GEM TN-93-441

Cryostat Test Status Meeting - SSCL

July 16, 1993

Abstract;

Agenda, attendees, and presentations of the GEM Cost/Schedule Review Meeting held at the SSC Laboratory on July 16, 1993.

CRYOSTAT TEST STATUS MEETING

July 16, 1993

9:00 - B119

1. **Specification and Requirements Status**
2. **Schedule Update Status**
3. **Cryostat Design Status**
4. **Cryostat Lines Status**
5. **Other Business**

Attendees

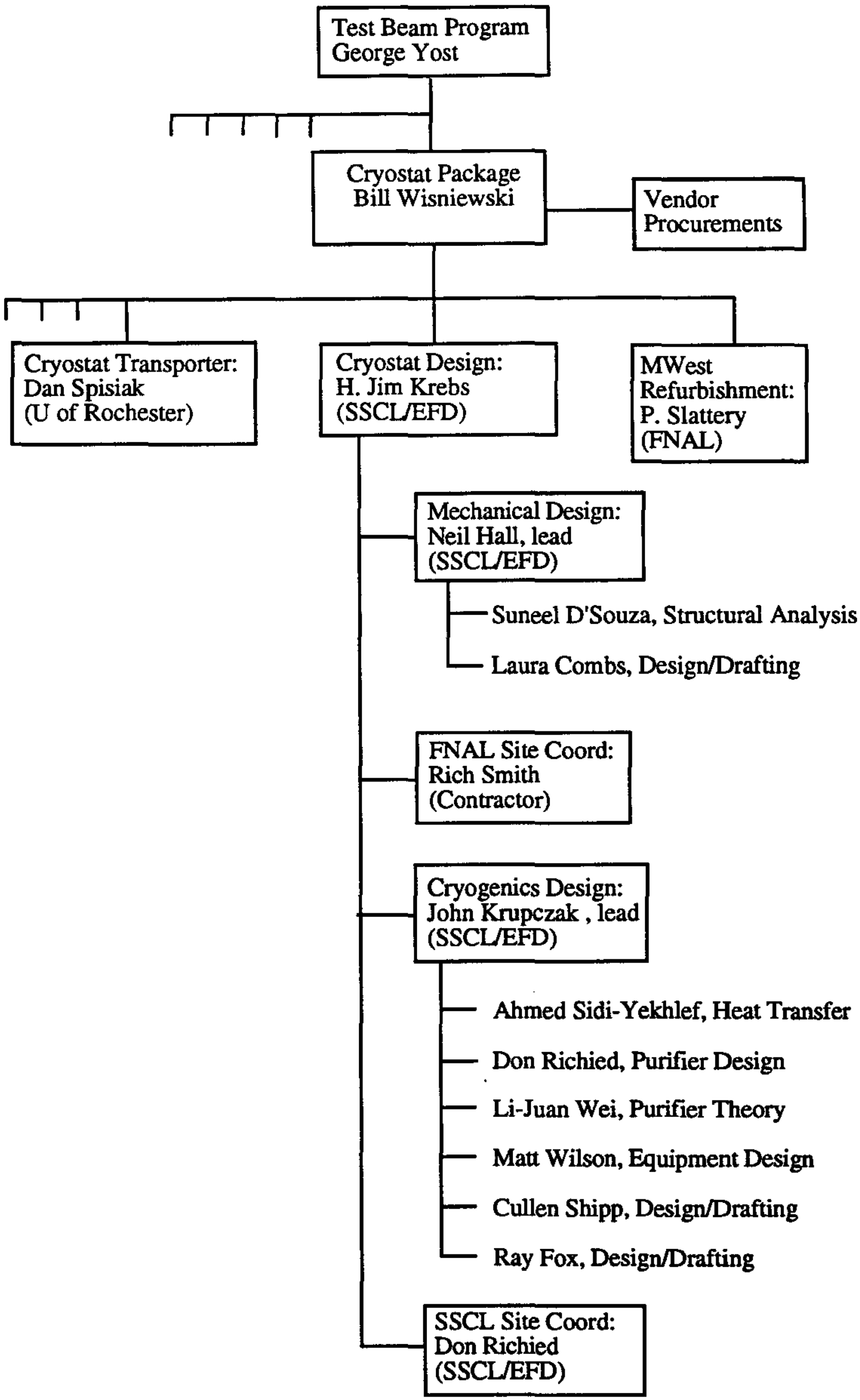
Bill Wisniewski	[illegible]	GEM	[illegible]
RONN WOOLLEY	6079	GEM ES+H	WOOLLEY::SSCVX1
Don Richied	4038	EFD –	RICHIED:: SSCVX1
MATT WILSON	X2019	EFD CRYO	SSCVX1::WILSON
Robt Smith	6279	GEM –	Gmeth@SSCVX
DUKE CASIAS VACUUM	3045	PRD-VAC	—
TONY SPADAFORA	6181	PRD	SPADAFOR@SSCVX1
SUNEEL D'SOUZA	3077	EFD/STRUCT.	SUNEEL@NOVA
Smehanath Asuri	6180	EFD/STRUCT	
Jim Krebs	1196	EFD	SSCVX1::KREB
Ken Freeman	1113	PRD/GEM ELECTR.	sscvx1::kfreeman
G.R.Chapman	6330.	PRD	SSCVX1::GCHAPMAN
Kent SWARTS	4481	GEM ES&H	SWARTS@SSVX1
George YOST	6028	GEM	SSCVX1::YOST
Neil Hall	6180	EFD	SSCVX1::HALL
Mike Harris	6143	GEM	SSCVX1::HARRIS

Cryostat – Beam Test

Cryostat Test Status Meeting
July 16, 1993
Presented By

Jim Krebs
SSCL

Excerpt from GEM - EFD Memorandum of Understanding

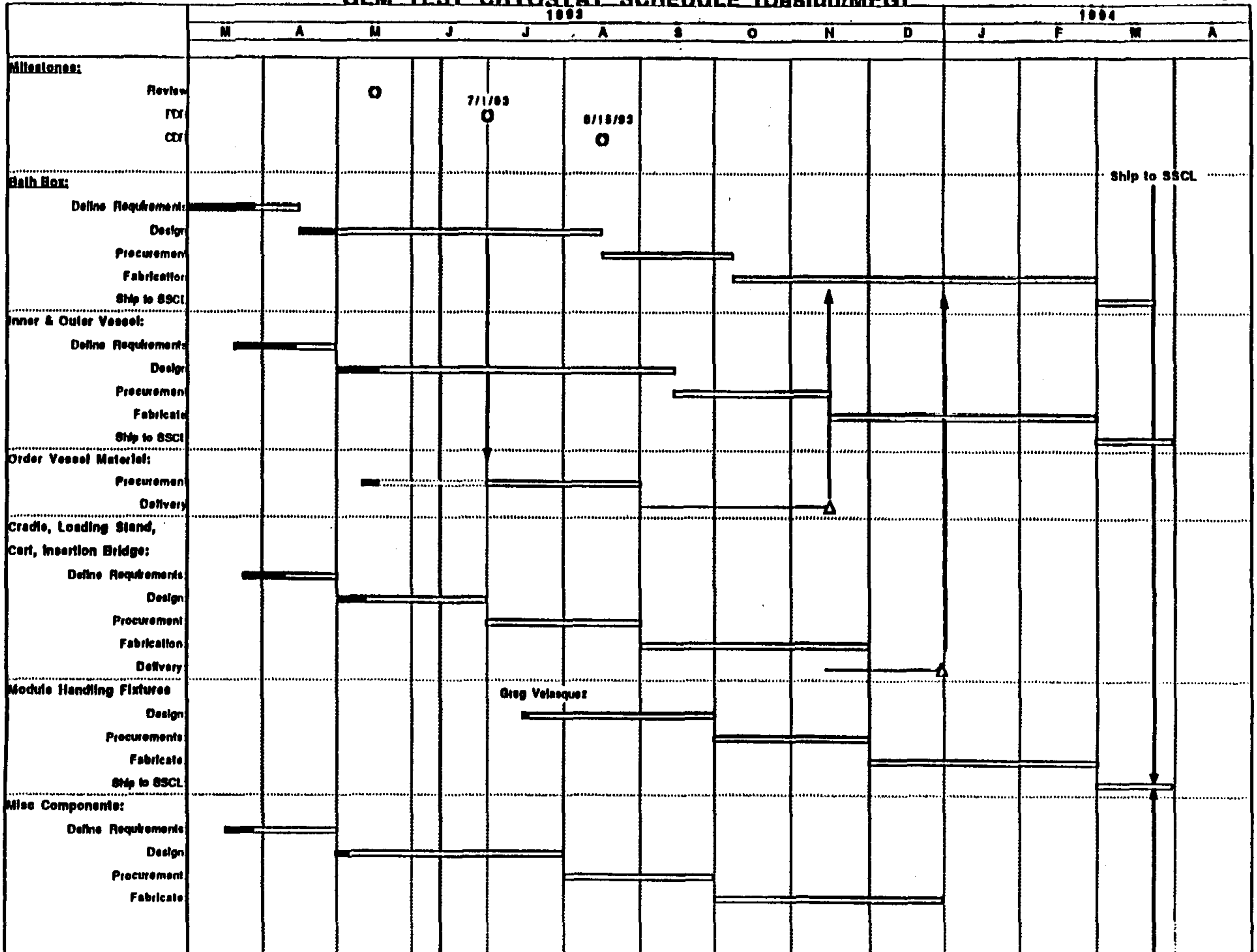


GEM Test Beam Cryostat
Major Design Milestones

Test Cryostat:	
Preliminary Design Review	9-1-93
Critical Design Review	10-1-93
Cryogenics System:	
Preliminary Design Review	9-1-93
Critical Design Review	10-1-93

gem

GEM TEST CRYOSTAT SCHEDULE (Design/MFG)



Neil Hall, X-6190, Ewald Zimmer-Nixdorf X-6205

Friday, June 11, 1993

5

PS & FL schedule @ FNAL

3/1/94
Beneficial Occupancy MWEST Hall

8/1/94
Feed throughs delivered to cryostat vendor

8/15/94
Transporter arrives at FNAL

9/15/94
Transporter fully assembled for cryostat

10/1/94
Cryostat delivered to FNAL;
Cryostat plumbing at FNAL ready to connect to cryostat;
Transporter and cryostat controls at FNAL

11/1/94
Begin assembly of modules into support structure;
External cables and junction boxes arrive at FNAL

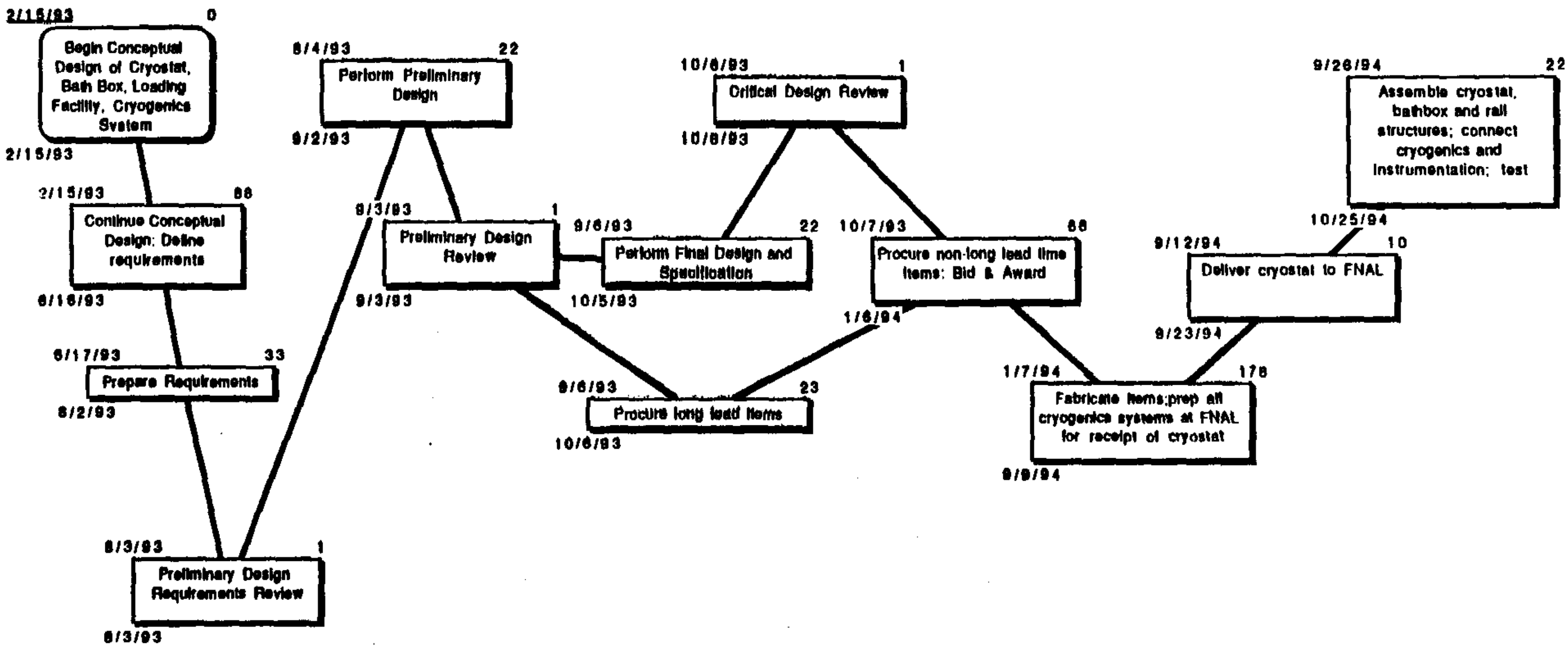
12/1/94
Partial delivery of shapers;
DAQ adequate to system test

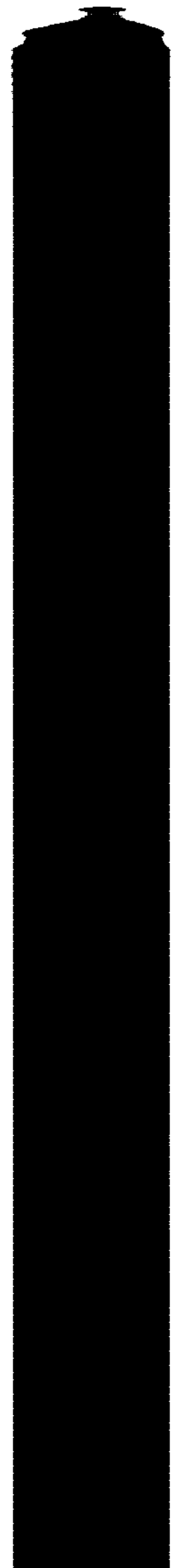
1/1/95
Module installation complete;
Begin cable and cryo line internal hookup

2/15/95
Cryostat and contents ready for cooldown

3/1/95
Begin beam test

beginnings of full schedule



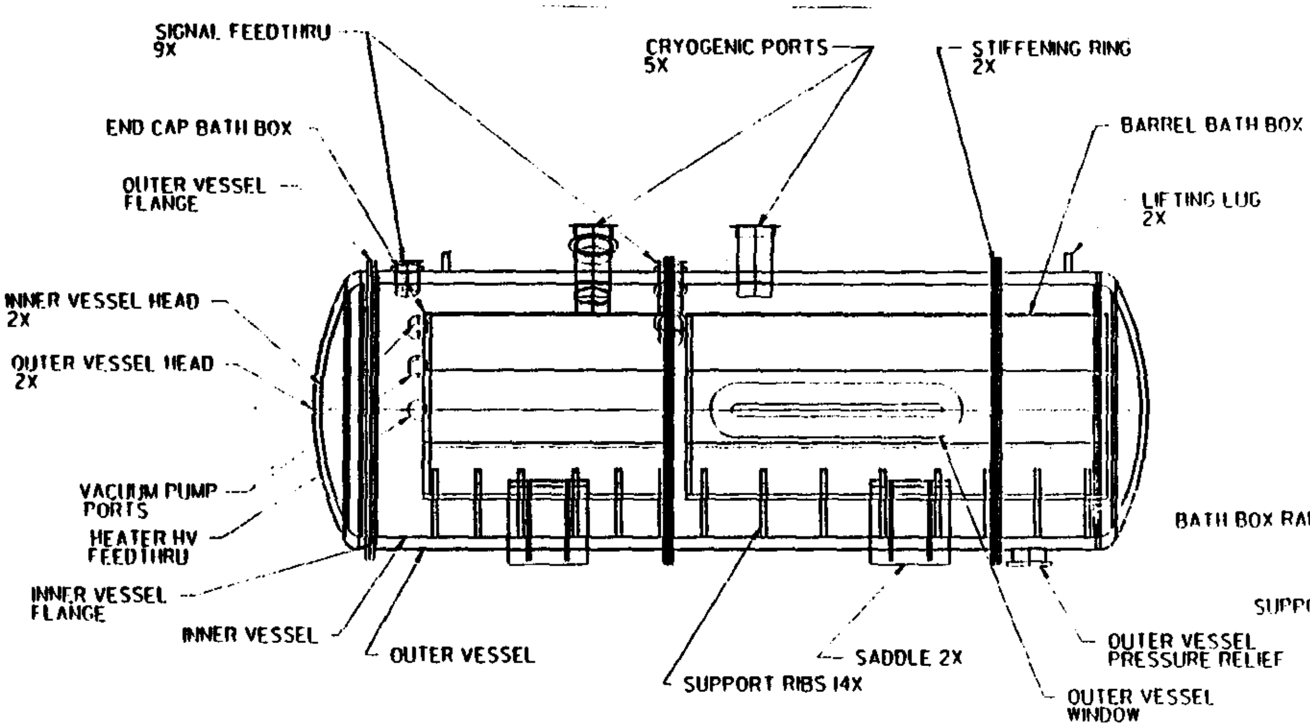


GEM TEST BEAM
CRYOSTAT STATUS

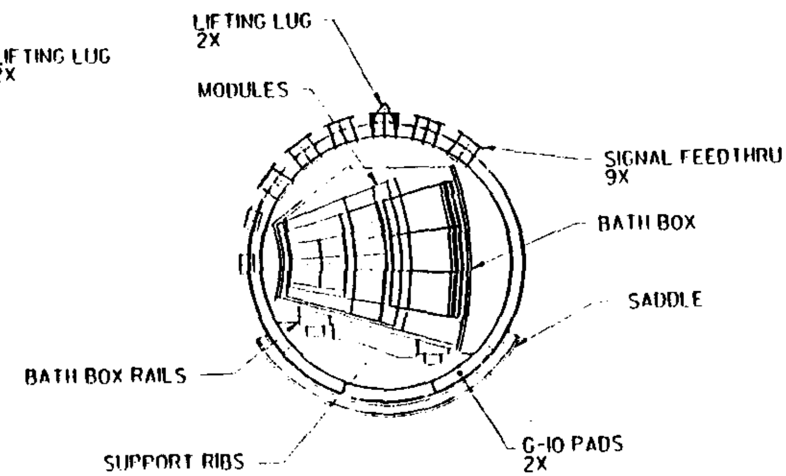
SSCL STATUS MEETING 7/16/93

Neil Hall - SSCL
(214) 708-6180

GEM TEST BEAM CRYOSTAT DESIGN STATUS
CRYOSTAT ARRANGEMENT



SIDE VIEW



END VIEW

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July 15, 1993

GEM TEST BEAM CRYOSTAT DESIGN STATUS
MODULE CONFIGURATION

- BARREL MODULES
  - 6 Outer Hadron's
  - 8 Inner Hadron's
  - 2 EM's
- ENDCAP MODULES
  - 3 Outer Hadron A's
  - 3 Outer Hadron B's
  - 2 Inner Hadron A's
  - 2 Inner Hadron B's
  - One 27° EM Segment
- BARREL EM ROTATED 2.25° CCW
- ENDCAP OUTER HAD's A & B HAVE SAME CLOCKING
- ENDCAP INNER HAD's A & B HAVE SAME CLOCKING AND ARE CENTERED ON CRACK 1
- CRYOSTAT WILL PROVIDE ROLL OF ± 4.0°. THIS ALLOWS BEAM TO FAN 1.75° BEYOND CRACKS 1 & 2

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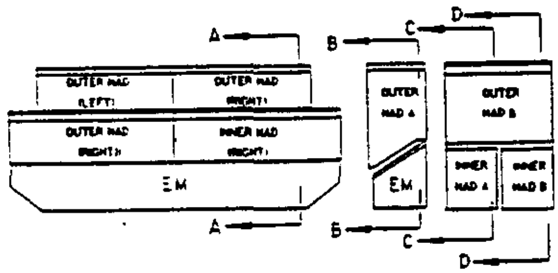
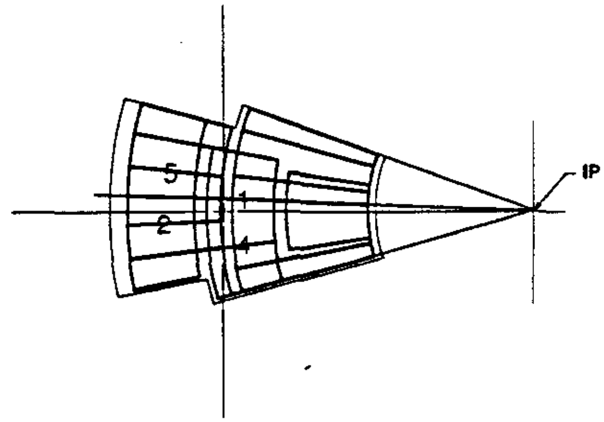
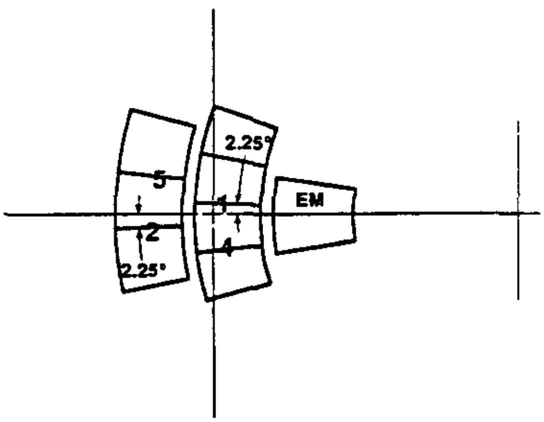
GEM TEST BEAM CRYOSTAT MODULE ARRANGEMENT

Rev: 6/11/93

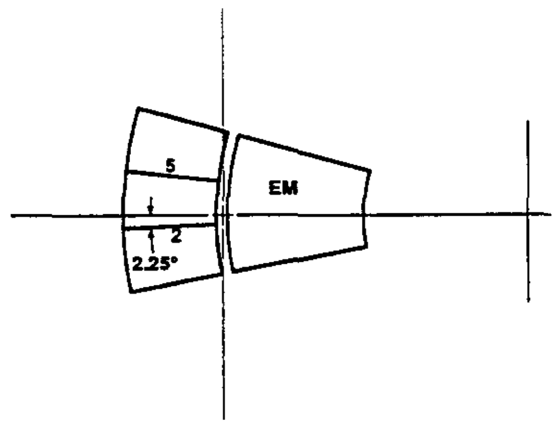




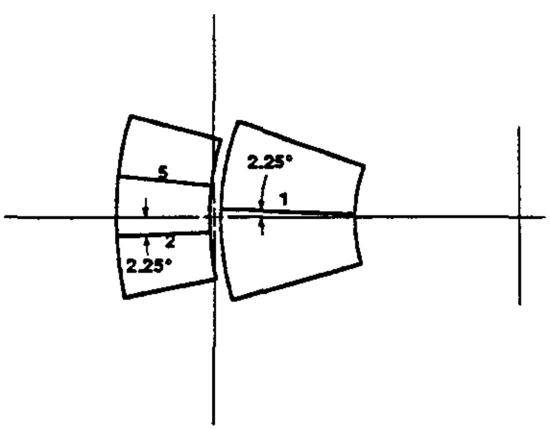
COMPOSITE VIEW
ROTATED 90°



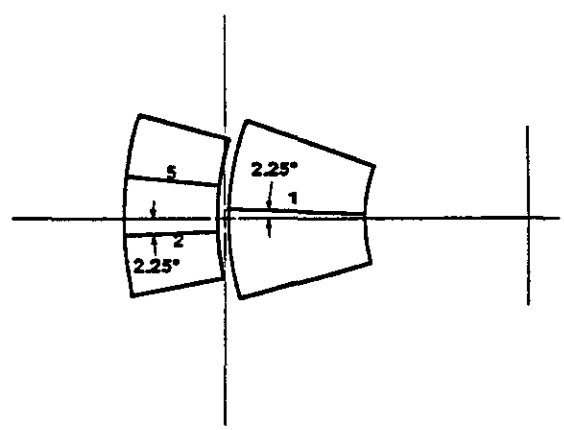
SECTION A-A (BARREL)
ROTATED 90°



SECTION B-B (ENDCAP)
ROTATED 90°



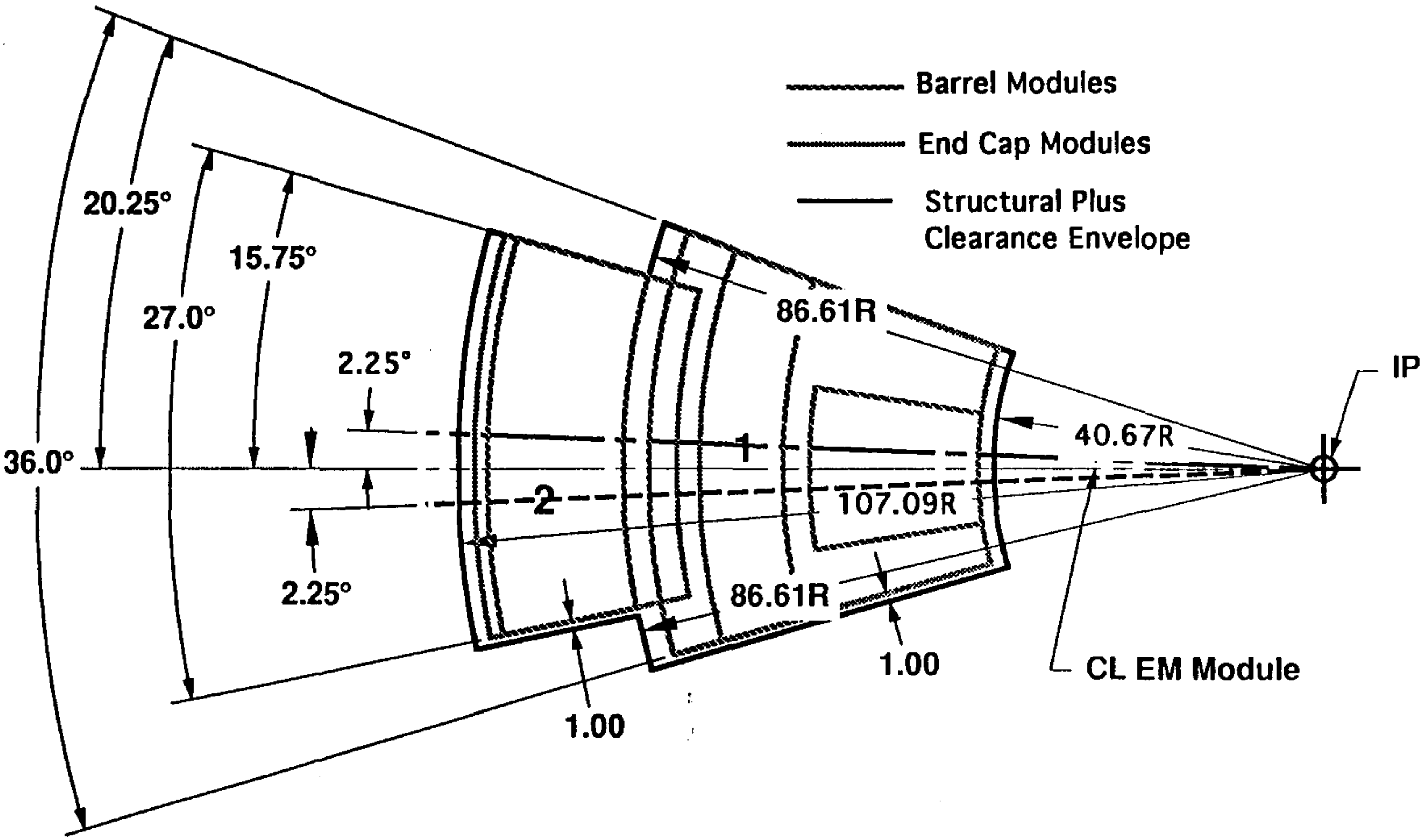
SECTION C-C (ENDCAP)
ROTATED 90°



SECTION D-D (ENDCAP)
ROTATED 90°

GEM Test Beam Cryostat
Module Envelope

Rev: 6/24/93



GEM TEST BEAM CRYOSTAT DESIGN STATUS
BATH BOX

- TWO SEPARATE BATH BOXES — ONE FOR BARREL MODULES, ONE FOR END CAP MODULES
- EACH BOX INDIVIDUALLY INSERTABLE
- BATH BOX TO INNER VESSEL PIN DOWN POINT AT FRONT END OF EACH BATH BOX
- WALL THICKNESS OF BATH BOX IS 1.25" WITH LOCAL THINNING AS NECESSARY IN AREA OF BEAM
- LIQUID EXCLUDERS WILL BE PROVIDED WITH BOTH BOXES TO MINIMIZE LKr REQ'MTS
- BATH BOX DESIGN MUST CONSIDER MODULE INSTALLATION
  - All Hadron Modules Are Mounted on Radial Keyways
    - √ Requires Installation From Horizontal direction
    - √ Small End Of Module Must Lead During Insertion
  - Barrel and End Cap EM Modules to be Inserted From Horizontal Direction
- REAR WALL OF BATH BOX WILL BE REMOVABLE (BOLTED) — ALL OTHER WALLS WILL BE WELDED.
- TOP OF BATH BOXES WILL BE OPEN TO RECEIVE CONDENSED CRYOGEN
- DESIGN IN INITIAL STAGES — NEED BETTER DEFINITION OF MODULE ATTACHMENT/INSERTION TOOL

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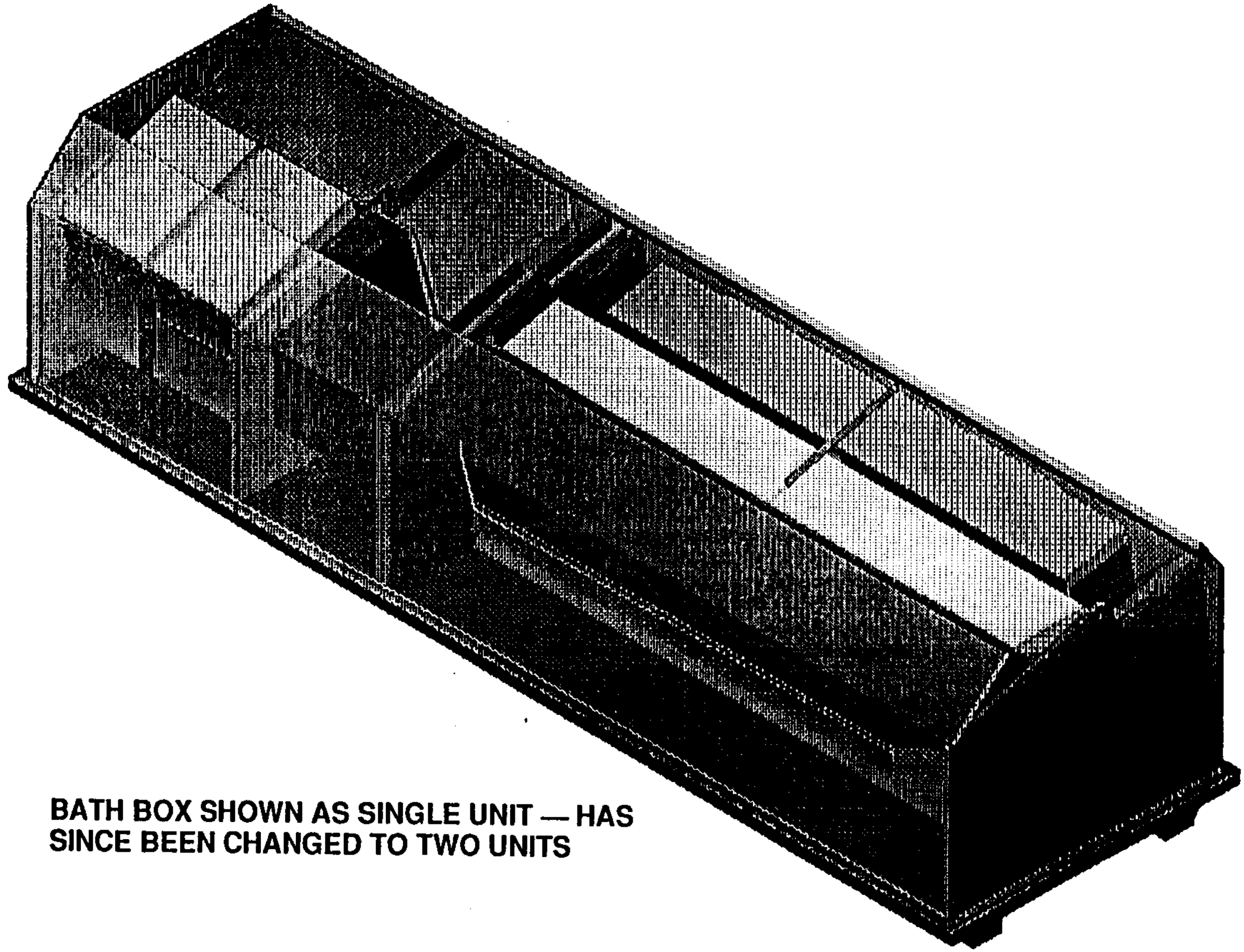

- BATH BOX SHOWN AS SINGLE UNIT — HAS SINCE BEEN CHANGED TO TWO UNITS

GEM TEST BEAM CRYOSTAT
MODULE/BATHBOX VOLUMES/WEIGHTS
REV: 7/14/1993

LKr= 2.416 g/cm^3
LAr= 1.4 g/cm^3

Module	Location	No. Mods in GEM Cal.	No. Mods in Test Cal.	Total Mod Wet Wt, Mg	Wet Wt of One GEM Mod, Mg	Vol of One GEM Mod, L	Vol of One Test Mod, L	Tot Wet Wt of Test Mods, Mg [1]	Tot Vol of Test Mods,L	Liquid Fraction	Tot Vol of Liq in Test Mods, L	Wt of Liq in Test Mods, Mg [1]	Tot Dry Wt of Test Mods, Mg
Outer Had (left)	Barrel	80	3	174.275	2.18	247.4	247.4	6.54	742.14	0.1683	124.9	0.30	6.23
Inner Had (left)	Barrel	80	4	162.226	2.03	230.3	230.3	8.11	921.11	0.1683	155.0	0.37	7.74
Outer Had (right)	Barrel	80	3	174.275	2.18	247.4	247.4	6.54	742.14	0.1683	124.9	0.30	6.23
Inner Had (right)	Barrel	80	4	162.226	2.03	230.3	230.3	8.11	921.11	0.1683	155.0	0.37	7.74
EM	Barrel	40	2	63.524	1.59	379.9	379.9	3.18	759.86	0.6706	509.6	1.23	1.95
Outer Had A	End Cap	80	3	113.297	1.42	198.4	198.4	4.25	595.13	0.2211	131.6	0.18	4.06
Outer Had B	End Cap	80	3	172.015	2.15	301.2	301.2	6.45	903.57	0.2211	199.8	0.28	6.17
EM	End Cap	2	27° Segment	46.098	1.73	5869.3	288.6	1.13	288.58	0.6390	184.4	0.26	0.88
Inner Had A	End Cap	40	2	97.048	2.43	339.9	241.5	3.45	482.93	0.2211	106.8	0.15	3.30
Inner Had B	End Cap	40	2	97.112	2.43	340.1	241.4	3.45	482.85	0.2211	106.8	0.15	3.30
Total				1262.095	20.15	8384.04		51.20	6839.42		1798.7	3.60	47.59

[1] - Weight based on LKr in Barrel, LAr in End Cap

Volume of Liquid in Bathbox (both boxes with LAr)

Bathbox Lg = 246.78 in

Section	Vol, in^3	Vol, Liters
I	161991	2655
II	554183	9082
III	28331	464
IV	8664	142
V	145555	2385
VI	43174	708
Total	941899	15436

	Vol, Liters	Wt, lbs
Vol of Bath box=	15436	
Vol of modules=	6839	
Vol of Liquid in Modules=	1799	
Vol of liquid in Bathbox=	10395	32082

Volume of Liquid in Bathbox (Barrel Box with LKr; EC box empty)

Bathbox Length 149.003937 in

Section	Vol, in^3	Vol, Liters
I	97817	1603
II	334639	5484
III	17107	280
IV	5232	86
V	87892	1440
VI	26070	427
Total	568758	9321

	Vol, Liters	Wt, lbs
Vol of Bath box=	9321	
Vol of modules=	4086	
Vol of Liquid in Modules=	1069	
Vol of liquid in Bathbox=	6304	33966

3000 liters is the goal

GEM TEST BEAM CRYOSTAT DESIGN STATUS
INNER VESSEL

- 5083-O ALUMINUM
- DESIGNED PER ASME CODE
  - Welds Assumed to be Double-Groove
  - Welds Will Not Be Radiographically Inspected (Knockdown Factor=.70)
  - Corrosion Allowance = 0.0 (Working Fluids/ Environment not Corrosive)
- 50 PSID INTERNAL PRESSURE; NO EXTERNAL PRESSURE REQUIREMENT
- 91.0" OD, 90.25" ID, .375 THK", 301.0"(25'1") LG
- BOLTED FLANGE/SEAL ON ONE END FOR ACCESS; DESIGN IN PROCESS
- VESSEL WILL BE LEAK CHECKED WITH HELIUM AFTER FABRICATION
- STIFFENING RIBS NOT REQUIRED

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July 15, 1993

GEM TEST BEAM CRYOSTAT DESIGN STATUS
OUTER VESSEL

- 5083-O ALUMINUM
- DESIGNED PER CGA CODE
- 15.0 PSID VACUUM; NO INTERNAL PRESSURE REQUIREMENT
- 100.0" OD, 99.0" ID, .50 THK", 305.0"(25'4") LG (LENGTH IS PRELIMINARY!!)
- BOLTED FLANGE/SEAL ON ONE END FOR ACCESS; DESIGN IN PROCESS
- THREE STIFFENING RIBS ADDED TO PREVENT BUCKLING; TWO RIBS FROM 3 X 5 I-BEAM; ACCESS FLANGE CONSIDERED AS THIRD RIB
    - Critical Length between Stiffeners = 156.0"
    - Interference Exists Between Stiffening Rib and Ports — Currently Resolving
- VESSEL WILL BE LEAK CHECKED WITH HELIUM AFTER FABRICATION
- INNER TO OUTER VESSEL PIN DOWN POINT 33.13" FROM VESSEL CENTERLINE

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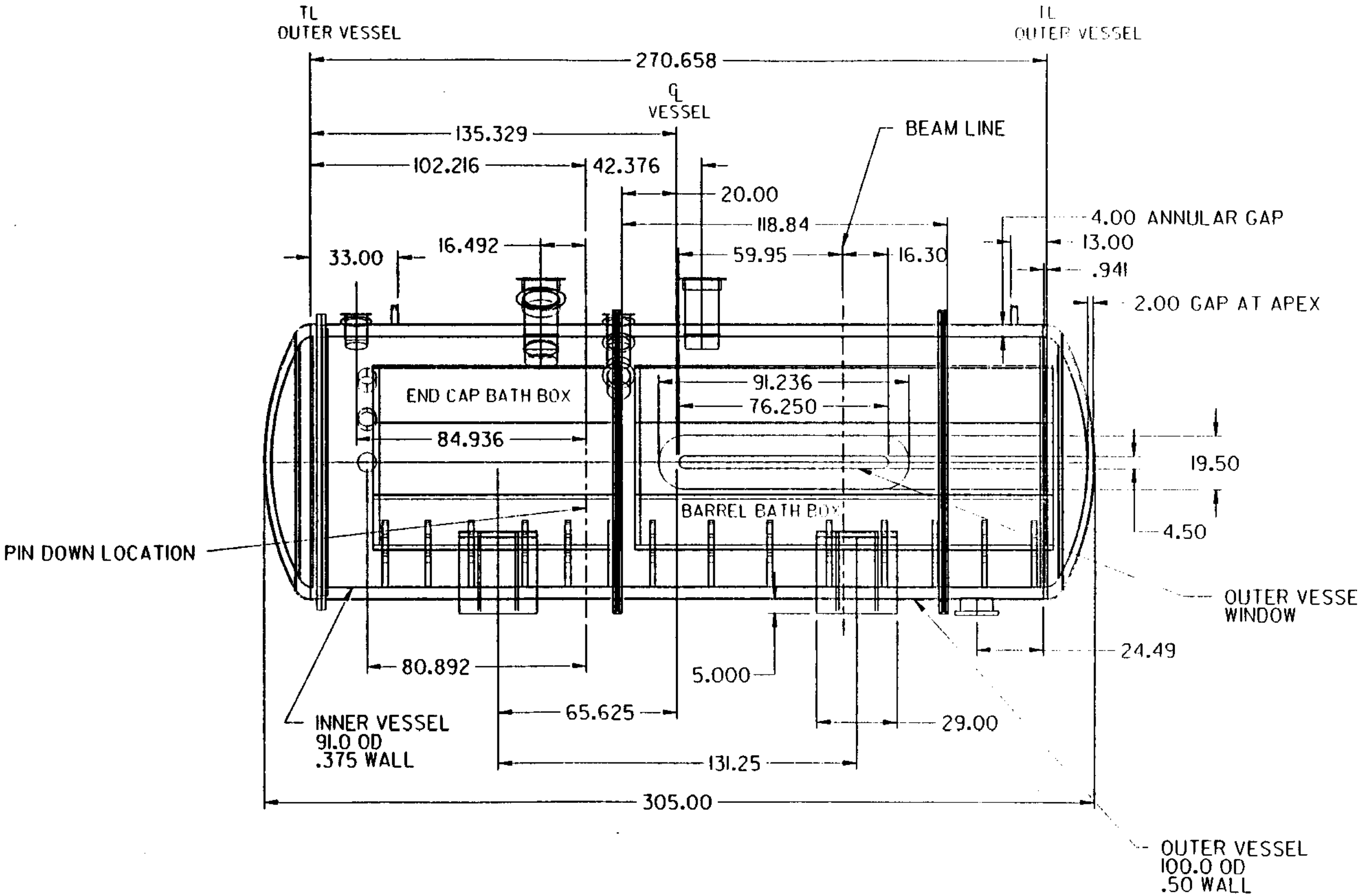
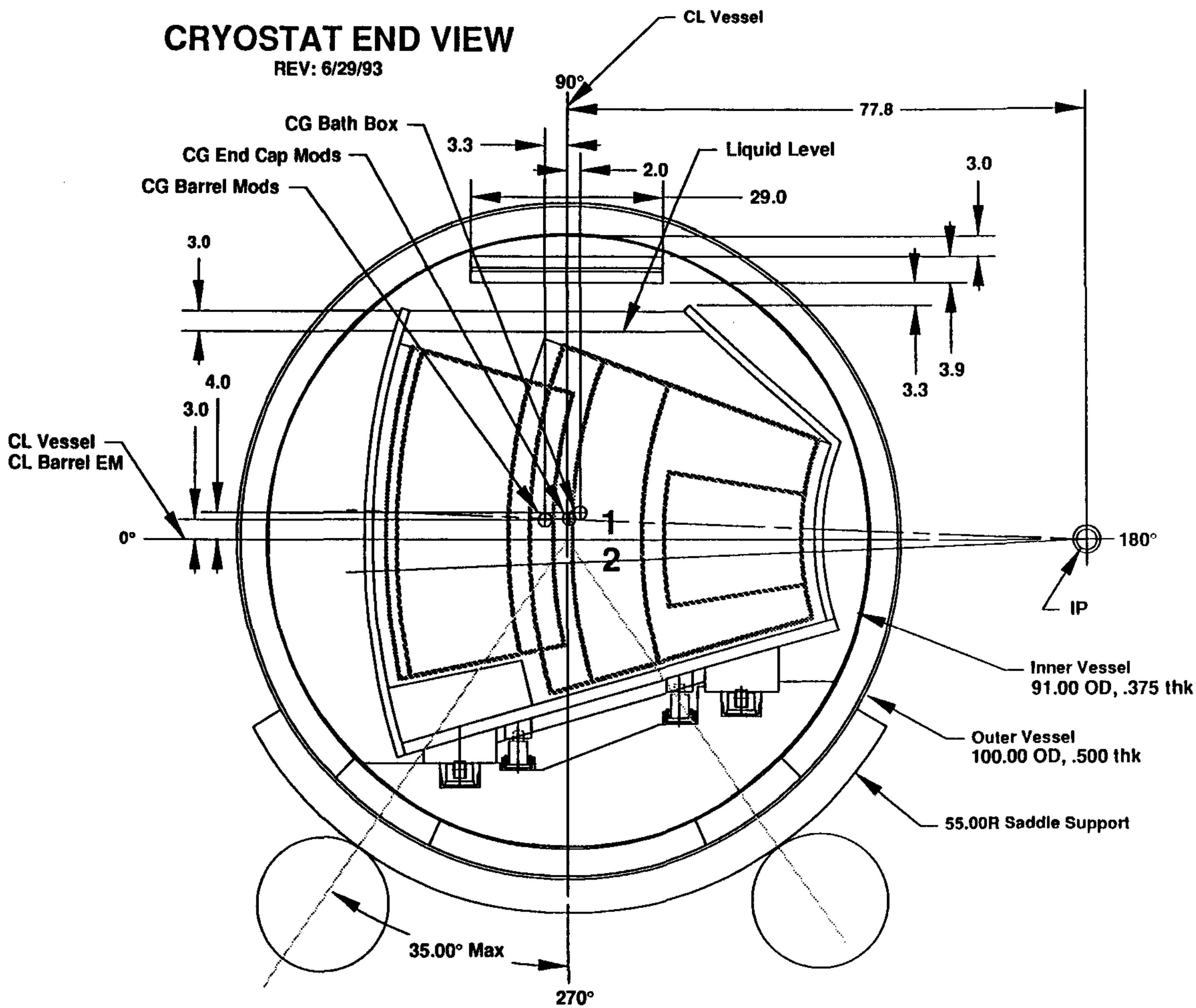
July 15, 1993


TL
OUTER VESSEL
TL
OUTER VESSEL
270.658
℄
VESSEL
135.329
BEAM LINE
102.216
42.376
20.00
118.84
4.00 ANNULAR GAP
13.00
16.492
33.00
59.95
16.30
.941
2.00 GAP AT APEX
END CAP BATH BOX
91.236
76.250
84.936
19.50
BARREL BATH BOX
4.50
PIN DOWN LOCATION
OUTER VESSEL
WINDOW
24.49
80.892
5.000
65.625
29.00
INNER VESSEL
91.0 OD
.375 WALL
131.25
305.00
OUTER VESSEL
100.0 OD
.50 WALL

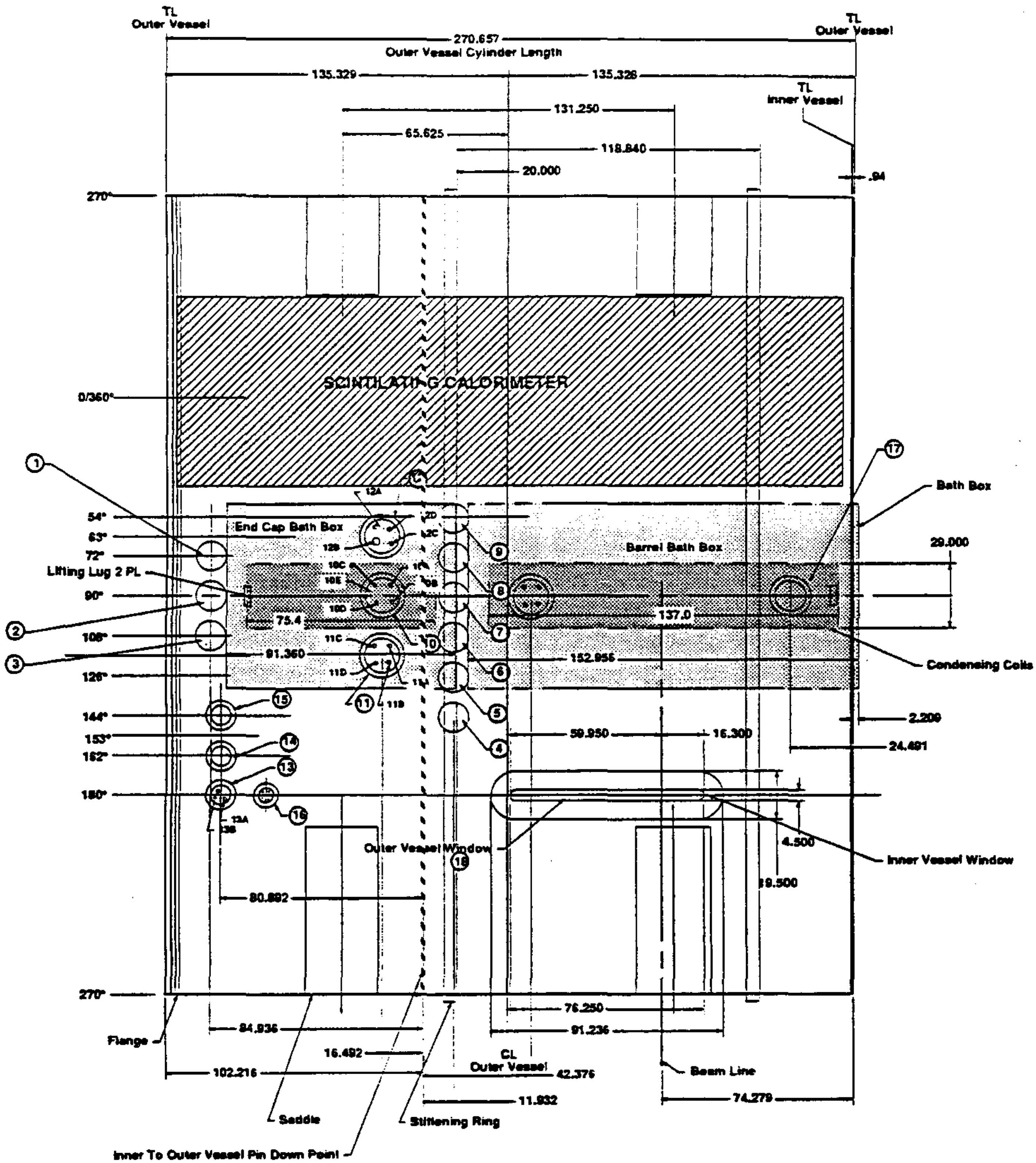
CRYOSTAT END VIEW

REV: 6/29/93



Cryostat Outer Vessel Unwrapped View
(Heads Not Shown; Head Depth = 17.17")

Rev: 7/8/93



Problems:
1. Stiffening Ring interferes with center ports
2. Signal feedthru ports are now 12.0" dia and old spacing (shown) probably will not work.

Notes
1. Axial thermal shrinkage at any point on inner vessel can be calculated by mutipling length from pin point by -.00454.
2. Inner vessel radial shrinkage is.41".

GEM TEST BEAM CRYOSTAT DESIGN STATUS
VESSEL PENETRATIONS/PORTS

- APPROXIMATELY 19 MAJOR PENETRATIONS IN CRYOSTAT
  - 15 Penetrate Through Both Vessels — Require Bellows
  - 3 Penetrate Through Outer Vessel Only (Press Relief, Vacuum Pump-out, Window)
  - 1 Penetrates Through Inner Vessel Only (Window)
- MODULE SIGNAL, DC, AND HV FEEDTHRUS
  - Nine Total 11.75 Dia — Six for Barrel, Three for End Cap
  - GEM Feedthru Adapted to Test Cryostat
  - Ports Require Separate Vacuum Pump-out
  - Preliminary Design Complete
- CRYOGENIC PORTS
  - Five Allocated — 18.0 Dia
  - Design in process — Cryogenics Group Responsible
- VACUUM PUMP-OUT PORTS
  - Two Total — One for Annular Vacuum, One for Internal Vessel Vacuum
  - Vacuum Group Currently Defining Tube/Flange Sizes
- OTHER
  - HV feedthru For Strip Heaters — No Design Effort Yet
  - Outer Vessel Window 4.5" Ht X 76.25" Lg; Frame 3.5" Thk X 7.5" Wd
  - Inner Vessel Window 5.0" Ht X 88.38" Lg; Frame 3.0" Thk X 5.0" Wd

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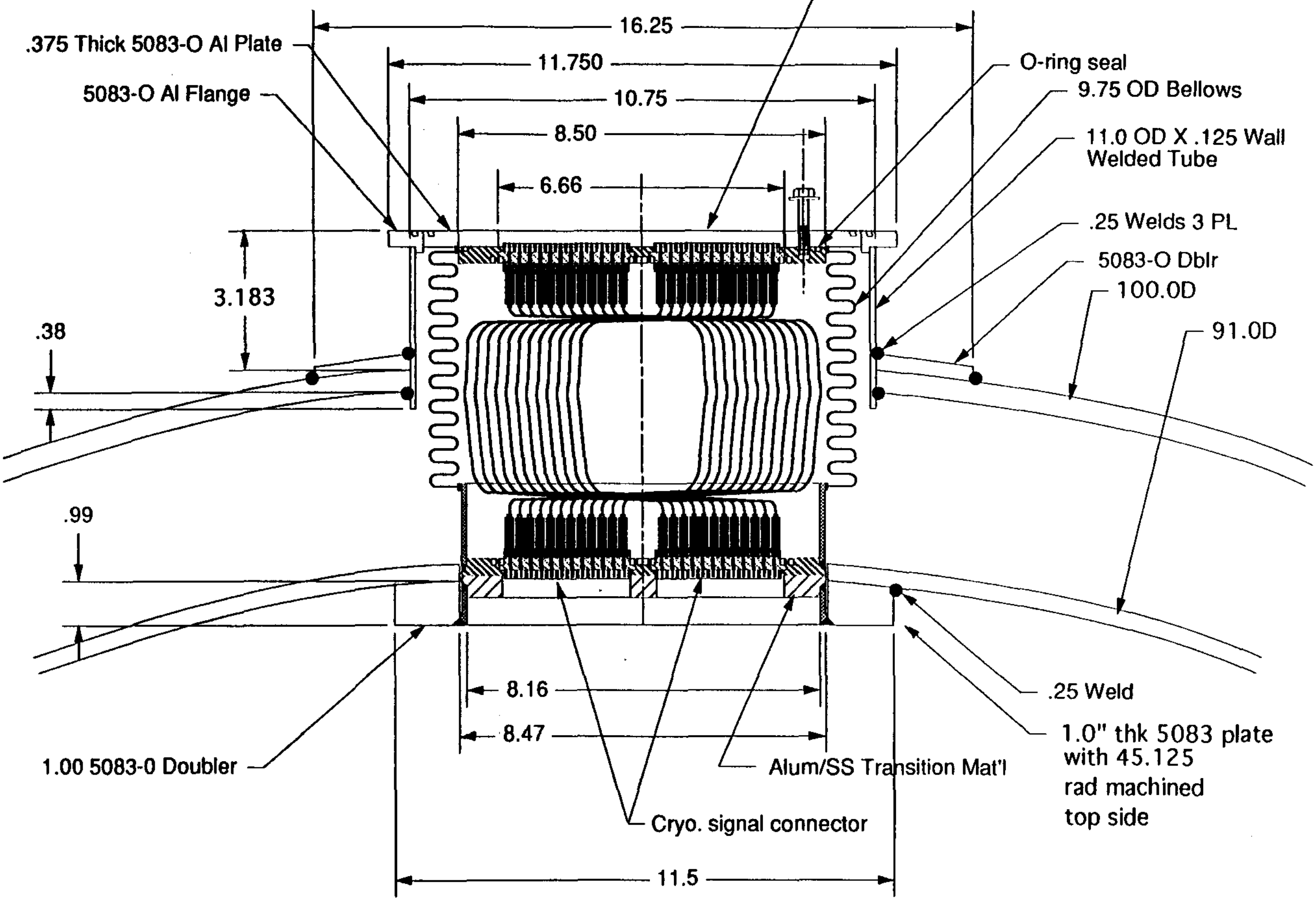
July 15, 1993

GEM Signal feedthru
Adapted forTest Beam Cryostate



N.Hall 7/14/93

GEM TEST BEAM CRYOSTAT DESIGN STATUS
LOAD SUMMARY

Component	Weight, Lbs
Inner Vessel	3291
Outer Vessel	4924
Flanges	1100
Windows	958
Ports	1275
Stiffeners	203
Support Ribs	2030
G-10 Pads	840
Support Saddles	1407
Modules, Dry Weight	104917
Bath Box	16571
Excluders	31668
Cryogenic/Electrical	8000
LKr	29634
Total	206819

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July 15, 1993

GEM TEST BEAM CRYOSTAT DESIGN STATUS
LOAD TRANSFER STRUCTURE

- INNER VESSEL
  - Fourteen 2" Ribs Support Bath Boxes in Inner Vessel
  - Eight Ribs Under Barrel, Six Ribs Under End Cap
  - Bath box Load Transferred In Bending Through Vessel - Minimal Stress
  - Inner Vessel Supported On Four G-10 Pads Located In Annular Gap
- OUTER VESSEL
  - Outer Vessel Supported on Two 120° Saddles Located on OD of Outer Vessel Directly Below G-10 Pads
  - Load Transferred From Inner Vessel Through G-10 Pads to Saddle to Transporter
    - √ Outer Vessel Sees Only Local Stresses Around G-10 Pads

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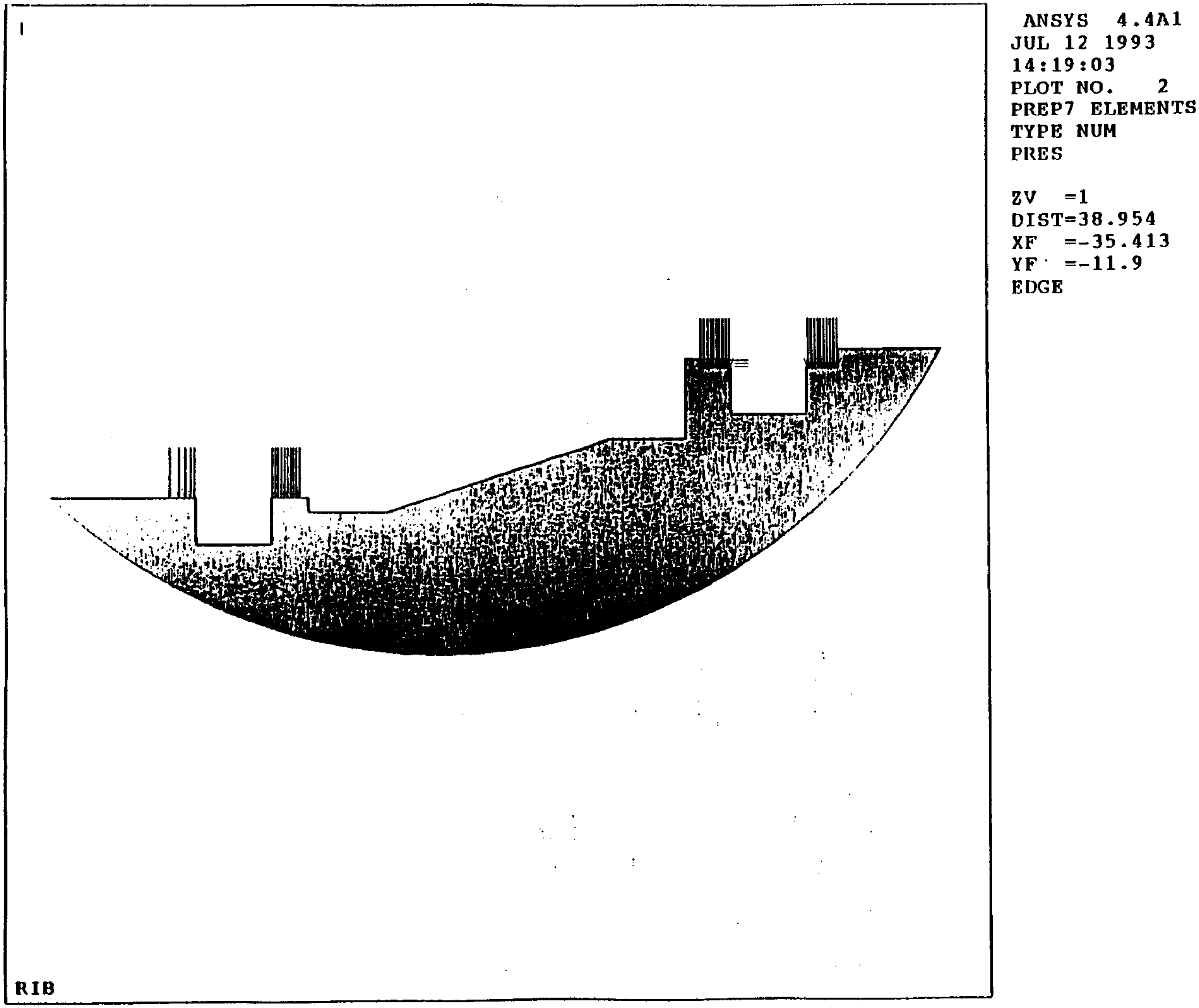
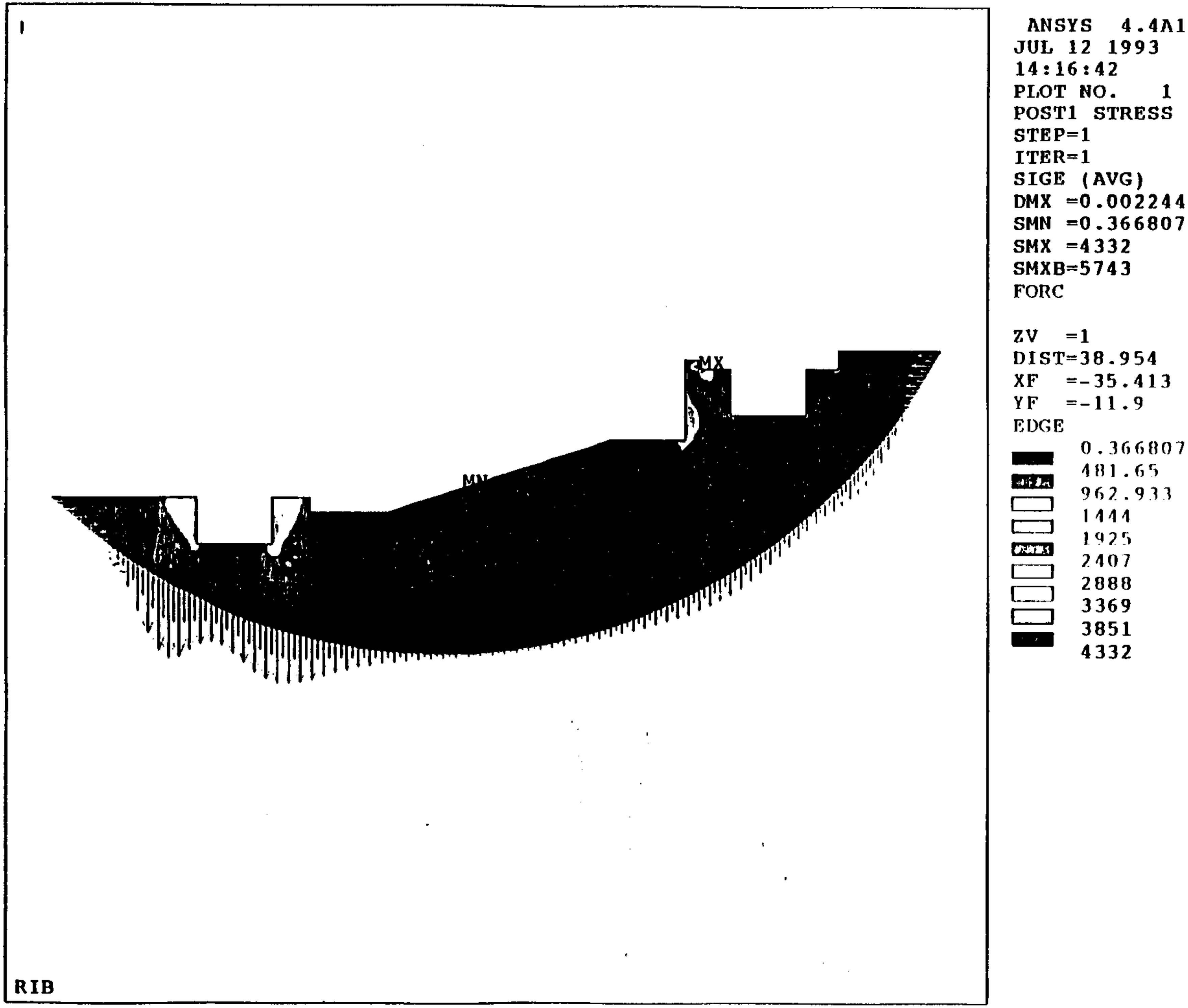
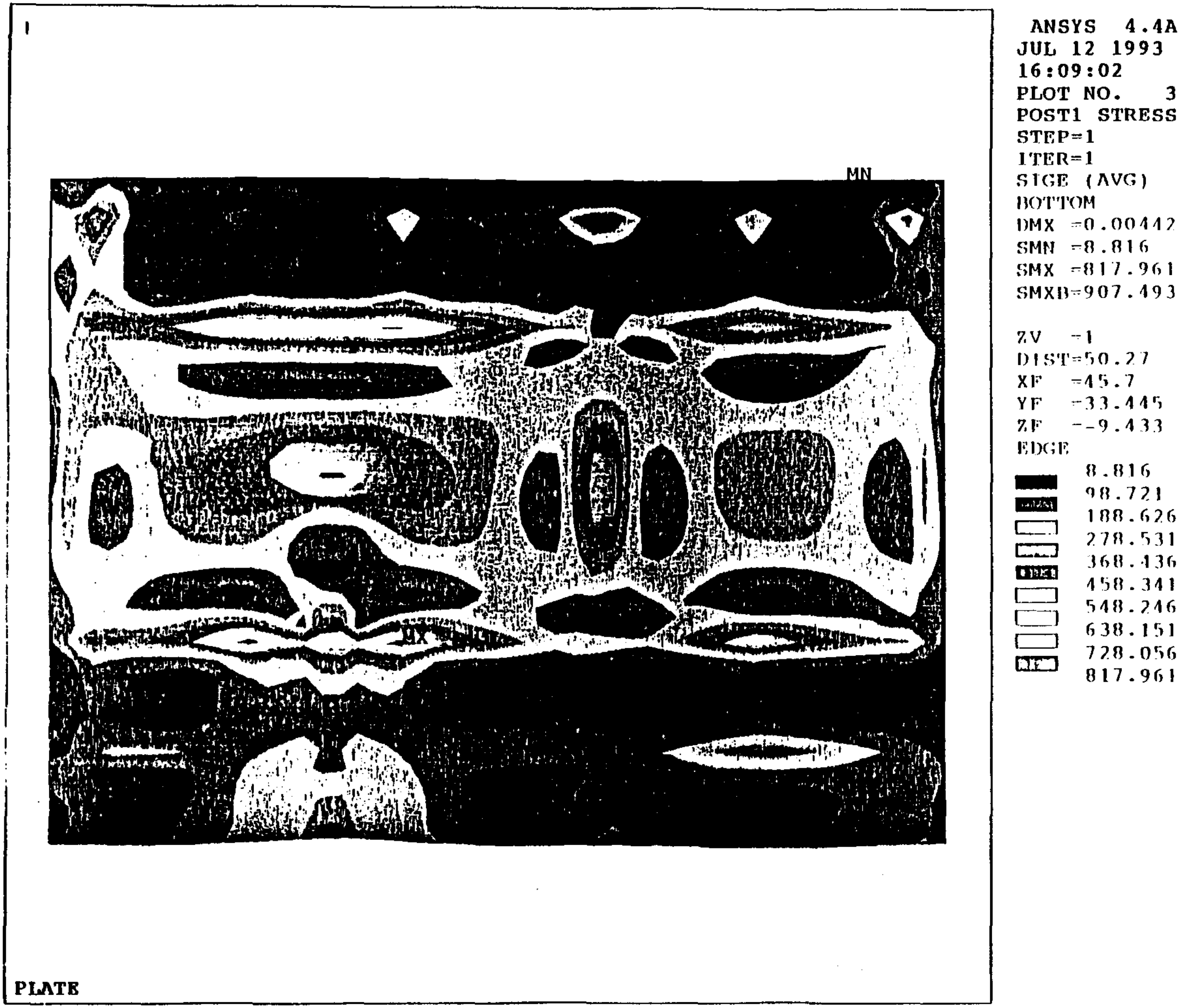
July 16, 1993


ANSYS 4.4A1
JUL 12 1993
14:19:03
PLOT NO. 2
PREP7 ELEMENTS
TYPE NUM
PRES
ZV =1
DIST=38.954
XF =-35.413
YF =-11.9
EDGE
1
RIB

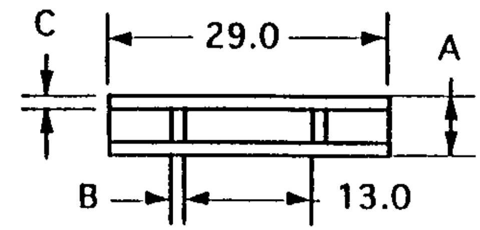

ANSYS 4.4A1
JUL 12 1993
14:16:42
PLOT NO. 1
POST1 STRESS
STEP=1
ITER=1
SIGE (AVG)
DMX =0.002244
SMN =0.366807
SMX =4332
SMXB=5743
FORC
ZV =1
DIST=38.954
XF =-35.413
YF =-11.9
EDGE
0.366807
481.65
962.933
1444
1925
2407
2888
3369
3851
4332
MX
MN
RIB


ANSYS 4.4A1
JUL 12 1993
16:09:02
PLOT NO. 3
POST1 STRESS
STEP=1
ITER=1
SIGE (AVG)
BOTTOM
DMX =0.004427
SMN =8.816
SMX =817.961
SMXB=907.493
ZV =1
DIST=50.27
XF =45.7
YF =33.445
ZF =-9.433
EDGE
8.816
98.721
188.626
278.531
368.436
458.341
548.246
638.151
728.056
817.961
MN
MX
PLATE

GEM TEST BEAM CRYOSTAT
SADDLE ANALYSIS

- **SIMPLIFIED ANALYSIS COMPLETED**

Dimension	Case 1	Case 2	Case 3
A , in	6	5	4
B , in	0.875	1	N.A.
C , in	0.875	1	N.A.
Inertia, in^4	400	303	220
Stress, psi	7400	8000	9000



Beam X-section

- **SADDLE MATERIAL IS ALUMINUM 5083-O – ALLOWABLE STRESS 10 KSI**
- **FACTORS NOT CONSIDERED IN ANALYSIS:**
  - **LOCAL DEFORMATION OF BEAM AT ROLLERS**
  - **EFFECT OF DEFORMATION OF ROLLERS ON REACTION FORCES**
  - **INNER VESSEL AND SUPPORT STRUCTURE CONSIDERED RIGID**

Neil Hall, SSCL - (214)708-6180
June 16, 1993

GEM TEST BEAM CRYOSTAT
LOADING STAND/INSERTION OF MODULES

- PRELIMINARY SIZE IS 12' WD X 30' LG X 8' HT
- ELEVATES BATH BOX TO LEVEL OF CRYOSTAT
- PROVIDES 3 FOOT WIDE WALKWAY AROUND BATH BOX
- MAY BE MOUNTED ON RAILS
- SIX FOOT LONG REMOVABLE BRIDGE TO BE INSTALLED BETWEEN LOADING STAND AND VESSEL
  - NECESSARY TO SPAN OVER CABLE TRAY
- ROLLER/JACK ASSEMBLY USED TO TRANSFER BATH BOX FROM LOADING STAND TO SUPPORT STRUCTURE ON INSIDE OF VESSEL

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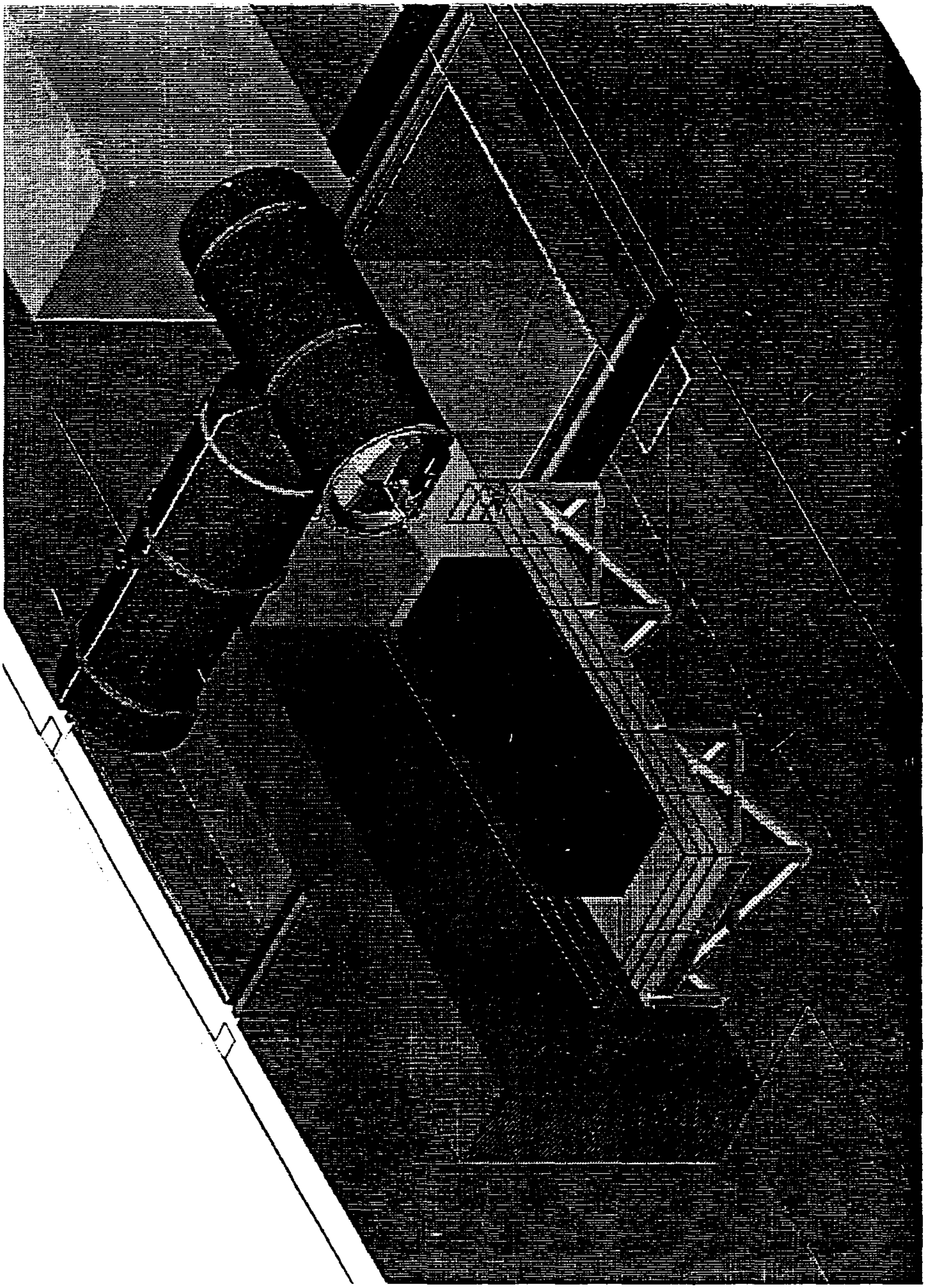
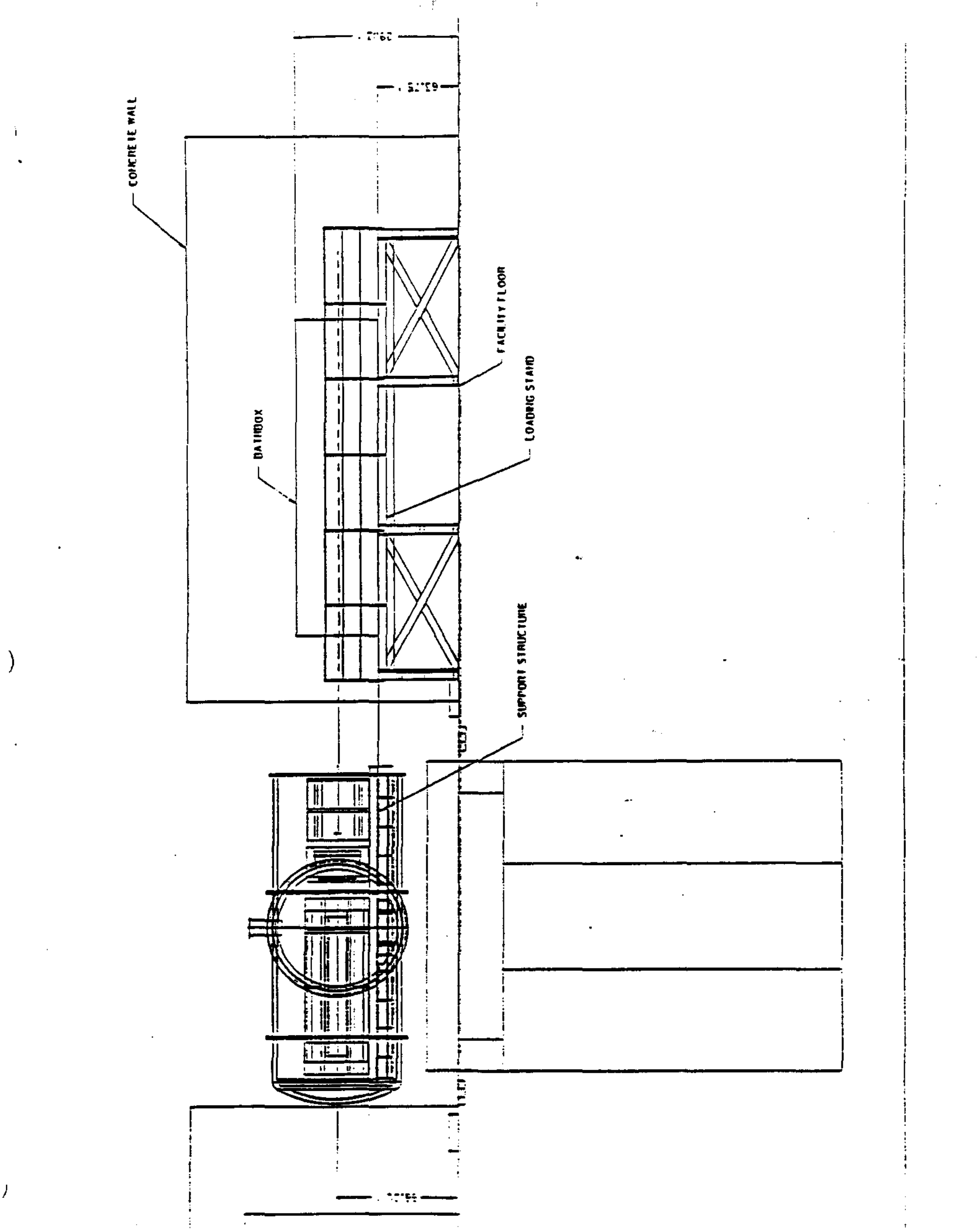
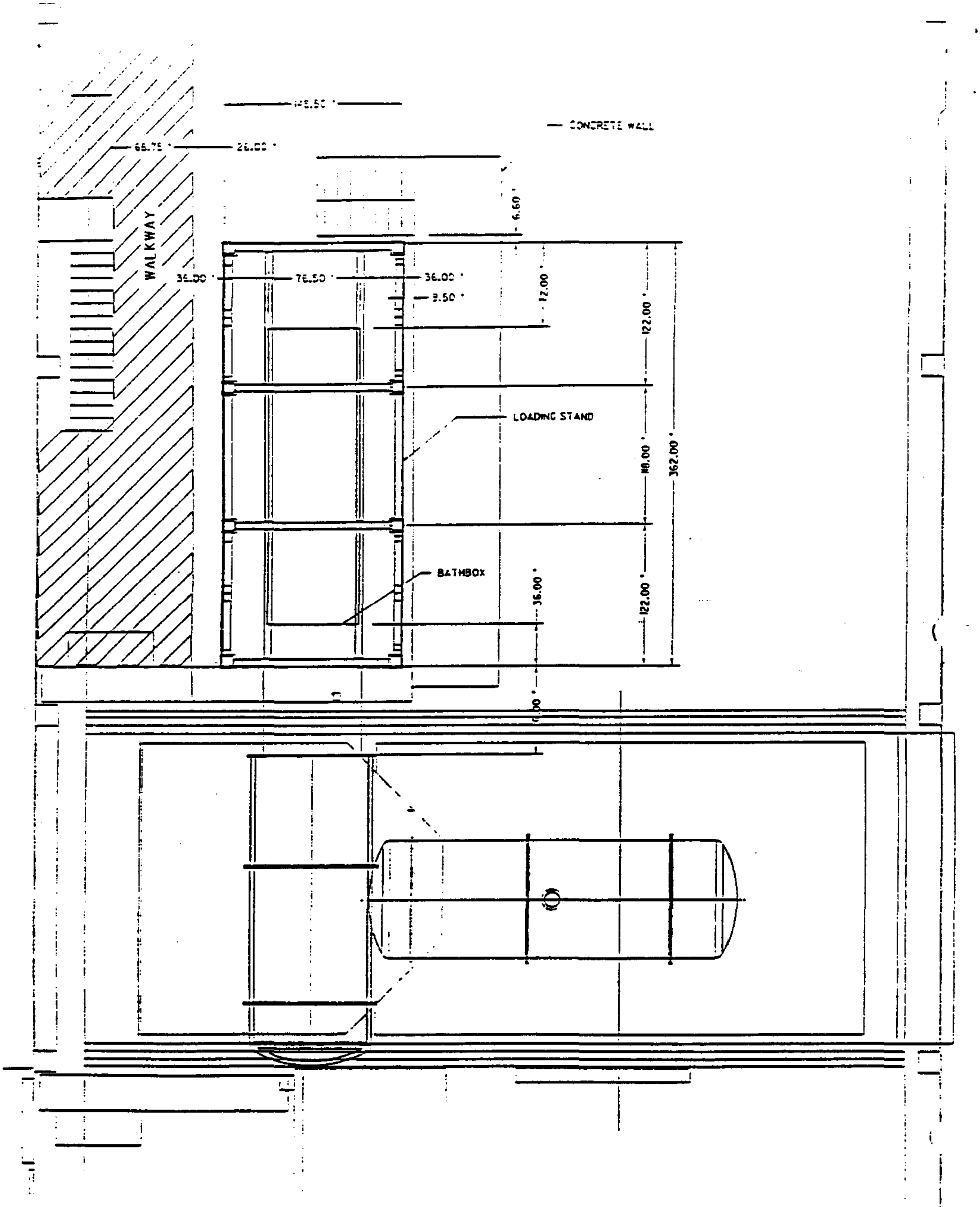
July 15, 1993




CONCRETE WALL
FACILITY FLOOR
LOADING STAND
SUPPORT STRUCTURE


CONCRETE WALL
WALKWAY
66.75 "
26.00 "
6.60 "
36.00 "
76.50 "
36.00 "
122.00 "
LOADING STAND
362.00 "
BATHBOX
36.00 "
122.00 "

GEM TEST BEAM AT FERMI LABS

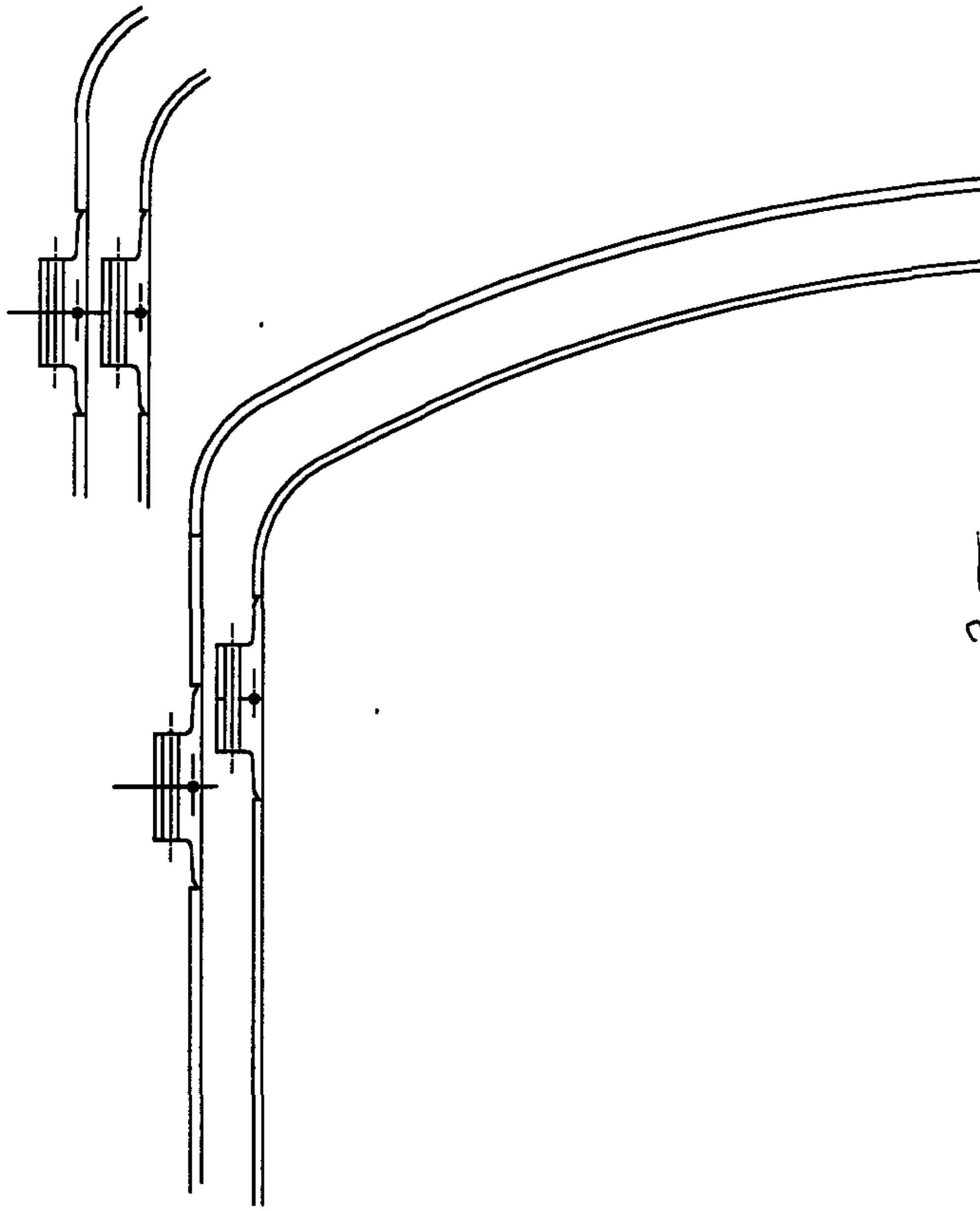
1. CRYOSTAT FLANGE
   DESIGN & ANALYSIS

2. FERMI LAB CRYOGENICS

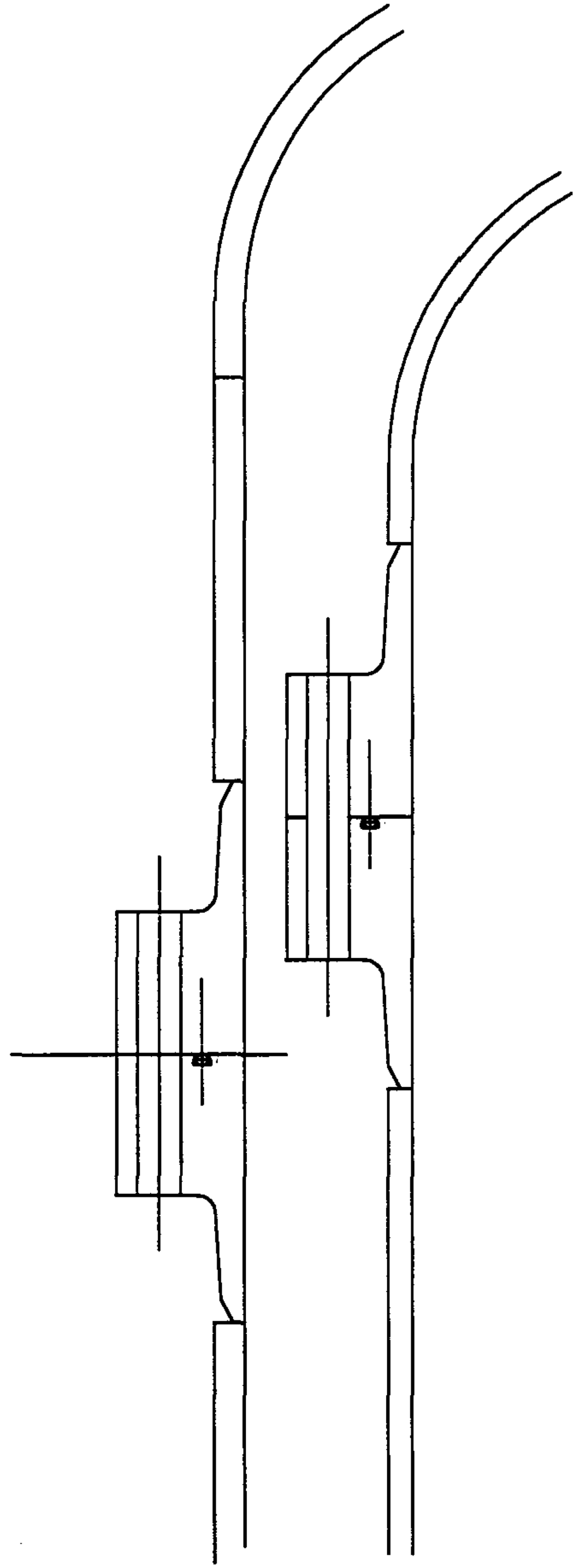
3. INNER VESSEL SUPPORT
   DESIGN CONCEPT

4. REPORTS REQUIRED

R.G. Smith
7-16-93



-2-



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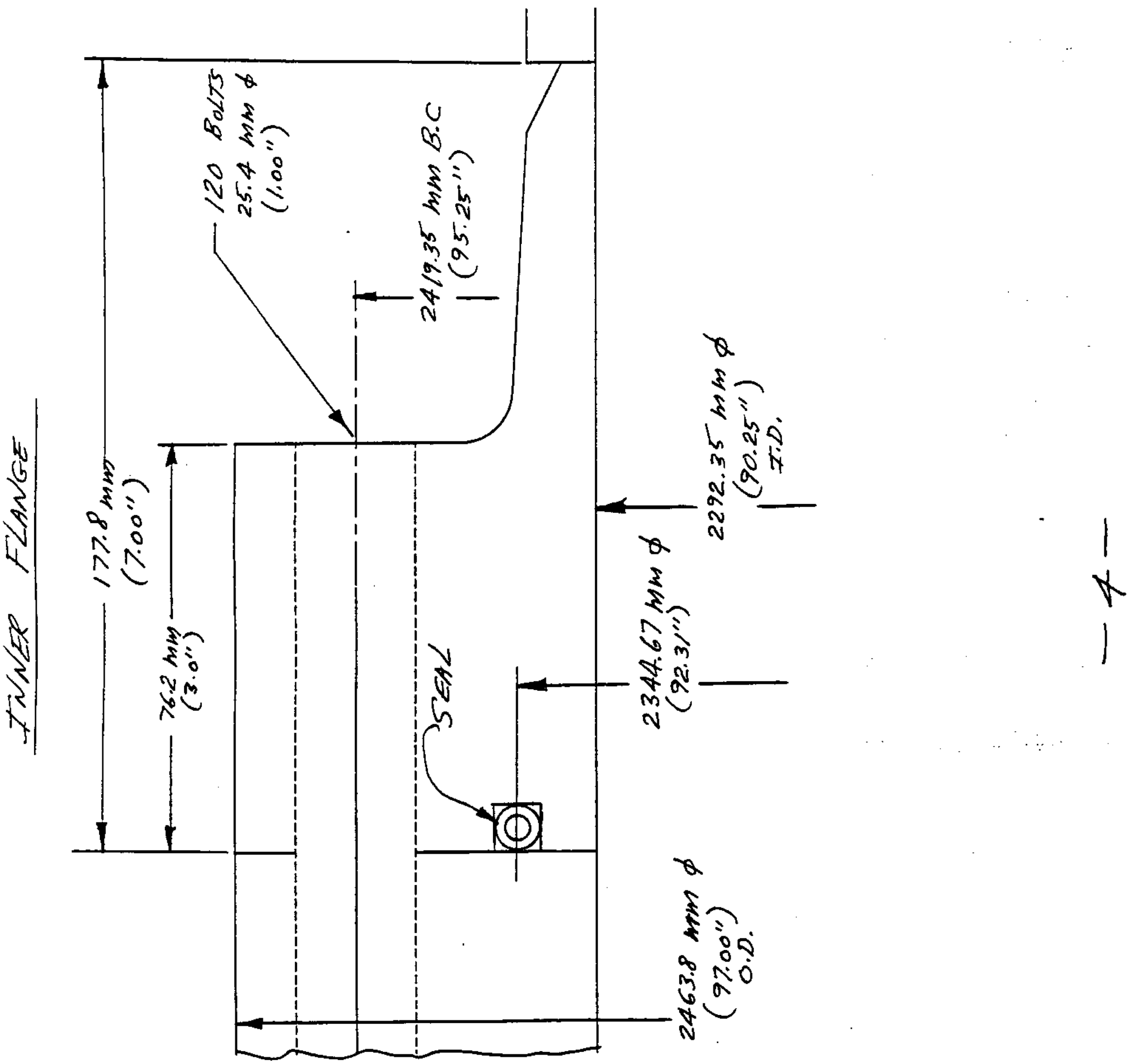
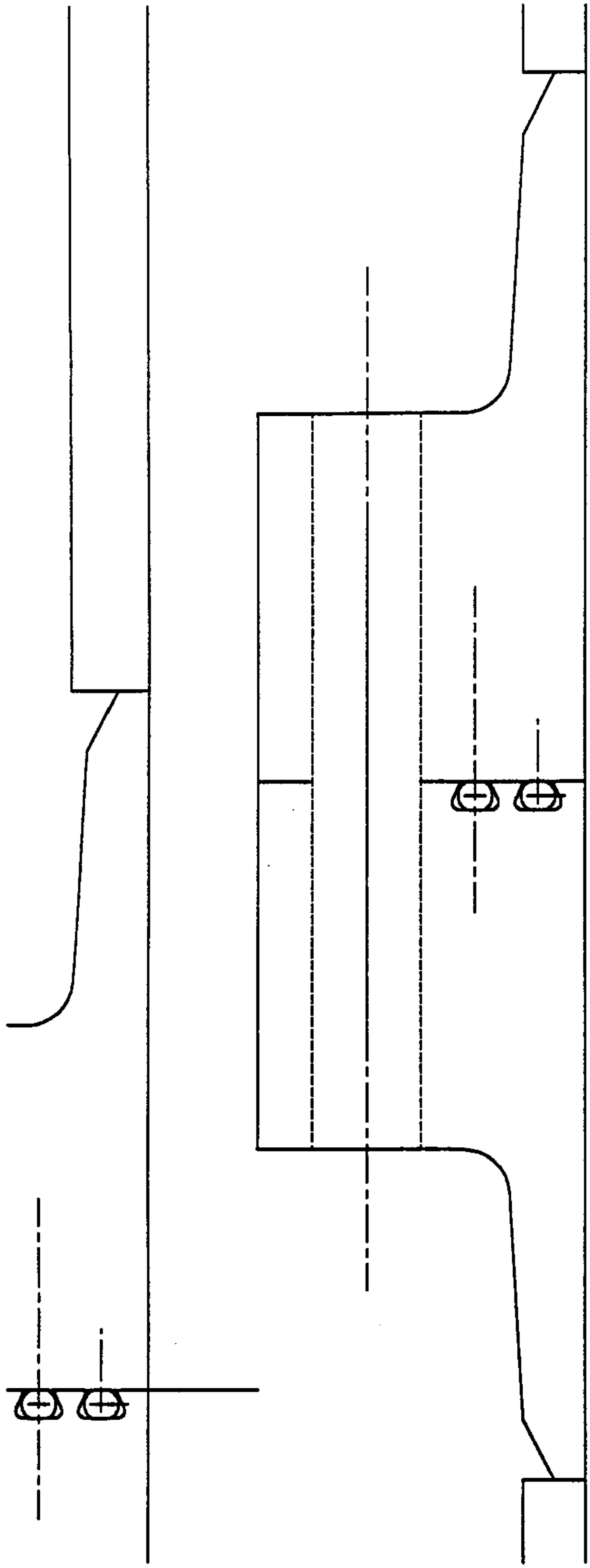

INNER FLANGE
177.8 mm
(7.00")
76.2 mm
(3.0")
120 BOLTS
25.4 mm ϕ
(1.00")
2419.35 mm B.C
(95.25")
SEAL
2344.67 mm ϕ
(92.31")
2292.35 mm ϕ
(90.25")
I.D.
2463.8 mm ϕ
(97.00")
O.D.
A



-5-

CRYOSTAT SEAL

"CERN DESIGN"

HELICOFLEX △

Technical data

Dimensions : Ø 10 to Ø 000 mm

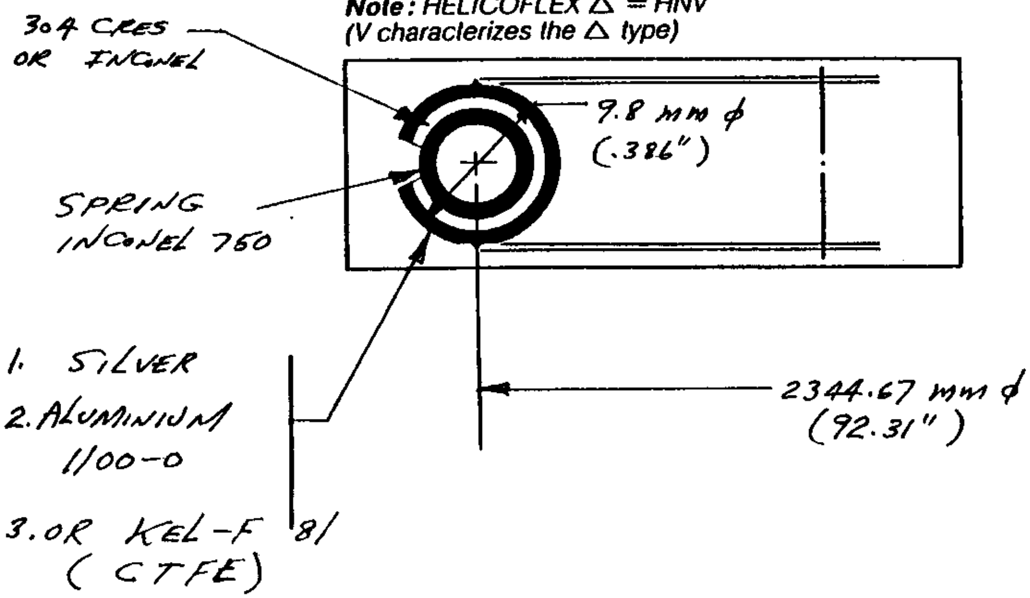
Temperature : - 272 to 520 °C (ductile linings)

- 272 jto 700 °C (non-ductile linings)

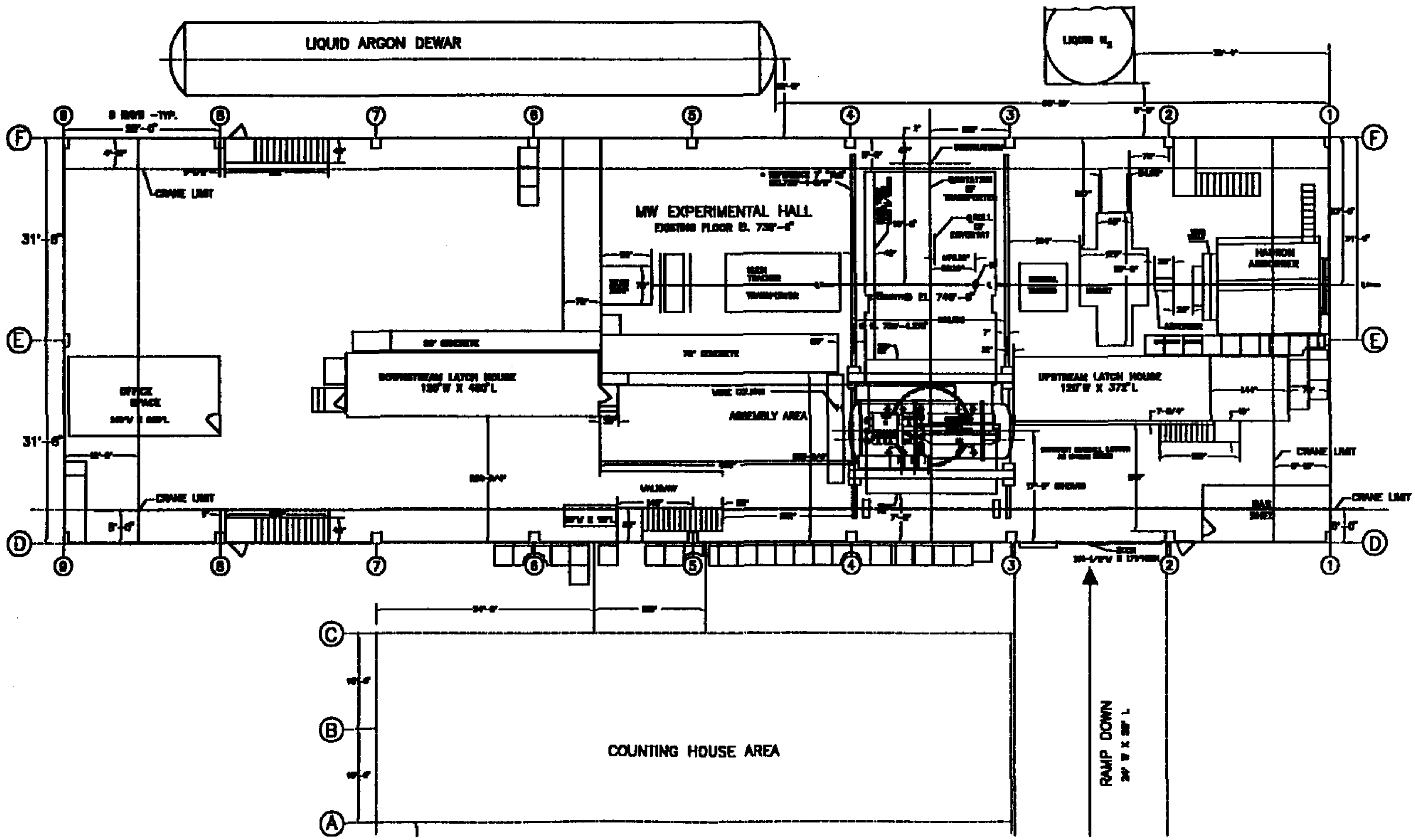
Helium sealing level : Q ≦ 10^{-11} atm cm^3 S^{-1}

***Note :** HELICOFLEX △ = HNV*

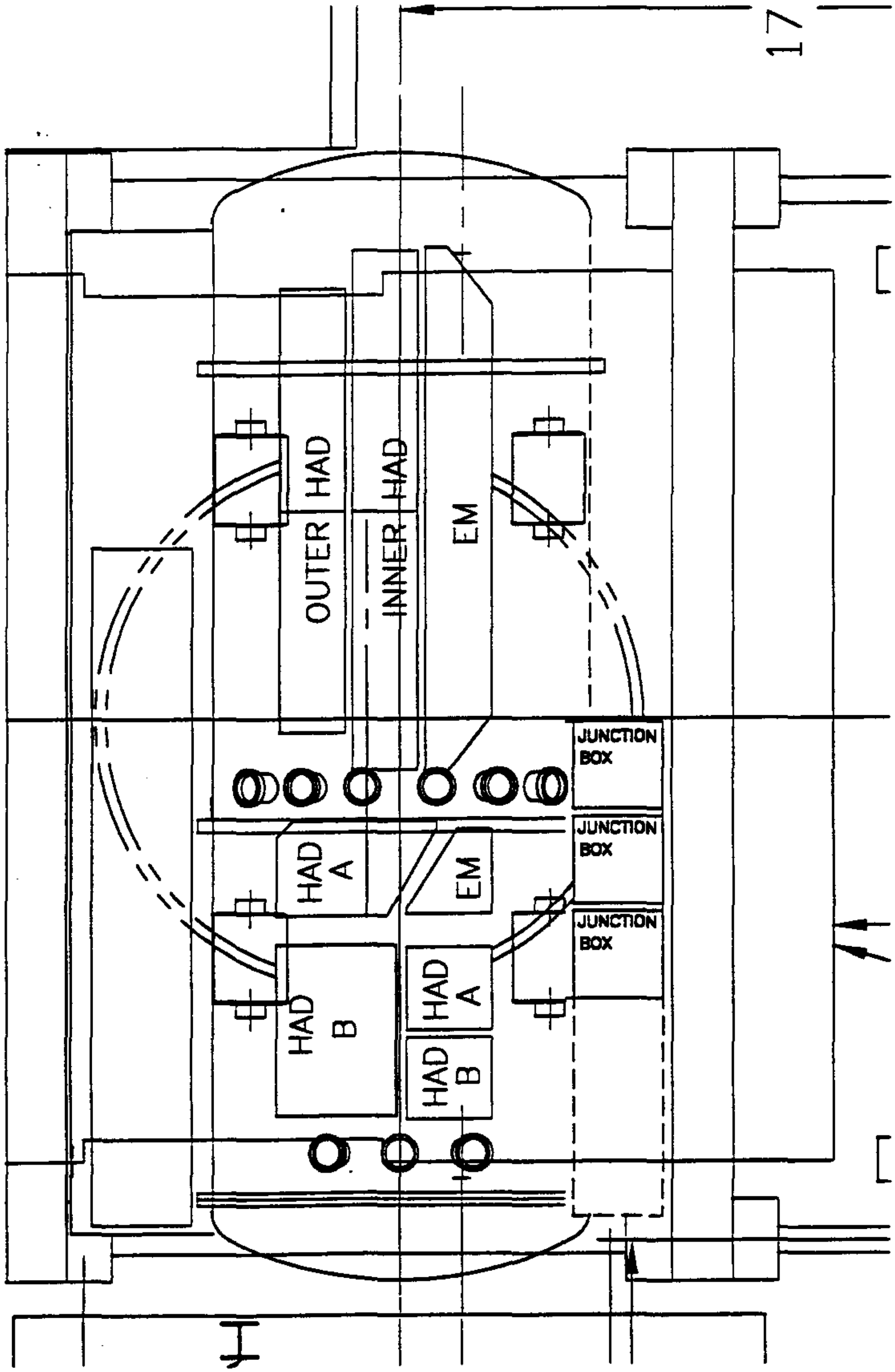
(V characterizes the △ type)



FERMI LAB - MWEST LAYOUT



-6-


17
OUTER HAD
INNER HAD
EM
JUNCTION BOX
JUNCTION BOX
JUNCTION BOX
HAD A
EM
HAD B
HAD A
HAD B

– 7 –

FORMAL ENGINEERING REPORTS NEEDED FOR GEM TEST BEAM PROGRAM CRYOSTAT ASSEMBLY AND FACILITIES CRYOGENIC SYSTEM AT FERMI LAB

<u>CRYOSTAT ASSEMBLY</u>

TEST PROCEDURES

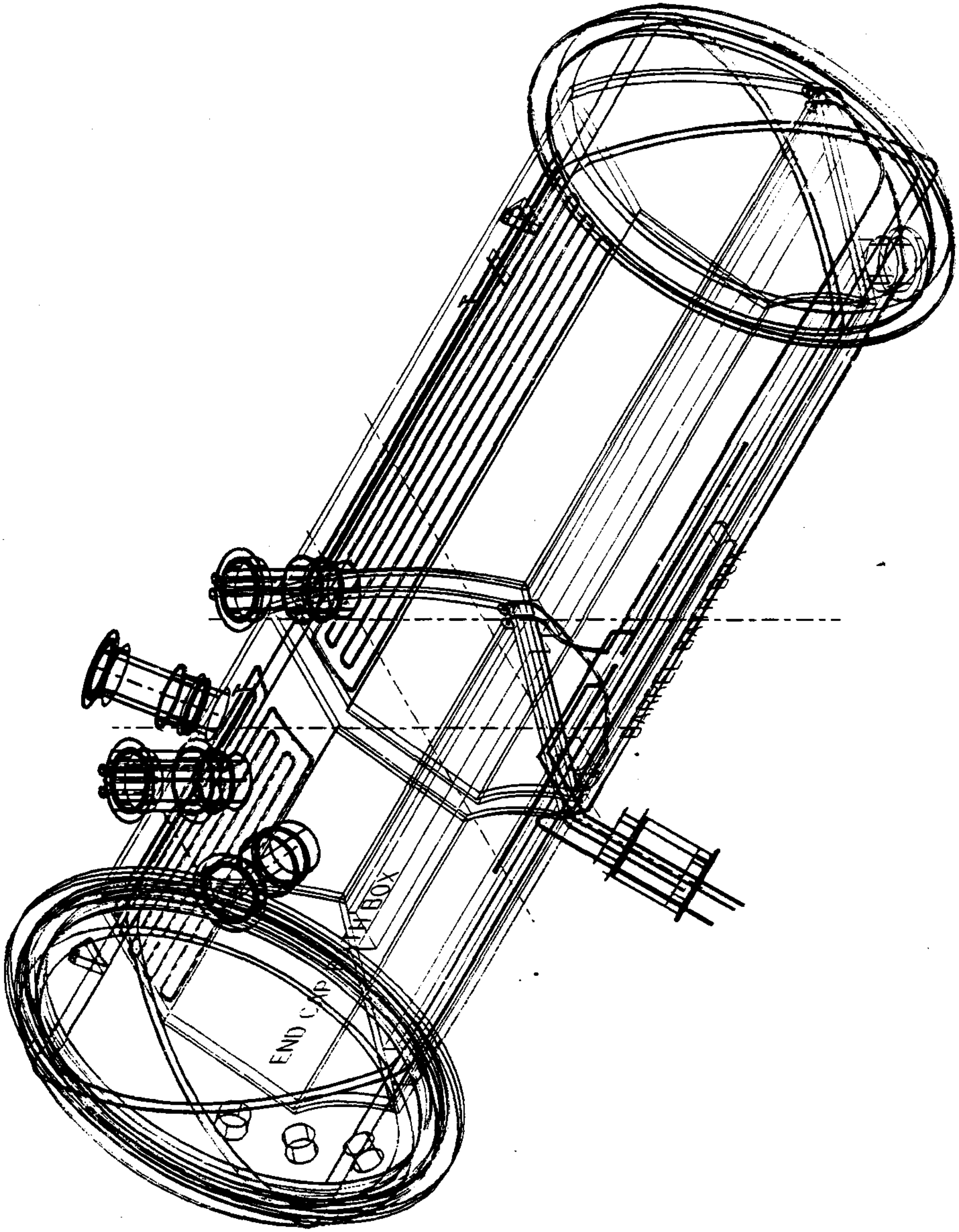
1. STRUCTURAL ANALYSIS REPORT
2. HEAT TRANSFER ANALYSIS REPORT
3. VACUUM SYSTEM ANALYSIS REPORT
4. HELIUM LEAKAGE SPECIFICATION
5. SHIPPING AND HANDLING ANALYSIS REPORT
6. LIQUID AND GAS FLOW (PRESSURE DROP) ANALYSIS REPORT
7. ASME WELDING SPECIFICATION
8. INNER AND OUTER FLANGE BOLT TORQUE (PRELOAD) ANALYSIS

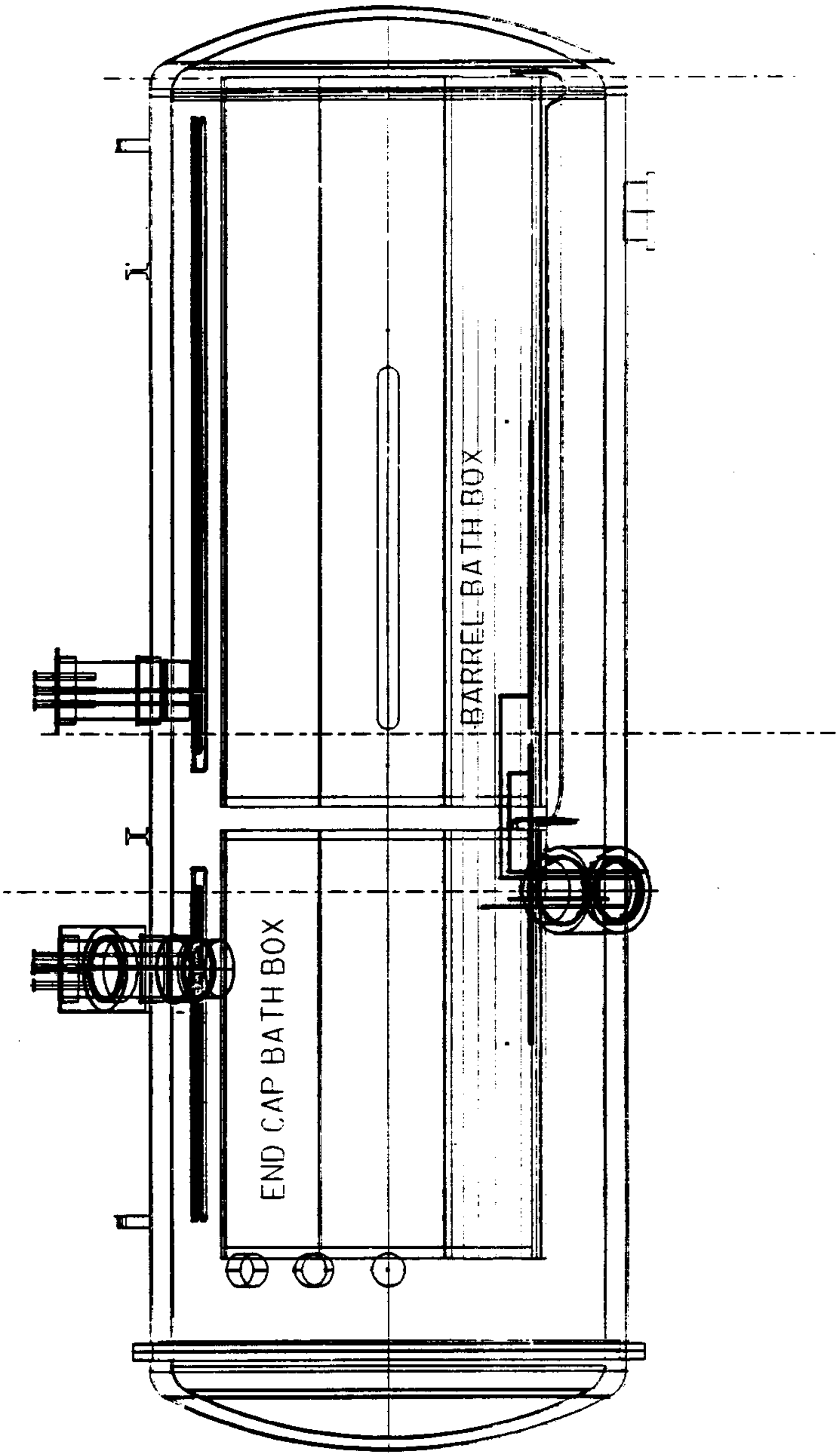
<u>CRYOGENIC FACILITIES AT FERMI LAB</u>

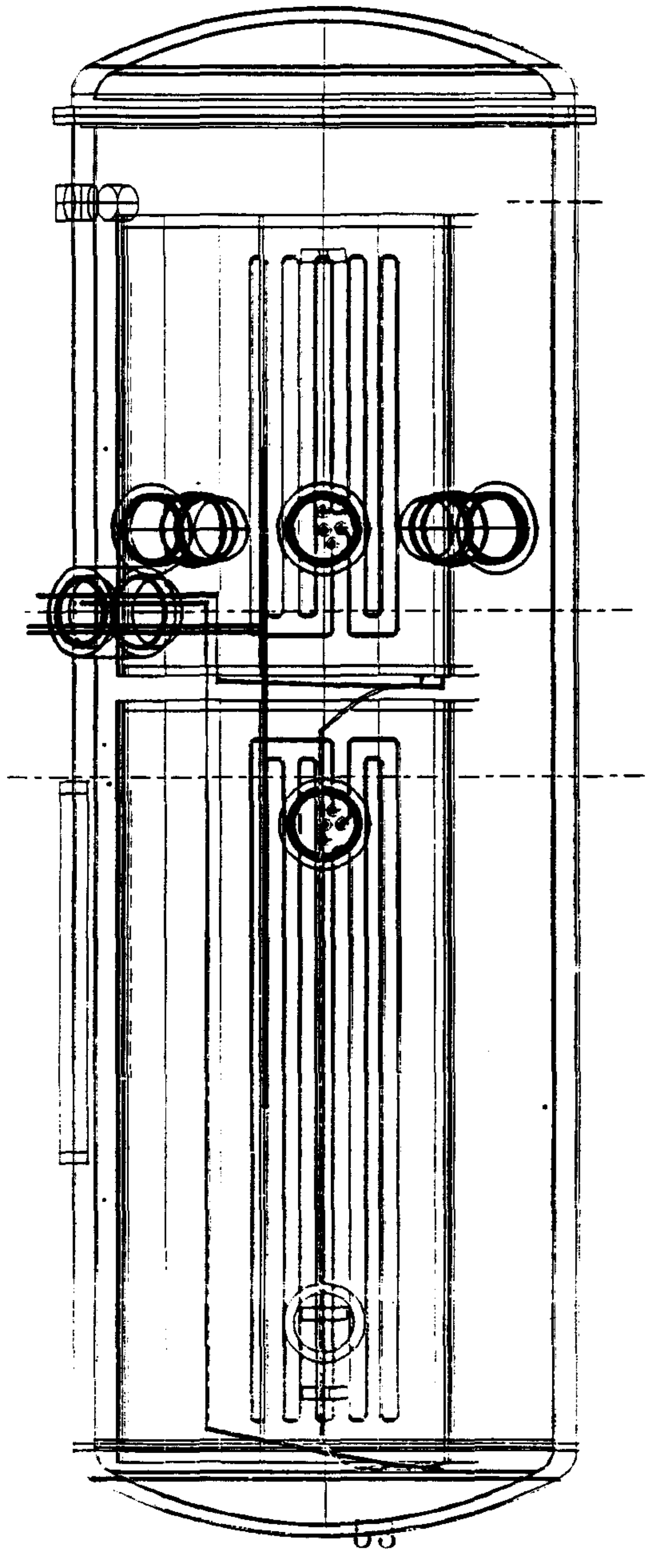
TEST PROCEDURES

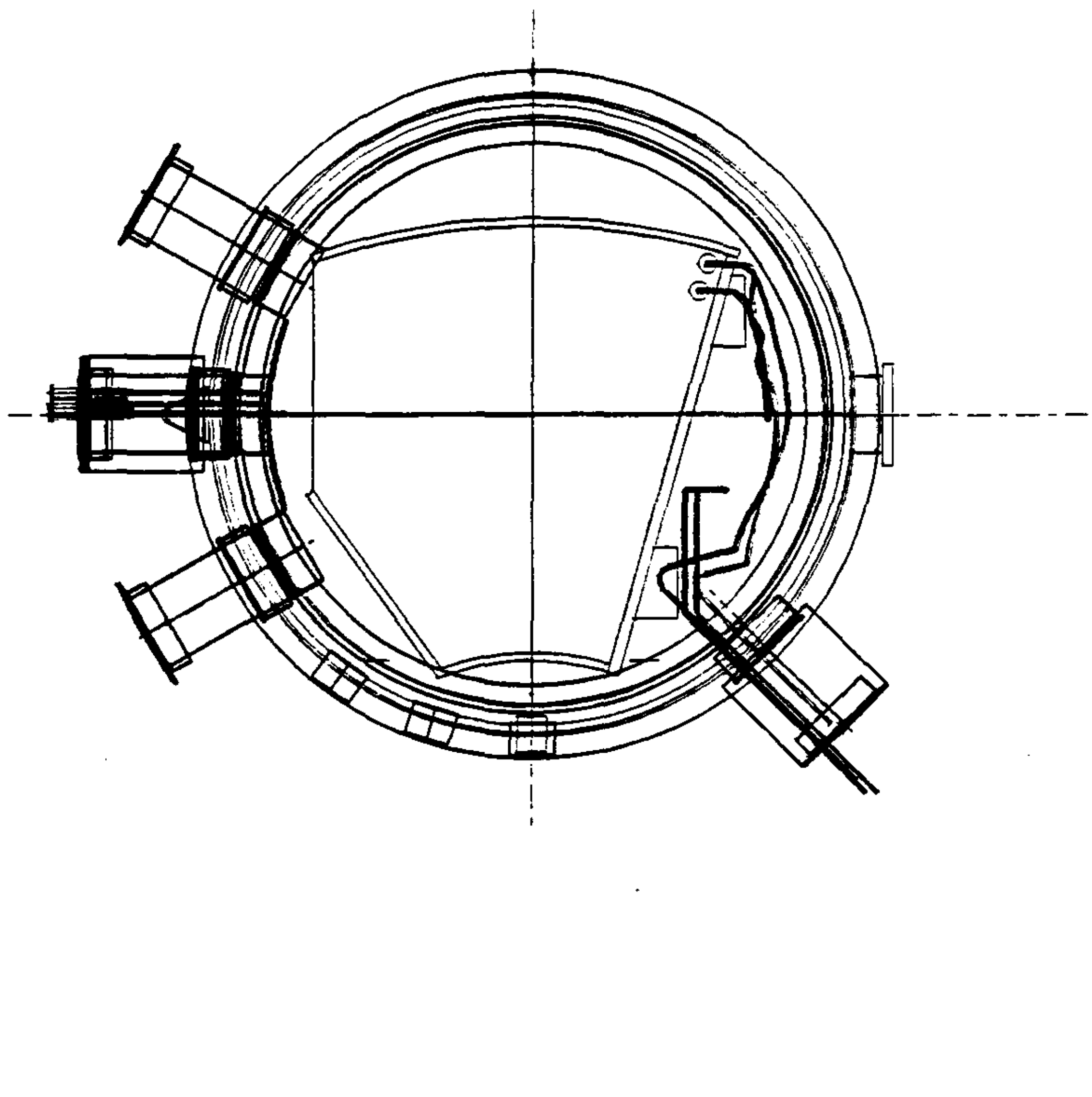
1. STRUCTURAL ANALYSIS REPORT
2. HEAT TRANSFER ANALYSIS REPORT
3. VACUUM SYSTEM ANALYSIS REPORT
4. HELIUM LEAKAGE SPECIFICATION
5. LIQUID AND GAS FLOW (PRESSURE DROP) ANALYSIS REPORT
6. ASME WELDING SPECIFICATION

gem


END C
H BOX


BARREL BATH BOX
END CAP BATH BOX



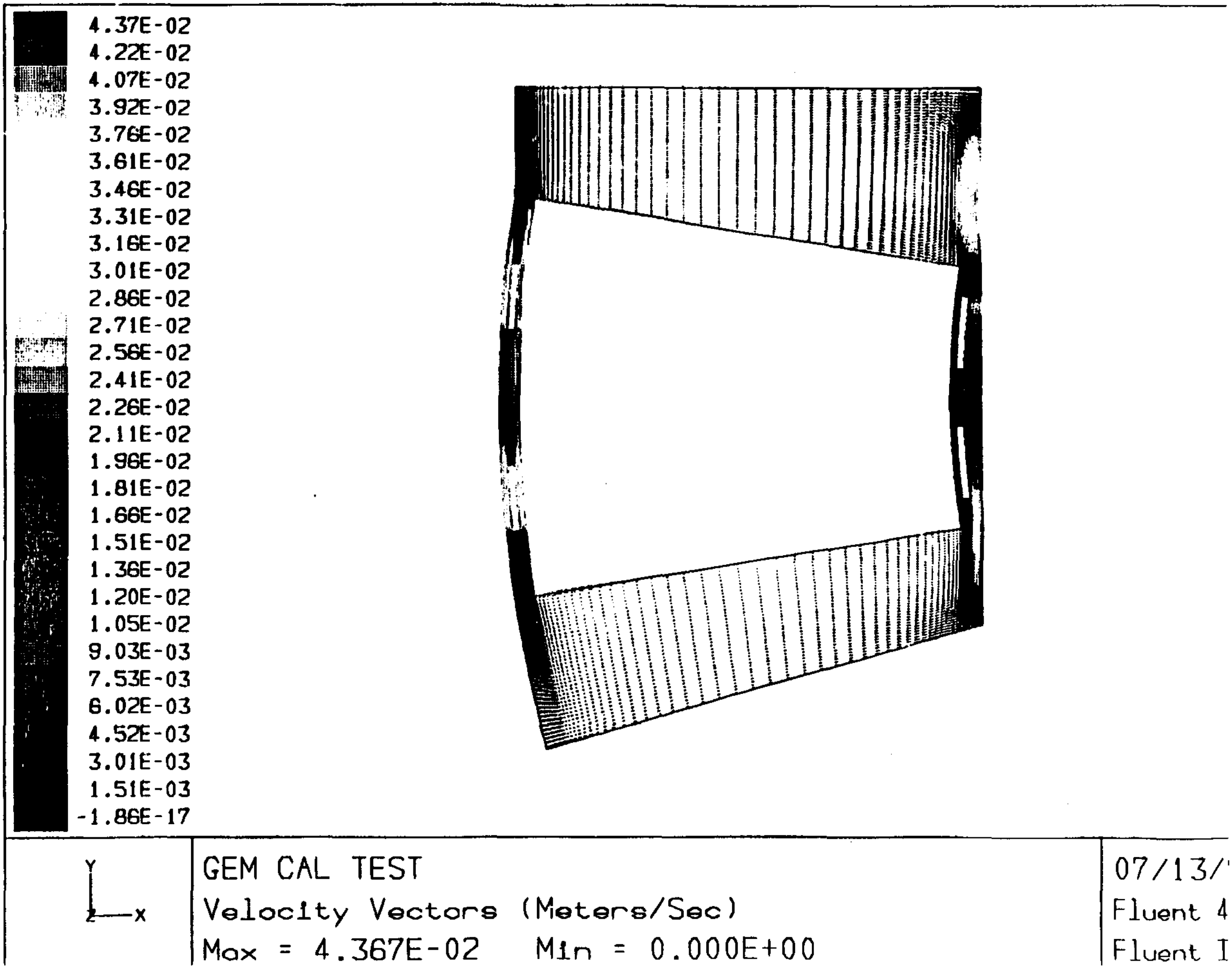


Purification System

Baseline: Oxysorb™ and catalytic getter, gas phase

Potential Improvements:

- molecular sieve, liquid phase
- electron capture, liquid phase
- Oxysorb™, liquid phase
- copper reduction, gas phase
- distillation, vapor phase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4.22E-02
4.07E-02
3.92E-02
3.76E-02
3.61E-02
3.46E-02
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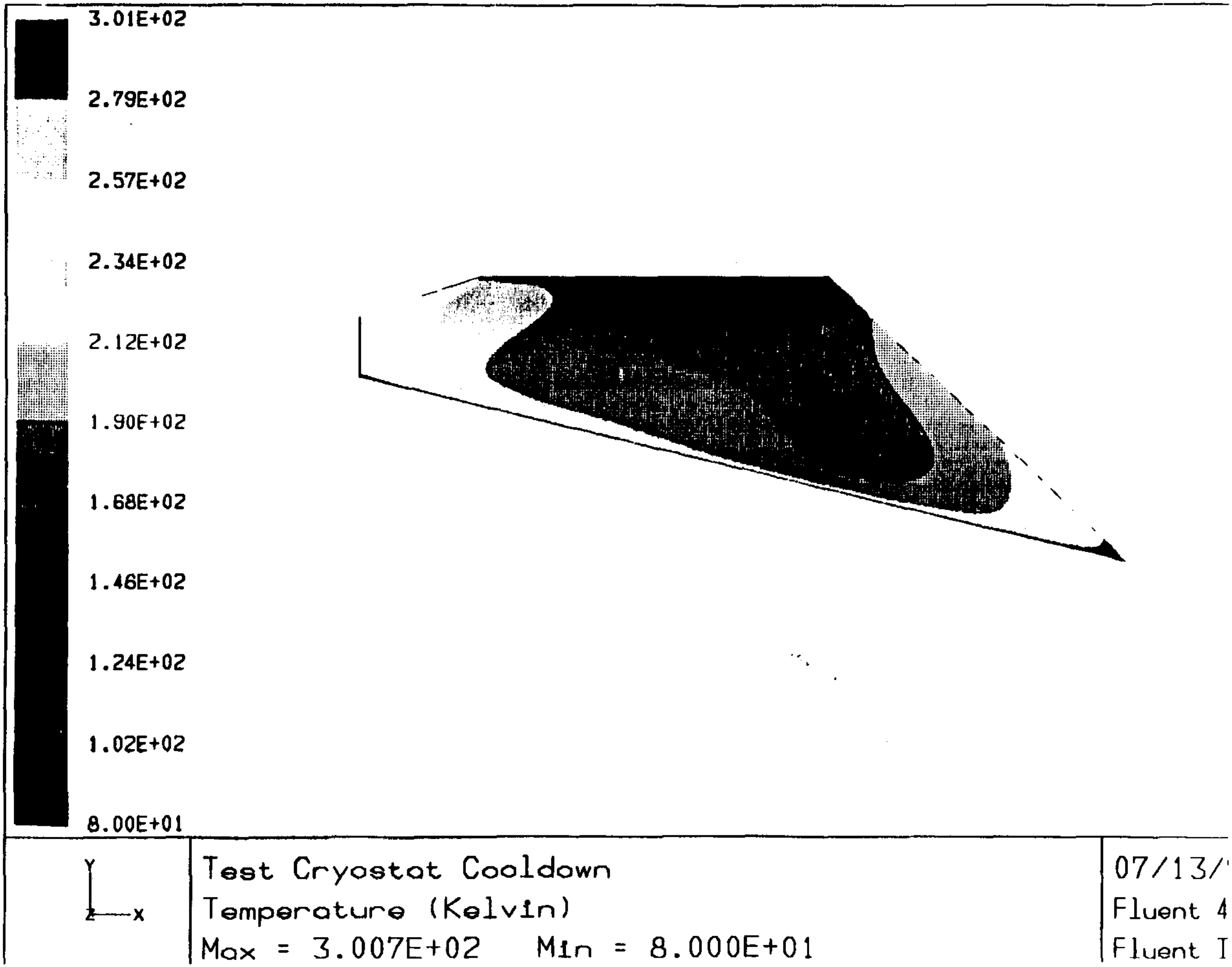
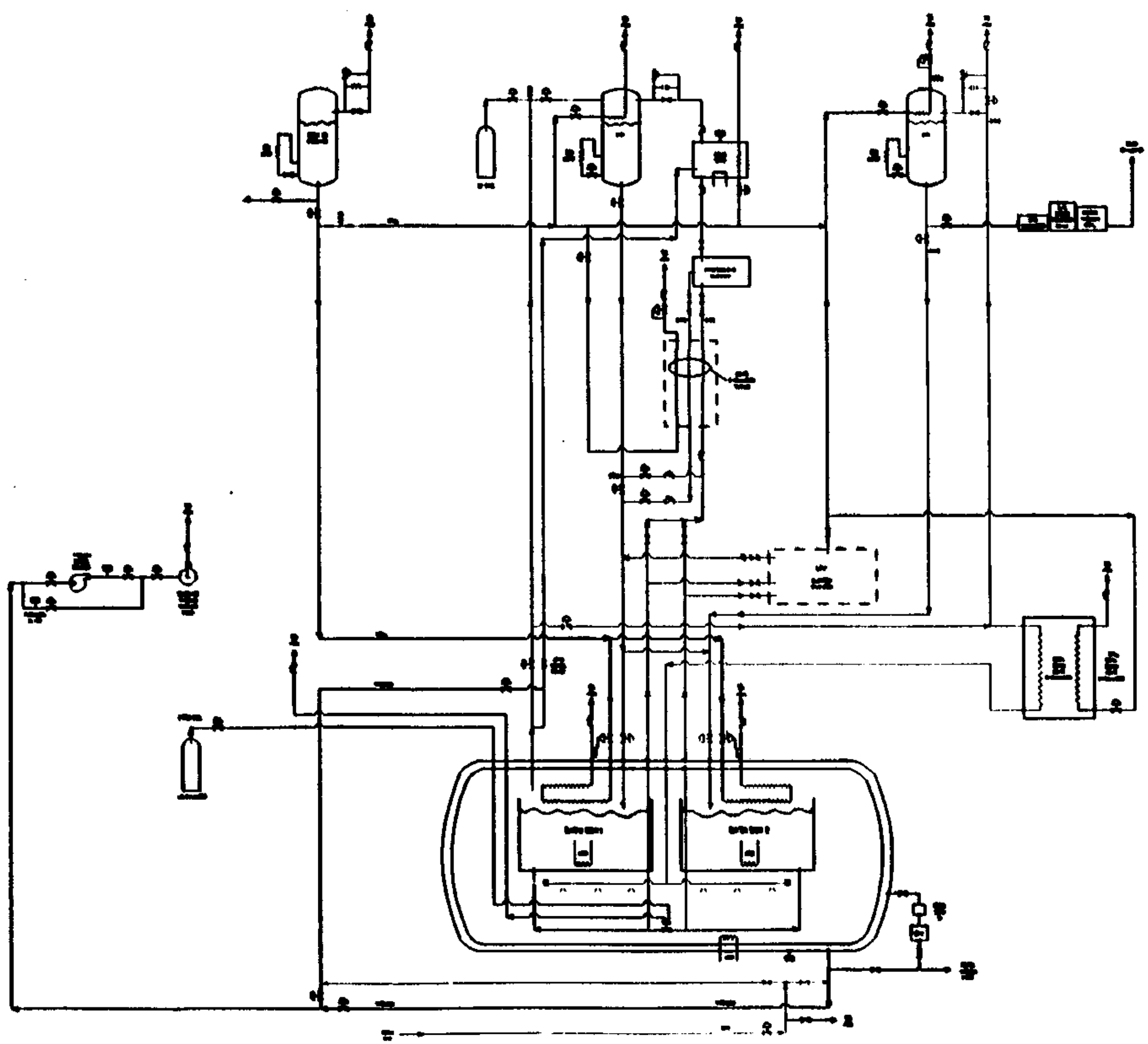
3.16E-02
3.01E-02
2.86E-02
2.71E-02
2.56E-02
2.41E-02
2.26E-02
2.11E-02
1.96E-02
1.81E-02
1.66E-02
1.51E-02
1.36E-02
1.20E-02
1.05E-02
9.03E-03
7.53E-03
6.02E-03
4.52E-03
3.01E-03
1.51E-03
-1.86E-17
Y
X
Z
GEM CAL TEST
Velocity Vectors (Meters/Sec)
Max = 4.367E-02   Min = 0.000E+00
07/13/
Fluent 4
Fluent I


3.01E+02
2.79E+02
2.57E+02
2.34E+02
2.12E+02
1.90E+02
1.68E+02
1.46E+02
1.24E+02
1.02E+02
8.00E+01
Y
Z
X
Test Cryostat Cooldown
Temperature (Kelvin)
Max = 3.007E+02   Min = 8.000E+01
07/13/
Fluent 4
Fluent I

Superconducting Super Collider Laboratory

Cryogenics Group

Physics Research Division



Calorimeter Module Test Heat Loads

Steady State

Source	Heat Load (W)	Notes
G10 Supports	1400	4 Supports: 3.5" thk x 26" wide x 29" depth 0.5" square grooves on each side grooves cover 50% of surface area
Thermal Radiation	650	Assumes MLI, 30 Layers, 5x10-3 Torr pressure Q is 10 W/m^2 (If no MLI polished surface Q is 50 W/m^2) Reference: Q.S. Shu, Adv.Cryo.Eng(1985) Total surface area is approx 65 m^2
Module Preamps	400 X 2	4000 preamps @ 100 ~~mA~~ W each
Penetrations	216	9 Signal feedthroughs @ 10 W ea incl. wires 8 Other penetrations @ 14.5 W ea
Wiring	144	Copper wire for heaters, thermometry, etc.
Cryogenic Piping	11	6 Pipes 1/2 in sch 10, length = 18" 6 Pipes 3/4 in. sch 10, length = 27"
Anti-condenstation Bottom Heater	300	Worst case scenario with heater on to prevent condensation on cryostat bottom
TOTAL	**3121**	(Increases to 6000 W if no MLI used)

Cooldown

Energy to be removed (J)	5.40E+09	Includes: inner vessel and all contents Cooldown from 300 to 85 K
Cooldown time (days)	5	
Cooling rate (W)	**12500**	

Cryogenics System Status

Where we've been:

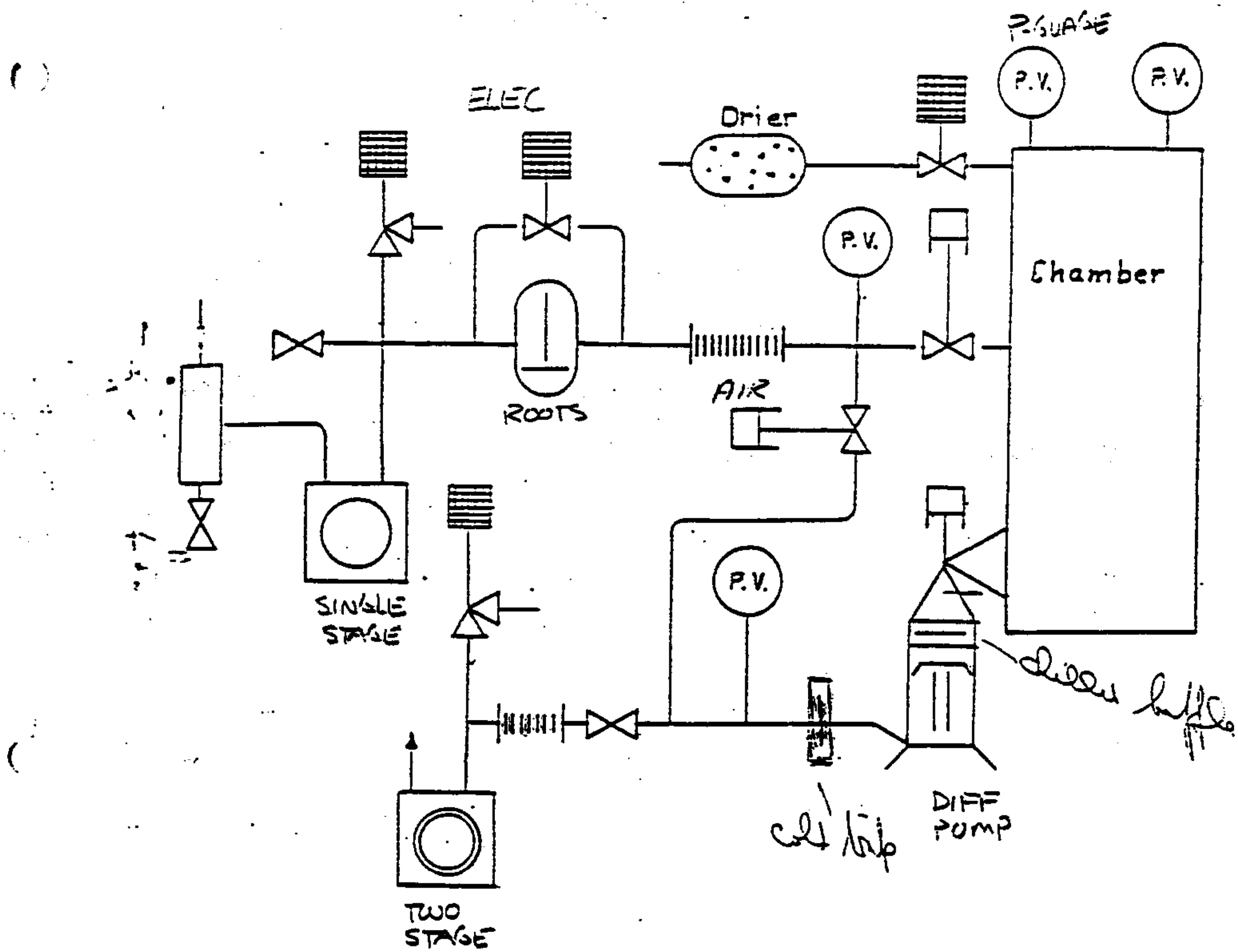
- Received requirements 28 June 1993
- Literature search completed
- Preliminary design completed

Where we are:

- Developing detailed Process and Instrument diagram of cryo system
- Investigating liquid purification designs
- Thermal analysis of cryostat and modules
- Layout of cryo equipment in MWest Hall
- Preparation for Preliminary Design Review

Where we're going:

- Process simulation
- Detailed equipment design and specification
- Engineering documentation
- Preparation for Critical Design Review



The schematic diagram shows a system using a single stage rotary pump with single stage Roots pump. It is capable of quickly roughing out the chamber to 10^{-1} torr - 10^{-2} torr at which pressure the diffusion pump can be brought in. During the high pressure operation of the diffusion pump, adequate backing is obtained from the roughing set. When the pressure reaches a few torr, a small two stage rotary pump provides adequate backing allowing the larger set to be shut down. This small pump also acts as a holding pump maintaining the backing pressure while the chamber is being reloaded. An alternative to the holding pump is a large volume in the backing arm with pressure gauge and alarm.

If pressures below 10^{-3} torr are not required, the diffusion pump is best replaced by one of the large oil boosters.

G. CHAPMAN
9 July 1993

Received: by qmail.ssc.gov with SMTP;28 Jun 1993 15:07:49 -0600
Date: Mon, 28 Jun 1993 15:07:45 -0500 (CDT)
From: WJW@SSCVX1.SSC.GOV
To: bill_wisniewski@qmail.ssc.gov, wjw@slacvm.slac.stanford.edu
Message-Id: <930628150745.210081ac@SSCVX1.SSC.GOV>
Subject: v5 cryostat spec

From: URHEP::LOBK "F. LOBKOWICZ/ROCHESTER" 28-JUN-1993 13:18:12.38
To: @TESTBEAM
CC: LOBK
Subj: Version 5 of testbeam specifications

This is the "preliminary final" version of the specifications for the testbeam calorimetry setup at FNAL. It gives specifications on the cryostat, transporter, electrical connections, and cryogenic demands. I would expect it to change from now on only in minor details. In some places in this document, however, we say only that specifications will be provided in the future.
As far as this writer (F. Lobkowicz) is concerned, further refinements to this document should be done by the new testbeam calorimetry coordinator whose appointment was suggested by the PAC review pannel. I will continue only for a few more days until such a person is officially appointed.

SPECIFICATIONS FOR FNAL TESTBEAM CRYOSTAT AND TRANSPORTER.
(This is Version 005, June 28, 93)

I. Time scale.
In order to be ready for taking beam in March 1995, all the necessary components should arrive at FNAL in the fall of 1994. The following schedule is specified:
Beneficial occupancy of MWEST by GEM March 1,94 /1/
Transporter arrives at Fermilab August 15, 94 /2/
Transporter is fully assembled for cryostat Sept 15, 94
Feedthrus ("Seattle version") are delivered to cryostat vendor by August 1 for welding in.
Cryostat arrives at Fermilab Oct 1, 94
All necessary cryostat plumbing is ready Oct 1, 94
All cryostat/transporter control components are at Fermilab oct 1
Assembly of modules into support structure begins Nov 1, 94

Junction boxes and outside cables are at FNAL on Nov 1,94
Partial delivery of shapers (enough for test) by Dec 1, 94
DAQ adequate to test system Dec 1,94
Modules inserted in cryostat, internal hookup begins, Jan 1, 95

******* Cryostat ready for cooldown Feb 15, 95. ***********

II. Cryostat and arrangement of modules

NOTE: The modules inside the cryostat are to simulate the real GEM detector arrangement as closely as possible. This implies that all particles hitting the calorimeter modules are to be imagined to come from the "interaction point (IP) - actually a thin axial line ca 15 cm long centered on the IP. See Figure 1 for the arrangement of the real GEM detector, and Figure 2 for its simulation in the test detector. All specific distances mentioned in this document assume that the IP is 76" +/- 2" away from the axis of the cryostat, and that "crack # 1" = upper crack in inner hadronic barrel modules is at an angle of 2.25 degrees above the horizontal. Figures 3 and 4 give the definition of the IP in our setup

1) The cryostat is to accommodate: 2 Barrel EM modules, 4 Barrel inner hadronic modules /3/, 3 Barrel outer hadronic modules, 3 Endcap outer A and B hadronic modules, 2 Endcap inner hadronic A and B modules and at least a section of a simulated endcap EM. /4/

2) When looking downstream, with the beam (that is NORTH), the endcap modules are ON THE LEFT (West). /5/

3) Outer cryostat diameter is AT MOST 102.5". Neil Hall will attempt to make it smaller. The cryostat length is AT MOST 308" /6/. Every effort should be made to make the cryostat shorter.

4) The inner cold cryostat vessel is to be designed for an operating overpressure of 50 psid as a ASME CODE VESSEL. The inner vessel is not required to hold -15 psid (vacuum), but positive pressure relief must be provided to that the inside pressure can never be less than outside pressure. The warm vessel is to be designed for vacuum using the CGA code and FNAL safety codes. /7/

5) There are two stiffening rings of AT MOST 6" thickness between the cryostat and the rocking wheels on the transporter. The inside load of modules,

bathtub, etc has to be transferred to these two stiffening rings. The separation between these stiffening rings is 131.25" (Center to center) /8/

6) The cryostat (both cold and warm vessel) are to be flanged at the Endcap end. The recommended seals for the cold vessel are compression ring seals such as manufactured by

Helicoflex Seals
P.O. Box 9889
Columbia S.C. 29290
803-783-1880

Such seal rings are standard at CERN. There are other manufacturers of such seals. The warm vessel can be sealed by an ordinary O-ring.

7) The beam is to hit the detector (cryostat) always going through the IP region. The sensitive region is defined as a region rotating 65 degrees counterclockwise, 30 degrees clockwise around a vertical axis, and +/- 4 degrees rocking of the cryostat. In the sensitive region the total wall thickness (cold and warm vessel) should not exceed 0.25 radiation length AS REFERRED TO NORMAL INCIDENCE. This can be accommodated either by a thin window or keeping the overall wall thickness below the limit. /9/

7) The baseline design of the cryostat is an aluminum vessel, both inside and outside. The vessel is to be a code vessel.

8) The cryostat with its internal support structure for the individual modules is to be designed by SSCL.

9) The assembled cryostat will be tested cold by vendor before shipping./10/

III. Cryostat and transporter.

1) The cryostat will sit on a transporter, to be designed by Rochester./11/

2)The cryostat on its transporter has to be movable /12/ /13/:
(i) East-west along the whole track in MWEST, with continuous motion of at least 10'.
(ii) Around a vertical axis at least 65 degrees clockwise (into the endcap) and 30 degrees anticlockwise.
For installing the modules on their support vehicles the cryostat has to rotate by 90 degrees with the endcap section pointing North (downstream).

(iii) The rolling motion (around the cryostat axis) is to be at least +/- 4 degrees with the cryostat bathtubs filled with liquid.
(iv) The vertical motion has to accommodate the rocking motion, keeping the calorimeter modules in the right orientation to the beamline. /14/

3) There will be a position measurement system accessible to the DAQ system which will locate all degrees of freedom to approx +/- 1 mm.

4) a section of the warm (scintillating) calorimeter will be sitting behind the cryostat; this will participate in the horizontal and up/down motion as well as in the rotation about a vertical axis. the scintillator calorimeter will not participate, however, in the rocking motion of the cryostat.

5) A small X-Y set of drift chambers (with positional accuracy of 0.1 mm) will be mounted at the imaginary intersection point from where all particles must seem to emanate. The chamber should be mounted on an arm extending from the cryostat, thus participating in all of its motions. It should be sufficiently large that one can simulate the length of the interaction pencil in the real GEM experiment (7 cm r.m.s.). /15/

5) The transporter is to be designed for the following loads:
(i) The Hillman Rollers supporting the transporter will be rated at at least 200 tons each /16/
(ii) The elevation (up/down)motion will be designed to support 200 tons total. This implies four 100-ton jacks.
(iii) The cryostat and its inside load is not to exceed 120 tons.
(iv) The scintillation calorimeter (See III-3) is to consist of two pieces, each of less than 25 tons INCLUDING ANY LIFTING/SUPPORT MECHANISMS.

6) No part of the transporter, at a height of 60" or higher above floor level, can in any position and orientation protrude more than 154" south of the center between the rails. This condition has to be satisfied either by physical design of transporter or by positive lockouts of positions where this condition could be violated. /17/
Below the level of 60", about 3.5" more is available. /18/

7) The topmost table on the transporter (rotating around a vertical axis and carying the cryostat) will be equipped with an elevated platform which gives access to the top of the cryostat for cabling, cryo connections etc. The platform will be at a height slightly above the cryostat, and will cover most of the cryostat except

where there are penetrations. /19/
The topmost transporter table and the platform together must accommodate the liquid purifying mechanism (approx 6'w x 4'd x 7' h), the gas purification mechanism (approx 4'w x 4'd x 7'h), a vacuum pump (approx 2' x 2' x 2'), all local control mechanisms (appros three 6' tall electronics racks) and has to leave clear space for the junction boxes mounted on the cryostat.
None of these structures can interfere with the beam entering the detector modules inside the cryostat, nor can they intrude outside of the 154" radius limit from the vertical axis of rotation. /20/

IV. Electrical connections.

GENERAL COMMENT: All power fed onto the transporter, and a fortiori all power fed into the cryostat, has to be "clean power". This means that insulation transformers have to be used for all AC lines which are active during data taking.
Ground loops are also to be eliminated wherever possible. This implies that the transporter is to be insulated from the Hillman rollers which support it, and that all cryogenic connections need to have an insulating section. Such sections have been designed for the D0 test beam area.

1) There will be approx 5000 signal and calibration connections from the calorimeter modules. The signals will come from internal preamplifiers.

2) There will be 100-200 HV connections into the cryostat - half for the barrel and half for the endcaps
There will be 100-200 DC power connections for the preamplifiers into the cryostat. Each will cary AAA amperes at +/- VVV Volts.
The HV and power connections will use the same feedthru ports as the signal connections.

3) The cryostat is to have nine feedthru ports for accommodating the signals as well as the auxiliary connections (thermometry, pressure and level monitoring, heaters etc). Of these six will be above the separation region between barrel and endcap modules, while three

will be near the cold flange. Each of these ports must be suitable for the Seattle type feedthrus; P.MOCKETT will provide more detailed specs by July 15, 93. Each of the feedthrus is capable of transmitting 860 signals, as well as the corresponding HV leads and the power to the preamplifiers. /21/ /22/

4) All control and power wiring into the cryostat has to be filtered and/or shielded to prevent coherent noise. This means that any signal of 100 kHz or higher frequency has to be attenuated by at least 60 dB.

5) From the feedthrus the signal cables will go to junction boxes (one per signal feedthru) which are mounted on the cryostat directly above the feedthru port. These junction boxes, together with the feedthru port, are to form a local Faraday cage. The Junction boxes have a depth (back to front - input cable to output cable) of 304 mm, and a width of 268.75 mm. The length depends on the number of driver cards in each bos. The barrel junction boxes have 17 cards and a length of 312 mm, the endcap junction boxes have 21 cards and a length of 384 mm. The power consumption is 0.2W/channel. The junction boxes are to be water cooled. The power supplies will be mounted next to the junction boxes. /23/ /24/

5) From the junction boxes, cables will go up to an arm which allows the cables to move while the cryostat is rotated, without interfering with the cryo lines. /25/
From there on cables of 40-45 meter length will lead to the shapers/ADC-s located in the upstream latchhouse.
The cable layout has to allow initial connections to be made while the cryostat is still open. These connections will then stay continuously closed while the cryostat is pumped down, the modules cooled, the cryostat brought into the beam, and during a whole run.

3) There will be heaters inside the cryostat:
(i) a heater of ca 1 kW max. in contact with the bottom of the cryostat (under the bathtubs, bot NOT in contact with them) will warm the cryostat wall to a temperature slightly above that inside the modules, thus preventing pooling of liquid at the bottom. This heater will be on at all times with the DC current being regulated by the temperature; the typical power consumption will be a few hundred Watt.
(ii) a heater of 10-20 kW is to be used for emptying the vessel - evaporating the liquid. Half of this heater should be attached to the underside of

the barrel module support, and half below the endcap modules.

6) There will be many more thermometers in the testbeam vessel than in the real cryostat. We estimate at least 100-200 such thermometers, mostly of the 4-lead platinum type. Some of these should be next to the EM amplifiers.

7) There will be at least two (probably more) alpha - source purity monitoring cells inside the liquid. These will be read out using the same preamplifiers as are used in the detector. No beta sources will be used for monitoring. /26/

8) All AC power for power supplies of electronics on the transporter and inside the cryostat has to be filtered against SCR spikes from powersupplies on the whole FNAL site. The definition of "clean power" is <10 mV at frequencies above 200 kHz between any two power leads or between AC power and ground. /29/

9) The total power required for motor control for the various motions will be specified later. Unless these lines can be disconnected during data taking, they will have to be "clean power".
About 2-3 standard racks should be reserved for controls of motors, temperature monitoring, purity monitoring, etc.

V. Cryogenic specifications

1) The modules will be filled with either LAr or LKr. The maximum available amount of LKR during the first test (Phase 1)will be approx 3000 liters./27/ Both Argon and Krypton will be introduced as gas, and at the end expelled as gas. Every effort should be made to make the bathtubs as compact as possible, unused volume which cannot be eliminated can in principle be filled with Aluminum blocks, but this is not a cheap filler material.

2) There will be two separate "vehicles": one carrying the barrel modules, one the endcap modules. These have to be individually and separately movable. The separation between the two "vehicles" is to be as similar as possible to the actual separation between endcap and barrel. Each vehicle carries a bathtub which contains the liquid.

3) The bathtubs have to be connected by a pipe AFTER they are wheeled into place. There should be a helium acuated valve which can shut off this connection. /28/

4) Each bathtub is to contain as little extra liquid as possible. The bathtubs should be made very compact, and any free space left over filled with a filler (probably Aluminum).

5) There will be two LN2 cooling loops at the top of the cryostat, one above each bathtub. There will be either an inside set of Helium actuated valves allowing either of the two cooling loops to be activated, or there will be separate inlets and outlets for the two loops (so that the loops can be turned on/off externaly).

5) Each bathtub will have a small (1/8") pipe leaving it at the bottom. This pipe has to continue downwards at least to the inner vessel bottom. From then on it can go to a cryo port at the top./30/

6) Each bathtub needs a separate drain which is to be connected to an opening at the top of the cryostat. This drain consists of a tube reaching to the bottom of each bathtub, which becopmes double walled (cryo insulating) BEFORE it reaches the top of the cryostat. A liquid return which ends near the top of each bathtub is also required. These inlets and outlets will be connected to the liquid purifier. All need the possibility to be valved off. /31/

6) There will be at least one gas port on the cryostat, which will carry relief valves, pumpout connections, and connection to stored Krypton gas, connection too a gas purification system etc. etc. /32/

7) A large vacuum pump to evacuate the inside of the cryostat will be situated on the building floor. A diffusion pump with a forepump mounted on the cryostat will pump the insulating vacuum.

6) There may also be continuous gas purification of LKr. The purification in gas form will use the drain to flash liquid from the bottom of a bathtub.

7) The approx 4000 preamplifiers will not be separately cooled. Adequate thermometry must be provided to monitor the quality of the liquid near the preamplifiers.

VI. Insertion of modules.

1) The cryostat has to be filled from the downstream (North) side in the MWEST hall. Figure 5 shows the approx. arrangement during installion of modules. /33/

2)The region between the two bathtubs should closely simulate the transition between the real cryostats. This means that the "barrel bathtub" should end on the endcap side with a reasonable thin wall.
The bathtub should also incorporate a segment of the cylindrical stay at r = 1670 mm. The same consideration applies to the endcap bathtub: on the barrel side its endwall should be reasonably thin. /34/ It should also ioncorporate the various support stays which are part of the endcap cryostat. The hadron modules will be mounted in as much the same way as possible to the mounting in the real cryostat.

3) The barrel bathtub is to be reasonably thin at the entrance over the region of the EM modules./35/

In the back the bathtub should also be reasonably thin; the total thickness of bathtubs + inner cryostat + outer cryostat in the back should not exceed 5.8 cm (2.3") of Aluminum.

4) Both the barrel and the endcap bathtub should include the relevant segments of the reinforcing stays in the real endcaps.

5) The mounting details for the endcap modules will be provided by Mockett and LLMASON

6) The mounting details for the barrel module will be provided by Lobkowicz and LLMASON.

Figure captions: (Figures are sent out by FAX - one copy to each institution)

Figure 1: GEM Calorimeter dimensions according to the TDR.

Figure 2: Layout of the modules inside the testbeam cryostat. Also shown are the approx. locations for the electrical feedthrus.. Other ports (Cryo, gas, pumpdown, safety etc) are not shown.

Figure 3: Overview of the transporter and definition of the intersection point IP. The angular region which one can accommodate within the limits of motion is also given; the actual limit is the horizontal travel along the tracks (max 14 feet with existing screws).

Figure 4: Endview of the cryostat on the transporter, showing also the center of the "rocking" motion (around cryostat axis)

Figure 5: Overall view of building with the transporter and cryostat in the position where modules are loaded.

Comments and footnotes

/1/ This is a specification agreed upon by G. Ginther representing the FNAL side of the operation.

/2/ According to D. Spisiak this is reasonable assuming that PO can be sent out by Sept. 15, 93

/3/ Further MCarlo studies will be required to determine for certain whether 3 or 4 inner barrel hadronic modules are needed for full shower containment. The bathtub should be designed to hold 4 inner modules if at all possible.
Note also that the initial complement of hadronic modules covers only half of the region to be tested. In order to study the region around the washer, one needs a double complement (8 inner and 6 outer) of hadronic barrel modules.

/4/ Phase 1 (spring 95) of the test program assumes that no endcap EM accordion segment is available. A section of such a segment is to be available for phase 2 of the test - approx spring 96.

/5/ This specification is driven by the nearness of the East wall, and the end of the trough, when the calorimeter is in the beamline. Reversing the orientation leads to interference with the wall.

/6/ The "upstream latchhouse" is 154" away from the centerline between the rails. If any part of the transporter protgrudes more than 154" from its vertical axis of rotation, interlocks have to be provided to that the latchhouse is NEVER hit.

/7/ The leaktesting of the inner vessel (it has a flange!) will be cumbersome although possible (Overpressure of helium inside WITHOUT EVER PUMPING ON INSIDE). FNAL safety will have to sign off on this before design can be finalized. However, this spec is probably necessary if there are to be no windows.
Note also that at FNAL vacuum means collapse pressure of at least 30 psid.

/8/ This distance specifies the distance between the support rollers on the transporter.

/9/ The IP is about 25" +/-2" in front of the warm vessel. The range of -65/+30 degrees implies a window over 70" long in the warm vessel, and correspondignly longer in the cold vessel. It is likely that the most reasonable way to accomplish the "window" is to make the whole cryostat as thinwalled as possible between reinforcing hoops spaced approx 70" apart. This is the origin of the specification II-4. The individual calorimeter specialists should carefully consider whether such an extreme angular range is necessary.

/10/ This means that either the feedthrus have to be delivered to vendor for welding in before shipping, or vendor has to test with blank flanges and welding in of feedthrus requires separate cooldown. In the time schedule (part I) we assume that the feedthrus are delivered directly to the manufacturer.

/11/ See Figures 3 and 4 for an overview of the transporter. One should note that the building has a 25 ton crane; this limits the maximum weight of items to be handled inside the building.

/12/ All moving parts of the drives have to be covered to satisfy OSHA requirements.

/13/ There are two schools of thought on how to move the transporter during "scanning across modules". The first school envisages occasional motion of the transporter and cryostat, followed by electrically disconnecting the power to the controls and taking data. A second school envisages scanning "on the fly", moving the detector between beamspills by small amounts, and taking only approx one beamspill per position.
While the second school, if successful, would increase data collection speed, it is unclear whether this scheme is able to adequately suppress electronic noise and effects of liquid sloshing around inside the bathtubs. At a minimum only "clean power" could be used for the motor drives and controls. See the section on electrical specifications.

/14/ The amount of vertical modion depends on the distance from the cryostat axis to the intersection point.

/15/ With the assumed locations of the modules, the chambers are about 25" in front of the warm cryostat vessel. The asembly should probably be rotatable (in fixed increments for accuracy) about a vertical axis so that the beam impinges always approx. normally to the chambers.

/16/ Existing rollers are rated at 300 tons each.

/17/ This is to prevent the "upstream latchhouse" to be hit.

/18/ The Hillman rollers, situated on the rails, exceed the 154" limit, but do not interfere with the latchhouse.

/19/ Attention must be paid that during the various rotations of the cryostat the platform does not interfere with the upstream latchhouse, concrete shielding or any other obstruction. Attention also must be paid that the rocking cryostat does not pinch any cabling or other connections between cryostat and platform.

/20/ The sum total of all these requirements will produce an arrangement which will be extremely unwieldy and probably impossible. The specialists should carefully consider whether their demands cannot be met by more modest space demands.

/21/ However, the assembly scheme is somewhat different from that in the real Gem detector.

/22/ Actually only seven of the ports will be used for the usual signal/HV/premp power connections similar to those in the real detector. One will be used for auxiliary connections (heaters, pressure monitoring, temperature monitoring etc), and one will be used for the test sources whjich monitor liquid purity. Figure 2 shows the desired location of the ports.

/23/ At present there is no detailed design of the junction boxes with the associated power supplies. Somebody better supply one before it is too late. The design should also incorporate stress reliefs for the cables into and out of the junction boxes.

/24/ At the Seattle meeting the electronics experts (VR) stated that one can violate the "equality to real detector" in considering cable length between feedthrus and junction boxes. In the real detector these are approx 3 meters for the barrel feedthrus, 0.4 meters for the endcaps.

/25/ Having the cables go up from the junction boxes rather than down was a decision made at the Seattle meeting. The detailed design of the cable layout has to be done simultaneously with the layout of the cryo lines. F.L. anticipates troubles and still counsels to have the cable snake initially down to the floor. In either case it is unlikely that 40 meters is enough to go to the counting room area.

/26/ The fast shaper experts stated that studying the shape of an alpha pulse allows to separately determine recombination, drift time and loss by attachment. Then there is no need for a beta source monitor.

/27/ This means that at least initially it will not be possible to fill both barrel and endcap modules with LKr. Once more Kr is available, a complete test should be made (probably in phase 2)

/28/The remote opening of the connection is necessary if one wants to fill both bathtubs with argon, and then empty and refill one bathtub with krypton without opening the vessel.

/29/ A common experience at FNAL is a slow drop of the 60 Hz AC power voltage by 5-10 Volt during a spill. The raw AC lines have spikes on them (in the few MHz

/30/ The purpose of this pipe is to mmeasure the liquid depth by measuring the pressure difference between the top and bottom of the bathtub. The pipe has to warm up BEFORE turning upwards to that no liquid can accumulate in it. As an alternate to leading the pipe all the way to the bottom one could install a small heater at the lowest point of the pipe.

/31/ The drain pipe forms part of the bathtub, and has to be connected to the line going through the cryo port after the bathtub is inserted. The same is true for the return line.

Since it is possible that later on we will have ennough LKr, both bathtubs should be able to to be connected to the purifier. We may even want to purify the LAr.

/32/ several such ports are obviously preferable.

/33/ There may not be enough space to insert individual modules from the "natural" side, that is from the East. The available space between the imaginary centerline through the cryostat and the concrete wall is about 105" = 2.67 m. If this is not enough to install the modules, the "assembly area" should be on wheels so that it can be moved further West.

/34/ By "reasonably thin" we mean thinner than the cold+ warm vessel thickness in that region. The idea is to be able to measure how much adding material will degrade the resolution. For this purpose one wants to start with "too little" and then add more wall material.

/35/ By reasonably thin we mean that the total of cryostat wall and bathtub wall before a particle hits the EM detector should be no more than in the real GEM detector. This is best achieved by inserting a window where the bathtub is crossed by the beam, This window should not exceed 0.25" of aluminum, but can be somewhat curved. The region above and below in front can be heavy, and can be used to reinforce the support plate. Provisions should be made for mounting additional pieces of aluminum to the front of the EM modules, so that one can study the effect of material in front of the detector.