GEM TN-93-397

GEM Muon Engineering Status Meeting - SSCL

April 15, 1993

Abstract:

Agenda, attendees, and presentations of the GEM Muon Engineering Status Meeting held at the SSC Laboratory on April 15, 1993.

Date: Fri, 9 Apr 1993 15:00:33 -0500 (CDT)
From: MARX@SSCVX1.SSC.GOV (MICHAEL MARX BACK AT THE SSC AGAIN 214 708 6188)
Message-Id: <930409150033.2022f8c4@SSCVX1.SSC.GOV>
Subject: MUON ENGINEERING STATUS REVIEW AT SSCL THURSDAY APRIL 15
To: WUEST@EDSEQ1.llnl.gov, neuromancer@draper.com, lau@uhibpd.phys.uh.edu,
horvath@lll.llnl.gov, belser@lll.llnl.gov, nimblett@draper.com,
hbaker@draper.com
X-Vmsmail-To: @ENG.LST

AGENDA FOR ENGINEERING REVIEW (PRE PAC)
THURSDAY APRIL 15 SSCL
9AM ROOM TO BE FIXED (DURDEN)

We will hold a one day review of the ENGINEERING status of the muon system. The meeting will be in 2 parts; the morning will be spent on presentations of the status and requirements which drive the current design; the afternoon will examine what work needs to be done to defend the CURRENT design, and discussions of possible means of improvements. We will then attempt to prioritize the efforts and distribute the load. All speakers in the morning should give a crisp presentation of the design status, indicating where possible the driving constraints, and also discuss the areas where the design is weak and needS further work. Minimal attention should be paid to historical perspectives and philosophical issues. This review should serve as a practice for the May PAC presentations. All those who attend should be critical in order to expose our weaknesses in a friendly environment.
Please make sure that all key people from your institution attend. I do not have a complete list of email addresses so I rely on you to pass the word. Attendance at this meeting is intended for all key engineering staff, and a limited number of cognizant physicists who can provide guidance for the design.

In the agenda I list the major topics and some issues that come to mind. This is not an exclusive list, rely on your judgement in selection of material

1 INTRO....M .MARX/ C. WUEST
2 CHAMBER DESIGN STATUS.... Y.KIRYUSHIN/C JOHNSON
   Include design details, manufacturing constraints, assembly constraints
   Tolerances on manufacture
3 CHAMBER SUPPORT REQUIREMENTS..... J HORVATH
   Chamber rigidity and possible support/stiffening schemes
4 ALIGNMENT REQUIREMENTS... PARADISO/MITSELMAKHER
   Requirements on system design from alignment
      Paths,tolerances(chamber and positioning),thermal....
5 SUPPORT STRUCTURE.... NIMBLETT
6 INTERFACES..... NIMBLETT
7 ASSEMBLY/COMMISSIONING.... NIMBLETT
8 SERVICES.... JOHNSON
   Requirements on system from service routing,connections,access...
9 REVIEW OF MAJOR ISSUES/DESIGN DEFICITS
10 DISCUSSION...ACTION ITEMS....RESPONSIBILITIES

GEM MUON ENGINEERING STATUS MEETING 4/15/93

NAME	ORGANIZATION	TEL / E-MAIL	
CURT BELSER	LLNL	510-423-2472	BELSER@LLL.LLNL.GOV
STEVE PRATUCH	LLNL	510-423-2818	N/A
JOHN HORVATH	LLNL	510-422-1486	HORVATH@LLL.LLNL.G..
Yuri Kiryushin	SSCL	708-6303	SSCVX::KIR
FRED HOLDENER	LLNL	510-422-7003	HOLDENER@LLL.LLN..
TOM LEE	DraperLabs	(617) 258-4186	twL4186@Draper.com
Frank Taylor	MIT	617-253-7249	FET@MITLNS
Peter Seberius	DRAPER LAB	(617) 258-8149	SEBERIUS@DRAPER.COM
Howard Baker	Draper	(617) 258-3411	hbaker@draper...
Vinnie Polychronakos	BNL	(516) 282-3982	POLYCHRON@BNLDAG..
MITCH HANSBERRY	DRAPER LAB	617-258-1272	MHANSBERRY@DRA..
FRANK NIMBLETT	DRAPER LAB	617-258-1343	Nimblett@draper.com
ED HUDSON	SSCL	214-708-	
DAN GAIGALAS	SSCL	708-3266	DANIEL_GAIGALAS.SSC..
Craig Wuest	LLNL	(510) 423-2909	WUEST@LLNL.GOV
Joe Paradiso	Draper	617-258-2413	[illegible]@draper
COLEMAN JOHNSON	SSCL	214-708-1188	JOHNCOLE@SSCVX1

Simpson Gumpertz & Heger Inc.
consulting engineers

Arlington, MA • San Francisco, CA

297 Broadway
Arlington, Massachusetts 02174-5310
(617) 643-2000 Telex 940103 Fax 643-2009

DATE: 15 APRIL 1993

FAX #: 214 708 6088

COMM.: 93095

NO. OF PAGES TO FOLLOW: 2

FROM: RASKO OJDROVIC

SUBJECT: PRELOADED CONNECTIONS

TO: SSCL

ATTN.: DR. MICHAEL GAMBLE

CC:

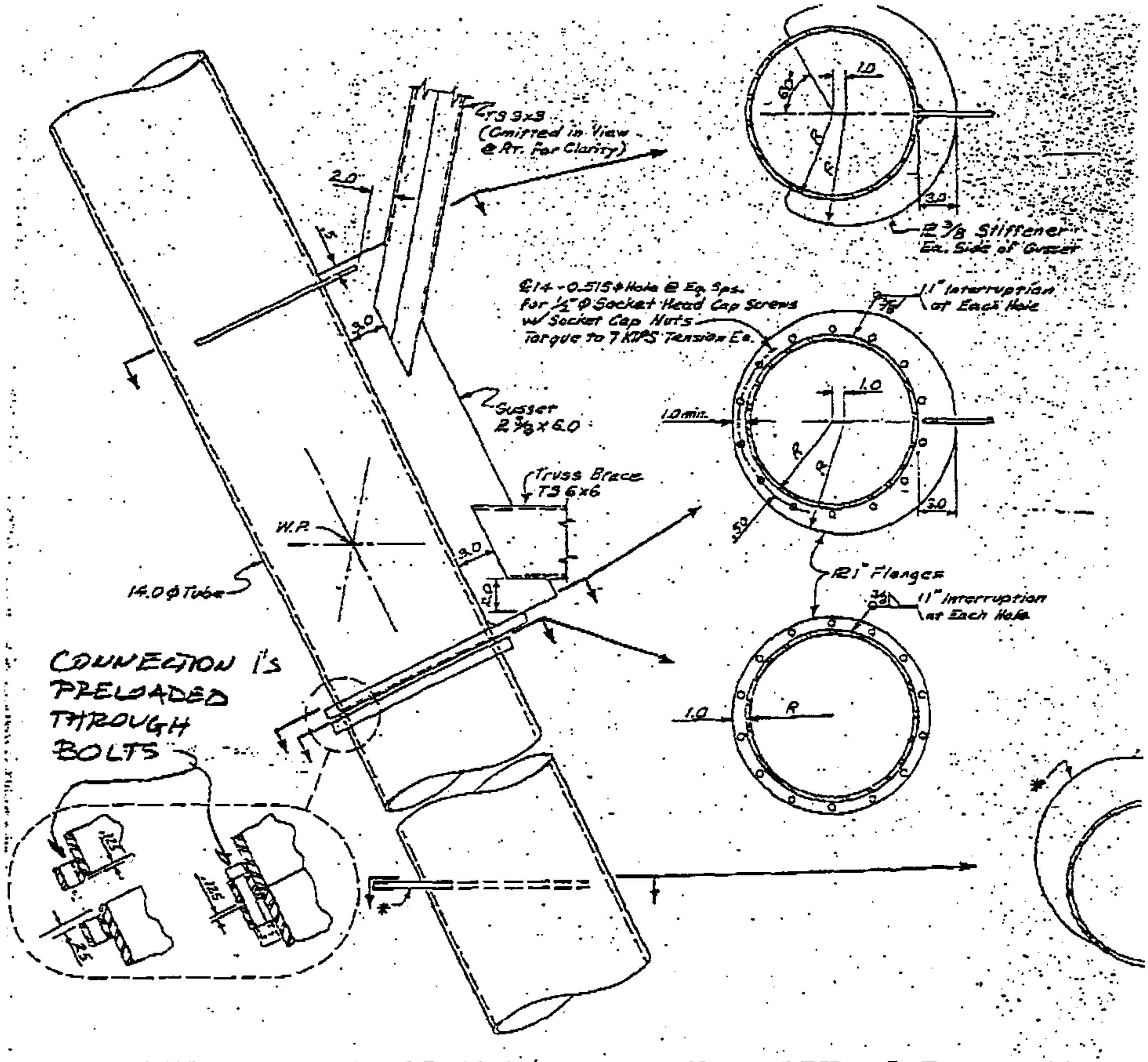
If you have not received all of the pages listed, contact us at extension 300 of the above number.

NOTE:

ENCLOSED ARE SKETCHES OF TWO PRELOADED CONNECTIONS.

→ Typical high-precision and dimensionally stable "bolted" joint used for radio telescope assembly.

M Gamble



MID-MEMBER SPLICE & CONNECTION DETAILS (A / S-7)

Scale: ⅛ Actual Size Ref. S-1

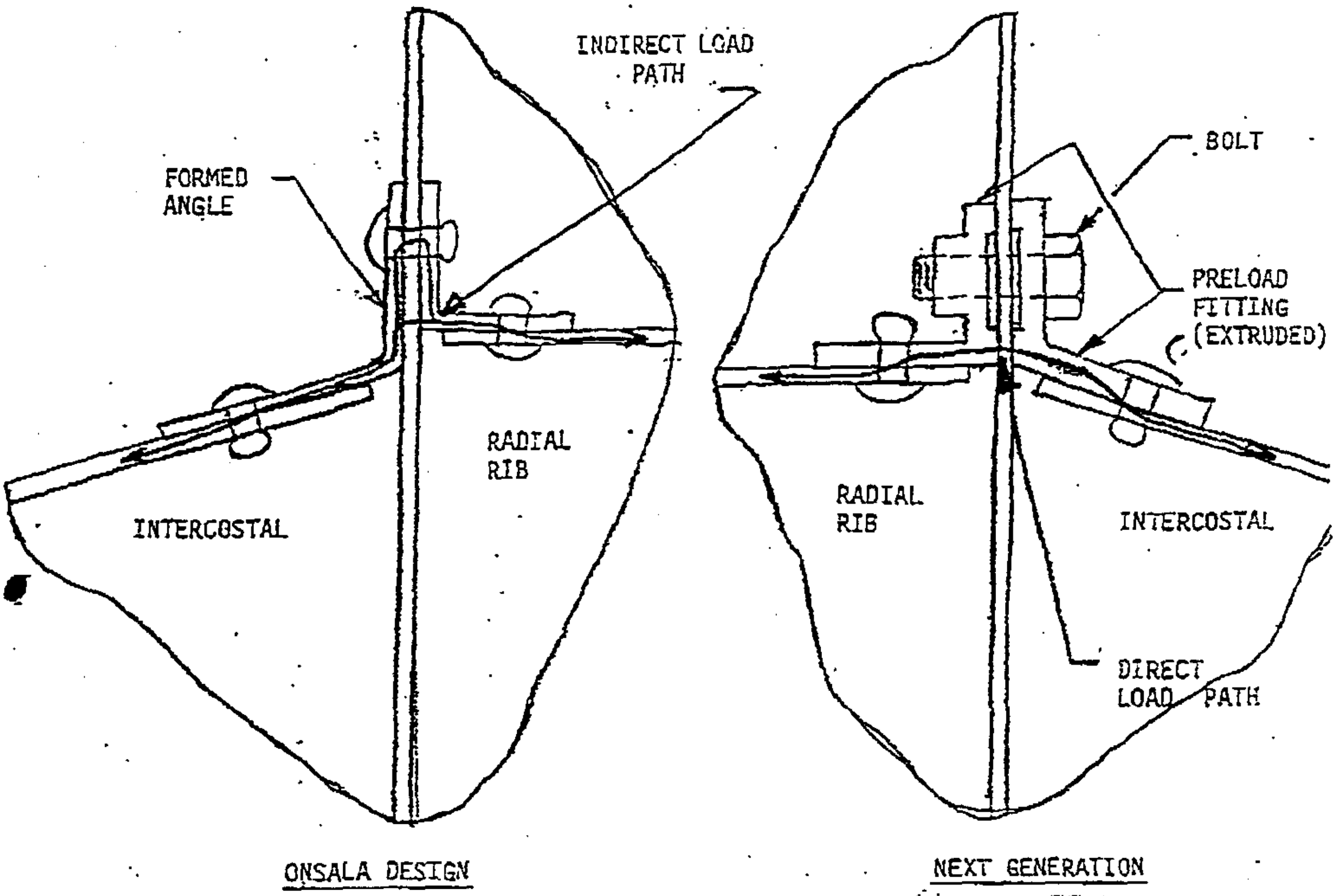


FIGURE 1 RIB/INTERCOSTAL JOINT DESIGN

gem γeμ

Presentation by:

Frank Nimblett

Structure

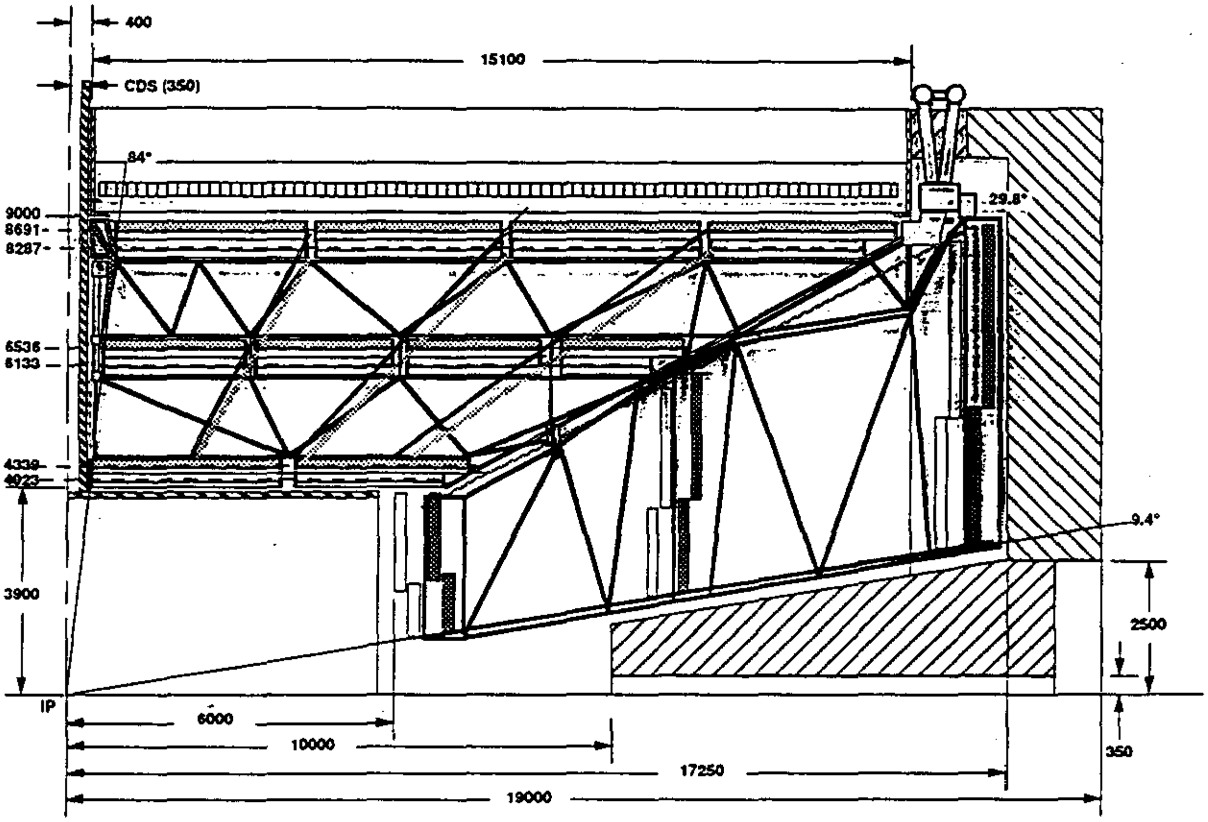


Figure 4.1a: Overview of GEM Muon Sytem (quadrant elevation view)

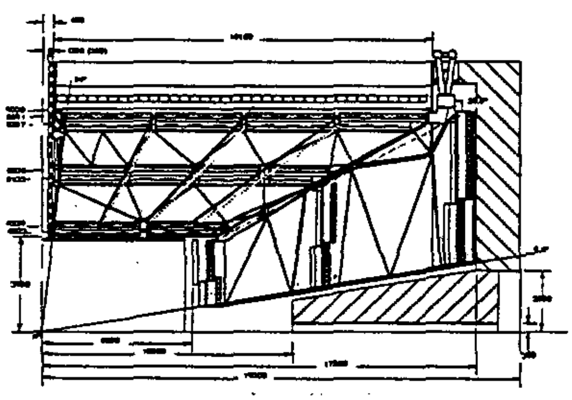
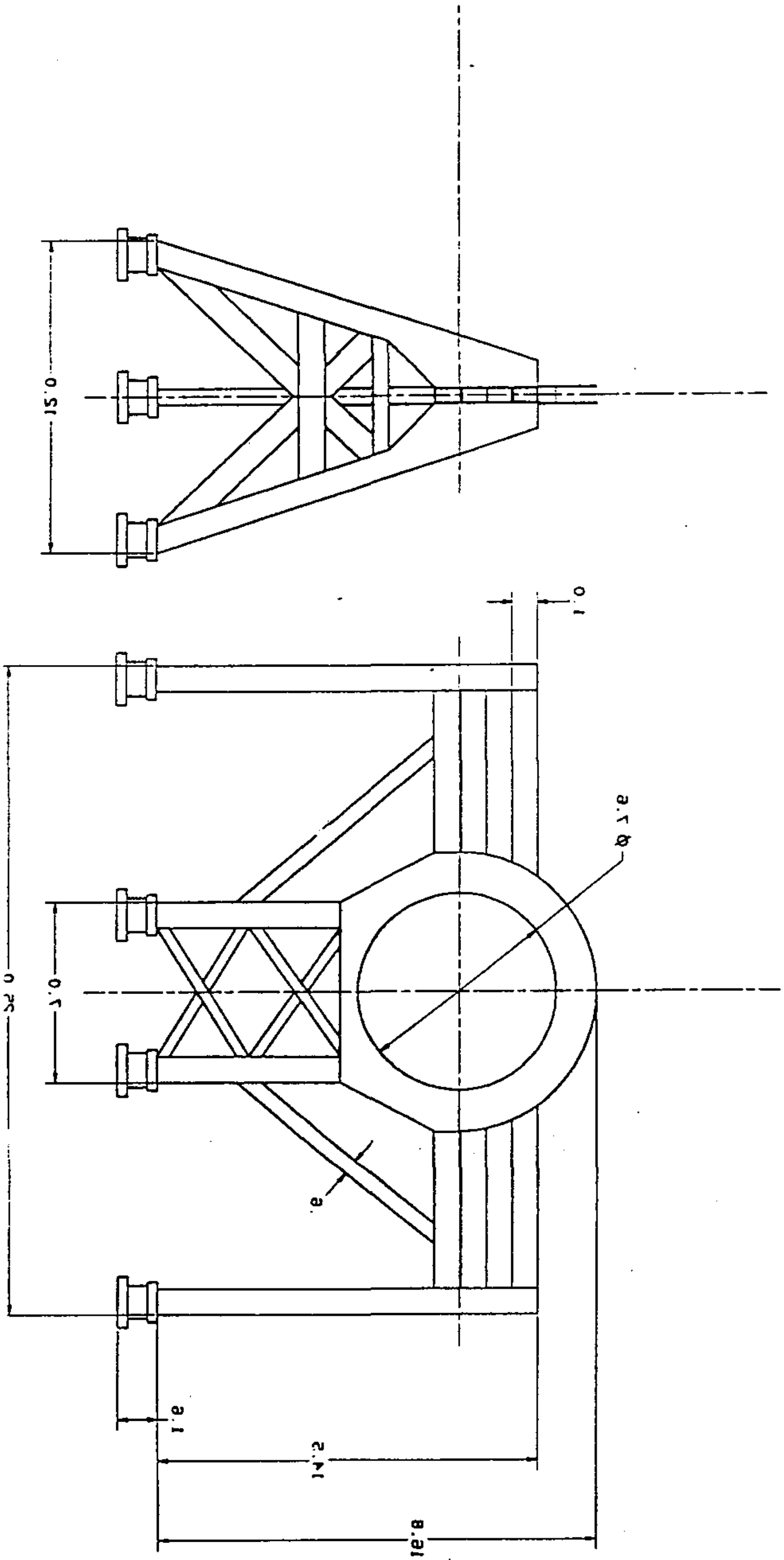
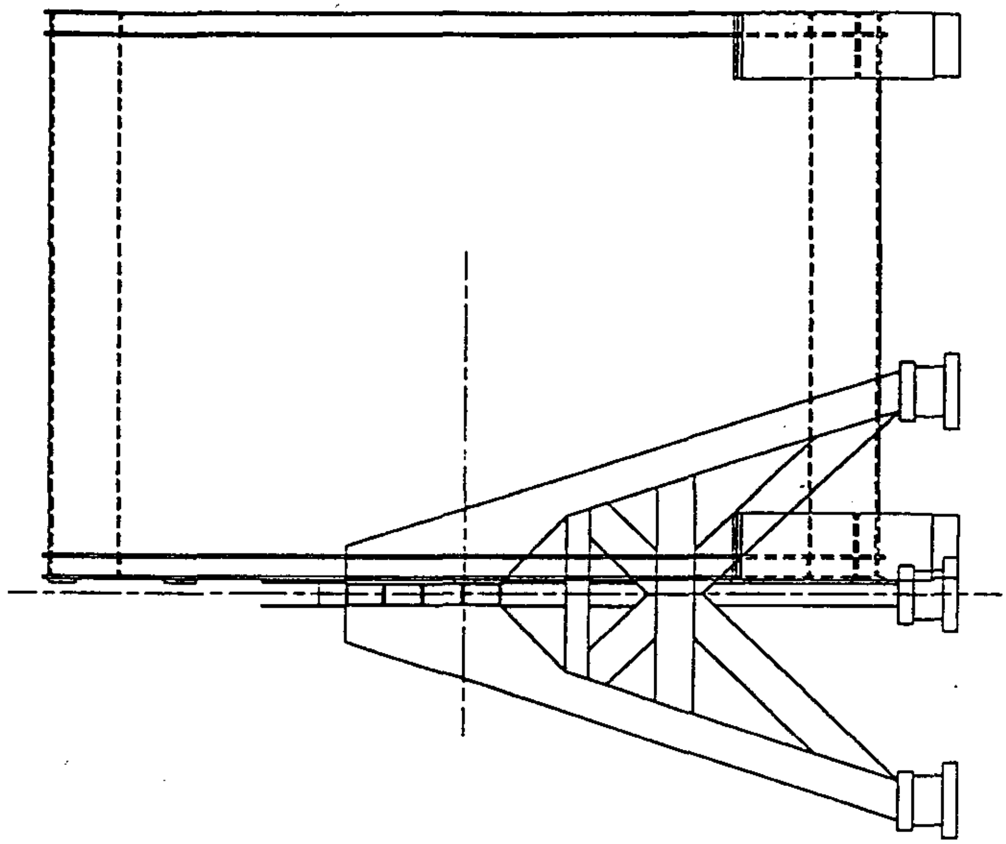
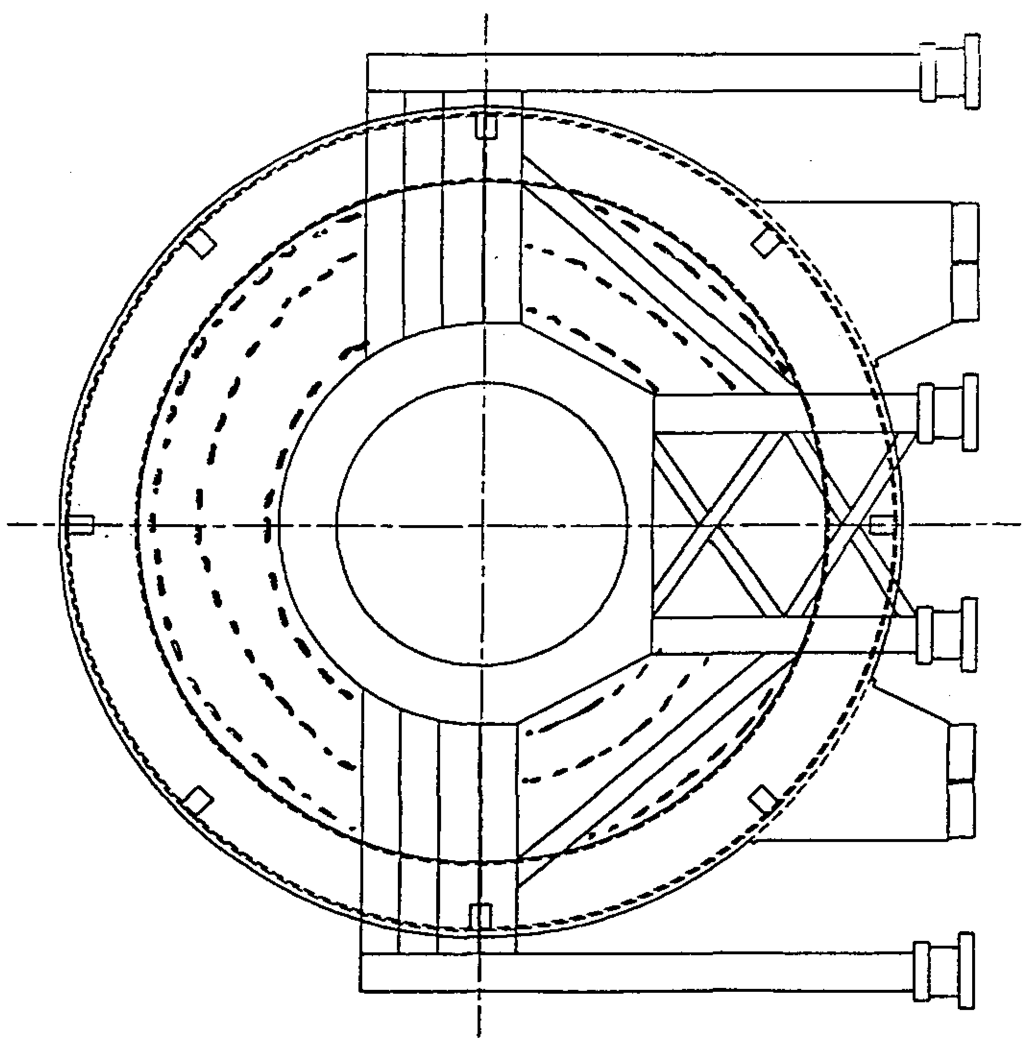


Figure 4.1a: Overview of GEM Muon Sytem
(quadrant elevation view)


15.0
25.0
7.0
1.0
1.8
14.2
16.8





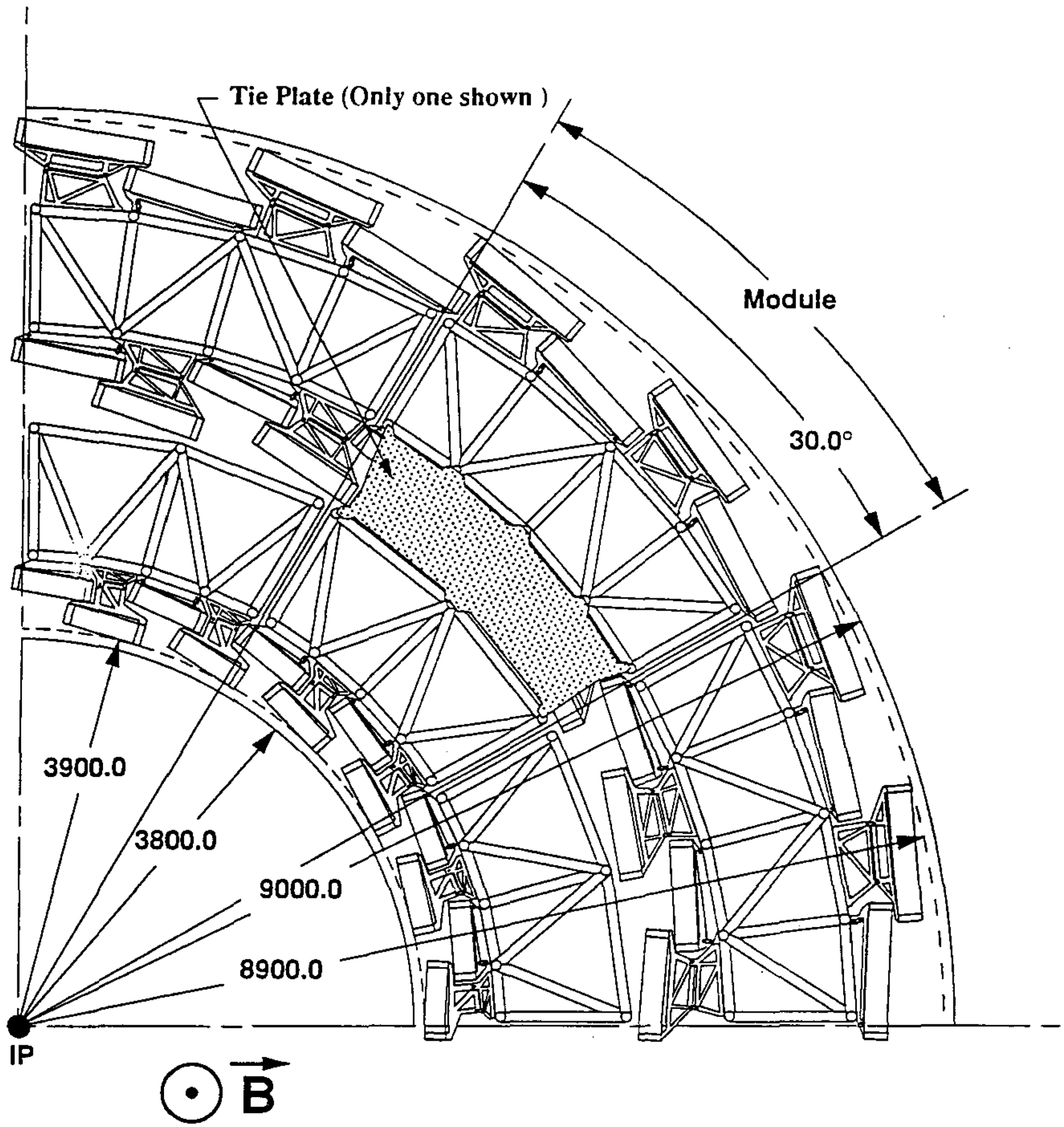


Figure 4.1b: Muon System End View (1/4 Section)
View from North End of UG Hall

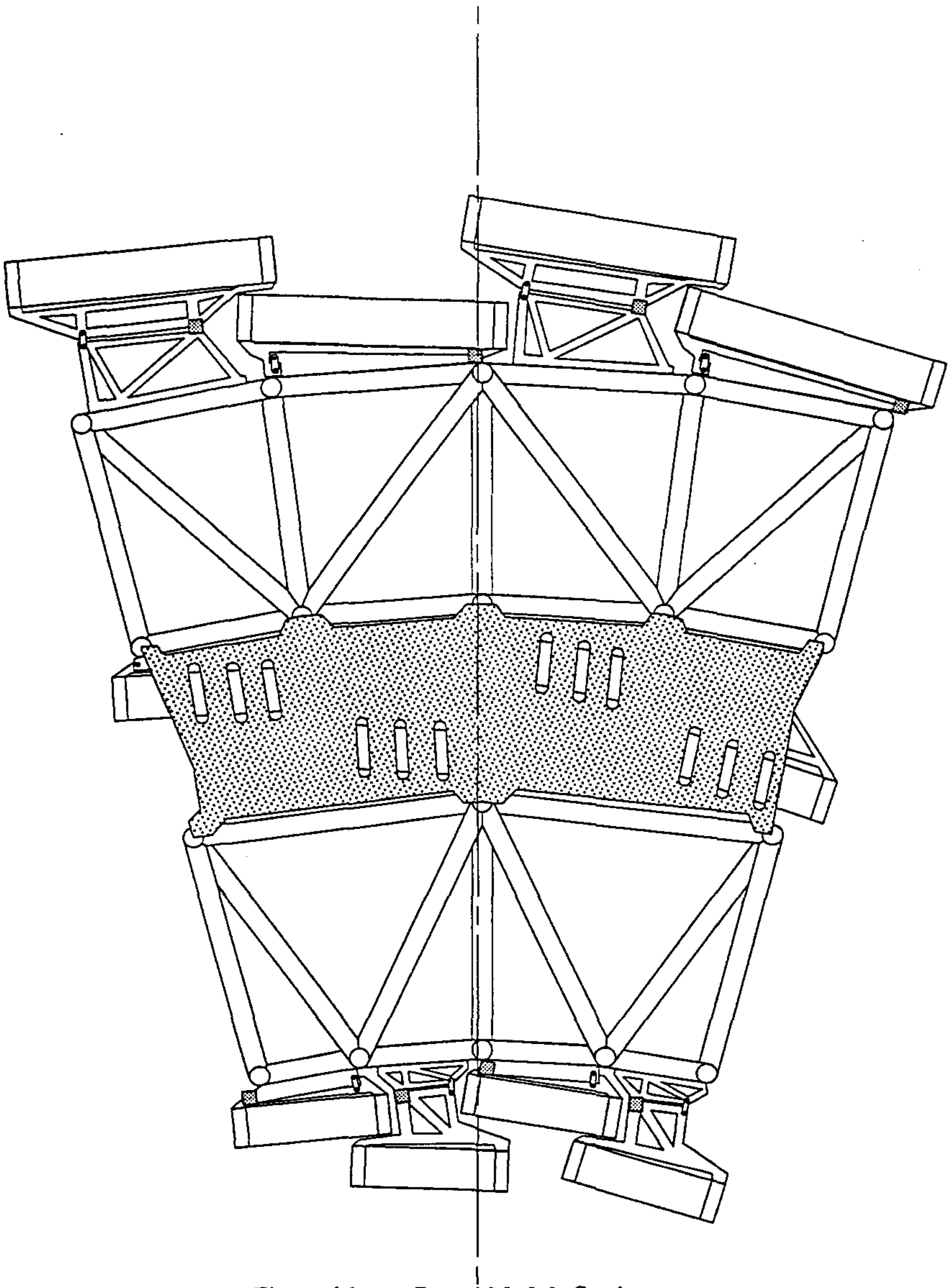


Figure 4.3.x.y: Barrel Module Section

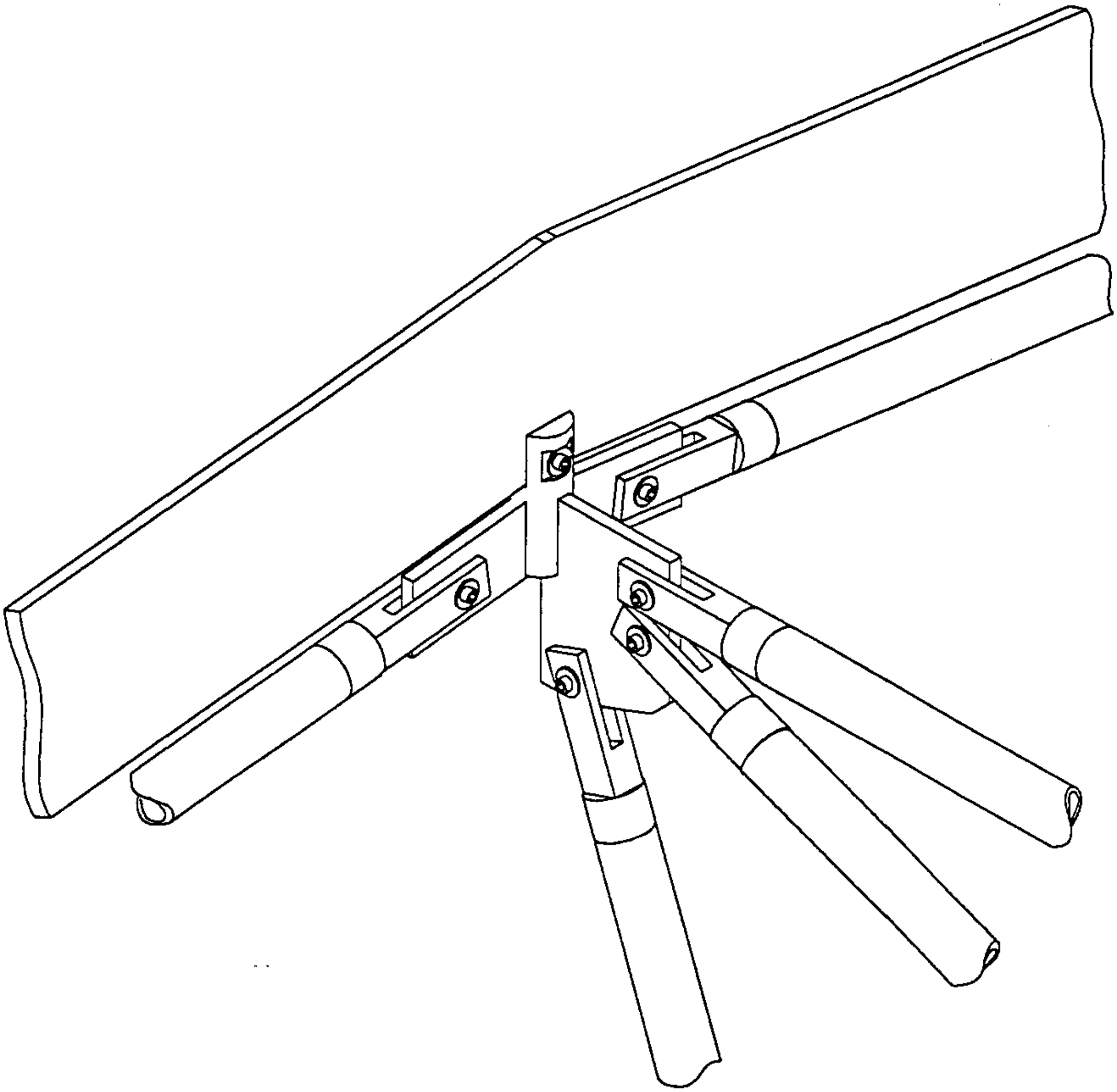


Figure 4.3.3.5; Truss Joint Detail

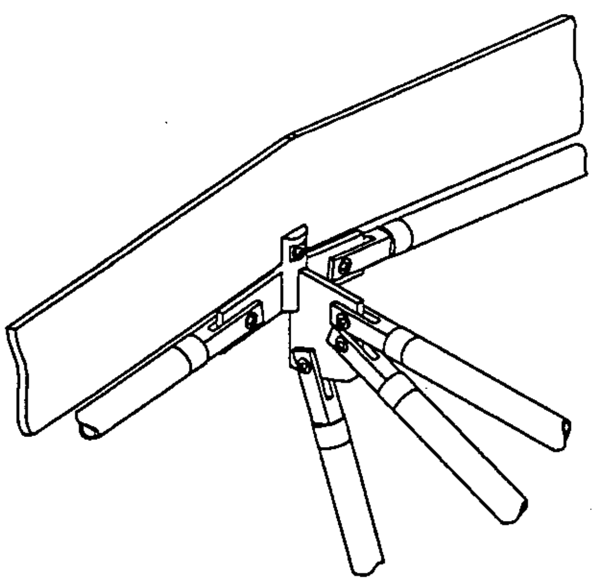


Figure 4.3.3.5; Truss Joint Detail

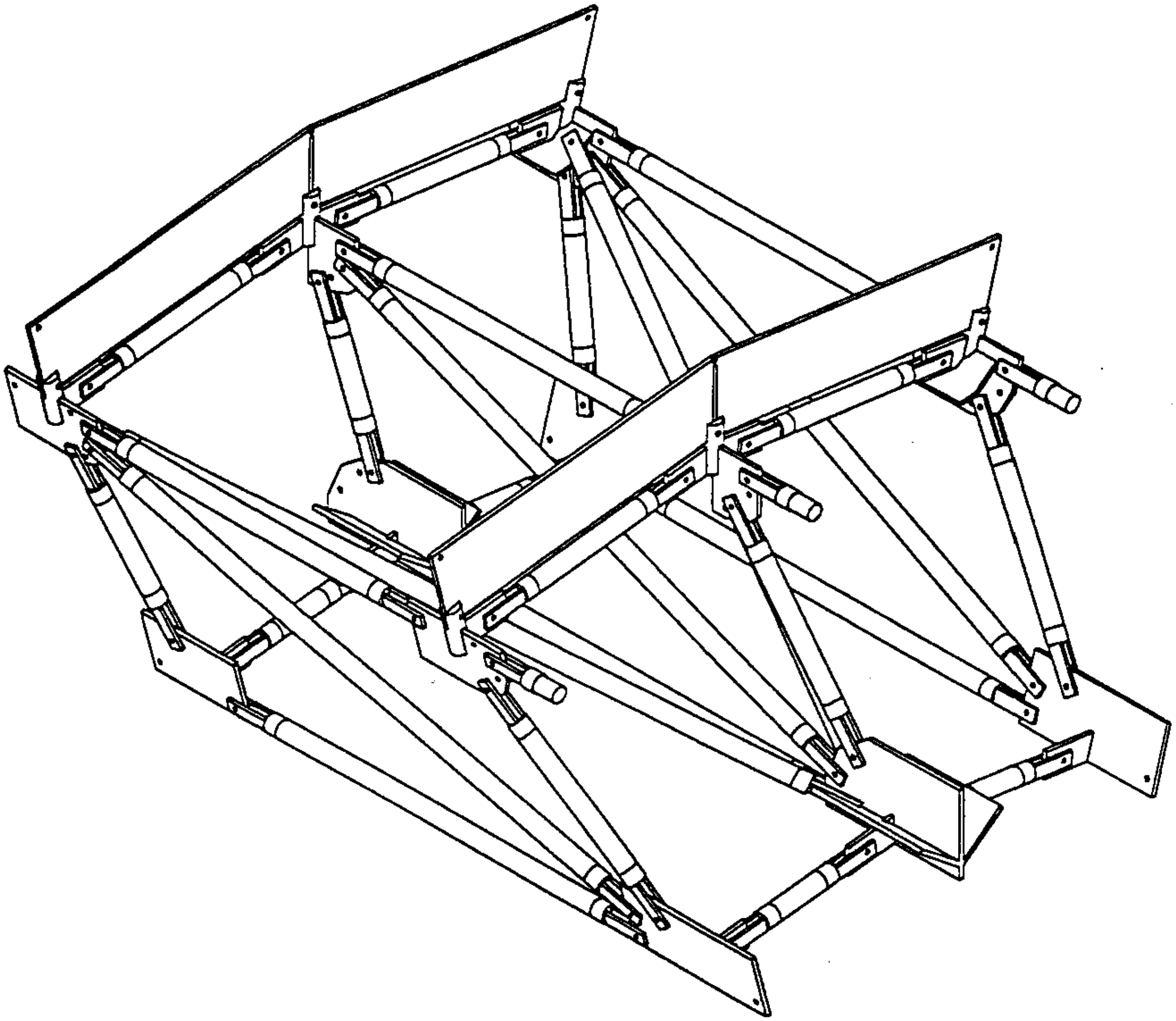


Figure 4.5.1: Muon Support Structure Detail

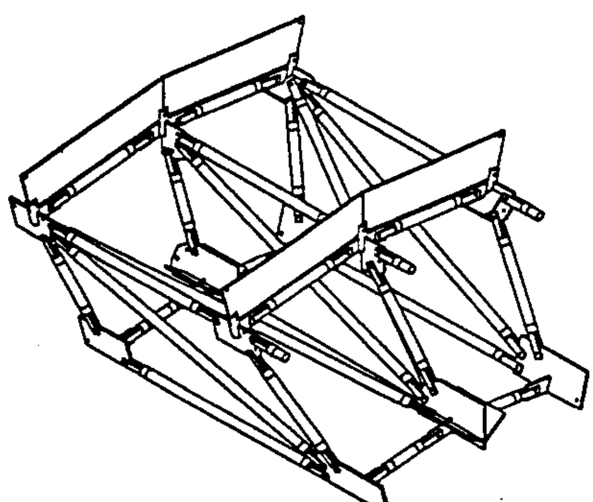
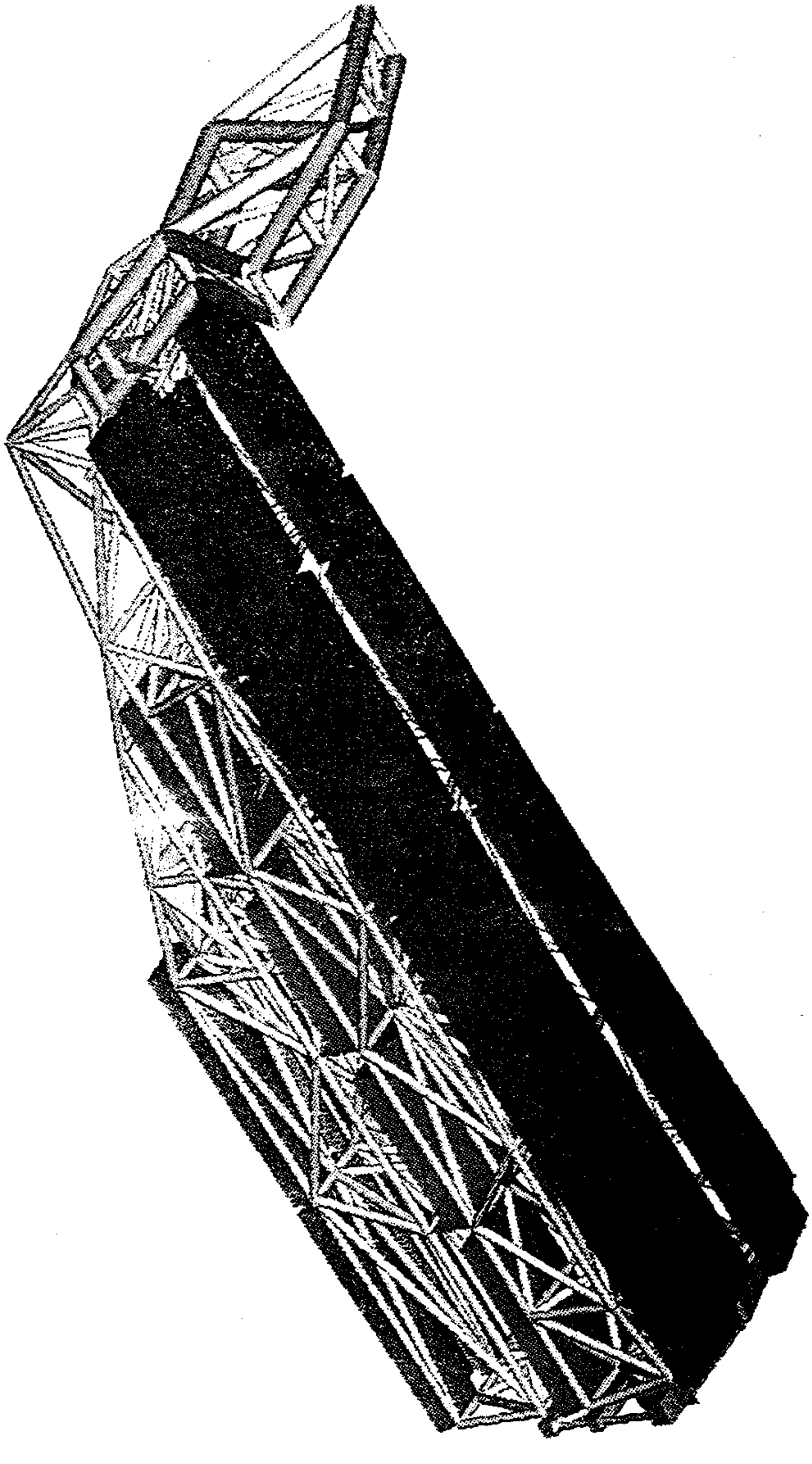
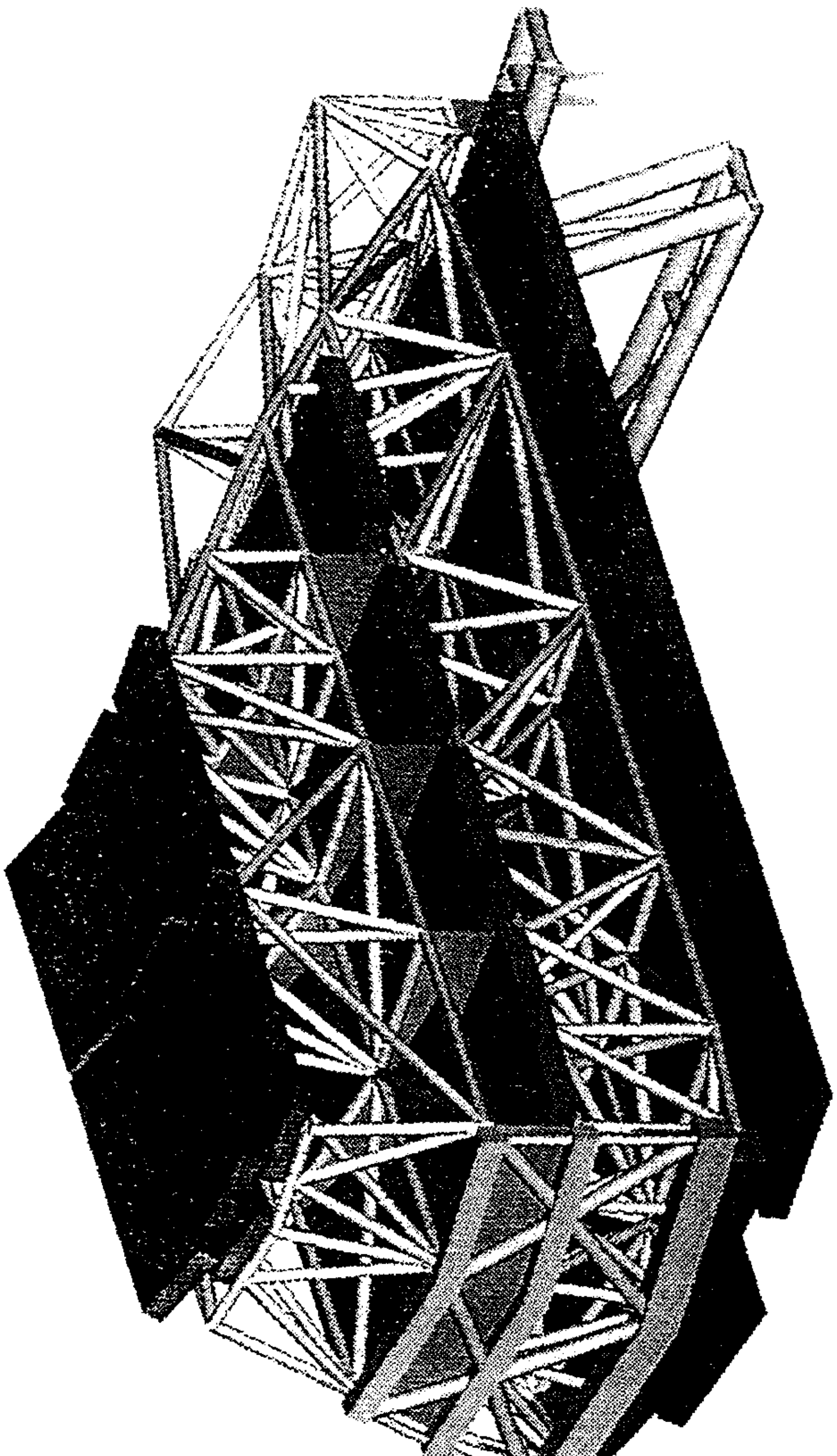
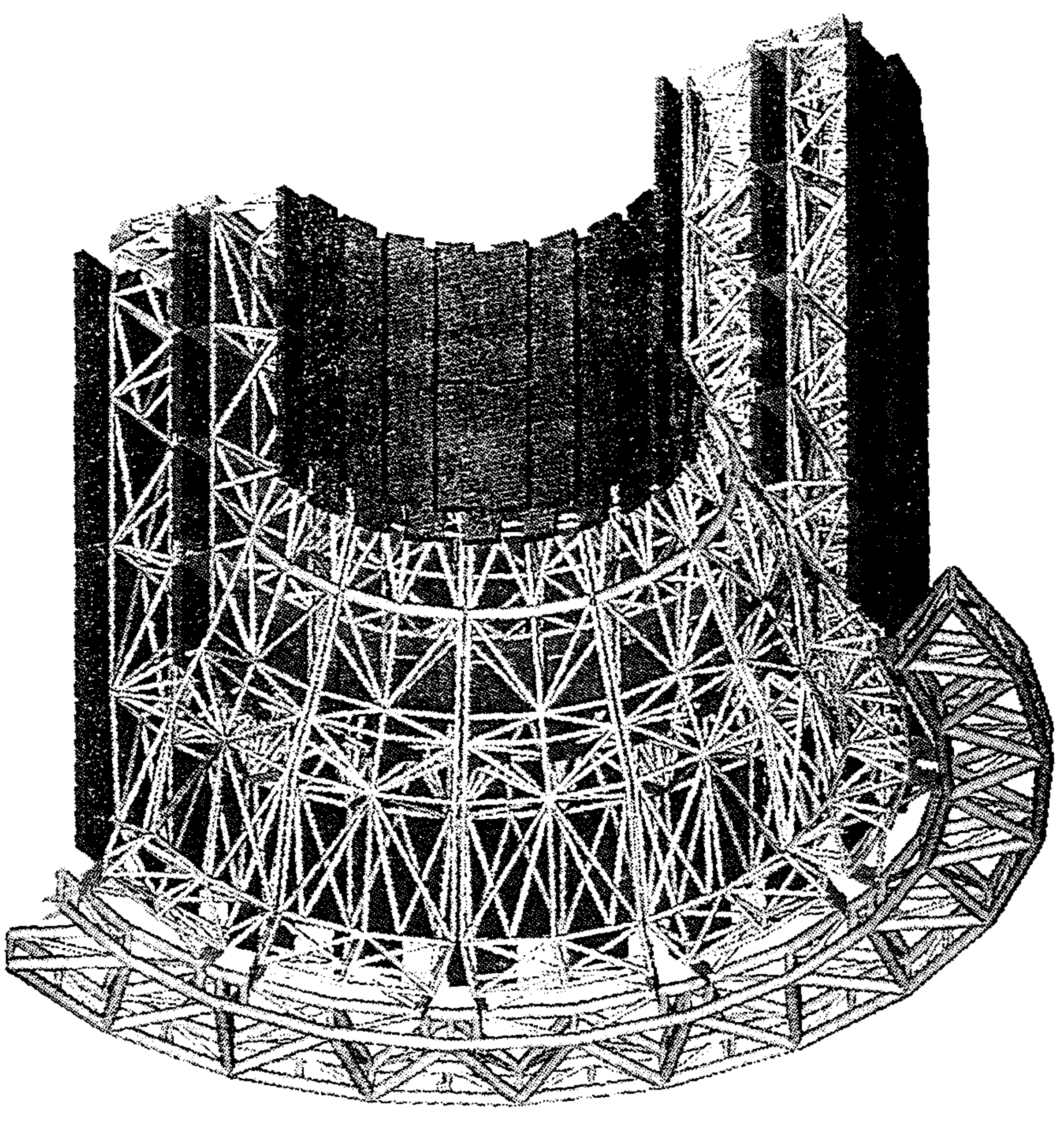
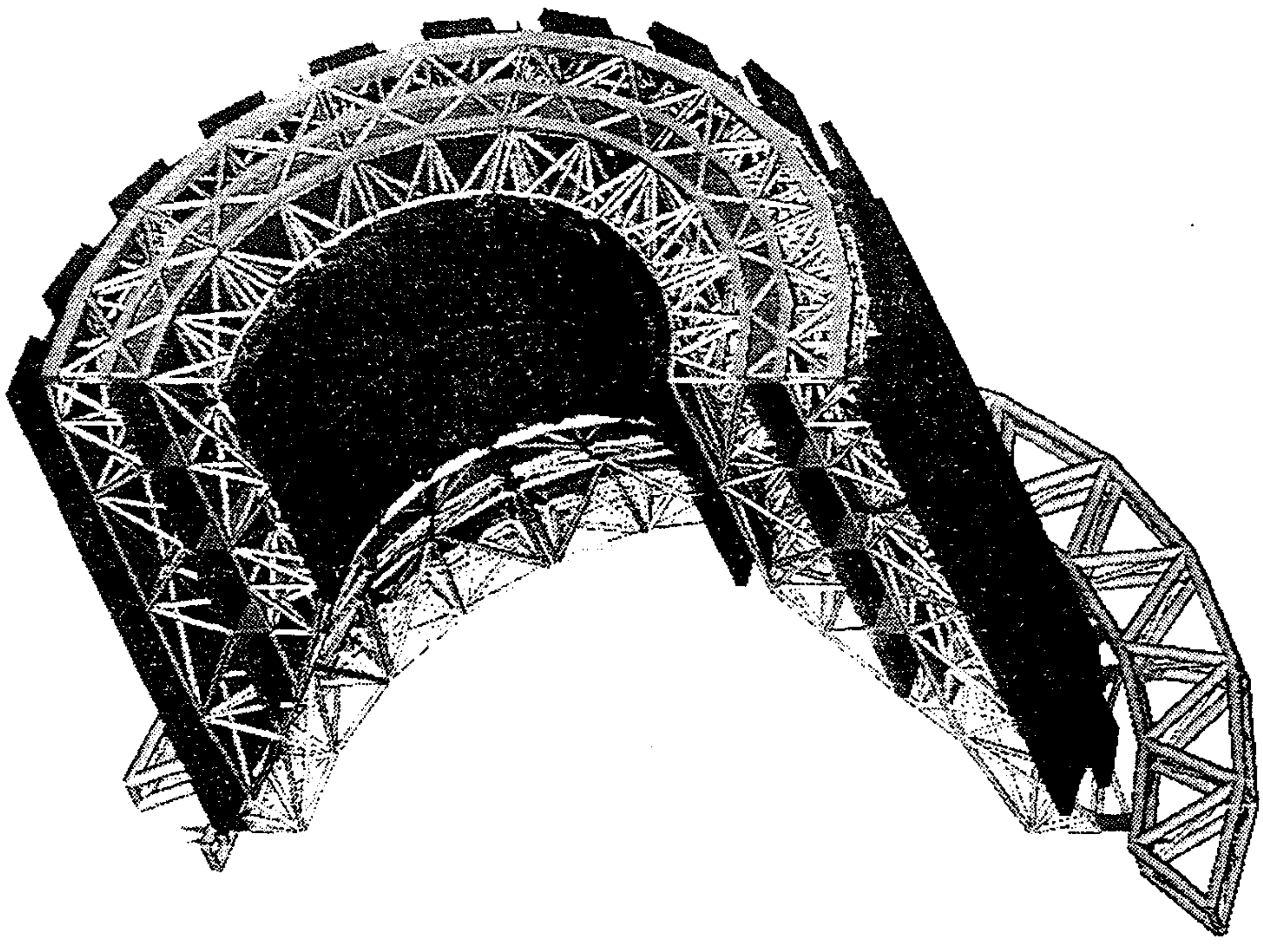


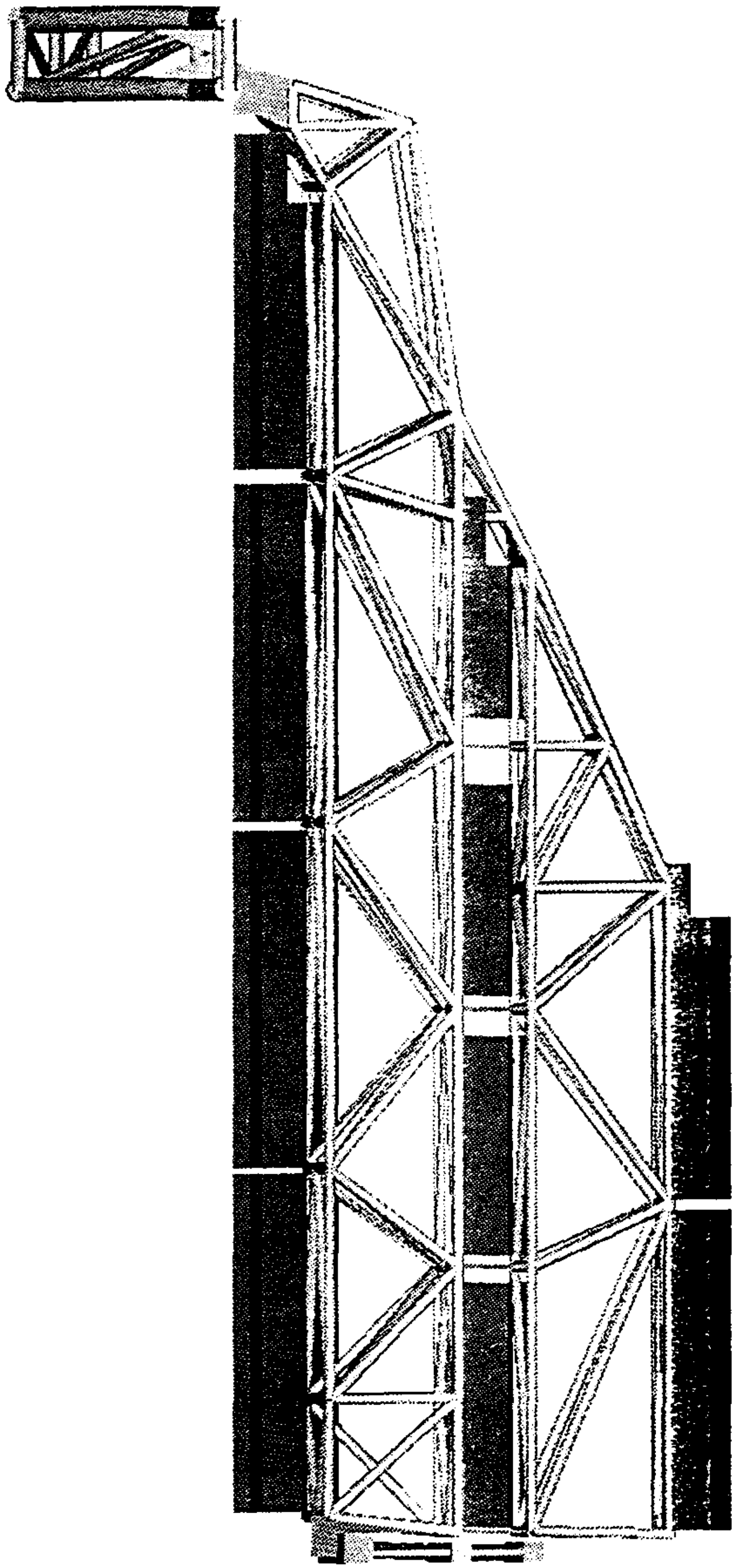
Figure 4.5.1: Muon Support Structure Detail











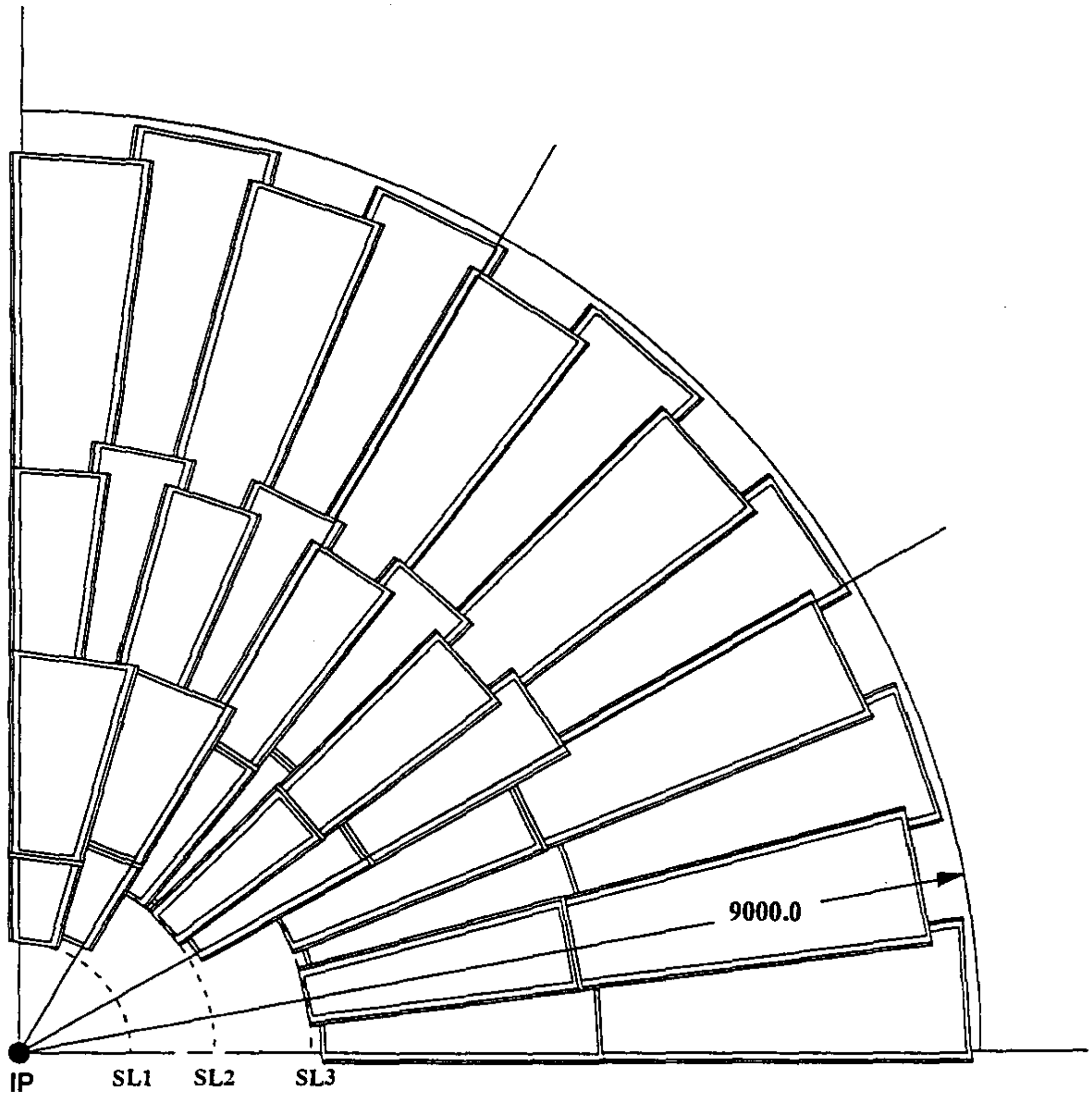


Figure 4.1c: Endcap Muon Chamber Layout (1/4 Section) View from IP

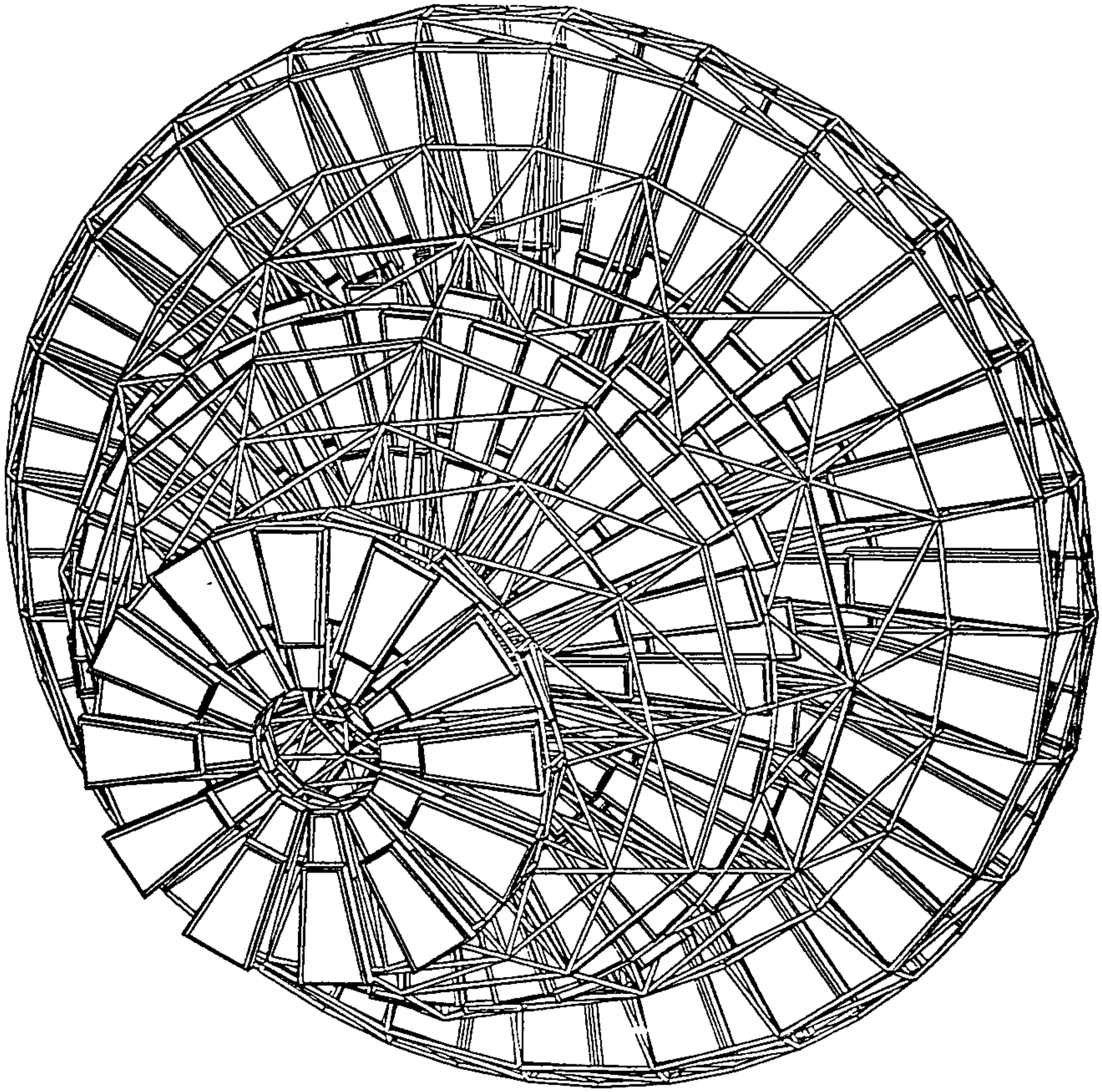


Figure 4.1.x.y: Endcap Assembly

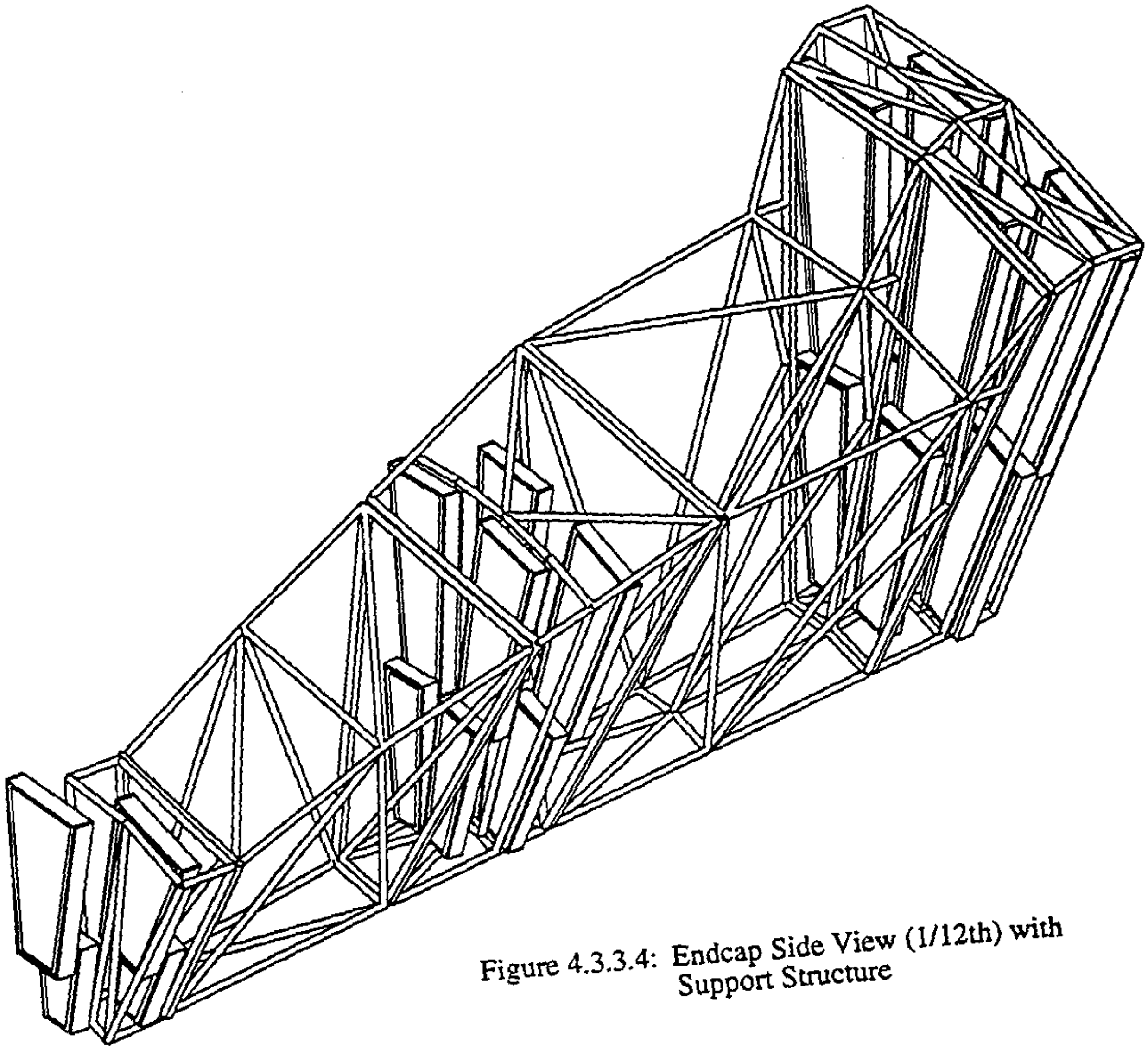


Figure 4.3.3.4: Endcap Side View (1/12th) with Support Structure

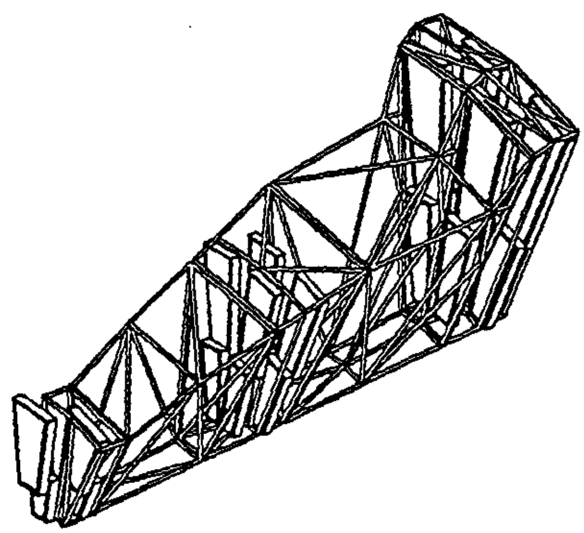


Figure 4.3.3.4: Endcap Side View (1/12th) with Support Structure

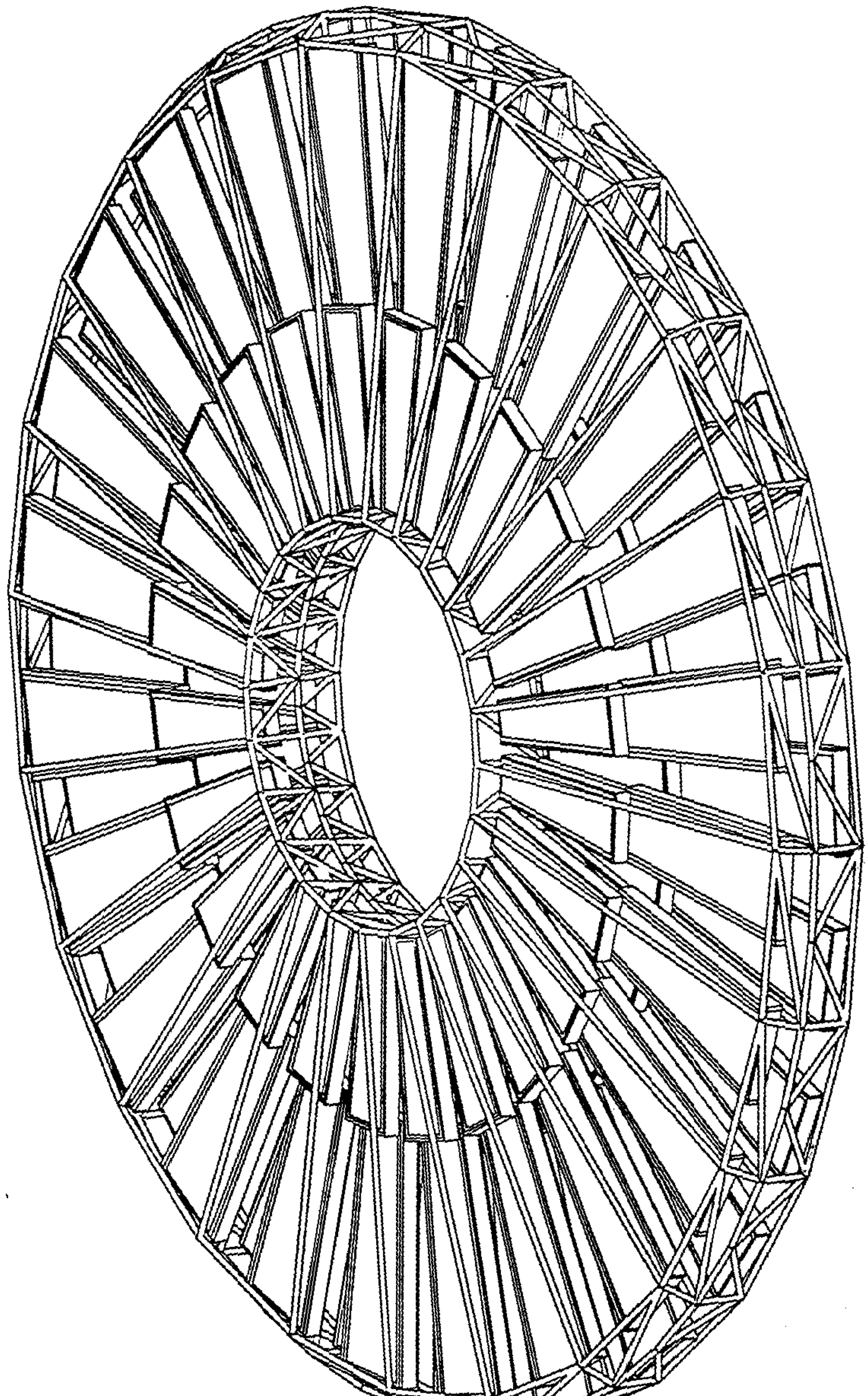


Figure 4.3.3.7: Endcap Outer Superlayer Wheel Structure

T. Lee/M. Furey
C. S. Draper Lab
4/14/93

Muon Detector Structures

- An Evaluation

1. CDS Support Ring

Gross Weight = 15200 lb
Maximum deflection of the ring alone, under static 1 G loading. The ring is constrained at its base in two (2) locations.

Load Dir.	x	y	z
x	0.110"	0.024"	0.078"
y	0.006	0.013	0.016
z	0.039	0.068	10.983

Advantages

- Assembly aid during barrel module insertion with other barrel modules
- Convenient method for attaching barrel assembly to magnet rail/legs
- Alignment fixture for locating the barrel module to adjacent modules
- ring design is in repeating 12th segments for ease of assembly.

Concerns

- Eccentric loading conditions during barrel module assembly may cause instability in the CDS support ring. Lateral bracing (z dir.) required to minimize excessive out of plane bending.
- slim width of ring (12 inch at OD) make it very susceptible to out of plane bending and possible buckling.
- The CDS support ring should be restrained from 180°-240° during the barrel module assembly phase
- CDS support ring should be attached to each barrel module at 6 places. The connections along the ring OD minimize bending moment to the ring. The other connections are rigid ones.
- system requirement for lateral restraint of the muon detector system at the CDS end.

  Need to cut back on some chambers to allow for lateral restraint hardware

2. FFS Support Ring

Advantages

- Overall structure of trusses with various size tubes
- Current ring width is 39.4" (1 m). Results of the design analysis are:

Gross Weight = 36500 lb.
Maximum deflection of ring alone under static 1 G loading. The ring is constrained at its base across its width in two (2) locations.

Load Dir.	x	y	z
x	0.526"	0.149"	0.017"
y	0.041	0.074	0.009
z	0.096	0.329	12.982

- Increasing the ring width to 50" (1.27 m) increases the ring's lateral stiffness

Gross Weight = 37500 lb.
Maximum deflection of ring alone under static 1 G loading

Load Dir.	x	y	z
x	0.546"	0.155"	0.015"
y	0.042	0.076	0.006
z	0.095	0.287	8.382

- ring design is in repeating 12th segments for ease of assembly

Concerns — FIXES!

- * sufficient lateral strength and stiffness to support barrel and end cap structures during lateral loading such as random vibration
- * minimize transfer of bending moments from the barrel and end cap structures to the support ring
- * need to laterally brace the support ring during barrel module insertion to prevent it from tipping.

3. End Cap Structure

Gross Weight = 71900 lb.
= 32265 lb (chamber) + 39635 lb (structure)

The structures were evaluated for overall stiffness and possible buckling conditions under static 1 G loads. The wheel structures were held at four (4) points along the wheel OD. The safety factor in the table is an evaluation of critical buckling loads for all truss elements using Euler's equation for simply supported axial members. The analysis results are presented below:

Component	Load Dir.	Max. x Deflection	Max. y Deflection	Max. z Deflection	Safety Factor
Wheel 1	x	0.095"	0.004"	0.477"	36
	y	0.004	0.095	0.477	36
	z	0.015	0.015	0.668	25
Wheel 2	x	0.085"	0.021"	0.149"	3

	y	0.021	0.085	0.149	3
	z	0.089	0.089	0.397	3
Wheel 3	x	0.132"	0.075"	0.088"	4
	y	0.075	0.132	0.088	4
	z	0.177	0.177	3.905	1
Support Ring 2 and Wheel 3	y	0.058"	0.143"	0.103"	3

Advantages

- Monolithic Structure with multiple constraints

  Three wheels to hold chamber groups 1-6

  Two support rings to add stiffness to the structure
- Multiple wheel concept allows for simplified chamber insertion
- Merging two chambers allows simplified chamber mounting to the structure
- Greater design flexibility

  Modify wheel designs for better accessibility

  Modify support ring designs for greater stiffness
- Individual wheel and support ring designs are in repeating 12th segments for ease of assembly

Concerns

- low lateral stiffness, in z direction of wheel 3. Concerns over low safety factor in this loading condition.

  Need to minimize movement of wheel 3 during assembly by bringing other structures to it

  Can improve lateral stiffness by

  1. increasing size of tubes from 3" to 5" about the wheel OD and back outboard face (closest to FFS support ring)
  2. Use shorter tube lengths on current design in the same areas
- Increased design complexity to increase design envelop for barrel structure
- Need improved accessibility to chamber mounting areas specifically on wheel 1 and 2. Current design has some bracing on wheel outboard faces that may be temporarily removed during assembly. Alternative is to redesign wheel structures.

4. Barrel Assembly Structure

Gross Weight = 24000 lb. for single barrel module

Maximum deflection of barrel module alone under static 1 G loading. The module is constrained along its OD in four (4) locations to simulate handling loads

BARREL MODULE

Load Dir.	Max. Deflection	Safety Factor (Buckling)
x	0.15"	15
y	0.26	4
z	0.07	15

Advantages (STRUCTURAL)!

- Modular design based on 12th segments to form a ring assembly.
- * SIMPLE CHAMBER INSERTION INTO MODULES
- Rough alignment of chambers at module stage
- Increased design envelop about interface to end cap structure (More SPACE/OPTIONS)

  Increased structure increases overall bending stiffness of the design for 1G vertical loading
- Internal ring design near CDS support ring (CLOSER TRUSS SPACING)
- Additional ring to attach end cap structure to barrel assembly
- * Simplified module assembly procedures

  Axial insertion of modules through FFS support ring to CDS support ring

Concerns

- ** current positioning of detector chambers forces large number of joints and truss interconnections to those joints. Truss design is complex.
  - * 1. need to simplify and optimize structure design
  - * 2. merge chambers
- lack of space at middle chamber layer for joining the upper and lower module sections. Now using 1" Al plate to connect the two sections. This is less efficient than using truss elements, but there is not enough space for larger structural elements. (TRADE-OFF WITH COVERAGE!)
- limited accessibility through structure

T. Lee
C. S. Draper Lab
4/14/93

End Cap Assembly Procedures

1. The end cap assembly contains five (5) major subassemblies
   - wheel 1 contains the 1/2 chamber group
   - wheel 2 contains the 3/4 chamber group
   - wheel 3 contains the 5/6 chamber group
   - support ring 1 connects wheel 1 and 2
   - support ring 2 connects wheel 2 and 3
2. The truss structure for the two support rings are assembled on the ground in the flat.
3. Three scaffold fixtures are erected to assemble and hold the truss structure for each wheel. The wheel's center axis is aligned horizontal with the ground.
   - The scaffold restrains the outer diameter of each ring for a minimum of 180°
4. Chamber Mounting (MANEUVERABLE)
   - With the aid of an elevated platform and a ~~flexible~~ gantry arm, the chambers are oriented and brought to the wheel.
   - The chambers are brought laterally through the outboard faces and are mounted onto the wheel center spoke.
   - On wheels 2 and 3, there is no bracing on the wheels' inboard and outboard faces to interfere with this chamber mounting.

     Wheel 1 the inner 1B/2B chambers may be inserted radially through the wheel outer diameter. An alternative is to temporarily remove a cross brace on its outboard face, laterally insert the chamber. The chamber is mounted onto the wheel and the cross brace is reattached.
5. Assembly of support ring 2 to wheel 3
   - The support ring 2 is hoisted from the flat into a vertical 90° orientation.

     Using a hoist, raise one end of the support ring off the floor and onto a standoff. The standoff is secured to the floor.

     The other end of the ring (180° away) is secured to an overhead crane using chains. The ring is raised to its vertical position.
   - The support ring 2 is transported to the wheel 3 by the overhead crane
   - a standoff is placed near the wheel 3 scaffold. The support ring 2 is brought to rest on the standoff. Eight (8) initial attachments are made along the OD at their interface. ADJUSTABLE SHIMS!

     The chains to the overhead crane are released. The remaining attachments along the OD and ID interface are made.

6. Assembly of support ring 1 to wheel 1
   - Repeat procedure from step 5.
7. Assembly of major subassemblies
   - the support ring 1 and wheel 1 assembly is brought to wheel 2 scaffold fixture using the overhead crane
   - a standoff is placed near the wheel 2 scaffold. The support ring 1 and wheel 1 assembly is brought to rest on the standoff. Eight (8) initial attachments are made along the OD at their interface. ADJUSTABLE SHIMS!

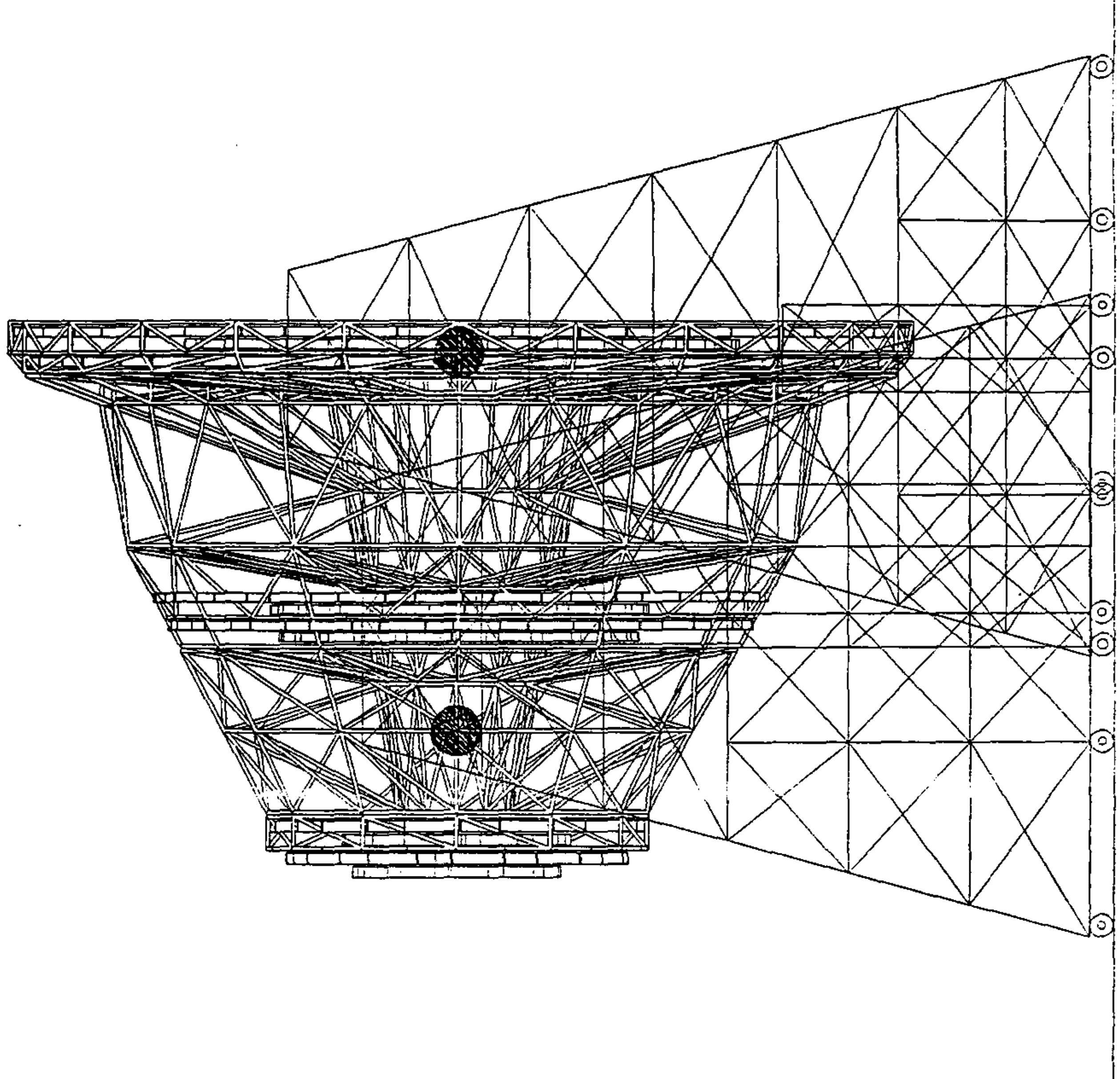
     The chains to the overhead crane are released. The remaining attachments along the OD and ID interface are made.
   - Two additional attachments of support ring 1 to the scaffold

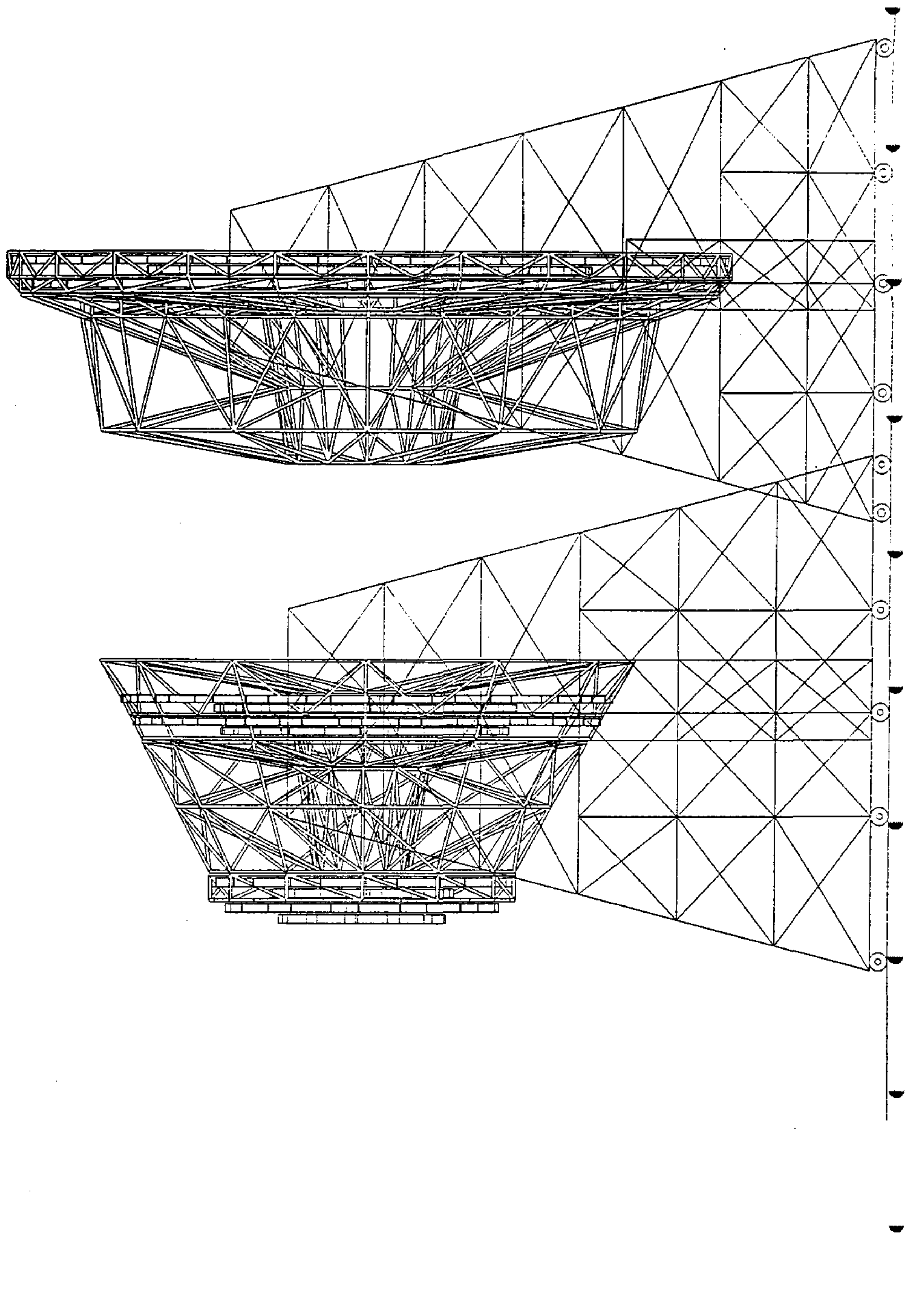
     (These attachments are part of the chamber alignment procedure)
   - the wheel 1, support ring 1, and wheel 2 assembly and its scaffold assembly fixture is brought over to the wheel 3 and support ring 2 assembly. Again attachments are made along the ID and OD of their interface
8. Initial Chamber Alignment
   - The existing scaffold fixtures are used to simulate the primary support of the completed end cap structure.

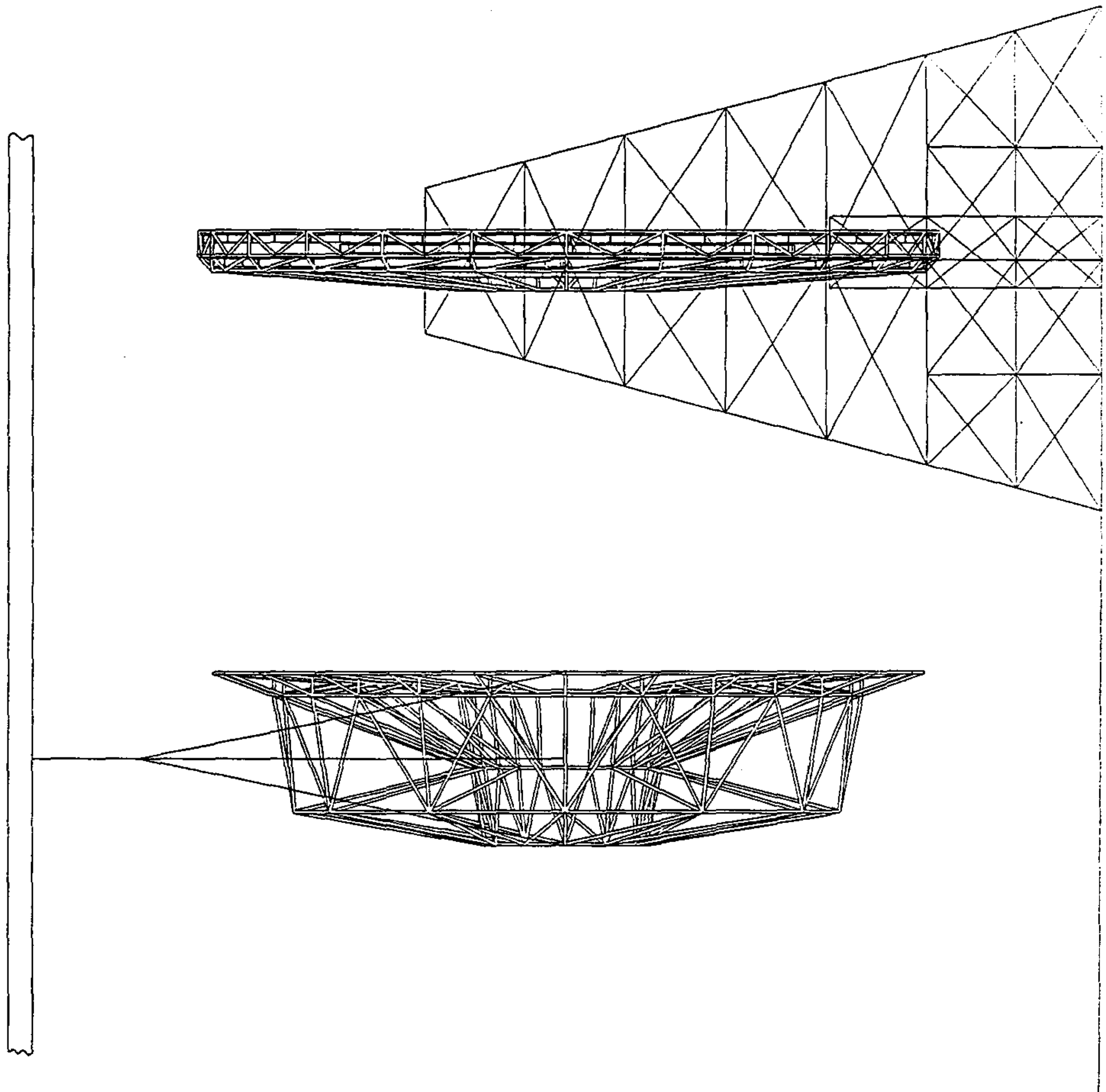
     The end cap structure is held at four points,

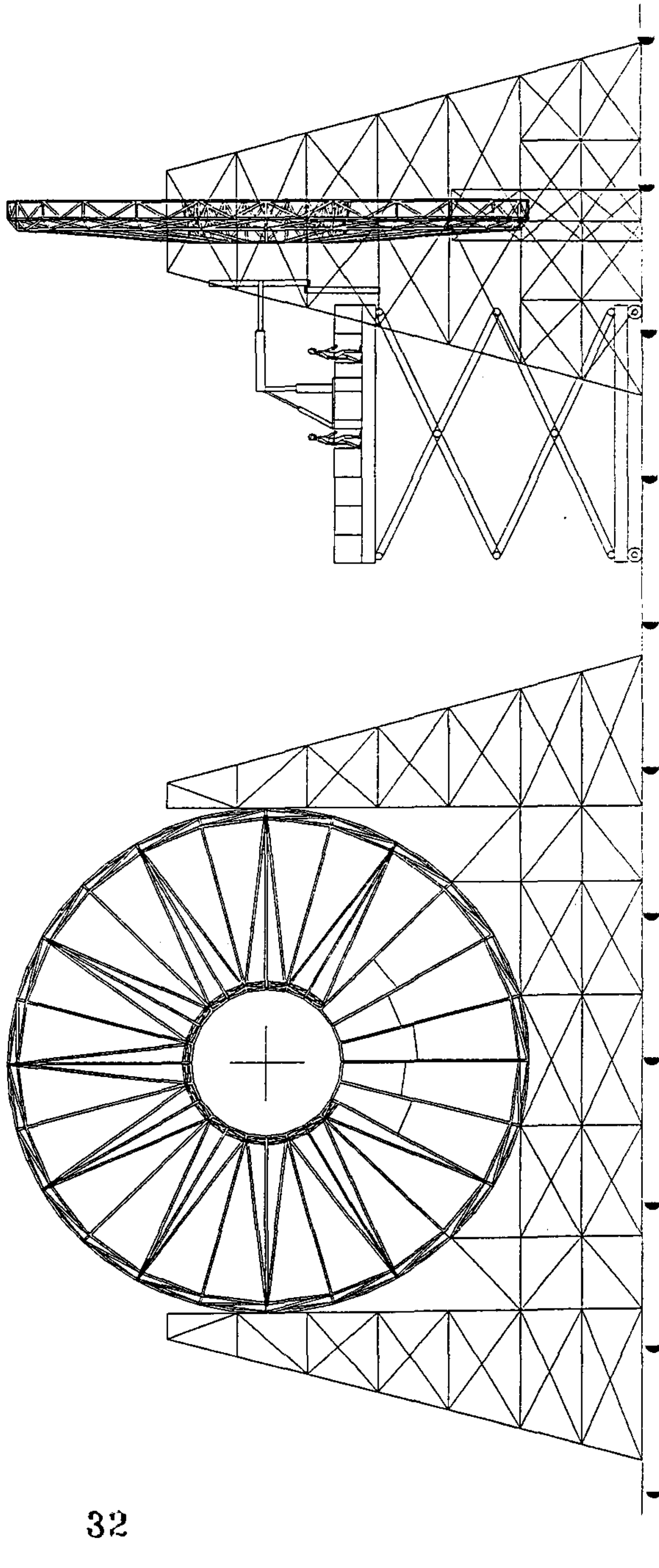
     2 on the support ring 1 OD

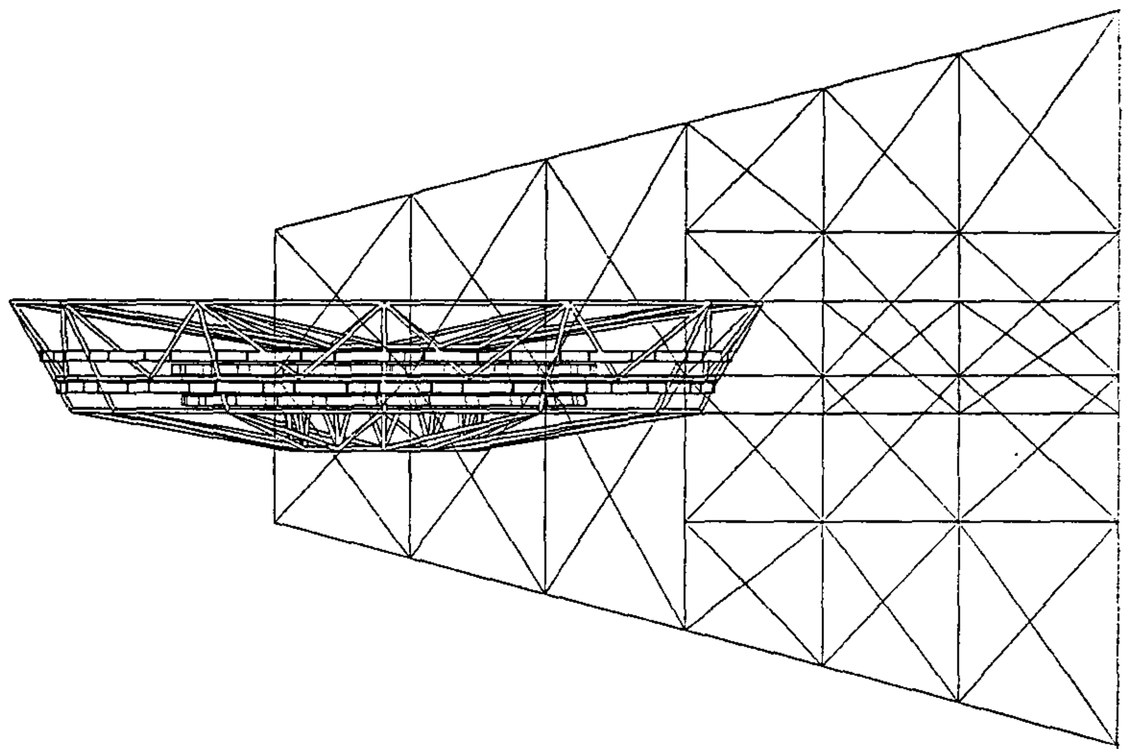
     2 on wheel 3 OD
   - The chambers are roughly aligned.

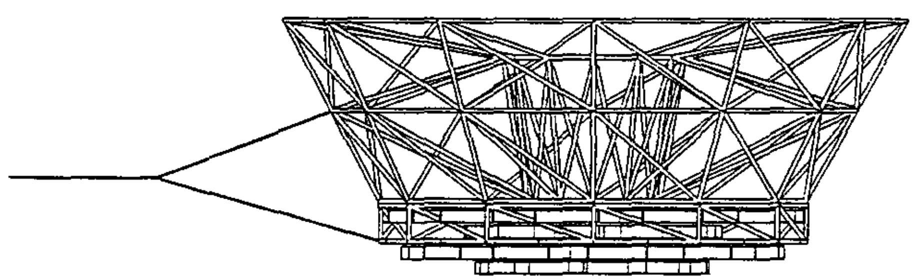


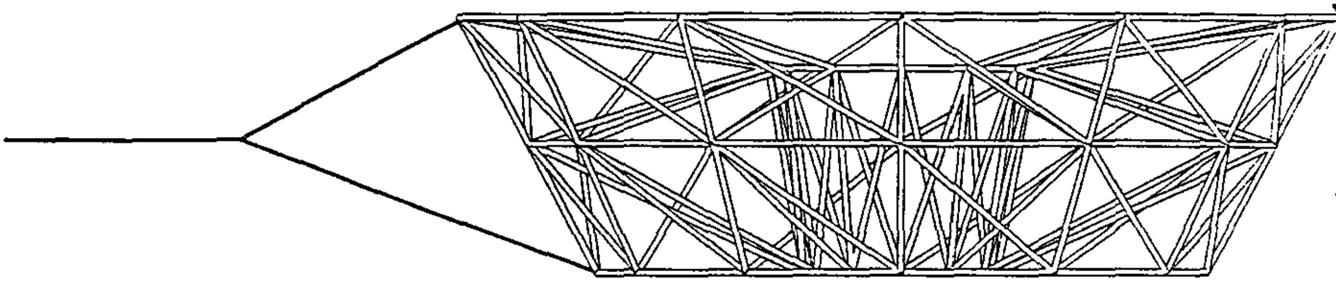


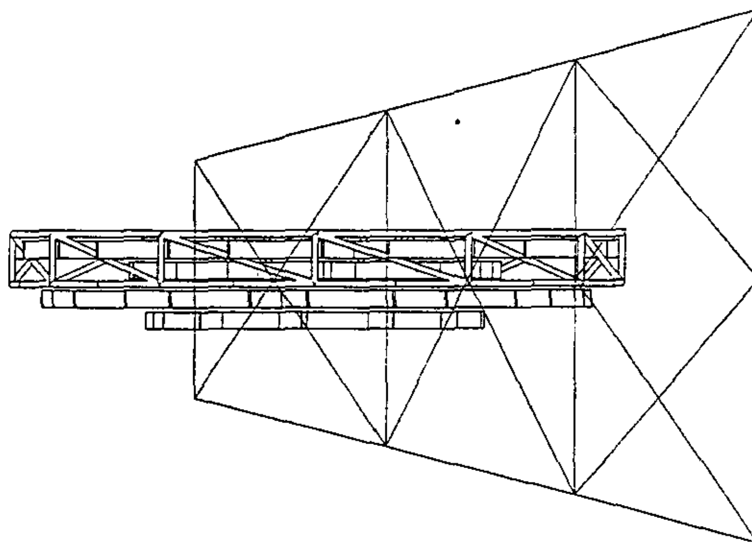


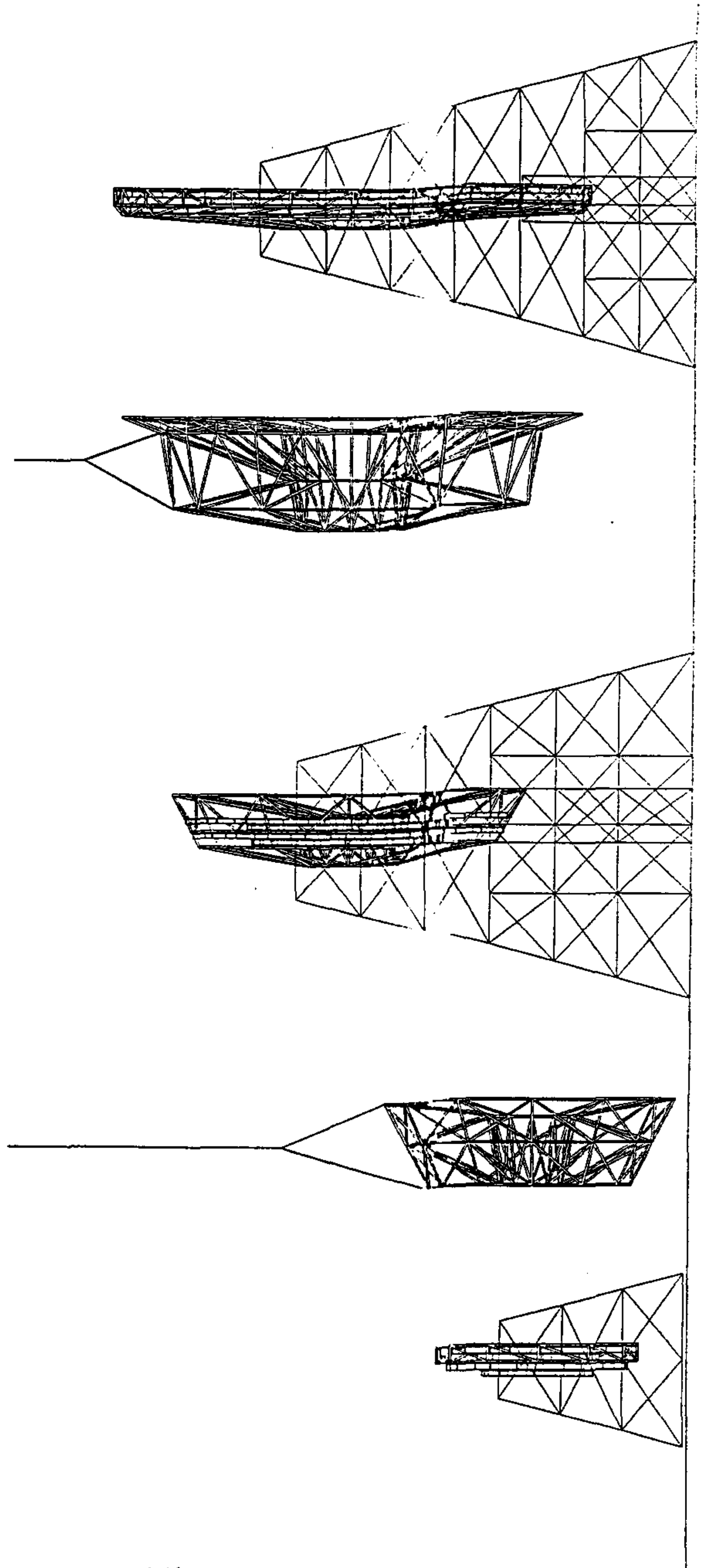


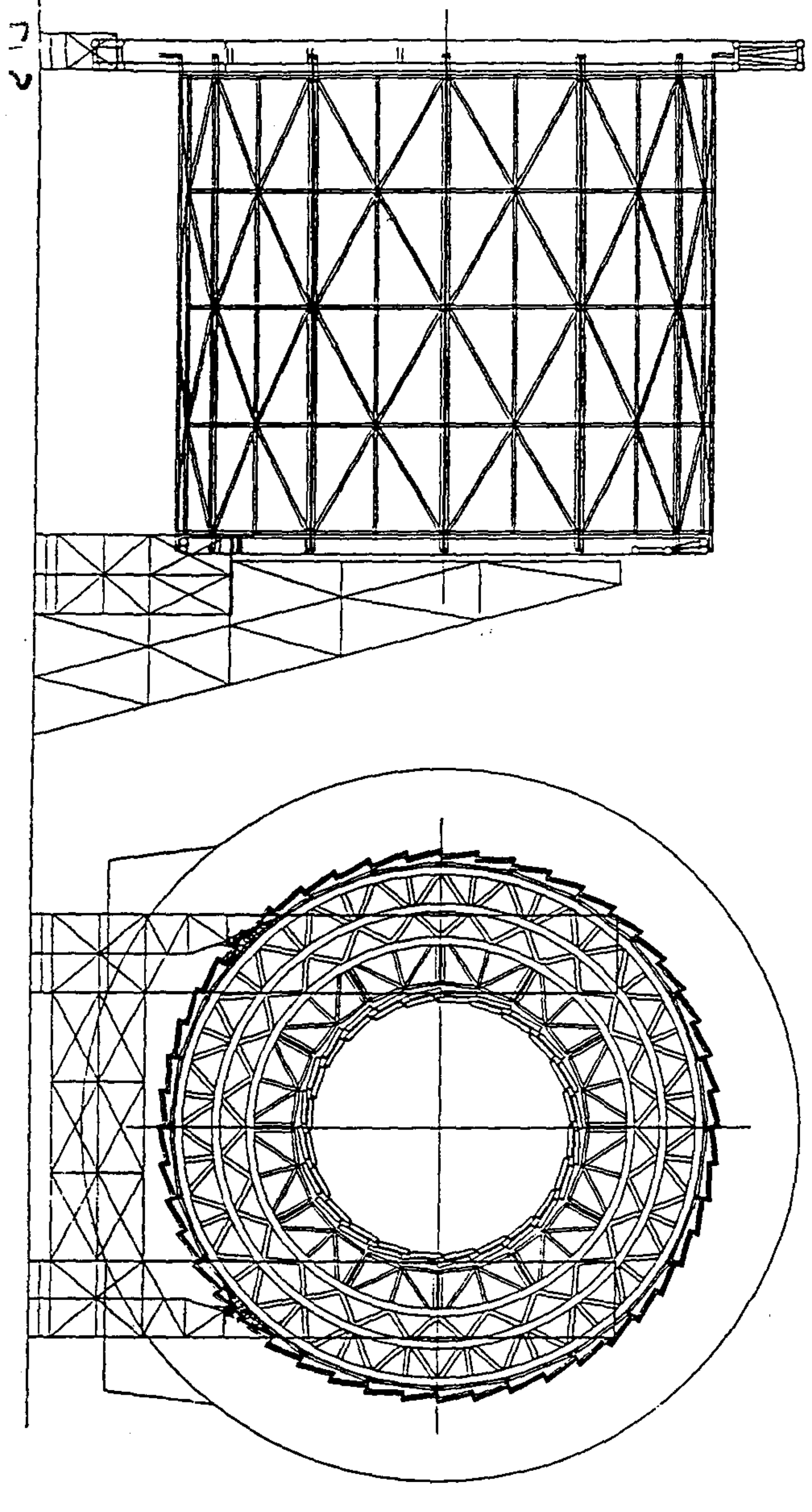












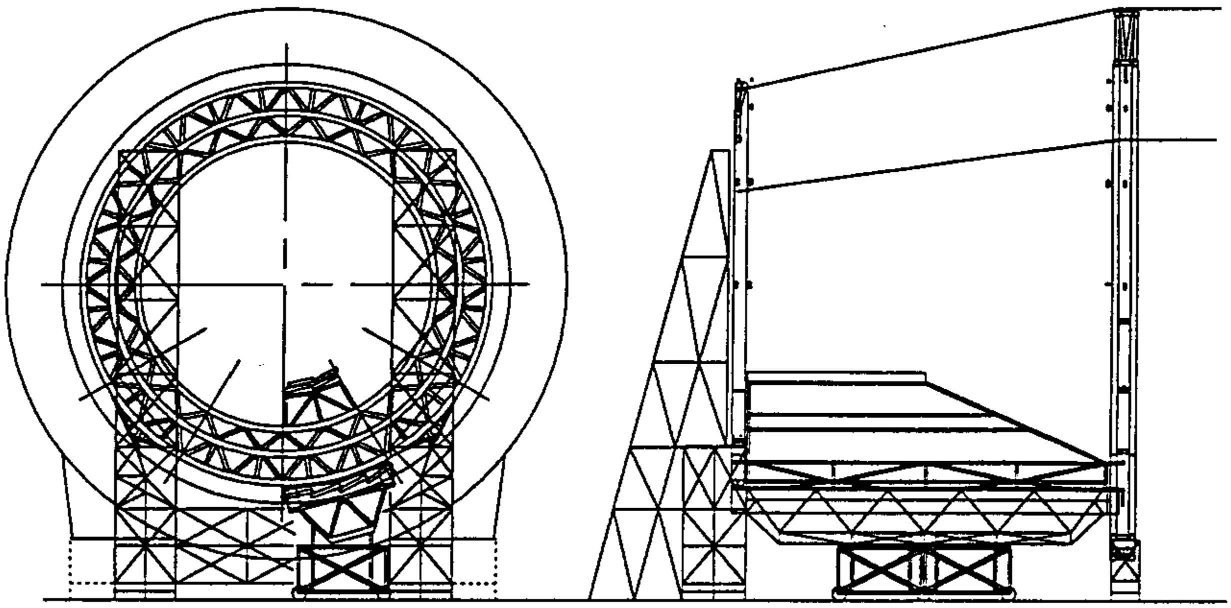


Figure 4.5.4: Initial Module Assembled Between
End Support Rings

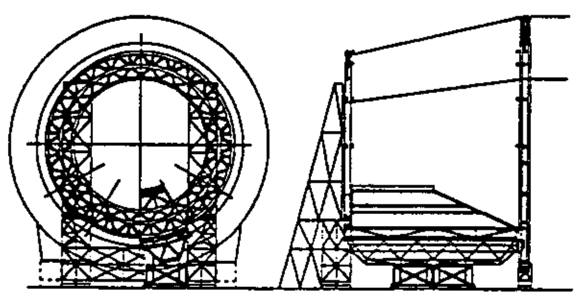


Figure 4.5.4: Initial Module Assembled
Between End Support Rings

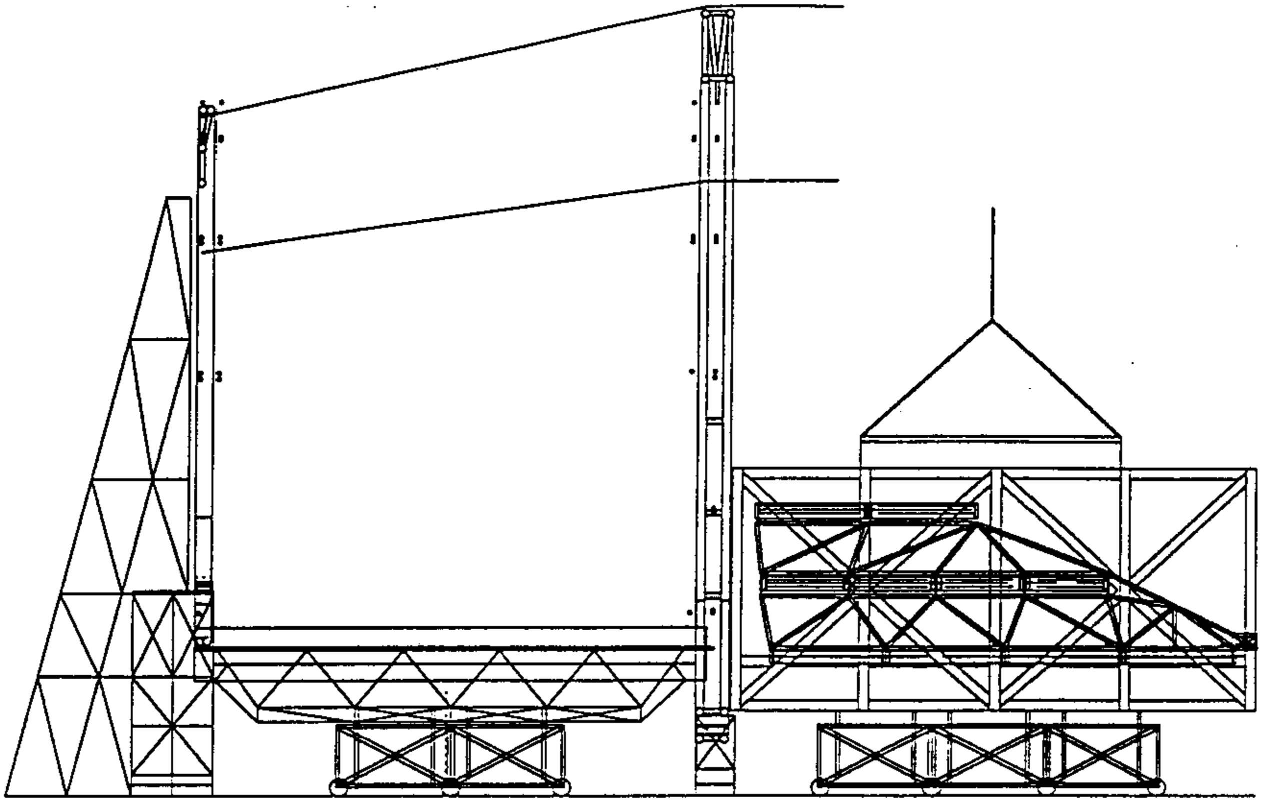


Figure 4.5.3: Initial Module Assembly Into Barrel Monolith

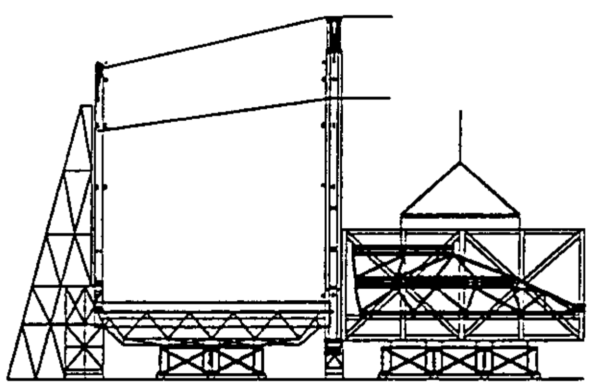


Figure 4.5.3: Initial Module Assembly
Into Barrel Monolith

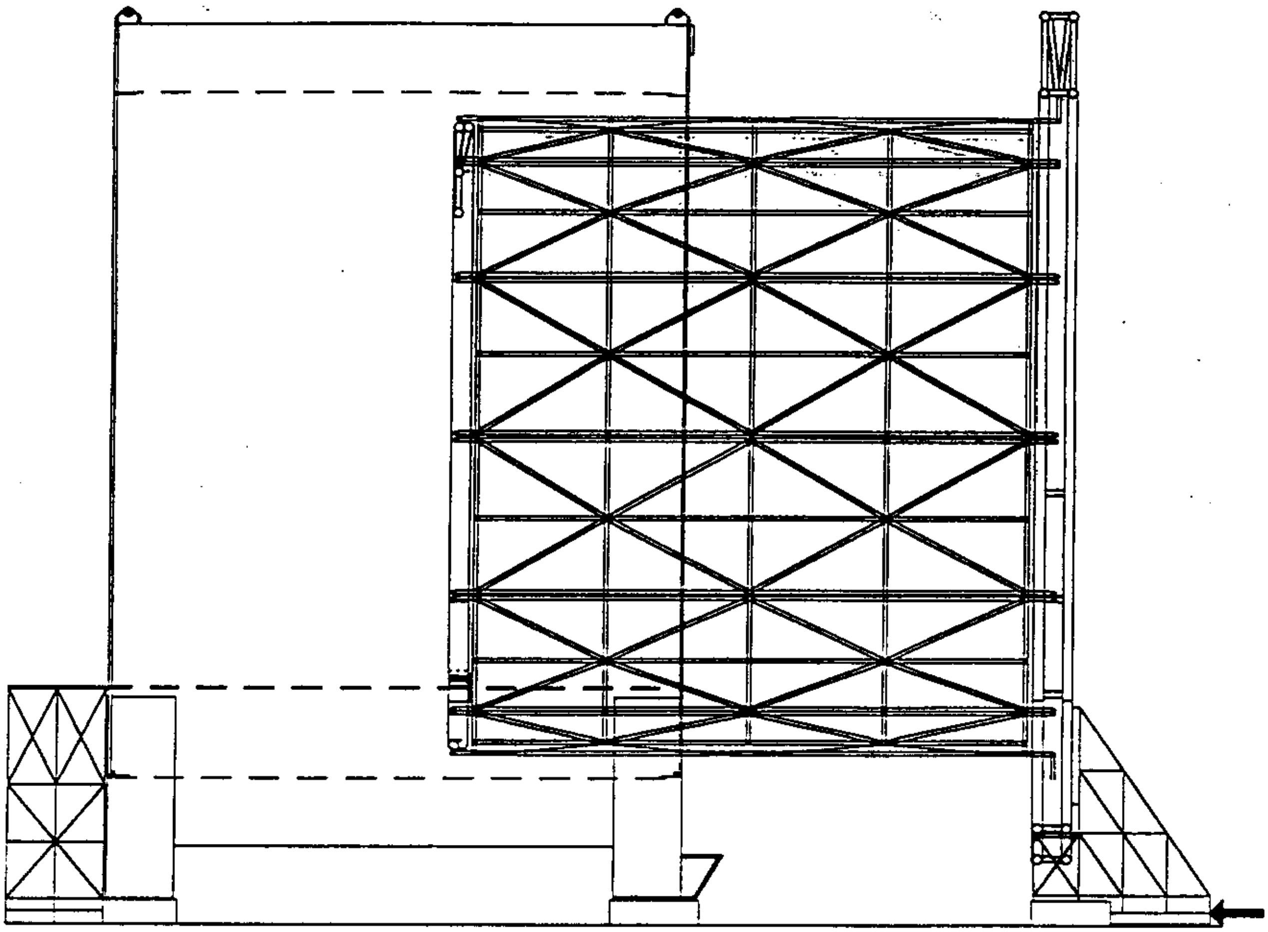


Figure 4.5.5: Barrel Monolith Installation Into Magnet

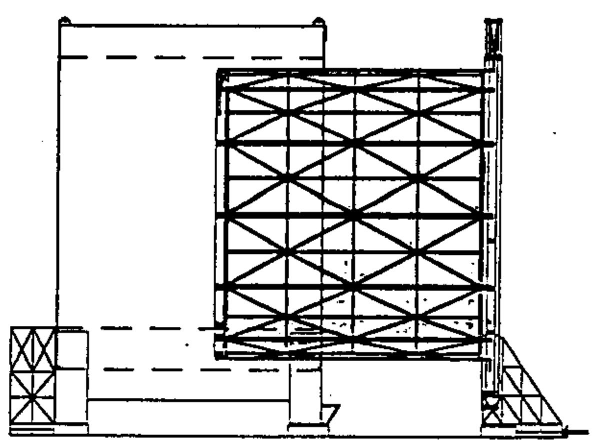


Figure 4.5.5: Barrel Monolith Installation
Into Magnet

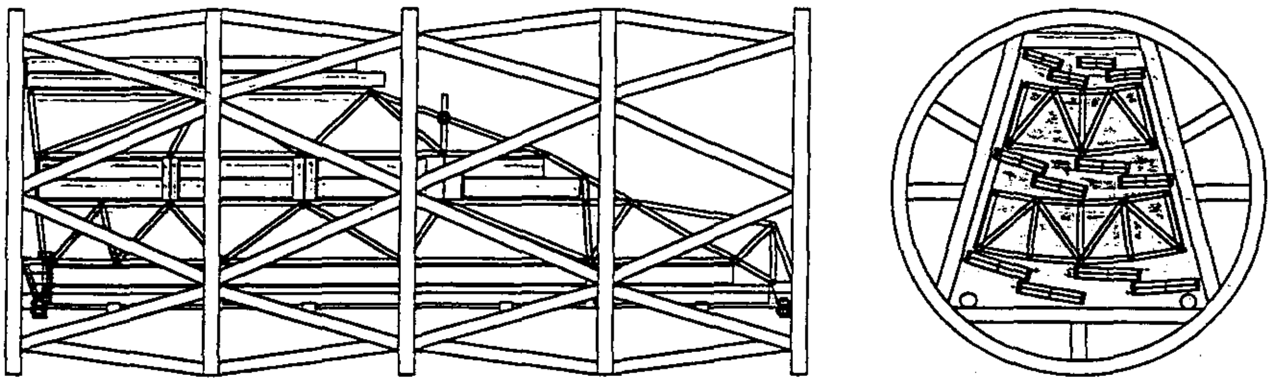


Figure 4.5.2: Module Installation Fixture

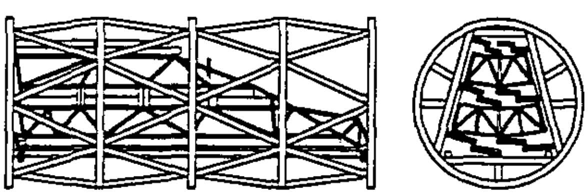
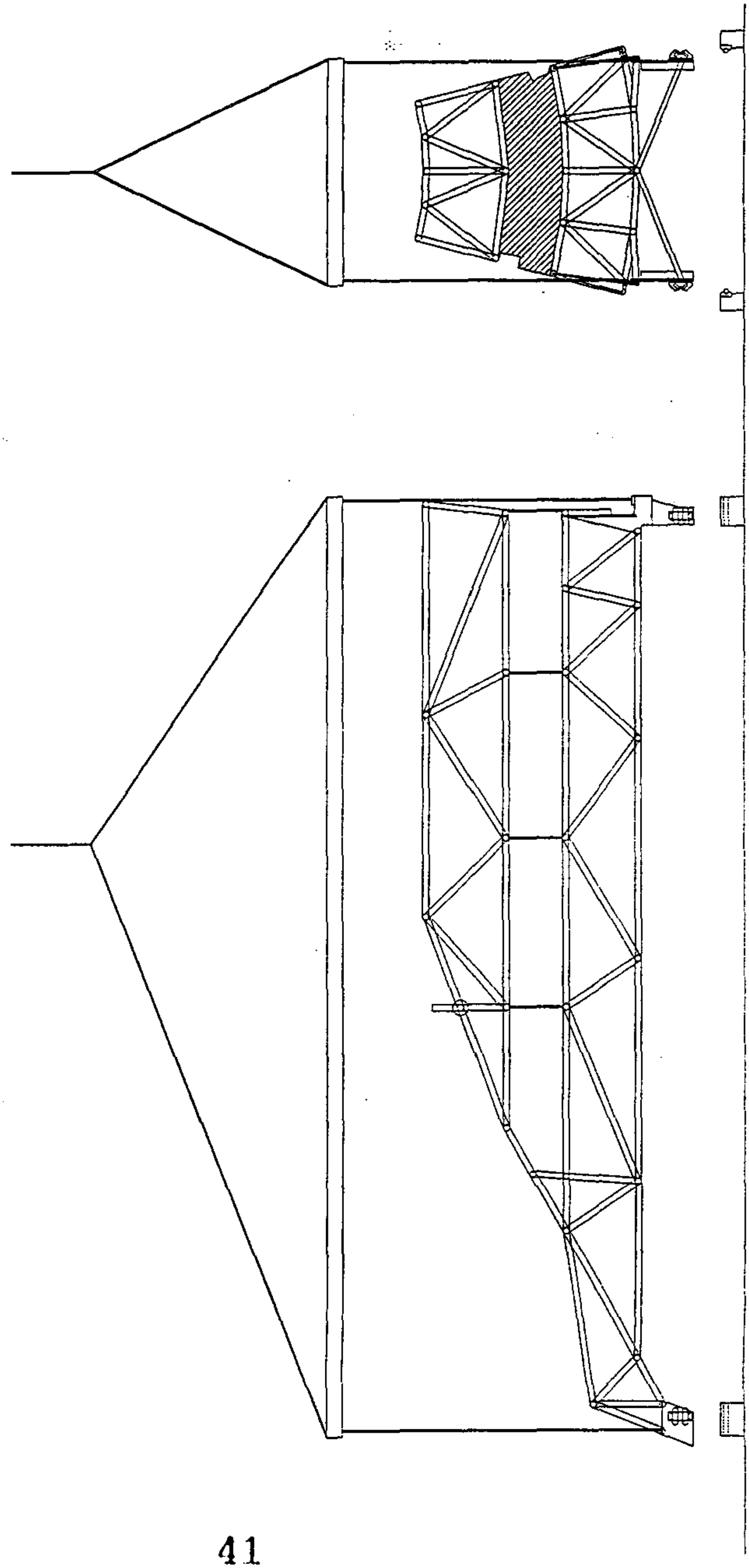
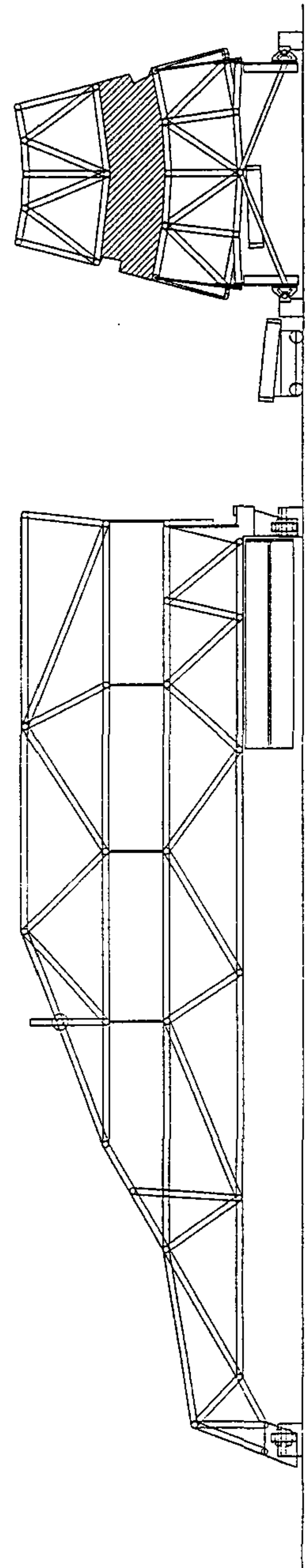
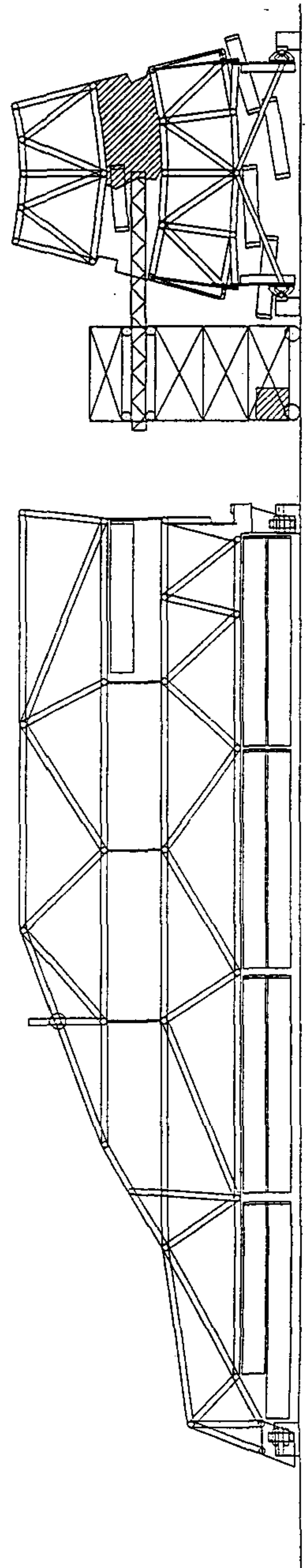
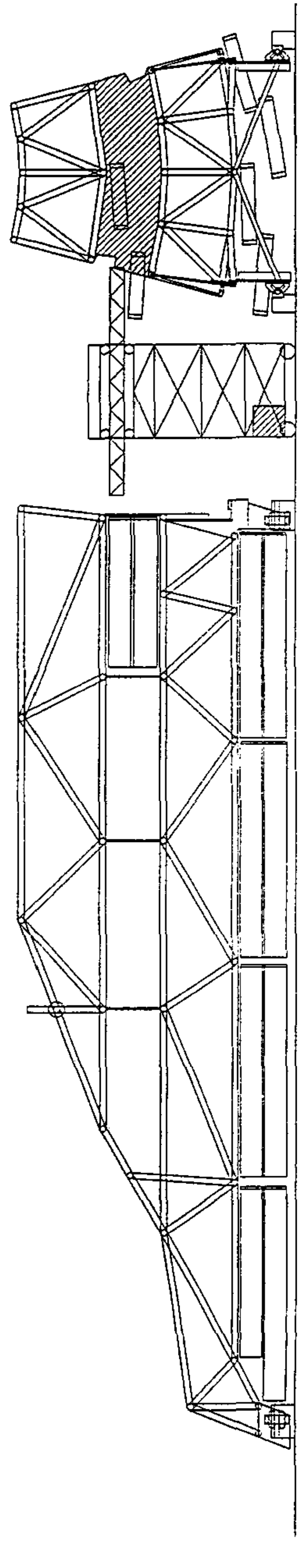


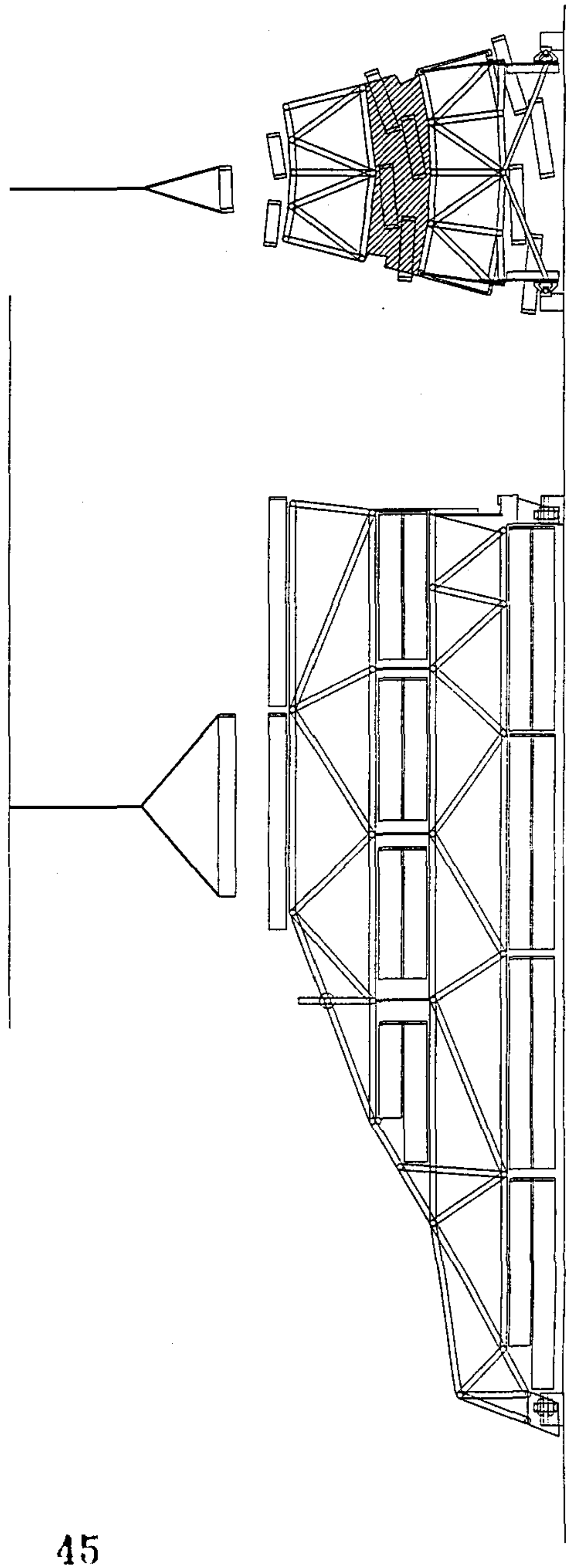
Figure 4.5.2: Module Installation Fixture

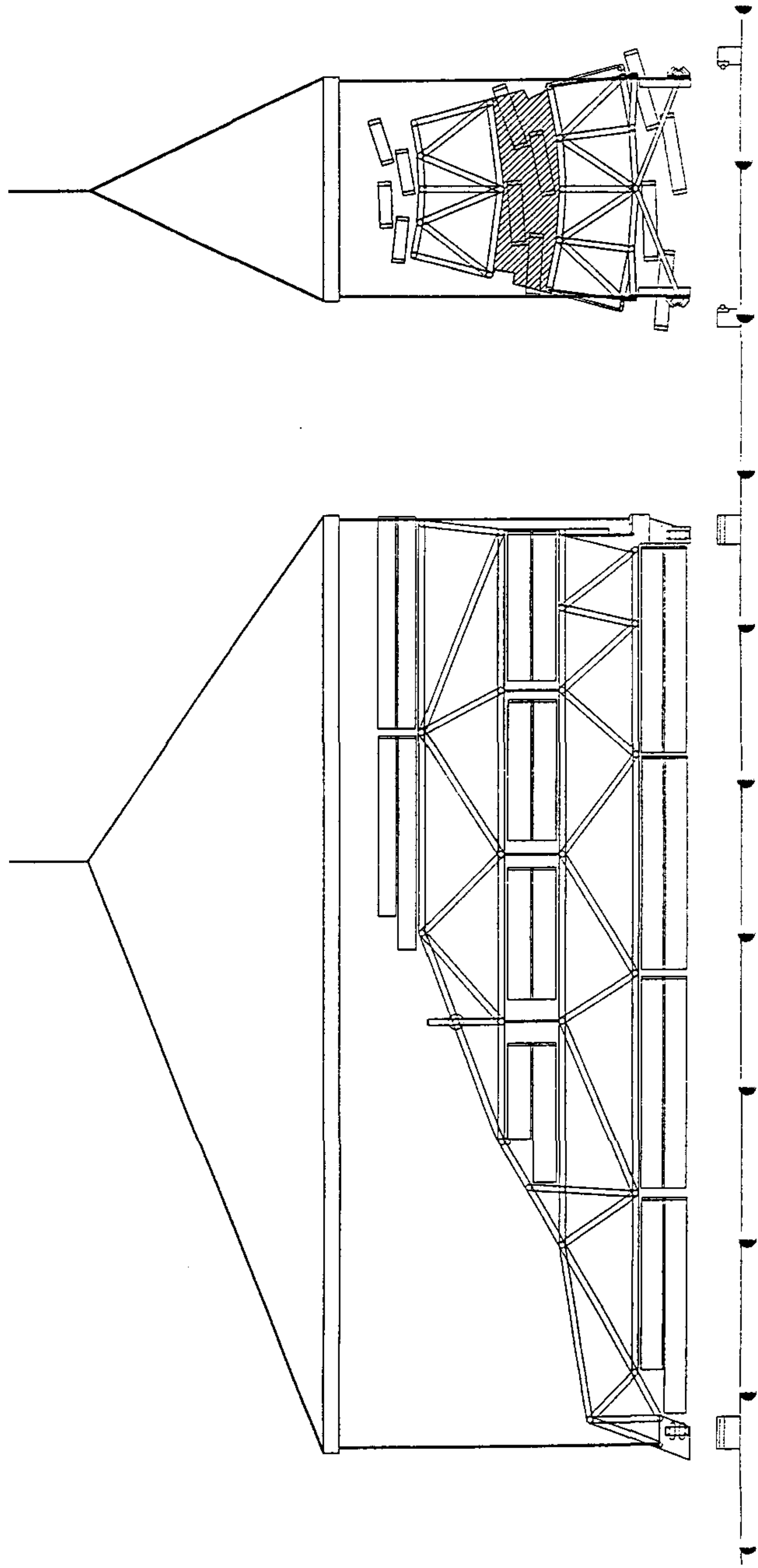












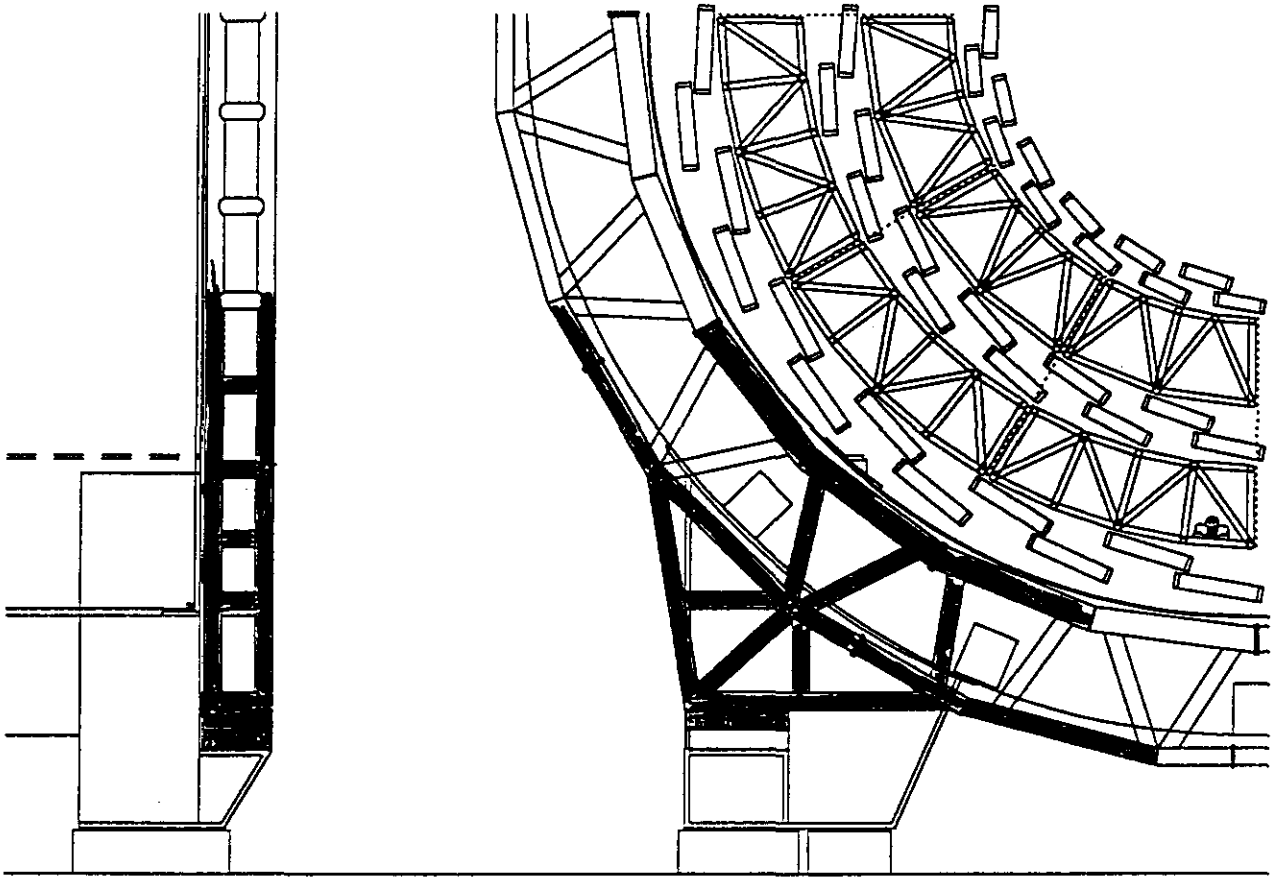


Figure 4.3.3.9b: FFS Ring to Magnet Interface

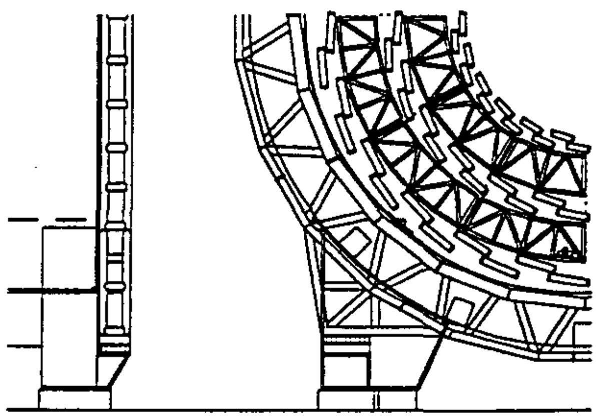


Figure 4.3.3.9b: FFS Ring to Magnet Interface

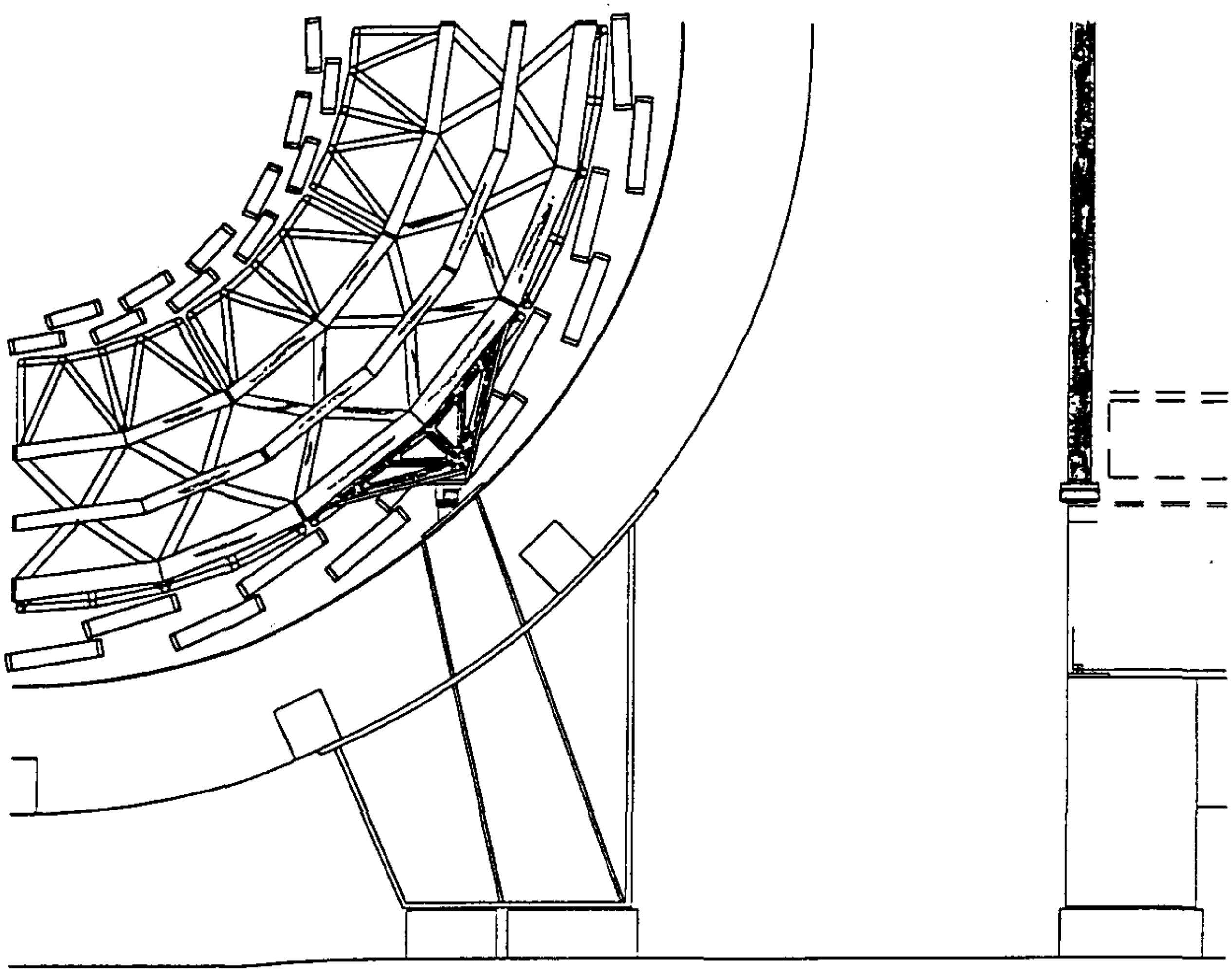


Figure 4.3.3.8b: CDS to Magnet Interface

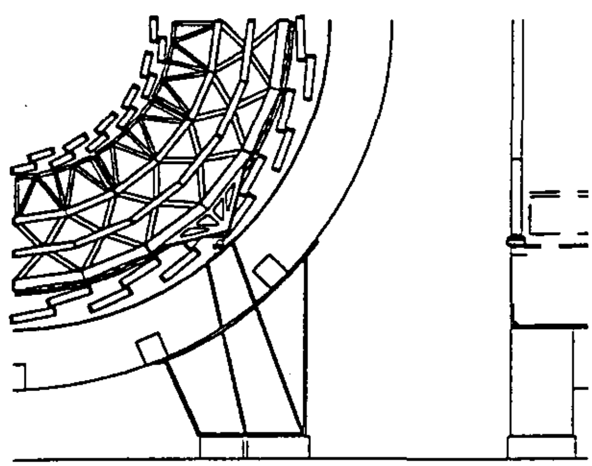


Figure 4.3.3.8b: CDS to Magnet Interface

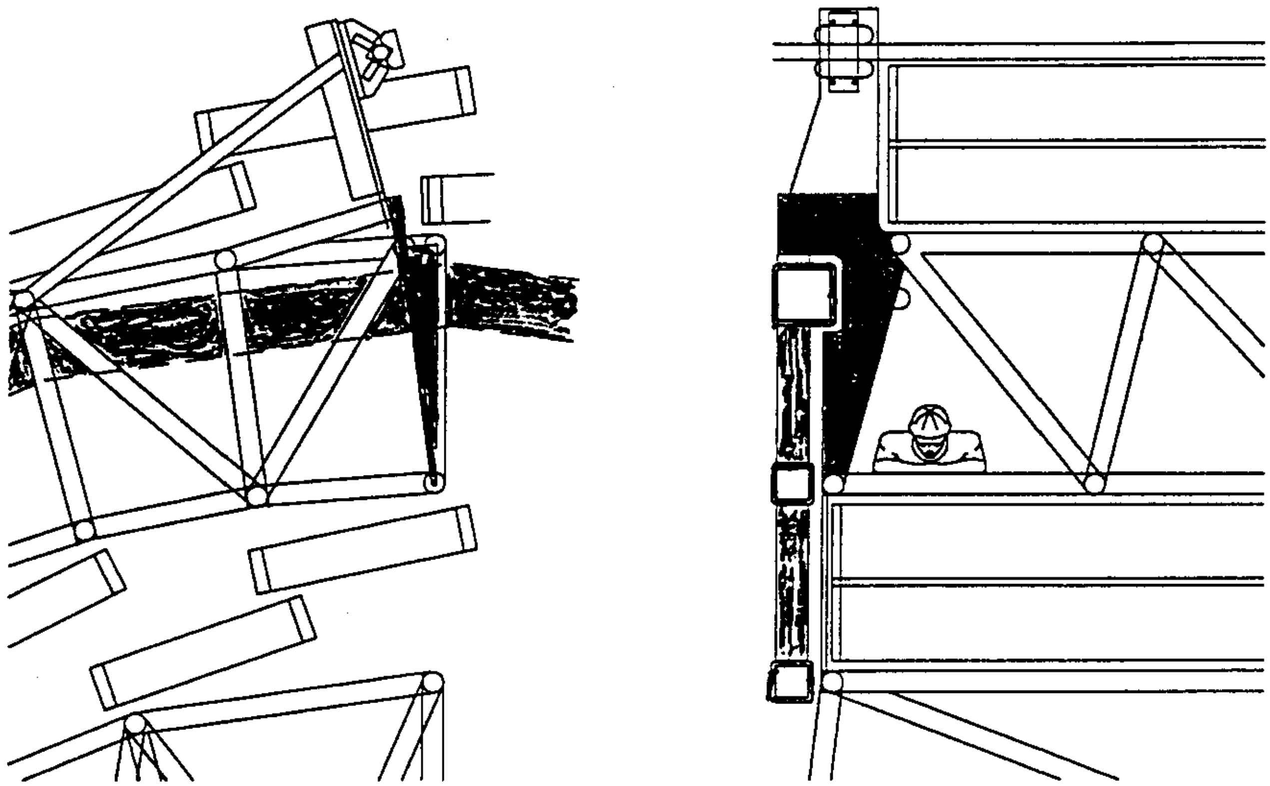


Figure 4.3.3.8a: CDS to Module Interface

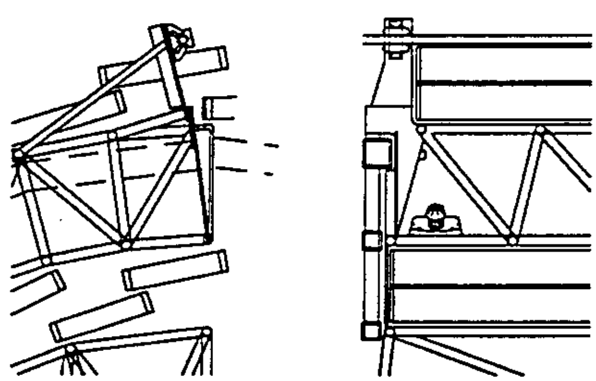


Figure 4.3.3.8a: CDS to Module Interface

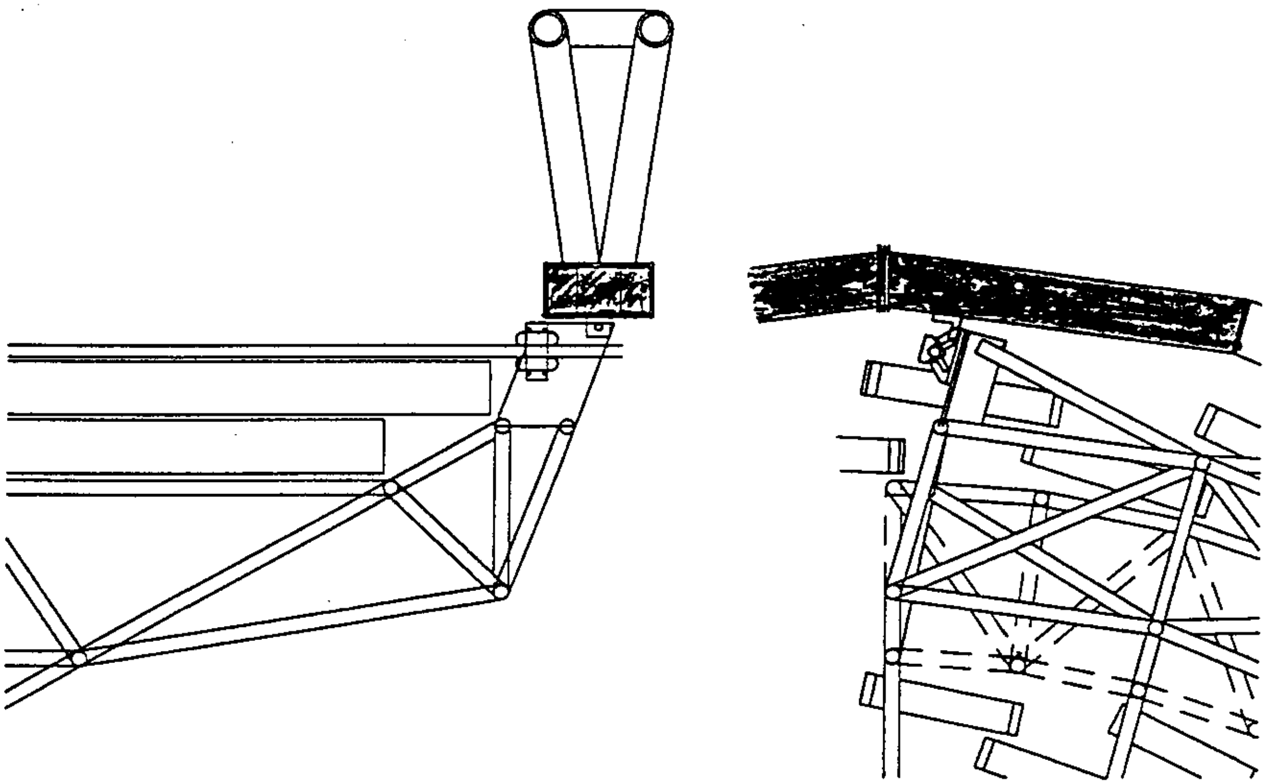


Figure 4.3.3.9a: Module to FFS Ring Interface

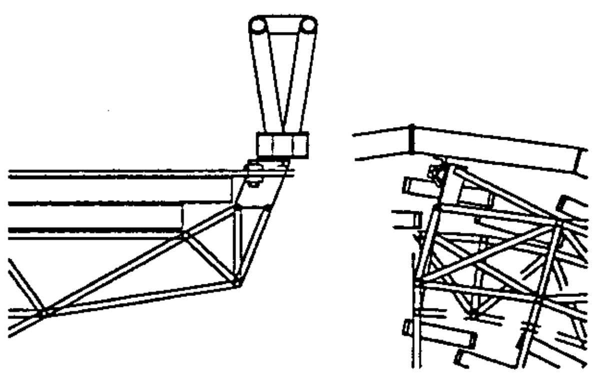
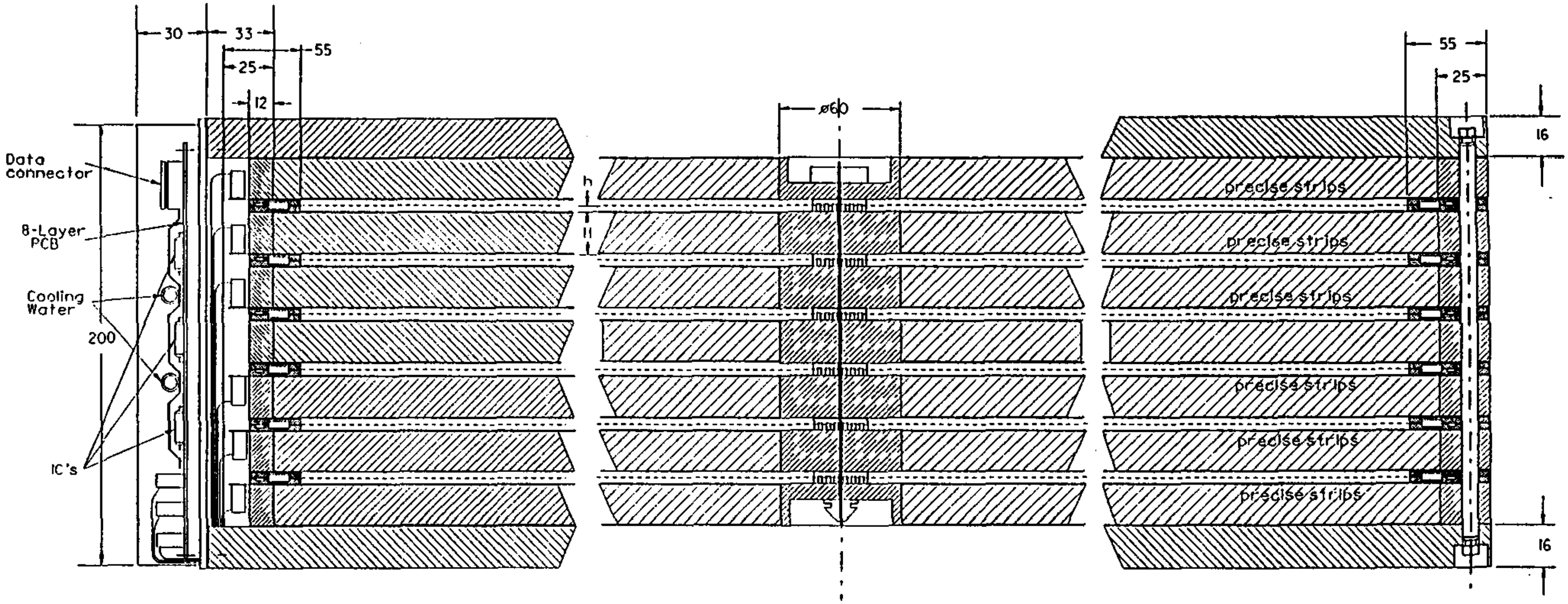


Figure 4.3.3.9a: Module to FFS Ring Interface

Presentation by:

Coleman Johnson

Chamber Design



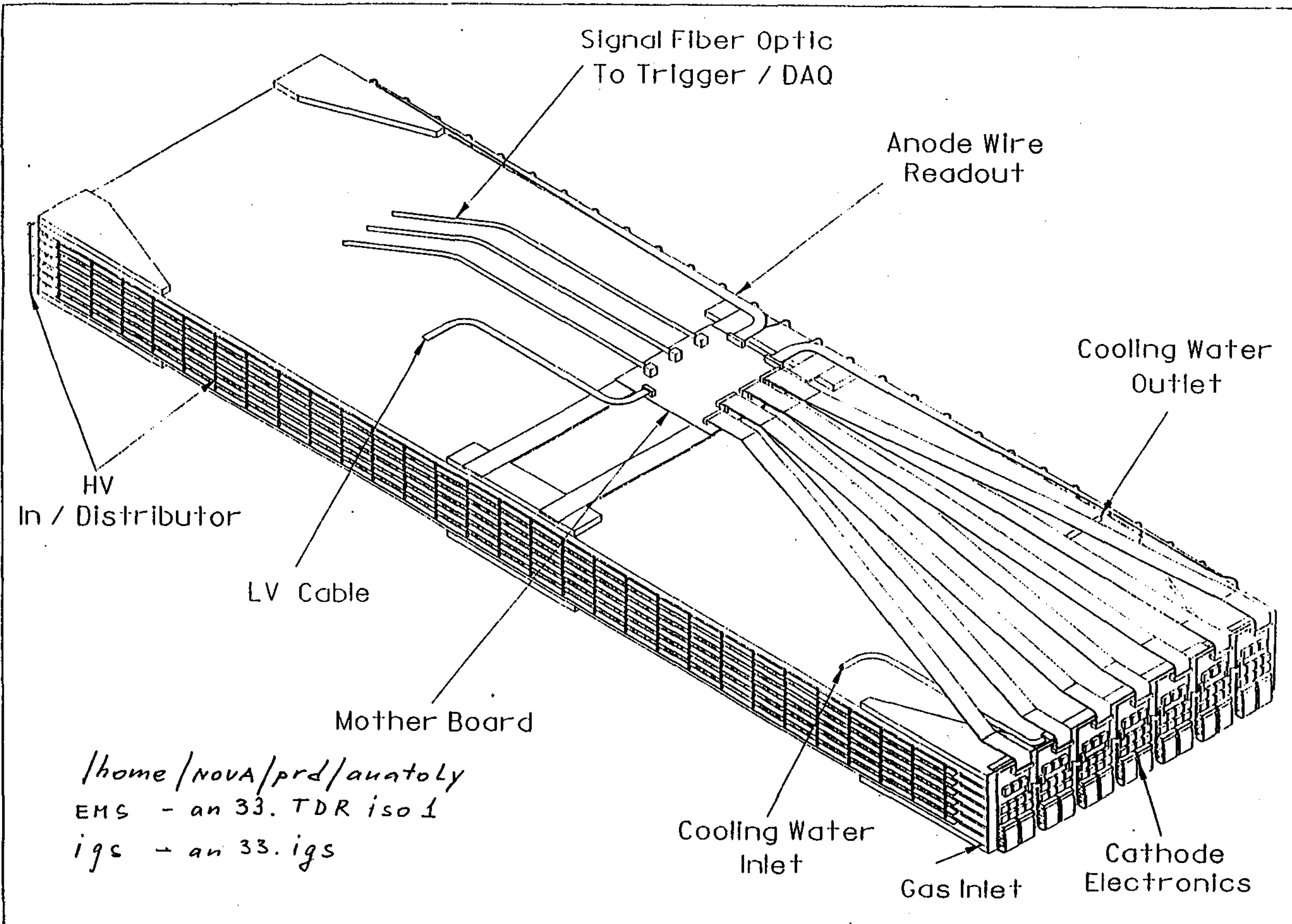
SECTION A-A
(ALONG WIRES)

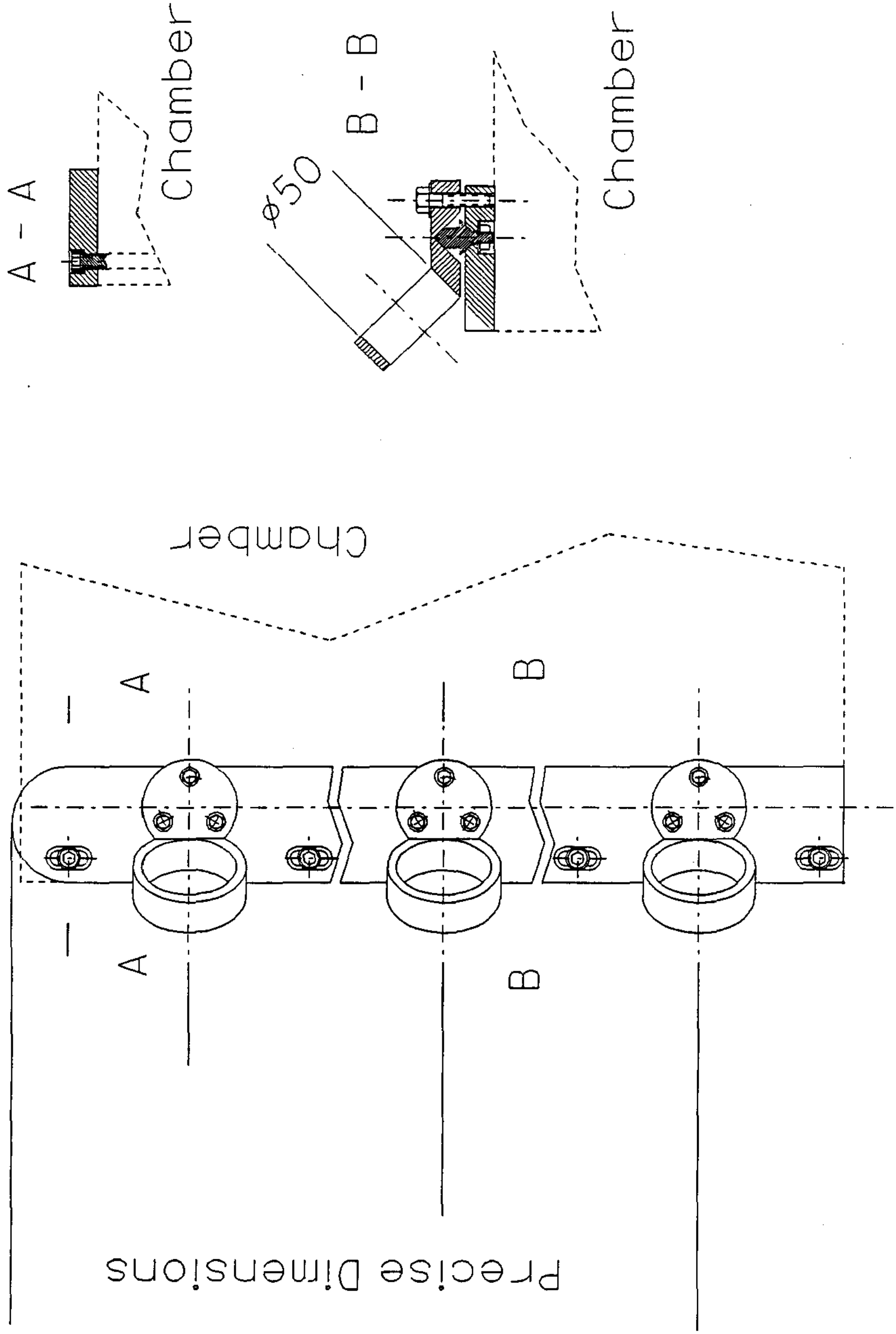
	OUTER LAYER	MIDDLE LAYER	INNER LAYER
h mm	5.0	4.0	2.5

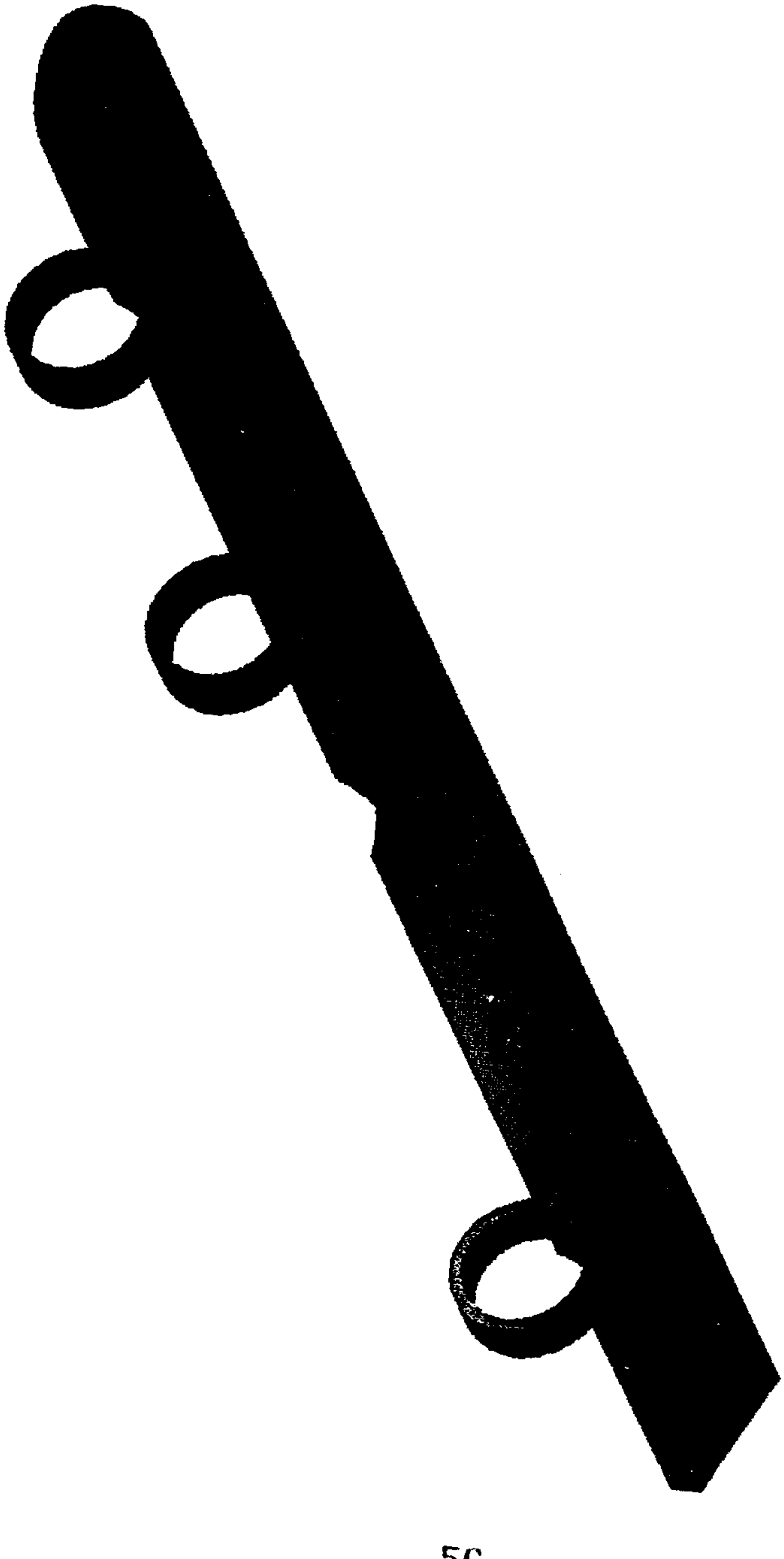
PRECISE STRIP READOUT

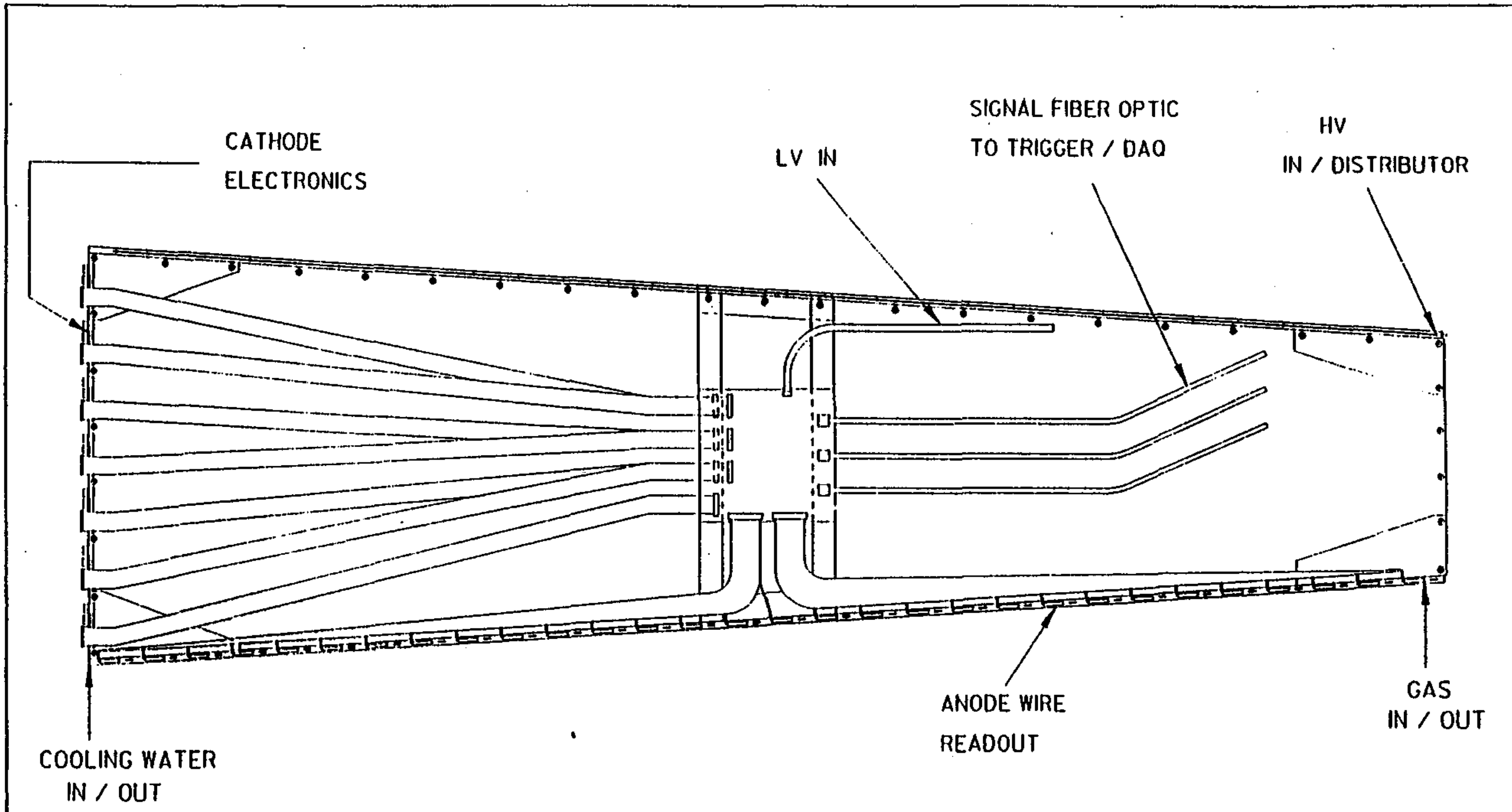
H = 20 mm

I.GOLUTVIN
Y.KIRYUSHIN
03/03/1993


Signal Fiber Optic
To Trigger / DAQ
Anode Wire
Readout
Cooling Water
Outlet
HV
In / Distributor
LV Cable
Mother Board
Cooling Water
Inlet
Gas Inlet
Cathode
Electronics
/home/nova/prd/anatoly
EMS - an 33. TDR iso 1
igs - an 33. igs


A - A
Chamber
B - B
ϕ50
Chamber
Chamber
A
A
B
B
Precise Dimensions

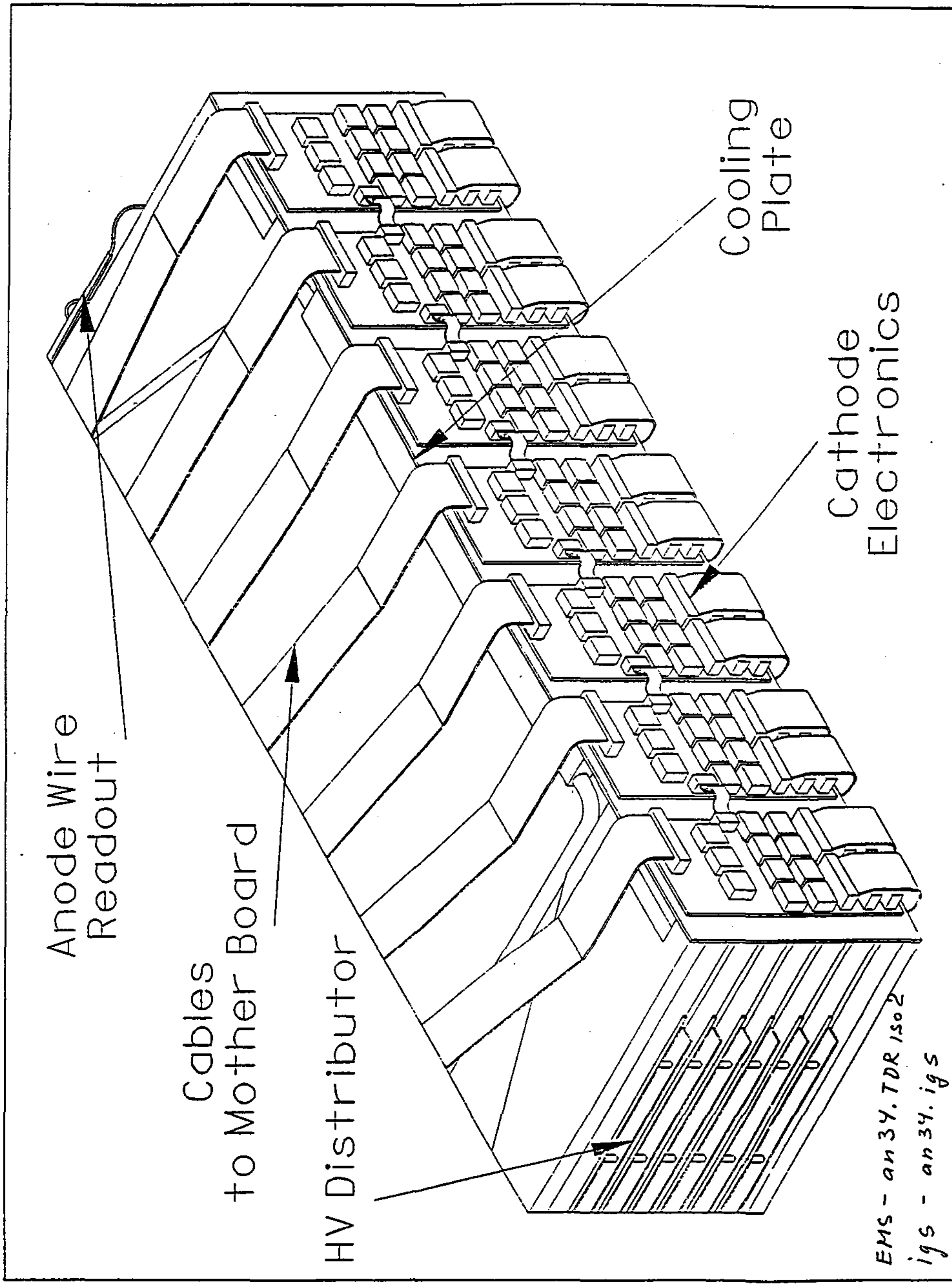




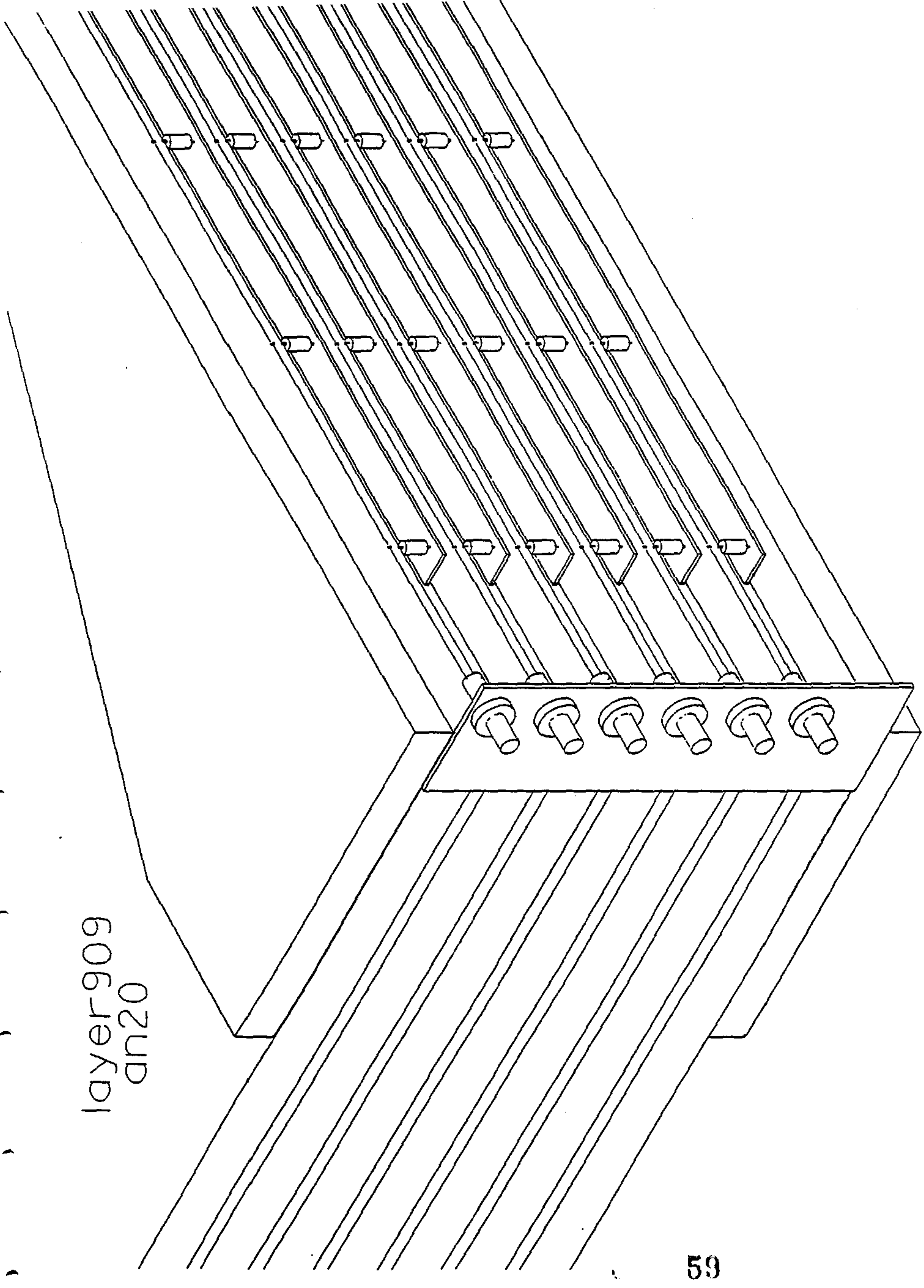
ENDCAP MODULE

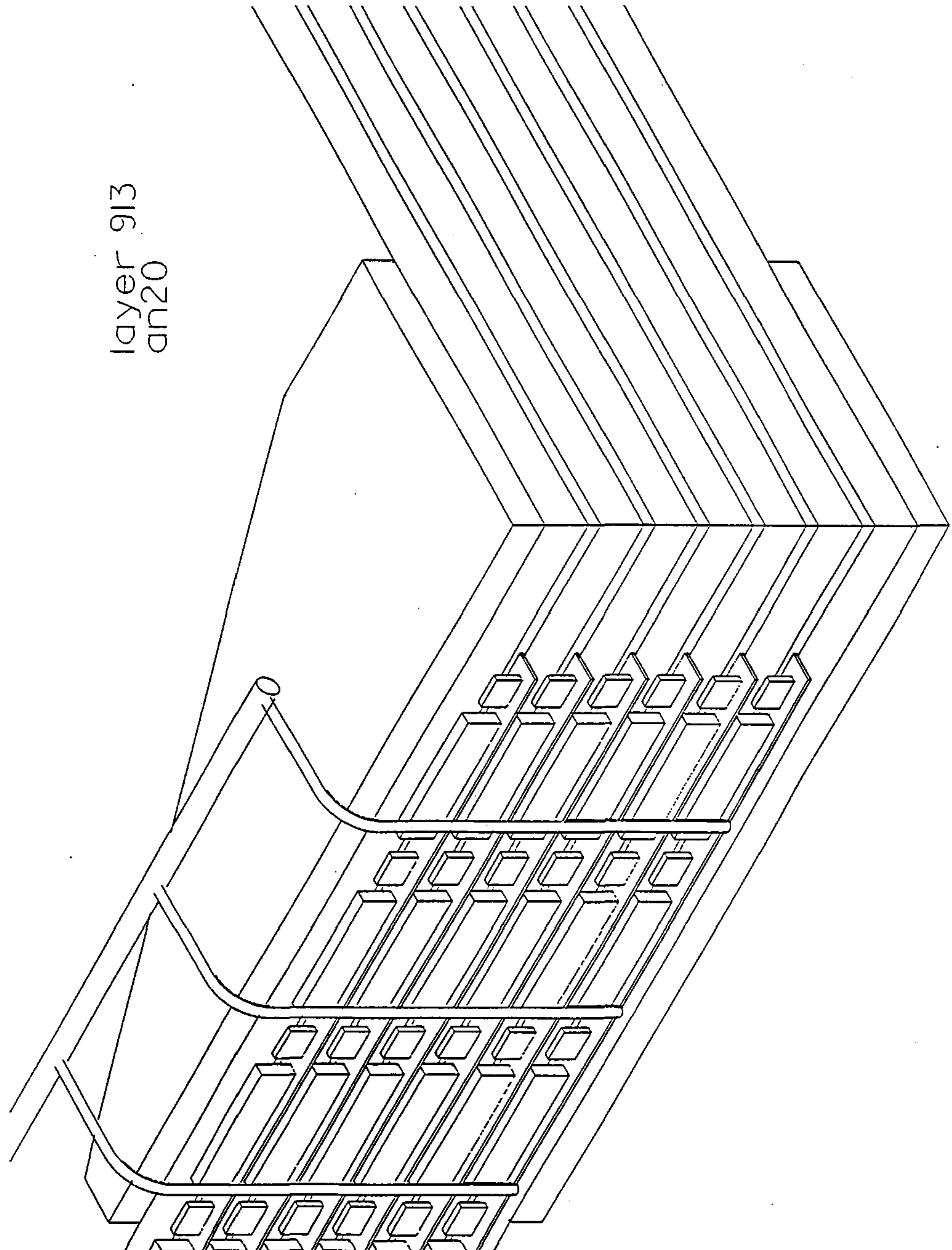
EMS - an38.TDR endcap
igs - an38.igs

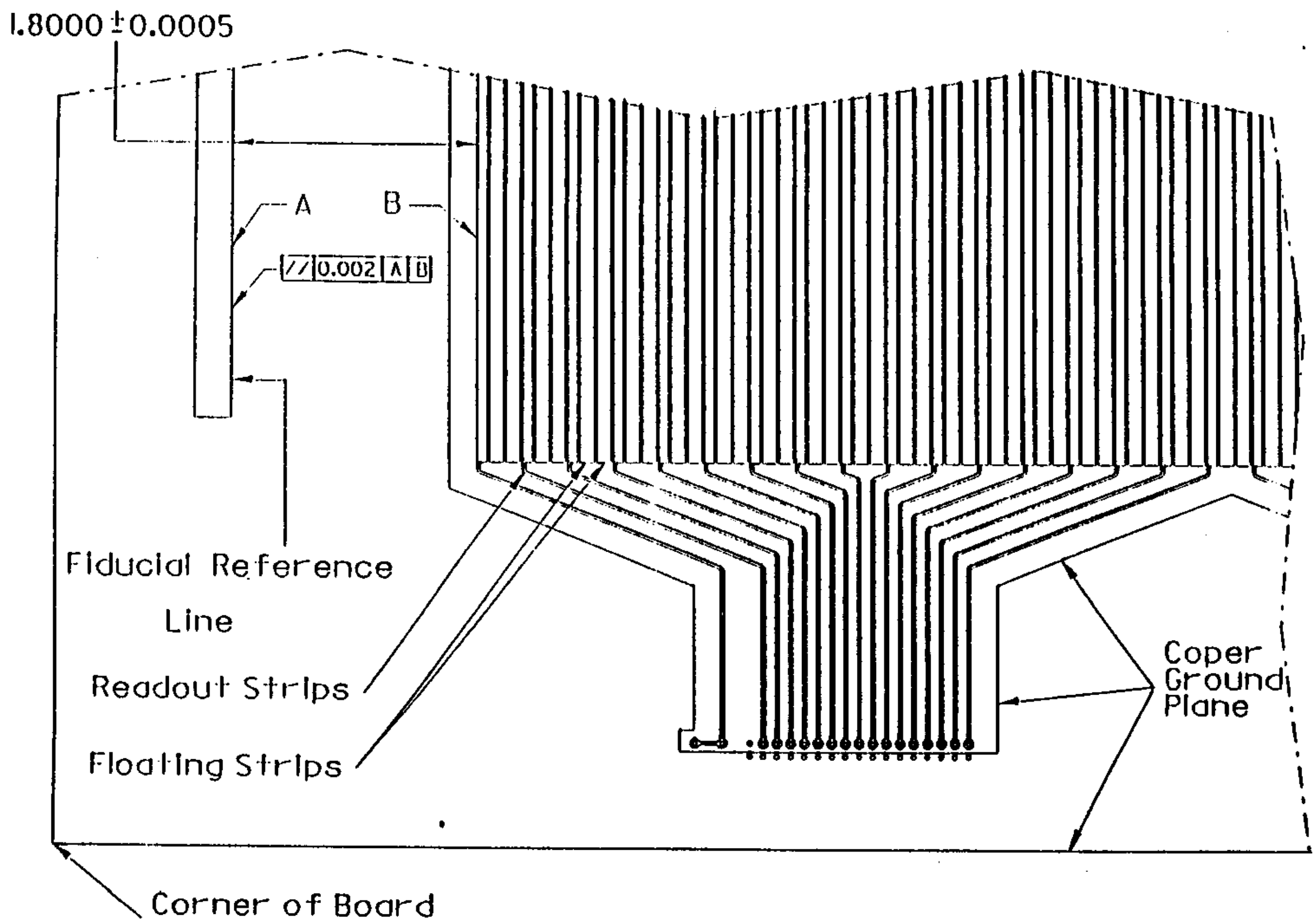
4-52



Anode Wire
Readout
Cables
to Mother Board
HV Distributor
Cooling
Plate
Cathode
Electronics
4-53
EMS - an34. TDR iso2
igs - an34. igs


layer909
an20

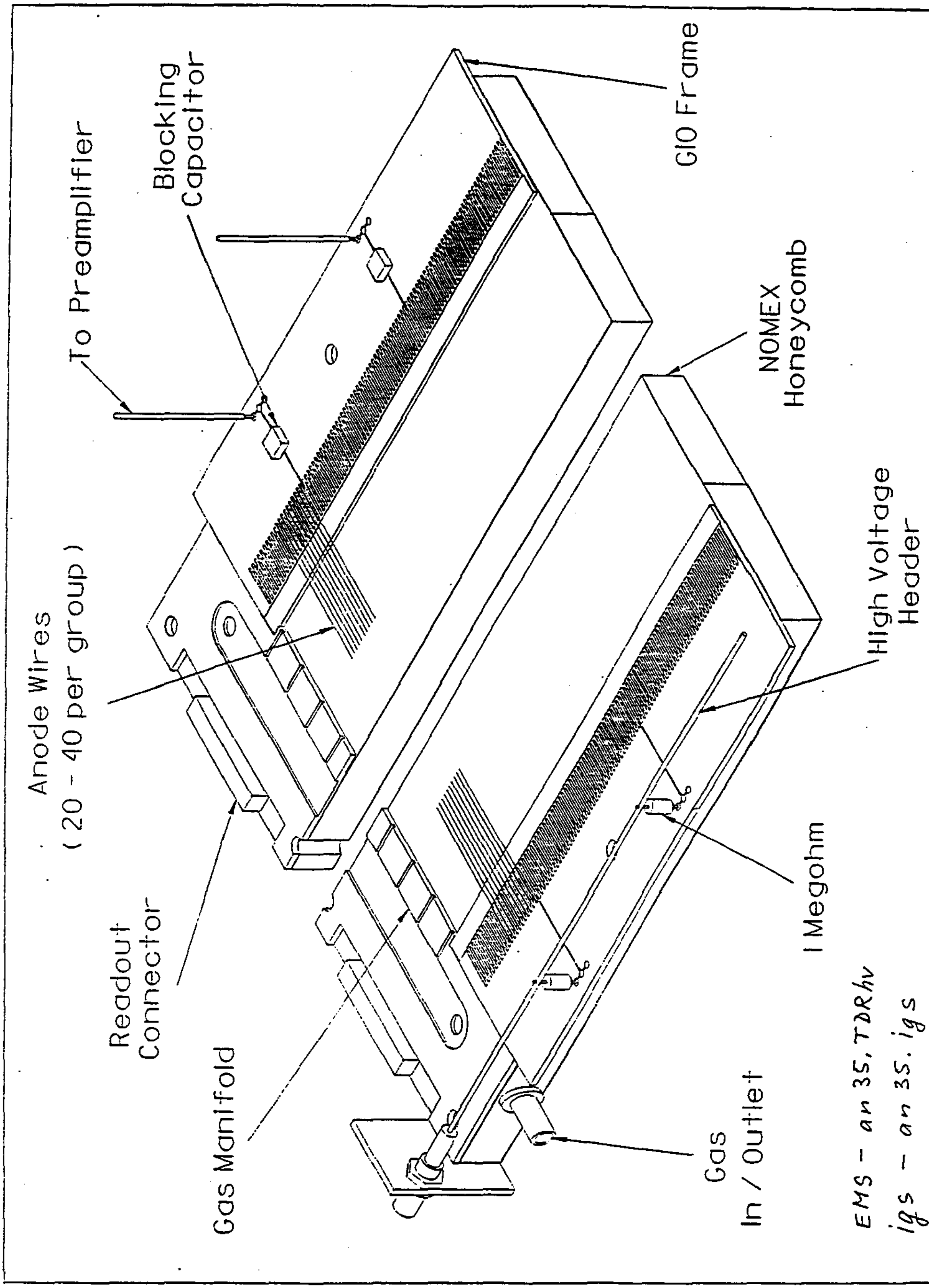

layer 913
an20

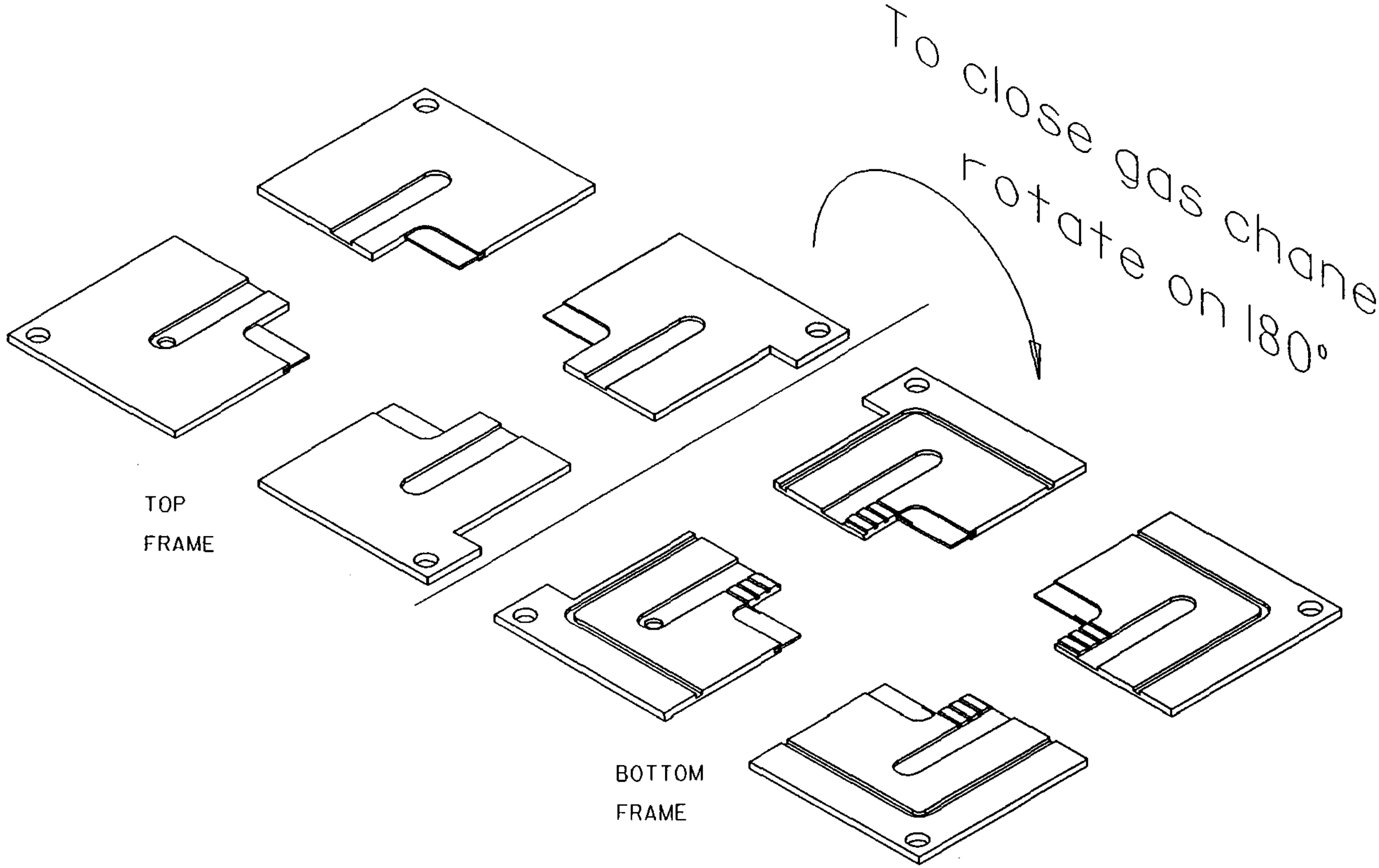


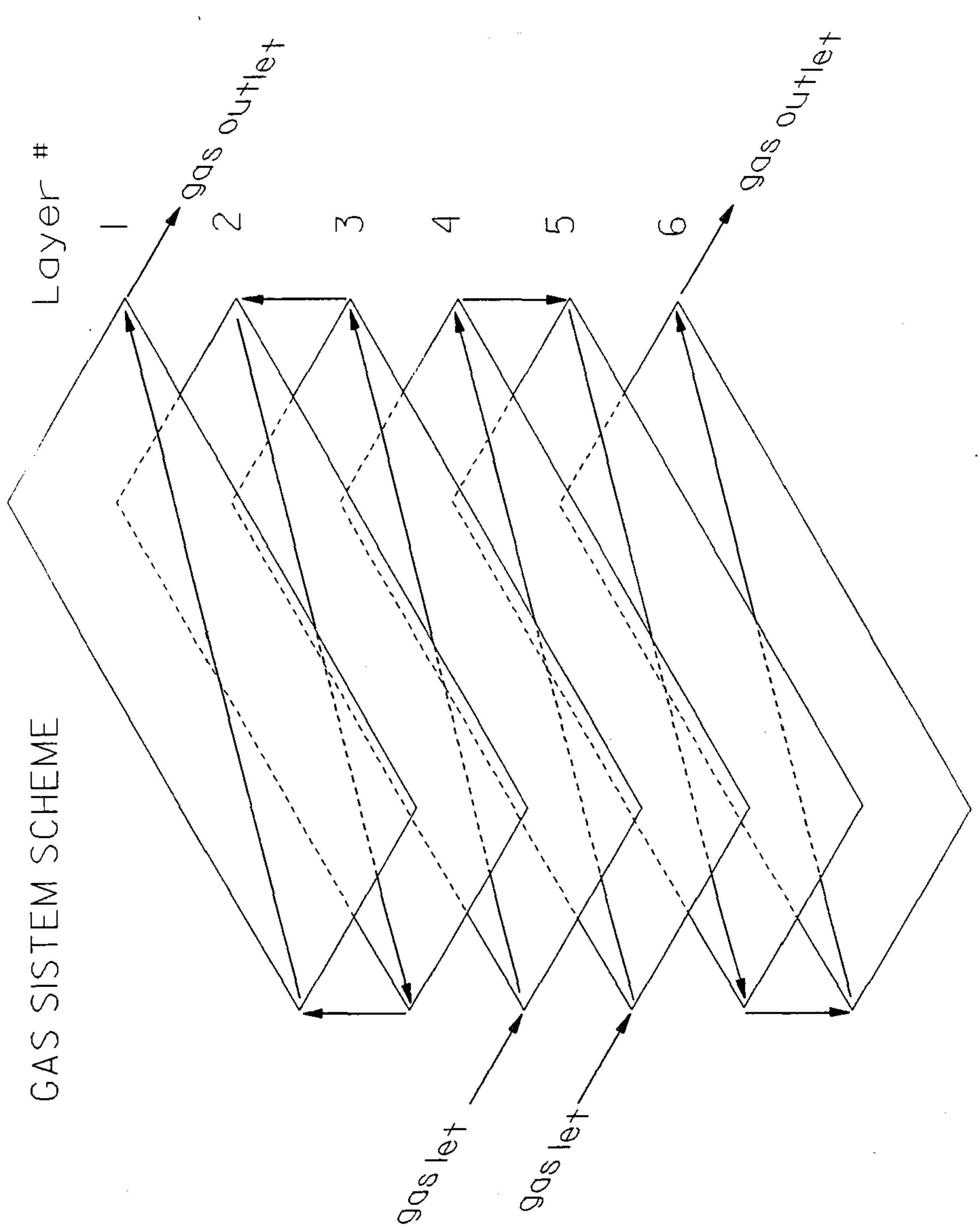
DETAILS OF CSC STRIP CATHODE

EMS – an 37, TDR strip
igs – an 37, igs.

4-55


To Preamplifier
Blocking
Capacitor
G10 Frame
Anode Wires
(20 - 40 per group)
NOMEX
Honeycomb
High Voltage
Header
Readout
Connector
1 Megohm
Gas Manifold
Gas
In / Outlet
EMS - an 35, TDRhv
igs - an 35. igs
4-54


To close gas chanel
rotate on 180°
TOP
FRAME
BOTTOM
FRAME


GAS SISTEM SCHEME
Layer #
1
2
3
4
5
6
gas outlet
gas outlet
gas let
gas let

Presentation by:

John Horvath

Chamber Support

Chamber Support Requirements

Chambers are supported such that non-flatness w/t projective alignment fiducials meets requirements defined in GEM TN-93-333, "Alignment Requirements for the GEM Muon System", A. Ostapchuk.

Chamber deflection prediction methods are detailed in GEM TN-93-350, "Cathode Strip Chamber Deflection Calculations and Sensitivity Analyses", J. Horvath.

Baseline-2 chamber description

- dimensions
  - outer superlayer chamber dimensions
    - max. l = 3,500 mm, max. w = 1,330 mm, thickness = (200+32) mm
  - middle superlayer chamber dimensions
    - max. l = 2,655 mm, max. w = 1,079 mm, thickness = (188+32) mm
  - inner superlayer chamber dimensions
    - max. l = 3,500 mm, max. w = 771 mm, thickness = (170+32) mm
- designed primarily for physics performance
- external support interface locations are provided

Design status

- baseline-2 chamber sizes as defined above are assumed
- chambers are not paired
- no stiffeners added to baseline-2 chambers
- long-edge support at optimum locations via separate frames to reduce sag

Driving constraints

- 200-micron limitation on gravity sag for projective alignment
- stayout zones for projective alignment
- space frame radial load path stayout zones
- interface to current space frame structure must be at chamber ends
- amount and nature of material in system

Areas where weak

- currently requires carrier frame or chamber exoskeleton (lots of material)
- paired chambers not part of baseline-2 and not consistent with carrier drawing
- nat. frequencies of whole system not done (chambers + [illegible] frame [illegible]) (may require stiffeners to increase wn)
  what is basis for barrel region chamber wt?

Chamber support options for achieving required flatness:

1. non-optimized baseline 2
   unstiffened chamber is supported at optimum locations
   carrier frame transfers load to space frame
   gravitational sag is reduced to acceptable level

2. optimized space frame
   unstiffened chamber is supported at optimal locations
   space frame is modified to eliminate carrier frames
   gravitational sag is reduced to acceptable level

3. record and subtract
   unstiffened chamber is supported at ends
   gravitational sag is recorded once upon installation
   gravitational sag effect is eliminated during data reduction

4. track and subtract
   unstiffened chamber is supported at ends
   gravitational sag is continuously measured during use
   gravitational sag effect is eliminated during data reduction

5. stiffen chamber
   stiffened chamber is supported at ends
   external cage or apparatus is attached directly to chamber
   gravitational sag is reduced to acceptable level

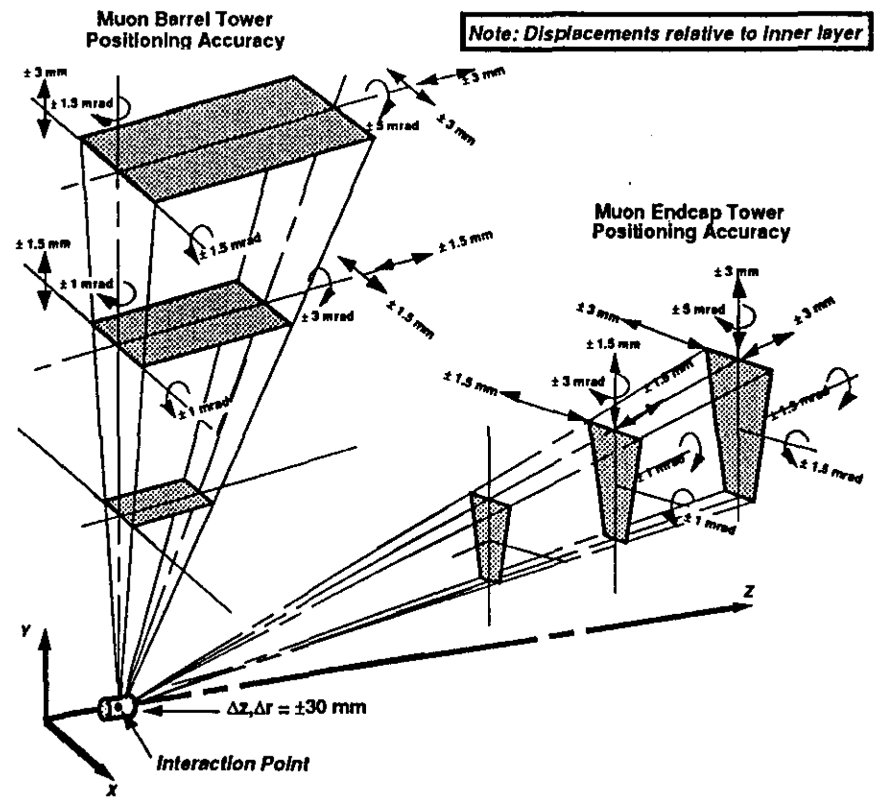
PrePAC Review

Muon Alignment Status and Suggestions

- J. Paradiso
14-April-93

GEM

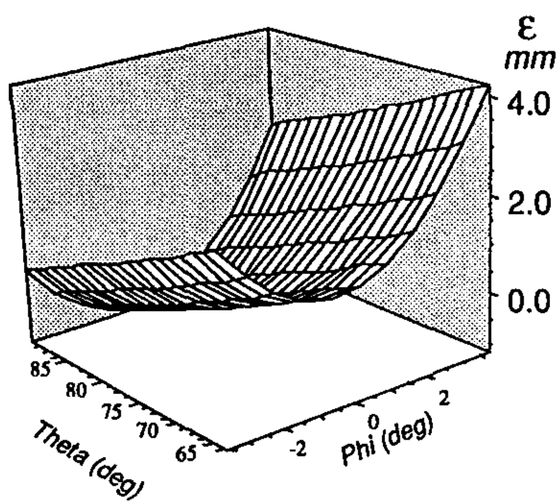
Requirements and Analysis



- Analyzed by Andrey Ostapchuck before departure
  - Included many effects
  - ±1.5 mm tolerance on middle layer looks real tight!!
  - Must extend (z Res, other contributions, *more information!*)

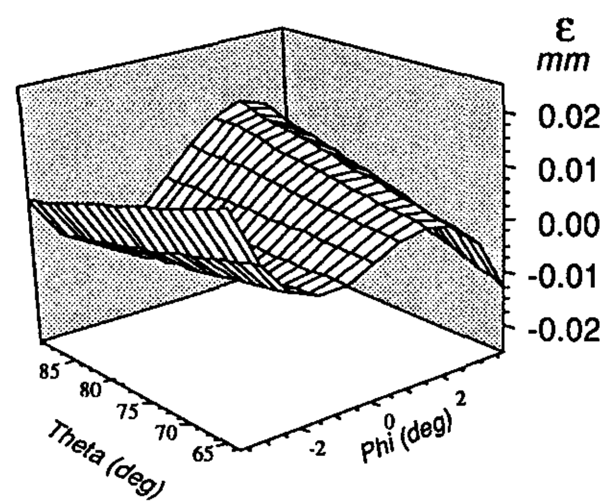
Alignment Correction Function

Sagitta Errors Before Alignment Correction



<|ℰ|> = 1.1 mm

Sagitta Residual After Alignment Correction



<|ℰ|> = 5.0 μm

Correction function uses only monitor sagitta-axis measurements!

Analyze the alignment from the point-of-view of an optimal estimator; i.e. all information (from x and y alignment coordinates, muon data, temperature monitors, structural model) is fused together in the best fashion (i.e. something like a Kalman filter) to deliver the sagitta error over a wide range of positioning error.

☛ **Increase Range of correction (thus positioning)!**

GEM

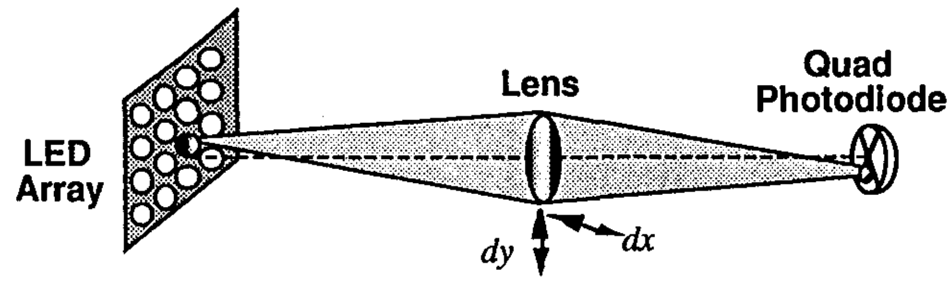
Hardware; LED Option

- A cute idea.
- One LED block already tested
- Must look at resolution, calibration
- Modify electronics, mill out LED diffuser, or make custom array to get performance at long range.
- Candidate for alignment test rig.
- Test for thermal sensitivity, etc. over long path lengths

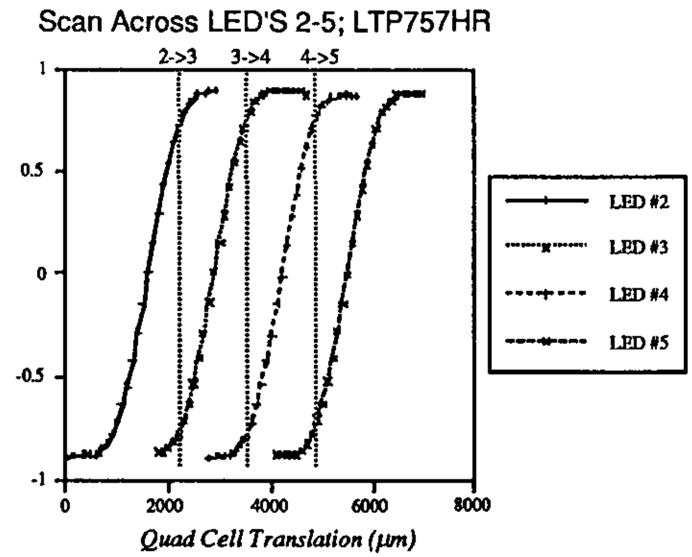
72

Plan to incorporate into GEM TN-93-331:

Paradiso, J., Goodwin, D., "Testing and Development of Extended Range Straightness Monitor Systems"

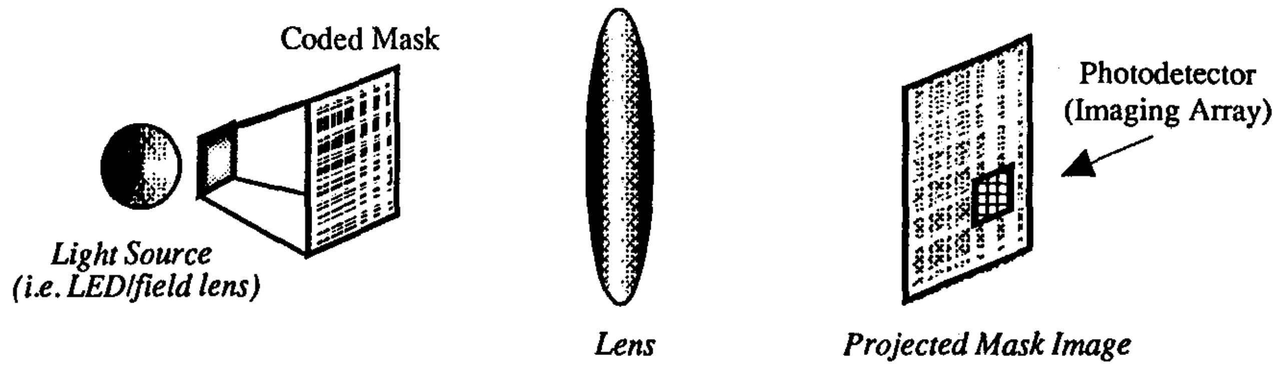


a) Multiple-LED Alignment System



b) Test results for LED block w. 2.5 mm pitch

Hardware; Video Option



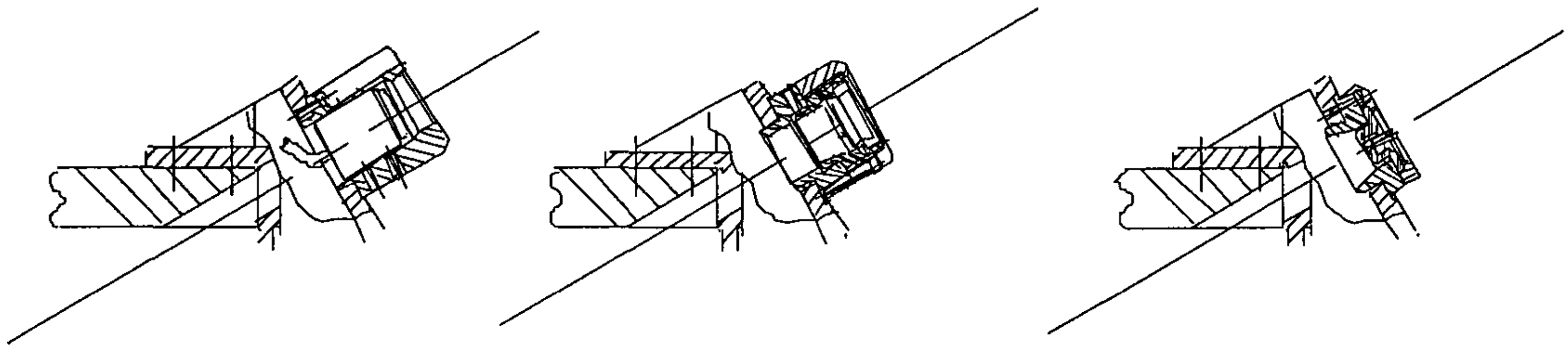
- Very successful demonstrations; extremely promising
- Data taken with new bar code; must develop new parser and analyze!
- Tests now underway in CSDL Optics Lab to document and analyze:
  - Degradation of image with lens diameter over 9 meter path
  - Rotational effects of mask image
  - Rotational effects of field lens
  - Tolerance to defocus
  - Thermal effects
- Main topic of GEM TN-93-331, TBC...
- Accepted in 1993 Annecy Accelerator Conference

Fixturing

DETECTOR ASSEMBLY *(QUAD-CELL, PHOTOPOT, IMAGING ARRAY)*

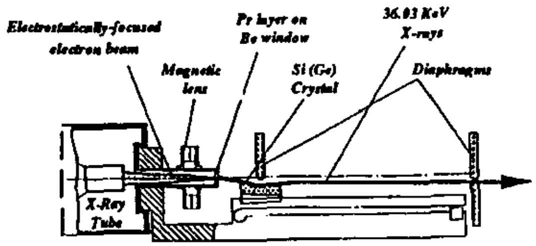
LENS ASSEMBLY

LIGHT SOURCE ASSEMBLY *(LED, LED BLOCK, OR ILLUMINATED MASK)*

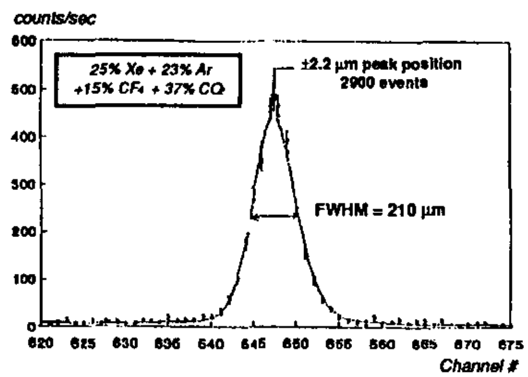


- This picture is real old (i.e. sketches for TTR as of last summer), and is really for LED/LENS/QUAD system.
- Essential idea is intact; optical element calibrated to fiducial edge.
- Must develop new (simple!!) fixtures for video array, mask assembly, LED blocks, together with calibration procedure.
- Prototypes needed soon for Alignment Test Stand (ref. JP. Amory's work).
- Must also integrate with chamber design to devise viable scheme for fiducializing to chamber layer (plus fit with minimal lever arm, impact).

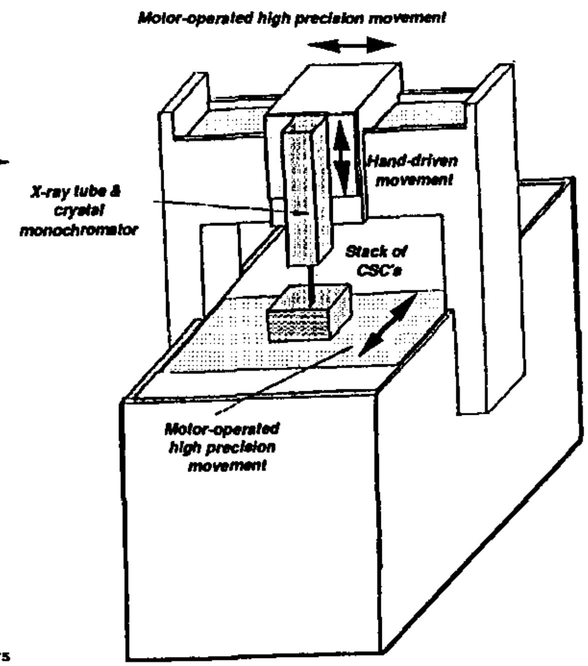
X-Ray Table



a) Schematic of single-crystal monochromator



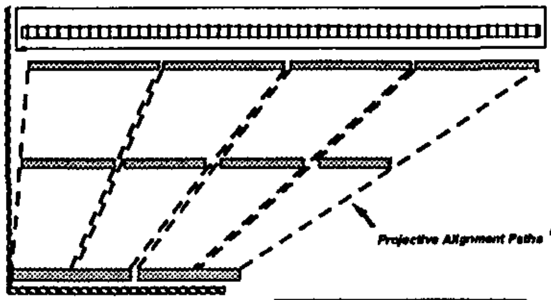
b) X-Ray beam profile as measured with a CSC



c) CSC scan calibration table

- **Component tests, results at PNPI and relevant institutes (BNL,LLNL).**
- **Big X-ray head and procedures for calibrating 3 superlayers on installation?**

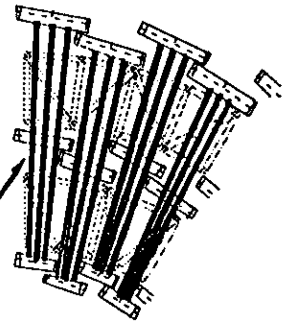
Barrel/Endcap Layouts



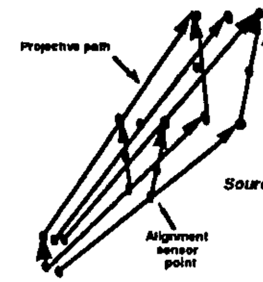
Local Alignment Monitors Needed:

Barrel Module ($\Delta\phi = 7.5°$) = 24
Assembly Sector ($\Delta\phi = 30°$) = 96
Net GEM Barrel = 2304

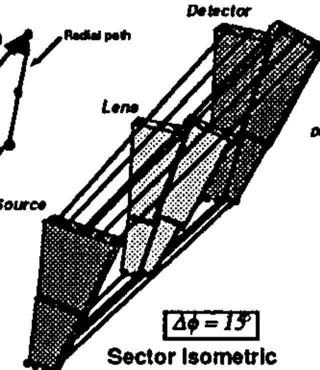
A) Side view ($r\theta$)



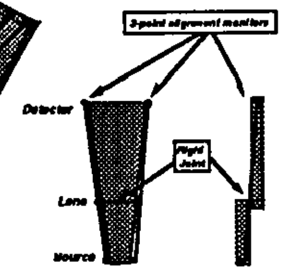
B) End view ($r\phi$)



Tower alignment paths
(5 projective plus 5 radial coupling paths)



Sector isometric
(with projective alignment)

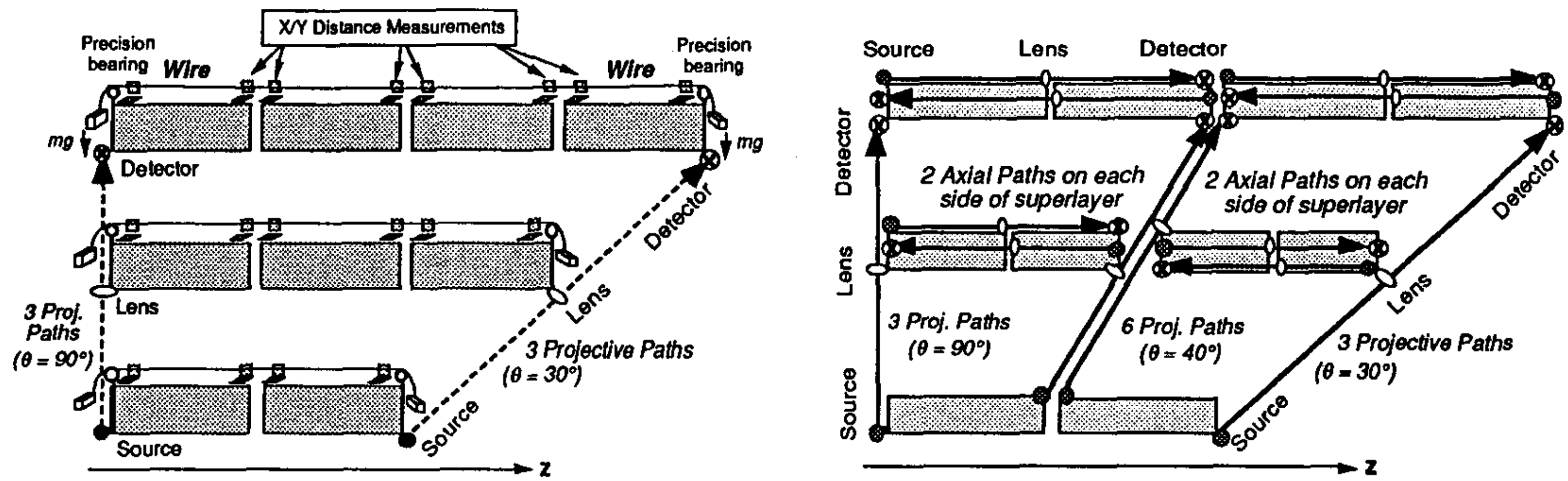


Front/side superlayer views
(with radial alignment paths)

- There is a concept...
- Directly measures sagitta error (within projective scale factor)
- Lottsa red/orange flags:
  - Effect of projective gaps on barrel acceptance
  - Chambers ever smaller -> Too many alignment paths?
    - * *Join chamber packages together?? (needs analysis)*
  - Need many different fixtures, angled in theta and phi
  - Installation, survey.
- Endcap design could use some analysis

GEM

Alternative Barrel Layouts



a) Hybrid Axial/Projective Scheme　　*b) All-Optical Axial/Projective Comprimise*

77

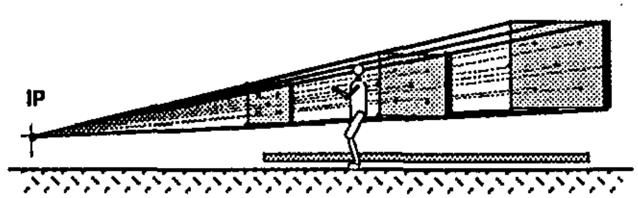
- **These can close the alignment gaps (amount saves depends on deadspace at ends *[overlap?]*).**
- **Option (a) requires wire technology to be pursued (some work done/proposed at CERN, LLNL, MIT).**
  - **Step toward "sector alignment frame" approach that may save survey effort, aid global alignment**
- **Option (b) uses current technology, but institutes another projective path.**

Alignment precision tightened ~ 2x because of transfer between systems.

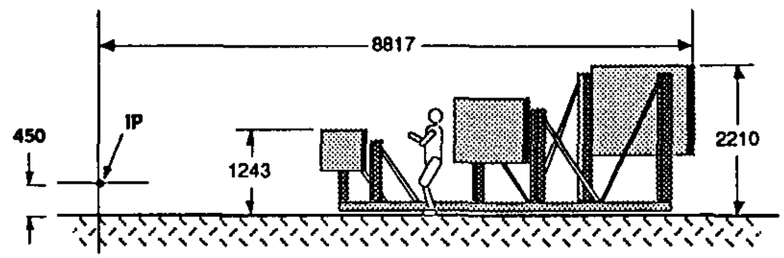
GEM

Radically new ideas; i.e. do it all with X-rays??

Alignment Test Stand



Proposed Projective Alignment Lines of Sight

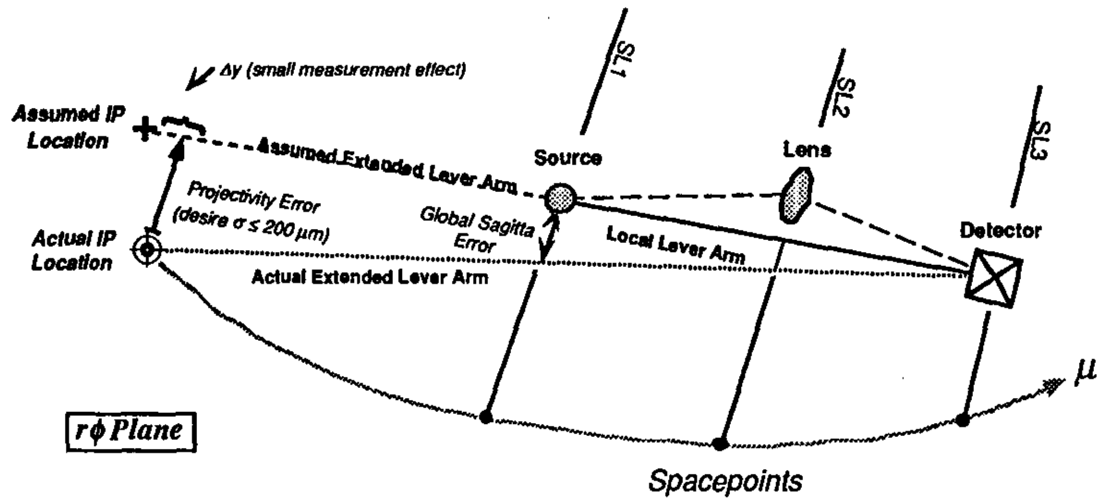


Mechanical Design and Fixturing

78

- **Nice demonstration of technology.**
- **If chamber panels are realistic, it may even produce some useful data**
- **Much detailed work already finished by JP Amory**
- **Can not test multipoint, axial concepts easily**
- **This effort will probably require the dedication of most alignment staff.**

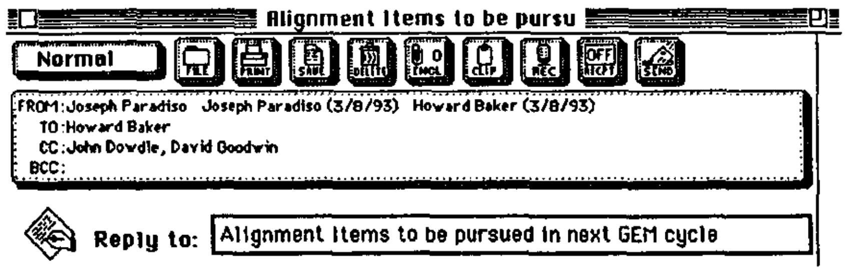
Global Alignment



- No complete concept for instrumenting this; do through muons.
- Very useful analysis completed by Andre Ostapchuk; results:
  - Several hours of statistics @ standard luminosity needed for 200 μm vertex constraint.
    - * Systematics helped by opposite sign tracks; must investigate more.
  - Use of muon information to verify the local alignment and widen the local positioning requirements?

79

Some Bullets



- Continue developing software to perform automated device scanning and calibration on the Macintosh.
- Quantify the systematic error sources and magnitudes for the 3-point video straightness monitor (VSM) system; much of this will be finished in March, but some things may continue in April.
- Investigate radiation & magnetic sensitivity of the candidate alignment sensors:
  1) Bring them to the 1.5 Tesla MIT cyclotron magnet, and determine magnetic field effects.
  2) Bring them to a source (i.e. Californium), and observe the background rate at 10**5 neutrons/cm**2-hz.
  3) Bring them to a high-rate reactor/source facility, and see how they hold up under the total expected SSC dose (10**12 - 10**14 neutrons/cm**2).
- Design inexpensive, precision alignment fixtures to hold the components & mount to the chambers, and determine an efficient calibration procedure
- Continue in the analysis effort; determine how to use the information in the non-sagitta readout coordinate to extend the correction range, and refine the global alignment procedures.
- If the Projective Alignment Simulation (PASS) setup is constructed at SSC, we will have to provide a set of monitors and fixtures, plus participate extensively with SSC personnel in setting up the hardware and interpreting/analyzing the results. This in itself will be a significant effort.
- Join the GEM engineering/programs community in developing strategies/schedules etc. for alignment installation, producing refined cost estimates, supporting PAC meetings, etc.

Alternative Schemes....

Presentation by:

Fred Holdener

Alignment Test System

March 29, 1993
Fred R. Holdener

GEM-MIDPLATE

GEM (Gammas, Electrons, Muons) - MIDPLATE (Muon Image Detector Projective Lens Alignment Trial Experiment

Goals of Experiment - In Order of Priority:

(1) To provide a 'test bed' for proposed projective alignment hardware that allows for measurements of 'in-field' accuracies.

(2) To provide variable temperature conditions as would be seen in the field

(3) To see the effects of air disturbances on the measurements of an actual structure

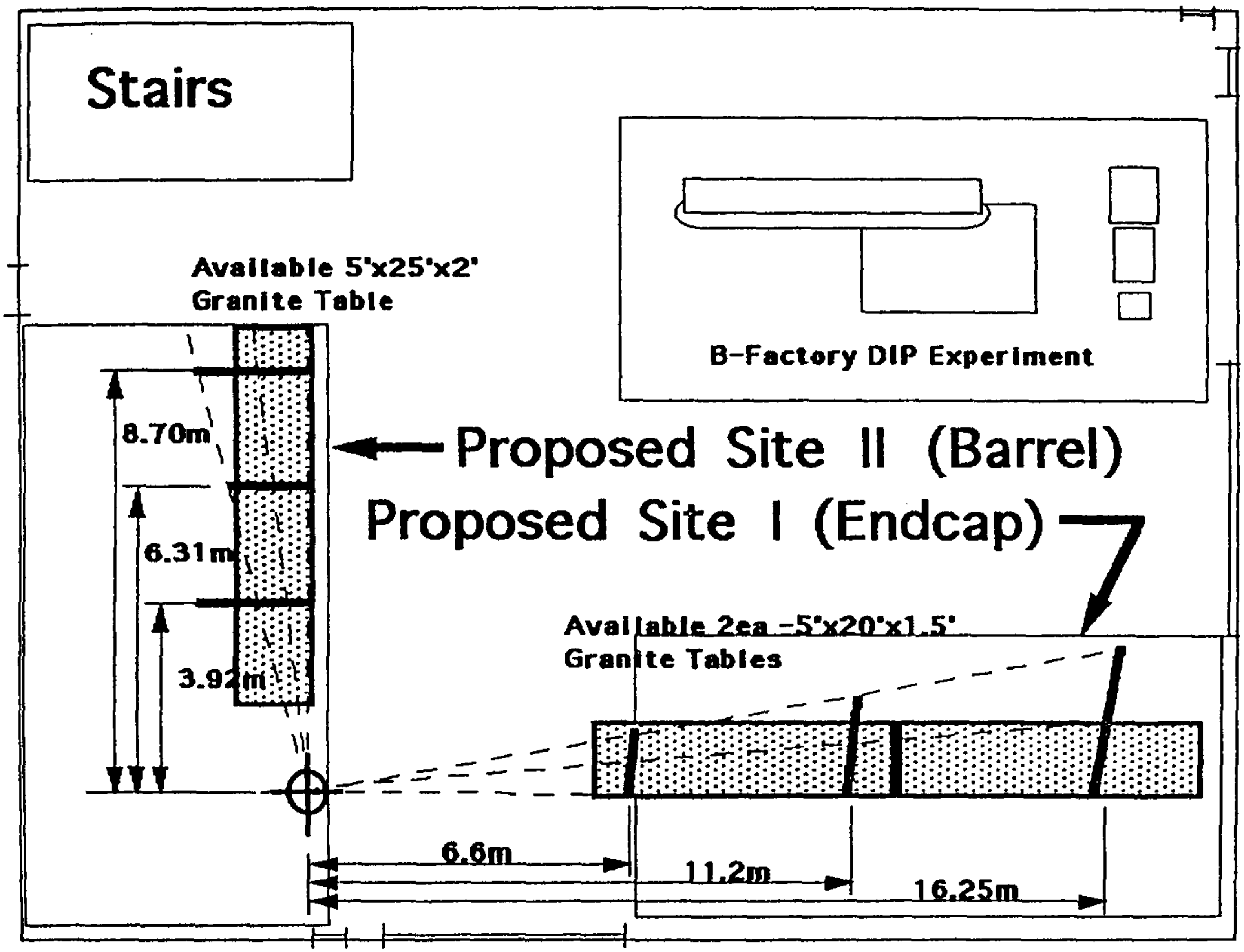
(4) To test the cathode plate structural deflections due to expected mechanical loadings (gravitational, vibrational, assemble, etc....)

(5) To test impacts of various alignment schemes on the actual structural hardware designs

(6) To provide a 'test bed' for actual alignment procedure development, testing and certification

(7) To demonstrate the physical constraints on various alignment schemes

(8) To test positioning actuators and kinematic mounting schemes for mounting the cathode plates to the support frame structure.



Building 432 R-1300 Floor Layout - Proposal For GEM Muon Detector Projective Alignment Experiment

Energy Program's Building Space Loan Authorization Form

Building/Rooms: B432 - R 1300

Occupation Date: 13 Apr 93 Scheduled end of use Date: 31 Mar 94

Name: Fred Holdener Phone # 27003 Mail Stop L-533

Description of use of building space:

Set up and operate a GEM Muon Detector alignment Experiment

Is building modification proposed? (yes/(no))
If yes, give details: *

However, some equipment will have to be relocated, the new equipment will have to be anchored to the floor.

Please provide account numbers for the following services if applicable:

	Account No.
ES&H/QA	8863-09
Building facilitator services	8863-09
Charge for power and utilities	8863-09
Computer hook-up	8863-09
Storage	8863-09
Clean-up of occupied facilities	8863-09
Space Charge	

Is an OSP required? ((yes)/no)
If yes, the OSP will need to be reviewed and signed by Hazards Control Team 2, responsible Energy Program Facility Manager and Energy Program Assurance Officer.

Concurred, Principal Assistant to Associate Director, Energy Program: Carla J Lewis Date: 4/13/93

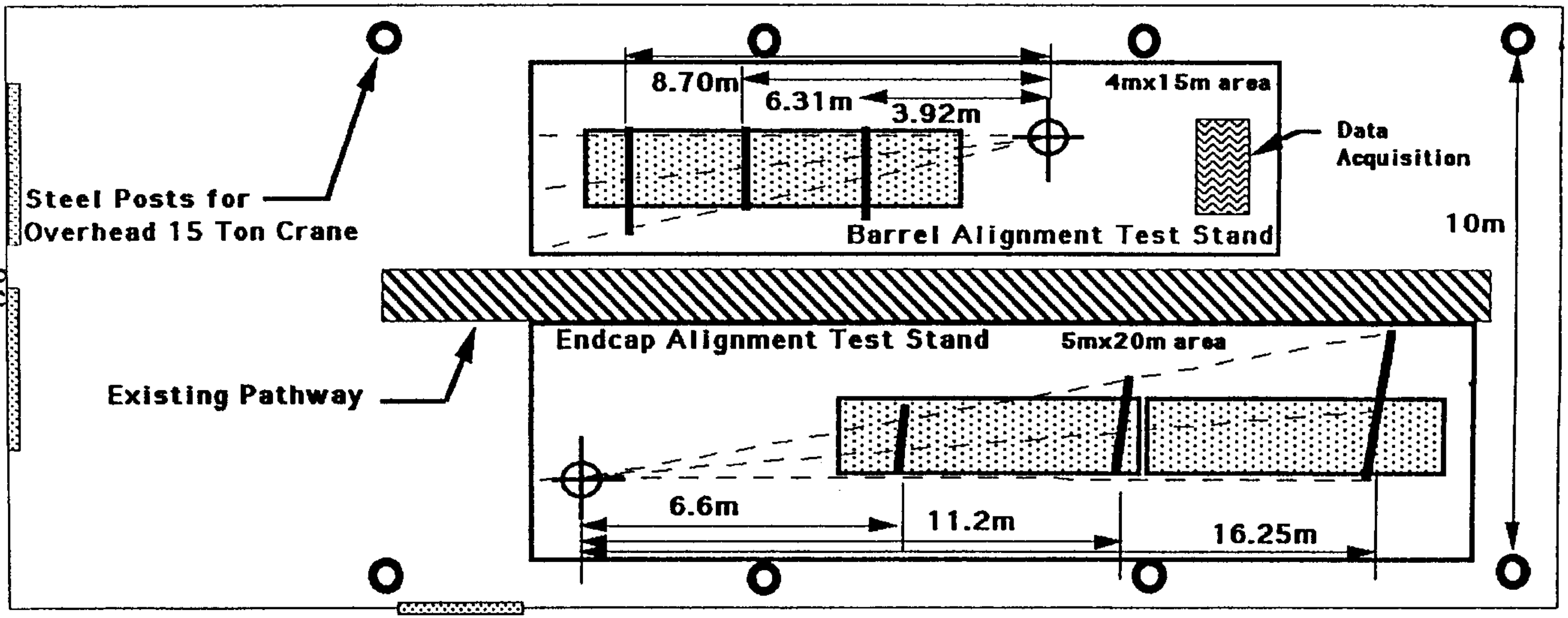
Assurance Manager, Energy Program: Denny Bell Date: 13 Apr 93

Concurrence, Tenant: Fred R Holdener Date: 4/13/93

The Energy Program holds the right to reclaim occupied space if programmatic needs deem it necessary. The Energy Program will provide a written 30 day notice-to-vacate (although as much advance notice as possible will be provided).

* Tenant will provide account number for all modifications and Energy Program will not be held financially responsible for any modifications to the building/room that is done by the tenant, nor will the tenant hold the Energy Program responsible to reimburse for modifications when the tenant no longer occupies the facility. All modifications will be based on approval of the Energy Program.

Original retained by Principal Assistant to Associate Director, Energy Program L-640



SSC Laboratory - Proposal For GEM Muon Detector
Projective Alignment Experiments

Presentation by:

Craig Wuest

Alternative Chamber Layouts

Strawman Muon System Chamber Layouts

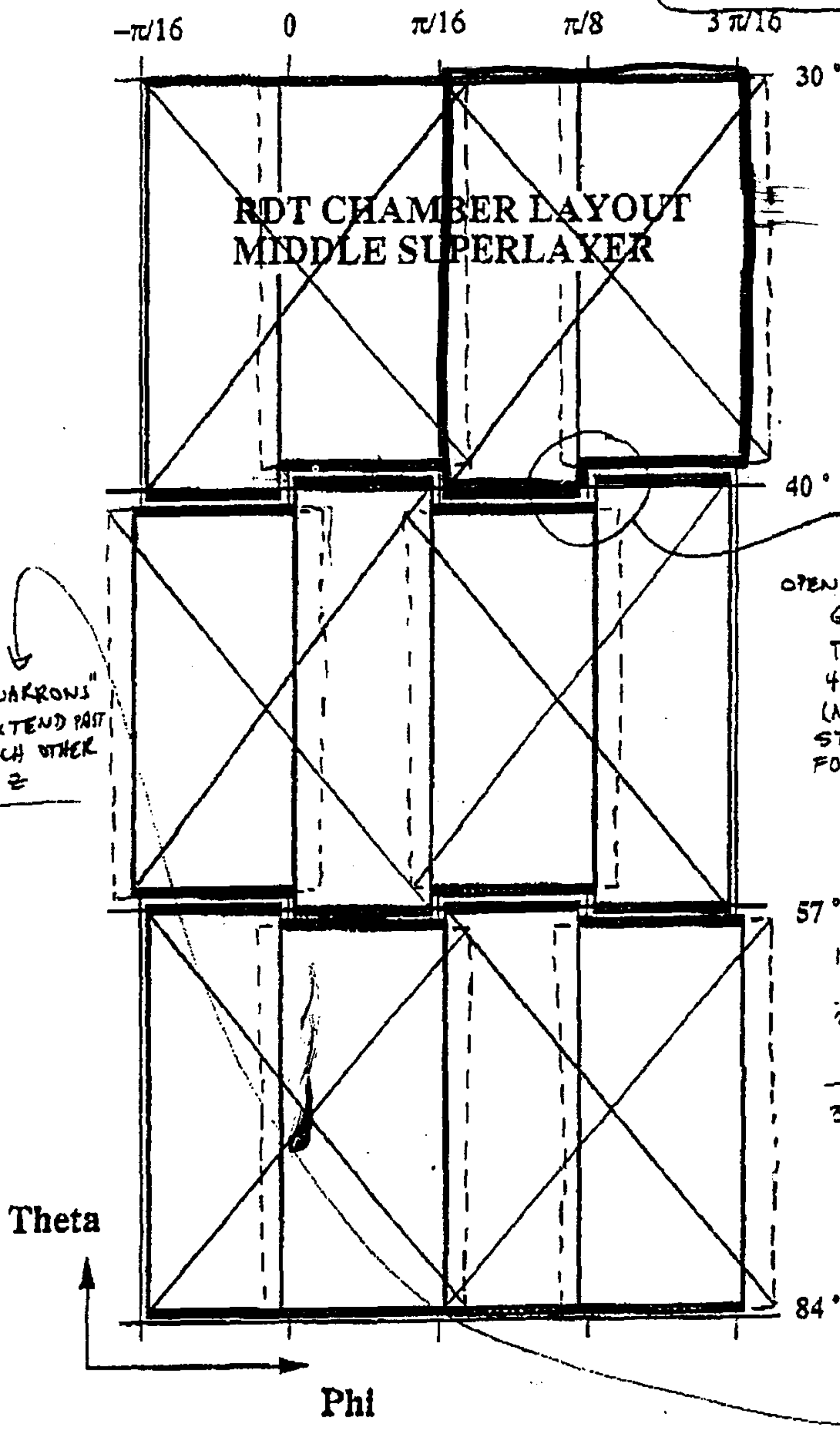
- Staggered chambers as proposed for RDT system (two concepts):
  - advantages are decreased theta gaps in middle superlayer by about 50%, reduced alignment paths.
  - disadvantages include complications for structure, necessary to tie two chambers together in all superlayers (24-phi segmentation).

- Middle superlayer "superchambers," combining four chambers into one ~ 2 m x 5 m
  - advantages include decrease in number of chambers in middle superlayer by a factor of 4 (384 –> 96), decrease in length and amount of chamber frames by 50% (2.7 km –> 1.3 km), simplification of support structure, decrease in theta gaps.
  - disadvantages include need to fabricate and align 4 cathode planes onto a panel, large chamber size and weight (~1 ton), chamber deformation increased (~ 4 mm supported at the corners, reduced to 359 μm for quarter-point support).

- Middle superlayer "semi-superchambers," ~ 2 m x 2.5 m.
  - advantages include decrease in number of middle chambers by a factor of 2, decrease in chamber edges, simplification of support structure - straight-forward extension to semi-superchambers in inner and outer superlayers.
  - see above.

J. HORVATH
3/31/93

1/7



(X DENOTES PANEL PAIRING)

(- - - - DENOTES ADDED WIDTH FOR OVERLAP IN φ)

CROSS-HATCHED OPEN ZONE MUST BE GREATLY INCREASED TO ACCOMODATE 4 TO 6 LOS "PIPE" (NEGLECTING STRUCTURAL FRAME FOR NOW)

5. "NARROWS" EXTEND PAST EACH OTHER IN Z

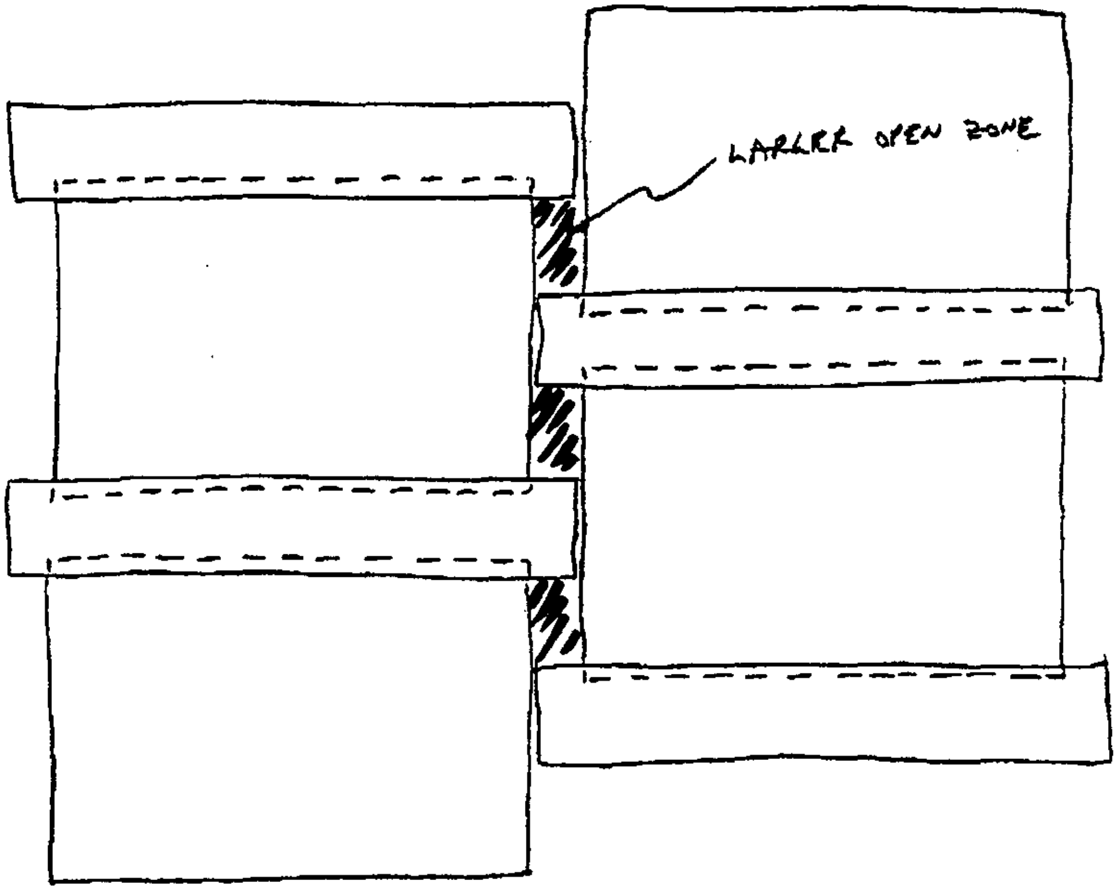
IDENTIFYING FEATURES OF THIS LAYOUT:

1. "WIDES" SHORTER THAN "NARROWS"
2. "WIDE" BUTTS TO "NARROW" AT ENDS
3. "NARROW" IS CENTERED ON "WIDE" AT END BUTT INTERFACE
4. OPEN ZONES ARE BOUNDED BY SIDE OF NARROW IN φ AND BY END-OF-WIDE IN Z

2/7

EVOLUTION #1

MAINTAIN ALL IDENTIFYING FEATURES FROM RDT LAYOUT
BUT INCREASE SIZE OF OPEN ZONES TO A REASONABLE AMOUNT FOR ALIGNMENT PIPES & STRUCTURE.



PROBLEMS:
- "WIDE" PANELS BECOME VERY WIDE.
- "NARROW" PANELS BECOME VERY NARROW
- DID NOT TAKE OPPORTUNITY TO OVERLAP IN Z WHERE POSSIBLE (WHEN BUTTED PANELS ARE AT DIFFERENT R's)

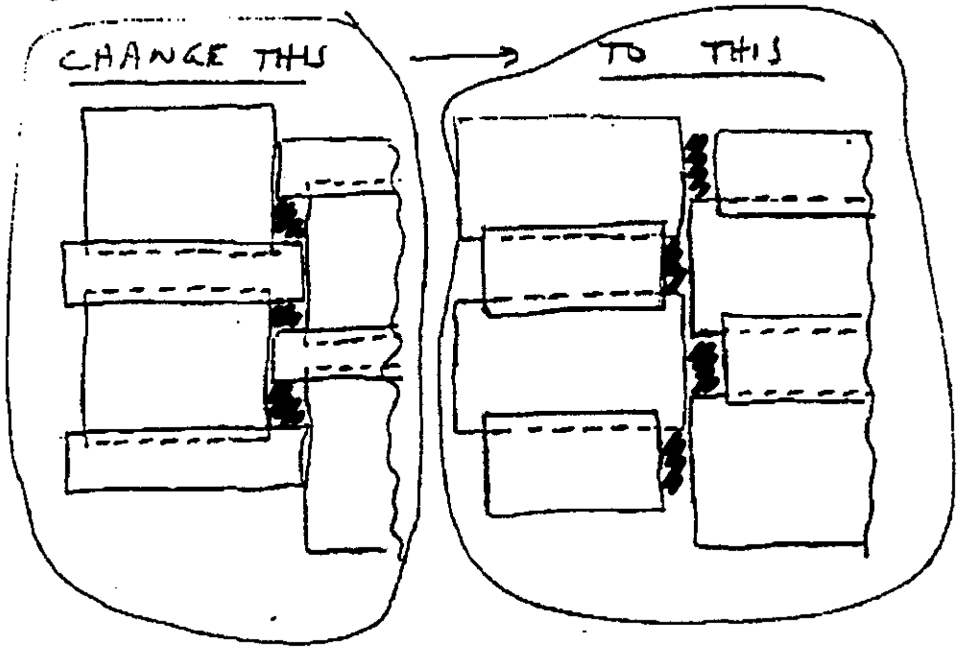
MODIFY TO CORRECT PROBLEMS:

3/7

EVOLUTION #2 (3 LAYOUTS ATTACHED)

ALLOW NARROW PANELS TO BE SHORT AND WIDE PANELS TO BE LONG. THIS MAKES "WIDE" NARROWER AND "NARROWS" WIDER —

SOLVES PROBLEMS ① & ②



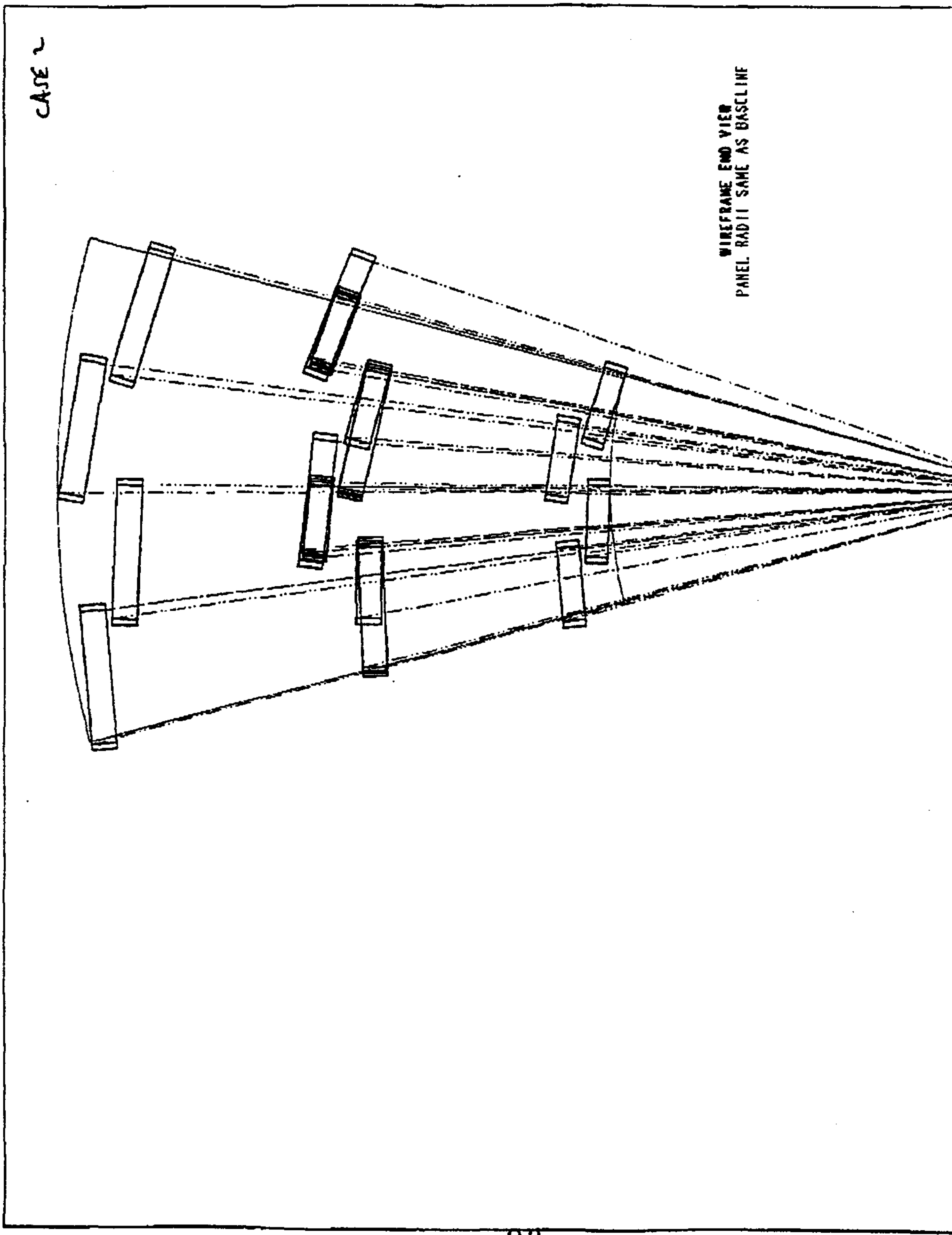
EVOLUTION #3 (1 LAYOUT ATTACHED)

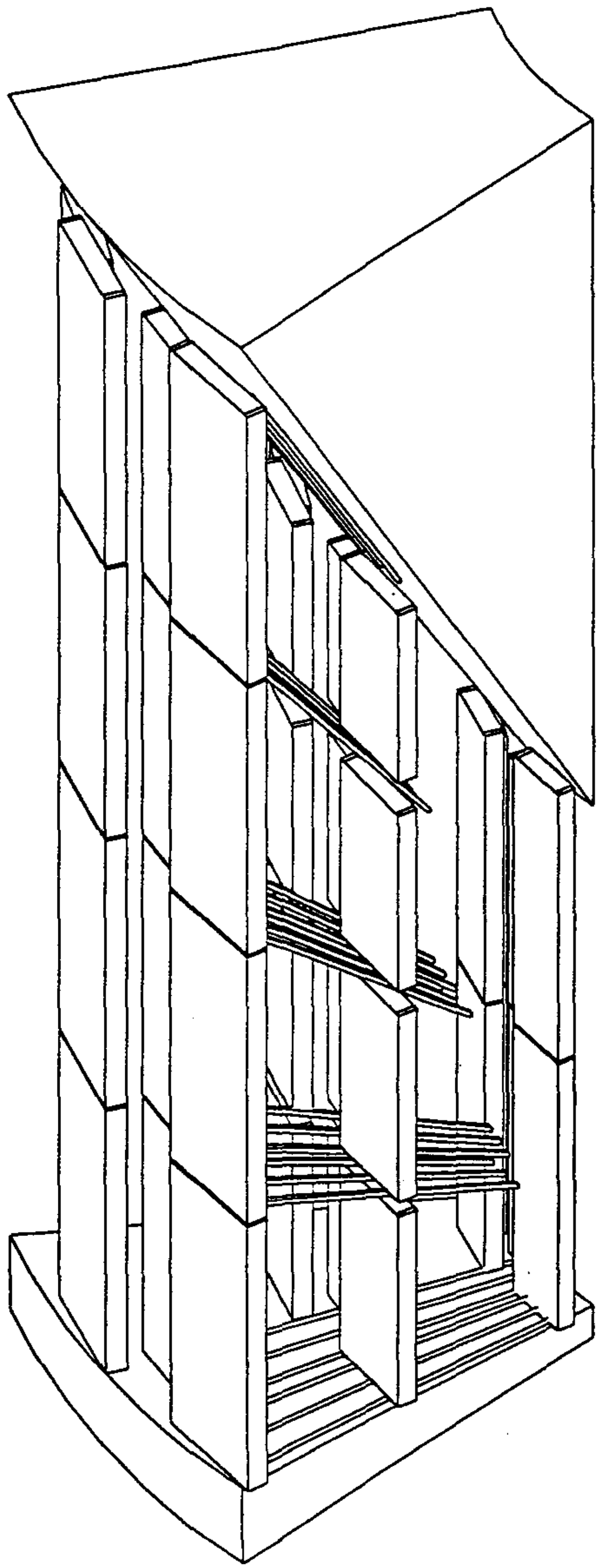
ALLOW NARROW PANELS TO EXTEND PAST EACH OTHER IN Z. THIS SOLVES PROBLEM ③

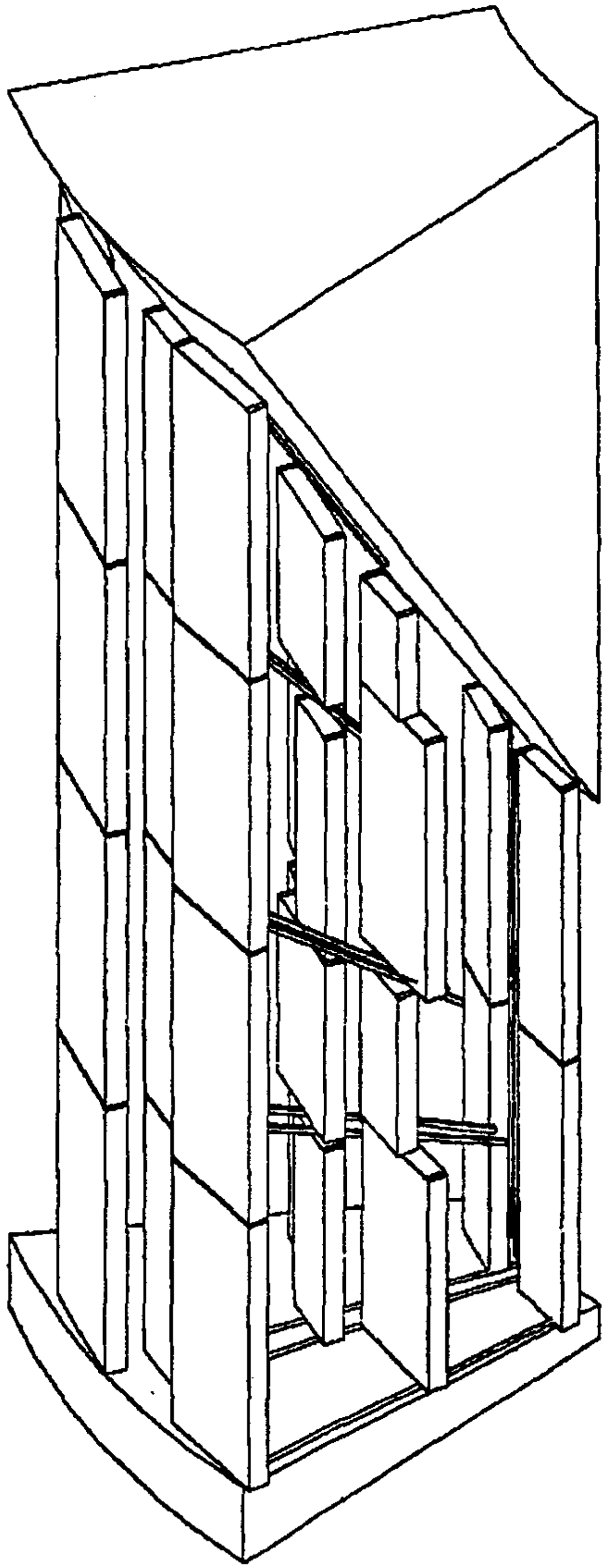
THIS BRINGS US TO WHERE WE WERE EARLIER THIS WEEK.

THE MOST RECENT TRIAL CASES WE HAVE DONE ARE ON A DIFFERENT EVOLUTIONARY TRACK.

BOTH ARE WORTH MORE STUDY.

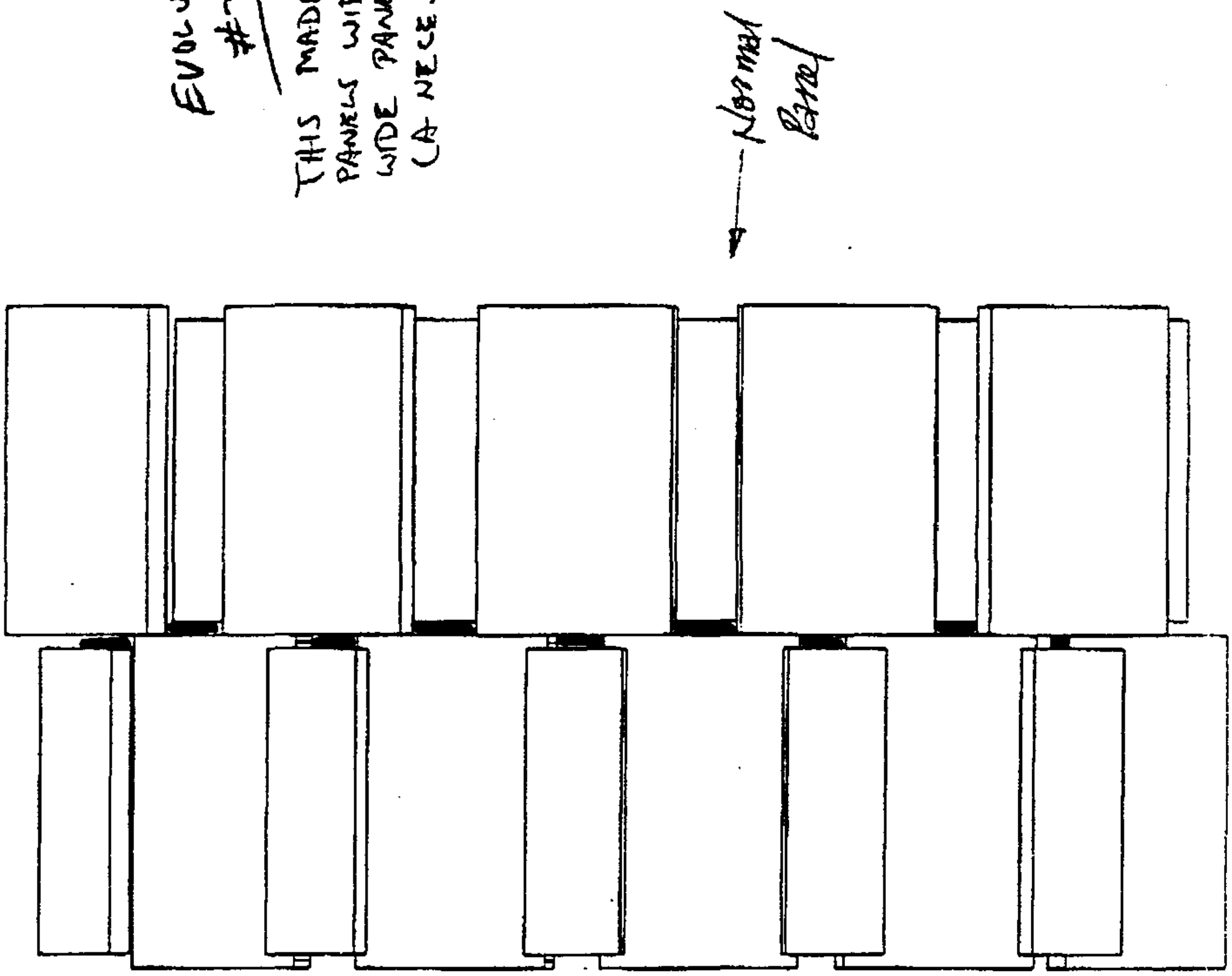

CASE 2
WIREFRAME END VIEW
PANEL RADII SAME AS BASELINE



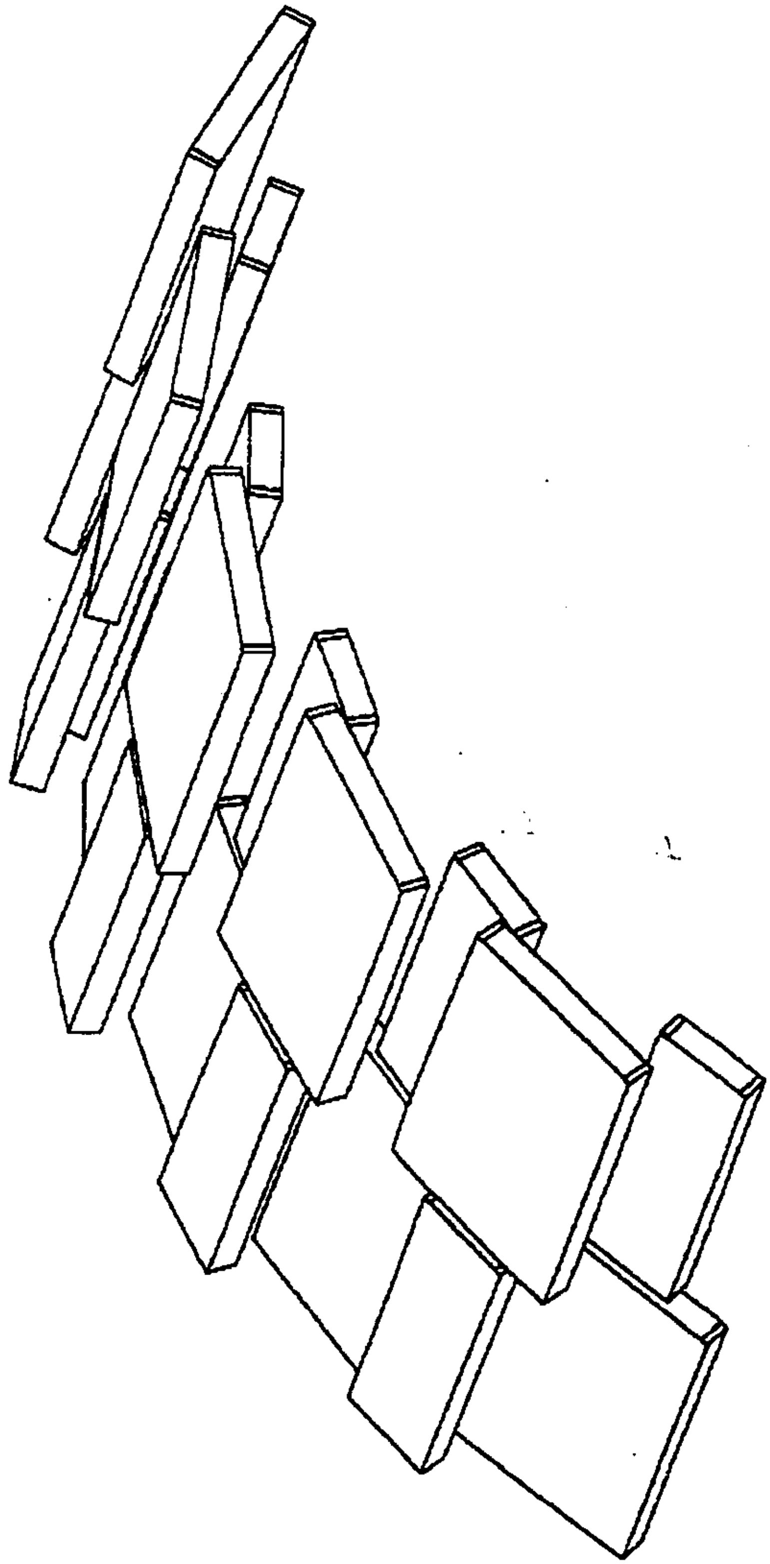


EVOLUTION #2

THIS MADE NARROW PANELS WIDER & WIDE PANELS NARROWER (A NECESSITY)

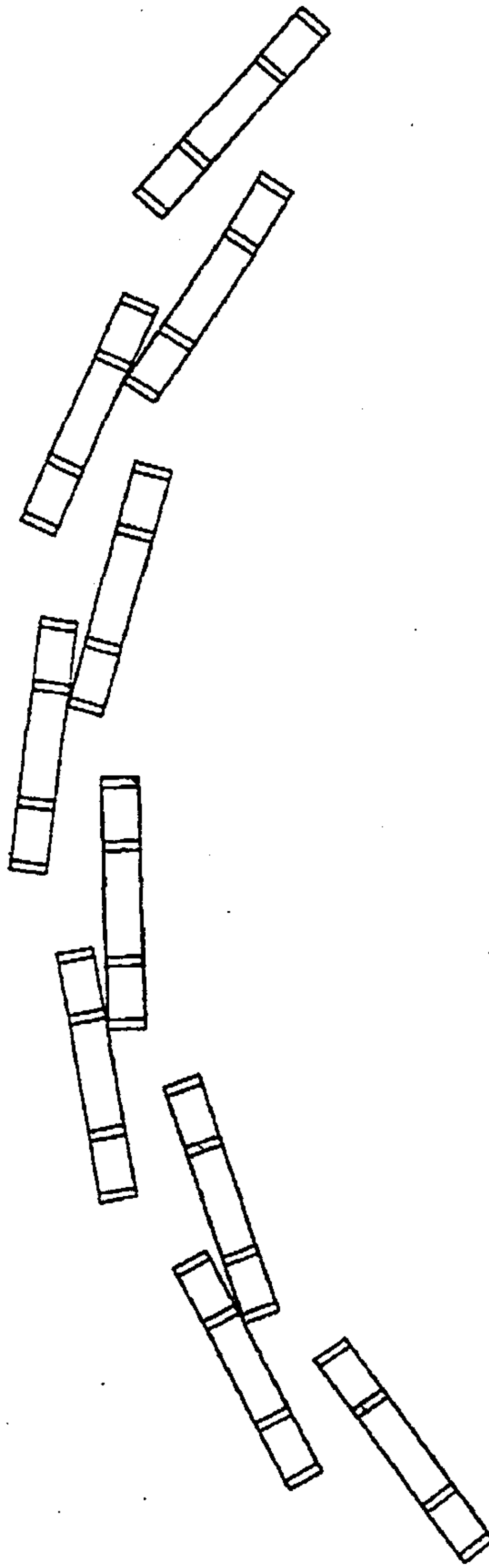


EVOLUTION #2
(CONTINUED)

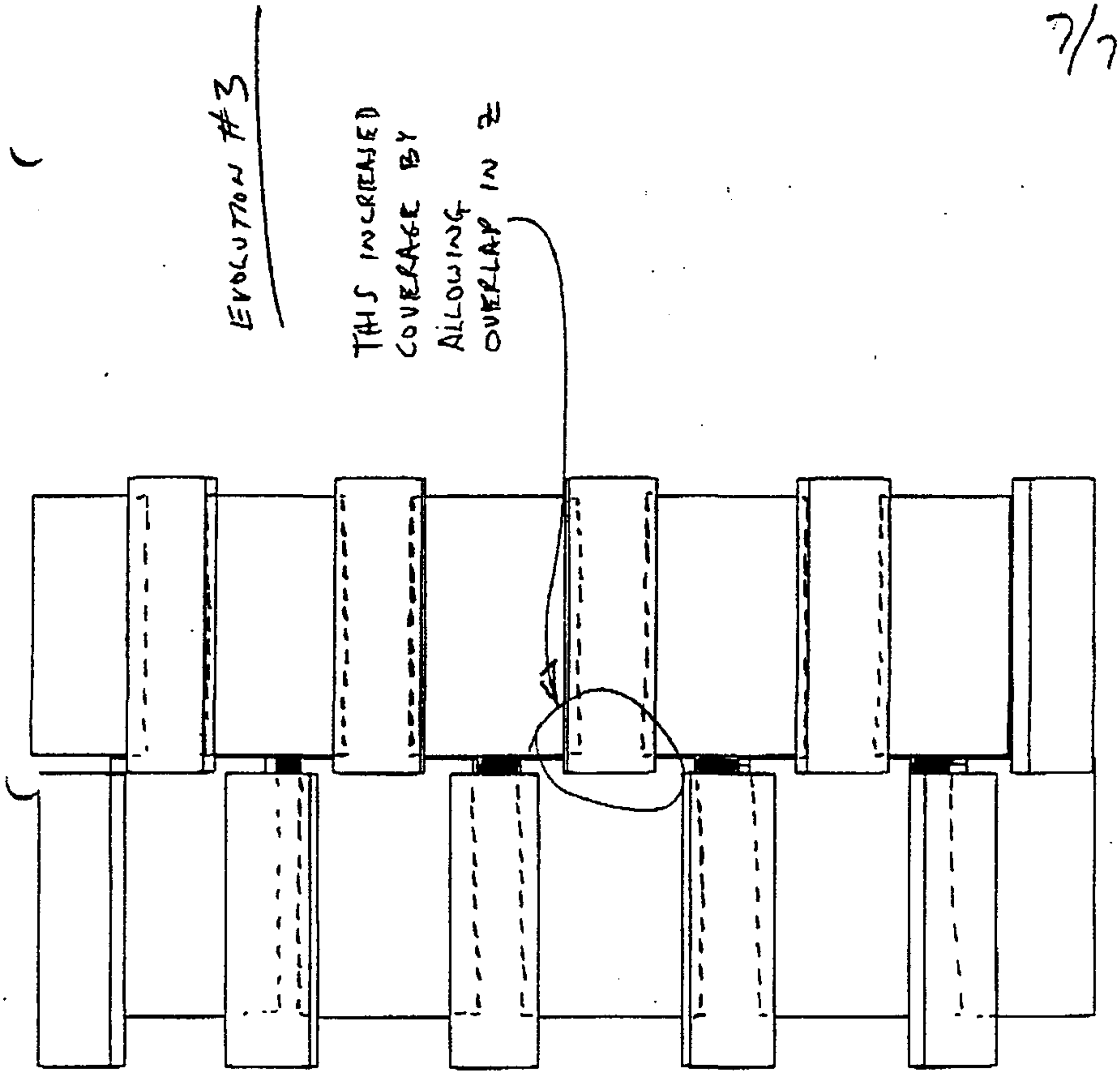


6/7

EVOLUTION #2 (CONTINUED)

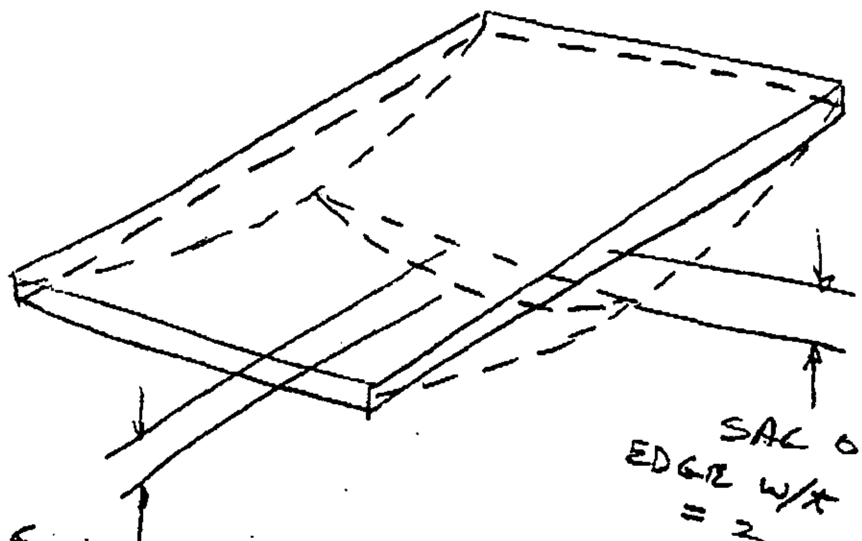


7/7


EVOLUTION #3
THIS INCREASED COVERAGE BY ALLOWING OVERLAP IN Z

J. HORVATH 12

5.0 m × 1.9 m SUPERPANEL
SAG CALCULATIONS (FIRST ORDER)



TOTAL MAX. SAG = 3.622 + 0.283

= 3.905 mm

FOR A BASELINE II MIDDLE SUPERLAYER CSC WHICH IS 188 mm TOTAL (7 @ 20 mm + 6 @ 8 mm)

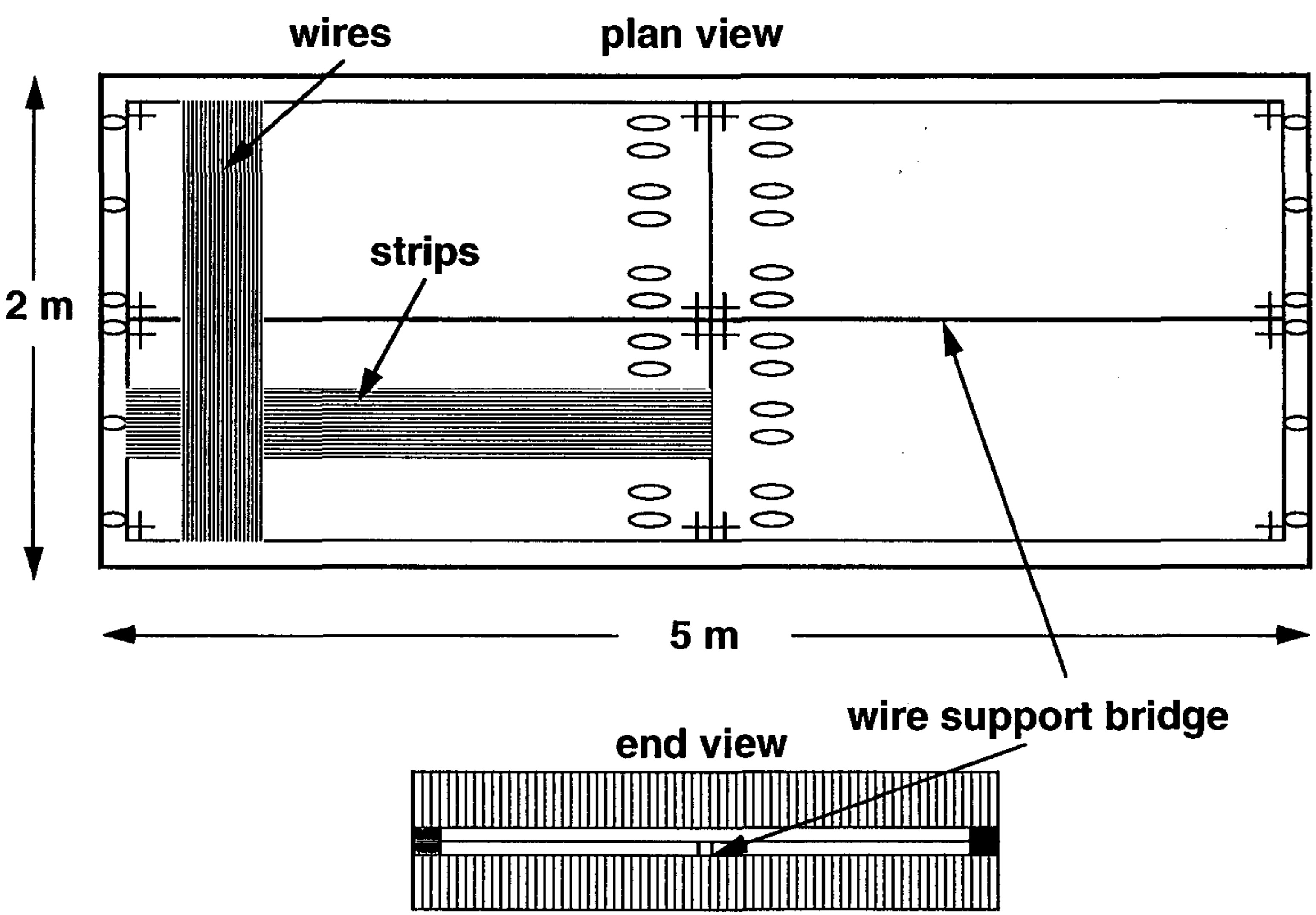
OPTIMUM LONG-EDGE SUPPORT WOULD REDUCE THIS TO THE FOLLOWING:

$$\text{TOTAL MAX. SAG} = \frac{3.622}{48} + 0.283$$

= 0.359 mm

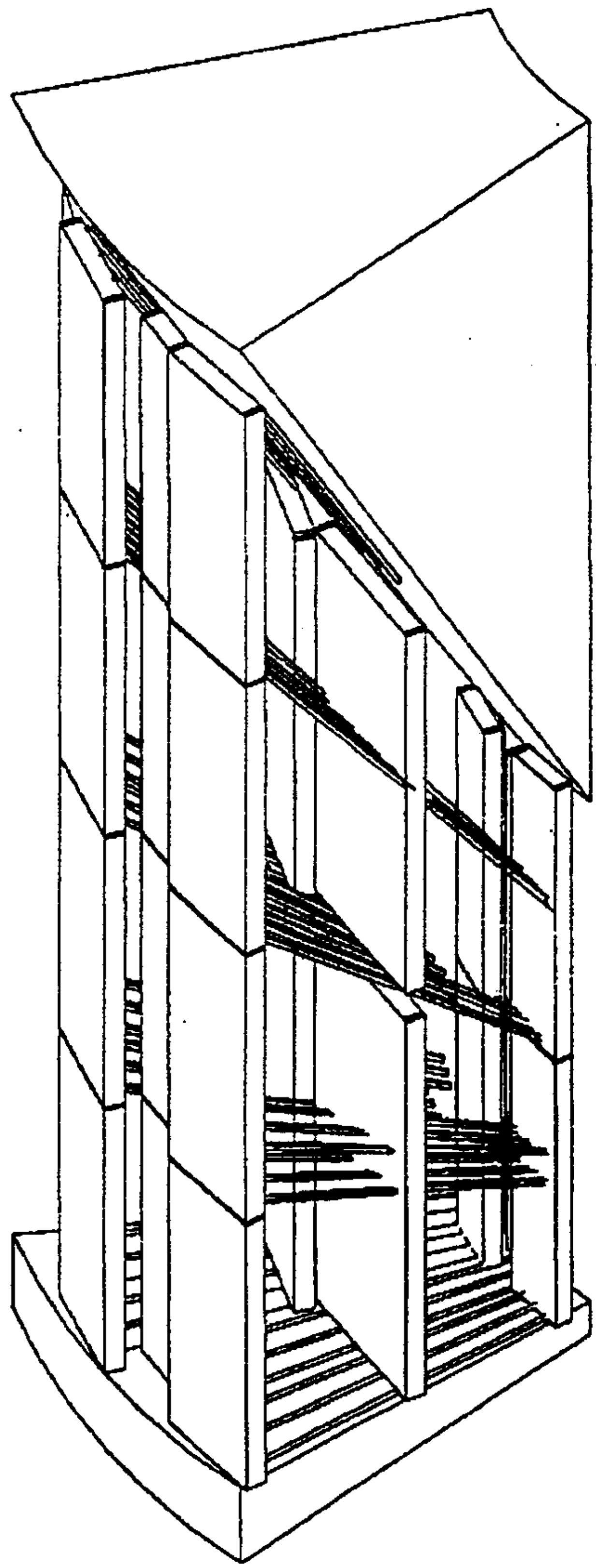
(THE CENTER w/r EDGE COMPONENT NOW DOMINATES)

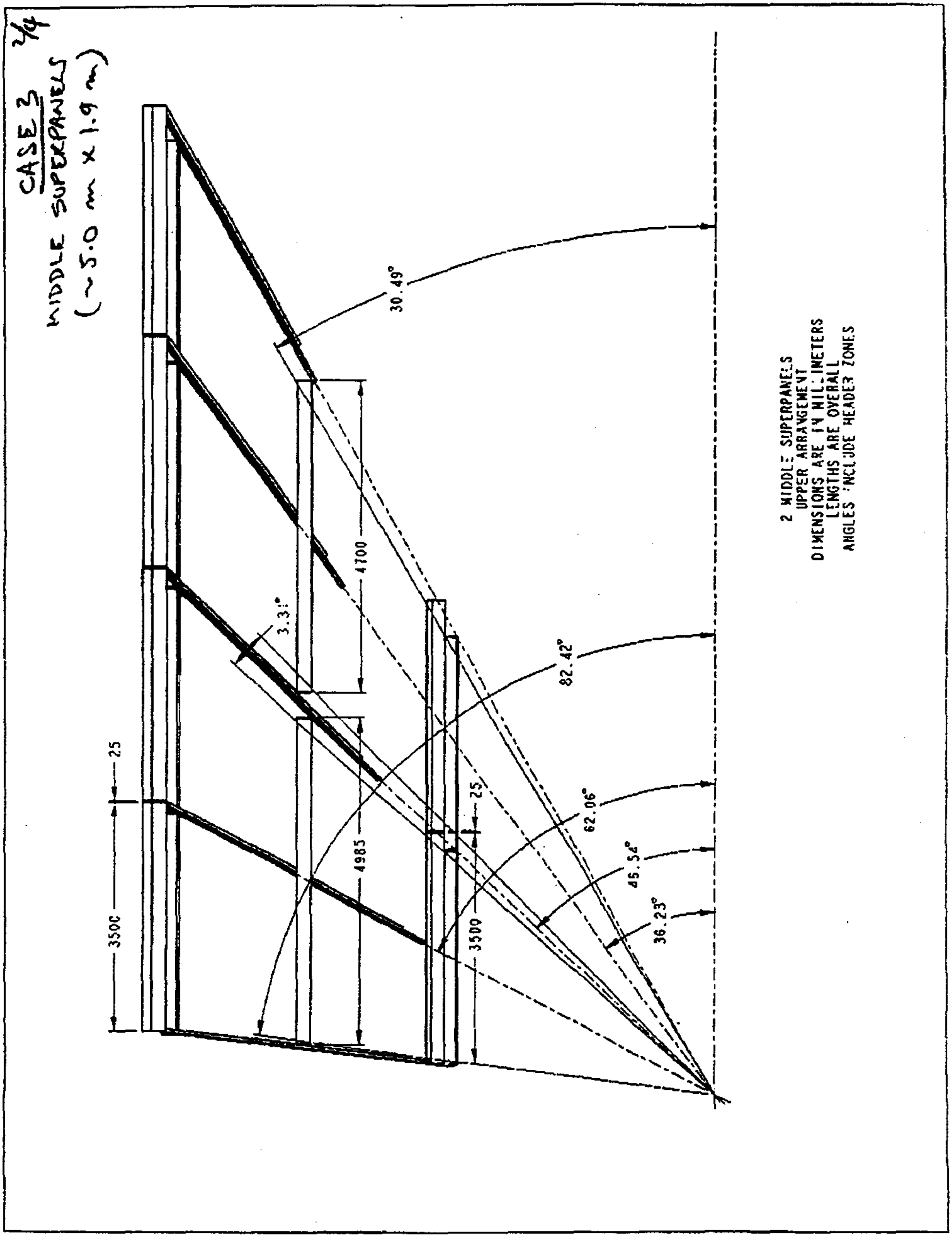
Superchamber concept



CASE 3 1/4

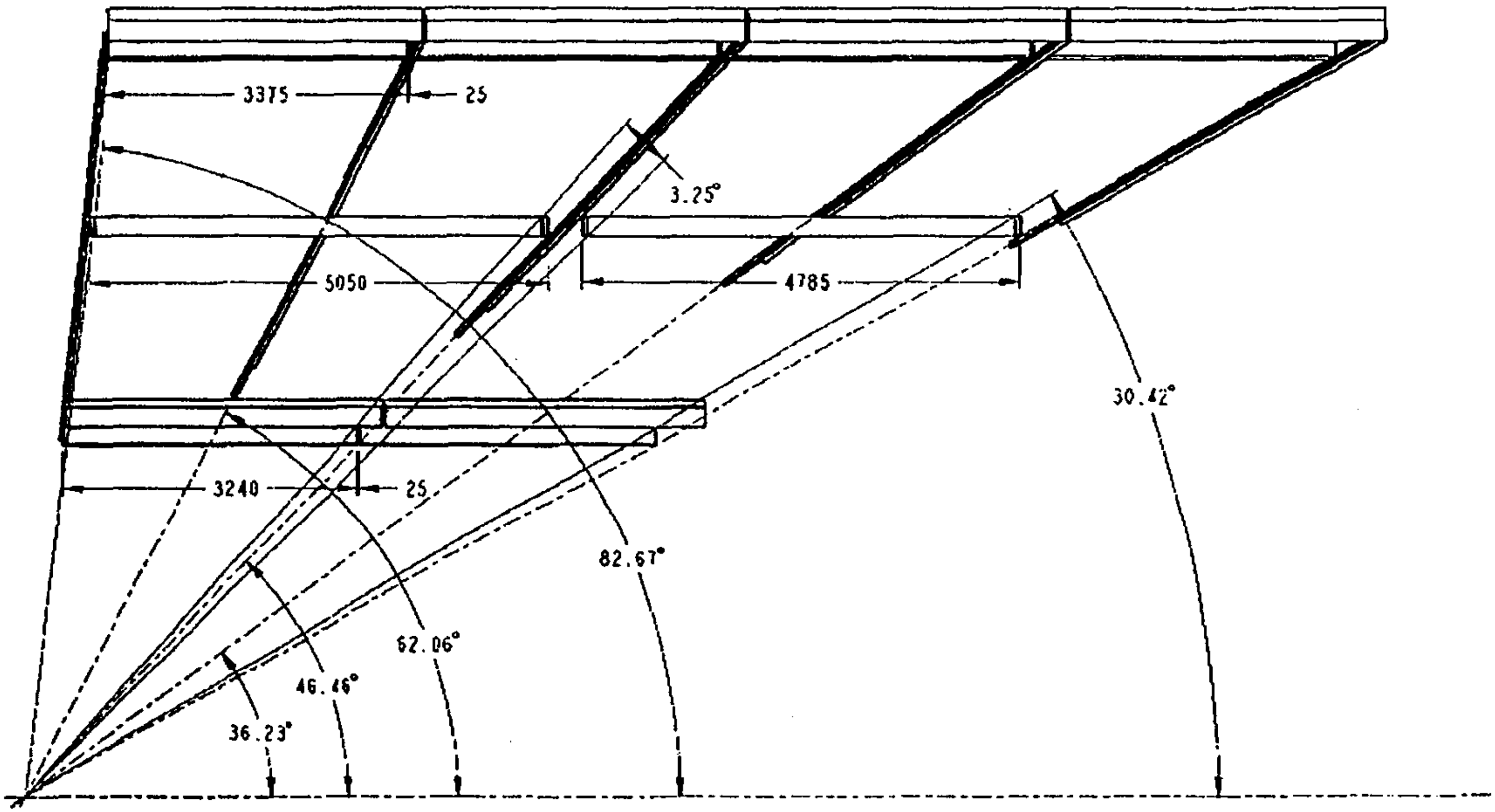
MIDDLE SUPERPANELS (~5.0 m x 1.9 m)



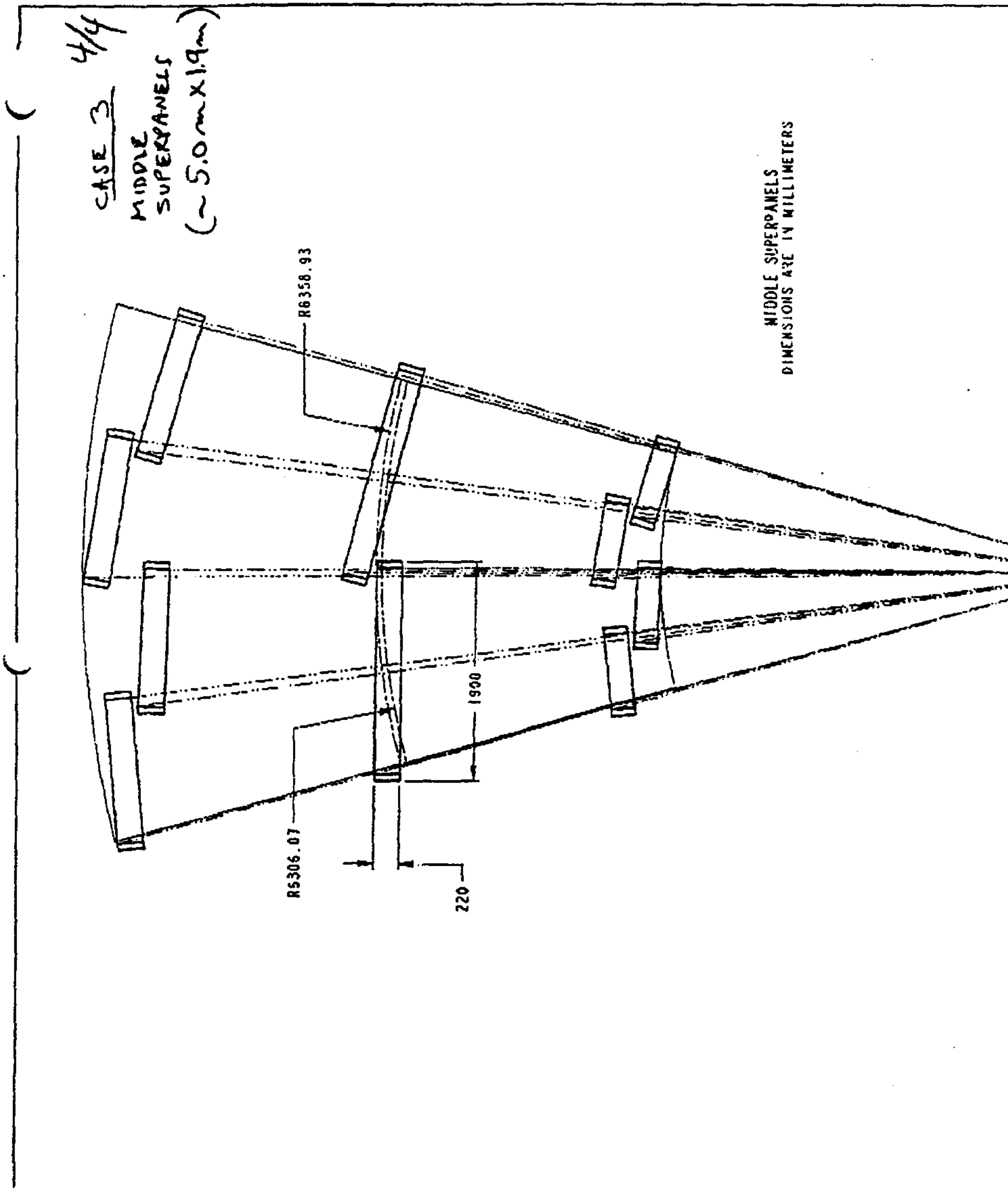

CASE 3
3/4
MIDDLE SUPERPANELS
(~5.0 m x 1.9 m)
30.49°
4700
82.42°
62.06°
45.54°
36.23°
25
3500
4985
25
3500
2 MIDDLE SUPERPANELS
UPPER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLUDE HEADER ZONES

CASE 3 3/4

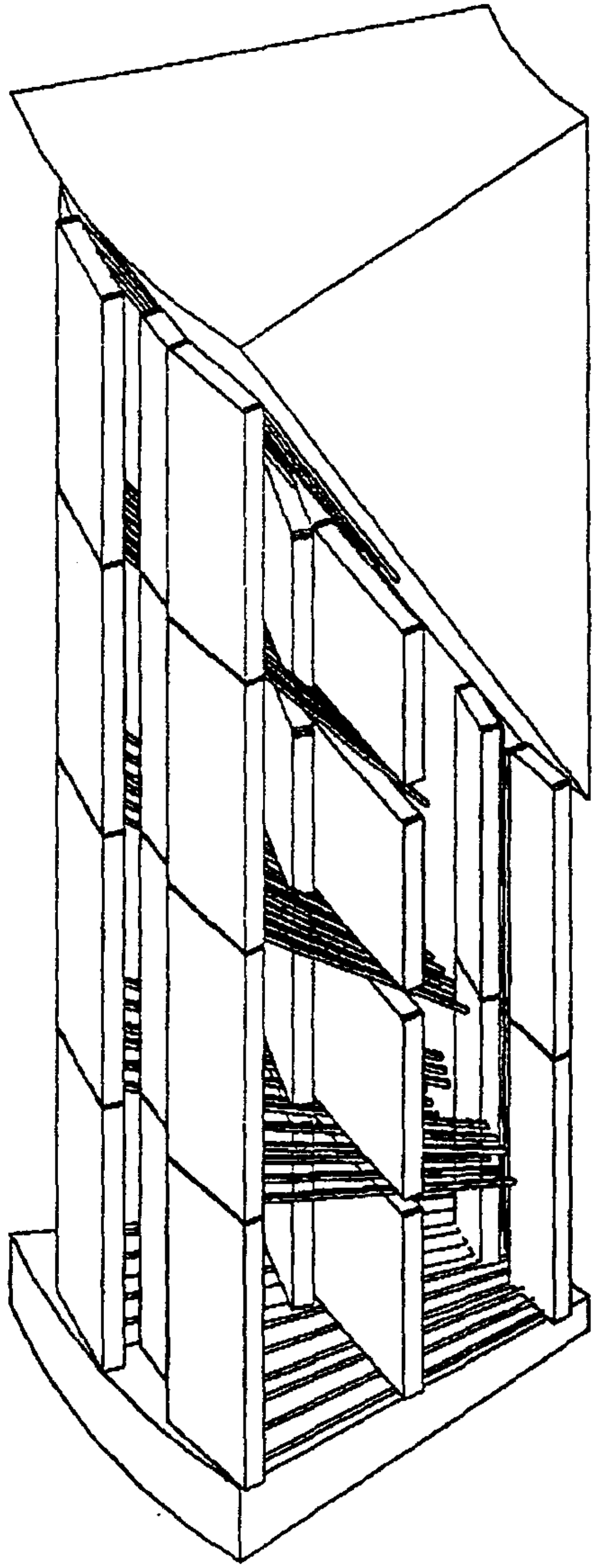
MIDDLE SUPERPANELS
(~5.0 m x 1.9 m)

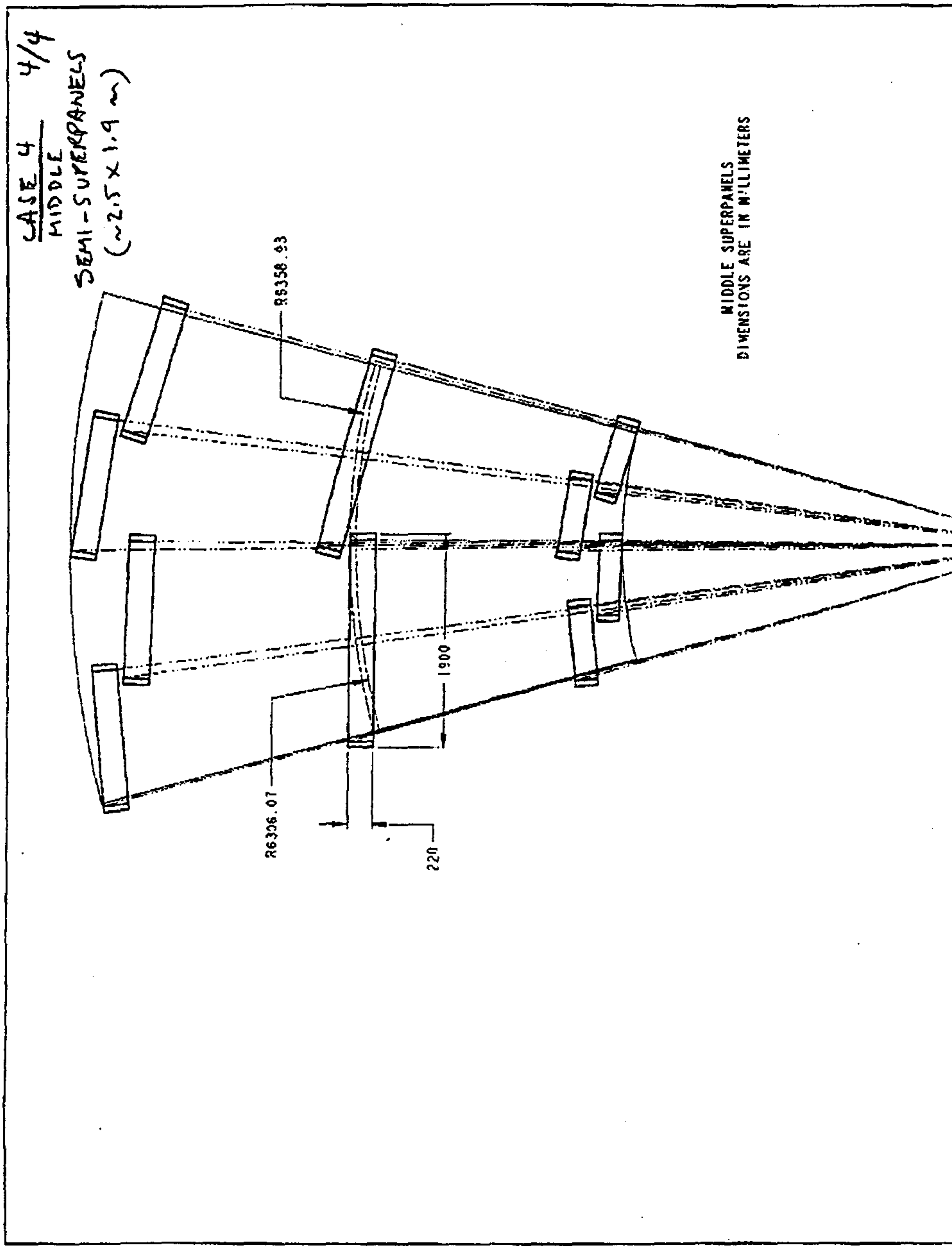


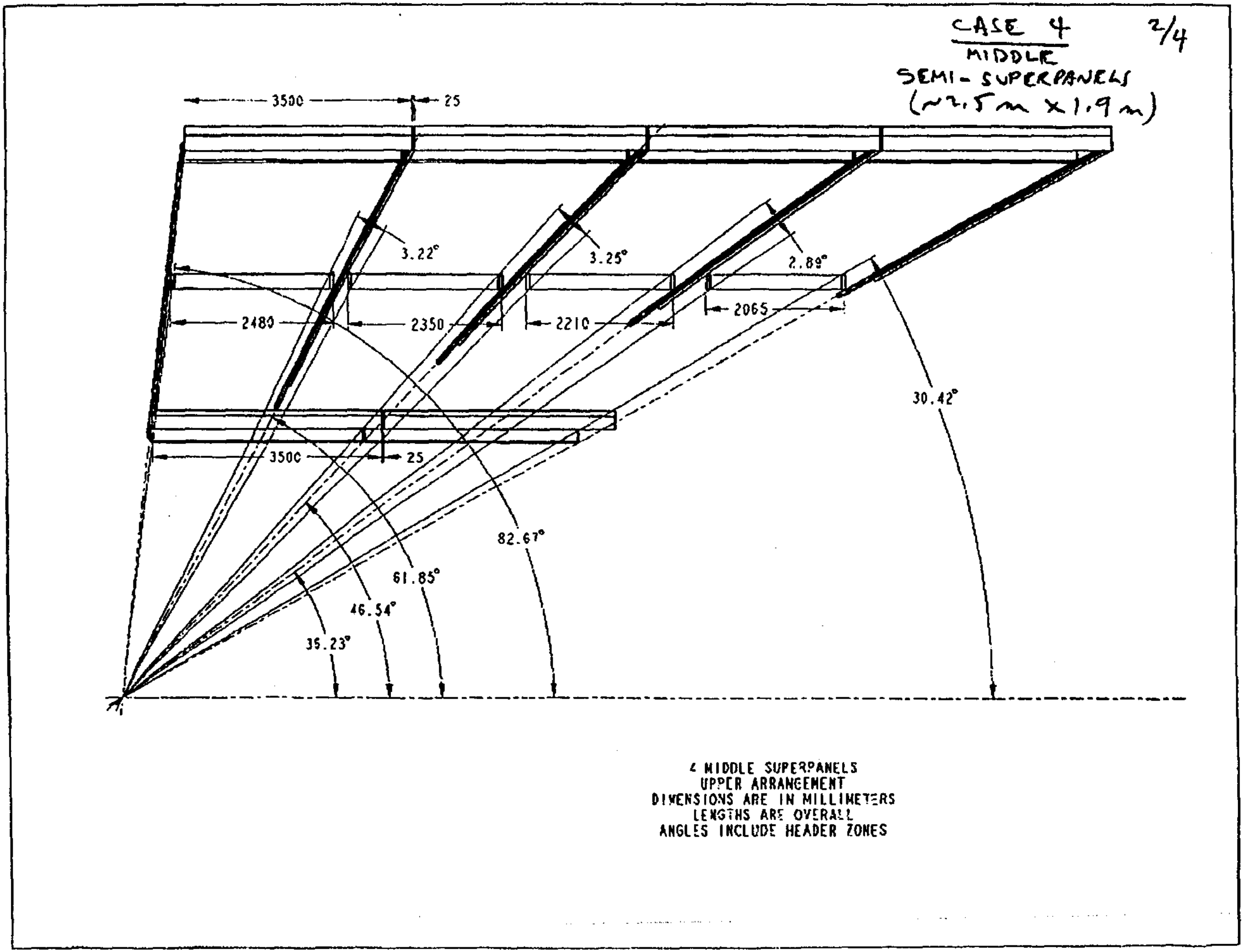
2 MIDDLE SUPERPANELS
LOWER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLURE HEADER ZONES

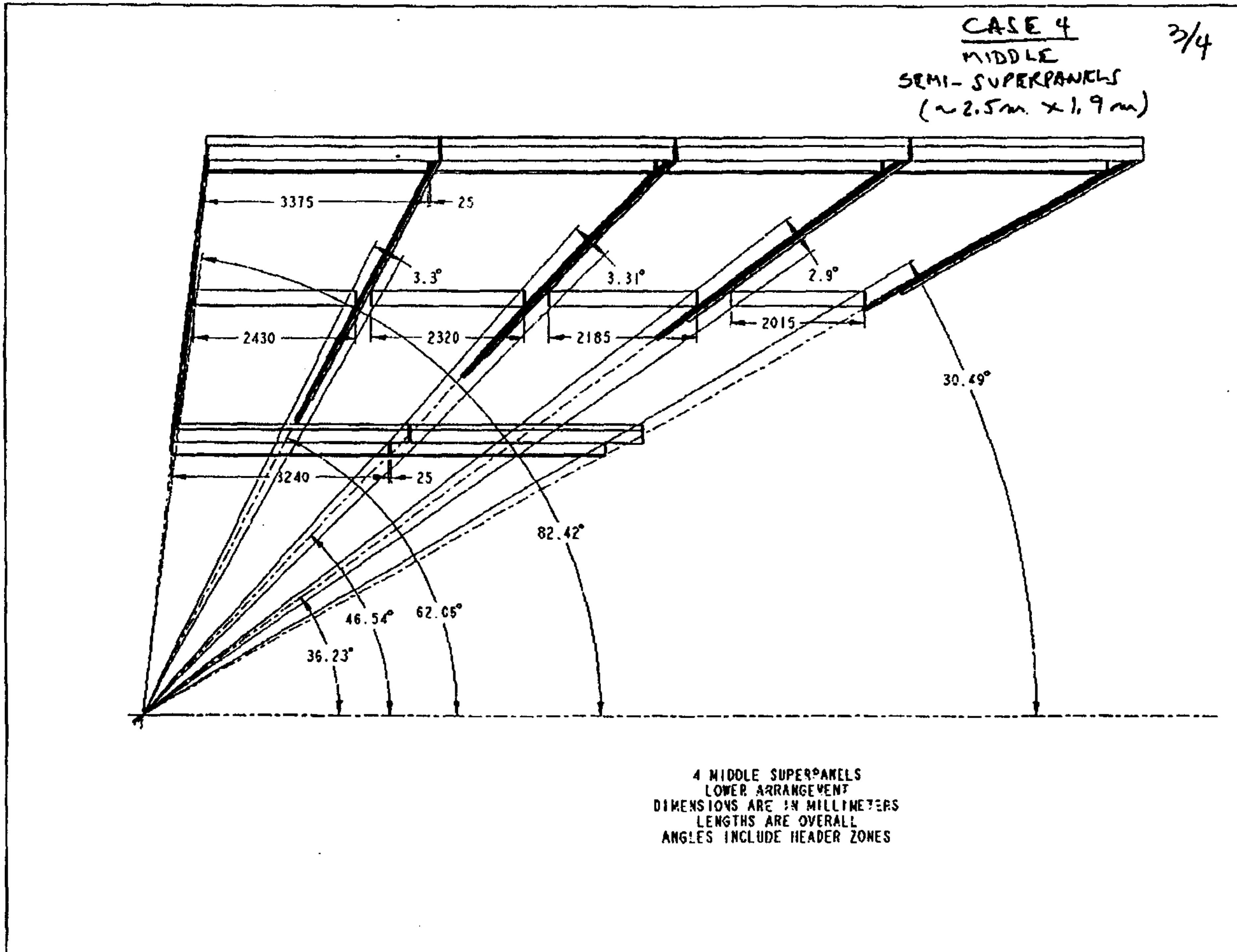

CASE 3
MIDDLE SUPERPANELS
(~5.0m x 1.9m)
4/4
MIDDLE SUPERPANELS
DIMENSIONS ARE IN MILLIMETERS
R6358.93
R5306.07
1900
220

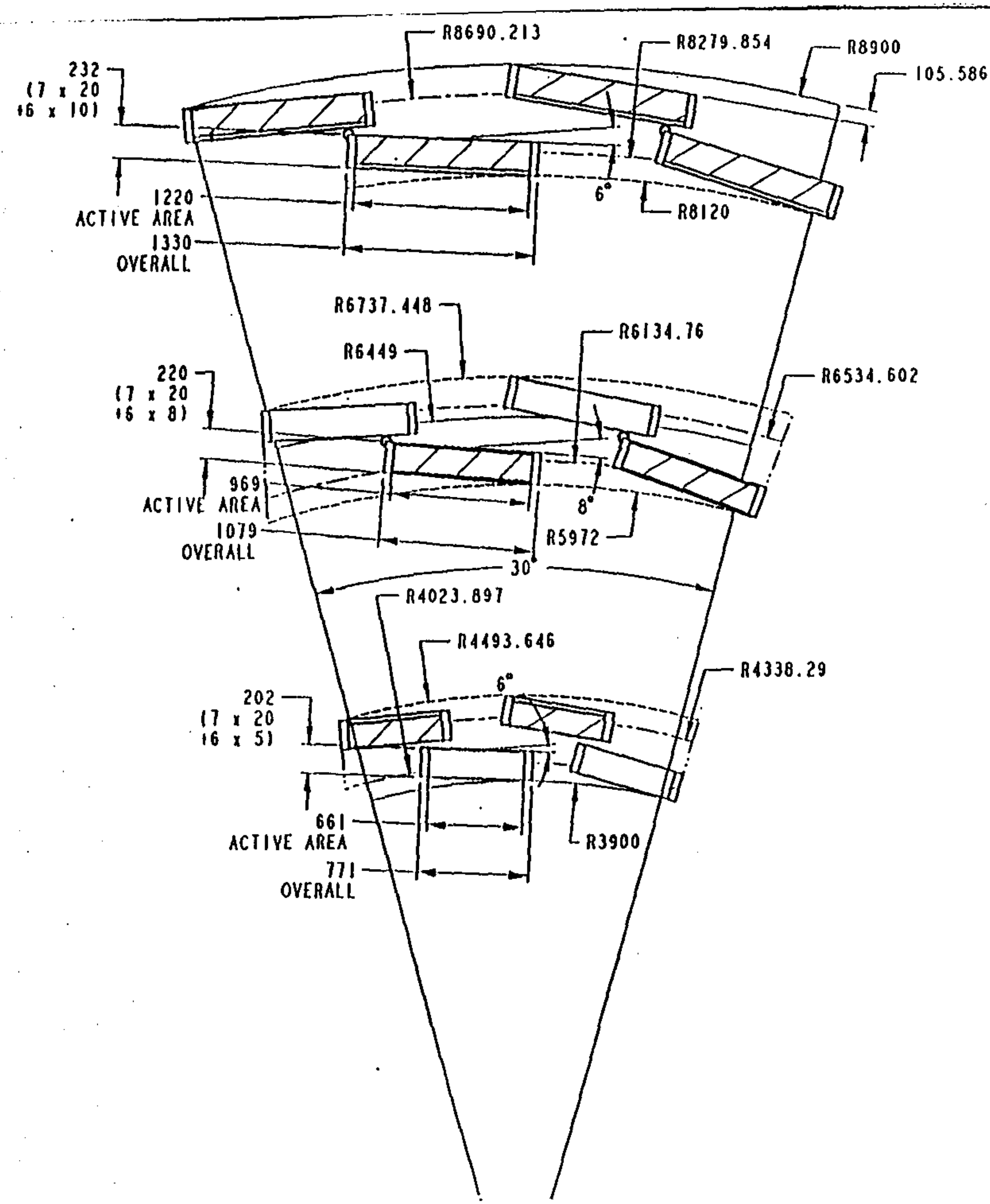
CASE 4 1/4
MIDDLE
SEMI-SUPERPANELS
(~2.5m x 1.9m)



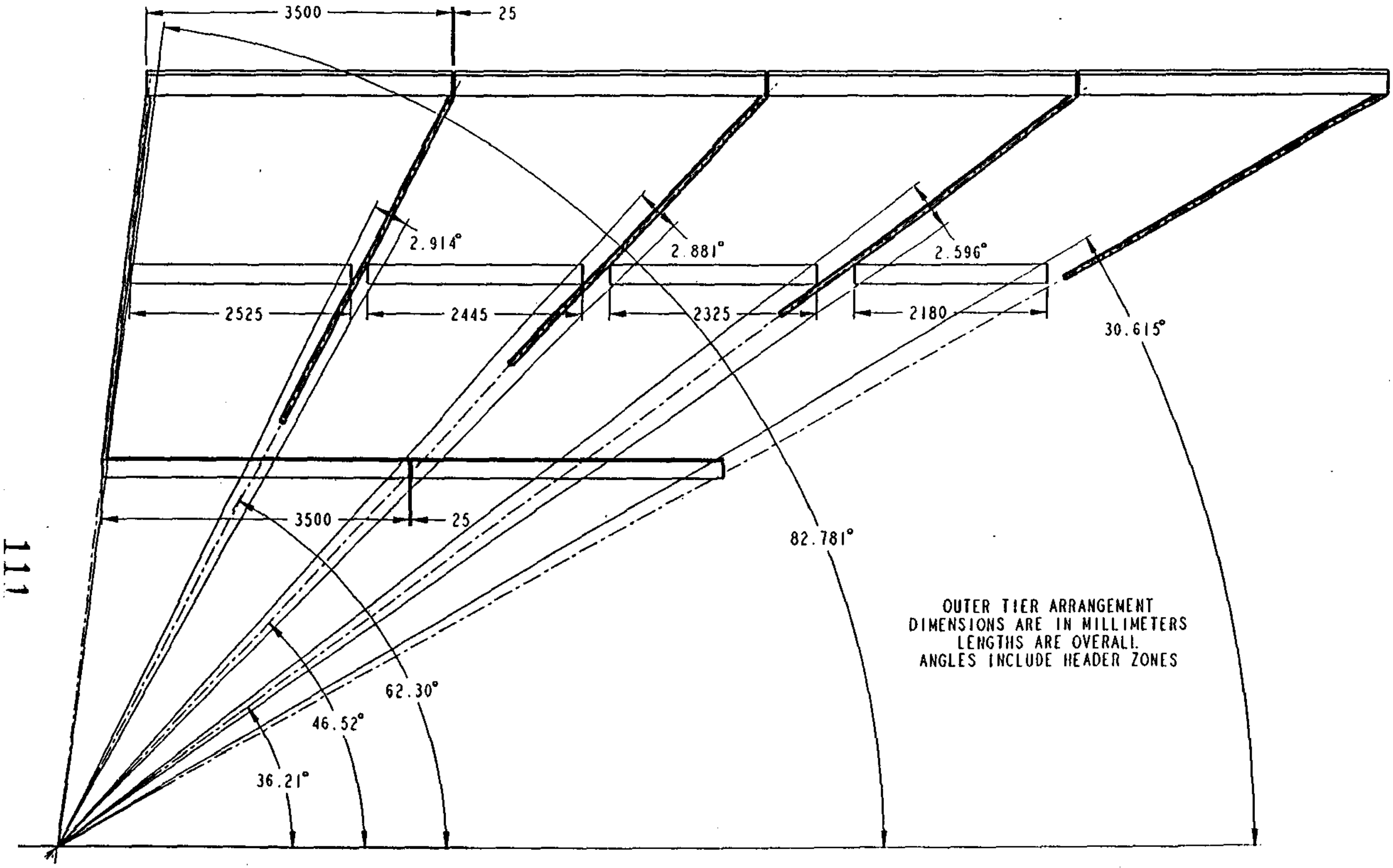

CASE 4 4/4
MIDDLE
SEMI-SUPERPANELS
(~2.5 x 1.9 m)
R5358.93
MIDDLE SUPERPANELS
DIMENSIONS ARE IN MILLIMETERS
1900
R6336.07
220

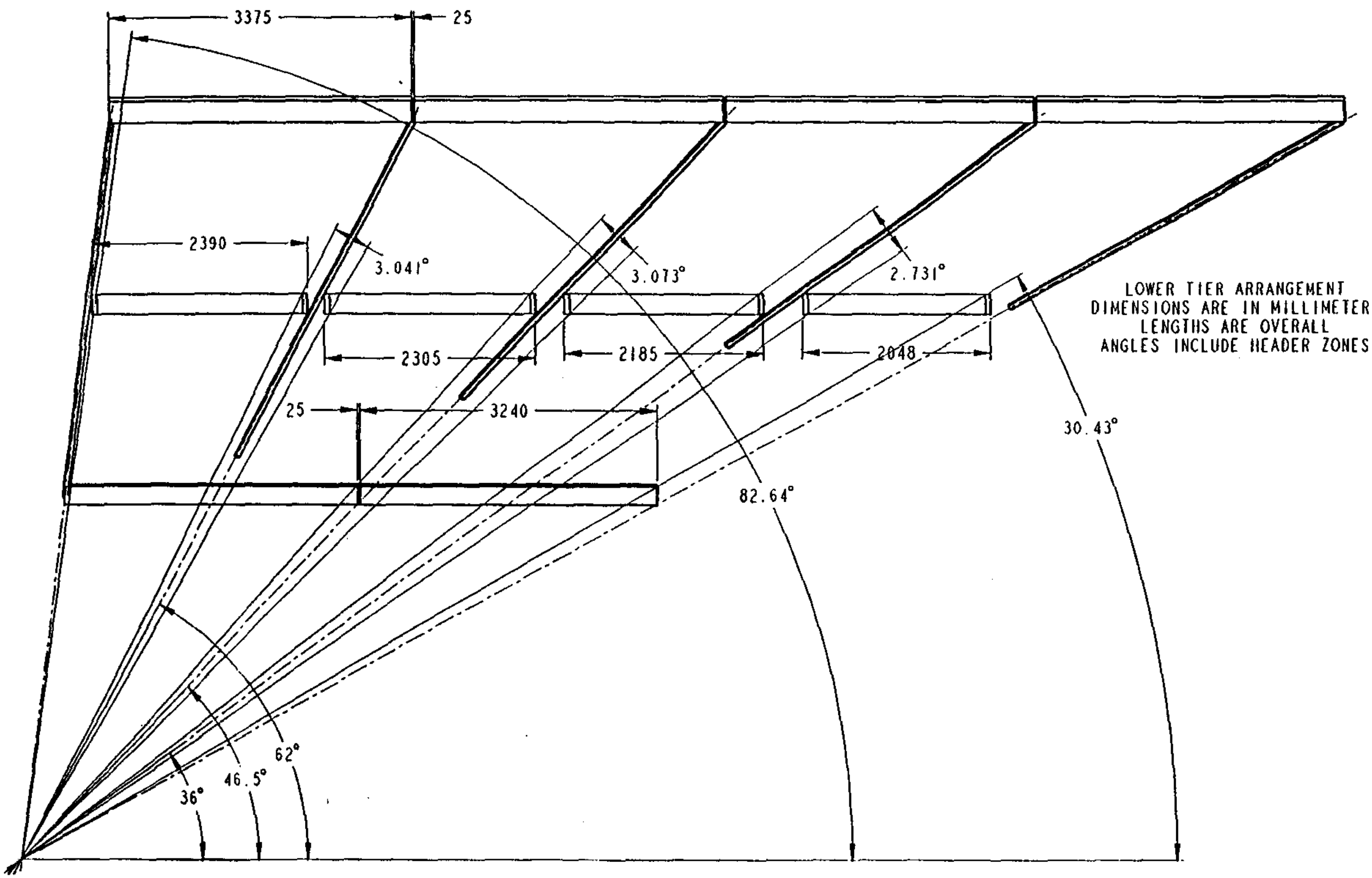

CASE 4
MIDDLE
SEMI-SUPERPANELS
(~2.5m x 1.9m)
2/4
3500
25
3.22°
3.25°
2.89°
2480
2350
2210
2065
30.42°
3500
25
82.67°
61.85°
46.54°
35.23°
4 MIDDLE SUPERPANELS
UPPER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLUDE HEADER ZONES


CASE 4
MIDDLE
SEMI-SUPERPANELS
(~2.5m x 1.9m)
3/4
3375
25
3.3°
3.31°
2.9°
2430
2320
2185
2015
30.49°
3240
25
82.42°
46.54°
62.05°
36.23°
4 MIDDLE SUPERPANELS
LOWER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLUDE HEADER ZONES



R8690.213
R8279.854
R8900
105.586
232
(7 x 20
+6 x 10)
1220
ACTIVE AREA
1330
OVERALL
6°
R8120
R6737.448
R6449
R6134.76
R6534.602
220
(7 x 20
+6 x 8)
969
ACTIVE AREA
1079
OVERALL
8°
R5972
30°
R4023.897
R4493.646
R4338.29
6°
202
(7 x 20
+6 x 5)
661
ACTIVE AREA
771
OVERALL
R3900


3500
25
2.914°
2.881°
2.596°
2525
2445
2325
2180
30.615°
3500
25
82.781°
62.30°
46.52°
36.21°
OUTER TIER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLUDE HEADER ZONES


3375
25
2390
3.041°
3.073°
2.731°
2305
2185
2048
25
3240
LOWER TIER ARRANGEMENT
DIMENSIONS ARE IN MILLIMETERS
LENGTHS ARE OVERALL
ANGLES INCLUDE HEADER ZONES
30.43°
82.64°
62°
46.5°
36°