GEM TN-92-95

Collaboration Council Meeting SSCL

April 30, 1992

Abstract:

Agenda and presentation of the GEM Collaboration Council Meeting held at the SSC Laboratory on April 30, 1992. Agenda items were: Status and News; GEM Facilities; Baseline 1 Overview; Subsystem Reports: Central Tracker; Calorimeters, Muons, Triggering/Electronics, Computing, Magnet, and Physics; Test Beam Report; R&D/Engineering; Cost Review; and Report/Discussion GEM Organization Committee.

DRAFT AGENDA
GEM Collaboration Council Meeting
April 30, 1992

9:00 I. Status and news (Barish)
9:15 II. GEM Facilities (Harris)
9:45 III. Baseline 1 Overview (Marx)

10:15 Coffee Break

IV. Subsystem Reports

10:30 1. Central Tracker (Baltay)
10:50 2. Calorimeters (Kamyshkov), Newman, Gordon
11:20 3. Muons (Taylor)
11:45 4. Triggering/Electronics (Shaevitz)
12:00 5. Computing (McFarlane)

12:15 Lunch

1:15 6. Magnet (Stroynowski)
1:45 7. Physics (Lane)

2:00 V. Test Beams Report (Yost)
2:15 VI. R&D/Engineering (Webb)
2:30 VII. Cost Reviews (Sanders)
2:45 VIII. Report/Discussion GEM Organization Committee (Baltay)

3:00 Adjourn

gem

γeμ

Presentation by:

Barry Barish

B. Barish

GEM Collaboration Council

April 30, 1992

Highlights since Tucson

① GEM BASELINE 1
- Copper
- 75 cm central tracker
- Moveable magnet

(some schedule, parameter problems)

② Facilities in Title I
- Coil Winding → IR5

③ Magnet
- Management
- Conductor Choice

(2)

P. Reardon : Magnet Project Manager

G. Deis : Assist Magnet Proj. Manager
Chief Magnet Engineer

- Acquisition Plan

* Exec committee recommends pursue vigorously.

- Cost Reviews Underway

Baseline Evaluation ⇒ Baseline 2

JUNE

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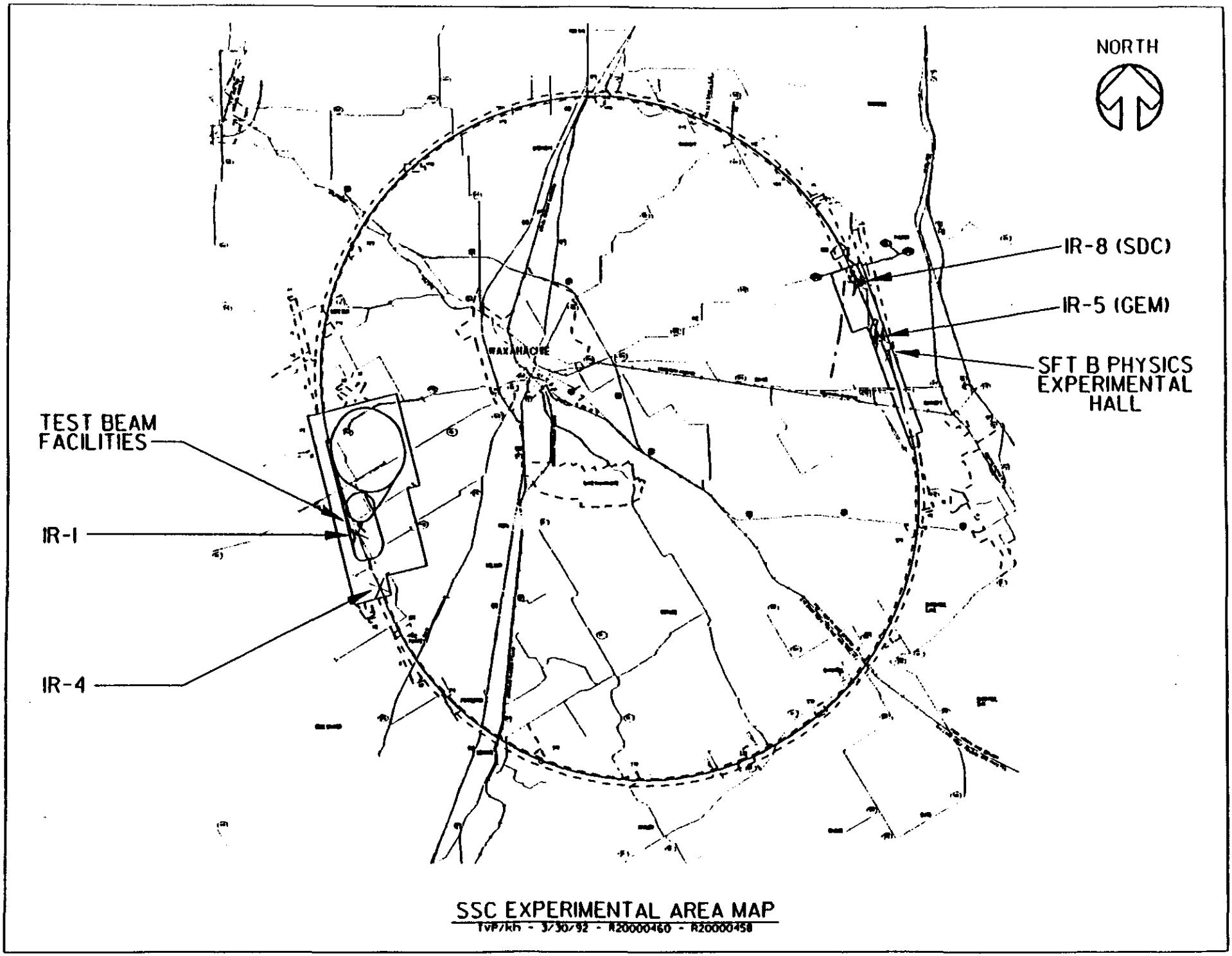
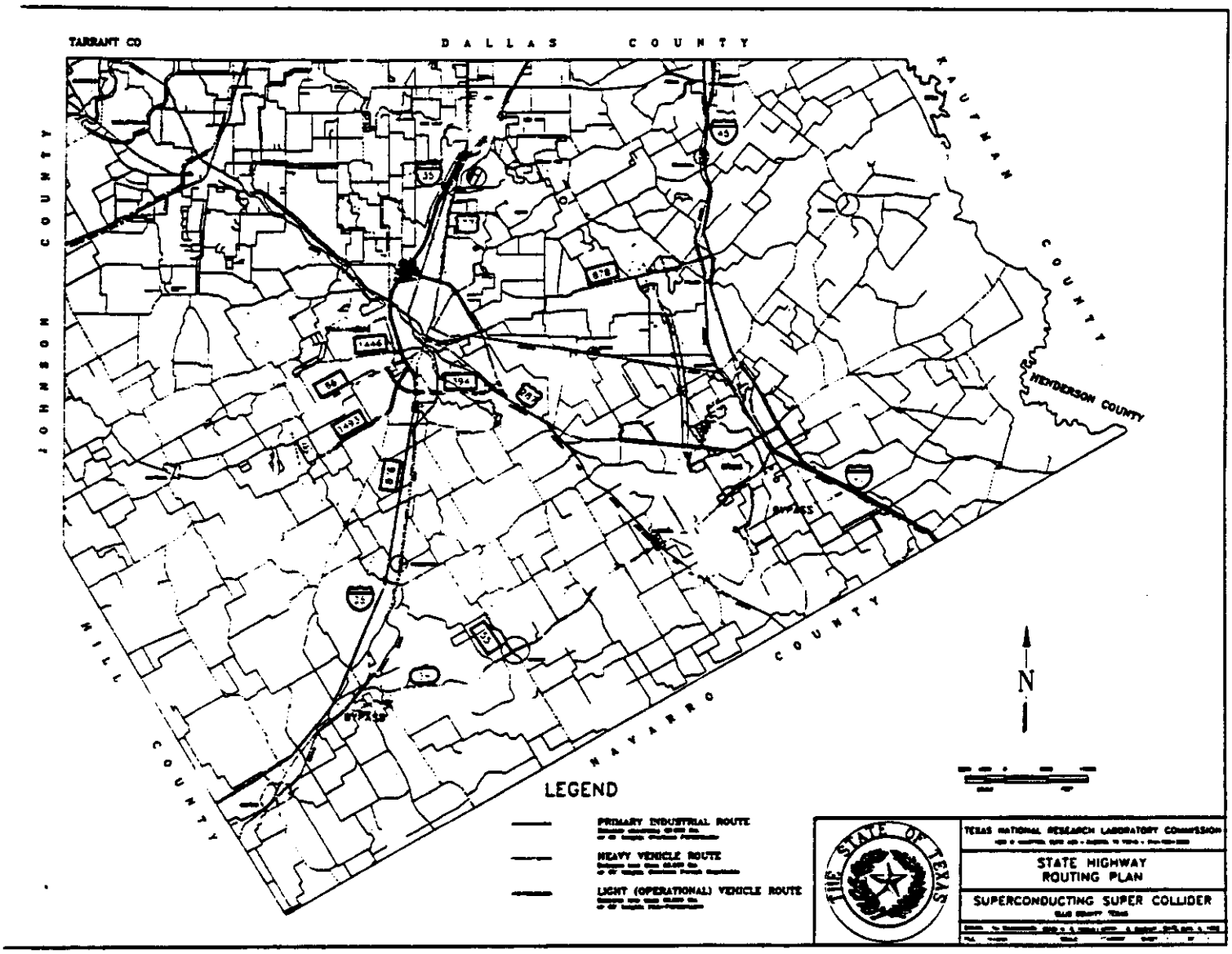
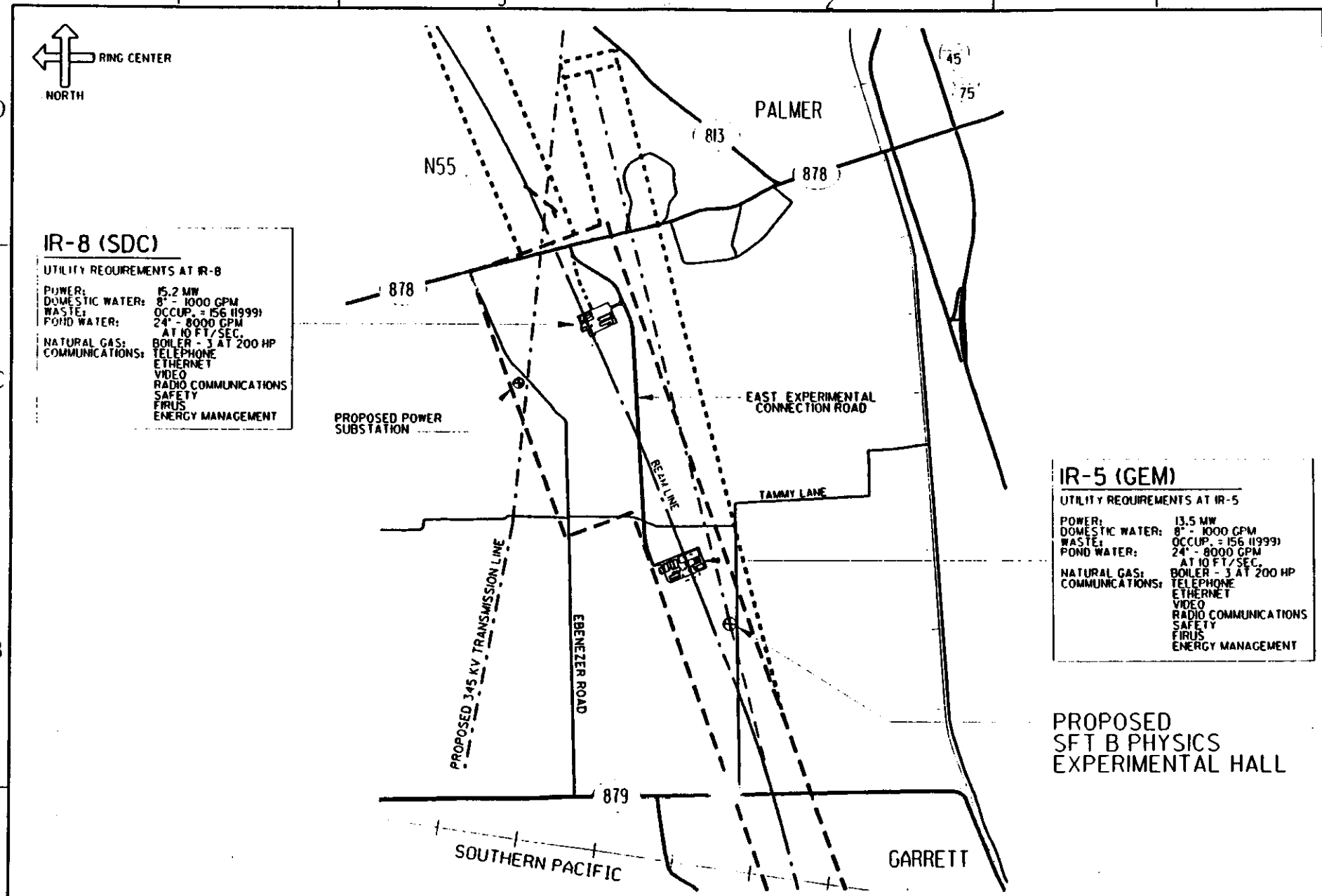
Presentation by:

Tom Prosapio
(For Mike Harris)


NORTH
IR-8 (SDC)
IR-5 (GEM)
SFT B PHYSICS
EXPERIMENTAL
HALL
TEST BEAM
FACILITIES
IR-1
IR-4
SSC EXPERIMENTAL AREA MAP
TVP/kh - 3/30/92 - R20000460 - R20000458


TARRANT CO
DALLAS COUNTY
JOHNSON COUNTY
KAUFMAN COUNTY
HENDERSON COUNTY
HILL COUNTY
NAVARRO COUNTY
N
LEGEND
PRIMARY INDUSTRIAL ROUTE
HEAVY VEHICLE ROUTE
LIGHT (OPERATIONAL) VEHICLE ROUTE
THE STATE OF TEXAS
TEXAS NATIONAL RESEARCH LABORATORY COMMISSION
STATE HIGHWAY
ROUTING PLAN
SUPERCONDUCTING SUPER COLLIDER



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HAWKES

T. PROSAPIO

PHYSICS RESEARCH DIVISION

SSC

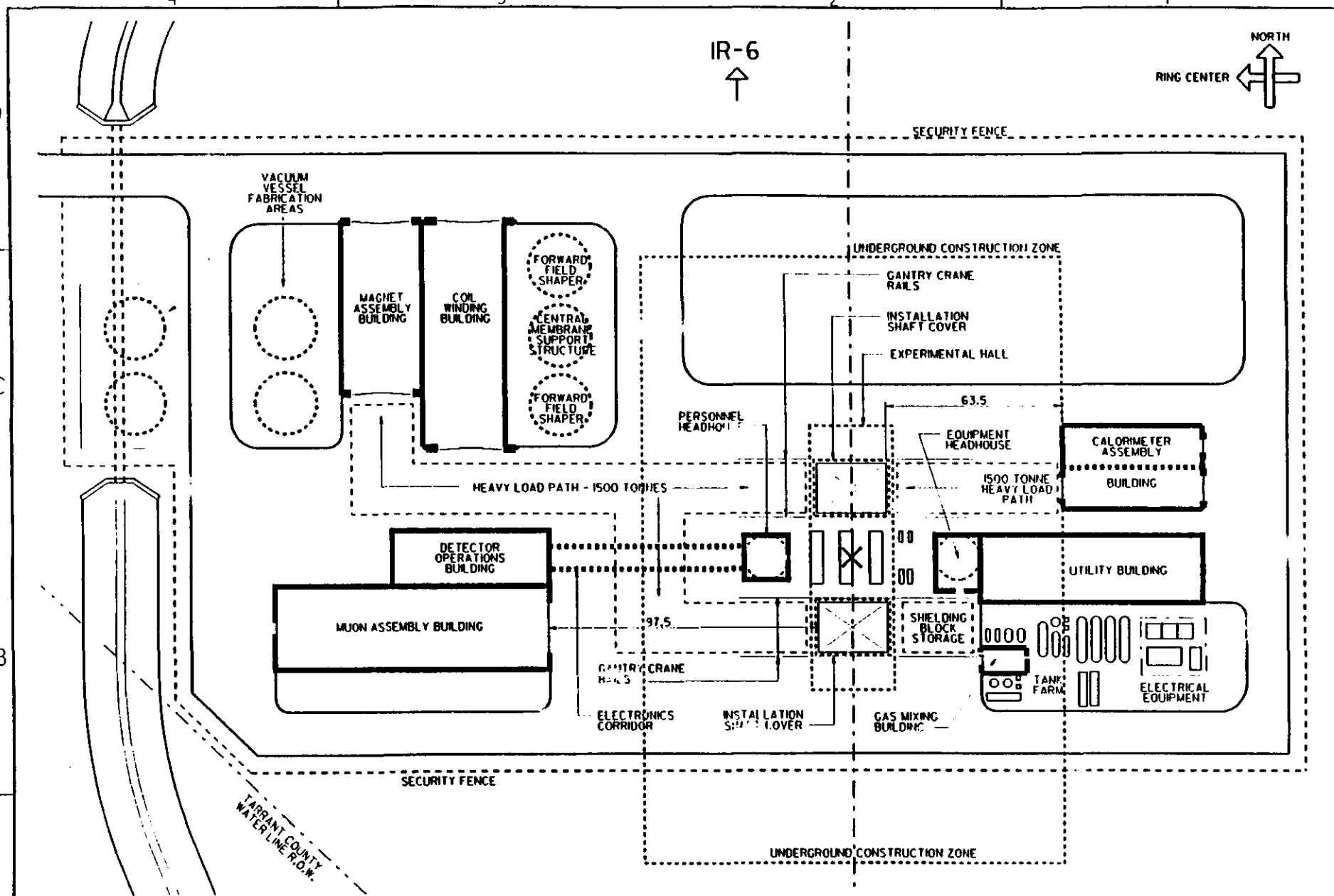
SSC EXPERIMENTAL FACILITIES

EAST CAMPUS

SITE PLAN

4/28/92

R20000488



SITE PLAN

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DIMENSIONS ARE SHOWN IN METERS UNLESS NOTED OTHERWISE.

K. HAWKES

T. PROSAPIO

PHYSICS RESEARCH DIVISION

SSC

CONTRACT NUMBER DE-AC35-89ER40486

GEMF ITAL FACILITIES

IR-5

SITE PLAN

SCALE NONE

DATE 04-27-92

SIZE C

PROJECT NUMBER

DRAWING NUMBER

GCD-000143

REVISION A01

gem

γeμ

Presentation by:

Mike Marx

GEM TN-92-76

GEM Baseline 1

April 23, 1992

Abstract:

This document details parameters of the current GEM detector baseline design. This design will be used for an in-depth analysis of cost, schedule and physics performance.

GEM BASELINE 1

TABLE OF CONTENTS

1.0	OVERVIEW
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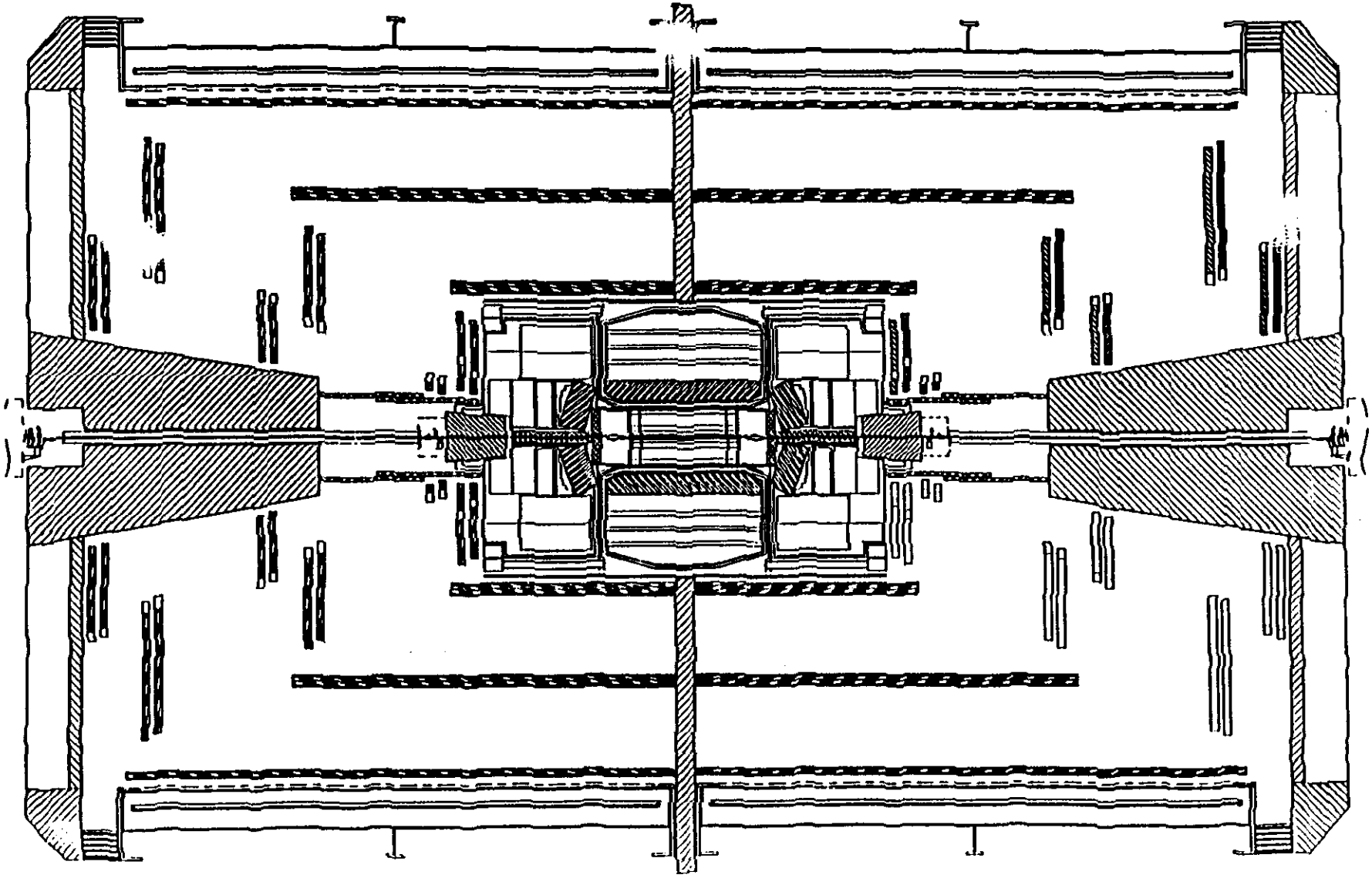
5.0	DETECTOR ACCESS
6.0	BEAM LINE
7.0	MAGNET AND FIELD SHAPER
8.0	MAGNETIC FIELD
9.0	TRACKER
10.0	CALORIMETER
11.0	MUONS
12.0	ALIGNMENT
13.0	ELECTRONICS
14.0	APPENDIX

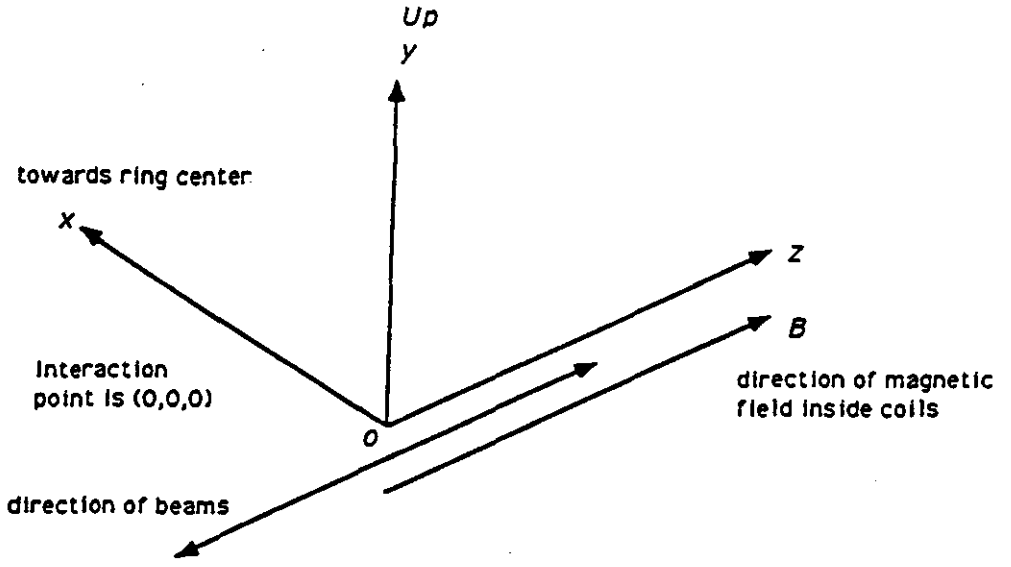
Next Version
Rad Levels + Activation
?

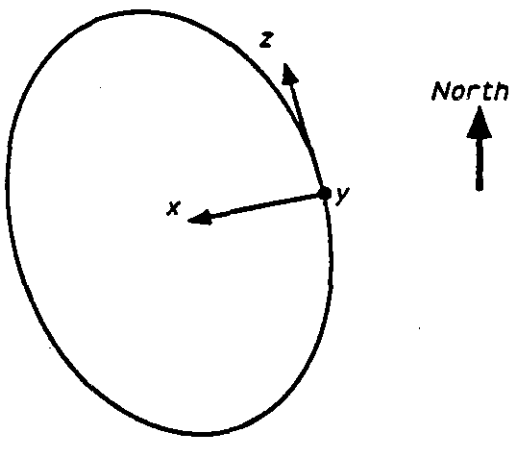
GEM DETECTOR LAYOUT



INTRODUCTION

GEM Coordinate System and Field Direction





The GEM coordinate system is right-handed with its origin at the nominal interaction point, the z direction is along the beam direction and positive z is North. The positive x direction is towards the machine center and y is up.
The magnetic field is parallel to the z axis, roughly in the same direction as the Earth's field.

Figure 1.7

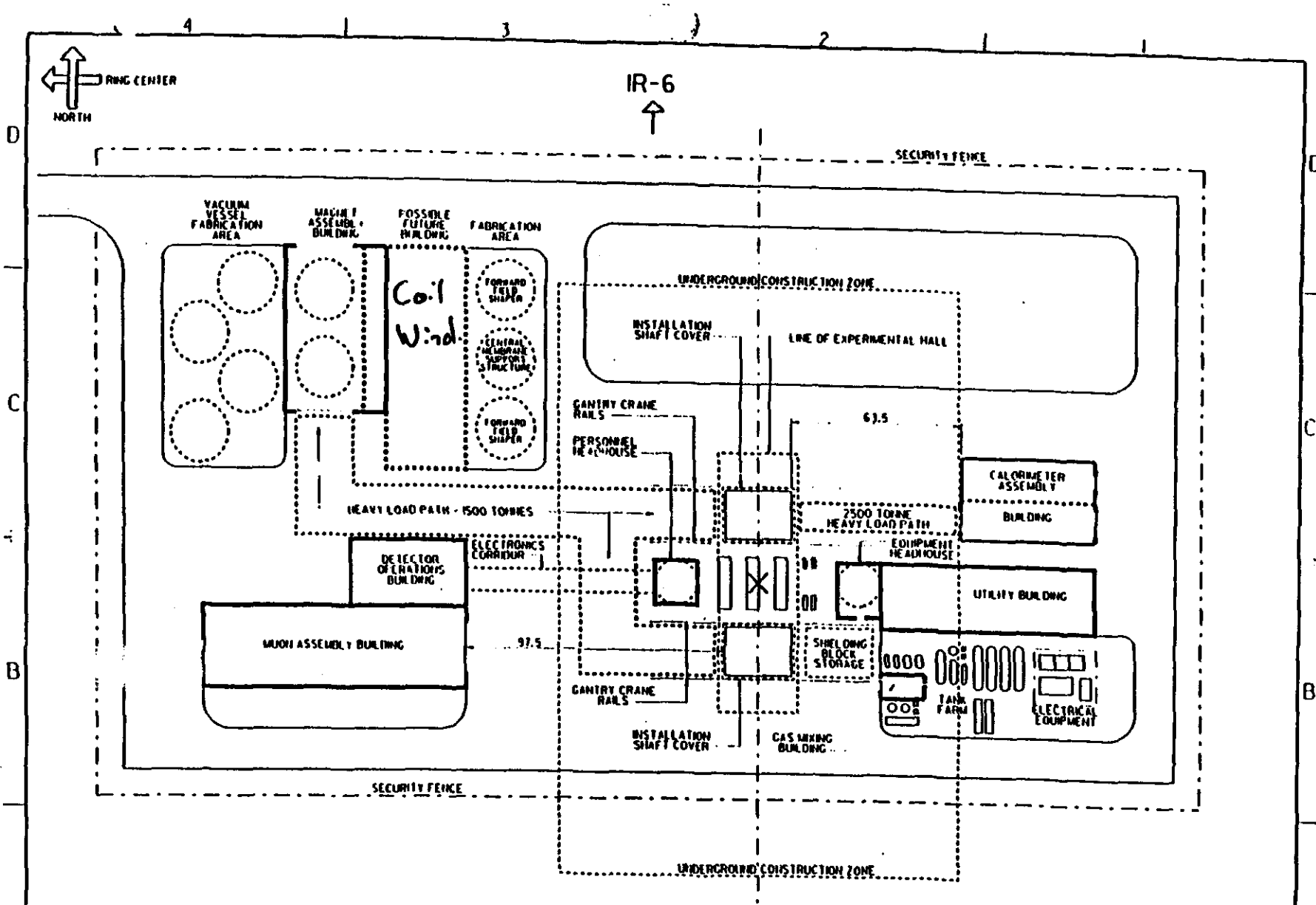
SCHEDULE/MILESTONES

INSTALLATION SEQUENCE REQUIREMENTS

1.	Underground Hall ready (unequipped)	January, 1996
2.	Install Magnet Rails	January, 1996
3	Underground Hall completed	April, 1996
4.	Install Magnet Flux Concentrator (south)	May, 1996
5.	Install Magnet Half Coil (south)	May, 1996
6.	Install Central Membrane	June, 1996
7.	Install Magnet Half Coil (north)	June, 1996
8.	Install Magnet Flux Concentrator (north)	June, 1996
9.	Test Magnet Systems	February, 1997
10.	Map Magnet Field	March, 1997
11.	Install Calorimeter	June, 1997
12.	Install Muon Barrel	September, 1997
13.	Cold Test Calorimeter	October, 1997
14.	Install Tracker	December, 1997
15.	Close Magnet Coil Halves	February, 1998
16.	Install Muon Endcaps	March, 1998
17.	Complete Subsytem Connections	September, 1998
18.	Close Detector	October, 1998
19.	Install Collider Components	October, 1998
20.	Complete Beamline	January, 1999
21.	Complete Tests and Checkouts	March, 1999
22.	Commission Collider	April, 1999
23.	Detector Ready for Physics	October 1999

Still Conflicts to Resolve

Source: MH
Update



SITE PLAN

DIMENSIONS ARE SHOWN IN METERS UNLESS NOTED OTHERWISE.

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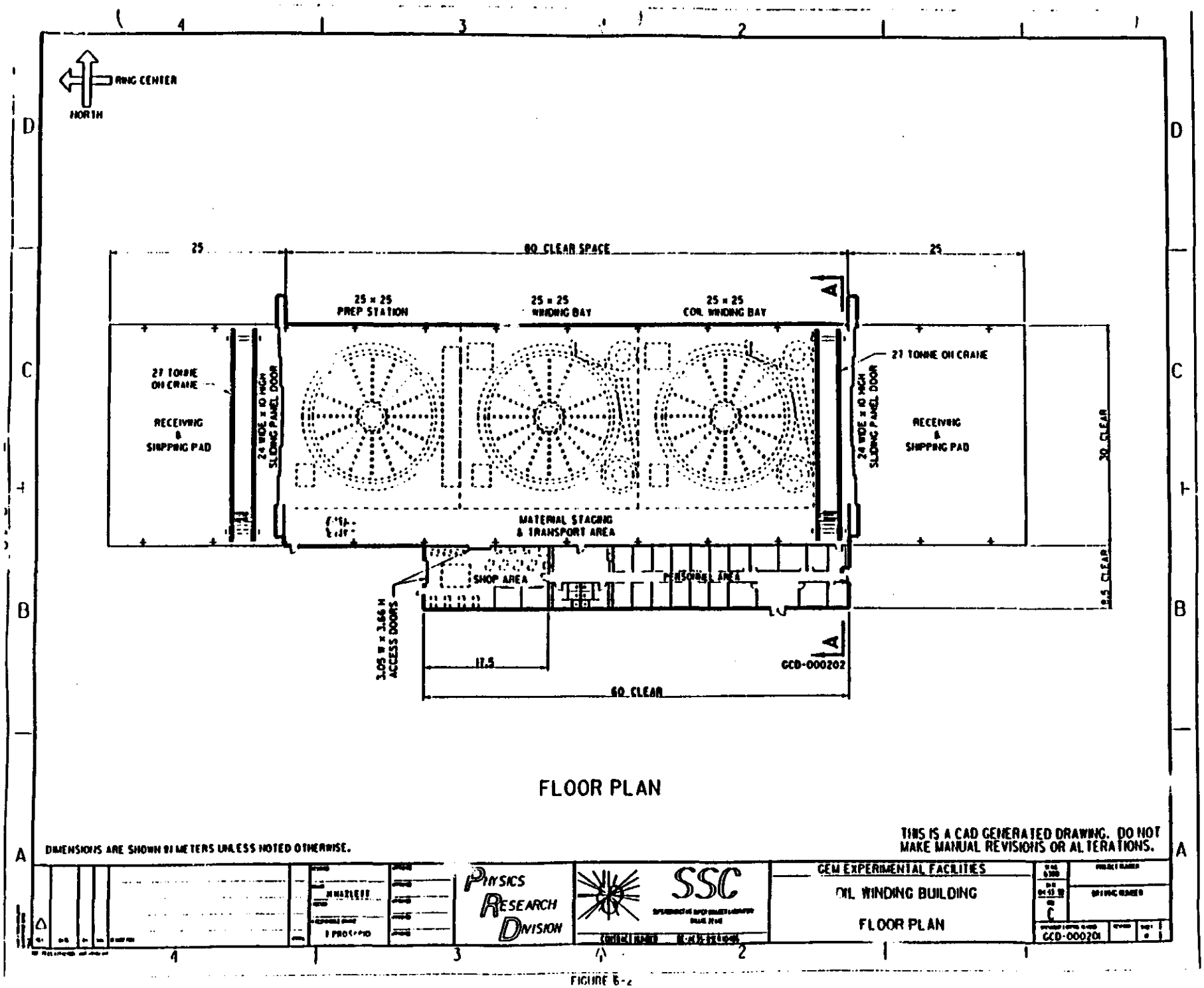
GEM EXPERIMENTAL FACILITIES

IR-5

SITE PLAN

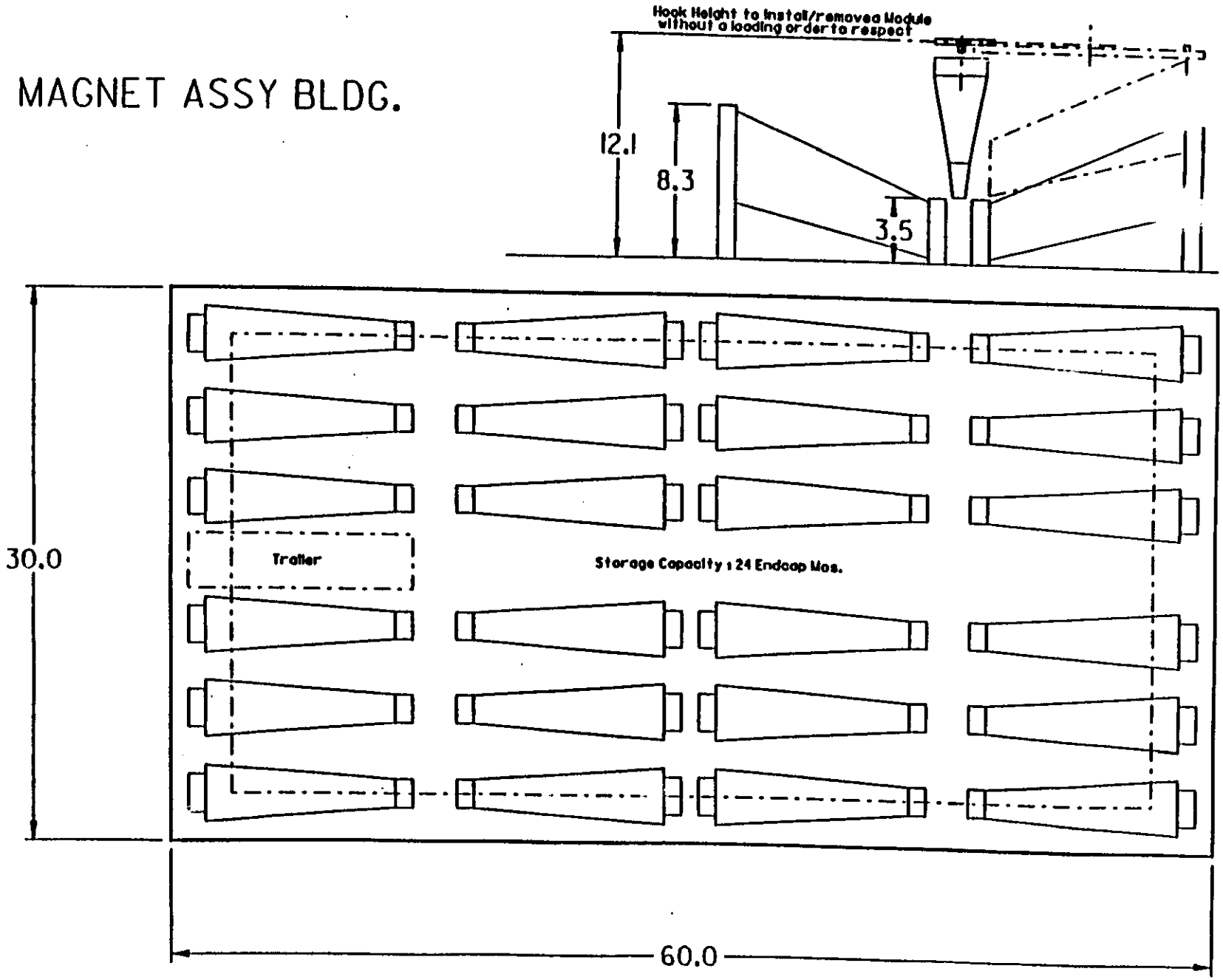
GCD-00043



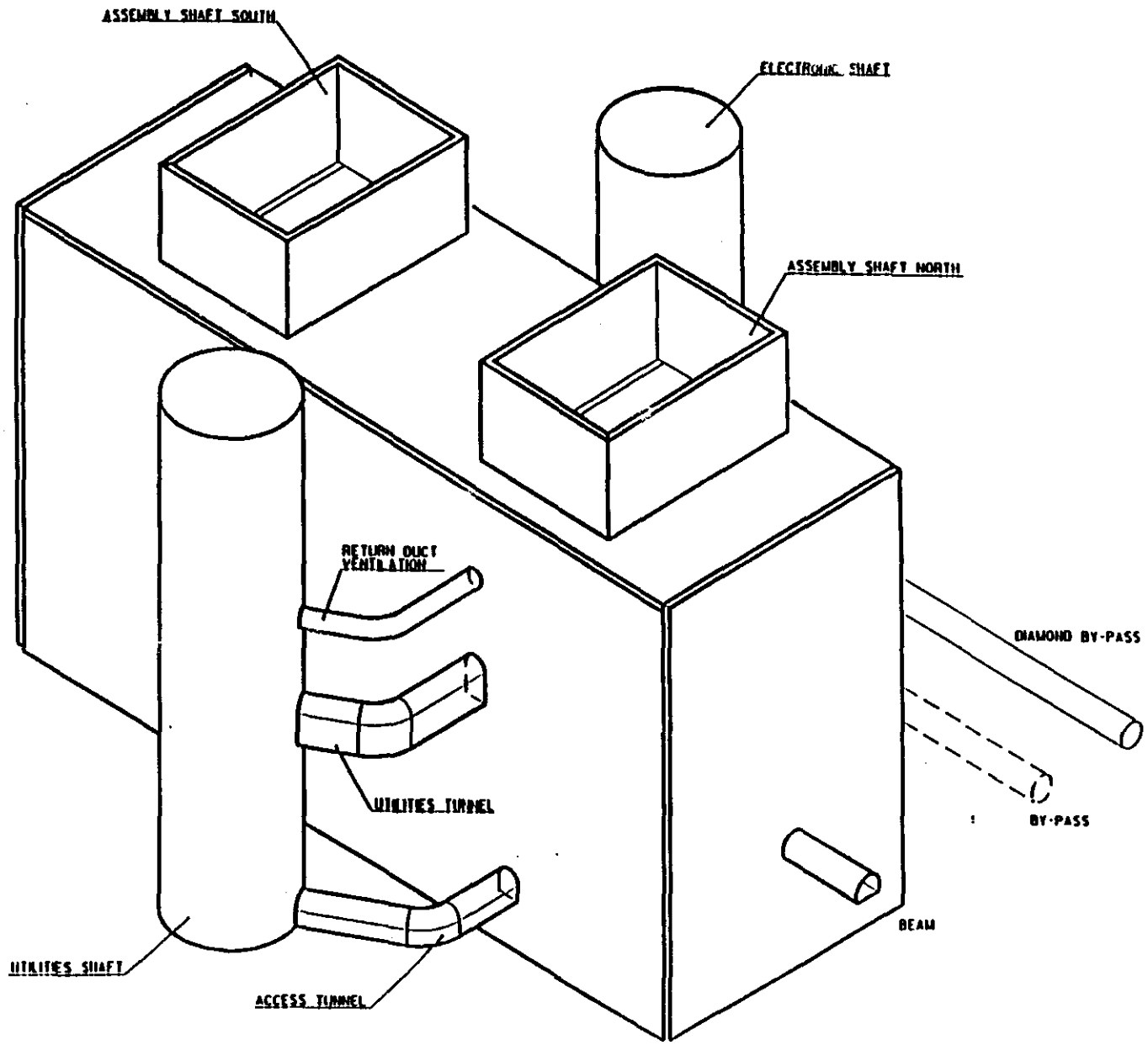
FLOOR PLAN

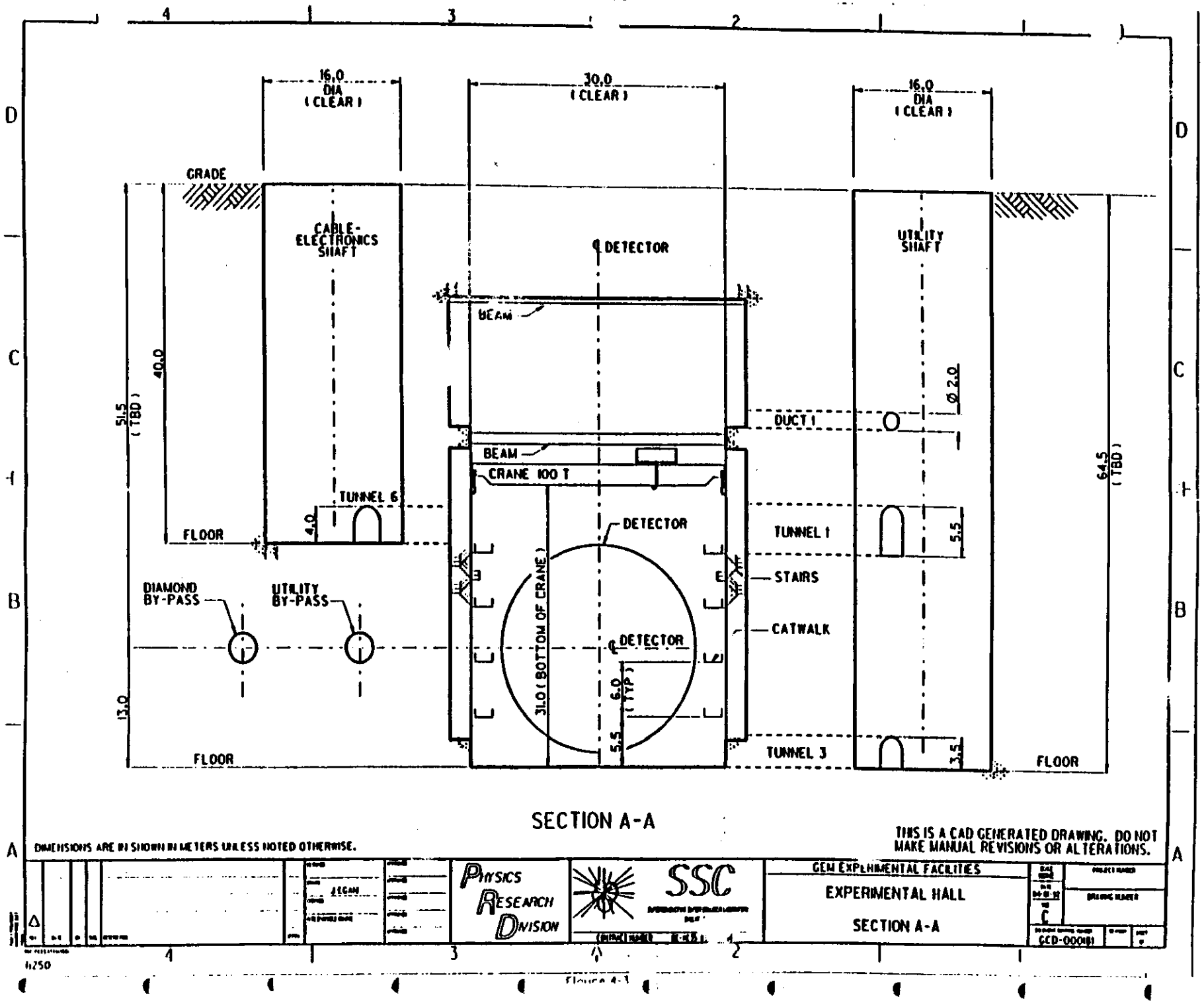
FIGURE 6-2

MAGNET ASSY BLDG.



GEM'S EXPERIMENTAL HALL




16.0 DIA (CLEAR)
30.0 (CLEAR)
16.0 DIA (CLEAR)
GRADE
CABLE-ELECTRONICS SHAFT
DETECTOR
UTILITY SHAFT
BEAM
40.0
51.5 (TBD)
Ø 2.0
DUCT 1
BEAM
CRANE 100 T
64.5 (TBD)
TUNNEL 6
4.0
FLOOR
DETECTOR
TUNNEL 1
5.5
STAIRS
DIAMOND BY-PASS
UTILITY BY-PASS
31.0 (BOTTOM OF CRANE)
CATWALK
DETECTOR
6.0 (TYP)
13.0
5.5
TUNNEL 3
3.5
FLOOR
FLOOR
SECTION A-A
DIMENSIONS ARE IN SHOWN IN METERS UNLESS NOTED OTHERWISE.
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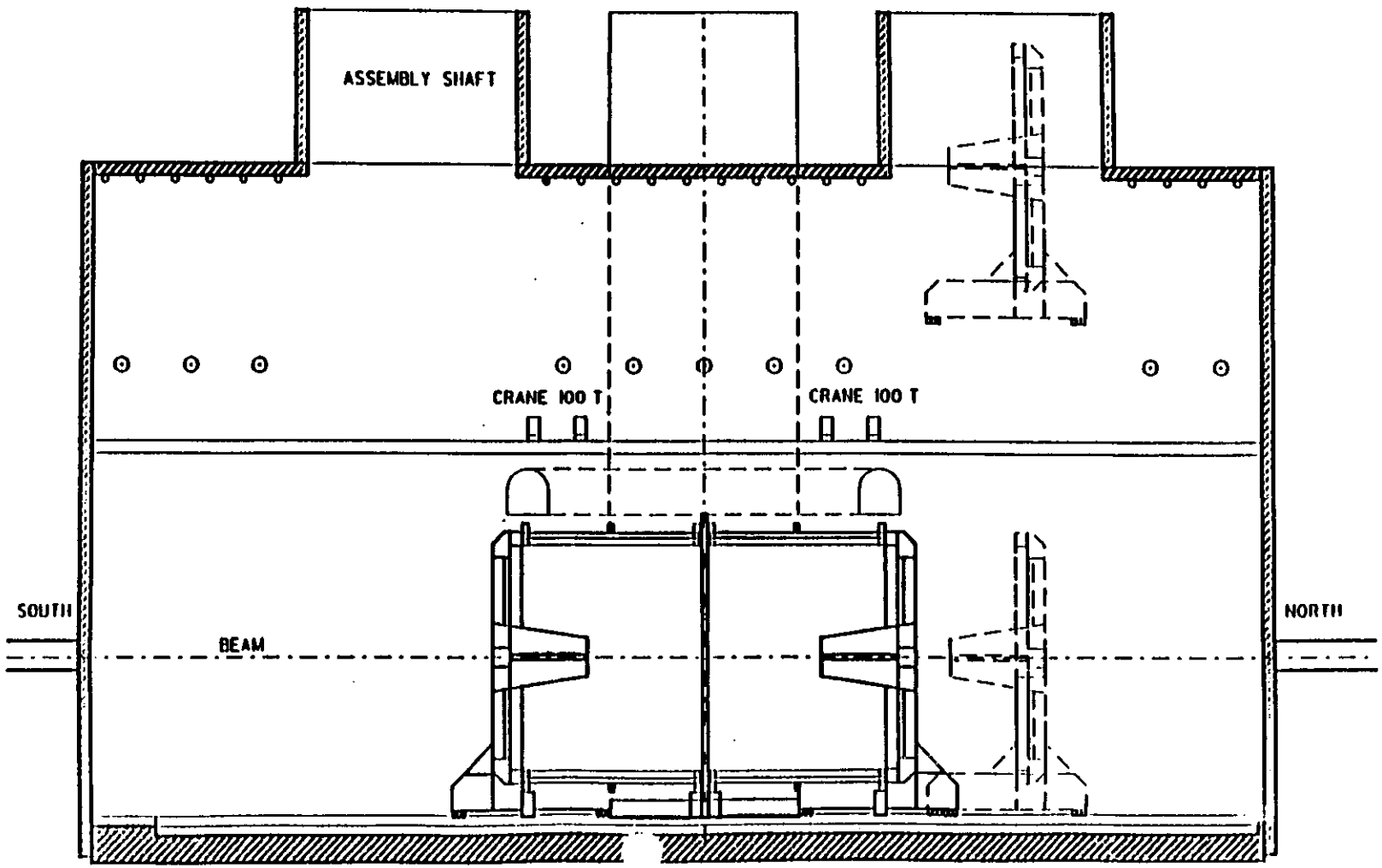
SSC
GEM EXPERIMENTAL FACILITIES
EXPERIMENTAL HALL
SECTION A-A
CCD-00081
1:250

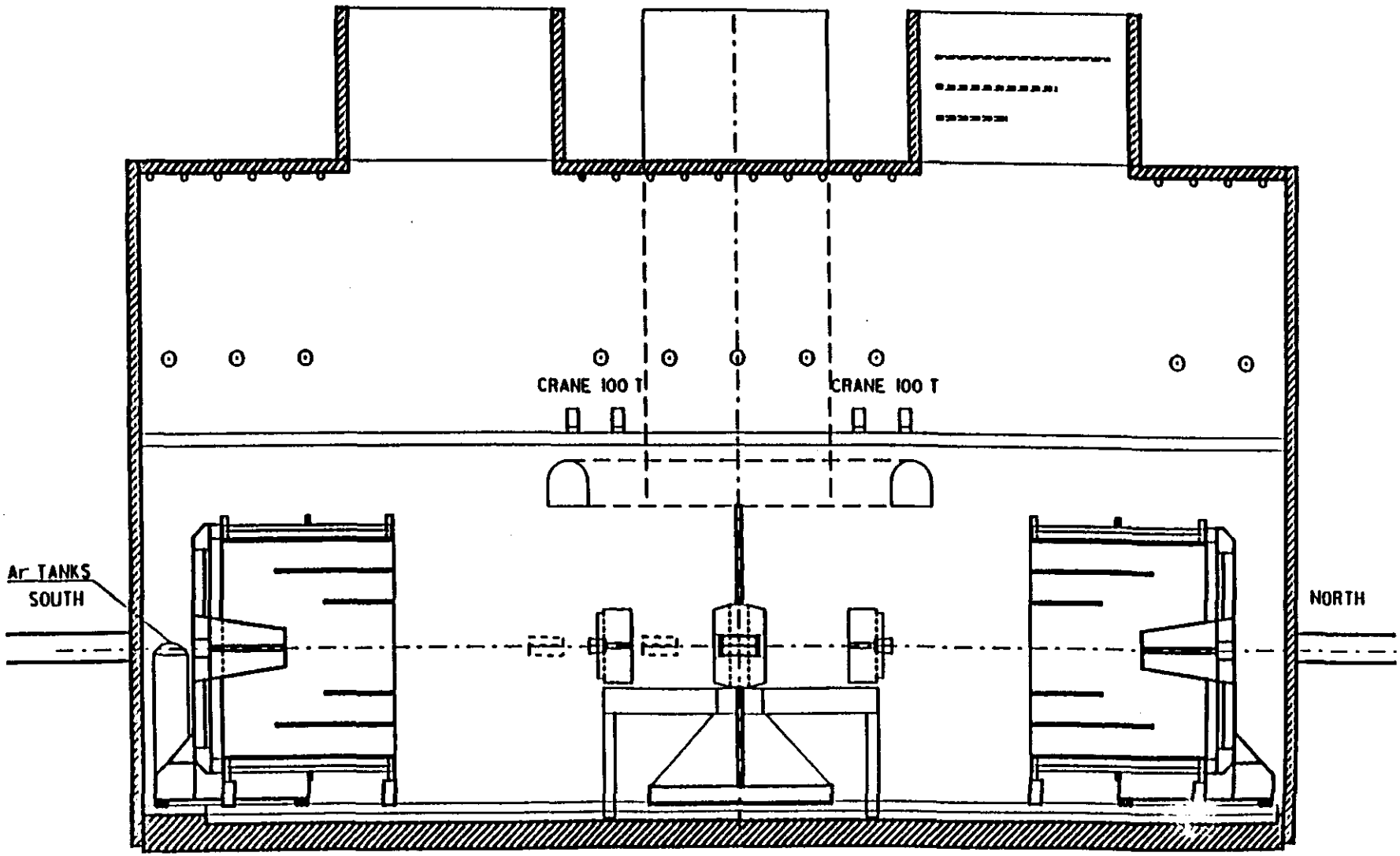
Figure 4-1

PHASE 6
INSTALL FORWARD FIELD SHAPER _NORTH

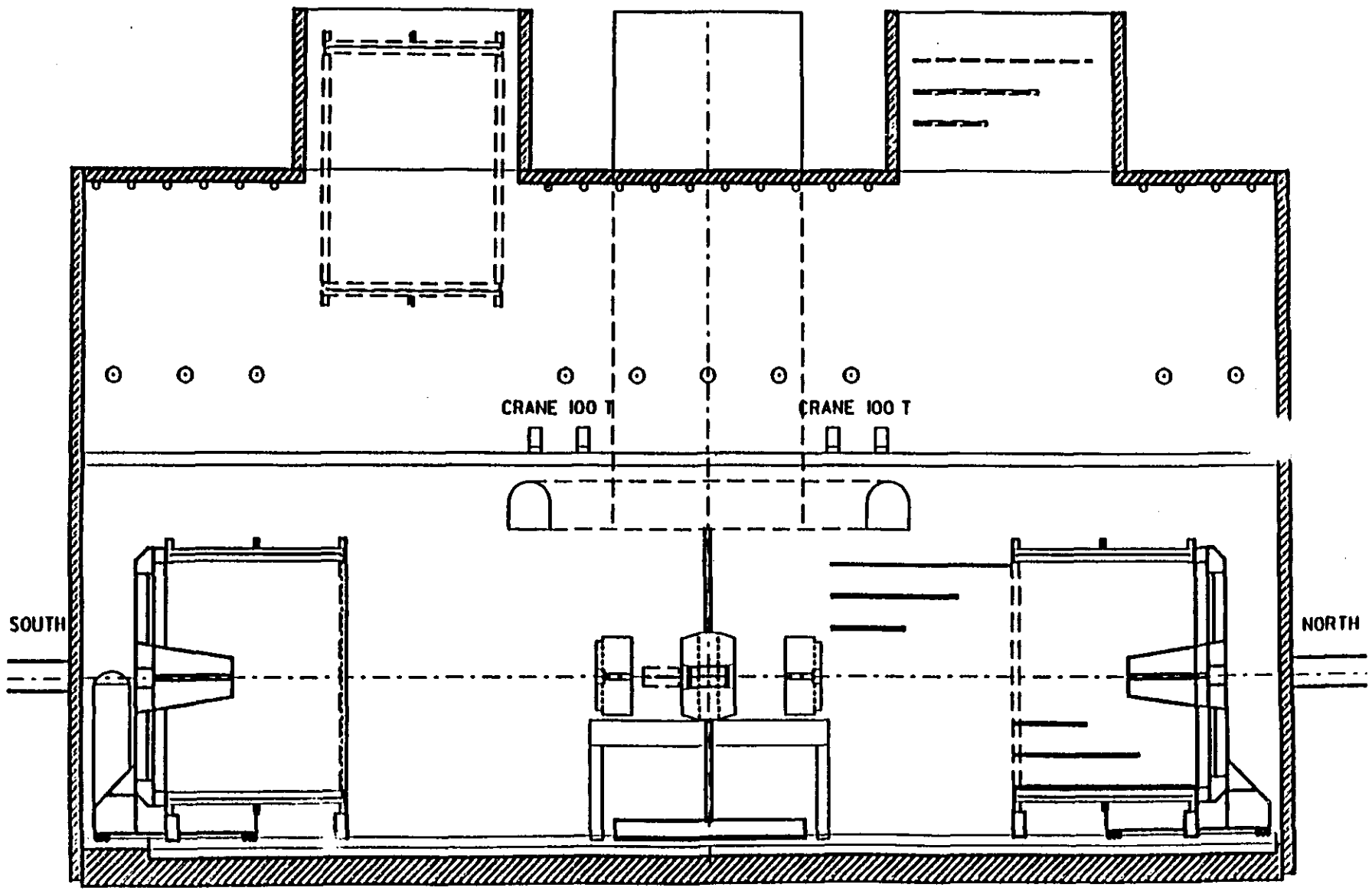


PHASE 12

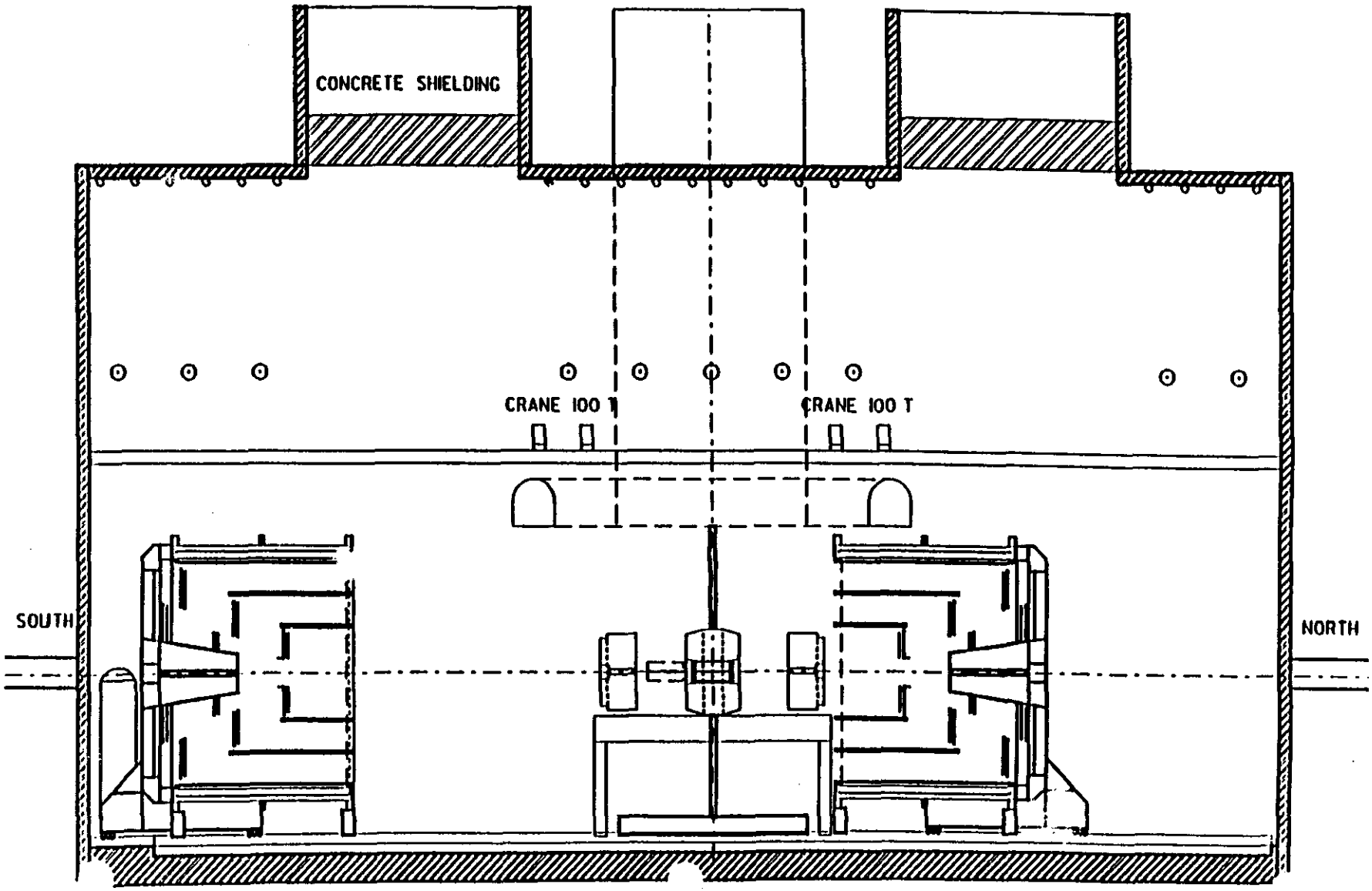
INSTALL MUON BARREL NORTH - TRACKER VACUUM PIPE (BERYLLIUM PART)



AL TERNATE MAGNET INS LLATION

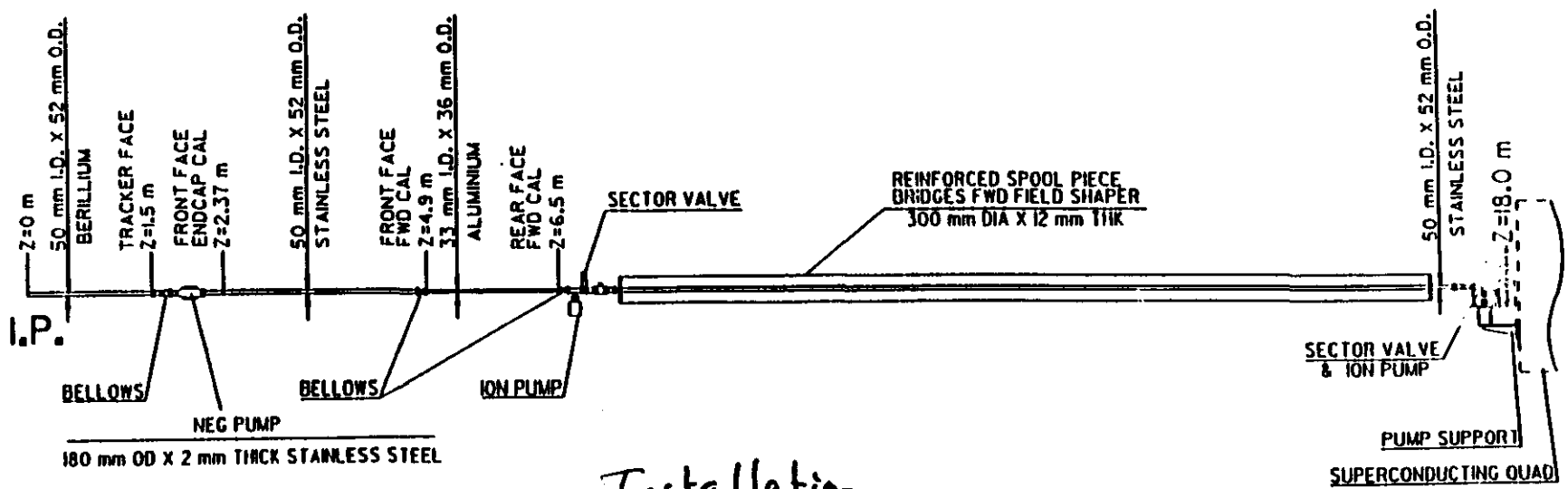


TRACKER MAINTENANCE / INSTALLATION



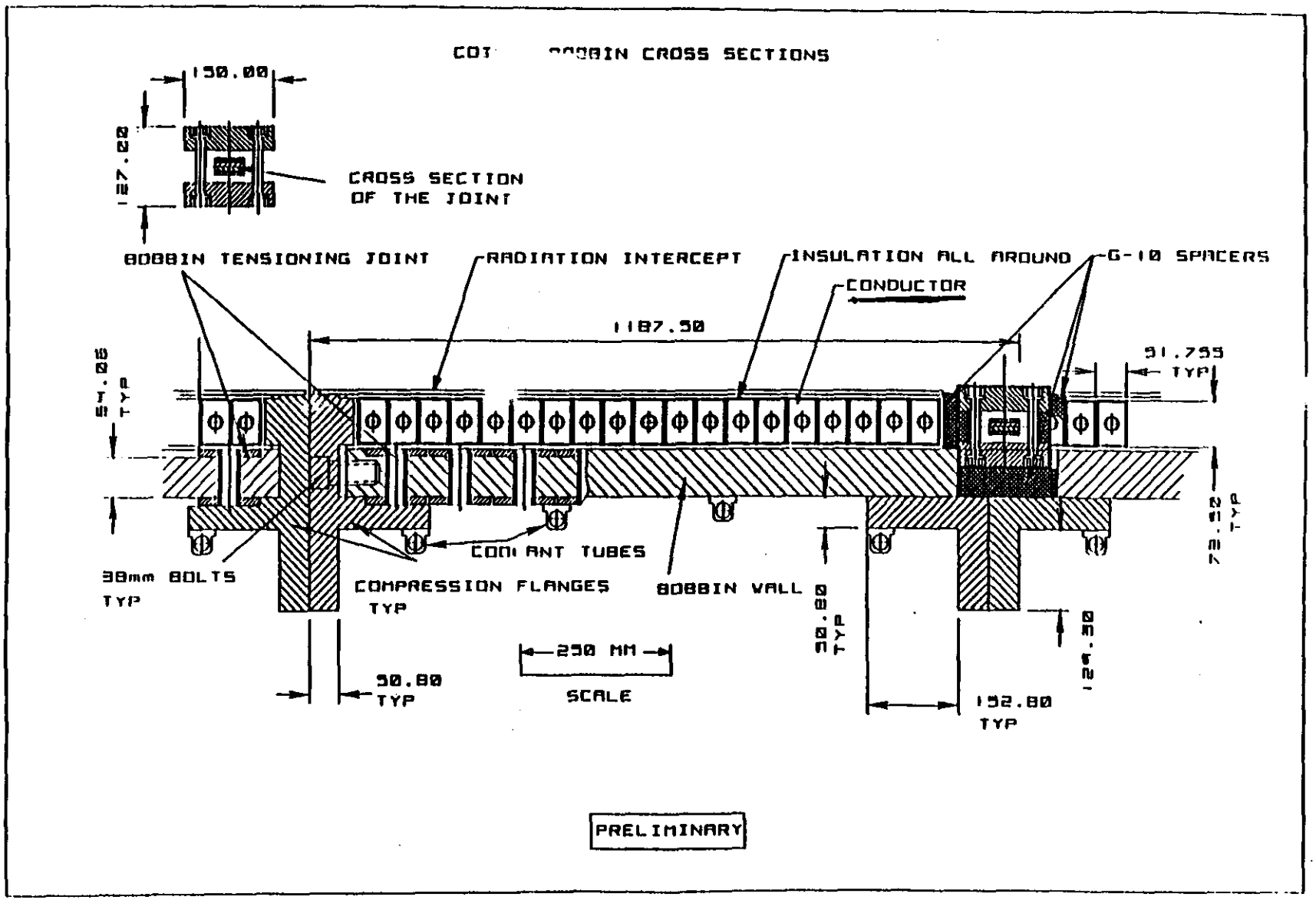
BEAM LINE LAYOUT

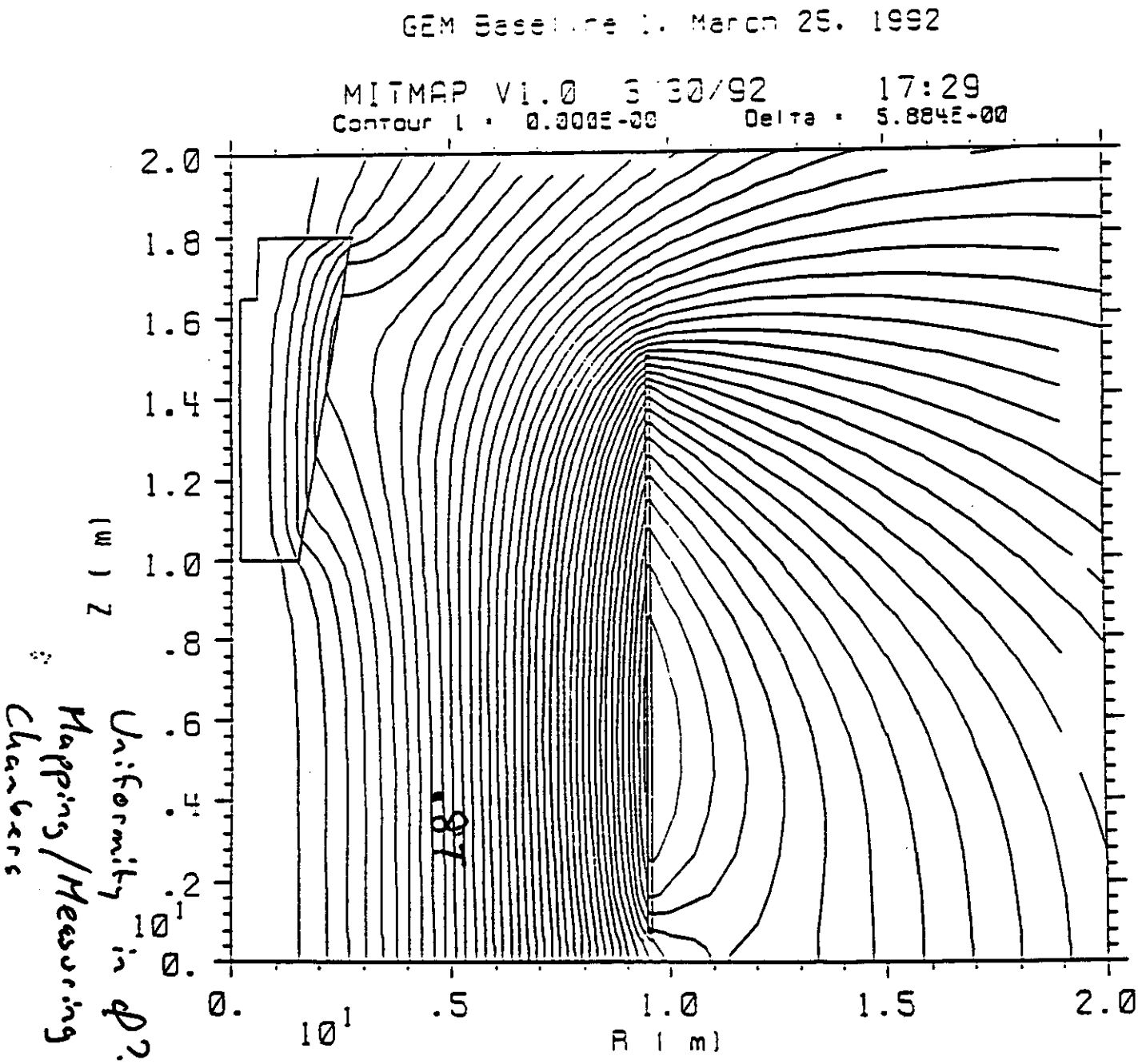
FOR GEM DETECTOR



Installation
Getter Pumps
Forward Calorimeter

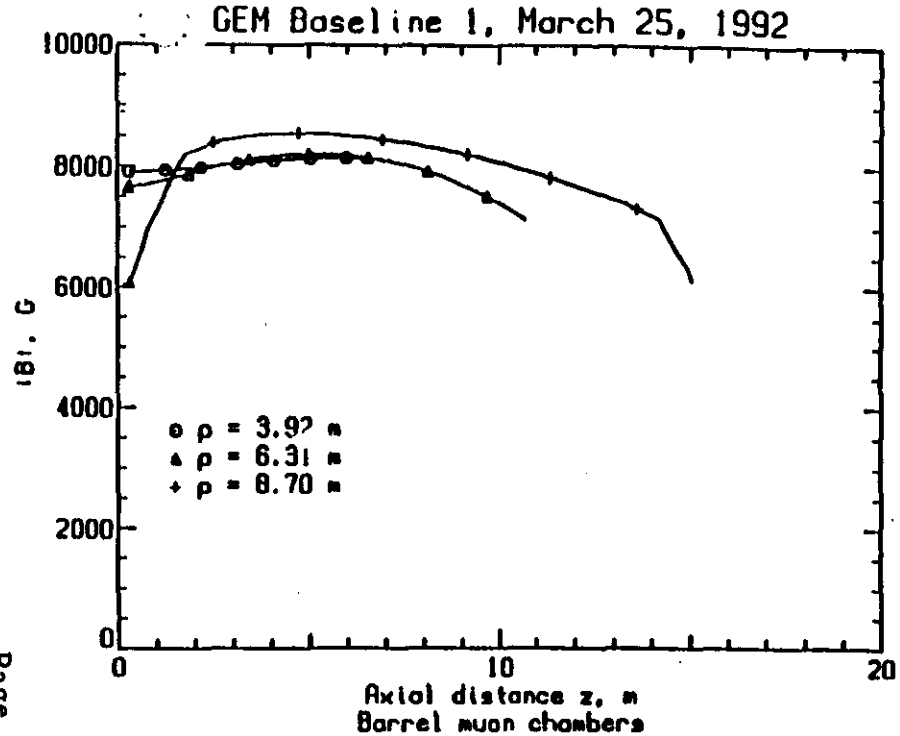
(GEMDP020326ZC)

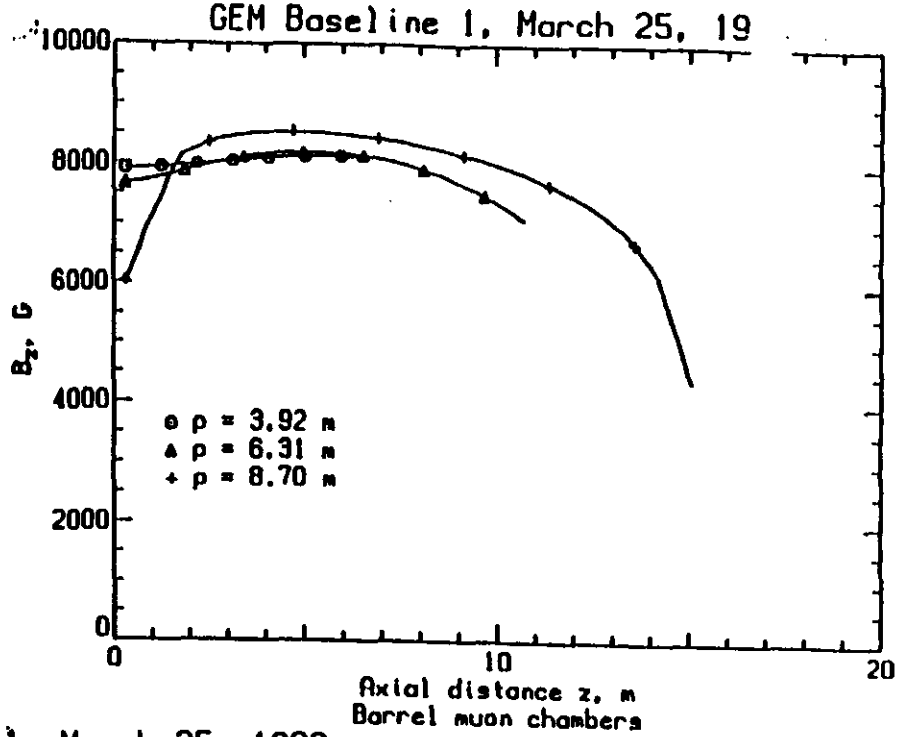

COI BOBBIN CROSS SECTIONS
150.00
127.00
CROSS SECTION
OF THE JOINT
BOBBIN TENSIONING JOINT
RADIATION INTERCEPT
INSULATION ALL AROUND
G-10 SPACERS
CONDUCTOR
1187.50
51.755
TYP
54.05
TYP
73.52
TYP
38mm BOLTS
TYP
COMPRESSION FLANGES
TYP
BOBBIN WALL
50.80
TYP
124.30
250 MM
SCALE
50.80
TYP
152.80
TYP
PRELIMINARY

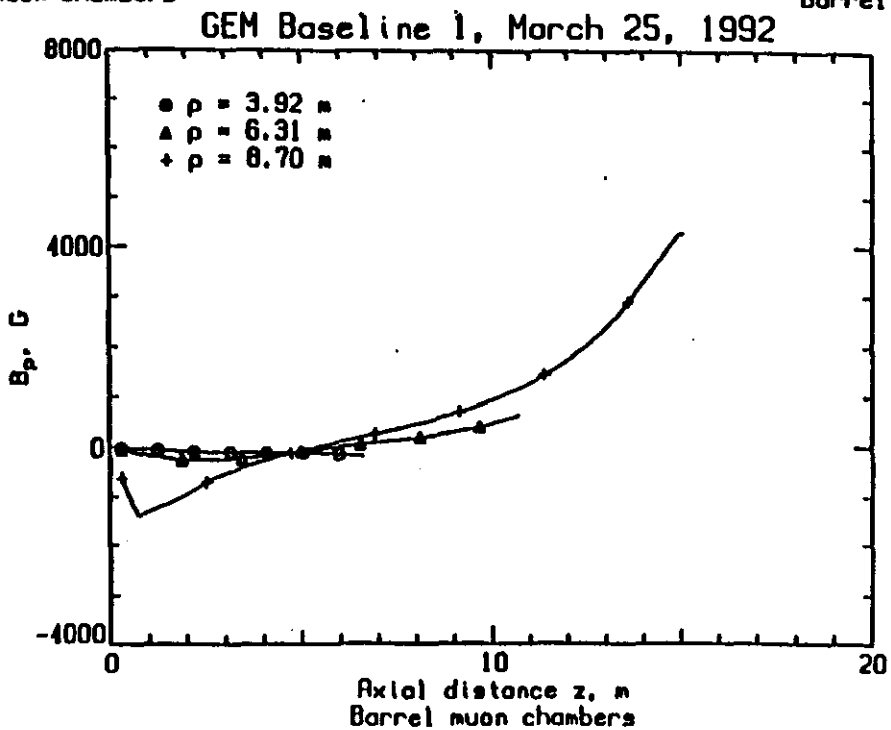


CONTOURS OF CONSTANT FLUX

Figure 1: Lines of constant magnetic flux in a meridional half-plane; the figure is rotationally symmetric about the horizontal axis and has mirror symmetry about $Z = 0$. Note: the beam axis, Z, is vertical while the transverse axis, R is horizontal. Both axes extend from 0 to 20 m and the field is in gauss. A sketch of the superconducting winding and the forward field shaper is also shown.

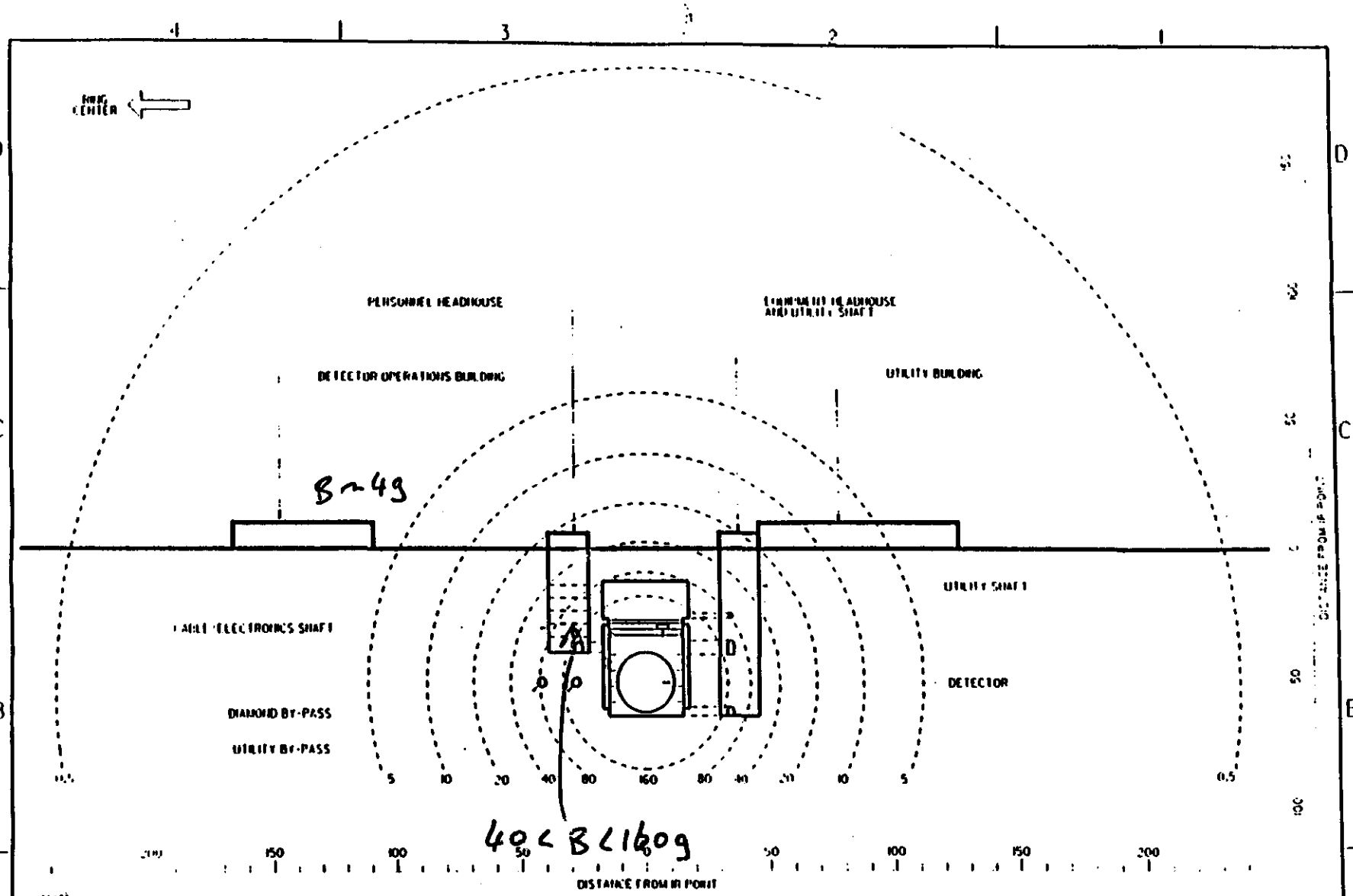






Plots of the magnetic field along the barrel muon chambers: the total field B, axial component B_z, and radial component B_ρ are shown.

Chamber Performance
Lorentz Angle.


RING CENTER
PERSONNEL HEADHOUSE
DETECTOR OPERATIONS BUILDING
UTILITY BUILDING
UTILITY SHAFT
DETECTOR
DIAMOND BY-PASS
UTILITY BY-PASS
B~49
40<B<160g
DISTANCE FROM IR POINT
NOTE:
EARTH'S GEOMAGNETIC FIELD LEVEL (0.56 G) WAS NOT INCLUDED IN CALCULATING THE FIELD PATTERNS SHOWN.
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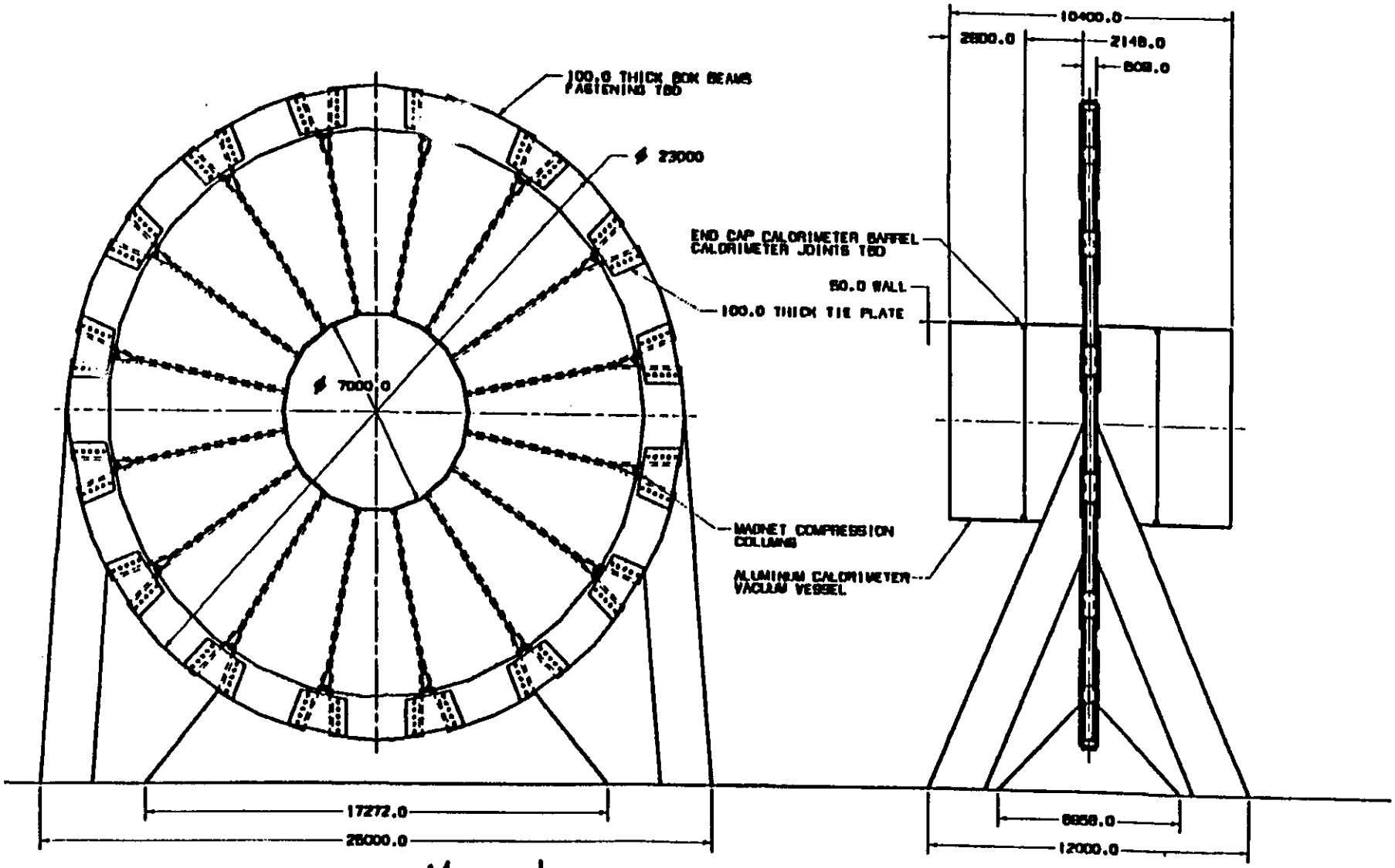
SSC
GEM EXPERIMENTAL FACILITIES
MAGNETIC FIELD PATTERN AT SURFACE
SECTION VIEW AT IR-5

INTEGRAL CALORIMETER SUPPORT MEMBRANE



Magnetic
Legs?
Vibrational Stability

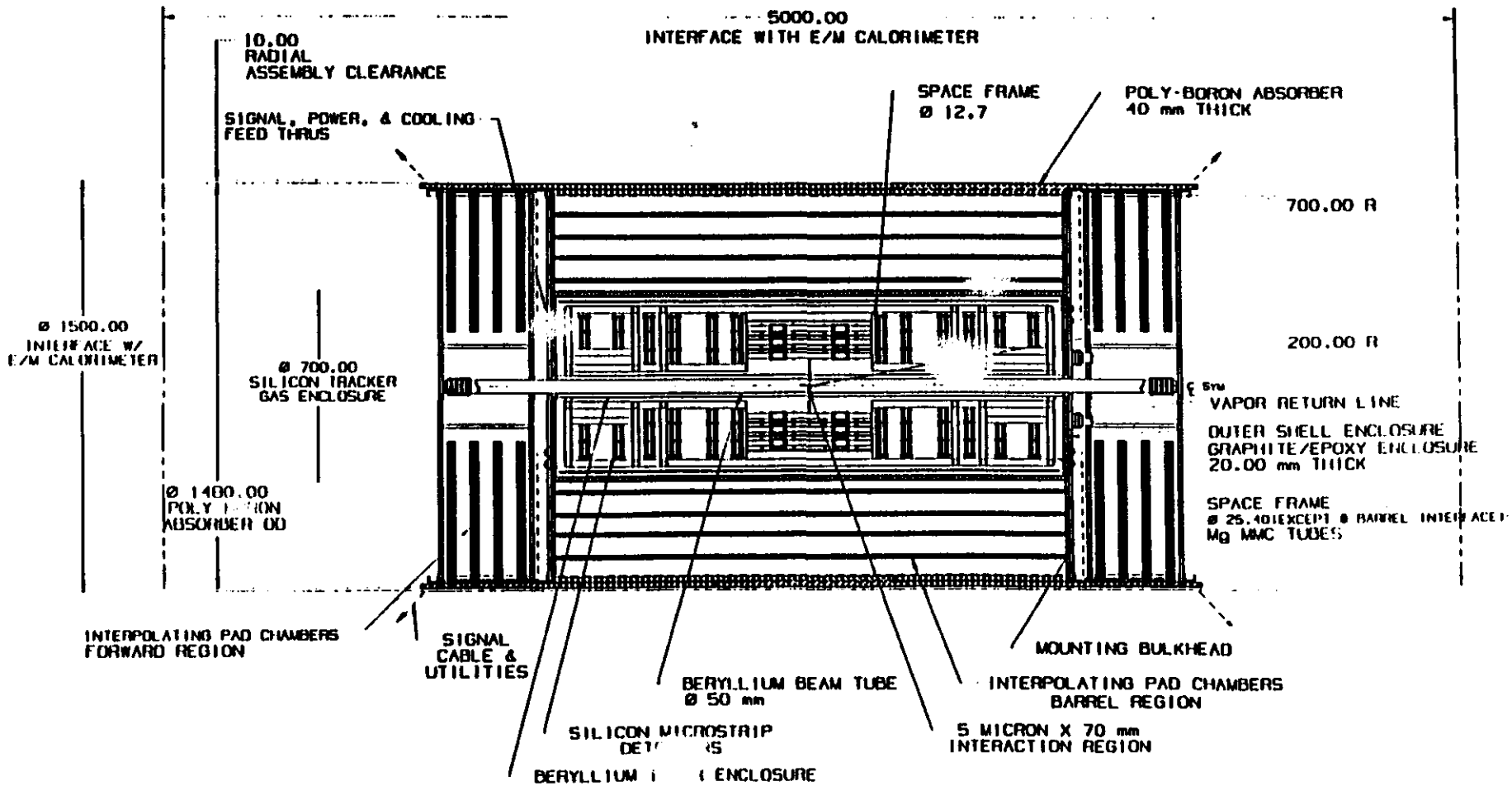
LOS ALAMOS

MEE-12
MECHANICAL AND ELECTRONIC
ENGINEERING DIVISION

Most Progress

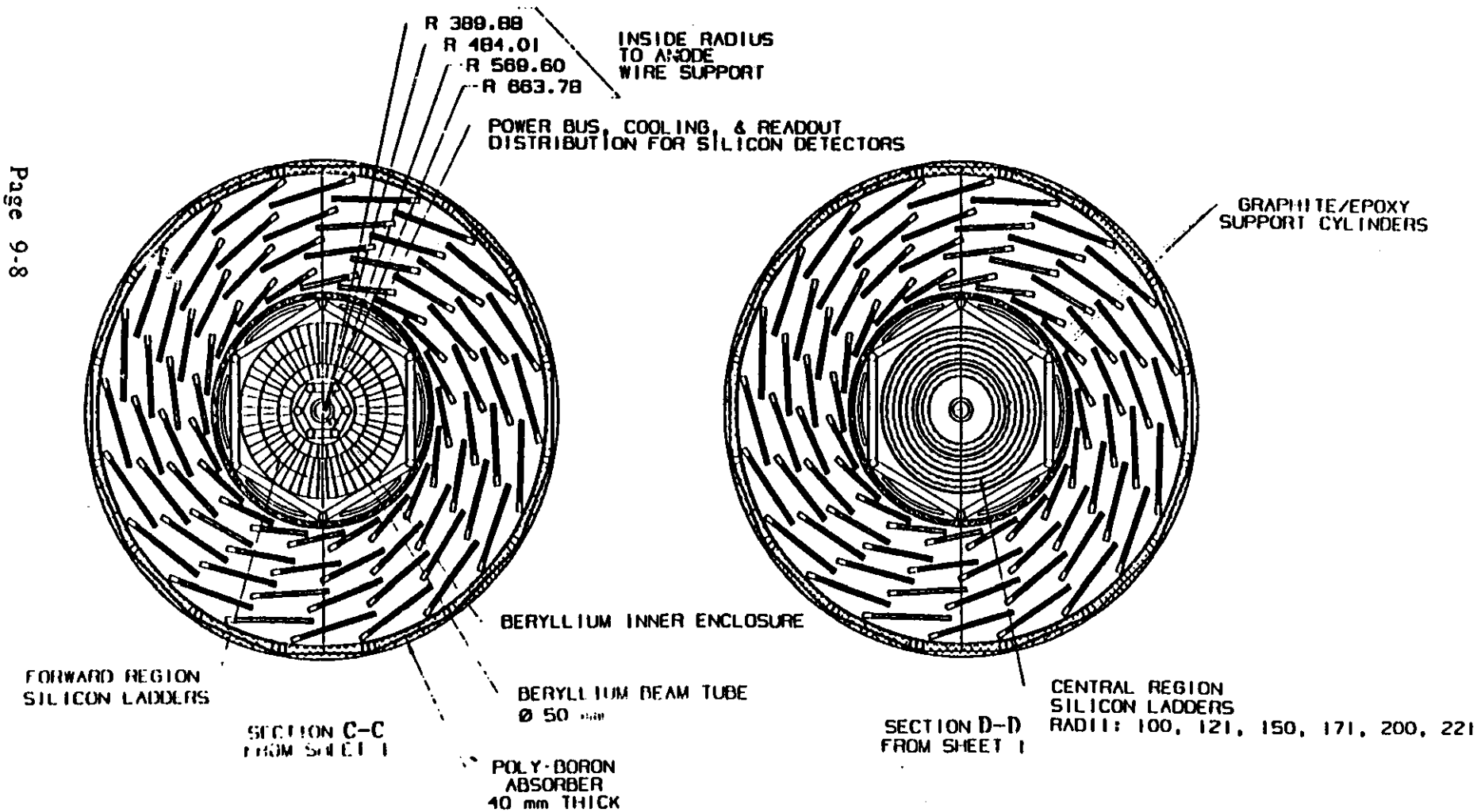
X_0

Electronics - Rad Hardness
- Cost



GEM CENTRAL TRACKI

GEMVB-128-JV

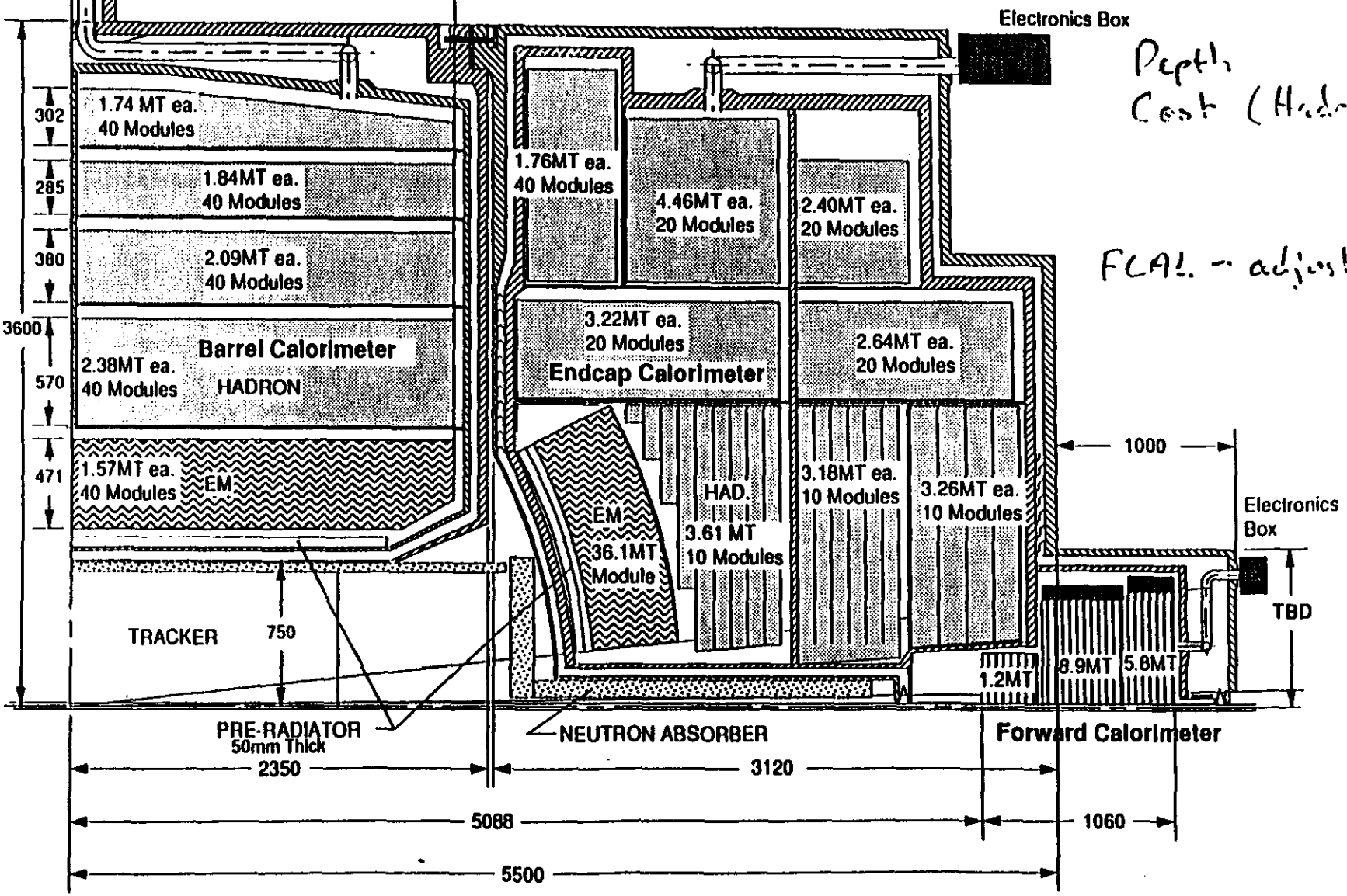

R 389.88
R 484.01
R 569.60
R 663.78
INSIDE RADIUS
TO ANODE
WIRE SUPPORT
POWER BUS, COOLING, & READOUT
DISTRIBUTION FOR SILICON DETECTORS
GRAPHITE/EPOXY
SUPPORT CYLINDERS
BERYLLIUM INNER ENCLOSURE
FORWARD REGION
SILICON LADDERS
BERYLLIUM BEAM TUBE
Ø 50 mm
SECTION C-C
FROM SHEET 1
POLY-BORON
ABSORBER
40 mm THICK
SECTION D-D
FROM SHEET 1
CENTRAL REGION
SILICON LADDERS
RADII: 100, 121, 150, 171, 200, 221

GEM Liquid Argon Calorimeter

1/4 Section "Off Vertical"
Copper Hadron Absorber

Shows General Configuration with Electronic feed throughs

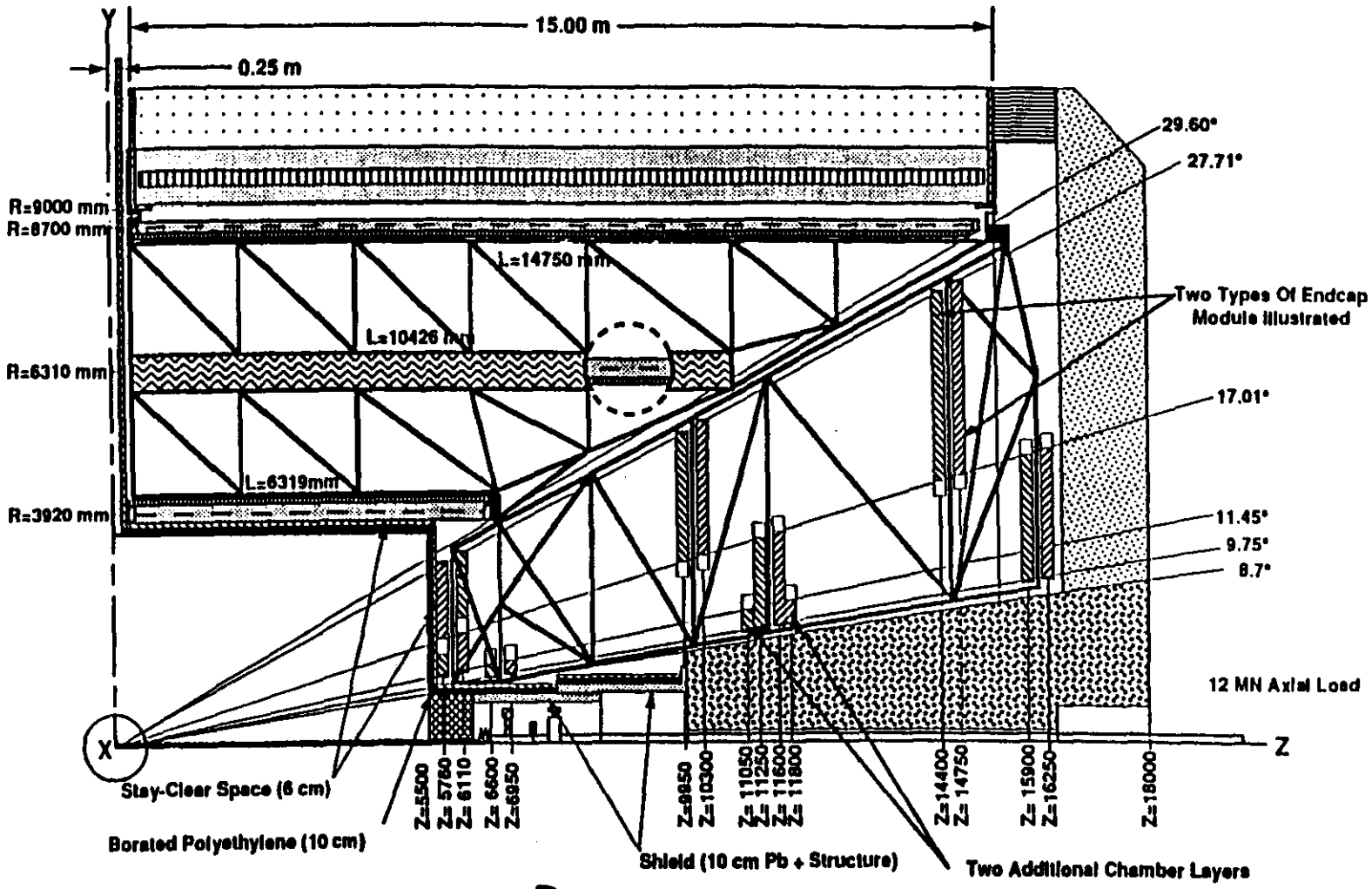
CENTRAL BARREL CALORIMETER WEIGHT = 775 MT
ENDCAP CALORIMETER WEIGHT = 505 MT each
TOTAL CALORIMETER WEIGHT = 1785 MT
Weights have zero Margin



Depth
Cost (Hadron)

FCAL - adjustable?

LLMason 3/23/92



Alignment – Align or Measure?
Module – Overlap/Acceptance
– Independence

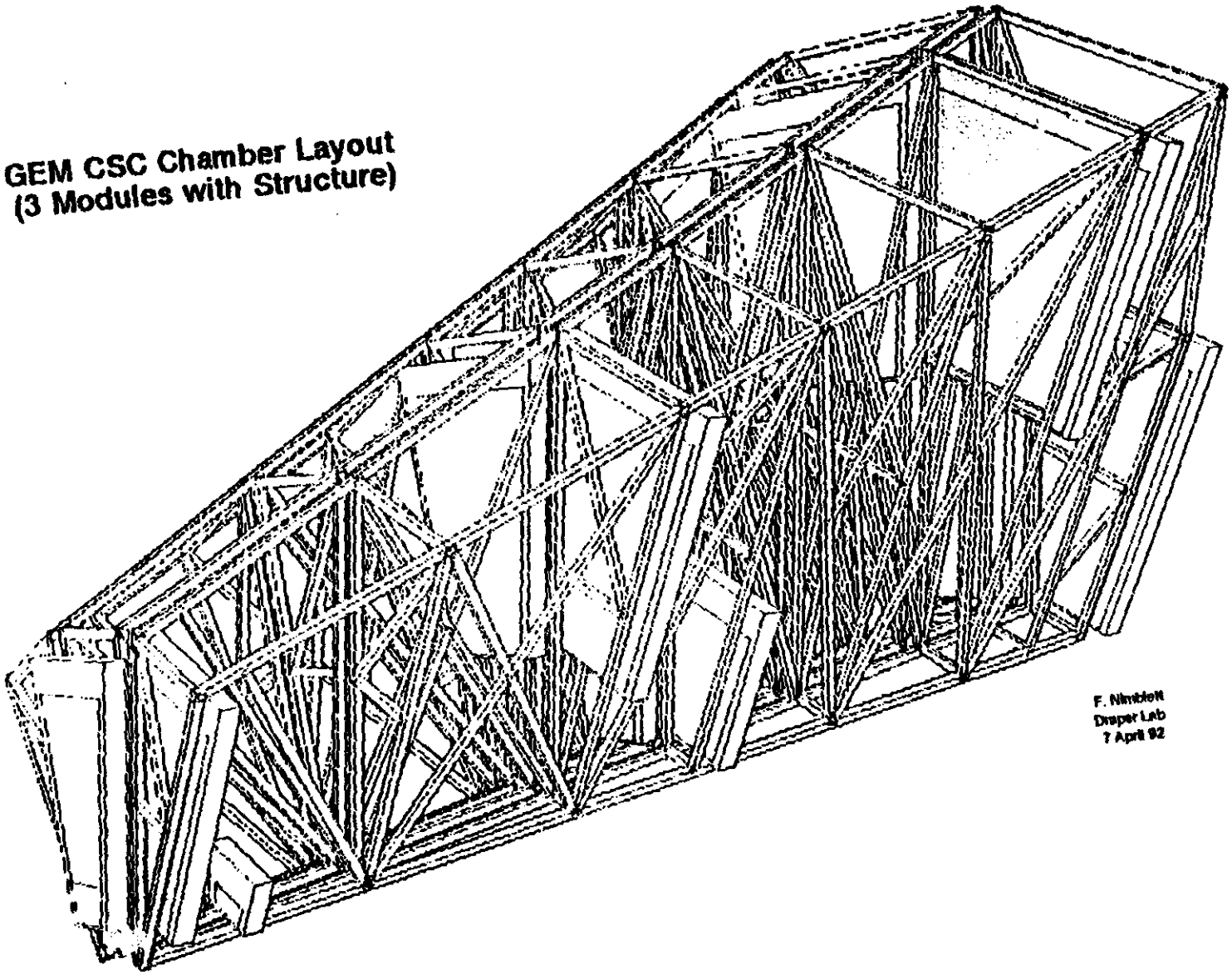
GEM MUON SYSTEM (BASELINE)

(4/8/4 layers for Theta = 9.75° to 11.45°)

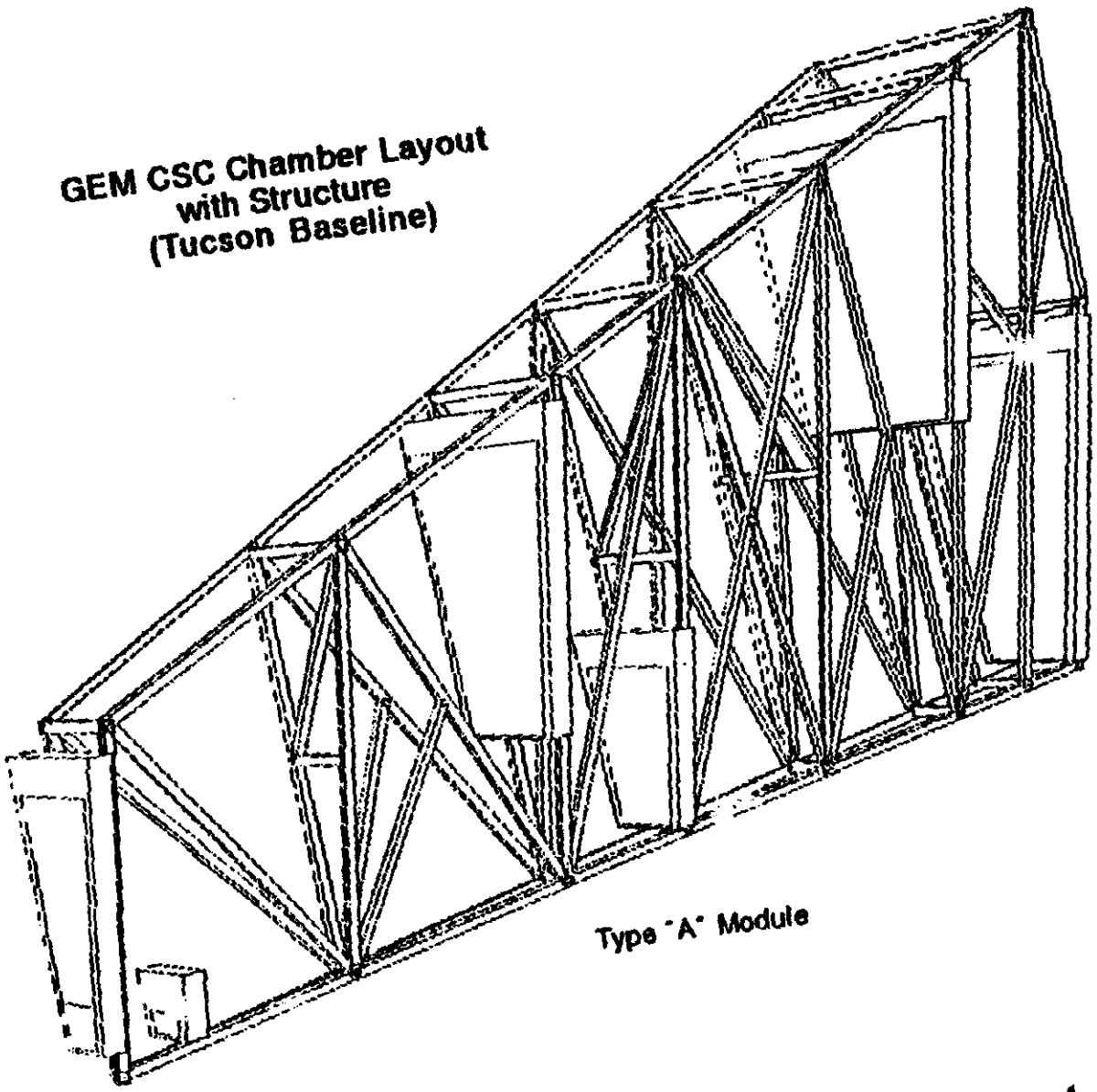
Draper Laboratory	
GEM Muon System (BASELINE) 4/8/4 Layers 9.75° to 11.45°	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0009	3/27/92
Approved by:	

Fig. 3.1

GEM CSC Chamber Layout
(3 Modules with Structure)



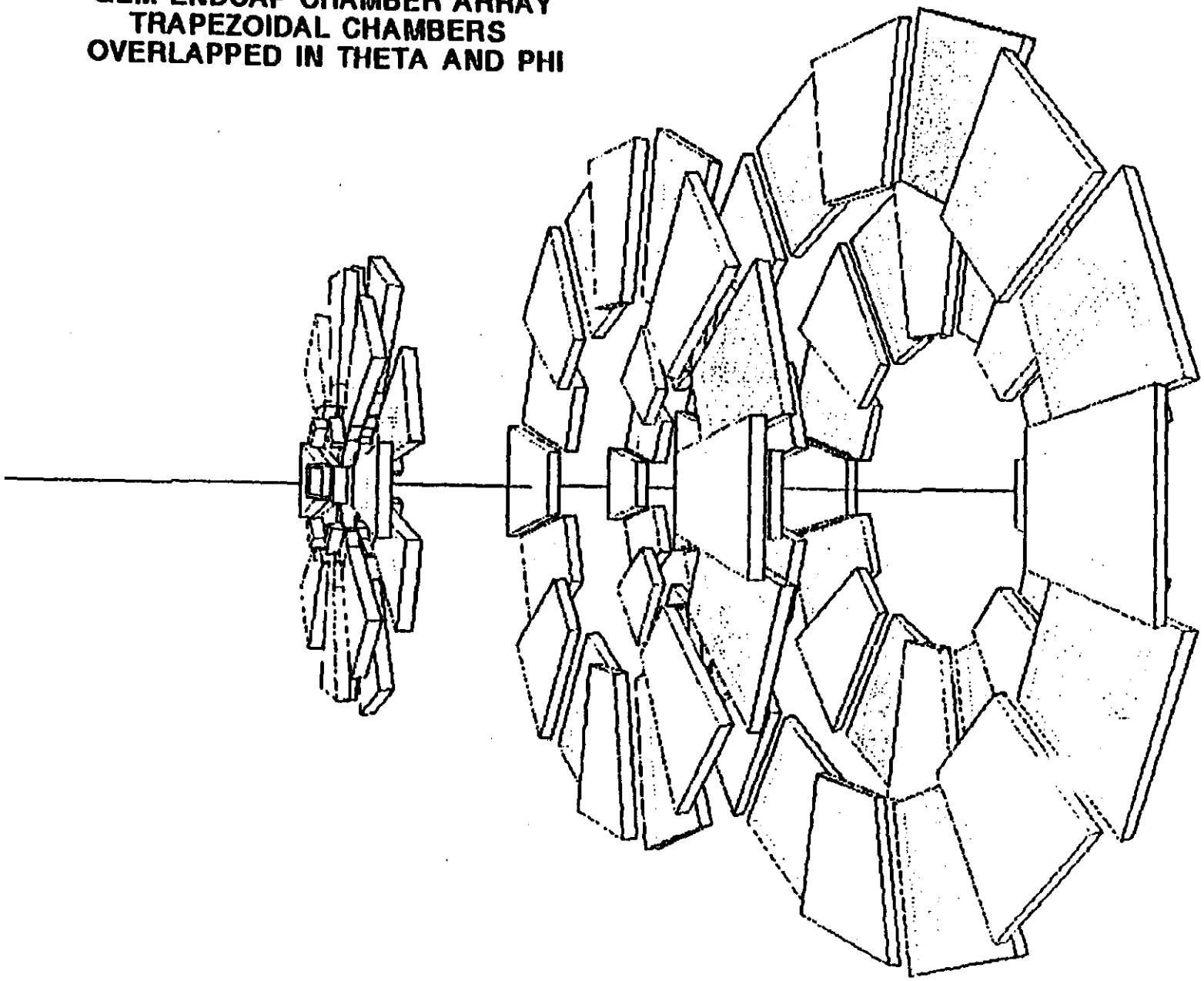
GEM CSC Chamber Layout with Structure (Tucson Baseline)



Type "A" Module

F. Nimblett
Draper Lab.
7 April 92

GEM ENDCAP CHAMBER ARRAY
TRAPEZOIDAL CHAMBERS
OVERLAPPED IN THETA AND PHI



F. Nimblett
Draper lab
7 April 92

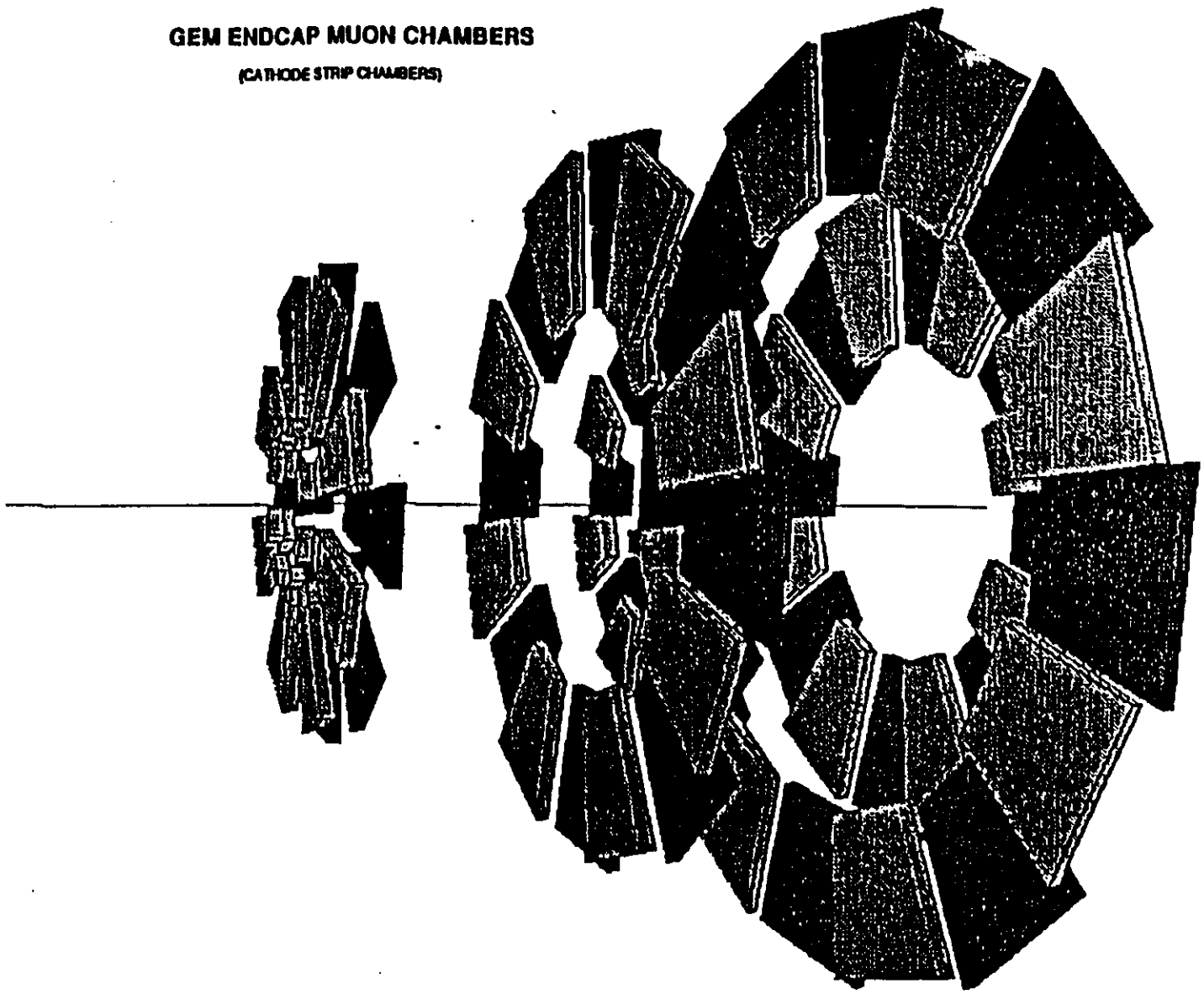
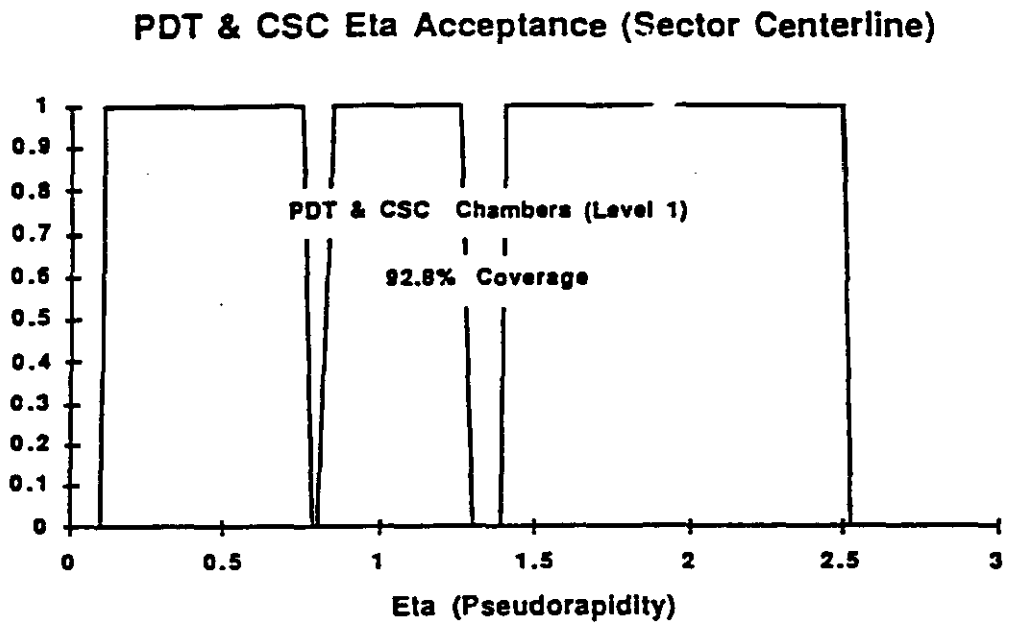

GEM ENDCAP MUON CHAMBERS
(CATHODE STRIP CHAMBERS)
DePiero/Nimblett
Draper Laboratory
18 March 1992

Fig. 3.5


PDT & CSC Eta Acceptance (Sector Centerline)
PDT & CSC Chambers (Level 1)
92.8% Coverage
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
Eta (Pseudorapidity)

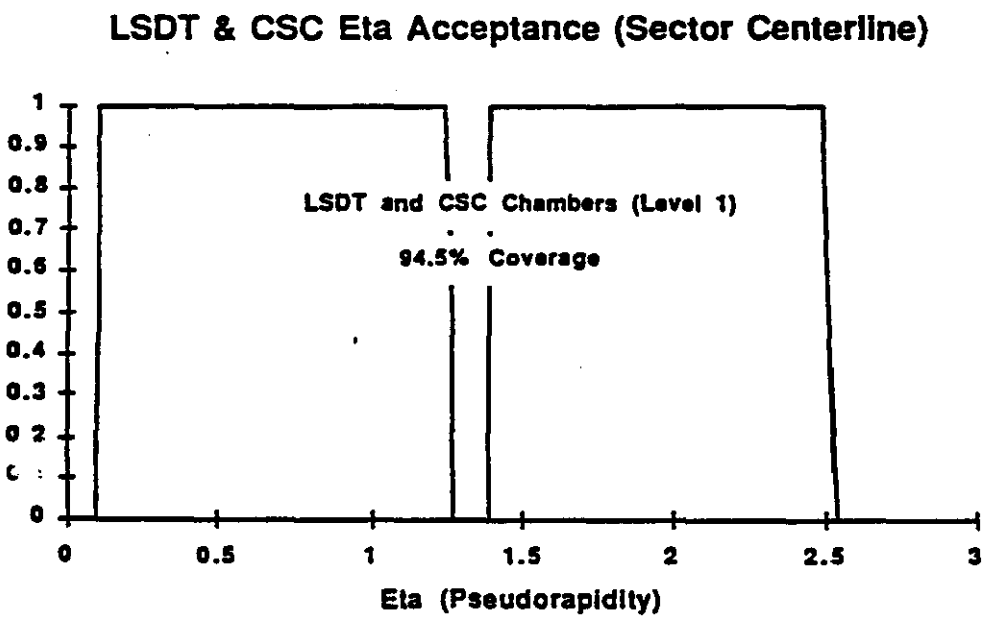

LSDT & CSC Eta Acceptance (Sector Centerline)
LSDT and CSC Chambers (Level 1)
94.5% Coverage
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
0
0.5
1
1.5
2
2.5
3
Eta (Pseudorapidity)

Fig. 3.6 a

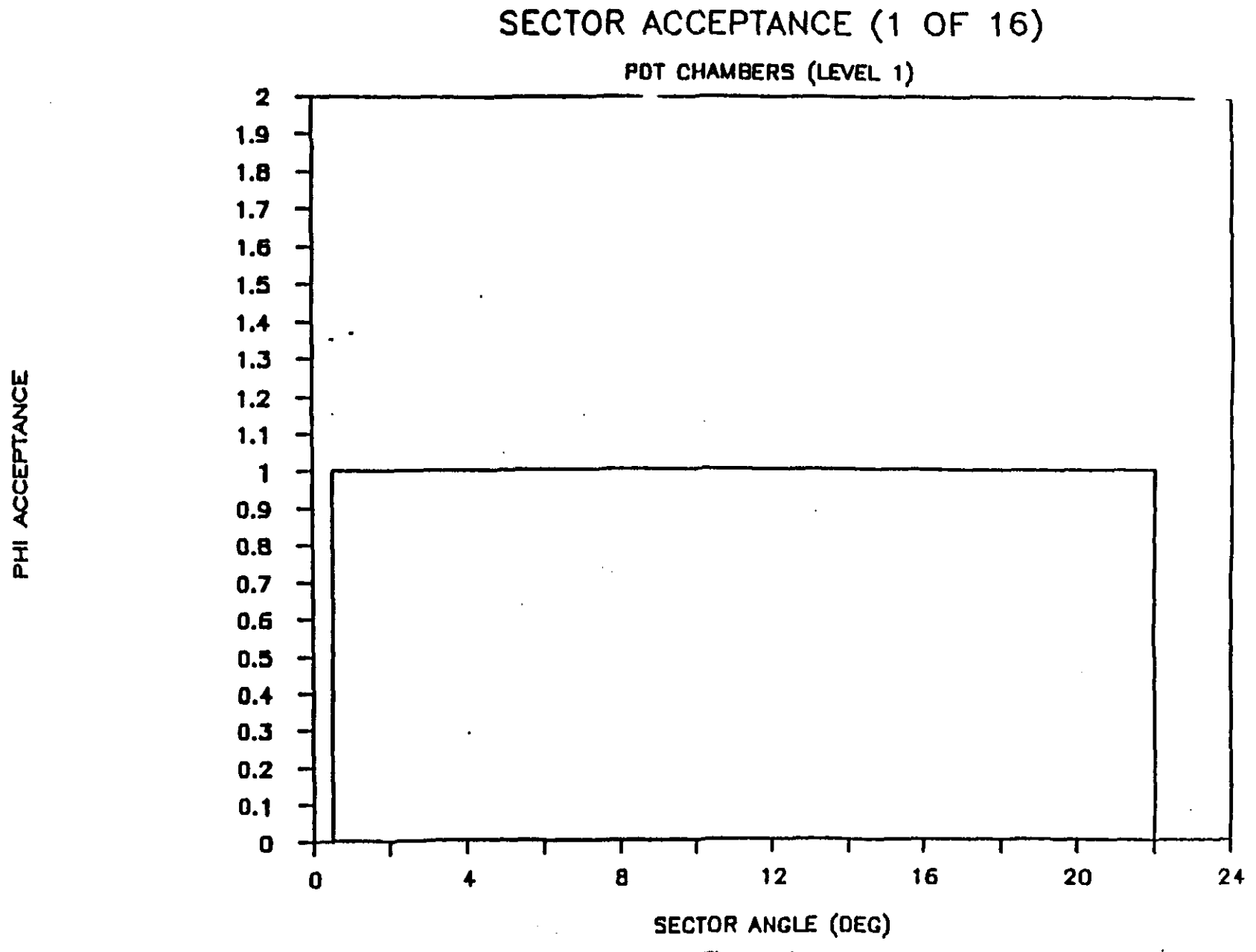

SECTOR ACCEPTANCE (1 OF 16)
PDT CHAMBERS (LEVEL 1)
PHI ACCEPTANCE
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
24
SECTOR ANGLE (DEG)

Fig. 3.6 b

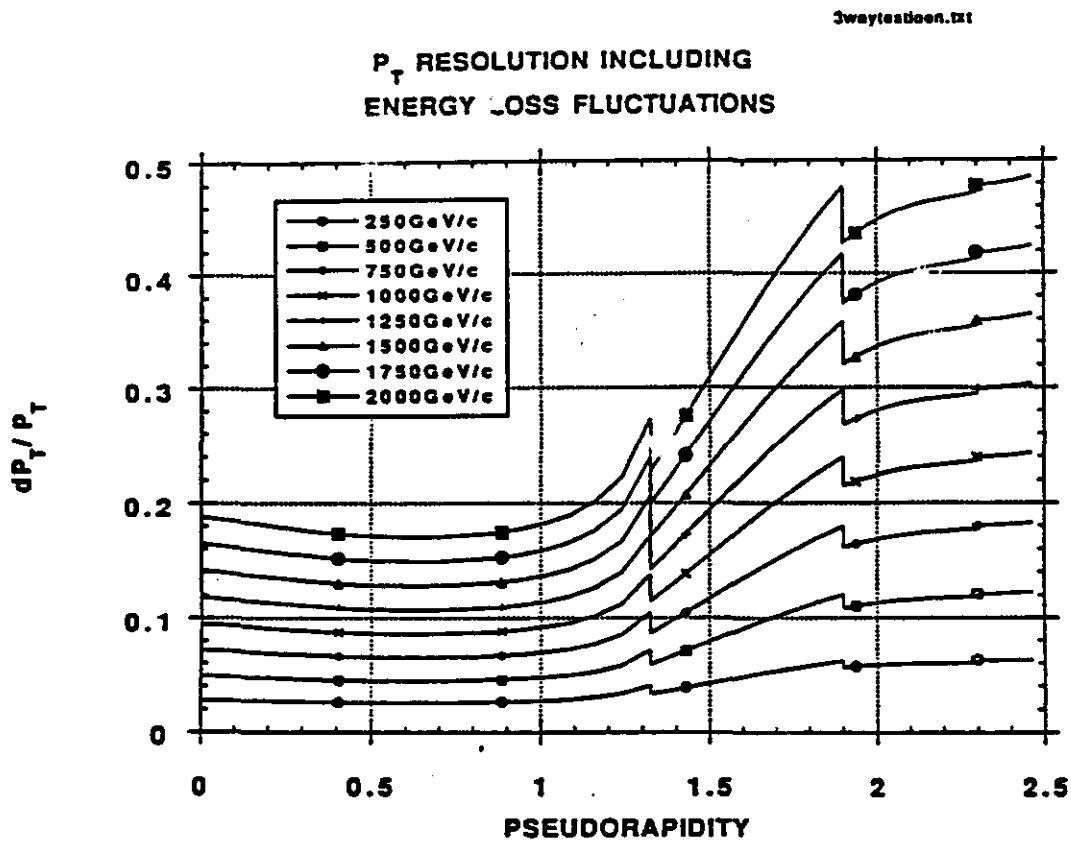

3waytestbeen.txt
P_T RESOLUTION INCLUDING
ENERGY LOSS FLUCTUATIONS
250GeV/c
500GeV/c
750GeV/c
1000GeV/c
1250GeV/c
1500GeV/c
1750GeV/c
2000GeV/c
dP_T/P_T
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
PSEUDORAPIDITY

Fig. 4.3.1b

SURVEY AND ALIGNMENT REQUIREMENTS

The following requirements are for initial design purposes while exact tolerances and variances are determined.

Positioning Accuracy Requirements

The detector subsystems must be positioned to the following accuracies:

Sub-System	Alignment Description	Tolerance
Beampipe	Radial	±1mm
Tracking Systems	Radial Relative to Calorimeter	±10mm ±1-5mm
Calorimeter Systems	Axial Radial	±1mm * ±1mm *
Muon systems	Described elsewhere	Described elsewhere
Magnet	Axial Radial Magnet Halves relative to each other Flux Concentrator relative to magnet	±10mm ±10mm TBD TBD

* The physics requirement for all calorimeter components.

Measurement Accuracy Requirements

The position of the detector subsystems must be known to the following accuracies:

Sub-System	Measurement Description	Tolerance
Tracking Systems	Radial Relative to Muon Chambers	±0.1mm ±0.2mm
Calorimeter Systems	Axial Radial	±1mm ±1mm
Muon systems	Described elsewhere	Described elsewhere

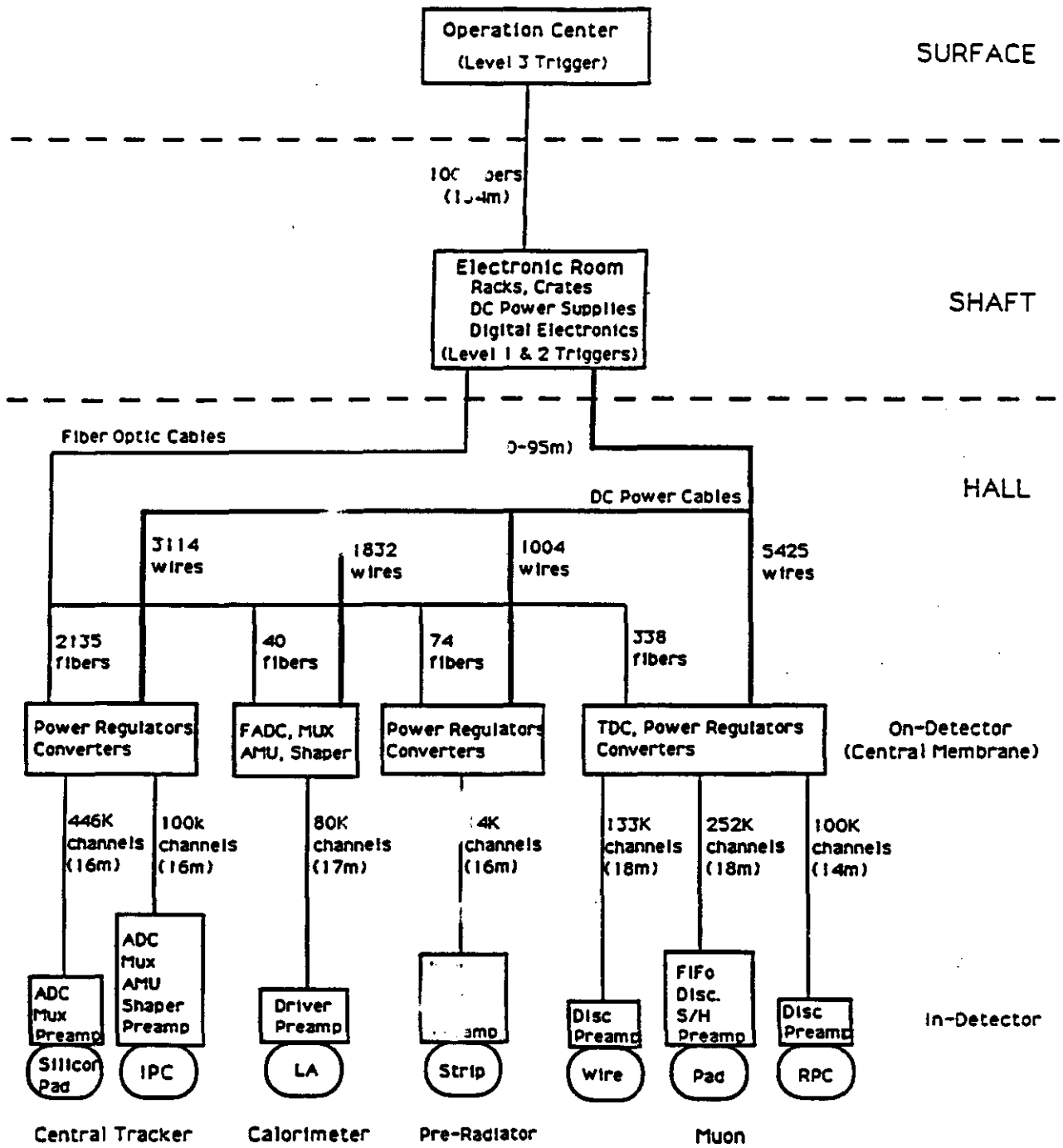


Fig. 13.1 Electronics System Layout

gem

γeμ

Presentation by:

D. Lu

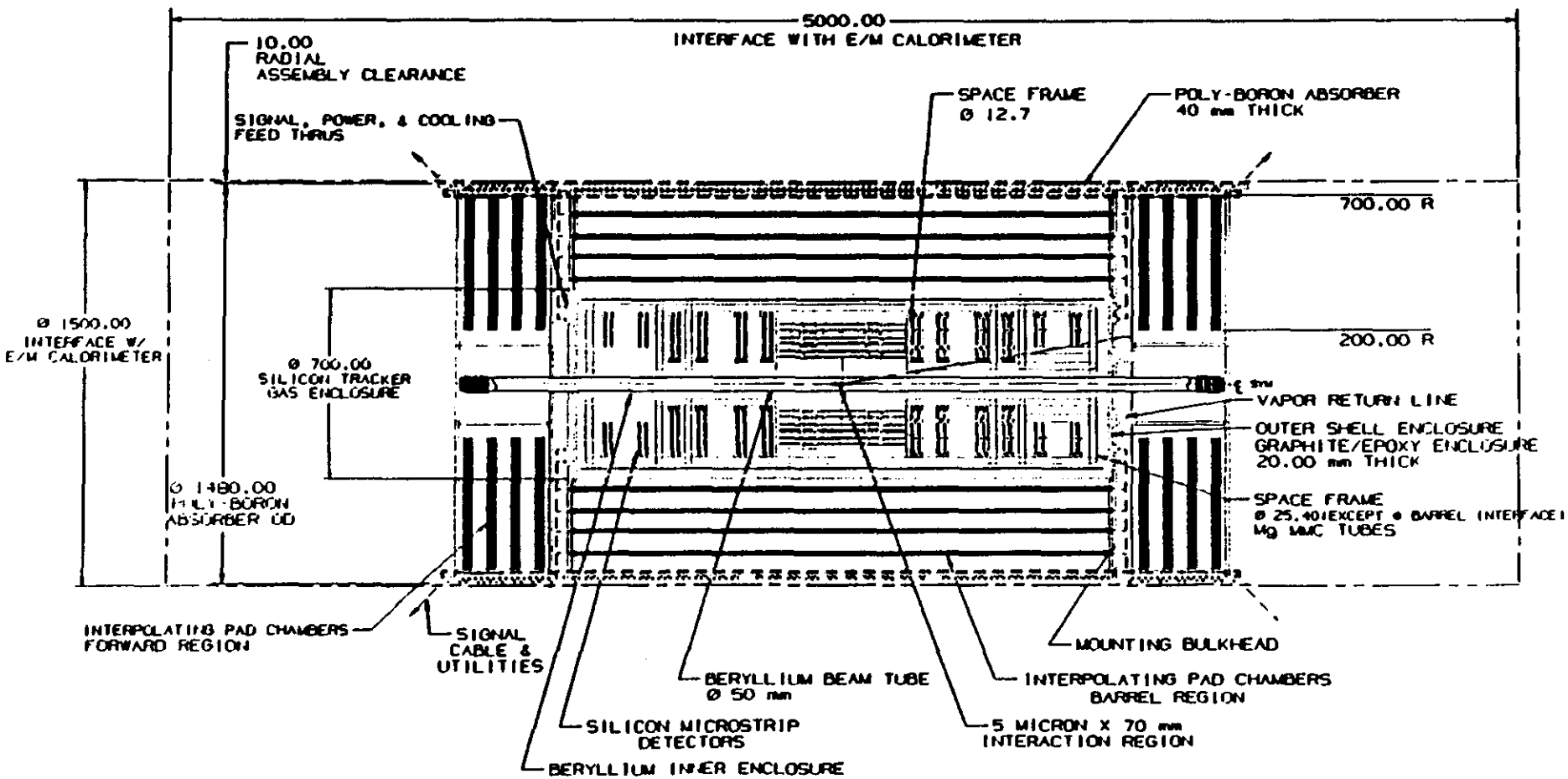
(For C. Baltay)

GEM TN-92-63

THE GEM CENTRAL TRACKER

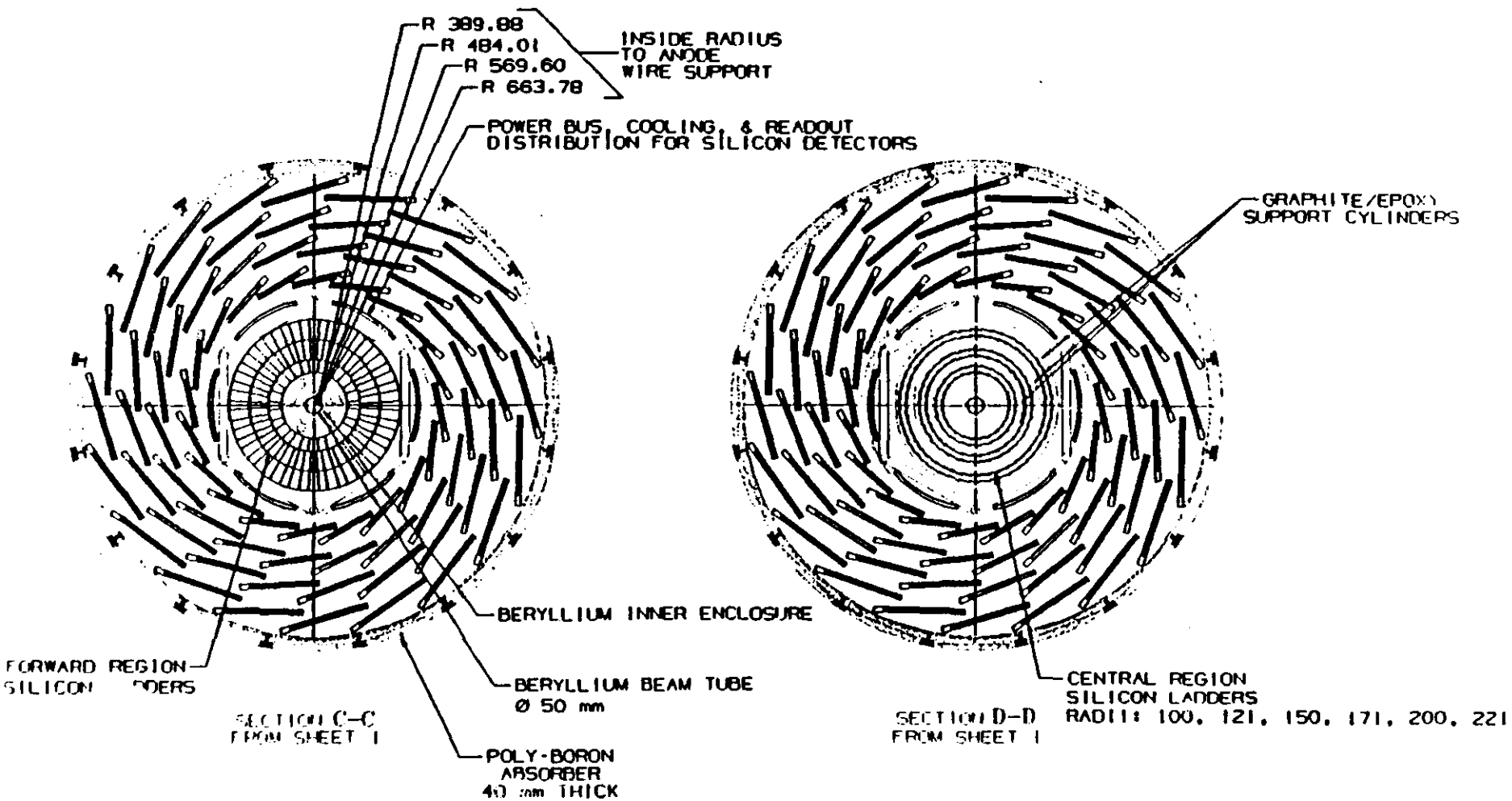
A Progress Report

March 1992



GEM CENTRAL TRACKER

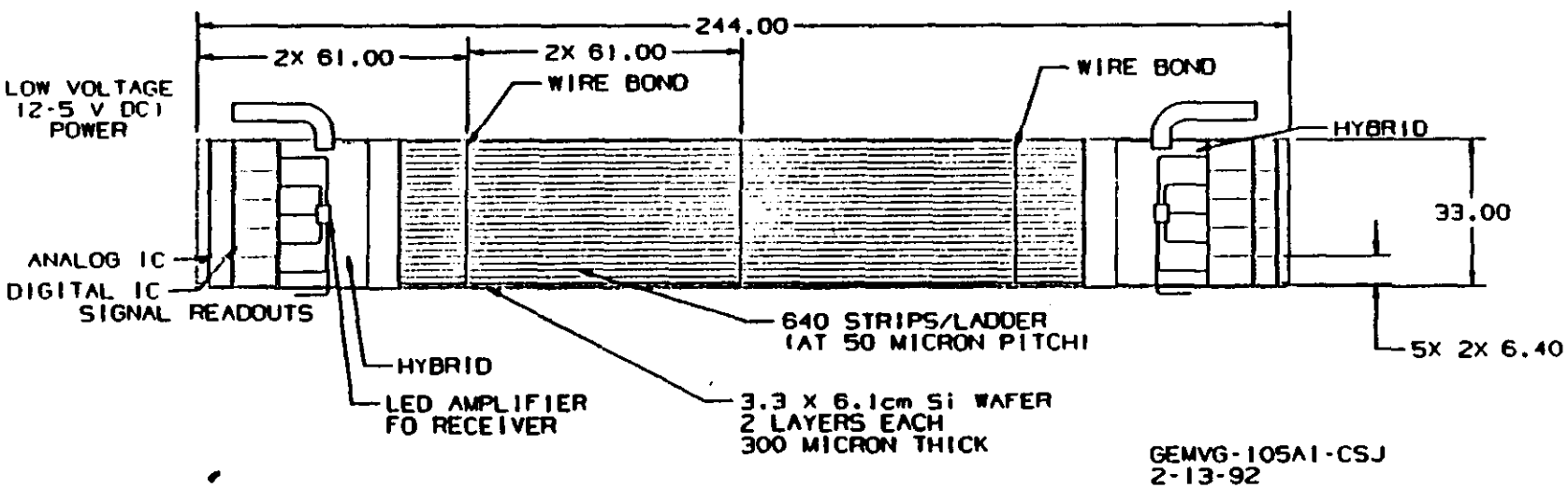
GEMVG-126-JV



GEMVG-109B-JV 3-23-92

GEM SILICON TRACKER

CENTRAL REGION LADDER ASSEMBLY



GEMVG-105A1-CSJ
2-13-92

ALL DIMENSIONS ARE IN mm

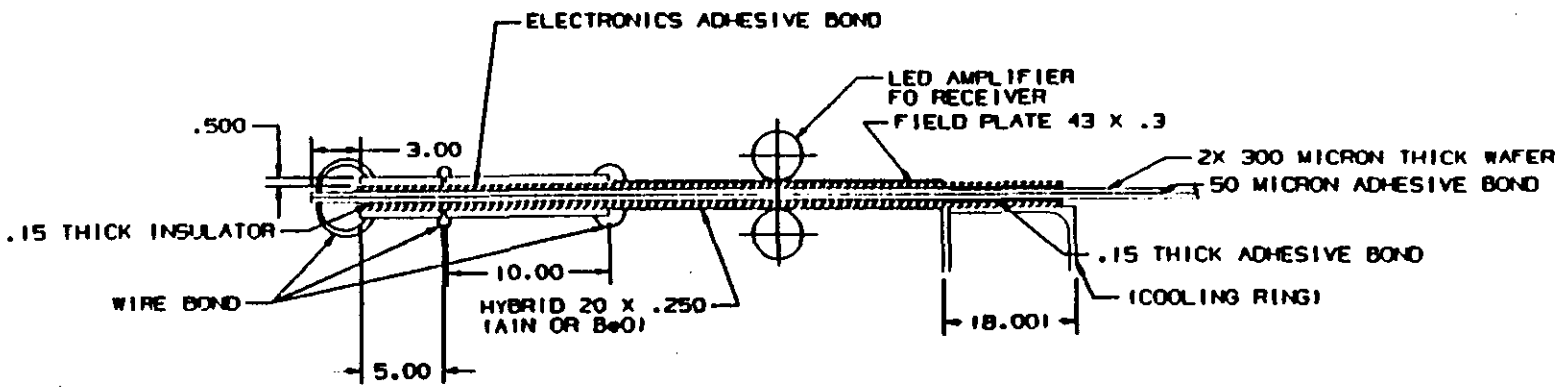
LOS ALAMOS

MET. 17
MECHANICAL AND ELECTRONIC
ENGINEERING DIVISION

GEMVG-105A1-CSJ 02-24-92

GEM SILICON TRACKER

LADDER ELECTRONICS ASSEMBLY

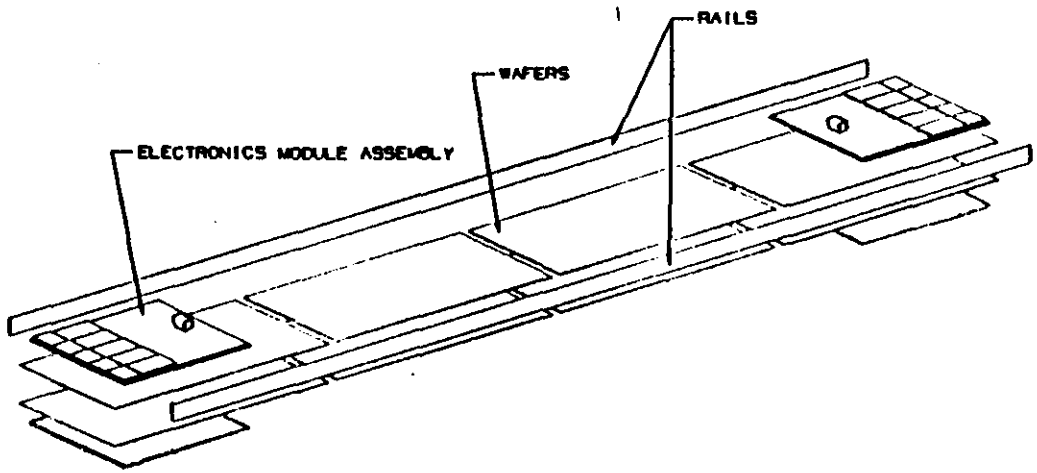


ALL DIMENSIONS ARE IN mm

LOS ALAMOS

MECHANICAL AND ELECTRONIC ENGINEERING DIVISION

GEMD-108A2-CEJ 02-24-92



PRELIMINARY
NOT TO BE USED FOR FABRICATION

METRIC
THIRD ANGLE PROJECTION

Los Alamos

A1 SK-GEM12-02E 1

Silicon Electronics Developements

- **Non-Disclosure agreements Completed with:**

  Orbit Semiconductor: Received Design Rules
  UTMC

- **Non-Disclosure agreements in Progress with:**

  Motorola :
  - Multi-Chip Module Technology
  - MOSAIC Transistor Design
    - (14Ghz @200μA)

- **Front-End Electronics Block Diagram: First Attempt**

  Need additional custom chip for:
  - Inerface/Control
  - Line Driver/Receiver
  - Housekeeping(Stateof-Health):
    - Amplifier, A/D

  Cable Cost Estimates with Lenthor, PentaFlex

- **IC Cost estimates:**

  Yield plays an important role: $Y = \frac{1}{(1+dA)}$

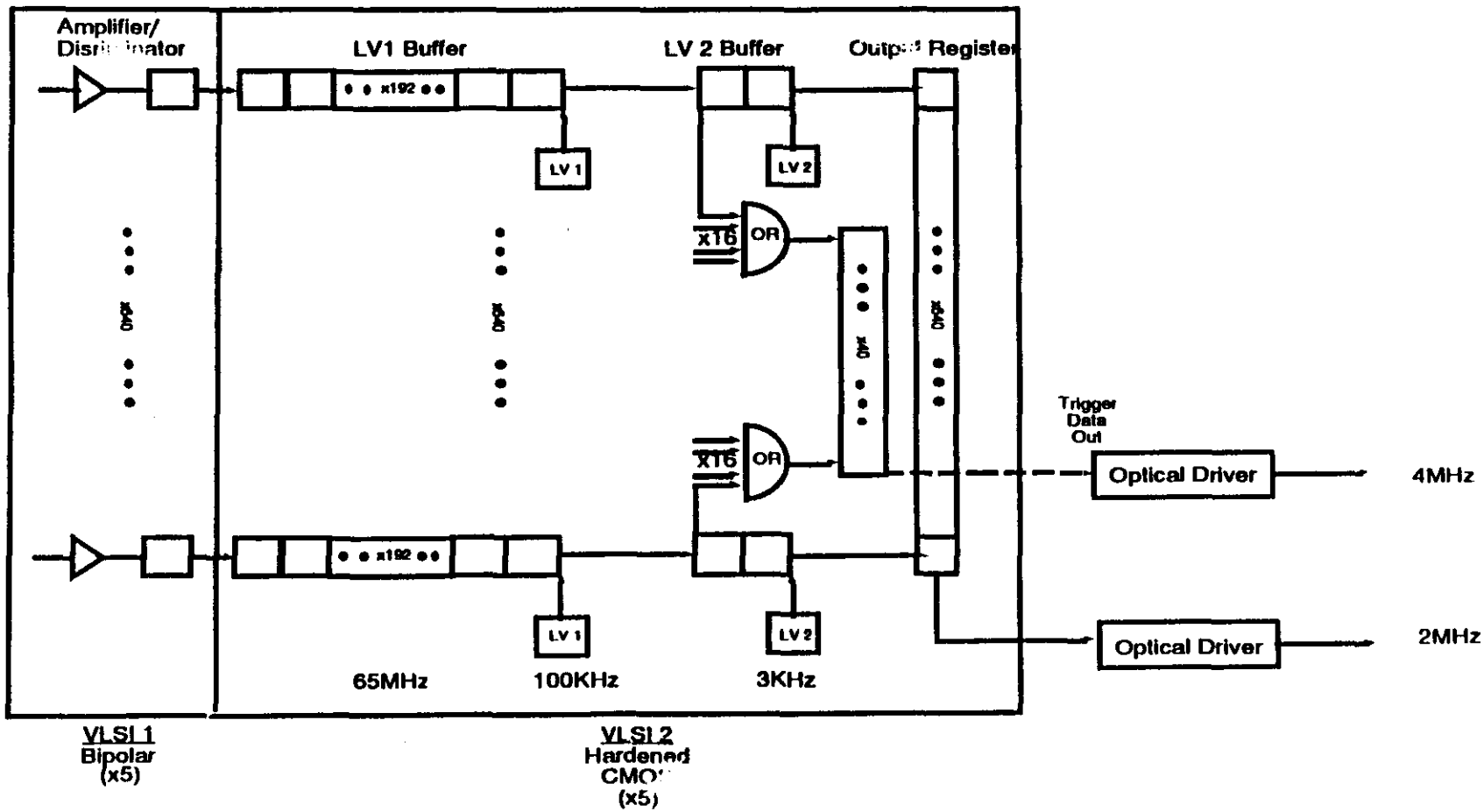
  where :
  - d=# defects/area(d <100/in^2 for Harris UHF)
  - A=area

  for zero defects:
  - Y~ 0.2 for Harris UHF, A=6.4x6.4mm^2

  Need to optimize allowed channel failure rate, number of channels per wafer, and die size.

Silicon Strip Readout

Electronics Schematic for Half Ladder



HYBRID

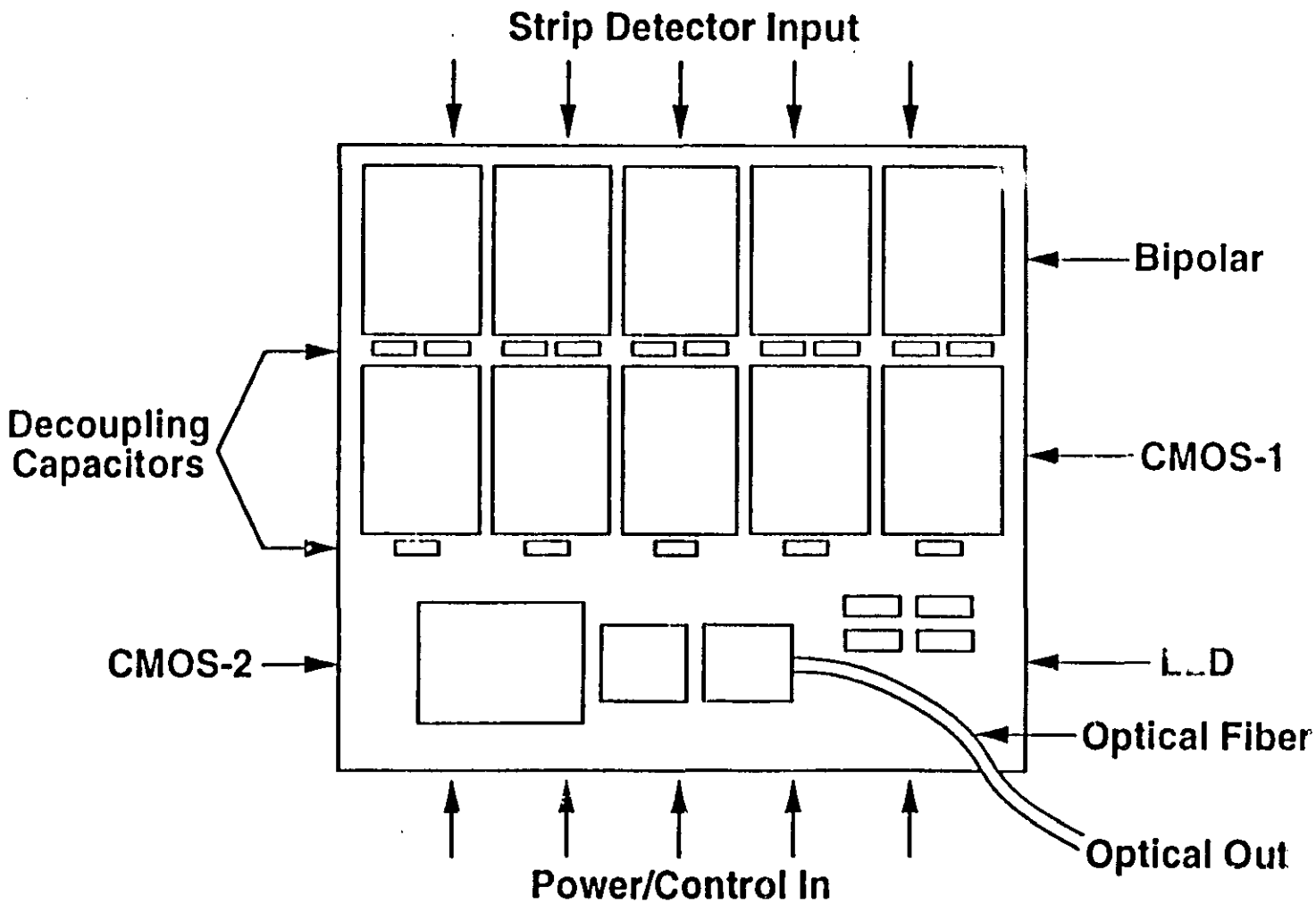


Fig. 1. Conceptual Layout of Si-Tracker MCM

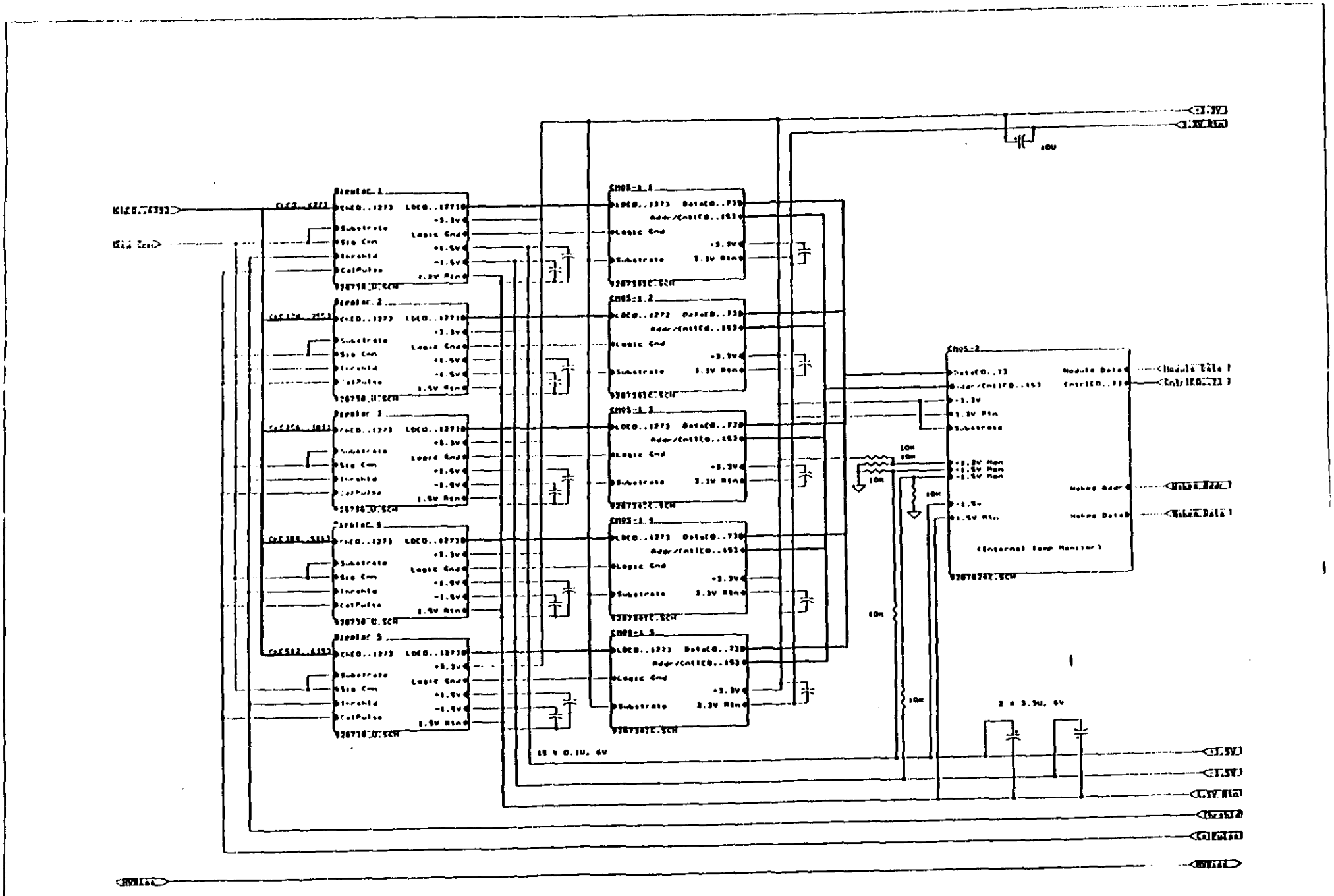
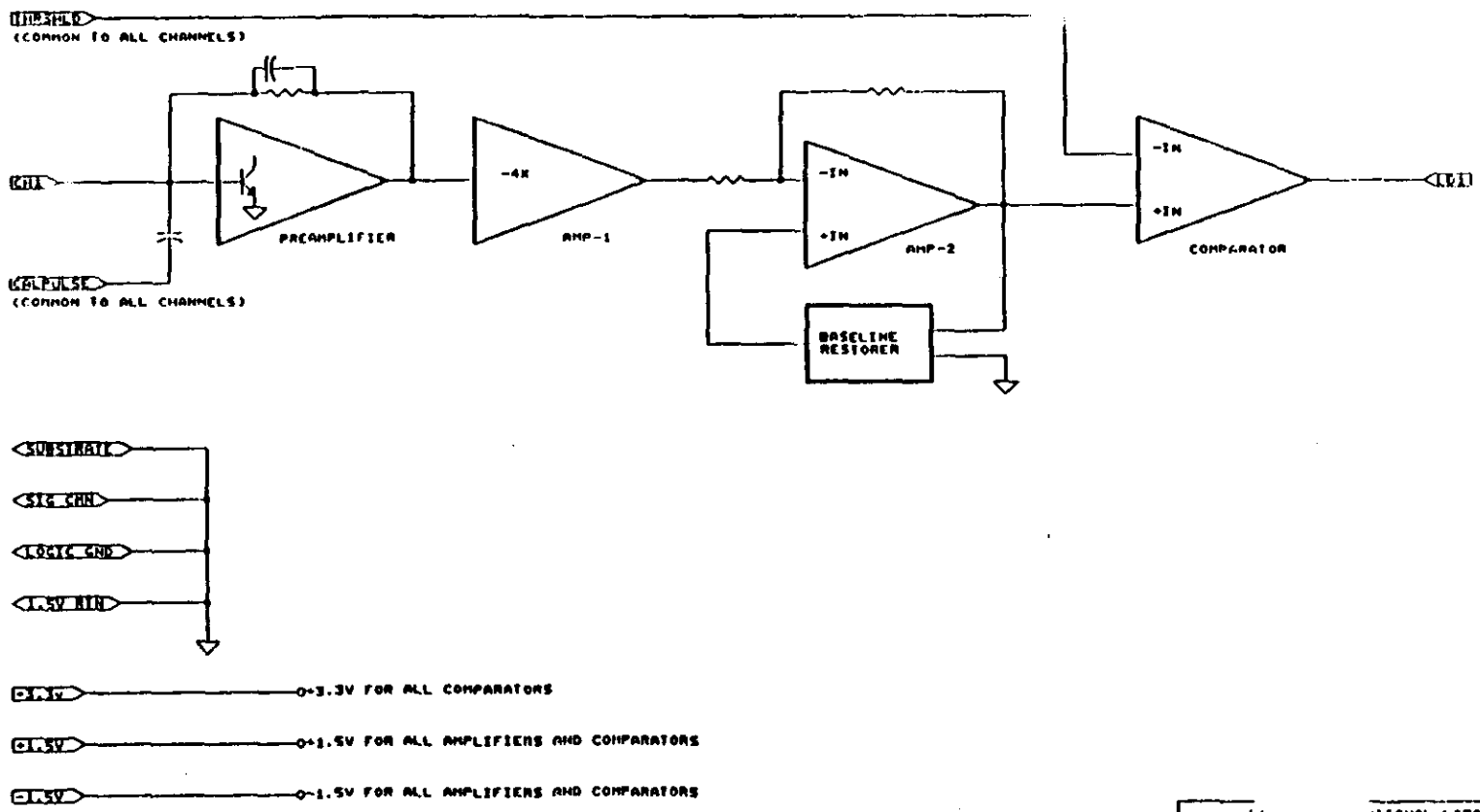


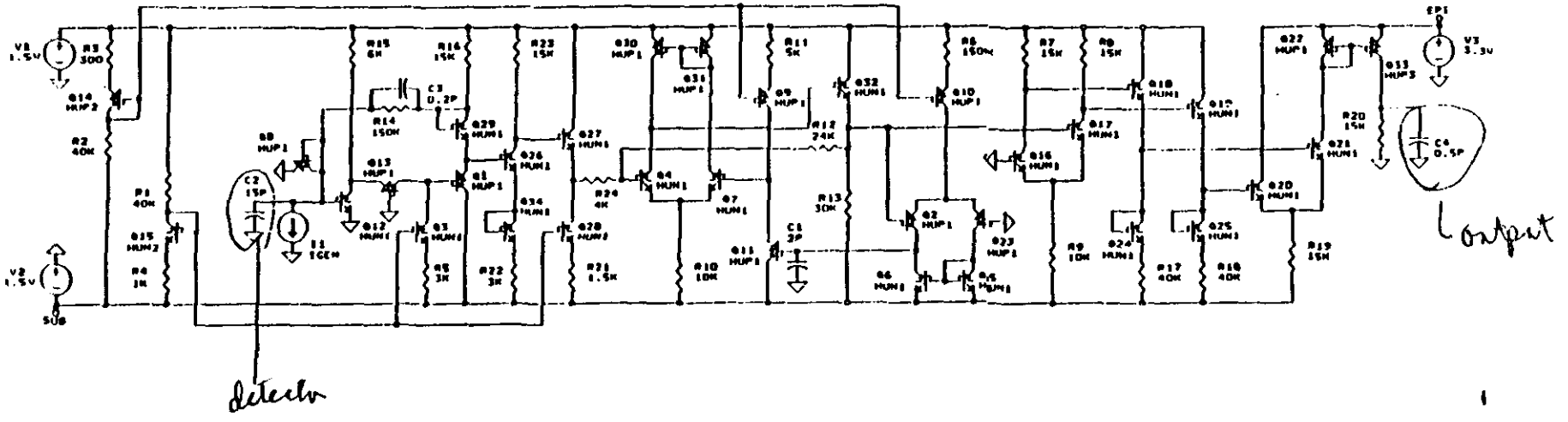
Figure 2. Multi-Chip Module for Si-Tracker

Los Alamos National Laboratory
Title
Si-Tracker Multi-Chip Module

NOTE: THIS IS FOR CHANNEL-1 OF
128 IDENTICAL CHANNELS ON THE BIPOLAR CHIP.

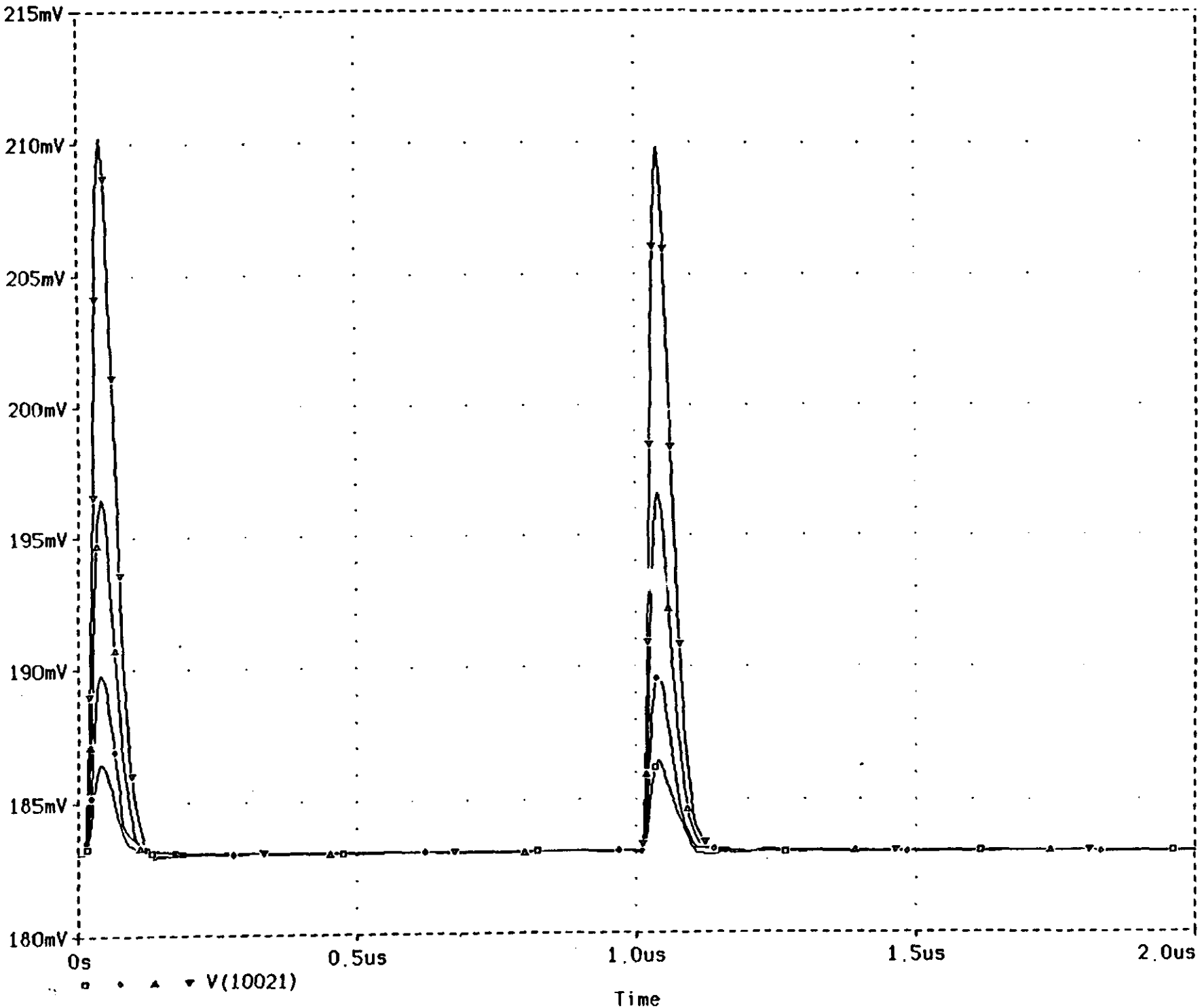


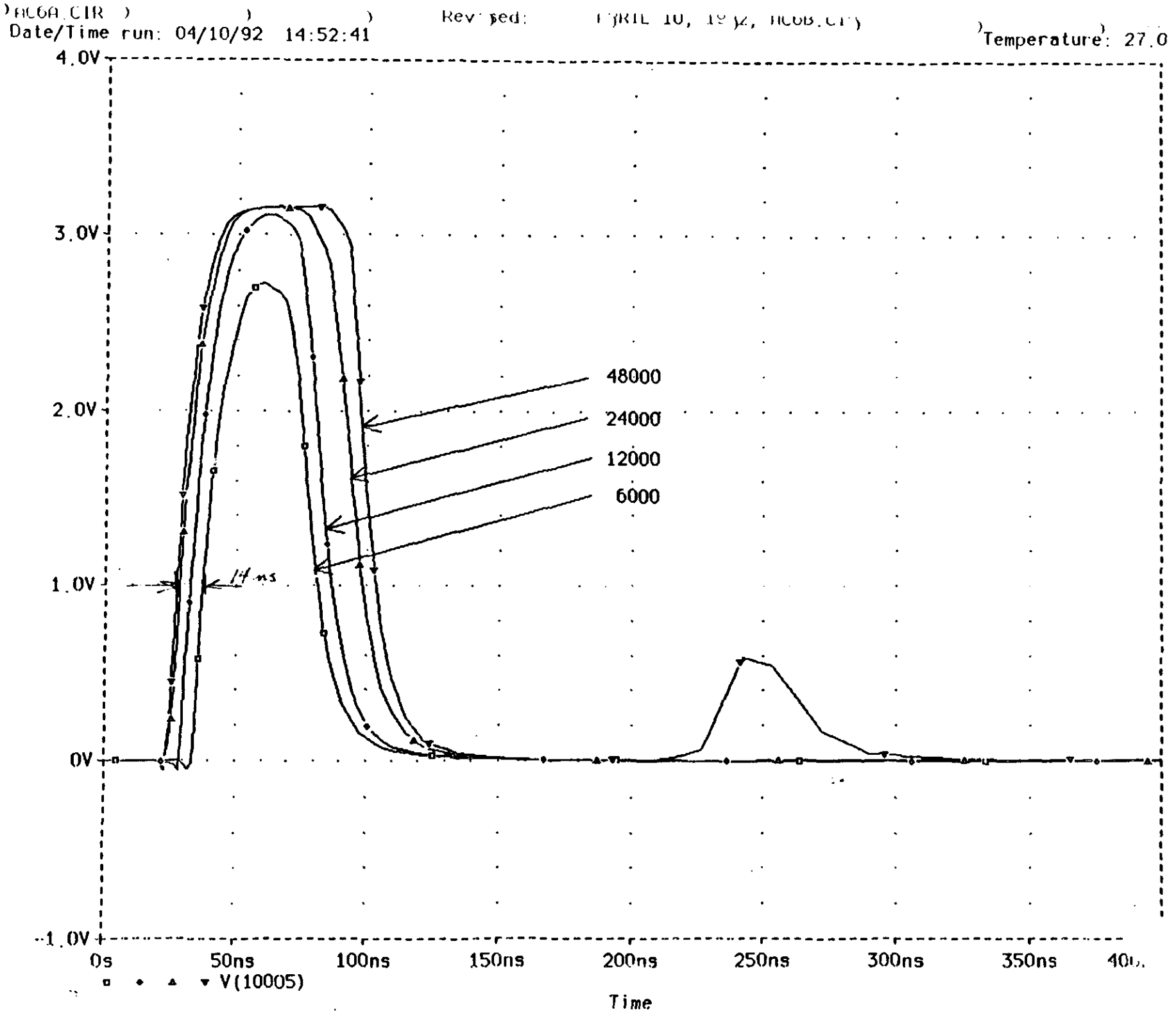
L[illegible]	[illegible]IONAL LABORATORY
Title	BIPOLAR CHIP BLOCK DIAGRAM
Size B	Document Number	REV
Date: April 15, 1992	Sheet 1 of 1


V1 1.5V
R3 300
Q14 HUP2
R2 40K
P1 40K
Q15 HUM2
R4 1K
V2 1.5V
SUB
R15 6K
R16 15K
C3 0.2P
R14 150K
Q29 HUN1
Q13 HUP1
Q1 HUP1
Q12 HUN1
Q3 HUN1
Q5 3K
R23 15K
Q27 HUN1
Q26 HUN1
Q34 HUN1
R22 3K
Q28 HUN1
R21 1.5K
Q8 HUP1
C2 15P
I1 TCEM
Detector
Q30 HUP1
Q31 HUP1
R24 4K
Q4 HUN1
Q7 HUN1
R10 10K
R11 5K
Q9 HUP1
R12 24K
C1 3P
Q11 HUP1
Q32 HUN1
R13 30K
Q6 HUN1
R6 150K
Q10 HUP1
Q2 HUP1
Q23 HUP1
Q16 HUN1
Q6 HUN1
R7 15K
R8 15K
Q17 HUN1
R9 10K
Q18 HUN1
Q24 HUN1
R17 40K
Q19 HUN1
Q25 HUN1
R18 40K
Q22 HUP1
Q20 HUN1
R19 15K
Q21 HUN1
Q33 HUP3
R20 15K
C4 0.5P
Output
EPI
V3 3.3V

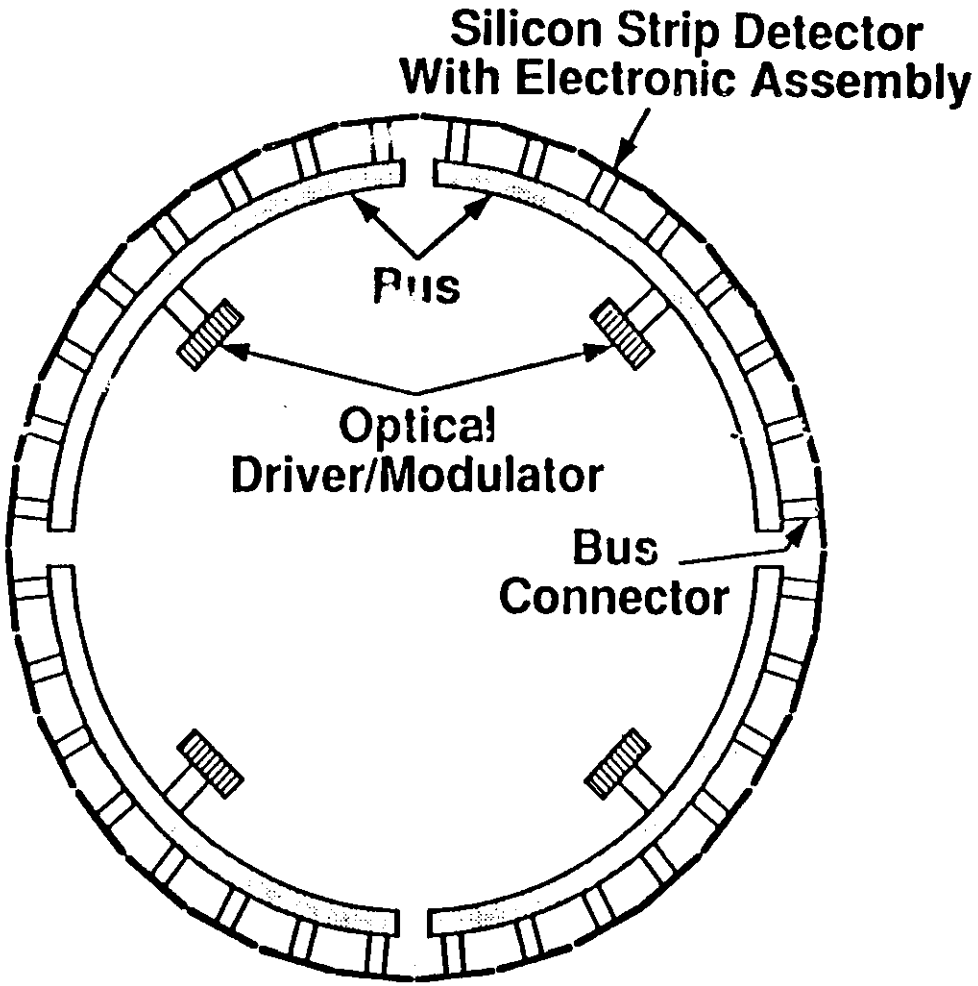
AC6A.CIR Revised: APRIL 10, 1992, AC6B.CIR

Date/Time run: 04/10/92 14:52:41 Temperature: 27.0

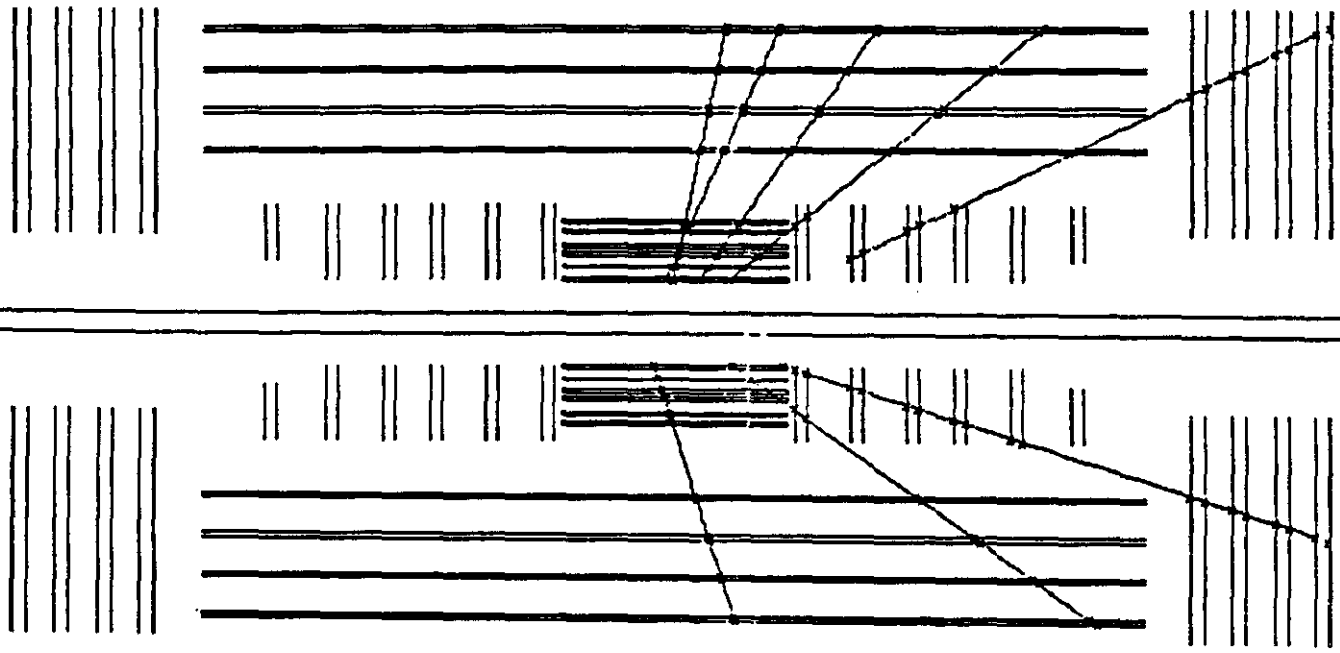



Date/Time run: 04/10/92 14:52:41
Temperature: 27.0
4.0V
3.0V
2.0V
1.0V
0V
-1.0V
48000
24000
12000
6000
14 ns
0s
50ns
100ns
150ns
200ns
250ns
300ns
350ns
V(10005)
Time

SILICON TRACKING SYSTEM WAFER SHELL



LSDT RUN NR 1
EVENT NR 0 1/ 4/92



Los Alamos

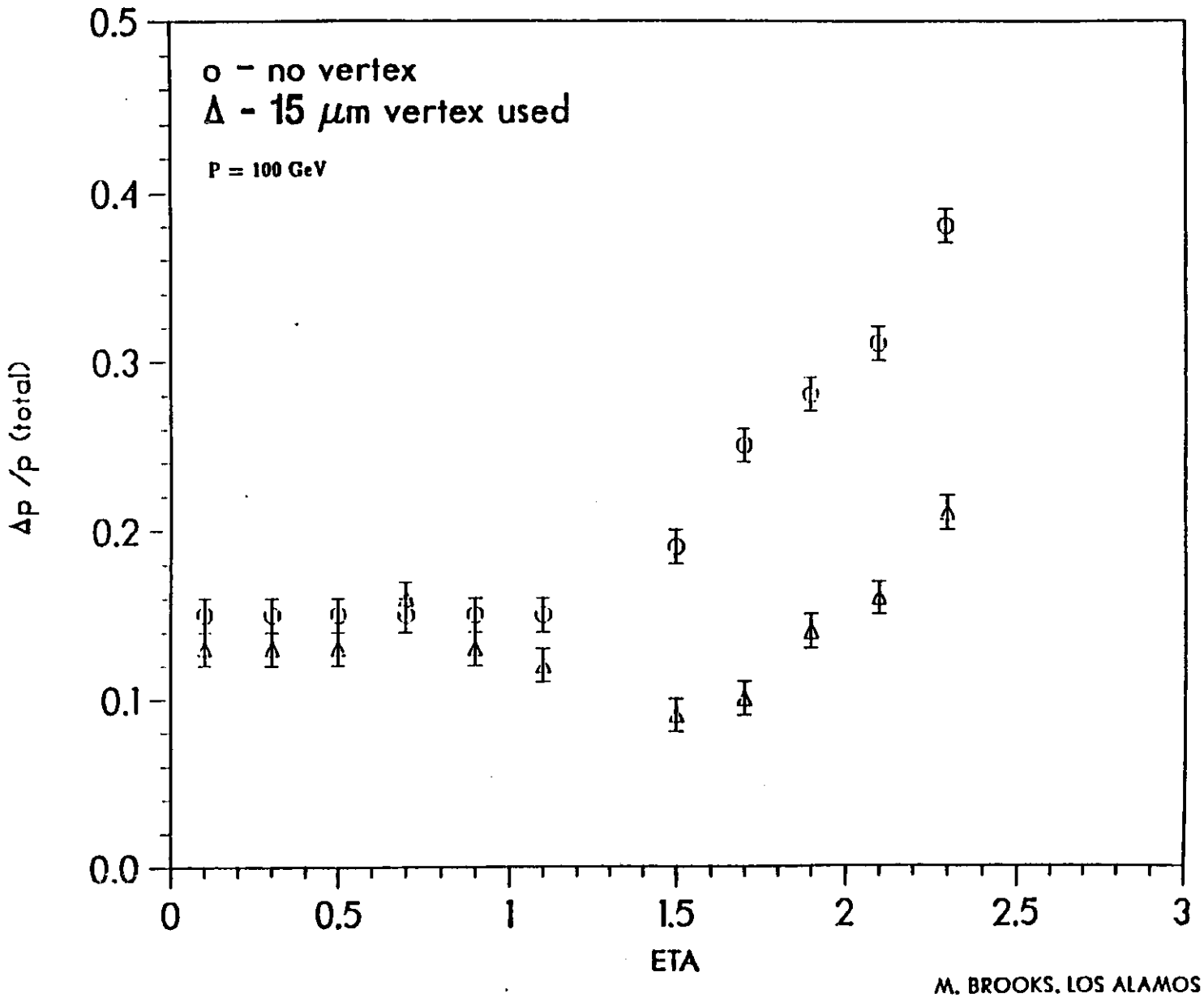

o - no vertex
Δ - 15 μm vertex used
P = 100 GeV
Δp /p (total)
ETA
0.0
0.1
0.2
0.3
0.4
0.5
0
0.5
1
1.5
2
2.5
3
M. BROOKS, LOS ALAMOS

Figure 2.3b

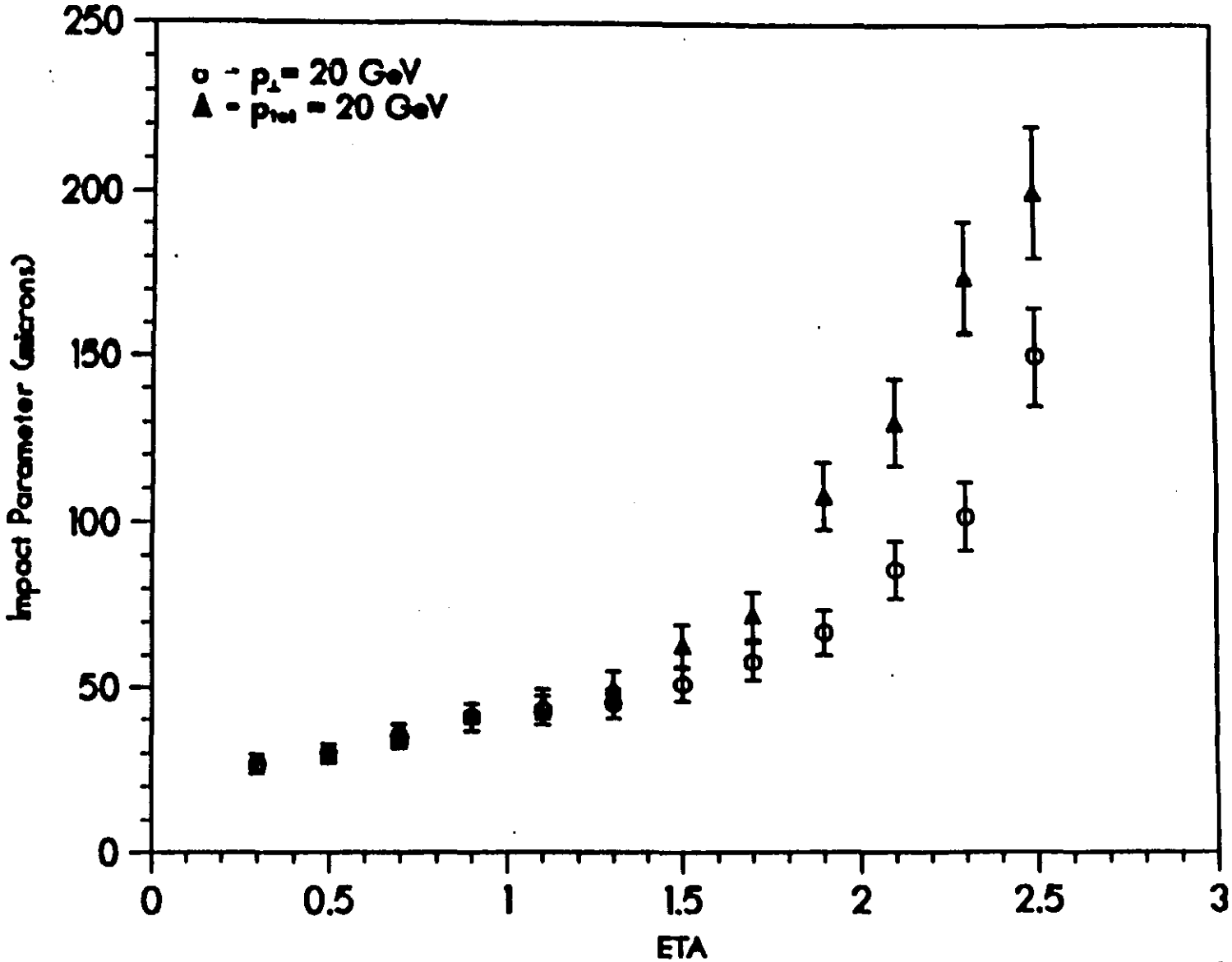


Figure 7.3.7

M. BROOKS, LOS ALAMOS

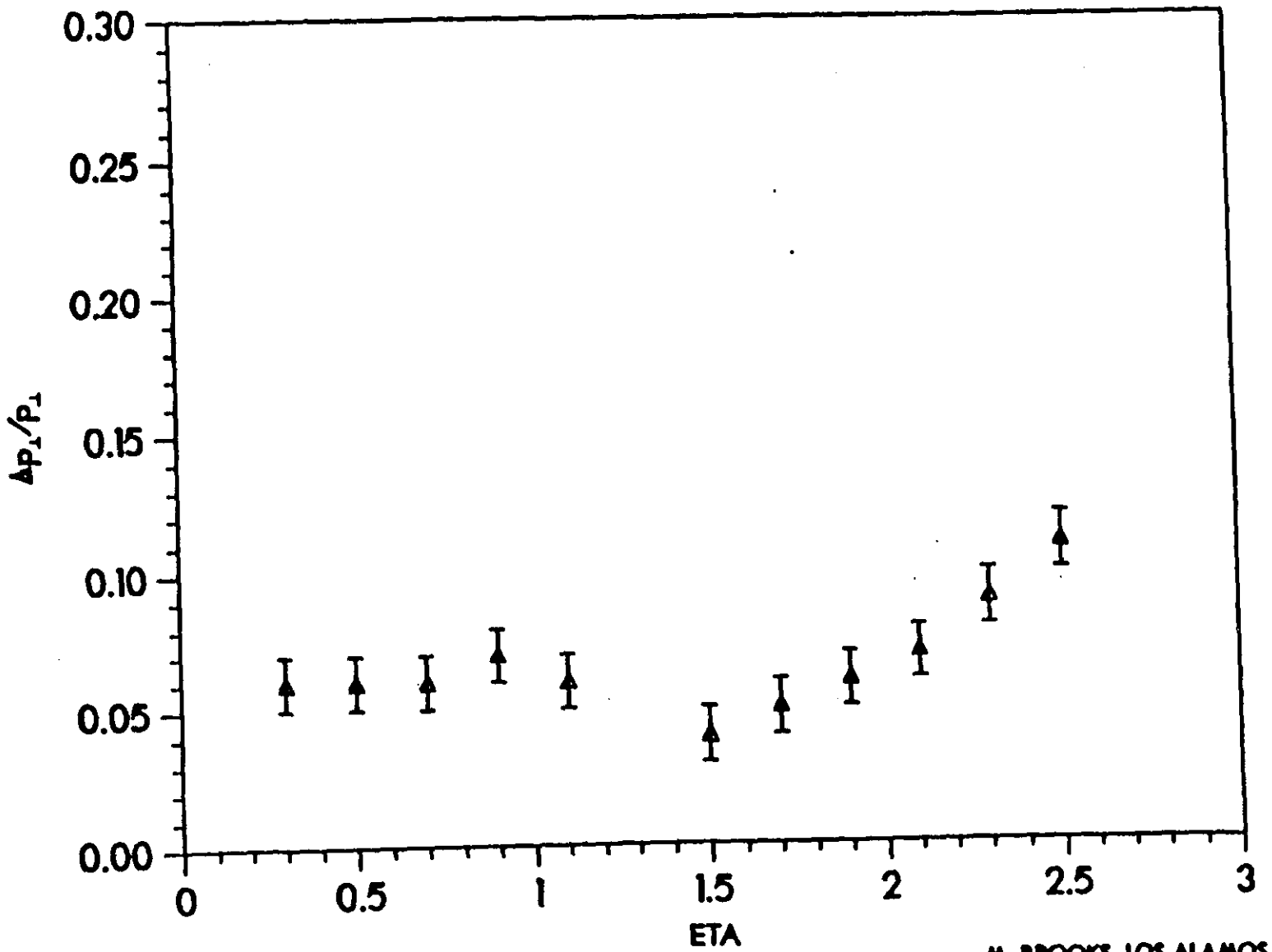


Figure 7.3.8

M. BROOKS, LOS ALAMOS

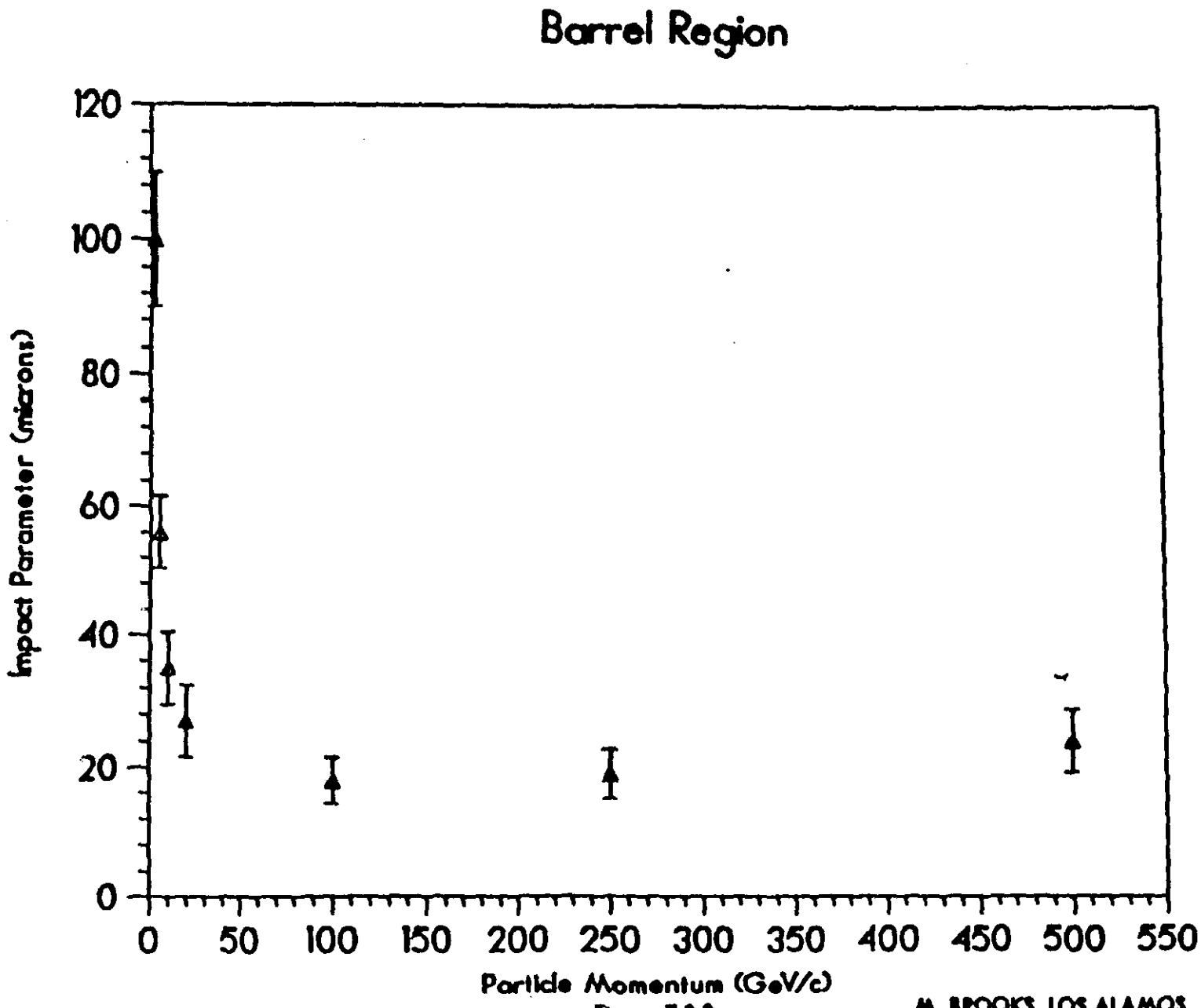

Barrel Region
Impact Parameter (microns)
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
550
Particle Momentum (GeV/c)
M. BROOKS, LOS ALAMOS

Figure 7.3.3

Central Tracker Radiation Environment

from L. Waters

Charged Fluence (SSC year) = 1.6×10^{13} @ 10 cm

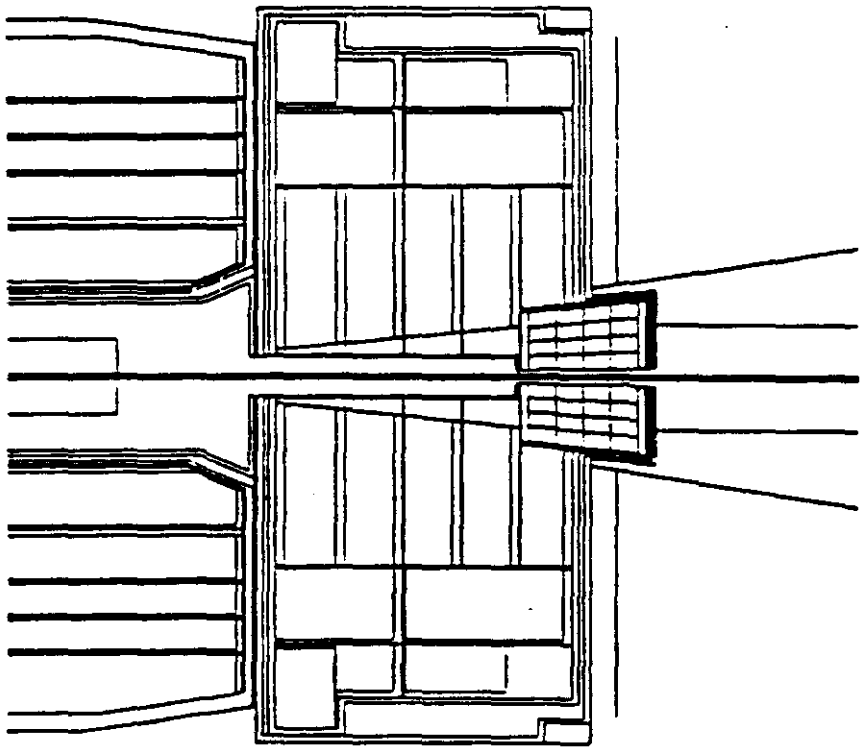
Dose(Rads/SSC year) = 3.5×10^{5} @ 10 cm

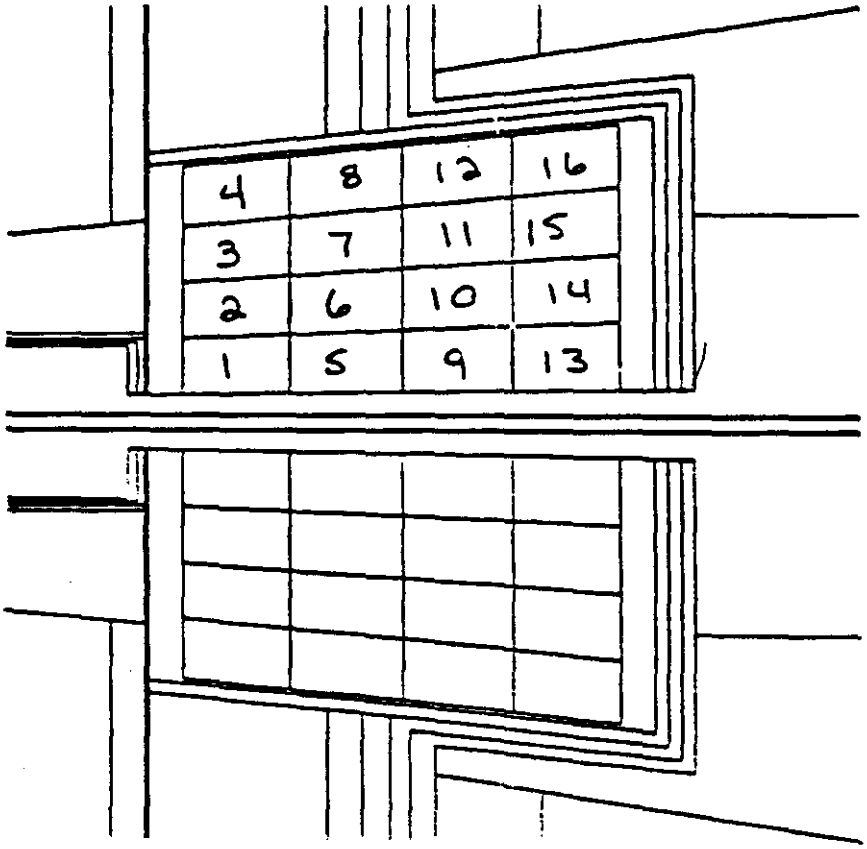
Neutron Fluence(SSC year) = 2×10^{12} @ $E_n > 100$ keV

= 5×10^{12} Total

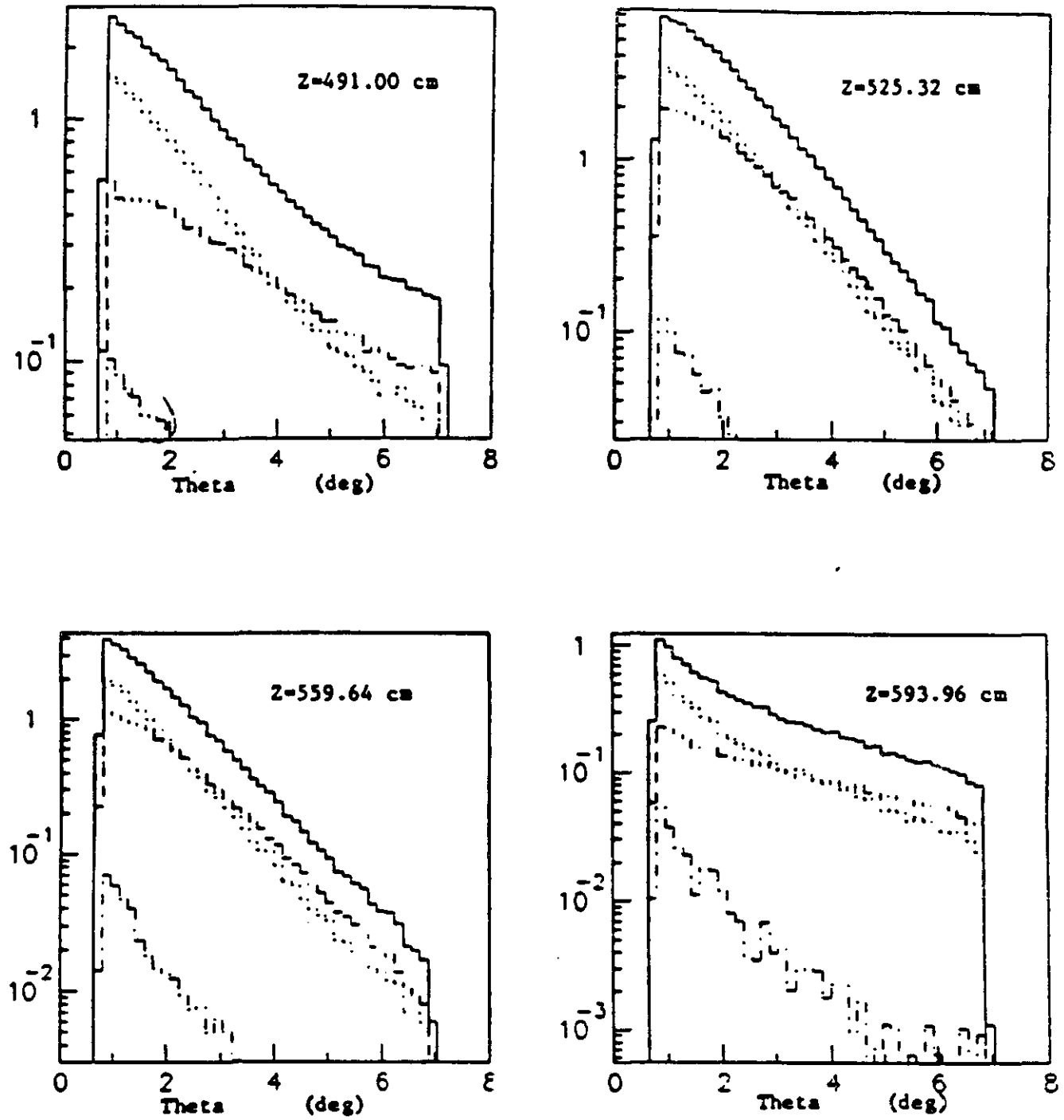
Effect Of Hadron Calorimeter on Central Volume - None

Effect of Forward Calorimeter on Central Volume - very small



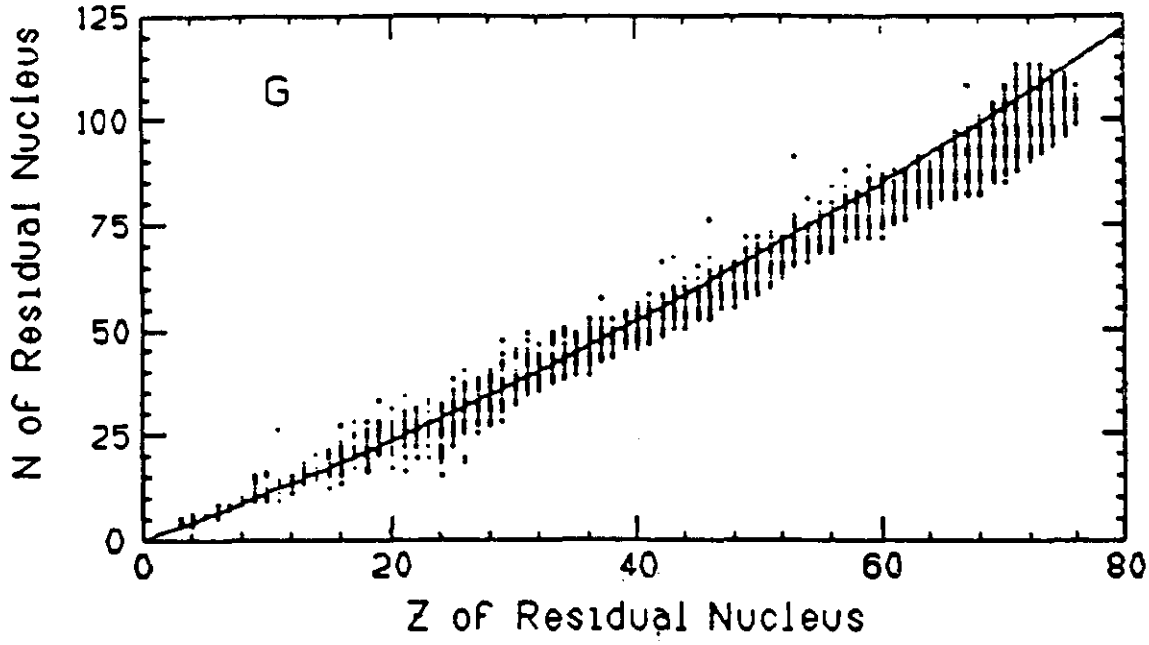


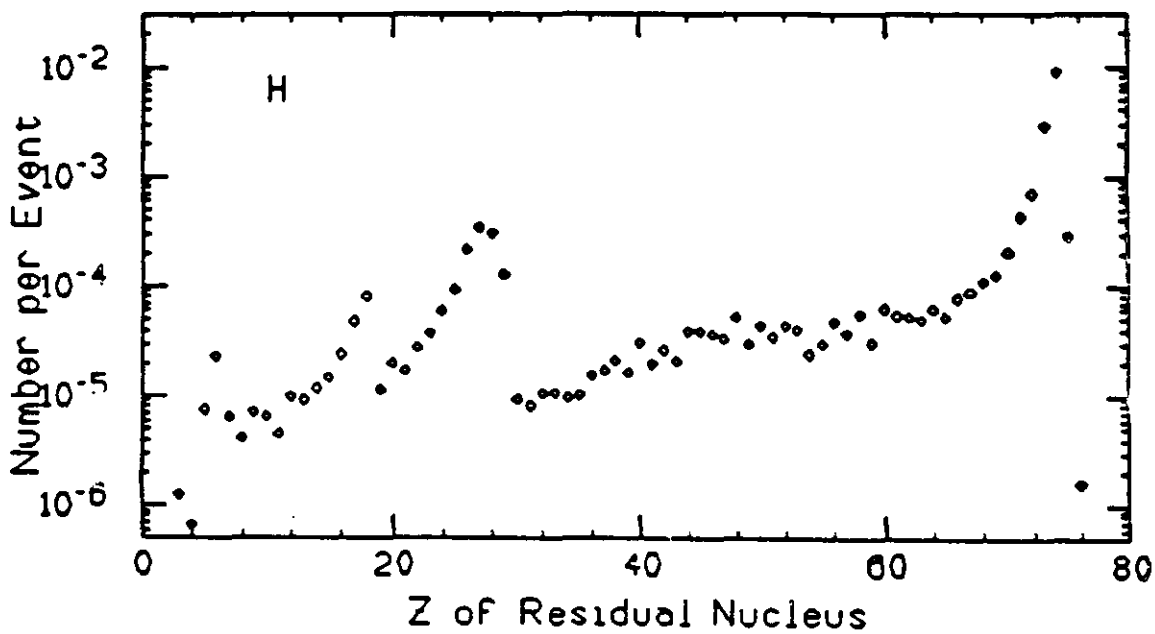
WATERS



FCAL Neutron Fluence by plane

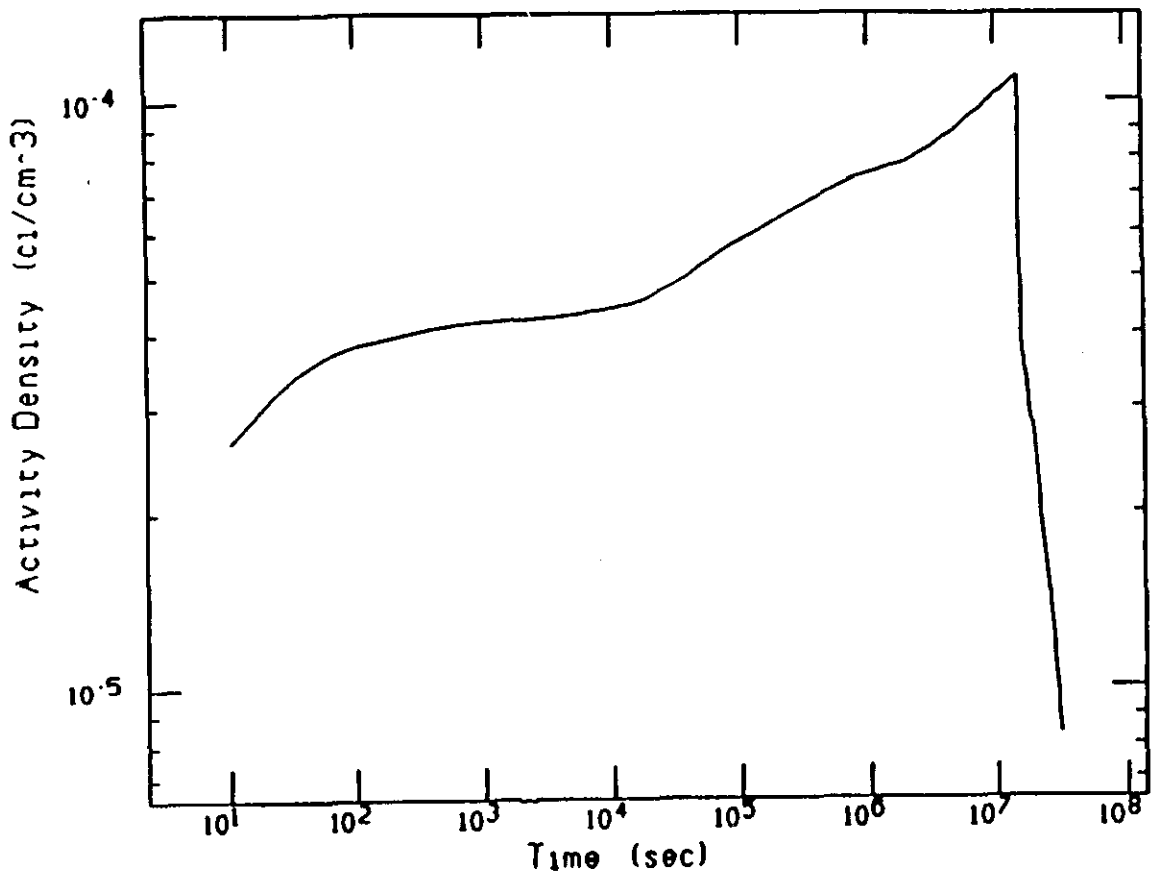
solid	total
dash	neutron kinetic energy less than 100 keV
dots	neutron ke gt 100 keV, lt 20 MeV
dotdash	neutron ke gt 20 MeV


G
N of Residual Nucleus
Z of Residual Nucleus
0
25
50
75
100
125
0
20
40
60
80


H
Number per Event
Z of Residual Nucleus
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
20
40
60
80

ATE DS

REGION #1



PEAK =
1.0923×10^{-4}
ci/cm^3

VOLUME = 3.024×10^{4} cm^3
x 2 FCALS

Cost Reduction Efforts

Silicon Tracker

Refine Mechanical Engineering design

Share Costs with SDC

Reduce the Number of Silicon Strips

Lengthen Ladders

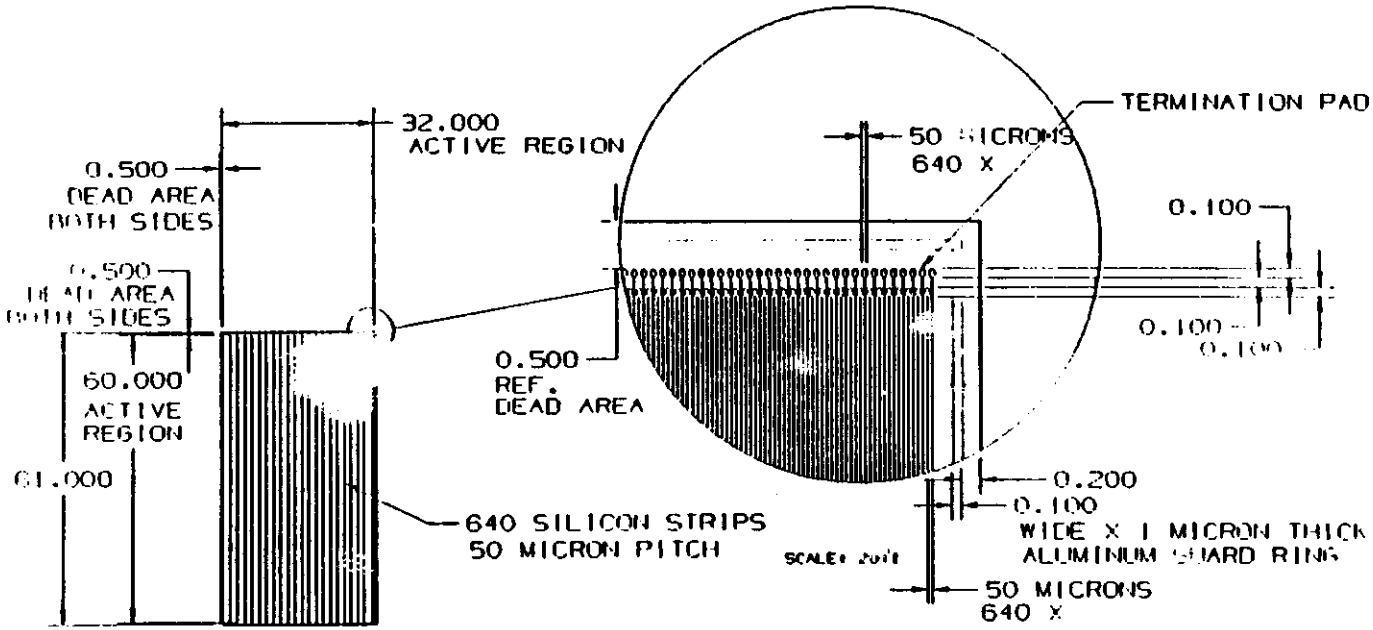
Integrating Pad Char bers

Investigate VLSI Technology and MCM's

Reduce Pad Count

GEM 3" ICON TRACKER

SILICON WAFER DETAIL



TYPICAL SILICON WAFER
X - LAYER

ALL DIMENSIONS ARE IN mm

LOS ALAMOS

MEET 12
MECHANICAL AND ELECTRONIC
ENGINEERING DIVISION

SINGLE VS DOUBLE SIDED

- **Radiation Resistance**

  Single and Double able to be depleted up to 10^{14} p/cm^2-~~sec~~ YEAR.

- **Capacitance**

  S/N of Bipolar frontend scales as the square of the detector capacitance.

  N- side of double sided has 1.5 to 2.5 x the capacitance of p side. 1.3 - 1.5

- **Radiation Length**

  Expected radiation length of tracker ~ 15 % - 20%

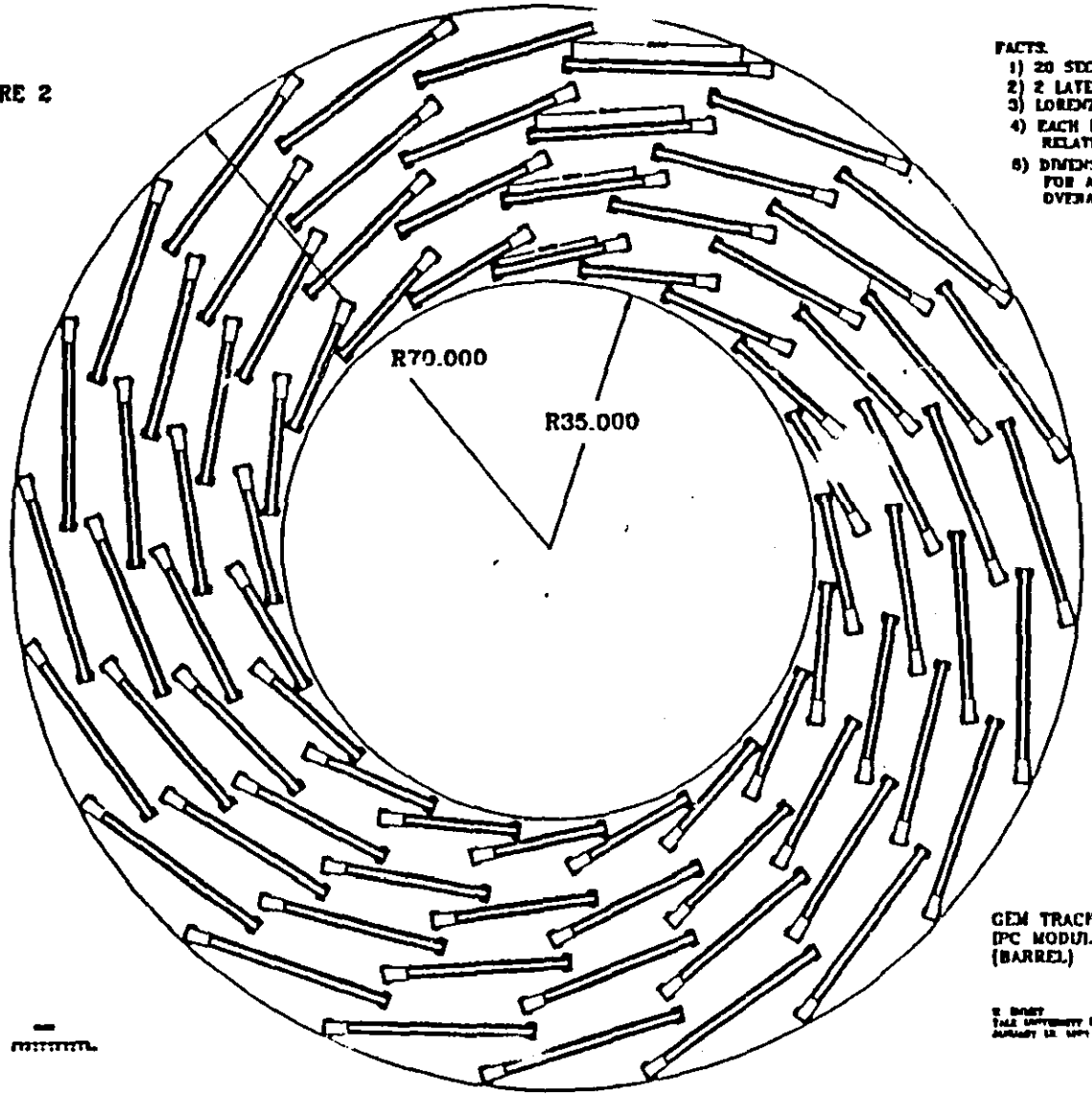
  Support structure the same for single and double sided

  Savings for double sided ~ 1.85% of total

- **Cost**

  double = (3 - 5) x single (3.5)

FIGURE 2

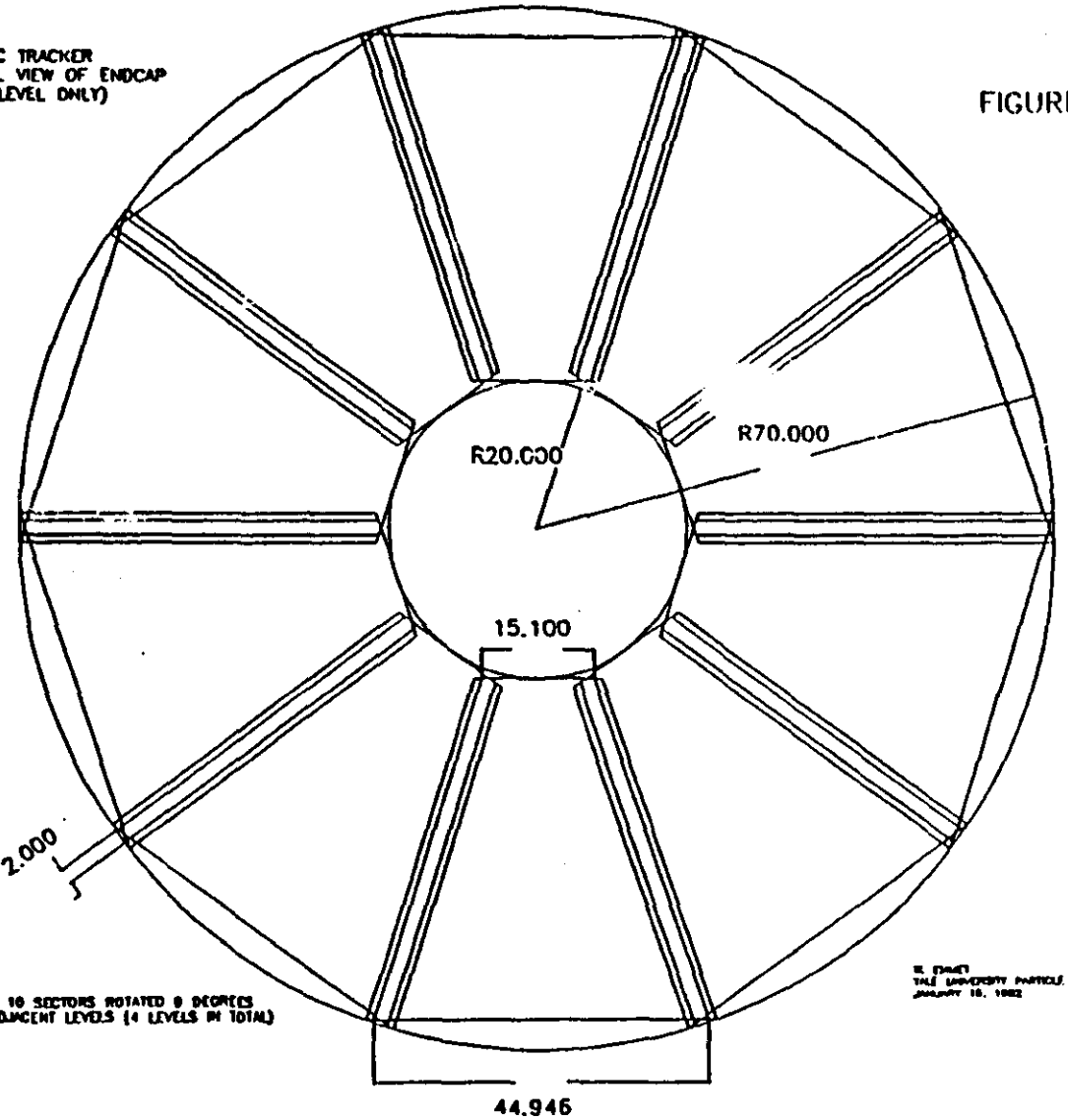


FACTS:
1) 20 SECTORS OF 4 SUPERLAYERS EACH
2) 2 LAYERS PER SUPERLAYER
3) LORENZ ANGLE~12 DEGREES
4) EACH LEVEL ROTATED 4.5 DEGREES RELATIVE TO ADJACENT LEVELS
5) DIMENSIONS FOR CHAMBERS ARE FOR ACTIVE WIDTHS (ADD 6 CM FOR OVERALL WIDTHS)

GEM TRACKER
IPC MODULE LAYOUT
(BARREL)

GEM IPC TRACKER
FRONTAL VIEW OF ENDCAP
(FIRST LEVEL ONLY)

FIGURE 3



NOTE: EACH LEVEL OF 10 SECTORS ROTATED 9 DEGREES
RELATIVE TO ADJACENT LEVELS (4 LEVELS IN TOTAL)

E. [illegible]
YALE UNIVERSITY PARTICLE PHYSICS GROUP
JANUARY 15, 1982

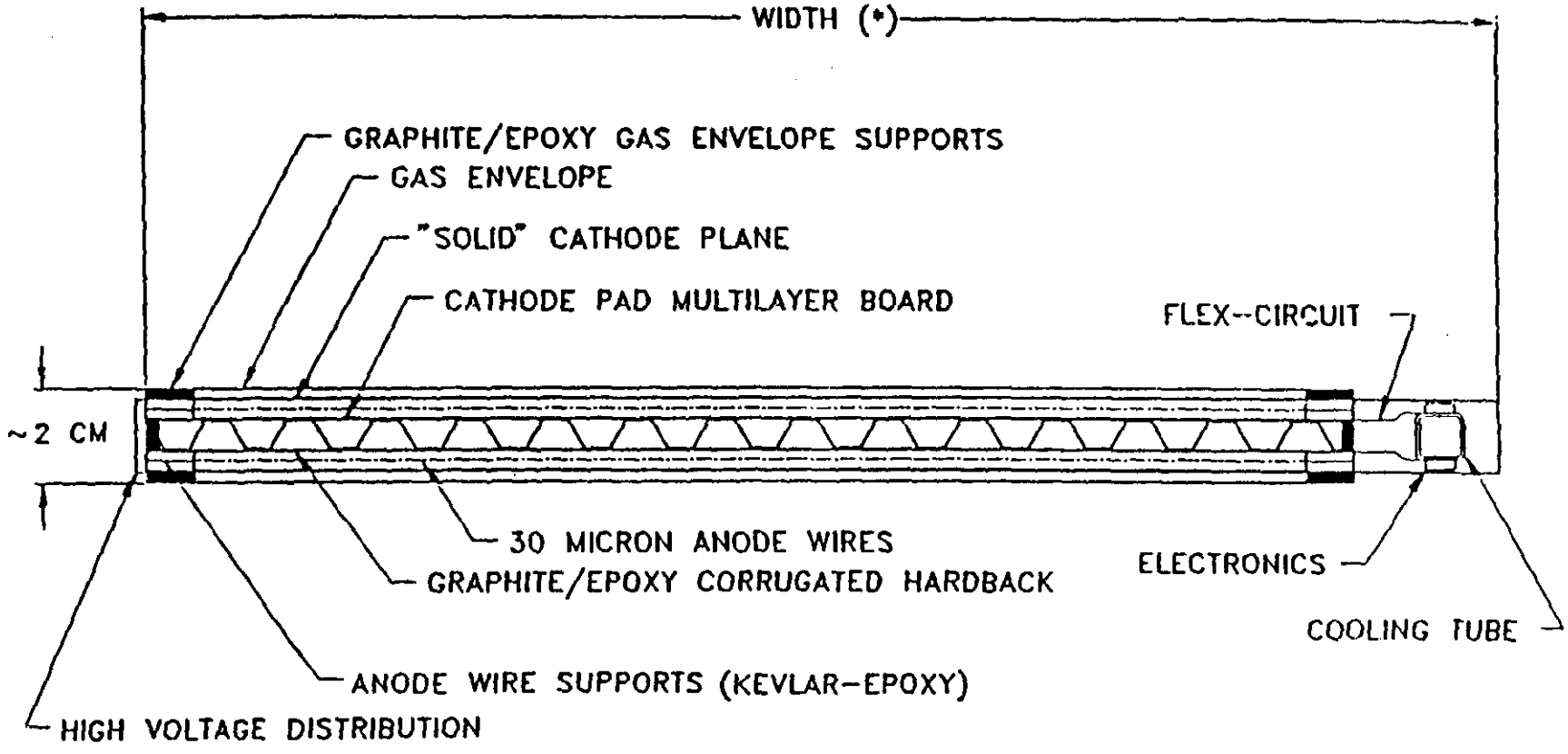


FIGURE 4:

GEM TRACKING IPC SUPERLAYER

SECTIONAL OF TYPICAL BARREL MODULE

*NOTE: LEVEL I = 18 CM
LEVEL II = 21.8 CM
LEVEL III = 24.5 CM
LEVEL IV = 27.4 CM
(SUBTRACT 5 CM FOR ACTIVE WIDTH)

W. EMMET
YALE PPG 22-JAN-1992

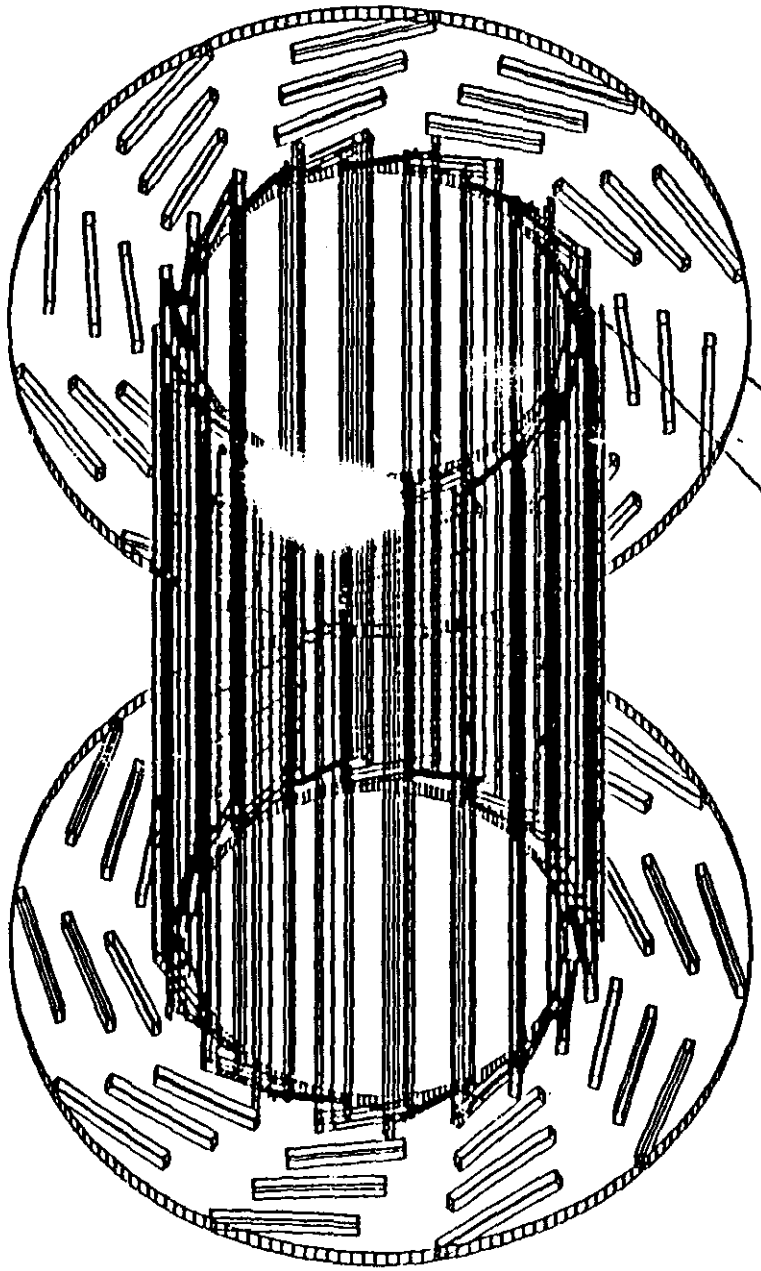


FIGURE 5

GEM TRACKER
INTERPOLATING PAD CHAMBER ARRAY (BARREL)
20 SECTORS
4 SUPERLAYERS PER SECTOR
2 LAYERS PER SUPERLAYER
LORENZ ANGLE = 12 DEGREES

NOTE: ONLY THE INNERMOST LAYER OF MODULES HAVE BEEN SHOWN FOR PURPOSE OF CLARITY.

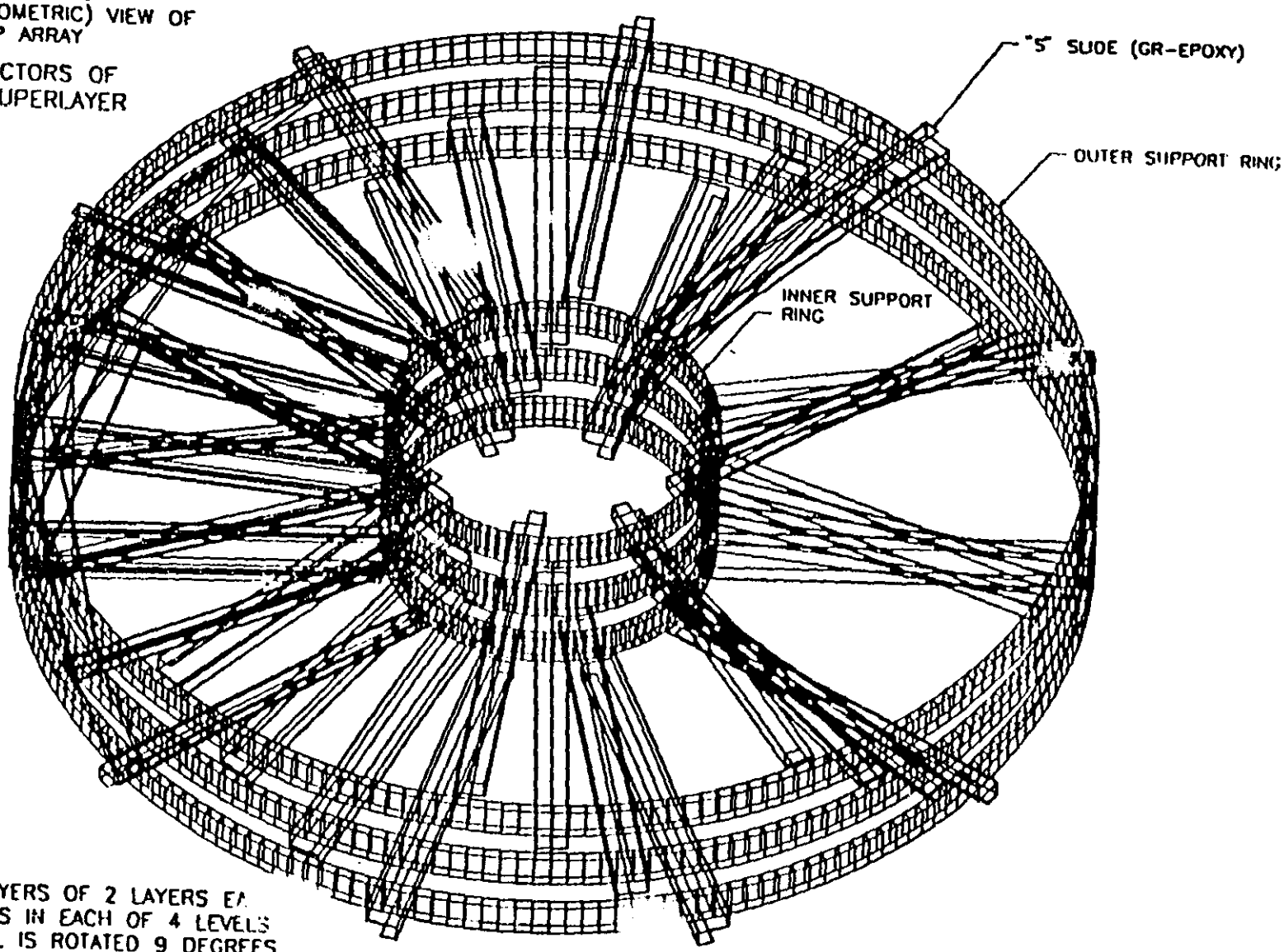
HOLLOW GRAPHITE/EPOXY END SUPPORTS DOUBLE AS STRUCTURAL AND GAS CONDUITS
ALTERNATE SECTORS ARE INSTALLED THROUGH ALTERNATE END SUPPORTS

GRAPHITE/EPOXY SLIDES FOR GUIDING MODULES INTO POSITION

W. DIMET
YALE PARTICLE PHYSICS GROUP
JANUARY 19, 1992 (REV. 2)

FIGURE 6:
GEM IPC TRACKER
3-D (ISOMETRIC) VIEW OF
END CAP ARRAY

TWO SECTORS OF
EACH SUPERLAYER
SHOWN



FACTS:

1) 4 SUPERLAYERS OF 2 LAYERS EA
2) 10 SECTORS IN EACH OF 4 LEVELS
3) EACH LEVEL IS ROTATED 9 DEGREES
4) Z(min)=110 CM; Z(max)=140 CM
5) R(min)=20 CM; R(max)=70 CM

Figure 6

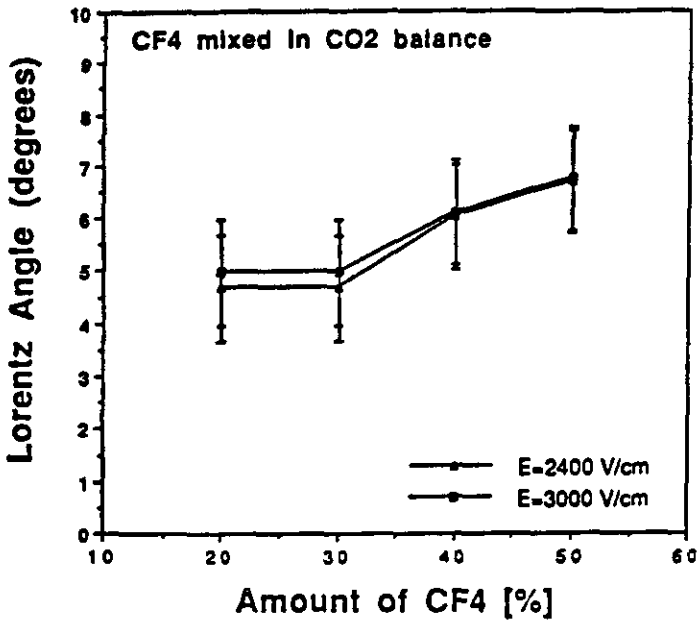


Figure 4.2.1
Lorentz Angle vs Freon Concentration

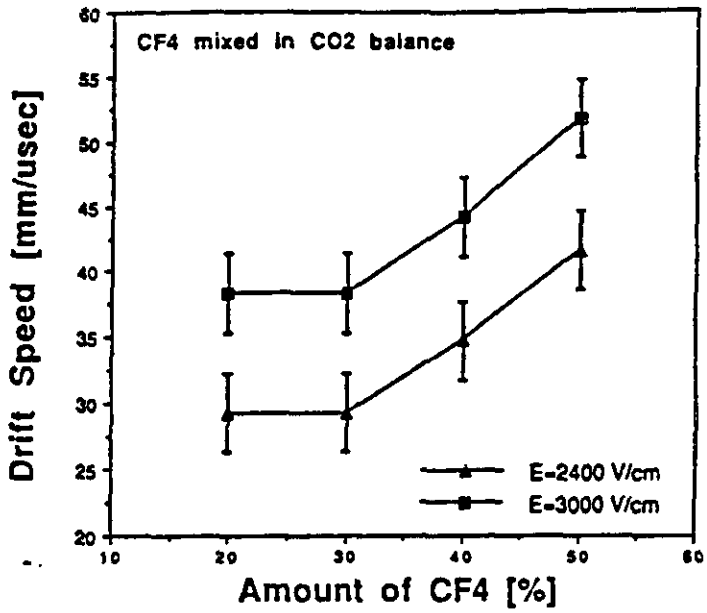


Figure 4.2.2
Drift Velocity vs Freon Concentration

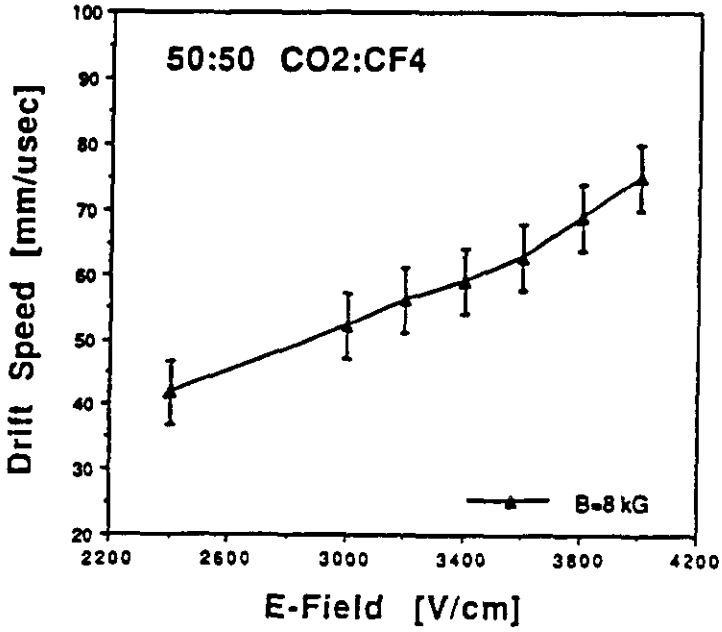


Figure 4.2.3
Drift Velocity vs Electric Field

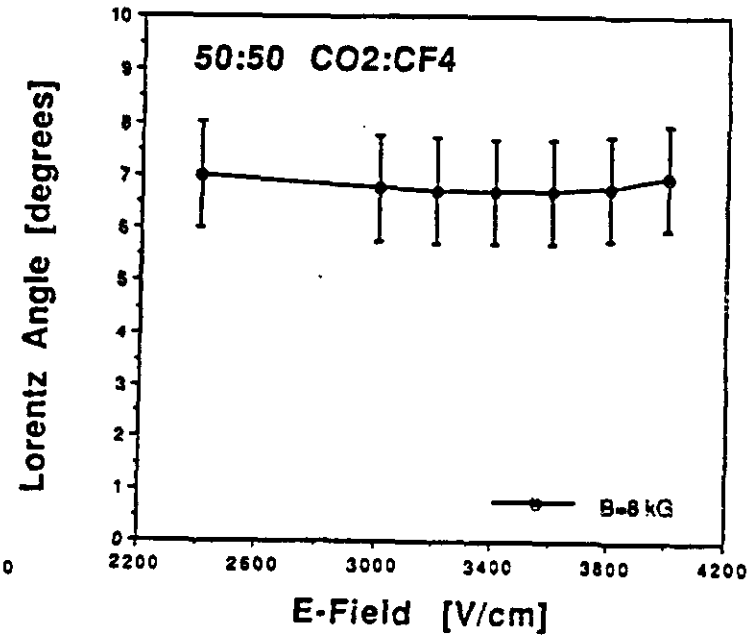
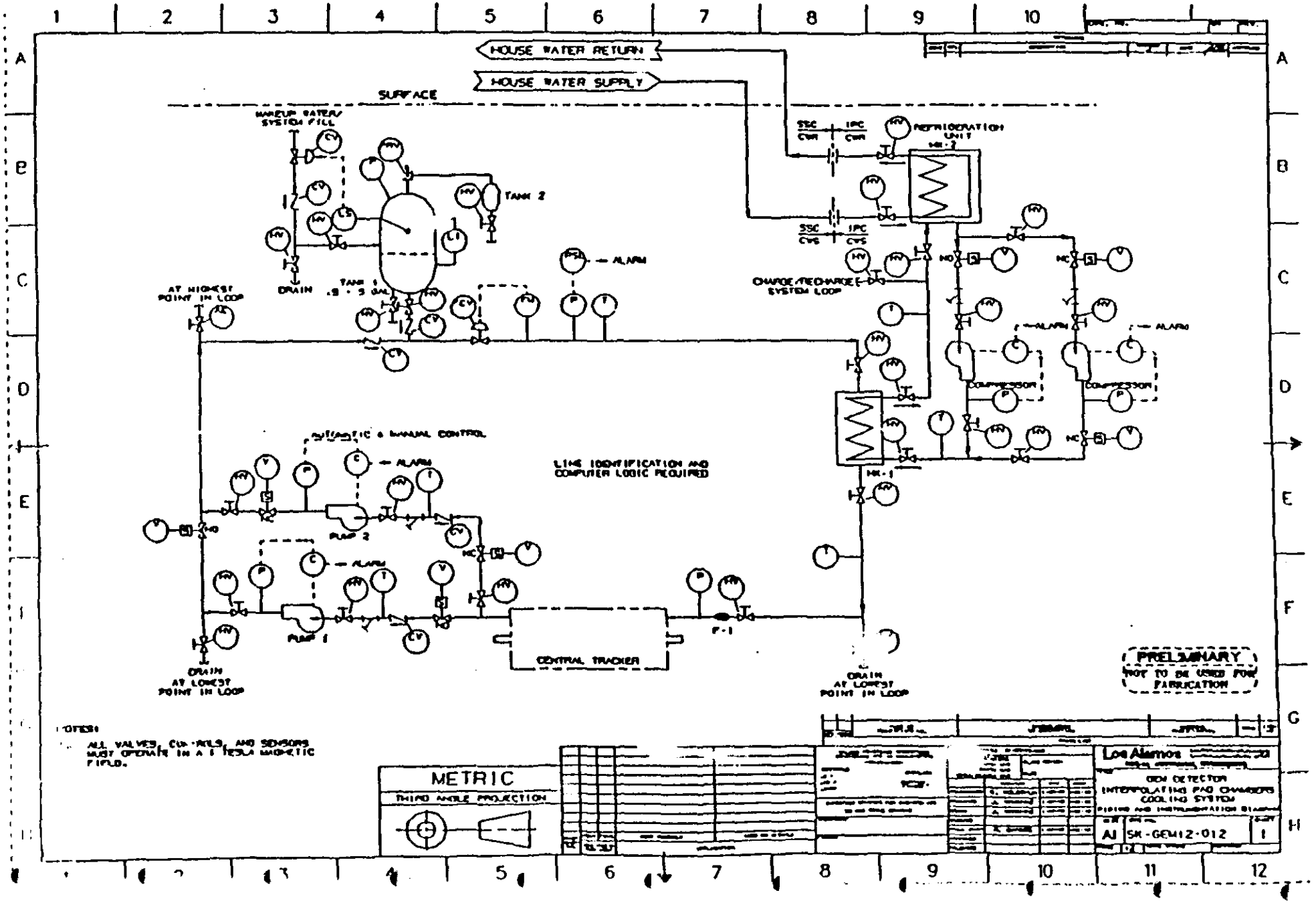


Figure 4.2.4
Lorentz Angle vs Electric Field


HOUSE WATER RETURN
HOUSE WATER SUPPLY
SURFACE
MAKEUP WATER/ SYSTEM FILL
TANK 2
DRAIN
TANK 1
ALARM
AT HIGHEST POINT IN LOOP
SSC CWR
IPC CWR
SSC CWS
IPC CWS
REFRIGERATION UNIT
HX-2
CHARGE/RECHARGE SYSTEM LOOP
COMPRESSOR
AUTOMATIC & MANUAL CONTROL
LINE IDENTIFICATION AND COMPUTER LOGIC REQUIRED
PUMP 2
PUMP 1
HX-1
F-1
CENTRAL TRACKER
DRAIN AT LOWEST POINT IN LOOP
PRELIMINARY
NOT TO BE USED FOR FABRICATION
NOTES:
ALL VALVES, CONTROLS, AND SENSORS MUST OPERATE IN A 1 TESLA MAGNETIC FIELD.
METRIC
THIRD ANGLE PROJECTION
Los Alamos
GEM DETECTOR
INTERPOLATING PAD CHAMBERS
COOLING SYSTEM
PIPING AND INSTRUMENTATION DIAGRAM
A1
SK-GEM12-012
1

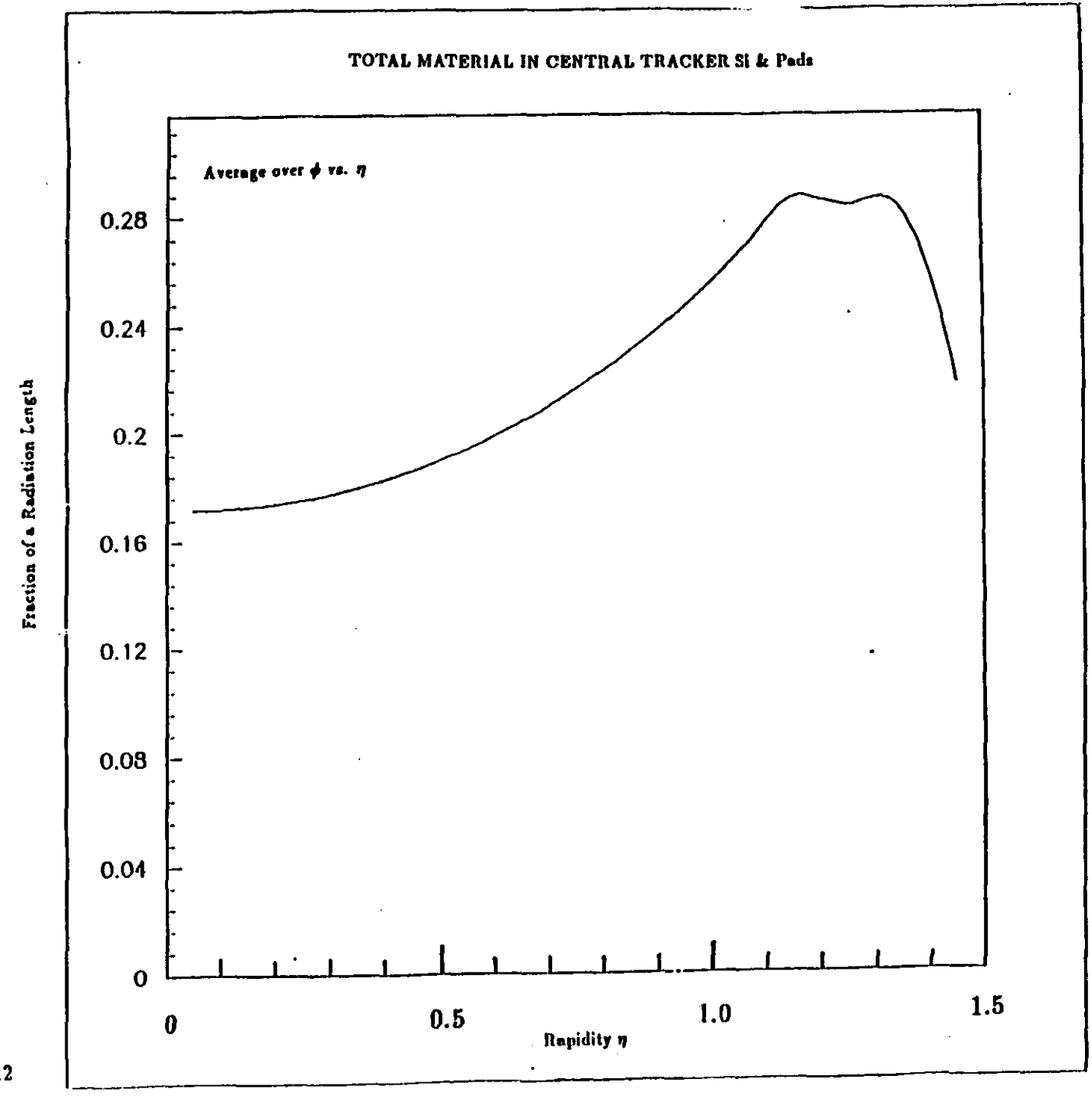

TOTAL MATERIAL IN CENTRAL TRACKER Si & Pads
Average over ϕ vs. η
Fraction of a Radiation Length
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
0
0.5
1.0
1.5
Rapidity η

Figure 2.2

LOS ALAMOS SIMULATION STATUS

Silicon Geomtry

1. Silicon Baseline Geometry Installed
2. Correct 2mm overlap
3. Support Structure (Barrel)
   a. Mechanical is up-to-date
   b. Electronics - still to be done (now- +30% of Si)
4. Pattern Recognition
   a. fit track in Silicon
   b. fit track in Pads
   c. join both

Fast Parameterization

1. provided tables for
   a. deltap/p vs. eta and p
   b. deltap/p (vertex constraint) vs. eta and p
   c. impact parameter vs. eta and p

Work in Progress

1 Pattern Recognition

a. Improve Pattern Recognition - IN PROGRESS

b. Correct Covariance Error Matrix for Fit - done

2 Update Silicon Geometry - done

3 Include Complete Coordinate Inefficiencies

a Dead Time - done

b Dead Strip - done

c Electronic Noise

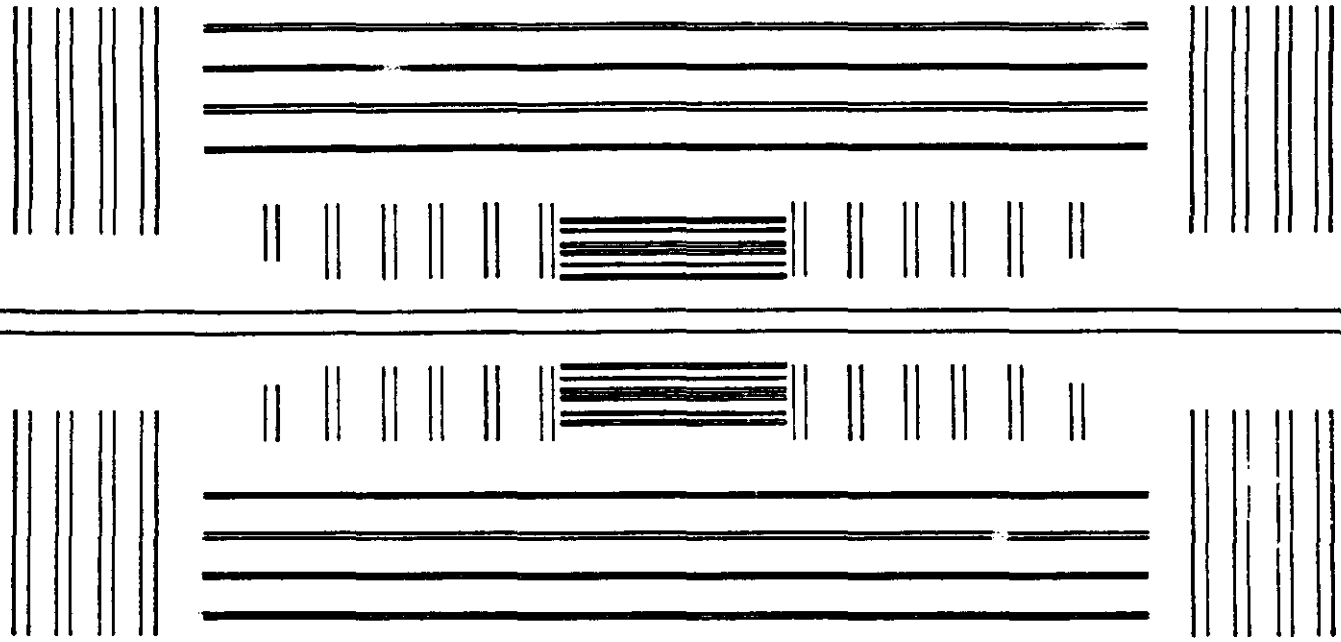
d Dead Spaces - done

IPC Geometry

a Implement IU Geometry into Geant

b Ship to SSC

LSDT RUN NR 1 EVENT NR 0 1/ 4/92



Los Alamos

gem

γeμ

Presentation by:

Yuri Kamyshkov

Calorimeter system report

Yu. Kamyshkov	Intro	10′
H. Gordon	LAr	15′
H. Newman	BaF_2	15′

Comments

- Baseline LAr (em + hadr + forw) $ 152 M
- Alternative (BaF2 + SciFi + forw) $ 152 M

- LAr hadronic @ R = 360 cm and Z = 550 cm

  doesn't satisfy baseline parameters :

  only 10.2 λ at $\eta = 0.$ and

  11.5 λ at $\eta = 3.$

  The problem is being fixed.

- Alternative option @ R = 330 cm and Z = 470 cm

  provides 12 λ at $\eta = 0.$ and

  14 λ at $\eta = 3.$

- SciFi engineering progress was demonstrated

- Cost of BaF2 can potentially go up if individual crtystal treatment will be required

- LAr e-m accordion end cap design - no progress

Cost Review of Calorimetry Options

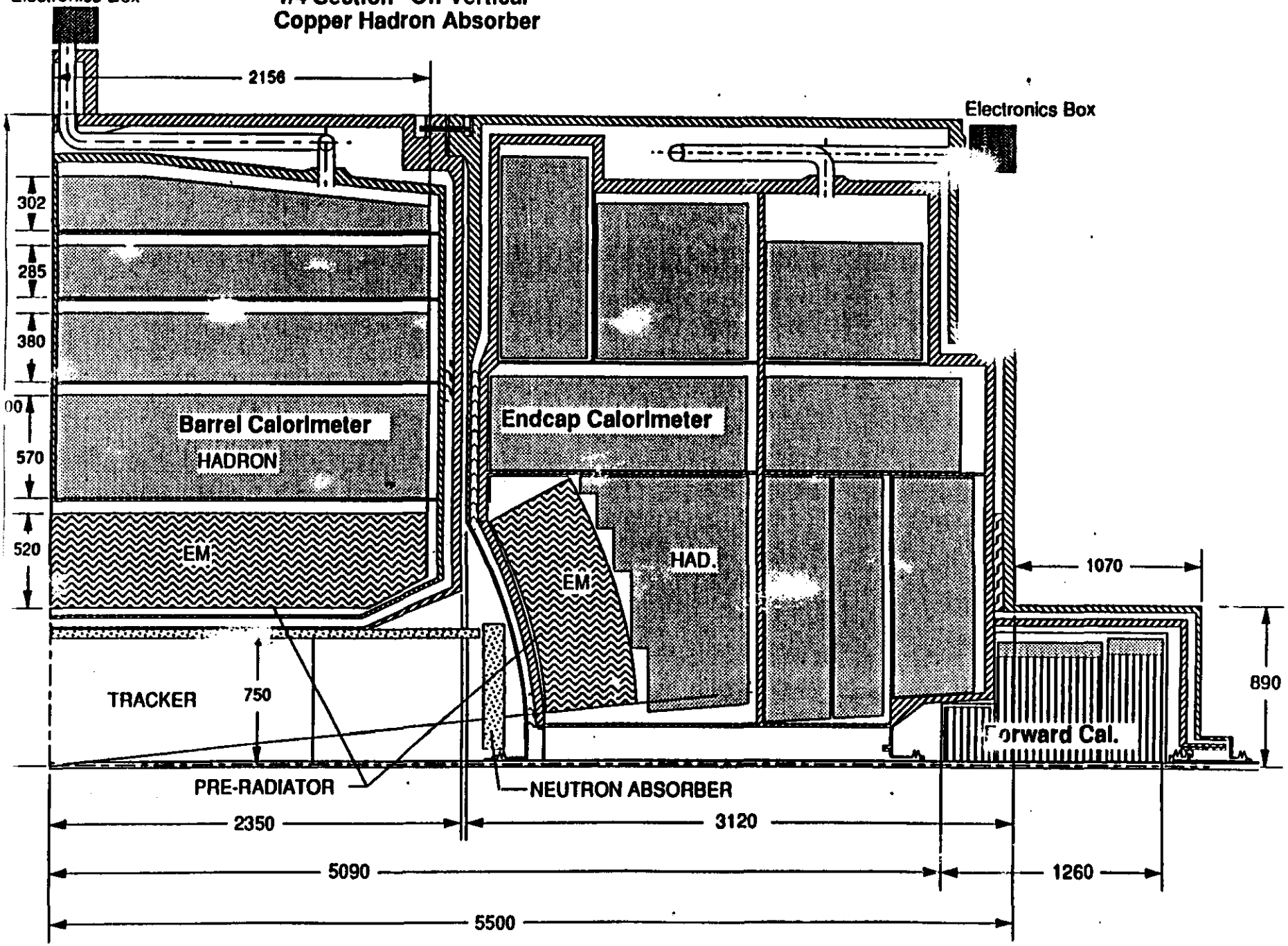
(SSCL April 21-22)

Preliminary

→ 1.	BaF2	$ 80.3 M	China $15 M ?
→ 2.	Sci. Fibers	$ 55.7 M	Albania Belorus $11 M ?
→ 3.	Forw. Liq. Sci.	$ 16.4 M	China ?
4.	Sci. Tiles	$ 51.8 M	
→ 5.	LAr e-m + hadr	$ 136.7 M	(+ 4-5% 91→92 $) China e-m ? Russia hadr. mod. Korea cryostat ?
5.1	LAr separate e-m	$ ~ 60.0 M	
5.2	LAr e-m + hadr. forw	$ ~ 84.0 M	
5.3	add accordion prerad	$ > 5.0 M ?	
→ 6.	Forward LAr	$ 15.3 M	
7.	LKr parall. plates + π^0	$ > 37.8 M ?	(cryostat, install. etc. not included)
8.	Si prerad	$ 16.0 M	

GEM Liquid Argon Calorimeter

1/4 Section "Off Vertical"
Copper Hadron Absorber



LLMason GEMLAC.4/21/92

E – m

- More engineering efforts (+? money) are needed for LAr e-m accordeon option

- Engineering aspects of the separate e-m LAr calorimeter option should be studied (M. Rennich, L. Mason)

A. Requirements for BaF2 technology :

1. Demonstrate substantial improvement in radiation resistance of large BaF2 crystals (20-25 cm long) towards the GEM specifications - reach absorbtion length of at least >60 cm at 220 nm after 1MRad irradiation with photons, and if possible high energy hadrons. Present a detailed plan to obtain final GEM quality crystals, along with evidence of manufacturability and cost, including work required to prepare crystals after delivery.

   by August 1, 1992

2. As proposed by the expert panel, produce small radiation-hard crystals to demonstrate there are no fundamental limitations in making rad hard BaF2 crystals. (eg. absorbtion length >= 95 cm at 220 nm after 1 MRad)

   by August 1, 1992

3. Address in detail questions of preradiation, wrapping, residual non-uniformity, etc in crystals we can practicably expect to manufacture. Cosmic ray transverse measurements in produced crystals could provide useful data. Provide detailed practical plan for calibration of BaF2 system in-situ :describe calibration strategy, RFQ layout, required calibration time for each proposed technique to achieve necessary accuracy.

   by July 1, 1992

4. Show by MC and by lab.tests that the following effects do not destroy the resolution of the BaF2 system (maximum tolerable constant term is 0.6%) :

   - residual non-uniformity (as installed);
   - non-uniformity developed by possible further radiation damage of "saturated" crystals and/or by possible annealing;
     (note - the expert panel and executive committee are not convinced of the proposal to preradiate the crystals)
   - accuracy of intercalibration (see point 3);
   - short term instabilities of readout system;
   - linearity, linearity calibration and dynamic range of readout system.

   by July 1,1992

B. Requirements for LAr-Kr technology :

1. Demonstrate by beam tests stochastic term in resolution for non-projective geomet <= 7%/sqrt(E). Determine angular dependence of this resolution.
by August 1,1992

2. Produce detailed mechanical design/analysis of e-m barrel and end caps with optimization of gap between barrel and end cap, wall thicknesses, etc.
by July 1,1992

3. Demonst by MC simulations for realistic projective geometry and full angular range (between 90 and 5.7 degrees) the resolution
<= 7%/sqrt(E) + 0.4%
and physics consequences of the gap between barrel and end cap, wall thicknesses, etc.
by July 1, 1992

Hadronic section

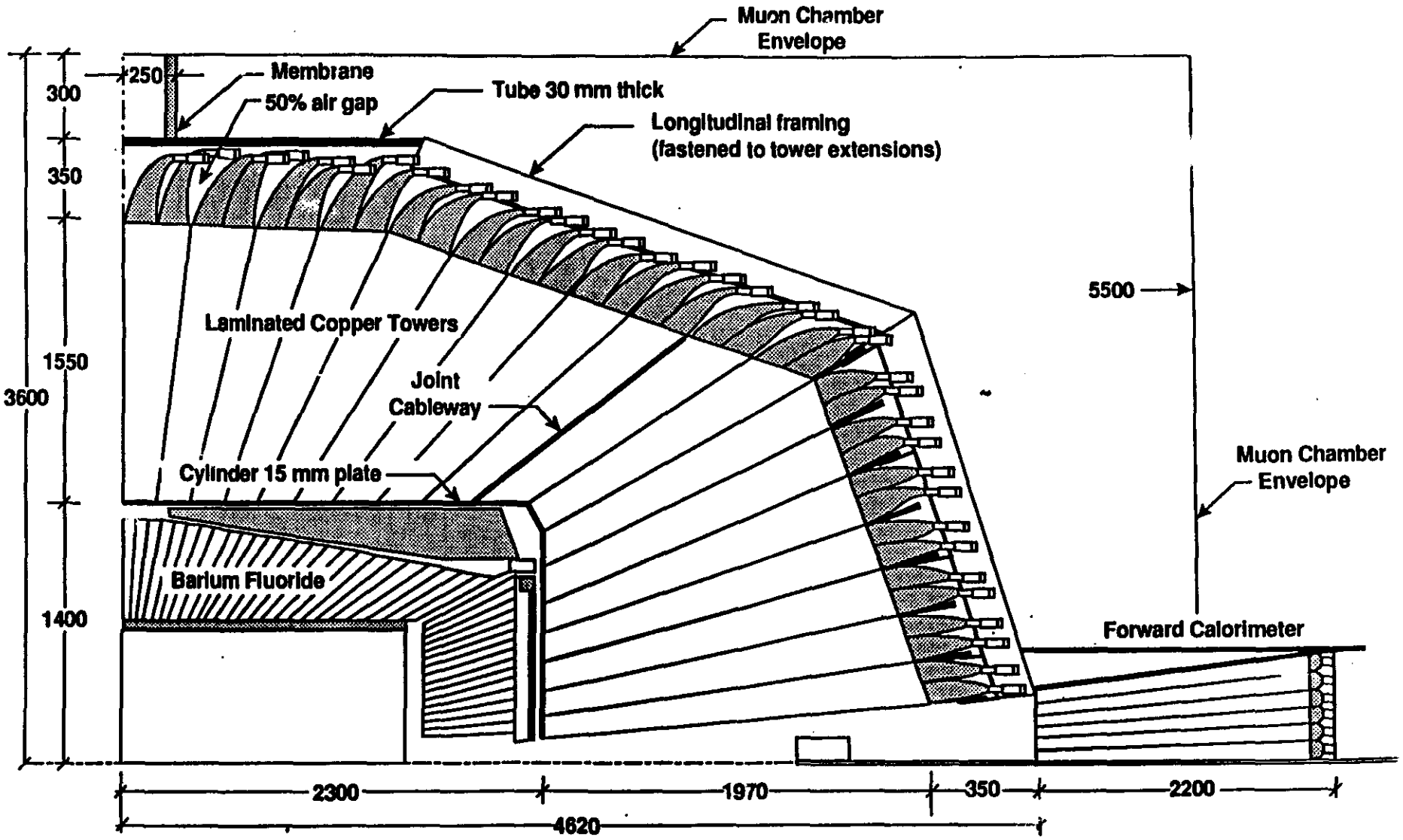
- Hadronic LAr cost:

  $ (136.7 − 60) · 1.04 ≃ 80 M

  If lambda shortage will be fixed cost most likely will go up

- Hadronic scint. cost:

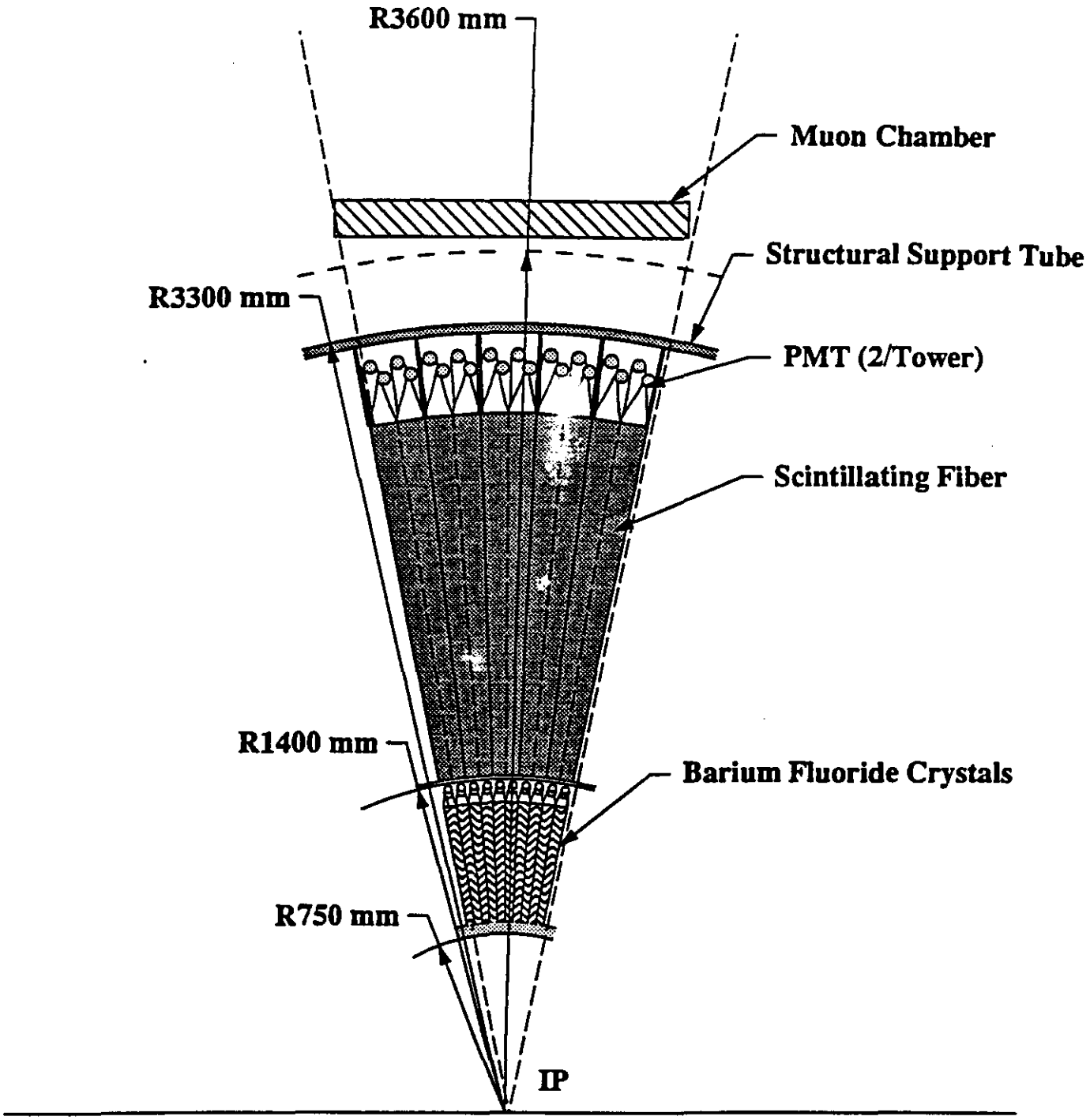
  $ 52 - 56 M



Dimensions in millimeters

GEM Scintillator Calorimeter System

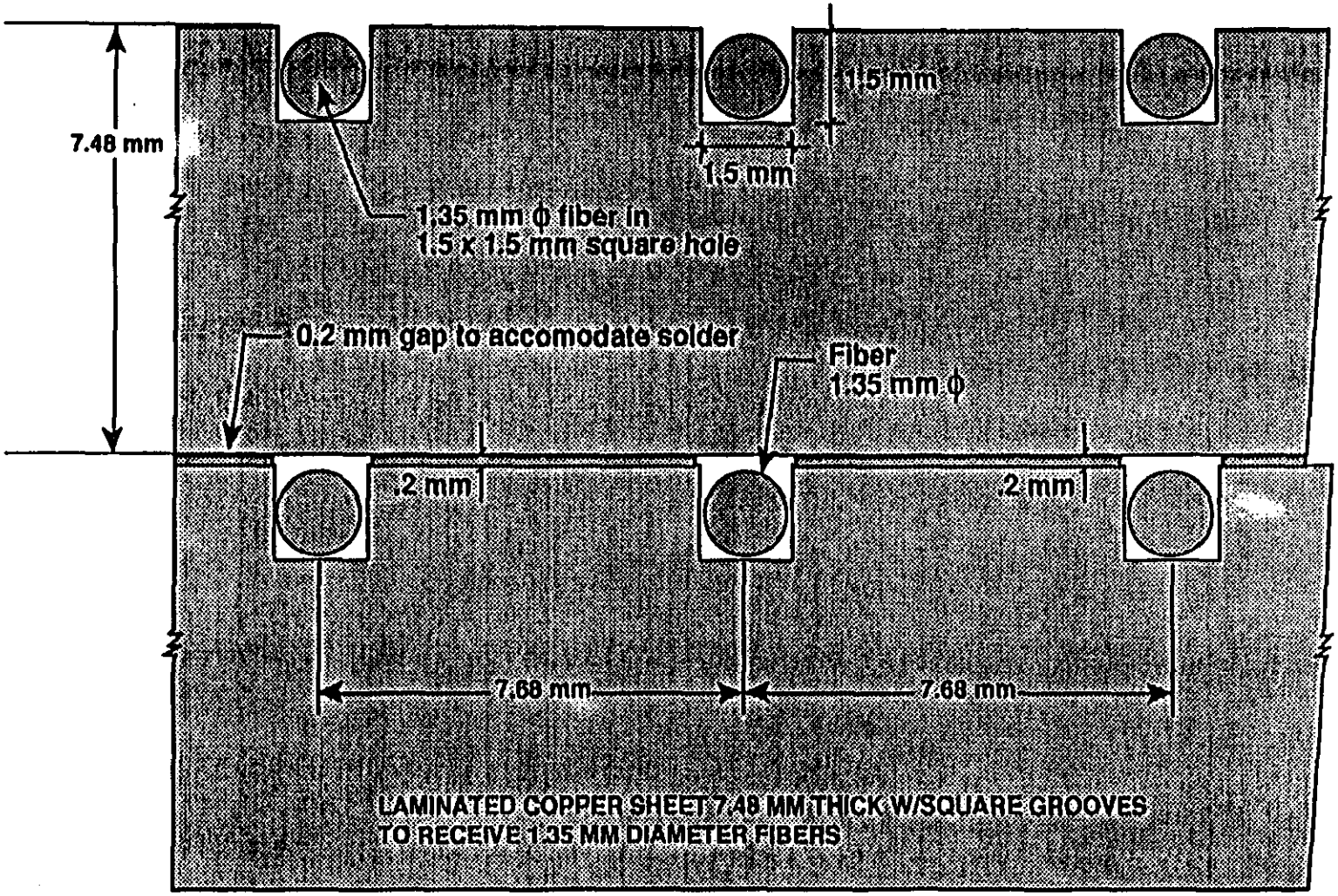
F. Ayer 9203D270



GEM Detector
Barium Fluoride/Scintillating Fiber Calorimeter
End Section View at 90 Degrees

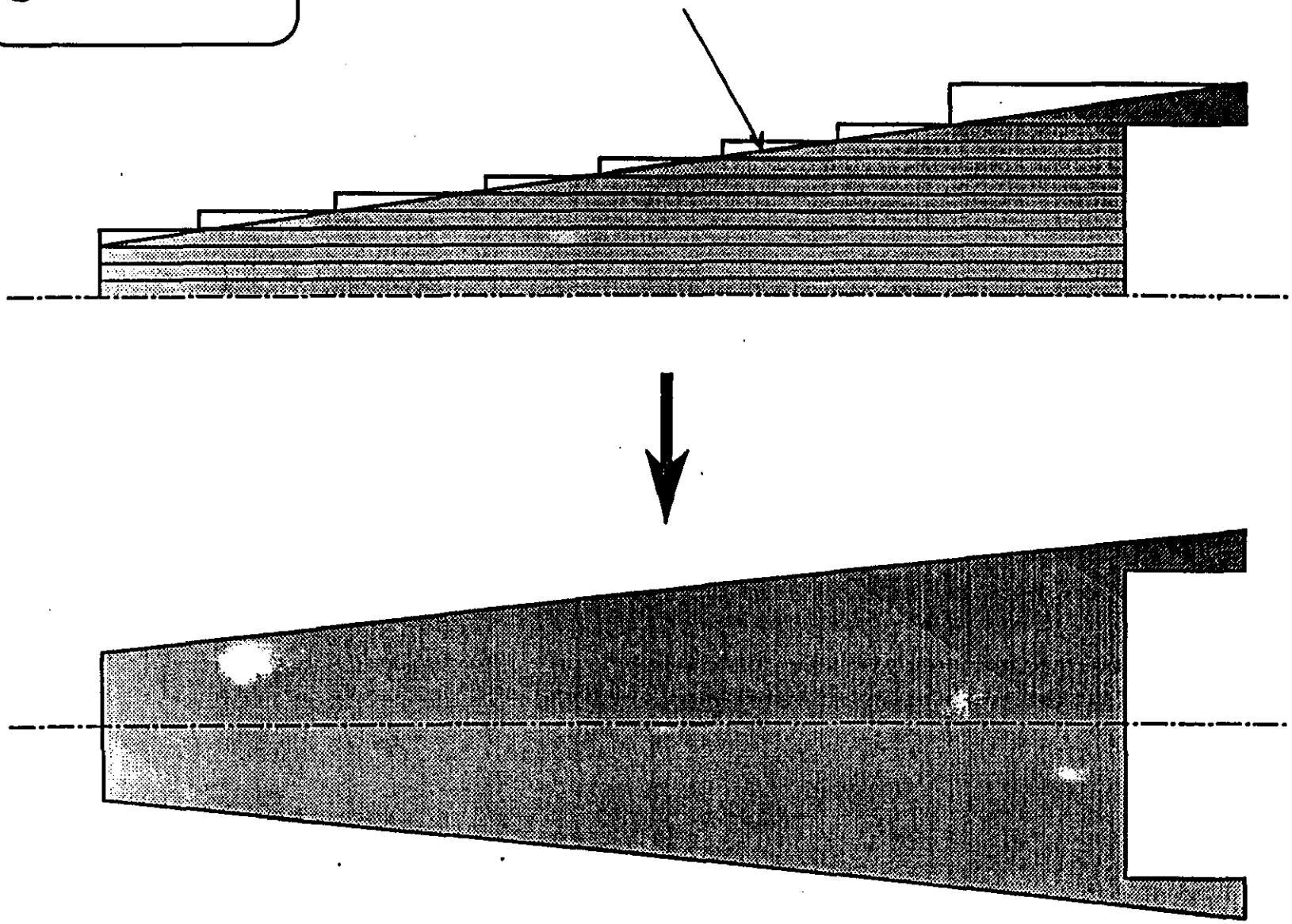
G.03.CU.003 Rennich

COPPER CALORIMETER TOWER GEOMETRY



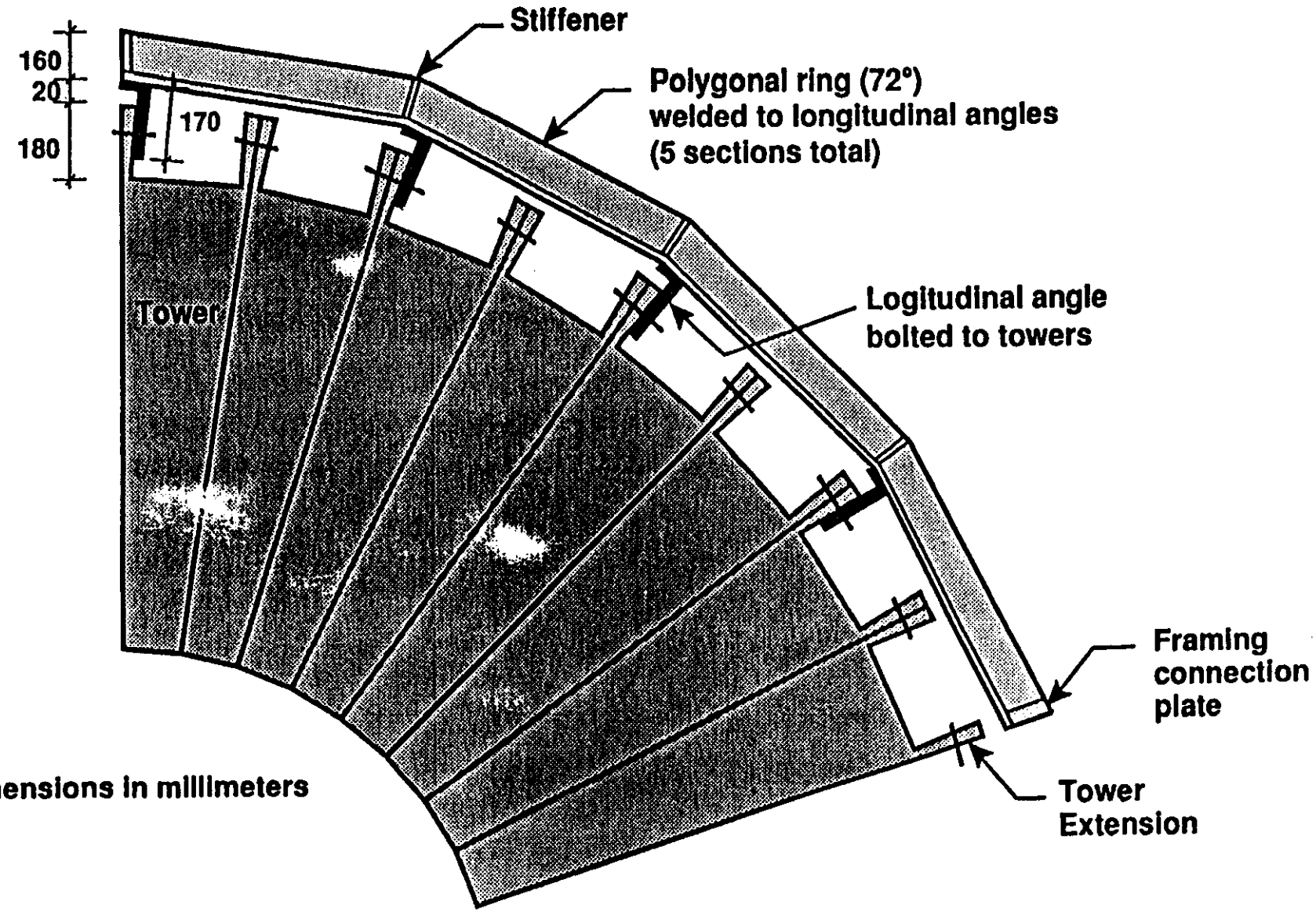
Ayer/4/9/92

5 Machining



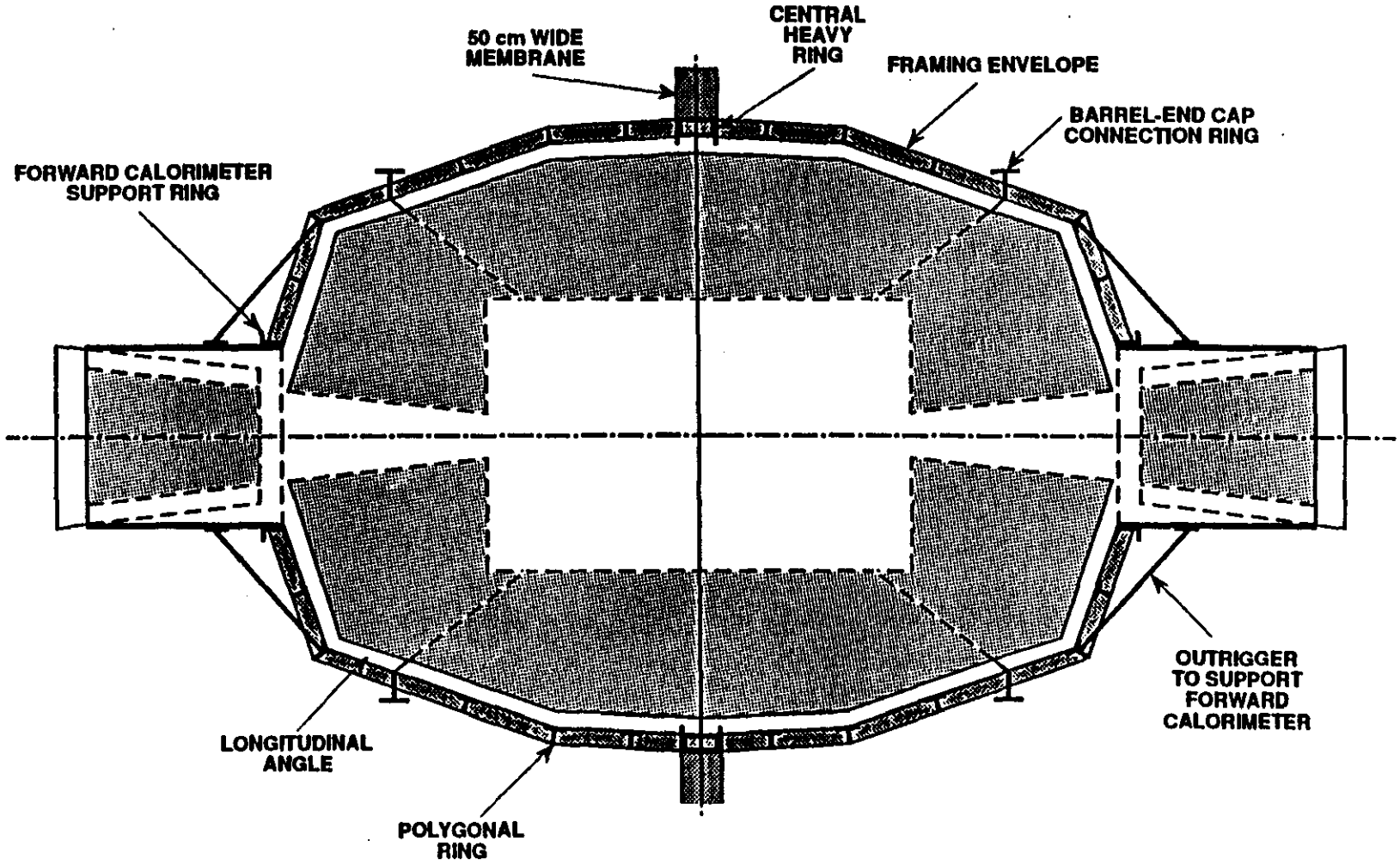
9204F253/AYER

Framing-Tower Attachmen Concept



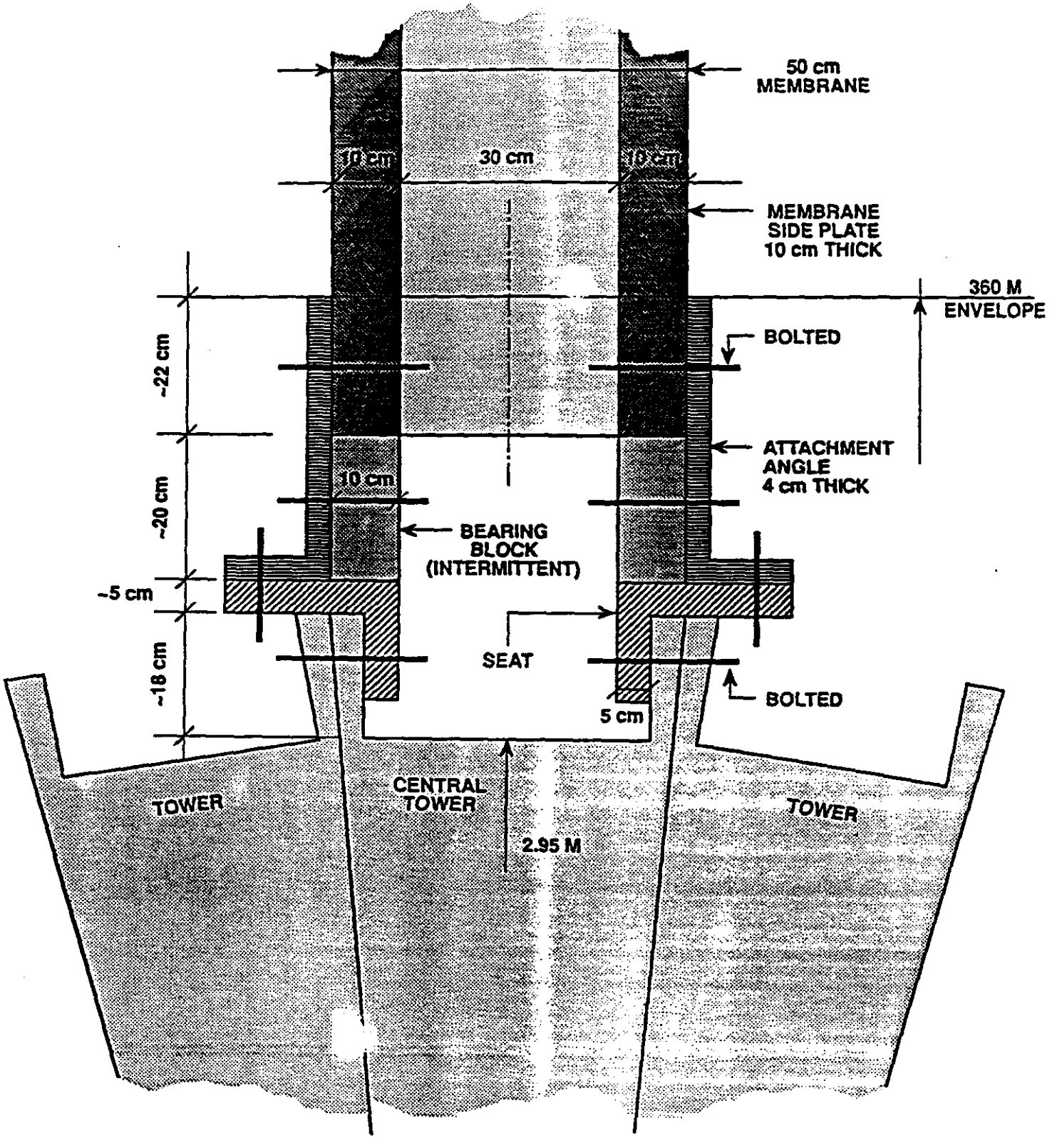
Dimensions in millimeters

GEM SCINTILLATOR CALORIMETER STRUCTURAL SUPPORT SYSTEM
(SCHEMATIC)

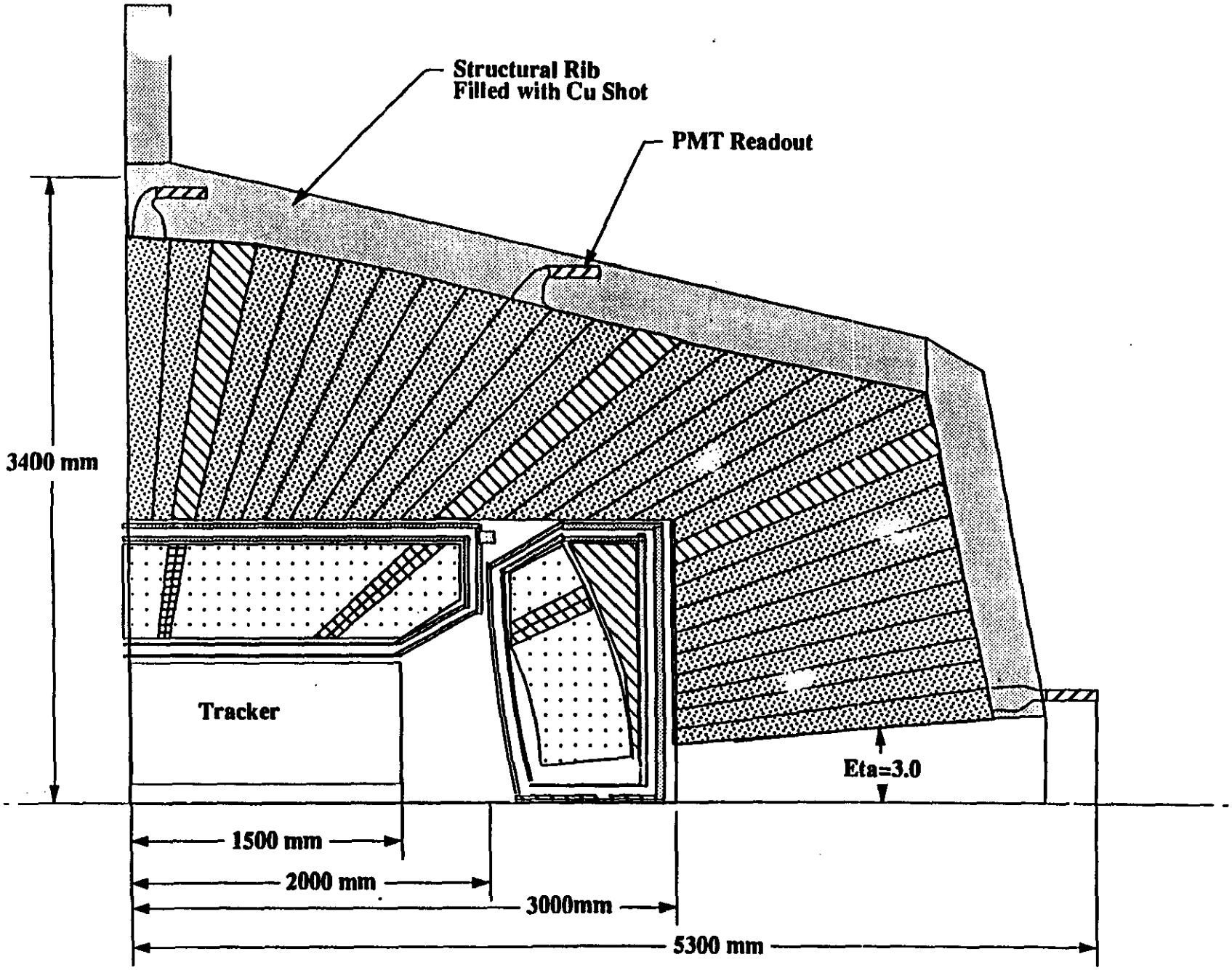


CONNECTION DETAIL WITH MEMBRANE

(PRELIMINARY)



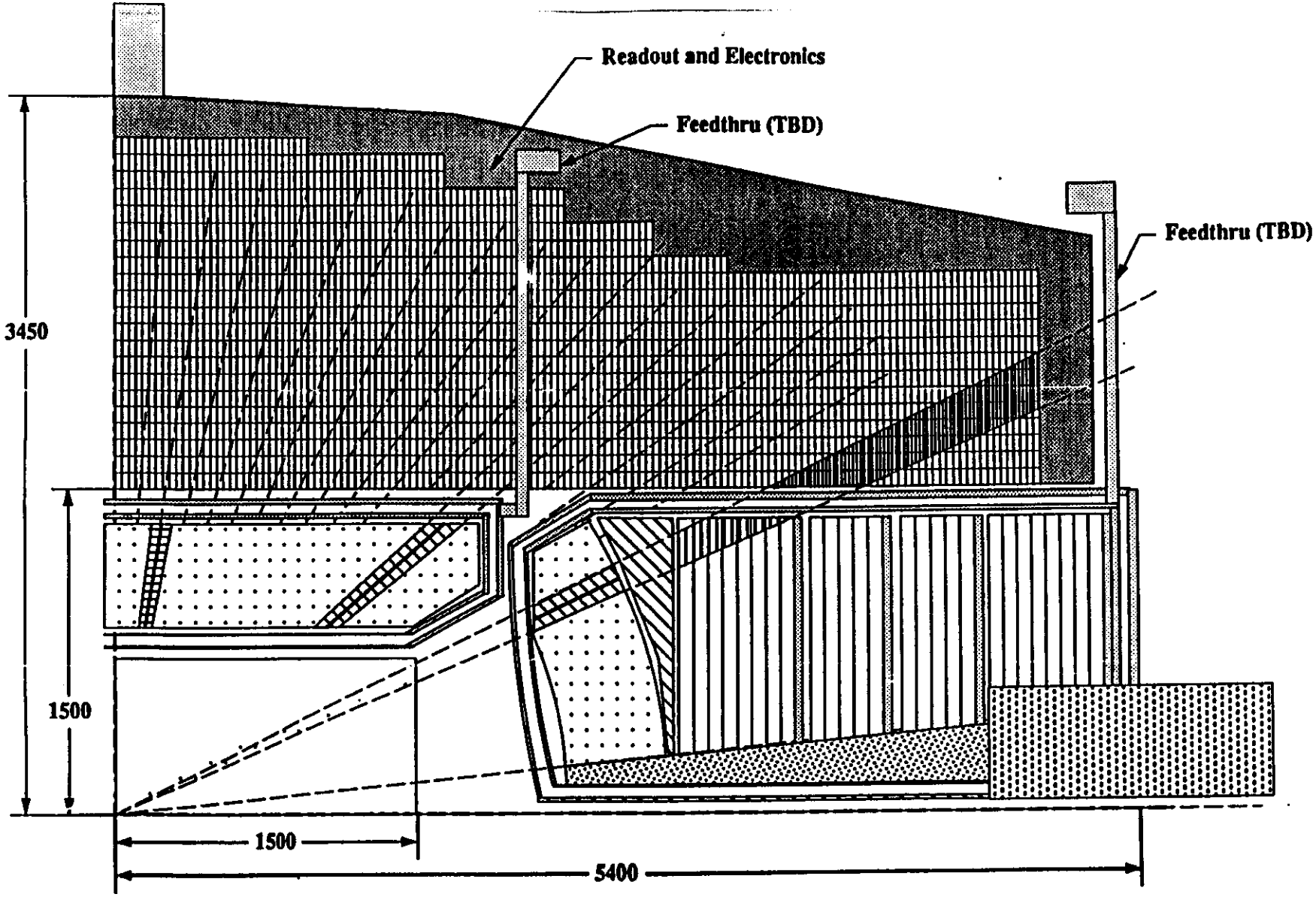
9204F253/AYER



Spaghetti Hadron Calorimeter
Copper Fill/0.12 Segmentation
Liquid Argon EM Calorimeter

G.03.SC.00080

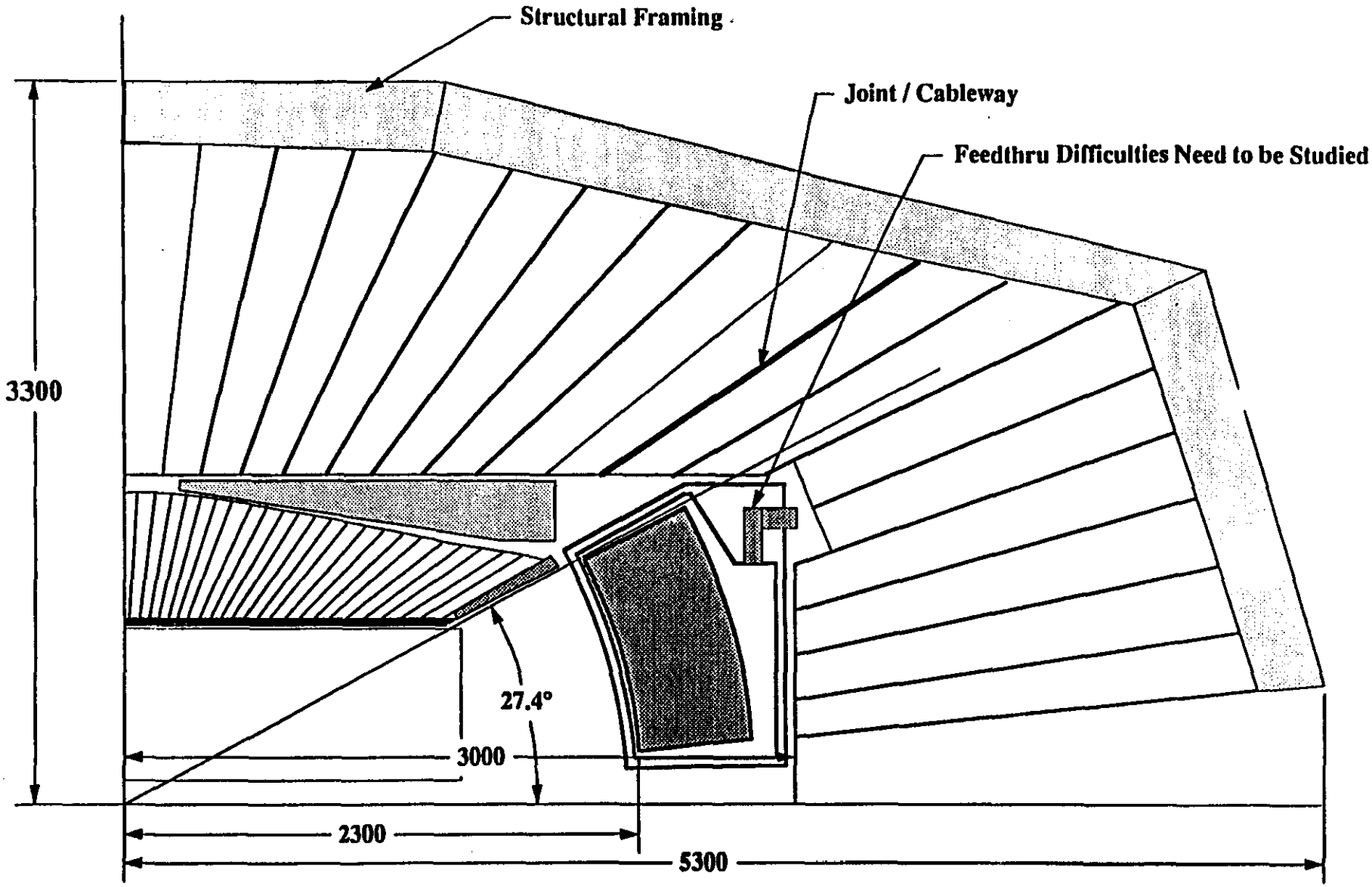
Rennich



GEM Detector
Plastic Tile/Copper
Hadron Barrel Calorimeter,
LAr EM - Hadron End Cap and
LKr EM Barrel Calorimeter

G.03.T.018

Rennich

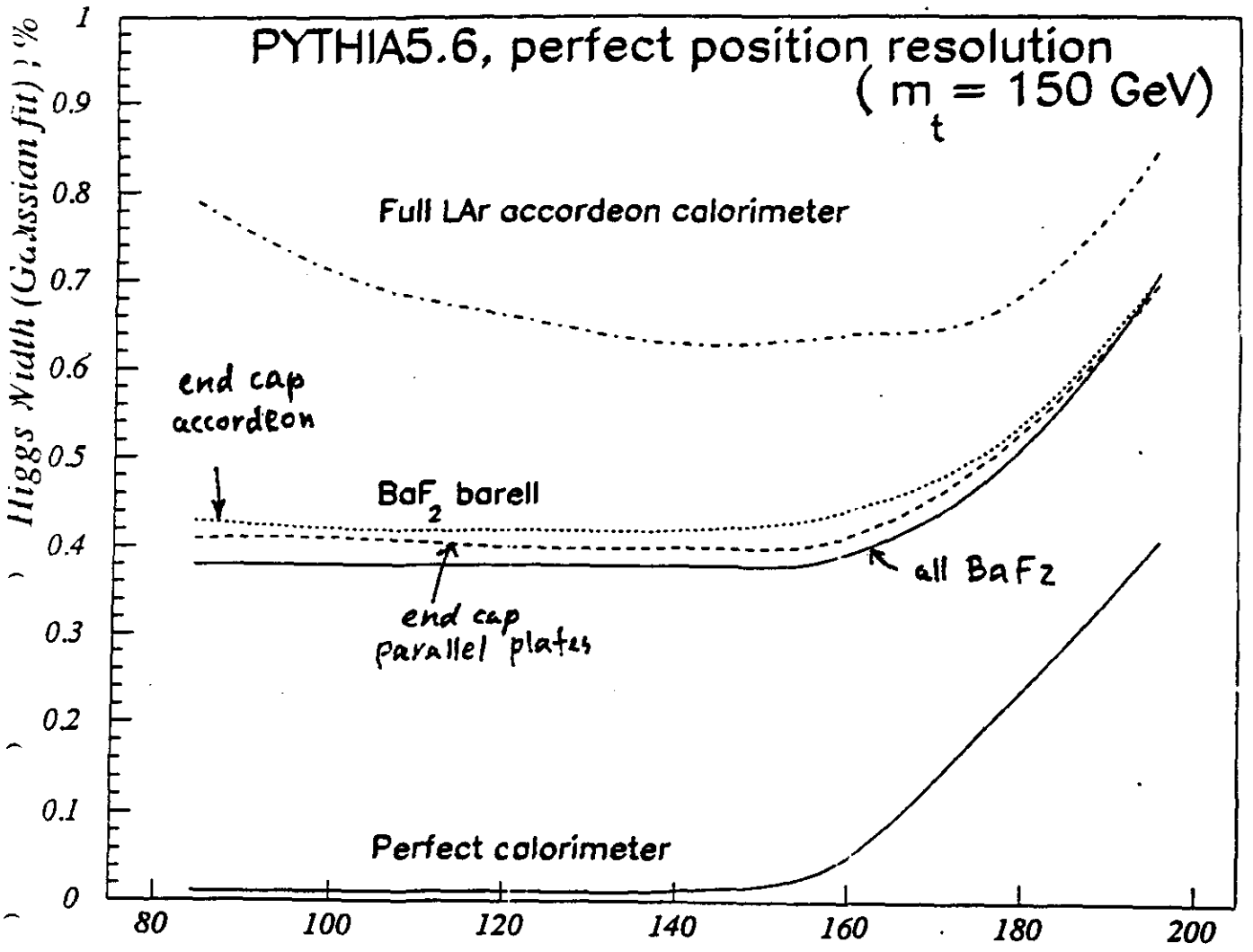


GEM Detector
BaFFiLAr Calorimeter

G.03.CU.017

Rennich

HIGGS MASS RECONSTRUCTION

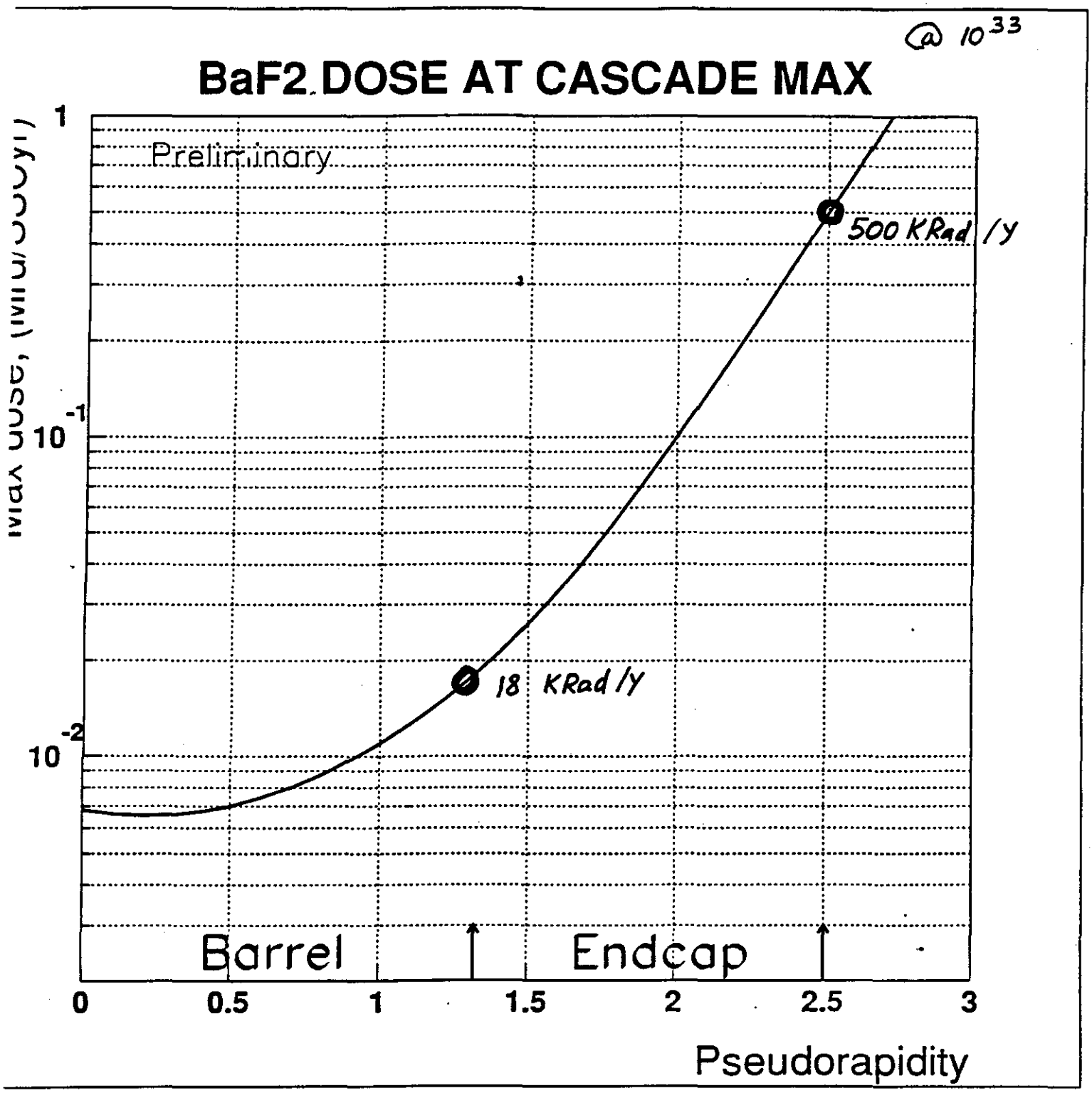


HIGGS MASS (GeV)

BaF_2+LAr accordeon endcap

BaF_2+LAr plates endcap

BaF_2 full calorimeter


@ 10^{33}
BaF2 DOSE AT CASCADE MAX
Preliminary
500 KRad/y
18 KRad/y
1
10^{-1}
10^{-2}
Barrel
Endcap
0
0.5
1
1.5
2
2.5
3
Pseudorapidity

International contributions to Calorimetry

- Meeting at ITEP Moscow May 14 with Russian GEM Collaborators to understand possible Russian contributions to Calorimetry.

- Discussions with Chinese ~ May 20 on GEM contributions.

28 April 1992

D R A F T

Prof. Gu
Institute of High Energy Physics
Beijing, China

Re: Construction of Liquid Argon Modules.

Dear Prof. Gu:

The design of the liquid argon calorimeter system for GEM is far enough along that we will benefit greatly by involving at this stage the physicists and engineers who will produce the different components. More details of the liquid argon calorimeter can be found in the GEM Baseline 1 Document - GEM TN 92-76 (which should have been sent to you recently) and in the Liquid Argon Calorimeter Cost Review Meeting - SSCL, April 22, 1992 - GEM IN 92-3 which is enclosed. The modular construction of the liquid argon calorimeter should enable us to benefit from contributions from many diverse institutions. In this note, we list the major components that are involved in building the electromagnetic (EM) and hadron modules and that we can see being built overseas.

EM modules:

The construction of the EM modules can be separated into three main components: production of the absorber plates, production of the readout electrodes and the assembly of those two components into modules that will fit into the final calorimeter.

Absorber Plates:

The absorber plate is made of a thin layer of lead sandwiched between two thin layers of stainless steel. The lead and the stainless are bonded together with a layer of prepreg. This sandwich needs to be bent into the accordion shape and then heat and pressure activate the prepreg. There are at least two different methods for achieving the accordion shape that are being considered. There will be one shape for all the 800 plates for the barrel. For the endcap, the design is has many options - but all involve at least one different shape than that used in the endcap.

EM Readout Electrodes:

We are considering two basic solutions at this moment. In the so-called standard solution, the readout board is made of a large multilayer board of Kapton and copper. In the second option, the multilayer board is made out of Lead strips sandwiched between electrodes of polysolfoam clad with copper. In either case there are silk screened resistive areas required. The electrodes then would be bent into the accordion shape.

Module assembly:

The proposal is to build modules that subtend about 9° in ϕ in the barrel region (similar size for the endcap) and assemble these modules outside of the SSC site. At this stage we expect that the preamp and calibration motherboard will be installed and tested.

Hadronic Modules:

Here we can separate the work into two main activities. First the fabrication of the pieces: absorber/readout plates made from the copper tiles, solid ground plates, and module structure. Second the stacking of these pieces into modules for installation in the calorimeter. A significant component of the labor required for these modules is in the fabrication of laminations of copper tiles sandwiched between thin sheets of fiberglass. The weight of the hadronic modules is of the order of 1500 MT. There are $\approx 20,000m^2$ of laminations to be made.

The detailed technical solutions one will choose clearly depends on who at the end will actually produce the calorimeter components. We feel strongly that it is very important to get the engineers and physicists from the responsible collaborating institutions involved in the design now so we can benefit from their input when deciding the appropriate technical solutions. The modularity of the liquid argon lends itself to dividing the construction responsibility between different institutions. We will be glad to supply more details and up-to-date drawings when requested, and would like to encourage an immediate exchange of physicists and engineers as soon as possible.

We hope to discuss this further with you and your colleagues at the May, 1992 GEM meeting in Beijing. We hope that in June, 1992 the first engineer(s) and physicist(s) can visit BNL.

Sincerely yours,

Howard Gordon,
David Lissauer

Encl: GEM IN 92-3

gem

γeμ

Presentation by:

H. Newman

H. Newman

BaF_2 EM CALORIMETER REQUIREMENTS FOR 8/92 GEM DECISION:

DEMONSTRATE CAPABILITY TO MAINTAIN THE HIGH RESOLUTION IN SITU

• RADIATION HARD CRYSTALS

(1) Demonstrate Substantial Improvement in 20 - 25 cm Crystal $\lambda > 60$ cm After 1 MRad By 8/92.

(2) Produce Small Rad Hard Crystals: $\lambda \geq 95$ cm After 1 MRad. Show There are No Fundamental Limitations. (Recommended By Expert Panel).

LIGHT COLLECTION UNIFORMITY

(1) Develop Detailed Plan for Obtaining Uniform Crystals After Wrapping Or Coating.

(2) Demonstrate Stability, Or Specify Max. Non-Uniformity (and Time Dependence) Induced By Irradiation.

(3) Pre-Irradiation Question: Method; Time Dependence Due To Incomplete Saturation, or Annealing In Situ.

(4) Cosmic Ray Measurements With Transverse Muons

BaF_2 EM CALORIMETER
1992 R&D PROGRAM

- BaF_2 CRYSTAL PRODUCTION:
  (SIC, BGRI)

✱ • RADIATION DAMAGE STUDY:
  (SIC, BGRI, CALTECH, BNL, TIFR, LNPI;
  CEA, OPTOVAC; NRL, UWV)

✓ • UV MONITORING SYSTEM:
  (CMU,UCSD)

✓✓ • SURFACE PREPARATION,
  UV COATING:
  (LLNL; CEA, CIT, BNL)

✓✓ • PROTOTYPE ENGINEERING DESIGN;
  DESIGN MANUFACTURING PROCESS:
  (ORNL; CALTECH, UCSD, LLNL)

✓ • PROTOTYPE ELECTRONIC READOUT
  (ORNL, PRINCETON)

✓ • CALII ATION, UNIFORMITY, STABILITY:
  COSMIC RAY STAND; RFQ SYSTEM:
  (UCSD, CALTECH)

- BaF_2 CRYSTAL ACCEPTANCE TEST;
  MATRIX ASSEMBLY:
  (CALTECH, UCSD)

- SIMULATION and ANALYSIS:
  (CALTECH, ORNL; UCSD, CMU)

BaF_2 EM CALORIMETER
1992 R&D PROGRAM
RADIATION HARD CRYSTAL PRODUCTION

- 25 Full Sized Pairs With Improved Hardness Ordered (6/92)
- 5 Full Sized Pairs Approaching Rad Hard Specs Ordered (7/92)
- Large Rad-Hard Crystals Meeting Specs: Target Date End 92

BaF_2 EM CALORIMETER
12/91 BEAM TEST

- CALORIMETER RESOLUTION:
  BaF_2-SPECTROMETER DIFFERENCE
  - Resolution 20×20 mm^2: 1.0%
  - Instrumental Contributions
    - * Spectrometer Resol'n: $0.5 \pm 0.2\%$
    - * Pedestal Diff. Linearity: 0.4%
  - BaF_2 Matrix Resolution (at 68 GeV):
    $0.77\ (+0.12 - 0.18)\%$

  - Further Contribution (Not Subtracted):
    Crystal Non-Uniformity: $0.5 \pm 0.1\%$
  - Possible Calorimeter Resolution:
    $0.6 \pm 0.2\%$

Hans

UCSD : COSMIC RAY TEST STAND

Cosmic Ray Telescope

The mechanical work on the stand has been completed. Eight chambers (4 x-chambers and 4 y-chambers) are in place. Two chambers (one x-chamber and one y-chamber) have broken wires, which will be fixed once the remaining chambers are operational. The components of the gas and low voltage distribution systems are expected at UCSD by the end of April and should be installed early in May. The read out system is currently being tested.

Trigger counters and electronics are currently being brought up.

ORNL Base and Preamp

A prototype preamp, with both high and low gain outputs, has been designed and built by Chuck Britton from ONRL. It is currently being set up for cosmic ray tests with a standard BaF2 crystal.

UV pulsed source

Delivery of a Hamamatsu TNLD1401 ultraviolet source is expected for this k. A quartz fiber distribution system from Polymicro Technologies Inc. has been purchased. We expect to start testing with a standard BaF2 crystal as a diffuser in about two weeks. If everything works out we will order a quartz diffuser system.

High Speed CAMAC crate controller

A Kinetic Systems 3929 SCSI crate controller and a Rancho Technologies Fiber optics communications system have been processed. It needs a software driver which will be written once the above higher priority (for us) items have progressed. It should increase the CAMAC data acquisition rate to well over 100 Kword/sec.

April 27, 1992

Harvey Newman

Status Report for GEM Barium Fluoride Detector

The following describes the work on the GEM barium fluoride detector development:

1. A program was written to find the new dimensions of the prototype detector crystals, 30 mm x 50 mm x 500 mm. The crystals are dimensioned so that two edges when extended will converge on a 10 mm diameter circle about the centerline of the bore, and that three faces are perpendicular to each other to help fabrication and inspection.

2. Preliminary design of a test box for both cosmic ray testing and a future beam test continuing. This box will have the capacity for a 7 x 7 array of crystals, and have the capability to replace a photodetector and electronics in-situ without disturbing the crystals. The test box will be compatible with two different existing photodetectors. Titanium foil, approximately 0.1 mm thick, will be used between the crystals. This will not be a welded or bonded structure as it would be in the GEM detector. The fabrication drawings for the test box should be finished in the next month or two.

3. Craig Wuest and I have discussed the machining capabilities at LLNL, and it appears that LLNL has the technology to provide matched crystal pairs will be machined so that they can be properly fitted in the test box and ultimately the GEM detector.

4. A trip is to be made the first week in May to CERN to meet with Michel Lebeau. Discussions will include the fabrication concepts for a cell structure to be used in the actual GEM detector, the current crystal growing, machining, and inspection methods used in China.

5. A trip is being planned to visit China the last full week of May with Ben Fuchs of LLNL to get started on the machining of the prototype size crystals. The trip will be contingent on getting approval for the travel authorization for DOE.

J. L. Heck

BaF_2 EXPERT PANEL

RECOMMENDED R&D PROGRAM IN ADDITION TO R&D IN CHINA

- **CRYSTAL PROCESSING STUDY:** (SIC; BGRI; OPTOVAC)
  Grow, Characterize and Measure
  - ✓ – Small Specially Pure Crystals
  - – Compare Crystals From Common Raw Material: China, Optovac
  - ✓ – Improve Growth Process: Crucible, Residual Gas Analysis, Control of Atmosphere
- **IMPURITY and DEFECT ANALYSIS**
  - ✓ – Experimental and Theoretical Study of Impurity Effects
  - ✓ – Trace and Defect Analysis of:
    - Raw and Preprocessed Materials ✔
    - Finished Crystals ✔
    - Longitudinal Profile ✔
    - Surface Damage ✔
    - Subsurface Defects ✔

BaF_2 RADIATION DAMAGE PROGRAM STATUS (Cont'd)

- FIRST RESULTS from CEA (Charles Evans & ASSOCIATES)
  - Bulk Impurities: High Levels of O_2, S, Cl in Both Optovac and Chinese Crystals
  - Surface Damage Established: Improve Polishing (LLNL)
  - Subsurface Inclusions Observed: Depth Profiling; Microanalysis {Clustering at Domain Boundaries}
- SMALL RAD HARD CRYSTAL PROGRAM At OPTOVAC
  - Study Raw Material Purity Effect, Crucible Effect, Oven Variables
  - Residual Gas Analysis
  - Small Crystals and 15-20 cm Rods
  - First Crystals By 5/92
  - Rad Hard Crystals By 8/92
- COLOR CENTER STUDY At UNIV. WEST VA: Paramagnetic and Low Temperature Spectroscopy
  - EPR: Energy Levels of Two Predominant Color Centers Determined
  - Correlated With Absorption Bands at Liquid Nitrogen Temperature
  - Further Paramagnetic Studies (ENDOR):
    - Color Center Hyperfine Splitting
    - Test Role of Interstitial Ions: Hydrogen, Oxygen

BaF_2 R&D 3/92 - 5/92:
MATERIALS STUDIES

- **CHARLES EVANS & ASSOCIATES**
  - Tests of O_2,C,H,S in Prototype Crystal Cleaved in 31 Slices
  - "Nomarsky" Profilometry: Dislocation Lines
  - Discovery of Inclusions Decorating Dislocation Boundaries: Impurities Highly Localized.
- **LLNL: SURFACE PREPARATION**
  - Diamond Turning On Lathe With Ultrapure Mineral Oil (6 A°/80 A° RMS)
  - Standard Polishing On a Diamond Pad With and Oil, as for Laser Mirrors (20 A° RMS)
  - Argon Ion Beam Milling : 2 μm/Hour; Follows Original Surface Quality.
  - Lapping With Diamond-Impregnated Pitch: (10 A° RMS); Good for Mass Production.
  - Nomarsky and X-Ray Diffraction Studies
- **CE&A and LLNL: SURFACE STUDIES With RBS**
  - AIM Best; Diamond Pad Next.
  - Retest Diamond Turning; Test Diamond Pitch, and Acid Etched (35 A° RMS) Surfaces
- **LLNL: UV Reflector Al + MgF_2:**
  - Front Reflectance 90% (220 nm)
  - Back Reflectance 81% (Through BaF_2): Sensitive To Surface Preparation
- **NAVAL RESEARCH LAB: Dielectric Relaxation**
  Technique: 10 - 100 ppb Trace Limit

OPTOVAC
An EM Industries Company
Associate of E. Merck, Darmstadt, W. Germany
NORTH BROOKFIELD, MA 01535
TEL. 508-867-6444
FAX 508-867-8349

Optical Crystals

To Harvey Newman

From Rob Sparrow

4/28/92

BARIUM FLUORIDE : STATUS REPORT

1. Growth crucibles of graphite have been fabricated and then given a proprietary cleaning treatment. CRUCIBLE

2. Using Merck Optipur raw material furnace conditions have been established. Crystals are grown in groups of three, each crystal being 32 mm diameter. In the first run the as grown ingots are 275 mm long. The power to the furnace, however was not sufficient to remove all the lead fluoride scavenger and the ingots all had absorption bands at 207 nm. GROWTH CONDITIONS
In the second trial growth run more power was added and the ingots are currently being tested for lead absorption.

3a. For future work, high purity custom synthesized raw material has been ordered and delivery is expected at the end of May. PURE MATERIALS

3b. A sublimation unit has been fabricated and cleaned and will now be used for subliming Optipur powder.

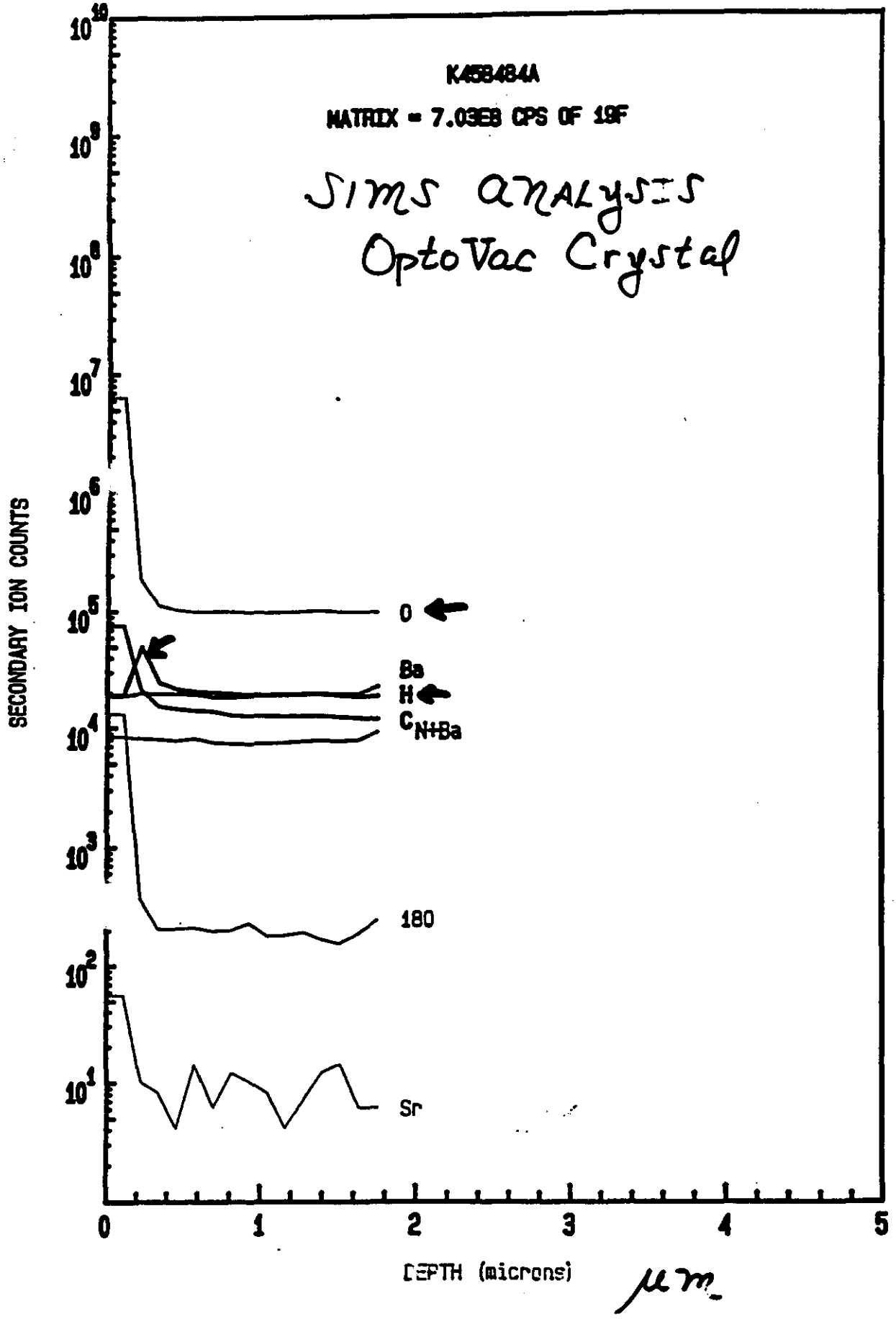
4. Trial runs have been made using a reactive gas. This caused some problems as the gas reacted with the vacuum pump oils. A design change has been made to the growth furnaces, the necessary components ordered and the modification will be complete by the beginning of May. REACTIVE GAS; RGA

PROCESSED DATA

13 Jan 92 .8

CHARLES EVANS AND ASSOCIATES

FILE: 15

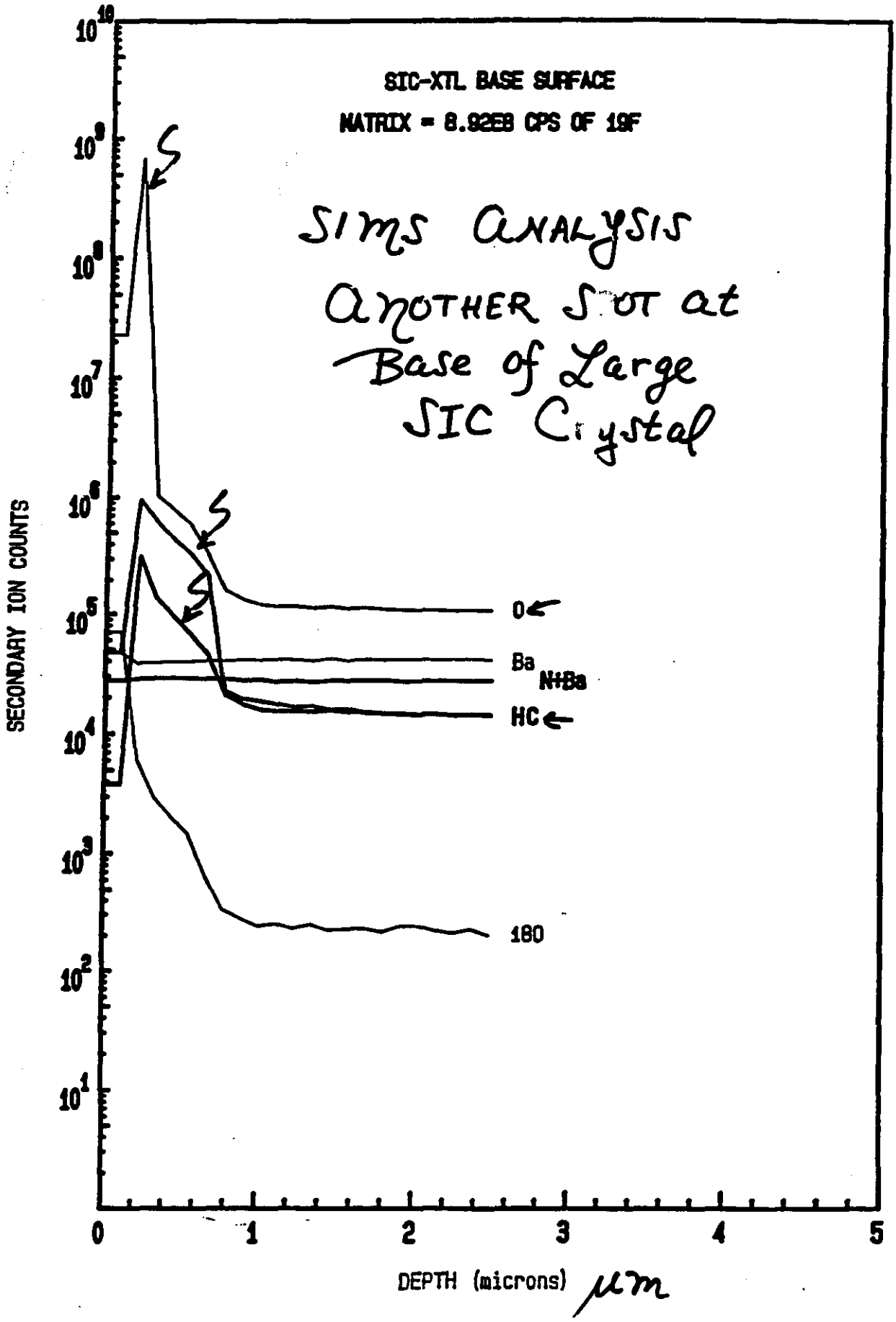


PROCESSED DATA

13 Jan 92 Cs

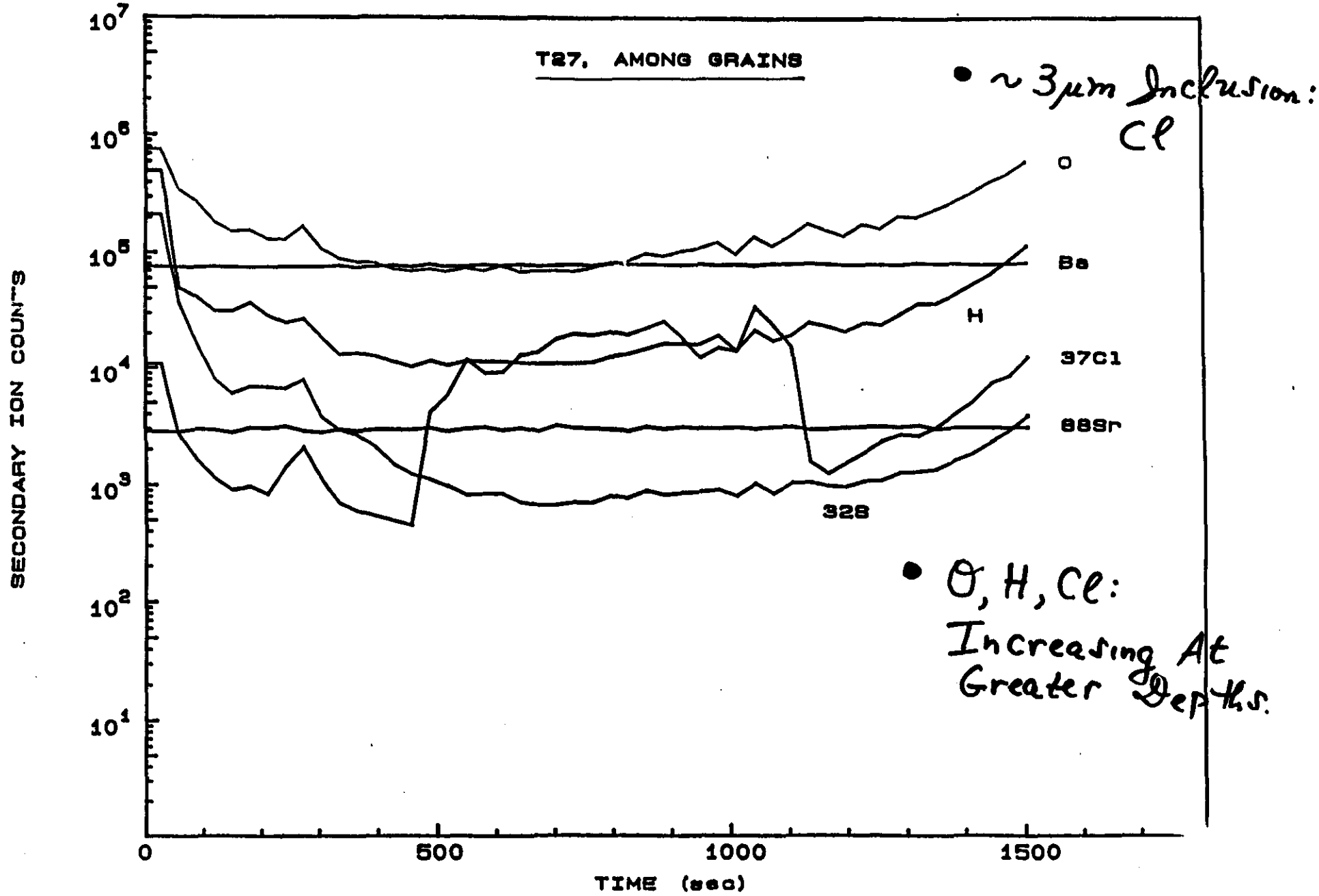
CHARLES EVANS AND ASSOCIATES

FILE: 4



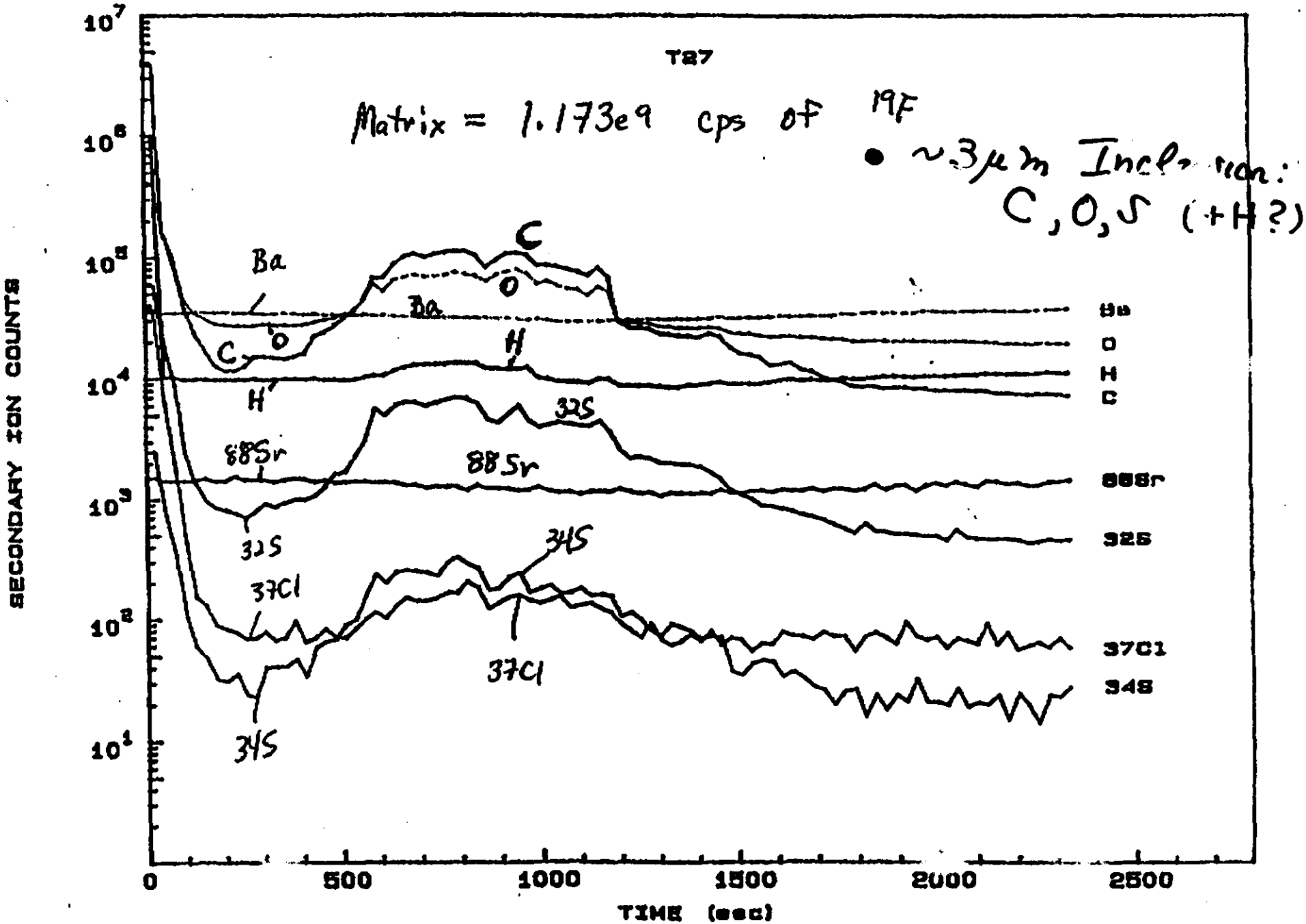
PROCESSED DATA
1 Apr 92 Cs

CHARLES EVANS AND ASSOCIATES
FILE: 11



PROCESSED DATA
9 Apr 92 Cs

CHARLES EVANS AND ASSOCIATES
FILE: 5



LECO®

LECO CORPORATION

LABORATORY ANALYSIS REPORT

Date 04/21/92

W.O. # 7256

Gas Fusion Analysis of C, S, O, H

LECO® Sample No.	Customer Sample No.	Percent Carbon C	Percent Sulfur S	Percent Oxygen O	PPM Hydrogen H	
002069	T1 Slice 1	.0012	.0026	.0087	<2.0	
		.0037	.0020	.0086	<2.0	
		.0025	.0032			
002070	T5 5	.0006	.0026	.0061	<2.0	
		.0003	.0024	.0064	<2.0	
		.0006	.0018			
002071	T8 8	.0015	.0029	.0070	<2.0	
		.0247	.0019	.0061	<2.0	
		.0004	.0030	.0047		
				.0059		
002072	T10 10	.0012	.0021	.0036	<2.0	
		.0009	.0027	.0050	<2.0	
		.0044	.0020	.0060		
002073	T15 15	.0021	.0089	.0063	<2.0	
		.0018	.0078	.0060	<2.0	
		.0008	.0068			
002074	T20 20	.0064	.0065	.0053	<2.0	
		<.0003	.0048	.0043	<2.0	
		.0004	.0033	.0047		

• Profile; Variability

Form No 203-505-131

03-28-88

LECO®

LECO CORPORATION

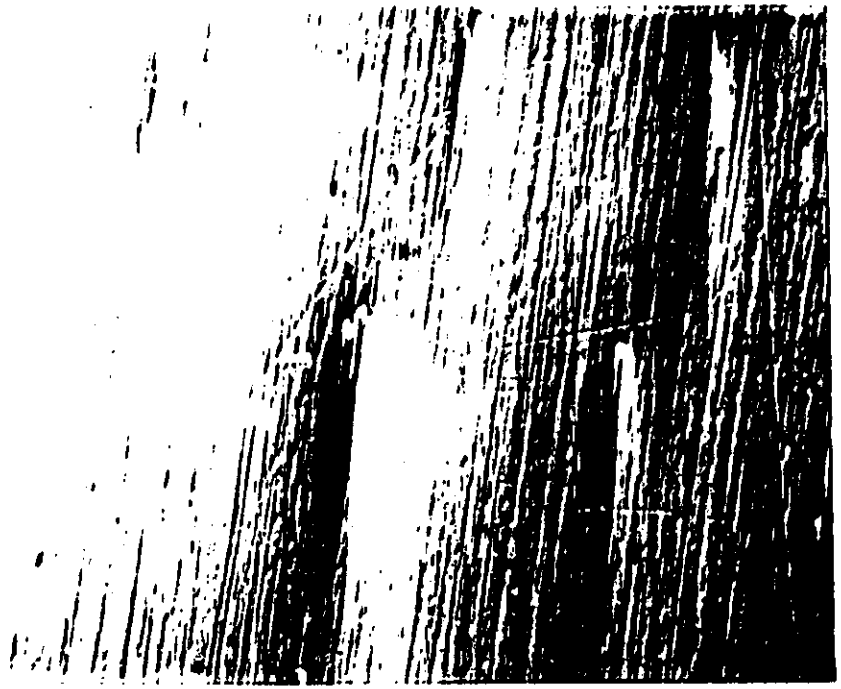
LABORATORY ANALYSIS REPORT

Date 04/21/92

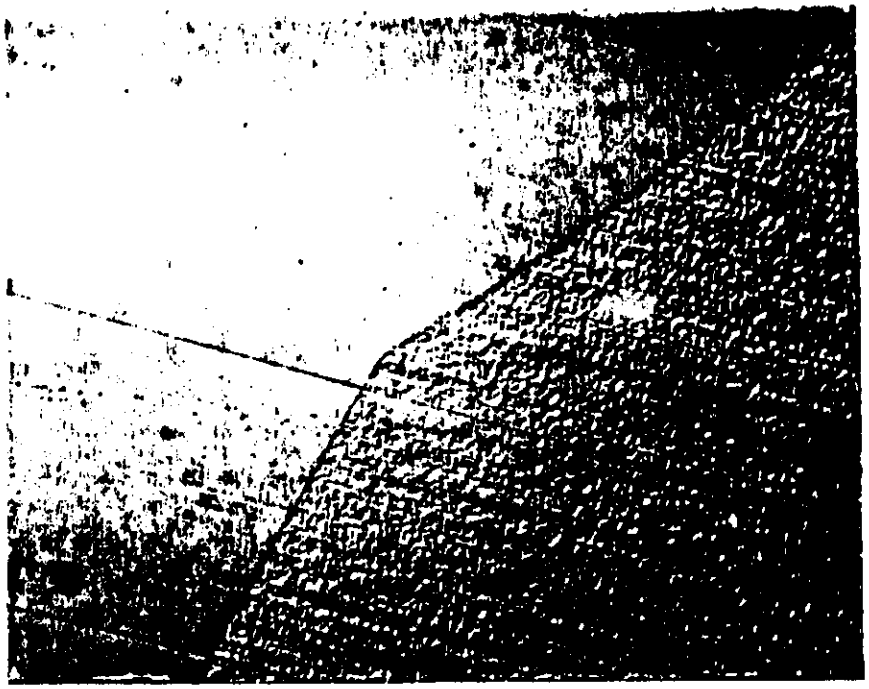
W.O. # 7256

LECO® Sample No.	Customer Sample No.	Percent Carbon	Percent Sulfur	Percent Oxygen	PPM Hydrogen	
002075	T23-B 23	.0076	.0022	.0034	<2.0	
		.0005	.0028	.0034	<2.0	
		.0334	.0020			
		.0007	.0019			
002076	T25 25	<.0003	.0064	.0056	<2.0	
		.0007	.0030	.0032	<2.0	
		.0061	.0058	.0023		
		<.0003	.0038			
002077	T29 29	<.0003	.0018	.0065	<2.0	
		<.0003	.0043	.0045	<2.0	
		.0015	.0026	.0045		
002078	T31 31	.0424	.0022	.0041	<2.0	
		.0236	.0037	.0039	<2.0	

Barium Fluoride Calorimeter R&D



BaF2 crystal surface as provided by SIC - 200 Å RMS

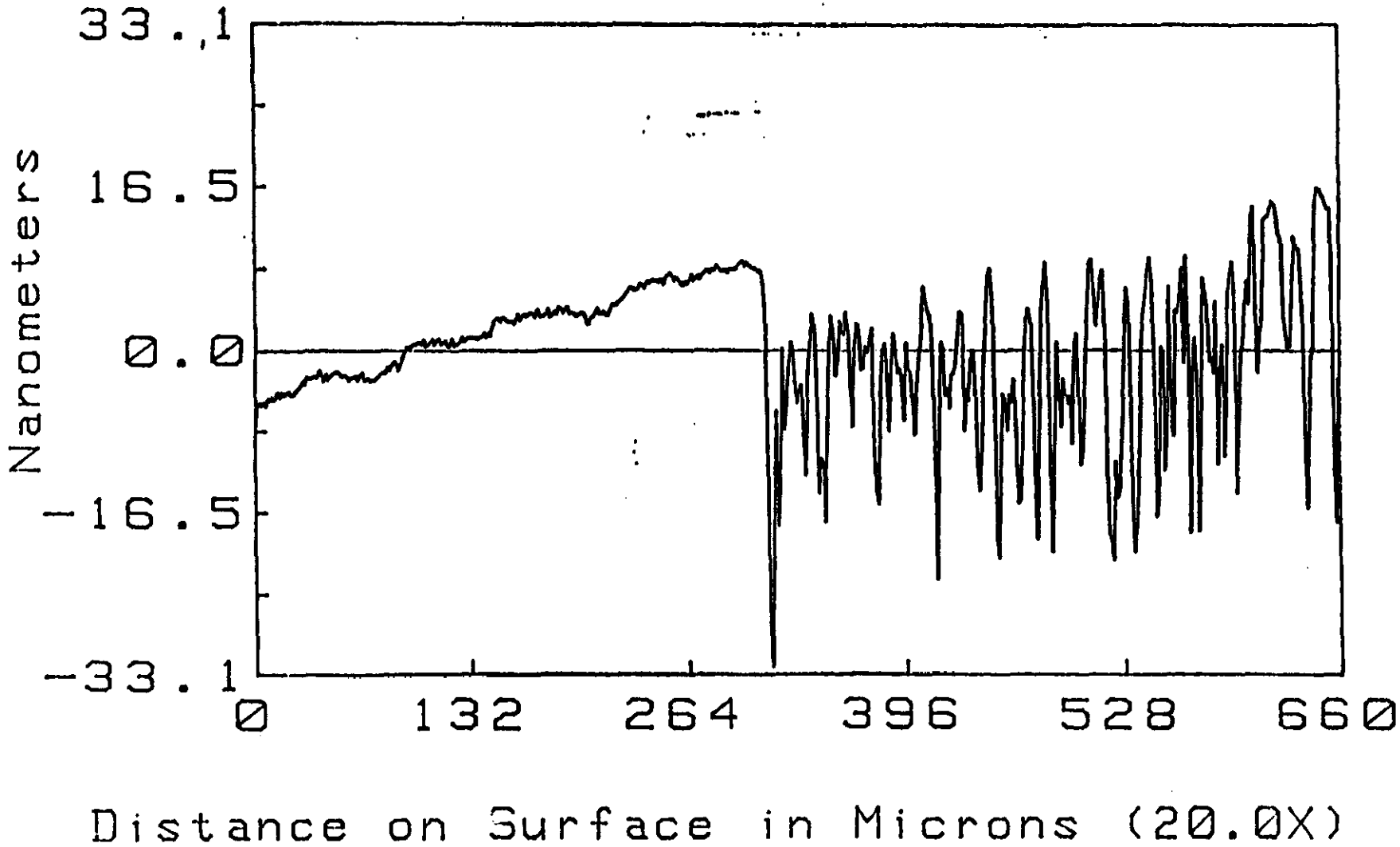


Diamond Turned Sample 6 Å RMS/80 Å RMS

BEN Time: 14:01 Date:3/18/92

RMS: 7.46nm PROFILE PV: 49.5nm

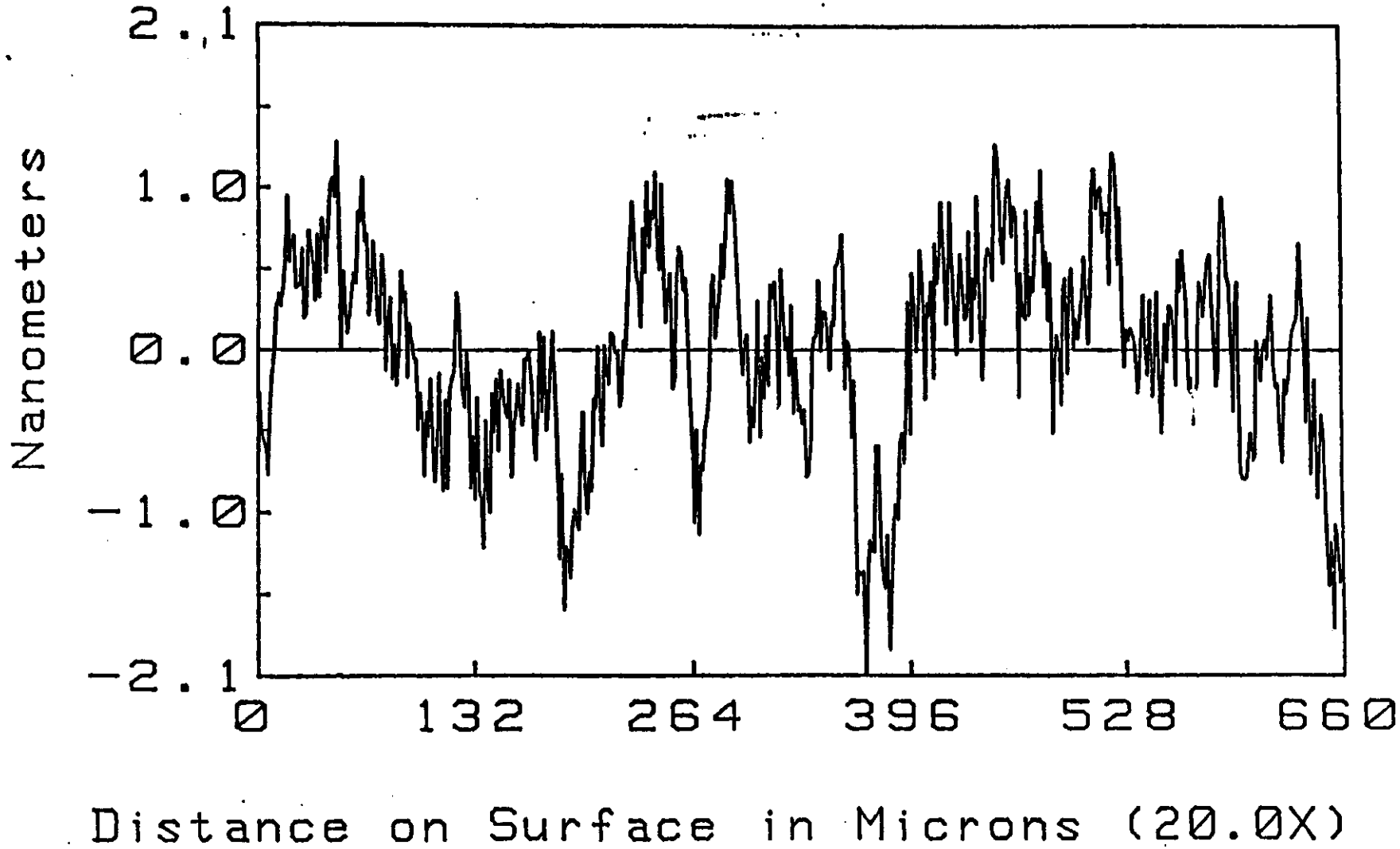
RA: 5.69nm RC: 22.2 m

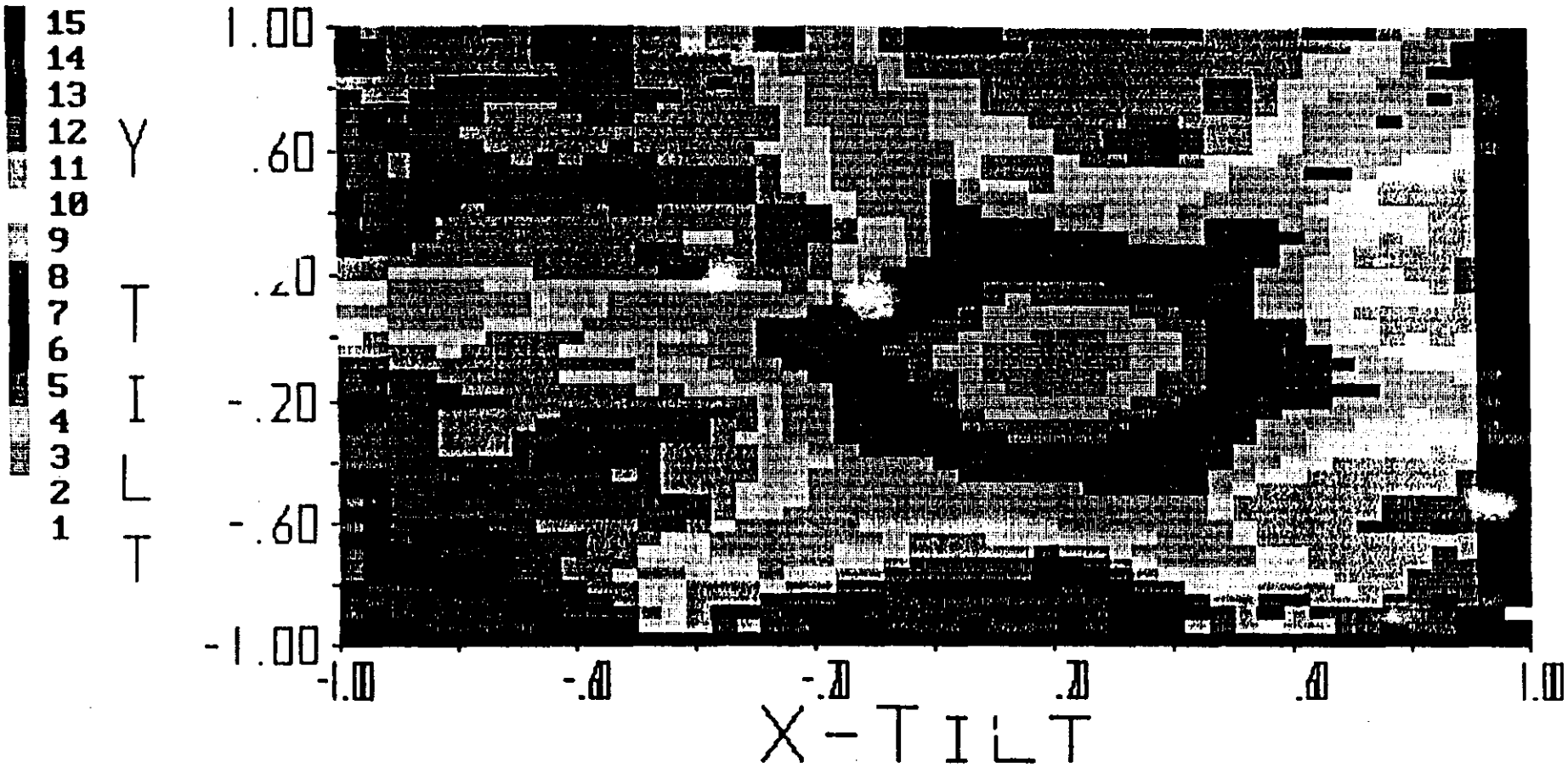


B.F Time: 14:36 Date:3/17/92

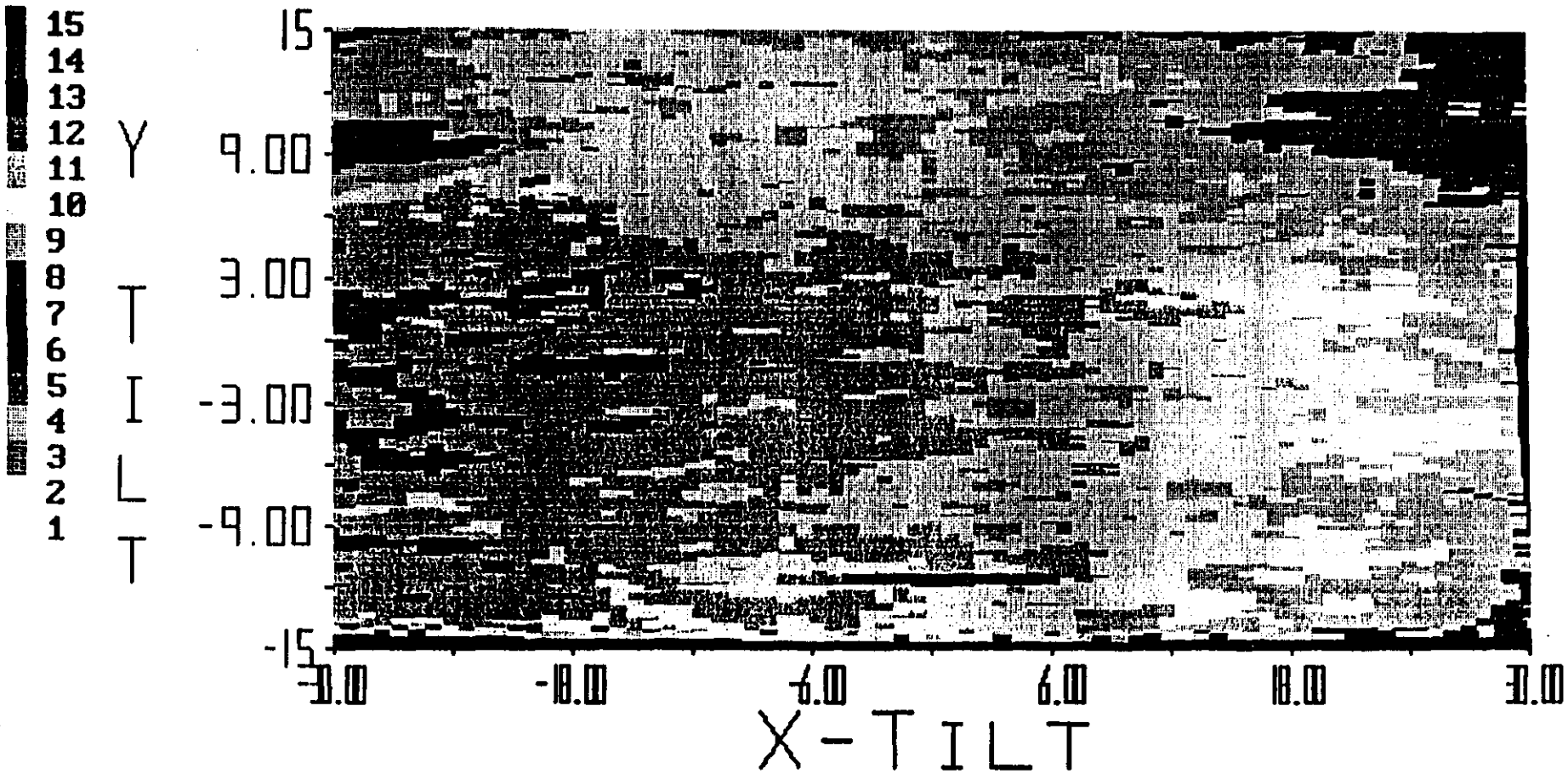
RMS: 0.638nm PROFILE PV: 3.60nm

RA: 0.510nm RC: 11.4 m

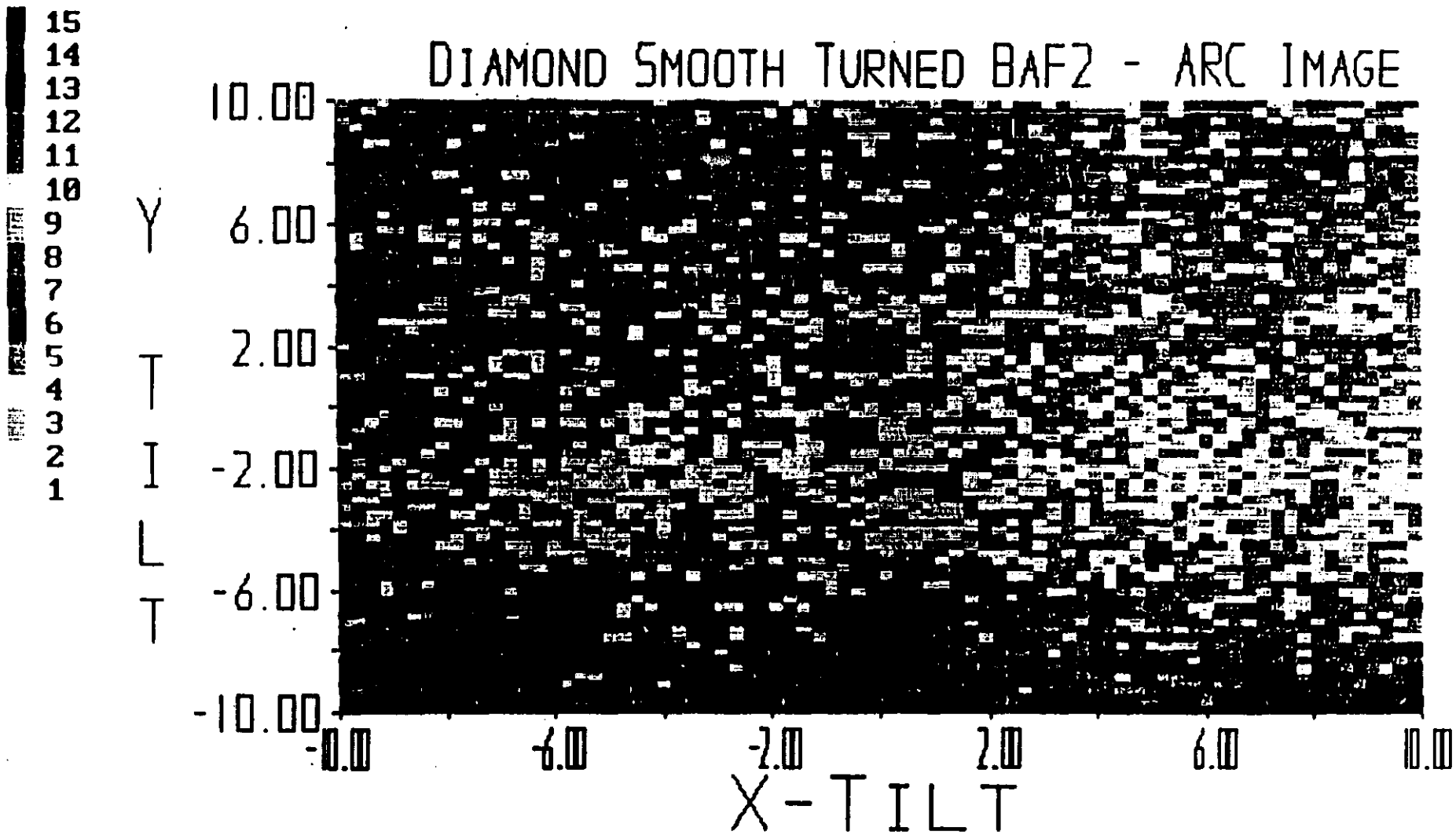


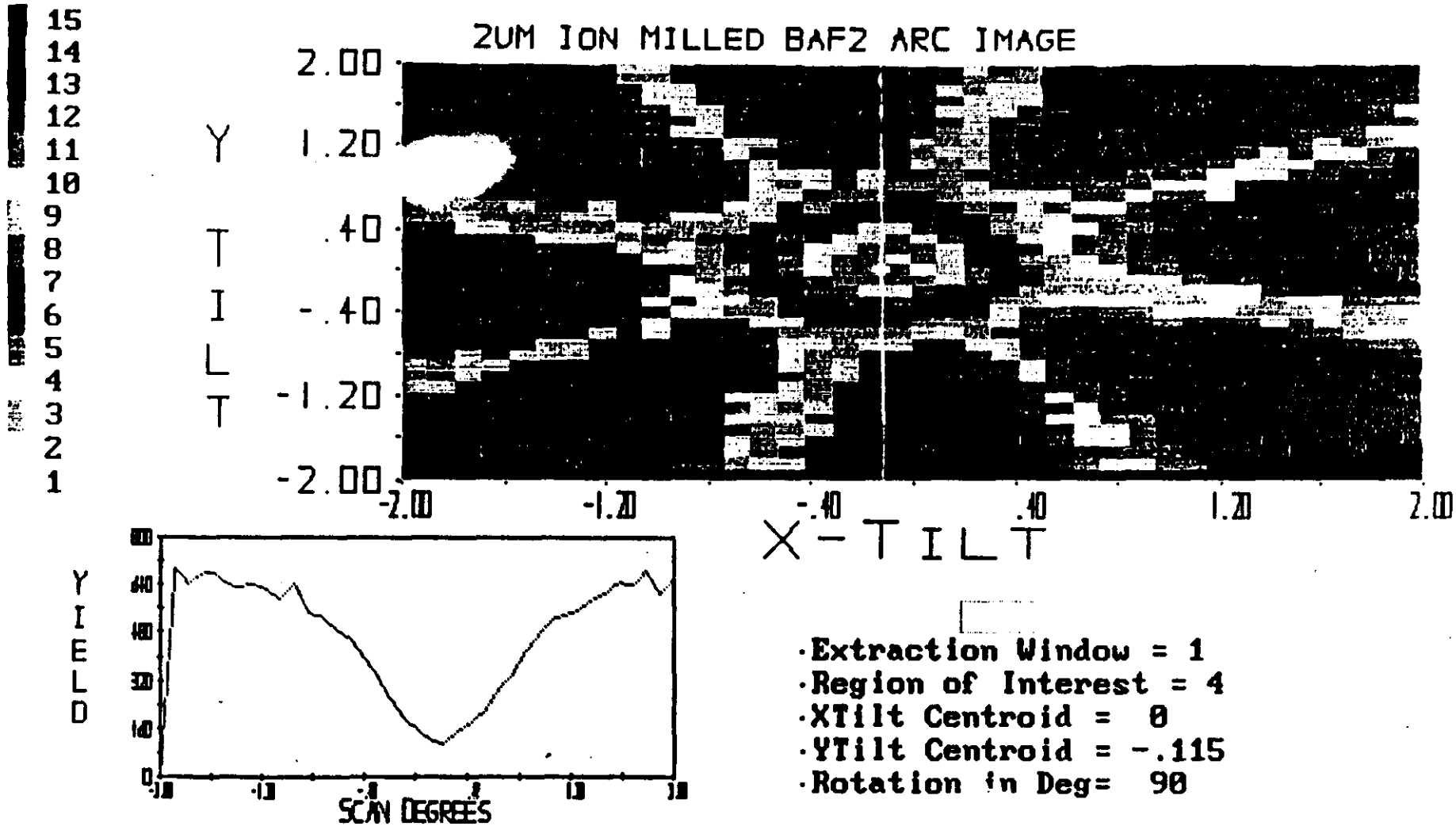


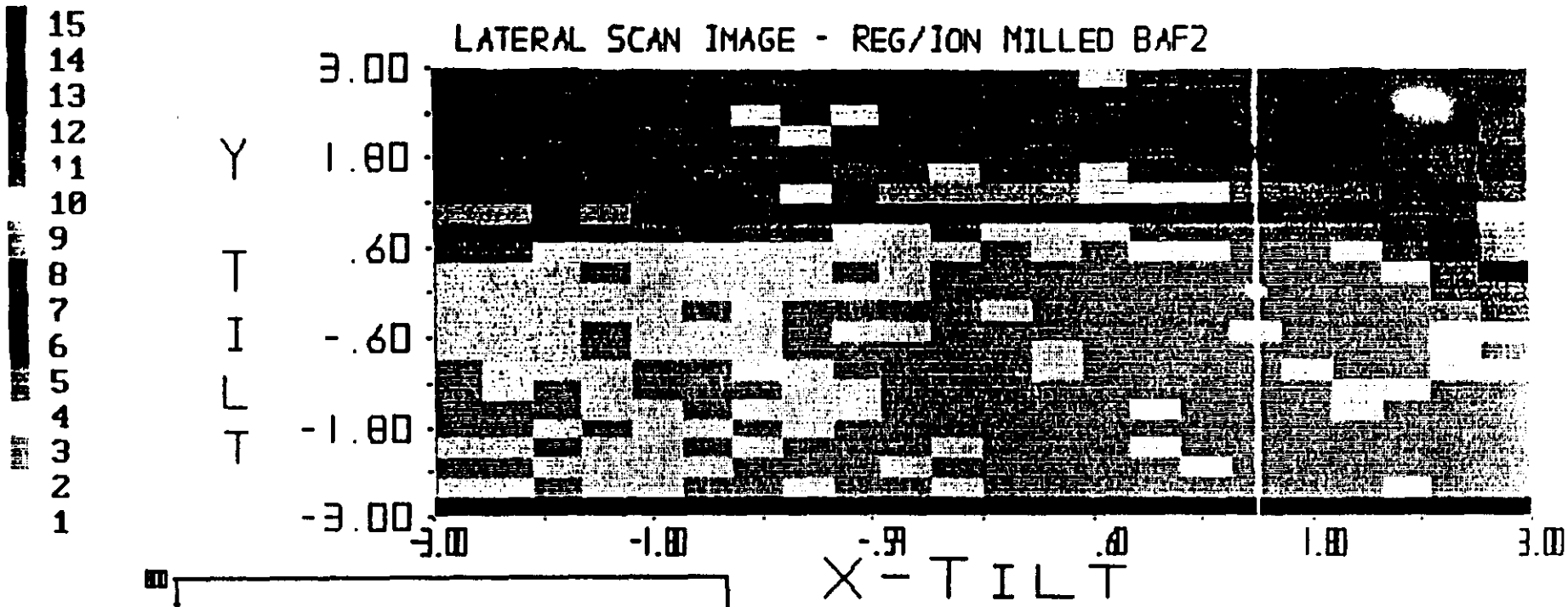
Data Name = CRYSTAL SCAN: SSC MDS XTL TIP "Cleaved" <CS>

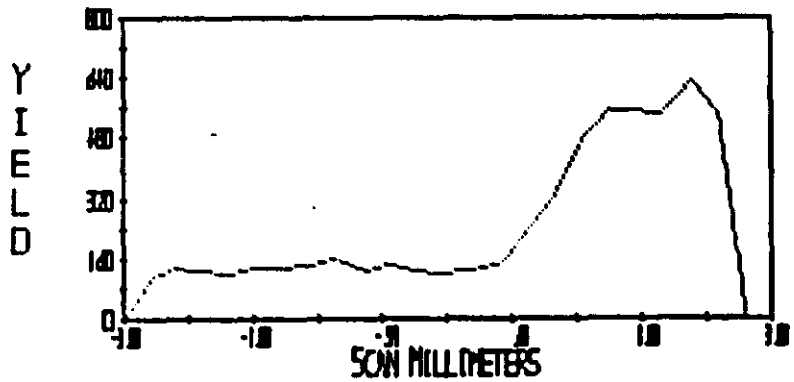


Data Name = CRYSTAL SCAN: SSC MDS Tip Surface LS <CS>


DIAMOND SMOOTH TURNED BAF2 - ARC IMAGE
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Y TILT
10.00
6.00
2.00
-2.00
-6.00
-10.00
-10.0
-6.0
-2.0
2.0
6.0
10.0
X-TILT


2UM ION MILLED BAF2 ARC IMAGE
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Y TILT
2.00
1.20
.40
-.40
-1.20
-2.00
-2.00
-1.20
-.40
.40
1.20
2.00
X-TILT
YIELD
SCAN DEGREES
·Extraction Window = 1
·Region of Interest = 4
·XTilt Centroid = 0
·YTilt Centroid = -.115
·Rotation in Deg= 90





- Region of Interest = 4
- XTilt Centroid = 0
- YTilt Centroid = 1.495
- Rotation in Deg= 90
- Length in Deg = 3

BaF_2 R&D 3/92 - 5/92:
RADIATION DAMAGE

- **CHINA: PRODUCTION IMPROVEMENTS**
  - Liquid N_2 Trap on SIC Oven
  - Tantalum Getter Trial; RGA
  - LeE u 4/92 Visit (Vacuum, Cutting, Polishing)
  - ORNL and LLNL Visit: End of May
- **CALTECH TESTS**
  - Tests on New Large Czech Samples: Early May
  - Tests of New SIC + OPTOVAC Samples: Second Half of May
  - 800 MeV Proton Test (1 MRad) At LANL in June
- → **UNIV. WEST Va. OPTOELECTRONICS GROUP**
  - EPR Identification of H^0 and O^- As Causing UV Bands: Heat Treatment in Air
  - Studies of Nature of Color Centers: Radiation Damage Mechanism
  - Studies of Post Annealing to Increase Rad Hardness
- **BNL: RADIATION DAMAGE TESTS**
  - Confirmed Caltech Results on Large Improved SIC Crystal
  - → Neutron Test With Univ. Lowell VdG (Low γ's).
  - → Hadron Shower Test at AGS Primary Target Cave in May;
  - Thermoluminescence (TLD) Tests

ASPECTS OF THE RADIATION DAMAGE PROBLEM IN BaF_2

L. E. Halliburton, M. P. Scripsick, and G. J. Edwards
Optoelectronic Research Group
Department of Physics
West Virginia University
Morgantown, WV 26506

Telephone: (304) 293-3422
FAX: (304) 293-5732

ROOM TEMPERATURE RADIATION DAMAGE MECHANISM

(Jongji University)

Oxygen and hydrogen are present in the crystal as OH^- ions substituting for fluorine ions.

Fluorine Vacancies

Radiation does two things:

- 1) Radiation creates F centers and clusters of H centers (i.e., fluorine vacancies and fluorine interstitials).

- 2) Radiation also dissociates the OH^- ions into O^- and H_i^0 centers.

→ A portion of the H_i^0 centers will recombine with F centers to form H_s^- centers.

→ The 220-nm UV absorption is due to these H_s^- centers.

TWO WAYS TO MINIMIZE RADIATION DAMAGE IN BaF_2

- 1) Prevent OH^- from entering the crystal during growth.

- 2) Prevent the formation of F centers by removing impurities that stabilize the fluorine interstitials (H centers).

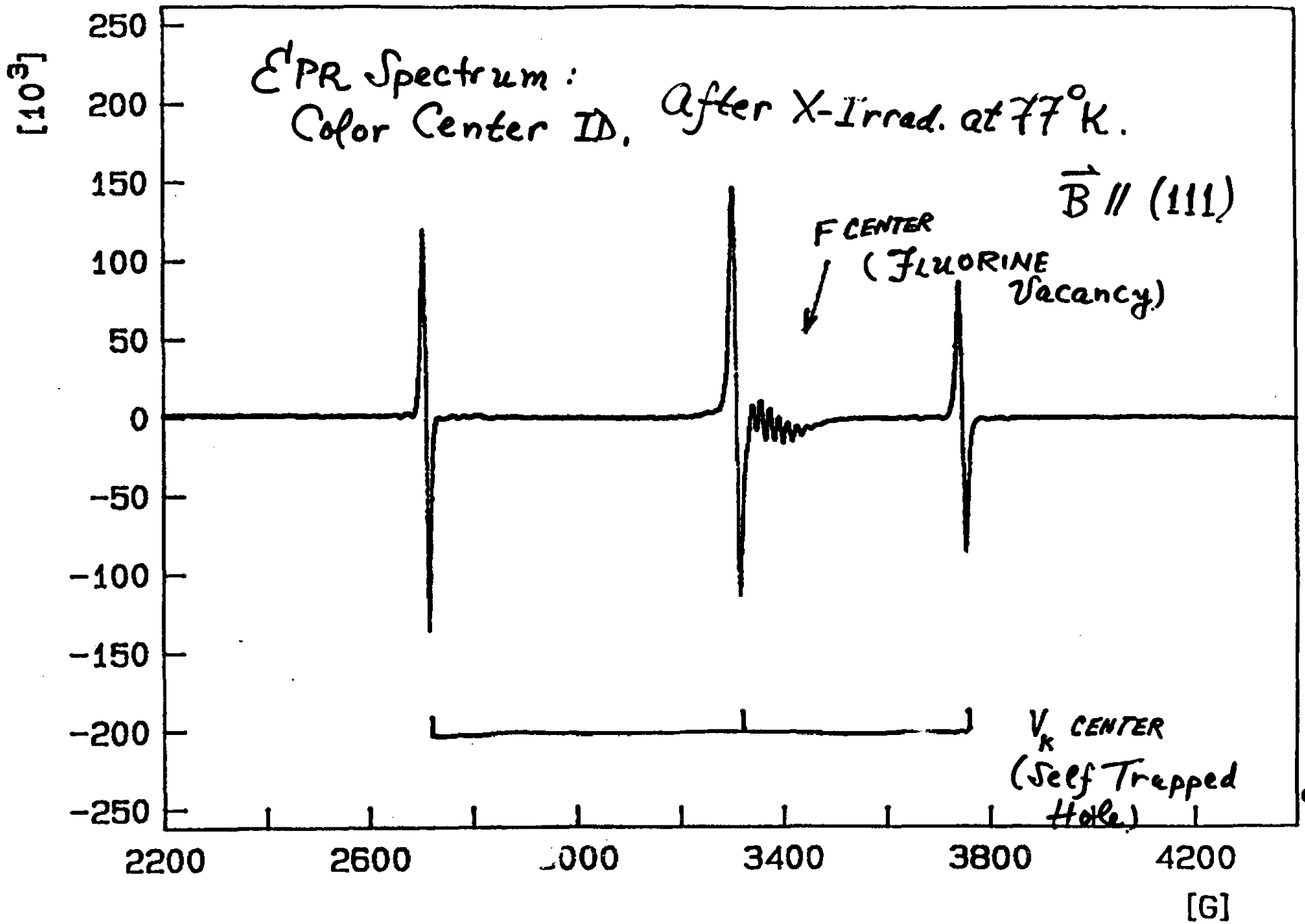
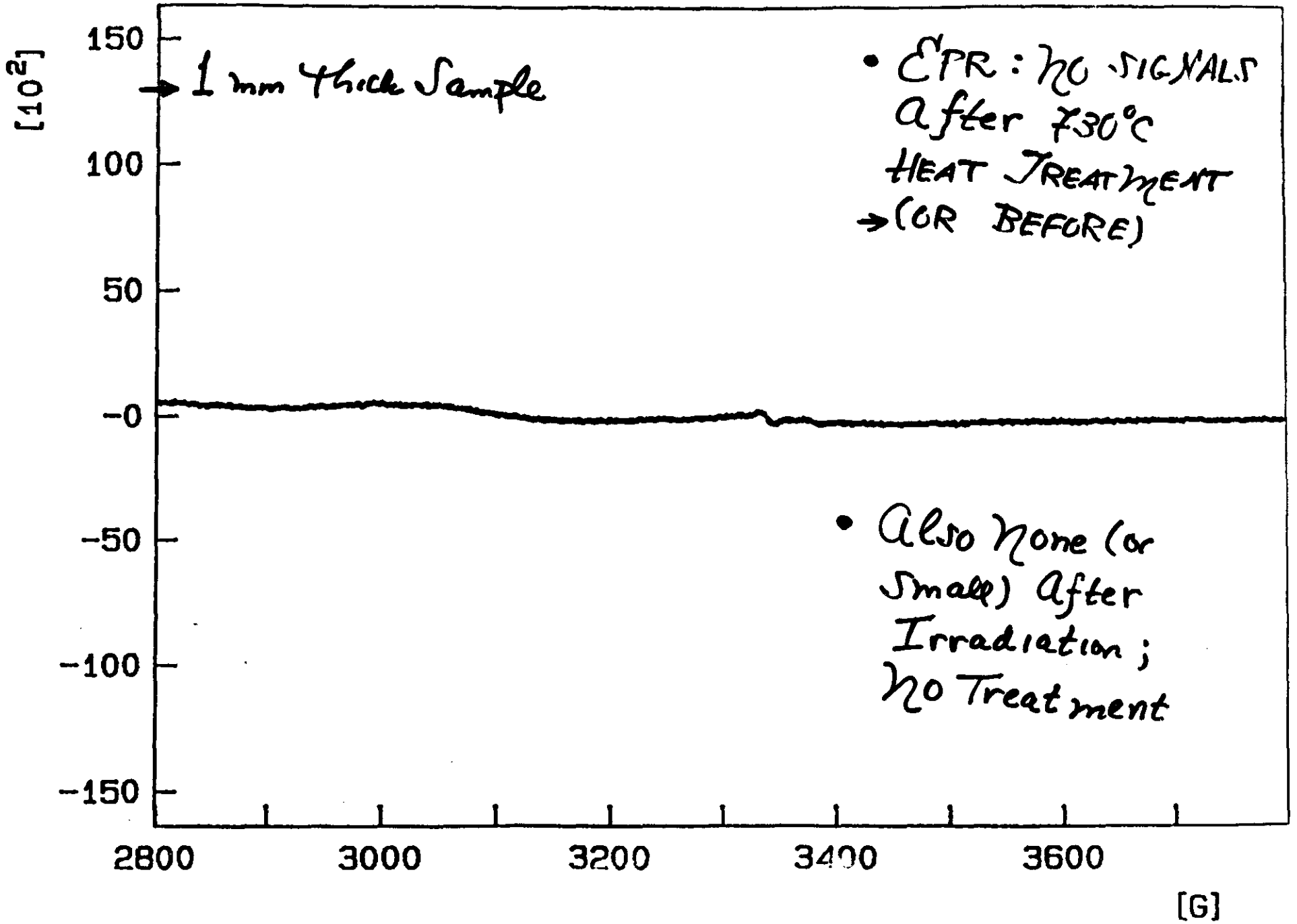
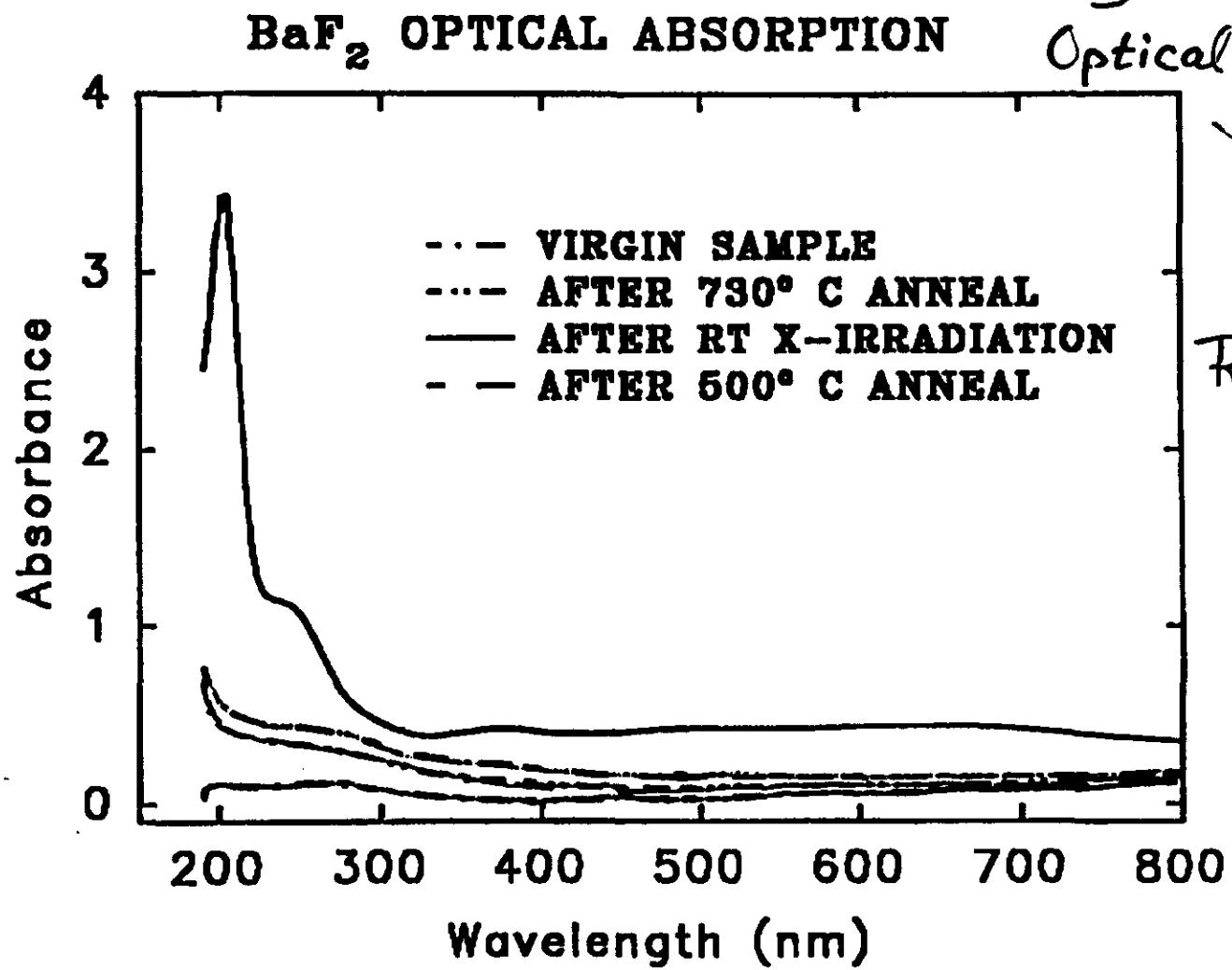

EPR Spectrum :
Color Center ID, After X-Irrad. at 77°K.
$\vec{B}$ // (111)
F CENTER
(FLUORINE Vacancy)
V_K CENTER
(Self Trapped Hole)
[10^3]
250
200
150
100
50
0
-50
-100
-150
-200
-250
2200
2600
3000
3400
3800
4200
[G]

Figure 1

Filename : BaF0-450a Comment : BaF2, nearly along [111], after 725 anneal. Date : 10-MAR-1985

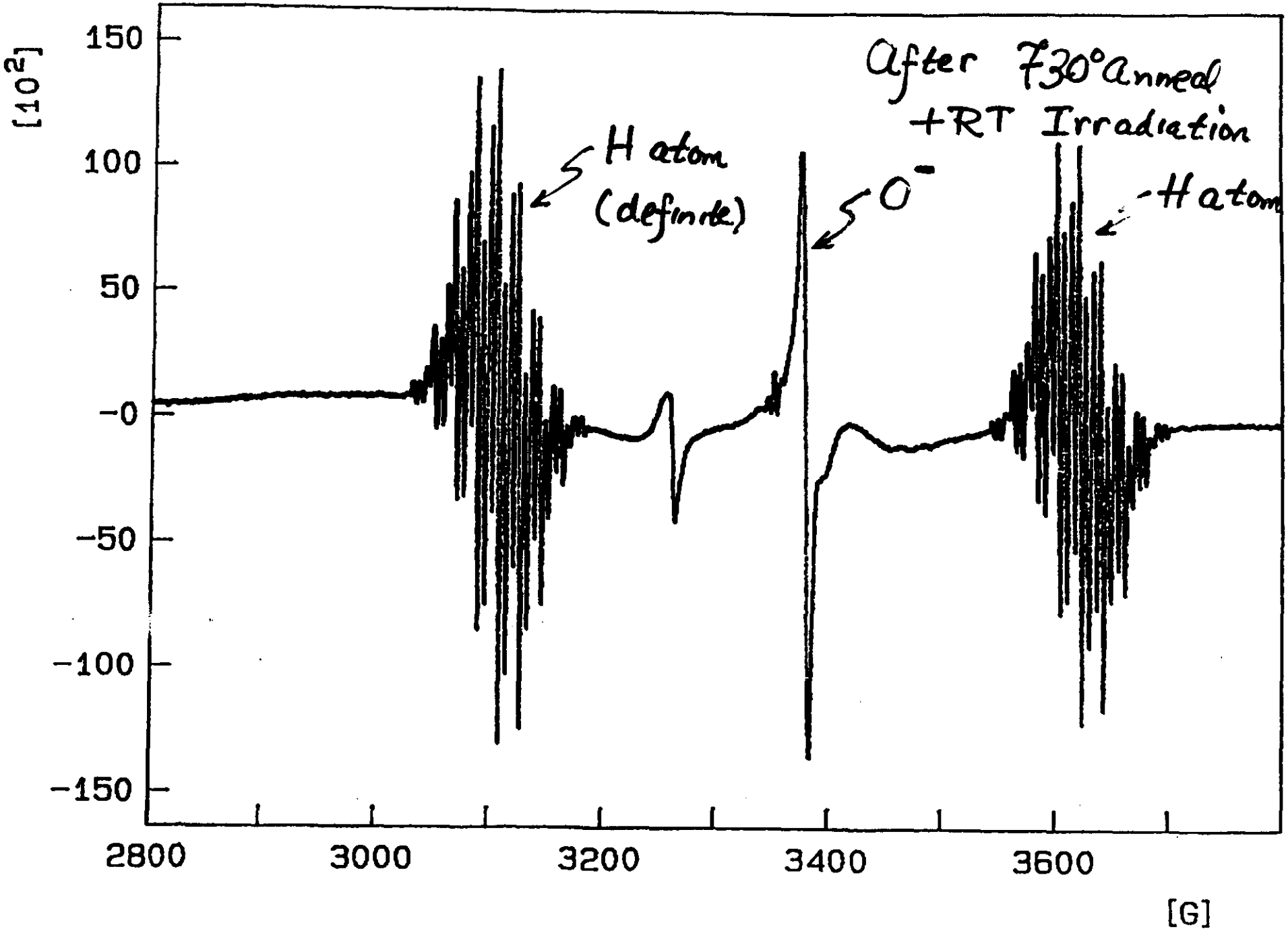


Thermal Treatment
+ Irradiation
Optical + EPR
Studies

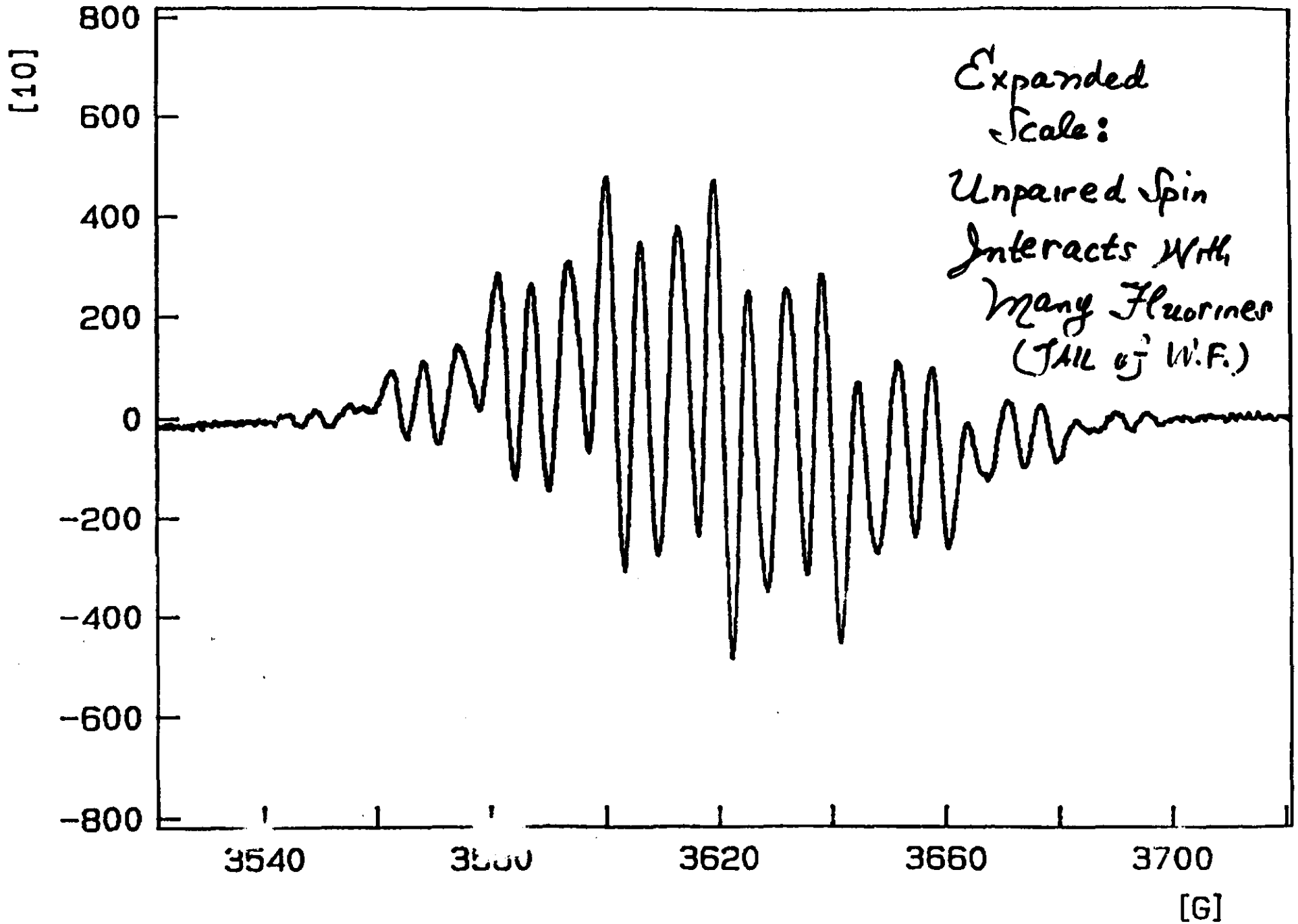


ROOM TEMP.

Filename : baf0423b Comment : BaF2, nearly along [100], after 725 anneal + RT irrad Date : 10-MAR-1989



Filename : baf042bc Comment : BaF2, nearly along [100], after 725 anneal + RT irrad. Date : 10-MAR-1988



The above-described results are most interesting and suggest addition experiments. Among the questions that need to be answered are: 1) What is an optimum heat treatment temperature to introduce oxygen and hydrogen into the crystal, 2) What is an optimum radiation dose to convert the oxygen and hydrogen into ultraviolet-active defects, 3) What anneal temperature is required to destroy the oxygen and hydrogen related ultraviolet absorption bands introduced by radiation, 4) What are the optical bleaching characteristics of these ultraviolet bands, 5) What is the exact nature of the oxygen center giving rise to the EPR spectrum, i.e., what is the model for this defect, and 6) Which is more important, oxygen or hydrogen, in producing ultraviolet absorptions.

We propose during the coming month to fully characterize this phenomenon of introducing oxygen and hydrogen into BaF_2 by heat treatment. Special attention will be given to developing possible procedures for reversing the process. If successful, such procedures would allow post-growth treatments of Chinese-grown BaF_2 which would render them sufficiently radiation-hard for use in a particle detector.

BARIUM FLUORIDE EM CALORIMETER R&D FOR 1992

By Carrying Out Our R&D Program, We Expect To Have The Following Information By August 1992:

- Improved Understanding and Control of Radiation Damage In BaF_2
- Small Rad Hard Crystals
- Large Crystals Approaching the Final Specifications for Rad Hardness
- Realistic Evaluation of the Prospects for Rad Hard Crystal Mass Production
  - -- At $ 2.5/cc Fixed Price
- Demonstration of the Ability To Maintain The High Resolution In Situ
  - -- Uniformity, Stability and Calibration
  - -- Constant Term of 0.5%

A Sufficient Demonstration of the Promise of the BaF2/Scintillating HCAL System in Time for the GEM Calorimetry Choice

gem

γeμ

Presentation by:

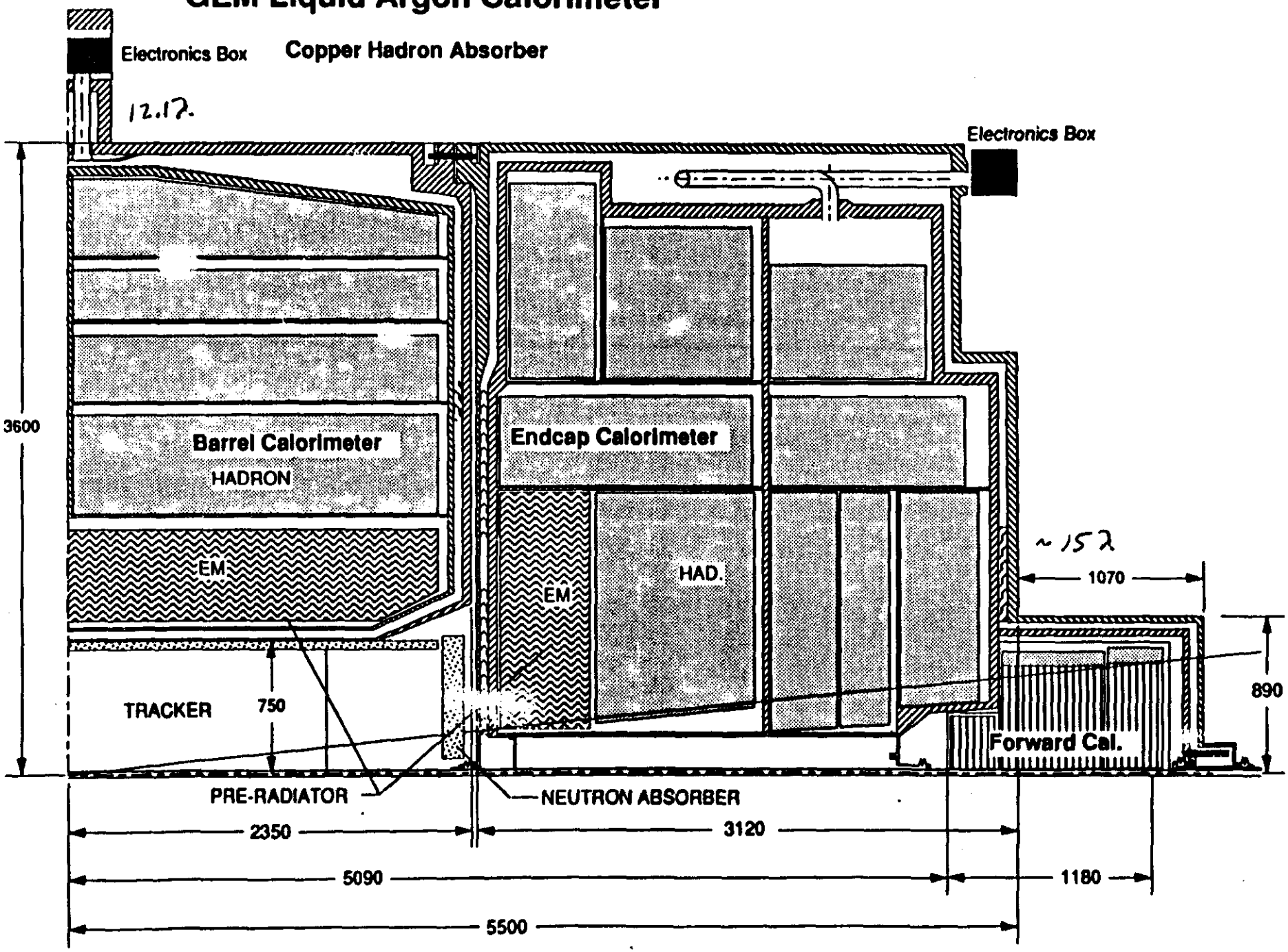
H. Gordon

H. Gordon
April 30, 1992

Engineering Progress on the Liquid Argon Baseline Design

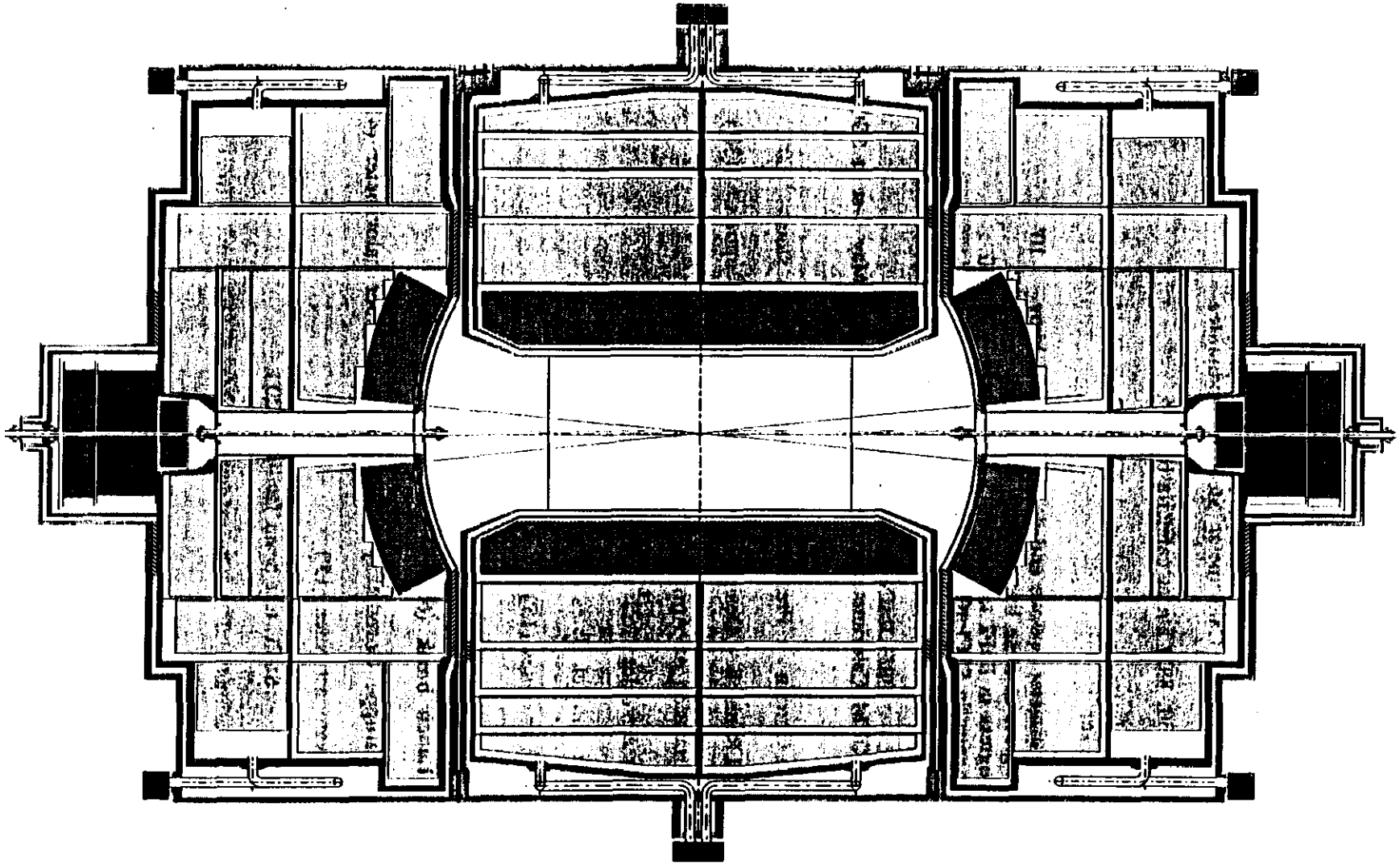
Date	Focus	Absorber	r(m)	z(m)	EC
Aug. '91	Endcap accordion	Fe			C curved F flat
Oct. '91	Cryostat SS->Al				
Nov. '91	LoI	Fe	4.0	6.0	F
Feb. '92	Space for μ	DU	3.5	5.5	C
Mar. '92	Services				
Mar. '92	Background for μ	Cu	3.6	5.5	C
Apr. '92	Cost review				
Apr. '92	Facilities - assembly and test beams....				F

GEM Liquid Argon Calorimeter

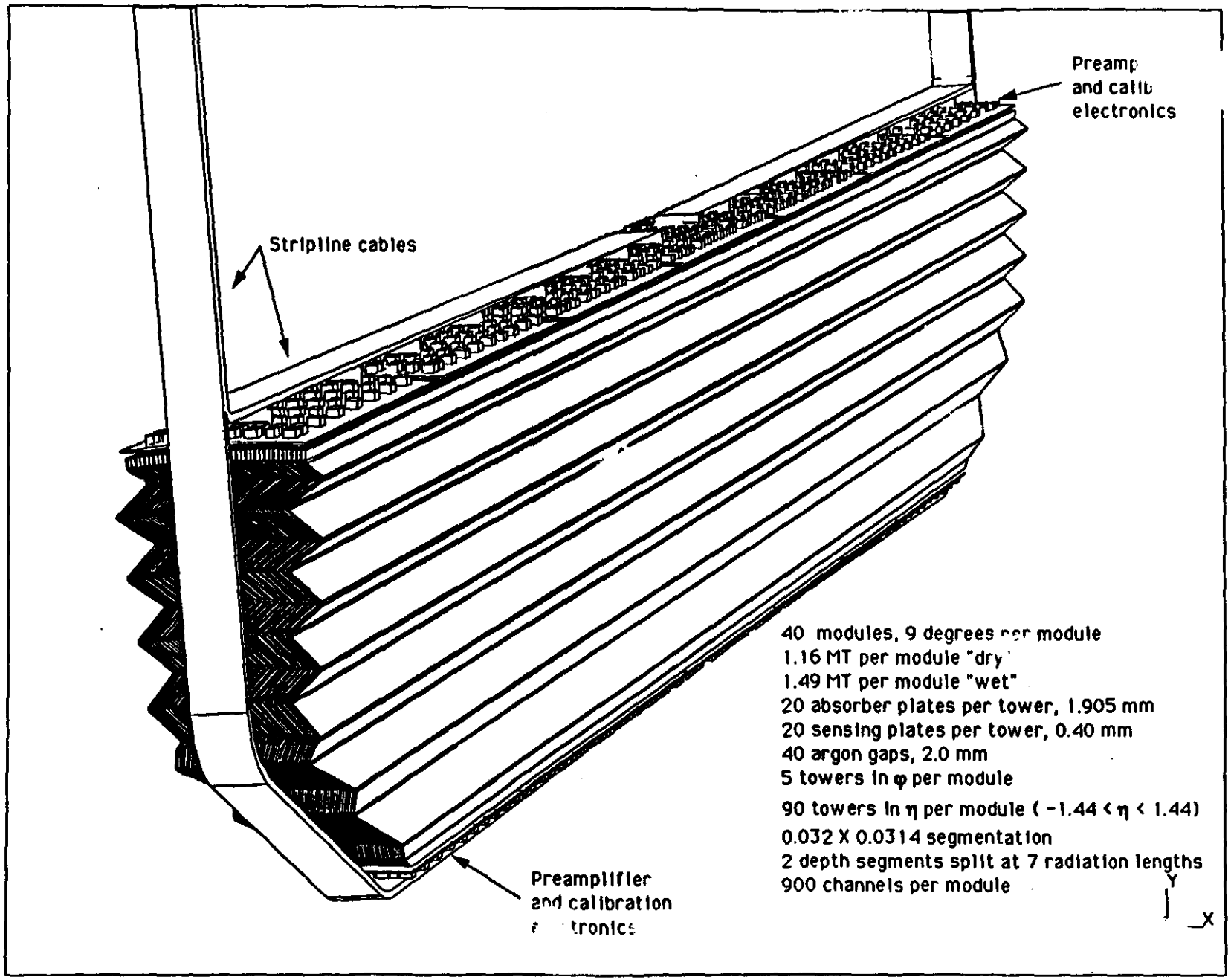


LLMason GEMLAC.Packed4/28/92

GEM Liquid Argon Calorimeter

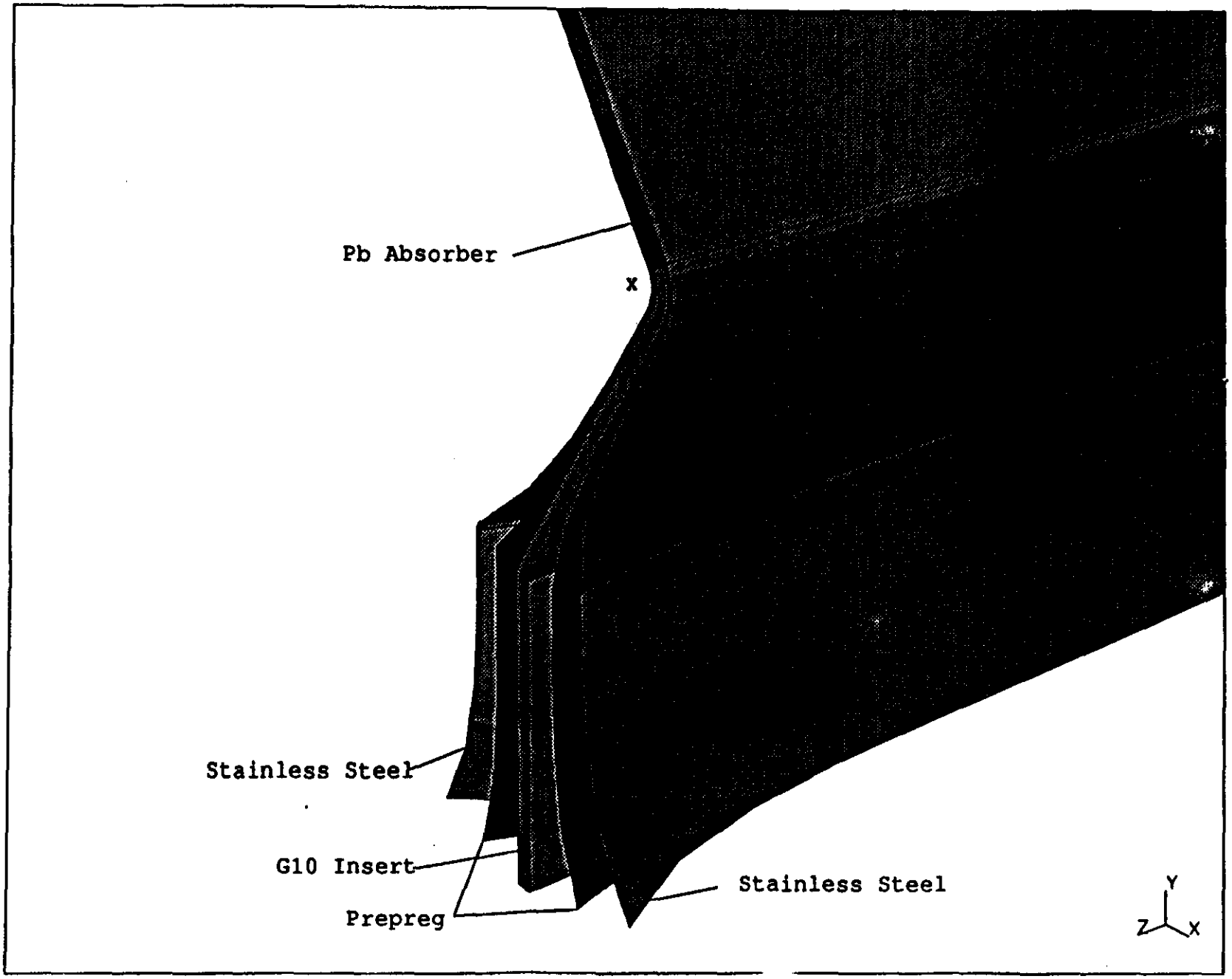


Barrel Accordion Electromagnetic Module

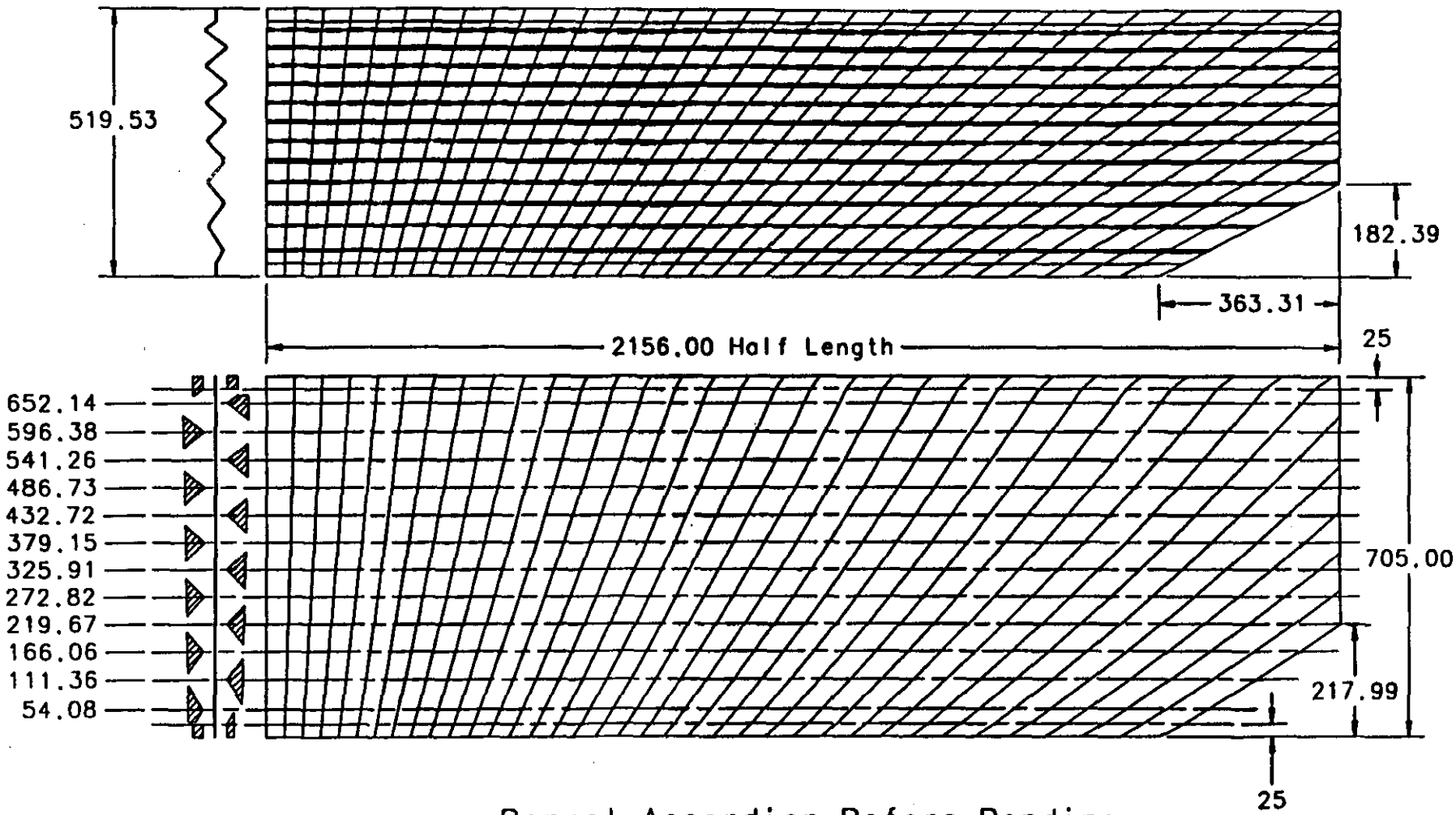


40 modules, 9 degrees per module
1.16 MT per module "dry"
1.49 MT per module "wet"
20 absorber plates per tower, 1.905 mm
20 sensing plates per tower, 0.40 mm
40 argon gaps, 2.0 mm
5 towers in φ per module
90 towers in η per module ($-1.44 < \eta < 1.44$)
0.032 X 0.0314 segmentation
2 depth segments split at 7 radiation lengths
900 channels per module

Layers of the Accordion Absorber plate

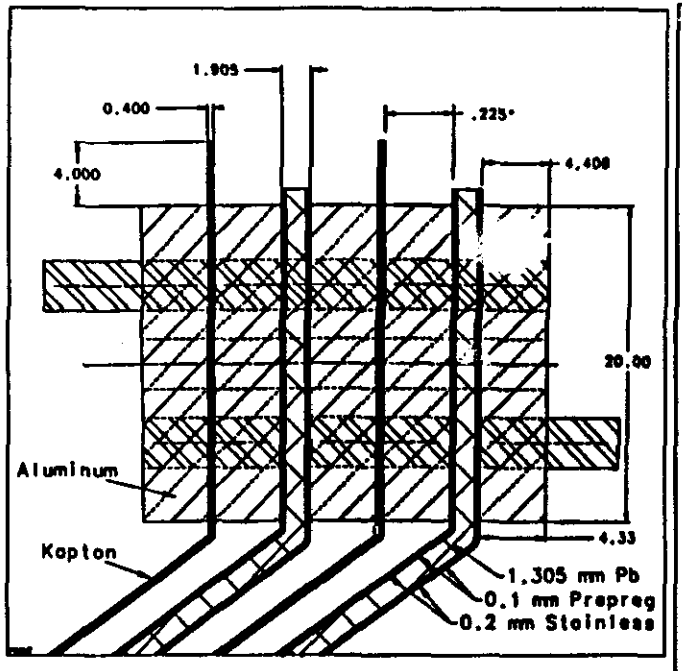


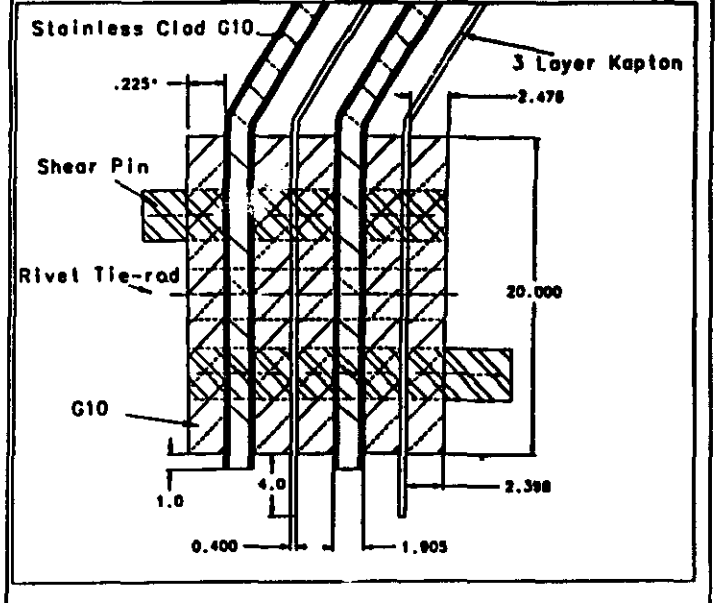
Barrel Accordion After Bending

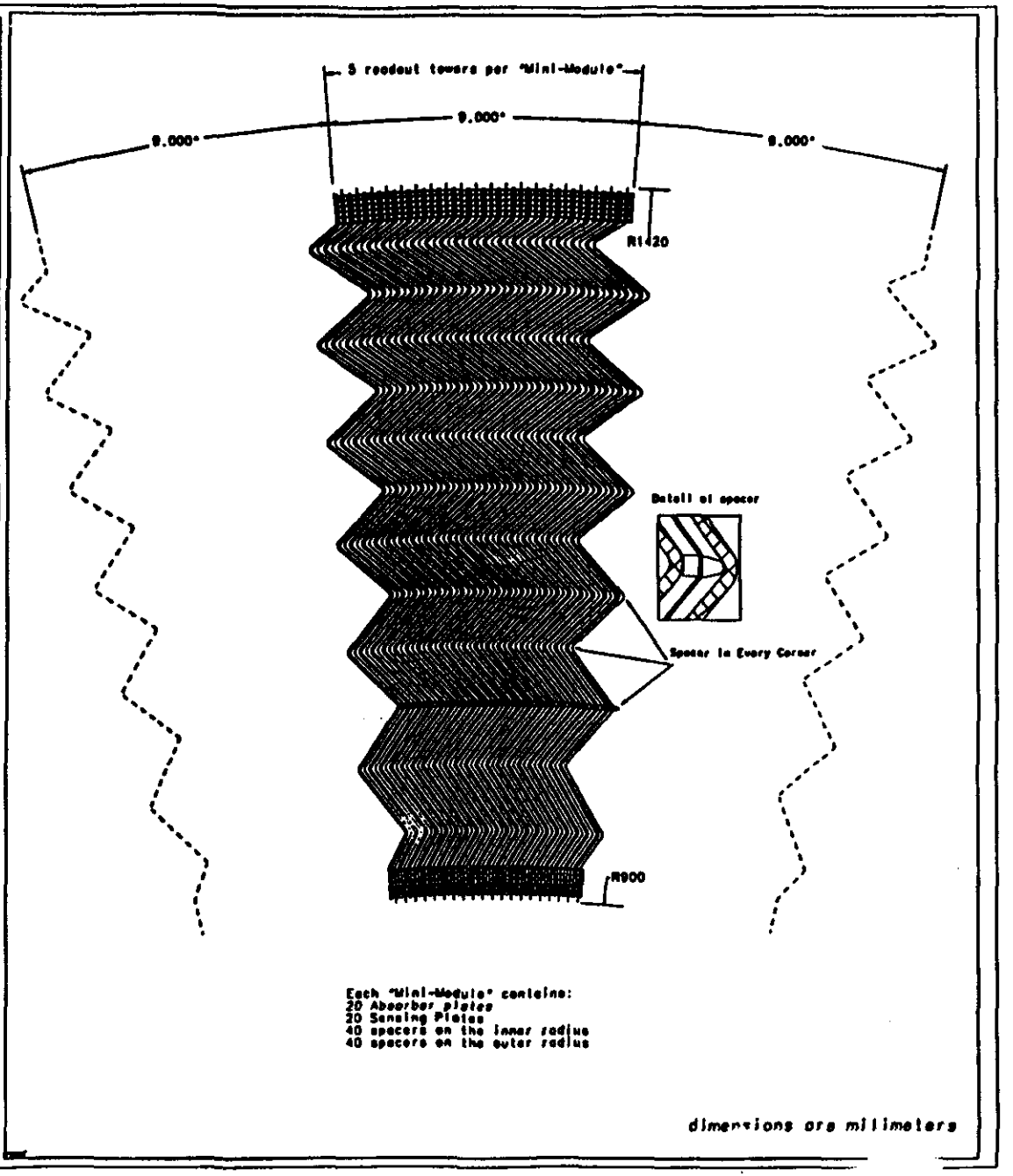


Barrel Accordion Before Bending

Typical but obsolete
200 absorber and 200 sensing plates
with .04 X .04 Segmentation


1.905
0.400
.225"
4.000
4.408
20.00
Aluminum
Kapton
4.33
1.305 mm Pb
0.1 mm Prepreg
0.2 mm Stainless


Stainless Clad G10
3 Layer Kapton
.225"
2.478
Shear Pin
Rivet Tie-rod
20.000
G10
1.0
4.0
2.398
0.400
1.905

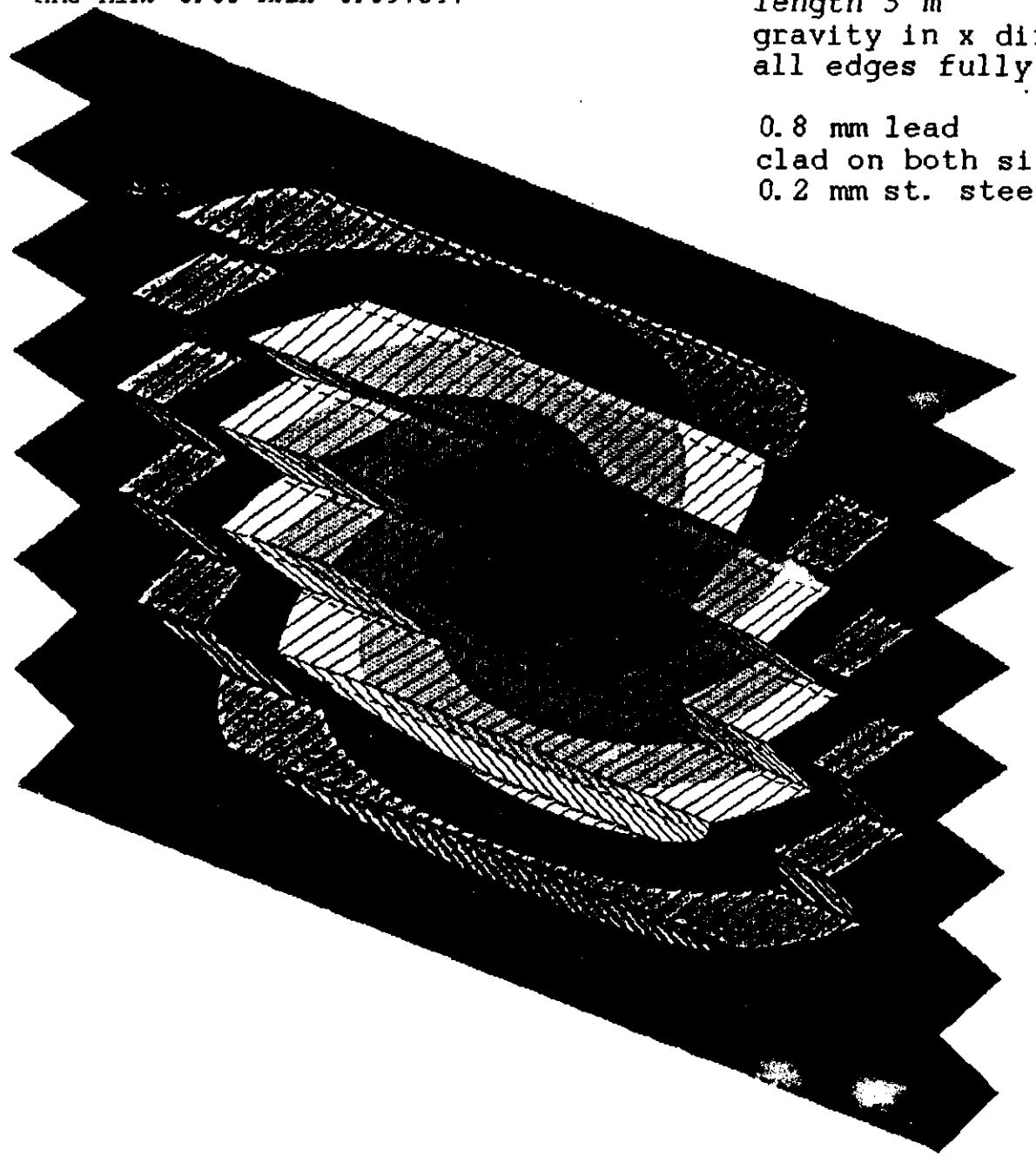

5 readout towers per "Mini-Module"
9.000"
9.000"
9.000"
R1420
Detail of spacer
Spacer in Every Corner
R900
Each "Mini-Module" contains:
20 Absorber plates
20 Sensing Plates
40 spacers on the inner radius
40 spacers on the outer radius
dimensions are millimeters

acordcomp

LOADCASE: 2
FRAME OF REF: GLOBAL
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.097847

length 3 m
gravity in x direction
all edges fully supported

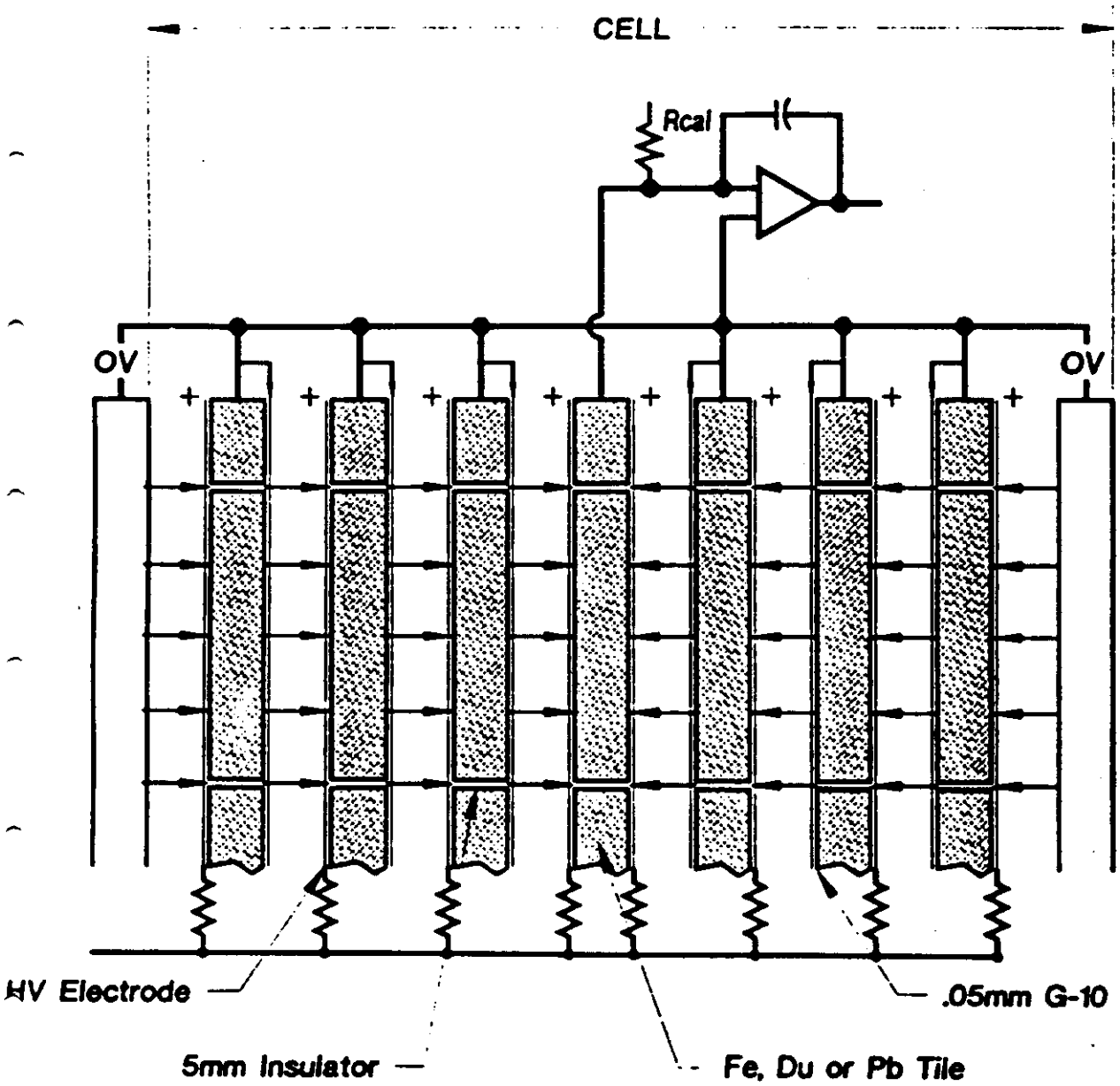
0.8 mm lead
clad on both sides with
0.2 mm st. steel



0.097847
0.083869
0.069891
0.055913
0.041934
0.027956
0.013978
0.00

Y
Z

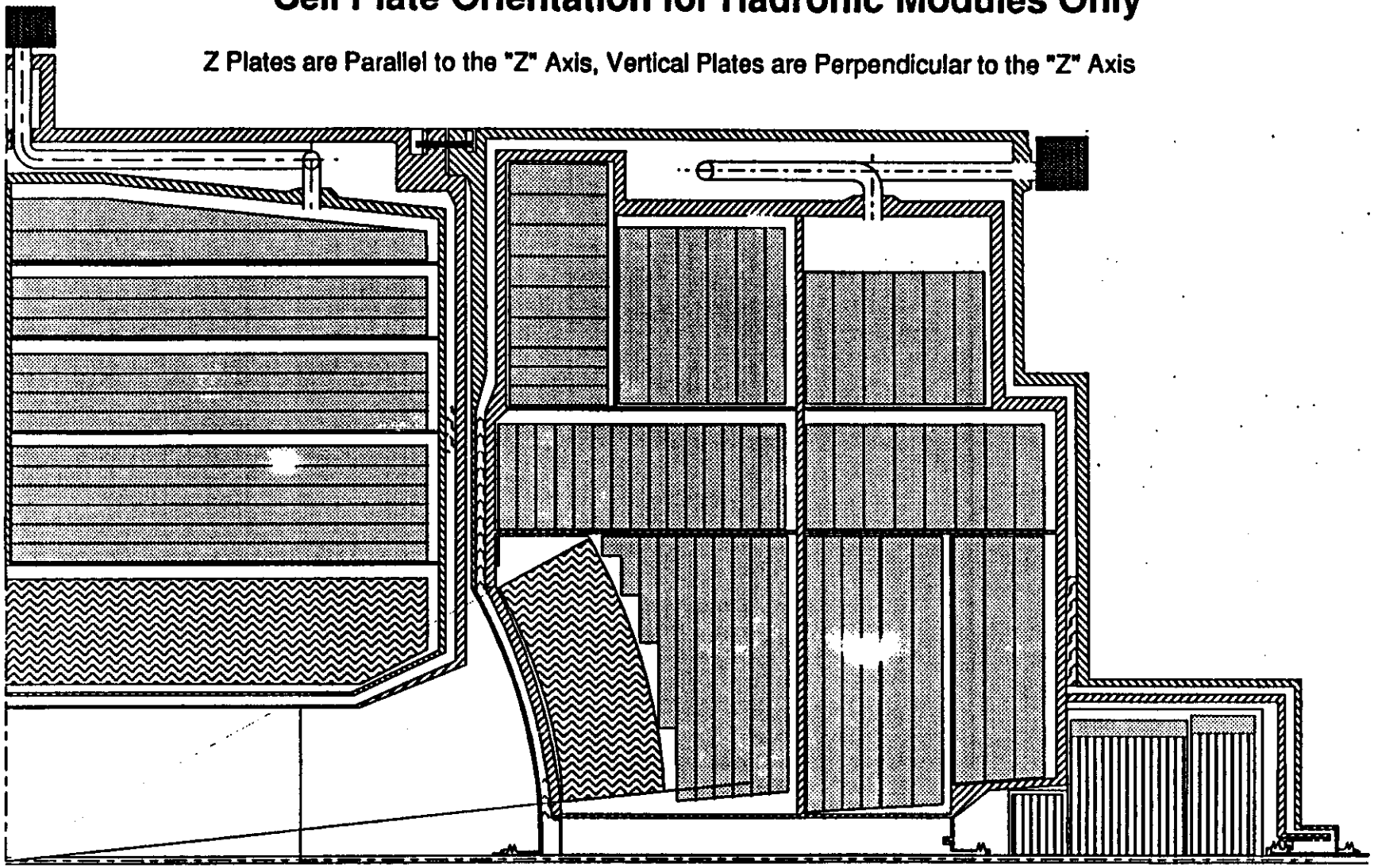
Hadronic Configuration with Electrostatic Transformer



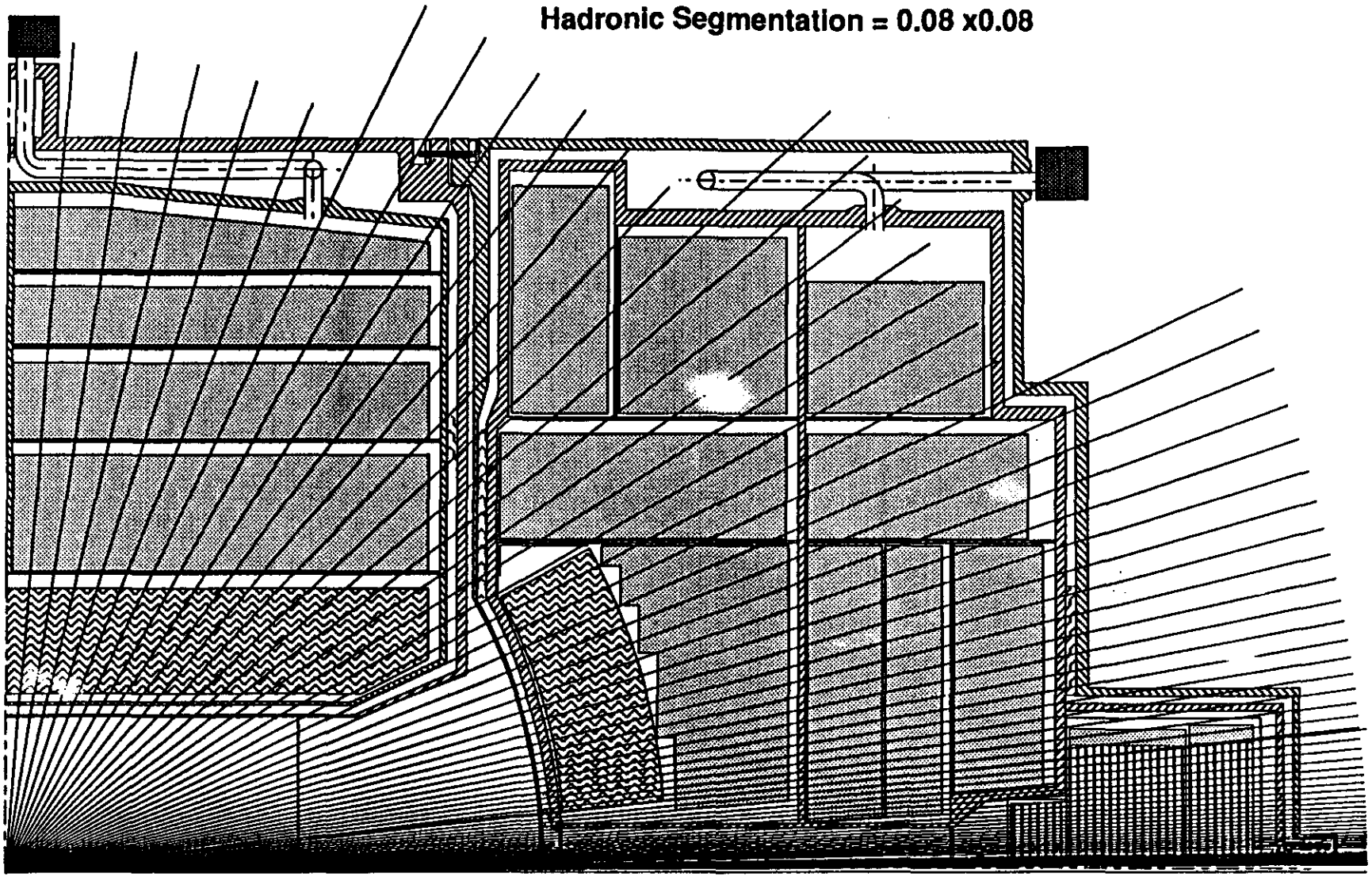
	Barrel		End Cap	
	Fine	Course	Fine	Course
P				
π				
Rs				
Cell				

Cell Plate Orientation for Hadronic Modules Only

Z Plates are Parallel to the "Z" Axis, Vertical Plates are Perpendicular to the "Z" Axis



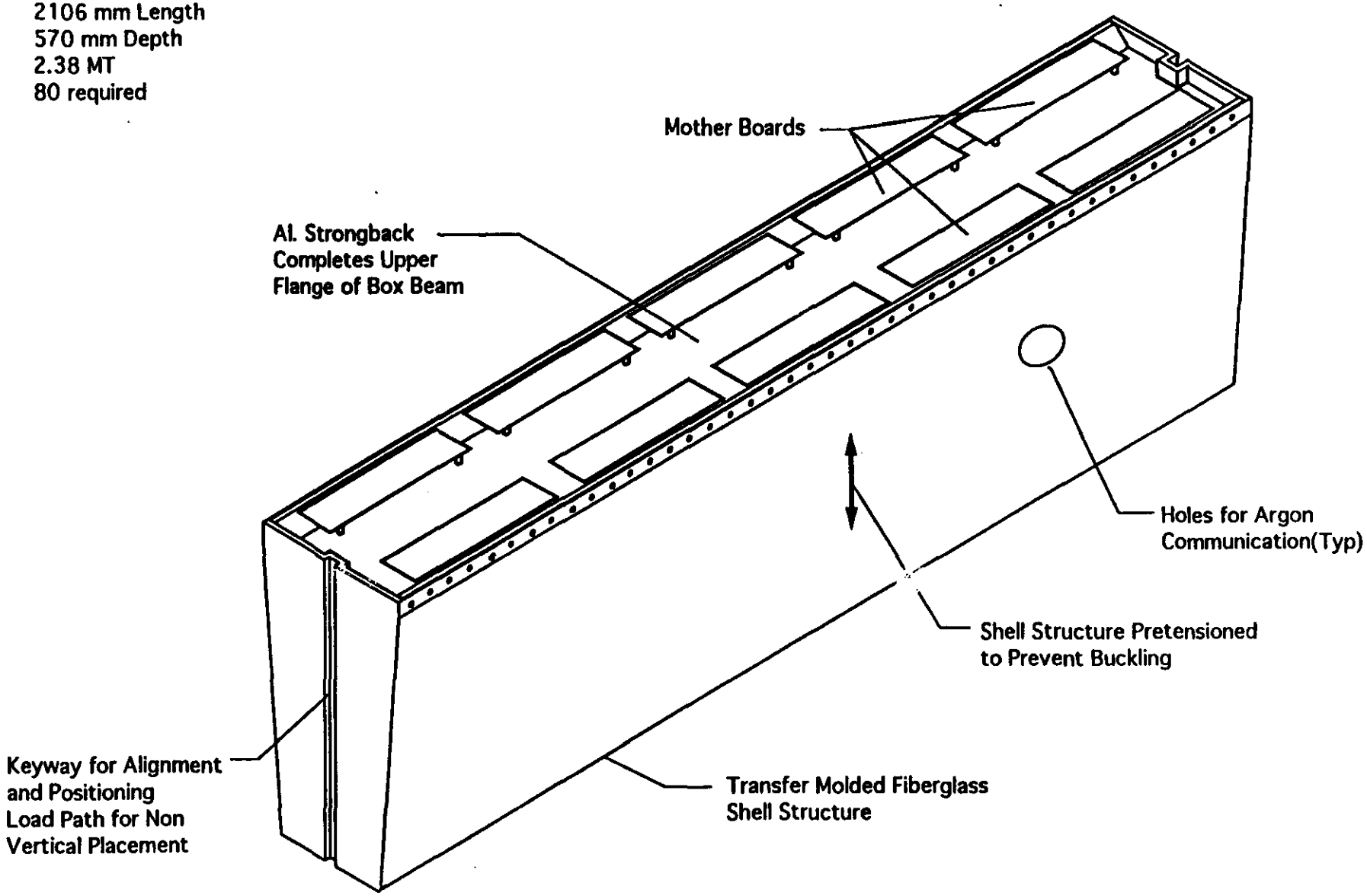
GEMLAC.Cell Orientation4/16/92



LLMason GEMLAC.RAY 4/16/92

COMPOSITE SHELL MODULE CONCEPT (Module #2)

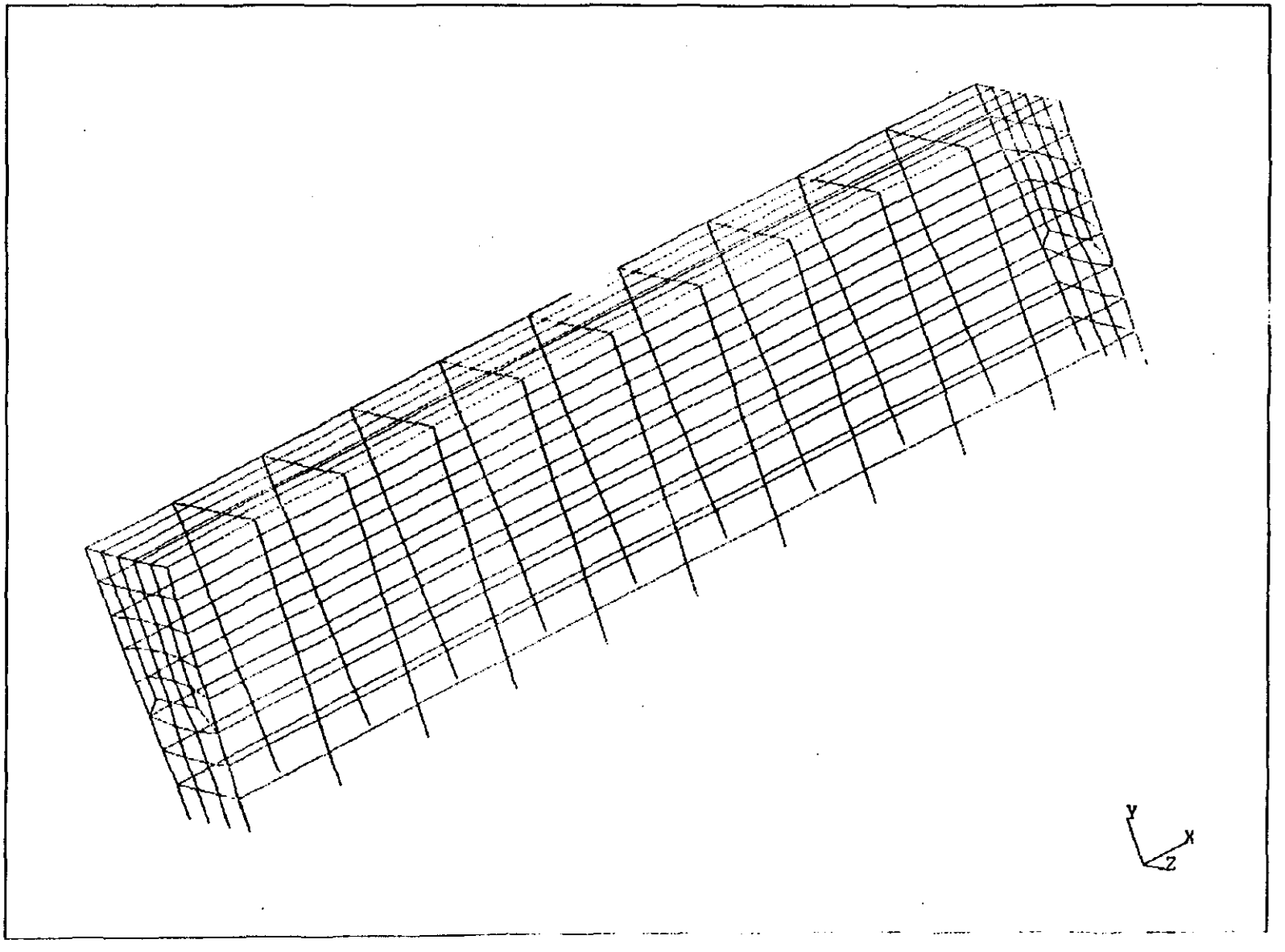
9 degree Included Angle
2106 mm Length
570 mm Depth
2.38 MT
80 required



SDRC I-DEAS V: FE_Modeling_&_Analysis 13-APR-92 13:41:29

Database module
View No stored View

Units : IN
Display No stored Option

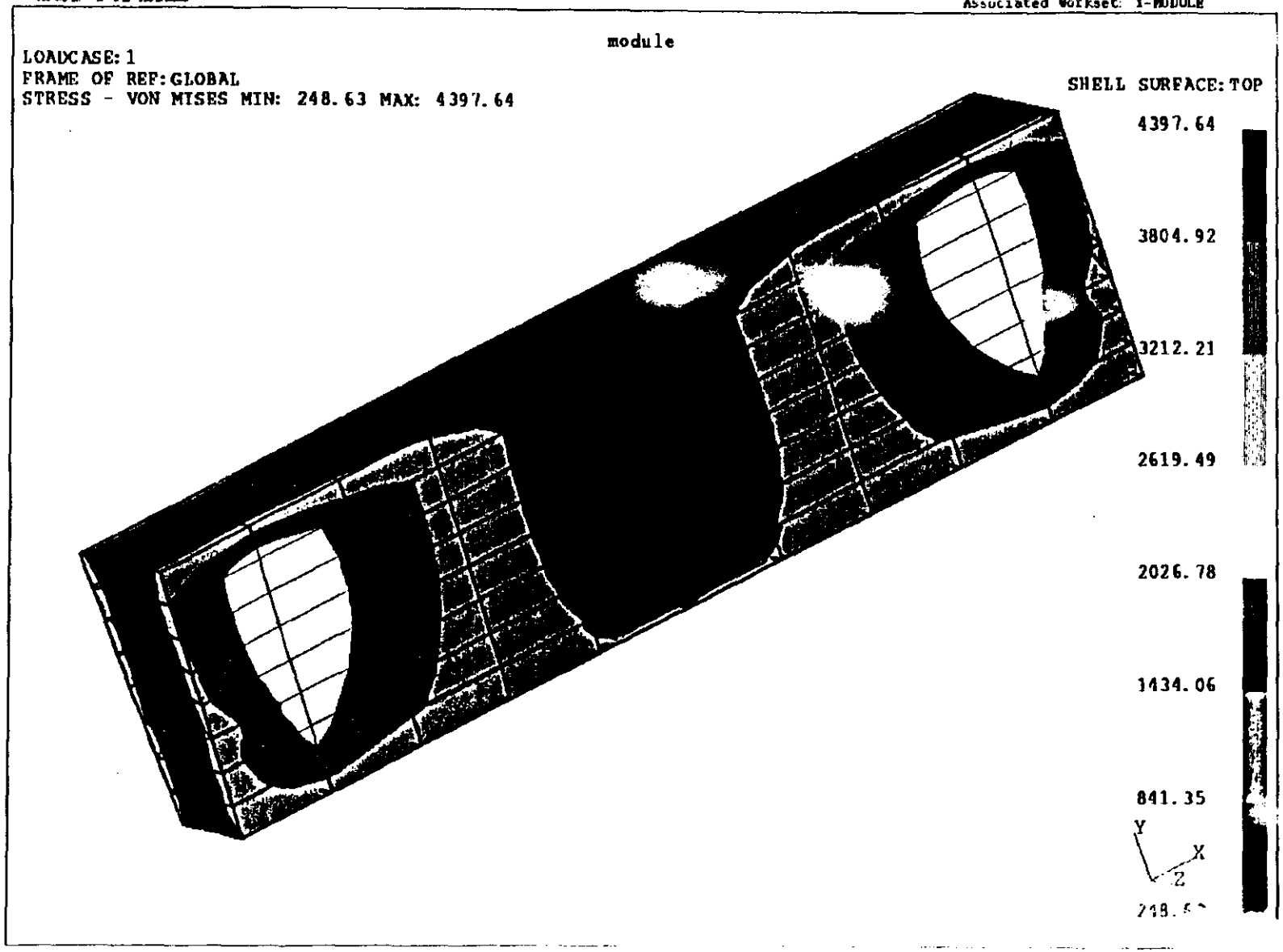


SDRC I-DEAS V: FE_Modeling_& _Analysis

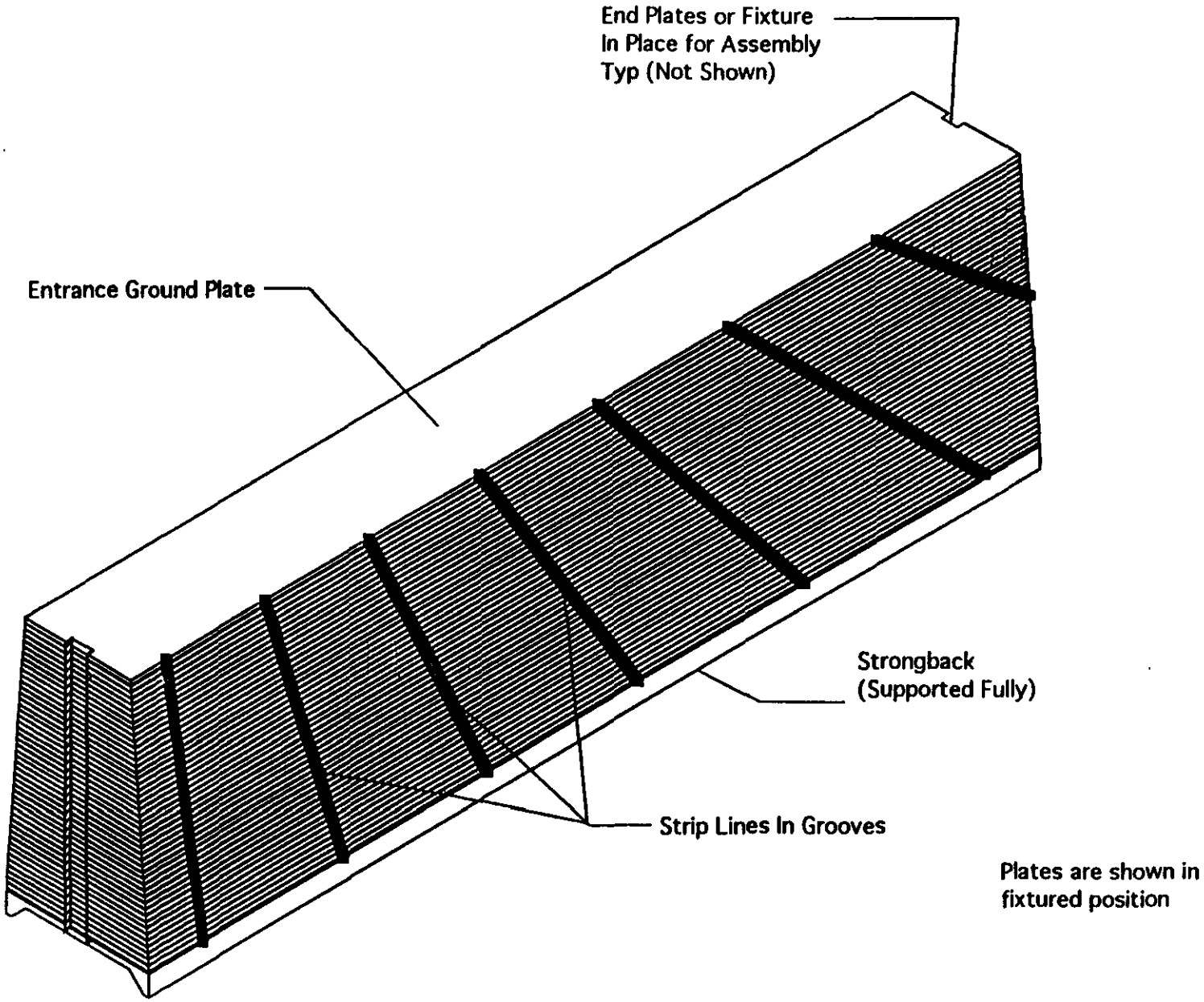
13-APR-92 13:45:54

Database module
View No stored View
Task: Post Processing
Model: 1-FE MODEL1

Units : IN
Display : No stored Option
Model Bin: 1-MAIN
Associated Workset: 1-MODULE

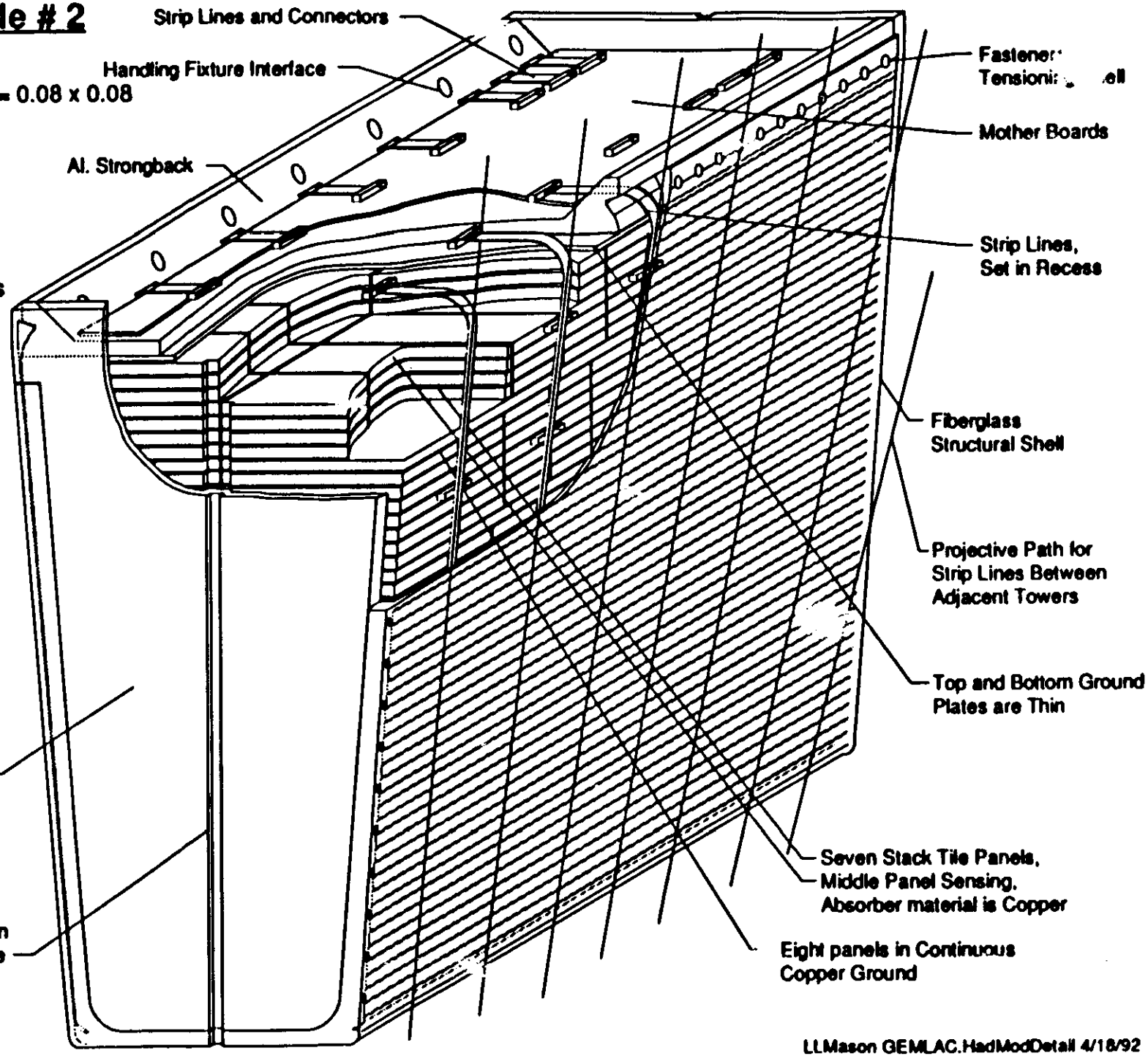


ASSEMBLY POSITION (Module #2)



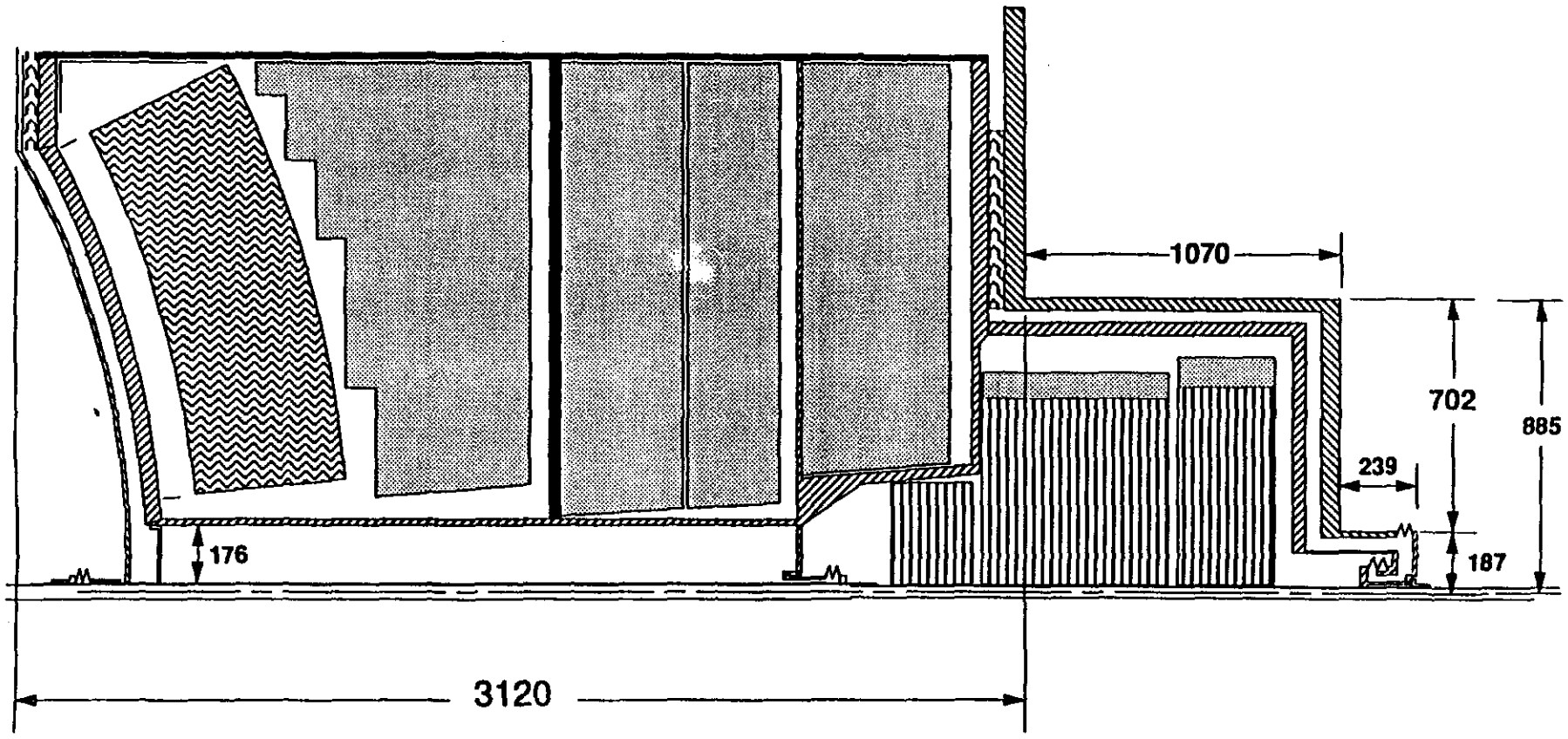
Hadron Module # 2

Six Cells Depth
Segmentation $\Delta\eta \times \Delta\varphi = 0.08 \times 0.08$
80 Modules Required
Wt. = 2.38 MT each
Each Module Contains the Following:
1 - Top Ground Plate
1 - Bottom Gnd Plate
5 - Included Gnd Plates
36 - Tile Plates Containing 948 Tile
6 - Sensing Plates Containing 258 Tile
1 - Strongback
1 - Structural Shell
2 - End Plates
28 - Towers with Strip Lines and Electronics
X - Mother Boards



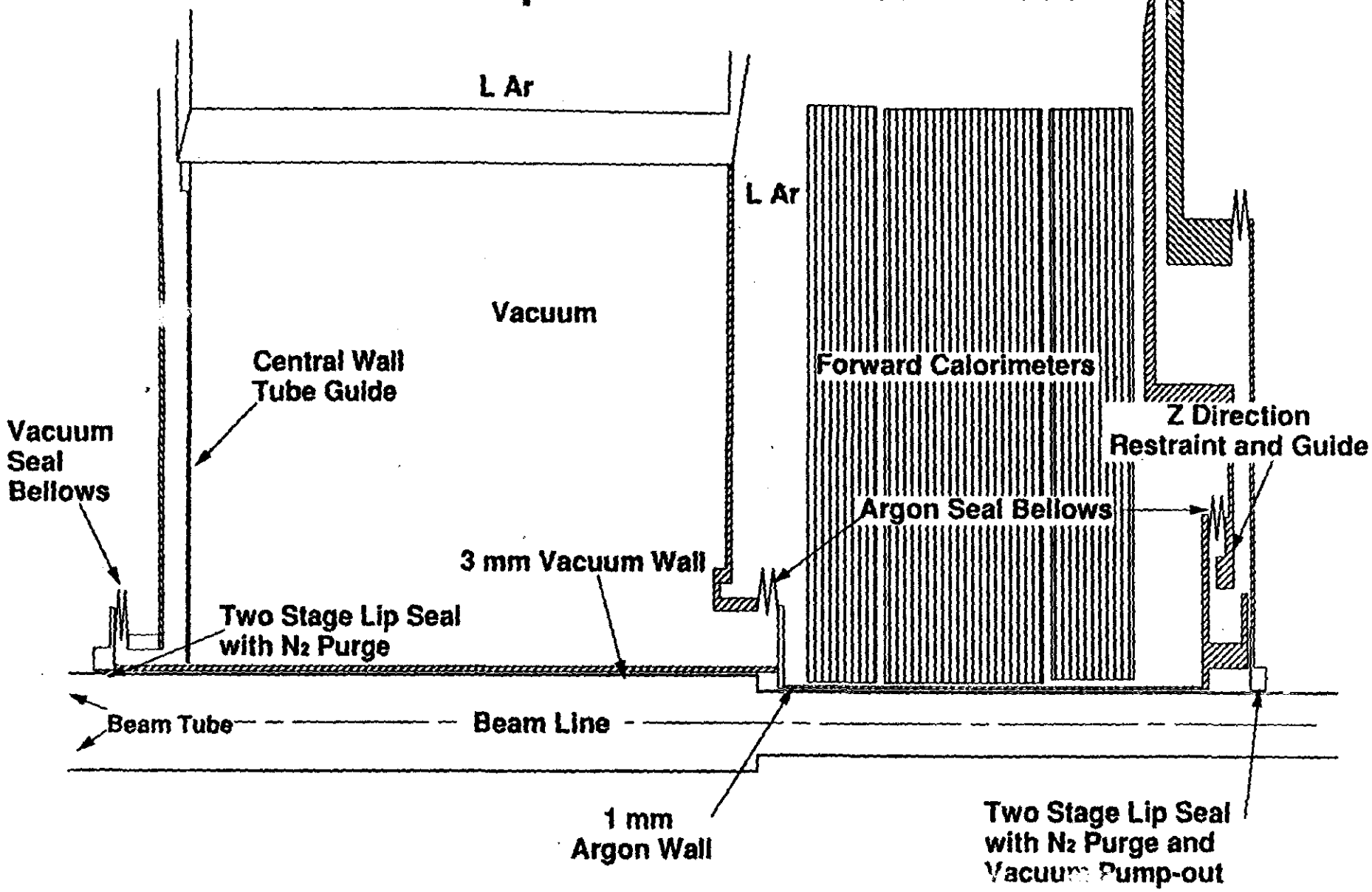
LLMason GEMLAC.HadModDetail 4/18/92

Blow-Up of Central Endcap and Forward Calorimeter



KLKillian Central Calorimeter Walls 4/20/92

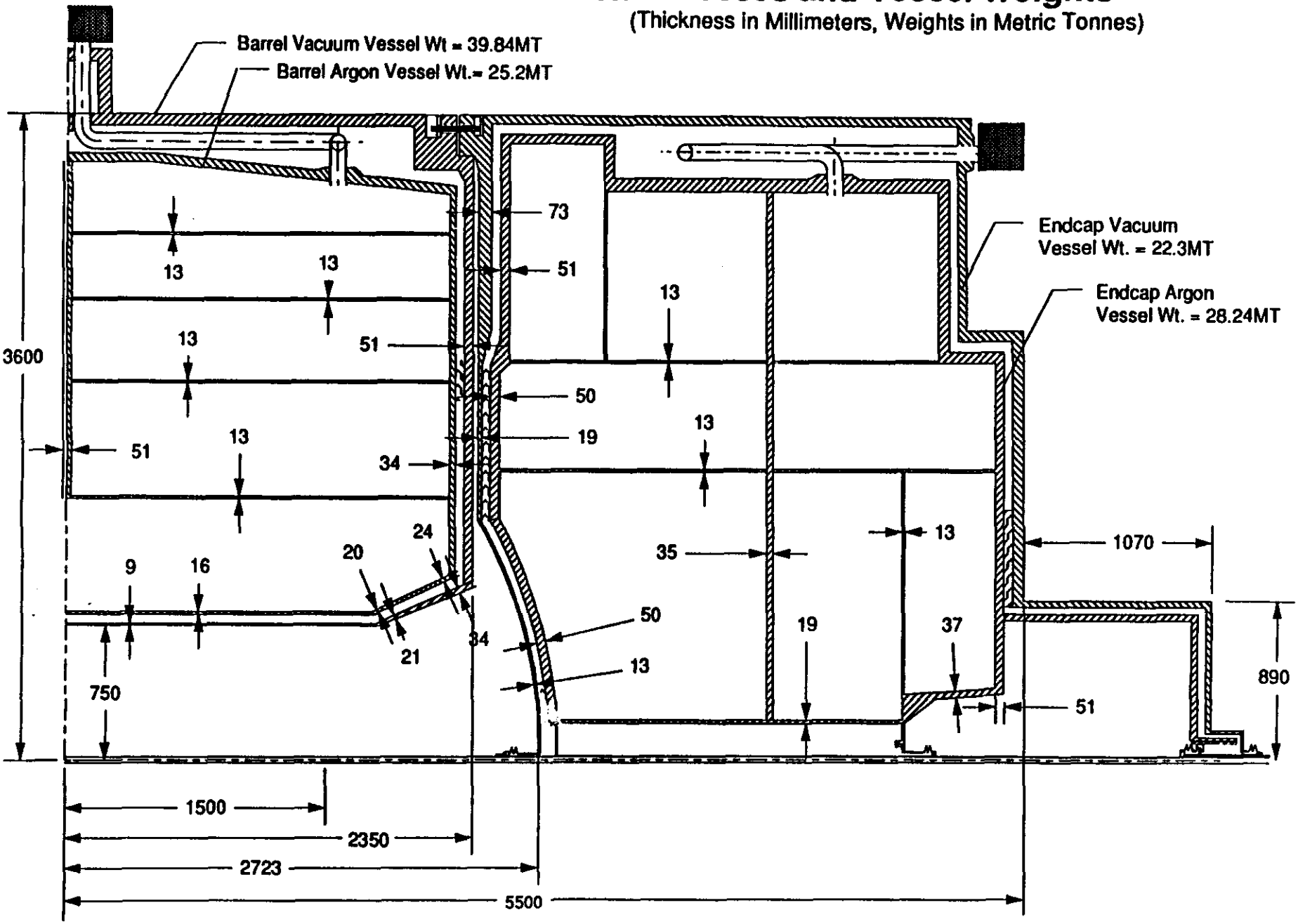
View with10x Expansion in Vertical Direction



KLKillian Central Calorimeter Walls 4/20/92

GEM Calorimeter Wall Thicknesses and Vessel Weights

(Thickness in Millimeters, Weights in Metric Tonnes)

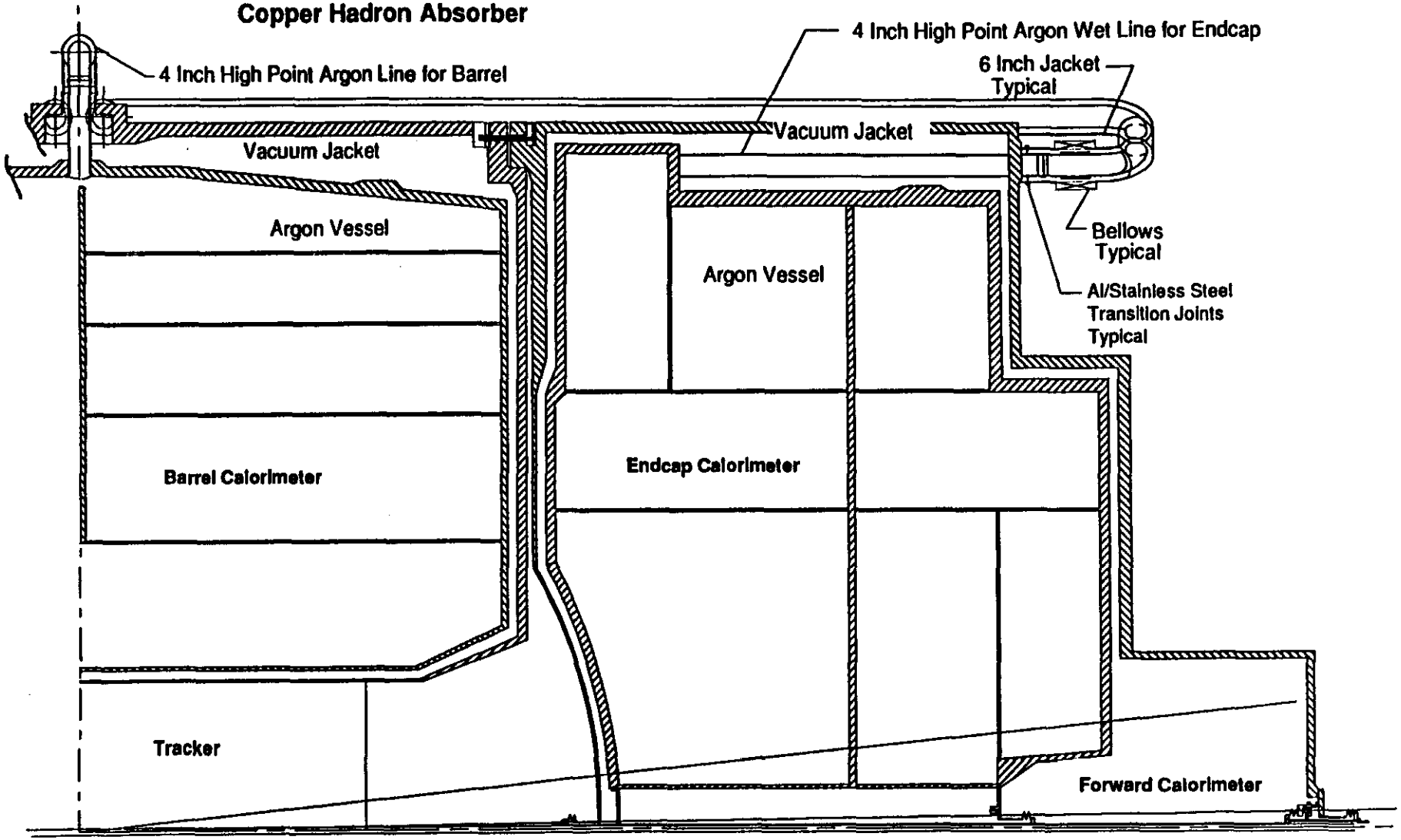


LLMason GEMLAC. Thicknesses 4/16/92

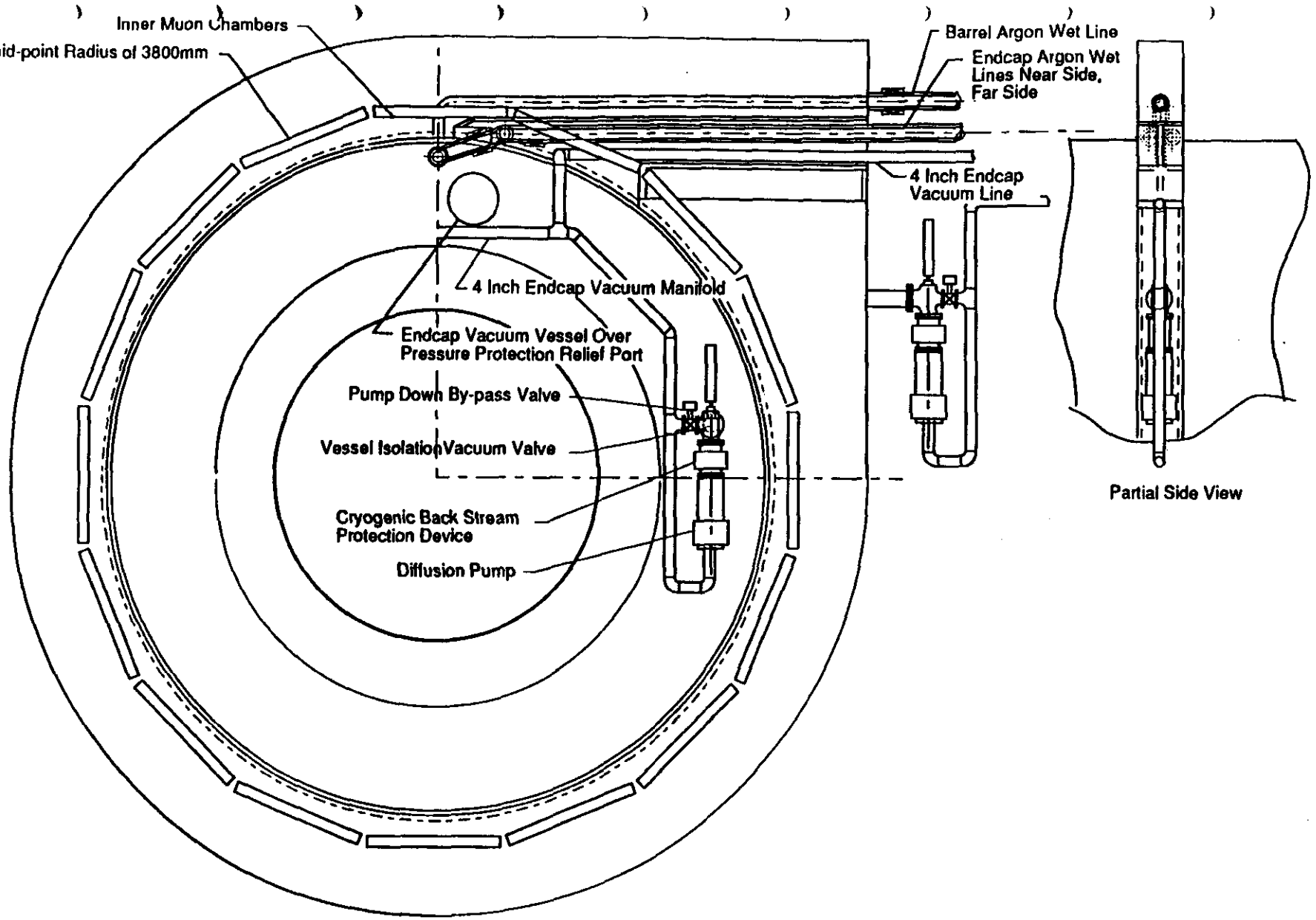
GEM Liquid Argon Calorimeter

Shows General Configuration with High Point Argon Piping

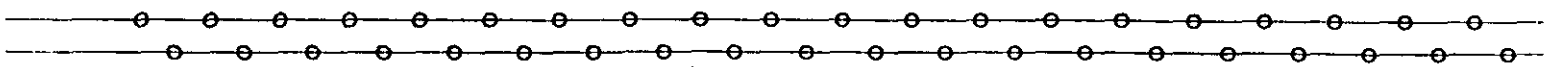
1/4 Section "Vertical"
Copper Hadron Absorber



LLMason GEMLAC.E & Piping 4/17/92



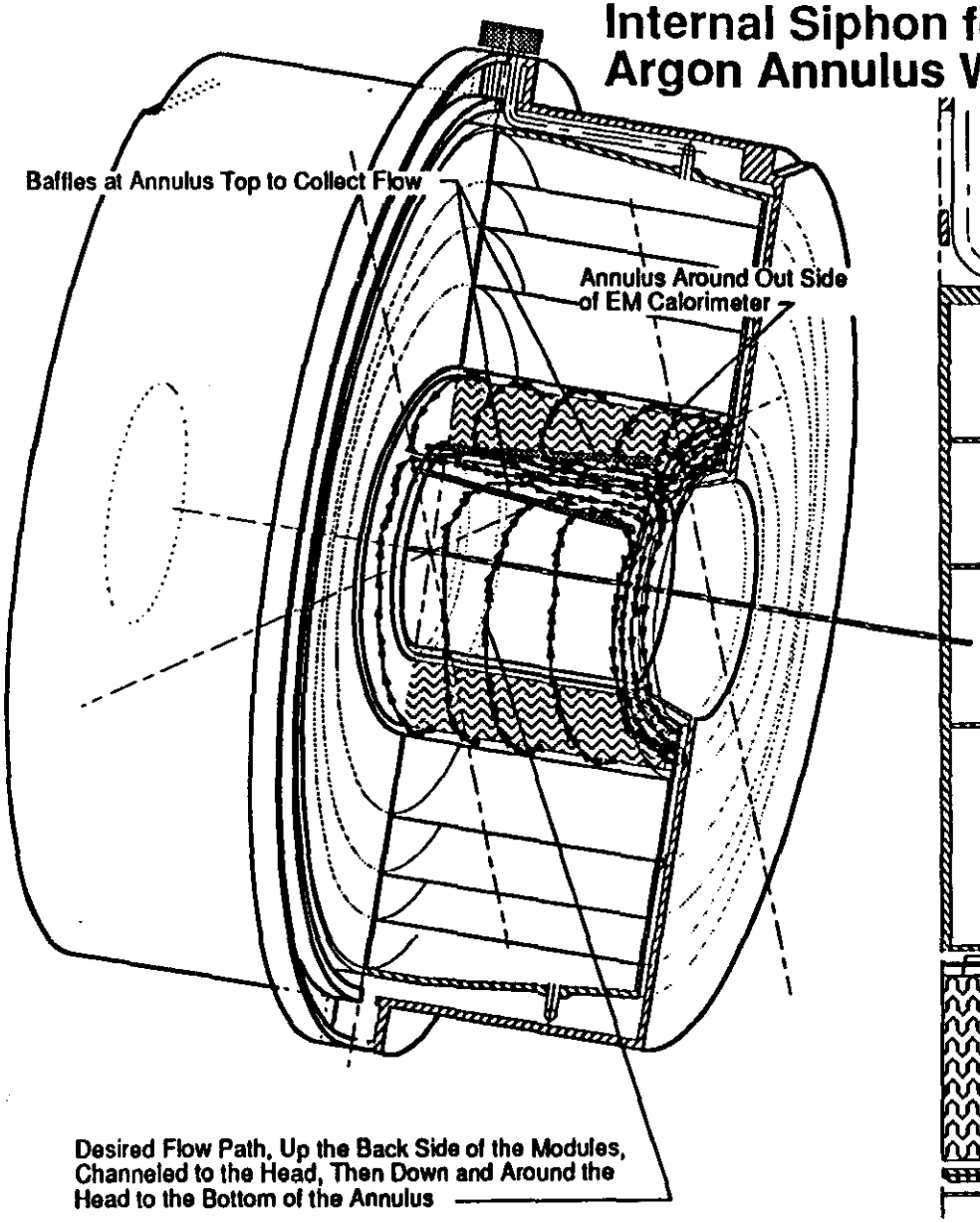
Endcap Calorimeter End View Showing Vacuum System and Argon Wet Line to Head Vessel



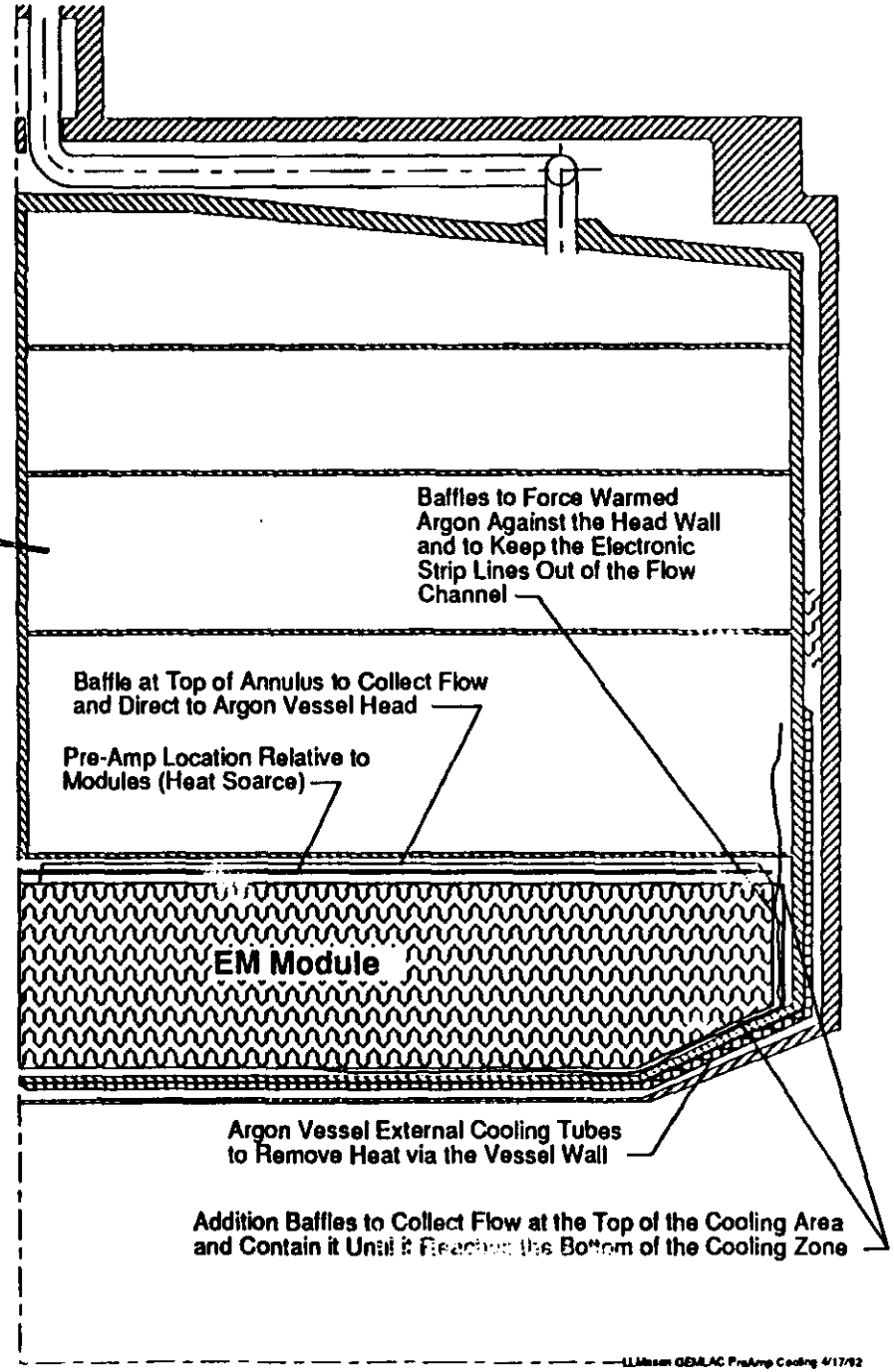
Spacing for Electronic Feed Throughs Penetrating the Barrel Vacuum Vessel, 40 Shown, 80 Required

LLMason GEM.AC E & Piping 4/17/92

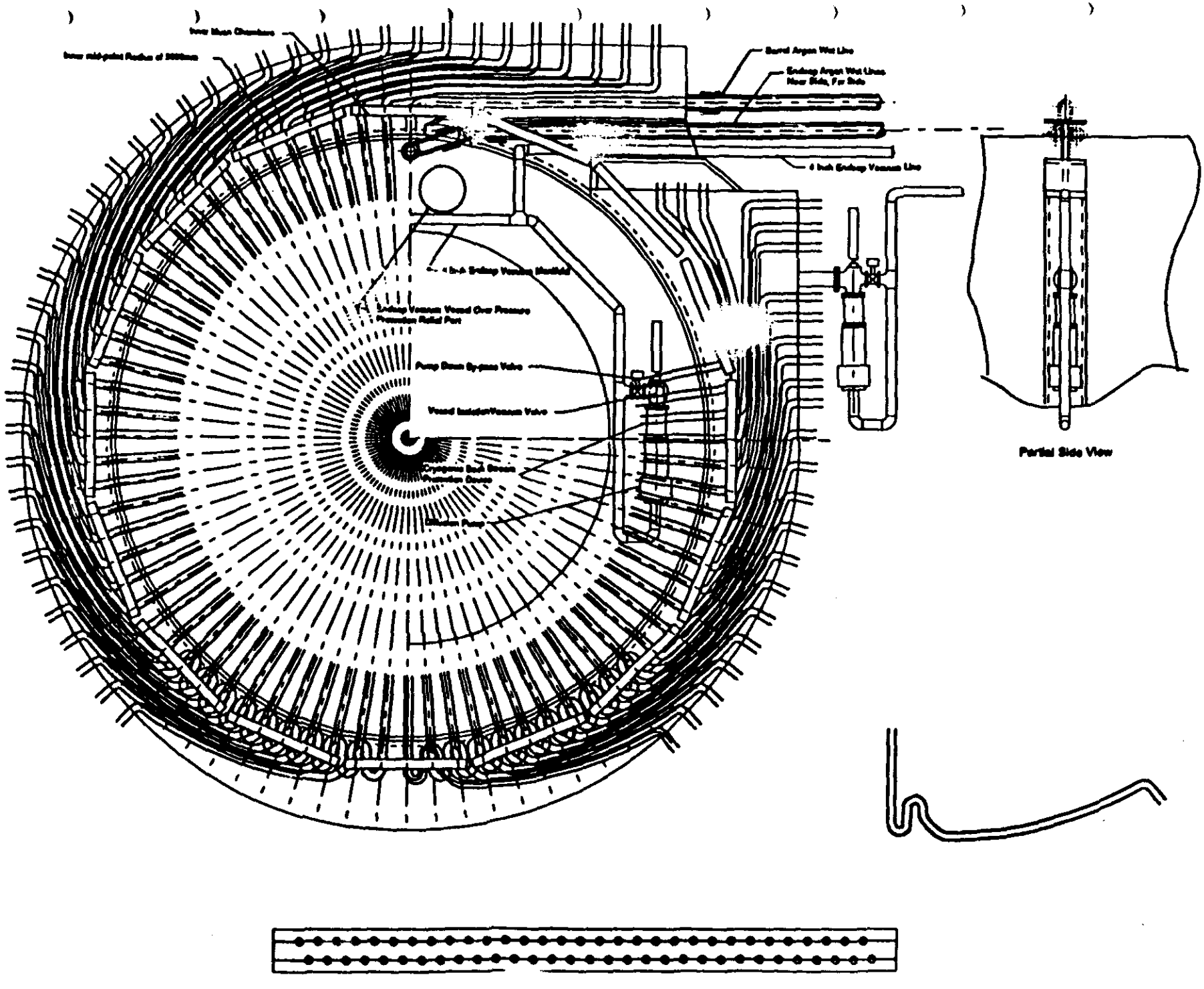
Internal Siphon for Cooling Pre-Amplifiers in the Argon Annulus Within the Barrel Calorimeter

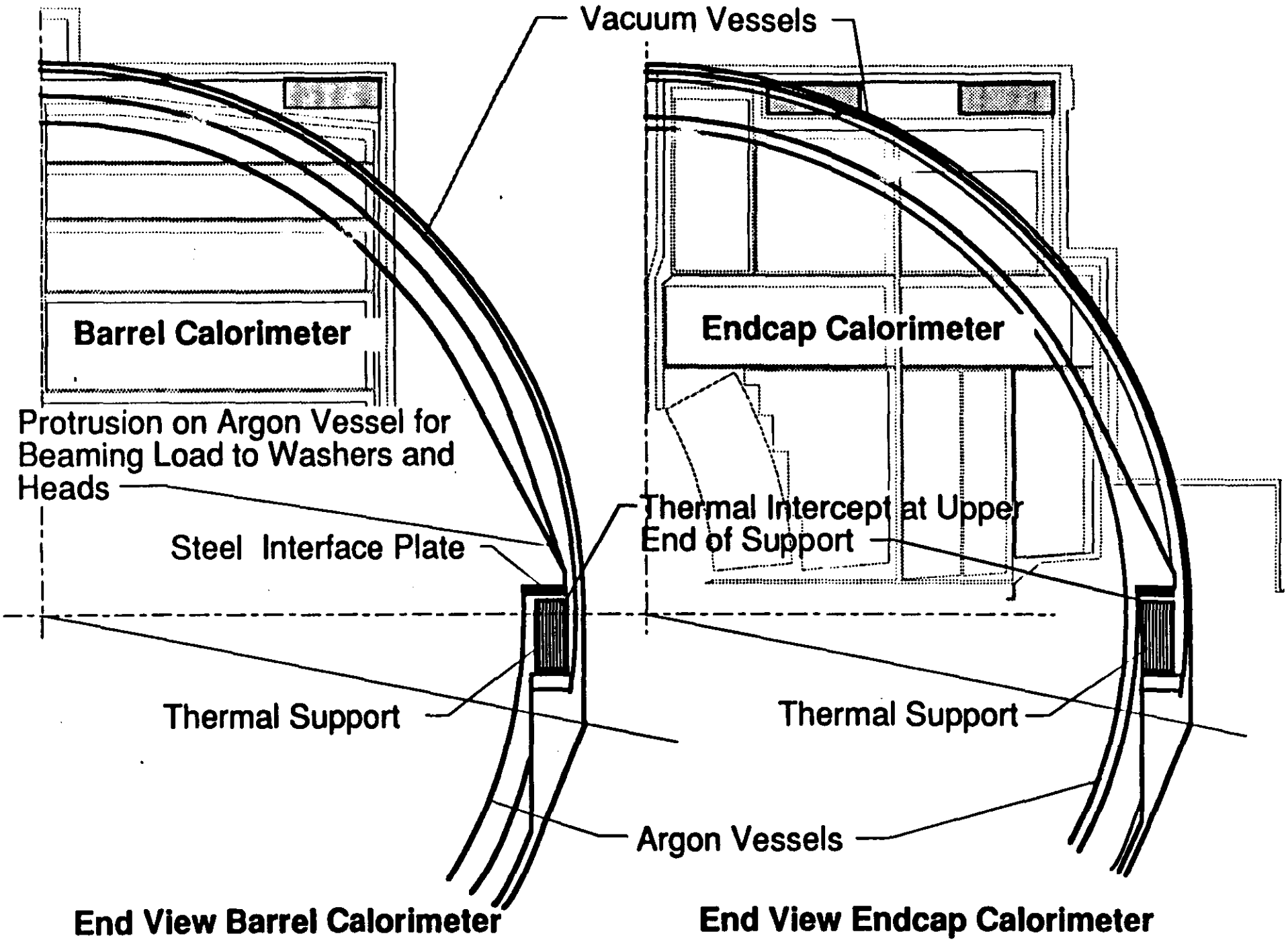


Barrel Liquid Argon Calorimeter



LLMason GEMLAC PreAmp Cooling 4/17/92

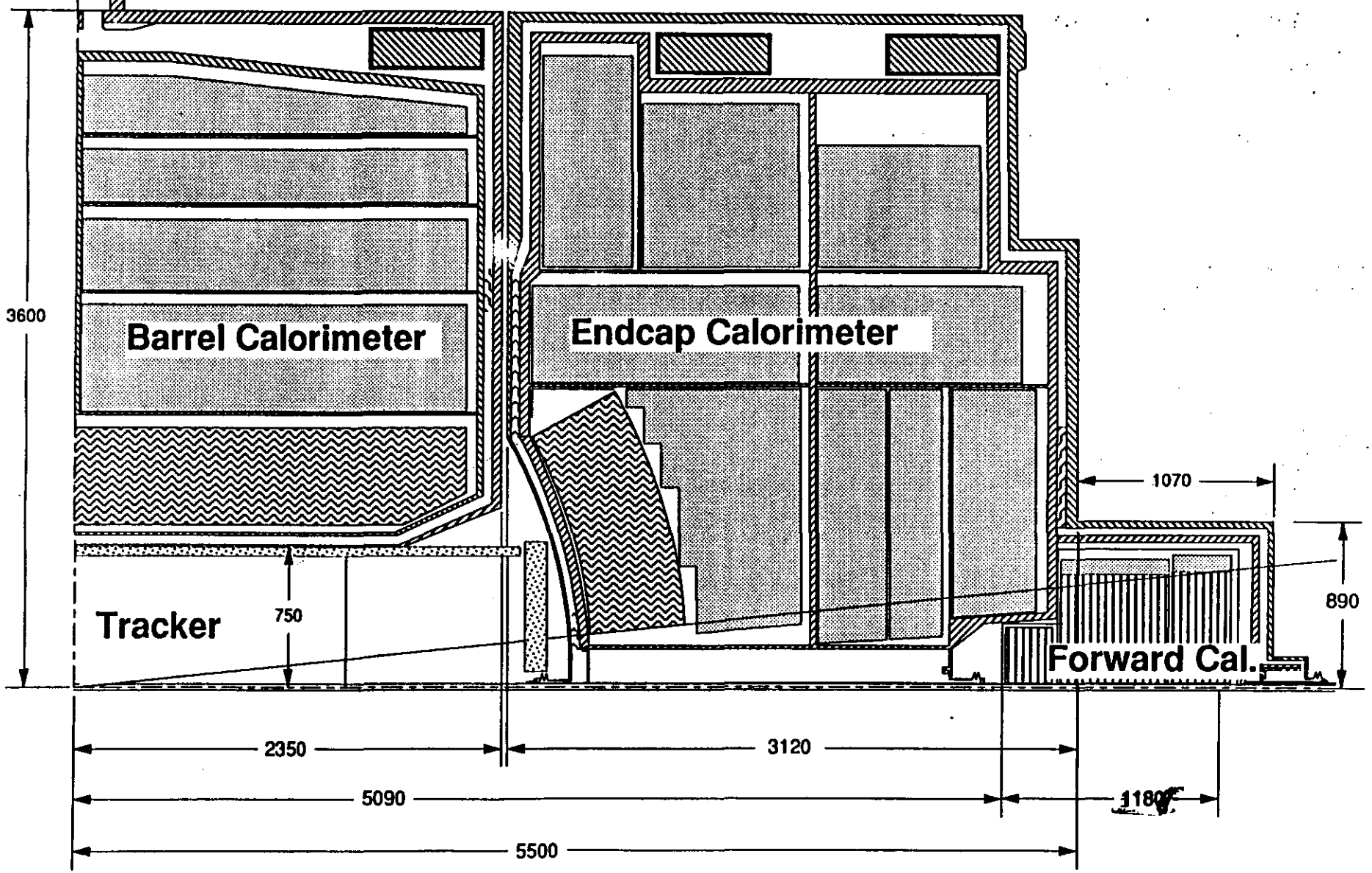

Inner Main Chamber
Inner mid-plane Radius of 3000mm
Barrel Argon Wet Line
Endcap Argon Wet Lines
Near Side, Far Side
4 Inch Endcap Vacuum Line
4 Inch Endcap Vacuum Manifold
Endcap Vacuum Vessel Over Pressure
Protection Relief Port
Pump Down Bypass Valve
Vessel Isolation/Vacuum Valve
Cryogenic Back Stream
Protection Device
Diffusion Pump
Partial Side View


Vacuum Vessels
Barrel Calorimeter
Endcap Calorimeter
Protrusion on Argon Vessel for Beaming Load to Washers and Heads
Steel Interface Plate
Thermal Intercept at Upper End of Support
Thermal Support
Thermal Support
Argon Vessels
End View Barrel Calorimeter
End View Endcap Calorimeter

GEM Liquid Argon Calorimeter

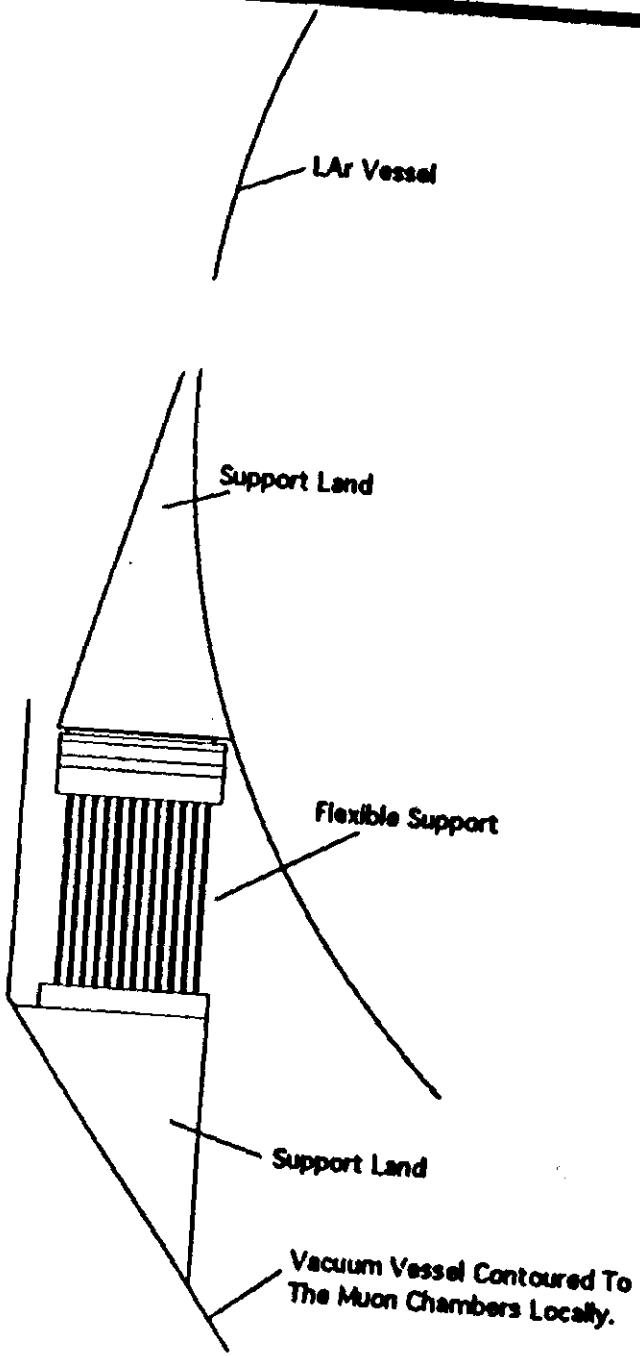
1/4 Section "Vertical Section"

Barrel Argon Vessel and Calorimetry Wt. = 743 MT
Endcap Argon Vessel and Calorimetry Wt. = 497 MT ea.



LLMason GEMLAC.Supports4/17/92

Supports

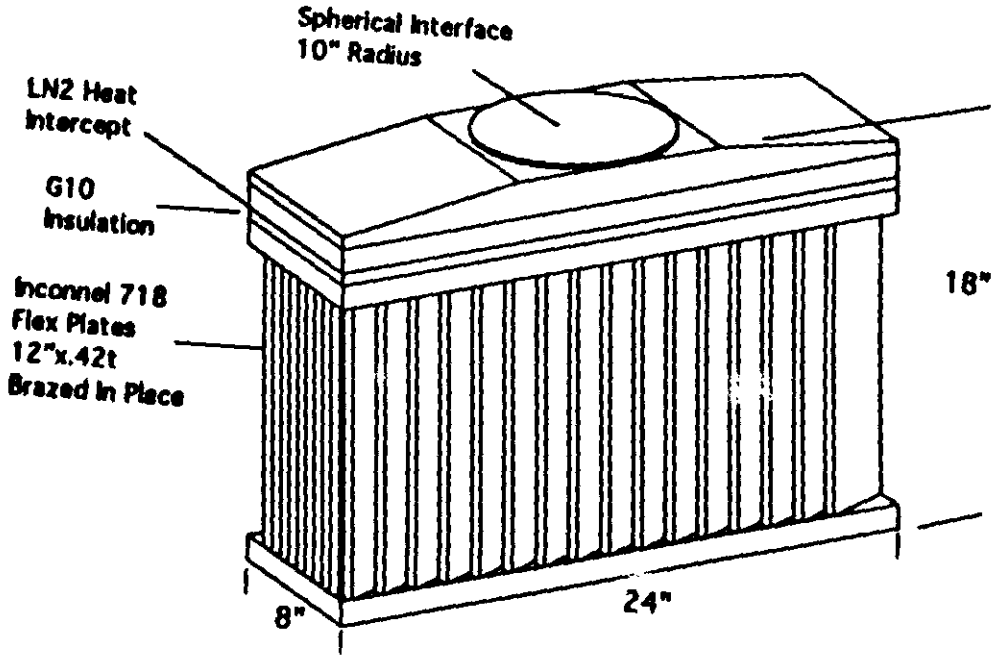


Structural Characteristics

- Deflection of +/- 0.3" Towards Interaction Point
- Design Load Of The Barrel Support of 337 MT
- Design Load Of The Endcap Support Is TBD
- Heat Intercept
  - Stainless Steel Or Aluminum
  - Cooling Tubes Integral
  - LN2 Cooling Is Baseline
  - 0.5" Cooling Tubes Leaves Greater Than The Necessary 60 in2 To Carry Load

Thermal C[illegible]aristics

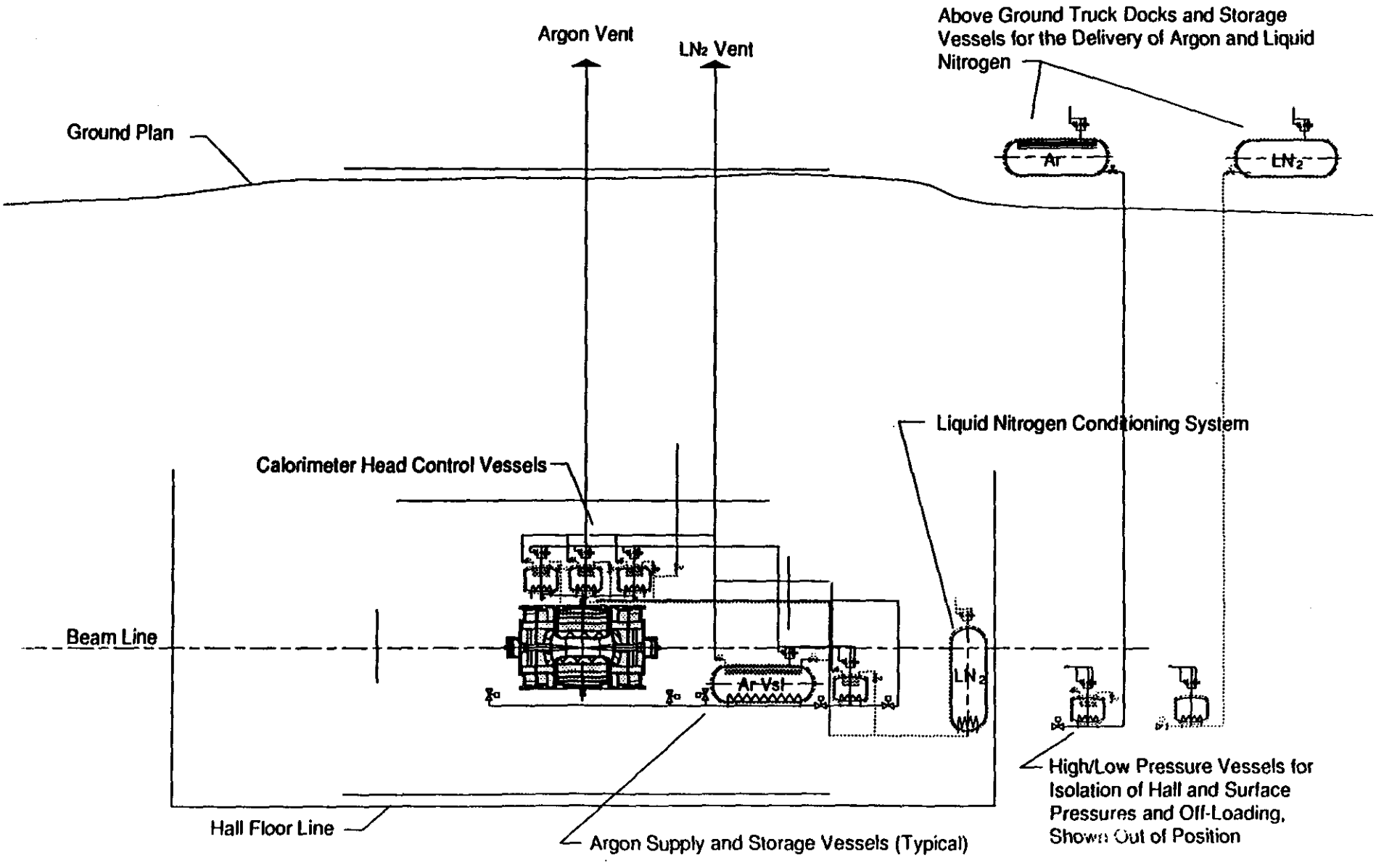
Barrel - 4 x 155 = 620 W
Endcaps - 8x 155 =1240 W
Total = 1860 W



ARGON VESSEL SUPPORT

Study of Cryogenic Systems for GEM Surface and Hall Facilities

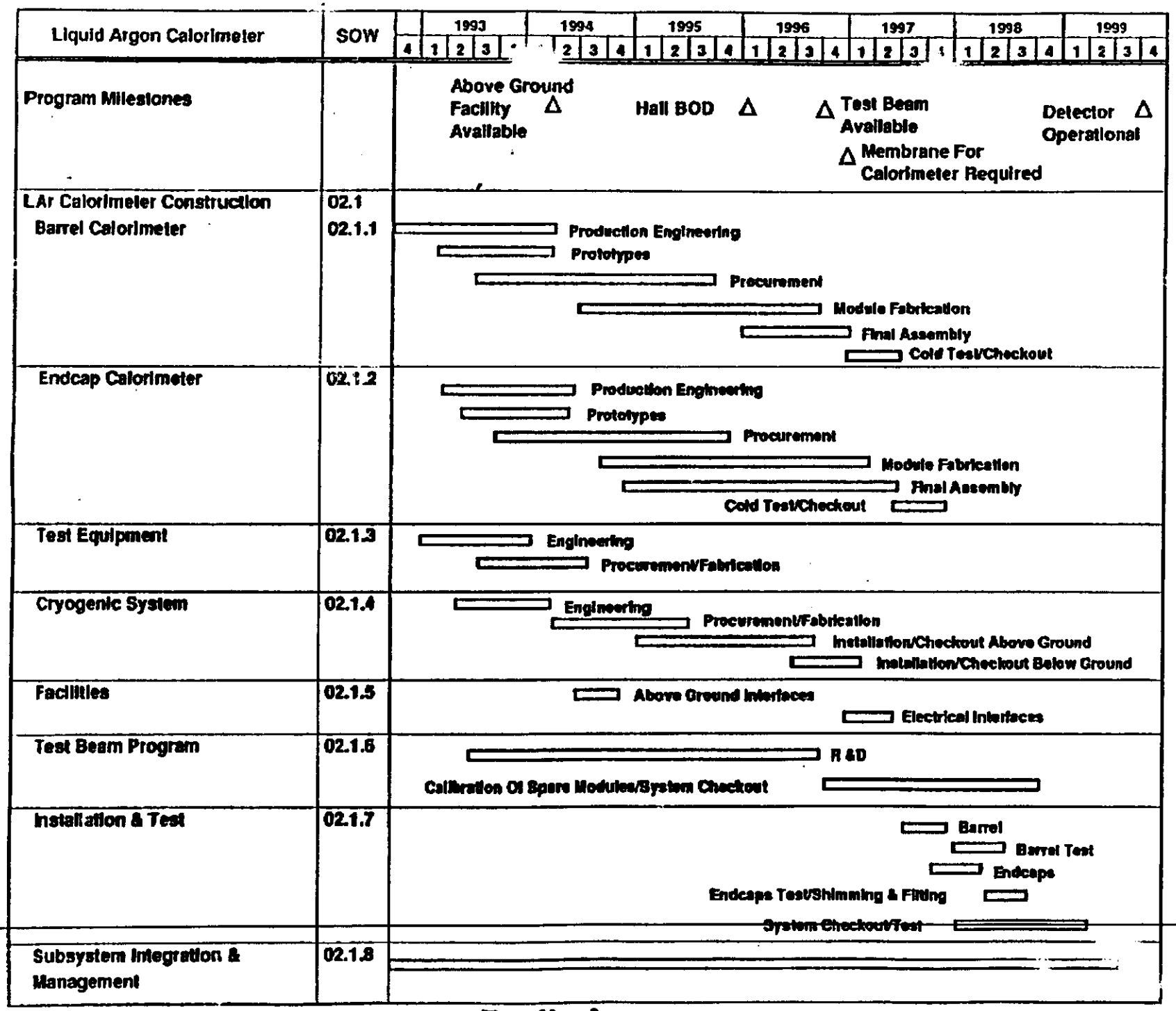
(Very Preliminary)



LLMason GEMLAC.Cryo_System 4/19/92

Summary

- Requirements and Engineering Parameters Definitized
- Interface Constraints Identified and Accepted
- Module Structures Developed
  — Endcap EM Being Finalized
- Electronics Heat Removal
  — Baseline: Thermal Siphon Using Internal Argon Cooling
- Vessels Defined and Sized
- Feedthroughs, Vacuum and Cryogenic Systems Defined
- Support System and Assembly Scenario Defined



WCY-4/20/92

Preliminary

Progress on R&D

RD3 - Produced 4 m projective accordion aborber plates

BNL Tests: 1 mm, 2 mm, chevron

All absorber plates are made

First 1 mm electrodes made this week

2 mm electrodes expected next week, then stacking

Entire electronics chain has been set up and tested in the beam, including Nevis analog pipeline.

Cryostat is being leak checked and foam insulated

Simulation efforts:

Nonprojective accordion (beam test) - H. Ma (new GEM Technical Note)

Understanding of effects of electric fields - I. Stumer and H. Ma.

Barrel projective accordion - M. Seman

End cap accordion designs - M. Leltchouk and A. Masslenikov

Hadronic - electrostatic transformer - E. Kistenev

EM Configuration

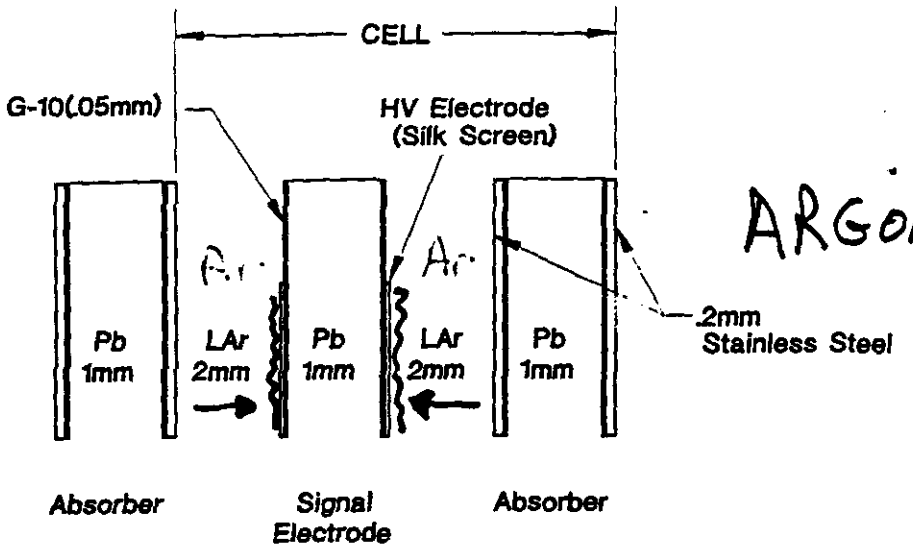
Goal $\leq 7.5\%/\sqrt{E}$

"1mm" option

increase sampling frequency

1mm OPTION

P=
X.=
Tl=
Rs=21.1%
Cell=6.6mm



ARGON

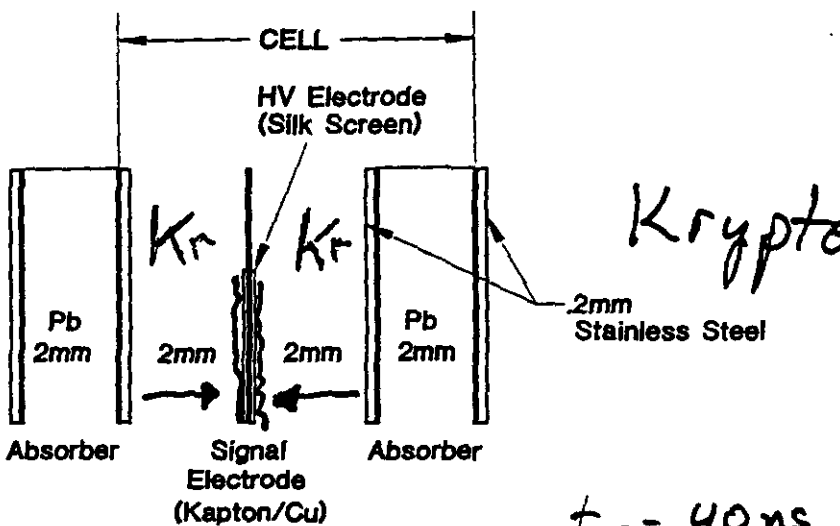
"2 mm" Option

decrease absorber thickness

increase sampling fraction

2mm OPTION

P=
X.=
Tl=
Rs=22.8%
Cell=6.6mm

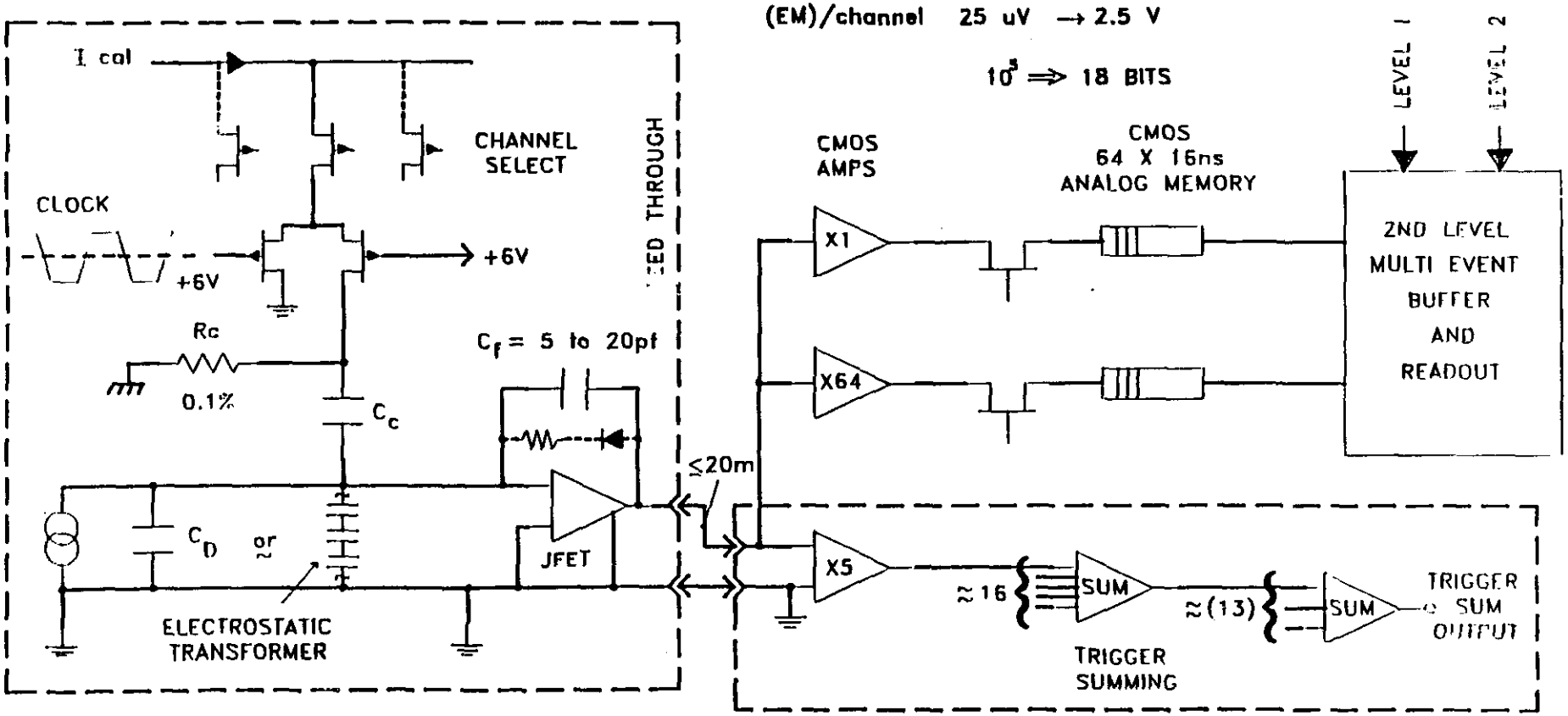


Krypton

$t_p = 40$ ns

Goal [redacted] $\frac{7.5\%}{\sqrt{E}}$

PREAMPLIFIER AND CALIBRATION SYSTEM

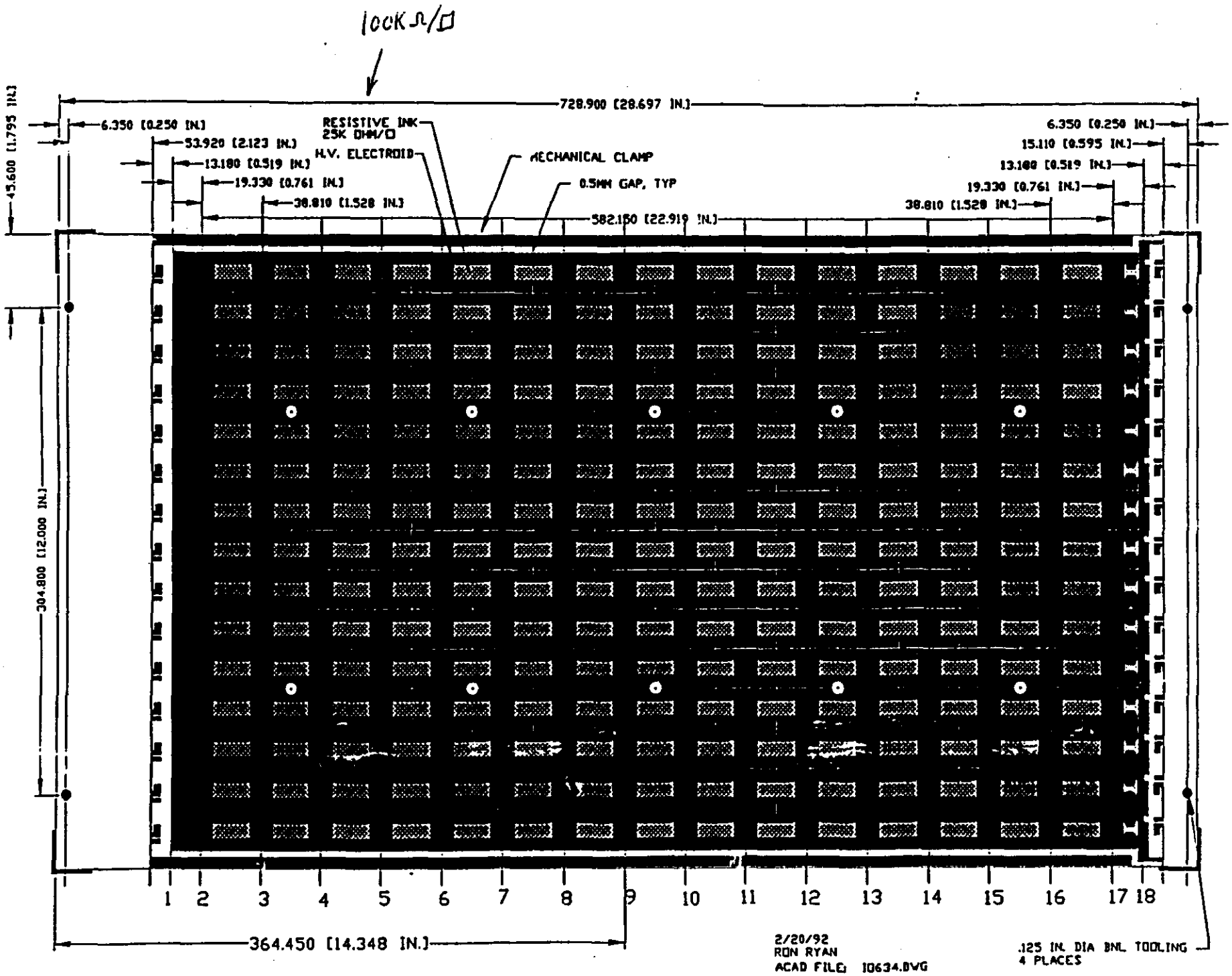


NOTES

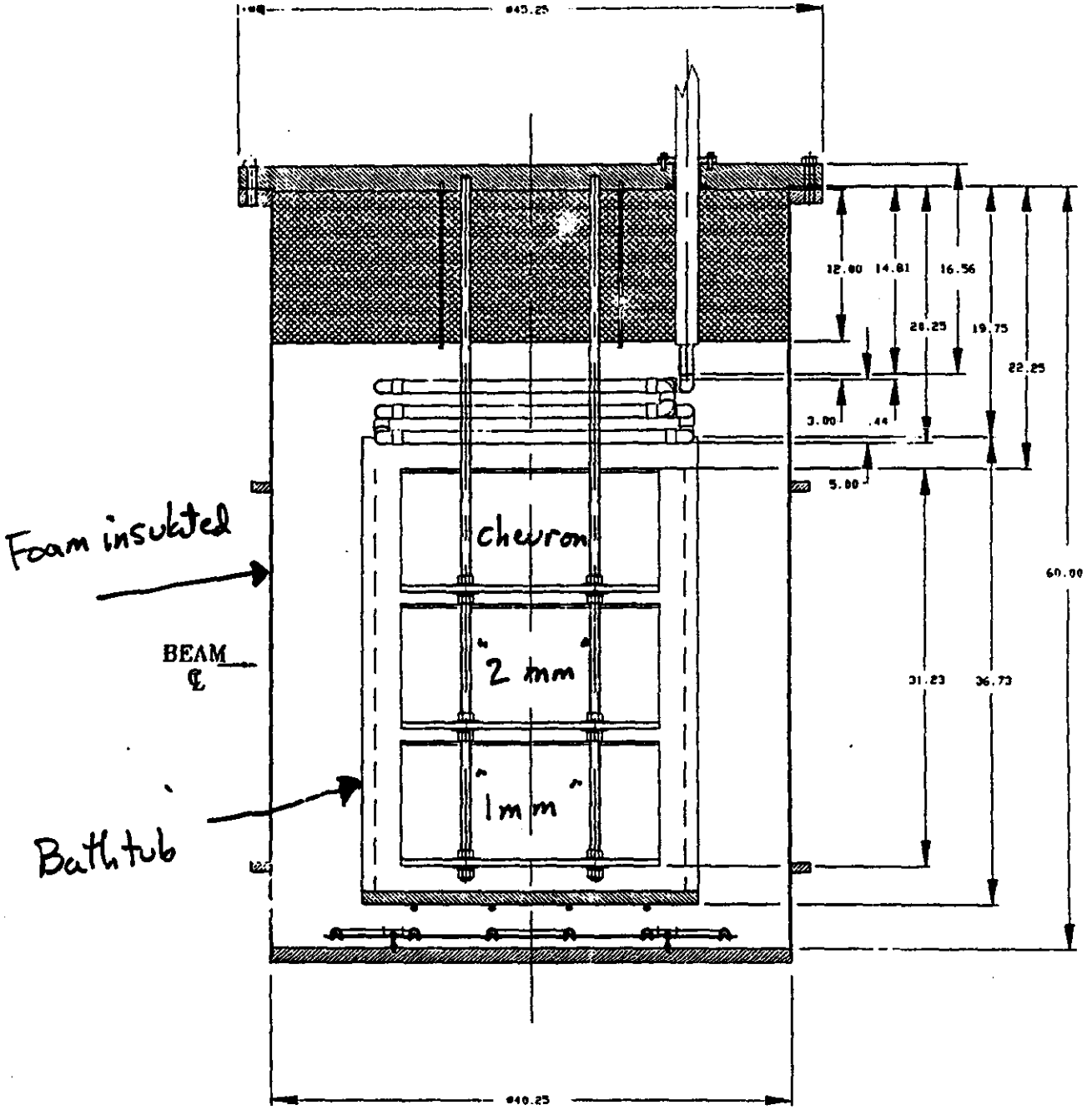
DYNAMIC RANGE 25 MeV → 2.5 TeV
(EM)/channel 25 uV → 2.5 V

10^5 ⇒ 18 BITS

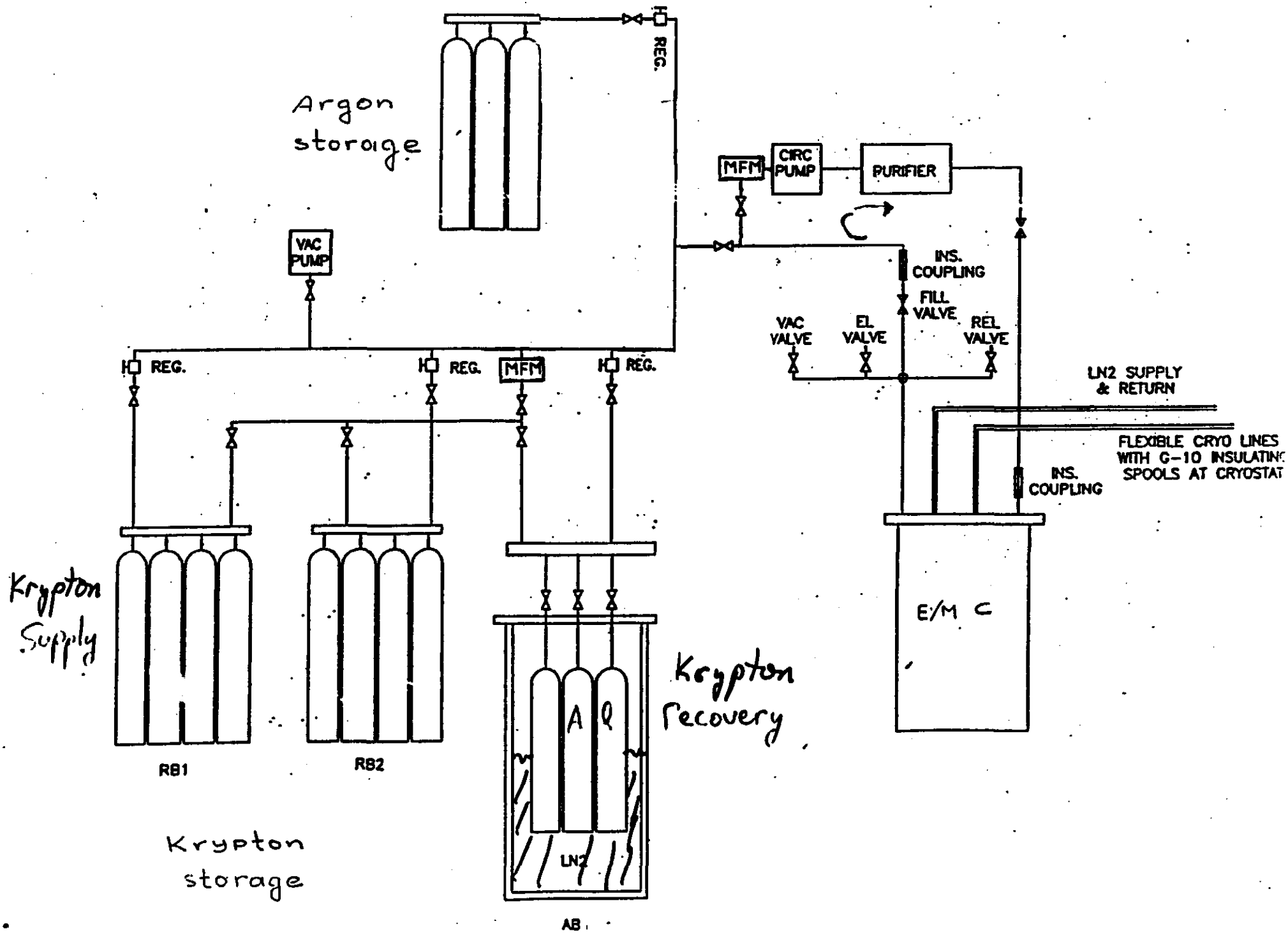
BNL-OMEGA JMH
SSC LA CAL SSCT002

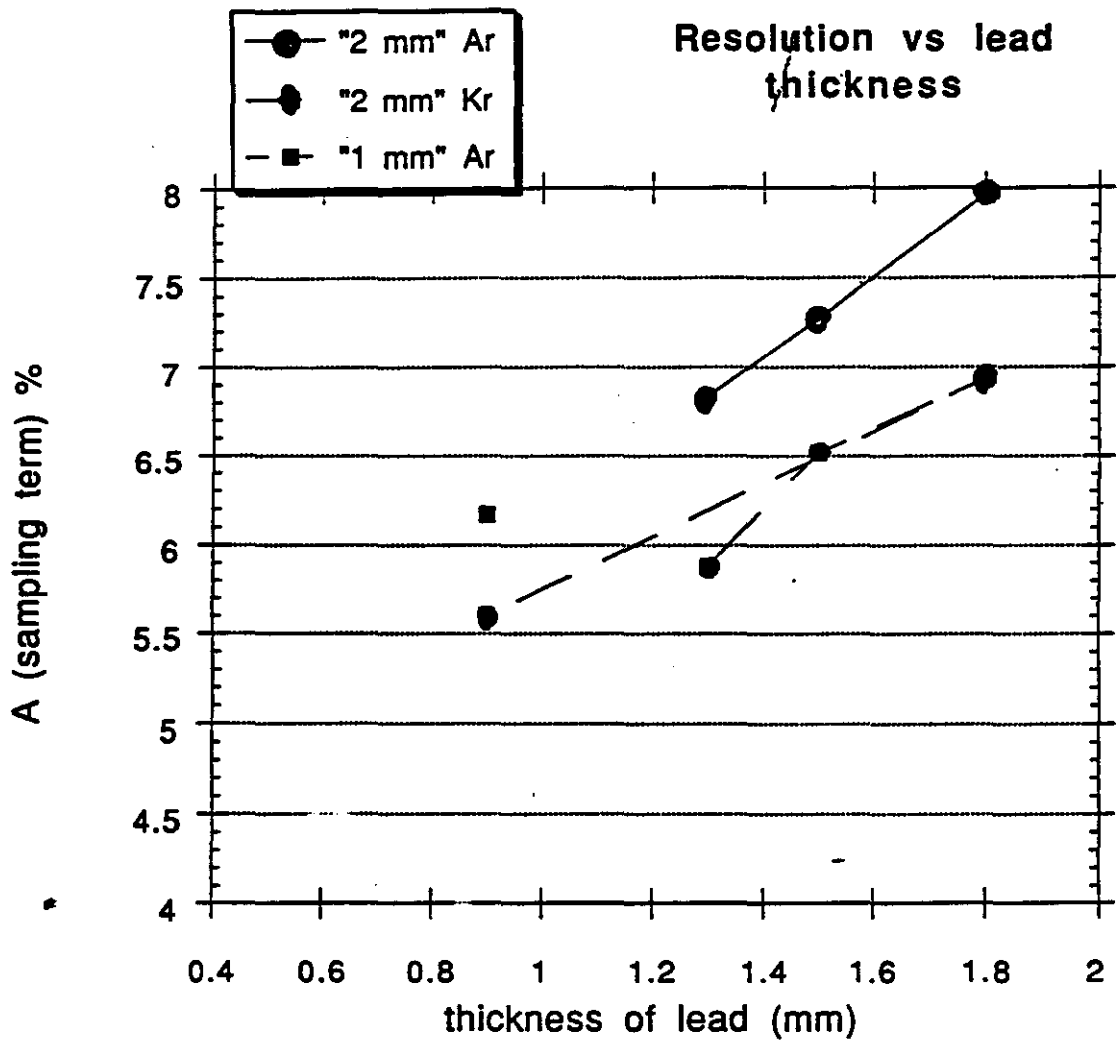

10cK Ω/□
728.900 [28.697 IN.]
6.350 [0.250 IN.]
53.920 [2.123 IN.]
13.180 [0.519 IN.]
19.330 [0.761 IN.]
38.810 [1.528 IN.]
582.150 [22.919 IN.]
RESISTIVE INK
25K OHM/□
H.V. ELECTRODE
MECHANICAL CLAMP
0.5MM GAP, TYP
6.350 [0.250 IN.]
15.110 [0.595 IN.]
13.180 [0.519 IN.]
19.330 [0.761 IN.]
38.810 [1.528 IN.]
45.600 [1.795 IN.]
304.800 [12.000 IN.]
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
364.450 [14.348 IN.]
2/20/92
RON RYAN
ACAD FILE: 10634.DWG
.125 IN. DIA BNL TOOLING
4 PLACES

1992 GEM Test Beam Cryostat
at AGS



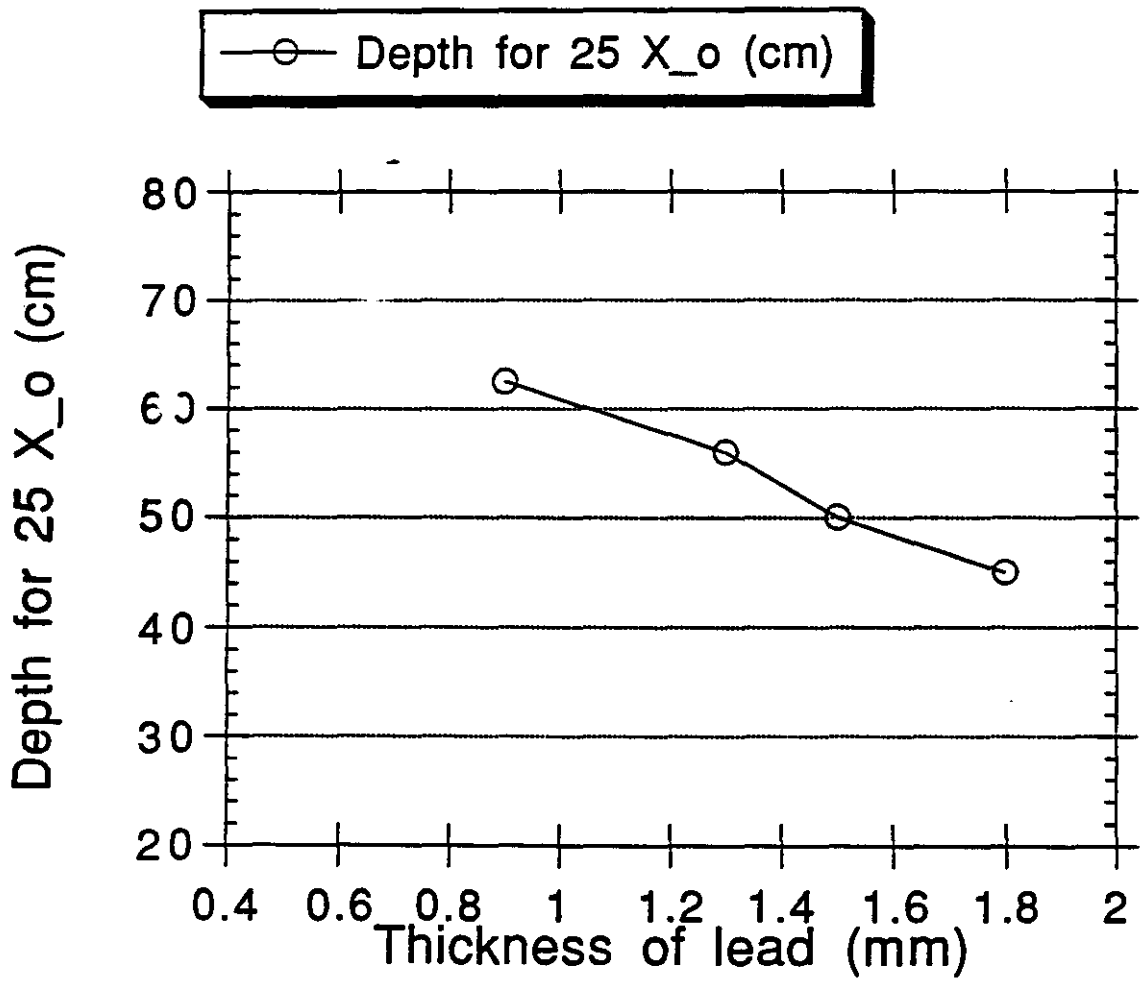
3/26/92


Argon storage
REG.
MFM
CIRC PUMP
PURIFIER
VAC PUMP
INS. COUPLING
FILL VALVE
VAC VALVE
EL VALVE
REL VALVE
REG.
REG.
MFM
REG.
LN2 SUPPLY & RETURN
FLEXIBLE CRYO LINES WITH G-10 INSULATING SPOOLS AT CRYOSTAT
INS. COUPLING
Krypton Supply
E/M C
Krypton recovery
A
Q
RB1
RB2
Krypton storage
LN2
AB



Total energy
He expected

"2 mm" Argon

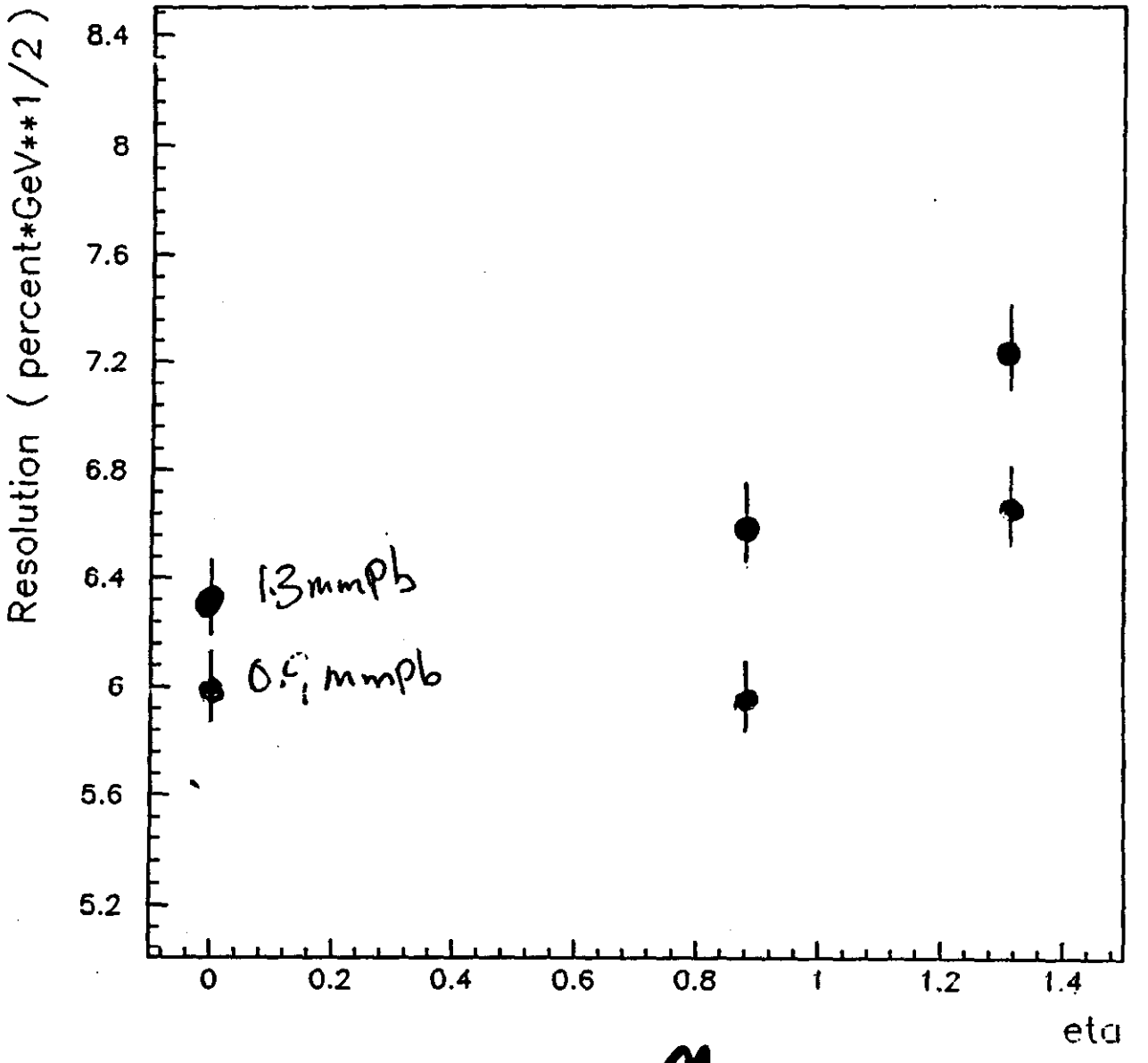


No cryostat
total energy 3xB 20% worse...

7% increase w/o mesoboes gap

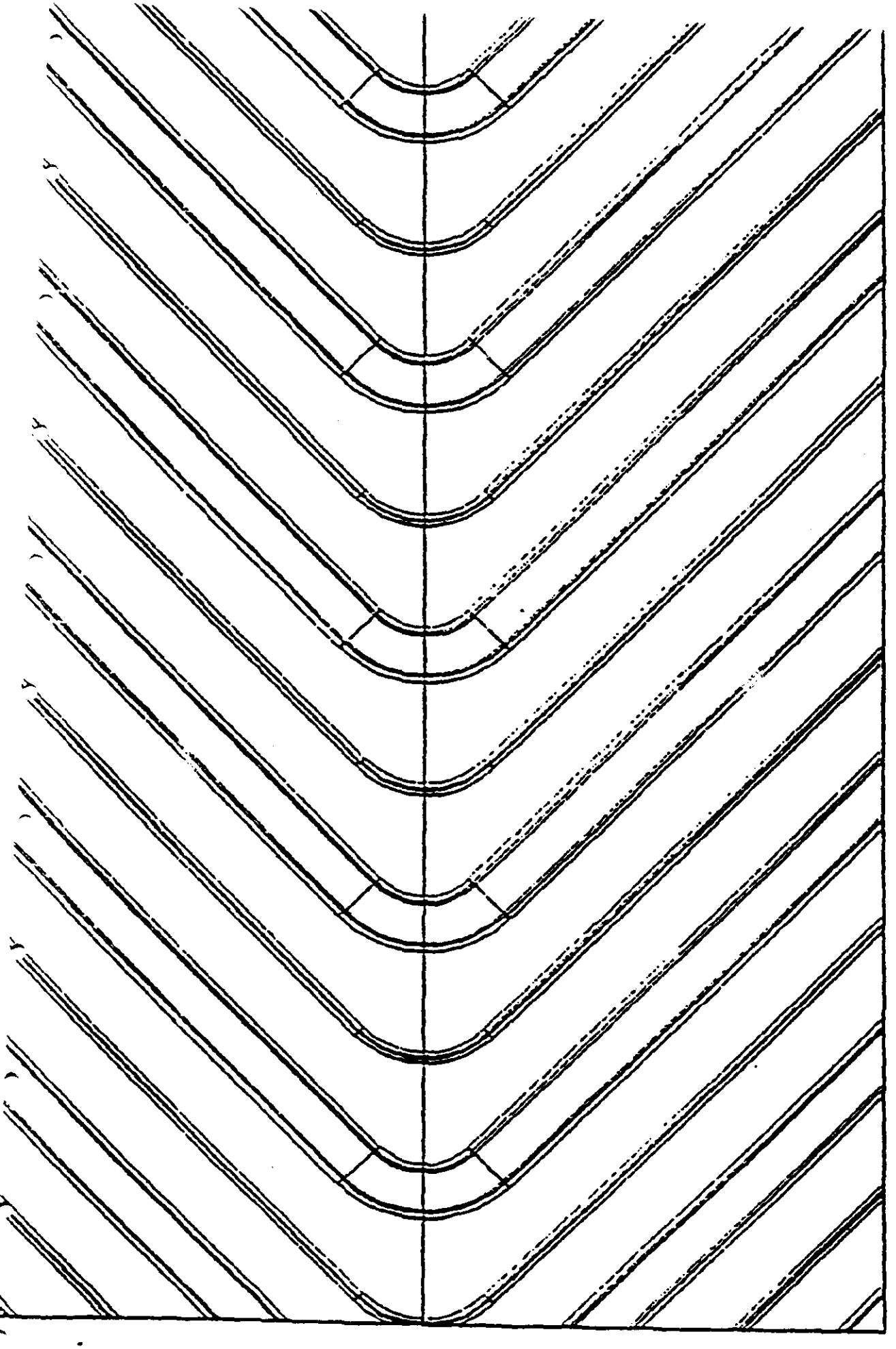
No cr, . stat, non-uniformity corrected, average

Accordion



η

5X.5

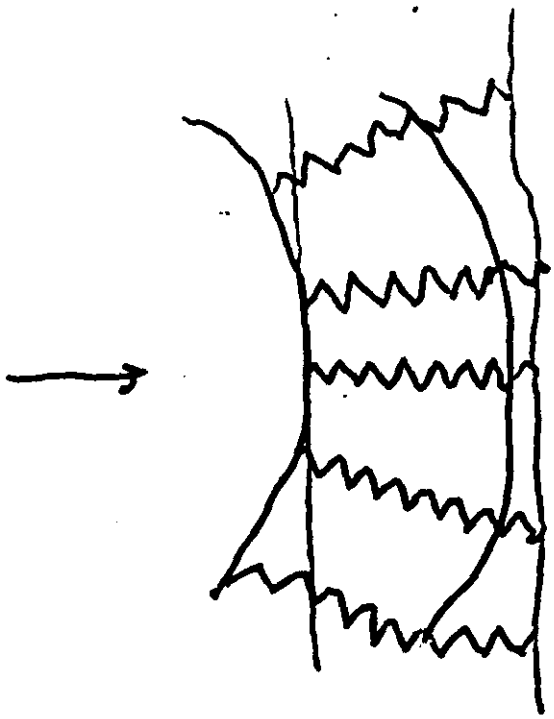


Flat End Cap Options Being Studied

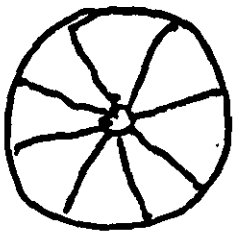
I. Monolithic – no cracks – (less) (not) projective

A. Totally non-projective

B. Section of cylinder

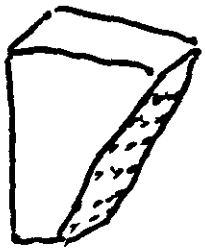


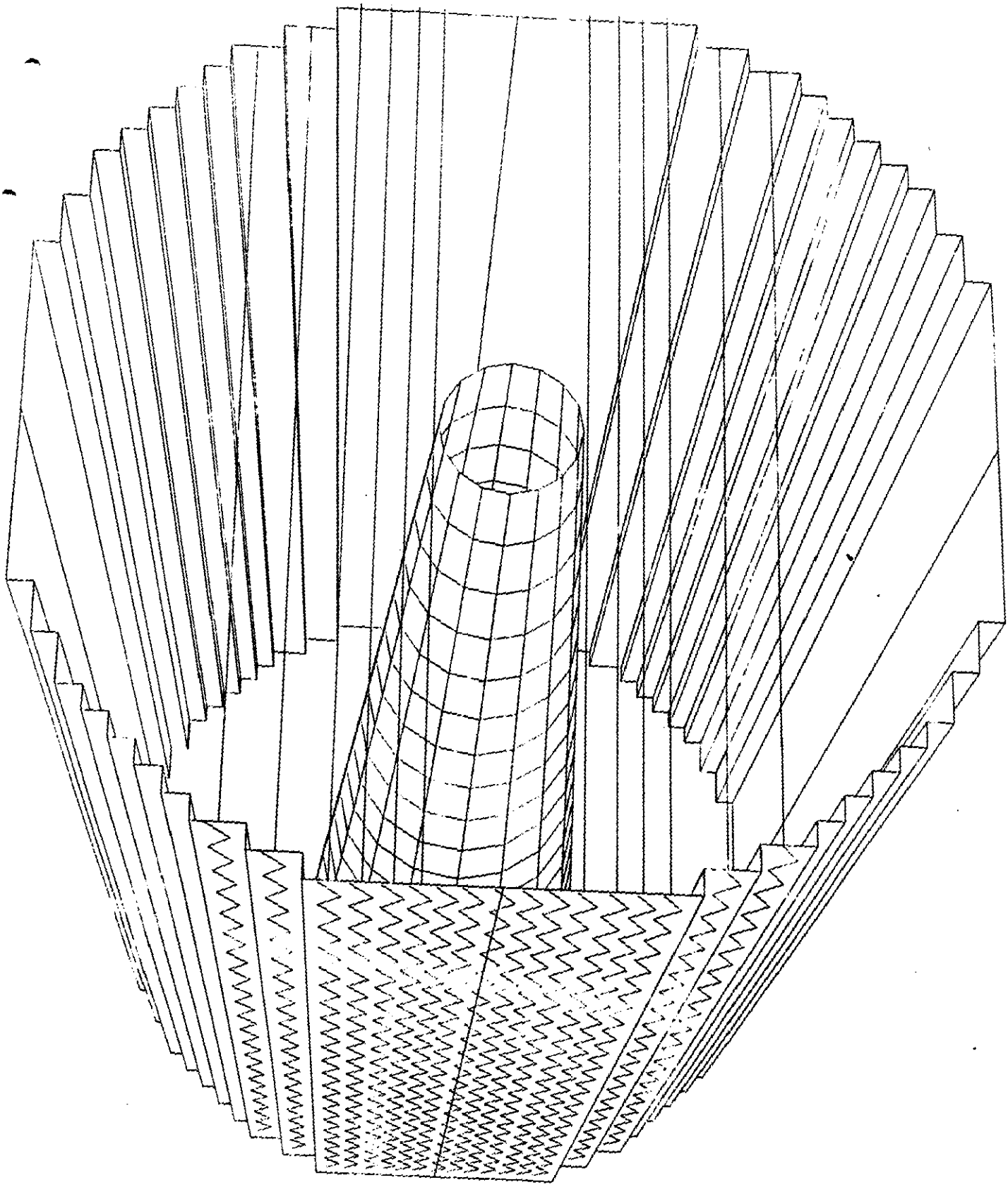
II. Sectors in $\phi \Rightarrow$ cracks?



A.

B





gem

γeμ

Presentation by:

Frank Taylor

Status of Muon System:

FET 4/29/92

(1) Baseline performance:

o momentum resolution:

meets design goal in barrel region < 5 %

needs improvement in endcaps (11.8 % versus 10%)

o chamber coverage:

100 % in endcaps with θ and Φ overlap

95 % in barrel with θ overlap (loss in Φ between sectors)

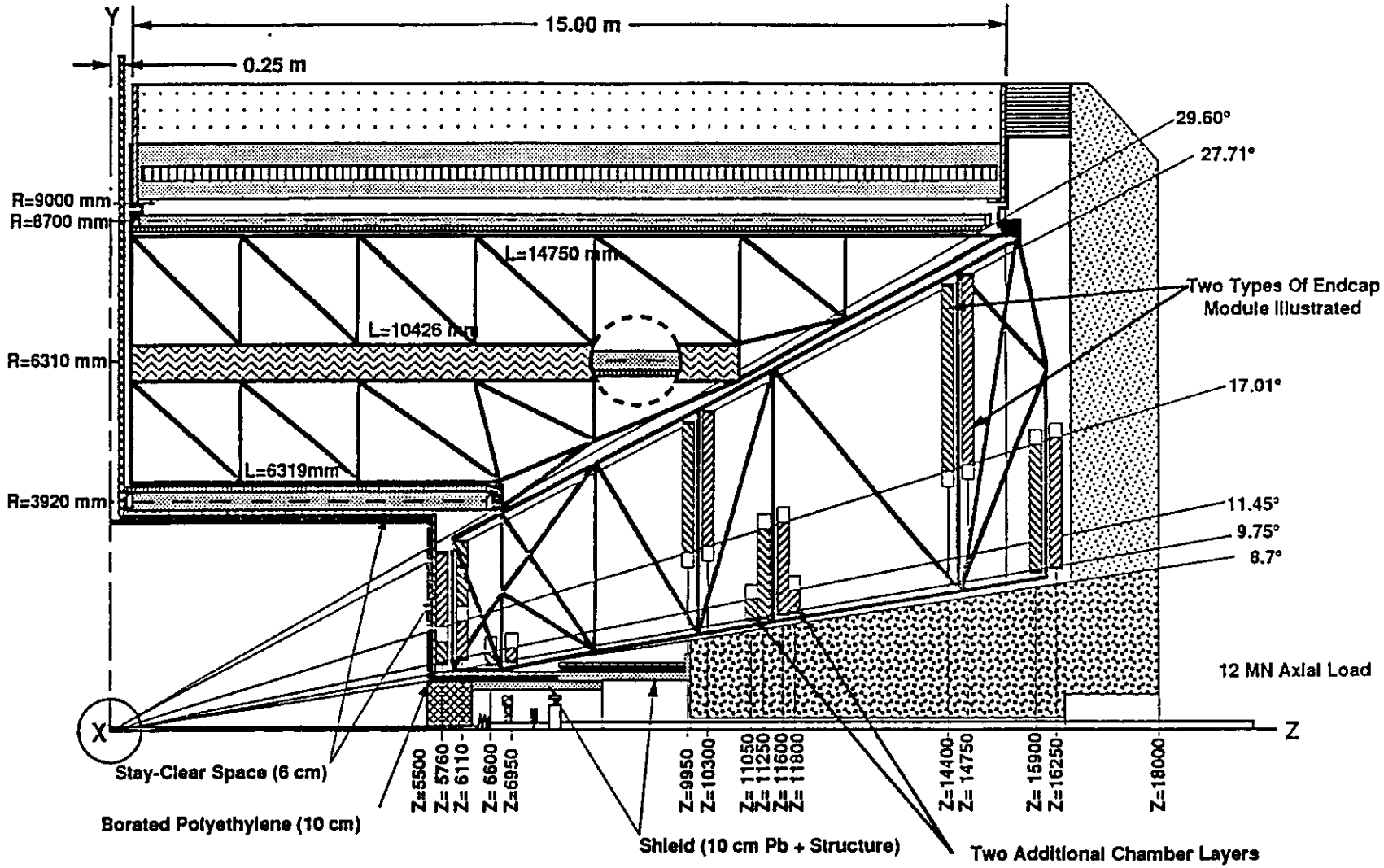
gap between barrel and endcaps

small angle coverage only down to 9.75 degrees

o backgrounds:

hadron punchthrough OK for 12 and 14 λ

neutron background being evaluated



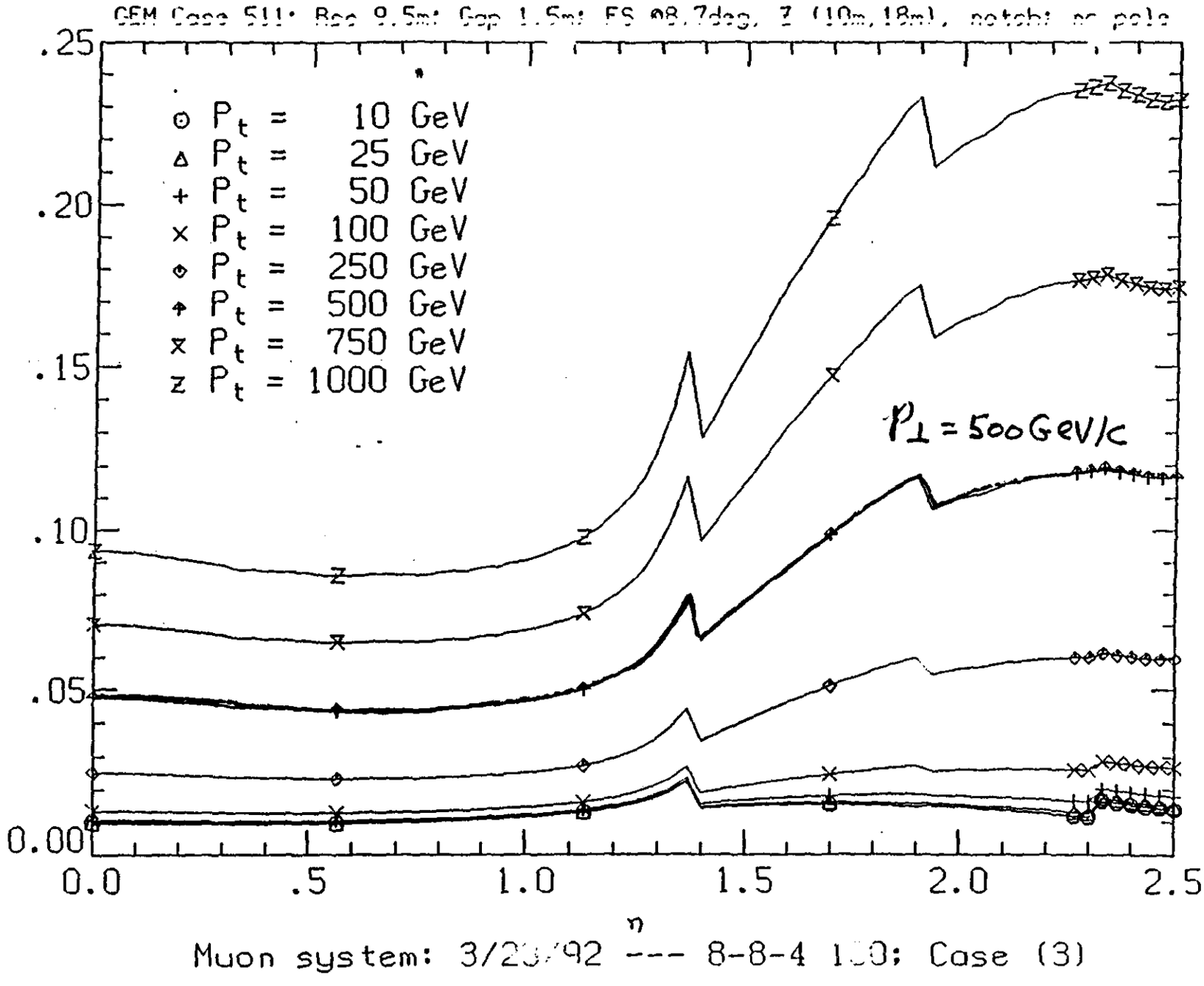
GEM MUON SYSTEM (BASELINE)

(4/8/4 layers for Theta = 9.75° to 11.45°)

Draper Laboratory	
GEM Muon System (BASELINE) 4/8/4 Layers 9.75° to 11.45°	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0009	3/27/92
Approved by:	

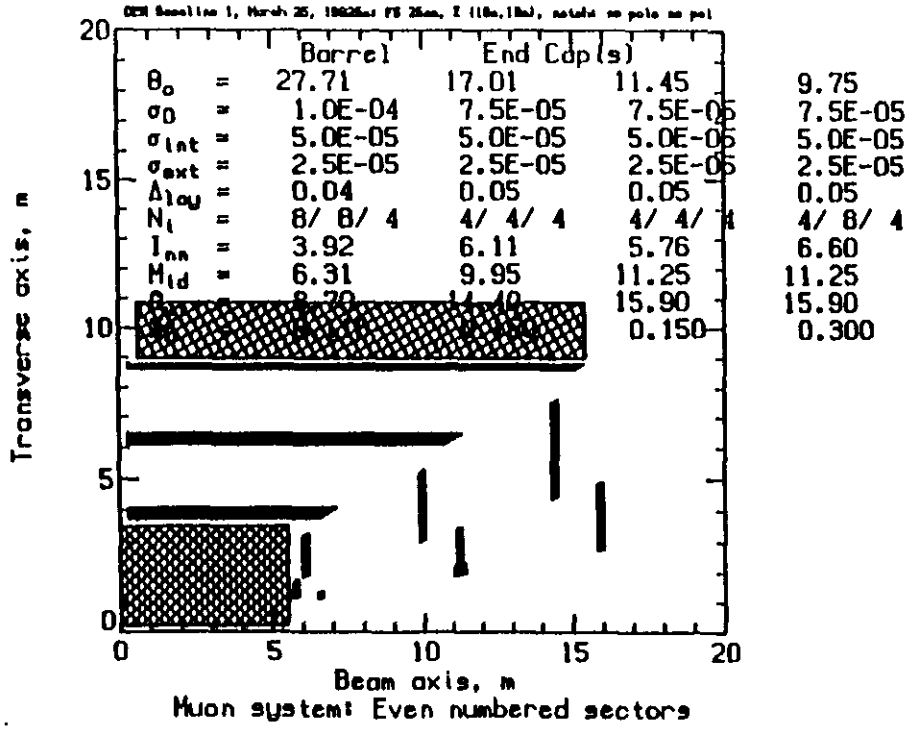
Fig. 3.1

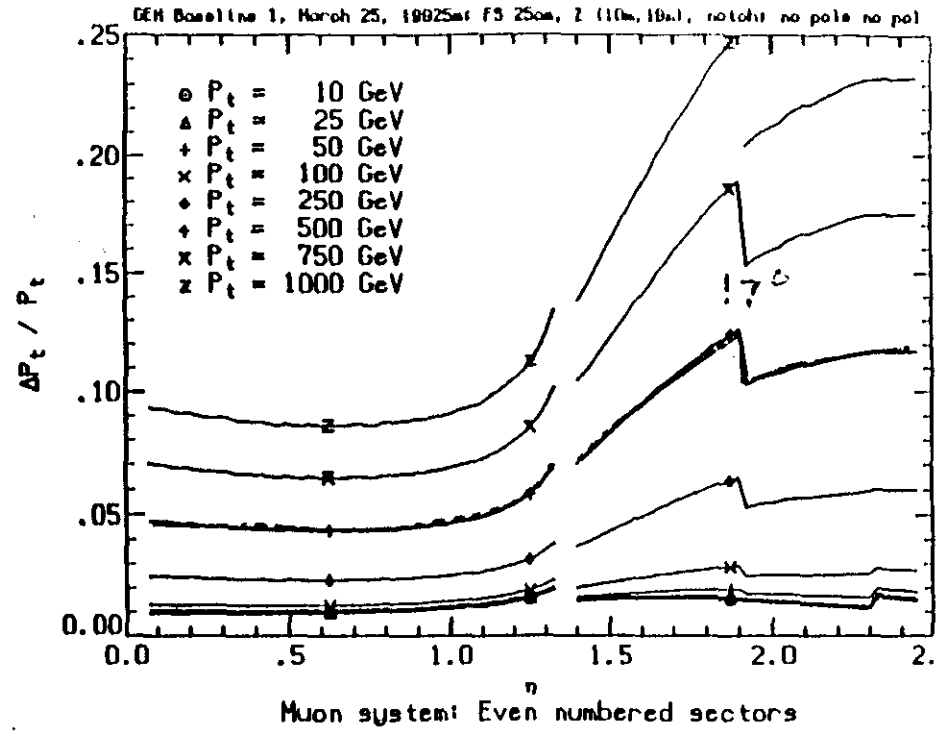
J. Sullivan

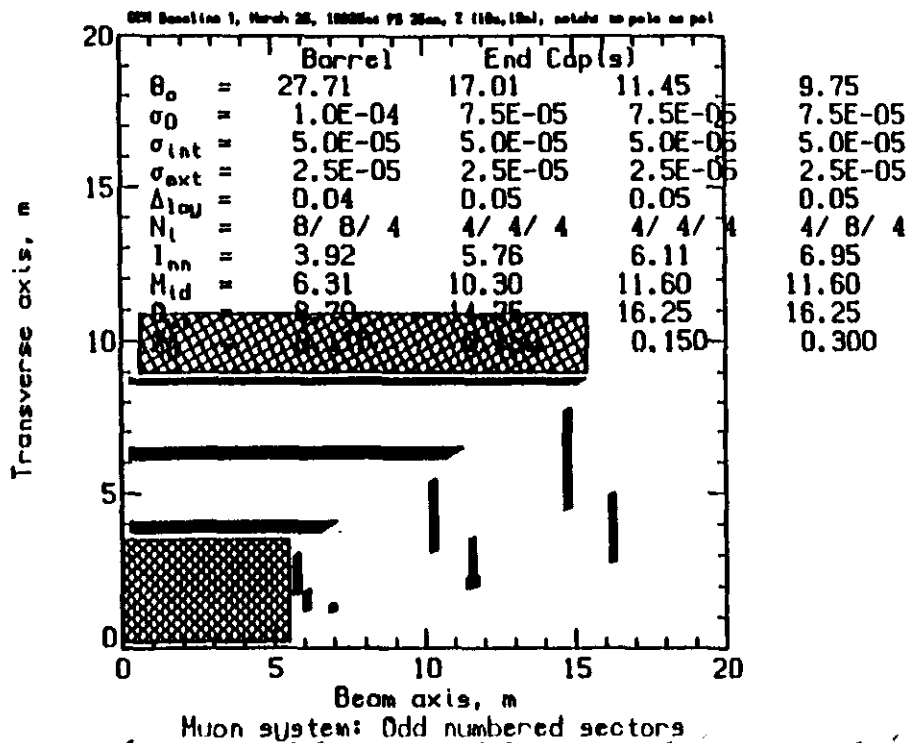


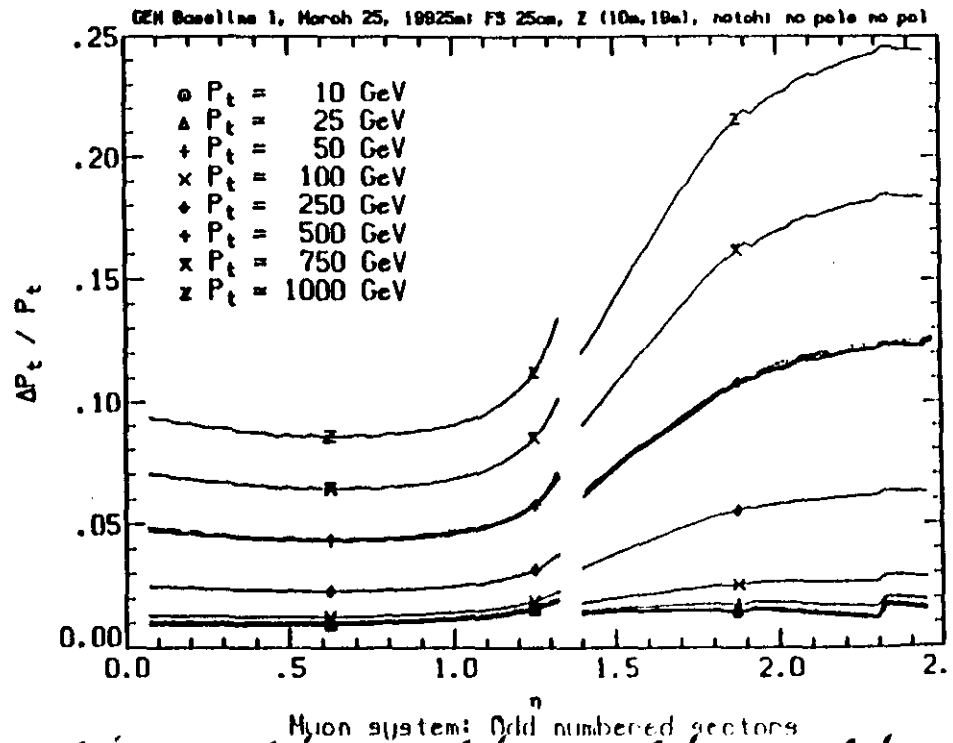
Muon system: 3/20/92 --- 8-8-4 100; Case (3)

Fig. 4.1.1

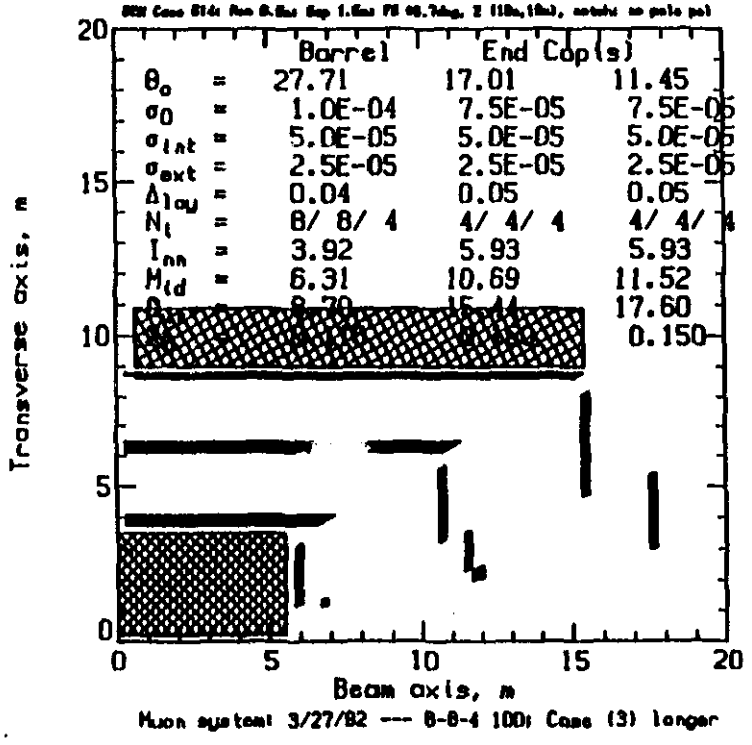

Barrel
End Cap(s)
θ_o = 27.71 17.01 11.45 9.75
σ_0 = 1.0E-04 7.5E-05 7.5E-05 7.5E-05
σ_{int} = 5.0E-05 5.0E-05 5.0E-05 5.0E-05
σ_{ext} = 2.5E-05 2.5E-05 2.5E-05 2.5E-05
Δ_{lay} = 0.04 0.05 0.05 0.05
N_l = 8/ 8/ 4 4/ 4/ 4 4/ 4/ 4 4/ 8/ 4
l_{nn} = 3.92 6.11 5.76 6.60
M_{id} = 6.31 9.95 11.25 11.25
15.90 15.90
0.150 0.300
Transverse axis, m
Beam axis, m
Muon system: Even numbered sectors

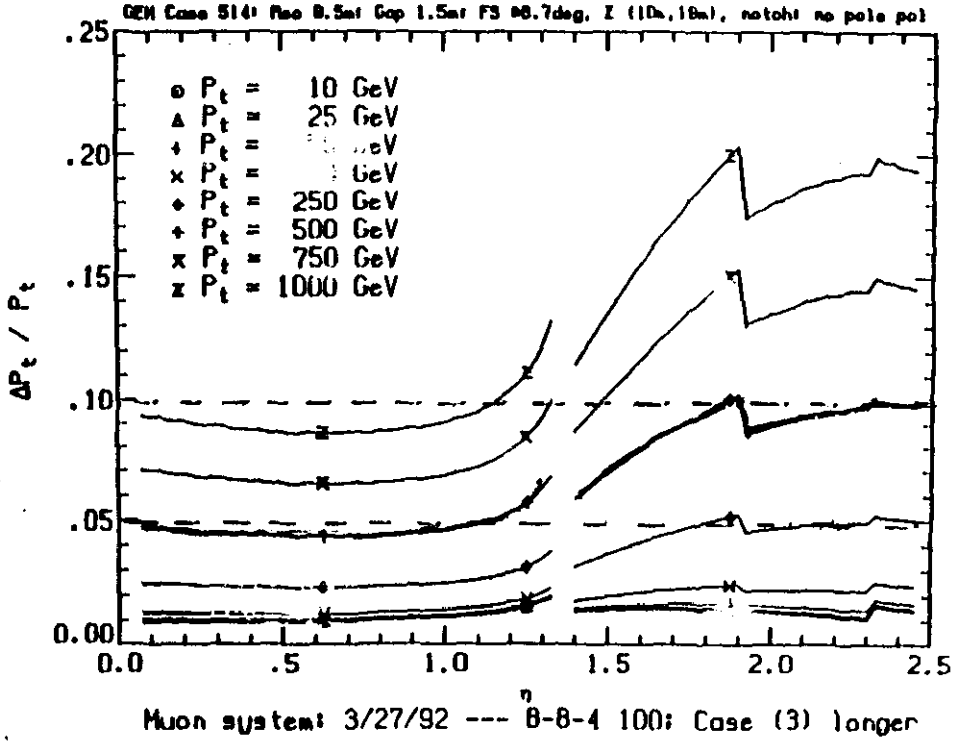

GEM Baseline 1, March 25, 19925mt FS 25cm, Z (10m,19m), notoh1 no pole no pol
P_t = 10 GeV
P_t = 25 GeV
P_t = 50 GeV
P_t = 100 GeV
P_t = 250 GeV
P_t = 500 GeV
P_t = 750 GeV
P_t = 1000 GeV
$\Delta P_t / P_t$
η
Muon system: Even numbered sectors


Barrel
End Cap(s)
θ_o = 27.71 17.01 11.45 9.75
σ_0 = 1.0E-04 7.5E-05 7.5E-05 7.5E-05
σ_{int} = 5.0E-05 5.0E-05 5.0E-05 5.0E-05
σ_{ext} = 2.5E-05 2.5E-05 2.5E-05 2.5E-05
Δ_{lay} = 0.04 0.05 0.05 0.05
N_l = 8/ 8/ 4 4/ 4/ 4 4/ 4/ 4 4/ 8/ 4
l_{nn} = 3.92 5.76 6.11 6.95
M_{id} = 6.31 10.30 11.60 11.60
16.25 16.25
0.150 0.300
Transverse axis, m
Beam axis, m
Muon system: Odd numbered sectors


GEM Baseline 1, March 25, 19925mt FS 25cm, Z (10m,19m), notoh1 no pole no pol
P_t = 10 GeV
P_t = 25 GeV
P_t = 50 GeV
P_t = 100 GeV
P_t = 250 GeV
P_t = 500 GeV
P_t = 750 GeV
P_t = 1000 GeV
$\Delta P_t / P_t$
η
Muon system: Odd numbered sectors

Longer Flux Concentrator
EC chambers further back





Energy Loss Fluctuations

R. McNeil

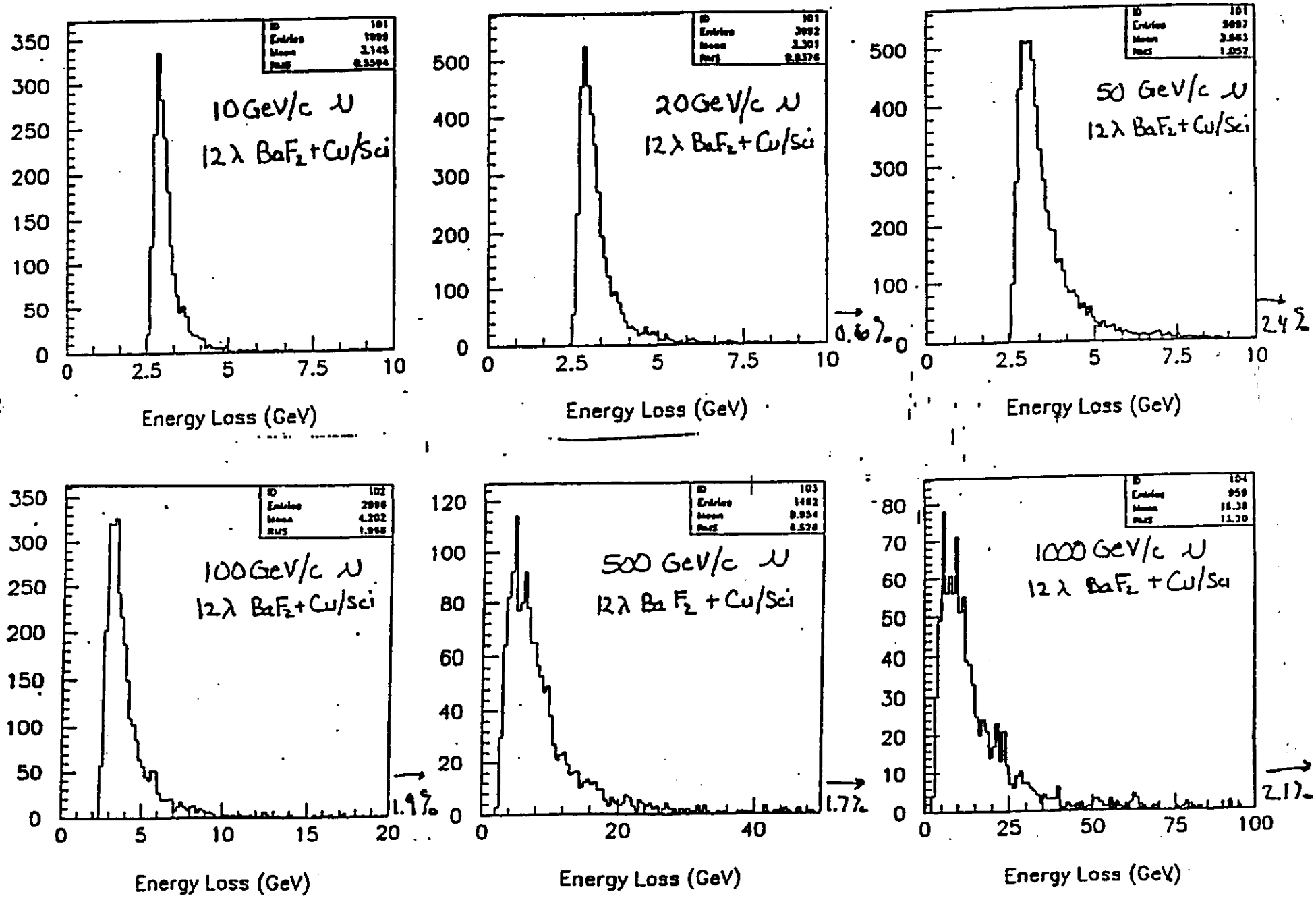
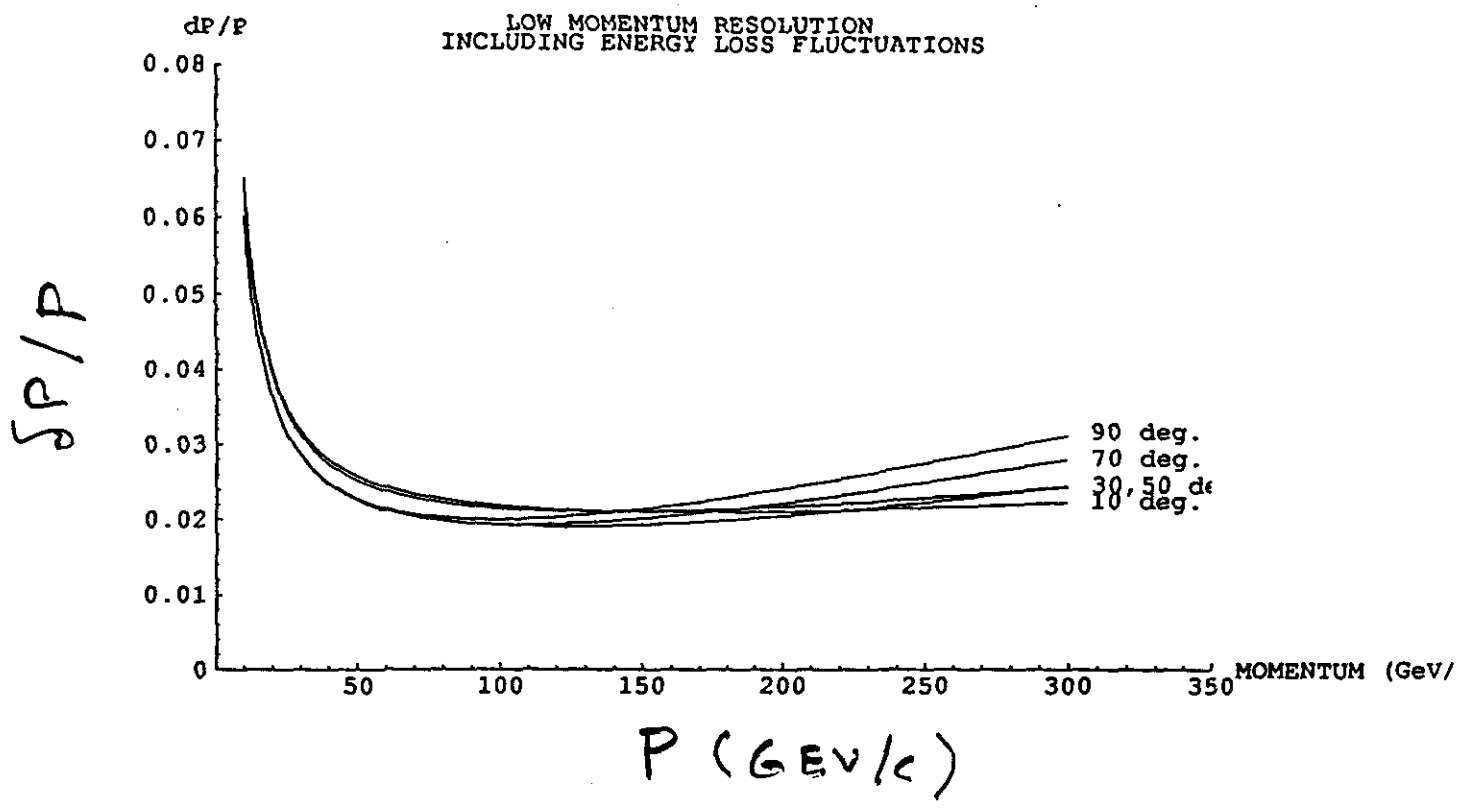


Fig. 4 2.2

L. Rossensen



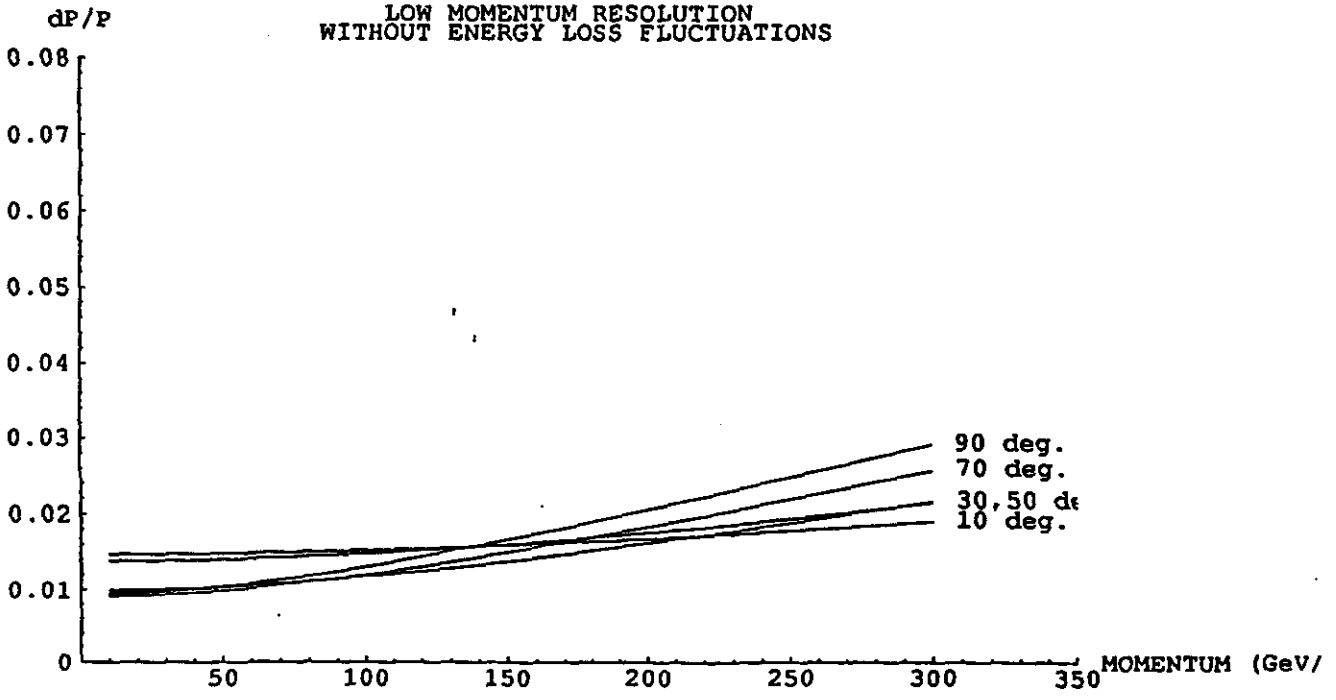
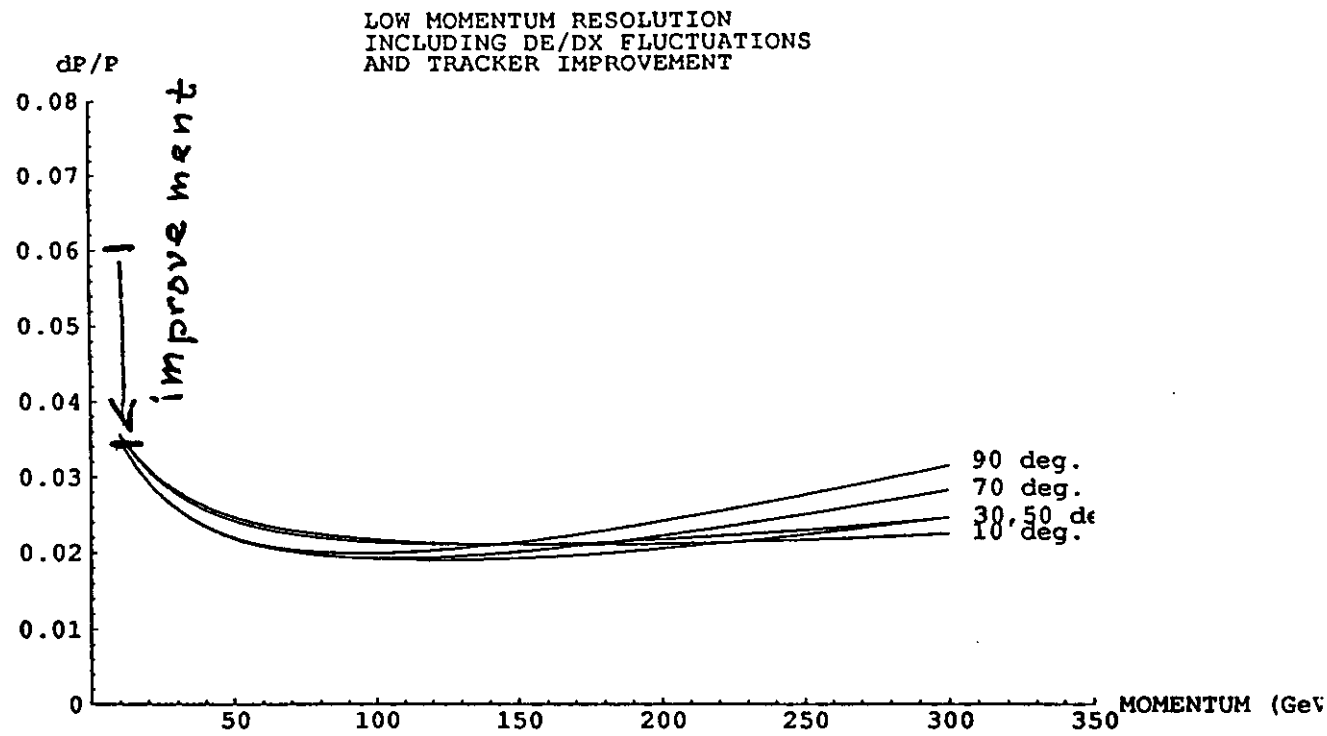


Fig. 4.3.1a



Central tracker:

$$\frac{\delta p}{p^2} = 1.5 \times 10^{-3} \, (\mathrm{GeV}/c)^{-1} \quad \text{high energy}$$

$$\frac{\delta p}{p} = 4\,\% \quad \text{at low energy.}$$

Neutron Background

L. Waters 4/28/92

o Time distribution up to 10 millisec after beam crossing

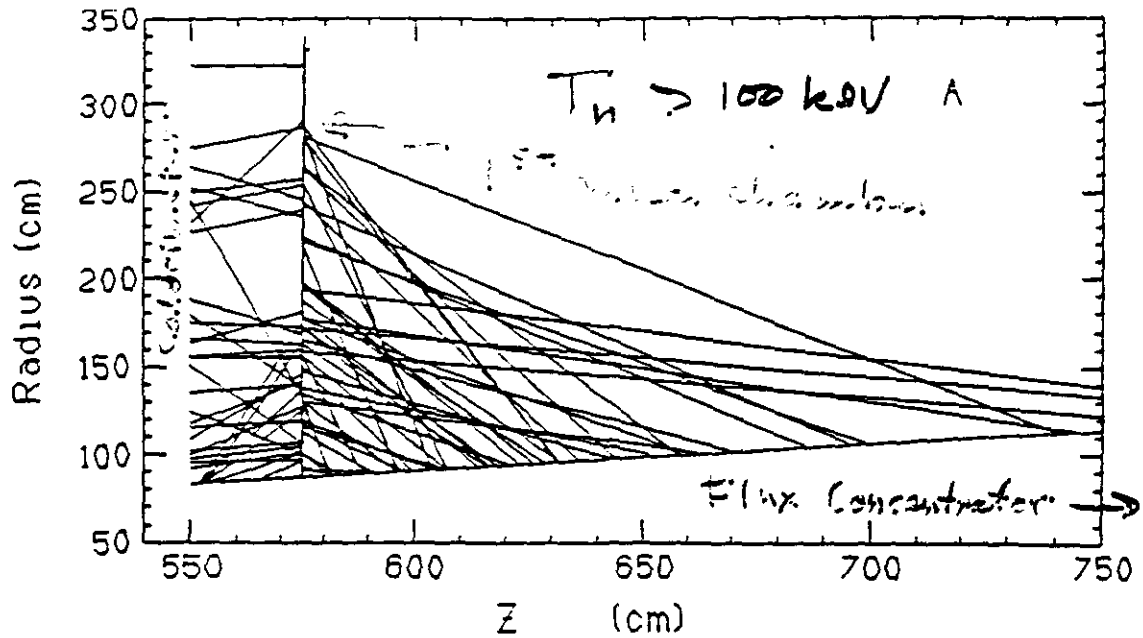
o Energy spectrum computed from 10 eV to GeV

o fluence from Cu the same as from U

o magnitude of fluence a few $10^5/cm^2$ sec

One SSC Event

L. Waters 4/28/



COPPER HADRONIC CALORIMETER

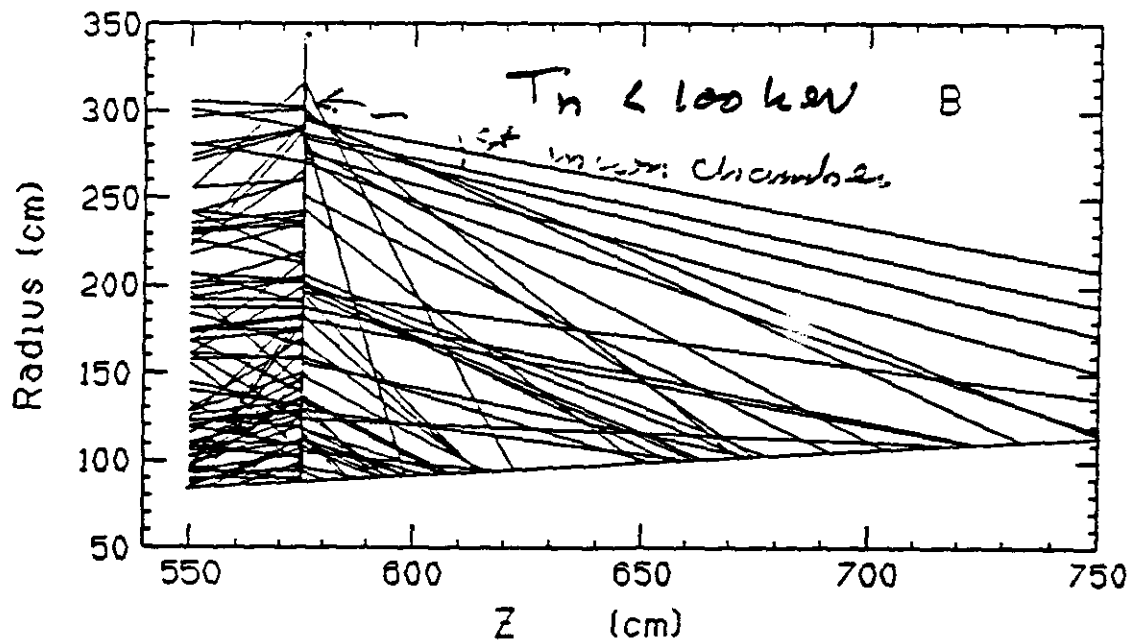


Figure 19: The 6 figures on this and the next two pages show the paths of neutrons hitting the first drift chamber (Z=5.75 m). A and B are for the copper case, C and D for copper with no FCAL, E and F for copper with no forward elements. A, C and E are for neutrons with kinetic energies greater than 100 keV (note, no particle has energy greater than 20 Mev); B, D and F for neutrons with kinetic energies less than 100 keV. Only one SSC event is illustrated. waters/4-4-92

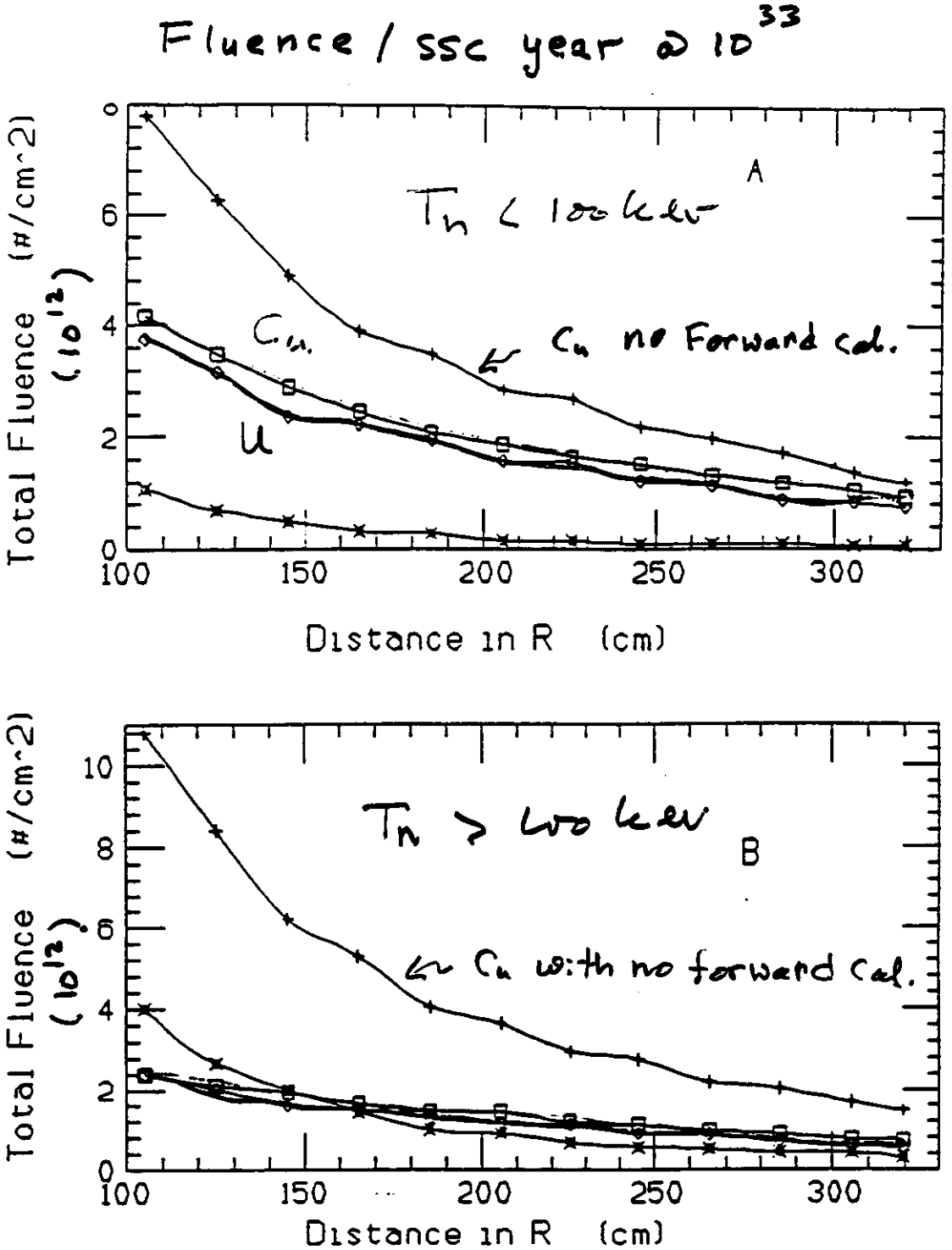
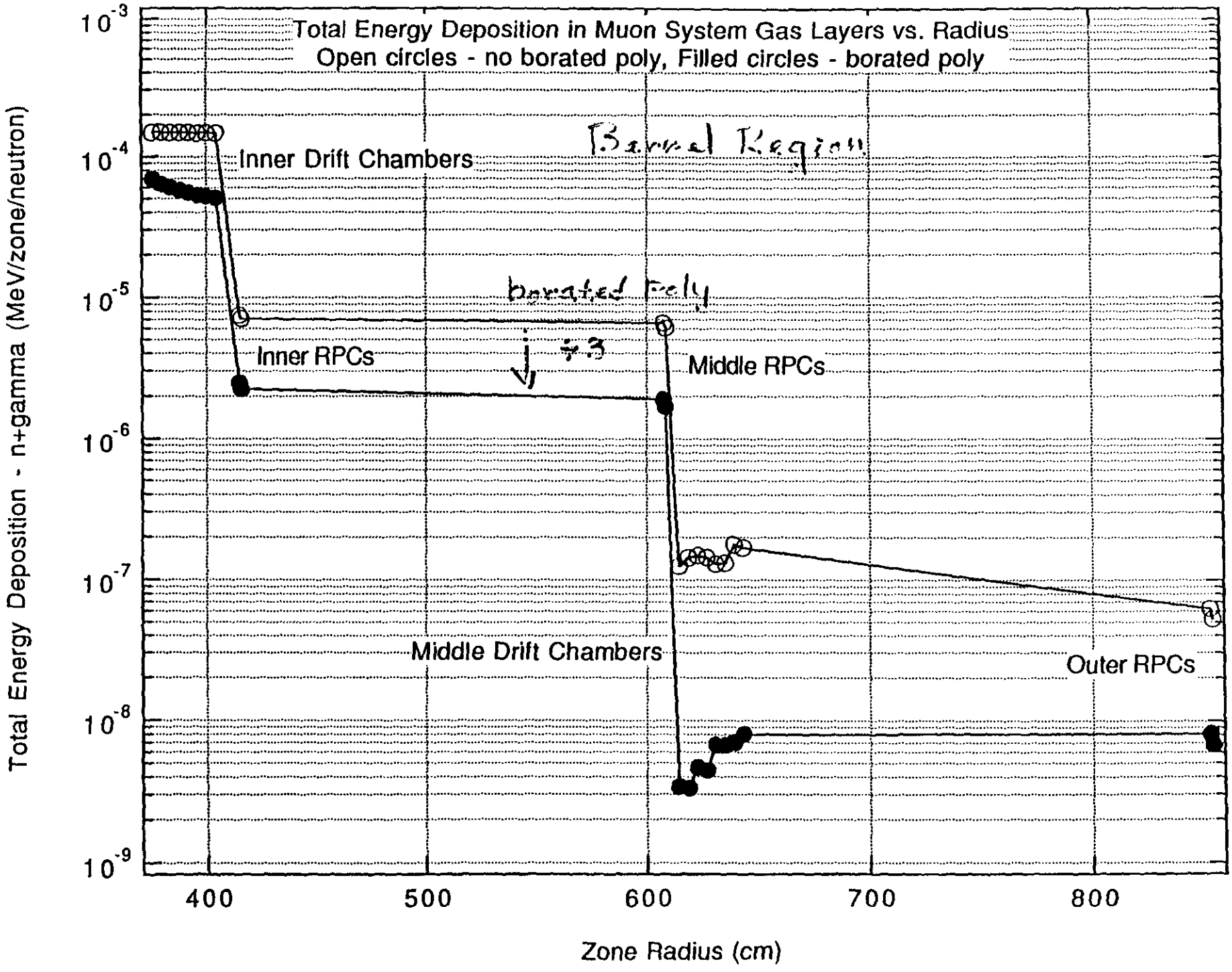


Figure 16: Total neutron fluence within 20 cm increments along the plane at Z=5.75 meters. Data is taken from table 7, and is in units of 10^{12} neutrons per cm^2 per SSC year. A) neutrons with kinetic energies less than 100 keV, B) neutrons with kinetic energies greater than 100 keV. Symbols for both figures are: Diamonds - Uranium setup, Squares - Copper setup, Plus sign - Copper with no FCAL, Cross sign - Copper with no forward elements. waters/4-4-92


Total Energy Deposition in Muon System Gas Layers vs. Radius
Open circles - no borated poly, Filled circles - borated poly
Barrel Region
Inner Drift Chambers
borated poly
Inner RPCs
÷3
Middle RPCs
Middle Drift Chambers
Outer RPCs
Total Energy Deposition - n+gamma (MeV/zone/neutron)
Zone Radius (cm)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
400
500
600
700
800

(2) Outstanding Issues:

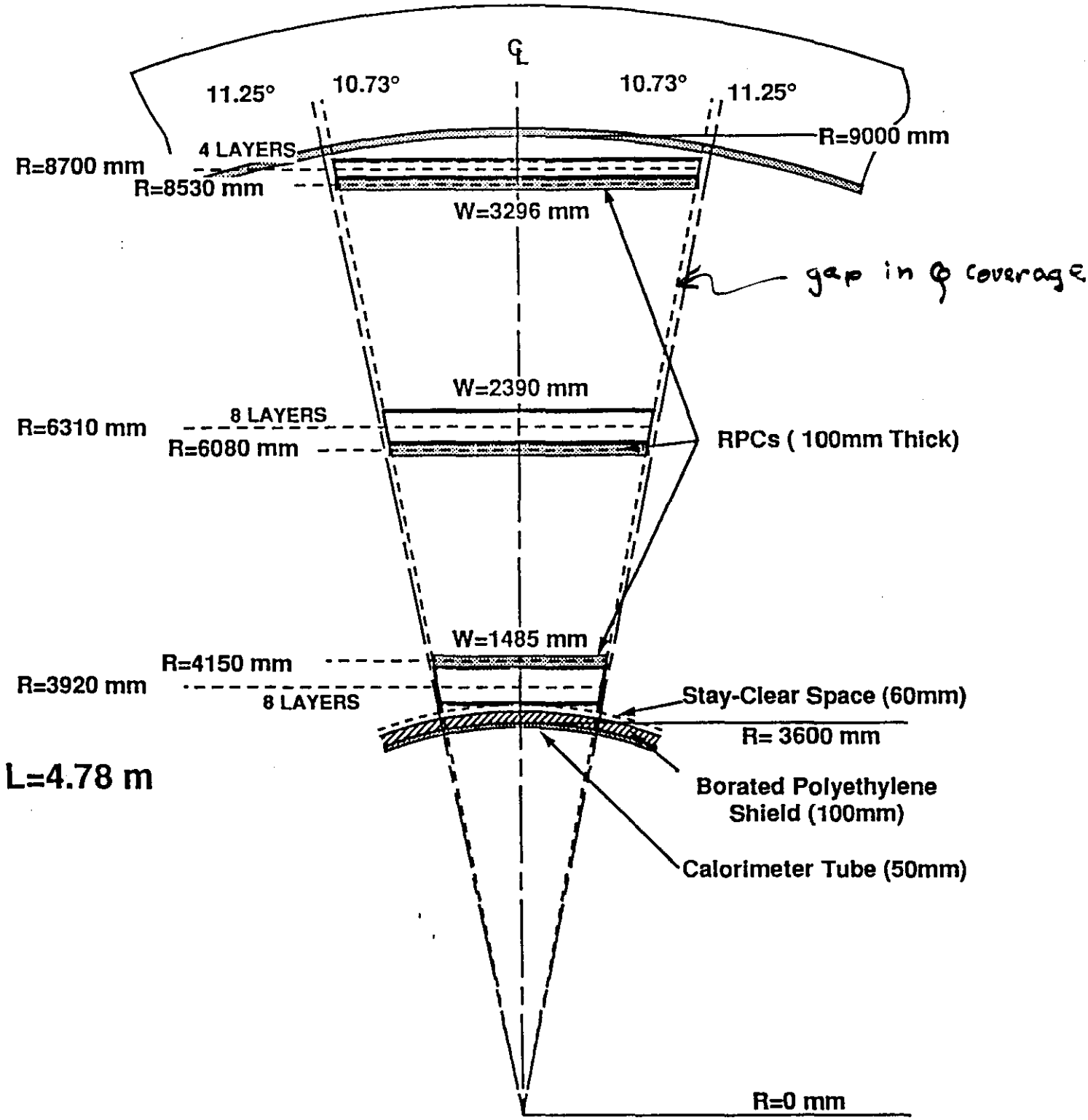
o alignment system:
  + aware of problem
  - how to achieve $\sigma \sim 25\ \mu m$?
  - how to integrate chamber technologies ?
  - integration with a GEM system ?

o calorimeter:
  - can 12 and 14 λ really be achieved ? yes (even LA)
  - neutron background Cu versus ~~Pb~~ U ? [Cu same as U) but m.s. 1.7x larger for U
  - reconstruction of $\Delta E\mu$ in calorimeter ?

o flux concentrator:
  + longer will help $\delta P\mu/P\mu$ at $\eta = 2.5$
  - move EC chambers further out ?

o Φ coverage in barrel (improve 95%)

o coverage between barrel and endcaps (2° not covered)



GEM BARREL REGION (PDT)

(Chamber Endview)

BASELINE

Draper Laboratory		
GEM Muon System (endview)		
Drawn By:	F. Nimblett	Rev (-)
Dwg. No:	GMU0002	3/25/92
Approved by:		

Fig. 3.2 b

BARREL REGION - PDT CHAMBER - 8/8/4 CONFIGURATION

"FLIP-FLOP" ARRANGEMENT - MAXIMIZE THETA ACCEPTANCE

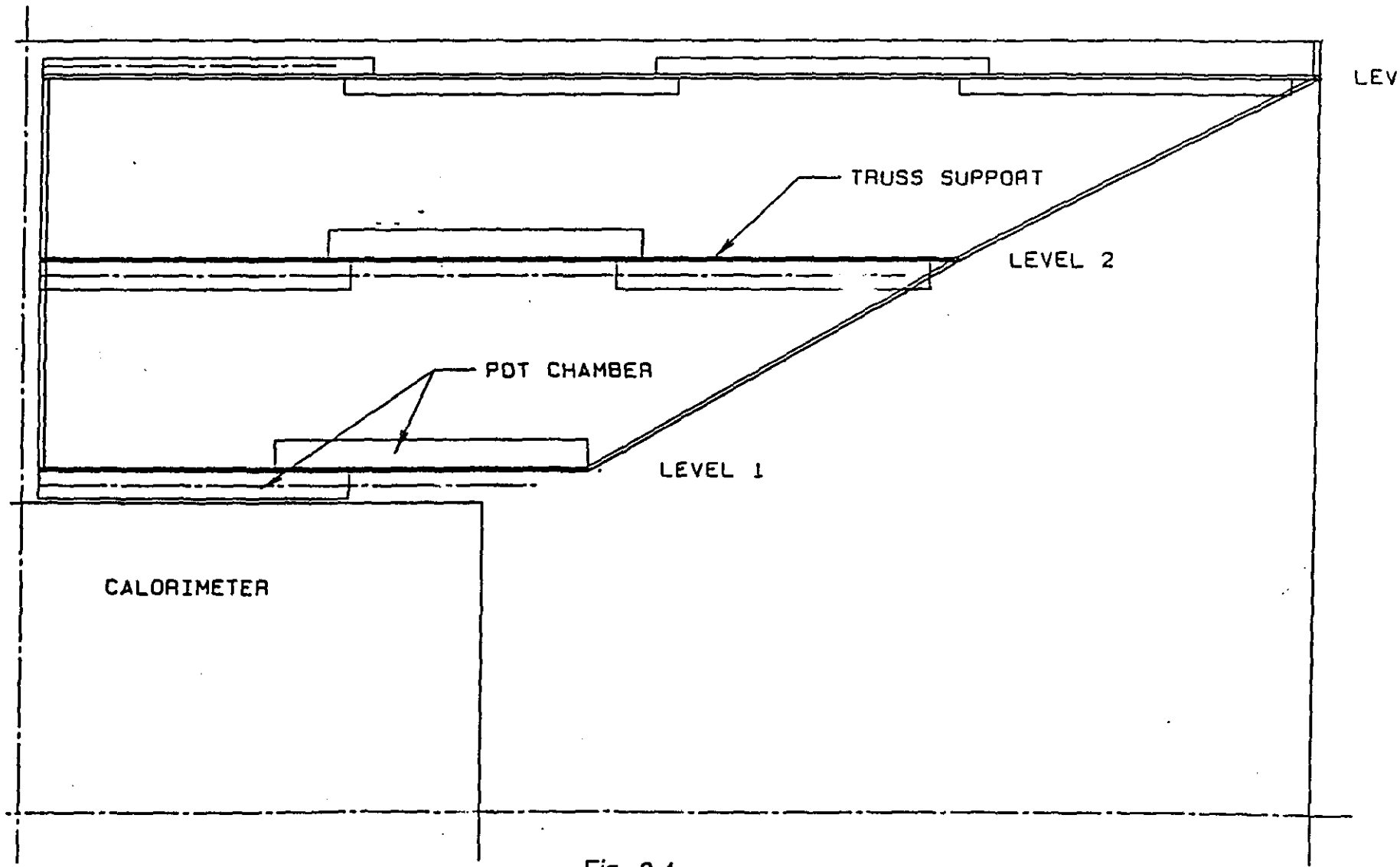
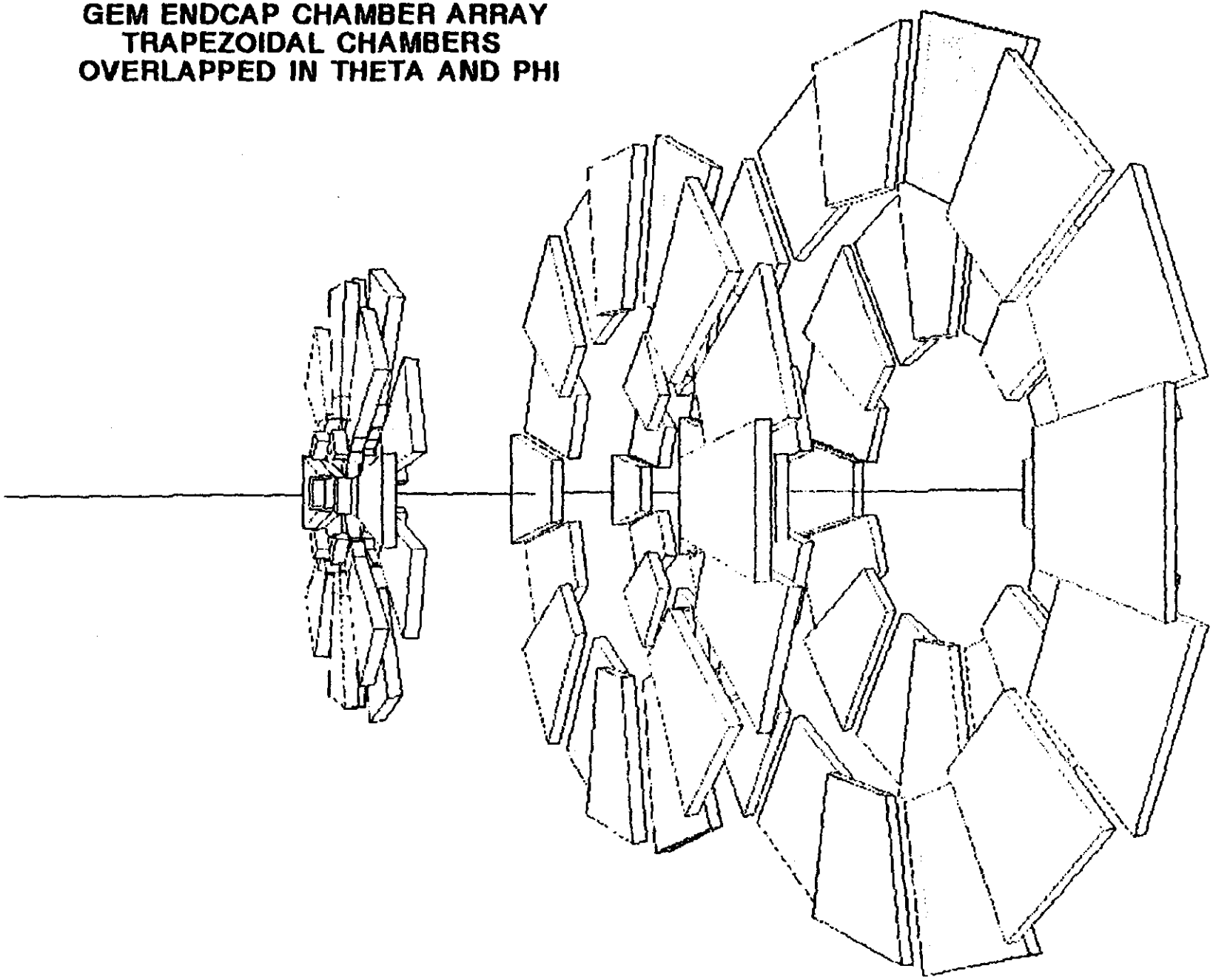


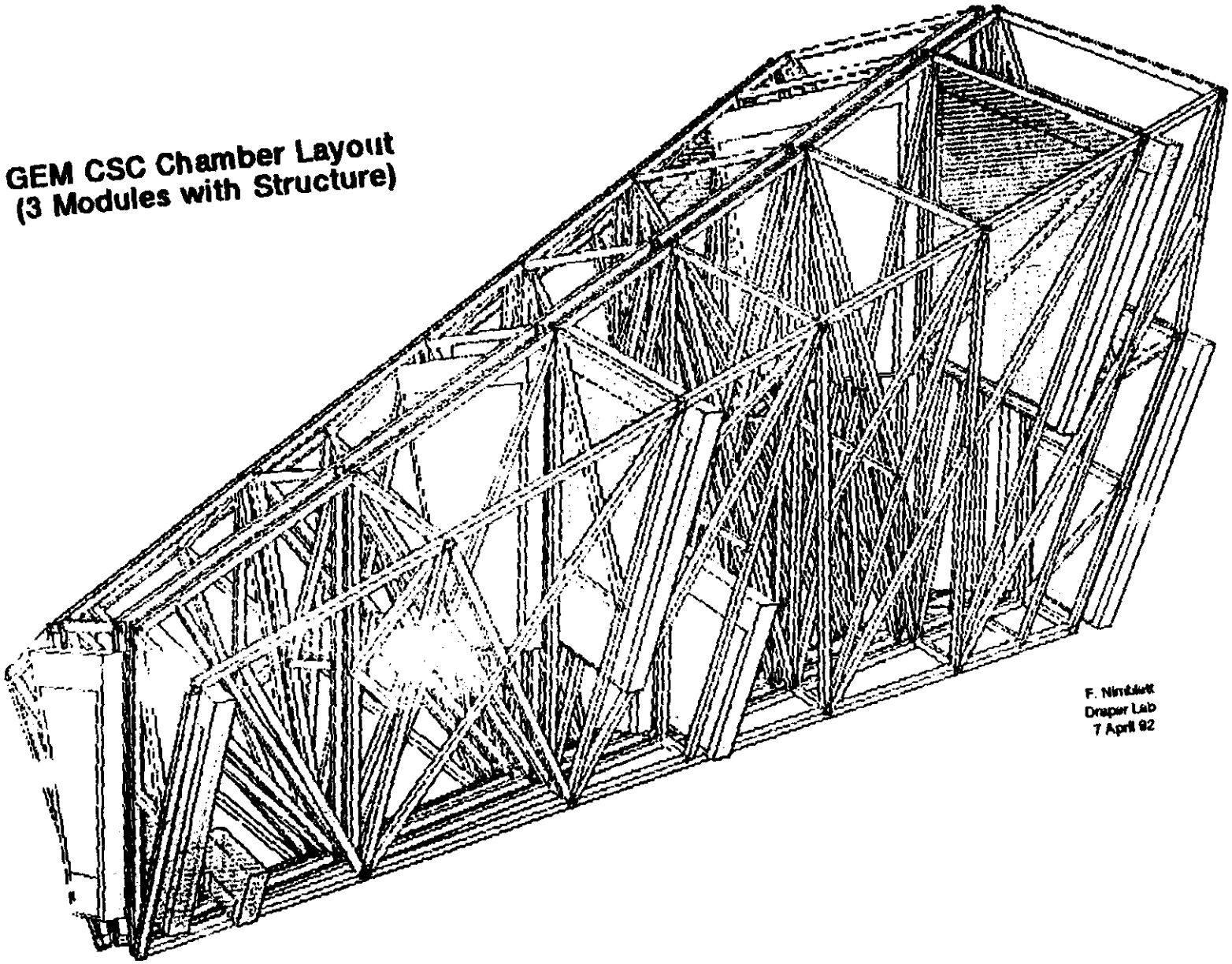
Fig. 3.4

GEM ENDCAP CHAMBER ARRAY
TRAPEZOIDAL CHAMBERS
OVERLAPPED IN THETA AND PHI



F. Nimblett
Draper lab
7 April 92

GEM CSC Chamber Layout
(3 Modules with Structure)



F. Nimblett
Draper Lab
7 April 92

Contingencies:

- o CSC everywhere
  - channel count/costs ?
  - Russia to fabricate electronics ?
- o LSDT everywhere
  - can radial wires be fabricated for EC ?
  - how to trigger ?
- o PWC trigger in both endcaps and barrel
- o White Paper on trigger alternatives
- o What are the engineering/cost implications ?

TDR

Chamber Technologies:

TTR:

- performance evaluation in TTR summer '92
  - layer resolution with cosmics
  - absolute alignment needed (25 μm)

RD5:

- test CSC at CERN fall '92
- hadron punchthrough

Decisions:

o criteria:
- layer resolution 100 μm/b - 75 μm/ec
- alignment $\sigma \sim 25$ μm
- pattern recognition
  - pileup
  - sensitivity to backgrounds
- costs
  - number of layers affordable
- who makes it ?

Choices:

- CSC for endcaps
- RPC trigger barrel
- PDT tracking barrel
- LSDT tracking barrel

What is needed for TDR:

- o more engineering support for alignment and system integration

- o hit level Monte Carlo
  - study pattern recognition problems
  - determine robustness of $P\mu$ resolution
  - detailed simulation of trigger
  - performance evaluation/physics processes

- o neutron background calculations
  - started at LANL

- o measurement of chamber sensitivity to neutrons
  - started at MIT

- o cost review 5/5/92

- o plans and schedules for
  - chamber fabrication
  - electronics fabrication
  - support structure
  - alignment

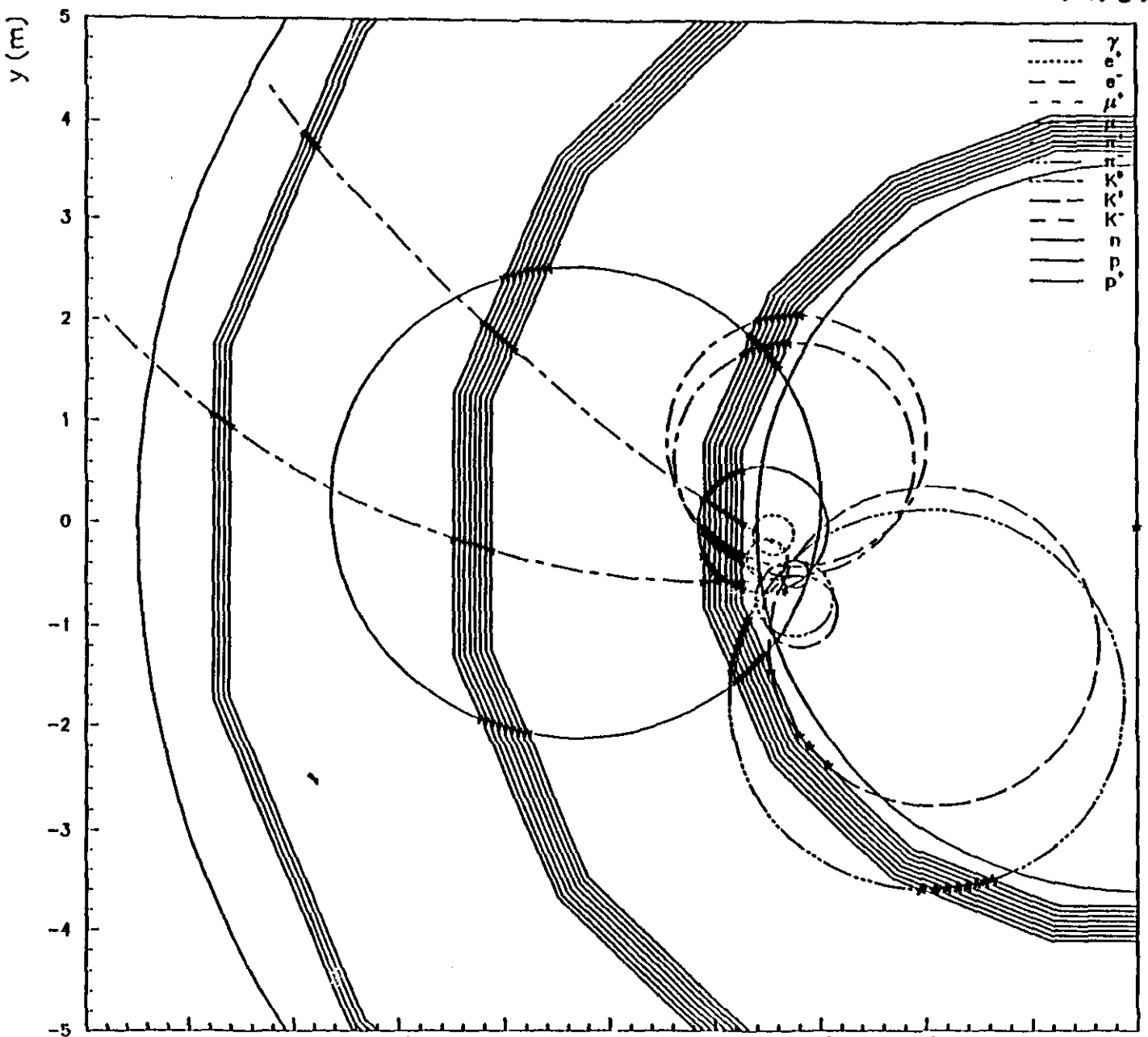
Hit Level M.C.

GEM Data Plot

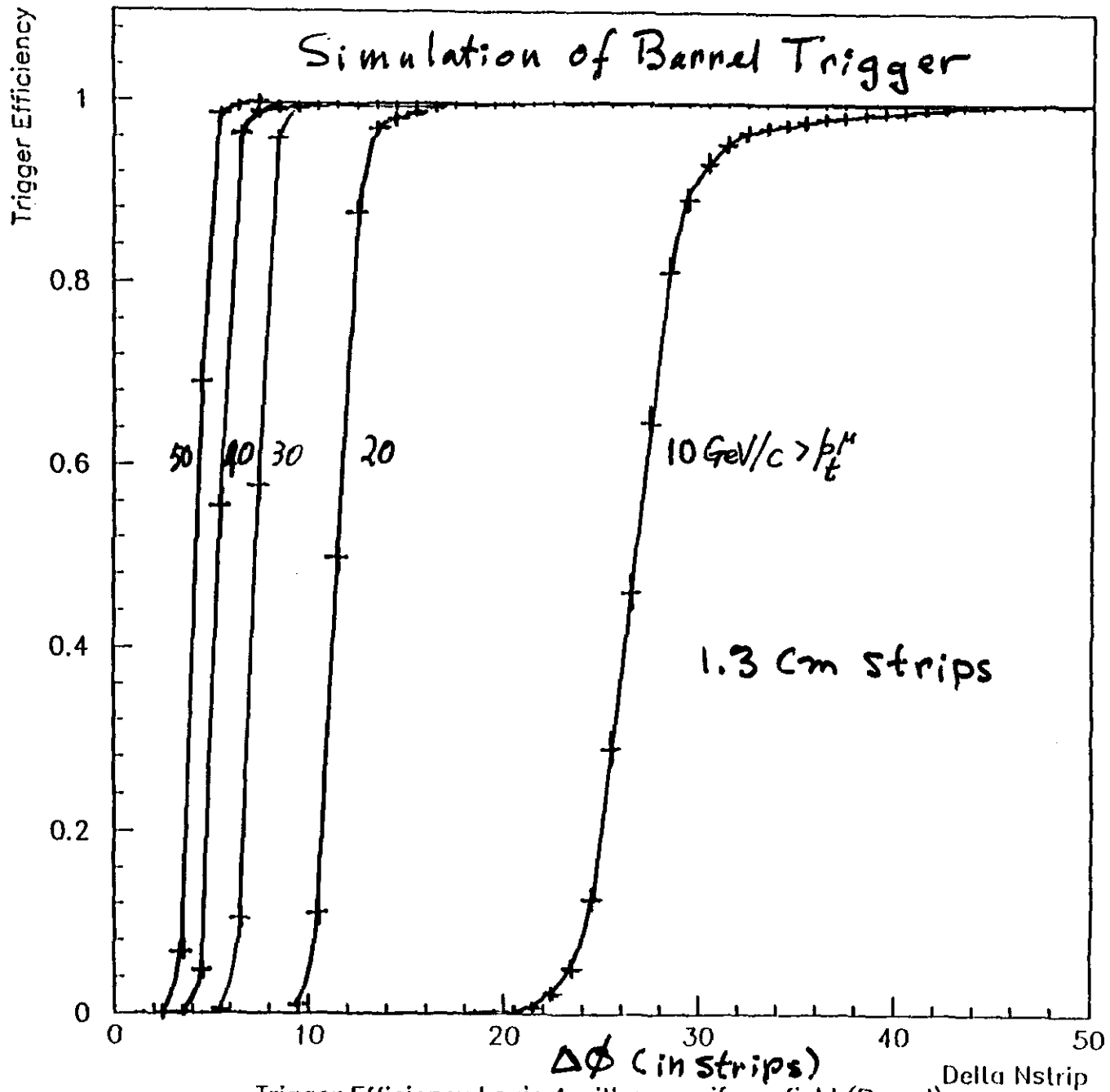
Chiaki Yanagisawa

μ^-

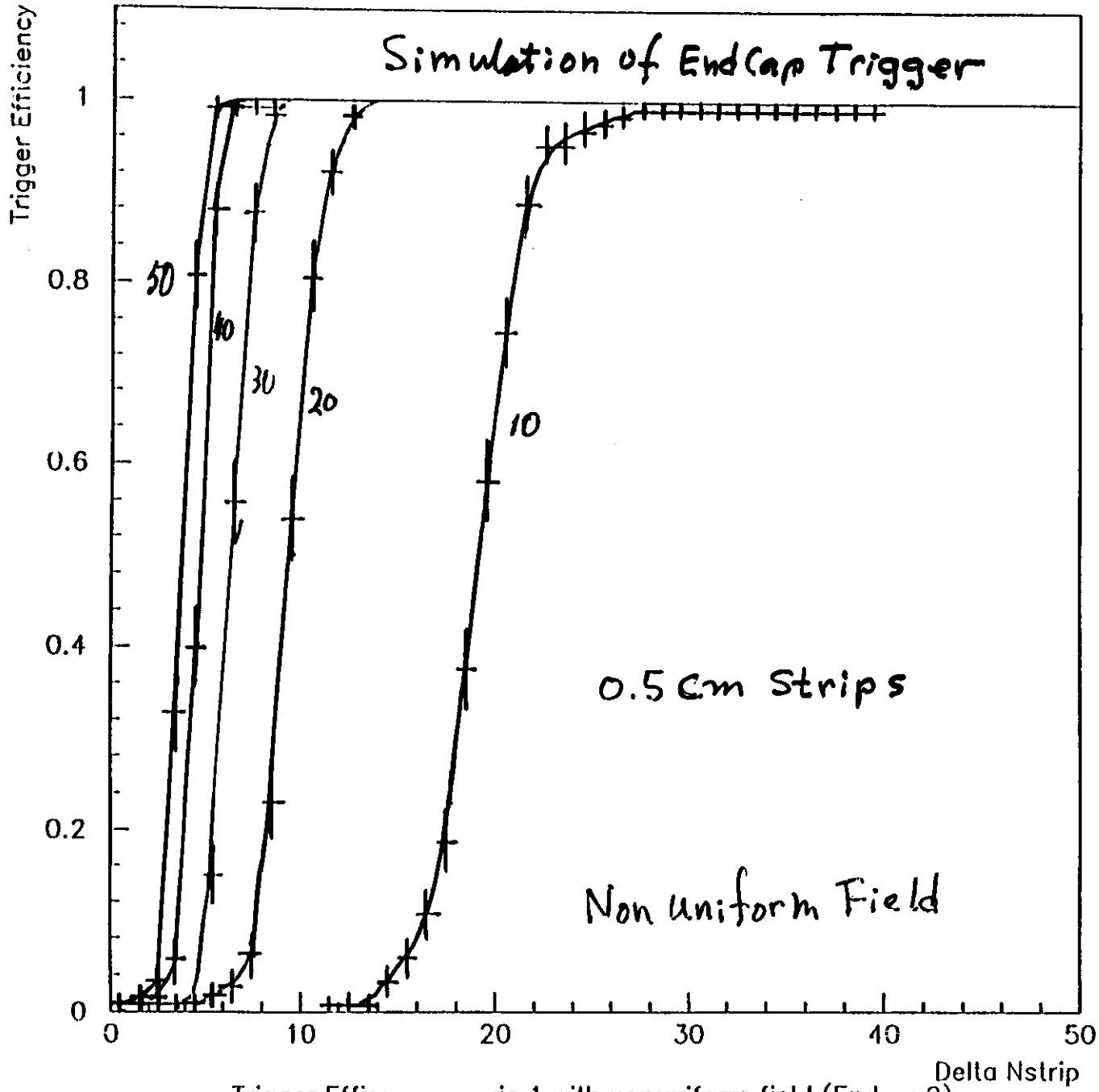
$t\bar{t} \to W b W b$



Event-No.: 133



Trigger Efficiency Logic 1 with nonuniform field (Barrel)



Trigger Effic gic 1 with nonuniform field (End p2)

gem

γeμ

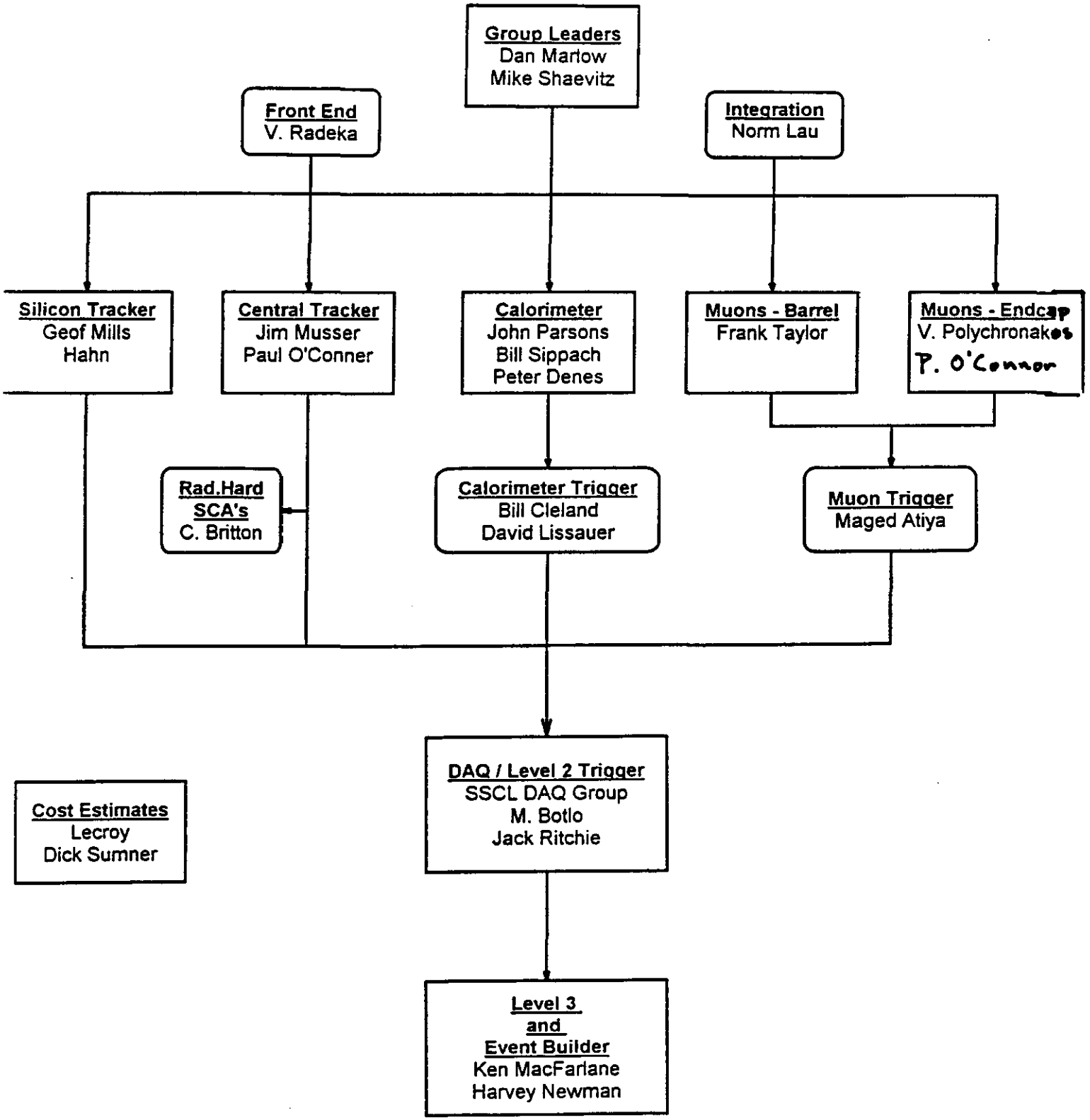
Presentation by:

Mike Shaevitz

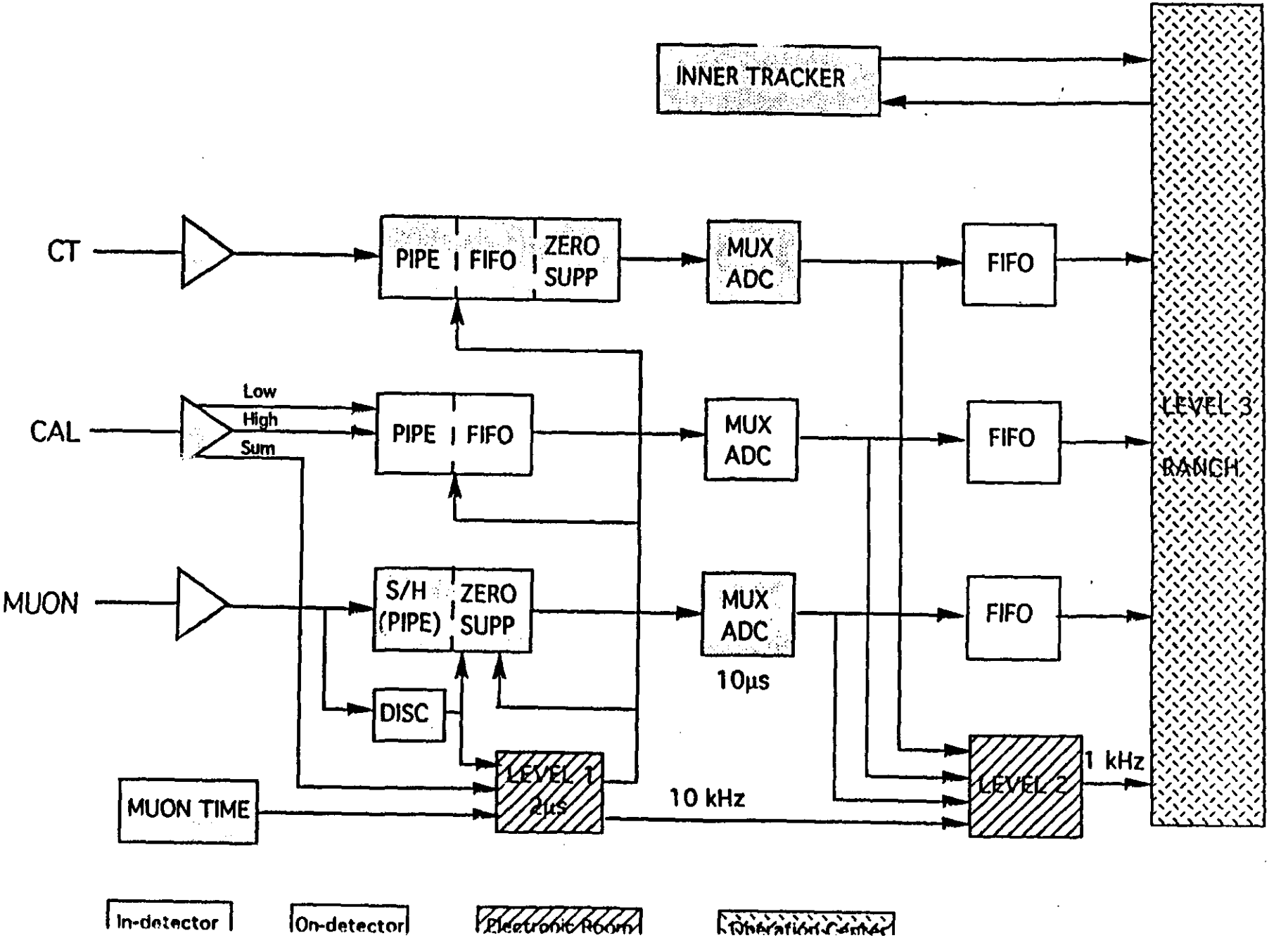
Electronics, Data Acquisition, Triggering

- Review of Baseline
- Highlights of Progress:
  - Central Tracker
  - Calorimetry
  - Muons
- Data Acquisition / Trigger Simulation
- Electronics Cost Review

Electronics, Data Acquisition, and Trigger Group

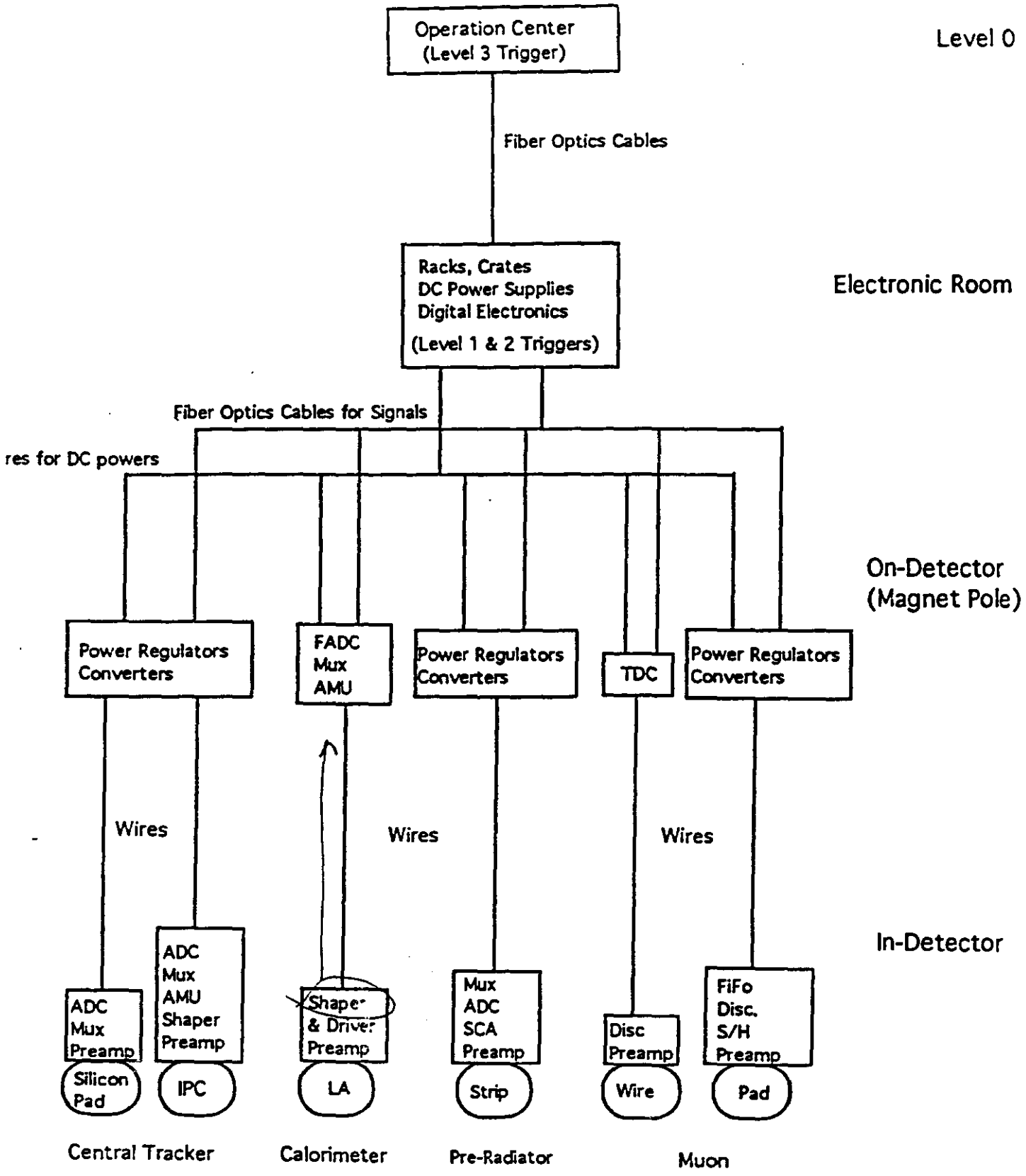


GEM DAQ ARCHITECTURE



TRIGGER RATE TABLE
(MARCH 18, 1992)

GEM Trigger/DAQ Design Goals				
Level	Rate In	Rate Out	Latency	Comments
1	60 MHz	10 kHz	2μs	Synchronous, Pipelined
2	100 kHz	300 Hz	100μs	Asynchronous, Monotonic
3	3 kHz	10 Hz	–	CPU Ranch



Electronics System Layout

Central Tracker Electronics

(J. Musser, P. O'Conner, C. Britton)

Main Issue: Rad. Hard Analog Memory Units
(Switched Capacitor Arrays)
"SCA's"

- Two Companies: Harris + UTMC
  - Non-disclosure agreements signed
  - Design rules transmitted to labs.

- Meeting with UTMC
  - No suitable capacitors available in their process
  - Requested GEM to pay $75K for developing MOS caps ⇐ Too Expensive, Too Delayed

- Harris process seems okay

- Plan:
  1) Fab. Soft Versions of Preamp / Shaper + SCA — May
  2) Irradiate test structures from Harris
  3) • Layout 16 channel / 128 deep SCA "ORNL"
     • Layout Preamp / Shaper "BNL"
     ⇒ Rad. Hard Run in Nov. — Harris

Calorimetry Electronics

J. Parsons, B. Sippach, P. Denes

Main Issue: SCA's
- Dynamic Range
- Pedestal Fluctuation
- Readout speed.

- Development at Nevis
  - Test structures / prototypes being produced thru ORBIT

- Test Beam (May/June) at BNL
  - Use modified SCA pipelines from ZEUS to take data.

STATUS OF SCA DEVELOPMENT

Apr 2/92

→ 2 test chips submitted to ORBIT on Mar. 30:

(1) 4 channels × 8 cells, no decoding, <u>all</u> CLKs brought off chip

↳ designed to allow study of cell structure, timing issues

(2) 4 channels × 48 cells with decoder

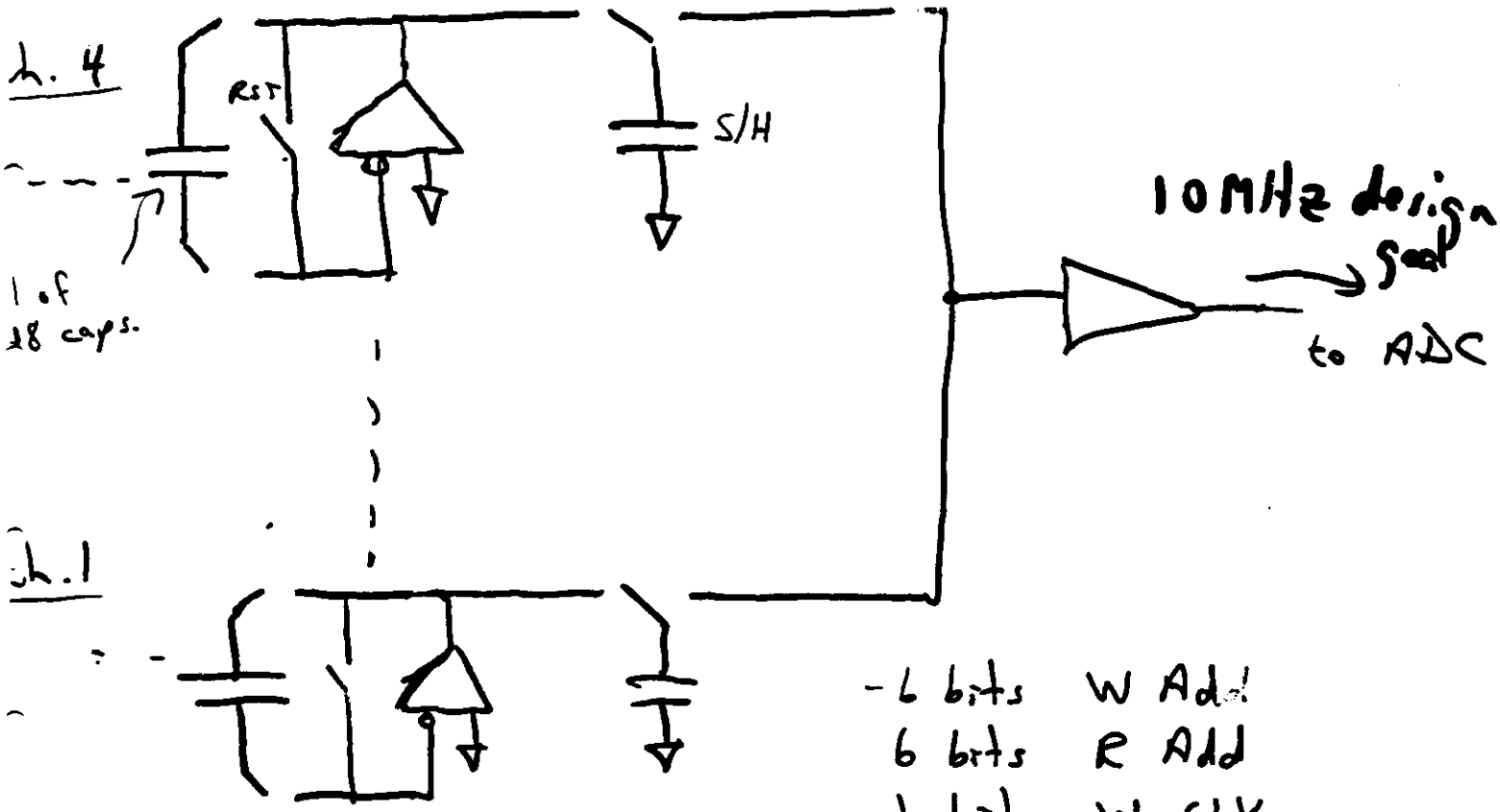
↳ test decoder, look at ped. structure, etc.

→ should receive chips ~ mid-May.

(in meantime, test jigs will be built)

Next step:

① - incorporate analog MUX + driver to commercial ADC.



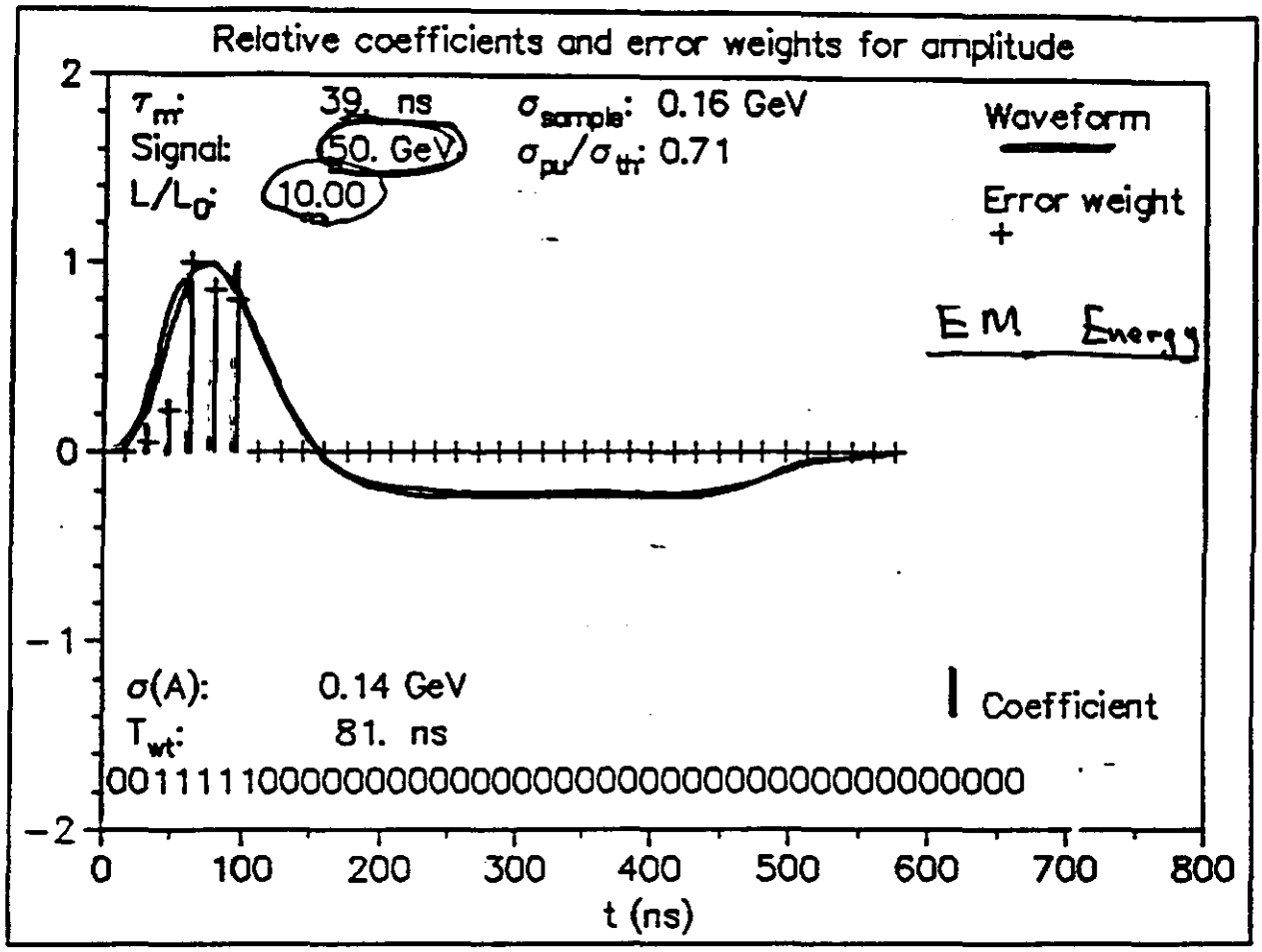
- 6 bits W Add
- 6 bits R Add
- 1 bit W CLK
- 1 bit R CLK
- 2 bits MUX Ad
- (1 bit MUX CLK)

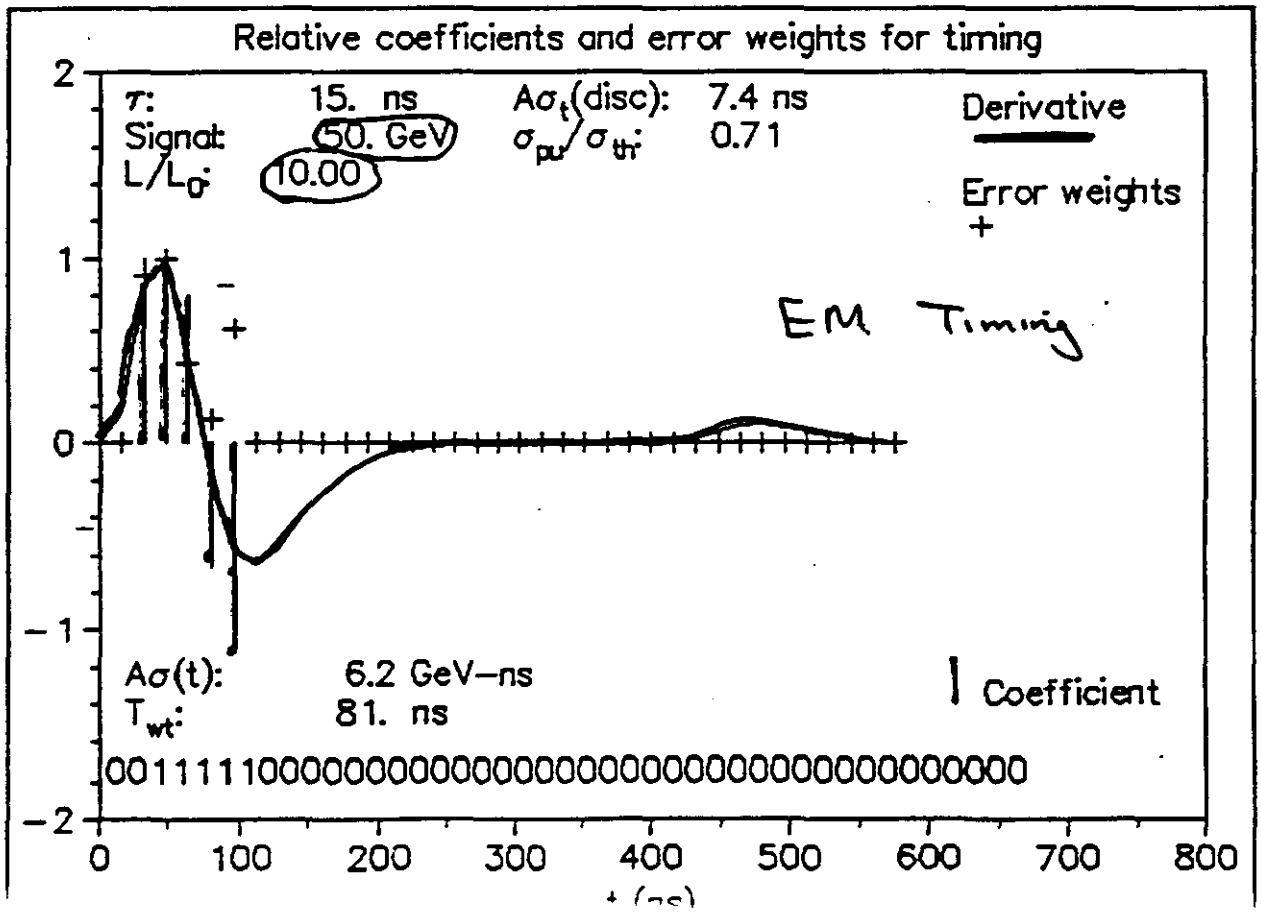
Commercial ADC's
(all 12-bit)

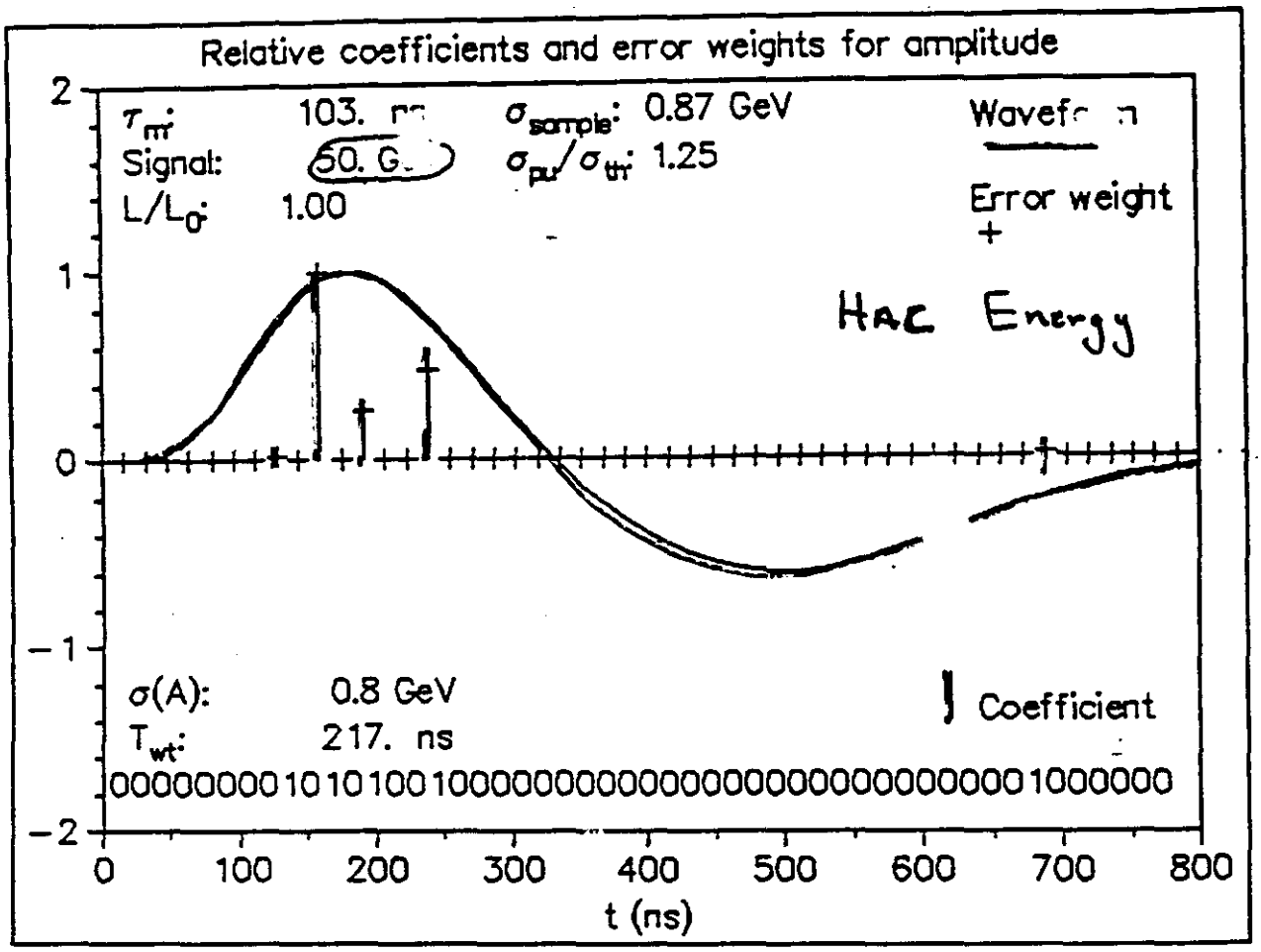
AD 872	- 10 MHz
SPT 9710	- 10 MHz
SPT 9712	- 30 MHz

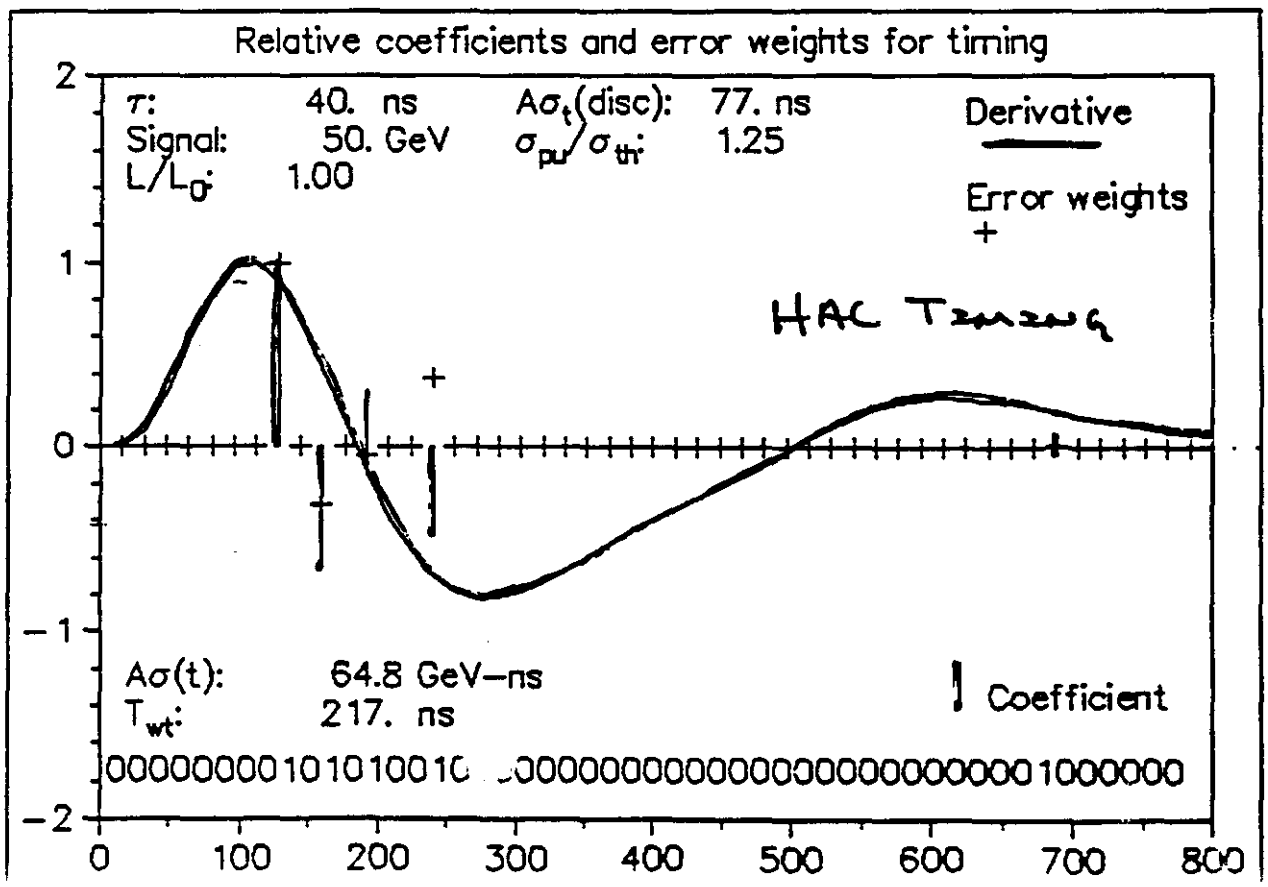
② time-over-threshold measurement

5 samples 10


Relative coefficients and error weights for amplitude
τ_m: 39. ns
Signal: 50. GeV
L/L_0: 10.00
σ_{sample}: 0.16 GeV
σ_{pu}/σ_{th}: 0.71
Waveform
Error weight
EM Energy
$\sigma(A)$: 0.14 GeV
T_{wt}: 81. ns
Coefficient
0011111000000000000000000000000000000000
t (ns)


Relative coefficients and error weights for timing
τ: 15. ns
Signal: 50. GeV
L/L_0: 10.00
$A\sigma_t$(disc): 7.4 ns
σ_{pu}/σ_{th}: 0.71
Derivative
Error weights
EM Timing
$A\sigma(t)$: 6.2 GeV–ns
T_{wt}: 81. ns
Coefficient
0011111000000000000000000000000000000000


Relative coefficients and error weights for amplitude
τ: 103. ns
Signal: 50. G
L/L0: 1.00
σsample: 0.87 GeV
σpu/σth: 1.25
Waveform
Error weight
+
HAC Energy
σ(A): 0.8 GeV
Twt: 217. ns
Coefficient
00000000101010010000000000000000000000000000000000
t (ns)


Relative coefficients and error weights for timing
τ: 40. ns
Signal: 50. GeV
L/L0: 1.00
Aσt(disc): 77. ns
σpu/σth: 1.25
Derivative
Error weights
+
HAC Timing
Aσ(t): 64.8 GeV–ns
Twt: 217. ns
Coefficient
00000000101010010
1000000

Noise Contribution to Resolutions

Energy

$$\delta E \approx .15\,\text{GeV} \quad @ \quad 10^{33}$$

$$(.35\,\text{GeV}) \quad @ \quad 10^{34}$$

Timing

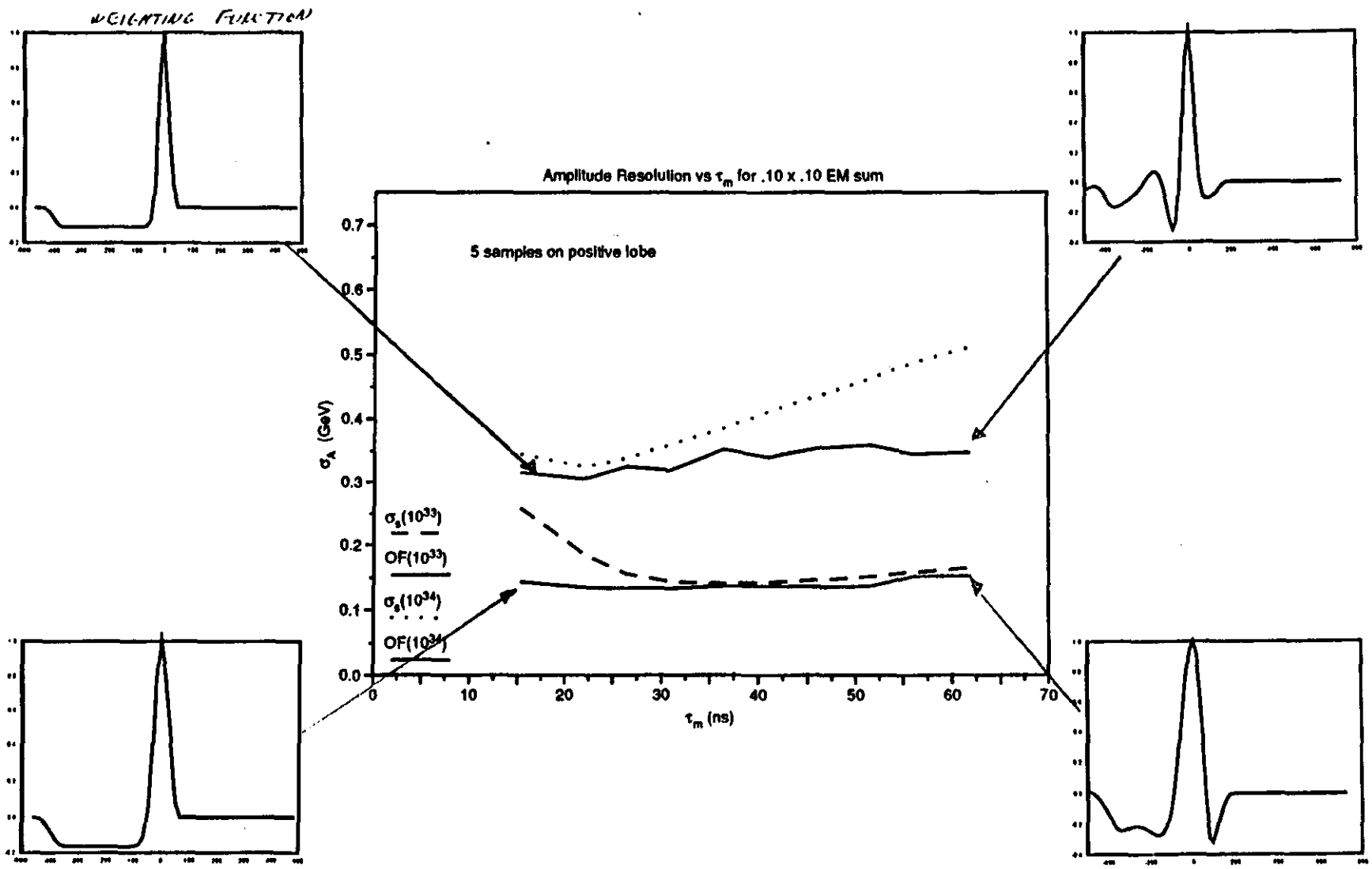
$$\delta(E\sigma_t) \approx 6 \ \text{GeV-ns} \quad @ \quad 10^{33}$$

$$(10 \quad @ \quad 10^{34})$$

For $E = 100$ GeV @ 10^{33}

$$\frac{\delta E}{E} = \text{[redacted]}\ .15\%$$

$$\delta t = .06 \text{ nsec.}$$


WEIGHTING FUNCTION
Amplitude Resolution vs τ_m for .10 x .10 EM sum
5 samples on positive lobe
σ_A (GeV)
τ_m (ns)
$\sigma_s(10^{33})$
$OF(10^{33})$
$\sigma_s(10^{34})$
$OF(10^{34})$
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60
70

B. Cleland

Sampling Considerations

John Parson's questions:

1) how many samples need to be digitized?
   $3 \leq n \leq 5$
2) what shaping times will be used for EMC and for HAC?
   $\tau_p(EM) \approx 40\,nsec$ $\quad \tau_p(HAC) \approx 100\,nsec$
3) for each shaping time, what sort of schemes might be implemented for determining which samples should be digitized?
   Optimal filtering suggests error weights
4) what parameters (eg. luminosity) might affect the sampling scheme, and how?
   $R = \sigma_{PU}/\sigma_s = \sigma_{PU} / (\sigma_{th}^2 + \sigma_{PU}^2)^{1/2}$
5) for long shaping times (eg HAC), is it necessary to run the pipeline at 60MHz, or can we run slower?
   Yes, but how?
6) how sensitive is the timing/energy resolution to the exact samples which are digitized?
   Not very, if τ_p close to τ_{opt}.

Muon Electronics

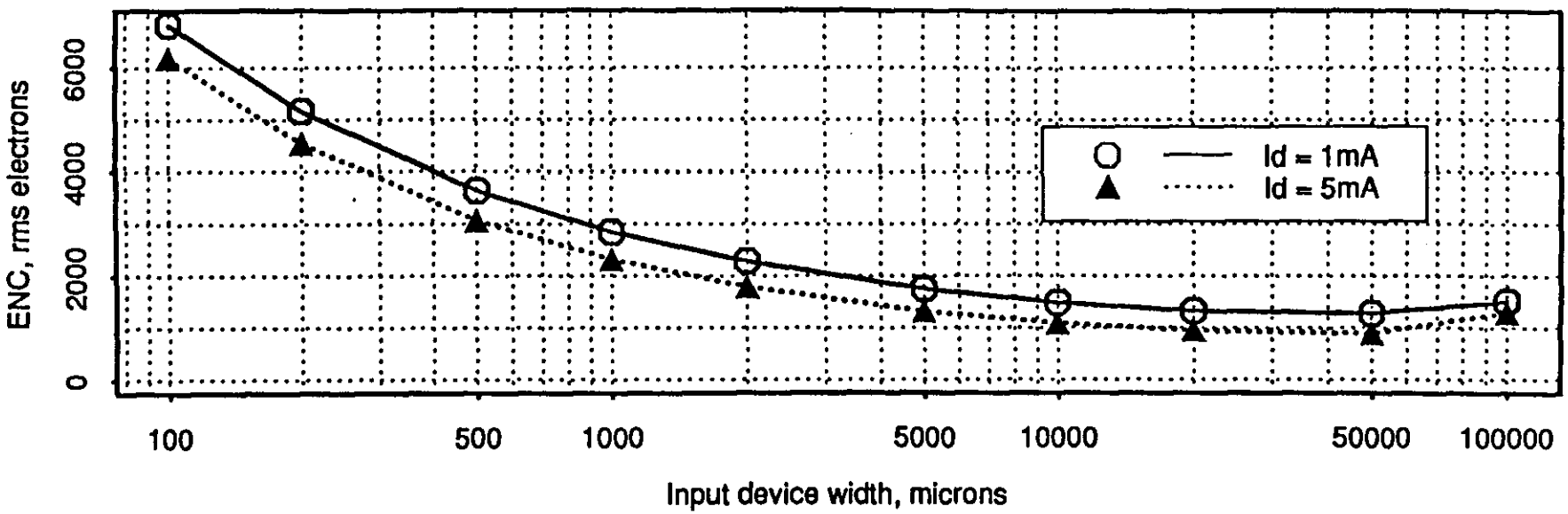
V. Polychronakos, P. O'Connor, V. Radeka

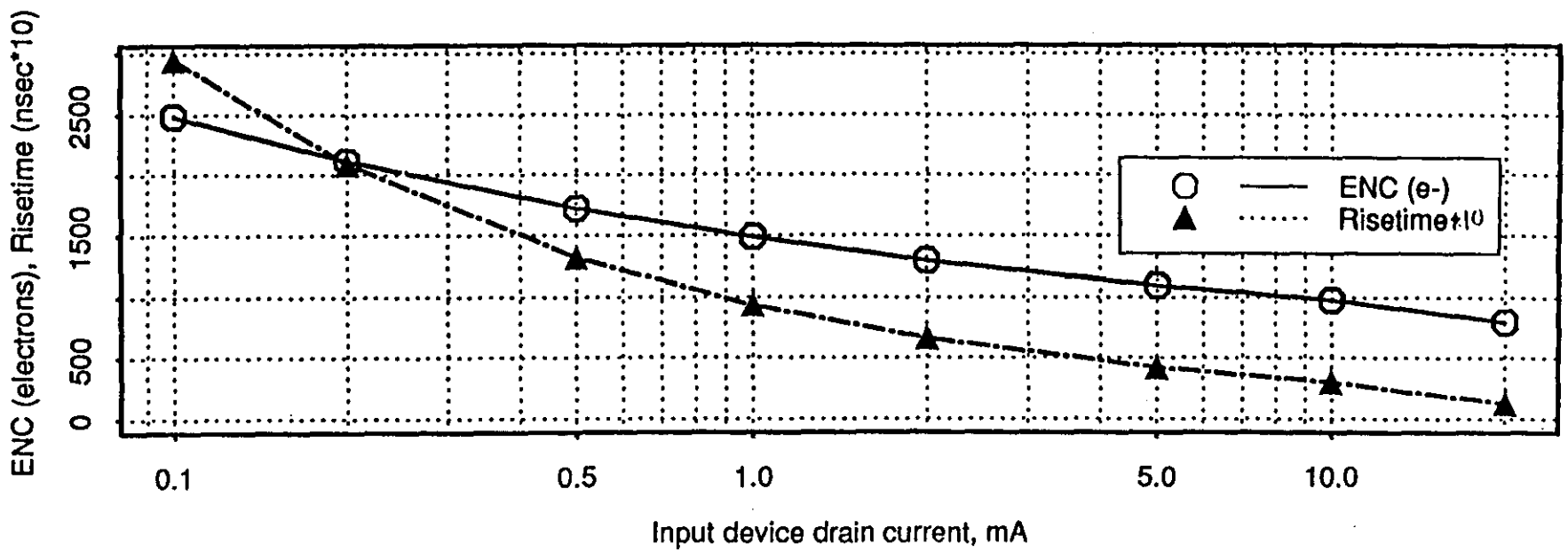
Main Issue: Develop Preamp/Shaper with Fast Risetime that can handle large capacitance.

- Prototype design complete
- In prototype fab. May

C_d - 150 pF
t_p = 1 μsec
p-chan input device

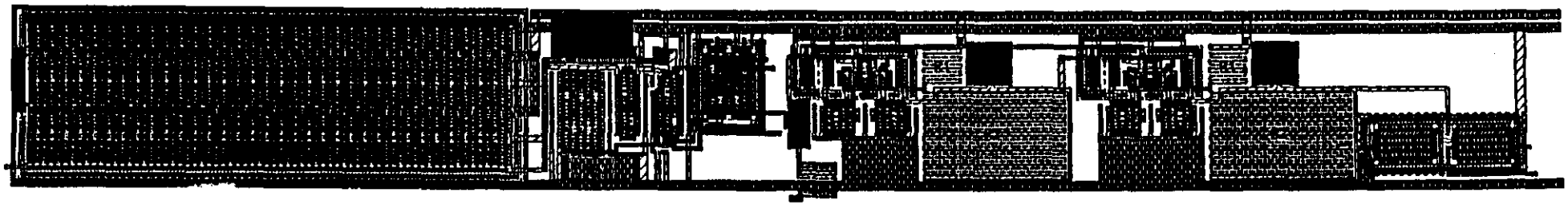
Pad Preamp Optimization

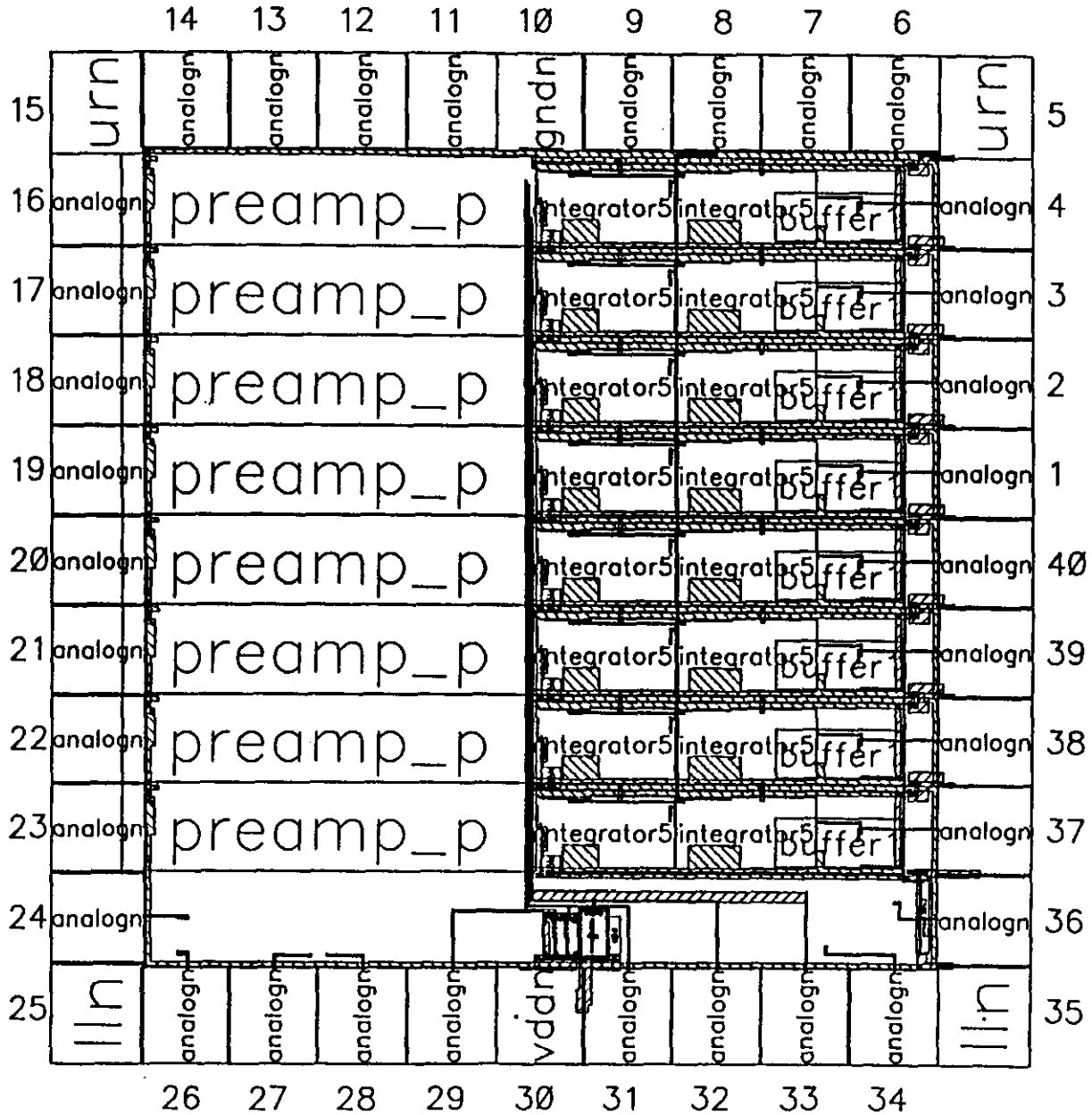




Preamp

Fast Shaper

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Data Acquisition and Triggering

M. Botlo, J. Ritchie, SSCL DAQ Group

(Simulation Workshop @ SSCL, April 23-25)

- SSCL has installed and debugged "MODSIM" simulation package.
  - Test data flow + control strategies
  - Identify bottlenecks / req. in system
  - Set buffer sizes

- Time for GEM to tap into this work
  - Work with SSCL group (Botlo)
  - Develop / Test trigger + control strategies
  - Help provide parameters and "raw data" (GEANT MC)

ELECTRONIC COST SUMMARY

	Channel Count (K)	Prototype k$	Prototype Cont.(%)	Production Cont. (%)	Cost per channel	Total Cost (k$)	
Muon							
RPC	85	585.7	19.5	18.9	48.75	5629.97	
PDT/LSDT	133	1253.2	37.1	32	48.9	10305.58	
CSC Wire	133(?)	949.8	34.5	30.4	8.19	2700.28	
CSC PAD	252	1985.7	37.9	42.5	26.85	12383.08	
							31.0M
Central Tracker							
Inner	Silicon Tracker						12.3M
Outer PAD	446	3012.2	49.7	48.7	26.21	21896.43	
Outer Wire	100	2517.7	51.9	43.9	19.03	6566.13	
							28.5M$
Calorimeter							
LA	80	3043.1	25.9	29.3	141.7	18499.37	
							18.5M$
~~Pre-radiator~~	~~14~~	~~2956.2~~	~~50.2~~	~~32.5~~	~~56.0~~	~~5479.9~~	

Trigger/DAQ

Level 1	Cal.	7.5M$	
	Muon	4.8 M$	
Level 2		3.0 M$	
DAQ		13.6 M$	
			28.9 M$

TOTAL ≅ 120M$

Increases:

+10M$ Outer Tracker

+20 M$ Trig/DAQ

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Presentation by:

Ken McFarlane

Computing

Simulation: (Lane, Perrier, subgroups)

- FAST1 package — Baseline I detector
  - Subsystem parameterizations
    - CT
    - CA — LAr
      - EC — BaF_2
      - HC — Scintcal
    - FC — 4 types
    - MU
    - TR
    - [PLE radiator]
  - Driver package
    - STDHEP (Lynn Garren, FNAL)
    - ISAJET
    - PYTHIA
    - Single particle
    - HERWIG
      - pileup

May 6th V1

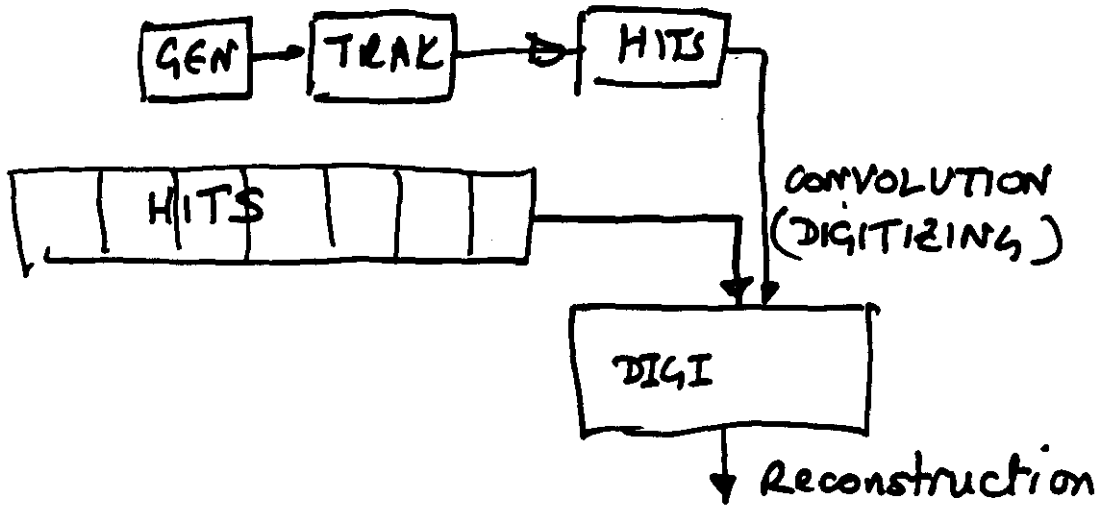
- FULL GEANT simulation

  Based on L3 structure (Yu. Fisyak)

  full set of facilities

  ZEBRA structures

  New pileup feature



- July 1.

-

- Slow Control
  DAQ, Accel (Magnet)

- On-line
- Off-line
- Storage

} ESystems, SSCL PR Computing

- Analysis

<u>Opportunity to work on:</u>

- Software methodologies (UTArlington, SSCL)
- Data Base (SDC, SSCL ..)
- TDR

gem

γeμ

Presentation by:

R. Stroynowski

R. STROYNOWSKI
SMU

MAGNET

1. PROGRESS SINCE TUCSON MEETING

- BASELINE DESIGN APPROVED AND FROZEN
  - RADIUS, LENGTH, FIELD
  - FORWARD FIELD SHAPER
  - FREE STANDING CENTRAL MEMBRANE
  - MOBILE COILS

- CONDUCTOR DECISION
  - CONDUCTOR IS A CRITICAL PATH ITEM
  - NEEDS SUBSTANTIAL R&D AND MANUFACTURABILITY TESTS
  - CLOSELY COUPLED TO WINDING PROCEDURE

WORKSHOPS: DEC. 2-4, 1991
JAN. 14-15, 1991
MAR. 23-24, 1992

ATTENDED BY: MIT-PFC & LLNL TEAMS AND REPRESENTATIVES FROM NHMFL (FLORIDA) RUTHERFORD LABORATORY, KURCHATOV INSTITUT EFREMOV INSTITUTE AND INDUSTRIAL REPRESENTATIVES.

INITIALLY – MANY OPTIONS (AND HIGH EMOTIONAL ATTACHMENTS)
→ SELECTED 2 FOR FURTHER STUDIES

- SELECTION CRITERIA

  CONDUCTOR MUST CARRY CURRENT WITH ADEQUATE MARGINS
  - NOT QUENCH UNDER ANY CONDITIONS
  - SURVIVE A QUENCH
  - REQUIRE NO MAINTENANCE
  - ALLOW FOR SIMPLE/RELIABLE MANUFACTURING AND WINDING

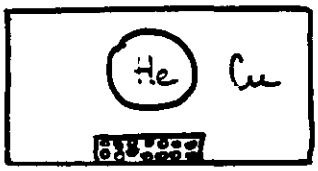
SELECTED OPTIONS:

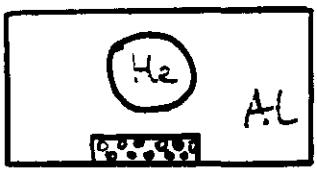
<u>INDIRECTLY COOLED</u>
- SIMPLE TO MANUFACTURE
- SMALL STABILITY MARGIN
- NO PRETESTING POSSIBLE
- STRICT REQUIREMENTS ON WINDING
- HAS BEEN USED BEFORE

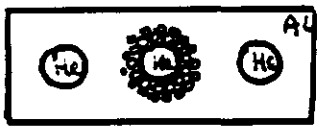
<u>CABLE-IN-CONDUIT</u>
- COMPLICATED TO MANUFACTURE
- TOOLING EXIST
- HAS BEEN USED BEFORE
- VERY HIGH STABILITY MARGIN
- PRETESTING POSSIBLE
- JOINTS NEED DEVELOPMENT

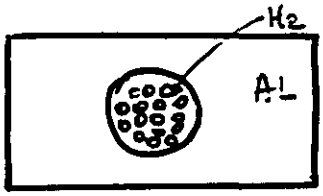
CONDUCTOR OPTIONS

INDIRECTLY COOLED
(RUTHERFORD LAB.)









CABLE-IN-CONDUIT
(MIT-PFC)

+

others

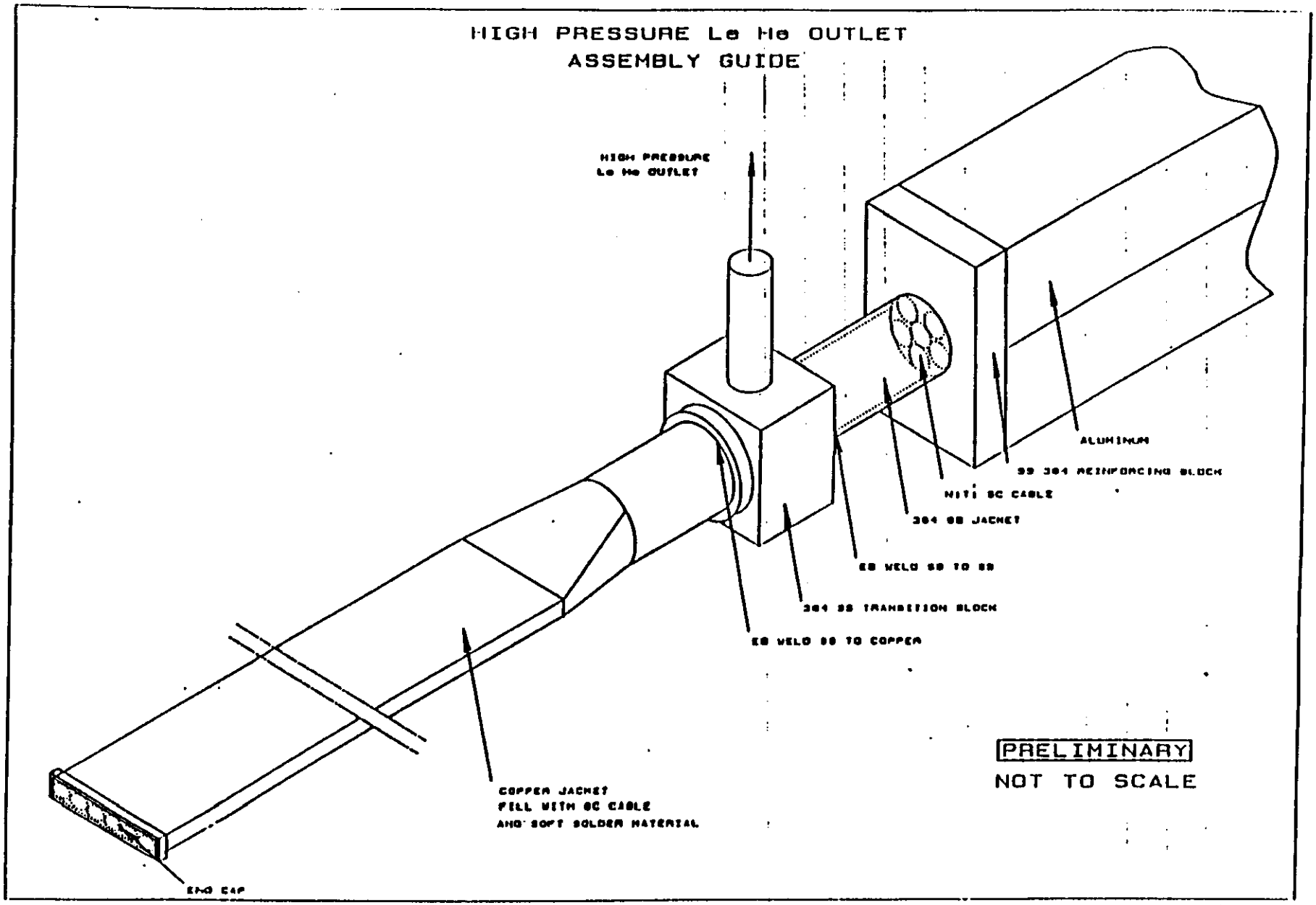


Figure 5-9 Joint Subassembly

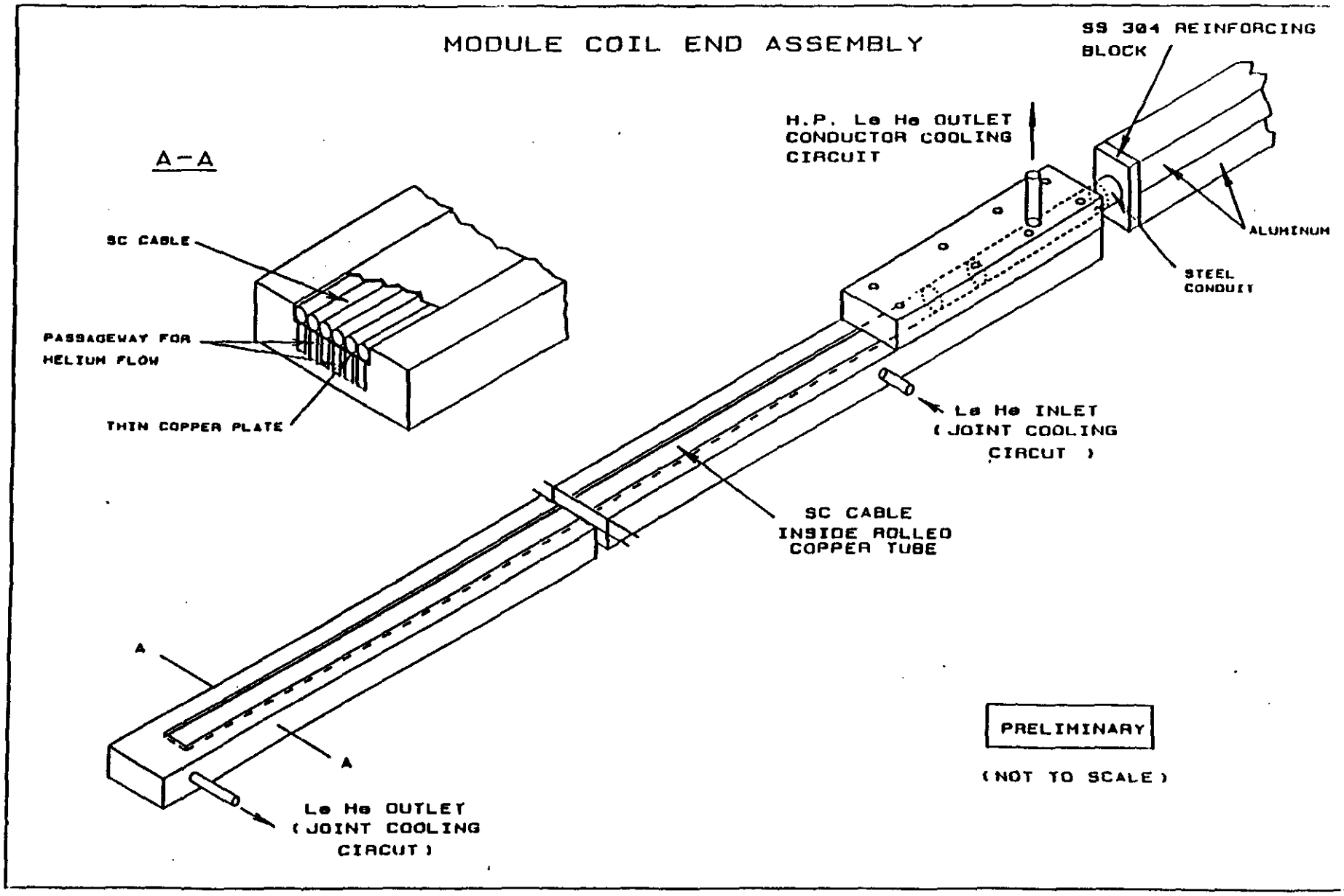


Figure 5-10 Joint Half

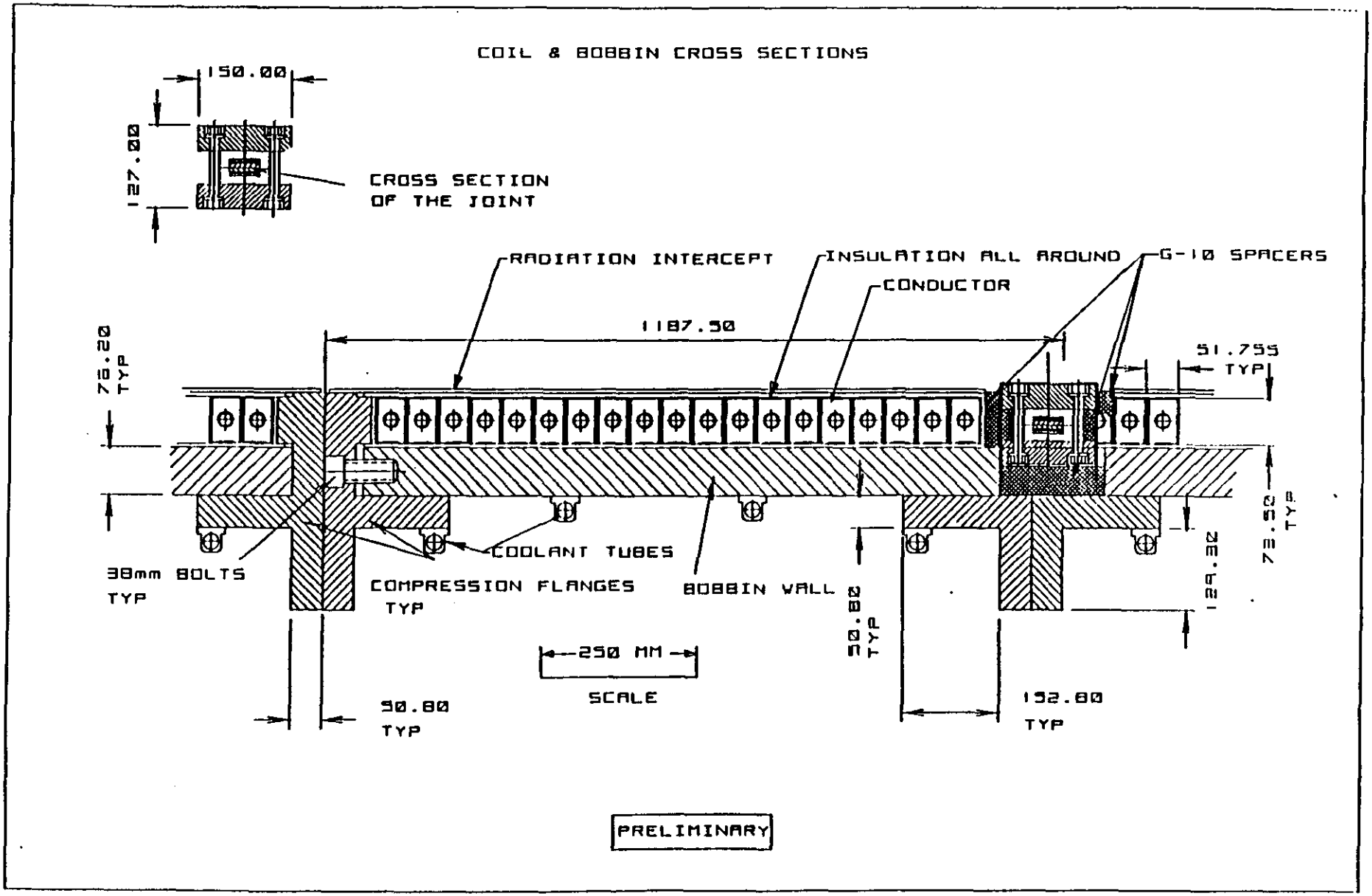


Figure 5-2 Coil Module Cross Section

CONDUCTOR DECISION

G. DEIS, M. HARRIS, N. MARTOVETSKY, P. REARDON, R. STROYNOWSKI

BOTH DESIGNS MAY WORK

COST ESTIMATES VERY CLOSE

CABLE-IN-CONDUIT – MORE COMPLICATED TO PRODUCE BUT

- HAS MUCH HIGHER STABILITY MARGIN
- MANUFACTURING EXPERTIZE EXISTS AT MIT
- CAN BE PRODUCED AND PRETESTED IN INDUSTRY
- MAY BE EASIER TO WIND (?)
- JOINT DESIGN EXISTS

→ RECOMMENDED FOR FURTHER DEVELOPMENT AS GEM MAGNET CONDUCTOR

R&D

- MANUFACTURE STRANDS, BRAID CABLE AND TEST INDUSTRIAL PROCESS
- TEST JOINT AT LIQUID HELIUM TEMPERATURE

3. OPEN QUESTIONS

- WINDING STRATEGY : INSIDE vs OUTSIDE
  BENDING vs PREFORMING
  ⋮

- SUPPORT STRUCTURE FOR THE FORWARD FIELD SHAPER

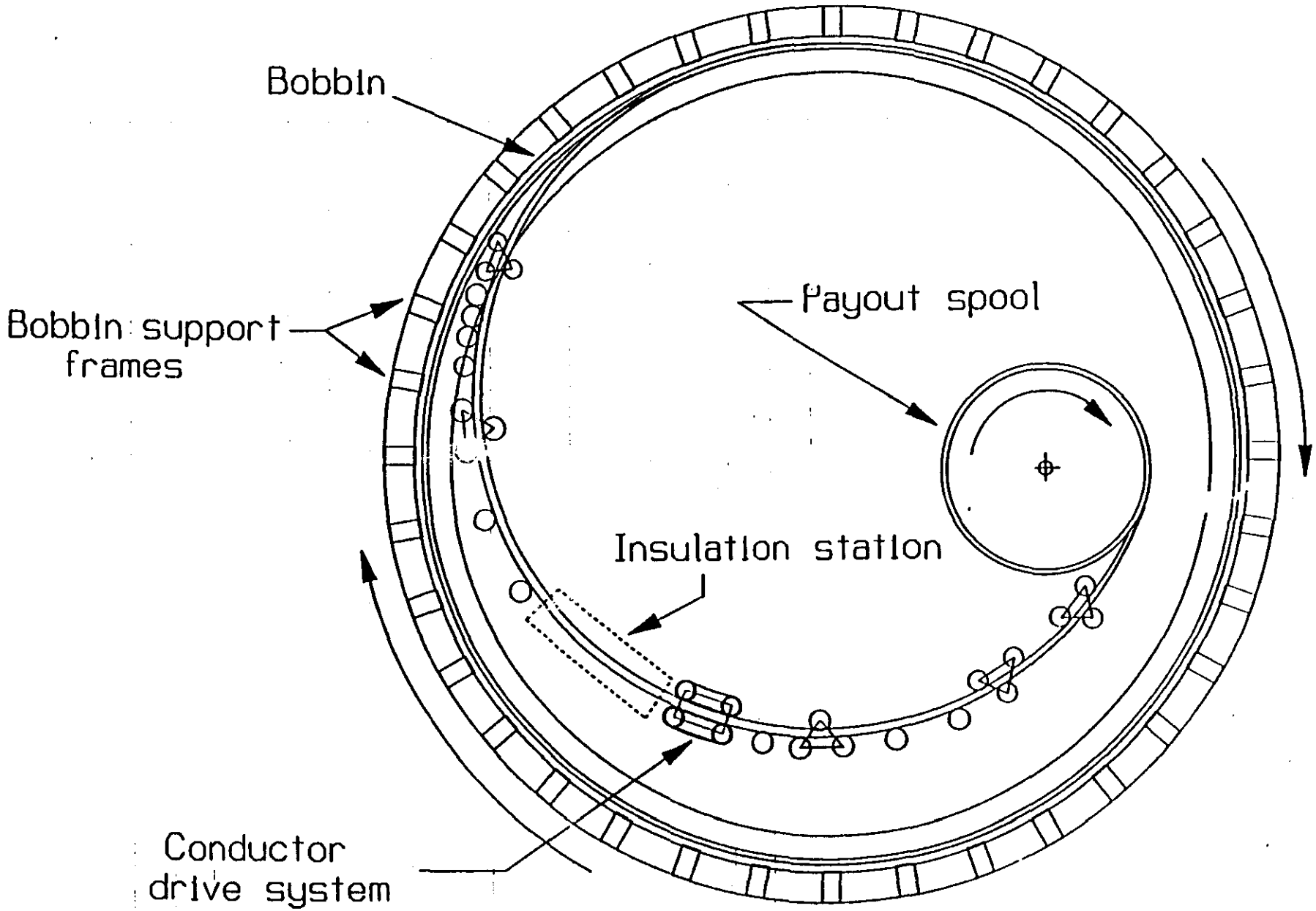
  CAN IT BE COUPLED TO THE COIL ?

- CRYOGENICS CONTROL SYSTEM

- POWER SUPPLIES AND DUMP RESISTORS

- EDDY CURRENTS DURING EMERGENCY DISCHARGE

⋮



Module Winding Concept

Figure 7.1.0

2. TECHNICAL WORK IN PROGRESS

- "COLD MASS" - MIT
  - PLAN TO MANUFACTURE STRANDS OF SUPERCONDUCTOR, TEST ITS PROPERTIES AND MAKE A FULL SIZE CONDUCTOR JOINT
  - WINDING DEVELOPMENT - MIT/RUTHERFORD/LLNL DESIGN THE WINDING SCHEME AND ASSOCIATED TOOLING.

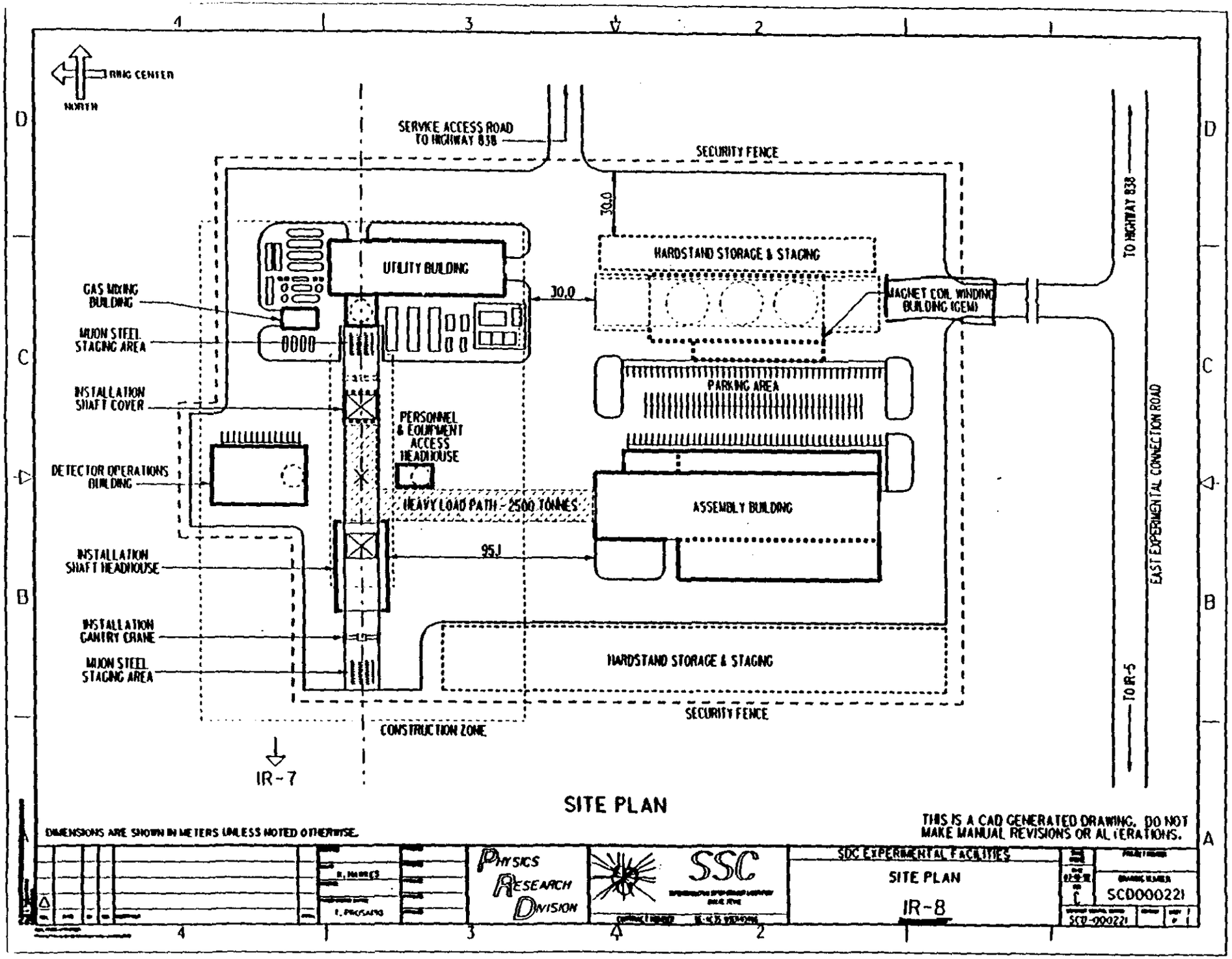
- STRUCTURAL ANALYSIS - LLNL
  - PREPARATION TO MAKE COMPLETE, DYNAMICAL MODEL OF THE MAGNET (including gravitational, atmospheric pressure and magnetic forces)
  - DETAILED DESIGN OF THE VACUUM VESSEL, CRYOGENIC SYSTEMS, POWER SUPPLIES AND CONTROLS

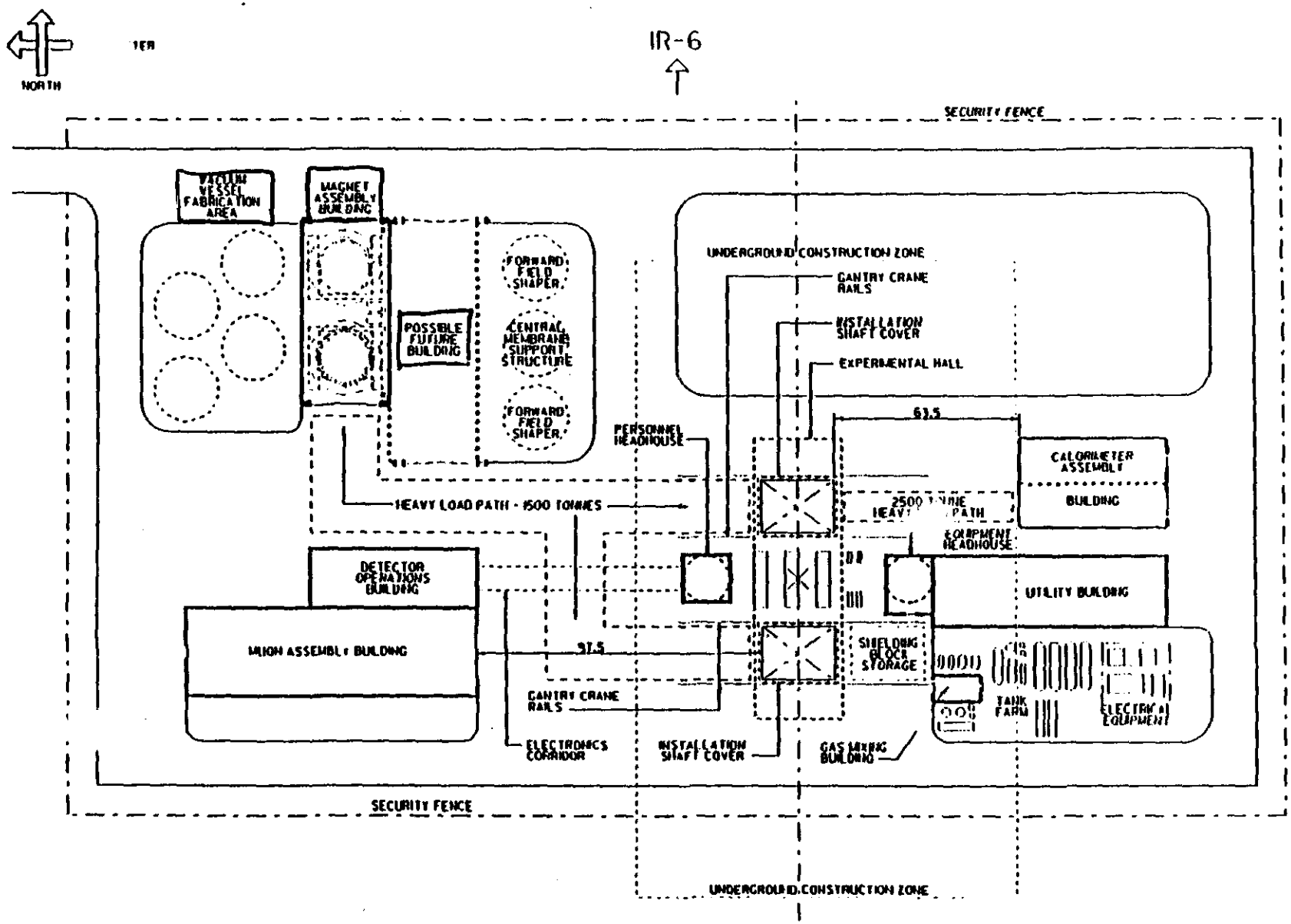
- DESIGN OF FACILITIES - SSC
  - COIL WINDING BUILDING DESIGNED BOTH FOR IR8 AND IR5. WILL NEED ROAD IMPROVEMENT
  - PRELIMINARY DESIGN OF COIL ASSEMBLY BUILDING EXISTS.
  - COUPLED TO WINDING AND ASSEMBLY SCHEME

- COIL WINDING BUILDING

  - Title I shows it in IR 8 in order to have building ready in time to start winding.
  - It is awkward to have it in different IR and will need road improvement between IR5 and IR8.
  - There is a possibility of placing it in IR 5 if permits could be obtained in time and if we could get south entrance road improved in time.

NEEDS ATTENTION !!


RING CENTER
NORTH
SERVICE ACCESS ROAD TO HIGHWAY 838
SECURITY FENCE
30.0
UTILITY BUILDING
HARDSTAND STORAGE & STAGING
GAS MIXING BUILDING
MUON STEEL STAGING AREA
30.0
MAGNET COIL WINDING BUILDING (GEM)
TO HIGHWAY 838
PARKING AREA
INSTALLATION SHAFT COVER
PERSONNEL & EQUIPMENT ACCESS HEADHOUSE
DETECTOR OPERATIONS BUILDING
HEAVY LOAD PATH - 2500 TONNES
ASSEMBLY BUILDING
EAST EXPERIMENTAL CONNECTION ROAD
INSTALLATION SHAFT HEADHOUSE
95.1
INSTALLATION GANTRY CRANE
MUON STEEL STAGING AREA
HARDSTAND STORAGE & STAGING
TO IR-5
SECURITY FENCE
CONSTRUCTION ZONE
IR-7
SITE PLAN
DIMENSIONS ARE SHOWN IN METERS UNLESS NOTED OTHERWISE.
THIS IS A CAD GENERATED DRAWING. DO NOT MAKE MANUAL REVISIONS OR ALTERATIONS.
PHYSICS RESEARCH DIVISION
SSC
SDC EXPERIMENTAL FACILITIES
SITE PLAN
IR-8
SCD000221



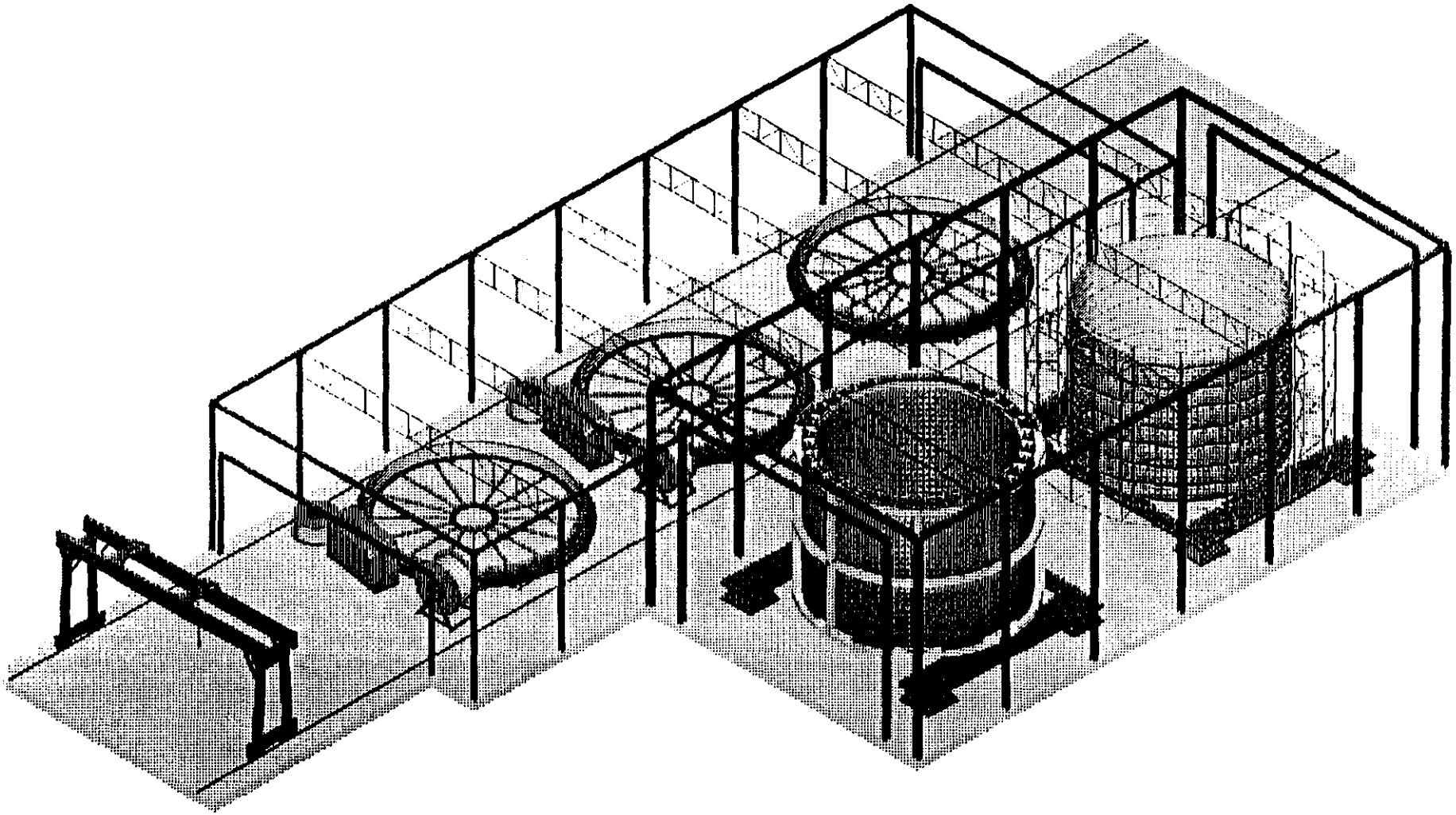
SITE PLAN

DIMENSIONS ARE SHOWN IN METERS UNLESS NOTED OTHERWISE.

THIS IS A CAD GENERATED DRAWING. DO NOT MAKE MANUAL REVISIONS OR ALTERATIONS.

E. HAWKES	Physics Research	SSC	CEM EXPERIMENTAL FACILITIES
E. PROSAPIO			IR-5 SITE

CED-000443 | 001



ACQUISITION PLAN

- STILL UNDER INTENSE DISCUSSION.
- OBJECTIVE – HOW TO REACH MANUFACTURING STAGE WITH INDUSTRY ON-BOARD AND STAY WITHIN LEGAL RESTRICTIONS AND TIME CONSTRAINTS

- VENDORS CONFERENCE APRIL 1st.

  - PRESENTATION OF UP-TO-DATE STATUS OF DESIGN TO INDUSTRY REPRESENTATIVES. TRANSPARENCIES REPRESENT BEST SUMMARY OF MAGNET DESIGN AND ARE DISTRIBUTED AS [illegible]. ABOUT 100 PEOPLE FROM ~20 COMPANIES SHOWED UP.

  - IN ADDITION TO TECHNICAL DETAILS THEY WERE TOLD THAT WE ARE PREPARING TECHNICAL DESIGN REPORD FOR THE MAGNET FOR THE JULY'S PAC MEETING AND INTEND TO SUBMIT IT FOR DOE REVIEW

  - PENDING DOE APPROVAL, THE MAGNET CONSTRUCTION BID COULD BE AWARDED IN JANUARY 1993.

> IT IS CRUCIAL THAT THE MANUFACTURING CONTRACT BE AWARDED EARLY IN 1993 IF WE WANT TO HAVE EXPERIMENT IN PLACE AT THE START OF THE SS BEAMS

→ TECHNICAL DESIGN REPORT – IN PREPARATION. FIRST DRAFT EXPECTED MID-MAY.

- TECHNICAL DESIGN REPORT - MAGNET SECTION

- SEPARATED FROM TDR FOR REST OF GEM
- OUTLINE, LIST OF CHAPTERS AND WRITERS EXISTS
- TEXT STARTED ARRIVING AT SSCL
- EXPECT TO HAVE REASONABLE 1st DRAFT BY MAY 10.
- STRATEGY :
  - SUBMIT TO PAC FOR JULY 10 MEETING
  - ASK FOR A DOE REVIEW IN SEPTEMBER
  - ASK FOR PERMISSION TO SEND OUT RFP IN OCTOBER AND PLACE CONTRACT IN JANUARY 93
- PROBLEMS
  - PRECIPITATES QUESTION HOW TO FUND 2 EXPERIMENTS
  - MAY EXPECT RESISTANCE AT EVERY STEP
  - DELAYS AT THIS STAGE TRANSLATE INTO REAL DELAYS FOR THE EXPERIMENT

MAGNET MANAGEMENT ORGANIZATION

R. STROYNOWSKI
W. WISNIEWSKI (?) } Physicists
N. MARTOVECKY — Magnet designer
P. Marston, B. Smith
J. Minnervini et al } MIT-PFC Design Team (Cold mass design)

G. Deis, C. Johnson,
R. Yamamoto, J. Bowers et al } LLNL Design Team (structures, cryo, controls etc)

P. Clee, E. Baynham et al - Rutherford Laboratory Design Consulting Team

PAUL REARDON — ASSOCIATE GEM PROJECT MANAGER FOR THE MAGNET

GARY DEIS — DEPUTY PROJECT MANAGER FOR THE MAGNET AND LEAD MAGNET ENGINEER.

RICHARD FISCHER — PROGRAM PLANNER / BUSSINESS OPERATIONS
ALAN TINKER — SUBCONTRACT COORDINATOR

BOB JOHNSON (ex GD)
BILL FLICK (ex Lockheed) } CONSULTANTS ON ACQUISITION PLAN

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Presentation by:

Kenneth Lane

PHYSICS PROGRESS REPORT - APRIL 30

PHYSICS SIMULATIONS FOR THE PAC REPORT

(JULY 10? - REPORT ON JUNE 12)

- FAST 1 SIMULATION PACKAGE (BASELINE 1)

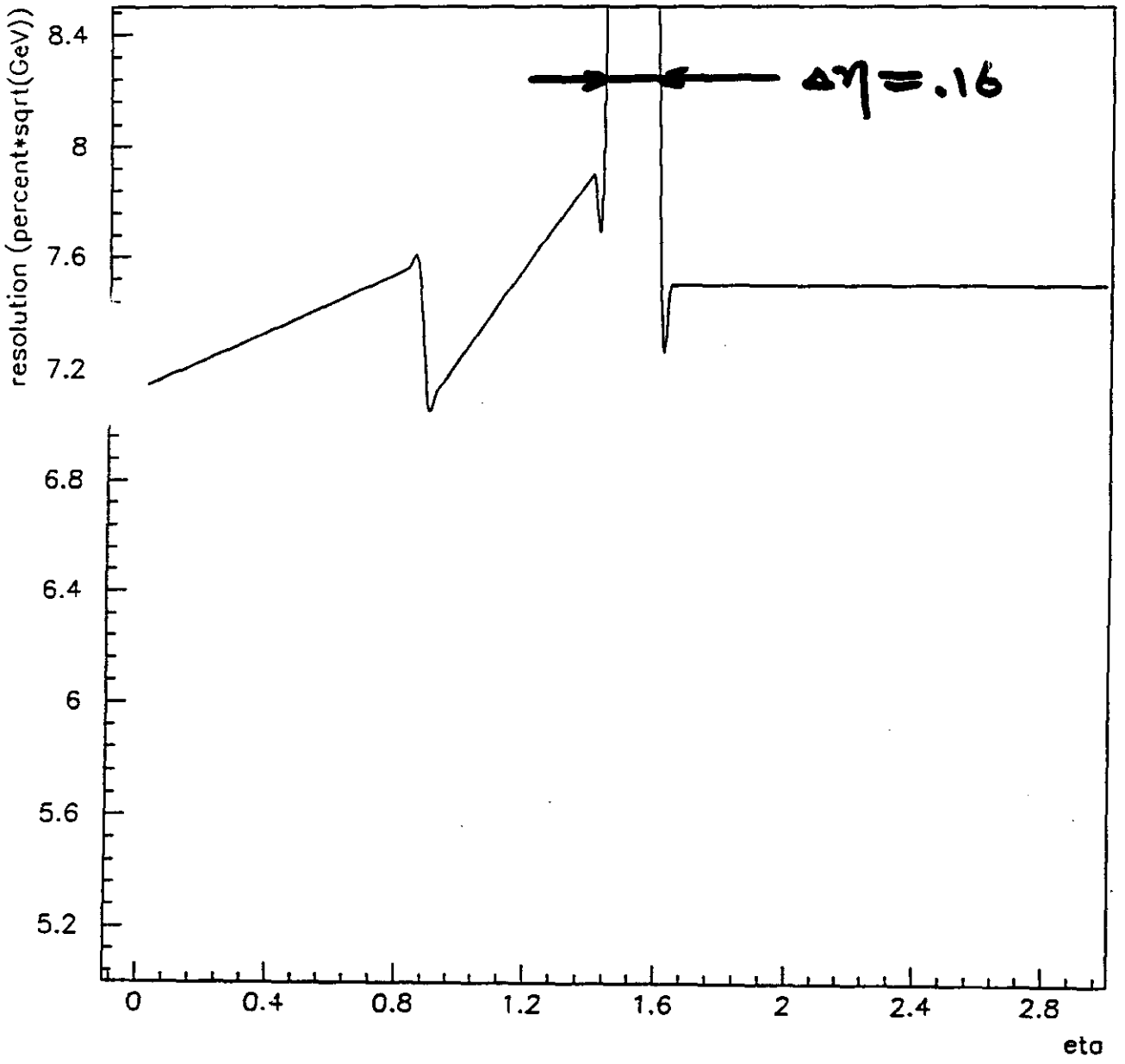
SEPARATE PROGRAMS IN PLACE:

- CT — McKEE, et al.
- FC — SHUPE
- EC — MA; SHI → LAR EM RES...
- HC — MA; CAREY
- MU — DINGUS, et al.
+ TR — ALLEN (CAL.);

ASSEMBLY INTO DEBUGGED GRAND UNIFIED PACKAGE IN ≤ 1 WEEK (MAY 7)

- McFARLANE, PAIGE, DINGUS

LAr - EM RESOL'N VS. η



- RESPONSE TO PAC CONCERNS - MAY 22!

I. $H^0 \to \gamma\gamma$ - ZHU, YAMAMOTO

1. • REPEAT WITH BASELINE AND WORSENED RESOLUTIONS.
   • BACKGROUNDS FROM MIS-ID'D $e^\pm$; DRELL-YAN
   • CT MUST FIND EVENT VERTEX ~ 1 mm.

2. $t\bar{t}H \to l_{isol.} + \gamma\gamma$
   • CAREFUL BACKGROUND ESTIMATES.

3. $H^0 \to \gamma\gamma$ (w/ OR w/o $t\bar{t}$) AT $\mathcal{L} = 10^{34}$??

II $H^0 \to ZZ^* \to e^+e^-e^+e^-$ - ZHU, YAMAMOTO

1. REPEAT WITH BASELINE AND WORSENED RESOLUTIONS

2. $e^\pm$ ID EFFICIENCY IN ENDCAP EC.

III. FLAVOR TAGGING VIA $b \to \mu$ INCLUSIVE
- C. YANAGISAWA, C.K. JUNG

1. HEAVY t ($m_t = 200 - 250$ GeV) DISCOVERY

e.g. $gg \to t\bar{t} \to e^{\pm}_{isol.} + \mu^{\mp}_{isol} + \mu^{\pm}_{incl.} + \cdots$

2. m_t DETERMINATION IN

$$gg \to t\bar{t} \begin{cases} \to W^-\bar{b} \to \ell^-_{isol.} + \mu^+_{incl.} \to \text{TAG.} \\ \to W^+ b \to jjj \to m_t, M_W \end{cases}$$

3. GENERIC $b \to \mu_{incl.}$ + JET - P. DINIGUS

IV. ELECTRON ID + MEASUREMENT AT $\mathcal{L} = 10^{34}$

1. GENERAL ISSUES - π/e ; JET $\to e$; PILE-UP NOISE
- ZHU, YAMAMOTO

2. 800 GeV $H^0 \to e^+e^-\mu^+\mu^-$ - ~~A. SUMAROKOV~~

3. 4 TeV $Z'^0 \to e^+e^-$ - SUMAROKOV ; LANE + ...
- <u>TRACK POINTING</u>! - BACKGROUNDS AT 10^{34} ?

V. Muon ID & Measurement at $\mathcal{L} = 10^{33}, 10^{34}$

1. Detector Issues – λ, X_0, punchthrough (MS Weil)
   - Triggering, etc.
   - Role of CT in background rej'n.
   - ... See PAC reports!

2. Physics –
   γ/ℓ substructure in $\mu^+\mu^-$ prod'n.
   $Z'^0 \to \mu^+\mu^-$; asymmetries
   } Lane, Simmons, Golden, Shrock, Mohammadi

VI. $\not{E}_T$ Physics

1. $\tilde{g}\tilde{g} \to \not{E}_T + \bar{X}$ – Paige, Shupe
   - credible FG in MSMA
2. $\tilde{g}\tilde{g} \to \ell^\pm\ell^\pm + \bar{X}$ – Yale CT (Sem, Wolin)
3. Leptoquark (Π_{QL}) pair production
   - $\Pi_{QL}\,\Pi_{L\bar{Q}} \to b\tau^+ + \bar{b}\tau^-$ – Yale/Albany CT
   - $\Pi_{QL}\,\Pi_{L\bar{Q}} \to b\mu^+ + \bar{b}\mu^-$ – P. Dinous.

DEFINITIZED TIMETABLE

MAY 7 - FAST1 PACKAGE OPERATIONAL, DELIVERED.

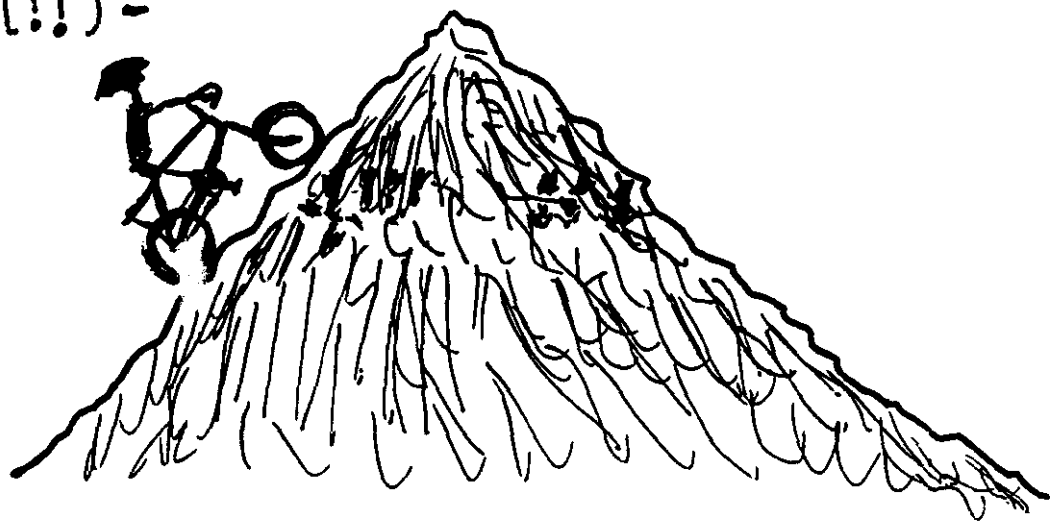
MAY 22 - ALL PHYSICS SIMULATIONS COMPLETE, DELIVERED WITH WRITE-UPS !

JUNE 1 - 1ST DRAFT - PHYSICS RESPONSE TO PAC
+ CORRECTIONS, FINE TUNING OF SIMULATIONS
+ 1ST DRAFT - VOL. 8 OF TDR.

JUNE 12 - FINAL DRAFT - PHYSICS RESPONSE TO PAC

JULY 10(?) - PAC AT WOODS HOLE

JULY 12(!!) -



Exercise on Physics Questions from PAC

Ren-yuan Zhu
Caltech

GEM Physics Meeting, SSCL

April 28, 1992

- H$\rightarrow \gamma\gamma$:
  - Effect of Energy Resolution $\Rightarrow$ **done**;
  - Effect of Drell-Yan Background $\Rightarrow$ **done**;
  - Effect of Misidentified Electron $\Rightarrow$ **in progress**.
- H$t\bar{t} \rightarrow \ell\gamma\gamma X$:
  - $t\bar{t}$ background $\Rightarrow$ **done**;
  - $t\bar{t}\gamma\gamma$ background $\Rightarrow$ Kunszt?
  - Other background?
- Electron ID in High L:
  - Isolated Electron/Isolated charged $\pi \Rightarrow$ **done**.
  - Fake isolated electron from jet $\Rightarrow$ **in progress**;
  - High $\mathcal{L} \Rightarrow$ high pile-up noise in isolation cone.

Time Factor in Discovering Higgs via H$\rightarrow \gamma\gamma$

As function of energy resolution (**a** and **b**)

$$\delta E/E = (a/\sqrt{E} \oplus b)\ \%$$

$$\delta x = 1.0 \text{ mm}$$

a	2.0	3.0	5.0	7.5	10	15
b=0.5	**1.0**	1.1	1.4	1.8	2.3	3.4
b=.75	1.4	1.5	1.7	2.1	2.6	3.6
b=1.0	1.8	1.9	2.1	2.4	2.9	3.7
b=1.5	2.6	2.6	2.8	3.1	3.4	4.1
b=2.0	3.4	3.4	3.5	3.7	4.0	4.7

- Note: Different detectors have **different acceptance and background rate**. This table is for detectors with the same acceptance and background rate.

Drell-Yan Background Rejection

Production X-Section: 2.1 nb for $\hat{p}_T > 20$ GeV.

- Acceptance of event selection cuts: 41%;
- DY Z peak x-section: 20 pb/0.1 GeV;
- Irreduciable $\gamma\gamma$ background at Z peak: 0.13 pb/0.1 GeV;
- Drell-Yan x-section is 160 times larger;
- Need $\mathbf{R(\gamma/e)} < 6 \times 10^{-2} \Rightarrow$ to reduce Drell-Yan background to ~0.5 of irreduciable $\gamma\gamma$ background;
- Feasibility: L3 TEC chamber has 2×10^{-4} rejection to Bhabha, i.e. 1.4×10^{-2} single track rejection.

Drell-Yan Background Rejection needs 6×10^{-2} charged track rejection.

Misidentified Electron Background

- Background for H$\rightarrow \gamma\gamma$:
  - Drell-Yan: $R^2(\gamma/e)$;
  - γ-j t: $R(\gamma/jet) + R(e/jet)$ [illegible] (γ/e)
  - 2jets: $R^2($ [illegible] $jet) + 2R(e/jet)R(\gamma/e)R(\gamma/jet) + R^2(e/jet)R$ [illegible] (γ/e)
- R(e/jet) analysis $\Rightarrow$ in progress, following R(γ/jet) analysis by H. Yamamoto.
- Isolated electron/π rejection OK $\Rightarrow$ at High $\mathcal{L}$, since the usage of central tracker is not essential.

$DD \rightarrow Ht\bar{t}X \rightarrow \gamma\gamma l\nu X$

Production Cross-Section and Events/SSCY
PYTHIA 5.5 (M_{top}=140 GeV)

M_H(GeV)	$\sigma_{\gamma\gamma t\bar{t}X}$(fb)	$N_{\ell\gamma\gamma}(0.3)$	$N_{\ell\gamma\gamma}(0.45)$	$N_{\ell\gamma\gamma}(0.6)$
80	18	17	16	14
90	17	25	22	16
100	16	19	16	16
120	14.5	20	16	14
140	8.5	15	12	10
150	5.2	15	7	5

- $|\eta_\ell| < 2.5$, $P_T^\ell > 20$ GeV, R = 0.3.
- $|\eta_\gamma| < 2.5$, $P_T^\gamma > 20$ GeV, R = 0.3, 0.45, 0.6
- isolation cut $\Rightarrow$ reject $t\bar{t}$

$$\sum_{r<R} E_T - E_T^{photon} < 5GeV + 0.1E_T^{photon}$$

- P_T of di-photon > 50 GeV $\Rightarrow$ reject $t\bar{t}$
- Shower Shape Analysis: $\bar{\theta} < 5$ mrad
- Preradiator: $\theta_M < 2$ mrad

pp $\rightarrow Ht\bar{t}X \rightarrow \gamma\gamma\ell\nu X$ (Cont.)

2.6 M $t\bar{t}$ Background

R_{cut}	0.3	0.45	0.6
Isolation	45	26	11
$R_{\gamma/q-jet}$ (10^{-3})	3.5	2.6	1.7
75 GeV< $M_{\gamma\gamma}$ <165 GeV	11	7	4
$p_T(2\gamma)$ > 50 GeV	5	3	1
Shower Shape	2	1	0
$R_{\ell\gamma\gamma}$ (10^{-6})	0.8	0.4	<0.4
X-Section (fb)	12.8	6.4	<6.4
• Events/SSCY	128	64	<64
Preradiator	2	1	0
$R_{\ell\gamma\gamma}$ (10^{-6})	0.8	0.4	<0.4
X-Section (fb)	12.8	6.4	<6.4
• Events/SSCY	128	64	<64

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Presentation by:

George Yost

YOST

CEM TEST BEAMS

COMMITTEE: Peter Oeues (CERN)
Hans Kobrak (FNAL)
Peter Yamin (BNL)
G. Yost (chair)

We will coordinate all test beams activity so CEM appears to speak with one voice. Our job is to expedite, not be just another level of bureaucracy.

CURRENT ACTIVITY:

2 URGENT AREAS (plus additional activity which seems to be proceeding nicely):

1) HIGH ENERGY BEAMS IN '93, '94, '95 ??

2) SSCL BEAM REQUIREMENTS

1) '93, '94, ... HIGH ENERGY BEAMS

($\gtrsim$ 100 GeV)

CERN: Presents difficulties due to cost.

CERN is requesting usage charges based on personnel, power, amortization of equipment.

Additional costs: computer time, materials & equipment, transportation, expensive per diem, ...

CERN offers 100 GeV beam to us (exclusively, if we want)

But: due to costs, 1992 requests for GEM were withdrawn. 1993 ??

Possible bright spots:

Collaboration with RD5 (Proposed)

(Della Negra / Rademacher)

CSC performance

μ backgrounds: punch-through

μ - Beams

GEM people involved in RD5 proposal:

V. Polychronakos, M. Tannenbaum BNL

A. Johnson, J. Shank, S. Whitaker BU

C. Lyndon, R. McNeil LSU

M. Mahammadi, M. Rijssenbeek, C. Yanagisawa Stony Brook

Not yet approved. Will involve a contribution for supplies, ..., if accepted.

3 reasons for optimism, but cautious.

Collaboration with RD3. (C. Fabjan)

LAr calorimetry test.

GEM people:

H. Gordon
V. Polychronakos
V. Radeka
V. Rahm
S. Rescia
I. Stumer

} BNL

Fermilab beams: None in 1992.

1993 ?. None currently scheduled.

John Peoples interested in assisting the SSC program.

DØ, CDF will not want to shut down.

Possibility between Runs Ia, Ib in 1993.

But: <u>Depends on $\bar{p}p$</u>. If some evidence seen, they will almost surely not shut down to run test beams.

If CDF or DØ develop major problems, might shut down, but – difficult to stay ready to use the time.

Urgent need: Develop a plan for running, assuming 1) FNAL, or
2) CERN

FNAL management require this plan as a start. Also, SSCL management needs this plan.

During May.

The other crisis — SSCL test beams.

Counting back from turn on in 1996, the schedule requires architectural design start now. Already in Title I (preliminary architectural design) underway.

Plan calls for

1 beam GEM
1 beam SDC
1 beam small experiments

All from the MEB ⇒ ~120 GeV max energy.

Indefinite future: 3 more MEB beams
3 HEB beams.

Can we live with this?

Goes to Title II in ~2 months.

Major issues:

- Anything affecting safety
- Beam intensity needed; composition
- Size and configuration of calibration hall
- Utilities - power, cooling, LCW, gas, ...

Meeting Saturday 9 AM

SSCL test beams issues

Next few years issues

Other running:

BNL - LAr tests

LANL - Central tracking

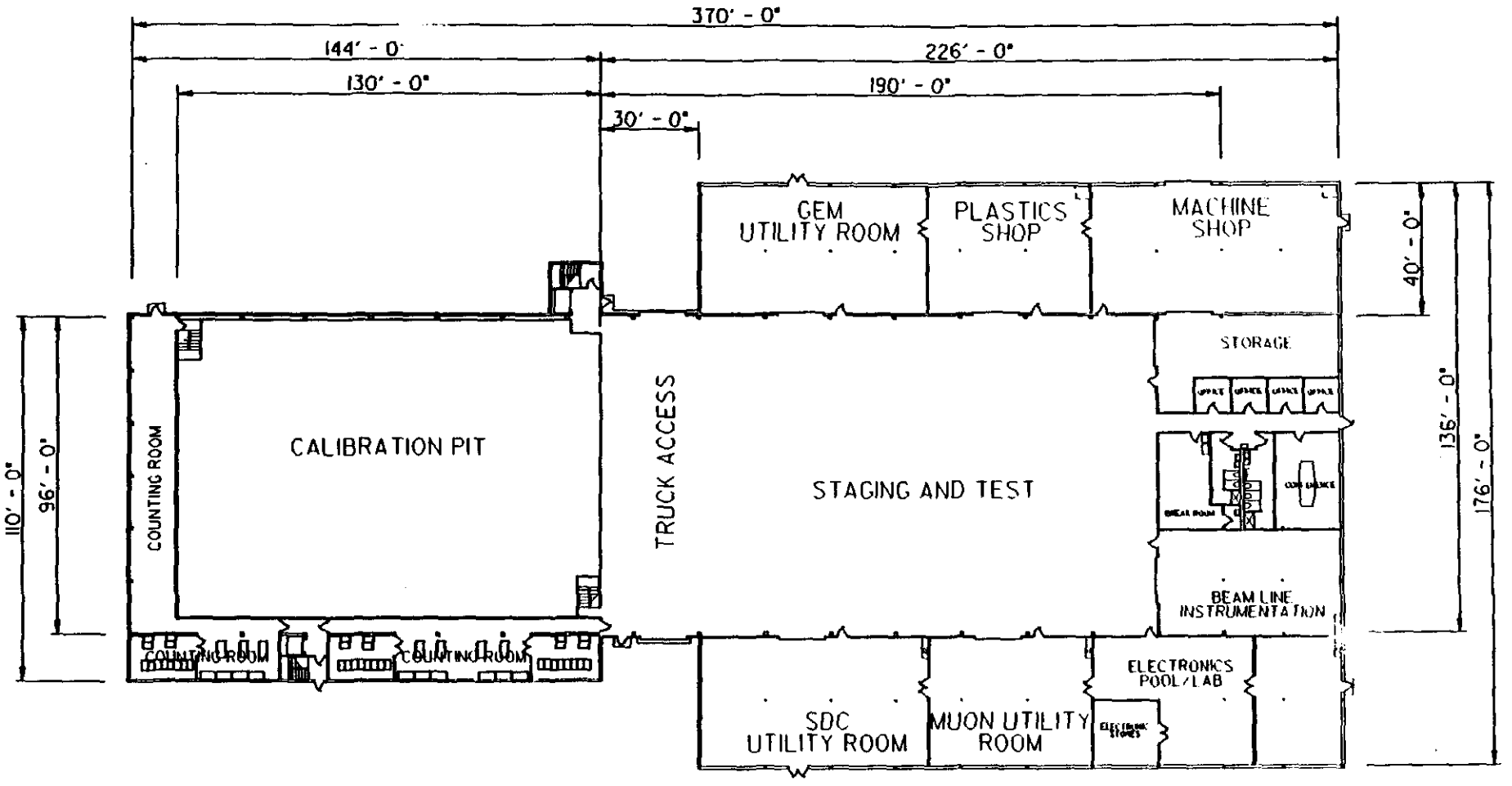
CDF's beam - μ chamber tests

Other possibilities:

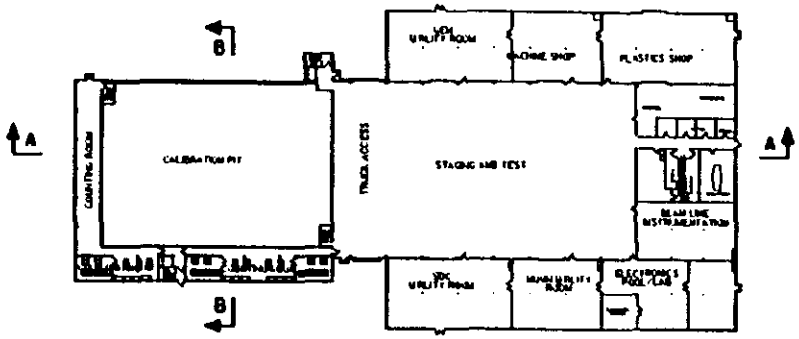
SLAC

Protvino

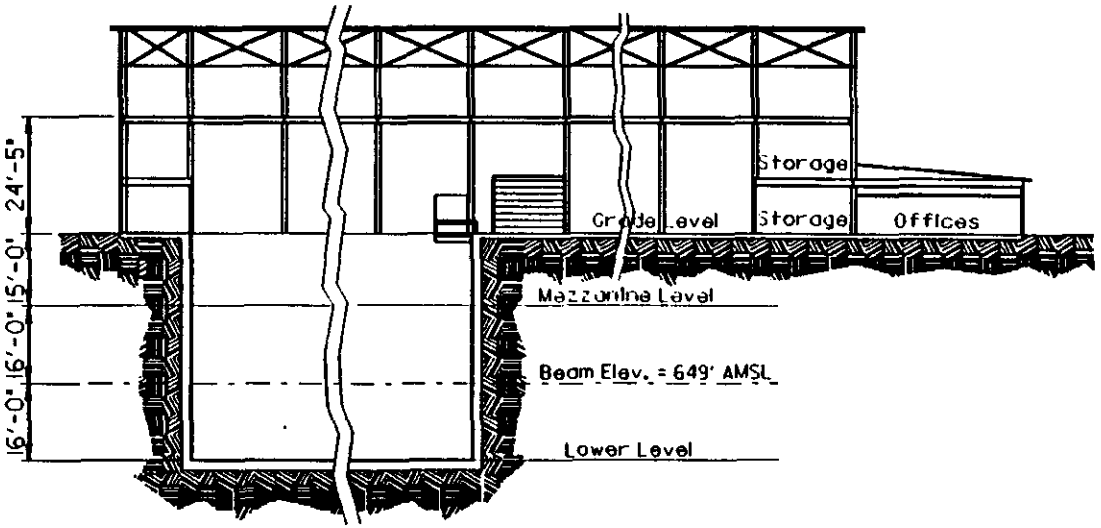
Other Russian


370' - 0"
144' - 0"
226' - 0"
130' - 0"
190' - 0"
30' - 0"
GEM UTILITY ROOM
PLASTICS SHOP
MACHINE SHOP
40' - 0"
STORAGE
CALIBRATION PIT
COUNTING ROOM
TRUCK ACCESS
STAGING AND TEST
136' - 0"
176' - 0"
110' - 0"
96' - 0"
BEAM LINE INSTRUMENTATION
COUNTING ROOM
COUNTING ROOM
ELECTRONICS POOL/LAB
SDC UTILITY ROOM
MUON UTILITY ROOM

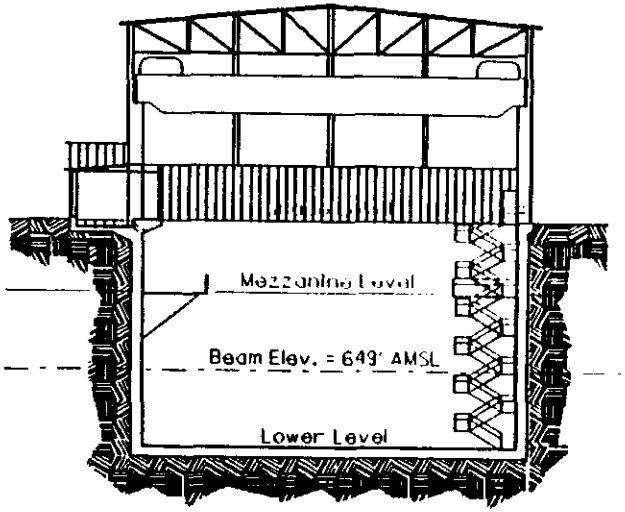
PLAN VIEW



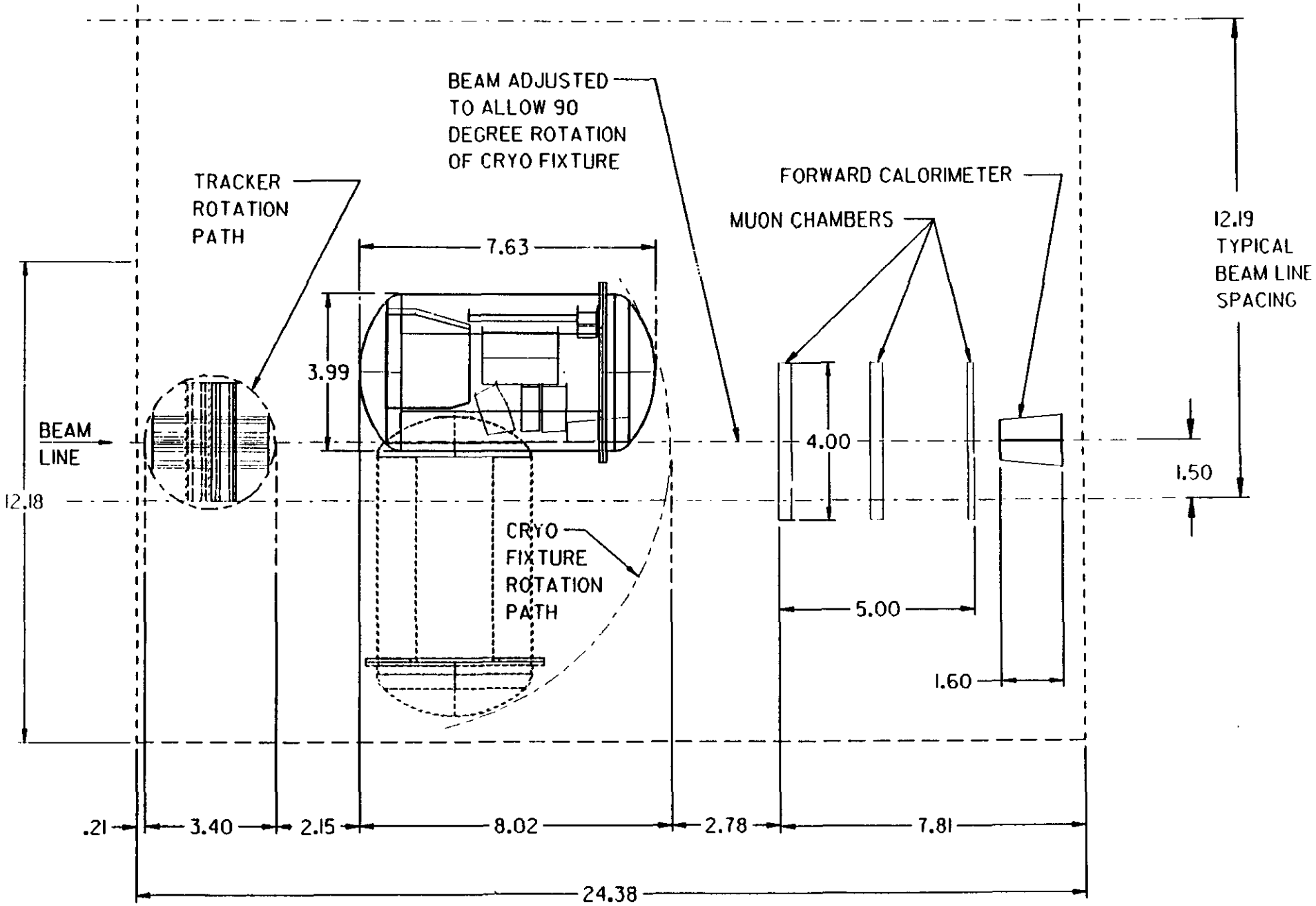
PLAN VIEW



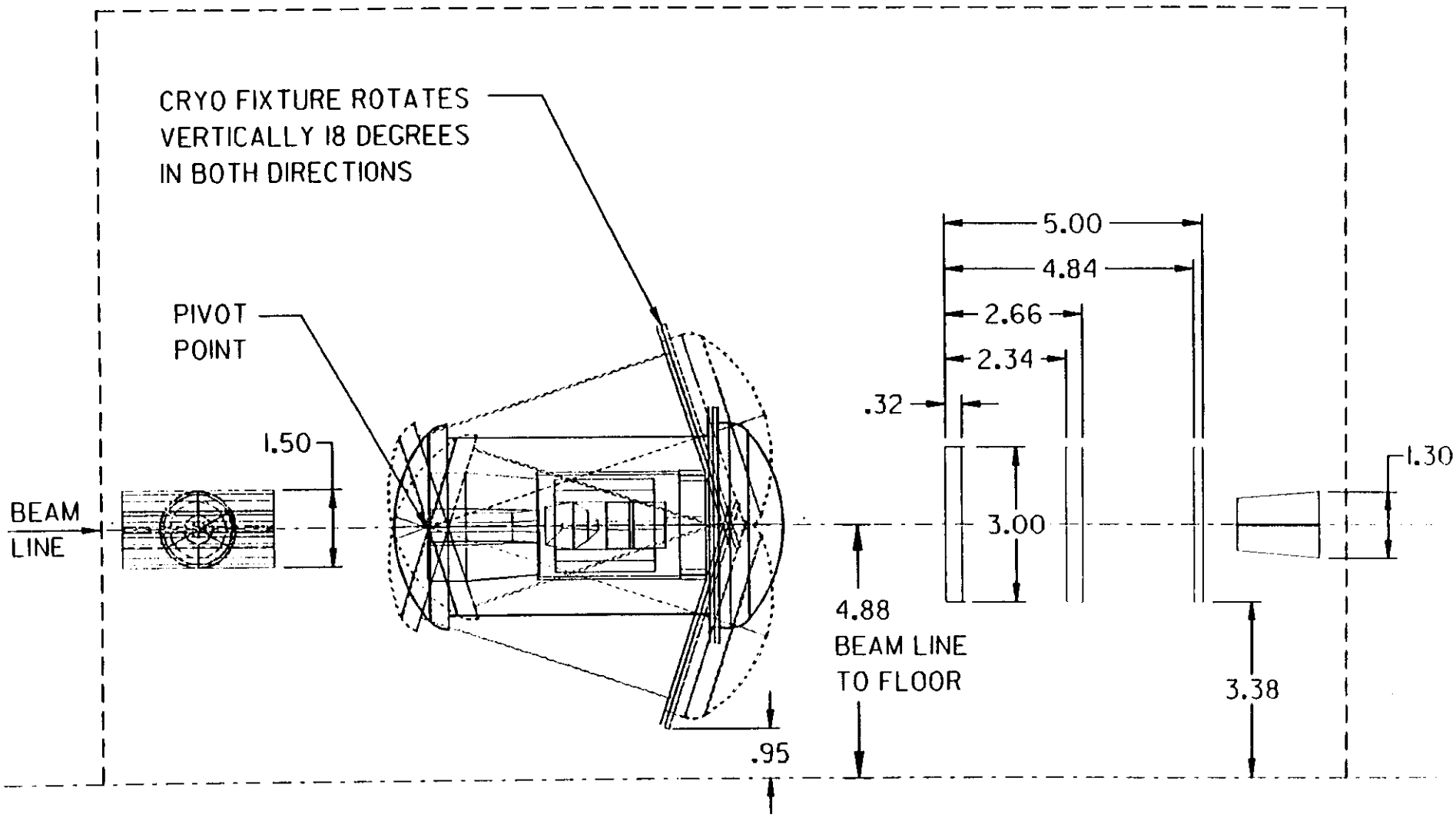
SECTION A-A



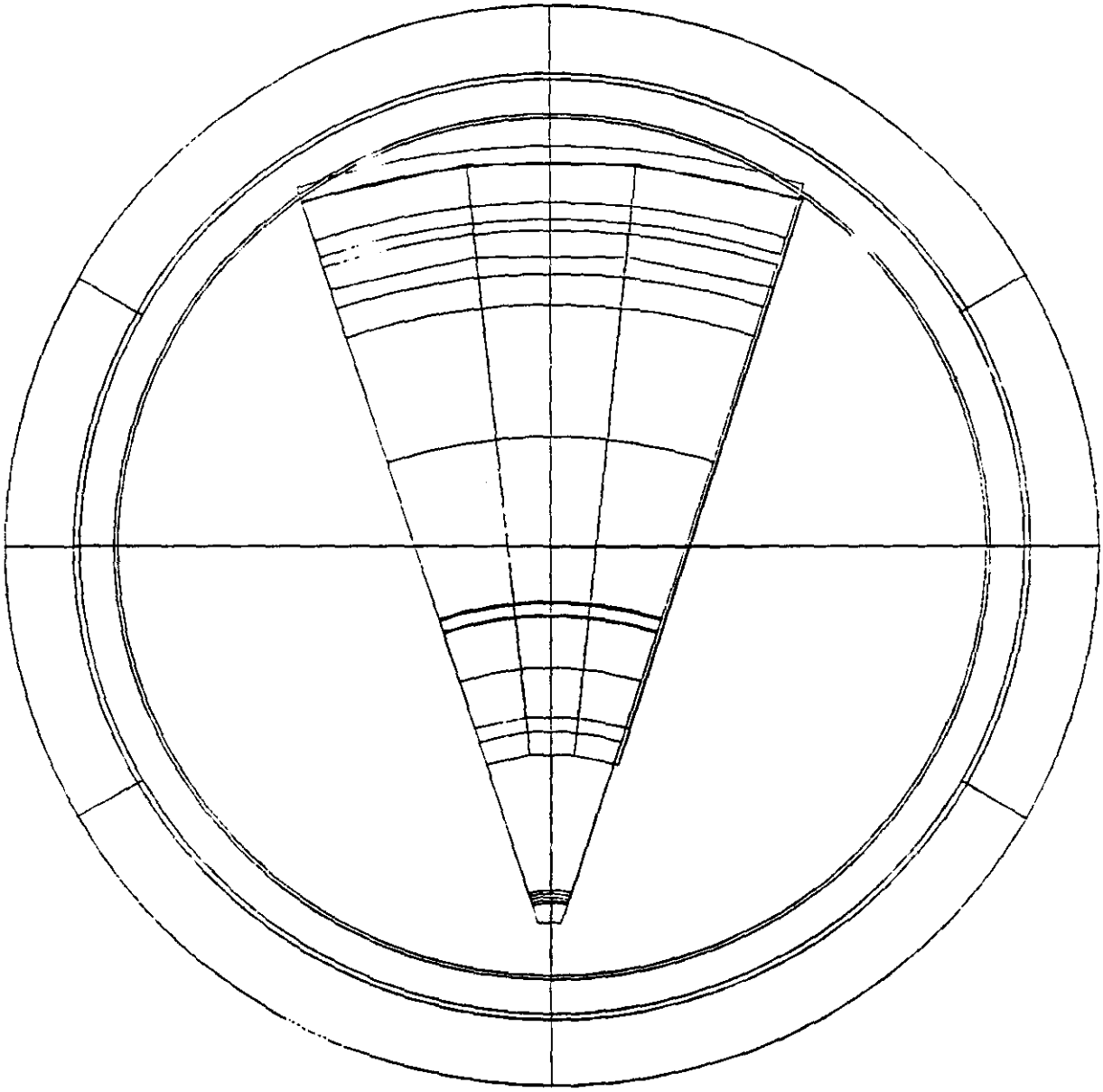
SECTION B-B

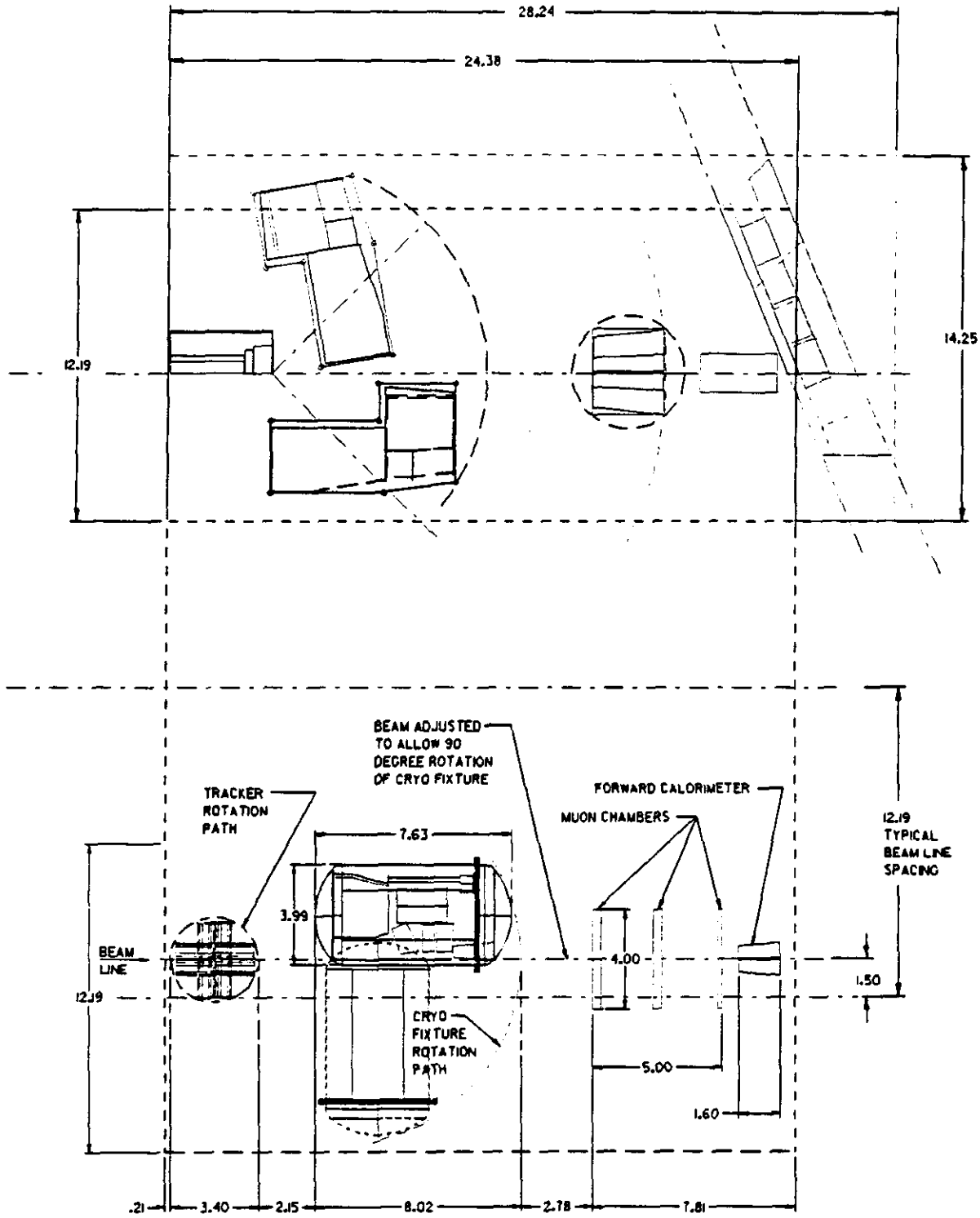

BEAM ADJUSTED
TO ALLOW 90
DEGREE ROTATION
OF CRYO FIXTURE
TRACKER
ROTATION
PATH
FORWARD CALORIMETER
MUON CHAMBERS
12.19
TYPICAL
BEAM LINE
SPACING
7.63
3.99
BEAM
LINE
12.18
4.00
1.50
CRYO
FIXTURE
ROTATION
PATH
5.00
1.60
.21
3.40
2.15
8.02
2.78
7.81
24.38

PLAN VIEW


CRYO FIXTURE ROTATES
VERTICALLY 18 DEGREES
IN BOTH DIRECTIONS
PIVOT
POINT
1.50
BEAM
LINE
5.00
4.84
2.66
2.34
.32
3.00
1.30
4.88
BEAM LINE
TO FLOOR
3.38
.95

ELEVATION




28.24
24.38
14.25
12.19
BEAM ADJUSTED TO ALLOW 90 DEGREE ROTATION OF CRYO FIXTURE
TRACKER ROTATION PATH
FORWARD CALORIMETER
MUON CHAMBERS
7.63
12.19 TYPICAL BEAM LINE SPACING
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CRYO FIXTURE ROTATION PATH
5.00
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2.15
8.02
2.78
7.81

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Presentation by:

R. Webb

4/30/92

Report on GEM

R&D / Engineering

FY '92 and beyond

- Brief Summary of work done in November/December time frame.

  GEM ENGINEERING and R&D PLAN
  GEM-TN-91-34

- Review of "Final" R&D plan. (as of January 27, 1992)
- MOU's + Proposals (some still needed)
- Planning for FY '93 and beyond

R. Webb (!)

FY '92

GEM R&D PLAN

	Total	SSC/DOE†	TNRLC*
Magnet	$5M	$5M	—
Calorimeter	4.26M	3.65M	.61M
Muons	2.43M	1.56 M	.86 M
Tracking	.84M	.842	—
Computing	0	—	—
Reserve	.41 M	.41 M	—
TOTALS	$14M	$12M	2M

as of January 27, 1992

* call for proposals April 1, 1992. Hope to hear from Commission by end of May!!

† letter from Fred Gilman received March 23, 1992.

Further Changes in the January Plan.
and requests for additional R&D monies.

- BaF_2 (change in scope resulted in slight downsizing of this program)
- Muon System Needs
  Alignment
  Detector
- Calorimeter

total in contingency $414K

BaF_2 downsizing 79K

$493K available

Supplemental Requests ~$550K

LESSONS We have LEARNED

- The best laid plans ..... BUT the alternative is frightening.

- We can't start planning too early!

- Money will always flow much slower than we can spend it!

- Are there ways that we can streamline the paperwork necessary to carry out the required GEM R&D? (MOU's, proposals, TNRCC submittals ...)

Planning for FY '93

Following the various subsystem cost reviews, we should now have a better idea as to the needed R&D/E for FY'93.

We need to assemble an R&D/E plan based on these plans for TJR, hence we need to assemble these various plans.

NEED COPIES OF DESCRIPTION OF WORK ALONG WITH BUDGETS — FAX, e-mail to R. Webb (409) 845-2590 WEBB@TAMUPHYS

BY MAY 31st.

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Presentation by:

Gary Sanders

GEM COSTS STATUS

APRIL 29, 1992

The straw man is smoldering!

BACKGROUND

1. SSC baseline has $550 million in FY90 for two detectors without escalation.
2. GEM promised to design to cost in FY91 to $500 million.
3. December GEM estimate was $510 million in FY91.
4. Annual escalation is about 5%.
5. Items 1- 3 make sense in traditional DOE accounting practices.

6. SSCL planned Theriot review of GEM costs about now.
7. SSCL canceled this review in the face of high sensitivity during HEPAP deliberations.
8. Schwitters wrote new guidance letter covering detector costs asking for a "funding plan", not a cost estimate.
9. WHAT WILL PAC EXPECT FROM US AT JULY REVIEW???
10. We have proceeded with internal cost reviews as a needed management tool to measure ourselves against DOE style costs and all previous detector reviews.
11. We have initiated incorporation of "planned" costs into estimate.
12. GEM WBS revised to latest SSC PM guidance and to possible consistency with SDC.
13. Revised cost estimating plan published.
14. Reviews of magnet, all calorimeters and electronics have been held.
15. Muon and tracker reviews next week. PM, interface systems and computing not scheduled yet.
16. New estimates done in FY92 dollars, so $500 million escalates to $525 million.

REVIEWS

PARAMETERS
2. ENGINEERING DESIGN, LAYOUT, ANALYSIS
3. ASSEMBLY/INSTALLATION PLAN. LABOR ANALYSIS.
4. CONTINGENCY ANALYSIS
5. R&D ESTIMATE
6. VENDOR ESTIMATES
7. TOOLING, FIXTURES
8. SUBSYSTEM PROJECT MANAGEMENT
9. VENDOR MARKUPS (MAGNET)

10. ELECTRONICS COST ESTIMATE USING CATEGORY RATES FROM LECROY

SUMMARY RESULTS

MAGNET FY91 target = $120 million + R&D 5-10%
Estimate $135 million FY92 including R&D

ELECTRONICS no FY91 target except for DAC/TRIGGER = $10 million but estimate totals $120 million with $80 million in subsystems, so $40 million FY92 compares to $10 million FY91. R&D outside this set of numbers.

CALORIMETER FY91 target = $150 million + 11% R&D. Estimates are:

LAC (integrated)	$136 million ($80 million is hadronic) FY91with R&D
SCI-FI	$57 million FY92 with R&D
BaF2	$80 million FY92 with R&D
Plastic Tile hadron	$52 million FY92 with R&D
Liq. krypton parallel	$38 million FY92 with R&D
Liq. argon forward	$15 milllion FY92 with R&D
Scintillating liq. forward	$16 million FY92 with R&D

WE ARE POTENTIALLY $40 million OVER TARGET WITHOUT TRACKER AND MUON SYSTEMS.

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Presentation by:

C. Baltay

GEM ORGANIZATION COMMITTEE

1. Present Membership
   - C. Baltay
   - J. Branson
   - A. Chargin
   - J. Friedman
   - G. Mitselmakher
   - I. Pless
   - J. Reidy
   - J. Rutherfoord
   - N. Samios
   - R. Stroynowski
   - Xiao-Qi Yu

2. Time scale of Deliberations
   - Preliminary report by July 92
   - Final report by November 92

3. Collect information on organization of other large Collider Detector Groups

4. Input from GEM Collaboration
   - Call for comments, letters, etc
   - Discussions at Collaboration Meetings
   - Possibly more specific questionaire or poll of entire Collaboration

GEM COMMITTEE ON ORGANIZATION

Areas of Concern

1. Organization chart
   - Function of each element
   - Interrelation of elements

2. Procedures
   - Who gets to be in each box
   - For how long (terms of office)
   - Who selects them, and how
   - New Collaborators
   - Relations with SSCL and DOE

3. Frequency and Sequence of Various Meetings