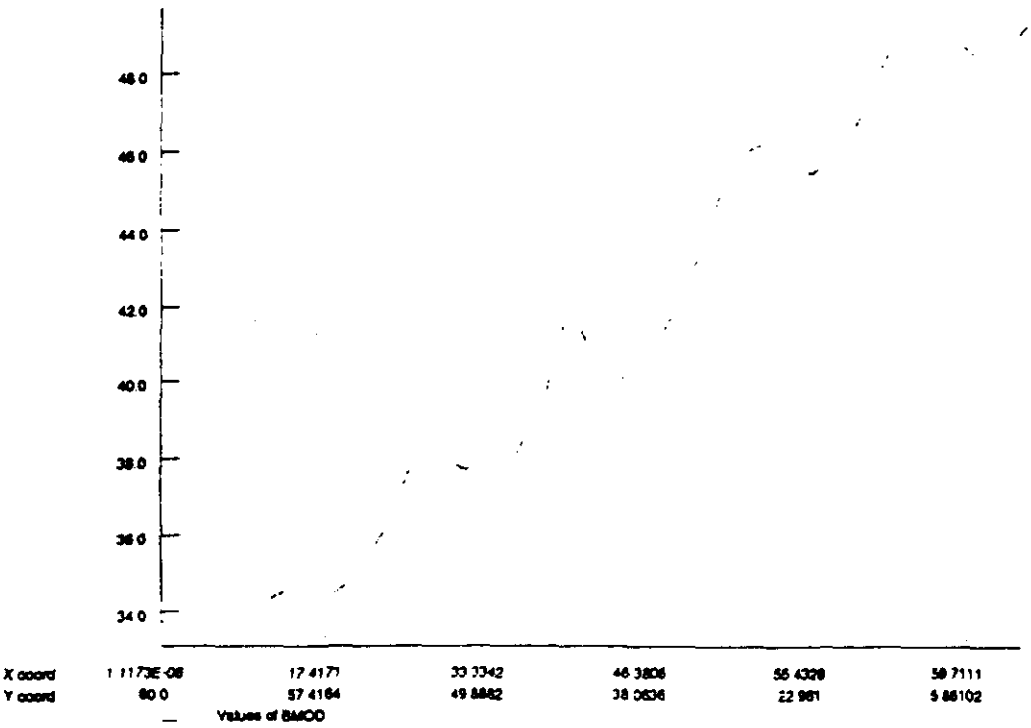
23JUL91 10:03:30 Page 6 LINE 0 40 40 0 CUs 1/40 NP=32 COMP=BMOD



VF/PE2D.8

FRINGE.PIC
23JUL91 10:04:01 Page 9 LINE 0 80 80 0 CUs 1/80 NP=32 COMP=BMOD



VF/PE2D.8

FRINGE.PIC
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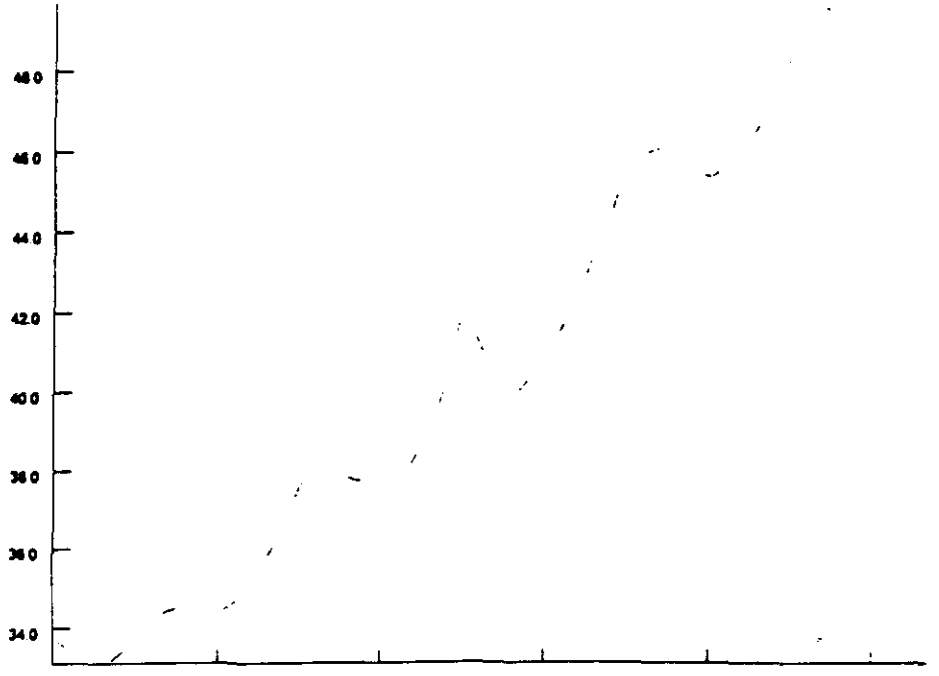

X coord	1.1173E-05	17.4171	33.3342	46.3806	56.4328	59.7111
Y coord	60.0	57.4164	49.6882	36.0636	22.991	5.88102

... Values of BMOD

VF/PE2D.8

FRINGE.PIC
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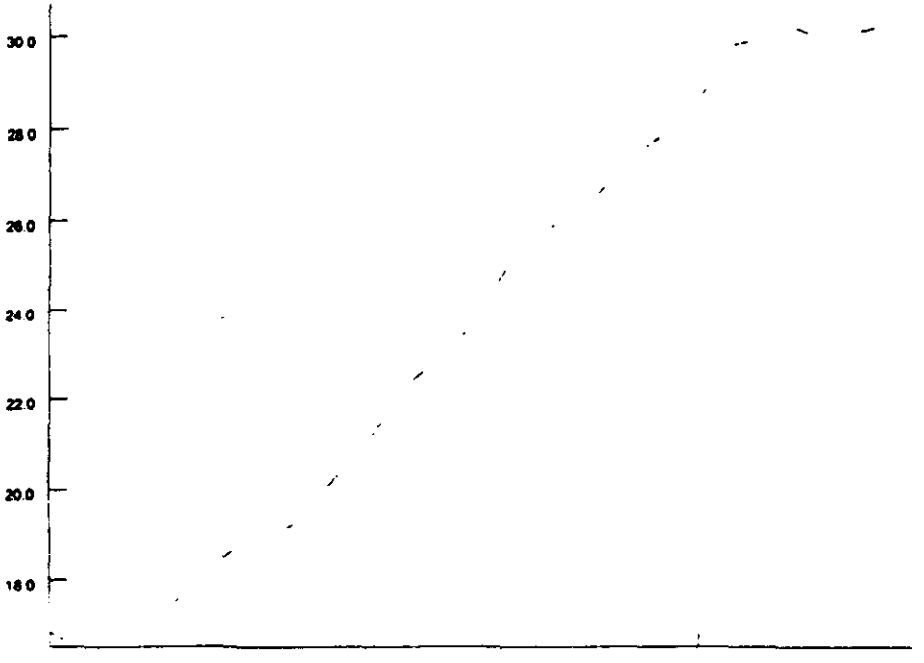

X coord	7.6294E-06	23.2228	44.4456	61.8406	73.9104	79.6148
Y coord	60.0	76.5562	66.5176	50.7515	30.6147	7.84137

Values of BMOD

VF/PE2D.8

FRINGE.PIC
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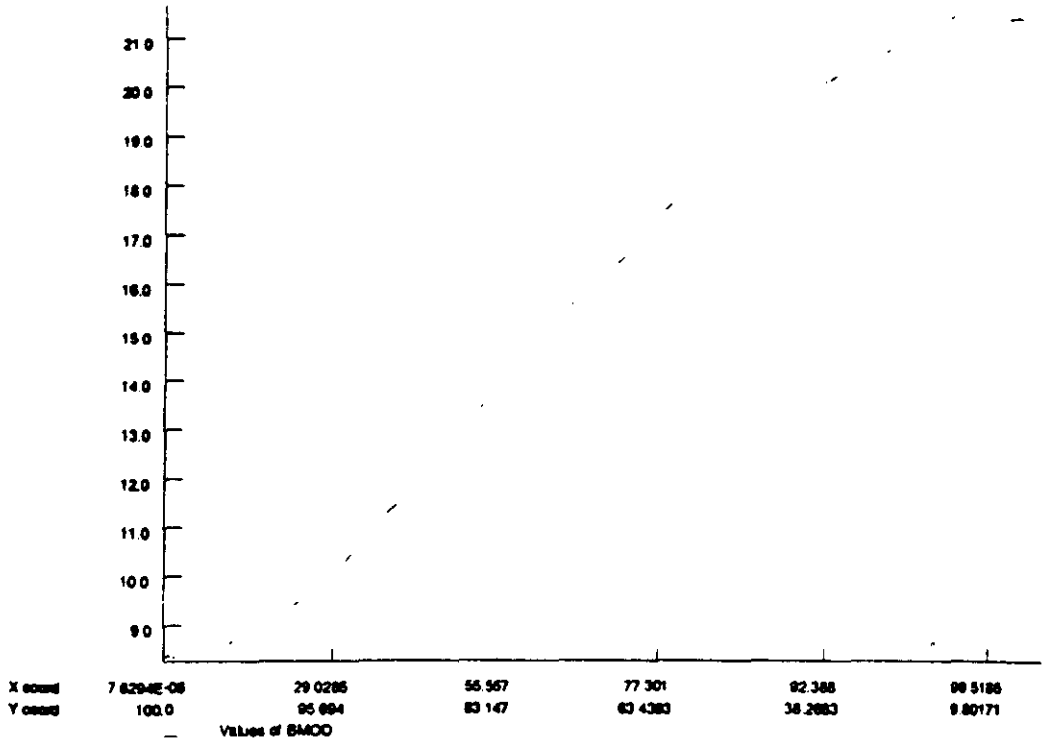
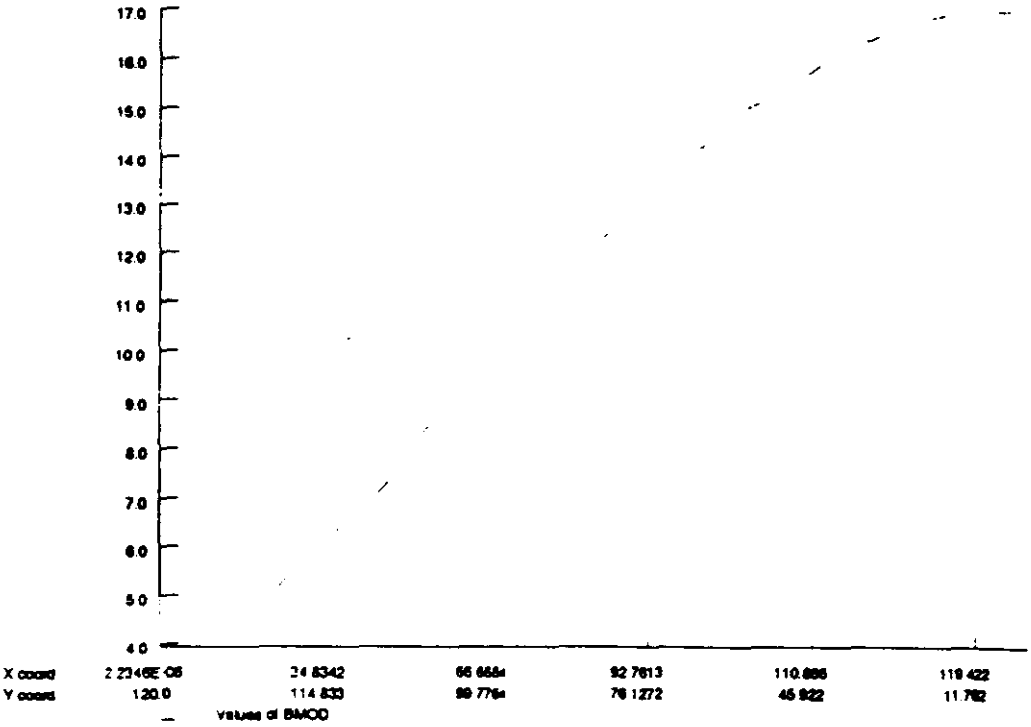


VF/PE2D.8

FRINGE.PIC
23JUN91 10:05:36 Page 13 : LINE 0 120 120 0 CUs V120 NP=32 COMP=BMOD



VF/PE2D.8

From: Ronn Woolley (10/23/91)
To: Ray StefanskiCC: Mike Harris, Tim Thurston
REGARDING Site surface magnetic fields at boundaries
Ray,

If we extrapolate the furnished Contour plots out to 1 gauss (note that this is '1 gauss' OVER earth's background level), we arrive at the following corrected surface field dimensions:

Preliminary, full-pole, surface field size measurements are roughly: 320m x 400m (diam.), for IR's 1&8 (at 47/48m depth); 300m x 380m (diam.), for IR 5 (at 51.5m depth); and 380m x 460m (diam.), for IR 4 (at 35.7m depth).

The reason for the alterations of these figures from the previous, is a discrepancy within the contour plots which I originally used.

Regarding site boundary trespass by the above estimated fringe fields, there is no location where the 1-gauss level exceeds the site boundary, and even the 0.5 gauss field limit lies within all locations' site boundaries.

Ronn
==========

Superconducting Super Collider Laboratory
2550 Beckleymeade Avenue, Mail Stop 2000
Dallas TX 75237-3946
(214) 708–6018
Fax: (214) 708-0006

Experimental Facilities Group

Memorandum

To Joe Cipriano
From: Ray Stefanski
Subject: FAA communication on GEM solenoidal magnet
Date: Mon, Oct 7, 1991

Larry Coulson and Roy Schwitters have determined that we should seek comments from the FAA on the stray magnetic fields that would be associated with the GEM solenoidal magnet. We're uncertain whether the communication should be made by Roy, or whether they should come from the DOE. Please advise us on the course of action you would recommend.

A copy of the draft letter is included with this memo. If you have any questions, call me at (X6018) or Ronn Woolley at (X6079).

xc: F. Gilman
R. Woolley
S. Brumley
R. Schwitters
L. Coulson
R. Kasper

Superconducting Super Collider Laboratory
Physics Research Division
2550 Beckleymeade Avenue
Mail Stop 2001
Dallas, TX 75237-3946
(214) 708-6113• FAX (214) 708-0006

Monday, October 7, 1991

Mr. Harold W. Becker, Manager
FEDERAL AERONAUTICS ADMINISTRATION
Air Space Rules & Aeronautical Information Division
Headquarters FAA, ATP-200
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Mr. Becker,

We would like to bring to your attention our potential plans to construct a facility as part of the new Superconducting Super Collider Laboratory, which will result in a localized direct current, static magnetic anomaly. As part of the experimental facilities for the SSC Laboratory, we may construct a large solenoidal magnet located in an underground hall, 154 ft. below grade. During operation of the facility (which may begin operation in 1997) this magnet would produce an external field of less than 0.2 gauss (half of the earth's field) at a height of about 460 ft. directly above the facility. This field will drop off rapidly with horizontal distance from the site. For example, it will reach one-tenth of the earth's magnetic fie;ld (i.e. 0.02 gauss) directly overhead, at about 1,200 ft. from the center of the facility, and will taper off to zero gauss well within the site boundaries of the Laboratory.

We enclose specifications of the magnet and facility, for your information. This program is funded by the Department of Energy.

If we can be of any further assistance, please don't hesitate to Dr. Ray Stefanski at (214) 708-6018.

Sincerely yours,

Roy Schwitters, Director

Attachment

FG/rw

cc: Steve Brumley
Terrell Cone - DOE
Roy Schwitters
Ed Siskin

Phil Stafford - TNLRC
Ray Stefanski

bcc: Larry Coulson
Mike Harris
Gary Sanders - LANL
Phil Shelley
Tim Thurston

ATTACHMENTS

Following is a brief outline describing the content of each of the attachments:

FIGURE 1 - Map of the entire Supercollider project referenced to nearby cities and highways. Shows East and West Campuses, where surface facilities and underground detector halls would be located.

FIGURE 2 - Close-up of the East Campus property, showing the IR-5 and IR-8 underground halls locations, with respect to the accelerator 'rings', and the relative size of their 10-gauss surface field.

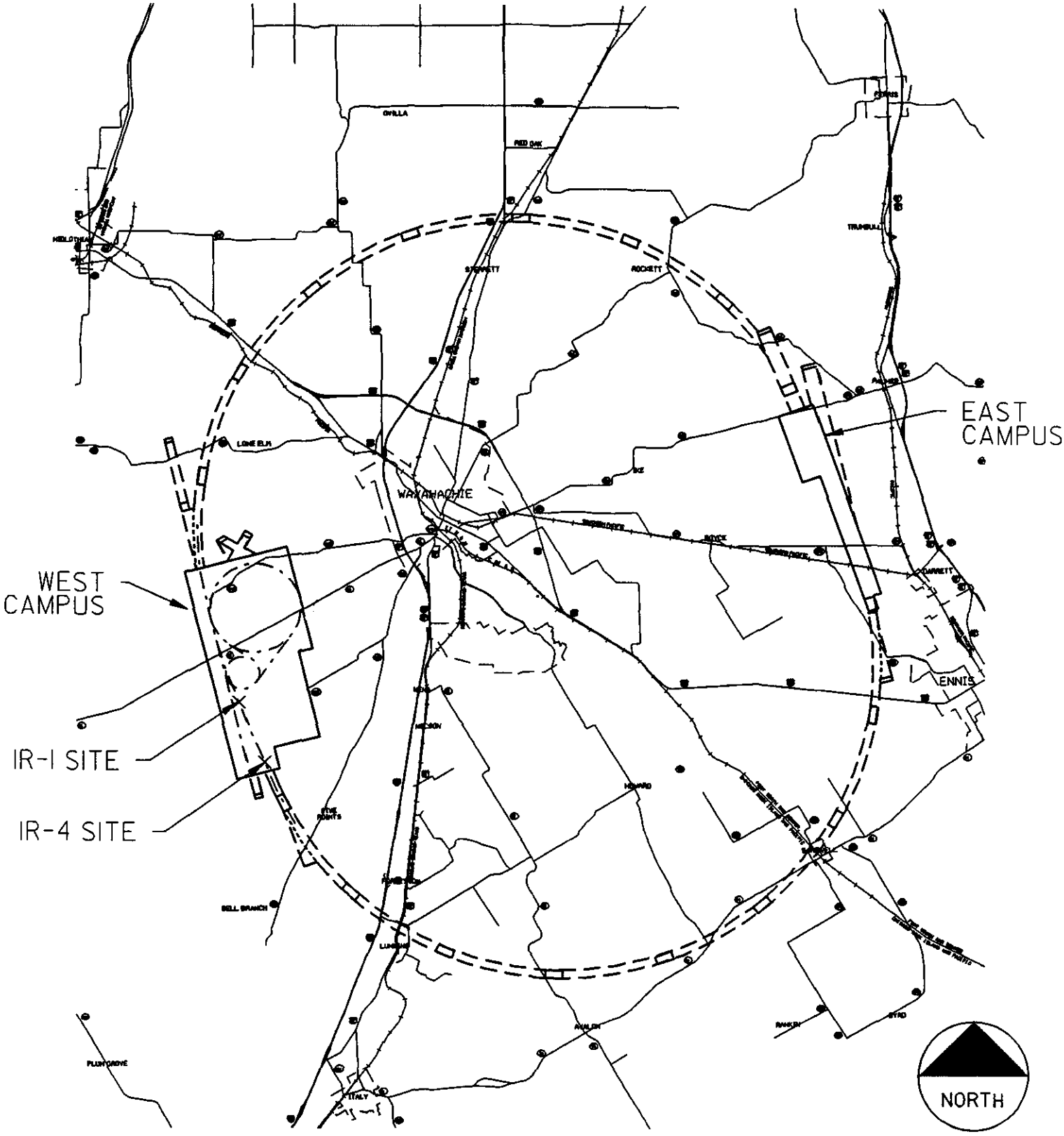
FIGURE 3 - Close-up of the West Campus property, showing the IR-1 and IR-4 underground halls locations, with respect to the accelerator 'rings', and the relative size of their 10-gauss surface field.

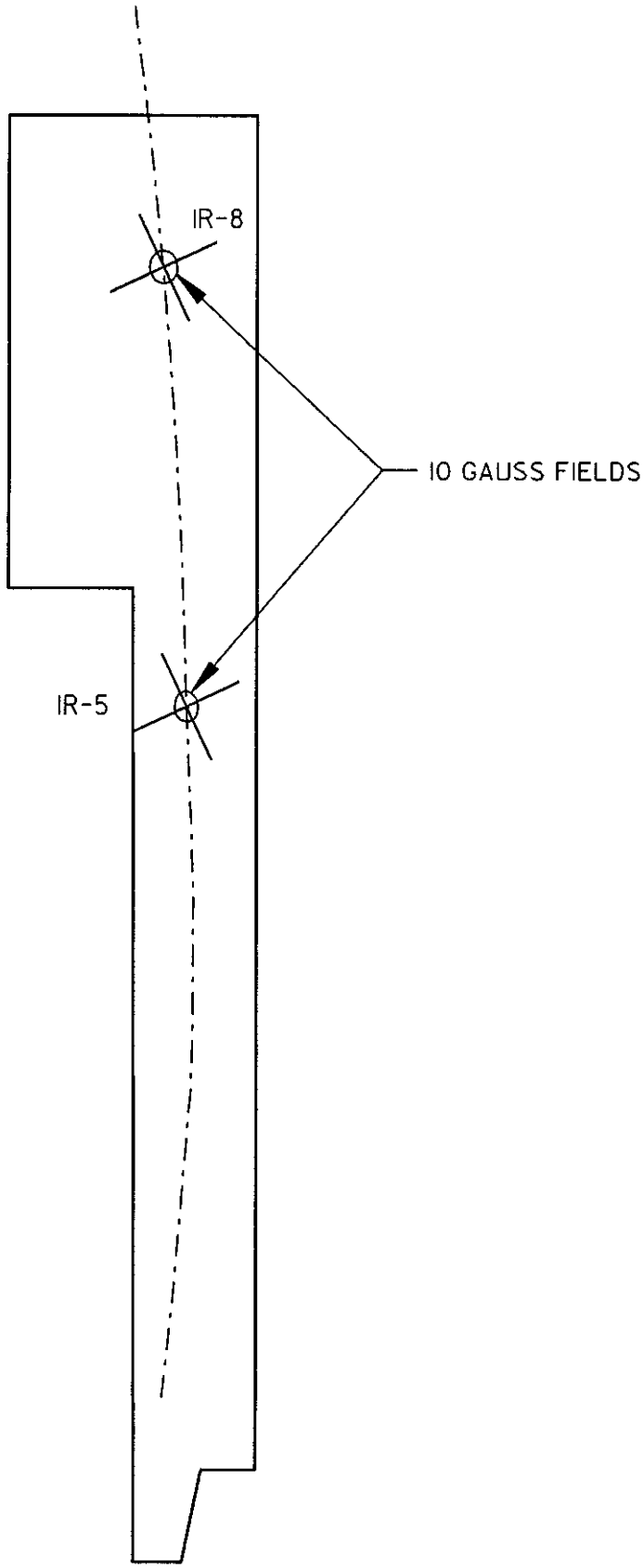
FIGURE 4 - FAA Aeronautical map of Dallas-Ft.Worth area (scale 1:500,000) showing the locations, and relative-size 10-gauss surface fields, of the underground detectors.

FIGURE 5 - FAA Aeronautical map of Dallas-Ft.Worth area (scale 1:250,000) showing the locations, and relative-size 10-gauss surface fields, of the IR-5 and IR-8 underground detectors.

FIGURE 6 - Overhead view of the magnetic surface field extent of the IR-1 and IR-8 underground detector halls. They are basically the same, for both halls, due to the similar sub-surface elevations.

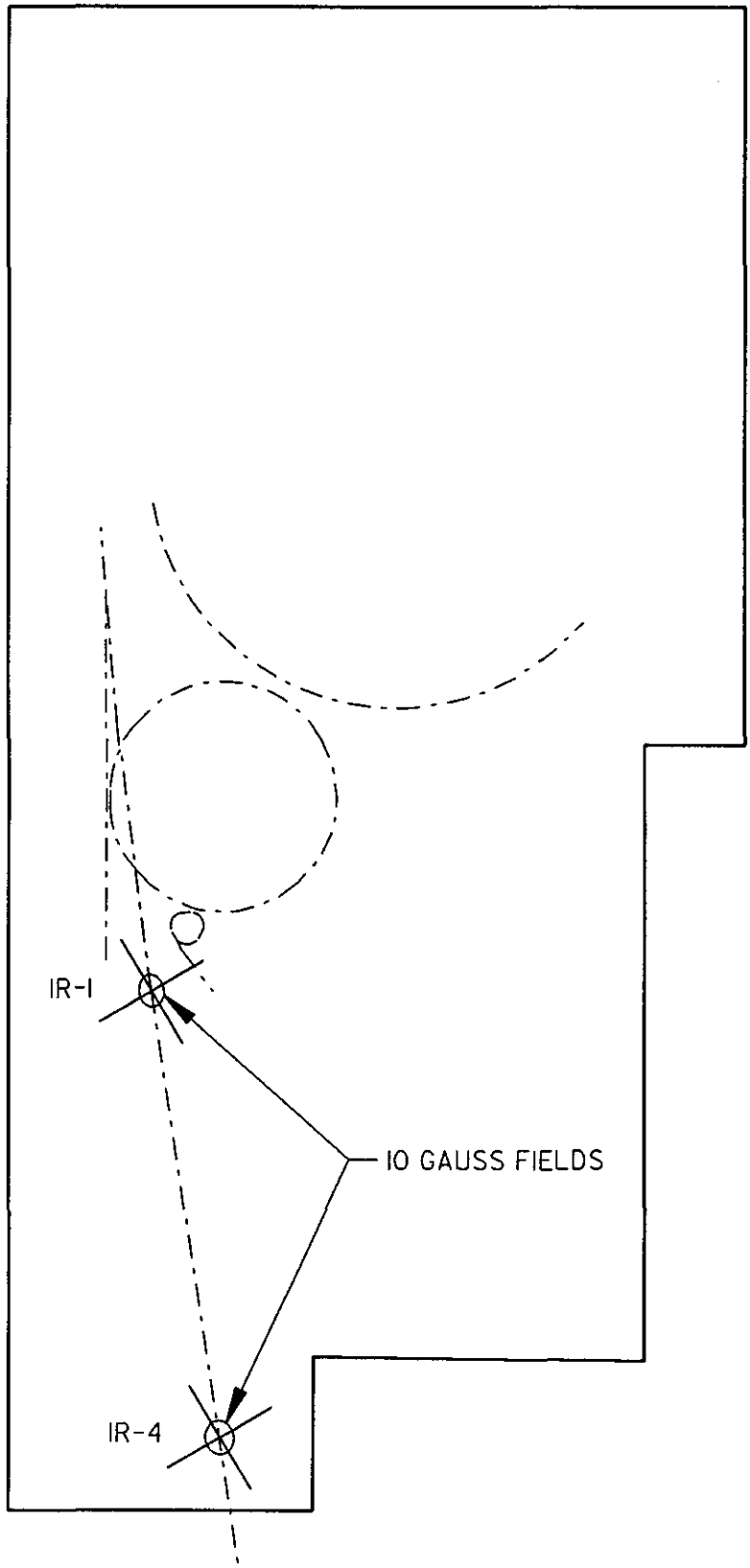
FIGURE 7 - Cross-sectional or lateral view of the IR-1 underground detector hall, showing the magnetic field contours from beam-line elevation and vertically to above the surface. Surface facilities are also illustrated.


EAST CAMPUS
WEST CAMPUS
IR-1 SITE
IR-4 SITE
WAXAHACHIE
ENNIS
NORTH



1:4000

10 GAUSS FIELDS
AT IR SITES



1:4000

10 GAUSS FIELDS
AT IR SITES

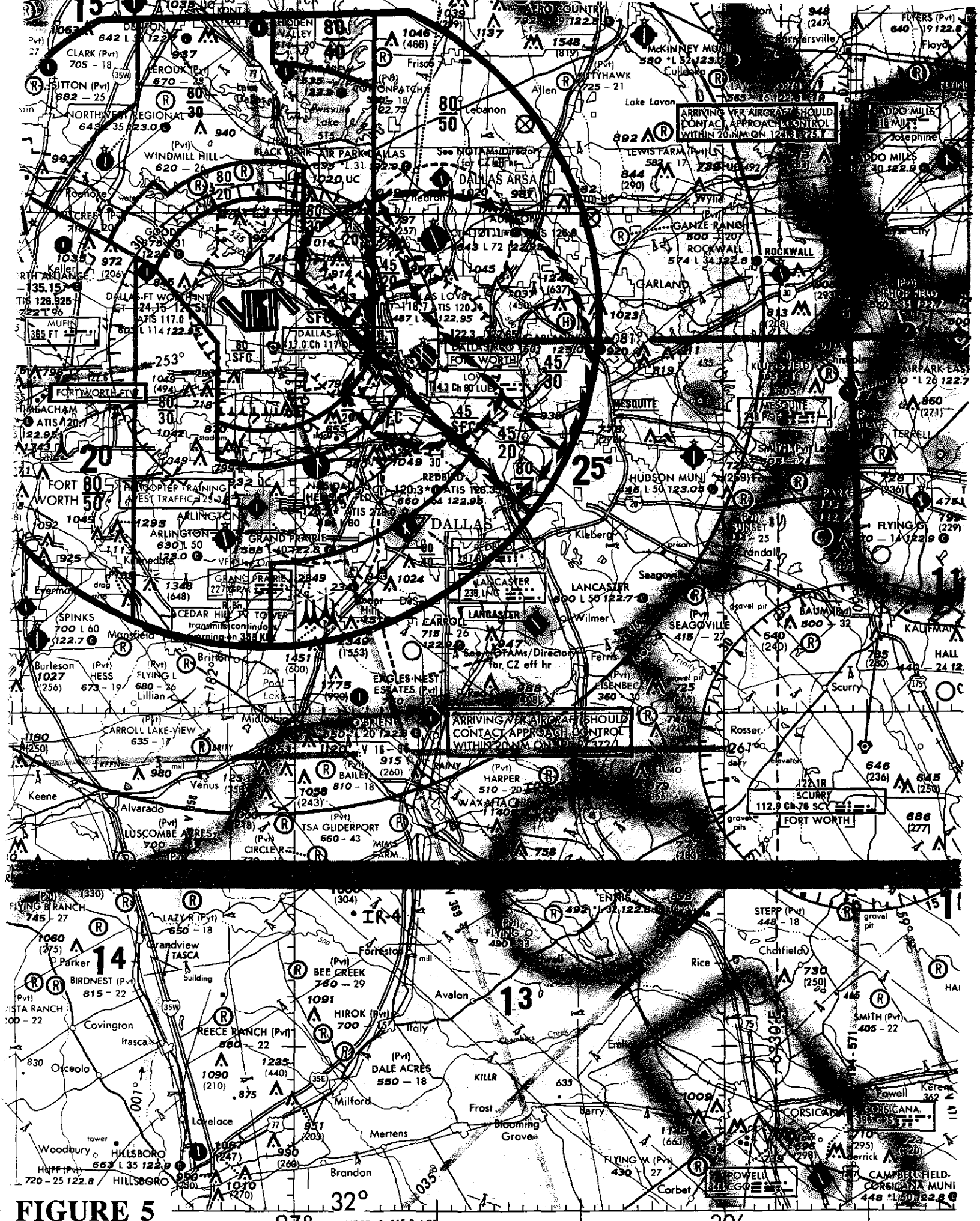

DALLAS
FORT WORTH
ARLINGTON
GRAND PRAIRIE
LANCASTER
MESQUITE
ROCKWALL
GARLAND
DALLAS ARSA
McKINNEY MUNI
HUDSON MUNI
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 123.8 125.7
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 123.8 125.7
See NOTAMs/Directory for CZ eff hr
See NOTAMs/Directory for CZ eff hr
VORTAC 115.3 ACT
97°
32°
30'

FIGURE 5

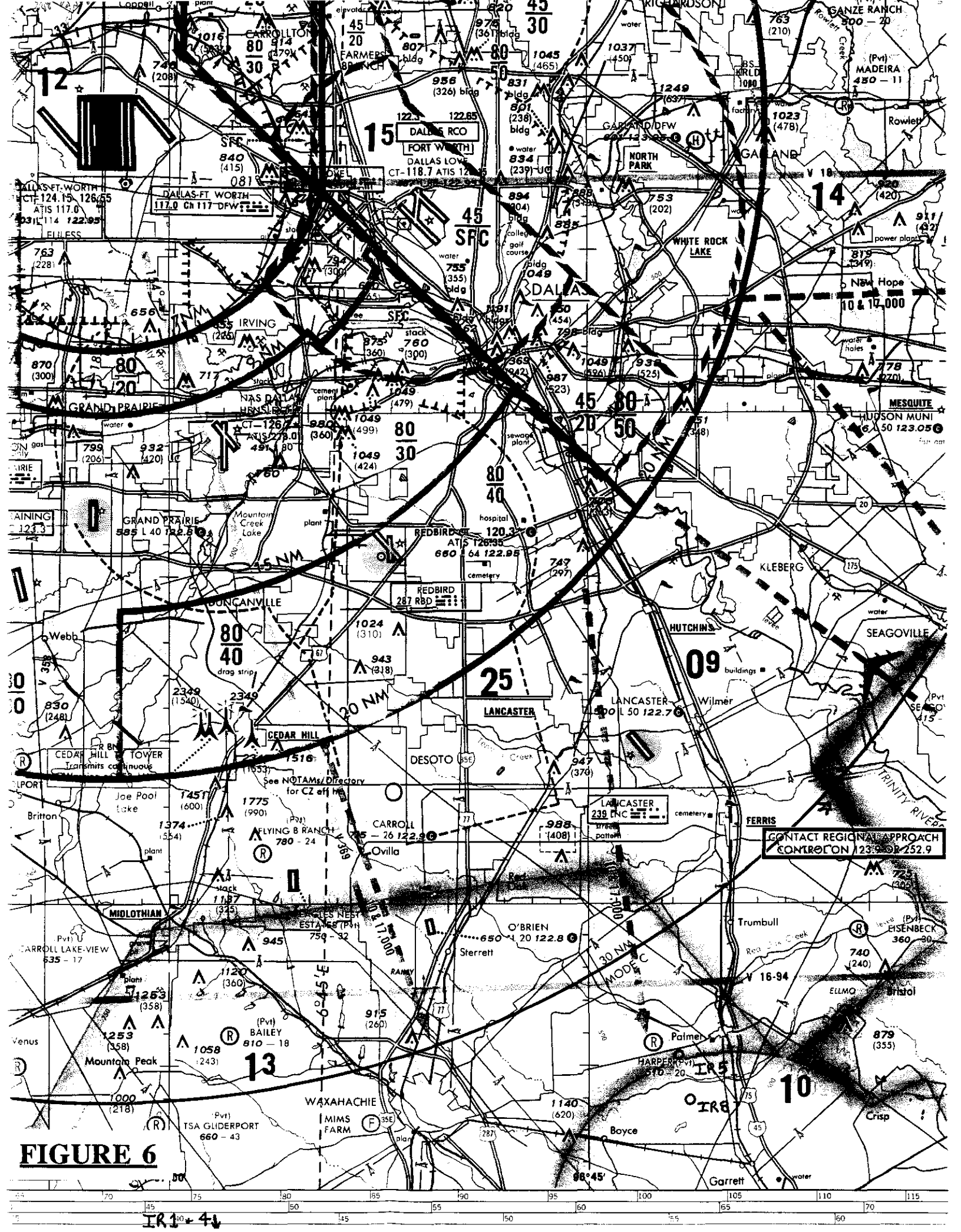


FIGURE 6

IR1 - 4

FIELD ON THE SURFACE IR 1 _ IR 8

IR 1 : BEAM 46.9 m /surface

IR 8 : BEAM 48.1 m /surface

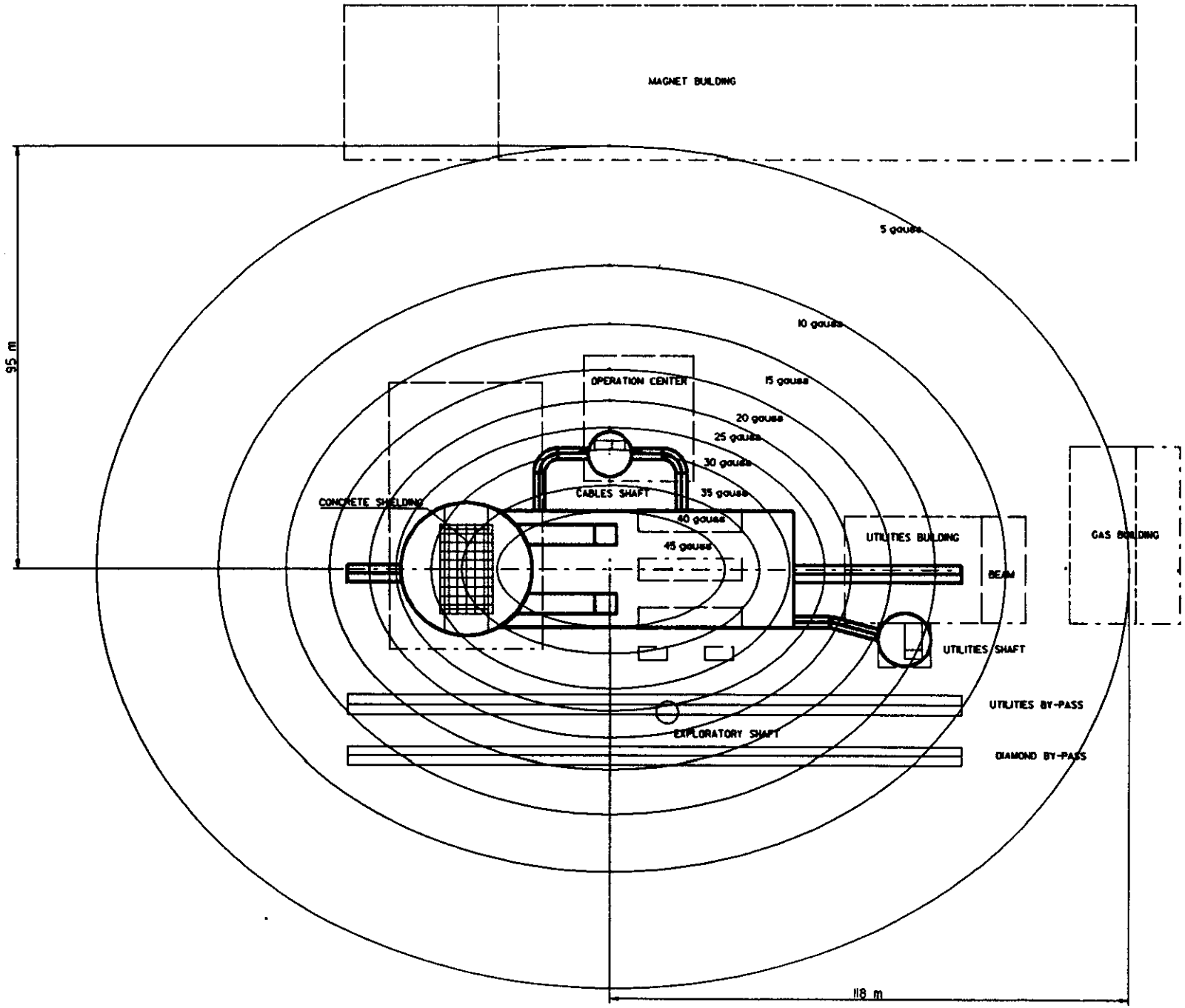


FIGURE 1

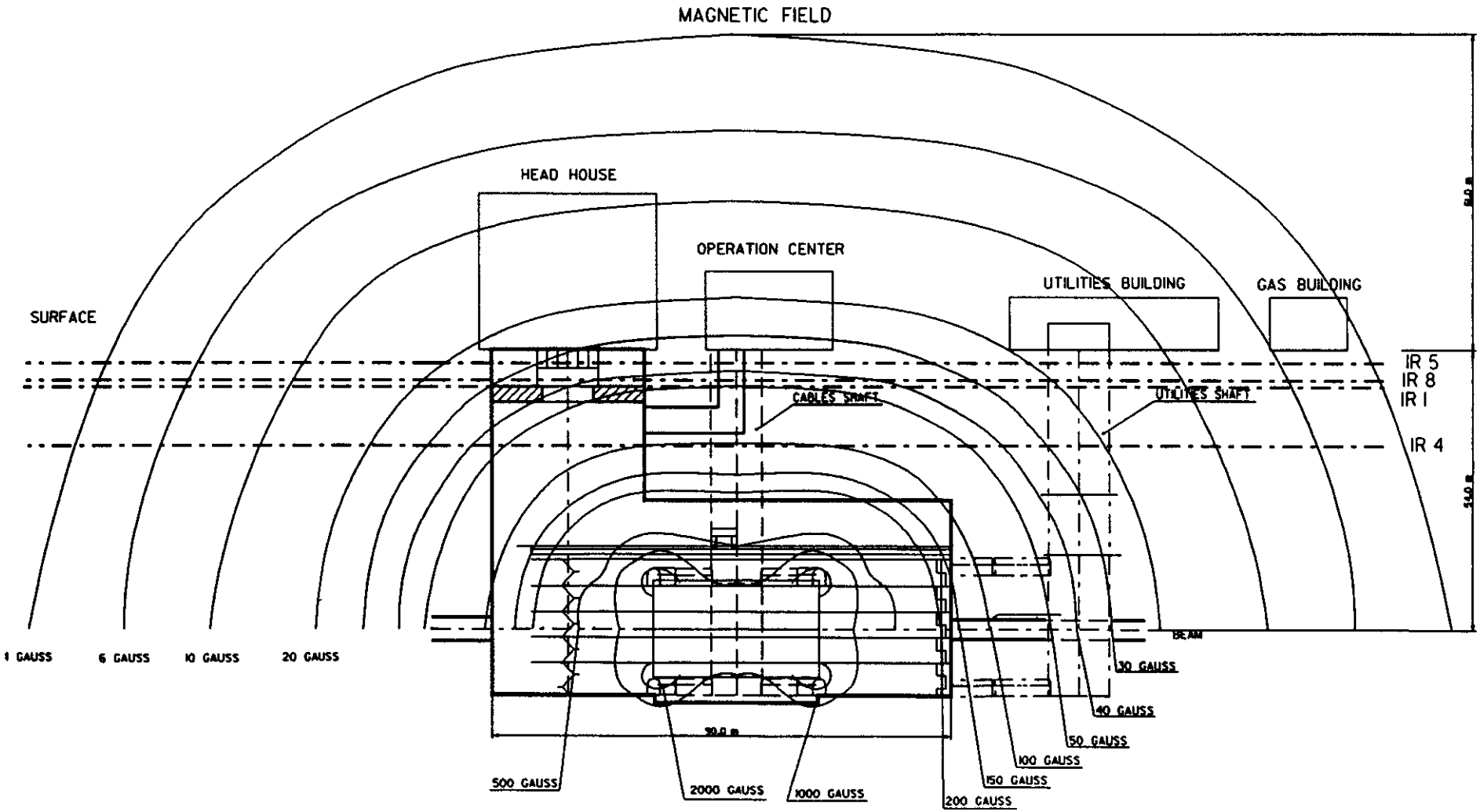

MAGNETIC FIELD
HEAD HOUSE
OPERATION CENTER
UTILITIES BUILDING
GAS BUILDING
SURFACE
IR 5
IR 8
IR I
IR 4
CABLES SHAFT
UTILITIES SHAFT
BEAM
1 GAUSS
6 GAUSS
10 GAUSS
20 GAUSS
30 GAUSS
40 GAUSS
50 GAUSS
100 GAUSS
150 GAUSS
200 GAUSS
500 GAUSS
2000 GAUSS
1000 GAUSS

FIGURE 2

KAY

SSC LABORATORY
Stoneridge Office Park
2550 Beckleymeade Avenue
Dallas, Texas 75237

MS2011E
12 October 1991

MEMORANDUM

TO: Ronn Wooley

FROM: Tim Toohig

SUBJECT: Lab Environmental Commitments on Stray Magnetic Fields

---

Ronn,

Rather than seek a legal determination, I would see about working with ES&H on this. Larry Coulson has been the Lab lead in this area.

In laying out the problem I would try to state explicitly, and succintly what the problem is, i. e.,

1. The GEM detector preference is to use a very large unshielded magnet, which will result in a measurable magnet field at the surface, as far as we can determine now.

2. The EIS states categorically that "... no magnetic field source term would be presented at the surface of the SSC site or at its boundaries." (DEIS, Vol. IV, App. 10)

3. The Safety Review Document, which is incorporated by reference into the FEIS, states that magnetic fields around the detectors will be appropriately posted without any surface commitment. (atchd.)

4. Comments in the FEIS and SEIS seem to imply that the reference in the DEIS may only have been considering the fields due to accelerator magnets. (atchd)

5. The DOE and SSCL have made written responses to enquiries about potential interference with aircraft navigation equipment relative to O'Brien Airport and Waxahachie-Midlothian Aiport respectively. These reference back to the SEIS statement, which addresses fields from the accelerator magnets. (atchd)

The question to be asked then is whether stray field at the level of about 10 Gauss can be accommodated within the parameters defined by the environmental Record of Decision for the project, relying on the posting called out in the Safety Review Document.

I believe you have all the reference, except for the DOE letter, which Nat Brown said he would put in the mail.

cc: Phil Shelley

Cost increase to add IRON Return to unshielded single coil $Δ

Case 1 1.3m thk 2.37 T Pole Sat

19025t barrel 6752t Pole

− 5013 pole without barrel

$ 48.89 m 1739

$ 6.347 M

$ 55.24 M = $Δ

Case 2 2.0 thk 1.7 T Pole Sat

30 268t B 5378t ×2

×$2.57/kg 10,756t − 5013t

$77.79 M ×$3.65/kg

$ 20.96 M

$ 98.75 M = $Δ

Case 1 surface < 10 G

Case 2 " < 1 G

GEMAG IRON Costs

ENGINEERING & DESIGN

POLE (includes CROWNS)		$308 k ($0.05/kg
BARREL		$305 k ($0.02/kg

MACHINING

Pole (" ")		$0.71 /kg
BARREL		0.58

INSTALLATION AND ASSEMBLY

Pole (" ")	100 MAN YEARS		
BARREL	180 " "		
AT $60 k /MAN YEAR :			
Pole $6000 k	=>	$0.89 /kg	
BARREL $10800 k		0.57	

MACH + INST + ASSY

Pole	$1.60 /kg	✓
Barrel	$1.15 /kg	

MATERIAL

Pole	$ 2 /kg	$3.65 /kg
BARREL	$ 1.4	2.57

St	Input	Name	Output	Unit	Comment
	250	Rhole		cm	Radius of hole in door
	8.30	Recran		m	Internal free radius
	8.90	Rwindin		m	Mean radius of winding
	29.00	Dpole		m	Internal free length
	.80	B		T	Magnetic induction
L	130	Spcond		cm	Space for coil from screen to barrel
	2.37	BsatPol		T	Induction in pole
		BsatMan	2.37	T	Induction in barrel

	3.65	PriceIP		$/kg	Price of iron for pole fully erected
	2.57	PriceIB		$/kg	Price of iron for barrel fully erected
L		Price_B	48.89	M$	Price of Barrel fully erected
		Price_P	12.32	M$	Price of one Pole fully erected
		Price_T	73.54	M$	Total price of iron fully erected

		W_I_T	25776	t	Optimized weight of iron
		W_B	19025	t	Weight of barrel
		W_Door	1533	t	Weight of mobile part
		W_Cro	1842	t	Weight of one crown
		W_P	3376	t	Weight of one pole
		Rinman	9.60	m	Internal radius of barrel
L		Rexman	10.90	m	Outside radius of barrel
		Dextpol	32.15	m	External length of magnet
	130.00	T_B		cm	Thickness of barrel
		T_door1	44.30	cm	Thickness of door near hole
		T_door2	147.09	cm	Thickness of door near free aperture
		T_P	157.72	cm	Thickness of pole at Rwinding
		T_P_Bxt	122.09	cm	Thickness of pole on barrel outside di
		H	636620	Oe	Magnetic field
		At	19.94	MAt	Needed ampere-turns
		Flux	199.08	Wb	Flux
		Sman	88.31	m^2	Cross section of barrel
		IronSpC	7.43	t/m^3	Specific mass of iron with packing
		tpsn	.41421356	-	Tangente(pi/N)
	8	N		-	Number of sides of barrel
	1.05	FoisIro		-	Packing factor for iron
	7.80	IronSp		t/m^3	Specific mass of iron
	1.08	FactAt		-	Factor for ampere-turns
		Energy	1.84	GJ	Stored energy
		μ0	1.2566E-6	A/m	Vacuum permeability
	50000.00	Current		A	Current
		Induct	1.47	H	Coil inductance
		Nturn	398.78	-	Number of turns

St	Input	Name	Output	Unit	Comment
	250	Rhole		cm	Radius of hole in door
	8.30	Recran		m	Internal free radius
	8.90	Rwindin		m	Mean radius of winding
	29.00	Dpole		m	Internal free length
	.80	B		T	Magnetic induction
L	130	Spcond		cm	Space for coil from screen to barrel
	2.37	BsatPol		T	Induction in pole
		BsatMan	3285.27	T	Induction in barrel

	3.65	PriceIP		$/kg	Price of iron for pole fully erected
	2.57	PriceIB		$/kg	Price of iron for barrel fully erected
L		Price_B	.04	M$	Price of Barrel fully erected
		Price_P	9.17	M$	Price of one Pole fully erected
		Price_T	18.38	M$	Total price of iron fully erected

		W_I_T	5040	t	Optimized weight of iron
		W_B	14	t	Weight of barrel
		W_Door	1533	t	Weight of mobile part
		W_Cro	980	t	Weight of one crown
		W_P	2513	t	Weight of one pole
		Rinman	9.60	m	Internal radius of barrel
L		Rexman	9.60	m	Outside radius of barrel
		Dextpol	32.15	m	External length of magnet
	.10	T_B		cm	Thickness of barrel
		T_door1	44.30	cm	Thickness of door near hole
		T_door2	147.09	cm	Thickness of door near free aperture
		T_P	157.72	cm	Thickness of pole at Rwinding
		T_P_Bxt	138.61	cm	Thickness of pole on barrel outside di
		H	636620	Oe	Magnetic field
		At	19.94	MAt	Needed ampere-turns
		Flux	199.08	Wb	Flux
		Sman	.06	m^2	Cross section of barrel
		IronSpC	7.43	t/m^3	Specific mass of iron with packing
		tpsn	.41421356	-	Tangente(pi/N)
	8	N		-	Number of sides of barrel
	1.05	FoisIro		-	Packing factor for iron
	7.80	IronSp		t/m^3	Specific mass of iron
	1.08	FactAt		-	Factor for ampere-turns
		Energy	1.84	GJ	Stored energy
		μ0	1.2566E-6	A/m	Vacuum permeability
	50000.00	Current		A	Current
		Induct	1.47	H	Coil inductance
		Nturn	398.78	-	Number of turns

St	Input	Name	Output	Unit	Comment
	250	Rhole		cm	Radius of hole in door
	8.30	Recran		m	Internal free radius
	8.90	Rwindin		m	Mean radius of winding
	29.00	Dpole		m	Internal free length
	.80	B		T	Magnetic induction
L	130	Spcond		cm	Space for coil from screen to barrel
		BsatPol	1.70	T	Induction in pole
		BsatMan	1.49	T	Induction in barrel

	3.65	PriceIP		$/kg	Price of iron for pole fully erected
	2.57	PriceIB		$/kg	Price of iron for barrel fully erected
L		Price_B	77.79	M$	Price of Barrel fully erected
		Price_P	19.63	M$	Price of one Pole fully erected
		Price_T	117.05	M$	Total price of iron fully erected

		W_I_T	41024	t	Optimized weight of iron
		W_B	30268	t	Weight of barrel
		W_Door	2139	t	Weight of mobile part
		W_Cro	3239	t	Weight of one crown
		W_P	5378	t	Weight of one pole
		Rinman	9.60	m	Internal radius of barrel
L		Rexman	11.60	m	Outside radius of barrel
		Dextpol	33.40	m	External length of magnet
	200.00	T_B		cm	Thickness of barrel
		T_door1	61.80	cm	Thickness of door near hole
		T_door2	205.17	cm	Thickness of door near free aperture
	220.00	T_P		cm	Thickness of pole at Rwinding
		T_P_Bxt	160.03	cm	Thickness of pole on barrel outside di
		H	636620	Oe	Magnetic field
		At	19.94	MAt	Needed ampere-turns
		Flux	199.08	Wb	Flux
		Sman	140.50	m^2	Cross section of barrel
		IronSpC	7.43	t/m^3	Specific mass of iron with packing
		tpsn	.41421356	-	Tangente(pi/N)
	8	N		-	Number of sides of barrel
	1.05	FoisIro		-	Packing factor for iron
	7.80	IronSp		t/m^3	Specific mass of iron
	1.08	FactAt		-	Factor for ampere-turns
		Energy	1.84	GJ	Stored energy
		μ0	1.2566E-6	A/m	Vacuum permeability
	50000.00	Current		A	Current
		Induct	1.47	H	Coil inductance
		Nturn	398.78	-	Number of turns

IRON RETURN CONCEPT REPORT

The panel has compared the iron return yoke concept to the single coil superconducting unshielded concept in respect to cost and schedule.

Two different versions for the shielded concept are considered ; one being a stray field limit at the surface below 10 gauss and the second being the minimum field practical, which is considered to be 1.0 gauss. A distance of 50m from the surface to the magnet center is assumed.

The reason for choosing the 10 gauss figure for one case is to align with the safe limit for people with pace makers where similar fields may be found in public areas.

Parameters of the two versions are shown in the accompanying sheets and the cost evaluation is given below.

Version 1. (1.3m thick barrel.)

Cost of the extra 20 ktonnes of iron	55.5M$

Version 2. (2.0m thick barrel)

Cost of the extra 36 ktonnes	99.0M$

The addition of some surface shielding with the version 1 concept may be an alternative to version 2, if the field has to be reduced to the 1.0 gauss level.

The schedule impact of the extra iron stated in the above version has been examined and is integrated with the single coil superconducting unshielded concept schedule. The detailed difference is shown in the attached sheets and the overall difference is 3.5 months.

Since the planning is based on only handling large pieces a contingency increase in schedule estimate should be considered. This is estimated as giving a total schedule difference range of approximately 3.5 - 6 months.

A way of reducing the schedule increase may be the addition of another construction shaft in the underground hall and carry out parallel installations. This solution would have an extra cost impact on the experimental facilities

It should be noted that iron shielding may eliminate one possibility of increasing the resolution performance of the detector, where it is proposed by the collaboration to add muon chambers around the exterior of the magnet barrel in a future upgrade.

10/11/91 DRAFT

St	Input	Name	Output	Unit	Comment
	250	Rhole		cm	Radius of hole in door
	8.30	Recran		m	Internal free radius
	8.90	Rwindin		m	Mean radius of winding
	29.00	Dpole		m	Internal free length
	.80	B		T	Magnetic induction
L	130	Spcond		cm	Space for coil from screen to barrel
		BsatPol	1.70	T	Induction in pole
		BsatMan	1.49	T	Induction in barrel

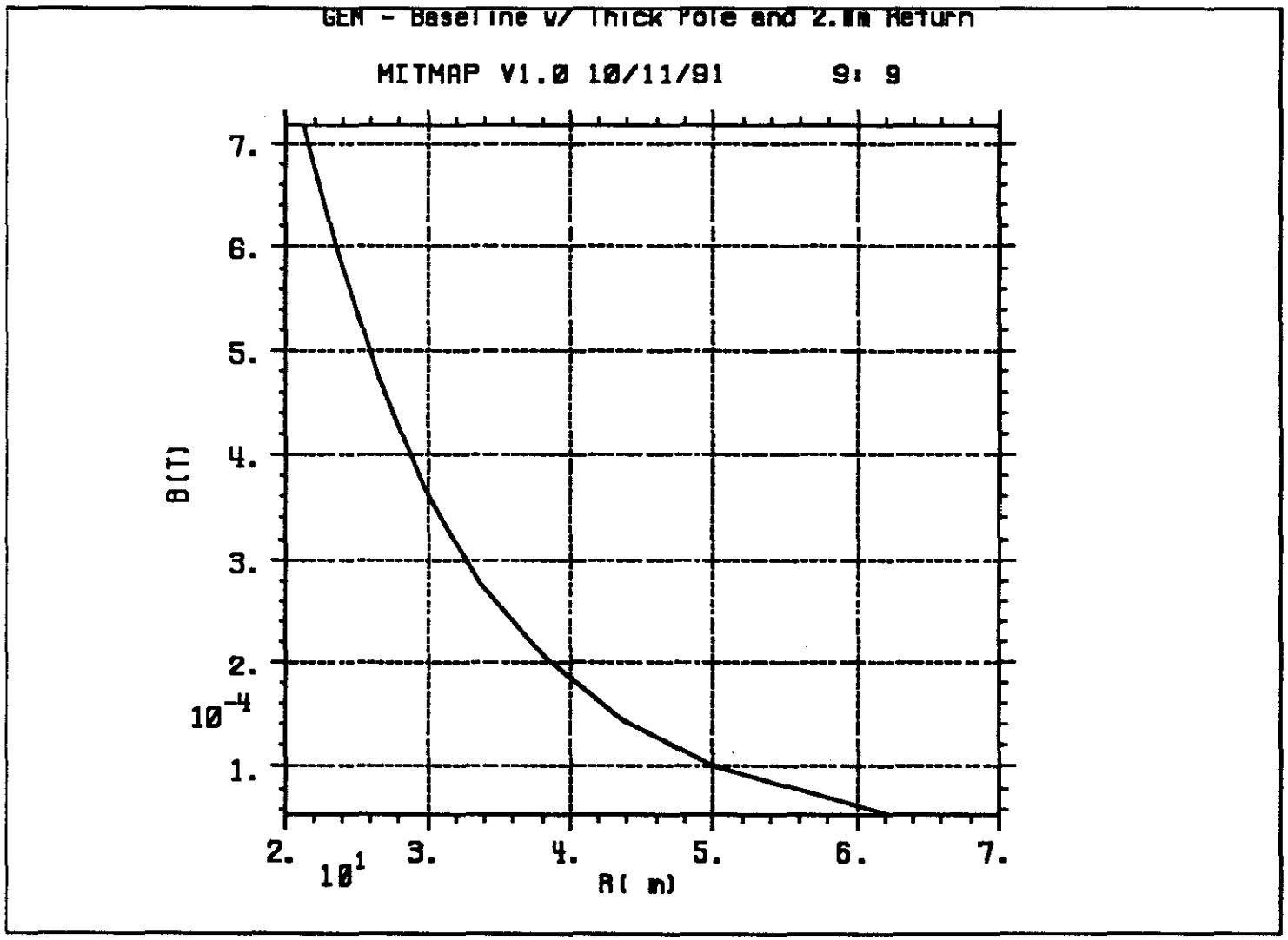
		PriceIP	3.58	$/kg	Price of iron for pole fully erected
		PriceIB	1.89	$/kg	Price of iron for barrel fully erected
L		Price_B	57.10	M$	Price of Barrel fully erected
		Price_P	19.28	M$	Price of one Pole fully erected
		Price_T	95.65	M$	Total price of iron fully erected

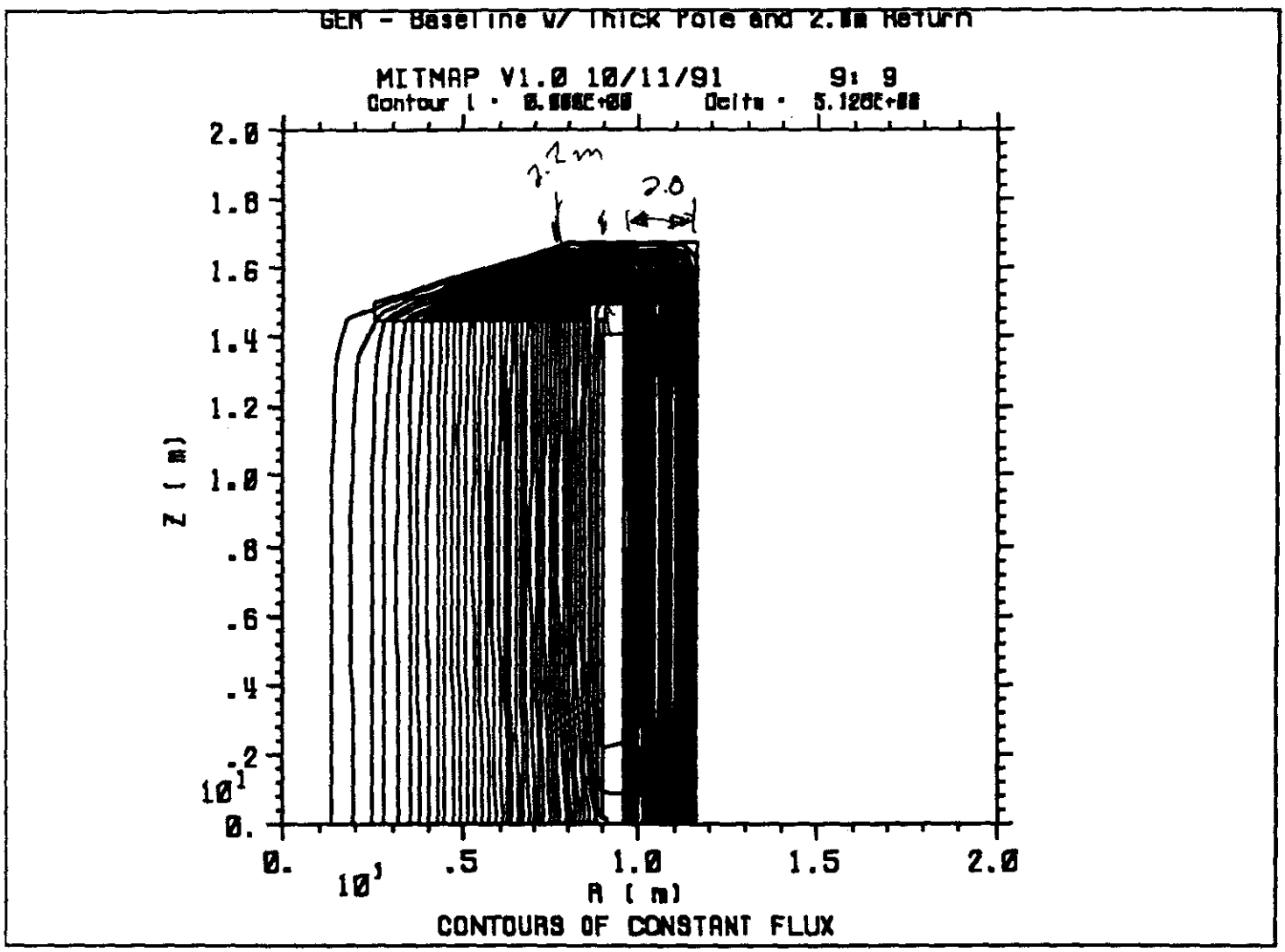
		W_I_T	41024	t	Optimized weight of iron
		W_B	30268	t	Weight of barrel
		W_Door	2139	t	Weight of mobile part
		W_Cro	3239	t	Weight of one crown
		W_P	5378	t	Weight of one pole
		Rinman	9.60	m	Internal radius of barrel
L		Rexman	11.60	m	Outside radius of barrel
		Dextpol	33.40	m	External length of magnet
	200.00	T_B		cm	Thickness of barrel
		T_door1	61.80	cm	Thickness of door near hole
		T_door2	205.17	cm	Thickness of door near free aperture
	220.00	T_P		cm	Thickness of pole at Rwinding
		T_P_Bxt	160.03	cm	Thickness of pole on barrel outside di
		H	636620	Oe	Magnetic field
		At	19.94	MAt	Needed ampere-turns
		Flux	199.08	Wb	Flux
		Sman	140.50	m^2	Cross section of barrel
		IronSpC	7.43	t/m^3	Specific mass of iron with packing
		tpsn	.41421356	-	Tangente(pi/N)
	8	N		-	Number of sides of barrel
	1.05	FoisIro		-	Packing factor for iron
	7.80	IronSp		t/m^3	Specific mass of iron
	1.08	FactAt		-	Factor for ampere-turns
		Energy	1.84	GJ	Stored energy
		μ0	1.2566E-6	A/m	Vacuum permeability
	50000.00	Current		A	Current
		Induct	1.47	H	Coil inductance
		Nturn	398.78	-	Number of turns

St	Input	Name	Output	Unit	Comment
	250	Rhole		cm	Radius of hole in door
	8.30	Recran		m	Internal free radius
	8.90	Rwindin		m	Mean radius of winding
	27.00	Dpole		m	Internal free length
	.83	B		T	Magnetic induction
L	130	Spcond		cm	Space for coil from screen to barrel
	2.00	BsatPol		T	Induction in pole
		BsatMan	2.46	T	Induction in barrel

		PriceIP	3.67	$/kg	Price of iron for pole fully erected
		PriceIB	2.10	$/kg	Price of iron for barrel fully erected
L		Price_B	37.14	M$	Price of Barrel fully erected
		Price_P	15.25	M$	Price of one Pole fully erected
		Price_T	67.63	M$	Total price of iron fully erected

		W_I_T	26013	t	Optimized weight of iron
		W_B	17713	t	Weight of barrel
		W_Door	1885	t	Weight of mobile part
		W_Cro	2265	t	Weight of one crown
		W_P	4150	t	Weight of one pole
		Rinman	9.60	m	Internal radius of barrel
L		Rexman	10.90	m	Outside radius of barrel
		Dextpol	30.88	m	External length of magnet
	130.00	T_B		cm	Thickness of barrel
		T_door1	54.47	cm	Thickness of door near hole
		T_door2	180.84	cm	Thickness of door near free aperture
		T_P	193.91	cm	Thickness of pole at Rwinding
		T_P_Bxt	150.11	cm	Thickness of pole on barrel outside di
		H	660493	Oe	Magnetic field
		At	19.26	MAt	Needed ampere-turns
		Flux	206.54	Wb	Flux
		Sman	88.31	m^2	Cross section of barrel
		IronSpC	7.43	t/m^3	Specific mass of iron with packing
		tpsn	.41421356	-	Tangente(pi/N)
	8	N		-	Number of sides of barrel
	1.05	FoisIro		-	Packing factor for iron
	7.80	IronSp		t/m^3	Specific mass of iron
	1.08	FactAt		-	Factor for ampere-turns
		Energy	1.84	GJ	Stored energy
		µ0	1.2566E-6	A/m	Vacuum permeability
	50000.00	Current		A	Current
		Induct	1.47	H	Coil inductance
		Nturn	385.20	-	Number of turns


GEM - Baseline W/ Thick Pole and 2.mm Return
MITMAP V1.0 10/11/91 9: 9
7.
6.
5.
4.
3.
2.
1.
B(T)
10^-4
2.
3.
4.
5.
6.
7.
10^1
R(m)


GEM - Baseline W/ Thick Pole and 2.00 Return
MITMAP V1.0 10/11/91
9: 9
Contour 1 = 0.000E+00
Delta = 5.120E+00
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0.
Z (m)
0.
.5
1.0
1.5
2.0
R (m)
CONTOURS OF CONSTANT FLUX

SUMMARY

The GEM Magnet Technical Panel convened three times to study issues related to the technical credibility of the magnet concept, the cost estimate, proposed schedule, and operational issues. The meetings were held on September 4-6, September 25-27, and October 10 & 11, 1991. Individual reports were written for each of the first two meetings. The third and final report of the technical Panel summarizes the findings of all three meetings.

The charge to the panel was to determine whether the construction of a baseline magnet concept consisting of a large superconducting solenoid, in either single or double coil version , is feasible and to estimate the cost, manpower requirement and schedule.

The Technical Panel considered four magnet design options; the unshielded single solenoid, an unshielded single solenoid with a surface iron plate, a single solenoid with a barrel iron flux return, and a double coil solenoid. All four of these options had iron poles.

In response to the charge, the panel finds:

1. Although all four of the considered options are technically feasible, the unshielded solenoid is the preferred magnet configuration for the GEM Detector. Should the field at the surface be unacceptable, surface shielding iron could be added as a backup, at an approximate cost of $5-10M.

2. The initial unshielded solenoid design, manufacturing, and operational concept for the magnet conductor, coil, cryostat, and supports all appear to be feasible. The estimated cost of $95M, the required manpower, and proposed schedule appears credible.

3. The relative cost for the iron barrel shielded system is a factor of 1.5 - 2 larger and the schedule impact is 3.5 - 6 months. The relative cost for the double solenoid is a factor of 2 larger and the schedule impact is 6 - 8 months. Design and manufacturing requirements and instasllation schedule are different for various options. The manpower requirements are reflected in cost estimates.

4. The unshielded solenoid can be operated within all known regulations.

5. The permanent surface facilities for the unshielded solenoid concept can be substantially descoped from the proposed initial concept; however several less costly temporary structures are required. Either shielded concept requires additions to surface facilities, especially for the dual coil concept which requires additional winding space.

6. A procurement strategy is currently not defined, and must be selected and implemented to avoid schedule delays. We recommend that early and intensive discussions between the SSCL and the Department of Energy be initiated.

7. Rapid commencement of conductor development is recommended to support the schedule requirements.

8. Magnetic forces on structural steel in the underground hall due to the unshielded magnet do not impose significant constraints on the conventional civil engineering structural design.

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Physics Research Division
(214) 708-6079, Fax (214) 708-6174

DRAFT

To: Steve Brumley

From: Ronn Woolley

Date: October 10, 1991

Subject: FEIS Magnetic Field Requirements

The concern has surfaced regarding the requirement for limiting the amount of static magnetic radiation, on the surface above the GEM interaction hall. The GEM Technical Panel requires a legal interpretation of the Final Environmental Impact Statement (FEIS) and other potentially binding documents, in order to ascertain our magnet requirements. Please review the enclosed documents with the following questions in mind:

1) Are the documents' magnetic field limits references specifically legally binding?

2) Is there any flexibility as to interpretation of the applicable magnetic field references?

3) What are our specific responsibilities, as dictated by the binding applicable references?

4) Do the specific applicable magnetic field references require SSCL to limit the level of static magnetic radiation to that of background (0.5 gauss) at the ground surface? If not, then what maximum level would be acceptable?

5) What legal alternatives toward compliance adherence can SSCL exercise?

Please advise Phil Shelley or Ray Stefanski of our position on this issue, as expeditiously as possible. If you have any specific questions or concerns of a technical nature, please address them to Ray Stefanski or Ronn Woolley.

Thank you for your consideration of this important matter.

Attachments

RS/RW

cc: Larry Coulson
Fred Gilman
Mike Harris
Phil Shelley
Ray Stefanski
Tim Thurston
Tim Toohig
Barry Barish - CalTech
William Willis - Columbia Univ.

10.1.3.2 Nonionizing Radiation and Hazardous/Toxic Materials

A. Nonionizing Radiation

1. Microwave Energy

Power to the RF cavities for each of the SSC rings will be supplied by klystron tubes, each with an output power of about 1 MW. The klystrons will be housed in above-ground shelters with concrete pads. The RF energy generated by the klystrons will be supplied to the cavities in the tunnel via metal waveguides. Since the RF waves will be totally enclosed by the waveguides, microwave leakage from the accelerating system would be negligible. (SSC CDG 1988) Health and safety personnel at the Stanford Linear Accelerator (SLAC) indicate that microwave leakage from RF system components is not measurable at the SLAC facility. (Schenker 1987) Therefore, no source term was identified for microwave energy associated with the RF accelerating system.

When operating properly, klystrons at the SSC should emit only extremely low levels of X-rays. However, klystron tubes can emit significant amounts of X-rays when they are operating out of specification. Source terms of 10 to 15 mrem/h at the tube surface have been measured at SLAC. At a distance of 3 ft (1 m), the measured emission rate dropped to about 0.75 mrem/h. At the CERN LEP accelerator facility, X-ray levels are specified to be less than 0.5 mrem/h in the aisleway along the klystron gallery (Goebel 1987), and similar specifications will be adopted for the SSC.

2. Magnetic Fields

The superconducting magnets used in the SSC operation and experiments will be designed to produce steady high magnetic fields within the vacuum chambers containing the beams of particles. Similarly, the conventional electromagnets in the booster accelerators as well as those associated with the klystrons will, by definition, produce magnetic fields. In these cases, the fields are lower than those produced by the superconducting magnets by a factor of at least 3.

All of the above magnets are being designed with iron yokes for magnetic field and field quality enhancement. However, the iron also serves another purpose; it considerably reduces the "stray field" of the magnetic flux appearing outside the physical dimensions of the magnets. For example, the magnetic field at the outside surface of the superconducting magnets will be less than 1/100th of the field at the center of the vacuum chamber beam tube. At the surface of the cryostat surrounding the magnets, the field strength will be diminished by another factor of 60. Finally, at a point next to the tunnel wall, the magnetic field from any of the superconducting or conventional magnets will be about the same magnitude as the earth's magnetic field. **Thus, no magnetic field source term would be present at the surface of the SSC site or at its boundaries.**

Operations areas, such as control rooms, would be located tens of meters or more from the magnets themselves. Because the strength of a magnetic field decreases rapidly with distance, the field would be much less than the earth's magnetic field in such areas, and operating personnel would be unaffected. Since no personnel would be allowed in the tunnel when the magnets would be energized, and since there is no "residual" magnetic field when the machine is not operating, there is no operational (worker) source term.

B. Hazardous/Toxic Materials

1. Cryogens

Liquid nitrogen, liquid helium, and helium gas will be used and stored in large quantities throughout the facility. None of these materials are toxic. These cryogens will continually circulate through the collider ring to provide cooling for the superconducting magnets. All three materials will be stored in above-ground tanks at each of the ten service areas. Standard safety procedures exist for dealing with cryogens, and workers would be trained in these and in handling techniques. Since the cryogens are contained in closed systems, no source term is associated with the cryogenic materials during normal operations. The impacts of a major cryogen release are discussed in Appendix 12.

2. Other Hazardous/Toxic Materials

Some of the hazardous/toxic materials (HTMs) health hazards that would be most likely to result from SSC construction activities include welding fumes, rock dust (from tunneling), and solvent vapors. Source terms are not available for these potential hazards since the operations involved are transient and variable in scope and duration. The hazards would be standard to any construction activity, and no unusual circumstances or conditions are present.

HTMs similar to the above (except for those associated with tunneling, and as indicated below) would be likely to be encountered by workers at the SSC during the course of normal operation and maintenance activities, but would be limited to the experimental areas and the support facilities. Again, these hazardous materials would be typical of light industry operations both in diversity and quantity, and industry standards and handling procedures will be adopted.

Based on the experimental activities at Fermilab and CERN, it is anticipated that detectors built for SSC experiments could include the use of flammable/toxic gases and possibly other hazardous materials, such as depleted uranium. A thorough evaluation of safety considerations, would be performed for each detector prior to its approval for construction.

Information obtained from Fermilab indicates that flammable gases are commonly used in experimental areas (Baker 1987). They have included isobutane and mixtures of argon/ethane and argon/methane. Hence, the threat of fire is a constant hazard since high voltage is an intrinsic part of the physics experiments and can provide a "ready" spark source

Following that, arguments to justify the construction and operations of the research devices are made to the national and international communities of scientists. In the case of the SSC, the merit of the undertaking has been debated extensively among the scientists, within the Government agencies, and before peer review groups (Volume I, Chapter 2, Section 2.2.2).

See Comment Response 1276.01.

0497.13

SSC project cost estimates were adjusted to reflect savings that would be realized by using the Fermilab Tevatron as the SSC injector facility. Other credits considered for the Illinois site cost estimate include reduced construction costs for utility systems and campus facilities, and reduced operating expenses due to cost sharing with ongoing, funded Fermilab research programs. See EIS Volume IV, Appendix 2, Section 2.4.2.2. To develop this adjustment, the DOE considered all available data such as the site proposal, Conceptual Design Report, and DOE Fermilab experience. Cost, however, is only one criterion used in the site decision.

0497.14

The CERN accelerator that spans the border of France and Switzerland did have flooding problems during construction. The flow was stopped by the installation of a tunnel liner. There has been no problem since the tunnel liner was put in place.

Where the SSC ring will be below the water table, a concrete liner or grouting will be used to stop flooding.

0497.15

The inability of recent experimental advances in high-temperature superconductors to meet SSC project requirements is identified in the EIS in Volume I, Chapter 3, Section 3.2.

0497.16

The electromagnetics used in the SSC will not expose the public to measurable magnetic fields. The superconducting magnets will be designed with iron yokes, which considerably reduce the magnetic field from extending beyond the vacuum beam tube. The field produced by the magnets will not affect the public, because the strength of the SSC-induced fields at the tunnel wall will be about the same as that of the earth's magnetic field (EIS Volume IV, Appendix 10, Section 10.1.3.2).

For a discussion of the possible hazards of power distribution and transmission lines, see Comment Response 733.02.

will be two new sections of 230-kV line constructed (2.1 and 1.9 mi long). There also will be two new 12-kV lines constructed to provide power to pumping operations for the SSC water supply.

0733.02

Over the past several years, research has been conducted to examine the possible health effects associated with human exposure to electromagnetic fields that are produced by power lines and some electrical appliances. Some of the studies have suggested a link between exposure and health outcomes such as childhood cancer, occupational cancers, or occupationally related reproductive effects. There have also been studies which have not demonstrated any such relationships. Furthermore, some of the studies that have suggested possible effects have had weaknesses that limit the validity of the results. Thus, a combination of the lack of consistent findings among the studies, the absence of a dose-response relationship, and the lack of a biological explanation for the way in which electromagnetic fields can produce a health effect, has made many scientists doubtful at this time that there is a causal relationship between exposure to electromagnetic fields and various alleged chronic effects.

However, concern that the transmission and distribution power lines could pose a health hazard is appropriate, and additional research is needed before any conclusion can be reached. Studies are currently underway by the government and private firms to better understand the possible hazards of electromagnetic fields. In addition, several states are considering new regulations on the placement of power lines. The placement of power lines will be done in compliance with applicable regulations. See EIS Volume I, Chapter 6 for the DOE's policy regarding compliance with environmental regulations.

0733.03

See Comment Response 733.01.

0734.01

The potential for relocating Camp Butner is dependent on site selection and the DOE determining the final design configuration of the SSC. The decision to include part of Camp Butner in the North Carolina's proposal was the responsibility of the State. Contingent upon final design, the DOE is not aware of any safety or programmatic reasons why Camp Butner would need to be relocated if the North Carolina site is selected.

Should North Carolina be selected as the site and if Camp Butner were to be affected, the resulting impacts and proposed mitigations would be part of the Supplemental EIS to be prepared prior to a decision to construct or operate the SSC.

The proposed total acreage required for the North Carolina SSC site is 15,897 acres (see Volume I, Chapter 3, Section 3.4). The EIS also notes that the number of affected land parcels and ownerships may vary by as

LETTER 497

STATEMENT
IN OPPOSITION TO THE SSC IN TENNESSEE
DOE HEARINGS; MTSU; SEPTEMBER 29, 1988

My remarks are submitted as those of a private citizen and do not represent the position of the state of Tennessee or the Rutherford County Department of Health & Environment.

Last February, several of us spoke in opposition to the SSC based principally on losing our homes and properties. We also expressed concern over the effects of possible radiation dangers, the destruction and diminution of water wells, the expected demands on the county infrastructure, the possible danger to the environment. Attached is a later letter of March 21, 1988, to our Representative Bart Gordon from several individuals listing a number of these questions and concerns. *

Of course, we are still concerned, distressed, dismayed over the prospect of losing our homes (as are property owners in the six other contending states). However, the other arguments against the collider in this particular area of Tennessee now seem much more convincing and compelling in lieu of information that has been forthcoming and information gleaned from the recent Environmental Impact Statement (EIS).

1 It is very difficult to accept reassurances the SSC will not produce harmful radiation. Areas of greatest danger are: (1) the six reaction chambers where protons collide to produce highly penetrating neutrons, muons and radionuclides; (2) the abort beam dump areas that are very close to Colonial Estates and its 400 residents and Bill Rice Ranch with thousands of summer campers; and (3) the construction of some 30 huge silo-like ventilation shafts and the tunneling itself that may permit the gradual or accidental leak of water-soluble radionuclides (Sodium 22 and Tritium) into the ground water and hence our water supply. The radionuclides isolated in the air, water and ground at Fermilab are considered "acceptable" or meet certain "standards." As many scientists believe there is no "safe" level of radiation, we are reminded the SSC is to be 20 times more powerful than Fermilab and that accidents do happen. The argument over radiation dangers may not be resolved until the facility is operational, and if misfortune strikes, it may be too late for those thousands of citizens that are thus jeopardized.

2 The EIS estimates 350 wells will be lost. We understand 150 more wells, adjacent to the tunnel, may also be affected. The state has promised to provide water lines to these individuals. Does this mean the state will also pay for the future water bills for farmers who, having lost their wells, must depend thereafter on utility water not only for family members but also for herds of stock animals?

* also attached: letter to Rep Gordon from Dr Jack Neff, Sierra Club

R.S. SANDERS

IIA.1- 632

The EIS informs us there will be markedly increased amounts of dust produced from the dolomite limestone as some four million tons of rock and dirt are brought to the surface during construction of the tunnel and downshafts. These "spoils," enough to fill 200,000 20-ton trucks, may be transported across our country and state roads or stored in huge heaps near the same 30 vertical downshafts. It is feared this dust may seriously affect many individuals who have chronic lung disease, bronchitis, emphysema, asthma and respiratory allergies; especially if such persons live downwind from the major construction, e.g. in Muirfield and Muirfieldbore areas. Workers in the immediate construction area may be at risk to develop silicosis. This dust, this air pollution, will be with us at least six years or throughout the construction period.

More recent scientific information strongly suggests the delicate nature of caves. Karsts and sinkholes may make this area unacceptable, even a disaster, for the SSC site location.

The SSC impact on the local city and county infrastructure will be dramatic and significant. Many public services will require expansion: schools, law enforcement, human services, public health, utilities, roads, water supply, sewage and solid waste disposal. Recent news articles report the state will help; to what extent is not clear. City and county officials should carefully estimate costs for these long-term expansion and service needs and negotiate a clear understanding of financial support from the state.

There is also a sobering concern that this huge, very expensive project could be started, then stopped, abandoned during construction or even after a few years of operation, leaving in our community, our state, yet another incomplete fiasco, such as the Hartsville Nuclear Plant. Several factors could influence such a happening:

- Many U.S. scientists believe the billions budgeted for the SSC, a basic science (not applied science) project, will siphon off funds from other more important national programs. Dr. Frank Press, president of the National Academy of Sciences, and Dr. Robert Rosenweig, president of the Association of American Universities, both recently stated (New York Times, May 3, 1989) the SSC should be designated a "secondary priority" to more urgent "highest priority" scientific endeavors such as (1) the training and education of young scientists, (2) the resolution of certain national crises such as "AIDS," and (3) research in superconductivity.

- Space scientists are vigorously competing for these same billions of dollars to build a space station and explore Mars.

- National and international research may, in a few years, provide better and cheaper methods to accelerate and collide protons rather than using this 1970 technology planned for the SSC. Such research could make the SSC obsolete. European scientists (Chicago Tribune, July 10, 1988) believe the U.S. has "jumped the gun" to proceed with the 53 mile SSC; they contend the U.S. should permit the upcoming research at the

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CERN lab to come to fruition so the U.S. could profit by pitfalls and mistakes at CERN. Apparently, we have decided to rush ahead, to possibly blunder ahead, in order to be "number one."

Our plea, therefore, to the DOE is this: if the SSC is indeed funded, this project will be so immense, so disruptive, so possibly dangerous to this area, we strongly suggest the SSC should go to an alternate site where it will affect far less people and their environment. For example, the ~~aquifer~~ will be above the ground water in Arizona and Texas; and we understand only four homes in Arizona and two homes in Colorado will be moved.

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Finally, when Dr. Leon Lederman, the Director of Fermilab, first designed the SSC, he called it the "Desertron." Many of us agree with Dr. Lederman's foresight and wisdom, and believe, as he apparently did, this huge project, with so many unknowns, should be correctly and more safely placed in a remote part of the country.

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LETTER 497 (CONTINUED)

SSC Fact Finding Group
P.O. Box 5
Rockvale, TN 37153
March 23, 1988

Congressman Bart Gordon
1517 Longworth House Office Building
Washington, D.C. 20515

Dear Bart,

Thank you for meeting with several of us on March 5 to hear our concerns about the proposed Superconducting Super Collider (SSC).

As you suggested, we are submitting several questions to your office which we understand will be forwarded to certain individuals and agencies in order to obtain definitive answers in writing. As we were further assured, should we consider any answers indefinite, incomplete or unsatisfactory, then your office would seek information from scientific sources, independent of the Department of Energy, and free of possible conflict of interest.

The following are current questions that concern us:

8 1. Will construction of the underground tunnel drain or exhaust adjacent well water?

25 2. Should such damage to well water occur, can the affected farmer and home owner expect the state to supply ample and safe water for both household and stock animal use?

3. Will ground water leak into and damage the tunnel?

26 4. Are not the Arizona and Texas plans for a tunnel above the water table more feasible, both in construction costs and ground water safety?

5. As many of our wells and ground water deposits contain sulfur, as hydrogen sulfide, how does this compound affect construction of the SSC, and later the gaseous environment of the completed tunnel?

27 6. We understand certain radionuclides (such as Tritium, Sodium 22, Cobalt 60, Manganese 54, Beryllium 7) are produced by the SSC. Tritium and Sodium 22 are water soluble. How are these (and other potentially toxic agents) to be safely contained? And, should these agents escape into water, soil or air, what could be their specific genetic, mutagenic or somatic effect on humans, or other mammals, fowl, marine and plant life? What has been this specific experience at the Fermi Lab in Illinois during the past 20 years? Are there measurable levels of these substances in ponds, rivers, streams, drinking water and air adjacent and near the Fermi LAB?

9 7. What are the emission products from the ventilation shafts and the refrigeration units scattered at intervals along the tunnel? Are these airborne products toxic and how? Will the noise produced by the refrigeration units be disturbing to adjacent citizens?

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10 9. What are the safeguards in the "collision chambers" (when protons collide) to prevent radiation spill to adjacent rock, ground water, especially as we understand the collision forces will be 40 times greater than that at the Fermi Lab?

11 10. What are potential problems related to removal of the thousands of tons of rock or rubble in construction of the tunnel? Where will this material be stored and how transported and used? How will the resulting dust and leachate affect local air, stream, ground water and place quality?

12 10. We understand a majority of the nation's scientific community is opposed to proceeding with this exceedingly costly project when so many other research avenues are considered more important. Can your office document this? And, should this not have bearing on the nation's budgeting process for prioritizing scientific projects?

13 11. If the SSC is funded, would it not be more reasonable and fiscally responsible to build/incorporate the SSC adjacent to or in connection with the existing Fermi Lab in Illinois where a campus, including a usable accelerator, and a scientific community are already established?

14 12. We have understood the Franco-Swiss SSC has suffered water damage, that some two feet of water have flooded the tunnel. Could your office document this misfortune? Is this a significant omen for the SSC in this country, especially in those five states where the tunnel is planned to be below the water table?

15 13. We understand there is current research in superconductors, earth oxides and plasma, which in a few years may make the proposed SSC obsolete. If your office can document this startling information, would it not be irresponsible to fund the SSC, to acquire property, to move families, to begin construction only to have the whole project declared obsolete in the light of emerging information? Would this result in not only the loss, even the waste, of billions of federal tax dollars, but also millions of Tennessee tax dollars?

16 14. Inasmuch as an enormous amount of electricity will be needed to supply and operate the SSC, thus creating strong electromagnetic fields both at the SSC facility and about the feeding transmission lines, what are the possible harmful effects to humans of these electromagnetic fields?

17 15. What are the specific plans for "decommissioning" the SSC once its usefulness is exhausted in some 20-25 years? Can we be guaranteed these facilities and tunnel space will be used for purposes that are not harmful to the community? Will it be possible for certain citizens to "buy-back" their property that was condemned and purchased by the state for the SSC?

18 16. Why in New York state would so many citizens and their elected officials so strongly oppose the SSC that their state's proposal was

withdrawn by Governor Cuomo? Does New York know something we don't? You may wish to discuss this with your colleague, Congressman Frank Horton of New York.

17. Can we and other Tennessee citizens be assured that [illegible] "[illegible]" brewing to "reward" Tennessee with the SSC provided Tennessee accepts the Monitored Retrievable Storage (MRS) facility for nuclear waste in Oak Ridge?

18. Finally, should all these concerns and questions be resolved in favor of proceeding with the SSC, we do ask our help and request that you and other elected officials strongly consider the merit of locating the SSC in states whose sites seem more reasonable: Illinois with its existing campus and resident scientists; in Arizona or Texas where the tunnel will be above the ground water table; and, in particular, Arizona, where we understand the proposed site includes significant federally owned land and where very few homes and families will be affected. Further, we hope you and elected officials will insist the DOE name a preferred site by the end of 1988, as promised, even if further funding is not assured. This will relieve the other six states and their anxious and anguished citizens.

We, therefore, appeal to you as affected land owners whose homes will be destroyed, whose rural community and "quality of life" will be severly disrupted, and whose county and city government services (schools, roads, utilities, public health) will be uncommonly strained should the SSC come to Rutherford County. Once the issue is studied and the many questions are answered, we believe our neighbors in Bedford, Marshall and Williamson Counties will similarly urge the Tennessee proposal for the SSC be withdrawn.

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Please note we are sending copies of this letter to Congressman Jim Cooper and Senators Jim Sasser and Al Gore. Hopefully, these gentlemen and their staffs may be of assistance to you.

Sincerely,

Brady Alfred

Amy Alfred

Sue Parsley

Bert Parsley

Connie Yeargan McGehee

Everett (Mac) McGehee

Pat Sanders

Robert S. Sanders, M.D.

be

Enclosures