GEM TN-92-142

Muon Engineering Meeting - SSCL

August 12, 1992

Abstract:

Agenda, attendees and presentations of the GEM Muon Engineering Meeting held at the SSC Laboratory on August 12, 1992. Agenda items were: Status of Structure Decision Memo; Gussets?; Review of Facilities Needed BW vs. S; Alignment Paths in Support Structure; Status of Stress Analysis; Optimization of Support Structure; and Who's Doing What - Action Items.

Agenda of Muon Engineering Meeting: 8/12/92

Time: 8:30 to 12:30 Wednesday 8/12/92
Place: SSCL room to be arranged

Agenda:

(1) Status of Structure Decision Memo	Rick Sawicki Frank Nimblett
(2) Gussets?	Frank Nimblett 8:30 - 9:30
(3) Review of facilities needed BW vs. S	Bill Wisniewski 9:30 - 10:00
(4) Alignment paths in support structure	Gena Mitselmakher 10:00 - 10:30
(5) Status of stress analyses	Mike Gamble Martin Fuery 10:30 - 11:30
(6) Optimization of support structure	Mike Marx 11:30 - 12:00
(7) Who's doing what - action items	Group 12:00 - 12:30

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Name	Organization	E Mail
R. Humphreys	SSC/MMC	@ sim.den.MMC.COM
F. Nimblett	DRAPER	NIMBLETT@DRAPER.COM
M. Marx	SSC	MARX
Frank Taylor	MIT	FET @ MITNS
Mike Harris	SSCL	SSCVI :: HARRIS
MIKE GAMBLE	SSCL	SSCVX1 gamble ::
[illegible]	SSCL	SSCVX1 :: [illegible]
COLEMAN JOHNSON	SSCL	SSCVX1 :: JOHNSON
Igor Golutvin	JINR/Dubna	SSCVX1 :: IGOLUTVIN
Andrey Ostapchuk	SSCL/ITEP	SSCVX1:: OSTAPCHUK
Genn Mitselmakher	SSCL	SSCVX1:: MITSELMAKHER
Bill Wisniewski	SSCL	SSCVX1 :: WJW
[illegible]	SSCL/DOD	SSCVX1 :: HENDERSON

August 6, 1992
MM and FET

List of GEM Muon Engineering Tasks:

(The focus is on the decision between the big wheel or individual sectors support structure and the technology choices.)

(I) High priority items:

(1) Alignment paths in big wheel support structure. Indicate locations for PDT, LSDT, and CSC options in barrel, as well as the "effective big wheel" of the endcaps. Implement Gena's scheme. Will it have impact on the support structure? Note that the big wheel does not have a "natural" clear path between sectors (except at the ends of chambers) as the separate sector approach does.

Sawicki & Mitselmakher

(2) Finish stress analysis of the big wheel. Some elements will have to be strengthened over the preliminary design. The stress analysis should take into account both the construction and final configurations.

Gamble & Fuery

(3) Specify the details of the facilities needed for the big wheel option. Contrast them with those required of the individual sector approach.

Humph~~eries~~ rays & Nimblett

(II) Second priority items:

(1) Calculate the coverage of chambers in barrel for the big wheel. Compare with sector approach. (Compute the coverage of both θ and ϕ.) Can chambers be overlapped in the big wheel concept?

Nimblett

(III) Items concerning the CSCs:

(1) The details of the support structure for the CSCs in the barrel have to be worked out. Note that the CSC proponents have to agree on the Lorentz angle rotation. Is it sufficient in terms of resolution to rotate the middle layer by α and the outer layers by something less?

(2) Attachment of CSC to support structure, both in barrel and EC. Where on the CSCs will the attachment be made? (Someone should do a stress analysis the mechanics of the chambers themselves.) Will the flexural elements of the Draper design work - including the various construction attitudes?

(3) Is the sector approach really precluded for the CSC in the barrel? We need to specify the details.

Pier Amory & Johnson

(IV) Items concerning the LSDTs in barrel:

(1) Compute the coverage for the LSDTs. The square chamber sides will have impact on the ϕ-coverage. This will probably be a factor in evaluating the technologies.

Nimblett

Presentation by:

F. Nimblett

Superconducting Super Collider Laboratory
2550 Beckleymeade Avenue, Mail Stop 2005
Dallas TX 75237-3946
(214) 708-6325
Fax: (214) 708-6088

Memorandum

To: Frank Taylor
From: B. Humphreys/F. Nimblett/R. Sawicki
Subject: Evaluation Criteria for Sector/Bigwheel Comparison
Date: August 5, 1992

The process for evaluating the relative merits of the sector and Bigwheel muon support structure options (barrel only) has been determined. Attached please find the criteria which will be used and a schedule of events leading up to the final report and recommendation. These tables are submitted for your review and approval.

The criteria table lists five different categories that will be used in the evaluation process: design, assembly, transportation, installation and cost/schedule. Over the next three weeks, each responsible person will compile a set of vu graphs that will address each of these subjects with as much detail as time permits. It is expected that this will include procedure descriptions, analysis results, performance projections, cost comparisons, schedule implications and other details necessary for a comprehensive and fair evaluation. Each topic will be summarized with a top level comparison which will qualitatively present the relative strengths and weaknesses of each concept. These summaries, with the backup detail, will be the basis for the final recommendation. That final recommendation will be a concise report which will summarize the findings and present the arguments supporting the conclusion. Vu graphs and comparison tables will be attached as an addendum.

The accompanying schedule shows that an intense, coordinated effort over the next three weeks is required. Coordination meetings will be held on a weekly basis at the SSCL commencing August 13. Responsible persons will attend as well as technology leaders to assure compatibility of the structure concept with all technical requirements. A final oral presentation is planned for Sept. 1.

cc: M. Attiya
H. Baker
C. Bromberg
D. Gustavson
M. Furey
M. Gamble
M. Harris
C. Johnson
M. Marx
J. Pier-Amory
V. Polychronakis
G. Sanders
S. Whitaker
C. Wuest

AS OF 8/12/92

	Person	Key Issues	August 13	August 20	August 27
Design					
•Big Wheel					
– Design Concept	Pier-Amory		Vugraphs	Status	Final
– Analysis	Gamble	Deformations, Stability	Preliminary	Status	Final
– Test/Prototyping	Sawicki	Feasibility, Subscale Testing	Preliminary	Status	Final
– Coverage	Pier-Amory	Loss of Coverage	Vugraphs	Status	Final
• Sector (2,3,3) PDT					
DONE – Design Concept	Nimblett		Vugraphs ✓	Status	Final
DONE – Analysis	Furey	Deformations, Stability	Vugraphs ✓	Status	Final
– Test/Prototyping	Sawicki	Feasibility, Subscale Testing	Initial	Status	Final
DONE – Coverage	Nimblett	Loss of Coverage	Vugraphs ✓	Status	Final
• CSC Concept (2,4,4) Sector + Big Wheel					
DONE – Design Concept	Nimblett		Concept ✓	Status	Final
STARTED – Analysis	Furey	Deformations, Stability	Approach	Status	Final
– Test/Prototyping	Sawicki	Feasibility, Subscale Testing	Preliminary	Status	Final
DONE – Coverage (CONTINUING)	Nimblett	Loss of Coverage	Preliminary	Status	Final
Assembly					
• Big Wheel					
– Component Fab	Pier-Amory	Feasibility	Concept	Status	Final
– Assy of Structure	Pier-Amory	Procedures, Equipment, Time	Concept	Status	Final
– Alignment	Sawicki	Procedure, Equipment, Time	Concept	Status	Final
– Facilities	Johnson	Size, Storage, Layout, Usage	Concept	Status	Final
– Support Equipment	Pier-Amory	Types and Quantities	Initial List	Status	Final
• Sector					
– Component Fab	Pier-Amory	Feasibility	Concept	Status	Final
– Assy of Structure	Pier-Amory	Procedures, Equipment, Time	Concept	Status	Final
– Alignment	Sawicki	Procedure, Equipment, Time	Concept	Status	Final
– Facilities	Johnson	Size, Storage, Layout, Usage	Concept	Status	Final
– Support Equipment	Pier-Amory	Types and Quantities			
• CSC	TBD		TBD	TBD	TBD

TIME → MAN HOURS

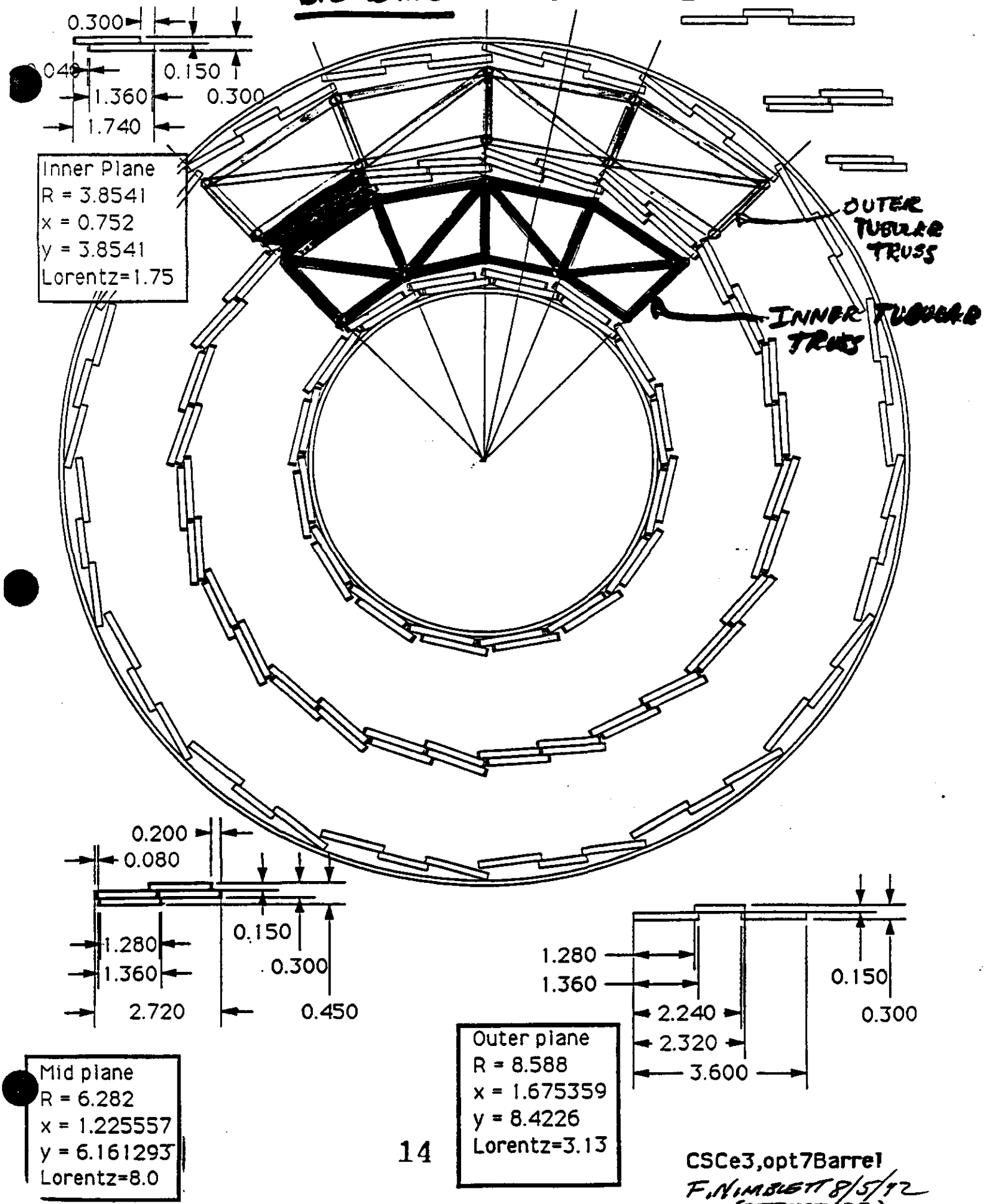
AS OF 8/12/92

	Person		Aug 13	Aug 20	Aug 27
Transportation					
• Big Wheel	Pier-Amory		Vugraphs	Final	
– Offsite		Procedure, Equipment, Time			
– Onsite		Procedure, Equipment, Time			
• Sector	Pier-Amory		Vugraphs	Final	
– Offsite		Procedure, Equipment, Time			
– Onsite		Procedure, Equipment, Time			
Installation					
• Big Wheel					
– Installation	Pier-Amory	Provedure, Equipment, Time	Vugraphs	Final	
– Alignment	Sawicki	Procedure, Time, Access	Vugraphs	Final	
– Maintenance	Pier-Amory	Procedure, Components	Vugraphs	Final	
• Sector					
DONE – Installation	Nimblett	Procedure, Equipment, Time	Vugraphs	Final	
– Alignment	Sawicki	Procedure, Time, Access	Vugraphs	Final	
* – Maintenance	Nimblett	Procedure, Components	Vugraphs	Final	
Cost					
DONE • Big Wheel	Gustavson	All Structure Related Impacts	Data Needs (Vugraphs)	Initial	Final
• Sector (2,3,4 PDT DONE)	Gustavson	All Structure Related Impacts	Initial	Update	Final
Schedule					
• Big Wheel	Pier-Amory	Schedule Interface Dates	Initial	Status	Final
* • Sector	Nimblett	Schedule Interface Dates	Initial	Status	Final

* – NOT STARTED

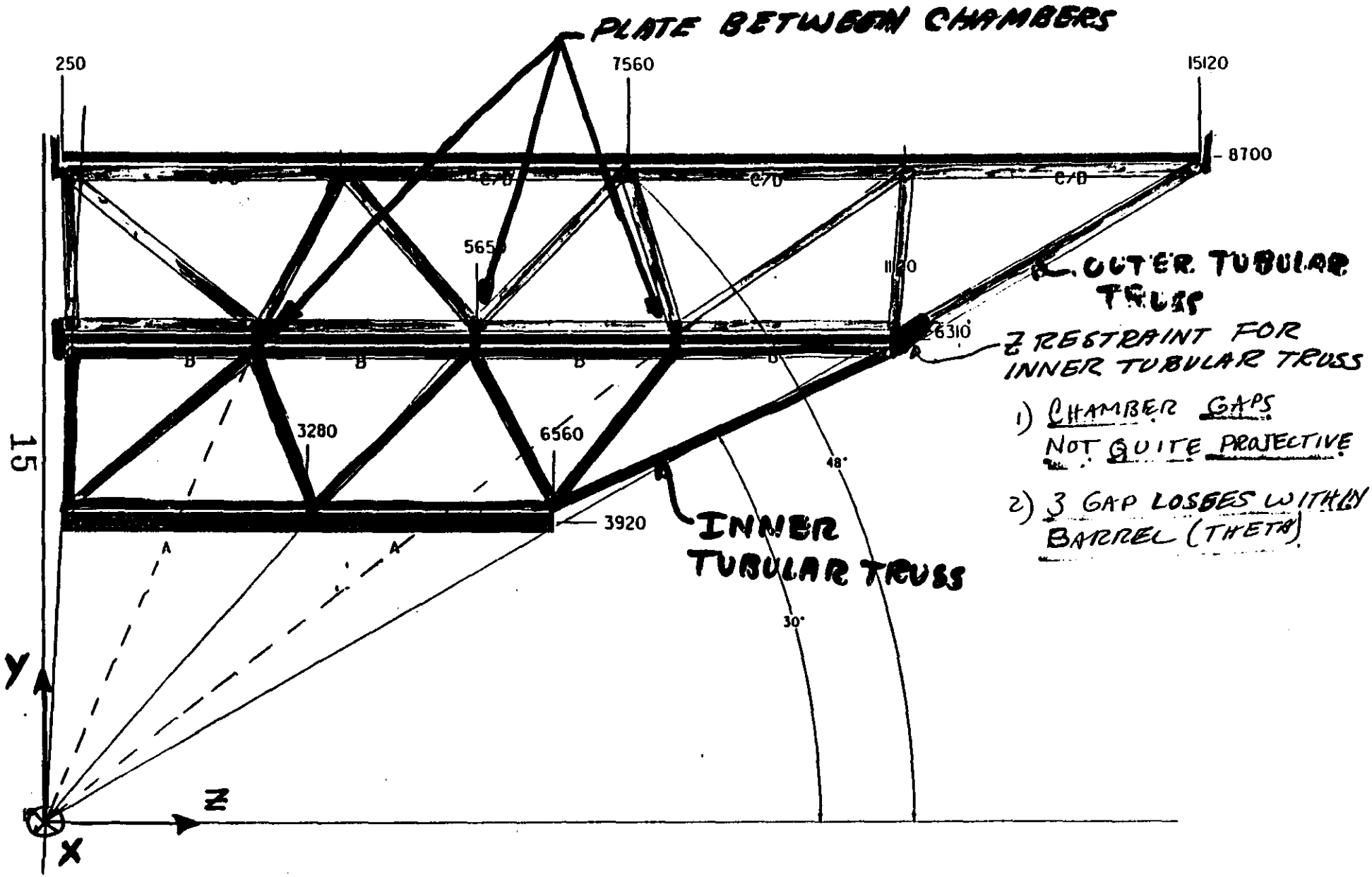
TIME → MANHOURS

"BIG WHEEL" CSC STRUCTURE



CSCe3,opt7Barrel

F. NIMBLETT 8/5/92
(STRUCTURE)

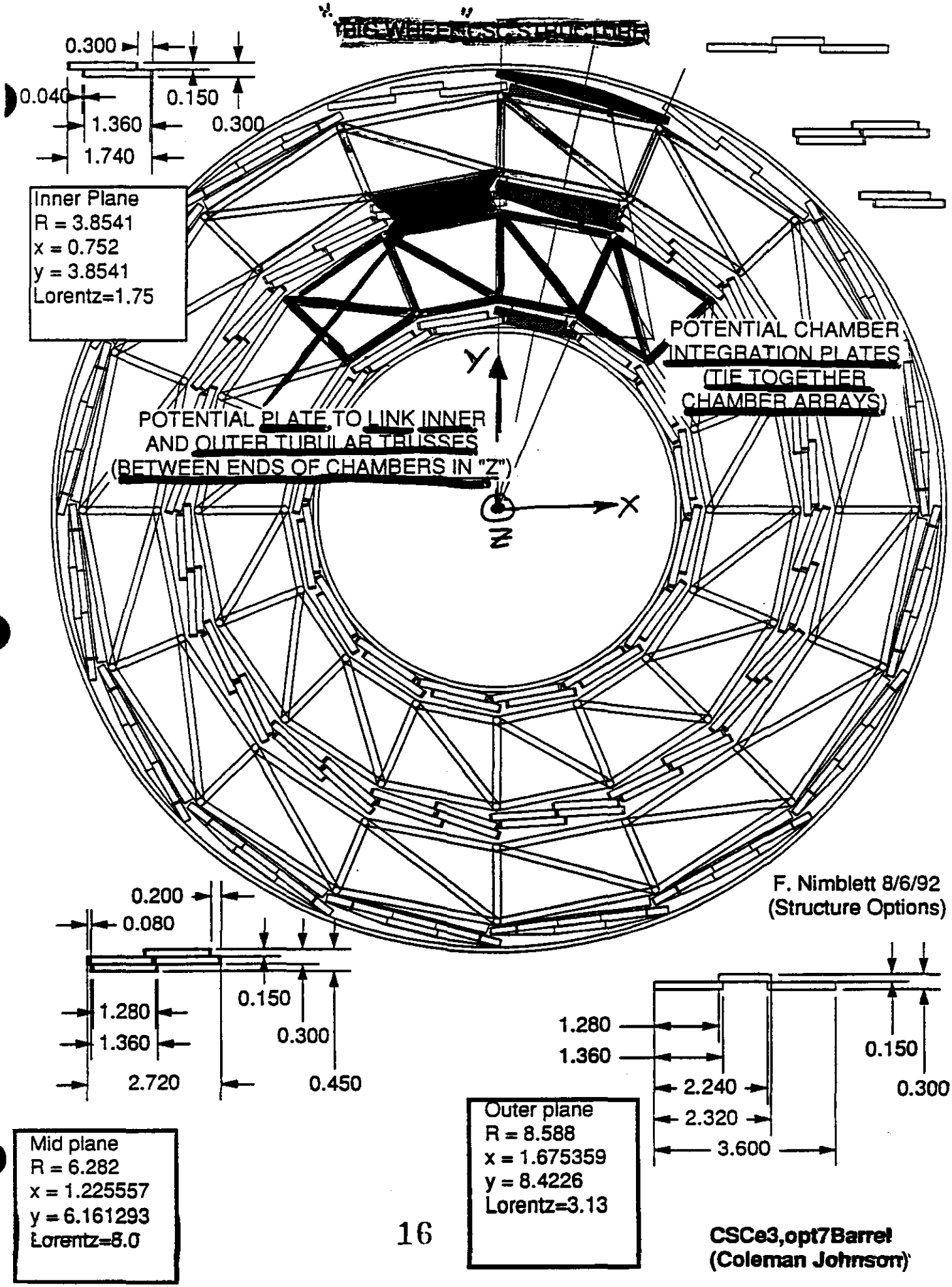


1) CHAMBER GAPS NOT QUITE PROJECTIVE

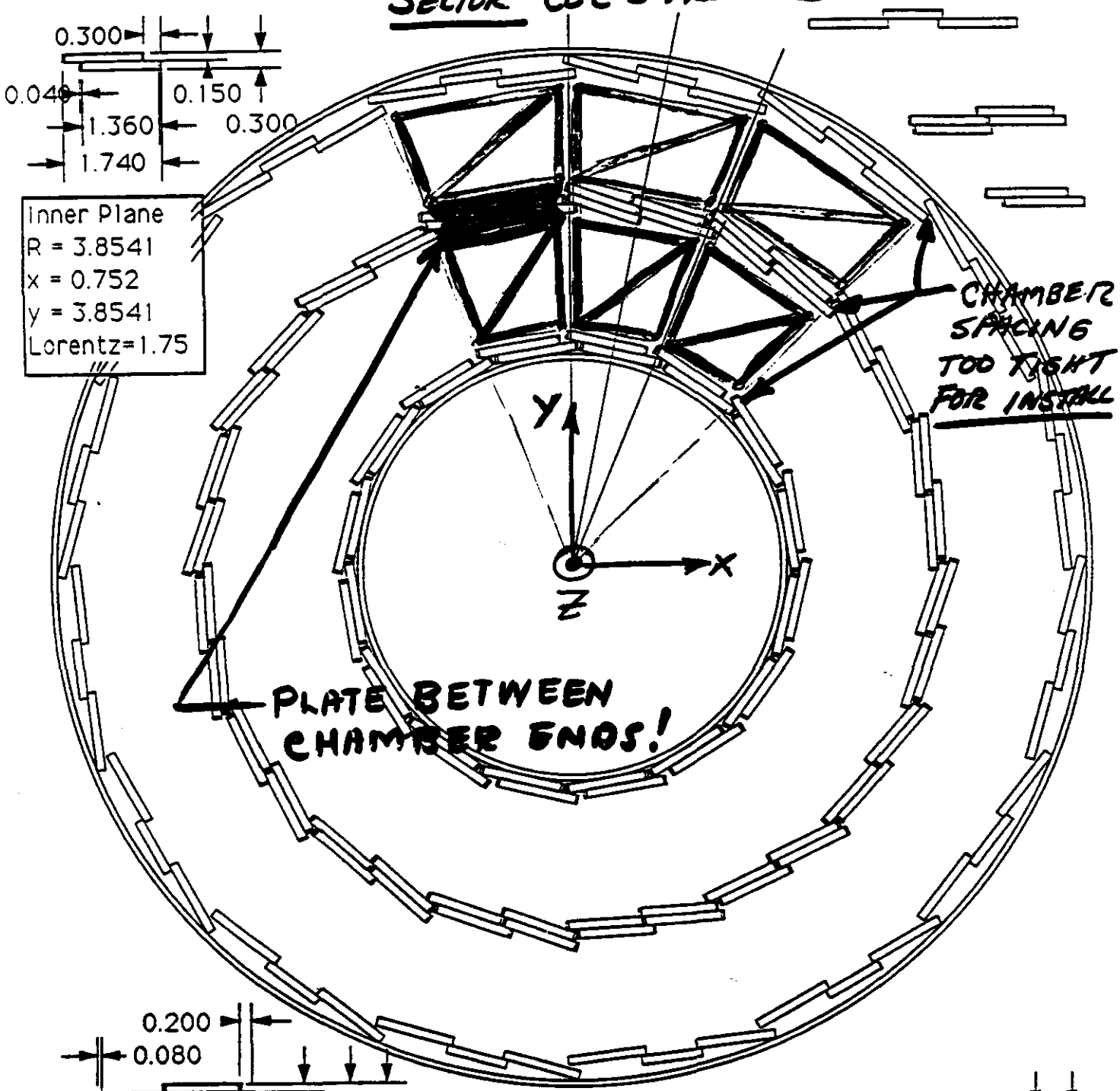
2) 3 GAP LOSSES WITHIN BARREL (THETA)

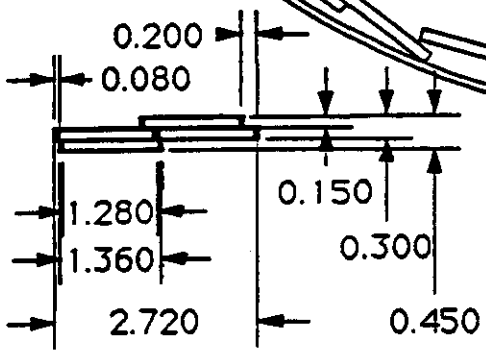
BARREL CSC CHAMBERS - SIDE VIEW

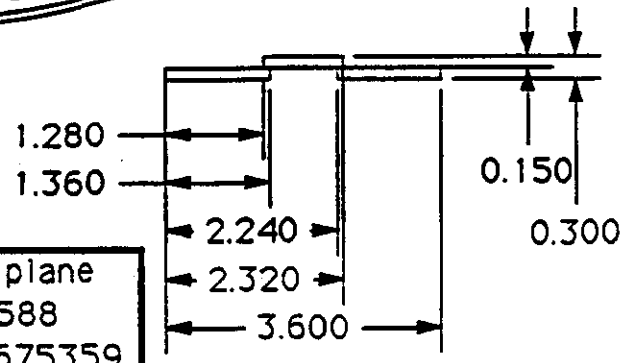
F. NIMLETT
8/5/92 (STRUCTURE)


[redacted]
0.300
0.040
0.150
1.360
0.300
1.740
Inner Plane
R = 3.8541
x = 0.752
y = 3.8541
Lorentz=1.75
POTENTIAL CHAMBER INTEGRATION PLATES (TIE TOGETHER CHAMBER ARRAYS)
POTENTIAL PLATE TO LINK INNER AND OUTER TUBULAR TRUSSES (BETWEEN ENDS OF CHAMBERS IN "Z")
Y
X
Z
F. Nimblett 8/6/92
(Structure Options)
0.200
0.080
0.150
1.280
1.360
0.300
2.720
0.450
Mid plane
R = 6.282
x = 1.225557
y = 6.161293
Lorentz=8.0
1.280
1.360
0.150
2.240
2.320
0.300
3.600
Outer plane
R = 8.588
x = 1.675359
y = 8.4226
Lorentz=3.13
CSCe3,opt7Barrel
(Coleman Johnson)

"SECTOR" CSC STRUCTURE







Mid plane
R = 6.282
x = 1.225557
y = 6.161293
Lorentz=8.0

Outer plane
R = 8.588
x = 1.675359
y = 8.4226
Lorentz=3.13

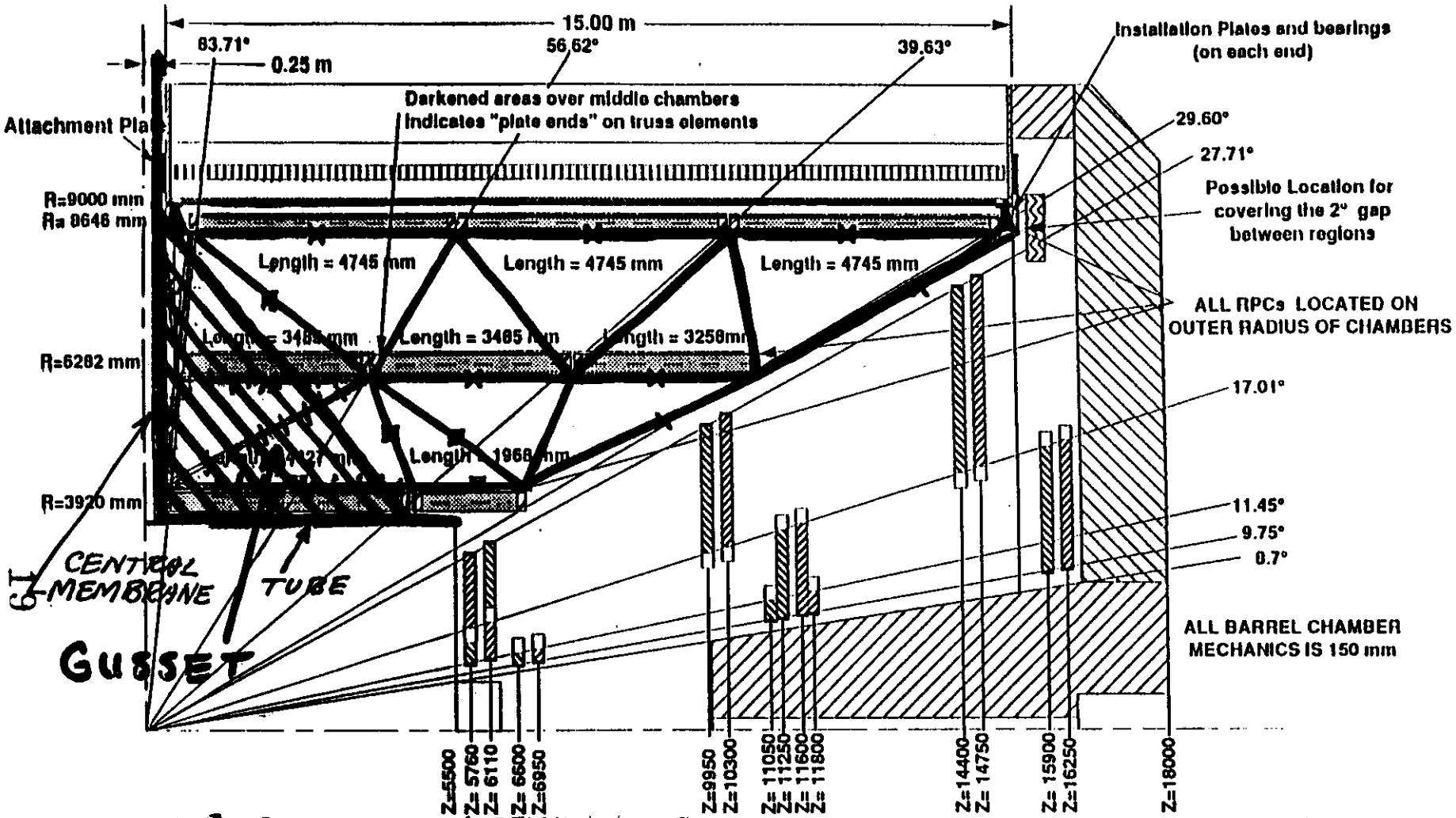
CSCe3,opt7Barrel

F. NIMBLETT 8/5/92
(STRUCTURE)

GUSSETS ??

- CENTRAL MEMBRANE GUSSETS MAY MAKE A COMEBACK!
- EFFECTS OF GUSSETS ON MUON SUPPORT STRUCTURE
  - SECTOR OPTION
    - "ϕ" COVERAGE LOST FOR MEMBRANE THICKNESS.
    - "ϕ" COVERAGE LOST FOR CLEARANCE + ADJUSTMENT SPACE.
  - BIG WHEEL OPTION
    - "ϕ" COVERAGE LOST FOR BOTH MEMBRANE THICKNESS AND FOR CLEARANCE + ADJUSTMENT SPACE.
    - "BIG WHEEL STRUCTURE" NEAR MEMBRANE MUST RESEMBLE "SECTOR OPTION"
    - LOADS ASSOCIATED WITH "4-POINT SUSPENSION" FOR BIG WHEEL IS NOT LIKELY COMPATIBLE WITH GUSSETS!

FRM



STRUCTURE AFFECTED BY [illegible] FOR "[illegible]"

X - - - - - Indicates Frame which has Crossed Bracing

■ - - - - - Indicates Frame which has Crossed Bracing and Mult. Scatt Concerns

GEM MUON SYSTEM CHAMBER LAYOUT
BASELINE I.I
(2,3,3 Chambers per Layer-PROJECTIVE GAPS)
WITH PROPOSED MODULE STRUCTURE

Draper Laboratory	
GEM 2,3,3 PDT Projective Muon System	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0016	7/17/92
Approved by: fen	

GEM Muon Subsystem

Design Issues

Theoretical % coverage

Technology understanding

Fabrication techniques

Assembly techniques

Installation techniques

Mechanical interfaces

Stiffness / stability

Manufacturing Issues

Number to be built

Alignment criteria

Fabrication procedures

Assembly procedures

Installation procedures

Schedule

Storage requirements

Production Improvement

Muon Subsystem Support Structure

Manufacturing issues

Need design manpower estimate for all systems.

Need fabrication procedure (or quote) for all components (chamber parts, structural members, joints, etc.)

Need assembly procedure (with manpower and tooling costs) for each chamber type. (LSDTs, PDTs, CSCs)

Need assembly procedure (with manpower and tooling costs) for each structure type.

Muon Subsystem Support Structure

Manufacturing issues

Need installation (in hall) procedure for each structural alternative.

Global and local alignment to be included in the assembly / installation procedures.

What are the storage requirements for chambers ?

How easily can chambers be replaced ?

TO: Muon Subsystem Engineering Group
FROM: R.E. Gustavson
DATE: July 28, 1992
SUBJECT: Barrel Structure Comparison Chart

Attached is my first attempt at a quantitative method for comparing the "big wheel" method and the sector approach with regard to assembly / installation. It is based upon a product design technique (Pugh chart) developed in England.

For current purposes, we shall use the following definitions:

Characteristic - A quantifiable parameter which should help distinguish between alternatives.

Weighting Factor - An initially arbitrarily assigned value for each characteristic. It is intended to establish the relative importance of each characteristic within the group. When all factors have been assigned, the initial sum is determined. Since the total of weighting factors *must* equal 100, we shall multiply all (input) values by 100 and divide by the initial sum to obtain the actual weighting factors.

Value - the (usually) numerical value for the characteristic. Generally, each alternative has a unique value. ?

Rating - on a scale of 1 (lowest) to 10 (highest), the actual value as a proportion of the "optimum" is declared. Note that one of the ratings is the nominal for each characteristic; alternatives can have a higher, the same or a lower rating.

Risk Factor - the uncertainty in the value and / or rating of the characteristic expressed as a percentage.

Score - the mathematical combination of the parameters according to

$$\text{Score} = \frac{(\text{Weighting Factor})\ \text{Rating}}{\left(1 + \frac{\text{Risk \%}}{100\%}\right)}$$

Difference - "sector score" minus "big wheel" score.

FOR CHARLES STARK DRAPER LABORATORY USE ONLY

GEM Muon Subsystem Barrel Structure Sector / Big Wheel Comparison 8/11/92

Characteristic	Weighting Factor	Sector Value	Sector Rating	Sector Risk Fctr.	Sector Score	Big Wheel Value	Big Wheel Rating	Big Wheel Risk Fctr.	Big Wheel Score	CSC Big Wheel Value	CSC Big Wheel Rating	CSC Big Wheel Risk Fctr.	CSC Big Wheel Score	Sector : Big Wheel Difference	Sector : CSC Big Wheel Difference
Number required	2.1	34	7	30%	11.63	2	7	25%	11.63	2	7	25%	11.63	0.00	0.00
"learning" possible?	2.1	yes	6		12.46	no	2		4.15	no	2		4.15	8.30	8.30
Design															
Concept	3.5				0.00				0.00				0.00	0.00	0.00
Analysis	2.4				0.00				0.00				0.00	0.00	0.00
Test / Prototyping	2.4				0.00				0.00				0.00	0.00	0.00
Coverage	3.5				0.00				0.00				0.00	0.00	0.00
Assembly															
Component Fab. / Assy.	1.7				0.00				0.00				0.00	0.00	0.00
Fabrication of Structure															
Procedures	2.1				0.00				0.00				0.00	0.00	0.00
Equipment required	3.1				0.00				0.00				0.00	0.00	0.00
Person-months required	3.1				0.00				0.00				0.00	0.00	0.00
Schedule requirements	3.5				0.00				0.00				0.00	0.00	0.00
Assembly of Structure															
Procedures	2.1				0.00				0.00				0.00	0.00	0.00
Equipment required	3.1				0.00				0.00				0.00	0.00	0.00
Person-months required	3.1				0.00				0.00				0.00	0.00	0.00
Schedule requirements	3.5				0.00				0.00				0.00	0.00	0.00
Alignment															
Procedures	3.1				0.00				0.00				0.00	0.00	0.00
Equipment required	2.1				0.00				0.00				0.00	0.00	0.00
Person-months required	3.1				0.00				0.00				0.00	0.00	0.00
Schedule requirements	3.5				0.00				0.00				0.00	0.00	0.00
Facilities															
Space requirements	3.5				0.00				0.00				0.00	0.00	0.00
Calendar requirments	3.5				0.00				0.00				0.00	0.00	0.00
Support Equipment	3.1				0.00				0.00				0.00	0.00	0.00
Transportation															
Offsite															
Procedure	1.7				0.00				0.00				0.00	0.00	0.00
Equipment required	1.7				0.00				0.00				0.00	0.00	0.00
Time required	1.7				0.00				0.00				0.00	0.00	0.00
Onsite															
Procedure	1.7				0.00				0.00				0.00	0.00	0.00
Equipment required	1.7				0.00				0.00				0.00	0.00	0.00
Time required	1.7				0.00				0.00				0.00	0.00	0.00
Installation															
Procedures	3.1				0.00				0.00				0.00	0.00	0.00
Equipment required	3.1				0.00				0.00				0.00	0.00	0.00
Person-months required	3.1				0.00				0.00				0.00	0.00	0.00
Schedule requirements	3.5				0.00				0.00				0.00	0.00	0.00
Alignment															
Procedures	3.1				0.00				0.00				0.00	0.00	0.00
Person-months required	3.1				0.00				0.00				0.00	0.00	0.00
Accessibility	2.6				0.00				0.00				0.00	0.00	0.00
Maintenance															
Procedures	2.4				0.00				0.00				0.00	0.00	0.00
Spare components	2.4				0.00				0.00				0.00	0.00	0.00
TOTALS	100.0				24.08				15.78				15.78	8.30	8.30

1 (lowest) <= rating <= 10 (highest). Risk expressed as a percentage. Score = (Wt. Factor) * Rating / (1 + Risk %/100%)

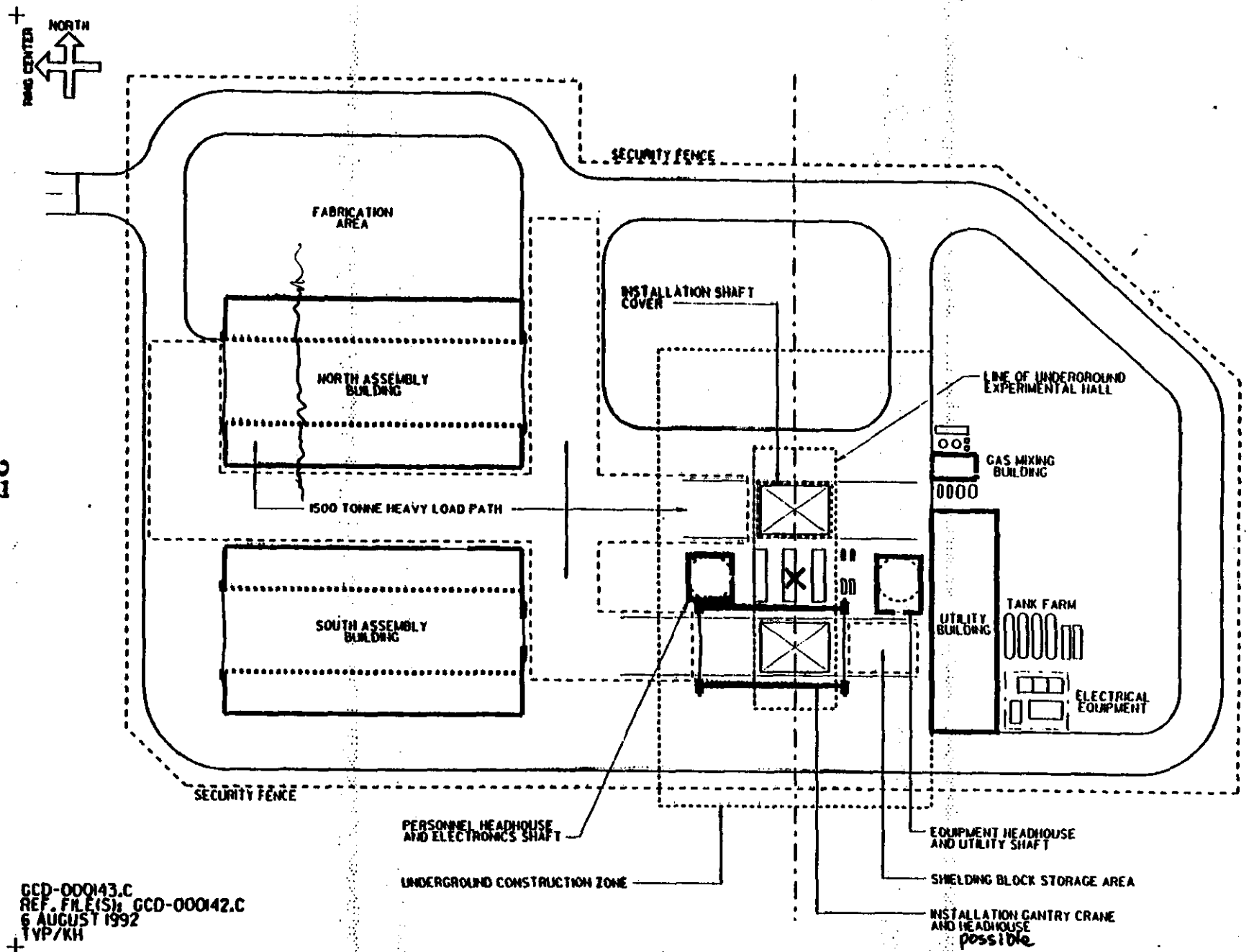
gem

γeμ

Presentation by:

Bill Wisniewski

Surface Facilities - IR5



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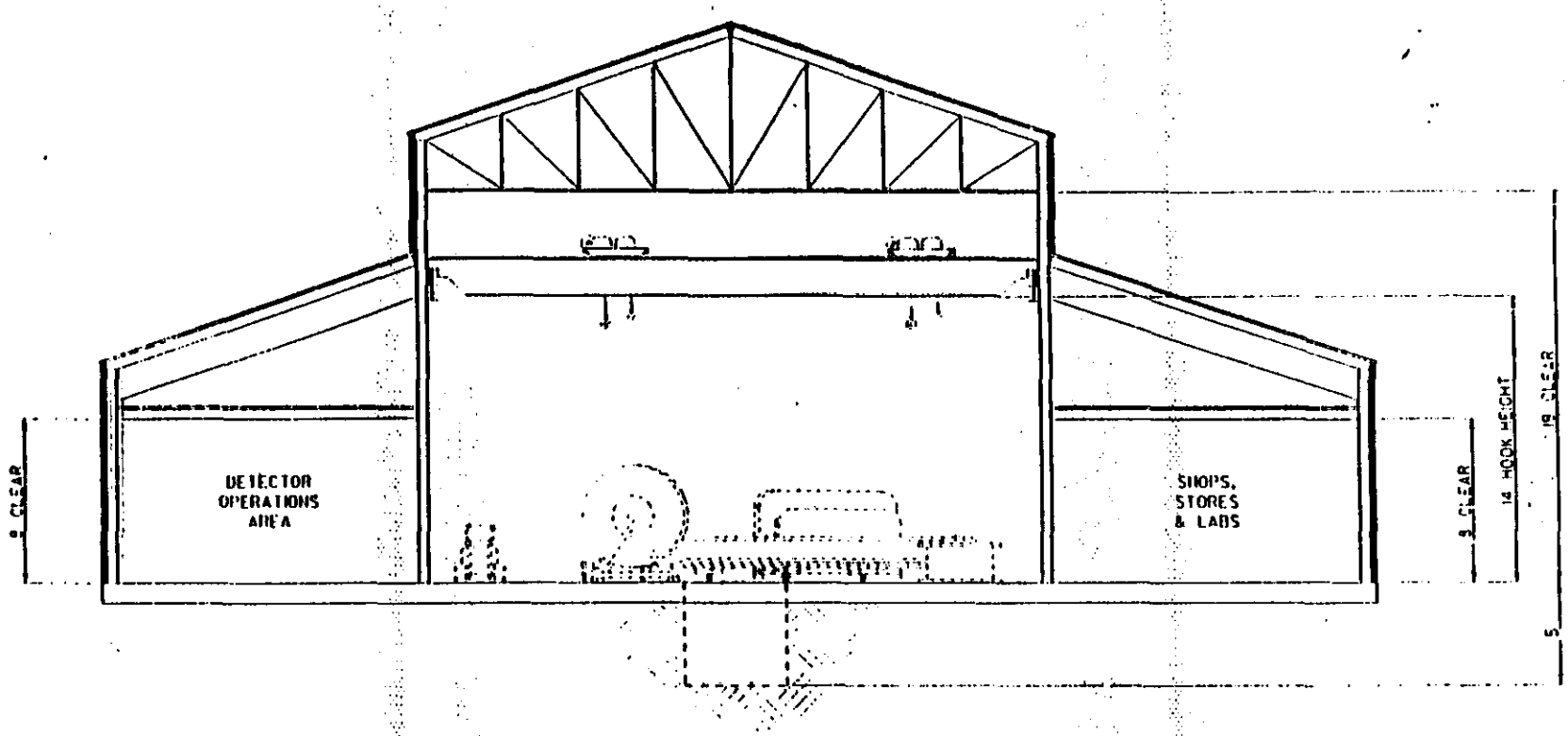
6 AUGUST 1992
TVP/KH



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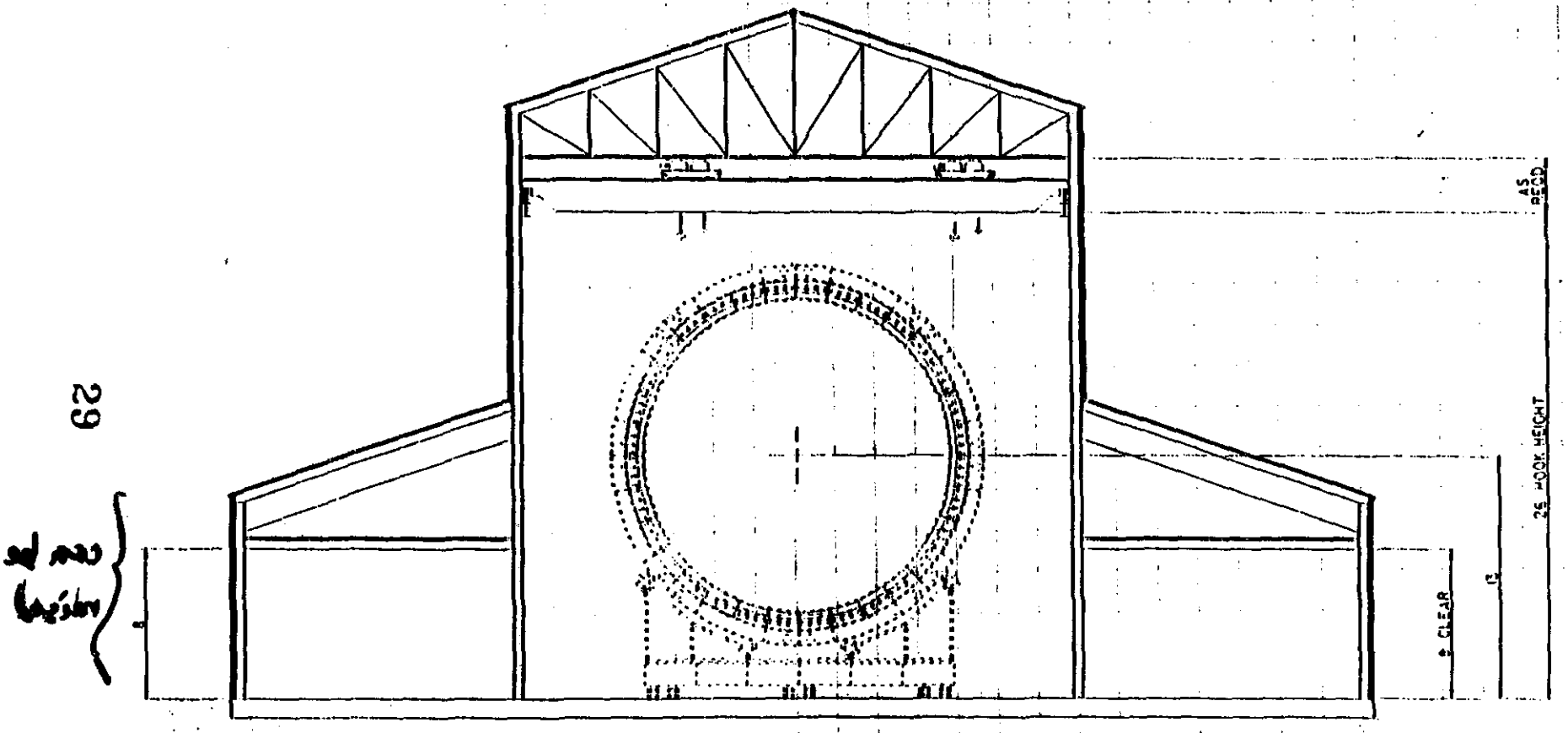
08-06-92
HAZLETT



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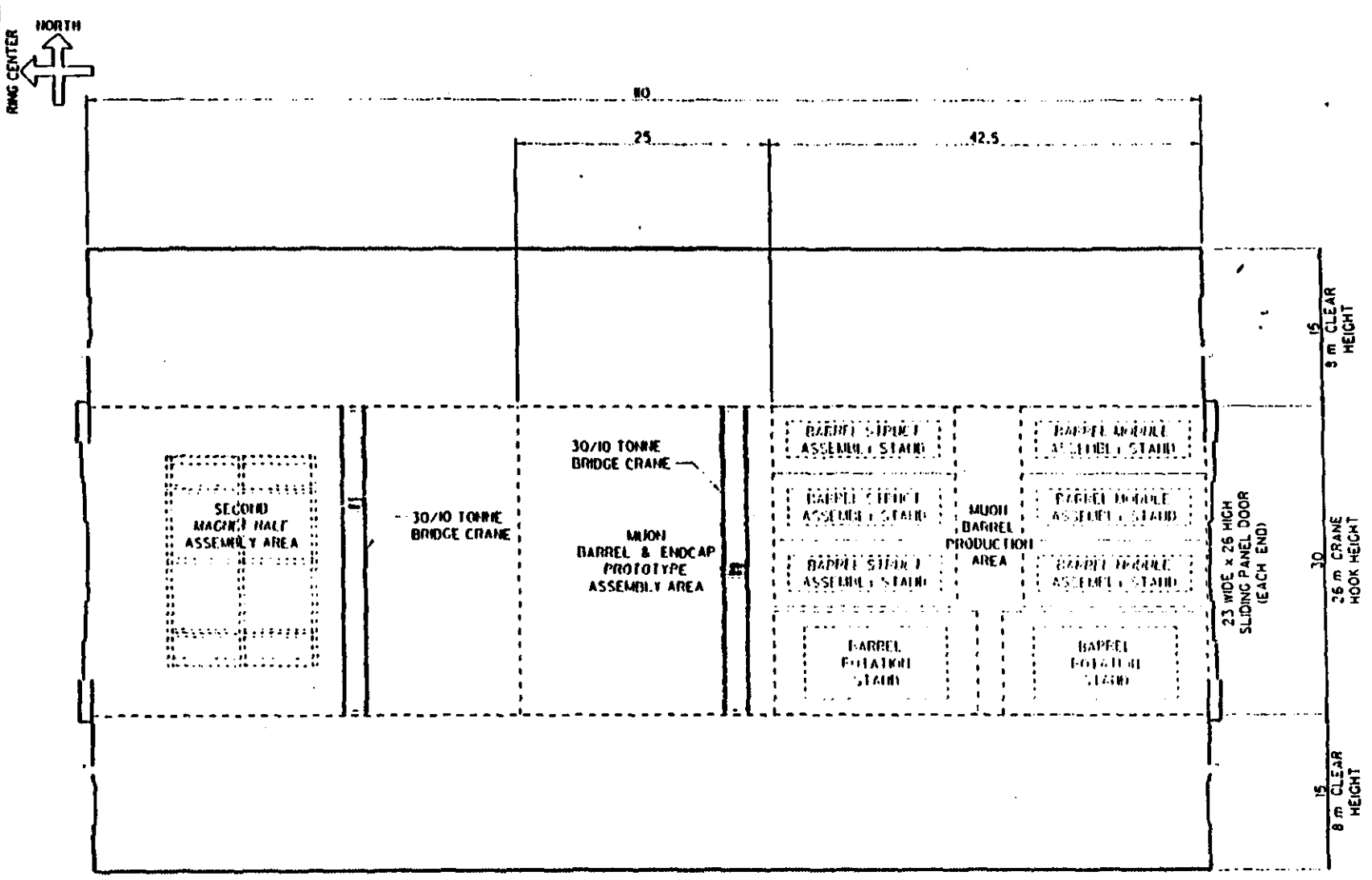
H HAZLETT



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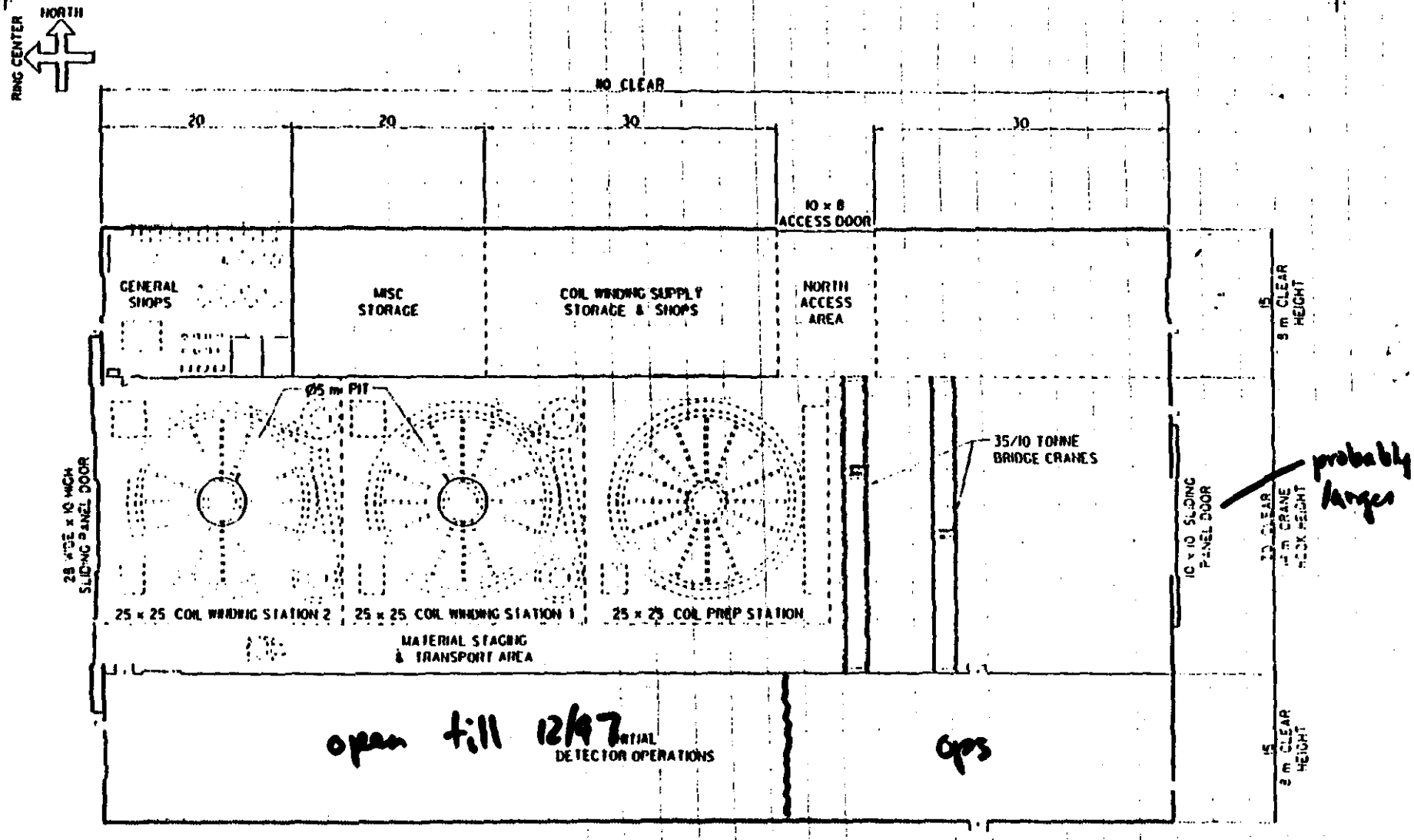
HHAZLETT



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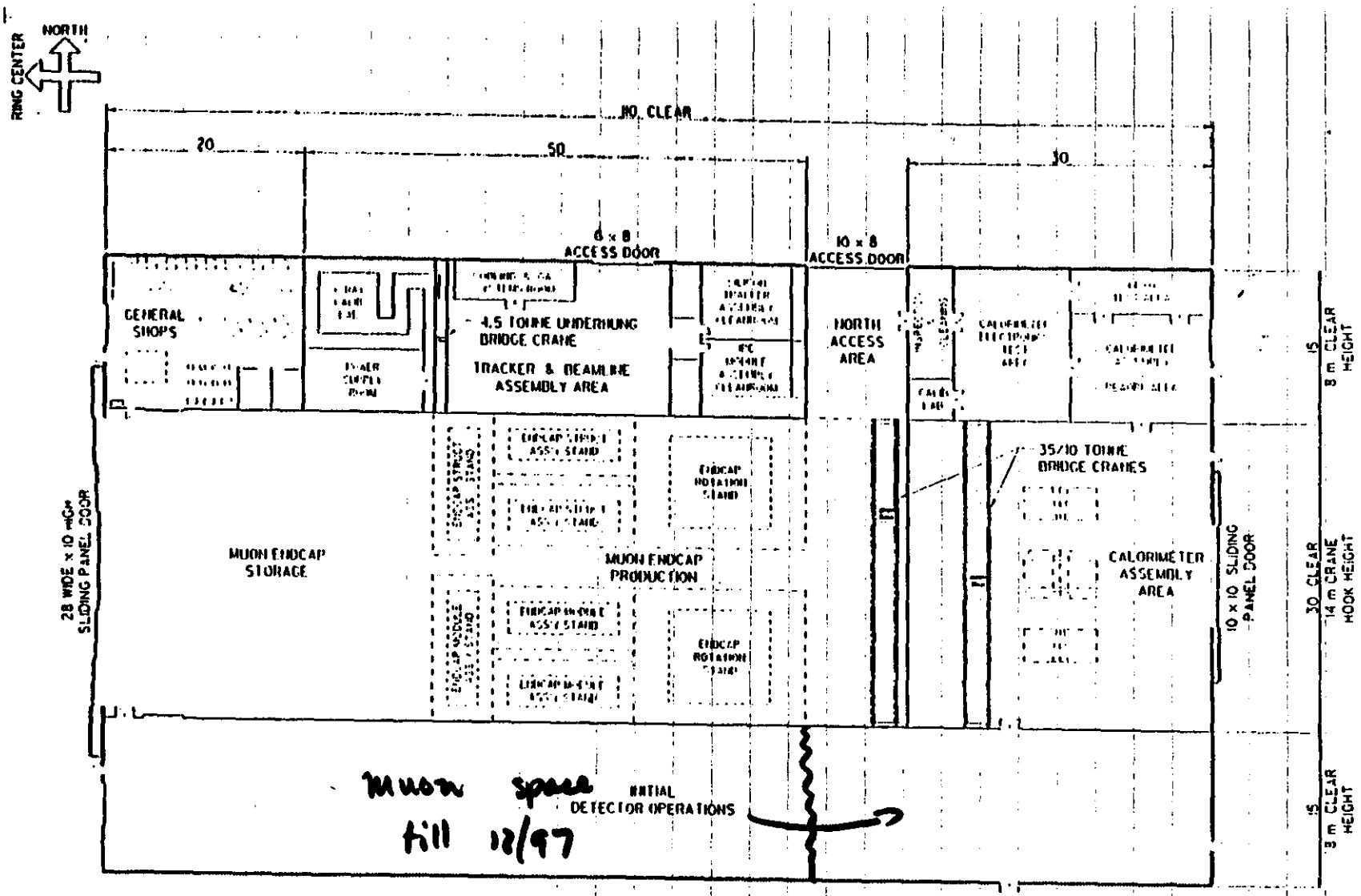
H HAZLETT



gcd000201.006
REF: gcd000236.003
08-05-92
H HAZLETT

gem

γeμ

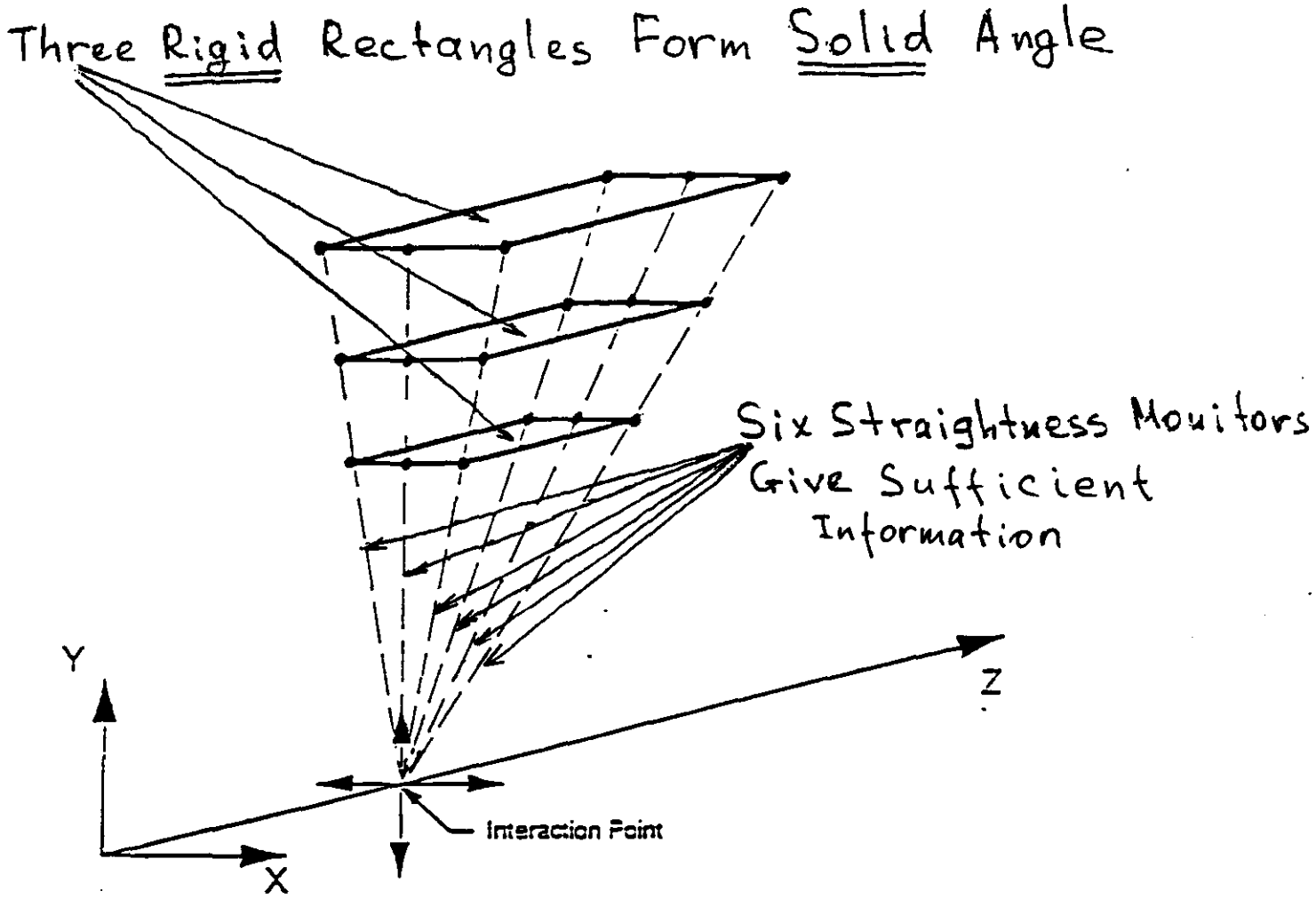
Presentation by:

G. Mitselmakher
A. Ostapchuk

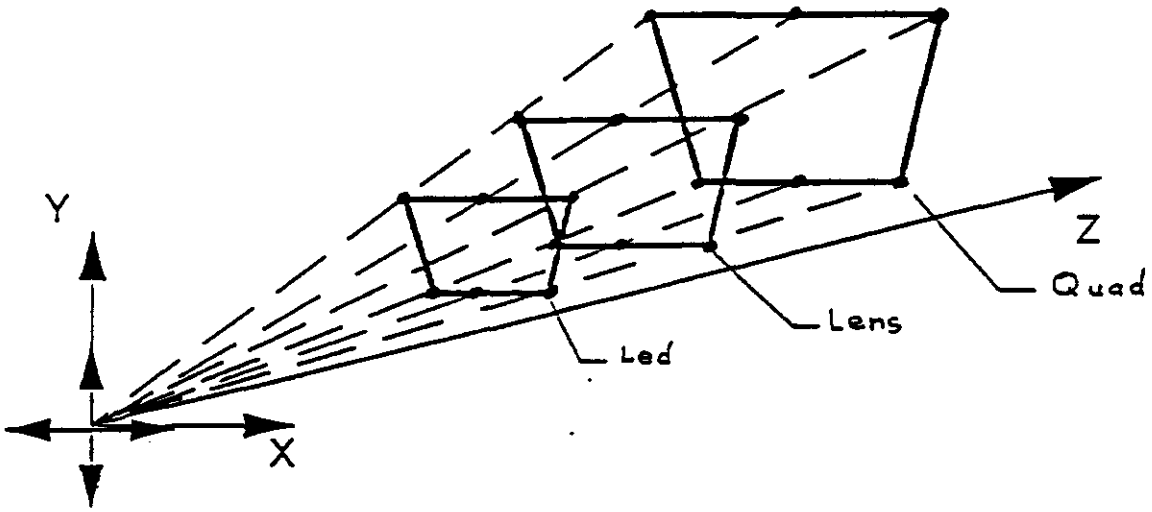
Projective Alignment Scheme
General Features

G. Mikenberg
A. Ostapchuk
08.12.92

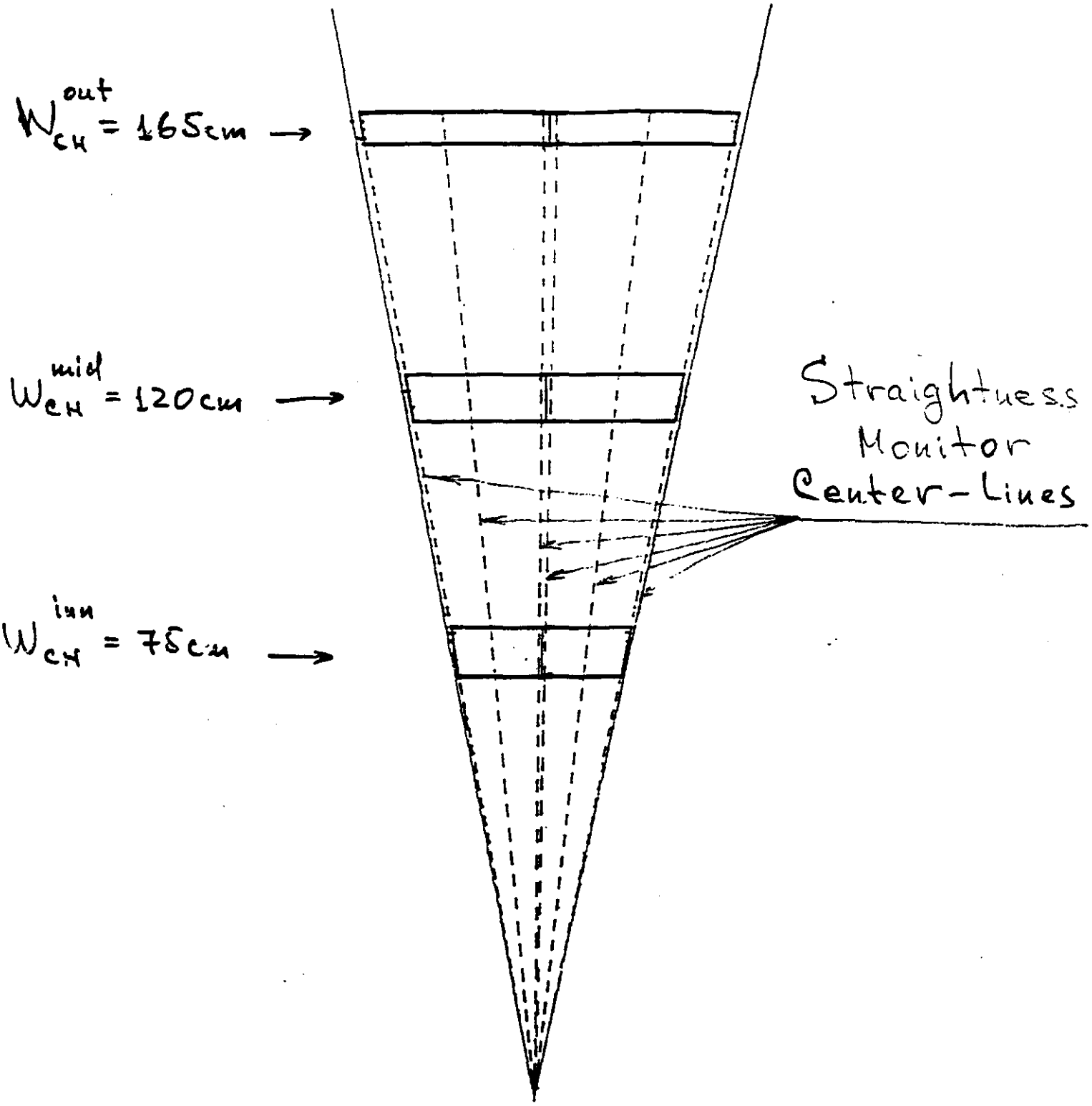
1. Local alignment (muon tower)
   a. Barrel
      - projective geometry of muon modules; three types of moduls in barrel
      - monitors are on short edges of moduls in existing θ-gaps
      - no φ-gaps; overlapping chambers
      - not more than 36 monitors in one barrel sector or 1152 for total barrel
   b. Endcups
      - one more θ-gap near 17° region; angle lost ≲ 1°
      - no φ-gaps; overlapping chambers
      - 12 straightness monitors in an endcups sector or 384 for endcups
2. Global alignment
   - the scheme depends on the choose wheel / sector option
   - tolerances are of order few mm (due to trigger requirements and dynamic range of monitors)



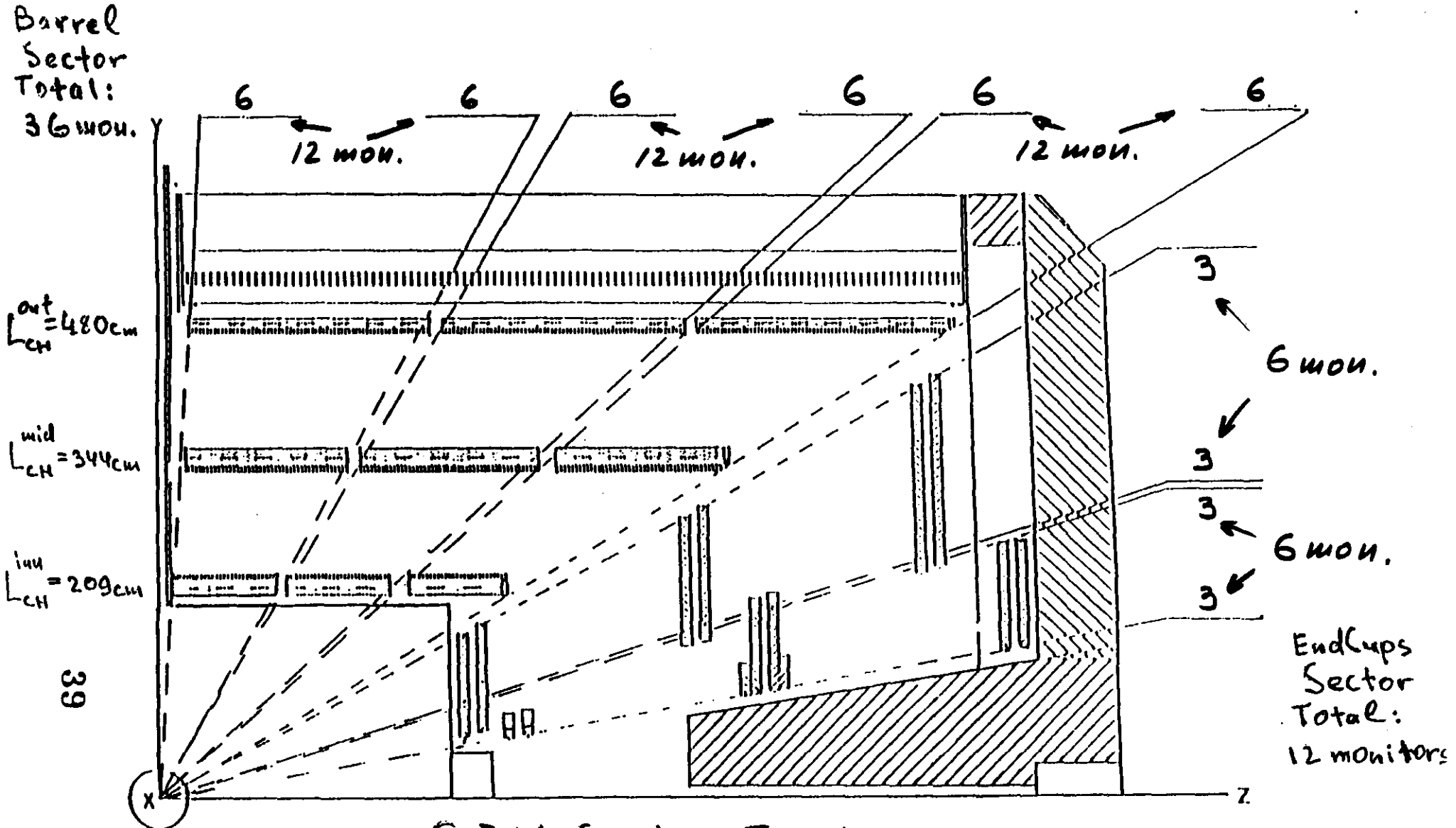
Muon Barrel Module
(General Scheme)



Muon Endcap Module
(General Scheme)



GEM Barrel Sector
(Chamber Endview)



GEM Sector Total: 36 + 12 = 48 monitors

GEM Total: 32 × 48 = 1436 monitors

GEM MUON SYSTEM CHAMBER LAYOUT

gem

γeμ

Presentation by:

M. Gamble
M. Furey

"BIGWHEEL" STRUCTURAL ANALYSIS UPDATE

M. Gamble and M. Furey

12 August 1992

REMARKS ON FINITE ELEMENT ANALYSIS

Because the simple models of the muon structure predict approximately 4mm of vertical deflection, the system is not over designed because:

- o All connections are assumed ideal,
- o All supports are assumed infinitely rigid,
- o All material properties are assumed perfectly uniform, and
- o No account is taken for plates required to connect beams

The 6 in. OD x 0.188 in.-wall tubes used in the model are reasonable because:

- o The maximum axial stress borne by any member is near 50% of the precision elastic limit for the 6061- T6 aluminum material planned for the system
- o The maximum compressive stress borne by any member is approximately 25% of the buckling stress for that member, and
- o 95,000 kg of chamber payload, assuming PDT, technology is being supported by22,000 kg of structural mass yielding a 4:1 ratio ; very appropriate for sparse structural support

ANALYSIS RESULTS FOR "BIGWHEEL" MUON SYSTEM

The BIGWHEEL (BW) described below is characterized by:

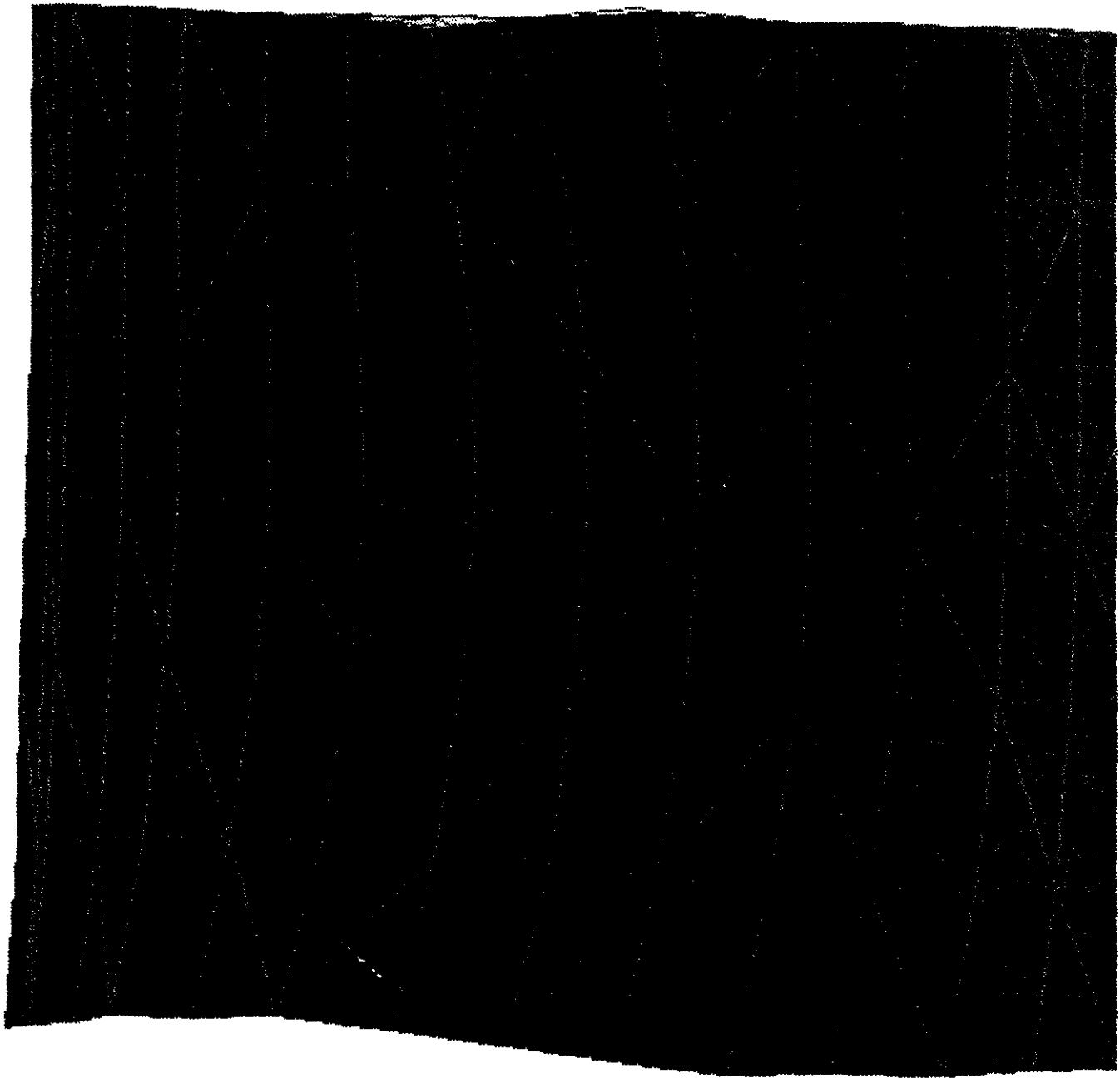
- o Kinematic support at 4 points near its horizontal midplane,
- o 6 in. OD x 0.188 in.-wall aluminum tubes everywhere excepting the 12 in. x 0.687 in.-wall End Ring where applicable, and
- o PDT technology contributing to a total mass of approximately 120,000 kg

	BW w/o End Ring		BW w/ End Ring	
	Static Deflection (mm)	Fund. Freq. Vibration (Hz)	Static Deflection (mm)	Fund. Freq Vibration (Hz)
M. Gamble	3.1	4	2.9	4
M. Furey	6.8	4	5	4.6

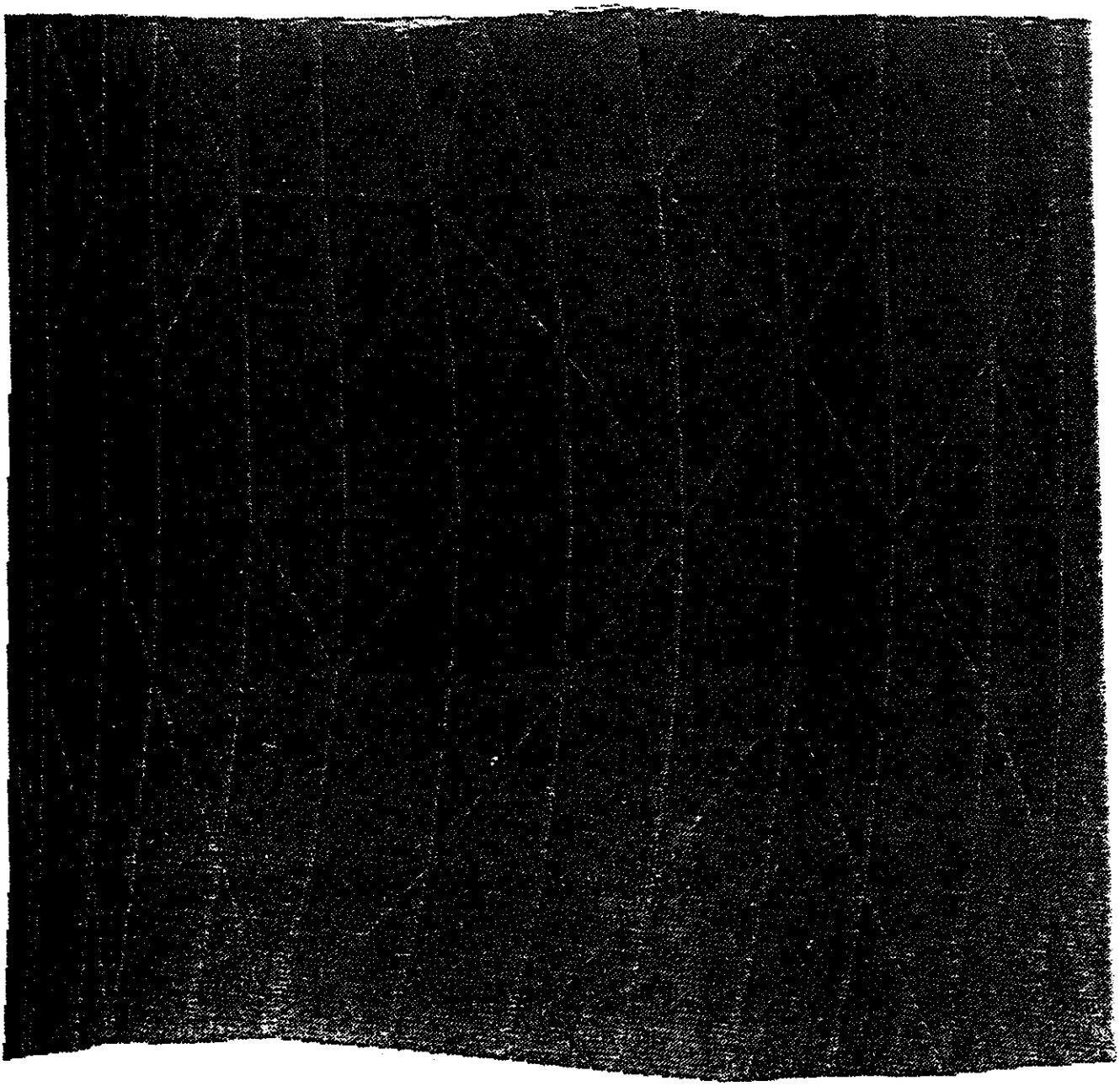
An AXIAL view, SIDE view, and INTENSITY plot, of deflections,and AXIAL view of fundamental natural frequency of vibration, respectively,of M. Gamble's BW w/ End Ring, as well as a SIDE and AXIAL view, respectively of deflections and fundamental natural frequency of vibration of M. Furey's BW follow

DEF Lc=1

DEF Lc=1

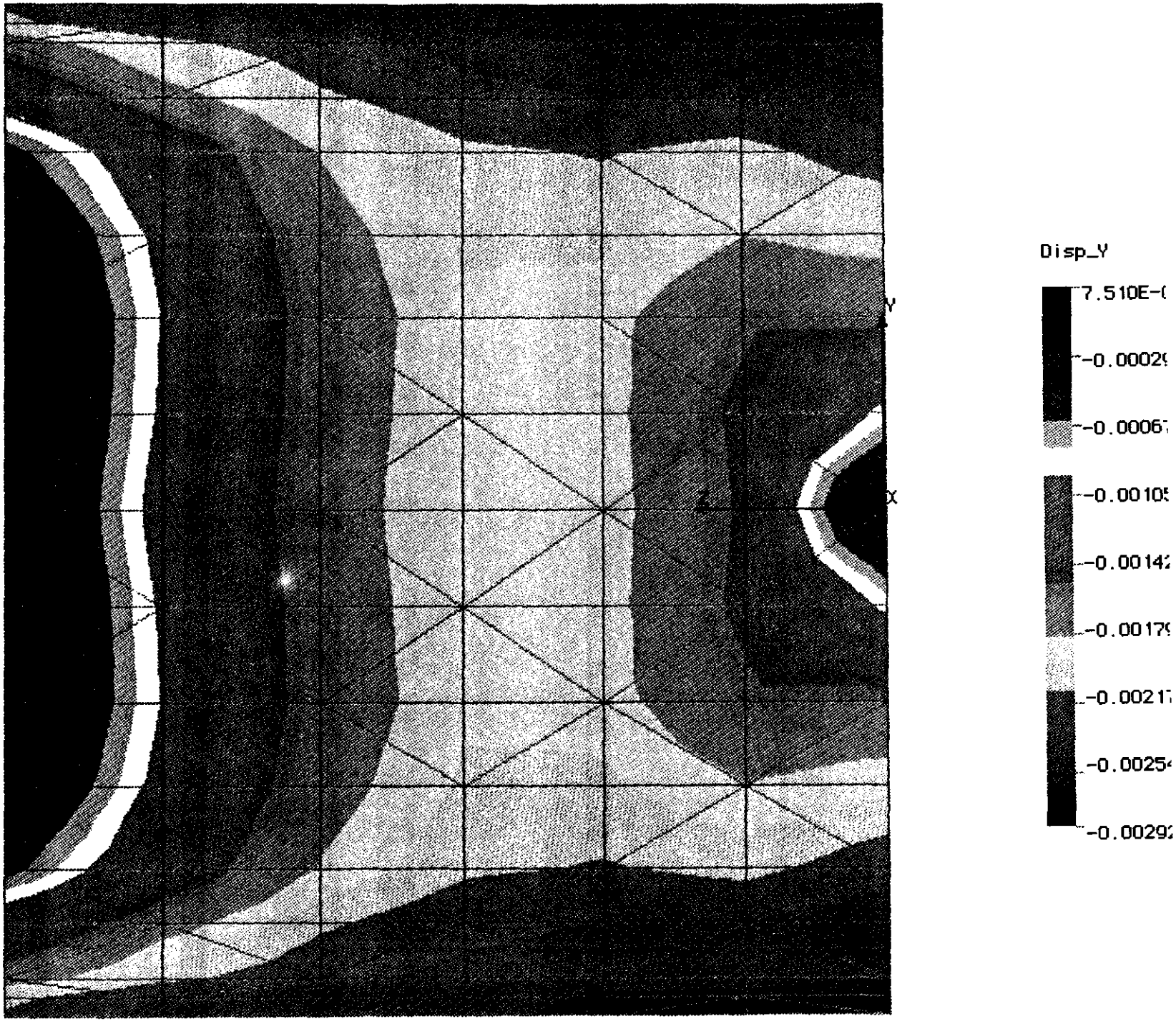


EF Lc=1

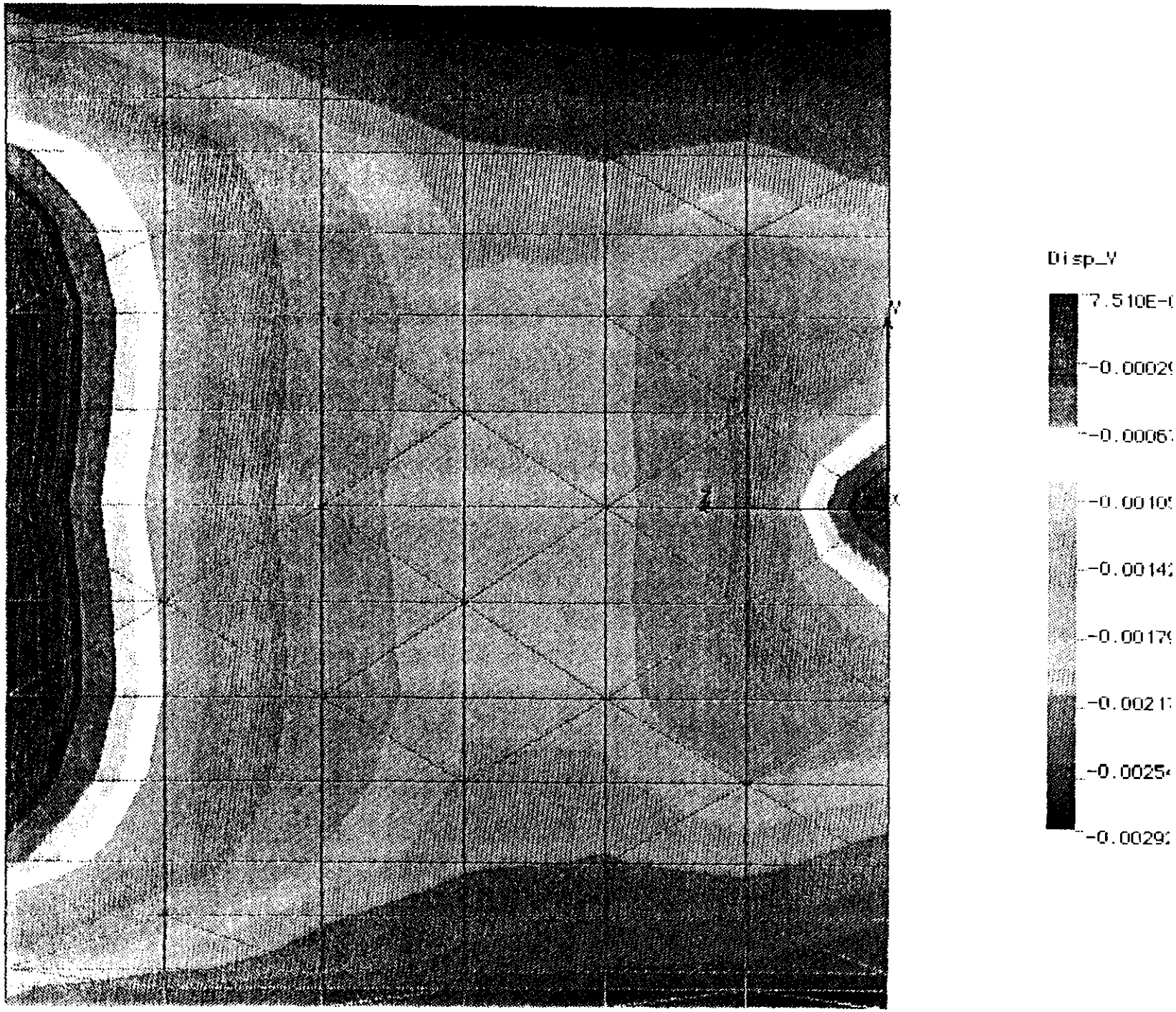


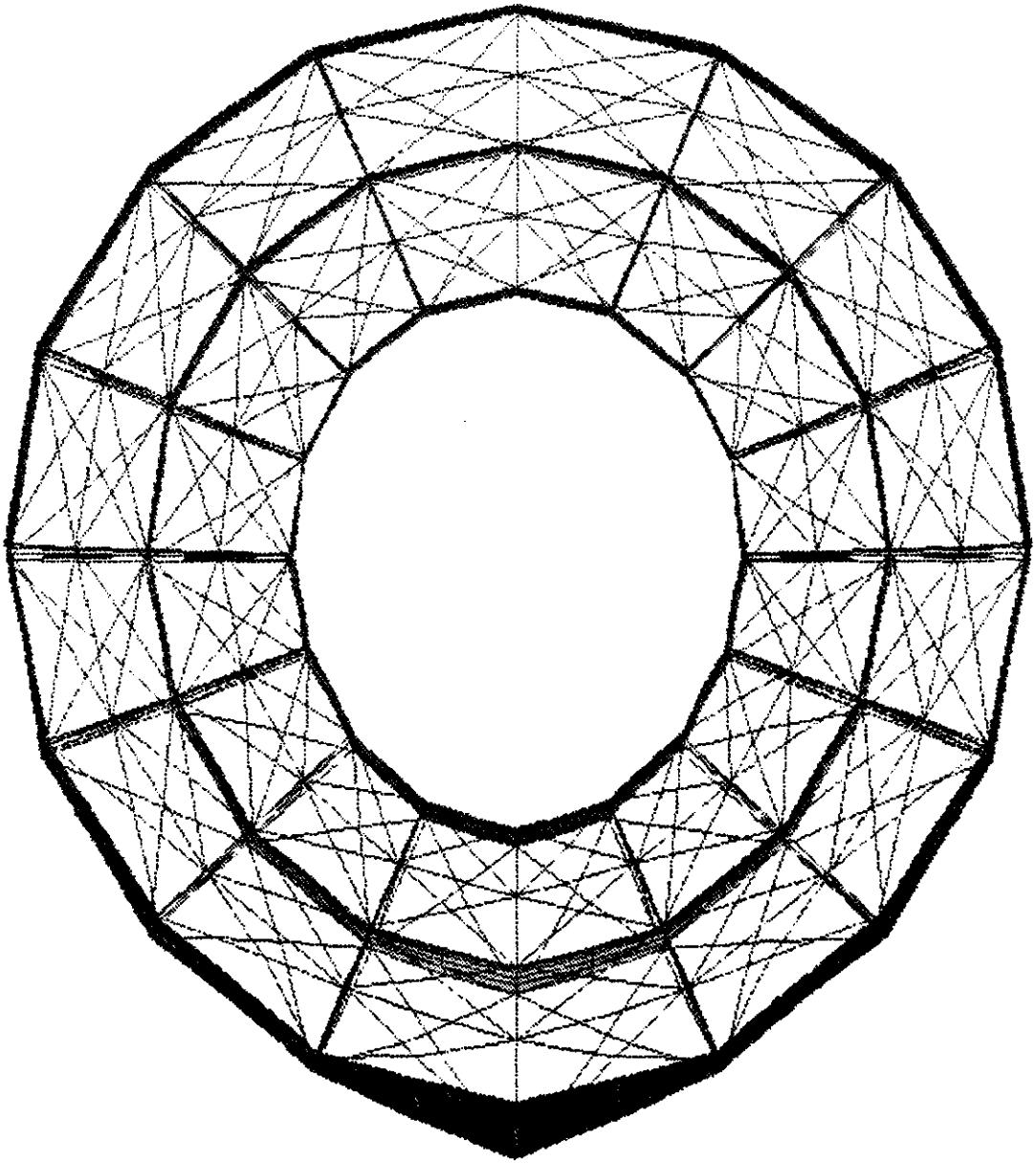
in DEF Lc=1

ISP Lc=1


Disp_Y
7.510E-(
-0.0002
-0.0006
-0.0010
-0.0014
-0.0017
-0.0021
-0.0025
-0.0029
Y
X

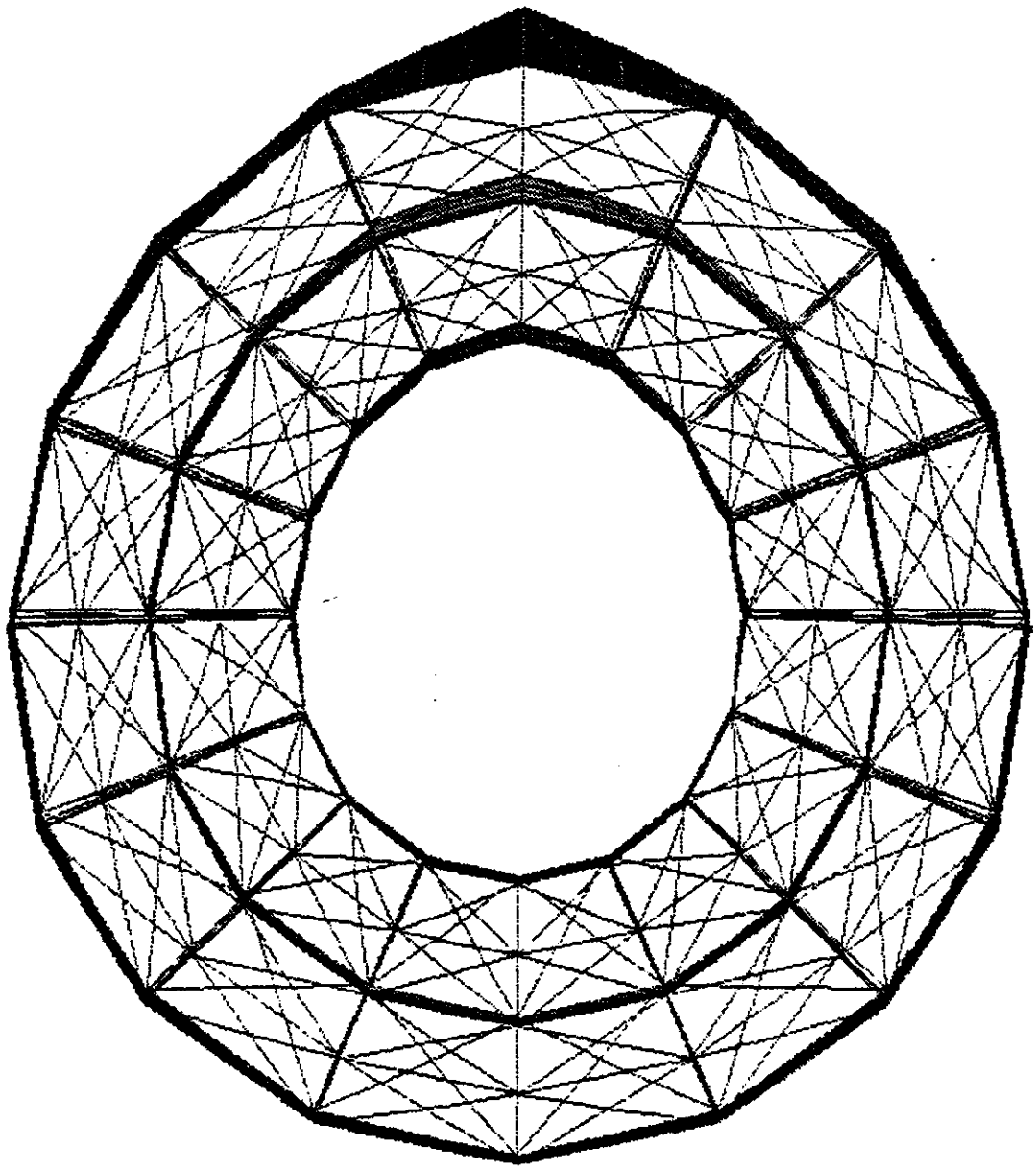
SP Lc=1


Disp_V
7.510E-0
-0.00029
-0.00067
-0.00105
-0.00142
-0.00179
-0.00217
-0.00254
-0.00292



F_Mode=1 4 Hz

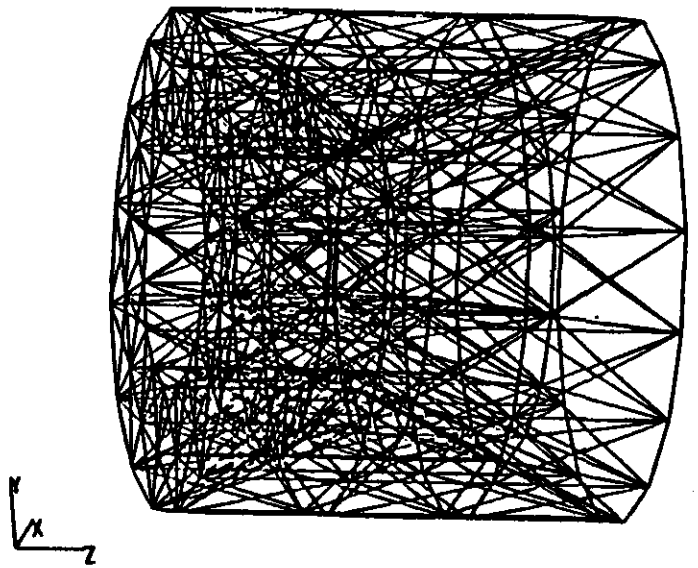
F_Mode=1 4 Hz



BARREL REGION
BIG WHEEL OPTION

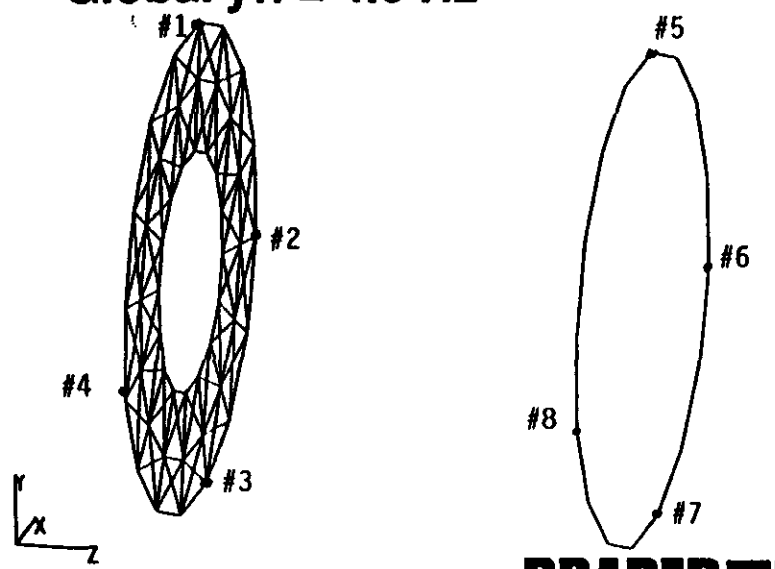
G.E.M. — 12 August 1992

- 6 in. o.d. x 0.188 in. thick wall members except for nominal 12 in. end ring

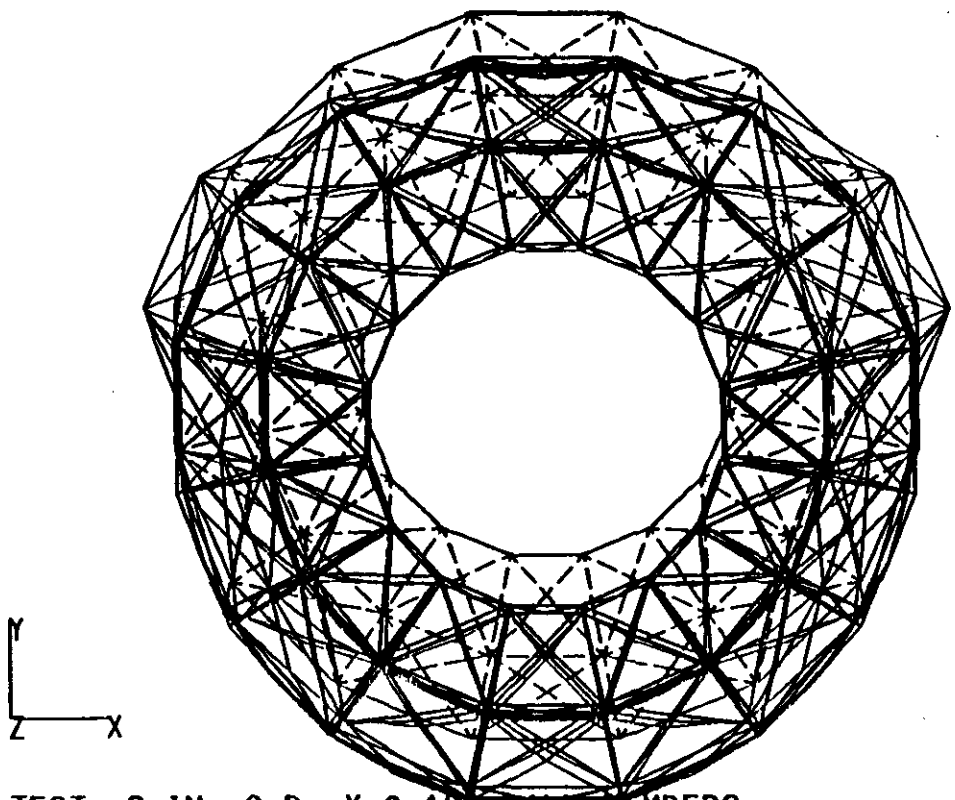


- Results Summary
  - Max. deflection 5.2 mm
  - Margin of safety positive relative to microcreep
  - Max. axial force ≈ 9.6E4 N
  - Global fn = 4.6 Hz

NODE #1 X CONSTRAINED
NODE #2 Y, Z CONSTRAINED
NODE #3 X CONSTRAINED
NODE #4 Y, Z CONSTRAINED
NODE #5 X CONSTRAINED
NODE #6 Y CONSTRAINED
NODE #7 X CONSTRAINED
NODE #8 Y CONSTRAINED



DRAPER LABORATORY



BIG WHEEL TEST, 6 IN. OD X 0.188 WALL MEMBERS
12 IN. END RING, 1 G LOAD IN THE -Y DIRECTION
1 G GRAVITY LOAD, -Y