GEM TN-93-433

GEM Muon Review Meeting - SSCL

June 30, 1993

Abstract:

Agenda, attendees, and presentations of the GEM Muon Review Meeting held at the SSC Laboratory on June 30, 1993.

June 30, 1993
GEM muon group meeting
AGENDA

- Gena Mitselmakher - Chamber development plan
- Coleman Johnson - Chamber engineering at the SSCL
- Otto Steger - Strip board measurements
- Vinnie Polychronakos - BNL chamber / electronics progress
- Curt Belser - LLNL chamber activities
- Scott Whitaker - BU chamber / electronics activities
- Igor Golutvin - Dubna progress with large prototype
- Yinzhi Huang - Progress in IHEP
- Dan Marlow - Plans of muon electronics development
- Craig Wuest - Alignment Test Rig plans and chamber / alignment interface prototyping
- Joe Paradiso - Alignment monitor prototyping and simulations
- Alignment discussion - contributions from Gershtein and Korytov (presented by Mitselmakher)
- Joe Antebi - Monolith support structure
- Frank Nimblett - Support structure
- Mike Marx - Compare TDR and SGH support structures
- Discussion

GEM Muon Group Meeting

Name	Inst	Phone	Node
G. Mitselmakher	SSCL	(214)-708-6001	SSCVX1::Mitselmakh
V. Polychronakos	BNL	(516) 282-3982	BNLDAG::POLYCHRC
Craig Wuest	LLNL	(510) 423-2909	WUEST@LLNL.GOV
L. Osborne	MIT	(617)253-2396	Osborne@MITL
Carl Bromberg	MSU	(517)353-1809	BROMBERG@MSU
OTTO STEGER	SSCL	(214) 708-1188 (temp)	
COLEMAN Johnson	SSCL	(214) 708-1188	JohncoLE@SSC
Yuri Gershtein	SSCL/ITEP	(214) 708-30-07	GERSTEIN@SSC
Jörg Pyrlik	Houston	(713) 743-3600	PYRLIK@UHIBPD.PHYS.UH.E
Peter Sebelius	Draper	(617)258-3149	SEBELIUS@DRAPER.COM.
FRANK NIMBLETT	DRAPER	(617) 258-1393	NIMBLETT@DRAPER.COM
Roger McNeil	LSU	(504)-388-6857	PHMCNE@LSUVAX
Joe Antebi	SGH	(617)643-2000	72262,3420@COMPUSERV.COM
Mike Marx	SUNY	516 632 8102	SBHEP::MARX
LARRY ROSENSON	MIT	617-253-7595	ROSENSON@MITLNS
Dick Edelstein	CMU	412-268-2760,2740	EDELSTEIN@CMPH
Igor Golutvin	JINR	(214) 708-3064	IGOLUTVIN@SSCUX
Yuri Bonushkin	SSCL	(214) 708-3078	BONUSHKIN@SSCVX
Joe Paradiso	Draper	(617) 258-2413	newromancer@draper.
OLEG PROKOFIEV	SSCL	(214) 708-4486	PROKOFOE@SSCVX
Scott Whitaker	Boston U.	(617) 353-8916	SCOTT@BUPHYC.BU.EDU
Dan Marlow	Princeton U	609 258 4383	MARLOW@PUPHEP.PRINCETO

Name	Inst.	Tel	Email
Yanxin GUO	SSCL	ext-4457	SSCVX1::GUO
Yin-Zhi HUANG	SSCL	6009	SSCVX1::HUANGYZ
CURT BELSER	LLNL	510-423-2472	BELSER1@LLNL.GO
Slava Timofeev	SSCL	x6292	sscvx1::timofeev

Draft-3

GEM Post TDR Muon R&D Program for FY93

May 7, 1993

Abstract

The objectives of the Post-TDR FY93 R&D and Engineering Program for the GEM Muon System are to carry the chamber design, alignment, and support structure into fully integrated, and engineered system. In contrast, the Pre-TDR program concentrated on the conceptual design of the muon system and on extexsive investigations of various chamber technologies. This effort lead to our choosing Cathode Strip Chambers for both the triggering and tracking functions of the muon system. In the Post-TDR program certain aspects of the Cathode Strip Chamber design will be developed and tested by means of small prototype chambers where the parameters of interest will be varied. Such issues as the resolution of the chamber for different anode-cathode gaps will be investigated. In addition, the full engineering details and "industrialization" of the chamber design will be conducted with the intent of setting up a pilot factory and producing first production chambers in FY94. The design of the chamber support and alignment systems will be developed in sufficient detail to allow for the fabrication of a sector prototype in late FY94. The construction of an alignment test-stand will be an important objective for this phase of the R&D program. The test stand will enable the concept of the "false-sagitta" measaurement and interpolation to be validated.

Table of Contents

Compiled by:

Gena Mitselmakher - SSCL [SSCVX1::MITSELMAKHER]
Frank Taylor - MIT [MITNLS::FET]

In order to manage the activities of the groups contributing to the chamber design a Chamber Commitee will be created with the primary function to overlook all activities and coordinate chamber design. The chairman of the Commitee is the Task Coordinator.

The proposed work is broken down into the following subtasks:

Deliverables:

(2.1.0) Purchase common parts (raw materials) for chamber construction.
(2.1.1) Fix the baseline chamber design for barrel and endcap chambers. Document all mechanical tolerances and dimensions. Compile a set of drawings. Integrate with electronics, alignment, gas and services.
(2.1.2) Investigate and validate with reduced size prototype measurements of different aspects of chamber design:
a) resolution performance vs. gap and strip segmentation;
b) investigation of different possibilities of calibration: with wire induced signal, electronically and using data from real particles.
c) consider the possibility of molded chamber frame production.
(2.1.3) Construction of full size prototypes:
a) "-1 generation" prototype of a barrel middle layer chamber: 3m by 1.1m - six 4mm gaps;
b) "0 generation" prototype of a barrel outer layer chamber: 3.5m by 1.4m - six 5mm gaps;
c) "0 generation" prototype of an end cap middle layer trapezoidal chamber: 2.2m by 0.9/0.61m - six 4mm gaps.

Task Coordinator: Gena Mitselmakher - SSCL

Chamber Commitee: Carl Bromberg. Igor Golutvin, Ya-nan Guo, Coleman Johnson, Yuri Kiryushin, Kwong Lau, Louis Osborne, Vinnie Polychronakos, Alexei Vorobyov, Craig Wuest, Scott Whitaker.

Task Contributors:

BNL
M. Atiya, M. J. Murtagh, V. Polychronakos, V. Radeka
BU
J. Shank, S. Whitaker, F.S.U. visitor, eng1, eng2, tech1, tech2
IHEP-Beijing
Y. Chen, Y. Guo, Y. Xie, physicists and engineers
ITEP
M. Danilov, V. Gavrilov, L. Laptin, P. Murat, V. Nagovitsin, A. Ostapchuk, V. Popov, V. Shibaev, V. Stolin, V. Tchistilin, I. Tikhomirov.
JINR-Dubna
Yu. Ershov, I. Golutvin, N. Gorbunov, Yu. Kiryushin, A. Makhankov, S. Movchan, V. Rashevsky, L. Simov, S. Sergeev, D. Smolin, V. Perelygin, V. Zhiltsov
PNPI - St. Petersburg
V. Andreev, N. Bondar, G. Gavrilov, V. Grachev, O. Kiselev, A. Krivshich, V. Maleev, V. Mylnikov, S. Patrichev, O. Prokofiev, A. Vorobyov
SSCL

- Prototypes

a) Small "performance optimization" prototypes.
(Cell geometry optimization, performance in magnetic field - barrel, endcap, wire - strip angle effect on resolution, etc...)
committed: SSCL (laser test stand), ITEP, PNPI, BNL, Dubna

b) Engineering prototypes - parts of chambers (panels, frames from new materials etc.)
committed - SSCL, BNL, LLNL ...need more

c) Large prototypes
(-1) generation barrel chamber 3m by 1.1m , six 4mm gaps - Dubna (with SSCL participation - components, BNL, BU , PNPI - electronics)
August 1993

(0) generation barrel outer layer chamber 3.5m by 1.4m - six 5mm gaps
producer TBD (SSCL, LLNL, Dubna ???)
design by November 1993
construction by January 1994

(0) generation endcap chamber
design by December 1993
construction be February 1994
producer TBD (MIT, PNPI ???)

- Electronics for prototypes.

a) Cathode electronics - 2000 channels - Amplex based - BNL
b) Anode electronics - 500 channels - BU,PNPI(hybrids)

- Prototypes of "real electronics" - first samples in 1994 -
first production for prototypes for Sector test and Fermilab tests 1995
(discussed with Marlow)

(4.0) Schedules and Milestones

4.1 Chamber Design, Prototyping and Studies. Tasks 1 and 2.

Item (Task)	M (1993)	J	J	A	S	O	N	D	J (1994)	F
1. Barrel Chamber design (2.1.1a)		xxx	xxx	xxx	xxx	xxx ^Design Parameters Fixed	xxx	xxx	xxx	
2. End Cap Chamber Design (2.1.1b)			xxx	xxx	xxx	xxx	xxx ^Design Parameters Fixed	xxx	xxx	xxx
3. Barrel type (-1) generation prototype (2.1.3a)	Construction xxx	xxx	xxx	xxx	Tests xxx	xxx				
4. Barrel type (0) generation prototype (2.1.3b)				Design xxx	xxx	xxx	xxx	Construction xxx	xxx	xxx
5. Endcap type (0) generation prototype (2.1.3c)					Design xxx	xxx	xxx	xxx	xxx Construction	xxx
6. Tests of small chambers (2.2.2, 2.2.3, 2.2.4)	Construction xxx	xxx	xxx	xxx	Tests xxx	xxx				
7. Construction of engineering prototypes (large panels, molded frames) (2.1.2)	Construction xxx	xxx	xxx	xxx	Tests xxx	xxx				

Note: In the original, the "Construction" bars for items 3, 6 and 7 run from May to August. The "Tests" bars for items 6 and 7 begin in June, and the one for item 3 begins in August; all three end in October.

CHAMBER WEIGHTS

Different "baselines" considered

- BNL cast edges: nominal 3.5 x 1.19 m chamber
  epoxy edges, G-10 frames, no electronics, etc
  baseline chamber weight = 134 kg
  cast polymer frame weight = 103 kg, i.e. 77%
- SSC minimization design: nominal 2.55 x 1.08 m chamber
  epoxy edges, G-10 frames, no electronics, etc
  baseline chamber weight = 93.6 kg
  minimization design weight = 69.5 kg, i.e. 74%
- Both designs baselines use epoxy in HC close-outs
  consider lower density material, ie from 1.23 to 0.5 gm/cc
  could lower SSC design to 59.4 kg, ie 63.5 %
- TDR weights based on incorrect densities
  realistic chamber weights 3/4 of TDR
  However, cables, tubes not included

DESIGN

Current efforts:

- Reduce materials in "edges"
- Wire fixation concepts
- High voltage distribution details
- Gas distribution system details
- "Spacer" details
- Alignment transfer details

Questions to be answered soon

- Flatness requirements
- edge material concept
- Solder vrs epoxy for wire fixation
- Anode plane relative alignment requirements

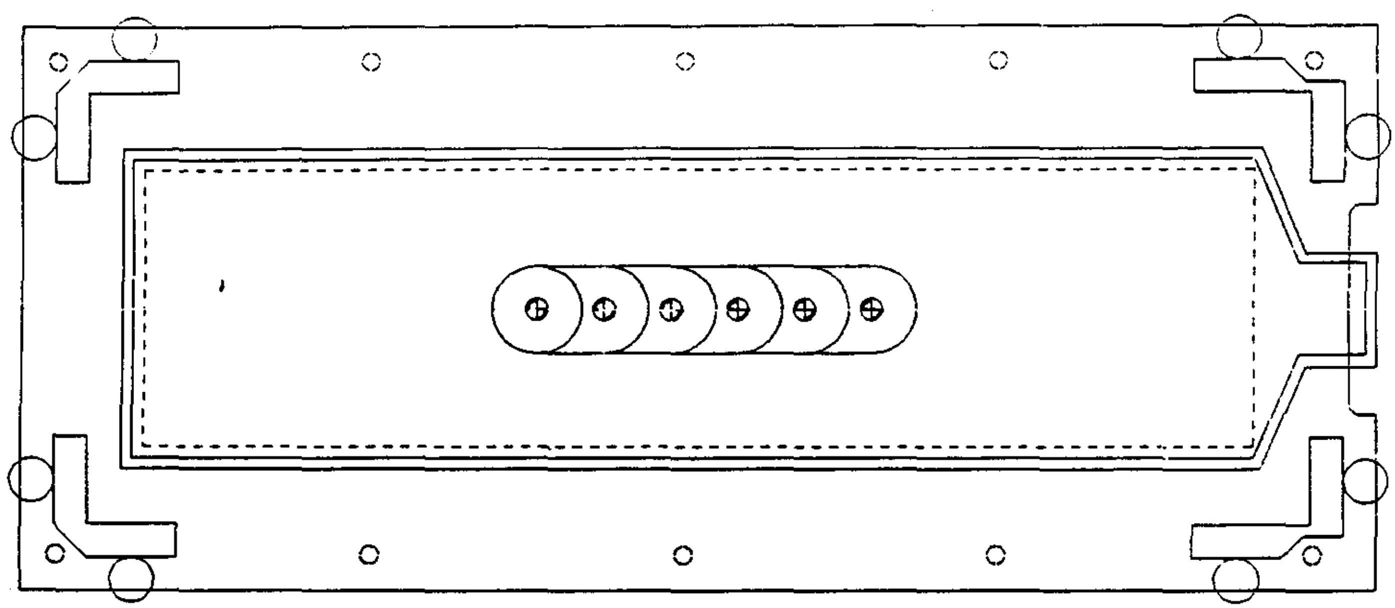
Plans:

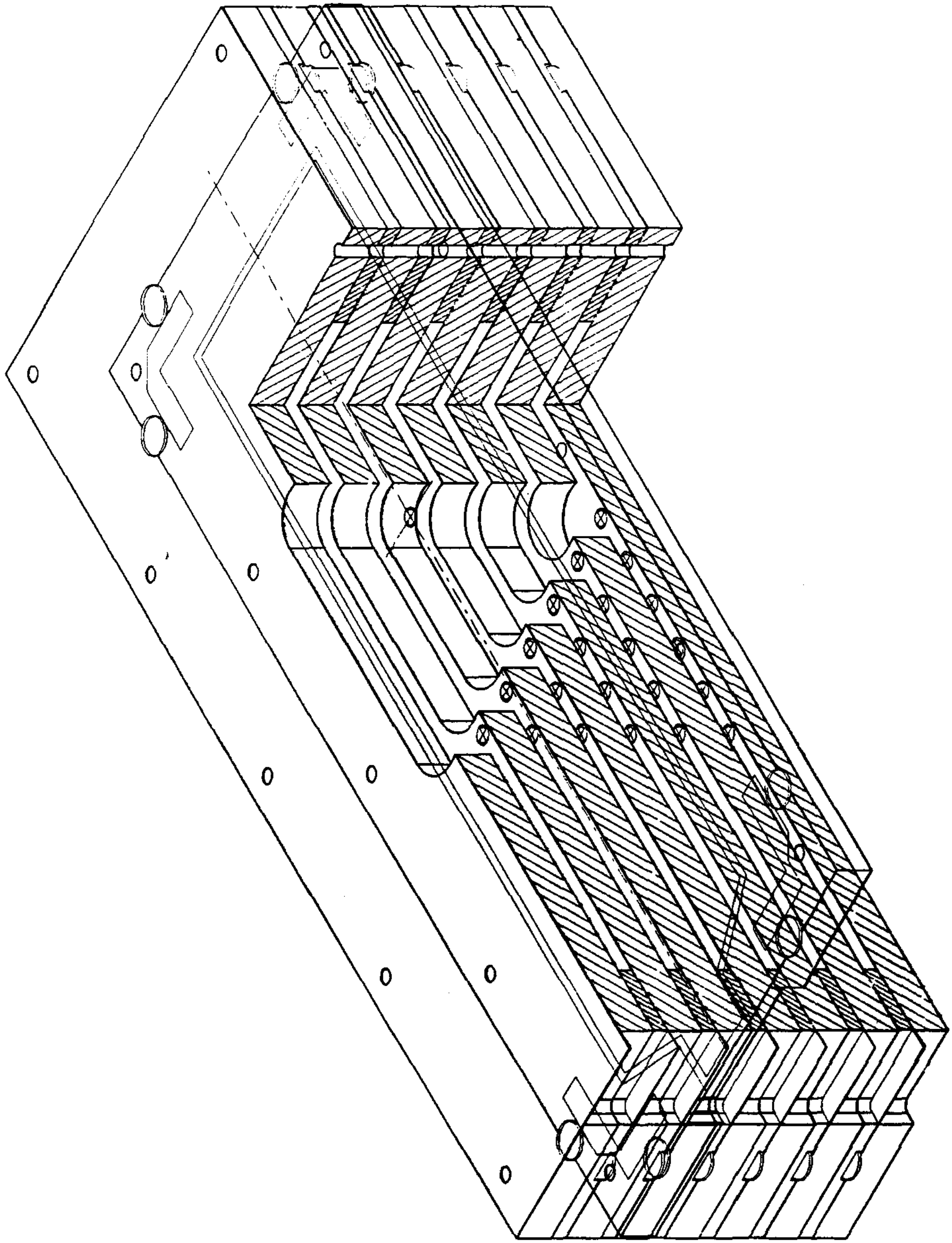
Full sized, mid layer prototype:

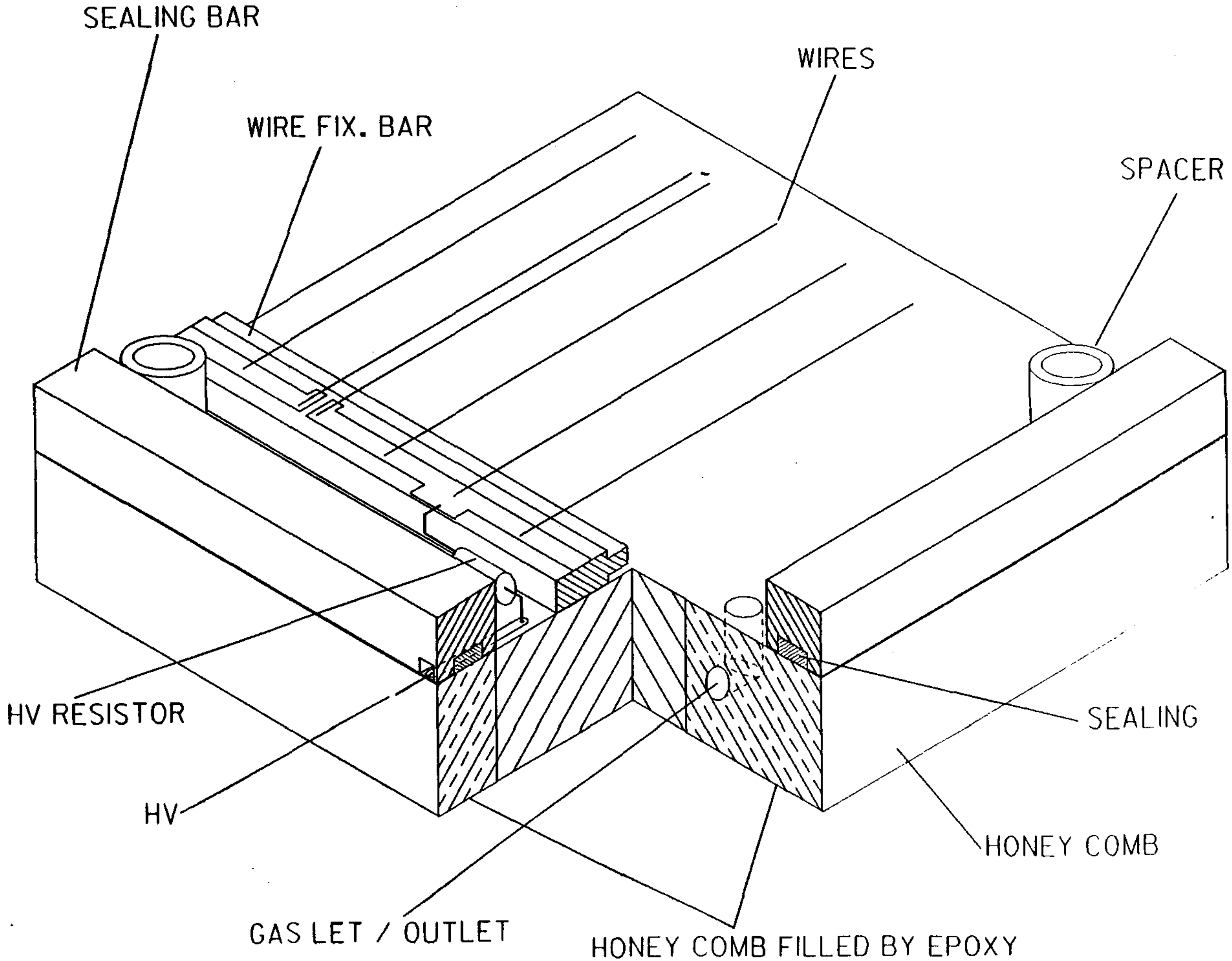
- ship parts
- build six gap chamber, starting mid July
- test in TTR, results by Sept?

15 **Full sized, largest barrel prototype:**

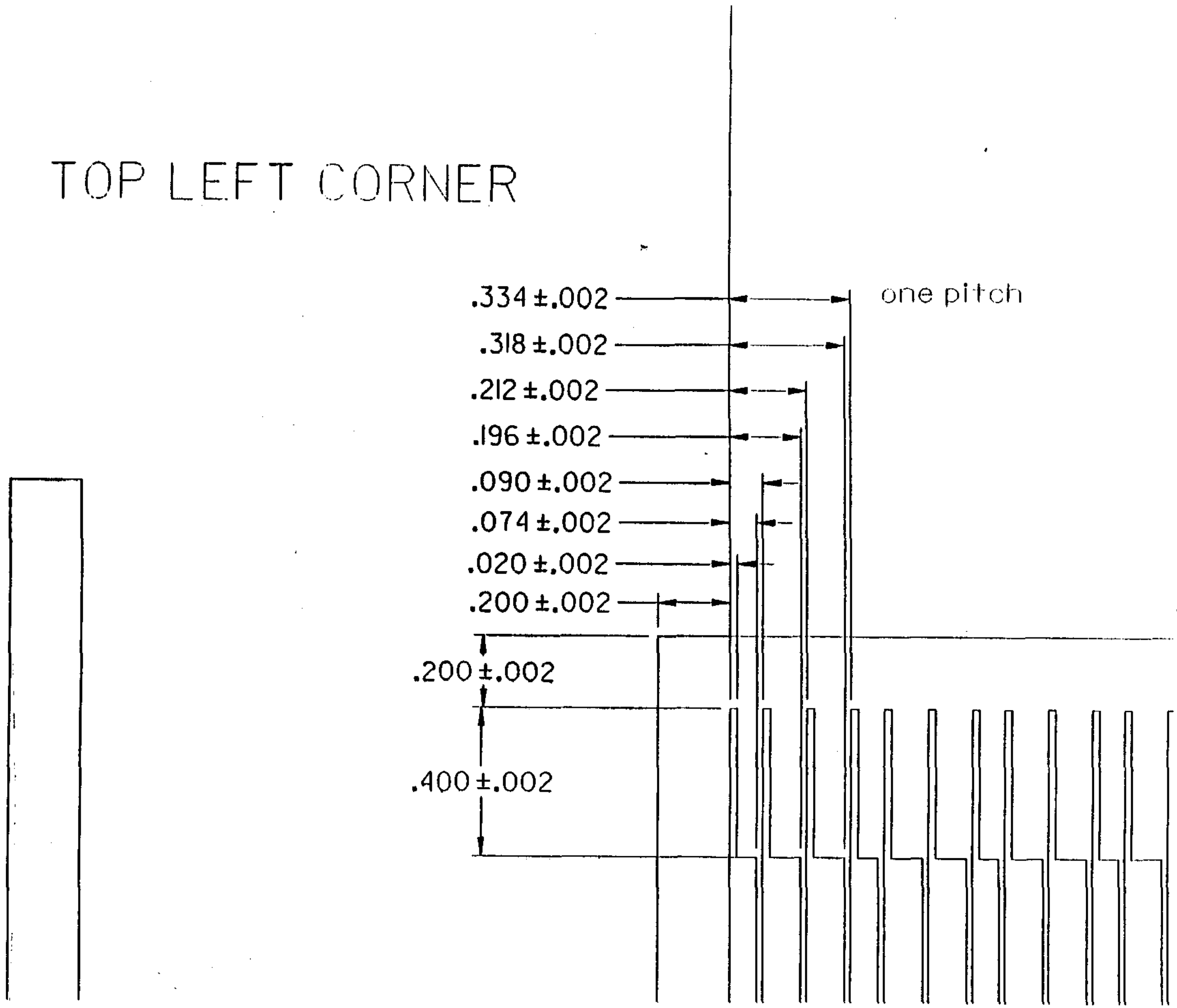
- Results of summer design effort
- Choose representative design features
- Complete design drawing package by Nov
- Manufacture components by anticipated mass prod
- First cut at "final" chamber building techniques
- Available for test by Feb, 94??

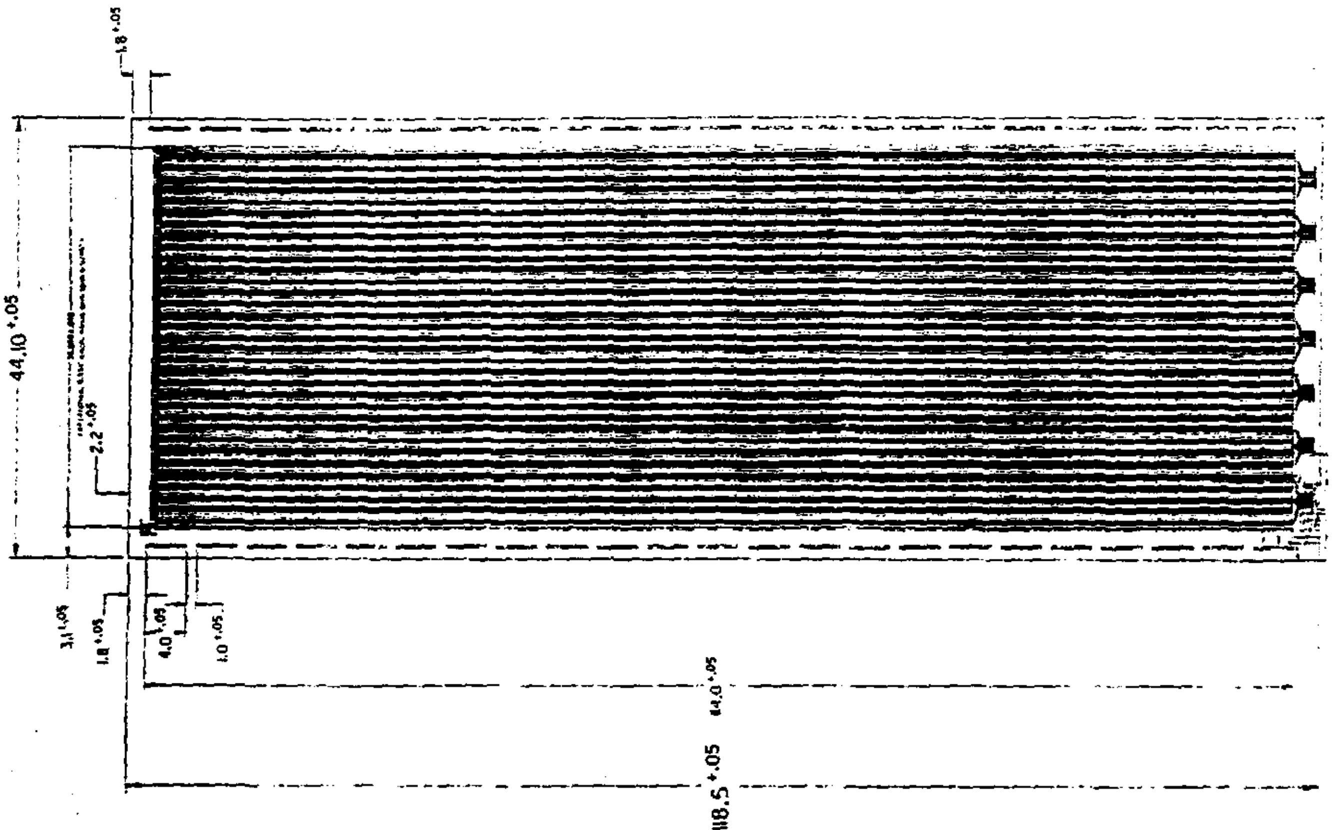





SEALING BAR
WIRE FIX. BAR
WIRES
SPACER
HV RESISTOR
HV
GAS LET / OUTLET
HONEY COMB FILLED BY EPOXY
SEALING
HONEY COMB

TOP LEFT CORNER





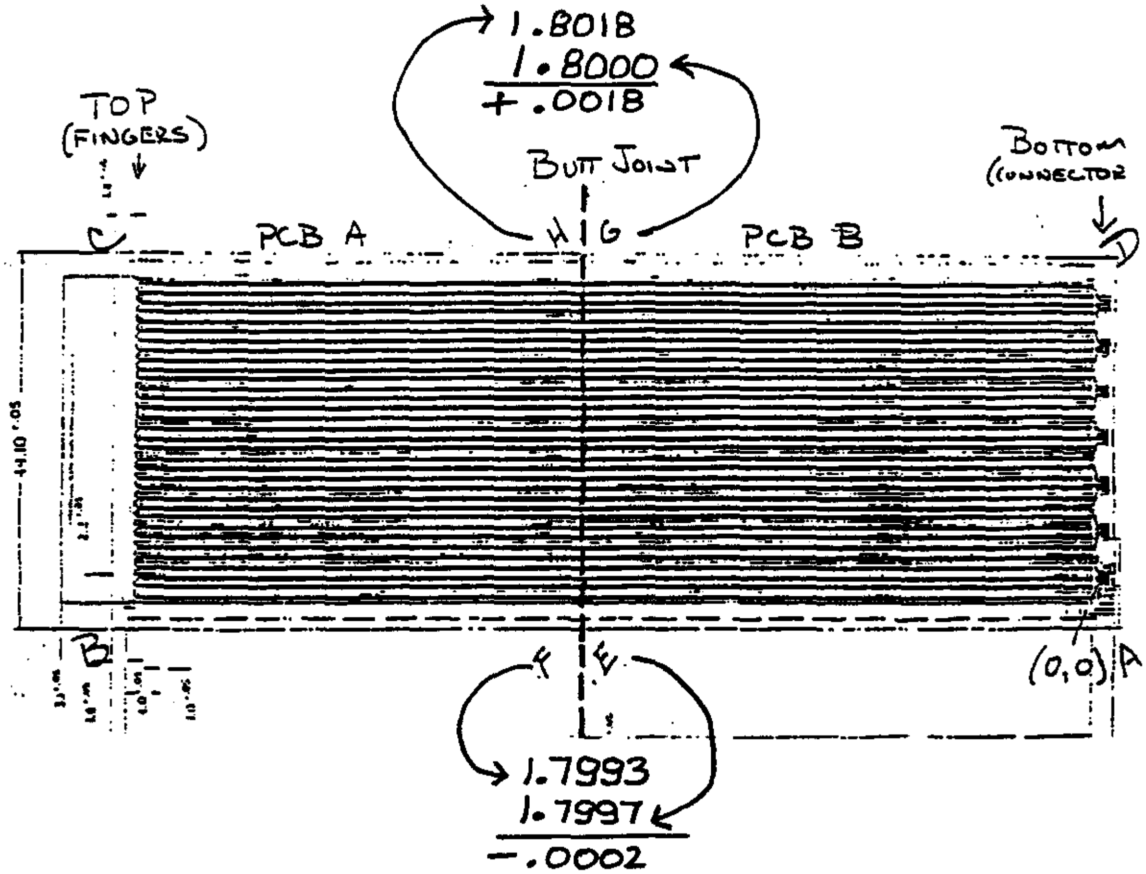
1.8 +.05
44.10 +.05
2.2 +.05
3.1 +.05
1.8 +.05
4.0 +.05
1.0 +.05
44.0 +.05
118.5 +.05

PROTOTYPES

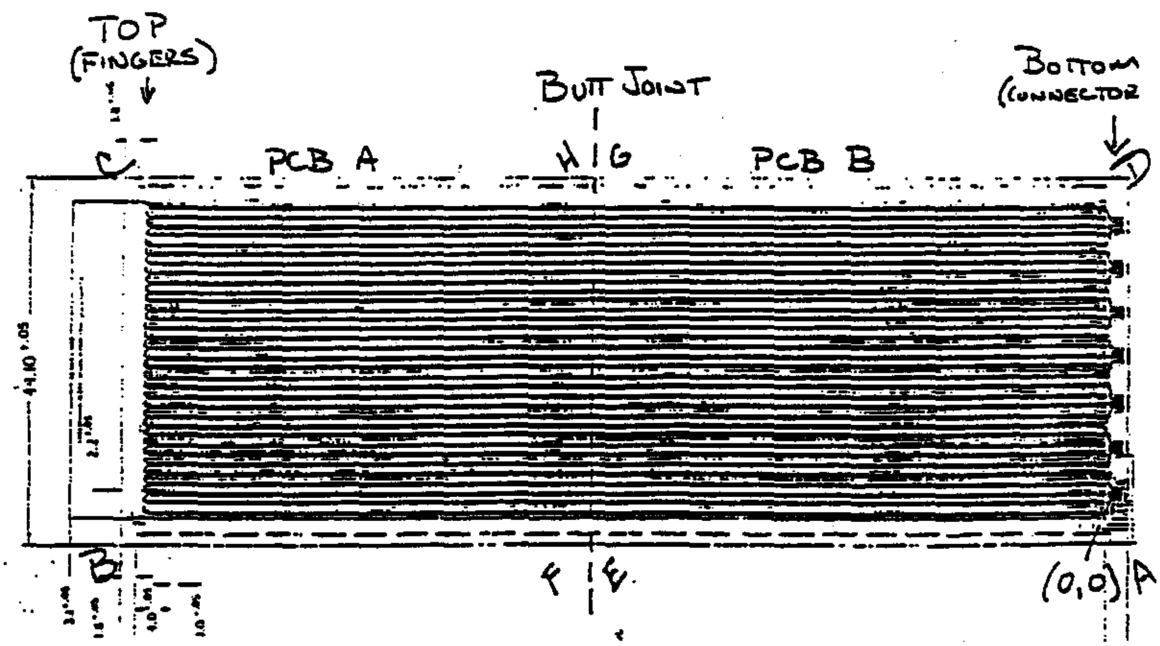
PROGRESS:

- Full sized, mid layer prototype
  3 x 1.1 m
  cathode strip boards manufactured, being measured
  other parts packaged for shipping
- Reduced material edge design prototypes
  BNL cast edge concept
  SSC minimization design
- Error transfer prototype
  LLNL design, test

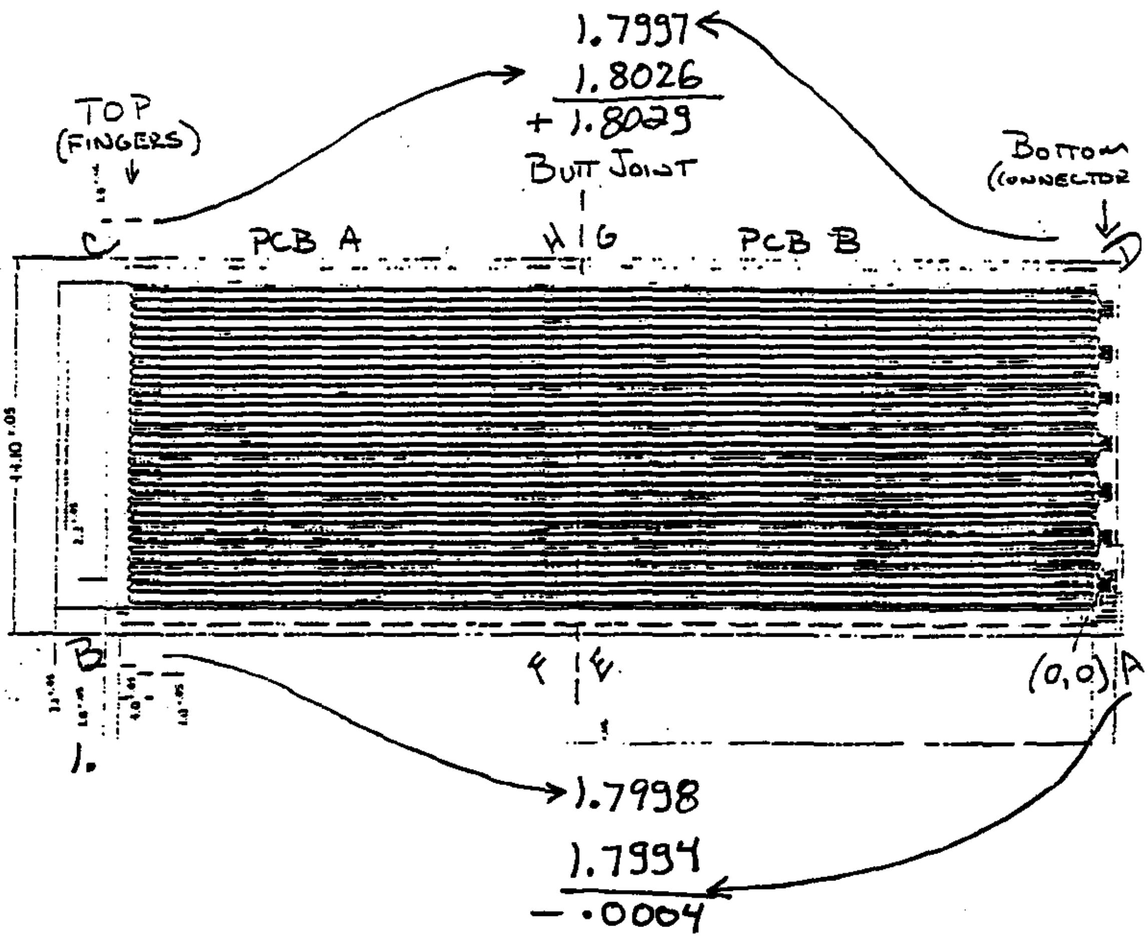
CCT


1.8018
1.8000
+.0018
TOP (FINGERS)
BUTT JOINT
BOTTOM (CONNECTOR
C
PCB A
H
G
PCB B
D
B
F
E
(0,0)
A
1.7993
1.7997
-.0002

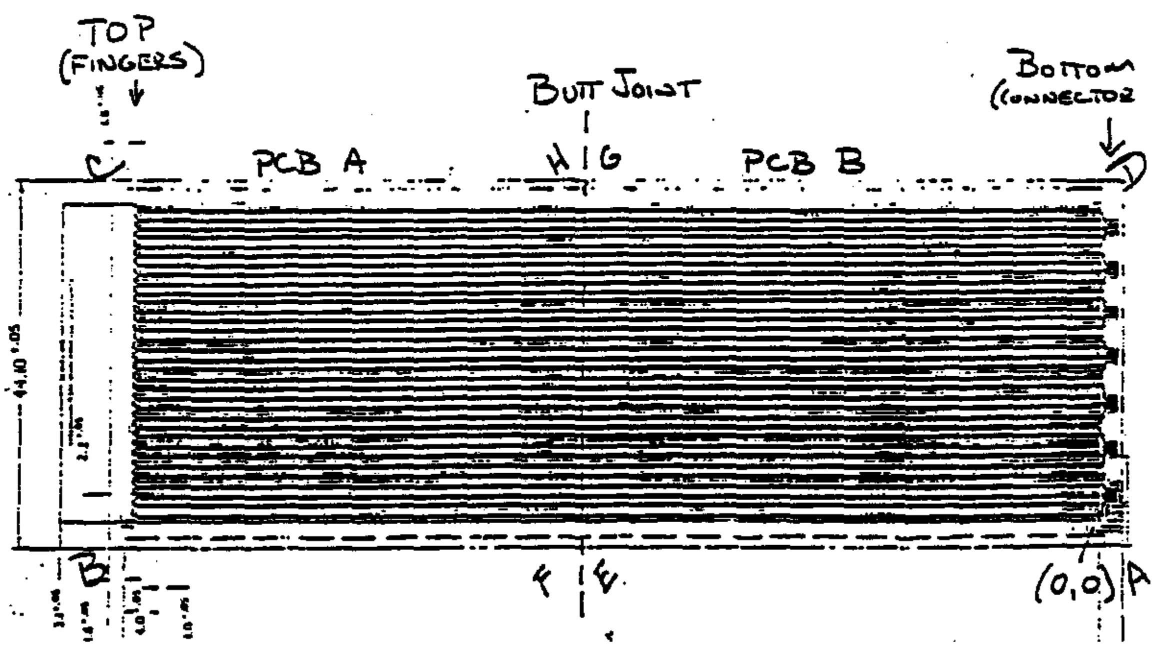
MIT

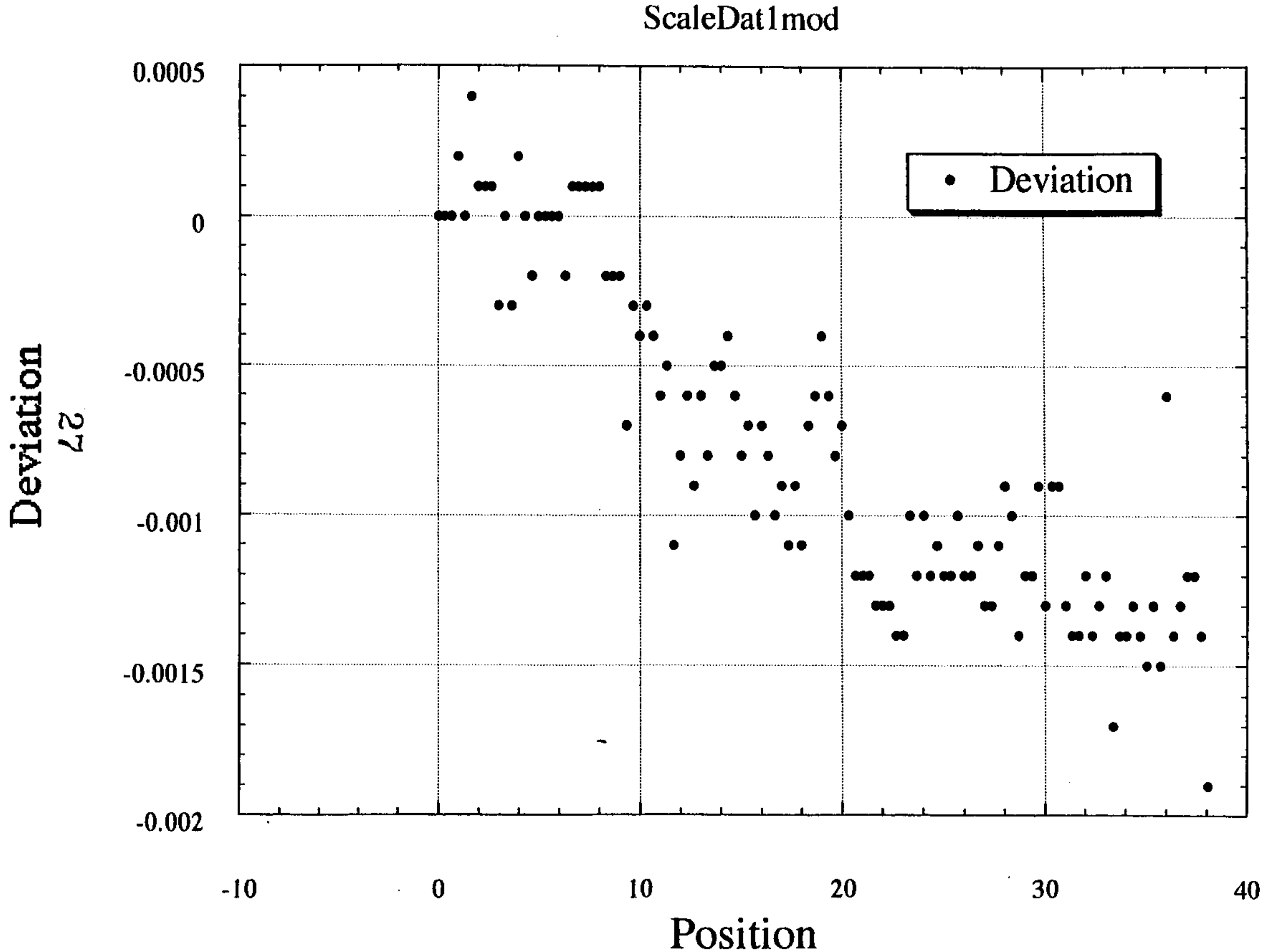

TOP (FINGERS)
BUTT JOINT
BOTTOM (CONNECTOR
C
PCB A
H
G
PCB B
D
B
F
E
(0,0)
A

CCT

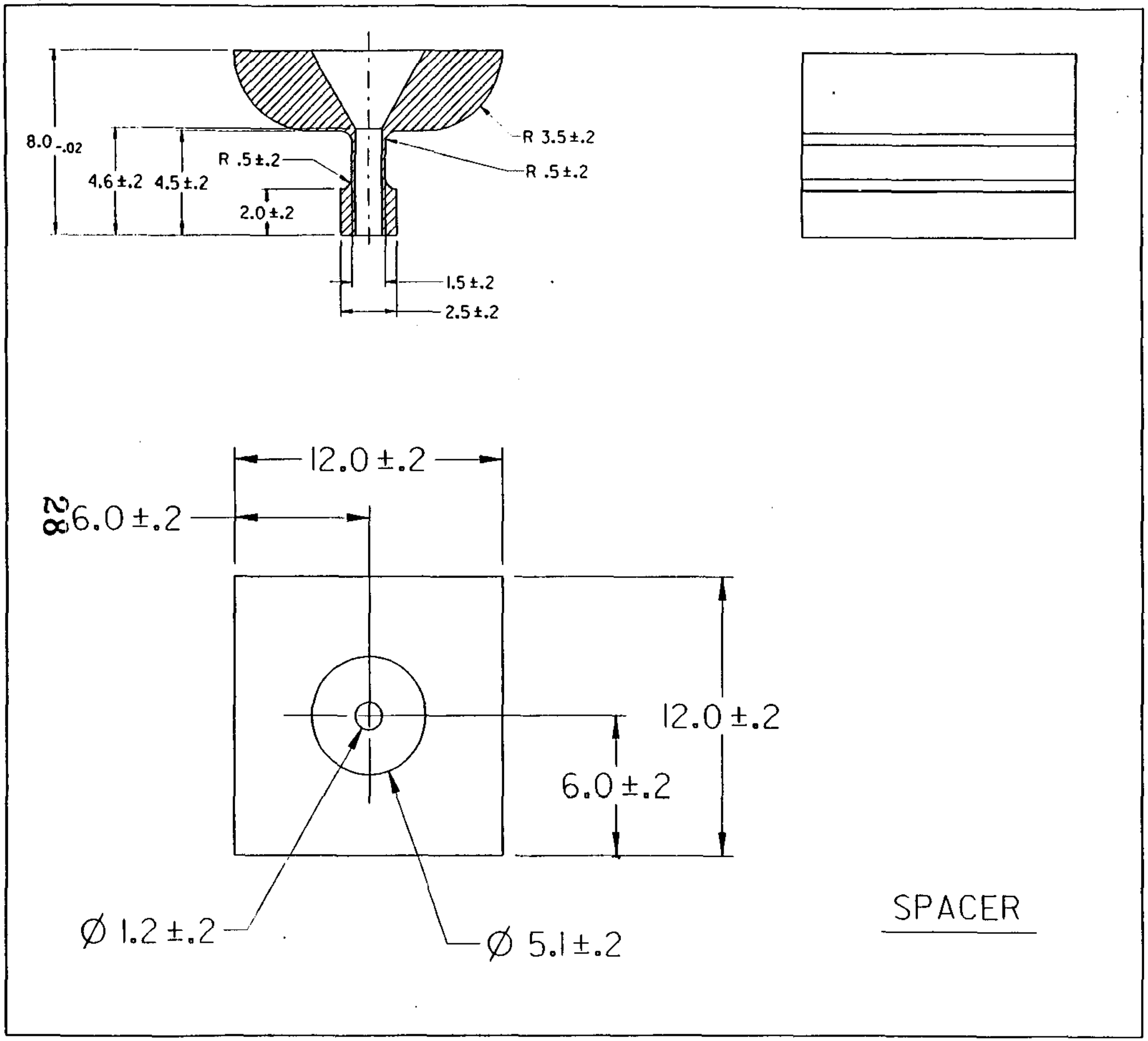

1.7997
1.8026
+ 1.8029
TOP
(FINGERS)
BUTT JOINT
BOTTOM
(CONNECTOR
C
PCB A
H | G
PCB B
D
B
F | E
(0,0) A
1.
1.7998
1.7994
− .0004

MIT

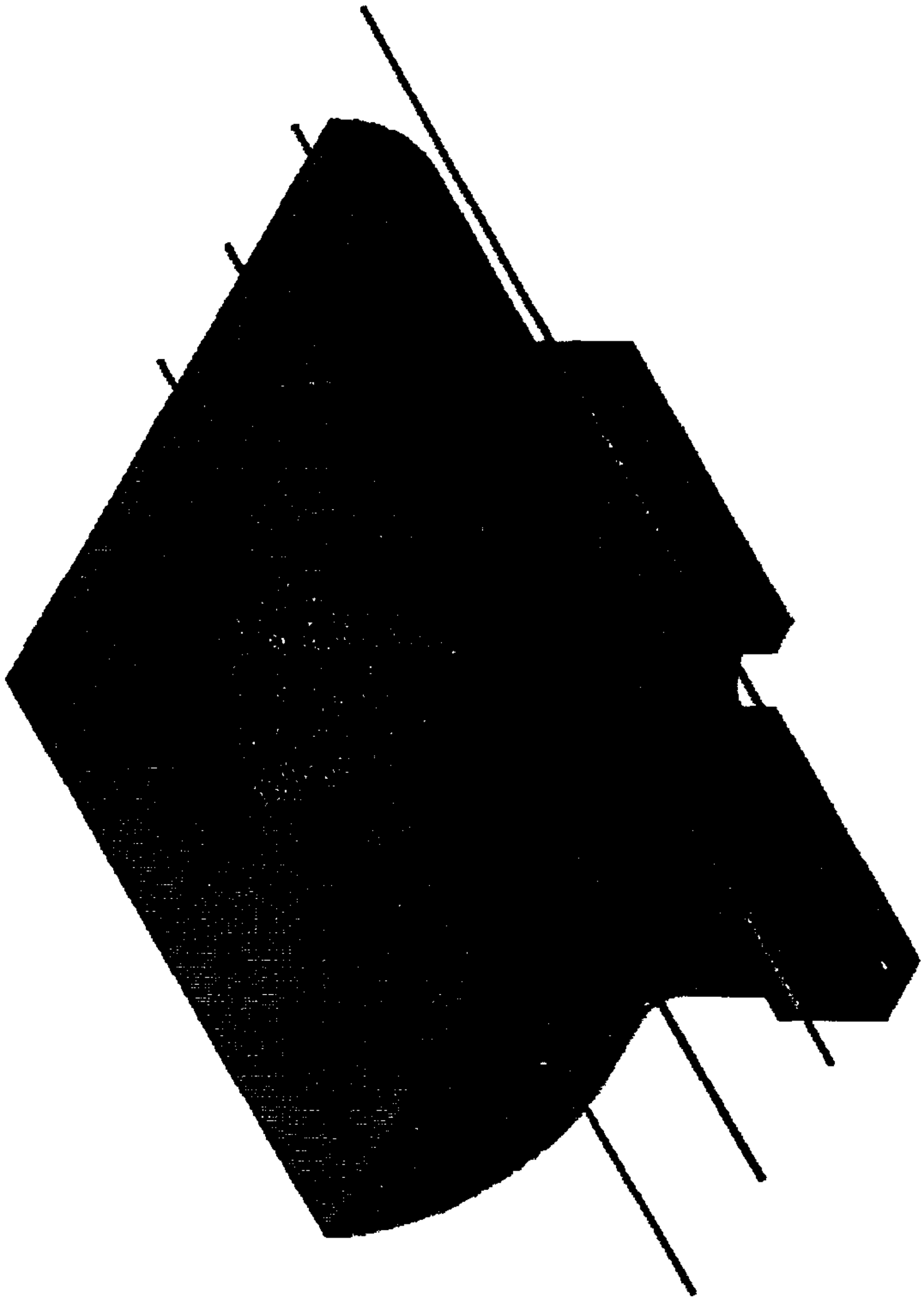

TOP
(FINGERS)
BUTT JOINT
BOTTOM
(CONNECTOR
C
PCB A
H | G
PCB B
D
B
F | E
(0,0) A


ScaleDat1mod
Deviation
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
-10
0
10
20
30
40
Position
Deviation

REC 6/21/93
Amoto

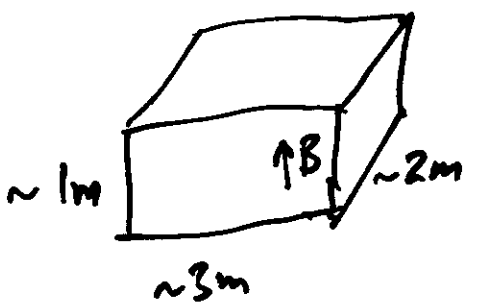


28



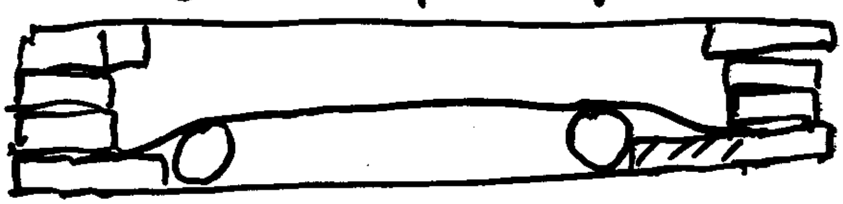
BNL Activities with ø money

1. Measure Lorentz effect in an Endcap configuration using the BNL MPS magnet and cosmic rays



10 kG
3 MW

2. Use small chambers to kludge 3d Superlayer geometry.



3 Repeat x-ray measurements now that we understand electronics better and have 10-bit FADC.

Polymer Concrete (PC)

Works just like concrete with Portland Cement. Properties are analogous to concrete, i.e. good compressive strength, poor tensile strength (unreinforced).

- Many different polymer resins
- Many aggregates

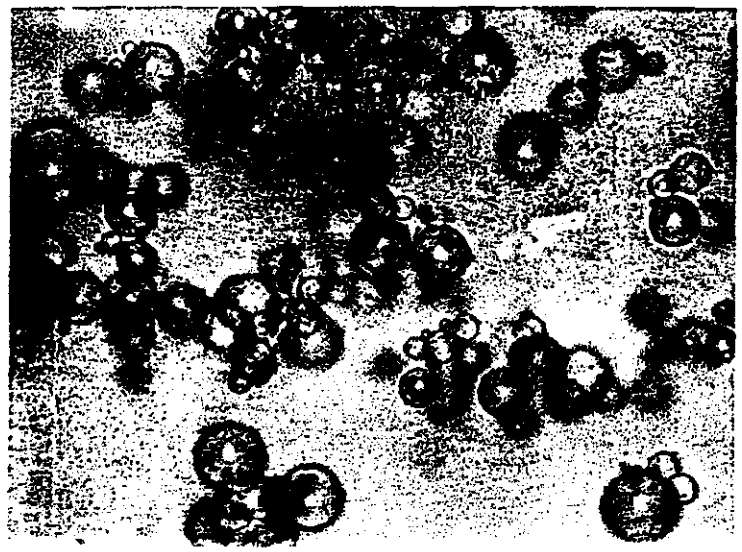
Selection depends on desired properties.

Usage of interest: PC for machine tool bases.
PC for machine tool bases used instead of cast iron.

- High stiffness to weight ratio
- Dimensional stability
- High vibration damping coefficient
- Low thermal conductivity
- Low production cost
- Minimum machining required after casting

In our case:

- Use hollow glass microspheres as a filler
- Density of 0.4 g/cm^3



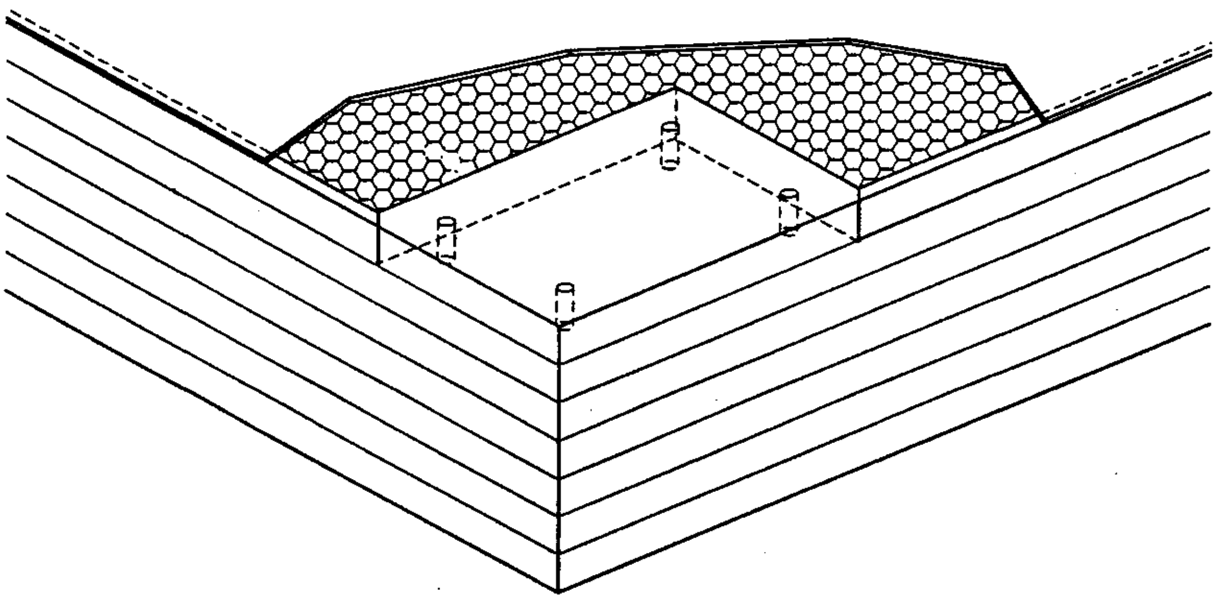
100μm

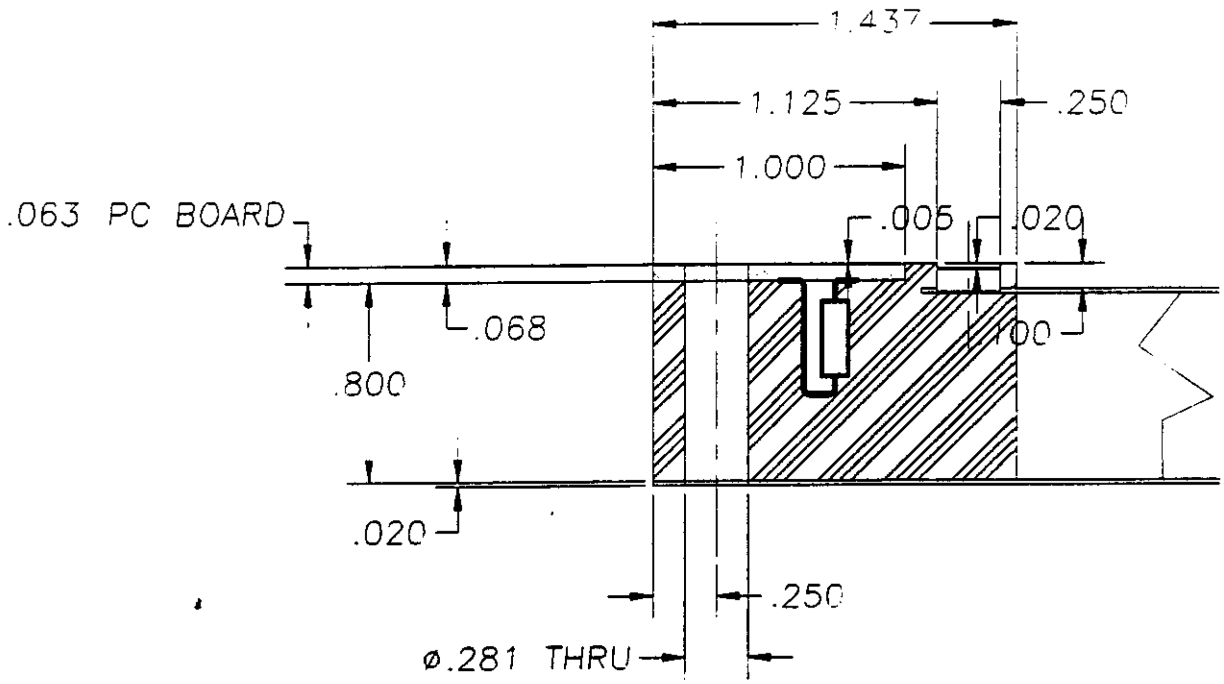
LIGHTWEIGHT PC TARGET FRAME SYSTEMS

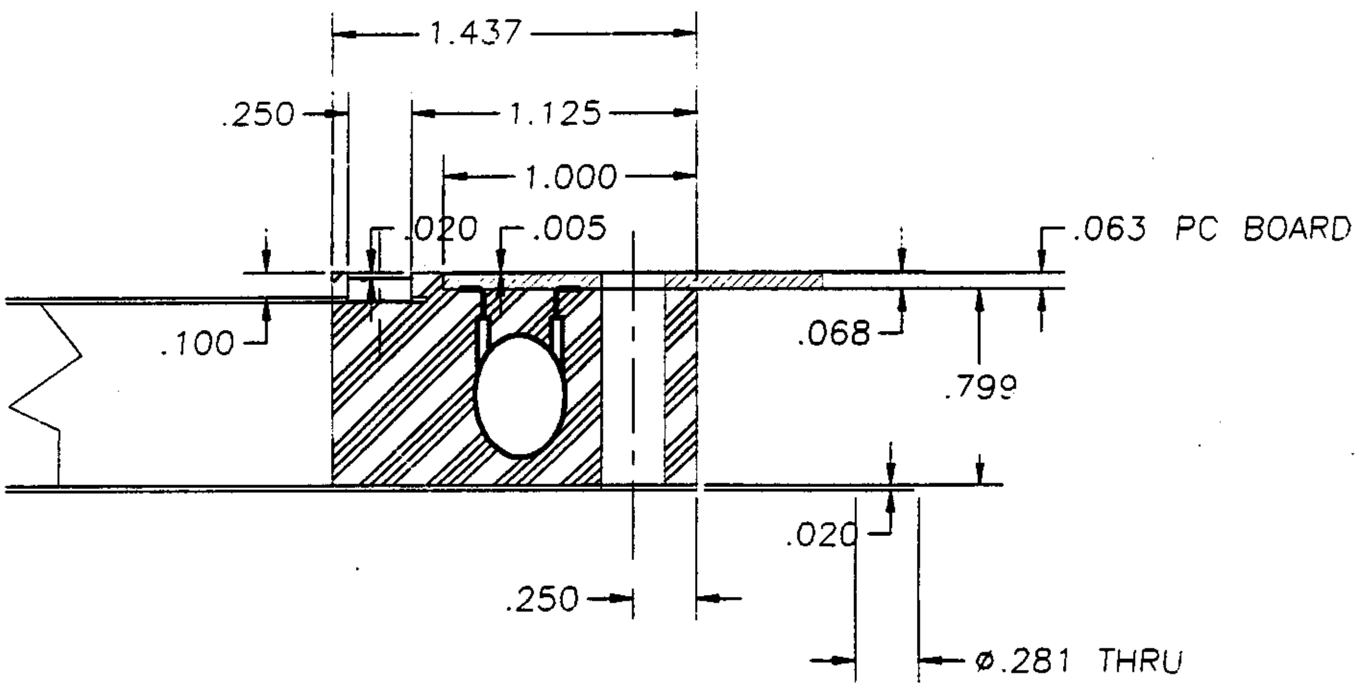
PROPERTY	SYSTEM	
	1	2
System Formulation, wt%:		
Resin	53	64
Hardener	9	10
Black	1	2
Glass spheres	37	24
Flexure Strength, psi	1225	--
Flexual Modulus of Elasticity, psi	139,500	--
Compressive Strength, psi	1755	3925
Young's Modulus, psi	98,395	142,700
Density, lb/cu ft	26.2 (0.42)	34.6 (0.55)

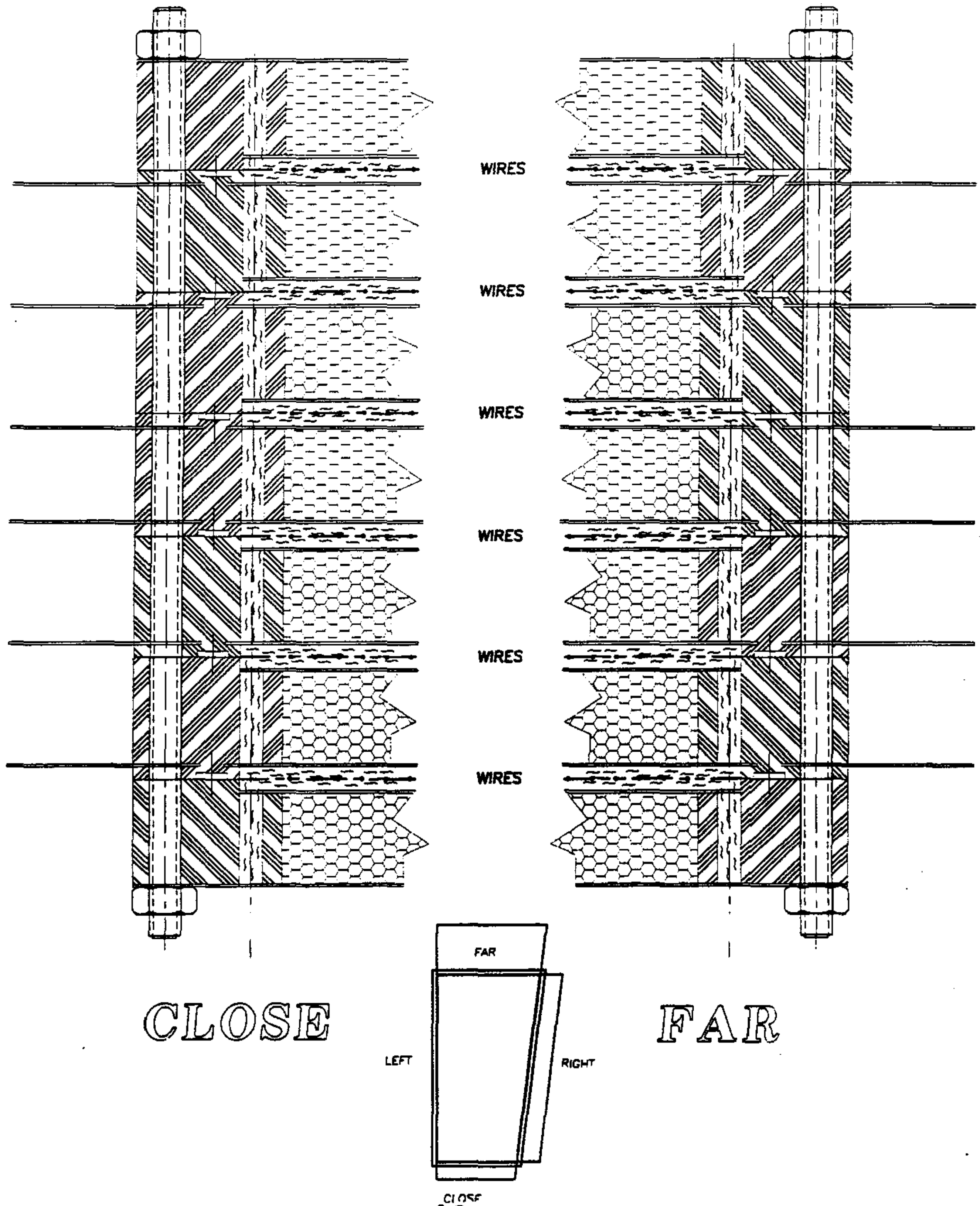
Desired Properties

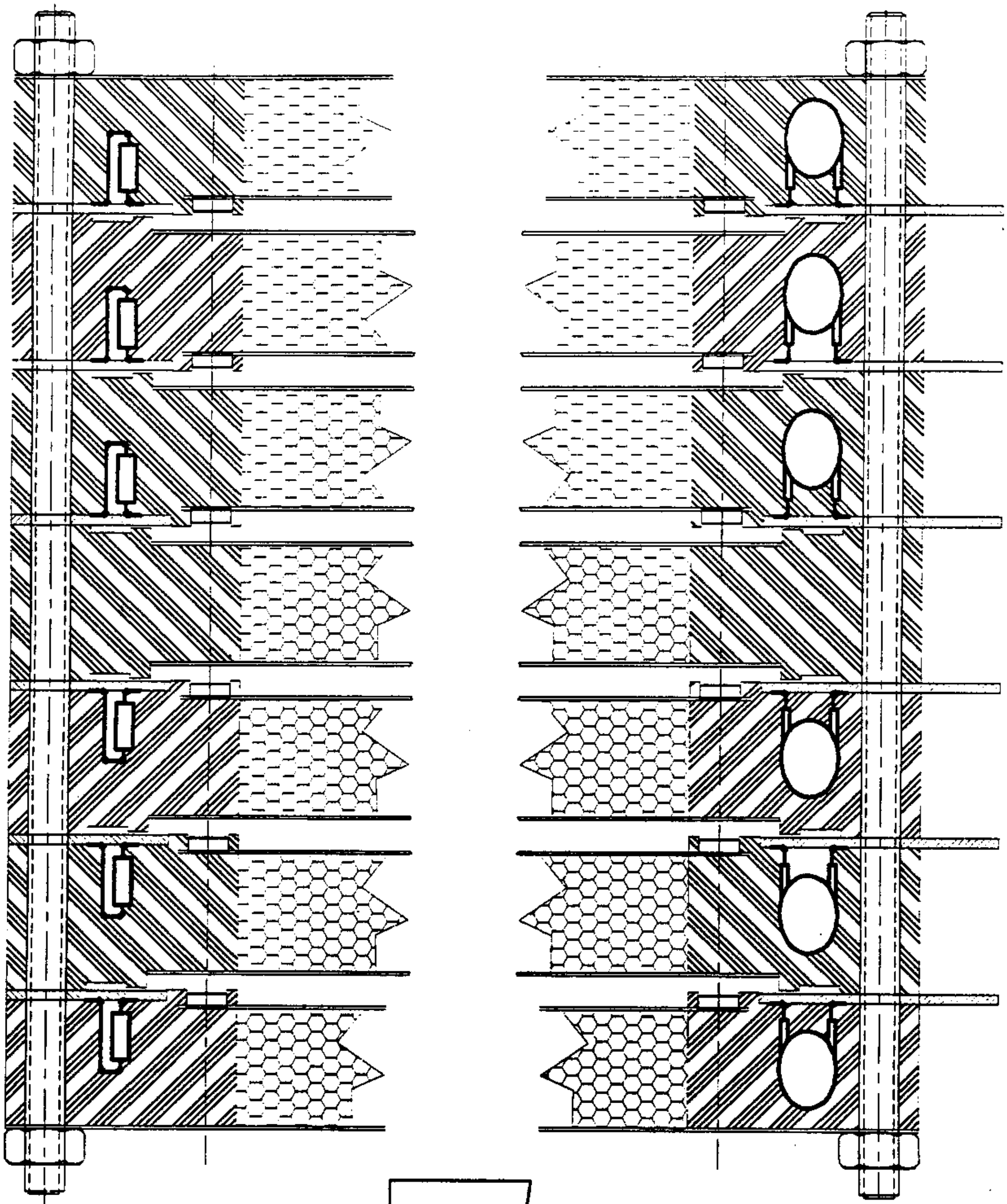
1. Low Density ($< 0.5gr/cm^3$)
2. Dimensional Stability
   - Low casting shrinkage ($< 0.05\%$)
   - Low creep
   - TAC 1–3 $10^{-5}in/in/C^\circ$
3. No outgassing
4. Resistant to water vapor absorption
5. Good adhesion to G10, Al, Cu
6. Low viscosity (possible to cast features ≈2.0mm)
7. Modulus of elasticity (¿5,000,000 psi)
8. Dielectric constant (<4)
9. Dielectric strngth
10. Vibration damping factor (¿0.003)



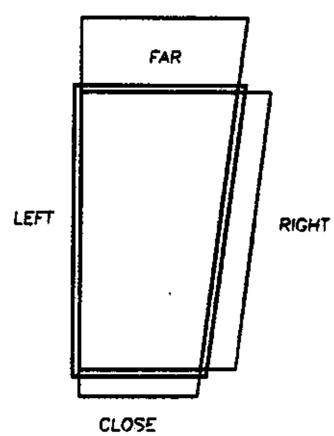

1.437
1.125
.250
1.000
.063 PC BOARD
.005
.020
.068
.100
.800
.020
.250
ø.281 THRU


1.437
.250
1.125
1.000
.020
.005
.063 PC BOARD
.100
.068
.799
.020
.250
ø.281 THRU

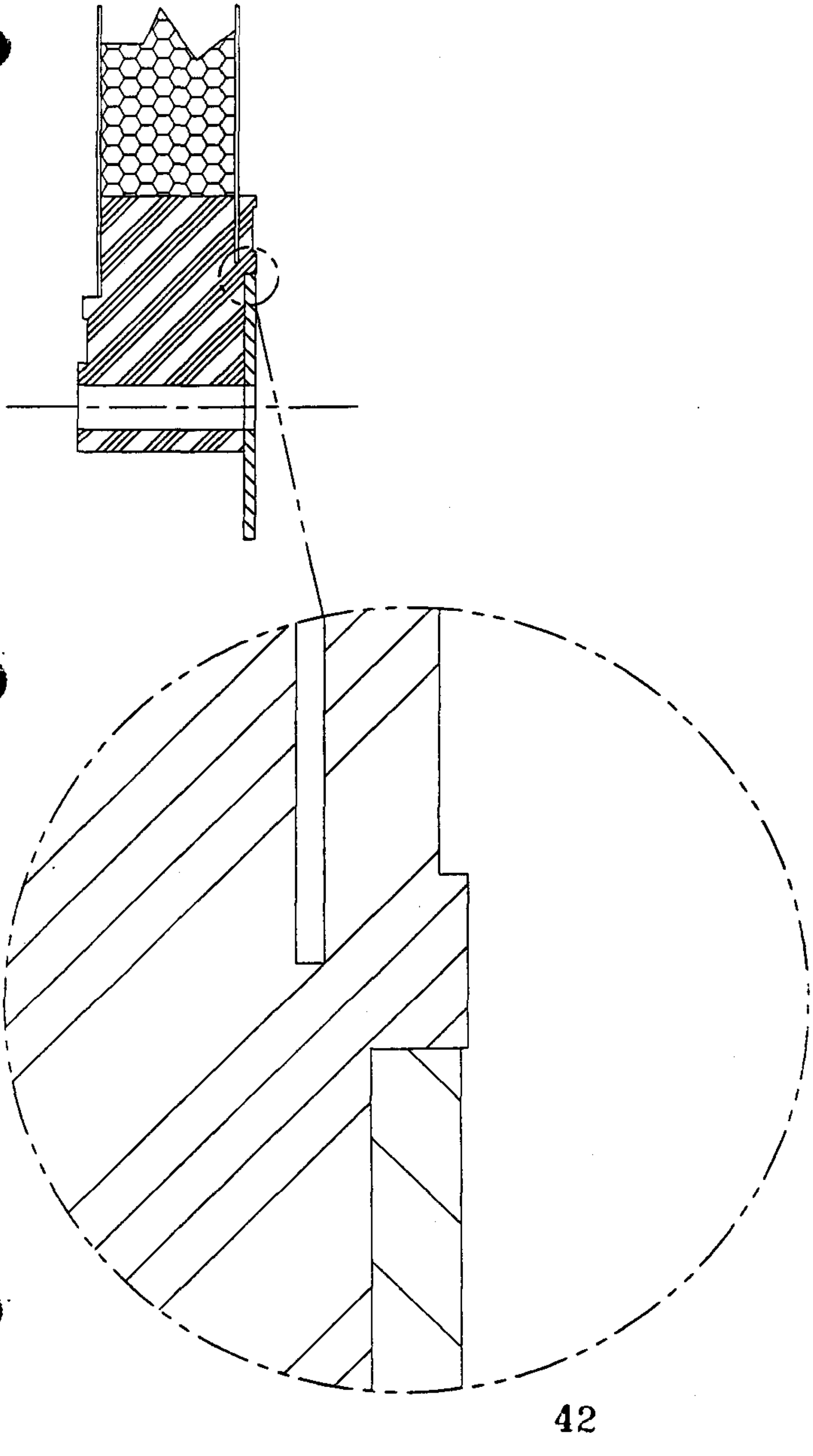

WIRES
WIRES
WIRES
WIRES
WIRES
WIRES
CLOSE
FAR
FAR
LEFT
RIGHT



LEFT



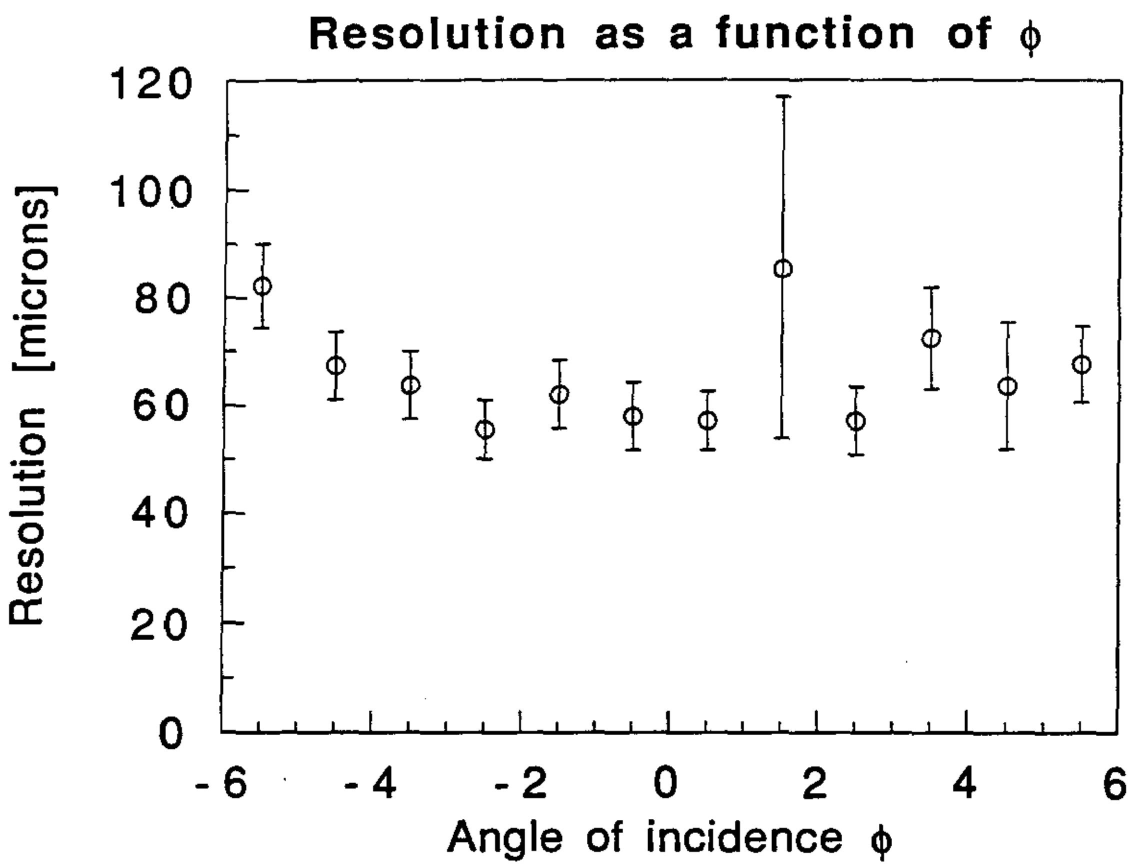
RIGHT

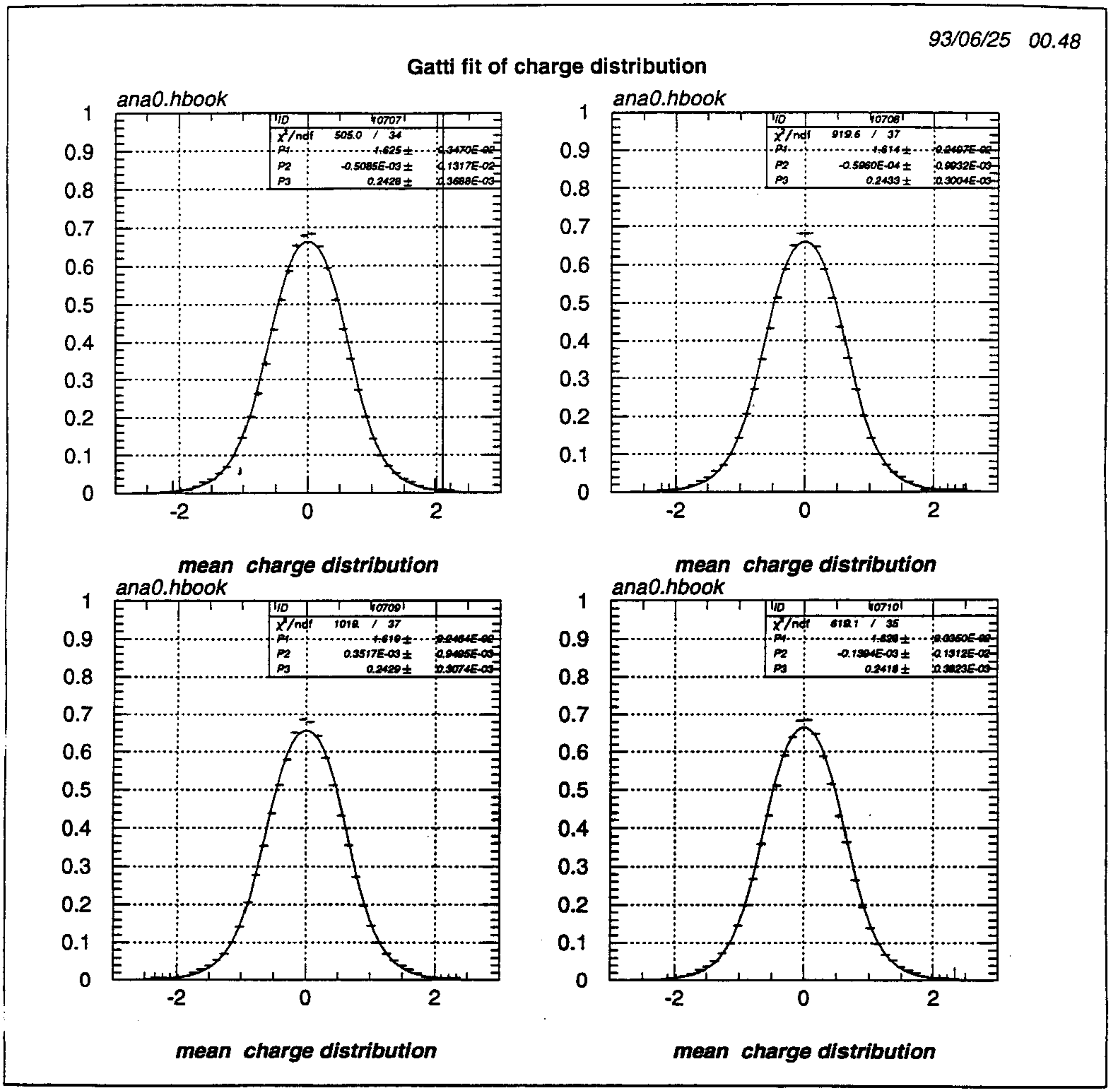


	SL1	SL2	SL3
Module Length L		257	
Module Width W		114	
Skin thickness G10		0.05	
Copper thickness		0.0017	
Frame thickness h		0.4	
Frame Width		6.5	
Panel thickness (epoxy)		2	
Width of epoxy		1.5	
Cross Section of Polymer		9.4072	
G10 boards for wire attachement xsection		0.4064	
Density of G10		1.7	
Density of copper		8.96	
Density of epoxy		1.3	
Density of Nomex Honeycomb		0.029	
Density of Polymer		0.4	

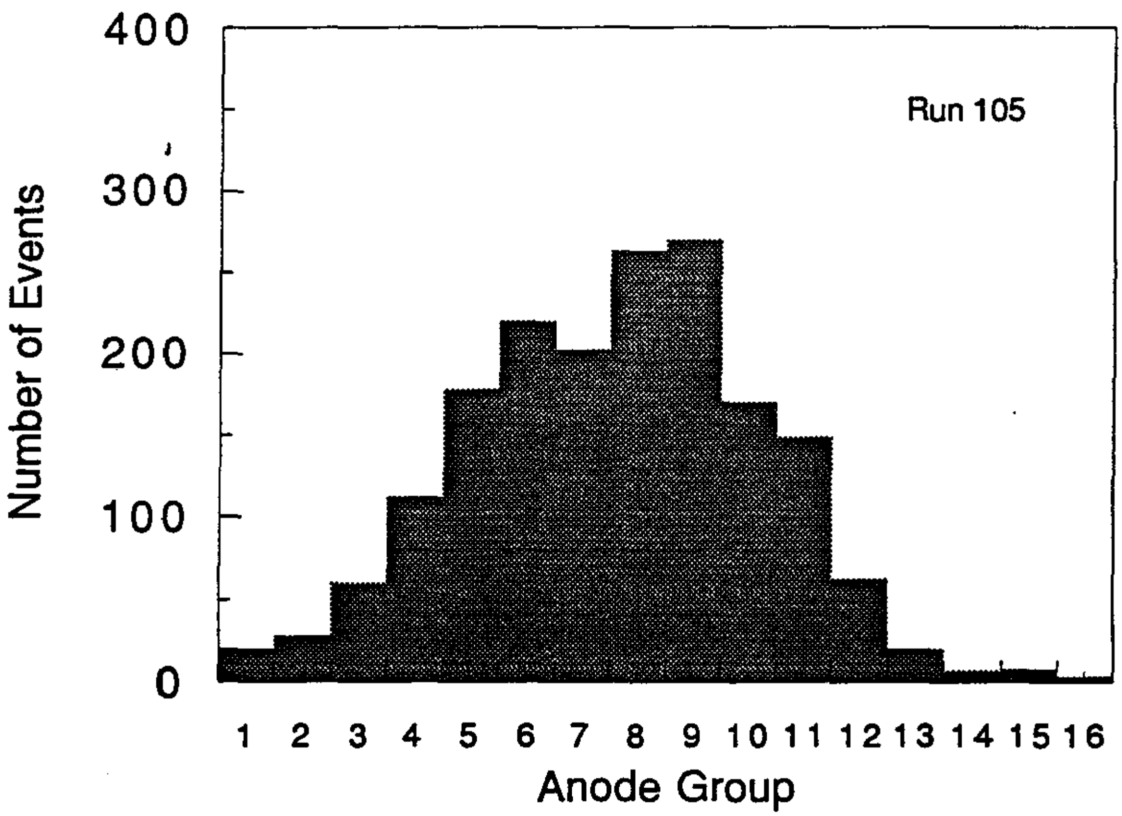
		Total weight	
		Current Design	Polymer Frames
Weight of Frame		29517	
Weight of Epoxy Border		20257	
Weight of Skins (G10)		34865	34865
Weight of Skins (Copper)		6248	6248
Weight of Honeycomb		11895	11895
Weight of G10 wire attachment boards			2131
Weight of Polymer Frame			19544
	Total	102781	~~53607~~ 74683
Frame weight reduced by	~~2.55~~ 0.43		
Total weight reduced by	~~1.94~~ 0.73		

Note: The weight of the the frame assumes that 25% of the volume is machined out


Resolution as a function of ϕ
Resolution [microns]
120
100
80
60
40
20
0
-6
-4
-2
0
2
4
6
Angle of incidence ϕ



93/06/25 00.48
Gatti fit of charge distribution
ana0.hbook
ID 10707
χ²/ndf 505.0 / 34
P1 1.625 ± 0.3470E-02
P2 -0.5085E-03 ± 0.1317E-02
P3 0.2428 ± 0.3688E-03
mean charge distribution
ana0.hbook
ID 10708
χ²/ndf 919.6 / 37
P1 1.614 ± 0.2407E-02
P2 -0.5960E-04 ± 0.9932E-03
P3 0.2433 ± 0.3004E-03
mean charge distribution
ana0.hbook
ID 10709
χ²/ndf 1019. / 37
P2 0.3517E-03 ± 0.9495E-03
P3 0.2429 ± 0.3074E-03
mean charge distribution
ana0.hbook
ID 10710
χ²/ndf 619.1 / 35
P3 0.2418 ± 0.3823E-03
mean charge distribution



400
300
200
100
0
Number of Events
Run 105
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Anode Group

What is the next step(s)

1. Continue experimenting with different polymer to filler mixing ratios to achieve stiffest possible PC while maintaining the low density.
2. Produce a $2 \times 4 ft^2$ panel to study potential problems in the casting process and study the mechanical properties of the panel.
3. If [2] successful then proceed to make panels to be used for the construction of a prototype module with real dimensions (e.g. inner endcap)

LLNL Engineering Activities to the End of FY93

Optimize Chamber/Support Structure Interface

- Kinematic mounts
- Quarter point chamber supports vs. end supports
- Endcap chamber support (radial merging or alternatives)
- Resolve alignment requirements w.r.t. minimized actuator deployment

Alignment Test Stand

51

- Obtain "go ahead" to proceed with project and finalize schedule
  - Basic preparations for facility are complete at LLNL
  - Identify interface requirements and plans for eventual move to SSCL
- Preliminary Design Review to be scheduled in July
  - Design and drafting are proceeding
  - Procurement and fabrication need approval from GEM management

"Wire Positioning Machine" Proposal to be circulated in July

LLNL Engineering Activities (cont.)

Participation in Muon Chamber Workshop

- Verify intra-chamber alignment scheme
  - Fiducial transfer "steps" from cathode strips to chamber assembly
  - Fiducial transfer from chamber assembly to projective alignment components
  - Develop statistics for accuracies obtained during each transfer
  - Investigate alternate transfer techniques as warranted
- Prepare "CSC Structural Design Bible" draft for circulation (early July)
- Resolve chamber over-pressure design issues (specification)
- Provide general engineering and analysis support during workshop
- Fabricate models of concepts as necessary
- Develop "CSC Process Bible" during workshop
  - Refine process steps, assembly techniques, testing, and QA/QC requirements
  - Follow-up with "CSC Prototype Factory Proposal"

CSC Structural Design Bible

OBJECTIVE: A design guide for optimizing the CSC structure

- Summary of the "major players" in the CSC structural assembly and relative importance of each component in the overall structural design (stiffness and other mechanical properties)
- Detailed analysis and parameter studies are included in appendices
- Trade-offs of geometry and material selection vs. effect on chamber sag
- "Rule of thumb" equations describing relations between chamber sag, stress, etc. vs. various geometry, environment, or material property parameters (where possible)

CSC Structural Design Bible (cont.)

Contents

- CSC Structural Components and Effects on Chamber Mechanical Properties

  a) Honeycomb panel (geometry and materials)
  - Skin (G-10 composite with Cu cathode strips)
  - Core
  - Edge fillers/inserts
  - Adhesives and assembly/bonding techniques
  - Composite assembly

  b) Gap frame (geometry and materials)

  c) Chamber Assembly
  - "Shear link" between panels
  - Bolted or glued interfaces between panels
  - Chamber support attachment points

  d) General considerations
  - Designing with composites
  - Designing for creep
  - Stability of materials
  - "Shear" lag

CSC Structural Design Bible (cont.)

- Manufacturing and other practical considerations

  a) Cathode strip panel faces (G-10 "skins")

  b) ...

- Baseline Design description
  - List of the assumptions used in the analyses (geometry and material properties)
  - To be updated with the new baseline design at the end of the workshop

- Appendices
  - Detailed analyses
  - Parameter studies

Additional analyses are being prepared

- Optimum bolt pattern and sizing around perimeter of chamber
- Alternate methods of stiffening chamber (external)
- Chamber support attachment points
- "Shear lag" effects on modeling assumptions

Prepare "Mechanical Properties Test Plan" to verify analyses

An Integrated 3D Muon System Model is Needed

A self-consistent, 3D CAD model of the Muon Subsystem must be used as the basis for configuration control and physics performance optimization.

- Includes support structure, chambers, chamber interface, alignment system components and lines-of-site, and eventually utilities and services.
- Manufacturing drawings and other 2D representations are "extracted" from the 3D model and linked to the model database. This allows automatic updating of 2D drawings when the model changes.
- Used as an aid to laying out utilities and services and can reduce the use of expensive mockups.
- Analysis models are dependent on data from the 3D CAD model.
- Multiple, "un-linked" software packages result in multiple versions of the same design - *poor configuration control leads to confusion!*
    - Built in inertia against design changes (even if driven by physics)
    - Less efficient; slow turn around for a design evaluation means fewer complete evaluations and uncertainty if design is optimum
    - Slow evaluation of "radical" ideas (brainstorming discouraged)
    - Fiscal pressures encourage premature defense of a design

Integrated 3D Muon System Model (cont.)

Integrated modeling of the Muon Subsystem must be used as the basis for physics performance optimization.

- GEANT geometry should include support structure, chambers, chamber interface, alignment system components and lines-of-site, and eventually utilities and services.

  – "extracted" from the 3D model and linked to the GEANT model.

- In its recent review of the GEM TDR, the Program Advisory Committee emphasized the importance of establishing strong links between hardware design and physics performance studies.

- Close linkage can be achieved through the interaction of the Muon Group physics team, in close communication with the broader physics group, with the muon design and engineering effort.

- Close coupling between hardware engineering and physics modeling provides rapid feedback on the physics impact of design modifications and is essential to producing an optimized detector design.

Status Report on Muon System Activities at Boston University

Scott Whitaker

SSCL
29 June 1993

I. Electronics

- Anode readout electronics for next prototypes
- HV monitoring / current measuring

II. Temperature and humidity effects on FR4/hexcell laminations

III. Angled-wire test chamber with variable wire/strip angle

- Being designed

IV. RD5 activities

- Results from last summer's tests
- Plans for September run

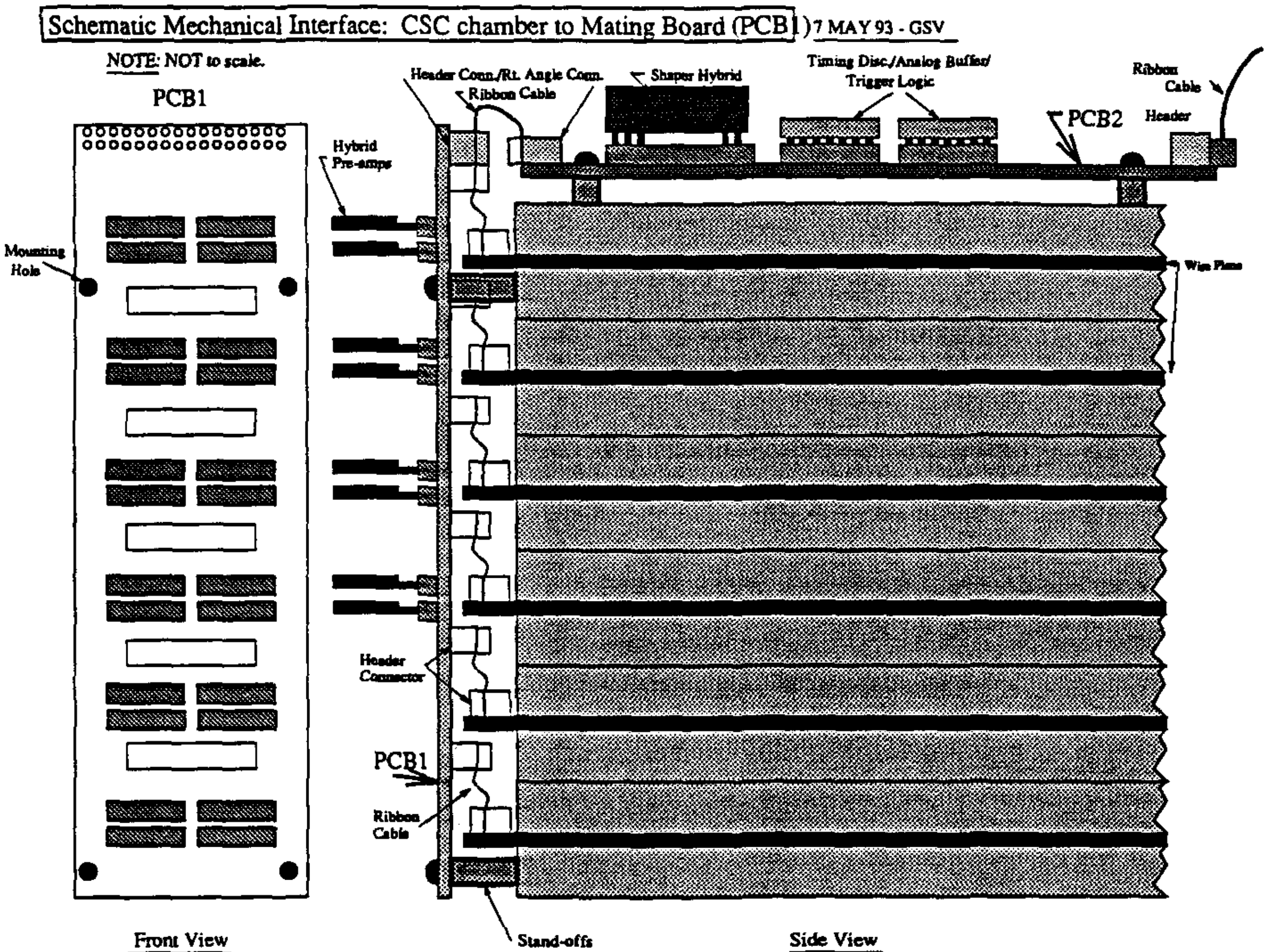


Figure 2: Mechanical Interface Diagram. Side view shows explicitly the flexible interconnection of the ribbon cable between CSC anode tongues and the pre-amp/interface board (PCB1). For specific dimensions of PCB1 and PCB2, see figures 4 and 5.

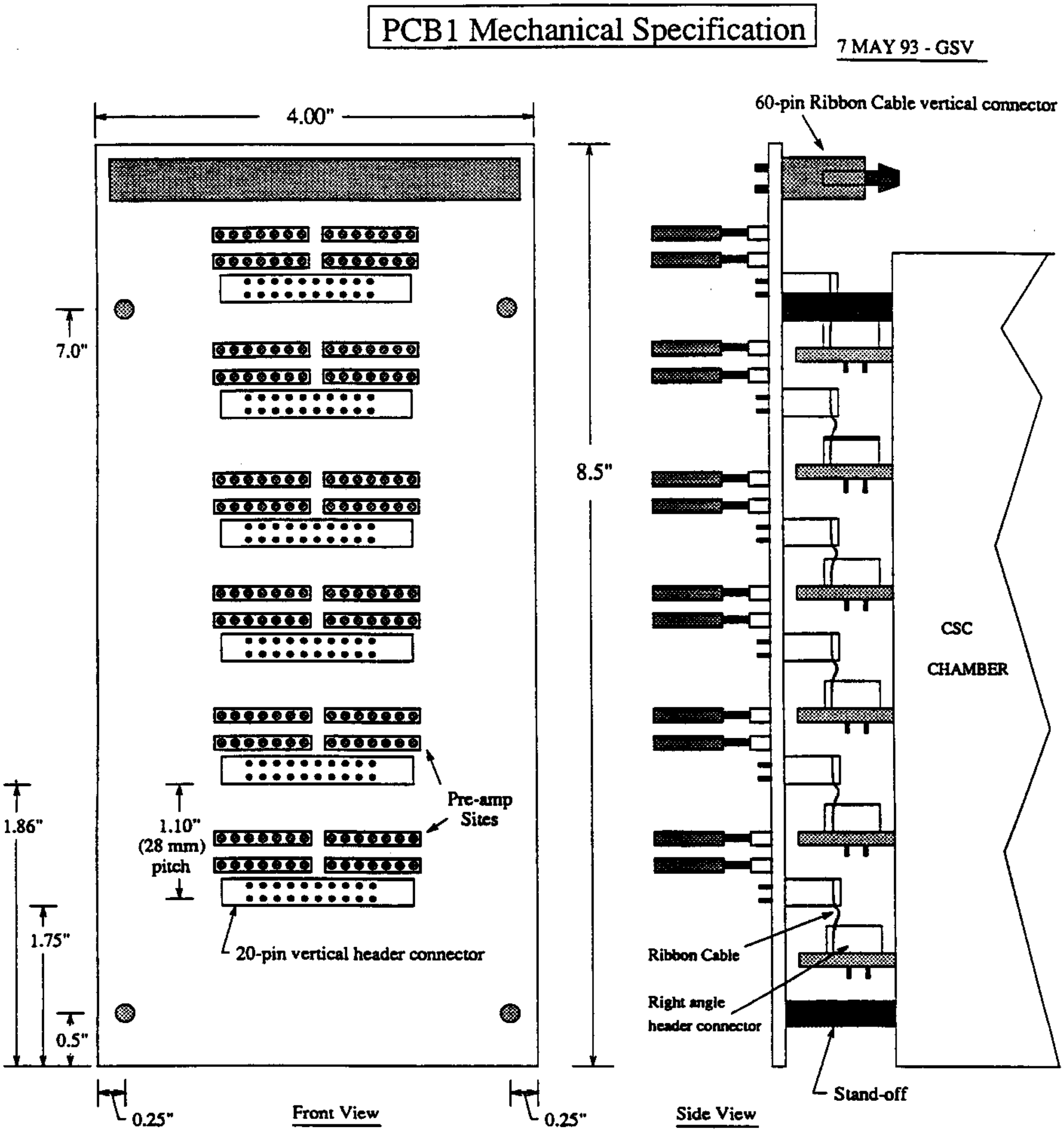


Figure 4: Mechanical dimensions and preliminary component placement for PCB1. Note that filter and bypass capacitors are supressed for clarity,

Anode Electronics Delivery Schedule

as of 1 June 93

Item	Allocated Time	Completion Date
PCB1 Design Review	1 day	1 JUN
PCB1 Layout	1.5 weeks	16 JUN
PCB2 Design Finalization	2 weeks	21 JUN
PCB2 Prototype Layout	2 weeks	2 JUL
PCB1 and PCB2 Delivery	4/1 weeks	12 JUL
PCB1 and PCB2 Testing	1 week	19 JUL
Update schematics/layout	1 week	26 JUL
Receive Production Boards	2 weeks	9 AUG
Prod. Proto. and Test	1 week	16 AUG
Prod. Assembly and Test *	3 weeks	3 SEP

* This assumes in-house assembly. Faster (1 or 2 weeks) with outside assembly.

NOTE: This schedule assumes 3 weeks dedicated technician/engr layout time. Individual items represent "good" guesses at their completion time, the cumulative date represents the cumulative error in the estimates.

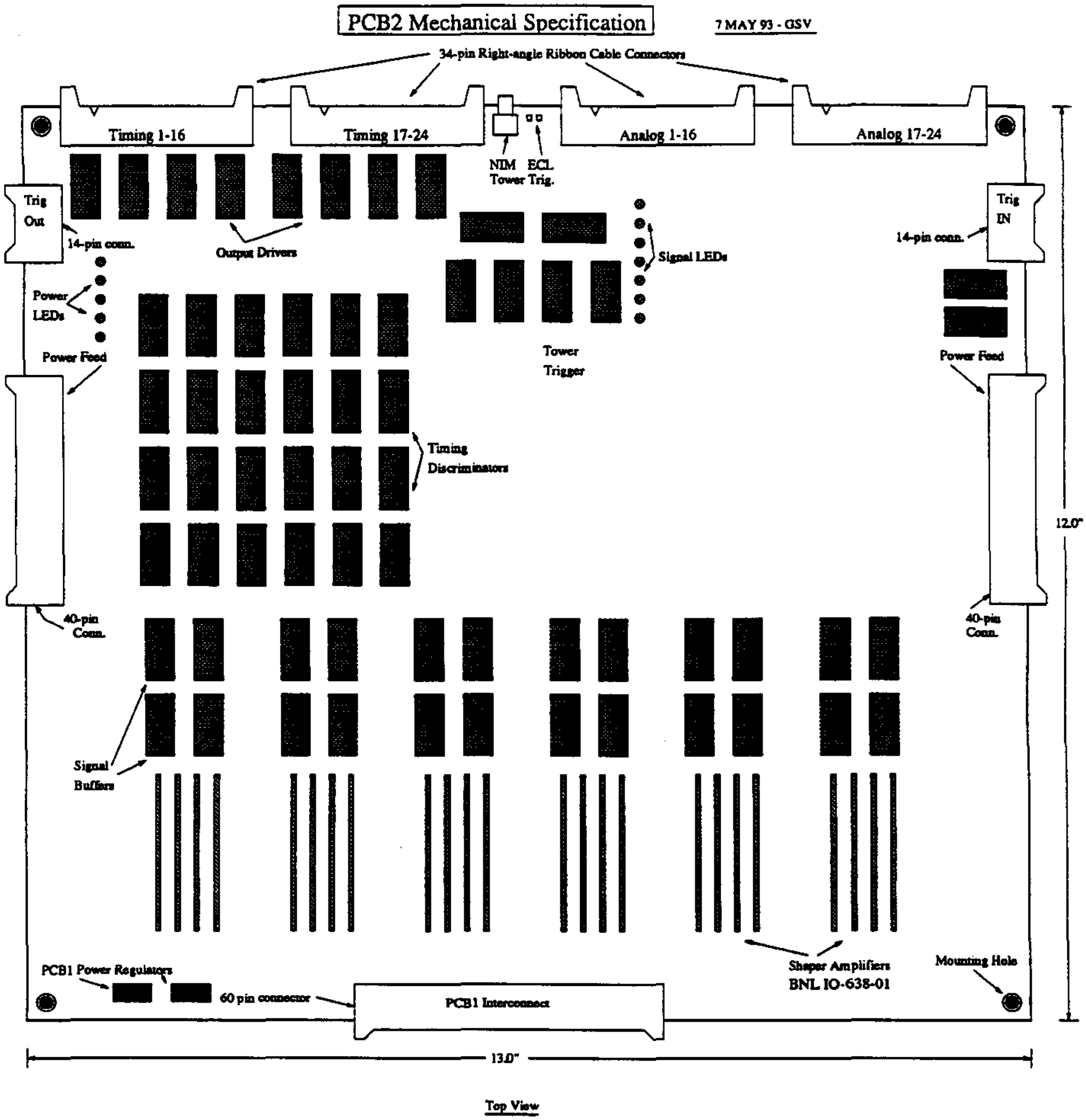
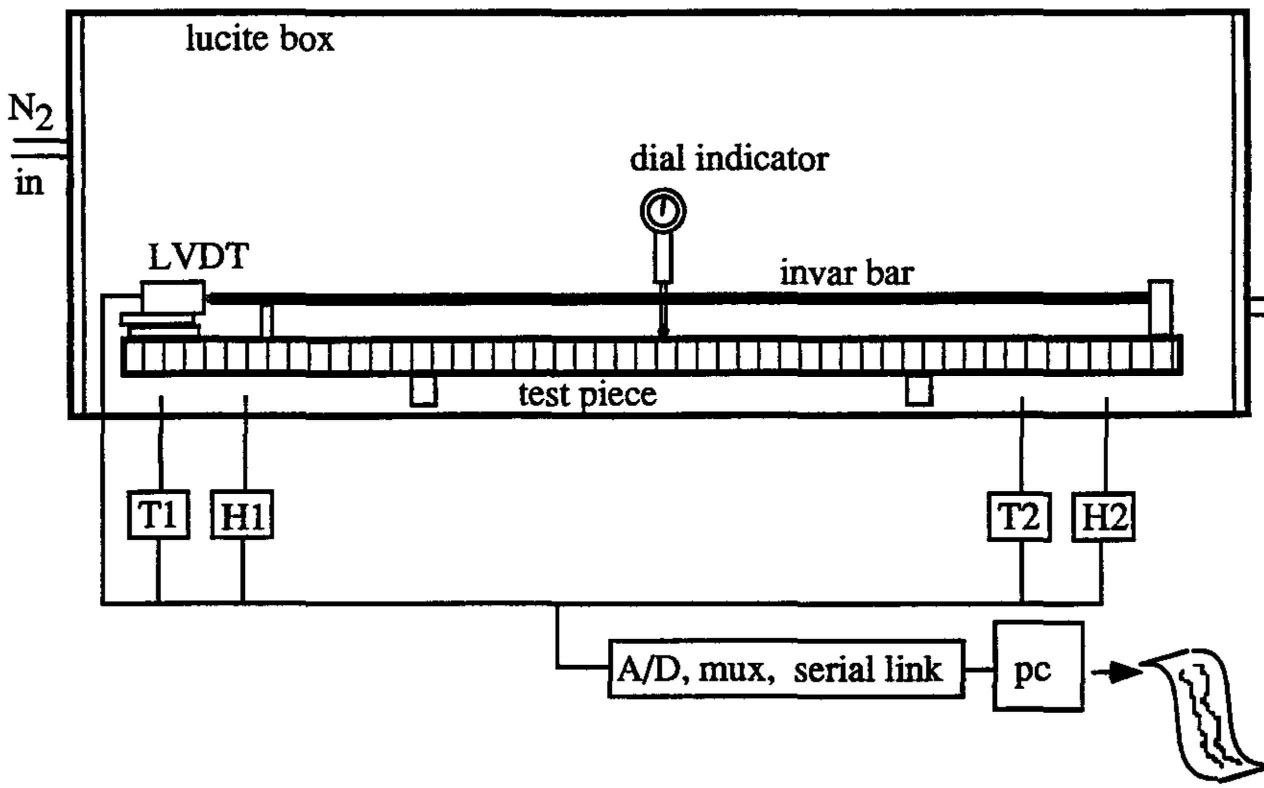


Figure 5: Mechanical dimensions and preliminary component placement for PCB2. Note that bypass caps, filter caps, resistors, and heatsinks are supressed for clarity.

Environmental Test Chamber

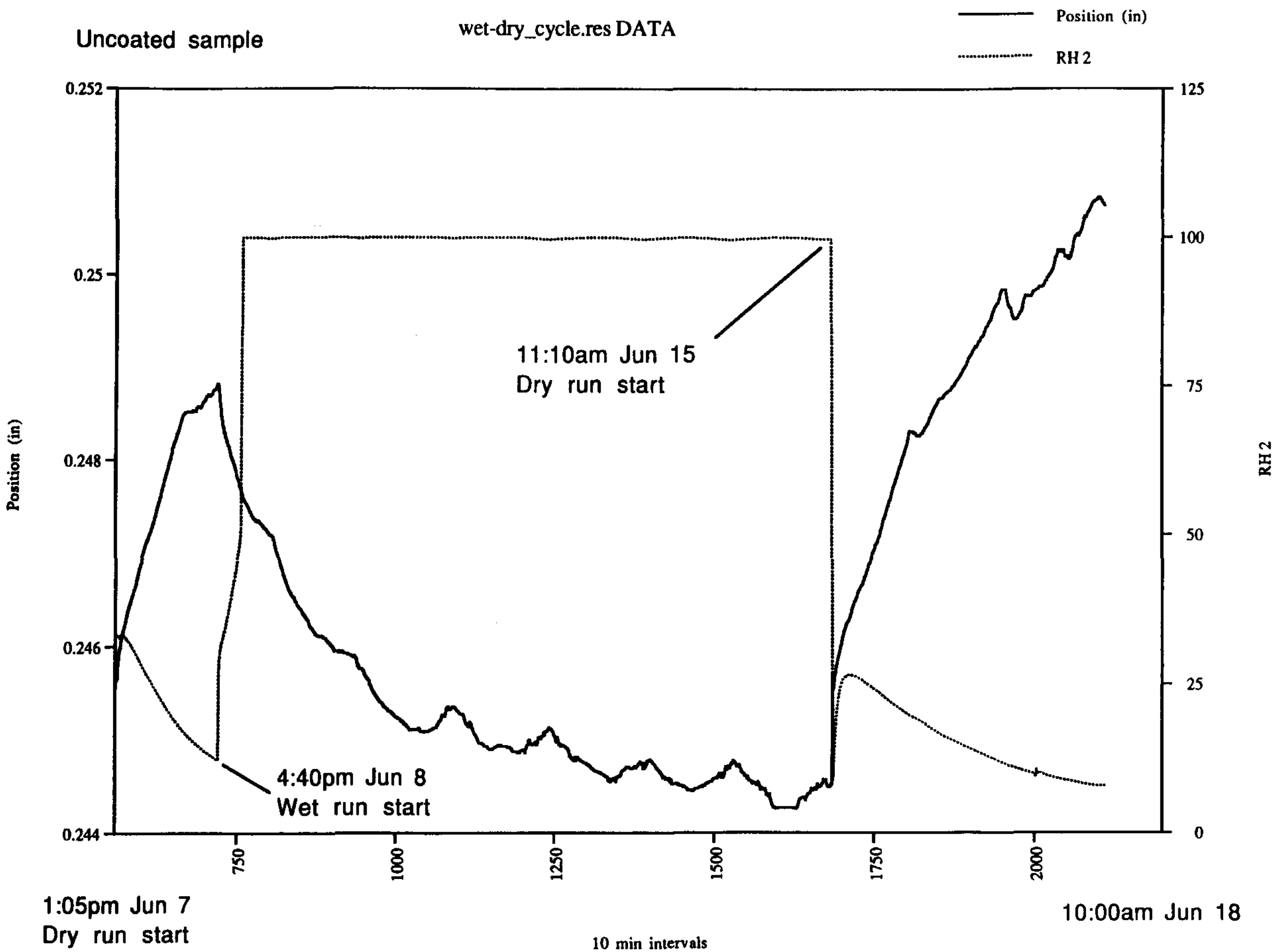


Monitoring length of a mock CSC versus temperature, humidity:

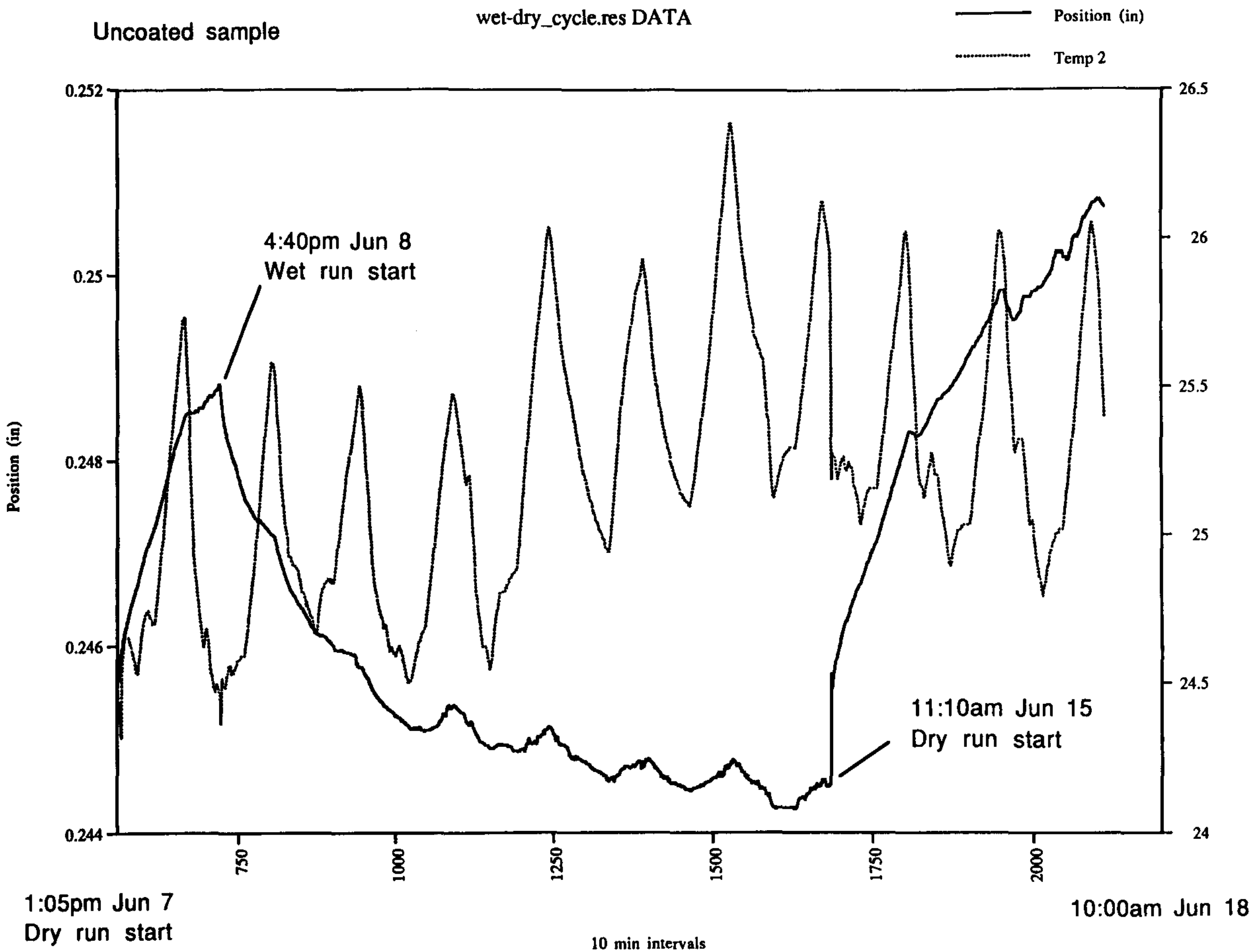
humidity control: dry = purge box with dry N2
wet = seal box with dish of water inside

humidity measurement: Phys-Chem Scientific PRCR-11
temperature measurement: AD590JH
length measurement: Schaevitz Eng. (via CSDL) Model 100HR LVDT,
on a 2D micrometer stage for calibration

test piece: 36" x 7.5" x 1"
2 x 0.031" FR4 solid copper-clad, 0.5 oz/ft^2, both sides of each piece
0.908" hexcell CIBA Geigy HMX20, 1/4" cell, 4 lb/ft^3
glued with Ecobond epoxy



Uncoated sample
wet-dry_cycle.res DATA
Position (in)
RH 2
0.252
0.25
0.248
0.246
0.244
125
100
75
50
25
0
750
1000
1250
1500
1750
2000
11:10am Jun 15
Dry run start
4:40pm Jun 8
Wet run start
1:05pm Jun 7
Dry run start
10:00am Jun 18
10 min intervals


Uncoated sample
wet-dry_cycle.res DATA
Position (in)
Temp 2
4:40pm Jun 8
Wet run start
11:10am Jun 15
Dry run start
1:05pm Jun 7
Dry run start
10:00am Jun 18
10 min intervals
0.252
0.25
0.248
0.246
0.244
26.5
26
25.5
25
24.5
24
750
1000
1250
1500
1750
2000

RD5 -- Results and Plans

Results from last summer written up in J. Shank et. al, GEM TN-93-402

- gas gain limited to ~$1x10^4$ due to low tension in some (hand-strung) wires
- position resolution 79 μm rms
- measurements with Ruthenium source on 4th layer at beam spot =>
  position resolution independent of rate at least up to ~5 KHz per strip

Plans for upcoming run:

- use small BNL prototype ~ .5m x .5m
- study resolution vs
  - gas mixtures, gas gain
  - rate dependence
  - muon momentum
- possibly measure performance in a barrel-geometry magnetic field
- Installation of detectors starts ~August 15
- data-taking ~August 31--September 14

Tentative Results for properties of laminations

Thermal expansion coefficient $1.6\times10^{-5}/°C$ at 11.5% RH

Humidity effects are evident:

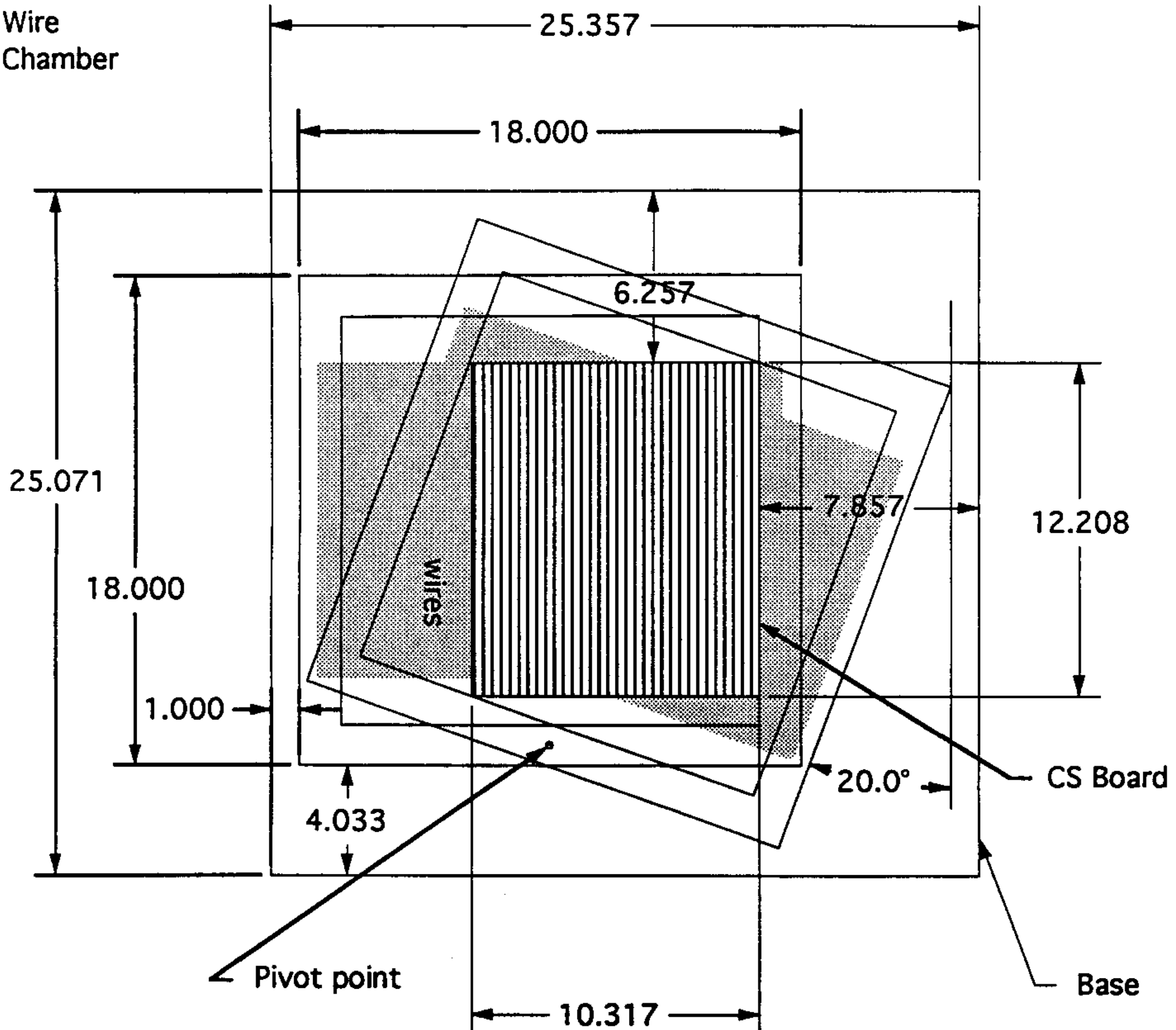
- apparent length decreases with increased humidity!
- response is slow -- several (3--7) days to reach ~ asymptotic reading

But may have several sources:

- still studying contributions from edges
- application of flexible epoxy water sealant to Cu surfaces reduced but did not eliminate humidity response
- need a dummy run to observe response of electronics only
- bowing is eliminated as a significant source of apparent shrinkage

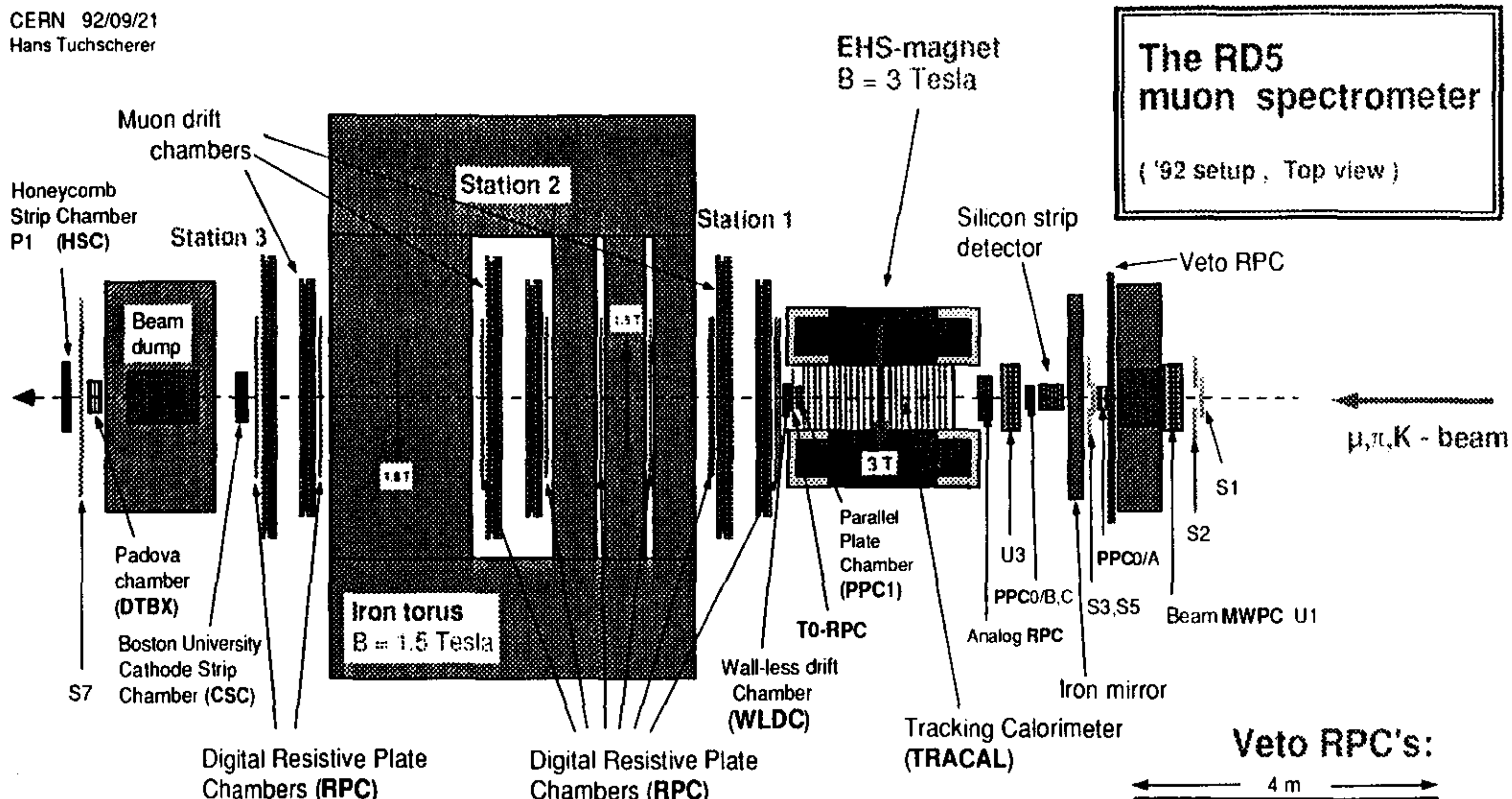
IF the observed decrease in length measurement is due to shrinkage of the lamination: -6.6×10^{-3}" over 33.5" for relative humidity 10% -> 10% then the coefficient for fractional change in length is $\frac{\Delta l}{l} \approx -2\times10^{-6}\ /\ \%RH$

Moveable
Wire
Chamber



Notes:
- 115 wires per wireframe
- 3/8" thick jig plate for base
- 30 micron wire
- 4 wireframes
- 5 hexcell sandwiches
- 1/2" thick plexiglass enclosure

All units in inches



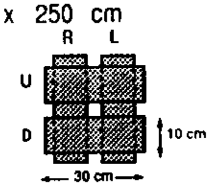
Trigger:

	μ	π		
		min.bias.	>10 λ	>20 λ
S1 x S5	●	●	●	●
VETO	●	●	●	●
PPC0	●	●	●	●
Station 1	●		●	●
Station 2	●			●
TRACAL		●	●	●

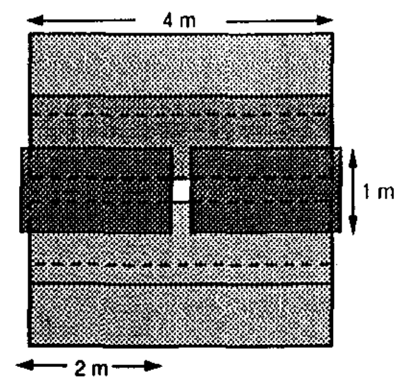
Scintillation counters:

S1: 10 cm x 15 cm
S5: 15 cm x 15 cm
S7: 100 cm x 250 cm

S2, S3 counters:



Veto RPC's:



STATUS OF MUON R&D AT DUBNA

I. GOLUTVIN

29/06/93

CONTENT:

- 0.3m × 3.0m 4 LAYER PROTOTYPE

- 1.1m × 3.0m 6 LAYER PROTOTYPE
    - LAYOUT
    - FACILITY
    - SCHEDULE

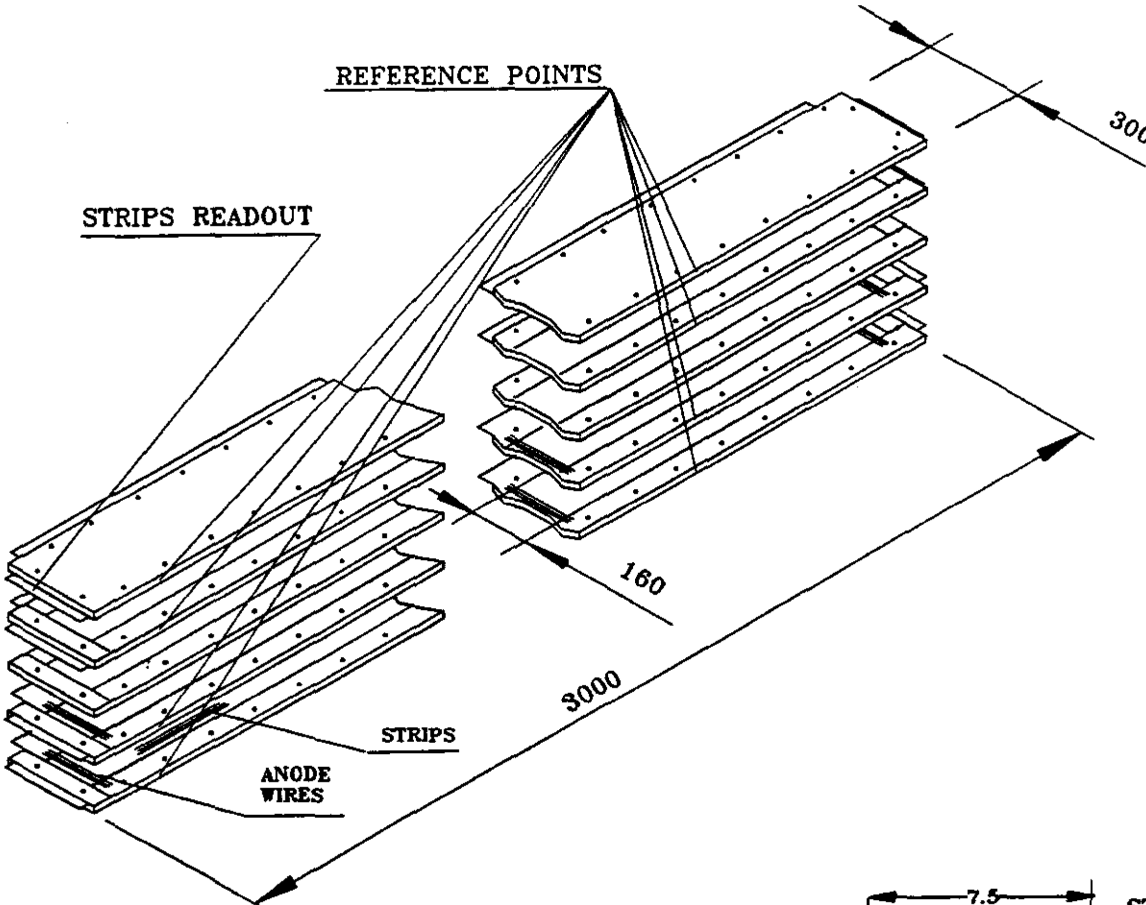
- MASS-PRODUCTION FACILITY DESIGN
    - TOOLS
    - AREA & CLEAN ROOMS

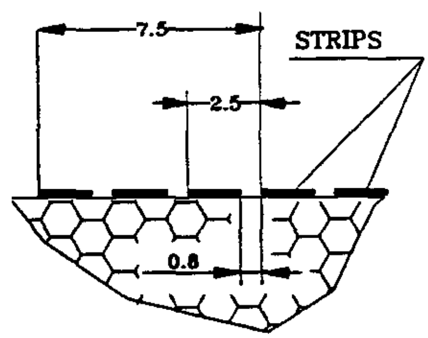
GOAL

⇓

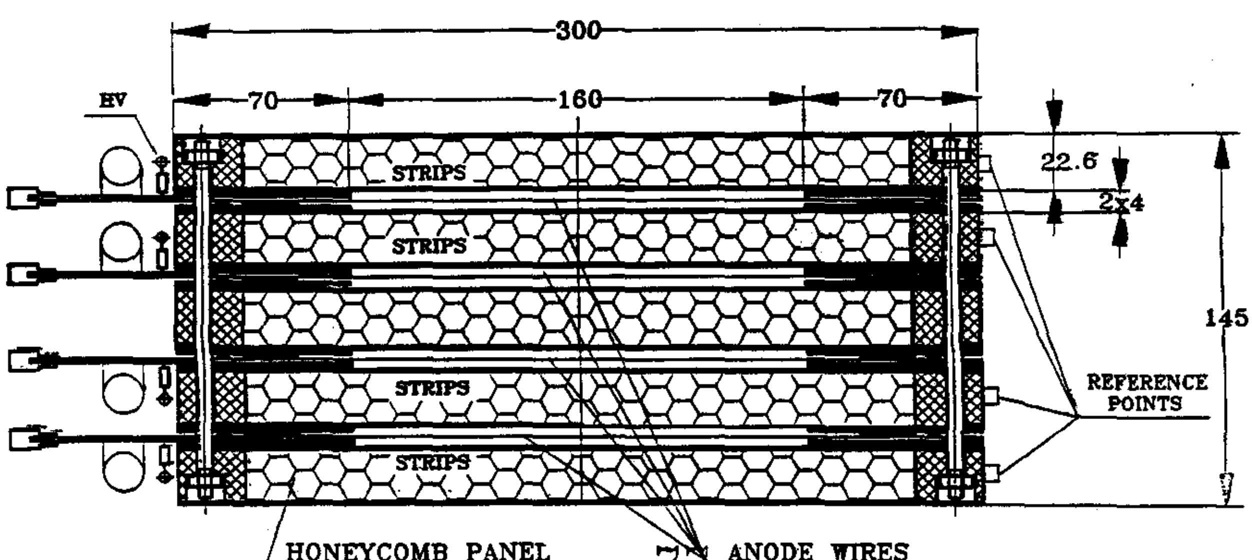
TO DESIGN THE TECHNOLOGY

CSC 3m x 0.3m

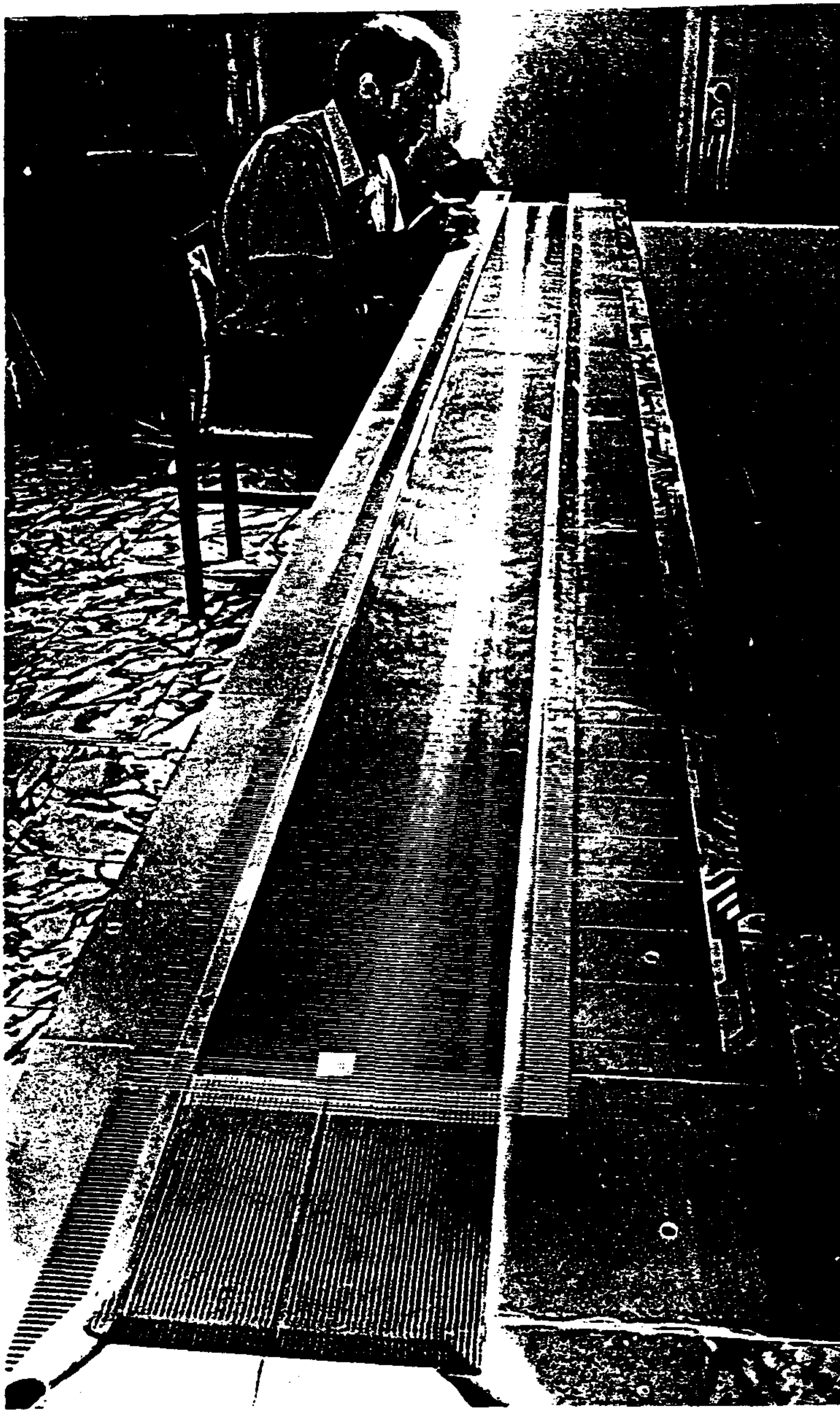


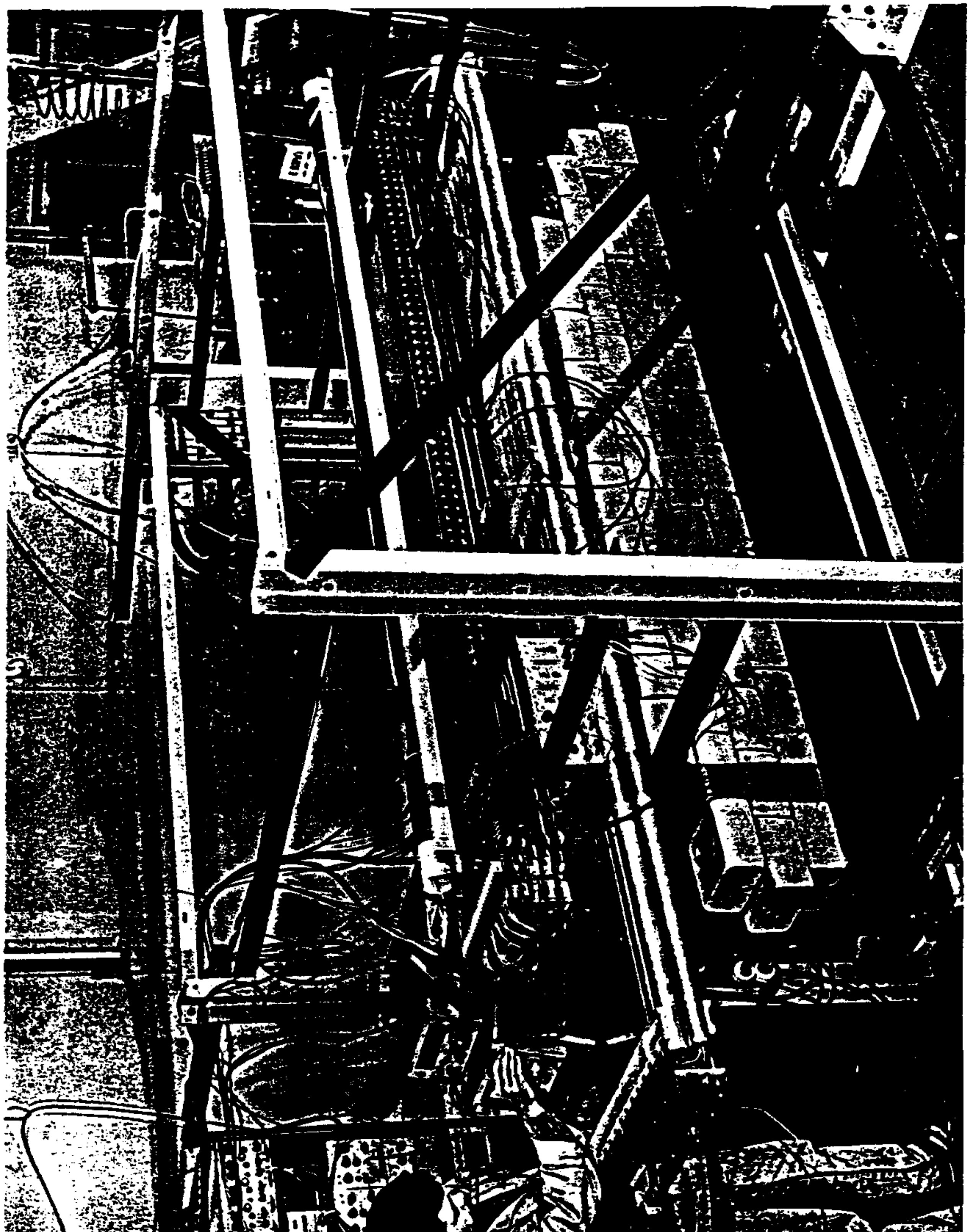


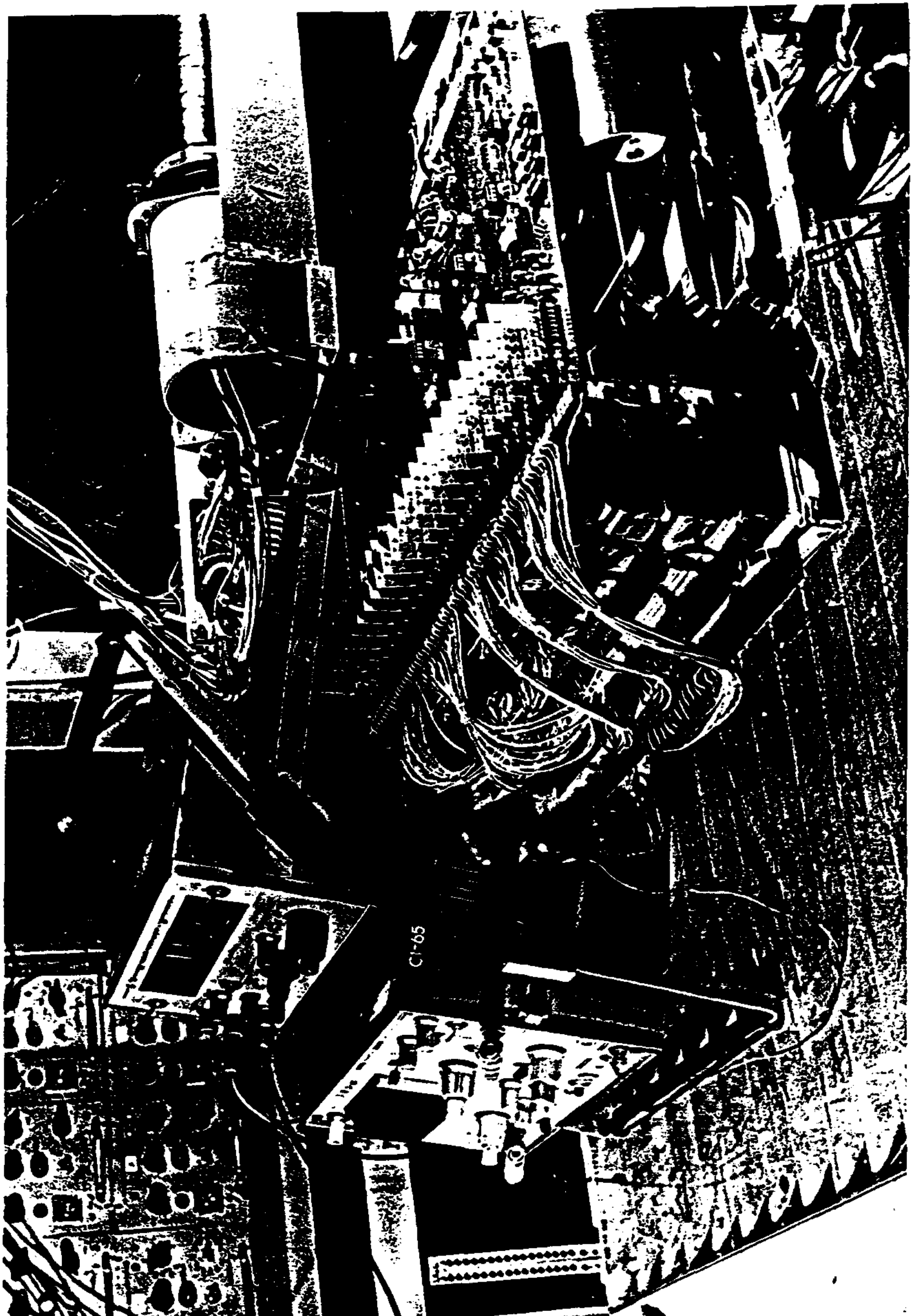
CROSS SECTION
ALONG THE WIRE

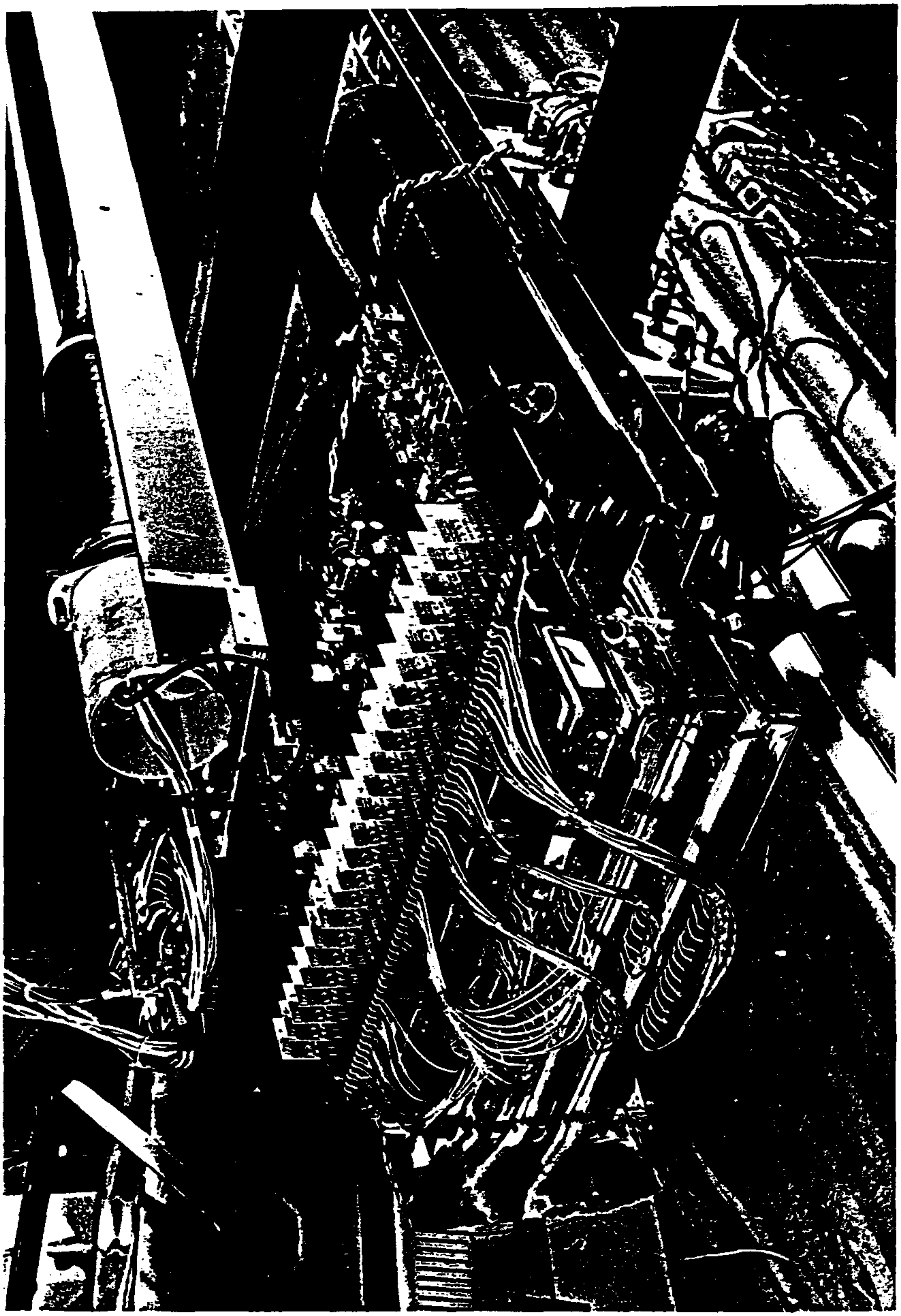


77






C1-65



THE MAIN CONCLUSION:

TO ASSEMBLE 1.1m x 3m PROTOTYPE WE NEED BETTER CLEAN ROOM

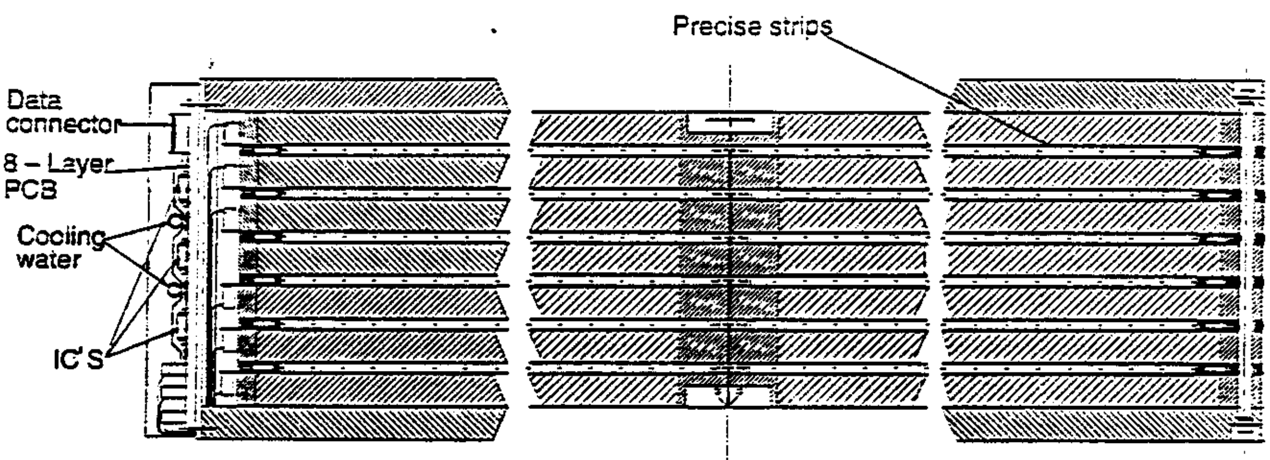
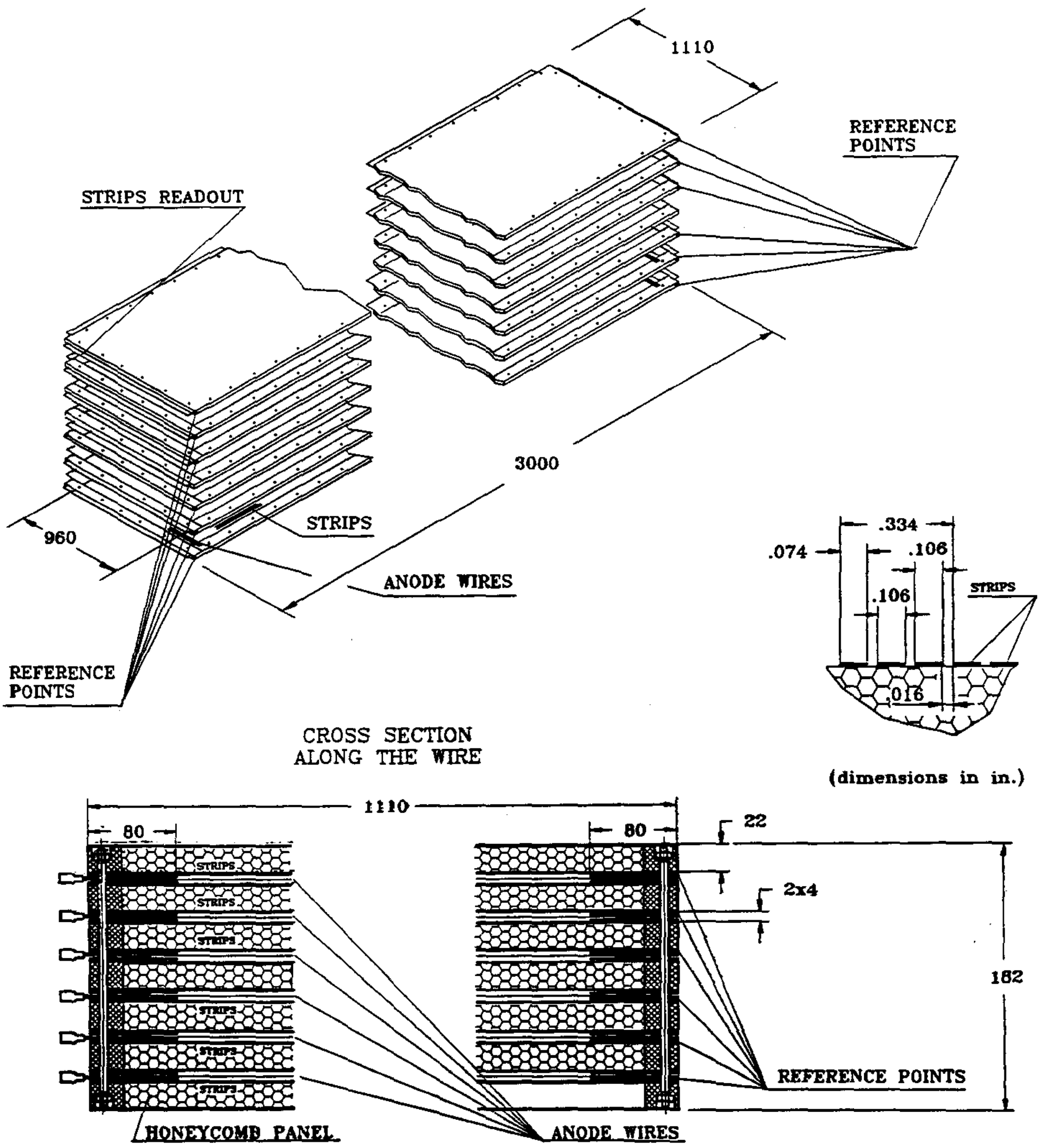


fig4_49

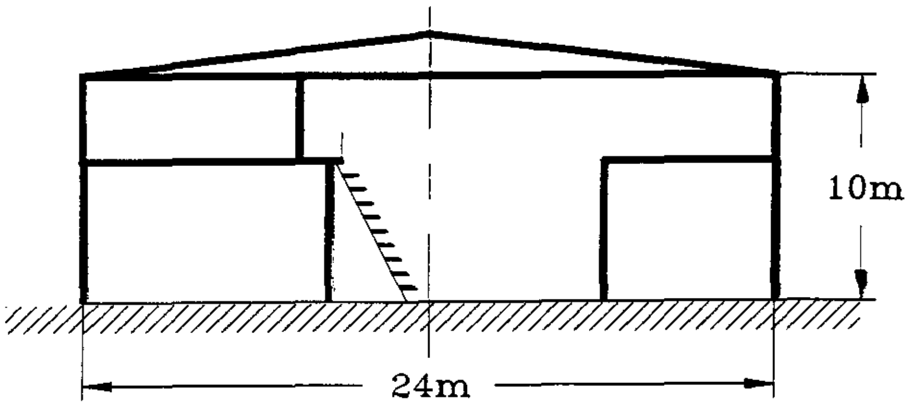
PRECISE STRIP READOUT

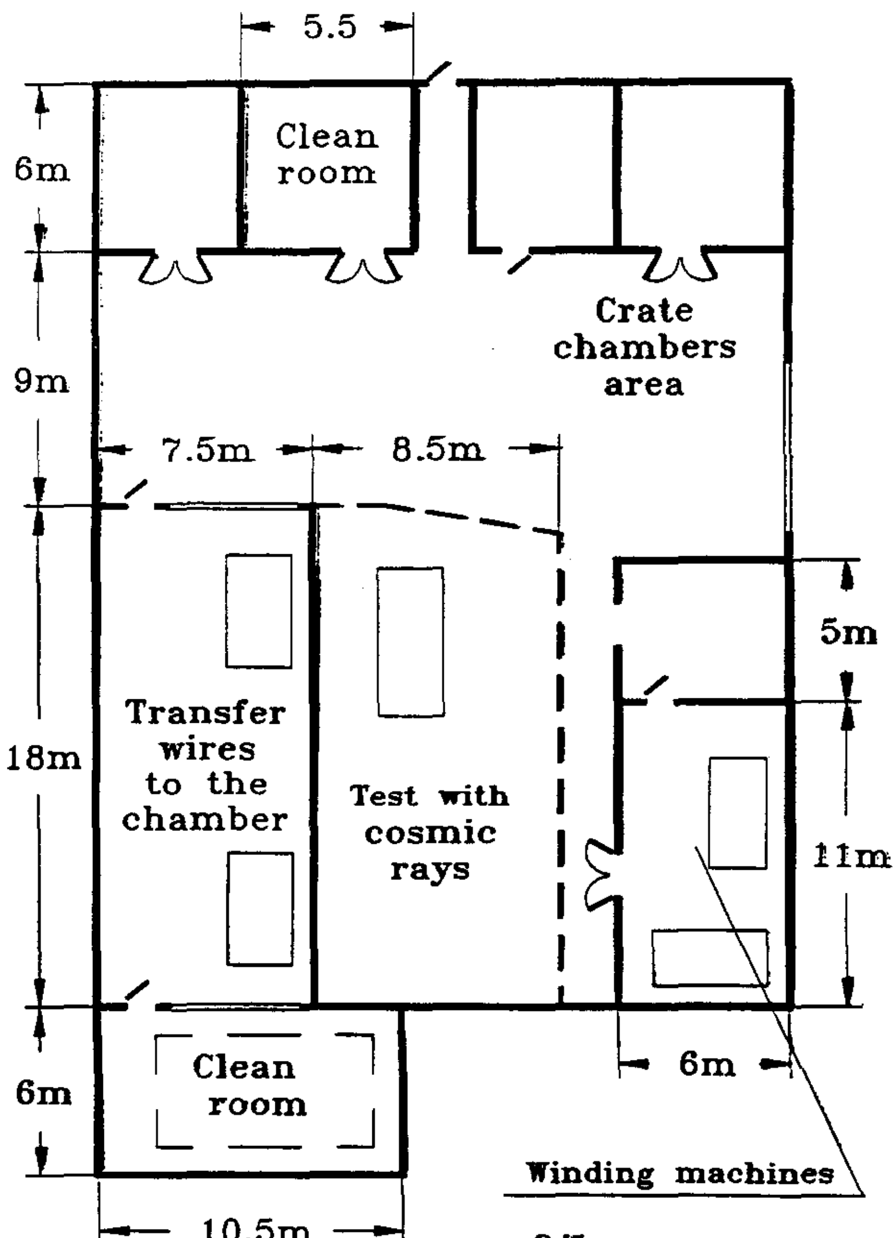
CSC 3m x 1.1m



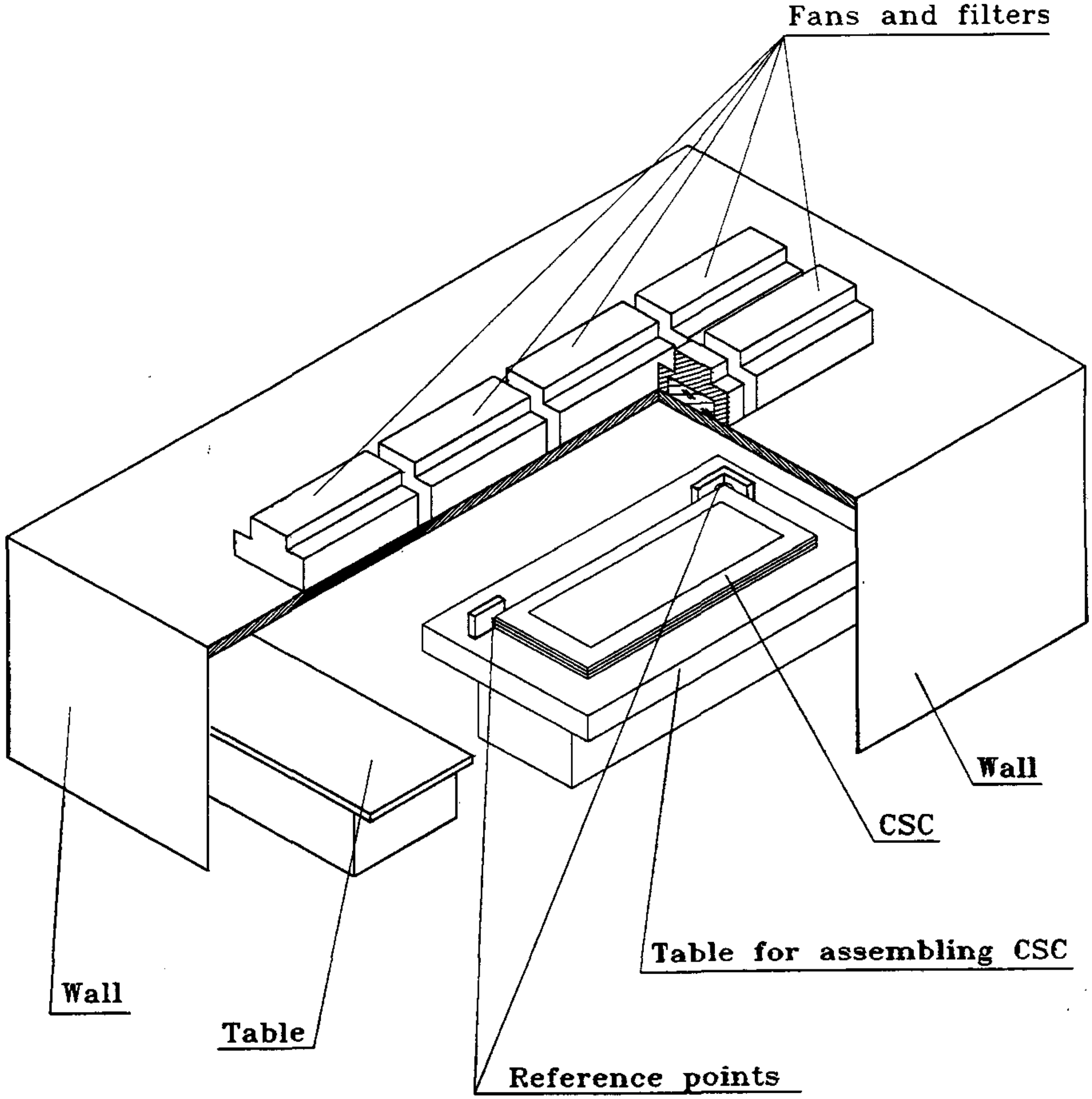
(dimensions in mm)

CSC PROTOTYPES PRODUCTION FACILITY





CLEAN ROOM



T = 20 C
HUMIDITY = 60%
AIR RATE CLEAN =10 000 dust part./cu.ft

CSC PROTOTYPE MILESTONES

* 1.	Panels preprocessing	**June 1993**
* 2.	Materials from SSCL received	**June 1993**
3.	Panels processing, precise gauges mounting, stripped boards gluing	2 August 1993
4.	Getting bars ready for gluing	13 August 1993
5.	Glue bars to panels	15 August 1993
6.	Drill holes	16 August 1993
* 7.	Test assembly of the panels	**17 August 1993**
8.	Assemble spacers and gas outlets	24 August 1993
9.	Cover strips with resistive mater.	25 August 1993
10.	Install anode wires	1 September 1993
11.	Mount Capacitors, resistors, connectors	2 September 1993
*12.	Assembled planes acceptance check	**3 September 1993**
13.	Get planes ready to assemble, clean	4 September 1993
*14.	Assemble chamber	**5 September 1993**
15.	Mount exterior parts	8 September 1993
*16.	Final test	**9-13 September 1993**
*17.	Packing	**14 September 1993**

Steps 4-6, 8-9, 10-13 go in parallel for all planes.
Key operations are shown in bold.

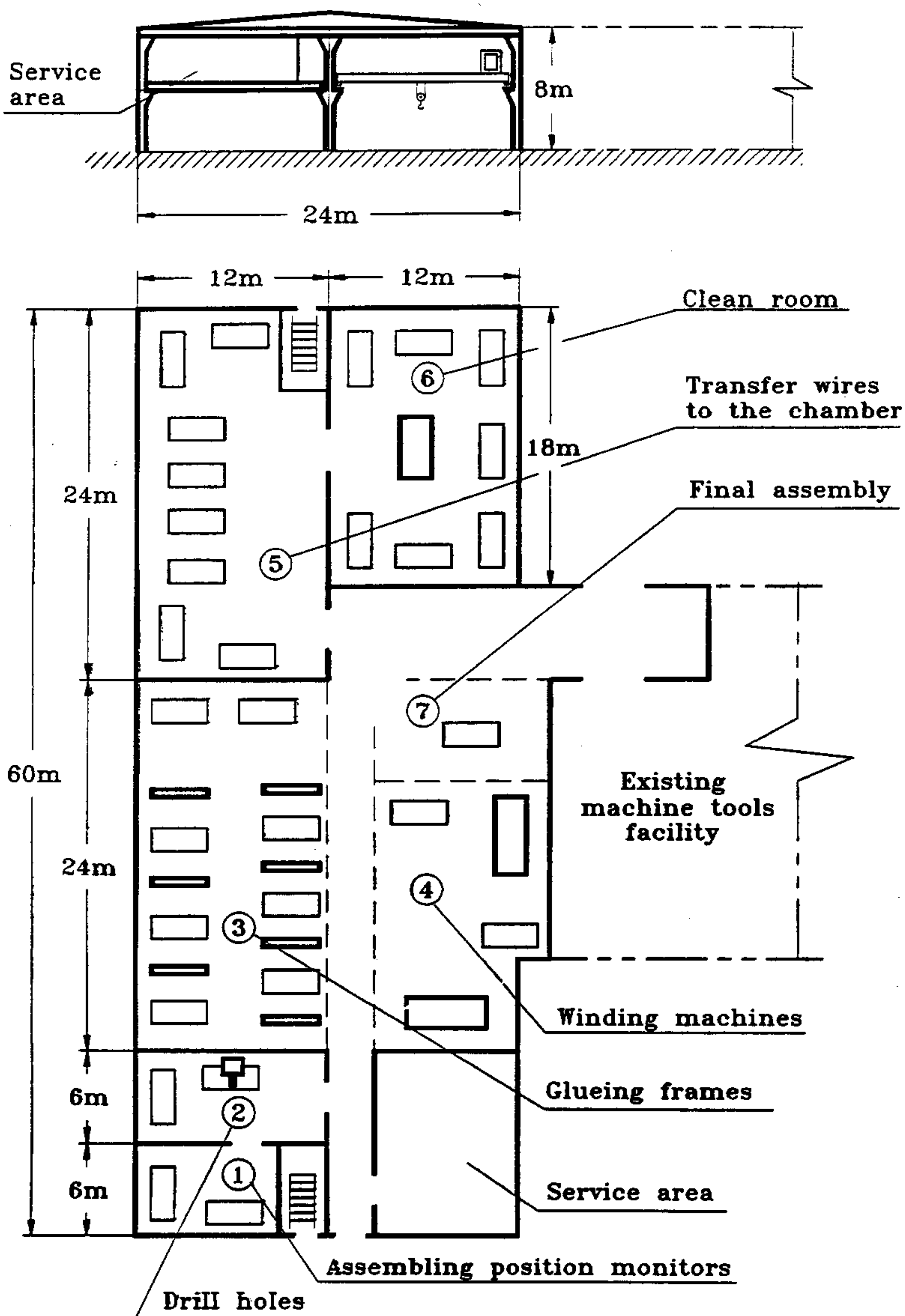
WHAT IS STILL NEEDED TO COMPLETE THE TASK?

- PARTS SHIPMENT EXPENSES
  SSC → DUBNA
- PROTOTYPE SHIPMENT EXPENSES
  DUBNA → SSC
- TRAVEL EXPENSES (CRUCIAL)

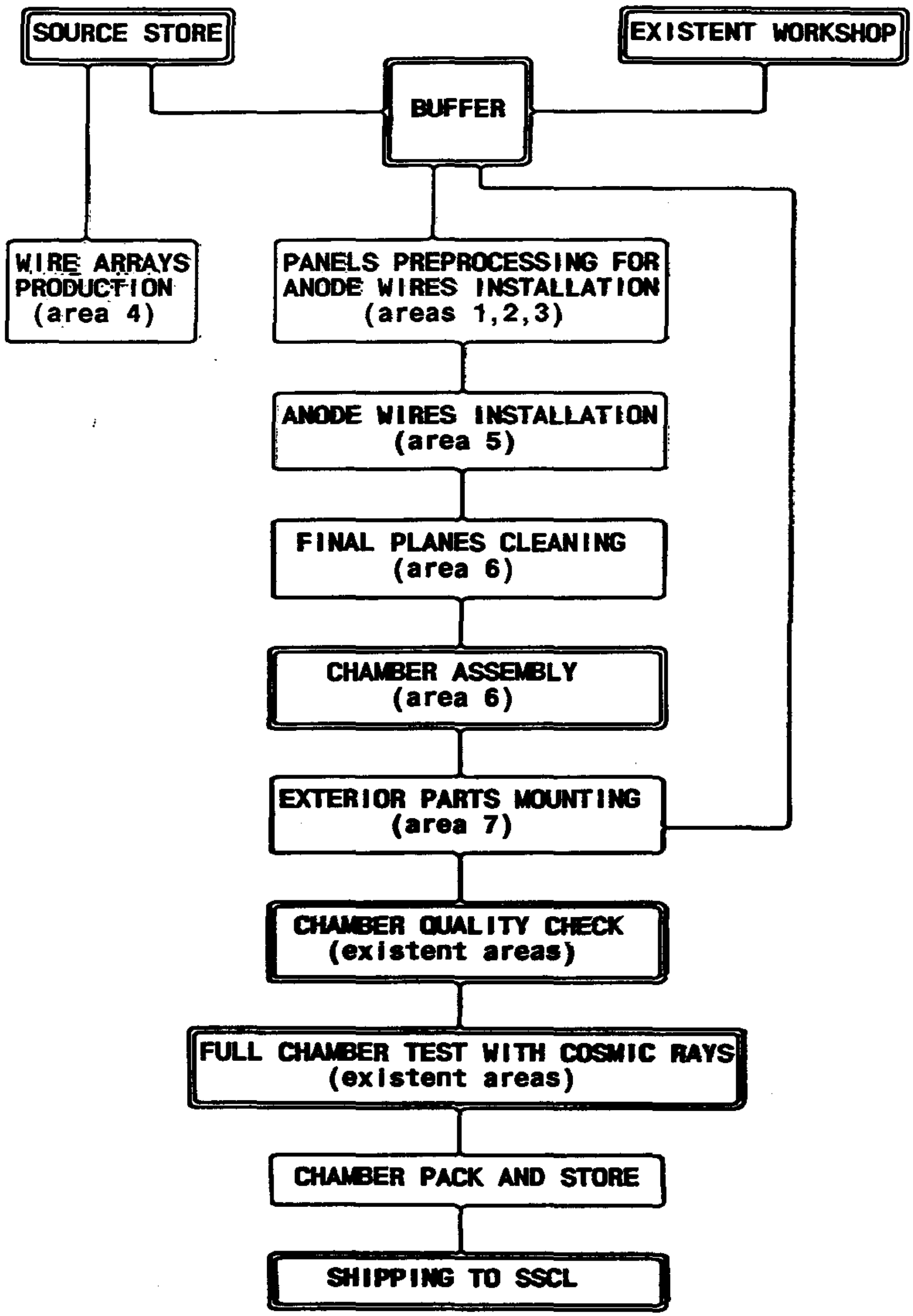
★ ELECTRONICS !!!

CSC MASS PRODUCTION FACILITY

(PROJECT)



CSC MASS PRODUCTION TECHNOLOGICAL CHAIN AT CSC FACTORY (project)



(continue)

Procedures in Bld. 6

Items	Area (m^2)
1. Solder resistors	10 (5*2)
2. Clean cathodes and chamber frames	10 (5*2)
3. Wind wires and wire tension control	30 (6*5)
4. Solder wires	20 (5*4)
5. Wire tension, location & connection check	20 (5*4)
6. Assemble chamber	20 (5*4)
7. Connectors	16 (6.5*2.5)
8. Gas leak test & HV training	22 (5.5*4)
9. Gas supply & final test	45 (5*9)
10. Package	35 (7*5)

The Objects of GEM in IHEP

and

Advance in GEM Muon Detector in IHEP

Yinzhi Huang

29

June ~~18~~, 1993

Status and Objects

•Muon system:

1. R and D of CSC Prototypes: Baby, Mini, Full-size
2. Mass-Production of Muon Chambers:
   40-50 % of Barrel Part
3. Electronics and Trigger for Muon System
4. MC Simulation for Muon System
5. Coordinator for Some Materials:
   Sandwich Panels from MRI (BIAM)
   Strip Boards from CPEIAI
6. Take Part in the Beam Test for Muon Chamber

•Calorimeter:

1. Coordinator and Quality Control
2. MC Simulation
3. Take part in the Beam Test for Calorimeter

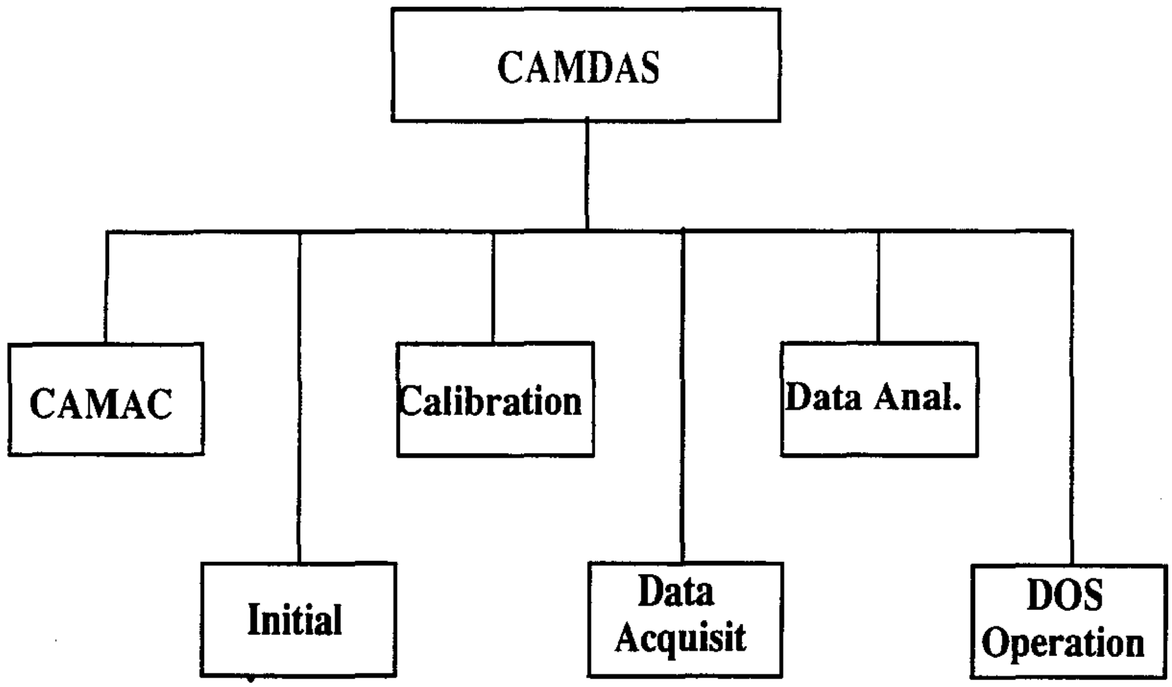
Advance in Muon Camber of GEM in IHEP

•Baby Prototype: 18*25 cm^2

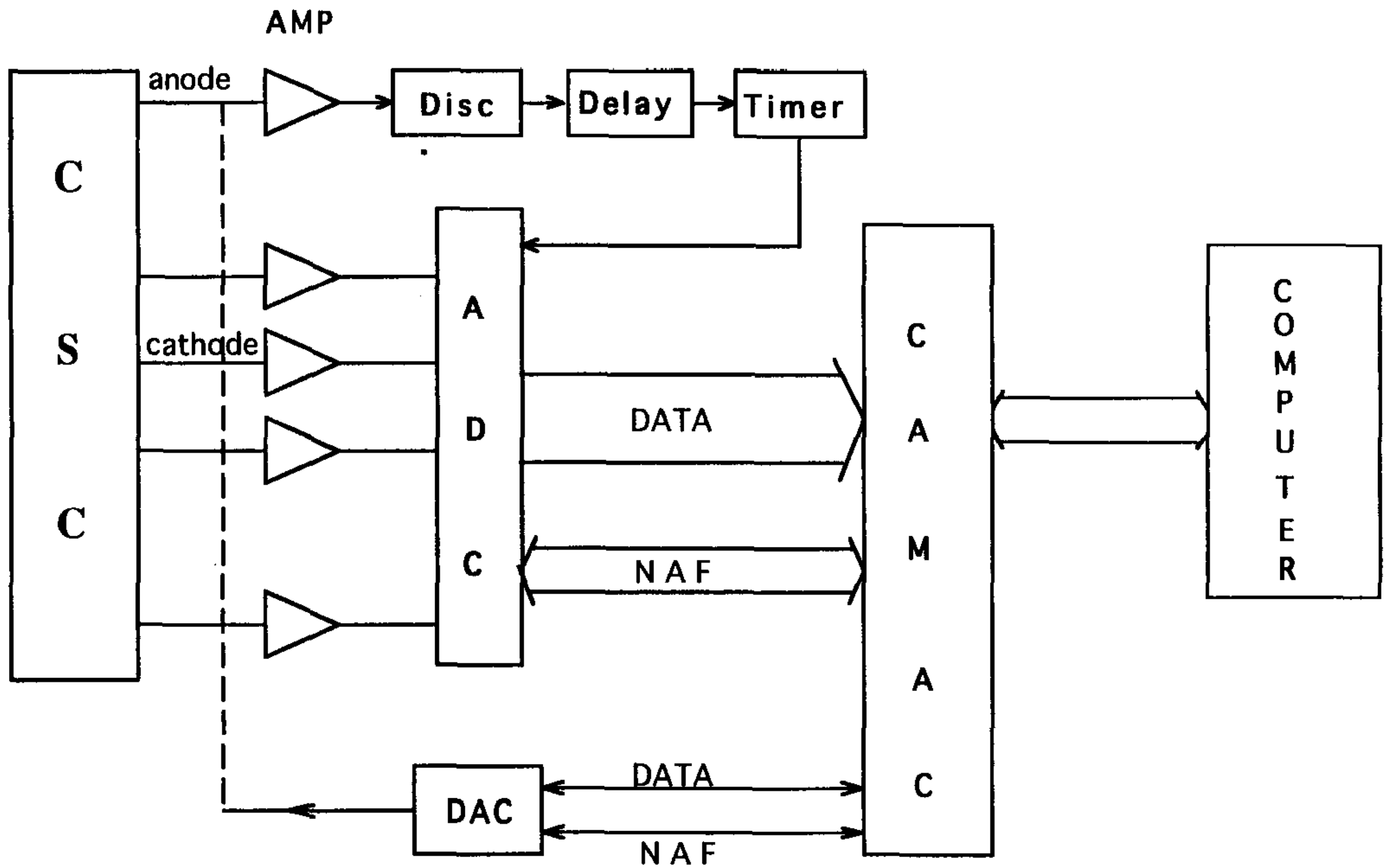
1. The chamber prototype and test facilities have been built.
2. The signals from both cathodes and anodes have been gotten (after preamplifier and shaping amplifier).
3. CAMAC data acquisition system has been developed (can be used for both Baby and Mini). We call it CAMDAS.
4. The CAMDAS working with Baby is good, and the Baby has good centroid distribution.

•Mini Prototype: 50*50 cm^2, 2 or 4 gaps

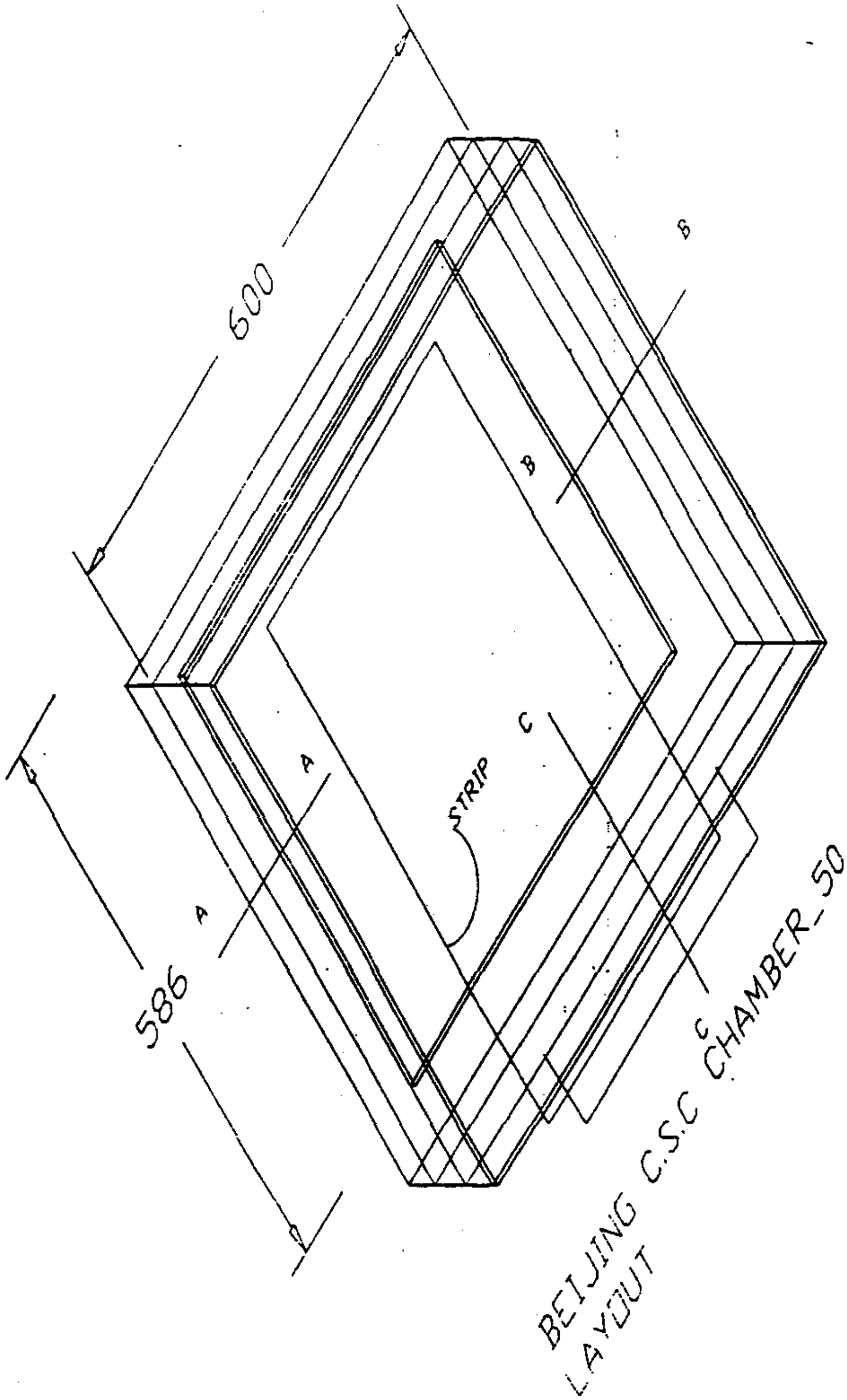
1. The design and drawings for manufacture have been completed , using partly US and partly Chinese components. It is ready for machining.
2. Depending on the budget problem (US$30k have not been received yet), we are considering some substitute materials (much cheaper than exist one). The mainly consideration is concentrating on the characteristics influencing the quality, feasibility and economy.

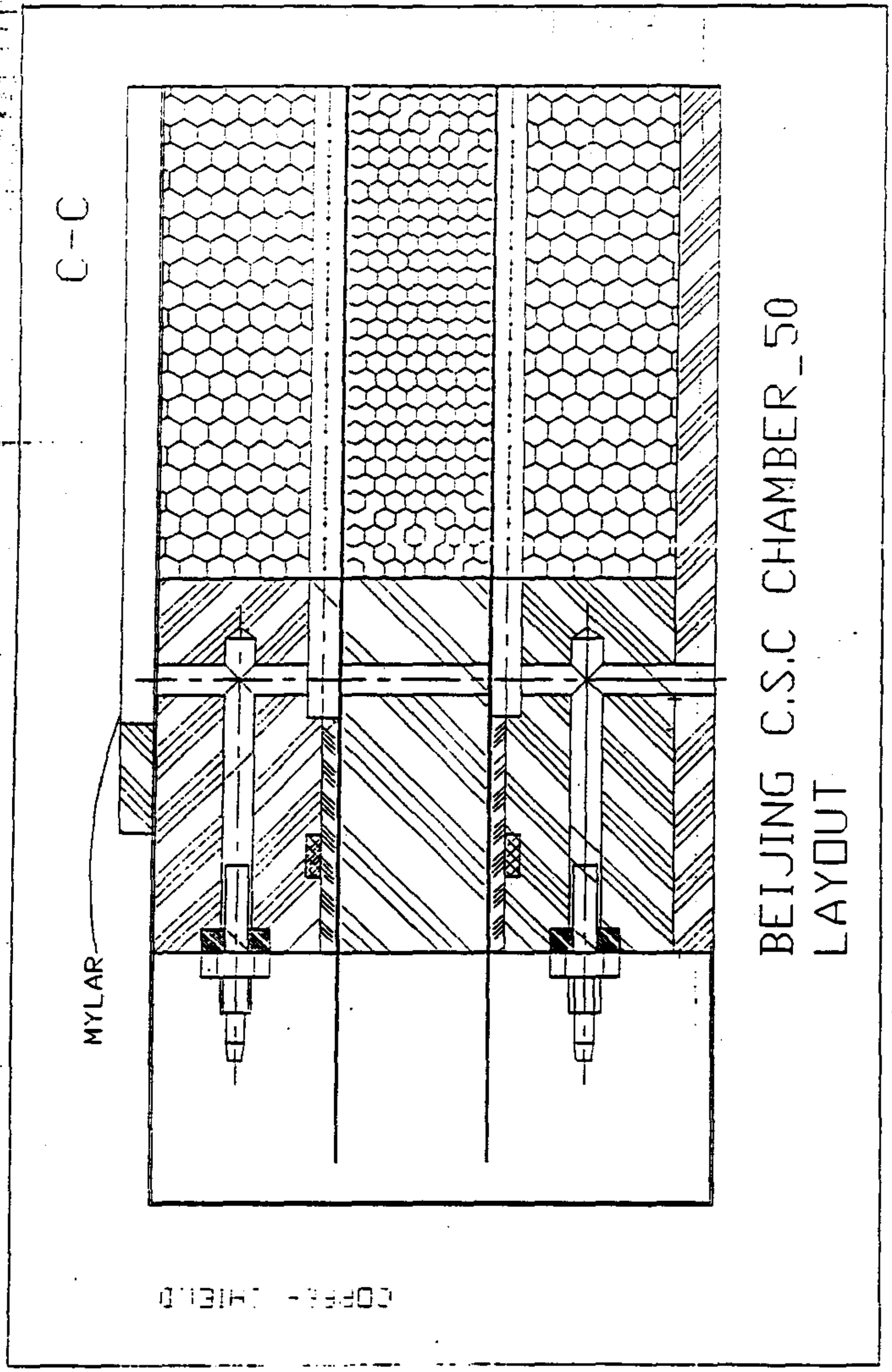


Data Acquisition Software Block Diagram



Data Acquisition System Hardware


600
586
A
A
B
B
C
C
STRIP
BEIJING C.S.C CHAMBER_50
LAYOUT


C–C
MYLAR
BEIJING C.S.C CHAMBER_50
LAYOUT

•Coordinator for Some Materials

As a coordinator of other two Chinese institutes intending to produce CSC components, i.e. cathode strip boards (China Precision Engineering Institute for Aircraft Industry) and hexcel panels (Material Research Institute or call Beijing Institute of Aeronautical Materials), we keep contacts and have many discussions with them. The status's are:

1. The strip boards made by CPEIAI have been used in our Baby CSC and are working good. Now, we are working together in making the boards for our Mini prototype.
2. The hexcel panels made by MRI (BIAM) have been shown to GEM Muon delegation and we are working together with MRI in making hexcel panels for our Mini prototype.

•Full Size Prototype:

1. The working table (+- 10 μm) and other facilities for both full size CSC and mass production are being prepared.

2. The stretching wire machine for Full size prototype has been designed.

3. The gas system and 32 channels HV power supply are ready to use now.

4. Data acquisition system has been prepared for both Full size prototype and mass production. These are:

   Super 386 computer,

   CAMAC crate and modules,

   NIM crate and modules,

   Scintillators.

•Preparations for Mass Production

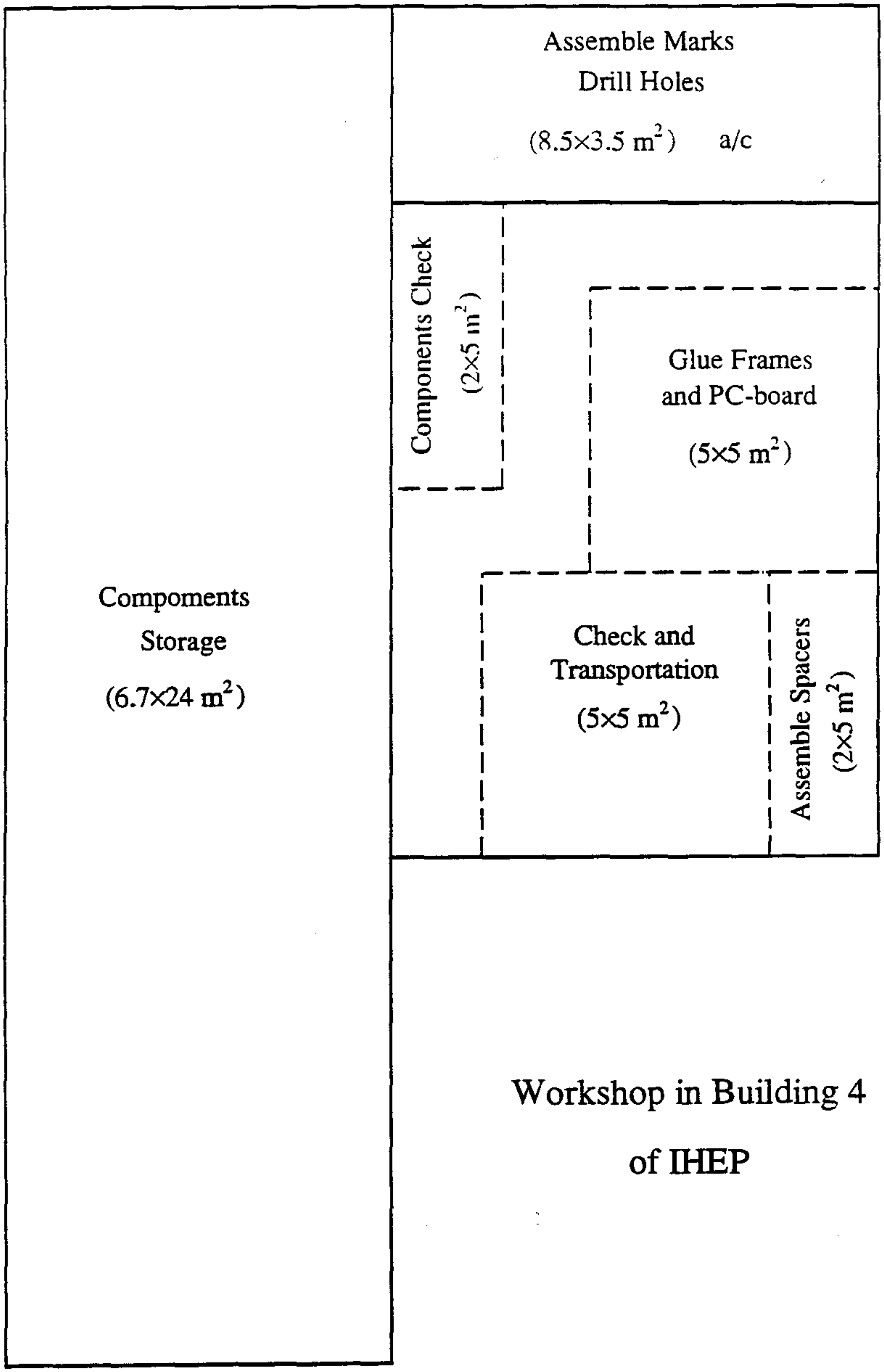
1. The data acquisition system, HV power supply and gas mixture system for Full size CSC prototype can be used for mass production.

2. Wire tension test system and precision measurement system are ready to be used.

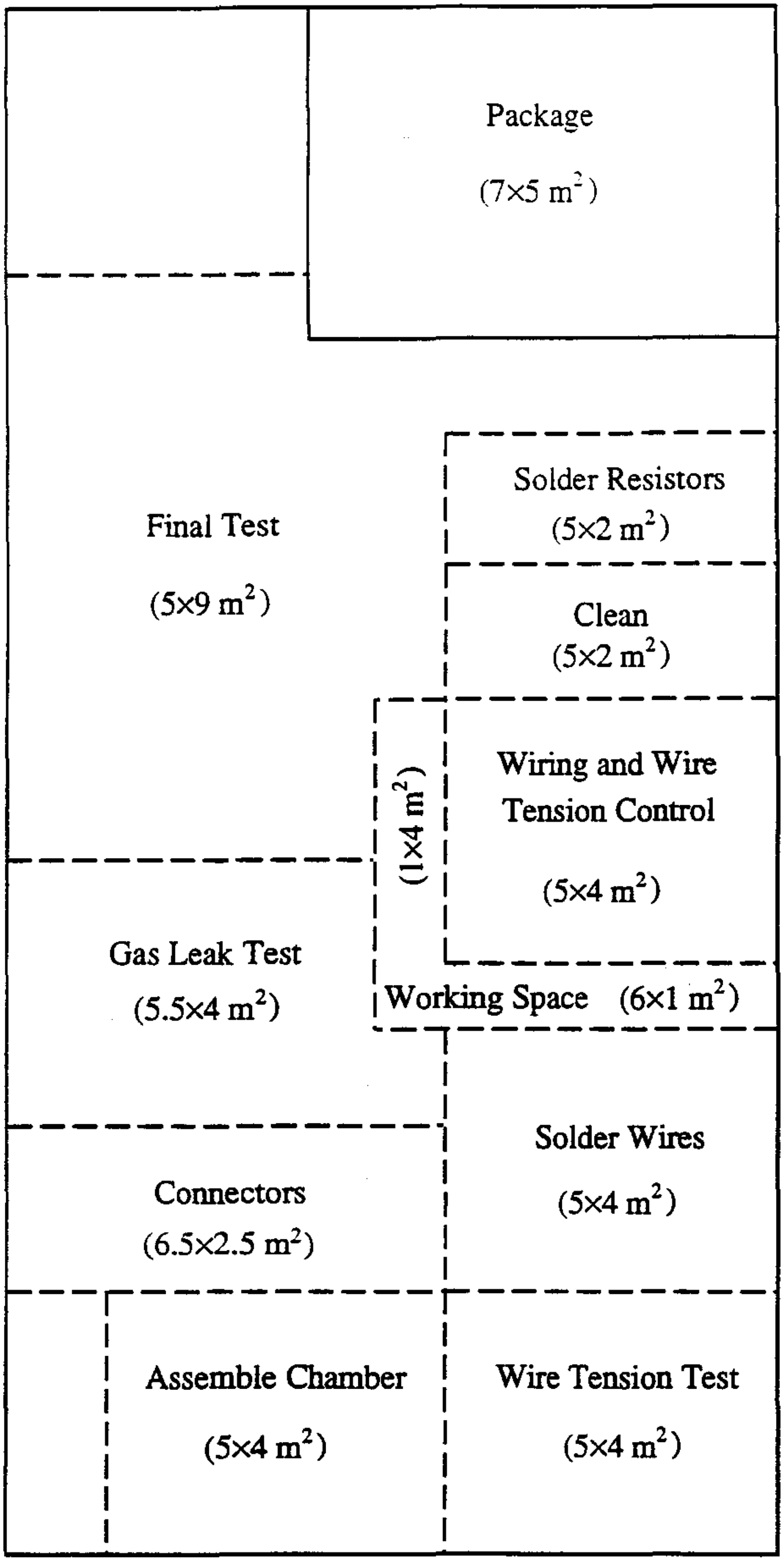
3. 550 m^2 workshop space has been vacated for chamber assembly, test and storage:

Procedures in Bld. 4

Items	area (m^2)
1. Components storage	160 (6.7*2.4)
2. Components acceptance, check	10 (2*5)
3. Assemble fiducial marks and drill holes	30 (8.5*3.5) (Air conditioning)
4. Glue chamber frames and PC-boards	25 (5*5)
5. Assemble spacers	10 (2*5)
6. Check and transportation	25 (5*5)



Workshop in Building 4 of IHEP



Workshop in Building 6 of IHEP

CSC Front End Readout

- Status of SCA Development

- 2nd Generation Prototype Schedule

109

GEM Muon Meeting
SSC Laboratory
June 29, 1993

Daniel Marlow
Princeton University

SCA Prototype Tests

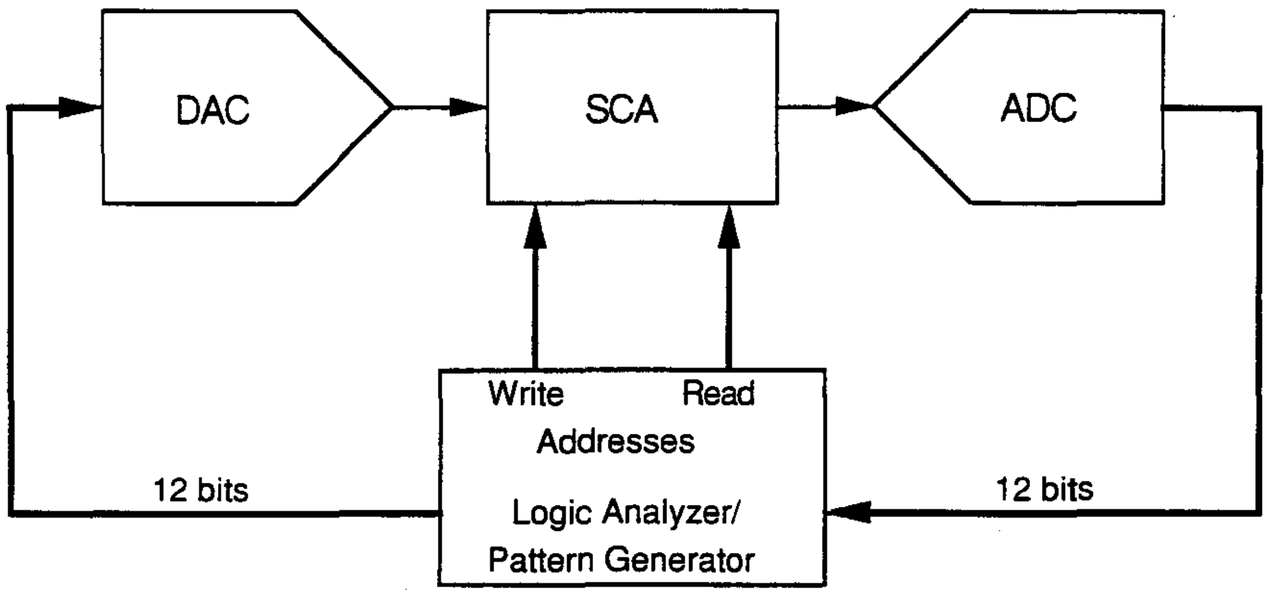
-Work of Bob Wixted & Stan Chidzik

-Prototype is 3-channels, each having 28 storage cells.

-CSC Requirement is 10 bits with 100 ns sampling.

-Test setup uses 12-bit DAC and 12-bit ADC (Analog Devices HAS 1201)

-Write address and read address generated using HP pattern generator. Test using FPGA List Processor'' will commence soon. The latter will allow simultaneous read/write operati



SCA Test Fixture

Conclusions

-Initial tests look promising

- 10-11 bit SCA operation on first iteration.

- Cell "gains" the same from cell to cell.

- Cell-dependent pedestals at 9 bit level..

-Work to be done

- Complete testing of SCA#1: amplifier settling time, capacitor decay time, additional channels.

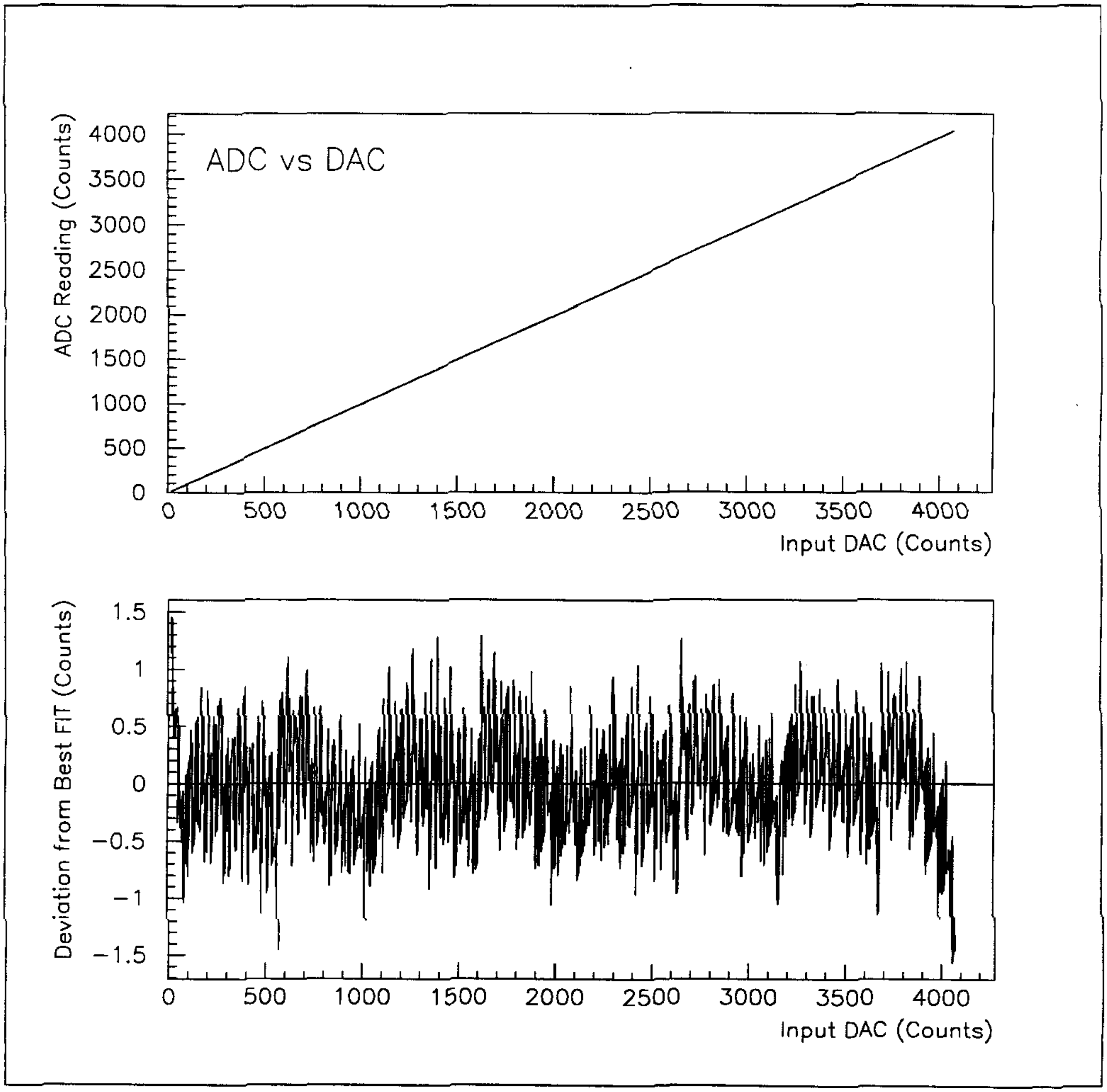
- Improved test setup: 16-bit ADC plus other odds & ends.

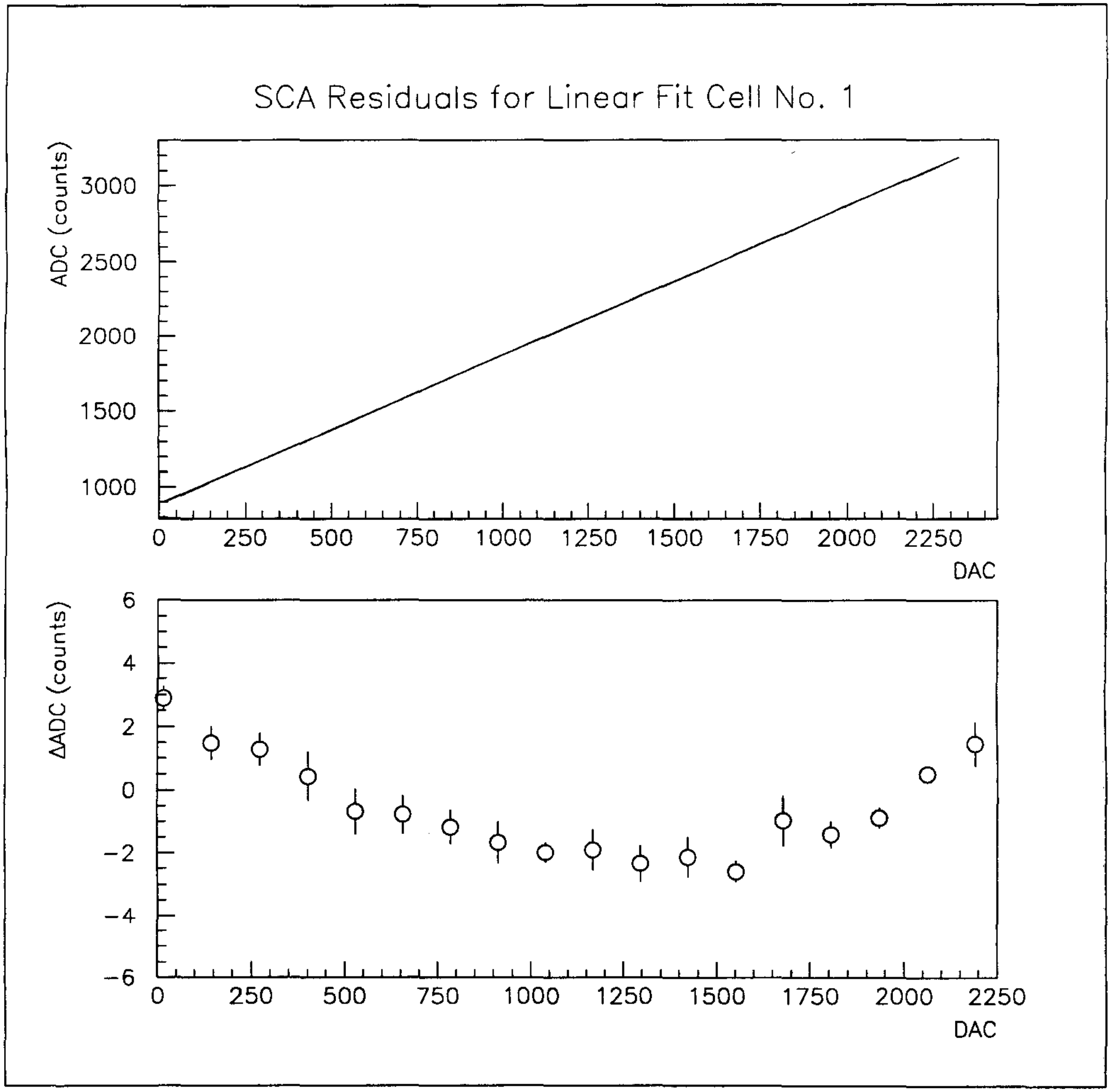
- Submit next iteration with on-chip buffer

- Understand and reduce cell-dependent pedestals.

- Test and characterize integrated Turko & Smith CFD

-


ADC vs DAC
ADC Reading (Counts)
0
500
1000
1500
2000
2500
3000
3500
4000
Input DAC (Counts)
Deviation from Best FIT (Counts)
−1.5
−1
−0.5
0
0.5
1
1.5
Input DAC (Counts)


SCA Residuals for Linear Fit Cell No. 1
ADC (counts)
3000
2500
2000
1500
1000
0
250
500
750
1000
1250
1500
1750
2000
2250
DAC
ΔADC (counts)
6
4
2
0
−2
−4
−6
0
250
500
750
1000
1250
1500
1750
2000
2250
DAC

SCA Based CSC Readout Electronics Schedule

```
                 1993                          |                      1994
             Jun  Jul   Aug  Sep  Oct  Dec   Jan  Feb  Mar  Apr  May  Jun  Jul

                 test
Prot SCA#1   ------->

               design         fabricate  test
Prot SCA#2     ---------->--------->----->

                        design          fabricate    test
Prod SCA#1          --------------->--------->----->

                                                   design  fabricate   test
Prod SCA#2                                         ----->--------->---->

Prot P/A#1     --->---------->--------->

                        design     fabricate     test
Prod P/A#1            --------->----------->------->

                                                design       fabricate    test
Prod P/A#2                                     - -------->--------->----->

                    study heatflow, packaging, & EMI issues
PCB R&D             ------------------------------>

                          design       fab    test
Prod PCB#1             ------------->---->------>

                                                design          fab   test
Prod PCB#2                                    ---------------->---->----->
```

Alignment System R&D Program

The Alignment System R&D Program will study a number of different alignment concepts and straightness monitor technologies including:

Alignment Concepts:

- 3-point Projective Alignment.
- Hybrid Axial/Projective.
- All-optical Axial/Projective.
- X rays.

Straightness Monitors:

- Multiple LED/Lens/quad-cell.
- Video Straightness Monitor (VSM).
- Stretched Wire Alignment (Capacitive Pick-up and Inductive Pad).

A dedicated facility, the Alignment Test Stand will be constructed at SSCL to test these and other options as our R&D program evolves.

be checked against a precise external alignment system for a realistic path lenght with realistic chambers.

In summary the Alignment R&D program will cover the following:

- Assess technology options and develop them for GEM application (LED-LENS, or CCD, etc).
- Set up test bench to evaluate technologies in a standard way.
- Integrate alignment technology with chamber design and support structure.
- Set up Alignment Test Rig (ATR) to evaluate alignment technology with chamber mock-ups.
- Design complete system - specifying the type, number, and deployment of monitors.
- Simulate operation of complete system and validate the design and its error budget.
- Evaluate X-ray alignment scheme. Develop mass production techniques for aligning layers within a chamber module.

A revised WBS with task and sub-task leaders follows for the Muon System Alignment Task.

2.4.1 Define and develop alignment technology (LLNL, SSCL, Draper; Joe Paradiso - Task Leader)

2.4.1.1 Review alignment systems on other HEP experiments. (C. Wuest, J. Paradiso)
2.4.1.2 Review Draper R&D results. (J. Paradiso)
2.4.1.3 Review LLNL R&D results. (C. Wuest)
2.4.1.4 Review Tsinghua University R&D results. (C. Wuest)
2.4.1.5 Review PNPI x-ray alignment results. (A. Vorobyov, C. Wuest)
2.4.1.6 Review MIT stretched wire/inductive pad results. (A. Korytov)
2.4.1.7 Review six-point interpolation technique. (J. Paradiso, Yu. Gerstein)
2.4.1.8 Define alignment technology (or technologies) for GEM. (J. Paradiso, C. Wuest, G. Mitselmakher)

2.4.2 X-ray alignment methods – inter-layer alignment. (PNPI, SSCL, LLNL; A. Vorobyov, Task Leader)

2.4.2.1 Construction of a movable table (CMM) at PNPI, modification of existing CMM at LLNL. (A. Smirnov, O. Prokofiev, C. Wuest)
2.4.2.2 Computer controlled motion system and metrology development. (A. Smirnov, O. Prokofiev, C. Wuest)

R&D of Alignment Technology
Second Half FY 1993 Detailed Breakdown and Budget

Craig R. Wuest, Joseph A. Paradiso

Lawrence Livermore National Laboratory
Charles Stark Draper Laboratory

June 9, 1993

(2.4) Task 4: Alignment Technology

The detailed design of the chamber precision alignment system will be developed and analyzed. Emphasis will be placed on the evaluation of sensors, integration of alignment systems with the chosen technologies, and testing of the alignment system. Cost and schedule estimates for the alignment system will be formulated. The design will be documented in terms of drawings and specifications so that a prototype of the alignment system can be built.

One of the improvements of the TDR design worth considering is to increase the solid angle coverage. Several strategies are under consideration depending on the the location of the non-coveraged. For example, small chambers can be inserted in some regions near the CDS. These chambers will have to be aligned by some means. Another area is the gaps in the barrel region where an axial alignment scheme has been discussed. All of these improvements will be evaluated.

The alignment of the individual layers of cathode boards in a chamber is an important engineering issue and key to acheiving the desired performance of the chamber modules. For this task it has been proposed by the PNPI contingent in collaboration with LLNL to employ penetrating X-rays to orient the individual layers together.

To validate the concept of the sagitta correction function determined by projective alignment of the chambers, the basis of all proposed GEM alignment schemes, a prototype alignment system will be constructed, called the "Alignment Test Rig" (ATR). Some specific engineering approaches will be tested as well. The ATR will consist of three dummy chambers representing the three superlayers of the barrel (endcap). Each of the dummy chambers will be instruemented with positioning actuators used to place the chambers within the few millimeters dynamic range of the alignment system, and alignment fixtures. A series of tests will be conducted whereby the alignment system will

Task Consultants:
Andrei Korytov, Gena Mitselmakher, Frank Nimblett, Yuri Gerstein, Fred Holdener

Task Collaboration:

Draper Lab.
Howard Baker, Frank Nimblett, Joe Paradiso, mechanical engineer, optics engineer
ITEP
V. Balagura, I. Korolko, V. Gavrilov, A. Ostapchuk
LLNL
Elden Ables, Curt Belser, Fred Holder, Craig Wuest, Martin Roeben
MIT
Andrei Korytov, Louis Osborne
MSU
Carl Bromberg, R. Miller, R. Richards, B. Tigner
PNPI
A. Vorobyov, et al.
SSCL
G. Crutcher, M. Jons, G. Mitselmakher, Yu. Gerstein, D. Weal
Tsinghua University-Beijing
Ni Weidou, Rencheng Shang, Keren Shi, Li Dachen

Appendices:

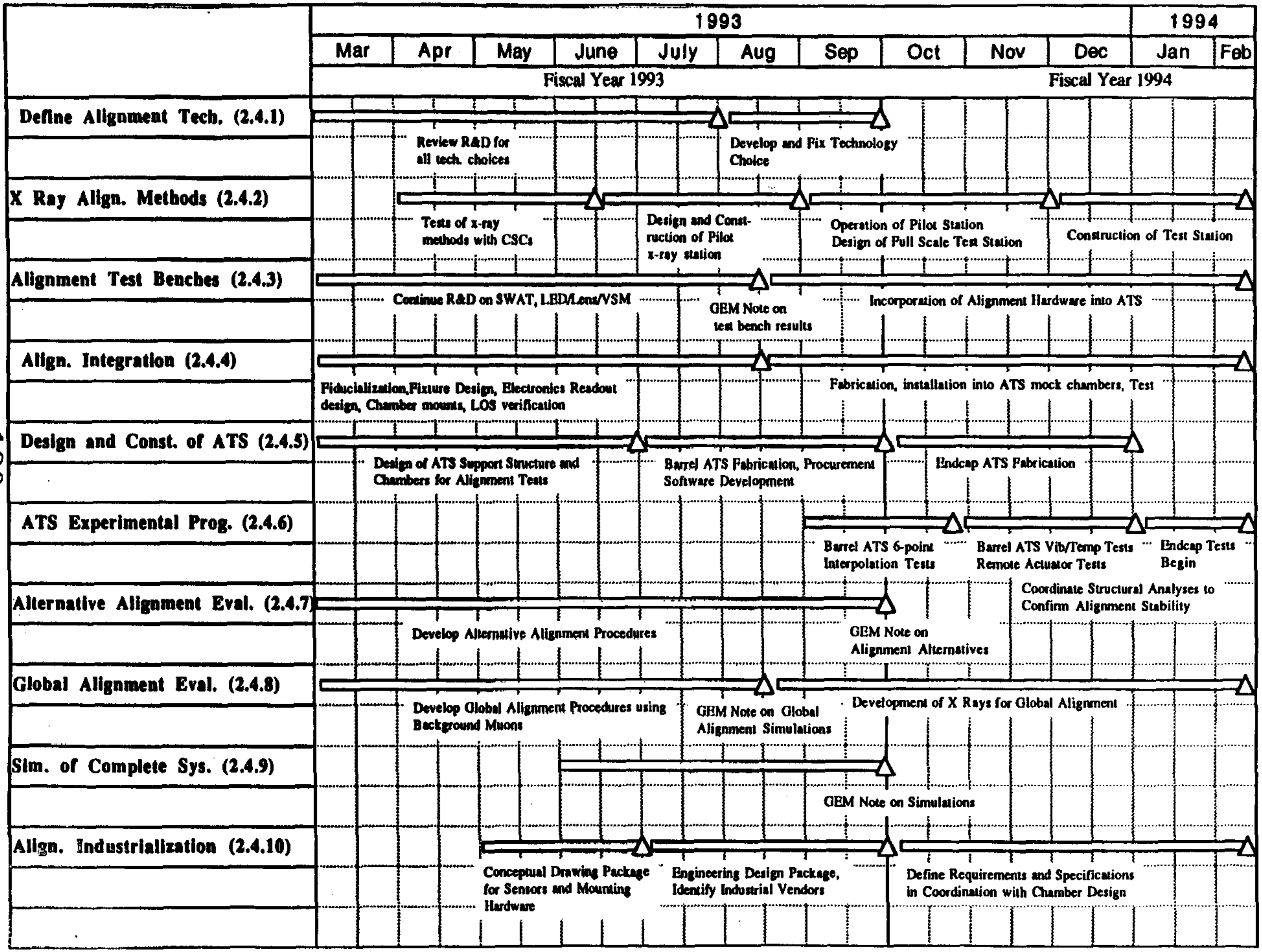
1. Fred R. Holdener and F. Curtis Belser, "Alignment Test Stand and Experimental Test Program Project Plan for SSC GEM Detector Muon Subsystem," May 21, 1993.

2. Li Dachen, "R&D (1993) of Alignment at Tsinghua University," April 30, 1993.

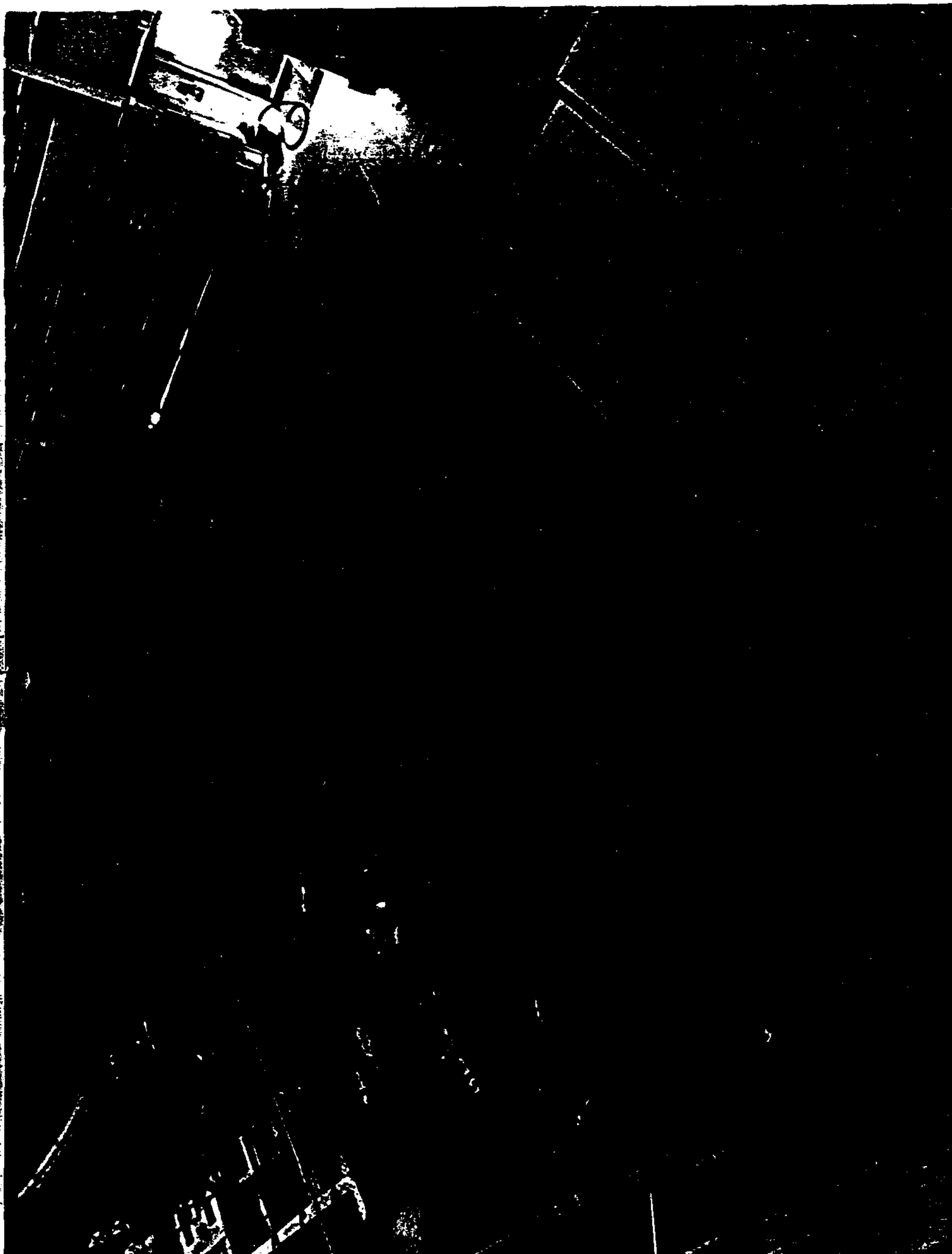
3. A. Vorobyov, et al., "X-ray Test Station for Cathode Strip Muon Chambers at SSCL, Technical Proposal," March 31, 1993.

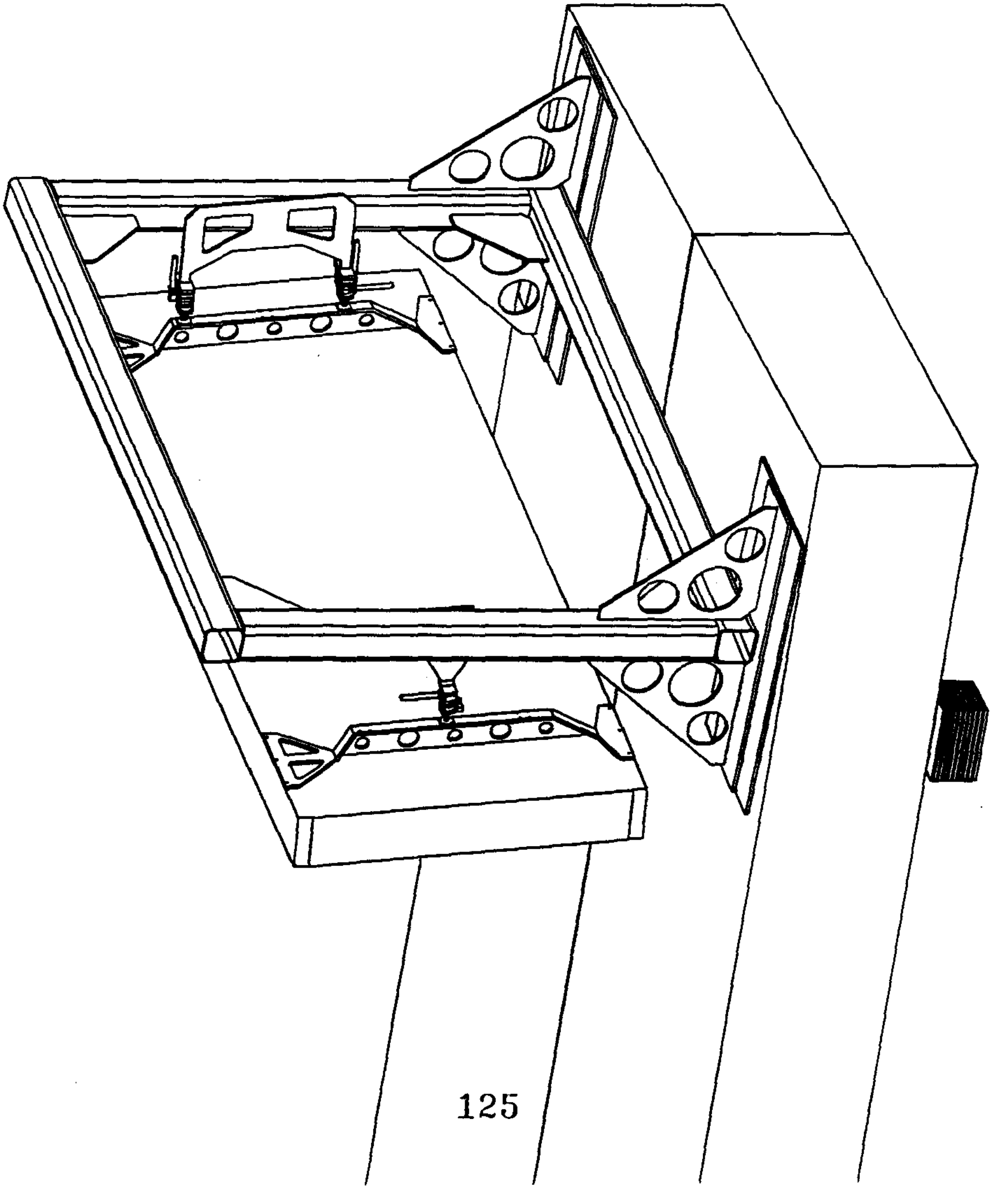
4. O. Prokofiev, et al., "Plans for R&D on GEM End Cap Muon Chambers for the Second Half of FY93," April 20, 1993.

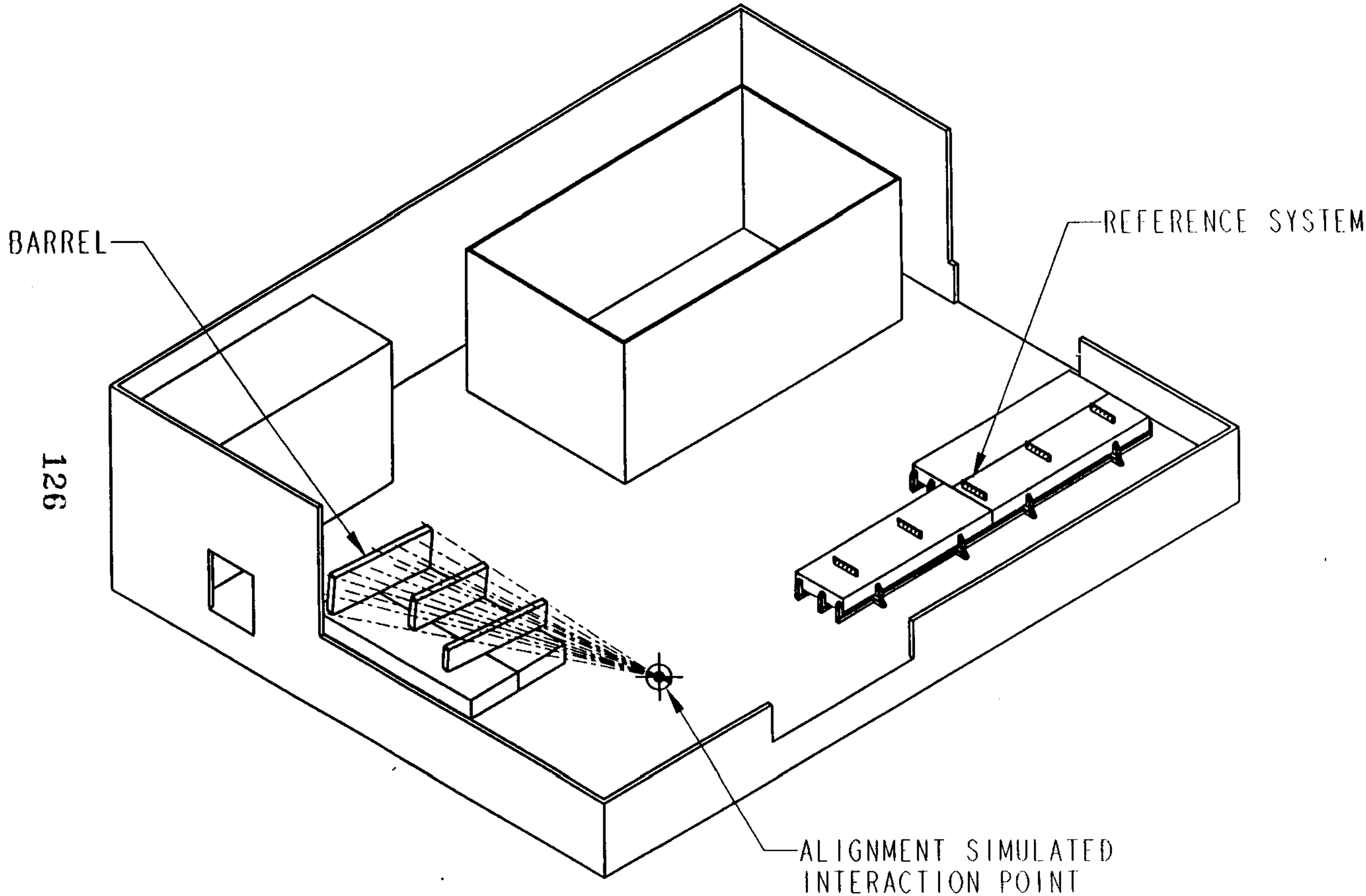
5. A. Vorobyov, et al., "GEM Global Alignment Test with X-ray Beams, Technical Proposal," April 3, 1993.

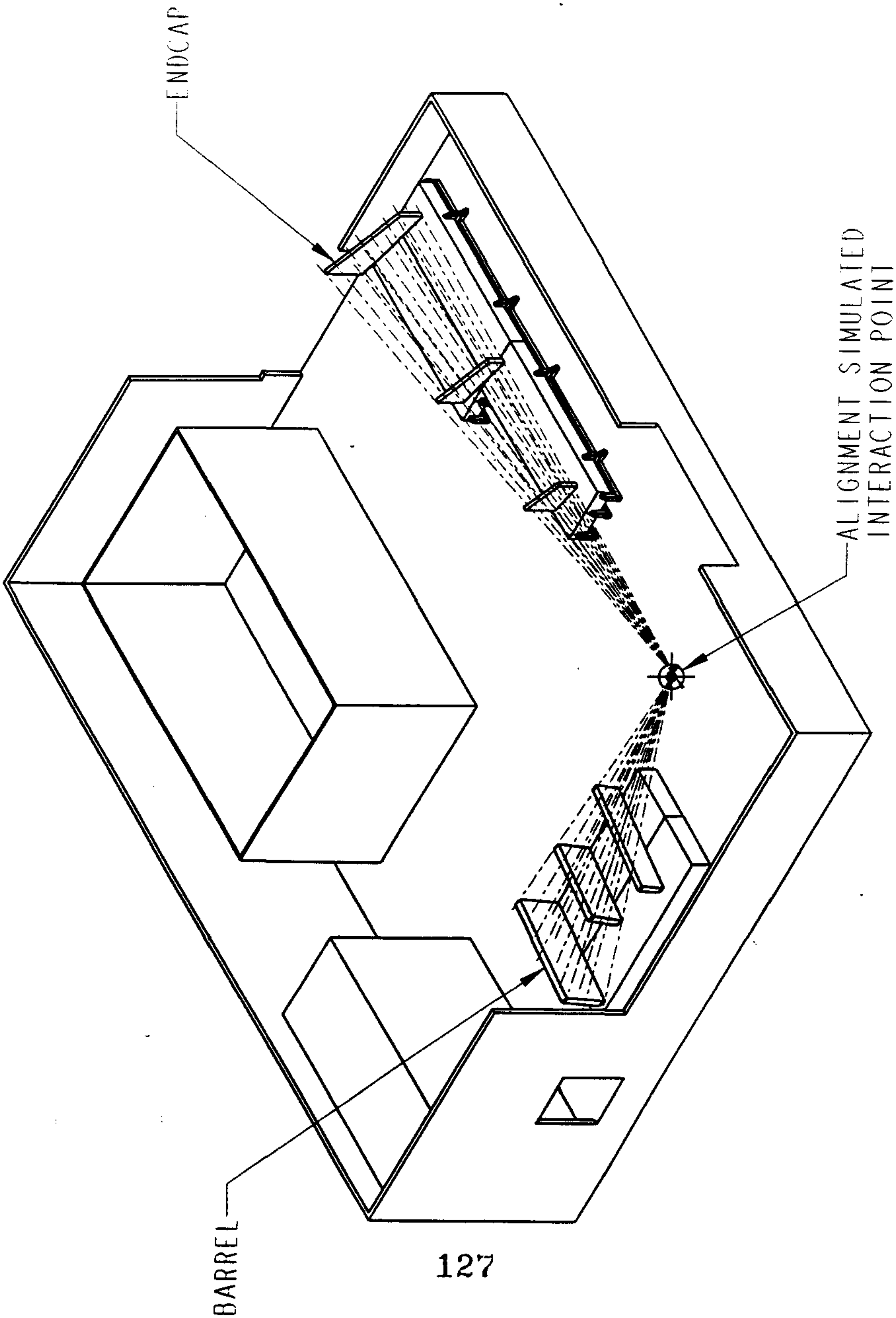


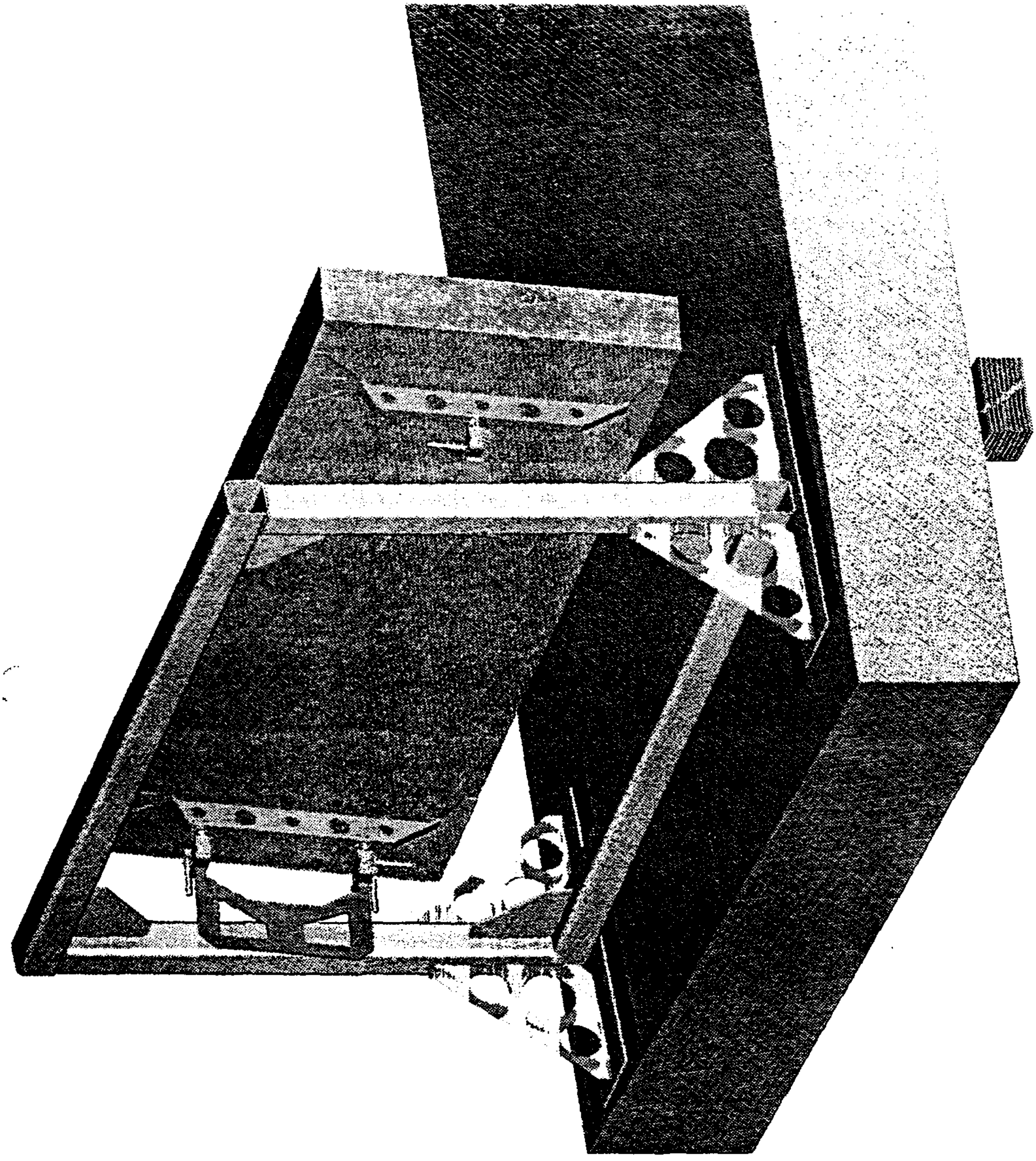
Wednesday, June 9, 1993






BARREL
REFERENCE SYSTEM
ALIGNMENT SIMULATED
INTERACTION POINT


ENDCAP
ALIGNMENT SIMULATED
INTERACTION POINT
BARREL



Alignment System R&D Program

ATS Experimental Plan

- Measure stability of alignment hardware for 3-point projective alignment scheme.
- Measure sensitivity of alignment hardware to temperature and atmospheric variations.
- Study procedures for installation of CSC mock chambers and chamber/structure interface hardware concepts.
- Study quadratic interpolation method by intentionally distorting chambers in controlled ways.
- Evaluation of remote actuator system, operation of remote position actuators and encoders, and development of alignment procedures.
- Vibration sensitivity measurement.
- Hardware optimization, including chamber interface hardware.
- Repeat tests for all straightness monitor technologies.

More Muon Alignment

24 x 24 mm

New Barcode

12 x 12 mm

Old Barcode

133

- New VSM Test Results
- New Gear for ATS DAQ
- More Implementation Analysis
  - Refined axial simulation

- J. Paradiso, SSCL, 6/30/93

PostScript Barcode Mask

24 x 24 mm

New Barcode

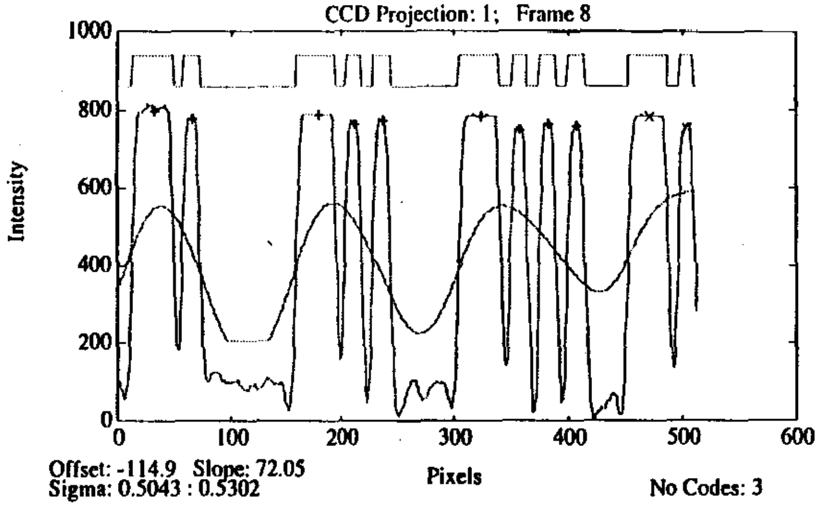
- Programmed in PostScript
  - Accurate to full printer resolution
- Binary-encoded digits
  - Width of number field and absence/presence of bar encodes digit
- Digits scrambled for uniform feature density

Precision Digital Gauge now used to automatically read scan position in Lab

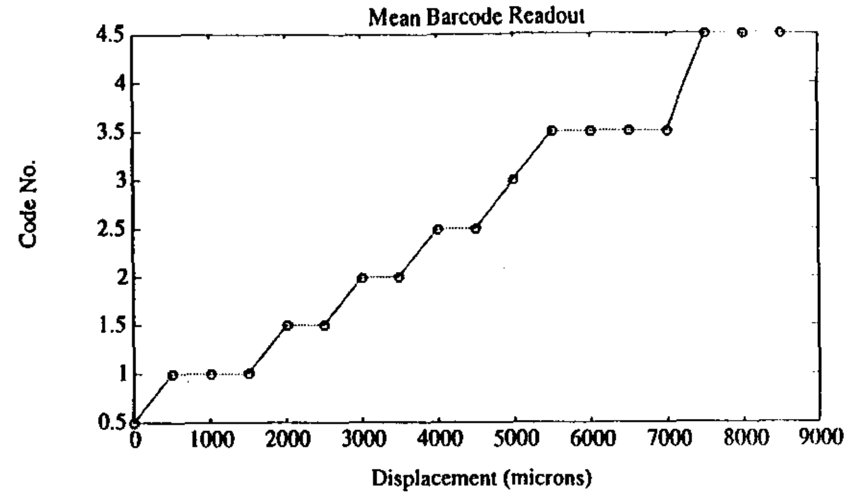
Lens position monitored

CCD Alignment System Performance; 1 cm scan, 500 μm intervals

9 meter optical baseline; 15 frames averaged at 1 Hz; simple monotonic barcode



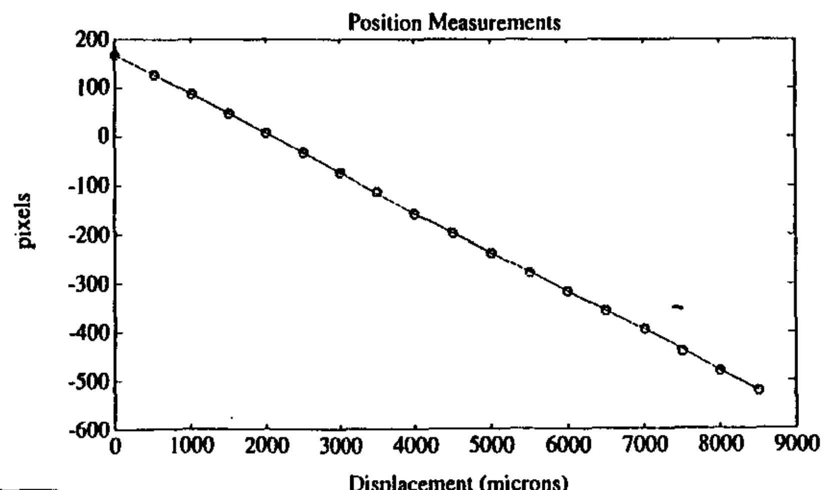
Sample data frame; X Projection



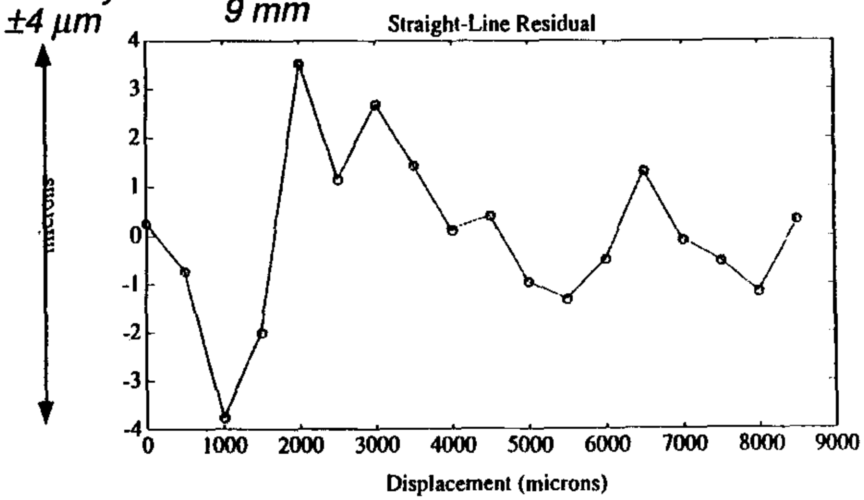
Average Barcode Digits

Accuracy: ±4 µm

Range: 9 mm



Measurement vs. Micrometer Position

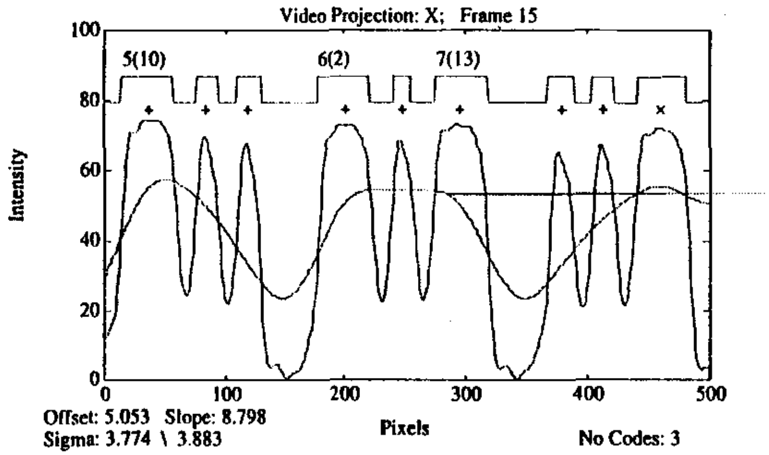


Deviation from Linearity

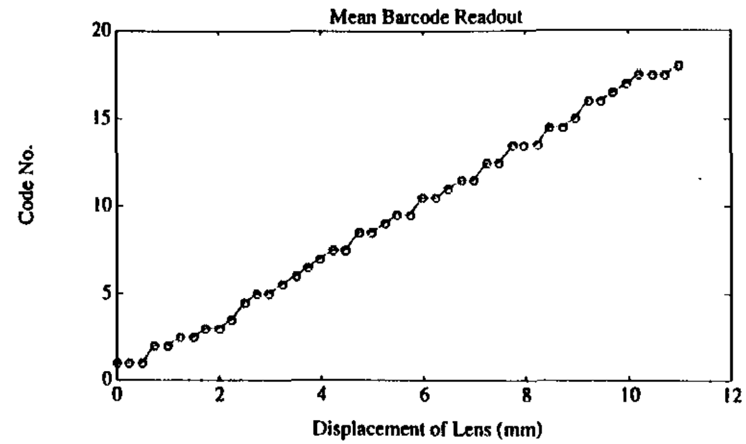
GEM

VSM Performance; 1.2 cm X-Coordinate lens scan, Chinon mini-çamera

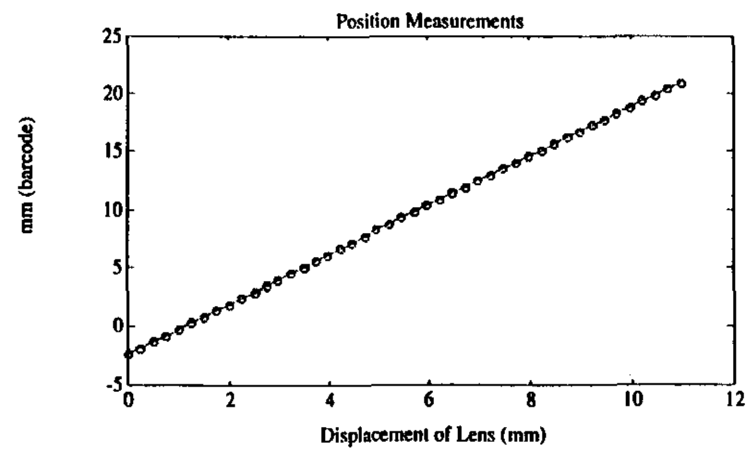
9 meter optical baseline; 15 frames averaged at 1 Hz; PostScript barcode



Sample data frame; X Projection

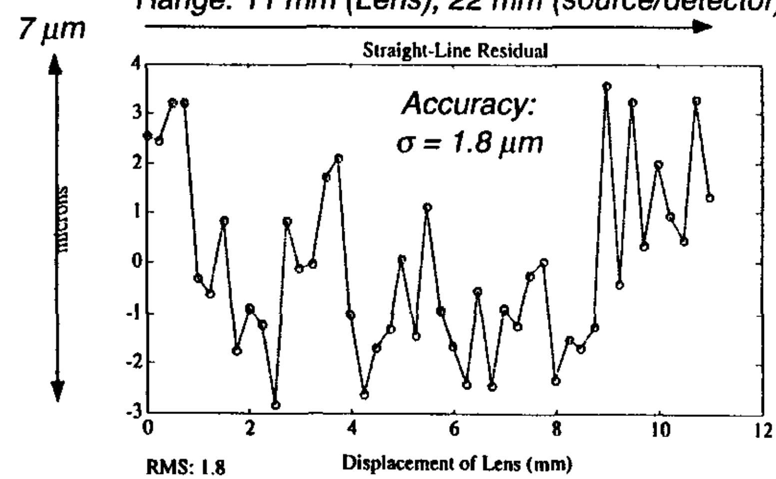


Average Barcode Digits



Measurement vs. Micrometer Position

Range: 11 mm (Lens), 22 mm (source/detector)



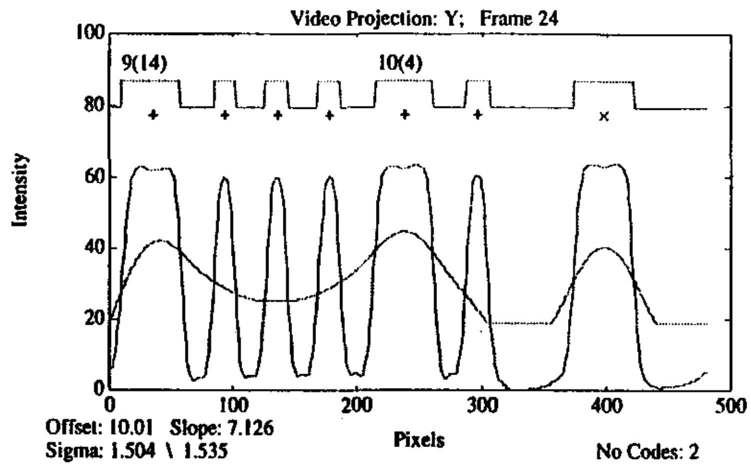
Deviation from Linearity

GEM

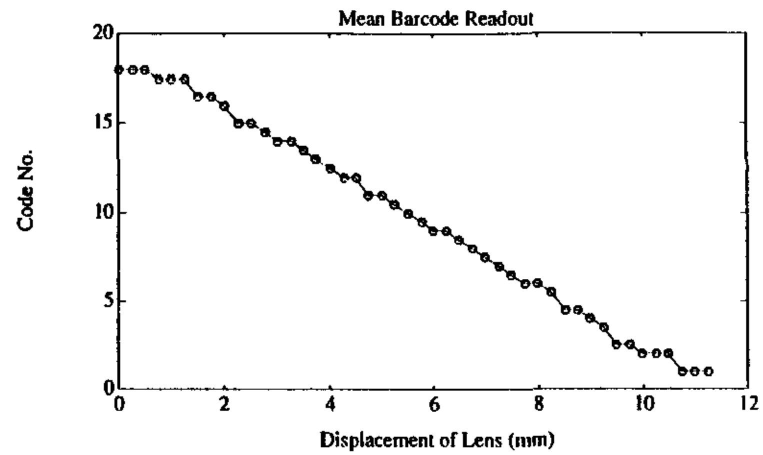
Note: Scale and Offset both determined in frame coordinate fits

VSM Performance; 1.2 cm Y-Coordinate lens scan, Chinon mini-camera

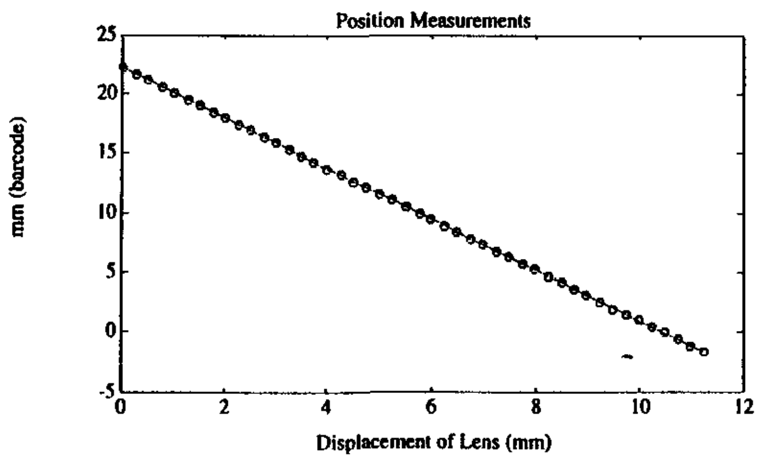
9 meter optical baseline; 15 frames averaged at 1 Hz; PostScript barcode



Sample data frame; Y Projection

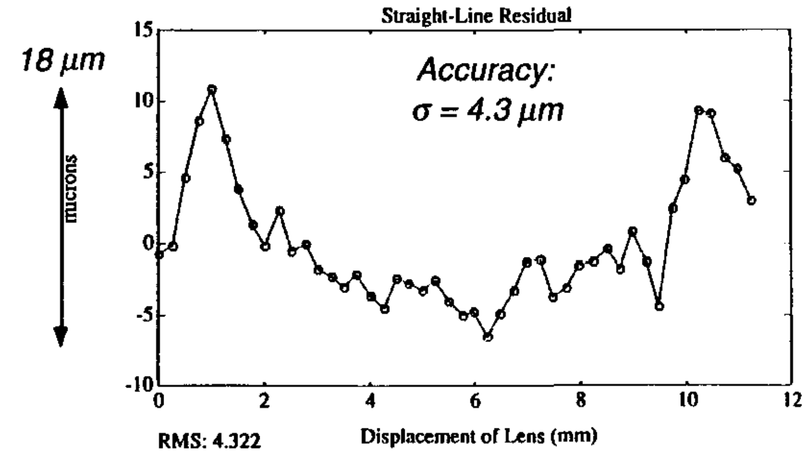


Average Barcode Digits



Measurement vs. Micrometer Position

Range: 12 mm (Lens), 24 mm (source/detector)



Deviation from Linearity

GEM

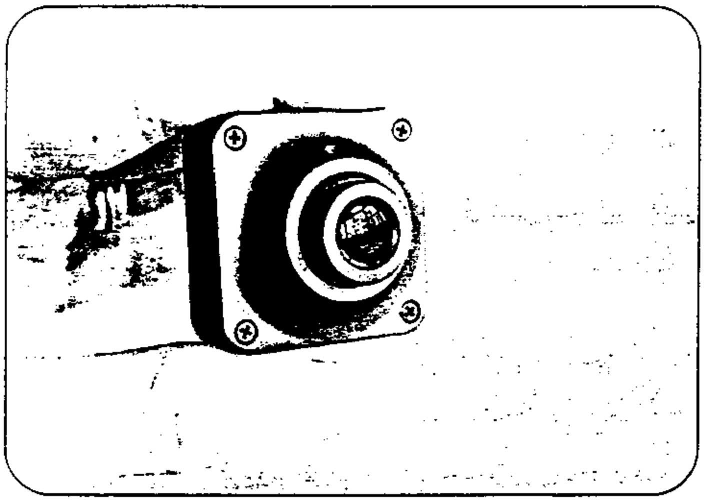
Note: Scale and Offset both determined in frame coordinate fits

>200 Units: Chip = £ 29.-
PCB = £ 9.-
Full Camera = £ 55.-

→ Can be made to work in B
→ Low-Noise Design

VVL

Meet the *Peach* video camera...



Peach is a different kind of 35mm camera; its external profile is 35mm square! This tiny technological miracle runs off a single DC supply, outputting a CCIR-compatible (625-line) monochrome video signal.

Peach features include:

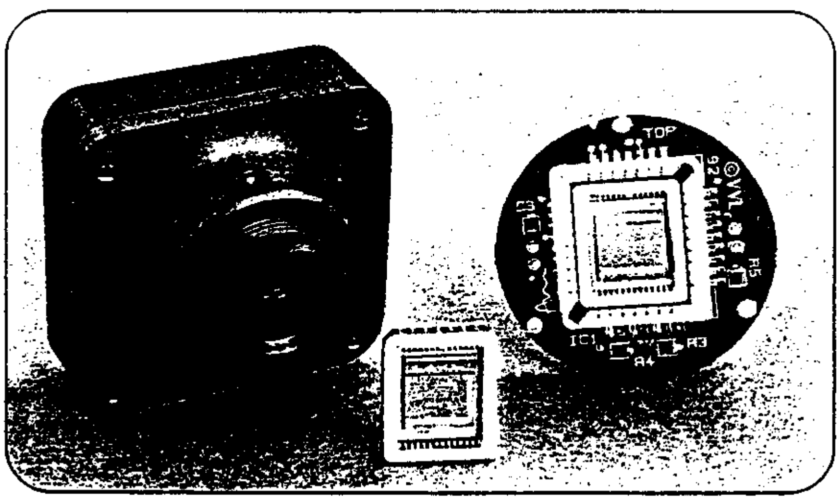
- 89,500 pixel resolution (312 x 287)
- electronic exposure and gain control
- operation down to 5 lux
- 78° field of view
- 40mA nominal supply current
- totally self-calibrating
- control in/out for digital video

Unprecedented integration of electronic vision function on a single CMOS silicon chip – *VVL's* ASIS-1011-B – means that ***Peach*** is completely self-calibrating, and capable of over 15 hours continuous operation from an alkaline PP3 battery. Along with a 1/2" format image sensor array, ASIS-1011-B includes the circuits which control and read the array, plus a comprehensive control input and output set for digital video applications.

Such versatility combined with amazingly low cost, size and power consumption makes ***Peach*** a juicy proposition indeed....

...and the ~~pip~~ chip inside!

Now OEMs can enjoy the cream of chip technology on which ***Peach*** is built. The ASIS-1011-B video camera chip is available by itself or mounted on an evaluation PCB. Developers of low-cost, low size and low-power vision applications, such as robot eyes, computer input devices or CCTV, need look no further than ASIS-1011-B for robust and flexible image sensing function.



Contact: VLSI Vision Ltd.
Aviation House
31 Pinkhill
Edinburgh EH12 8BD

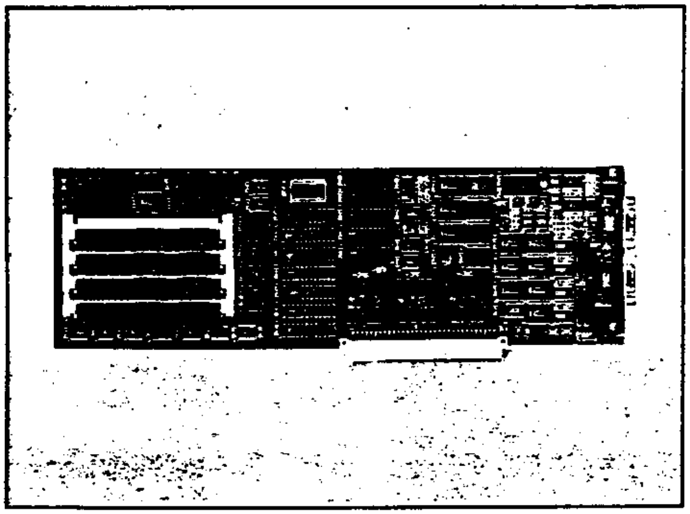
Telephone 031-539 7111
Facsimile 031-539 7140

Scion Corporation

$815.-
+$75. (Cckit kit)

1 unit does entire ATS!

LG-3



Features

- Low-noise 8 bit grayscale image digitizer
- Captures 640 x 480 frames in 1/30 of a second
- Expandable frame buffer — 1 MByte to 64 MBytes
- Captures complete frames or single fields
- Software control of range of digitization
- Up to 4 input sources — select sync from any source
- Analog and digital I/O capabilities
- Compatible with all Macintosh II or Quadra computers
- Supported by many popular image analysis packages
- Full 30 day money back guarantee of satisfaction

The LG-3 is a scientific quality frame grabber suitable for use with high end CCD cameras and other imaging equipment. Images are captured in 8 bit depth at a speed of 1/30 of a second. Image resolution is 640 x 480 pixels.

Images are captured to the LG-3's expandable on-board frame buffer. This buffer, expandable from 1 to 64 MBytes, is composed of standard Macintosh SIMM's for easy field upgrades. SIMM's 100 ns or faster may be used.

The LG-3 provides features which make it particularly suited for use by developers of custom configurations. Four TTL input lines and four TTL output lines are available for monitoring and controlling external events. Also provided are two analog outputs which may be varied from 0 to 5 Volts in 256 steps.

The LG-3 allows software control of gain and offset through control of the range of digitization. The digitized data may be modified using one of eight input look-up tables. Images are captured from one of four input sources, and the sync information may be selected from any of the input sources.

Full capturing flexibility is provided. Frames may be captured with either the even or the odd field first. Single fields may also be captured, with either the even or odd field specified. The LG-3 allows software to detect video information such as field status and vertical sync.

The LG-3 ships with a cable and a copy of the "Image" software package developed at the National Institutes of Health. In addition the LG-3 is supported by a variety of other third party image analysis packages.

Specifications

Digitizing Speed: 1/30 second
Pixel Depth: 8 bits
Image Resolution: 640 x 480 pixels
Pixel Aspect Ratio: 1 to 1

Capture Mode: field or frame
Initial Field: even or odd

Frame Buffer: 1 to 64 MBytes
Input Look-up Tables: 8
Input Sources: 4, AC coupled

Digital Inputs: 4 TTL level
Digital Outputs: 4 TTL level
Digitizing Range, Bottom: 0 to 2 Volts
Digitizing Range, Top: 0 to 2 Volts
Analog Outputs: 2, 0 to 5 Volts

Video Input Level: 1 Volt peak to peak
Video Signal Type: RS-170 or similar

Installation: 1 NuBus slot
Video Connector: 9 pin D shell
Utility Connector: 15 pin HD D shell

Operating Conditions : 0 to 70° C
Power: 12.5 Watts maximum

System Requirements and Support

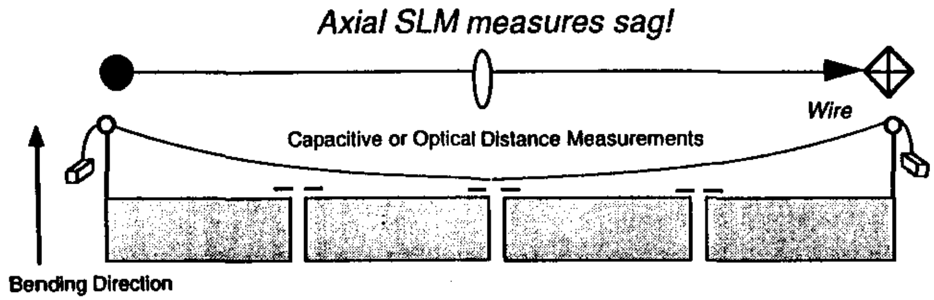
The LG-3 is compatible with all Macintosh II and Quadra family computers and may be used with grayscale video sources having RS-170 timing characteristics. It is designed for use with high-quality CCD imaging equipment, and as such incorporates no time base correction.

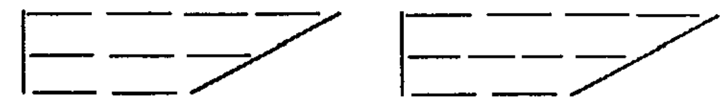
The LG-3 comes with a complete 30 day money back guarantee. The LG-3 is warranted against defects in materials and workmanship for a period of one year. An extended warrantee is available.

Scion Corporation

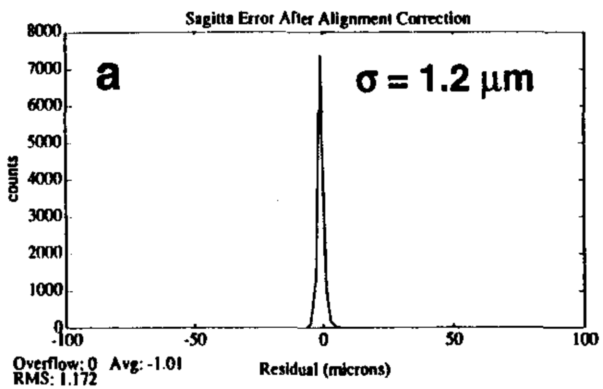
152 West Patrick Street Frederick, Maryland 21701
Tel: (301) 695-7870 Fax: (301) 695-0035 AppleLink: D1337

Hybrid Wire Monitors Revisited

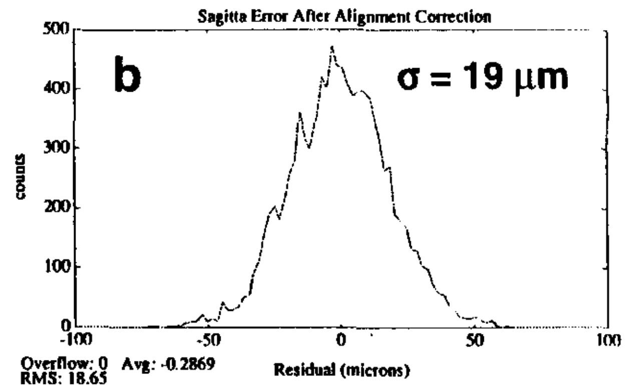




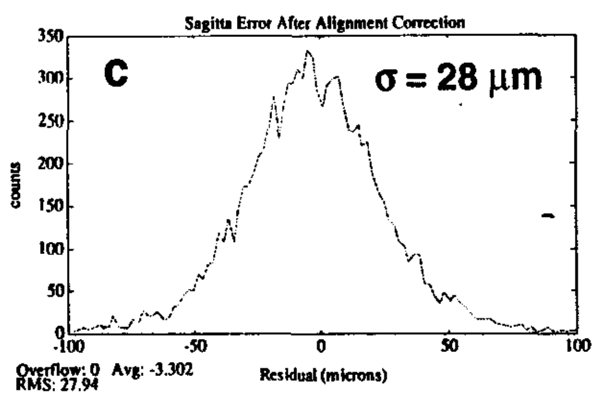
Note: BL1 Used **Not TDR**



Ideal; no SLM, Projectivity errors

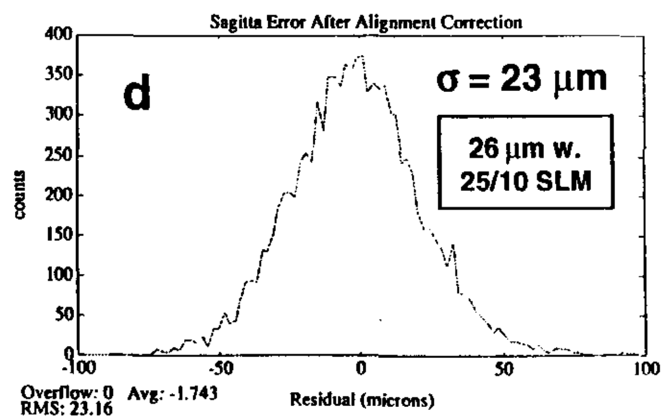


25/10 µm SLM, 15/10 µm wire, 10 µm handoff



Projectivity, Bunch smear, 60% ϕ spacing

Note:
300 µm Δy resolution produces little difference after other errors!

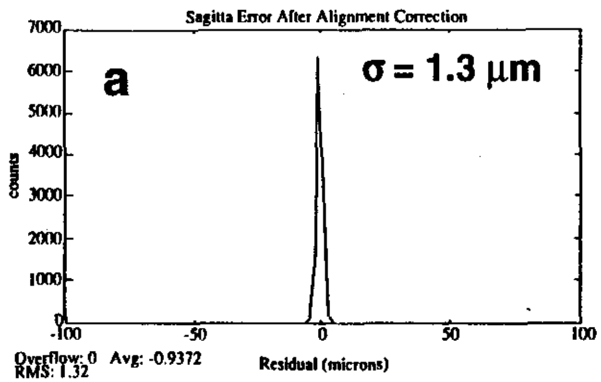


12/10 µm SLM, 10/5 µm wire

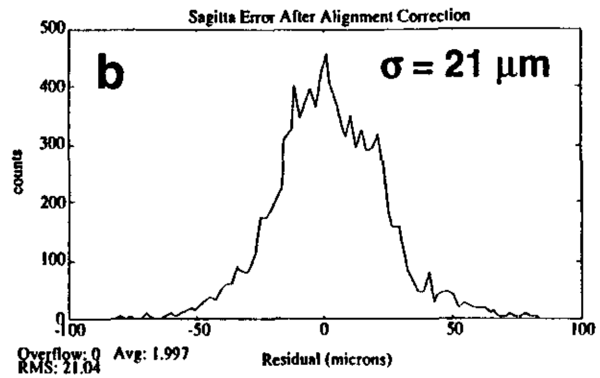
Hybrid Nested Optical Monitors Revisited

Again, BL1 not TDR!

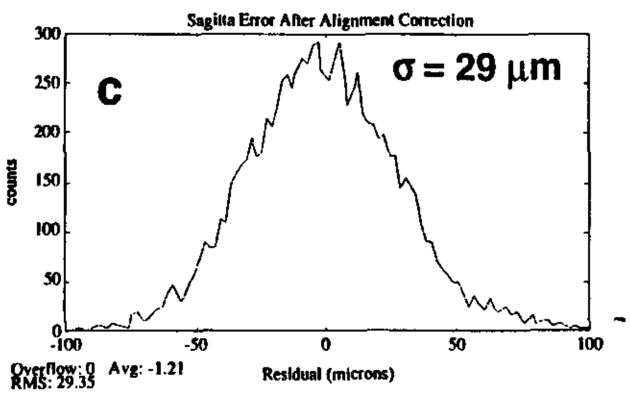
2 Sets of nested straight ness monitors for opposite corners



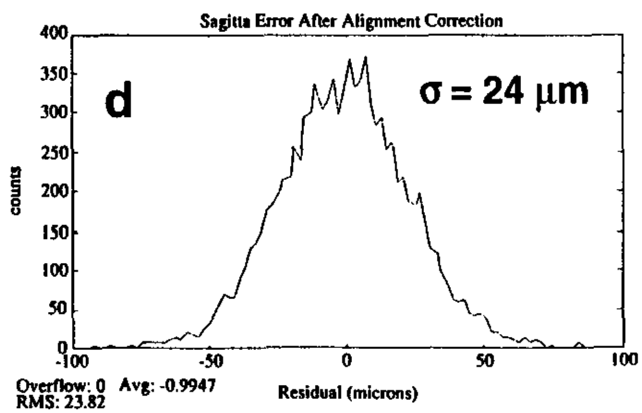
Ideal; no SLM, Projectivity errors



25/10 μm SLM 10 μm handoff



Projectivity, Bunch smear, 60% ϕ spacing



12/10 μm SLM

141

Endcap chambers alignment

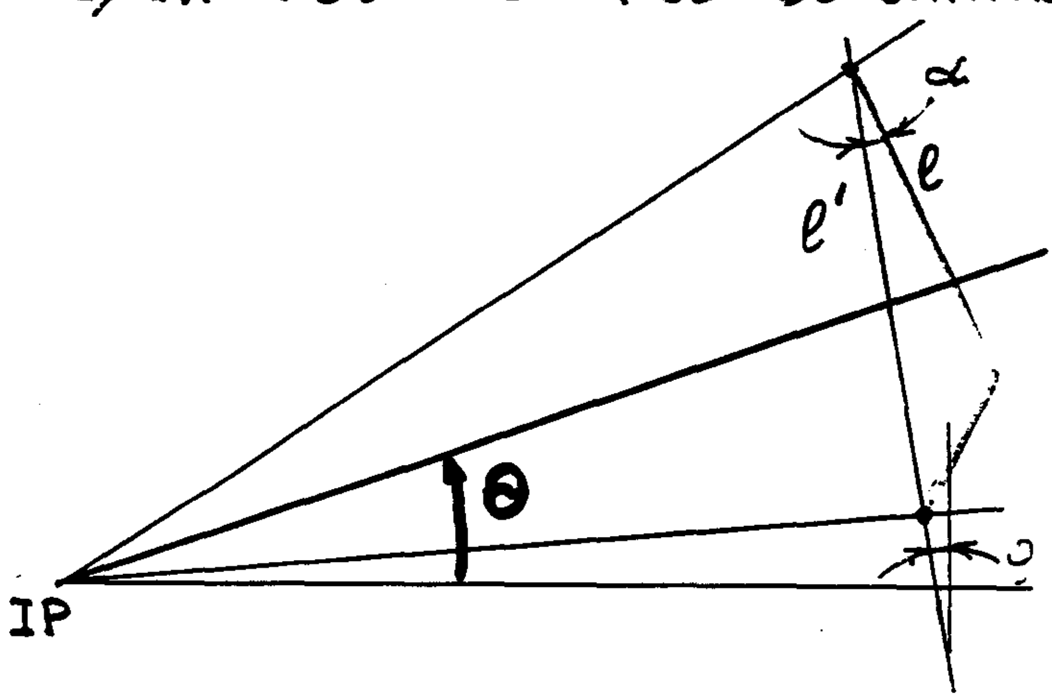
Differencies from BARREL:

- 5-point option
- Two chambers per SL

  Angle between the chambers is measured by planar monitors

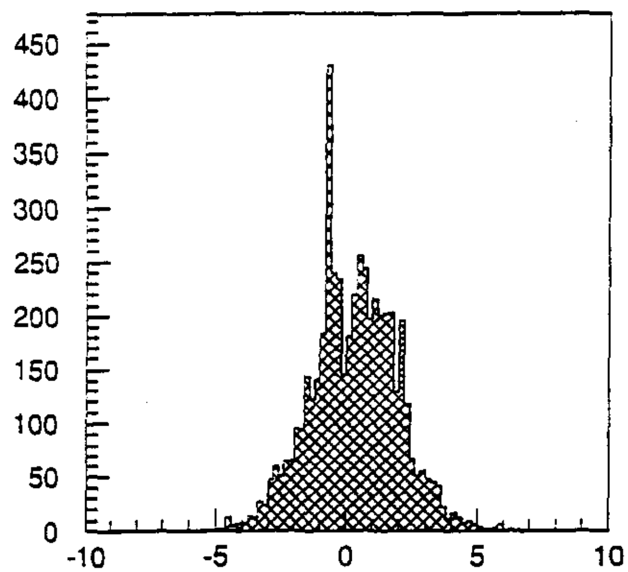
The false sagitta method assumes that chambers are flat ⇒

⇒ introduce "PSEUDO-CHAMBER FRAME"



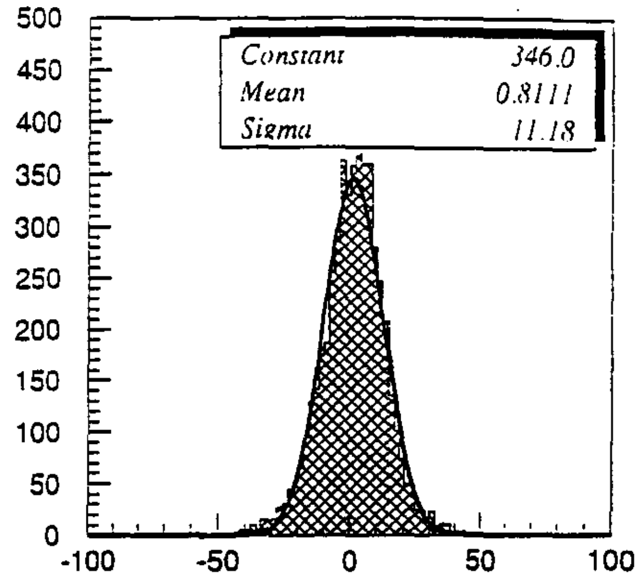
$$\ell' = \ell \cdot \left(1 + tg(\Theta + \varphi) \cdot \alpha\right)$$

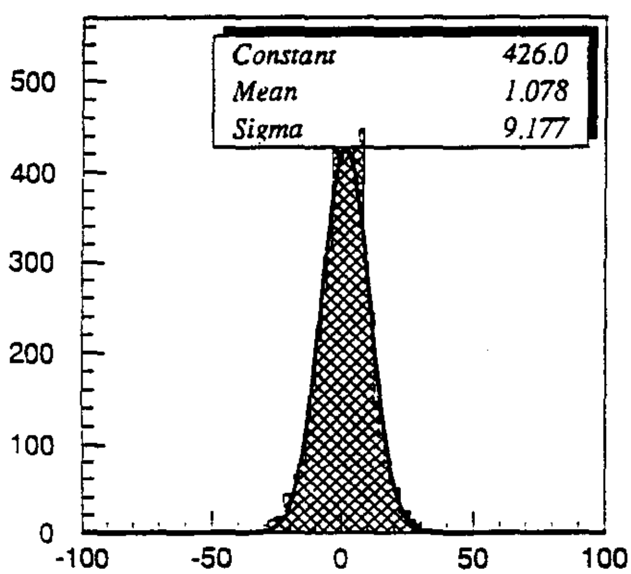
False sagitta



corrected saggita

5-point option

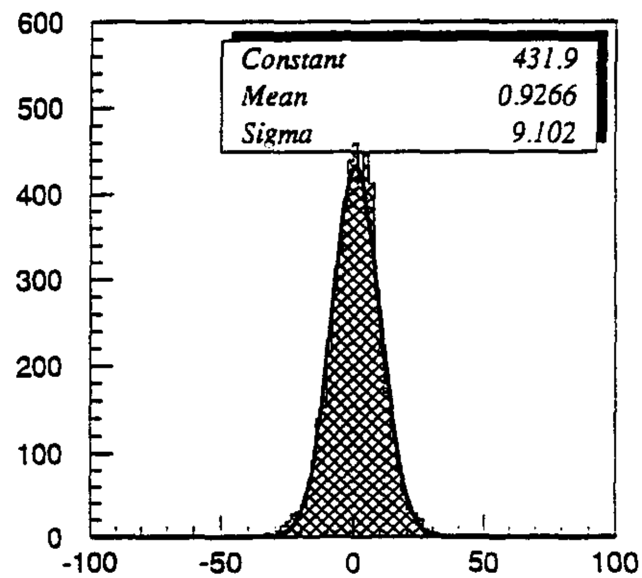




corrected saggita

5-point option with

planar correction

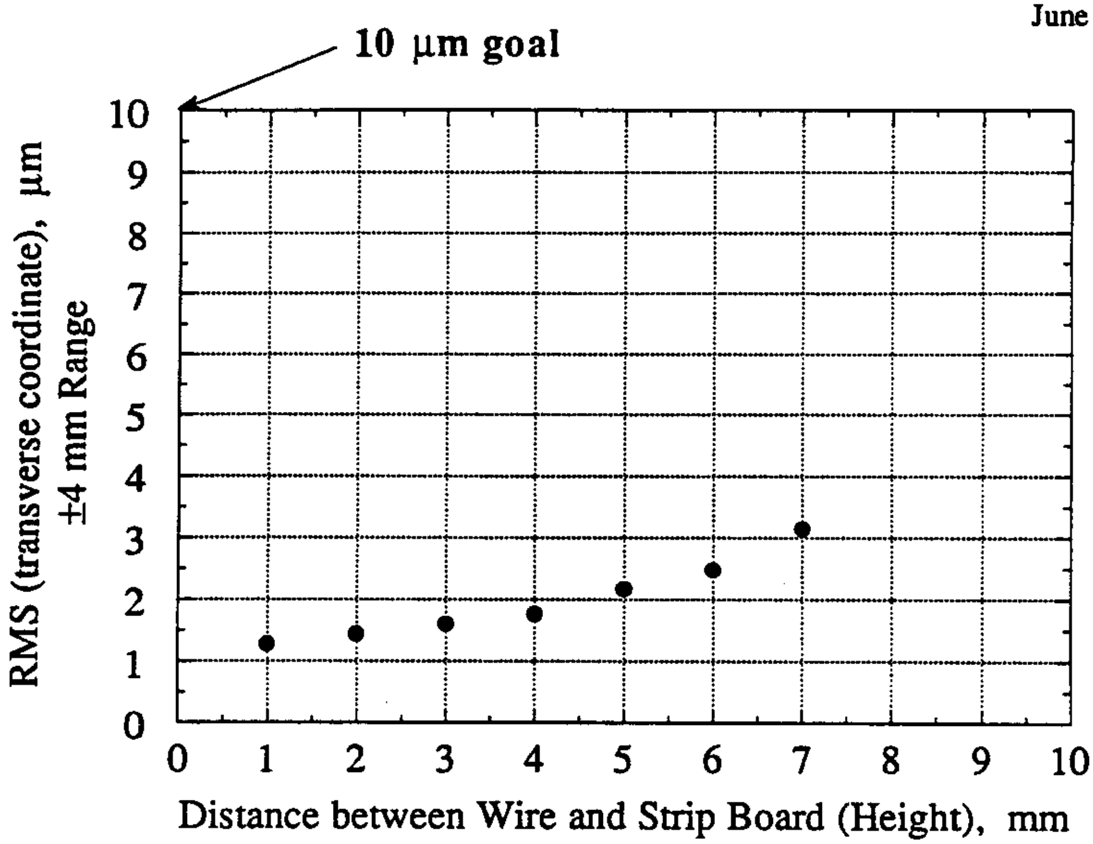


corrected saggita

only shifts and rotations

RESULTS OBTAINED WITH 11 (1 mm wide) STRIPS

June 24, 1993



A. Korytov

Modular Barrel vs Integrated Monolith

- Structure assembly (barrel)
- Chamber Insertion (barrel)
- Chamber Insertion (endcap)
- Monolith Assembly (barrel/endcap)
- Installation
- Commissioning
- Coverage
- Structure Performance

Structure assembly (barrel)

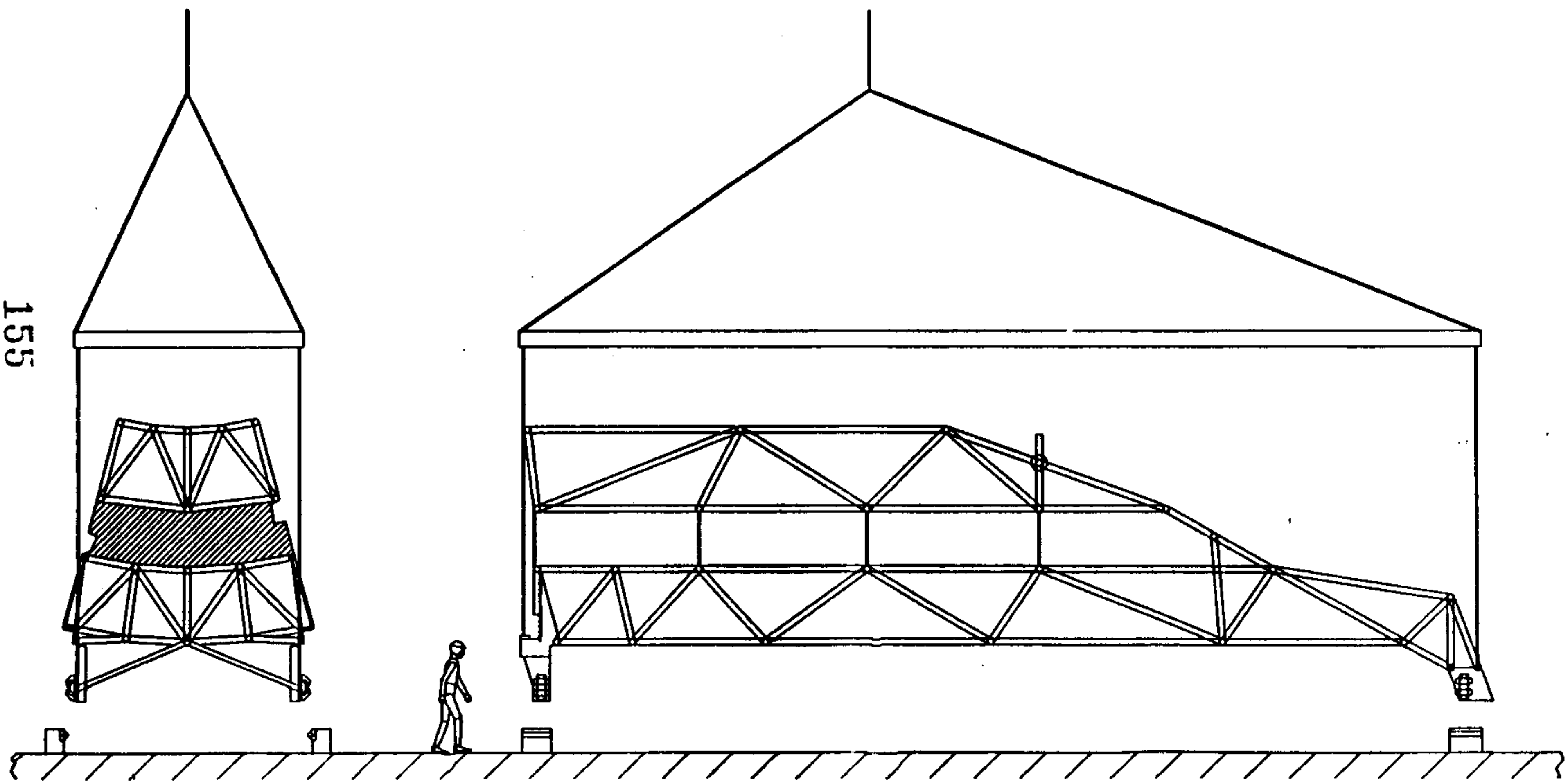
gem γeμ

MODULAR

- Module concept permits the complete assy of structure associated with a three-layer measurement unit
- Module structure can be fully evaluated before insertion of chambers.

INTEGRATED MONOLITHIC

- Integrated monolith has elements of reticulated shells and diaphragms as the subassemblies which are then merged into full shells and diaphrams,(still no complete structure!)
- Optimized structure creates assembly differences in the various subassemblies whose effects will not be evaluated until completion of the major assemblies.



ASSEMBLED BARREL MODULE STRUCTURE

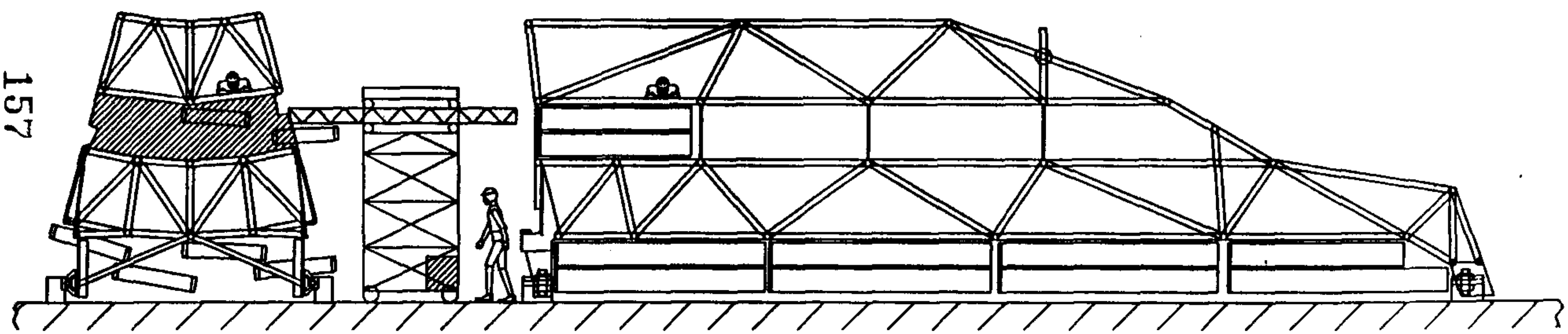
Chamber Insertion (barrel)

MODULAR

- Modular design permits easy access for all three layers to insert chambers into fully assembled modular structure
  - All three layers that make up a measurement unit can be inserted with simple fixtures at relatively low elevations. (repeatable, easily measured and verified).
  - Requires several size chambers to be available to complete module assembly.
  - Barrel module is complete and commissionable!!

INTEGRATED MONOLITH

- Chambers are installed in layers a process where the structures are rotated about a large shaft to permit repeatable and simple installation process.
- Process requires that chambers for specific layers be available in adequate numbers to complete major assemblies.



ASSEMBLY OF CHAMBERS
INTO
SUPPPORT STRUCTURE

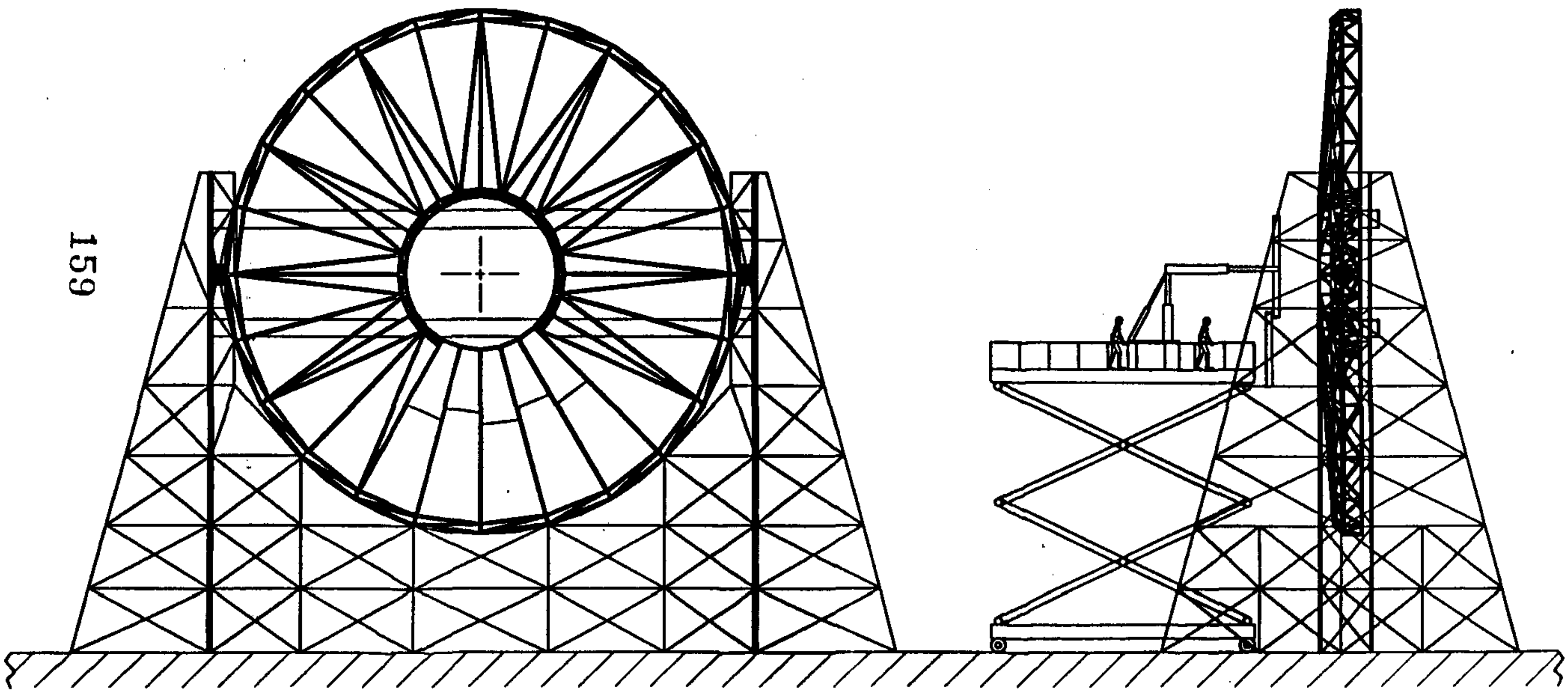
Chamber Insertion (endcap)

Modular endcap (three wheel assemblies)

- Support Structure is assembled before insertion of chambers
- Three wheel assemblies allow simple insertion of chambers on both sides of wheel structure
- Wheel assemblies do require fixturing for stabilization during the insertion process
- Services can be attached by the layer rather than the three-layer grouping. Same as Integrated Monolith.
- Chamber insertion done in NAB.
- Installation "Staged" should be much faster than IM

Integrated Monolith

- Chambers are either inserted in the middle of the assembly of integrated structure or in a slightly more difficult procedure relative to the Modular Endcap.
- Option exists for install chambers through the structure in the underground hall.
- Option requires separate chambers radially (BETTER CHAMBER STRUC TURE)

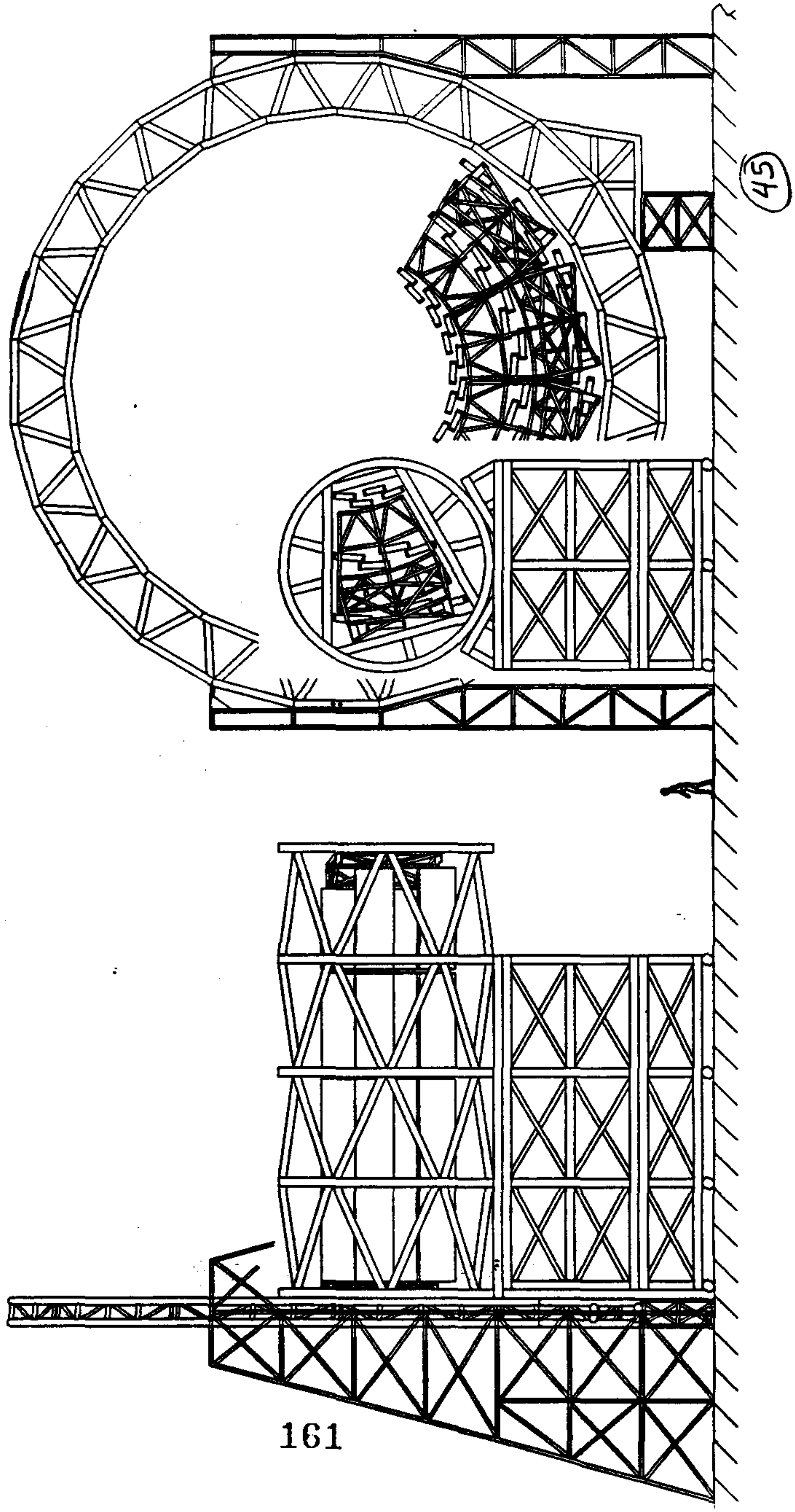


ASSEMBLY OF CHAMBERS
INTO
OUTER SUPERLAYER

Monolith Assembly (barrel/endcap)

MODULAR

- Barrel Monolith requires two end support rings and fixturing to complete assembly of the twelve modules into an monolithic barrel structure.
- Local alignment,IF MAINTAINED IN ASSY.,offer significant advantage (R&D on prototype should resolve issue).
- Assembly merges prealigned modules with two preassembled and braced end ring support structures.
- Individual modules can still be adjusted as an assembly after all 12 modules per monolith assembly have been inserted and the support rings are deformed in their final configuration.
- Endcap monolith is assembled in NAB, installation is planned using the FFS as a transport tool to insert endcap into barrel, transfer load and connect with barrel to merge structures.


45

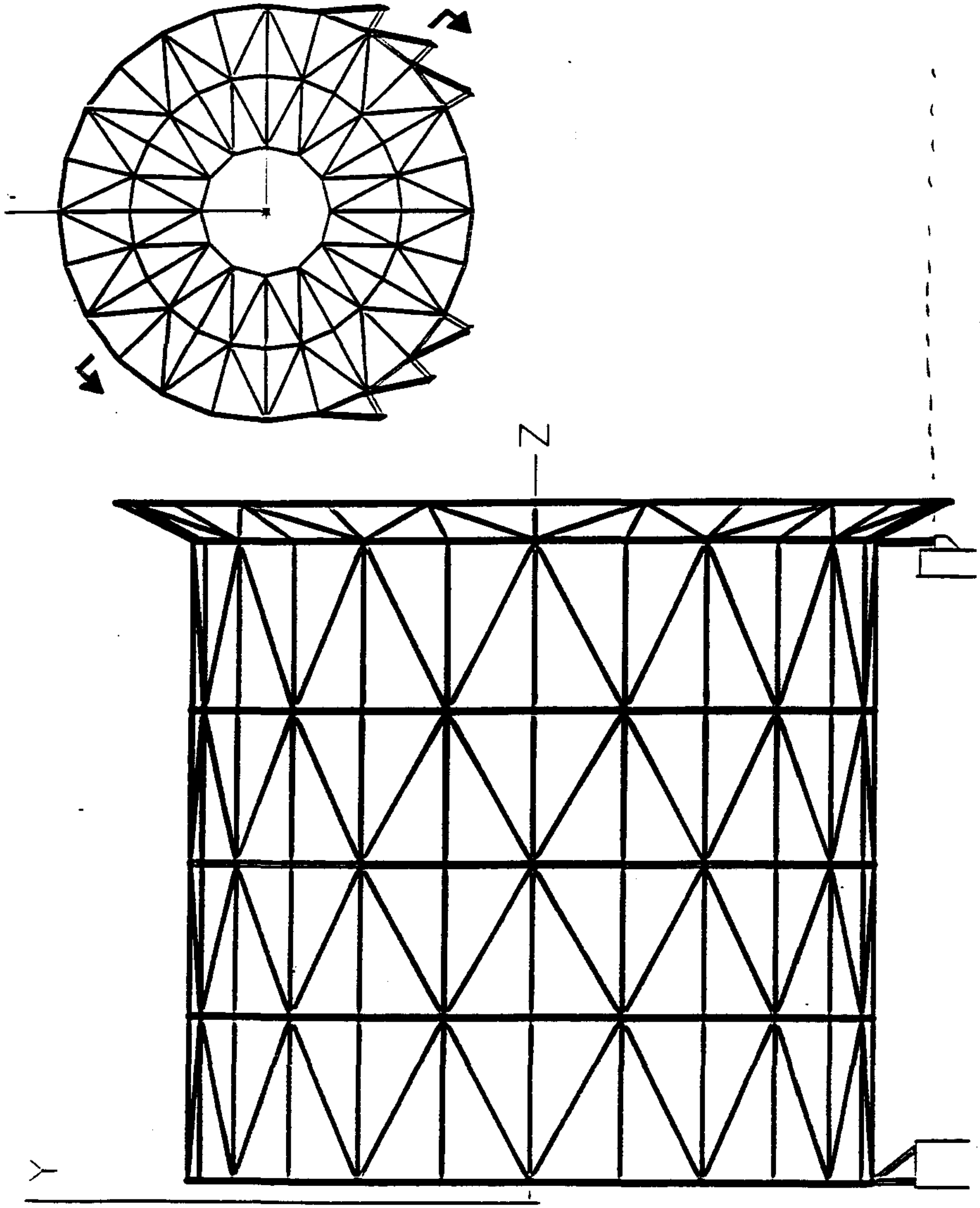
Installation

MODULAR

- Options exist to install either a barrel monolith followed by a completed endcap later or as a complete assy.
- FFS Ring requires no additional structure for installation (Unified Monolith appears to need extensions for installation)
- Z-restraint does not sacrifice coverage for this function as in the the case of the IM concept.
- Z-Restraint used by "IM" could be partially used at the same loss of chamber coverage as for the "IM" concept.
- EITHER Z-RESTRAINT WILL PROBABLY WORK WITH EITHER STRUCTURE!!

INTEGRATED MONOLITH

- Essentially the same concept of installation.
- Z-restraint chops off 6-12 chambers on the CDS end
- Unclear how installation actually can be done with the present rail concept (APPEARS TO NEED HARDWARE TO PROVIDE TEMPORARY ATTACHMENTS ON FFS END OUT BEYOND THE STRUCTURE THAT HOLDS SL3 ENCAP CHAMBERS IN ORDER TO GET TO A RAIL WHICH WOULD CLEAR THIS STRUCTURE DURING INSERTION!)



Supports for Muon Subsystem Structure

Commisssioning

MODULAR

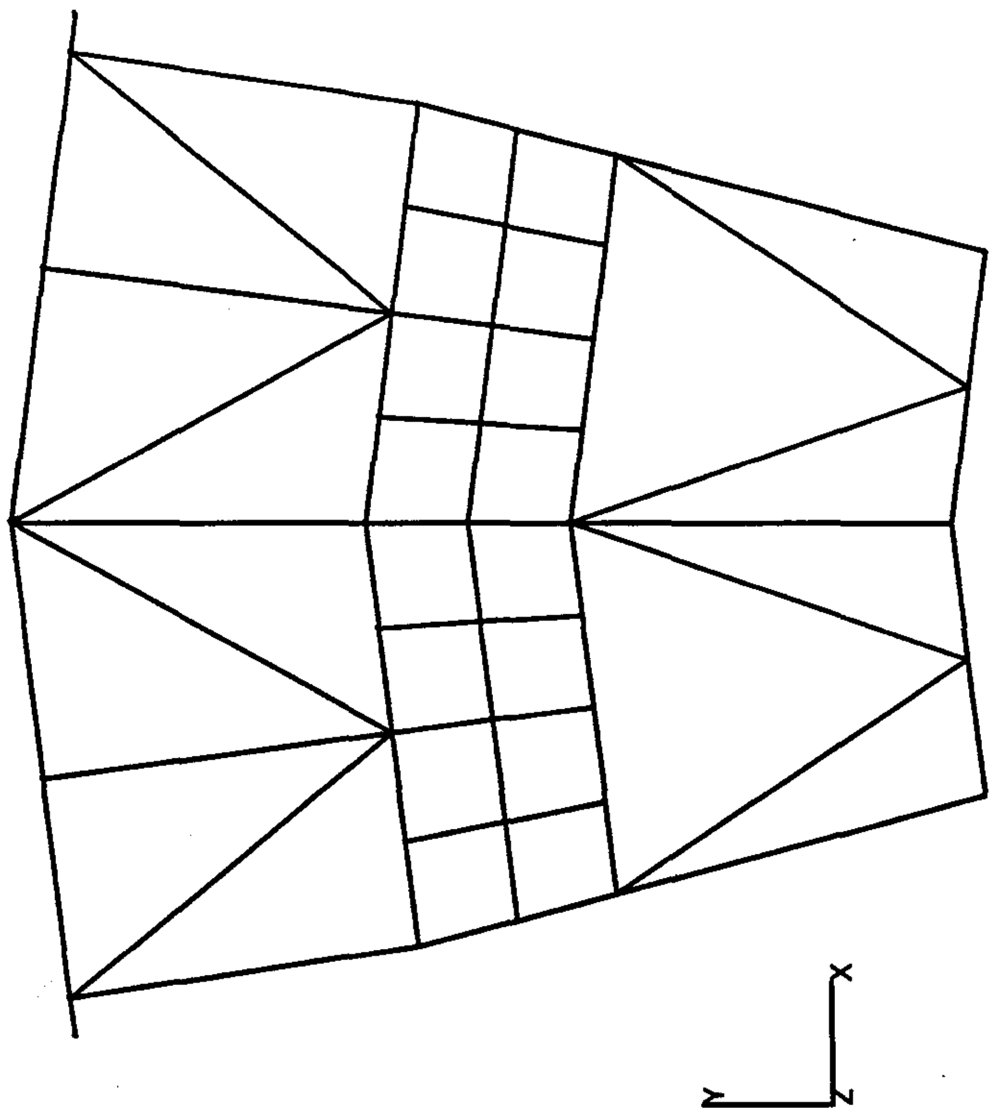
- Modules are essentially commissioned at the module level along with addtional checkout time during the Monolith Assembly phase. These are complete system checkouts up to the final manifold and junction boxes.
- Final commissioning should be limited to the final connections of cables to the magnet mounted service junction boxes.

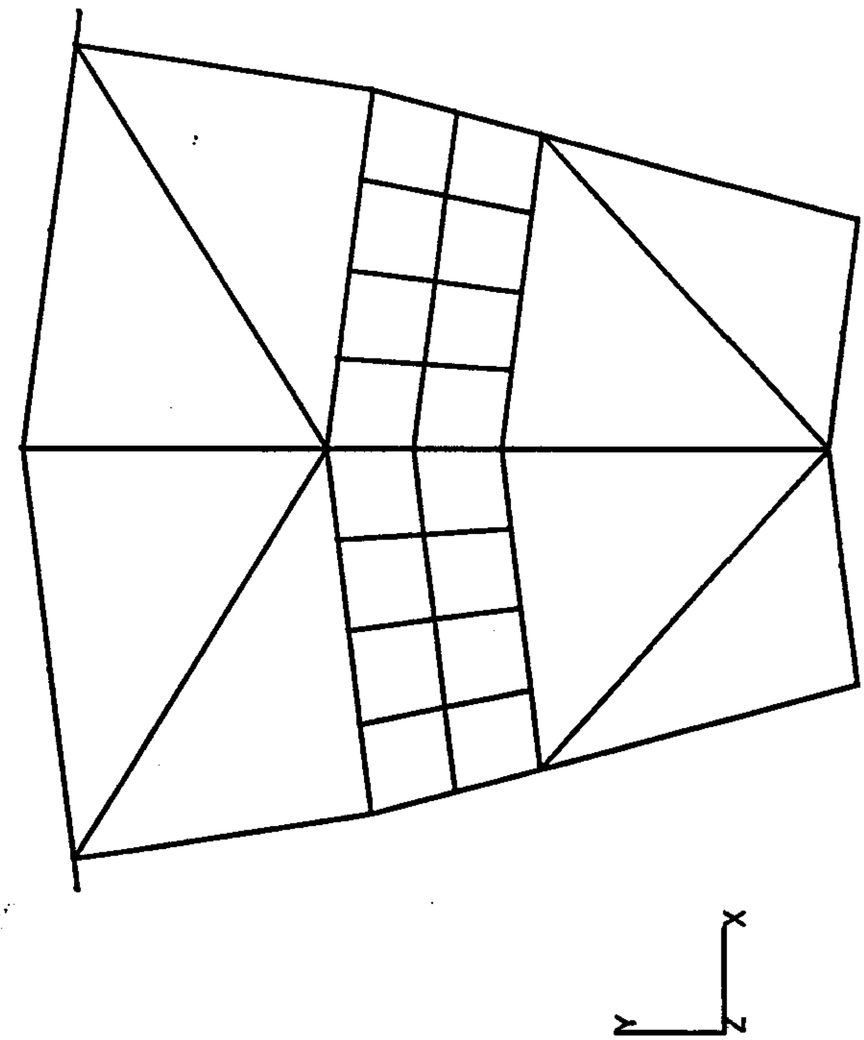
INTEGRATED MONOLITH

- Commissioning can perhaps be initated as the chambers are attached to the various superlayers(similar to the situation of the endcap monolith in the modular concept)
- Evaluation of entire three-layer measurement units cannot start until the unified monolith is completely assembled.

ACCESS

- EITHER THE IM OPTION OR A AN OPTIMIZED MODULAR WILL PROVIDE VERY SIMILAR SPACE FOR ACCESS. REAL ACCESS PROBLEM IS PLACEMENT OF SERVICABLE ITEMS ON CHAMBERS SO THAT THEY CAN BE REACHED FROM THE VARIOUS STRUCTURE SITES.


X
Y
Z


X
Y
Z

Coverage

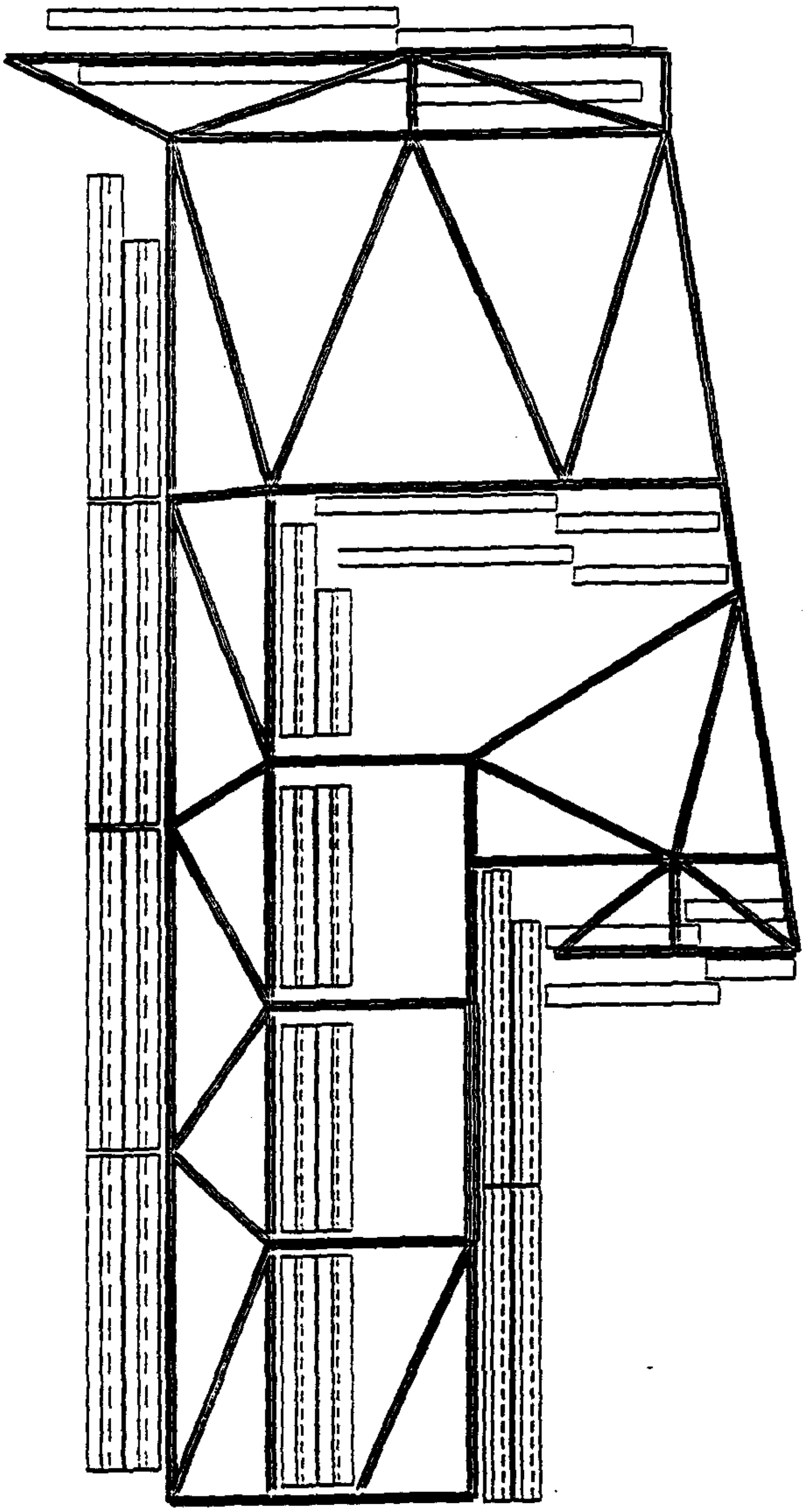
gem γeμ

MODULAR

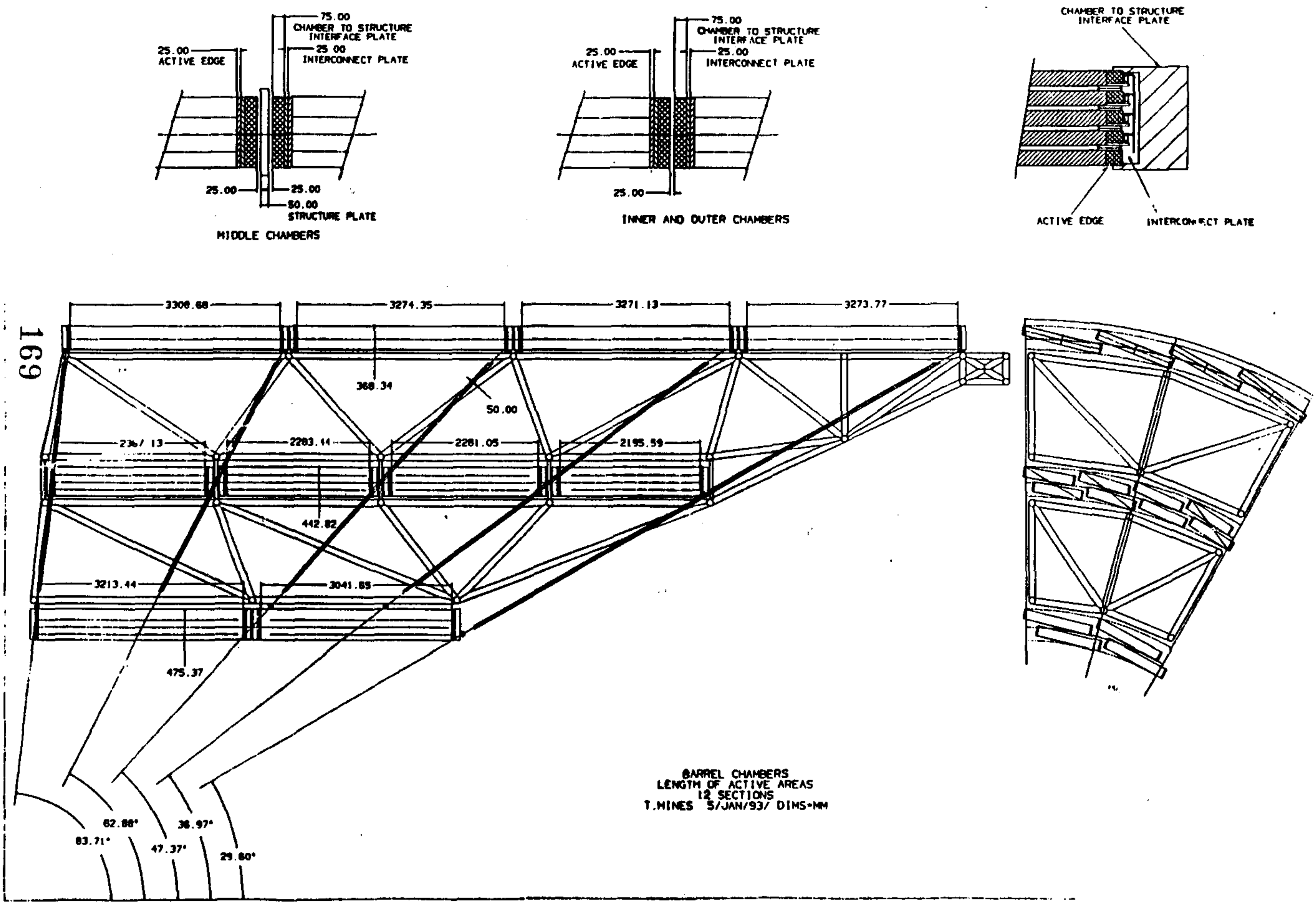
- Gap at 30° must allow for at least the structure in the barrel plus two alignment lines of sight (best is 1.4°) ← Middle Layer of chambers
- Gaps in barrel must allow for passage of plate structure between chamber ends (50mm total 25 mm structure plus 25mm per side for clearance)

INTEGRATED MONOLITH

- Gap at 30° can be as small as 0.5° ← ?
- Similar restriction to Modular in barrel for MIC1 concept
- Barrel gaps in MIC2 concepts can be reduced by another 25 mm from the Modular concept.



Quadrant Elevation View of MIC1 Muon Subsystem Structure


75.00
CHAMBER TO STRUCTURE INTERFACE PLATE
25.00
INTERCONNECT PLATE
25.00
ACTIVE EDGE
25.00
25.00
50.00
STRUCTURE PLATE
MIDDLE CHAMBERS
75.00
CHAMBER TO STRUCTURE INTERFACE PLATE
25.00
INTERCONNECT PLATE
25.00
ACTIVE EDGE
25.00
INNER AND OUTER CHAMBERS
CHAMBER TO STRUCTURE INTERFACE PLATE
ACTIVE EDGE
3308.68
3274.35
3271.13
3273.77
368.34
50.00
2283.14
2281.05
2195.59
442.82
3213.44
3041.85
475.37
62.88°
83.71°
47.37°
36.97°
29.60°
BARREL CHAMBERS
LENGTH OF ACTIVE AREAS
12 SECTIONS
T.MINES 5/JAN/93/ DIMS=MM

Structural Performance

- **Material in the detector**

  Modular Structure (TDR) in detector (65300 Kg.)

  Expected Structure Mass Full Optimized (49000 Kg.)

  Integrated Monolith Structure mass (37000 Kg., MIC1)

  Uniformity of Mass with Phi (good with Modular)

  Uniformity of Mass for Unified Monolith is limited by optimization of support structure.

- **Random vibration performance**

  Presentation of integrated Monolith utilized lower PSD input than was used to evaluate the TDR muon support structure.

  When TDR structure is excited with same base motion PSD as used for Integrated Monolith, TDR response is smaller than that of IM even comparing the MIC1 structure.

- **Is performance still going to be the "TOP DOG" of evaluation criteria?**

- **WHAT ARE THE IMPORTANT CRITERIA? WHAT ARE THE RELATIVE RATINGS??**

Complete Muon Chamber Support Structure

- Vibration Performance
  - Natural Frequency
  - Random Vibration

	First Nat'l Freq.	# Modes under 20 Hz	Random Vib Response (Barrel Monolith) • 1 milli g RMS	Random Vib Response (Barrel Monolith) • Magnet Supports
TDR Design	**2.36 Hz**	**68**	**2.4 µm**	**25.0 µm**
SGH Design	**5.0 Hz**	**-**	**12.4 µm**	
TDR Design w/8 Z constraints used by SGH	**3.92 Hz**	**50**	**1.9 µm**	**23.4 µm**

Muon System Weights

gem

Barrel Mass Summary

• Barrel Module Structure	4274 Kg.
• FFS Support Ring	14700 Kg.
• CDS Support Ring	5455 Kg.
• Barrel Module (w/chamb)	11000 Kg.
• *Barrel Structure (modules TDR, half)*	*51300 Kg.*
• *Barrel Structure (modules Opt,half)*	*38500 Kg.*
• Barrel Structure (half)	73400 Kg.
• Barrel Region (w/chamb, half)	152200 Kg.
• *Barrel Structure (SGH Mono)*	*37000-42000Kg.*

Endcap Mass Summary (half)

• Structure Mass (half)	14000Kg.
• Total Mass (w/chamb, half)	40300 Kg.
• Outer Wheel (struct/total)	4000 / 18350 Kg.
• Middle Wheel (struct/total)	2100 / 9900 Kg.
• Inner Wheel (struct/total)	1100 / 5200 Kg.
• Outer/Middle Structure	4650 Kg.
• Middle/ Inner Stucture	1650 Kg

Total Struct. Mass in detector (MOD/TDR) 65300 Kg.
(Optimized MOD barrel, same endcap) 52500 Kg.
(Optimized MOD barrel and endcap) 49000 Kg.
SGH IM Min. 37000 Kg.
(25% less than Optimized MOD version)

M. MAN...
6/29/93

Comparison of TDR Structure with SGH Monolith

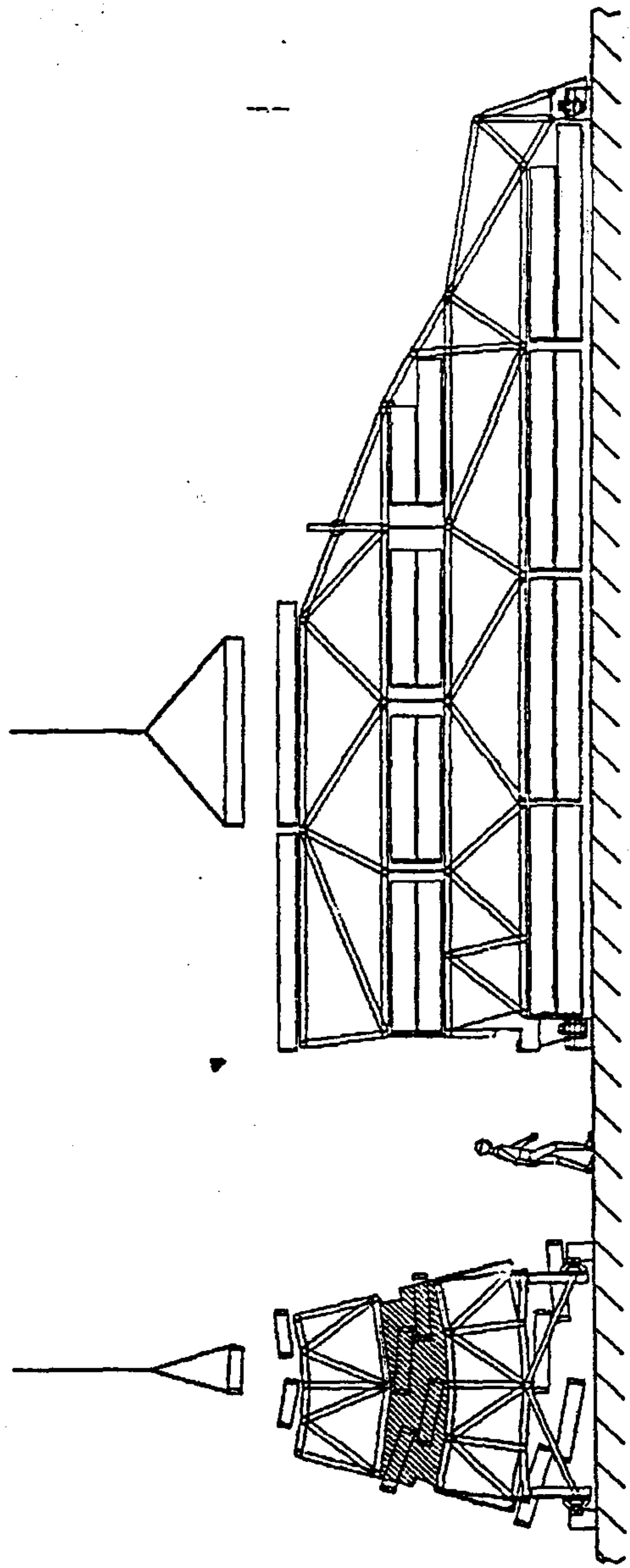
TDR	SGH
Separate End/Barrel	Integrated End/Barrel Structure
Built of Modules/Wheels	Monolith
Joined as Little as Required	Joined as Completely as Possible
Chambers Installed/Commissioned in Module	Chambers Installed into Monolith
Stage by Installing Complete End	Stage by Installing Chambers
Chamber Support at Nodes	Support Between Nodes

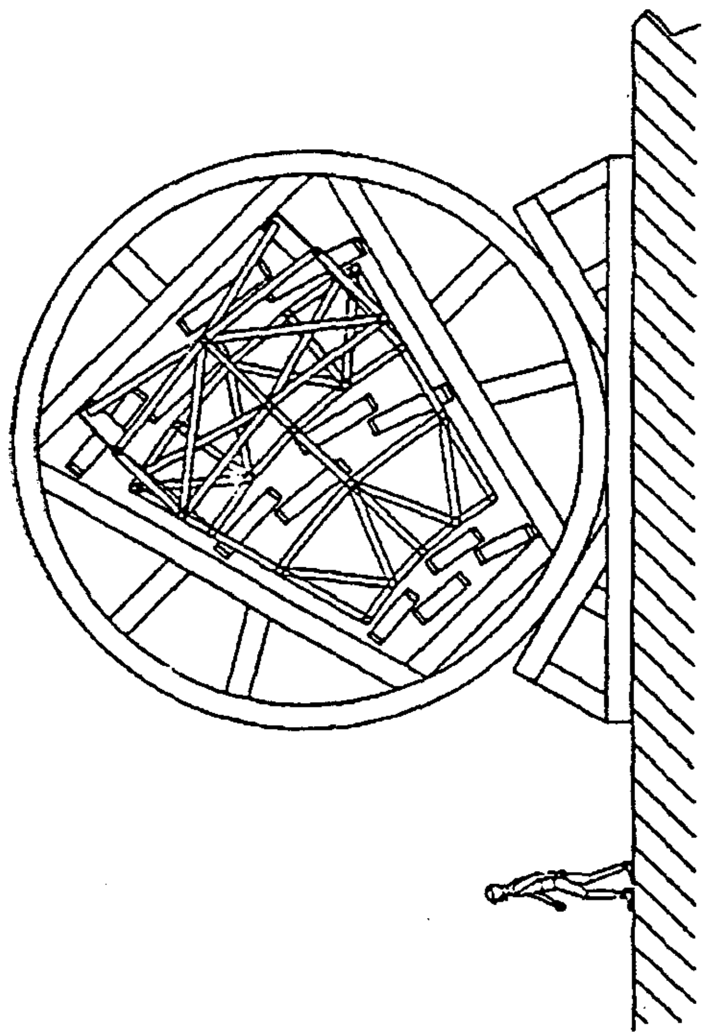
TDR Structure

+	−
Access to chambers during install	End/Barrel Gap
Modules commissioned	End Support
Prototypability	More Material
	Tight Access

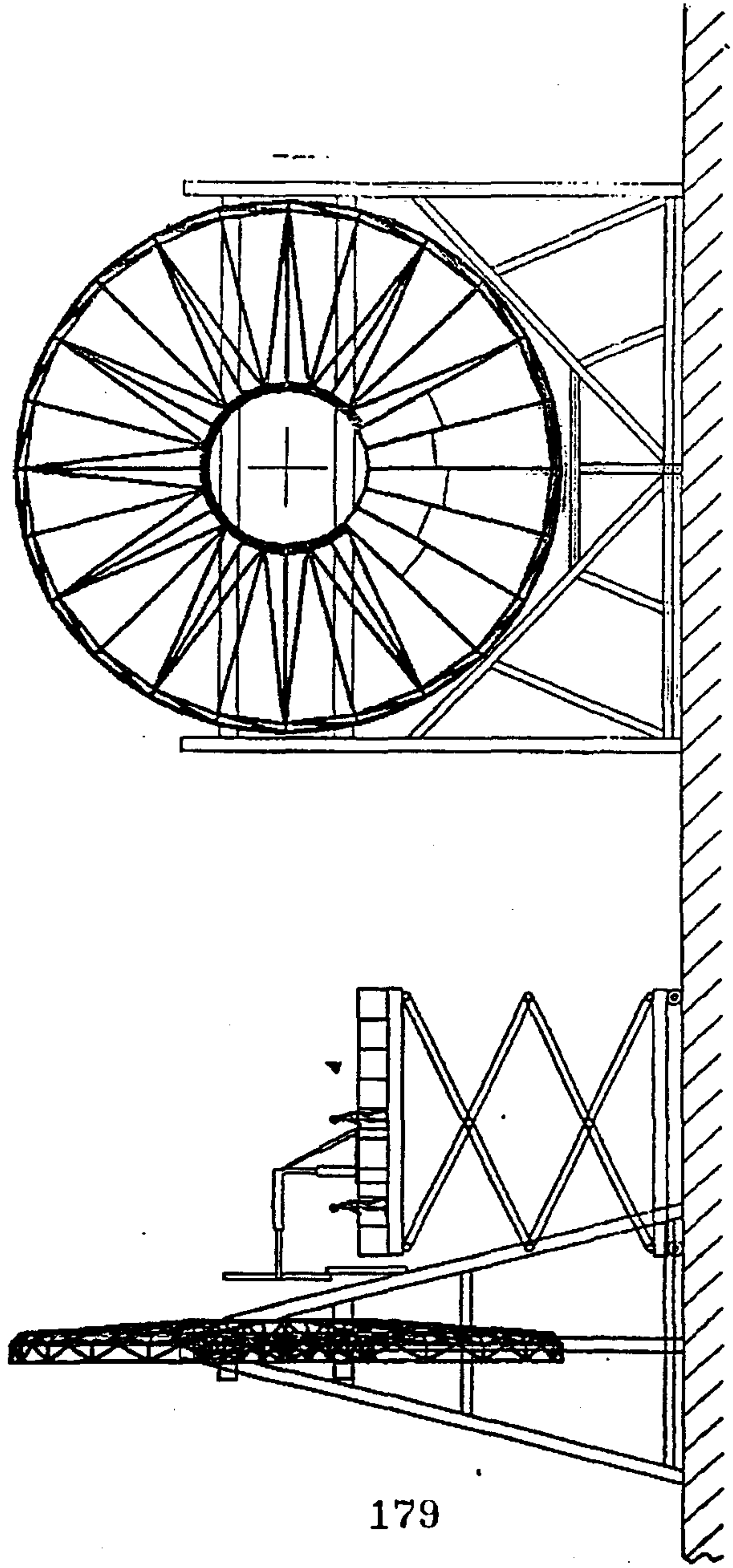
SGH Structure

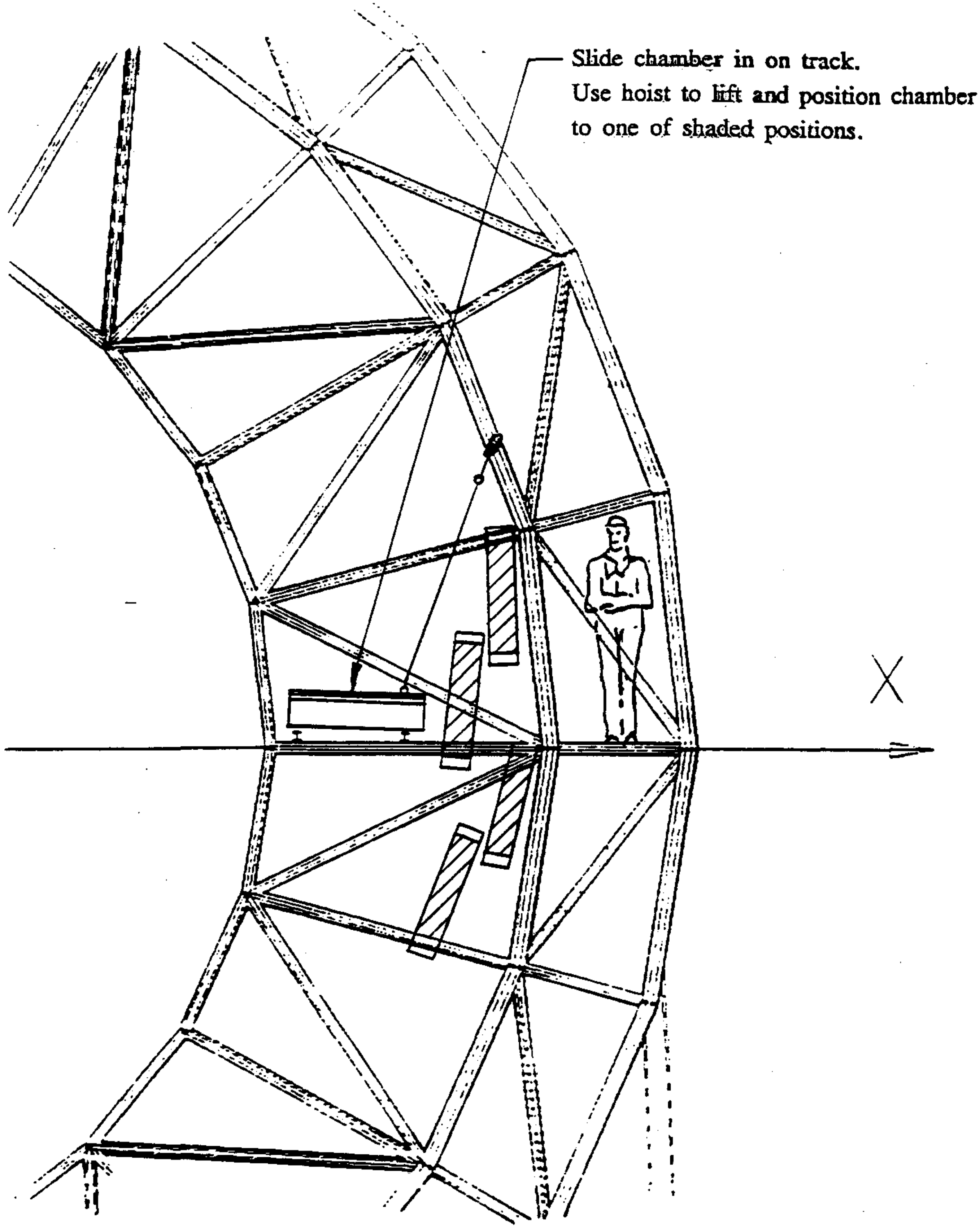
+	−
Smaller 30° Gap	No prototype
Lighter Structure	More awkward chamber handling
Stability	Commissioning.
Easier Access	



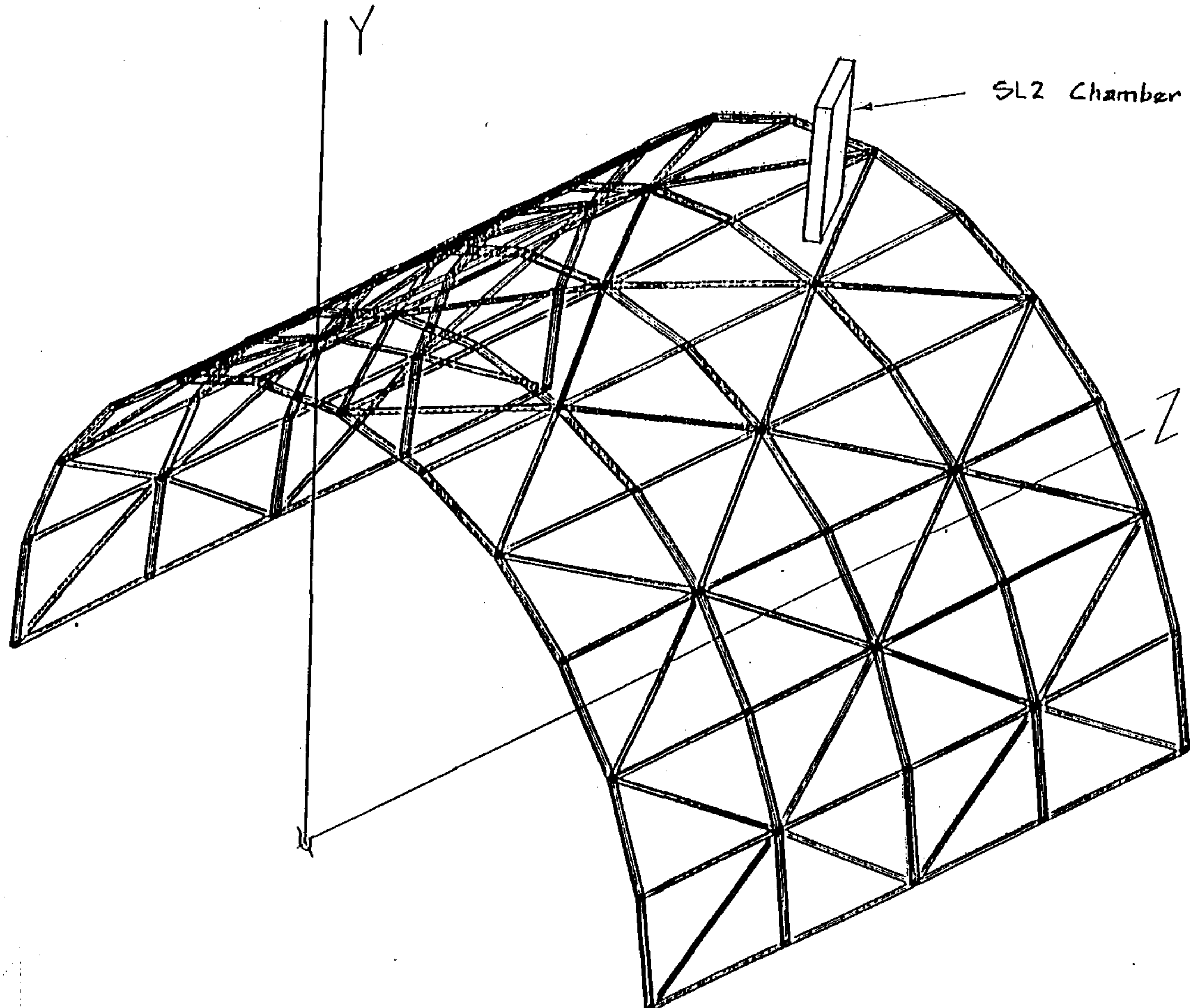


ORIENTED FOR ALIGNMENT





Insertion of SL2 Barrel Chambers – MIC1



Installation — SL2 Ch...

Many SGH Improvements should be included in final structure:

- Shells, diaphragms
- Lateral Restraint
- Chamber Support away from nodes
- Simplify Chamber Support + Adjustment
- Approach to Global Alignment
- Optimization Approach