Fermilab

SDC SOLENOID DESIGN NOTE #134

TITLE: REPORT OF SDC SOLENOID WORKING GROUP

DATE: FEBRUARY 13, 1991

AUTHORS: FAST, WANDS, KREBS, STEFANIK

ABSTRACT: This design note contains the viewgraphs that were shown at the general SDC meeting at Fermilab on Wednesday, February 13, 1991. Jim Hylen's report is Design Note #133.

AGENDA

Introduction----Ron Fast

Effects of uniformity on tracking----Jim Hylen

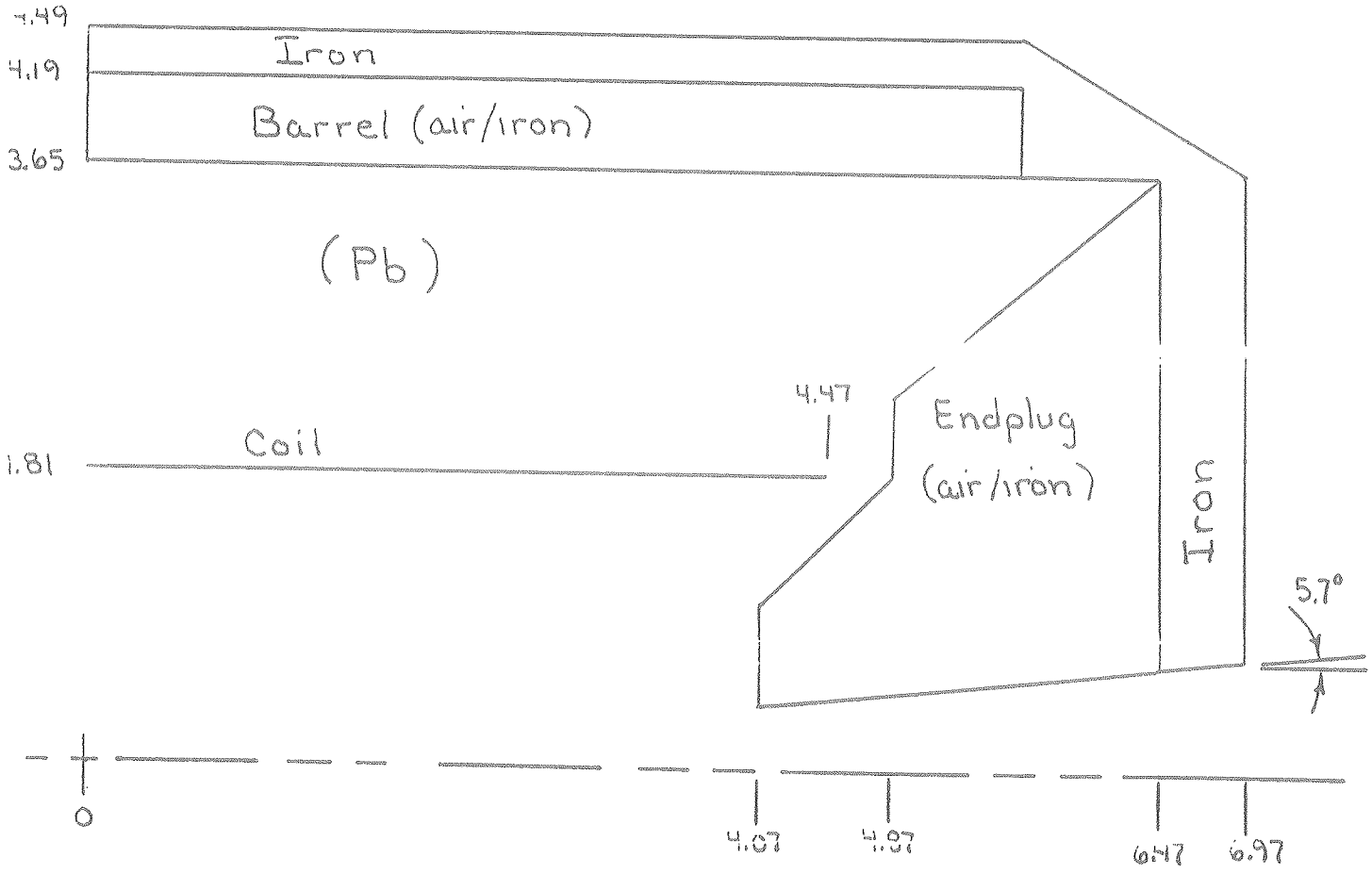
Magnetostatics----Bob Wands

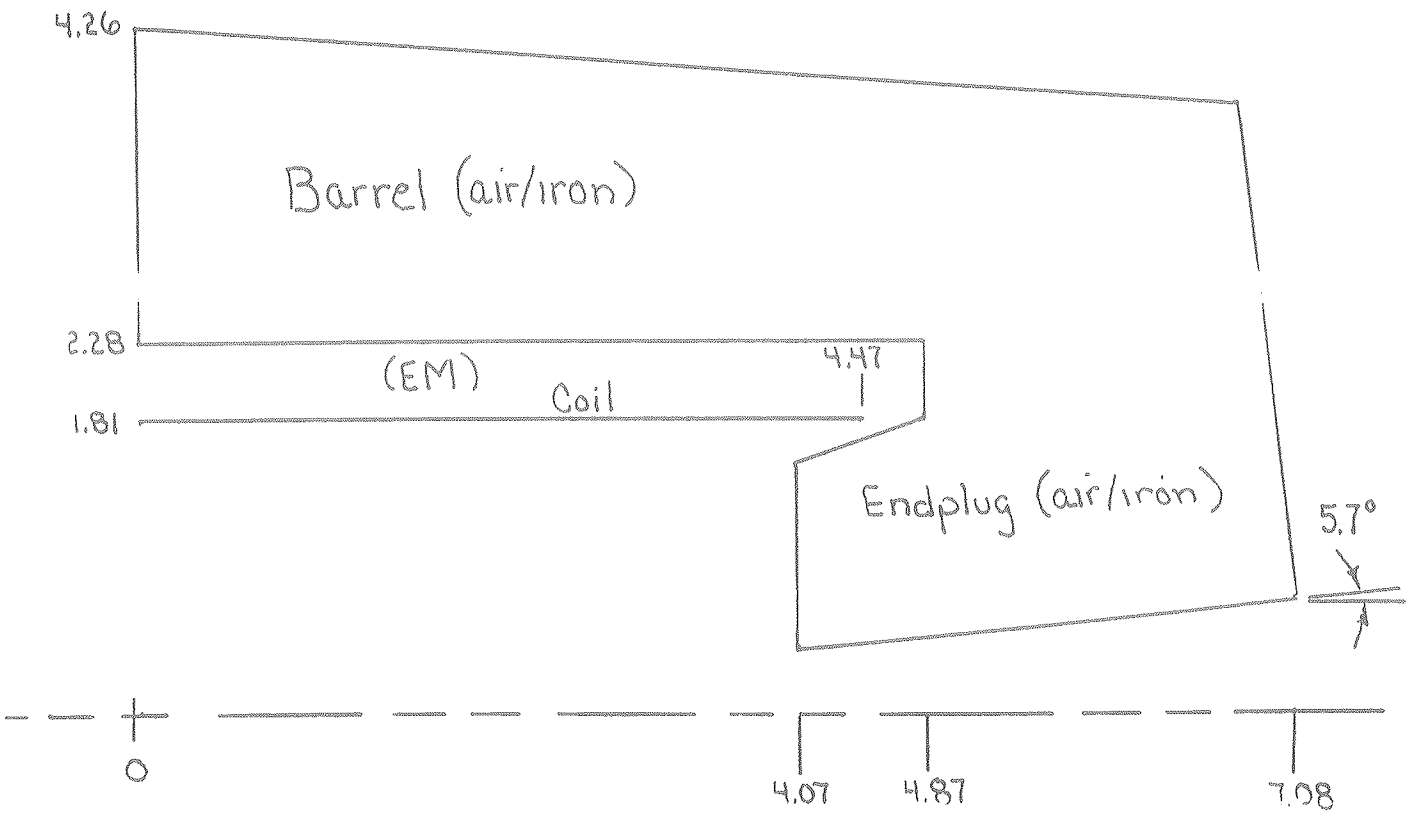
Support systems----Jim Krebs

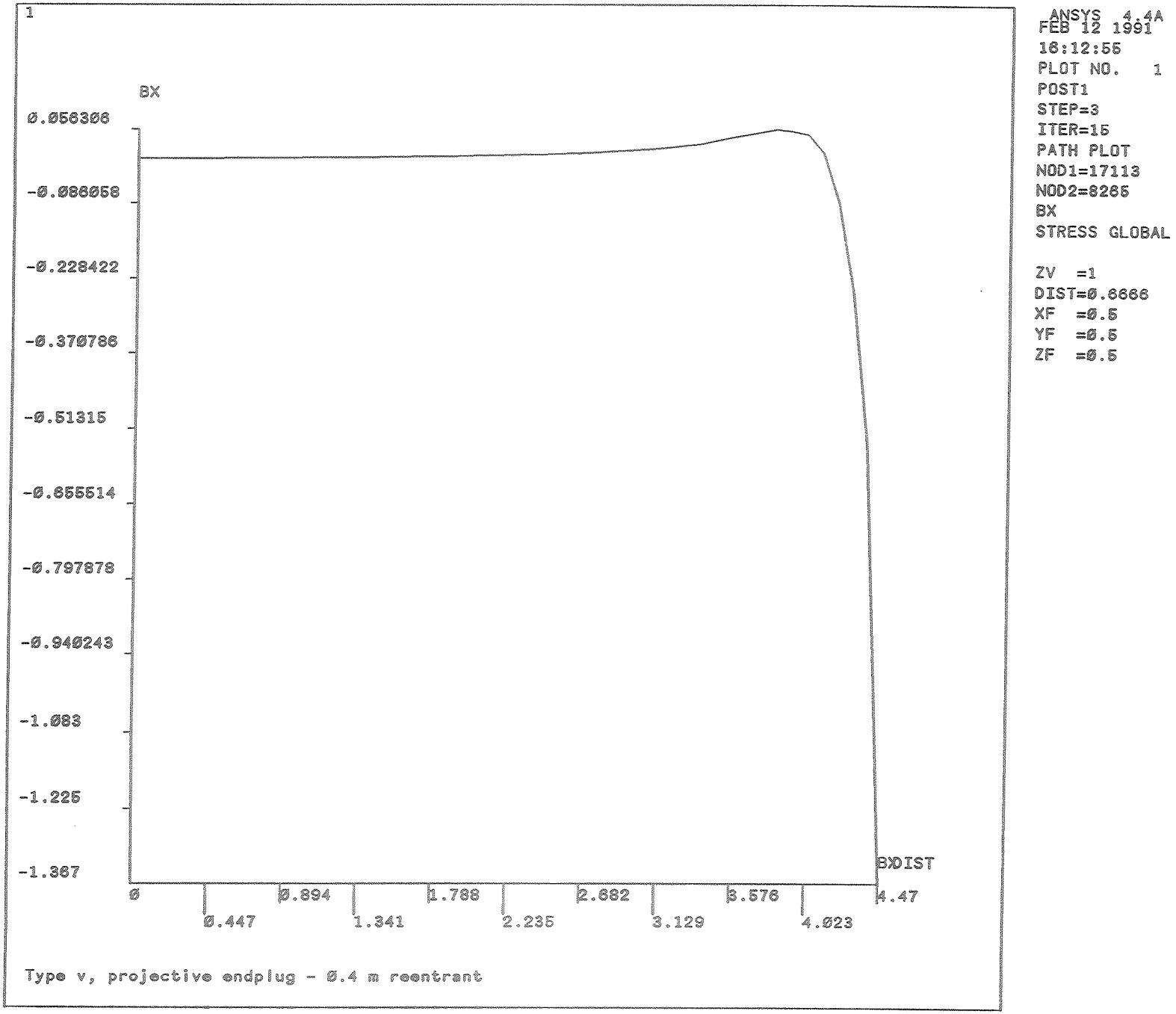
Outer vacuum shell----Ron Fast

Cryostat chimney----Andy Stefanik

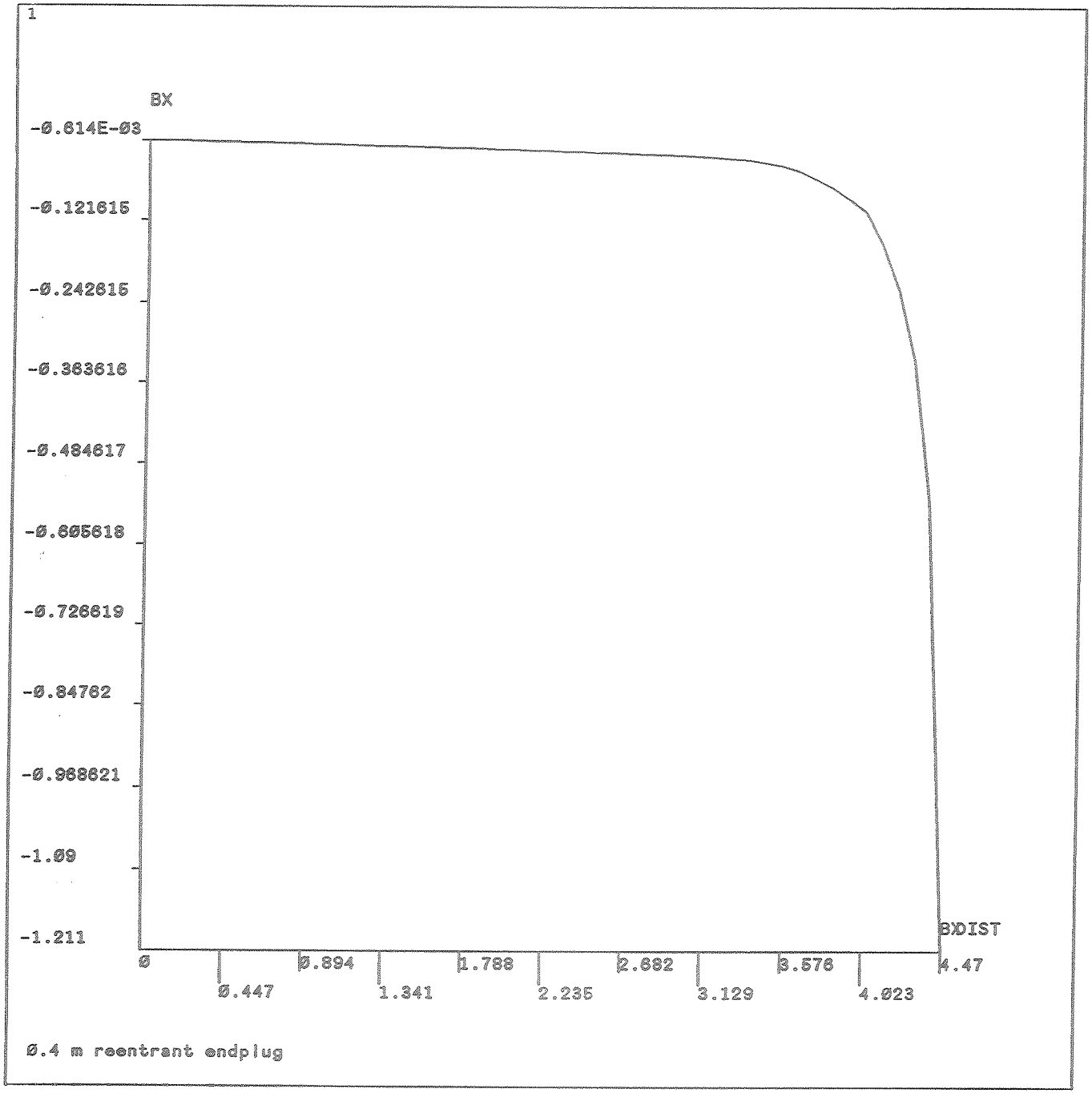
Cooldown and quench recovery----Andy Stefanik


4.49
4.19
3.65
1.81
Iron
Barrel (air/iron)
(Pb)
Coil
4.47
Endplug
(air/iron)
Iron
5.7°
0
4.07
4.97
6.47
6.97


4.26
Barrel (air/iron)
2.28
(EM)
Coil
4.47
1.81
Endplug (air/iron)
5.7°
0
4.07
4.87
7.08


1
BX
0.056306
-0.086058
-0.228422
-0.370786
-0.51315
-0.655514
-0.797878
-0.940243
-1.083
-1.225
-1.367
BXDIST
0
0.447
0.894
1.341
1.788
2.235
2.682
3.129
3.576
4.023
4.47
Type v, projective endplug - 0.4 m reentrant
ANSYS 4.4A
FEB 12 1991
16:12:55
PLOT NO. 1
POST1
STEP=3
ITER=15
PATH PLOT
NOD1=17113
NOD2=8265
BX
STRESS GLOBAL
ZV =1
DIST=0.6666
XF =0.5
YF =0.5
ZF =0.5

Wands-3



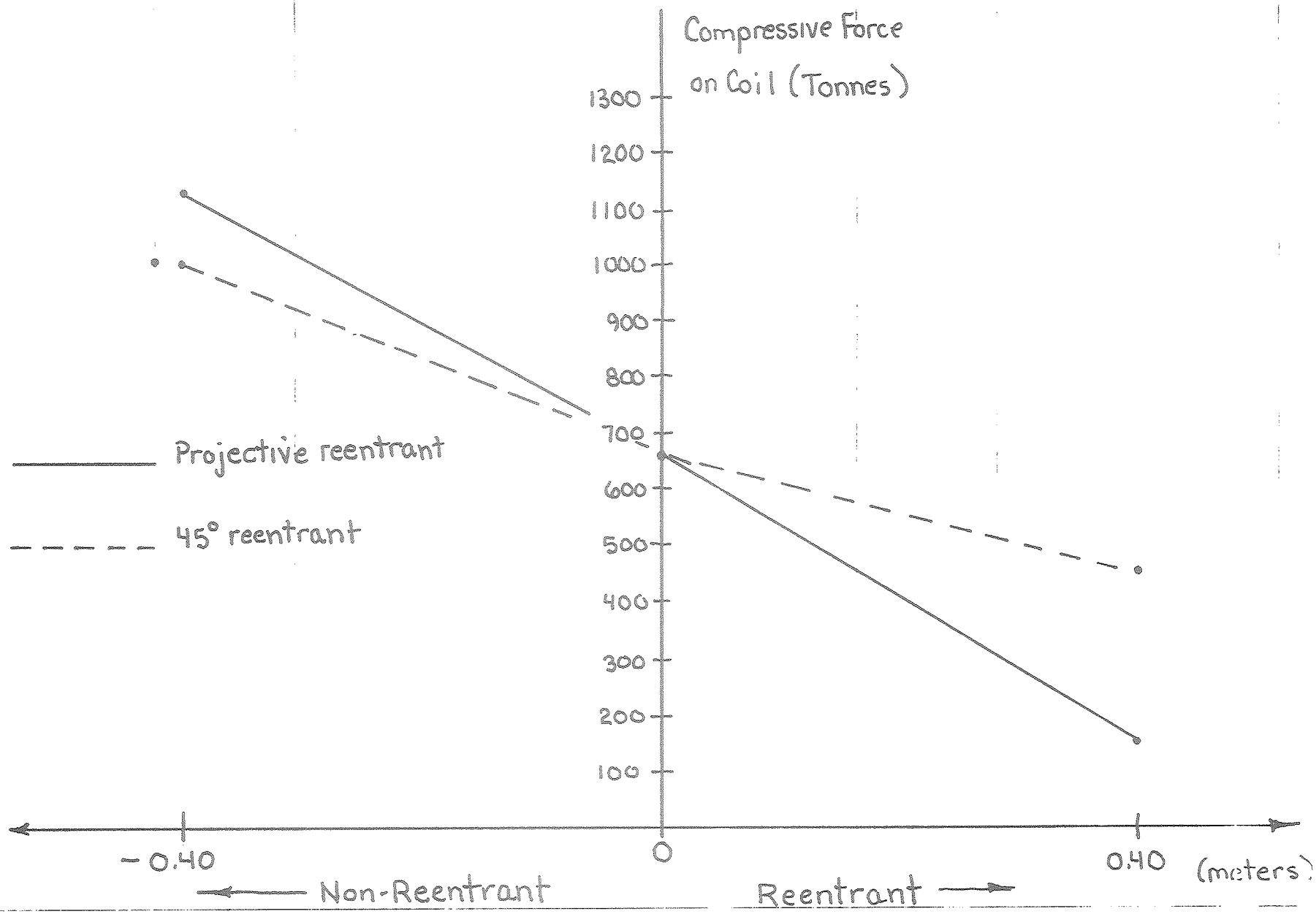
ANSYS 4.4A
FEB 12 1991
16:43:06
PLOT NO. 1
POST1
STEP=2
ITER=15
PATH PLOT
NOD1=15191
NOD2=6282
BX
STRESS GLOBAL

ZV =1
DIST=0.6666
XF =0.5
YF =0.5
ZF =0.5

Wands-4

Comparison of Axial Compressive Force on Coil for Reentrant Endplugs

2/1 91



Wands - 5

Functions of Supports

1) support the dead weight of the superconducting coil inside the vacuum space.

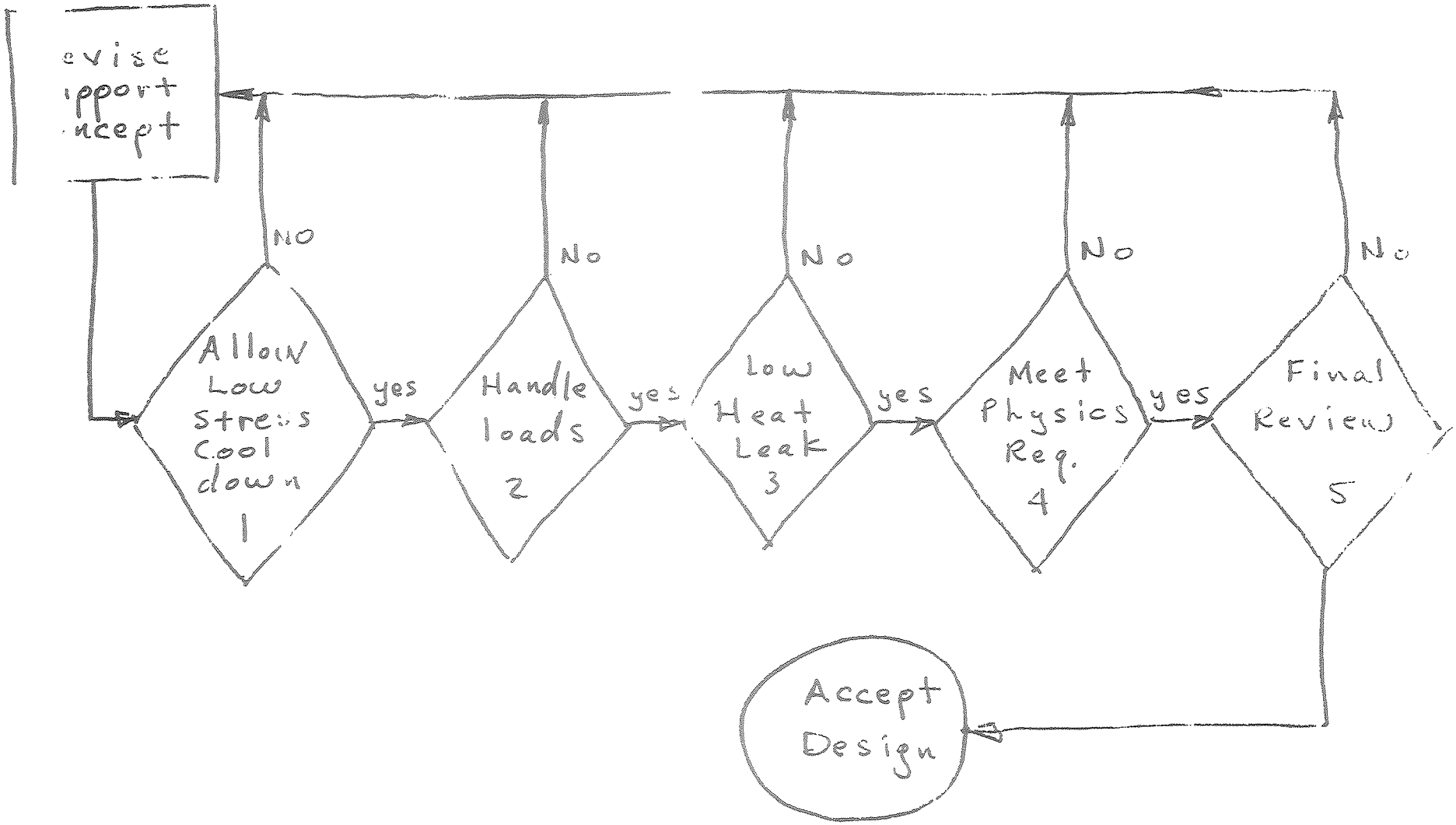
2) Transmit the electromagnetic loads to some "external structure

Support Design Considerations

1) Magnitude and direction of loads
2) Cooldown of s.c. coil
3) Where do forces exit vacuum can
4) Heat leak
5) Quality of analysis
6) Tensile or compressive or both
7) Assembly
8) Cost
9) Radiation environment

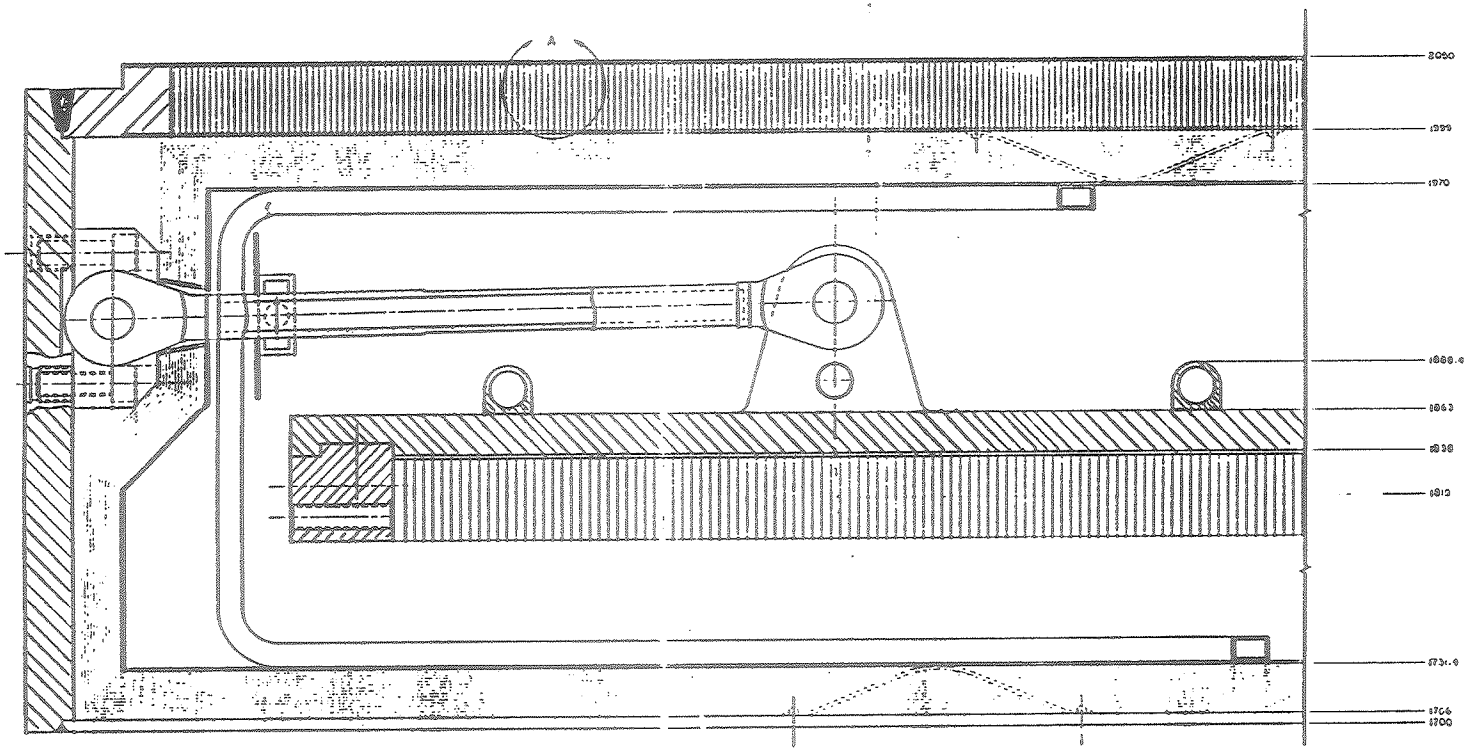
   ⋮ Testing

n) How does the addition of support material affect the physics?



Method of approach

Krebs-3



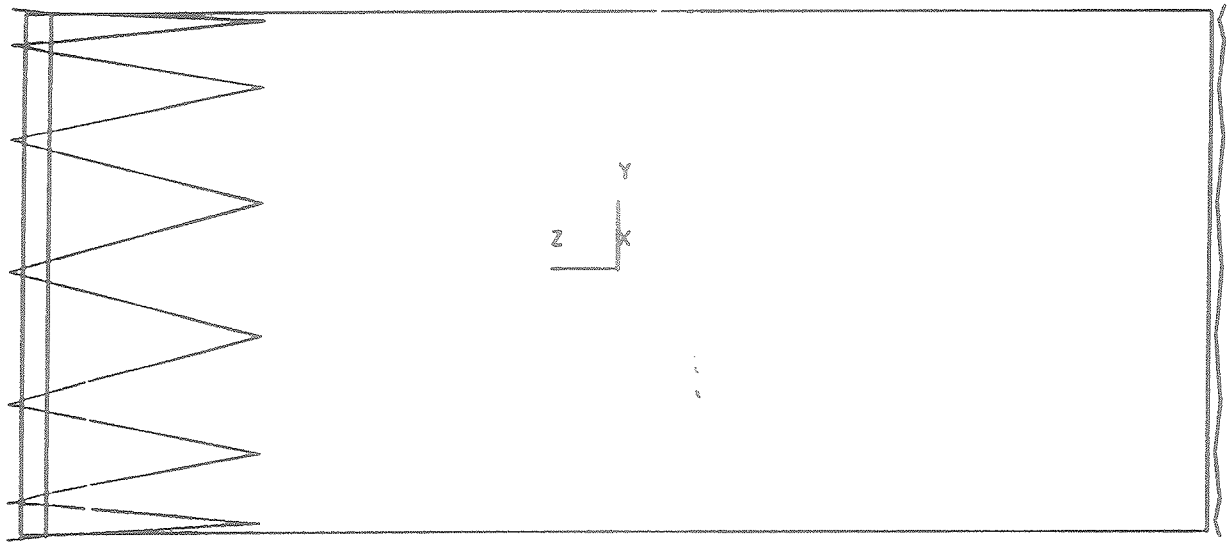
Kvebs-4

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	REQ'D
		PARTS LIST	

		DIMENSIONS	
		DRAWN	
		CHECKED	
		APPROVED	
		USED ON	
		MATERIAL	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID; TYPE I
CROSS SECTION (HONEYCOMB SHELL)

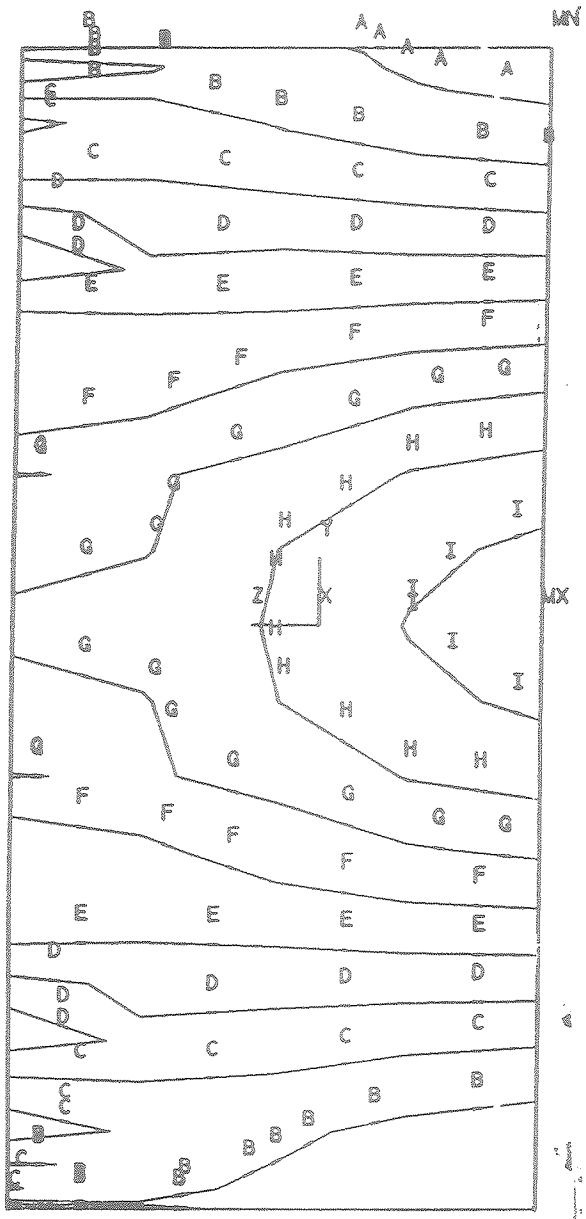


ANSYS 4.4A
FEB 7 1991
14:05:53
PLOT NO. 1
POST1 ELEMENTS
TYPE NUM

XV =1
DIST=193.05
XF =37.75
EDGE

Cooldown optimization with coil support at 60 percent of coil half longt

Krebs-5

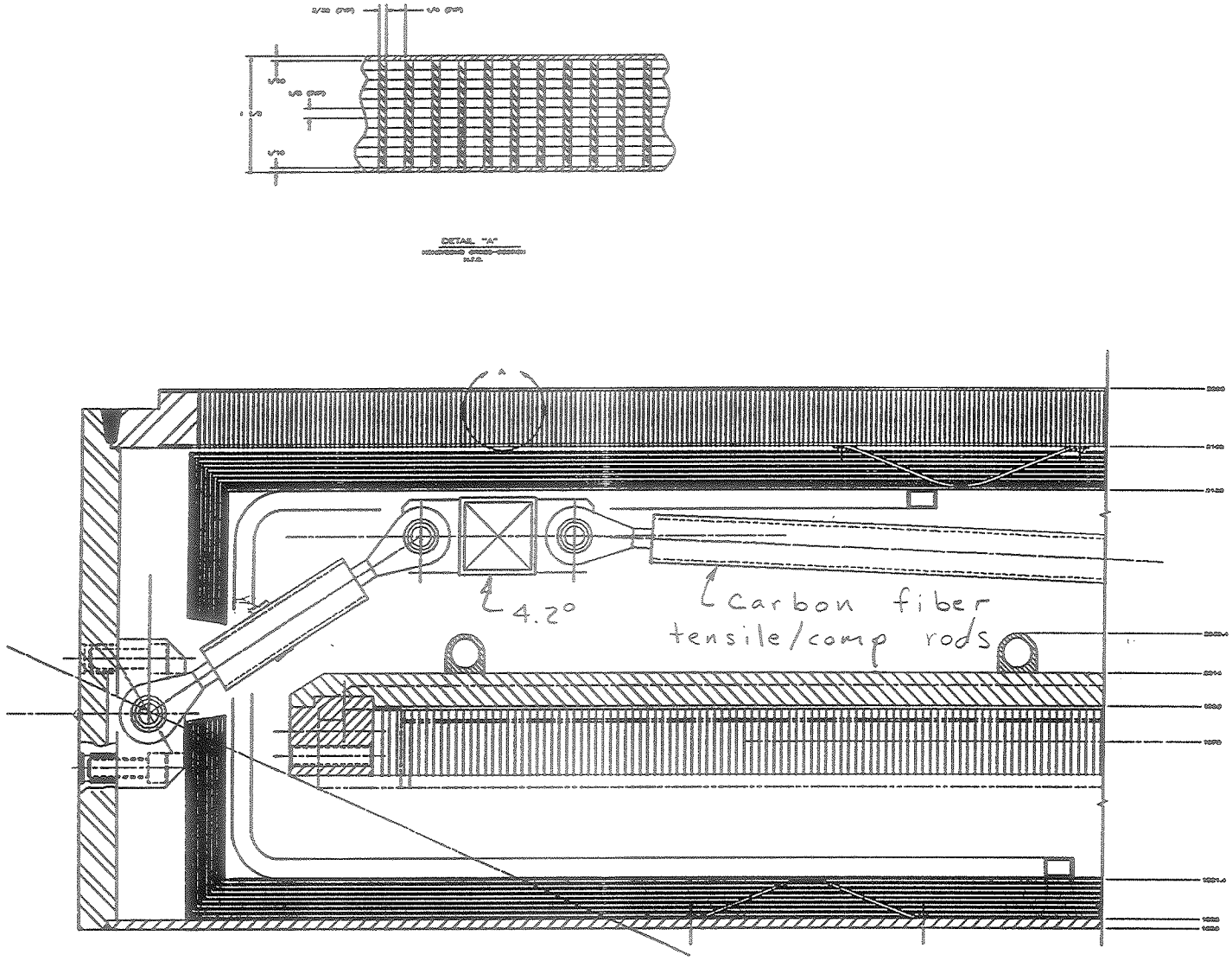


ANSYS 4.4A
FEB 7 1991
14:06:50
PLOT NO. 3
POST1 STRESS
STEP=1
ITER=1
SZ (AVG)
MIDDLE
S GLOBAL
DMX =0.006227
SMN =365.844
SMX =390.343

XV =1
DIST=81.479
XF =37.038
EDGE
A =367.205
B =369.927
C =372.649
D =375.371
E =378.094
F =380.816
G =383.538
H =386.26
I =388.982

Cooldown optimization with coil support at 60 percent of coil half longt

Krebs-6



Krebs-7

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

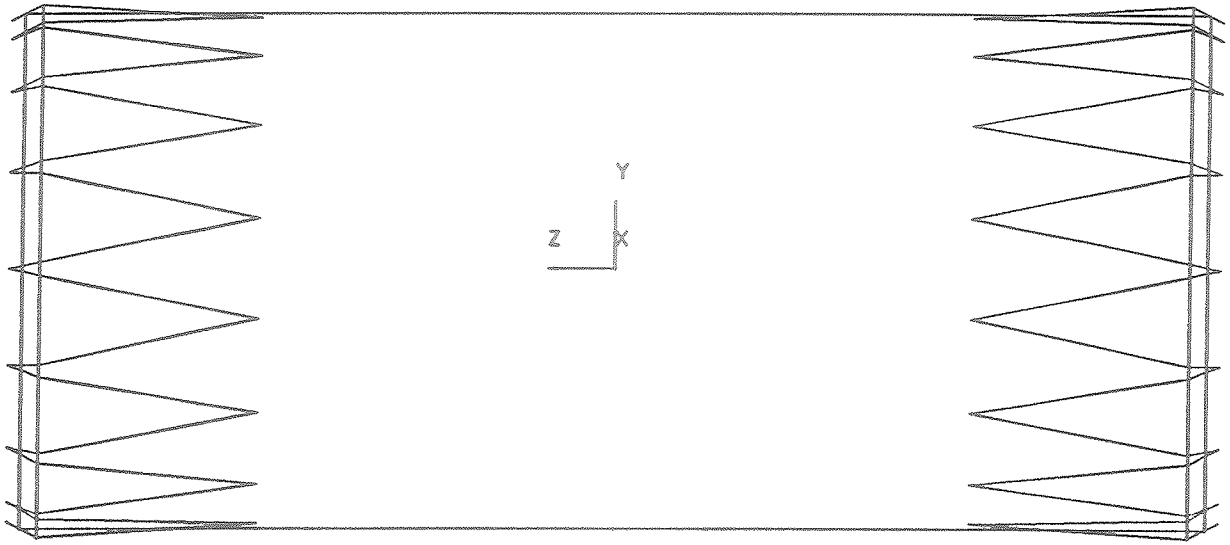
SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID TYPE I
CROSS SECTION (HONEYCOMB SHELL)

SPPRTARM.DWG

1

ANSYS 4.4A
FEB 4 1991
16:03:29
PLOT NO. 1
PREP7 ELEMENTS
TYPE NUM

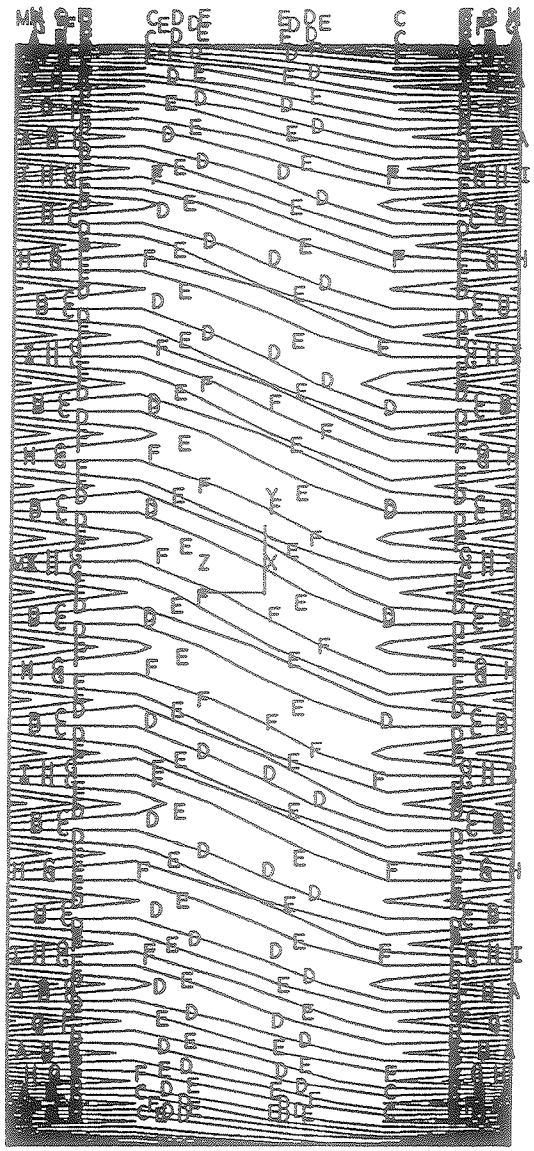
XV =1
DIST=193.05
XF =38.25
EDGE



Cooldown optimization with coil support at 60 percent of coil half lengt

Krebs - 8

1



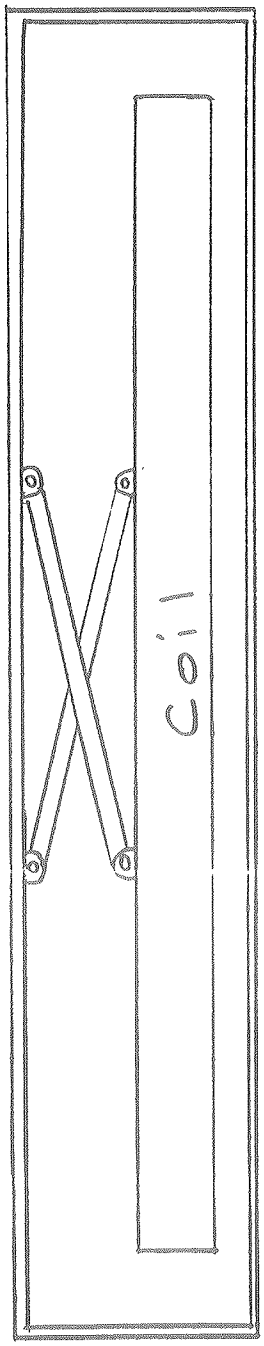
ANSYS 4.4A
FEB 4 1991
15:59:56
PLOT NO. 1
POST1 STRESS
STEP=1
ITER=1
SZ (AVG)
MIDDLE
S GLOBAL
DMX =0.343821
SMN =993.372
SMX =1027

XV =1
DIST=81.479
XF =37.036
EDGE
A =995.219
B =998.911
C =1003
D =1006
E =1010
F =1014
G =1017
H =1021
I =1025

Cooldown optimization with coil support at 60 percent of coil half lengt

Krebs-9

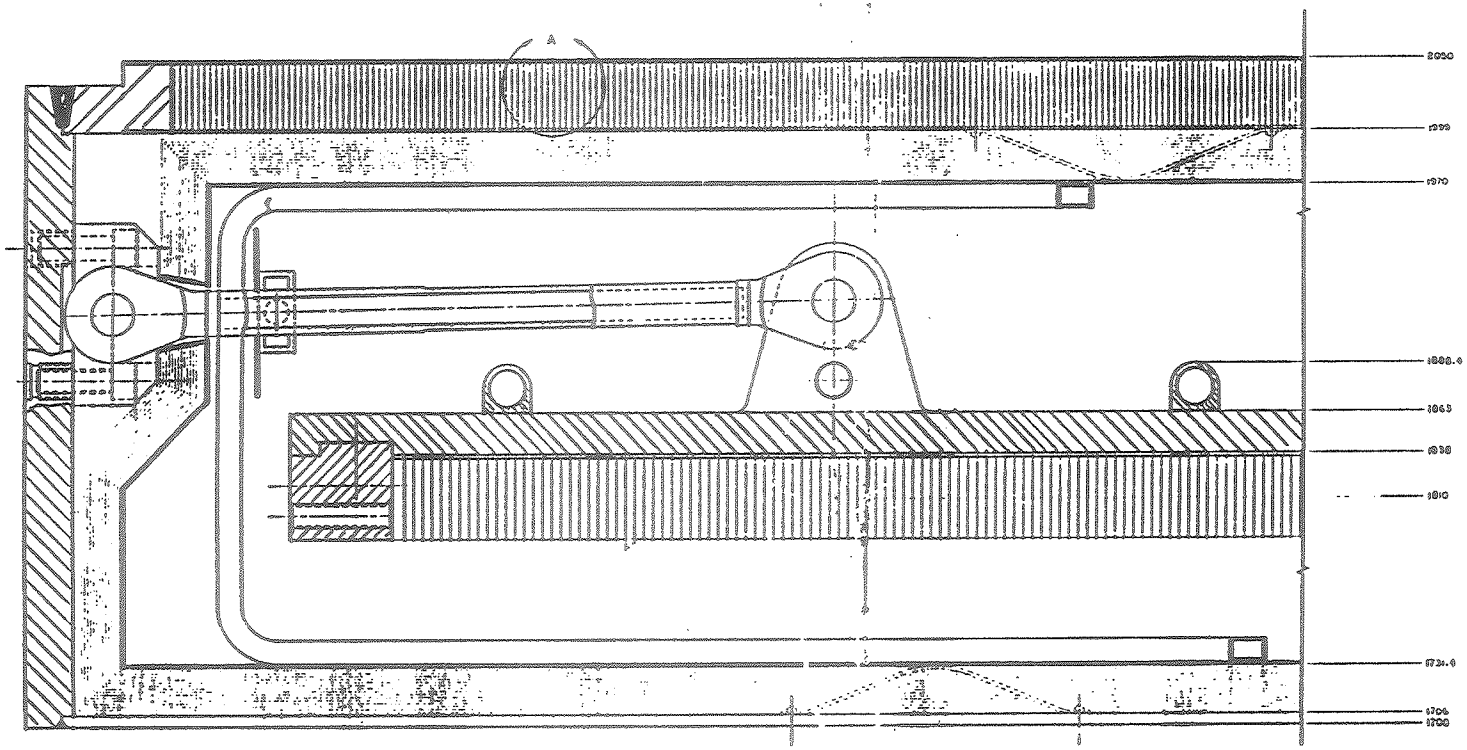
Krebs-10



Support Materials

1) Metals
   a) Aluminum 7075-T6
   b) Inconel 718

2) Composites
   a) Carbon fiber filament
   b) Glass fiber filament



Fast-1

RADIATION THICKNESS OF COIL COMPONENTS

OD = 4.1 m, L = 8 m

Item	Thickness (mm)	mm/RL	Thickness (RL)
Coil, Al only	75.	90	0.83
Inner vac shell	6.	90	0.07
Outer vac shell:			
Solid Al plate	22.5	90	0.25
Al isogrid	14.	90	0.15
CFRP, with	22.5	~350	0.100
Al skin	3.0	90	

Sum of these components is 1.00 RL to 1.15 RL. Total thickness will be about 0.1 RL more due to superconductor, insulation, etc.

Honeycomb

Sandwich Construction

Fast-3

The facings of a sandwich panel used as a beam act similarly to the flanges of an I beam by taking the bending loads — one facing in compression and the other in tension. Expanding this comparison further, the honeycomb core corresponds to the web of the I beam. This core resists the shear loads, increases the stiffness of the structure by spreading the facings apart, but unlike the I beam's web, gives continuous support to the flanges or facings. The core-to-skin adhesive rigidly joins the sandwich components and allows them to act as one unit with a high torsional and bending rigidity.

Figure 1

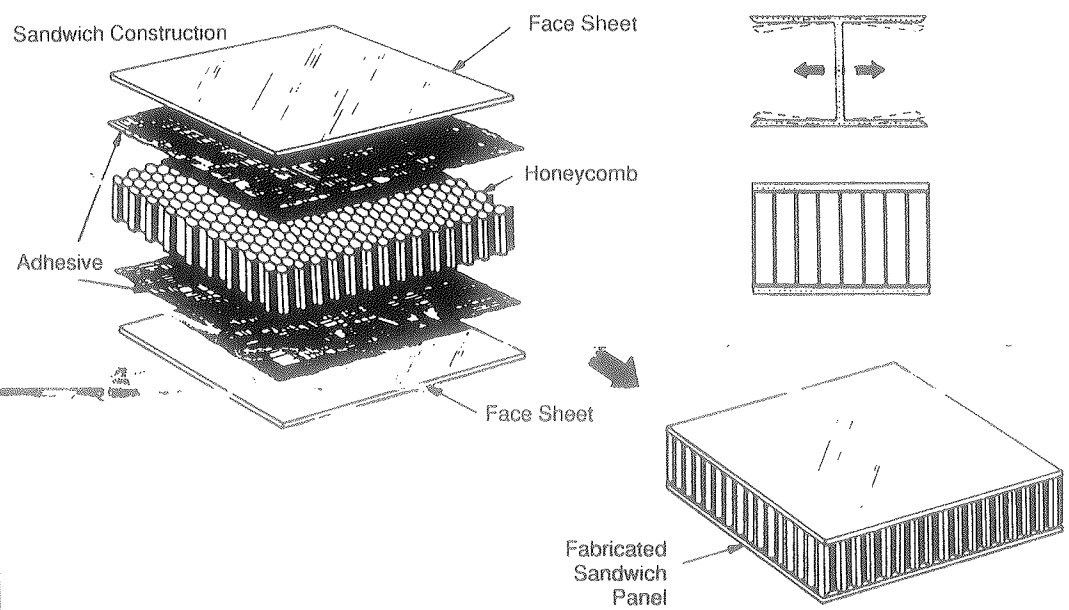
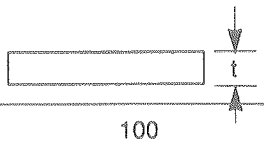
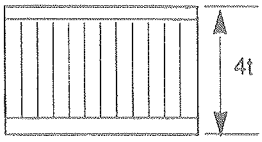


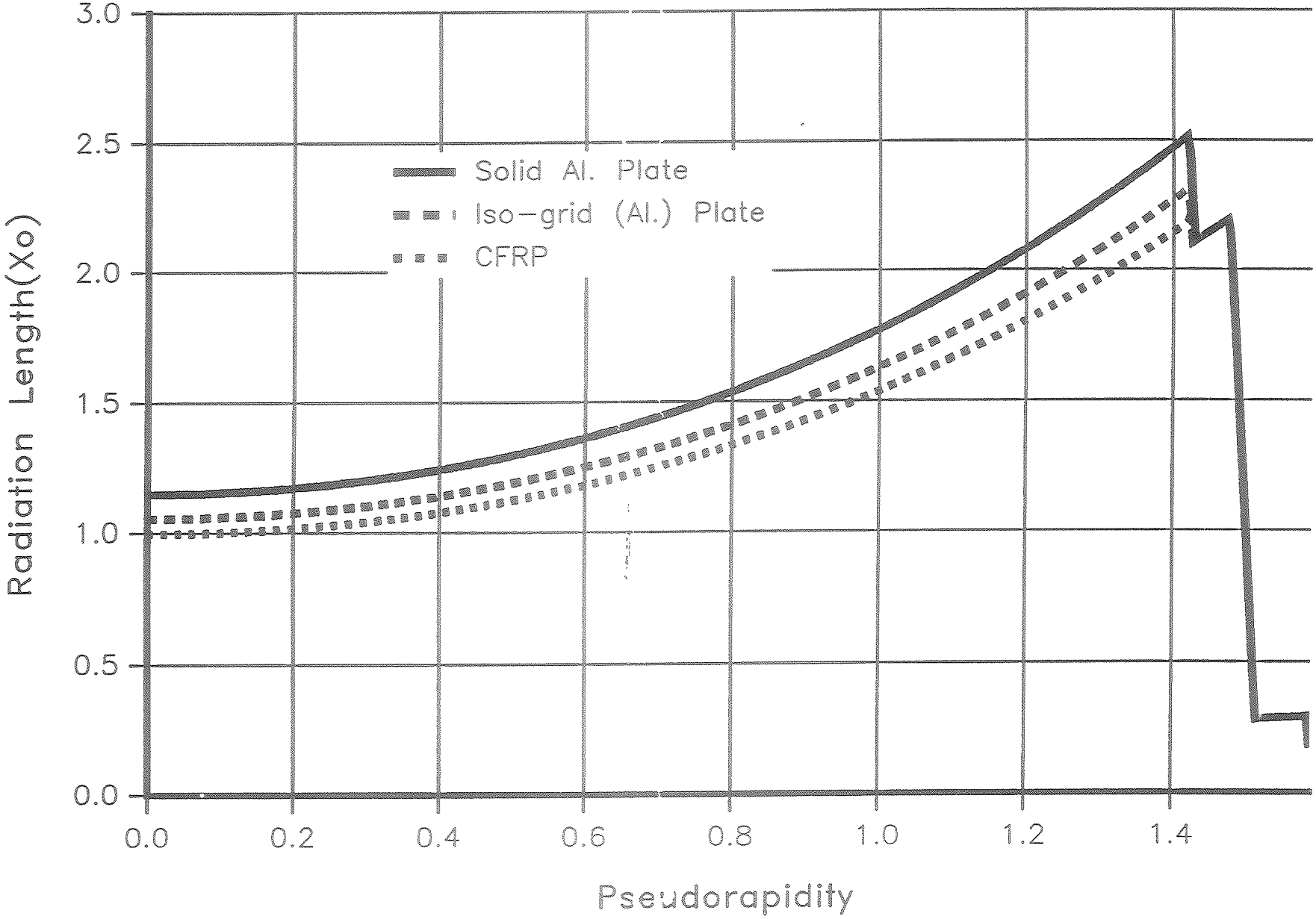
Figure 2

			
Relative Stiffness (D)	100	700	3700
Relative Strength	100	350	925
Relative Weight	100	103	106

A striking example of how honeycomb stiffens a structure without materially increasing its weight.

Radiation Length V.S. the Pseudorapidity

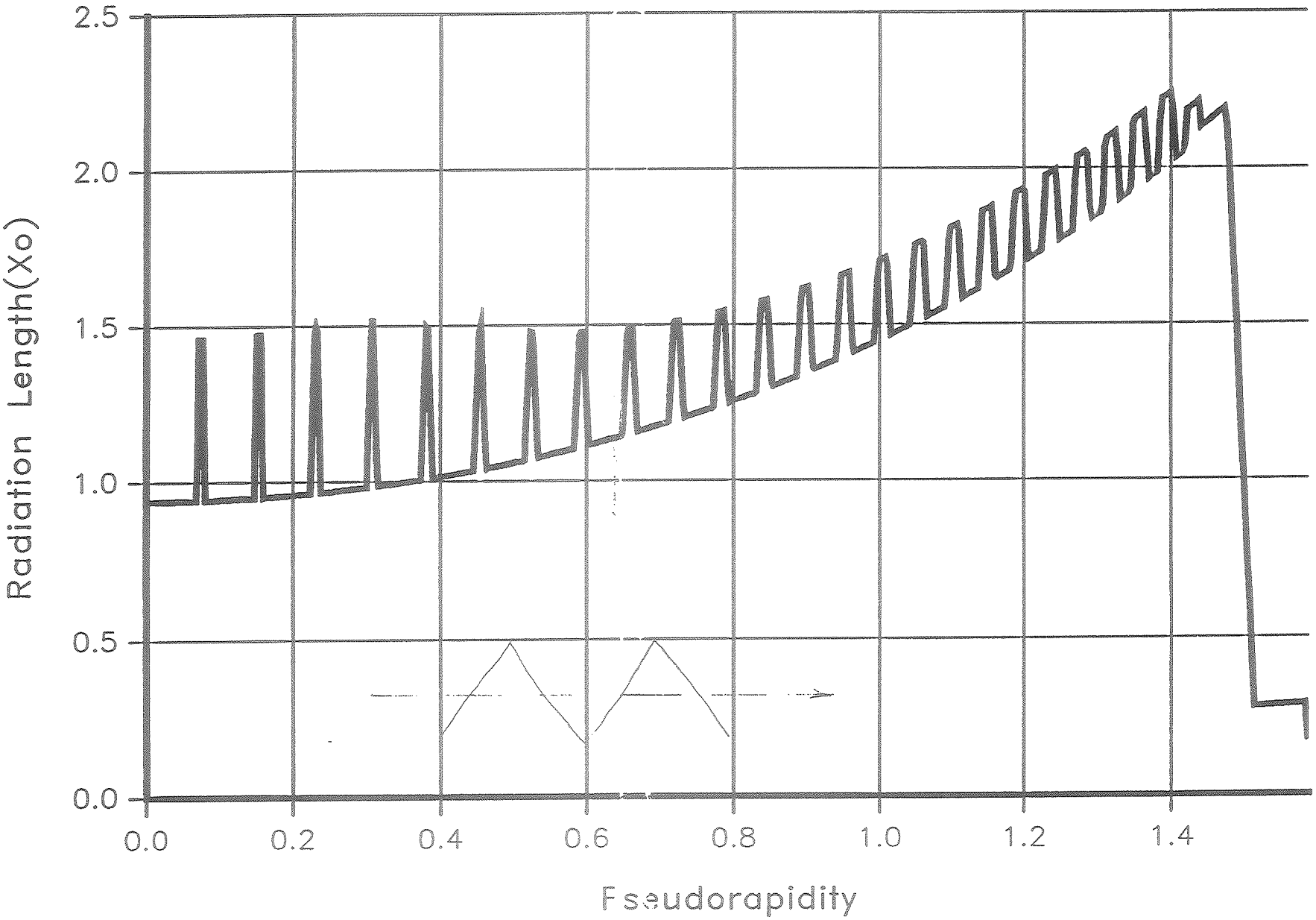
The Comparison of the Differen·· Materials For Outer Vacuum Shell



Fast-4

Radiation Length V.S. the Pseudorapidity

For Iso-grid Plate



Fast-5

CHIMNEY

Functions

1. Passage for cryogenic lines, power leads and possibly instrumentation wiring
2. Pressure relief of vacuum shell
3. High vacuum pumping of leaks

Stefanik - 1

CHIMNEY

Physics Design Requirements

1. Minimize radiation thickness
2. Specified space: ~12" square
3. Route through detector
4. Location on cryostat

Stefanik - 2

CHIMNEY

Design Basis

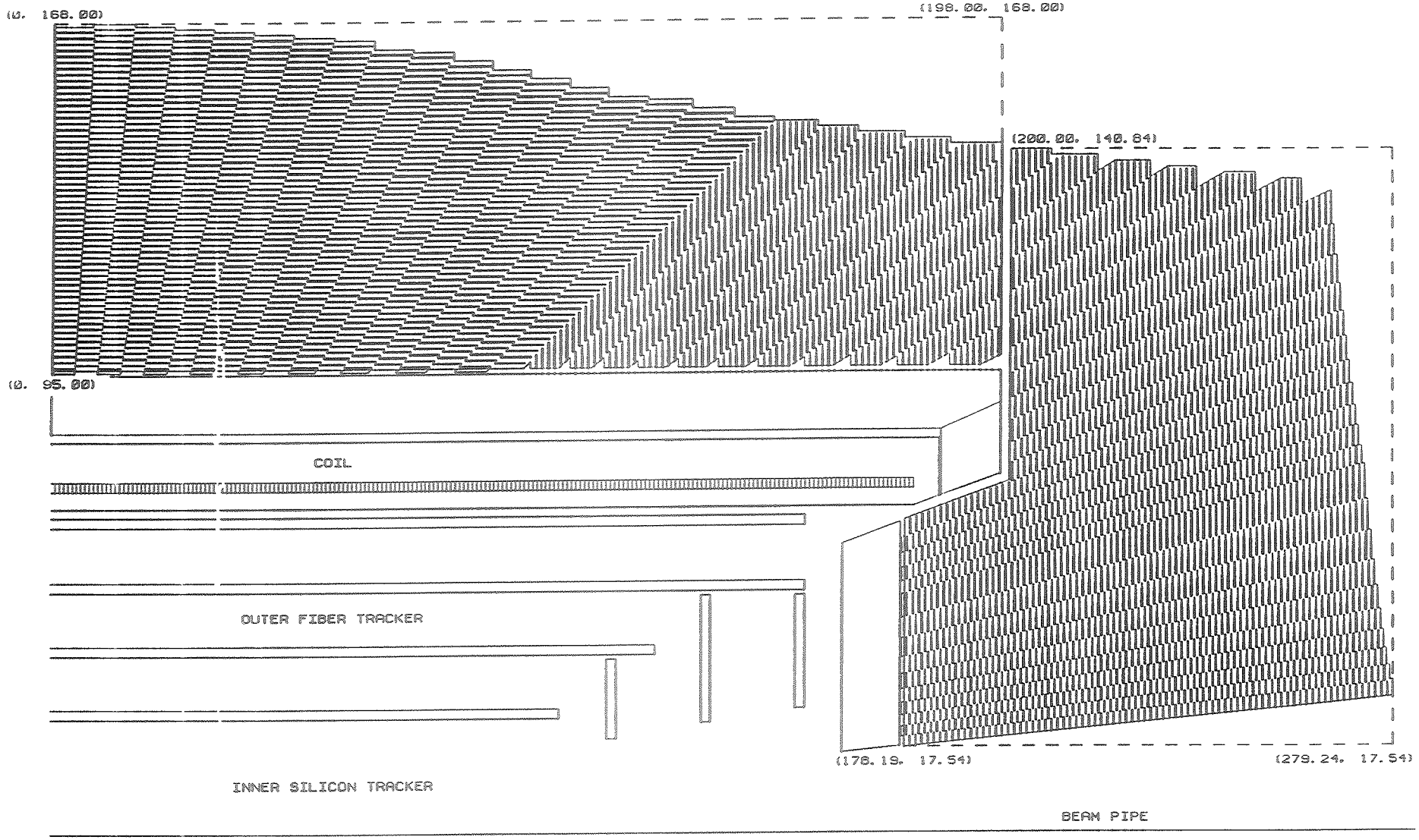
1. Aluminum construction
2. ASME Section VIII, Div 1
3. One chimney
4. Located on top at end of cryostat

Stefanik - 3

SDC HADRON CALORIMETER

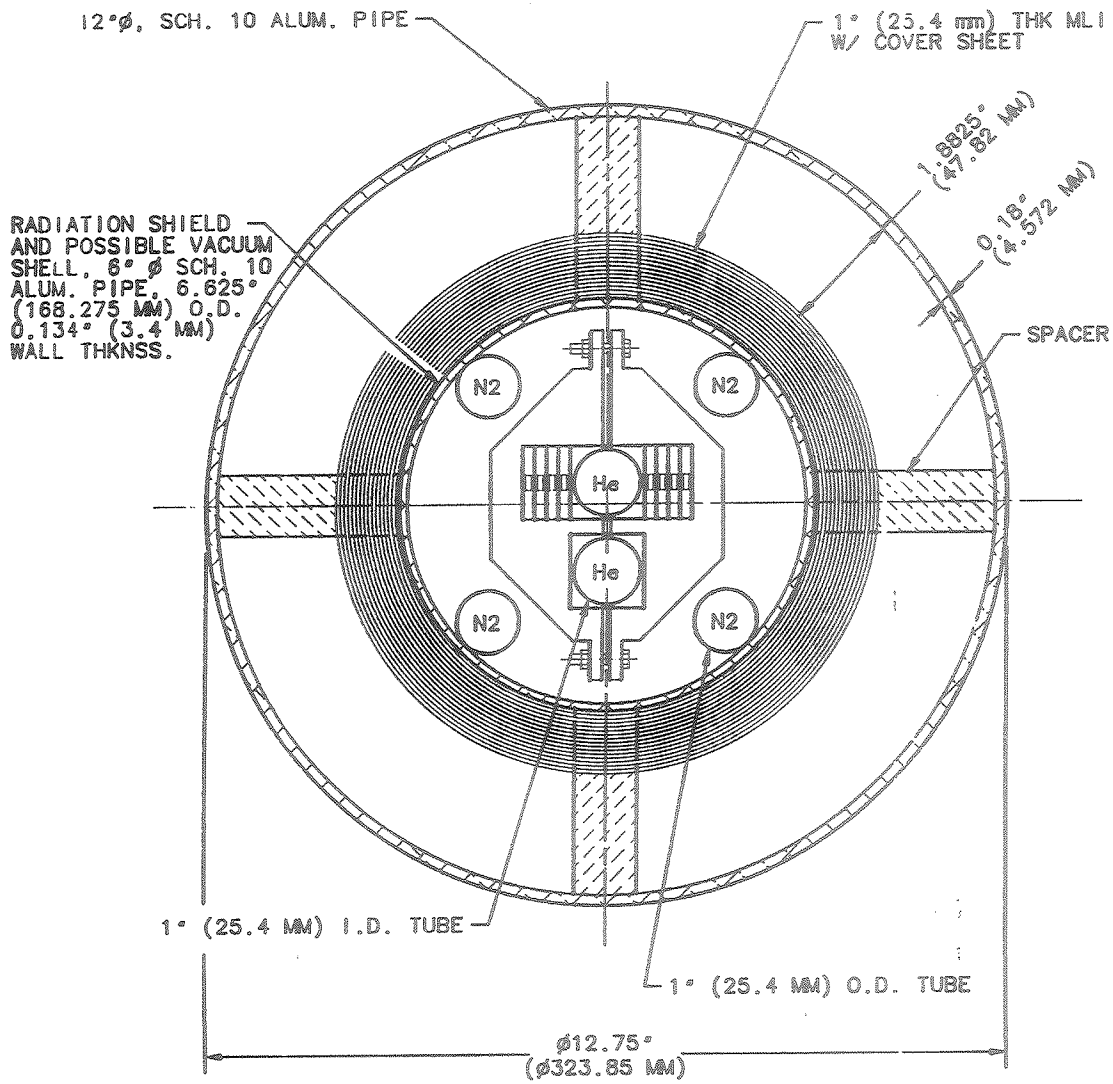
ALL DIMENSIONS INCHES

STAMPED
LAMINATION
PATTERN



S-4

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	A. STEFANIK	2/91
FRACTIONS	DECIMALS	ANGLES	DRAWN	D. FRIEND	2/12/91
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX. 2. DO NOT SCALE DRWG. 3. DIMENSIONING IN ACCORD WITH ANSI Y14.5 STD'S.			APPROVED		
			USED ON		
√ MAX. ALL MACHINED SURFACES			MATERIAL		B

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID; TYPE I
CHIMMNEY CROSS SECTION; 12" NOM.

SCALE	DRAWING NUMBER	SHEET NO.	REV.
HALF		1	

CHIMNEY

Current Design

1. Vacuum vessel relieving pressure is 0.1 psig

   Current design pressure is 0.7 psig

2. High vacuum throughput appears to be sufficient when compared to CDF leak

CHIMNEY

Options

1. Square cross section
2. Located away from ends
3. Multiple chimneys
4. Notch either one or two modules for chimney

REFRIGERATION

Physics Design Requirements

1. Time:

   - Cooldown - 10 days
   - Quench Recovery - 4 hours

2. Reliability:

   - Reserve Capacity
   - No Operating Equipment In The Detector Hall - Pumps, Cold Compressors.

REFRIGERATION

Refrigerator Size

1. Charging: 500 W and 35 ℓ/hr (1.2 g/s)

   Refrigeration - 620 Watts
   Liquefaction - 6.2 g/s
   Cost Factor - 1

2. Cooldown: 366 ℓ/hr (12.5 g/s)

   Refrigeration - 1,250 Watts
   Liquefaction - 12.5 g/s
   Cost Factor - 1.6

3. 4 Hour Quench Recovery: 1,756 ℓ/hr (60 g/s):

   Refrigeration - 6,000 Watts
   Liquefaction - 60 g/s
   Cost Factor - 4.9

REFRIGERATION

Refrigerator Size

4. <u>Alternative to #3</u>

- 6,000 ℓ stored liquid helium
- 60 g/s helium gas recovery system
- Reliquefy with SDC or SSCL Refrigerator
- Reliquefy in 17 hours with extra capacity of 1500 W Refrigerator

REFRIGERATION

System Configuration

1. Single loop with reserve capacity and pressure transfer (like CDF)
2. Single loop with reserve capacity and surface pumps
3. Thermosiphon at solenoid
4. Pump circuit at solenoid

REFRIGERATION

Quench Recovery

1. 190 MJ stored energy
2. 24 Tonne cold mass
3. 75 K equilibrium temperature
4. 4 hour recovery to LHe temperature
5. 6,000 ℓ stored liquid helium
6. 60 g/s helium gas recovery system